What gamma-ray detector for GASPARD ?

By Marc Labiche

on behalf of the GASPARD simulation working group

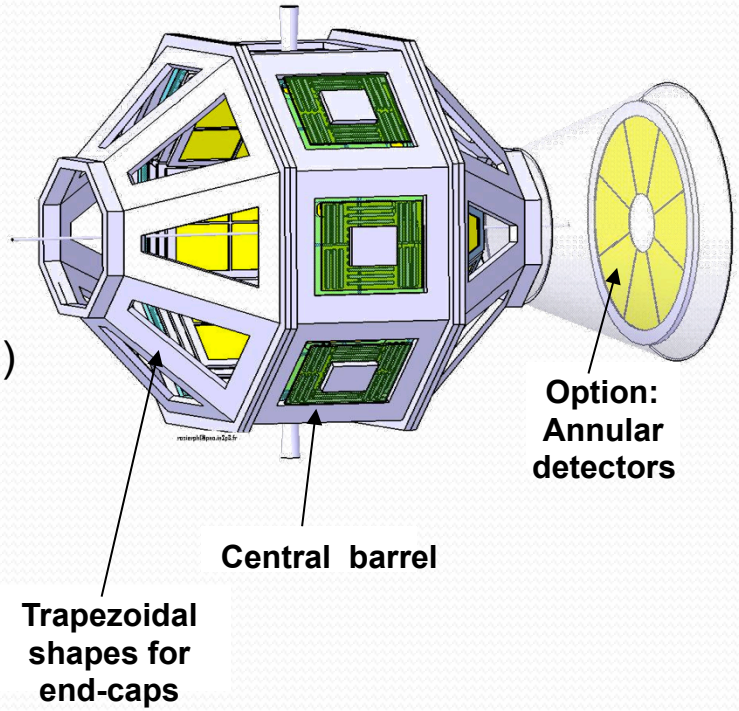
Paris Collaboration meeting
Bormio, 21 Feb 2012

Science & Technology Facilities Council
Nuclear Physics Group

GASPARD (Gamma Spectroscopy and Particle Detection)

Initial concept: 4π particle and 4π gamma array for the study of direct reactions

Particle Array:
- Good position resolution (0.5 mm) over ~4π
- Large dynamic range
- Low threshold
- Allows for time-of-flight measurement and PSD
- Gas and cryogenic targets
- Low gamma-ray absorption (below 10% for 1 MeV gammas)



Gamma Array :
- 50 keV (FWHM) energy resolution for gammas of 1 MeV
- Dynamic range from 0.1 to 5 MeV.
- Total detection efficiency of 75% for 1 MeV gammas.
- Granularity will be such that the Doppler broadening is below 30 keV.

PARIS and AGATA

Simulations for GASPARD & HYDE

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Nicolas de Séréville, IPN Orsay
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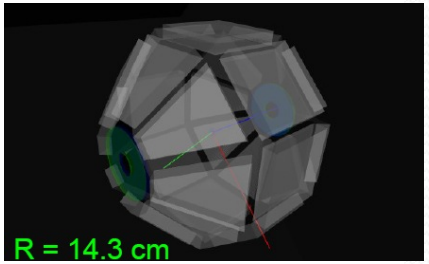
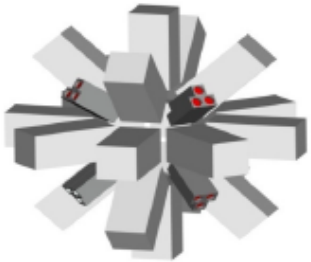
Anna Maria Corsi, Saclay

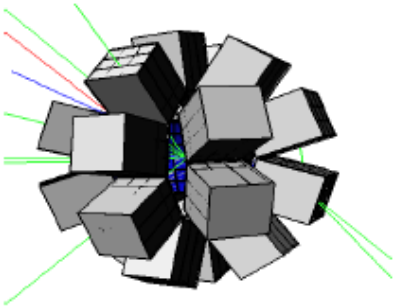


- Developments of the NPTOOL based simulation package
  Exploitation of the charged particle generator
  (inclusion of the "GASPHYDE" geometry, …)

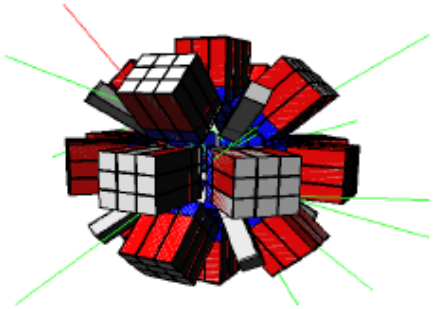
- Include GAMMA detection, e.g. the PARIS array



PARIS180
18 clusters + 18 phoswich
R = 235 mm
(8 clusters in main ring)

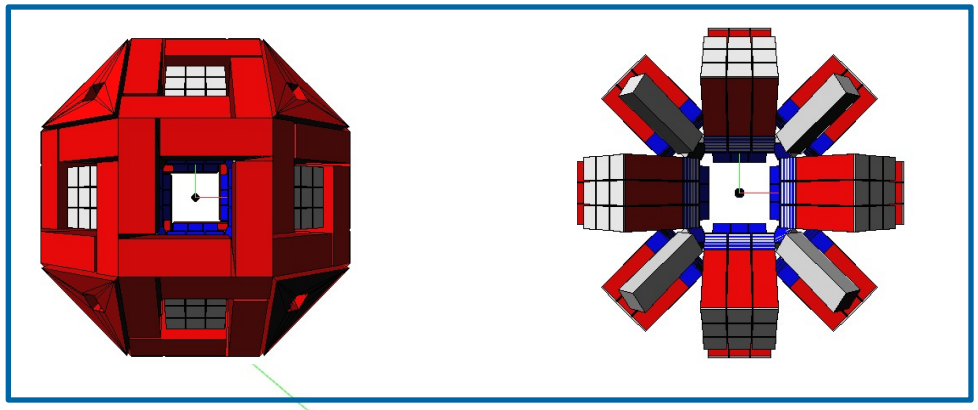


PARIS234
26 clusters
R = 235 mm
(10 clusters in main ring)

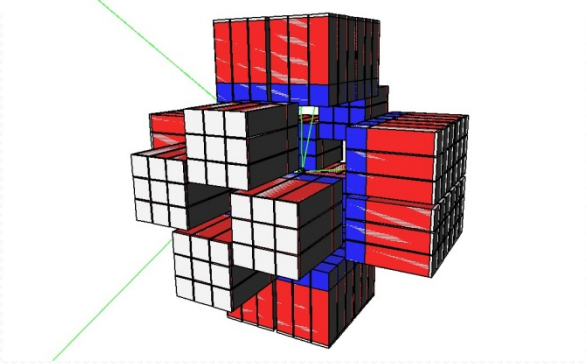


PARIS170
18 clusters + 6 phoswich
R = 208 mm
(8 clusters in main ring)

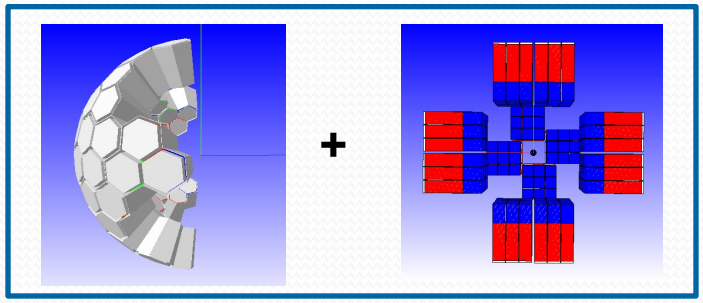
What PARIS configurations for GASPARD ?



