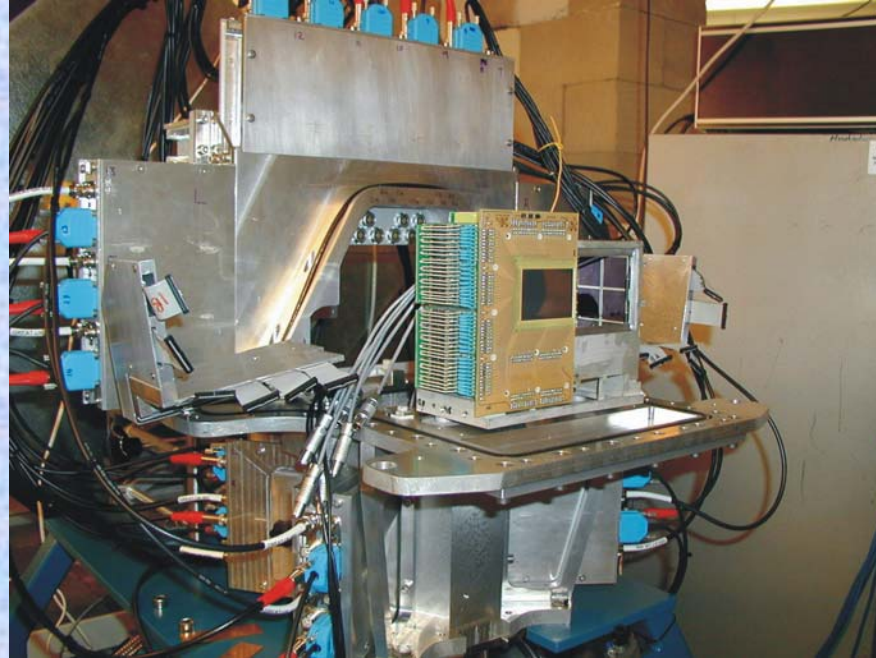


The GREAT Spectrometer



John Simpson
Nuclear Physics Group



Stopped beam RISING Technical Workshop
GSI 16 April 2004



**Rising Stopped Beam Workshop,
University of Surrey, 29-30 March 2004**

Adapting GREAT + TDR for RISING?

R.D. Page



THE UNIVERSITY
of LIVERPOOL

GREAT: Liverpool – Daresbury – Jyväskylä – Keele – Manchester – Surrey – York

JUROGAM + RITU + GREAT



The set-up at Jyväskylä

JUROGAM



43 HPGe
detectors

$\varepsilon = 4.3\%$

(c.f. 1.4%)

RITU



Improved beam
rejection

Differential pumping

GREAT



Tagging Spectrometer

GREAT

Triggerless Data
Acquisition (TDR)

GREAT Design Criteria

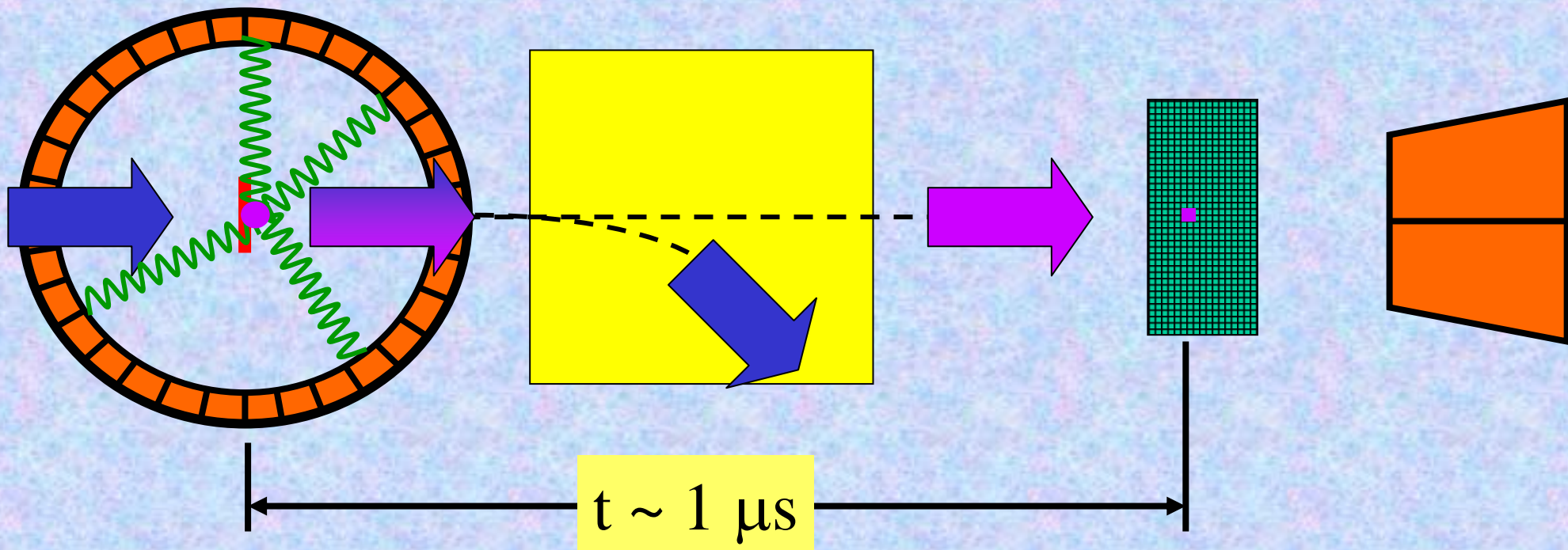
Detect all radioactive decay modes (α , β , p, e^- , X, γ)

Focal plane area (120 mm x 40 mm ~ 90 %)

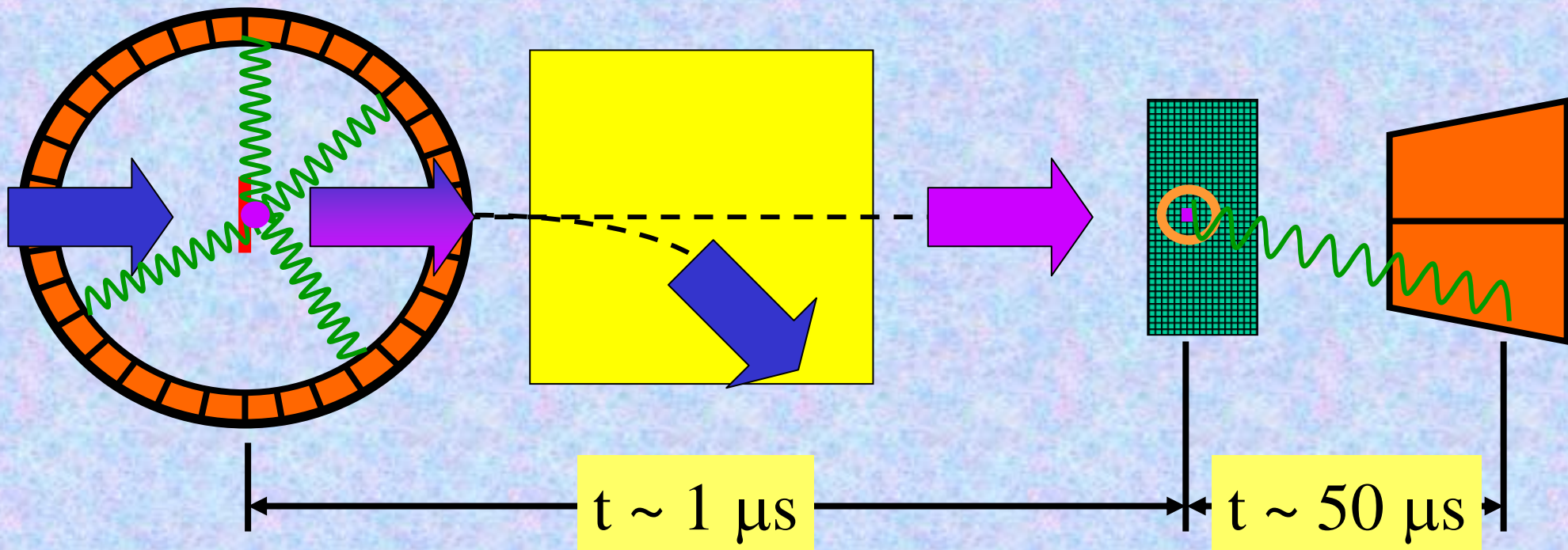
Implantation depth profile (within few μm of surface)

