Measurement of the 2νββ decay half-life and search for the 0νββ decay of ^{116}Cd

supernemo collaboration

LAPP Enigmass The enigma of mass

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NEMO-3 was a ββ decay experiment located in the Modane underground laboratory which combined tracker and calorimetric measurement.

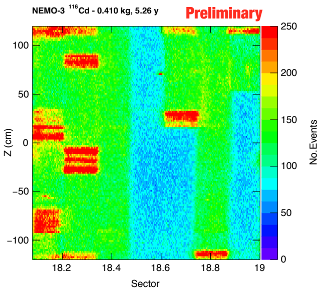
The detector took data from February 2003 to January 2011 with 10kg of different ββ, among which ^{100}Mo (7 kg) and ^{82}Se (1 kg).

Cd-116 source

440 g of metallic Cadmium shaped in 7 thin foils were installed in NEMO-3.

The sample was enriched in ^{116}Cd by the centrifugation separation method.

An average enrichment of (93.2±0.2)% was achieved.

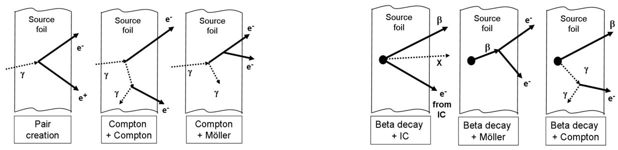


The data shows a non uniform event rate on the foil surface in the 1e channel suggesting the foils suffer from different background levels.

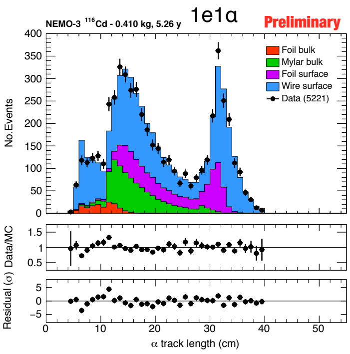
Three foil regions are defined and studied separately.

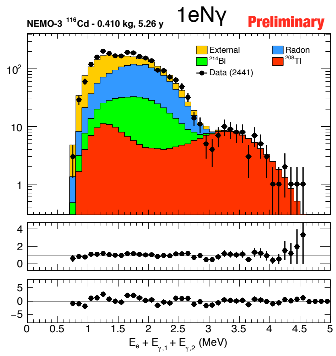
Backgrounds

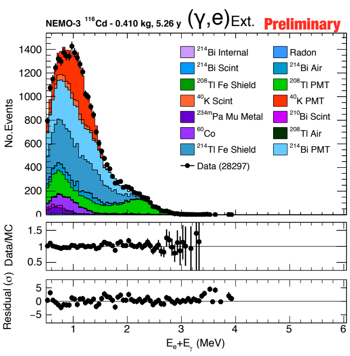
- Radio-impurities in material, γ from (n,γ) and μ bremsstrahlung
- ^{208}Tl (from ^{232}Th) and ^{214}Bi (from ^{238}U) contamination in foil source
- ^{214}Bi from Rn decay in tracker volume

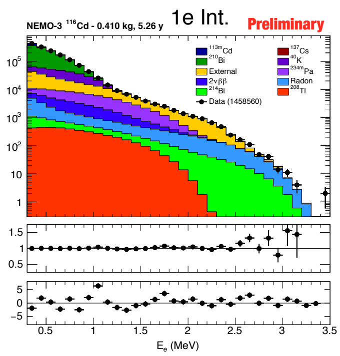


Take advantage of PID capabilities of NEMO-3 (e^-, e^+, γ, α) and TOF measurement to constrain the background model in different channel.







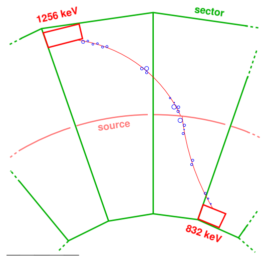


2νββ decay

The best sensitivity to the 2νββ decay rate is obtained in the 2 electron channel.