EXOGAM-like configuration with and without NaI shield around the phoswich cluster

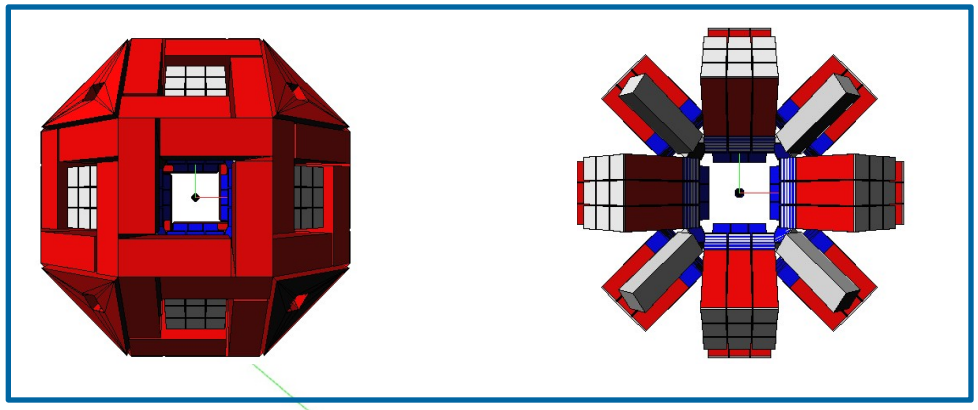


A cube configuration

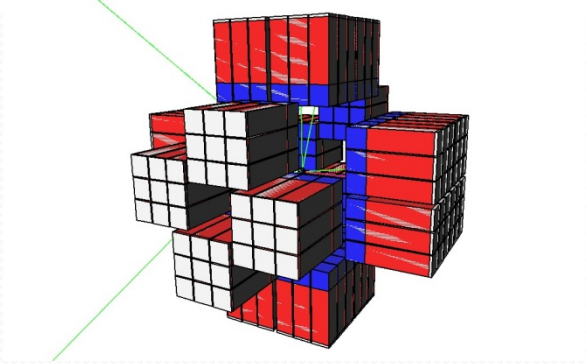


AGATA + PARIS ½ cube configuration

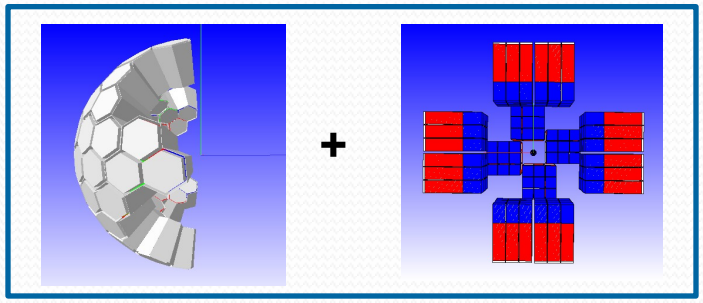
What PARIS configurations for GASPARD ?



