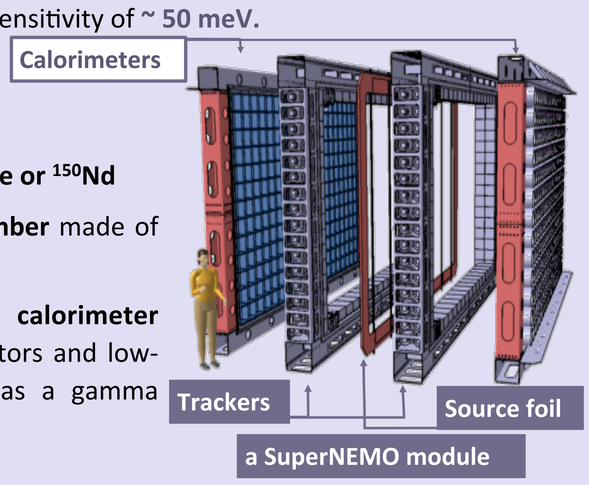
High resolution low background calorimeter for SuperNEMO

Christine Marquet, Cédric Cerna
CENBG – Bordeaux – France
On behalf of the SuperNEMO Collaboration

The SuperNEMO detector

SuperNEMO is a **0νββ experiment** based on the NEMO-3 technique of tracking and calorimetry. It will search for neutrinoless double beta decay in ~ 100 kg of enriched isotopes, reaching a half-life sensitivity of $T_{1/2} \approx 10^{26}$ **years**, which corresponds to a neutrino mass sensitivity of **~ 50 meV.**



20 modules each containing :

- a central thin **source of 5 kg ^{82}Se or ^{150}Nd**
- surrounded by a **tracking chamber** made of 2000 drift cells in Geiger mode
- enveloped in an **electron calorimeter** consisting of 712 plastic scintillators and low-radioactivity PMTs acting also as a gamma tagger

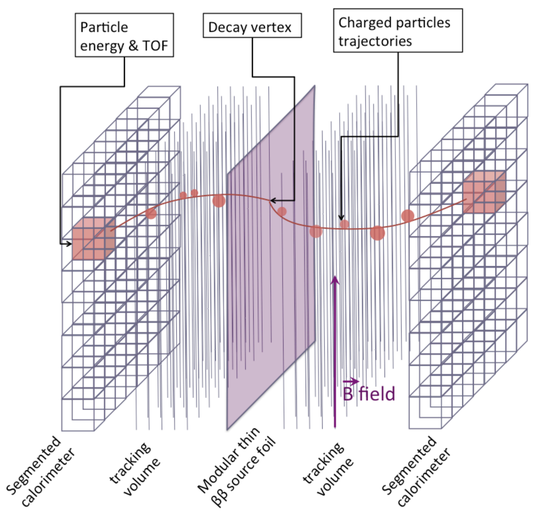
The demonstrator :

Intermediate phase to test the technical feasibility of the experiment and the background levels with **1 module :**

- 7 kg x 2 years of ^{82}Se
- **$T_{1/2}(\beta\beta0\nu) > 6.6\ 10^{24}$ years**
- $\langle m_\nu \rangle < (0.15 – 0.4)$ eV

Starts running in 2015 in LSM

A tracker-calorimeter



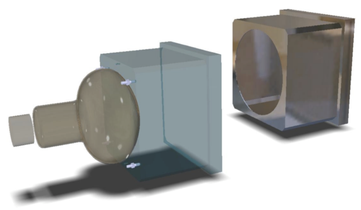
A calorimeter to measure the:

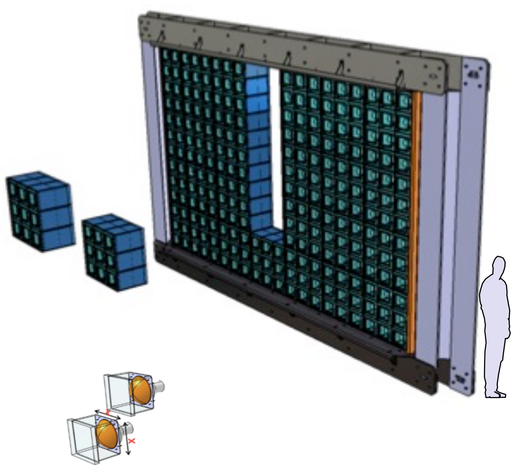
- Individual deposited **energy**
- **Time of flight** difference between each fired counter

The main wall calorimeter design

520 Optical Modules each made of

- 10 L Envinet polystyrene scintillator
- R5912-03mod Hamamatsu Photonics 8'' PMT
- Teflon and mylar wrapping





Individual pure **iron magnetic shields** (25 G)
Relative time/energy **calibration with LED**
Absolute energy **calibration with ^{207}Bi sources**

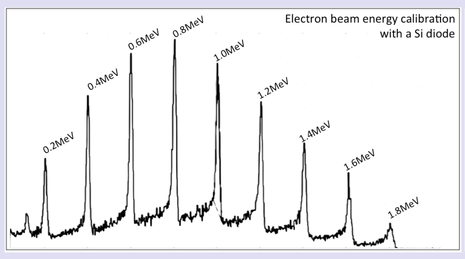
Requirements

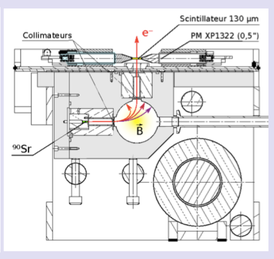
- **Resolution ≲ 8 % [FWHM] /√E [MeV]**
  note : NEMO3 ≈ 16 % [FWHM] /√E [MeV]
- Time resolution 300 ps (σ) @ 1 MeV
- No ageing in 5 years
- Gain survey with an accuracy < 1 %
- Low background PMT (Radon emanation)
- Low backscattering
- 4π γ tagging 50 % @ 500 keV

Unique characterisation tools

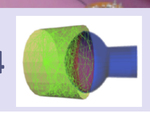
➢ 2 electron beam spectrometers to qualify the optical modules

- Mono-energetic electron beam from a ^{90}Sr 370 MBq β source
  - $\sigma_{x,y} \approx 3$ mm
  - Energy range [0.4-2.0] MeV
  - **FWHM @ 1 MeV = 1.0 ± 0.2 %**
- Automated X/Y scanning [2 m x 1 m]





And a fine tuned optical simulations based on GEANT4

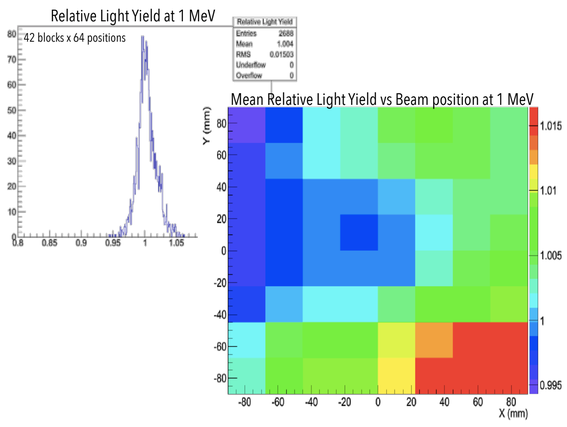


Optical modules performances

envinet NUVIA GROUP

Polystyrene scintillator

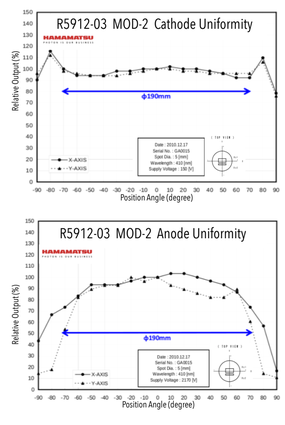
- 10 L volume
- 10 000 γ/MeV
- Highly uniform Light Yield

