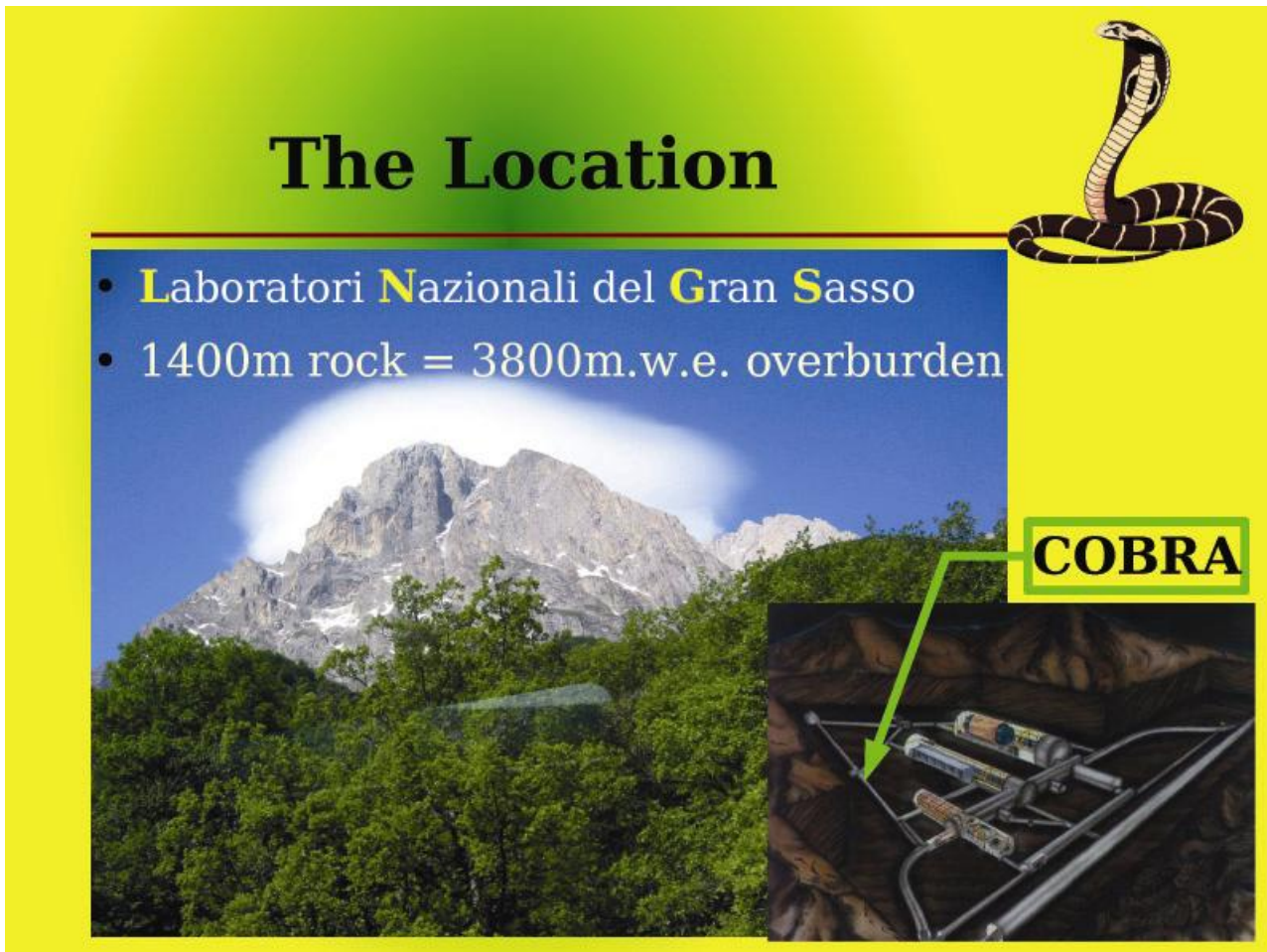
COBRA Double Beta Decay



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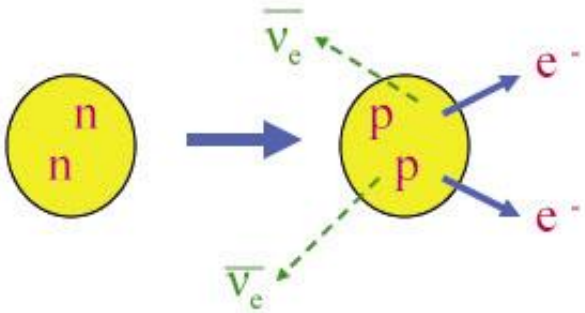
How to weigh neutrinos?

