Simulation on the DEGAS array

Guang-Shun LI &
Cesar Lizarazo

Gammaspektroskopie
GSI Helmholtzzentrum für Schwerionenforschung GmbH

Outline

1 Research motivation

2 Examining the simulation framework

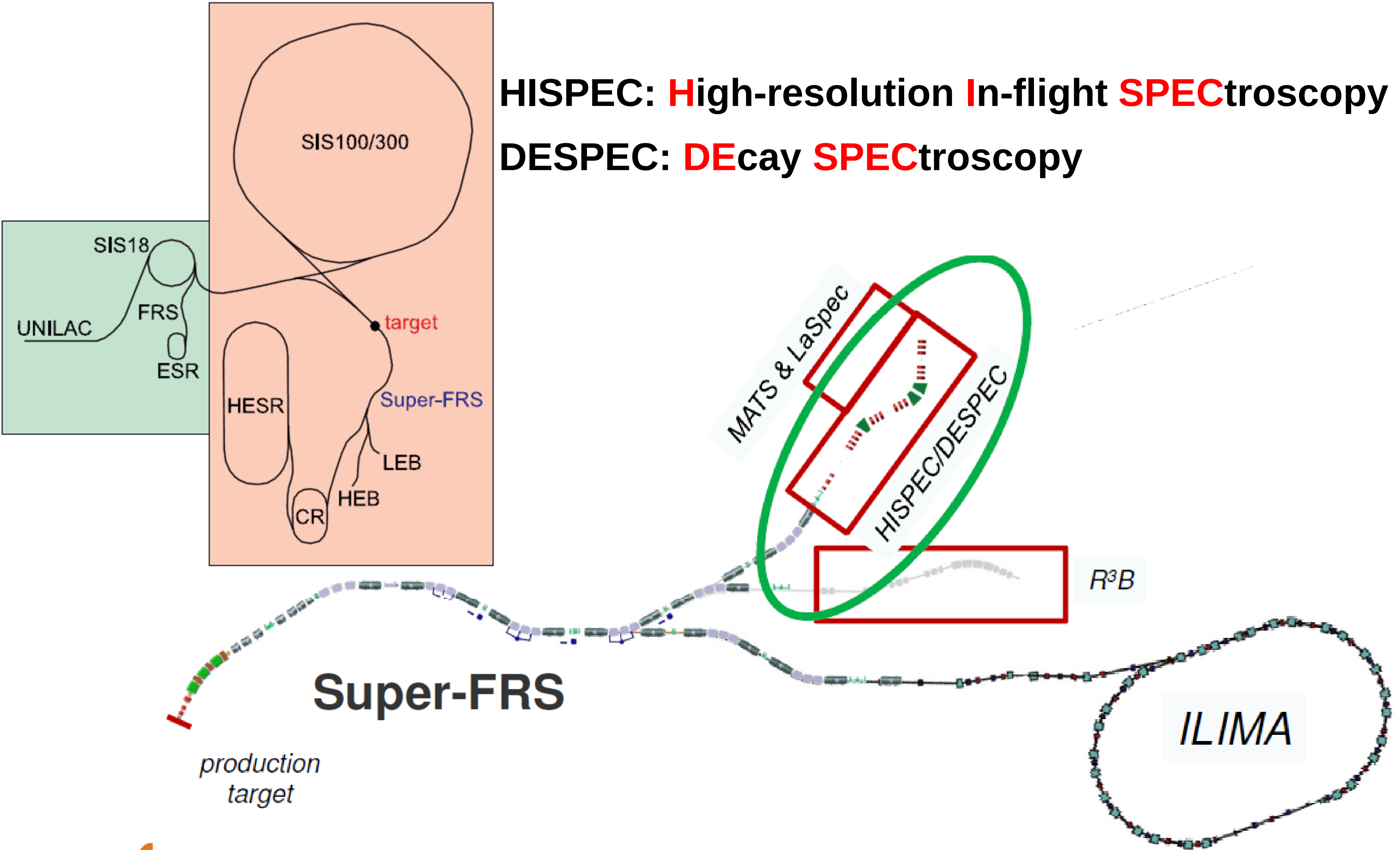
3 Simulation on the DEGAS

4 Summary

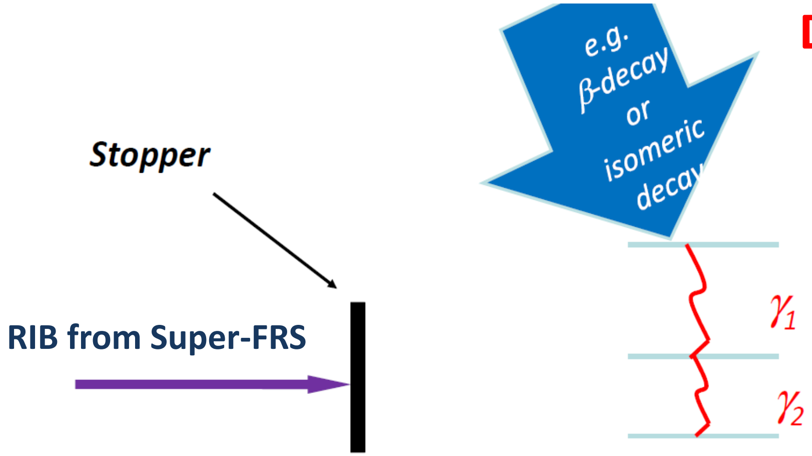
HISPEC/DESPEC program at the NUSTAR project

HISPEC: High-resolution In-flight SPECtroscopy

DESPEC: DEcay SPECtroscopy



DESPEC: DEcay SPECtroscopy

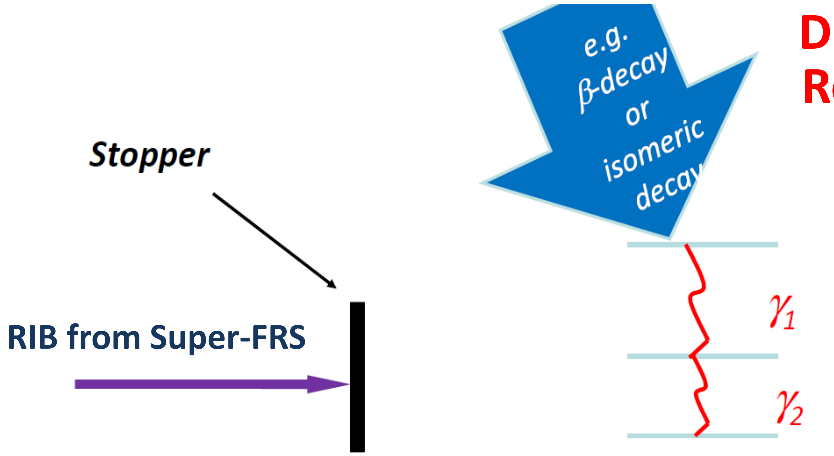


(picture from DESEPC collaboration)

Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

DESPEC Germanium Array Spectrometer (DEGAS)

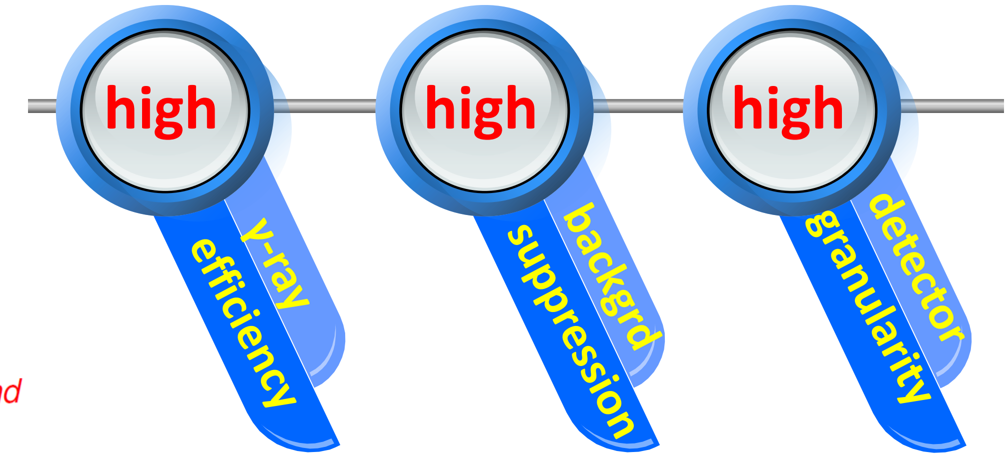
DESPEC: DEcay SPECtroscopy



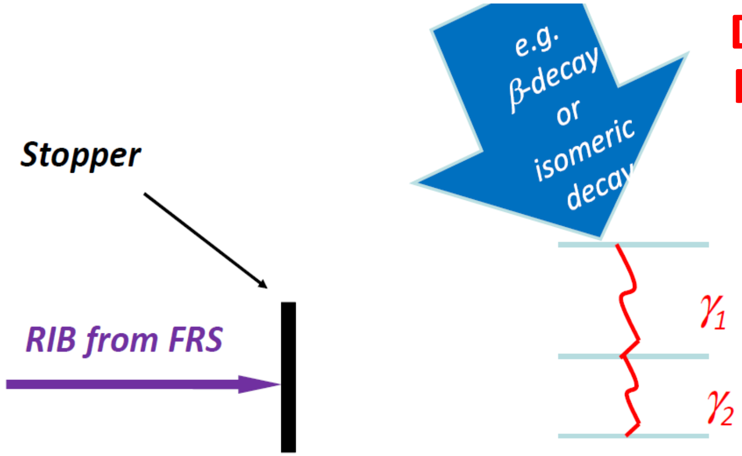
(picture from DESEPC collaboration)

Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

DESPEC Germanium Array Spectrometer (DEGAS)
Requirements:

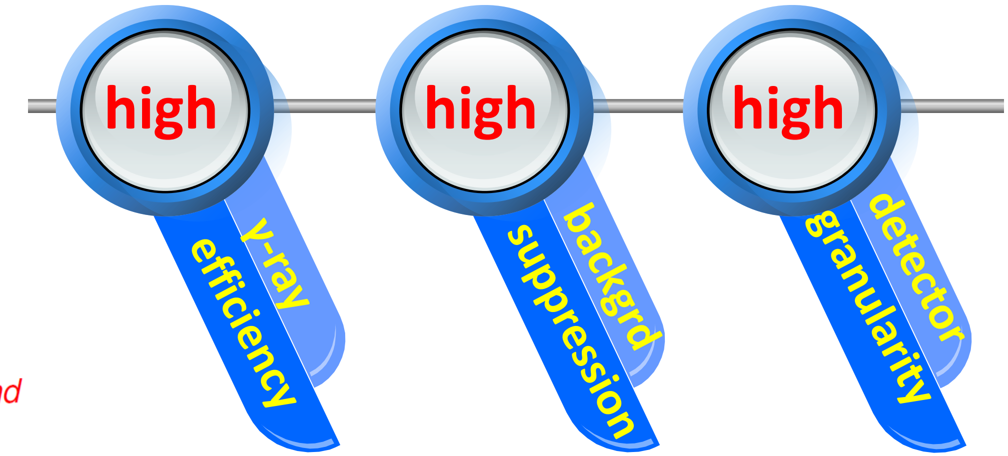


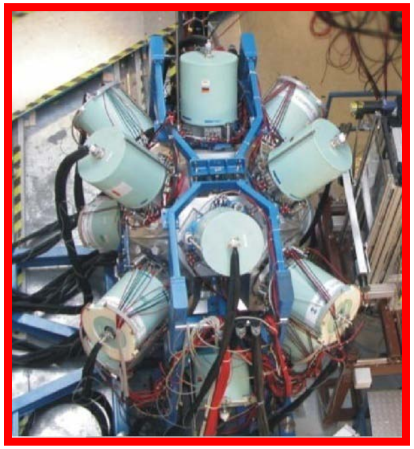
DESPEC: DEcay SPECtroscopy



Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

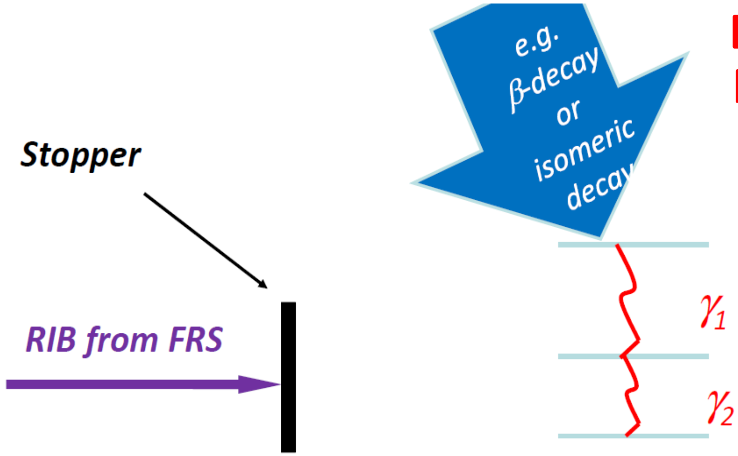
DESPEC Germanium Array Spectrometer (DEGAS) Requirements:





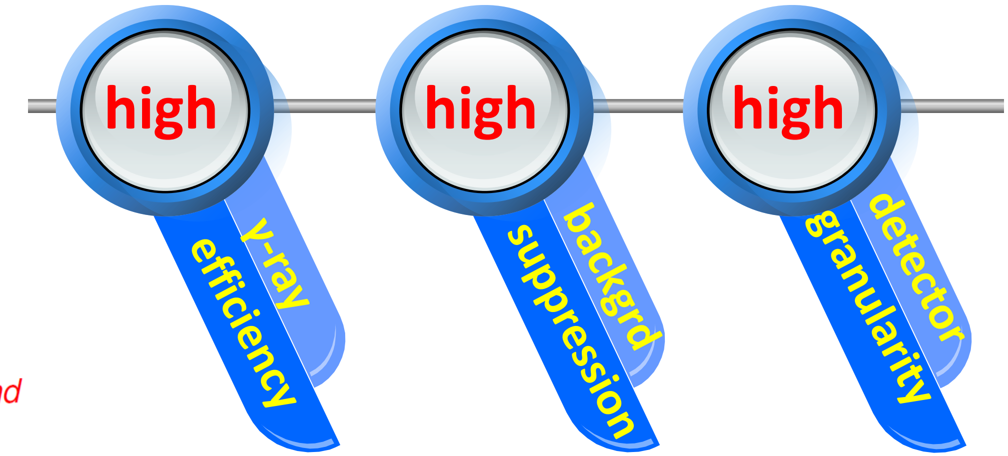
RISING configuration

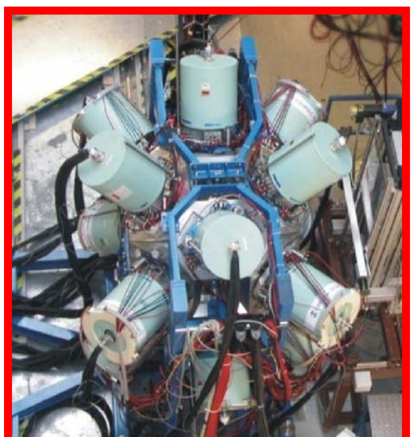
DESPEC: DEcay SPECtroscopy



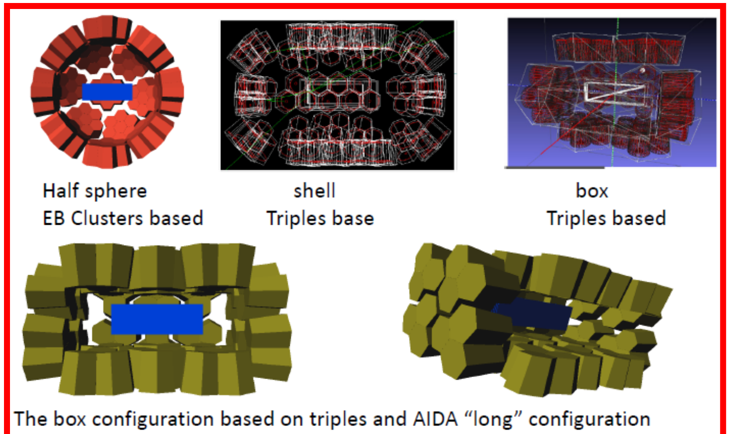
Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

DESPEC Germanium Array Spectrometer (DEGAS) Requirements:



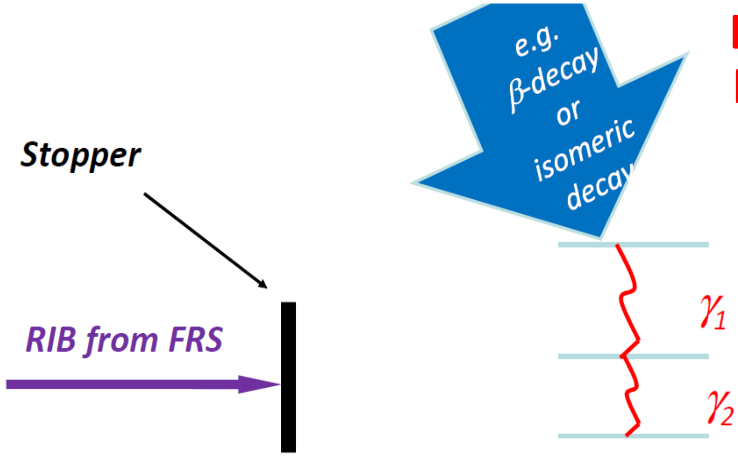


RISING configuration



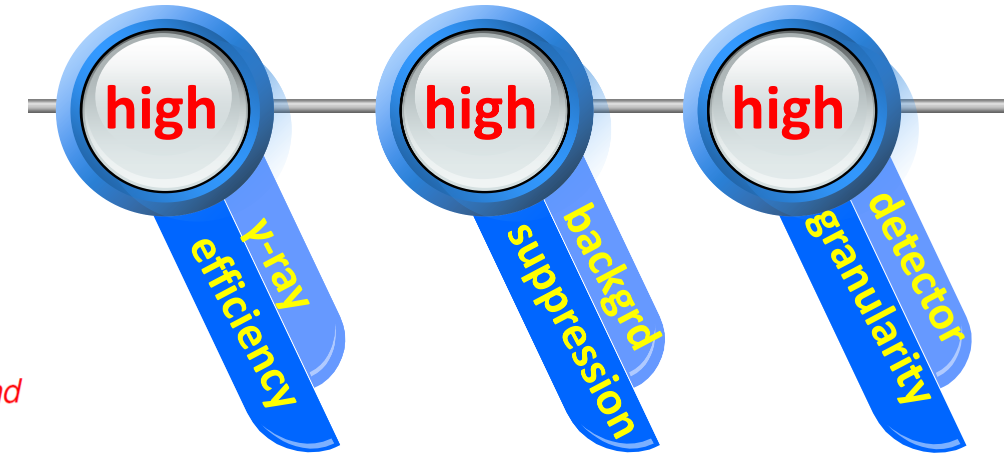
DEGAS configuration candidates

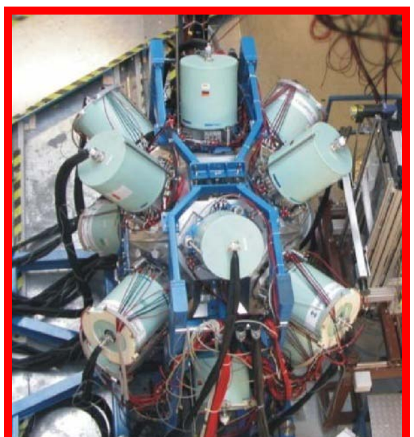
DESPEC: DEcay SPECtroscopy

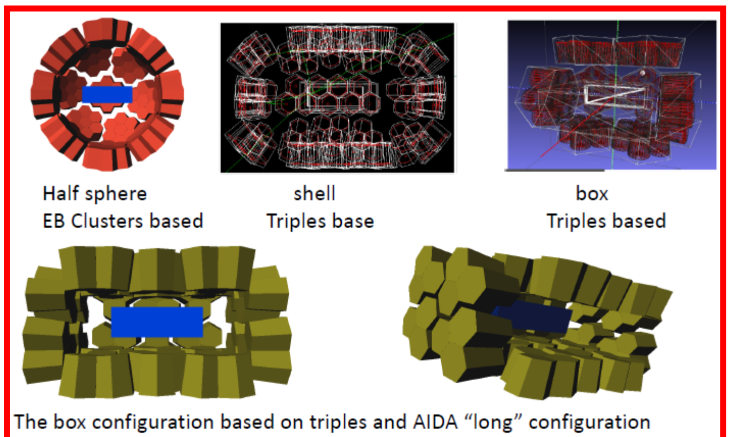


Get first information on lifetimes, decay modes, Q-values and scheme of excited levels

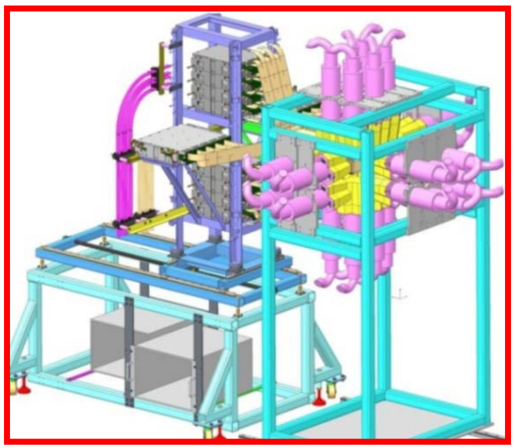
DESPEC Germanium Array Spectrometer (DEGAS) Requirements:




RISING configuration

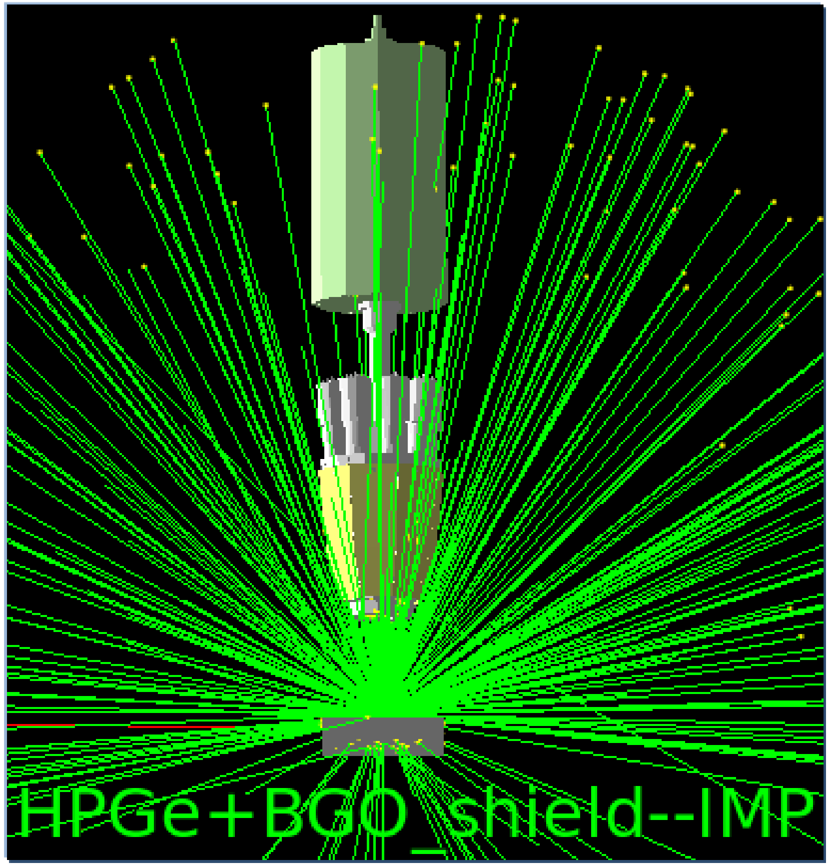


DEGAS configuration candidates


DEGAS I configuration

Simulation on the spectra of HPGe with BGO shields

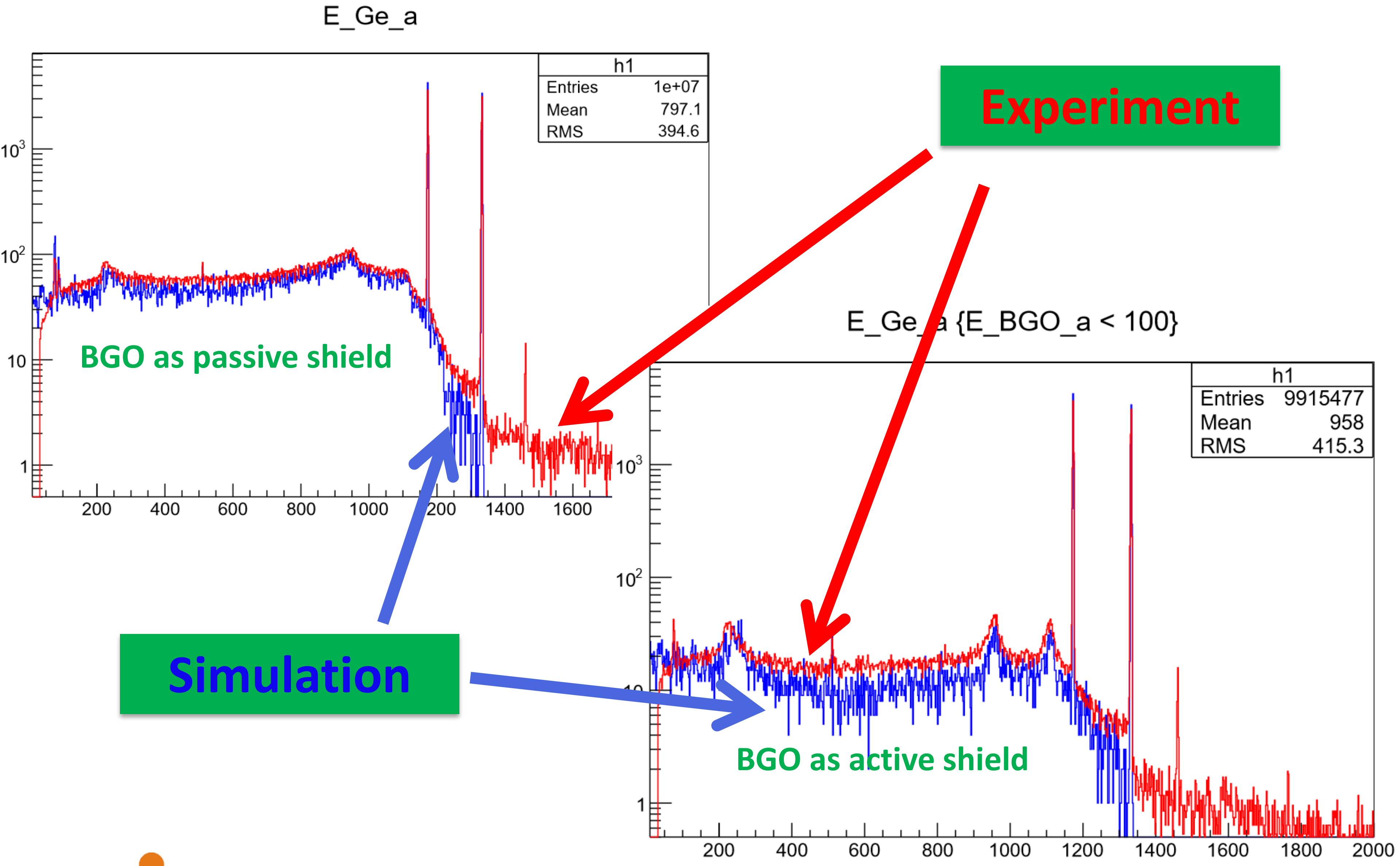
HPGe detector and BGO shields



Geometry in Geant4

Source: ^{60}Co in front of HPGe

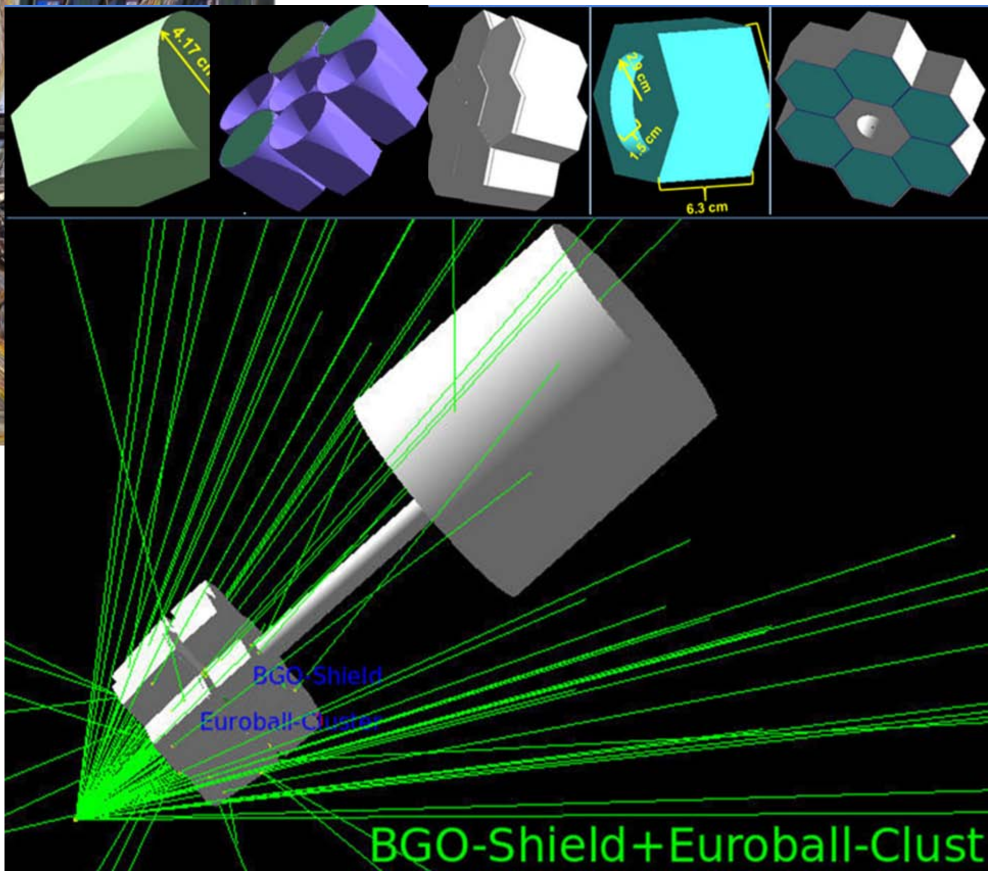
Simulation on the spectra of HPGe with BGO shields



