SuperNEMO

Construction of the tracking detector

Justin Evans (justin.evans@hep.manchester.ac.uk)
School of Physics and Astronomy, Oxford Road, Manchester, M13 9PL
For the SuperNEMO collaboration

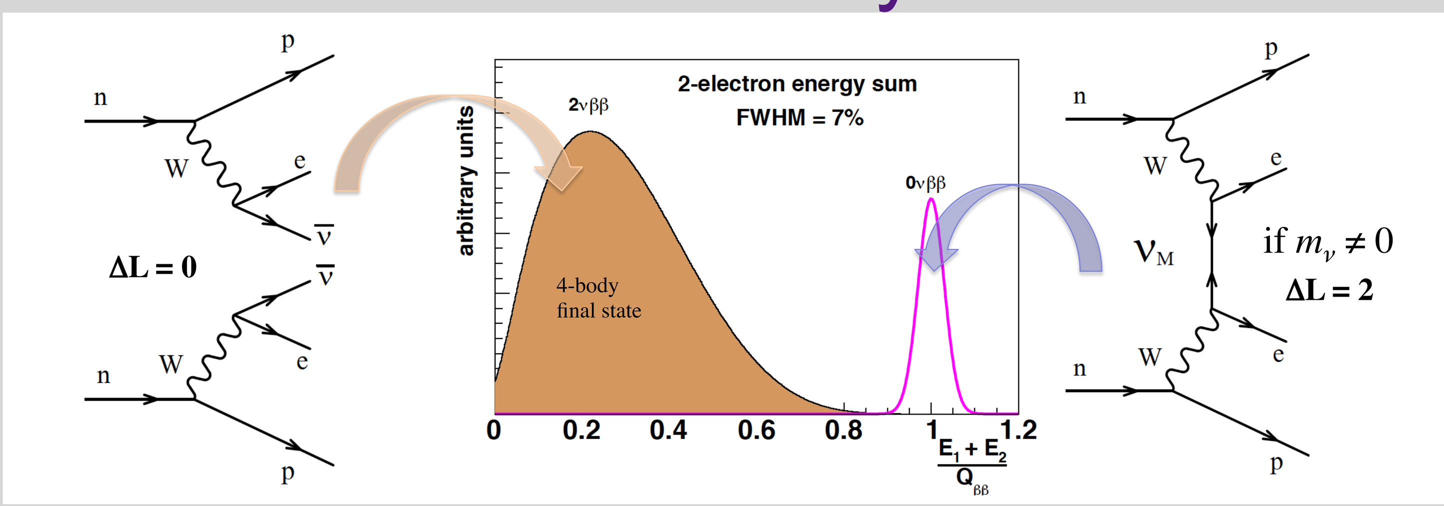
MANCHESTER 1824
The University of Manchester

Neutrinoless Double Beta Decay

Neutrinos are the only neutral fermions. Their masses are much lighter than any other massive particles. Only left handed neutrinos and right handed neutrinos have been observed. This all suggests that the study of neutrinos might open a window into new physics.

Ettore Majorana showed that, since the neutrino is neutral, a Lagrangian can be written in which the neutrino is its own antiparticle. The Majorana mass term is very different from the Dirac term that describes all other fermions. It violates absolute lepton number. It also allows neutrino mass to be generated with only the left handed antineutrinos and right handed antineutrinos that are observed in nature.

The Majorana mass generation mechanism opens up the possibility of see-saw models. These models explain the unnatural lightness of neutrinos through the introduction of additional heavy neutrinos at the GUT scale. If proven, they offer a way of probing GUT-scale physics at accessible energies.



Double beta decay is a rare but well-understood process. It has been observed in 11 nuclei for which the simultaneous beta decay of two nucleons is an energetically favourable process. This opens up the possibility of observing two Majorana neutrinos annihilating with each other. If observed, this would be evidence for total lepton number violation and would allow a direct measurement of the absolute mass of the neutrino.

$$\frac{1}{T^{0\nu}_{1/2}} = G_{0\nu}(Q^5_{\beta\beta}, Z)\,|M_{0\nu}|^2\,\langle m_{\beta\beta}\rangle^2$$

