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R&D activities toward a High Pressure Xenon TPC (NEXT)

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Double beta decay is a very rare nuclear decay process in nature characterized by changing the ordering number Z by two units and leaving the massnumber A constant. It can occur in two modes, with the emission of two electrons and two anti-neutrinos or the emission of two electrons only. While the first mode is in agreement within the Standard Model, the neutrino-less double beta decay is not. It can only occur if the neutrino is its own antiparticle and massive (Majorana-Mechanism). As ^{136}Xenon is one of the few elements, which decays by a double beta decay a high-pressure, gaseous ^{136}Xenon TPC has good prospects to proof the existence of the Majorana nature of the neutrino.

Our Collaboration follows the gaseous concept, as pioneered by the Gotthard experiment [1]. The name of our project is NEXT which stands for **N**eutrino **E**xperiment with a **X**enon **T**PC. Different to the Gotthard approach the NEXT TPC will use either pure Xenon or Xenon with a small contribution of a quencher. This will provide a significant amount of primary scintillation light which triggers the data acquisition and allows a full three dimensional particle reconstruction. It overcomes one significant drawback of the Gotthard approach.

Such an object could explore the degenerated hierarchy and provide a deep understanding of the experimental techniques to suppress backgrounds required for larger detectors. A general introduction and the physics motivation of this topic can be found in [2]. The current R&D status will be presented in this paper.

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1. Introduction

Designing a Xenon based TPC, one can consider two options: liquid Xenon (LXe), as adopted by the EXO collaboration [3], or high pressure gaseous Xenon (HPXe) NEXT. Our collaboration is planing a gaseous ^{136}Xenon detector of a mass of about 100 kg.

As a liquid Xenon TPC has the obvious advantage of compactness, the key advantage of the gaseous version is the very specific signature of potential $\beta\beta^{0\nu}$ events. This provides an excellent chance to reduce significantly a lot of background, especially in the interesting region at the endpoint of the $\beta\beta^{2\nu}$ spectra where background rejection becomes most significant.

2. Organization and scientific challenges of NEXT

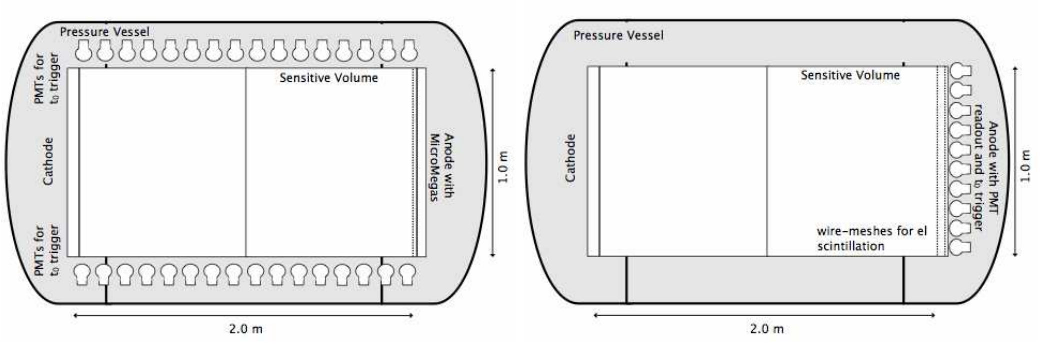

Figure 1: The Figure shows two possible detector designs of the final NEXT 100 TPC.

Due to the positive decision of the Spanish Ministry of Science the newly founded NEXT collaboration will be financed by the Consolider program [4]. To accomplish the realization of a final 100 kg High Pressure Xenon TPC in the newly established Underground Laboratory of Canfranc an ambitious R&D program have been set up. In a time period of two to three years starting from 2009 the project has to reach the maturity to face the challenge of building large scale prototypes. The full period has to end with the construction and commisioning of the 100 kg High Pressure Xenon TPC in 2014.

One of the major technology decision will be how the primary charges will be amplified and read out. A conventional charge amplification as well as a scintillation light read out will be investigated. Following criteria will be applied to decide the technology decision:

- What is the optimal granularity for pattern recognition ?
- What is the maximal achievable energy resolution ?
- What is the maximal operation pressure of the technology ?
- Which technology has the best long term behavior in operation stability and homogeneity ?
- What is the level of radioactivity ?
- Can the criteria be fulfilled for large scale prototypes ?
- What would be the costs of the final detector ?

The second major decision, which has to be made after the R&D phase is finished, if searches for **W**eakly **I**nteracting **M**assive **P**articles (WIMPs) can be technically realized within the same detector.
The final size of the TPC will be determined mainly by the pressure the detector can operated with. For 10 bar a fiducial volume of $1\times1\times2$ m^2 would be needed to have 100 kg of 100 % enriched ^{136}Xenon.

3. First R&D Activities and Results

3.1 Outgassing Studies

The key issue of the high-pressure ^{136}Xe TPC is an excellent energy resolution, which can be determined by a precise charge measurement. It is of uppermost importance to use only materials which do not add electro-negative components to the gas. Therefore we want to examine all materials and components used in the gas volume by their outgassing behavior. We have setup a small TPC box, which is radiated with a ^{55}Fe-source to monitor any drop in the gain by a specific material. Currently a system which stores all slowly changing parameters is setup. A precise knowledge of pressure, temperature or oxygen content is needed to reduce the effect of gain fluctuations.

3.2 Resolution Measurement

First energy resolution measurements have been performed under high pressure using a conventional charge amplification TPC with Micromegas. The gas mixture used was Ar/iC_4H_{10} in the ratio 98/2. The signal was read out on the upper side of a 3×3 cm^2 Micromega mesh, which was connected by clamps. The TPC was radiated with a ^{136}Am-source, which emits α-particles with an energy of 5.5 MeV. The best energy resolution which could be achieved with this parameter set was around 0.7 % (FWHM). Measurements with pure Xenon will be carried to find out if this promising energy resolution can be maintained with such a technique. It might be, that a small contribution of a quencher is needed to operate a charge amplification TPC.

References

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[2] J.Martin-Albo, *NEXT: a high-pressure Xe TPC for double beta decay searches*, `PoS(Nufact08)130`.

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