Conceptual design of the Ge detector array (DEGAS) for the DESPEC experiment

M. Doncel, B. Cederwall

Royal Institute of Technology (KTH), Stockholm, Sweden

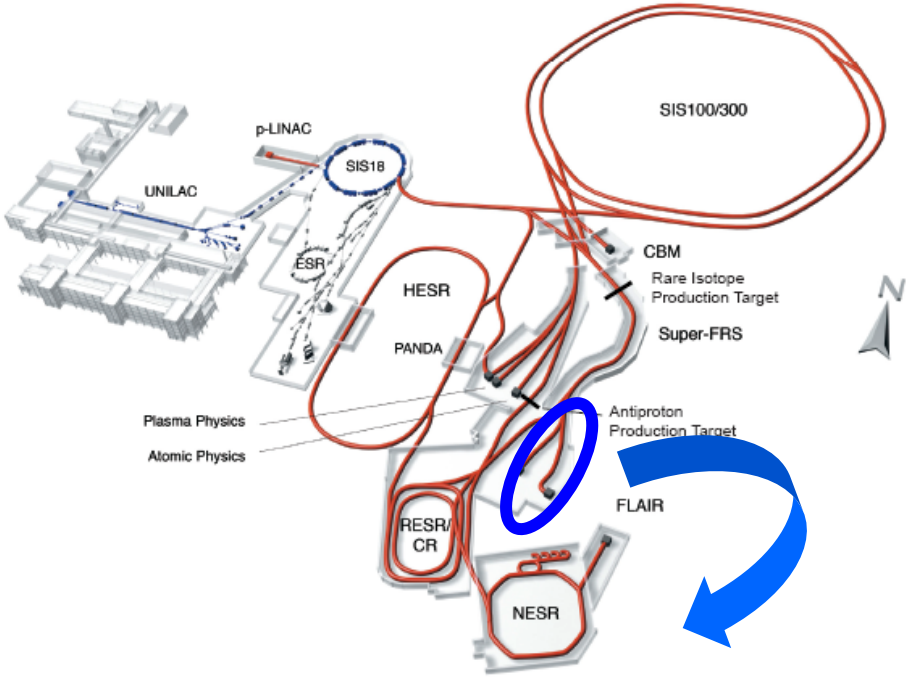
ROYAL INSTITUTE OF TECHNOLOGY

Decay studies of exotic nuclei at FAIR

ROYAL INSTITUTE OF TECHNOLOGY

FAIR (*Facility for Antiproton and Ion Research*)
NUSTAR (*NUclear STructure Astrophysics and Reactions*)

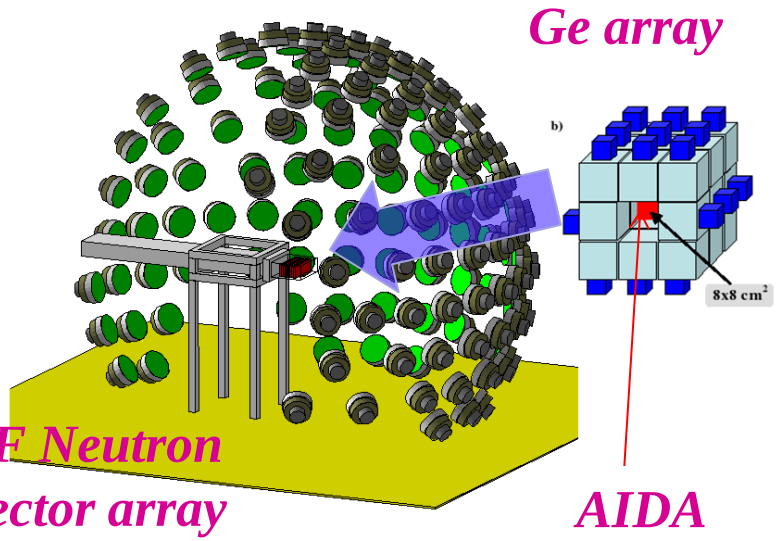
Super-FRS: *In Flight separator* producing beam species ranging from H to U with high intensities; antiproton beams up to 20 GeV and heavy-ion beams up to 30 GeV/nucleón.



Low Energy Branch → **DESPEC Experiment**

The DESPEC experiment

DEcay SPECtroscopy experiment at the Super-FRS of FAIR at GSI

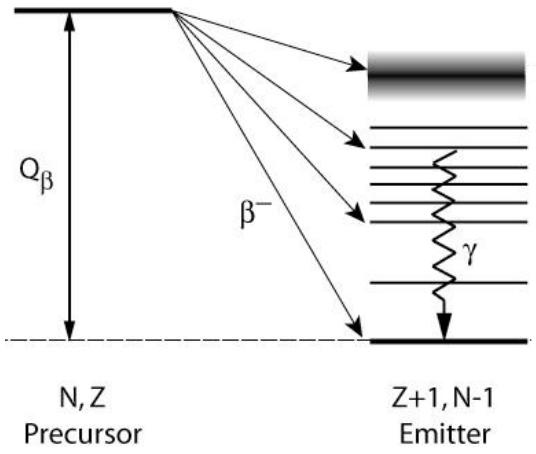


Due to the capabilities of the Super-FRS is possible to measure neutron-rich exotic nuclei with short half lifes ($T_{1/2}$>100 ns).

Experiments proposed for DESPEC:

- Beta decay experiments
- Isomer decay experiments

High gamma efficiency, background reduction and good energy and position resolution required.



Staged development of the Ge array: DEGAS

ROYAL INSTITUTE OF TECHNOLOGY

Initial technical proposal based on planar detectors

Replaced by staged development

1st phase: ***Upgrade of the existing RISING set-up***

based on EUROBALL cluster detectors

2nd phase: ***+ AGATA type detectors (1st order imaging)***

3rd phase: ***Full imaging array (long term goal)***

Possibility of Integrated Ge implantation detector

TDR submitted in August

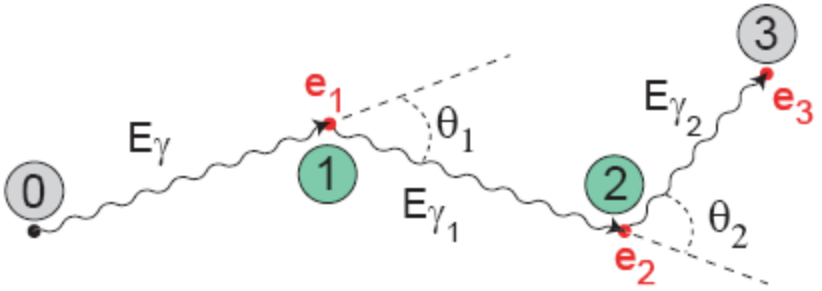
Tracking & imaging concepts

ROYAL INSTITUTE OF TECHNOLOGY

Tracking: Reconstruct the path of γ rays to improve P/T and background reduction.

Requirements:

1. Good energy and position resolution.
2. High granularity.

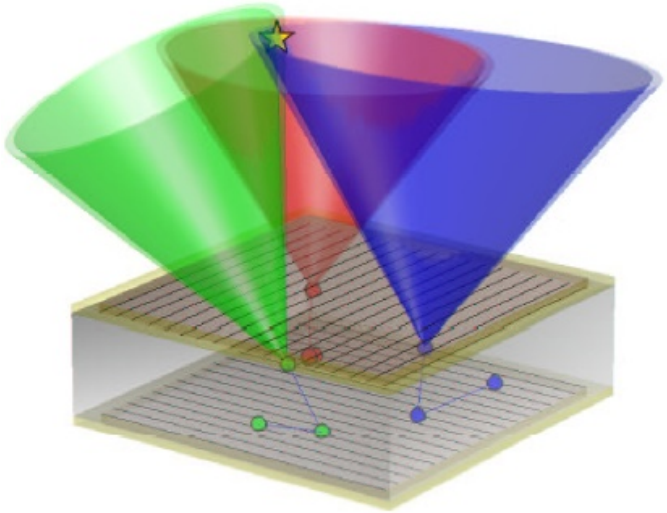


Full imaging:

Reconstruct the origin of the γ ray in the implantation plane for the isomeric decay.

