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EXO: the Enriched Xenon Observatory for Double Beta Decay

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ABSTRACT

EXO is a search for neutrinoless double beta decay in ^{136}Xe. An active R&D program for a 10 ton, enriched ^{136}Xe liquid phase detector is now underway. Current research projects are: decay product extraction, Xe purity studies, energy resolution studies, and Ba+ ion laser-tagging. Half lives of up to 5.0x10^{28}yr will be ultimately probed, corresponding to a sensitivity to Majorana neutrino masses $\geq$ 10meV.

1 Introduction

The EXO experiment is a search for $0\nu\beta\beta$ in ^{136}Xe, using several unique strategies to achieve high sensitivity to small neutrino masses. It consists of a liquid Xe TPC in which we read out both the ionization and the scintillation signals produced by double beta decays, thereby obtaining the requisite energy resolution. It also incorporates a technique for laser tagging the daughter nucleus, ^{136}Ba. We refer the reader to an earlier publication by our collaboration that describes in detail the theory of our detection scheme [1]. Here, we give a status report on the R&D program currently underway that is leading to a 10 ton liquid ^{136}Xe detector that incorporates this novel approach.

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2 Xenon purification and Ba ion extraction R&D

In our system optimum Xe purity is achieved by means of a SAES hot Zr getter through which the Xe gas is passed, leaving behind any substances that react with the hot Zr. Figure 1 shows a simplified diagram of our setup.

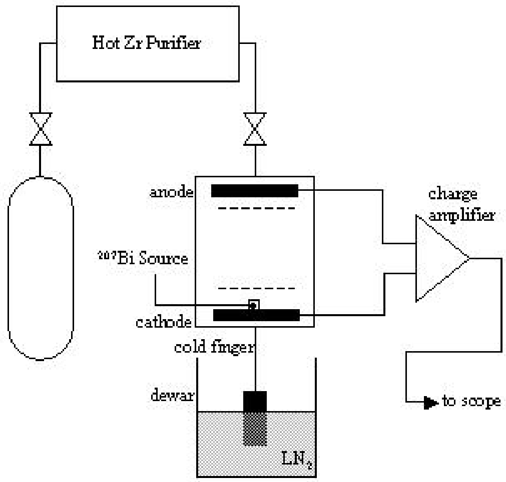


Figure 1: *Simplified diagram of the Xe purification and purity monitoring setup.*

Using an adaptation of a technique first demonstrated by Carugno, et al. [2], we measure the resulting purity by condensing the Xe into a test cell and drifting electrons through it. Our test cell holds about 100cc of liquid Xe and contains an anode, field shaping electrodes and a cathode with a ^{207}Bi source attached to it. Using an adaptation of a technique first demonstrated by Carugno, et al. [2], we measure the resulting purity by condensing the Xe into a test cell and drifting electrons through it. Our test cell holds about 100cc of liquid Xe and contains an anode, field shaping electrodes and a cathode with a ^{207}Bi source attached to it. The ionization charge liberated by the radioactivity from the source is drifted across the 6cm length of the cell. The electron lifetime is determined by comparing the charge signal amplitude when it leaves the cathode to when it arrives at the anode. Figure 2 shows a diagram of our purity cell and a sample oscilloscope trace of the shaped output from our charge sensitive amplifier. In the scope trace, the positive pulse corresponds to the signal induced by electrons leaving the cathode; the negative pulse, electrons arriving at the anode. Note that only a very slight decrease in pulse amplitude is apparent.

We are also investigating the possibility of extracting the Ba ion from the liquid and releasing it into an analysis chamber for identification. We have developed