Eliminate common dead time for recoil decay tagging

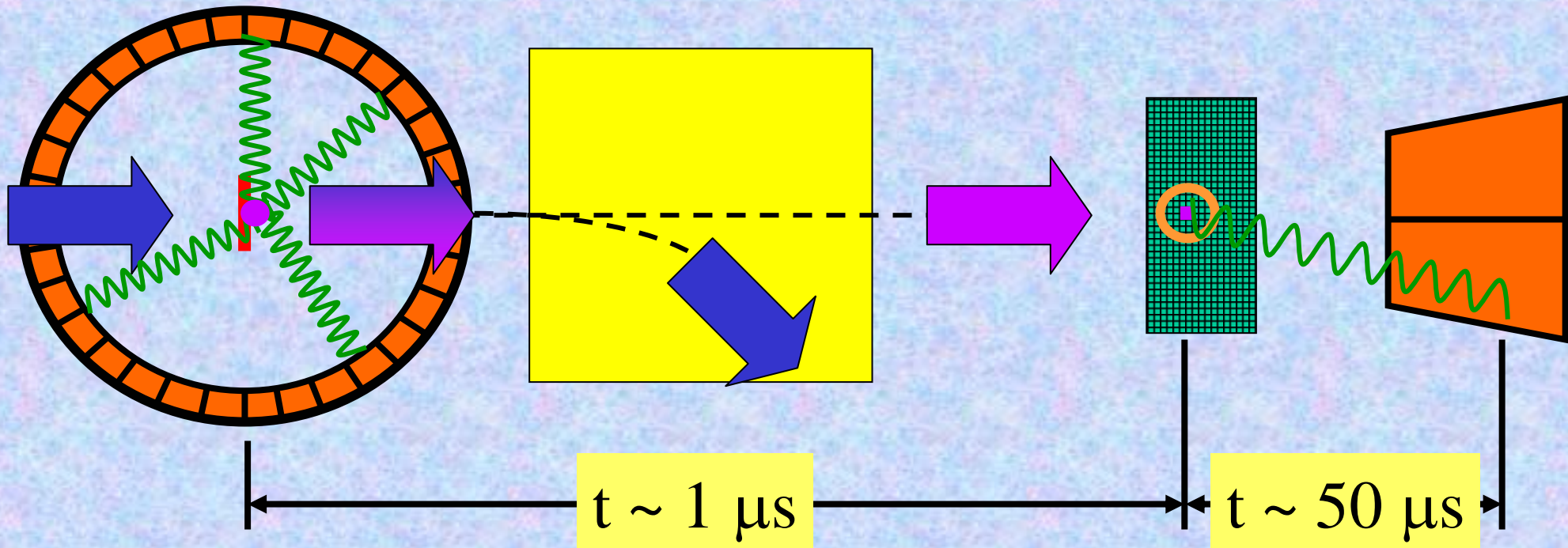
Recoil Decay Tagging



Recoil Decay Tagging

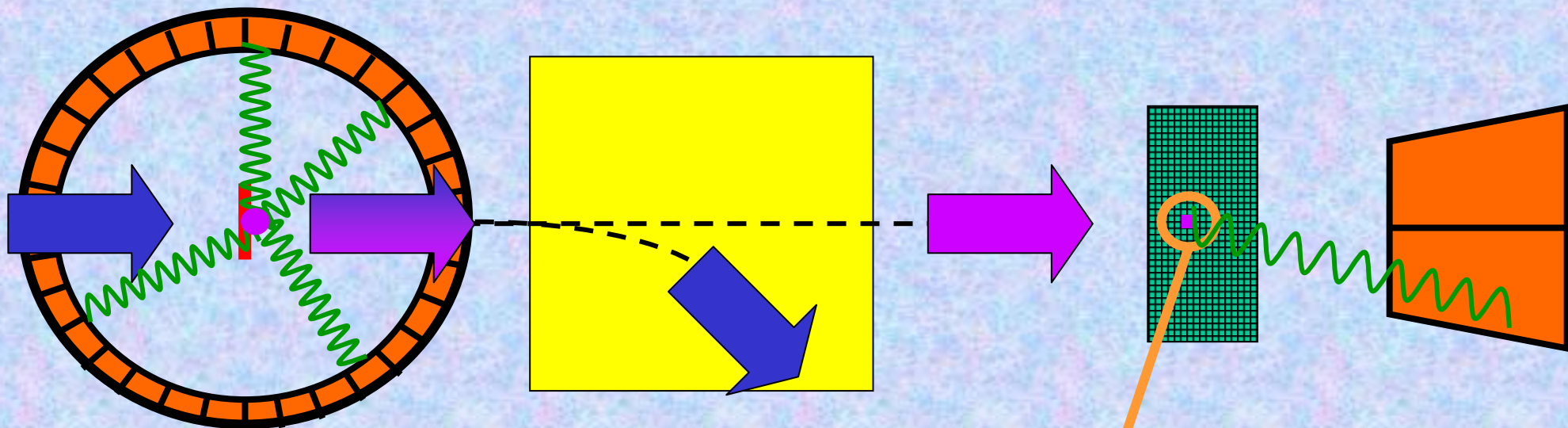


Recoil Decay Tagging

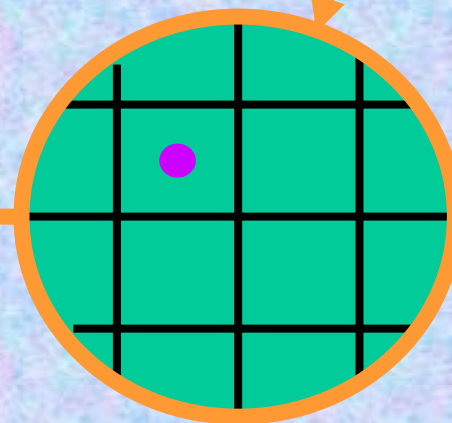
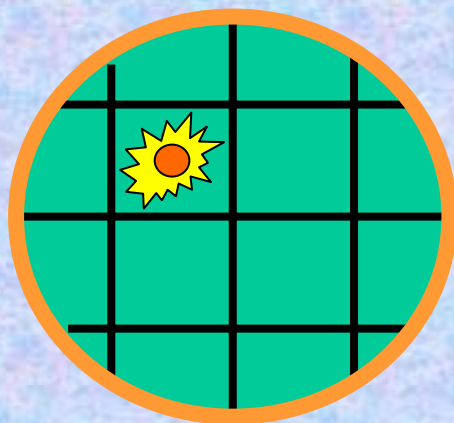


$$2 \text{ kHz} \times 50 \mu\text{s} = 10 \%$$

Recoil Decay Tagging

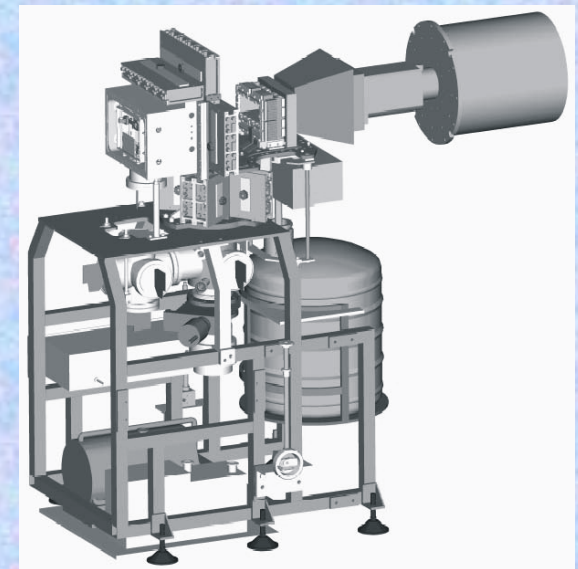
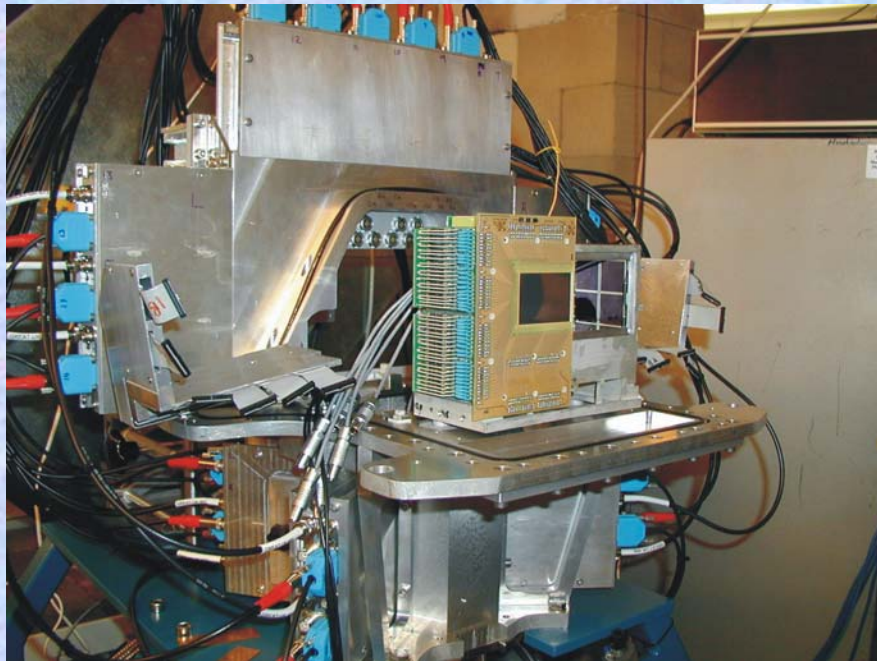


$t \sim \mu\text{s} - \text{hours}$

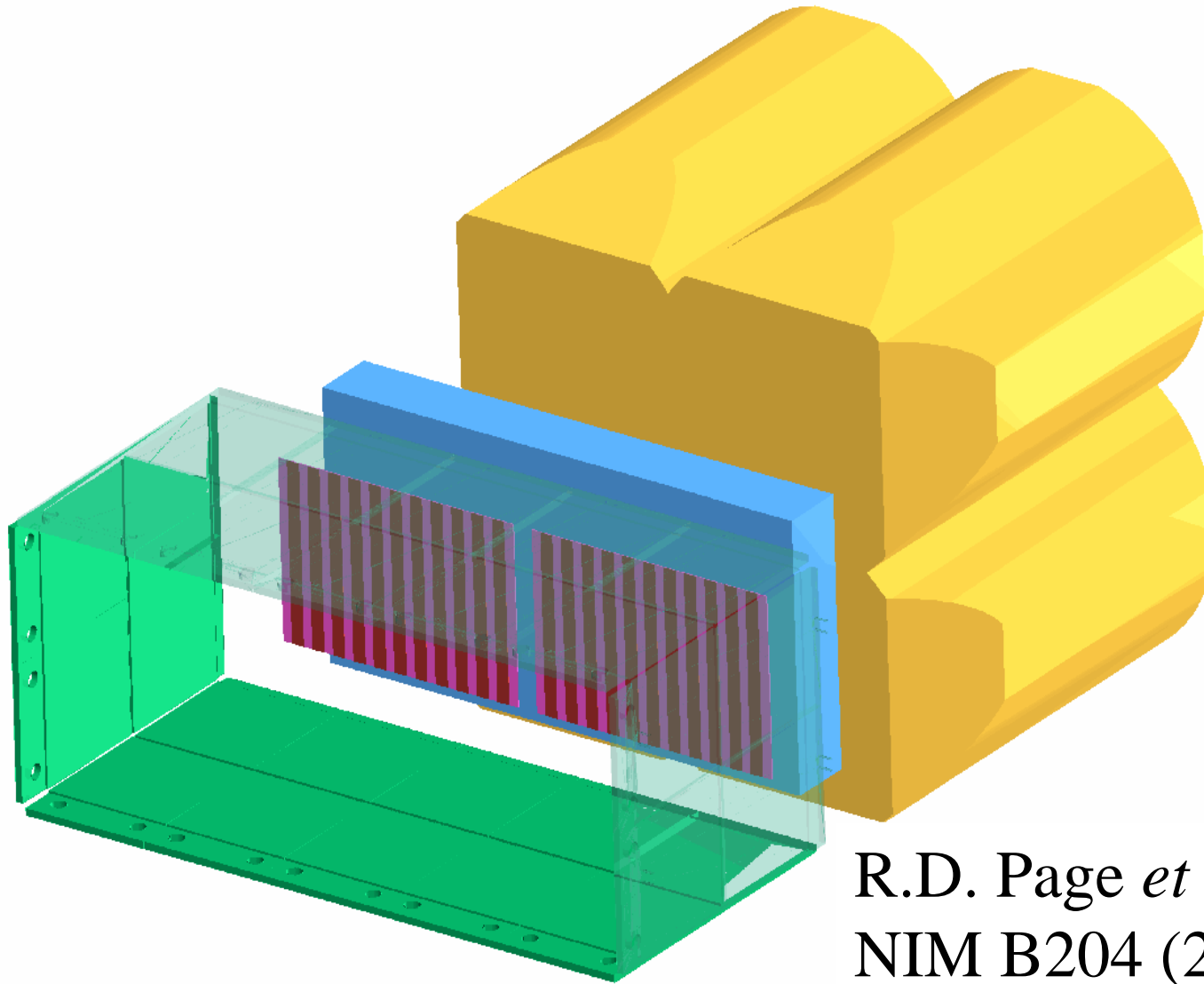


The GREAT focal plane spectrometer

- 200 Channels DSSD (2 x 60mm x 40mm)
- 28 PIN Diode detectors
- Segmented Planar Ge (120mm x 60mm)
- Segmented Clover Ge (4 x 70% Crystals)
- Gas detector (MWPC)
- Recoils/ α
- e^- detection
- β & Low energy γ
- γ
- TOF - $\Delta E/E$

