First Energy Calibration of SuperNEMO's Calorimeter using its Tracko-Calo Technology

Aguerre Xalbat, Koňařík Filip, Patrick Cheryl, Křižák Tomáš,
on behalf of the SuperNEMO collaboration

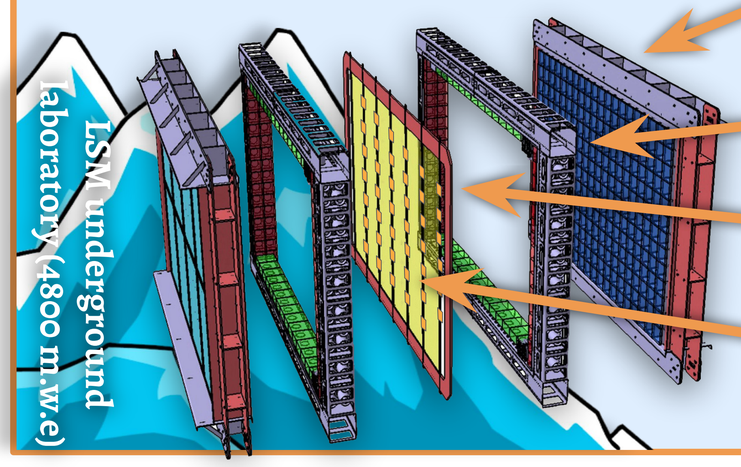
SuperNEMO - a full topological design to understand double-beta decay

SuperNEMO specifications:

➔ **Background:** < 10^{-4} events /(keV.kg.yr)

➔ **Full kinematics of ββ decays:**

- Discriminate **0νββ mechanisms**
- Study of **2νββ and decay to excited states**
- Constrain the **quenching of g_A**



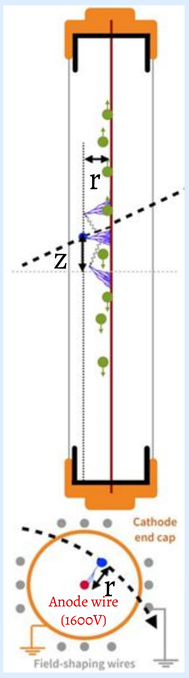
Calorimeter: 712 optical modules (OM)
- photomultiplier tubes and plastic scintillator

Tracker: wire chamber
- 2034 Geiger cells

0νββ source foil:
6.11 kg of ^{82}Se

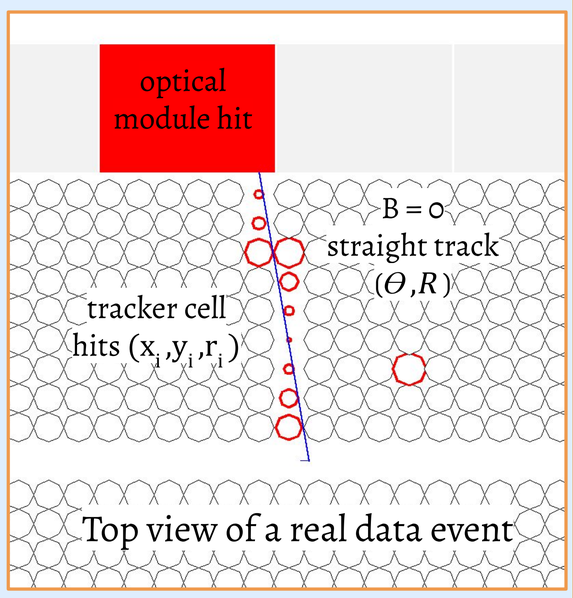
Calibration system:
42 deployable point-like ^{207}Bi sources

