

ENGINEERING NOTE**FE3100****M7892****1 of 25**

Author

Daniel W. Cheng

Department

Mechanical Engineering

Date

5/10/00

Program - Project - Job: SNS-FE Ion Source/LEBT
Faraday Cup

Title: SNS-Front End Systems Faraday Cup Diagnostic

1. Scope

This report describes the design of the 65 mA H- Faraday cup diagnostic that was originally built for the SNS Front End Systems R& D effort. The simulations were performed by Matthaeus Leitner in September 1998, and the design details were completed in October 1998. This report contains the complete drawings set of the Faraday cup.

2. Background

The ion source and Low Energy Beam Transport of the SNS Front End systems is designed to produce and transport a 65 mA H- beam at a 6% duty factor and 65 keV energy into the Radio Frequency Quadrupole (RFQ) for further acceleration. However, prior to the installation of a full Low Energy Beam Transport (LEBT) or an RFQ, the ion beam extracted from the plasma generator must be characterized. An emittance scanner and Faraday cup are key to this characterization process, and this report covers the design of the Faraday cup.

3. Requirements

While the Faraday cup must accurately measure the H- ions that are being extracted from the plasma generator, it must also reject the signal of the electrons that are inherent in a plasma of H- ions. Most electrons are already filtered by the outlet electrode's magnetic field and by the use of cesium in the plasma generator, but the small percentage that remains with the extracted beam must then be dealt with by a magnetic field in the Faraday cup. In order to dump 30 keV electrons, the magnetic field at the entrance of the Faraday cup must be near 360 Gauss (see Figures A2, A3). In order to adequately dump 65 keV electrons, however, the field strength at the entrance must be close to 700 Gauss (see Figure A8). For this reason, the magnets must be interchangeable to accommodate different beam energies (30 keV electrons may *not* be adequately dumped in a 700 Gauss field--see Figure A9). **It is advisable to measure the field strength of the cup using a Hall probe prior to any use, and also at regular intervals.** Lastly, the heat generated by the dumped electrons is detrimental to the magnets that produce the magnetic field, therefore water cooling is necessary to keep temperatures reasonable.

4. Design Overview

The Faraday cup was constructed in a shell of 1006 low-carbon steel for its magnetic properties. Because of the magnetic field generated by the SmCo filter magnets, the steel serves as a field clamp that reduces fringe fields that could affect the extraction of the ion beam from the plasma generator. The filter magnets are installed transversely at the top and bottom of the front plate, which produce a downward B field. This is designed to deflect the electrons to the side, where they will be absorbed and trapped by graphite plates. Due to the heat generated, the magnets are shielded by a copper sheet that is edge-cooled by brazed copper tubing to minimize any degradation of the magnetic field due to temperature effects.

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The target where the H⁻ ions will strike is simply a graphite plate at the rear of the Faraday cup, but is electrically isolated from the body where the electrons are dumped. This provides the filtering needed to ensure a clean reading on the H⁻ signals. Water cooling was not implemented for the 30 keV dumping, but the issue may be revisited for the 65 keV case.

Depending on the Faraday cup's use and application, the hanger bracket (Drawing 21G6912) can be either substituted or modified in order to mount the cup adequately.

5. Design Package

The drawings for all the Faraday cup parts are as follows:

21G690 3	Faraday Cup Assembly & Mount
21G663 1	Faraday Cup Graphite Liner 1
21G664 1	Faraday Cup Graphite Liner 2
21G665 1	Faraday Cup Graphite Liner 3
21G666 1	Faraday Cup Graphite Liner 4
21G667 1	Faraday Cup Graphite Liner 5
21G668 1	Faraday Cup Graphite Liner 6
21G669 1	Faraday Cup Graphite Dump
21G670 1	Faraday Cup Bottom Plate
21G671 1	Faraday Cup Back Clamp Plate
21G672 1	Faraday Cup Cover Plate
21G673 1A	Faraday Cup Top Plate
21G674 1	Faraday Cup Side Plate
21G675 1	Faraday Cup Graphite Dump Insulator
21G676 1	Faraday Cup Insulator Support
21G677 1	Faraday Cup Insulator Washer
21G688 1	Faraday Cup Magnet Heat Shield
21G691 2	Hanger Bracket Faraday Cup Mount

All drawings are included with this document.

6. Additional Reference Documents

- 6.1 See Appendix A. for magnetic field simulations.
- 6.2 See Appendix B. for electron deflection simulations at various beam energies.
- 6.3 FE-PH-011, Calibration of H⁻/e⁻ Faraday Cup

7. SNS-FE Design Personnel

Matthaeus Leitner, Primary Physicist

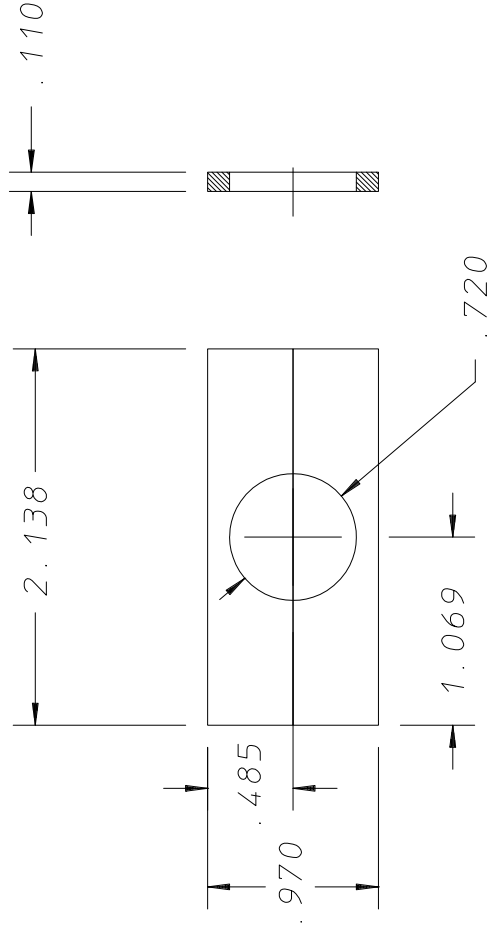
Daniel Cheng, primary Engineer & Designer

REV	ITEM	PART NUMBER	DESCRIPTION
2	1	2166631	FARADAY CUP GRAPHITE LINER 1
2	2	2166641	FARADAY CUP GRAPHITE LINER 2
2	3	2166651	FARADAY CUP GRAPHITE LINER 3
1	4	2166661	FARADAY CUP GRAPHITE LINER 4
6	5	2166671	FARADAY CUP GRAPHITE LINER 5
5	6	2166681	FARADAY CUP GRAPHITE LINER 6
1	7	2166711	FARADAY CUP BACK CLAMP PLATE
1	8	2166691	FARADAY CUP GRAPHITE DUMP
1	9	2166731	FARADAY CUP TOP PLATE
1	10	2166701	FARADAY CUP BOTTOM PLATE
2	11	2166721	FARADAY CUP COVER PLATE
2	12	2166741	FARADAY CUP SIDE PLATE
2	13	2166881	FARADAY CUP MAGNET HEAT SHIELD
12	14	2166771	FARADAY CUP INSULATOR WASHER
4	15	2166761	FARADAY CUP INSULATOR SUPPORT
4	16	2166751	FARADAY CUP GRAPHITE DUMP INSULATOR
8	17	-	SCREW, BUTTONHEAD, 2-56 x .4, LG
4	18	-	SCREW, BUTTONHEAD, 2-56 x .375, LG
4	19	-	SCREW, FLATHEAD, 2-56 x .375, LG
4	20	-	SCREW, BUTTONHEAD, 4-40 x .875, LG
4	21	-	SCREW, SHCS 5-40 x .625, LG
1	22	2166912	HANGER BRACKET FARADAY CUP MOUNT

