ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Nuclear and Particle Physics Proceedings 273–275 (2016) 2621–2623

www.elsevier.com/locate/nppp

Development of NEW, towards the first physics results of NEXT

F. Monrabal on behalf of NEXT Collaboration

Instituto de Física Corpuscular (IFIC), CSIC & Universitat de València, Calle Catedràtic José Beltrán, 2, 46980 Paterna, Valencia, Spain

Abstract

The NEXT $\beta\beta0\nu$ experiment will use a high-pressure gas electroluminescent TPC to search for the decay of Xe-136. The development, construction and installation of NEXT-WHITE (NEW), the first radio-pure version of NEXT, will take place this year at Laboratorio Subterráneo de Canfranc. NEW will run initially using 10 kg of natural xenon during which time NEXT technology will be validated and the topological reconstruction algorithms refined. Moreover, the background model will be benchmarked using data. A second run will use enriched xenon and will make a first measurement of the two neutrino channel ($\beta\beta2\nu$) by NEXT. This poster will present the various technical aspects of the detector detailing the radio-pure solutions for a low backgorund experiment and the low noise, high resolution measurement of both energy and position.

Keywords: NEXT, neutrinoless double-beta, neutrino

1. NEW Detector

Next-generation double beta decay experiments have to be sensitive to effective Majorana neutrino masses smaller than 100 meV, and the next-to-next generation must reach 20-25 meV if a discovery is not made previously. Designing a detector capable of identifying efficiently and unambiguously such a rare signal is a major experimental challenge. The NEXT collaboration has been operating with medium scale prototypes for the last 3 years. The prototypes, have fully demonstrated the capabilities of the SOFT concept [1] and NEXT technology. The NEXT Collaboration aims to build a detector sensitive to the current limit for the half life of the neutrinoless double beta decay and the corresponding neutrino mass. A detector holding 100 kg of enriched Xenon has been designed and it is being built. The detector implements the NEXT technology concept that has been tested in the NEXT-DEMO detector. The so called NEXT-100 detector is a radiopure detector that will start operation in Laboratorio Subterráneo de Canfranc (LSC) in the following years. The first stage of the NEXT experiment is the NEW detector.

2. Pressure Vessel

The pressure vessel (Fig. 1) is the responsible for holding the enriched Xe at pressure, so it has been designed to allow a maximum loss of enriched Xe to atmosphere of 10g/year. The NEW pressure vessel (NPV) has been manufactured with the same steel alloy selected for the NEXT-100 detector. With an internal diameter of 64 cm and a length of 950 mm, the dimensions of the NPV are intermediate between NEXT-DEMO and NEXT-100. The NPV can hold pressures of up to 50 bar. Each end-cap has one of the photosensor detection systems attached (energy plane or tracking plane).

3. Field Cage

The main objective of the field cage is to provide an homogeneous electric field in the whole fiducial volume that will drift the ionizing electrons to the electroluminescent region without deformation of the event topology. Moreover, the field cage should be able to degrade the voltage of the cathode to near zero volts at the PMT's windows.

http://dx.doi.org/10.1016/j.nuclphysbps.2015.10.009

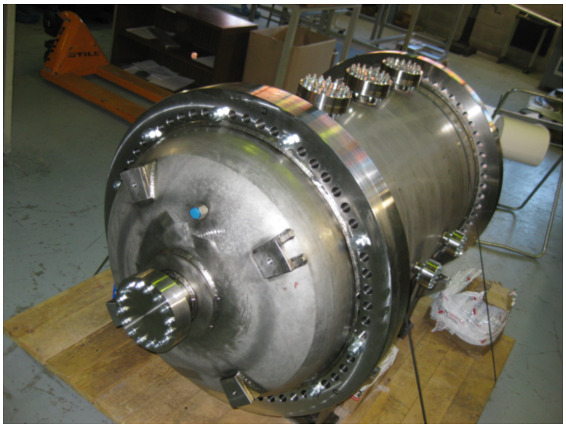

Figure 1: The NEW pressure vessel (NPV).

