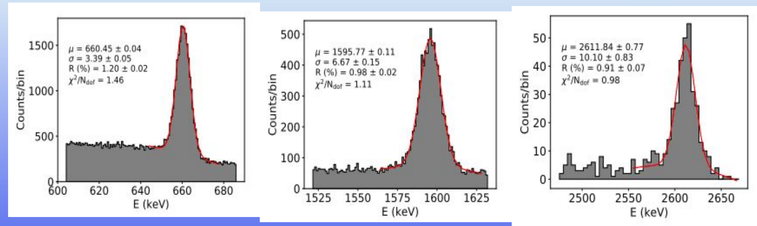
The NEXT-100 neutrinoless double beta decay experiment

J. Haefner on behalf of the NEXT Collaboration

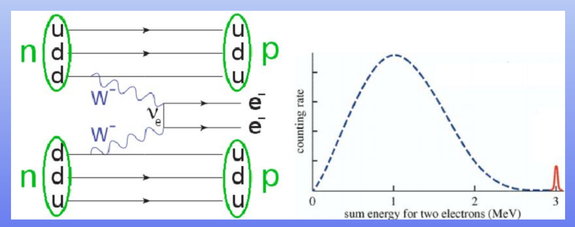
Abstract: The NEXT experiment is searching for neutrinoless double beta decay ($0\nu\beta\beta$) in an electroluminescent high pressure gaseous ^{136}Xe time projection chamber (HPGXeTPC). Positive detection would indicate that the neutrino, unlike all other fundamental leptons, has a Majorana mass term, and that lepton number is not conserved. The NEXT experiment leverages several advantages of the HPGXeTPC technology, including excellent energy resolution (<1% FWHM at the decay energy) and background rejection through track reconstruction. The detector is under construction with installation and commissioning planned for late 2020 or early 2021. NEXT-100 will reach a sensitivity of 2.8 × 10^{25} years (95% CL) for an exposure of 100 kg-year, or 6.0 × 10^{25} years after an effective three years run time.

Resolution

Excellent resolution in current detector (NEXT-White), expect similar < 1% at Qββ in NEXT-100



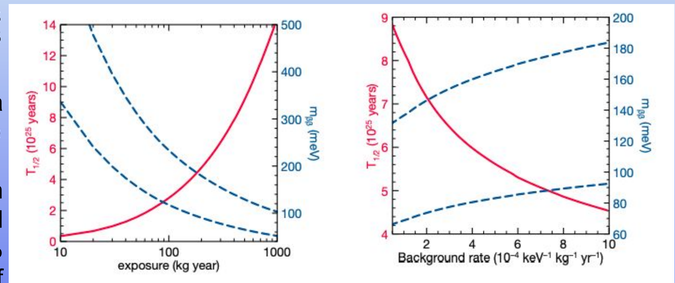
Searching for Majorana neutrinos



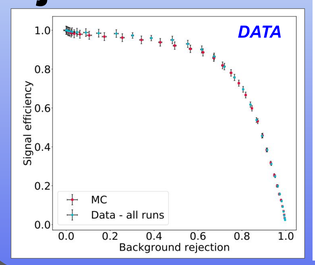
- Neutrinoless double beta decay ($0\nu\beta\beta$) is the most sensitive probe for a Majorana nature of the neutrino
- $0\nu\beta\beta$ unequivocally indicates neutrino is Majorana by the "black box theorem"
- $0\nu\beta\beta$ tells us whether neutrinos are their own antiparticles
- $0\nu\beta\beta$ would indicate lepton number is violated

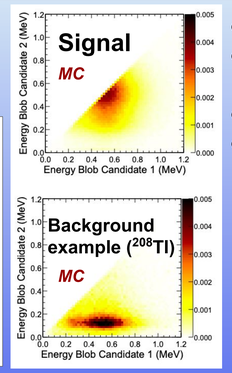
Sensitivity

- NEXT-100 will reach a sensitivity of 2.8 × 10^{25} years (95% CL) for exposure of 100 kg-year, or 6.0 × 10^{25} years after effective three years run time
- This corresponds to an upper limit on the Majorana neutrino mass of 80–160 meV, depending on the used NME calculation
- More sophisticated reconstruction and selection algorithms (currently under development) should make it possible to reach an energy resolution ~0.5% FWHM at 2.5 MeV and fully exploit the potential of the tracking signature

