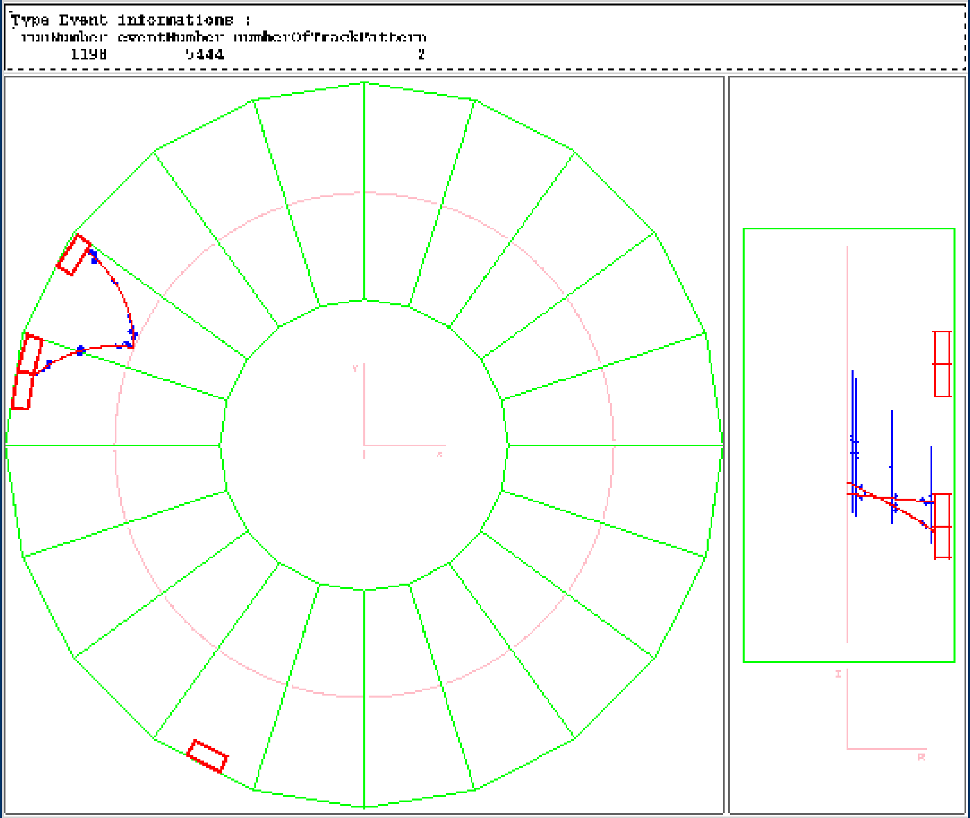
Stefan Soldner-Rembold, Manchester

Tracking R&D for SuperNEMO

Tracker is essential for SuperNEMO design



- Triggering
- Offline identification and reconstruction of events (charge, vertex)
- Suppression of internal and external background sources

Design is based on experience from NEMO-2 and NEMO-3 tracker

Geiger Cells (NEMO-3)

- Cylindrical volume with 20 sectors
- 6180 open octagonal drift cells
- Gas

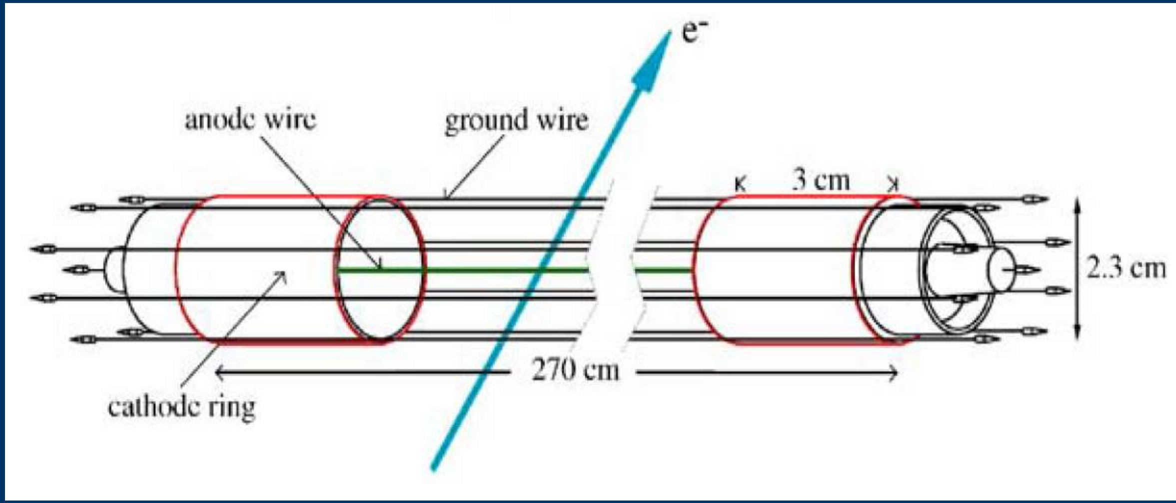
  95 % Helium (low Z !)

