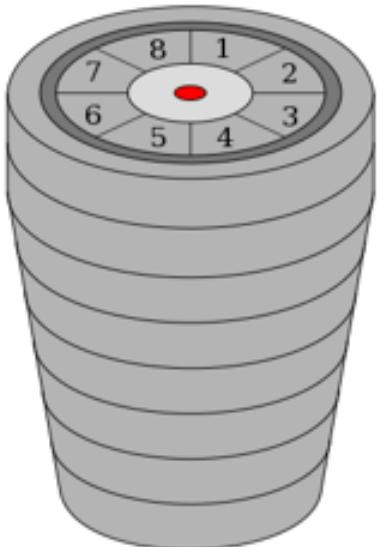




Laura Harkness-Brennan, Dan
Judson & Fiona Pearce

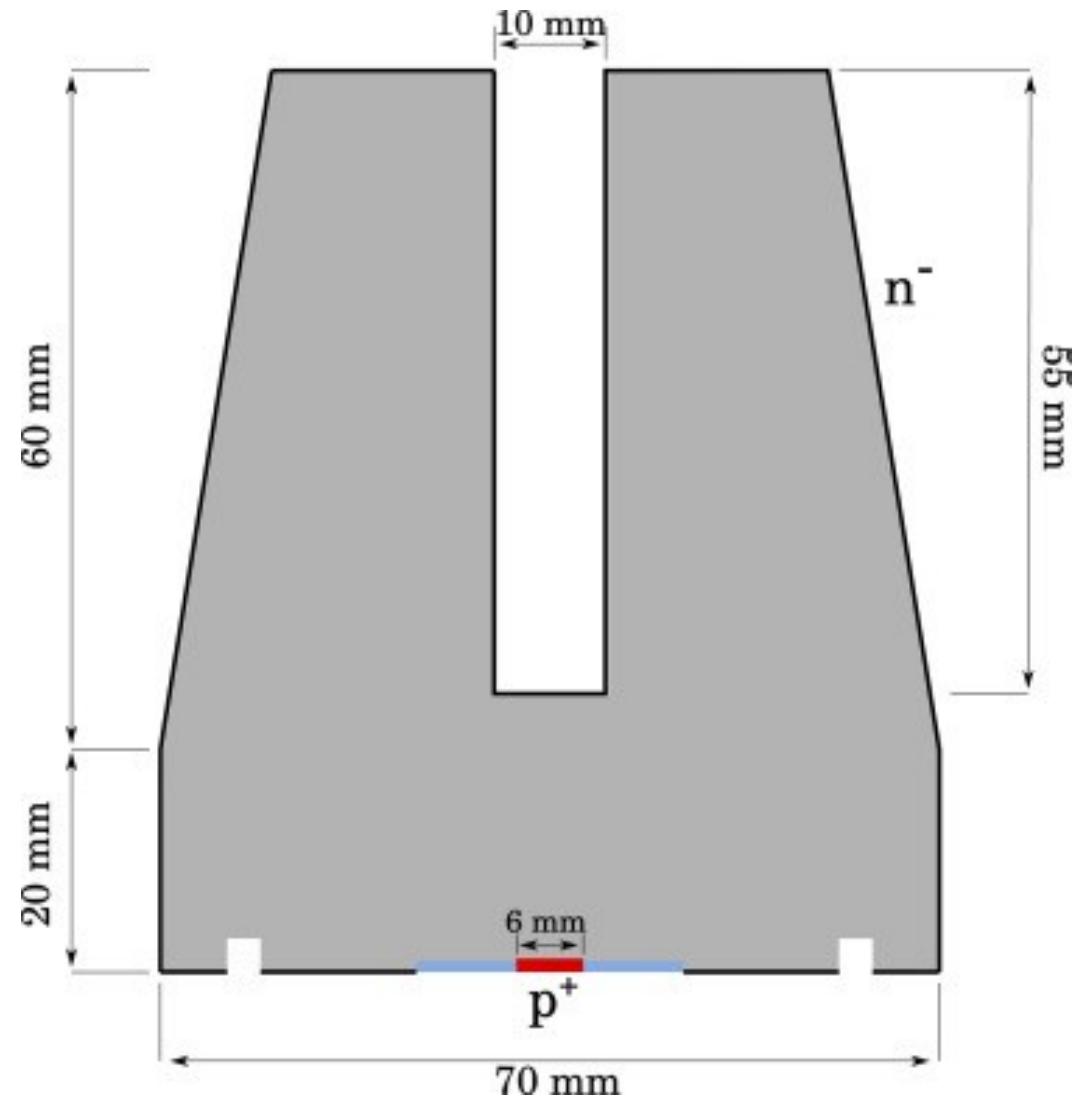


*Third AGATA-GRETINA/GRETA tracking arrays
collaboration meeting 03/10/19*

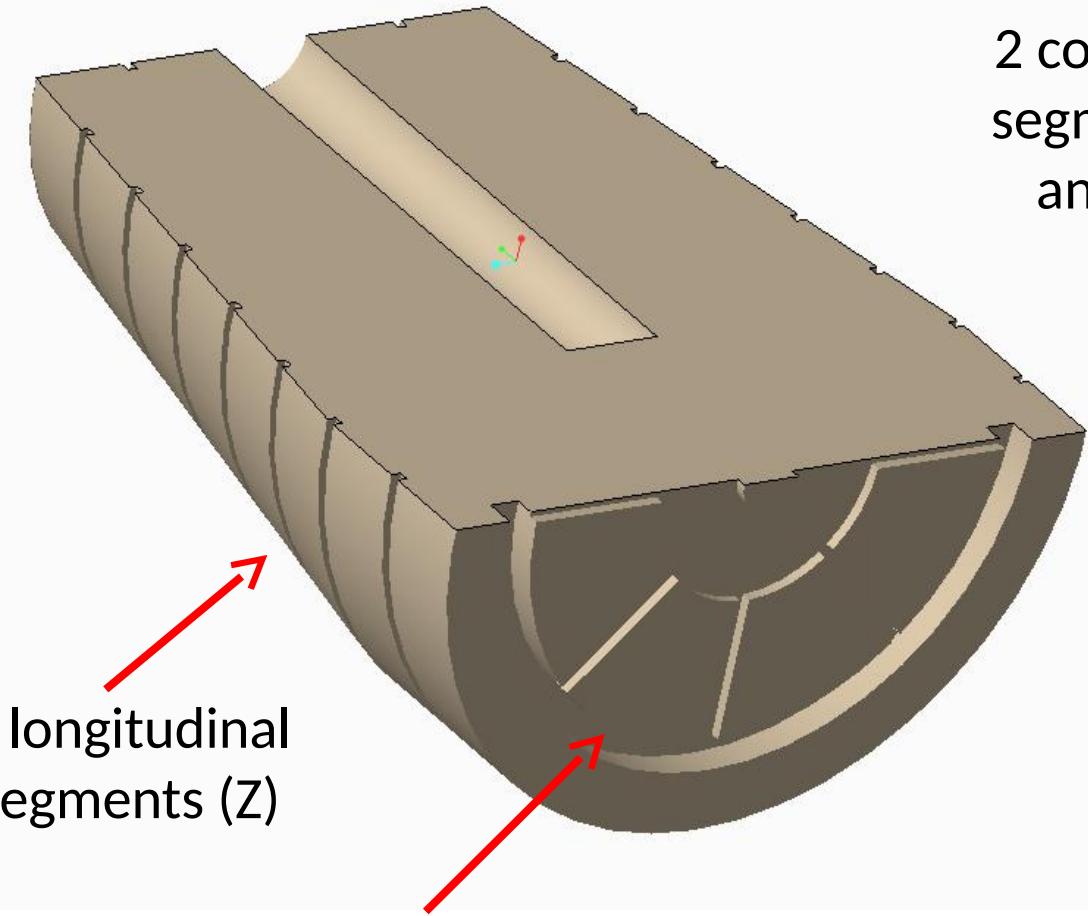


SIGMA geometry

- Segmented Inverted-coaxial GerMAnium Detector
- First p-type detector of its kind
- Expect improvement in position resolution over gamma-tracking arrays (*R Cooper NIM A 665 2011*)
- Simpler to analyse multiple interactions
- Reduction in cost and complexity (fewer readout channels than AGATA)



