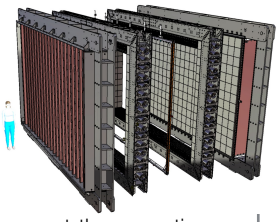
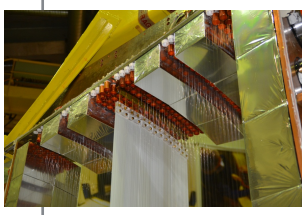
The isotopic double-beta decay source for SuperNEMO

Remoto A., Le Noblet T., LAPP, Annecy-le-Vieux (France)
on behalf of the SuperNEMO collaboration



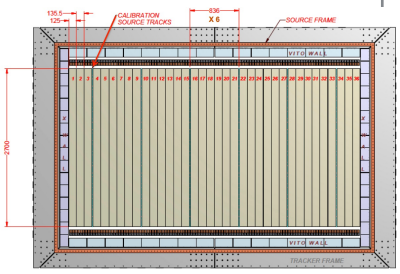
SuperNEMO will search for the 0νββ decay in 100 kg of ββ emitter, exploiting tracking-calorimetry technique pioneered by NEMO3. The detector has been designed to reach a sensitivity $T_{1/2}^{0\nu} > 10^{26}$ y in 5 years

SuperNEMO will be able to study different isotopes at the same time. ^{48}Ca, ^{82}Se and ^{150}Nd are currently under consideration.



In the demonstrator phase, the ββ source is made of enriched ^{82}Se powder shaped in thin foils to minimise the energy loss of the out-coming particles and placed in the middle of the detector.

7 kg of ^{82}Se will be distributed over 36 strips 2700 cm long and ~13 cm wide for a thickness of about 200 µm. The strips will be hung on the source frame and placed in the middle of the detector.



Foil Design

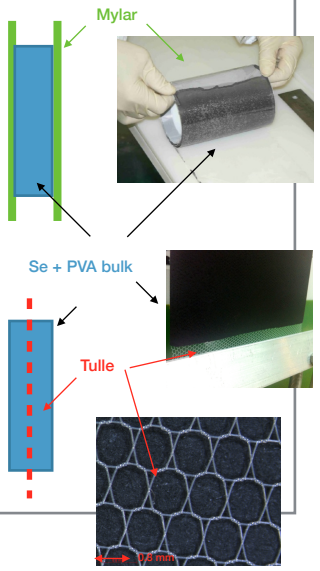
The ^{82}Se powder is mixed with a polyvinyl-alcohol (PVA) glue to produce a solid and uniform thin foil. A mechanical support is required to provide enough strength over 3 m long foil. Two designs are under consideration.

MYLAR Design: Two thin layers of mylar film envelop the Se+PVA bulk.

The mylar acts as the physical bound of the foil, preventing loss of the powder. About 5-10 % of PVA is enough to glue the Se.

TULLE Design: A thin bobbinet tulle produced by warp & weft nylon monofilament is embedded in the foil.

The tulle is a lighter support w.r.t. to the Mylar inducing a lower background rate for a similar material contamination. About 10-15 % of PVA is required to glue the Se.

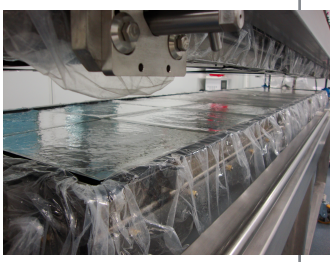


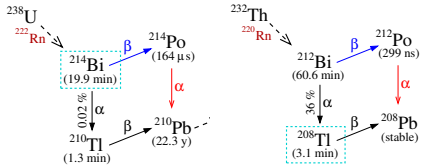
Radio-purity

To eliminate background events from impurities in the source foil, the required radio-purity level for ^{208}Tl and ^{214}Bi are 2 µBq/kg and 10 µBq/kg.