Requirements:

1. Good energy and position resolution.
2. High granularity.
3. Large separation between Ge in the stacks (increase average distance between interactions)



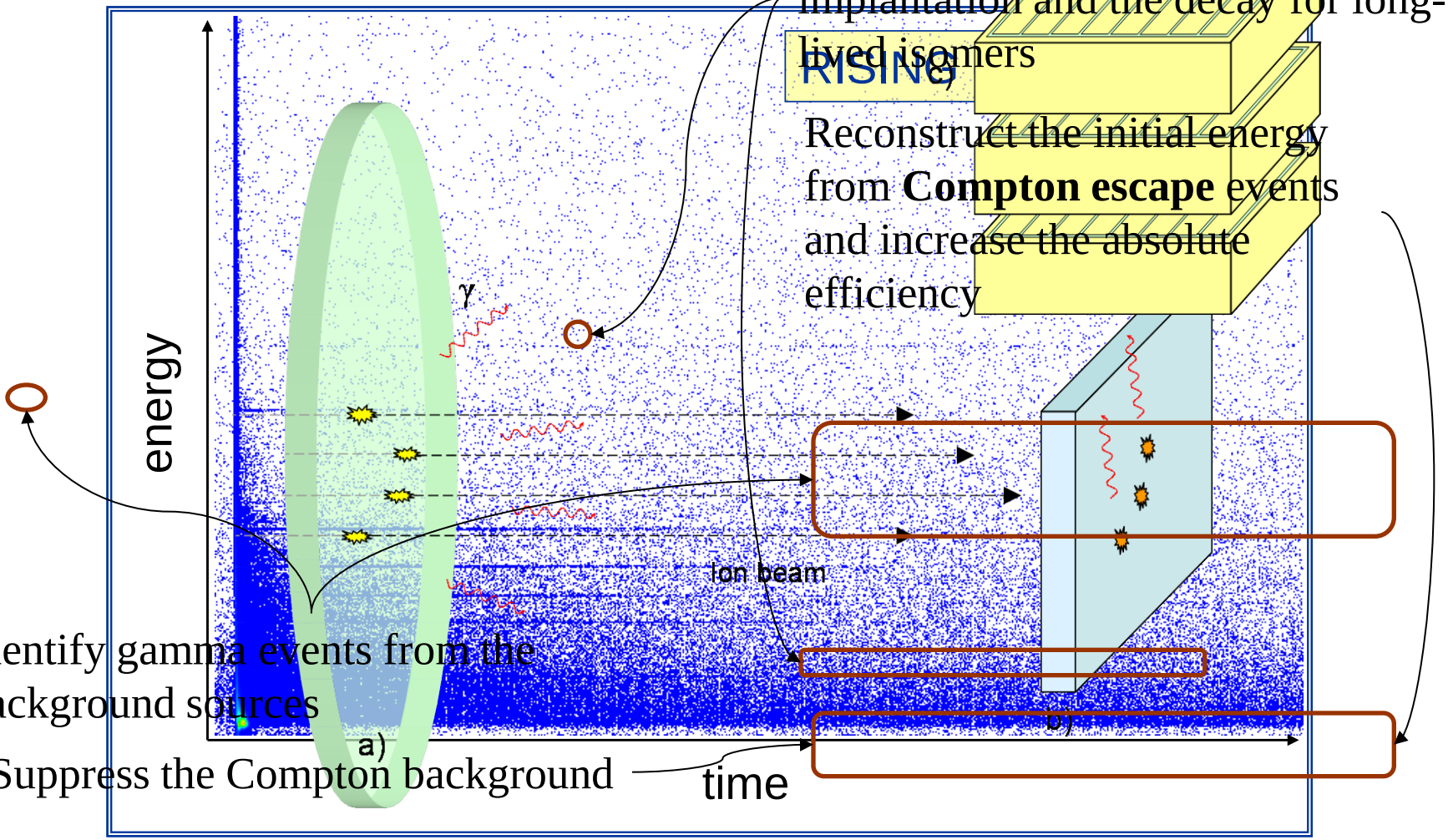
Background suppression for tagging of γ rays in isomeric and radioactive decays

ROYAL INSTITUTE OF TECHNOLOGY

Improve the correlation between the implantation and the decay for long-lived isomers

RISING

Reconstruct the initial energy from **Compton escape** events and increase the absolute efficiency



Identify gamma events from the background sources

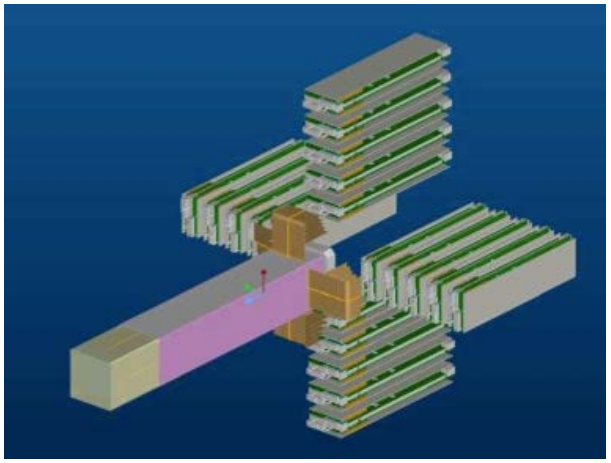
Suppress the Compton background

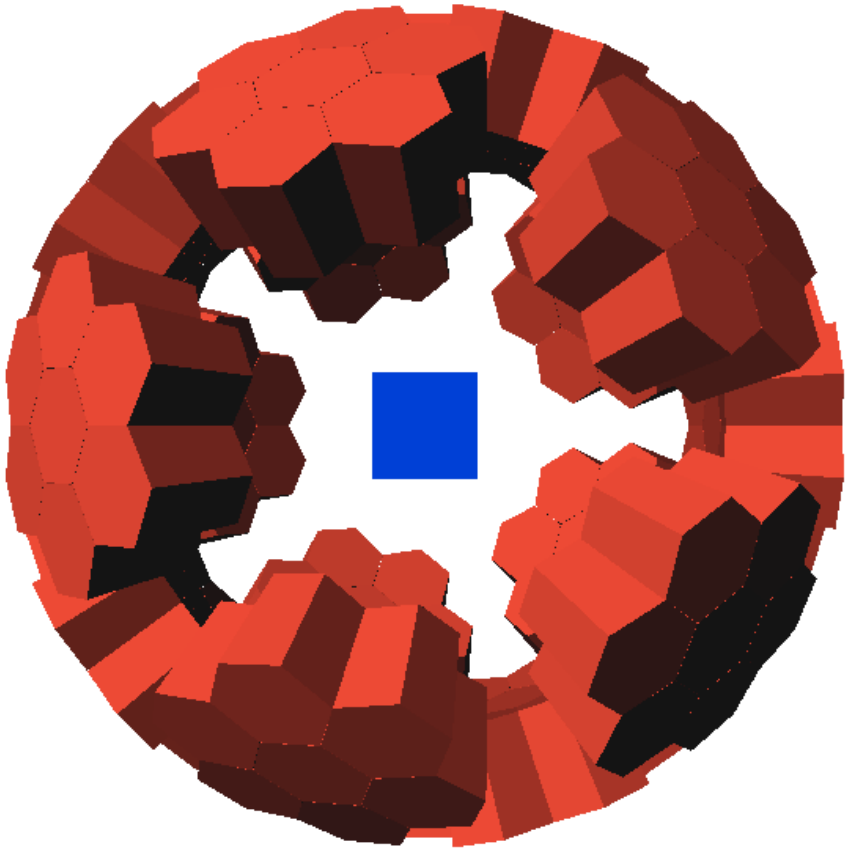
“Phase 0” RISING stopped beam setup “Benchmark configuration”

