DRAFT NEXT-100 Gas System Requirements

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1 Purpose and Summary

This is a document listing the requirements for a gas control system for the NEXT100 Xe double beta decay experiment.

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2 Introduction

NEXT (Neutrino Experiment with a Xenon TPC) is an institutional collaboration formed for the purpose of either discovering, or setting new exclusion limits on neutrinoless double-beta decay. The existence of neutrinoless double beta decay will indicate the neutrino is its own antiparticle and allow calculation of its mass, as well as indicate the next direction for physics beyond the Standard Model. A partial list of current collaborating institutions is: Instituto de Física Corpuscular(IFIC), in Valencia, Spain, Lawrence Berkeley National Laboratory, Berkeley, California, and Texas A&M University. Xenon 136 is an isotope of Xenon which can undergo double beta decay; if the neutrino is its own antiparticle, as some theories suggest, a small fraction of these double beta decays will be neutrinoless, instead of the more common 2-neutrino type. NEXT100 is a detector which will contain and observe 100 kg of enriched Xe 136 (EXe) in gas phase, for double beta decay events, measuring both decay energy to high accuracy and event topology by imaging the decay tracks which ionize the surrounding Xenon gas.

3 Description

The detector consists of a pressure vessel, with Xe 136 gas filling the entire volume.

Below is a cross section 1 showing the detector:

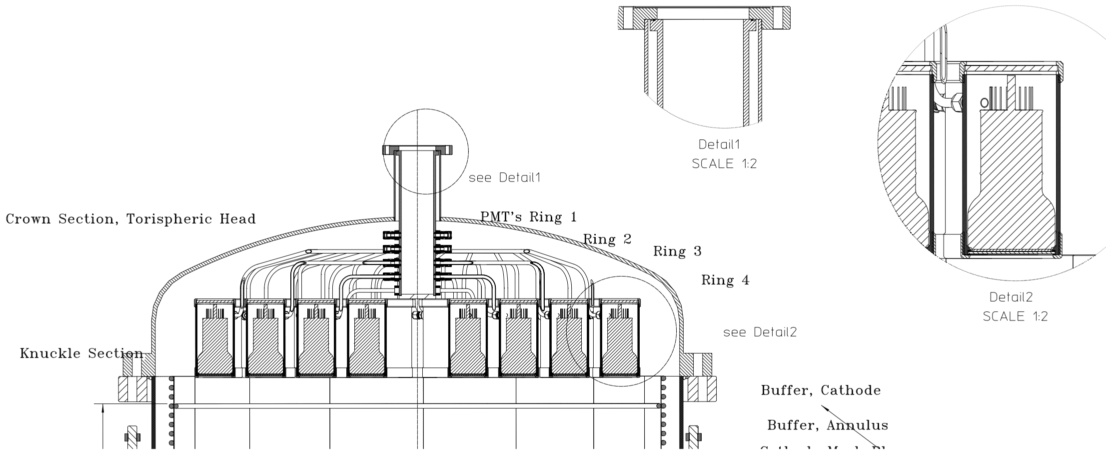

Figure 1: NEXT100, detector cross-section

During operation of the detector, Xe is circulated continuously through the Xe vessel using an axial flow pattern; it is fed in on one end and out the other end where the effluent is passed through a gas purification system.

Inside the pressure vessel, mounted to one head is an array of photomultiplier tubes (PMTs). These PMTs are designed to capture the light from electroluminescence of the EXe which is the technique used to count the total number of ionization electrons from a double beta decay event. The PMT's cannot withstand the 15 bar Xe pressure, so they are enclosed in titanium tube pressure-proof enclosure having a sapphire window on one end. Cables from the PMT exit through a flare fiting into a copper tube that connects to a central manifold that is bolted to the underside of the axial flange of the pressure vessel head. 1 atm N2 gas is is maintained inside this central manifold (and thus to the inside of the PMT enclosures); this allows both the PMTs operate normally, with no flashover, and the enclosures to be sniffed for Xe leakage. All seals to the outside world on the pressure vessel and the quartz tube assemblies will be double seals and vacuum will also be supplied to the space between them in order to detect either Xenon or N2 leaking out or water leaking in