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SNS-FE ION SOURCE R&D	
ION SOURCE DEVELOPMENT	
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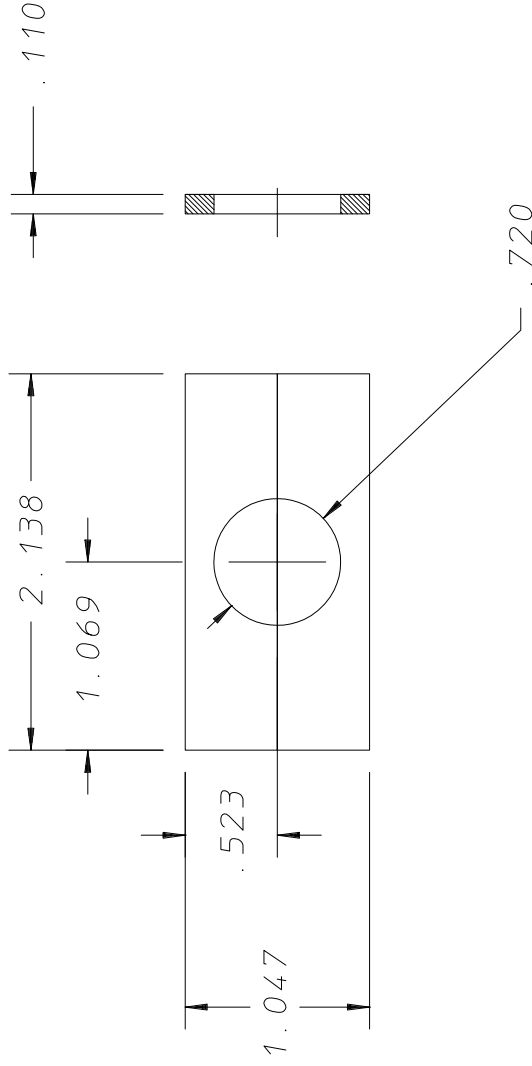
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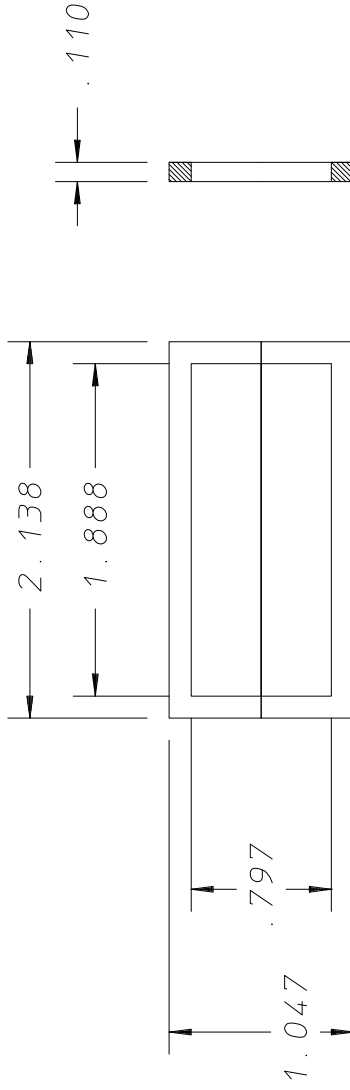


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FARADAY CUP GRAPHITE LINER 2

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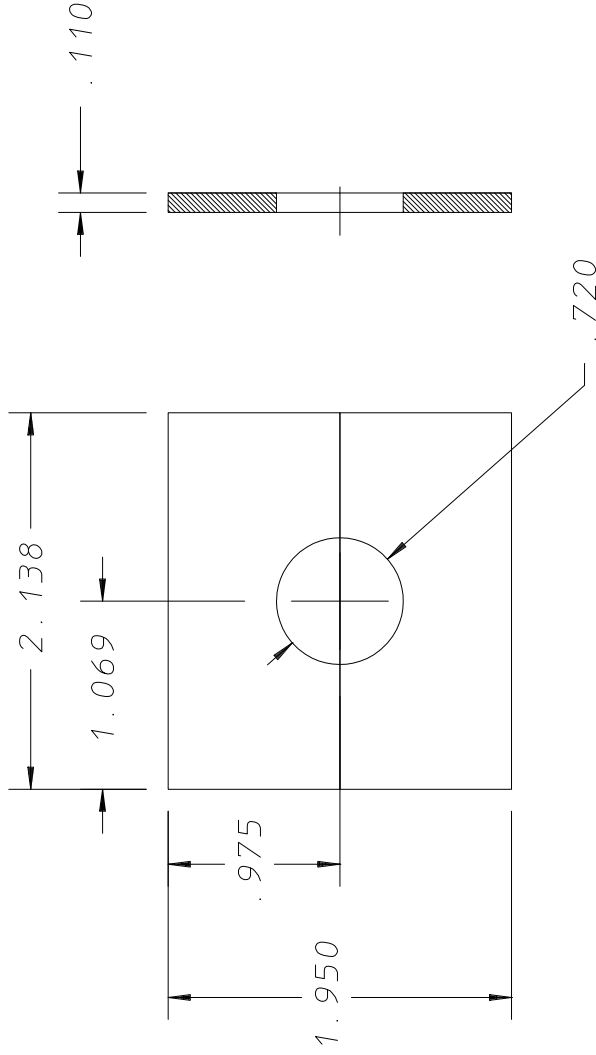


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 FARADAY CUP GRAPHITE LINER 3

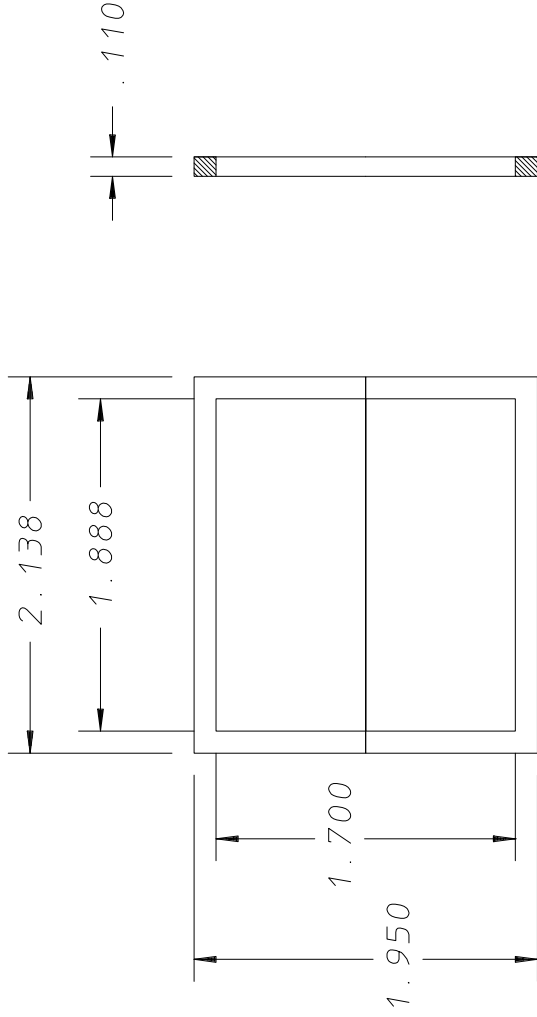
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 FARADAY CUP GRAPHITE LINER 4

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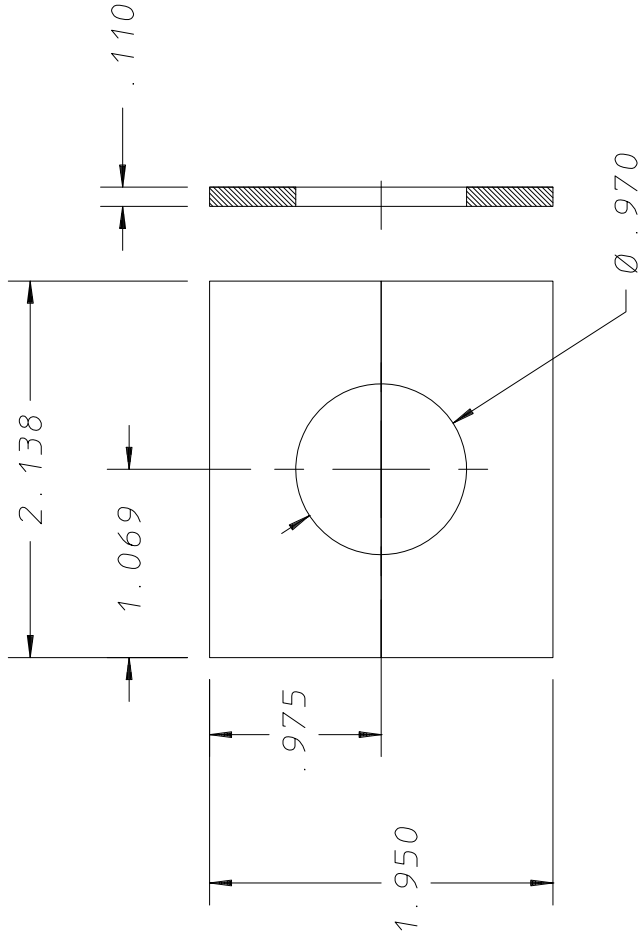
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Rev					

