

The NEXT detector: an Electroluminescence Xenon TPC for neutrinoless double beta decay detection

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on behalf of the [NEXT Collaboration](#)



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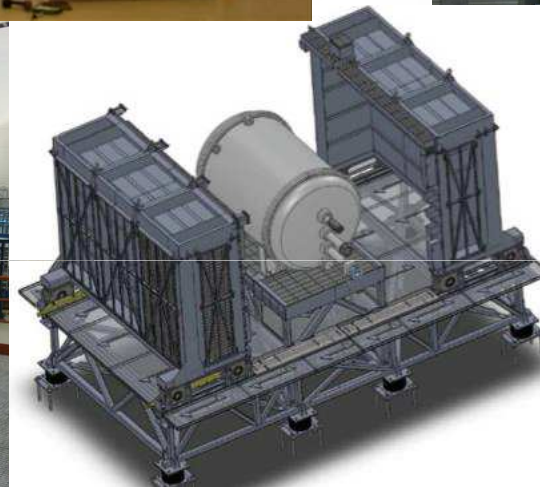
Outlook

- The NEXT Experiment
- Key Requirements (ER, Topology & Tracking, BG, Scalability)
- Detector Concept
- Detector NEXT-DEMO
- Detector NEXT-NEW
- The future

NEXT - the Neutrino Experiment with a Xenon Time projection chamber

- NEXT aims to search for neutrinoless double beta decay ($\beta\beta 0\nu$) events in xenon gas, enriched at 90% in the isotope ^{136}Xe .
- Xe is chosen due to easy to enrich, purify and scale.
- The detector is a High-Pressure TPC, filled with Xe at 10-15 bar.
- The signal amplification process is Electroluminescence (EL).
- The experiment will run in the Canfranc, Underground Laboratory (LSC).
- The NEXT Collaboration includes institutions from Spain, Portugal, USA, Russia and Colombia.

The LSC Lab in Canfranc, Spain



Seismic platform and lead castle already in place

Key Requirements for the NEXt detector

- The capability to achieve an optimal energy resolution, $< 1\%$ FWHM @ Xe $Q\beta\beta$ (2.458 MeV);
- The event topology reconstruction competence proving the possibility to identify the distinct dE/dx of electron tracks;
- The capability of high background suppression;
- The aptitude to be expanded to a large-scale system (Ton-scale).

