02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Cristiano Galbiati

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☒ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Peter D Meyers

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Ed V Hungerford

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Katsushi Arisaka

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: David B Cline

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: C. J. Martoff

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☐ White

Disability Status: (Select one or more)
☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other
☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Uwe Oberlack

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Petr Chaguine

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Elena Aprile

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Karl L Giboni

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Andrew K Alton

Gender: ☐ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Andrea P Pocar

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☒ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Micheal H Zehfus

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Jocelyn R Monroe

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				002484665	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

210634501

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Princeton University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0026278000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Off. of Research & Proj. Admin.
4 New South Building
Princeton, NJ 08544-0036

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **1,746,893**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER
609-258-2496

PI/PD POSTAL ADDRESS
226 Jadwin Hall
Washington Road
Princeton, NJ 08544
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Cristiano Galbiati**	**PhD**	**1999**	**609-258-1245**	**galbiati@princeton.edu**
CO-PI/PD **Peter D Meyers**	**PhD**	**1983**	**609-258-5581**	**meyers@princeton.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919281

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**036837920**	**01/09/2009 3:33pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

746001399

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Houston

AWARDEE ORGANIZATION CODE (IF KNOWN)

0036525000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of Houston
4800 Calhoun Boulevard
Houston, TX. 772042015

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **398,799**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER
713-743-3589

PI/PD POSTAL ADDRESS
4800 Calhoun

Houston, TX 77204
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Ed V Hungerford**	**PH.D.**	**1967**	**713-743-3549**	**hunger@uh.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919259

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**092530369**	**01/09/2009 3:34pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

956006143

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of California-Los Angeles

AWARDEE ORGANIZATION CODE (IF KNOWN)

0013151000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

11000 Kinross Avenue
Suite 102
LOS ANGELES, CA 90095-1406

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **797,001**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Department of Physics and Astronomy

PI/PD FAX NUMBER
310-267-2483

PI/PD POSTAL ADDRESS
475 Portola Plaza
UCLA
Los Angeles, CA 90095
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Katsushi Arisaka**	**PhD**	**1985**	**310-825-4925**	**arisaka@physics.ucla.edu**
CO-PI/PD **David B Cline**	**PhD**	**1965**	**310-825-1673**	**dcline@physics.ucla.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Kristen Lund**	**Electronic Signature**	**Jan 9 2009 3:12PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
310-794-0171	**ocga3@research.ucla.edu**	**310-943-1656**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919169

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**057123192**	**01/09/2009 3:34pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

231365971

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Temple University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0033712000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

1601 N. Broad Street
406 USB, 083-45
PHILADELPHIA, PA 19122-6099

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **252,433**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER
215-204-5652

PI/PD POSTAL ADDRESS
1900 North 13th Street

Philadelphia, PA 19122
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **C. J. Martoff**	**PhD**	**1981**	**215-204-7634**	**jeff.martoff@temple.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Robert W Gage**	**Electronic Signature**	**Jan 9 2009 2:24PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
215-204-8691	**ecicinsk@temple.edu**	**215-204-7486**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919203

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**050299031**	**01/09/2009 3:35pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

741109620

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

William Marsh Rice University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0036046000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

William Marsh Rice University
6100 MAIN ST
HOUSTON, TX. 770051827

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **259,027**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics and Astronomy

PI/PD FAX NUMBER
713-348-3690

PI/PD POSTAL ADDRESS
6100 Main Street, MS-16
P.O. Box 1892
Houston, TX 772511892
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Uwe Oberlack**	**PhD**	**1997**	**713-348-3640**	**oberlack@rice.edu**
CO-PI/PD **Petr Chaguine**	**PhD**	**1990**	**713-348-3691**	**pshagin@rice.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Eric H Jordan**	**Electronic Signature**	**Jan 9 2009 2:44PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
713-348-6173	**ehj2@rice.edu**	**713-348-5425**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919198

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**049179401**	**01/09/2009 3:35pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

135598093

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Columbia University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0027078000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Columbia University
2960 Broadway
NEW YORK, NY. 100276902

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **606,516**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Columbia Astrophysics Laboratory

PI/PD POSTAL ADDRESS
550 West 120th Street

New York, NY 10027
United States

PI/PD FAX NUMBER
212-854-8121

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Elena Aprile**	**PH.D.**	**1982**	**212-854-3258**	**age@astro.columbia.edu**
CO-PI/PD **Karl L Giboni**	**Ph.D.**	**1980**	**914-591-2878**	**kgiboni@astro.columbia.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Jennifer Lomboy**	**Electronic Signature**	**Jan 9 2009 2:41PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
212-854-6868	**jl3292@columbia.edu**	**212-854-2738**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				076974088	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

460224588

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Augustana College

AWARDEE ORGANIZATION CODE (IF KNOWN)

0034587000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Augustana College
29th & S. Summit Ave.
Sioux Falls, SD. 57197

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **33,409**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER
605-274-4492

PI/PD POSTAL ADDRESS
29th and Summit

Sioux Falls, SD 57197
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Andrew K Alton**	**DPhil**	**2000**	**605-274-0770**	**drew.alton@augie.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919262

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**153926712**	**01/09/2009 3:35pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

043167352

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Massachusetts Amherst

AWARDEE ORGANIZATION CODE (IF KNOWN)

0022210000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Research Administration Building
70 Butterfield Terrace
AMHERST, MA 01003-9242

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **40,000**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER

PI/PD POSTAL ADDRESS
Research Administration Building
70 Butterfield Terrace
AMHERST, MA 010039242
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Andrea P Pocar**	**PhD**	**2003**	**413-545-0698**	**pocar@physics.umass.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Jennifer Donais**	**Electronic Signature**	**Jan 9 2009 3:15PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
413-545-5896	**jadonais@research.umass.edu**	**413-545-1202**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0919039

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**929922805**	**01/09/2009 3:36pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

466000364

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Black Hills State University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0034595000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Black Hills State University
1200 University Street
Spearfish, SD. 577999500

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **42,163**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Department of Chemistry

PI/PD FAX NUMBER
605-642-6762

PI/PD POSTAL ADDRESS
1200 University St., Unit 9088

Spearfish, SD 57799
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Micheal H Zehfus**	**Ph.D.**	**1984**	**605-642-6028**	**MichaelZehfus@bhsu.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Sharon D Hemmingson**	**Electronic Signature**	**Jan 9 2009 12:48PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
605-642-6371	**sharonhemmingson@bhsu.edu**	**605-642-6193**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Corrected : 01/09/2009

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 09-1

NSF 09-500 **01/09/09**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

PHY - UNDERGROUND PHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

0918864

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/09/2009	**2**	**03010000 PHY**	**7235**	**001425594**	**01/09/2009 3:36pm**

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

042103594

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Massachusetts Institute of Technology

AWARDEE ORGANIZATION CODE (IF KNOWN)

0021782000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Massachusetts Institute of Technology
77 MASSACHUSETTS AVE
Cambridge, MA. 021394307

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **41,000**	**36** months	**07/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Physics

PI/PD FAX NUMBER
617-253-0111

PI/PD POSTAL ADDRESS
77 MASSACHUSETTS AVE
26-561
Cambridge, MA 021394307
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Jocelyn R Monroe**	**DPhil**	**2006**	**617-253-1000**	**jmonroe@mit.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Kimberly L Mann**	**Electronic Signature**	**Jan 9 2009 8:59AM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
617-253-3907	**kmann@mit.edu**	**617-253-4734**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Project Summary

Evidence for the existence of dark matter is now compelling, but its nature remains a fundamental mystery. Particularly intriguing is the possibility that dark matter is made of Weakly Interacting Massive Particles (WIMPs). WIMPs may be detectable by their collisions with nuclei on Earth, but the low expected rate of such collisions and low energy of the recoil nuclei requires massive detectors with extremely low background rates, located in a deep underground laboratory. The development of a Deep Underground Science and Engineering Laboratory (DUSEL) will enable the deployment within the U.S. of WIMP detectors several orders of magnitude more sensitive than those operating today.

Liquid argon and xenon are promising media for WIMP detection due to their efficient conversion of energy from WIMP-induced nuclear recoils into both ionization and scintillation. In a Time Projection Chamber (TPC) scintillation and ionization can be independently detected and spatially resolved through large volumes of liquid. The relative size and time dependence of these signals permits discrimination of nuclear recoils from background events. By exploiting these methods and the self-shielding capability of the dense liquids, the leading xenon and argon TPC experiments have already achieved competitive sensitivity to WIMPs.

In 2007, the XENON-10 experiment reported a spin-independent (SI) cross section limit of $\sim 10^{-43}\,\mathrm{cm}^2$ and the WARP argon experiment reported a limit of $10^{-42}\,\mathrm{cm}^2$. Since mid-2008 the XENON collaboration has been operating at Laboratori Nazionali del Gran Sasso (LNGS) the first WIMP dark matter detector at the 100-kg scale (XENON-100). The Princeton group is participating in the WARP-140 kg experiment, now being commissioned at LNGS. Both experiments are expected to reach sensitivities of $\sim 10^{-45}\,\mathrm{cm}^2$ or to detect a handful of WIMPs if the cross section is $\sim 10^{-44}\,\mathrm{cm}^2$.

To make a convincing detection of dark matter, measurements of the interaction rate on multiple target nuclei will be required. Recognizing the significant synergy between argon and xenon as target/detectors for dark matter and the common engineering challenges of building liquid TPCs at the ton scale and beyond, we have decided to share knowledge and expertise and to design in parallel a large argon and a large xenon detector in a single collaboration: "Multi-ton Argon and Xenon TPCs" (MAX for short). Each detector will have sensitivity to the WIMP-nucleon cross section of $10^{-47}\,\mathrm{cm}^2$, 3–4 orders of magnitude better than existing limits. Both will be proposed for the DUSEL Initial Suite of Experiments (ISE). Together they will explore the most interesting region of the SUSY parameter space for WIMP dark matter, with the important features of verifying the A^2 dependence of the SI cross section and the spin dependent coupling offered by the xenon target.

The use of a common engineering team to develop the design of several major subsystems shared by the argon and xenon detectors will realize significant savings in time and cost while enabling an effective sharing of already-tested technologies.

Two important new technologies developed by collaboration members greatly enhance the power of the present collaboration to design the best xenon and argon detector system for the discovery and identification of WIMPs: (1) the development within the XENON collaboration of a new low-radioactivity, high-quantum-efficiency hybrid photomultiplier tube, the Quartz Photon Intensifying Detector or QUPID, designed at UCLA in partnership with Hamamatsu and (2) the discovery of underground sources of argon gas low in the isotope ^{39}Ar by the Princeton and Notre Dame groups, supported by the NSF. Designs incorporating these developments can achieve larger sensitive masses with much lower backgrounds than would otherwise have been possible.

INTELLECTUAL MERIT: The proposed activity will lay the engineering foundation for the next generation of larger noble liquid detectors, designed to advance our knowledge of elementary particles and cosmology in fundamental ways by detection of extremely weak, rare, low energy phenomena at DUSEL. These detectors will either detect WIMP dark matter for the first time or exclude a substantial fraction of the favored parameter space. The work will also prepare the way for a following generation of still-larger detectors (10 ton xenon TPC, 50 ton depleted argon TPC). These will be required to detect WIMP dark matter if the cross section is below the $10^{-47}\,\mathrm{cm}^2$, or to perform high-statistics, detailed studies of WIMP properties if WIMP dark matter is discovered using DUSEL-ISE experiments.

BROADER IMPACT: The proposed activity will advance the development of DUSEL and its scientific and educational mission in a variety of ways: (1) it will help the visibility of DUSEL as an international facility, through cooperation and partnership of US universities and national laboratories with European and Japanese groups; (2) it will offer an excellent opportunity for the training of students, who will have a chance to contribute to the success of a cutting edge project in fundamental science and advanced engineering; (3) it will benefit society through commercial applications of noble liquid detectors and associated technologies in areas ranging from national security to medical imaging; (4) it will support continued development of successful EPO programs such as the Princeton-Abruzzo-South Dakota summer school for high school students.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

	Total No. of Pages	Page No.* (Optional)*
Cover Sheet for Proposal to the National Science Foundation		
Project Summary (not to exceed 1 page)		
Table of Contents	1	
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**	0	
References Cited		
Biographical Sketches (Not to exceed 2 pages each)	2	
Budget (Plus up to 3 pages of budget justification)	6	
Current and Pending Support	1	
Facilities, Equipment and Other Resources	2	
Special Information/Supplementary Documentation	1	
Appendix (List below.) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**		
Appendix Items:		

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

	Total No. of Pages	Page No.* (Optional)*
Cover Sheet for Proposal to the National Science Foundation		
Project Summary (not to exceed 1 page)		
Table of Contents	1	
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**	0	
References Cited		
Biographical Sketches (Not to exceed 2 pages each)	8	
Budget (Plus up to 3 pages of budget justification)	6	
Current and Pending Support	3	
Facilities, Equipment and Other Resources	1	
Special Information/Supplementary Documentation	1	
Appendix (List below.) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**		
Appendix Items:		

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

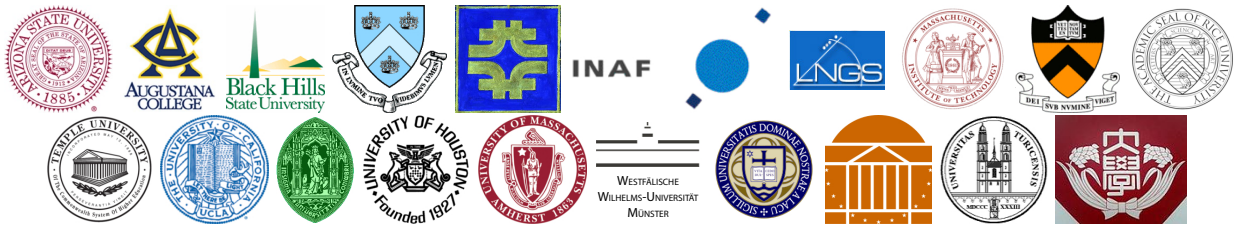
*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

I. THE MAX COLLABORATION



Arizona State University, USA Prof. Ricardo Alarcon, Septimiu Balascuta
Augustana College, USA Prof. Drew Alton
Black Hills State University, USA Prof. Dan Durben, Prof. Kara Keeter, Prof. Michael Zehfus
Columbia University, USA Prof. Elena Aprile, Dr. Karl-Ludwig Giboni, Dr. Tom Haruyama, Dr. Rafael Lang, Dr. Antonio Jesus Melgarejo, Dr. Kaixuan Ni, Guillaume Plante, Bin Choi, Kyungeun Elizabeth Lim, Taehyun Yoon, Dr. Gordon Tajiri
Fermi National Accelerator Laboratory, USA Dr. Steve Brice, Dr. Aaron Chou, Pierre Gratia, Dr. Jeter Hall, Dr. Stephen Pordes, Dr. Andrew Sonnenschein
Instituto Nazionale di Astrofisica (INAF) Gianmarco Bruno, Dr. Walter Fulgione
Laboratori Nazionali del Gran Sasso (LNGS), Italy Dr. Francesco Arneodo, Serena Fattori
Massachusetts Institute of Technology, USA Prof. Jocelyn Monroe
Princeton University, USA Alvaro Chavarria, Ernst de Haas, Prof. Cristiano Galbiati, Victor Garzotto, Augusto Goretti, Andrea Ianni, Tristen Hohman, Ben Loer, Prof. Peter Meyers, David Montanari, Allan Nelson, Marc Osherson, Eng. Robert Parsells, Richard Saldanha, Eng. William Sands
Rice University, USA Prof. Uwe Oberlack, Yuan Mei, Marc Schumann, Peter Shagin
Temple University, USA Prof. Jeff Martoff, Prof. Susan Jansen-Varnum
University of California at Los Angeles, USA Daniel Aharoni, Prof. Katsushi Arisaka, Ethan Brown, Prof. David Cline, Jonathan Kubic, Dr. Emilija Pantic, Prof. Peter F. Smith, Artin Teymourian, Chi Wai Lam, Dr. Hanguo Wang
University of Coimbra, Portugal Dr. Joao Cardoso, Luís Carlos Costa Coelho, Prof. Joaquim Marques Ferreira dos Santos, Prof. José António Matias Lopes, Dr. Sonja Orrigo, Antonio Ribeiro
University of Houston, USA Prof. Ed Hungerford and Prof. Lawrence Pinsky
University of Massachusetts at Amherst, USA Prof. Andrea Pocar
University of Muenster, Germany Dr. Marcus Beck, Dr. Volker Hannen, Karen Hugenberg, Dr. Hans-Werner Ortjoahnn, Prof. Christian Weinheimer
University of Notre Dame, USA Prof. Philippe Collon, Daniel Robertson, Christopher Schmitt
University of Virginia, USA Prof. Kevin Lehmann
University of Zürich, Switzerland Ali Askin, Prof. Laura Baudis, Dr. Alfredo Ferella, Marijke Haffke, Alexander Kish, Dr. Roberto Santorelli, Dr. Eirini Tziaferi
Waseda University, Japan Prof. Tadayoshi Doke, Prof. Nobuyuki Hasebe, Mitsuteru Mimura, Dr. Mitsuhiro Miyajima, Dr. Shinichi Sasaki, Dr. Satoshi Suzuki, Prof. Shoji Torii

II. INTRODUCTION

There is a wide range of astronomical evidence that the visible stars and gas in all galaxies, including our own, are immersed in a much larger cloud of non-luminous matter, typically an order of magnitude greater in total mass. The existence of this "dark matter" is consistent with evidence from large-scale galaxy surveys and microwave background measurements, indicating that the majority of matter in the universe is non-baryonic. The nature of this non-baryonic component is still totally unknown, and the resolution of the "dark matter puzzle" is of fundamental importance to cosmology, astrophysics, and elementary particle physics [1–3].

A leading explanation, motivated by supersymmetry theory, is the existence of as yet undiscovered Weakly Interacting Massive Particles (WIMPs), formed in the early universe and subsequently clustered in association with normal matter. WIMPs could, in principle, be detected in terrestrial experiments by their collisions with ordinary

nuclei, giving observable low energy (<100 keV) nuclear recoils. The predicted low collision rates require ultra-low background detectors with large (0.1–10 ton) target masses, located in deep underground sites to eliminate neutron background from cosmic ray muons. The establishment of the Deep Underground Science and Engineering Laboratory for large-scale experiments of this type would strengthen the current leadership of US researchers in this and other particle astrophysics areas.

The discussion in Sec. III shows that a genuine coherent dark matter signal can be identified by two features (i) the cross section per target nucleus contains a term proportional to the square of the target atomic number A and (ii) its recoil energy spectrum gives an estimate of the WIMP mass which must be independent of the target material. Identification by these features requires two target elements significantly different in A, ideally in detectors of similar principles and configuration. This proposal takes advantage of the fact that such detectors have already been developed for Liquid Ar (LAr) and Liquid Xe (LXe), with A=40 and $A\sim$131 respectively. Among the liquid-based detector technologies, time projection chambers (TPCs) are particularly promising. Both LAr and LXe are excellent scintillators, enabling detectors with low energy threshold. Their ionization response to radiation has been studied for decades and is well known.

We propose to detect nuclear recoils by scintillation and ionization in ton-scale liquid noble gas targets, using techniques already proven in experiments at the 0.01–0.1 ton level. For typical WIMP-nucleon cross sections expected from supersymmetry (10^{-43} cm^2 to 10^{-46} cm^2), the interaction rates are in the range 0.1–10^{-4} events per day per kg of target material. The experimental challenge is to identify these events in the presence of background events from gammas, neutrons, and alphas. These arise from radioactivity intrinsic to the detector and shielding material and cosmic ray muons, the latter requiring the experiments to be run deep underground.

The combined ionization and scintillation signals in the TPCs are rich in information, permitting a very effective separation of β/γ background radiation and multiple-sited, neutron-induced nuclear recoils from single-sited nuclear recoils, which are the expected signature of WIMP dark matter interactions [4, 5]. The separation methods are:

1. **Scintillation to Ionization Ratio.** The primary scintillation signal ($S1$) in a noble liquid TPC is detected by photosensors placed around the active volume. The TPC also produces an ionization signal by drifting the electrons to the top of the liquid volume and extracting them into a gas layer, a "two-phase" configuration. A strong electric field in the gas produces a secondary, drift-time-delayed light signal ($S2$) by electroluminescence. Only the ionization electrons that survive recombination with ions [6] contribute to the ionization signal $S2$. Electron-ion recombination depends very strongly on the ionization density of a track, and it is dramatically different for β's, α's, and nuclear recoils [7–9]. For the more heavily ionizing particles the ionization signal is strongly suppressed. The $S2/S1$ ratio provides a factor of $\sim$200–1000 separation between nuclear recoils and other event types [4, 5].
2. **Position Reconstruction and Fiducialization.** A noble liquid TPC is a homogeneous, 3-D position sensitive device. The drift direction (z) coordinate is measured with sub-millimeter precision by the time difference between the $S1$ and $S2$ signals. The x-y coordinates are reconstructed from the distribution of the $S2$ light over the top array of photosensors, with a precision which varies from millimeters to centimeters, depending on the granularity of the array. Diffusion of the ionization electron during the long drift is negligible in the dense noble liquids [7], preserving precise localization information in $S2$, which is not available in single-phase detectors. Precise event localization is extremely useful for both argon and xenon targets to reduce the residual neutron background via reconstruction of multiple interactions and to reject backgrounds that come from the container walls. In a single-phase detector with 4π optical coverage the $S1$ signals can be reconstructed by exploiting the photon time of flight and/or the intensity distribution of the collected primary scintillation photons, resulting in a much coarser spatial resolution (10 cm or more). This feature is retained as an additional localization method in our two-phase TPC with 4π optical coverage.
3. **Pulse Shape Discrimination.** As discovered by Doke and colleagues, the scintillation of noble liquids depends very strongly on the ionization density of the tracks [8, 10]. Boulay and Hime pointed out that pulse shape discrimination applied to the $S1$ primary scintillation can be very powerful in liquid argon [11], due to a very large decay time difference between the two excimer states (singlet and triplet), which are populated differently by low- and high-density tracks [8]. In argon, the technique has been proven to reject β/γ background by a factor of up to 3×10^7 [5, 12]. The technique is very challenging in xenon due to the similar decay times of the singlet and triplet excimers [7, 8].

For large noble liquid TPCs the bulk radioactivity due to isotopic impurities, present even at exceedingly low levels in the natural targets, can limit the sensitivity to dark matter. One of the main background sources in large argon detectors is ^{39}Ar, a β-emitter produced in the atmosphere by cosmic rays. The specific activity of ^{39}Ar (Q=565 keV, τ=388 yr) is $\sim$1 Bq/kg for atmospheric argon, corresponding to a concentration of

^{39}Ar/Ar=8×10^{-16} [13, 14]. The $S1$ pulse shape discrimination is strong enough to discriminate against the ^{39}Ar activity in atmospheric argon in moderate sized detectors, but event pile-up limits the size of unsegmented atmospheric argon detectors to about 1 ton. Bigger unsegmented detectors can only be built with isotope-depleted material. Such material is now available at moderate cost [15], allowing us to propose a multi-ton argon detector.

Liquid xenon has no short-lived intrinsic radioactive impurities, with the exception of ^{85}Kr. The typical concentration of Kr in commercial xenon gas is at the ppm level. Beta decays of ^{85}Kr (Q=687 keV, τ=15.5 yr) contribute a serious background. For the reduction of ^{85}Kr level to $<$1 ppt, required by the sensitivity goal of a ton-scale Xe TPC, a cryogenic distillation column has been shown to be very effective [16] and has been adopted by the current XENON-100 experiment [17].

The discrimination power, the precision in x, y, and z on the event position, and the effectiveness of chemical purification and cryogenic distillation methods have been successfully demonstrated in published results from Xe and Ar detectors involving many members of this collaboration. The XENON-10 detector [4] with a 5 kg fiducial mass, has set a cross section limit of $<6\times10^{-44}$ cm^2 at 90% CL with a 136 kg·day in LNGS, and has now been succeeded by XENON-100 (50 kg fiducial mass), currently operating at LNGS. The ZEPLIN-II detector (UCLA/UK) with a 8 kg fiducial mass [18] has set a limit of $<6\times10^{-42}$ cm^2 in a 240 kg·day run in 2006, and is now succeeded by the UK ZEPLIN-III detector [19], reaching a sensitivity comparable with that of XENON-10 and similarly undergoing an upgrade. The Princeton group participates in the WARP collaboration and has contributed to the operation of a 3.2 kg Ar prototype reaching a sensitivity of 10^{-42} cm^2 in a 100 kg·day run [5]. This effort has been succeeded by a 140 kg Ar detector, WARP-140, which is now being commissioned and is the largest noble liquid WIMP detector to date. XENON-100 is expected to reach a cross section sensitivity of $\sim10^{-45}$ cm^2 in 7 months of running. The same sensitivity is projected for WARP-140 in a 2 yr run. These experiments will fully confirm the detection principles and the operational feasibility of both Ar and Xe detectors for Dark Matter searches.

The experience gained from all these experiments gives us the confidence to proceed to larger-scale detectors. We propose the construction of ton-scale detectors with sensitivities three orders of magnitude beyond currently published results, capable of setting upper limits of 10^{-47} cm^2 (if no events are seen) or obtaining a scientifically useful number of events at a cross section of 10^{-46} cm^2. Two developments allow larger noble liquid detectors with lower backgrounds than would otherwise have been possible: (1) the recent invention and development at UCLA of a new ultra-low radioactivity photosensor – the QUPID – which has a sufficiently low activity ($\sim$100 times better than the lowest activity PMTs) to be used directly in the proximity of the detector, improving light collection and position resolution and lowering energy threshold; (2) the discovery of underground sources of argon gas low in the radioactive isotope ^{39}Ar (Depleted Argon, DAr) by the Princeton and Notre Dame groups, with the support of the National Science Foundation.

The combination of DAr and Xe detectors, using similar detection principles and operating under similar conditions, can provide clear confirmation of a genuine signal from coherent WIMP interactions. A larger mass is required for the DAr detector to offset the lower cross section in argon per unit mass. With about 50% odd isotopes, natural Xe also permits a search for spin-dependent WIMP interactions.

The DARCSIDE and XENON collaborations have formed a partnership, the MAX collaboration, to submit this proposal for the preliminary design of a DAr TPC with 5.0 ton active (2.7 ton fiducial) DAr mass and a Xe TPC with 2.4 ton active (1.0 ton fiducial) Xe mass, as dark matter detectors for inclusion in the DUSEL ISE program, at the 4850 ft campus. While the DARCSIDE and XENON collaborations are pursuing their own programs for DAr and Xe TPCs in the pre-DUSEL phase, we are joining in a single S4 proposal recognizing the advantages of merging the US dark matter community into a few larger collaborations with the required critical mass and expertise to develop the first suite of DUSEL experiments in a timely and cost effective way. The use of a common engineering team to develop the design of several major subsystems shared by the argon and xenon detectors is intended to realize significant savings in time and cost and will enable an effective sharing of already-tested technologies. In particular, both detectors will make use of the same photosensor technology, electronics, shielding scheme, and purification strategy, and will face similar issues in cryogenics, safety, and underground operation.

We have identified a Project Manager and lead engineers for the design work for the major subsystems (see Sec. XIV). The bulk of our requested funding supports these people and some additional engineers and consultants. Appendix A (in the supplementary materials) specifies the tasks and their managers in WBS form. We summarize the major elements of the WBS in Table I.

The DAr and Xe TPCs will require shielding against external β/γ radioactivity and external and cosmogenic neutrons. Water shielding provides the most cost-effective solution. Our collaboration strongly endorses the effort towards a community-wide engineering of water-based shields and ^{222}Rn-suppressed cleanrooms through a related S4 Proposal (submitted by Princeton University, PI: Frank Calaprice).

Element	Subsystem	Example tasks	Element	Subsystem	Example tasks
1.1	TPCs	Field cage mechanics	1.2	Inner Vessels	Vessel mechanics and seals
1.3	Photodetector	Photosensor testing	1.4	Cryogenic Systems	Cryo cooling systems
1.5	Pre-Purification	DAr extraction	1.6	Runtime Purification	Selection of getters
1.7	Electronics	Design of digitizers	1.8	DAQ	Digitizer readout
2.	Simulations	Neutron background simulations	3.	Shielding/Muon Veto	Design of shield
4.	DUSEL Interface	Facilities interconnects	5.	Radiation Screening	Materials validation
6.	Safety	Hazard analyses	7.	Installation	Procedures
8.	Commissioning	Procedures	9.	Operations	Procedures
10.	E&O	Davis-Bahcall Scholarship			

TABLE I: Summary of major elements of the S4 WBS. Also reported, for each major element, a sample task for illustrative purposes. We refer the reader to Appendix A for the WBS.

III. PHYSICS REACH

The features available to identify a genuine spin-independent dark matter signal are (1) the A^2 factor in the nuclear cross section due to the coherent nature of the interactions [20, 21]; (2) the shape of the recoil energy spectrum for targets with different A [22, 23]. These features can be exploited effectively by operating two detectors of similar sensitivity, but with targets of distinctly different atomic number. Figure 1a shows the recoil energy spectra for Xe and Ar with M_χ=100 GeV and a spin-independent $\sigma_{\chi N}$=10^{-47} cm^2. Xe is seen to have a greater sensitivity per unit mass than Ar at low energy, but Ar is less affected by the nuclear form factor correction so higher energy recoils can usefully contribute. Combined data from Xe and Ar in combination provide powerful information that can be used to verify the predicted A dependence of both the rate and the spectrum shape [24]. It is also evident from Figure 1a that to achieve similar counting rates, the Ar detector must have a larger fiducial mass.

The DAr TPC (Sec. IX) to be designed in the present work will have a 5.0 ton total (2.7 ton fiducial) target mass. The background rejection from the pulse shape depends critically on the number of photons detected, which depends in turn on the photosensor coverage and the photosensor quantum efficiency [11]. The larger the photo-electron yield, the lower the threshold. The baseline design should achieve a photoelectron yield >7 p.e./keV$_{ee}$ at null electric field. Monte Carlo simulations indicate that a neutron background of < 0.2 event/yr above the planned 30 keV$_r$ threshold for nuclear recoils is achievable with a conventional shielding scheme and existing photodetectors. The β/γ background, reduced by the use of depleted argon, is expected to be negligible after discrimination (pulse shape and $S2/S1$). For M_χ=100 GeV, the experiment would be able to set a limit $\sigma_{\chi N} \leq 10^{-47}$ cm^2 or count a few events/yr for a cross section of 10^{-46} cm^2 in a 5-yr run, corresponding to an exposure of 12 ton·yr after fiducialization and accounting for nuclear recoils acceptance of analysis cuts.

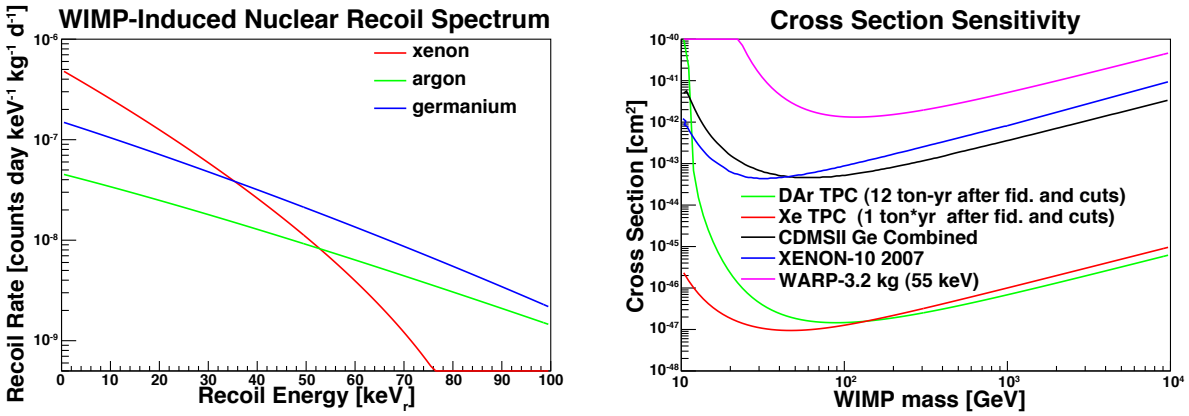


FIG. 1: **(a)** Nuclear recoil spectrum for Ar and Xe targets (M_χ=100 GeV and $\sigma_{\chi N}$=10^{-47} cm^2). **(b)** Physics reach of the 5.0 ton DAr TPC (5-yr run, 12 ton·yr exposure after fiducial and analysis cuts) and of the 2.4 ton Xe TPC (2-yr run, 1 ton·yr exposure after fiducial and analysis cuts) presented in this proposal, compared with the limits achieved by CDMS, XENON, WARP, and ZEPLIN [4, 5, 18, 19, 25].

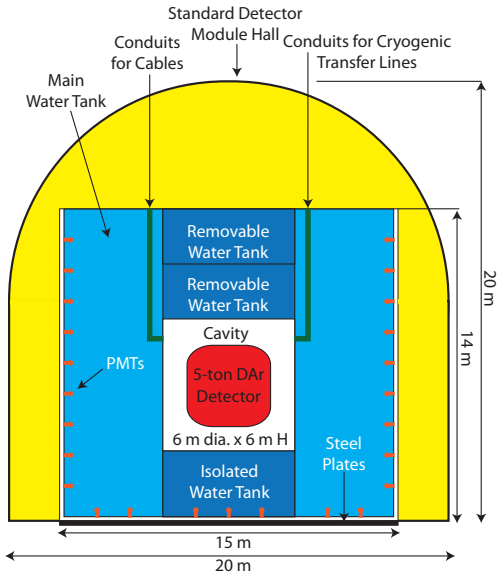


FIG. 2: Water Shielding Tank. The detector will be mounted in a re-entrant tube that serves as an air-filled "detector room" at the center of the tank.

The Xe TPC baseline design (Sec. X) will have a 2.4 ton total (1 ton fiducial) mass and light yield >7 p.e./keV$_{ee}$ at null electric field, achieved by covering the detector with a 4π array of QUPID photodetectors (see Sec. V below). Based on Monte Carlo simulations, the projected β/γ background is 10^{-7} events/(kg·keV·d) and the neutron-induced background is <0.1 events/yr above the planned 4 keV$_r$ threshold after fiducialization and $S2/S1$ discrimination. This low background is made possible by the use of the novel QUPID photodetectors (see Sec. V below) and by careful selection of the detector materials. The experiment would have a WIMP counting rate of ~10 event/yr for a cross section of 10^{-46} cm^2 and a limiting sensitivity of $\sigma_{\chi N} \leq 10^{-47}$ cm^2 in a 2-yr run, corresponding to an exposure of 1 ton·yr after fiducialization and accounting for the nuclear recoils acceptance (50%) of the analysis cuts. Figure 1b shows the physics reach of the proposed experiments along with current published limits.

The Xe TPC will also be sensitive to WIMPs interacting through a spin dependent (SD) channel, since natural Xe contains approximately equal fractions of odd and even isotopes. However, as in any SD experiment, the accessible cross section is much larger than for the SI case because the coherent A^2 factor is no longer present and there are additional nuclear coefficients to be included [23]. The sensitivity to SD cross section for the Xe TPC is $\sigma_{\chi N} \leq 10^{-42}$ cm^2 for pure neutron coupling.

Both the DAr and Xe TPCs will be capable of exploring other possible WIMP scenarios, including the recently suggested model of a dark matter multiplet interacting with regular matter through a light vector boson [26, 27]. The reach of a given experiment is highly sensitive to the galactic escape velocity. However, for a reasonable $v_{esc} \sim 600$ km/s, the xenon TPC will have sensitivity to $\sigma_{\chi N} \approx 5 \times 10^{-46}$ cm^2 for an inelastic splitting of $\delta = 100$ keV and M_χ=100–1000 GeV. The argon TPC is robustly sensitive to cross sections of $\sigma_{\chi N} \approx 6 \times 10^{-47}$ cm^2 at δ=50 keV M_χ=100–1000 GeV. Due to the lighter argon mass, the ability to probe the high δ range is highly sensitive to the galactic escape velocity, but is significant with v_{esc}=600 km/s.

IV. NEUTRON SHIELD AND MUON VETO

The primary sources of background external to the cryostats containing each noble liquid TPC are: 1) muons, producing γ-rays and high energy neutrons either in the rocks surrounding the lab or in the shielding material; 2) airborne contaminants such as ^{222}Rn and its daughters and ^{85}Kr; 3) U, Th, and K in the rocks, producing γ-rays and neutrons from fission and (α,n) reactions; 4) U, Th, and K in the shielding material and in the external parts of the detector, producing γ-rays and neutrons.

REQUIREMENTS:

The above background will be mitigated by an external shield, designed to satisfy the following requirements:

1. The external shield must identify cosmic ray muons crossing the shield itself with efficiency >99%.
2. The shield must reduce the external β/γ background in the fiducial region of the TPCs to below 1 events/(kg·keV·d) for the DAr TPC and below 10^{-5} events/(kg·keV·d) for the Xe TPC (This is prior to further background rejection by the methods of Sec. II.) This is to be achieved in combination with supplementary shielding materials in the outer layers of the TPC, and using progressively cleaner shielding material in layers closer to the active target mass.
3. The shield must suppress the large flux of high- and low-energy neutrons coming from the rocks and the flux of high-energy neutrons coming from cosmogenic interactions in the shield itself to less than 0.1 events in the exposures of the experiments after analysis cuts (12 ton·yr for DAr and 1 ton·yr for Xe). This is to be achieved in combination with supplementary shielding materials in the outer layers of the TPC.

WBS SECTIONS: 3.1, 3.2, 4., 5., 6.

Water shielding can provide a cost-effective shield against gamma rays, neutrons, and muon-induced radiation. Standard methods of producing high purity water yield very low levels of U and Th, typically at the level

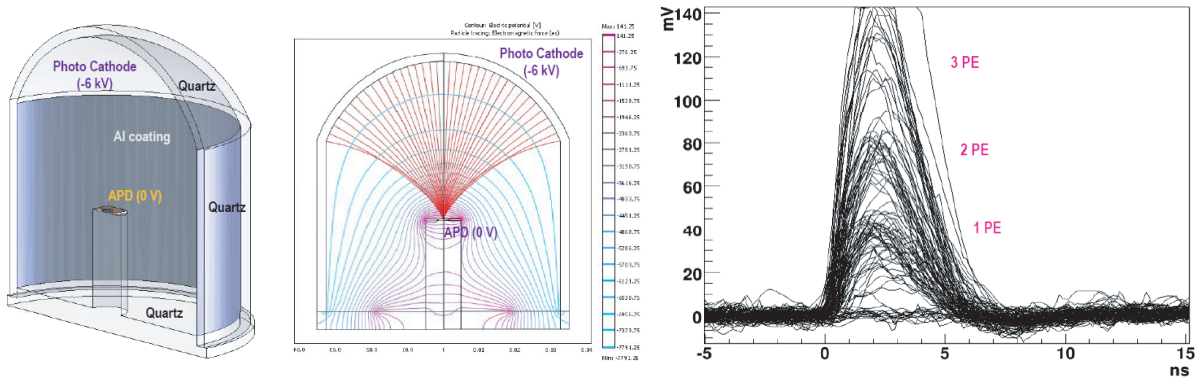


FIG. 3: **a)** Structure of the QUPID. **b)** Electron optics of the QUPID. **c)** Digitized QUPID waveforms: note the separated bands corresponding to detection of 1, 2, and 3 photoelectrons.

of 10^{-15} g/g [28–30]. Radioactivity from a stainless steel water containment vessel is sufficiently low and is mostly shielded by the water or, where needed, by additional shielding in the internal detector structure, so that it has negligible impact on the detector background [31]. The main potential background problem with water shields is ^{222}Rn and its radioactive daughters, especially ^{214}Bi, which emits high-energy gamma rays. Radon contamination can occur due to air leaks or emanation from sealing materials or dirt in the vessel. Avoiding polymer materials with high levels of ^{238}U and high radon diffusivity and using good cleaning techniques can minimize radon contamination.

We foresee the need for independent tanks for the DAr and Xe TPCs. Monte Carlo simulations performed with GEANT4 and FLUKA indicate that 3.0 m of water in all directions, or the equivalent combination of water and steel, is enough shielding to make the neutron background negligible for several ton-years of operation of a detector at the 4850 ft level of DUSEL [32]. However, the Monte Carlos do not correctly predict the rate of high neutron multiplicity events observed in Borexino and SNO [33–35]. Such cosmogenic neutrons may be characterized by a very hard spectrum, which could result in the presence of a more penetrating and dangerous cosmogenic neutron component. A specific activity of a separate community-wide S4 water-shield proposal (PI: Frank Calaprice, Princeton) is to perform a coordinated study of neutron data from existing large underground detectors, to assist in choosing the final water tank dimensions. Our baseline design has a minimum of 4.5 m of water-equivalent shielding on all sides to provide additional assurance against backgrounds not modeled by the current Monte Carlos and to allow future mounting of detectors with substantially larger active volumes in the same water tanks.

Figure 2 shows a water shield for the DAr TPC. The water is instrumented with photomultiplier tubes to tag muons and secondary neutrons from muon interactions in the materials surrounding the active argon volume. The detector is placed in an air-filled cavity within the water shield, capped with removable plugs. This design provides adequate shielding while also solving one of the major safety issues confronting cryogenic detectors in water tanks–the danger of rapid boiling of the cryogen in thermal or direct contact with water in the case of a rupture of one of the cryostat vessels (see Sec. XIII). A design for the Xe TPC, based on the same concept and with the possible addition of a passive lead and copper shield to attenuate γ-rays from the steel of the re-entrant tube, will be developed as part of the S4 effort.

V. PHOTODETECTORS

REQUIREMENTS:

The DAr and the Xe TPC baseline design relies on currently existing photosensors with known characteristics, including radioactivity budget, as summarized in Table II.

WBS SECTIONS: 1.3

The photodetectors required to instrument the TPCs are (along with their electronic bases) among the dominant source of γ-rays and neutrons inside the detector. The success of multi-ton noble liquid TPCs thus depends on the development of ultra-low-radioactivity, high-efficiency photon detectors. To address this challenge, the UCLA group collaborated with Hamamatsu Corporation to invent and produce prototypes of an innovative photon detector, the Quartz Photon Intensifying Detector (QUPID). The QUPIDs are based on a proprietary design and

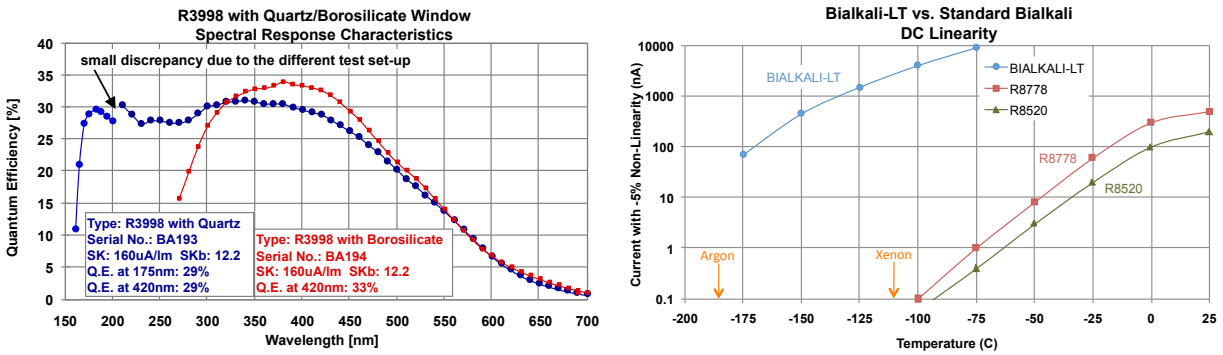


FIG. 4: **a)** Quantum efficiency of the Bialkali-LT photocathode on quartz and borosilicate windows. **b)** DC linearity for the Bialkali-LT photocathode versus temperature, compared with the same quantity for the PMTs R8778 and R8520, equipped with traditional bialkali photocathodes.

their availability is restricted to the MAX program by a MOU between UCLA and the Hamamatsu Corporation. As shown in Figure 3a, the QUPID is a hybrid PMT: photoelectrons emitted from the 3" diameter hemispherical photocathode are accelerated onto an Avalanche PhotoDiode (APD), resulting in a total gain of 2×10^5 [36, 37]. The QUPID envelope is fabricated from low-radioactivity synthetic fused silica, with good transparency for visible and UV light. This allows direct, efficient detection of the 175 nm xenon scintillation light. These devices can drive several meters of cable without pre-amplification, while preserving very sharp timing characteristics (transit time spread=250 psec, rise time=1.3 nsec, fall time=2.6 nsec, and pulse width FWHM=3.1 nsec). A simple readout scheme can therefore be used, with a linear amplification stage followed by direct digitization of the waveform. Moreover, thanks to the high gain of the electron bombardment, the noise is low and, as a result, clear peaks of not only one but also of two and three photoelectrons can be observed (see Figure 3c).

The first four prototype QUPIDs were screened for radioactivity in a 1-month run in the Germanium-based screening facility dedicated to XENON-100 at LNGS. The radioactivity of the QUPID was too low to be detected above the intrinsic background of the detector, resulting in 95% C.L. limits of ^{238}U<0.49 mBq, ^{232}Th<0.40 mBq, ^{60}Co<0.21 mBq, and ^{40}K<2.40 mBq. These upper limits can be compared to the activity in PMTs used in current dark matter TPCs: ∼15 mBq total activity per 2" PMT Hamamatsu R8778, or ∼1 mBq total activity per 1" PMT Hamamatsu R8520-06-AL, used in XENON-100. The neutron emission rate from the QUPID (as calculated with the SOURCES package [38]) is less than 10^{-3} $n/(\text{yr}\cdot\text{cm}^2)$, a limit more than ten times better than the rate for the 1" PMT Hamamatsu R8520.

Both TPCs will benefit from use of the QUPIDs. The xenon TPC will have 4π coverage with QUPIDs. In the DAr TPC, QUPIDs will be used to view the top of the detector where their low radioactivity allows use of a thin acrylic window rather than a thick neutron-moderating shield. With this setup, the transverse coordinates of a pointlike event can be reconstructed with sub-cm precision. The very strong $S1$ pulse shape discrimination leads to relaxed requirements on β/γ background radiation, which allows a baseline design in which the sides and bottom are viewed using 8" Hamamatsu R5912-MOD02 PMTs with a specially developed low-radioactivity borosilicate glass envelope (^{238}U=0.4 Bq, ^{232}Th=0.2 Bq, ^{40}K=0.3 Bq, 0.6 $n/(\text{yr}\cdot\text{cm}^2)$). Neutrons from these PMTs can be shielded by 30 cm of acrylic, achieving a dramatic cost savings without important effects on event reconstruction and with only a moderate loss of light. Since neither acrylic nor quartz are transparent to the 128 nm argon scintillation light, the light must be shifted into the visible range by a TetraPhenylButadiene (TPB, peak emission at 430 nm) layer lining the entire active volume.

The photosensors must operate at cryogenic temperatures where standard bialkali photocathodes can have extremely low saturation currents. The standard solution, depositing a thin platinum conducting layer over the photocathode, substantially impairs the quantum efficiency. Hamamatsu has developed a breakthrough "Bialkali-LT" (Low Temperature) photocathode, which operates down to LAr temperatures with high QE. The QE of the Bialkali-LT has already reached 28% (at both 175 and 430 nm) on the quartz faceplate of the QUPIDs and 33%

Photosensor	^{238}U [mBq/unit]	^{232}Th [mBq/unit]	^{40}K [mBq/unit]	Neutrons $[n/(\text{yr}\cdot\text{cm}^2)]$	Photocathode	T Range [K]	QE Achieved [%]	QE Goal [%]
R5912-MOD02	400	200	300	0.6	Bialkali-LT	70–330	33	>35
3" QUPID	<0.49	<0.40	<2.40	$<10^{-3}$	Bialkali-LT	70–330	28	>35

TABLE II: Characteristics and background of the photosensors in the baseline design for the DAr and Xe TPCs.

on a borosilicate faceplate (see Figure 4a). Figure 4b illustrates the difference in saturation current performance at liquid argon and liquid xenon temperature between the Bialkali-LT and a traditional bialkali photocathode. Hamamatsu has agreed to produce both QUPIDs and 8" R5912-MOD02 PMTs with this novel photocathode.

VI. DEPLETED ARGON COLLECTION

FIG. 5: The two stage Vacuum and Pressure Swing Adsorption plant developed at Princeton. The plant was operated on a CO_2 stream producing 0.7 kg per day of depleted argon.

The background discrimination of a two-phase TPC would be sufficient to discriminate against the $\sim$1 Bq/kg ^{39}Ar levels found in atmospheric argon, even for a fairly large detector, provided that the scintillation light is detected with high efficiency to fully exploit the powerful pulse shape discrimination. However, background from ^{39}Ar can cause a loss of live time due to pileup between candidate signal events and ^{39}Ar decays during the electron drift time. This becomes problematic for a two-phase detector with mass $>$1 ton.

Centrifugation or differential thermal diffusion are established methods for ^{39}Ar/^{40}Ar isotopic separation. However, with very high costs ($40k/kg) and a global production capacity of a few kg/month, these options are not practical for large detectors. Since ^{39}Ar is produced in the atmosphere by cosmic ray interactions on ^{40}Ar, such as ^{40}Ar$(n,2n)^{39}$Ar, one might expect that a source of underground argon which has been protected from cosmic rays for many ^{39}Ar halflives would have a very low ^{39}Ar content. The Princeton group, in a 2-year NSF-sponsored R&D program, has identified two such underground sources of argon-containing gas capable of producing in excess of 30 tons of argon per year, at an anticipated cost of $\sim$\$0.5–1.0k/kg for a 5 ton batch.

