Advanced GAmma Tracking Array

Performance of an AGATA prototype detector estimated by Compton-imaging techniques

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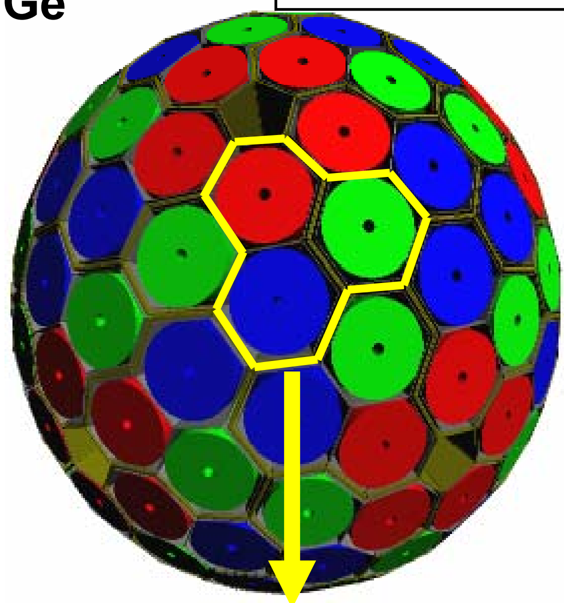
on behalf of the AGATA collaboration

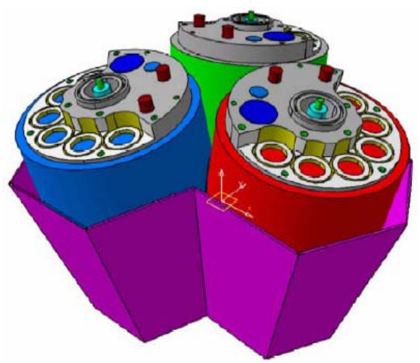
The γ-ray spectrometer AGATA

R_{int} = 23 cm

R_{ext} = 32 cm

180 HPGe





Triple cluster

Design values:
5 mm of position resolution assumed

Efficiency: 43% (M_γ=1) 28% (M_γ=30)
today's arrays ~10% 5%

Peak/Total: 58% (M_γ=1) 49% (M_γ=30)
today ~55% 40%

Angular Resolution: ~1º

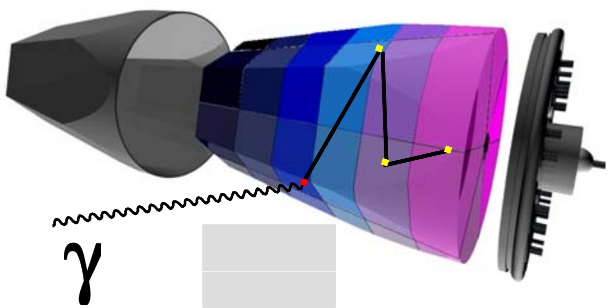
FWHM (1 MeV, v/c=50%) ~ 6 keV
today ~40 keV

- 180 large volume 36-fold segmented Ge crystals packed in 60 triple-clusters
- Digital electronics and sophisticated Pulse Shape Analysis algorithms
- Operation of Ge detectors in position sensitive mode for γ-ray tracking

Ingredients of γ-ray tracking

1

Highly segmented HPGe detectors



2

Digital electronics to record and process segment signals

Identified interaction points

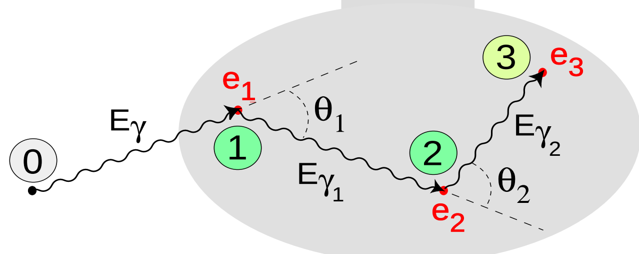
$(x,y,z,E)_i$

Pulse Shape Analysis to decompose recorded waves

3

4

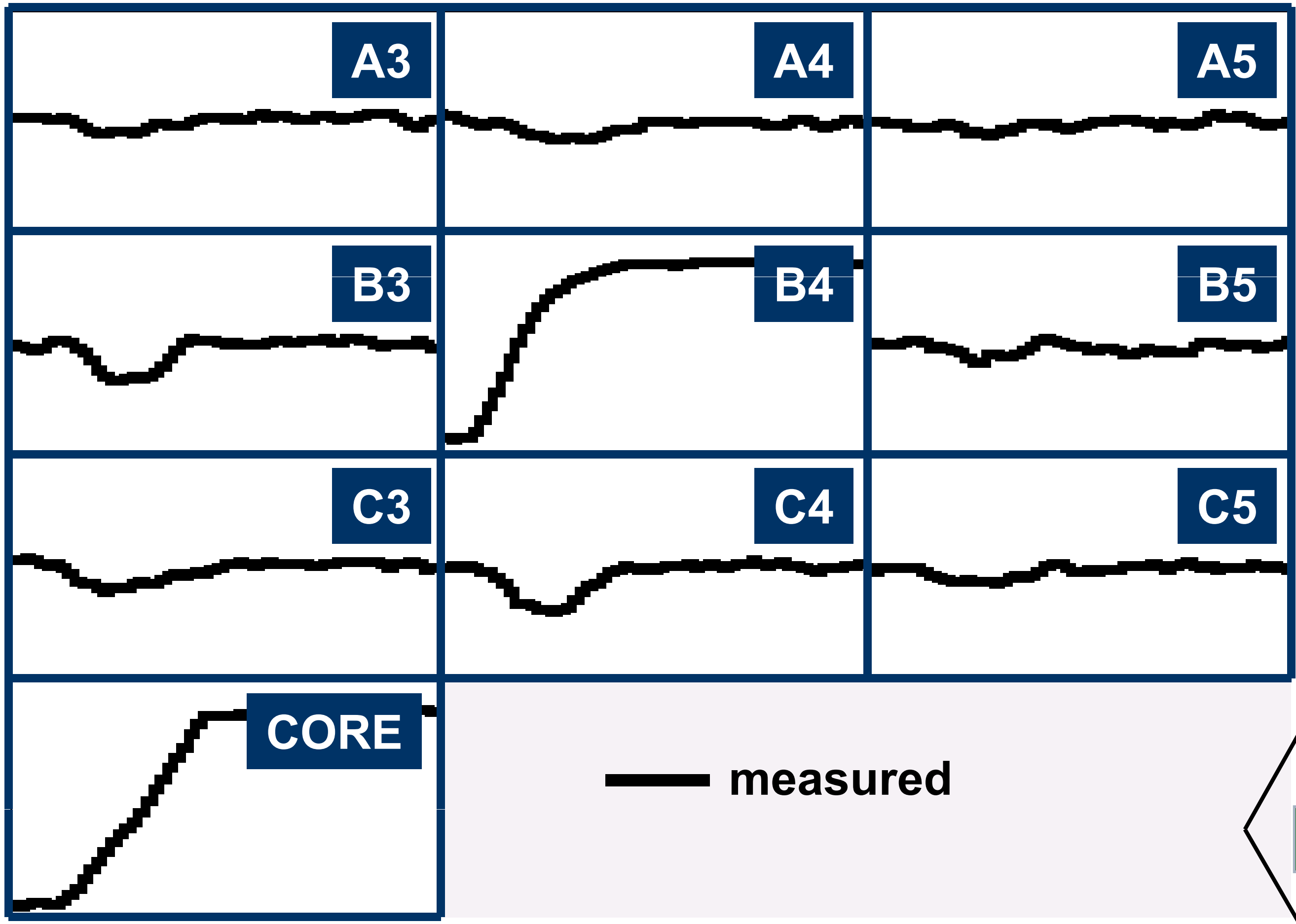
Reconstruction of scattering sequence from Compton vertices

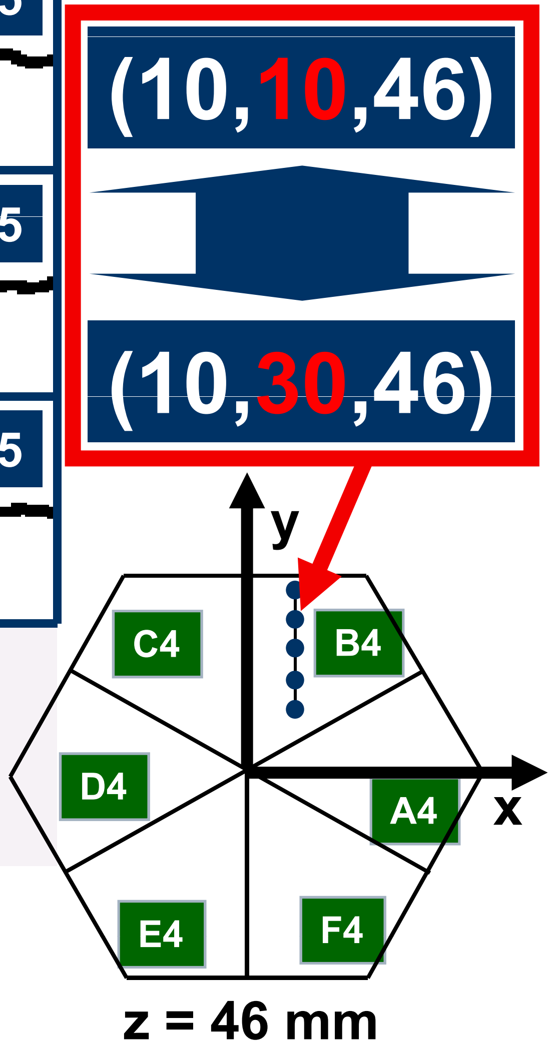


$$E_{\gamma'} = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_0 c^2}(1 - \cos\theta)}$$