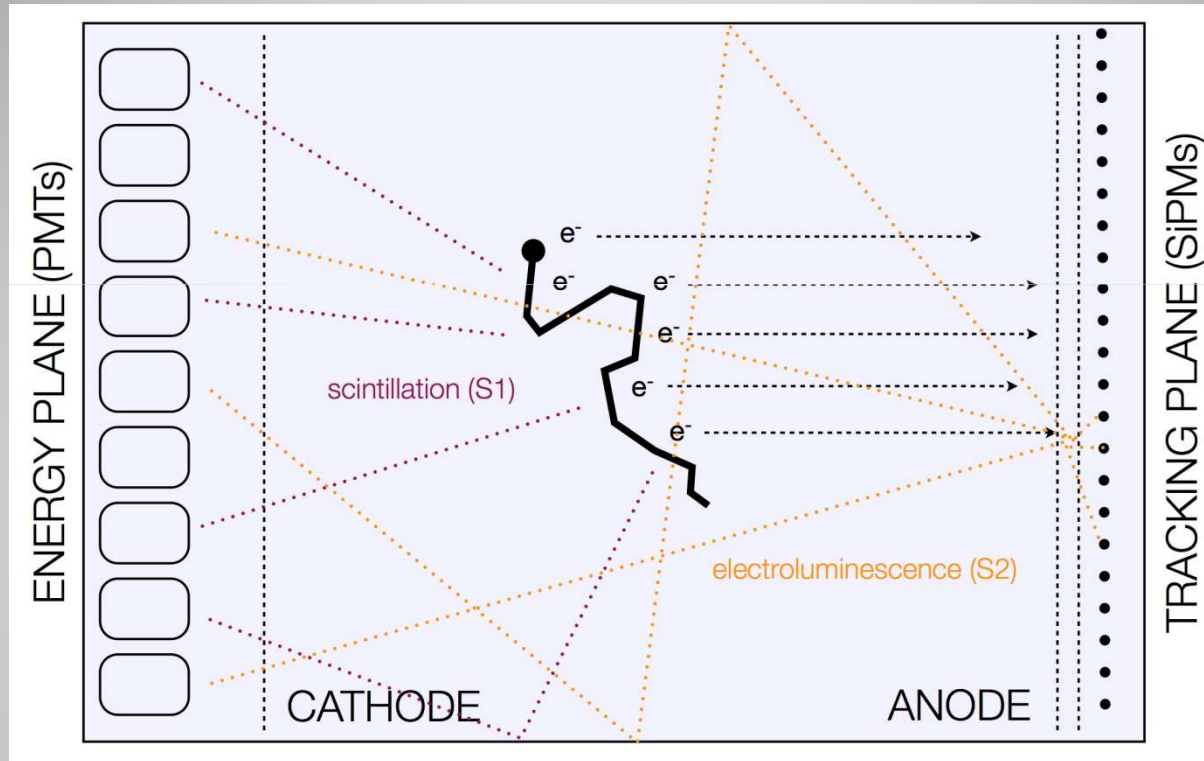
Solutions chosen

For optimal energy resolution - electroluminescence as the amplification technique for the primary ionisation of xenon, (over the charge amplification technique)

For event topology - SiPMs were elected as the readout sensors for the topological recognition (and PMTs for the energy plane); They are inexpensive, suitable for detecting the EL signal and cover a large area.

Background suppression – in addition to the above, using radio-clean materials, including the SiPMs, for the most part made of silicon.

Detector concept

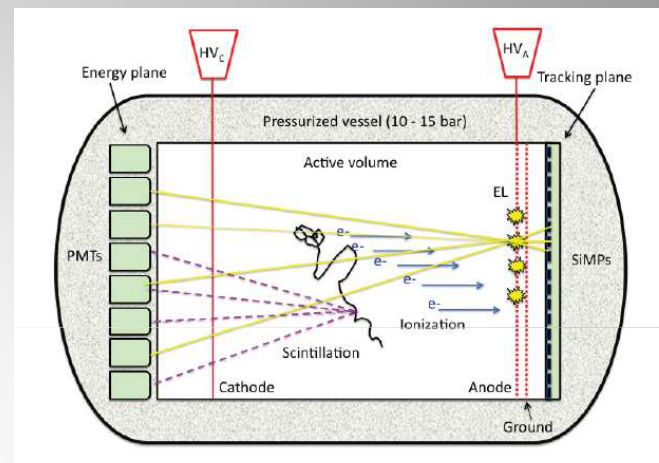


The SOFT Concept (Separate, Optimized Functions) in the NEXT experiment:

- Electroluminescence (EL) generated at the anode is collected in the photosensor plane behind it and is used for tracking;
- EL is also collected in the photosensor plane behind the transparent cathode and used for a precise energy measurement.
- The detection of the primary scintillation light (S1) constitutes the start-of-event, t_0 .