REQUIREMENTS:

The source and plants selected for the collection of DAr must satisfy the following requirements:

1. The source must contain argon with ^{39}Ar/Ar$\leq 4\times10^{-17}$ (*i.e.*, less than 5% of the ^{39}Ar/Ar in the atmosphere). This will limit the total pile-up fraction in a 5 ton detector to $\approx$10% and the fractional loss of exposure after software pile-up removal to $\leq$2%.
2. The plants must enrich the $\leq$0.1% DAr content of the natural gas stream at the well head to a level 10% by volume or larger, at a production rate of > 20 kg/d of depleted argon.

WBS SECTIONS: 1.5

Preliminary work by the Princeton group with NSF support shows a path toward satisfying Requirement 1. The two underground argon sources identified so far are the National Helium Reserve (Amarillo, TX) and the Doe canyon CO_2 Formation (Cortez, CO). These were sampled during 2008, using a two-stage VPSA system designed by Koch Modular Process Systems (KPMS) and built by Princeton. The collected $\sim$1 kg argon samples were assayed by low level counting, obtaining respective upper limits of 5% and 25% for the ^{39}Ar isotope content relative to atmospheric argon.

The present upper limit on ^{39}Ar/Ar (5% relative to the atmospheric ^{39}Ar/Ar) in gas from the National Helium Reserve already satisfies the requirement for the present experiment. We believe that the ultimate ^{39}Ar/^{40}Ar ratio at both sources could be much lower than this upper limit. Members of the collaboration are building a low-background ^{39}Ar counter with a 1 kg depleted argon target mass that will improve the sensitivity to 0.1% of the atmospheric activity [39–41], and are also pursuing improvements to Accelerator Mass Spectroscopy that may result in measurement of the ^{39}Ar activity with sensitivity below 0.5% of the atmospheric ^{39}Ar/Ar [42–44].

Owners of the gas streams from both sources (Linde USA, drawing crude helium gas from the National Helium Reserve, at its Global Helium plant in Otis, KS; the Kinder Morgan Corporation, owner of the gas mining rights at Doe Canyon) support the MAX efforts towards the extraction of very large batches of depleted argon: see their letters of support attached to in the "Supplementary Documentation" section of this proposal.

The KPMS design study for the VPSA system also addressed subsequent purification of the crude well head stream to 99.999% argon or better, using a 60' cryogenic distillation column with 120 equilibrium stages. This is a

conventional method used by commercial firms to produce "research grade" noble gases. A significant engineering effort will be required to design a system capable of producing multi-ton quantities of argon at the source selected for production. It is proposed to sub-contract the engineering for this portion of the S4 work to Linde USA (see their letter of support).

VII. CHEMICAL PURIFICATION OF DEPLETED ARGON AND XENON

DAr and Xe gas require several stages of purification before they are suitable for use in detectors. DAr is extracted from an underground natural gas stream in which the argon starts out as only a minor constituent. This is first refined at the well head into a crude mixture with typical argon concentration $\sim$ 10% by volume, with the remaining fraction largely N_2, CH_4, and He. Cryogenic distillation plants can be designed for operation in a large range of temperatures and for the removal/separation of virtually all gaseous chemical components, and is the most effective method to separate N_2, CH_4, and He from Ar while maintaining a $> 95\%$ recovery of the Ar.

Commercial Xe gas of "research grade" (99.999% purity) typically contains <0.1 ppm of O_2, N_2, and CO_2, water at the 10 ppb level, and Kr at a few ppm level. Some specialty gas companies are equipped to further reduce Kr by a factor of 1,000 using specially designed cryogenic distillation columns at a significant additional cost. Given that purification for Kr-removal beyond this is required for a dark matter search with a ton-scale Xe TPC, it is cost effective to develop a dedicated cryogenic distillation facility, and start with lower cost "research grade" Xe gas.

Under the contract issued by Princeton in 2007, Koch Modular Process Systems (KPMS) performed a preliminary study resulting in a conceptual design for a cryogenic distillation column capable of meeting the distillation requirements for DAr and Xe. Results indicates that it is possible to rely on a single unit to remove N_2, CH_4, and He from Ar, and Kr from Xe, with very high efficiency and meeting the required purification specs. We propose to engineer a single, common cryogenic distillation plant suitable for purification of both the crude argon and commercial Xe with ppm levels of Kr. The cryogenic distillation column will be sited at DUSEL, either above ground or in a shallow underground location.

After reduction of electronegative impurities to the level of 0.1 ppm or better, experience shows that runtime purification with getters (both single-pass and recirculating) is necessary and sufficient to reduce chemical impurities in the detector gas to the levels needed to obtain adequate electron drift lifetime and production and collection of scintillation light. The impurities of greatest concern are O_2, N_2, and H_2O. Electronegative contaminants such as O_2 and H_2O capture electrons during drift and reduce the number surviving to the gas phase [45]. An O_2 contamination <0.1 ppb is required to achieve an electron drift lifetime >1 ms [46], as required for both the DAr and Xe TPC with drift lengths over 1 m. While pure Ar and Xe both transmit their own scintillation, the light can be absorbed by chemical impurities. The MEG collaboration reported that contamination of H_2O in LXe at the level of 100 ppb resulted in a scintillation light absorption length of $\sim$1 m [47]. Studies by the WARP collaboration using LAr also showed significant scintillation light attenuation in small scale detectors containing ppm levels of N_2 and O_2 [48].

REQUIREMENTS:

The plants and methods for pre-purification and runtime purification must satisfy the following requirements:

1. The cryogenic distillation column must be capable of accepting a crude argon stream (typical argon concentration 10% by volume, major contaminants N_2, He) and producing DAr with 99.999% purity or better, at a rate of 50 kg/day or greater.
2. The same column must be capable of accepting Xe with initial purity of 99.999% or better, and of reducing the Kr contamination below 1 ppt (this level will result in 7 events/(keV·ton·year) from the β^- decay of ^{85}Kr, before $S2/S1$ discrimination and other analysis cuts.)
3. Filters and getters for runtime purification must further reduce all non-noble contaminations to <0.1 ppb.
4. The recirculation rate for the DAr and Xe targets through the in-situ filters and getters must be sufficient to offset any influx of contamination due to outgassing or dissolution, maintaining the concentration of all non-noble contaminants (especially electronegative contaminants) in the targets below 0.1 ppb.

WBS SECTIONS: 1.5, 1.6

For the DAr detector, the baseline design calls for post-distillation purification of the DAr gas by a single pass through a heated Zr-based getter during the initial fill of the storage dewar. Heated-getter systems capable of reducing the concentration of N_2, O_2, and H_2O below 1 ppb in noble gases at flow rates sufficient for the present proposal (15–150 m^3/hr, 26–260 kg/hr of argon), are commercially available [49]. Once the detector itself is filled,

the argon is continuously recirculated in a loop which withdraws gaseous argon, passes the gas through the same heated Zr-based filter and activated copper filters, and then recondenses it and returns it to the detector. The copper filter removes O_2 to below 10 ppt. Care must be taken to ensure that the filter-materials are not sources of radioactive contamination [50]. To avoid this, it is possible that charcoal filters followed by a particulate filter will also be needed to avoid streaming of radioactive material from the zeolite.

Purification of the target is expected to be well under control for the argon, due to (1) the very low temperature resulting in an extremely low outgassing rate of O_2 and H_2O from surfaces and (2) data and experience from the extensive R&D performed by the ICARUS collaboration and by the FNAL liquid argon group on argon purification. For example, the maximum electron drift time in the depleted argon TPC, at the baseline drift field of 800 V/cm and with a maximum drift distance of ∼2 m, is ∼1 msec. In tests at FNAL, drift lifetimes of several msec have been achieved [46] using getter systems as described above.

Similar getter systems also achieve purity levels sufficient to guarantee very low absorption of scintillation light, as seen from recent tests at Princeton. A single-phase liquid argon scintillation detector was built in a cylindrical volume 20 cm tall and 20 cm in diameter (9 kg active mass). The detector volume was delimited on the side by a TPB-coated PTFE reflector and on the top and bottom by 20-cm diameter TPB-coated acrylic windows. Two 8" Hamamatsu R5192-MOD02 PMTs, with 18% quantum efficiency, viewed the active target through the two acrylic windows. The 9 kg active mass was served by a single purification loop along with a larger, 90 kg mass of argon outside the active region. The detector was filled by passing high-purity commercial argon (99.999% purity) through a hot Zr-based getter [49]. This detector gave a photoelectron yield of 5 p.e./keV$_{\rm ee}$. Equipping the detector with Hamamatsu R5192-MOD02 PMTs with the 30% QE Bialkali-LT photocathode should give about 8 p.e./keVee.

Purification issues for charge and light collection in liquid xenon are similar to those in argon, with ppb levels of O_2 and H_2O necessary to maintain the electron lifetime. Maintaining adequate purity of the xenon target is somewhat more challenging than in the case of argon, due to larger impurity vapor pressures at the higher temperature and the stronger solvent properties of LXe. Continuous xenon gas circulation through a high temperature Zr getter has produced ∼2 ms electron lifetime in XENON-10 [51], corresponding to 4 m drift length. A 1 ton xenon detector will require sophisticated set-ups for proper bake-out of the different components and may require the higher throughput of a liquid circulation system. The radioactivity of standard zeolites is too high to allow their use in liquid circulation systems such as developed in the MEG experiment [52]. An R&D program focused on methods to improve the purity of detector materials in contact with liquid xenon and to maintain the liquid purity with time will be initiated by the Münster group independent of S4 funding. This group, which has substantial experience in related fields, will study more radiopure zeolites and will test a purification method based on a continuous spark discharge between titanium electrodes [53].

VIII. MITIGATION OF SURFACE BACKGROUND AND CONTAMINATION

Mitigation of surface background is a crucial task for the success of the experiment. Radioactive daughters of ^{222}Rn plate out on surfaces and are the major contributors to surface α activity. Cross sections for (α,n) reactions indicate that one in every 10^6–10^7 α-decay produces a low-energy neutron [54]. α-decays on the inner surface of the detector are particularly dangerous – about half the time, the α goes deeper into the surface, and the daughter nucleus recoils into the active volume, mimicking a WIMP recoil. Surface contamination can be effectively mitigated by locating the last steps of construction and assembly in a ^{222}Rn suppressed cleanroom [55–57]. Such a facility already exists at Princeton University and will make possible the pre-assembly of certain parts of the detectors. The full construction will also require construction of a ^{222}Rn suppressed cleanroom in the 4850 ft campus of DUSEL (see Sec. IV).

REQUIREMENTS:

The surface background will be mitigated by controlling the exposure of the TPC materials during construction. The following requirements apply:

1. All detector surface must be pre-cleaned to remove not only implanted radon daughters but also particulates (another important source of α and β/γ activity) and possible hydrocarbon layers (which would absorb the scintillation photons before they strike the TPB or QUPID).
2. α contamination of inner surfaces must be at or below 10 events/(m^2·d). This contamination level will reduce the unvetoed background induced by surface α's to less than 0.1 counts in the lifetime of each experiment.

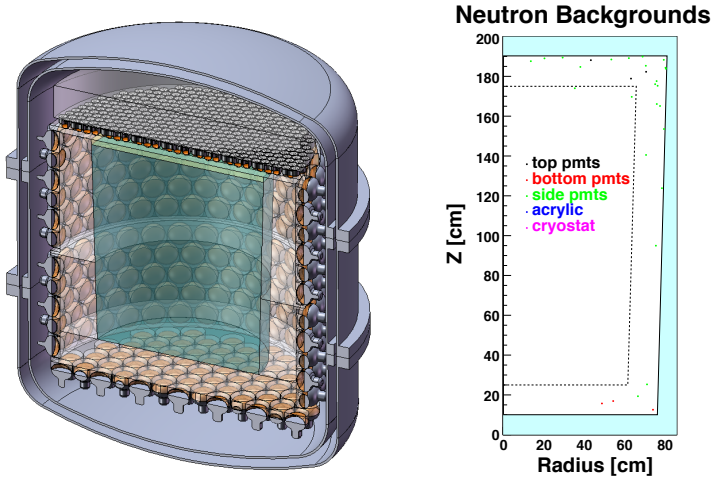


FIG. 6: **(a)** Conceptual drawing of the 5 ton DAr TPC. **(b)** Monte Carlo simulation of the residual nuclear recoil background from neutrons: background events obtained in a 50-yr run.

WBS SECTIONS: 3.3

Requirement 1 is achievable through advanced cleaning techniques developed for Borexino [55]. The cleanrooms at Princeton and at the 4850 ft campus of DUSEL must be equipped with systems to suppress ^{222}Rn activity to 1 Bq/m^3 of air or lower. Exposure of the inner surfaces of the TPCs to air after the last cleaning procedures must be minimized, typically to no more than a few hours. The MIT group will investigate surface alpha reduction for the TPC materials, demonstrate the required reduction factors after cleaning, and determine exposure time limits for detector components. Requirement 2 was met in the construction of the Borexino vessels and the SNO NCD detectors [57].

IX. DEPLETED ARGON TPC

A conceptual drawing of the proposed DAr TPC is shown in Figure 6a. This design is based on concepts that have been developed over many years and have been demonstrated by the successful runs of the WARP, XENON, and ZEPLIN chambers and in large single phase TPCs for neutrino detection [4, 5, 18, 19, 58].

REQUIREMENTS:

The DAr TPC must satisfy the following requirements:

1. The TPC will have an active DAr mass of 5.0 ton (2.7 ton fiducial) and a threshold of 30 keV$_r$ for nuclear recoils.
2. The drift field must be designed to give efficient charge collection throughout the active mass, in particular for α-induced events on the cylindrical inner surface.
3. The 3D position reconstruction of the $S2$ pulses must have a resolution of 1 mm in z (obtained by measuring the drift time) and of $\sim$1 cm in x and y (obtained by fitting the spatial distribution of the $S2$ photoelectrons detected in the top array of QUPIDs.)
4. The accuracy of reconstruction of the $S1$ pulses must be $\sim$20 cm in x,y, and z, and 1 ns in t at the energy threshold (all obtained by fitting the spatial distribution and arrival times of the primary scintillation photons, see Ref. [59].)
5. The reconstruction of the $S2$ pulses must result in a rejection factor for surface α activity of $>10^6$.
6. The TPC must have an $S1$ photoelectron yield in excess of 7 p.e./keV$_{ee}$ at zero electric field.
7. The β/γ background in the fiducial region must be less than 1 events/(kg·keV·d) before cuts, then reduced by analysis cuts to less than 1 event in the anticipated 12 ton·yr fiducial exposure of the experiment.
8. The total neutron-induced nuclear recoil background must be less than 1 event in the anticipated 12 ton·yr exposure of the detector. This is obtained by shielding and by applying a set of straightforward analysis cuts such as rejecting multiple interactions and events too near the walls.

WBS SECTIONS: 1.1, 1.2, 1.4, 2., 7., 9., 10.

The DAr TPC will consist of six principal subsystems (see Table III for a summary of dimensions):

(a) The active volume will contain 5 tons of DAr and will be fitted with field shaping structures (drift cathode,

Component	Characteristics	Component	Characteristics
Active Liquid Volume Height	180 cm	3" QUPIDs, Top	745
Gas Height	5 cm	8" R5912-MOD02 PMTs, Bottom	109
Drift Electric Field	800 V/cm	8" R5912-MOD02 PMTs, Side	363
Extraction Field	3.8 kV/cm	Mean Photocathode Coverage	60%
Active Volume Diameter, Top	162 cm	Depleted Argon Mass	5 tons
Active Volume Diameter, Bottom	152 cm	Acrylic Mass	10 tons
Acrylic Minimum Thickness	40 cm	Cryostat Steel Mass	20 tons
Cryostat, Height	380 cm	Cooling Argon Mass	∼10 tons
Cryostat, Diameter	366 cm	Mass of Detector, Full	55 tons
Cooling Power	440 W		

TABLE III: Depleted argon TPC: detector dimensions and other parameters

field cage, grids). These structures drift and extract charge from the liquid into the gas and form a delayed scintillation signal ($S2$) by electroluminescence.

(b) A thick acrylic vessel coated on the inside with TPB wavelength shifter and viewed on all sides by photodetectors will allow efficient collection of scintillation light. The thick acrylic (40 cm on the sides and bottom, 5 cm on the top plus another 35 cm layer above the top QUPID array) is required to moderate neutrons from the side and bottom photomultipliers and from the stainless steel cryostat.

(c) An additional non-instrumented, non-depleted LAr volume surrounding the active volume, plus external cooling plants, will maintain stable cryogenic conditions inside the conventional double-walled stainless steel cryostat.

(d) Purification and recirculation plants (not shown in Fig. 6) will maintain the high purity of the active LAr required to produce strong $S1$ and $S2$ signals.

(e) Electronic support systems will provide high voltages to the TPC and the PMTs; transport, digitize and record the signals from interactions in the active volume; monitor and control experiment parameters; and produce and tag calibration events.

(f) Shielding against neutrons and gamma rays from radioactivity and cosmic ray interactions in the mine rock will be provided by an external, fully contained water shield surrounding the experiment. The shield will also be instrumented as a muon veto.

Requirement 1 is satisfied by design. Requirement 2 will be satisfied by design of the field cage and the configuration of the electrostatic fields in the detector. Requirements 3 and 4 are satisfied by the performance of two-phase noble liquid-gas TPCs in the literature [4, 5, 18, 19]. We performed a full Monte Carlo simulation with the GEANT4 package and verified that the baseline design presented in this proposal can meet these requirements. Requirement 5: our simulations indicate that a fiducial cut at ∼10 cm from the walls in the x-y plane provides a rejection factor $>10^7$. A cut in z of 1 cm provides the same rejection for surface events on the cathode of the detector. This rejection is sufficient to reduce surface recoils to less than 0.1 events in the 12 ton·yr anticipated exposure of the detector. Requirement 6 is satisfied by the use of novel and high efficiency photosensors (see Sec. V) and by the use of ultra-high purity DAr (see Sec. VII). Requirement 7 is satisfied by the extremely high $S1$ pulse shape rejection factor for β/γ events available in liquid argon [5, 12], by the use of DAr (see Sec. VI), and by careful choice of materials and shielding that guarantees external β/γ background below 10^{-1} events/(kg·keV·d). In fact, the 10^{-1} events/(kg·keV·d) external β/γ background that can be tolerated by the DAr TPC is relatively high (six orders of magnitude above the 10^{-7} events/(kg·keV·d) background level achieved in the Borexino fiducial volume). This fact will very significantly ease the selection of materials and result in significant cost and schedule savings. Requirement 8 is achieved by the use of radioclean photosensors (Sec. V), by acrylic shielding of the inner vessel, by the use of an external water shield (Sec. IV), and by mitigation of the surface background (Sec. VIII).

The TPC will be built within an acrylic vessel with a liner coated on its inner surface with TPB. The baseline design uses a field cage of 2 mm tall metal rings on 25 mm pitch, inserted in grooves machined in the OD of the liner. Transparent conductive plastic or inorganic films are under study to replace the rings and other field shaping structures to improve the light collection and mitigate possible charging effects. The drift cathode must be supplied with a potential of ∼145 kV. The required "High-High Voltage" (HHV) feedthrough from air into liquid argon will be based on the successful 150 kV feedthrough for Icarus T-600 (designed by our UCLA colleagues) [58]; an alternative design has been developed at Fermilab for LAr neutrino detectors. Demountable seals operating at liquid argon temperatures must be provided for the endcaps of the 40-cm-thick acrylic vessel.

Source	Quantity	^{238}U, ^{232}Th [Bq, total]	n [n/yr]	n after cuts [(12 ton·yr)$^{-1}$]	β/γ before cuts [ev/(kg·keV·d)]
Water tank steel	100 ton	1200, 400	10^5	$\ll$0.1	$\ll10^{-5}$
Water	2500 ton	0.25, 0.1*	2.5×10^5	$\ll$0.1	$\ll10^{-5}$
Reentrant tube steel	25 ton	300, 48	1.3×10^4	$\ll$0.1	2×10^{-5}
Cryostat steel	20 ton	240, 40	2×10^4	$\ll$0.1	0.2
Vessel acrylic	10 ton	0.1, 0.04	2	$\ll$0.1	0.04
^{39}Ar	5 ton DAr	250**	–	–	10
8" PMTs	472	190, 85	10^5	0.3	3
3" QUPIDs	745	<0.4, <0.3	<35	$\ll$0.1	<0.07

TABLE IV: Background sources and background budget for the DAr TPC. The fifth column reports the β/γ background before any cuts (pulse shape discrimination, $S2/S1$, multiple deposition cuts). *Low energy neutrons from radioactivity in the water do not contribute significantly to the background – the 2.5×10^5 n/yr are high-energy cosmogenics. **Beta decays of ^{39}Ar.

Spring-energized O-ring seals have been found to produce acceptable results on small diameter acrylic joints, and it is anticipated that this will work for the larger diameter seals. Similar seals will attach a stainless steel flange carrying feedthroughs for grid and drift cathode high voltages to the acrylic vessel. Photosensors will be mounted to the outside surface of the acrylic with >60% photocathode coverage. The spaces between tubes will be coated with a high-reflectivity film. A thin layer of the non-instrumented liquid argon between the photocathode face and the acrylic vessel acts as an optical coupling.

The total cooling power required for the cryostat will be less than 400 W. Cooling will be provided through a gravity-fed liquid nitrogen loop, supplied by a large storage dewar. In normal circumstances, the nitrogen gas will be re-liquefied with a redundant system of two or more pulse tube cryocoolers. In case of power failure, the nitrogen storage dewar will have enough capacity to maintain system temperature for a minimum of one week. The nitrogen system will be able to provide significant extra cooling power beyond steady-state requirements, for detector filling or emergency situations such as a softening of the cryostat insulating vacuum. Two independent continuous circulation and purification systems will be implemented for the DAr TPC, one for the active argon target (5.0 ton of DAr) and one for the passive argon bath (∼10 ton of regular $^{\rm nat}$Ar).

We have evaluated backgrounds from the components of the DAr TPC and from the major components of the external shield with a GEANT4 simulation. Input parameters and results are summarized in Table IV. We assumed that the muon veto efficiency in the external shield is 99%. For β/γ rejection, we assumed the pulse shape parameters measured in Ref. [60] and independently with the WARP-3.2 kg prototype. Multiple nuclear recoils in the active mass were rejected if any two recoils were separated by more than 0.5 cm vertically or 15 cm laterally. External neutrons from cosmic ray interactions in rock and the water shield at the 4850 ft DUSEL level [32] were accounted for. Events that produced recoils within 15 cm from any edge of the active volume were removed by a fiducial cut. The remaining fiducial mass after this cut is 2.7 tons. The β/γ background is reduced to a negligible level, $\ll$0.1 ev/(kg·keV·d), after application of the pulse shape and $S2/S1$ discriminations, preserving a 90% acceptance for nuclear recoils. The simulated residual background after cuts, dominated by nuclear recoils from neutrons, is <0.5 event in the 12 ton·yr exposure anticipated for the DAr detector, see Table IV.

X. XENON TPC

Due to the large atomic number and the coherent A^2 factor in the spin-independent cross section, a fiducial mass of 1 ton of xenon is sufficient to reach a sensitivity of 10^{-47} cm^2 in 1–2 yr. The high density of LXe, about a factor of two higher than LAr, is such that the total active mass of 2.4 ton can be contained in a cryostat of modest dimensions. This also means that a scale-up to a TPC with about 10 times the total mass (20 ton) can be based on the same design strategy to be optimized with the proposed study, with minimal technical changes. The use of the low-radioactivity QUPIDs and of a low activity copper cryostat, will allow us to reach the background required for maximum sensitivity with a minimal LXe for self-shielding, *i.e.* ∼10 cm. The baseline design of the proposed Xe TPC, with full coverage of the LXe volume with sensitive photodetectors, results in the maximal use of the fraction of active xenon as fiducial, combining the advantage of a two-phase noble liquid TPC with simultaneous charge and light, with the superior light collection efficiency achieved by a single-phase noble liquid

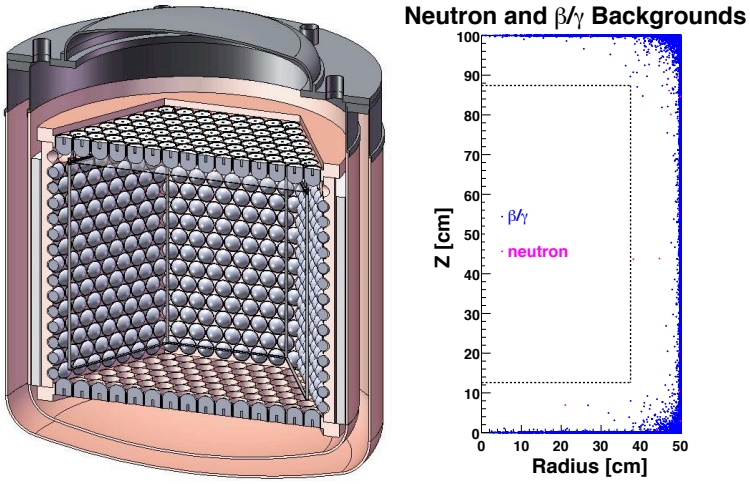


FIG. 7: **(a)** Conceptual drawing of the 2.4 ton Xe TPC. **(b)** Monte Carlo simulation of the residual background from nuclear recoils and β/γ events: backgrounds events obtained in a 10-yr run.

detector. A conceptual drawing is shown in Figure 7a.

REQUIREMENTS:

The requirements for the Xe TPC are similar to those listed for the DAr TPC (see Sec. IX), with these notable differences:

1. The TPC will have an active Xe mass of 2.4 ton (1.0 ton fiducial) and a threshold of 4 keV$_r$ for nuclear recoils.
2. The design must minimize the passive Xe mass that gives an $S1$ but not an $S2$ signal.
7. The β/γ background in the fiducial region must be less than 10^{-5} events/(kg·keV·d) before discrimination by $S2/S1$, which is reduced to less than 1 event, after discrimination and all analysis cuts, in the anticipated 1 ton·yr exposure of the experiment.
8. The total neutron-induced nuclear recoil background must be less than 1 event in the anticipated 1 ton·yr exposure of the detector (after fiducialization and other analysis cuts.)

WBS SECTIONS: 1.1, 1.2, 1.4, 2., 7., 9., 10.

The Xe TPC will consist of six principal subsystems (see Table V for a summary of dimensions). They are the same as in the list (a)–(f) for the DAr TPC (see Sec. IX), with these notable exceptions:

(a) The active volume will contain 2.4 tons of Xe.

(b) There will be no inner acrylic vessel between QUPIDs and Xe in the baseline option. The total active Xe is contained in a low activity, vacuum insulated, vessel built largely out of OFHC copper.

(c) Non-instrumented LXe volume is not required for stable cryogenics operation and is kept to a minimum by a special mounting scheme of the QUPIDs.

Requirement 2 will be satisfied by an optimized design of the TPC electrodes structure and electric field cage, using many of the techniques developed and adopted for the XENON10/100 TPCs, including low radioactivity, custom-made grid electrodes and HV feedthroughs. Given the 4π coverage with QUPIDs, an open field cage made with double field shaping wires provides the uniform drift field with minimal charge-insensitive regions. Alternative designs, including one based on a transparent acrylic vessel with a wavelength shifter to convert the Xe VUV light

Component	Characteristics	Component	Characteristics
Active Liquid Volume Height	90 cm	3" QUPIDs, Top	169
Gas Height	5 cm	3" QUPIDs, Bottom	169
Drift Electric Field	1 kV/cm	3" QUPIDs, Side	630
Extraction Field	5 kV/cm	Mean Photocathode Coverage	60%
Active Volume Diameter	100 cm	Active Xenon Mass	2.4 tons
Cryostat, Height	200 cm	Passive Xenon Mass	0.6 tons
Cryostat, Diameter	180 cm	Cryostat OFHC Cu Mass	6.8 tons
Cooling Power	300 W	Mass of Detector, Full	10 tons

TABLE V: Xenon TPC: detector dimensions and other parameters

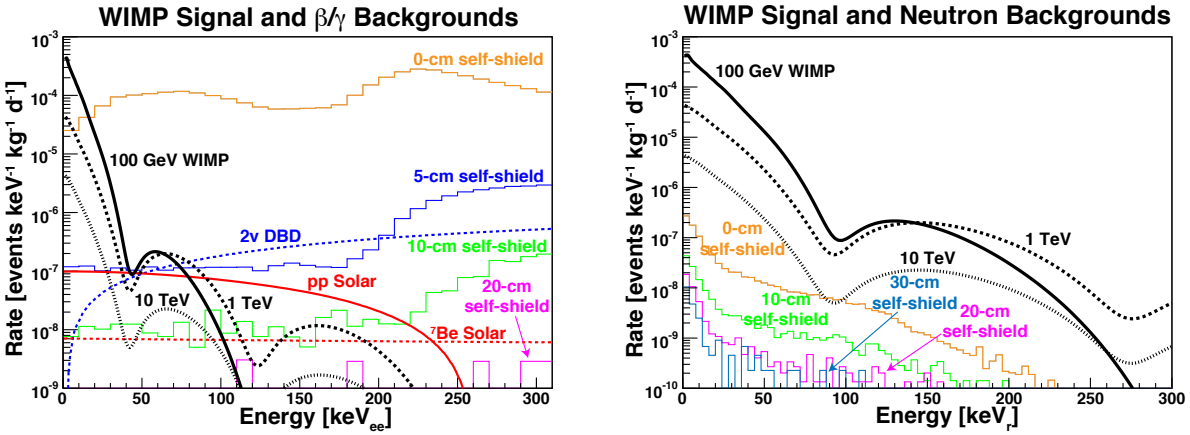


FIG. 8: Expected energy spectra of WIMP interactions, solar neutrinos, two-neutrino double beta decays from ^{136}Xe (assuming τ=10^{22} yr) and gamma ray backgrounds as a function of self-shielding cuts (after $S2/S1$ and multiple-scattering cuts.)

(175 nm) to 430 nm, as in the DAr TPC baseline, will be studied and tested in dedicated set-ups. Requirement 7 will be met by shielding, fiducialization, and proven $S2/S1$ rejection. Requirement 8 will be achieved by the use of a 4π coverage with low-activity QUPIDs to reduce the neutron rate and by applying a set of straightforward analysis cuts such as rejecting events with multiple interactions. As part of the design process, we will study measures to reduce radioactivity from the reentrant tube to the level of that of the QUPIDs and cryostat. In the baseline design this is achieved by adding a passive Cu+Acrylic shielding between the reentrant tube and the cryostat. A second possibility is to build the tube out of acrylic.

The cryogenics system for the Xe TPC will be based on Pulse Tube Refrigerators (PTRs) with temperature-regulated cold-heads. The estimated heat load on the detector, dominated by conduction through signal/HV cables and feedthroughs, is ∼300 W. The PTR currently in use on XENON-100 provides cooling power of 160 W, hence two such units would be sufficient to offset the heat load. Additional or larger units will provide cooling and liquefaction during gas recirculation and filling. The large LXe mass stabilizes the temperature in operating conditions, and the system can be held for very long times at a chosen operating point. XENON-10 and XENON-100 proved temperature stability of ∼1 mK over months using this approach. Even in the case of system failure the inertia of the large cryogenic mass will provide sufficient time to terminate the experiment in a controlled and safe fashion: see Sec. XIII for a description of the planned zero-boiloff, fail-safe recovery system. The considerations on cooling of the detector carry over to the DAr TPC.

The 4π coverage of QUPIDs ensures optimal $S1$ signal detection, with minimum variation with event location within the sensitive volume. GEANT4 simulations indicate a light yield of >7 p.e./keV$_{ee}$ at zero field for 20 m absorption length and taking into account the 50 cm Rayleigh scattering length of liquid xenon. We note that with QUPIDs only on the top and bottom of the sensitive liquid volume and a conventional teflon liner with 98% reflectivity on the side walls, the light yield decreases to ∼5 p.e./keV$_{ee}$ with significant non-uniformity. The main rejection of β/γ background is via the difference in the ratio of ionization to scintillation. The strategy to achieve a multi-ton·year background-free exposure then relies on elimination of the β/γ background by fiducialization of the target. Utmost attention must be paid to any material with even low levels of contamination by gamma or neutron emitters (in particular U/Th) close to the target. We performed a full GEANT4 simulation of β/γ backgrounds, focused on the radioactivity of the QUPIDs, electrons from pp solar neutrinos, and ^{136}Xe 2-ν

Source	Quantity	^{238}U, ^{232}Th	n	n after cuts	β/γ before cuts
		[Bq, total]	[$n$yr]	[(1 ton·yr)$^{-1}$]	[events/(kg·keV·d)]
Water tank steel	100 ton	1200, 400	10^5	$\ll$0.1	$\ll10^{-6}$
Water	2500 ton	0.25, 0.1	3×10^5	$\ll$0.1	$\ll10^{-6}$
Reentrant tube	25 ton	300, 48	1.3×10^4	$\ll$0.1	$\ll10^{-6}$
Cryostat OFHC	6.8 ton	<0.1, <0.1	<15	<0.1	$\ll10^{-6}$
3" QUPIDs	968	<0.5, <0.4	<45	<0.2	$<5\times10^{-6}$

TABLE VI: Background sources and background budget for the Xe TPC. The sixth column reports the β/γ background before removal with $S2/S1$ discrimination.

double-β decay. We neglect contamination of other detector materials, expected to be negligible compared to the QUPIDs. We also tracked nuclear recoils induced by neutrons from (α,n) or fission reactions in all detector materials. Simulations show that both low energy neutrons from U/Th in the rock and high energy neutrons from cosmic ray muon absorption and spallation can be rejected or attenuated to a negligible level by >3 m of active water shield. Table VI summarizes the background estimates. For more details we refer to [24].

Figure 8 shows the expected rate of WIMP signal (for masses of 0.1, 1, 10 TeV and $\sigma_{\chi N}$=10^{-44} cm^2), compared with the total γ-ray background rate, and neutron background rate after $S2/S1$ and multiple-scattering cuts. The expected background from pp solar neutrinos and ^{136}Xe 2-ν double-β decay is also shown. The power of the LXe self-shielding is apparent. A cut of only ~10 cm of active LXe is sufficient to reduce the overall background rate below 10^{-7} events/keV/kg/d. Figure 7b shows the spatial distribution of the overall γ-ray and neutron backgrounds in the TPC. With the ~10 cm self-shielding cut, the residual backgrounds are 0.15 γ/yr and 0.13 n/yr, with pp-chain solar neutrinos becoming the irreducible background at a level of 0.5 event/ton/year.

XI. ELECTRONICS & DAQ

The DAr and Xe TPCs present similar challenges for the readout electronics. In both detectors, we need to read out and identify fast signals (a few ns) from QUPIDs and PMTs, with the common requirement of identifying and measuring each photoelectron with similar precision for time and charge, and for event lengths that in both detectors are determined by the drift time and are of the order of 1 ms.

REQUIREMENTS:

The conceptual design for the electronics is common to the two detectors and must satisfy the following requirements:

1. The electronics must be capable of measuring single-photoelectron signals with timing resolution of 1 ns and charge resolution of 0.1 photoelectron.
2. The electronics must introduce no more than 5% deadtime.
3. $S2$ signals from few-MeV γ-rays measured by the top array of QUPIDs could be as large as 10^6 p.e., with a pulse width of 100–1000 ns. With this time dispersion, 16 bits of vertical resolution are required for the FADCs.
4. The electronics must produce a trigger whenever 5 PMTs/QUPIDs are triggered by signals above a threshold of 0.3 p.e. in a window of 100 ns.
5. For the DAr TPC, the electronics must produce a 2$^{\rm nd}$-level trigger capable of rejecting β/γ events by pulse shape or $S2/S1$ discrimination prior to data transfer.

WBS SECTIONS: 1.7, 1.8

We expect that the argon and xenon experiments can use essentially the same digitizer and trigger boards with relatively small changes in signal conditioning and firmware. There are several commercial digitizers available that may meet our requirements, albeit at a significant cost (see for example, the `V1721` digitizer from CAEN [61] and the `SIS3350` digitizer from Struck [62]). Fortunately, high-speed FADCs (up to 500 MHz) and large capacity Field Programmable Gate Arrays (FPGAs) are widely available today at reasonable cost. We therefore plan to design our own custom board using high-speed FADCs (with a sampling rate of 200–500 MHz) and FPGAs with a large on-board memory.

Requirement 1 can be met by digitizing the PMT and QUPID signals with a frequency above 200 MHz after analog filtering and linear amplification (×10 for PMTs and ×50 for QUPIDs). Requirement 2 will be particularly challenging for the DAQ system for the DAr detector: with the expected ≤250 Hz trigger rate due to ^{39}Ar and the $\sim$ 1 ms drift time the detector is almost always active. This translates into a more stringent demand on memory and data transfer rate. The maximum drift time of ~1 ms implies that the size of raw data per event per photosensor is ~200k words, which could be zero-suppressed on-board to less than 20k words. Requirement 3 can be satisfied by two FADC chips per PMT/QUPID, each with 10-bit vertical resolution and overlapping ranges (with different input gains) to realize the required 16-bit resolution. The presence of on-board FPGAs enables a variety of triggering and deadtime-free readout strategies, satisfying Requirement 4. Concerning Requirement 5, we remark that the Princeton group operated successfully a 2$^{\rm nd}$ level trigger on the WARP-3.2 kg detector, with a FPGA connected to an ADC digitizing the analog sum of all PMT signals.

One of the advantages of the QUPID is that it does not require a conventional base or resistor chain, which is a large source of radioactivity and heat. For the PMTs in the DAr TPC, several possibilities for the bases are under consideration, including the generation of sets of dynode high voltage levels external to the cryostat and generation of high voltages locally at the PMTs with low-power Cockroft-Walton supplies.

The electronics will also include conventional slow controls to monitor conditions of the experiment. A standard industrial control system will monitor and operate the cryogenics and purification plants.

XII. CALIBRATION

The proposed DAr and Xe TPCs have a significant discovery potential and, in case of detection of a potential WIMP signal, a careful calibration strategy is essential to demonstrate that this is not background. The similar energy ranges and quenching factors for nuclear recoils permit the use of similar calibration schemes for DAr and Xe. Calibration sources of x-rays or electrons, neutrons, and alpha particles are required, interacting both at known discrete locations and distributed through the sensitive volume. The source outputs must be controllable or must lie well outside the dark matter region of parameter space.

REQUIREMENTS:

The calibration system must satisfy the following requirements:

1. To create calibration data demonstrating the electron rejection, a tagged electron source is required. For the argon TPC the source must generate $>10^8$ events in each full calibration run. These events should be produced throughout the sensitive volume.
2. To demonstrate external neutron rejection by analysis cuts, a tagged or at least switchable source of 10–100/sec low-energy neutrons is needed.
3. To demonstrate the reconstruction accuracy and absence of non-statistical tails needed for the $\sim 10^6$ surface α and α-induced recoil rejection requires development of a suitable system of multiple radioactive sources located at known positions in the detector. Source selection for the x-y reconstruction calibration will be investigated with small prototype detectors in the pre-DUSEL program.
4. The sources satisfying the requirements above will also measure the energy threshold and energy response.
5. The Xe TPC will use an optical fiber system to supply light pulses to the TPC for QUPID gain calibration and monitoring using their single photoelectron resolution, and for functional tests after integration. For the DAr TPC, the combination of the reconstruction calibration sources and the uniformly distributed ^{39}Ar will provide sufficient information for monitoring the stability of the detector optics with time.
6. To monitor the electronics pedestal, gain, and non-linearity as a function of time, the sources satisfying the requirements above plus an electronic calibration-event generating system will be developed.

WBS SECTIONS: 1.1.8, 1.1.9, 1.2.2.4, 1.7.7, 7.1, 8.1

Requirement 1 would be satisfied by a pyroelectric crystal generator of penetrating ($\sim$100 keV) x-rays, or by mixing ^{83m}Kr (IT, τ=12.6 hr, 18 and 32 keV electrons and 13 keV x-rays) into the targets [63]. The calibration with ^{83m}Kr is currently being tested in XENON-100. Requirement 2 would be satisfied by either an external or internal/removable d–d generator, or by AmBe source(s) with the Be on a movable shutter. Physics studies and engineering to satisfy requirement 3 will be carried out under the present proposal. Requirement 4 will be satisfied by the sources discussed above. Requirement 5 will be satisfied by the design of an optical pulser system for the Xe TPC, and is otherwise fulfilled by the same sources as for the previous requirements. Requirement 6 will be satisfied as part of the DAQ design under the present proposal.

XIII. SAFETY

WBS SECTIONS: 6

Safety hazards and environmental risks are very similar for the Ar and Xe experiments. Identifying these and engineering means to mitigate them are a crucial part of the proposed S4 effort. Table VII gives a summary of currently identified hazards.

Given the presence of large quantities of liquid cryogens, the most significant potential hazard requiring early attention by designers is related to the structural integrity of the cryostats. The depleted argon TPC will contain 15 tons of liquid argon (5 tons active material plus a 10 ton cooling bath). The total inventory of xenon foreseen for the xenon TPC is 3.0 tons. A rupture disk will provide fail-safe protection of the detector against overpressure. Loss of insulating vacuum in the cryostat would lead to an estimated argon vapor loss rate of 270 m^3/hr. This failure can be mitigated by admitting the gas into a holding tank, backed up by the facility ventilation system in case of a breach to atmosphere. Flooding the vacuum space of the cryostat with water from the shield would generate 12,600 m^3/hr of gas, with a conservative choice of the heat transfer coefficient. The possibility of this

Hazard	Type	Mitigation
Chemicals	Alcohols, acids	MSDS, secondary containment
Electrical	High Voltage (up to 160 kV)	National code
Asphyxiation	Oxygen Depletion	Ventilation
Hoisting and rigging	Crane	Procedure
Ionizing radiation	Calibration sources	Procedure, Shielding
Fire	Electrical, Chemical	Detectors, Suppression systems
Confined space	Tank entry	Procedure
Cryostat Integrity	Mechanical, oxygen depletion	Ventilation
Flooding, drowning	Valve misalignment	Secondary containment, monitoring

TABLE VII: Potential general safety and environmental hazards

failure mode (and the even more dramatic case of uncontrolled mixing between liquid argon and shielding water) can be reduced to essentially zero by using the water tank shielding design discussed in Sec. IV. In this scheme, the cryostat is not in direct contact with the water, but rather sits in a separate, air-filled volume. During the Preliminary Design phase, we expect to work closely with the designers of the DUSEL facility to prepare a full risk-based contingency analysis and mitigation plan, paying particular attention to the critical issue of ventilation.

Both the depleted argon and the xenon TPCs will be equipped with independent zero-boiloff recovery and storage systems, similar to that devised for the MEG experiment [64] and capable of recovering and storing the total inventory of the noble target either in gas phase in high-pressure tanks or in liquid phase in a dewar equipped with redundant active cooling (cryocoolers and a large reservoir of LN_2). The system will be used when emptying the detector. It will also allow the rapid transfer of the noble target to the recovery system in case of problems with the structural integrity of the detector cryostat. In case of problems with the cooling of the detector, the recovery and storage system will allow initial recovery of the excess boil-off from the noble target during the maintenance of the cooling loop.

XIV. PROJECT MANAGEMENT

The MAX collaboration is a partnership between two groups of physicists (the DARKSIDE collaboration and the XENON collaboration) for the design of liquid argon and liquid xenon dark matter detectors at DUSEL. The collaborations are joining in a single S4 proposal to exploit the substantial overlap in physics reach and engineering of the noble liquid TPCs. Both the DAr and Xe detectors to be designed are two-phase TPCs with simultaneous measurement of ionization and scintillation signals for effective and redundant discrimination of signal from background. Areas of common engineering include photodetectors, electronics and data acquisition, cryogenics, water tank/shielding design, HV and drift-field design, and construction and operation underground.

As well as recognizing common engineering challenges, the formation of this partnership helps ensure that the results of the engineering studies are available for both argon and xenon based experiments. A management structure has been adopted to organize the engineering studies consistent with this philosophy.

The Project Manager responsible for overall workflow and WBS conformance will be Engineer R. Parsells (Princeton University), who will be supported with S4 funds if this proposal is funded. Detector Managers for the DAr and Xe TPC will be respectively Engineer W. Sands (Princeton University, Temple University) and Engineer G. Tajiri (Columbia University), also supported by S4 funds.

Policy questions arising during the course of the S4 project will be decided by consensus of a Project Board, composed of the MAX PI and Co-PIs and additional members appointed by the PI, expected to include representatives of National Laboratories, DOE-supported university groups and foreign institutions. If a consensus in the collaboration board cannot be reached, decisions will be made by voting. The Project Board will elect every six months a Chairperson for a single, non-renewable term, alternating representation between Project Board Members with primary interest in the xenon and argon programs.

The DOE OMBE document "PROJECT MANAGEMENT PRACTICES - Work Breakdown Structure (Rev. E June 2003)" states that each WBS item must be a "product". The products of S4 will be engineering design reports describing the dimensions, structure, materials, and possibly method of construction of each item or subsystem comprising the noble liquid detectors under consideration. All items can be classified into those that are wholly or substantially the same for DAr and LXe (class **C**), and those for which the DAr and LXe versions differ substantially, and need to be addressed in a specific way for each of the two detectors (classes **AR** and **XE**

respectively). Items of classes **AR** and **XE** will require engineering targeted to the special element in consideration, but in most cases not double the effort since the underlying engineering physics constraints and techniques are similar in the two cases. **See Table I for the major elements of the WBS. See Appendix A, provided among the supplementary documentation, for the full WBS.**

We would like to address several specific topics suggested by the DUSEL S4 solicitation:

Qualifications of team. The MAX collaboration is an international team of scientists actively participating in the currently-leading argon and xenon dark matter experiments (WARP, XENON, ZEPLIN). The collaboration also includes scientists from other successful dark matter experiments (CDMS, DRIFT, COUPP). Several collaborators are from neutrino experiments (SNO, Borexino, MiniBooNE, SuperKamiokande, GERDA, KATRIN). We propose a significant role for Fermilab, where our collaborators have close connections to the liquid argon program for long-baseline neutrino oscillation studies at DUSEL. Collectively, we have expertise in a wide range of relevant experimental techniques and have successfully executed a number of projects of similar complexity and scale. More details on the qualifications of the collaboration will be found in the attached letters of support and biographical sketches.

Anticipated lifetime of the proposed experiment. We propose a 5-year run for the argon TPC and a 2-year run for the Xe TPC. We would expect to be able to construct the detectors over a three year period beginning with the availability of NSF construction funds.

A timeline and budget for the proposed design work. We expect that the Preliminary Design work will be completed within three years of the NSF S4 award. We expect to complete a Conceptual Design Report about one year after the award and a Preliminary Design Report two years later. Our estimates assume NSF funding at the requested level for several university-based groups and subcontracts to industry (see Budget). We will seek additional support from Fermilab and the Department of Energy HEP University Program, with 2.5 FTEs of design effort requested at Fermilab, 0.5 FTE in the UCLA DOE group (PI's Cline and Arisaka) and 0.5 FTE at Princeton (Meyers). During this time period, we expect to proceed in parallel with pre-DUSEL detectors, including the completion of the current and upgraded XENON-100 and WARP-140 programs, as well as the development of a US-based liquid argon program.

Preliminary information on project cost. At present, only very preliminary cost estimates for construction are available. We estimate the equipment costs for the argon experiment to be approximately 16 M$ and the xenon experiment to be 18 M$, both including 30% contingency. A provisional summary of costs is offered in Appendix B.

Description of any limited and targeted R&D. In early conceptual design work we have sought technical solutions that would minimize the amount of R&D required for the Preliminary Design. A small fraction of the S4 resources will be used for studies of surface backgrounds at MIT and development of 8-inch QUPID light detectors in partnership with Hamamatsu (part of the UCLA budget). We expect to continue a parallel R&D effort on advanced detector concepts using other resources and the results of this effort may be exploited to improve the Preliminary Design as warranted. In particular, we note that there is ongoing work on improvements of light-collection and purification at Princeton and Columbia and on transparent electrode structures at Fermilab and UCLA.

Potential for possible future upgrades. We anticipate that the proposed argon and xenon detectors will not be the end of the line for this technology, but rather a practical next step that can be accomplished on a reasonable schedule, with minimal R&D and with only early-stage DUSEL laboratory infrastructure. This project will itself create infrastructure and know-how for the construction of even more sensitive devices. We note that, in particular, that the construction of a plant which produces $\sim$1 ton/month of argon from underground sources would, over time, allow the construction of much larger argon detectors, with low incremental costs.

XV. EDUCATION & OUTREACH, BROADER IMPACT, AND PREVIOUS RESULTS

EDUCATION & OUTREACH: Princeton hosts a summer school for high school students from the Gran Sasso Abruzzo region of Italy [65]. The school, which was initiated by Professors Calaprice and Galbiati in 2003, brings 20-40 students each year to Princeton to study basic physics and to be exposed to the exciting scientific research that is carried out at the Gran Sasso underground laboratory. Physics classes are supplemented with lectures on topics in astrophysics, including dark matter, gravity waves, supernovae, and neutrinos. The school is open to students enrolled in their fourth and fifth years in high schools of the Abruzzo region. Participants are selected on a competitive basis and are provided transportation to and from Princeton, with room and board on

the Princeton University campus. Student expenses are financed by the INFN Italian science agency, the regional government of Abruzzo, and through contributions from private groups in Italy and Princeton. Researchers and faculty from Princeton and Italy teach classes and give lectures on a volunteer basis.

With the establishment of the Sanford Laboratory and plans for the Deep Underground Science and Engineering Laboratory (DUSEL) in the Homestake mine of South Dakota, the summer school was expanded in 2008 to include three students from South Dakota [66]. Following a successful first year of the joint program with Italian and American participants, the program will continue in 2009 with ten American students and twenty Italian students. The summer school will provide a rich cultural experience and a unique opportunity to learn about the science and engineering focused on some of the most exciting science in modern times. It will also foster international relationships between researchers and government leaders of both regions that will benefit underground science in both countries.