SuperNEMO
A unique approach

Complete topological reconstruction of the double beta decay event

Allows unprecedented levels of background rejection

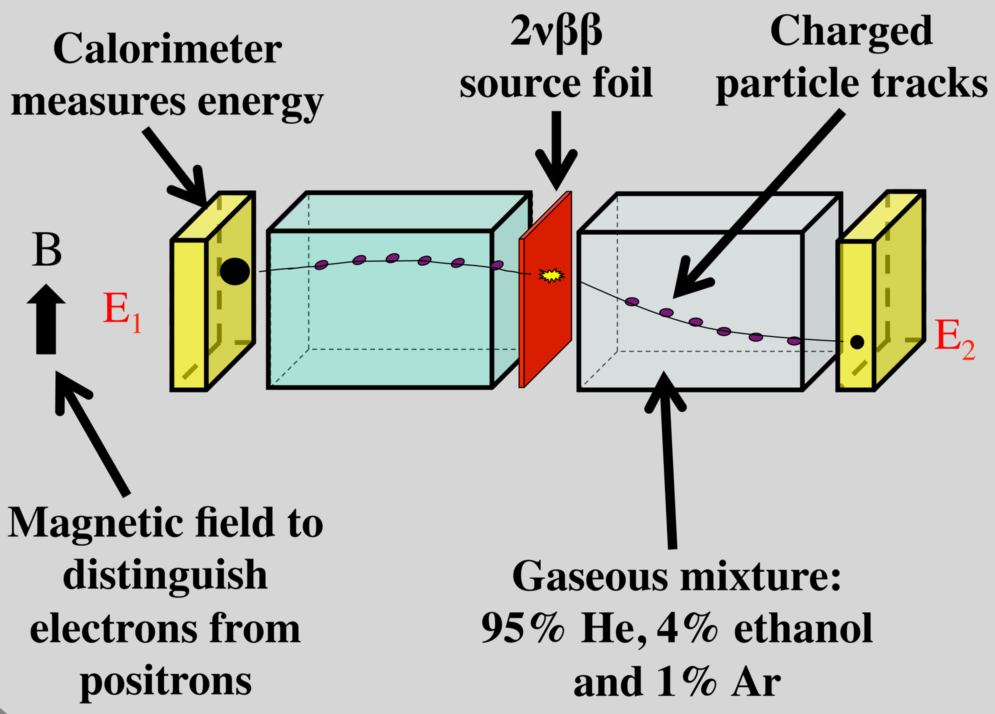
- Electrons can be separated from α and γ particles
- The Demonstrator module will be a zero-background experiment

Allows a determination of the mechanism underlying any observed neutrinoless double beta decay process