Reconstructed gamma-rays

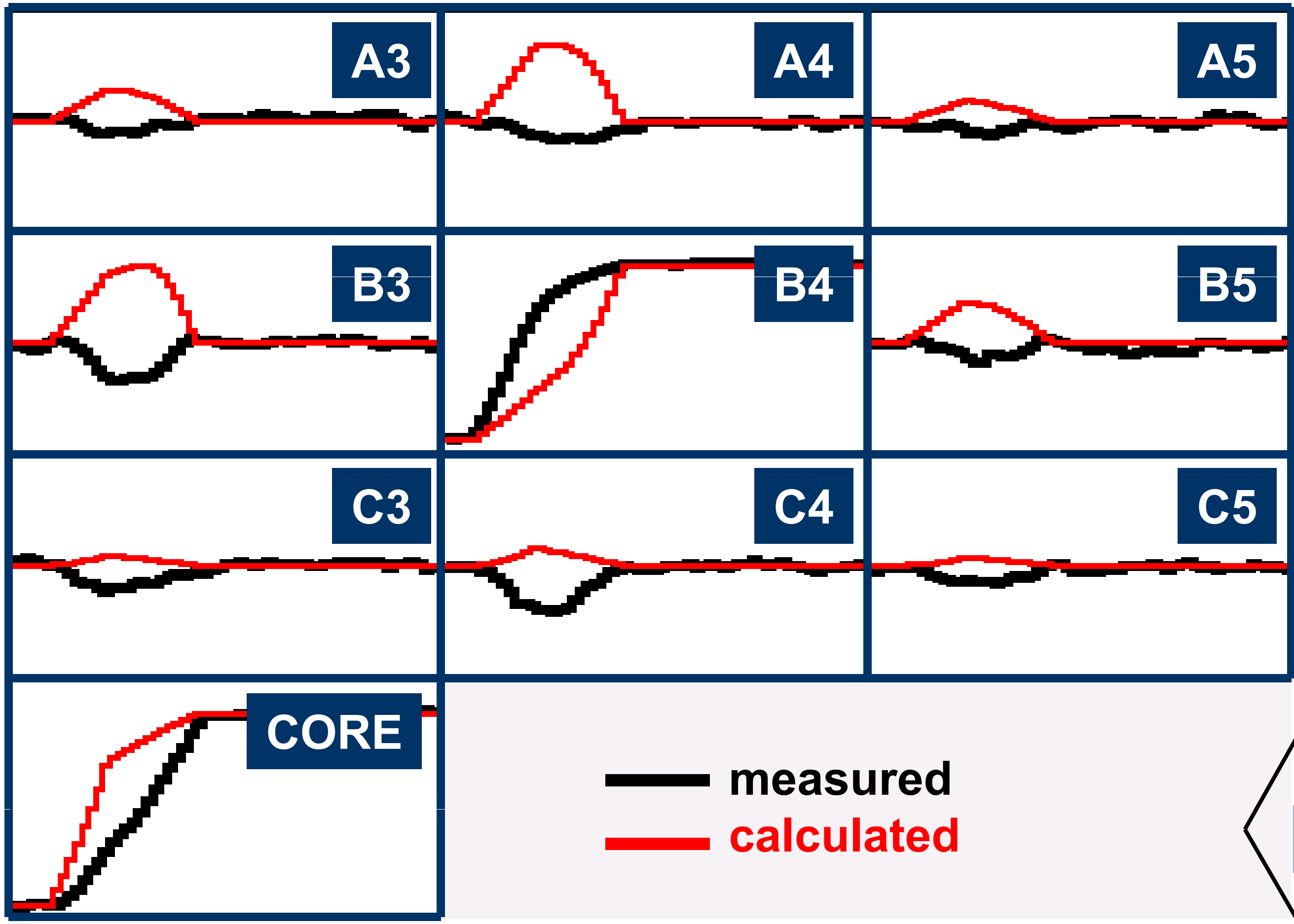
Pulse Shape Analysis concept



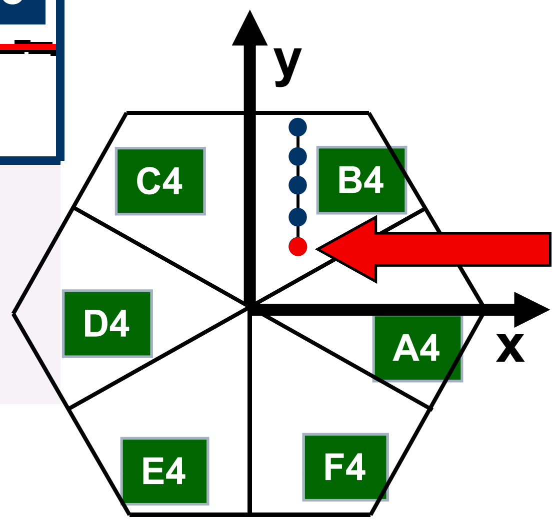


791 keV deposited in segment B4

Pulse Shape Analysis concept



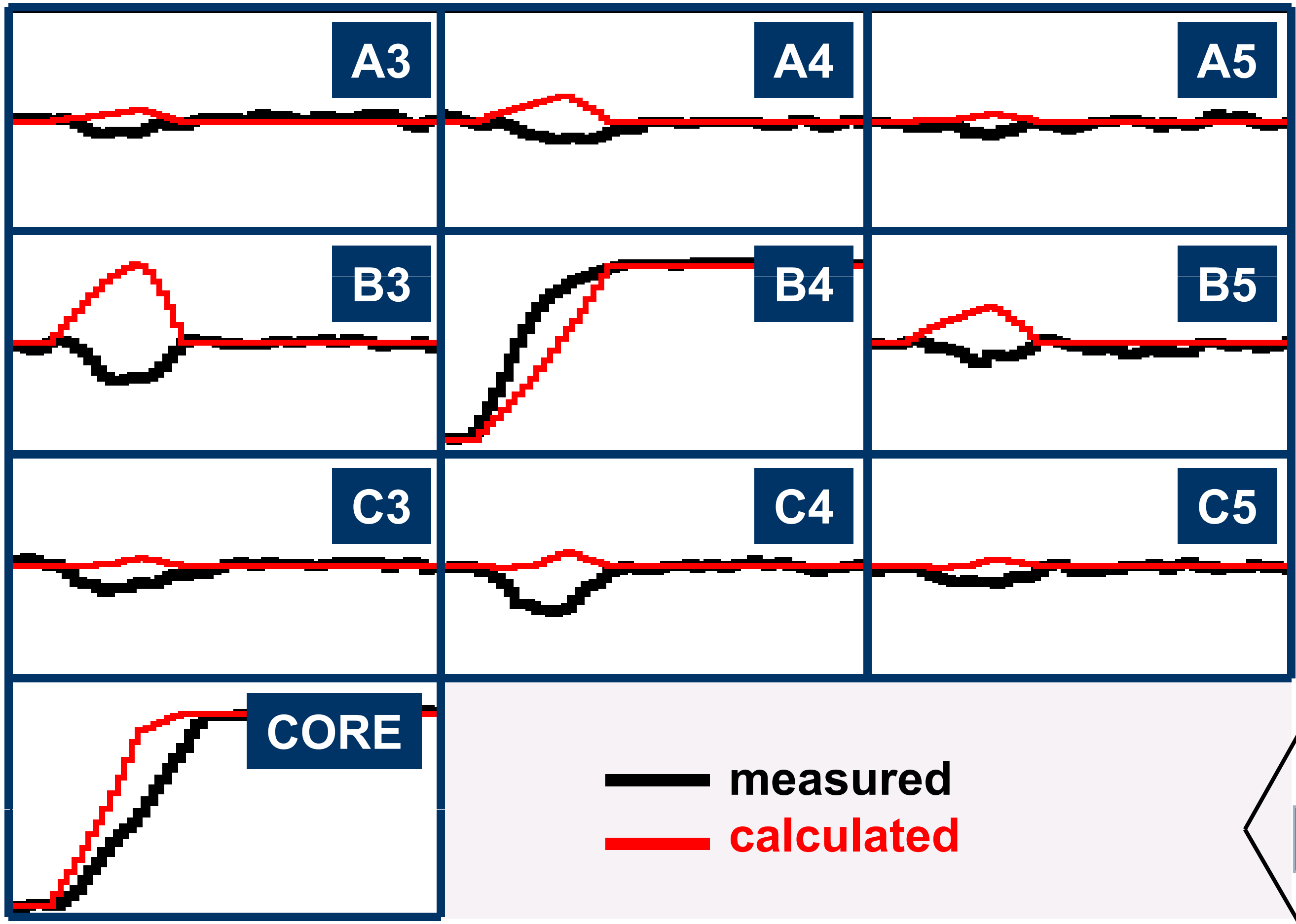
(10,10,46)