  4 % Ethanol (quenching)

  1 % Argon (quenching)
- Operates in Geiger mode
- Length 270 cm
- Diameter 3 cm
- Each cells consists of

  8 cathode wires (0V)

  1 anode wire (1.9 kV)

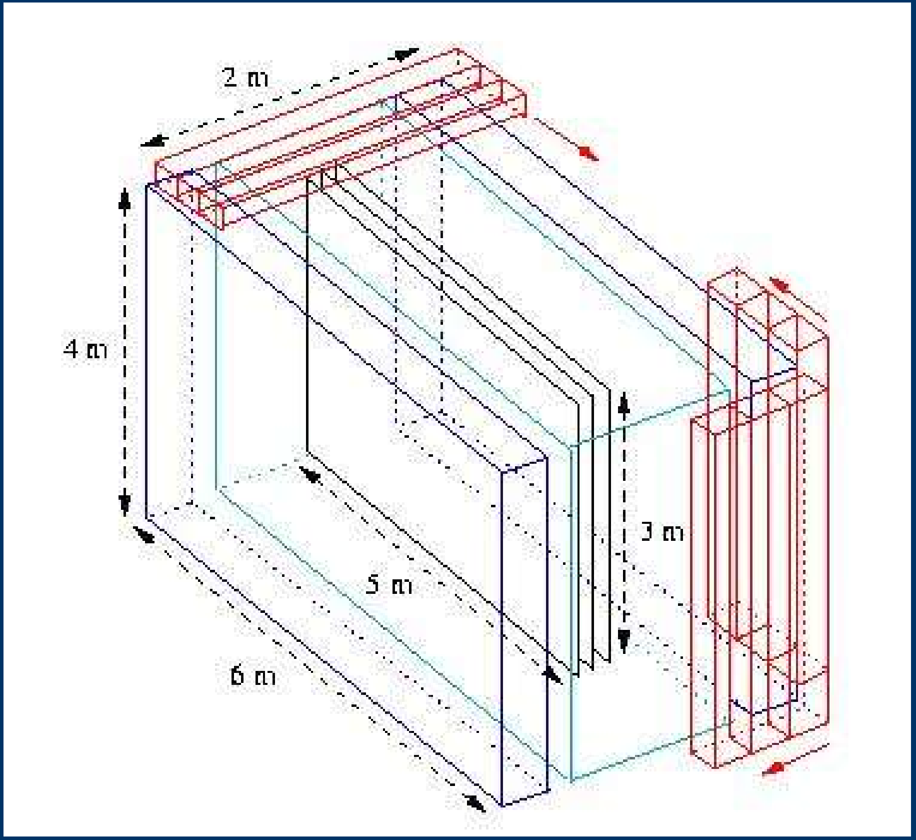


- After ionisation Geiger plasma travels with a velocity of 6 cm/μs
- Copper cathode rings at both ends detect arrival of Geiger plasma

SuperNEMO

Main challenges:

- Scaling design by one order of magnitude
- Optimize acceptance and efficiency
- Minimize absorption and energy loss due to tracker material
- Develop methods and tools for large scale production



