- ***Dorothée Lebhertz***
  Spherical designs and application to the radiative capture case
- ***Anil Kumar Gourishetty***
  G4 simulations of a single LaBr3 detector and large NaI(Tl) detector arrays
- ***Dipak Chakrabarty***
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- ***Michal Ciemala***
  Energy resolution changes in phoswitch like detector
- ***Olivier Stézowski***
  Response function at high multiplicity : first algorithms

- ***Jonathan Strachan***
  Review of Mechanical options for PARIS

Simulations & mechanical design WGs

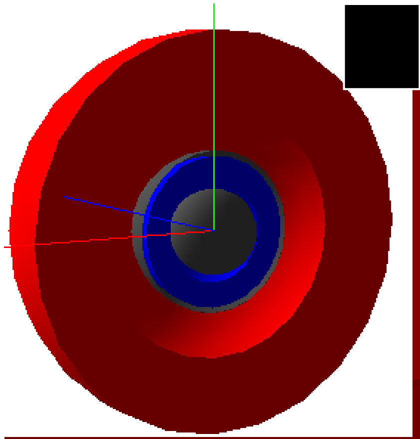
Adam Maj

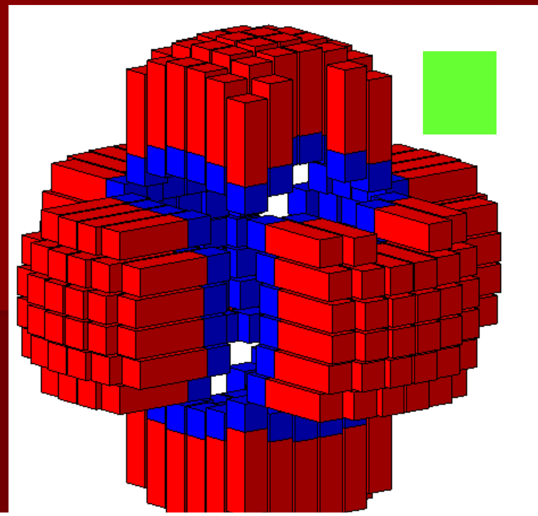
Decisions to be taken

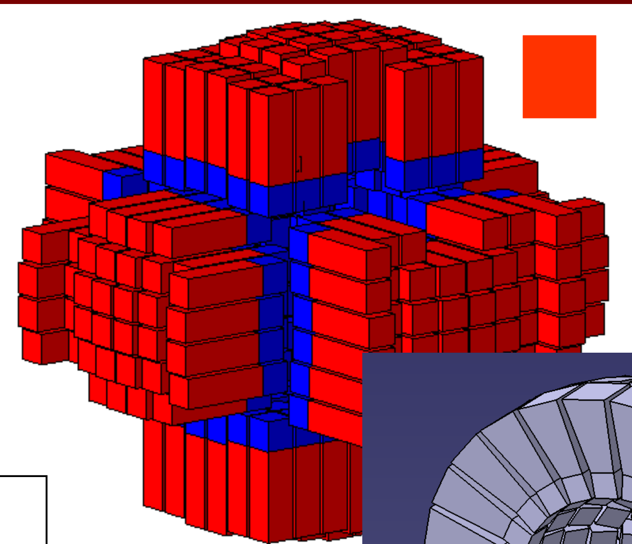
(Project leader proint of view)

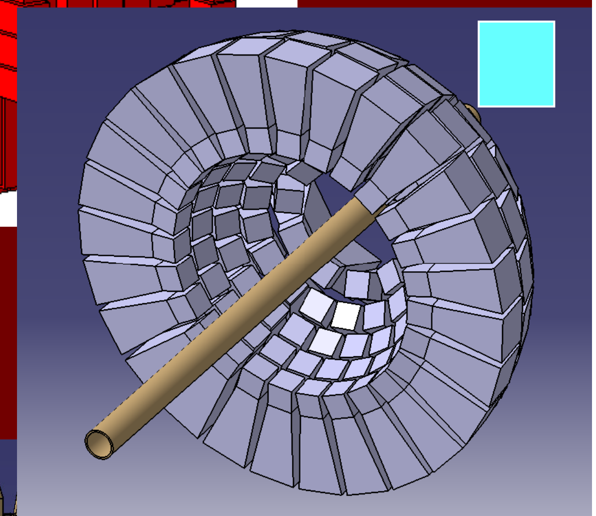
Kraków, 15.16.2009

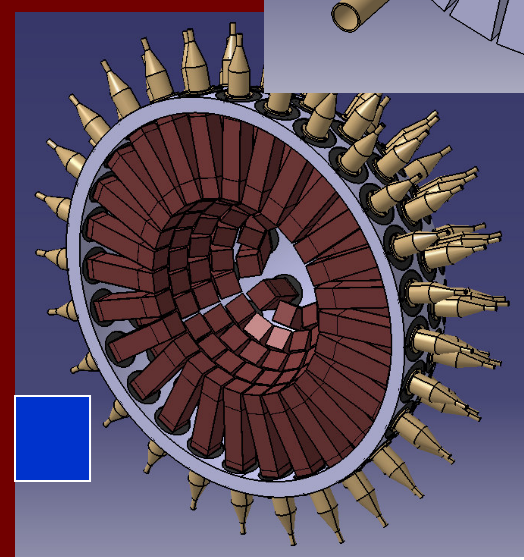
Cubic vs. Radial geometry

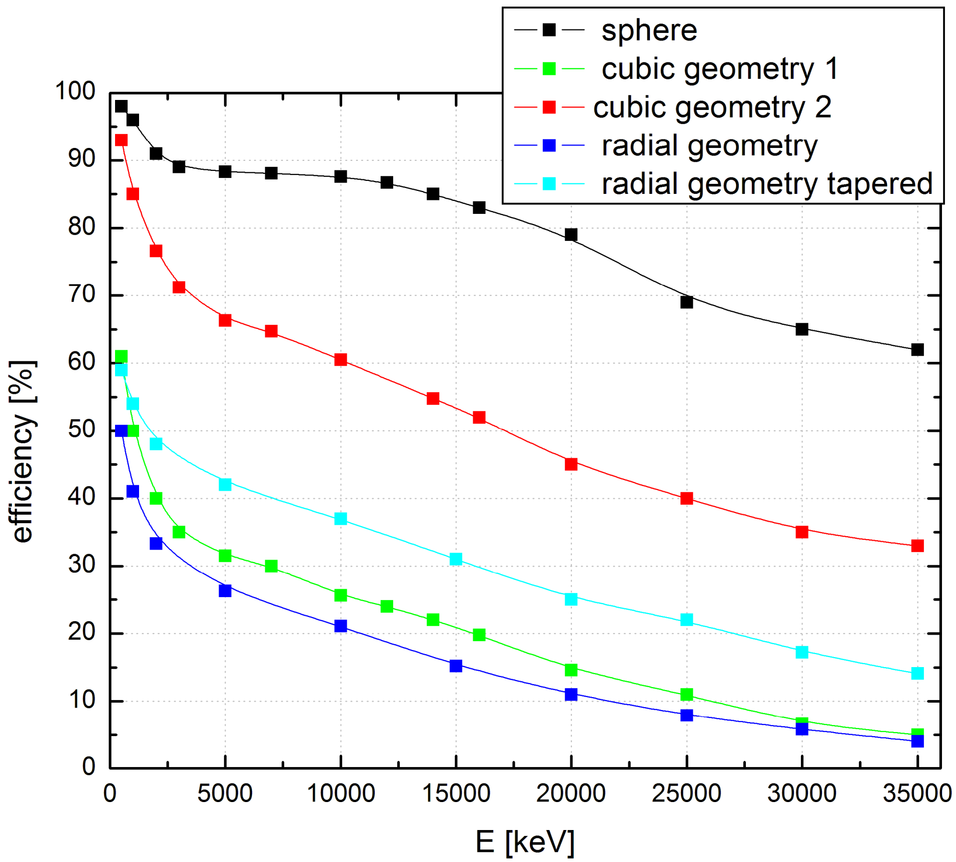












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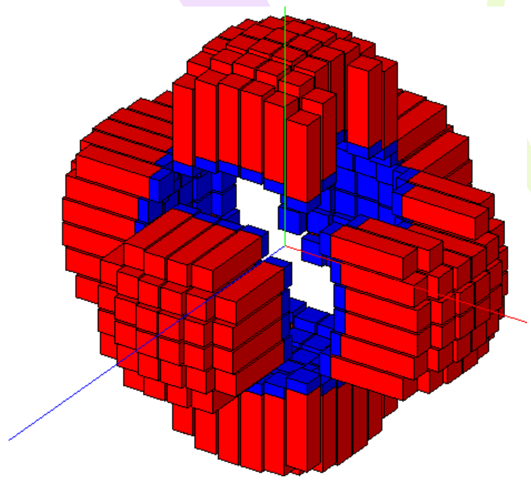
Energy resolution of PARIS calorimeter with phoswitch type crystals

Michał Ciemała
IFJ Kraków

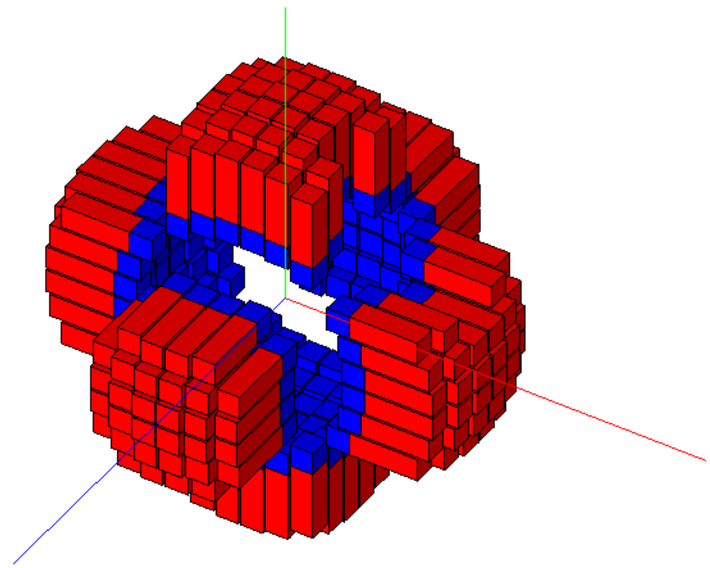
Introduction

GEANT4 simulations were performed to investigate energy resolution in the phoswitch type detectors.

Two different sizes of crystals were chosen:

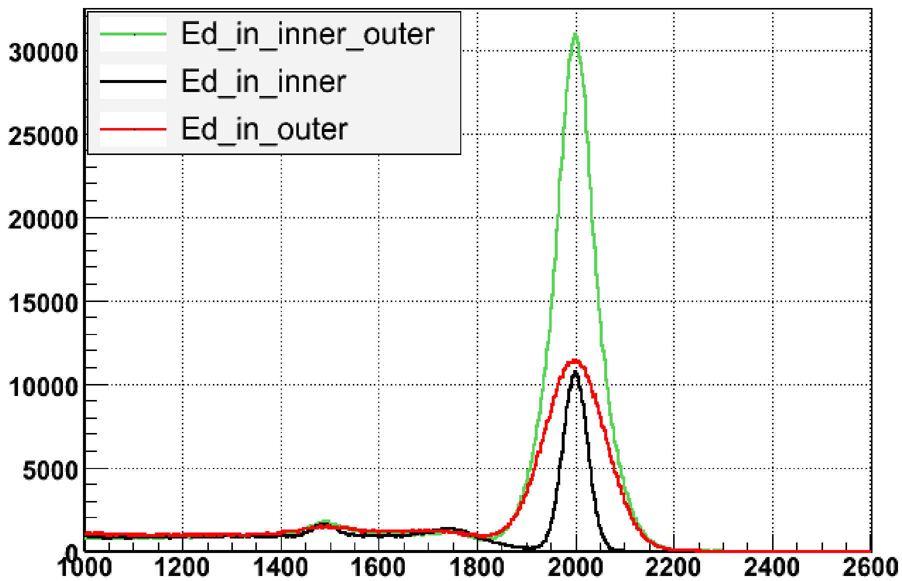


2”x2”x1” $LaBr_3$ + 2”x2”x7” CsI

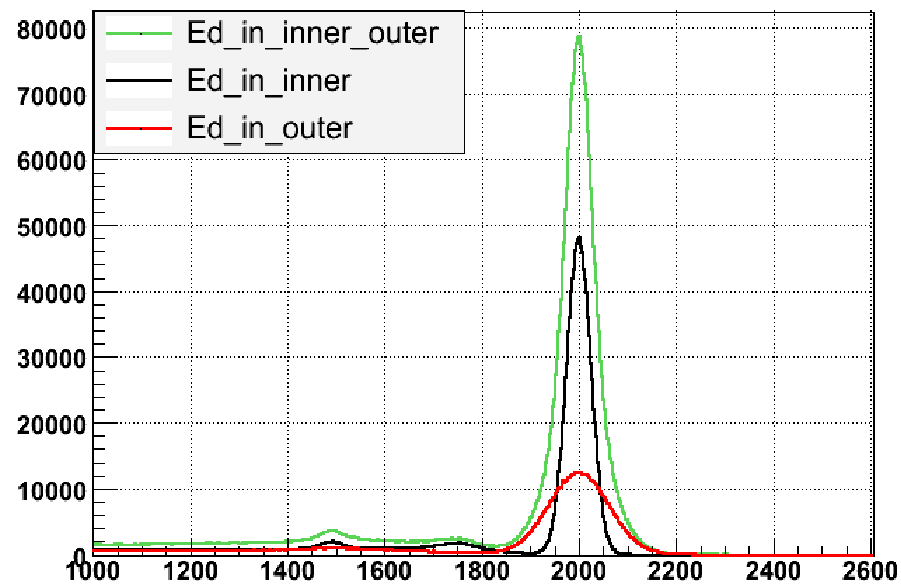


2”x2”x2” $LaBr_3$ + 2”x2”x6” CsI

Sample spectra (2MeV)



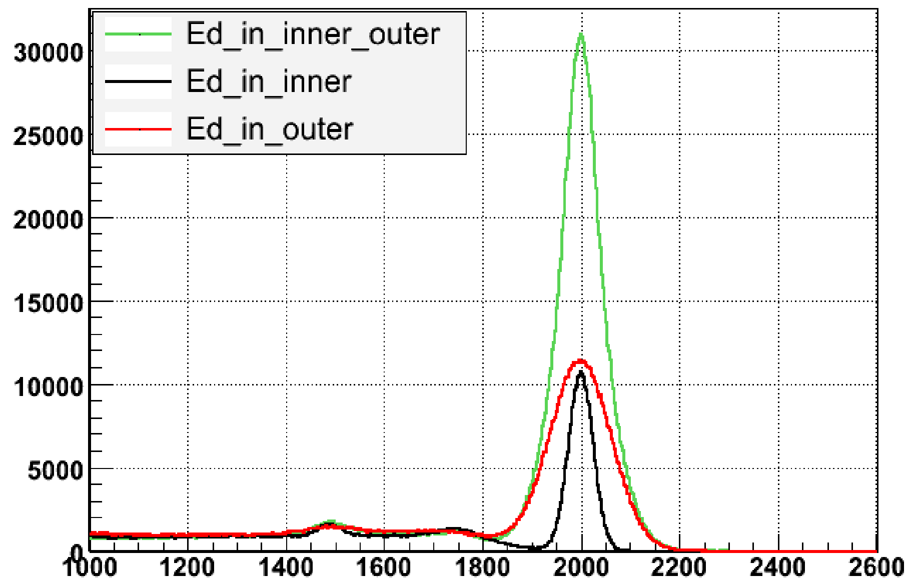
2”x2”x1”

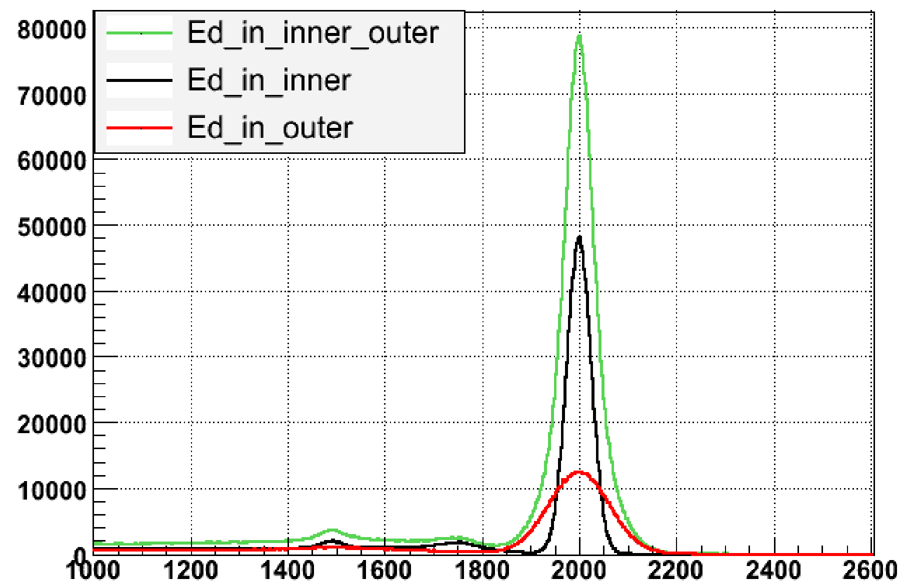


2”x2”x2”

- Shape of spectra obtained for gamma energy 2 and 10 MeV. On each picture black line is a $LaBr_3$ spectrum, red line is CsI spectrum, and green line is sum of energy deposited in $LaBr_3$ and CsI.