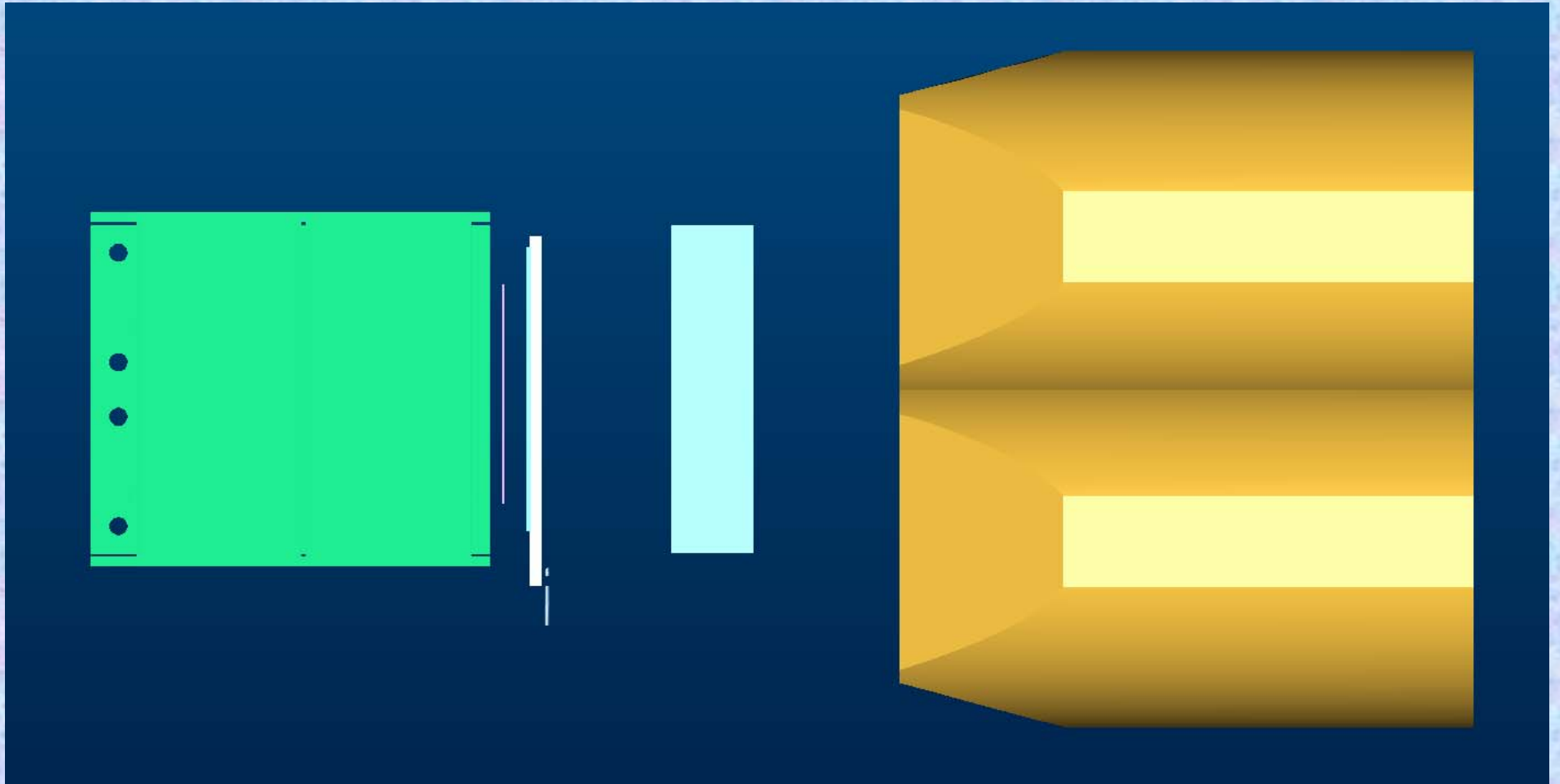


The GREAT Spectrometer



R.D. Page *et al.*
NIM B204 (2003) 634

Side view of GREAT



MultiWire Proportional Counter

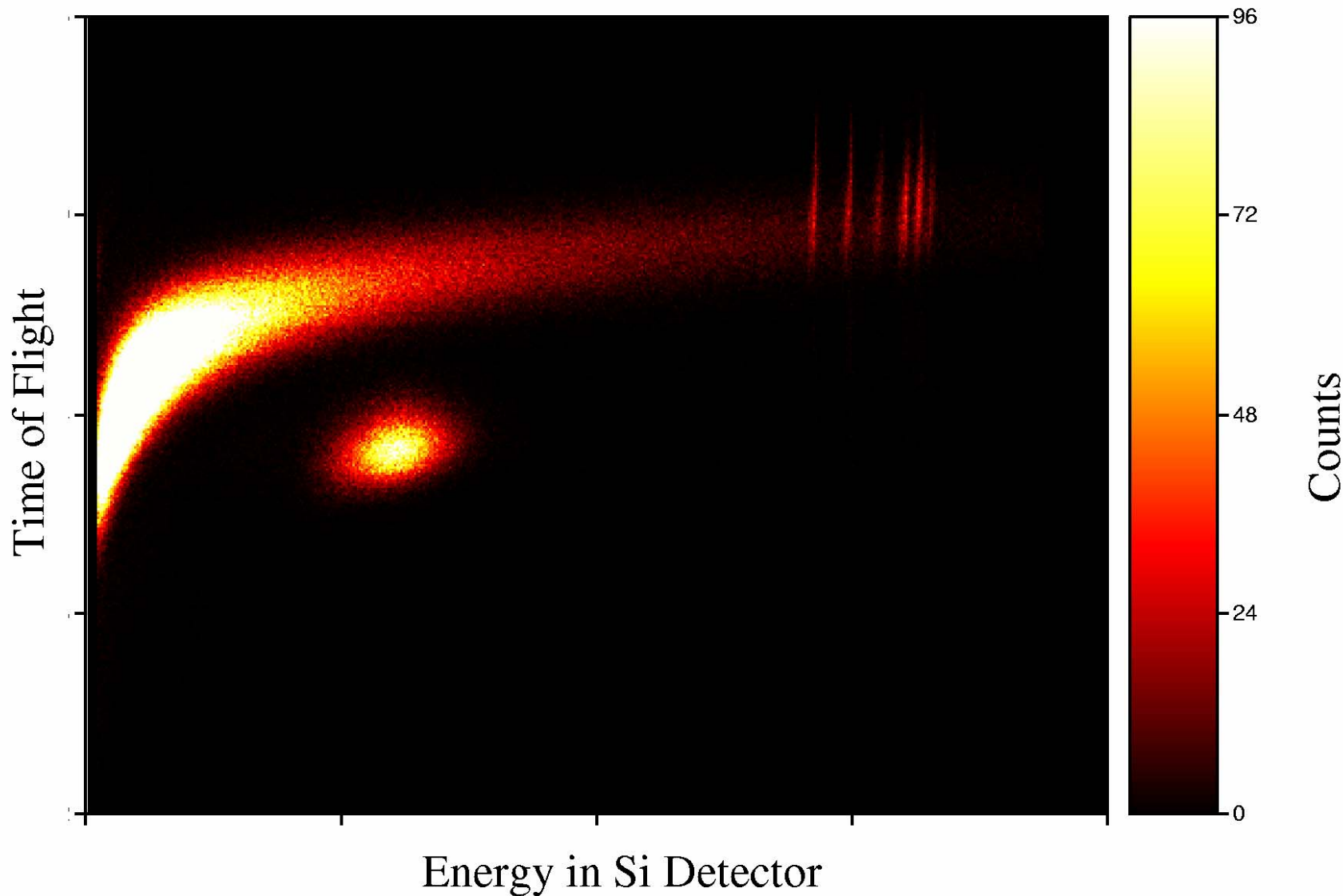


- Energy loss
- Timing

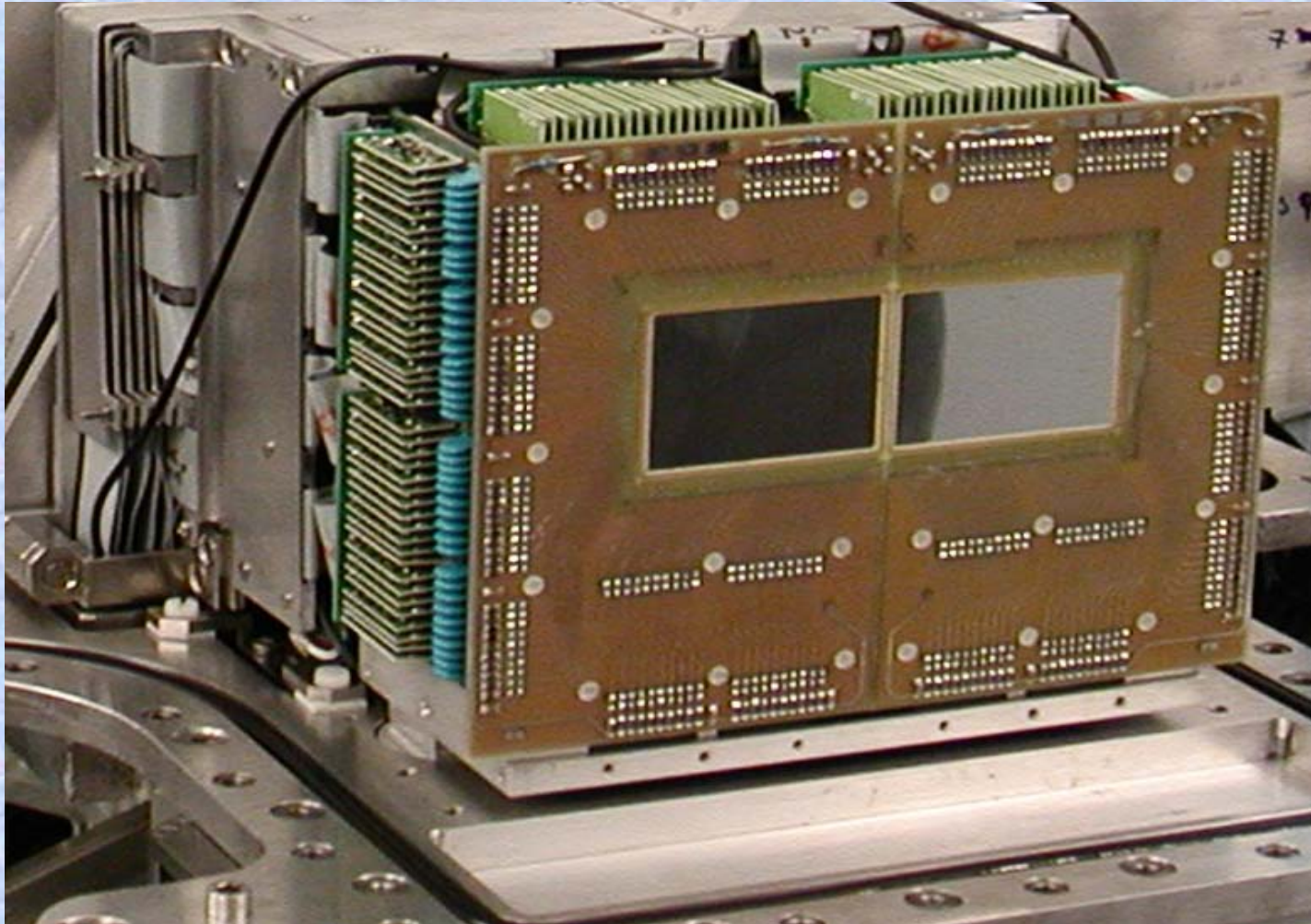
- Left/right
- Up/down

Evaporation residue selection

$^{83}\text{Kr} + ^{109}\text{Ag} @ 357 \text{ MeV}$

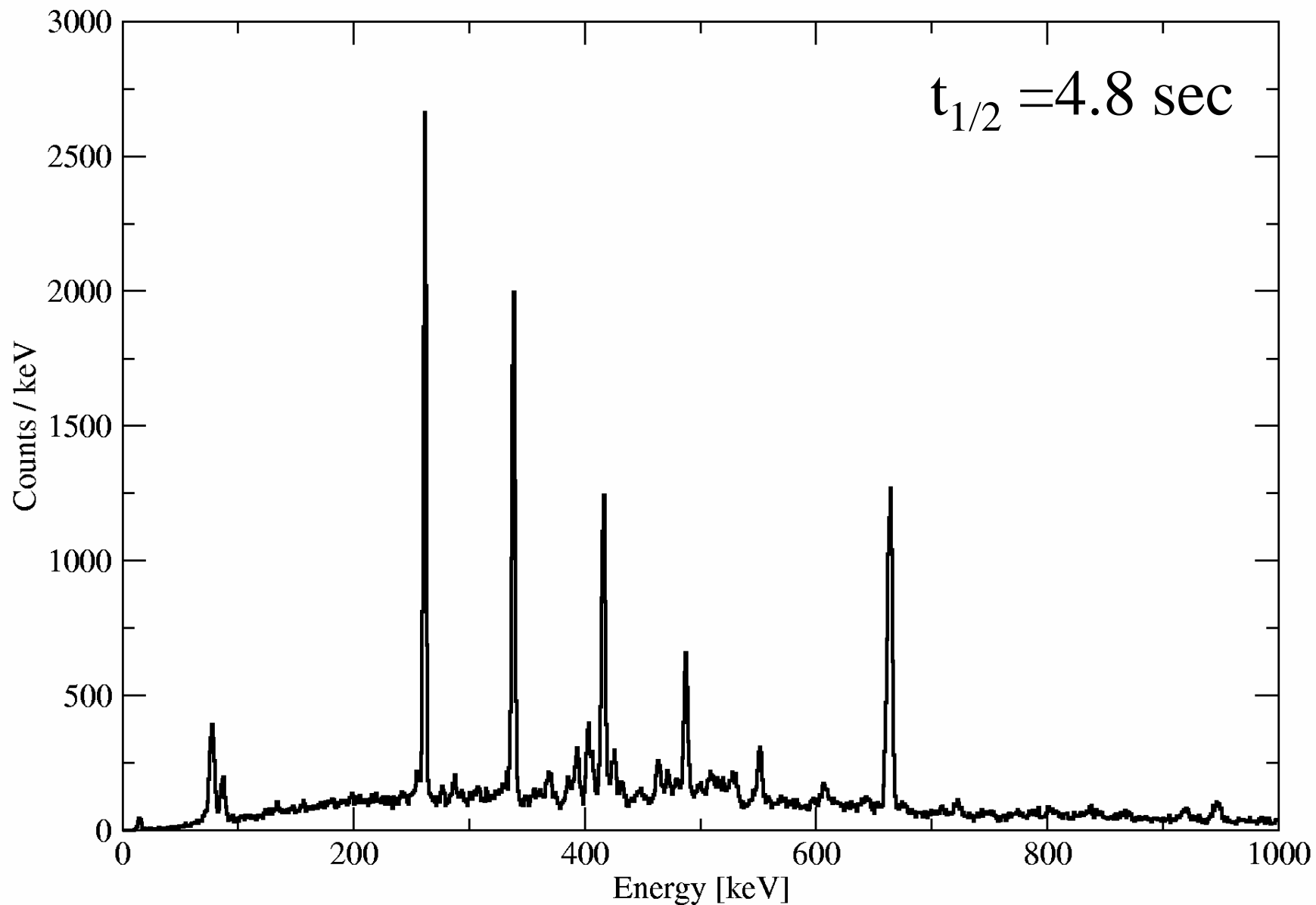


