Construction, commissioning and transport of the tracker module for the SuperNEMO experiment

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Double Beta Decay

For certain isotopes, the two neutrino double beta decay process may be observed, consisting of the simultaneous beta decay of two neutrons.

If the neutrino is a Majorana particle, a related process – neutrinoless double beta decay – is possible. In this process a neutrino is first emitted, then reabsorbed as an antineutrino.

Evidence for this process would manifest itself as a peak in the tail of the summed two electron energy distribution.

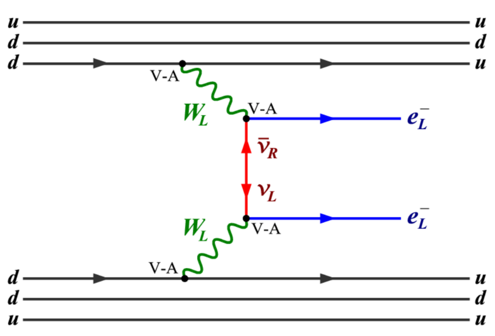

FIG 1: Feynman diagram for neutrinoless double beta decay

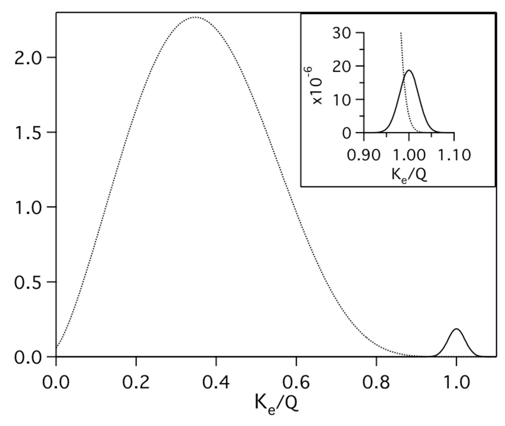

FIG 2: Experimental signature

A Majorana neutrino is needed for the see-saw mechanism to provide an explanation for the very light neutrino mass. [1]

Detector Design

The demonstrator module will consist of a ^{82}Se source foil surrounded by a 2034 cell drift chamber and scintillator calorimeter in a planar geometry. 7kg of ^{82}Se will be used to achieve a sensitivity to the half life of the neturinoless double beta decay process of $T_{1/2}(0\nu) > 6.6\text{x}10^{24}$y after 2.5 years.

The design provides a complete topological reconstruction of decay events, allowing for very high signal purity.

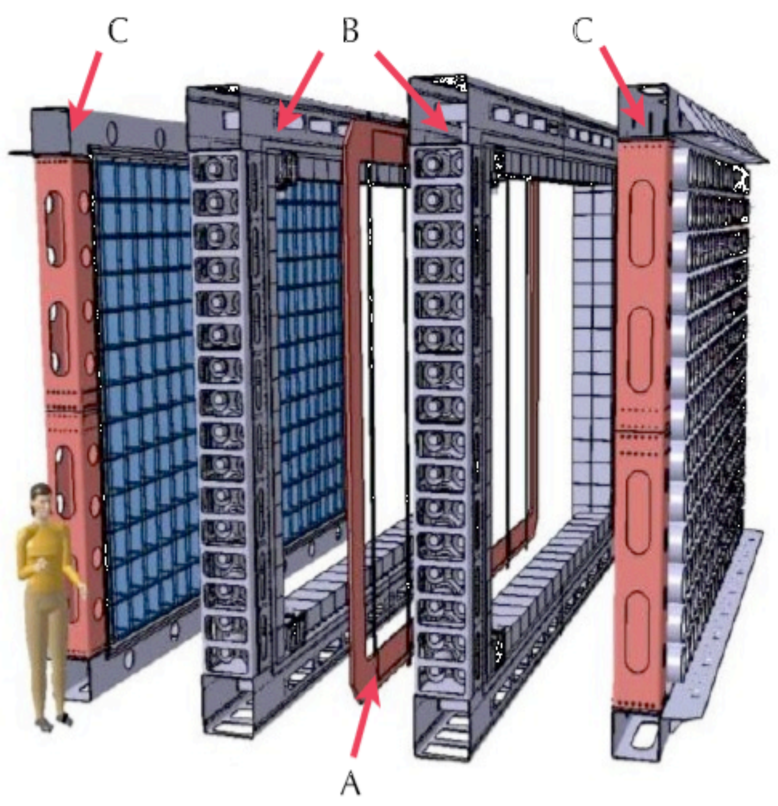

FIG 3: TheSuperNEMO demonstrator module, containing A: Source frame, B: Drift chamber, C: Calorimeter

To maintain the tracking properties of the detector, the mixture ratio of the gas must be kept constant (95% Helium, 4% Ethanol and 1% Argon). He and Ar are supplied to the gas system where the Ethanol is added in two stages. Approximately 4% is added in the primary bubbler. This is left at room temperature and the ethanol fraction added to the gas is controlled by keeping it at a high pressure. The fraction is fine tuned in the secondary bubbler, kept at 14 C.

