
EXO experiment

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EXO group

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EXO program

- A phased program aimed at building an enriched xenon double beta decay experiment with a one or more tonne ^{136}Xe source
- Ability to detect the two electrons emitted in the decay in coincidence with the positive identification of the ^{136}Ba daughter via optical spectroscopy
- First phase “EXO-200”, a 200 kg double beta decay experiment, begins data taking FY2011. Expect to measure $2\nu\beta\beta$ mode and confirm or rule out Klapdor³ claim at 5σ after 2 yr runtime
- EXO-200 also tests backgrounds at 2000 mwe, LXe enrichment tech., low-radioactivity TPC components, light readout (518 LAAPDs)

Case	Mass (tonne)	Efficiency (%)	Run Time (yr)	σ_E/E @ 2.5 MeV (%)	$2\nu\beta\beta$ background (events)	$T_{1/2}^{0\nu}$, 90% CL (yr)	Majorana mass sensitivity (meV)	
							RQRPA ¹	NSM ²
EXO-200	0.2	70	2	1.6	40	6.4×10^{25}	109	135
Conservative	1	70	5	1.6	0.5 (use 1)	2×10^{27}	19	24
Aggressive	10	70	10	1	0.7 (use 1)	4.1×10^{28}	4.3	5.3

1. Simkovic et al., *Phys. Rev. C* **79**, 055501 (2009)

2. Menendez et al., *Nucl. Phys. A* **818**, 139 (2009)

3. *MPL A* 21 (2006) 1547

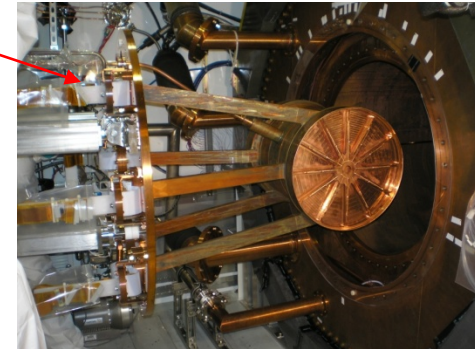
Assumptions:

- 80% enrichment in ^{136}Xe
- Intrinsic low background + Ba tagging eliminate all radioactive background
- Energy resolution only used to separate 0ν from 2ν modes: Select 0ν events in a $\pm 2\sigma$ interval centered around the 2458 keV endpoint
- Use for $2\nu\beta\beta$ $T_{1/2} > 1 \times 10^{22}$ yr (Bernabei et al.)

