AGATA detector PSCS simulations and first 2D scan with 152Eu

20th AGATA week and 4th PSeGe Workshop
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Summary

I. Simulated scans on a A-type AGATA Detector

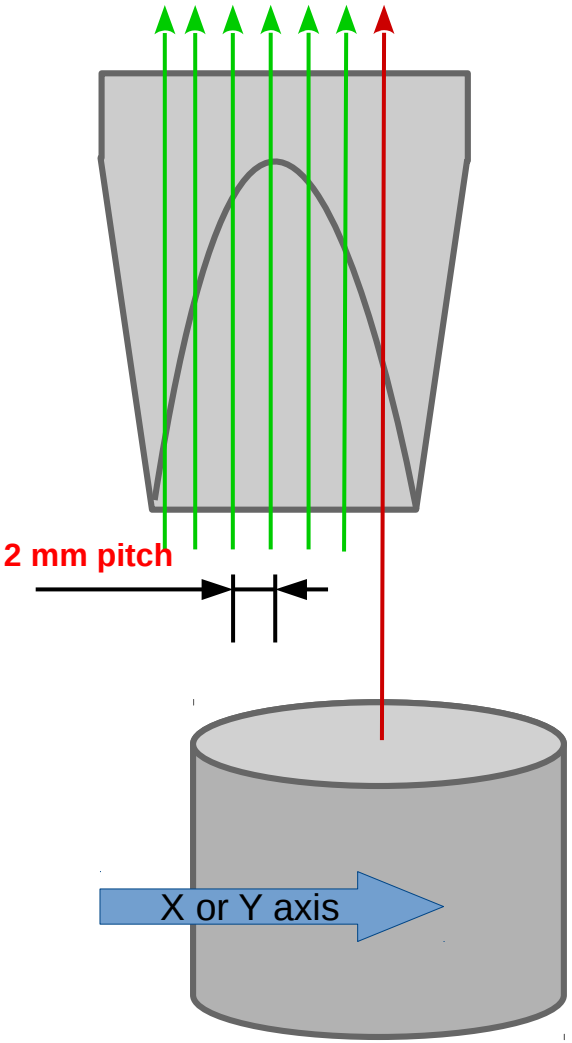
II. Early results of 2D scans on the S001 AGATA detector

PSCS technique [1]

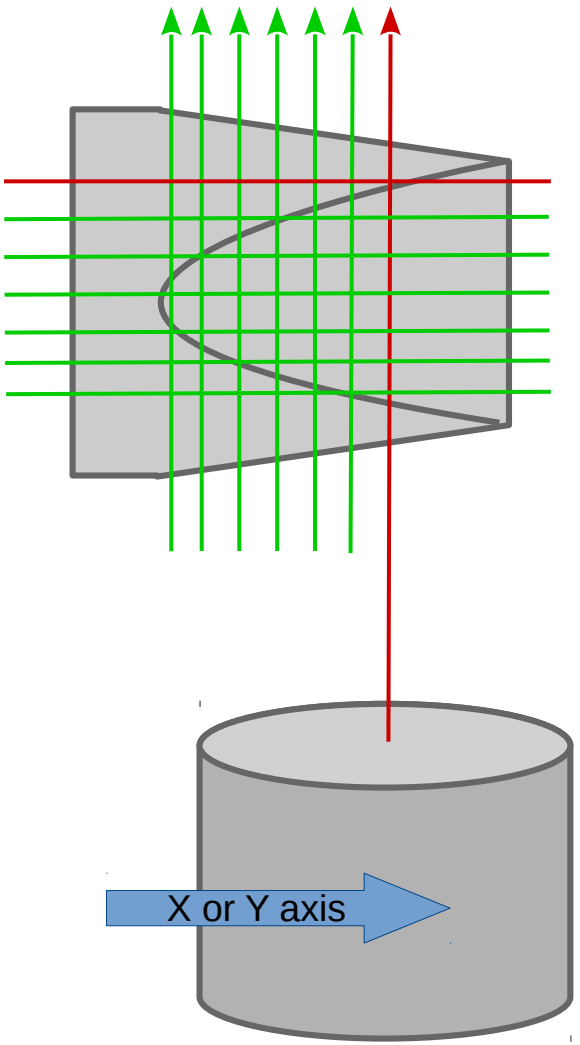
Pulse **S**hape **C**omparison **S**can

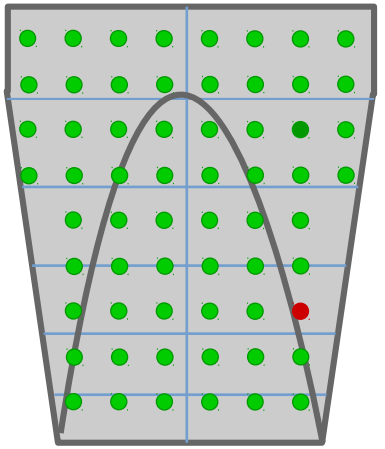
F. Crespi et al. “A novel technique for the characterization of a HPGe detector response based on pulse shape comparison” - *Nuclear Instruments and Methods A* - 593(3):440-447-2008

VERTICAL CONF.



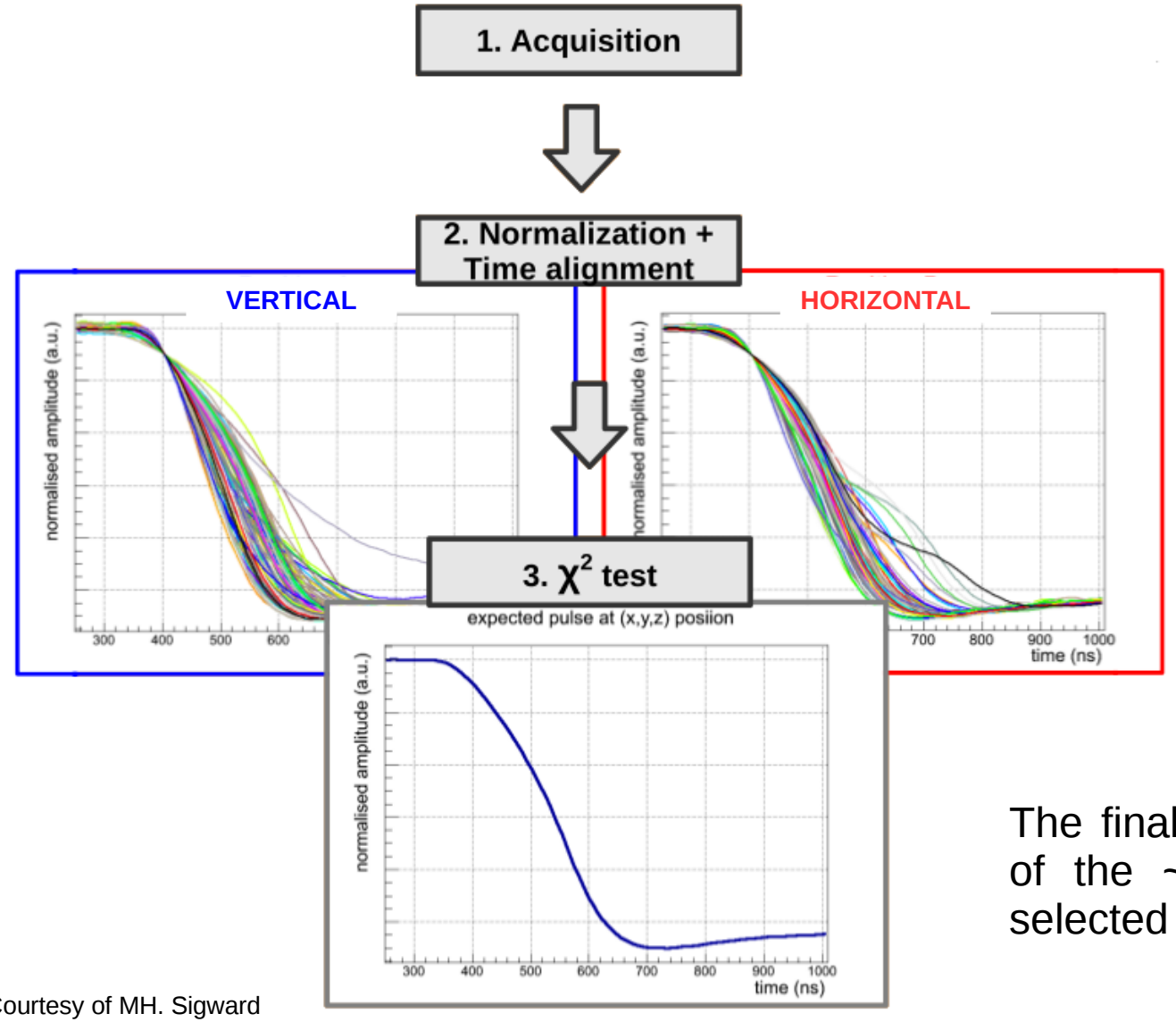
HORIZONTAL CONF.



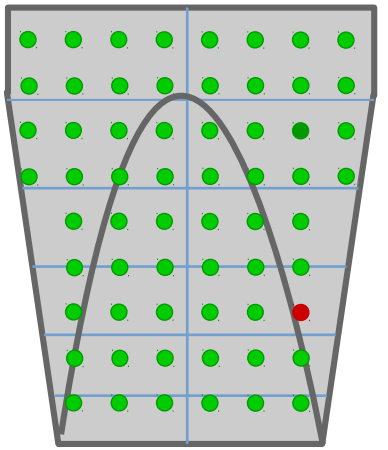


Using pulse shape comparison algorithms it is possible to extract the specific pulse shape at each crossing point of the grid, comparing two crossing datasets.

PSCS technique [2]



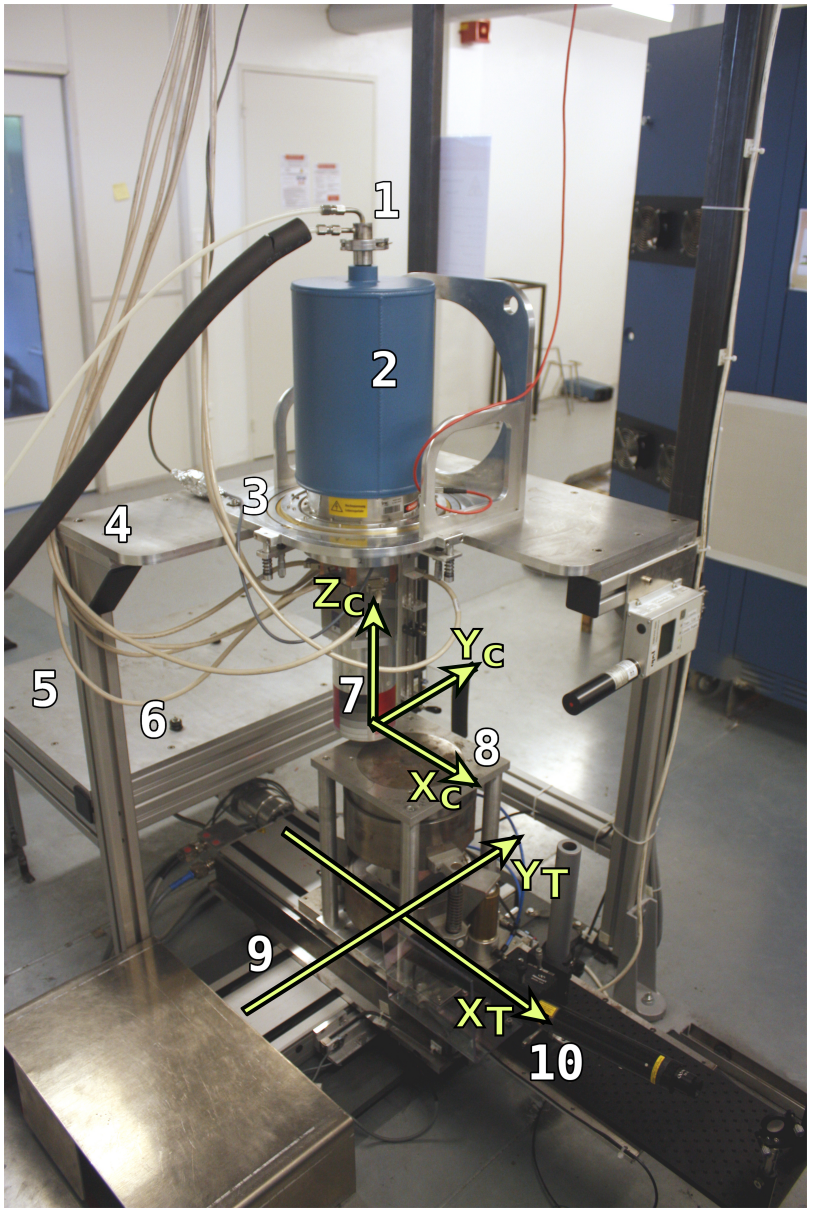
Courtesy of MH. Sigward



Using pulse shape comparison algorithms it is possible to extract the specific pulse shape at each crossing point of the grid comparing two crossing datasets.