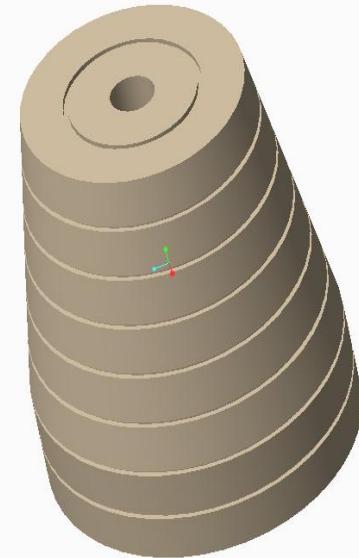
SIGMA segmentation



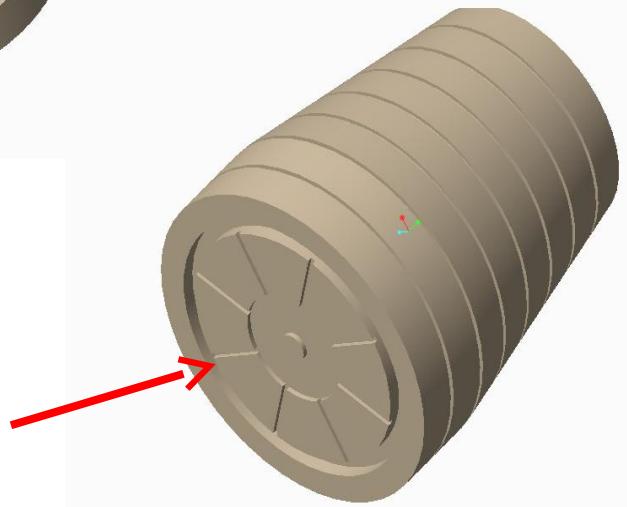
8 longitudinal
segments (Z)

8 azimuthal
segments (ϕ)

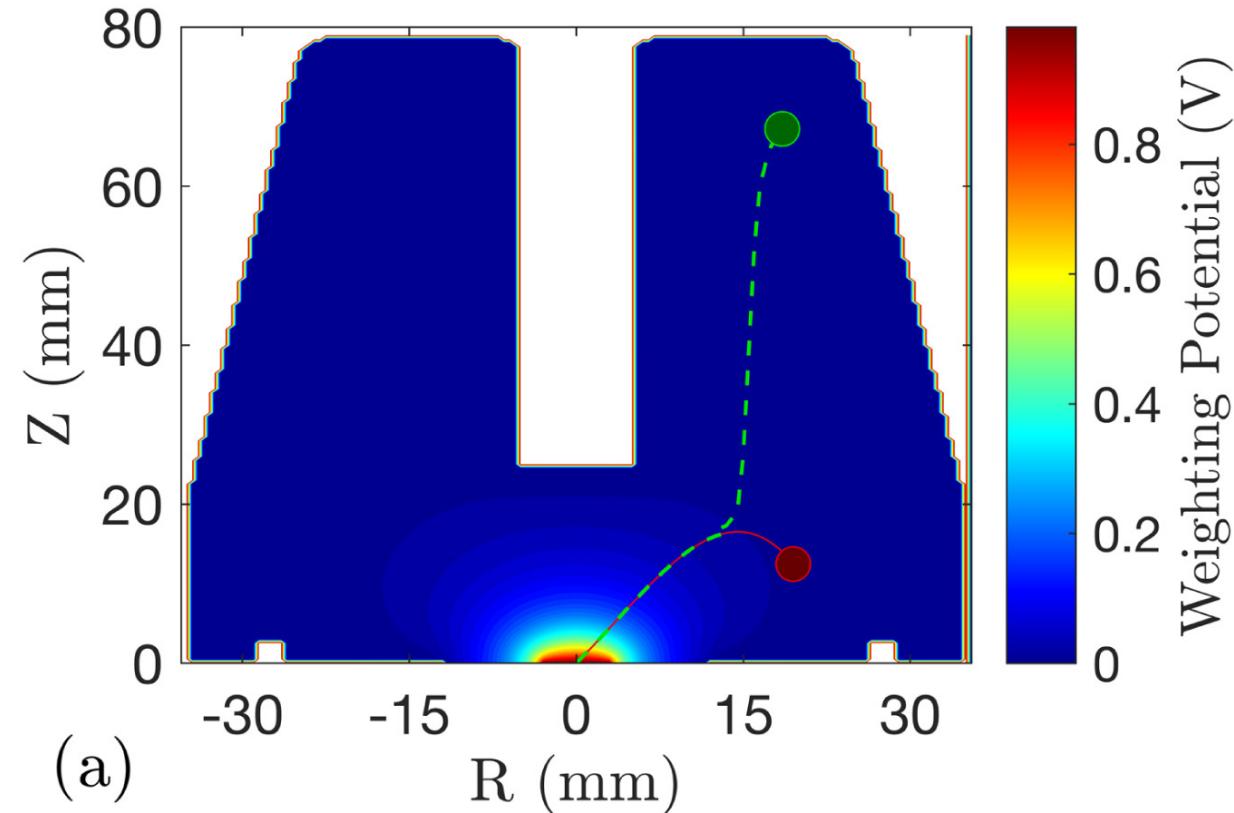
2 concentric
segments (r)
and core



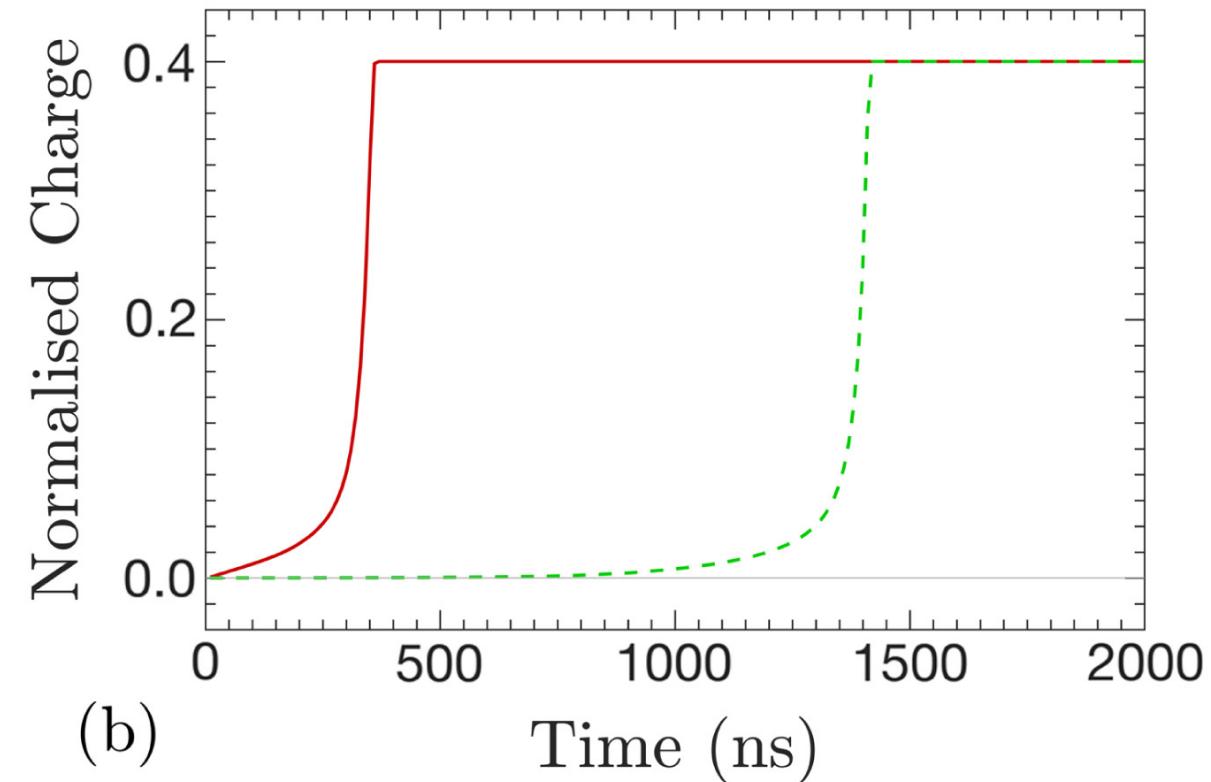
1 point
contact (E)



GMA detector weighting potential

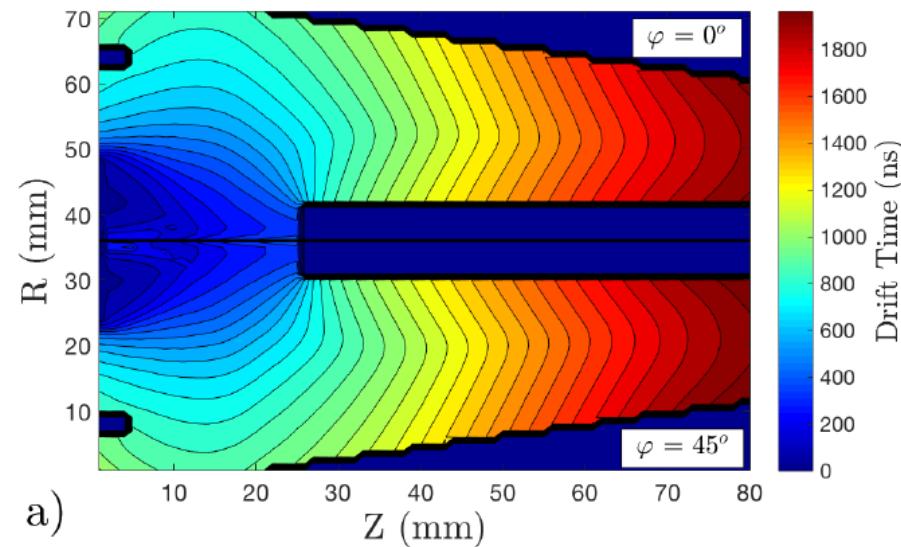


Weighting potential for point contact (FieldGen
and SigGen... thanks David et al!)