Detection process and principle

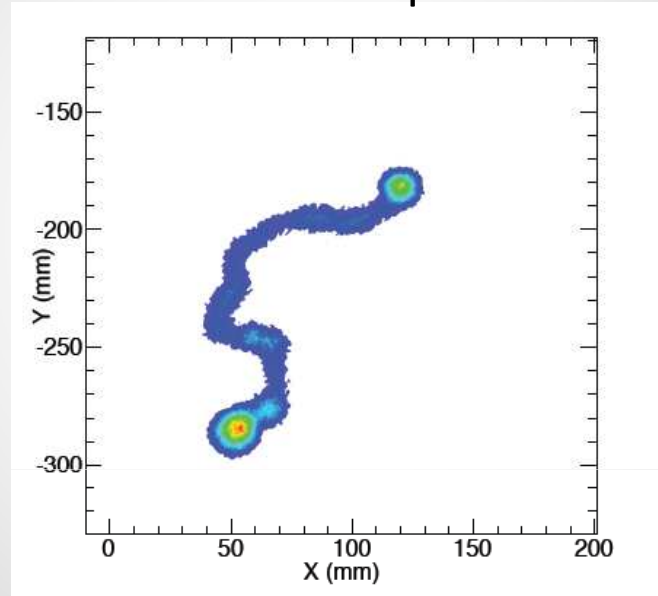
- Particles interacting HPXe transfer their energy to the medium through ionization and excitation.
- Excitation energy gives prompt emission of VUV (178 nm) scintillation (S1).
- Ionization tracks (ions and free e^-) from the particle do not recombine due to electric field (0.3-0.5kV/cm). Ionization e^- drift toward the TPC anode, into a region with high electric field (3kV/cm/bar).
- There, VUV photons are produced isotropically by EL processes.
- Both scintillation and ionization produce an optical signal, detected with PMTs (the energy plane - behind the cathode).
- The primary scintillation signal (S1) establishes the start-of-event (t_0).
- The EL signal (S2) provides an energy measurement.
- EL is also used for tracking, being detected as well at the anode plane, by an array of 1-mm² MPPCs, 1-cm spaced (the tracking plane).



NEXT Conceptual Idea: tracking capabilities

Close to the EL region is the tracking plane, where TPB coated SiPMs will reconstruct the two electrons tracks from the 2β -decay.

They form a single twisted line (because of multiple scattering) with a strong energy deposition at both ends. This technique is crucial to reject background events.



MC simulation of charge released in a $\beta\beta$ decay in ^{136}Xe gas at 10 bar:

The tortuous ionization track with 2 *blobs*, one on each end of the track
→ the unambiguous signature of a $\beta\beta$ event.

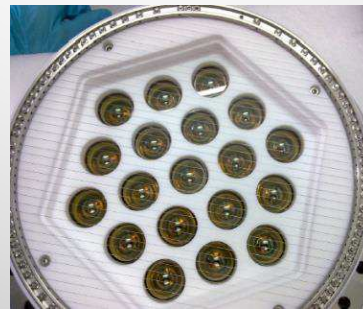
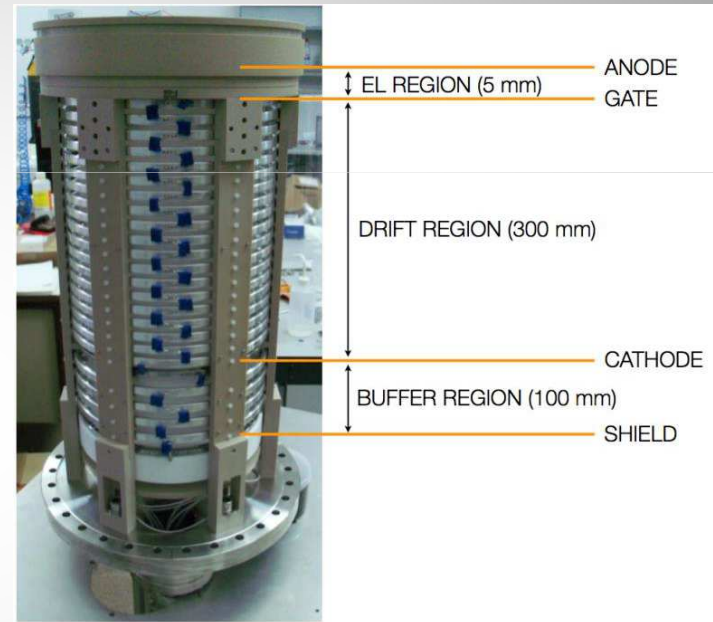
NEXT - DEMO

