EXO-200 and nEXO

G. Gratta
Physics Dept
Stanford University
Double-beta decay:

a second-order process only detectable if first order beta decay is energetically forbidden

Candidate nuclei with Q>2 MeV

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Q (MeV)</th>
<th>Abund. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{48}$Ca$\rightarrow^{48}$Ti</td>
<td>4.271</td>
<td>0.187</td>
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<tr>
<td>$^{76}$Ge$\rightarrow^{76}$Se</td>
<td>2.040</td>
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<td>$^{82}$Se$\rightarrow^{82}$Kr</td>
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</tr>
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</table>
There are two varieties of $\beta\beta$ decay

2ν mode: a conventional 2nd order process in nuclear physics

0ν mode: a hypothetical process can happen only if:

- $M_\nu \neq 0$
- $\nu = \bar{\nu}$
- $|\Delta L| = 2$
- $|\Delta(B-L)| = 2$
There are two varieties of $\beta\beta$ decay:

0$\nu$ mode: a hypothetical process can happen only if: $M_\nu \neq 0$

$\nu = \bar{\nu}$

$|\Delta L| = 2$

$|\Delta (B-L)| = 2$

$\nu\beta\beta$ is the most sensitive probe of the Majoranas/Dirac nature of neutrinos.
The two can be separated in a detector with sufficiently good energy resolution.

Topology and particle ID are also important to recognize backgrounds.
Need very large fiducial mass (tons) of isotopically separated material (except for $^{130}\text{Te}$)

[using natural material typically means that 90% of the source produced background but not signal]

This is expensive and provides encouragement to use the material in the best possible way:

For no bkgnd $\langle m_\nu \rangle \propto 1 / \sqrt{T_{1/2}^{0\nu\beta\beta}} \propto 1 / \sqrt{Nt}$

For statistical bkgnd subtraction $\langle m_\nu \rangle \propto 1 / \sqrt{T_{1/2}^{0\nu\beta\beta}} \propto 1 / (Nt)^{1/4}$

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Shielding a detector from gammas is difficult because the absorption cross section is small.

Example: \( \gamma \) interaction length in Ge is 4.6 cm, comparable to the size of a germanium detector.

Shielding \( \beta \beta \) decay detectors is much harder than shielding Dark Matter ones.

We are entering the "golden era" of \( \beta \beta \) decay experiments as detector sizes exceed int lengths.
- High Q value reduces backgrounds and increases the phase space & decay rate,
- Large abundance makes the experiment cheaper
- A number of isotopes have similar matrix element performance
It is very important to understand that a healthy neutrinoless double-beta decay program requires more than one isotope. This is because:

• There could be unknown gamma transitions and a line observed at the “end point” in one isotope does not necessarily imply that $0\nu\beta\beta$ decay was discovered

• Nuclear matrix elements are not very well known and any given isotope could come with unknown liabilities

• Different isotopes correspond to vastly different experimental techniques

• 2 neutrino background is different for various isotopes (apparently quite small for $^{136}\text{Xe}$)

• The elucidation of the mechanism producing the decay requires the analysis of more than one isotope
The virtues of $^{136}$Xe in a large TPC

- No need to grow crystals
- Can be re-purified during the experiment
- Noble gas: easy(er) to purify
- Can be easily transferred from one detector to another depending on results and available technology
- Good (although not best) energy resolution coupled with large homogeneous and imagining detector is very powerful
- No long lived Xe isotopes to activate
- $^{136}$Xe enrichment easier and cheaper:
  - noble gas (no chemistry involved)
  - centrifuge feed rate in gram/s, all mass useful
  - centrifuge efficiency $\sim \Delta m$. For Xe 4.7 amu
- Only known case where final state identification appears to be not impossible
  $\to$ eliminate all non-$\beta\beta$ backgrounds, possibly only chance of getting to Normal Hierarchy
- $^{136}$Xe can be replaced with Nat’l’Xe if a signal is observed!
Underground location: Waste Isolation Pilot Plant (WIPP) Carlsbad, NM