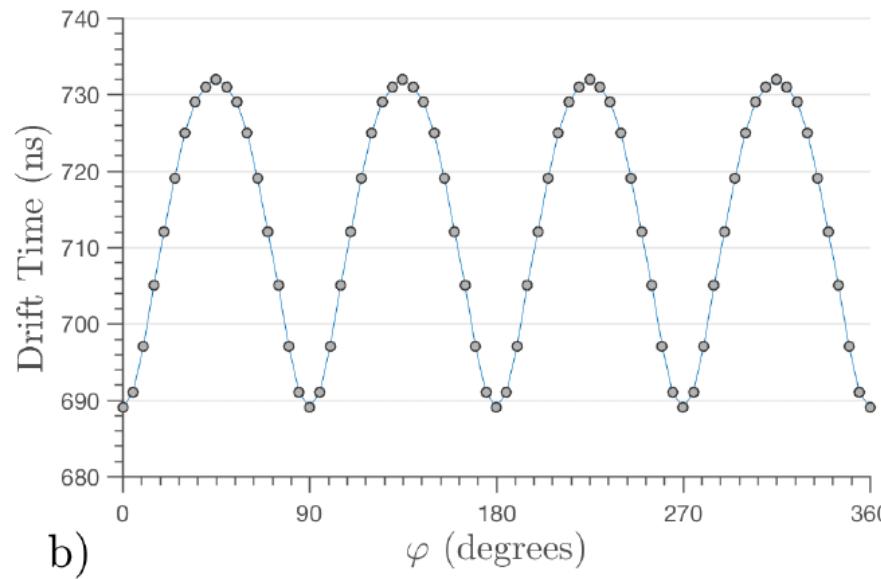


Two example point contact charge pulses resulting
from different gamma-ray interaction positions

IGMA detector drift times

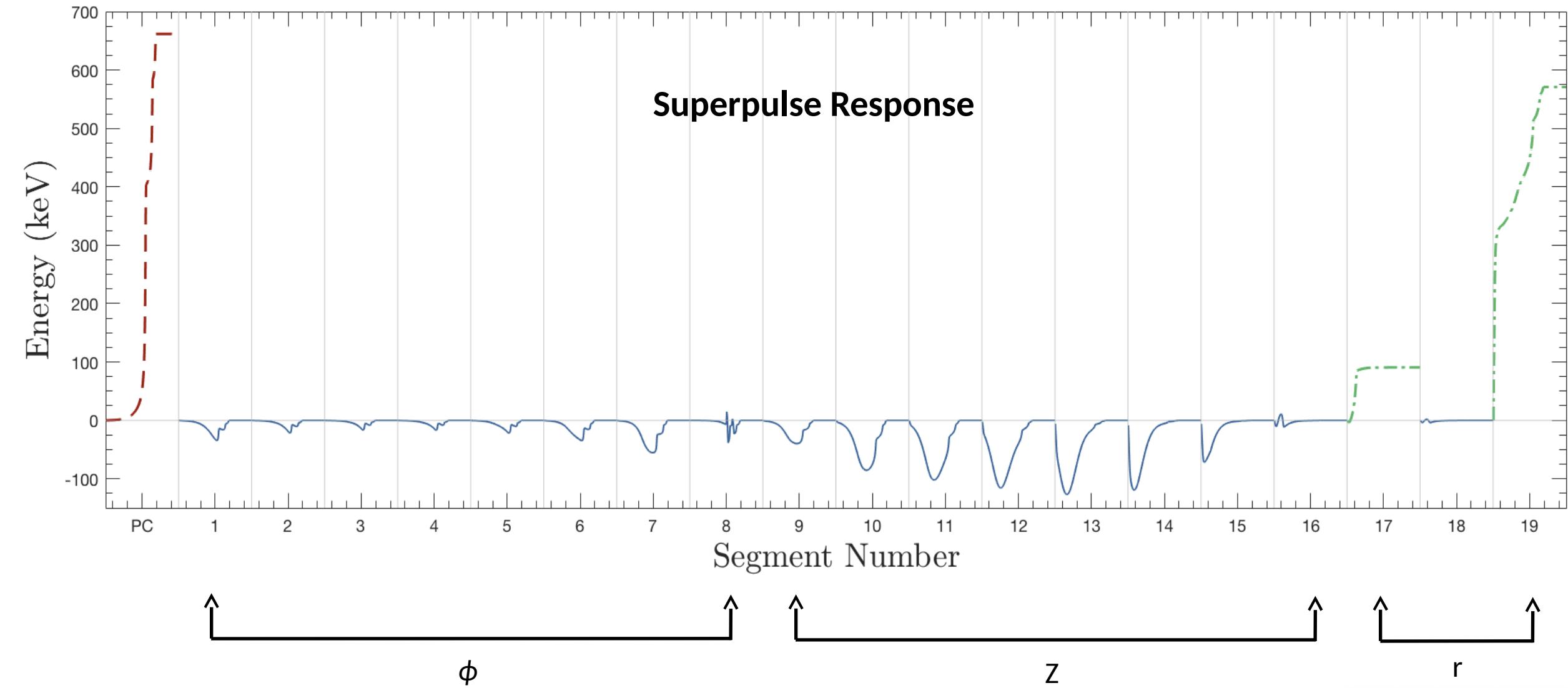


Drift time distribution as a function of γ -ray interaction position. Slight variation between 0 and 45° due to crystallographic axis

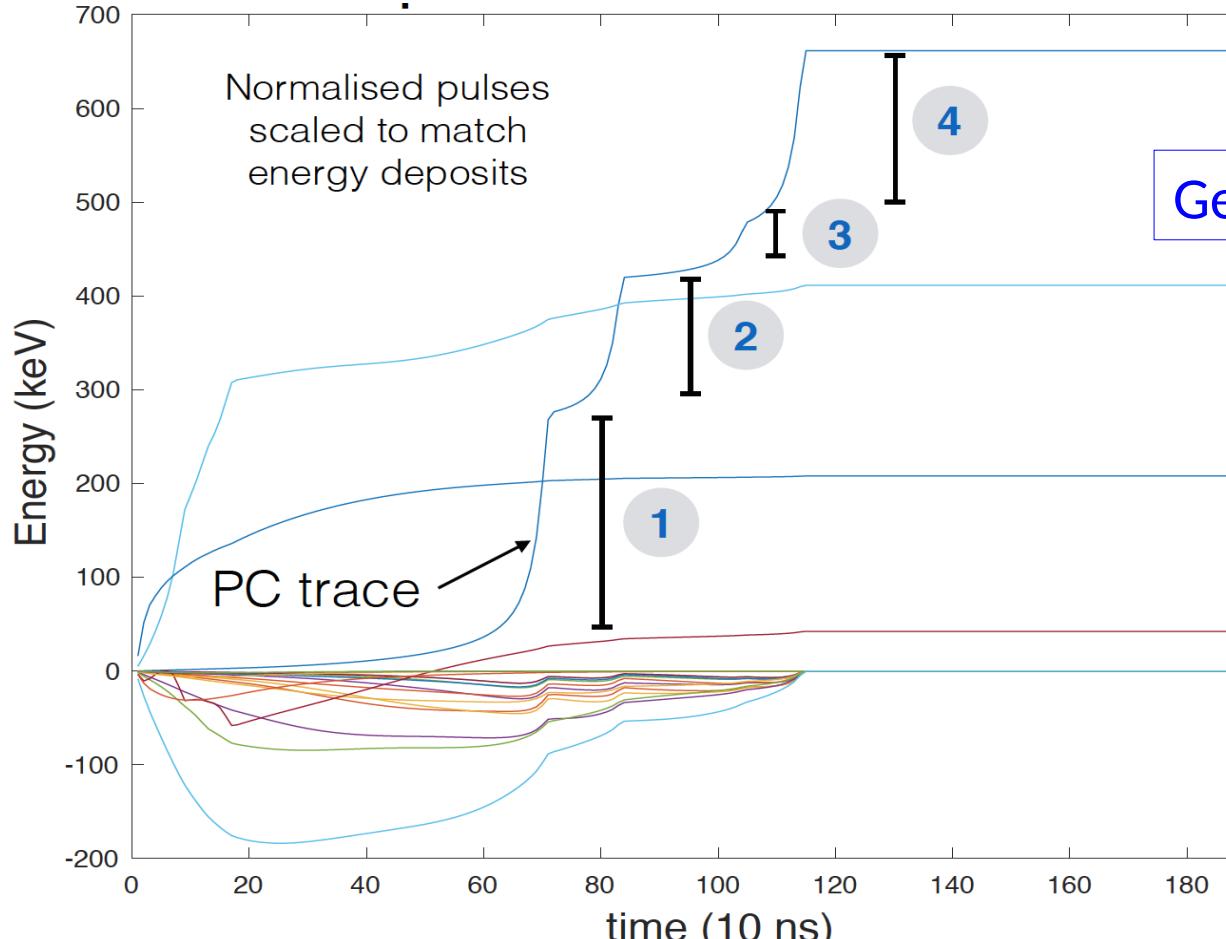


Variation in drift time as a function of azimuthal angle for γ -rays at $(r,z)=(20,20)$. Approx 6% peak to peak