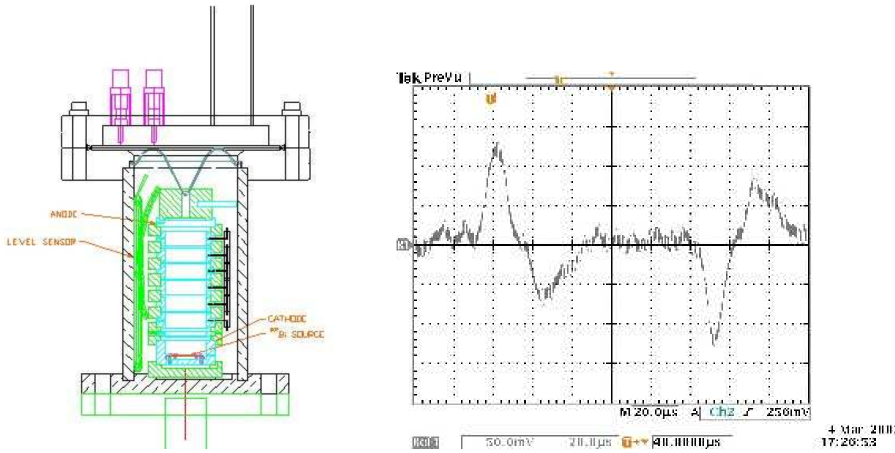


Figure 2: *Left: purity monitor cell for measuring electron lifetime in liquid Xe. Right: Oscilloscope trace of one ionization event.*

a special cell in which a small amount of liquid Xe is condensed. A ^{230}U source emits ^{222}Ra ions into the liquid. We then attempt to extract these ions from liquid solution by means of an electrostatic probe, thereby proving the overall principle of individual ion extraction. Our initial tests are currently being performed with a bare tungsten tip that is held at a negative high voltage in order to collect ions from solution. We have just begun initial testing of this system.

3 Conclusion

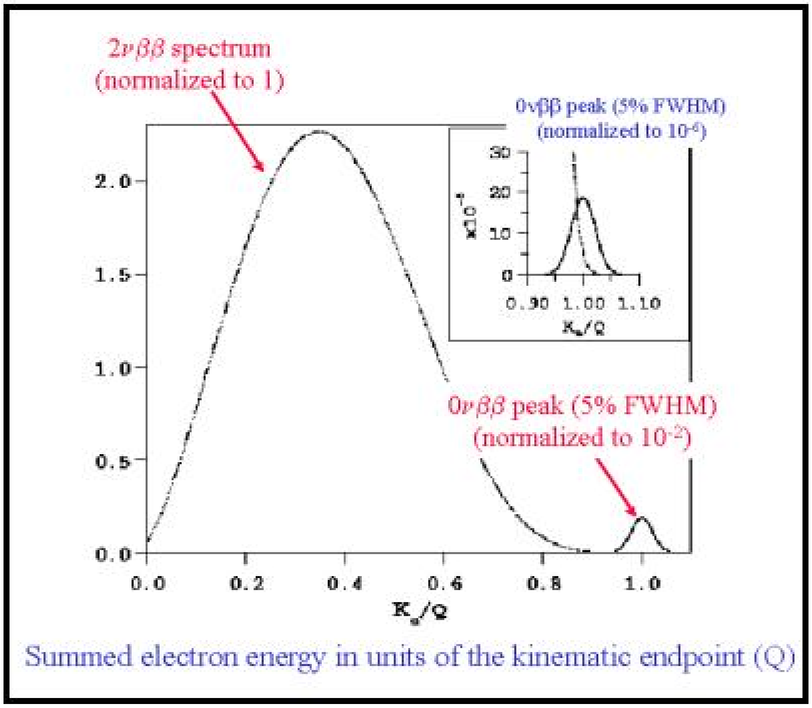
The remainder of our R&D program includes a setup for the optimization and study of the energy and position resolution achievable in liquid Xe and an experiment to determine the viability of trapping and spectroscopic study of the Ba^{+} and the Ba^{++} ion. We expect to publish initial results from these activities in the near future. Once all of the various techniques are brought together in an ultimate 10-ton experiment, we expect to be sensitive to half lives as long as 5.0x10^{28}yr, or an effective neutrino mass in the range 10-50meV. This is about a factor of 10 below the world's current best value, as reported in [3].

References

1. M. Danilov *et al*, Phys. Lett. B **480,** 12 (2000).

2. G. Carugno *et al*, Nucl. Inst. Meth. A **292,** 580 (1990).

3. M. Guenther *et al*, Phys. Rev. D **55** 54 (1997).


2νββ spectrum
(normalized to 1)
0νββ peak (5% FWHM)
(normalized to 10^-6)
x10^-8
0.90 1.00 1.10
Ke/Q
0νββ peak (5% FWHM)
(normalized to 10^-2)
0.0 0.2 0.4 0.6 0.8 1.0
Ke/Q
Summed electron energy in units of the kinematic endpoint (Q)