ROYAL INSTITUTE OF TECHNOLOGY

15 EUROBALL clusters of seven capsules (in total 105) at nominal position (22 cm from center of AIDA)

DSSSD of 80*80*1 mm^3 surrounded by an Al housing of 1 mm of 100*100 mm^2

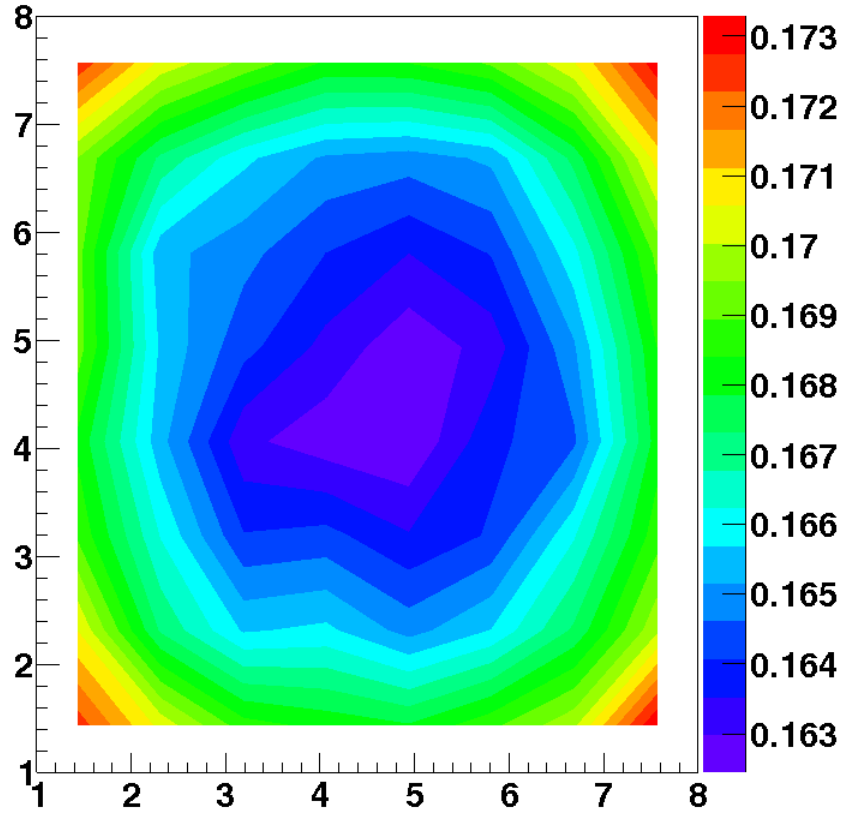




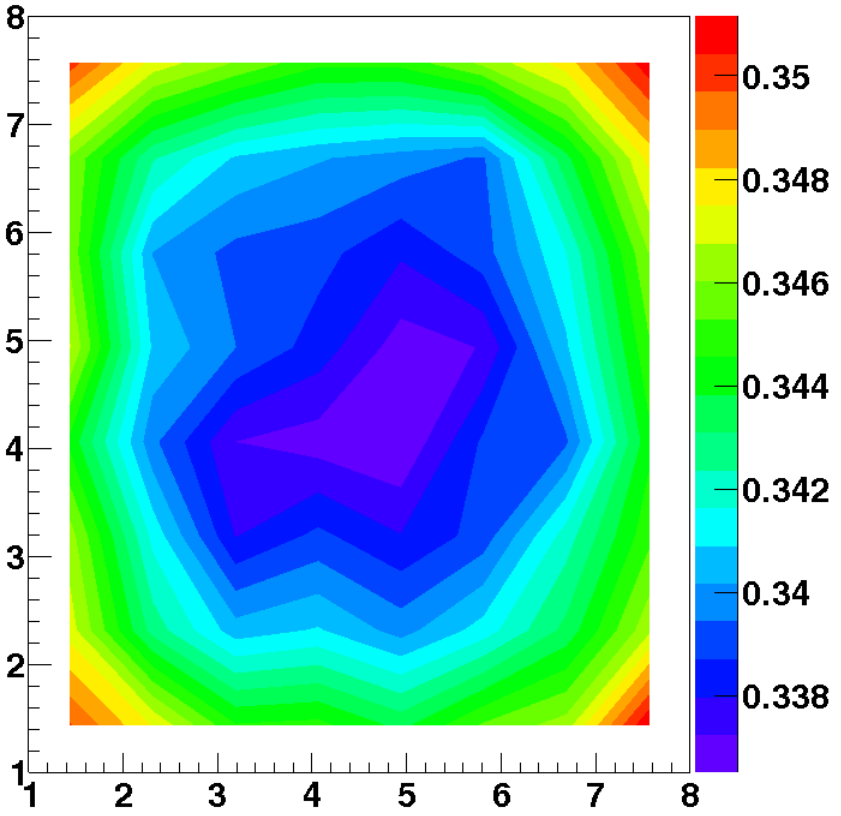
RISING stopped beam setup as a benchmark (Phase 0) – results from G4 simulations

ROYAL INSTITUTE OF TECHNOLOGY

Peak Efficiency



P/T



E = 1.332 MeV

“Phase 1” based on EUROBALL cluster detectors

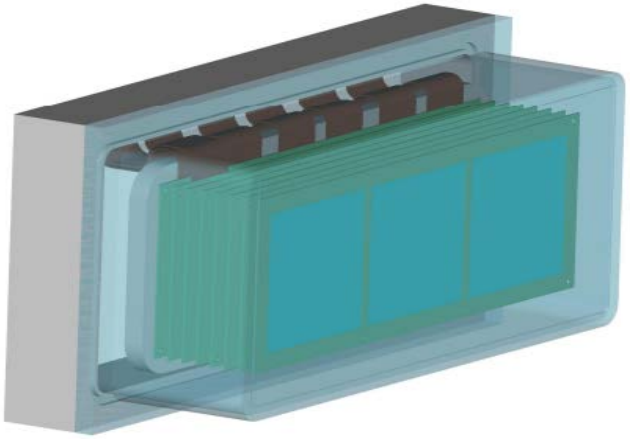
ROYAL INSTITUTE OF TECHNOLOGY

Implantation plane:

- ***“cocktail mode”*** AIDA: 24*8 cm^2

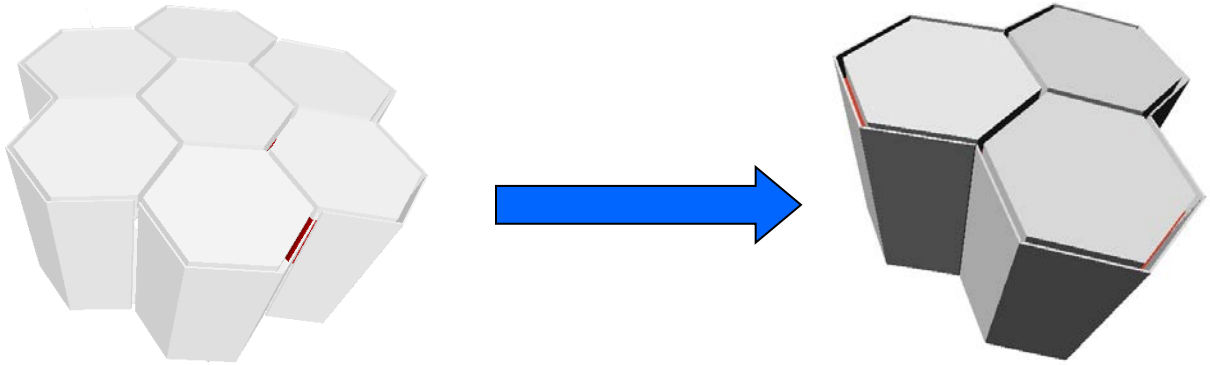
many isotopes measured simultaneously

- ***“high efficiency mode”*** AIDA: 8*8 cm^2



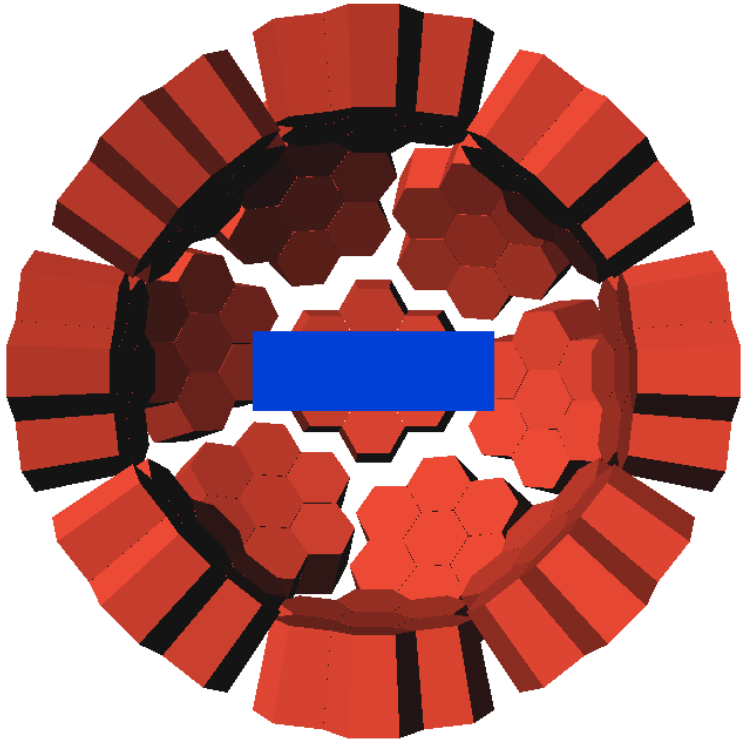
AIDA (cocktail mode)

Re-arrangement of seven-EUROBALL clusters in triple-cluster detectors to increase the solid angle coverage of the implantation plane



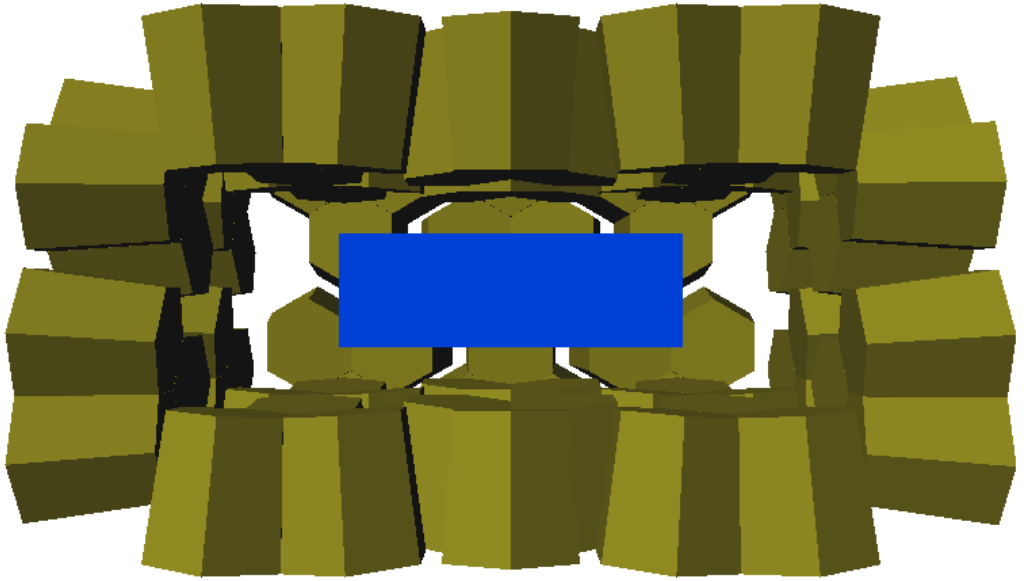
“Phase 1” based on EUROBALL cluster detectors

ROYAL INSTITUTE OF TECHNOLOGY



35 EUROBALL seven clusters (105 capsules) placed in a compact half sphere geometry close to the AIDA plane

26 EUROBALL triple clusters (78 capsules) in a box geometry



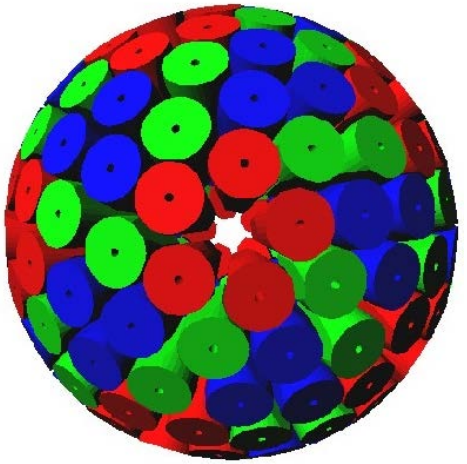
“Phase 2” based on EUROBALL detectors coupled to AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

Advanced GAmma Tracking Array (AGATA) type detectors in DESPEC

- AGATA is a 4π highly segmented γ-spectroscopy system built by an European collaboration. It consists of 180 Ge detectors in the full configuration
- AGATA is designed to optimally exploit experimental conditions at HISPEC
- It has been realized that AGATA type detectors are needed at DESPEC

- ε larger than 40% for M=1 and larger than 25% for M=30
- P/T around 60% for M=1
- Position resolution better than 5 mm FWHM
- High granularity to improve the Doppler correction

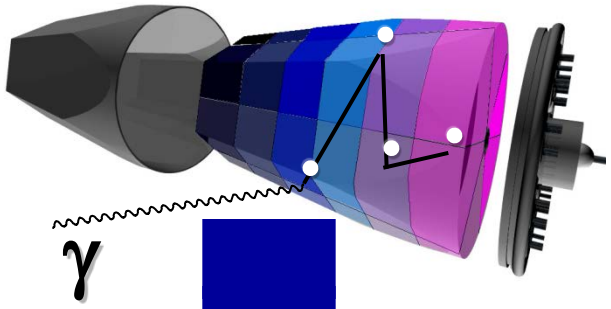


“Phase 2” based on EUROBALL detectors coupled to AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