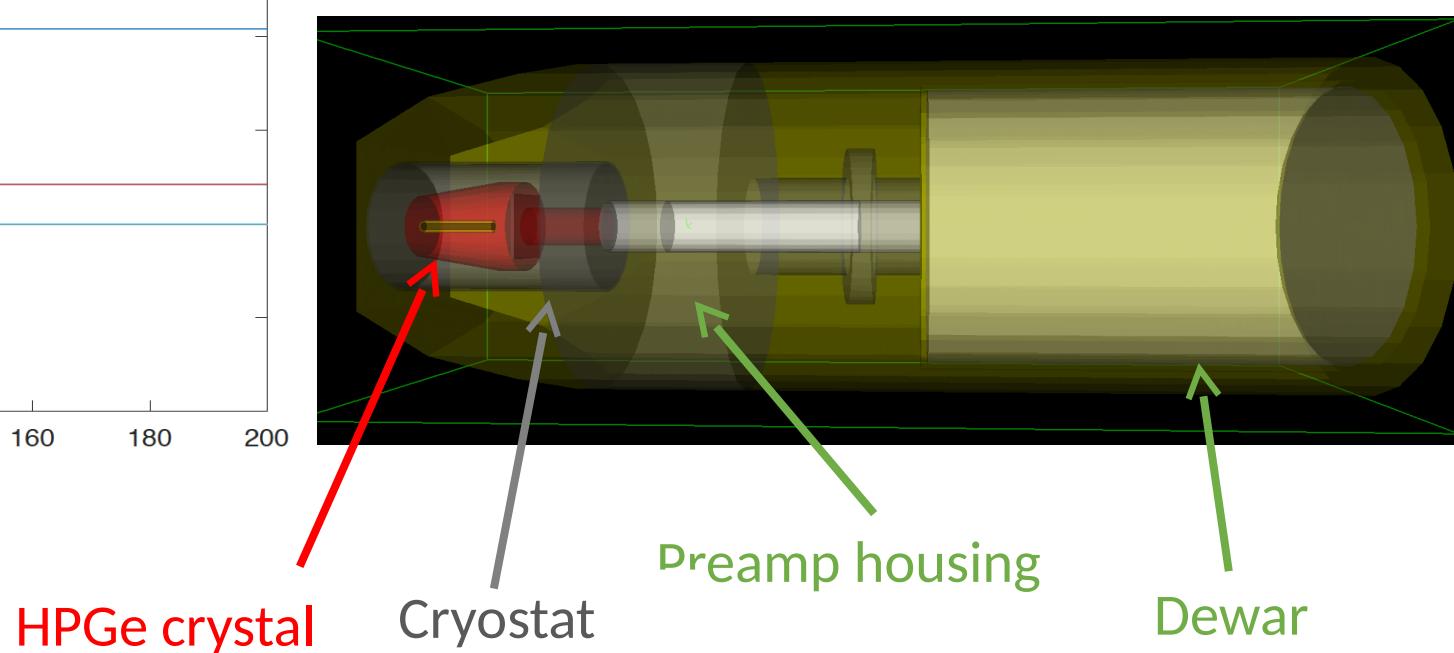
Position Identification



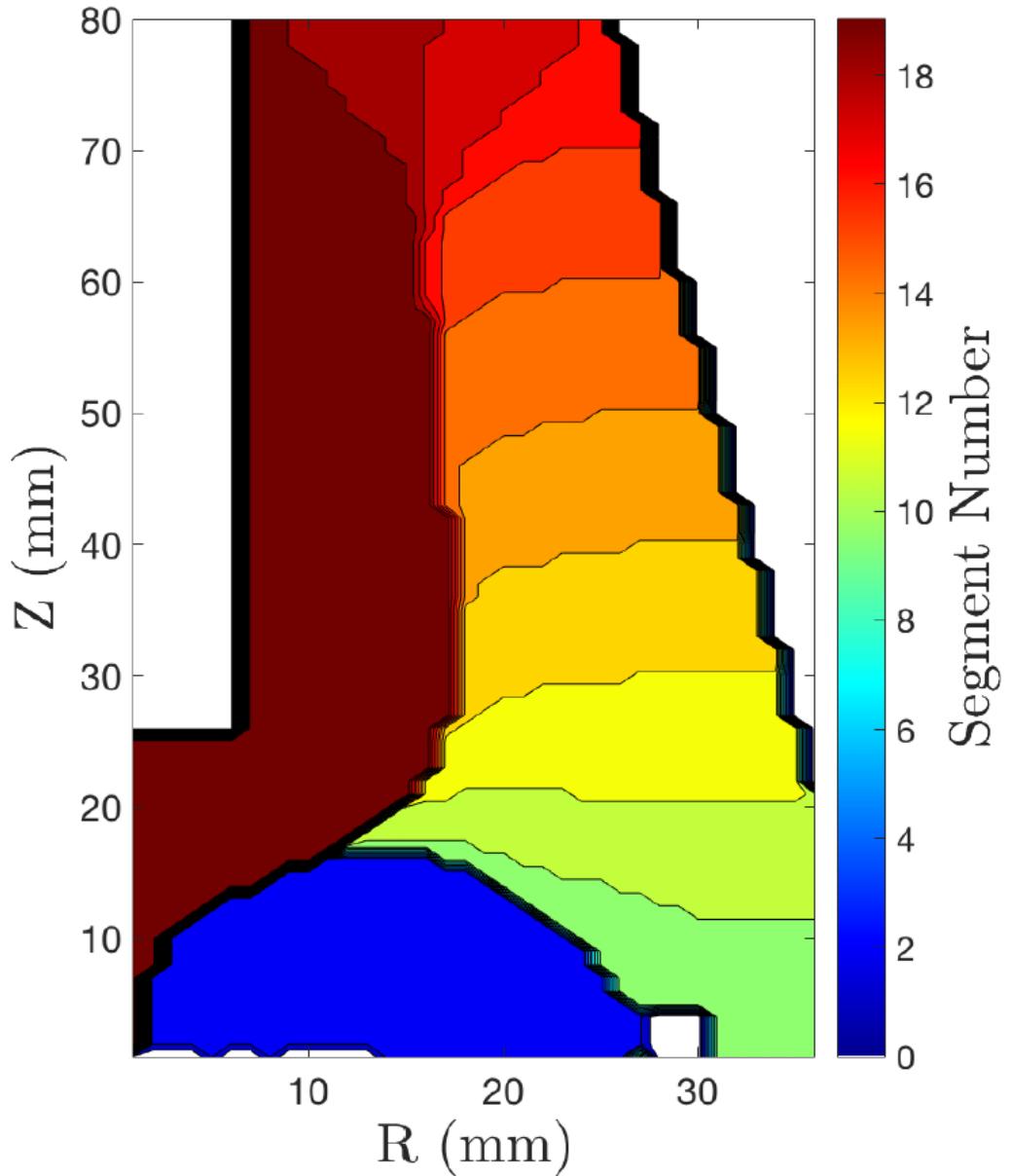
Multiple interactions



Geant4 x,y,z,E and fieldGen/sigGen



GMA detector position sensitivity

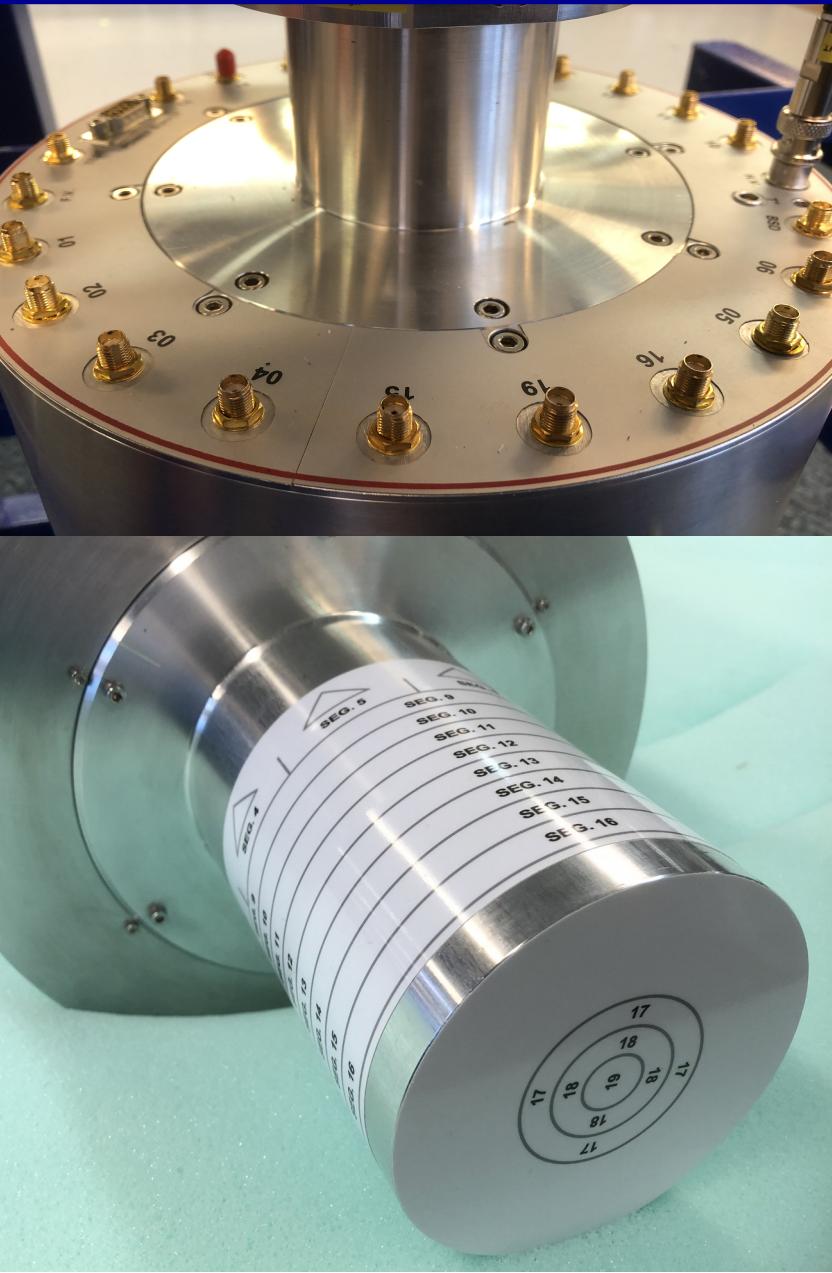


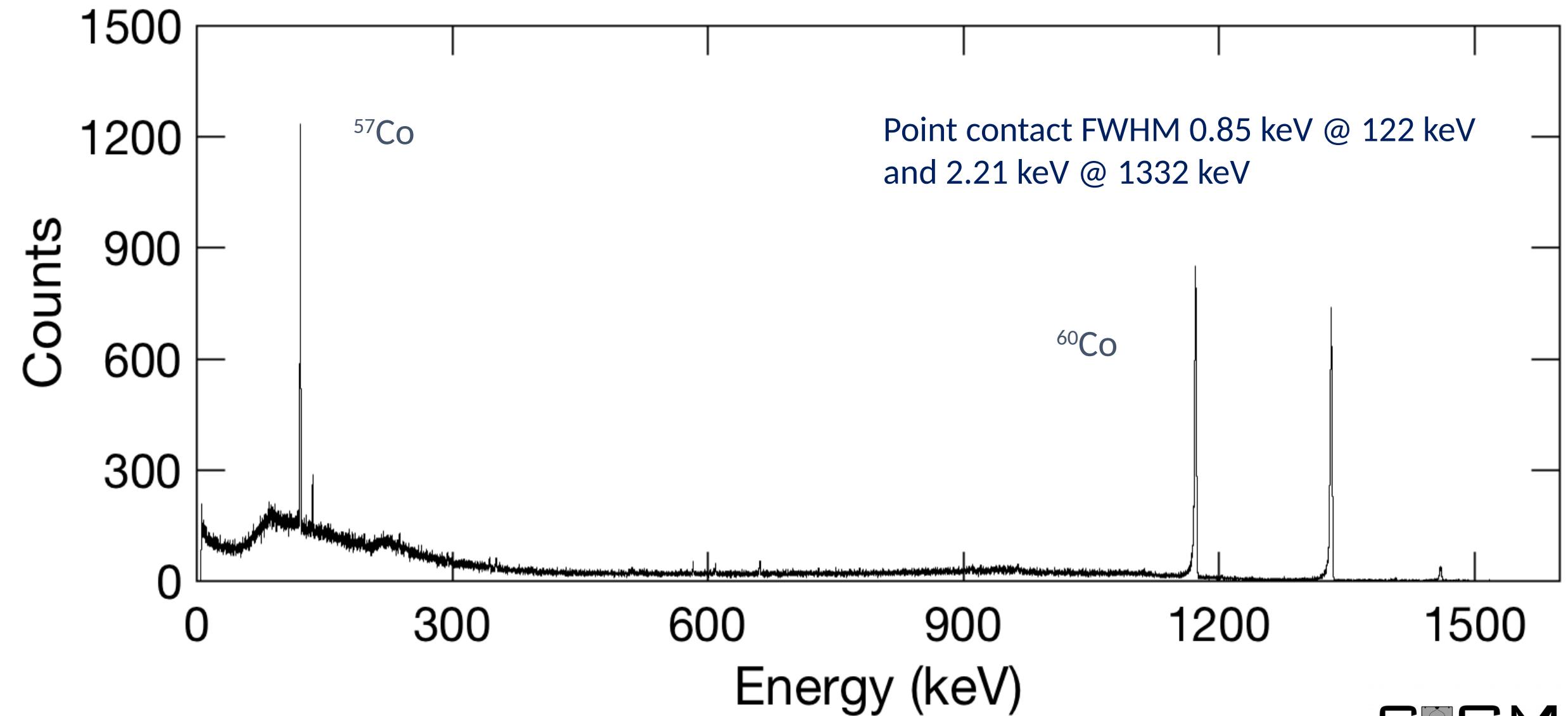
J Wright et al , NIM A (2019) 892, 84-92

The electron collecting electrode (outer hit segment) as a function of γ -ray interaction position.

