SuperNEMO design study
The Calorimeter

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Outline

Why improve energy resolution

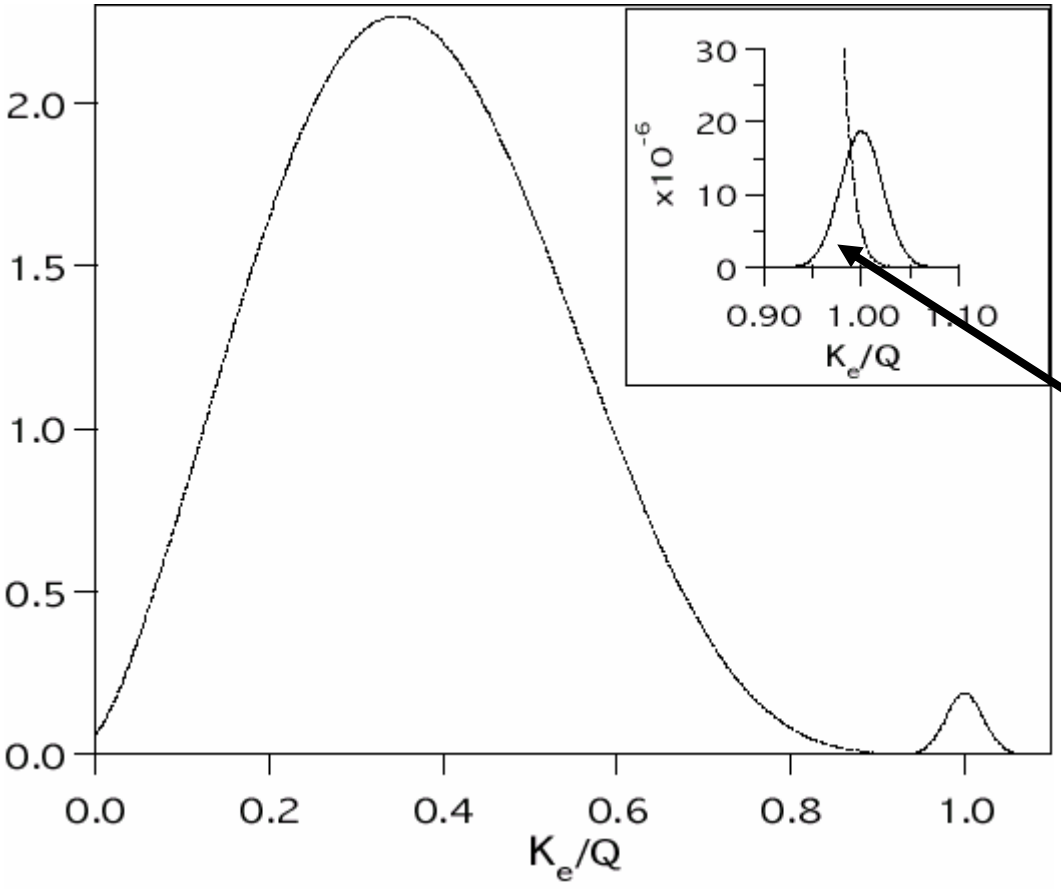
Scintillator R&D: Status to date

Scintillator R&D: Future plans

Calorimeter vs detector shape and layout

Energy resolution and background

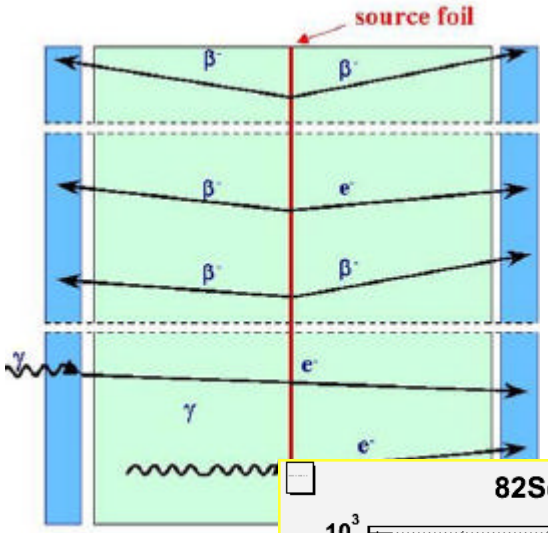
A generic source=detector case