- Neutrino Oscillations
- Direct Beta Decay Endpoint
- Cosmology
- Double Beta Decay

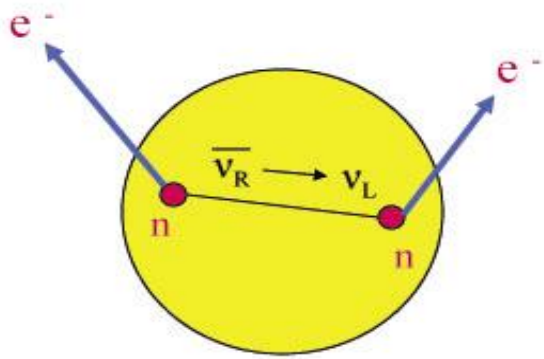
Double Beta Decay: The Process

$2\nu\beta\beta$



Allowed and observed

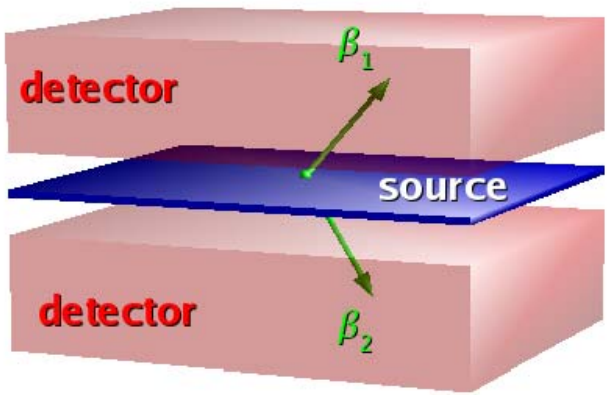
$0\nu\beta\beta$

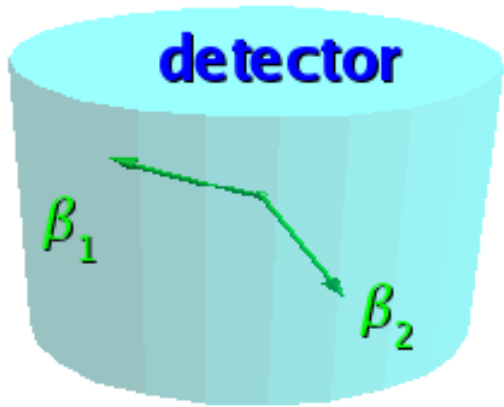


Forbidden – Interesting !

Neutrinos must be massive Majorana particles

Experimental Techniques





$$T_{1/2} \propto \varepsilon \frac{a}{A}\sqrt{\frac{M \times t}{\Delta E \times B}}$$

A. Nucciotti, IDM2004, Edinburgh

Improvements: HowTo's

$$T_{1/2} \propto \varepsilon \frac{a}{A}\sqrt{\frac{M \times t}{\Delta E \times B}} \qquad \left\langle m_{\nu_e} \right\rangle \propto 1/\sqrt{T_{1/2}}$$

Current sensitivity for <m>: 200 – 500 meV

On the way to 100meV: Missing factor 2-5 gained by

a) 16-625 fold increase in exposure (Mt) and/or
b) 16-625 fold reduction of background, B

