# Construction of the tracker for the SuperNEMO experiment

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**Abstract.** The SuperNEMO experiment will search for neutrinoless double $\beta$ decay with a sensitivity two orders of magnitude greater than its predecessor NEMO-3, achieved through better energy resolution and unprecedented background levels. A Demonstrator module of the detector is currently under construction, due to begin data taking in 2015. A vital component of the detector is the tracker, a wire chamber made from 2,034 cells operating in Geiger mode. This is important for triggering, background discrimination, and measurement of the kinematic properties of the decay. The tracker production procedure and status is presented.

## 1. Introduction

The SuperNEMO experiment will search for neutrinoless double $\beta$ decay, with a half-life sensitivity of around $10^{26}$ years. It will be made of 20 modules, each one using 5–10 kg of source isotope in a $4 \times 3.7$ m$^2$ foil sheet. A magnetised tracker volume will occupy the space on both sides of the foil. The tracker will be made of 113 rows of 9 tracker cells per side. A calorimeter will surround the tracker, formed of around 500 scintillator blocks coupled to PMTs. The purpose of the calorimeter is to measure the energy and time of the $\beta$ decay electrons and other background particles. The tracker will be used to discriminate between electrons, positrons, photons and alphas, as well as for measuring event kinematics and topology, and allow for in-situ measurements of background sources. The first of the 20 modules (the 'Demonstrator') is currently being manufactured.

## 2. The tracker cell

The basic unit of the tracker is the wire cell, shown schematically in Figure 1. This is formed of a 2.7 m long, 40 $\mu$m diameter, stainless steel anode wire, surrounded by 8 grounded cathode wires (50 $\mu$m diameter), making a $3 \times 3$ cell with 2 cm separation. At both ends of the anode wire is a copper cathode end cap. The cell is operated in Geiger mode, with an operating voltage of around 1800 V. Charged particles passing through the cell leave ionisation electrons that drift towards the anode wire. In the high field region close to the wire, further ionisation produces UV light which induces new ionisation further out. This sets up a chain reaction, and a gas of ionised plasma spreads out from the initial track point, parallel to the wire. The time that this plasma reaches the end caps is used to calculate the longitudinal position of the initial track.

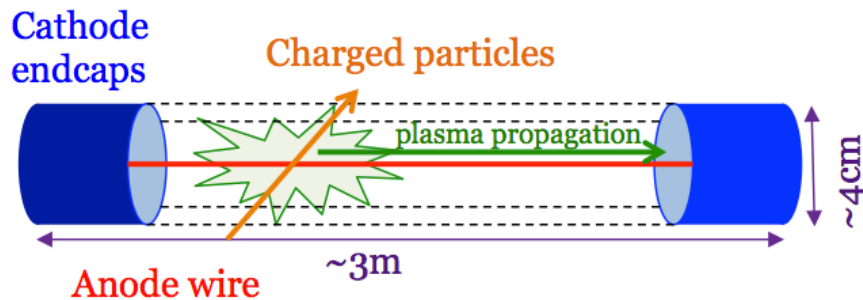More details on the functionally-identical NEMO-3 tracker cell are given in section 2.3.1 of [1].

**Figure 1.** Schematic of a single tracker cell, showing the anode wire (red line), ground cathode wires (dashed lines), and end caps (blue).

### 3. Tracker production

All components of the cells are cleaned beforehand, in ultrasonic baths, with the wires being spooled through the baths. The components are assembled in a class 1000 clean room, where a specially designed wiring robot has been created for the tracker production task. The robot allows automation of the construction, with minimal human contact that could introduce impurities into the system. It also allows for outsourcing the production to multiple parallel hosts, when the remaining 19 modules of the experiment are built. The robot produces one tracker cell in around 20 minutes.

Eighteen of these cells are assembled into one 'cassette' – a modular unit with two rows of nine cells. This unit allows easy handling for testing, transportation and installation. A total of 113 cassettes will be built for the whole Demonstrator module.

### 4. Testing

Following construction, the cassettes are tested using cosmic rays, inside an air-tight gas chamber. The gas used is a mixture of 95% helium, 1% argon and 4% ethanol. A measurement of the trigger rate is made while the voltage is scanned, and is used to determine the Geiger plateau, which starts at approximately 1700 V. An example of this measurement is shown in Figure 2. Cells can be rejected at this stage if their cosmic trigger rate is lower than around 40 Hz (indicating an inefficiency), or if the plateau is narrower than 100 V.