5 Kg of Xe; 30 cm vessel

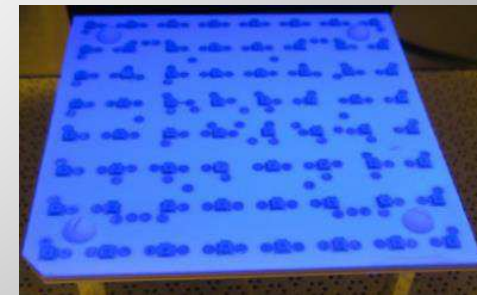
Developed at IFIC (Valencia)

Purpose of NEXT-DEMO:

- Demonstrate energy resolution and tracking over a sizeable region.
- See the Blob-topology.
- Verify Fiducialization.
- Make the needed Corrections



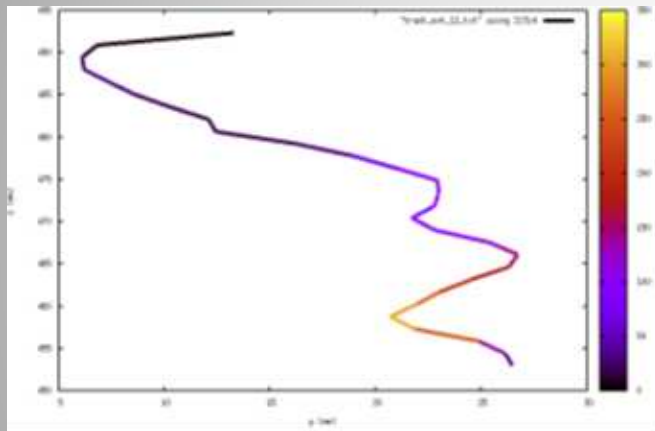
energy plane



tracking plane

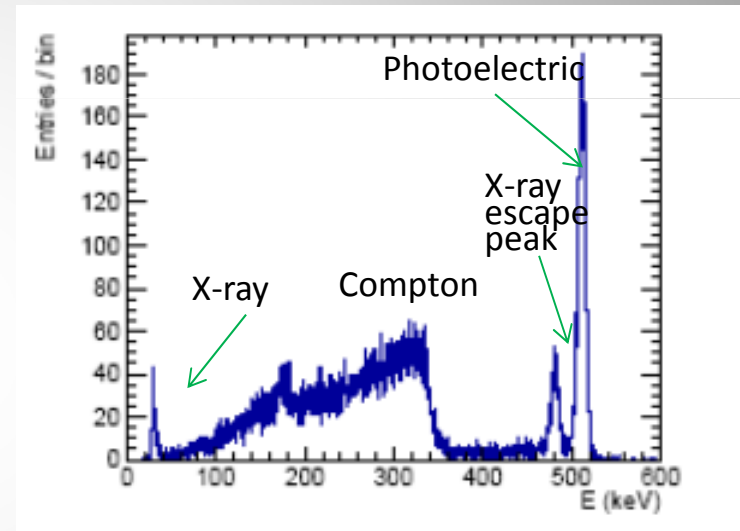
NEXT- DEMO : Results

SiPM-based read-out planes in NEXT-DEMO clearly demonstrated good tracking capability



Reconstructed track left by a photoelectric electron produced by the interaction of a 662-keV gamma (from a ^{137}Cs calibration source) detected by NEXT-DEMO.

Near-intrinsic energy resolution reached in NEXT-DEMO with a value $\sim 1.8\%$ FWHM for 511-keV e^- , extrapolating to $\sim 0.8\%$ FWHM @ $Q\beta\beta=2.458$ MeV



Energy spectrum for 511 keV γ .

From low- to high energy-region:

- Xe X-ray peak (~ 30 keV),
- Compton continuum (100-340 keV),
- Xe K X-ray escape peak (~ 480 keV),
- photo-electric peak (full energy).