16 Phoswich Clusters
+
8 single Phoswich

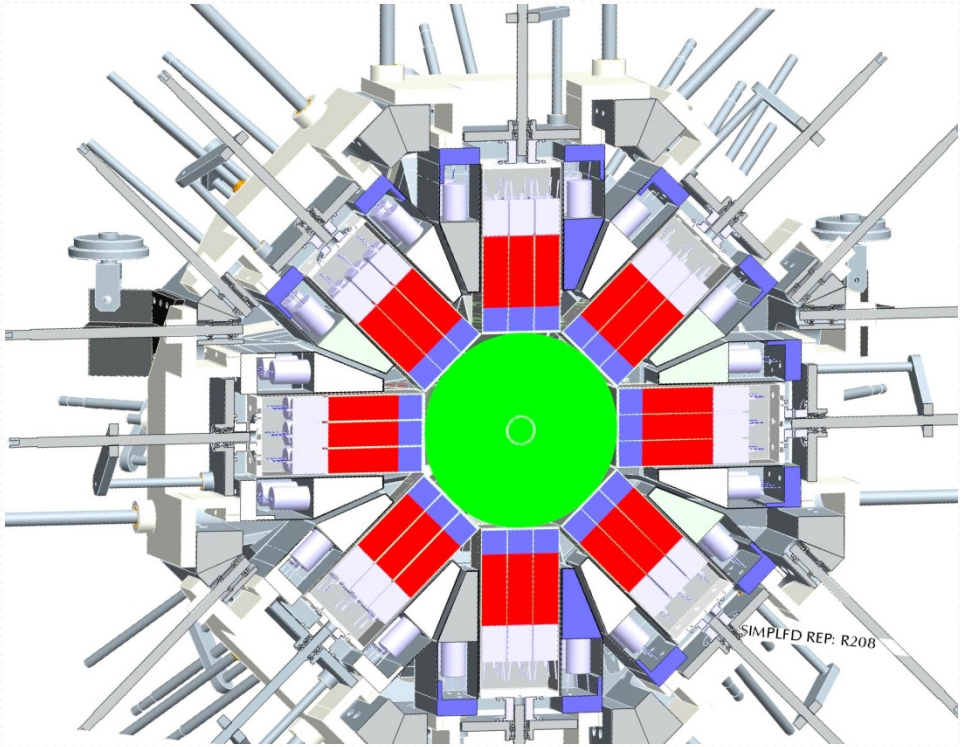


24 Phoswich clusters

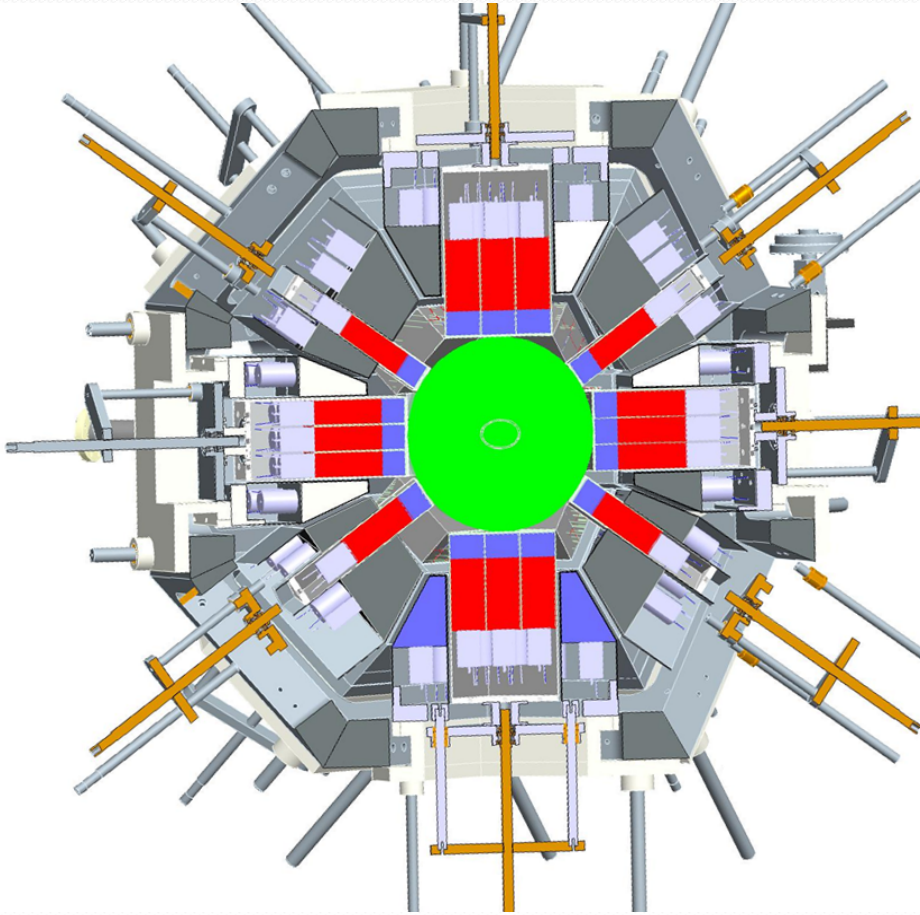


20 AGATA triple clusters
+
12 PARIS Phos. clusters

PARIS CAD drawings for the EXOGAM-like configuration



Cross section of the central ring

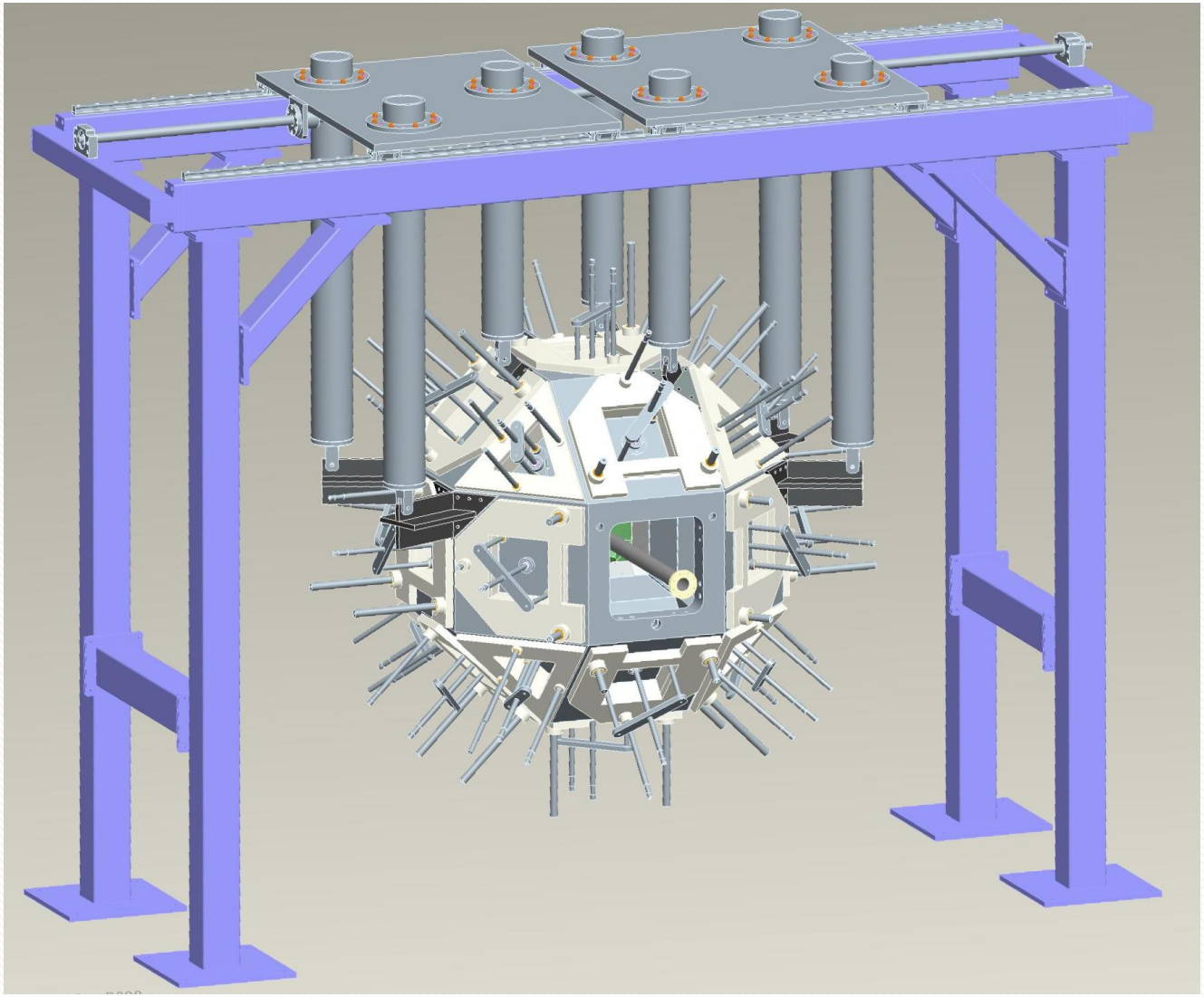


Cross section of backward/forward ring

Courtesy of S. Postlethwaite and J. Strachan

Could be suspended from above

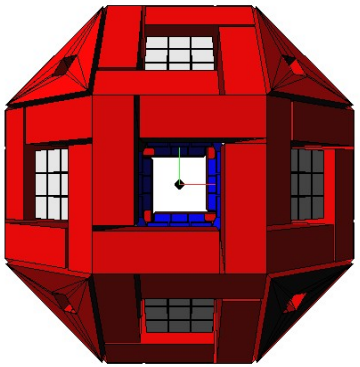
Possibility to split the array from left or right to access the target area



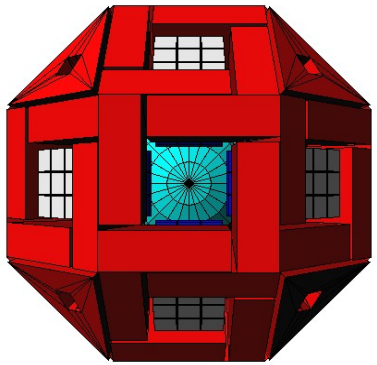
Courtesy of S. Postlethwaite and J. Strachan

Photon attenuation through GASPARD with the EXOGAM-like configuration of PARIS

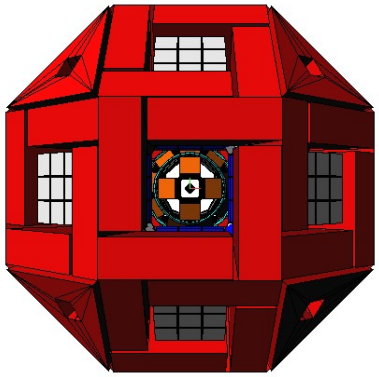
1: PARIS only



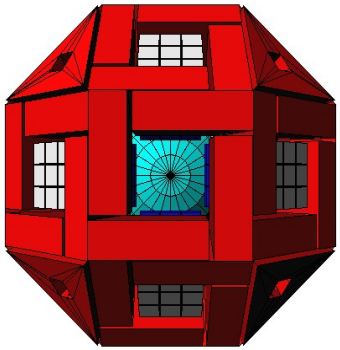
2: PARIS + chamber (Al . 2 mm)



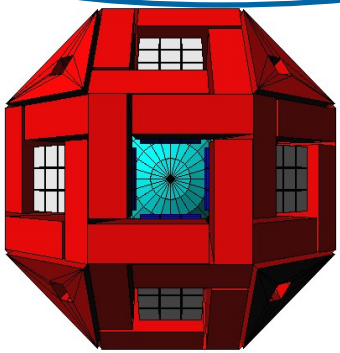
3: PARIS + GASPARD

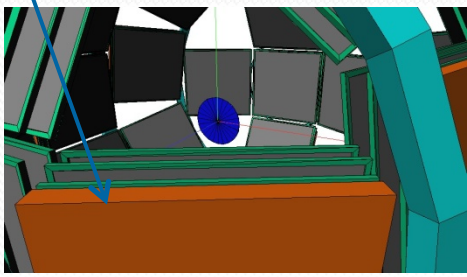


4: PARIS + chamber + GASPARD



5: PARIS + chamber + GASPARD
+ 4 mm Cu (cooling)





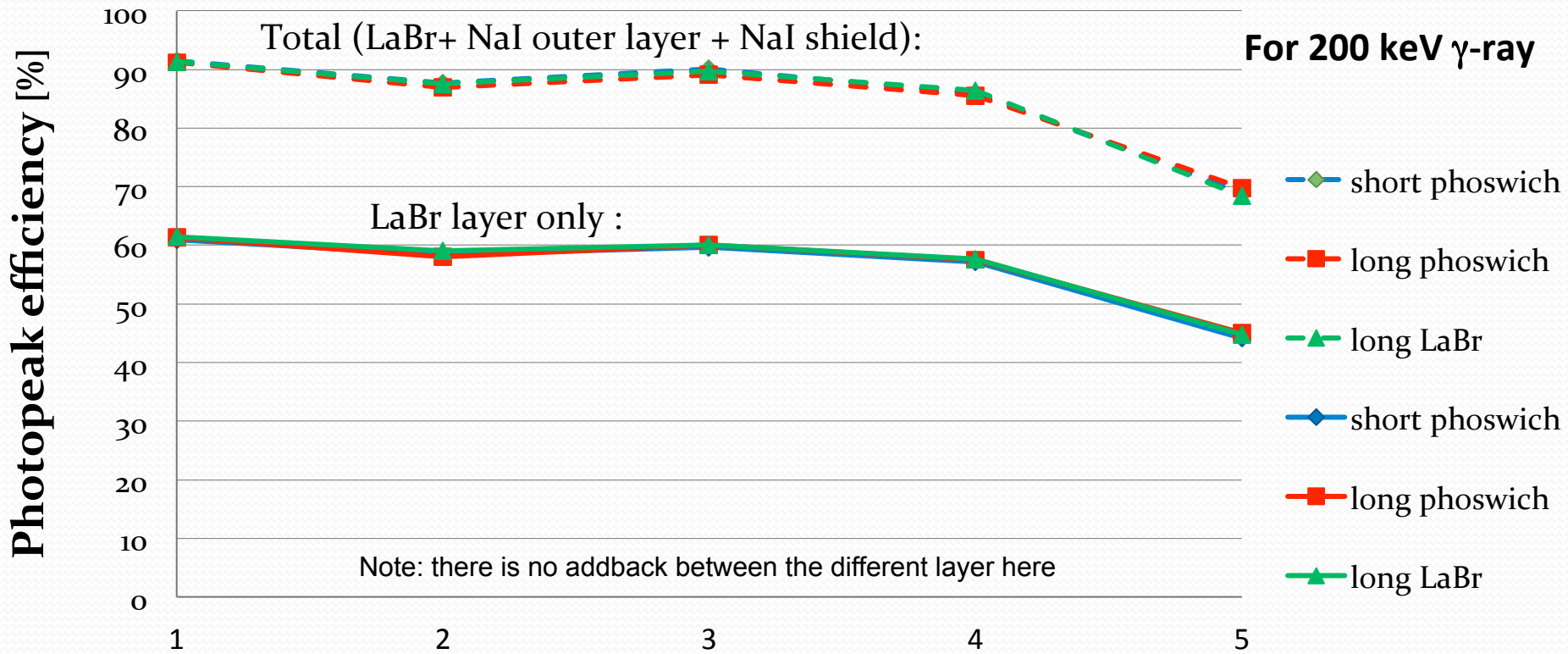
With different Phoswich configurations:

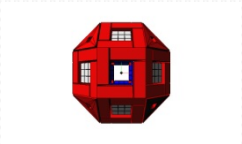
- Short phoswich: LaBr 2” + NaI 6”