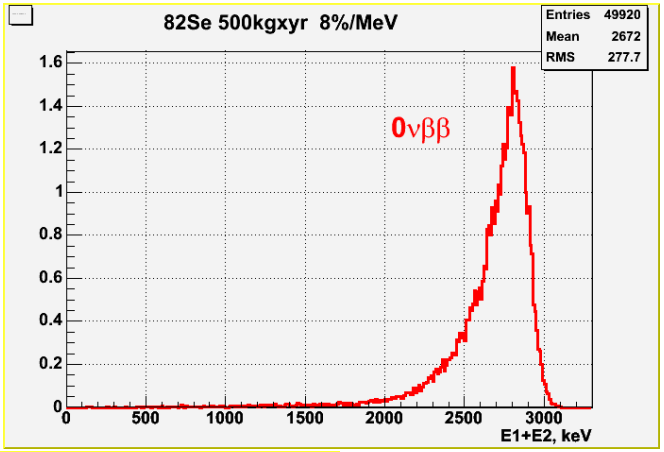


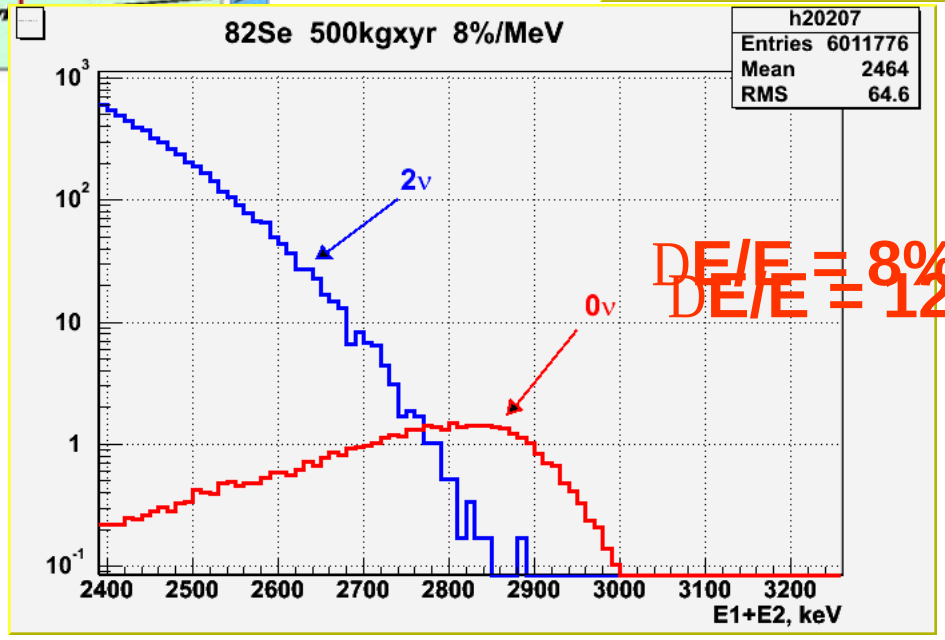
$F^{2n} \sim (s/E)^6$

Energy resolution and background

SuperNEMO (source ? detector) case





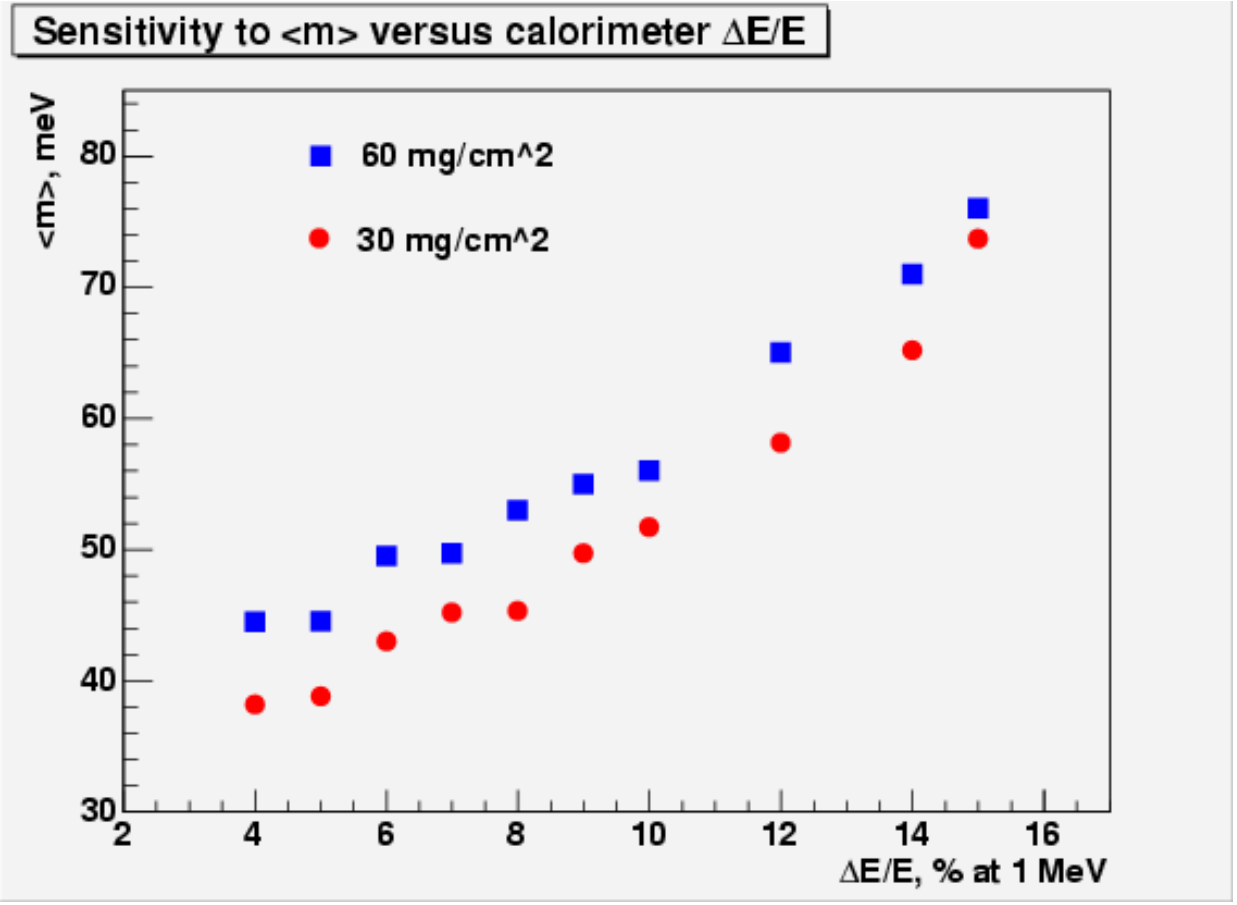


2ν tail is only
BG in SuperNEMO

ΔE/E = 8% at 1 MeV
ΔE/E = 12% at 1 MeV

Energy resolution, foil thickness and sensitivity

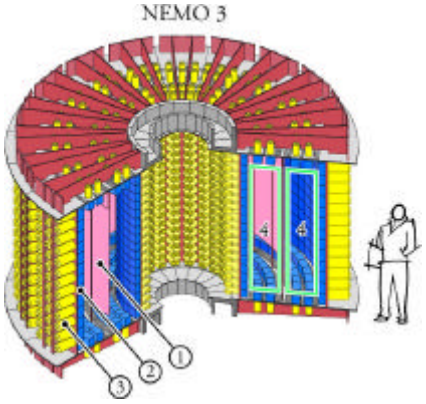
MC simulations



