Calibration Systems for the SuperNEMO Experiment

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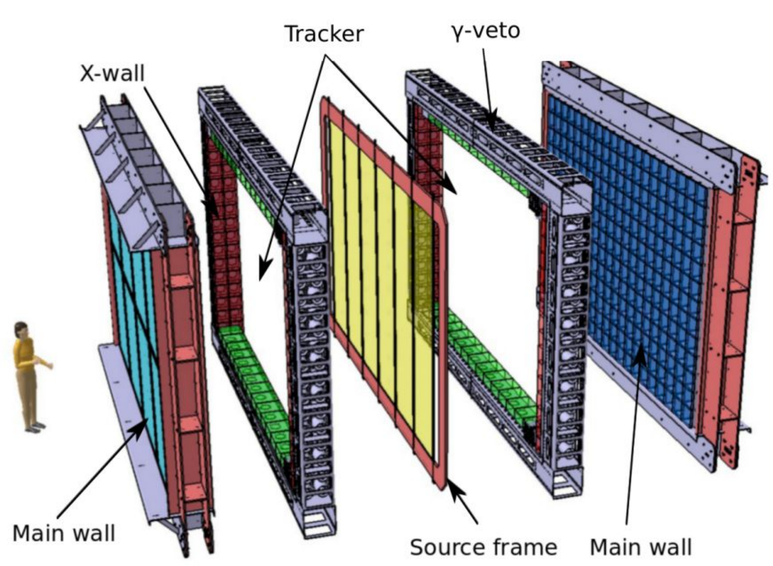
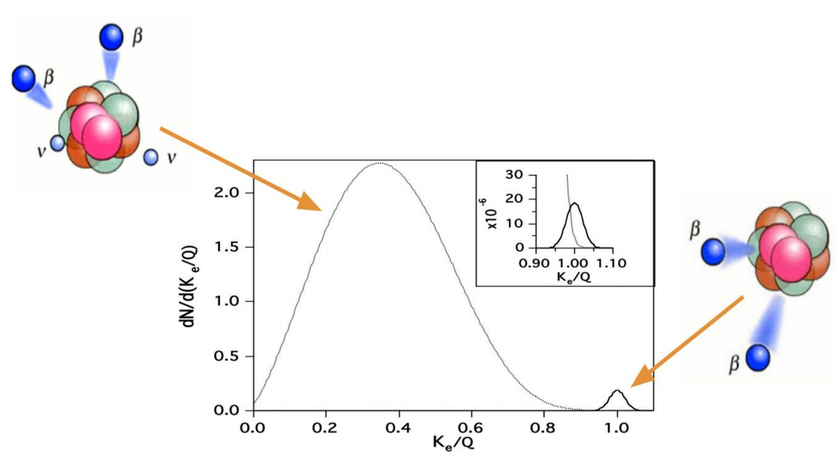
SuperNEMO Detector

- Search for **neutrinoless double beta decay** ($\beta\beta0\nu$) using **^{82}Se** in the form of thin foils inside a detector with a tracker-calorimeter architecture
  - Observations of $\beta\beta0\nu$ would suggest that neutrinos are Majorana particles, and allow to calculate the **effective Majorana neutrino mass**
- Exposure of the full detector will be **500 kg·yr,** reaching a sensitivity to the $\beta\beta0\nu$ half-life of 10^{26} years corresponding to an effective mass of **50 - 100 meV** [1]
  - A demonstrator with an exposure of 17.5 kg·yr (7 kg of ^{82}Se for 2.5 years) is under construction





Calibration

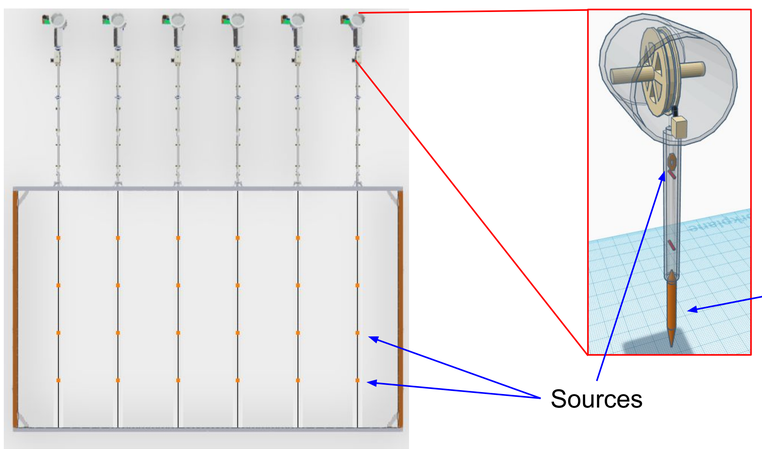
- Searches for $\beta\beta0\nu$ requires regular and high precision monitoring of the calorimeter
  - A robust two part system has been developed to achieve a precision of 1%

★ Source Deployment System
- Perform absolute calibrations
- Deploy twice a month

★ Light Injection System
- Perform relative calibrations
- Operate daily

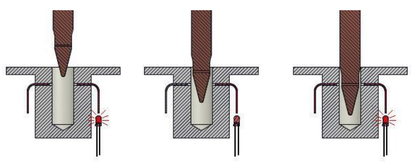
Source Deployment System

- Introduce **^{207}Bi sources** into the detector by deploying plumb bobs
- Calorimeter will see the ^{207}Bi EC peaks (**482, 976, and 1682 keV**)
- Retrieve sources after calibration
- **Fully automated** (using LabVIEW)