Simulation on Eruoball Cluster and BGO Back-catcher

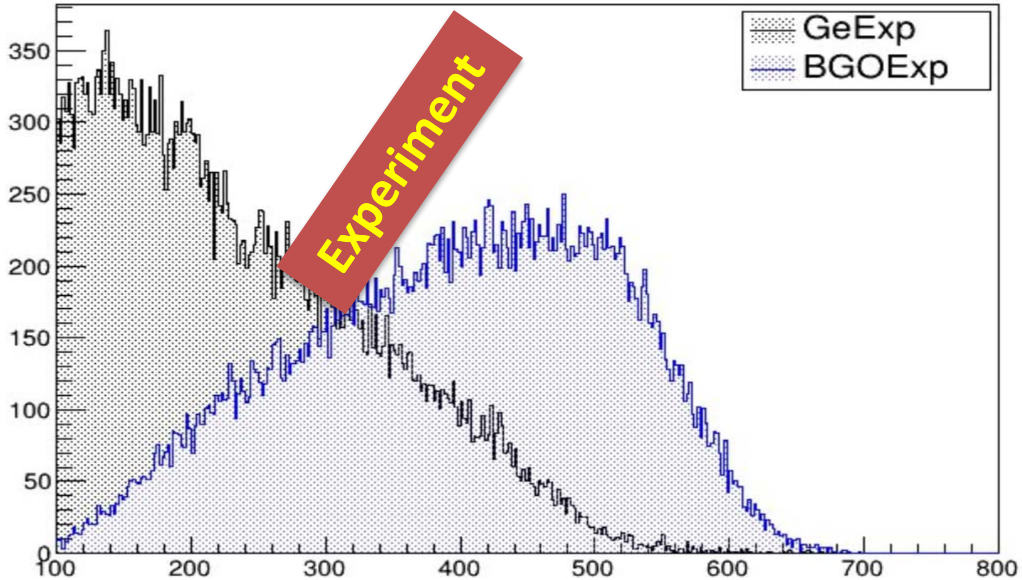
EUROBALL Cluster and BGO Back-catcher

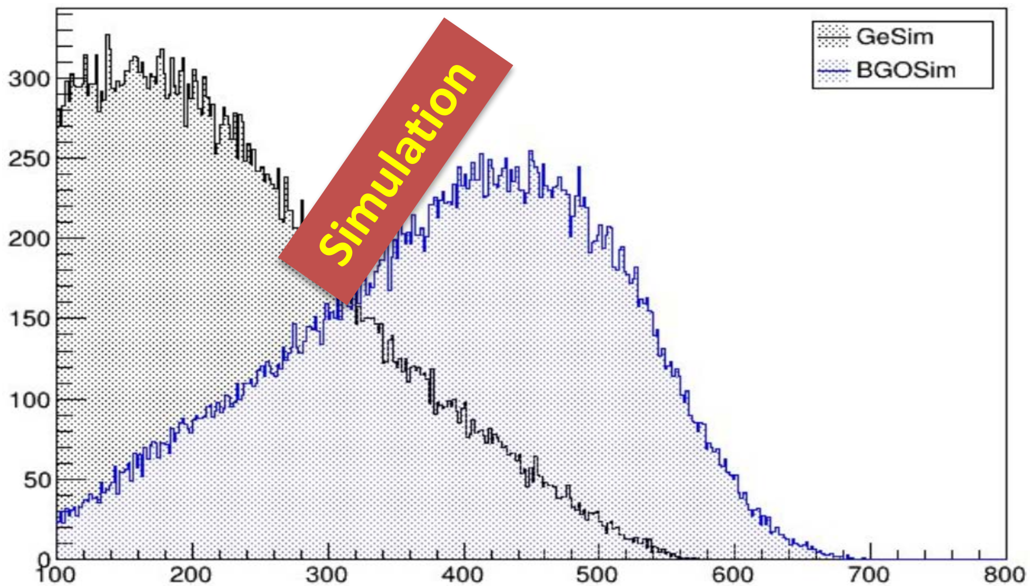
Source: ^{137}Cs top and bottom

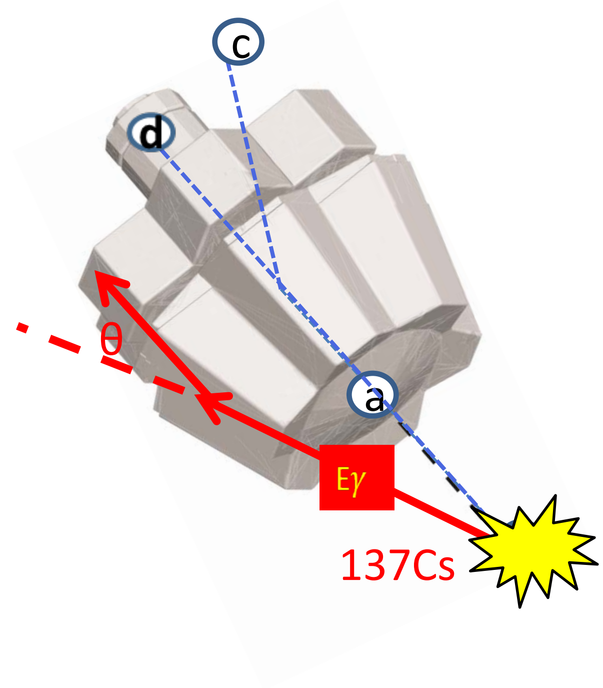


Geometry in Geant4

Energy distribution of full energy sharing events

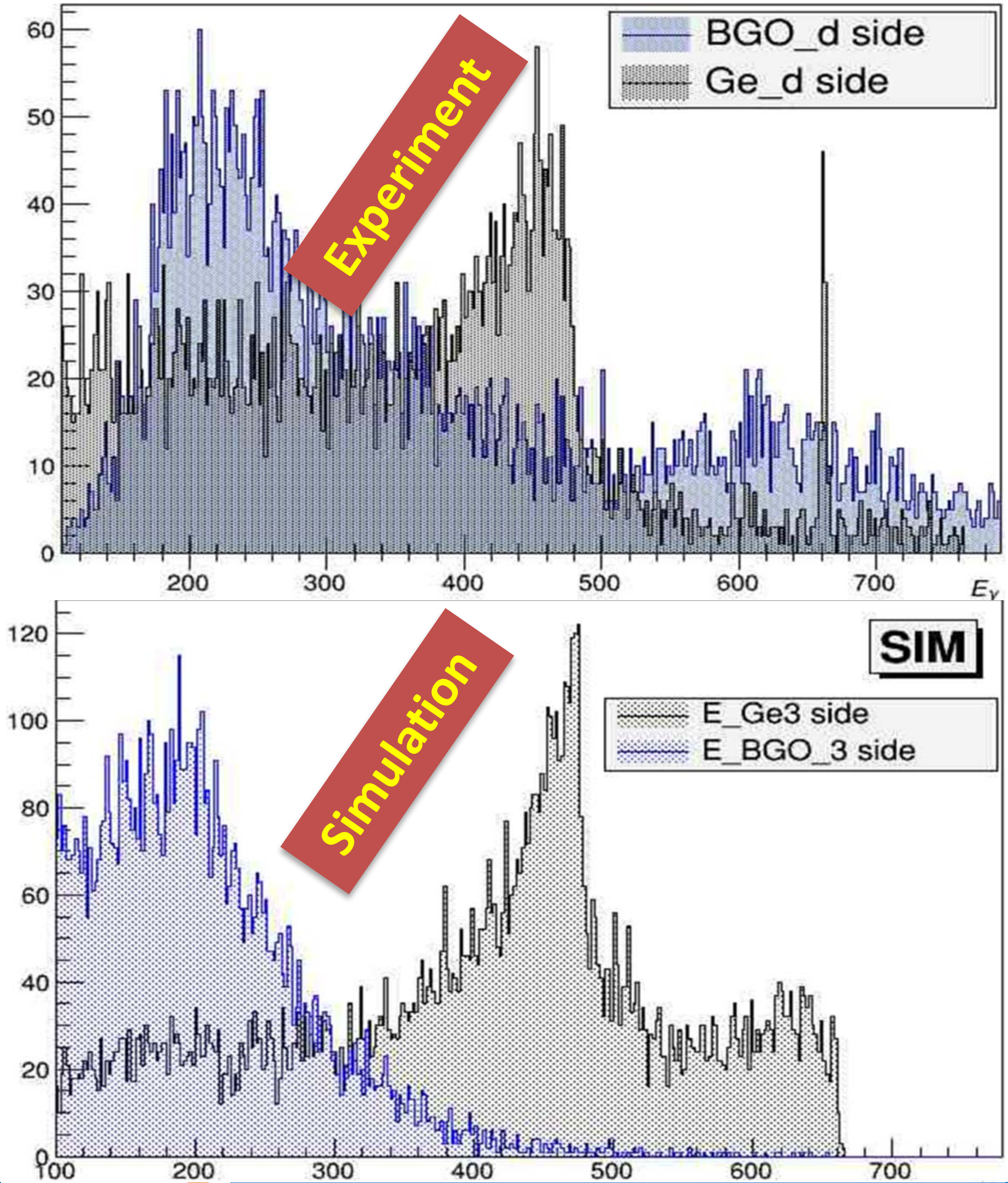


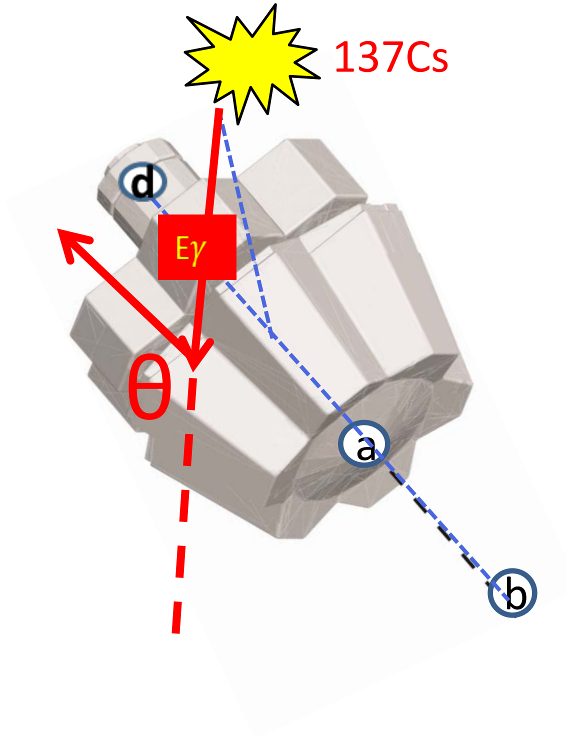




Smaller scattering angle at Ge leads to smaller energy deposition in Ge and larger energy depostion in BGO

Energy distribution of events in coincidence

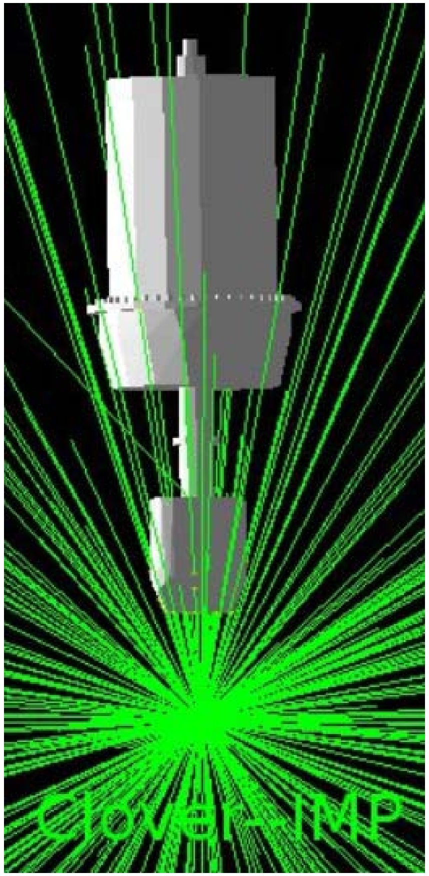




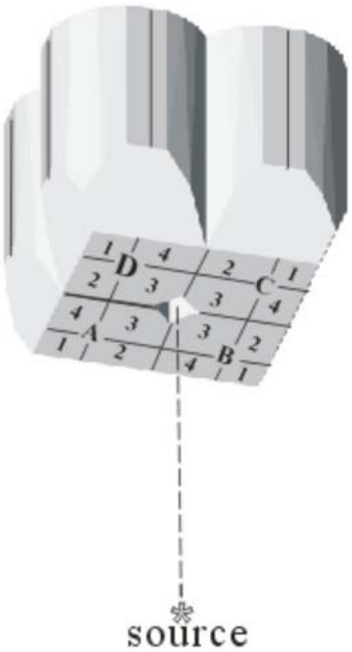
Larger scattering angle at Ge leads to larger energy deposition in Ge and smaller energy depostion in BGO

Simulation on the Clover detector

Clover detetor

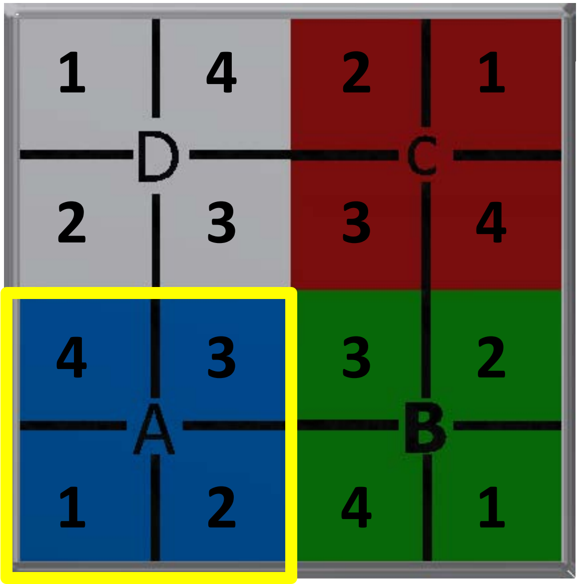


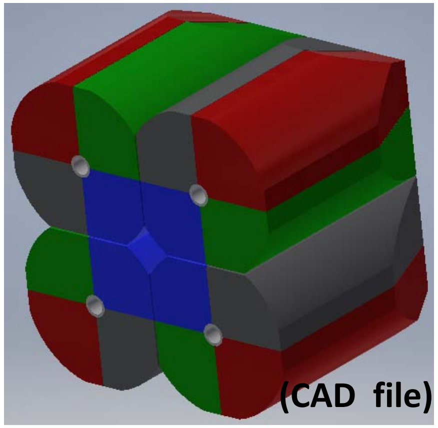
Geometry in Geant4

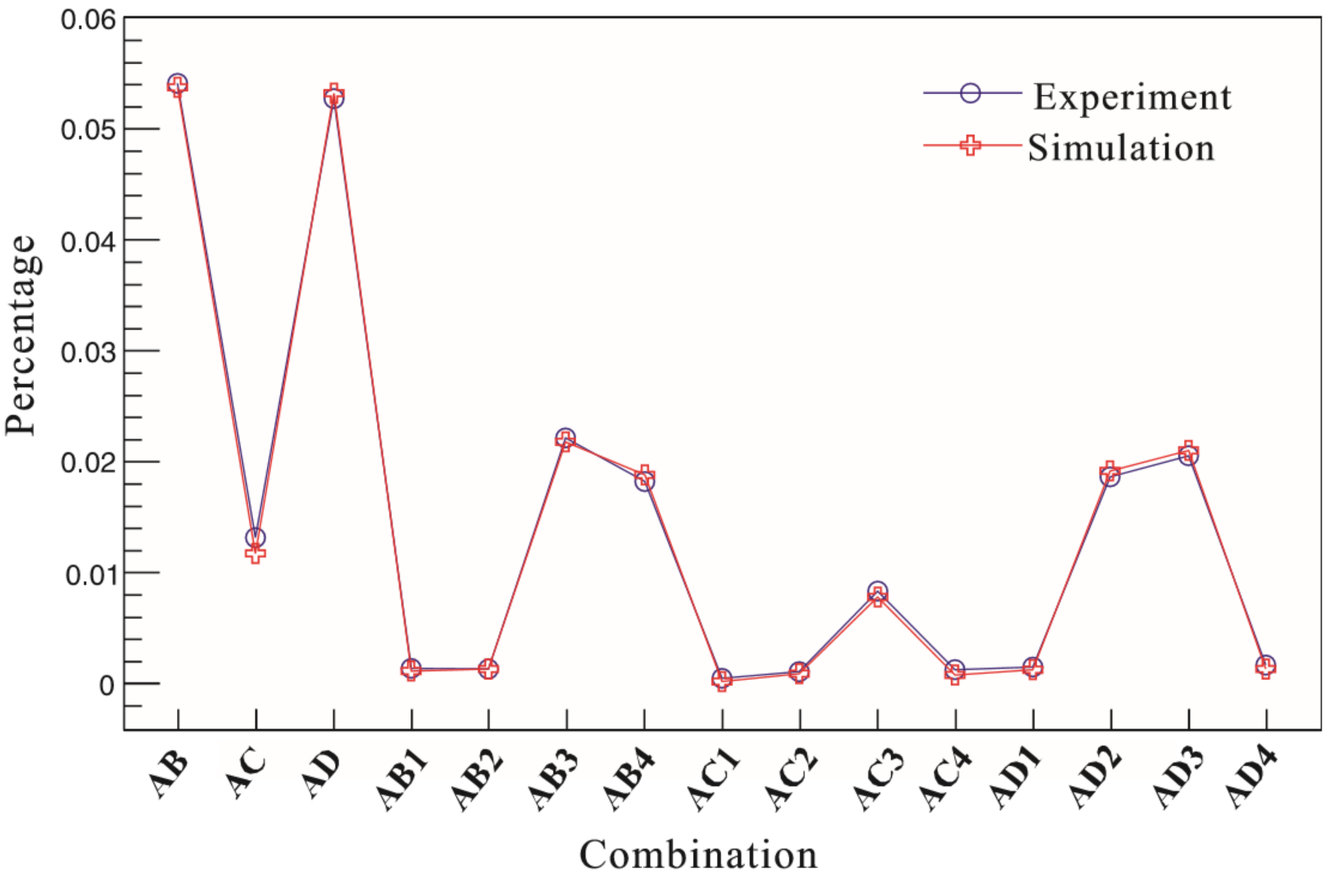


Source: ^{137}Cs in front of the detector

Percentage of two-elements energy sharing event

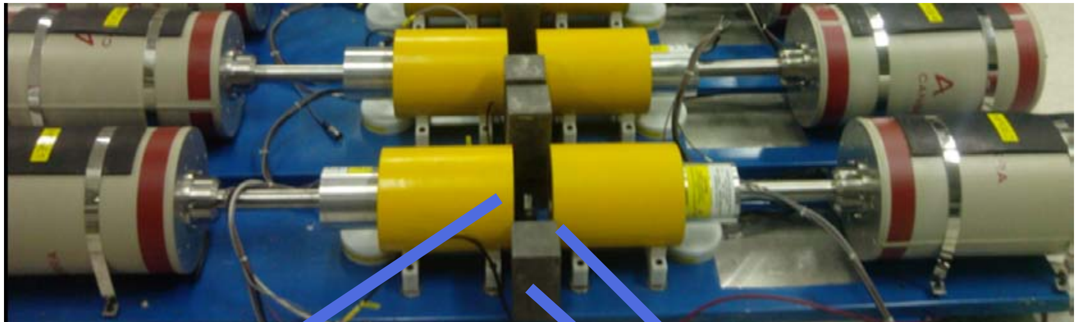






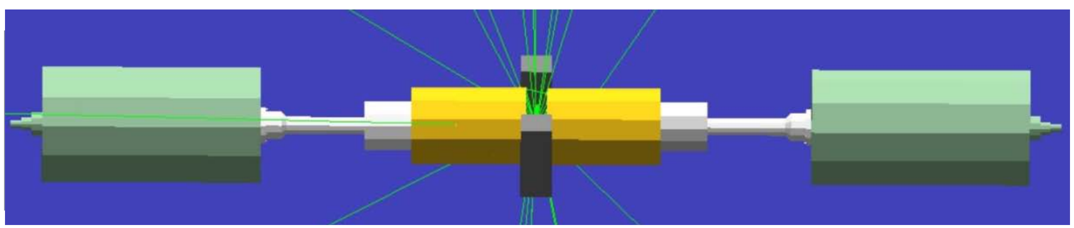
Source: ^{137}Cs in front of the detector