BiPo is a dedicated detector for the measurements of ultra-low levels of contamination present in the SuperNEMO source foils.

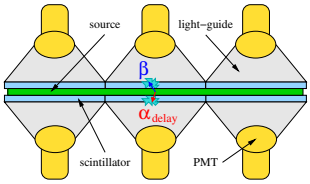
The measurement is based on the detection of the BiPo cascade: e^- followed by a delayed α.





^{208}Tl: Q_β (^{212}Bi) = 2.25 MeV
E_α(^{212}Po) = 8.8 MeV
^{214}Bi: Q_β (^{214}Bi) = 3.27 MeV
E_α(^{214}Po) = 7.7 MeV

- 40 paired optical modules: 3.6m^2 active surface
- 2 mm thick polystyrene scintillator plates
- Nitrogen flushing for Rn suppression
- 2 detectors: measure 8 SuperNEMO foil strips simultaneously



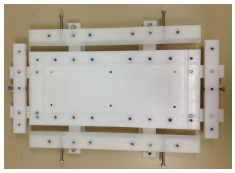
BiPo is taking data since January 2013 at the Canfranc Underground Laboratory in Spain.

In order to choose the best materials to build the source foil, the radio-purity of each component is measured in BiPo.

Sample	Mass fraction w.r.t. Se Mass	A(208-Tl) [µBq/kg] @ 90% C.L.	A(214-Bi) [µBq/kg] @ 90% C.L.
PVA	0.10	< 64.9	[532.3 – 1093.8] ± 76.8
Mylar	0.10	[63.8 - 229.3] ± 13.9	[618.0 – 1637.4] ± 106.3
Tulle	0.015	[125.6 – 363.0] ± 23.1	[646.6 – 1539.3] ± 103.4
Se	1.00	Planned in summer 2014	

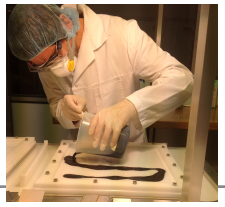
Foil Production

The PVA powder is dissolved in ultra-pure water at 80 °C to produce a liquid glue which is mixed with Se powder.



The tulle (or the mylar) is installed on a dedicated support specifically designed to keep the tulle fabric in place.

The Se powder mixed with the liquid PVA glue is poured on the support and spread uniformly. Upon drying, the foil is resistant and flexible.



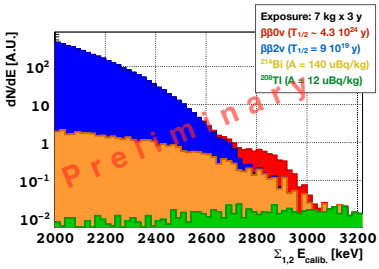
Sensitivity studies

Study the detector performance w.r.t. the foil design.

Measured value of contamination in ^{208}Tl and ^{214}Bi are used. The background levels depend on the foil component and their relative mass fraction w.r.t. Se.

$$T_{1/2}^{0\nu} > \frac{\log 2 N_A}{W} \times \epsilon_{0\nu} \frac{M \times T}{N_{\mathrm{EXC.}}}$$

N_A : Avogadro number
W : Se Atomic mass
$\epsilon_{0\nu}$: Selection efficiency
$M \times T$: Exposure
$N_{\mathrm{EXC.}}$: Excluded $\beta\beta0\nu$ @ 90% C.L.



Foil design	R.O.I. [MeV]	ε (Signal) [%]	Background [c.t.s.]	Half-life [y x 10^{24}]
Ideal	[2.72 ; 3.20]	19	1.7	5.39
Mylar	[2.69 ; 3.20]	19	4.5	4.11
Tulle	[2.71 ; 3.20]	17	2.8	4.32

Preliminary

Expected half-life sensitivity @ 90% C.L. for 7kg x 3y exposure (SuperNEMO demonstrator).

The plot shows the detector response for the "Tulle" foil design.