Transverse dimension given by scintillator timing resolution

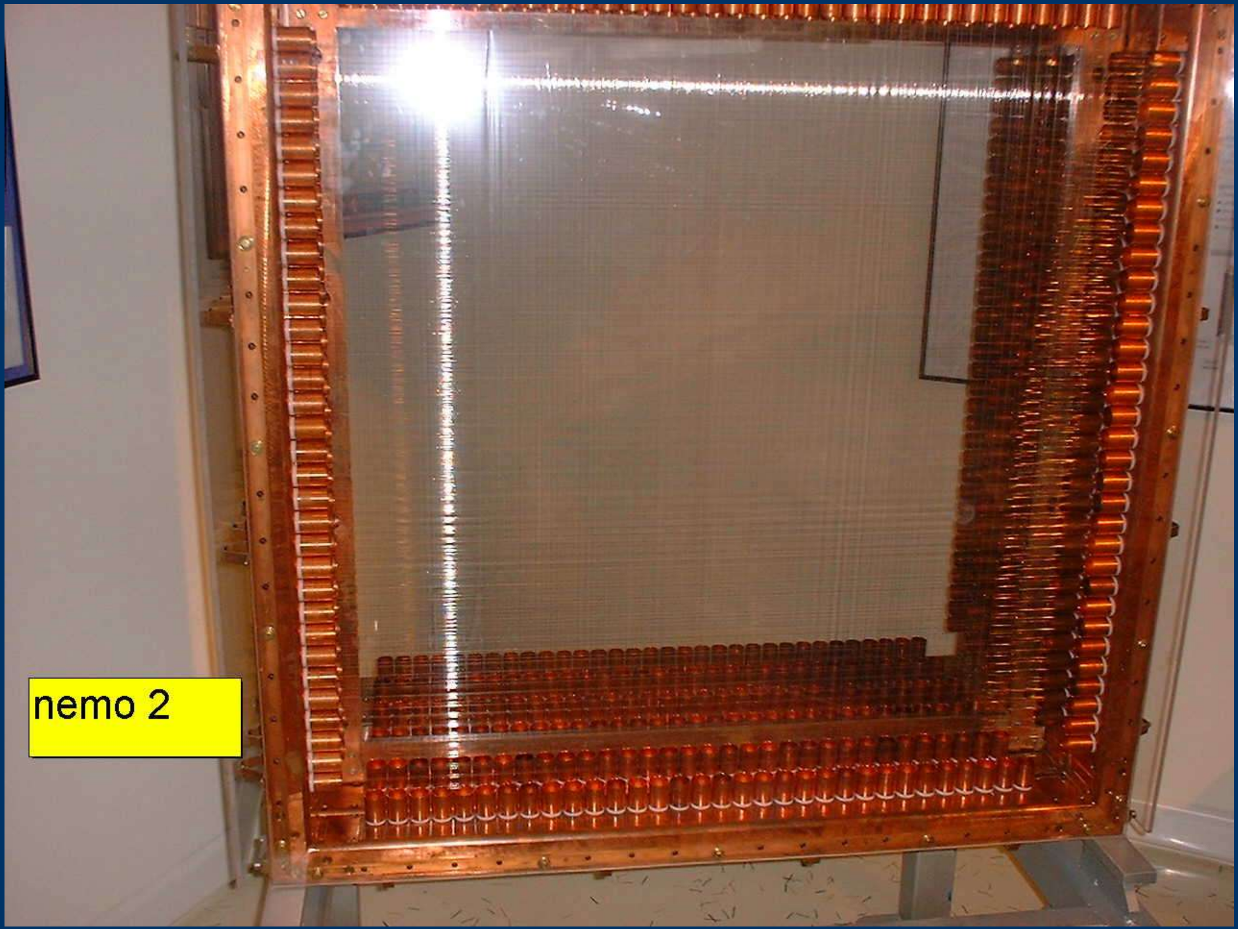
SuperNEMO geometry will be rectangular to ensure modular design

Prototype Cells

Collaboration between

- Manchester
- UCL/MSSL
- LAL Orsay (France)