- ~1600 meter water equivalent flat overburden
- Relatively low levels of U and Th (<100 ppb in EXO-200 drift)
- Low levels of Rn (~20 Bq/m³)
- Rather convenient access with large conveyance
EXO-200 does not have Ba tagging but it is compatible with Ba tagging.
APDs are ideal for our application:
- very clean & light-weight,
- very sensitive to VUV

\[ \text{QE} > 1 \text{ at } 175\text{nm} \]

Gain set at 100-150
\[ V \sim 1500\text{V} \]
\[ \Delta V < \pm 0.5\text{V} \]
\[ \Delta T < \pm 1\text{K} \] APD is the driver for temperature stability
Leakage current OK cold

Ultra-low activity Cu vessel

- Very light (~1.5mm thin, ~15kg) to minimize materials

- Different parts e-beam welded together
- Field TIG weld(s) to seal the vessel after assembly (TIG technology tested for radioactivity)
- All machining done by in the CR-shielded HEPL building

LNGS, Sapienza, LNF, Feb 2014
EXO-200 & nEXO
- Copper vessel 1.37 mm thick
- 175 kg LXe, 80.6% enr. in $^{136}$Xe
- Copper conduits (6) for:
  - APD bias and readout cables
  - U+V wires bias and readout
  - LXe supply and return
  - Epoxy feedthroughs at cold and warm doors
- Dedicated HV bias line

EXO-200 detector: JINST 7 (2012) P05010
Characterization of APDs: NIM A608 68-75 (2009)
The EXO-200 Detector

- HV FILTER AND FEEDTHROUGH
- FRONT END ELECTRONICS
- VACUUM PUMPS
- VETO PANELS
- HIGH PURITY HEAT TRANSFER FLUID (HFE7000)
  - > 50 cm
- DOUBLE-WALLED CRYOSTAT
  - 25 mm ea
- LXe VESSEL
  - 1.37 mm
- LEAD SHIELDING
  - > 25 cm
Massive effort on material radioactive qualification using:

- NAA
- Low background $\gamma$-spectroscopy
- $\alpha$-counting
- Radon counting
- High performance GD-MS and ICP-MS

At present the database of characterized materials includes >300 entries


The impact of every screw within the Pb shielding is evaluated before acceptance

$\rightarrow$ Goal: 40 cnts/2yr in the $0\nu\beta\beta \pm 2\sigma$ ROI in 140kg of LXe
A substantial system is required to

• protect the 1.5mm thin LXe container from pressure
• recirculate Xe in gas phase to purify it
• fill/empty the detector
• manage emergencies
Xe purity is essential for good energy resolution

Xenon gas is forced through heated Zr getter by a custom ultraclean pump.

At $\tau_e = 3$ ms:
- drift time <110 $\mu$s
- loss of charge: 3.6%
  at full drift length

Ultraclean pump: Rev Sci Instr. 82 (10) 105114
Xenon purity with mass spec: NIM A675 (2012) 40
Gas purity monitors: NIM A659 (2011) 215
A two-site Compton scattering event.

All scintillation light arrives at the same time, indicating that the two energy depositions are simultaneous.

The scintillation light is brighter and more localized on Side 1 where the scattering occurs.
Tracking: an essential tool to identify and suppress backgrounds

Low background data

$^{228}\text{Th}$ calibration source

$2\nu\beta\beta$ single cluster

multiple cluster
Combining Ionization and Scintillation

Anticorrelation between scintillation and ionization in LXe known since early EXO R&D


Note improvement due to LAAPD denoising

Rotation angle chosen to optimize energy resolution at 2615 keV

228Th source

Combining Ionization and Scintillation

Anticorrelation between scintillation and ionization in LXe known since early EXO R&D


Note improvement due to LAAPD denoising

Rotation angle chosen to optimize energy resolution at 2615 keV
EXO-200 and nEXO resolutions

- EXO-200 Proposal
- EXO-200 now
- EXO-200 upgrade/nEXO

Scintillation absolute resolution, (photon statistics + noise) [keV]

Rotated resolution, $\sigma/E$

- EXO-200 Thorium source Data (non-denoised)
- EXO-200 Thorium source Data (denoised)
- NEST MC (10% L.E., realistic U-wire noise level)
Events removed by diagonal cut:

- $\alpha$ (larger ionization density $\rightarrow$ more recombination $\rightarrow$ more scintillation light)
- events near detector edge $\rightarrow$ not all charge is collected
**Rn Content in Xenon**

Long-term study shows a constant source of $^{222}\text{Rn}$ dissolving in $\text{enrLXe}$: $360 \pm 65 \mu\text{Bq (Fid. vol.)}$

$^{214}\text{Bi} - ^{214}\text{Po}$ correlations in the EXO-200 detector

Total $^{222}\text{Rn}$ in LXe after initial fill
Energy and position spectra are reproduced by the Monte Carlo with high fidelity.