Sample spectra (2MeV)



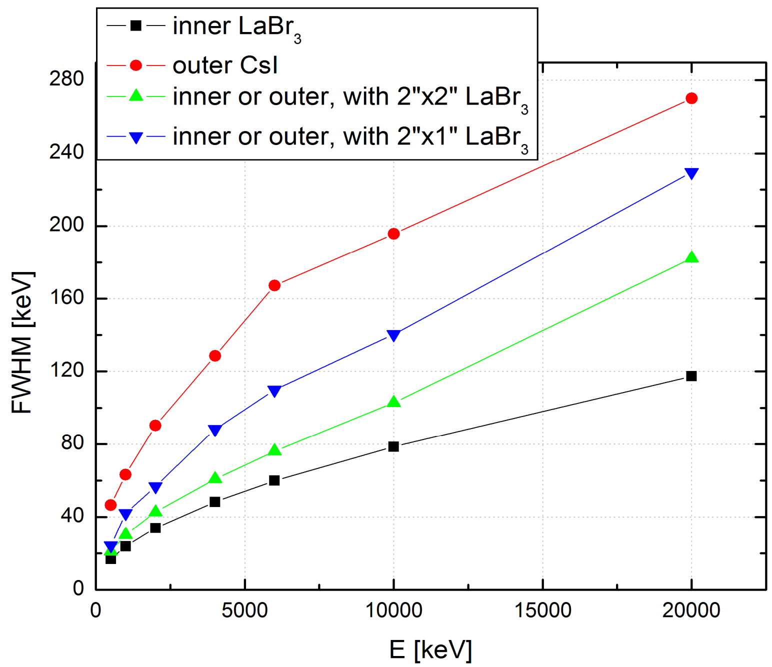


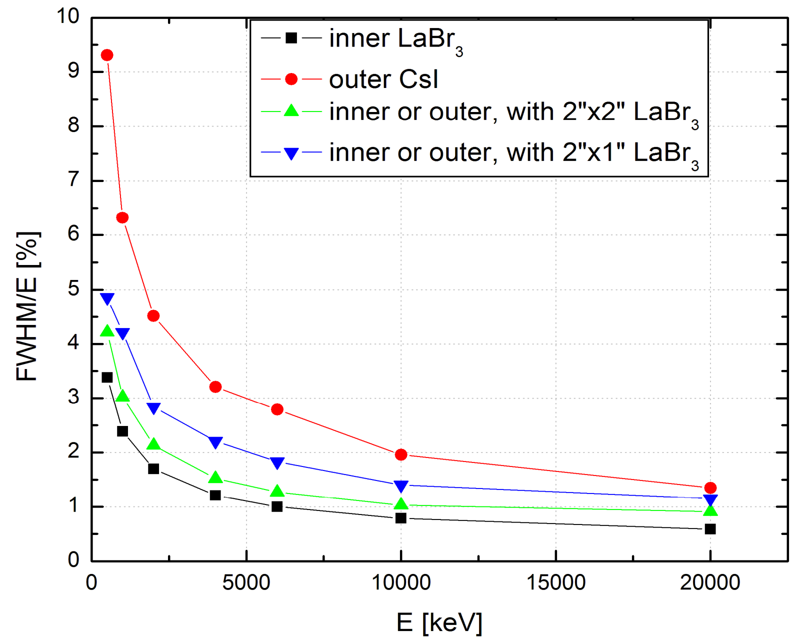
2”x2”x1”

2”x2”x2”

- Shape of spectra obtained for gamma energy 2 and 10 MeV. On each picture black line is a $LaBr_3$ spectrum, red line is CsI spectrum, and green line is sum of energy deposited in $LaBr_3$ and CsI.

Conclusions - FWHM





Increasing $LaBr_3$ shell length from 1” to 2” improves strongly peaks FWHM in “summing mode”. That “summing mode” is necessary to provides 25% efficiency at 5MeV.

GEANT4 simulations of a single $LaBr_3$(Ce) detector and large NaI(Tl) detector arrays

Anil Kumar Gourishetty

Instytut Fizyki Jądrowej, Krakow

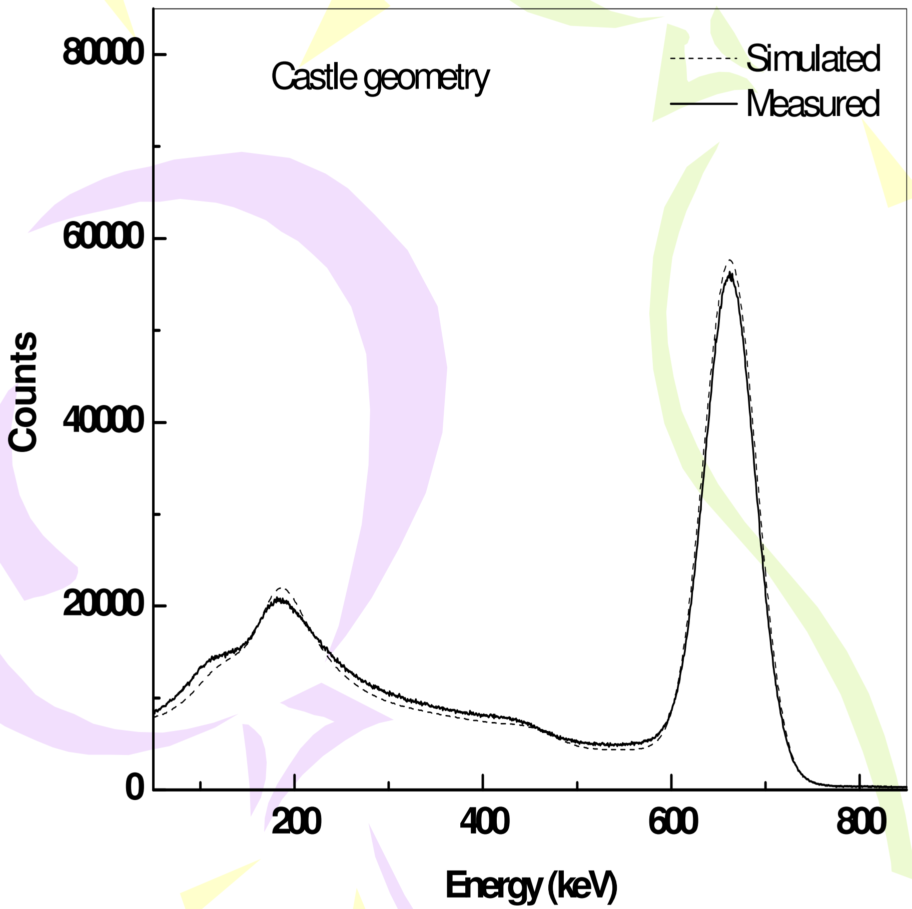
15th Oct.2009
PARIS Meeting, IFJ PAN, Krakow

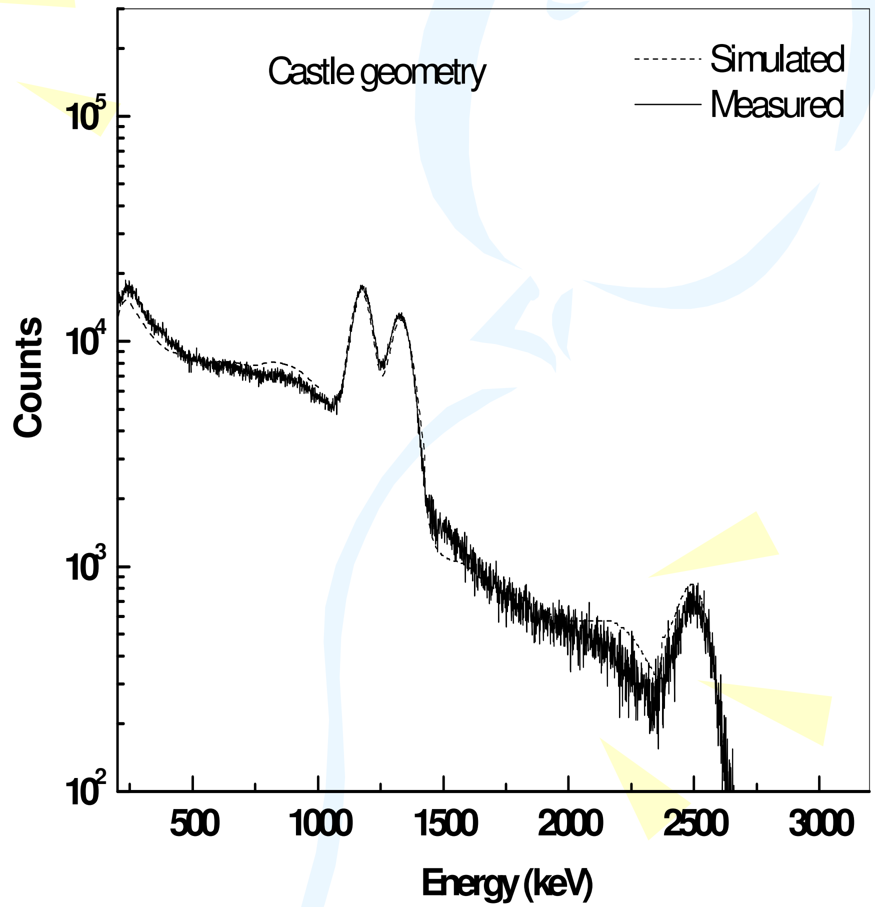
Aim

- To calculate the detection efficiencies of the individual detectors and the entire 4π array using GEANT4 and comparison with measurements.

- To carry out efficiency measurements and GEANT4 simulations for a smaller array of 14 straight NaI detectors of hexagonal cross sections packed in castle geometry and the comparison of the results with the 4π array.

- To calculate fold distributions for different gamma multiplicities for both the 14 elements and the 4π array.


Castle geometry
Simulated
Measured
80000
60000
40000
20000
0
Counts
200
400
600
800
Energy (keV)


Castle geometry
Simulated
Measured
10^5
10^4
10^3
10^2
Counts
500
1000
1500
2000
2500
3000
Energy (keV)

Summary

Close geometry efficiency calibration and coincidence summing correction have been performed for a single $LaBr_3(Ce)$ cylindrical detector, an array of 32 conical NaI(Tl) detectors in soccer-ball geometry and an array of 14 straight hexagonal NaI(Tl) detectors in castle geometry

A good agreement between simulations and measurements has been achieved

The present work demonstrates the reliability of the coincidence summing correction method for efficiency calibration of 3 very different configurations.

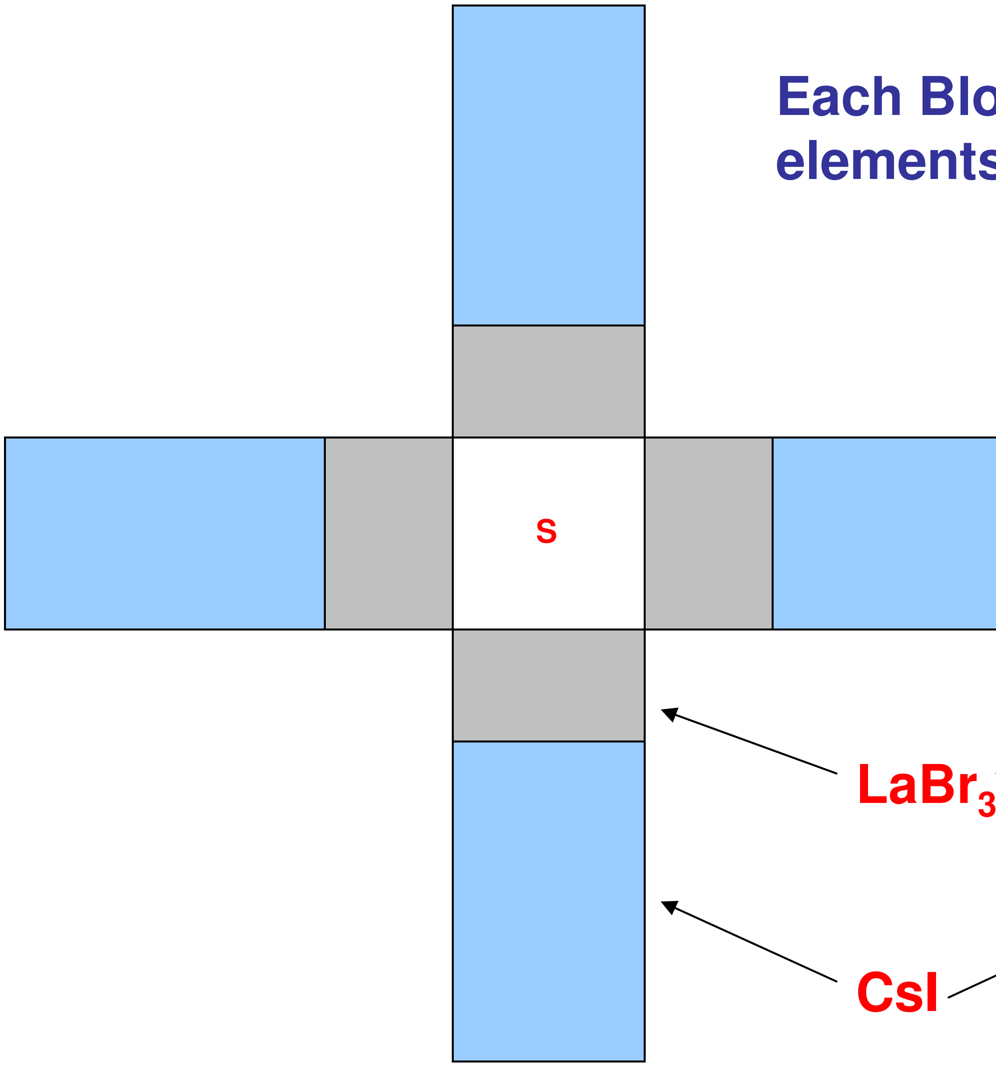
GDR experiment with an ideal six-box two-layered detector array: an EGS simulation

D. R. Chakrabarty

BARC, Mumbai

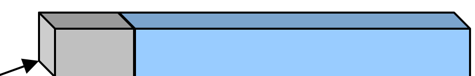
Detector Array:

Six rectangular blocks facing each other. Gamma source (S) at the centre



Each Block has 6X6 detector elements

Each element is 5cmX5cm in cross section



Front $LaBr_3$ is 5 cm long and back CsI is 15 cm long

Event Description

A. Monoenergetic high energy gamma ray

B. High energy gamma ray selection guided by a CASCADE output with the GDR strength function

In both cases, associated multiplicity of low-energy gamma rays has a triangular distribution upto Mmax and energy distributed linearly from 0 to Emax.