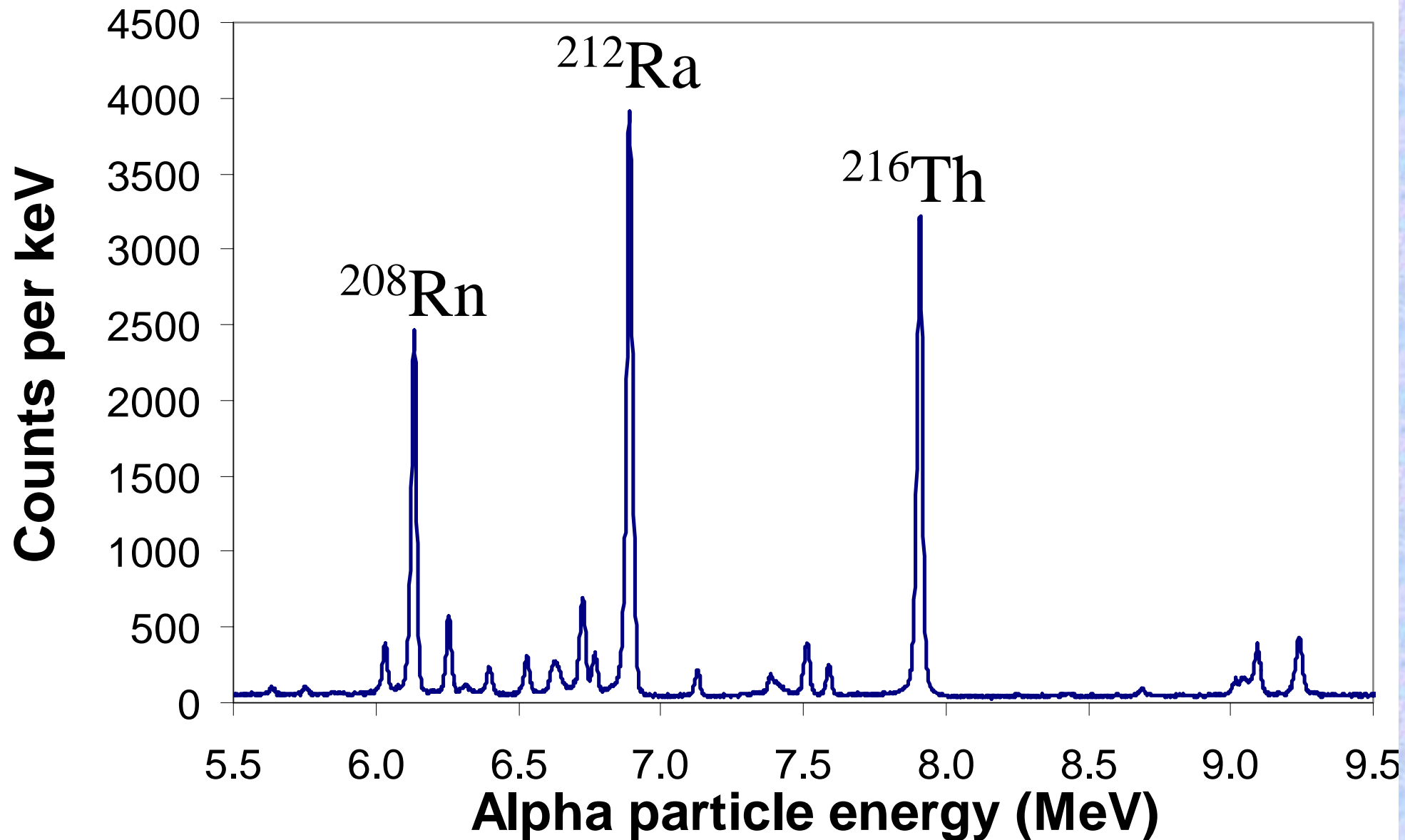
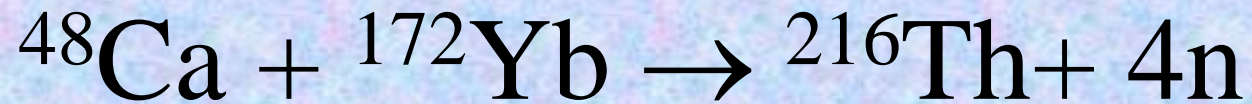
Double-Sided Silicon Strip Detectors



2 x DSSD (60mm x 40mm x 300 μ m) 1mm strips, 4800 pixels, $\Delta E \sim 20$ keV
+ Si punch through detectors (60mm x 60mm x 475 μ m) ~ 5 mm behind

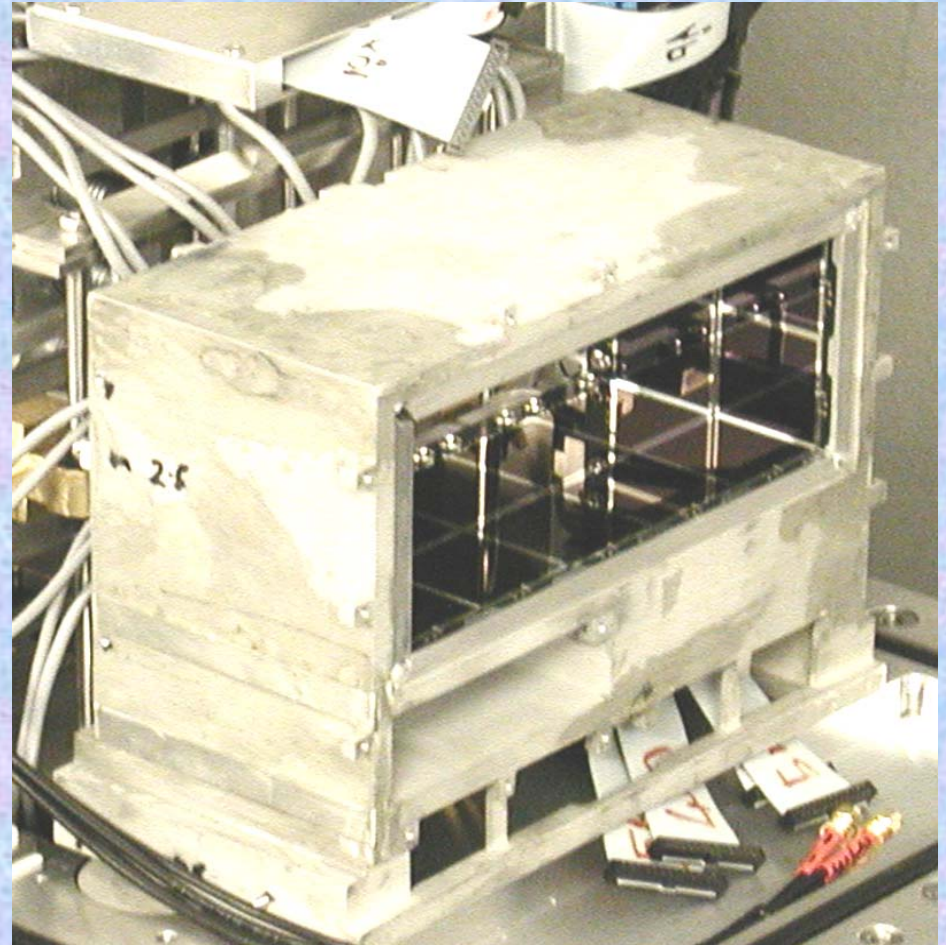
^{186}Pb α -tagged γ - γ projection
 $^{83}\text{Kr}(^{106}\text{Pd},3n)^{186}\text{Pb}$ @ 355 MeV