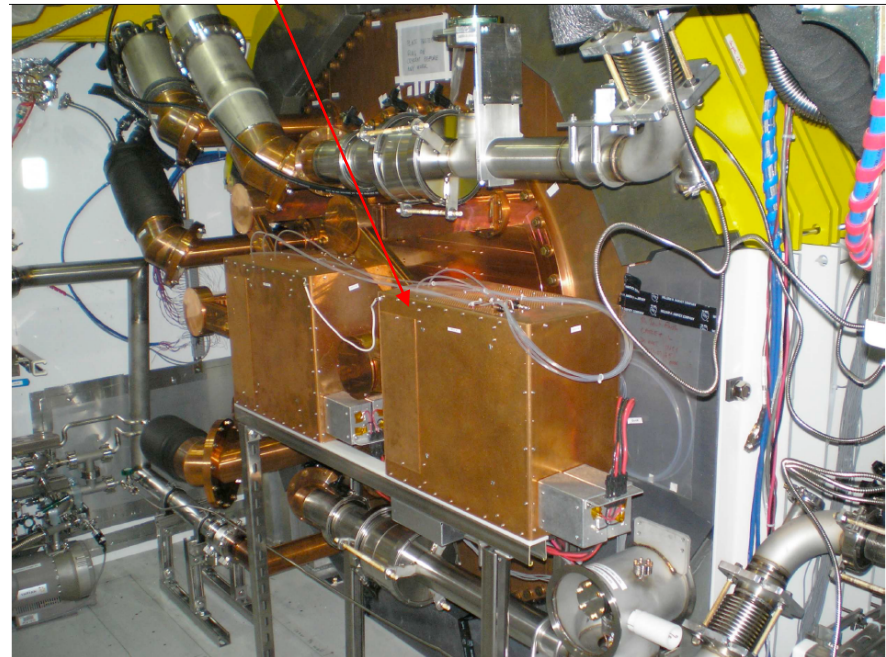
FY2010 activities & accomplishments

- Commissioned cryogenics at WIPP in Nov-Dec 2009
- Installed TPC in Jan-Mar 2010
- Discovered problem with power installation at WIPP, substantially degrading reliability. Upgraded EXO-200 power distribution.
- Electronics running since Apr 2010, DAQ commissioning ongoing.
- Circulating warm Xe since May 2010. Waiting for WIPP's end of power and network distribution fixes (this is limiting progress).
- Should have LXe ~a month after the power issues are resolved
- Tonne-scale EXO design in relation to DUSEL

TPC installation

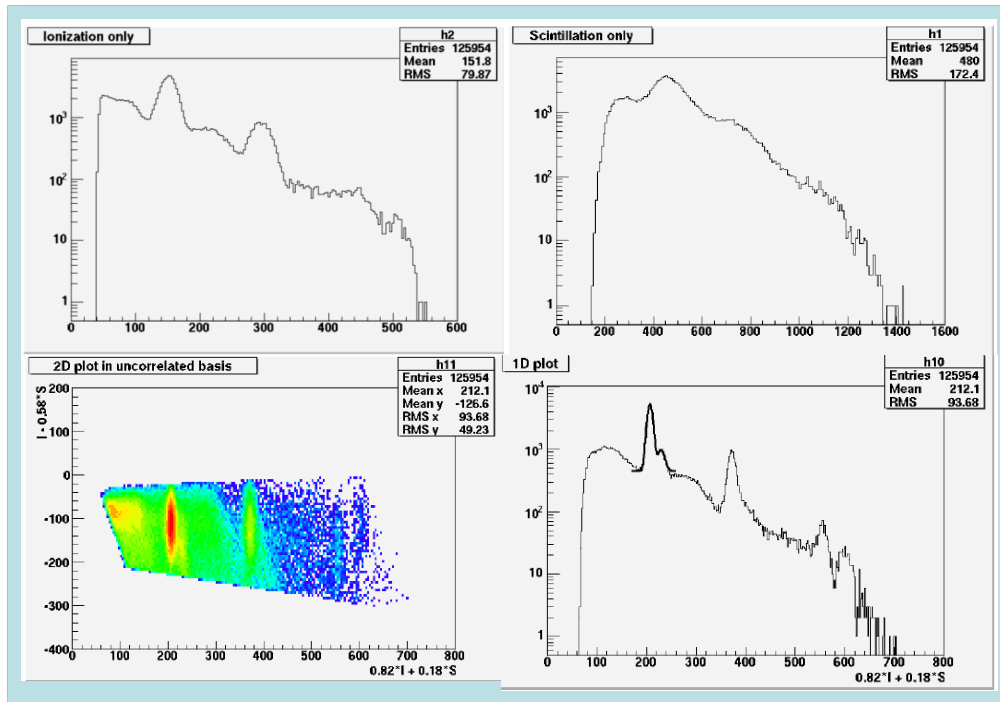


EXO-200 electronics installed and running at WIPP



FY2010 activities & accomplishments

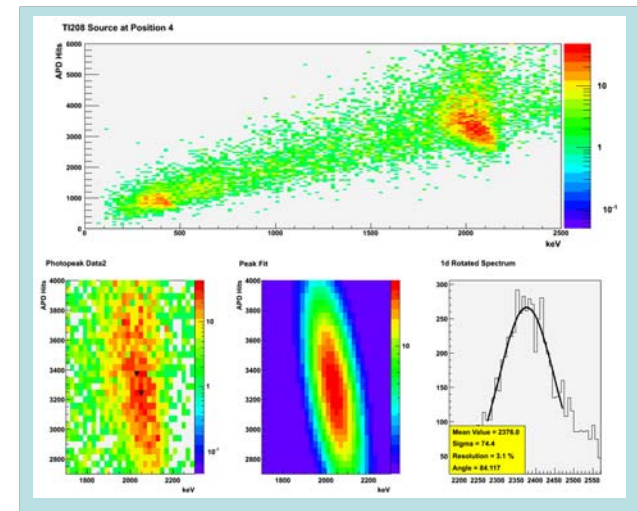
- Two independent analysis groups making headway on analysis techniques
- Special emphasis on understanding LXe anticorrelation and how it improves detector energy resolution
- Monte Carlo studies of EXO-200 TPC ongoing