The final pulse shape is the average of the ~150 best matching signals selected by the χ^2 selection

The IPHC scanning table



(1) LN2 pipes

(2) test-cryostat Dewar

(3) adjustment frame

(4) holding plate for vertical positioning

(5) holding plate for horizontal positioning

(6) fixing studs

(7) end cap of the detector

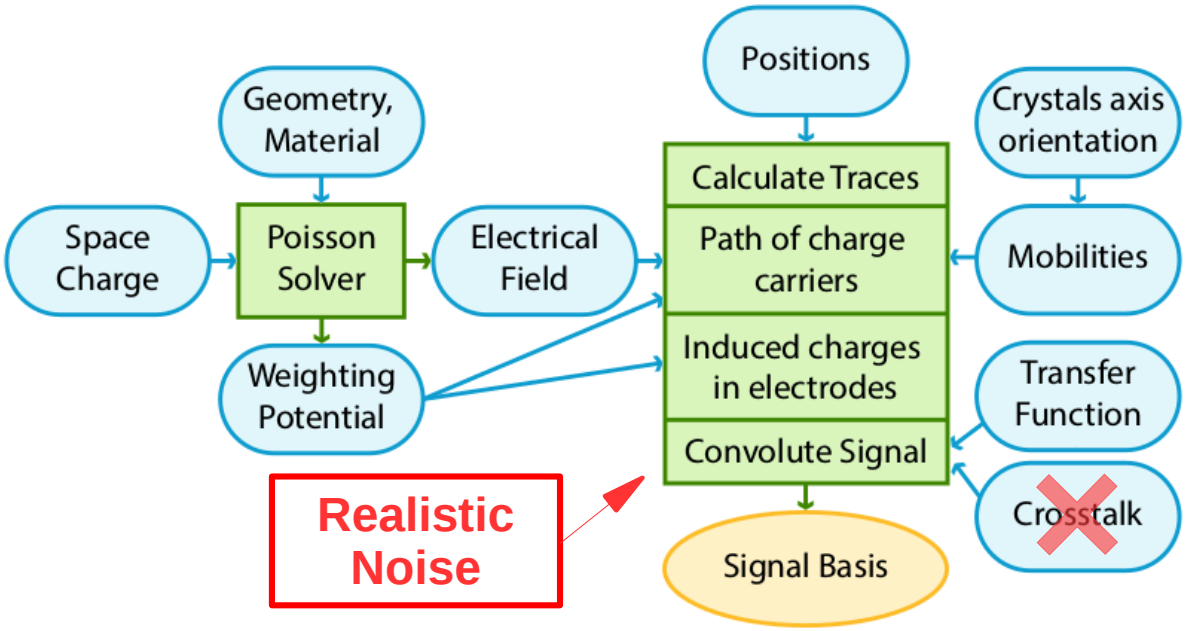
(8) collimator (Ø 1.0mm 0.5mm 0.2mm)

(9) scanning table motorized axes

(10) alignment laser

Simulation tools

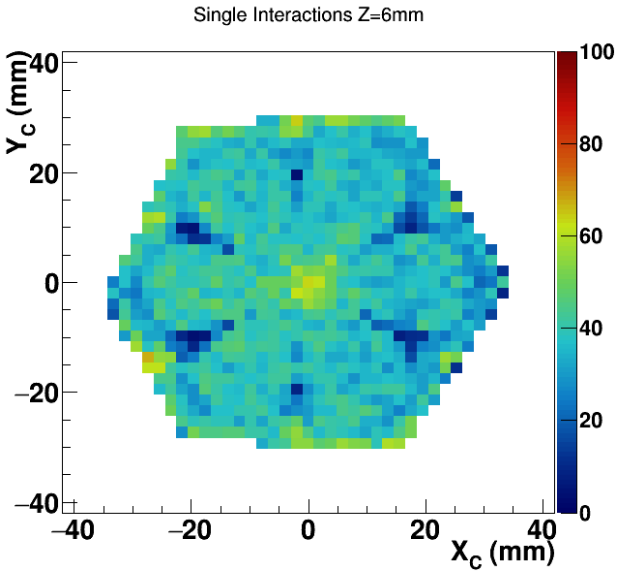
G4 + SIMION + ADL → Pulse shape calculation



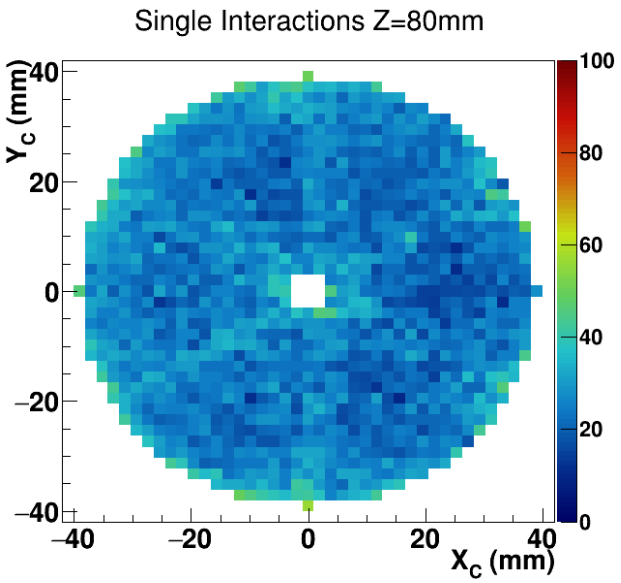
B. Bruyneel et al.
DOI: 10.1140/epja/i2016-16070-9

Electron mobility parameters			
Mobility along ⟨100⟩		Inter valley scattering rate	
E_0 [V/cm]	507.7	E_0 [V/cm]	1200
β	0.804	ν_0	0.459
μ_0 [cm^2/V s]	37165	ν_1	0.0294
μ_n [cm^2/V s]	−145	ν_2	0.000054
Hole mobility parameters			
Mobility along ⟨100⟩		Mobility along ⟨111⟩	
E_0 [V/cm]	181.9	E_0 [V/cm]	143.9
β	0.735	β	0.749
μ [cm^2/V s]	62934	μ [cm^2/V s]	62383

Simulations on A-type detector: Single interaction pulses

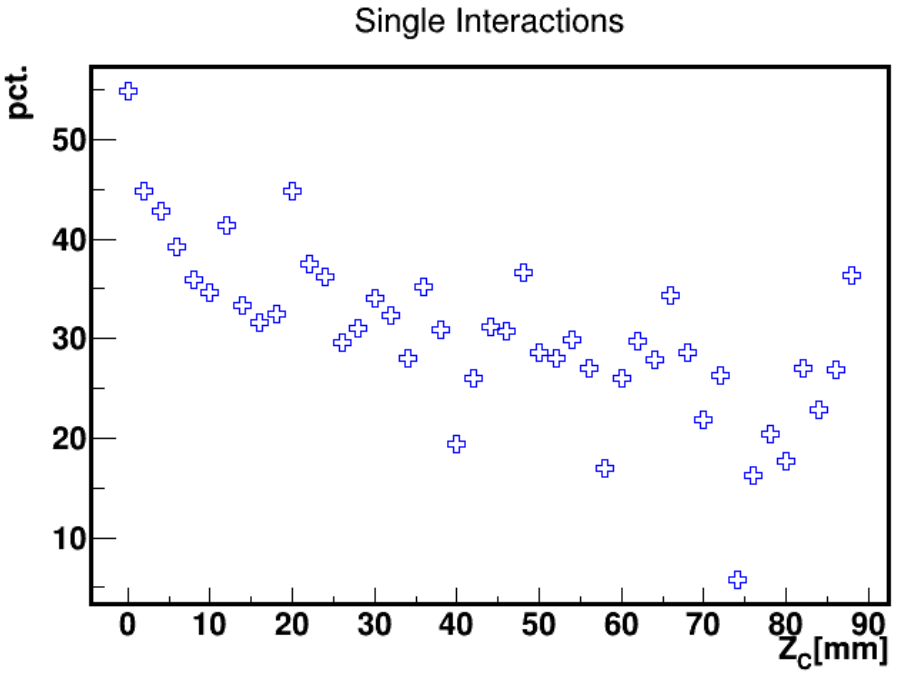


2mm slices in Z [1 grid unit]

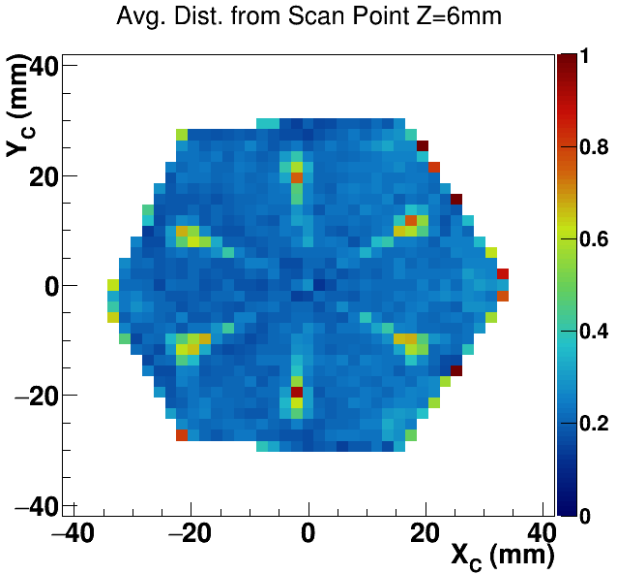


Scan pitch of 2mm @662keV
$Ø_{coll}$ 1.5mm

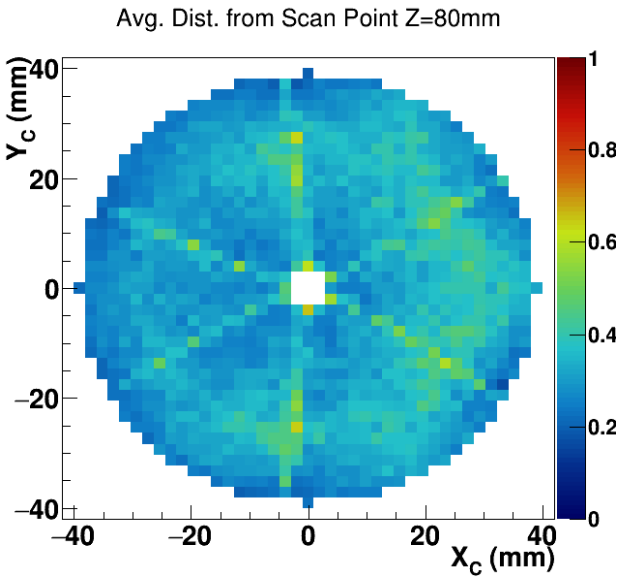
The number of single interaction pulses selected by the procedure varies between 50% and 20% depending on the depth of the detector.



Simulations on A-type detector: avg. dist. from scan point

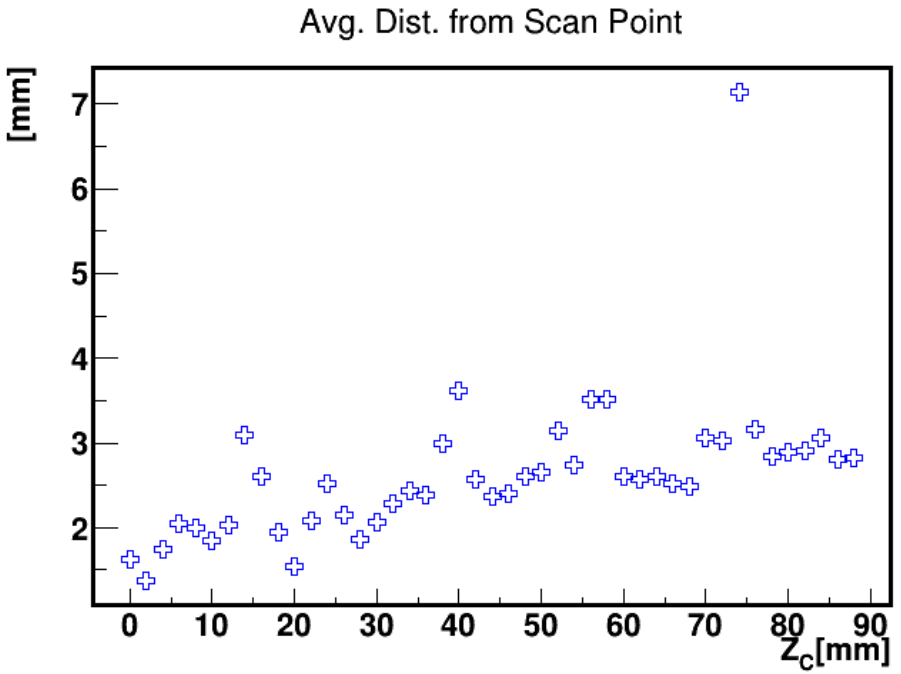


2mm slices in Z [1 grid unit]