The American students will be supported by the Davis-Bahcall Scholarships, funded by the 3M Corporation. Named for two great physicists, the Davis-Bahcall Scholarship is intended to spark an interest and promote the exploration of science in South Dakota's young minds. Nobel Prize winner Dr. Ray Davis and Dr. John Bahcall are the two scientists most responsible for the field of solar neutrino physics and neutrino astronomy. Recipients will have the opportunity to spend approximately one month of their summer digging deep into science at the Sanford Laboratory at Homestake in Lead, S.D. and the Gran Sasso National Underground Laboratory in Italy. Participants will also study physics at Princeton University in New Jersey. Coursework will cover a variety of science-related fields, including the subjects of physics, engineering, biology, and geology. Participants will also have the opportunity to interact and learn from distinguished professors from all over the world. College credit is offered to the American students.

As part of the S4 activities, Prof. Keeter of BHSU will focus on integrating the Davis-Bahcall Scholarship with DUSEL in cooperation with the DUSEL E&O team. Other collaboration members will spend a portion of their time teaching in the school.

BROADER IMPACT: There is no doubt that the science question addressed by the MAX experiments has all the ingredients to captivate the interest and imagination of young students and the general public alike. The technologies and methods that will be refined within the scope of the proposed design study will advance the application of noble liquids as imaging detectors in fields outside of particle astrophysics, including national security and medical imaging research. Equally relevant is the impact that this proposal will have in helping the visibility of DUSEL as an international facility, recognized among a distinguished group of underground laboratories worldwide. The MAX project will involve groups from Europe (Germany, Italy, Portugal, Switzerland) and Japan, with an opportunity for them to be part of the exciting development phase of the new laboratory. International cooperation and partnership is not only vital for DUSEL but also essential to achieve the scientific goals of DUSEL in the most cost-effective way and with the broadest involvement of the worldwide scientific community.

PREVIOUS RESULTS: The Princeton group, supported by award **PHY-0503816** and **PHY-0802646** completed commissioning of and operated the Borexino detector, resulting in the measurement of ^{7}Be solar neutrinos and in the first measurement of ^{8}B solar neutrinos with a liquid scintillator target. Supported by award **PHY-0603376**, the Princeton group took part in the WARP-3.2 kg experiment, resulting in the first dark matter search with an argon target [5] and in the WARP-140 kg detector, the largest detector for dark matter searches, currently being commissioned at LNGS. The Princeton and Notre Dame groups, supported by award **PHY-0704220**, conducted the study of underground argon that resulted in the discovery of sources of argon depleted in ^{39}Ar [15]. Other papers recently published by the Princeton group include Refs. [5, 14, 15, 30, 48, 55, 59, 67–78].

Following the conclusion of the XENON10 experiment and publication of its results [4, 51], under under award **PHY-0201740** to Columbia University, the Columbia, UCLA and Rice groups, supported by awards **PHY-0705337** and **PHY-0705326** and by the DOE base grant at UCLA, have focused on the design, construction and underground deployment of a new experiment, XENON-100, aiming at a factor 100 reduction in background over XENON-10 and a ten-fold increase in fiducial mass. Commissioning of XENON-100 has just been completed and the new detector is currently operating at LNGS in the same location and shielding used for XENON-10. A proposal for the XENON-100 upgrade (100 kg fiducial mass and factor of 10 lower background, with deployment of QUPIDs for the top PMTs array) has been submitted to the NSF in Fall 2008, by a larger collaboration, including new groups from Japan, Germany and France.

[1] Committee on the Physics of the Universe, Board on Physics and Astronomy, Division on Engineering and Physical Sciences of the National Research Council of the National Academies, "Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century", www.nap.edu/catalog.php?record_id=10079, National Academies Press (2003).

[2] National Science and Technology Council, Committee on Science, "A 21st Century Frontier of Discovery: The Physics of the Universe", www.ostp.gov/html/physicsoftheuniverse2.pdf (2004).

[3] The Dark Matter Scientific Assessment Group, *Report on the Direct Detection and Study of Dark Matter*, www.science.doe.gov/hep/hepap_reports.shtm.

[4] J. Angle et al., (XENON Collaboration), Phys. Rev. Lett. **100**, 021303 (2008).

[5] P. Benetti et al., (WARP Collaboration), Astopar. Phys. **28**, 495 (2008).

[6] G. Jaffé, Ann. Phys. **42**, 203 (1913); G. Jaffé, Le Radium **10**, 126 (1913); G. Jaffé, Ann. Phys. **85**, 137 (1928).

[7] E. Shibamura, K. Masuda, and T. Doke, Research Report to the Ministry of Education, Science, Sport, and Culture for Grant-in-Aid Scientific Research(C), No. 62540284 (1988).

[8] S. Kubota, M. Hishida, and A. Nohara, Nucl. Instr. Meth. **150**, 561, (1978); M.J. Carvalho and G. Klein, J. Lumin. **18-19**, 487 (1979); J.W. Keto et al., J.Chem. Phys. **71**,2676 (1979); T. Suemoto and H. Kanzaki, J. Phys. Soc. Japan **46**, 1554 (1979); S. Kubota et al., Nucl. Instr. Meth. **196**, 101 (1982); S. Kubota et al., Phys. Rev. B **20**, 3486 (1979).

[9] P. Benetti et al., Nucl. Instr. Meth. A **327**, 203 (1993).

[10] A. Hitachi et al., Phys. Rev. B **27**, 5279 (1983).

[11] M.G. Boulay and A. Hime, Astropart. Phys. **25**, 179 (2006).

[12] M. Boulay for the DEAP/CLEAN Collaboration, *DEAP/CLEAN Experiment at SNOLAB*, Talk at the IDM2008, Stockholm, Sweden (2008). Slides available at agenda.albanova.se/conferenceDisplay.py?confId=355.

[13] H.H. Loosli, Earth Plan. Sci. Lett. **63**, 51 (1983).

[14] P. Benetti et al., (WARP Collaboration), Nucl. Instr. Meth. A **574**, 83 (2007).

[15] D. Acosta-Kane et al., Nucl. Instr. Meth. A, **587**, 46 (2008).

[16] K. Abe et al. (XMASS Collaboration), *Distillation of Liquid Xenon to Remove Krypton*, arXiv:0809.4413v2.

[17] E. Aprile, Acta Phys. Polon. B **39**, 2747 (2008).

[18] G.J. Alner et al. (ZEPLIN-II Collaboration), Astopart. Phys. **28**, 287 (2007).

[19] V. Lebedenko et al. (ZEPLIN-III collaboration), to be published in Astropar. Phys. (2009).

[20] A. Drukier and L. Stodolsky, Phys. Rev. D **30**, 2295 (1984).

[21] M.W. Goodman and E. Witten, Phys. Rev. D **31**, 3059 (1985).

[22] G. Jungman, M. Kamionkowski, and K. Griest, Phys. Rep. **267**, 195 (1996).

[23] P.F. Smith and J.D. Lewin, Phys. Rep. **187**, 203 (1990); J.D. Lewin and P.F. Smith, Astropart. Phys. **6**, 87 (1996).

[24] K. Arisaka et al., *XAX: a multi-ton, multi-target detection system for dark matter, double beta decay and pp solar neutrinos*, submitted to Astropart. Phys., arXiv:0808.3968.

[25] Z. Ahmed et al., (CDMS Collaboration), arXiv:0802:3530.

[26] N. Arkani-Hamed, D.P. Finkbeiner, T. Slatyer, and N. Weiner, "A Theory of Dark Matter", arXiv:0810.0713.

[27] D. Smith and N. Weiner, Phys. Rev. D **64**, 043502 (2001); D. Tucker-Smith and N. Weiner, Phys. Rev. D72, 063509 (2005); S. Chang, G.D. Kribs, D. Tucker-Smith, and N. Weiner, arXiv:0807.2250 (2008).

[28] G. Alimonti et al. (Borexino Collaboration), Phys. Lett. B **349**, 422 (1998).

[29] G. Alimonti et al. (Borexino Collaboration), Nucl. Instr. Meth. A **406**, 411 (1998).

[30] G. Alimonti et al. (Borexino Collaboration), *The Borexino detector at the Laboratori Nazionali del Gran Sasso*, in press on Nucl. Instr. Meth. A (2009).

[31] C. Arpesella et al. (Borexino Collaboration), Astrop. Phys. **18**, 1 (2002).

[32] D.-M. Mei and A. Hime, Phys. Rev D **73**, 053004 (2006).

[33] A. Razeto for the Borexino Collaboration, *First results on ^{7}Be solar neutrinos from the Borexino real time detector*, Talk at International Workshop on Standard Model and Beyond, Valparaiso, Chile (2008). See in particular slides 26 and 27 of the presentation file, available at http://www.fis.utfsm.cl/hep2008/files/razeto.pdf for a description of the upgraded Borexino electronics.

[34] C. Galbiati for the Borexino Collaboration, *New Results on Solar Neutrino Fluxes from 192 Days of Borexino Data*, Talk at the Neutrino 2008 Conference, Christchurch, New Zealand (2008). See in particular slides 55 and 56 of presentation file, available at www.slac.stanford.edu/econf/C0805263/Slides/Galbiati.pdf for the visualization of two characteristics multi-neutron events. The conference proceedings are at www.slac.stanford.edu/econf/C0805263/ProcContrib/galbiati_c.pdf, to appear in the "Proceedings of Neutrino 2008 Conference" (IOP).

[35] Private conversations with SNO and Borexino collaborators on unpublished studies on cosmogenic-induced cascades accompanied by very high multiplicity neutrons.

[36] K. Arisaka, Nucl. Instrum. Meth. A **442**, 80 (2000)

[37] K. Arisaka, "Summary Talk", 4th International Conference on New Developments in Photodetection (Beaune 05),

Beaune, France, 19-24 Jun 2005.
[38] W. Wilson, R. Perry, W. Charlton, T. Parish, G. Estes, T. Brown, E. Arthur, M. Bozoian, T. England, D. Madland, et al., *SOURCES 4A: A Code for Calculating (α,n) Spontaneous Fission, and Delayed Neutron Sources and Spectra* LA-13639-MS, LANL (1999).
[39] Ph. Collon, F. Calaprice, C. Galbiati, and S. Mukhopadhyay, *Study of Argon for WIMP Dark Matter Detectors and Earth Sciences*, Proposal to NSF, Princeton University (2006).
[40] F. Calaprice, C. Galbiati, and P. Meyers, *DUSEL R&D: Depleted Argon from Underground Sources*, Proposal to NSF, Princeton University (2007).
[41] A. Sonnenschein et al., *DUSEL R&D Proposal: Measurement of Ar-39 in Argon*, FNAL (2007).
[42] P. Collon, W. Kutschera and Z. T. Lu, Ann. Rev. Nucl. Part. Sci. **54**, 39 (2004).
[43] Ph. Collon et al., Nucl. Instr. Meth. B **223-224**, 428 (2004).
[44] M. Gaelens, M. Loiselet, G. Ryckewaert, R.C. Pardo, R.H. Scott, R. Vondrasek, Ph. Collon, W. Kutschera, Rev. Sci. Instrum. **75**, 1916 (2004).
[45] G. Bakale, U. Sowada, and W.F. Schmidt, J. Phys. Chem. **80**, 2556 (1976).
[46] P. Cennini et al. (ICARUS Collaboration), Nucl. Inst. Meth. A **333**, 567 (1993); D. Finley et al., "Work at FNAL to achieve long electron drift lifetime in liquid argon", FERMILAB-TM-2385-E (2006).
[47] A. Baldini et al. (MEG Collaboration), Nucl. Inst. Meth. A **545**, 753 (2005).
[48] R. Acciarri et al. (WARP Collaboration), "Effects of Nitrogen contamination in liquid Argon", `arXiv:0804.1217` (2008); R. Acciarri et al. (WARP Collaboration), "Oxygen contamination in liquid Argon: combined effects on ionization electron charge and scintillation light", `arXiv:0804.1222` (2008).
[49] See the brochure of the SAES Getters PS5 Series at `saespuregas.com`.
[50] L. Grandi, University of Pavia, Doctoral Thesis, pages 178-179 (2005).
[51] E. Aprile et al. (XENON Collaboration), "The XENON10 Dark Matter Search Experiment", in preparation for Phys. Rev. D.
[52] S. Mihara et al., Cryogenics **46**, 688 (2006).
[53] S.E. Ulin et al., SPIE **3114**, 499 (1997).
[54] R. Heaton, H. Lee, P. Skensved, and B. Robertson, Nucl. Instr. Meth. A **276**, 529 (1989).
[55] J. Benziger et al., Nucl. Instr. Meth. A **582**, 509 (2007).
[56] A. Pocar, *Low Background Techniques and Experimental Challenges for Borexino and its Nylon Vessels*, Ph.D. Dissertation, Princeton University (2003).
[57] B. Aharmim et al. (SNO Collaboration), Phys. Rev. Lett. **101**, 111301 (2008).
[58] S. Amerio et al., (ICARUS Collaboration), Nucl. Instr. Meth. A **527**, 329 (2004).
[59] C. Galbiati and K. McCarty, Nucl. Instr. Meth. A **568**, 700 (2006).
[60] H. Lippincott et al., Phys. Rev C **78**, 035801 (2008).
[61] See the relevant brochures at `www.caen.it`
[62] See the relevant brochures at `www.struck.de`
[63] D. Vénos, O. Dragoun, A. Spalek, and M. Vobecký, Nucl. Instr. Meth. A **560**, 352 (2006).
[64] T. Iwamoto et al., *Development of a large volume zero boil-off liquid xenon storage system for muon rare decay experiment (MEG)*, in press on Cryogenics (2009).
[65] Website of the Gran Sasso–Princeton–South Dakota Physics Summer School, `www.physics.princeton.edu/www/jh/gransasso/`.
[66] Website of the David-Bahcall Scholarship, `www.SummerScience2009.com`.
[67] J. Benziger et al., *The Scintillator Purification System for the Borexino Solar Neutrino Detector*, submitted to Nucl. Instr. Meth. A, arXiv:0709.1503 (2007).
[68] M. Balata et al. (Borexino Collaboration), Eur. Phys. Jour. C **47**, 21 (2006).
[69] H. Back et al. (Borexino Collaboration), Phys. Rev. C **74**, 045805 (2006).
[70] H.O. Back et al. (Borexino Collaboration), *Response to the critics of Borexino result in "A new experimental limit for the stability of the electron" by H.V. Klapdor-Kleingrothaus, I.V. Krivosheina, and I.V. Titkova*, submitted to Astrop. Phys., arXiv:hep-ex/0703044 (2007).
[71] H.O. Back et al. (Borexino Collaboration), accepted for publication in Nucl. Instr. Meth. A, `doi:10.1016/j.nima.2007.09.036`, arXiv:/0705.0239 (2007).
[72] G. Bellini et al. (Borexino Collaboration), *Search for solar axions emitted in the M1-transition of $^7Li^*$ with Borexino CTF*, submitted to Eur. Phys. Jour. C (2007).
[73] H.O. Back et al. (Borexino Collaboration), accepted for publication in Nucl. Instr. Meth. A, `doi:10.1016/j.nima.2007.10.045`, arXiv:physics/0408032, (2007).
[74] C. Arpesella et al., (Borexino Collaboration), Phys. Lett. B **658**, 101 (2008).
[75] C. Arpesella et al., (Borexino Collaboration), Phys. Rev. Lett **101**, 091302 (2008).
[76] G. Bellini et al., (Borexino Collaboration), *Measurement of the solar ^8B neutrino flux with 246 live days of Borexino and observation of the MSW vacuum-matter transition*, submitted to Phys. Lett. B (2008).
[77] A.A. Aguilar-Arevalo et al., (MiniBooNE Collaboration), Phys. Rev. Lett. **98**, 231801 (2007).
[78] A.A. Aguilar-Arevalo et al., (MiniBooNE Collaboration), Nucl. Instr. Meth. A **599**, 28 (2009).

CRISTIANO GALBIATI

Physics Department, Jadwin Hall 226, Princeton University

BIOGRAPHICAL SKETCH

Professional Preparation

1995	"Laurea in Fisica", Università degli Studi di Milano, Milan, Italy
1999	"Dottorato di Ricerca in Fisica", Università degli Studi of Milano, Milano, Italy
1998	Reserve Officers Course as "Guardiamarina del Genio Navale", Naval Academy, Livorno, Italy
1999 – 2002	Postdoc in Astroparticle Phsyics, Physics Department of Princeton University

Appointments

Jul 2002 – present	Assistant Professor, Princeton University
Sep 2001 – Jun 2002	Instructor, Princeton University
Jan 2001 – Aug 2001	Lecturer, Princeton University
Jul 1999 – Dec 2000	Research Associate, Princeton University
Jul 1999 – Jul 2001	Istituto Nazionale di Fisica Nucleare (INFN) post-doctoral Fellow
May 1998 – May 1999	Guardiamarina at the "Istituto di Elettroacustica" of the Italian Navy, La Spezia, Italy
Sep 1995 – Dec 1995	Visiting scientist at the Laboratory of Nuclear Sciences, MIT
Oct 1994 – Sep 1995	Istituto Nazionale di Fisica Nucleare (INFN) undergraduate Fellow

Publications most closely related to the proposed project

1. P. Benetti et al. (WARP Collaboration), "First results from a Dark Matter search with liquid Argon at 87 K in the Gran Sasso Underground Laboratory", Astroparticle Physics 28, 495 (2008).
2. D. Acosta-Kane et al., "Discovery of underground argon with low level of radioactive 39Ar and possible applications to WIMP dark matter detectors", Nuclear Instruments and Methods A 587, 46 (2008).
3. P. Benetti et al. (WARP Collaboration), "Measurement of the specific activity of ^{39}Ar in natural argon", Nuclear Instruments and Methods A 574, 83 (2007).
4. C. Arpesella et al. (Borexino Collaboration), "First real time detection of ^{7}Be solar neutrinos by Borexino", Physics Letters B 658, 101 (2008).
5. C. Arpesella et al. (Borexino Collaboration), "New results on solar neutrino fluxes from 192 days of Borexino data", Physical Review Letters 101, 091302 (2008).
The list of authors of the Borexino and WARP collaboration is reported in the section on "Collaborators".

Other publications

1. J. Benziger et al., "The Nylon Scintillator Containment Vessel for the Borexino Solar Neutrino Experiment", Nuclear Instruments and Methods A 582, 509 (2007).
2. C. Galbiati, L. Cadonati, D. Franco, A. Ianni, A. Pocar and S. Schönert, "Cosmogenic 11C production and sensitivity of organic scintillator detectors to pep and CNO neutrinos", Physical Review C 71, 055805 (2005).
3. G. Alimonti et al. (Borexino Collaboration), "Light propagation in a large volume liquid scintillator", Nuclear Instruments & Methods A 440, 360 (2000).
4. G. Alimonti et al. (Borexino Collaboration), "Measurement of the 14C abundance in a low-background liquid scintillator", Physics Letters B 422, 349 (1998).
5. G. Alimonti et al. (Borexino Collaboration), "Ultra-low background measurements in a large volume underground detector", Astroparticle Physics 8, 141 (1998).
The list of authors of the Borexino and WARP collaboration is reported in the section on "Collaborators".

Synergistic Activities

Cristiano Galbiati has a solid background in teaching and training of undergraduate students. He has been teaching in undergraduate level courses at the Physics Department of the Princeton University for a number of years. As a past Lab Manager for the PHY101 and PHY102 courses, in collaboration with then course directors Lyman Page and Ed Groth, he reorganized the Labs curricula and the Lab manuals. In the past two years, serving as Lab Manager of PHY103, he reorganized the curriculum of the PHY103 Labs. Starting from the Fall 2005, he served as director of the PHY101 course.

Cristiano Galbiati has engaged in research projects at Princeton or at Gran Sasso a number of undergraduate students, a large fraction of whom were women or minority students. Undergraduate students supervised include Emma Torbert (1999, supported by the NSF R.E.U. fund, worked on an upgrade of the loadcells system of Borexino at Gran Sasso); Thomas Zhang and Joseph Stritar (2000, performed a series of measurements on the nylon for the Borexino vessels at Princeton); Eric Hopkins (2001, supported by the NSF R.E.U. fund, designed a system to humidify the nylon sheets for the Borexino vessels at Princeton); Julie Bert and Joel Greenberg (2002, NSF R.E.U. fund, worked on the completion of the nylon vessels in Princeton); Elan Nieves and Chris Bohn (2003, worked at Gran Sasso).

Cristiano Galbiati is also strongly committed to outreach efforts. In 2004 Galbiati, with colleagues Frank Calaprice (Princeton), Chiara Nappi (Princeton) and Coccia (director of LNGS), founded the "Gran Sasso – Princeton Summer School of Physics". The program has already run successfully for two years, bringing each year twenty high school students from the Gran Sasso area to Princeton in the summer 2004 for a four-week program in physics. The initiative was sponsored by INFN, by the Italian Embassy in U.S., and by italian and american private groups, and came at no cost to the students. With colleagues Chiara Nappi (Princeton), Andrea Pocar (Stanford), and Aldo Ianni (Gran Sasso), Galbiati is the teaching faculty for first the year of the program. More than 50% of the students participating in the program are women, and 25% of the students participating changed their plans to enroll in a scientific major after attending the program.

Collaborators and Other Affiliations

Cristiano Galbiati is a member of the WARP Collaboration, which includes Flavio Cavanna (L'Aquila), Alfredo Cocco (Napoli), Giuliana Fiorillo (Napoli), Claudio Montanari (Pavia), Carlo Rubbia (Pavia/ENEA).

Cristiano Galbiati is co-author of papers in collaboration wih with Laura Cadonati (UMass), Davide Franco (MPI Heidelberg), Aldo Ianni (Gran Sasso), Andrea Pocar (Stanford), Stefan Schoenert (MPI Heidelberg), and John Beacom (Ohio State University).

Cristiano Galbiati is a member of the "Borexino Collaboration", which includes the following list of scientists: G. Bellini (Milano), F. Calaprice (Princeton), M. Chen (Queen's), F. von Feilitzsch (Munich), R. Ford (SNOLab), G. Heusser (MPI Heidelberg), A. Ianni (Gran Sasso), H. de Kerret (Collège de France), T. Kirsten (MPI Heidelberg), M. Laubenstein (Gran Sasso), G. Manuzio (Genova), E. Meroni (Milano), L. Oberauer (Munich), M. Pallavicini (Genova), L. Perasso (Genova), A.Pocar (Umass), R.S.Raghavan (Virginia Tech), G.Ranucci (Milano), C.Salvo (Gran Sasso), S.Schoenert (MPI Heidelberg), T.Shutt (Case Western), A.Sonnenschein (FNAL), R.Tartaglia (Gran Sasso), G.Testera (Genova), R.B.Vogelaar (Virginia Tech).

Cristiano Galbiati is a member of the SAUND Collaboration, which includes Giorgio Gratta (Stanford).

Cristiano Galbiati is a member of the MAX/DArcSide Collaboration, which includes Ricardo Alarcon (ASU), Drew Alton (Augustana), Dan Durben (BHSU), Kara Keeter (BHSU), Michael Zehfus (BHSU), Elena Aprile (Columbia), Steve Brice (FNAL), Aaron Chou (FNAL), Stephen Pordes (FNAL), Andrew Sonnenschein (FNAL), Jocelin Monroe (MIT), Peter Meyers (Princeton), Uwe Oberlack (Rice), Jeff Martoff (Temple), Susan Jansen-Varnum (Temple), Katsushi Arisaka (UCLA), David Cline (UCLA), Peter Smith (UCLA), Hanguo Wang (UCLA), Jose Lopes (Coimbra), Ed Hungerford (Houston), Larry Pinsky (Houston), Andrea Pocar (UMass), Christian Weinheimer (Münster), Philippe Collon (Notre Dame), Kevin Lehmann (Virginia), Laura Baudis (Zürich), Tadayoshi Doke (Waseda).

Cristiano Galbiati's Graduate Advisor was Gianpaolo Bellini (Milano), and his Postdoctoral Advisor was Frank Calaprice (Princeton).

Graduate students advised include: David Krohn, Ben Loer, John Appel, Richard Saldanha, Alvaro Chavarria, Tiberiu Tesileanu, Catherine Visnjic, Joshua Ruderman, Anand Murugan.

BIOGRAPHICAL SKETCH

Peter D. Meyers
Department of Physics, Jadwin Hall, Princeton University

Professional Preparation:

Harvard University	Physics	B.A. 1975
University of California, Berkeley	Physics	Ph.D. 1983

Appointments:

1998-Present	Professor of Physics, Princeton University
1992-1998	Associate Professor of Physics, Princeton University
1985-1992	Assistant Professor, Princeton University
1984-1985	Research Associate, Princeton University

Publications most closely related to the proposed project

1. A.A. Aguilar-Arevalo *et al*., (MiniBooNE Collaboration), *The MiniBooNE Detector*, Nucl. Inst. Meth. A **599,** 29 (2009).

2. A.A. Aguilar-Arevalo *et al*., (MiniBooNE Collaboration), *Search for Electron Neutrino Appearance at the* $\Delta m^2 \sim 1$ eV^2 *Scale*, Phys. Rev. Lett. **98**, 231801 (2007).

3. S. Adler *et al*., (E-787 Collaboration), *Evidence for the Decay* $K^+ \rightarrow \pi^+ \nu\nu$, Phys. Rev. Lett. **79**, 2204 (1997).

Other publications

A.A. Aguilar-Arevalo *et al*., (MiniBooNE Collaboration), *Measurement of Muon Neutrino Quasi-Elastic Scattering on Carbon*, Phys. Rev. Lett. **100**, 032301 (2008).

S. Adler *et al*., (E-787 Collaboration), *Further evidence for the decay* $K^+ \rightarrow \pi^+ \nu\nu$, Phys. Rev. Lett. **88**, 041803 (2002).

M.S. Atiya *et al*., (E-787 Collaboration), *Upper Limit on the Branching Ratio for the Decay* $\pi^0 \rightarrow \nu\nu bar$, Phys. Rev. Lett. **66**, 2189 (1991).

Relevant Professional Activities

Professor Meyers has worked for many years in searches for rare particle-physics processes. Most recently, this has been in the MiniBooNE search for medium-baseline $\nu_\mu \rightarrow \nu_e$ oscillations at Fermilab. Meyers's group designed and built the phototube array in the MiniBooNE detector and was responsible for developing much of the published oscillation analysis. Prior to MiniBooNE, Meyers worked on Brookhaven E-787, which found evidence for the decay $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ at near the Standard Model level of 10^{-10} in branching ratio.

Meyers's former graduate students include Ryan Patterson (Caltech) and Mark Convery (SLAC), and he co-advised Rob McPherson (IPP, Victoria) and Dan Akerib (Case Western). Postdocs include Hirohisa Tanaka (IPP, U.B.C.) and Andrew Bazarko (Schlumberger, working on this argon project.)

Meyers has won teaching awards from the president of Princeton University and (twice) from the Engineering Council, a group of engineering students. He just completed a 6-year stint as head of the Princeton undergraduate physics program. He headed the graduate program from 1994 to 1997.

Meyers was co-chair of the NSF-DOE/HEPAP-NSAC Neutrino Scientific Assessment Group (NuSAG, 2005-2007). He served on HEPAP (2004-2007), and on the Fermilab Physics Advisory Committee (1998-2002), chairing it from 1999 to 2002.

Ricardo O. Alarcón

Department of Physics
Arizona State University
Tempe, AZ 85287-1504
480-965-8549
ralarcon@asu.edu
http://physics.asu.edu

Professional Preparation

- University of Chile; physics; B.S., 1978 and M.S., 1980.
- Ohio University; physics; Ph.D., 1985.

Appointments

- Professor of Physics, Arizona State University; 2000-present.
- Visiting Professor, Massachusetts Institute of Technology; 1999-2001.
- Associate Professor of Physics, Arizona State University; 1995-2000
- Visiting Associate Professor, Massachusetts Institute of Technology; 1996-97.
- Visiting Research Scientist, MIT-Bates Linear Accelerator Center; 1995-96.
- Assistant Professor of Physics, Arizona State University; 1989-95.
- Research Scientist, University of Illinois; 1988-89.
- Post-Doctoral Research Associate, University of Illinois; 1985-88.

Professional Activities

- Scientific Assessment of Free Electron Laser (FEL) Technology for Naval Applications Committee, National Academy of Sciences, National Research Council, Member, 2007-2009.
- NSF Nuclear Physics Program Panel, 2008-2009.
- Committee on Education, American Physical Society, Division of Nuclear Physics, Member, 2007-2009.
- Rare Isotope Science Assessment Committee (RISAC) of the National Academy of Sciences, National Research Council, Member, 2005-2007.
- DOE Technical, Cost, Schedule and Management review of the STAR TOF detector, Panel member, Brookhaven National Laboratory (2005-2008).
- Nuclear Science Advisory Committee (NSAC) for the Department of Energy and the National Science Foundation, Member, 2001-2005.
- Executive Committee, APS Topical Group on Few Body Systems and Multiparticle Dynamics, 2004-2007.
- Project Manager, BLAST project at MIT-Bates, 1999–2002.
- Scientific Spokesperson, BLAST Collaboration, 2000–2005.
- Member, Committee on Minorities (American Physical Society), 2001-2003.
- Proposal Reviewer for
  - National Science Foundation (NSF) and Department of Energy (DOE)
  - National Sciences and Engineering Council of Canada (NSERC)
  - Chilean Foundation for Science and Technology
  - Coalition to Increase Minority Degrees (CIMD)
- Reviewer for Physical Review Letters and Physical Review.

Awards and Honors

- Fellow, American Physical Society, 2003.
- President, Bates Linear Accelerator Users Group Inc., 1998-2001.

Professional Affiliations

- American Physical Society
- Chilean Society of Physics
- American Association for the Advancement of Science

Publications and Presentations

104	articles and letters
3	edited proceedings
3	national research reports
90+	contributed papers to scholarly meetings
90+	invited meeting and colloquium talks
15	other research publications

Grants and Contracts (last 10 years as PI)

- Research in Fundamental Nuclear Physics, PI, NSF, 2007-2010; $450,000.
- Research in Intermediate Energy Nuclear Physics, PI, NSF, 2004-2007; $450,000.
- Medium Energy Nuclear Physics with Electrons at Arizona State University (ASU), PI, NSF, 2001-2004; $320,729.
- Medium Energy Nuclear Physics with Electrons at Arizona State University, PI, 2003 (ASU Cost-share); $22,625.
- Construction of BLAST Cerenkov Detectors, PI, MIT-subcontract; 2000-2002; $480,000.
- Medium Energy Nuclear Physics with Electrons at Arizona State University, PI, NSF, 1998-2000; $184,000.
- Construction of BLAST Cerenkov Detectors, PI, MIT-subcontract, 1998-99; $84,359.

Thesis Graduate Advisor and Postgraduate Scholar Sponsor

S. Choi, Arizona State University, M.S., 1994.
D. Martinez, Arizona State University, M.S., 1994.
E. Six, Arizona State University, Ph. D., 1999.
A. Young, Arizona State University, Ph. D., 2004.
E. Geis, Arizona State University, Ph. D., 2007.
S. Balascuta, Arizona State University, Ph. D., work in progress.
B. O'Neill, Arizona State University, Ph. D., work in progress.

J. Gorgen, ASU/Bates, postdoc, 1992-95.
S. Dolfini, ASU/Bates, postdoc, 1995-97.
E. Six, ASU/Bates, postdoc, 1999-2001.
B. Tonguc, ASU/Bates, postdoc, 2003-2004.
L. Barron, ASU, postdoc, 2005-2007.

Aaron S. Chou Biographical Sketch

Professional Preparation:

Cornell University	Physics, B.A., Magna cum laude 1993
Stanford University	Applied Physics, M.S. 1995
Stanford University	Applied Physics, Ph.D. 2002
Stanford Linear Accelerator Center	International Linear Collider, 2001-2002
Fermi National Accelerator Laboratory	Pierre Auger Observatory, GammeV, 2002-2007

Academic/Professional Experience:

2008–present:	Robert R. Wilson Fellow	Fermilab
2007–2008:	Senior Research Scientist	New York University
2007–present:	co-spokesperson, GammeV Experiment	

Publications:

· *Search for chameleon particles using a photon regeneration technique*
A.S. Chou, W. Wester, A. Baumbaugh, H.R. Gustafson, Y. Irizarry-Valle, P.O. Mazur, J.H. Steffen, R. Tomlin, A. Upadhye, A. Weltman, X. Yang, J.Yoo. arXiv:0806.2438 [hep-ex]. Accepted for publication in Physical Review Letters, 2009.

· *Observation of the suppression of the flux of cosmic rays above* 4×10^{19} *eV*
Pierre Auger Collaboration. arXiv:0806.4302 [astro-ph], Phys.Rev.Lett. 101:061101, (2008).

· *Search for axion-like particles using a variable baseline photon regeneration technique*
A.S. Chou, W. Wester, A. Baumbaugh, H.R. Gustafson, Y. Irizarry-Valle, P.O. Mazur, J.H. Steffen, R. Tomlin, X. Yang, J.Yoo. arXiv:0710.3783 [hep-ex], Phys.Rev.Lett. 100, 080402 (2008)

· *A model-independent method for determining energy scale and muon number in cosmic ray surface detectors*
F. Schmidt, M. Ave, L. Cazon, and A.S. Chou. arXiv:0712.3750 [astro-ph]. Astropart.Phys. 29:355-365 (2008).

· *Upper limit on the cosmic-ray photon flux above* 10^{19} *eV using the surface detector of the Pierre Auger Observatory*
Pierre Auger Collaboration. arXiv:0712.1147 [astro-ph]. Astropart.Phys.29:243-256 (2008).

· *Upper limit on the diffuse flux of UHE tau neutrinos from the Pierre Auger Observatory*
Pierre Auger Collaboration. arXiv:0712.1909 [astro-ph]. Phys.Rev.Lett. 100:211101 (2008).

· *Correlation of the highest energy cosmic rays with the positions of nearby active galactic nuclei*
Pierre Auger Collaboration. arXiv:0712.2843 [astro-ph]. Astropart.Phys.29:188-204 (2008).

· *Correlation of the highest energy cosmic rays with nearby extragalactic objects*
Pierre Auger Collaboration. Science (front cover), Vol. 318, no.5852, pp.938-943 (2007). http://www.sciencemag.org/cgi/content/abstract/318/5852/938

· *An upper limit to the photon fraction in cosmic rays above 10^{19} eV from the Pierre Auger Observatory*
J. Abraham et.al, (Pierre Auger Collaboration), astro-ph/0606619, Astropart.Phys. 27, 155 (2007).

· *Deep Shower Interpretation of the cosmic ray events observed in excess of the Greisen-Zatsepin-Kuzmin energy*
A. Chou, astro-ph/0606742, Phys. Rev. D74, 103001 (2006).

Synergistic Activities

· Mentoring and supervision of undergraduate and graduate student for the Fermilab summer research program.

· Giving tours of Fermilab to high school students for the Fermilab Saturday Morning Physics program.

Collaborators and Co-editors

K. Arisaka (UCLA), M. Ave (U. Chicago), P. Bauleo (Colorado State), A. Baumbaugh (FNAL), A. Castellina (INFN Torino), L. Cazon (U. Chicago), J. Cronin (U. Chicago), G. Farrar (NYU), J.L. Harton (Colorado State), H.R. Gustafson (U. Michigan), Y. Irizarry-Valle (U. Puerto Rico), R. Knapik (Colorado State), P. Lebrun (FNAL), P. Mantsch (FNAL), P.O. Mazur (FNAL), G. Mueller (U. Florida), G. Navarra (INFN Torino), F. Schmidt (U. Chicago), P. Sikivie (U. Florida), J.H. Steffen (FNAL), D. Tanner (U. Florida), R. Tomlin (FNAL), A. Upadhye (U. Chicago), K. van Bibber (LLNL), A. Weltman (Cambridge U.), W. Wester (FNAL), X. Yang (BNL), T. Yamamoto (Konan U.), J.Yoo (FNAL). To a lesser extent, all members of the Pierre Auger Collaboration, http://www.slac.stanford.edu/spires/find/hep/wwwauthors?key=7556861 .

Graduate and Postdoctoral Advisors

Martin Breidenbach (SLAC), John Jaros (SLAC), Paul Mantsch (FNAL), Glennys Farrar (NYU)

Philippe Collon

Department of Physics
University of Notre Dame
Notre Dame, IN 46556
Home page

Phone: (574) 631-3540
Fax: (574) 631-5952
e-mail: pcollon@nd.edu
www.physics.nd.edu/Faculty/collon.html

Date of Birth: February 03, 1968

citizenship: Belgian (H1-B visa)

Professional preparation

1993	Licencié en Sciences Physiques,	Université Catholique de Louvain
1999	Ph.D. in Nuclear Physics,	Universität Wien

Appointments

2003-present	Assistant Professor	University of Notre Dame
2001-2003	Postdoctoral Research Scientist	Columbia University
1999-2001	Postdoctoral Research Scientist	Argonne National Laboratory
1993-1999	Teaching and Research Assistant	Universität Wien

Publications

Ref. Papers: 23 (15 since 2003); Seminars and Colloquia: 30 (11 since 2003)

Ten sample publications

"A new AMS setup for Nuclear Astrophysics experiments", **D. Robertson, C. Schmitt, P. Collon**, D. Henderson, B. Shumard, L. Lamm, E. Stech, T. Butterfield, P. Engel, G. Hsu, G. Konecki, S. Kurtz, R. Meharchand, A. Signoracci, J. Wittenbach, *Nucl. Instr. and Meth. B* **259** (2007) 669-672.

"Tracing Noble Gas Radionuclides in the Environment", **P. Collon**, Z.T. Lu, W. Kutschera, *Ann. Rev. Nucl. Part. Sc. A***54** (2004)39-67

"Development of an AMS method to study oceanic circulation characteristics using cosmogenic ^{39}Ar", **P. Collon**, M. Bichler, J. Caggiano, L. DeWayne Cecil, Y. El Masri, R. Golser, C.L. Jiang, A. Heinz, D. Henderson, W. Kutschera, B.E. Lehmann, P. Leleux, H.H. Loosli, R.C. Pardo, M. Paul, K.E. Rehm, P. Schlosser, R.H. Scott, W.M. Smethie, Jr., R. Vondrasek, *Nucl. Instr. And Meth. B* **223-224** (2004) 428-434.

"The stellar (n,γ) cross section of ^{62}Ni", H. Nassar, M. Paul, I. Ahmad, M. Bettan, D. Berkovits, **P. Collon**, S. Dababneh, S. Ghelberg, J.P. Greene, A. Heger, M. Heil, D.J. Henderson, C.L. Jiang, F. Kppeler, H. Koivisto, S. O'Brien, R.C. Pardo, N. Patronis, T. Pennington, R. Plag, K.E. Rehm, R. Reifarth, R. Scott, S. Sinha, X. Tang, R. Vondrasek, *Phys. Rev. Lett.* **94**, 092504 (2005)

"Ultra-sensitive detection of p process nuclide ^{146}Sm produced by (γ,n), (p,pnϵ) and (n,2n) reactions", N. Kinoshita, T. Hashimoto, T. Nakanishi, A. Yokoyama, H. Amakawa, T. Mitsugashira, T. Ohtsuki, N. Takahashi, I. Ahmad, J.P. Greene, D.J. Henderson, C.L. Jiang, M. Notani, R.C. Pardo, N. Patel, K.E. Rehm, R. Scott, R. Vondrasek, L. Jisonna, **P. Collon, D. Robertson, C. Schmitt**, X.D. Tang, Y. Kashiv, H. Nassar and M. Paul. *Journal of Physics G: Nuclear and Particle Physics as Proceedings of the "Nuclear Physics in Astrophysics", XXI International Nuclear Physics Divisional Conference of the European Physical Society (26-31 March 2007, Dresden, Germany)* Submitted.

"^{81}Kr in the Great Artesian basin, Australia: A new method for dating very old groundwater." **P. Collon**, W. Kutschera, B. Lehmann, H. H. Loosli, R. Purtschert, A. Love, L. Simpson, D. Cole, B. Davids, D. J. Morrissey, B. M. Sherrill, M. Steiner, R. Pardo, M. Paul, *Earth and Planetary Science Letters*, **182**, 103-113, (2000)

"A comparison of ^{81}Kr, ^{36}Cl and ^{4}He-groundwater dating in 4 wells in the Great Artesian Basin, Australia", B.E. Lehmann, A. Love, R. Purtschert, /bf P. Collon, H. H. Loosli, W. Kutschera, U. Beyerle, W. Aschbach-Hertig, R. Kipfer, S.K. Frape, A. Herczeg, J. Moran, I.N. Tolstikhin, M. Groening, , *Earth and Planet. Sci. Let.* **211**, 3-4 (2003) 237-250

"Influence of nuclear structure on sub-barrier hindrance in Ni+Ni fusion", C.L.Jiang, K.E.Rehm, R.V.F.Janssens, H.Esbensen, I.Ahmad, B.B.Back, **P.Collon**, C.N.Davids, J.P.Greene, D.J.Henderson, G.Mukherjee, R.C.Pardo, M.Paul, T.O.Pennington, D.Seweryniak, S. Sinha, Z. Zhou, , *Phys. Rev. Lett.* **93**, 012701 (2004)

"A new focal-plane detector system at the Argonne Fragment Mass Analyzer for low fusion-evaporation cross section measurements", C.L.Jiang, D.J.Henderson, T.O.Pennington, D.Seweryniak, I Tanihata, K.E.Rehm, C.N.Davids, B.B.Back, **P.Collon**, J.P.Greene, R.V.F.Janssens, **S. Kurtz**, C.J. Lister, R.C.Pardo, M.Paul, D. Peterson, B. Shumard, S. Sinha, X. D. Tang, S Zhou, *Nucl. Instr. and Meth.* A **554** (2005) 500-513

"First evidence of fusion hindrance for a small Q-value system", C.L. Jiang, B.B. Back, H. Esbensen, R.V.F. Janssens, S. Misicu, K.E. Rehm, **P. Collon**, C.N. Davids, J. Greene, D.J. Henderson, L. Jisonna, **S. Kurtz**, C.J. Lister, M. Notani, M. Paul, R. Pardo, D. Peterson, D. Seweryniak, B. Shumard, X.D. Tang, I. Tanihata, X. Wang, S. Zhu, *Phys. Let.* B **640** (2006)18-22.

Synergistic Activities

Teaching in RIA smmer school, Argonne National Laboratory.
Development of research program for in experimental nuclear physics for undergraduate students (21 participants).
Development of modern physics course for undergraduates as well as nuclear physics course for graduate students.
Collaboration in the IAEA research program "*CRP on Isotope Techniques for the Assessment of the Slow Moving Deep Groundwater and their Potential Applications for the Assessment of Waste Disposal Sites*".
Supervision of Summer REU students at the NSL.
Undergraduate student supervisor 8-10 students/year.

University activities

Member of Faculty Senate 2004 to 2007.
Chair of Student Affairs committee of Faculty Senate 06-07.
Faculty Senate Representative to Student Senate 2004 to 2007.
Ex-Officio Member of the Academic Council 06-07.
Member of the Advisory Committee to the Provost on the Evaluation of Teaching (ACPET) 2005-present.

Ph.D. advisor	**Postdoctoral advisors**
W. Kutschera U. Wien, Austria	E. Rehm ANL, USA, P. Schlosser LDEO of Columbia U., USA

Ph.D. advisees in past 5 years Dan Robertson, Chris Schmit, Matt Bauer, Wenting Lu

KEVIN K. LEHMANN

Present Academic Address:
Department of Chemistry
University of Virginia
McCormick Road
Charlottesville VA 22904-4319
Ph. (434) 243-2130
Email: Lehmann@virginia.edu

Professional Preparation:

Cook College, Rutgers University	Chemical Physics and Mathematics	B.S. 1977
Harvard University	Chemical Physics	PhD. 1983
Harvard Society of Fellows	Junior Fellow	1983-1986

Appointments:

Aug. 2005	Professor of Chemistry & Physics, University of Virginia
July 1995	Professor of Chemistry, Princeton University
Feb. 1997	JILA Visiting Fellow, University of Colorado
July 1991	Associate Professor of Chemistry, Princeton University
Sept. 1985	Assistant Professor of Chemistry, Princeton University
Aug. 1983	Visiting Scientist, George R. Harrison Spectroscopy Laboratory

Publications - related

1. G. Engel, W.B. Yan, J. Dudek, K. Lehmann, and P. Rabinowitz, Ring down spectroscopy with a Brewster's angle prism resonator, *in Laser Spectroscopy XIV International Conference*, Eds. R. Blatt *et al*. pgs. 314-315 (World Scientific, 1999).
2. Peter B. Tarsa, Paul Rabinowitz, and Kevin K. Lehmann, Evanescent field absorption in a passive optical fiber using continuous wave cavity ring-down spectroscopy, *Chemical Physics Letters* **383**, 297-303 (2004).
3. John B. Dudek, Peter B. Tarsa, Armando Velasquez, Mark Wladyslawski, Paul Rabinowitz, and Kevin K. Lehmann, Trace moisture detection using continuous-wave cavity ring-down spectroscopy, *Analytical Chemistry* **75**, 4599-4609 (2003).
4. C.R. Bucher, K.K. Lehmann, D.F. Plusquellic, and G.T. Fraser, Doppler-free nonlinear Absorption in ethylene by use of cw cavity ring down spectroscopy, *Applied Optics*, **39**, 3154-3164 (2000).
5. D. Romanini and K.K. Lehmann, Ring-down absorption spectroscopy of the very weak HCN overtone bands with six, seven, and eight stretching quanta, *J. Chem. Phys.* **99**, 6287-301 (1993).

Publications – other

1. Kunal K. Das, Yuri V. Rostovtsev, Kevin Lehmann, and Marlan O. Scully, Thermodynamic and noise considerations for the detection of microscopic particles

in a gas by photoaccoustic Raman spectroscopy, *Optics Communications* **246**, 551-559, 2005.
2. Kevin K. Lehmann and Adriaan Dokter, Evaporative cooling of helium nanodroplets with angular momentum conservation, *Physical Review Letters* **92**, 173401 (2004).
3. H. K. Srivastava, A. Conjusteau, H. Mabuchi, A. Callegari, K.K. Lehmann, and G. Scoles, A sub-Doppler resolution double resonance molecular beam infrared spectrometer operating at chemically relevant energies (similar to 2 eV), *Review of Scientific Instruments* **71**, 4032-4038 (2000).
4. J. Higgins, C. Callegari, J. Reho, F. Stienkemeier, W.E. Ernst, K.K. Lehmann, M. Gutowski, and G. Scoles, Photoinduced Chemical Dynamics of High Spin Alkali Trimers, *Science* **273**, 629-631 (1996).
5. D.C. Hovde, J. Timmermans, K.K. Lehmann, and G. Scoles, High Power Injection Seeded Optical Parametric Oscillator, *Optics Comm.* **86**, 294-300 (1991).

Synergistic Activities:

Research in my laboratory has lead nine US patents dealing with advances in cavity-ring down spectroscopy (CRDS). This technology provides the technological foundation for a new company, Tiger Optics, that has been the first commercial supplier of CRDS based chemical sensors. I have developed an educational web page, BadChemistry, that has been widely sited and downloaded over 320,000 times. I have also developed a large number of Educational Software documents, using the MATHCAD suite of programs, that deal with topics such as Quantum Mechanics, Spectroscopy, and Statistical Analysis. Several of these have been included in an NSF funded web site.

Collaborators & Other Affiliations:

Collaborators and Co-Editors (last 48 months): S. Carter (U. of Reading), Yu Chen (Tiger Optics), E. W. Draeger (Sandia National Labs), G.T. Fraser (NIST), M. Gruebele (U. Illinois), M. Gutowski (PNL), H. Mabuchi (Cal Tech), R.E. Miller (UNC), M. Nooijen (U. Waterloo), T. Onstott (Princeton), D.F. Plusquellic (NIST), P. Rabinowitz (Princeton), M.O. Scully (Texas A&M), G. Scoles (Princeton), F. Stienkemeier (Freiburg), W. S. Warren (Duke), W-B Yan (Tiger Optics). Co-Editors; Udo Buch (Max-Planck-Institut fuer Dynamik und Selbstorganisation) and Gang-Yu Liu (UC Davis).
Graduate Advisor: William A. Klemperer (Harvard). (Graduate advisor).
Thesis Advisor and Postgraduate-Scholar Sponsor: Postdocs (6): Carlo Callegari (U. Gratz), Pierre Çarçabal (Oxford), Raul Z. Martinez (U. Helsinki), U. Merker (BMW), Irene Reinhard (U. Heidelberg) , Irene Scheele . Graduate Students (13): Ozgur Birer, Christine Bucher (Inst. Defense Analysis), Carlo Callegari (U. Gratz), Andre Conjusteau (Cal. Tech.), John Dudek (U. New Hampshire), Robert Fehnel, Haifeng Huang, Paul Johnston, Mathew Radcliff (U. Montana), Paulo Moreschini, James Reho (Easter Carolina Univ.), Peter Tarsa (M.I.T), Roman Schmied (Max Planck Institute for Quantum Optics)
Undergraduate Students: (8) Casey Clements, Ryan Coleman, Adriaan Dokter (U. Amsterdam), Erin Kaller, Vincent Lonij (U. Leiden), Reed Nessler, Samuel Tenney (REU), Wilton Virgo (MIT)

Mechanical Engineer: Robert F Parsells has 25 years of experience in plasma and fusion engineering and process engineering at Princeton Plasma Physics Laboratory, where he has participated in the design, testing, and fabrication of various diagnostics and components used in fusion and plasma-related research. He has participated in the design of the Borexino water tank, sphere, and inner nylon vessel.

Mr. Robert Parsells, PPPL
Distinguished Engineer
Fellow for 2002

Awards:

"Outstanding Engineering Achievement Award" from the New Jersey Society of Professional Engineers.

"Distinguished Research and Engineering Fellow", from the U.S. Department of Energy,

Professional Preparation

New Jersey Institute of Technology, Mechanical Engineering, BSME, 1963.
New Jersey Institute of Technology, Mechanical Engineering, MSME, 1967.