PIN diode array

- conversion electrons
- 28mm x 28mm Si PIN diodes
- 2 PIN diodes per PCB
- 14 pairs = 28 PIN diodes
- Solid angle $\approx 30\%$
- Energy resolution $\sim 5\text{-}10\text{keV}$



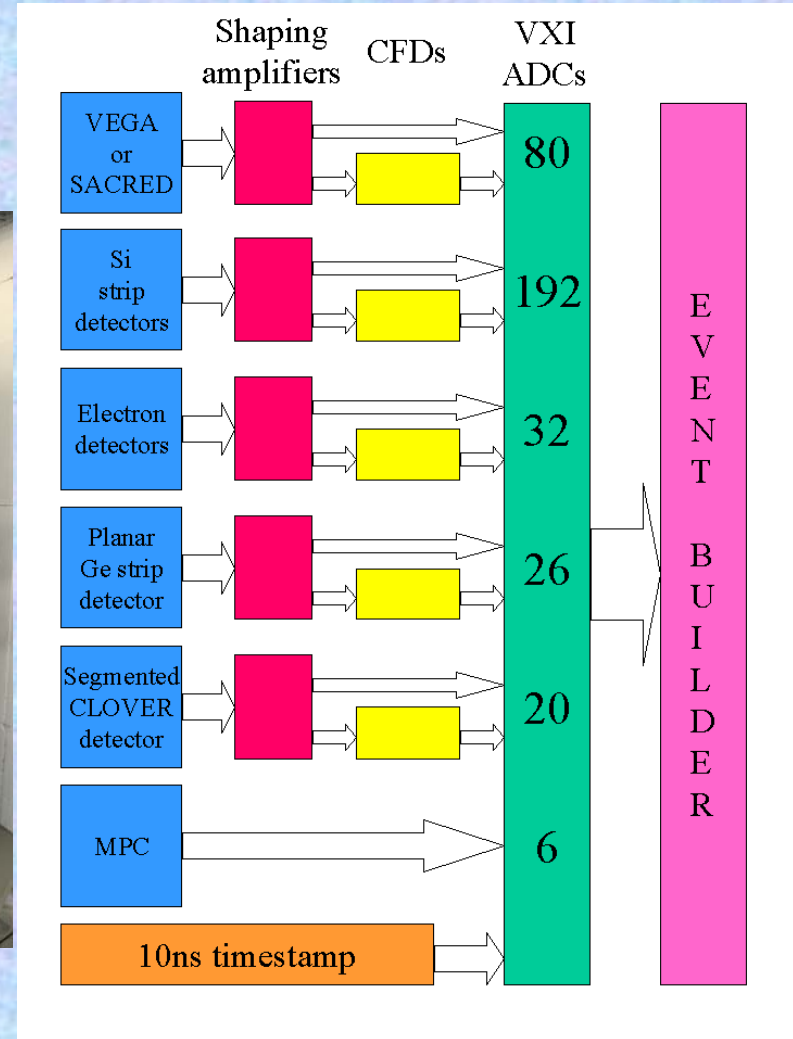
Planar Germanium Strip Detector

- Double-sided design
- Inside vacuum chamber
- 120mm x 60mm x 15mm
- 5mm strip pitch
- 24 x 12 = 288 pixels
- Energy resolution
 $\approx 1.6\text{keV}$ at 122keV



GREAT TDR

- Total Data Readout
- No Hardware Trigger
- All data associated with a 48 bit 10ns time stamp



<http://npg.dl.ac.uk/GREAT>

I.H. Lazarus *et al.*, IEEE Trans. Nucl. Sci. **48**, 567 (2001)

TDR vs Conventional electronics

Conventional

- Common dead time DAQ
- Trigger conditions set in Hardware
- Missing events
- Relatively simple hardware requirements

TDR

- No common dead time
- Trigger conditions set in software
- No missing events
- Requires powerful computer processors and large amounts of memory

Spectroscopy at the FRS

production target

primary beam:
Pb @ 1 GeV/u

dipole : Bρ

middle focus S2

end focus S4

Degrader

SCI

MW:x,y

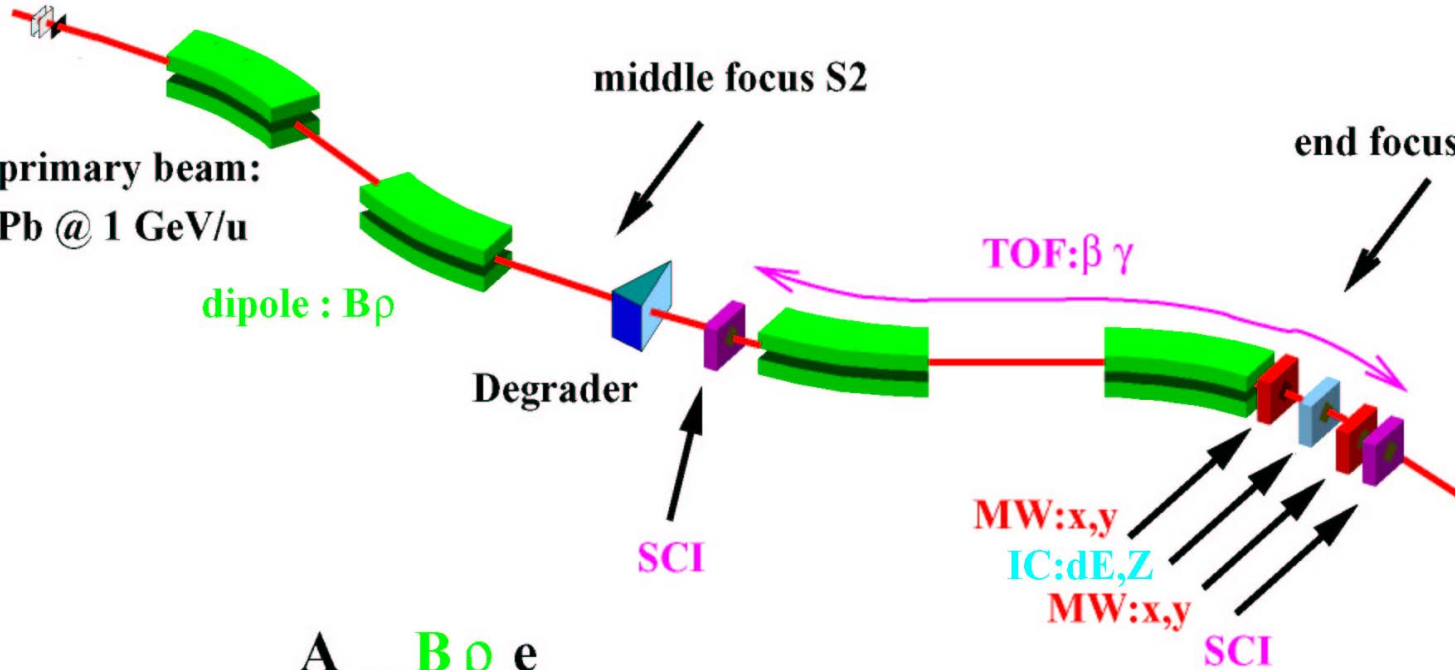
IC:dE,Z

MW:x,y

SCI

TOF:β γ

$$\frac{A}{Q} = \frac{B \rho e}{\beta \gamma c u}$$



Design Criteria – RISING cf. GREAT

Detect all radioactive decay modes (α , β , p , e^- , X , γ)

Same for FRS

Focal plane area (120 mm x 40 mm ~ 90 %)

150 mm x 50 mm

Implantation depth profile (within few μm of surface)

several mm distribution

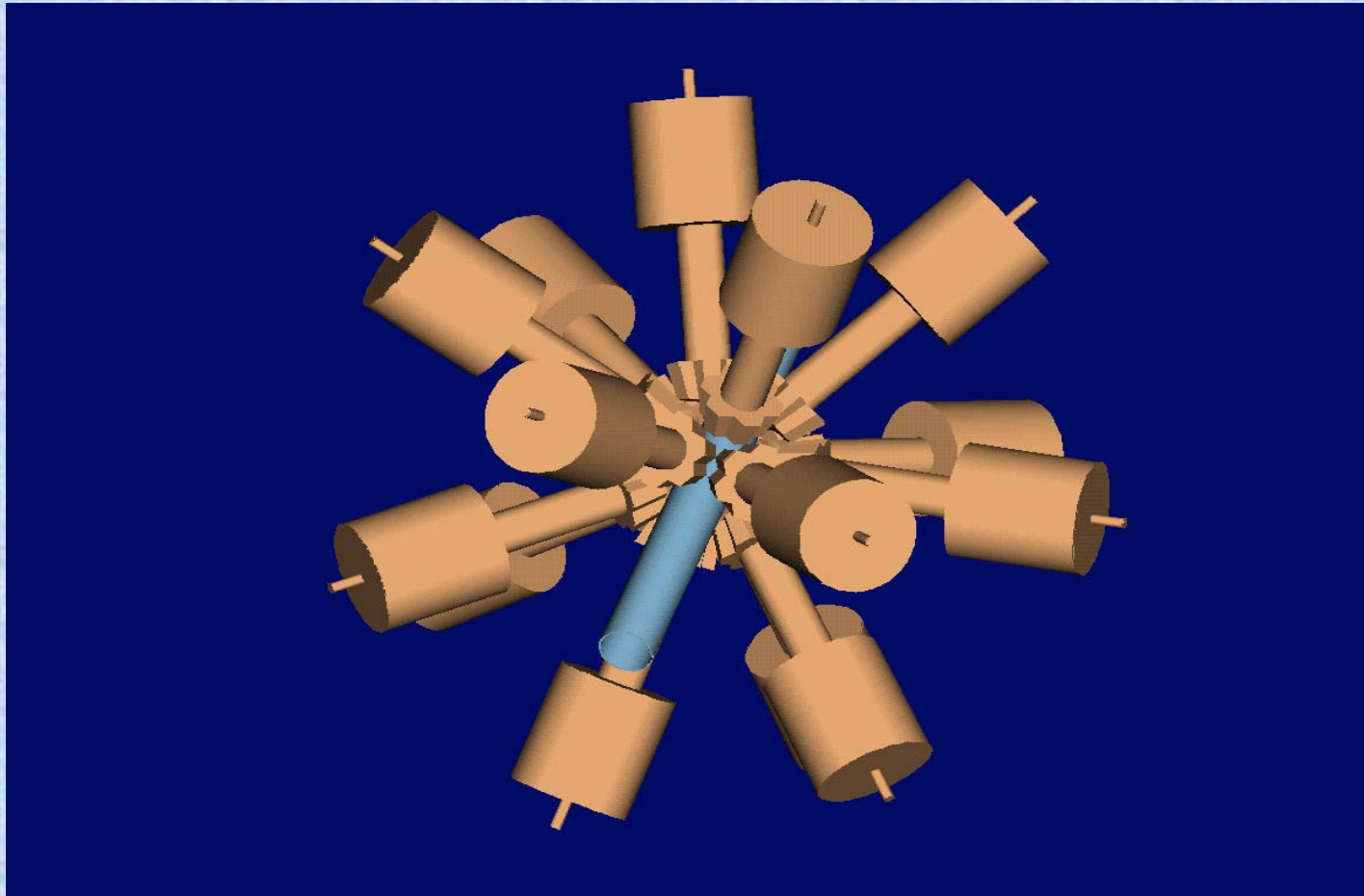
Eliminate common dead time for recoil decay tagging

Something simpler for RISING?