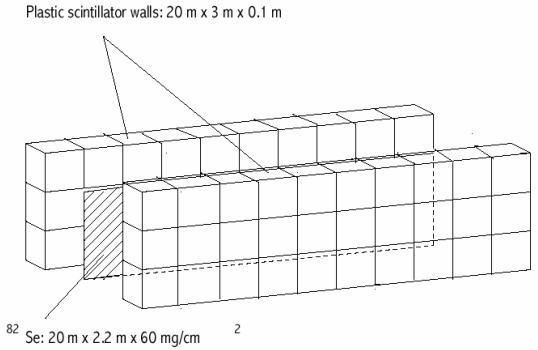
NME from Stoica *et al*., Nucl. Phys. A 694 (2001).

Scintillator R&D status

ΔE/E = 14-17% at 1MeV



ΔE/E = 7-9% at 1MeV
(or better?)



Main Ideas

- Replace polystyrene with polyvinyltoluene (PVT)*: BC404, 408
- Reduce scintillator thickness 10cm → 2cm

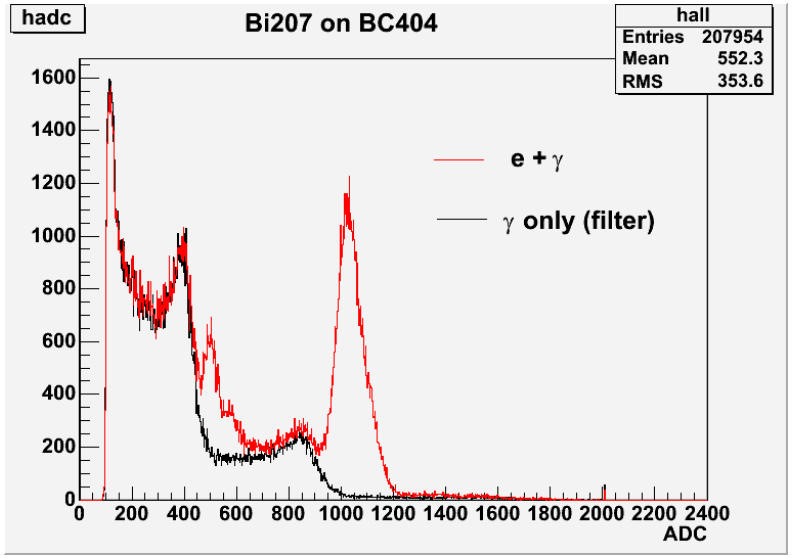
* Polystyrene option is being pursued by French collaborators