Appointments

Founded *Design & Project Engineers* in 1969 and consulted to corporate research departments. During the next thirteen years, managed engineering projects involving:

- The design and construction of a SO_2 gas recovery pilot plant. A zinc producer needed an economic pollution control of a roasting operation. The recovery of waste sulfuric acid by a high temperature spray drying process provided the solution.
- The design and construction of a flavors and fragrance facility expansion. A British-based firm, U.S. corporate owned, needed to consolidate two plants and expand extraction facilities.
- The design for cofferdam construction with a new design that established a world record for excavation depth in varved clay with a sheeted cofferdam in the New Jersey Meadowlands.
- The design of spray dryers for a magnesium producer that established a world record for d/t ratio for vessel under negative pressure.

Joined the Princeton Plasma Physics Laboratory in 1982 and for the next twenty five years managed engineering projects involving:

- The design of tritium shipping containers of the DT run of TFTR that provided safe, economic shipping and storage.
- The design, manufacture, and test of diagnostics that measure the dynamic performance of the plasma and its nuclear reactions throughout its electromagnetic and its nuclear spectrum, including a Multi-Channel Neutron Collimator, an X-Ray crystal Spectrometer, an ECE Fourier Transform, an Escaping Alpha, a μWave Reflectometer and others.

- The design of visible spectrum diagnostics for the Radiative Divertor, a research project for the International Tokamak Engineering Reactor (ITER).
- The design of LHD ECE Antenna for NIFS, Japan. The design, fabrication, and test of the front-end collection optics for Electron Cyclotron Emission.
- The design of E-Beam window using silicon and Peltier cooling for the Naval Research Laboratory. A patent application for the cooling concept in transmission windows has resulted.
- The design and implementation of the diamond wire cutting for the Tokamak Fusion Test Reactor D&D project. This received the project of the year award from the Society of Professional Engineers and the "Distinguished Research and Engineering Fellow" award from the U.S. Department of Energy. The technology has been patented and licensed.

Publications

Decommissioning of the Tokamak Fusion Test Reactor
*Authors***:** E. Perry, J. Chrzanowski, C. Gentile, R. Parsells, K. Rule, R. Strykowsky, and M. Viola Online: http://www.pppl.gov/techreports.cfm

Engineering Design of the National Spherical Torus Experiment
Authors: Neumeyer, C., P. Heitzenroeder, J. Spitzer, J. Chrzanowski, A. Brooks, J. Bialek, H.M. Fan, G. Barnes, M. Viola, B. Nelson, P. Goranson, R. Wilson, E. Fredd, L. Dudek, R. Parsells, M. Kalish, W. Blanchard, R. Kaita, H. Kugel, B. McCormack, S. Ramakrishnan, R. Hatcher, G. Oliaro, E. Perry, T. Egebo, A. Von Halle, M. Williams, and M. Ono Online: http://www.pppl.gov/techreports.cfm

"The nylon scintillator containment vessels for the Borexino solar neutrino experiment", *Authors*: J. Benziger, L. Cadonati, F. Calaprice, E. de Haas, R. Fernholz, R. Ford, C. Galbiati, A. Goretti, E. Harding, A. Ianni, An. Ianni, S. Kidner, M. Leung, F. Loeser, K. McCarty, A. Nelson, R. Parsells, A. Pocar, T. Shutt, A. Sonnenschein, and R. B. Vogelaar, Nucl. Instr. Meth. A 582 (2007) 509-534.
Online: doi:10.1016/j.nima.2007.08.176

Dr. Stephen Pordes 1/8/2009
MS 122
Fermi National Accelerator Laboratory
Batavia, IL 60510
Office phone: 630-840-3603 Email: stephen@fnal.gov

Professional Preparation

Oxford University, England	Physics	B.A. (1970)
Harvard University	Physics	Ph.D. (1976)
CERN Fellow	Experimental Physics	1976 - 1979
Rockefeller University (postdoc)	Experimental Physics	1979 - 1980

Appointments

Fermi National Accelerator Laboratory	Scientist II	1993 – present
Fermi National Accelerator Laboratory	Scientist I	1987 – 1993
Fermi National Accelerator Laboratory	Associate Scientist	1980 – 1987

Selected Publications relevant to proposed project

"Work at FNAL to achieve long electron drift lifetime in liquid argon". D. Finley, W. Jaskierny, C. Kendziora, J. Krider, S. Pordes, P.A. Rapidis, T. Tope (Fermilab) . FERMILAB-TM-2385-E, Oct 2006.
http://www-spires.fnal.gov/spires/find/hep/www?r=FERMILAB-TM-2385-E

"Test of purging a small tank with argon". W. Jaskierny, H. Jostlein, S. Pordes, P.A. Rapidis, T. Tope (Fermilab) . FERMILAB-TM-2384-E, Oct 2006.
http://www-spires.fnal.gov/spires/find/hep/www?r=FERMILAB-TM-2384-E

"A large liquid argon time projection chamber for long-baseline, off-axis neutrino oscillation physics with the NuMI beam". D. Finley et al. (18 authors) FERMILAB-FN-0776-E, Sep 2005.
http://www-spires.fnal.gov/spires/find/hep/www?r=FERMILAB-FN-0776-E

Other selected Publications

"Signal processing for longitudinal parameters of the Tevatron beam".
S. Pordes, J. Crisp, B. Fellenz, R. Flora, A. Para, A.V. Tollestrup (Fermilab) . FERMILAB-CONF-05-178-AD, PAC-2005-RPAT013, May 2005
http://www-spires.fnal.gov/spires/find/hep/www?j=CONFP,C0505161,136

"Precision measurements of charmonium states formed in anti-p p annihilation, E760 Collaboration (T.A. Armstrong et al.). Phys.Rev.Lett.68:1468-1471,1992
http://www-library.desy.de/cgi-bin/spiface/find/hep/www?j=PRLTA,68,1468

"A Search for Shortlived Particles Produced in an Electron Beam Dump". A. Bross, M. Crisler, S. Pordes, J. Volk (FNAL) , S. Errede, J. Wrbanek (U. Illinois) Phys.Rev.Lett.67, 1991.
http://www-library.desy.de/cgi-bin/spiface/find/hep/www?j=PRLTA,67,2942

"Search for Direct Single Photon Production at Large p(T) in Proton Proton Collisions at $\sqrt{s}$ = 62.4-GeV", A.L.S. Angelis et al., (CERN-Columbia-Oxford-Rockefeller Collaboration) Phys. Lett. B94:106,1980.
http://www-library.desy.de/cgi-bin/spiface/find/hep/www?j=PHLTA,B94,106

"Measurement of the Proton Structure Function from Muon Scattering."
H.L. Anderson et al., Phys.Rev.Lett.38:1450-1454,1977.
http://www-library.desy.de/cgi-bin/spiface/find/hep/www?j=PRLTA,38,1450

Synergistic Activities
Supervisor of summer interns at Fermilab for past several years.

Collaborators & Other Affiliations

Collaborators of past 48 months:
The MicroBooNE Collaboration (~40 names) (BNL, Columbia, Fermilab, LANL, St. Mary's, Michigan State, M.I.T., Princeton, U.Texas at Austen, Yale)
The Fermilab E835 Collaboration (~40 names) (Fermilab, Ferrara (Italy), Genoa (Italy), INFN (Italy), Irvine, Minnesota, Northwestern, Turin (Italy))

Graduate Advisors and Postdoctoral Sponsors:
Richard Wilson (Harvard) emeritus; Rod Cool (Rockefeller University) deceased; L. di Lella (CERN) now at Scuola Normale, Pisa, Italy.

Mechanical Engineer: **William R. Sands III** has over thirty years of experience in the particle detector field of high energy physics research. Skilled in design and fabrication of particle detectors and the management of personnel and facilities for construction and installation of particle detectors.

EDUCATION

Associate of Applied Science, Mechanical Engineering, Mercer County Community College, Mercerville, N.J. 1989

Bachelor of Science, Mechanical Engineering, Trenton State College, Trenton, N.J. 1996

PROFESSIONAL EXPERIENCE

PRINCETON UNIVERSITY, Princeton, N.J.
Physics Department 1977-2009

2007-Present Engineering Design and Fabrication Consultant – CMS (CERN)

2007-Present Senior engineer for RPC gas bubbler system responsible for design and fabrication - Daya Bay Neutrino Experiment

2007-2008 Engineering Design and Construction Consultant- NCSX (Princeton Plasma Physics Lab)

2006-2007 Design Engineer (Princeton) Merit Experiment Hg Target

2002-2007 Project engineer BaBar LST upgrade. Responsible for design, fabrication and installation of experimental apparatus, SLAC

1999-2001 Project engineer for Mini BooNE PSS (phototube support structure). Responsible for design fabrication and installation of experimental apparatus, Fermilab

1994-1998 Design and fabrication for engineer for Belle (KEK) RPC's and and installation apparatus

1991-2007 Manage 2 buildings and their personnel. Design and manage the fabrication and installation of particle detectors for international high energy physics experiments with total experiment costs exceeding $200 million. Detectors installed at Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Stanford Linear Accelerator, CERN (Switzerland), DESY (Germany) and KEK (Japan)

1984-1987 Assisted in design of range stack proportional chambers and Cherenkov Counter for experiment 787 (BNL) and managed fabrication and installation of RSPC and Cherenkov Counter.

1983-1991 Fabrication of particle detectors and design of fixtures for detector assembly. Organize and manage production of particle detectors.

1977-1983 Machine shop practices including computer numerical control machines, milling machines and lathes with an emphasis on shop safety. Machining of parts for particle detectors and detector installation.

Publications

The MiniBooNE Detector Technical Design Report, Fermilab-TM-2207

Authors: (Princeton Only) A.O. Bazarko, P.D. Meyers, W. Sands, F.C. Shoemaker
Mini BooNE Collaboration

ENGINEERING ACCOMPLISHMENTS IN THE CONSTRUCTION OF NCSX, PPPL TECHNICAL REPORT 4350

Authors: G. H. Neilson, P. J. Heitzenroeder, B. E. Nelson, W. T. Reiersen, A. Brooks, T. G. Brown, J. H. Chrzanowski, M. J. Cole, F. Dahlgren, T. Dodson, L. E. Dudek, R. A. Ellis, H. M.Fan, P. J. Fogarty, K. D. Freudenberg, P. L. Goranson, J. H. Harris, M. R. Kalish, G. Labik, J. F. Lyon, N. Pomphrey, C. D. Priniski, S.Raftopoulos, D. J. Rej, W. R. Sands, R. T. Simmons, B. E. Stratton, R. L. Strykowsky, M. E. Viola, D. E. Williamson, and M. C. Zarnstorff

Dr. Andrew Sonnenschein
Fermi National Accelerator Laboratory
MS 209
Batavia, IL 60510
Office phone: 630-840-2883
Fax: 630-840-8231
Email: Sonnenschein@fnal.gov

Professional Preparation

Brown University	Physics	Sc.B. (1992)
University of California, Santa Barbara	Physics	Ph.D. (1999)
Princeton University	Nuclear Physics	1999-2002.
University of Chicago	Astrophysics	2002-2005.

Appointments
Wilson Fellow (Associate Scientist), Fermi National Accelerator Laboratory, 2005-present.

Selected Publications
E. Behnke, J.I. Collar, P.S. Cooper, K. Crum, M. Crisler, M. Hu, I. Levine, D. Nakazawa, H. Nguyen, B. Odom, E. Ramberg, J. Rasmussen, N. Riley, A. Sonnenschein, M. Szydagis, R. Tschirhart (The COUPP Collaboration), "Improved Spin-Dependent WIMP Limits from a Bubble Chamber", Science 319:933-936 (2008).

C. Arpesella *et al*. (The Borexino Collaboration), "Direct Measurement of the Be-7 Solar Neutrino Flux with 192 Days of Borexino Data", Phys. Rev. Lett. 101:091302 (2008).

C. Arpesella *et al.*, (The Borexino Collaboration) "Measurements of extremely low radioactivity levels in Borexino", hep-ex/0109031, Astropart. Phys. 18, 1-25 (2002).

R. Abusaidi *et al.*, (The CDMS Collaboration) "Exclusion limits on the WIMP nucleon cross-section from the cryogenic dark matter search", astro-ph/0002471, Phys. Rev. Lett. 84, 5699-5703 (2000).

Collaborators and Other Affiliations
(1) The COUPP Collaboration (E. Behnke, J.I. Collar, P.S. Cooper, K. Crum, M. Crisler, M. Hu, I. Levine, D. Nakazawa, H. Nguyen, B. Odom, E. Ramberg, J. Rasmussen, N. Riley, A. Sonnenschein, M. Szydagis, R. Tschirhart)
(2) The Borexino Collaboration (72 authors)
(3) Graduate advisors and sponsors: D. Caldwell (University of California, Santa Barbara), F. Calaprice (Princeton University), J. Collar (University of Chicago)

Biographical Sketch

PERSONAL

Ed Vernon Hungerford, III
M.D. Anderson Professor of Physics
Department of Physics, University of Houston
Houston, TX 77204
(713)743-3549; Fax:(713)743-3589; HUNGER@UH.EDU

PROFESSIONAL PREPARATION

Georgia Tech	Physics	BS 1960
Georgia Tech	Physics	PhD 1967
ORNL	Physics	1967-1969

APPOINTMENTS

1980-present	Professor - University of Houston
1973-1980	Associate Professor - University of Houston
1972-1973	Assistant Professor - University of Houston
1969-1972	Assistant Professor - Rice University
1967-1969	Post Doctoral Appointment - ORNL
1960-1963	Officer USMC

SELECTED REFERRED PUBLICATIONS PERTINENT TO THE PROPOSAL

"A Pipelined Front-end, Timing and Amplitude Digitizing System" K. A. Lan, Y. Cui, and E. V. Hungerford, IEEE Transactions on Nuclear Science **51**(2004)2362

"A Front-end DAQ with Buffer and Flexible Triggers", Y. Cui, K. A. Lan, and E. V. Hungerford, IEEE Transactions, **53**(2006)

*0.5cm "Static forces on Anode wires in a Straw Chamber", G. XU and E. Hungerford, IEEE Trans. on Nucl. Sci., **53**(2006)549

"Performance of a prototype tracking detector with waveform sampling electronics", Y. Cui, K. Lan, and E. V. Hungerford, IEEE Trans. on Nucl. Sci **53**(2006)2281

"A Conceptual Design of the readout system for the Neutrino Experiment at the SNS", A. Lan and E. Hungerford, IEEE Trans. on Nuclear Science**54**(2007) pp1816-1823

SELECTED BOOKS & REVIEW PAPERS

"Strange Nuclear Physics" E. V. Hungerford, Chapter in book, "Lecture Notes in Physics No 724", Springer, 2007

SAMPLING OF SYNERGISTIC ACTIVITIES

1990-1996	Dissertation Awards Committee, DNP
1998	SKS Review Committee chair, KEK Japan
1999-2000	Program Committee, DNP
2004	Lecturer Fermi Summer School, Varenna, Italy
2006	Lecturer Indian Summer School, Prague, Czech Republic

COLLABORATIONS

As the number of collaborators is very large the most recent collaborating institutions are listed below

Collaborating Institutions by Experiment

Experiment	Institution
AGS 940 (MECO)	Boston University, Brookhaven National Lab, Univ. California - Irvine, Univ. Massachusetts, New York University, Osaka Univ., Univ. of Pennsylvania, Syracuse Univ,Univ. of Pennsylvania, William and Mary Univ
CLEAR Collaboration	Yale University, Duke University, University of Tennessee Oak Ridge National Lab, N. Carolina Central
Jlab 89-009,01-011	Florida International Univ., Hampton Univ., Thomas Jefferson National Lab, Univ of Tokyo Tohoku Univ.Univ. Tokyo, Zagreb Univ.
Jlab 03-103	Argonne National Lab, Jlab, University of Virginia

Graduate Advisors D. H. Wyly, C. H. Braden, deceased

25 Graduated PhD Students - Most Recent Students

A. Alaniz	PhD, 2001	Staff Los Alamos National Lab
M. Sarsour	PhD, 2002	Faculty Georgia State University
V. Rodigues	PhD 2006	Faculty Universidad Metropolitana, San Juan, P. R.
M. Bukhari	PhD 2006	Faculty Pakistan University
S. Randanyia	PhD 2007	Postdoctoral Appointment Rice University
A. Daniel	PhD. 2007	Postdoctoral Appointment Ohio University
N. Kalantraians	PhD 2008	Postdoctoral Appointment Univ. Virginia
N. ElKahari	PhD 2009	Postdoctoral Appointment

Lawrence Steven Pinsky

CURRENT POSITION

Professor of Physics and Chairperson, Physics Department, University of Houston

EDUCATION

LL.M. (Information and Intellectual Property Law) University of Houston (2001)
J.D. (Law-magna cum laude) University of Houston, Houston, Texas (1997)
Ph.D. (Physics) University of Rochester, Rochester, New York (1973)
M.A. (Physics) University of Rochester, Rochester, New York (1969)
B.S. (Physics) Carnegie Mellon University, Pittsburgh, Pennsylvania (1968)

CHRONOLOGY OF EXPERIENCE

1995-present—Chairperson, University of Houston, Physics Department.
1990-present—Professor of Physics, University of Houston, Physics Department.
1981-1990—Associate Professor of Physics, University of Houston, Physics Department.
1975-1981—Assistant Professor of Physics, University of Houston, Physics Department,
1972-1975—Postdoctoral Fellow, Physics Department, University of Houston.
1969-1972—2Lt-1Lt-Capt, United States Army Corps of Engineers, primary duty station: NASA, Johnson Space Center (Manned Spacecraft Center), Houston, Texas.

SELECTED REFEREED PUBLICATIONS - L. S. PINSKY (05/08) (145 total):

Visual Sensations Induced by Relativistic Nitrogen Nuclei, Science 178 (1972) 160.

Light Flashes Observed by Astronauts on Apollo 11 through Apollo 17, Science 183 (1974) 957.

Apollo Light Flash Investigations, Biomedical Results of Apollo, NASA SP-368, National Aeronautics and Space Administration, Washington, D. C. 20546 (1975) p. 355-367.

Development of a Space Radiation Monte-Carlo Computer Simulation Based on the FLUKA and ROOT Codes, L.S. Pinsky, et al., Physica Medica, 17, Supplement 1 (2001) 86-89.

Simulation of the Space Shuttle Neutron Measurements with FLUKA, L. Pinsky, F. Carminati and A Ferrari, Rad. Meas. 33 (2001) 335-339.

The FLUKA code for Space Applications: Recent Developments, V. Andersen, et al., Advances in Space Research 34(6), (2004) 1302-1310 .

Heavy ion interactions from Coulomb barrier to few GeV/n: Boltzmann Master Equation theory and FLUKA code performances., G. Battistoni, et al., Brazilian Journal of Physics 34, 897-900 (2004).

Update on the Status of the FLUKA Monte Carlo Transport Code, L. Pinsky, et al., Proc. Computing in High Energy and Nuclear Physics (CHEP) conference, Interlaken, Switzerland, Sept 27-Oct 1, 2004. Published in the web. (http://chep2004.web.cern.ch/chep2004/)

Models and Monte Carlo Simulations of GCR and SPE Organ Doses with Different Shielding, Based on the FLUKA Code Coupled with Anthropomorphic Phantoms, F. Ballarini, et al., The 35th COSPAR Scientific Assembly, Paris, France, July 2004, (published as CD).

System-Size Dependence of Strangeness Production in Nucleus-Nucleus Collisions at S(NN)^(1/2) = 17.3-GeV, By NA49 Collaboration (C. Alt et al.), Phys.Rev.Lett. 94 (2005) 052301.
Multiplicity Fluctuations in Nuclear Collisions at 158-A-GeV, By NA49 Collaboration (M Rybczynski et al.), J. PhysConf.Ser. 5 (2005) 74-85.
System Size and Centrality Dependence of the Balance Function in A+A Collisions at an S(NN)^1/2 = 17.2-GeV, By NA49 Collab. (C. Alt et al.), Phys.Rev. C71,(2005) 034903.
Indications for the Onset of Deconfinement in Nucleus-Nucleus Collisions, D. Flierl et al.. AIP Conf.Proc.756 (2005) 433-435.
Indications for the Onset of Deconfinement in Pb-Pb Collisions at the CERN SPS from NA49, By NA49 Collab. (P. Seyboth, et al.). Acta Phys. Polon. B36 (2005) 565-573.
Nuclear Models in FLUKA: Present Capabilities, Open Problems and Future Improvements, F. Ballarini et al.. AIP Conf.Proc.769 (2005)1197-1202.
Omega- and anti-Omega+ production in central Pb + Pb collisions at 40-AGeV and 158-AGeV. By NA49 Collaboration (C. Alt et al.) Phys.Rev.Lett.94 (2005) 192301.
Update on the Status of FLUKA, Including Preliminary Results from the July 2005 AGS Run, L. Pinsky, et al.,Proceedings of the IEEE Aerospace Conference, Big Sky, Montana, March 6-10, 2006 (Published on CD).
The FLUKA Code: an Overview. F. Ballarini et al. J.Phys.Conf.Ser.41 (2006)151-160.
A Monte Carlos Approach to Study Neutron and Fragment Emission in Heavy-Ion Interactions, M.V. Garzelli et al., Submitted to Adv. Space Res., 2006.
A QMD description of the interaction of ion beams with matter, M.V. Garzelli, et al., Proceedings of the 25th Workshop on Nuclear Theory, Rila Mountains, Bulgaria, June 26 - July 1, 2006, S. Dimitrova edt., DioMira pub., Sofia (2006), 123 – 131.
Heavy-ion collisions described by a new QMD code interfaced to FLUKA: model validation by comparisons with experimental data concerning neutron and charged fragment production, M.V. Garzelli, et al., Proc. 11th International Conference on Nuclear Reaction Mechanisms, Varenna, Italy, June 12 - 16 2006, Journal-ref: Ricerca Scientifica ed Educazione Permanente Suppl. 126 (2006), Univ. Milano (E. Gadioli edt.), pp. 515 – 524.
GCR and SPE organ doses in deep space with different shielding: Monte Carlo simulations based on the FLUKA code coupled to anthropomorphic phantoms, F. Ballarini, et al., Adv. Space Res. 37(9), (2006) 1791-7.
Development of a New Active Personal Dosimeter for Use in Space Radiation Environments, L. Pinsky and J. Chancellor, Proceedings of the IEEE Aerospace Conference, Big Sky, Montana, March 5-9, 2007, (Published on CD).
A Monte Carlo approach to study neutron and fragment emission in heavy-ion reactions, M.V. Garzelli, et al., Advances in Space Research 40 (2007), 1350 – 1356.
The hadronic models for cosmic ray physics: the FLUKA code solutions, G. Battistoni, Proceedings of the International Symposium on Very High Energy Cosmic Rays, Weihai, China, August 15 - 22 2006, Journal-ref: Nuclear Physics B (Proc. Suppl.) 175 - 176 (2008), 88 – 95.
Secondary Cosmic Ray particles due to GCR interactions in the Earth's atmosphere, G. Battistoni, et al., Proceedings of the Carpathian Summer School of Physics - Exotic Nuclei & Nuclear/Particle Astrophysics, Sinaia, Romania, August 20 - 31 2007, AIP Conf. Proc. 972 (2008), 449 – 454.

Biographical Sketch

Katsushi Arisaka, Ph. D

Professor of Physics and Astronomy, UCLA

Department of Physics and Astronomy
University of California, Los Angeles
405 Hilgard Ave., Knudsen 4-145
Los Angeles, CA 90095-1547

Tel: (310) 825-4925
Fax: (310) 267-2483
Email: arisaka@physics.ucla.edu

(a) Professional Preparation

1981-1985	Doctor of Science in Physics, University of Tokyo, Japan
1979-1981	Master of Science in Physics, University of Tokyo, Japan
1974-1979	Bachelor of Science in Physics, University of Tokyo, Japan

(b) Appointments

July 1995 -Present	Professor, Department of Physics and Astronomy, UCLA
July 1991 -June 1995	Associate Professor, Department of Physics, UCLA
July 1988 -June 1991	Assistant Professor, Department of Physics, UCLA
Feb. 1985 -June 1988	Research Investigator, University of Pennsylvania

Academic Honors:

2005	Outstanding Teacher of the Year (Physics 6B: Electricity and Magnetism for Life Science Major)
2004, 2006, 2007	Distinguished Teaching Award (Physics 6B, Physics 128: Cosmology and Particle Astrophysics)
1995	Distinguished Teaching Award. (Physics 126, Elementary Particle Physics for Physics Major)
1990 –1991	SSC Junior Faculty Fellowship.

(c) Publications: Total 157 publications

(i) List of 5 publications most closely related to the proposed project:

1. K. Arisaka, et al, “XAX: a multi-ton, multi-target detection system for dark matter, double beta decay and pp solar neutrinos”, arXiv:0808.3968 to be appeared at Astroparticle Physics
2. Michalet, X., Cheng, A., Antelman, J., Suyama, M., Arisaka, K., Weiss, S. “Hybrid photodetector for single-molecule spectroscopy and microscopy”, Proceedings of SPIE **6862**: *in press* (2008)
3. Pierre Auger Collaboration (J. Abraham et al), Property and performance of the Prototype Instrument for the Auger Observatory. NIM.A523:50-95,2004
4. A.K. Tripathi, S. Akhanjee, K. Arisaka, D. Barnhill, C. D'Pasquale, C. Jillings, T. Ohnuki, P. Ranin A Systematic Study of Large PMTs for the Pierre Auger Observatory , N.I.M .A497:331-339,2003
5. K. Arisaka, “New Trends on Vacuum Based Photon Detectors.”, Invited talk presented BEAUNE 99, Beaune, France, June 21-15, 1999. N.I.M. A442 (2000) 80-90.

(ii) List of 5 other significant publications:

There are published by the Pierre-Auger collaboration.

1.	Correlation of Highest Energy Cosmic rays	Science, Vol. 318 938-943, 2007
2.	Correlation of Highest Energy Cosmic rays	Astroparticle Phys., 29, 188-204, 2008
3.	Upper limit on Photon Flux above 10 EeV	Astroparticle Phys., 29, 243-256, 2008
4.	Observation of Suppression of Flux > 40 EeV	Phys.Rev.Lett. 101: 061101, 2008
5.	Upper Limit on Tau Neutrino Flux	Phys.Rev.Lett. 101. 21101 , 2008

(d) Synergistic Activities

Member of organizing committees on the following conferences:

1. NSS/IEEE (Seattle 1999, Lyon 2000)
2. Advances on Photon detection (Beaune 1996, 1999, 2002 2005 and 2008),
3. DPF99 (UCLA)
4. SCIFI97 (Notre Dame)
5. Workshop on UHECR (Aspen, 2005)

(e) Collaborators & Other Affiliations

1.	Dark Matter(XENON100):	Elena Aprile (Columbia), Uwe Oberlack (Rice)
2.	Dark Matter (MAX):	Christiano Galbiati (Princeton), Andrew Sonnenschein (FNAL)
3.	Pierre-Auger:	J. Cronin (Chicago), A. Watson (Leeds), P. Mantsch (FNAL),
4.	KTeV:	T.Yamanaka (Osaka), B. Winstein (Chicago)
5.	Bio-Imaging (NSF MRI):	J. Feldman (UCLA), A. Charles (UCLA), S. Weiss (UCLA), J. Miao (UCLA), D. Bozovic (UCLA)

Graduate and Postgraduate Advisors:

Toshi Koshiba (Tokyo), Yuji Totsuka (Tokyo), Alfred Mann (Pennsylvania), William Molzon (UC Irvine)

Thesis Advisor and Post Graduate-scholar Sponsor:

Thesis:	Doug Roberts, Matthew Weaver, Matthew Spencer, Elizabeth Turner, Tohru Ohnuki, David Barnhill, Joong Lee, Matthew Healy, Pedram Boghrat, Ethan Brown, Artin Teymourian, Daniel Aharoni, Adian Cheng, Lea Fredrickson, Chi Wai Lam
Post Graduate:	John Jennings, Arun Tripathi, Chris Jillings, Yuri Bonushkin, Mikhail Ignatenko, David Barnhill, Luis Beltran-Parrazal

DAVID B. CLINE

ADDRESS:
Department of Physics & Astronomy,
University of California, Los Angeles
PO Box 951547,
Los Angeles, CA 90095-1547

Phone: (310) 825-4649
Fax: (310) 206-1091
E-mail: dcline@physics.ucla.edu

EDUCATION:

Kansas State University	Physics, B.S., 1959 with High Honors
Kansas State University	Physics, Masters, 1961
University of Wisconsin	Physics, Ph.D. 1965

PROFESSIONAL EXPERIENCE:

Department of Physics & Astronomy, UCLA:	Professor (1986 - present)
Department of Physics, Univ. of Wisconsin:	Professor (1967 - 1986)
	Associate Professor (1966 - 1967)
	Assistant Professor (1965 - 1966)
National Bureau of Standards	Research Physicist (1965-1966)

SELECTED RELEVANT PUBLICATIONS:

1) D. B. Cline, F. Raffaelli, F. Sergiampietri, "LANNDD – A Line of Liquid Argon TPC Detectors Scalable in Mass from 200 Tons to 100 KTons," in JINST 1 T09001, 2006, online at http://www.iop.org/EJ/1748-0221/09/T09001 .
2) D. B. Cline, Direct Search for Dark Matter Particles with Very Large Detectors, in Beyond the Desert 2003, Springer/Proceedings in Physics, Hans-Volker Klapdor-Kleingrothaus, (ed.), 92, 2004.
3) D. B. Cline, J. Learned, K. McDonald, F. Sergiampietri "LANNDD—A Massive Liquid Argon Detector for Proton Decay, Supernova and Solar Neutrino Studies and a Neutrino Factory Detector", Nucl. Instrum. Meth. A 503, 136-140, 2003.
4) D. B. Cline, A. Curioni, A. Lamarina, G. Mannocchi, S. Otwinowski, L. Periale, R. Periale, P. Picchi, F. Pietropaolo, H. Wang and J. Woo, A WIMP detector with two-phase xenon, Astroparticle Physics, Volume 12, Issue 4, 373-377, January 2000.
5) D. B. Cline, "Fundamentals of Liquid-Xenon SUSY-WIMP Detection," in Proceedings of Intl. Workshop on the Identification of Dark Matter (The University of Sheffield, UK, World Scientific, Singapore), Sept. 1996.

OTHER SIGNIFICANT PUBLICATIONS

1) D. B. Cline, E. Fenyves, G. Fuller, B. Mayer, et al., "A New Method for Detection of Distant Supernova Neutrino Bursts," Astrophys. Lett. **27**, 403-409, 1990.
2) D. B. Cline, "Signals of Primordial Black Holes," in Neutrino Telescopes (Proc., Fifth Intl. Workshop, Venice, March 1993), ed. M. Baldo Ceolin (Istituto Veneto di Scienze, Lettere ed Arti, Venice, 1993), pp. 377-385.
3) D. B. Cline and W. Hong, "The Observation of Unusual Gamma Ray Bursts From Primordial Black Hole Evaporation," in Gamma-Ray Bursts (Proc., 2nd Huntsville Symp., Huntsville, AL, Oct. 1993), AIP Conference Proceedings 307, eds. G. J. Fishman, J. J. Brainerd, and K. Hurley (American Institute of Physics, Woodbury, NY, 1994), pp. 557-580.

4) D. B. Cline, "The Supernova Burst Observatory: A Prototype Extra Galactic SN Detector and Supernova Watch," in Sources and Dark Matter in the Universe (Proc., 1st Intl. Symp., Bel Air, CA, Feb. 1994), ed. D. B. Cline (World Scientific, Singapore, 1995), pp. 303-322.
5) D. B. Cline and G. M. Fuller, "Neutrino Astrophysics," in Particle and Nuclear Astrophysics and Cosmology in the Next Millennium" (Proc., 1994 Snowmass Summer Study, Snowmass, CO, June 1994). eds. E. W. Kolb and R. D. Peccei (World Scientific, Singapore 1995), pp. 247-255.

SYNERGISTIC ACTIVITIES:

a) Associate Editor of Nuclear Physics B
b) Developed the Honors Collegium Course (HC 73) for the Elementary Particles and the Universe
c) Initiated the UCLA Center for Advanced Accelerators
d) Former member of HEPAP and former member of scientific program Committees at BNL, Fermilab, Gran Sasso, and SLAC
e) Professor Cline has published more than 300 papers on subjects including Neutrino Physics, W/Z Discovery, Rare K Decays, Dark Matter Search and ICARUS.

COLLABORATORS AND OTHER AFFILIATIONS

Collaborators and Co-Editors: M. Atac (Fermilab/UCLA), P. Chen (Stanford), P. Picchi (CERN), W. Reay (Kansas State University), C. Rubbia (CERN), N. Smith (RAL), P. Smith (RAL/UCLA), N. Spooner (Sheffield University), T. Sumner (Imperial College), J. White (TAMU)

Graduate and Postdoctoral Advisors: William Fry, University of Wisconsin-Madison

Graduate Students Advised: A. Boden (NASA), D. Chrisman (Rutgers), W. Hong (Unknown, Korea), C. Nantista (SLAC), Y. Seo (UCLA), P. Kwok (Stanford), S. Rajagopalan (Anna Univ. India), H. Wang (UCLA), Y. Liu (Stanford), D. Ramachandran (Unknown), C. Ho (Unknown), L. MacDonald (Unknown), M. Zhou (University of Massachusetts), J. Woo (Unknown), M. Cheng (Unknown), J. Rosenzweig (UCLA), J. Wang (BNL)

Postdoctoral Scholars Sponsored: S. Masuda (UCLA), W. Gabella (Vanderbilt), K. Lee (UCLA), H. Wang (UCLA)

Biographical Sketch of Hanguo Wang

Work Address:	Physics and Astronomy Department University of California, Los Angeles PAB 1-707K 430 Portola Plaza, Los Angeles, CA 90095
Telephone:	310-206-3656
Fax:	310-206-1091
E-mail:	WangH@physics.ucla.edu

Education

University of California, Los Angeles,	Physics	Ph.D	1998
University of California, Los Angeles	Physics	M. Sc.	1996
Harbin Institute of Technology, China	Physics	B. Sc.	1982

Employment History

July 2008 – Present	Research Physicist, UCLA
July 2002 – June 2008	Associate Research Physicist, UCLA
Jan. 2000 – June. 2002	Assistant Research Physicist, UCLA
Nov. 1998 – Dec. 1999	Postdoctoral Fellow, UCLA
Sept. 1992 – Oct. 1998	Graduate Student Researcher, UCLA
Jan. 1989 – Aug. 1992	Research Associate, INFN, Frascati, Italy (ICARUS)
May 1986 – Dec. 1989	Research Associate, U.C. Riverside (at CERN, OPAL)
July 1982 – May 1986	Research and Teaching Assistant, H. I. T. China.

Synergistic Activities

A) OPAL Hardon Calorimeter at CERN. The strip readout system production, installation and testing.
B) First 3-ton liquid argon TPC prototype for ICARUS. Purification system, low noise charge readout electronic, wire chamber optimization, Argon purity monitor system.
C) R&D on properties of liquid xenon for dark matter detection. Zeplin II detector design, construction and testing. Funding member of ZEPLIN.
D) Principle Investigator of NSF funds for ZEPLIN II operation and ZEPLIN IV R&D.

Collaborators: M. Atac, D. Cline, P. Picchi, C. Rubbia, B. Shen, NJT Smith, PF Smith, NJC Spooner, N Spooner, TJ Sumner, JT White, And Members from The OPAL experiment at LEP, the ICARUS experiment, members of UKDMC and Member of XENON collaboration.

Thesis: David B Cline (UCLA)
Post Doctoral Adviser: David B Cline (UCLA)
Post doctoral Advised: Yu Chen, Emilija Pantic
Graduate Student Advised: Weichung Ooi, Youngho Seo

Relevant Publications

1. **First limits on WIMP nuclear recoil signals in ZEPLIN-II: A two phase xenon detector for dark matter detection**
   Astroparticle Physics 28 (2007) 287-302
   G. J. Alner et al.,
2. **Limits on spin-dependent WIMP-nucleon cross-sections from the first ZEPLIN II data**
   Physics Letters B 653 (2007) 161–166.
   G. J. Alner et al.,
3. **Scintillation efficiency of nuclear recoil in liquid xenon**
   Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 449, Issues 1-2, 11 July 2000, Pages 147-157
   F. Arneodo, B. Baiboussinov, A. Badertscher, P. Benetti, E. Bernardini, A. Bettini, A. Borio di Tiogliole, R. Brunetti, A. Bueno, E. Calligarich *et al.*
4. **A WIMP detector with two-phase xenon**
   Astroparticle Physics, Volume 12, Issue 4, January 2000, Pages 373-377
   D. Cline, A. Curioni, A. Lamarina, G. Mannocchi, S. Otwinowski, L. Periale, R. Periale, P. Picchi, F. Pietropaolo, H. Wang and J. Woo
5. **Xenon as a detector for dark matter search**
   Physics Reports, Volume 307, Issues 1-4, 1 December 1998, Pages 263-267
   Hanguo Wang

Other Publication

1. **A simple and effective purifier for liquid xenon**
   Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 329, Issues 1-2, 15 May 1993, Pages 361-364
   P. Benetti, A. Bettini, E. Calligarich, F. Casagrande, P. Casoli, C. Castagnoli, P. Cennini, S. Centro, S. Cittolin, D. Cline *et al.*
2. **Detection of energy deposition down to the keV region using liquid xenon scintillation**
   Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 327, Issue 1, 20 March 1993, Pages 203-206
   P. Benetti, E. Calligarich, R. Dolfini, A. Gigli Berzolari, F. Mauri, L. Mazzone, C. Montanari, A. Piazzoli, A. Rappoldi, G. L. Raselli and D. ScannicchioA. Bettini *et al.*
3. **Design, construction and tests of the ICARUS T600 detector**
   Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 527, Issue 3, 21 July 2004, Pages 329-410
   S. Amerio, S. Amoruso, M. Antonello, P. Aprili, M. Armenante, F. Arneodo, A. Badertscher, B. Baiboussinov, M. Baldo Ceolin, G. Battistoni *et al.*
4. **Status of ZEPLIN II and ZEPLIN IV study**
   Nuclear Physics B - Proceedings Supplements, Volume 124, July 2003, Pages 229-232
   D. B. Cline, Y. Seo, F. Sergiampietri, H. Wang, J. T. White, J. Gao, P. Picchi, G. Mannocchi, L. Periale, F. Pietropaolo *et al.*
5. **Simulation results with ZEPLIN II**
   Nuclear Physics B - Proceedings Supplements, Volume 124, July 2003, Pages 221-224
   Y. Seo, H. Wang and D. B. Cline

Biographical Sketch: Professor C. J. Martoff

(a)Professional preparation:

Undergraduate Institution:	Stanford University
	B.A. Physics 1975 (with distinction; Phi Beta Kappa)
Graduate Institution:	University of California at Berkeley
	PhD 1981
Postgraduate Institutions:	(1) University of Zurich, Switzerland
	Medium Energy Physics (1980-2)
	(2) American University, resident group at SLAC
	electron scattering (1982)

(b)Appointments:

Current appointment:	Professor, Department of Physics, Temple University
Career appointments:	1982-1989, Assistant Professor of Physics, Stanford University
	1988-1990, Associate Professor of Physics, Temple University
	1990-present, Professor of Physics, Temple University
	2004-2007, Department Chair, Department of Physics, Temple University
	2008, ORAU Senior Fellow, NASA Goddard Space Flight Center

(c)Selected Publications

1. Limits on Sensitivity of Large Si Bolometers for Solar Neutrino Detection. C.J. Martoff, Science **237**, 507 (1987).

2. Energy Deposition of Energetic Silicon Atoms Within a Silicon Lattice. P. Zecher, D. Wang, J. Rapaport, C.J. Martoff, B. Young. Phys. Rev. **A 41**, 4058 (1990).

3. COSMO–a program to estimate spallation radioactivity produced in a pure substance by exposure to cosmic-radiation on the Earth. C. J. Martoff, P. D. Lewin, Computer Physics Comm. **72**, 96 (1992).

4. Prototype direction-sensitive solid-state detector for dark matter. C. J. Martoff, A. Garzarella, A.; M. Getaneh, E. Kaczanowicz, B. Neuhauser, D. Snowden-Ifft, X. X. Wang, Y. Zhang. Phys. Rev. Lett. **76**, 4882 (1996).

5. Suppressing drift chamber diffusion without magnetic field. C. J. Martoff, D. P. Snowden-Ifft, T. Ohnuki, N. Spooner, M. Lehner Nucl. Inst. Meth. **A440**, 355 (2000).

6. The DRIFT-I dark matter detector at Boulby: design, installation and operation. G.J. Alner, H. Araujo, R. Ayad, A. Bewick, J. Burwell, M.J. Carson, C. Chen, J. Dawson, T. Gamble, M. Garcia, J. Heidecker, A.S. Howard, M. Katz-Hyman, W.G. Jones, J. Kirkpatrick, V.A. Kudryavtsev, T.B. Lawson, V. Lebedenko, M.J. Lehner, J.D. Lewin, P.K. Lightfoot, I. Liubarsky, R. Luscher, J.E. McMillan, C.J. Martoff, B. Morgan, J. Mulholland, G. Nicklin, T. Ohnuki, S.M. Paling, A. Petkov, R.M. Preece, J.J. Quenby, J.W. Roberts, M. Robinson, E. Rykoff, A. Sanders, D.P. Snowden-Ifft, N.J.T. Smith, P.F. Smith, N.J.C. Spooner, T.J. Sumner, D.R. Tovey, N. Villaume and R. Walker Nucl. Inst. Meth. **A535**, 644 (2004).

7. Backgrounds to sensitive experiments underground. J. A. Formaggio, C. J. Martoff, Ann. Rev. Nucl. Part. Sci. **54**, 361 (2004).

8. GEM operation in negative ion drift gas mixtures. J. Miyamoto, I. Shipsey, C. J. Martoff, M. Katz-Hyman, R. Ayad, G. Bonvincini and A. Schreiner. Nucl. Inst. Meth. **A526**, 409 (2004).
9. Negative Ion Drift and Diffusion in a TPC near 1 Bar. C. J. Martoff, R. Ayad, M. Katz-Hyman, G. Bonvincini, A. Schreiner. Nucl. Inst. Meth. **A555**, 55 (2005).
10. A benign, low Z electron capture agent for negative ion TPCs C.J. Martoff, M.P. Dion, M. Hosack, D. Barton and J.K. Black. Nucl. Inst. Meth., 2008 (in press; http://dx.doi.org/10.1016/j.nima.2008.09.042

(d)Synergistic Activities:
1. COSMO Cosmic-Ray Activation program; This program (Comp. Phys. Comm. **72**, 96 (1992) has been used by some of the leading groups in low background work to estimate cosmic ray activation of components.
2. Neutron Camera; In-flight fast neutron capture allows a true Neutron Camera to be constructed. The technique is patented (U.S. Patents 7049603, 7157719) and a prototype camera has been built at Lawrence Livermore National Laboratory.
3. Negative Ion TPC; This technique I invented has been adopted or is under consideration by several NASA-GSFC space experiments using photoelectric polarimetry: Gravitation and Extreme Magnetism SMEX, J. Swank, PI; GRB-Chasing X-ray Polarimeter, J. Hill, PI; and Imaging X-ray Polarimeter for Solar Flares, B. Dennis, PI.
4. Undergraduate Student Supervision; Temple is an urban research university with substantial minority enrollment. I have provided employment and exposure to research for numerous undergraduate students from under-represented groups in connection with NSF funded research. I have also created course materials, taught classes and supervised research for Bridges to the Baccalaureate and Science in the City programs.

(e)Principal collaborators;
Co-Authors for previous 4 years;
Principal: R. Ayad, J. A. Formaggio (MIT), D.P. Snowden-Ifft (Occidental College), N.J.C. Spooner (Sheffield University)
Minor: G. Bonvincini (Wayne State), JE McMillan (Sheffield University), J. Miyamoto, I. Shipsey (Purdue University), R. Schreiner

Graduate & Postdoctoral sponsors;
Professor Kenneth M. Crowe, UCB/LBL (ret.)
Professor P. Truol, Uni. Zurich (ret.)
Professor R. Arnold, American U.

Thesis, etc. advisor (grad students: 6, postdocs 2)
Dr. P. Ambrozewicz (North Carolina A & T), Dr. R. Ayad, Dr. A. Garzarella (Naval Research Lab), Dr. M. Getaneh (Univ. Tennessee Martin), Dr. X. X. Wang, Dr. Y. Zhang

BIOGRAPHICAL SKETCHES

Uwe Gerd Oberlack (Principal Investigator – Rice University)

A. PROFESSIONAL PREPARATION

Ph.D. in Physics ('passed with distinction'), Technical University of Munich, Germany, and Max Planck Institute for Extraterrestrial Physics; (December 1997)
Otto Hahn Medal (1997) by the German Max Planck Society for the Advancement of Science. (Annual national award for the best PhD theses.)
Physics Diploma, Technical University of Munich, Germany (1992)

B. APPOINTMENTS:

Assistant Professor of Physics and Astronomy, and William V. Vietti Junior Chair of Space Physics, Rice University, Houston, TX, 2001-present
Associate Research Scientist, Columbia University, New York, NY, 1999-2001
Postdoctoral Research Scientist, Columbia University, New York, NY, 1998-1999

C. PUBLICATIONS:

5 Most Closely Related Publications:

(1) XENON10 Collaboration, "Limits on spin-dependent WIMP-nucleon cross-sections from the XENON10 experiment," Phys. Rev. Lett. **101**, 091301 (2008).
(2) XENON10 Collaboration, "First Results from the XENON10 Dark Matter Experiment at the Gran Sasso National Laboratory," Phys. Rev. Lett. **100**, 021303 (2008).
(3) E. Aprile et al. "XENON: a 1 tonne Liquid Xenon Experiment for a Sensitive Dark Matter Search", Internatl Workshop on Techniques and Applications of Xenon Detectors (Xenon01), World Scientific (2002), 165-178 (astro-ph/0207670)
(4) E. Aprile, A. Curioni, K.-L. Giboni, M. Kobayashi, K. Ni, U. Oberlack, "A new light readout system for the LXeGRIT time projection chamber", IEEE Trans. Nucl. Sci. 50 (2) (2003) 1303-1308.
(5) U. Oberlack et al. "Performance of the light trigger system in the liquid xenon gamma-ray telescope LXeGRIT", IEEE Trans. Nucl. Sci. 48 (4) (2001) 1041–1047.

5 Other Publications:

(1) A. Pullia, F. Zocca, C. Olsen, P. Shagin, U. Oberlack "A Cold Low Noise Preamplifier for Use in Liquid Xenon" IEEE Nuclear Science Symposium Conf. Rec. 1 (2007) 424-428
(2) G. Weidenspointner, M. Varendorff, U. Oberlack, D. Morris, S. Plüschke, R. Diehl, S. C. Kappadath, M. McConnell, J. Ryan, V. Schönfelder, H. Steinle, "The COMPTEL instrumental line background", A&A 368 (2001) 347–368.
(3) U. G. Oberlack, E. Aprile, A. Curioni, V. Egorov, K.-L. Giboni, "Compton scattering sequence reconstruction algorithm for the liquid xenon gamma-ray imaging telescope (LXeGRIT)", in: R. B. James, R. C. Schirato (Eds.), Hard X-Ray, Gamma-Ray, and Neutron Detector Physics II, Vol. 4141 of Proc. of SPIE, 2000, pp. 168–177, astro-ph/0012296.

(4) U. Oberlack, R. Diehl, J. Knödlseder, K. Bennett, H. Bloemen, W. Hermsen, D. Morris, V. Schönfelder, A. Strong, P. von Ballmoos, C. Winkler, "COMPTEL limits on ^{26}Al 1.809 MeV line emission from γ^2 Velorum", A&A 353 (2000) 715–721.
(5) U. Oberlack, K. Bennett, H. Bloemen, R. Diehl, C. Dupraz, W. Hermsen, J. Knödlseder, D. Morris, V. Schönfelder, A. Strong, C. Winkler, "The COMPTEL 1.809 MeV all-sky image", A&AS 120 (1996) C311–C314.

D. SYNERGISTIC ACTIVITIES

(1) Development of a senior undergraduate and graduate course "Experimental Space Science" at Rice University
(2) Mentoring of 2-3 undergraduate students / year for research experience in experimental physics and astrophysics
(3) Chairman of NSERC (Canada) review committee on the Dark Matter experiment PICASSO in 2007
(4) Annual judge in the Houston Science Fair (K-12)

E. COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators within last 48 months:

Member of collaborations XENON10, XENON100, ACT (Advanced Compton Telescope).

Rice University: Roman Gomez, Yuan Mei, Christopher Olsen, Marc Schumann, Peter Shagin. Brown University: Richard Gaitskell, Simon Fiorucci, Peter Sorensen, Luiz DeViveiros. Columbia University: Elena Aprile, Karl-Ludwig Giboni, Maria Elena Monzani, Kaixuan Ni, Guillaume Plante, Kyungeun Lim, Antonio Melgarejo, Masaki Yamashita. Case Western Reserve University: Tom Shutt, P. Brusov, Eric Dahl, John Kwong, Alexander Bolozdynya. Lawrence Livermore National Laboratory: Adam Bernstein, Norm Madden, Celeste Winant. Yale University: Daniel McKinsey, Alessandro Curioni, Angel Manzur, Kaixuan Ni. University of Zurich, Switzerland: Laura Baudis, Ali Askin, Alfredo Ferella, Alex Kish, Marijke Haffke, Aaron Manalaysay, Roberto Santorelli, Eirini Tziaferi. LNGS: Francesco Arneodo, Serena Fattori. Naval Research Laboratories: J. Kurfess. Radiation Monitoring Devices, Inc.: M. McClish, R. Farrell. University of Coimbra: Jose Matias Lopes, Luis Coelho, Luis Fernandes, Joaquim Santos. University of California Los Angeles (UCLA): Katsushi Arisaka, Hanguo Wang, Ethan Brown, Artin Teymourian. University of Milan: Alberto Pullia, Francesca Zocca. University of Minnesota: P. Cushman. University of New Hampshire: J. Ryan. UC Berkeley: S. Boggs, C. Wunderer, A. Zoglauer. Waseda University: T. Doke, A. Hitachi.