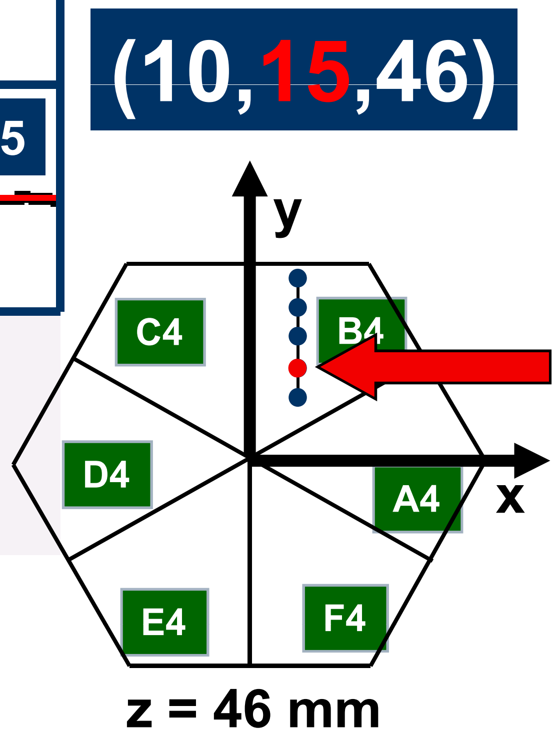


z = 46 mm

791 keV deposited in segment B4

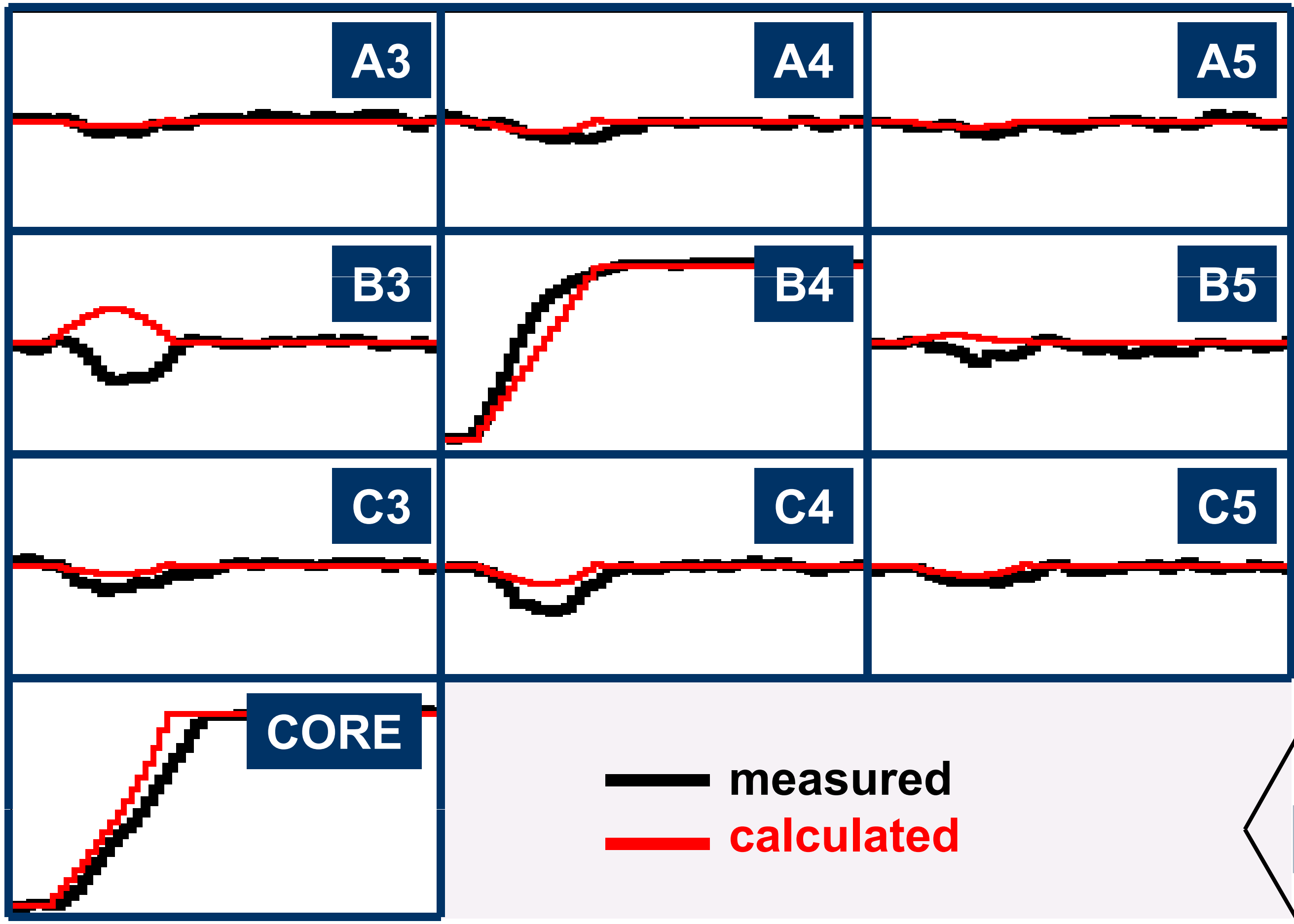
Pulse Shape Analysis concept

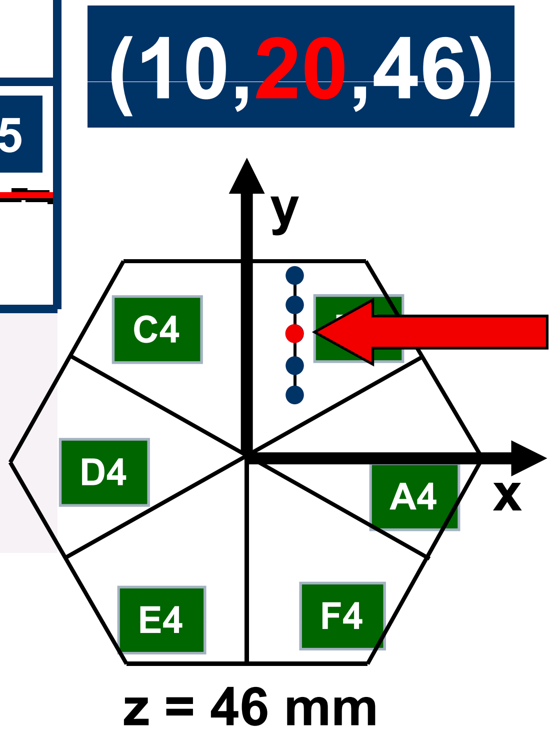




791 keV deposited in segment B4

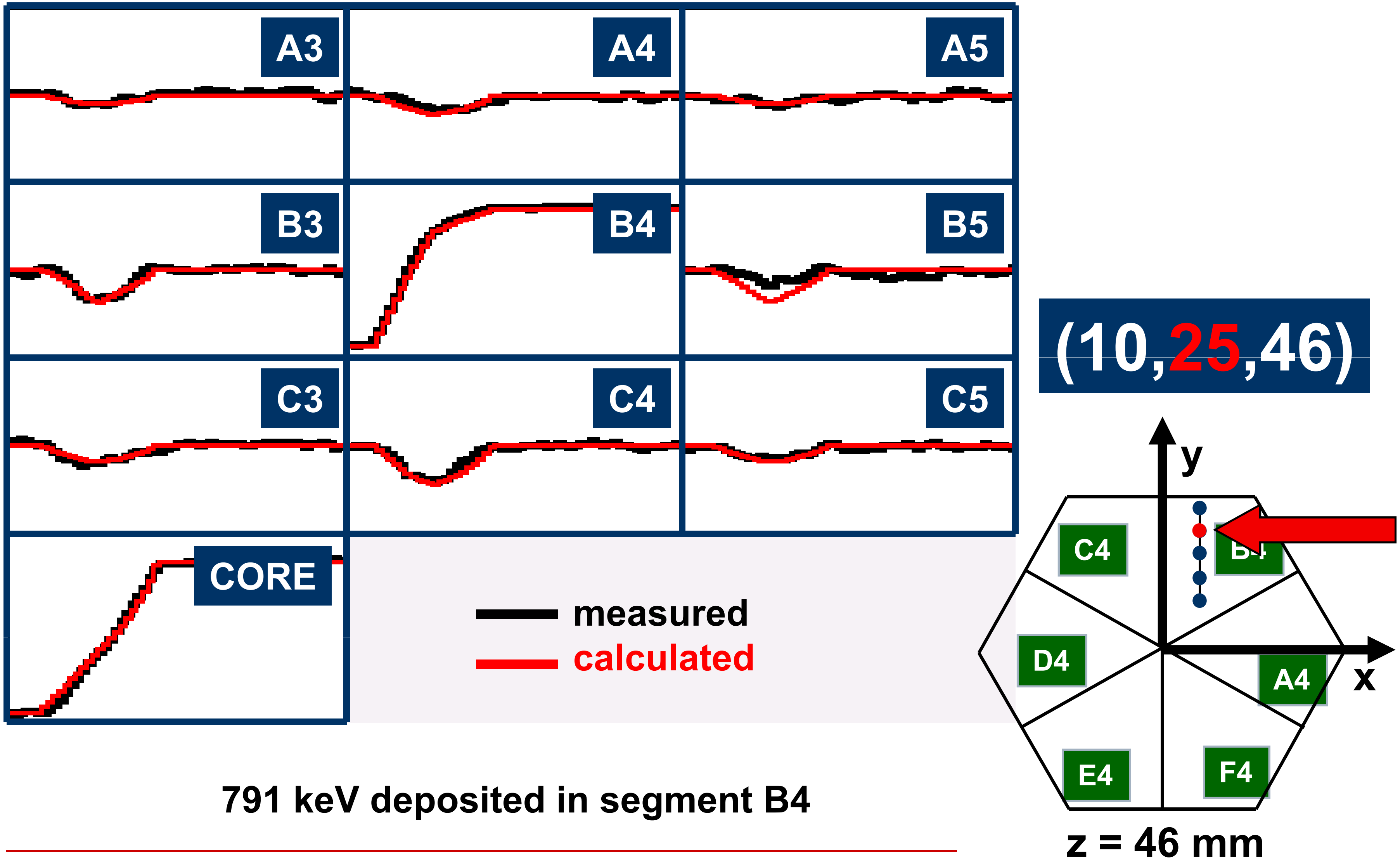
Pulse Shape Analysis concept





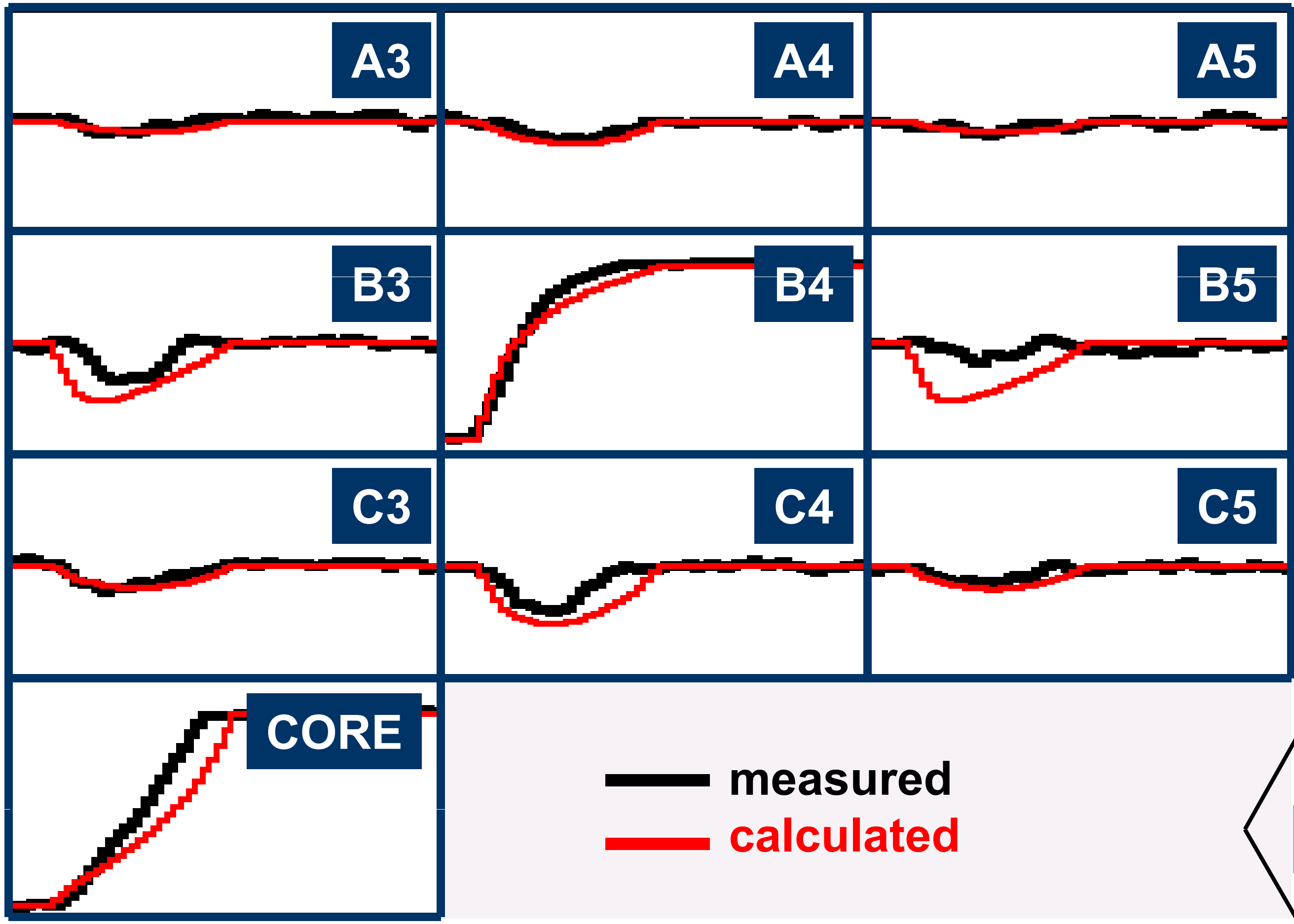
791 keV deposited in segment B4

Pulse Shape Analysis concept

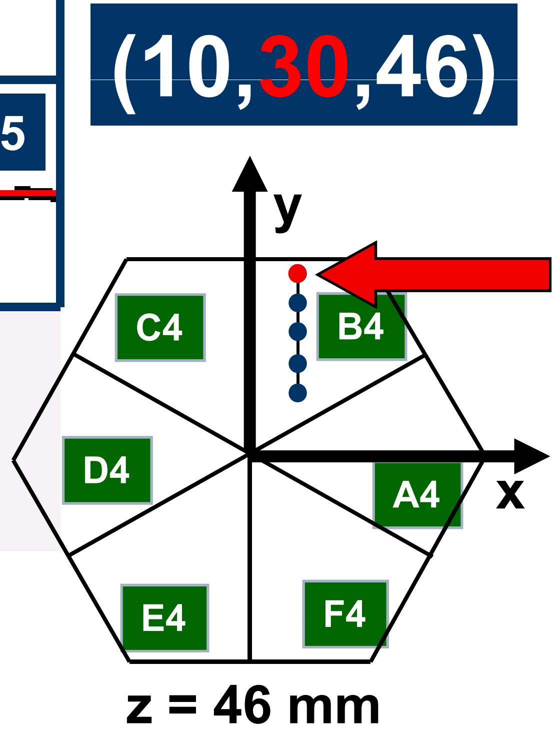


791 keV deposited in segment B4

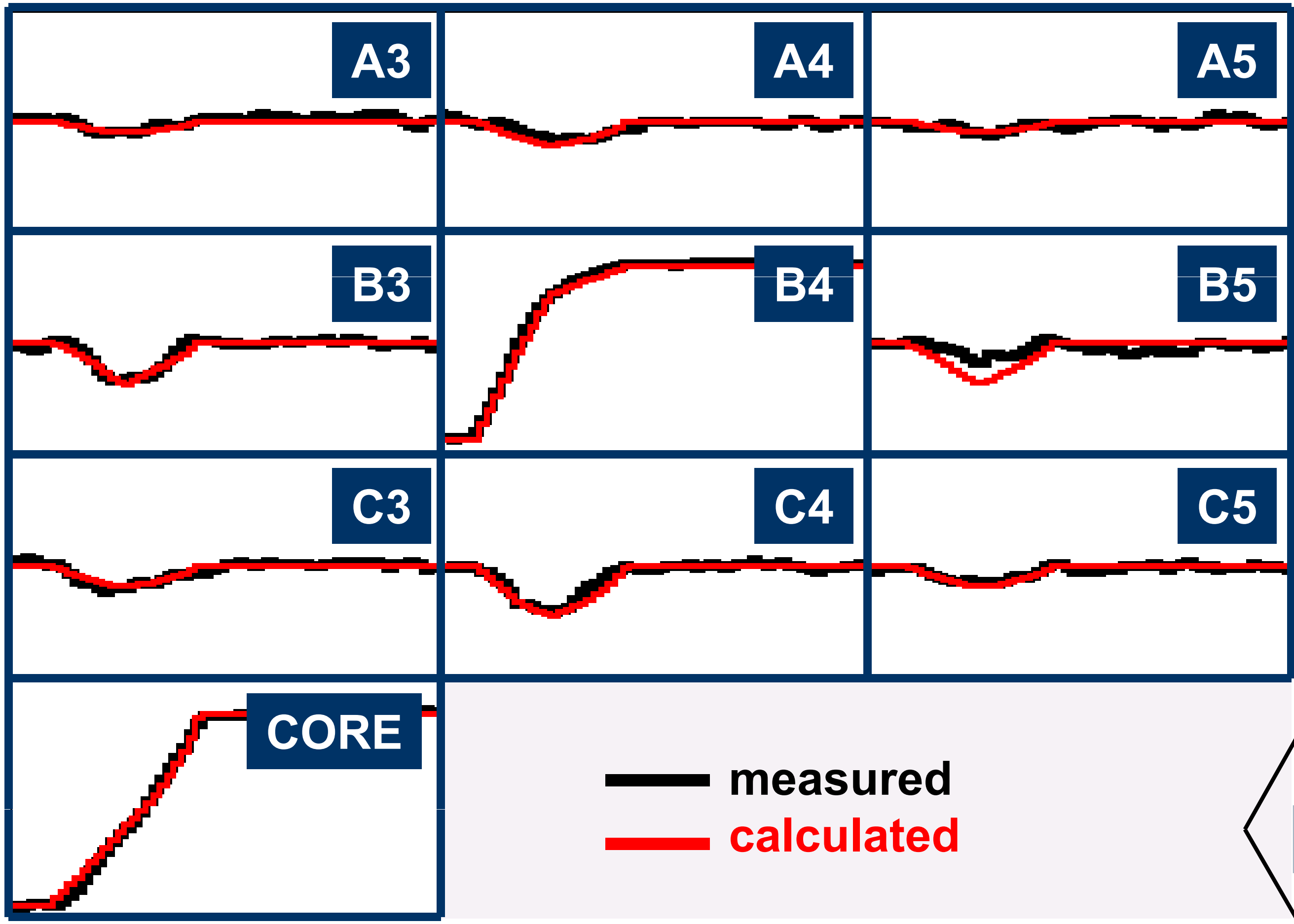
Pulse Shape Analysis concept



791 keV deposited in segment B4

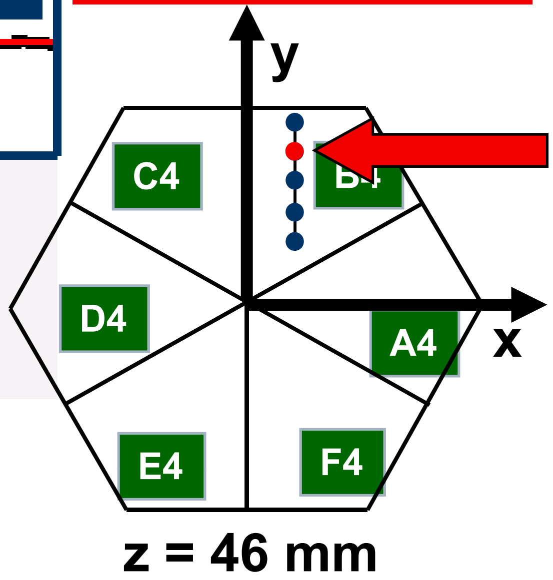