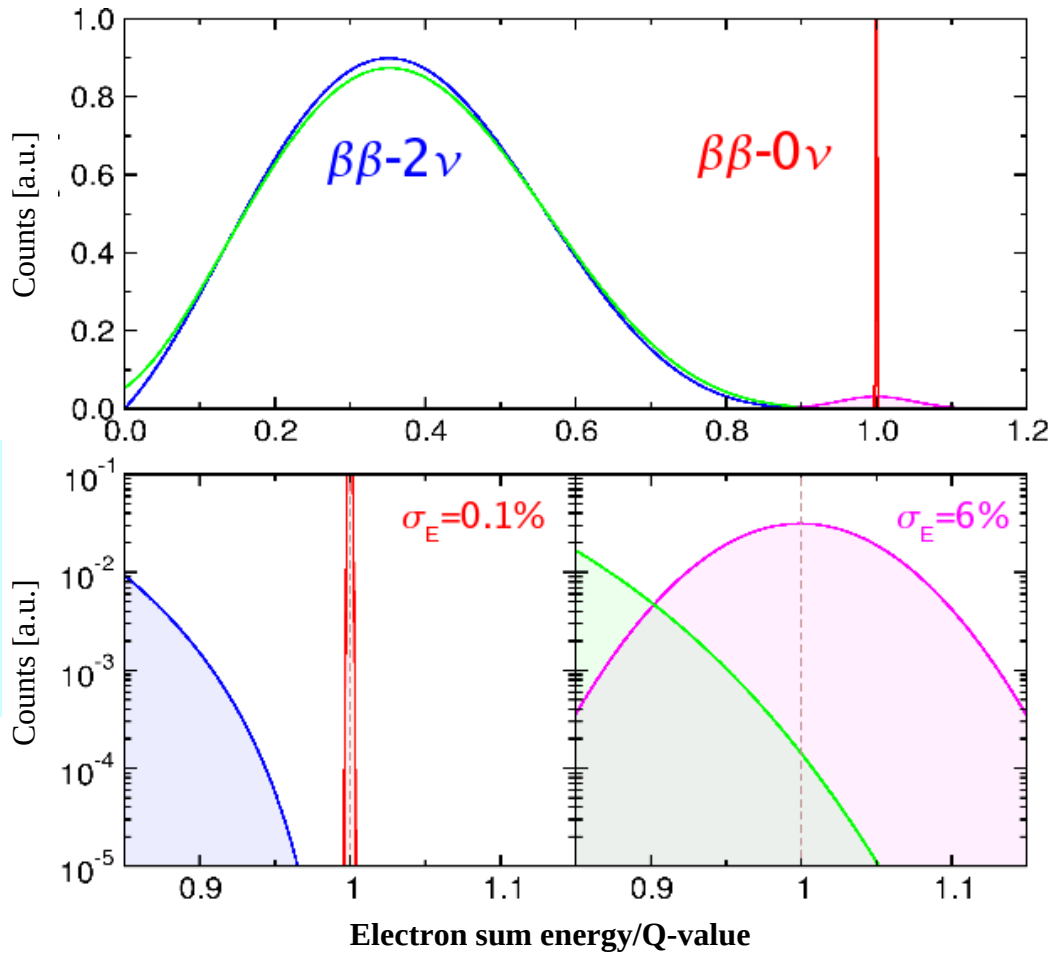
On the way to 10meV : Extrapolate existing experiments over 5-6 orders of magnitude !!!

Not at all hopeless, but a challenge !

HowTo 2

Energy resolution
and
Irreducible background (2νββ)

- Need good ΔE
- Need good ε
- Need high enrichment, a
- Measurement time t limited
- Background and Mass count most



Choose appropriate detector technology (ε, ΔE, a, t, cost for M) and work on B !

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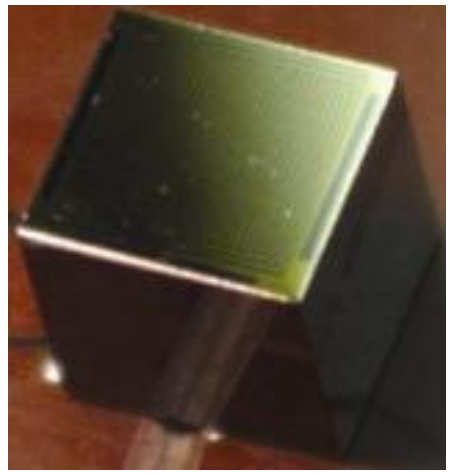
New UK Initiative: COBRA

(Cadmium-Telluride 0-neutrino double-Beta Research Apparatus)