(ii) Own Graduate and Post-doctoral Advisors: Elena Aprile, Columbia University (Post-doc advisor), Volker Schönfelder, Max Planck Institute of Extraterrestrial Physics & Technical University Munich, Germany (Ph.D. thesis advisor), Peter von Ballmoos, Centre d'Etude Spatiale des Rayonnements (CESR) and University Paul Sabatier, Toulouse, France (Diploma thesis)

(iii) Ph.D. students sponsored: (4 students) R. Gomez, Y. Mei, C. Olsen, O. Vargas

(iv) Postdocs sponsored: M. Schumann

BIOGRAPHICAL SKETCHES

Petr Shagin (Research Scientist – Rice University)

A. PROFESSIONAL PREPARATION

Moscow Physical Technical Institute, Russia: Magistr in Physics (July 1982)
Institute for High Energy Physics, Protvino, Russia: Nation Wide Young Scientist Prize (October 1986)
Institute for High Energy Physics, Protvino, Russia: Ph.D. in Physics (December 1990)

B. APPOINTMENTS:

Research Scientist, Department of Physics and Astronomy, Rice University, 2005-present
Research Associate, School of Physics and Astronomy, University of Minnesota, 2001-2005
Visiting Assistant Professor, Research Center for Nuclear Physics, Osaka University, Osaka, Japan 2000-2001
Senior Scientist, Institute for High Energy Physics, Protvino, Russia 1998-2000
Visiting Research Scientist, High Energy Accelerator Research Organization, Tsukuba, Japan 1997
Research Associate, European Organization for Nuclear Research (CERN), Geneva, Switzerland, 1996
Junior Scientist, Institute for High Energy Physics, Protvino, Russia 1982-1995

C. PUBLICATIONS:

5 Most Closely Related Publications:

(1) P. Shagin et al., "Avalanche Photodiode for Liquid Xenon Scintillation:Quantum Efficiency and Gain" accepted by Journal of Instrumentation **JINST_010P_0808**.
(2) J. Angle et al., "Limits on spin-dependent WIMP-nucleon cross-sections from the XENON10 experiment," Phys. Rev. Lett. **101**, 091301 (2008).
(3) J. Angle et al. [XENON Collaboration], "First Results from the XENON10 Dark Matter Experiment at the Gran Sasso National Laboratory," Phys. Rev. Lett. **100**, 021303 (2008).
(4) J. Angle et al. [XENON Collaboration], "3D position sensitive XeTPC for dark matter search," Nucl. Phys. Proc. Suppl. **173**, 117 (2007) [Erratum-ibid. **175-176**, E3 (2008)].
(5) E. Aprile, P. Cushman, K. Ni, P.Shagin, "Detection of Liquid Xenon Scintillation Light with a Silicon Photomultiplier," Nucl. Instr. and Meth. A 556, 215 (2006).

5 Other Publications:

(1) G. W. Bennett *et al.* [Muon (g-2) Collaboration], "Search for Lorentz and CPT Violation Effects in Muon Spin Precession," Phys. Rev. Lett. **100**, 091602 (2008)
(2) G.W. Bennett et al., "Final Report of the Muon E821 Anomalous Magnetic Moment Measurement at BNL," Phys. Rev., D73, 072003 (2006).
(3) P. Shagin et al., "Recent Results of Muon g-2 Collaboration,", eConf C040802: TUT007, (2004).
(4) T. Nakano et al., "Evidence for a Narrow S=+1 Baryon Resonance in Photoproduction from the Neutron," Phys. Rev. Lett., 91, 012002 (2003).

(5) P. Shagin et al., "LEPS Experiment at SPring-8: Detector Status and Preliminary Results," AIP Conf. Proc. 619, 705, (2002).

D. SYNERGISTIC ACTIVITIES

(1) Soviet Nation Wide Young Scientist Award, 1986.

E. COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators within last 48 months:

Columbia University: Elena Aprile, Karl-Ludwig Giboni, Maria Elena Monzani, Guillaume Plante, Roberto Santorelli, Masaki Yamashita

Brown University: Richard Gaitskell, Simon Fiorucci, Peter Sorensen, Luiz DeViveiros

Case Western Reserve University: Tom Shutt, Paul Brusov, Eric Dahl, John Kwong, Alexander Bolozdynya

Lawrence Livermore National Laboratory: Adam Bernstein, Norm Madden, Celeste Winant

Rice University: Uwe Oberlack , Roman Gomez, Chris Olsen, Marc Schumann, Yuan Mei

Yale University: Daniel McKinsey, Richard Hasty, Angel Manzur, Kaixuan Ni

University of Florida/RWTH Aachen, Germany: Laura Baudis, Jesse Angle, Joerg Orboeck, Aaron Manalaysay

LNGS:Francesco Arneodo, Alfredo Ferella

University of Coimbra: Jose Matias Lopes, Luis Coelho, Luis Fernandes, Joaquim Santos

University of Minnesota: Priscilla Cushman, Roger Rusack, Steven Giron, Long Duong, Tao Qian, Brian Sherwood

Boston University: R.M. Carey, J.P. Miller, R.L. Sulak, O. Rind, B.L. Roberts, J. Paley

Brookhaven National Laboratory: G.W. Bennett, G. Bunce, W.M. Morse, C.S. Osben, Y.K. Semertzidis

Cornell University: Y.Orlov

University of Illinois at Urbana-Champaign: P.T. Debevec, F.E. Gray, D.W. Hertzoq, R. McNabb, C.J.G. Onderwater, C.C. Polly

Yale University: H. Deng, S.K. Dhawan, F.J.M. Farley, M. Grosse-Pederkamp, D. Kawall, E.P. Sichtermann

Radiation Monitoring Devices Inc.: Mickel McClish, Richard Farrell, Kanai Shah

(ii) Own Graduate and Post-doctoral Advisors:

Priscilla Cushman, University of Minnesota (Post-doc advisor),

Yuri Prokoshkin, Institute for High Energy Physics, Russia (Ph.D. thesis adviser),

David Kakauridze, Institute for High Energy Physics, Russia (Magistr)

BIOGRAPHICAL SKETCH

Elena Aprile (Principal Investigator – Columbia University)

Columbia Astrophysics Laboratory
550 West 120th Street
New York, NY 10027

A. PROFESSIONAL PREPARATION

University of Naples, Italy: "Laurea" in Physics, cum Laude (July 1978)
University of Geneva, Switzerland: Ph.D. in Physics (November1982)

B. APPOINTMENTS:

Co-Director, Columbia Astrophysics Laboratory, 2003 – present
Professor of Physics, Columbia University, 2001-present
Associate Professor of Physics, Columbia Univeristy, 1991-2001
Assistant Professor of Physics, Columbia University, 1986-1990
Postdoctoral Research Associate, Harvard University, 1983-1985

C. PUBLICATIONS:

5 Most Closely Related Publications:

(1) E. Aprile et al., "Simultaneous Measurement of Ionization and Scintillation from Nuclear Recoils in Liquid Xenon as Target for a Dark Matter Experiment," Phys. Rev. Lett, 97, 081302 (2006).
(2) E. Aprile et al., "Response of Liquid Xenon to Low Energy Nuclear Recoils," Phys. Rev. D, 72, 072006 (2005).
(3) J. Angle et al. "First Results from the XENON10 Dark Matter Experiment at the Gran Sasso National Laboratory" Phys. Rev. Lett. 100, 021303 (2008).
4. J. Angle et al. " Limits on spin-dependent WIMP-nucleon cross sections from the XENON10 experiment" Phys. Rev. Lett. 101, 091301 (2008).
(5) P. Sorensen et al., "Determination of the scintillation and ionization yield of liquid Xe from the XENON10 experiment" accepted in Phys. Rev. D (2008) http://arxiv.org/abs/ 0807.0459

5 Other Publications:

(1) E. Aprile, P. Cushman, K. Ni, P. Shagin, "Detection of Liquid Xenon Scintillation Light with a Silicon Photomultiplier", Nucl. Instr. Meth. A 556 (2006) 215.
(2) K.Ni, E. Aprile, K.L. Giboni, P. Majewski, M. Yamashita, "Gamma Ray Spectroscopy with Scintillation Light in Liquid Xenon", JNIST 1 P09004 (2006).
(3) E. Aprile, K.L. Giboni, P. Majewski, K. Ni, M. Yamashita, "Observation of anticorrelation between scintillation and ionization for MeV gamma rays in liquid xenon", Phys. Rev. B . 76, 014115 (2007).
(4) E. Aprile, A. Curioni, K.L. Giboni,M. Kobayashi, U.G. Oberlack, S.Zhang, "Compton imaging of MeV gamma-rays with the Liquid Xenon Gamma-Ray Imaging Telescope (LXeGRIT)", Nucl. Instr. Meth. A 593 (2008) 414.
(5) E. Aprile, L. Baudis, B. Choi, K. L. Giboni, K. E. Lim, A. Manalaysay, M. E. Monzani, G. Plante, R. Santorelli, M. Yamashita," New Measurement of the Relative Scintillation Efficiency of Xenon Nuclear Recoils Below 10 keV", submitted to Phys. Rev.D (2008) http://arxiv.org/abs/0810.0274

D. SYNERGISTIC ACTIVITIES

(1) Consultant/Reviewer, Department of Energy annual review of High Energy Physics at Fermi National Laboratory, (M. Procario, Chair), May, 2005
(2) Working Group Co-Leader, Dark Matter Working Group, NSF Dusel S1 Solicitation, 2004
(3) Reviewer for NSF, DOE and NASA Proposals 1989-present
(4) Fellow, American Physical Society since 2000.
(5) NSF Career Award, 1991.

E. COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators within last 48 months:

Columbia University: Karl-Ludwig Giboni, Kaixuan Ni, Guillaume Plante, Bin Choi, Kyungjeun Lim, Roberto Santorelli, Masaki Yamashita, Antonio Melgarejo, Tanya Zelevinsky, Gordon Tajiri. *Rice University:* Uwe Oberlack , Marc Schumann, Peter Shagin. *Yale University:* Daniel McKinsey, Angel Manzur. *University of Zurich:* Laura Baudis, Aaron Manalaysay, Alfredo Ferella, Eirini Tziaferi . *LNGS:* Francesco Arneodo. *University of Coimbra:* Jose Matias Lopes, Luis Coelho, Luis Fernandes, Joaquim Santos. *University of Minnesota:* P. Cushman. *Berkeley:* S. Boggs. *Waseda University:* T. Doke, N. Hasebe, S.Suzuki, A. Hitachi. *UCLA:* K. Arisaka, H. Wang, D. Cline. *University of Muenster:* Christian Weinheimer. *KEK:* Tom Harayuma. *NYU:* Neal Weiner.

(ii) Own Graduate and Post-doctoral Advisors: Carlo Rubbia, Harvard University (Post-doc advisor), Roger Hess, Univ. of Generva, Switzerland (Ph.D. thesis advisor), Marco Napolitano, University of Naples, Italy (Laurea)

(iiii) Postdoctoral scientists supervised (within last 5 years): (9 post-docs) M. Yamashita (University of Tokyo); Kaixuan Ni (Columbia); Antonio Melgarejo (Columbia) M.E. Monzani (SLAC), P. Majewski (Sheffield), R.Santorelli (Zurich), Curioni (Yale), S.Kamat (Columbia), B. Singh (Univ. of Varanasi, India). **Ph.D. students sponsored (within last 5 years):** (7 students) Guillaume Plante, Bin Choi, Kyungeun Lim, Kaixuan Ni, Alessandro Curioni, Inna Shpiro, Fang Xu.

Karl-Ludwig Giboni (Columbia University)

Columbia Astrophysics Laboratory at Nevis Labs
136 South Broadway
Irvington-on-Hudson, NY 10533

A. PROFESSIONAL PREPARATION

Technische Hochschule Aachen, Aachen, Germany, 1970-1976, "Diplom Rer. Nat."

Techniche Hochschule Aaachen, Aachen, Germany, 1976-1981, Ph.D. in Physics

Postdoctoral Employment:

Harvard University, Research Associate 1983–1985
Columbia University, Senior Research Scientist, 1996–present
Waseda University, Fellowship for the Promotion of Science, 1995–1996
Schlumberger Ltd., New York, Senior Research Staff 1986–1995

C. PUBLICATIONS:

5 Publications Most Closely Related to Proposed Project:

[1] J. Angle, E. Aprile et al. (XENON Collaboration), "First Results from the XENON10 Dark Matter Experiment at the Gran Sasso National Laboratory", Phys. Rev. Lett. 100, 021303 (2008).
[2] E. Aprile et al., "Simultaneous Measurement of Ionization and Scintillation from Nuclear Recoils in Liquid Xenon as Target for a Dark Matter Experiment," Phys. Rev. Lett, 97, 081302 (2006).
[3] E. Aprile et al., "Response of Liquid Xenon to Low Energy Nuclear Recoils," Phys. Rev. D, 72, 072006 (2005).
[4] K. Ni et al., "Performance of a Large Area Avalanche Photodiode in a Liquid Xenon Ionization and Scintillation Chamber," Nucl. Instr. and Meth. A, 551 (2005) 356.
[5] K.L. Giboni, "A Two Kiloton Liquid Argon Detector for Solar Neutrinos and Proton Decay," Nucl. Instr. and Methods, A225, 579 (1984).

5 Other Publications:

[1] E. Aprile, K.L. Giboni, C. Rubbia; "A Study of Ionization Electrons Drifting Large Distances in Liquid and Solid Argon," Nucl. Instr. and Meth., A241, 62, (1985).
[2] K.L. Giboni, "Limited energy Resolution in Liquid Argon Due to δ-Ray Production," Nucl. Instr. and Methods, A269, (1988).
[3] T.J. Phillips, J. Matthews, E. Aprile, D. Cline, J. Gaidos, K.L. Giboni, G. Kalkanis, R. Loveless, R. March, R. McHenry, A. More, R. Morse, J. Negret, T.R. Palfry, C. Rubbia, G. Sembroski, C. Wilson, D.R. Winn and W. Worstell, "A Search for Nucleon Decay with Multiple Muon Decays," Physics Letters B, 224, Number 3, 348 (1989).
[4] G. Arnison et al. (Aachen - Annecy - Birmingham - CERN - Queen Mary College, London - College de France, Paris - Riverside - Rutherford Appleton Lab - Saclay - Vienna 'UA1'

Collaboration); "Observation of the Muonic Zo Decay at the p p- Collider", Phys. Lett. 147B, 241 (1984).
[5] K.L. Giboni, E. Aprile; "Evaluation of CdTe Detectors with Schottky Contacts for Imaging Applications," Nucl.Instr. and Meth., A416, 319 (1998).

D. SYNERGISTIC ACTIVITIES

(1) Co-organizer of specialized conferences on radiation detectors.
(2) Reviewer for NIM, IEEE, Astroparticle Physics, JINST Journals.
(3) Member of the Program Committee for the SPIE Conference on "Hard X-Ray, Gamma-Ray, and Neutron Detector Physics," S. Diego, 1999 and 2000.

E. COLLABORATORS AND OTHER AFFILIATIONS

(i) Collaborators within last 48 months:

Columbia University: Elena Aprile, Antonio Melgarejo, Maria Elena Monzani, Bin Choi, Kyeungjun Lim, Guillaume Plante, Roberto Santorelli, Gordon Tajiri, Masaki Yamashita, Tanya Zelevinsky. *Rice University:* Uwe Oberlack , Roman Gomez, Peter Shagin. *Yale University:* Daniel McKinsey, Richard Hasty, Angel Manzur, Kaixuan Ni. *University of Florida:* Laura Baudis, Jesse Angle, Joerg Orboeck, Aaron Manalaysay. *LNGS:* Francesco Arneodo, Alfredo Ferella. *University of Coimbra:* Jose Matias Lopes, Luis Coelho, Luis Fernandes, Joaquim Santos. *Waseda University:* T. Doke, S.Suzuki, A. Hitachi. *University of Muenster:* Christian Weinheimer. KEK: Tom Harayama.

(ii) Own Graduate and Post-doctoral Advisors: Carlo Rubbia, Harvard University (Post-doc advisor), Albrecht Bohm (Ph.D. thesis advisor), Helmut Faissner (Diploma thesis advisor)

(iii) Post-doctoral Scientists Supervised: Kaixuan Ni (Columbia), Antonio Melgarejo (Columbia) Alessandro Curioni (Yale), Uwe Oberlack(Rice University),Masanori Kobayashi (Waseda University, Japan)), Pawel Majewski (University of Shefield), Masaki Yamashita (Columbia University), Roberto Santorelli (Columbia University), Bhartendu Singh (University of Varanasi, India)

Biographical Sketch
Gordon Tajiri

Columbia Astrophysics Laboratory
550 West 120th Street
New York, NY 10027

(a) Professional Preparation:

University of Illinois - Chicago
Thermo-Mechanical Engineering (Heat Transfer and Thermodynamics)
Bachelor of Science in Engineering, June 1983

University of Illinois – Chicago
Mechanical Engineering (Numerical Multi-body Dynamics Analysis)
Master of Science in Engineering, December 1995

University of Illinois – Chicago
Mechanical Engineering (Cryogenic X-ray Optics and Finite Element Analysis)
Doctor of Philosophy in Mechanical Engineering, June 2001

(b) Appointments:

07/2004 – Present	Senior Staff Research Engineer Columbia Astrophysics Laboratory, Columbia University
10/2003 - 07/2004	Senior Mechanical FEA Analyst Moog Aerospace Inc., Systems Group
04/2003 – 10/2003	Senior Mechanical Engineer Eaton Aerospace Corporation
11/2000 – 01/2003	Lead Opto-mechanical Physical Design Engineer Lucent Technologies, Microelectronics Division
11/2000 – 01/2003	Thermal Mechanical Research Engineer Argonne National Laboratory, Advanced Photon Source
07/1989 – 03/1998	Senior Staff Mechanical Engineer Motorola Inc.

(c) Publications:

Five most closely related publications to this project:

Tajiri, G. C., Lee, W-K., Fernandez, P., Mills, D., Assoufid, L.: Cryogenically Cooled Monochromator Thermal Distortion Prediction-Using the Finite Element Analysis Method. Synchrotron Radiation Instrumentation 11th Conference Proceeding. pp. 299-303, 1999.

Tajiri, G. C., Lee, W.-K., Fernandez, P., Mills, D., Assoufid, L., Amirouche, F.: Nonlinear, Thermal-Distortion Predictions of a Silicon Monochromator Using the Finite Element Method. J. Synchroton Rad. Vol. 8, pp. 1140-1148, 2001.

Assoufid, L., Mills, D., Macrander, A., Tajiri, G.: Is colder better? - Exploring the feasibility of liquid-helium-cooled optics. SPIE Proceeding, High-Heat Flux Engineering. Vol. 3773, pp. 39-48, 1999.

Fernandez, P. B., Lee, W.-K., Mills, D. M., Tajiri, G., and Assoufid, L.: Double-undulator tests of a diamond monochromator at the Advanced Photon Source. Nuclear Instruments and Methods in Physics Research Section A: Accelerators,Spectrometers,Detectors and Associated Equipment, Volume 459, Issues 1-2, 21 February 2001, Pages 347-353

Lee, W.-K., Fezzaa, K., Fernandez, P., Tajiri, G.: Performance limits of indirectly cryogenically cooled silicon monochromators – experimental results at the APS. J. Synchrotron Rad. Vol. 8, pp. 22-25, 2001.

Five other significant publications:

Tajiri, G., Khounsary, A., Mancini, D.: A Simple and Effective Modification of a Sagittally Focusing X-ray Diffraction Optic. SPIE Proceeding, Vol. 4145, pp. 114-121, 2001.

Tajiri, G. C., Lee, W.-K., Fernandez, P., Mills, D., Assoufid, L., Amirouche, F.: Nonlinear, Thermal-Distortion Predictions of a Silicon Monochromator Using the Finite Element Method. J. Synchroton Rad. Vol. 8, pp. 1140-1148, 2001.

Sarah E. Tuttle; David Schiminovich; Bruno Milliard; Robert Grange; D. Christopher Martin; Shahinur Rahman; Jean-Michel Deharveng; Ryan McLean; Gordon Tajiri; M. Matuszewski: The FIREBall fiber-fed UV spectrograph. SPIE Proceeding, Ground-based and Airborne Instrumentation for Astronomy II. Vol. 7014, 9 July 2008

Jason E. Koglin; Finn E. Christensen; William W. Craig; Todd R. Decker; Charles J. Hailey; Fiona A. Harrison; Colin Hawthorn; Carsten P. Jensen; Kristin K. Madsen; Marcela Stern; Gordon Tajiri; Michael D. Taylor: NuSTAR Hard X-ray Optics. SPIE Proceeding, Optics for EUV, X-Ray, and Gamma-Ray Astronomy II. Vol. 5900, 24 August 2005

Jason E. Koglin, Wayne H. Baumgartner, C.M. Hubert Chen, James C. Chonko, Finn E. Christensen, William W. Craig, Todd R. Decker, Charles J. Hailey, Fiona A. Harrison, Carsten P. Jensen, Kristin K. Madsen, Michael J. Pivovaroff, and Gordon Tajiri: Calibration of HEFT hard X-ray optics, Proceedings of "The X-ray Universe 2005", p. 955-960, January 2006.

(d) Synergistic Activities

At Lucent Technologies, I developed a parametric finite element and numerical analysis modeling tool that combined the governing equations for heat transfer and Seebeck effect of a thermo-electric cooler with the non-linear thermal-structural response of a composite laminate structure to determine the pointing error of an actively cooled semiconductor laser. This was a cost and time saving numerical analysis tool that allowed efficient parametric studies of various composite material laminates, thermo-electric coolers, and thermal heat flux loads on laser coupling efficiency.

On the NuSTAR X-ray telescope satellite project, I collaborated with another research scientist in the development of a finite element and Monte Carlo ray trace based predictive analysis tool to determine effect of thermally induced sub-micron level surface distortions on the throughput at the telescope's detectors.

On the NuSTAR project, I collaborated with other research scientists and students to design, fabricate, and successfully implement a cost-effective, custom laser scanning system that accurately measures surface errors of the NuSTAR cylindrical optical elements/shells to a resolution of about 1 arcsec and repeatability of about 4-5 arcsec.

(e) Collaborators and Other Affilications:

Collaborators: Elena Aprile (Columbia), Lahsen Assoufid (Argonne Nat. Lab) Karl Giboni (Columbia). Charles Hailey (Columbia) , Patricia Fernandez (Argonne Nat. Lab), Fiona Harrison (Caltech), Ali Khounsary (Argonne Nat. Lab), Jason Koglin (Columbia), W-K Lee (Argonne Nat. Lab), Christopher Martin (Caltech), Kaya Mori (Columbia) David Shiminovich (Columbia),

Gradiate advosprs and sponsores: University of Illinois – Chicago: Farid Amirouche (Ph.D. advisor)

Thesis advisor and Postgraduate Scholar Sponsor: None.

Biographical Sketch
Tom Haruyama

Physics Division, Institute of Particle and Nuclear Studies
KEK, High Energy Accelerator Research Organization
1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan

(a) Professional Preparation

1988 Ph.D. (Doctor of Engineering), Keio University

(b) Appointments

2003-present: Professor (permanent position), Institute of Particle and Nuclear Studies
High Energy Accelerator Research Organization
Professor (co-position), Graduate University for General Studies

1998-2003: Associate Professor (permanent position), Physics Department
High Energy Physics Laboratory
Associate Professor (co-position), Graduate University for General Studies

(c) Publicaions

Five publications most closely related:

-**T. Haruyama**, "Boiling heat transfer characteristics of liquid xenon", *Advances in Cryogenic Engineering*, Vol. 47(2002) 1499-1506

-**T. Haruyama**, et al., "High-Power Pulse Tube Cryocooler for Liquid Xenon Particle Detectors", *Cryocoolers* 13 (2004) 689-694

-**T. Hauyama**, "Progress of xenon liquefaction technology by using a pulse tube cryocooler" Presented at *International Conference on Dielectric Liquid (ICDL 2005)* (2005), E-30 Coimbra, Portugal

-**T. Hauyama**, "Application of pulse tube cryocoolers to liquid xenon detectors" *XeSAT2005-Application of Rare Gas Xenon to Science and Technology (2005),* 163-166 Waseda University, JAPAN

-**T. Haruyama**, et al., "LN_2-Free Operation of the Meg Liquid Xenon Calorimeter by using a High-Power Pulse Tube Cryocooler", *Advances in Cryogenic Engineering*, Vol. 51(2006) 1695-1702

Five other significant publications:

-**T. Haruyama**, et.al., "Performance of vibration-free pulse tube cryocooler system for a gravitational wave detector", *Proceedings of International Cryogenic Engineering Conference (ICEC20)*(2006) 281-284

-S. Mihara, **T. Haruyama**, et.al., "Development of a method for liquid xenon purification using a cryogenic centrifugal pump", *Cryogenics* 46(2006) 688-693

-**T. Haruyama**, et.al., "Cooling operation of vibration-free pulse tube cryocooler system for the gravitational wave detector in the Kamioka mine", *Proceedings of International Cryogenic Engineering Conference (ICEC21)*(2006) 525-528

-**T. Haruyama**, "Cryogenic technology development for the MEG liquid xenon calorimeter ", *9th International Workshop on Nutrino Factories, Superbeams, and Betabeams-NuFact07* (2008) 366-368

-**T. Haruyama**, et al., "Performance of a Liquid Xenon Calorimeter Cryogenic System for the MEG Experiment", *Advances in Cryogenic Engineering*, Vol. 53(2008) 1193-1200

(d) Synergistic Activities

1. Editor of *Cryogenics* (International academic journal for low temperature physics) 1997-present

2. Chairman of the International Cryogenic Engineering Committee (ICEC) 2008-present

3. Executive Director of Cryogenic Association of Japan 2006-present

(e) Collaborators & Other Affiliations

(1) Collaborators and Co-Editors.

KEK: S. Mihara, A. Maki, T. Tauchi, K. Kasami, H. Nishiguchi, T. Suzuki. *PSI:* S. Ritt, P. Kettle. *ICEPP-University of Tokyo:* T. Mori, W. Otani, T. Iwamoto, R. Sawada. *ICRR-University of Tokyo:* K. Kuroda, M. Ohashi, T. Uchiyama, S. Miyoki, S. Moriyama, H. Ogawa, M. Yamashita, *Nantes University:* D. Thers, E. Morteau, N. Servagant. *Columbia University:* E. Aprile, K. Giboni, *CERN:* F. Haug. *Yokohama National University:* S. Nakamura

(2) Graduate Advisors and Postdoctoral Sponsors. S. Mori (Keio University), H. Hirabayashi (KEK), T. Ohmori (Teikyo University), Y. Ikushima (Sumitomo Heavy Ind.) (Ph. D. thesis advisor)

(3) Thesis Advisor and Postgraduate-Scholar Sponsor. Y. Fukuda, Y. Hashimoto, K. Tomita (Yokohama National University), K. Shiratori (Tohoku University) , D. Kaneko (University of Tokyo) (Master Thesis advisor)

Andrew Alton
Department of Physics, Augustana College, Sioux Falls**,** 57197
alton@augie.edu

Education and Training
BS 1992, University of Iowa, Physics
MS 1996, Ball State University, Physics
PhD: 2000: Thesis Advisor: Professor Tim Bolton at Kansas State University
Post-Doctoral: 2000-2006: University of Michigan: Advisor: Jianming Qian, University of Michigan.

Closely Related Publications:
V.M. Abazov et al., "Search for squarks and gluinos in events with jets and missing transverse energy using 2.1 fb-1 of p anti-p collision data at s**(1/2) = 1.96- TeV**.",** Phys. Lett. B660 (2008).
S. Avvakumov et al., "A Search for Muon-Neutrino →Electron-Neutrino and Muon-Anti-Neutrino→Electron-Anti-Neutrino Oscillations at NuTeV", Phys. Rev. Lett. 89 (2002).
J. A. Formaggio et al., "Search for the Lepton Number Violating Process Anti-Neutrino (Muon) E→ Muon-Anit-Neutrino(E)", Phys. Rev. Lett. 87 (2001).

Selected Publications:
V. M. Abazov et al., "Search for narrow resonance in Zg events gathered by DØ at √s =1.96-TeV", Phys. Lett. B641:415-422 (2006).
V. M. Abazov et al., "Measurement of the p-AntiP -> Wg + X cross section at √s =1.96-TeV and Wgg anomalous coupling limits", Phys. Rev. D71, 091108 (2005).
V. M. Abazov et al., "Limits on anomalous ZZg and Zgg production based on Zg events gathered at √s =1.96-TeV", Phys. Rev. Lett. 95, 051802 (2005).
A. Alton, et al., "Observation of neutral current charm production in nmFe scattering at the Fermilab Tevatron", Phys. Rev. D64 (2001).
A. Alton, et al., "Search for light-to-heavy quark flavor changing neutral currents in nmN and nmN scattering at the Fermilab Tevatron", Phys. Rev. D63 (2000).

Collaborators
NuTeV Collaboration: Todd Adams (Florida State University), Sergey Avvakumov (University of Rochester), Lucele de Barbaro (Northwestern University), Pavel de Barbaro (University or Rochester), Robert Bernstein (Fermi National Accelerator Laborator), Arie Bodek (University of Rochester), Timothy Bolton (Kansas State University), Steve Boyd(University of Pittsburg), Jim Brau (University of Oregon), David Buckholz (Northwestern University), Howard Budd (University of Rochester), Len Bugel (Fermi National Accelerator Laboratory), Janet Conrad (Columbia University), Robert Drucker (University of Oregon), Bonnie Fleming (Columbia University), Joseph Formaggio (Columbia University), Ray Frey (University of Oregon), Jesse Goldman (Kansas State University), Maxi Goncharov (Kansas State University), Debbie Harris (Fermi National Accelerator Laboratory), Randy Johnson (University of Cincinnati), John Kim (Columbia University), Sally Koutsoliotas (Columbia University),

Mike Lamm (Fermi National Accelerator Laboratory), William March (Fermi National Accelerator Laboratory), David Mason (University of Oregon), James McDonald (University of Pittsburg), Kevin McFarland (University of Rochester), Cindy McNulty (Columbia University), Donna Naples (University of Pittsburg), Paul Nienaber (Fermi National Accelerator Laboratory), Vocca Radescu (University of Pittsburg), Alex Romosan (Columbia University), William Sakumoto (University of Rochester), Heidi Schellman (Northwestern University), Michael Shaevitz (Columbia University), Paeniotis Spentzouris (Columbia University), Eric Stern (Columbia University), Narumon Suwonjandee (University of Cincinnati), N. Tobien (Fermi National Accelerator Laboratory), Artur Vaitaitis (Columbia University), M. Vakili (Columbia University), Unkee Yang (University of Rochester), Jae Yu (Fermi National Accelerator Laboratory), Gerilyn Zeller (Northwestern University), Eric Zimmerman (Columbia University).

D0 Collaboration:

See http://www-d0.fnal.gov/author/authorlist/run2/d0_author_list_r2.pdf

Andrea Pietro Pocar
Department of Physics, 418 Lederle Graduate Research Center
710 North Pleasant Street, University of Massachusetts, Amherst, MA 01003, USA

Research interests

Experimental Nuclear and Particle Physics, with emphasis on Neutrino Physics:

- neutrino-less double beta decay
- solar neutrinos
- direct particle dark matter search

Professional preparation

Università degli Studi di Milano (Milan State University), Milan, Italy	Laurea (1996)
Princeton University, Princeton, NJ, USA	Ph. D. (2003)

Appointments

2009-	Assistant Professor of Physics, University of Massachusetts, Amherst
2004-2008	Research Associate of Physics, Stanford University
2003-2004	Research Associate of Physics, Princeton University

Professional affiliations

- American Physical Society
- Società Italiana di Fisica (Italian Physical Society) (1994-1998)

Selected publications

1. "*A liquid xenon ionization chamber in an all-fluoropolymer vessel*", EXO collaboration, F. LePort, A. Pocar et al., Nucl. Instr. Meth. A **578**, 409 (2007).
2. "*Systematic study of trace radioactive impurities in candidate construction materials for EXO*", EXO collaboration, D. Leonard et al. Nucl. Instr. Meth. A **591**,490 (2008).
3. "*Observation of single collisionally cooled trapped ions in a buffer gas*", EXO collaboration, M. Green et al., Phys. Rev. A **76**, 023404 (2007).
4. *"A microfabricated sensor for thin dielectric layers*", P. Fierlinger et al., Rev. Sci. Instr. **79**, 045101 (2008).
5. "*A linear RFQ ion trap for the Enriched Xenon Observatory*", EXO collaboration, B. Flatt et al., Nucl. Instr. Meth. A **578**, 399 (2007).
6. *"Direct Measurement of the 7 Be Solar Neutrino Flux with 192 Days of Borexino Data",* Borexino collaboration, C. Arpesella et al., Phys. Rev. Lett. **101**, 091302 (2008).
7. "*First real time detection of ^{7}Be solar neutrinos by Borexino*", Borexino collaboration, C. Arpesella et al., Phys. Lett. B **658**, 101 (2008).
8. "*Cosmogenic ^{11}C production and sensitivity of organic scintillator detectors to pep and CNO neutrinos*", C. Galbiati, A. Pocar, D. Franco, A. Ianni, L. Cadonati, and S. Schönert,, Phys. Rev. C **71**, 055805 (2005).
9. "*The nylon scintillator containment vessel for the Borexino solar neutrino experiment*", J. Benziger et al., Nucl. Instr. Meth. A **582**, 509 (2007).
10. *"Discovery of underground argon with low level of radioactive ^{39}Ar and possible applications to WIMP dark matter detectors*", D. Acosta-Kane et al., Nucl. Instr. Meth. A **587**, 46 (2008).

Synergistic activities

- Lecturer and founding member of the Gran Sasso - Princeton Physics Summer School, 2004-05.

Collaborators and other affiliations

- **Collaboration Member**: EXO, Borexino, GLAST (1997-98), ATLAS (1995-96)
- **Collaborators**: M. Baldo Coelin (Padova), A. Bazarko (Schlumberger Princeton), G. Bellini (Milano), J. Benziger (Princeton), S. Bonetti (Mialano), M. Breidenbach (SLAC), B. Caccianiga (Milano), L. Cadonati (UMass), F. Calaprice (Princeton), E. Calligarich (Pavia), F. Cavanna (L'Aquila), M. Chen (Queen's), P. Collon (Notre Dame), M. Danilov (ITEP Moscow), A. de Bellefon (College de France), H. de Kerret (College de France), A. Derbin (St. Petersburg), R. DeVoe (Stanford), A. Etenko (Kurchatov Moscow), W. Fairbank (Colorado State), J. Farine (Laurentian), P. Fierlinger (TU München), R. Ford (SNOlab), C. Galbiati (Princeton), F. Gatti (Genova), G. Gratta (Stanford), C. Hagner (Hamburg), C. Hall (Maryland), W. Hampel (Heidelberg), G. Heusser (Heidelberg), A. Ianni (LNGS), J. Kiko (Heidelberg), T. Kirsten (Heidelberg), D. Kryn (College de France), K. Kumar (UMass), M. Laubenstein (LNGS), H. Loosli (Bern), G. Manuzio (Genova), S. Malvezzi (Milano), J. Maneira (Lisboa), F. Masetti (Perugia), U. Mazzucato (Perugia), D. McKinsey (Yale), E. Meroni (Milano), M. Moe (Irvine), C. Montanari (Pavia), A. Odian (SLAC), L. Oberauer (TU München), O. Palamara (LNGS), M. Pallavicini (Genova), L. Perasso (Genova), A. Piepke (Alabama), F. Pietropaolo (Padova), C. Prescott (SLAC), R. Purtschert (Bern), R. Raghavan (Virginia Tech), G. Ranucci (Milano), W. Rau (Queen's), E. Resconi (Heidelberg), P. Rowson (SLAC), C. Rubbia (LNGS), C. Salvo (LNGS), S. Scönert (Heidelberg), T. Shutt (Case Western), D. Sinclair (Carleton), O. Smirnov (Dubna), A. Sonnenschein (Fermilab), G. Testera (Genova), D. Vignaud (College de France), F. von Feilitsch (TU München), J.-L. Vuilleumier, P. Vogel (Caltech), R.B. Vogelaar (Virginia Tech), U. Wichoski (Laurentian), M. Wojcik (Krakow), O. Zaimidoroga (Dubna)
- **Graduate Advisors and Postdoctoral Sponsors**: Graduate advisor, F. Calaprice (Princeton); Principal Postdoctoral sponsors, F. Calaprice (Princeton), G. Gratta (Stanford)
- **Graduate students advised and postdoctoral scholars sponsored**: none

Micheal H. Zehfus

Education

A.B. 1976 Ripon College, Ripon, WI
M.S. 1977 University of Chicago, Chicago, IL
Ph.D. 1983 Oregon State University, Corvallis, OR

Professional Experience

1983-1987 Postdoctoral Researcher, Hershey Medical Center, Penn State University, Hershey, PA
1987-1990 Postdoctoral Researcher, University of Wisconsin, Madison, WI
1990-1997 Assistant Professor, Division of Medicinal Chemistry, College of Pharmacy, The Ohio State University, Columbus, OH
1997-1998 Visiting Assistant Professor, Chemistry Department, Ohio Northern University, Ada, OH
1998-2002 Assistant Professor, Science Department, Black Hills State University, Spearfish, SD
2002-2008 Associate Professor, Science Department, Black Hills State University, Spearfish, SD
2008- Professor, Science Department, Black Hills State University, Spearfish, SD

Publications

(Bold indicates undergraduate researchers)

Bergmann, D., Zehfus, M., **Zierer, L.**, and Gabel, M. Grass rhizoseaths, associated bacterial communities, and potential for Nitrogen Fixation. Western North American Naturalist – Accepted (2008)

Jones, T., S. Kulseth, M. Zehfus, **P. Brown**, and D. H. Siemens. Simultaneous evolution of competitiveness and defense: induced switching in *Arabis drummondii*. Plant Ecology 184(2), 245-257 (2006).

Barnes, M. E., M. H. Zehfus, **J. A. Schumacher, K. S. Stock, F. Farrohki, R. L. Nutter**, & Hanten, R. P. Maternal Liver and Egg Thiamine Concentrations in Lake Oahe, South Dakota, Fall Chinook Salmon. The Prairie Naturalist 35(3), 113-116 (2003).

M. H. Zehfus, Identification of compact, hydrophobically stabilized modules and domains containing one or more peptide chains. Protein Science 6, 1210-1219 (1997).

M. H. Zehfus, M. D. Reily, E. L. Ulrich, W. M. Westler, and J. L. Markley, ^{1}H, ^{13}C, and ^{15}N Resonance Assignments for a Ferrocytochrome c_{553} Heme by Multinuclear NMR Spectroscopy. Archives of Biochemistry and Biophysics 276, 369-373 (1990).

Students - Ph.D. Thesis advisor

Chi-Fon Chang, Postdoctoral fellow, Institute of Biomedical Sciences, AcademiaSinica, Taipei, Taiwan

M. W. Maciejewski, Postdoctoral Researcher, University of Connecticut Health Sciences Center , Storrs, CT

Students - Supervised within past 48 months

Jessica Partridge - Black Hills State University

Advisors

Ph.D.

W.C. Johnson, Oregon State University, Corvallis, OR

Postdoctoral

George Rose, Johns Hopkins University, Baltimore MD

John Markley, University of Wisconsin, Madison WI

Dan J. Durben
Physics, Black Hills State University

(a) Professional Preparation

Eastern Kentucky University	B.S. Chemistry	1982
Arizona State University	Ph.D. Chemistry	1993

(b) Appointments

1993 - Present	Associate Professor, Physics Black Hills State University, Spearfish, SD
1997 - 2000	Head Coach, USA Olympic Rifle Team USA Shooting, Colorado Springs, CO
1990 – 1993	Shell Research Fellow, Chemistry Department Arizona State University, Tempe, AZ
1989 – 1992	Teaching Assistant, Chemistry Department Arizona State University, Tempe, AZ
1984 – 1988	Laboratory Assistant, Sport Science and Technology Program, Biomechanics US Olympic Committee, Colorado Springs, CO
1982 – 1984	Teaching Assistant, Chemistry and Athletic Departments West Virginia University, Morgantown, WV
1982	Teaching Assistant, Chemistry Department Eastern Kentucky University, Richmond, KY

(c) Publications

Durben, D.J., P.F McMillan and G.H. Wolf (1993) Raman study of the high pressure behavior of forsterite (Mg_2SiO_4) crystal and glass. *American Mineralogist*, **78**, 1143-1148.

Durben, D.J. and G.H. Wolf (1992) High temperature behavior of metastable $MgSiO_3$ perovskite: a Raman spectroscopic study. *American Mineralogist*, **77**, 890-893.

Durben, D.J., G.H. Wolf and P.F. McMillan (1991) Raman scattering study of the high temperature vibrational properties and stability of $CaGeO_3$ perovskite. *Physics and Chemistry of Minerals*, **18**, 215-223.

Durben, D.J. and G.H. Wolf (1991) Raman spectroscopic study of the pressure-induced coordination change in GeO_2 glass. *Physical Review B*, **43**, 2355-2363.

Wolf, G.H., S. Wang, C.A. Herbst, D.J. Durben, W.F. Oliver, Z.C. Kang and K. Halverson (1992) Pressure induced collapse of the tetrahedral framework in crystalline and amorphous GeO_2. In *High pressure research in mineral physics*, edited by M. Manghnani and Y. Syono, American Geophysical Union, Washington, DC, pp. 503-517.

Zheng, Q., D.J. Durben, G.H. Wolf and C.A. Angell (1991) Liquids at large negative pressures: water at the homogeneous nucleation limit. *Science*, **254**, 829-832.

Green, J.L., D.J. Durben, G.H. Wolf and C.A. Angell (1990) Water solutions at negative pressure: Raman spectroscopic study to –80 megapascals. *Science*, **249**, 649-652.

Wolf, G.H., D.J. Durben and P.F. McMillan (1990) High pressure Raman spectroscopic study of sodium tetrasilicate ($Na_2Si_4O_9$) glass. *Journal of Chemistry and Physics*, **93**, 2280-2288.
Kellogg, S.D., Durben, D. and Ayars-Junek, S. (2004) Critical factors for success in an introductory astronomy class. ASEE/IEE Frontiers in Education 34: T1F3-8.

Barnes, M.E., D.J. Durben, S.G. Reeves, and R. Sanders (2006) Dietary Yeast Culture Supplementation Improves Initial Rearing of McConaughy Strain Rainbow Trout. Aquaculture Nutrition 12: 388-394.

(d) Synergistic Activities

a. Teaching undergraduate physics full time. Includes development of curriculum and pedagogical methods for all undergraduate lecture and lab courses, and development and mentoring of undergraduate research.
b. Research in astronomy education, studying critical factors for student success. Included the Effectiveness of Technology in Astronomy Classes Project, incorporating into the classroom the remote operation of the MIT Haystack radio telescope and Badlands Observatory telescope, computer interfacing of lab telescopes and NASA mission data, and assessing the effectiveness of web-based learning aids in these classes.
c. Worked with Paul Wildenhain, University of Pennsylvania in the neutrino lab at the 4850 ft level of the Homestake Mine just before it was shut down.
d. Scientific Knowledge for Indian Learning and Leadership (SKILL) Astronomy Workshop Presenter.
e. Member of the South Dakota Discipline Council in Physics.

(e) Collaborators and Other Affiliations

Collaborators

Barnes, Michael E.	South Dakota Game, Fish and Parks
Berger, Tracy J.	Biology, Black Hills State University
Dolan, Daniel	Mechanical Engineering, South Dakota School of Mines and Technology
Fletcher, Brian	South Dakota Game, Fish and Parks
Gabel, Audrey C.	Biology, Black Hills State University
Hawkins, Richard	Warnborough University
Hightower, Tim R.	Chemistry, Black Hills State University
Junek, Shauna	Black Hills State University & South Dakota School of Mines and Technology
Kellogg, Stuart D.	Industrial Engineering, South Dakota School of Mines and Technology
Reeves, Stuart G.	Diamond V Yeast
Simpson, Greg	South Dakota Game, Fish and Parks
Wood, Sommer	Civilian Marksmanship Program

Graduate Advisor

Wolf, George H.	Physical Chemistry, Arizona State University

Thesis Advisor and Postgraduate-Scholar Sponsor

Hawkins, Richard	Warnborough University
Junek, Shauna	South Dakota School of Mines and Technology
Steffes, Alexia	Black Hills State University

BIOGRAPHICAL SKETCH – KARA J. KEETER

Professional Preparation

Ph.D., Physics	1990	Duke University
M.A., Physics	1986	Duke University
B.S., Physics	1984	Tennessee Technological University

Appointments

2008 – present	Visiting Assistant Professor, Black Hills State University
2002 – present	Associate Professor of Physics, Idaho State University
1997 – 2002	Assistant Professor of Physics, Idaho State University
1995 – 1997	Research Assistant, University of Saskatchewan, Saskatchewan, Accelerator Laboratory
1993 – 1995	Post Doctoral Fellow, University of Saskatchewan, Saskatchewan Accelerator Laboratory
1990 – 1992	Post Doctoral Research Associate, University of Virginia

Selected Publications

"An Independent Measurement of the Total Active ^{8}B Solar Neutrino Flux Using and Array of ^{3}He Proportional Counters at the Sudbury Neutrino Observatory", The SNO Collaboration (B. Aharmim *et al.*, including K. J. Keeter), *arXiv:0806.0989v1 [nucl-ex]*, June 2008; *Physical Review Letters* **101**, 111301 (2008).

"First evidence for spin-flip *M*1 strength in ^{40}Ar", T.C. Li, N. Pietralla, A.P. Tonchev, M. Ahmed, T. Ahn, C. Angell, M. Blackston, A. Costin, K. J. Keeter, J. Li, A. Lisetskiy, Y. Parpottas, B. Perdue, I.V. Pinayev, G. Rainovski1 , W. Tornow, H.R. Weller, Y.K. Wu, *Physical Review C* **73**, 054306 (2006).

"Energy Dependence of the Astrophysical S Factor for the ^{6}Li(p,γ)^{7}Be reaction", R. M. Prior, M. C. Spraker, A. M. Amthor, K. J. Keeter, S. O. Nelson, A. L. Sabourov, K. Sabourov, A. P. Tonchev, M. W. Ahmed, J. H. Kelley, D. R. Tilley, H. R. Weller and H. M. Hofmann, *Physical Review C* **70**, 055801 (2004).

"Two-deuteron photodisintegration of ^{4}He at E_{γ} = 150-250 MeV", B. J. Rice, R. S. Canon, E. A. Wulf, H. R. Weller, K. Keeter, N. R. Kolb, C. Mueller, R. E. Pywell, G. A. Retzlaff, D. M. Skopik, G. Feldman, *Physical Review C* **61**, 064612 (2000).

"Differential cross sections for pion charge exchange on the proton at 27.5 MeV", E. Frlez, D. Pocanic, K. A. Assamagan, J. P. Chen, K. J. Keeter, R.M. Marshall, R. C. Minehart, L. C. Smith, G. E. Dodge, S. S. Hanna, B. H. King, J. N. Knudson, *Physical Review C* **57**, 3144 (1998).

"Measurement of the ^{1}H(γ,π^{+}) cross section near threshold", J. C. Bergstrom, J. M. Vogt, R. Igarashi, K. J. Keeter, E. L. Hallin, G. A. Retzlaff, D. M. Skopik, E. C. Booth, *Physical Review C* **53**, R1052 (1996).

Synergistic Activities

- Organized 1st International Double Beta Decay Workshop which resulted in formation of ^{150}Nd Consortium
- Leadership role in SNO+ material selections:
  - Rope studies: acquisition and testing of rope samples.
  - Developing and testing sample preparation techniques and procedures for ultra-low background AMS testing; close collaboration with INL and personnel at the testing facility at Notre Dame:

- Optical properties measurements of linear alkylbenzene ("LAB", the liquid scintillator for SNO+):
- Major contributor to the SNO distributed-source radon spike in August 2006, including optimizing extraction and injection methods, extracting radon from lab air, counting the source strength, injecting into the water system, monitoring the distribution over the next few hours and measuring the activity for the next two weeks, analysis of NCD data, radon spike data.

Collaborators and Other Affiliations

- Sudbury Neutrino Observatory (SNO) Collaboration since 2005.
- SNO+ Collaboration
- DArTPC Collaboration
- MAJORANA Collaboration
- Idaho National Laboratory: John Baker
- Idaho State University: Eddie Tatar
- CUNY: Jim Popp
- Notre Dame: Philippe Collon
- Triangle Universities Nuclear Laboratory (TUNL) and High-Intensity Gamma-ray Source (HIγS) at Duke University: Radiative Capture Group
- Graduate and Postdoctoral Advisors:
  - Ph.D. Advisor: Edward G. Bilpuch, Duke University and TUNL
  - Postdoctoral Advisors: Dinko Pocanic (University of Virginia), J. C. Bergstrom (University of Saskatchewan/Saskatchewan Accelerator Lab)
- Graduate Students:
  - Rubi Gul, ISU/BNL (Co-supervisor)
  - Chuck Taylor, ISU/SNOLAB
  - Daniel Robertson, Notre Dame (Supervised by Philippe Collon; collaborated on AMS measurements for SNO+)

Biographical Sketch for Jocelyn Monroe

Personal

Jocelyn Monroe
Building 26-561
77 Massachusetts Avenue
Cambridge, MA 02139
jmonroe@mit.edu
617-253-2332

Education and Training

Columbia University
Ph.D. (Physics) 2006 (Experimental High Energy Particle Physics)
M.A., M.Phil (Physics) 2002 (Experimental High Energy Particle Physics)
B.A., (Astrophysics) 1999

Research and Professional Experience

Massachusetts Institute of Technology, Department of Physics
Pappalardo Postdoctoral Fellowship 2006 – present
Assistant Professor of Physics beginning fall 2009
Fermi National Accelerator Laboratory, Batavia, Illinois, U.S.A.
Engineering Physicist 1999-2000 (Beams Division)

2006-Present: Member of DMTPC collaboration. Development and construction of proportional counter apparatus for gas scintillation and ionization properties measurements. Developed statistical techniques for analysis of directional dark matter search data. Developed charge readout electronics, prototype drift chamber, and vacuum system.