Gamma ray source has a velocity β

CASCADE calculation done for ^{132}Sn bombarding on ^{12}C target with beam energy 800 MeV. This corresponds to the source velocity of β~0.1

Two sets of GDR parameters taken

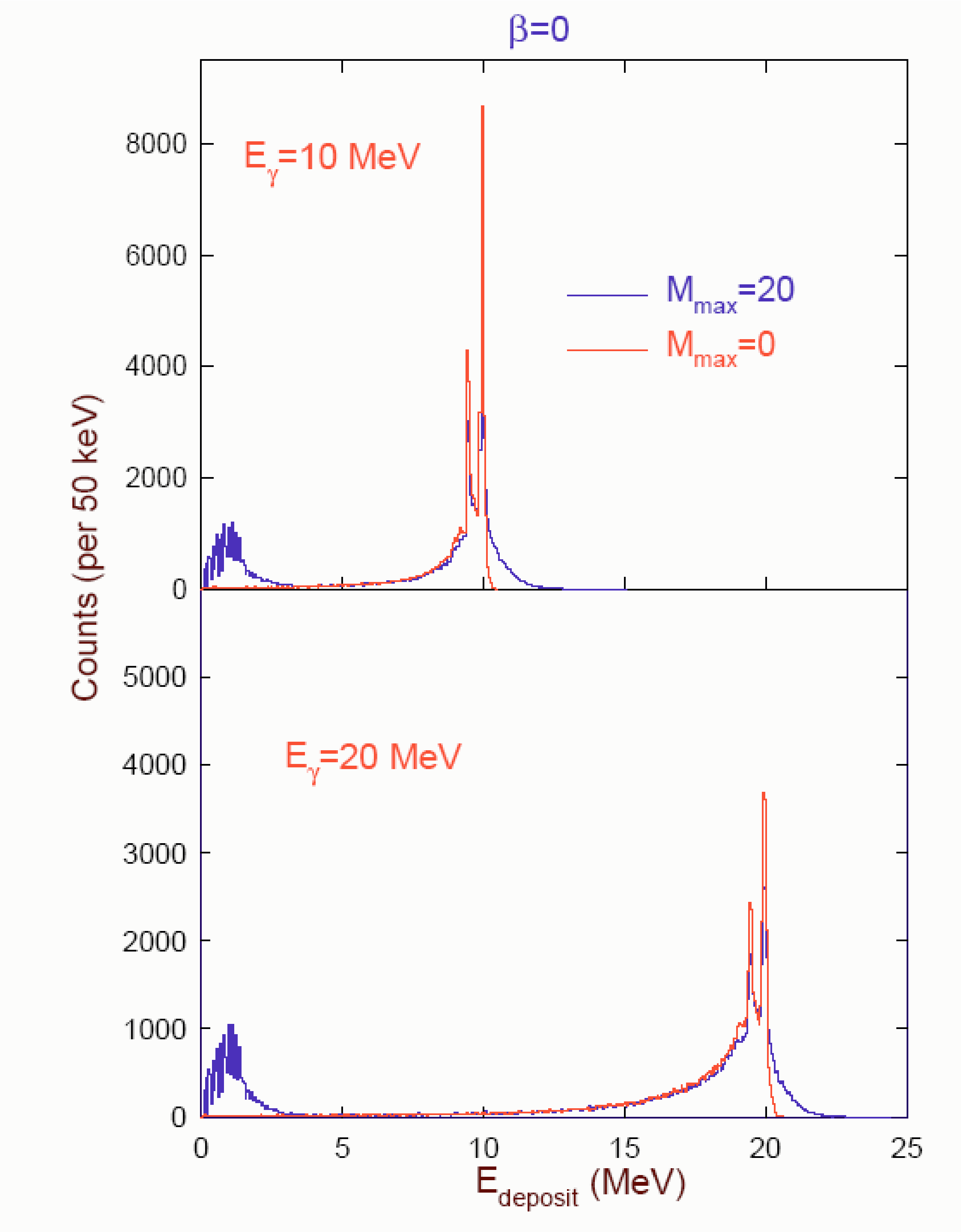
Set I: E_D=14.5 MeV and Γ_D=8.0 MeV

Set II: Main GDR as in set I +

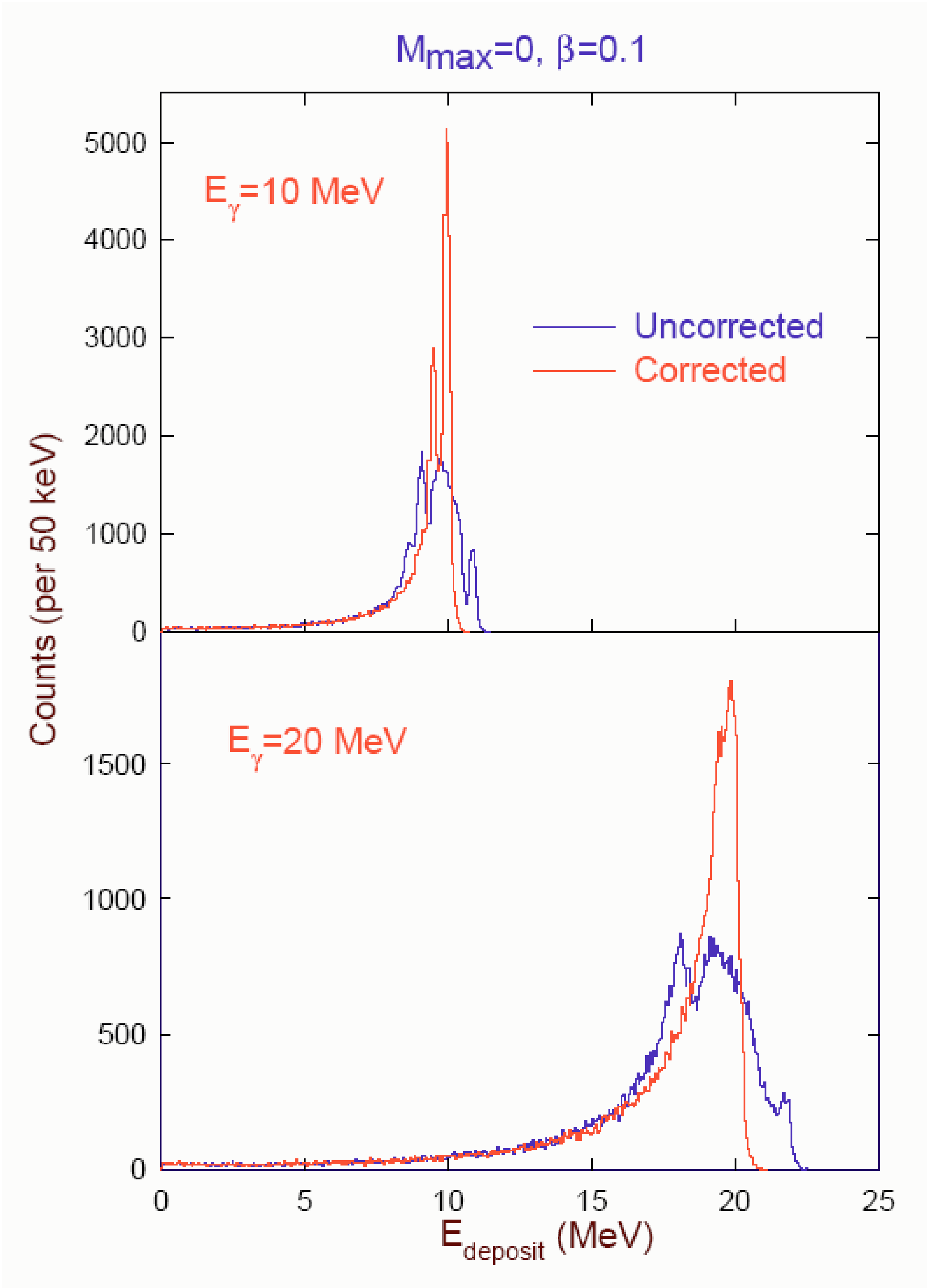
a pygmy resonance with E_D=8 MeV, Γ_D=4 MeV, S=10%

"Experimental" data (list file) created by a random choice of main Eγ (commensurate with the CASCADE output) and the multiplicity gamma rays, event by event.

The list file analysed with nearest neighbour energy addition and Doppler correction, as mentioned earlier, to create "experimental" gamma spectra



Effect of associated Multiplicity gamma rays : Emax=2.0 MeV



Effect of Source velocity

Set I

	E_D (MeV)	Γ_D (MeV)
Input	**14.5**	**8.0**
EGS (Mmax=20)	14.6	8.0
EGS (Mmax=17)	14.7	8.4
EGS (Mmax=23)	14.6	7.8

Set II

	E1	Γ1	E2	Γ2	S2
Input	**14.5**	**8.0**	**8.0**	**4.0**	**10%**
EGS (Mmax=20)	14.6	7.8	8.0	4.0	10%
EGS (Mmax=17)	14.6	8.0	8.0	4.0	10%
EGS (Mmax=23)	14.5	7.7	8.2	4.0	10%

Summary and conclusion

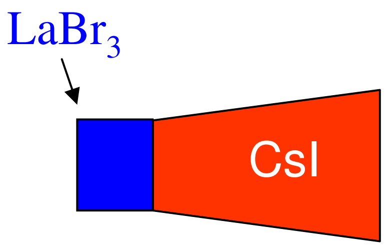
- Presented the EGS simulation of an ideal 6-box detector setup consisting of $LaBr_3$ and CsI
- The algorithm of adding nearest neighbours' energy used
- For the assumed granularity the Doppler correction is reasonably under control
- The presence of associated multiplicity spoils the line shape
- However, with a reasonable uncertainty in the multiplicity distribution around the actual value, one can extract the GDR strength function reasonably well

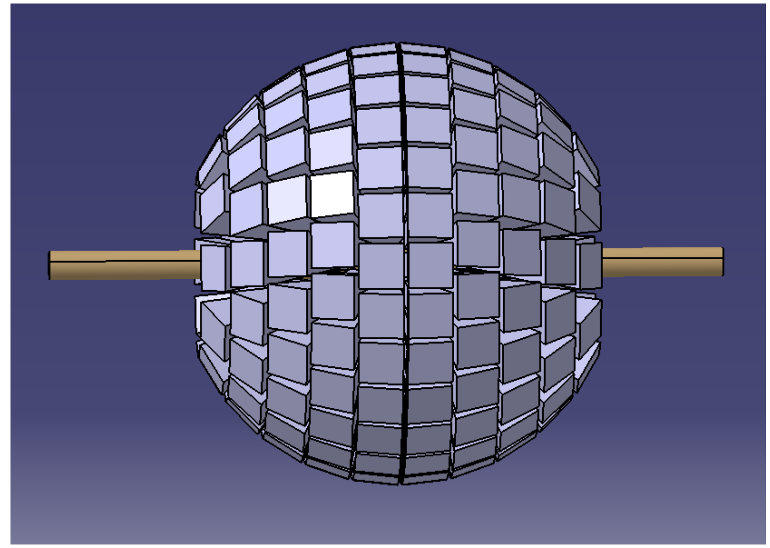
Spherical designs and application to the radiative capture case

WS PARIS (Krakow Oct 14-16, 2009)

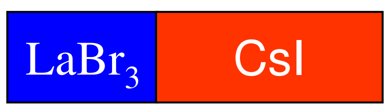
D. Lebhertz, S. Courtin, A. Michalon, A. Goasduff

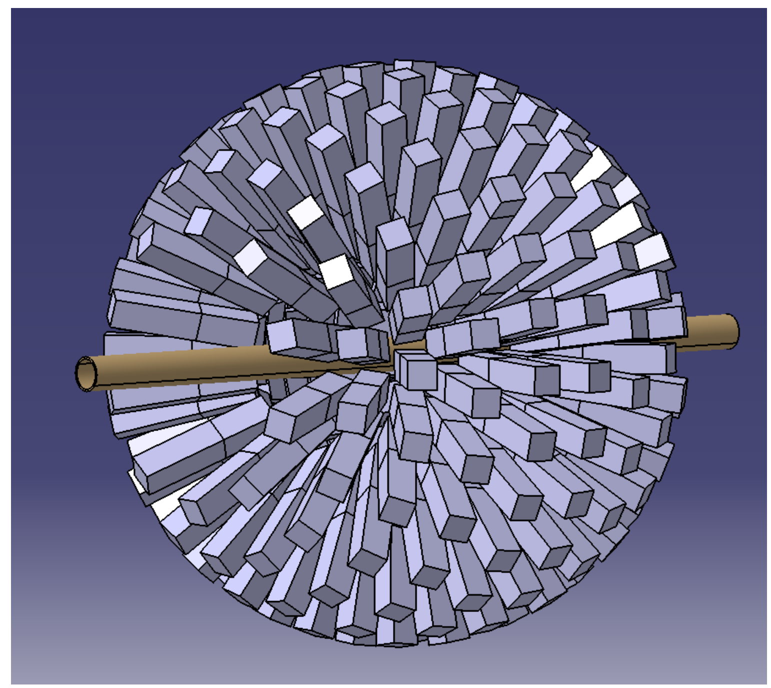
- Design 222-tapered



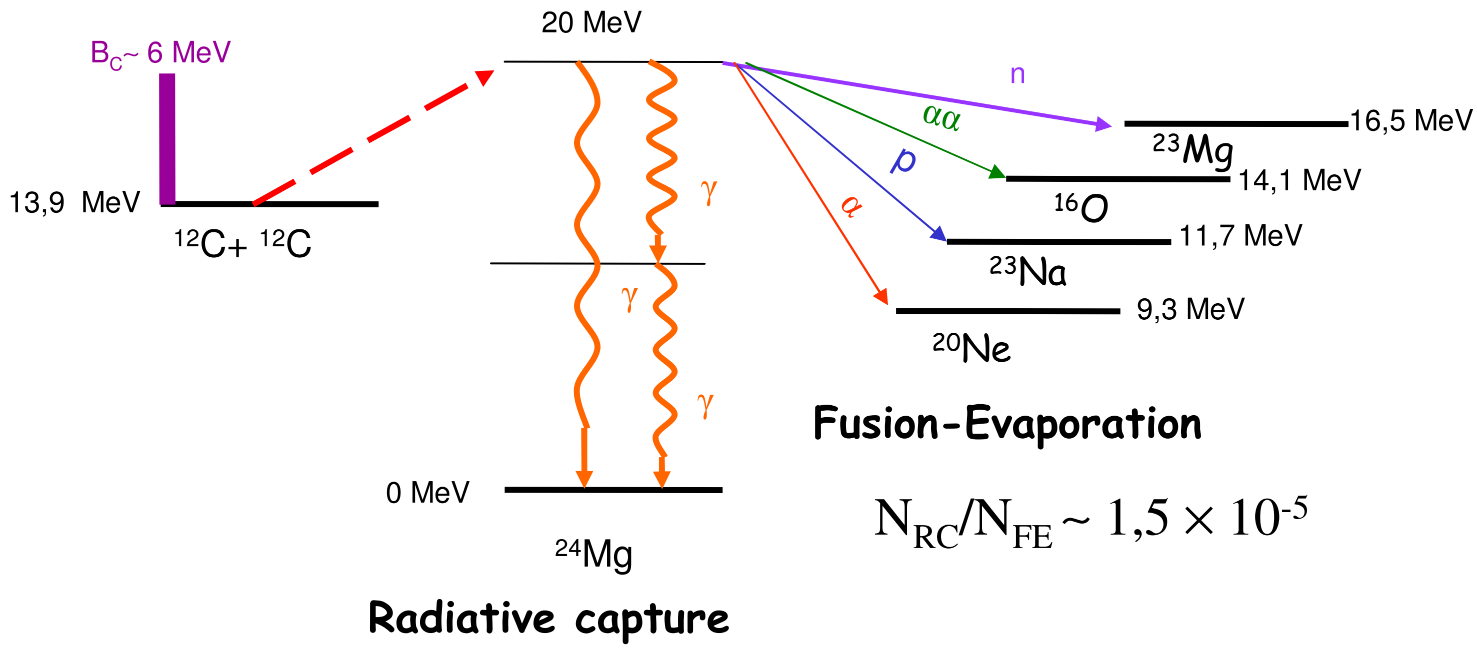


- Design 224-226





Physics case: radiative capture $^{12}C(^{12}C,\gamma)^{24}Mg$

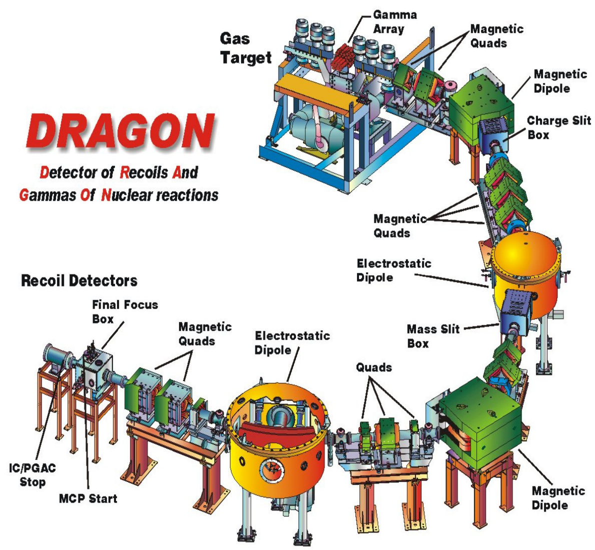


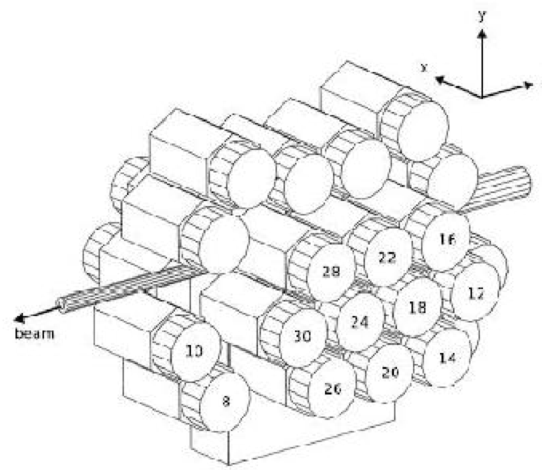
$N_{RC}/N_{FE} \sim 1{,}5 \times 10^{-5}$