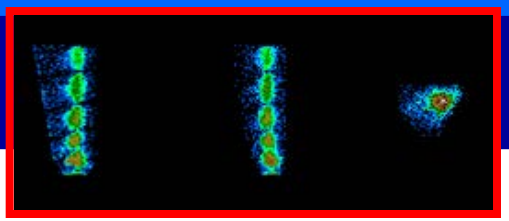
Highly segmented

HPGe detectors



Synchronized digital electronics

record and process the segment signals

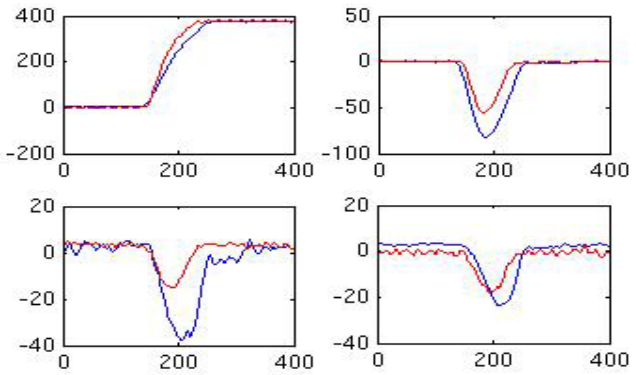


Identified

interaction points

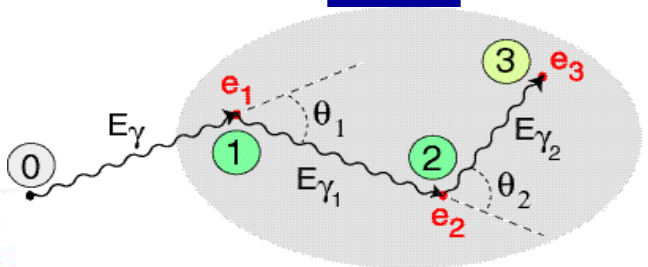
$(x,y,z,E,t)_i$

Pulse Shape Analysis to de-convolute the recorded waves



Reconstruction of interaction tracks

(tracking algorithms on interaction points)

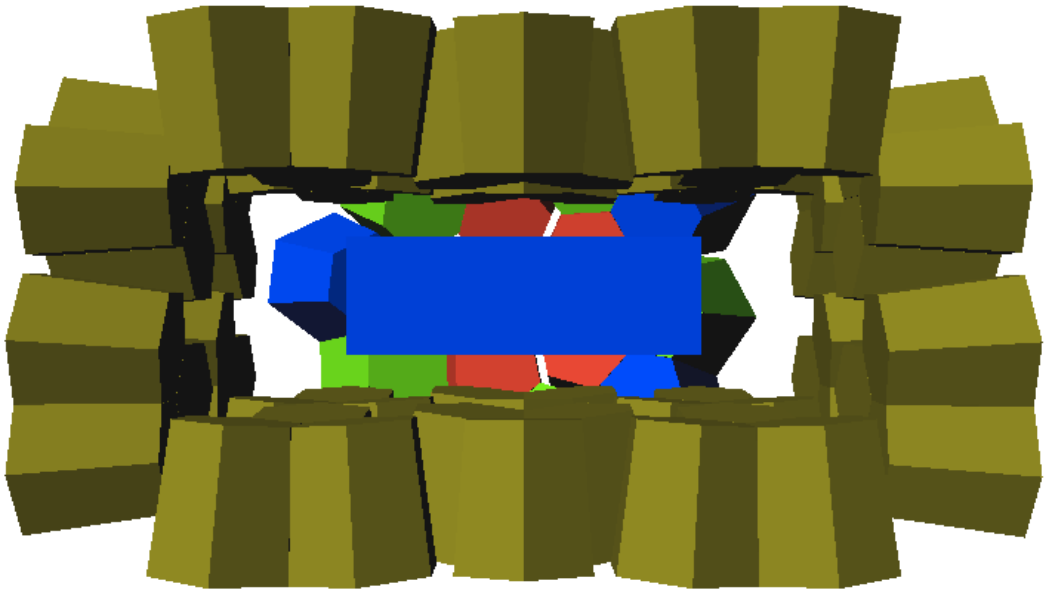


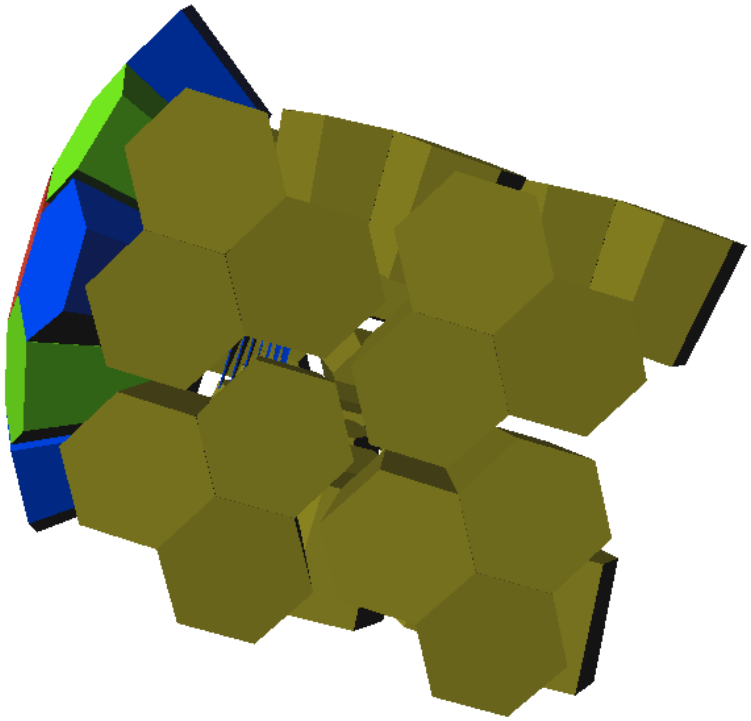
On-line reconstruction of γ-rays

“Phase 2” based on EUROBALL detectors coupled to AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

20 EB triple cluster detectors coupled to 5 ATC (replacing the 6 EB triple cluster detectors (end-cap) located downstream)



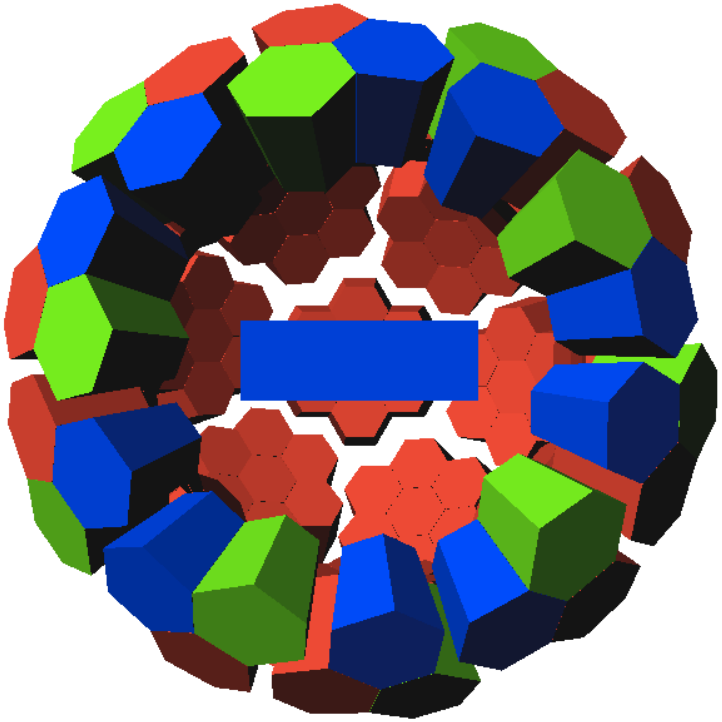


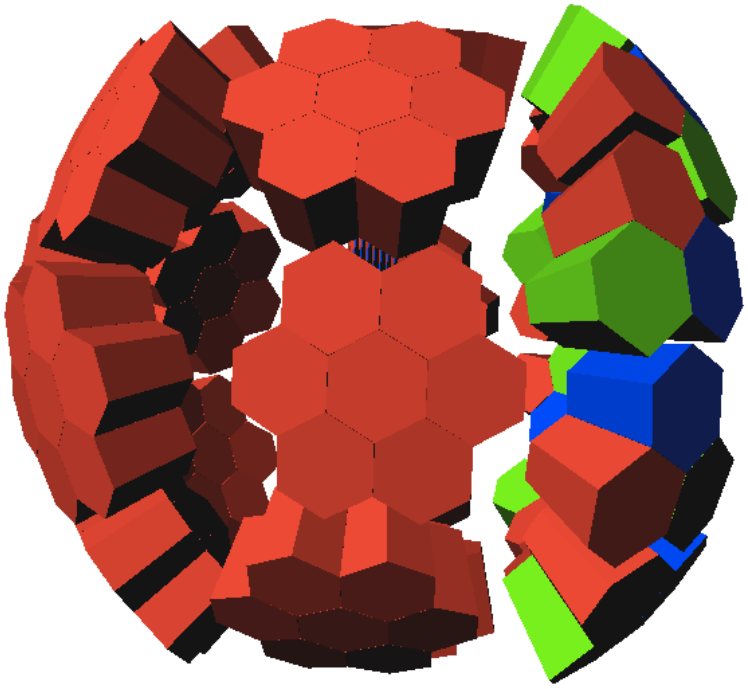
“Phase 2” based on EUROBALL detectors coupled to AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