Geiger cell



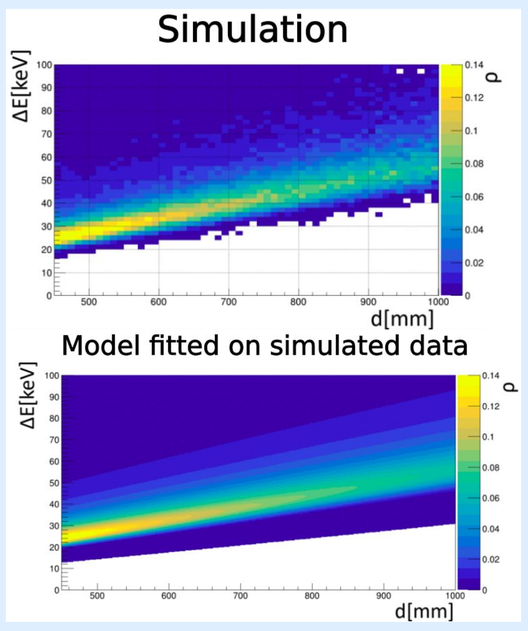
Particle Track Reconstruction

- Geiger cell:
  → height of the passing particle
  → distance r_i to the vertical anode wire
- **circular tracker hits** (x_i, y_i, r_i)
- reconstruction in horizontal plane is done using **Legendre transform**
- hits described in Legendre space by their tangent lines (Θ, R)
- intersection of Legendre images = reconstructed track



Electron Energy Loss Correction

- electrons lose energy while passing through tracker → influences calibration
- using tracker, electron's track length can be measured → **lost energy can be estimated** using suitable model

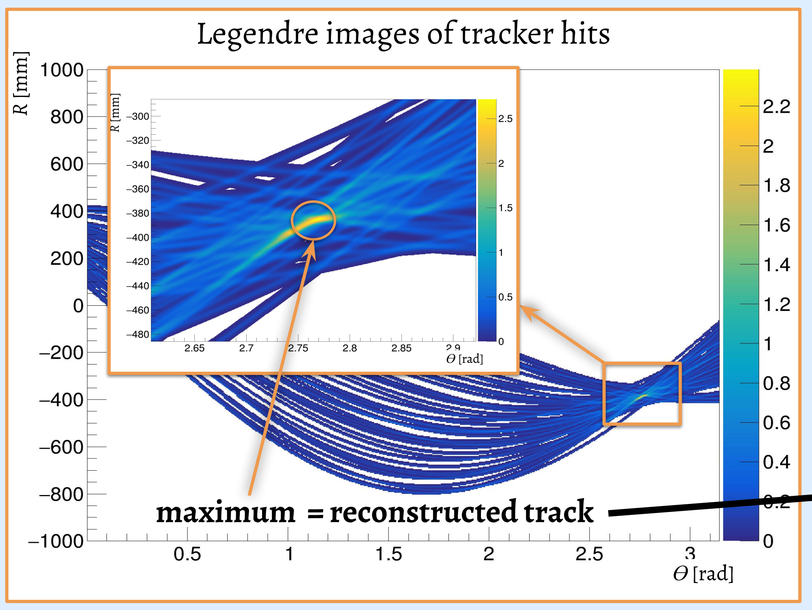


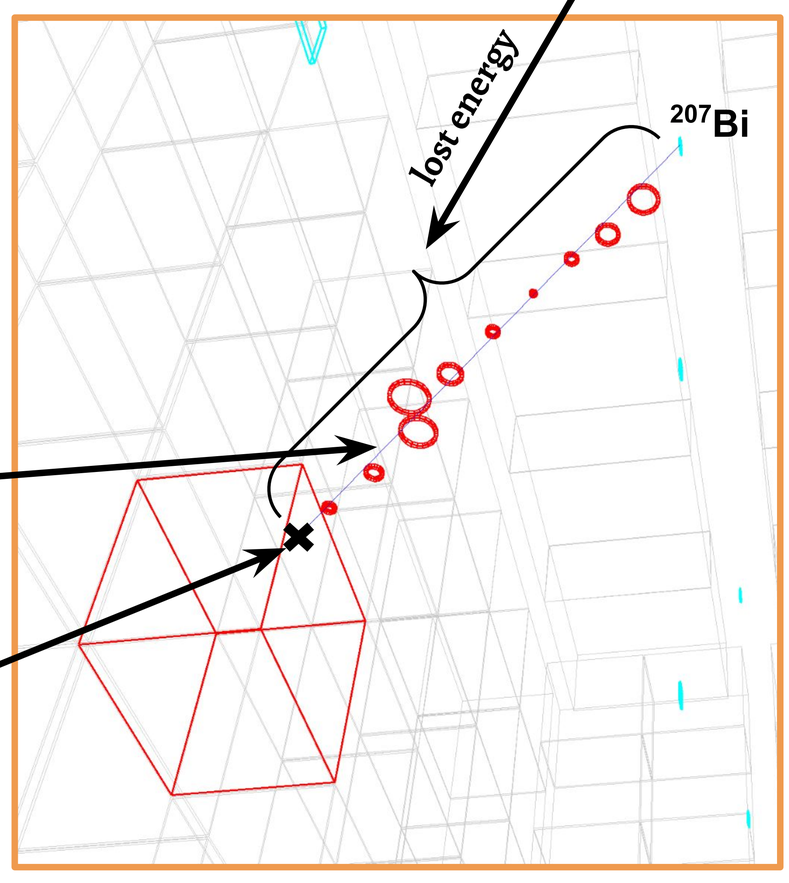
Energy loss model based on **Landau distribution**