2006-Present: Development and construction of scintillation detectors for neutron flux measurement at underground laboratories. Detector commissioning and calibration in the LANL WNR neutron beam using time of flight.

2006-Present: Member of SNO collaboration. Development of radioactive backgrounds analysis and Monte Carlo for ^{3}He-CF_4 proportional counter array. Chair of Physics Interpretation review committee, member of low-energy-threshold analysis review committee, member of SNO Executive Board (2006-2007).

1999 - 2006: Development of analysis for combined muon neutron and electron neutron oscillation search using charged current quasi-elastic scattering. Commissioning and calibration of beam toroid proton intensity monitor. Ph.D. Thesis.

1999 - 2000: Member of the Neutrino Factory Collaboration. Simulations and analytical formalism development for design of a muon ionization cooling system.

Selected Publications Relevant to This Proposal

DMTPC-10L: Direction-Sensitive Dark Matter Detector Prototype
By D. Dujmic, P. Fisher, R. Lanza, J. Lopez, A. Kaboth, G. Kohse, J. Monroe, R. Vanderspek, G. Sciolla, R. Yamamoto, S. Ahlen, K. Otis, A. Roccaro, H. Tomita, N. Skvorodnev, H. Wellenstein
e-Print: **arXiv:0810.2769** [physics.ins-det] October 2008.

DMTPC: a new apparatus for directional detection of Dark Matter
G. Sciolla, A. Lee, J. Battat, T. Caldwell, B. Cornell, D. Dujmic, P. Fisher, S. Henderson, R. Lanza, J. Lopez, A. Kaboth, G. Kohse, J. Monroe, T. Sahin, R . Vanderspek, R. Yamamoto, H. Yegoryan, S. Alhen, D. Avery, K. Otis, A. Roccaro, H. Tomita, A. Dushkin, H. Wellenstein
e-Print: **arXiv:0810.0291** [astro-ph] October 2008.

Observation of the 'head-tail' effect in nuclear recoils of low-energy neutrons
D. Dujmic, H. Tomita, M. Lewandowska, S. Ahlen, P. Fisher, A. Kaboth, G. Kohse, R. Lanza, J. Monroe, A. Roccaro, G. Sciolla, N. Skvorodnev, R. Vanderspek, H. Wellenstein, R. Yamamoto, **J.Phys.Conf.Ser.110:062006,2008**.

A Measurement of Photon Production in Electron Avalanches in CF4
A. Kaboth, J. Monroe, S. Ahlen, D. Dujmic, S. Henderson, G. Kohse, R. Lanza, M. Lewandowska, A. Roccaro, G. Sciolla, N. Skvorodnev, H. Tomita, R. Vanderspek, H. Wellenstein, R. Yamamoto, P. Fisher, **Nucl. Instrum. Meth. A 592, 63 (2008).**

Independent Measurement of the Total Active 8B Solar Neutrino Flux Using an Array of 3He Proportional Counters at the Sudbury Neutrino Observatory
SNO Collaboration, **Phys. Rev. Lett., 101, 111301 (2008)**

For a complete list of publications, please see
http://www.slac.stanford.edu/spires/find/hep/www?rawcmd=find+au+j+monroe

Synergistic Activities

1) Collaboration with Prof. Richard Yamamoto and Prof. Peter Fisher (MIT) to measure the cosmogenic neutron flux underground with a liquid scintillator-based detector.
2) Collaboration with DMTPC to develop direction-sensitive dark matter detectors using CF_4-filled low-pressure time projection chambers.
3) Collaboration with SNO on the analysis of alpha backgrounds in the Neutral Current Detector ^{3}He-CF_4 proportional counter array.

Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers
None.

Collaborators and Co-editors

Current collaboration memberships: DArT, DMTPC, SNO, MiniBooNE.
DMTPC Collaborators:
Prof. Steve Ahlen (Boston University), Dr. Denis Dujmic (MIT), Prof. Peter Fisher (MIT), Dr. Richard Lanza (MIT), Prof. Gabriella Sciolla (MIT), Dr. Roland Vanderspek (MIT), Prof. Hermann Wellenstein (Brandeis)

Graduate and Postdoctoral Advisors and Advisees

Advisor: Prof. Michael A. Shaevitz (Columbia U.)

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Princeton University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Cristiano Galbiati

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Cristiano Galbiati - PI**	0.00	0.00	0.00	$ **0**	$
2. **Peter D Meyers - Co-PI**	0.00	0.00	0.00	**0**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**115,960**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**115,960**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**39,310**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**155,270**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**300,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**300,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**455,270**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Off-campus) (Rate: 26.0000, Base: 455270)**					
TOTAL INDIRECT COSTS (F&A)				**118,370**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**573,640**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **573,640**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Cristiano Galbiati

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Princeton University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Cristiano Galbiati

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Cristiano Galbiati - PI**	0.00	0.00	0.00	$ **0**	$
2. **Peter D Meyers - Co-PI**	0.00	0.00	0.00	**0**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**120,598**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**120,598**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**41,486**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**162,084**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**300,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**300,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**462,084**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Off-campus) (Rate: 26.0000, Base: 462084)**					
TOTAL INDIRECT COSTS (F&A)				**120,142**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**582,226**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **582,226**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Cristiano Galbiati

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Princeton University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Cristiano Galbiati

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Cristiano Galbiati - PI**	0.00	0.00	0.00	$ **0**	$
2. **Peter D Meyers - Co-PI**	0.00	0.00	0.00	**0**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**125,422**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**125,422**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**43,647**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**169,069**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**300,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**300,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**469,069**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Off-campus) (Rate: 26.0000, Base: 469069)**					
TOTAL INDIRECT COSTS (F&A)				**121,958**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**591,027**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **591,027**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Cristiano Galbiati

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Princeton University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Cristiano Galbiati

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Cristiano Galbiati - PI**	0.00	0.00	0.00	$ **0**	$
2. **Peter D Meyers - Co-PI**	0.00	0.00	0.00	**0**	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**3**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	36.00	0.00	0.00	**361,980**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**361,980**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**124,443**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**486,423**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**900,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**900,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**1,386,423**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**360,470**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**1,746,893**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **1,746,893**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Cristiano Galbiati

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION PRINCETON

This proposal requests $1,746,893 over three years to allow the Princeton group to lead the collaborative effort to develop engineering for the PDR of "MAX - Multi Ton Argon and Xenon TPCs".

As the leading institution of the collaborative effort, the Princeton group will be responsible for major part of the engineering design of the detector, towards the delivery of a Preliminary Design Report. The Princeton group will support, with funds requested in this proposal, the Project Manager of the collaborative effort, Eng. Robert Parsells (1 FTE), and the DAr TPC detector manager, Eng. William Sands (1 FTE). The budget includes also a consulting agreement with Linde USA ($300,000 over three years) for the engineering and development of the extraction plants for depleted argon and of the cryogenic distillation plants for purification of the crude argon and of xenon.

The major areas of responsibility for the Princeton group include:

- Project management of the entire collaborative effort (Task 1.)
- Design of the inner vessel (Task 1.2)
- Design of the systems for pre-purification of the Ar and Xe targets (Task 1.5)
- Design of the shielding (Task 3.)
- Interface with DUSEL (Task 4.)
- Overall responsibility for safety aspects of the project (Task 6.)
- Overall coordination of the project

The PI and co-PI of the group, Profs. Galbiati and Meyers, do not request summer support, which is provided by their base grant. Profs. Galbiati and Meyers will be heavily involved in the major aspects of the collaborative effort. Princeton University fully supports the academic year salaries of Professors, Associate Professors, and Assistant Professors but makes no specific commitment of academic year time or salary to this particular research project. As a PI for the project, Prof. Galbiati will guarantee the overall coordination of the collaborative effort. Prof. Galbiati will also be Level 2 Manager for the group working on the pre-purification plants: he will set the specifications of the systems and he will be in charge of coordinating the preliminary design for the pre-purification plants. Prof. Meyer will act as a Level 2 Manager for the group in charge of designing the Inner Vessels.

The Princeton group will work in a very strong coordination with the group at Temple. The Detector Manager for the DAr TPC, Eng. William Sands, will work under the supervision of Prof. Jeff Martoff at Temple University. Prof. Martoff is Level 2 convener for the TPCs working group (Task 1.1).

ALLOCATION OF FUNDS

PRINCETON PERSONNEL

Funds are requested for Engineer William Sands, 1 FTE $115,960 year 1 (4% inflation for years 2 & 3). William Sands will act as detector manager for the Dar TPC and will work under the direct supervision of Prof. Jeff Martoff at Temple University.

FRINGE BENEFITS

Fringe Benefits are charged as follows:
33.9% for 07/01/2009 – 6/30/2010
34.4% for 07/01/2010 – 6/30/2011
34.8% for 07/01/2011 – 6/30/2012

CONSULTANTS

Funds are requested for Engineer Robert Parsells, 1 FTE ($200,000/yr). Robert Parsells is a retiree from PPPL and will serve as Project Manager for "MAX – Multi Ton Argon and Xenon TPCs" (2/3 FTE). Robert Parsells will also be responsible for engineering the water shield of the experiment and for dealing with the associated safety aspects (1/3 FTE). We note that the other proposal submitted by Princeton University (PI: Frank Calaprice) also requests support for 1/3 FTE of Parsells, for the purpose of engineering a water shield common to a large number of experiments. Should both proposals be approved, the support for Parsells on the Grant associated with this proposal should be reduced accordingly.
We also request funds for a consulting contract issued to Linde USA for the engineering of the extraction plants for depleted argon and of the cryogenic distillation plant ($300,000 over three years, at a flate rate of $100,000/yr).

INDIRECT COSTS

Under a DHHS agreement dated July 9, 2008, indirect costs are collected at a rate of 61% on-campus and 26% off-campus less any amounts for capital equipment and graduate student tuition. The DHHS Representative is Louis Martillotti, (212) 264-2069.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Houston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ed V Hungerford

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ed V Hungerford - none**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**57,600**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**57,600**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**17,228**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**74,828**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**5,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**3,854**	
TOTAL OTHER DIRECT COSTS				**9,354**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**89,182**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Computer workstation (Rate: 50.0000, Base: 3854) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**44,591**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**133,773**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **133,773**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ed V Hungerford

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

**** I- Indirect Costs**
salaries + fringe (Rate: 50.0000, Base 74828)
Supplies (Rate: 50.0000, Base 5500)
travel (Rate: 50.0000, Base 5000)

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Houston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ed V Hungerford

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ed V Hungerford - none**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**59,328**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**59,328**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**17,488**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**76,816**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**5,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**5,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**87,316**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries + Fringe (Rate: 50.0000, Base: 76816) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**43,658**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**130,974**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **130,974**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ed V Hungerford

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

**** I- Indirect Costs**
Supplies (Rate: 50.0000, Base 5500)
travel (Rate: 50.0000, Base 5000)

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Houston

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ed V Hungerford

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ed V Hungerford - none**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	**61,108**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**61,108**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**17,760**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**78,868**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**5,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**5,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**89,368**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries + Fringe (Rate: 50.0000, Base: 78868) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**44,684**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**134,052**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **134,052**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ed V Hungerford

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

**** I- Indirect Costs**
Supplies (Rate: 50.0000, Base 5500)
travel (Rate: 50.0000, Base 5000)

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **University of Houston**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Ed V Hungerford**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ed V Hungerford - none**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**3**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	36.00	0.00	0.00	**178,036**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**178,036**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**52,476**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**230,512**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**15,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**16,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**3,854**	
TOTAL OTHER DIRECT COSTS				**20,354**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**265,866**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**132,933**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**398,799**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **398,799**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Ed V Hungerford**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION
University of Houston

This proposal requests $398,799 over three years to allow the group at University of Houston to Participate in the collaborative development of the PDR of "MAX - Multi Ton Argon and Xenon TPCs".

The leading responsibilities of the University of Houston comprise electronic components and DAQ. Prof. Hungerford, the PI of the group, has extensive expertise in these areas. The PI, Professor Hungerford, does not request summer salary, but will be heavily involved in the research in this project. Since joining the development of noble liquid TPCs, dark matter research became the primary focus of research interest of his group. He will devote time to manage the work, to direct the electronics design, and to supervise the necessary simulation studies. In particular, he will design and direct the implementation of the architecture for the 2nd level trigger for the DAr TPC, in order to filter and exchange information among the master FPGAs of the DAQ boards, and to read out the data into the DAQ computers. Prof. Hungerford will also act as a Level 2 Manager for the DAQ task 1.8, and a convener for the related working group.

The group at University of Houston requests support for an (Electronics) Research Engineer, to be named, supported at the level of 1 FTE. We anticipate that the research engineer will have at least 5 years experience in the design of modern mixed-signal, nuclear electronics, and in particular experience in integration and design of firmware of Field Programmable Gate Arrays (FPGAs). As an example, our last employee in a similar position now holds a position with the Instrumentation Division at Brookhaven National Laboratories.

The major tasks to be performed by the group at University of Houston towards the preparation of a PDR for "MAX - Multi Ton Argon and Xenon TPCs" consist of the following.

- Design and implement the firmware of the ADC+FPGA boards for the digitizers, task 1.7.3. Specifications of signal bandwidth, vertical resolution, zero-suppression schemes. Code architecture. Implementation of zero suppression schemes. For the DAr TPC, design of memory holding systems compatible with the on-board suppression of events discarded by the 2^{nd} level trigger.
- 2^{nd} level DAr TPC trigger board, task 1.7.4. Specification of the communication protocol among the master FPGAs. Specification of the possible "smart trigger" systems in use to limit the rate of ^{39}Ar events transferred to bus and recorded on disk. Analysis of relative performance of "smart trigger" decisions performed on S2/S1 and on PSD (pulse shape discriminations) will require the extensive use of simulation tools, for which task the group at University of Houston will leverage upon the extensive in-house expertise on software simulations
- Slow Controls, task 1.7.7. Specifications, list of parameters to be controlled, architecture,
- GPS Clock, task 1.7.8. Specifications. Protocols for synchronizations with all FPGAs on all board. Time stamping of individual events and of individual photoelectrons. Integration with offline reconstruction schemes.

- DAQ Communications Links, task 1.8.1. Specifications, protocols.
- DAQ On-line Software, task 1.8.3. Specifications, architecture, protocols.
- Common simulation infrastructure, task 2.1. This will leverage on the extensive expertise available at the Physics Department of University of Houston on the development of packages for the FLUKA code. A senior research associate is a member of the FLUKA collaboration.

Salaries are detailed in the included salary schedule by year, which also provides percentages of commitment of each person to the project. Salaries are inflated at 3% per year.

The budget requests funds for a workstation for the Electronics Research Engineer. We maintain software licenses in collaboration with the electrical engineering department on campus for PCB layout and SPICE simulations. Our share of these fees are included in the budget. Travel provides funds for collaboration meetings, and coordination with other participating engineers at FNAL and UCLA. It is based on approximately 5-6 travels per year. Miscellaneous expenses include computer maintenance and telephone charges. Overhead is charged at the normal campus rate.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Katsushi Arisaka

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Katsushi Arisaka - Professor of Physics**	0.00	0.00	0.00	$ **0**	$
2. **David B Cline - Professor of Physics & Astron**	0.00	0.00	0.00	**0**	
3. **Hanguo Wang - Research Physicist**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.00	0.00	0.00	**63,690**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**63,690**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**17,833**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**81,523**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**7,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**10,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**100,000**	
6. OTHER				**750**	
TOTAL OTHER DIRECT COSTS				**110,750**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**202,273**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Modified Total Direct Cost (Rate: 54.0000, Base: 127273)**					
TOTAL INDIRECT COSTS (F&A)				**68,727**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**271,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **271,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Katsushi Arisaka

ORG. REP. NAME*
Kristen Lund

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Katsushi Arisaka

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Katsushi Arisaka - Professor of Physics**	0.00	0.00	0.00	$ **0**	$
2. **David B Cline - Professor of Physics & Astron**	0.00	0.00	0.00	**0**	
3. **Hanguo Wang - Research Physicist**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.00	0.00	0.00	**64,964**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**1**) UNDERGRADUATE STUDENTS				**1,200**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**66,164**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**18,226**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**84,390**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**7,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**10,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**100,000**	
6. OTHER				**805**	
TOTAL OTHER DIRECT COSTS				**110,805**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**205,195**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Modified Total Direct Cost (Rate: 54.0000, Base: 105195)**					
TOTAL INDIRECT COSTS (F&A)				**56,805**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**262,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **262,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Katsushi Arisaka

ORG. REP. NAME*
Kristen Lund

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Katsushi Arisaka

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Katsushi Arisaka - Professor of Physics**	0.00	0.00	0.00	$ **0**	$
2. **David B Cline - Professor of Physics & Astron**	0.00	0.00	0.00	**0**	
3. **Hanguo Wang - Research Physicist**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.00	0.00	0.00	**66,264**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**1**) UNDERGRADUATE STUDENTS				**1,200**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**67,464**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**18,590**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**86,054**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**7,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**10,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**100,000**	
6. OTHER				**440**	
TOTAL OTHER DIRECT COSTS				**110,440**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**206,494**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Modified Total Direct Cost (Rate: 54.0000, Base: 106494)**					
TOTAL INDIRECT COSTS (F&A)				**57,507**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**264,001**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **264,001**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Katsushi Arisaka

ORG. REP. NAME*
Kristen Lund

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Katsushi Arisaka

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Katsushi Arisaka - Professor of Physics**	0.00	0.00	0.00	$ **0**	$
2. **David B Cline - Professor of Physics & Astron**	0.00	0.00	0.00	**0**	
3. **Hanguo Wang - Research Physicist**	0.00	0.00	0.00	**0**	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**3**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	24.00	0.00	0.00	**194,918**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**2**) UNDERGRADUATE STUDENTS				**2,400**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**197,318**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**54,649**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**251,967**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**9,000**	
2. FOREIGN				**21,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**30,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**300,000**	
6. OTHER				**1,995**	
TOTAL OTHER DIRECT COSTS				**331,995**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**613,962**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**183,039**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**797,001**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **797,001**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Katsushi Arisaka

ORG. REP. NAME*
Kristen Lund

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification

This proposal requests $797,001 over three years to allow the UCLA group to be part of a collaborative effort to develop Multi-ton Argon and Xenon (MAX) TPCs. The budget proposed includes a sub-award ($300K over three years) to the Hamamatsu Photonics Corporation for the design, development and manufacture of 3-inch QUPIDs connected with the project.

The UCLA group will work on QUPID procurement, testing, QUPID readout system (preamp, digitization board), as well as the associated TPC structure. The proposed activities of the UCLA group for this project (with participation of members of the collaboration) are:

1) Procurement, test and optimization of QUPID in close collaboration with Hamamatsu. We plan to design the test facility for QUPID which will measure Gain, Dark current, Uniformity, Quantum efficiency as well as timing properties all down to Liquid Argon temperature (-185 ^{0}C)
2) Further improvement of QUPID and development of the mass production facility at Hamamatsu.
3) Design of the complete readout chain of QUPID, including preamp and pulse shaping amplifier, and custom digitization board consisting of high-speed Flash ADC and FPGA.
4) Design of the mechanical support, HV and signal cables of QUPID in Liquid and Gas, Xenon and Argon (i.e. four combinations).
5) Coordinating efforts of the TPC mechanical design, HHV distribution system and cryogenic system for both Argon and Xenon detectors.

The UCLA group consists of Professor Katsushi Arisaka, PI, Professor David Cline, Co-PI, Dr. Hanguo Wang, senior research physicist, and Jonathan Kubic, senior development engineer. Funding is requested to support the senior development engineer at 2/3 time over the three year term of the grant. Funding is also requested to support a part-time undergraduate student during the summer in years 2 and 3 of the grant. No funds are requested for the PI and other senior members of the project. The summer salaries of the PI and other faculty member are covered by DOE. The salary of the senior research physicist is covered by another NSF grant and the university.

Employee benefits are calculated using standard university tables for this purpose. These rates include an estimated increase of 4% for restarting the employer paid contribution to the University of California Retirement Program (UCRP), effective July 1, 2009, for eligible employees and is applicable to all university fund sources.

Domestic and foreign travel funding ($3K domestic and $7K foreign in each year) is requested to allow the PI two trips each year to Columbia University for collaborative purposes and two trips each year to the Hamamatsu Photonics Corporation in Japan to

review and discuss QUPID design, development, and manufacture issues connected with the project.

Funding is requested for materials and supplies. These include electronic and small mechanical components, special tools, and test instruments for electronic development and prototyping. We request $10K each year to acquire such materials and supplies.

Hamamatsu Photonics Corporation in Japan will play a key part in the design, development and manufacture of the QUPID connected with this project. UCLA plans to provide Hamamatsu $300K over three years under a sub-award to carry out its responsibilities for the project. Under separate attachment to this proposal is Hamamatsu's letter of commitment.

Other direct costs include UCLA's technology infrastructure fee (TIF) and an allowance (several hundred dollars per year) for shipping materials between collaborating institutions. The TIF supports the university network, backbone, internet connection, hardware and wireless services and is charged all extramural contracts and grants at a current rate of $40.75/month per FTE.

Facilities and Administrative Costs are calculated on total modified direct costs using the current on-campus rate of 54%.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Temple University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
C. J. Martoff

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **C. J. Martoff - PI**	0.00	0.00	2.00	$ **25,080**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	**25,080**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**18,000**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**43,080**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,708**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**46,788**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,750**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**1,500**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**3,250**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**55,038**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **TDC (Rate: 50.0000, Base: 55038)**					
TOTAL INDIRECT COSTS (F&A)				**27,519**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**82,557**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **82,557**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
C. J. Martoff

ORG. REP. NAME*
Robert Gage

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Temple University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
C. J. Martoff

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **C. J. Martoff - PI**	0.00	0.00	2.00	$ **26,083**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	**26,083**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**18,720**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**44,803**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,856**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**48,659**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,160**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,750**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**1,000**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**2,750**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**55,569**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **TDC (Rate: 50.0000, Base: 55569)**					
TOTAL INDIRECT COSTS (F&A)				**27,785**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**83,354**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **83,354**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
C. J. Martoff

ORG. REP. NAME*
Robert Gage

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Temple University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
C. J. Martoff

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **C. J. Martoff - PI**	0.00	0.00	2.00	$ **27,126**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	**27,126**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**19,469**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**46,595**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**4,010**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**50,605**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,326**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,750**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**1,000**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**2,750**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**57,681**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **TDC (Rate: 50.0000, Base: 57681)**					
TOTAL INDIRECT COSTS (F&A)				**28,841**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**86,522**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **86,522**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
C. J. Martoff

ORG. REP. NAME*
Robert Gage

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Temple University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **C. J. Martoff**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **C. J. Martoff - PI**	0.00	0.00	6.00	$ **78,289**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	6.00	**78,289**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**3**) GRADUATE STUDENTS				**56,189**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**134,478**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**11,574**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**146,052**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**13,486**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**5,250**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**3,500**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**8,750**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**168,288**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**84,145**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**252,433**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **252,433**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **C. J. Martoff**

ORG. REP. NAME*: **Robert Gage**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

TEMPLE UNIVERSITY

-

BUDGET JUSTIFICATION

This proposal requests $252,433 over three years to allow the Temple group to participate the collaborative effort to develop Multi Ton Argon and Xenon TPCs.

Prof. Martoff has a long track record on direct dark matter studies and has recently engaged in the effort to develop large noble liquid TPCs. Prof. Martoff is currently spending a 1-yr sabbatical at Fermilab, working in close cooperation with the local Liquid Argon group. The participation to the development of noble liquid TPCs has already become his principal research interest and project.

Prof. Martoff of Temple University will act as Level 2 Manager for the TPC engineering (Task 1.1). He will also coordinate the engineering of WBS items:
- 1.1.1.2 (high voltage structures)
- 1.1.3.2 (internal HV connections)
- 1.2.1.1(argon liner mechanical)
- 1.3.5.2 (8"PMT s Support)

A full time engineer on the Princeton payroll, William Sands, will largely work under the supervision of Prof. Martoff towards the engineering of the TPC. No line items for the salary of William Sands appears in the Temple budget.

Temple Chemistry Professor S. Jansen Varnum will assist with research on transparent conducting polymers and durable wavelength shifting films. In addition to scientific input in these areas of her expertise, Professor Jansen Varnum will contribute use of research equipment as well as undergraduate student participation from her substantial NIH and NSF outreach grants. Because she anticipates taking up a 12-month administrative appointment in AY 2009-10, no salary is requested for Professor Jansen Varnum.

Funds are requested for C. J. Martoff summer salary (2 mo.), plus full-year support for a graduate student. The student will assist Martoff with validating engineering designs using electrostatic and other physics simulations. They may also perform or arrange outsourcing of some limited lab work, for example measuring radiological, optical or electrical properties of manufacturer's samples or other candidate materials. Fifteen hundred dollars per year is requested for materials and supplies needed for e.g. sample preparation.

In addition to salaries, travel funds are requested for 4-5 domestic trips per year to attend collaboration and other meetings. The commercial software used for 3-D electrostatic modeling (COMSOL Multiphysics) costs $1100 per year for telephone support. In

addition a few hundred dollars are requested for express letter shipments and office supplies.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
William Marsh Rice University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Uwe Oberlack

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Uwe Oberlack - Assistant Professor**	0.00	0.00	0.00	$ **0**	$
2. **Petr Chaguine - Research Scientist**	6.00	0.00	0.00	**30,000**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	**30,000**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**30,000**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**7,890**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**37,890**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**6,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**7,500**	
TOTAL OTHER DIRECT COSTS				**13,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**56,390**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A (Rate: 52.5000, Base: 56390)**					
TOTAL INDIRECT COSTS (F&A)				**29,605**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**85,995**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **85,995**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Uwe Oberlack

ORG. REP. NAME*
Eric Jordan

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
William Marsh Rice University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Uwe Oberlack

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Uwe Oberlack - Assistant Professor**	0.00	0.00	0.00	$ **0**	$
2. **Petr Chaguine - Research Scientist**	6.00	0.00	0.00	**31,500**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	**31,500**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**31,500**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**8,285**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**39,785**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**6,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**6,000**	
TOTAL OTHER DIRECT COSTS				**12,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**56,785**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A (Rate: 52.5000, Base: 56785)**					
TOTAL INDIRECT COSTS (F&A)				**29,812**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**86,597**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **86,597**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Uwe Oberlack

ORG. REP. NAME*
Eric Jordan

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
William Marsh Rice University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Uwe Oberlack

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Uwe Oberlack - Assistant Professor**	0.00	0.00	0.00	$ **0**	$
2. **Petr Chaguine - Research Scientist**	6.00	0.00	0.00	**33,000**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	**33,000**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**33,000**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**8,679**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**41,679**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**5,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**5,000**	
TOTAL OTHER DIRECT COSTS				**10,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**56,679**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **F&A (Rate: 52.5000, Base: 56679)**					
TOTAL INDIRECT COSTS (F&A)				**29,756**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**86,435**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **86,435**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Uwe Oberlack

ORG. REP. NAME*
Eric Jordan

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **William Marsh Rice University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Uwe Oberlack**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Uwe Oberlack - Assistant Professor**	0.00	0.00	0.00	$ **0**	$
2. **Petr Chaguine - Research Scientist**	18.00	0.00	0.00	**94,500**	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	18.00	0.00	0.00	**94,500**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**94,500**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**24,854**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**119,354**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**15,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**17,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**18,500**	
TOTAL OTHER DIRECT COSTS				**35,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**169,854**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**89,173**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**259,027**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **259,027**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Uwe Oberlack**

ORG. REP. NAME*: **Eric Jordan**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION
Rice University

TASKS
This budget is for the design of components of the MAX experiment proposed for the Initial Suite of Experiments at the Deep Underground Science and Engineering Laboratory (DUSEL), and covers a period of 3 years.

Rice University will be responsible for:

1. Development and design of the cathode, field cage, and grids for the Xenon TPC. The TPC structure consists of the field cage and mechanical support, five meshes and electrode support structures, the mechanical interface to the top and bottom QUPID arrays, as well as the mechanical / optical interface to the surrounding QUPID structure. New grids will have to be developed for the large diameter of the Xe-TPC (1 m), requiring great mechanical strength while optimizing the uniformity of the electric field and electron path lengths in the luminescence region for uniform scintillation yield. At the same time, optical transparency of the meshes has to be maximized to enable low energy thresholds for the primary scintillation light. The Rice group was responsible this set of tasks for XENON100, hence we can draw on existing experience with a smaller TPC. Dr. Petr Chaguine will be in charge of this major task.
2. Design of an overall long levelmeter and four fine levelmeters surrounding the top electrodes for horizontal leveling of both the Xenon- and Argon-TPCs, and proper setting of the liquid/gas interface, including the readout of such systems. Design of a system to adjust the liquid level. Levelmeters were the responsibility of the Rice group for XENON100, so existing experience will guide the design of the two systems. Dr. Chaguine will be responsible for this design task.
3. Light and charge sources for the calibration of the Xenon-TPC. The Rice group will study some of the options using the existing xenon gas purification and cooling setup built at the Rice particle astrophysics lab. The system will comprise QUPID light calibration with a pulser, external LED, and quartz fibers, as well as options for bringing radioactive sources for gamma-ray/beta and neutron calibration to the heavily shielded detector interior. We will work closely with the MIT group in the areas where similar solutions for Ar- and Xe-TPC can be used. Prof. Uwe Oberlack will oversee this task, and involve undergraduate students in the testing of some of the concepts (e.g., low-activity internal sources deposited directly on electrodes). Dr. Chaguine will support this design and test effort.
4. Characterization of components regarding the radioactivity of QUPIDs and the materials in related structures. (Oberlack)
5. Definition of the specifications for offline analysis software. This includes, e.g., waveform analysis, and position reconstruction. Prof. Oberlack will work on this task, using his extensive experience in this area.
6. Prof. Oberlack will be resonsible for coordinating the procedures for TPC Operations as Level 2 Manager.

The Rice group has extensive expertise in liquid xenon TPCs. Dr. Oberlack has worked on LXeGRIT, a liquid xenon TPC for gamma-ray imaging, and has been an integral part of the XENON Dark Matter program since its inception. Liquid xenon detectors have been operated at Rice for the past 6 years in various R&D projects.

PERSONNEL
The Rice PI Prof. Uwe Oberlack will manage the Rice project activities and coordinate with the MAX collaboration as Co-PI and member of the Project Board, in addition to the specific tasks outlined above.
The budget covers the salary of research scientist and Co-Investigator Dr. Petr Chaguine for 6 months per year, at an anticipated salary of $60,000 at the start of this project, and increasing to $63,000 and $66,000 annually during the budget period. Dr. Chaguine's extensive experience in instrumentation and photosensors, and his experience with the design and fabrication of the XENON100 TPC and meshes is extremely valuable to the project. Dr. Chaguine is partially committed to the pending XENON100 Upgrade proposal. If both XENON100 Upgrade and this proposal are accepted, we will be able to reduce Dr. Chaguine's effort on XENON100 Upgrade by supplementing part of his effort with additional personnel, while leaving him in charge of the main design efforts.
Undergraduate students will gain research experience with the testing of some of the design concepts.

FRINGE BENEFITS
Fringe benefits and graduate student tuition remission are charged at the currently approved and anticipated rates (see Budget Attachment).

EQUIPMENT
None.

TRAVEL:

Domestic Travel:

Travel Item	Daily Costs(*)	Days / Trip	Airfare	Other Costs(#)	Travelers * Trips	Total
Domestic collaboration or In-person technical meetings	$150	3	$400	$250	2	$2,200
Domestic technical conference (IEEE)	$175	4	$400	$500	1	$1,600
DUSEL meeting / workshop	$150	3	$500	$250	1	$1,200
(*) Lodging & Per Diem, (#) Conference fees, Car rental, etc.					**Total:**	**$5,000**

We request annual travel funds of 5k$ domestic, as estimated in the table.

OTHER DIRECT COSTS

Materials and Supplies:	Year 1	Year 2	Year 3
Gases and cryogens: dry nitrogen and argon for cleaning of UHV parts, liquid nitrogen for cooling	$500	$500	$500
Cleaning products (Alcohol, deionized water, KimWipes, etc.)	$500	$500	$500
Cleanroom supplies (HEPA filter, gloves, masks, overalls, foot mats, ...)	$500	$500	$500
Materials for test setups, sources, etc.	$2,500	$2,500	$1,500
Small parts: electronic components, flanges, gaskets and fittings, valves, solder supplies, wire & cable, etc.	$2,000	$2,000	$1,500
Total:	**$6,000**	**$6,000**	**$4,500**

Other:			
Machine shop cost for test setups and design verification (electrodes, sources, etc.)	$4,000	$4,000	$2,500
License for CAD engineering software	$1,500		
Reproductions, mailings	$500	$500	$1,000
Office & computer supplies for research	$1,000	$1,000	$1,000
Telecommunication Charges	$500	$500	$1,000
Total:	**$7,500**	**$6,000**	**$5,500**

Our cost estimate will enable small laboratory setups to test some of the design features for electrodes, internal sources, etc.

FACILITIES AND ADMINISTRATIVE COST (F&A)
F&A is charged at the approved rate of 52.5% of modified total direct costs (MTDC) and 26% for off-campus costs. MTDC excludes equipment costs (items costing $5,000 or more) and pooled graduate student tuition remission.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Columbia University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Elena Aprile

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Elena Aprile - Prof.**	0.00	1.00	0.00	$ **0**	$
2. **Karl L Giboni - Dr.**	4.00	0.00	0.00	**39,184**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	4.00	1.00	0.00	**39,184**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**2**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.50	0.00	0.00	**62,893**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**102,077**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**27,867**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**129,944**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,000**	
2. FOREIGN				**6,900**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**9,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**800**	
TOTAL OTHER DIRECT COSTS				**11,300**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**150,144**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Morningside Heights Campus (Rate: 60.3000, Base: 73805)**					
TOTAL INDIRECT COSTS (F&A)				**44,504**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**194,648**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **194,648**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Elena Aprile

ORG. REP. NAME*
Jennifer Lomboy

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Elena Aprile**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Elena Aprile - Prof.**	0.00	1.00	0.00	$ **0**	$
2. **Karl L Giboni - Dr.**	4.00	0.00	0.00	**40,751**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	4.00	1.00	0.00	**40,751**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**2**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.50	0.00	0.00	**65,409**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**106,160**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**28,981**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**135,141**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,000**	
2. FOREIGN				**6,900**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**9,360**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**800**	
TOTAL OTHER DIRECT COSTS				**11,660**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**155,701**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Morningside Heights Campus (Rate: 61.0000, Base: 76308)**					
TOTAL INDIRECT COSTS (F&A)				**46,548**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**202,249**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **202,249**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Elena Aprile**

ORG. REP. NAME*: **Jennifer Lomboy**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Columbia University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Elena Aprile

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Elena Aprile - Prof.**	0.00	1.00	0.00	$ **0**	$
2. **Karl L Giboni - Dr.**	0.00	0.00	0.00	**42,381**	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	1.00	0.00	**42,381**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**2**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	8.50	0.00	0.00	**68,026**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**110,407**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**30,141**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**140,548**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,000**	
2. FOREIGN				**6,900**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**9,734**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**800**	
TOTAL OTHER DIRECT COSTS				**12,034**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**161,482**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Morningside Heights Campus (Rate: 61.0000, Base: 78913)**					
TOTAL INDIRECT COSTS (F&A)				**48,137**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**209,619**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **209,619**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Elena Aprile

ORG. REP. NAME*
Jennifer Lomboy

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Elena Aprile**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Elena Aprile - Prof.**	0.00	3.00	0.00	$ **0**	$
2. **Karl L Giboni - Dr.**	8.00	0.00	0.00	**122,316**	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	8.00	3.00	0.00	**122,316**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**6**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	25.50	0.00	0.00	**196,328**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**318,644**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**86,989**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**405,633**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**6,000**	
2. FOREIGN				**20,700**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**4,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**28,094**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**2,400**	
TOTAL OTHER DIRECT COSTS				**34,994**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**467,327**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**139,189**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**606,516**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **606,516**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Elena Aprile**

ORG. REP. NAME*: **Jennifer Lomboy**

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

COLUMBIA UNIVERSITY
Budget Justification

This proposal requests $606,516 over three years to allow the Columbia group to participate in the DUSEL S4 collaborative effort to develop Multi-ton Argon and Xenon (MAX) TPCs.

The Columbia group involved in MAX consists of Professor Elena Aprile (PI) , Dr. Karl-Ludwig Giboni, senior research scientist and Dr. Gordon Tajiri, senior mechanical engineer. Prof. Tom Haruyama, senior cryogenic engineer at the KEK laboratory in Japan, will serve as consultant to the Columbia team. Prof. Aprile will devote 1 academic month of her time at no salary cost to this project.

The proposed activities of the Columbia group for this project (with participation of members of the collaboration) are:

1) Design of the containment vessel for the 2.4 tonnes XeTPC, optimized for minimum weight and minimum radioactivity. The double-walled, super-insulated vessel will be made out of low activity copper, to be assembled by electron beam-welding. All connections and ports to pumps, gas filling/recovery lines and electrical signal feedthroughs as well as the overall mechanical and electrical systems integration will be part of the design.
2) Design of the cooling system with optimized heat exchangers fed by Pulse Tube Refrigerators (PTR) of the type already tested in XENON10 and XENON100 detectors. An independent LN2 based system will also be designed for emergency cooling. The PTR was developed by Dr. Haruyama of KEK for liquid xenon temperature. We have secured 1 month of his time as XeTPC cryogenics consultant. Dr Giboni, has worked closely with Dr. Haruyama to design the XENON10 and XENON100 vessels and cryogenic system which have shown excellent performance.
3) Design of the Xe gas purification/circulation/filling/recovery systems in close collaboration with the group of Prof. Weinheimer in Germany. Getters and other materials will be screened for radioactivity, before being adopted as Xe purifiers. Schemes for purification in liquid phase will also be tested in collaboration with the Columbia's group. The German group will also collaborate on the optimization of a cryogenic distillation tower for Kr-removal and on the measurement of Kr-85 contamination level at the part per trillion level. We will also coordinate, with the Coimbra University group, the design of the storage and handling of the 3 tonnes of Xe.
4) Identify the optimized procedure for underground installation, commissioning and operation of the XeTPC and its associated systems.

The proposed budget covers:

SALARIES AND WAGES:

For each of the 3 years of the proposed period of performance, we request 8 months salary for Dr. Tajiri, mechanical engineer and 4 months salary for Dr. Giboni , senior research scientist, both members of the Columbia Astrophysics Laboratory. Dr. Gordon Tajiri will be responsible for the the mechanical design of the XeTPC and will also serve as Project Manager for the XeTPC component of the MAX project. Dr. Giboni will be responsible for the cryogenics design of the XeTPC. We also request 0.5 months of administrative support (Donna Messina).

TRAVEL COSTS:
We request 2 Foreign trips, one for the consultant Prof. Tom Harayama to visit the Columbia team from Japan, and one trip for the Engineer to visit KEK, Japan. Each trip will be for a full week and we estimate expenditures as follows – airfare @ $1,500; Food/Lodging @ $250/day, & ground transportation/misc. expenditures @ 200. Each trip is estimated to cost $3450. Domestic travel funding is requested to allow the PI 2 trips each year to Collaboration/DUSEL meetings ($1,000 per trip).

OTHER COSTS: Other direct costs include consultant services from Prof. Tom Haruyama (listed in G.3.) of the NSF Budget forms. Dr. Haruyama will participate at the equivalent of 25 days/year as a consultant on the project ($360/day.) Funding is also requested for materials and supplies ($1,500) and for teleconferencing costs ($800) for each year.

FRINGE & INDIRECT COST RATES: The current fringe benefits rate for all salaries is 27.3%. Salaries are inflated at 4% for each year. The Columbia University Indirect Cost Reimbursement Rate is 60.3% for year 1 and 61% for years 2 and 3 on all direct costs *excluding* construction-related salaries and fringe for the engineer. The Columbia University indirect cost rate was established through an agreement with the Department of Health and Human Services, dated 4 June 2008.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Augustana College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrew K Alton

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrew K Alton - Assistant Professor**	1.00	0.00	1.00	$ **5,951**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	**5,951**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**5,951**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**613**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**6,564**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,614**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**8,178**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Senior Salary (Rate: 45.0000, Base: 5951)**					
TOTAL INDIRECT COSTS (F&A)				**2,678**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**10,856**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **10,856**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrew K Alton

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Augustana College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrew K Alton

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrew K Alton - Assistant Professor**	1.00	0.00	1.00	$ **6,130**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	**6,130**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**6,130**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**631**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**6,761**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,614**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**8,375**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Senior Salary (Rate: 45.0000, Base: 6130)**					
TOTAL INDIRECT COSTS (F&A)				**2,759**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**11,134**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **11,134**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrew K Alton

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Augustana College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrew K Alton

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrew K Alton - Assistant Professor**	1.00	0.00	1.00	$ **6,314**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	**6,314**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**6,314**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**650**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**6,964**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,614**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**8,578**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Senior Salary (Rate: 45.0000, Base: 6314)**					
TOTAL INDIRECT COSTS (F&A)				**2,841**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**11,419**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **11,419**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrew K Alton

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Augustana College**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Andrew K Alton**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrew K Alton - Assistant Professor**	3.00	0.00	3.00	$ **18,395**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	3.00	0.00	3.00	**18,395**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**18,395**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**1,894**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**20,289**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,842**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**25,131**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**8,278**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**33,409**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **33,409**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Andrew K Alton**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

AUGUSTANA COLLEGE

BUDGET JUSTIFICATION

This proposal requests a modest $33,409 over a three year period to facilitate Andrew Alton and Augustana College's participation in the Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs. Our primary responsibilities are in the area of the data acquisition system. Professor Alton has primary responsibility for task's 1.8.2 and 1.8.5, the DAQ computers and data recording.

Professor Alton recently began focusing his research on direct dark matter detection and has been collaborating with the DArcSide group. A student and I have managed to obtain funding from the South Dakota Space Grant to support him in summer research on dark matter. In addition to directing this student, Professor Alton will spend his time determining the requirements that experiments this size will have for data acquisition and recording. When contemplating a five year run, a stable data storage system is an important component.

In addition to the areas that are Professor Alton is primarily responsible, he will also contribute to research on cryogenic distillation and education and outreach. Specifically travel money is requested for him to travel to Princeton for two weeks in the summer, as part of the Princeton-Abruzzo-South Dakota summer school. During that same time it will prove useful to collaborate on cryogenic distillation.

Allocation of Funds

I. TRAVEL

This proposal requests funds to travel to Princeton for two weeks each the summer, to participate in the Princeton-Abruzzo-South Dakota summer school.

Augustana – Princeton:

Airfare (SF – Newark) + ground transportation:	$ 550
Housing @ $40/day x 14 days:	$ 560
Per Diem @ $36/day x 14 days:	$ 504
Total	$ 1,614

II. PERSONNEL

This proposal requests one month of summer salary for Andrew Alton, This funding is necessary to support the engineering of the DAQ storage.

SALARIES & WAGES

Assuming an annual 5% increase in base (academic year) salaries:

Durben Summer support, 1 months:	**$ 5,951**	**for year 1**
Durben Summer support, 1 months:	**$ 6,130**	**for year 2**
Durben Summer support, 1 months:	**$ 6,314**	**for year 3**

FRINGE BENEFITS

$ 613	**for year 1**
$ 631	**for year 2**
$ 650	**for year 3**

OVERHEAD

$ 2,678	**for year 1**
$ 2,759	**for year 2**
$ 2,841	**for year 3**

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Amherst

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrea P Pocar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrea P Pocar - PI**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**0**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**0**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **0**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrea P Pocar

ORG. REP. NAME*
Jennifer Donais

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Amherst

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrea P Pocar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrea P Pocar - PI**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
Radon emanation measurement apparatus $ **40,000**					
TOTAL EQUIPMENT				**40,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**40,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
(Rate: , Base:)					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**40,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **40,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrea P Pocar

ORG. REP. NAME*
Jennifer Donais

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Amherst

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrea P Pocar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrea P Pocar - PI**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**0**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**0**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **0**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrea P Pocar

ORG. REP. NAME*
Jennifer Donais

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Massachusetts Amherst

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Andrea P Pocar

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Andrea P Pocar - PI**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **$ 40,000**					
TOTAL EQUIPMENT				**40,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**40,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**40,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **40,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Andrea P Pocar

ORG. REP. NAME*
Jennifer Donais

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

UMass Budget Request Justification

Pocar is participating, as Co-PI, in a collaborative proposal to the National Science Foundation to support the design and engineering activities for the Multi-ton Argon and Xenon TPCs (MAX). Within the proposal, Pocar's activities will be focused on the Depleted Argon Cryostat for Scintillation and Ionization Detection (DArCSIDe) WIMP dark matter search experiment. The experiment is to be located in the Deep Underground Science and Engineering Laboratory (DUSEL) in South Dakota.

The Co-PI is currently a member of the EXO and Borexino collaborations, EXO being his main research engagement in his new role as Assistant Professor in the Physics Department starting January 2009. The PI has been awarded a generous startup package, including funds for equipment and manpower, to help launch his research. During his work on EXO and Borexino (4 and 9 years respectively) the Co-PI has had leading responsibilities in the design and construction of the inner detectors of both experiments and in their overall cleanliness and radio-purity. In particular, he has developed a particular expertise of radon-related backgrounds and techniques for their mitigation.

Within the DArCSIDe collaboration, the Co-PI is taking responsibilities in low background detector design, material selection and qualification, and R&D to address radon-related backgrounds at the challenging levels required by the proposed detector. For this collaborative proposal the Co-PI is requesting equipment funds to build and operate an apparatus for the measurement of radon emanation rates of detector components to be used at all stages of detector develepment. Because of the very stringent limits on the amount of radon tolerable in the liquid argon target of the detector, radon emanation rates will have to be measured for all components considered during the design of the detector. Once the detector and the auxiliary plumbing is installed, radon emanation can be used to measure the integral emanation rate of the entire, final apparatus, and pinpoint possible contamination sources and surface contamination occurred during construction. Such techniques were pioneered by the SNO and Borexino collaborations and were also recently used by the EXO collaboration. The proposed device follows the design of those operated by the SNO collaboration and it is small enough to be shipped where needed (detector assembly clean room, DUSEL experimental area, etc).

The radon emanation apparatus will be built by Pocar and a graduate (or undergraduate) student, starting in 2010, and is expected to take approximately six months. The time scale for NSF funding of the DArCSIDe proposal is 2009-2012. The Co-PI is requesting that all funds for construction work and initial operation at UMass be disbursed in year 2 of the 3 year grant period. In particular, no funds are requested for year 1 of the grant during which the Co-PI will focus almost entirely on the EXO experiment, with a limited participation on data analysis and shifts on the Borexino experiement. The Co-PI has requested support to NSF for EXO (as PI) and Borexino (as Co-PI) for the 2009-2012 period; both proposals are currently pending.

The entire requested amount ($40,000) is the estimated construction cost of the radon emanation chamber. It includes a vacuum chamber, components, instrumentation, and pumps ($29,000), and alpha detector with readout electronics ($5,000), and a data aquisition system ($6,000). It is expected that the machining of the chamber body and parts will take place in the UMass machine shop. Operations will be supported by Pocar's UMass startup funds and will employ students (graduate and undergraduate) as needed for sample screening. The time scale for operation of the apparatus covers all phases of the proposed experiment, from the R&D and design stages to the construction and operation of the DArCSIDe detector.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Black Hills State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Micheal H Zehfus

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Micheal H Zehfus - Co-PI**	0.00	0.00	0.00	$ **0**	$
2. **Dan Durben - Senior Personnel**	0.00	0.00	1.00	**6,817**	
3. **Kara Keeter - Senior Personnel**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	**6,817**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**6,817**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**1,704**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**8,521**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,700**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**10,221**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries plus benefits (Rate: 37.0000, Base: 8521)**					
TOTAL INDIRECT COSTS (F&A)				**3,153**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**13,374**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **13,374**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Micheal H Zehfus

ORG. REP. NAME*
Sharon Hemmingson

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Black Hills State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Micheal H Zehfus

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Micheal H Zehfus - Co-PI**	0.00	0.00	0.00	$ **0**	$
2. **Dan Durben - Senior Personnel**	0.00	0.00	1.00	**7,158**	
3. **Kara Keeter - Senior Personnel**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	**7,158**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**7,158**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**1,790**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**8,948**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,785**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**10,733**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries plus benefits (Rate: 37.0000, Base: 8948)**					
TOTAL INDIRECT COSTS (F&A)				**3,311**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**14,044**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **14,044**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Micheal H Zehfus

ORG. REP. NAME*
Sharon Hemmingson

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Black Hills State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Micheal H Zehfus

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Micheal H Zehfus - Co-PI**	0.00	0.00	0.00	$ **0**	$
2. **Dan Durben - Senior Personnel**	0.00	0.00	1.00	**7,516**	
3. **Kara Keeter - Senior Personnel**	0.00	0.00	0.00	**0**	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	**7,516**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**7,516**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**1,879**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**9,395**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**1,874**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**11,269**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Salaries plus benefits (Rate: 37.0000, Base: 9395)**					
TOTAL INDIRECT COSTS (F&A)				**3,476**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**14,745**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **14,745**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Micheal H Zehfus

ORG. REP. NAME*
Sharon Hemmingson

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Black Hills State University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Micheal H Zehfus

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Micheal H Zehfus - Co-PI**	0.00	0.00	0.00	$ **0**	$
2. **Dan Durben - Senior Personnel**	0.00	0.00	3.00	**21,491**	
3. **Kara Keeter - Senior Personnel**	0.00	0.00	0.00	**0**	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	3.00	**21,491**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**21,491**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**5,373**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**26,864**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,359**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**32,223**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**9,940**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**42,163**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **42,163**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Micheal H Zehfus

ORG. REP. NAME*
Sharon Hemmingson

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION BHSU

I. BHSU TRAVEL

This proposal requests funds for Keeter to travel to Princeton for two weeks each the summer, to participate in the Princeton-Abruzzo-South Dakota summer school. An annual increase in cost of 5% has been added for Y2 and Y3.