Other interesting geometries:

Phase 1 coupled with AGATA triple clusters: Maximum coupling performed with 10 AGATA triple clusters for AIDA long configuration



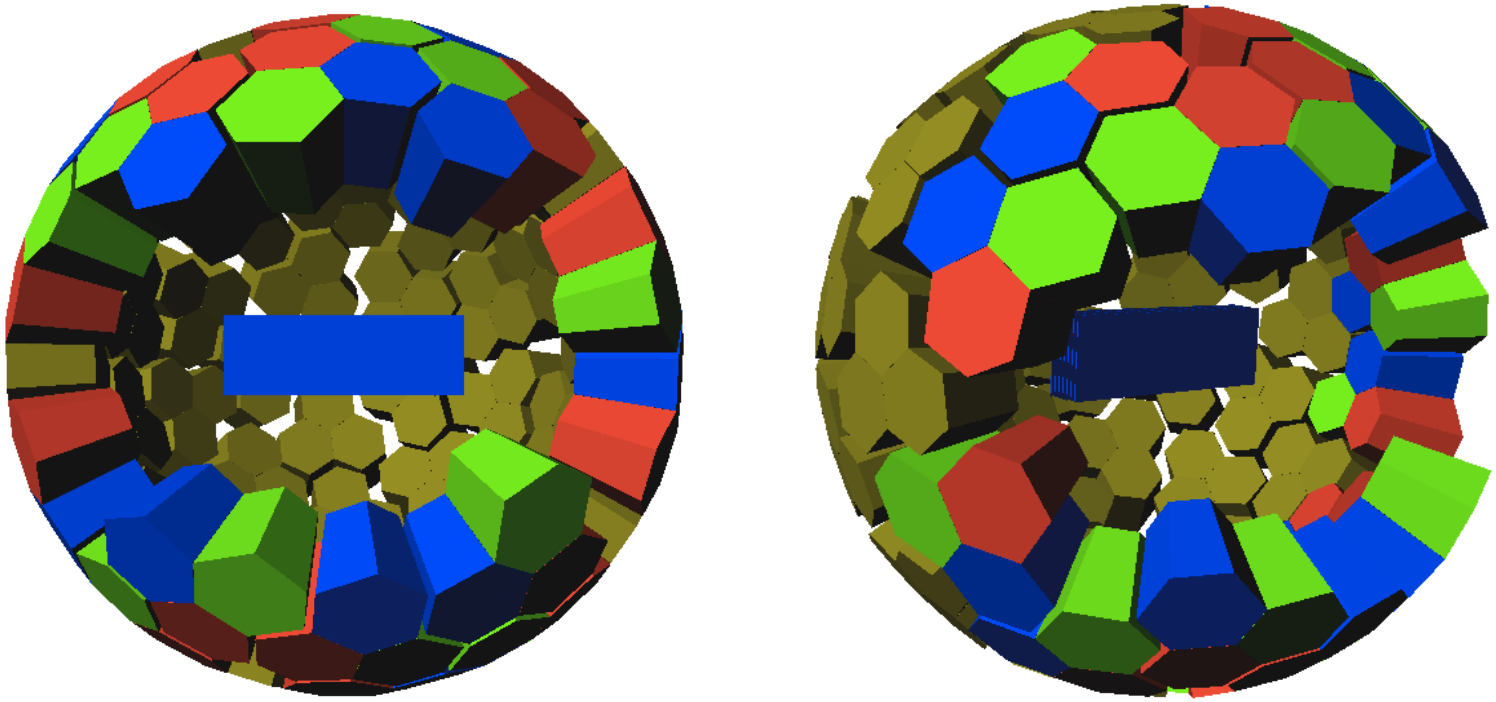


“Phase 2” based on EUROBALL detectors coupled to AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

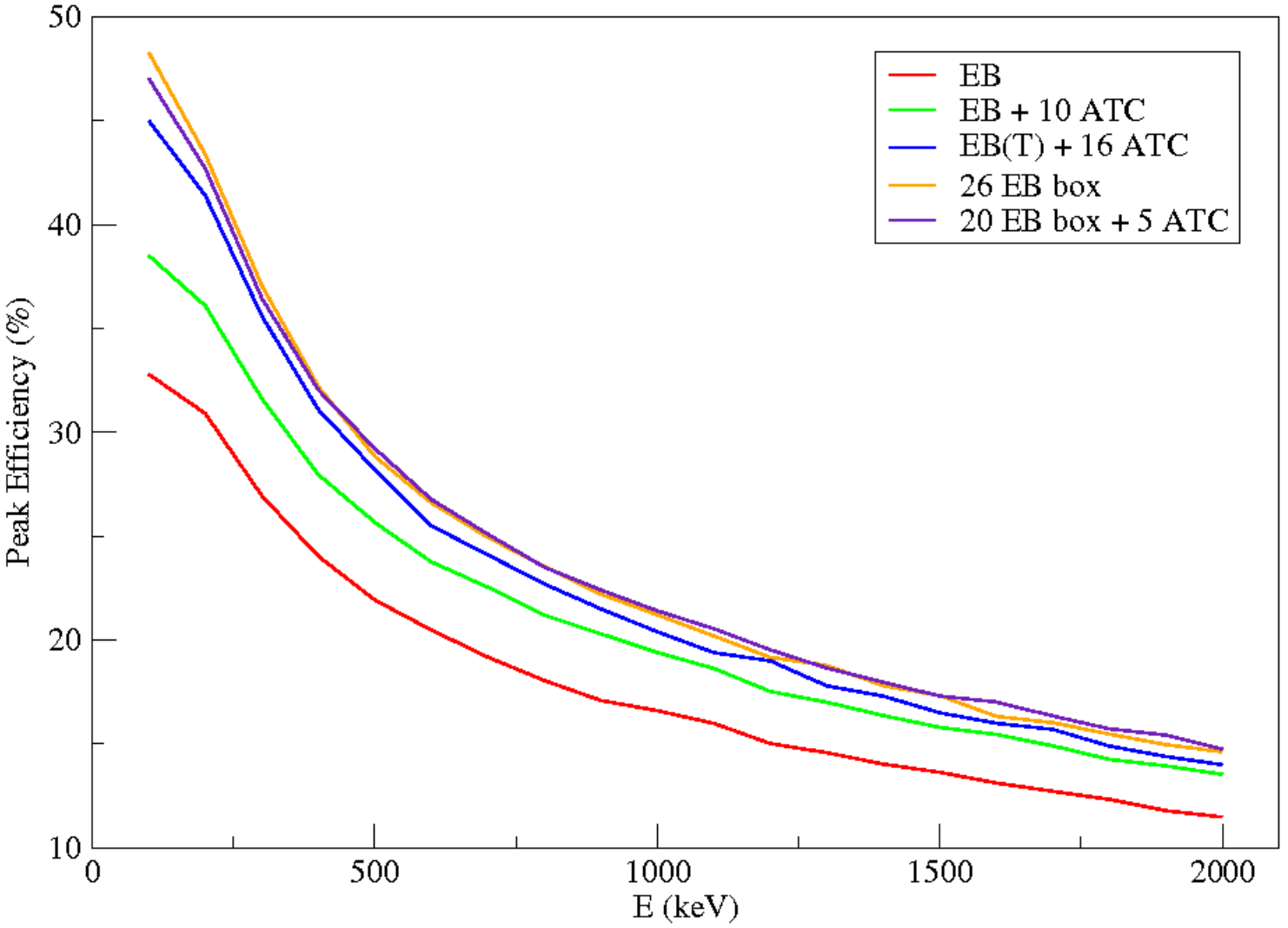
Other interesting geometries:

Re-arrangement of Phase 1 in 35 EUROBALL triple clusters (105 capsules) coupled with 16 AGATA triple clusters.