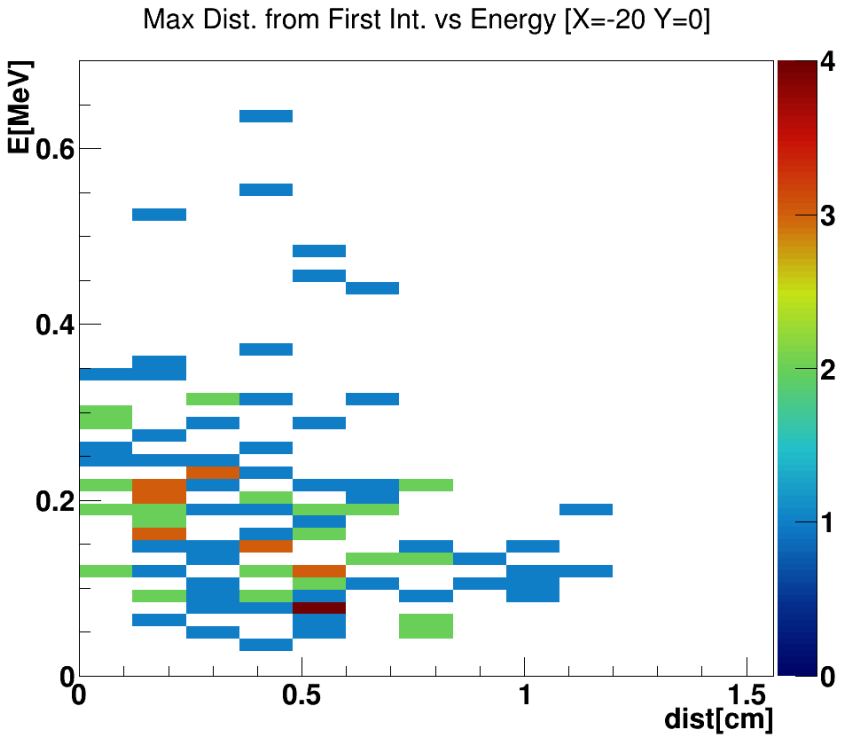
Scan pitch of 2mm @662keV
$Ø_{coll}$ 1.5mm

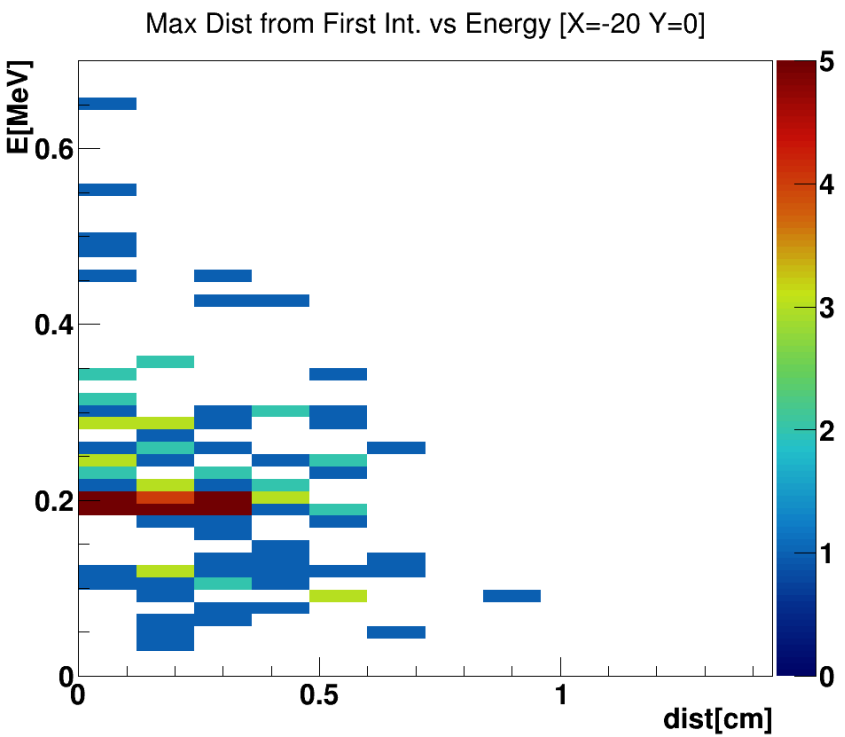
The average distance from the scanning point is around 2-3 mm, below the spatial resolution of the detector (~5mm).



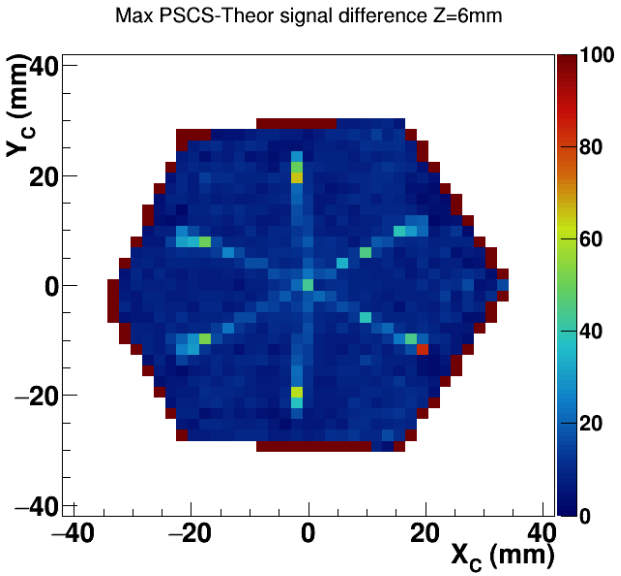
Simulations on A-type detector: max dist vs Energy

...Moreover for **multiple interactions events** the maximum distance from the first interaction vs its energy shows that the furthest interaction tendentially releases less energy. Thus it has less influence on the formation of the shape of the selected pulse.

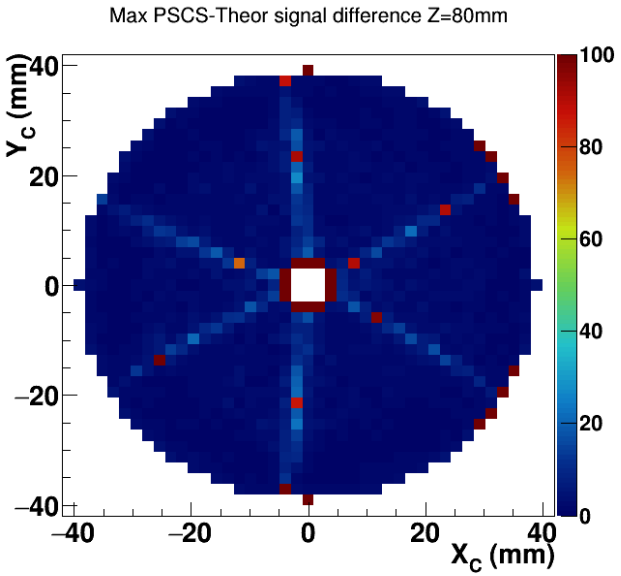




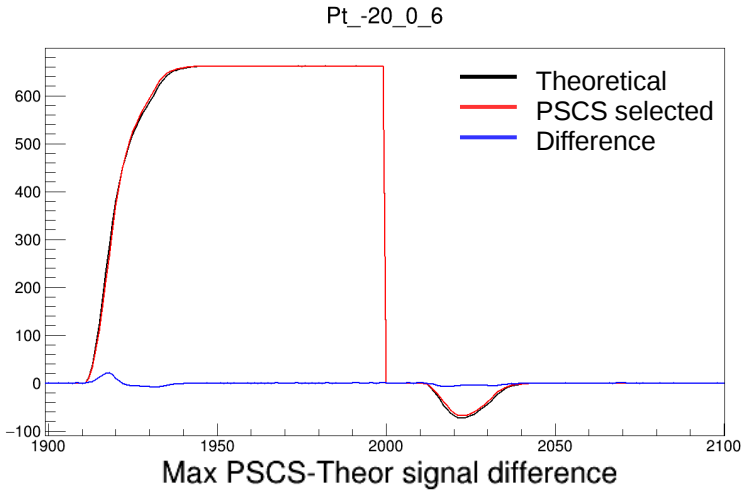
Simulations on A-type detector: PSCS-TH residuals

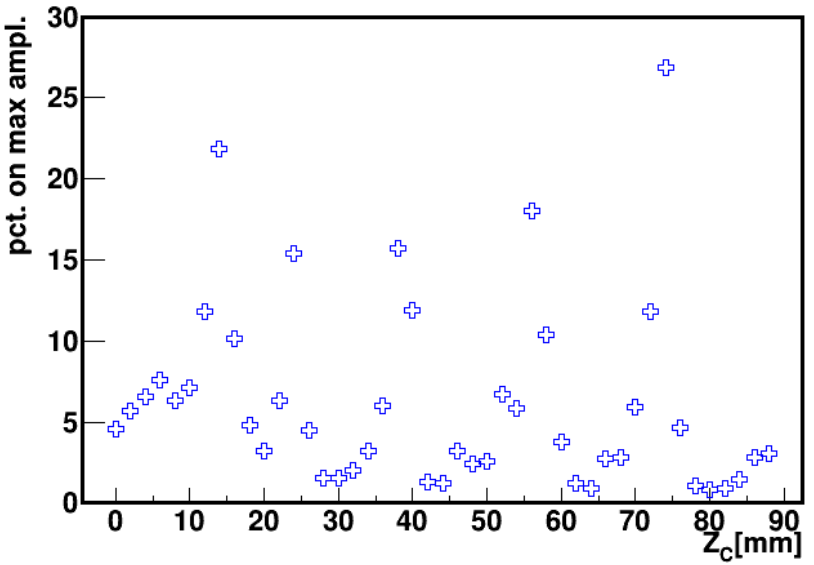


2mm slices in Z [1 grid unit]

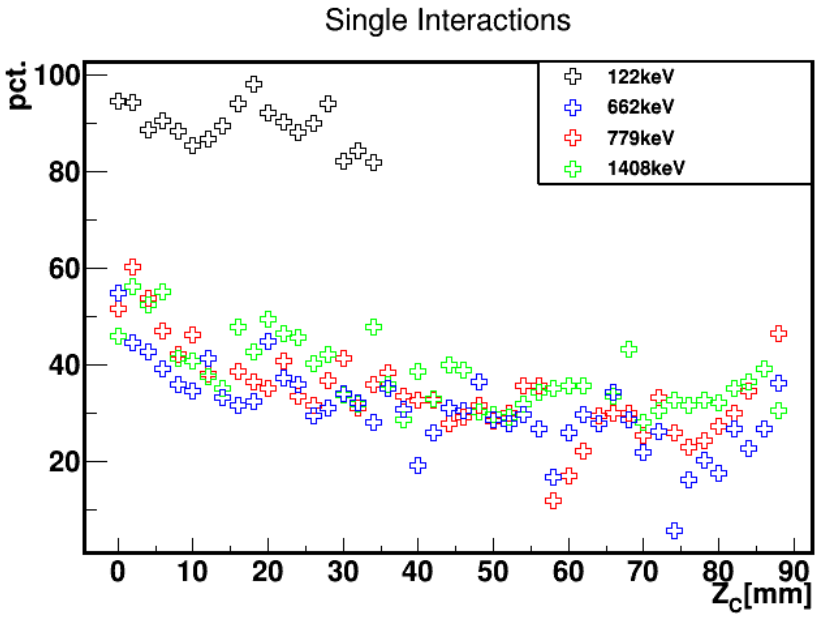


The maximum difference between the Theoretical signal (ADL) and the PSCS calculated one is below 10% varying with the depth of the detector.