Goals

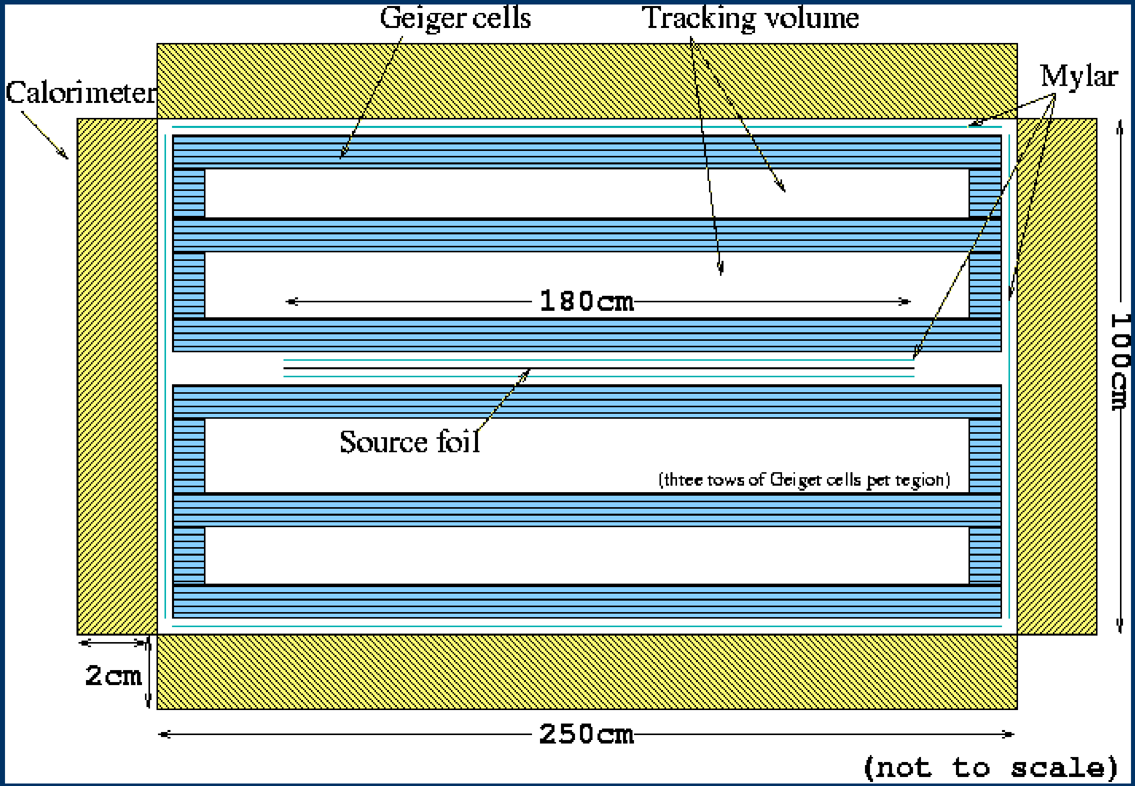


- reduce material
- increase wire length

Rectangular design similar to NEMO-2 but only 1-dimensional wiring
Longitudinal coordinate is reconstructed from propagation time

Frame Construction

UCL/MSSL in collaboration with J.Forget (Orsay)



Test Set-up (Manchester)

- 9 Geiger cell prototype
- originally based on NEMO-3 parameters
- VME based read-out
- variation of parameter to study design options

-

Variation of Parameters

1) **Wire Diameter**

Multiple scattering and energy loss due to wire material needs to be reduced

Test reduction of wire diameters from 50 microns to 40 /30 microns

2) **Wire Material**

Replace stainless steel cathode wires by copper plated nylon

3) **Wire Length**

Increase wire length from 2.7 m to 4 m (depending on design)
study plasma propagation

4.) Gas Composition

Multiple scattering dictates low Z for gas (Helium)

Quencher: Currently 1% Argon and 4% Ethanol

Changes to wire parameters will require optimisation of gas mixture

Low rate experiment → limited problems due to ageing but needs to be verified to ensure long term operations

Goal: R&D on frame and 9 cell prototype will be combined to build a 100 cell prototype (target: 4 m length and 30 micron wires)