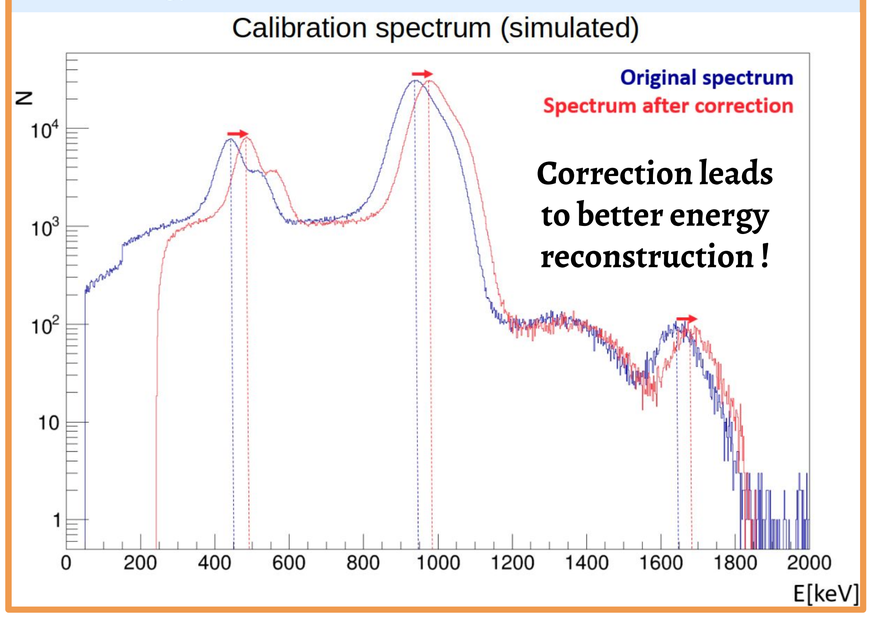
probability of losing energy ΔE — track length