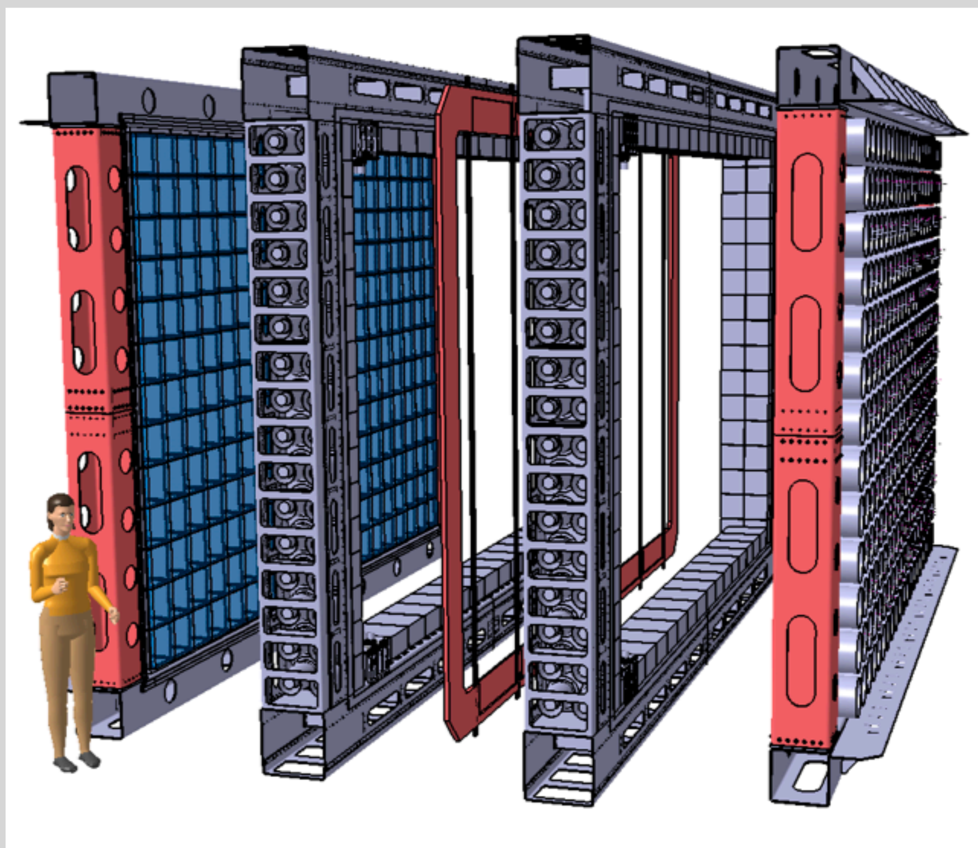
The source can be changed

Allows the study of any double beta decay isotope

The SuperNEMO technique



The SuperNEMO detector



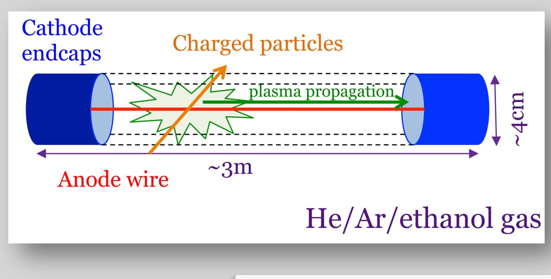
SuperNEMO takes the particle physicist's approach to detecting neutrinoless double beta decay: the detector will completely reconstruct the topology of the double beta decay event. This reconstruction is performed by a central tracking detector that surrounds the double beta decay source. Outside of the tracker, walls of scintillator calorimeter allow the measurement of the electron energies. The first module, the Demonstrator Module, is currently under construction.

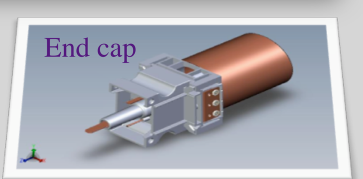
Tracker construction

The tracking detector is being assembled in quarters, at UCL's Mullard Space Science Laboratory. The frame of the first quarter is complete and the calorimeter modules, consisting of PMTs coupled to blocks of plastic scintillator, have been integrated around the edge. The gas-tightness of the frame has been tested, and the first tests of the gas system and radon emanation technology have been performed.

The insertion of the first Geiger cells into the frame has begun; 144 cells have now been inserted. Once the first quarter is fully populated, it will be commissioned, before being transported from the UK to the Modane Underground Laboratory for installation into the complete SuperNEMO detector.

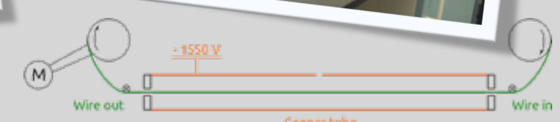
Drift Cells





The tracking in the Demonstrator Module is performed by 2034 drift cells operating in Geiger mode. A central anode wire is surrounded by twelve cathode wires, in a helium-argon gas mixture. The passage of a charged particle ionises the gas, resulting in an electron avalanche. This produces a plasma that propagates along the anode wire. The time difference between the signal arriving at each end provides the longitudinal location of the charged particle. (See also the poster by F. Nova.)

