

Neutrinoless double beta decay

Neutrinoless double beta decay ($0\nu\beta\beta$) is a postulated nuclear transition in which two neutrons undergo β decay simultaneously without the emission of neutrinos.

Evidence of this process would establish that massive neutrinos are Majorana particles, would be a hint of a new physics scale beyond the Standard Model and prove the violation of total lepton number, a key element to explain the observed asymmetry between matter and antimatter in the universe.

In addition, the measurement of the $0\nu\beta\beta$ would provide information on the absolute scale of neutrino masses.

$$(T_{1/2}^{0\nu})^{-1} \propto m_{\beta\beta}^2$$

Double beta decay experiments

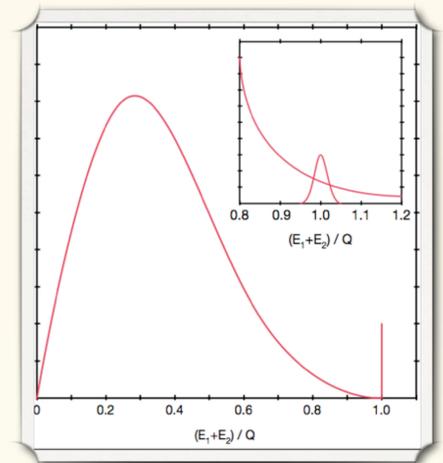
Double beta decay detectors measure the sum of the kinetic energies from the two released electrons, Q_{bb} .

Considering the finite energy resolution of any detector, other processes occurring in the detector, as the tail of $2\nu\beta\beta$ mode, can fall in the region of energies becoming a background.

As in other rare events detectors, backgrounds of cosmogenic origin and natural radioactivity from materials are a problem, and thus underground operation and selection of radiopure materials is essential.

Additional experimental features are desired to improve the sensitivity of the detector, such as extra background rejection, better detector efficiency or larger exposure.

$$T_{1/2}^{-1} \propto a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{\Delta E \cdot B}}$$



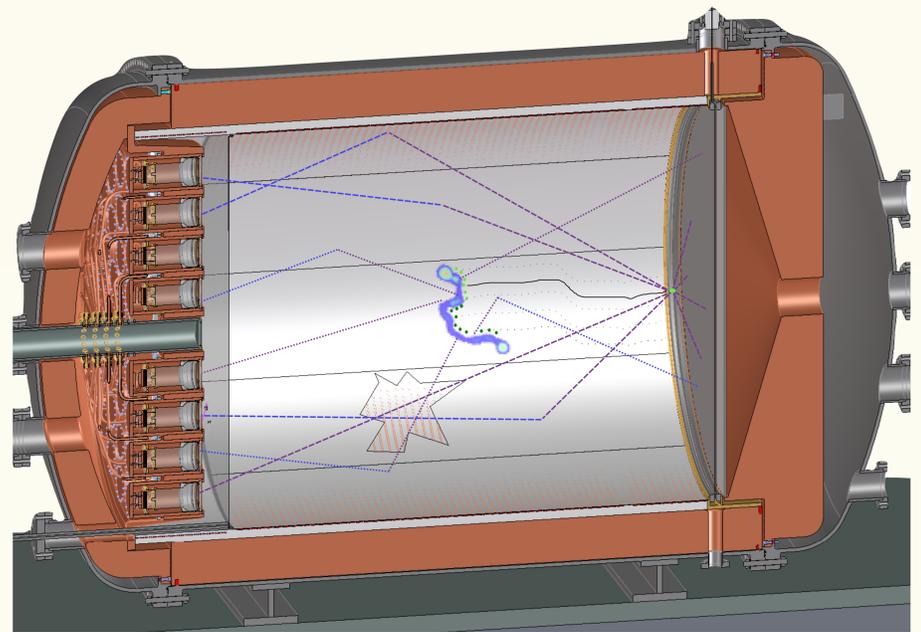
NEXT-100

The NEXT-100 detector will search for the neutrinoless double beta decay of ^{136}Xe at the Laboratorio Subterráneo de Canfranc. It uses a time projection chamber filled with 100 kg of enriched xenon gas at 15 bar pressure, with separated detection functions for calorimetry and tracking.

The gaseous xenon provides scintillation and ionization as primary signals. These are used to establish the start-of-event time (t_0) and for calorimetry/tracking respectively. In order to achieve optimal energy resolution, the ionization signal is amplified in NEXT using the electroluminescence (EL) of xenon.

Calorimetry : The energy plane is made of 60 photomultiplier tubes (Hamamatsu R11410-10 PMTs), located behind the TPC cathode for calorimetry and t_0 measurement. These PMTs will be sealed into individual pressure resistant, vacuum tight copper enclosures coupled to sapphire windows in order to withstand the high pressure of the gas.

Tracking : The tracking will be provided by a dense array of 1-mm² silicon photomultipliers (Hamamatsu S10362-11-050P SiPMs), measuring the forward-going secondary scintillation. It is located behind the anode, very close to the EL region, and is used for event topological reconstruction.