Pulse Shape Analysis concept



Result of *Grid Search* algorithm

(10,25,46)

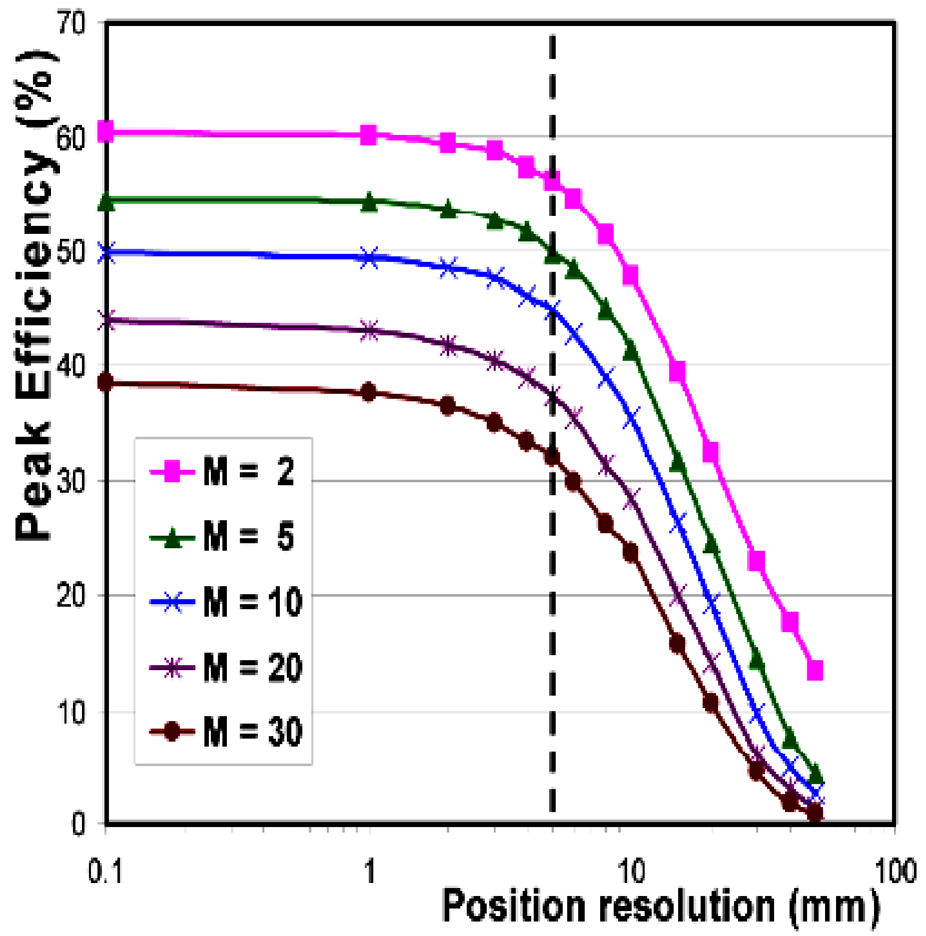


791 keV deposited in segment B4

The position resolution required for the AGATA detectors

Simulations suggest that the overall performance depends on the attainable **position resolution**

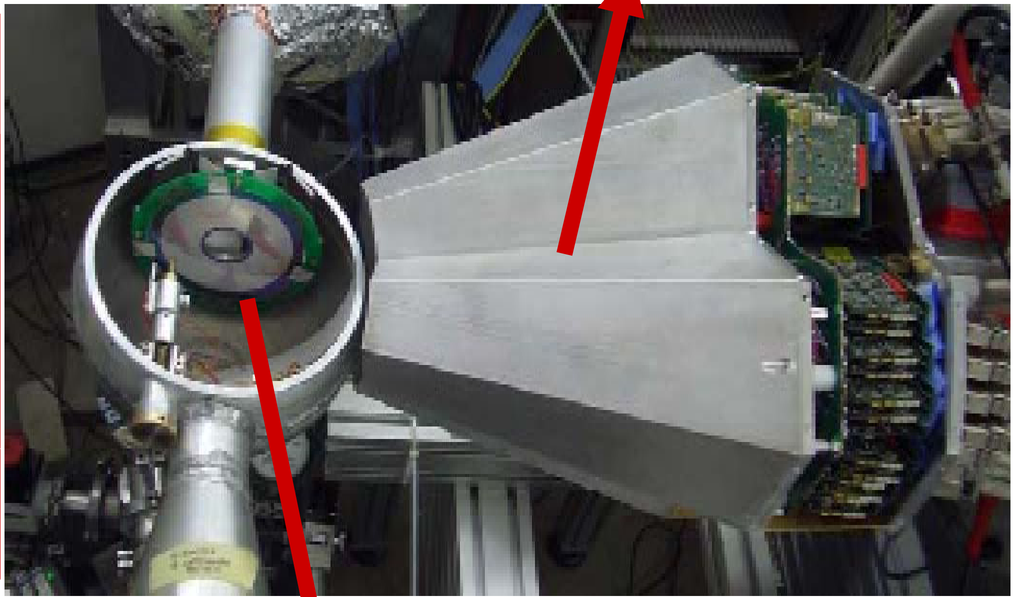
A **test-beam experiment** has been performed to measure this parameter in realistic experimental conditions



Setup of the in-beam experiment

d(^{48}Ti,^{49}Ti)p		
BEAM	^{48}Ti	100 MeV
TARGET	^{48}Ti + ^{2}H	220 μg/cm^2
Si detector DSSSD	Thickness: 300 μm	
	32 rings, 64 sectors	
AGATA symmetric triple-cluster		