GEANT-3 Simulation Studies at Manchester

Darren Price (MSc), SSR

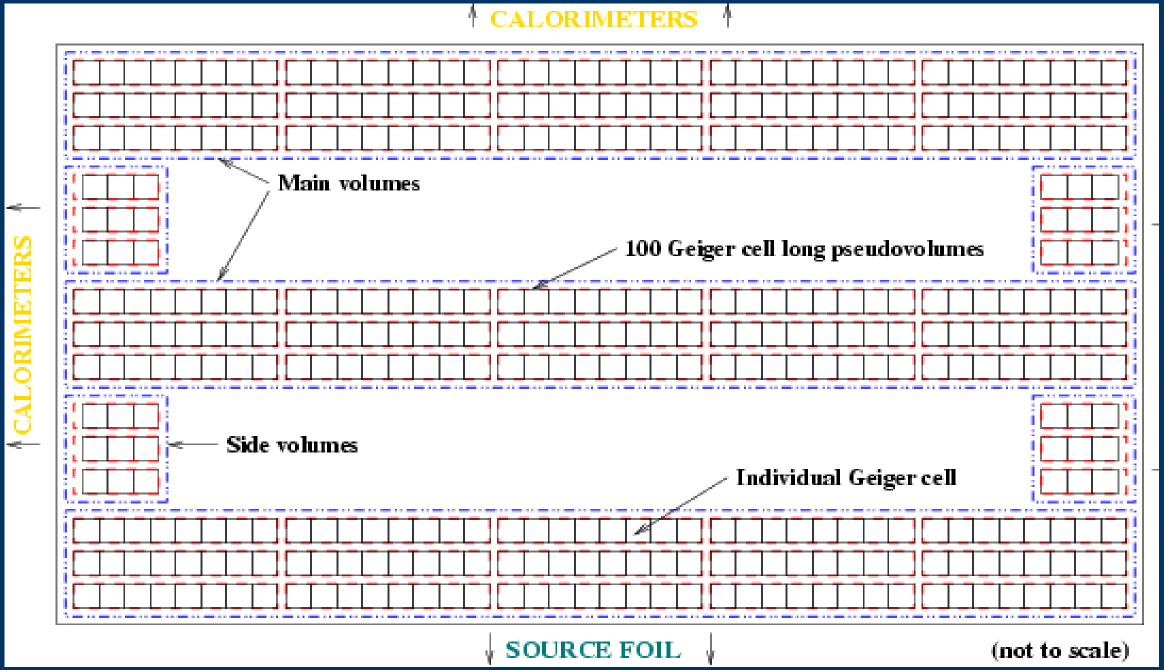
Motivation:

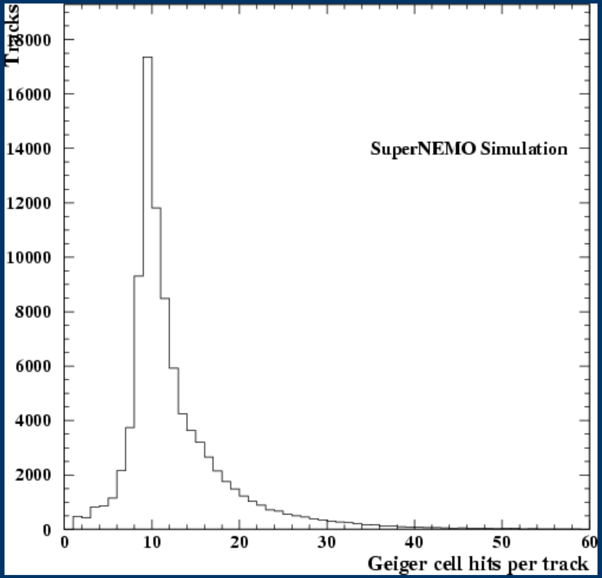
First full simulation of tracking volume with wires to study

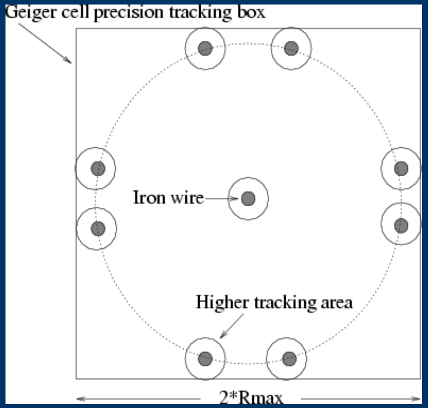
- chamber parameters
- sensitivity to half-life