Data from prototype TPC, 500 V/cm

Ionization only energy resolution 3.3% at Q-value

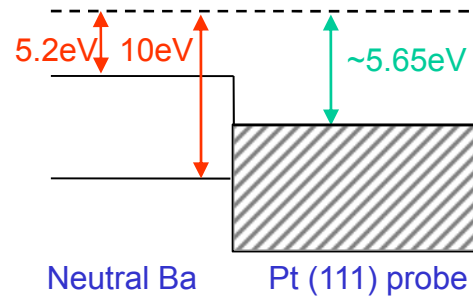
Ionization+scintillation *energy resolution improved from 1.9% to 1.3%* with new analysis techniques



EXO-200 MC study of 208Tl calibration source

FY2010 activities & accomplishments

- Built TOF spectrometer to study grabbing/release of single Ba with metal probes
- Ba⁺ from tagged ion source (later 0vββ) electrostatically captured on probe, neutralized
- Thermal desorption from high work function surface emits Ba⁺
- Eventually, guide Ba⁺ into ion trap for optical spectroscopy

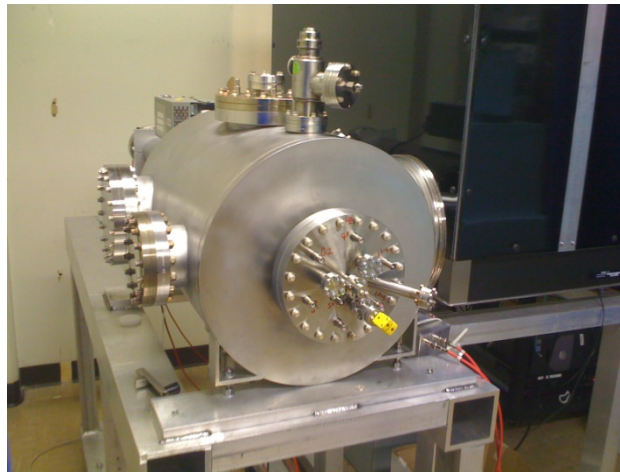
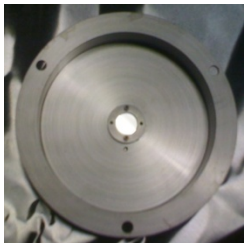


$$\frac{n^+}{n} = 2 \exp \left[\frac{e(\phi - IP)}{kT} \right]$$

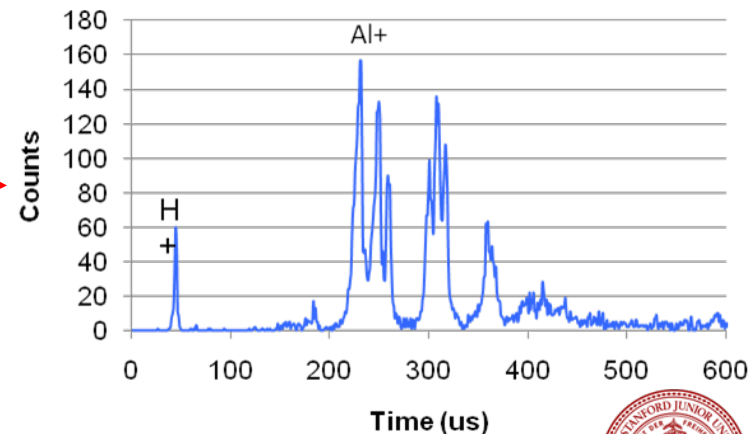
Φ = Work function
 IP = ionization potential