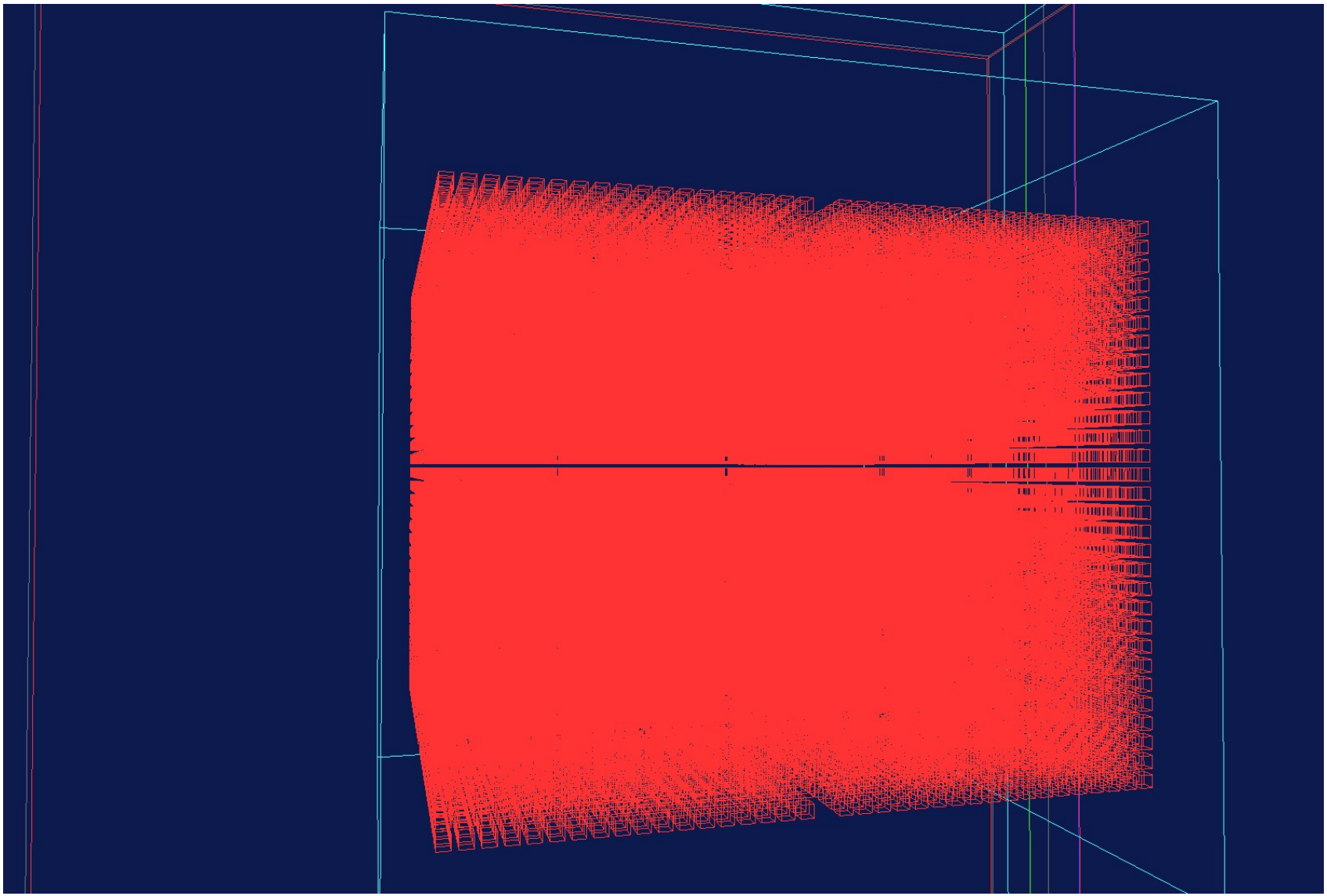


- Room-temperature semiconductor CdZnTe
  - Simple infrastructure – long-term operation
- 9 potential $0\nu\beta\beta$-emitter isotopes ($0\nu\beta^-\beta^-$ AND $0\nu\beta^+\beta^+$)
- Good energy resolution, needs further work
- Small crystal size –> many readout channels
- Needs enrichment (90% in ^{116}Cd exists)
- Crystals seem clean – infrastructure background needs investigation
- Collaboration formed (Birmingham, Dortmund, Gran Sasso, Liverpool, Sussex, Warwick, York) + 2 year R&D phase approved (PPARC)