Absolute efficiency measurement

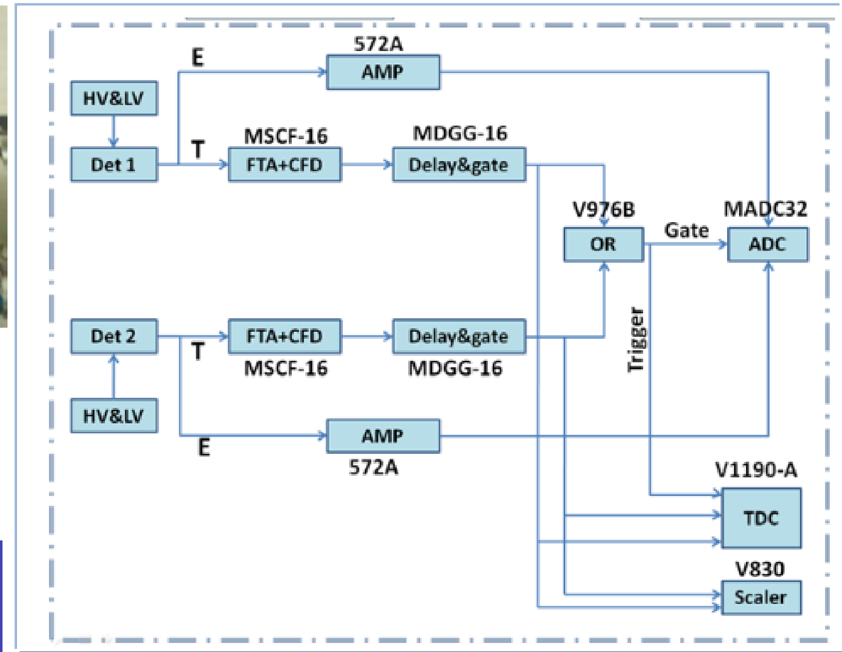


^{60}Co, ^{152}Eu, and ^{133}Ba sources

Pb shield

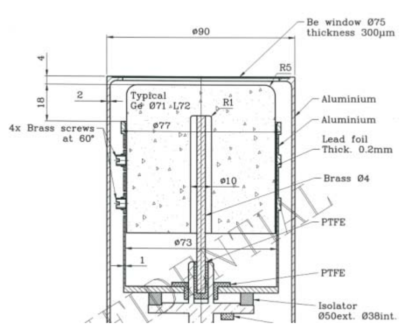


Geometry in the simulation

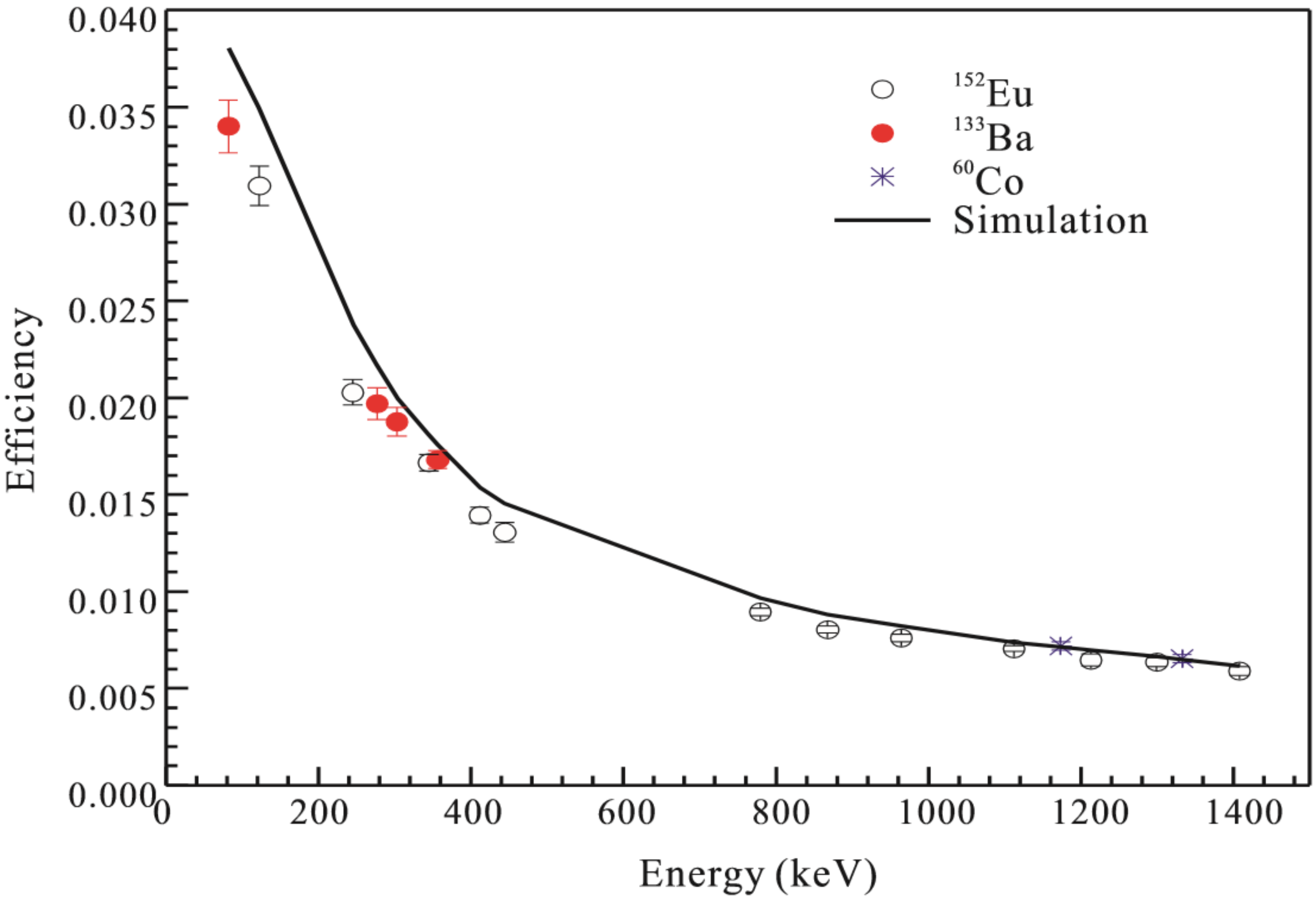


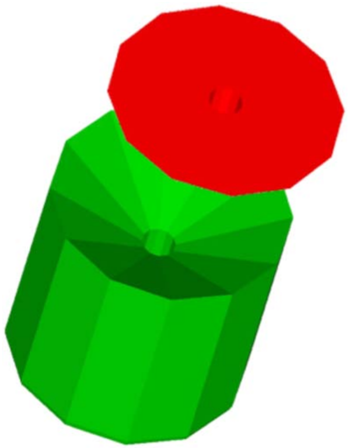
One neutron transfer reaction in the ^{9}Be+^{89}Y system