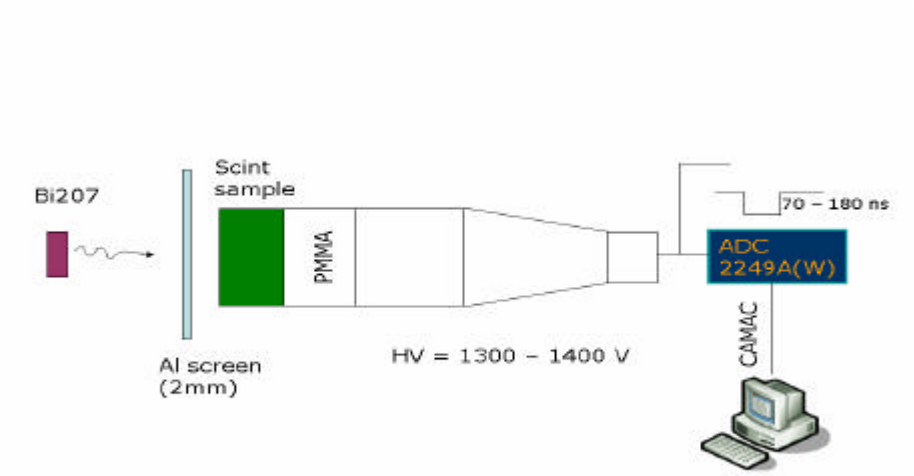
Scintillator R&D studies to date

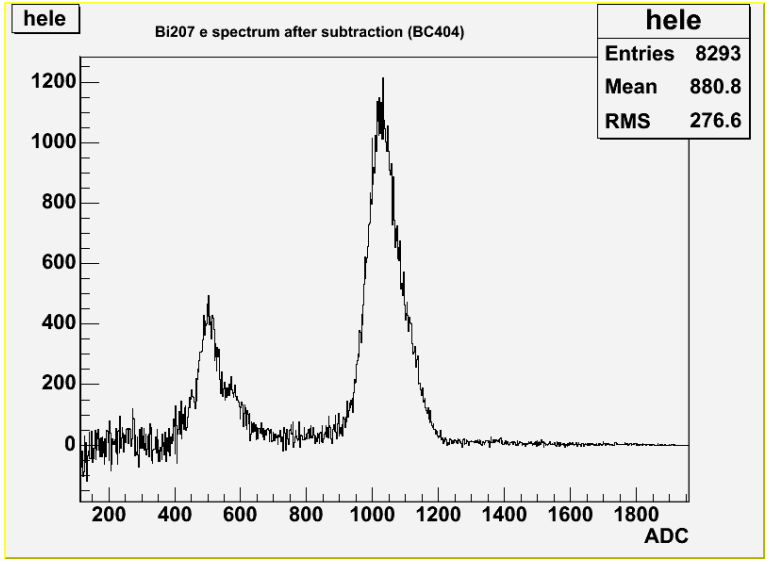
(funded by PPRP in January 2004)

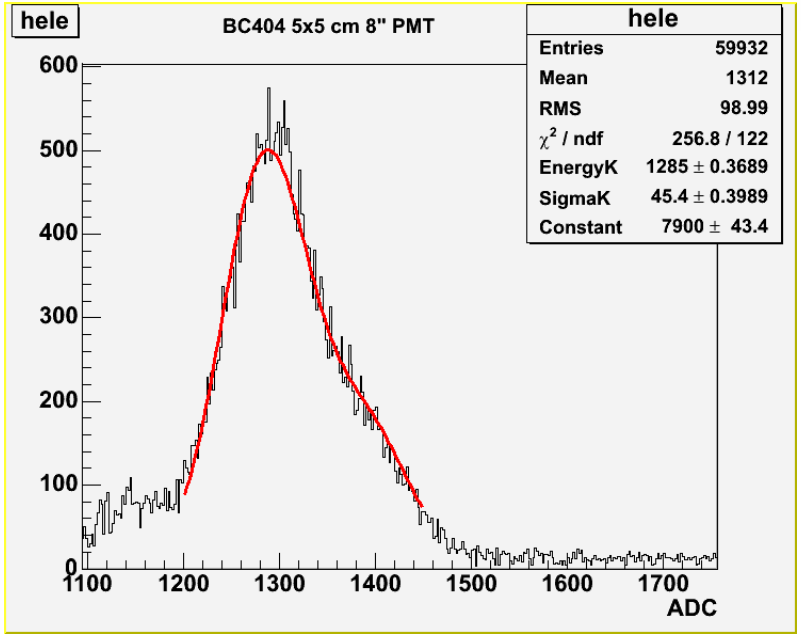
- Different sizes (2×2×2 cm^3, 5×5×2 cm^3, 9×9×2 cm^3, 15 ×15×2 cm^3)
- Surface treatment (polishing vs depolishing)
- Scintillator to PMT coupling
- Light guides
- Coating material (mylar, teflon, tyvec)
- PMT studies (Hamamatsu 5” and ETL 8” hemispherical, ETL 5” flat window).
- First look at scintillator bar readout (new since the last PPRP presentation

The Method


hadc
Bi207 on BC404
hall
Entries 207954
Mean 552.3
RMS 353.6
e + γ
γ only (filter)
ADC