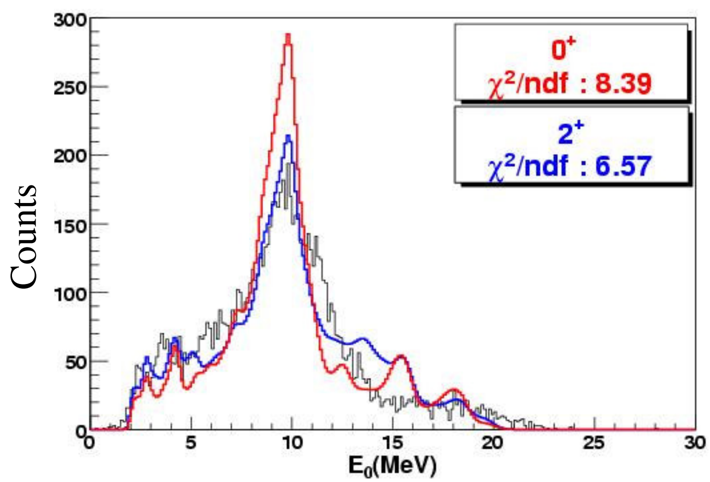
Selection of the radiative capture channel

- Detection of the recoil at 0° $\rightarrow N_{RC}/N_{Beam} \approx 6{,}5 \times 10^{-12}$
- Calorimeter mode ($\sum E\gamma \sim 20$ MeV)

Our Triumf Results

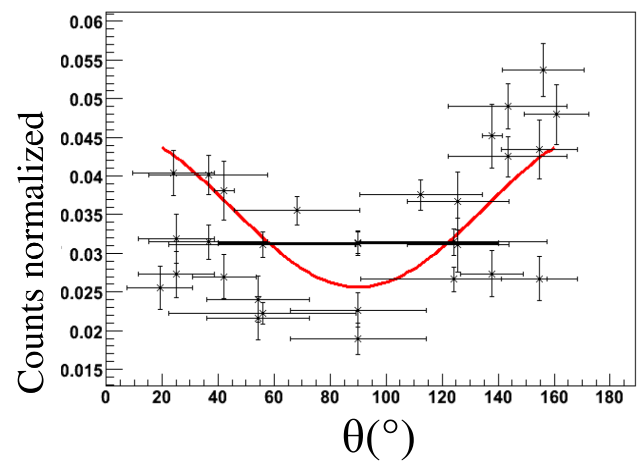






Resolution around 10 MeV …

Angular distribution

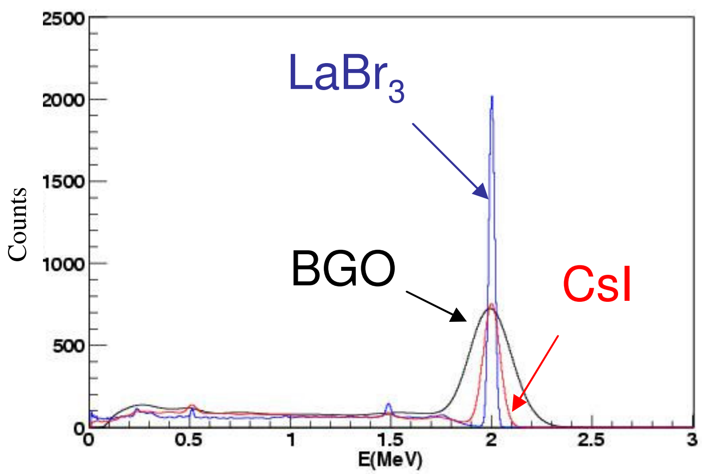


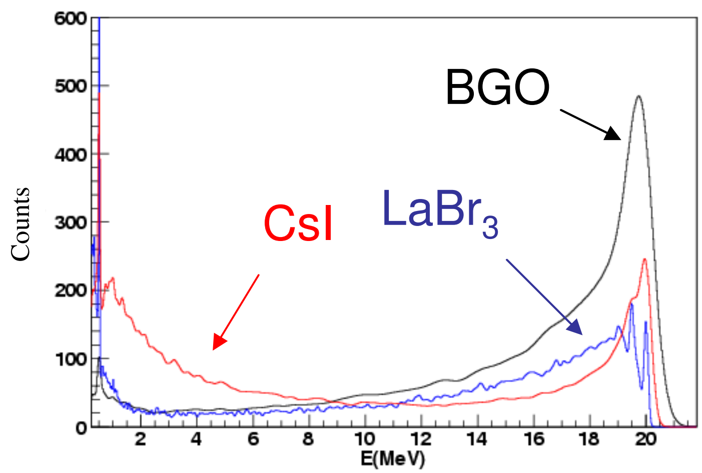
Resolution

Scintillators : FHWM = k √(E) MeV$^{1/2}$

Material	BGO	CsI	LaBr
k(MeV$^{1/2}$)	0.173	0.068	0.024

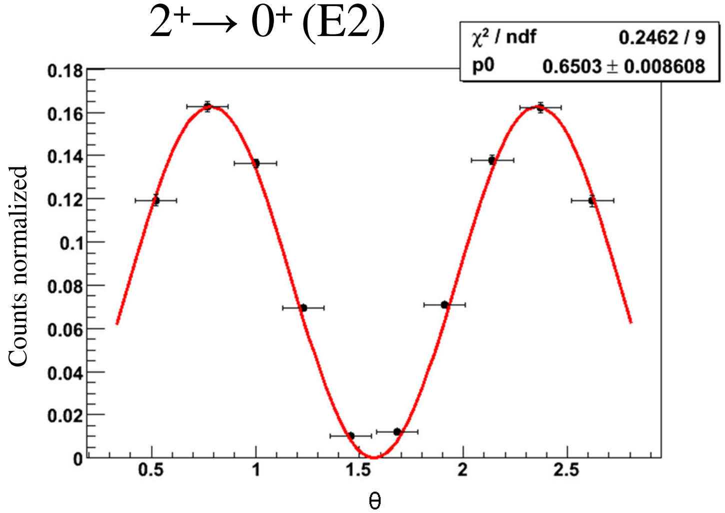
Simulation for 100 000 γ of 2 and 20 MeV



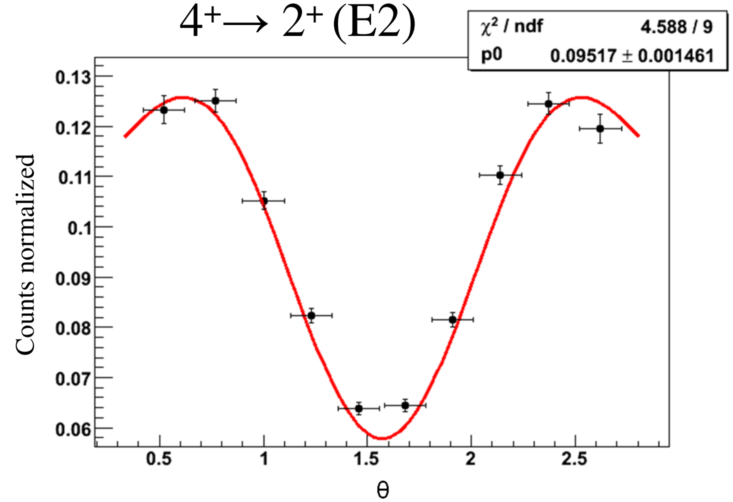


Angular distributions

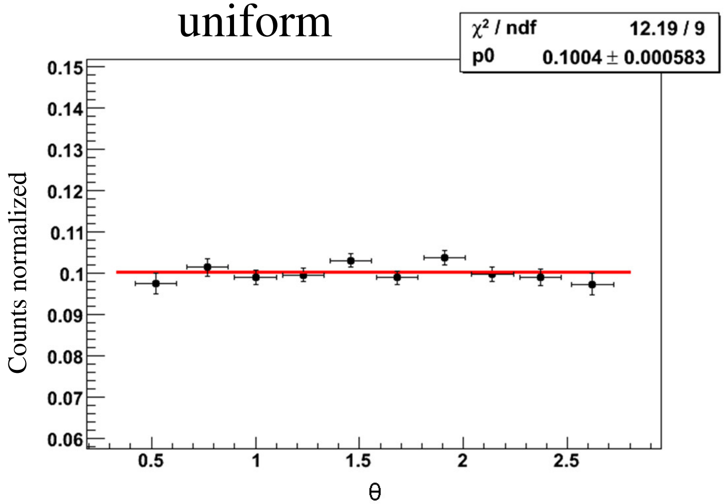
$2^+ \longrightarrow 0^+$ (E2)



$4^+ \longrightarrow 2^+$ (E2)



uniform



Simple algorithm:

- /Nbr of detector by rings
- Normalise to 1

⬇

We can distinguish easily
E1 / E2 / uniform distributions
and even ≠ E2 transitions

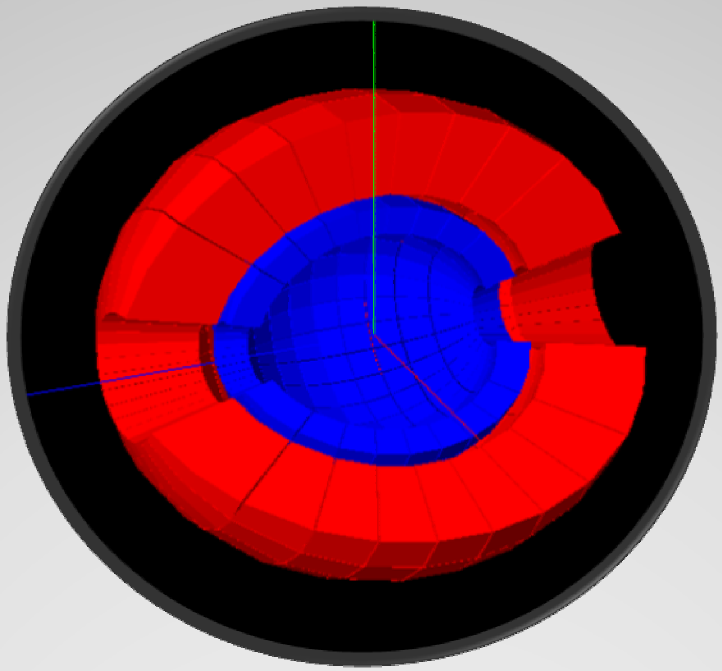
List of requirements related to the different physics cases to be a

Physics Case	Recoil mass	v/c [%]	E_g range [MeV]	DE_g/E_g [%]			W coverage	DT [ns]	Ancillaries	Comments
Jacobi transition	40-150	<10	0.1-30	4			2p-4p	<1	AGATA HI det.	High eff. Beam rej.
Shape Phase Diagram	160-180	<10	0.1-30	6	<5	4	2p-4p	<1	HI det.	High eff. Differential method Beam rej.
Hot GDR in n-rich nuclei	120-140	<11	0.1-30	6	<8	4	2p-4p	<1	HI det.	Beam re.
Isospin mixing	60-100	<7	5-30	6	-	-	4p	<1	HI det.	High eff. Beam rej.
Reaction dynamics	160-220	<7	0.1-25	6-8	<8	4	2p	<1	n-det. FF det.	Complex coupling
Collectivity vs. multi-fragmentation	120-200	<8	5-30	5	-	-	2p	<1	LCP det. HI det.	Complex coupling
Radiative capture	20-30	<3	1-30	<4	5	-	4p	<1	HI det.	High eff.
Multiple Coulex	40-60	<7	2-6	5	-	-	2p	<5	AGATA CD det.	Complex coupling
Astrophysics	16-90	0.1	0.1-6	6	5	-	4p	<1	Outer PARIS shell as active shield	High eff. Back-ground
Shell structure at intermediate energies (SISSI/LISE)	16-40	20-40	0.5-4	3 ✗	-	-	3p	<<1	SPEG or VAMOS	High eff. Low I_{beam} g-g coinc
Shell structure at low energies (separator part of S^3)	30-150	10-15	0.3-3	3 ?						High eff. Low I_{beam} g-g coinc
Relativistic Coulex	40-60	50-60	1-4	4 ✗	-	1	Forward 3p	<<1	AGATA HI analyzer	Ang. Distr. Lorentz boost

Doppler versus Opening Angle !!

Requirements from the physics cases

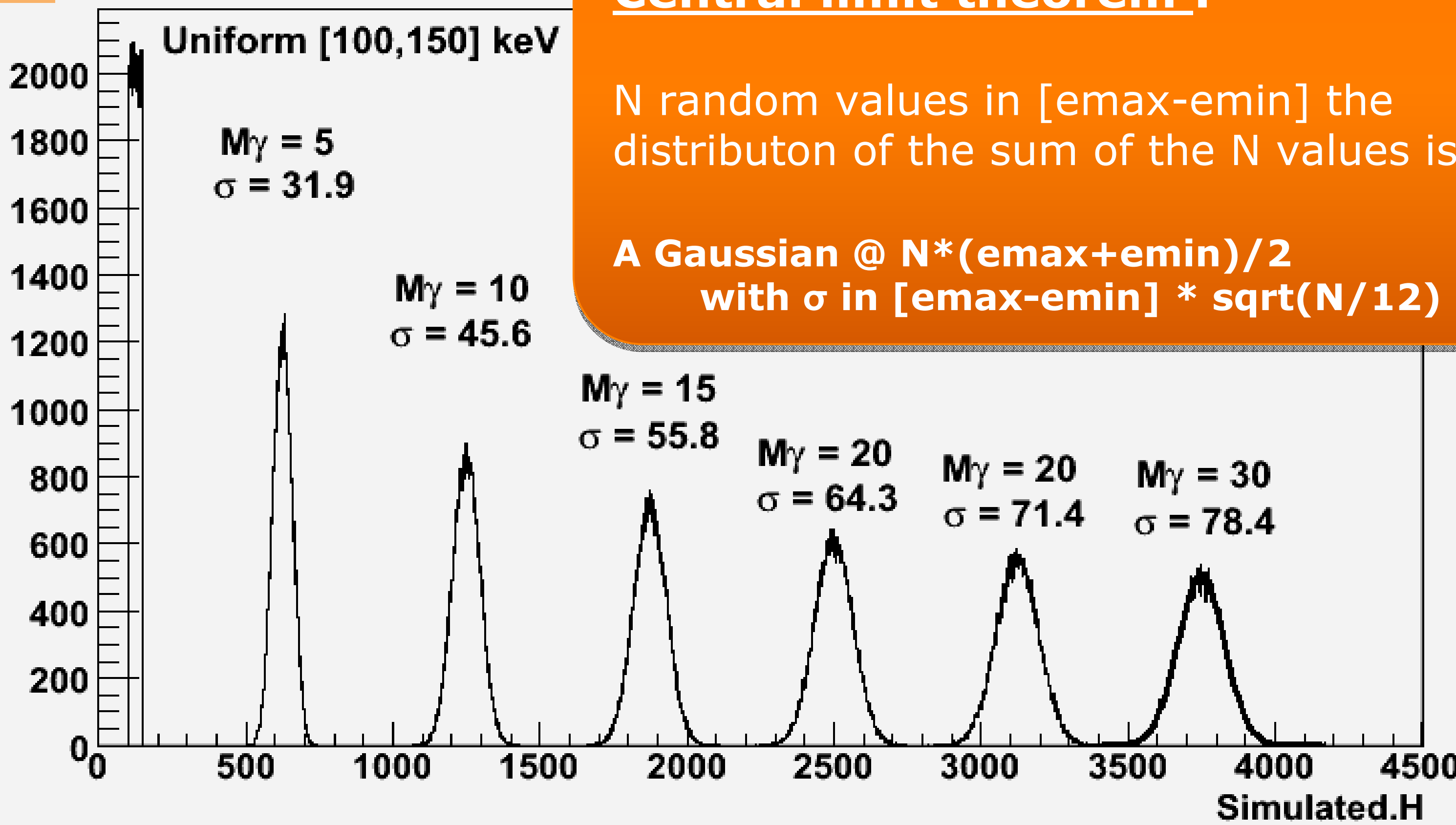
Geometry / Generator / Reconstruction



Study at high multiplicity

Mult {5, 10, 15, 20, 25, 30} over an uniform distribution [0,1.5 MeV]
No Doppler, source @ the center

Ex



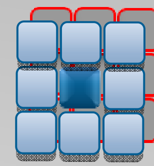
Central limit theorem :

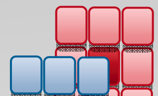
N random values in [emax-emin] the distributon of the sum of the N values is:

A Gaussian @ N*(emax+emin)/2 with σ in [emax-emin] * sqrt(N/12)

Generator

RawPerformances : one element = one γ –ray

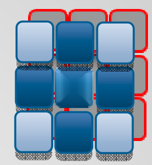
- **0_0 : only the first shell** 

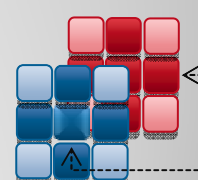
- **1_0 : both shells** 

AddBac

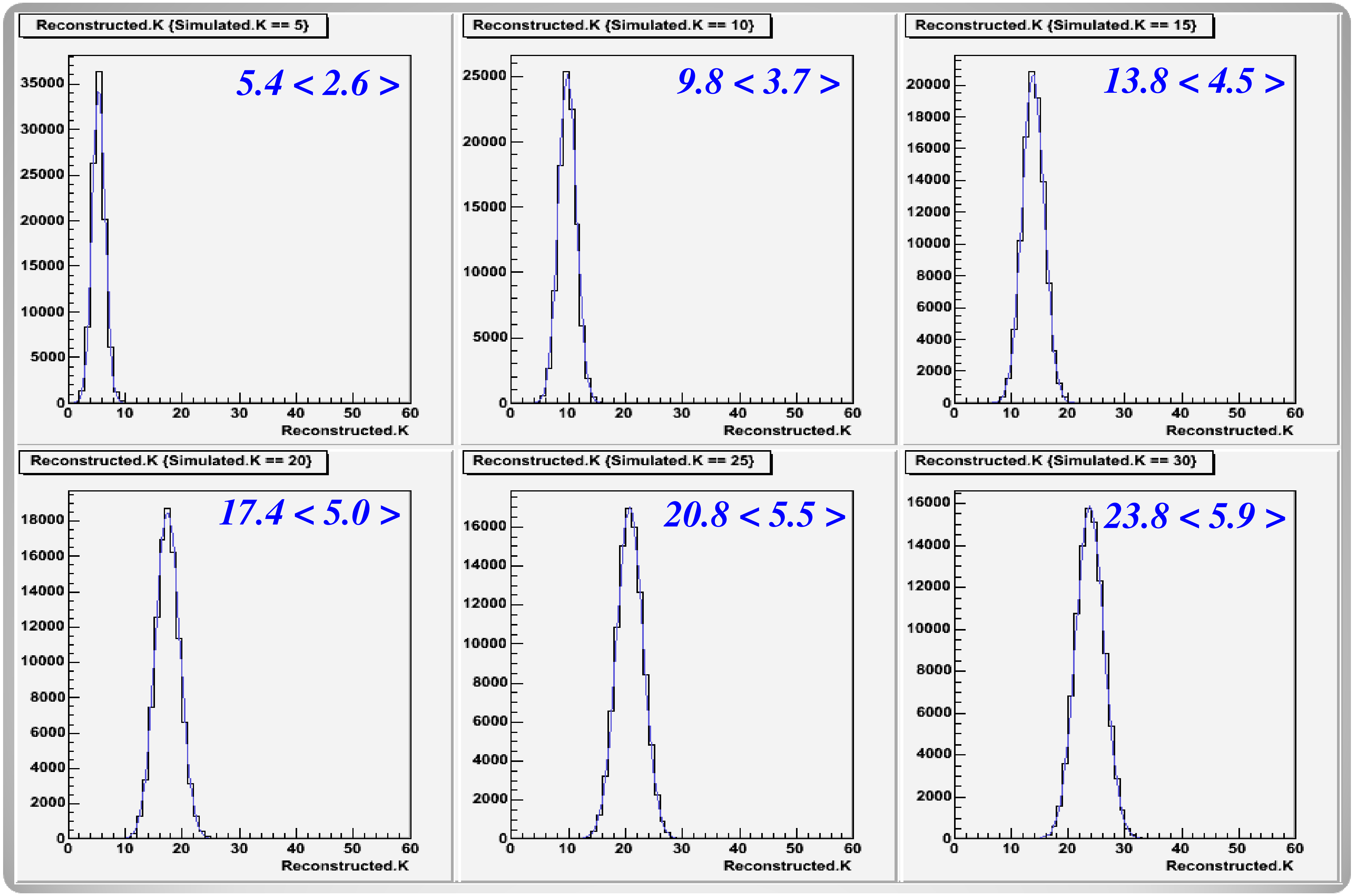
(start

H : detected energy
K : reconstructed multiplicity

0_0 : closest only in the first shell 

1_0 : + addback between the 2 shells 

Different clustering methods

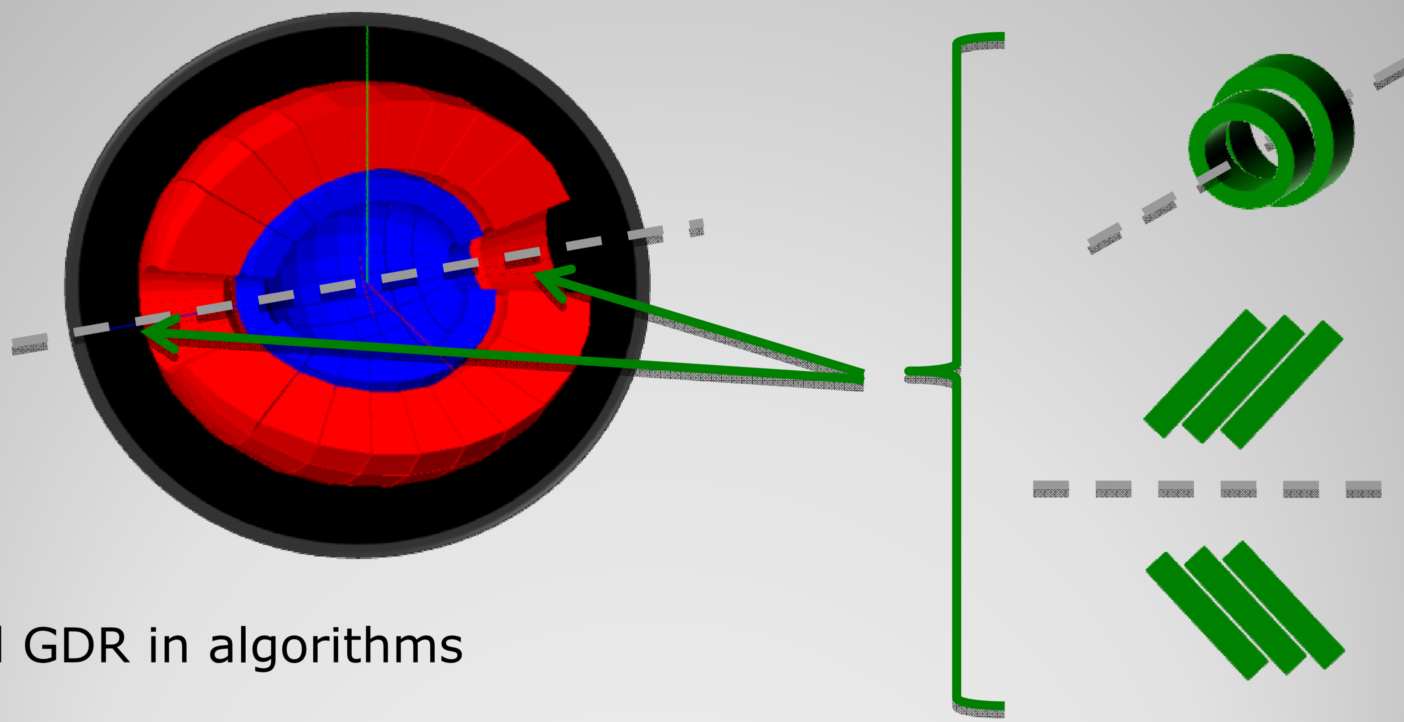


K with AddBack1_1

Conclusions

❖**Expected resolutions {H,K} not reached !!**

❖More studies concerning the resolution on {H,K}
- depends on the full efficiency ➔ ***ENDCAP***
- Test other clustering methods



❖Add GDR in algorithms

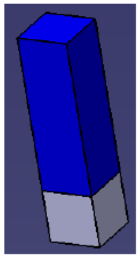
❖P/T and Photopic at low multiplicity 1➔ 5 (spectroscopy)

Review of Mechanical Options for PARIS

J. Strachan, S Courtin, A Smith, E Gamelin

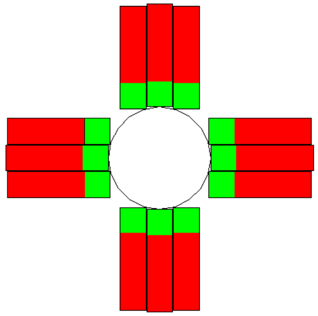
Cubic Array Options

Cubic Detector

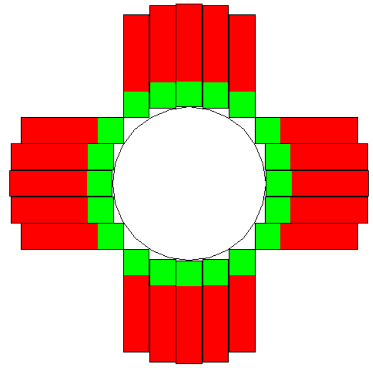


Simulations led by

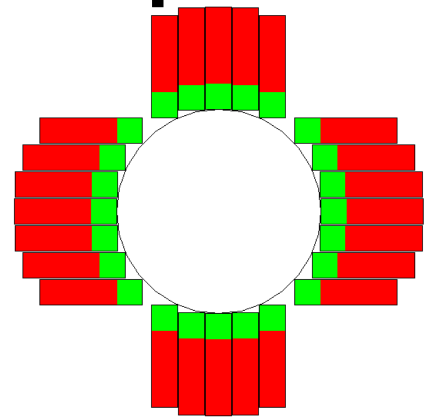
York/Krakow



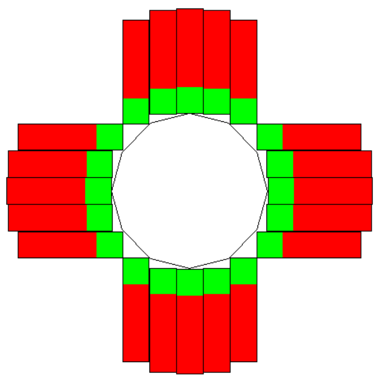
R = 100mm
12 detectors

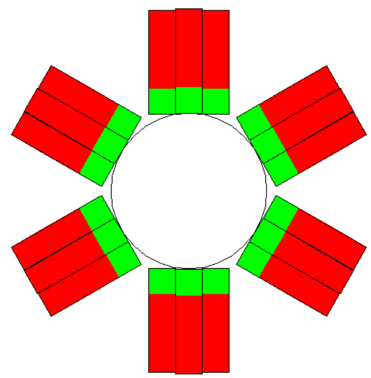


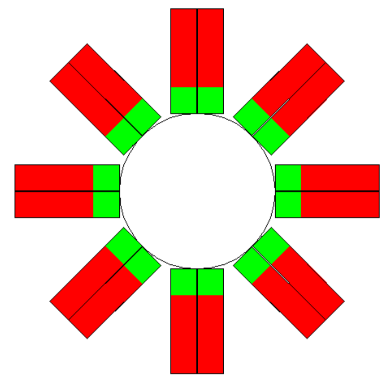
R = 150
20 detectors



R = 200
24 detectors







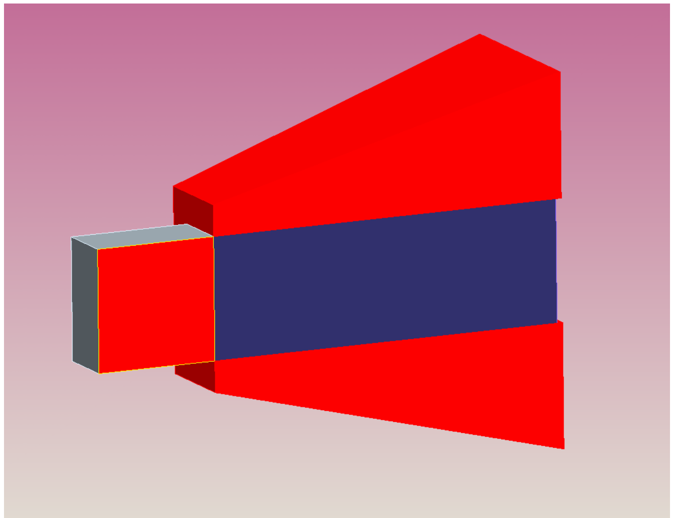
Hybrid Arrays

Next Steps

Once Array Type has been decided on
We should create the Mechanical Specification.

Crystal type(s) and size
Detector type(s) and size(s) – PMTs or photoavalanche diodes
Radius and Range
Location
Secondary detectors?

Is it possible to have a common mounting approach, and have a split csi crystal in this case the telescopes could be interchangable between array types.



Simulations

- Too soon to decide from one geometry to another one !
- Priority concerning the first experiment ?

- need to fill the gaps with ‘cheap’ scintillators
- Toward an EXOGAM like geometry ?

Mechanical

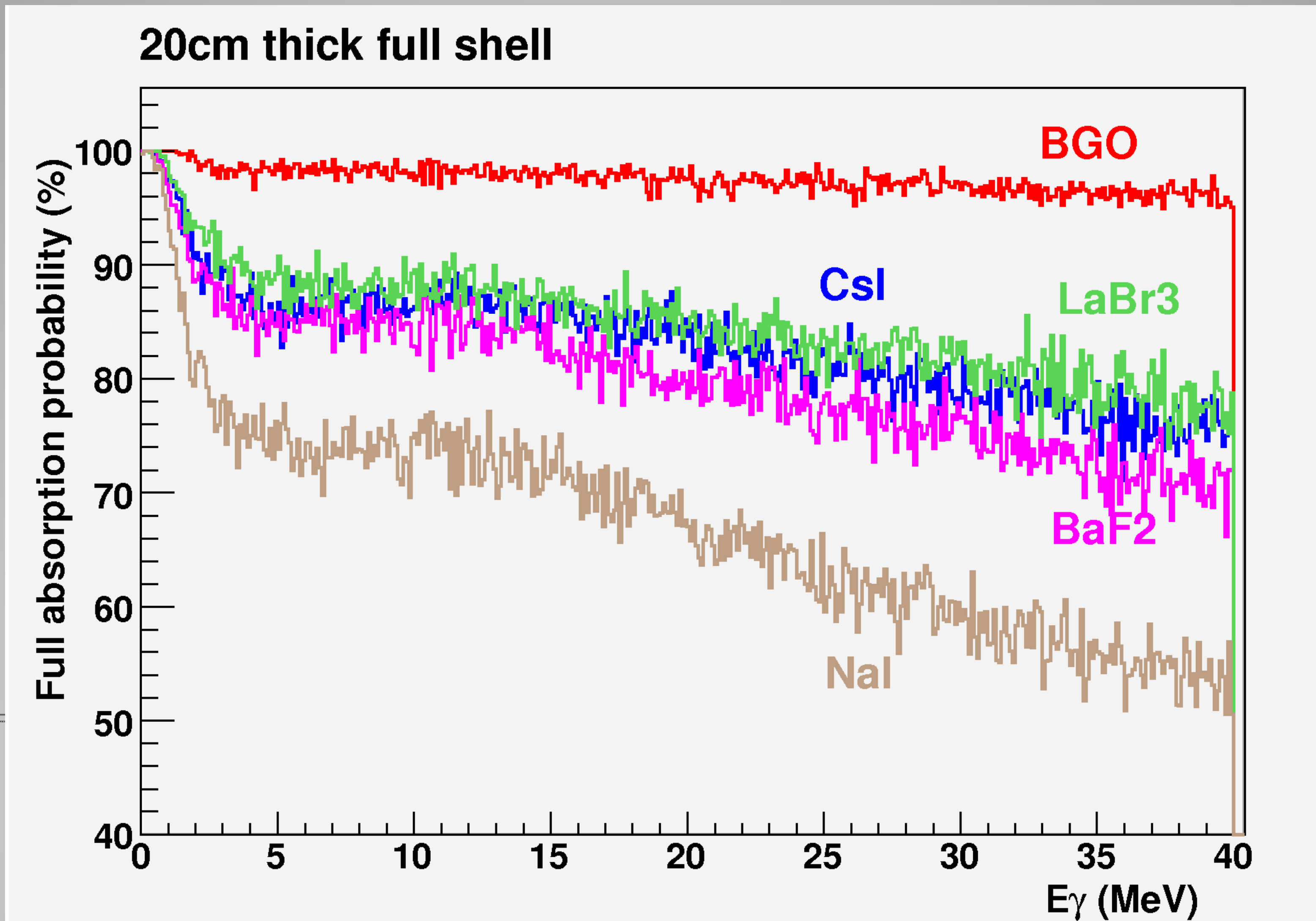
- Consider cubic/radial composite
- How to build wedge/collar
- How to build a cluster ?
- How to integrate PARIS within S3
- How to integrate PARIS with Gaspard