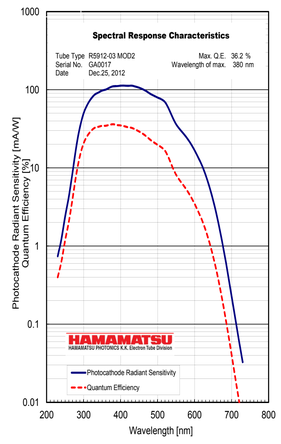


HAMAMATSU
HAMAMATSU PHOTONICS K.K. Electron Tube Division

New 8'' PMT (R5912-03 mod02)

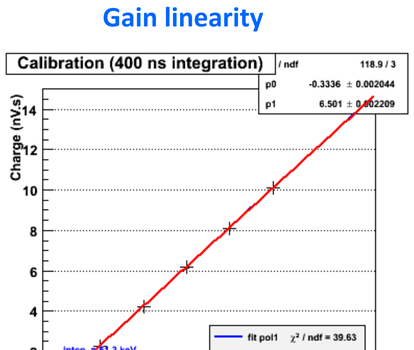
- 8 stages → G = 2.10^5 - 10^6
- QE > 30 % @ 420 nm
- High uniformity



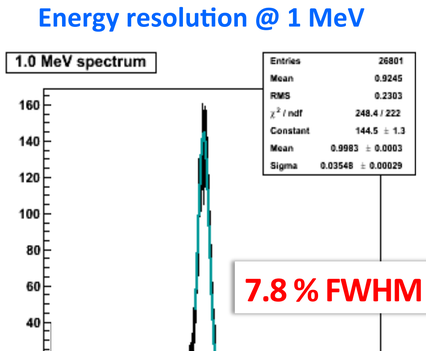


Optical Modules Energy Resolution

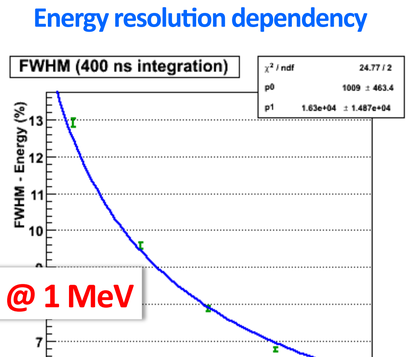
Gain linearity



Energy resolution @ 1 MeV



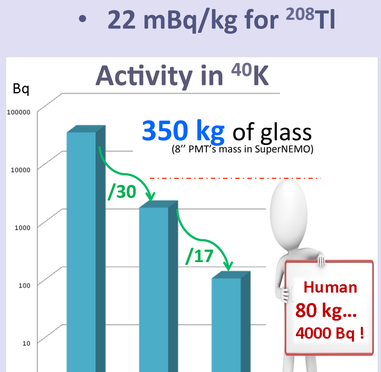
Energy resolution dependency



Radiopurity

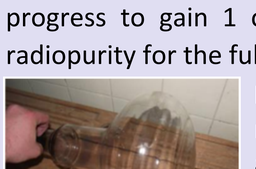
New glass for photomultipliers has been developped and characterised by Hamamatsu Photonics and the SuperNEMO collaboration to achieve a radiopurity of :

- **300 mBq/kg for ^{40}K**
- **120 mBq/kg for ^{214}Bi**
- **22 mBq/kg for ^{208}Tl**



The total activity of the **10 tons** of SuperNEMO materials will be less than 20 % of the PMT's activity (350 kg).

A new glass formula with synthetic silica is under progress to gain 1 order of magnitude more on the radiopurity for the full SuperNEMO Phase.



First bulb prototypes have been manufactured with this new glass and are currently tested by Hamamatsu Photonics.