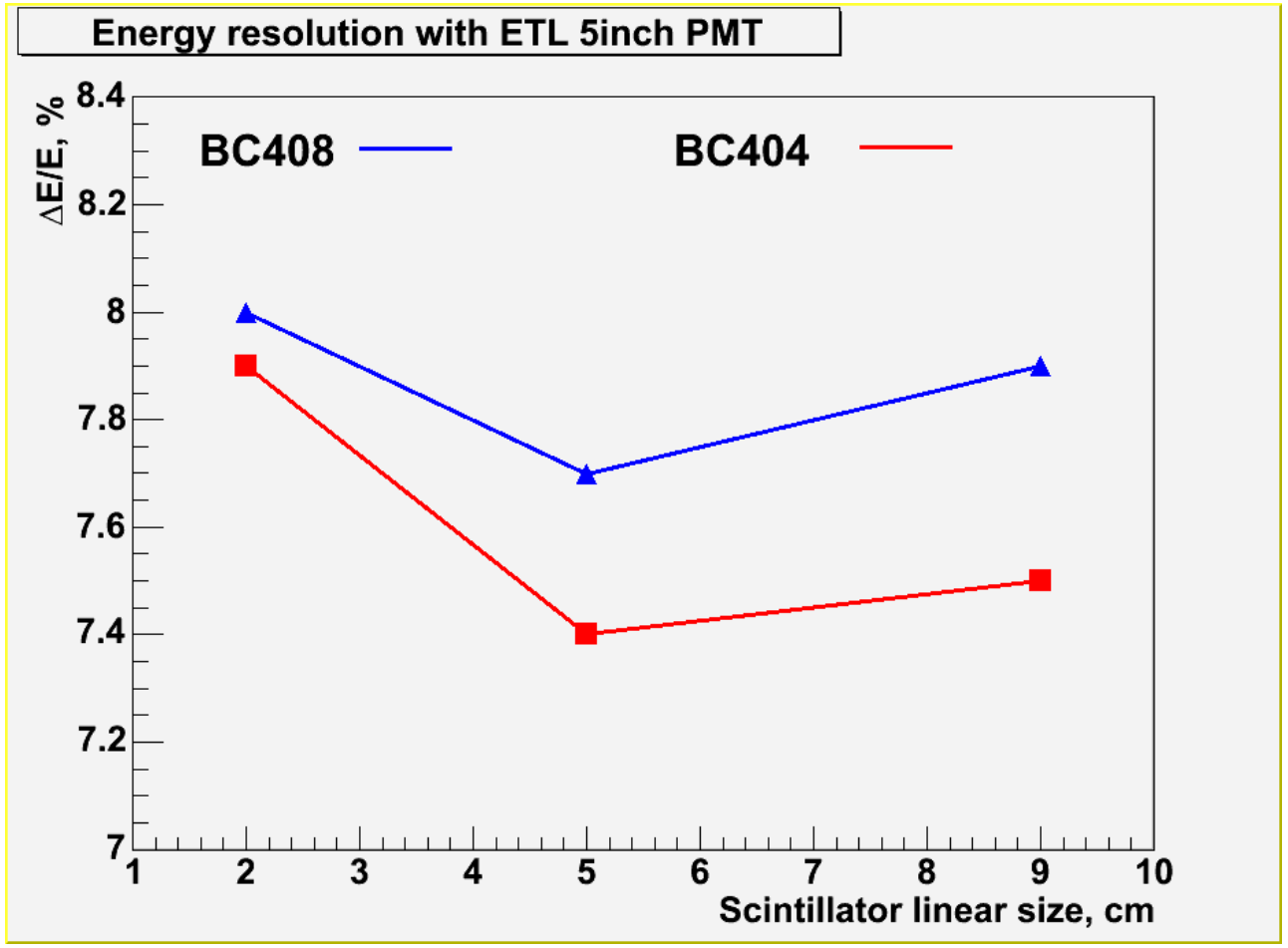

Bi207
Scint sample
PMMA
Al screen (2mm)
HV = 1300 – 1400 V
70 – 180 ns
ADC 2249A(W)
CAMAC


hele
Bi207 e spectrum after subtraction (BC404)
hele
Entries 8293
Mean 880.8
RMS 276.6
ADC


hele
BC404 5x5 cm 8" PMT
hele
Entries 59932
Mean 1312
RMS 98.99
χ² / ndf 256.8 / 122
EnergyK 1285 ± 0.3689
SigmaK 45.4 ± 0.3989
Constant 7900 ± 43.4
ADC

Scintillator R&D. Results to date.

Best results with ETL flat 5” PMT (no light guide) and scintillator depolished and wrapped with mylar/tyvec mixture

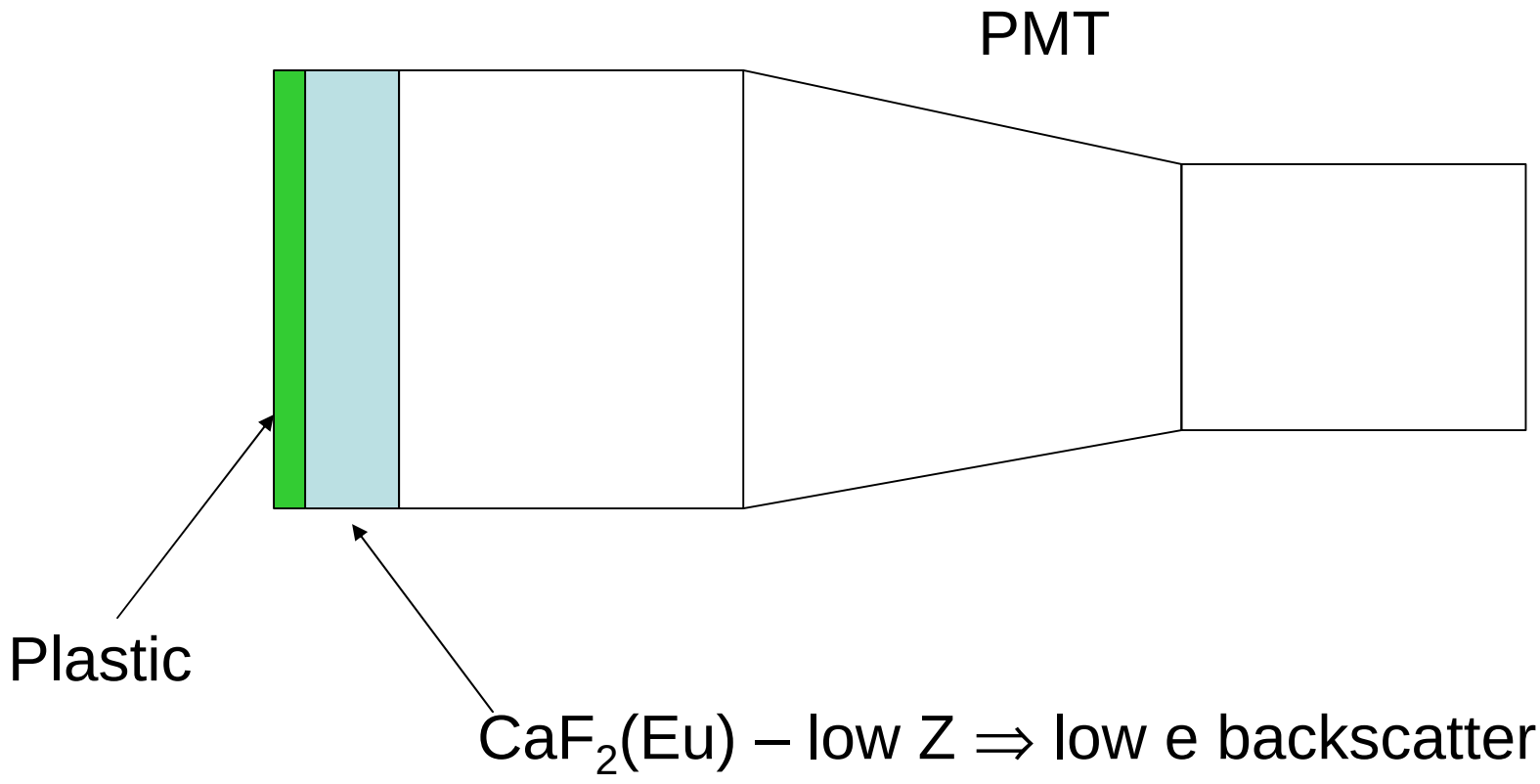


Scintillator R&D. Things to do.