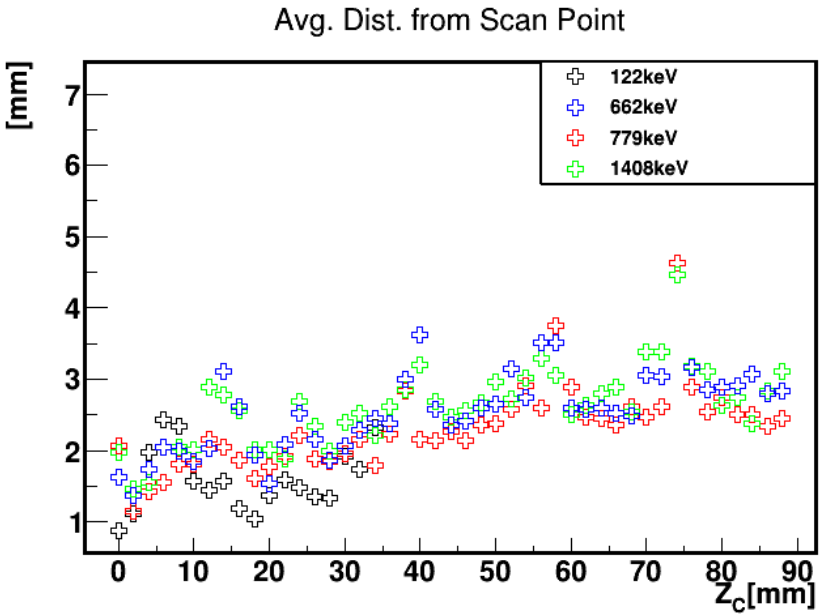


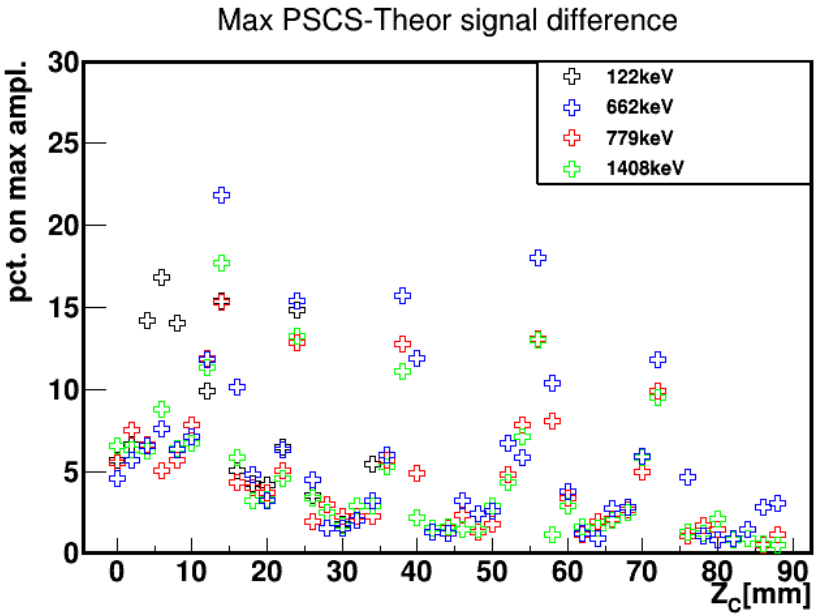


Simulations on A-type detector: different energy scans

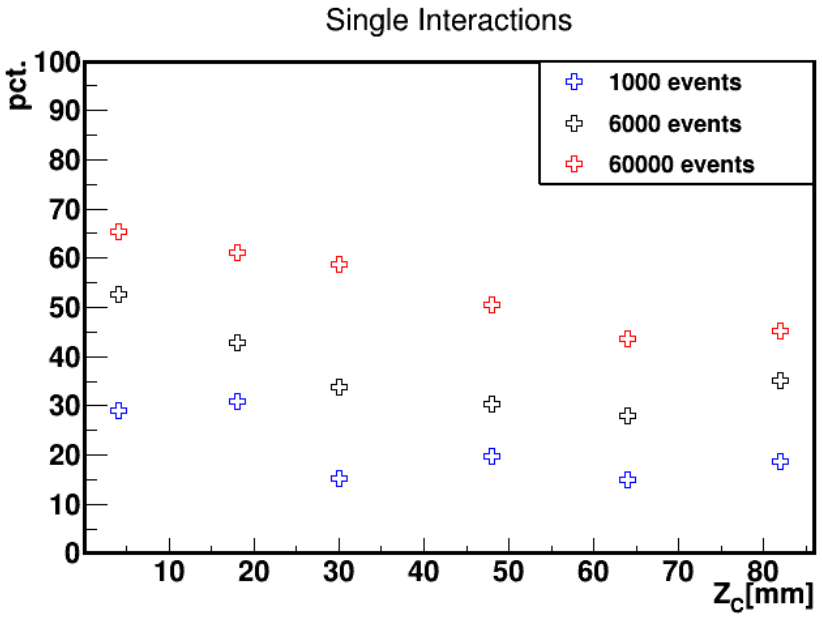


The parameters are overall independent from the energy of the incident gamma ray...

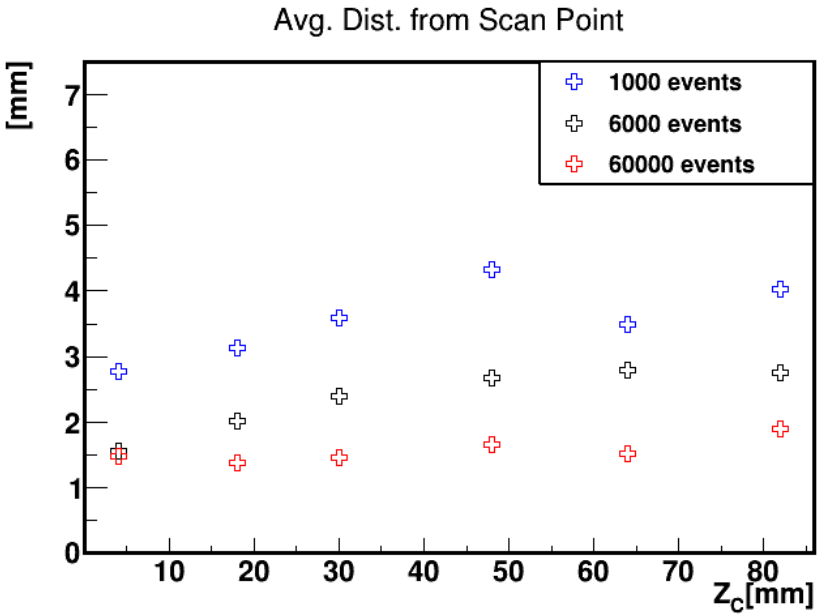


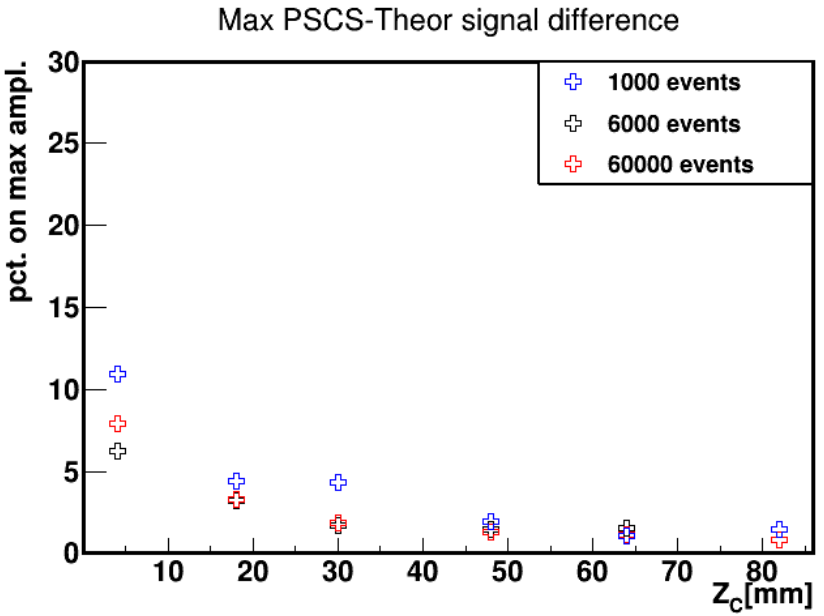


Simulations on A-type detector: different input statistics



...statistics seems to play a major role in the selection





Simulations on A-type detector: Conclusions

The PSCS technique on an AGATA detector seems reliable:

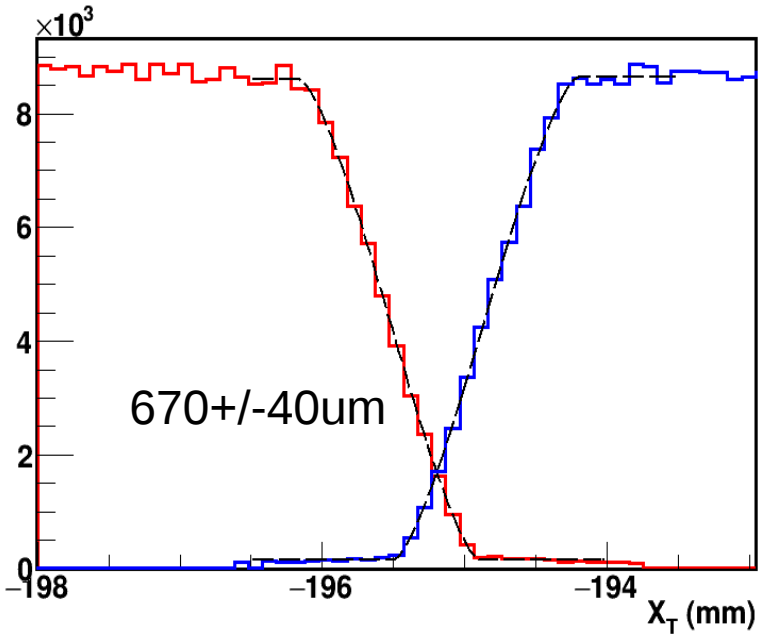
- The fraction of selected singles is not ideal ...but…
- Multiple interactions take place, in average, well below the detector position resolution
- The difference between the PSCS selected signal and the Theoretical (ADL) one is small

Measurements on S001

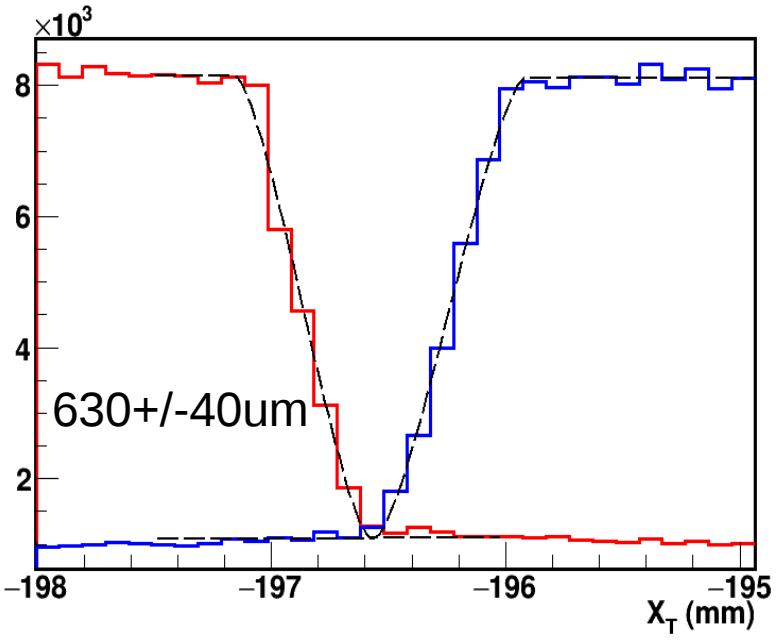
Measurements on S001: segmentation lines

The measurements are performed with an upgraded version of the collimator which allows to change the size of its diameter (Marie-Hélène Sigward talk).