G. S. Li *et al. EPJ WoC 86, 00024 (2015)*



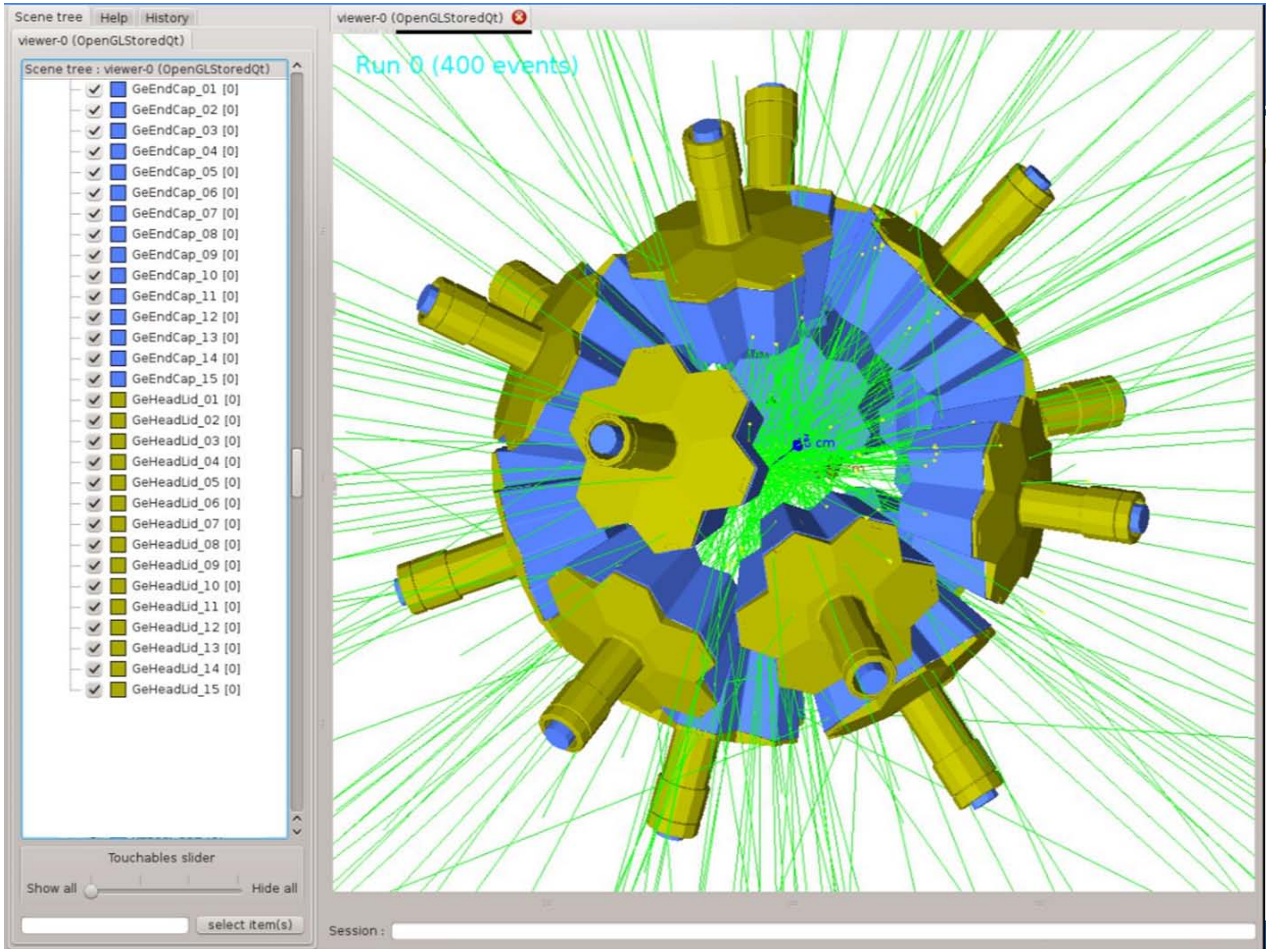
Comparison of the absolute efficiency

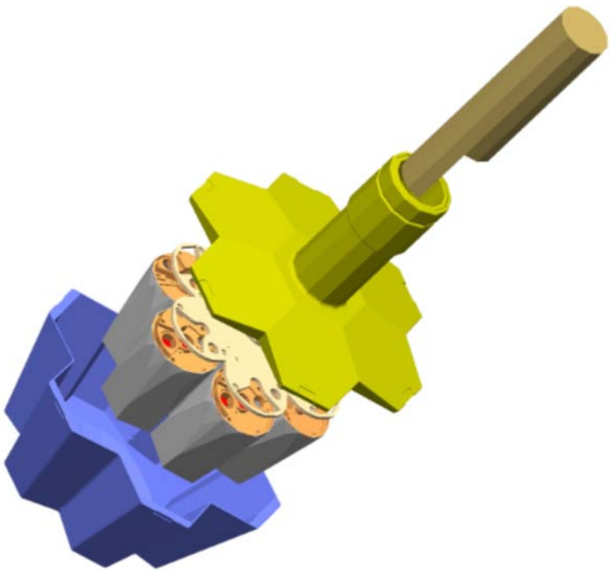


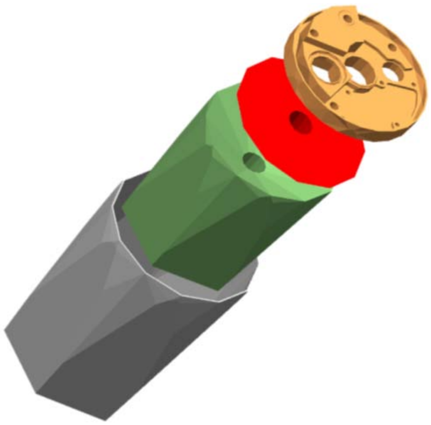


10% insensitive volume of cone shape is assumed in the simulation

Simulation on the RISING configuration

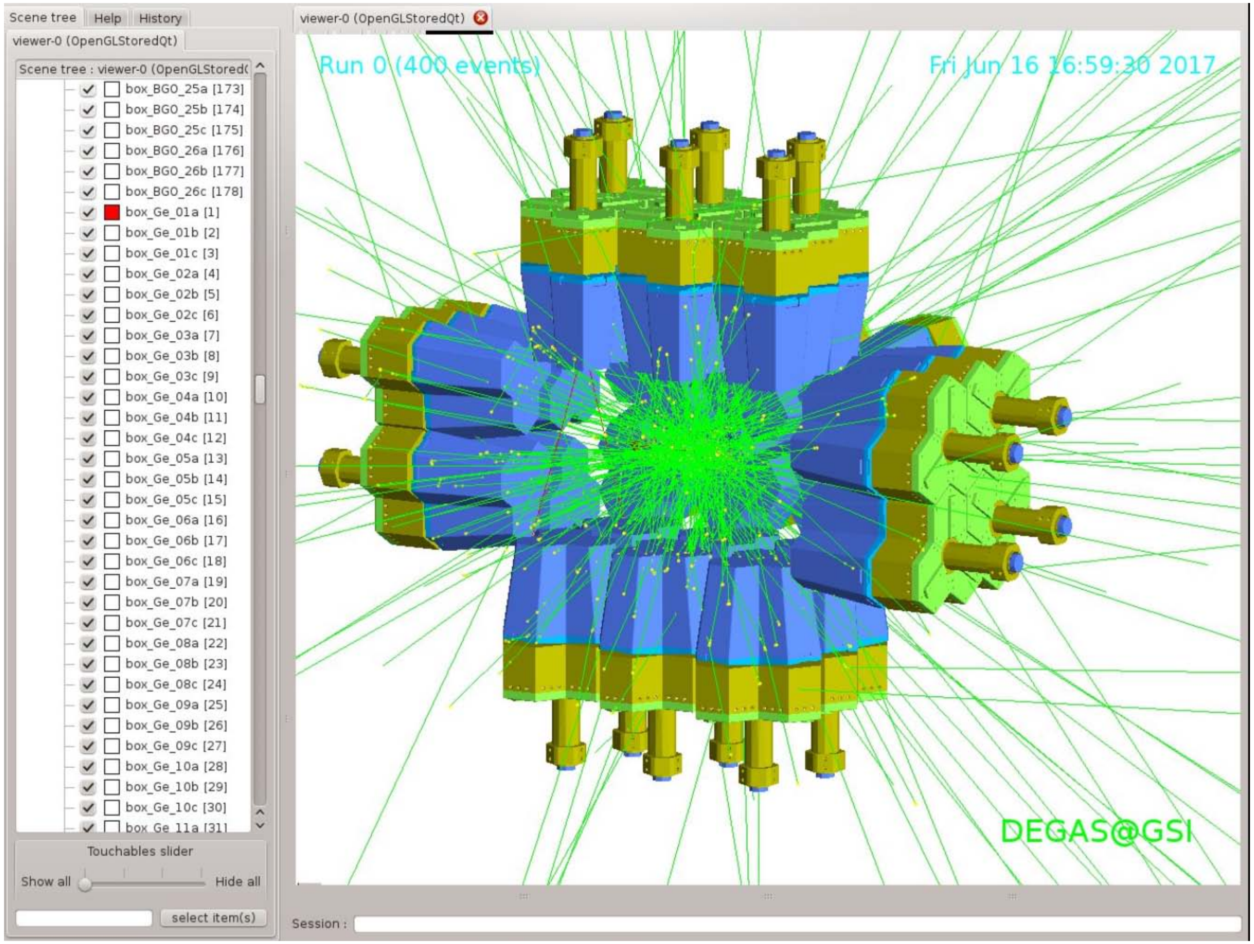


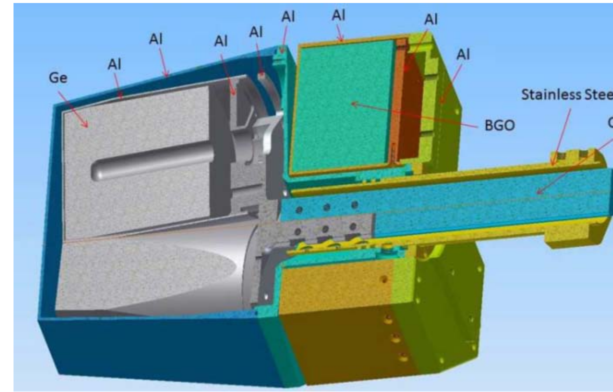




15 EUROBALL Clusters, consist of 105 Ge crystals, in three angular rings, 22 cm to the center

Simulation on the DEGAS / configuration



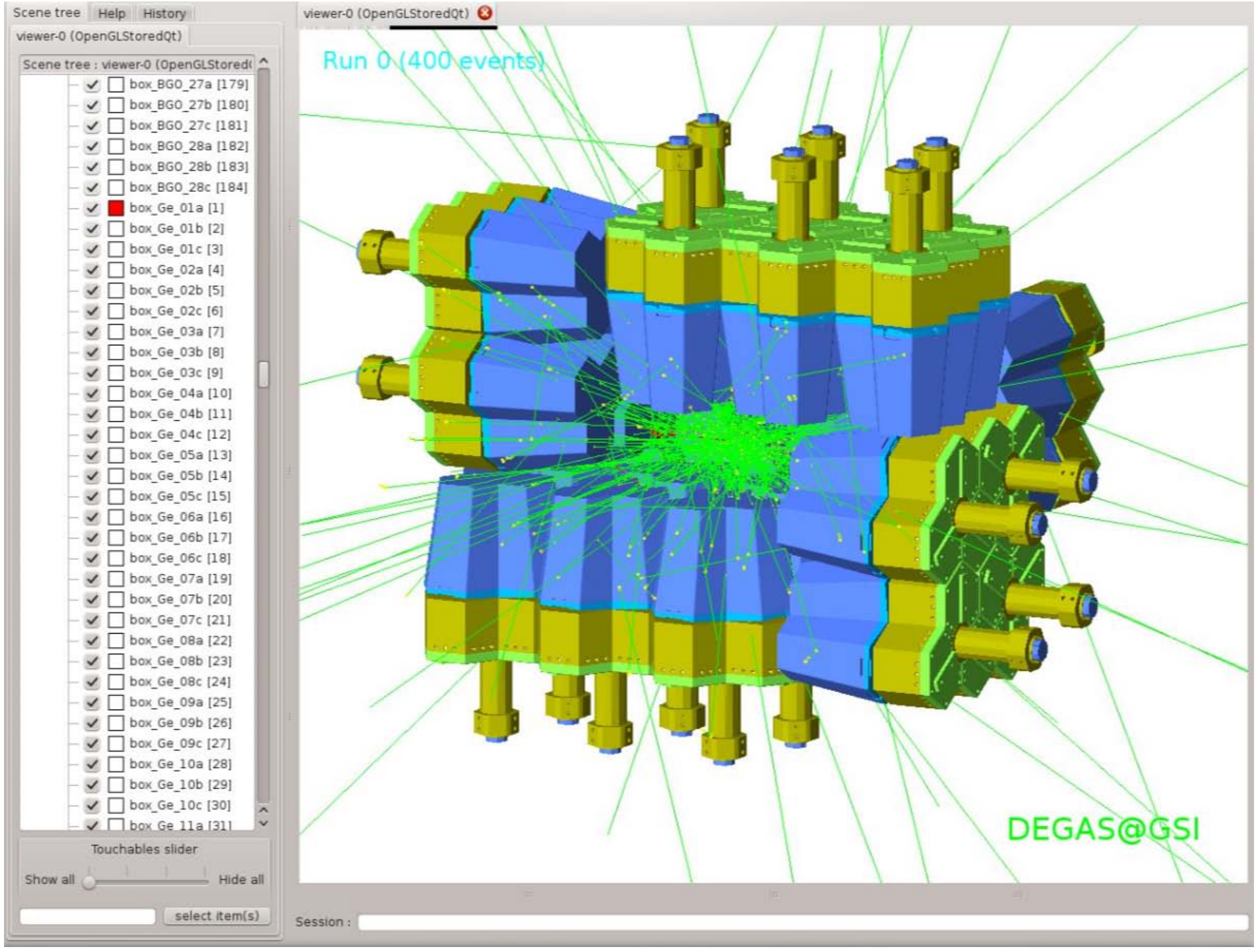


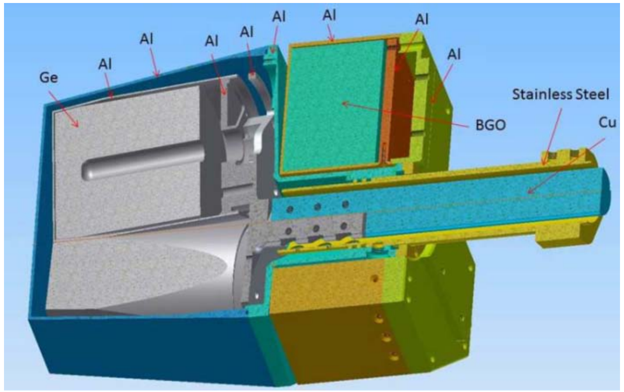
Mechanical lay-out of the DEGAS detector (CAD design file)

10% insensitive volume of at back of Ge is assumed

26 DEGAS clusters, consist of 78 Ge crystals, distance from the center: 12cm(back), 12cm(top and bottom), 22cm(left and right)

Simulation on the DEGAS II configuration



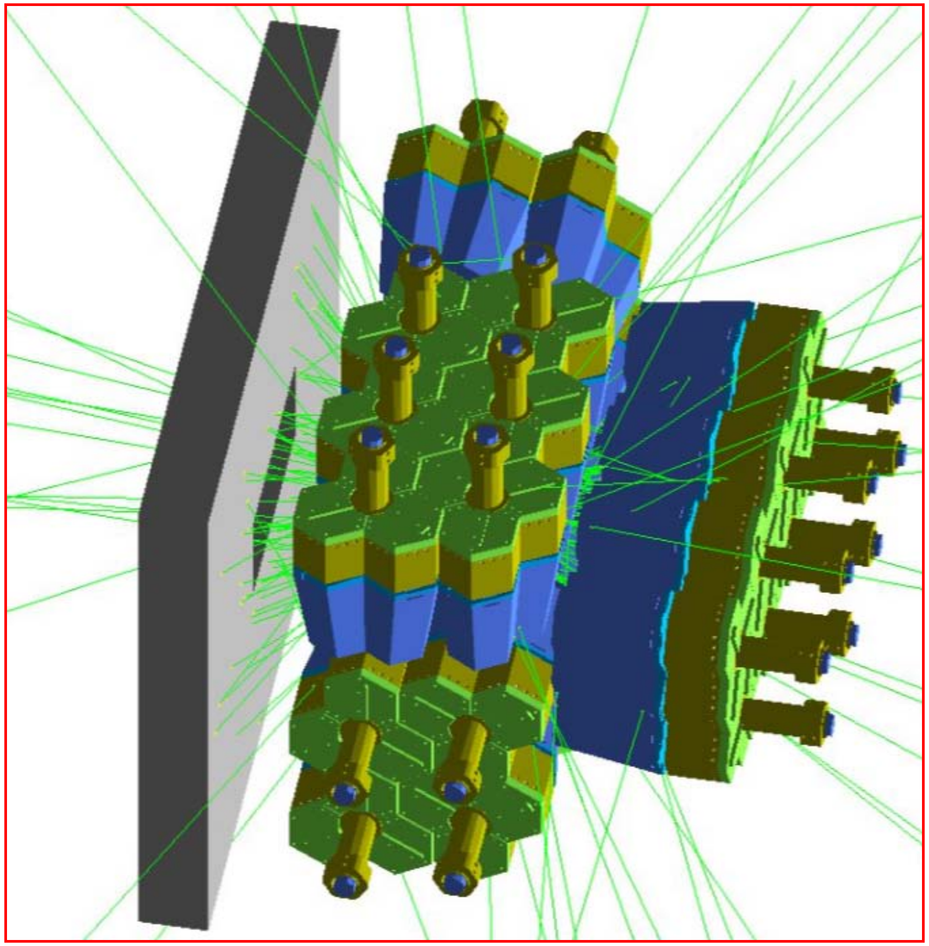


Mechanical lay-out of the DEGAS detector (CAD design file)

10% insensitive volume of at back of Ge is assumed

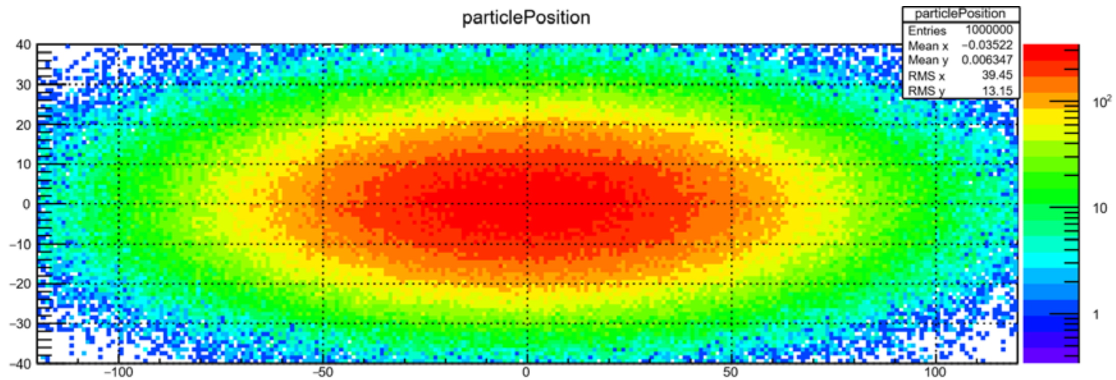
28 DEGAS clusters, consist of 84 Ge crystals, a space with cross section of 26 cm × 11 cm inside is reserved for the implantation detector

Pb wall

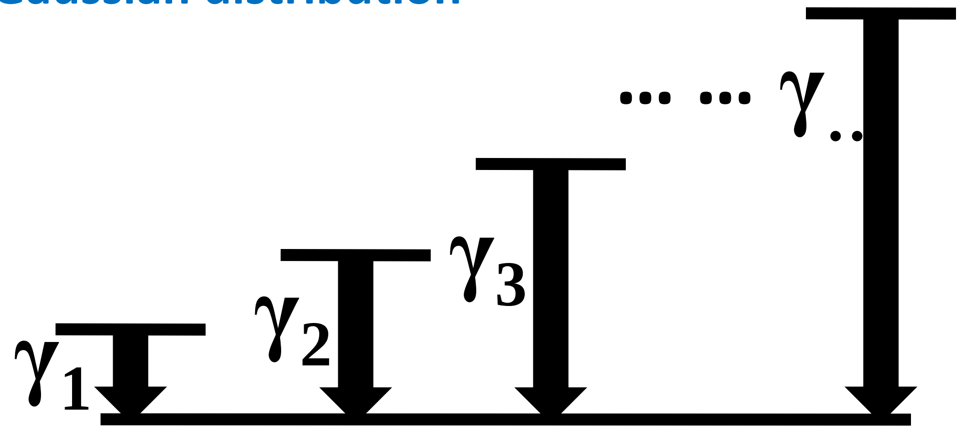


8 cm Pb-Wall assumed for all the three configurations

Gamma source considered



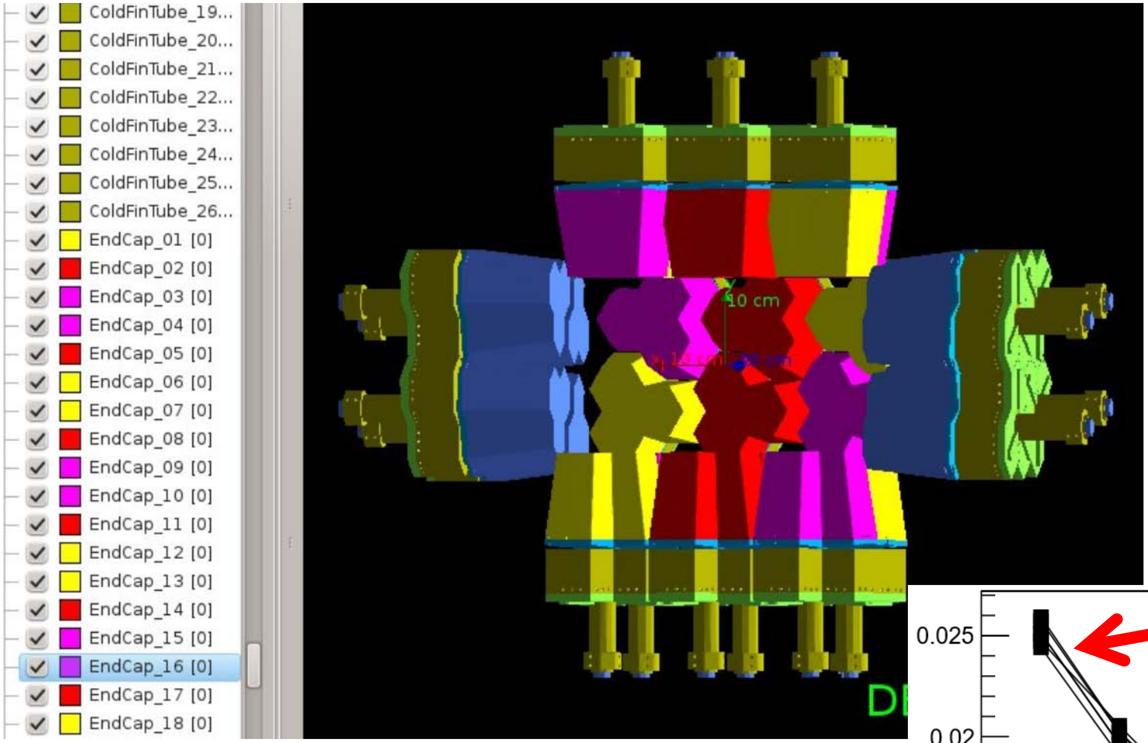
Gamma ray emitted from center of 8cm x 24 cm plate (AIDA), with intensity of Gaussian distribution



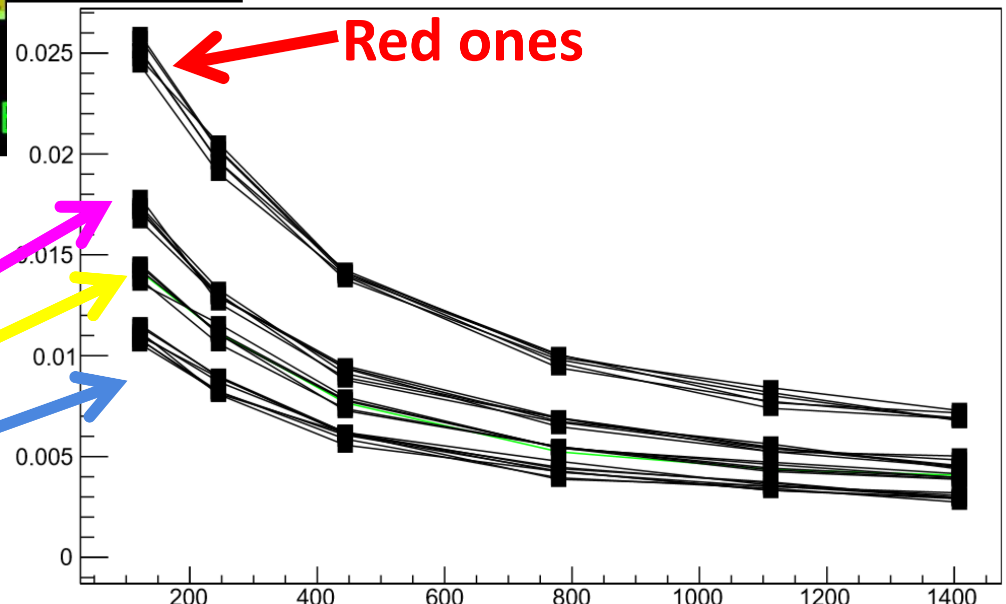
Non-cascade gamma ray

Group 1	121.8	244.7	441.1	778.9	1112.1	1408.0
Group 2	81.0	356.0	661.7	867.4	964.1	1332.5