$$\rho(\mathbf{\Delta E}; d, E_f)$$

energy at the end of the track

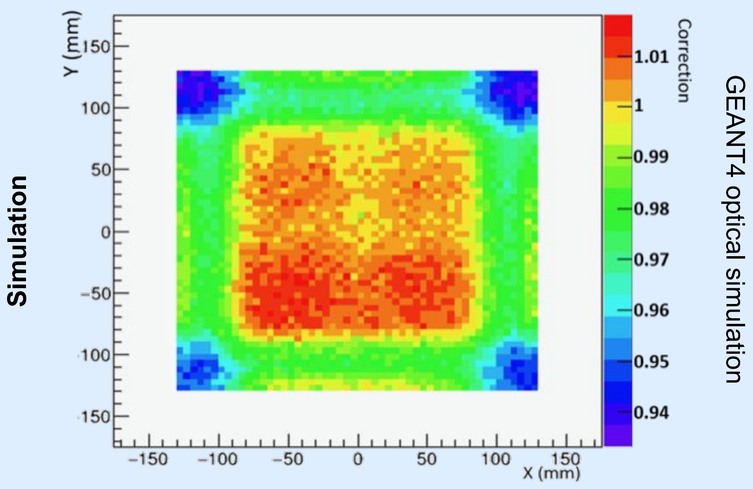


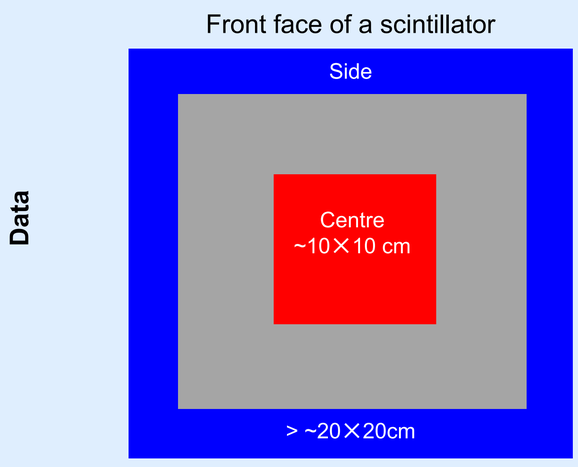


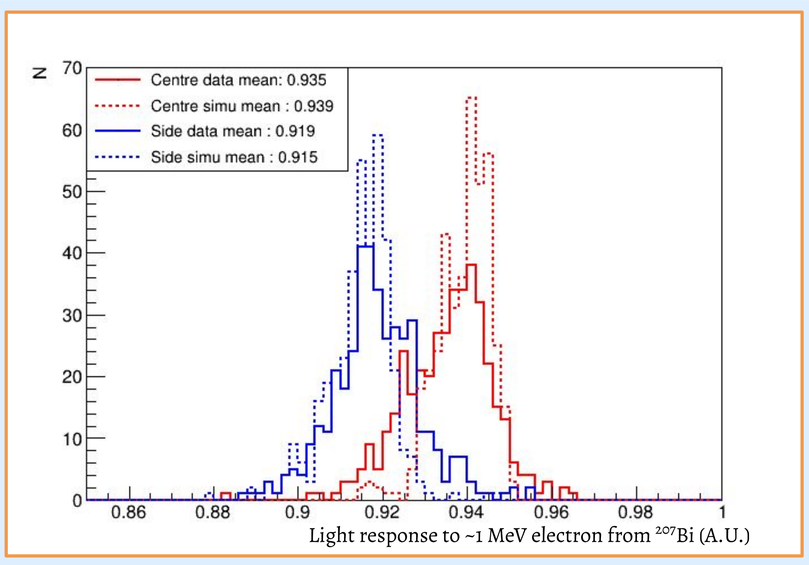


Scintillator Response Non-uniformity

The point where the electron hits an optical module can decrease **light collection** by up to 10%







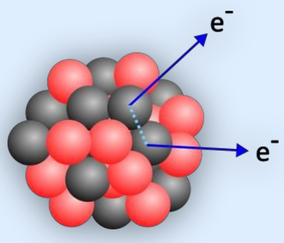
As expected, **better light collection on the centre than the side**

Simulation **completely compatible** with data!

First Energy Calibration of SuperNEMO's Calorimeter using its Tracko-Calo Technology

Aguerre Xalbat, Koňařík Filip, Patrick Cheryl, Křižák Tomáš,
on behalf of the SuperNEMO collaboration

SuperNEMO Demonstrator's search for 0vbb



Possible answer for various questions:

- ➔ **Neutrino = antineutrino ?**
- ➔ **Neutrino mass = ?**
- ➔ **Lepton number violation?**
- ➔ **Leptogenesis?**

SuperNEMO specifications:

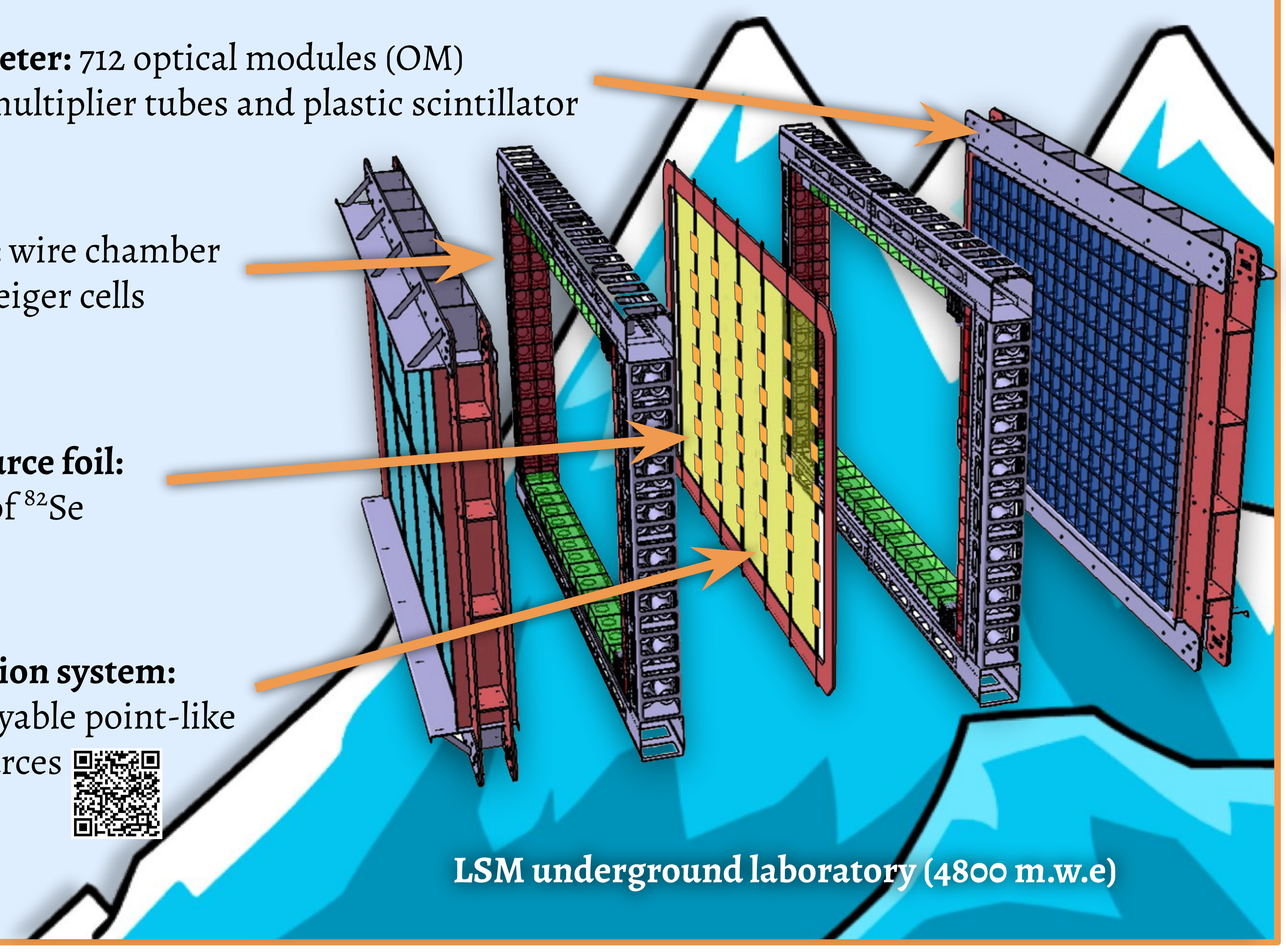
- ➔ **Background:** < 10^{-4} events /(keV.kg.yr)
- ➔ **Full kinematics of ββ decays:**
  - Discriminate **0νββ mechanisms**
  - Study of **2νββ and decay to excited states**
  - Constrain the **quenching of g_A**

Calorimeter: 712 optical modules (OM)
- photomultiplier tubes and plastic scintillator