60keV, Ø 1mm, pitch 100µm

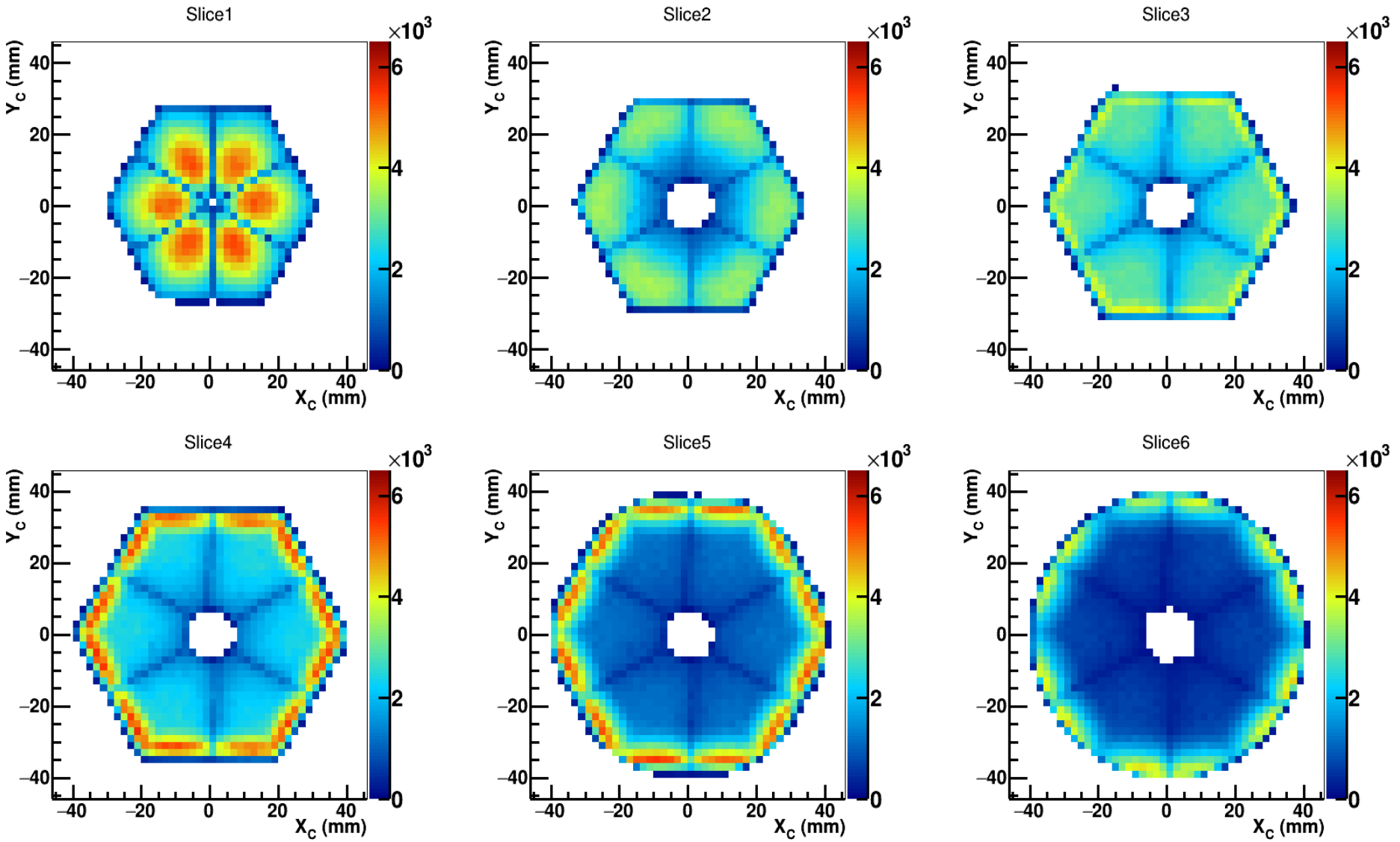


60keV, Ø 0.5mm, pitch 50µm



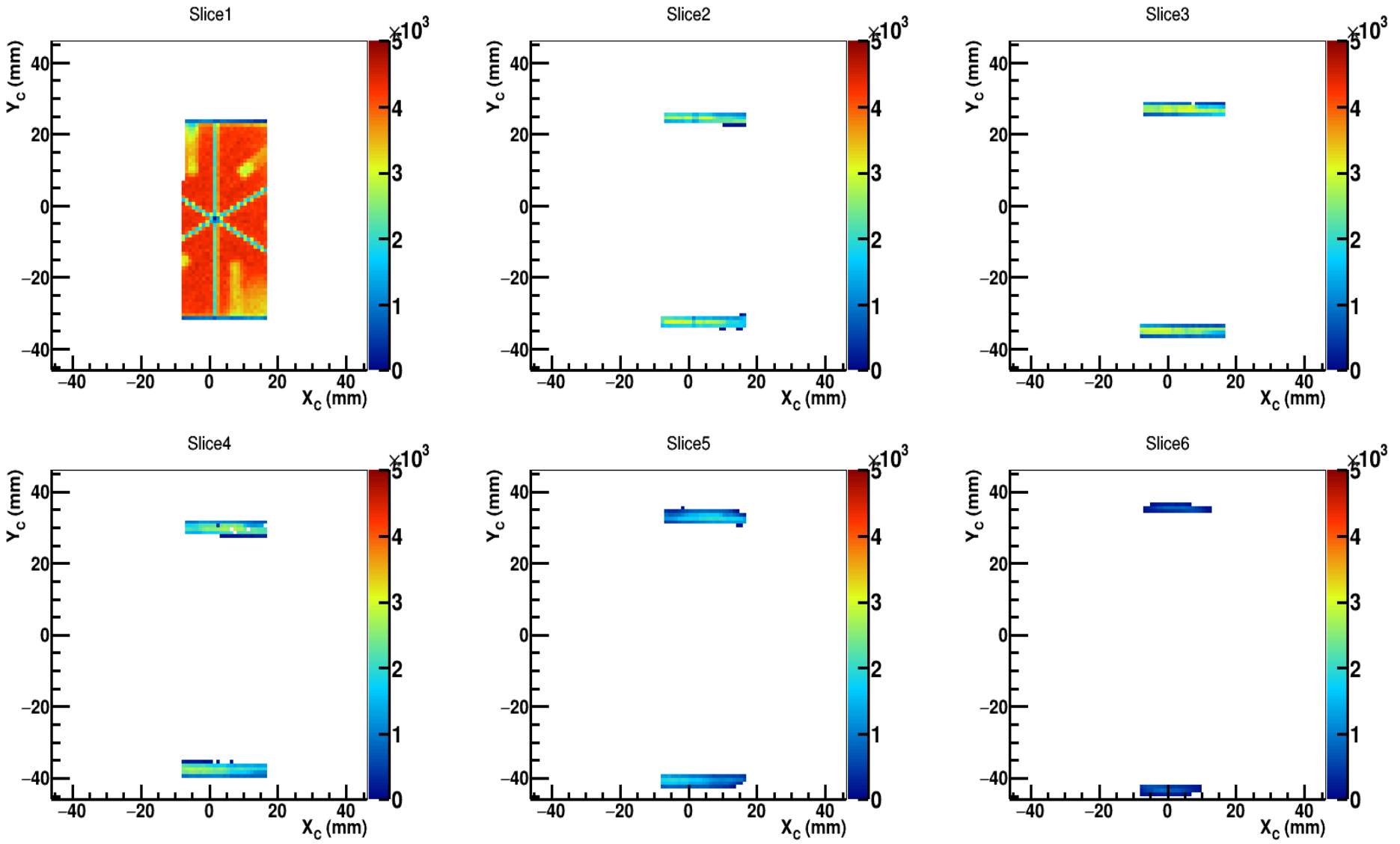
Measurements on S001: 2D scans @ 662keV

Full area scan: **137Cs** @ **662keV**, diam. 1.0mm, pitch 2x2mm^2

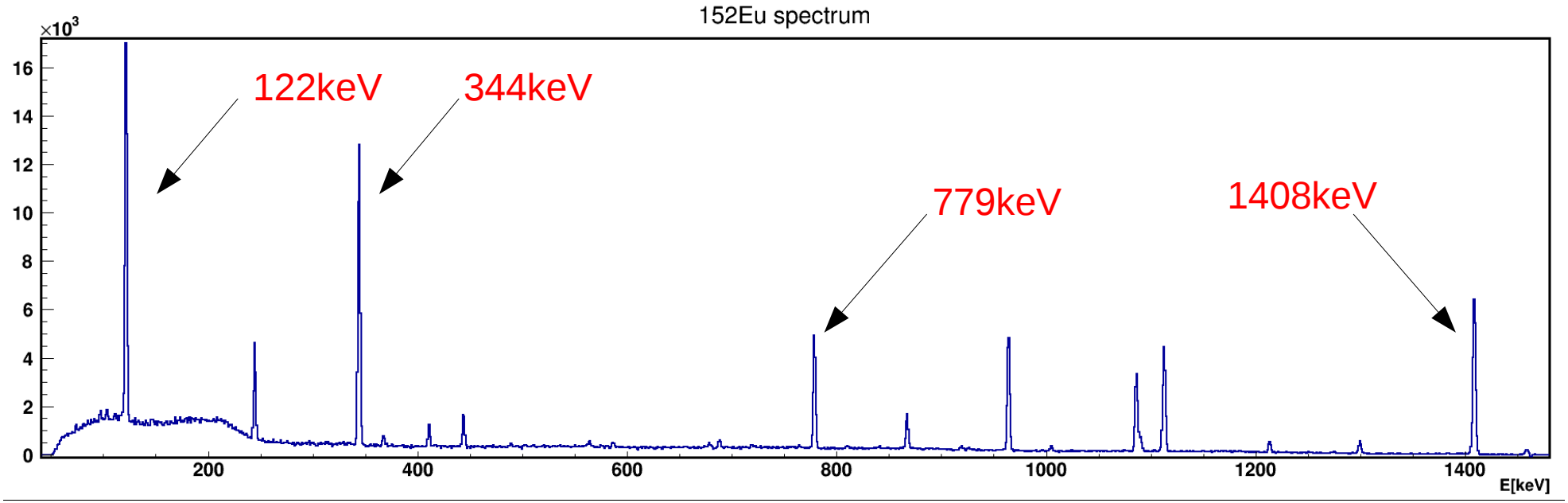


Measurements on S001: 2D scans @ 60keV

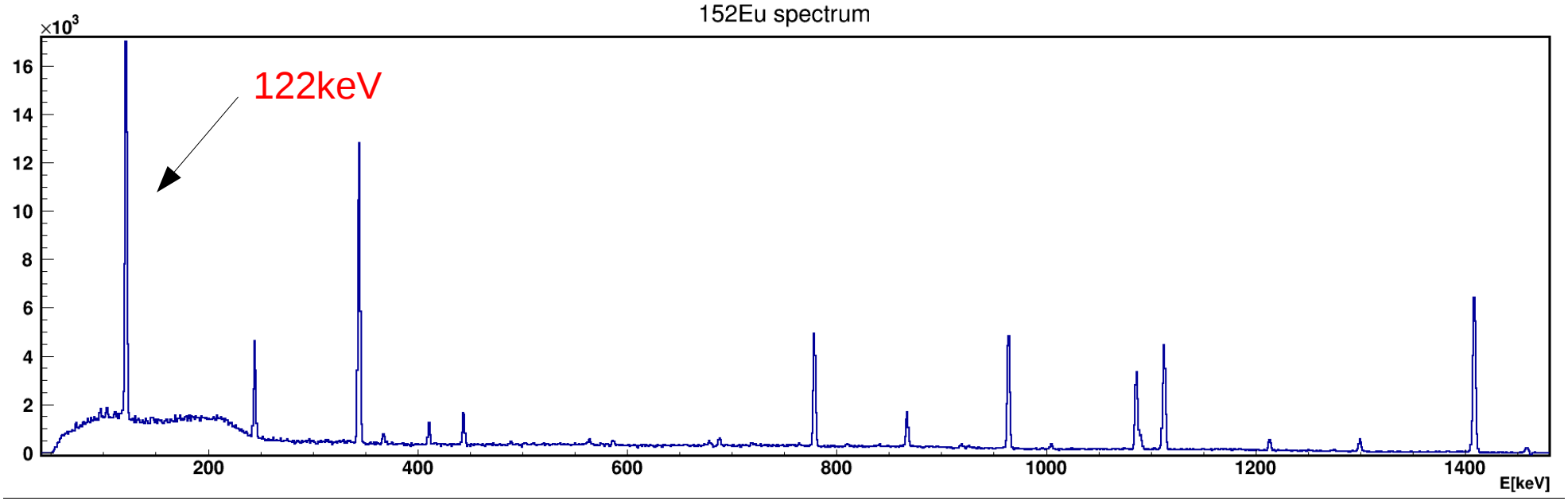
Full area scan: **241Am** @ **60keV**, diam. 1.0mm, pitch 1x1mm^2