Relative size of each is a direct result of the relative strengths of the weighting potentials

SIGMA arrived 2018



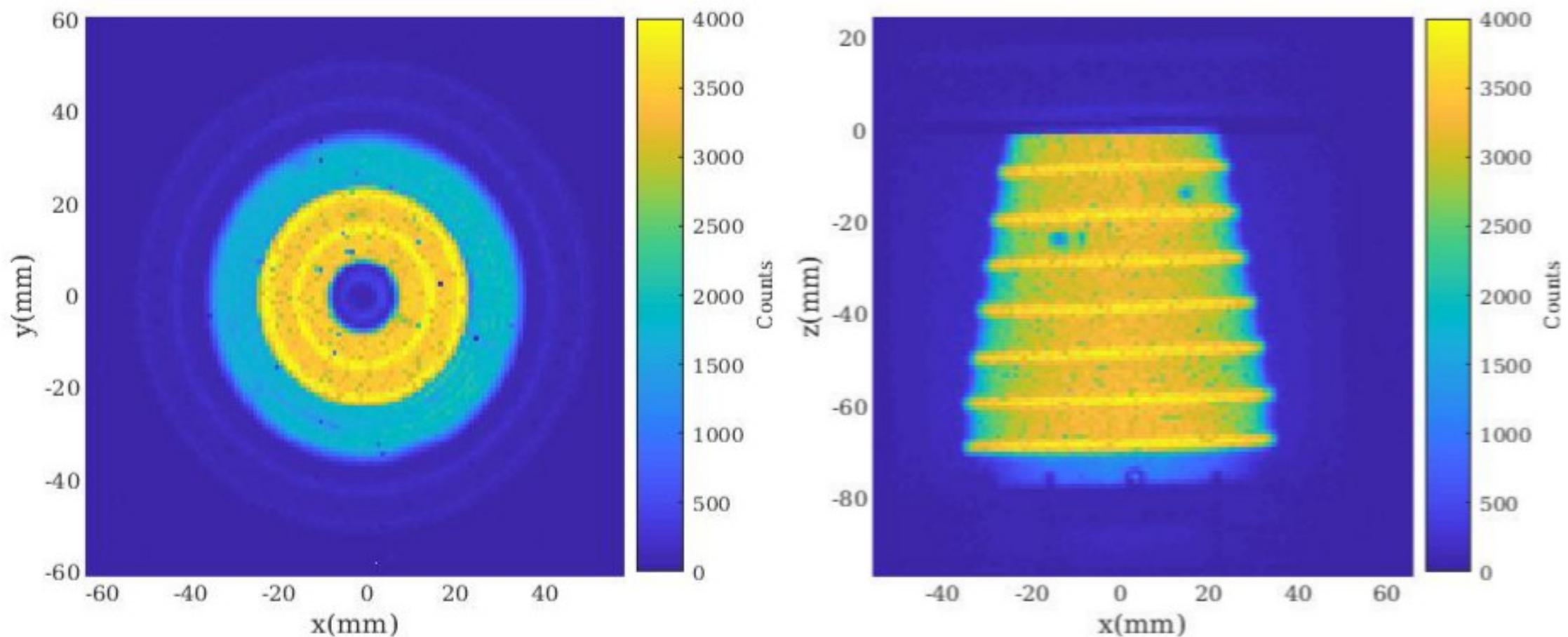


Spectroscopic performance

- Due to multiple reprocessing attempts during manufacture the crystal has lost some mass
- Relative efficiency $40.9 \pm 0.1\%$
- Segments 18 (concentric segment) and 19 (core) merged
- Segment 5 (azimuthal segment) faulty connection
- Segment 9 and 16 noisier than others
- FWHM_{Avg} 1.20 keV @ 122 keV and 2.47 keV @ 1332 keV