During operation, the EXe will be maintained as a gas at room temperature and 15 bar (abs) pressure inside the detector. Xenon is a rare and expensive gas even in its natural isotopic ratio (NXe) for which Xe 136 is 9% of the total. NEXT100 will utilize enriched Xe 136 at a 70% or greater ratio; estimated value is 1.5 M$ for 100 kg EXe. It is imperative that any significant loss of Xe is avoided, under any foreseeable circumstance. This is also true if running with depleted (of Xe136) Xe (DXe), which may be done as an experimental control.

4 Parameters

Table 1: NEXT100 Gas System Parameters

Parameter	amt.	units
Active Mass, Xe	100	kg
Total mass, Xe	140	kg
Maximum Operating Pressure (MOP)	15.0	bara
Maximum Allowable Working Pressure (MAWP)	16.4	bara
Pressure vessel Inner Radius	0.57	m
Pressure Vessel Inner length	1.6	m
Pressure Vessel Volume	1	m^3
Temperature Range, Pressure Vessel	10-30	C

5 Gas System Requirements

The pressure vessel/gas system must be capable of pressurizing, circulating, purifying, and depressurizing the detector with either EXe, NXe, DXe, He, Ar (for leak checking) with negligible loss, and without damage to the detector. There is a high priority on avoiding loss of EXe, due to its cost and availability. A list of requirements in approximate decreasing order of importance is shown below:

1. Pressurize vessel, vacuum to 15 bar absolute (bara) - 1 hour max. - EXe, DXe, Ar
2. Depressurize vessel, on fault command, 15 bara to 1 bara - 10 sec max. - to closed reclamation system
3. Depressurize vessel, normal operation, 15 bara to vac. - 1 hour max. - to closed reclamation system
4. Pressure relief for fire or other emergency condition (to ASME std.) - vent to closed reclamation system
5. Maximum leakage, EXe through seals (total combined) - 100 gm/yr
6. Maximum loss, EXe to atmosphere - 10 gm/yr
7. Accomodate a range of gasses - EXe, DXe, N2, dry air, Ar, 95N2/5H2, EXe/TMA, EXe/CF4
8. Circulate all gasses through detector- 10 SCM/min in axial flow pattern
9. Purify EXe continuously - inlet condition to be < 1ppb O2, CO2, N2, CH4, THC<1ppt Ra
10. Pull vacuum $1*10^{-6}$ torr at vessel port
11. Provide 1 bara N2 to PMT enclosure system
12. Provide gas circulation of 1 SCM/min through annulus

Requirement 1 above, is performed with a manual valve and regulator. 1/2" dia connections are sufficient to meet the fill time specification. Requirement 3 is provided by opening a valve to a pre-chilled cryogenic recovery high pressure cylinder, again 1/2 " dia. lines are sufficient for this flow rate. Requirement 2 exists to protect against excessive loss of EXe in case a leak develops. It is provided by opening a fast valve or fast-actuatable burst disk leading to an evacuated recovery cylinder of 15x the pressure vesssel volume; it will require a much larger port in the pressure vessel, 4" dia. There will be anumber of fault conditions that will open this valve, such as high Xe pressure in any of the sniffer ports that are installed between pressure vessel seals to satisfy requirement 5. Requirement 4 is met by having a pressure relief valve or burst disk mounted directly to the pressure vessel, with a low conductance pipe leading to the evacuated recovery cylinder. High reliability of recovery disallows use of an inflatable gas bag as an option to the recovery cylinder.

5.1 Pressure Control

Pressure control for Xenon, (whether EXe, NXe, or DXe) will be a semi-manual open loop control; the Xe pressure will be set to a set point (with a maximum ramp rate); the N2 buffer gas pressure will then track this Xe pressure, as it is raised or lowered.

5.2 Flow control

5.3 Gas Purification

5.4 Xenon Reclamation

5.5 Vacuum

5.6 Pressure relief, emergency conditions

1. Fire
2. earthquake
3. leak sense