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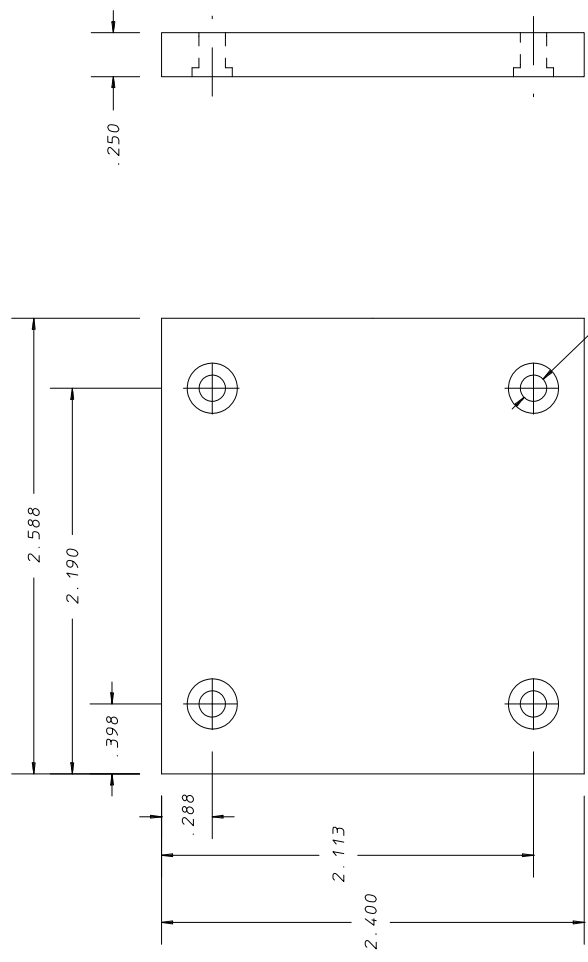
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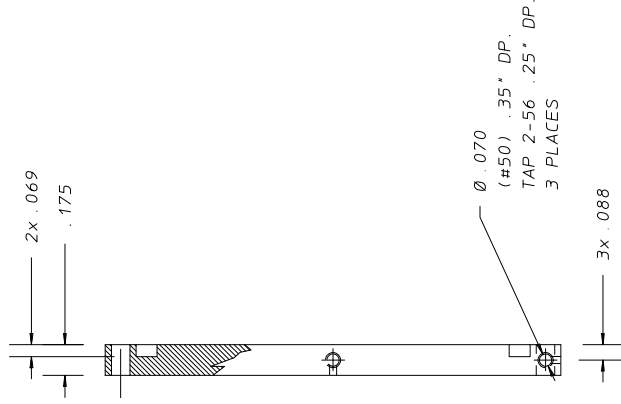
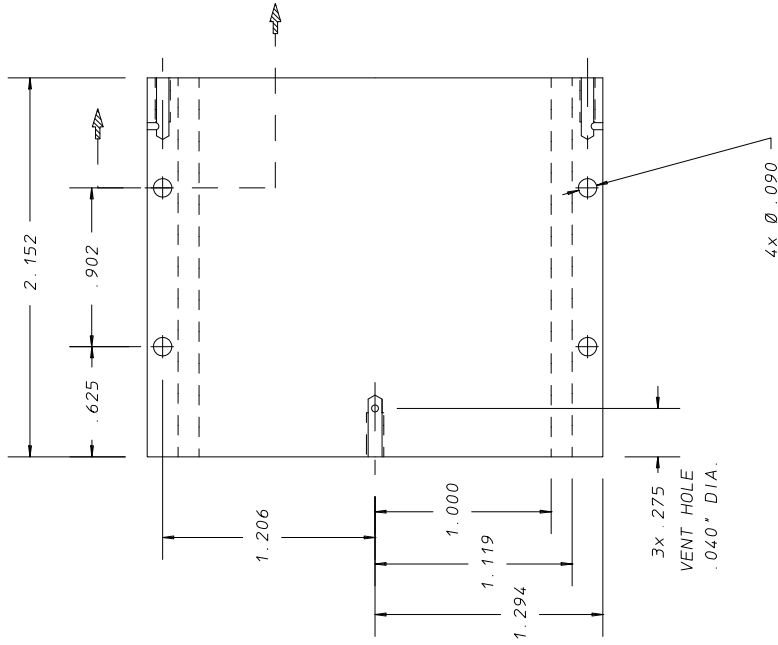
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 FARADAY CUP GRAPHITE DUMP