Additional topological requirements are used to increase S/B ratio.

The signal selection efficiency estimated from the MC is 1.769±0.003 %



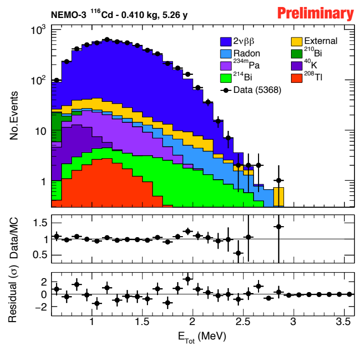
The 2νββ decay rate is determined adjusting the expected signal shape to the distribution of the sum of the 2 electron energy with a likelihood fit.

Backgrounds are constrained through Gaussian parameter to the values measured in the dedicated background channels.

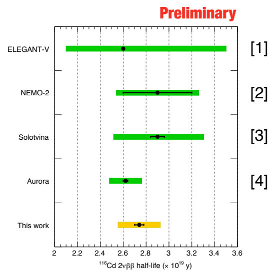
$$T^{2\nu}_{1/2} = [2.74 \pm 0.04(\mathrm{stat.}) \pm 0.18(\mathrm{syst.})] \times 10^{19} \quad \mathrm{y}$$

Results of the fit in the 2e channel

Contributions		A (mBq/kg)	N
^{208}Tl		0.13±0.03	19±2
^{214}Bi		0.4±0.1	30±5
^{210}B	Low	2804±49	0.2±0.1
	Medium	6707±49	24±10
^{40}K	Low	12.9±0.5	9.0±0.5
	Medium	23.7±0.5	26±1
^{234m}Pa	Low	2.7±0.5	28±5
	Medium	5.1±0.5	73±7
Externals		–	136±14
Radon		–	49±2
Total background		–	393±19
$2\nu\beta\beta$		–	4978±74
Data		–	5368



Comparison with previous results



Systematical uncertainties

Origin	Uncertainty on $T^{2\nu}_{1/2}$
Electron reconstruction efficiency	±5.5 %
^{116}Cd mass	±0.25 %
^{116}Cd foil modelling	[+2.2, −3.2]%
Energy calibration	±1.2 %
^{214}Bi background	±0.01 %
^{208}Tl background	±0.05 %
Radon background	±0.02 %
Internal background	±1.07 %
External background	[+0.45, −0.45] %
Total	[+6.2, −6.7] %

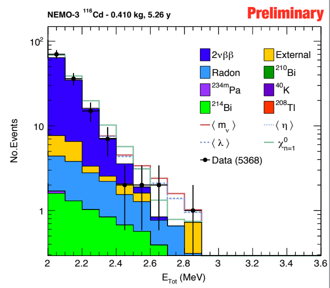
0νββ decay

No significant excess of data over the expected background is observed.

Different kinematical variables are combined into a BDT to enhance S/B and increase sensitivity by about 10%, depending on the mechanism.

Limits at 90% C.L. are set for different mechanism with a frequentist approach.

Mechanism	Obs. $T^{0\nu}_{1/2}$ limit	
$\langle m_{\beta\beta}\rangle$	≥ 1.0	$< (1.4 - 2.5)$ eV
λ'_{111}		$< 0.1 \times f$
$\langle \eta \rangle$	≥ 1.1	$< (2.5 - 11.9) \times 10^{-8}$
$\langle \lambda \rangle$	≥ 0.6	$< (3.6 - 43.0) \times 10^{-6}$
$\langle g_{\chi^0} \rangle$	≥ 0.085	$< (5.2 - 9.2) \times 10^{-5}$



A search for ββ decay of ^{116}Cd to the excited states of ^{116}Sn is ongoing

[1] K. Kume et al. (FRONTIER 1996). [2] D. Dassie et al. Nucl. Phys. A678, 341 (2000). [3] F. A. Danevich et al., Phys.Rev.C68, 035501 (2003). [4] F. A. Danevich et al., Arxiv:1601.05578v1.