Measurements on S001: Eu spectrum

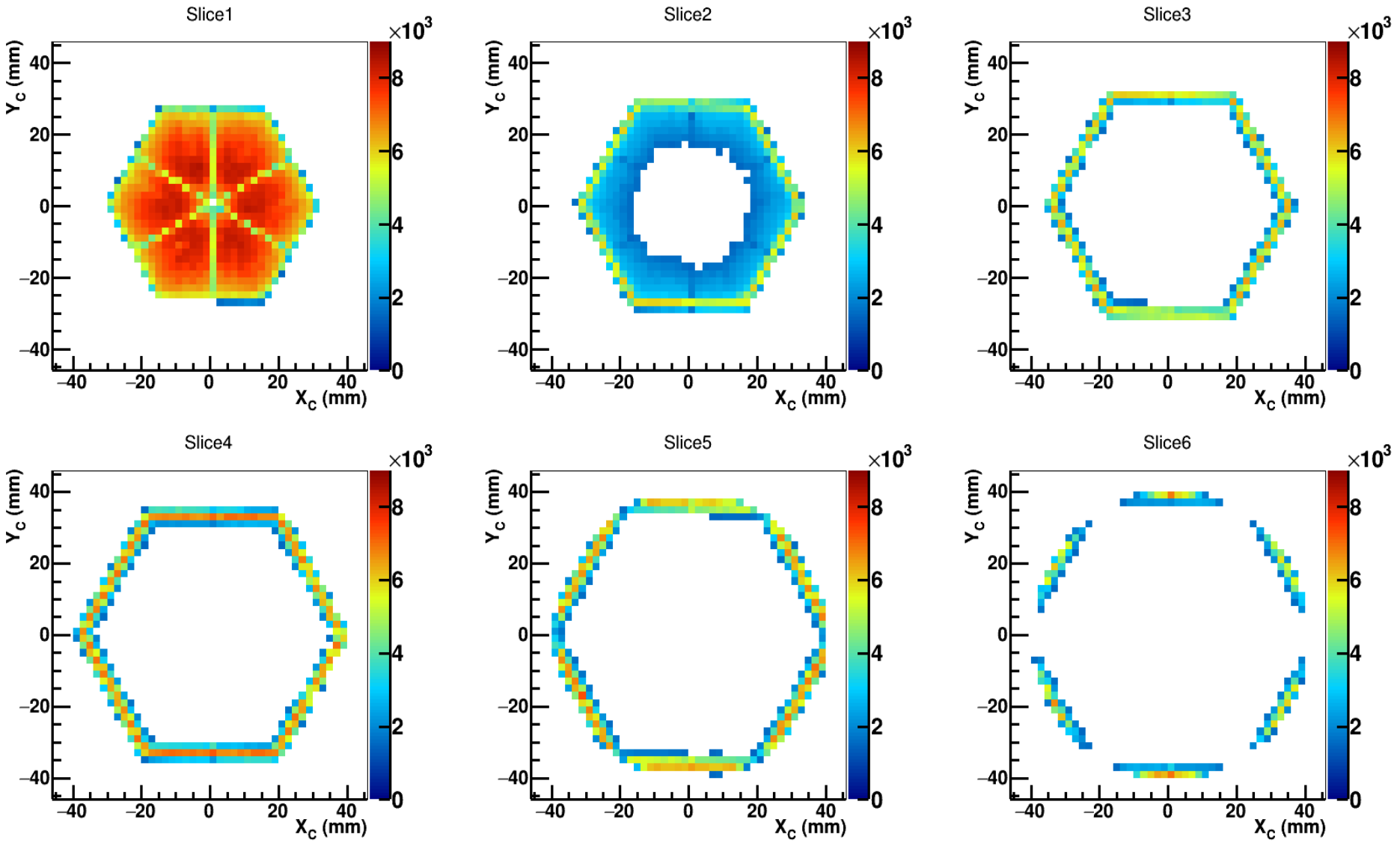


Measurements on S001: 2D scans @ 122keV

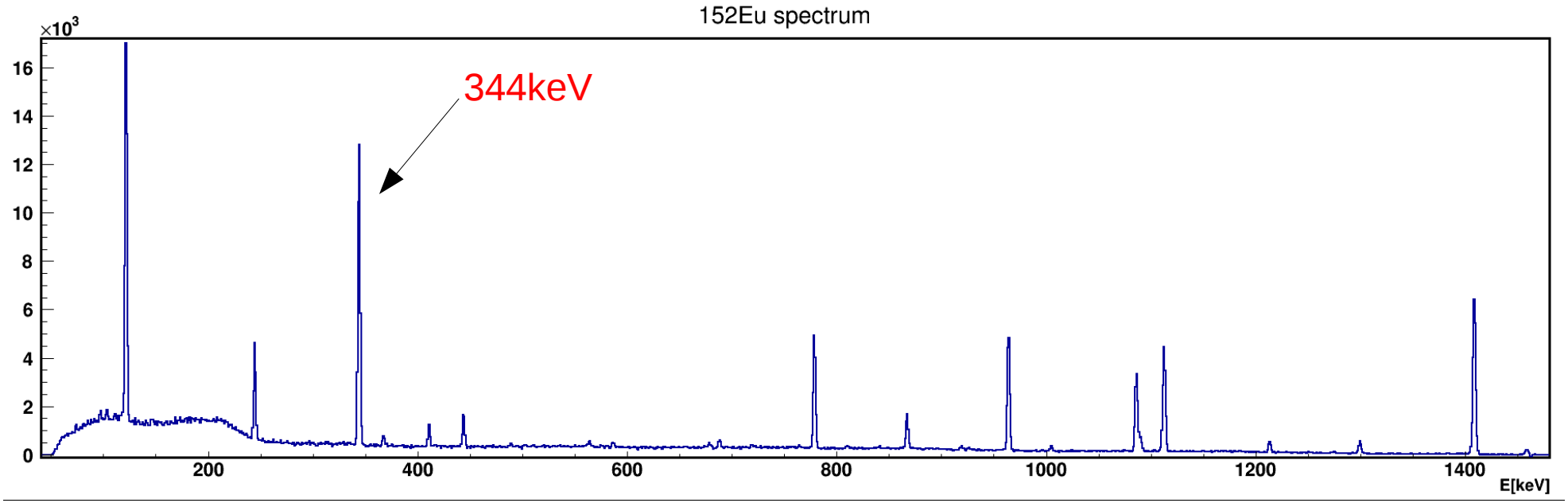


Measurements on S001: 2D scans @ 122keV

Full area scan: **152Eu** @ **122keV (BR 29%)**, diam. 1.0mm, pitch 2x2mm^2

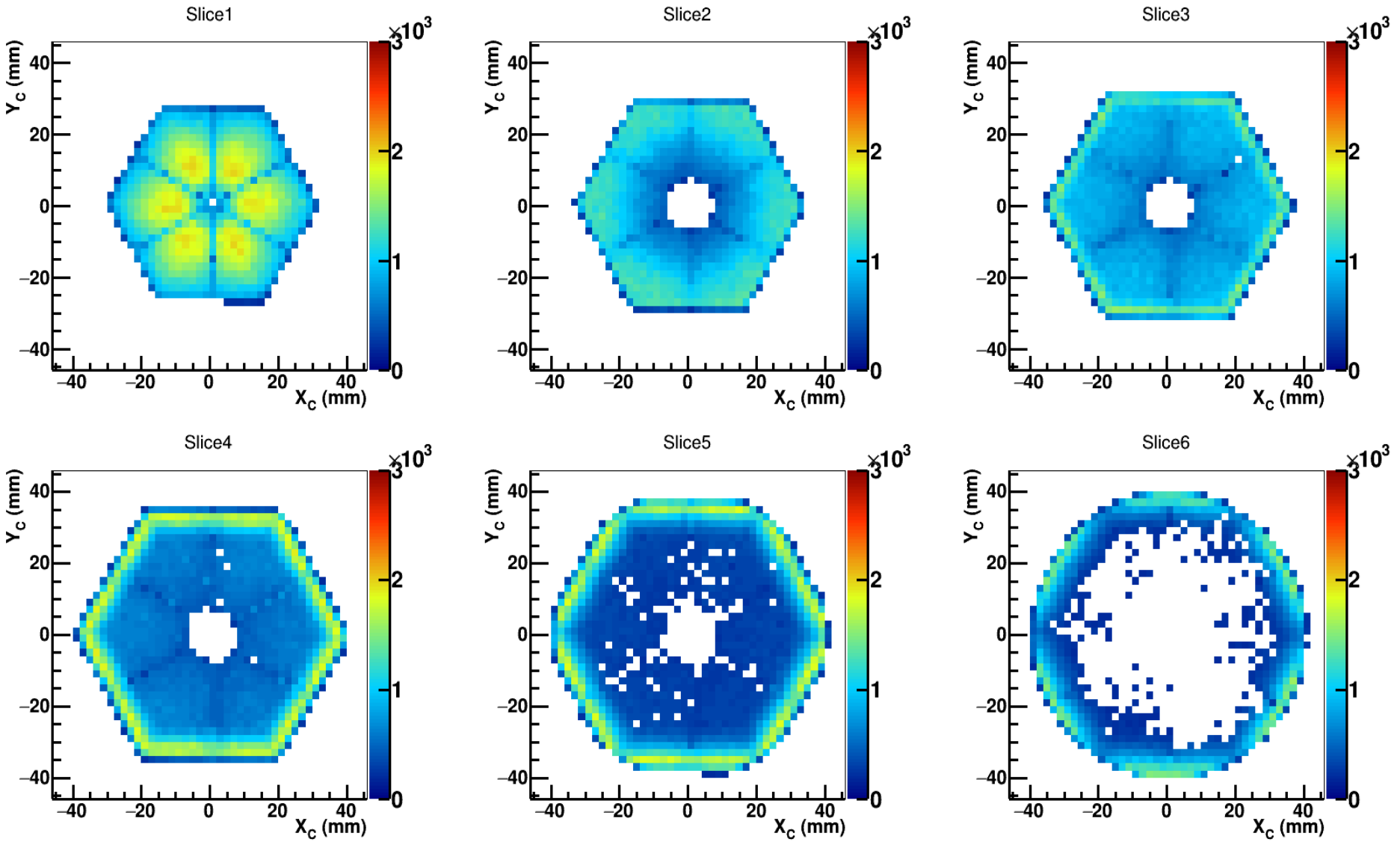


Measurements on S001: 2D scans @ 344keV

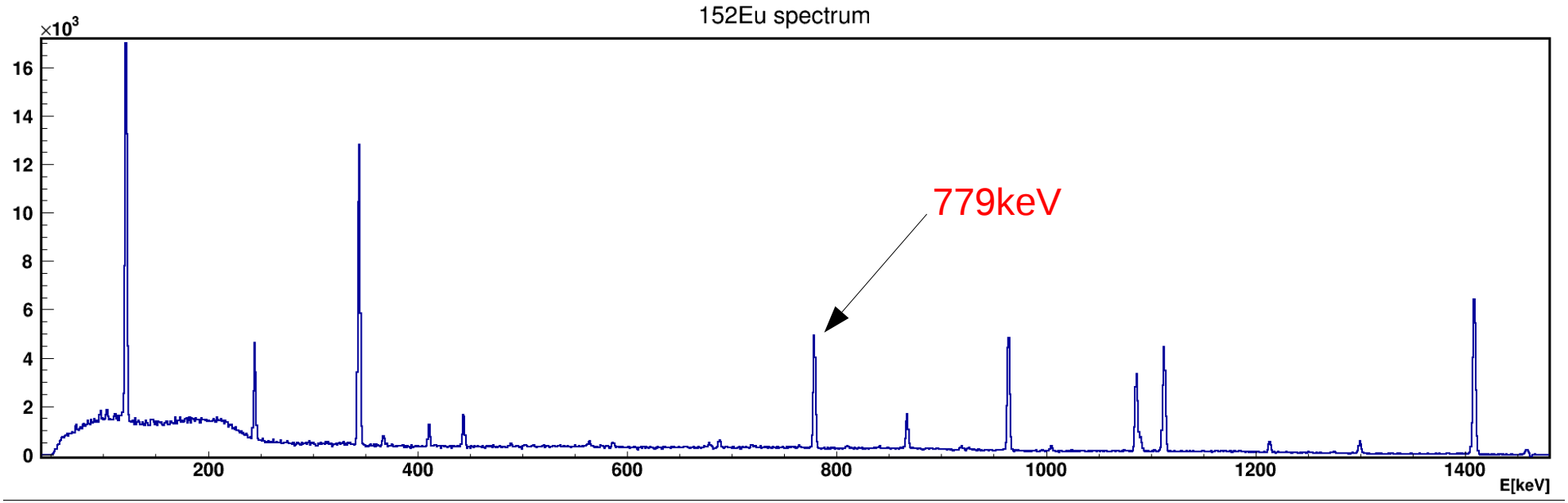


Measurements on S001: 2D scans @ 344keV

Full area scan: **152Eu** @ **334keV (BR 27%)**, diam. 1.0mm, pitch 2x2mm^2

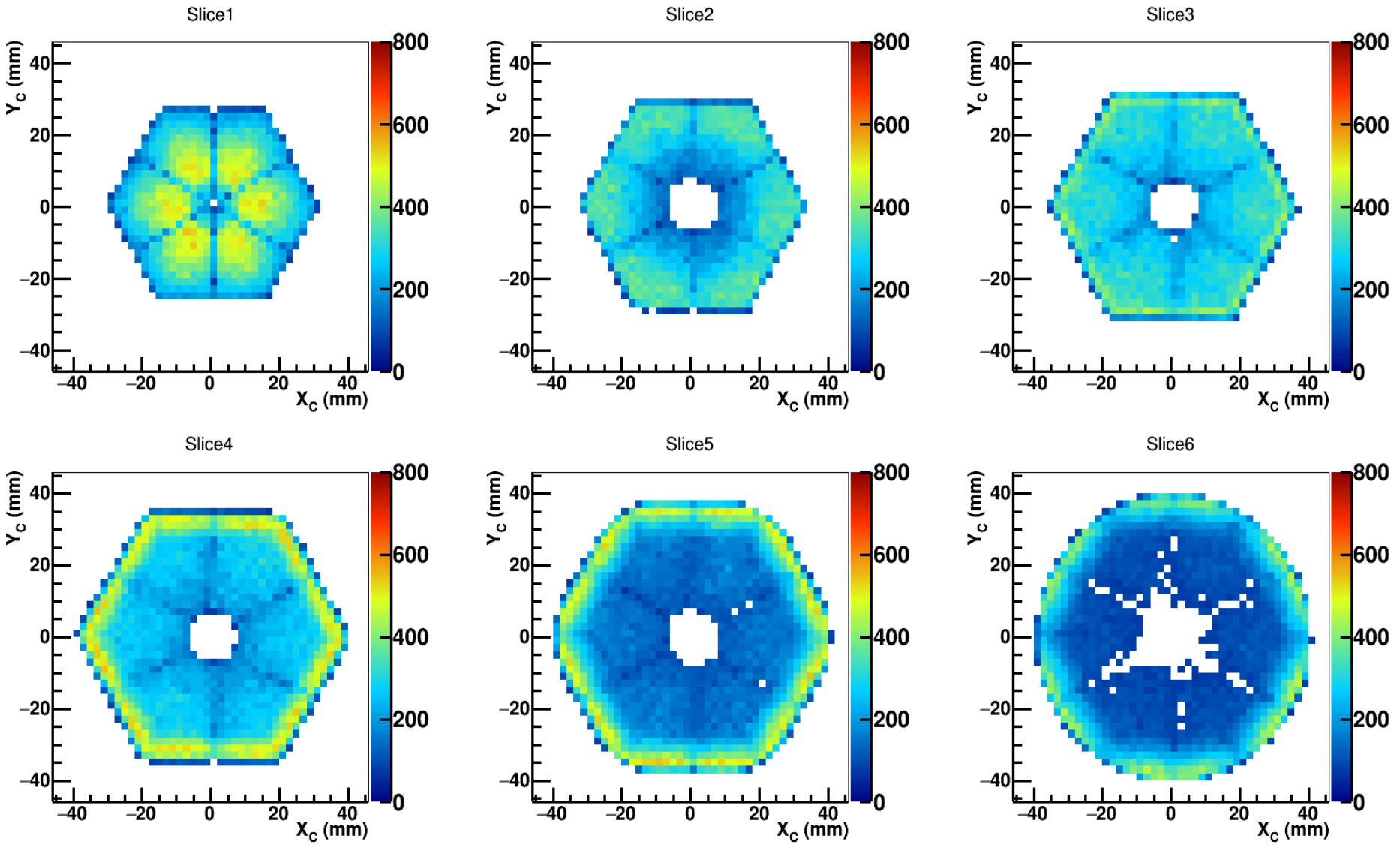


Measurements on S001: 2D scans @ 779keV