Segment	122keV FWHM (keV)	1332keV FWHM (keV)
PC	0.85	2.21
1	1.48	3.27
2	0.97	2.36
3	0.82	2.35
4	1.03	2.58
5	3.15	3.59
6	1.00	2.74
7	1.06	2.40
8	1.38	2.26
9	2.83	3.40
10	1.52	2.20
11	1.27	2.05
12	1.27	2.14
13	1.11	2.04
14	1.16	2.06
15	1.31	2.13
16	2.48	2.99
17	1.14	1.82
19	1.42	

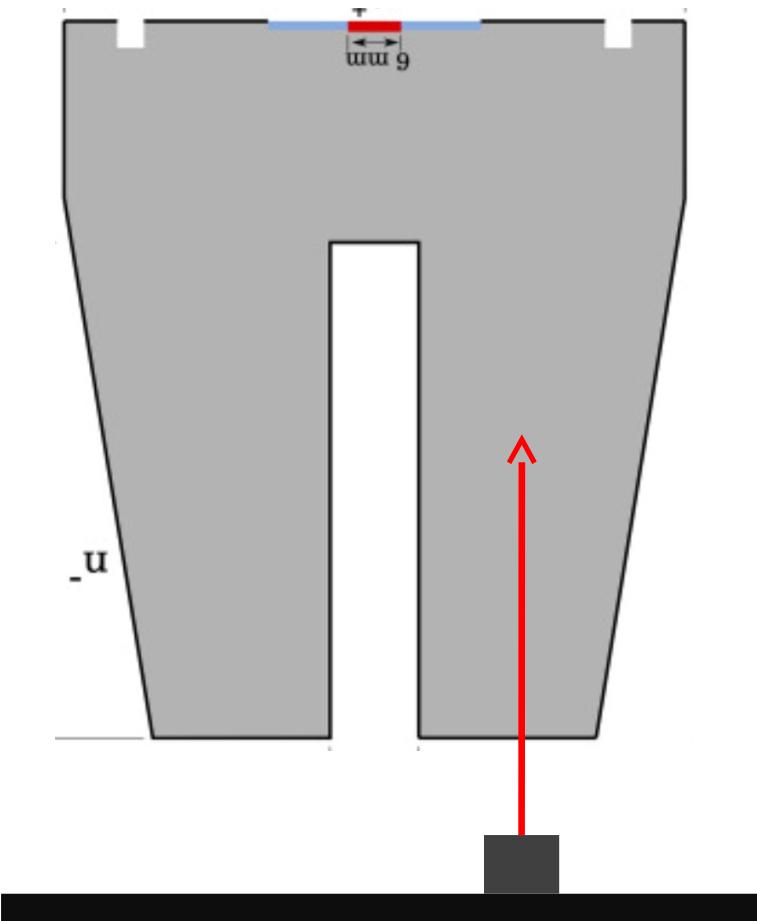
Surface scanning



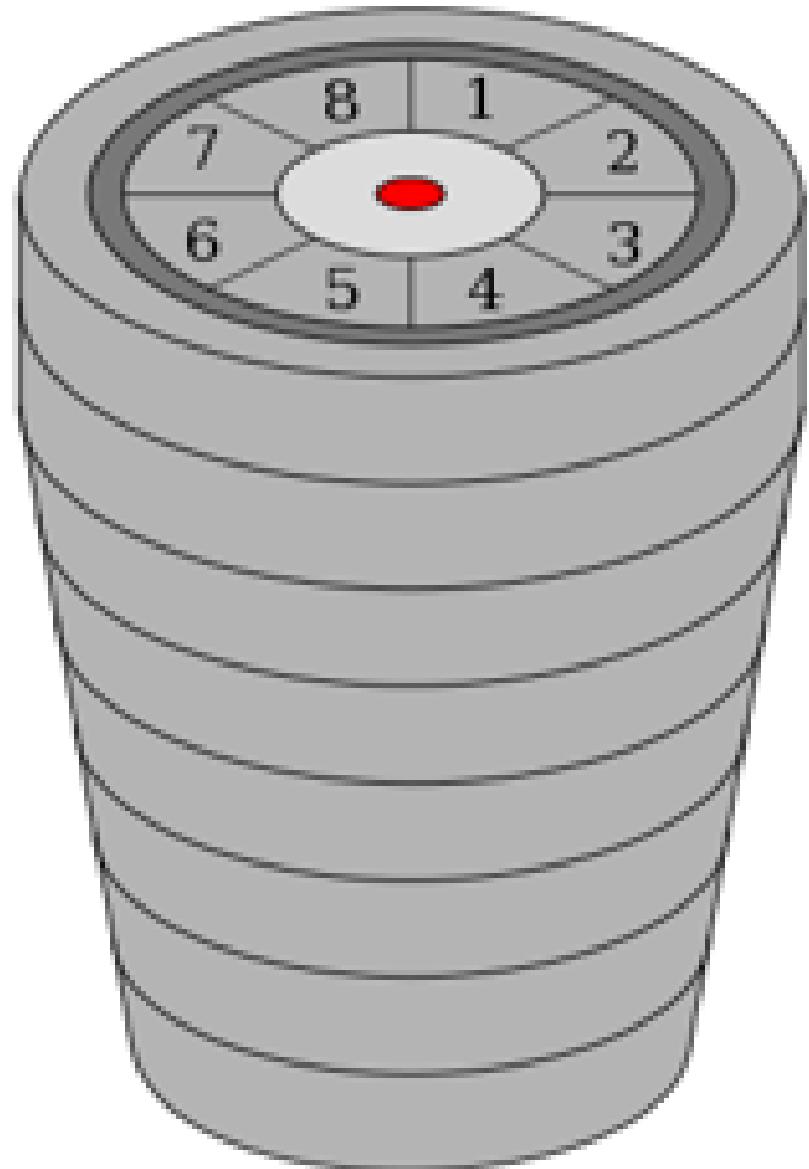
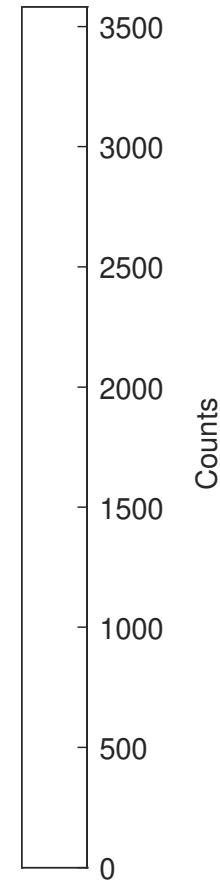
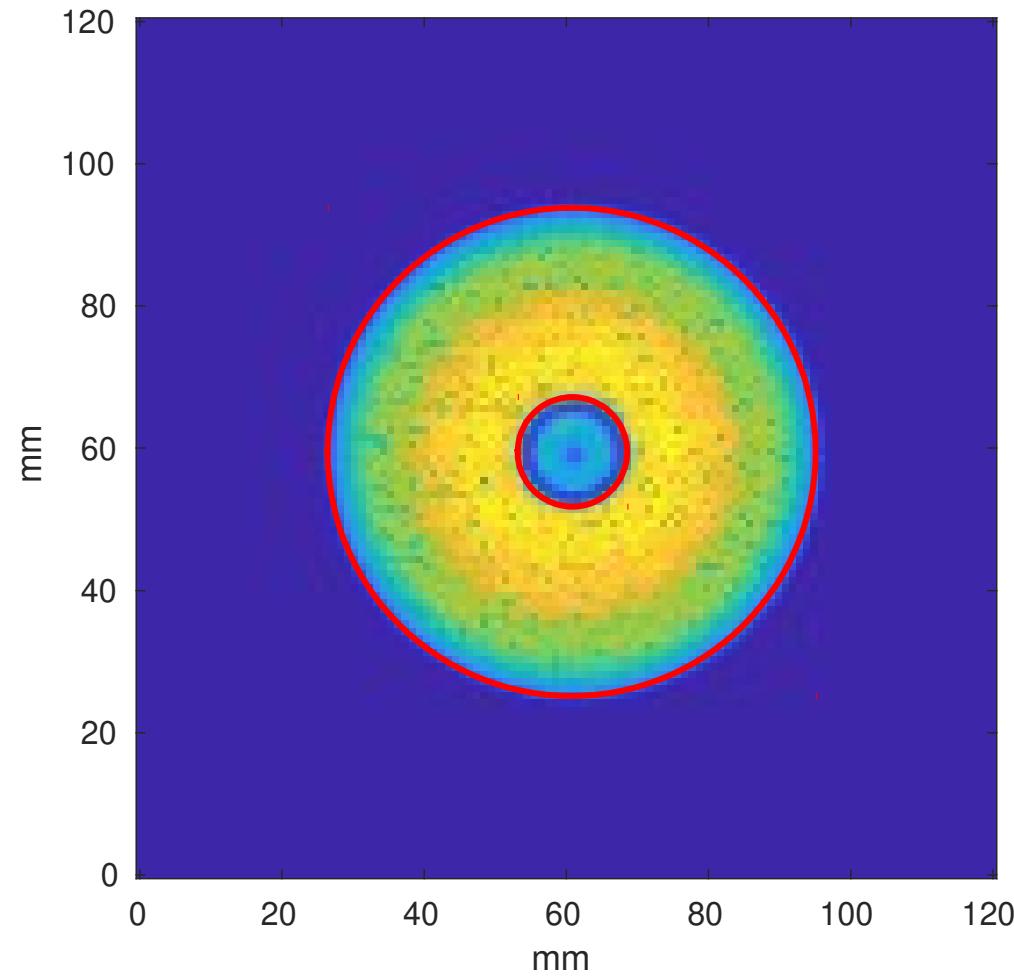
Collimated ^{241}Am source irradiating detector at known (x, y) and (x, z) , to probe surface and structure.
Confirmed crystal dimensions and the position of the detector in the lab frame of reference