How many signals?

What rates?

15 Clusters at GSI, Stopped beam setup

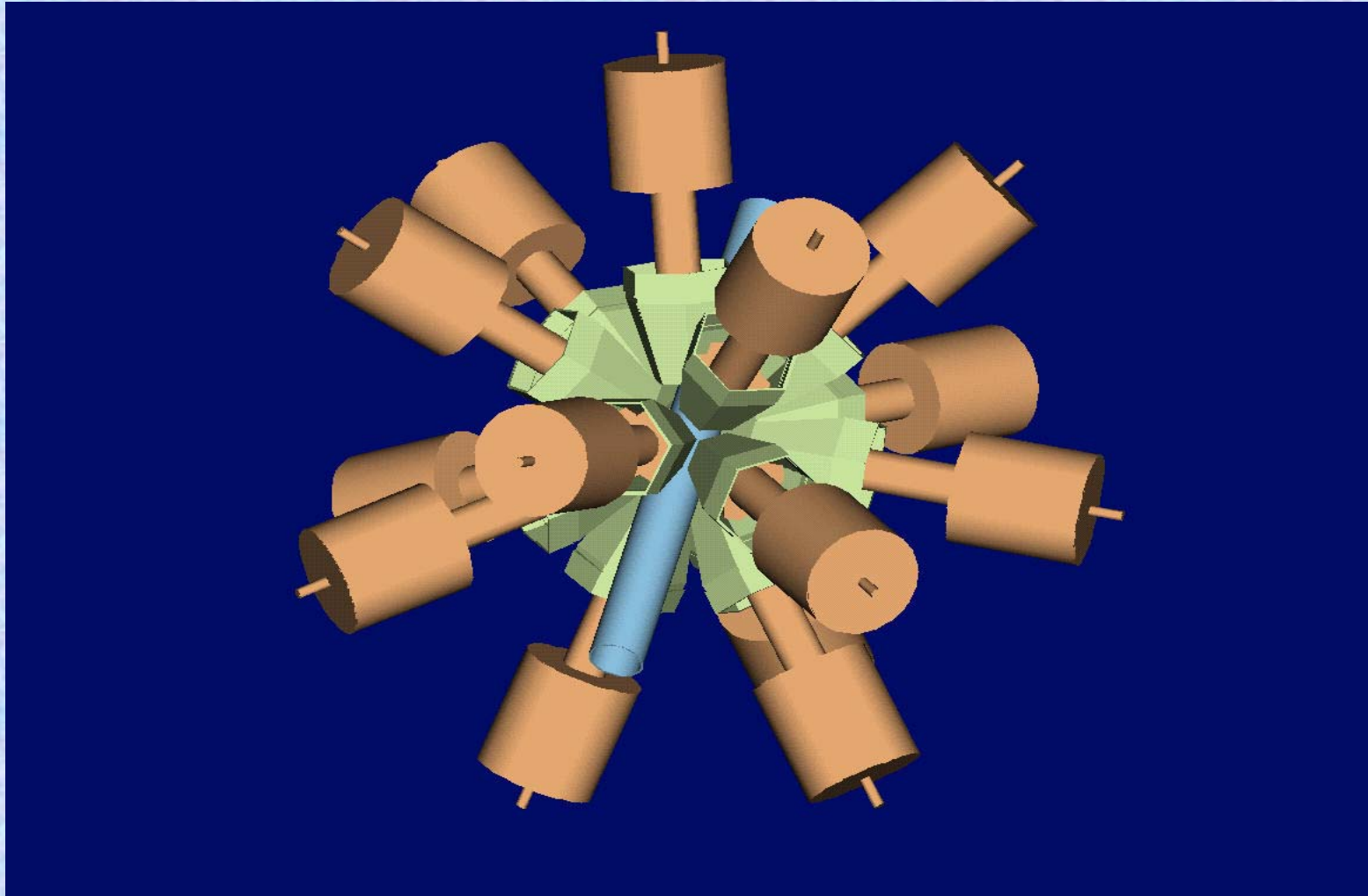


15 Clusters

5 at 132° (205mm) 5 at 90° (190mm), 5 at 48° (205mm)

Total efficiency 18.7%

15 Clusters with shields at GSI, Stopped beam setup

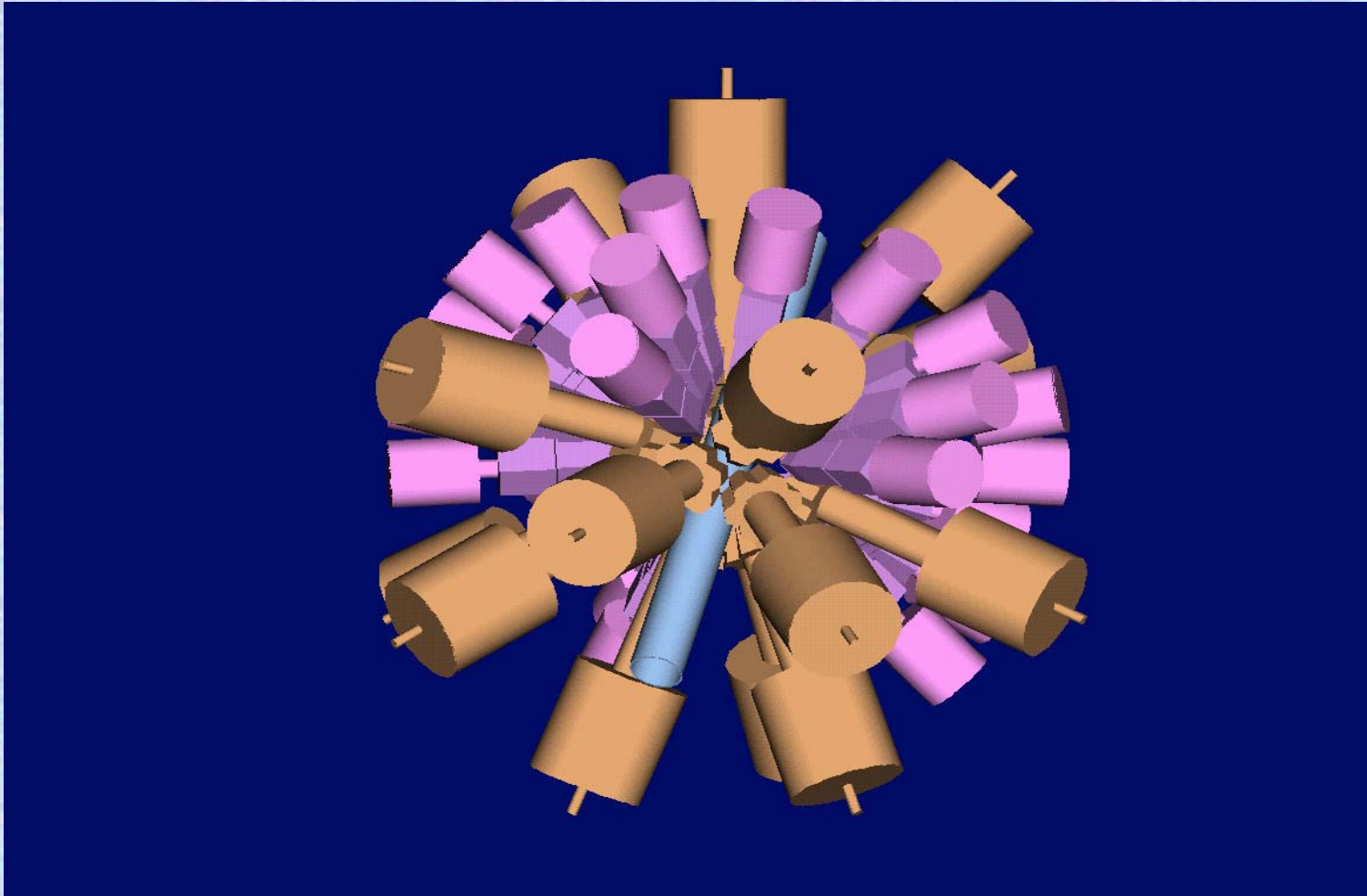


15 Clusters.

5 at 132° (282mm) 5 at 90° (250mm), 5 at 48° (282mm)