Single Site

Multi Site

---

EXO-200 & nEXO

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Low background single-site energy (and standoff) spectrum for 28.69 kg·yr (82.1 kg Xe, 127.6 d)

Signal-to-background ratio $10^{-20}$
Multi-site spectrum directly measures the (small) background.

Note that an unknown γ line at the ββ endpoint would produce a larger peak in the multi-site spectrum, providing a rejection.
...since the start of EXO-200 data taking in Jun 2011...

Discovery of 2ν mode \([PRL 107, 212501 (2011)]\)

Confirmation by KamLAND-Zen
\([PRC 85, 045504 (2012)]\)

\[ T_{1/2}^{2\nu\beta\beta} = \left( 2.165 \pm 0.016^{\text{stat}} \pm 0.059^{\text{syst}} \right) \cdot 10^{21} \text{ yr} \]
\([\text{Phys Rev C 89 (2014) 015502}]\)
...since the start of EXO-200 data taking in Jun 2011...

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\[ \text{[Phys Rev C 89 (2014) 015502]} \]

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>( T_{1/2}^{2νββ} \pm \text{stat} \pm \text{sys} )</th>
<th>rel. uncert.</th>
<th>( G^{2ν} )</th>
<th>( M^{2ν} )</th>
<th>rel. uncert.</th>
<th>Experiment (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{136}\text{Xe})</td>
<td>(2.165 \pm 0.016 \pm 0.059 \cdot 10^{21})</td>
<td>(\pm 2.83)</td>
<td>1433</td>
<td>0.0218</td>
<td>(\pm 1.4)</td>
<td>EXO-200 (this work)</td>
</tr>
<tr>
<td>(^{76}\text{Ge})</td>
<td>(1.84^{+0.08}<em>{-0.08}^{+0.11}</em>{-0.06} \cdot 10^{21})</td>
<td>(\pm 7.7)</td>
<td>48.17</td>
<td>0.129</td>
<td>(\pm 3.9)</td>
<td>GERDA [39] (2013)</td>
</tr>
<tr>
<td>(^{130}\text{Te})</td>
<td>(7.0 \pm 0.9 \pm 1.1 \cdot 10^{20})</td>
<td>(\pm 20.3)</td>
<td>1529</td>
<td>0.0371</td>
<td>(\pm 10.2)</td>
<td>NEMO-3 [40] (2011)</td>
</tr>
<tr>
<td>(^{116}\text{Cd})</td>
<td>(2.8 \pm 0.1 \pm 0.3 \cdot 10^{19})</td>
<td>(\pm 11.3)</td>
<td>2764</td>
<td>0.138</td>
<td>(\pm 5.7)</td>
<td>NEMO-3 [41] (2010)</td>
</tr>
<tr>
<td>(^{48}\text{Ca})</td>
<td>(4.4^{+0.5}_{-0.4} \pm 0.4 \cdot 10^{19})</td>
<td>(\pm 14.6)</td>
<td>15550</td>
<td>0.0464</td>
<td>(\pm 7.3)</td>
<td>NEMO-3 [41] (2010)</td>
</tr>
<tr>
<td>(^{96}\text{Zr})</td>
<td>(2.35 \pm 0.14 \pm 0.16 \cdot 10^{19})</td>
<td>(\pm 9.1)</td>
<td>6816</td>
<td>0.0959</td>
<td>(\pm 4.5)</td>
<td>NEMO-3 [42] (2010)</td>
</tr>
<tr>
<td>(^{150}\text{Nd})</td>
<td>(9.11^{+0.25}_{-0.22} \pm 0.63 \cdot 10^{18})</td>
<td>(\pm 7.4)</td>
<td>36430</td>
<td>0.0666</td>
<td>(\pm 3.7)</td>
<td>NEMO-3 [43] (2009)</td>
</tr>
<tr>
<td>(^{100}\text{Mo})</td>
<td>(7.11 \pm 0.02 \pm 0.54 \cdot 10^{18})</td>
<td>(\pm 7.6)</td>
<td>3308</td>
<td>0.250</td>
<td>(\pm 3.8)</td>
<td>NEMO-3 [44] (2005)</td>
</tr>
<tr>
<td>(^{82}\text{Se})</td>
<td>(9.6 \pm 0.3 \pm 1.0 \cdot 10^{19})</td>
<td>(\pm 10.9)</td>
<td>1596</td>
<td>0.0980</td>
<td>(\pm 5.4)</td>
<td>NEMO-3 [44] (2005)</td>
</tr>
</tbody>
</table>
Low background spectrum zoomed around the $0\nu\beta\beta$ region of interest (ROI)