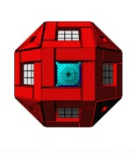
- Long phoswich: LaBr 3” + NaI 6”

- Long LaBr: LaBr 6”

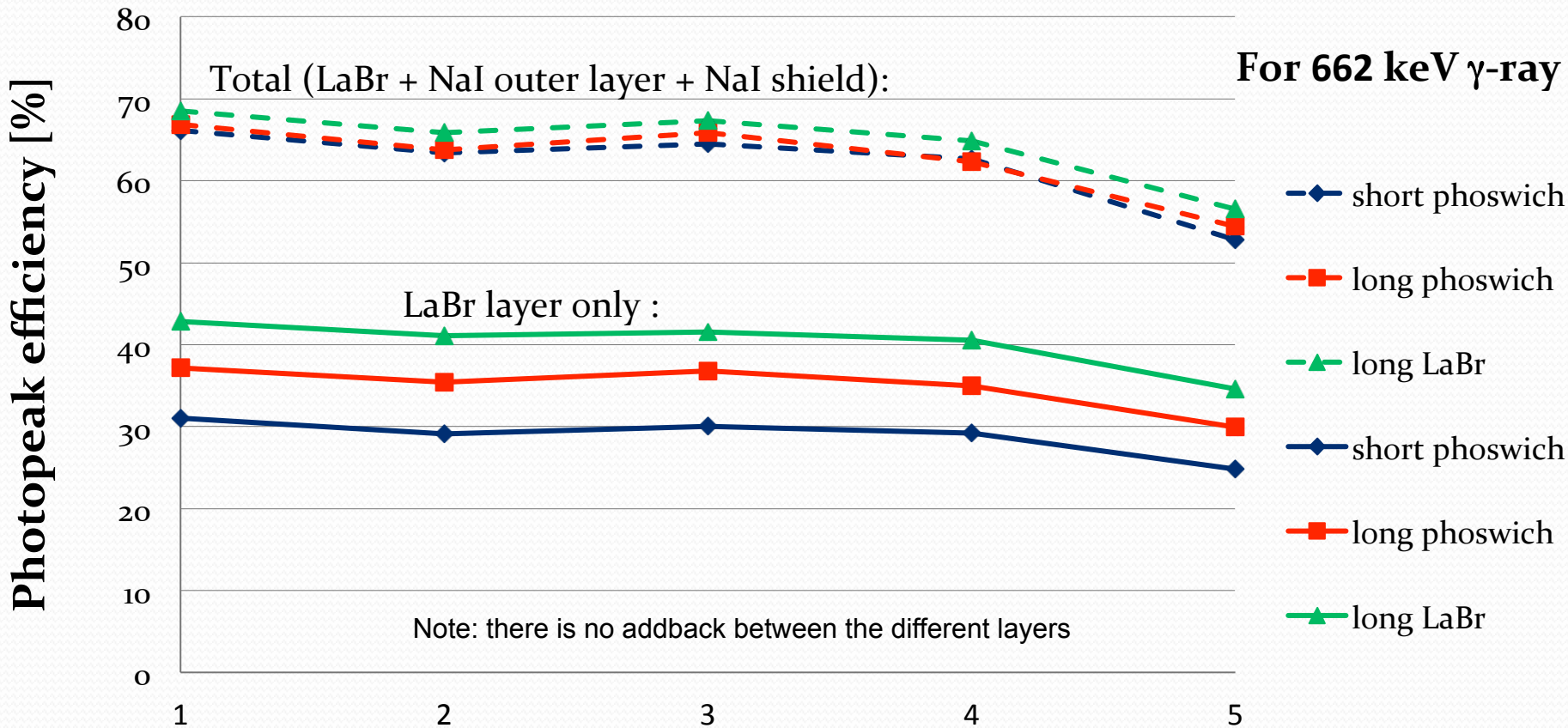
PARIS Spherical configuration



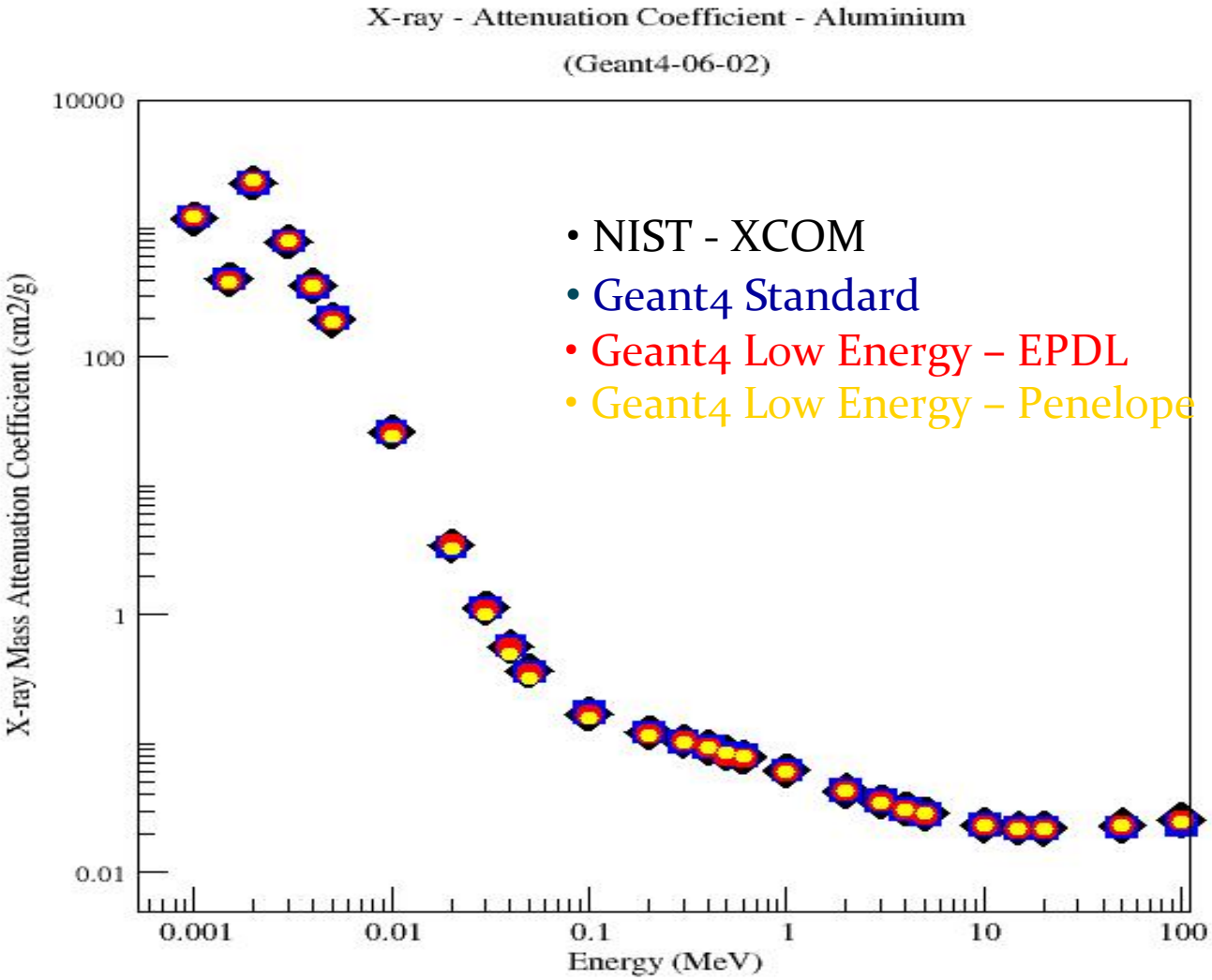


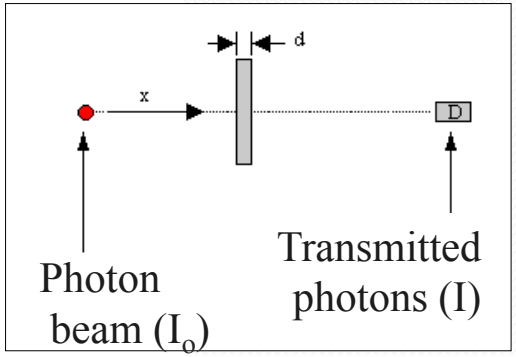

PARIS Spherical configuration

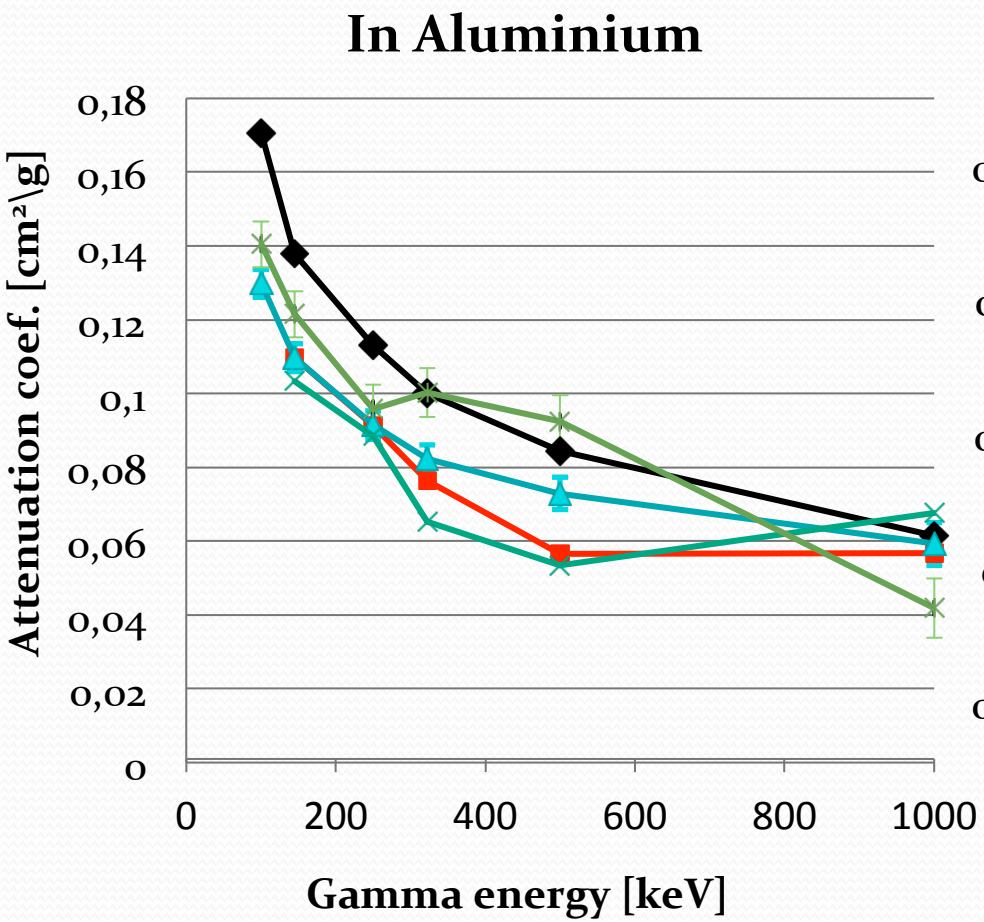


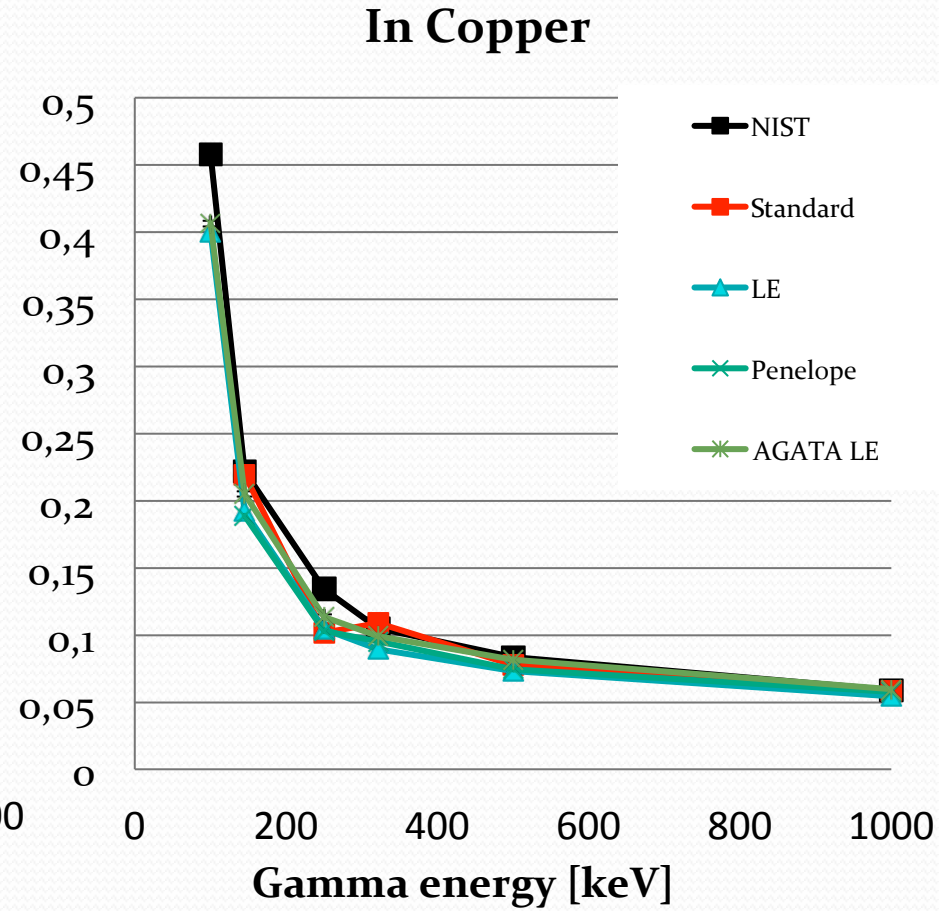
Photon Attenuation Coefficient: GEANT4 vs NIST