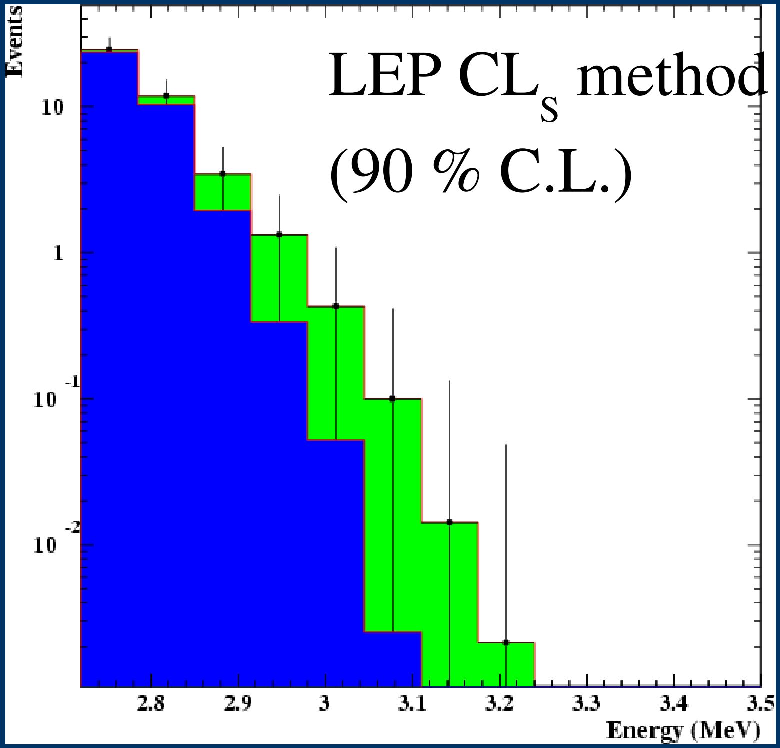
Simulation includes

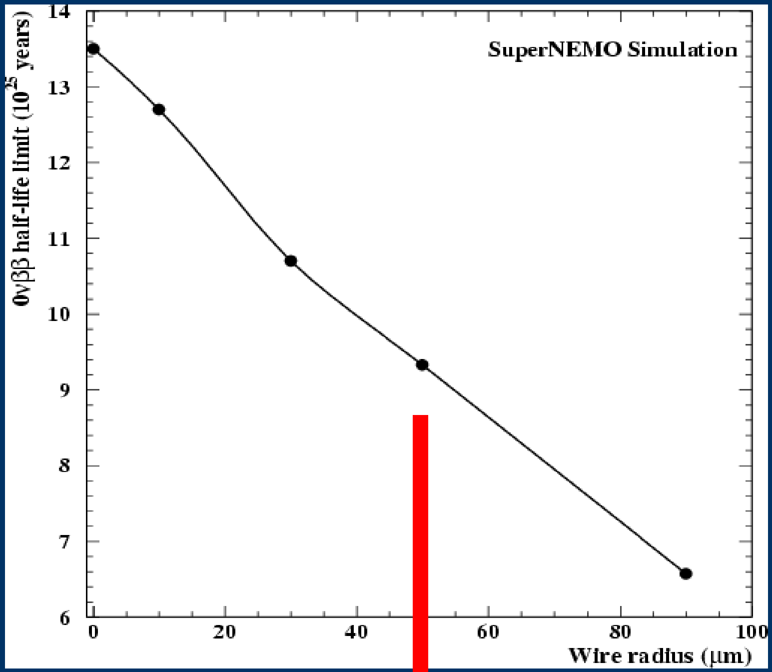
- foil
- tracking volume with wires
- calorimeter