The design consists of a high density polyethylene (HDP) cylindrical shell, 25 mm thick, which isolates the copper shield from the voltage in the copper rings and the cathode. The rings are placed inside grooves and connected by a resistor chain. The field cage has an outer diameter (OD) of 484 mm and a length of 510 mm. Thus, both the longitudinal and radial dimensions are roughly half of those of NEXT-100.

The field cage is terminated by a transparent cathode grid, placed at 100 mm from the PMTs and a grid and a fused silica plate for the gate and anode respectively, whose role is to provide the EL amplification system. The field is degraded to ground in the buffer region between cathode and PMTs by means of additional rings, closely spaced.

3.1. Electric Field

The electric field in the cage has been simulated with finite element algorithms using COMSOL Multiphysics. Critical regions of the cage (Drift, EL) have been carefully studied (Fig. 2) to optimise the geometrical and electrical design of the detector. The simulation of the electric field has been essential in choosing the right values of the different parameters. The drift region requires a moderate electric field (300- 600 V/cm). This electric field is enough to avoid electron recombination in gas and drift the charges towards the anode. This electric field should be highly uniform and homogeneous to avoid distortion of traces during drift. The buffer zone is necessary to degrade the electric potential from the cathode to nearly zero volts at the PMT window surface. In this region of the TPC we do not demand the electric field to be highly uniform.

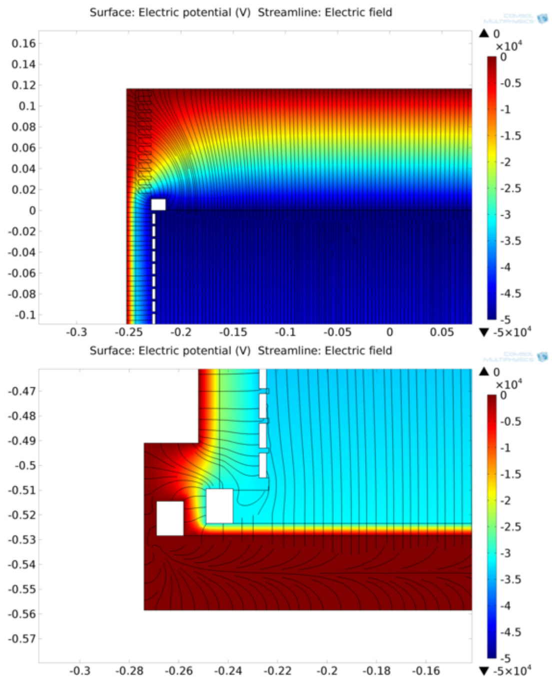

Figure 2: Results of the electric field in the field cage. The color shows the absolute value of the electric potential while the lines show the direction of the electric field. Bottom figure is a detail of the Cathode (up) and Gate (bottom) regions.

3.2. Electroluminescent Region

The EL region makes use of the combination of a mesh for the gate and a solid fused silica plate coated with Indium-Tin Oxide (ITO). This coating results in a 90% transparency conductive layer that permits the application of the voltage on the surface of the fused silica and the creation of a homogeneous field in the EL region. The fused silica plate has to be coated with TPB to shift the VUV light of the Xenon electroluminescence to blue to be detected by the tracking plane. A guard ring is needed to prevent concentration of electric field lines in the border of the TPB coated region. The fused silica solution has multiple advantages. It protects the SiPMs from sparking, removes the necessity of tension and strengthen one side of the mesh and simplifies the production of the EL region.

3.3. Buffer Region

The buffer zone is necessary to degrade the electric potential from the cathode to near zero volts at the PMT window surface. In that region of the TPC we do not demand the electric field to be highly uniform and then different degrading options are possible. The possibility to degrade the voltage without using rings or only a few is being explored. Independently of the chosen configuration the difficulty in this region is to avoid electric fields regions with electric field near the breakdown.