$$\frac{\mu}{\rho} = -\frac{1}{d\rho}\ln\left(\frac{I}{I_0}\right)$$

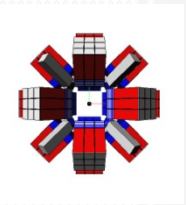


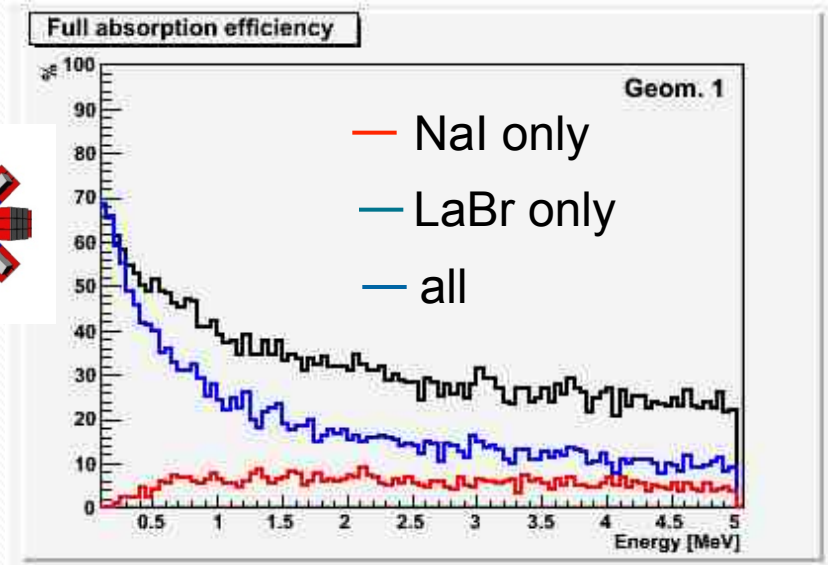


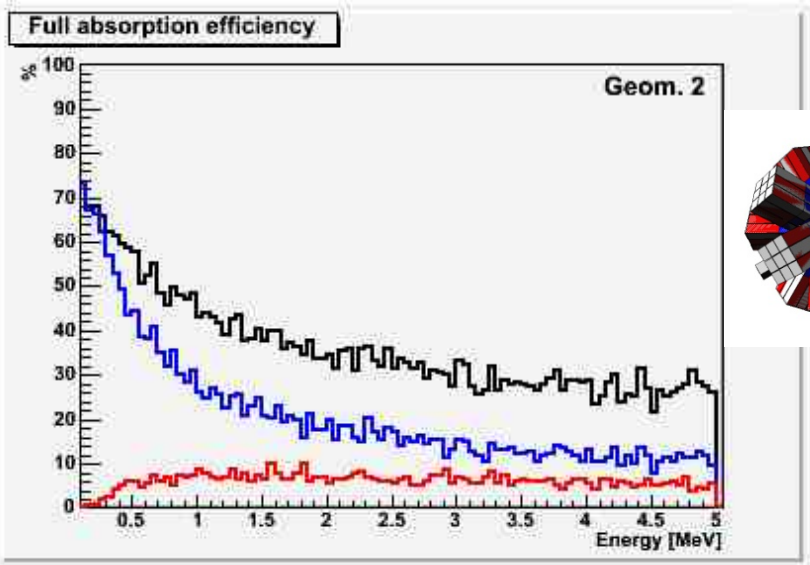


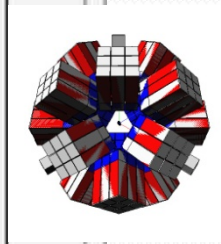
- Some discrepancies between NIST and GEANT4 (either NPTool or AGATA) are observed.
- At least between 100 KeV and ~500 keV, GEANT4 underestimates the attenuation.