Stringent limits on radon activity within the tracker volume must be achieved to reach the target sensitivity.

The activity target for the full demonstrator module is 0.15mBq/m^3. For further information please see 'P1.075 Radon mitigation strategy and results for the SuperNEMO experiment'.

Commissioning and Construction

The tracker module is being built in four sections, in a clean room environment at the Mullard Space Science Laboratory (MSSL). Three sections are fully constructed and commissioned, with construction of the fourth to be completed in the coming weeks. The complete demonstrator module is expected to be installed at the Laboratoire Souterrain de Modane (LSM) in the French-Italian Alps by the end of 2016.

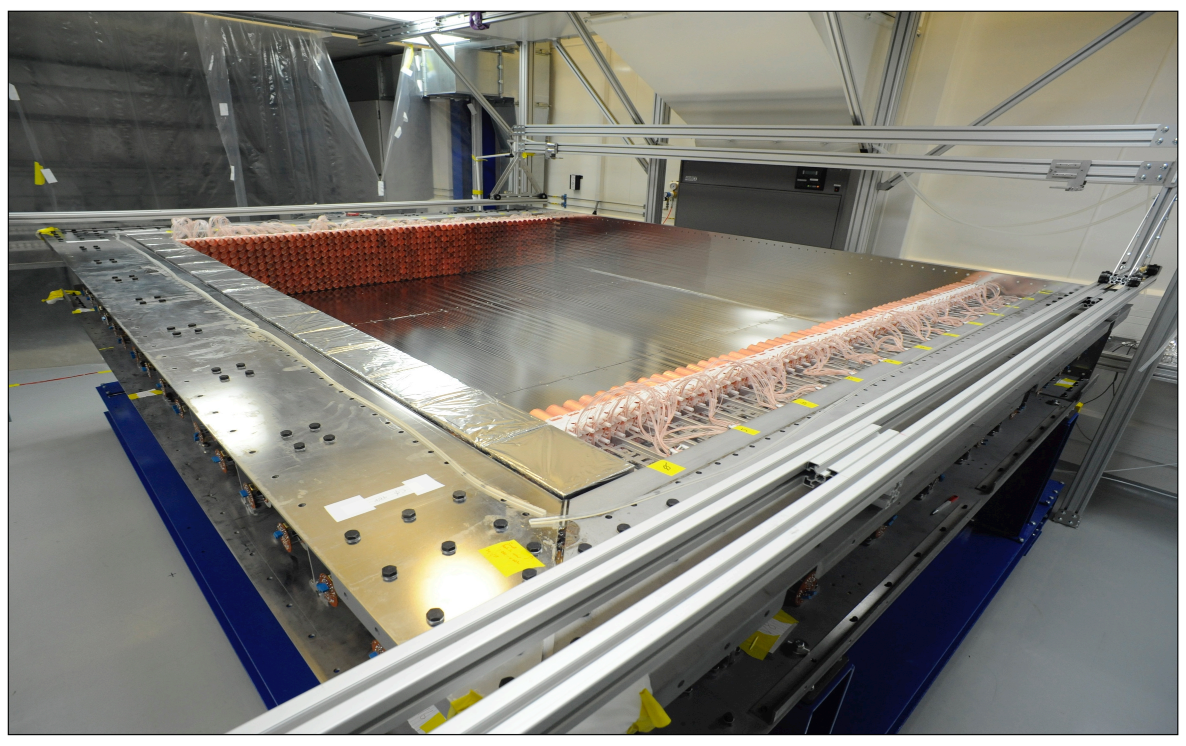

FIG 4: Fully populated tracker section

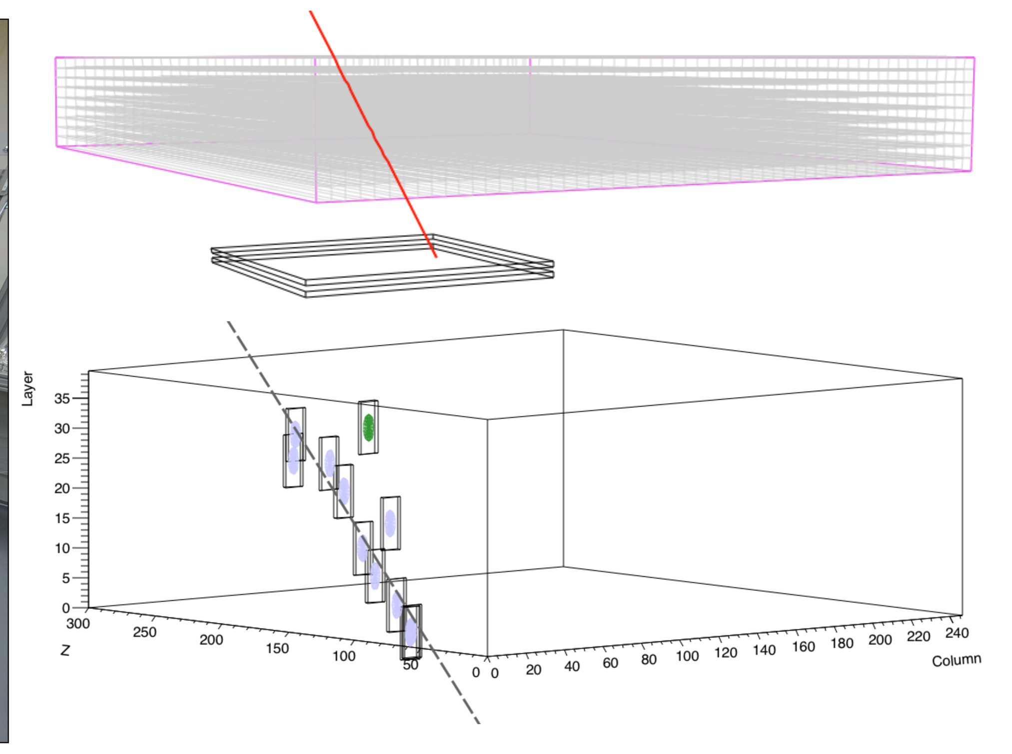

FIG 5 : Cosmic muon passing through the tracker. Above: Monte Carlo Below: Reconstructed.

Commissioning of the first tracker sections used cosmic muon events with scintillator planes below the tracker volume acting as a trigger. The relative occupancies of the cells were measured to ascertain the status of each anode channel in the tracker section.

Of the 1512 tested cells, 11 were electrically disconnected and 5 drew a current above the safe limit. 74 cells showed an above expected hit rate, but are to be recovered by conditioning at the LSM. The proportion of fully operational or recoverable channels is 99% over the first three trackers sections.

Gas System Automation