A detail of the current design is shown Fig. 3

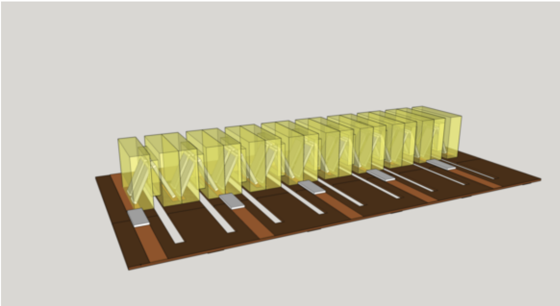

Figure 3: Detail of the resistor chain inside the vacuum epoxy. As two resistors are needed to hold the potential among rings they are soldered in a inverted ”V” shape to fit in the space between rings.

3.4. High Voltage Feedthrougs

NEW HHV feedthroughs need to operate at 50kV on the cathode and 20kV on the gate. The gate feedthrough is very similar to the one used in the DEMO detector, only small modifications are needed for a better connexion with the gate. The cathode feedthrough has been completely redesigned (Fig. 4) to ensure that it can easily hold the 50kV. The design has a conical shape to avoid field concentration on the edges of the polyethylene and phosphor bronze contact. It is based on an idea by H. Wang [2].

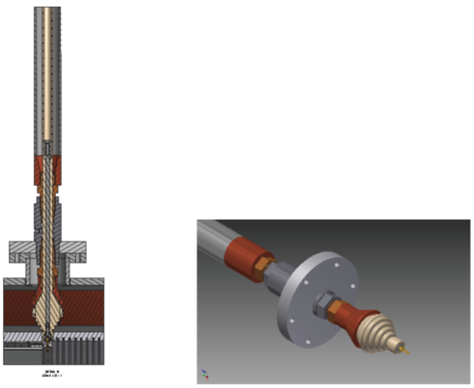

Figure 4: Cathode feedthrough. The conic shape prevents concentration of electric field lines at the edges of the feedthrough allowing for a higher voltage limit.

4. Energy Plane

The NEW energy plane (NEP) will use 12 R1141010 PMTs from Hamamatsu. The PMTs will operate with a gain of $5 \cdot 10^6$ in vacuum, inside the vessel. A thick copper plate separates the PMT-vacuum region from the high pressure region in the chamber, and acts also as a radiation shield. Sapphire windows coated with TPB protect each PMT. The PMT cans and the thick back copper plugs also act as shields of radiation. The signal will be read in differential mode. The resulting noise in each channel is sufficiently small to allow for resolution of single photoelectrons.

5. Tracking Plane

The NEW tracking plane is made of 28 Kapton DICE Boards (KDB). The KDBs over-cover the fiducial region ensuring that there are no dead regions. The measured radioactivity budget (only upper limits) indicates that kapton is a cleaner material than other alternatives. The SiPMs can be soldered in an oven and the circuit comes with its own pigtail. The connector is located at the end of the long tail, and is screened from the gas, in the fiducial volume, by a thick copper shield.

The final version of the DICE boards operates with a differential signal output that permits a better reduction of the noise during signal acquisition. Such design has been tested in a realistic set-up with 4 meter long cables, an operating DICE board and a front-end and it has proven to be able to separate single photoelectrons. That will allow for a direct calibration of the SiPMs.

6. Conclusions

The NEW detector will provide an intermediate step in the construction of the NEXT-100 detector that would allow the validation of the technological solutions proposed for NEXT. The NEW detector would permit a measurement of the energy resolution at high energy, and the characterisation of the 2-electron topological signature, by measuring the $\beta\beta2\nu$ mode. Finally, NEW will permit a realistic assessment of the NEXT background model before the construction of the NEXT-100 detector.

References

[1] V. Alvarez, et al., The NEXT-100 experiment for neutrinoless double beta decay searches (Conceptual Design Report)arXiv:1106.3630.

[2] E. by B. Rebel, et al., High voltage in noble liquids for high energy physicsarXiv:1403.3613.