Discussions

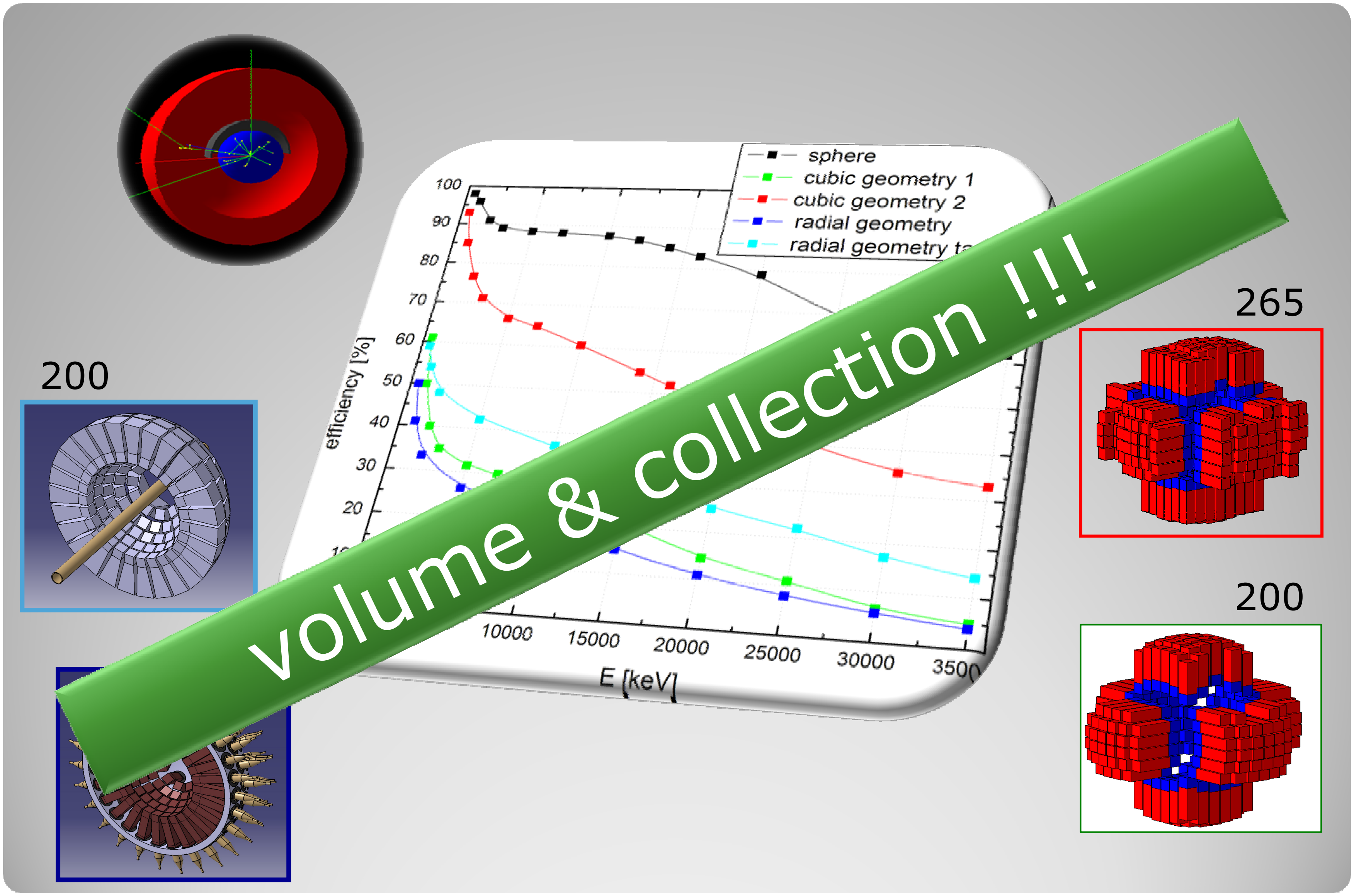
List of requirements related to the different physics cases to be addressed at PARIS

Physics Case	Recoil mass	v/c [%]	E_g range [MeV]	DE_g/E_g [%]	DE_{sum}/E_{sum} [%]	DM_g	W coverage	DT [ns]	Ancillaries	Comments
Jacobi transition	40-150	<10	0.1-30	4	<5	4	2p-4p	<1	AGATA HI det.	High eff. Beam rej.
Shape Phase Diagram	160-180	<10	0.1-30	6	<5	4	2p-4p	<1	HI det.	High eff. Differential method Beam rej.
Hot GDR in n-rich nuclei	120-140	<11	0.1-30	6	<8	4	2p-4p	<1	HI det.	Beam re.
Isospin mixing	60-100	<7	5-30	6	-	-	4p	<1	HI det.	High eff. Beam rej.
Reaction dynamics	160-220	<7	0.1-25	6-8	<8	4	2p	<1	n-det. FF det.	Complex coupling
Collectivity vs. multi-fragmentation	120-200	<8	5-30	5	-	-	2p	<1	LCP det. HI det.	Complex coupling
Radiative capture	20-30	<3	1-30	<4	5	-	4p	<1	HI det.	High eff.
Multiple Coulex	40-60	<7	2-6	5	-	-	2p	<5	AGATA CD det.	Complex coupling
Astrophysics	16-90	0.1	0.1-6	6	5	-	4p	<1	Outer PARIS shell as active shield	High eff. Back-ground
Shell structure at intermediate energies (SISSI/LISE)	16-40	20-40	0.5-4	3	-	-	3p	<<1	SPEG or VAMOS	High eff. Low I_{beam} g-g coinc
Shell structure at low energies (separator part of S^3)	30-150	10-15	0.3-3	3	-	-	3p	<<1	Spectrometer part of S^3	High eff. Low I_{beam} g-g coinc
Relativistic Coulex	40-60	50-60	1-4	4	-	1	Forward 3p	<<1	AGATA HI analyzer	Ang. Distr. Lorentz boost

Requirements from the physics cases

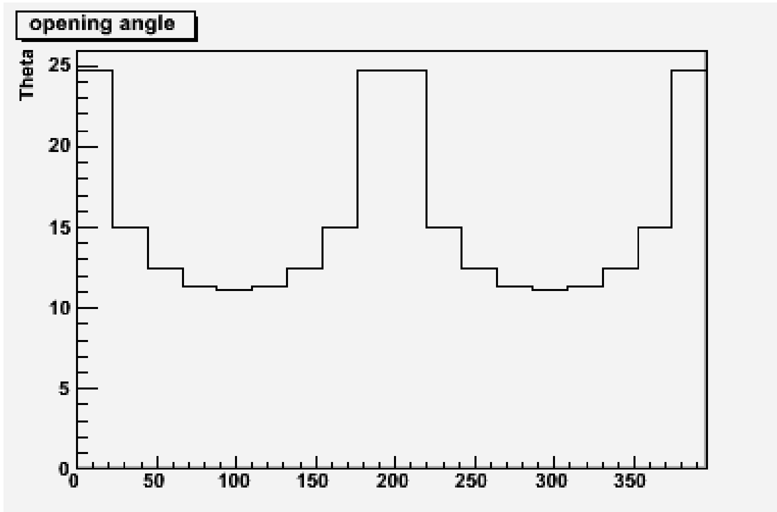


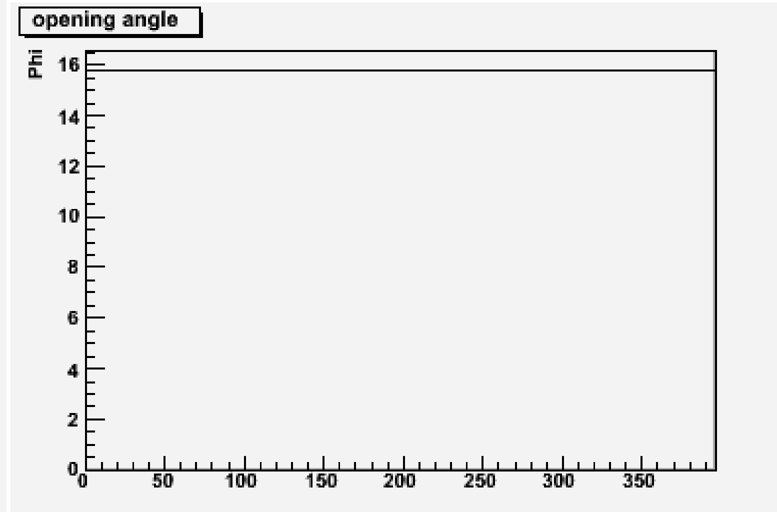
Algo depends on the physics cases !

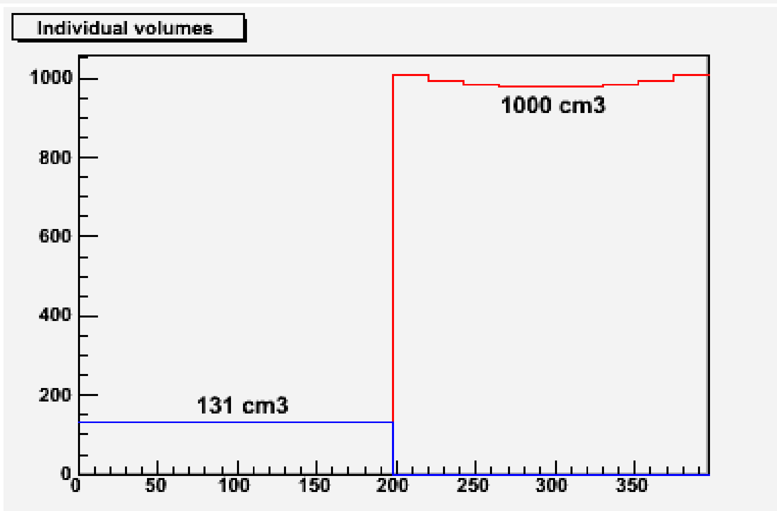


Efficiency @ multiplicity 1

Segmented geometry







Beam pipe : 5 cm radius

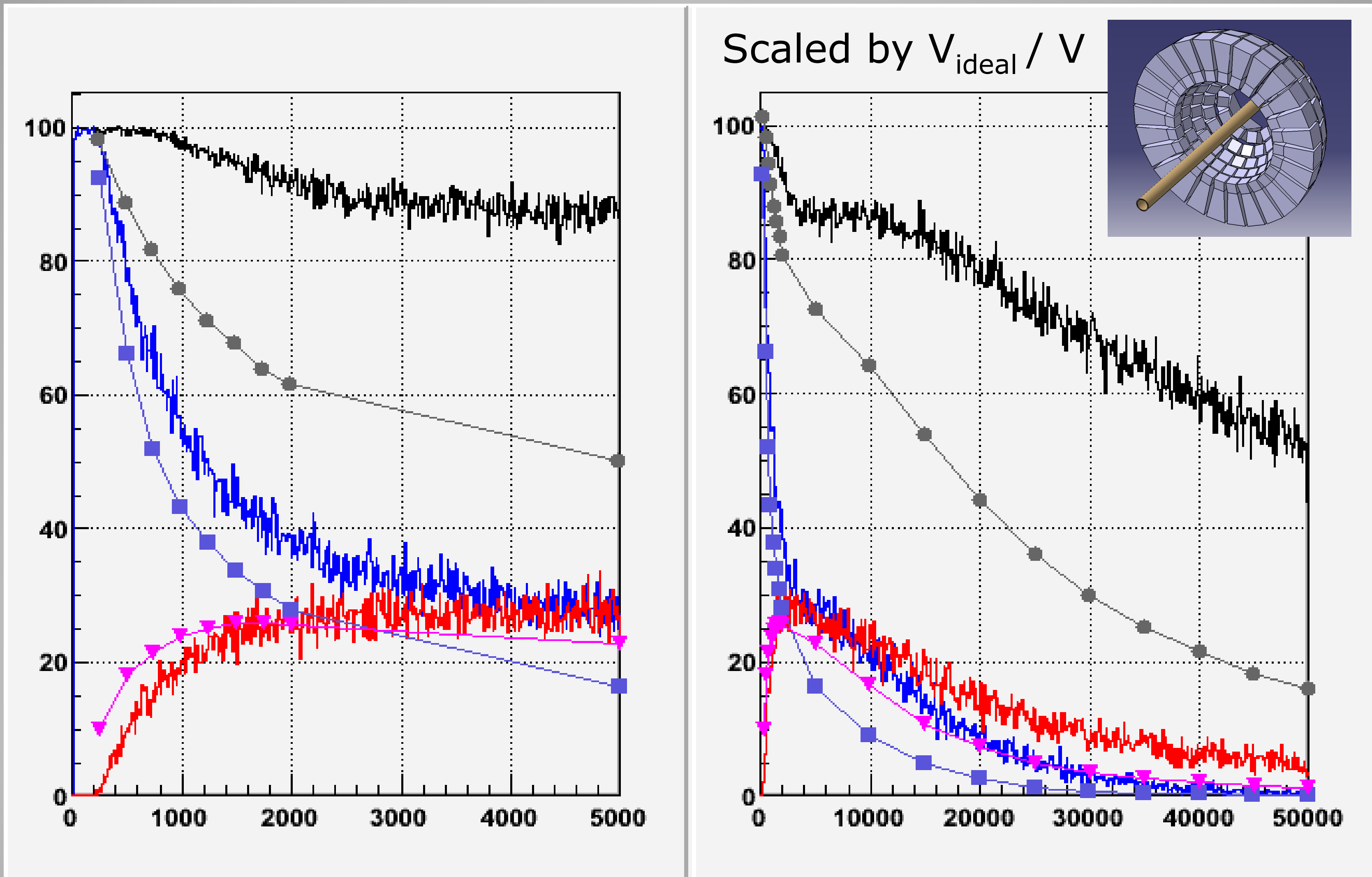
Separation between two inner elements 2mm

396 cells (9x22)

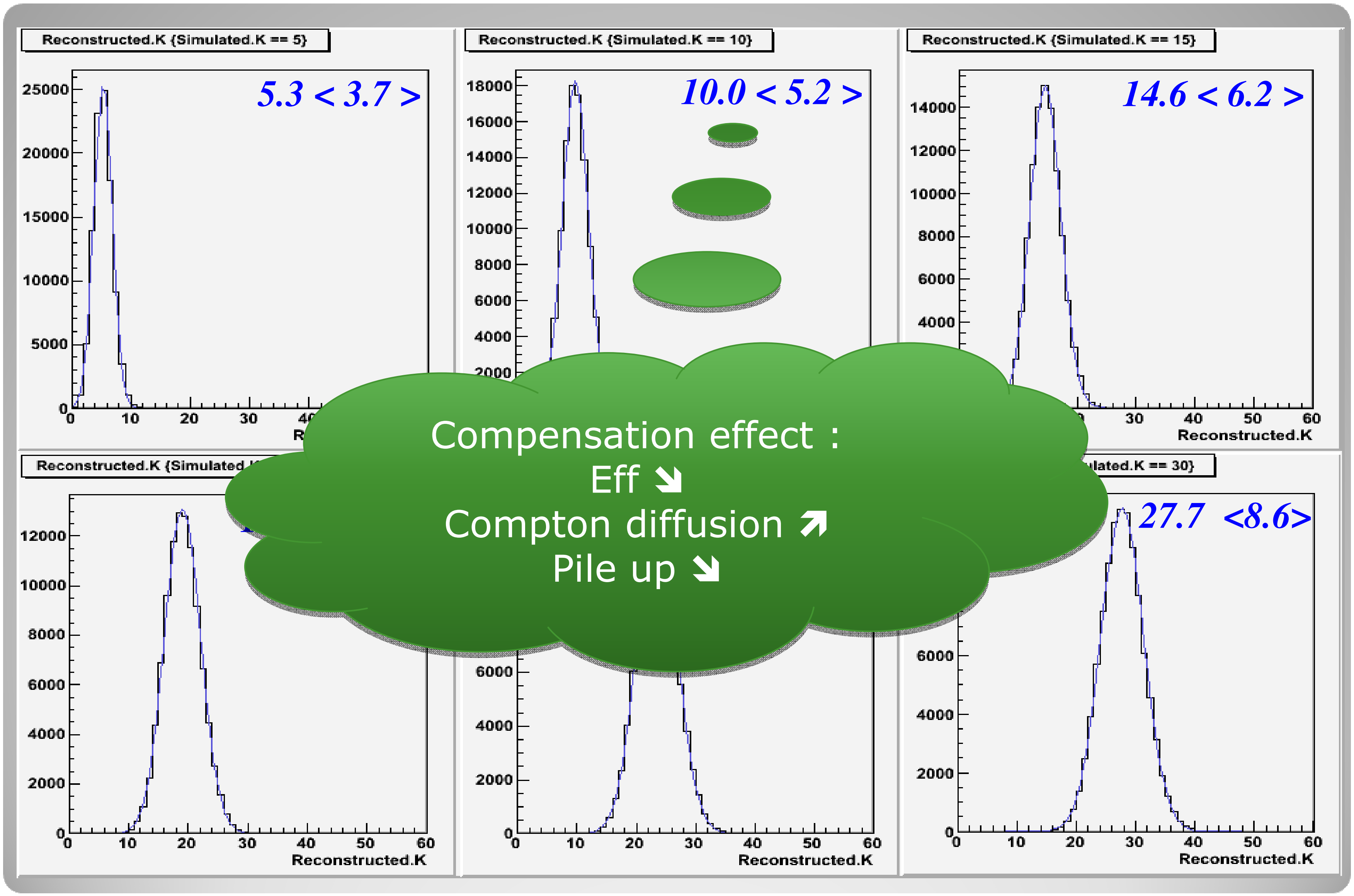
Total Volume of Shell 1 0.888106 % of 29.2084 dm3