Tracker: wire chamber
- 2034 Geiger cells

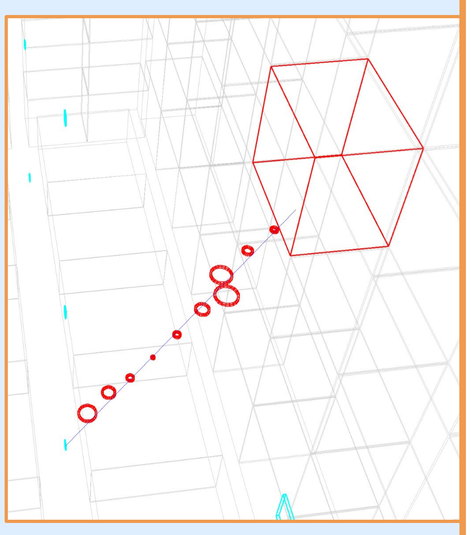
ββ0ν source foil:
6.11 kg of ^{82}Se

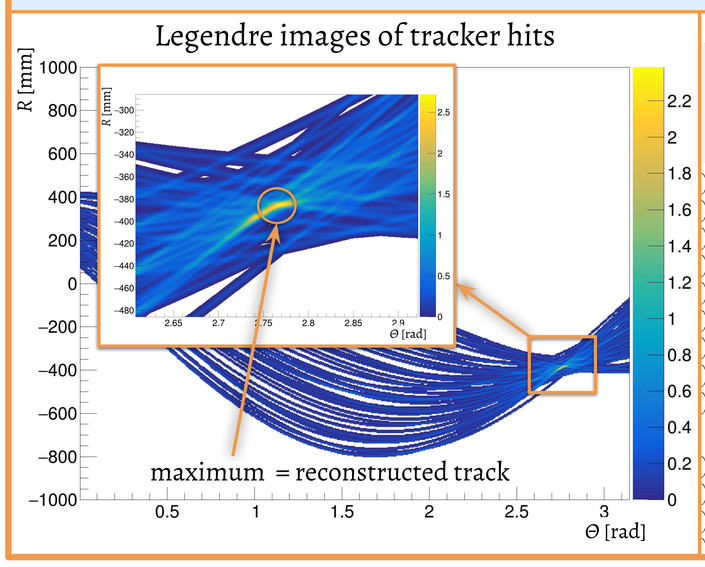
Calibration system:
42 deployable point-like ^{207}Bi sources

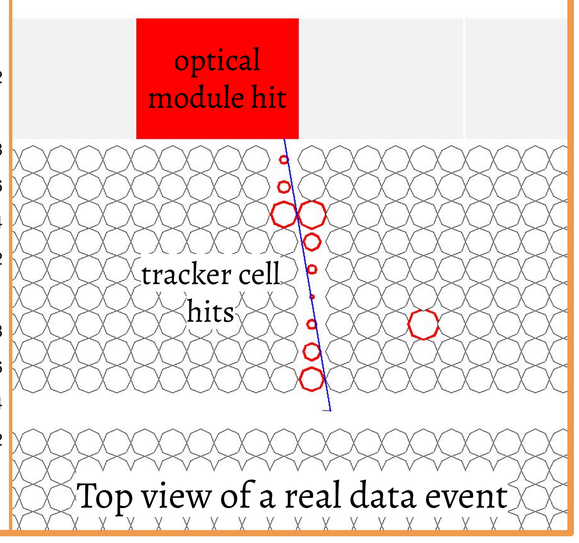


Particle track reconstruction

- each Geiger cell measures height of the passing particle and the distance to the anode wire → **circular tracker hits**
- no external magnetic field → **trajectory is a straight line tangent to the hits**
- reconstruction in horizontal plane is done using **Legendre transform**
- hits described in Legendre space by their tangent lines
- intersection of Legendre images = reconstructed track







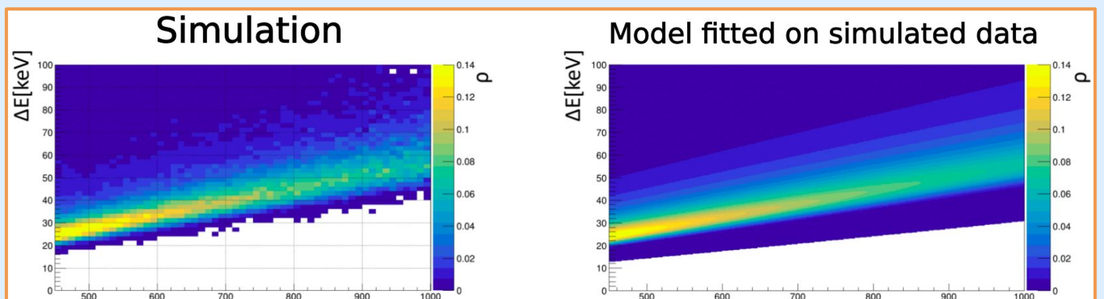
e^- energy loss correction

- electrons lose energy while passing through tracker → influences calibration
- using tracker, electron's track length can be measured → **lost energy can be estimated** using suitable model

