



Comenius University in Bratislava



Study of Deposition Quality of ^{207}Bi Calibration Sources for SuperNEMO Experiment

Miroslav Macko^{1,2,3}

on behalf of the SuperNEMO Collaboration

¹Institute of Experimental and Applied Physics, CTU in Prague, CZ-12800 Prague, Czech Republic

²FMFI, Comenius University, Mlynská dolina F1, SK-842 48 Bratislava, Slovakia

³Université de Bordeaux, CNRS/IN2P3, CENBG, F-33175 Gradignan, France

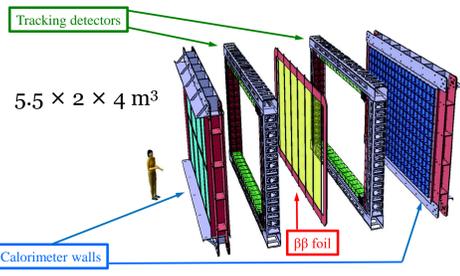


SuperNEMO Demonstrator

- **SuperNEMO** - Neutrino Ettore Majorana Observatory [1].
- Designed to study $2\nu\beta\beta$ and $0\nu\beta\beta$.
- Placed at **LSM** in **Fréjus tunnel** near **Modane** (FRA-ITA border).
- LSM is the **deepest European laboratory** (4800 m.w.e.)!
- Only **4 muons/day/m²**!

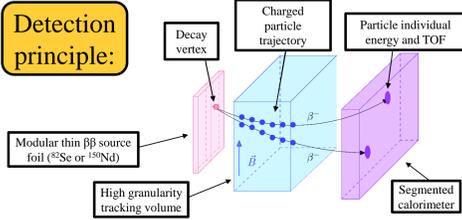


SuperNEMO module:



- First data in: **2018**
- Studied isotopes: ^{82}Se (^{150}Nd)
- **Planar, modular** design.
- Amount of isotope: **7kg** (100+ kg*)
- $0\nu\beta\beta$ half-life > 6×10^{24} y (10^{26} y*)
- Neutrino mass < **0.2 - 0.4 eV** (0.04 - 0.11 eV*)
- ^{208}Tl background < **2 $\mu\text{Bq/kg}$**
- ^{214}Bi background < **10 $\mu\text{Bq/kg}$**
- Energy resolution: **8% @ 1MeV**

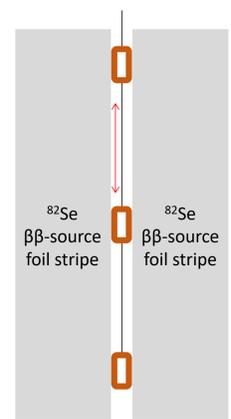
*Numbers with asterisk apply to full SuperNEMO experiment (20 modules)



Source Deployment System

- Automatic source deployment system will **insert ^{207}Bi sources between ^{82}Se $\beta\beta$ -source strips.**
- **Conversion e^- from ^{207}Bi will serve to calibrate calorimeter walls.**

Simplified scheme of SuperNEMO calibration source deployment system [2] - developed in University of Texas in Austin:

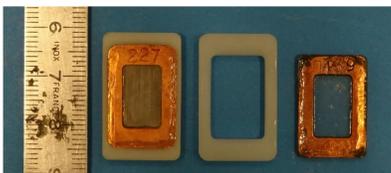


Goal of the presented study is to measure **spatial distribution and position of ^{207}Bi droplet** in SuperNEMO calibration sources. Knowledge of spatial distribution of ^{207}Bi within the calibration source **improves quality of calibration**. In the study, the main interest was whether the source is well centered inside of the Copper frame (see photo of sources). The length of „decentralization vector“ was defined as a measure of source centering. Results of the study will be used to **choose appropriate calibration sources for SuperNEMO demonstrator**.

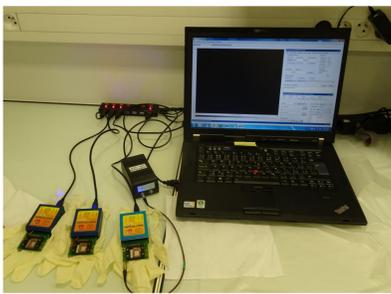
^{207}Bi Sources and Setup

- Source ^{207}Bi droplet is deposited between two transparent **mylar foils** sealed by **radiopure Copper rectangular frame**.