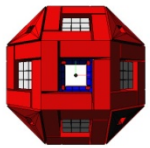
Efficiency curves for isotropic source & Mγ=1

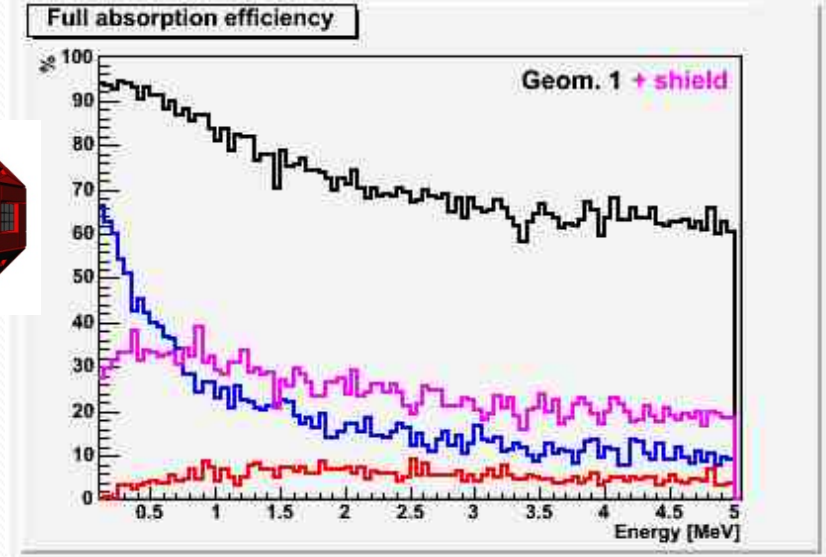


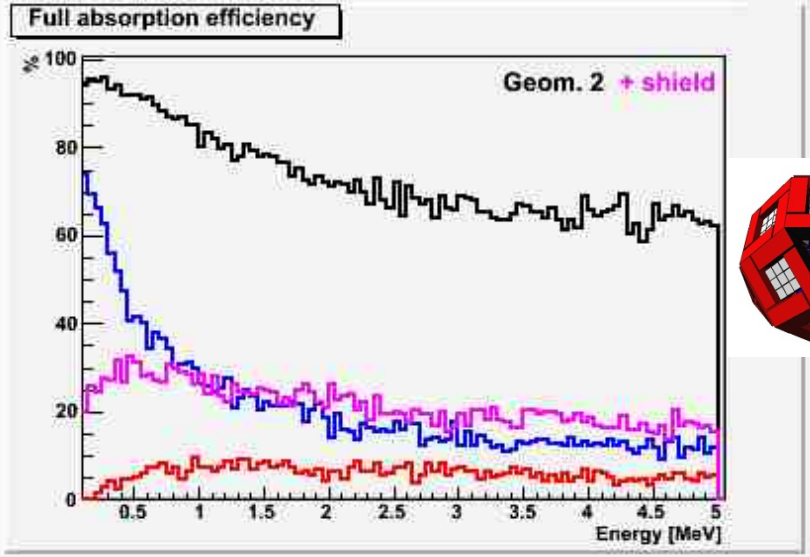








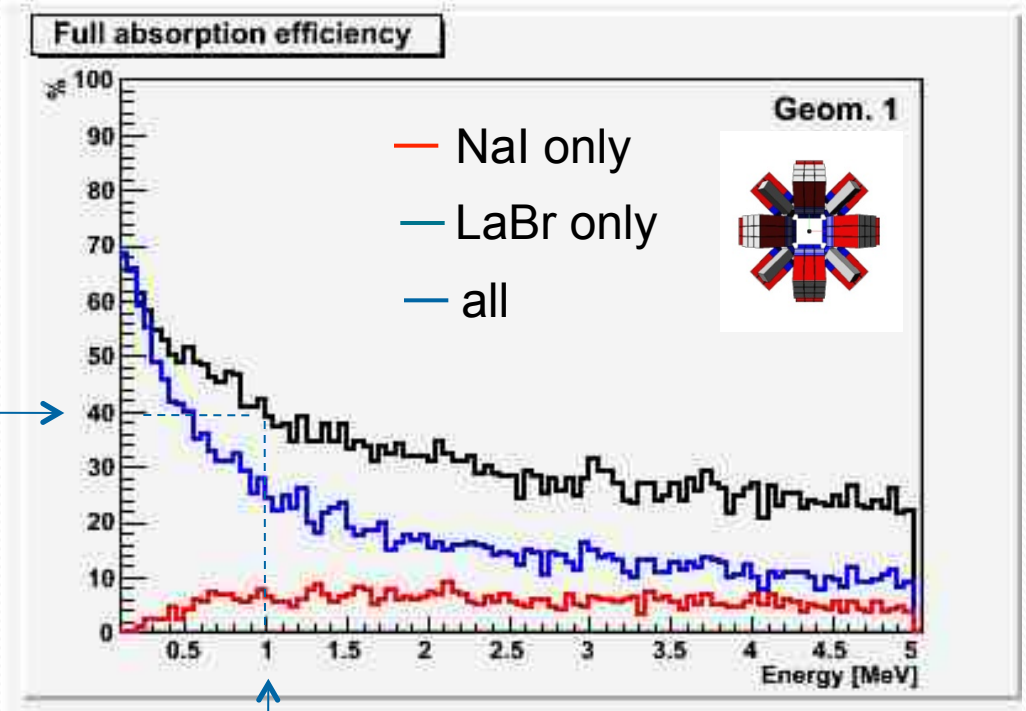




(= Results for short phoswich, with full addback)