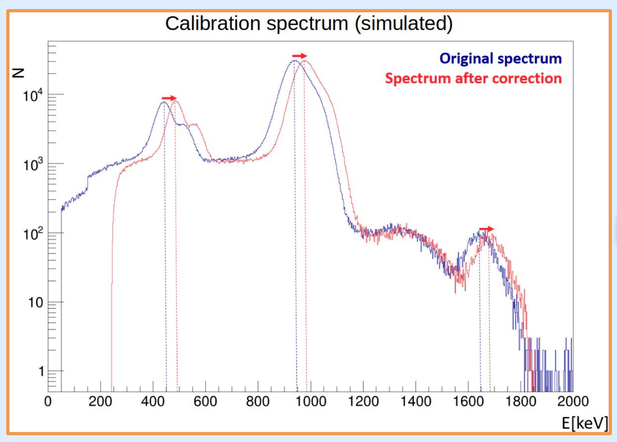
Energy loss model based on **Landau distribution**

$$\rho(\Delta E; d, E_f)$$

probability of losing energy ΔE — track length — energy at the end of the track



We can add estimated ΔE to measured energy of each electron:

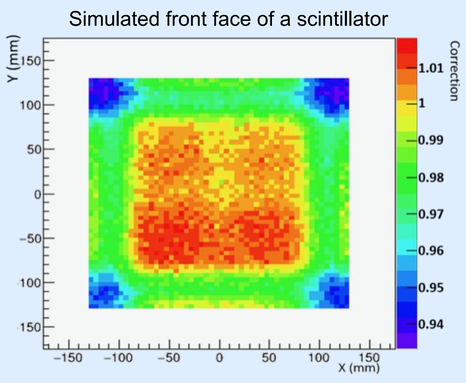


➔ **Better energy reconstruction**

Scintillator response non-uniformity

- Different photomultiplier **light collection** in function of the **impact point of the e^-** on the scintillator:
  - e^- in the **centre** of the scintillator → relatively **more light**
  - e^- in the **corner** of the scintillator → relatively **less light**

Prediction with Geant4 optical simulation
→ Maximal difference of ~10% on the light collection



First study of the non uniformity on SuperNEMO's final configuration

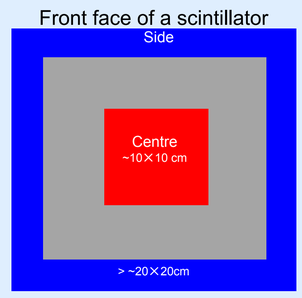
Data selected into two areas with respect to the scintillator face :

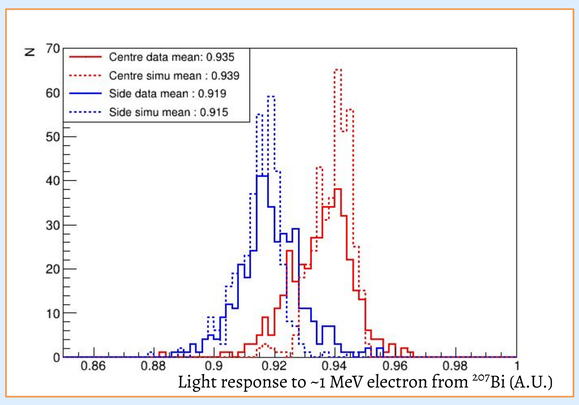
- **Centre**: < 10 cm from the centre
- **Side**: > 20 cm from the centre

As expected, **better light collection on the centre than the side**

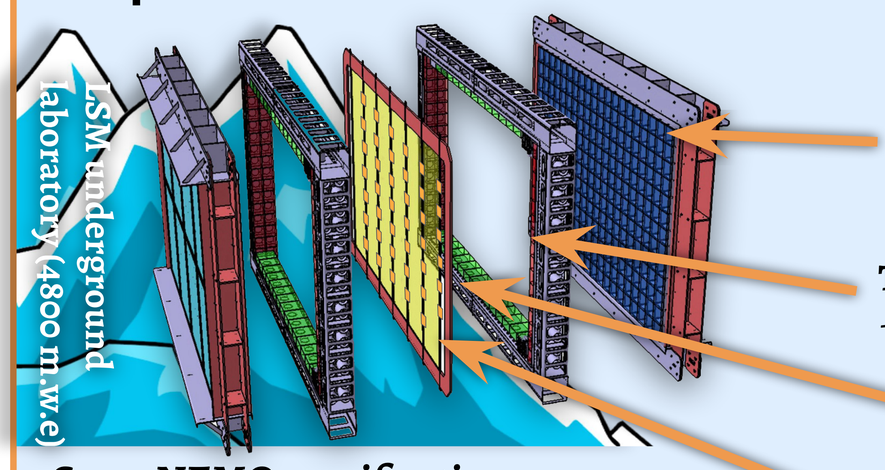
Simulation **completely compatible** with data!