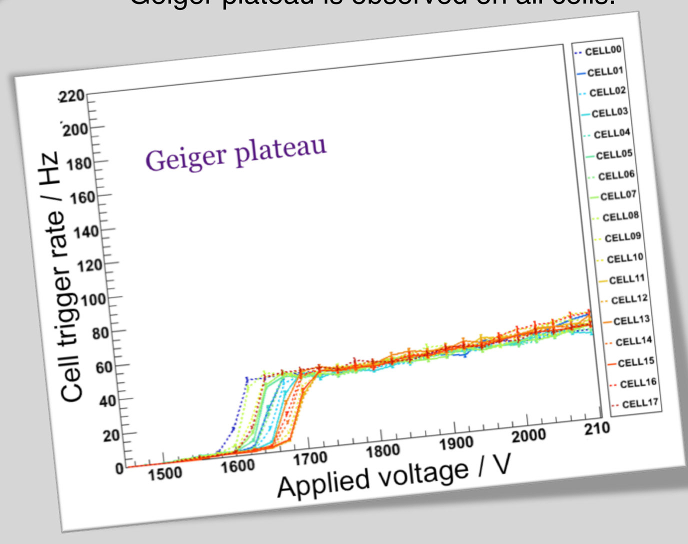
Component cleaning

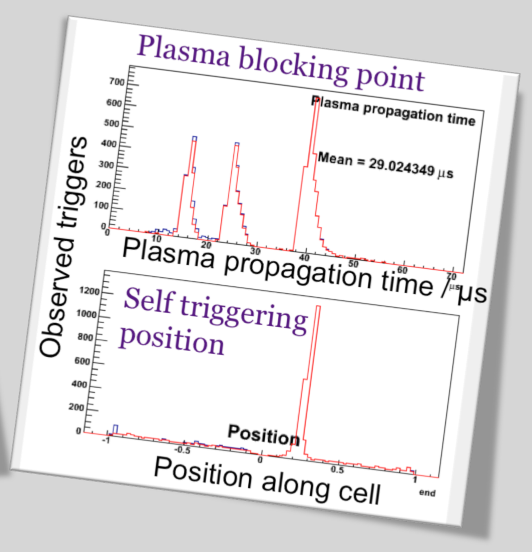


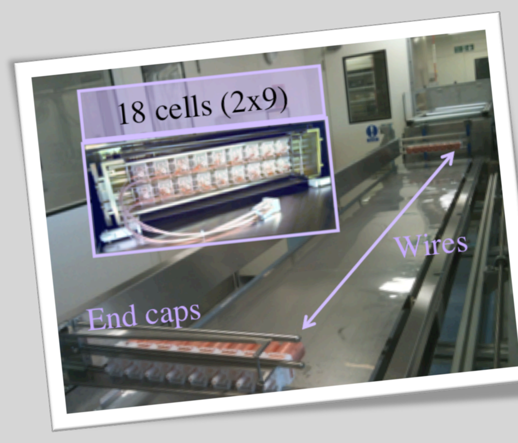
Radiopurity of all detector components is vital. Cells are made only from pure copper, steel and delrin. All components are cleaned, following a rigorous procedure: an ultrasonic bath in a detergent solution followed by an ultrasonic bath in distilled water. An automated spooling system takes the wire through the same procedure. All copper parts are then passivated in citric acid to prevent corrosion. After cleaning, all anode wire is tested before insertion into cells to check for plasma blockages or self-triggering points.

Cell production

To minimise human contact with the wires, the drift cells are produced by a wiring robot at the University of Manchester, in a cleanroom environment. Cells are produced in sets of 18. Each set of 18 cells is conditioned and tested immediately after production. The testing ensures there are no self-triggering or plasma-blocking points on any wires. The conditioning is continued until a good Geiger plateau is observed on all cells.







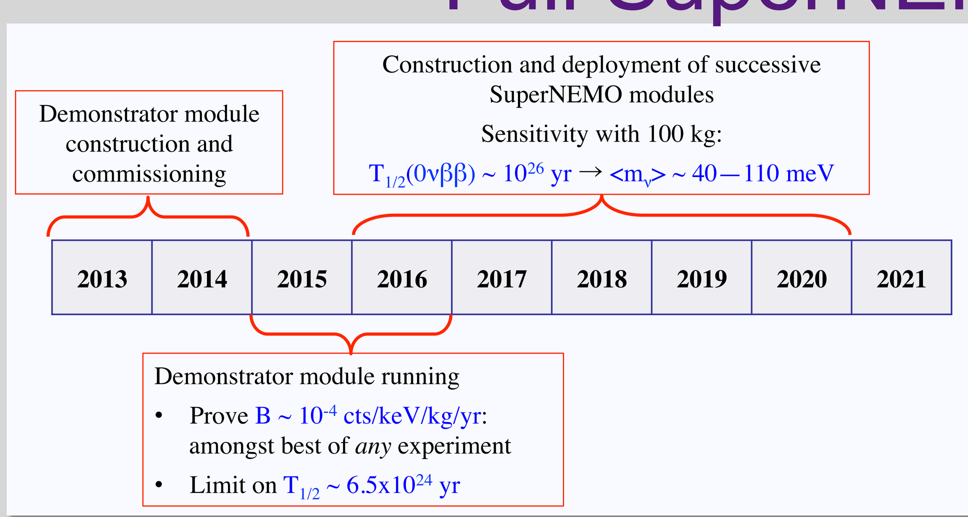
Demonstrator module

The first SuperNEMO module will demonstrate that the technology can achieve the low levels of background. After 17.5 kg.y of exposure, the Demonstrator will have a competetive sensitivity to neutrinoless double beta decay:

$$T^{0\nu}_{1/2} > 6.5 \times 10^{24}\text{yr}\ \ (90\%\text{C.L.})$$

$$|m_{\beta\beta}| < 200 - 400\,\text{meV}\ \ (90\%\text{C.L.})$$

Full SuperNEMO



The Demonstrator module will begin operation in the Modane Underground Laboratory in 2015. Following this, the remaining 19 modules will be constructed to achieve a detector with 100 kg of source.

Experiment	Background Rate (counts/keV/kg/yr)
GERDA	0.02
CUORE	0.01
EXO	0.0015
SuperNEMO	0.0001

supernemo collaboration