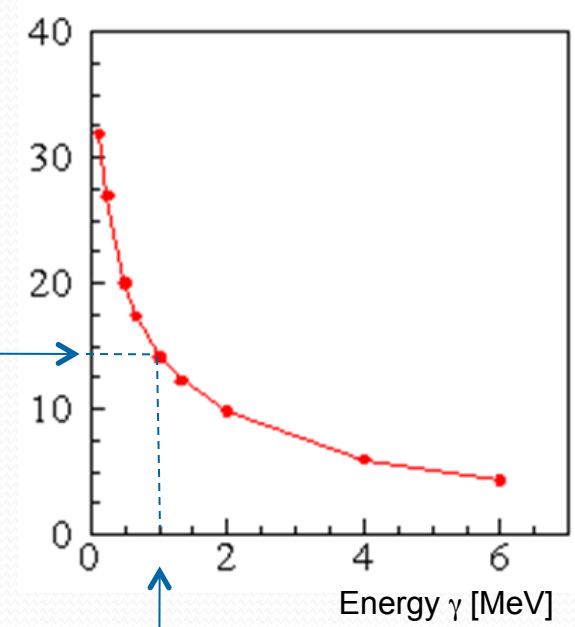
Comparison with EXOGAM

PARIS

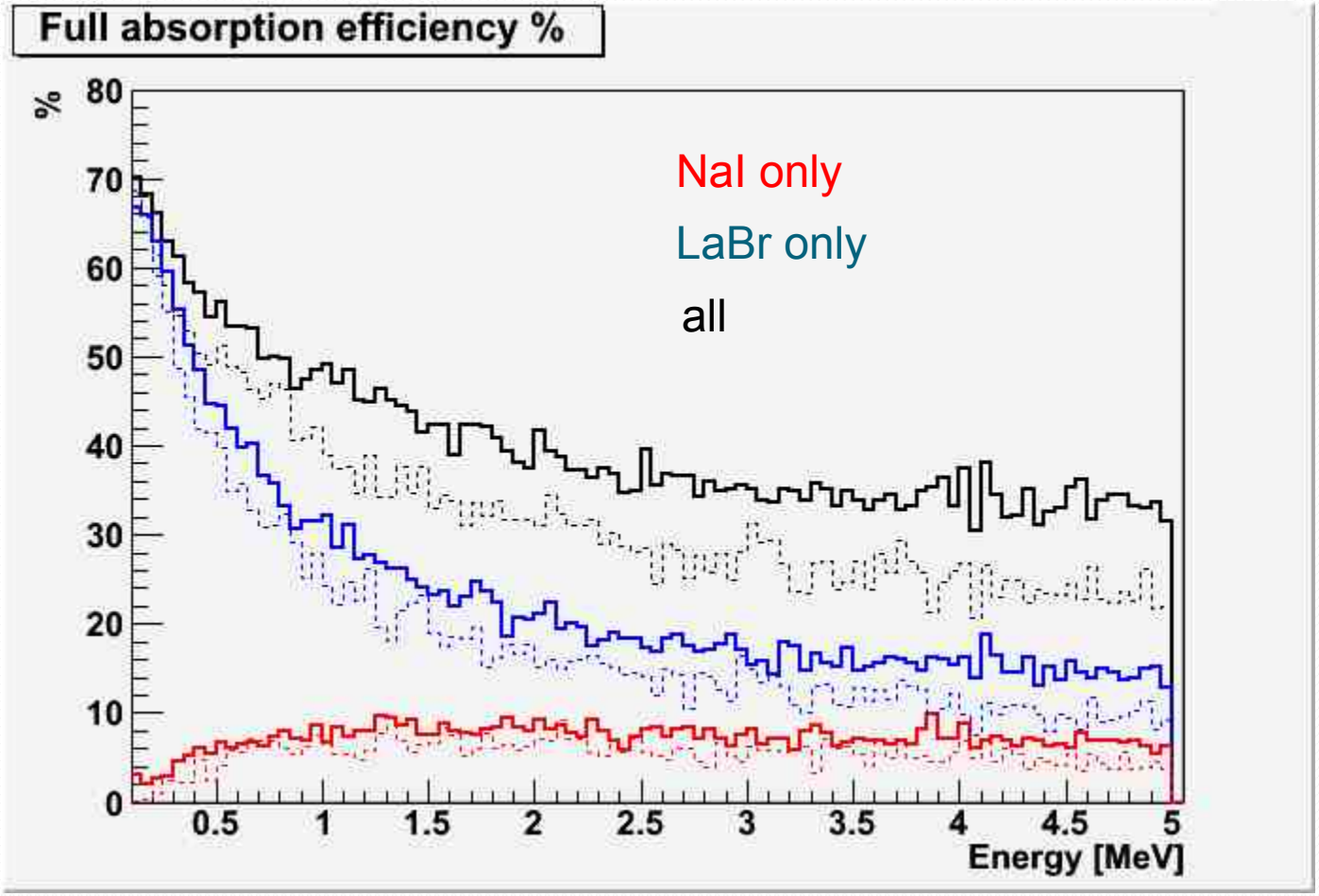


EXOGAM

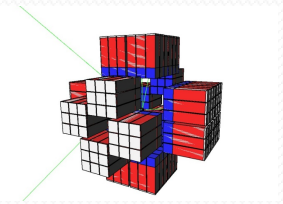
with 16 clovers. 11 cm away from the target



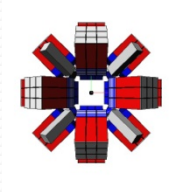
Cube vs EXOGAM-like configuration



Solid lines for :



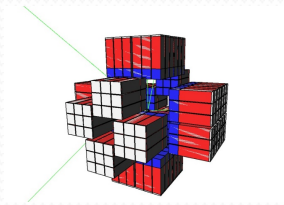
Dash lines for :



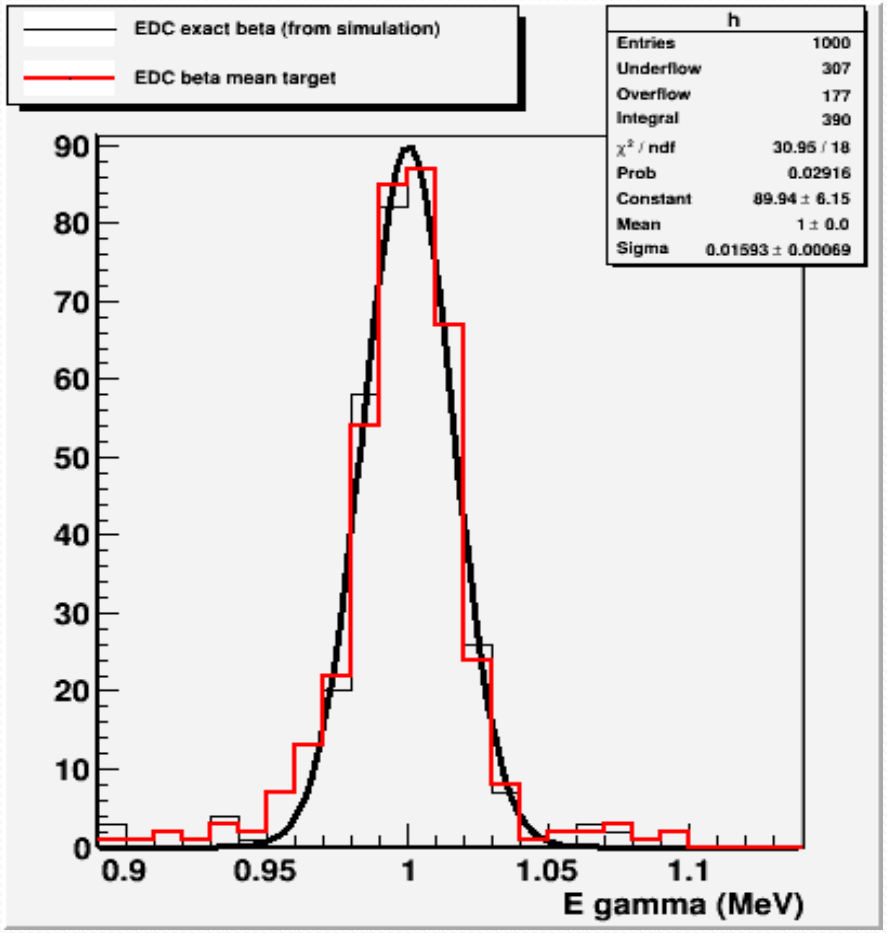
(= Results for short phoswich, with full addback)

96Kr(p,t)94Kr* with a hypothetical 1 MeV excited state

- With PARIS in a cube configuration with minimal distance to target =208 mm
- β=0.127



Doppler corrected spectrum



Results:

PP Efficiency = 50% < specs (75%)

FWHM = 37 keV < specs (50 keV)

(Note: with 4 EXOGAM clovers at ~5 cm to the target, efficiency is only ~17% and FWHM ~ 35keV)

Courtesy of Anna Maria Corsi, Saclay

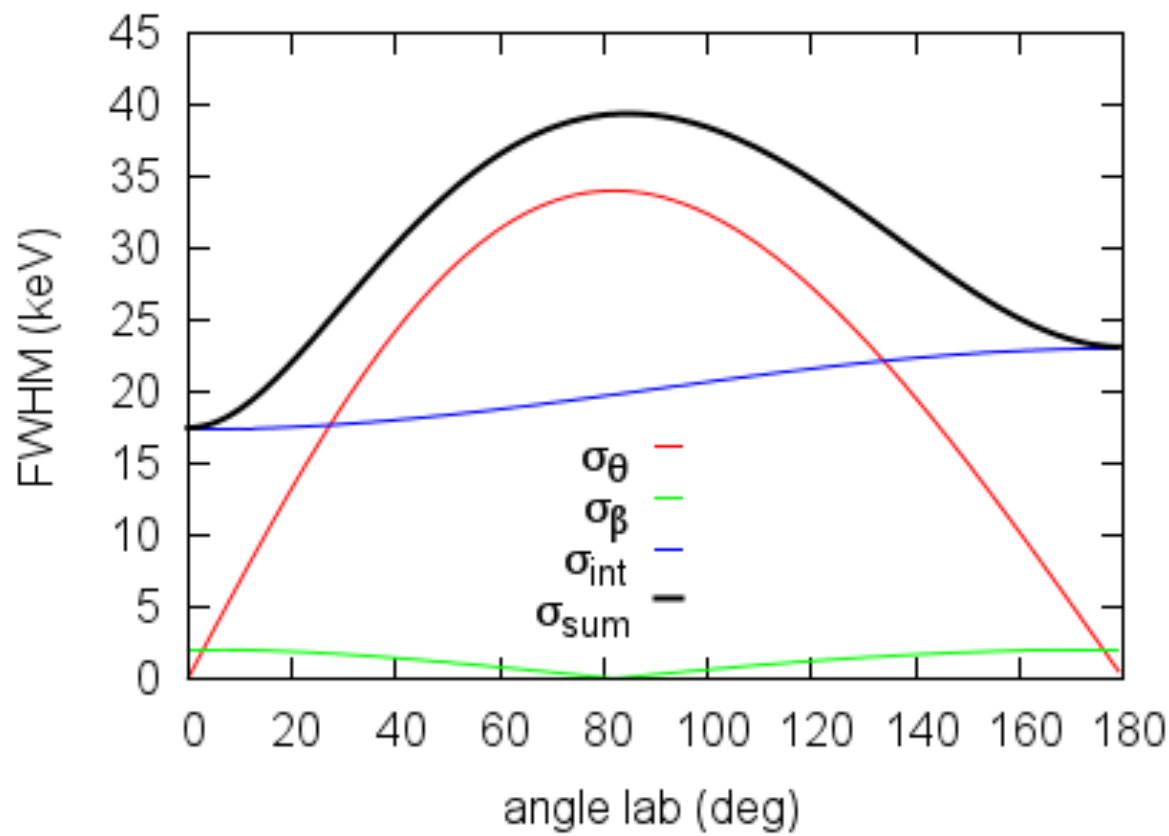
Propagation of the error in the doppler correction formula