Total efficiency 11%

Clovers and Clusters at GSI 25 Clovers, 15 Clusters no shields

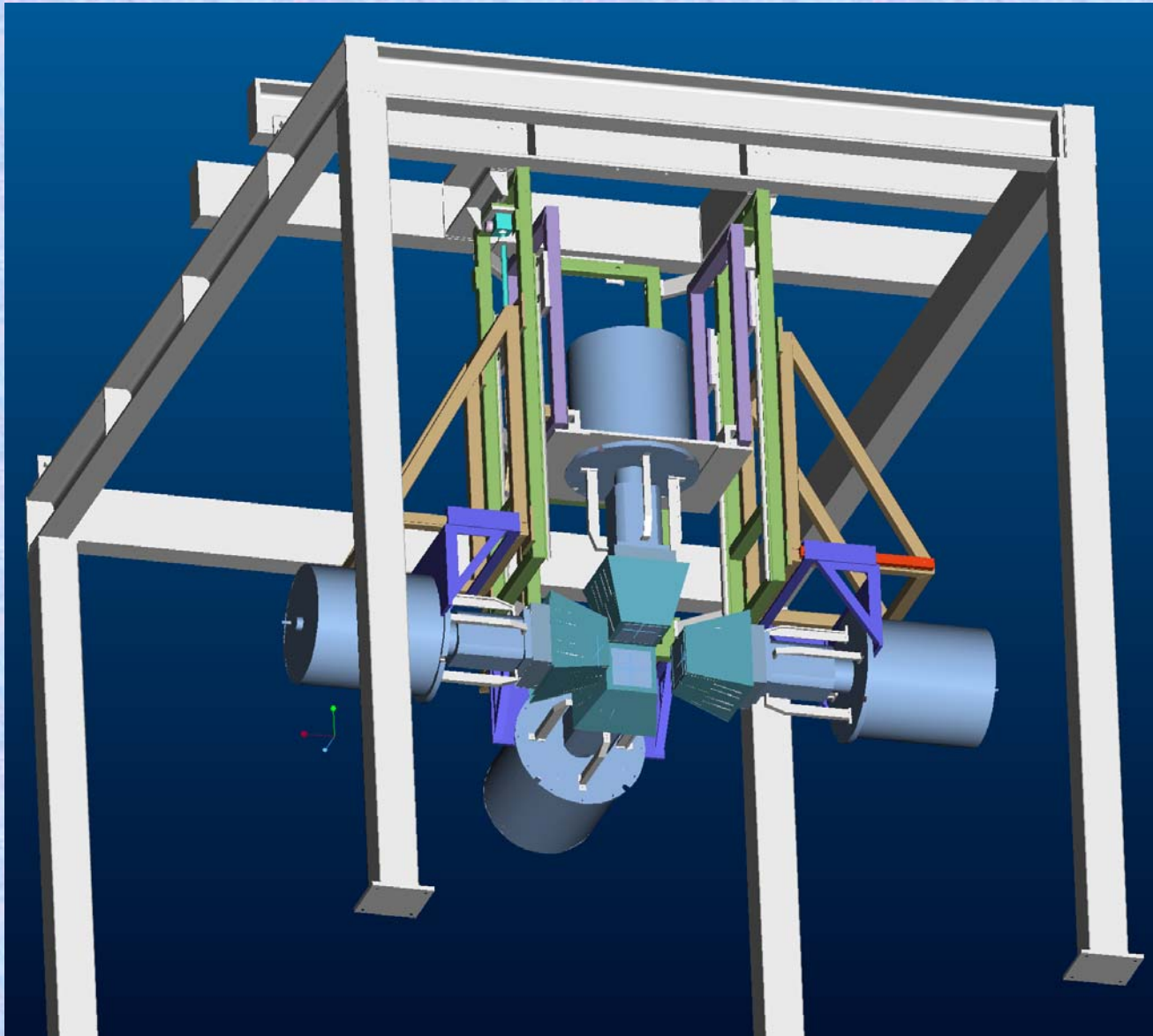


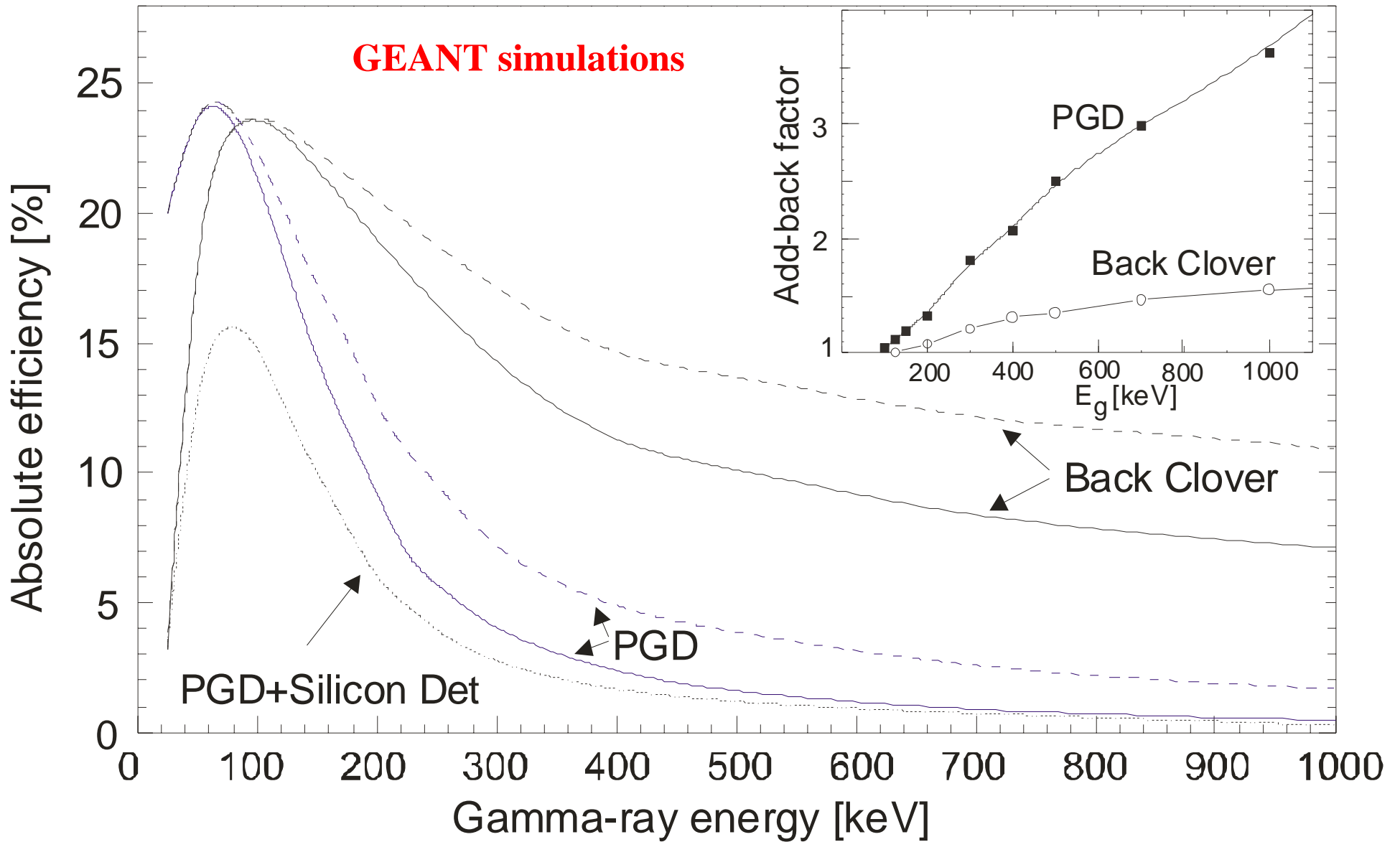
**15 Clusters all at 245mm
5 at 39°, 5 at 79°, 5 at 141°**

Total efficiency 15.7% (Cluster 13.0% Clovers 2.7%)

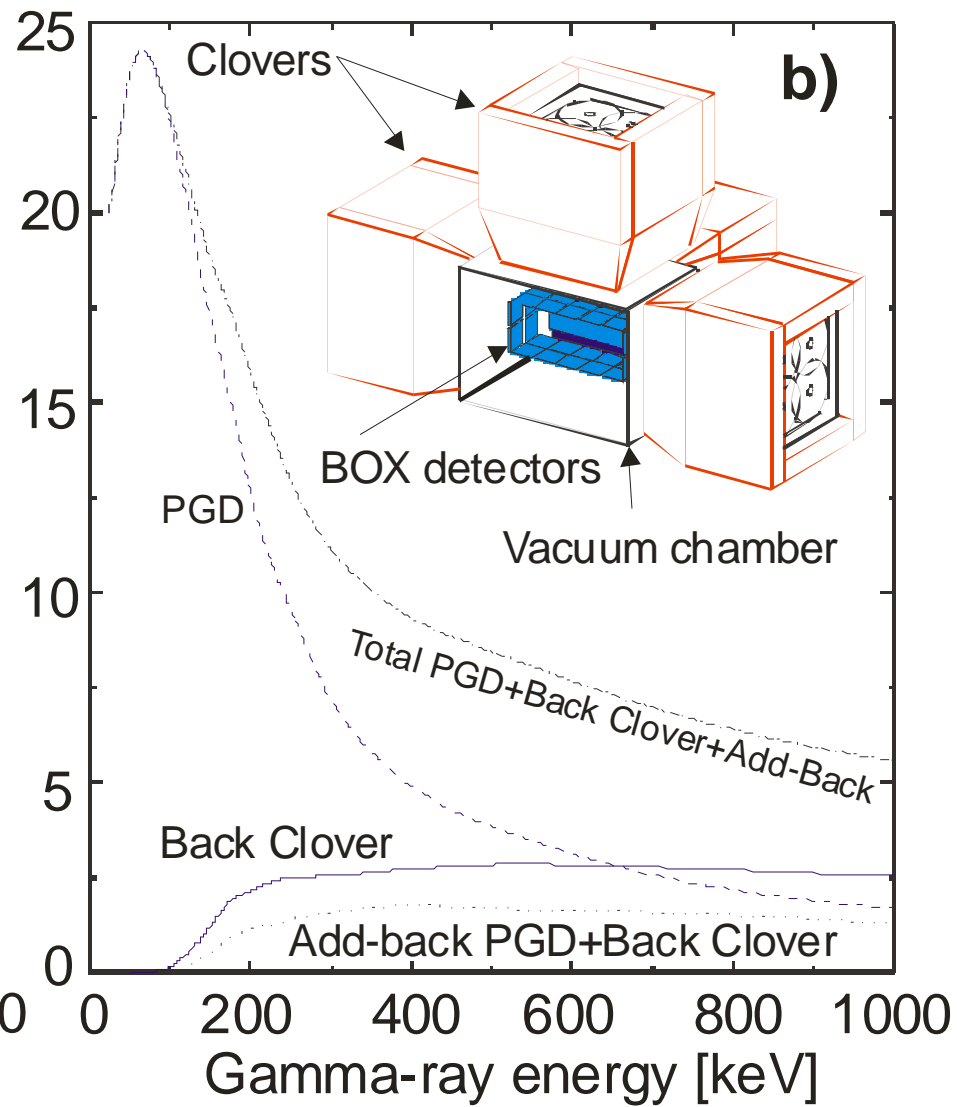
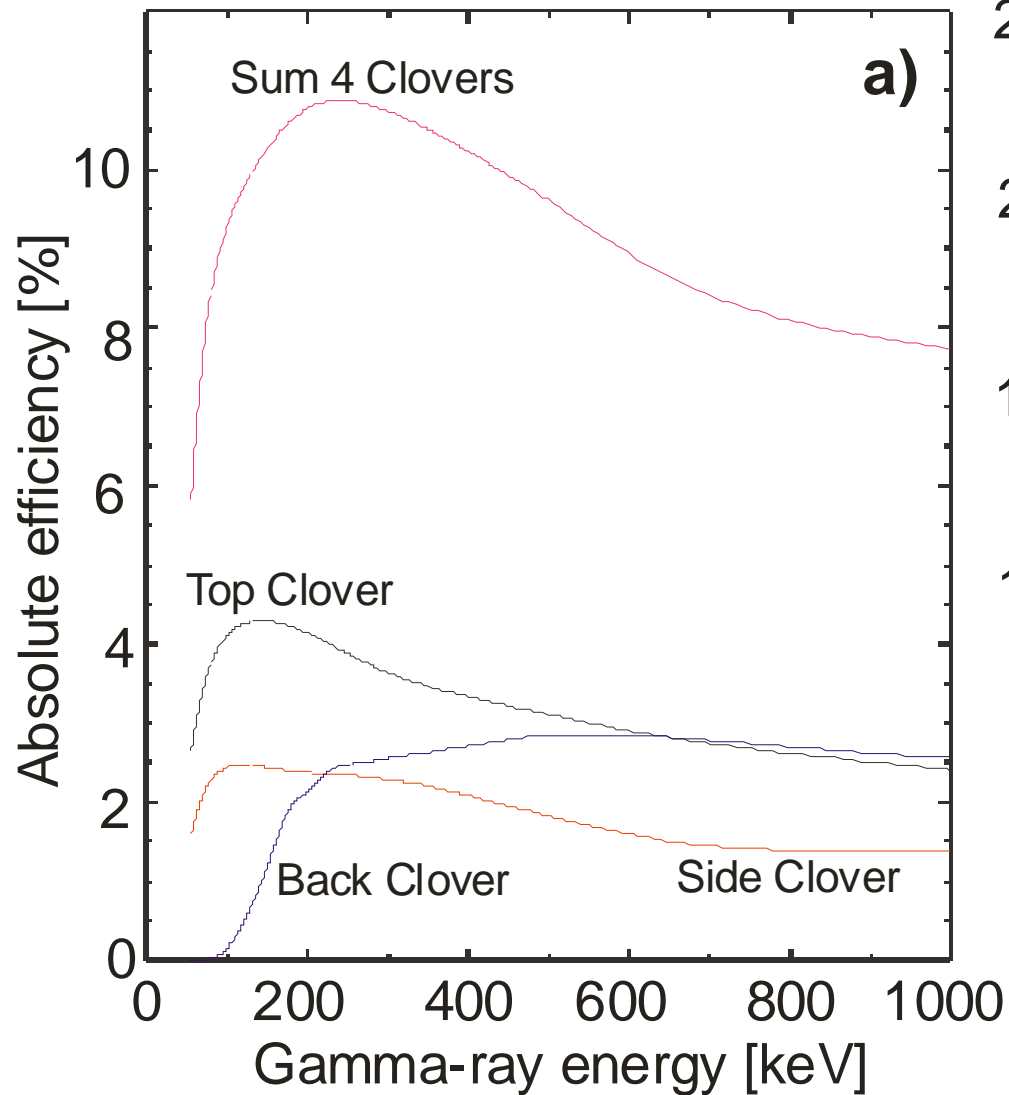
**25 Clovers all at 320mm
15 at 108°, 5 at 72°, 5 at 90°**