o picting sensitive regions of each segment

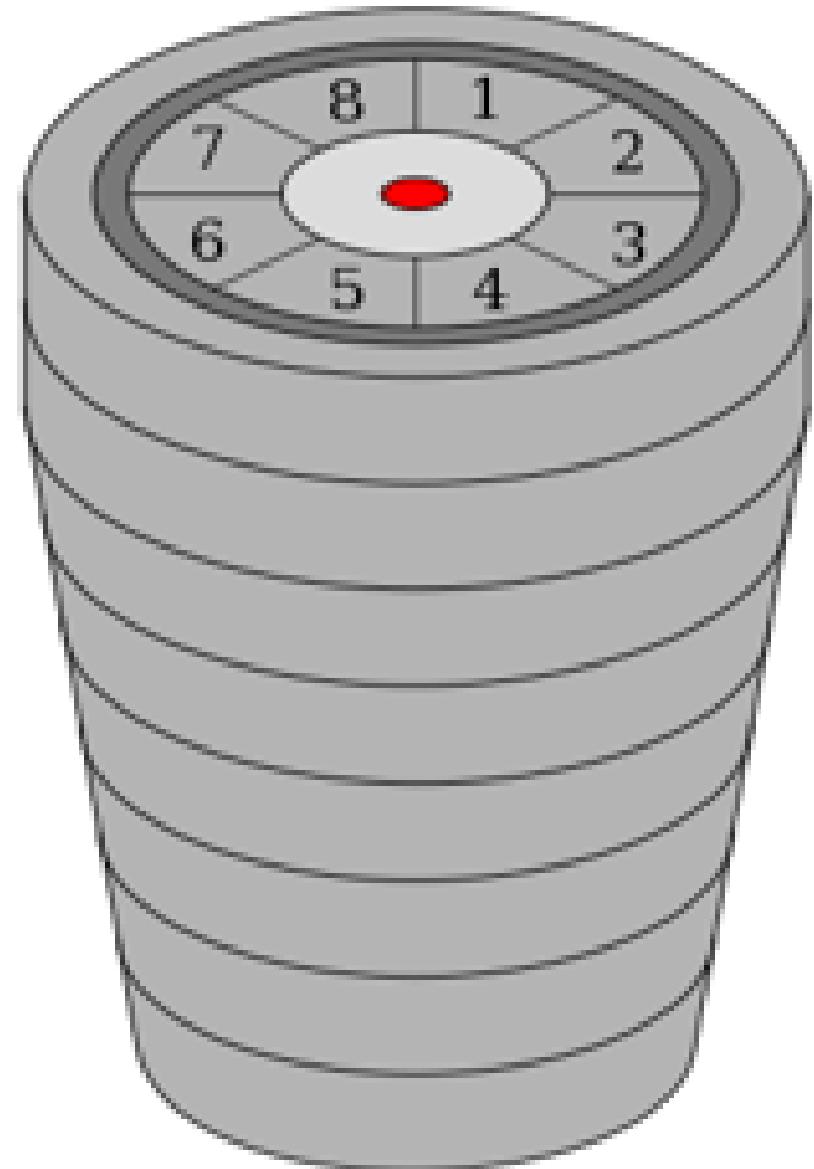
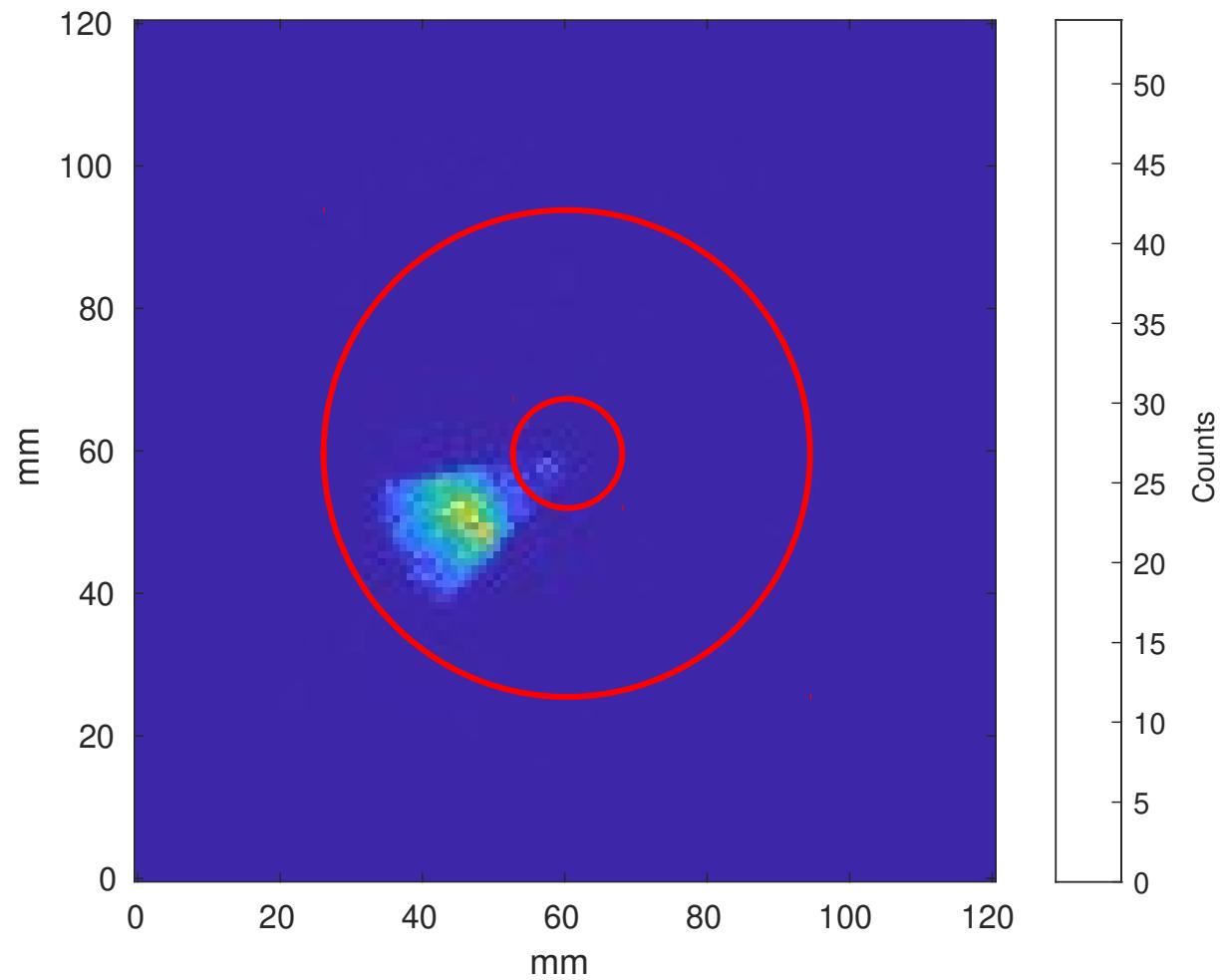
- Irradiate SIGMA through front face using collimated ^{137}Cs source in 1mm increments in a (x,y) grid
- Apply energy gate to only use photopeak events
- For each event, identify which segment observes a real charge signal and plot the (x,y) collimator position
- Demonstrates which electrode collects the electrons as a function of gamma-ray interaction position in the detector.