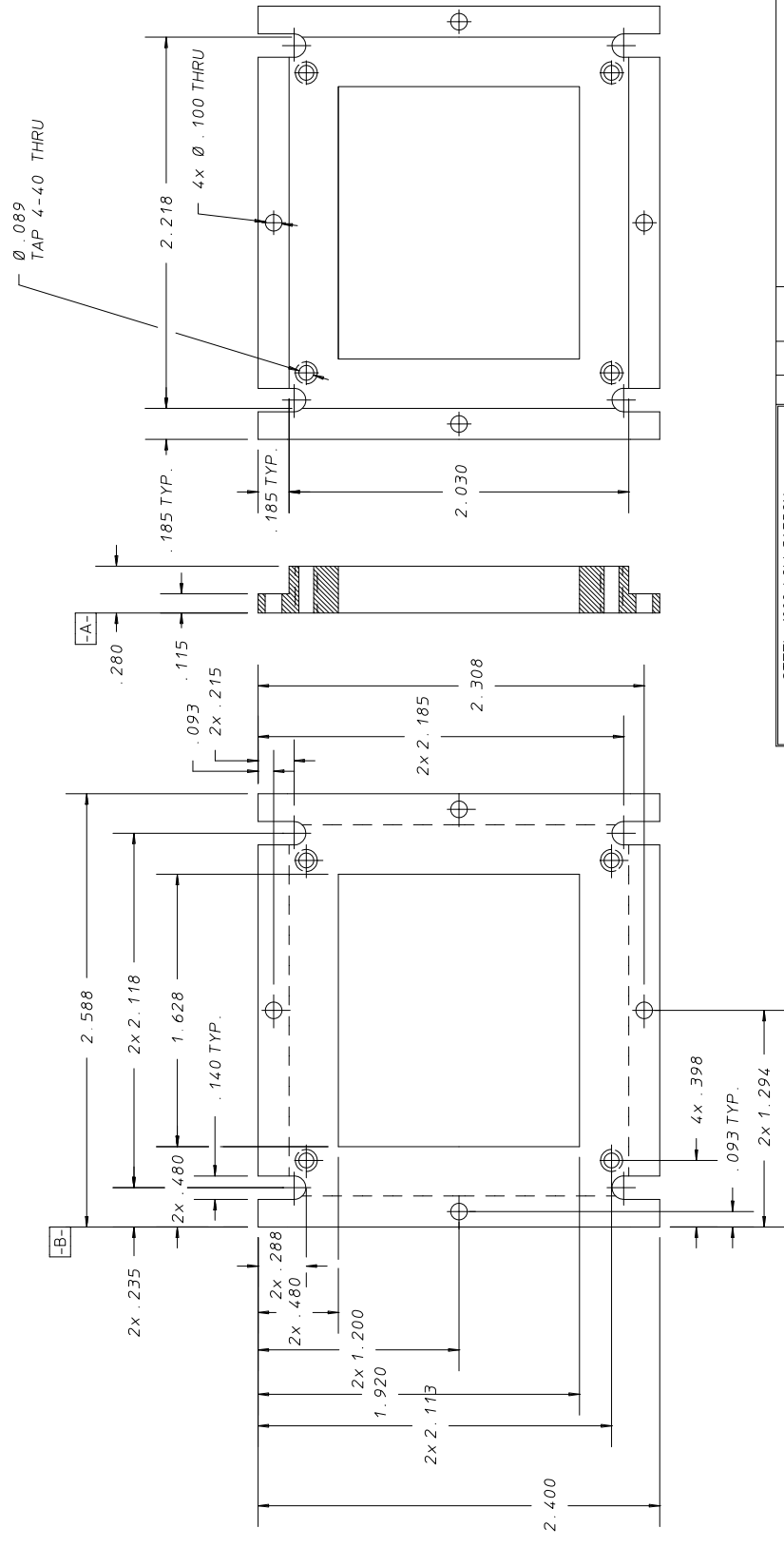


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 ION SOURCE DEVELOPMENT
 FARADAY CUP BOTTOM PLATE

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Size Rev



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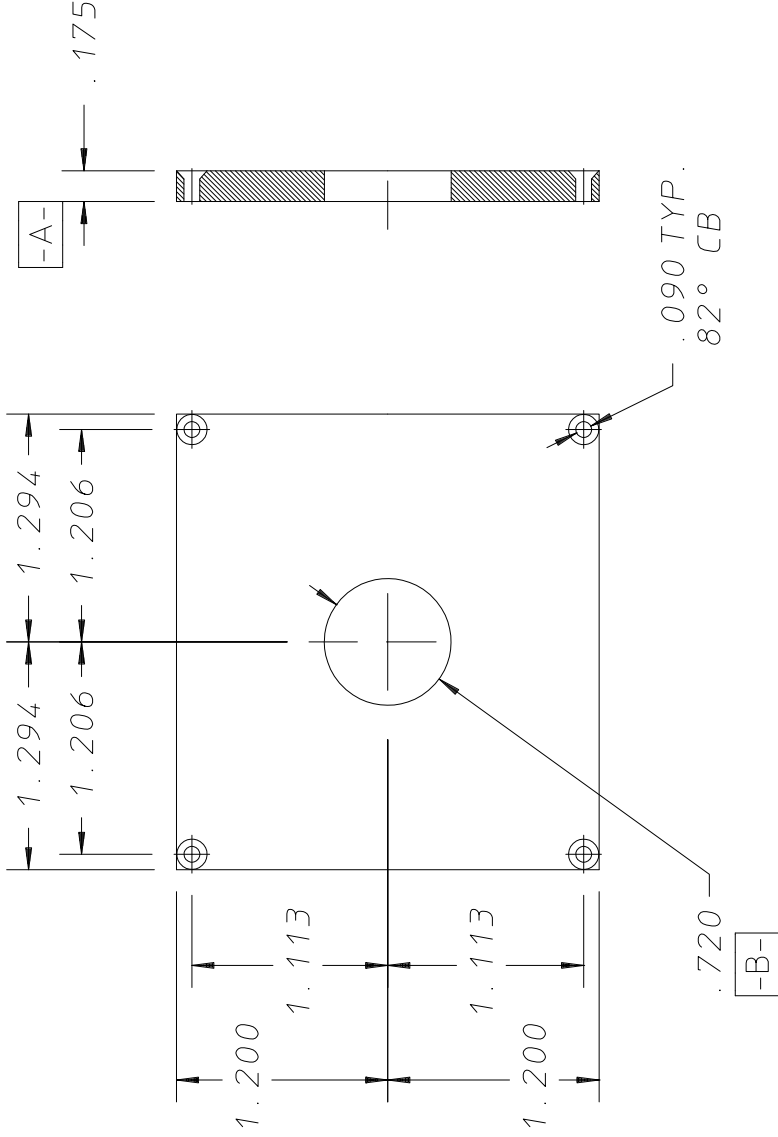
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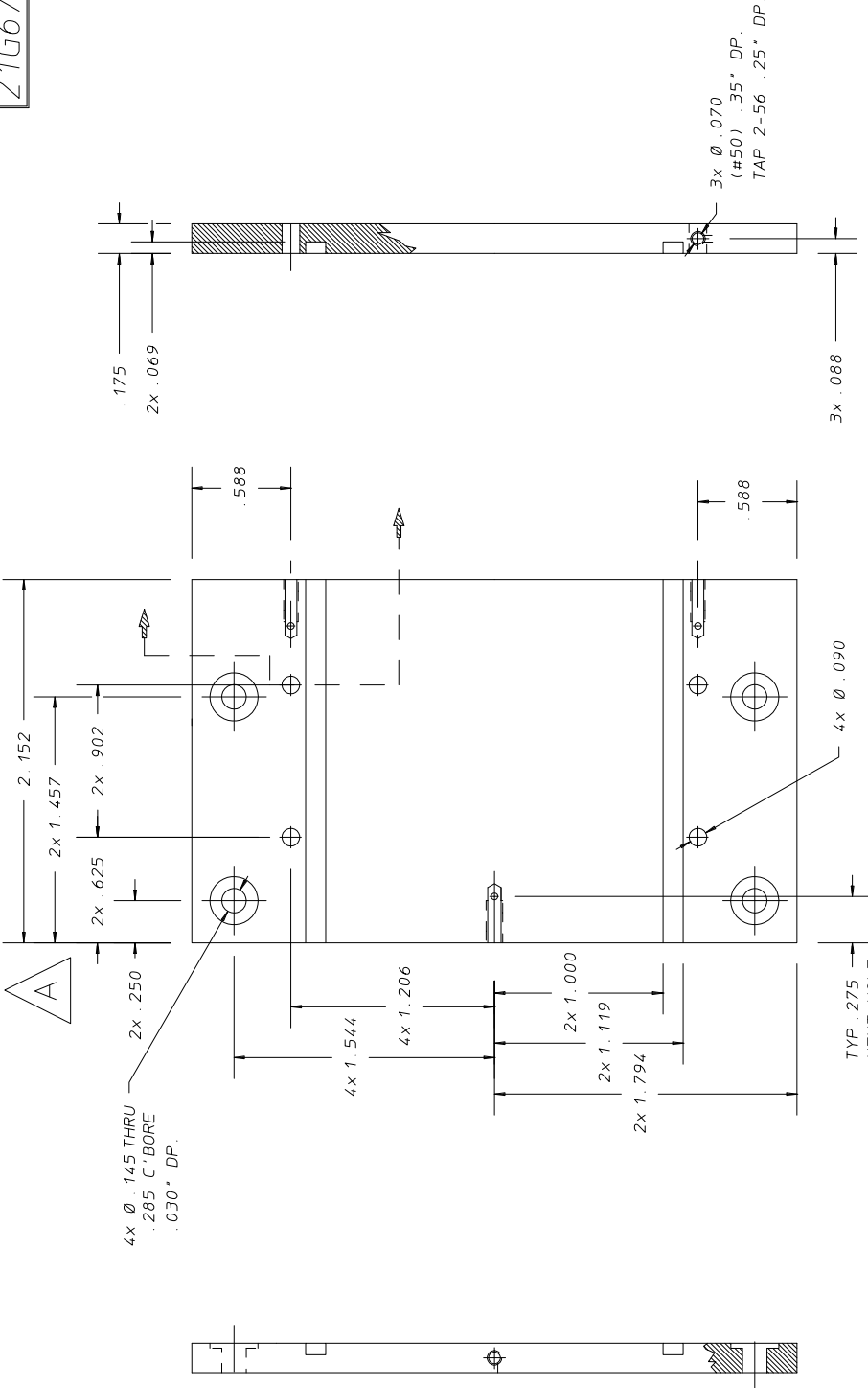
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By DAN CHENG	10-1-98	Size			
Check	Date	Detail			
By	Account	8210-11			

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 FARADAY CUP COVER PLATE

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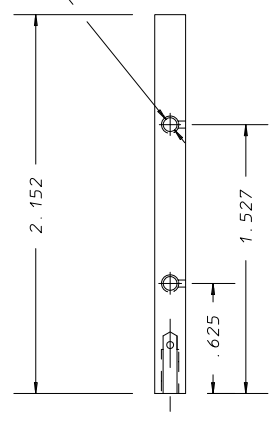