Efficiency of each DEGAS cluster



Different position, different efficiency

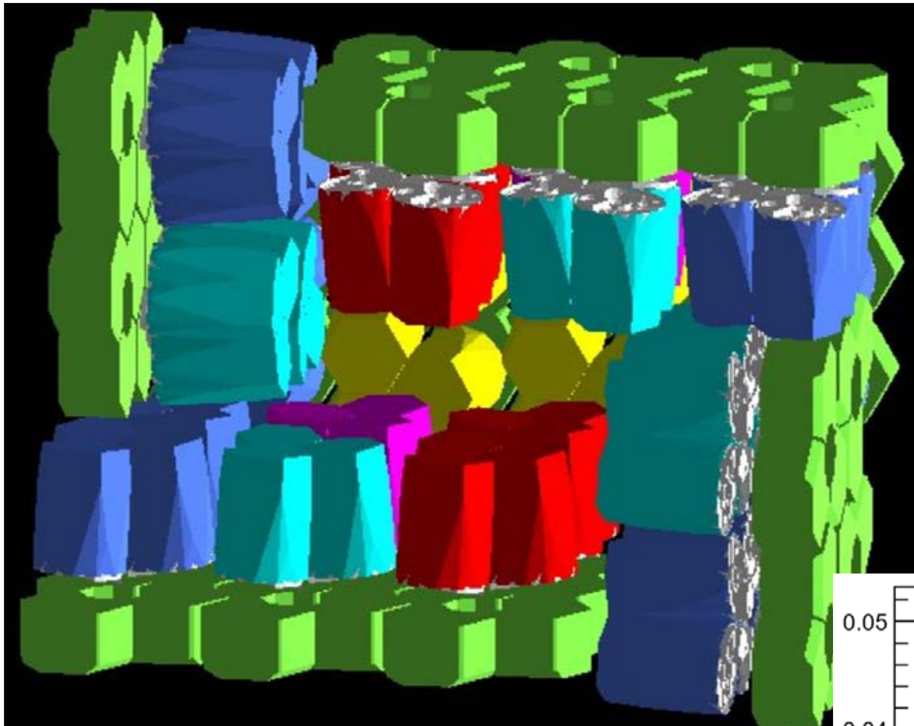


Magenta ones

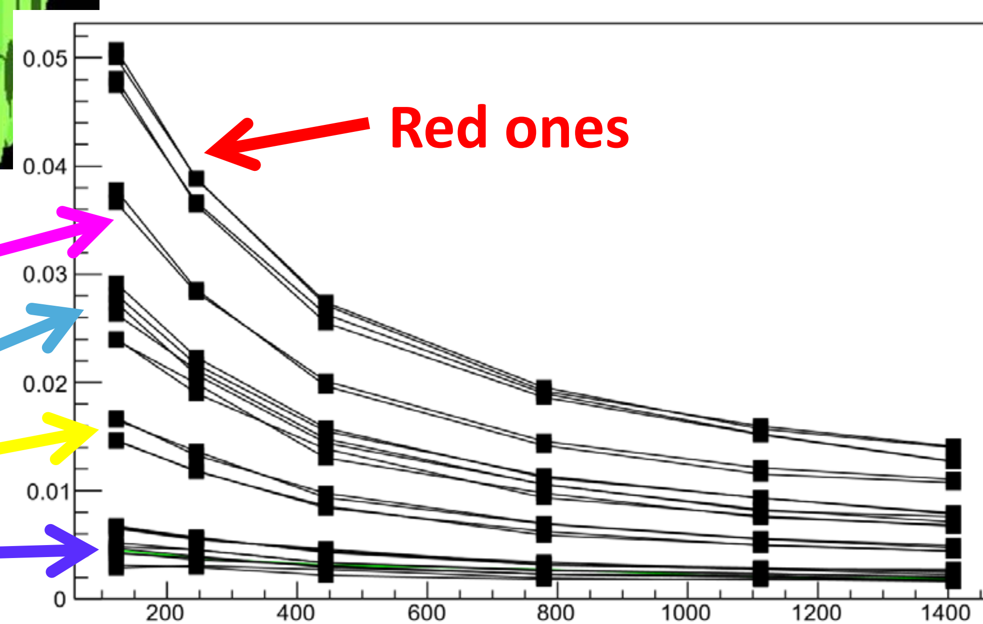
Yellow ones

Blue ones

Efficiency of each DEGAS cluster



Different position, different efficiency



Red ones

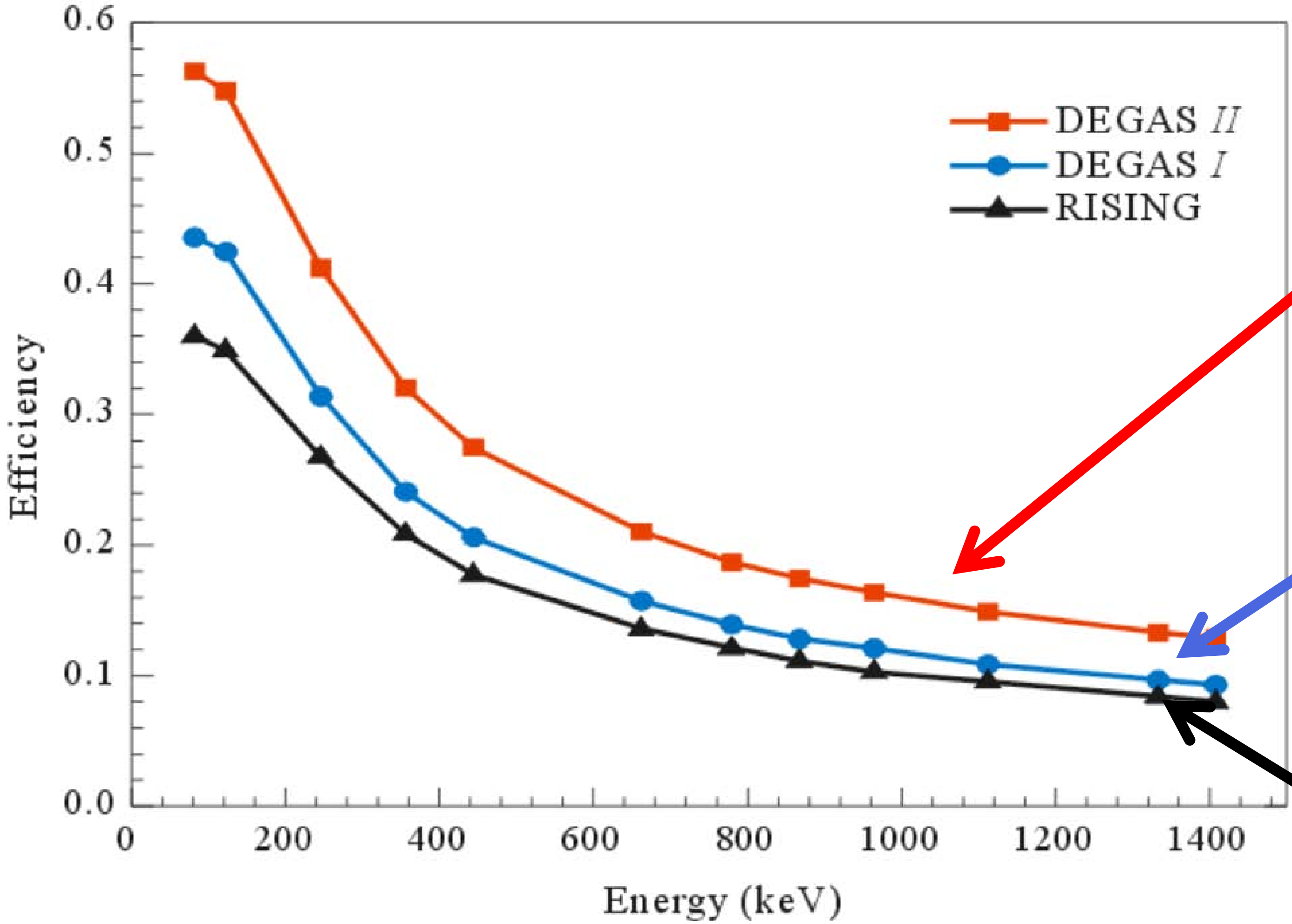
Magenta ones

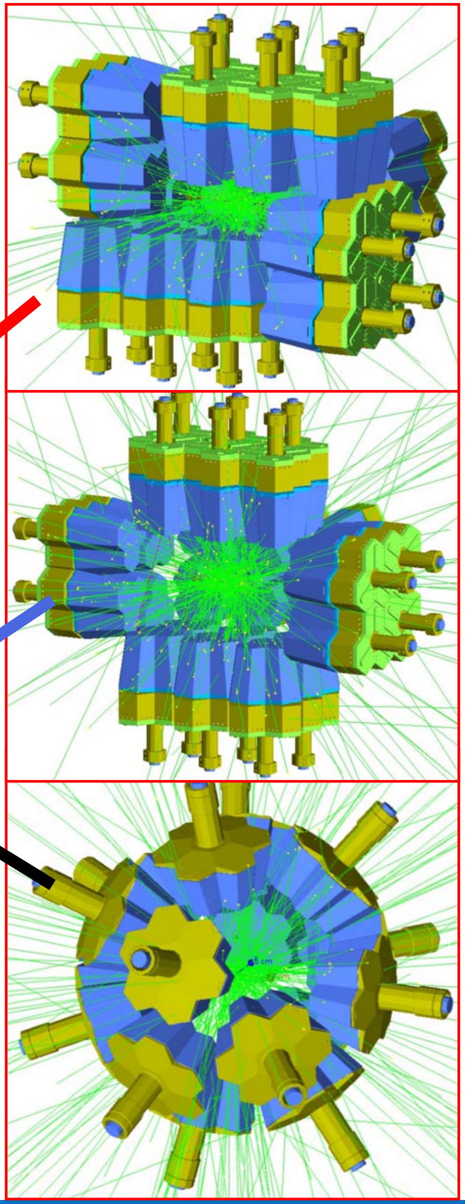
Light blue ones

Yellow ones

Blue ones

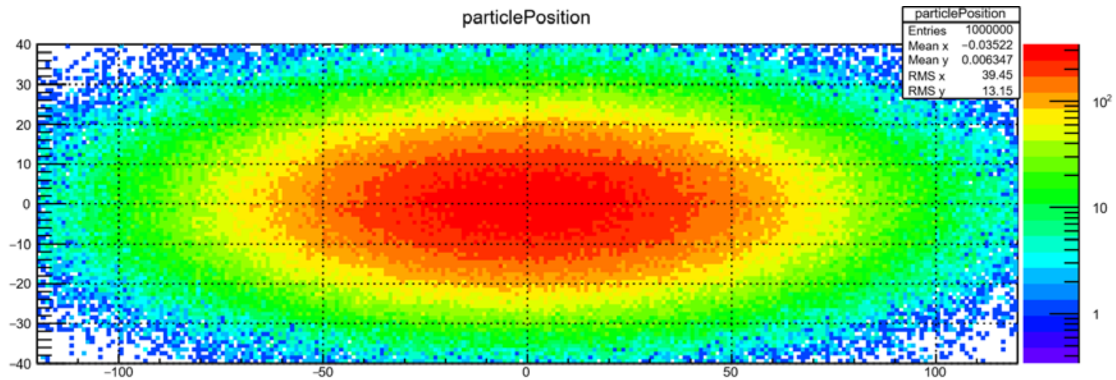
Comparison of the efficiency



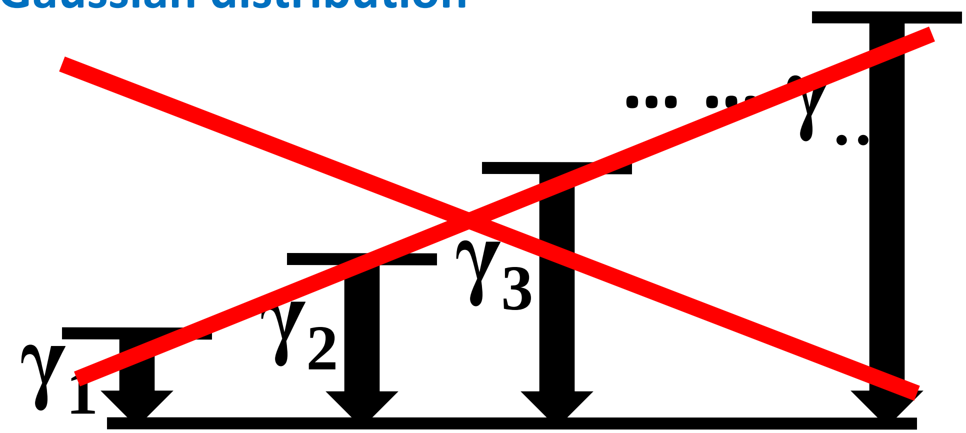


The efficiencies are deduced from Ge crystals without add-back between them

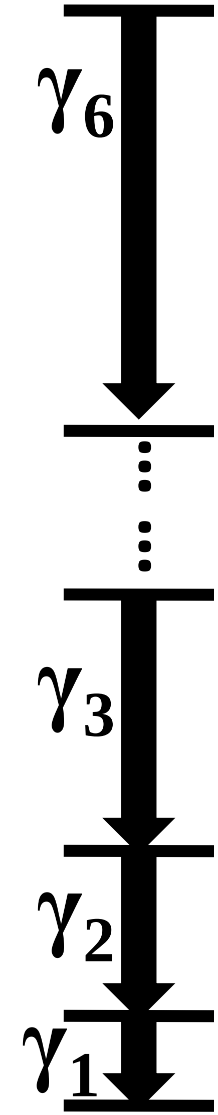
Gamma source considered



Gamma ray emitted from center of 8cm x 24 cm plate (AIDA), with intensity of Gaussian distribution



Non-cascade gamma ray



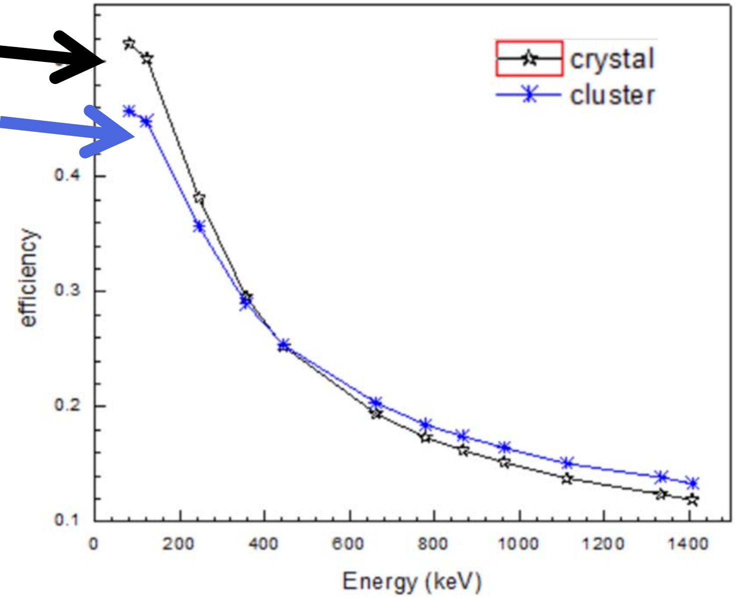
cascade

Group 1	121.8	244.7	441.1	778.9	1112.1	1408.0
Group 2	81.0	356.0	661.7	867.4	964.1	1332.5