BHSU – Princeton (Year 1) :

Airfare (RAP – JFK) + ground transportation:	$ 636
Housing @ $40/day x 14 days:	$ 560
Per Diem @ $36/day x 14 days:	$ 504
Total Year 1	$ 1,700

Total BHSU Travel:	**$ 1,700**	**for year 1**
	$ 1,785	**for year 2**
	$ 1,874	**for year 3**

BHSU has recently been invited to submit a proposal to form a QuarkNet Center at BHSU. Tom Jordan, QuarkNet Project Coordinator, visited BHSU in December and was very supportive of our proposal. We have identified two excellent local high school teachers as prospects for our core group. These teachers are eager to participate and to share their enthusiasm with their students. We plan to involve these teachers in building a trace gas analyzer based on innovative Cavity Ring-Down Spectroscopy (CRDS) technology at BHSU that will be used to detect impurities in the Ar or Xe gases used in the MAX detectors. As part of the MAX S4 activities, Keeter will focus on integrating the Davis-Bahcall Scholarship with DUSEL in cooperation with the DUSEL education and outreach team. The QuarkNet activities are complementary in that they involve high school teachers. The synergy of the QuarkNet program and the MAX S4 education and outreach program can be leveraged to broaden the base of South Dakota high school students in the sciences.

II. BHSU PERSONNEL

This proposal requests one month of summer salary for Dan Durben, a member of the group building the CRDS system under Keeter's NSF PNA proposal (#0903335). This funding is necessary to support the development of the CRDS system when either Keeter is traveling to Princeton to work on the Princeton-Abruzzo-South Dakota summer school, or when Zehfus is traveling to the University of Virginia to consult with Kevin Lehman's group.

SALARIES & WAGES

Assuming an annual 5% increase in base (academic year) salaries:

Durben Summer support, 1 months:	**$ 6,817**	**for year 1**
Durben Summer support, 1 months:	**$ 7,158**	**for year 2**
Durben Summer support, 1 months:	**$ 7,516**	**for year 3**

FRINGE BENEFITS

25% of Salary for Senior Personnel:	**$ 1,704**	**for year 1**
	$ 1,790	**for year 2**
	$ 1,879	**for year 3**

INDIRECT COSTS

37% of all Salaries plus Fringe Benefits:	**$ 3,153**	**for year 1**
	$ 3,311	**for year 2**
	$ 3,476	**for year 3**
Total BHSU Salaries, Wages, Fringe, Indirects:	**$11,674**	**for year 1**
	$12,259	**for year 2**
	$12,871	**for year 3**

III. BHSU EQUIPMENT AND SUPPLIES

Total CRDS Equipment and Components: $ 30,000 (NOT included in MAX S4 proposal)

Funds have been requested in Keeter's NSF PNA proposal (#0903335) to purchase the necessary equipment and supplies to build a custom-designed trace gas analyzer based on Cavity Ring-Down Spectroscopy (CRDS) technology. That project is a well-defined and feasible activity that allows BHSU to contribute in a very meaningful way in the search for dark matter in the form of WIMPs. The proposed CRDS system will be optimized to measure ultra-low levels (sub-ppb range) of nitrogen, oxygen, and water contaminants in noble gases as required by both the liquid argon and the liquid xenon detectors of the MAX Collaboration (see section VII of the Project Description).

Zehfus will visit Lehmann's lab at U.Va. at the beginning of the project, and a member of Lehmann's group will travel to BHSU for the final commissioning of the system. (These funds have been requested in the NSF PNA proposal mentioned above.)

Total BHSU Costs: (Travel & Personnel only)	**$ 13,374**	**for year 1**
	$ 14,044	**for year 2**
	$ 14,745	**for year 3**

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Massachusetts Institute of Technology

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jocelyn R Monroe

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jocelyn R Monroe - Principal Investigator**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
Radon Measurement System $ **41,000**					
TOTAL EQUIPMENT				**41,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**41,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**41,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **41,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jocelyn R Monroe

ORG. REP. NAME*
Kimberly MAnn

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Massachusetts Institute of Technology

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Jocelyn R Monroe

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Jocelyn R Monroe - Principal Investigator**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ **41,000**					
TOTAL EQUIPMENT				**41,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**41,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**41,000**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **41,000**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Jocelyn R Monroe

ORG. REP. NAME*
Kimberly MAnn

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

MIT Budget Request Justification

To demonstrate reduction of radon on detector surfaces to the level of $10/m^2$/day, we propose to build a system for "spiking" samples of detector materials with radon, and measuring the resulting alpha emission from the spiked sample. After this initial step, samples will be treated or machined to remove thin surface layers, of order microns, and the alpha emission will be remeasured. In this way, we can demonstrate reduction of surface alphas by large factors. This approach of measuring large reduction factors rather than tiny intrinsic contaminations was pioneered by SNO; it is necessary here because the best alpha screening devices have sensitivities of $1/m^2$/hour, while we need to demonstrate backgrounds a factor of ~2 below this level. We propose to build an apparatus with three parts: (1) in the radon spiking part of the system, dry N_2 gas is exposed to a kBq radium source, producing gas enriched with ^{226}Ra which decays to ^{222}Rn with a half-life of 4 minutes; (2) when the connection to the radium source is closed and the gas equilibrates, the enriched gas is flowed into a vacuum chamber containing the material sample to be spiked; and, (3) after the sample exposure time, the sample is removed to an alpha spectrometer, which read out with a multi-channel analyzer via a data acquisition computer.

We request that funds for this work be disbursed fully in the first year of the grant; no funds are requested for grant years two and three. MIT plans to start work on building and commissioning the apparatus in spring and summer 2010. Once the apparatus is operational, Monroe will recruit 1-2 undergraduates, through the MIT Undergraduate Research Opportunity Program, to help screen material samples. The time scale for operation of the apparatus is 2-3 years.

Description	Quantity	Unit Price	Total
roughing pump (Adixen 210SDMLAM)	1	$1,900.00	$1,900.00
activated charcoil filter system and oil mist trap for pump exhaust (Adixen 104199 and 55014 066845)	1	$900.00	$900.00
pressure sensors (Omega PX209)	2	$200.00	$400.00
radon monitor (Tecnical Associates TBM-IC-RN)	1	$2,000.00	$2,000.00
80/20 stand hardware, fittings, and tools for mounting Rn-exposure system	1	$2,000.00	$2,000.00

Description	Quantity	Unit Price	Total
vacuum system fittings (Lesker Vacuum 10 x QF25, 50 x (1/4”) SS Swagelok, 6 x Swagelok to QF adapters, 2 x QF25 Elbow, 2 x QF25 Tee, 6 x SS swagelok valves, 100’ PTFE tubing, etc.)	1	$3,000.00	$3,000.00
6”x6”x6” acrylic top door vacuum chamber (Terra Universal 5235-02A)	1	$1,300.00	$1,300.00
required metering valves for vacuum chamber (Terra Universal 5235-09)	2	$155.00	$310.00
required vacuum gauge (Terra Universal 5235-10)	1	$190.00	$190.00
raw material samples for screening	1	$2,000.00	$2,000.00
temperature, humidity sensors, humidity filter	1	$500.00	$500.00
Ortec alpha spectrometer system (2 x 676 modules, 1 x 920E MCA, AlphaVision software)	1	$20,500.00	$20,500.00
data acquisition computer (Dell)	1	$2,000.00	$2,000.00
MIT machine shop time ($80/hour)	50	$80.00	$4,000.00
		Total	$41,000.00

MIT’s on-campus overhead rate is normally 68% MTDC, but because this proposal is only for equipment (which is not part of MTDC) 0% is applied. MIT fully supports the academic year salaries of Professors, Associate Professors and Assistant Professors but makes no specific commitment to this project other than what is stated in this proposal.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Cristiano Galbiati	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs (This proposal)

Source of Support: NSF
Total Award Amount: $ 1,746,893 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 5.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Borexino Solar Neutrino Experiment

Source of Support: NSF
Total Award Amount: $ 2,904,476 Total Award Period Covered: 03/01/08 - 02/28/11
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 2.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Study of Argon for WIMP Dark Matter Detectors and Earth Sciences

Source of Support: NSF
Total Award Amount: $ 1,884,331 Total Award Period Covered: 06/15/07 - 05/31/10
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 3.00 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: DUSEL R & D: Depleted Argon from Underground Sources

Source of Support: DOE
Total Award Amount: $ 1,666,772 Total Award Period Covered: 07/01/08 - 06/30/10
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: DUSEL R & D: Depleted Argon from Underground Sources

Source of Support: NSF
Total Award Amount: $ 1,666,771 Total Award Period Covered: 07/01/08 - 06/30/10
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 0.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Peter Meyers	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs (This Proposal)

Source of Support: NSF
Total Award Amount: $ 1,746,893 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 4.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: DUSEL R & D: Depleted Argon from Underground Sources

Source of Support: DOE
Total Award Amount: $ 1,666,772 Total Award Period Covered: 07/01/08 - 06/30/10
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 1.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: DUSEL R & D: Depleted Argon from Underground Sources

Source of Support: NSF
Total Award Amount: $ 1,666,771 Total Award Period Covered: 07/01/08 - 06/30/10
Location of Project: Princeton University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 1.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Ed Hungerford	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: CLEAR Collaborative proposal for coherent neutrino scattering at the SNS

Source of Support: National Science Foundation
Total Award Amount: $ 563,540 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: Oak Ridge National Laboratory
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Selected Experiments at Intermediate Energy

Source of Support: US Department of Energy
Total Award Amount: $ 998,646 Total Award Period Covered: 02/01/04 - 01/31/09
Location of Project: University of Houston
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: MAX - Depleted Argon TPC

Source of Support: NSF
Total Award Amount: $ 398,799 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: University of Houston
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Lawrence Pinsky	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Selected Problems in Relativistic Heavy Ion Physics in Alice

Source of Support: US DOE

Total Award Amount: $ 310,000 Total Award Period Covered: 08/15/07 - 08/14/09

Location of Project: Houston

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: ALICE MECal

Source of Support: Subcontract - Wane State

Total Award Amount: $ 15,000 Total Award Period Covered: 08/15/07 - 08/14/09

Location of Project: niversity of Houston

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: QUARKNET Program

Source of Support: Subcontract Notre Dame

Total Award Amount: $ 24,160 Total Award Period Covered: 10/01/08 - 09/30/09

Location of Project: University of Houston

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Katsushi Arisaka	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Dark Matter Search and Hadron Collider Physics with CMS at CERN

Source of Support: DOE
Total Award Amount: $ 555,000 Total Award Period Covered: 01/15/08 - 01/14/09
Location of Project: CERN, UCLA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRI: Development of a High-Speed Confocal Microscope for 4D Live-Cell Imaging

Source of Support: NSF
Total Award Amount: $ 630,616 Total Award Period Covered: 09/01/07 - 08/31/10
Location of Project: UCLA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Multipixel Hybrid Photon-Counting Detector for High-Throughput Single-Molecule Assays (Co-PI)

Source of Support: NIH
Total Award Amount: $ 66,753 Total Award Period Covered: 05/05/08 - 04/30/09
Location of Project: UCLA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.50

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Development of Spatiotemporally Multiplexed Multi-focal Multi-photon Microscope

Source of Support: NSF
Total Award Amount: $ 408,184 Total Award Period Covered: 07/01/09 - 06/30/11
Location of Project: UCLA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Dark Matter Search and Hadron Collider Physics with CMS at CERN

Source of Support: DOE
Total Award Amount: $ 543,900 Total Award Period Covered: 01/15/09 - 01/14/10
Location of Project: CERN, UCLA
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 2.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Katsushi Arisaka	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Design of a Next Generation Liquid Argon Detector (Hanguo Wang, PI)

Source of Support: NSF

Total Award Amount: $ 675,000 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: UCLA, DUSEL

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs (this proposal)

Source of Support: NSF

Total Award Amount: $ 797,001 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: UCLA

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support Statement
David B. Cline

A. Current Support:

Project Title: Experimental High Energy Physics
Source of Support: U.S. Department of Energy
Total Award Amount: $225,000 (Task B, Univ. Base Program)
$1,018,000 (Task L, Univ. Base Program Shared with 5 Faculty)
Period Covered: January 15, 2008 through January 14, 2009
Location: CERN, Fermilab, Gran Sasso, Rutherford Lab., UCLA
Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 2.50 Sumr: 1.00

Project Title: Advanced Accelerator Physics Research at UCLA
Source of Support: U.S. Department of Energy
Total Award Amount: $312,000
Period Covered: November 1, 2008 through October 31, 2009
Location: BNL, Fermilab, UCLA
Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 1.80 Sumr: 1.00

Project Title: U.S. CMS Research Program (Robert Cousins, PI)
FY2008 UCLA EMU M&O Personnel Support
Source of Support: National Science Foundation
Total Award Amount: $99,780
Period Covered: November 1, 2007 through October 31, 2008
Location: CERN
Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.00

Project Title: A Fiber Research & Development Study for the NOvA Experiment at Fermilab
Source of Support: Fermi National Accelerator Laboratory
Total Award Amount: $69,500
Period Covered: June 1, 2006 through December 31, 2008
Location: UCLA
Person-Months Per Year Committed to the Project: Cal: 0.50 Acad: 0.00 Sumr: 0.00

Project Title: Discretionary Funding for Research Opportunities
Source of Support: University of California, Los Angeles
Total Award Amount: $15,000
Period Covered: July 1, 2008 through June 30, 2009
Location: UCLA
Person-Months Per Year Committed to the Project: Cal: 0.50 Acad: 0.00 Sumr: 0.00

B. Pending Support:

Project Title:	Experimental High Energy Physics
Source of Support:	U.S. Department of Energy
Total Award Amount:	$220,500 (Task B, Univ. Base Program) $1,033,000 (Task L, Univ. Base Program Shared with 5 Faculty)
Period Covered:	January 15, 2009 through January 14, 2010
Location:	CERN, Fermilab, Gran Sasso, Rutherford Lab., UCLA

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 2.50 Sumr: 1.00

Project Title:	Liquid Argon R&D for Large Detectors following P5 Recommendations
Source of Support:	National Science Foundation
Total Award Amount:	$ 671,885
Period Covered:	April 1, 2009 through March 31, 2011
Location:	CERN, UCLA, UTD

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.00

Project Title:	Collaborative Proposal: Continuation of the Xenon Dark Matter Project: Construction and Underground Operation of an Upgraded XENON100 Detector (Hanguo Wang, PI)
Source of Support:	National Science Foundation
Total Award Amount:	$ 1,015,018
Period Covered:	April 1, 2009 through March 31, 2012
Location:	Gran Sasso, Columbia, UCLA

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.50

Project Title:	Simulation of Active Detection Methods for Fissile Matter and the Danger to Humans
Source of Support:	Defense Threat Reduction Agency
Total Award Amount:	$ 184,383
Period Covered:	January 1, 2009 through December 31, 2010
Location:	UCLA

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.33

Project Title:	U.S. CMS Research Program (Robert Cousins, PI) FY2009 UCLA EMU M&O Personnel Support
Source of Support:	National Science Foundation
Total Award Amount:	$99,264
Period Covered:	November 1, 2008 through October 31, 2009
Location:	CERN

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.00

Project Title:	Collaborative Research: Design of a Next Generation Liquid Argon Detector (Hanguo Wang, PI)
Source of Support:	NSF
Total Award Amount:	$675,000
Period Covered:	July 1, 2009 through June 30, 2012
Location:	UCLA, DUSEL

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.00

Project Title:	Collaborative Research: MAX – Multi-ton Argon and Xenon TPCs (Co-PI) (Katsushi Arisaka, PI) (this proposal)
Source of Support:	National Science Foundation
Total Award Amount:	$797,001
Period Covered:	July 1, 2009 through June 30, 2012
Location:	UCLA, DUSEL

Person-Months Per Year Committed to the Project: Cal: 0.00 Acad: 0.00 Sumr: 0.00

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Hanguo Wang	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Request for Continued Operation and Study of the ZEPLIN II

Source of Support: NSF

Total Award Amount: $ 210,000 Total Award Period Covered: 09/01/07 - 08/31/09

Location of Project: Boulby Mine, UK and UCLA

Person-Months Per Year Committed to the Project. Cal: 2.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Request for UCLA Participation in the XENON100 Liquid Xe Dark Matter Detector

Source of Support: NSF (sub-award through Columbia University)

Total Award Amount: $ 120,000 Total Award Period Covered: 04/01/08 - 03/31/09

Location of Project: UCLA, Columbia, Gran Sasso

Person-Months Per Year Committed to the Project. Cal: 2.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: DUSEL R&D: New WIMP Detector Technique based on High Pressure Xenon

Source of Support: NSF

Total Award Amount: $ 25,200 Total Award Period Covered: 07/15/08 - 06/30/09

Location of Project: UCLA, TAMU, SUSEL

Person-Months Per Year Committed to the Project. Cal: 0.50 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Liquid Argon R&D for Large Detector following P5 Recommendations (Co-PI)

Source of Support: NSF

Total Award Amount: $ 671,885 Total Award Period Covered: 04/01/09 - 03/31/11

Location of Project: CERN, UCLA, UTD

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Proposal: Continuation of the Xenon Dark Matter Project: Construction and Underground Operation of an Upgraded XENON100

Source of Support: NSF

Total Award Amount: $ 1,015,108 Total Award Period Covered: 04/01/09 - 03/31/12

Location of Project: Gran Sasso, UCLA, Columbia University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 2.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Hanguo Wang	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Design of a Next Generation Liquid Argon Detector

Source of Support: NSF

Total Award Amount: $ 675,000 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: UCLA, Homestake, Minnesota

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs (this proposal)

Source of Support: NSF

Total Award Amount: $ 797,001 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: UCLA

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: C. J. Martoff	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Experiments in Particle Astrophysics

Source of Support: Fermi National Accelerator Lab
Total Award Amount: $ 18,711 Total Award Period Covered: 01/01/09 - 08/31/09
Location of Project: Temple University and Fermi Lab
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Experiments in Particle Astrophysics

Source of Support: Fermi National Accelerator Lab
Total Award Amount: $ 59,406 Total Award Period Covered: 11/01/08 - 08/31/09
Location of Project: Temple University and Fermi Lab
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 1.00 Sumr: 3.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

Uwe Oberlack – Principal Investigator (Rice University)

SUPPORT: Current
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The XENON Dark Matter Project: Construction and Underground Operation of a 100 kg Detector
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $275,000
TOTAL AWARD PERIOD: 04/01/08 - 03/31/09
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Sumr: 2

SUPPORT: Current
PROJECT/PROPOSAL TITLE: A Study of Liquid Xenon Detectors with Enhanced Spectroscopy and Time-of-Flight Background Rejection for an Advanced Compton Telescope
SOURCE OF SUPPORT: NASA
TOTAL AWARD AMOUNT: $618,800
TOTAL AWARD PERIOD: 02/01/05 - 1/31/09
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Sumr: 1

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The XENON Dark Matter Project: Construction and Underground Operation of an Upgraded XENON100 Detector
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $1,231,500
TOTAL AWARD PERIOD: - 04/1/2009-03/31/2012
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Sumr: 2

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: (THIS PROPOSAL) Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $259,027
TOTAL AWARD PERIOD: - 7/1/2009-6/30/2012
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Sumr: 0

Current and Pending Support

Petr Chaguine (Shagin) – Research Scientist (Rice University)

SUPPORT: Current
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The XENON Dark Matter Project: Construction and Underground Operation of a 100 kg Detector
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $275,000
TOTAL AWARD PERIOD: 04/01/2008 - 03/31/2010
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS COMMITTED TO PROJECT (total): 12 (completed before start of this proposal)

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The XENON Dark Matter Project: Construction and Underground Operation of an Upgraded XENON100 Detector
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $1,231,500
TOTAL AWARD PERIOD: - 04/1/2009-03/31/2012
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: 12 - 9 - 6 (yr1 - yr2 - yr3)

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: (THIS PROPOSAL) Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: $259,027
TOTAL AWARD PERIOD: - 7/1/2009-6/30/2012
LOCATION OF PROJECT: Rice Univeristy
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: 6

CURRENT AND PENDING SUPPORT: Elena Aprile, Principal Investigator

SUPPORT: Current
PROJECT/PROPOSAL TITLE: A Study of Liquid Xenon Detectors with Enhanced Spectroscopy and Time-of-Flight Background Rejection for an Advanced Compton Telescope
SOURCE OF SUPPORT: NASA NNG05WC31G
TOTAL AWARD AMOUNT: 216,400
TOTAL AWARD PERIOD: 2/1/05 – 1/31/09
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Summer: 1 mos.

SUPPORT: Current
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The Xenon Dark Matter Project: Construction and Operation of a 100 Kg Detector
SOURCE OF SUPPORT: NSF PHY 07-05337
TOTAL AWARD AMOUNT: 2,158,605
TOTAL AWARD PERIOD: 4/1/08 – 3/31/10
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Summer: 2 mos.

SUPPORT: Pending*
PROJECT/PROPOSAL TITLE: Collaborative Proposal: Continuation of the Xenon Dark Matter Project: Construction and Underground Operation of an Upgraded XENON100 Detector
SOURCE OF SUPPORT: NSF (PNA)
TOTAL AWARD AMOUNT: 3,299,984
TOTAL AWARD PERIOD: 4/1/09 – 3/31/12
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Summer: 2 mos.

SUPPORT: Pending* (to be submitted in the near future: 1/22/09)
PROJECT/PROPOSAL TITLE: Instrument Development for the XENON Dark Matter Search: An Atom Trap Trace Analysis System to Measure Kr/Xe at the ppt Level
SOURCE OF SUPPORT: NSF (MRI)
TOTAL AWARD AMOUNT: 1,129,110 requested, 1,613,015 (with 30% cost share)
TOTAL AWARD PERIOD: 8/1/09 – 7/31/12
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Summer: 1 mos.

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: (This Proposal) Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: 606,516
TOTAL AWARD PERIOD: 7/1/09 – 6/30/12
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Academic: 1 mos. (no salary)

---

*If the XENON100 renewal and the MRI are both approved, the PI will only take 1 month paid salary form the XENON100 project, instead of the proposed 2 months.

SUPPORT: Pending (supplemental request)
PROJECT/PROPOSAL TITLE: Collaborative Proposal: The Xenon Dark Matter Project: Construction and Operation of a 100 Kg Detector
SOURCE OF SUPPORT: NSF PHY 07-05337
TOTAL AWARD AMOUNT: 75,500 (supplemental request)
TOTAL AWARD PERIOD: 4/1/08 – 3/31/10
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Summer: 2 mos.

CURRENT AND PENDING SUPPORT: Karl Giboni, Co-Investigator

SUPPORT: Pending
PROJECT/PROPOSAL TITLE: As Co-I, (This Proposal) Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs
SOURCE OF SUPPORT: NSF
TOTAL AWARD AMOUNT: 606,516
TOTAL AWARD PERIOD: 7/1/09 – 6/30/12
LOCATION OF PROJECT: Columbia University
PERSON-MONTHS PER YEAR COMMITTED TO PROJECT: Calendar: 4 mos.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Andrew Alton	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs (this submission)

Source of Support: NSF
Total Award Amount: $ 33,408 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: DUSEL, Princeton University
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: SNO+ and DArTPC Collaboration Activities in Underground Particle Astrophysics

Source of Support: NSF
Total Award Amount: $ 10,960 Total Award Period Covered: 06/01/09 - 05/30/12
Location of Project: DUSEL, Black Hills State University and Princeton University
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: 1.00 Sumr: 1.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Searching for Physics Beyond the Standard Model in Data with Two Bosons

Source of Support: Research Corporation
Total Award Amount: $ 37,780 Total Award Period Covered: 05/01/09 - 02/01/11
Location of Project: Augustana College and Fermi National Accelerator Laboratory
Person-Months Per Year Committed to the Project. Cal: 2.00 Acad: 2.00 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Center for Detecting Rare Physics Processes with Ultra-Low Background Experiments at Sanford Lab

Source of Support: State of South Dakota
Total Award Amount: $ 59,077 Total Award Period Covered: 06/01/09 - 05/30/14
Location of Project: Travel to DUSEL
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Andrea Pocar	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPC (this proposal)

Source of Support: NSF
Total Award Amount: $ 40,000 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: University of Massachusetts, Amherst
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Neutrino-less double beta decay with EXO-200 and EXO

Source of Support: NSF
Total Award Amount: $ 791,166 Total Award Period Covered: 06/01/09 - 05/31/12
Location of Project: University of Massachusetts, Amherst
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Startup funds

Source of Support: University of Massachusetts, Amherst
Total Award Amount: $ 465,000 Total Award Period Covered: 01/25/09 - 08/31/11
Location of Project: University of Massachusetts, Amherst
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Solar Neutrino Science with Borexino

Source of Support: NSF
Total Award Amount: $ 397,979 Total Award Period Covered: 03/01/09 - 02/29/12
Location of Project: University of Massachusetts, Amherst
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Micheal Zehfus	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs (this proposal

Source of Support: NSF

Total Award Amount: $ 42,163 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: Black Hills State University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: SNO+ and DArTPC Collaboration Activities: Underground Particle Astrophysics at Black Hills State University

Source of Support: NSF

Total Award Amount: $ 693,689 Total Award Period Covered: 06/01/09 - 05/31/12

Location of Project: Black Hills State University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Dan Durben	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: SNO+ and DArTPC Collaboration Activities: Underground Particle Astrophysics at Black Hills State University

Source of Support: NSF

Total Award Amount: $ 693,689 Total Award Period Covered: 06/01/09 - 05/31/12

Location of Project: Black Hills State University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs (this proposal)

Source of Support: NSF

Total Award Amount: $ 42,163 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: Black Hills State University

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Kara Keeter	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: SNO+ and DarTPC Collaboration Activities: Underground Particle Astrophysics at Black Hills State University

Source of Support: NSF
Total Award Amount: $ 693,689 Total Award Period Covered: 06/01/09 - 05/31/12
Location of Project: Black Hills State University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Assay and Acquisition of Radiopure Materials

Source of Support: NSF
Total Award Amount: $ 1,234,600 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: Homestake, South Dakota
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 1.00 Sumr: 0.50

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: An Underground Collaboration:ISU's Contribution to SNO+ and SNO++

Source of Support: NSF
Total Award Amount: $ 235,000 Total Award Period Covered: 08/15/07 - 07/31/09
Location of Project: Sudbury Neutrino Observatory site, SNOLAB, Sudbury Ontario
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 3.00 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs (this proposal)

Source of Support: NSF
Total Award Amount: $ 42,163 Total Award Period Covered: 07/01/09 - 06/30/12
Location of Project: Black Hills State University
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jocelyn Monroe	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Measuring gas quenching for fundemental physics and homeland security

Source of Support: Dept. of Energy

Total Award Amount: $ 43,500 Total Award Period Covered: 05/01/09 - 04/30/10

Location of Project: MIT

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: MAX - Multi-ton Argon and Xenon TPCs (this proposal)

Source of Support: NSF

Total Award Amount: $ 41,000 Total Award Period Covered: 07/01/09 - 06/30/12

Location of Project: MIT

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

FACILITIES, EQUIPMENT AND OTHER RESOURCES AT PRINCETON UNIVERSITY

LABORATORY SPACE

The Physics Department of Princeton University provides the large space necessary for the laboratory activities. A new lab with a 12' height and an area of 20'x60' was assigned in 2007 for the development of PSA units. Space is available for the installation of the 30' prototype cryogenic distillation column (and of the 60' large-scale column) in the storage area for gas and liquid nitrogen, close to the Physics Department loading dock.

SPECIAL FACILITIES

A very large, class-100 clean room with a PSA filter for Rn suppression is available. The clean room was built and used for the construction of the Borexino nylon vessels. It was also used for the assembly of the Borexino purification plants. We plan to make extensive use of this facility, for pre-assembling in clean conditions certain parts of the noble liquid TPCs

MAJOR EQUIPMENTS AND OTHER RESOURCES

The Physics Department of Princeton University will grant access to the mechanical shop and to the electronics shop. The Department also employs an excellent electronics engineer, who is available to work as a consultant on the project. Other equipment available includes a variety of vacuum equipments and detectors, including dewars, turbopumps, Helium leak checker, and quadrupole mass spectrometers.

OFF-CAMPUS RESOURCES

Princeton personnel will have access at off-campus facilities of participating institutions, most notably at Fermilab and Temple University.

FACILITIES, EQUIPMENT, AND OTHER RESOURCES
at the UNIVERSITY OF HOUSTON

Computation and Simulation Facilities

The group has a cluster of 15 networked PC computers running LINUX. These machines are used for data analysis, computer simulation, and routine storage and file manipulation. The group has developed an electronic design and fabrication facility, and we are able to simulate, using professional software, circuits with mixed digital and analog signals. We also have available additional University cluster computing at reasonable cost.

Test and Design Facilities

The group has modest electronic test facilities, including fast, digital oscilloscopes, and network analyzers. We share additional test equiplent and computer aided design and simulation software with the department of Electrical Engineering for which we share license costs at a significant educational discount.

Laboratory Space and Other Resources

The group has adequate laboratory and office space for the proposed work, and access to the departmental machine shop at a subsidized rate. Finally, we can have available the services of a mechanical design engineer and an electronic design physicist in addition to the proposed hire. Both of these individuals retired from the group, but will work part time as needed.

Facilities, Equipment and Other Resources at UCLA

PI (Prof. Arisaka) has extensive experience in hardware development at UCLA for 20 years. Two major laboratories described below will be available for the proposed development of the QUPID.

Photon Detector Laboratory

The Photon Detector Laboratory (PDL) is housed in 1000 sq ft of laboratory space in Knudsen Hall and it has been maintained by Arisaka for the last two decades. This lab has the infrastructure to characterize photon detectors. The system includes the following:

- Quantum Efficiency measurement by automated wavelength scanning
- Gain and dark current measurement
- Photo-electron correction efficiency and dark pulse rate measurement
- 3-dimentionall scanner to scan the surface of a photon detector to measure position resolution, uniformity and cross talk.
- Temperature cycling system to measure temperature dependence.
- Pico second pulsed laser and fast TDC for time resolution study.

Major Equipment includes:

- CAMAC based multi channel data acquisition systems (up to 32 channels.)
- GHz bandwidth oscilloscopes
- Pico second laser (PLP-01 from Hamamatsu)
- Ti:Sa pulsed laser
- Various pulsed LED light sources
- Four dark boxes with optical bench

Dark Matter Laboratory

The Dark Matter Laboratory is housed in 1400 sq ft of laboratory space on the basement of the new PAB (Physics and Astronomy) Building. This lab is equipped with the following systems:

- Cryogenic system for liquid Xenon and liquid Argon detectors. (It has been used as a test bench for ZEPIN and LUX experiments).
- High-speed DAQ system, composed of a Aquiris 500 MHz FADC. (This will be used as a two channel QUPID readout system)

Other Facilities

In addition to above two laboratories, the following conventional facilities are available in Knudsen Hall.

Computer: 10 PCs are available for office use and instrumentation control. We also have a computer farm consisting of 36 PCs for numerically extensive simulations. MC simulation for this proposal was performed by this computer farm.

Office Space: In addition to office spaces for Arisaka and Wang, 600 sq ft of office space is available for graduate students and undergraduate students.

Machine Shop: The Department of Physics and Astronomy houses an extensive machine shop 50% subsided by the department. As a number of holders, adapters, and various mounting elements are required to optimize the geometry of the measurement configurations, these will all be custom-designed and machined in the departmental shop.

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory: Temple University

Clinical: n/a

Animal: n/a

Computer: Linux workstations and data acquisition computers suitable for simulation and engineering design work,

Office: We have offices.

Other:

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

This is an engineering-design only proposal so research equipment is not particularly relevant.

The Temple group possesses a 950 square foot Class 1000 clean room with versatile thin film deposition and patterning facilities; a 1200 square foot detector lab with vacuum and gas chambers for testing negative ion and other gas detectors and data acquisition and nuclear counting

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

The Temple Physics department possesses a staffed machine shop and electronics shop available to the project on a recharge basis, as well as basic secretarial and office services.

Continuation Page:

MAJOR EQUIPMENT (continued):

electronics.

Facilities, Equipment, and other Resources
Rice University

Laboratory

The Rice P.I.'s laboratory for high-energy and particle astrophysics is a modern lab with $>$ 1000 sqft area, and is equipped with tools and instruments necessary for liquid xenon detector, radiation instrumentation, and photosensor R&D. A cleanroom with a horizontal flow bench can produce locally class 100 air conditions, and class 1000 throughout the cleanroom. A xenon gas purification and recirculation system, as well as vacuum and cryogenic equipment is available for work on LXe detectors. The lab has a spot welding facility available, which can be used, e.g., for attachment of electrode meshes to support frames.

Clinical

None.

Animal

None.

Computer

A Linux cluster and several PC?s are available for data analysis, field simulations, Monte Carlo simulations, presentation and publication preparation. A departmental research computing center offers additional computing power for heavy-duty numerical work. In addition, Rice has large computing facilities that can be used on demand.

Office

Office space is available for all personnel and students both inside the Space Science lab, and in an adjacent office building.

Other Resources

The Rice machine shop is located right across the Oberlack lab.

Facilities, Equipment, and Other Resources

COLUMBIA UNIVERSITY

LABORATORY

Nevis Laboratory, located in Irvington, NY, is Columbia University's primary center for reseach in high energy and particle astrophysics, particle physics and nuclear physics. Major experiments are assembled and tested at Nevis and then shipped to their final destination.

The laboratory facilities of the investigators in this proposal are located in the Cyclotron Building at Nevis. Its 30,000 square feet of laboratory space are currently home to the activities of the Columbia Astrophysics Laboratory. All the different prototypes of various sizes for XENON were tested and operated here. Also, the XENON10 detector was assembled, tested and readied for shipment to the LNGS in this location. For XENON100, several components were tested and assembled at Nevis prior to shipping to LNGS. The building contains a high bay (including an 40 T overhead crane), a suite of 8 modern, self-contained laboratory modules and office and meeting space for faculty, students and staff. Some of the lab spaces are extremely large and are reconfigured according to projects underway. For the area occupied by our group the electrical power system was recently overhauled by adding an additional 200 A 3 phase connection. A 15 kW back up Motor generator was added in 2006 to support the long time test for XENON10. Additional office space for data analysis on XENON10 was also constructed during 2006.

In addition there is an accelerator which is used to generated a tunable, monochromatic neutron beam and a class 1000 clean room containing a $150,000 Zygo interferometer. During the Summer 2007, the neutron beam was used for new measurements of the scintillation efficiency of Xe ions in LXe. The large clean room facility is used for optical assemblies as well as activities which require a controlled, clean environment, such as assembling the TPCs of XENON. The Nevis machine shop is equipped with a large variety of conventional and CNC milling machines, and various other types of machines. It does precision grinding, sheet metal fabrication and tungsten inert gas welding. The shop works with ferrous and non-ferrous metals, plastics, scintillators, teflon and other materials. There is extensive experience in high vacuum systems and high vacuum welding techniques. An electronics and microcircuits lab includes about 10 engineers and technicians and a complete suite of equipment for the design, fabrication and testing of microelectronic circuitry both analog and digital.

Administrative staff and procurement specialists are on-site who work with the NSF/particle-nuclear physics people at Nevis and a separate group from the Columbia Astrophysics Laboratory supports the activities of XENON and other projects handled by CAL.

OFFICE

The PI and senior personnel have office spaces in the Morningside Campus of Columbia University. Prof. Aprile also has modern laboratory space on campus where R&D projects are carried out with undergraduate/graduate students' involvement.

FACILITIES, EQUIPMENT AND OTHER RESOURCES AT AUGUSTANA COLLEGE

LABORATORY SPACE

The Physics Department of Augustana College provides a space for the laboratory activities. A lab with 9' height and an area of 20'x25' is available for any activities that require a larger space. And a lab with an area of 15'x18' can be devoted to MAX activities.

COMPUTER FACILITIES

In addition to the PI's two personal machines, there are number of departmental computers that can be used for dark matter activities. The school also has a four node parallel processor cluster that the PI can make almost exclusive use of. Until recently it was used for simulations of ~100 atom interactions, however it is now unused.

OFFICE SPACE

The Physics Department provides generous office space for the PI, this includes secretarial support and printer/fax/etc. The department will provide similar space and personal computers for students working on the project, who will be funded from other sources.

FACILITIES, EQUIPMENT AND OTHER RESOURCES AT THE UNIVERSITY OF MASSACHUSETTS

LABORATORY SPACE

600 square foot laboratory with a 100 square foot clean room in an adjacent, 500 square foot laboratory (ventilation in place to achieve Class 1000), clean power and wet bench.

OFFICE

The PI has permanent office space in the physics department and students and post-docs are assigned shared space once they join the project

MAJOR EQUIPMENTS AND OTHER RESOURCES

The UMass Physics Department has an excellent machine shop facility with technicians for use by faculty, students, and post-docs. A well stocked materials and laboratory supplies store at the basement of the building that houses the PI's office and lab spaces.

FACILITIES, EQUIPMENT AND OTHER RESOURCES AT BLACK HILLS STATE UNIVERISTY

OFFICE SPACE

All senior personnel at BHSU have offices and access to office support equipment such as printers, copiers and fax machines and poster-size printing.

OTHER

Black Hills State is the home of the Center for the Advancement of Mathematics and Science Education (CAMSE), which can supply significant education and outreach support as well as extensive distance learning capabilities.

MAJOR EQUIPMENTS AND OTHER RESOURCES

Cavity Ring-Down Spectrometer for detection of sub-ppb impurities in Argon or Xenon

Funds have been requested in Keeter's NSF PNA proposal (#0903335) to purchase the necessary equipment and supplies to build a custom-designed trace gas analyzer based on Cavity Ring-Down Spectroscopy (CRDS) technology at Black Hills State. The proposed CRDS system will be optimized to measure ultra-low levels (sub-ppb range) of nitrogen, oxygen, and water contaminants in noble gases as required by both the liquid argon and the liquid xenon detectors of the MAX Collaboration (see section VII of the Project Description).

Very few commercial instruments are capable of detecting gas impurities below the 1 ppb level, and these instruments are designed to detect only a single impurity. The Tiger Optics LaserTrace System is a modular system that can detect O_2 at the 0.1 ppb level and H_2O at the 0.2 ppb level with the appropriate modules. However, after consulting with Kevin Lehmann, the inventor of the Tiger Optics system, it is believed that we can build an instrument with significantly better improved sensitivity. By changing the design of the instrument we expect to obtain sensitivities up to 10x lower (0.01 ppb) than any commercially available instrument for O_2 or H_2O, and, by exciting the metastable triplet states of N_2 by collision with metastable Ar produced in a discharge, we expect to also be able to detect N_2 at these levels as well.

The BHSU group greatly appreciates the input and assistance of Kevin Lehmann in the design of this CRDS system, and of his willingness to advise us in the commissioning of the system.

Facilities and Other Resources

The proposed research program will be carried out on the MIT campus, in an existing laboratory where Monroe currently works. We will use a residual gas analyzer apparatus currently operating in the Monroe laboratory to support the radon-enriched gas system development, as well as dry N_2 gas, NIM power supplies, and cables, to support the alpha spectrometer work. We will make use of the MIT machine shop for the fabrication of the apparatus. We will obtain radioactive sources for producing radon-enriched gas, and for alpha detector calibration, from the MIT Office of Environmental Safety and Health, and work with the MIT Laboratory for Nuclear Science safety officer to ensure compliance with radon safety standards.

ASU COLLEGE of LIBERAL ARTS & SCIENCES
ARIZONA STATE UNIVERSITY

Department of Physics
PO Box 871504
Tempe, AZ 85287-1504

(480) 965-3561
Fax: (480) 965-7954
physics.asu.edu

January 4, 2009

Professor
Cristiano Galbiati
Department of Physics
Princeton University
Princeton, NJ 08544

Dear Cristiano,

I am writing to state my strong support for the proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs", which is about to be submitted to the NSF by Princeton and the other institutions of the collaboration.

My group at Arizona State University has extensive experience in the fine element calculations of electromagnetic fields. This is particularly relevant to the electric field modeling of the proposal time-projection-chamber (TPC). As a matter of fact, one of my graduate students has already produced a preliminary modeling of the TPC field. We expect this to be relevant to other areas of the proposal research such as physics simulations, choice of materials, etc.

As you know the Department of Physics here at ASU has identified particle astrophysics as one of its growth areas. Dark matter detection experiments are considered to be a central part of this endeavor. This also fits extremely well with a university wide cosmology initiative that involves the School of Earth and Space Exploration and other ASU centers in addition to the Department of Physics.

I am very excited about the prospects of major dark matter detection experiments here in the US. I am sure this extends to ASU graduate and undergraduate students and postdoctoral fellows who may be available to significantly contribute in this scientific journey.

Sincerely,

Ricardo Alarcon
Professor of Physics

AUGUSTANA COLLEGE

January 5, 2008

Dr. Andrew Alton
Department of Physics
2001 S. Summit Avenue
Augustana College
Sioux Falls, SD 57197

Dear Dr. Alton:

Thank you for your work on the NSF Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs at Sanford Lab/DUSEL. I am writing to confirm that Augustana College endorses the proposal for an experiment at DUSEL and to confirm that we support the efforts of our faculty to make this project a success.

Augustana College is happy to be a partner in this research. We agree that the Sanford Lab and DUSEL especially this proposal represents an important opportunity to advance research in South Dakota and at Augustana College. This proposal will provide a necessary platform to encourage active involvement by scientists in the state's colleges and universities with experts in the field from across the nation and internationally.

Once again, thank you for contributing in the effort to put together this significant proposal. Please let me know if I can be of additional assistance.

Sincerely,

Mark. J. Braun, Ph.D.
Senior Vice President for Academic Affairs
Dean of the College

CC: Dr. Michael Wanous, Natural Science Division Chair
Dr. Eric Wells, Chair, Department of Physics
Ms. Christina Salem, Director of Grants

KINDER MORGAN
CO_2 COMPANY, L.P.

January 6, 2009

To whom it may concern:

This letter is written in support of the request for funding submitted by Princeton University and its partners for the development of a "MAX – Multi Ton Argon and Xenon", a large scale search for Dark Matter at the future Deep Underground Laboratory for Science and Engineering (DUSEL).

Kinder Morgan CO2 Company, L.P. ("Kinder Morgan") owns production rights for the CO2 source at Doe Canyon, located near Cortez, in Dolores County, Colorado. This source of mantle gas contains a very large fraction of noble gases, helium and argon. This CO2 reservoir has the highest noble gases concentration currently in production.

Kinder Morgan partnered with Princeton University in the extraction of argon gas from the Doe Canyon reservoir for use in direct dark matter searches. During 2008, Kinder Morgan and Princeton University agreed, executed, and implemented two "Facility Access Agreements" that allowed researchers from Princeton University to work on the premises of Kinder Morgan near Cortez, Colorado.

Under the provisions of the first agreement, researchers from Princeton University mapped the content of helium and argon in six wells in the Doe Canyon reservoir during August, 2008. This initial effort resulted in the determination that the argon in the Doe Canyon reservoir is depleted of the radioactive 39Ar.

The second agreement permitted the Princeton researchers access to the new Kinder Morgan Compressor Station at Doe Canyon. In their recent effort during December 2008, the Princeton researchers installed a 12'x15' plant for the separation of argon from CO2, and collected a first massive sample (~1 kg) of argon from Doe Canyon.

Kinder Morgan values the NSF-sponsored research that is contributing to advancing mankind's understanding of the Universe. We strongly support the effort of the Depleted Argon TPC collaboration led by Princeton University toward the development of a large argon detector for dark matter at DUSEL.

We look forward to continuing our co-operation with the Princeton University researchers and their partners in the extraction of depleted argon from the Doe Canyon Reservoir. We will continue to strongly support the effort of the Depleted Argon TPC

500 Dallas, Suite 1000 Houston, TX 77002 713/369-9113 Fax: 713/369-9195

collaboration to extract very large quantities of argon at Doe Canyon, if the Princeton University effort is chosen as a candidate for the initial group of experiments at DUSEL.

We draw to your attention that Kinder Morgan and Princeton University have already agreed on terms, as executed in the second Facility Access Agreement, for the collection of larger argon samples, on the order of 100 kg, which may allow the collaboration to deploy a first depleted argon detector in the near future. We are looking forward to the opportunity of supporting the work of the Princeton-led collaboration in the extraction of the material necessary for a larger scale search at DUSEL.

Please call me at 713-369-9113 if you have any questions.

Sincerely yours,

Kenneth H. Havens Jr.
Director of Source and Transportation

500 Dallas, Suite 1000 Houston, TX 77002 713/369-9113 Fax: 713/369-9195

THE LINDE GROUP

Linde

January 1, 2009

575 Mountain Avenue
New Providence, NJ 07974
Telephone: +1 (908) 771-6104
Fax: +1 (908) 771-6105
Email: art.shirley@linde.com

To whom it may concern:

This letter is written in support of the request for funding submitted to the National Science Foundations by Princeton University, Columbia University, and other institutions collaborating to "MAX – Multi Ton Argon Xenon".

We are thrilled to learn of the NSF plans for the start of design and engineering of a Deep Underground Laboratory for Science and Engineering. In consideration of our strong interest in the market for special gases, we are excited about the impending partnership with the MAX collaboration for the development of depleted argon and xenon detectors for dark matter.

Linde North America, Inc. (Linde USA) played a significant role in the research of underground argon for dark matter detectors. The support of Linde USA has enabled the first discovery of underground sources of depleted argon. Linde employees in Murray Hill, NJ, and Otis, KS, have been involved in the Princeton-led exploration of ^{39}Ar activity since the very beginning of this effort, in May 2006. We were pleased by the news that the argon gas in the National Helium Reserve contains a low activity in ^{39}Ar. We understand that the low level of ^{39}Ar in the gas makes this material suitable for the construction of large detectors for the study of elusive particles that may have played an important role in the evolution of the Universe.

Linde Global Helium, a division of Linde Gas North America LLC owns, through its subsidiary Kansas Global Helium, the largest helium production plant on US soil. The plant is located in Otis, Kansas, and processes a crude helium stream carried from the National Helium Reserve, located in Amarillo, TX, through the Helium Conservation Pipeline. It is the ideal facility for collection of argon from the Reserve. Six Linde employees - Dr. Art Shirley, Dr. Frank Fitch, Tom Pivonka, Lloyd Basgall, Terry Highfill, and Rosemary Highfill - and one former BOC employee and current consultant - Prof. Alberto LaCava - provided crucial help for the sampling of gas from the production plant in Otis, and are co-authors of a paper on the first ever measurement of ^{39}Ar from natural-gas originated streams. We are pleased at the possibility that gas processed through the Linde production facility in Kansas may play an important role in an important scientific endeavor, and may represent one of the assets of the future Deep Underground Laboratory in the United States (DUSEL). We look forward to continue the co-operation with Princeton University and its partners in this enterprise. We look forwards as well to the possibility of starting larger scale production of argon originating from the Helium National Reserve.

We would be an enthusiastic industrial partner in the exploitation of the argon contained in the National Helium Reserve for a large scale dark matter search at the upcoming DUSEL based on our expectation that this argon can be produced in an economically and environmentally sustainable fashion without significant impact on current Linde helium production or the integrity of the National Helium Reserve. As part of the current funding request, Linde would undertake engineering studies to select the best technical options for the collection, purification, storage and transportation of the ^{39}Ar from the crude helium, perform a detailed engineering design for the new equipment to be installed including integration of this equipment with existing operations and undertake detailed helium sustainability as well as environmental impact and safety assessments.

We realize that the argon gas contained in the Reserve represents a potentially valuable resource for the physics community. Given the current rate of depletion of the gas in the Reserve, we recognize the importance of taking soon the steps necessary to extract the argon, so as to extract as much as possible of this limited resource before it is exhausted.

We understand that a second option for the depleted argon source is under evaluation - the CO_2 stream at Doe Canyon, Colorado. Upon the assessment of the content of ^{39}Ar at the two sources, the MAX collaboration may decide to focus its efforts for extraction of depleted argon in that source. We would remain equally interested in performing the detailed engineering design for extraction and purification equipment. Indeed, many of the components of the system would be similar to those needed for the extraction and purification of gas from the National Helium Reserve.

Cryogenic distillation is an integral part of the plans for purification of the argon gas and offers an interesting synergy with the xenon portion of the project. Linde USA can bring to the table the wealth of expertise coming from the recent acquisition of Spectra Gases Inc., a company specialized in high purity gases which is among the latest arrival in our corporate family. Spectra Gases played a crucial role in the purification from Krypton impurities of the target for the XENON-100 programs. Linde USA can provide the unique expertise required for the design of a cryogenic distillation column for purification of the targets for MAX.

We estimate the cost for a preliminary engineering design of the argon extraction plants and for the cryogenic column at $300,000, spread over three years. Provisional estimate for the costs of construction for the plants are in the range $2-4 millions.

In a recent visit to LNGS in Italy, I had the opportunity of visiting and exploring the large number of experiments relying on the use of ultra high-purity gases – Borexino, WARP, XENON, ICARUS, CUORE, to name a few. Linde Gas Italia S.r.l., another member of our corporate family, is the general contractor of LNGS for the supply of high purity gases. We hope Linde USA may develop an equally strong partnership with the DUSEL Lab. We would be particularly interested in developing technological partnerships for the development of very large argon neutrino detectors a la ICARUS, should they be considered for the DUSEL program.