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 ION SOURCE DEVELOPMENT
 FARADAY CUP TOP PLATE

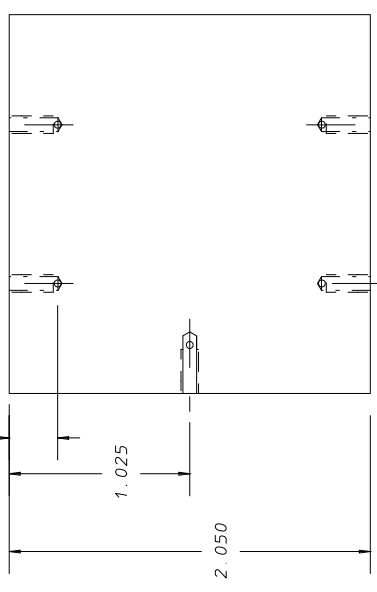
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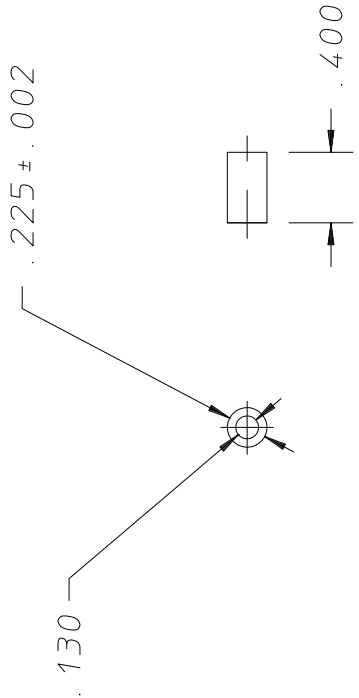
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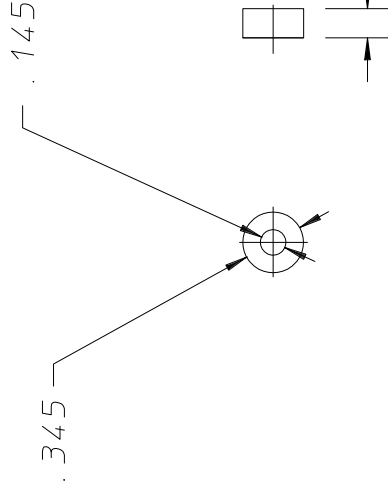
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Dwg. No. Size Rev
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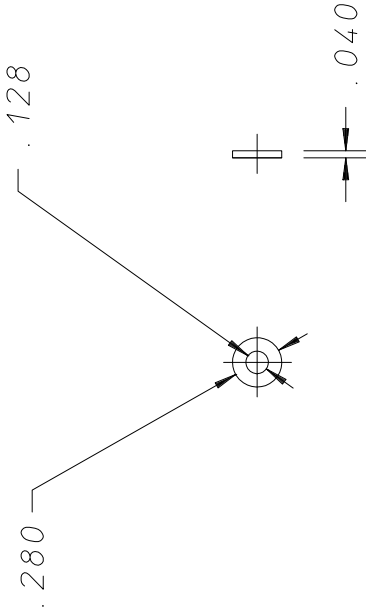
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 ION SOURCE DEVELOPMENT
 FARADAY CUP GRAPHITE DUMP INSULATOR



Material - ALUMINA, ROD STOCK		Rev	Dwn	Date	Changes
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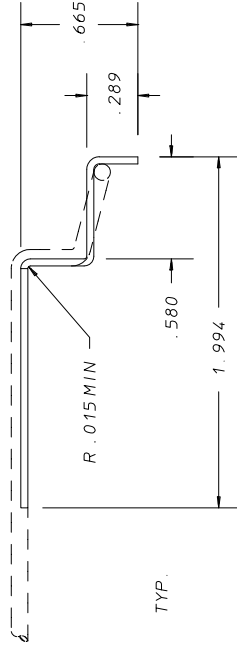
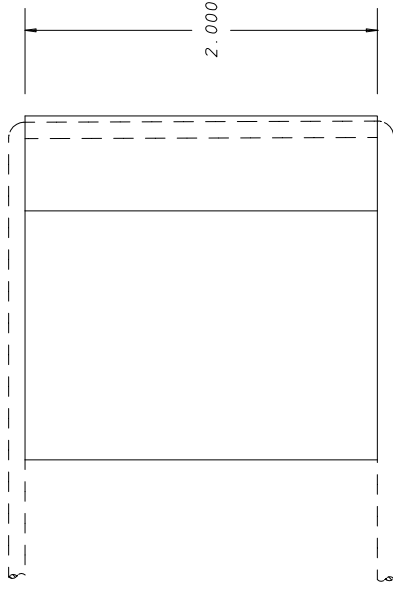
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 ION SOURCE DEVELOPMENT
 FARADAY CUP INSULATOR SUPPORT

Dwg. No. Size Rev
21G6771



Material - ALUMINA, ROD STOCK		Rev	Dwn	Date	Changes
Unless Otherwise Noted					
X ± .1	XX ± .025	XXX ± .010	Angles ± 5°		
Break Edges .016 Max on Machined Work					
Remove Burrs Weld Spallier and Loose Scale					
References: ANSI Y 14.5 & B46.1					
Account Number	Finish	Patent No.	ION SOURCE DEVELOPMENT		
Date Issued	Date Recd	Shown on Dwg No.	FARADAY CUP INSULATOR WASHER		
Number Required	Deliver To	Patent Filed	21G6903		
Surface Treatment	Degrease	Identifying Method	Category FE-1100		
Drawn By	DAN CHENG	Date	Drawing Scale Full		
Check By		Date	Drawing Detail		
		Design Account	8210-11		
		Dwg. No.	21G6771		
		Size			
		Rev			

Dwg. No. Size Rev
21G6881



Material - STEEL, 1008 LOW CARBON		Rev	Dwn	Date	Changes
Unless Otherwise Noted					
X ± .1	XX ± .025	XXX ± .010	Angles ± 5°		
Break Edges .016 Max on Machined Work					
Remove Burrs Weld Spatter and Loose Scale					
References: ANSI Y 14.5 & B46.1					
Account Number	Finish	Patent	Shown on	ION SOURCE DEVELOPMENT	
Date Issued	Date Recd	Filed	Dwg No	FARADAY CUP MAGNET HEAT SHIELD	
Number Required	Deliver To	Identifying Method	Category	FE-1100	
Surface Treatment	Degrease	Tag	Drawing Scale	Full	
Drawn By	DAN CHENG	Date	Design Account	8210-11	
Check By		Date	Dwg No	21G6881	
			Drawing Type	Detail	
			Do not Scale Prints	Size Rev	
				21G6881	

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University of California - Berkeley