NEXT-DEMO key for future NEXT-100 detector

NEXT– NEW

The **primary goal** of **NEXT-NEW** is to provide an **intermediate step** in the construction of the **NEXT-100** detector

- NEXT-NEW is NEXT-100 at scale 1:2
- 10-15 kg of high-pressure ^{136}Xe -> @ 10-15bar
- 20% of photosensors: 12 PMTs, 20 SiPMs boards

Purpose of NEXT-NEW:

- Consolidate the project (*now funded ERC – AdG*
- (*ERC-2013-AdG, PE2*), 2.4 MEuro)
- allow further validation of the technological solutions proposed for NEXT.
- permit a measurement of the energy resolution at high energy
- Characterize thoroughly the 2-electron topological signature, by measuring the $\beta\beta_{2\nu}$ mode.
- NEW will permit a realistic assessment of the NEXT background model before the construction of the NEXT-100 detector.
- Commissioning: 2014
- Data taking: 2015

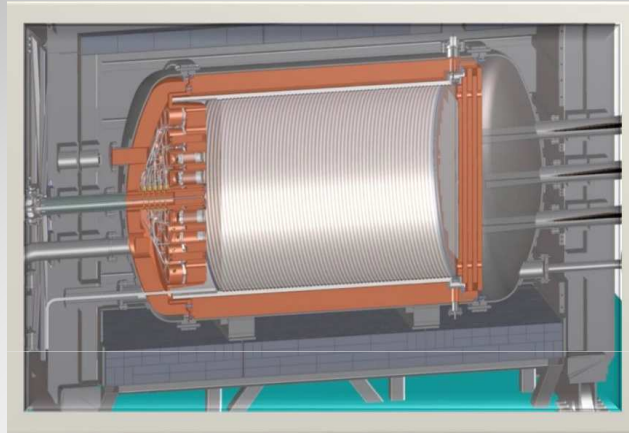


NEXT– NEW

Accomplished up to now:

- Construction of seismic platform and pedestal
- Platform installed at LSC
- 100kg of ^{136}Xe -enriched Xe (90%)
- Gas system delivered
- Vessel built
- Needed elements already screened for radiopurity

The Future - NEXT 100



- Vessel: 1.2 tons stainless steel ^{316}Ti alloy, very low radioactivity, with 12 cm inner copper shield (it blocks radiation by a factor of 100).
- Field cage: 130 cm long, 105 cm in diameter, high density polyethylene cylindrical shell.
- Energy plane: 60 PMTs, low radioactivity, 30% coverage, but encapsulated in cans with sapphire windows to hold pressure.
- Tracking plane: 7000 SiPM, 1-mm² active area, placed in boards (8x8 each), separated 1 cm, coated with a WLS (TPB).
- Most elements acquired. Some additional funding is required
- Complete Geant-4 MC simulation of detector and physics are being performed

Conclusions and outlook

- NEXT-100 is a 100 kg ^{136}Xe (90% enriched) High Pressure Gas TPC able to explore $\beta\beta_{0\nu}$ down to 100 meV effective ν masses.
- NEXT has an excellent energy resolution (<1%) FWHM at $Q\beta\beta$, extrapolated from the measurements done with NEXT-DEMO prototype.
- NEXT-DEMO has demonstrated the tracking capabilities of NEXT, for the chosen tracking plane (SiPMs); reconstruction of electron and identification of the 'blob' will significantly reduce the background level.
- NEXT-100 is currently under construction (vessel, sensors, electronic, DAQ, gas system,...). Installation and commissioning expected by 2016 at Canfranc Underground Laboratory, LSC (Spain).
- The first stage (10kg) NEXT-NEW will be deployed in 2014 at LSC. It will be able to measure $\beta\beta_{2\nu}$ and validate the background model and the topology reconstruction of 2 electrons.
- The strategies proposed by NEXT show potential for the 1 ton scale, that would theoretically allow probing ^{136}Xe $\beta\beta_{0\nu}$ decay down to 20 meV in ν effective mass.



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