Following the plateau measurement, the cells are individually tested at the correct operating voltage (at the centre of the plateau), with 10,000 cosmic triggers taken. This data is used to measure the cell performance: most importantly the cathode efficiency (the fraction of events with a signal at the cathode end caps), the plasma propagation time, and the longitudinal position of each cosmic ray. Examining the plasma propagation time can reveal any dust on the wire which stops the plasma propagation, as there will be a multiple peak structure depending on what side of the dust the cosmic ray was. The longitudinal position should be uniform, so any peaks in this distribution will reveal self-triggering points on the wire (areas where the electric field is strong enough to induce spontaneous ionisation). Examples of these failure-mode distributions are shown in Figure 3. Cells are rejected if they have any of these deficiencies.

### 5. Conclusion

The construction of the SuperNEMO tracker is well under way. To date, thirteen cassettes have been produced, of which only one has been rejected due to failing the testing procedure. The experiment is on target to begin data taking in late 2015.
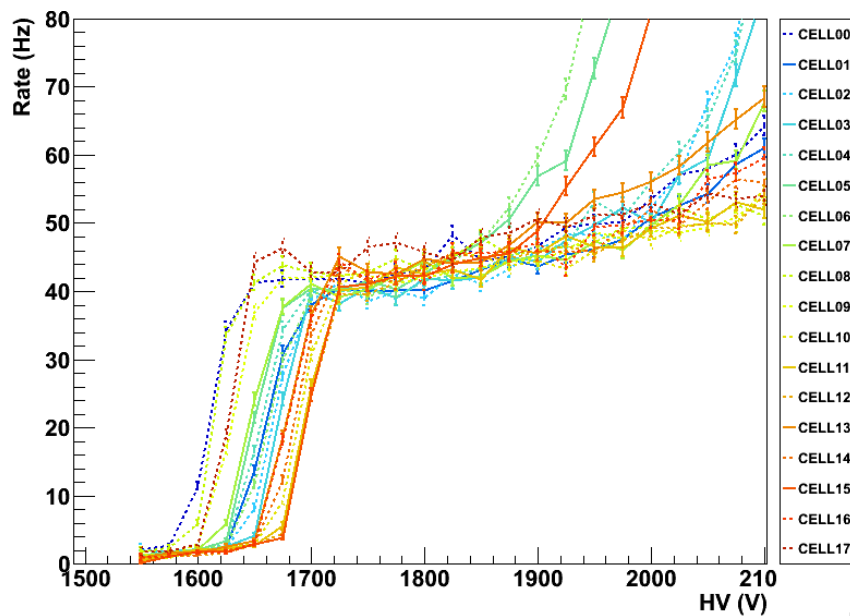
**Figure 2.** Geiger plateau measurement for 18 cells of a single cassette, showing an approximately constant trigger rate above a threshold voltage. For three of the cells, the plateau is relatively narrow, breaking down at around 1800 V.
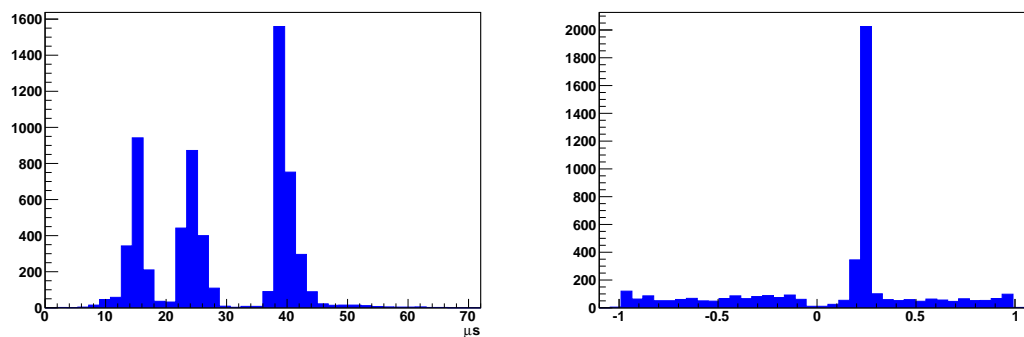


**Figure 3.** (L) Plasma propagation time for a cell with dust. A good cell will only have a single peak. (R) Position distribution (where 0 is at the centre of the cell, and ±1 are at the end caps) for a cell with a self-triggering point. A good cell will have a uniform distribution.

## References

[1] R. Arnold *et al.*, *Nucl. Instr. Meth. A* **536** 79 (2005)