Symmetric triple cluster

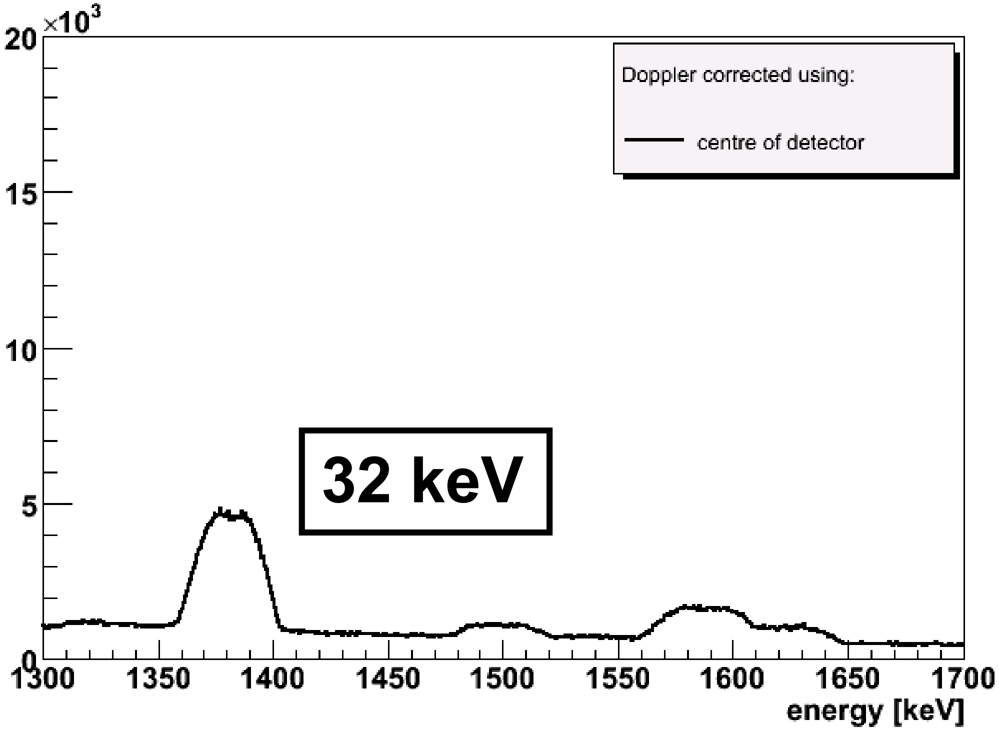


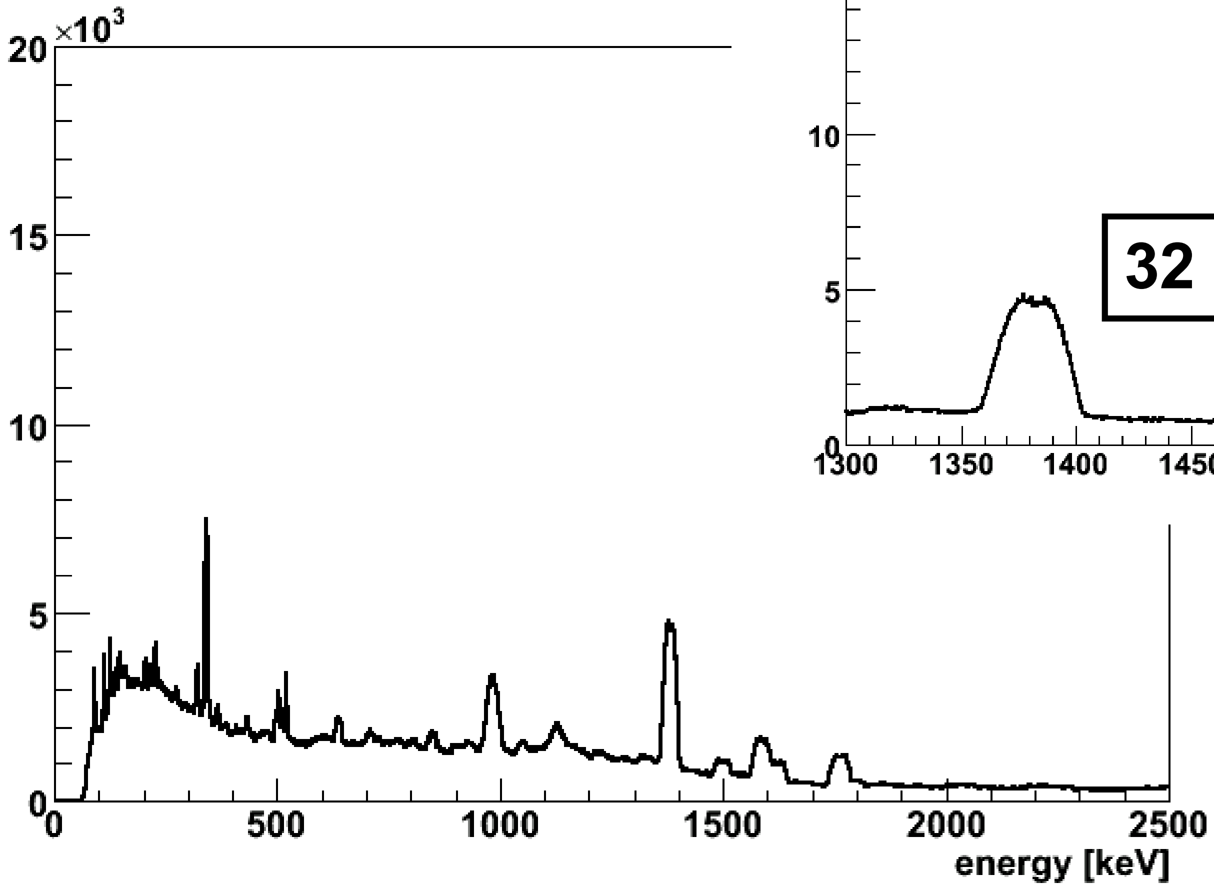
experiment performed at IKP of Cologne

Silicon detector

Digitizers:	
30 XIA DGF 4c cards	
40MHz	14 bit

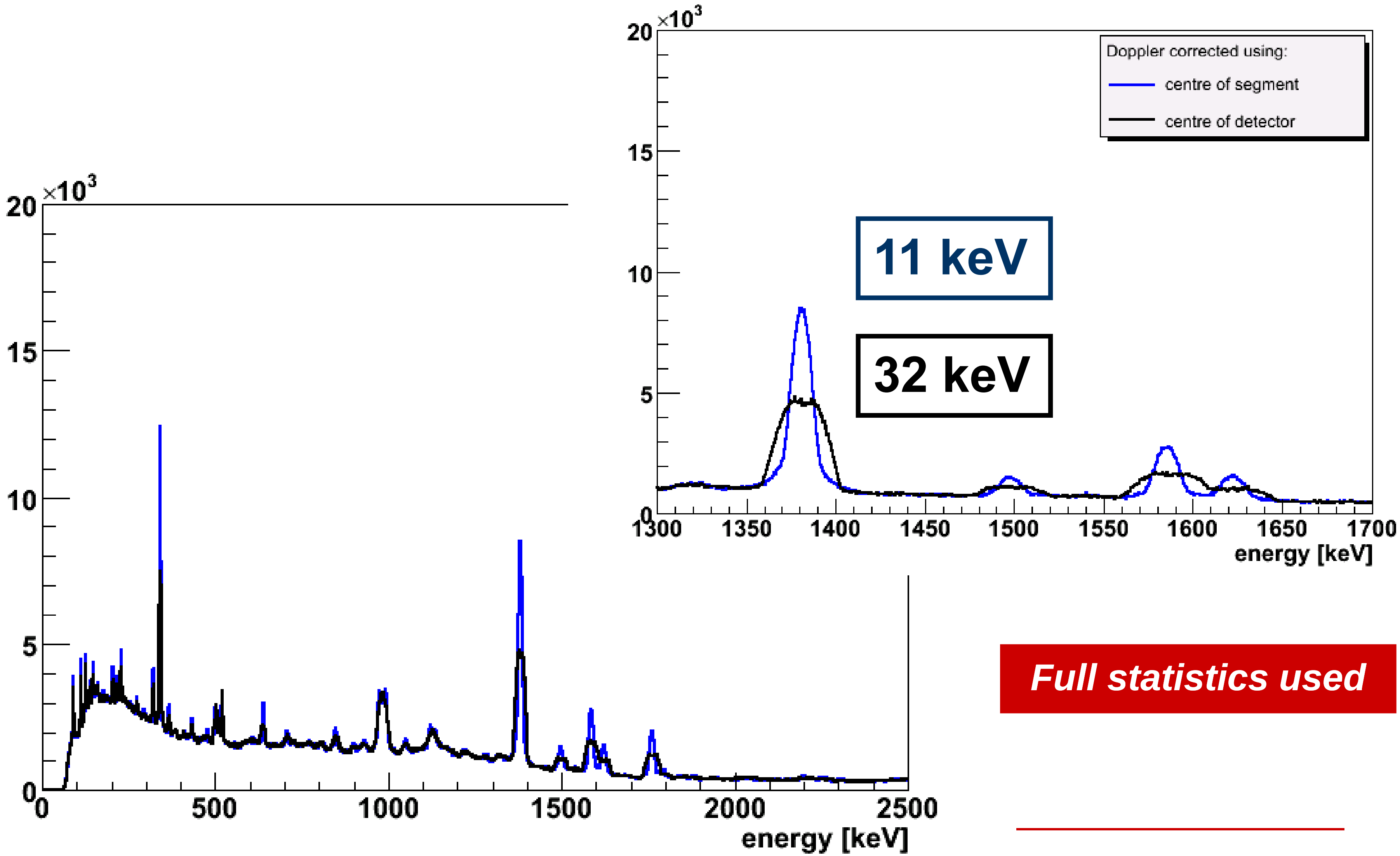
Doppler correction using PSA results





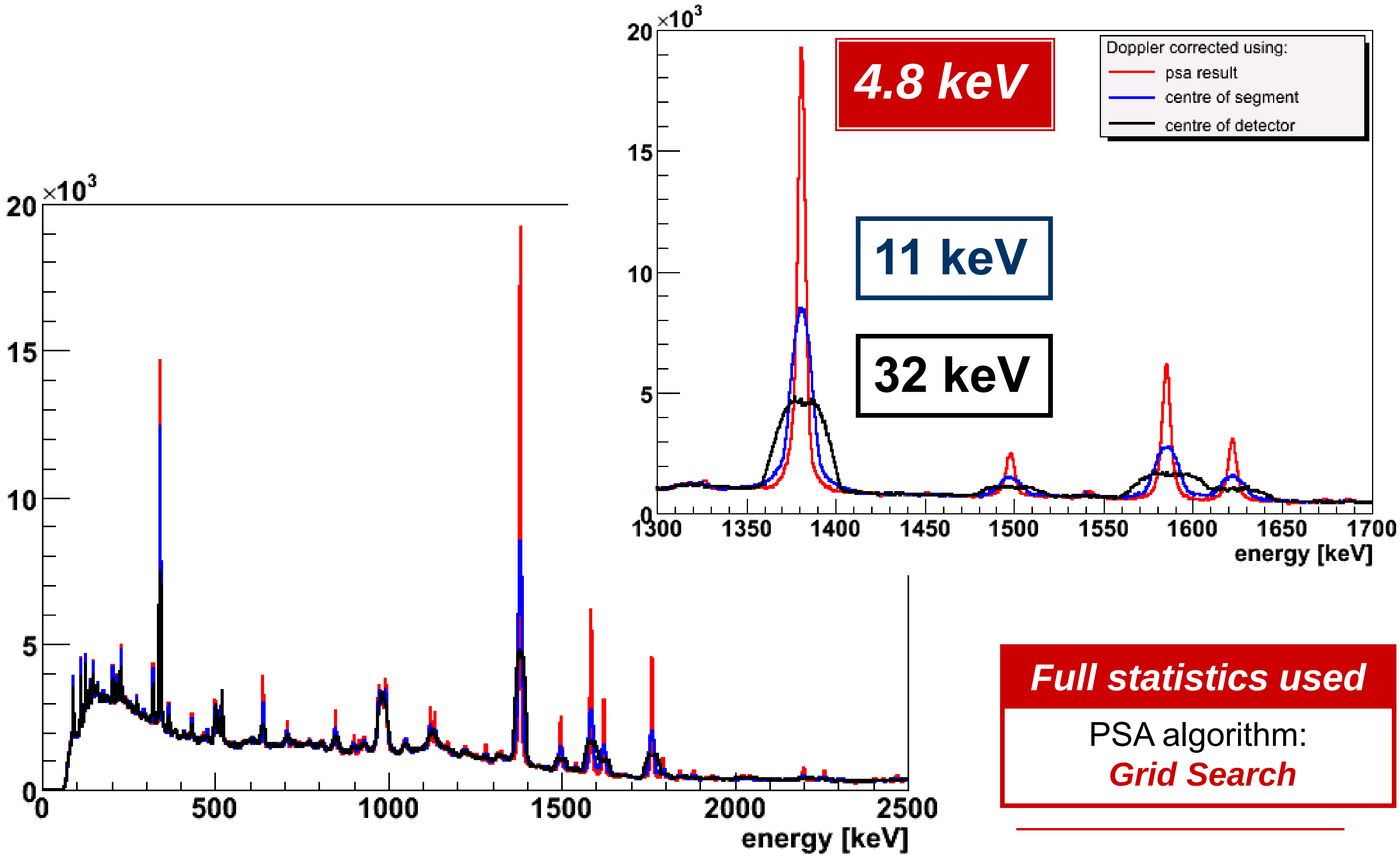
Full statistics used

Doppler correction using PSA results



Full statistics used

Doppler correction using PSA results



Full statistics used

PSA algorithm:
Grid Search

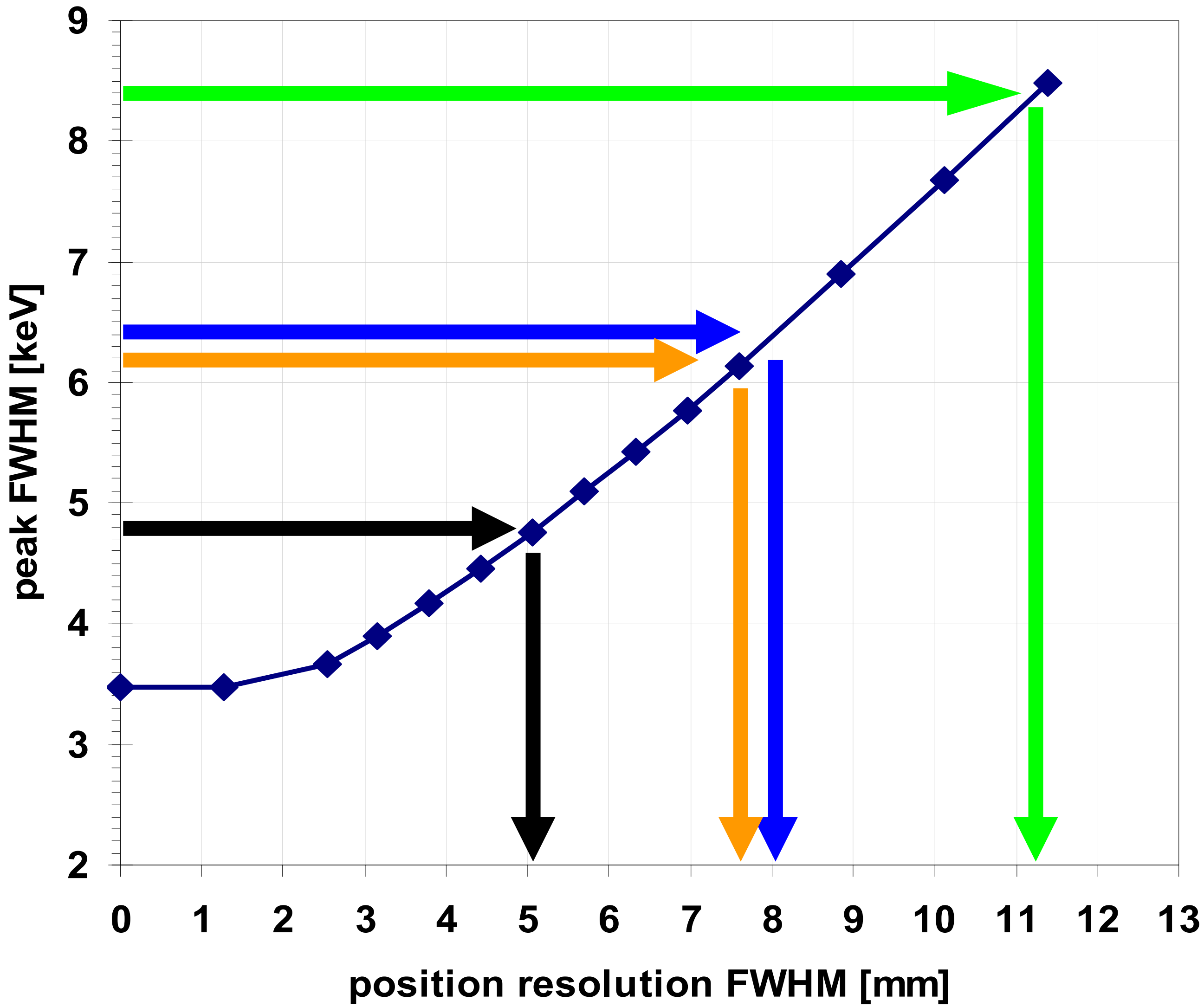
Simulation vs Experiment

Recursive Subtraction

Matrix Method

Miniball Algorithm

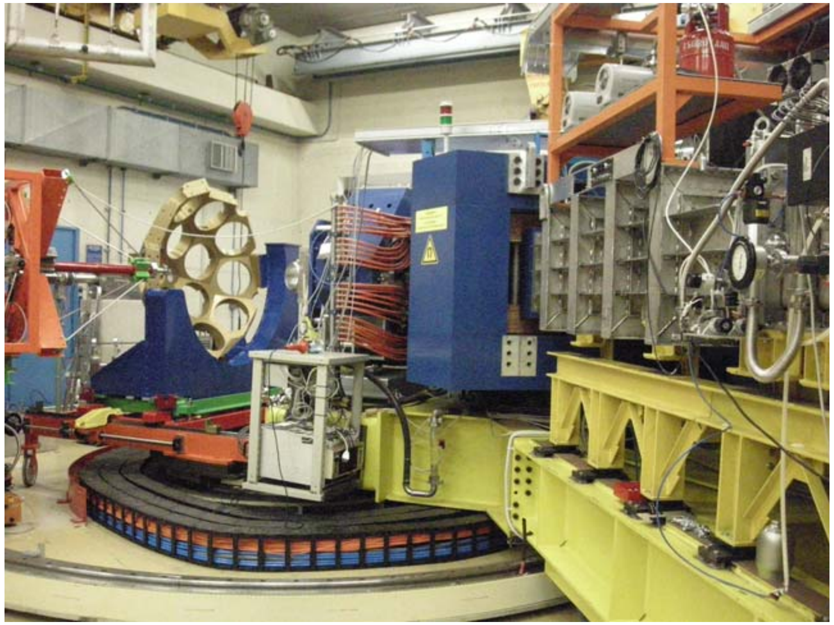
Grid Search