- Block size and uniformity studies
  - 100kg source $\Rightarrow$ 200m^2 source $\Rightarrow$ 400m^{2}scint $\Rightarrow$ 10,000 PMTs if 20×20 cm blocks or ~4500 PMTs if 30×30 cm blocks
- Mosaic scintillator blocks
  - If necessary $\Delta E/E$ with large blocks can not be achieved
- Scintillator thickness
  - Can it be increased to 3-4 cm to provide better γ-tagging without loss in $\Delta E/E$?
- France/Russia will carry out a similar programme for polystyrene
- PMT studies (Hamamatsu, ETL – UK, Photonis – France).
- Scintillator bars
- Phoswich

} see later

Phoswich

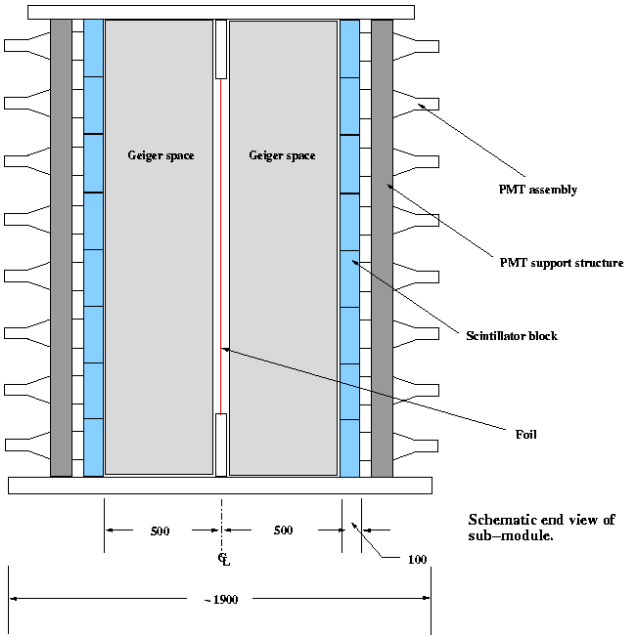


Combined good timing resolution of plastic ($t_{dec} \approx 2$ ns)
with high light output of $CaF_2(Eu)$ (25000 photons/MeV)

$\Delta E/E \sim 4\%$ @ 1MeV should be achievable

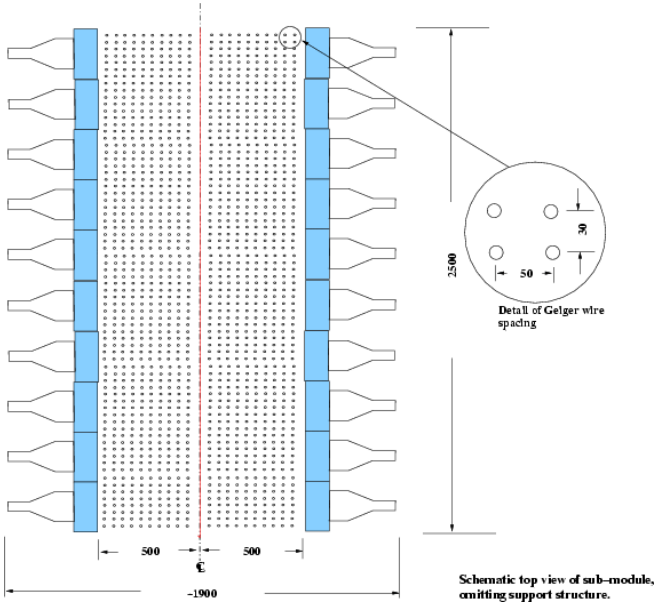
Disadvantages: cost, more complicated electronics

Baseline conceptual design. Scintillator blocks



Schematic end view of sub–module.

Schematic side view of sub–module omitting support structure



Schematic top view of sub–module, omitting support structure.

