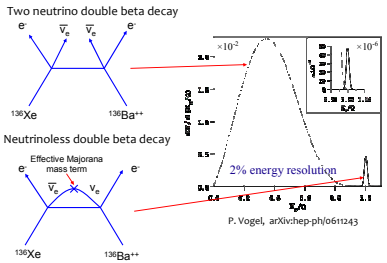
EXO-200

The Enriched Xenon Observatory (EXO) is a series of experiments designed to search for the neutrinoless double beta decay of Xenon-136. The first EXO experiment, known as EXO-200, is nearing completion. The centerpiece of EXO-200 is a liquid xenon TPC containing 200 kg of xenon enriched to 80% in Xenon-136, making it the largest double beta decay experiment ever attempted. EXO-200 will have a sensitivity to Majorana neutrino masses of ~150 meV. The cryogenics and fluid handling systems for EXO-200 were commissioned at Stanford University in 2007, and the experiment is currently being installed in its underground location at the WIPP facility in Carlsbad, New Mexico.

Neutrinoless Double-beta Decay



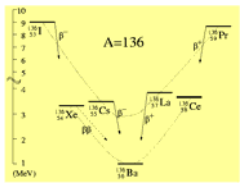
$$(T^{0\nu}_{1/2})^{-1} = G^{0\nu} \cdot |M^{0\nu}|^2 \cdot \langle m_{\beta\beta} \rangle^2$$

$M^{0\nu}$ calculated within particular nuclear models, ~ O(1)

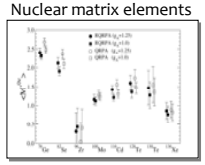
$G^{0\nu}$ a calculable phase space factor, dependent on Q and Z

$T^{0\nu}_{1/2}$ is the directly measured quantity (Hz)

$\langle m_{\beta\beta} \rangle^2 = |\sum_i U_{ei}^2 m_i|^2$ effective Majorana ν mass (can be zero: U_{ei}'s contain complex phases)



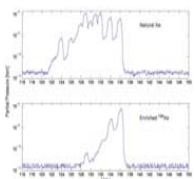
Nuclear matrix elements



Rodin et al., Nucl. Phys. A 766 (2006) 107

Enriched Xenon

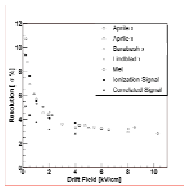
200 kg enriched xenon gas continuously monitored for leaks.



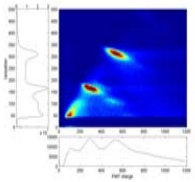
Xenon isotopically enriched to 80% in Xenon-136.

Time Projection Chamber

The EXO-200 detector is a double Time Projection Chamber (TPC) with a central cathode and two crossed wire anodes. Large Area Avalanche Photodiodes (LAAPDs) behind the anode wires detect the 175 nm xenon scintillation light. Improved energy resolution can be achieved by detecting both ionization and scintillation because of the observed anti-correlation in liquid xenon.

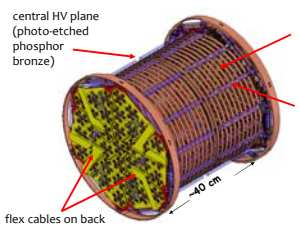


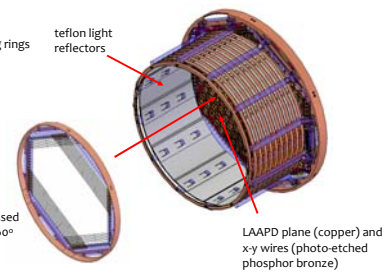
E. Conti et al., Phys. Rev. B 68,054201 (2003)



Bi-208 spectrum

Combining ionization and scintillation $\sigma(E)/E$ = 3.0% at 570 keV corresponding to 1.4% at $Q_{\beta\beta}$. Even better energy resolution can be achieved with higher light collection efficiency [E. Aprile et al. Phys. Rev. B 76, 014115 (2007)], which we will have in EXO-200.





516 LAAPDs detect scintillation light and provide a time-zero measurement. The LAAPDs have 200 mm² active area and are read out in gangs of seven.

Partial TPC prototype.

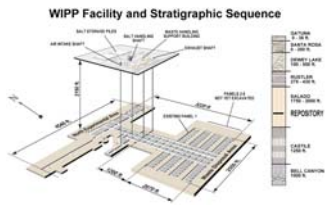
Xenon Vessel

The TPC is housed in a thin-walled low-activity copper vessel. The parts have been machined under 7 m.w.e. concrete to protect them from cosmogenic activation and are electron beam welded together.

Front End Electronics

152 ionization channels and 74 LAAPD channels are sampled at 1 MHz by 12-bit ADCs.

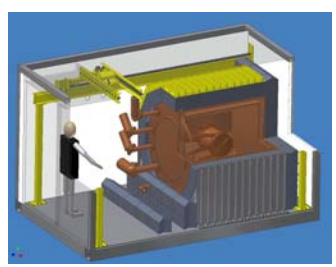
Underground Facility

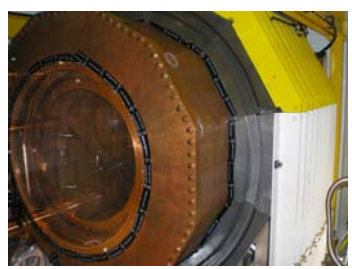


EXO-200 is located at ~1700 m.w.e. depth at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. The cryostat and ancillary systems are housed in modular clean rooms.

Cryogenics, Purification and Shielding

The TPC is contained in a double-walled low-activity copper cryostat filled with HFE-7000 acting as both a heat transfer fluid and radiation shield. The cryostat is surrounded by 25cm of lead for additional shielding.





HFE-7000 storage dewar and transfer lines

Xenon transfer and purification system.

Sensitivity

Case	Mass (ton)	Eff. (%)	Run Time (yr)	σ_E/E @ 2.5MeV (%)	Radioactive Background (events)	$T_{1/2}^{0\nu}$ (yr, 90%CL)	Majorana mass (meV) QRPA[1]	Majorana mass (meV) NSM[2]
EXO-200	0.2	70	2	1.6*	40	$6.4*10^{25}$	133	186

1) Rodin, *et. al.*, Nucl. Phys. A **793** (2007) 213-215
2) Caurier, *et. al.*, arXiv:0709.2137v1