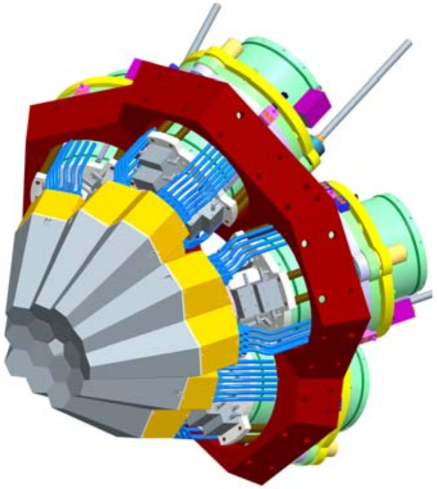
Results obtained with different PSA algorithm

Why Compton imaging?

- 15 days of beam-time to perform the test experiment
- 1 year of analysis
- PSA will be on-line

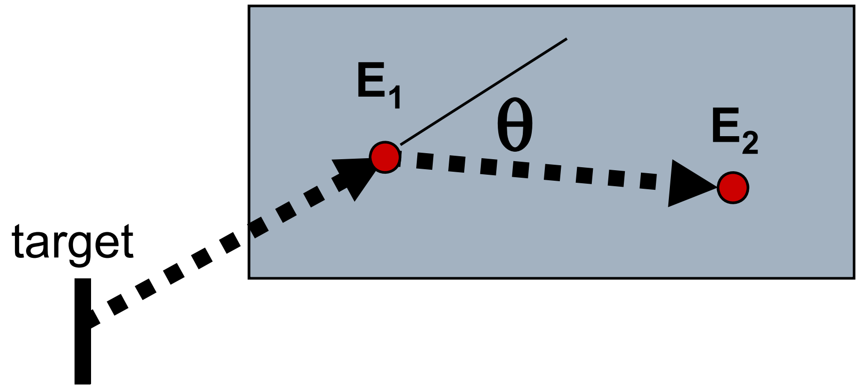


- Need for a ***simpler*** procedure
- Need an ***prompt feed-back*** from on-line analysis

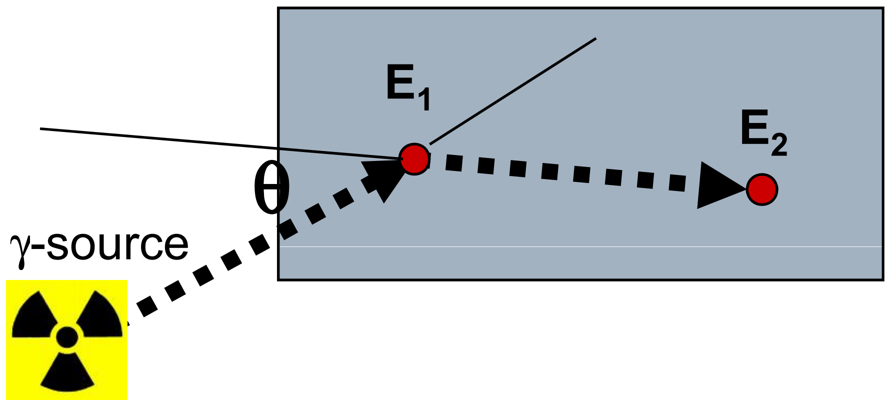


Compton imaging

- In-beam experiment:
  - typical conditions of future use



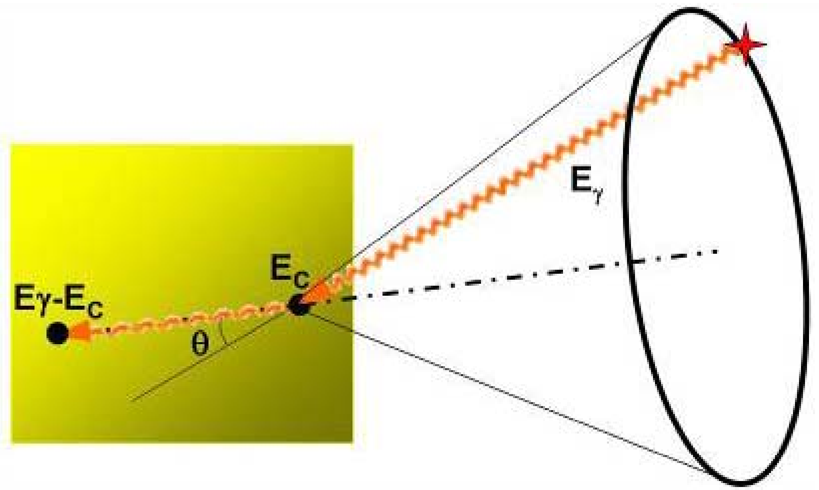
- Compton imaging of a radioactive source
  - inverse tracking

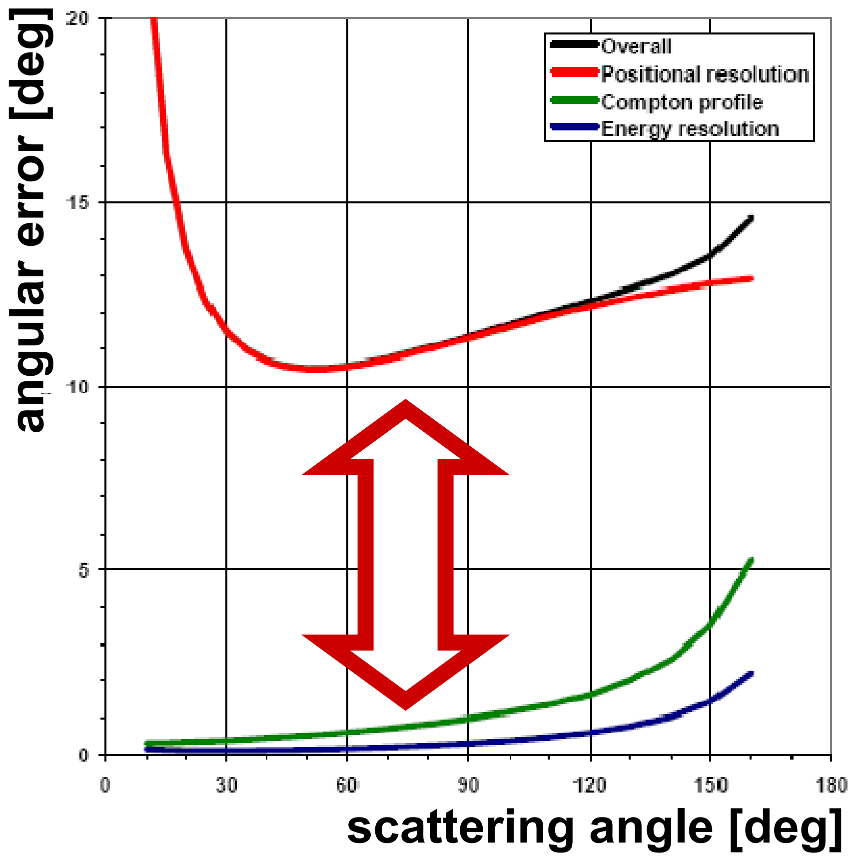


Compton imaging performance

Error on Compton identification of source direction from:

- **Position resolution** (axis)
- Energy resolution (scattering angle)
- Compton profile (scattering angle)



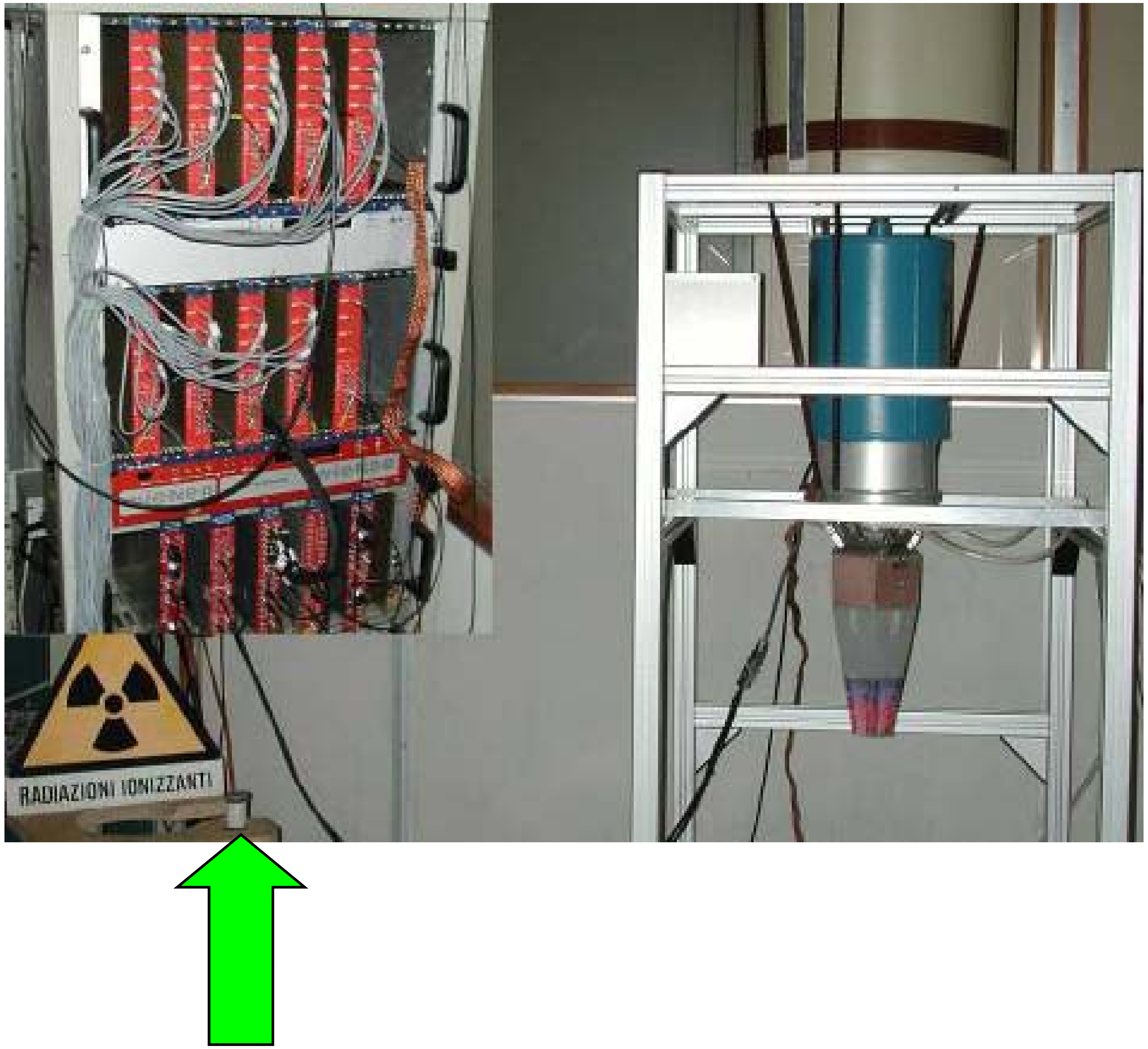


Imaging setup at LNL

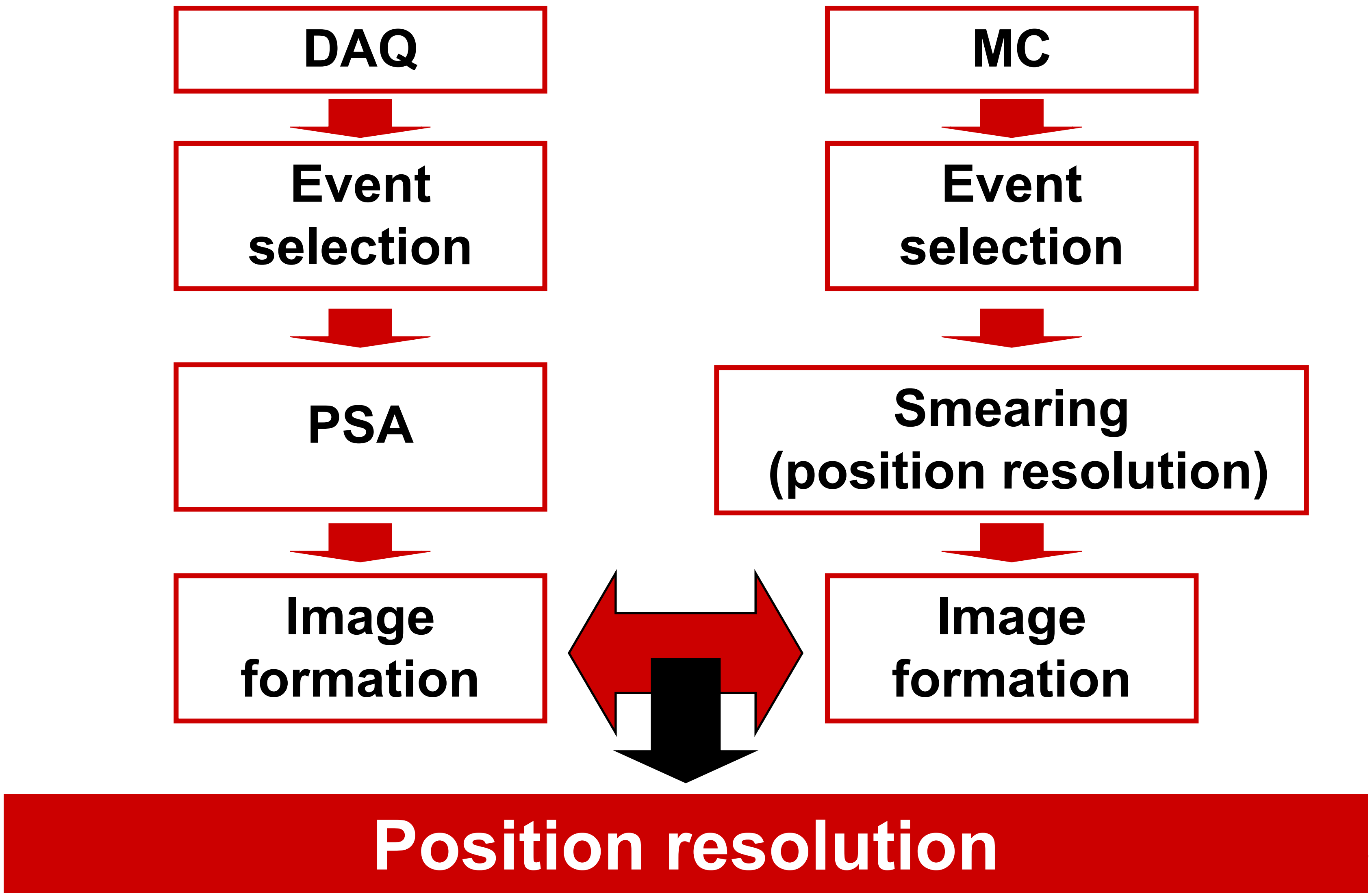
AGATA prototype detector

TNT2 Digitizers: 4ch 14bit 100MHz

^{60}Co source

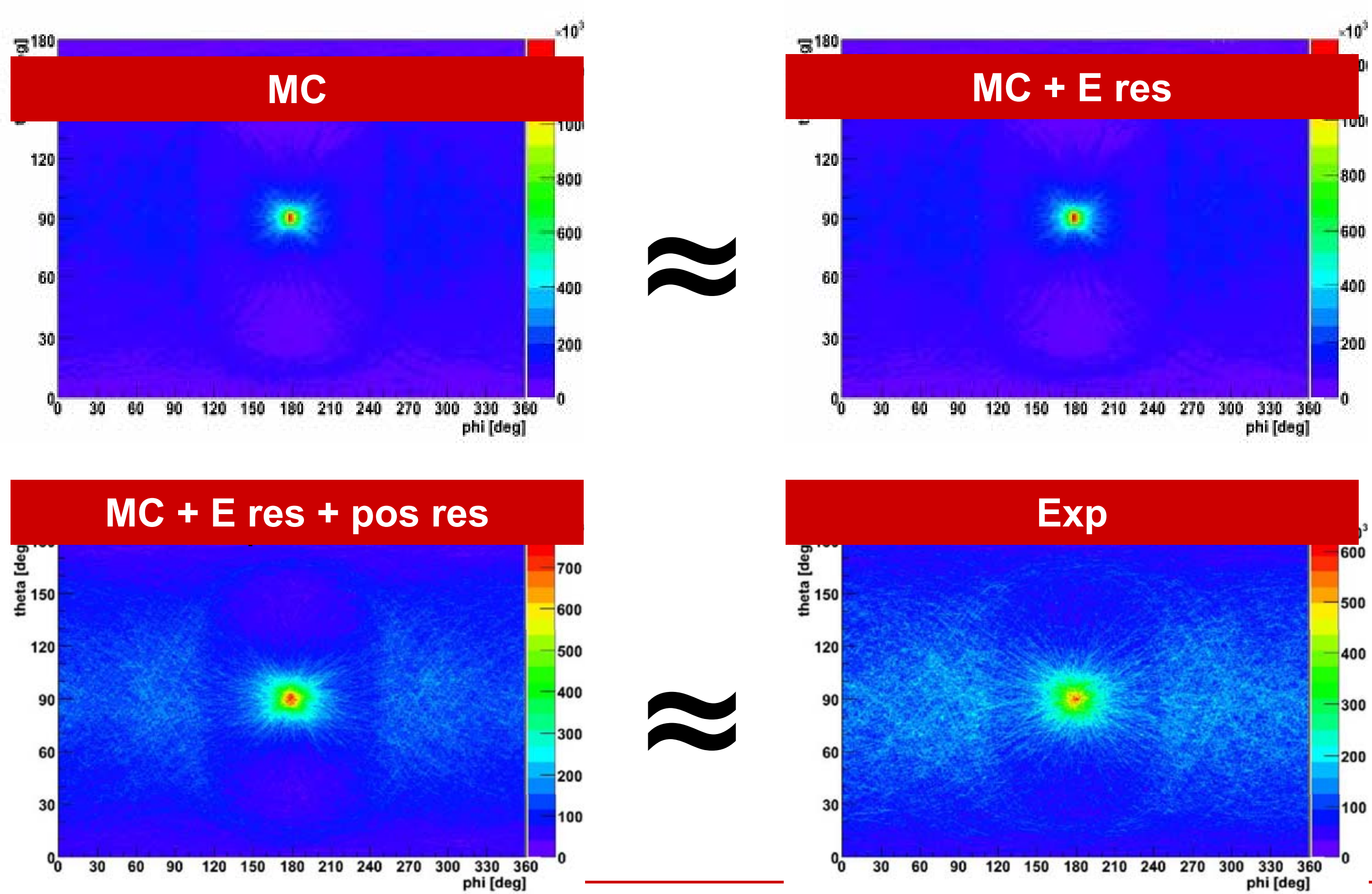


Outline of analysis/simulation

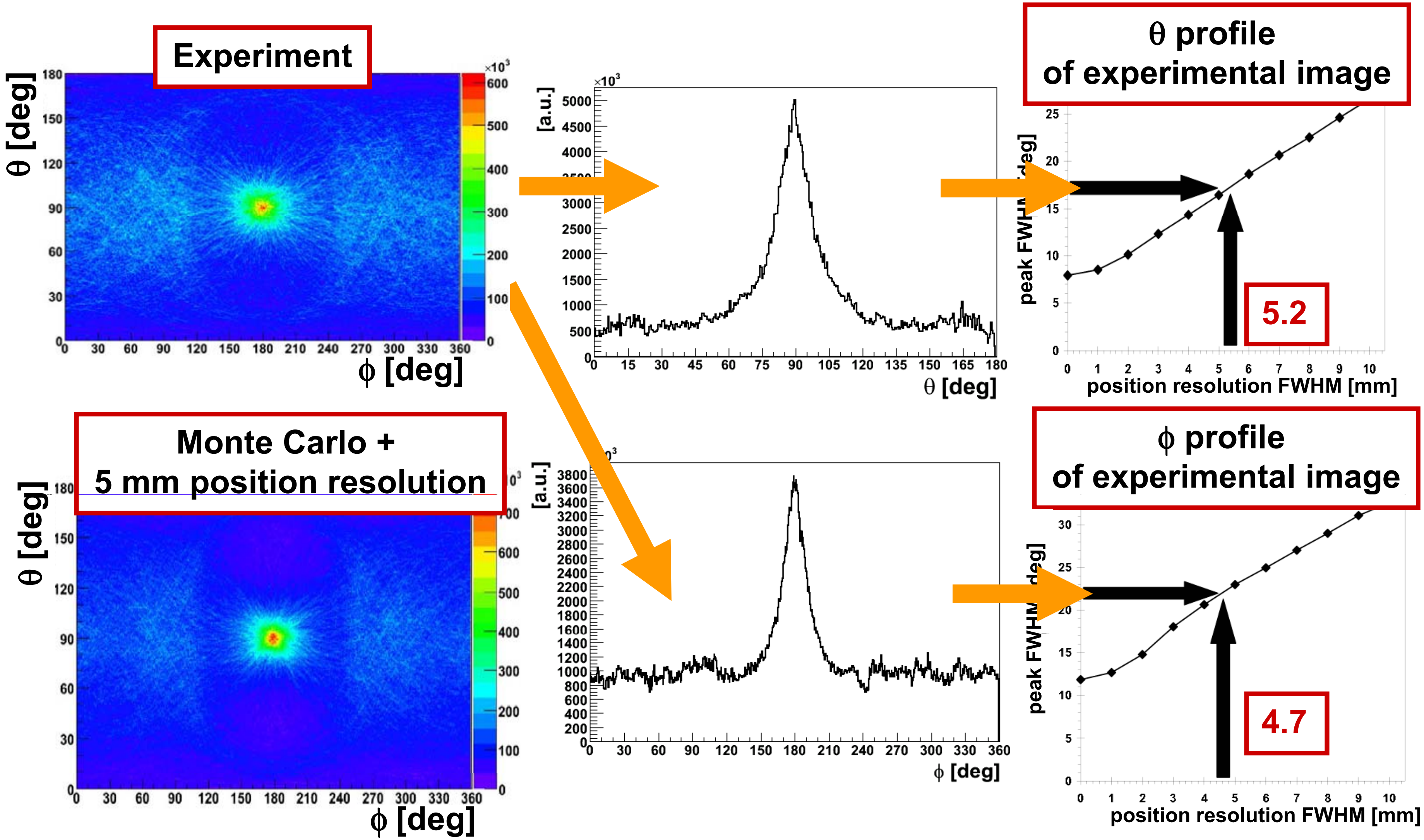


Comparison to simulation

Simple back-projections

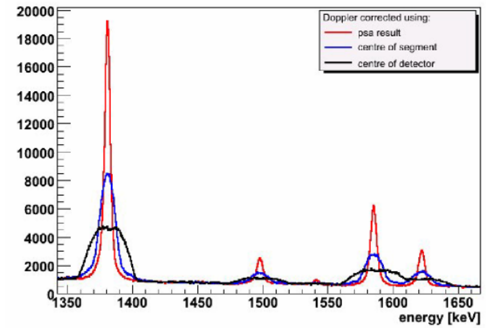


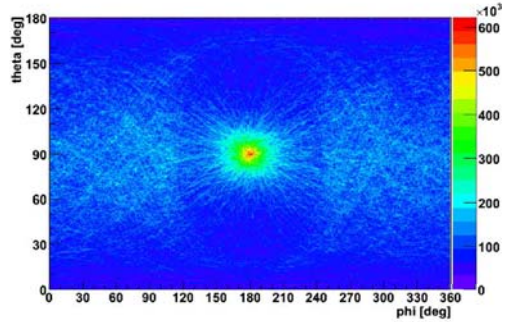
Comparison to MC simulation

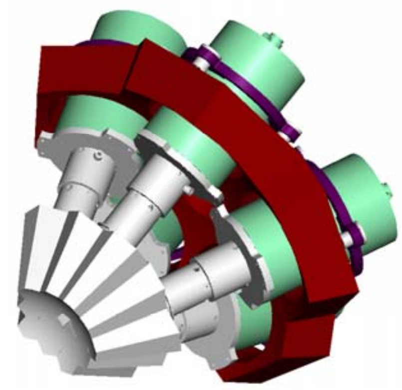


CONCLUSIONS

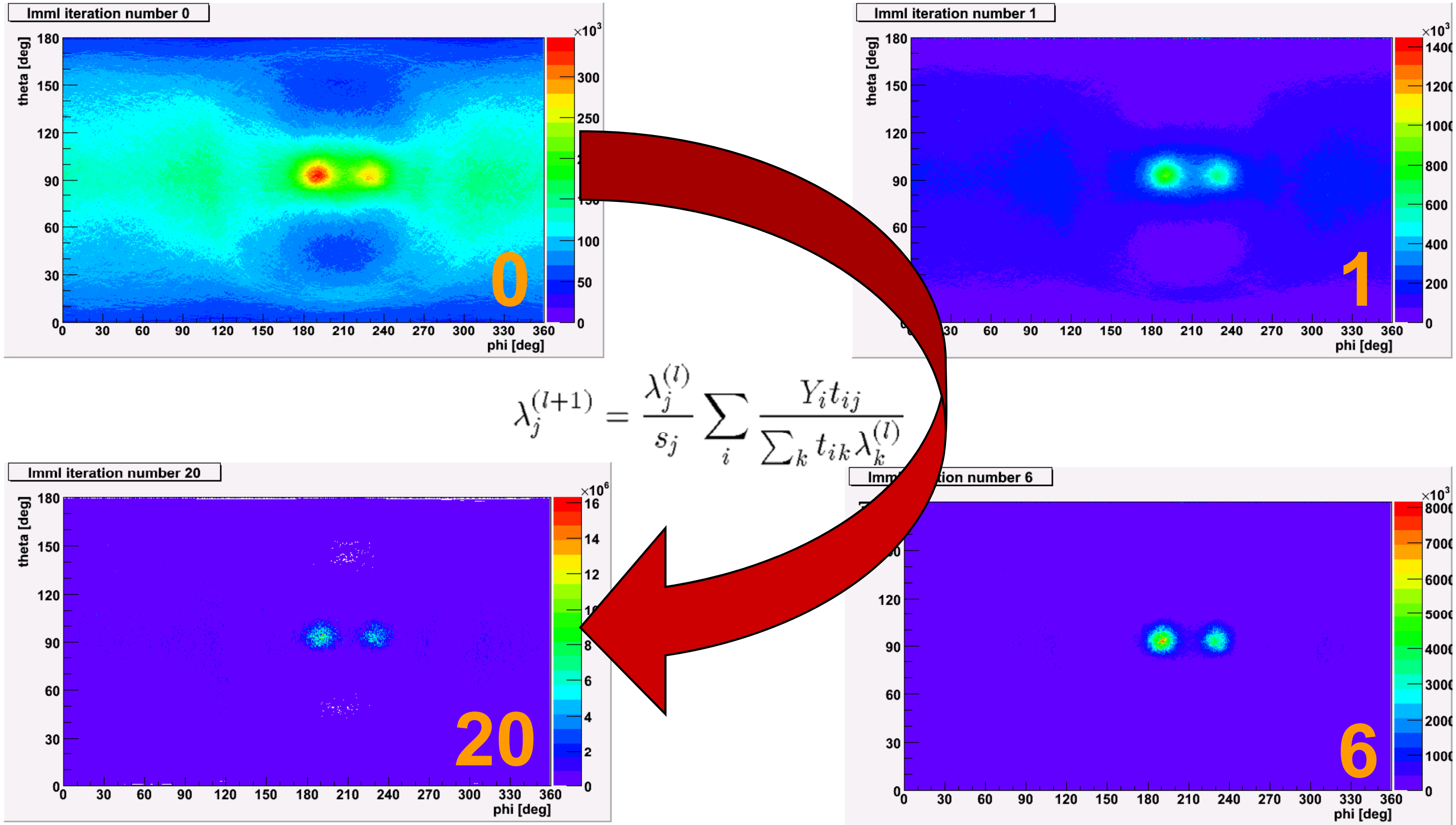
- Position resolution extracted by in-beam experiment and Compton imaging is **5 mm FWHM.**