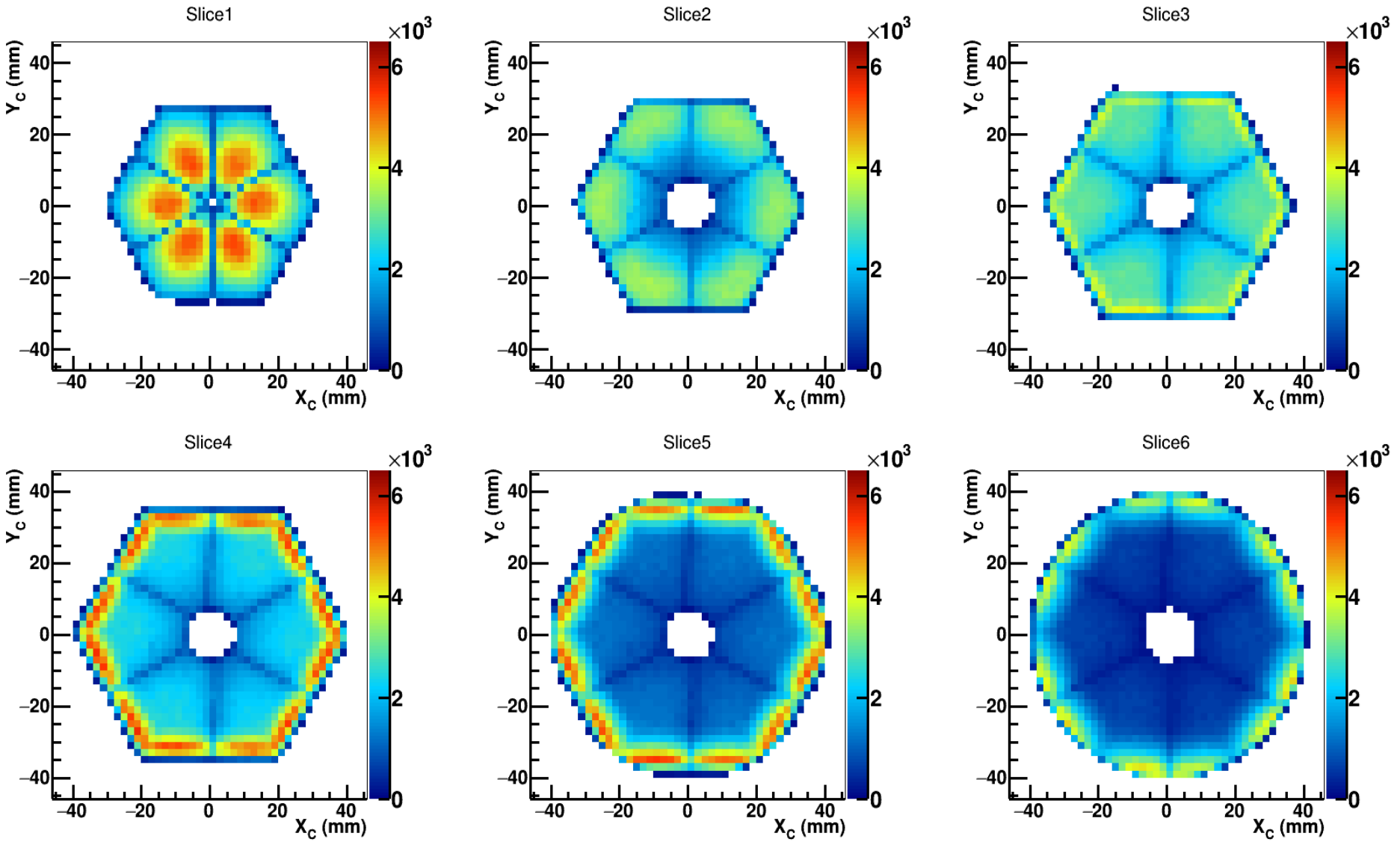
Measurements on S001: 2D scans @ 779keV

Full area scan: **152Eu** @ **779keV (BR 13%)**, diam. 1.0mm, pitch 2x2mm^2

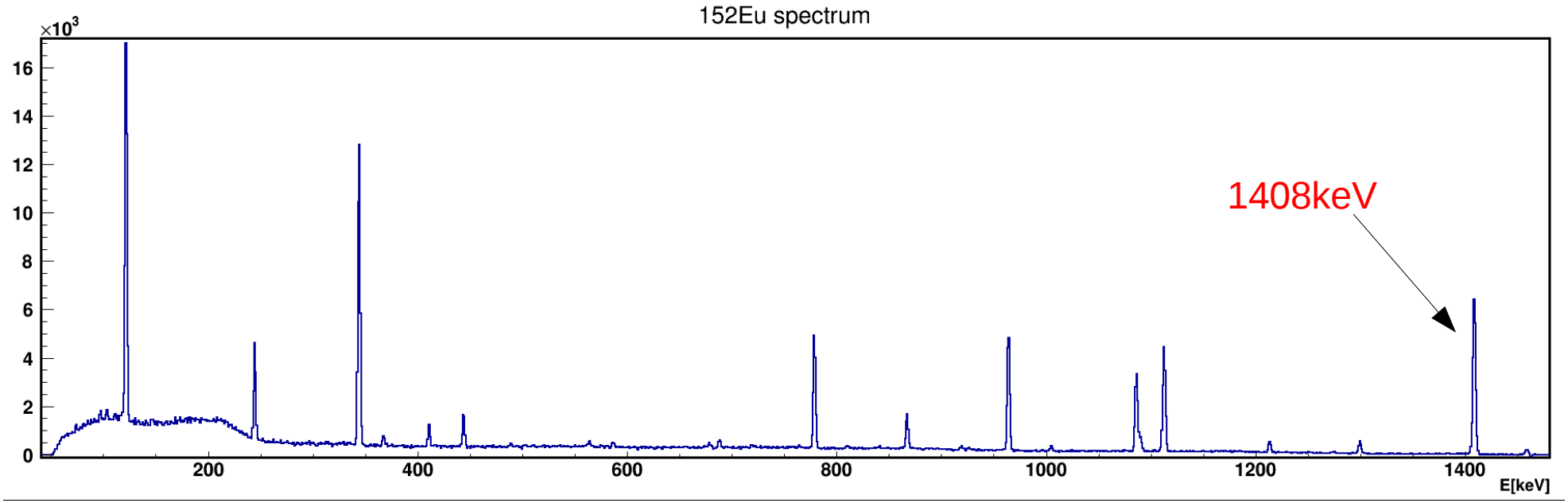


Measurements on S001: 2D scans @ 662keV

Full area scan: **137Cs** @ **662keV**, diam. 1.0mm, pitch 2x2mm^2

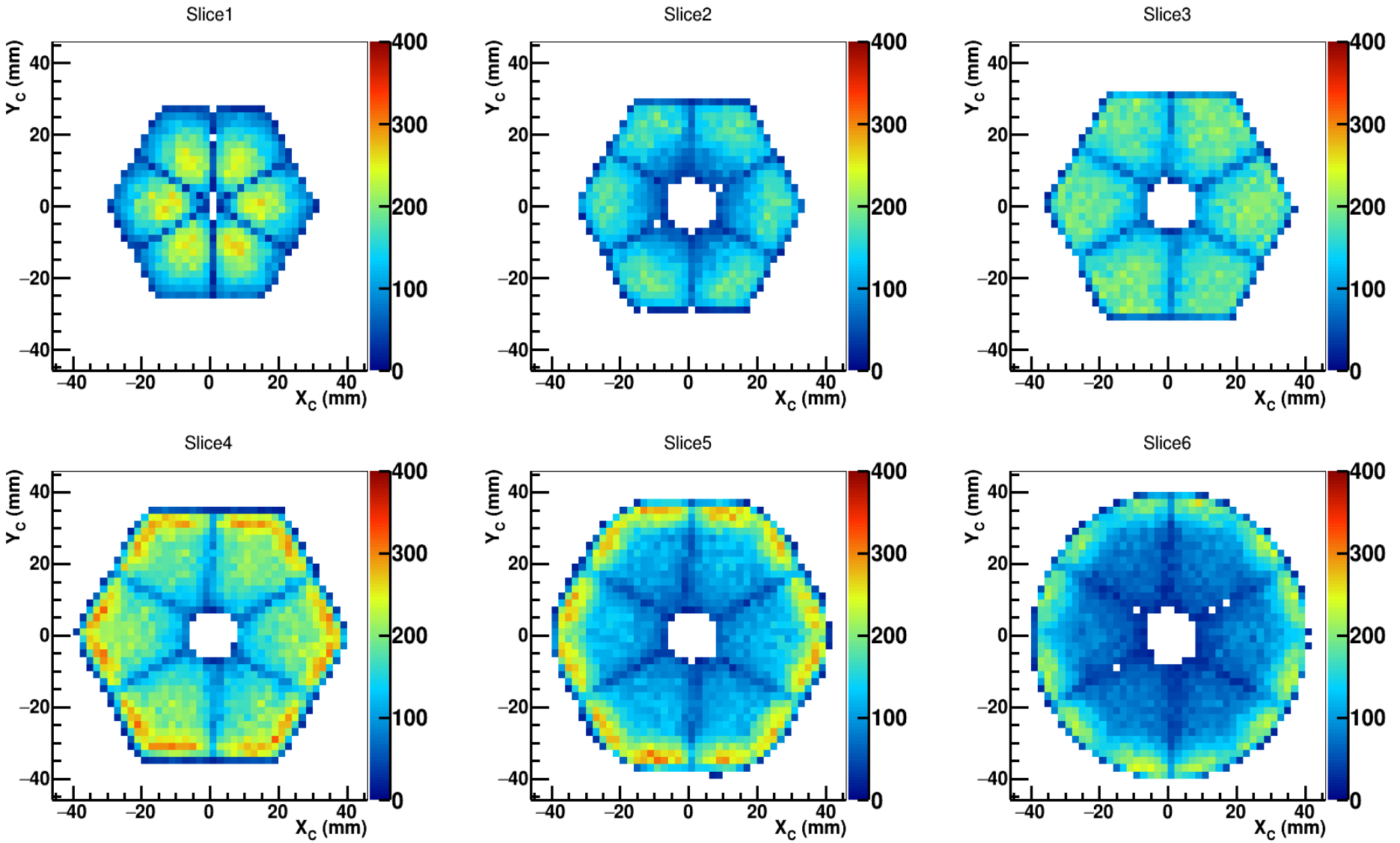


Measurements on S001: 2D scans @ 1408keV



Measurements on S001: 2D scans @ 1408keV

Full area scan: **152Eu** @ **1408keV (BR 21%)**, diam. 1.0mm, pitch 2x2mm^2



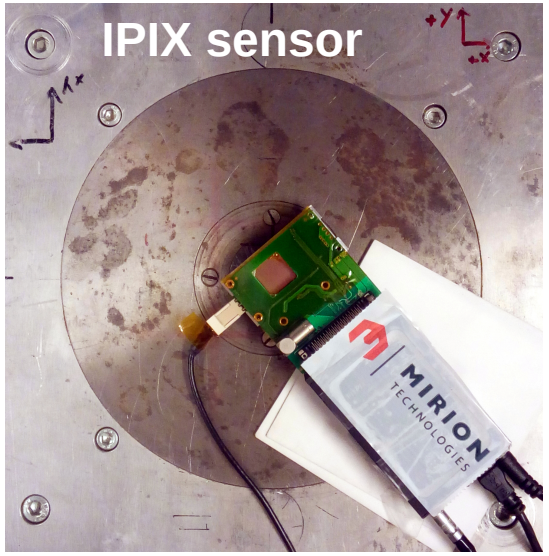
Next steps...

