DRAFT NEXT-100 Gas System Requirements DRAFT

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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 Xenon (containment) vessel that sits inside a larger pressure vessel, with nitrogen gas filling both the annulus and a second lower region, where the SiPM electronics are located, maintained at the same pressure as the Xenon. The pressure vessel, in turn, is submerged in a large vat of purified water, for shielding against background radiation. Services to the detector, including gas plumbing must be routed through a set of hollow detector support legs.

This double wall design allows the Xenon vessel to have a very thin wall (which is desirable), be made of a radiopure, nonconducting material of limited strength (such as acrylic or polycarbonate), and provides a safety buffer zone to avoid direct loss of Xe to the outside world. This buffer gas annulus also serves as a high reliability, low mass high voltage insulator, as the Xenon vessel serves as the structural support for the field cage, with one end at 200 kV. Below is a cross section 1 showing the Xe vessel, pressure vessel and water tank:

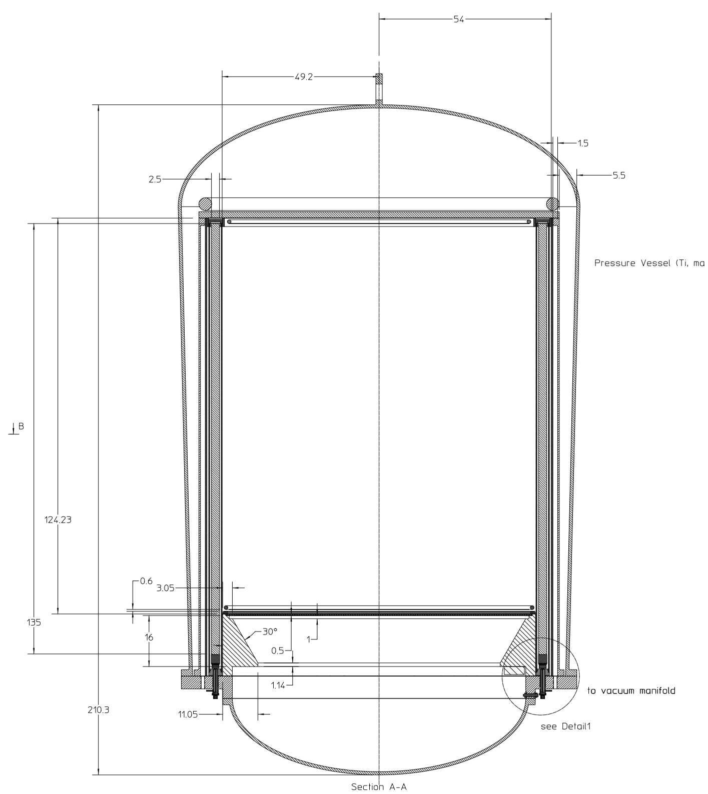

Figure 1: NEXT100, detector cross-section

The N2 buffer gas pressure must closely match the Xe pressure at all times in order to prevent damage to the Xe vessel. In the event of excessive pressure mismatch, the Xe is allowed to mix with the N2, through a passive relief valve or burst disk system, as Xe is easily separated from N2 cryogenically. During operation of the detector, Xe is circulated continuously through the Xe vessel using a transverse flow pattern; it is fed in on one side and out the other where the effluent is passed through a gas purification system. All gas ports to and from the detector are located on the main service flange.

Inside the Xenon Vessel, lining the inner radius is an circular array of quartz tubes, each tube having a wavelength shifting plastic bar with a photomultiplier tube (PMT) on one end. These assemblies 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 a the quartz tubes are sealed and a low vacuum is maintained inside the tube, just good enough to allow leak detection (Xe into tube. 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 Gas System Requirements

4.1 General

The 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. In addition, the gas system must also perform continuous leak checking of a number of safety buffer zones in the detector where gases or liquids may breach seals.

4.2 Parameters

Table 1: NEXT100 Gas System Parameters

Parameter	amt.	units
Active Mass, Xe	100	kg
Maximum Operating Pressure (MOP)	15.0	bar (abs)
Maximum Allowable Working Pressure (MAWP)	16.4	bar (abs)
Maximum Operating Differential Pressure on Xe Vessel (MODP)	0.2	bar
Maximum Allowable Differential Working Pressure on Xe Vessel (MADWP)	0.3	bar
Xenon Vessel Volume	1.0	m^3
Xenon Vessel inner Radius	0.61	m
Xenon Vessel Inner Length	1.6	m
Pressure vessel Inner Radius	0.70	m
Pressure Vessel Inner length	1.8	m

4.3 Pressure Control

Pressure control for Xenon, (whether EXe, NXe, or DXe) will be a semi-manual 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. Pressure control for the buffer gas volume is provided by a tracking regulator; this is a combination of a conventional (downstream reducing) regulator and a back pressure regulator (essentially a relief valve). If the gas volume is to low, compared to a setpoint, the conventional regulator opens to admit higher pressure (feed) and if the pressure becomes to high relative to the setpoint, the back pressure regulator opens to exhaust to a lower pressure region. The setpoint may be an electronic pressure signal, or a pilot pressure which acts to control the regulator (e.g. a dome loaded regulator) There will be a small deadband region between the differential pressure required to open either valve, in order to avoid oscillatory "pumping" action. This deadband region is determined by the maximum allowable differential pressure across the Xenon vessel wall (including the SiPM window).

By Though the Xenon pressure is set is one exception, in that the buffer gas pressure must be able to feedback to the Xe semi-manual pressure control in such a way to limit the raising or lowering of Xe pressure, in the case that the buffer gas control cannot

Since Xenon must be reclaimed cryogenically in order to provide high pressure feedstock for pressure control, it is advantageous to control

Since this process

4.4 Flow control

4.5 Gas Purification

4.6 Xenon Reclamation

4.7 Vacuum

Some