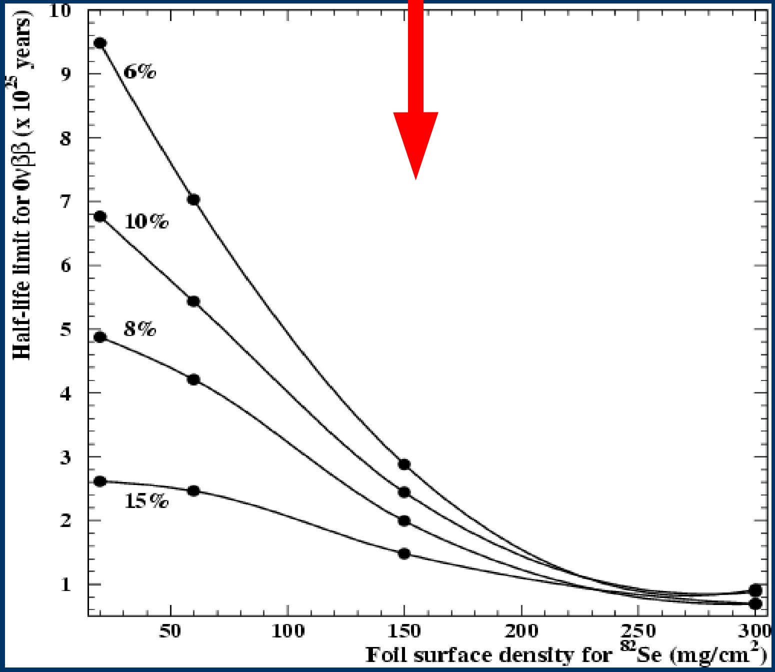












Other effects being studied:

- Acceptances/efficiencies
- Geometry/design
- Backscattering
- Simulation of low energy electrons

Future:

- Comparison with data
- GEANT-4/C++

Tracker Read-out Electronics

- Prompt signal from the anode wires (perpendicular coordinate)
- Delayed signal from cathode rings (position along the wire)
- TDC read-out with ~20 ns resolution
- Triggering based on track parameters

Custom discriminator chip
on or close to detector

Challenges:

- Large number of channels
  (~60000 drift cells with anode and cathode readout)
- High radiopurity

Tracker Front End ASIC

Applications Specific Integrated Circuits (ASIC)

Design and prototype at UCL/MSSL

amplifiers and discriminators with programmable thresholds and zero suppression

data collection and buffering/triggering/clock via serial link to minimize number of connections

exact ASIC specifications need to be developed

Tracker Readout Boards

Design and Prototype by Manchester

Concentrator boards receive data from ASIC:

- **provide data reduction and concentration (~ 10 ASIC per board)**
- **provide trigger data and first stage track reconstruction**

Final read-out/track reconstruction/online monitoring via a DAQ PC farm

FPGAs can be used to model ASIC for protoptyping

Wiring Robot

UCL/MSSL/Manchester

Wires must be

- strung
- terminated
- crimped

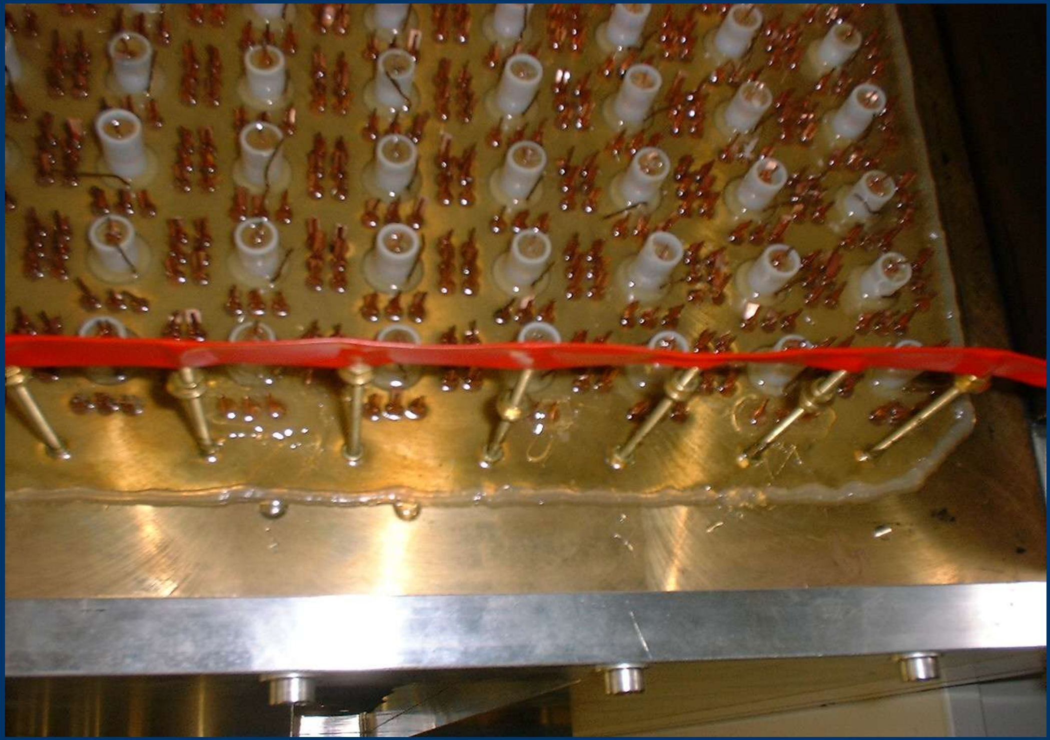
This cannot be done manually (~ 10 mins/wire)