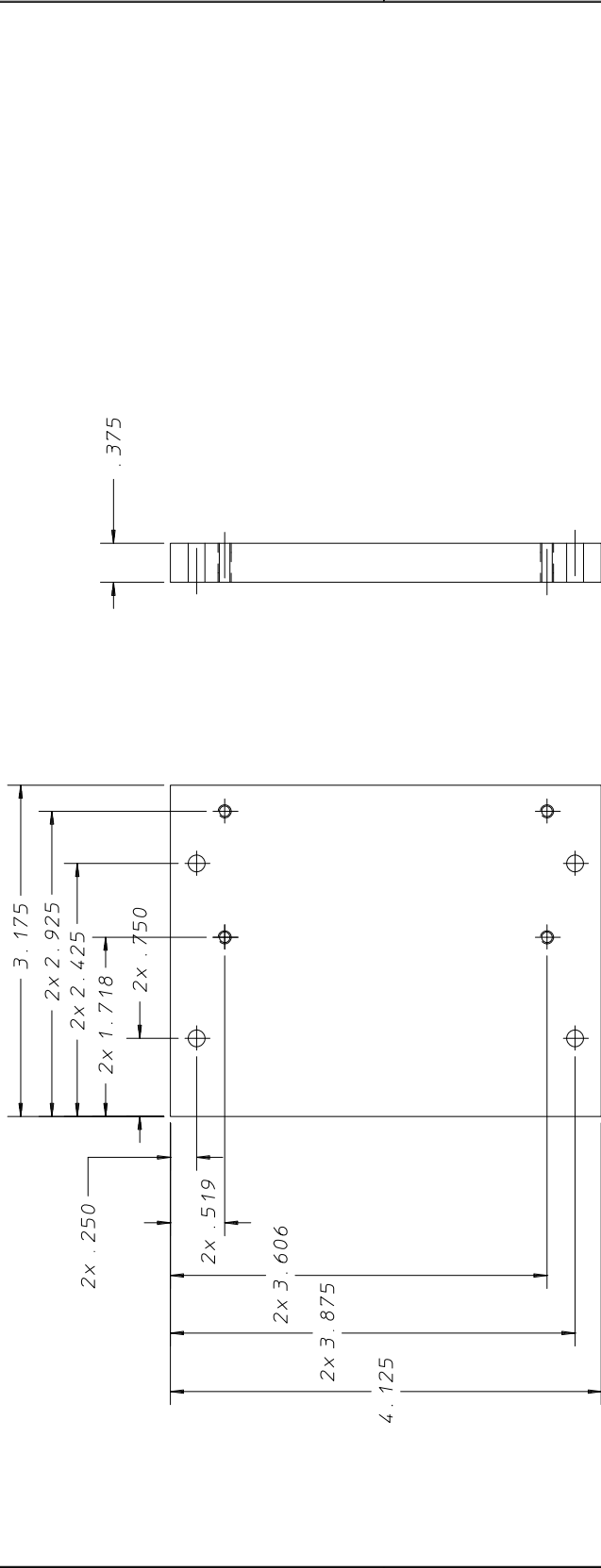
SNS-FE ION SOURCE R&D
 ION SOURCE DEVELOPMENT

FARADAY CUP MAGNET HEAT SHIELD

FE-1100
 Full
 Detail

21G6881
 Size Rev

RECD / ITEM PART NUMBER	DESCRIPTION
21G6912	



UNLESS OTHERWISE SPECIFIED	SHOP ORDERS
TOLERANCE X ± .1 .XX ± .01 .XXX ± .001 ACCT NO	DATE RECD NO SER NO
DATE TSSD DELIVER	DATE RECD NO SER NO
SURFACE FINISH 125 ✓	NO RECD
1. SAVED, FILM CUT	
2. SHEARED OR CUT STOCK FINISH	
3. THREADS CLASS 2	
4. CHAMFER ENDS OF ALL SCREW THRODS 30°	
5. 1/12 PITCH RELIEF WITH ROUND NOSE	
6. TOOL ON ALL MACHINE CUT THRODS	
7. BREAK EDGES 1/64 MAX ON MACHINE WORK	
8. REMOVE BURRS AND WELD SPATTER	
9. REF. UNS1 OR ASA 5105 SECT 1-14 & 846-1	
DATE 10-5-98	DATE 10-5-98
BY DWG D. CHENG	BY DWG D. CHENG
CHK	CHK
BY	BY
DESIGN ACCT NO 8210-11	FE1100
SCALE: FULL	DO NOT SCALE PRINTS
DWG TYPE DETAIL	00X0000
HANGER BRACKET FARADAY CUP MOUNT	ION SOURCE DEVELOPMENT
SNS-FE ION SOURCE R&D	UNIVERSITY OF CALIFORNIA-BERKELEY
LAWRENCE BERKELEY LABORATORY	

REV	DATE	DESCRIPTION
2	21G6912	
1		

Appendix A. Faraday cup simulations.

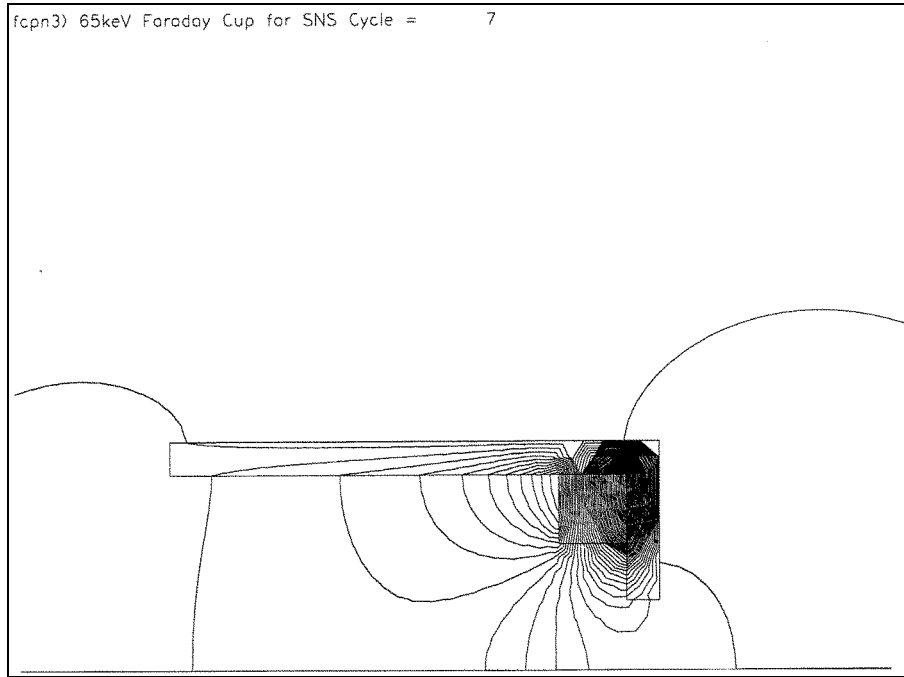


Figure A1. A 2-D magnetic field plot of Faraday cup shell & magnet.

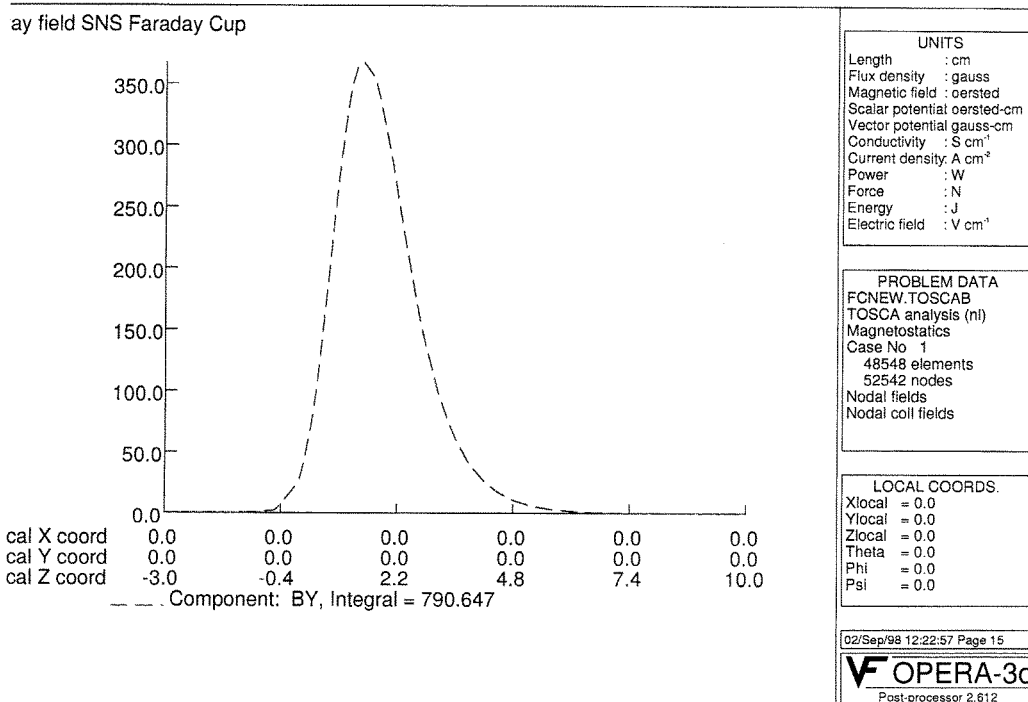


Figure A2. Magnetic field strength for the 30 keV dumping scenario, as a function of position.

Appendix A. (cont.)

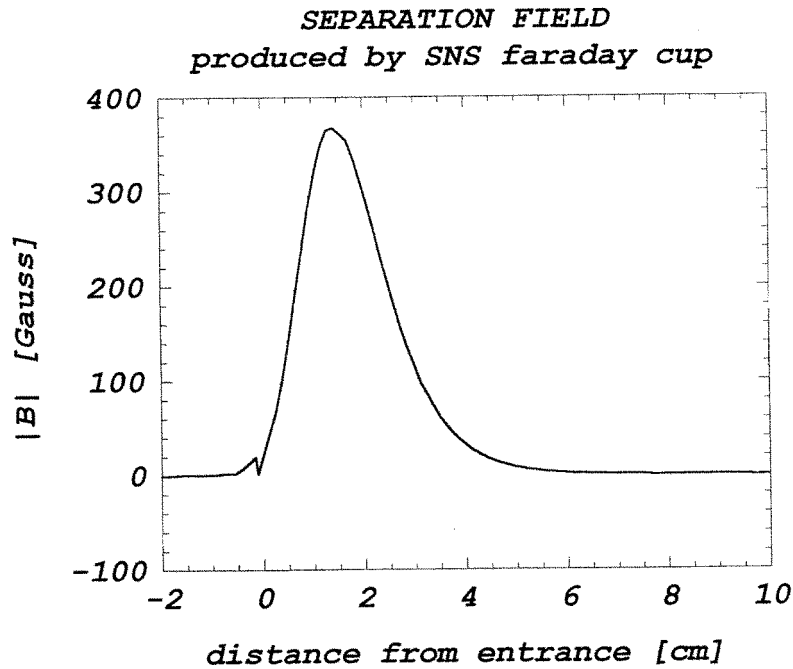


Figure A3. Magnetic separation field requirement for the 30 keV Dumping scenario, as a function of position.