Add-back analysis

Without add-back

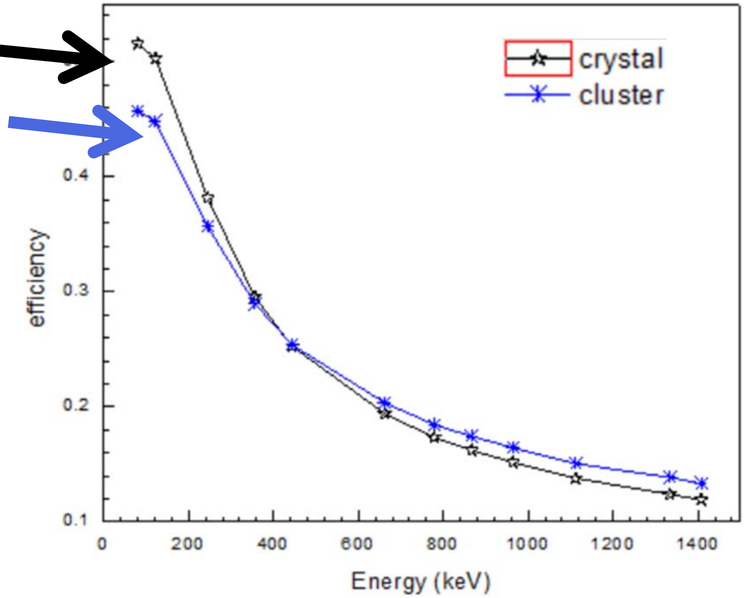
Inter-cluster add-back



Add-back analysis

Without add-back

Inter-cluster add-back

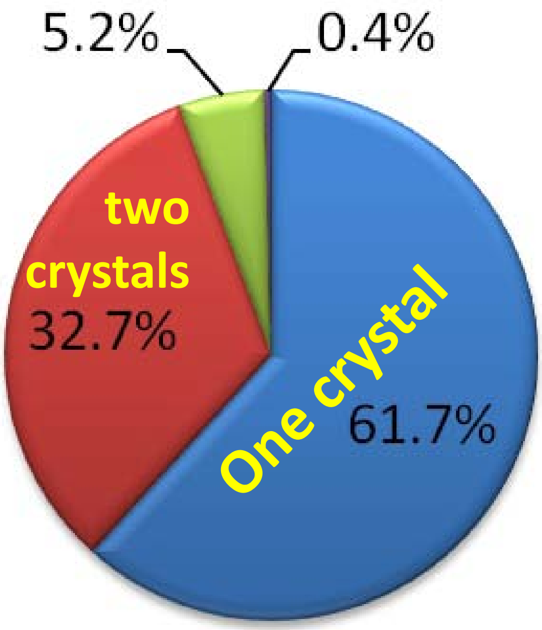


More adding, more full energy events

Less adding, less summing events

Interactions in the DEGAS *II* configuration

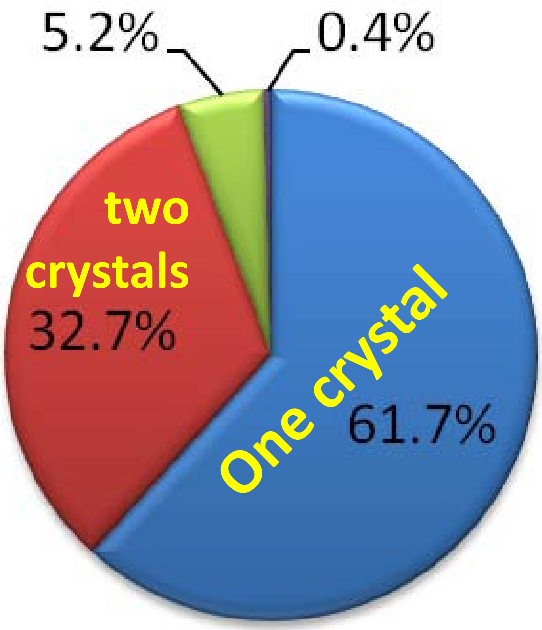
122 keV gamma ray



1408 keV gamma ray

Interactions in the DEGAS // configuration

122 keV gamma ray

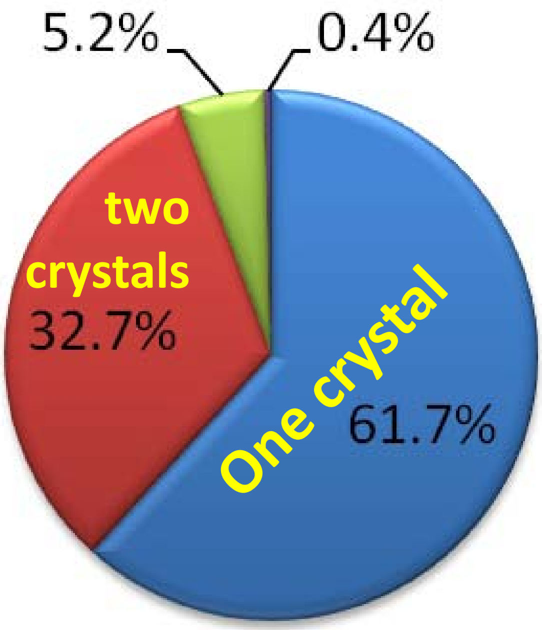


1408 keV gamma ray

- Two crystals shared full-energy events, **70% happen between neighbors**

Interactions in the DEGAS *II* configuration

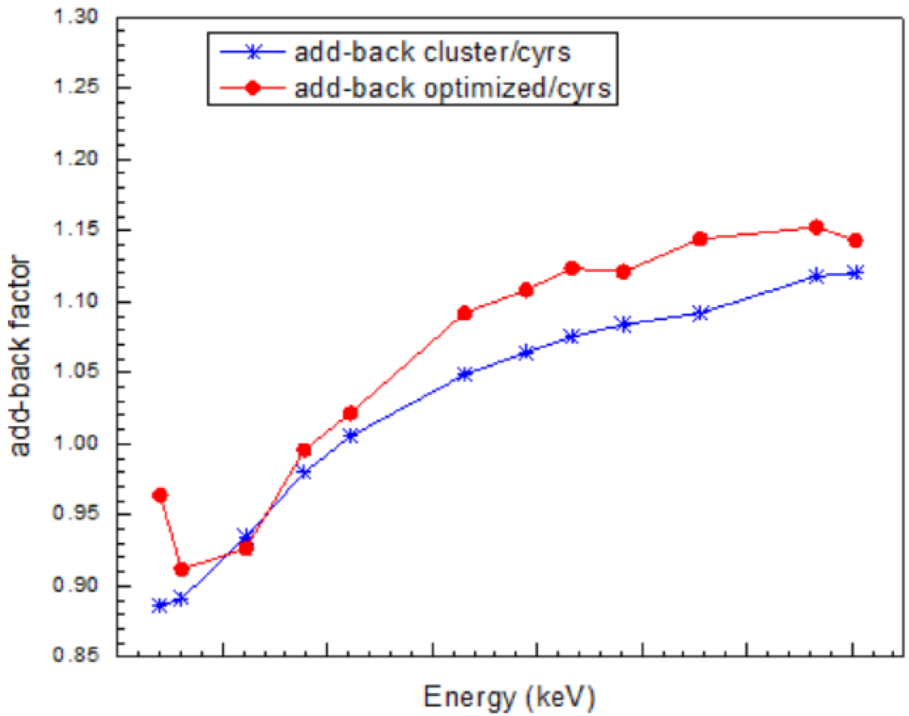
122 keV gamma ray

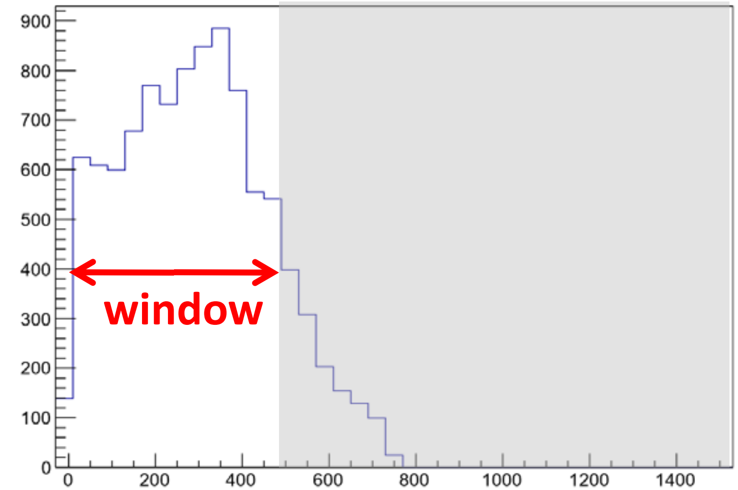


1408 keV gamma ray

- Two crystals shared full-energy events, **70% happen between neighbors**
- Try to **avoid using lower energy gamma ray** to add back, to reduce the risk of "false" gamma-ray summing

Add-back factor from the selected window

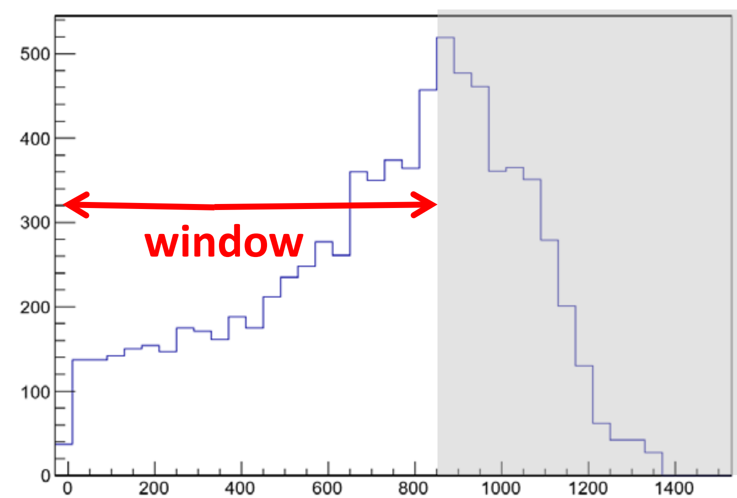




$\gamma_1 - \gamma_2$ for 779 keV

Inter-cluster neighbors : $\dfrac{|\gamma_1 - \gamma_2|}{\gamma_1 + \gamma_2} < 0.6$

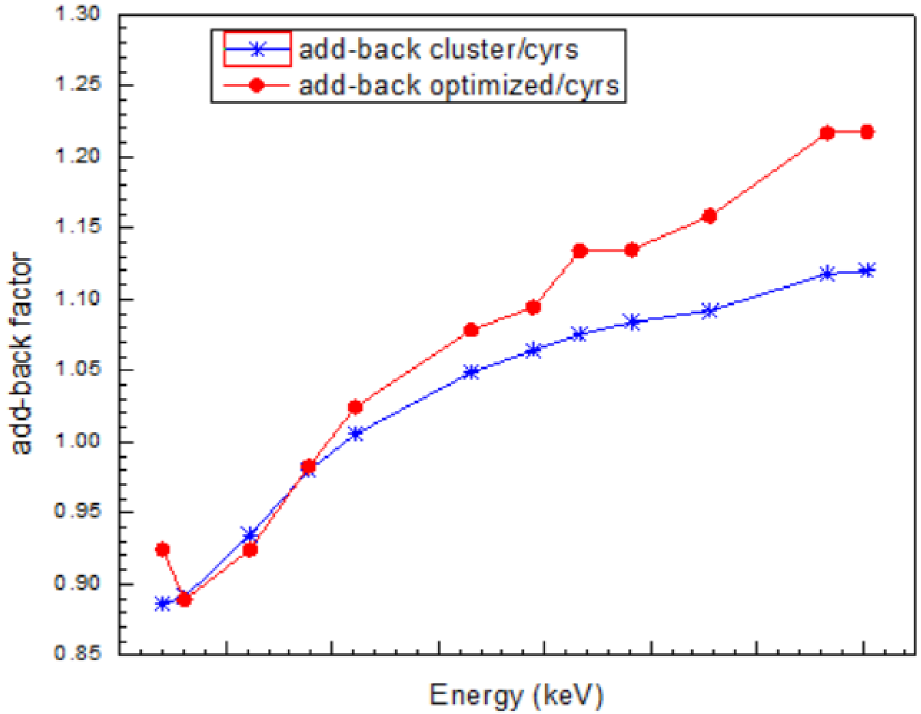
cross-cluster neighbors : $\dfrac{|\gamma_1 - \gamma_2|}{\gamma_1 + \gamma_2} < 0.2$

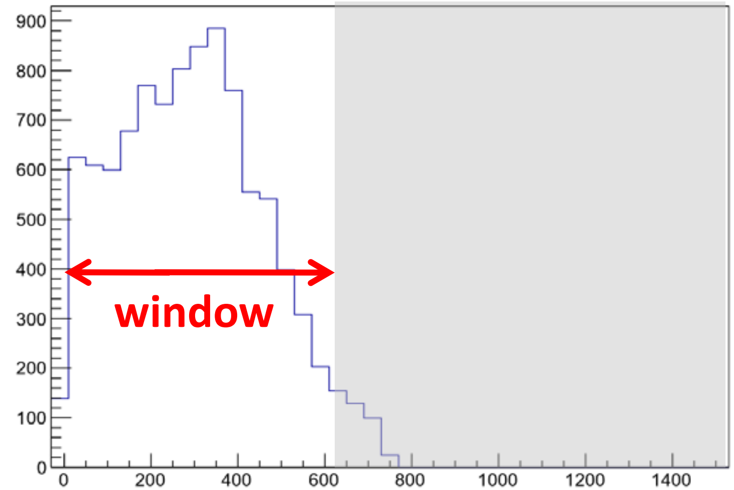


Window must be chosen according to physical request !!!

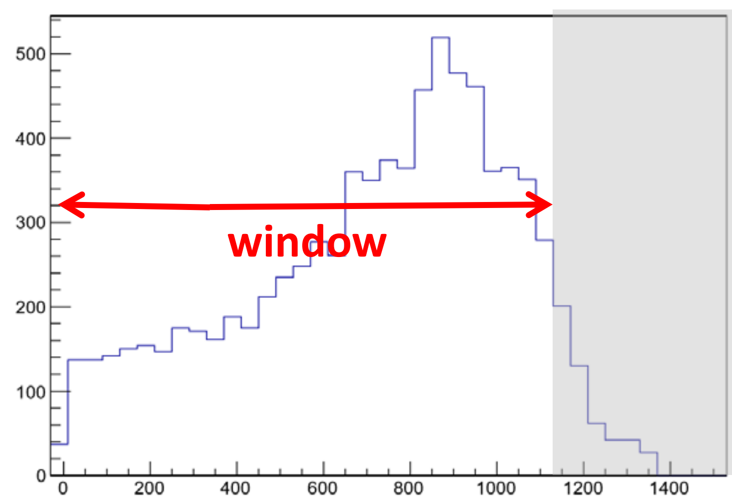
$\gamma_1 - \gamma_2$ for 1408 keV

Add-back factor from the selected window





$\gamma_1 - \gamma_2$ for 779 keV



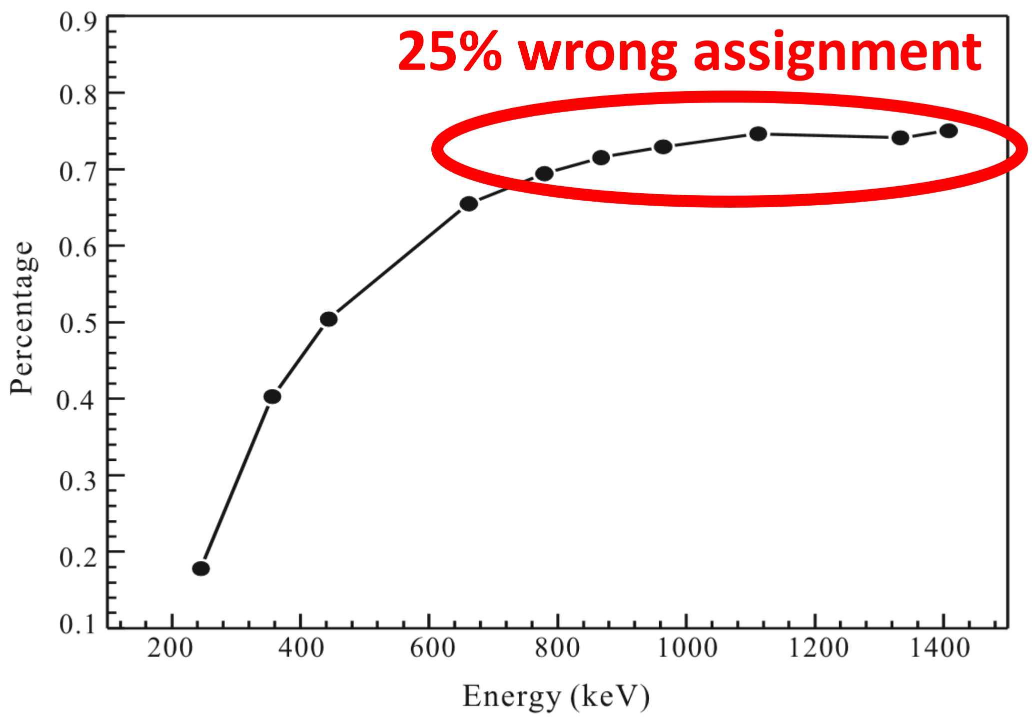
$\gamma_1 - \gamma_2$ for 1408 keV

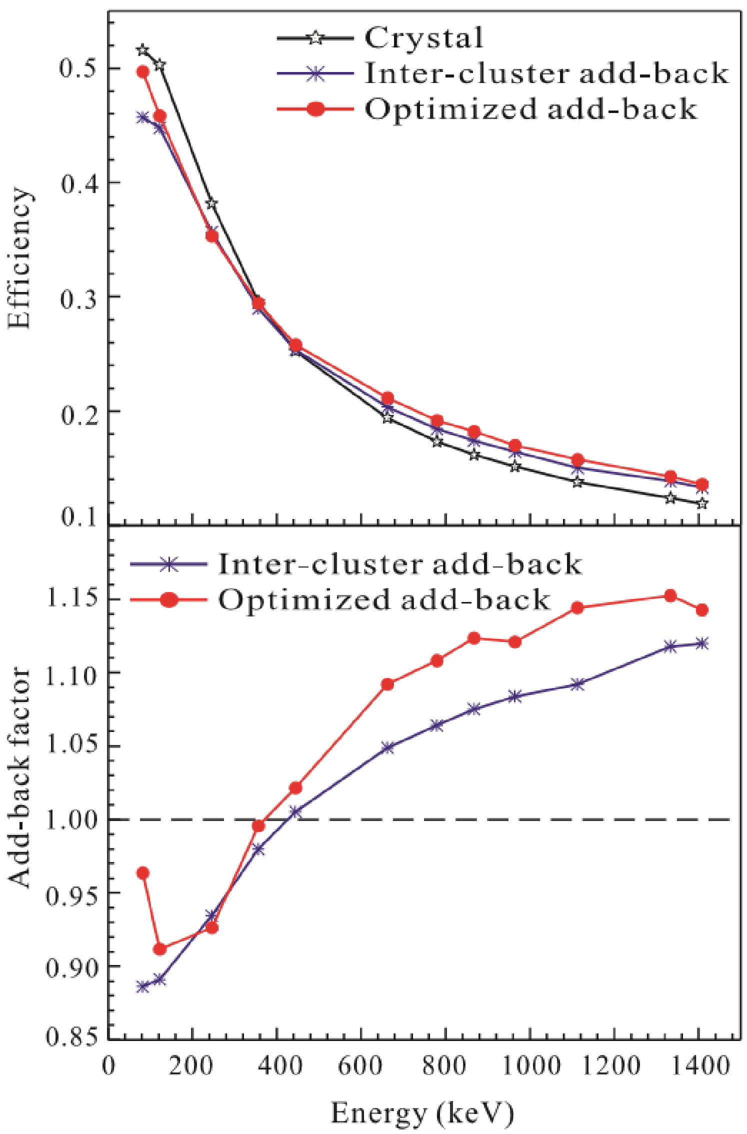
Inter-cluster neighbors : $\dfrac{|\gamma_1 - \gamma_2|}{\gamma_1 + \gamma_2} < 0.8$

cross-cluster neighbors : $\dfrac{|\gamma_1 - \gamma_2|}{\gamma_1 + \gamma_2} < 0.2$

Window must be chosen according to physical request !!!