No $0\nu$ signal observed in the ROI

Use likelihood fit to establish limit
Background counts in ±1,2 σ ROI

<table>
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<tr>
<th>Source</th>
<th>±1 σ</th>
<th>±2 σ</th>
</tr>
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<tr>
<td>$^{222}$Rn in cryostat air-gap</td>
<td>1.9</td>
<td>2.9</td>
</tr>
<tr>
<td>$^{238}$U in LXe Vessel</td>
<td>0.9</td>
<td>1.3</td>
</tr>
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<td>$^{232}$Th in LXe Vessel</td>
<td>0.9</td>
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<tr>
<td>$^{214}$Bi on Cathode</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>All Others</td>
<td>~0.2</td>
<td>~0.2</td>
</tr>
<tr>
<td>Total</td>
<td>4.1</td>
<td>7.5</td>
</tr>
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</table>

Observed

1 5

Background index $b$ (kg$^{-1}$yr$^{-1}$keV$^{-1}$)

$1.5 \cdot 10^{-3} \pm 0.1$  $1.4 \cdot 10^{-3} \pm 0.1$

60 cnts/2yr in the 0νββ ±2σ ROI in 140kg of LXe
Limits on $T_{1/2}^{0\nu\beta\beta}$ and $\langle m_{\beta\beta} \rangle$

From profile likelihood:

$T_{1/2}^{0\nu\beta\beta} > 1.6 \cdot 10^{25}$ yr

$\langle m_{\beta\beta} \rangle < 140$–380 meV

(90% C.L.)


* M.A gostini et al. PRL 111 (2013) 122503
** A.Gando et al. PRL 110 (2013) 062502
Data accumulation (6 Oct 2011 - 6 Aug 2013)

- Run 2a
- Live-time (days)
- Golden
- Not Golden
- Dead/Bad: 8.40%
- Calibration: 7.90%
- Physics: 83.70%

~3x dataset on disk

LNGS, Sapienza, LNF, Feb 2014
EXO-200 & nEXO
As EXO-200 continues data taking a new collaboration nEXO is being formed

- New groups have the opportunity to join as "charter members"
- Only conflict with ton-scale projects
- Larger collaboration organized to execute a larger and more formal project
nEXO

- 5 tonnes of $^{enr}\text{Xe}$: entirely cover inverted hierarchy
- LXe TPC “as similar to EXO-200 as possible”
- Provide access ports for a possible later upgrade to Ba tagging

A unique combination of conservative and aggressive design with important upgrade paths as desirable for a large experiment
Tracking: an essential tool to identify and suppress backgrounds

Low background data

228\text{Th} calibration source

2\nu\beta\beta

\gamma

Tracking gets more powerful as the detector size increases.