Total Volume of Shell 2 0.888779 % of 220.261 dm3

2″*2″*2″ @ 18.8cm + 2″*2″*6″

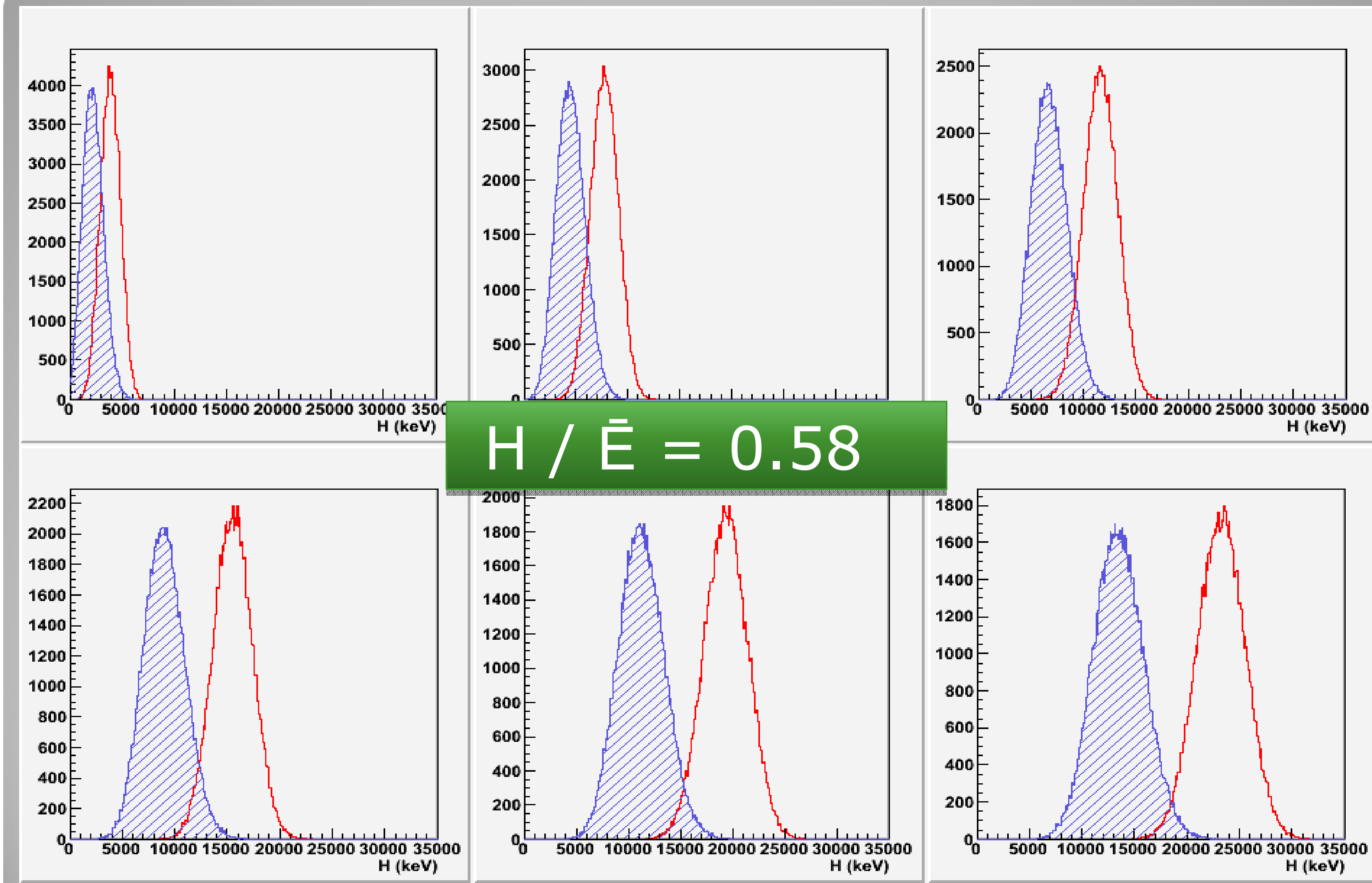


Full absorption @ multiplicity 1

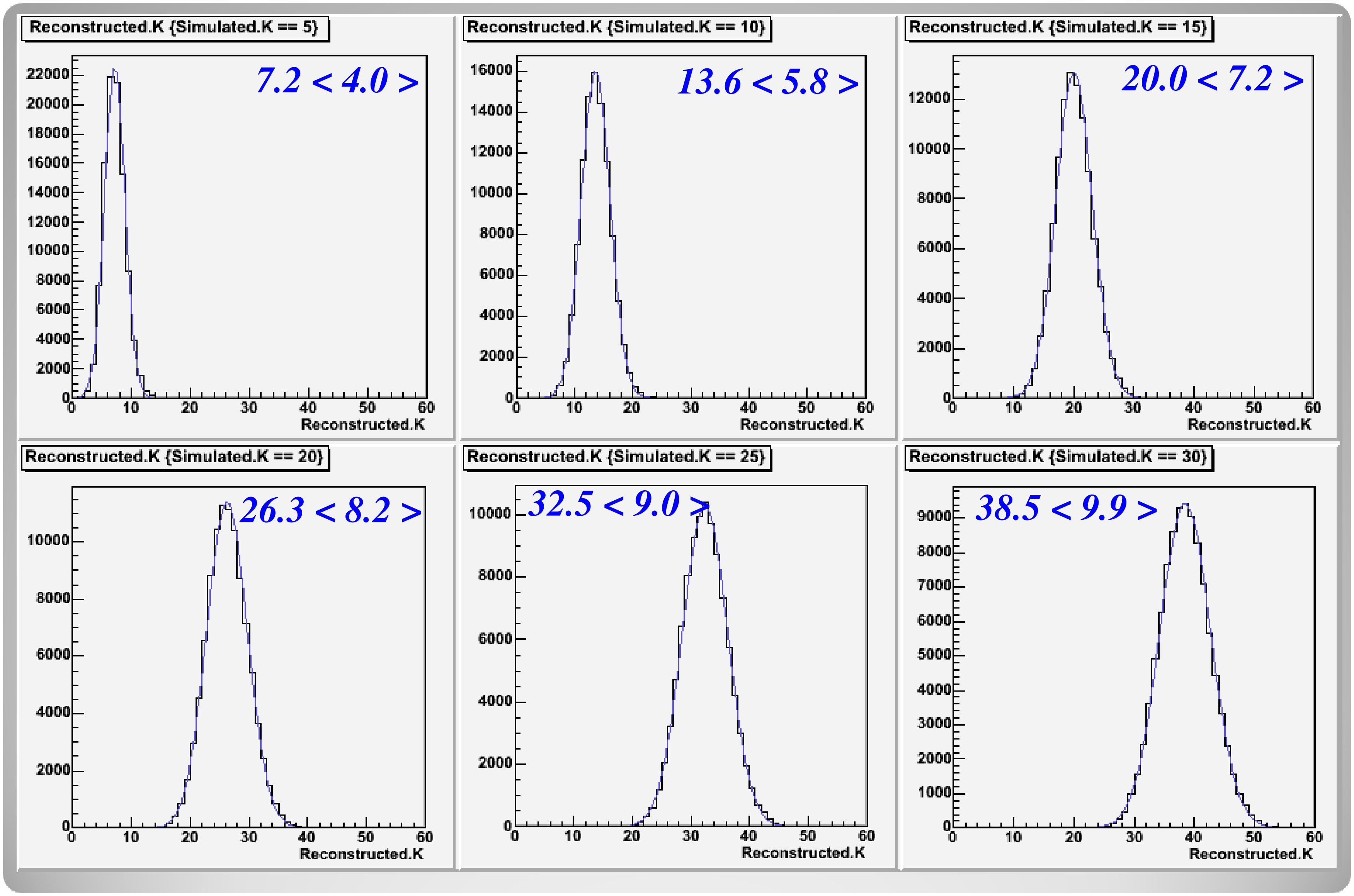


K with RawPerformances0_0

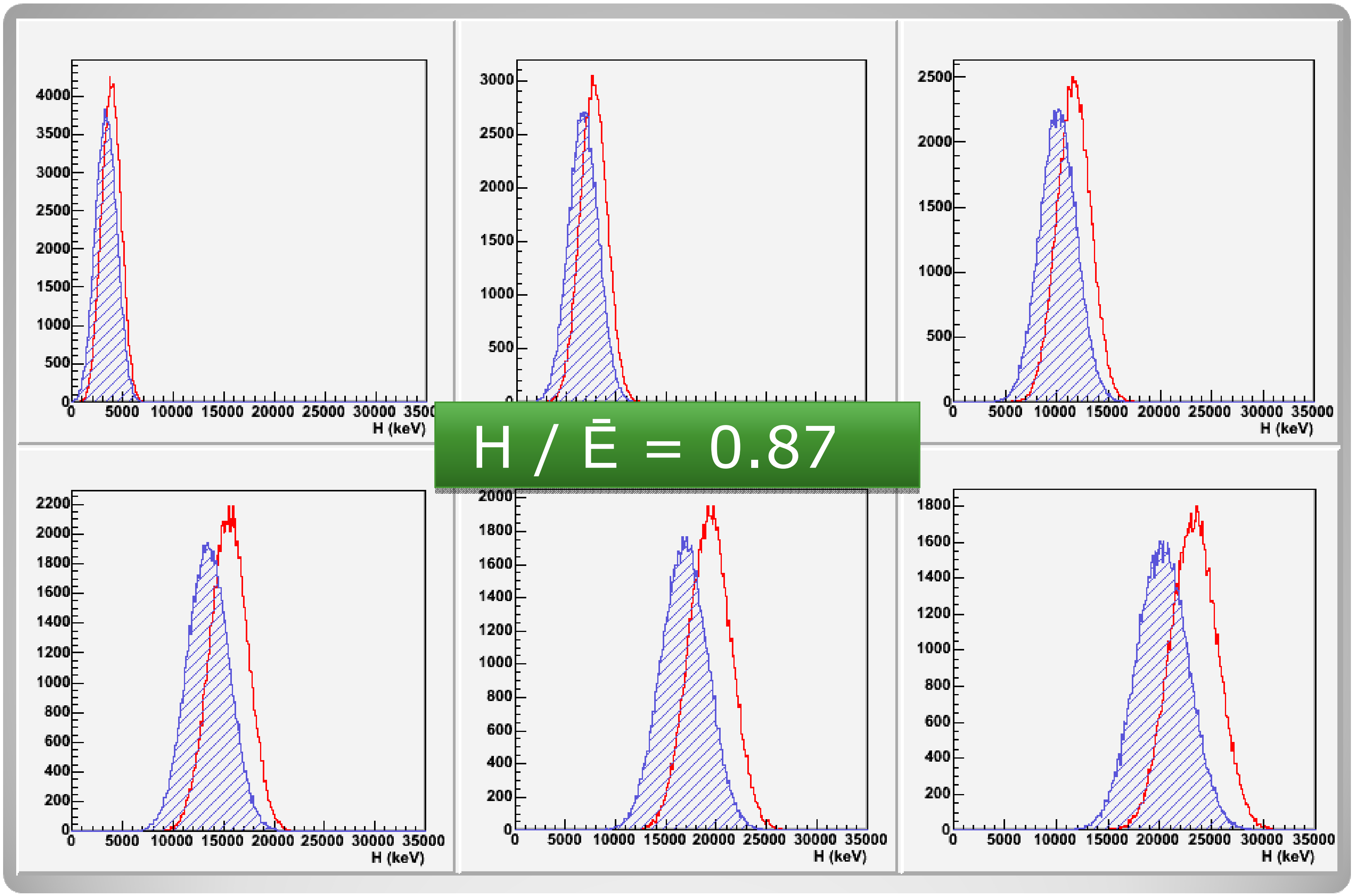
H with RawPerformances0_0



H / Ē = 0.58

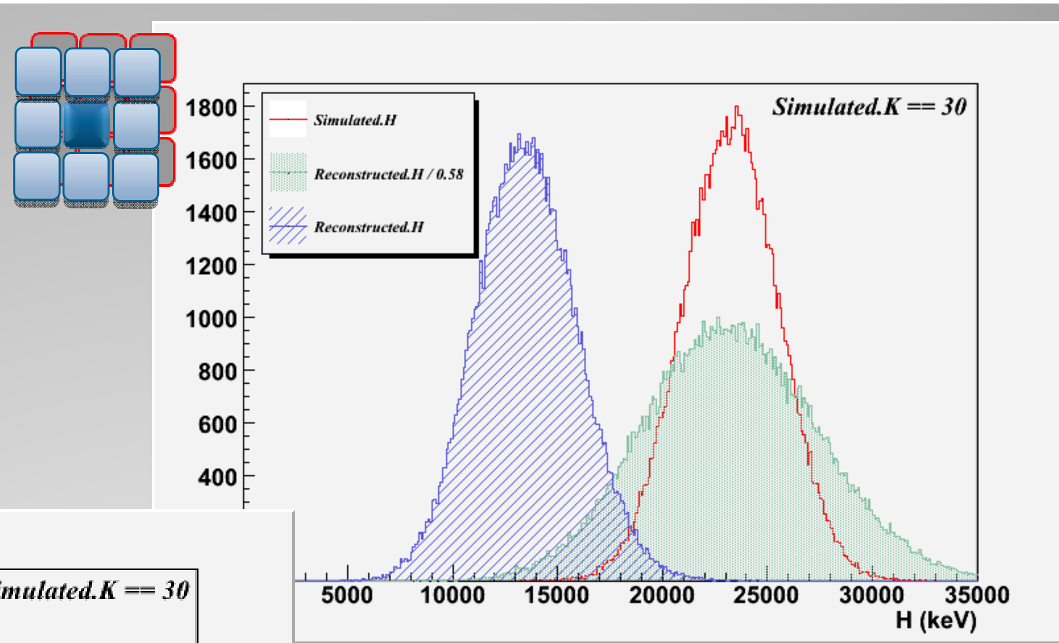


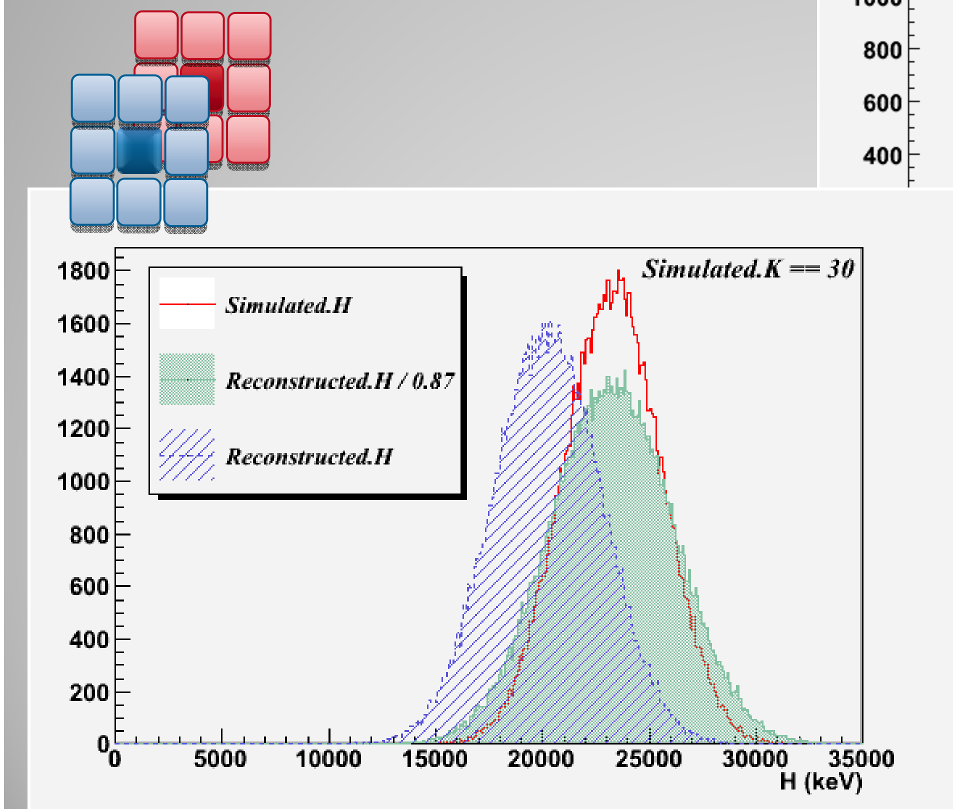
K with RawPerformances0_1

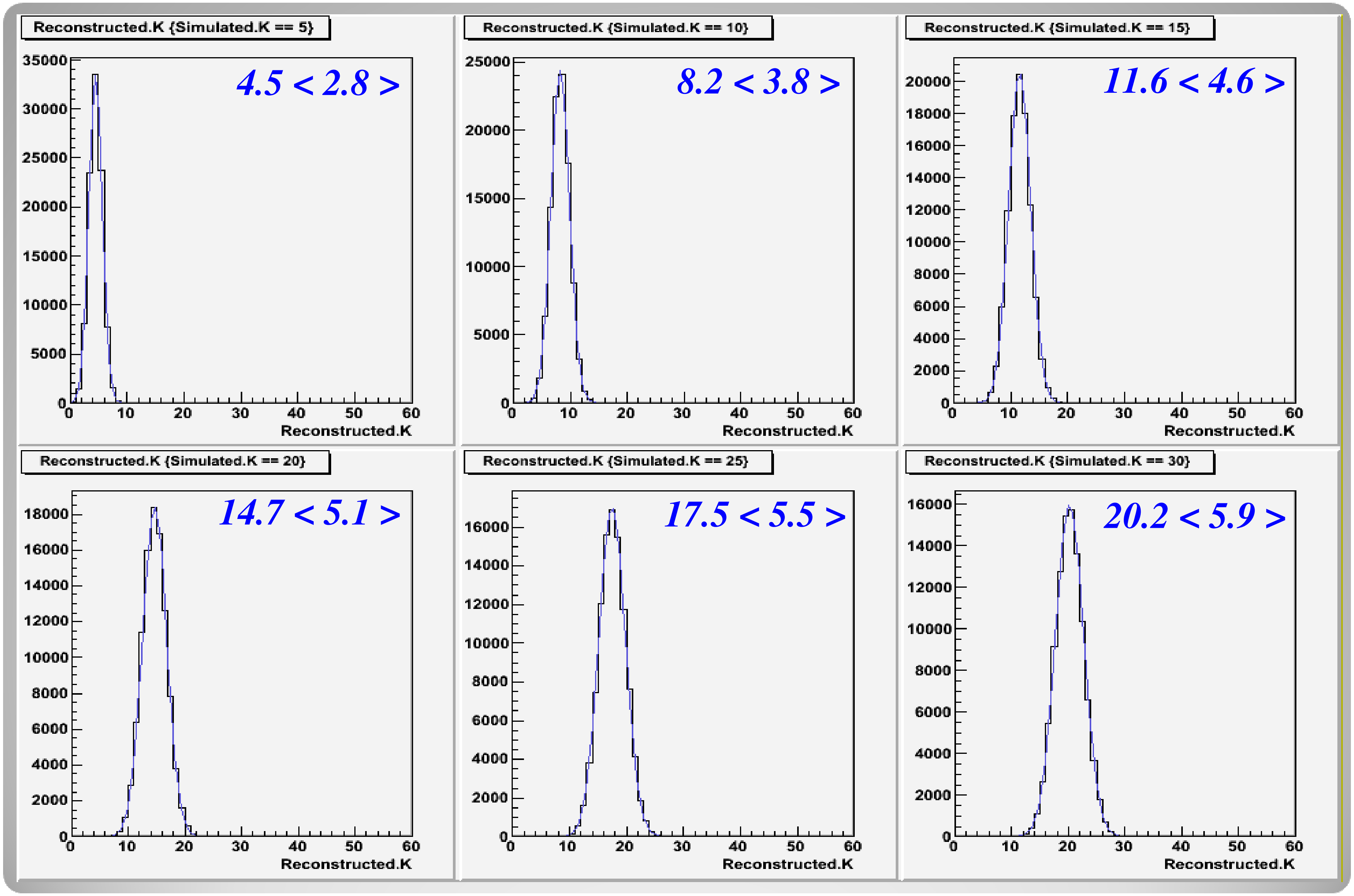


H / Ē = 0.87

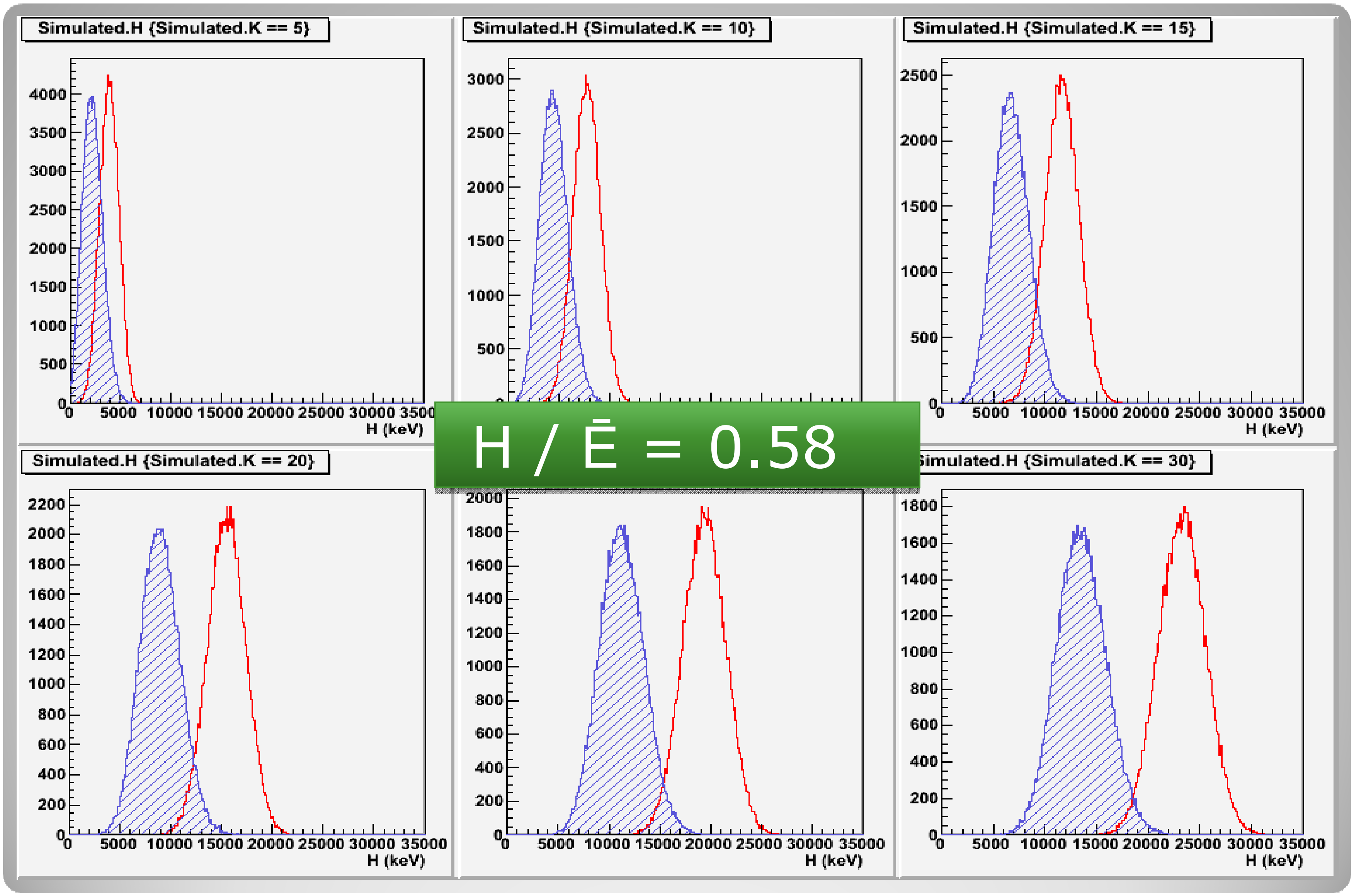
H with RawPerformances0_1