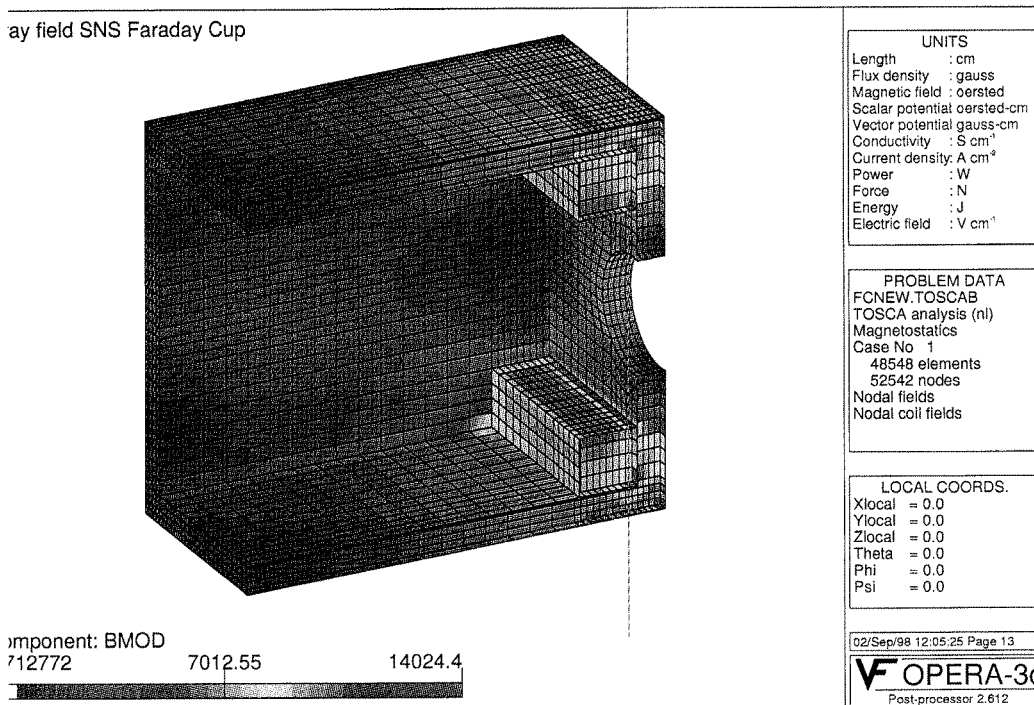


Figure A4. Fringe field plot of Faraday cup (colors not shown).

Appendix A. (cont.)

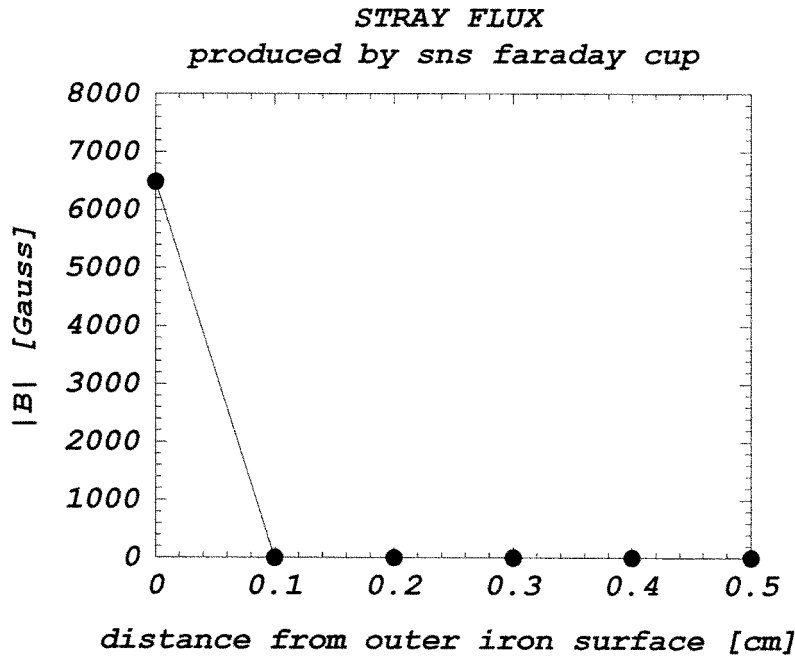


Figure A5. Stray magnetic flux, as a function of distance from iron surface.

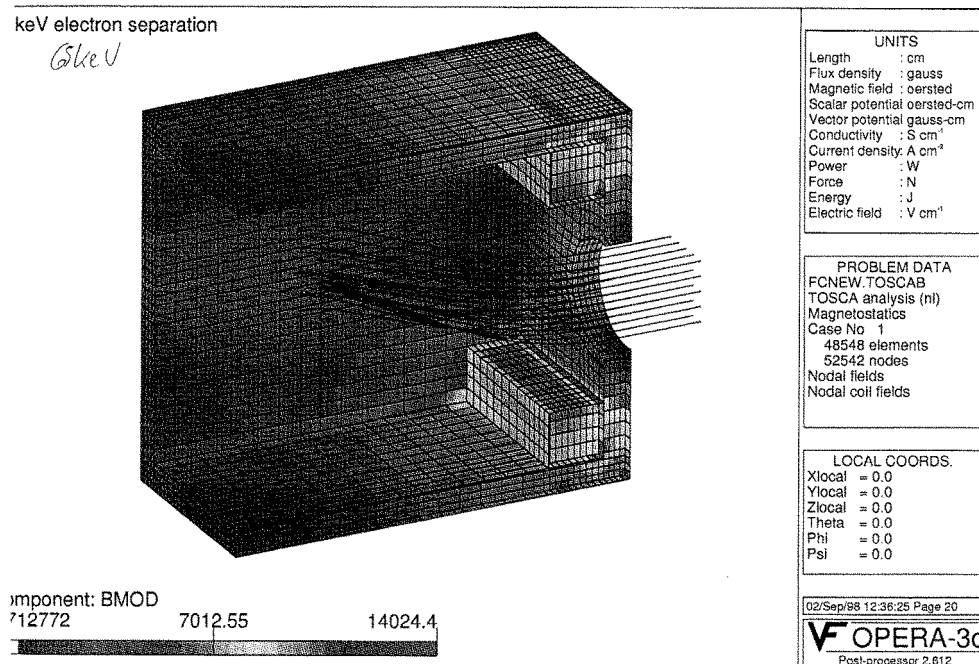


Figure A6. 3-D Plot of 65 keV electrons' deflection due to 360 Gauss magnetic field.

Appendix A. (cont.)

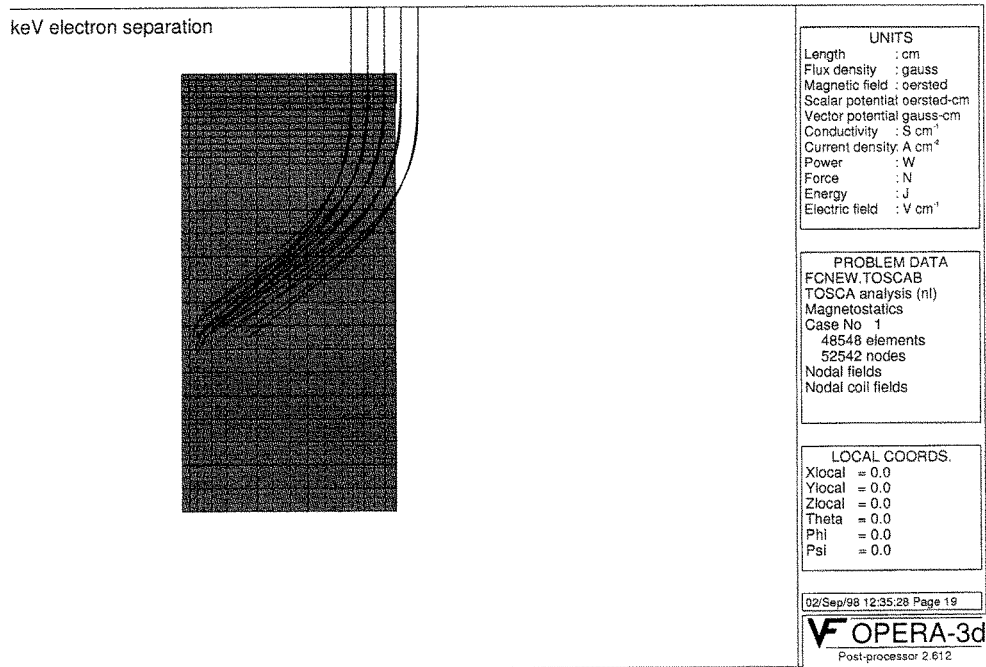


Figure A7. Top view of 65 keV electrons' deflection due to 360 Gauss field.