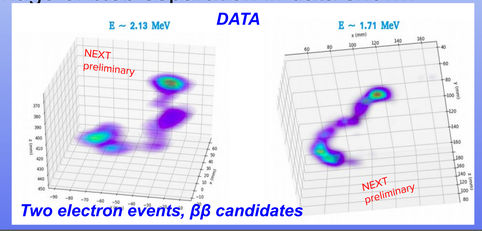


Background rejection



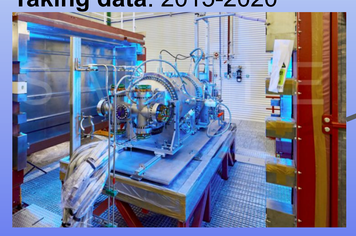


- As a gas TPC, NEXT can see extended tracks
- Presence of two distinct "blobs" of energy indicates 2 electrons ⇒ potential $0\nu\beta\beta$
- "Blob cut" significantly reduces backgrounds
- Image of blob separation in data shown



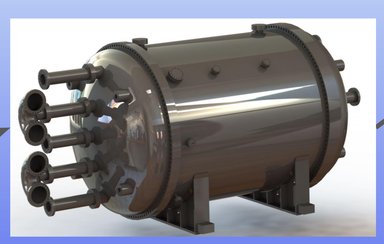
NEXT stages

NEXT White (NEW) - **Taking data**. 2015-2020

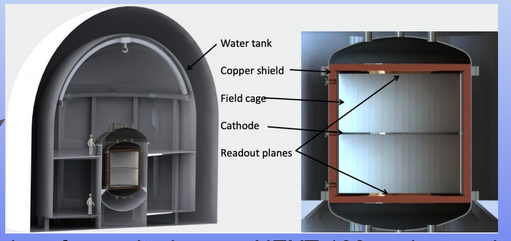


Excellent results - see poster #107

NEXT-100. Commissioning planned for 2020~2021



Tonne scale NEXT experiment

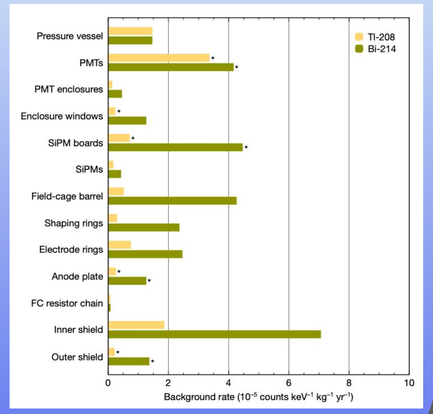


Order of magnitude over NEXT-100 and potential for barium tagging, see posters #150, #193

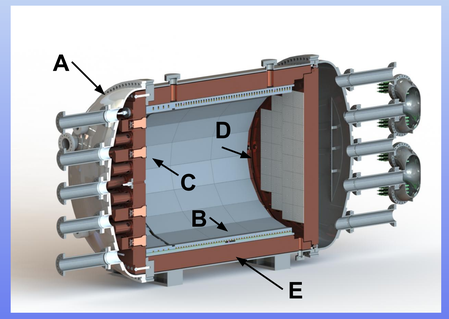
Backgrounds and materials

- Hypothetical $0\nu\beta\beta$ peak lies between the photo-peaks of the high-energy gammas emitted after β decays of ^{214}Bi and ^{208}Tl
- Backgrounds well understood, under control in construction. Background level indicated by subsystem
- Selection criteria allow strong further suppression of dominant backgrounds, based blob cut, fiducial volume cut, single track cut, and energy
- Predict NEXT-100 background 4 × 10^{-4} counts/(keV kg yr) max

Selection criterion	$0\nu\beta\beta$	$2\nu\beta\beta$	^{208}Tl	^{214}Bi
Fiducial, single track $E \in [2.4, 2.5]$ MeV	0.4759	8.06×10^{-9}	1.39×10^{-5}	3.40×10^{-6}
Track with 2 blobs	0.6851	0.6851	0.1141	0.1005
Energy ROI	0.8661	3.89×10^{-5}	0.1515	0.4795
Total	0.2824	2.15×10^{-13}	2.4×10^{-7}	1.6×10^{-7}



NEXT-100 Assembly



- Cross-section view of the NEXT-100 detector inside its lead castle shield. A stainless-steel pressure vessel (A) houses the electric-field cage (B) and the two sensor planes (energy plane, C; tracking plane, D) located at opposite ends of the chamber. The active volume is shielded from external radiation by at least 12 cm of copper (E) in all directions
- *Electroluminescence*: electrons liberated by ionizing particles drifts towards the TPC anode under moderate electric field (0.3–0.5 kV cm^{-1}), entering then into another region with stronger field (2–3 kV cm^{-1} bar^{-1}), exciting the Xe atoms but not enough to ionize them. This excitation energy is released with sub-Poissonian fluctuations
- *Energy plane* consists of 60 PMTs
- *Tracking plane* consists of 3584 SiPMs with 1.5 cm pitch
- 100 kg active volume of isotopically enriched high pressure gaseous ^{136}Xe