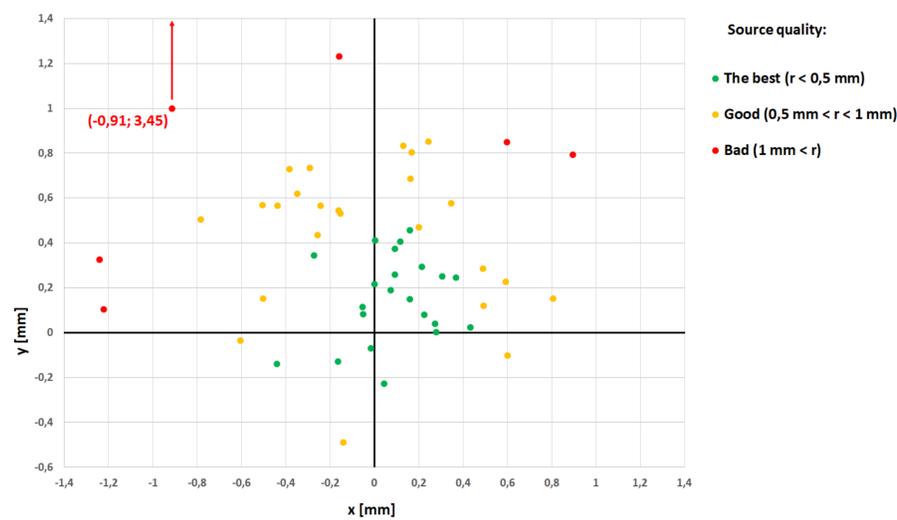
^{207}Bi calibration sources (No 227 and 139):



Measurement setup:



Result



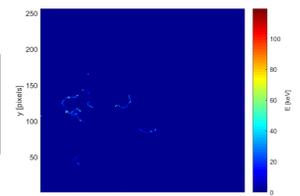
All **52 measurements** (49 sources) summed up in a single plot. Each dot represents **decentralization vector** for one measurement. Dot colour denotes source quality category based on the length of decentralization vector. x and y represent source coordinates with origin in the center of source frame.

Used Detectors

- **Timepix pixel detectors** [3], developed in IEAP CTU in Prague, were used in the study.
- We used **3 Timepix detectors** (two of them with 300 μm thick Si sensor, third with 1 mm thick Si sensor).
- Each detector has **14.08 \times 14.08 mm²** chip segmented into **256 \times 256 pixels**.

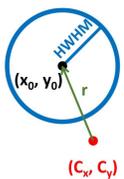
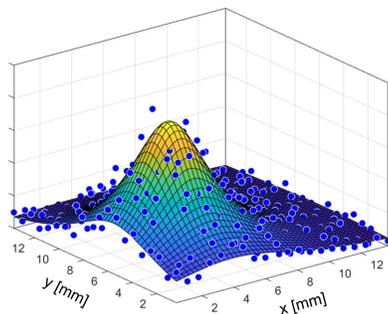


Example of one frame (1s data acquisition time):



Data Analysis

- All frames were superimposed, giving 2D deposition map.
- In ROI, events of **one pixel size** in energy range **3 keV < E < 30 keV** were chosen.
- Deposition distribution was fitted and several parameters were extracted.



- **Extracted parameters:**
- **HWHM:** \sqrt{r}
- **^{207}Bi droplet center:** (x_0, y_0)
- **Frame center:** (C_x, C_y)

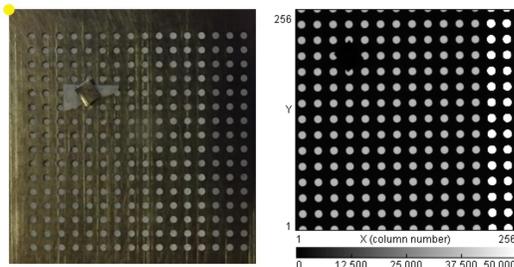
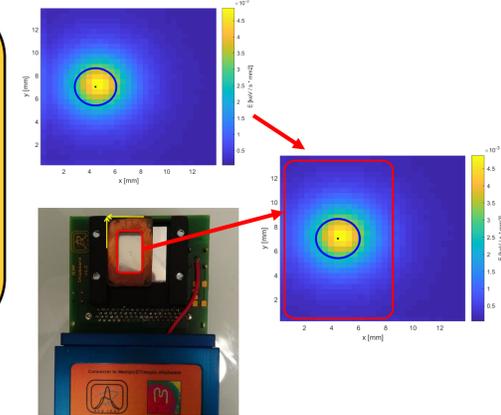
• **Fitting function:**

$$f(x, y) = \frac{N}{(x - x_0)^2 + (y - y_0)^2 + r}$$

• **Decentralization vector:** $\vec{r} = (x_0 - C_x, y_0 - C_y)$

Spatial Calibration

- ^{207}Bi droplet - **visible** in the detector.
- Copper frame - **invisible** in the detector.
- In order to extract the **relative position of the ^{207}Bi droplet and the Copper source frame** the spatial calibration of the chip was needed.
- Each source was carefully placed in **well defined reference position** (yellow arrows) on the detector which allowed to perform spatial calibration.



- Spatial calibration was performed using **metallic grid exposed to X-rays**.
- **One hole was covered** in order to identify position of the grid at the chip.

REFERENCES:

- [1] R. Arnold, C. Augier, J. Baker, et al., The European Physical Journal C 70, 927–943 (2010).
[2] R. Salazar, J. Bryant (SuperNEMO), PoS ICHEP2016 (2016) 808.
[3] X. Llopart, R. Ballabriga, et al., NIM Sec.A 585 (2008) 106 - 108.

ACKNOWLEDGEMENTS

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