Time of flight spectrometer

Tagged single aluminum ion source



Source spectrum

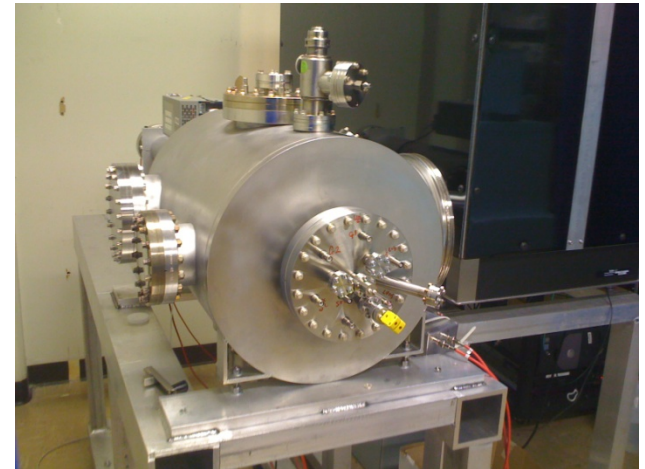


FY11 planned activities – EXO200

- Liquefy un-enriched xenon in TPC once WIPP power and network problems resolved
- Circulate LXe to clean TPC
- Noise studies
- Rn mitigation studies
- Continue Monte Carlo studies and analysis framework construction
- Install remaining Pb shielding
- Take physics data with un-enriched LXe
- Fill with enriched LXe, take physics data (est. ~ 5 yr run time)

FY11 planned activities – Ba tagging

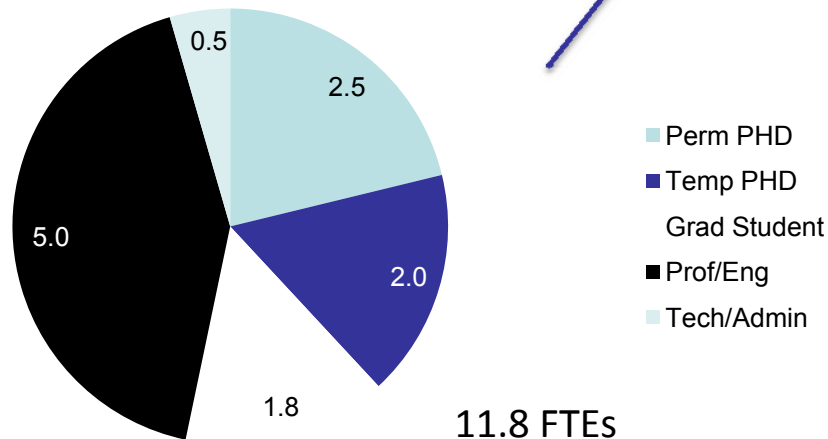
- Time of flight spectrometer with good energy resolution and ion collection efficiency completed.
- Single ion sources will be incorporated in the system.
- Samples with ultralow impurities have been prepared.
- Electron gun and pulsed laser heating systems as well as a fast temperature measurement system under construction.
- Will begin study of sample impurities and single barium surface desorption and ionization processes soon.
- R&D questions:
 - Ba background coming off the probe?
 - Surface ionization efficiency for a single Ba?
 - Effect of xenon gas on desorption and ionization processes?



Financials – Non-accelerator research (Intensity Frontier)

B&R	Description	FY 2009 Funding	FY 2010 Funding	FY 2011 Requested ¹	FY 2012 Scenario A' Super B
KA1301022	Non Acc Res. - Intensity - EXO	Inc. in KA1301020	\$ 3,199	\$ 3,519	\$ 2,521

FTE by Type



Issues and risks

- EXO risks
 - Neutrino might be Dirac and zero neutrino decay does not happen
 - Backgrounds might be insurmountable
 - Ba⁺ identification might not be practical
- EXO-200 issues and risks
 - How long to **clean detector** and achieve long drift?
 - How long to achieve **nominal noise**?
 - When do we close the **shield**?
 - When do we switch to **enriched Xe**?
 - What will the **radioactive backgrounds** be?
 - What **Rn mitigating measures** do we need?
 - **Power reliability** always a concern (not unusual in a **mine**)