Summary of G4 results (1.3 MeV)

ROYAL INSTITUTE OF TECHNOLOGY



Summary of G4 results (1.3 MeV)

ROYAL INSTITUTE OF TECHNOLOGY

GEOMETRY	ε_p (%)	$\varepsilon_{p\gamma\gamma}$ (%)	$\varepsilon_{p\text{-eff}}$ (%)
RISING (benchmark)	16.2	2.2	13.9
26 Triple EB clusters (box)	21.2	4.1	≈ 15
20 Triple EB clusters (box) + 5 ATC	21.4	4.2	≈ 19
Phase I (seven-fold) + 10ATC (incl. AGATA)	19.4	3.3	
Phase I (Triples) + 16 ATC (incl. AGATA)	20.4	3.6	

Background reduction with AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

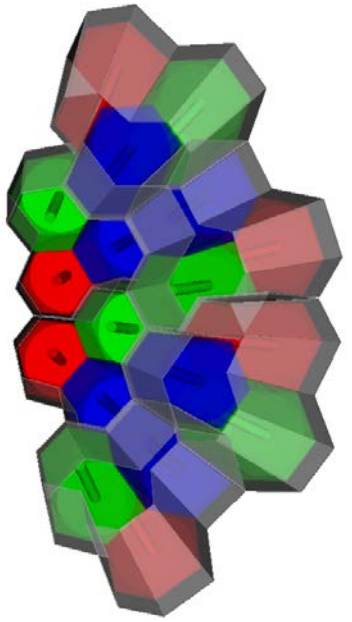
OFT (Orsay Forward Tracking) code

A. Lopez-Martens et al., Nucl. Instr. and Meth. A 533, 454 (2004)

Reconstruction of the interaction positions of the γ ray in the detector. Therefore, those γ rays not completely absorbed in the detector can be rejected leading to an increase in the P/T value and therefore, supressing the background.

Optimized code to enhance the background capablity of the system keeping a high tracking efficiency.

Applied to 6 AGATA Triple Clusters



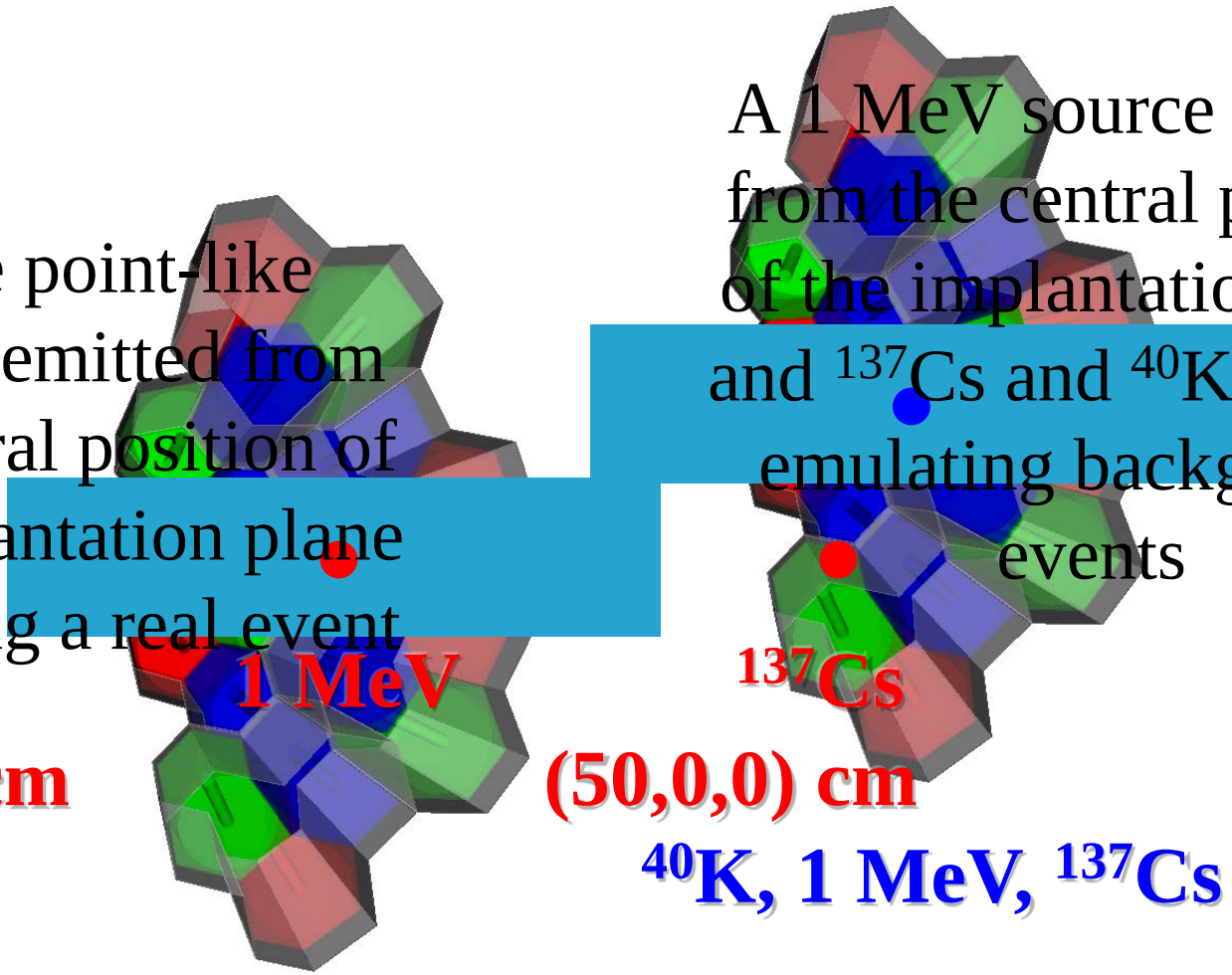
Background reduction with AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

Two different data sets:

2)

Three point-like sources emitted from the central position of the implantation plane emulating a real event



A 1 MeV source emitted from the central position of the implantation plane and ^{137}Cs and ^{40}K sources emulating background events