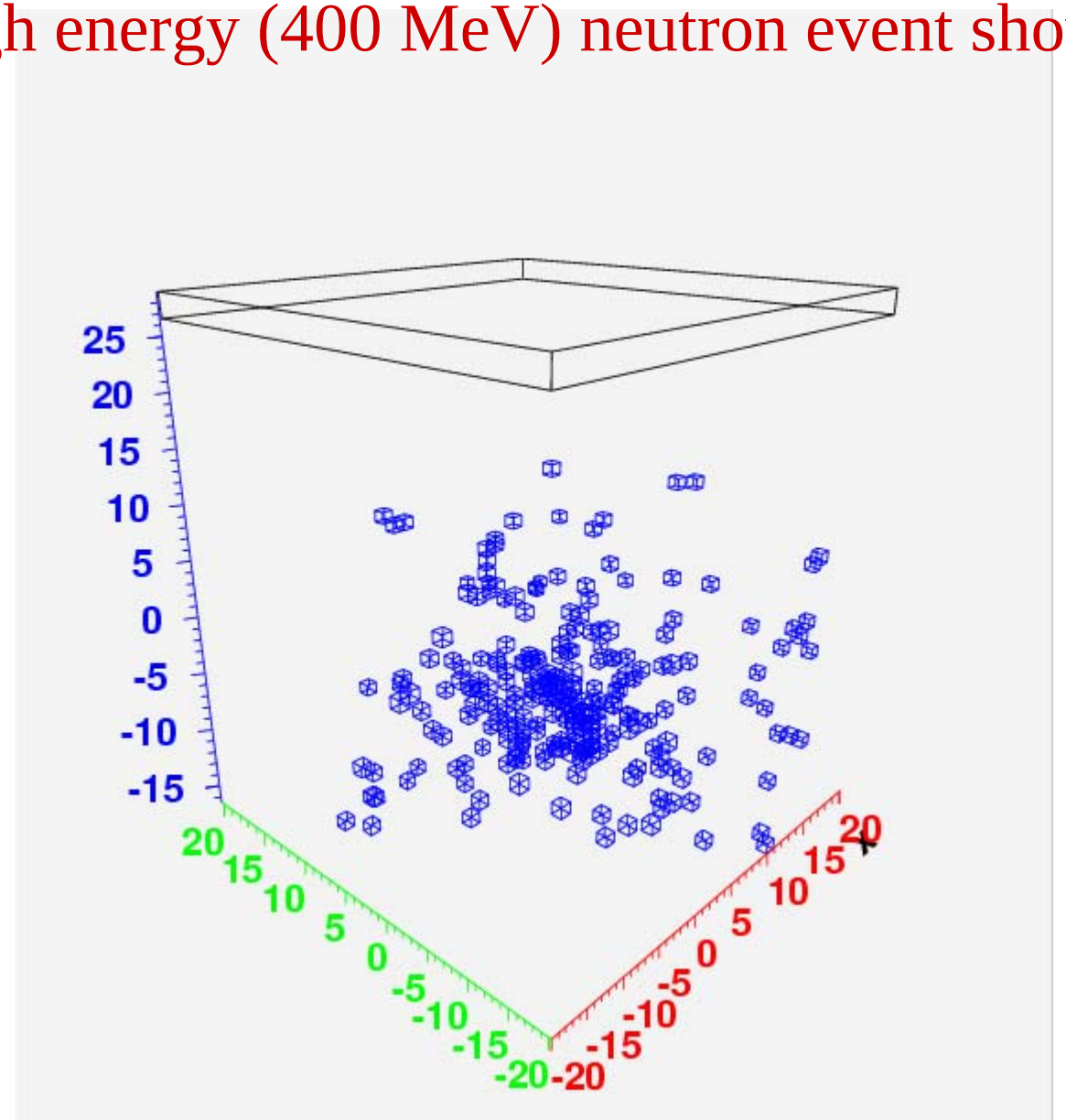
Meeting the Challenge

- Gain large factor in active mass (from 10kg go to 1 ton region):
  - Cost issue
  - Large number of readout channels – background issue
- Gain large factor by background reduction:
  - Improve energy resolution
  - New methods of shielding (Warwick)
  - Develop low-background electronics (Warwick)
  - Semiconductor tracking detector (Pixel, Strips) ?