As another example of the support given by Linde to the physics community, the helium chilling system installed in CERN's LHC - or Large Hadron Collider's underground circuit near Geneva was designed, constructed and installed by the Linde subsidiary, Linde Kryotechnik AG – whose headquarters are in Pfungen, Switzerland. Linde Kryotechnik AG was awarded the 'Golden Hadron Award' by CERN in 2003 for its outstanding achievements.

Dr. Aldo Belloni, member of the Executive Board of Linde AG, said in a press release on the opening of the LHC "We are pleased to be able to contribute our expertise to this unique, fundamental research project"... "After years of planning and preparation, we are now glad that we can make our contribution toward the attainment of new scientific insights." We look forward to accompany, as a strong corporate partner, the MAX collaboration and the larger DUSEL community in an equally compelling path of discovery.

Best Regards,

Dr. Arthur Shirley
Head Chemistry and Energy, Application Development
Linde North America, Inc.

RESEARCH INSTITUTE FOR
SCIENCE AND ENGINEERING,
WASEDA UNIVERSITY

3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan

Professor Elena Aprile
Columbia University
Physics Department
New York, NY 10027

January 2nd , 2009

Dear Prof. Elena Aprile,

It is my wish to express my strong support of the DUSEL S4 proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs" which is being prepared for submission to the NSF.

We remain enthusiastic of being part of the XENON collaboration, and we realize that DUSEL presents a great opportunity for a large scale version of the XENON concept for dark matter discovery and identification. We endorse the effort you made to combine the leading groups working on noble liquid TPCs for dark matter, given the important advantages of both a LAr and a LXe TPC of similar sensitivity for dark matter. We will support the XENON1T technical design study in any way we can, including sharing our knowledge and long-term expertise with noble liquid detectors.

The Waseda group has been studying the basic processes of ionization and scintillation in LAr and LXe for many years. I have a rich experience in high pressure Xe detector purification system of Xe gas. TPC and Prof. Doke is a pioneer of LXe detectors; Dr. Suzuki is currently operating a XeTPC for dark matter at Kamioka and Dr. Miyajima is a pioneer of the ββ–decay experiment using LXe. Prof. Shoji Torii is an expert in the field of high energy cosmic ray particle and gamma-rays, and in large-scale detector simulations. Our combined rich experience with xenon detectors will be an asset for the design study proposed with MAX.

Our team will continue to be involved in the current XENON100 experiment and its upgrade, with one postdoc, and three graduate students. We will be collaborating with Prof. Katsushi Arisaka at UCLA for design, fabrication and testing of the amplifier for QUPID. Also, we will study and realize the optimum design of the cable harness for the QUPID to minimize radioactivity and outgas, an improvement over the current single wire design.

Waseda University will apply for JSPS funding to support the MAX project. The very good results obtained so far by the XENON team, your leadership and knowledge of LXe detectors and the excitement to be part of the leading dark matter experiment with a large discovery potential in the next few years, made it easy for us to join XENON100 and we are happy to join the XENON1T step at DUSEL with the MAX project. We'll certainly do our best to make this experiment a success.

Sincerely yours,

Prof. Nobuyuki HASEBE
Research Institute for Science and Engineering, Waseda University
3-4-1 Okubo, Shinjuku, Tokyo, 169-8555 Japan
Tel/Fax : +81-3-5286-3897, E-mail : nhasebe@waseda.j

UNIVERSITY of VIRGINIA
DEPARTMENT of CHEMISTRY

January 6, 2009

Professor Cristiano Galbiati
Department of Physics
Princeton University
Princeton, NJ 08544

Dear Cristiano,

I am writing to state my strong support for the proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs", which is about to be submitted to the NSF by Princeton and the other institutions of our collaboration.

My research group has expertise in the detection of trace impurities in inert gases, such as Argon and Xenon. In particular, my group developed an extremely sensitivity technology known as continuous wave Cavity Ring-Down Spectroscopy (CRDS). I understand that it will be important in this project to monitor several key impurities (H_2O, O_2, and N_2) below one part per billion in the liquid Argon. We have established methodologies to measure H_2O and O_2 impurities down to one order of magnitude lower than this. I also have an idea for a modification that potentially would also allow the N_2 impurities with sufficient sensitivity. I look forward to the application of the CRDS technique in both xenon and argon targets.

I will collaborate with Dr. Keeter, Dr. Durben, and Dr. Zehfus at BHSU in their building an instrument for H2O and O2 detection based upon our existing technology. I will give them a list of needed components and their specs, suggest suppliers, and provide custom software. Before they commence construction, I will invite them to spend a period at the University of Virginia where they will have an opportunity to closely examine and use our existing CRDS instrument based upon the same technology. I am also willing to visit BHSU and help with the optimization of the instrument after it is constructed.

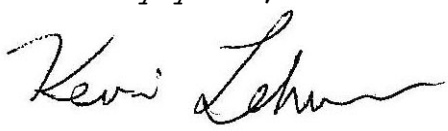
This collaboration will enhance my research program in using laser spectroscopy to advance analytical and physical chemistry. I anticipate that the development of a molecular nitrogen sensor will have multiple applications, including in industrial process control. Spectroscopy is an area of focus for the Chemistry and Physics Department at UVa. This application, that uses molecular spectroscopy (principally considered part of Physical Chemistry) to help address one of the most important outstanding questions

Chemistry Building, • McCormick Road • University of Virginia • Charlottesville, VA 22902-4319
Voice: (434)243-2130 • Fax: (434)243-2193 • E-mail: Lehmann@virginia.edu

in modern Physics and Astronomy will provide an excellent example of the broad importance of Spectroscopy.

I am very excited about the prospects of major dark matter detection experiments here in the US. I am sure this extends to UVa graduate and undergraduate students and postdoctoral fellows who may be available to significantly contribute in this scientific journey.

Sincerely yours,



Kevin Lehmann
Professor of Chemistry & Physics

Chemistry Building, • McCormick Road • University of Virginia • Charlottesville, VA 22902-4319
Voice: (434)243-2130 • Fax: (434)243-2193 • E-mail: Lehmann@virginia.edu

Universität Zürich
Physik-Institut

7.01.2009

To: Professor Elena Aprile
Columbia University
Physics Department
New York, NY 10027
USA

Laura Baudis
Professor
University of Zürich
Winterthurerstr. 190
CH-8057 Zürich
Tel: +41 44 635 5777
Fax: +41 44 635 5704
Laura.Baudis@physik.unizh.ch

Support of the MAX Proposal

Dear Elena,

I strongly support the DUSEL S4 proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs" which is being submitted to the National Science Foundation in January 2009.

My group is part of the XENON collaboration since the end of 2003 and I'm very excited about remaining an active part of a collaboration for a larger scale experiment, which will involve not only xenon but also argon as an active target for dark matter particles. I believe this is a great opportunity to exploit the predicted dependance of a WIMP recoil spectrum on the target material, leading to a much stronger signature than would be possible with one target alone. Crucial in this context is the proposed common engineering, design, signal readout technology and shielding, leading to very similar detectors and backgrounds, and thus reducing the systematics involved with operating different WIMP targets under very different conditions and environments (as it is currently the case for Ar and Xe detectors).

I'm also enthusiastic about the opportunity offered by DUSEL in designing, building and operating a next-generation dark matter experiment under ideal conditions regarding the available infrastructure, such as for instance space, shielding, laboratory depth and support provided for experimentalists.

Laura Baudis
Professor
University of Zürich
Winterthurerstr. 190
CH-8057 Zürich
Tel: +41 44 635 5777
Fax: +41 44 635 5704
Laura.Baudis@physik.unizh.ch

My team, currently including nine graduate students and four postdocs is strongly involved in the XENON and GERDA projects, with a remaining participation in CDMS-II (with two graduate students) until the end of its current phase. I strongly hope that with the experience we have gained in operating LXe and LAr (for GERDA) detectors and in low-background and Monte Carlo techniques we would be able to deliver a significant contribution to the a XENON1t detector in the framework of the MAX program at DUSEL. I am planning to apply for support for a larger Xe-TPC both at the University, as well as at the Swiss National Foundation level.

I am convinced that ton-scale LAr and LXe experiments will have a realistic chance to discover the nature of dark matter, should it be composed by new, stable particles with characteristic masses and cross sections at the weak scale. If no new particles will be discovered, an entire class of theoretical models can be ruled out.

With best regards,

Laura Baudis

Prof. Dr. Laura Baudis

University of Zurich

Switzerland

Westfälische
Wilhelms-Universität
Münster

Institut
für
Kernphysik

Prof. Dr.
Christian Weinheimer

WWU | Institut für Kernphysik | Wilhelm-Klemm-Str. 9 | D-48149 Münster

Wilhelm-Klemm-Straße 9
D-48149 Münster

Telefon: +49 251 8334971
Fax: +49 251 8334962
Mobil: +49 176 18300278
E-mail: weinheimer@uni-muenster.de

Professor Elena Aprile
Columbia University
Physics Department
New York, NY 10027
USA

Münster, 7. Januar 2009

Support of the "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs"

Dear Prof. Aprile, dear Elena,

I would like to express my strong support of the DUSEL S4 proposal
"Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs"
which is being submitted to NSF.

My group wants to contribute to the XENON collaboration at several fronts, especially to enable a large 1 ton or multi-ton scale experiment. We fully support the idea of bringing together the expertise of the two different liquid noble gas methods (LXe and LAr) for the detection of WIMP Dark Matter with cross sections down to 10^{-47} cm^2 and to unify the R&D efforts towards the multi-ton scale.

The prime aim of our group is to improve the cleaning of the liquid noble gases and especially LXe in order to allow long drift distances and to decrease the radioactive impurities. We will use the support of Münster University for a special installation grant of "Deutsche Forschungsgemeinschaft" to apply for the installation of a liquid noble gas cleaning and monitoring laboratory at Münster University to optimise the cleaning procedures for a large liquid noble gas Dark Matter experiment. We will then install the best purification solution at the location of the XENON experiment. Our purification work will be based on our experience from the KATRIN experiment in ultra-clean surface technologies for extreme vacuum applications and for ultra-precise electron calibration sources. We will provide the technology to use ^{83m}Kr as tracer for purification tests and for calibrations.

Secondly we will provide experimental facilities to investigate the out-gasing of all experimental components. Our present cleaning, out-baking and out-gasing setup allows to measure out-gasing rates down to 10^{-12} mbar l/s cm^2.

Presently the scientists in my group, who are involved in XENON, are the PhD student Karen Hugenberg, two senior scientists, Dr. Marcus Beck and Dr. Volker Hannen and myself. We plan to use the standard DFG funding to enlarge our XENON group at Münster by one postdoc and one or two PhD students. My colleague, Prof. Dr. J.P. Wessels, who is very well experienced in gaseous detectors, will also add his knowledge. Hans-Werner Ortjohann, a senior engineer in my group with large experience in cryogenics, will join the constructional work of the cleaning system. In addition, as one of the two directors I have full access to the mechanical and electronic workshops (including 8 technicians) as well to the additional 5 technicians of our institute.

I am very impressed by the results obtained by XENON10 and by the XENON100 detector. Having looked into several dark matter experiments and technologies I am convinced that the liquid noble gas method and especially your XENON technology is leading and has a huge discovery potential over the next few years. We will fully support the XENON program and we are aiming to do a significant contribution.

With best regards,

Christian Weinheimer

(Prof. Dr. Christian Weinheimer)

DEPARTAMENTO DE FÍSICA

UNIVERSIDADE DE COIMBRA
FACULDADE DE CIÊNCIAS
E TECNOLOGIA

Professor Elena Aprile
Columbia University
Physics Department
New York, NY 10027

Coimbra, January 7th, 2008

Dear Elena,

It is my wish to express my strong support to the DUSEL S4 proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs" which is being prepared for submission to the NSF.

The Coimbra team has been involved in the XENON collaborative effort since 2005.
On XENON100 we have been responsible for the development of the Slow Control system and have produced the new gas handling system, as well as other detector parts, using our machine shop. Our postdocs and students have also participated in the operations at LNGS since its beginning in 2007, taking on regular shifts.
In parallel we have been performing avalanche photosensor studies aiming to maximize the system sensitivity as well as the absolute xenon and argon electroluminescence yield determination.

I plan to increase our contribution in pursuing the MAX detector's technical design study. In particular Coimbra commits to design the gas storage and recovery system as specified in the WBS.

Our team will include one postdoc (Dr. Joao Cardoso, an expert in the slow control related software technologies), one MSc technician (Mr. Antonio Ribeiro, with two years experience in slow control systems), and one PhD student (Mr. Luis Coelho, with a 3 year long experience in the gas handling/purification of XENON) will be involved in the MAX experiment.

In addition, starting in March 2009, our group will hire a senior researcher, Dr. Sonja Orrigo, presently at Laboratori Nazionali del Sud, Catania, Italy, with experience in experimental nuclear physics and data analysis. Also, starting October 2009 we expect to hire a new postdoc researcher, Mr. Hugo Luz, that is currently finishing PhD in our group in micropatterned gas photosensors development.

I'm also planning to submit a funding proposal for the XENON experiment to the FCT next call, Spring 2009, that will include the MAX project.

We remain enthusiastic about the XeTPC concept for dark matter detection which has made tremendous progress thanks to your vision and leadership. We are excited to be part of the larger MAX collaboration and to support dark matter search with Xe and Ar TPC at DUSEL.

Sincerely yours,

Prof. Doutor José A. Matias-Lopes

Rua Larga, P-3004-516 Coimbra, Portugal
Tel. +351 239 410 667 Fax +351 239 829 158
fcjam@gian.fis.uc.pt

Black Hills State University

1200 University Street, Unit 9501
Spearfish, South Dakota 57799-9501

Associate Vice President for Academic Affairs

Phone: (605) 642-6093
Fax: (605) 642-6956

January 7, 2009

Cristiano Galbiati
Assistant Professor Physics Department
Joseph Henry Laboratories
Princeton University
Post Office Box 708
Princeton, New Jersey 08542

Dear Dr. Galbiati

This letter is written in support of Black Hills State University's involvement with the "MAX - Multi-ton Argon and Xenon TPCs" proposal. With our campus location twenty miles from the Deep Underground Science and Engineering Laboratory (DUSEL) in Lead, South Dakota, BHSU is committed to collaborations that focus on physics and other related research that will advance scholarship opportunities for our faculty and enhance undergraduate and graduate educational experiences for our students.

BHSU is eager to be involved in this collaboration that proposes to build a large multi-ton detector for Weakly Interacting Massive Particles (WIMP's) at DUSEL, and will involve both our faculty and our students in research at the very forefront of our understanding of the universe.

Likewise, the MAX proposal would connect with an earlier proposal written by three BHSU faculty, Kara Keeter, Dan Durbin and Mike Zehfus submitted to NSF PNA (#0903335- Keeter is PI) to build a trace gas analyzer using Cavity Ring-Down Spectroscopy. This instrument is vital to both the liquid argon or liquid xenon detector designs because trace impurities of O_2, N_2, or H_2O in either of these liquids radically lowers the sensitivity of these WIMP detectors. The instrument put forward in that proposal will be capable of measuring N_2, O_2, or H_2O contaminants at the .01 part-per-billion level, 10x better than any commercial instrument, and will have exactly the level of sensitivity needed for either of the MAX WIMP detectors. Although the BHSU proposal was originally aimed for use with the liquid Argon detector, inclusion of both the liquid Argon and liquid Xenon detectors in the MAX proposal broadens the scope and potential usefulness of this BHSU proposal.

In addition, the MAX proposal will support BHSU faculty researcher Kara Keeter's collaboration and participation in the Princeton-Abruzzo-South Dakota program at Princeton for two weeks annually where high school or first year college students from both South Dakota and Italy are mentored by physicists while studying physics and DUSEL-related research. This particular feature of the proposal complements our recent application to become a QuarkNet Center where local high school teachers attend BHSU summer workshops to do DUSEL related research, and inspire students in South Dakota with the excitement of cutting edge physics particle research.

Sincerely,

Kristi L. Pearce

Dr. Kristi L. Pearce
Associate Vice President for Academic Affairs

UNIVERSITY OF
NOTRE DAME
DEPARTMENT OF PHYSICS

January 7, 2009

Professor
Cristiano Galbiati
Department of Physics
Princeton University
Princeton, NJ 08544

Dear Cristiano,

I would like to express my strongest support for the proposal "Collaborative Proposal: MAX – Multiton Argon and Xenon TPCs", which is about to be submitted to the NSF by Princeton and the other institutions of the collaboration.

My group at the University of Notre Dame has extensive experience in the measurement of small concentrations of ^{39}Ar using Accelerator Mass Spectrometry (AMS). This technique is particularly well suited to the problem of locating a sub-surface argon reservoir depleted in the radioactive isotope ^{39}Ar. Our group has measured some of the lowest ^{39}Ar concentrations in argon samples to date (^{39}Ar/Ar ~ 4×10^{-17}). We are currently working on developing the AMS technique to measure a concentration of at least an order of magnitude lower. This is an essential part for the identification of an argon supply suitable for the development of a multiton Argon time-projection-chamber (TPC) suitable for the detection of dark matter WIMPs.

The focus of the research effort of the Institute for Structure and Nuclear Astrophysics (ISNAP) at the University of Notre Dame is nuclear astrophysics using a wide variety of detection techniques including AMS. The dark matter search, as well as the development of low background environments, is an area that is expanding in our laboratory and becoming ever more important for our research. This is highlighted by the recent effort to build an underground low energy accelerator in the US for the study of a number of important stellar reactions. The dark matter program also fits extremely well with the mission of JINA (Joint Institute for Nuclear Astrophysics) of which we are a founding member institution.

We are very excited about the prospects of major dark matter detection experiments here in the US as this will offer our undergraduate and graduate students as well as postdoctoral fellows exciting new research opportunities.

Sincerely,

Philippe Collon
Assistant Professor of physics

225 Nieuwland Science Hall
Notre Dame, Indiana 46556-5670 USA
Telephone (574) 631-3540 ● *Facsimile* (574) 631-5952
E-mail: pcollon@nd.edu

BERKELEY LAB

ENGINEERING DIVISION

Dear Cristiano Galbiati,

The group developing the MAX - Multi Ton Argon Xenon TPC dark matter proposal for the DUSEL at Homestake has been in close communication with DUSEL project engineers during the period leading up to the NSF S4 solicitation and proposal.

In meetings and teleconferences held in 2008 with you and your team we have discussed and taken note of the basic infrastructure needs for the proposed experiment as they are known, including the depth, number of rooms and their dimensions, etc. We note that you have shared a draft of your proposal with us. We understand the identified facility requirements as they are currently known and, with the exception of items identified below, found no major concerns for a possible implementation. Infrastructure needs, such as power, access, and issues related to safety are not unusual for an experimental setup and would not pose an unusual burden on the laboratory facility design, its construction or operation. The proposed experiment would fit in a standard DUSEL lab module.

The primary issues that will need to be addressed prior to installation at DUSEL are related to safety and potential hazards associated with the incorporation of a large volume of liquid argon and xenon within a water tank. This feature is shared by many of the proposed physics detectors. We understand that we will have to work closely with your collaboration and other experimental collaborations to develop safe and effective means for dealing with underground use of large volumes of cryogens.

We understand, and believe that the MAX collaboration understands, that the details of the laboratory and experiment interface will evolve as the facility and experiment designs mature. Continued communication between experiment collaborations and the facility will be necessary through the preliminary and final design stages to insure successful implementation of experiments within DUSEL.

Sincerely,

Steve Marks
Chief Engineer for Research Instrumentation

Azriel Goldschmidt
Lead Scientist for Physics Program Support

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

ONE CYCLOTRON ROAD | BERKELEY, CALIFORNIA 94720 | TEL: 510.486.6287 | FAX: 510.486.4711

Fermilab

Fermi National Accelerator Laboratory
P.O.Box 500 • Batavia, Il.• 60510-0500
630-840-3211 FAX 630-840-2900

Director's Office

January 8, 2009

Professor Cristiano Galbiati
Physics Department
Princeton University
226 Jadwin Hall, Washington Road
Princeton, NJ 08544

Dear Cristiano,

This letter is to confirm that Fermilab is committed to collaborating with you on the liquid Argon TPC as outlined in the S4 Science Collaboration Proposal for dark matter searches at DUSEL.

Currently we are supporting a program to measure ^{39}Ar counting rates. This effort and the proposed multi-ton noble liquid effort are important steps toward constructing a ton-scale dark-matter search experiment at DUSEL.

Our main contribution to 'MAX - Multi-ton Argon and Xenon TPCs' would be to provide further engineering and technical resources, along with scientific staff, to assist in the R&D leading to the design of a full-scale experiment for DUSEL, as outlined in the S4 proposal.

This effort is well aligned with our long-standing involvement in dark-matter experiments and with Fermilab's mission at the Cosmic Frontier. Fermilab will continue to support R&D towards future dark-matter experiments and looks forward to continuing our collaboration with you and the other collaborators on the S4 proposal.
.

Sincerely Yours,

Young-Kee Kim

Young-Kee Kim
Deputy Director
Fermi National Accelerator Laboratory

January 8, 2009

To: S4 review committee
From: Scientists in the US dark matter Community
Re: Roadmap for a powerful dark matter program at DUSEL

In this letter from the dark matter community, we wish to convey to the S4 review committee our shared vision of the dark matter science, of the roadmap for a powerful dark matter program at DUSEL, and the organization of the DUSEL Dark Matter Coordinating group (DDMC).

The scientific arguments for the search for Weakly Interacting Massive Particles (WIMPs)—the favored candidate for the mysterious dark matter in the universe—have been summarized in community-based white papers written for the DUSEL S1 study: http://lanl.arxiv.org/abs/astro-ph/0605719, http://dmtools.brown.edu/DMWiki/index.php/Dark_Matter_Working_Group#DMWG_White_Papers and http://lanl.arxiv.org/abs/0810.4551. WIMPs would explain both the dark matter and the stability of the electro-weak interaction scale at 100 GeV. If they exist, such WIMPs would be concentrated in the halo of our galaxy and could be detected through elastic scattering on suitable targets in an underground terrestrial laboratory (direct detection). At the same time such particles could be observed through their annihilation, for instance by the Fermi/GLAST satellite or IceCube (indirect detection) and produced at colliders such as the LHC. Dark matter is one of the central questions in modern science, and the combination of direct, indirect and accelerator experiments has a significant chance to lead to a discovery in the coming years.

Different detector technologies have been proposed to search for WIMPs elastic scattering in underground experiments and the signatories are pursuing a number of them in what we believe is an essential pre-DUSEL program. We have two goals: discover a potential signal in a time frame similar to the LHC, Fermi/GLAST and IceCube, and understand the advantages and limits of the various direct detection approaches to prepare for the next steps. In addition, we are actively engaged in a longer term R&D program.

In our mind, this effort will culminate with the DUSEL dark matter program. If a discovery has been made at that time, we will need to accumulate statistics on several targets to study the WIMPs (mass, couplings) and the distribution of dark matter in the galaxy (directionality, modulations, phase space distribution). If the WIMPs have not been detected in the pre-DUSEL direct-detection program, we will need very sensitive detectors to explore lower cross-section regions. This would be particularly urgent if LHC will have discovered new particles originating from supersymmetry or extra dimensions—in which case it would be essential to show that such particles are stable and indeed present in the cosmos, or if indirect detection observations have provided credible smoking guns for particle dark matter.

It is therefore essential to have a vibrant dark matter program at DUSEL, with the critical mass necessary to make significant progress and attract international collaborators, and with an optimal use of the available facilities: underground assembly areas; low background counting; the 4850 ft level, initially available but requiring additional shielding against neutrons; and the 7400 ft with its superbly low neutron and activation background. There is a broad consensus in our community that the DUSEL dark matter program requires at least two different detector technologies to cross-check each other, provide insurance against backgrounds unexpectedly appearing as we push down the sensitivity level, and determine the nature of couplings of WIMPs to nucleons—e.g., by measuring the atomic number dependence. This program should also be dynamic with the systematic inclusion in the first suite of experiments of the lessons learned during the pre- DUSEL, and possibilities of

extensions and installation of new technologies (e.g., directional) later on. Dark matter would naturally be a major theme of the laboratory education and outreach program. There is no doubt in our mind that the first suite of DUSEL experiments should include dark matter and this program should be strongly international with foreign participation in the DUSEL program and coordination worldwide to prevent duplication of major investments.

We are convinced that although it is driven by the detector technology, the science is more important than the technology, and, in order to achieve the critical mass advocated above, we understand that our US dark matter community will have to reconfigure into a few large collaborations (we are not sure how many at this stage but would suggest at least two active at DUSEL). We also understand the importance of defining in a timely manner the scope, cost and schedule of the first suite of experiments for DUSEL.

However, given the importance of the science, the fast evolution of our sensor technologies, their complementary potential advantages, and the intense international competition, we feel that it is important to maintain as much flexibility in the definition of the dark matter initial program at DUSEL as compatible with the MREFC schedule. We would argue that the best strategy at this time is to bring, through the S4 process, a diverse enough set of concepts to the level of engineering maturity (preliminary design) needed to define a compelling multifaceted first suite dark matter program in the MREFC proposal. Final designs and construction decisions for the 4850 and 7400 ft levels will clearly have to occur at the appropriate time, taking into account the results of the pre-DUSEL program and the status of the proposed technologies.

Even though we are competing for engineering studies of different concepts, the community is engaged in a number of collaborative endeavors, which will significantly improve the dark matter program at DUSEL, save engineering costs where possible and facilitate the formation of critical size collaborations. More specifically, building on the foundation of the DUSEL S1/DEDC dark matter working group, we are forming a coordinating structure, the DUSEL Dark Matter Coordinating group (DDMC), with a steering committee formed by a member of each of the present US dark matter collaborations interested in DUSEL (S4 proposals, R&D efforts). This coordinating group will act as a forum for the discussion of the science: theoretical evolution, impact of the pre-DUSEL program. It will launch a common study of backgrounds important for WIMP searches (e.g. cosmogenic neutrons MonteCarlo, normalized to modern data) in close contact with the AARM collaboration studying general background issues at DUSEL. Our coordination group will also act as a forum for engineering discussions, in close contact with the S3 facility study and the DUSEL Experiment Design Committee (DEDC). We believe that this will lead quite naturally to collaboration among our various groups on common engineering problems (e.g., safety) and components (e.g., water shields along the line proposed by the S4 water shield proposal)). Education and Outreach, using the fascinating question of the dark universe, is another area of collaboration.

To conclude, all the signatories of this letter share a strong common interest in dark matter science, and believe that WIMP searches should be a major component of the DUSEL program. We propose that the best scientific strategy at this time is to bring a large enough set of experimental concepts to the level of engineering needed to define the scope, sensitivity, cost and schedule of a dark matter program to be included in the DUSEL MREFC. Simultaneously, we are putting in place collaborative mechanisms that will help the crystallization of the community around at least two DUSEL experiments when construction decisions need to be made.

Signatories as of Thursday January 8, 2009 7:00 pm Pacific

COUPP
Juan Collar, Chicago
Andrew Sonnenschein, Fermilab

DEAP/CLEAN
Daniel McKinsey, Yale
Andrew Hime, Los Alamos
John Doyle, Harvard
Joseph Formaggio, MIT
Reyco Henning, U. of North Carolina
Ed Kearns, Boston University
Richard Schnee, Syracuse

DM TPC
Peter Fisher, MIT
Gabriella Sciolla, MIT
Steve Ahlen, Boston

DRIFT
Daniel Snowden-Ifft, Occidental

GEODM
Sunil Golwala, Caltech
Blas Cabrera, Stanford
Prisca Cushman, U. of Minnesota
Vuk Mandic, U. of Minnesota
Tarek Saab, U. of Florida
Richard Schnee, Syracuse
Bernard Sadoulet, UC Berkeley

LZ20
Richard Gaitskell, Brown
Dan Akerib, Case Western
Thomas Shutt, Case Western
Alexander Bolozdynya, Case Western
Michael Dragowsky, Case Western
Mani Tripathi, UC Davis:
Adam Bernstein, LLNL
Yuen-Dat Chan, LBL
Brian Fujikawa, LL
Carter Hall,University of Maryland
Dongming Mei, University of South Dakota
Harry Nelson, UCSB
James White, Texas A&M
Frank Wolfs, University of Rochester
Daniel McKinsey, Yale

MAX (Multi-ton Argon and Xenon TPCs)

Cristiano Galbiati, Princeton
C.J. Martoff, Temple
Ed Hungerford, Houston

Andrew Sonnenschein, Fermilab
Elena Aprile, Columbia
Karl-Ludwig Giboni, Columbia
Kaixuan Ni, Columbia
Uwe Oberlack, Rice
Katsushi Arisaka, UCLA
Hanguo Wang, UCLA

Theory
Baha Balantekin, University of Wisconsin
Paolo Gondolo, U. of Utah

Water tank S4
Frank Calaprice, Princeton

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso
Assergi, 67100 Italy

INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS
ISTITUTO DI FISICA DELLO SPAZIO INTERPLANETARIO
Corso Fiume, 4
10133 Torino
Italy

Francesco Arneodo, researcher
(INFN-LNGS)
and
Walter Fulgione, researcher
(IFSI-INAF)

Professor Elena Aprile
Columbia University
Physics Department
New York, NY 10027
USA

Dear Prof. Aprile,

with the present letter we wish to express our joint support to the proposal ""Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs"".

The Gran Sasso Laboratory has always supported Dark Matter Searches with noble liquids with the XENON and WARP programs and will continue to do so. Our groups, specifically, have been involved in the XENON program since long. In terms of physicists, the LNGS group is presently composed by Dr. F. Arneodo and Serena Fattori (PhD student). The group is also enriched by the contribution of the local engineers of LNGS whose past collaboration has proven precious in the XENON program.

The group of the IFSI-INAF institute is composed by Dr. Walter Fulgione and Gianmarco Bruno (PhD student).

For the present proposal, we would like to contribute with the design, test and implementation of a system for the measurement of the electron lifetime in the noble liquids. This is a critical parameter for the functioning of the noble liquid TPCs. We cannot rule out, however, the possibility of a wider contribution should our group become more numerous.

With best regards,

Francesco Arneodo

Walter Fulgione

Assergi, January 9, 2009

Fermilab

January 9, 2009

Professor Cristiano Galbiati
Deparment of Physics
Princeton University
Princeton, NJ 08544

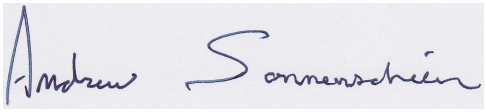
Dear Cristiano,

We are writing to express our interest and intent at Fermilab to participate in the design and eventual implementation of a liquid argon dark matter detector as described in the joint Argon-Xenon DUSEL S4 proposal by the MAX collaboration. This is a very exciting time in the field of direct detection of dark matter as various planned experiments zero in on the remaining parameter space available to supersymmetric WIMPS. We believe that our proposal for the joint development of argon- and xenon-based detectors directly addresses the issue of distinguishing a true WIMP signal from spurious excesses of nuclear recoil events which might otherwise mimic a dark matter signal.

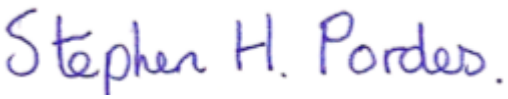
The Fermilab group has agreed to take responsibility for several elements of the S4 design, as detailed in the WBS attached to the proposal. In particular, Andrew Sonnenschein will contribute mechanical design experience to the design of the cryostat, Stephen Pordes will work on the argon-related issues, and Aaron Chou will serve as the level 2 manager for the electronics and data acquisition. We expect that this design effort will be supported and funded internally through Fermilab.

Sincerely,

Andrew Sonnenschein



Stephen Pordes



Aaron Chou

Fermi National Accelerator Laboratory / Kirk Road and Pine Street / P.O. Box 500 / Batavia, IL 60510 / 630.840.3000 / www.fnal.gov / fermilab@fnal.gov
Office of Science / U.S. Department of Energy / Managed by Fermi Research Alliance, LLC

Robert F Parsells
234 Western Way, Princeton, NJ 08540

Date: January 7, 2009

To: Prof. Cristiano Galbiati
Physics Department
Princeton University
Princeton, NJ 08544

Subject: MAX – Multi-ton Argon and Xenon TPCs

Dear Christian,

I am pleased to add my support for your application to the National Science Foundation for the DUSEL S4 proposal "Collaborative Proposal: MAX – Multi-ton Argon and Xenon TPCs."

My background as a project manager/engineer over the last 25 years at the Princeton Plasma Physics Laboratory will help me in supporting your project. My specific experience of working on the Borexino project will aid in my support for the work at DUSEL.

I am enthusiastic about the opportunity of joining the project and working with the MAX collaboration. I am happy to provide my professional services in the capacity of Project Manager of the experiment at the weekly rate of $4,000 (1 FTE equivalent).

Sincerely Yours,

Robert Parsells

Eng. Robert Parsells
234 Western Way
Princeton, NJ 08540
Ph.: 609-688-0988

Appendices

A. WBS

Element	Work package	Definition	Responsible	Class
	Noble Liquids TPCs	**Project Manager**	**Parsells (PRI)**	**C**
1.	**Dark Matter Detectors**		**Parsells (PRI)**	**C**
1.0.1	**DAr TPC**	**Detector Manager**	**Sands (PRI-TEM)**	**C**
1.0.2	**Xe TPC**	**Detector Manager**	**Tajiri (COL)**	**C**
1.1	**TPCs**	**Level 2 Manager**	**Martoff (TEM)**	**C**
1.1.1.1	Xe Electrodes	Cathode, field cage, & grids mechanics	Shagin (RIC)	**XE**
1.1.1.2	Ar Electrodes	Cathode, field cage, & grids mechanics	Martoff (TEM)	**AR**
1.1.2.1	Xe Electrostatics	Spec. & simulation of electrostatic fields	Wang (UCLA)	**XE**
1.1.2.2	Ar Electrostatics	Spec. & simulation of electrostatic fields	Alarcon (ASU)	**AR**
1.1.3.1	Xe HV interconnects	Internal connections to electrodes	Tajiri (COL)	**XE**
1.1.3.2	Ar HV interconnects	Internal connections to electrodes	Martoff (TEM)	**AR**
1.1.4.1	Xe gas & liquid interconnects	Interfaces to fill & purification system	Giboni (COL)	**XE**
1.1.4.2	Ar gas & liquid interconnects	Interfaces to fill & purification system	Sonnenschein (FNAL)	**AR**
1.1.5	Liquid level	Fill level measurement & control	Shagin (RIC)	**C**
1.1.6	TPC gas pressure	Gas pressure measurement & control	Sands (PRI-TEM)	**C**
1.1.7	Fluids	Interface to storage, fill, & empty systems	Tajiri (COL)	**C**
1.1.7.1	Xe specific fluids	Interface to storage, fill, & empty systems	Giboni (COL)	**XE**
1.1.7.2	Ar specific fluids	Interfaces to storage, fill, & empty systems	Pordes (FNAL)	**AR**
1.1.8	Calibration	Light & charge sources for calibration data	Monroe (MIT)	**C**
1.1.8.1	Xe Specific Calibration	Light & charge sources for calibration data	Oberlack (RIC)	**XE**
1.1.8.2	Ar Specific Calibration	Light & charge sources for calibration data	Monroe (MIT)	**AR**
1.1.9.1	TPC materials	Radioactivity budgets	Pocar (UMA)	**C**
1.1.9 .2	TPC materials	Radon plate-out	Monroe (MIT)	**C**
1.1.9 .3	TPC materials	Radon emanation	Pocar (UMA)	**C**
1.1.10.1	Xe TPC integration	Mechanical & electrical systems integration	Tajiri (COL)	**XE**
1.1.10.2	Ar TPC integration	Mechanical & electrical systems integration	Sands (PRI-TEM)	**AR**
1.2.	**Inner Vessels (IV)**	**Level 2 Manager**	**Meyers (PRI)**	**C**
1.2.1.1	Ar liner mechanical	Specifications & method of construction	Martoff (TEM)	**AR**
1.2.1.2	Ar WaveLength Shifter (WLS)	TPB films & their application	Galbiati (PRI)	**AR**
1.2.1.3	Ar liner interfaces	Interface to TPC electrodes & acrylic CV	Sands (PRI-TEM)	**AR**
1.2.1.4	Xe liner	Reflector, windows	Aprile (COL)	**XE**
1.2.2.1	Xe containment vessel	Vessel structure & manufacture	Tajiri (COL)	**XE**
1.2.2.2	Ar containment vessel	Acrylic vessel structure & manufacture	Sands (PRI-TEM)	**AR**
1.2.2.3	Mechanical seals	Top & bottom plate seals	Sonnenschein (FNAL)	**C**
1.2.2.4	HV & HHV seals	HV & HHV feedthrough flange seals	Wang (UCLA)	**C**
1.2.2.5	Vessels materials	Radioactivity budget	Pocar (UMA)	**C**
1.3	**Photodetector**	**Level 2 Manager**	**Arisaka (UCLA)**	**C**
1.3.1	QUPIDs radioactivity budget	Characterization of components	Oberlack (RIC)	**C**
1.3.2	8" PMTs radioactivity budget	Characterization of components	Pocar (UMA)	**AR**
1.3.3.1	Procurement	Procurement	Arisaka (UCLA)	**C**
1.3.3.2	Test	Test & characterization	Arisaka (UCLA)	**C**
1.3.3.3	Database	Database with photosensors characteristics	Arisaka (UCLA)	**C**
1.3.4	Photocathodes	Optimization of quantum efficiency	Suyama (Hamamatsu)	**C**
1.3.5.1	QUPIDs support	Mechanical support structure	Wang (UCLA)	**C**
1.3.5.2	8" PMTs support	Mechanical support structure	Martoff (TEM)	**AR**
1.3.6.1	QUPIDs signals	Thermal management of cable	Wang (UCLA)	**C**
1.3.6.2	PMTs signals	Cabling & thermal management	Sonnenschein (FNAL)	**AR**
1.4	**Cryogenic Systems (CS)**	**Level 2 Manager**	**Wang (UCLA)**	
1.4.1	Cooling Elements	Specifications & design	Haruyama (KEK)	**C**

1.4.2.1	LXe fill	Fill, empty, & purification of LXe	Giboni (COL)	**XE**
1.4.2.2	Inner LAr fill	Fill, empty, & purification of inner LAr	Pordes (FNAL)	**AR**
1.4.2.3	Outer LAr fill	Fill, empty, & purification of outer LAr	Pordes (FNAL)	**AR**
1.4.3.1	Ar dewar	SS double-walled cryostat	Sonnenschein (FNAL)	**AR**
1.4.3.2	Xe dewar	OFHC double-walled cryostat	Tajiri (COL)	**XE**
1.4.5.1	Ar top plate	HV, signal, fluid feedthroughs	Sonnenschein (FNAL)	**AR**
1.4.5.2	Xe top plate	HV, signal, fluid feedthroughs	Giboni (COL)	**XE**
1.4.6	Dewar mechanical	Support & leveling	Sonnenschein (FNAL)	**C**
1.4.7	Cooling	Steady-state & emergency cooling systems	Sonnenschein (FNAL)	**C**
1.4.8.1	Fluids	Common fill, empty, storage systems	Sonnenschein (FNAL)	**C**
1.4.8.2	Ar fluids	Ar fill, empty, storage systems	Sonnenschein (FNAL)	**AR**
1.4.8.3	Xe fluids	Xe fill, empty, storage systems	Lopes (COI)	**XE**
1.4.9	CS mechanics	Mechanical interfaces of all vessels	Sonnenschein (FNAL)	**C**
1.4.10	CS materials	Radioactivity budget & ^{222}Rn emanation	Pocar (UMA)	**C**
1.4.11	Recovery systems	Zero-boiloff gas/liquid recovery	Wang (UCLA)	**C**
1.5	**Pre-Purification (PP)**	**Level 2 Manager**	**Galbiati (PRI)**	**C**
1.5.1	Depleted argon collection	Engineering of collection system	Fitch (Linde)	**AR**
1.5.2	Cryogenic distillation of Ar & Xe	Engineering of cryogenic distillation column	Fitch (Linde)	**C**
1.6	**Runtime Purification (RP)**	**Level 2 Manager**	**Pordes (FNAL)**	**C**
1.6.1.1	Filters	Selection of filters & getters	Weinheimer (MUN)	**C**
1.6.1.2	Ar specific filters	Selection of Ar specific filters & getters	Galbiati (PRI)	**AR**
1.6.1.3	Filters	Selection of filters & getters	Weinheimer (MUN)	**XE**
1.6.2.1	Ar RP scheme	Fluid handling & control	Pordes (FNAL)	**AR**
1.6.2.2	Xe RP scheme	Fluid handling & control	Aprile (COL)	**XE**
1.6.3 .1	RP materials	Radioactivity budget & ^{222}Rn emanation	Weinheimer (MUN)	**C**
1.6.3.2	RP materials	Radioactivity budget & ^{222}Rn emanation	Pocar (UMA)	**C**
1.6.4.1	CRDS Enginering	Ultra-trace measurement of N_2, O_2, & H_2O	Lehmann (UVA)	**C**
1.6.4.2	CRDS Operations	Procedures & protocols	Zehfus (BHSU)	**C**
1.7	**Electronics**	**Level 2 Manager**	**Chou (FNAL)**	**C**
1.7.1	Voltage amplifiers	QUPIDs & PMTs	Arisaka (UCLA)	**C**
1.7.2	Digitizer layout	Specifications & design	Arisaka (UCLA)	**C**
1.7.3	Digitizer FPGA firmware	Specifications & code development	Hungerford (HOU)	**C**
1.7.4	2$^{\text{nd}}$ level DAr trigger board	Specifications & design	Hungerford (HOU)	**C**
1.7.5	HV supply	QUPIDs & PMTs	Pordes (FNAL)	**C**
1.7.6	Cables	QUPIDs & PMTs	Sonnenschein (FNAL)	**C**
1.7.7	Slow Controls	Monitoring of electronics & environment	Hungerford (HOU)	**C**
1.7.8	GPS Clock	Specifications & design	Hungerford (HOU)	**C**
1.7.9	Crates & racks	Specifications	Pordes (FNAL)	**C**
1.8	**DAQ**	**Level 2 Manager**	**Hungerford (HOU)**	**C**
1.8.1	Communications Links	Specifications & protocols	Hungerford (HOU)	**C**
1.8.2	Computers	Specifications	Alton (AUG)	**C**
1.8.3	On-Line Software	Specifications	Hungerford (HOU)	**C**
1.8.4	Off-Line software	Specifications	Oberlack (RIC)	**C**
1.8.5	Data Recording	Specifications & protocols	Alton (AUG)	**C**
2.	**Simulations**	**Level 2 Manager**	**Monroe (MIT)**	**C**
2.1	Common simulations	FLUKA & GEANT4 infrastructure	Hungerford (HOU)	**C**
2.1.1	Ar specific simulations	Complete simulations for Ar TPC	Monroe (MIT)	**AR**
2.1.2	Xe specific simulations	Complete simulations for Xe TPC	Baudis (ZUR)	**XE**
3.	**Shielding & Rn-free cleanroom**	Design, Coord. with Water Shield S4 Prop.	**Parsells (PRI)**	**C**
3.1	Shield design	Water-based external shield & muon veto	Parsells (PRI)	**C**
3.2	Shield interfaces	Interfaces to water shields S4 activity	Parsells (PRI)	**C**
3.3	Rn-free cleanroom	Specifications & design	Parsells (PRI)	**C**
4.	**DUSEL Interface**	**Level 2 Manager**	**Parsells (PRI)**	**C**
5.	**Radiation Screening**	**Level 2 Manager**	**Pocar (UMA)**	**C**

6.	**Safety**	**Level 2 Manager**	**Parsells (PRI)**	**C**
6.1	Standard Operating Procedures	Standard Operating Procedures	Parsells (PRI)	**C**
6.2	Hazard Analyses	Hazard Analyses	Parsells (PRI)	**C**
7.	**Installation**	**Level 2 Manager**	**Tajiri (COL)**	**C**
7.1	Common Installation	Procedures for installation	Tajiri (COL)	**C**
7.1.2	Xe specific installation	Ar procedures for installation	Sands (PRI-TEM)	**AR**
7.1.3	Xe specific installation	Xe procedures for installation	Giboni (COL)	**XE**
8.	**Commissioning**	**Level 2 Manager**	**Aprile (COL)**	**C**
8.1	Common commissioning	Initial fill, turn-on, & calibration	Pordes (FNAL)	**C**
8.2	Xe TPC Commissioning	Initial fill, turn-on, & calibration	Giboni (COL)	**C**
8.3	Ar TPC Commissioning	Initial fill, turn-on, & calibration	Pordes (FNAL)	**C**
9.	**Operations**	**Level 2 Manager**	**Oberlack (RIC)**	**C**
9.1	Common Operations	TPCs monitoring & maintenance procedures	Pordes (FNAL)	**C**
9.2	Xe TPC specific operations	TPC monitoring & maintenance procedures	Tajiri (COL)	**C**
9.1.1	Ar TPC specific operations	TPC monitoring & maintenance procedures	Tajiri (COL)	**C**
10.	**EPO**	**Level 2 Manager**	**Keeter (BHSU)**	**C**
10.1	Education	Davis-Bahcall Scholarship	Keeter (BHSU)	**C**

B. COSTS

Component	Cost [DAr TPC]	Cost [Xe TPC]
QUPIDs	$2.2 M	$2.9 M
8" PMTs	$0.9 M	
Cryostat	$1.5 M	$1.5 M
Cryo infrastructure	$0.5 M	$0.5 M
DAr collection plant	$3.0 M	
DAr collection operations	$1.0 M	
LXe procurement		$6.5 M
Cryogenic distillation plant	$1.0 M	
Electronics	$1.0 M	$0.6 M
DAQ & Computing	$0.3 M	$0.3 M
Water tank	$0.8 M	$0.8 M
Underground buildings	$0.5 M	
Acrylic vessel	$0.3 M	
Total	$12.3 M	$13.9 M
Total + 30% Contingency	$16.0 M	$18.0 M

TABLE IX: Very preliminary cost estimate. The totals split the common costs evenly.

HAMAMATSU
HAMAMATSU PHOTONICS K.K. Electron Tube Division
314-5, SHIMOKANZO, IWATA-CITY, SHIZUOKA PREF, JAPAN
TELEPHONE: 0539-62-5248
FAX: 0539-62-2205

January 5th, 2009

Professor Katsushi Arisaka
Department of Physics and Astronomy
UCLA
475 Portola Plaza
Los Angeles, CA 90095-1547

Dear Professor Arisaka:

We are very pleased to be part of your submission of the NSF DUSEL S4 proposal entitled "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs". We are writing this letter on behalf of Hamamatsu Photonics to confirm our company's keen interest and strong commitment on completing the development of 3" QUPID (as well as a feasibility study of a larger area QUPID) for liquid Argon and Xenon TPC detectors.

As we discussed, we confirm our commitment on the following specific R&D and engineering, contingent upon your funding:

1) Development of a mass production method for 3" QUPID, which can meet the production rate of > 100 QUPIDs per month, with the expected commercial price of $3,000 per unit.
2) Application of Hamamatsu's high Quantum Efficiency (>30%) photocathode in the wavelength range between 170 nm and 450 nm, with excellent linearity (> 1nA cathode DC current) at liquid Argon temperature (-185 °C) for a 3" QUPID.
3) Feasibility study of a larger area QUPID (5" – 8" diameter) with low radioactivity (< 10 mBq and < 1 neutron/year).

We estimate the engineering cost of the above projects to be $300k/year for three years. We are pleased to inform you that, if the MAX collaboration can provide $100k/year for three years through the DUSEL S4 program, we will match your funds by contributing $200k/year towards realization of the above three goals. During the development period, in return, we will provide you several prototypes every year for your evaluation. Please also understand that the large area QUPID may not be materialized in three years due to technical or cost-performance reasons, although we will do our best effort.

Starting from the development of 20 inch PMTs in the 1980's, we have three decades of productive collaboration in a wide range of photon detectors, spanning over high-energy, particle astrophysics, neutrino physics as well as for bio-imaging. Based on this experience, we are confident that we can maintain and advance our collaboration into this new exciting field of dark matter research. Thank you again for giving us this opportunity. We wish you good luck on successful funding on the DUSEL S4 program.

Sincerely yours,

Junichi Takeuchi
Executive Director, Electron Tube Division
Hamamatsu Photonics K.K., Japan

Akira Hiruma
President
Hamamatsu Corporation

INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

1-1.OHO.TSUKUBA-SHI
IBARAKI-KEN.305-0801 JAPAN
http://www.kek.jp/
E-Mail: koenetaro@post.kek.jp

Professor Elena Aprile
Physics Department
Columbia University
New York, NY 10027
USA

5 January 2009

Dear Prof. Aprile,

In support for your application to the National Science Foundation on the DUSEL S4 proposal "Collaborative Proposal: MAX - Multi-ton Argon and Xenon TPCs, I specify that my consulting work will concern the calculations of the thermal load of the Xe TPC cryostat and the design and specifications of the Pulse Tube Refrigerator based system required to cool-down, condense Xe gas and maintain the temperature of the liquid close to 165K. The work will be done in close collaboration with Dr. Giboni and Dr. Tajiri, of Columbia University. I will validate the final design of the cooling system, as integral part of the cryostat design, keeping in consideration the requirement of minimal mass and radioactivity close to the Dark Matter target.

My consulting fee, including inflation, is $9000 corresponding to 25 days per year of my time for the project. I also request a minimum of one trip per year to Columbia to discuss the project in person with Dr. Giboni and Dr.Tajiri. I expect the cost for me to travel to Columbia to be about $3450.

Sincerely yours,

Prof. Tom Haruyama
Institute for Particle and Nuclear Studies
KEK, High Energy Accelerator Research Organization
1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan
Te l: +81-29-864-5344
Fax: +81-29-864-2580
E-mail: haruyama@post.kek.jp