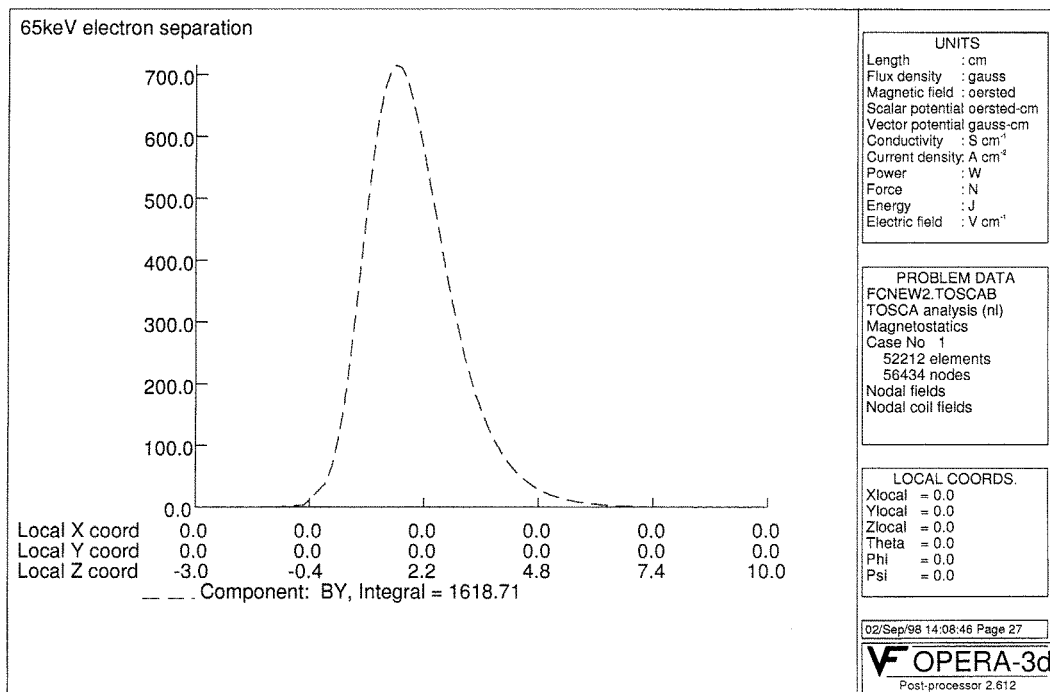


Figure A8. Electron separation field requirement for the 65 keV scenario, as a function of position.

Appendix A. (cont.)

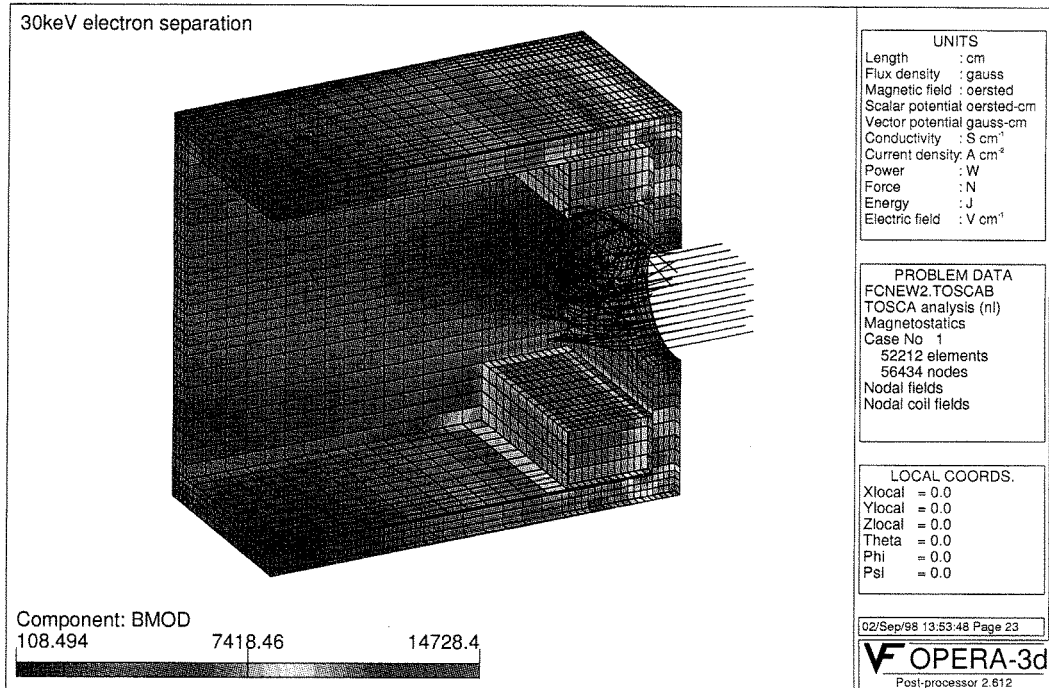


Figure A9. Plot of 30 keV electron separation in a 700 Gauss magnetic field.
Note the spiraling path of the electrons.

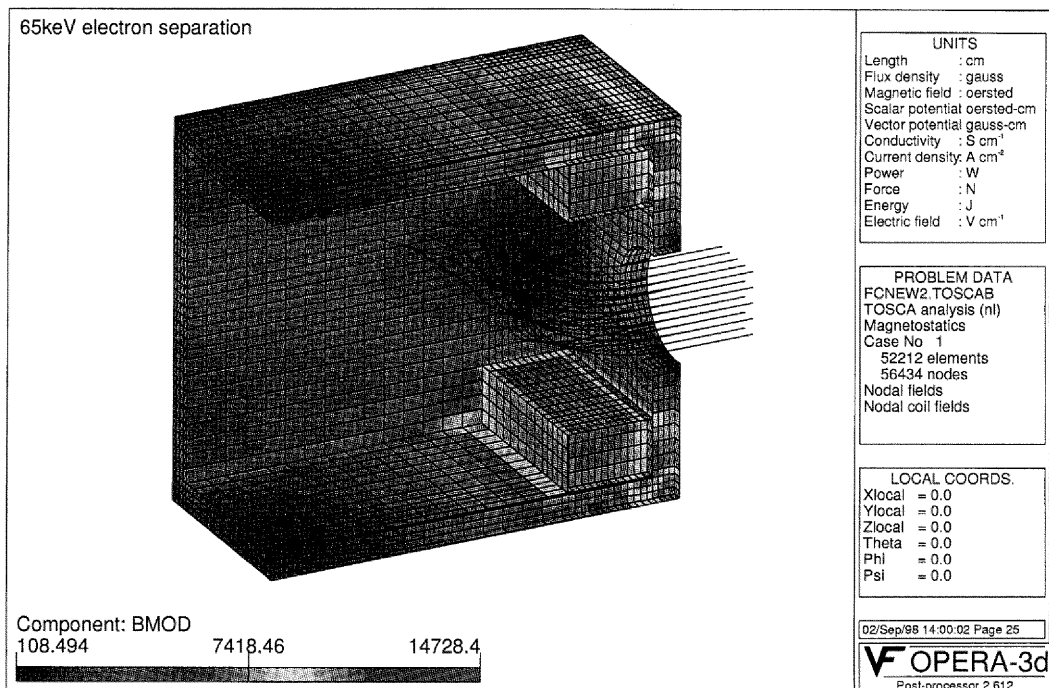


Figure A10. Plot of 65 keV electron separation in a 700 Gauss magnetic field.