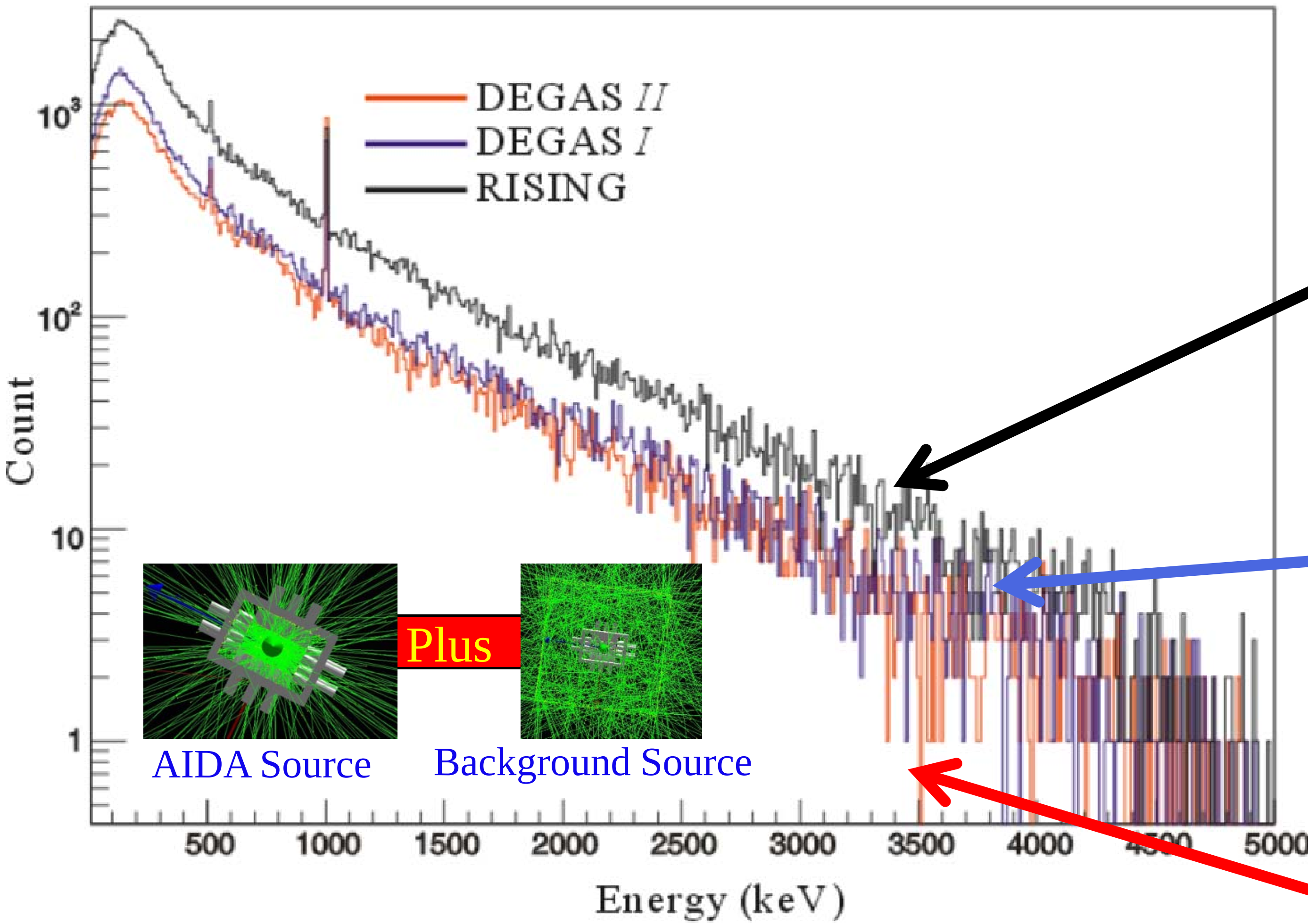
Possibility of wrong crystal assignment in add-back

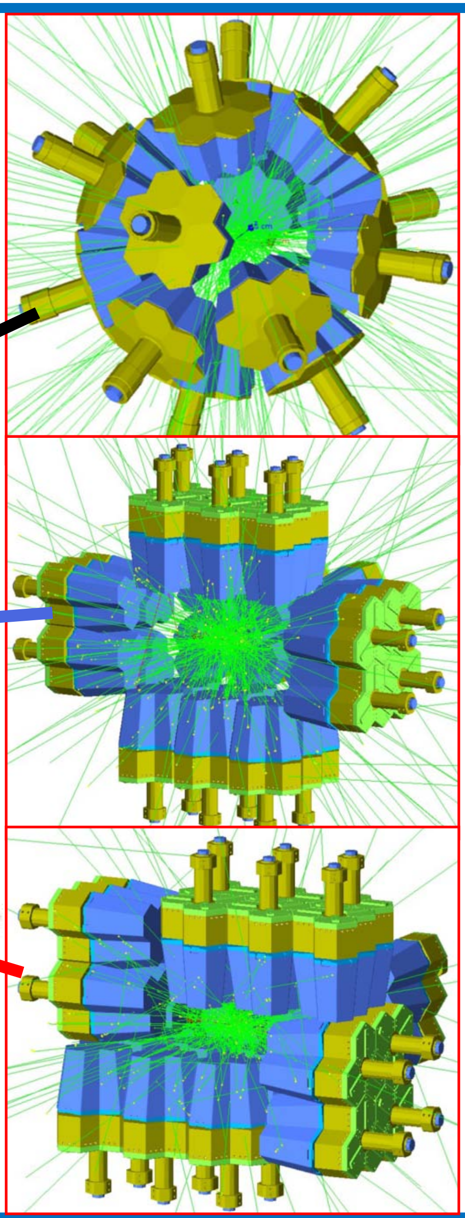




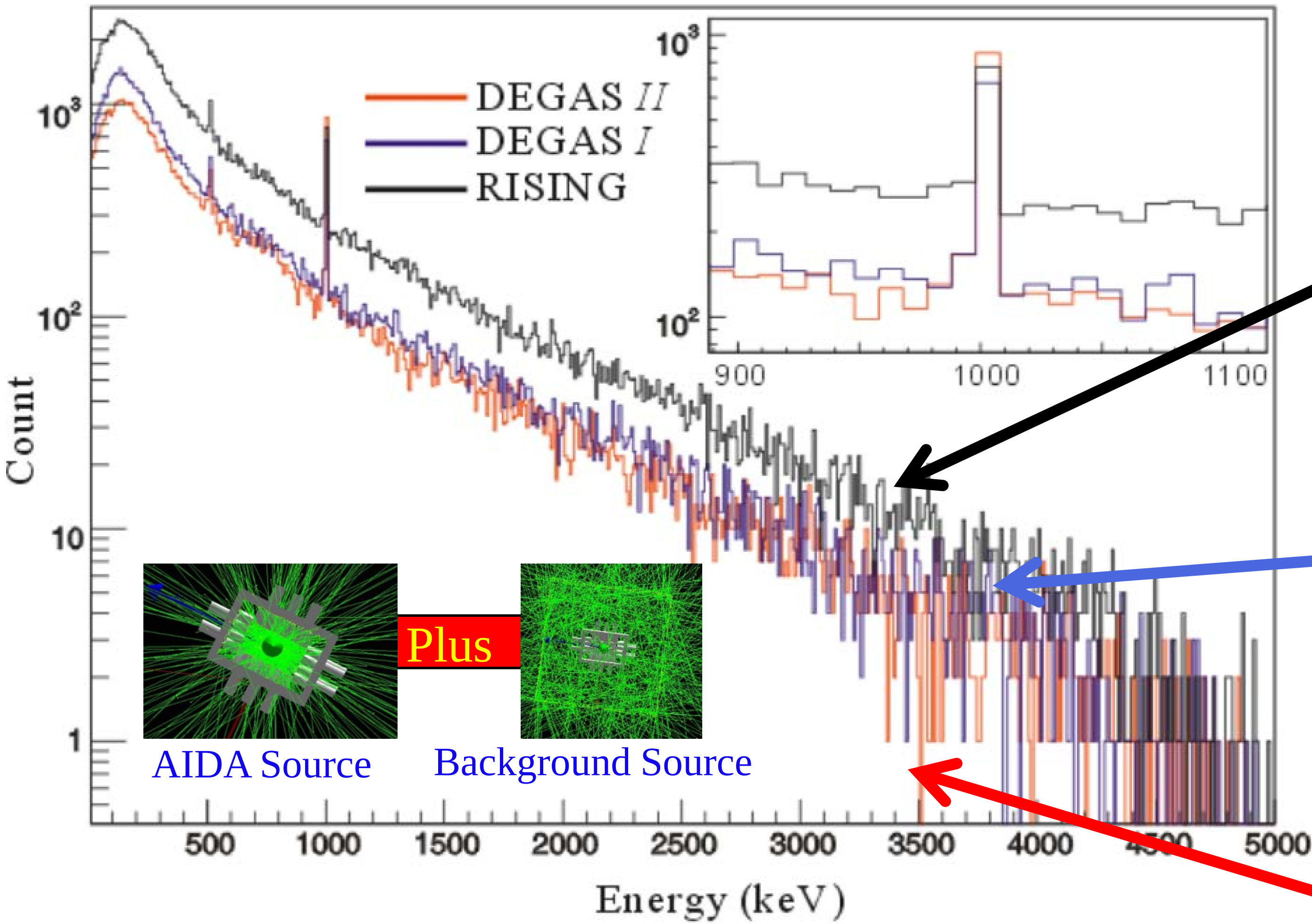
Percentage of larger energy deposition Ge crystal carrying earlier γ-ray interaction time in the two crystals energy sharing events

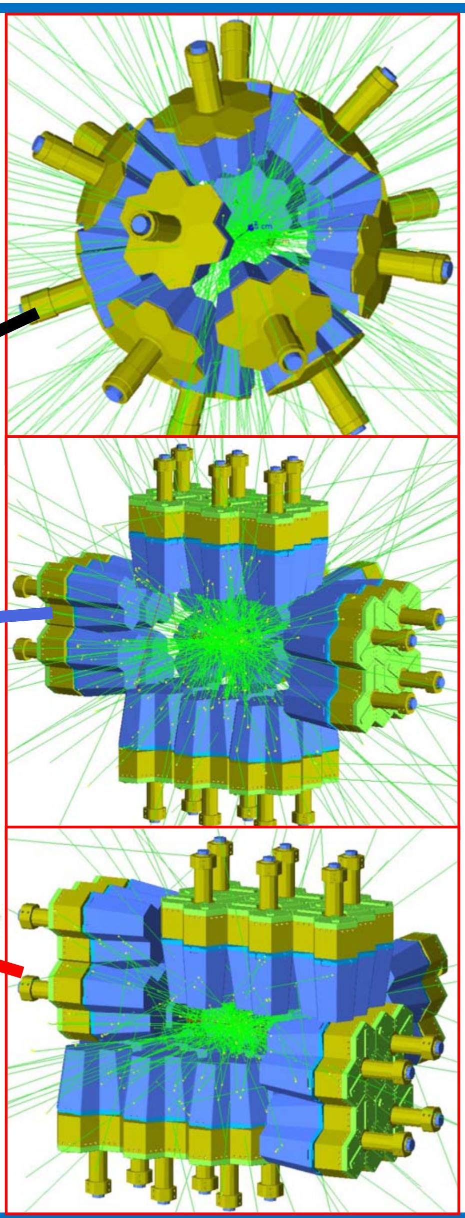
Comparison of the background suppression





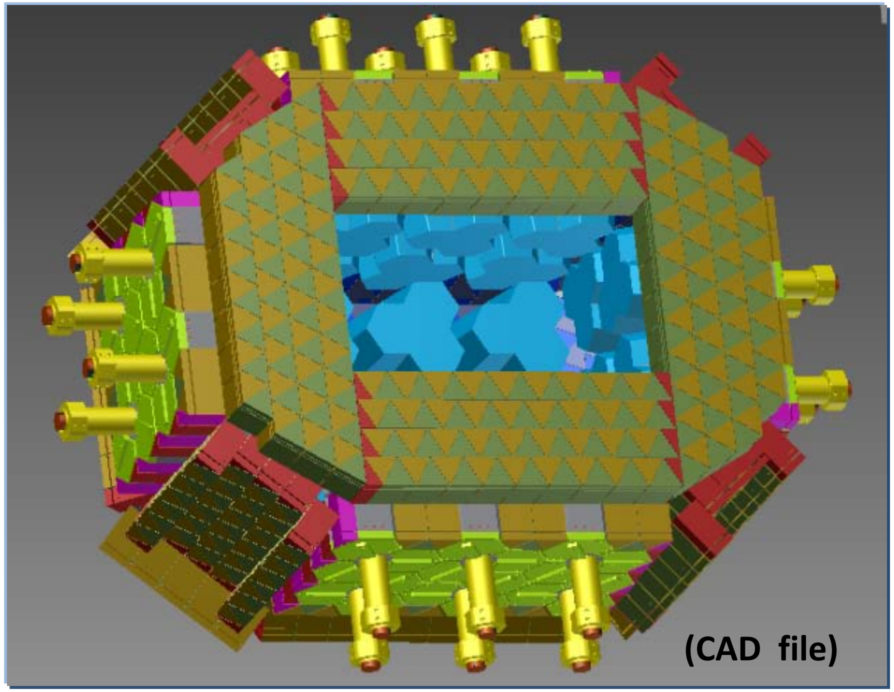
Comparison of the background suppression

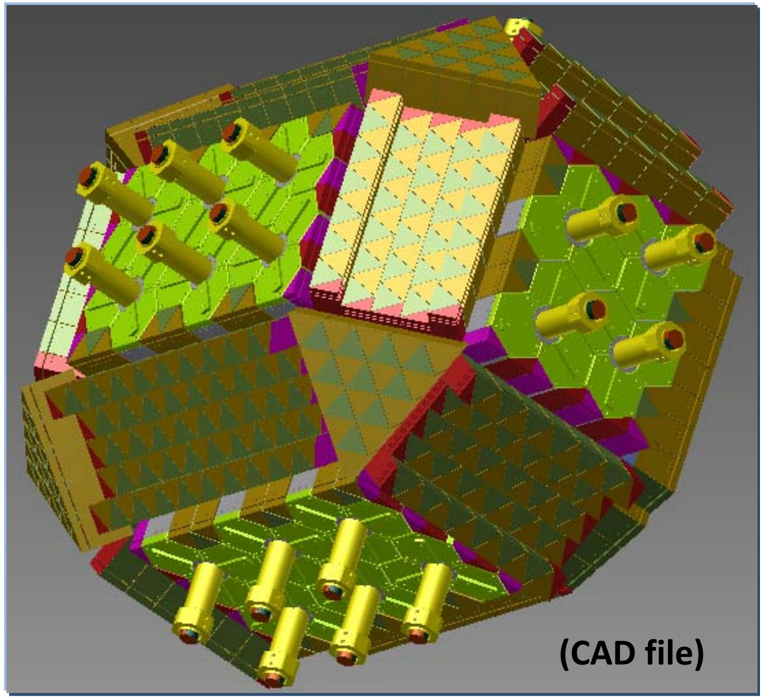




The DEGAS *II* configuration give the best P/T ratio

Future work on simulation—DEGAS I as example





Additional scintillators and passive shielding elements in the gaps of the DEGAS configuration, like the ones in the picture

Summary

- **Good agreement between simulation and experiment results…spectra, scattering and efficiency**

- **The DEGAS *II* configuration, 28 clusters in a more compact box goemtry gives the largest efficiency and best background suppression**

- **Add-back using inter-cluster and corss-cluster neighboring crystals give improved efficiency**

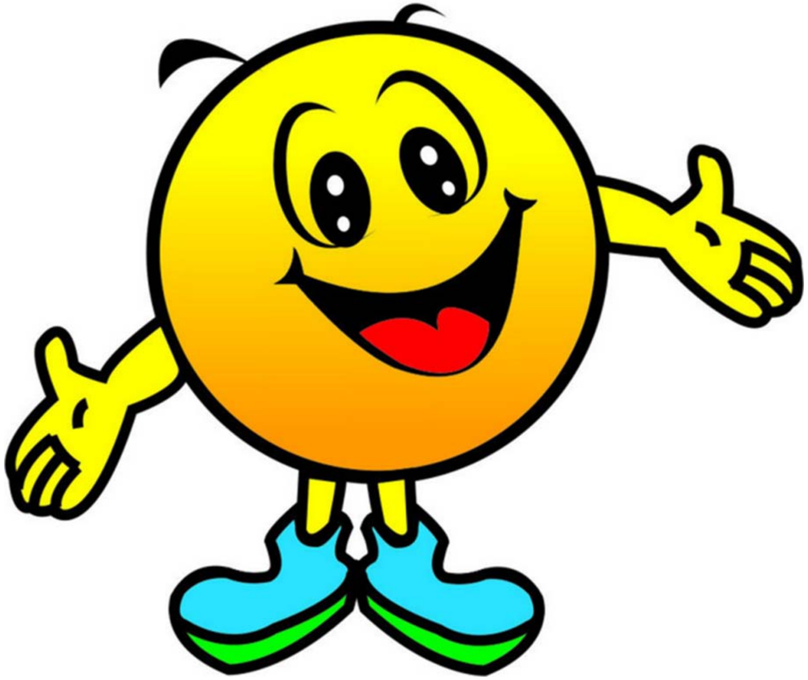
- **Improvement is expected using addtinal scintillators and passive shielding elements in the gaps**

Acknowledgement

J. Gerl, I. Kojouharov , H. Schaffner, M. Górska, S. Saha… …
GSI, Darmstadt

DEGAS workgroup ……

M. L Liu, X. H. Zhou ……
IMP, Lanzhou



Thank you for your attention!