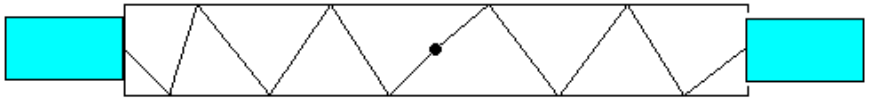
Detail of Geiger wire spacing

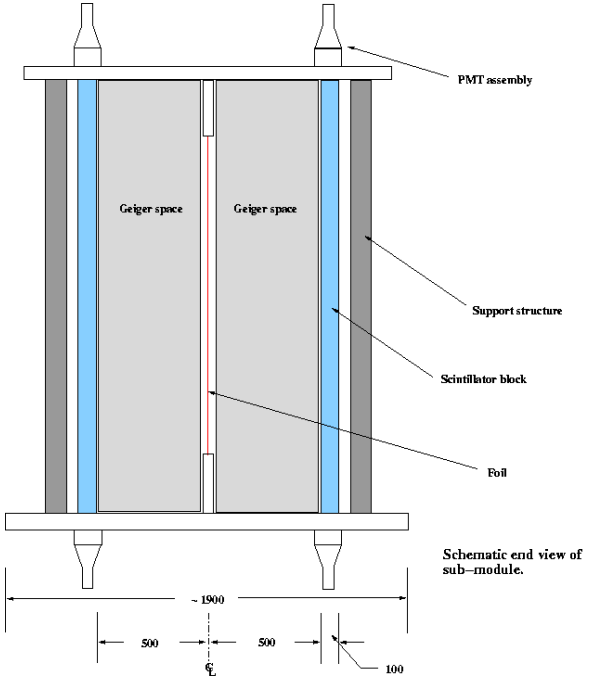
SuperNEMO = submodule × 50

100 kg of ^{82}Se (or other) in
2m×4m×40m
+
shielding
5,000 – 10,000 PMTs

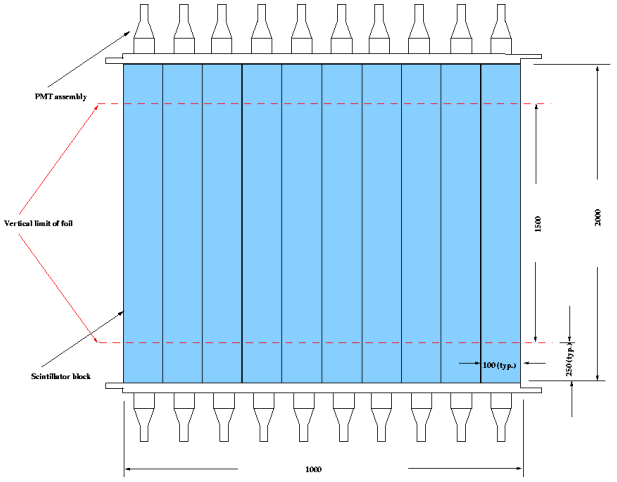
Scintillator bar design

Double sided readout

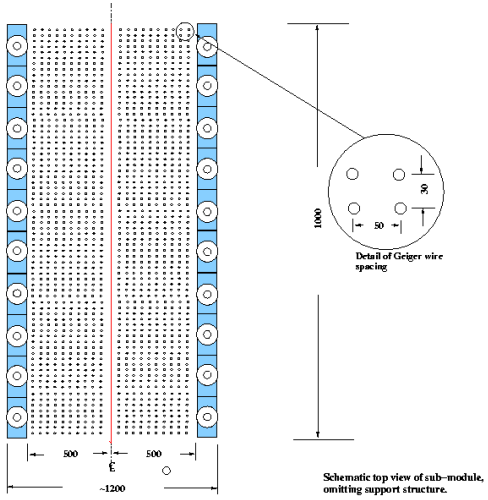




Schematic end view of sub–module.



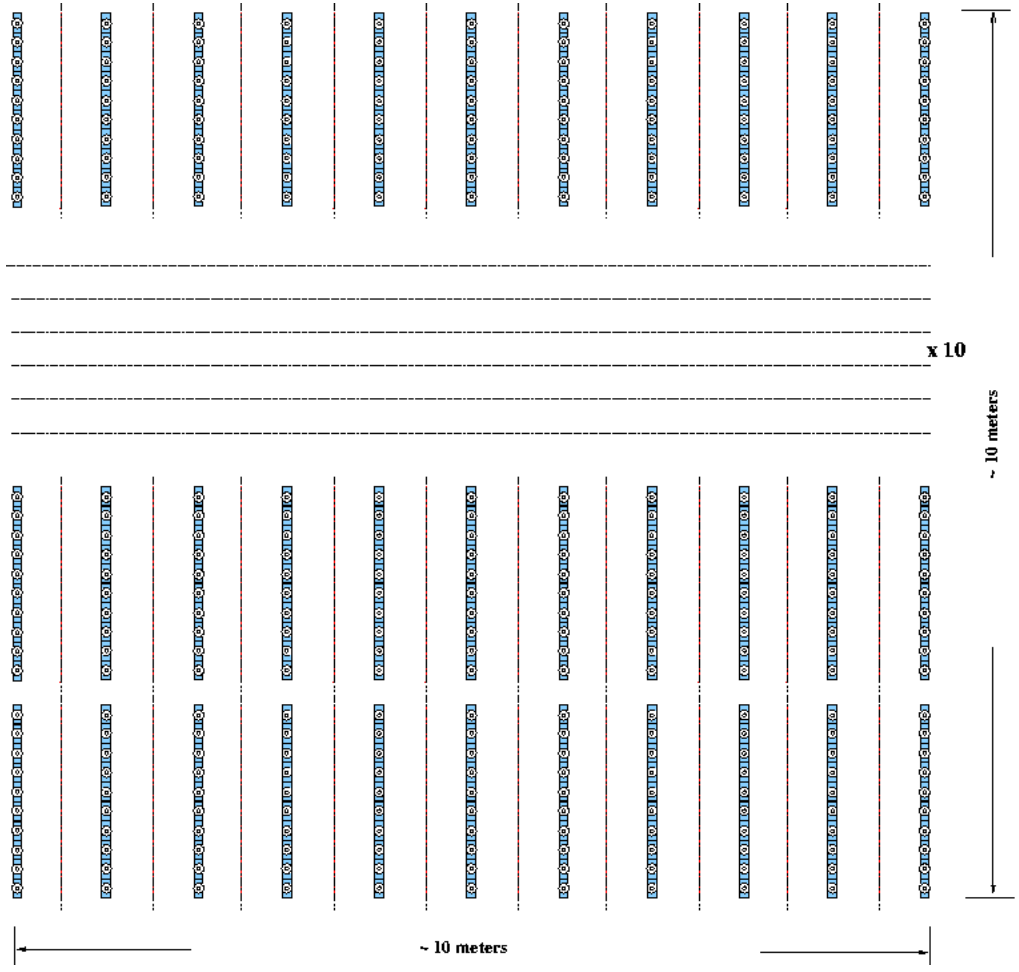
Schematic side view of sub–module omnitting support structure



Schematic top view of sub–module, omitting support structure.