- Comptons are better contained
- Better self-shielding

multiply cluster

single cluster
<table>
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<tr>
<th>LXe mass (kg)</th>
<th>Diameter or length (cm)</th>
</tr>
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<tr>
<td>5000</td>
<td>130</td>
</tr>
<tr>
<td>150</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
</tr>
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2.5MeV γ attenuation length 8.5cm = —

Monolithic detector is essential!
Material procurement

\(^{136}\text{Xe}\) enrichment easier and cheaper:

\[ \Rightarrow \quad 90\% \text{ enriched } ^{136}\text{Xe}: \sim 10$/g \]

90\% enriched \(^{76}\text{Ge}\): \sim 90$/g (\text{+xtal growth})

(EXO-200 uses 80\% enriched Xe. It now seems customary to do 90\% and it appears that there is no major cost difference)

Exact centrifuge capacity in Russia is classified but our contacts indicate that 5000kg in 5 years is comfortable

- \text{World nat'}\text{Xe production is } \sim 40 \text{ tonnes/yr } (\sim 4000kg ^{136}\text{Xe}), however large price fluctuations are not uncommon
- \text{Coordination with DM experiments, space agencies and commercial customers is desirable}
Flexible program based on the initial nEXO investment

1. Procure 5 tons of \(\text{enr}^\text{Xe}\) and build nEXO.

2. Run nEXO for 5 years.

   - **No**: Upgrade Ba tagging.
     - Run longer with better sensitivity.
   - **Yes**: Discover \(\beta\beta\) decay?
     - **No**: Replace \(\text{nati}^\text{Xe}\) or \(\text{depl}^\text{Xe}\).
     - **Yes**: Confirm discovery?
       - **Yes**: Build GXe TPC for same \(\text{enr}^\text{Xe}\).
       - **No**: Think!
       - Study electron correlations.

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Preliminary artist view of nEXO in the SNOlab Cryopit
nEXO design:

Rule #1: Follow as closely as possible the design of EXO-200 since EXO-200 works so well
Rule #2: When in doubt, look at Rule #1

→ Limited R&D required:
  much of the detector can be/is being designed now.

→ Low risk
What we need to change (Cat):
1. We know of a few things that were not quite right in EXO-200
2. Some items don't scale properly from 150kg to 5000kg

<table>
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<tr>
<th>Item/concept</th>
<th>Reason to change</th>
<th>Cat</th>
<th>Risk</th>
</tr>
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<tr>
<td>Water shield</td>
<td>More convenient for large size, very standard</td>
<td>2</td>
<td>Very low</td>
</tr>
<tr>
<td>Vertical detector axis</td>
<td>Horizontal for EXO-200 due to site constraint</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>Composite cryostat</td>
<td>Too large for conveyance at SNOlab, composite easier to build underground</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>One drift space</td>
<td>Lowest background in the middle</td>
<td>1</td>
<td>Medium</td>
</tr>
<tr>
<td>Internal electronics</td>
<td>Lower outgassing, lower activity, better S/N</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>SiPMs</td>
<td>Better S/N, Lower mass, More common, no HV</td>
<td>1, 2</td>
<td>Medium</td>
</tr>
<tr>
<td>No Teflon reflectors</td>
<td>Lower outgassing</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>Higher charge readout density</td>
<td>Better background rejection</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>High Voltage Noise</td>
<td>EXO-200 (and other LXe detectors) can’t reach full HV</td>
<td>1</td>
<td>Medium</td>
</tr>
<tr>
<td>Add LXe purity mtr</td>
<td>Longer drift, harder calibration</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>Add prepurif Xe source</td>
<td>No purity loss from feeds, higher live time</td>
<td>1</td>
<td>None</td>
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</table>
...it is remarkable that EXO-200 can achieve 5ms electron lifetime with a detector stuffed of (very clean and purged) plastics
Close-up of the field shaping rings, anode readout tiles and SiPMs
Detail of the cryostat concept

- Signal lines with electro-optic converter
- HFE inlet
- Xe line inlet
- Xe line out
- HFE out
- HV feedthrough
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<td>EXO-200 Low background run</td>
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<tr>
<td>EXO-200 Ultra-low background run</td>
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<tr>
<td>EXO-200 Detector R&amp;D</td>
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<td>nEXO R&amp;D</td>
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<td>DOE CD-4</td>
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<td>Xenon Procurement (5T enrichment)</td>
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</table>
Cosmogenic \( n \) backgrounds in nEXO simulated using FLUKA

...but, before relying on it, FLUKA’s prediction can be verified with actual EXO-200 data!