Clover Ge support structure



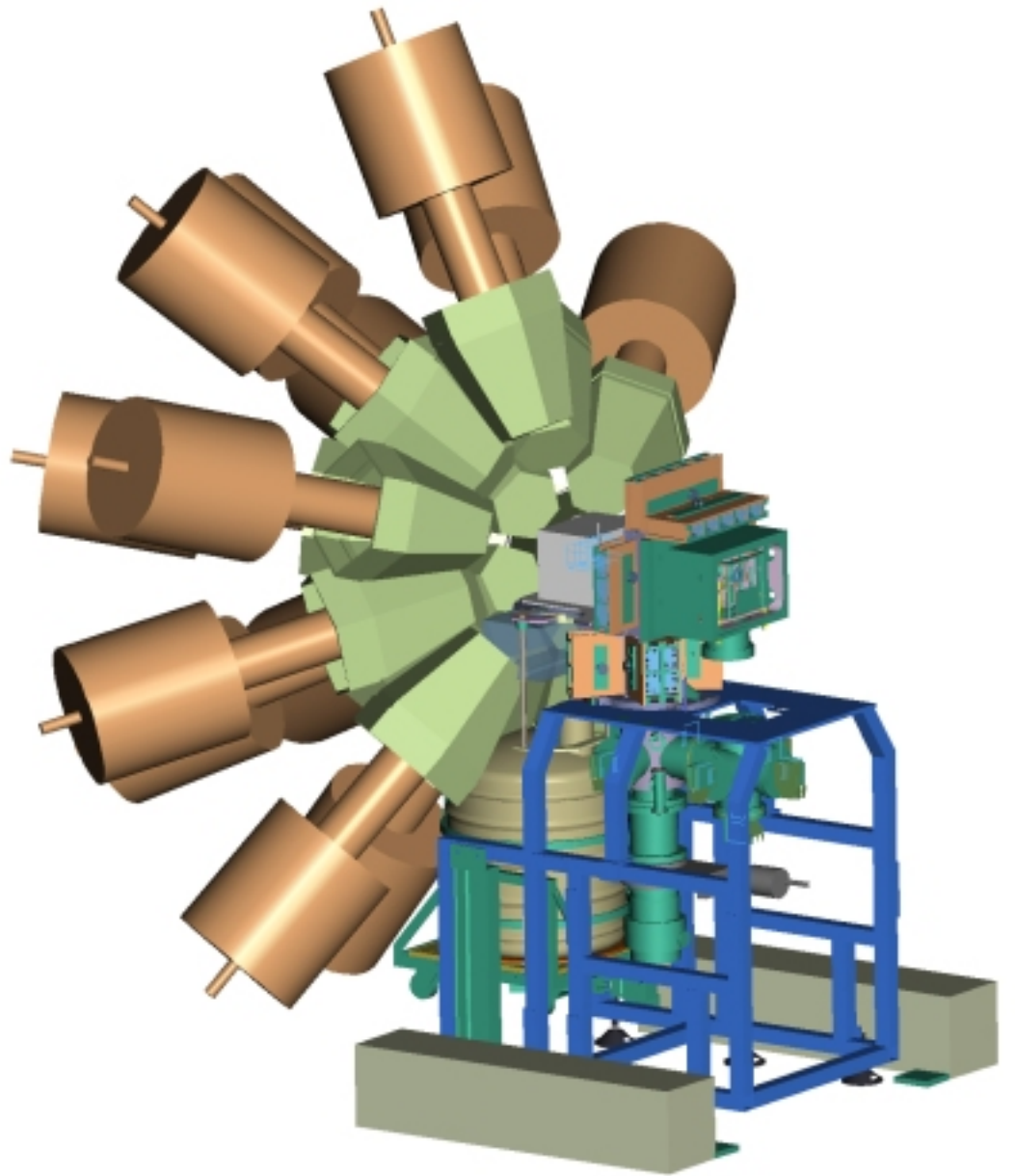


DSSD to Clover 10 mm closest geometry (no planar)



DSSD to back Clover 55 mm closest geometry

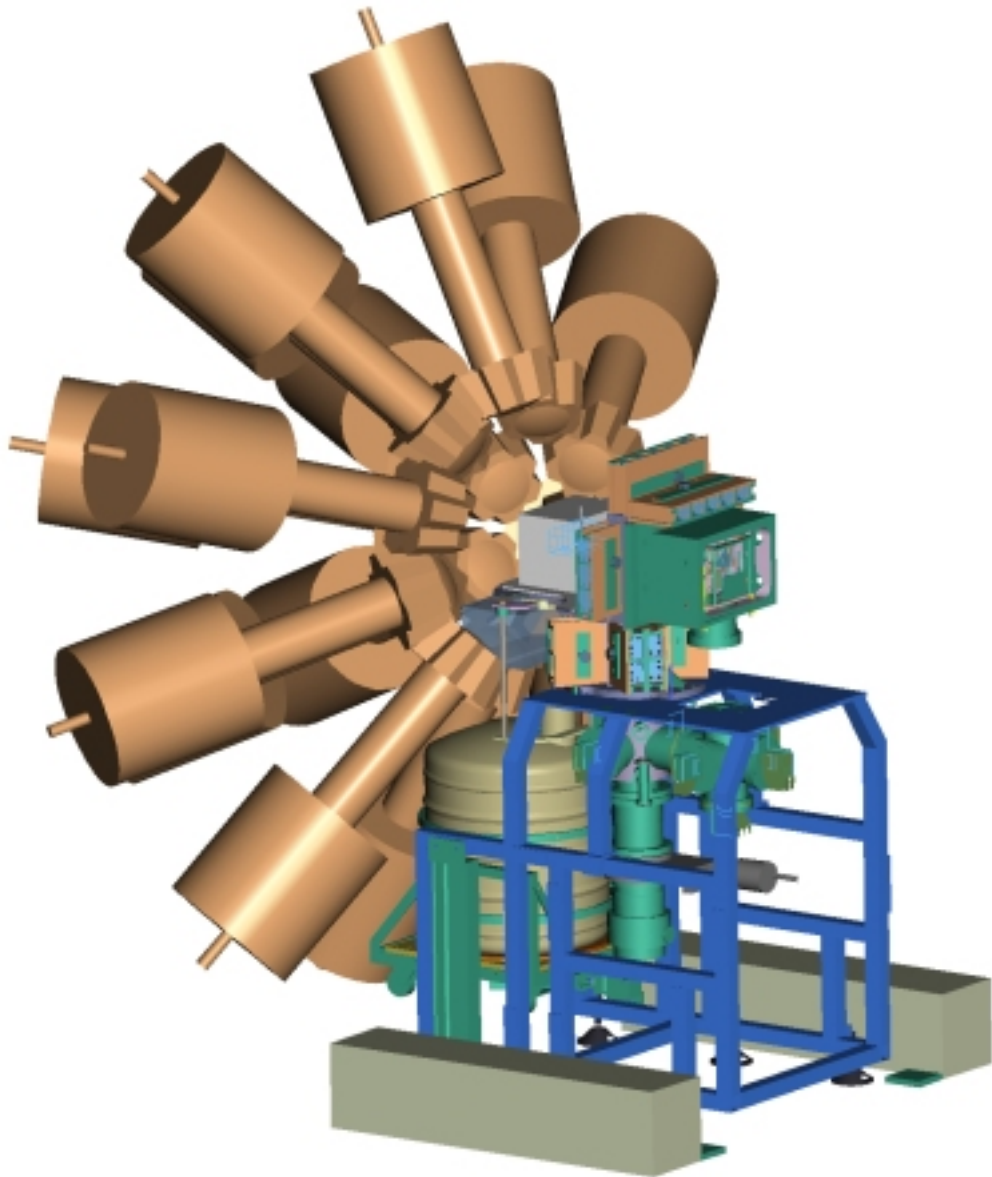
15 Clusters with shields behind GREAT



Design not optimised
Specification required
Could use Euroball geometry

$d = 410\text{mm}$ (centre of DSSD)
 $\varepsilon = 5.1\%$ @ 1.3 MeV
(from scaling not GEANT!)
Can go closer

15 Clusters without shields behind GREAT



Design not optimised
Specification required
Could use Euroball geometry

$d = 330\text{mm}$ (centre of DSSD)
 $\varepsilon = 7.6\%$ @ 1.3 MeV
(from scaling not GEANT!)
Can go closer

Stopped beam set-up

Rising detectors are heavy and expensive

A few set-ups as possible

Active or passive, same mechanical set-up?

Size of the focal plane?

Timescale short beams in autumn 2005

For Ge detectors if new mechanics and design required

6 months manufacture and assemble

6 months design

Need to specify as soon as possible!