Using the following parameters

$E\gamma$ = 1 MeV
$\Delta E\gamma/E\gamma$ =3% // LaBr

beta =0.127;
Δbeta =0.002;

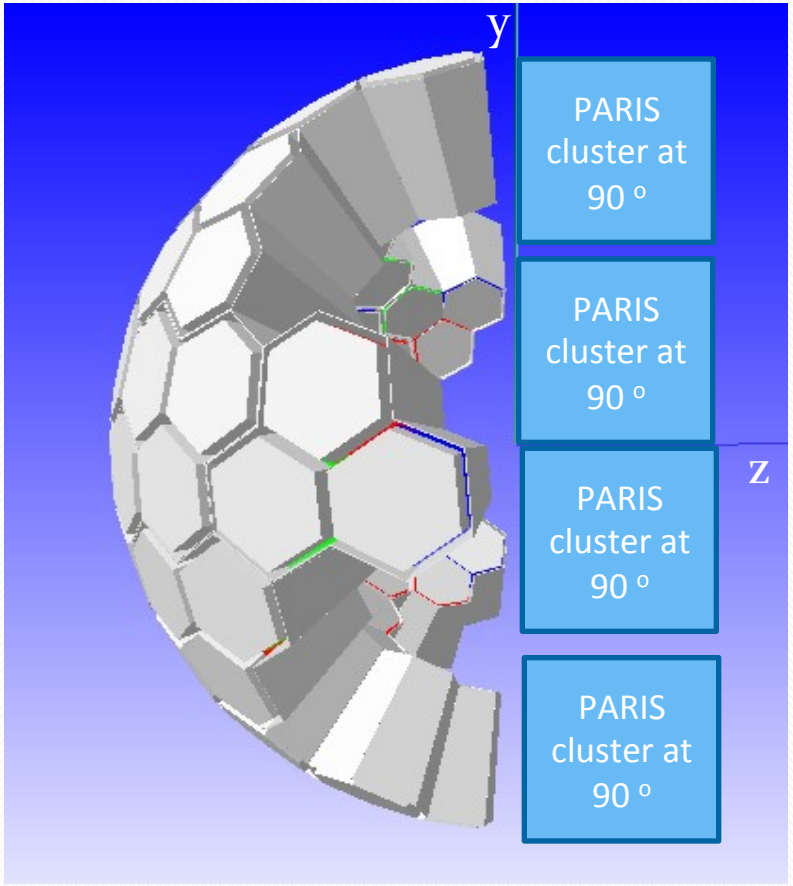
Δtheta=50./208.;
//crystal in paris cluster

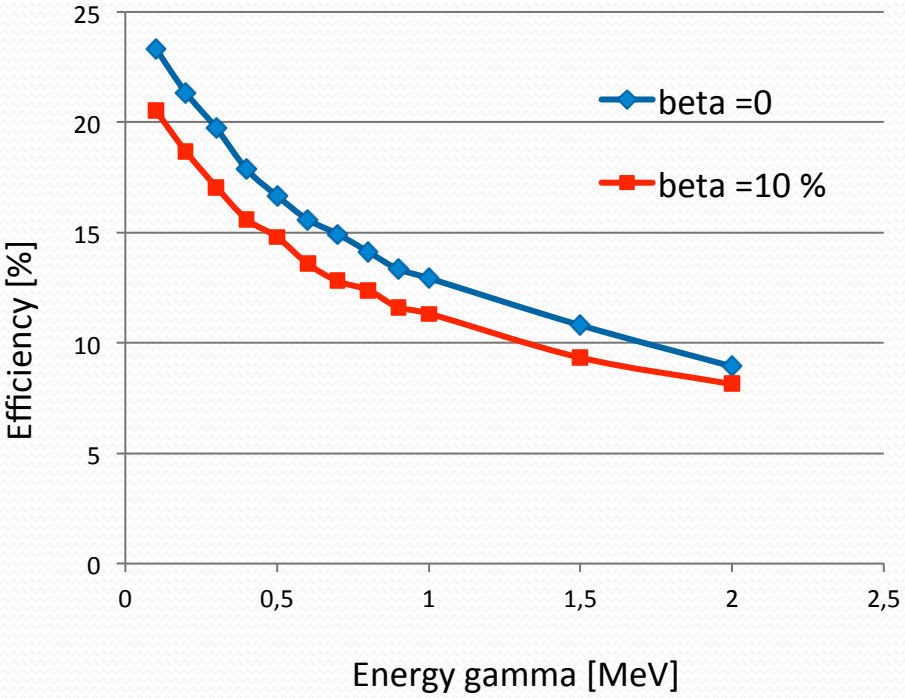


Courtesy of Anna Maria Corsi, Saclay

AGATA (~1.34pi) at backward angles

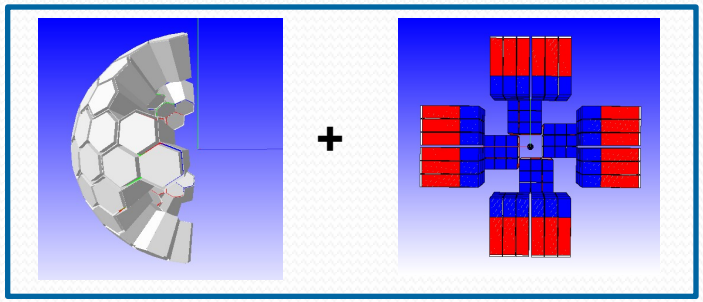
20 AGATA triple clusters



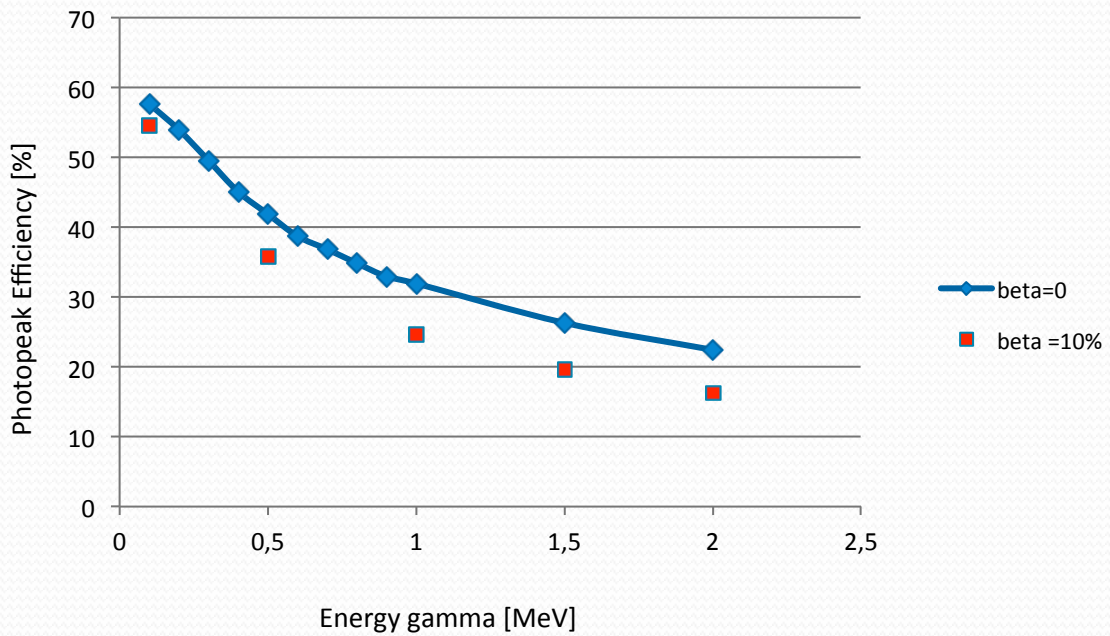


- Closest distance to target: 230 mm

PARIS + AGATA



20 AGATA clusters + 12 PARIS clusters



Conclusion

- PARIS at SPIRAL 2 meets most of the initial specifications for the GASPARD gamma detector part.
- There should be enough clearance to fit the Silicon array
- Without additional NaI shield, the cube configuration offers the highest PP efficiency (~50% at 1 MeV) compare with the EXOGAM-like configuration (~40%).
- There may be possibility to fit Additional single phoswich module which will certainly increase the efficiency, to get closer to the target of 75% efficiency at 1MeV
- Cube configuration of PARIS (2pi) + AGATA (1.3) would also be a good solution for GASPARD Day -1 experiment.

Efficiency reduction factor from NIST