EXO-200 spectra in-time with veto

Capture on H in the HFE7000

Capture on \( ^{136}\text{Xe} \)

\[ \Sigma(\text{data}) = 33 \text{ ev} \]

\[ \Sigma(\text{FLUKA}) = 33.5 \text{ ev} \]
Other n backgrounds

- Prompt events following a muon
- Neutrons from rock radioactivity
  - very strongly suppressed by the large water shield and give a negligible contribution

...and ν induced backgrounds

<table>
<thead>
<tr>
<th>Direct solar ν interaction</th>
<th>Rate all energies (ev/tonne/10yr)</th>
<th>Rate in ROI (ev/tonne/10yr FWHM)</th>
<th>Rate in ROI (ev/mol/yr FWHM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ne – e elastic scattering (8B+reactors+Geo)</td>
<td>17.6</td>
<td>0.16</td>
<td>3.1\times10^{-6}</td>
</tr>
<tr>
<td>ν capture on $^{136}$Xe (8B ν)</td>
<td>20</td>
<td>0.16</td>
<td>3.2\times10^{-6}</td>
</tr>
<tr>
<td>ν-induced $^{136}$Cs decay</td>
<td>50</td>
<td>0.03</td>
<td>4\times10^{-7}</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>0.35</td>
<td>6.7\times10^{-6}</td>
</tr>
</tbody>
</table>
From this study we can extract backgrounds as a function of depth.

Simulation done with muon spectrum and rate of LNGS.

**Conclusion:**
- SNOlab and Jinping are comfortable.
- SanfordLab at 4850 is probably ok.
- Gran Sasso is marginal but may be ok, needs veto study.
Summary of nEXO assumptions compared to EXO-200

<table>
<thead>
<tr>
<th>Parameter</th>
<th>nEXO</th>
<th>EXO-200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiducial Mass (kg)</td>
<td>4780</td>
<td>98.5</td>
</tr>
<tr>
<td>Enrichment (%)</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Data taking time (yr)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Energy resolution @Q_{\beta\beta} (keV)</td>
<td>58</td>
<td>88 (58)</td>
</tr>
<tr>
<td>Background in ROI (ev/yr/mol_{136})</td>
<td>$6.1 \cdot 10^{-4}$</td>
<td>0.022 (0.0073)</td>
</tr>
<tr>
<td>Background in ROI inner 3000kg (ev/yr/mol_{136})</td>
<td>1.6 $\cdot 10^{-4}$</td>
<td>-</td>
</tr>
</tbody>
</table>
Sensitivity and discovery potential as a function of time

$^{136}\text{Xe} T_{1/2}$

$\Delta m^2_{\beta\beta}$ (meV) GCM

EXO200, Ultimate

5σ Discovery, 50% Probability

Sensitivity (90% CL)

Exposure (yrs)

LNGS, Sapienza, LNF, Feb 2014

EXO-200 & nEXO
Sensitivity and discovery potential as a function of time

\[ 10^26 \leq 1^{36}\text{Xe} T_{1/2} \leq 10^29 \]

\[ 10^27 \leq m_{\beta\beta} (\text{meV}) \leq 10^2 \]

**EXO200, Ultimate**

- 5\( \sigma \) Discovery, 50\% Probability
- Sensitivity (90\% CL)

Exposure (yrs)
Sensitivity and discovery potential as a function of time

$^{136}\text{Xe} T_{1/2}$

$10^{26} \\ 10^{27} \\ 10^{28} \\ 10^{29}$

$5\sigma$ Discovery, 50% Probability

Sensitivity (90% CL)

Exposure (yrs)

$10^{-2} \\ 10^{0}$

EXO200, Ultimate

$\mu_{\beta \beta}$ (meV) R-QRPA

LNGS, Sapienza, LNF,
Feb 2014

EXO-200 & nEXO
Sensitivity and discovery potential as a function of time

EXO200, Ultimate

5σ Discovery, 50% Probability

Sensitivity (90% CL)
Sensitivity and discovery potential as a function of time

EXO200, Ultimate

5σ Discovery, 50% Probability
Sensitivity (90% CL)
Summary

• EXO-200 taking data since Jun 2011
• Discovered the 2νββ decay in $^{136}$Xe; most accurate measurement to date
• Very competitive limit on the 0νββ decay with the first 4 month of data
• ~3x dataset on disk, better analysis
• Rn abatement system and upgraded electronics being prepared
• Working on the design of nEXO
• Next few years will be very exciting!