Inner Chamber 36x36x30 detectors

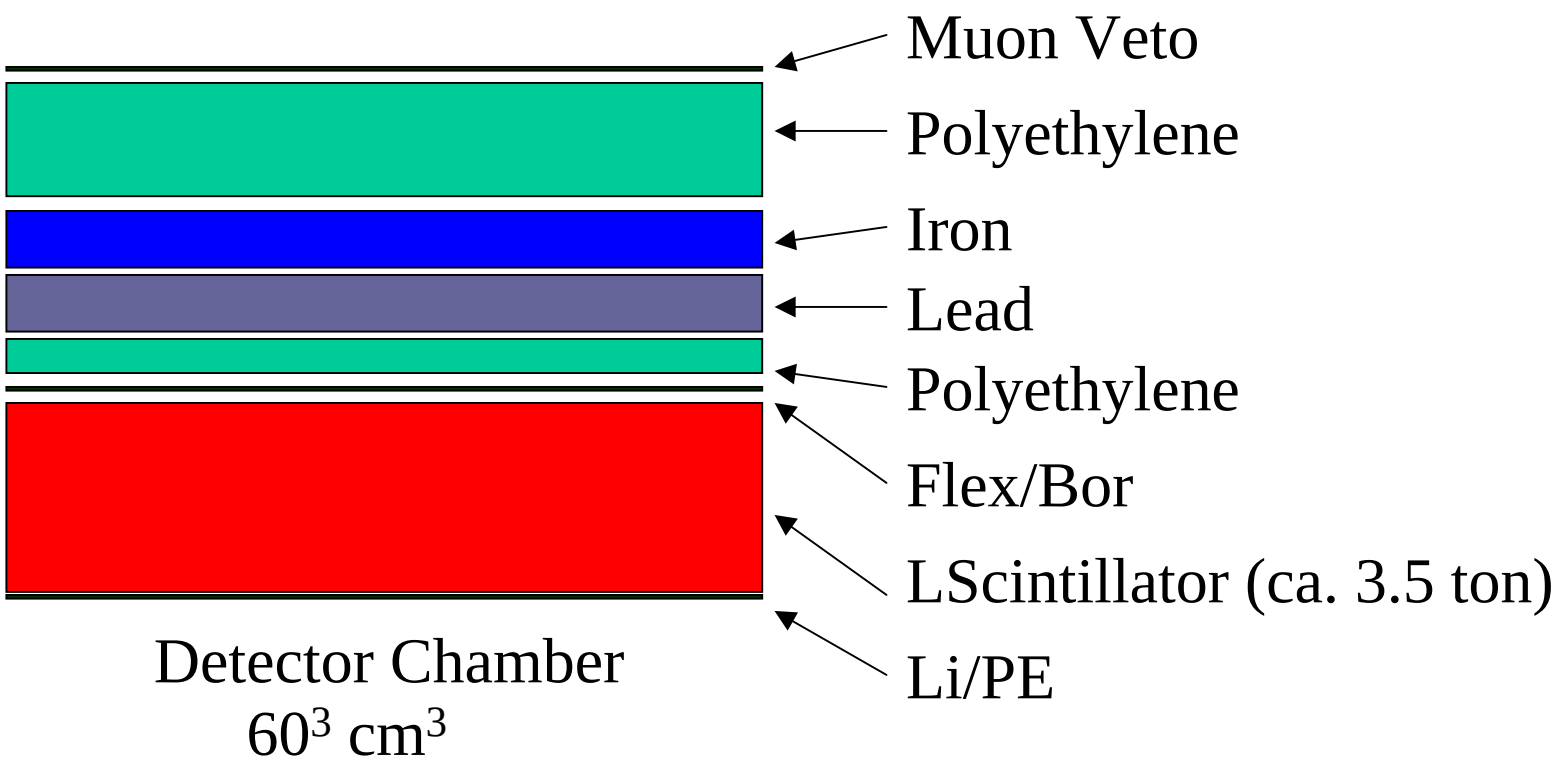


High energy (400 MeV) neutron event shower



Basic shield design

Improved versions exist already (Warwick MPhys project: F. Samsami, J. Morton) and will be tested in near future



Low background electronics: New project to be launched

Next 2 years: To-Do-List Warwick

- Low radioactivity light sensor to be developed
- Combine with liquid scintillator
- Low radioactivity electronics to be developed
- Optimising shield for costs and mechanical design