More detailed study to come!





SuperNEMO Demonstrator's Search for Neutrinoless Double Beta Decay (0vbb)

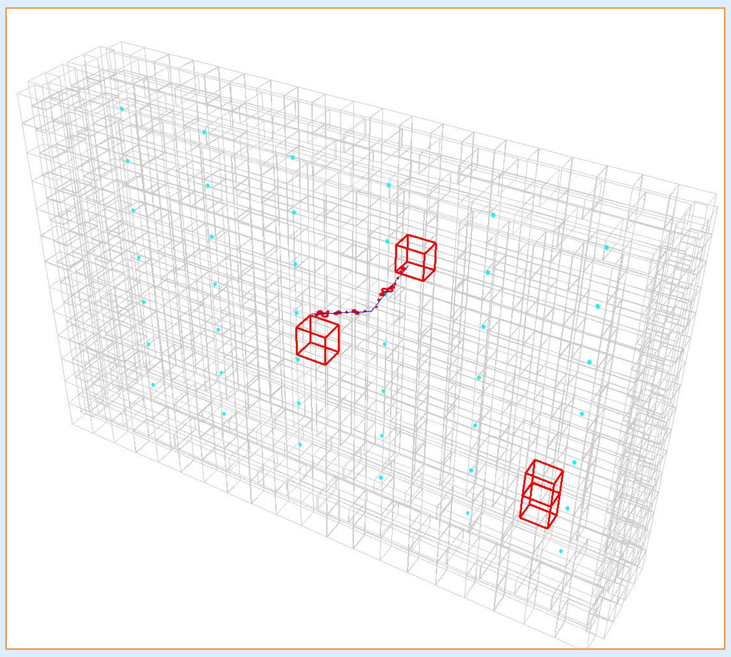


Calorimeter: 712 optical modules (OM)
- photomultiplier tubes and plastic scintillator

Tracker: wire chamber
- 2034 Geiger cells

ββον source foil:
6.11 kg of ^{82}Se

Calibration system:
42 deployable point-like ^{207}Bi sources



SuperNEMO specifications:

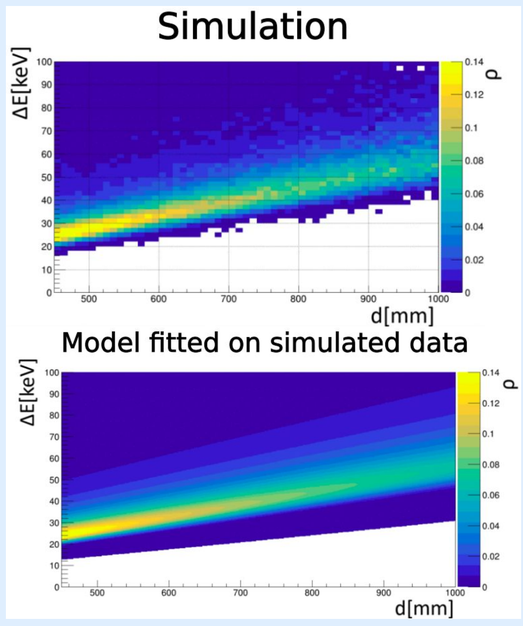
➔ **Background:** < 10^{-4} events /(keV.kg.yr)

➔ **Full kinematics of ββ decays:**

- Discriminate **ονββ mechanisms**
- Study of **2νββ and decay to excited states**
- Constrain the **quenching of g_A**

Electron Energy Loss Correction

- electrons lose energy while passing through tracker → influences calibration
- using tracker, electron's track length can be measured → **lost energy can be estimated** using suitable model



Energy loss model based on
Landau distribution

probability of losing energy ΔE

track length

$$\rho(\Delta E; d, E_f)$$

energy at the end of the track