The system requires safe, remote operation underground with little human intervention. A Raspberry Pi was chosen to readout temperatures and presssures for its cost effectiveness and adaptability. This also allows for the subsequent addition of cameras and screens to the system. The Pi was housed alongside several displays and feedthroughs in an electronics crate. Simple Python scripts have been written and integrated with SuperNEMO's slow control and monitoring system.

Pressure in the primary bubbler and temperature in both bubblers are monitored to ensure a consistent ethanol fraction in the gas. Alarms have been implemented to warn when a value deviates from the desired set point.

FIG 6: Gas System with Electronics Crate installed at MSSL

Transport

Two sections of the tracker have now made the journey from MSSL in Surrey, UK to the LSM where the demonstrator module is being assembled 1263m underground. These tracker sections were mounted on a vibration damping frame and continually purged with dry air throughout the journey, with attached sensors monitoring humidity, pressure and temperature within the transport container.

Upon arrival at the LSM they were installed into the clean tent and tested for damage sustained during transport. The half-tracker and first calorimeter wall will be integrated and tested later this year.

FIG 7: Left: tracker section leaving MSSL. Right: arriving at the LSM in Fréjus tunnel

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LSM Laboratoire Souterrain de Modane

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supernemo collaboration

[1] Avignone III, Frank T., Steven R. Elliott, and Jonathan Engel. "Double beta decay, Majorana neutrinos, and neutrino mass." *Reviews of Modern Physics* 80.2 (2008): 481.