Conceptual design. Scintillator bars. Full detector layout.

Top view



- Much more compact:
  10×10 m^2 floor area will
  accommodate a ~200 m^2 foil (~100 kg)

- External walls as active shielding

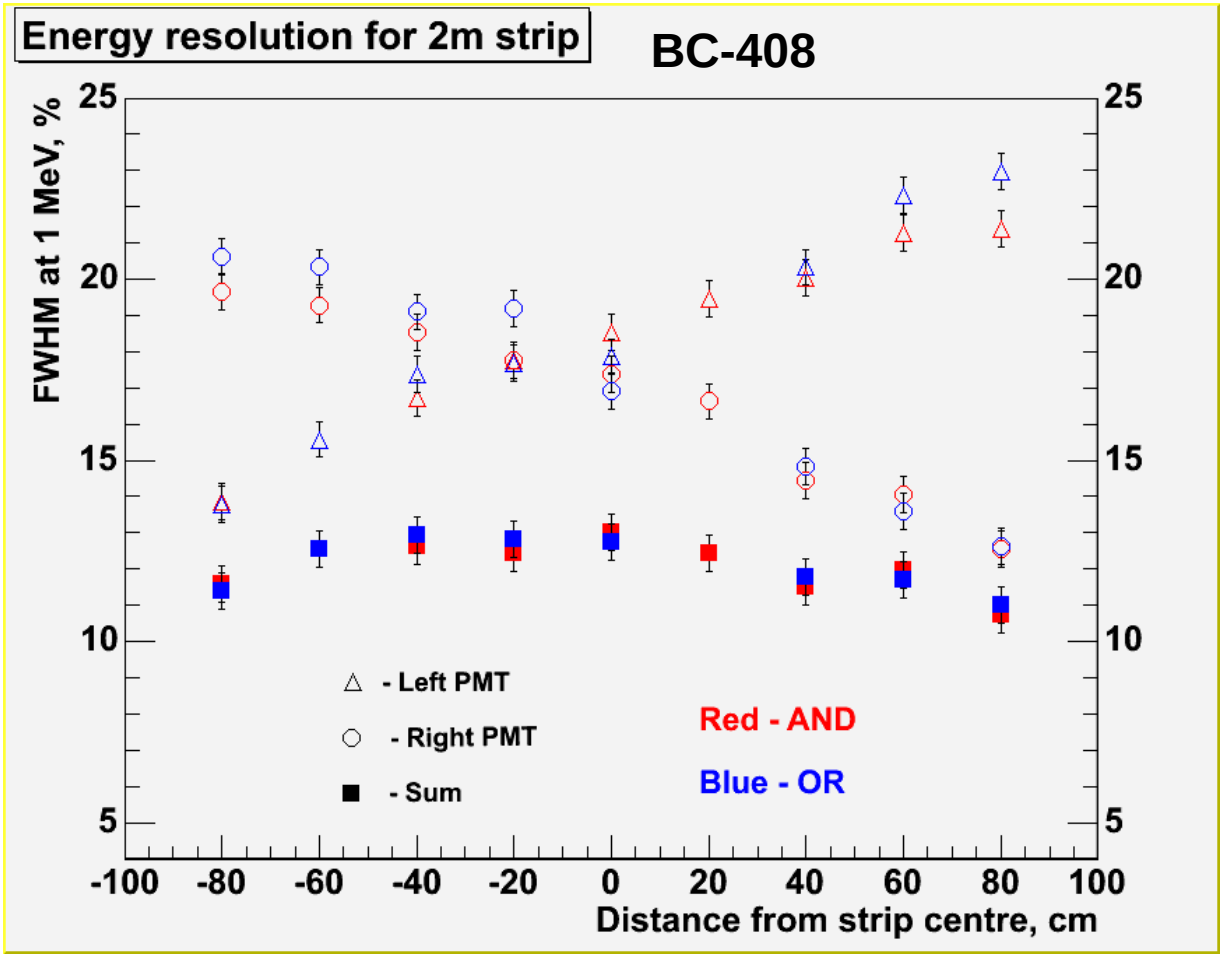
- Save on scintillator and
  number of PMTs:
  only 2200 cheap 5” PMTs

- Bigger mass or 30 mg/cm^2
  foil may be affordable?

Energy resolution
can be relaxed in this configuration
(10-11%? simulations needed)

2m scintillator strips ΔE/E. First tests.

- ✓ First results look better than originally expected
- ✓ The alternative design looks promising
- ✓ Need full MC simulations of this design (IC input)



Summary

- $\Delta E/E = 7 – 8$ % achievable at least for the baseline design without light guides
- First tests with scintillator bars look promising
- Need to complete this R&D to pick the final calorimeter design