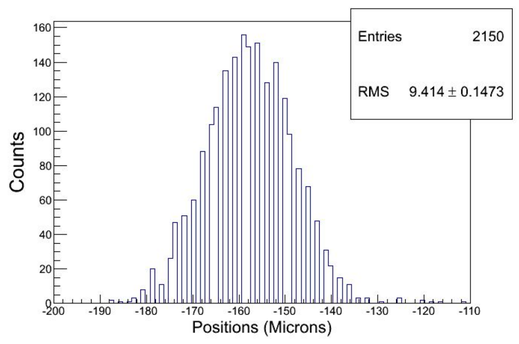


Drawing of a single vessel showing the mechanism used to deploy the plumb bobs together with the sources

Source Deployment System mounted on $\beta\beta$ source frame



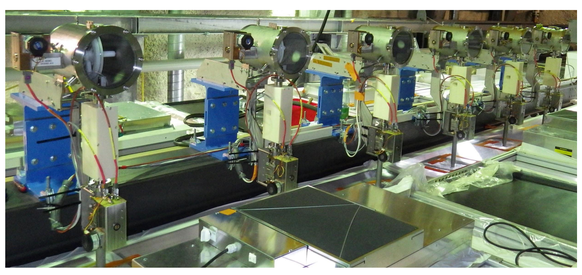
Optical system used to stop the plumb bobs (left)
Actual plumb bob stopped at the calibration position (right)



Stopping precision of the system

Installing the System

The Deployment System is being installed on the SuperNEMO detector.

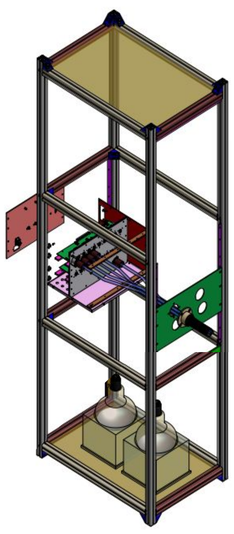


Vessels mounted on top of the detector

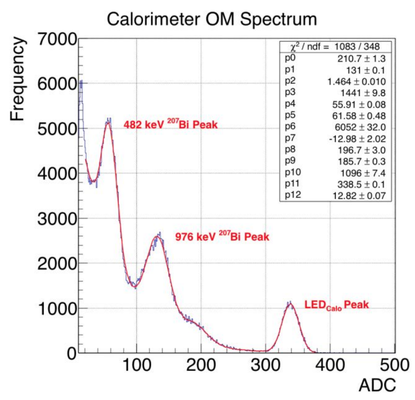
Plumb bobs being lowered into detector

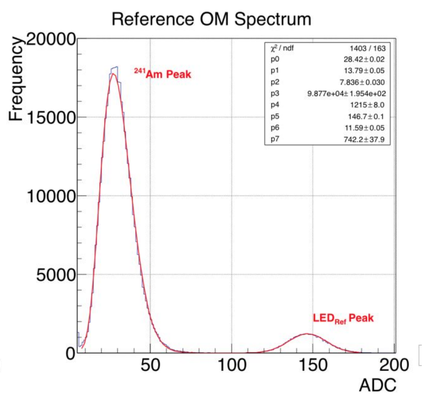
Light Injection System

- Inject light into every optical module (PMT + scintillator block)
  - 20 UV LEDs are pulsed to deliver light via optical fibers
- Light levels are understood relative to ^{241}Am sources monitored by optical modules outside of the detector
- **Test linearity of PMTs**



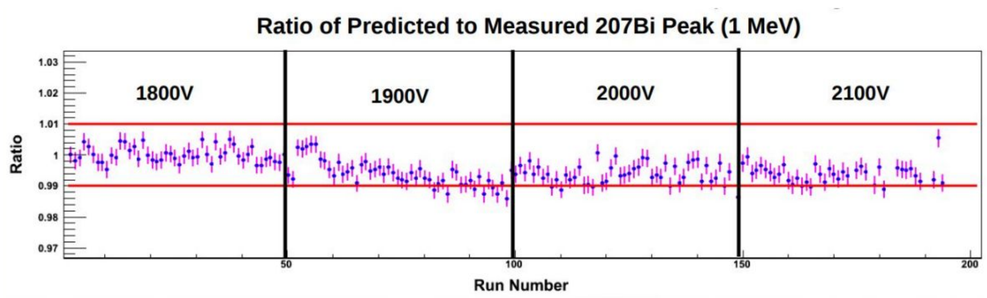
Optical Module (OM) - An 8'' PMT coupled to a 10 L scintillator block; the calorimeter is composed of 720 OMs, but a fraction of them are smaller than the one depicted here





Monitoring within 1%

Testing procedure:
- Measure a ^{241}Am source and an LED using an OM
- Measure a ^{207}Bi source and the same LED using a different OM
- The ^{241}Am is used to fix any drift on the LED
- The LED is used to predict any changes on the ^{207}Bi measurement
- Take the ratio of the predicted to measured ^{207}Bi
- Change PMT voltage to stimulate gain changes



References

[1] [The SuperNEMO Collaboration], SuperNemo Conceptual Design Report. (2010)

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