Simulated.K == 30
Simulated.H
Reconstructed.H / 0.58
Reconstructed.H
H (keV)


Simulated.K == 30
Simulated.H
Reconstructed.H / 0.87
Reconstructed.H
H (keV)

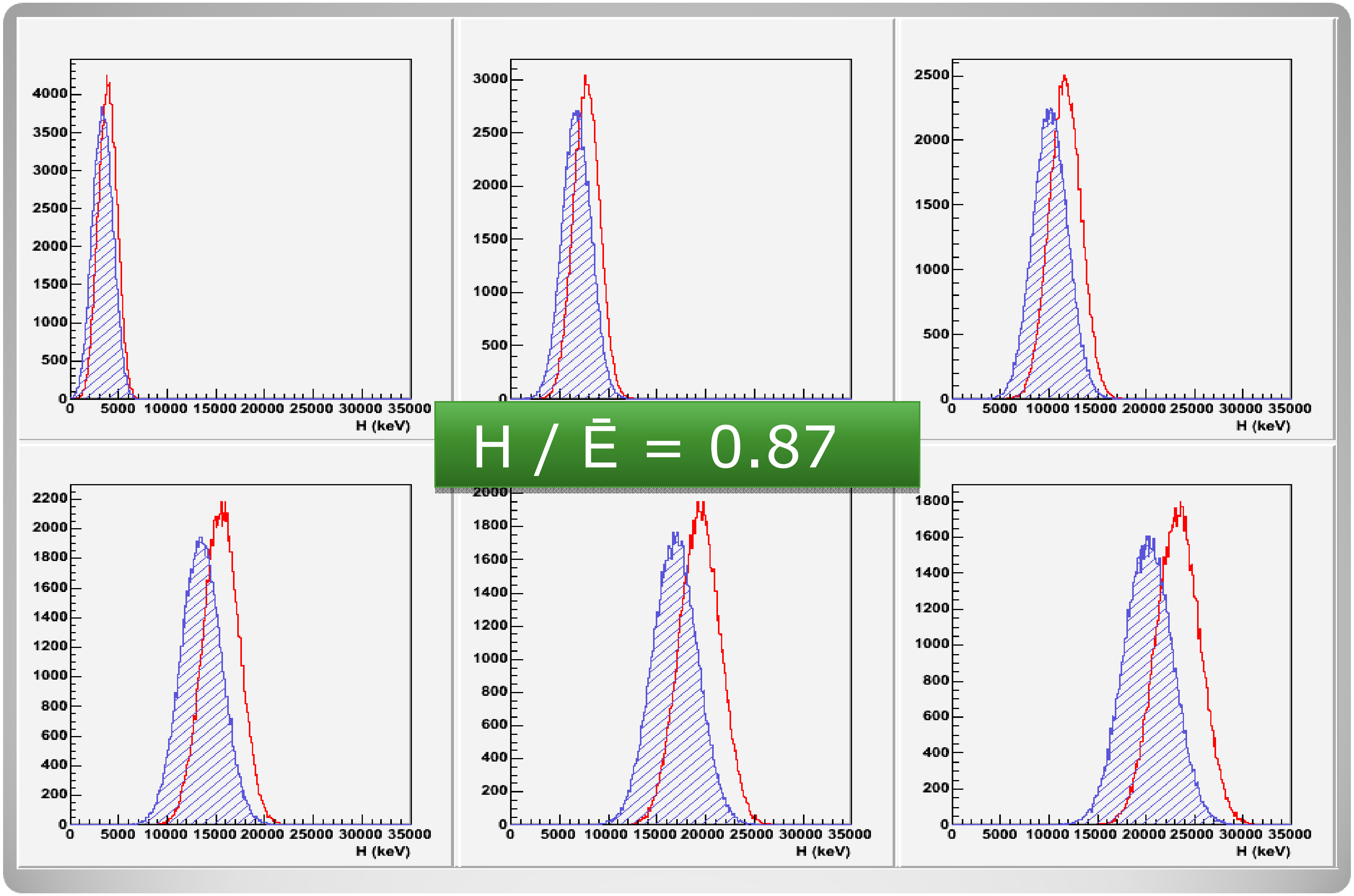


K with AddBack1_0



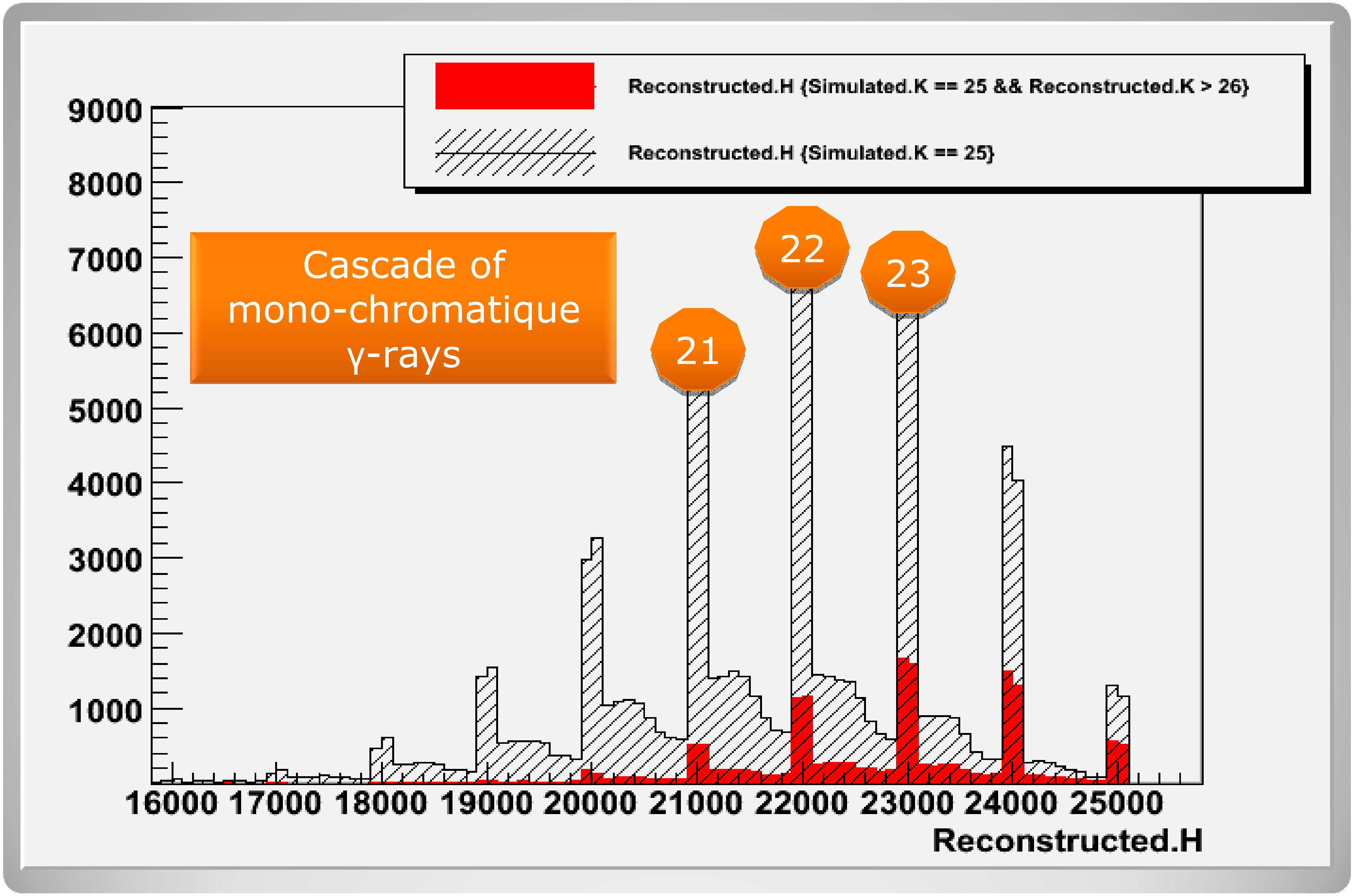
H / Ē = 0.58

H with AddBack1_0



H / Ē = 0.87

H with AddBack1_1



Resolution depends on efficiency !

What could/should be done ???

Discussions

Different clustering methods

RawPerformances : one element = one γ -ray

0_0 : only the first shell

1_0 : both shells