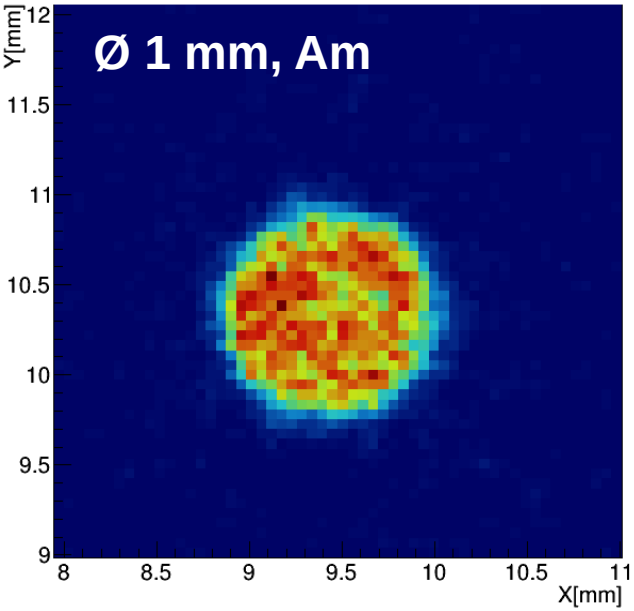
- Full volume scan with ^{137}Cs source (**Vertical done**)
- Full volume scan (of a sector) with ^{152}Eu source (**Vertical ongoing**)
- Comparison between simulations and real data scans

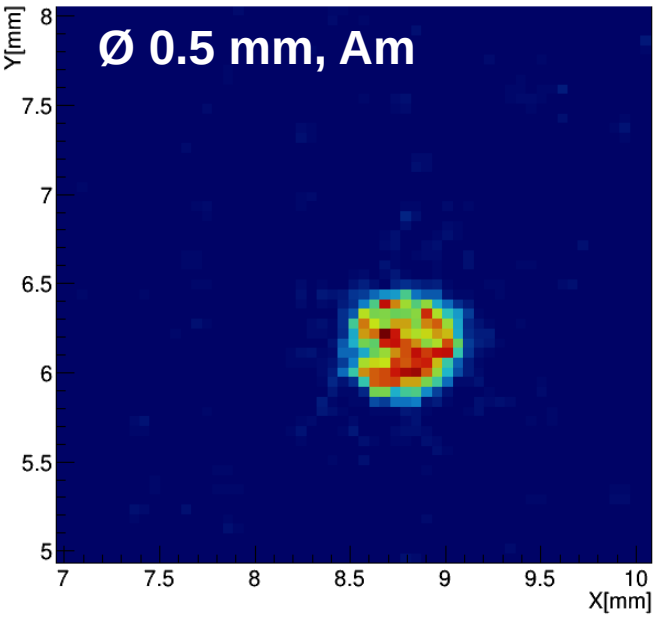
EXTRA

Measurements and simulations on the new collimators

- Measurements of the diameter of the collimator with a pixellated CdTe detector







- Simulations and measurements of the yield of the collimator
- Photo-peak counting rate in each segment of an AGATA detector (detector in vertical position)

Measurements on S001

Type de mesure	Mode	Collima-teur (µm)	Timeout par point	Durée tot du scan	Nbre de points
Scan 1x1 mm, Am, bande de 4 cm de large autour du trou 22 juillet 2019	E	1000	60 s	2 j ½	2769
Scan rond de diamètre 20 mm, 1x1 mm, Cs 25 juillet 2019	E	1000	120 s	12h	322
11 scans au travers de la ligne de segmentation EF, Am, pas de 100 µm sur 2 mm de long 28 juillet 2019	E	1000	120 s	22h	583
Taux de comptage au centre du segment A (X=20, Y=0), Am, Cs, Eu	E	1000 500 200	30 mn 30 mn 5 ou 10h		1
Scan en croix au travers du trou, Cs, 4x 40mm, pas de 100 µm 6 août 2019	E	1000	240 s	57 h	806
Scan en croix au travers du trou, Cs, 4x 30mm, pas de 100 µm 12 août 2019	E	1000	240 s	36 h	506
Scan toute surface frontale, Cs, 2x2 mm 14 août 2019	M	1000	150	2.5 j	1355
1 scan au travers de la ligne de segmentation EF, Am, pas de 50 µm sur 3 mm de long 19 août 2019	E	500	2000 s	34,1 h	61
Scan toute surface frontale, Eu, 2x2 mm 22 août 2019	M	1000	360	6 j	1355

- The measurements are going on quite smoothly despite some technical difficulties

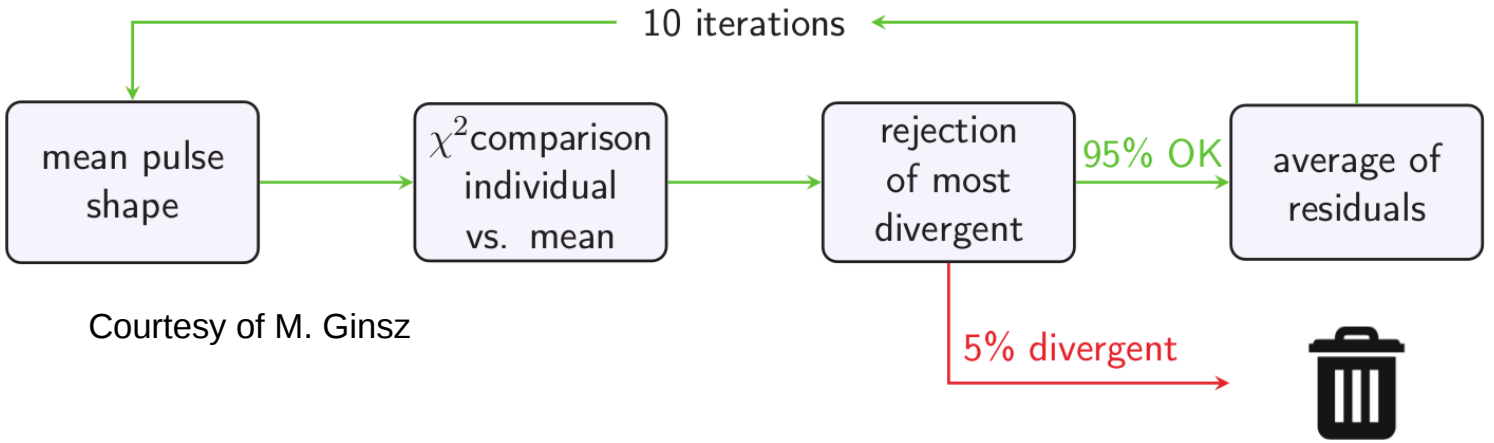
χ^2 Analysis [1]

$$\chi^2 = \frac{1}{N} \cdot \sum_{ch=0}^{9} \sum_{i=0}^{100} \left(\frac{H_{ch} - V_{ch}}{\sigma_{ch}} \right)^2$$

H_{ch} = Horizontal conf. data set
V_{ch} = Vertical conf. data set
N = total number of samples
σ_{ch} = noise amplitude of one channel

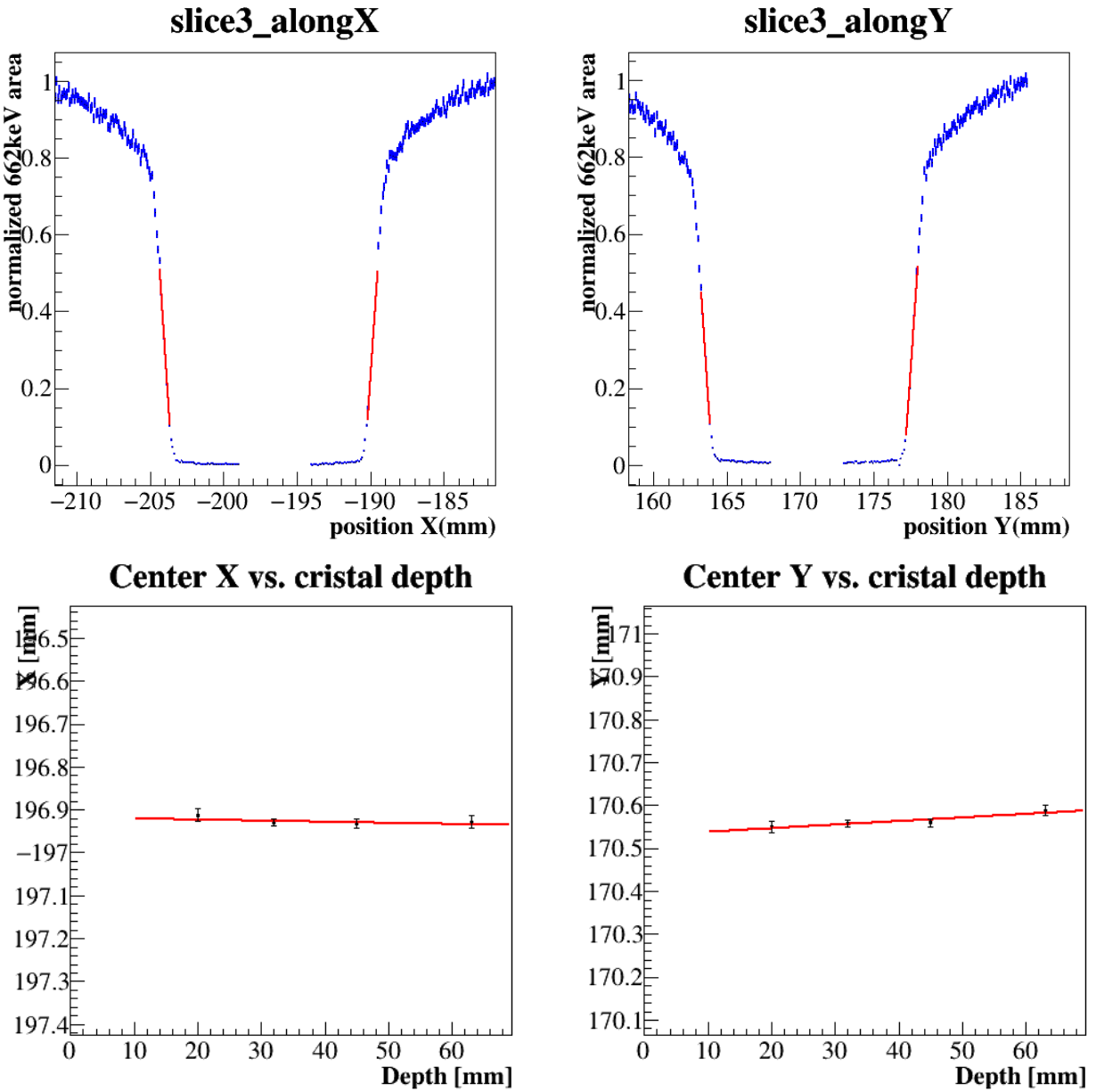
The χ^2 selection threshold is adaptive and at the end of the procedure the best 400 tests are selected (i.e.: 800 signals).

Refining procedure

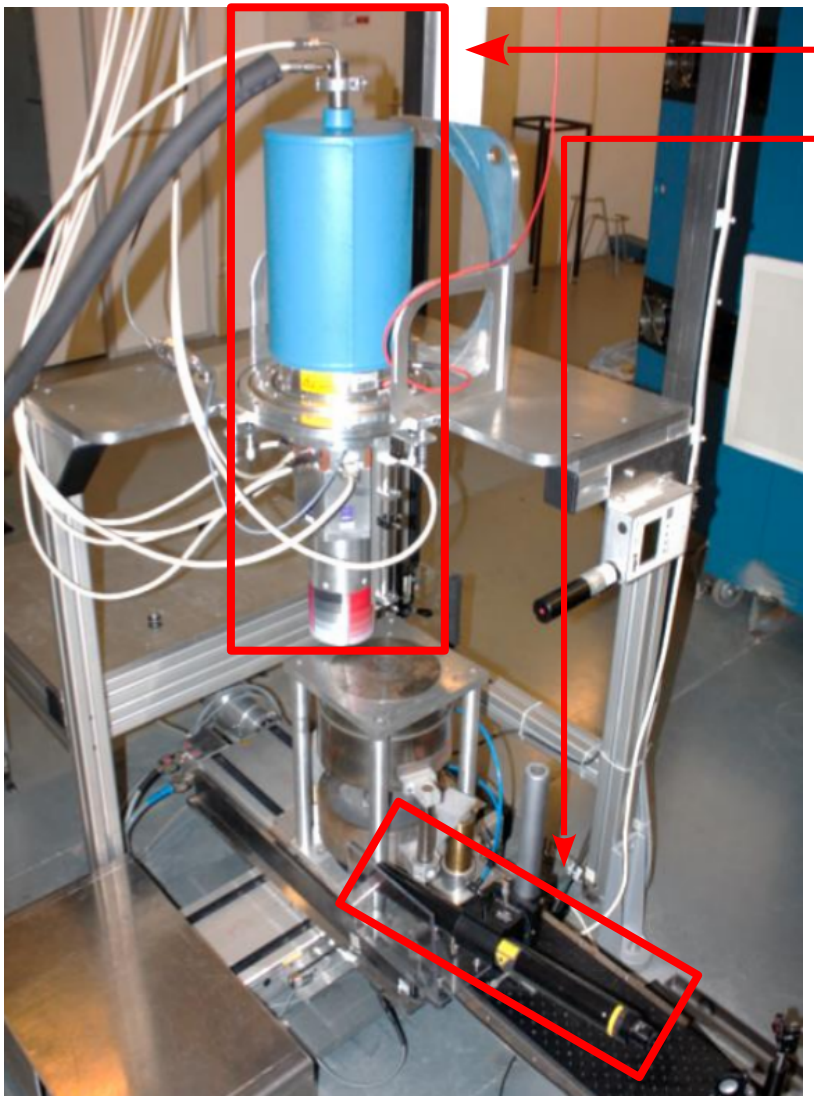


Courtesy of M. Ginsz

Hole alignment



The IPHC scanning table



The detector can be put on table in **vertical** or **horizontal** configuration

A **laser system** is used to align the detector

A cylindrical **collimator** collimates a strong gamma source into a **pencil-like beam**. It is moved in a plane by two perpendicular servo motors.