- This value is in line with the **design assumptions** of the AGATA spectrometer, confirming the feasibility of γ-ray tracking.
- AGATA will have a **huge impact on nuclear structure studies** (first phase of AGATA: LNL 2009…)
- Possible **applications** of γ-ray tracking detectors to imaging.







Basic implementation of LMML

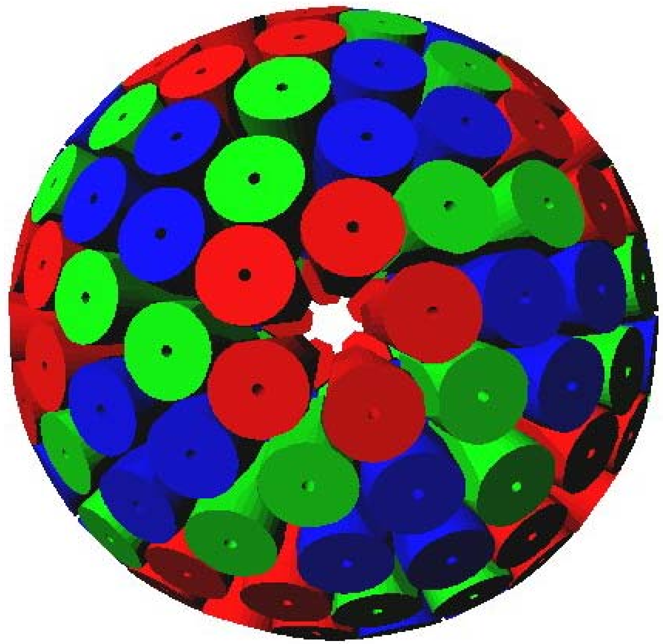


$$\lambda_j^{(l+1)} = \frac{\lambda_j^{(l)}}{s_j} \sum_i \frac{Y_i t_{ij}}{\sum_k t_{ik} \lambda_k^{(l)}}$$

generation
γ-ray spectrometer

AGATA is the next generation γ-ray spectrometer which will be used at radioactive ion beam facilities:

- High **efficiency** and **P/T** ratio.
- Capability to stand a **high counting rate**.
- Good position resolution on the individual γ interactions in order to perform a **good Doppler correction** and measure the linear **polarization**



Compton imaging application