Complications

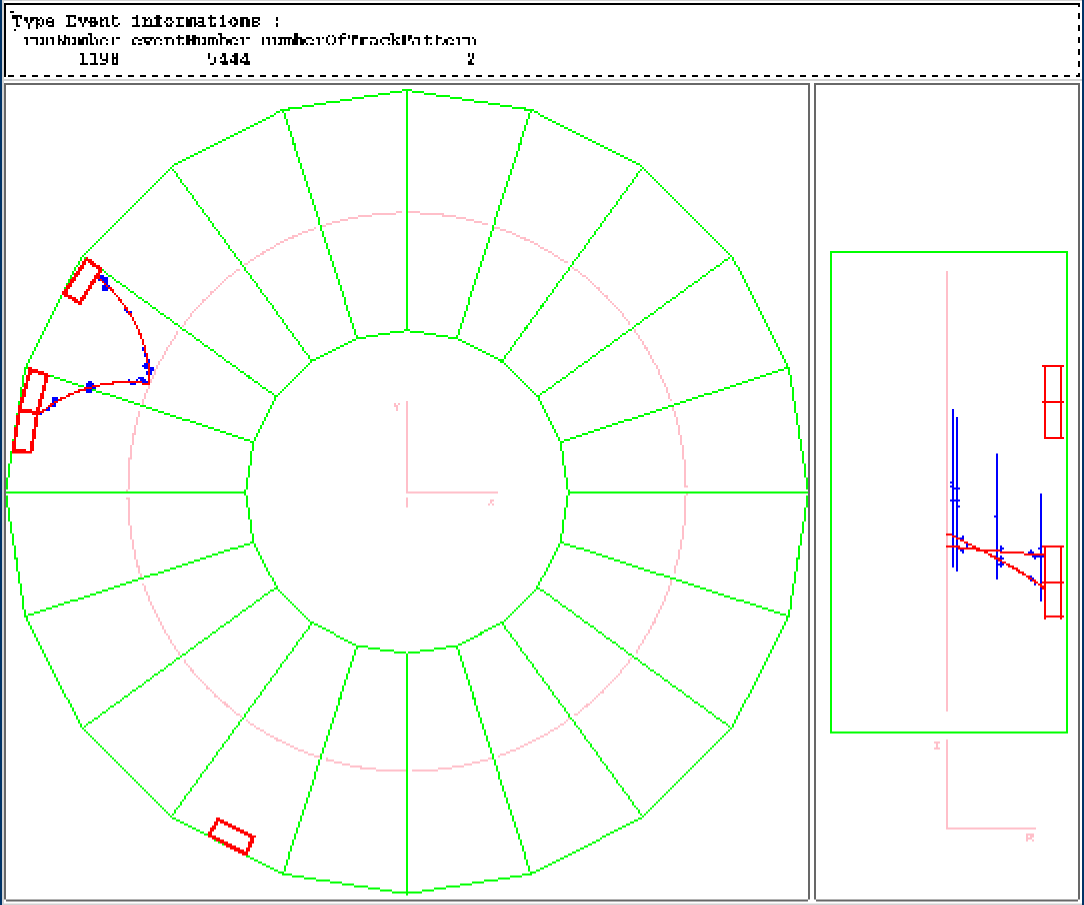
- Copper pick-ups
- Must be cost effective
- Solder cannot be used (radiopurity)

Automated wiring system have been used in HEP experiments

Manchester has built tracking chambers for OPAL/H1



Magnetic Field



NEMO-3: 25 G magnetic field

SuperNemo without a magnetic field ?

Advantages:

- simpler tracking
- higher efficiency

Disadvantage:

- no charge identification

Needs to be studied with simulations and with NEMO-3 data

To accomplish our ambitious physics goal, we need to

- optimize and improve tracking chamber design using simulations and test set-up
- build 100-cell prototype
- design and prototype tracker read-out chain
- study the need for a magnetic field
- automate large scale production