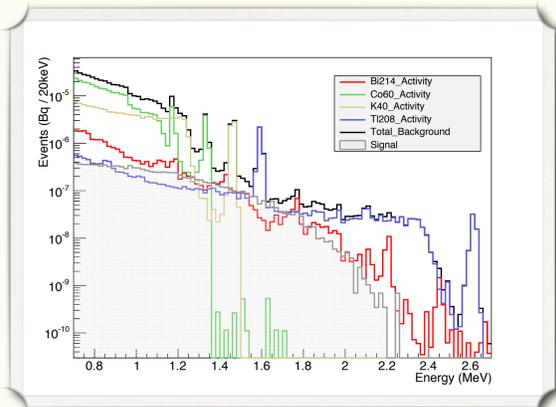
Background model

A Geant4 based simulation of the detector performance has been developed to evaluate all the main backgrounds that can mask the $0\nu\beta\beta$ signal, coming from the activities of the materials to be used in the construction. Those material have been screened by the LSC Radiopurity Service.

Component	Material	Unit	Quantity	²⁰⁸ Tl	²¹⁴ Bi	⁴⁰ K	⁶⁰ Co	Technique
Dice Boards		Bq/Unit	28 Units	4.00E-05	3.00E-05	1.21E-02	1.00E-05	NEXT
Field Cage	HDP	Bq/kg	18.626 kg	7.56E-06	6.20E-05	<3.40E-03	<1.40E-04	ICPMS/NEXT
	Resistors	Bq/Unit	106 Units	2.52E-06	1.64E-05	1.90E-05	1.10E-06	DarkSide
ICS	CuA1	Bq/kg	651.031 kg	1.44E-06	1.20E-05	3.70E-04	4.10E-05	GDMS/NEXT
PMT Body		Bq/Unit	12 Units	1.44E-04	5.00E-04	1.39E-02	4.40E-03	XENON/NEXT
Vessel	316Ti SS	Bq/kg	606.005 kg	1.48E-04	4.60E-04	1.20E-04	4.40E-03	GDMS
Carrier Plate	CuA1	Bq/kg	239.607 kg	1.44E-06	1.20E-05	3.70E-04	4.10E-05	GDMS/NEXT
Support Plate	CuA1	Bq/kg	272.614 kg	1.44E-06	1.20E-05	3.70E-04	4.10E-05	GDMS/NEXT
Enclosure Body	CuA1	Bq/Kg	79.941 kg	1.44E-06	1.20E-05	3.70E-04	4.10E-05	GDMS/NEXT
Enclosure Window	Sapphire	Bq/Kg	1.654 kg	<1.98E-03	<2.70E-03	<1.80E-02	<7.00E-04	NEXT
Shielding Lead	Lead	Bq/Kg	15614.7 kg	3.39E-05	3.47E-04	1.24E-04	9.00E-05	GDMS
Pedestal	316TiSS	Bq/Kg	360 kg	1.48E-04	4.60E-04	1.20E-04	4.40E-03	GDMS
Cu castle	CuA1	Bq/Kg	4056.568 kg	1.44E-06	1.20E-05	3.70E-04	4.10E-05	GDMS/NEXT

The accuracy of this model will be validated with the operation of the NEW prototype (see NEW poster and QR) and improved if needed.

Using this model the background rate expected in NEXT-100 is estimated to be as good as 5.0×10^{-4} counts/keV/kg/yr.

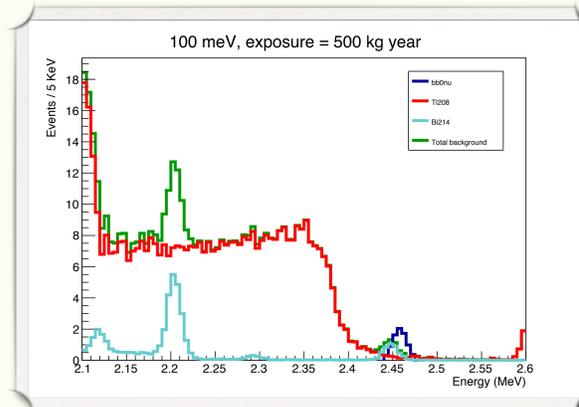
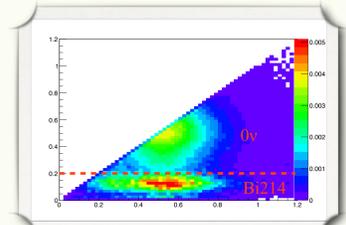


Analysis and Sensitivity

The analysis of the events simulated is done applying a chain of selection cuts :

- First raw cut on energy is made to reduce the amount of data written in the preprocessing.
- Events fully contained in the fiducial volume are selected.
- The energy of those 'true' events is smeared according to our energy resolution.
- A final cut on the Energy ROI window is made.
- The topology analysis starts with the voxelization of the events. The acceptance cut is made on those events that have one wire two bolbs topology.

Selection cut	Fraction of events			
	$\beta\beta 0\nu$	$\beta\beta 2\nu$	²¹⁴ Bi	²⁰⁸ Tl
$E \in (2.3, 2.6)$ MeV	0.776	3.31×10^{-6}	1.52×10^{-4}	8.02×10^{-3}
Fiducial	0.678	2.95×10^{-6}	1.13×10^{-4}	4.77×10^{-3}
Single track	0.508	2.27×10^{-6}	1.36×10^{-5}	8.44×10^{-4}
dE/dx	0.381	1.70×10^{-6}	1.36×10^{-6}	8.10×10^{-5}
ROI	0.319	3.24×10^{-12}	1.23×10^{-7}	3.23×10^{-7}



With the rejection factors aforementioned and the background model, the half-life sensitivity of NEXT-100 is estimated to be 1.1×10^{26} years, corresponding to an effective neutrino mass of ~ 100 meV, after 5 years running (500 kg·y of exposure).

Acknowledgments

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