^{40}K, 1 MeV, ^{137}Cs

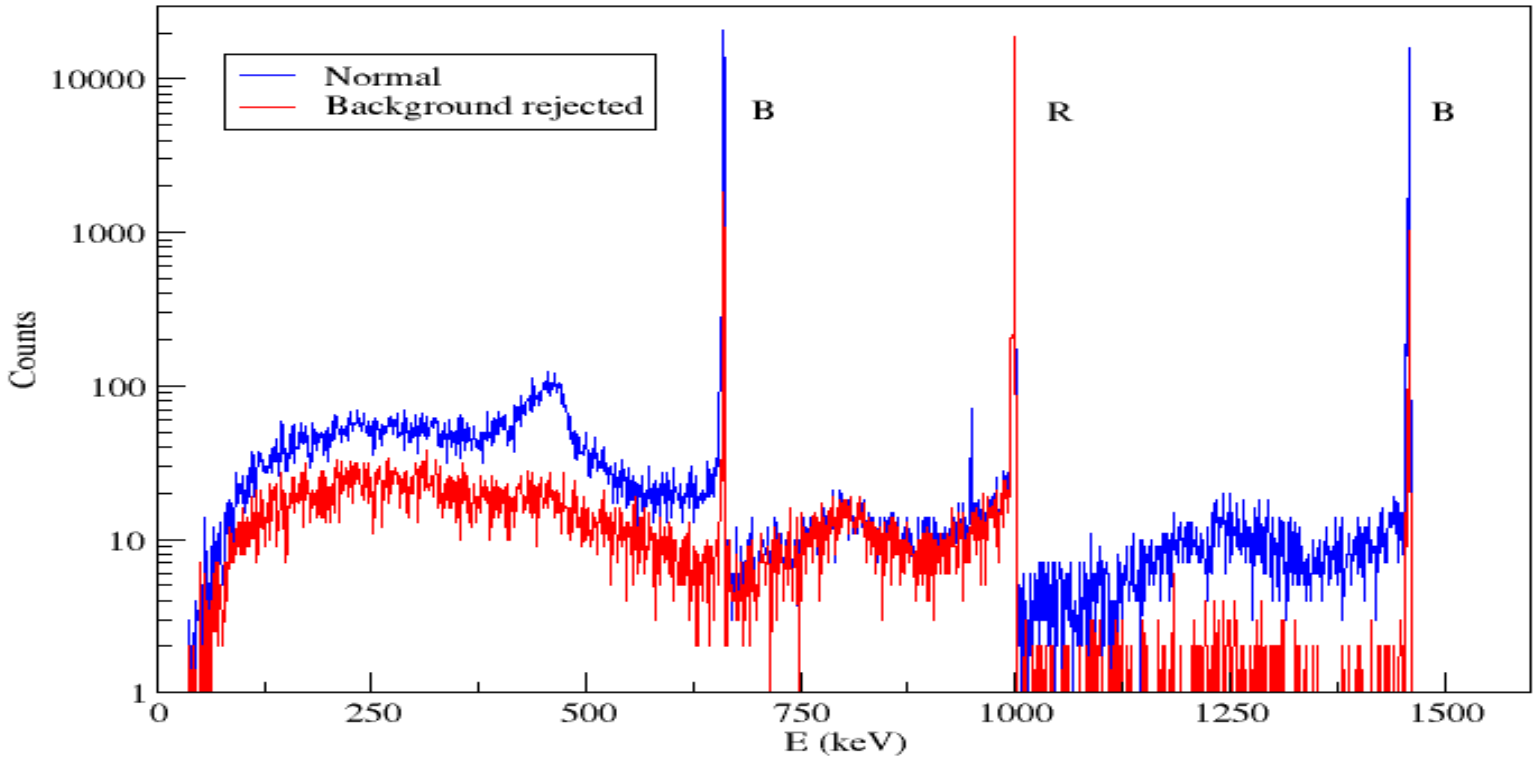
Background reduction with AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY

^{137}Cs, 1 MeV and ^{40}K sources at (0,0,0)

^{137}Cs, 1 MeV and ^{40}K sources at (50,0,0), (0,0,0) and (-50,0,0) cm, respectively.

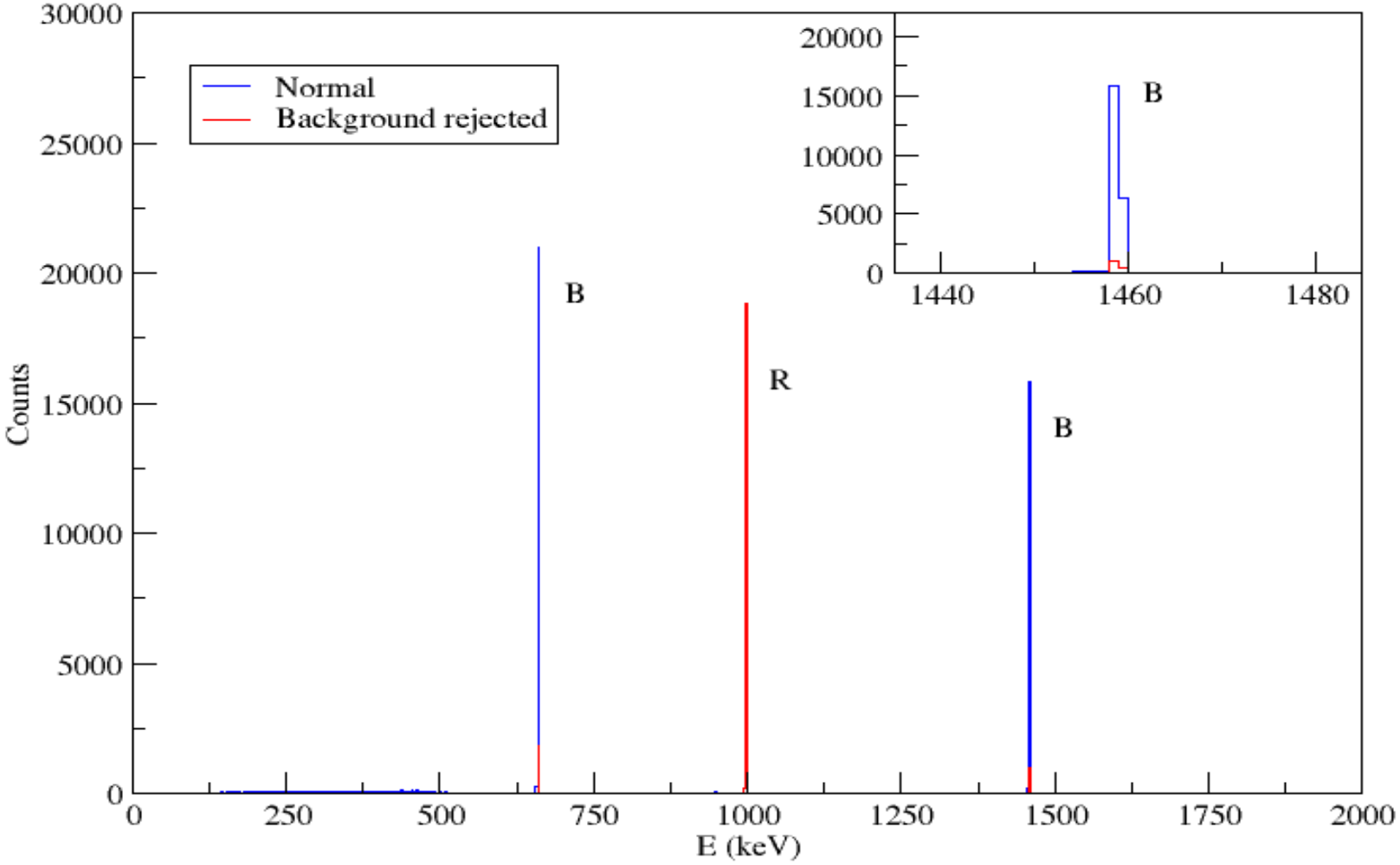
Both types of events tracked as coming from (0,0,0)



Background rejection factor ~ 3

Background reduction with AGATA detectors

ROYAL INSTITUTE OF TECHNOLOGY



Background rejection factor ~ 3

Conclusions

ROYAL INSTITUTE OF TECHNOLOGY

TDR already submitted

- *Physics requirements*
- *Conceptual design simulations and detector description*
- *Electronics, infrastructure and installation procedure*
- *Integration with other subsytems of HISPEC-DESPEC*
- *Costing*

To do list…

- *MC Simulation for a "real experimental case" using advanced event generators*
- *R&D based on Compton imaging for the third phase of DEGAS*

Thank You!!!