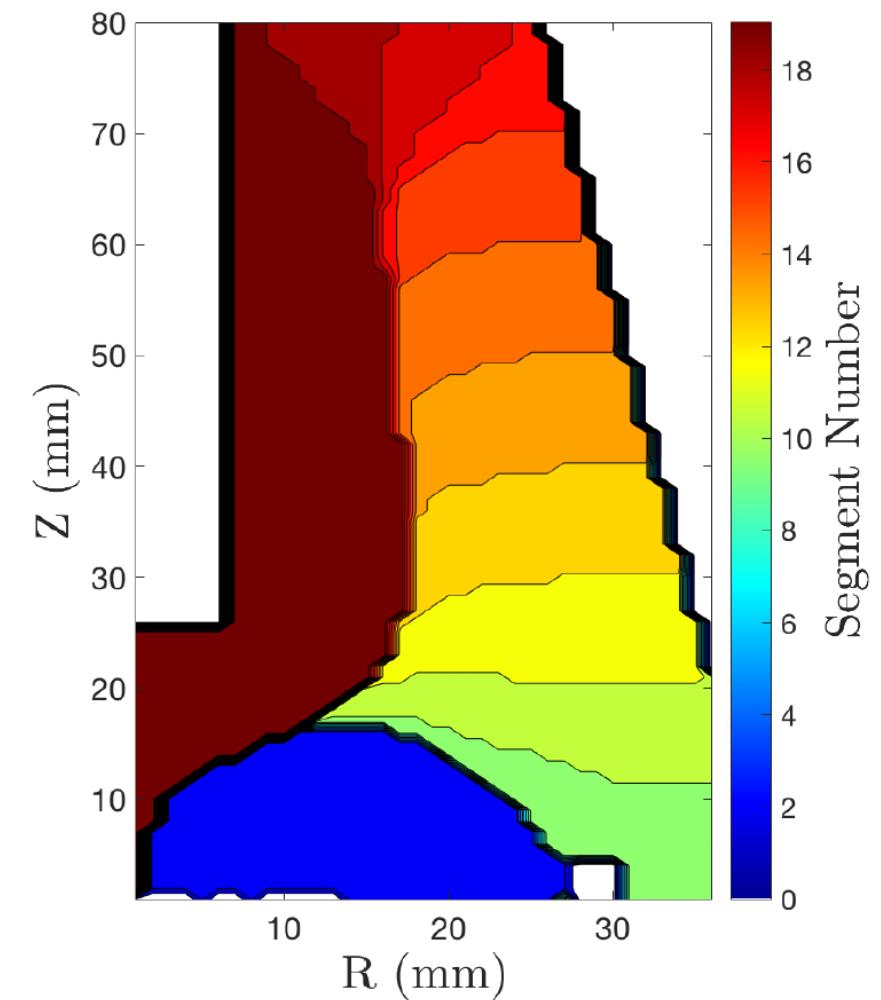
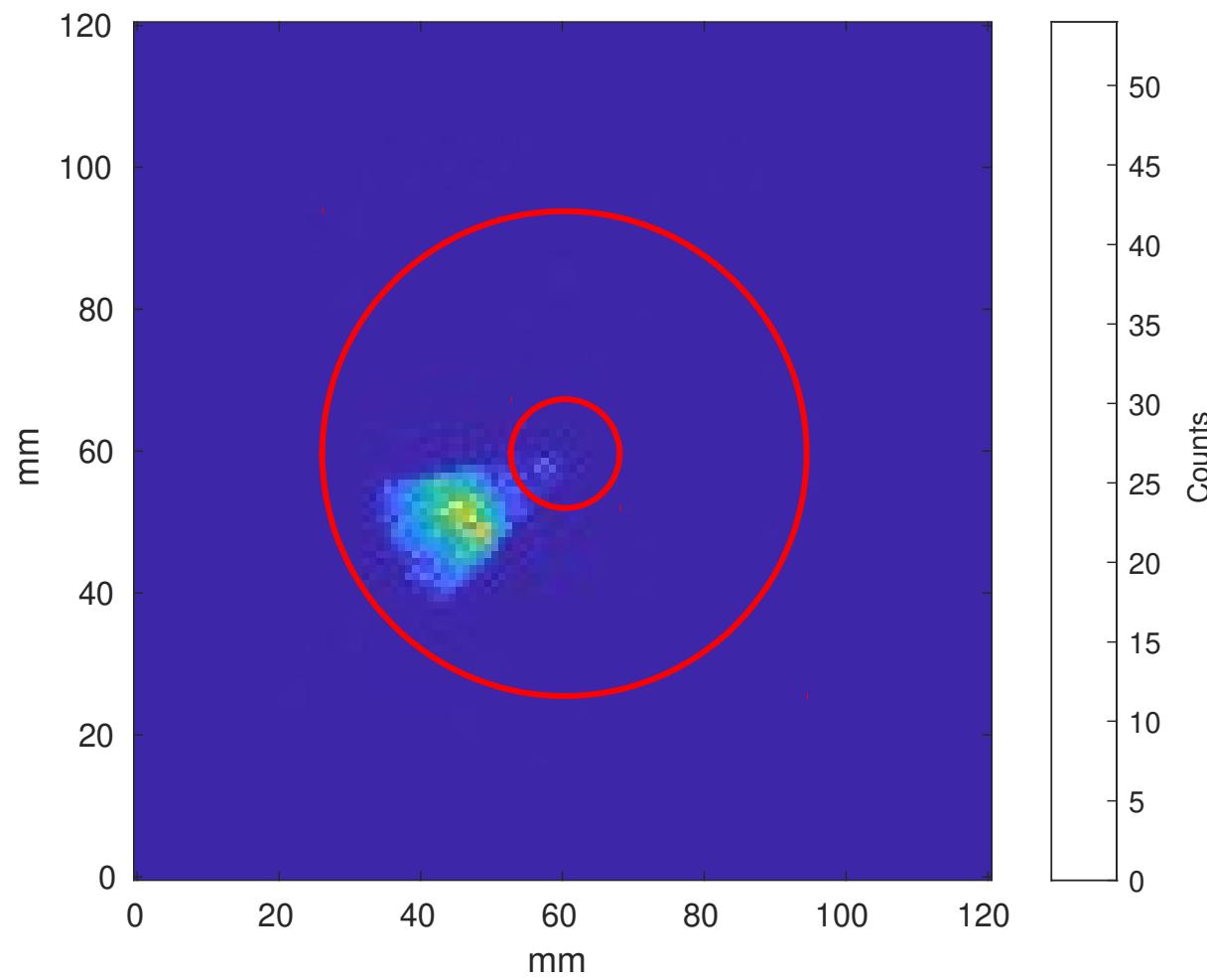
Point Contact



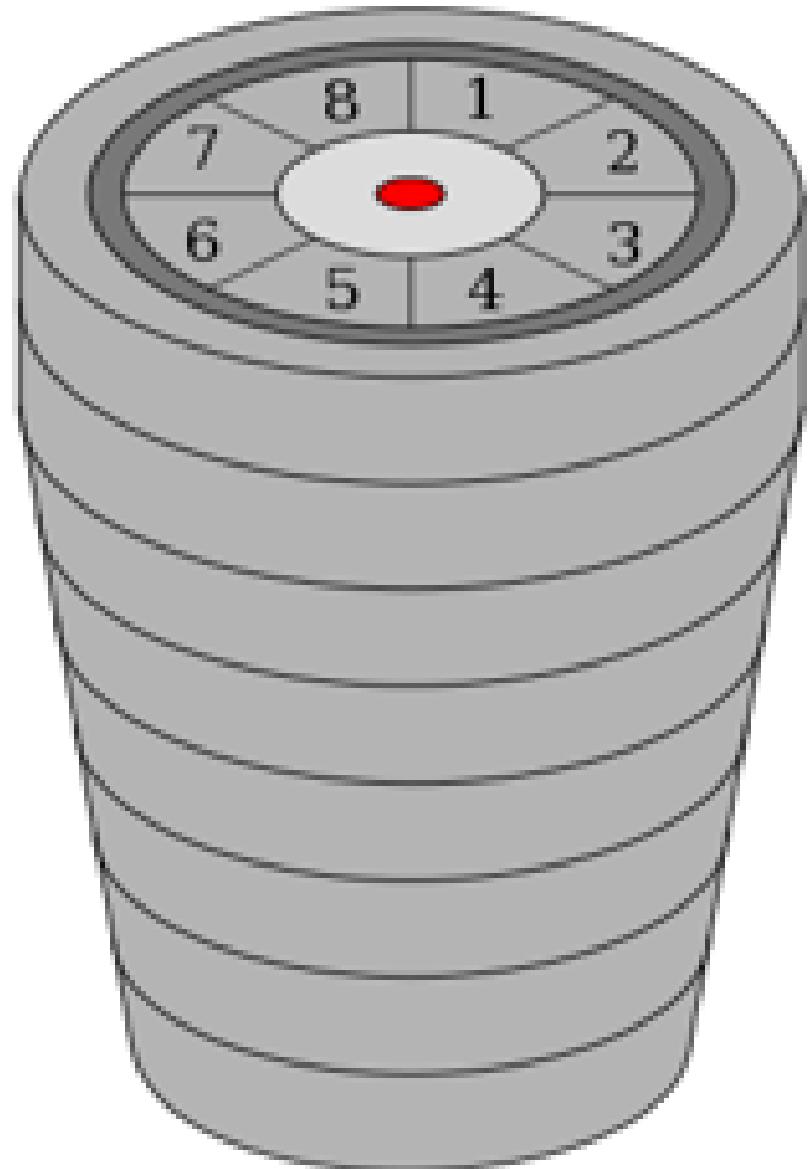
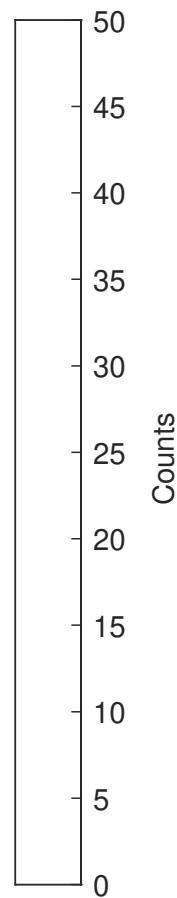
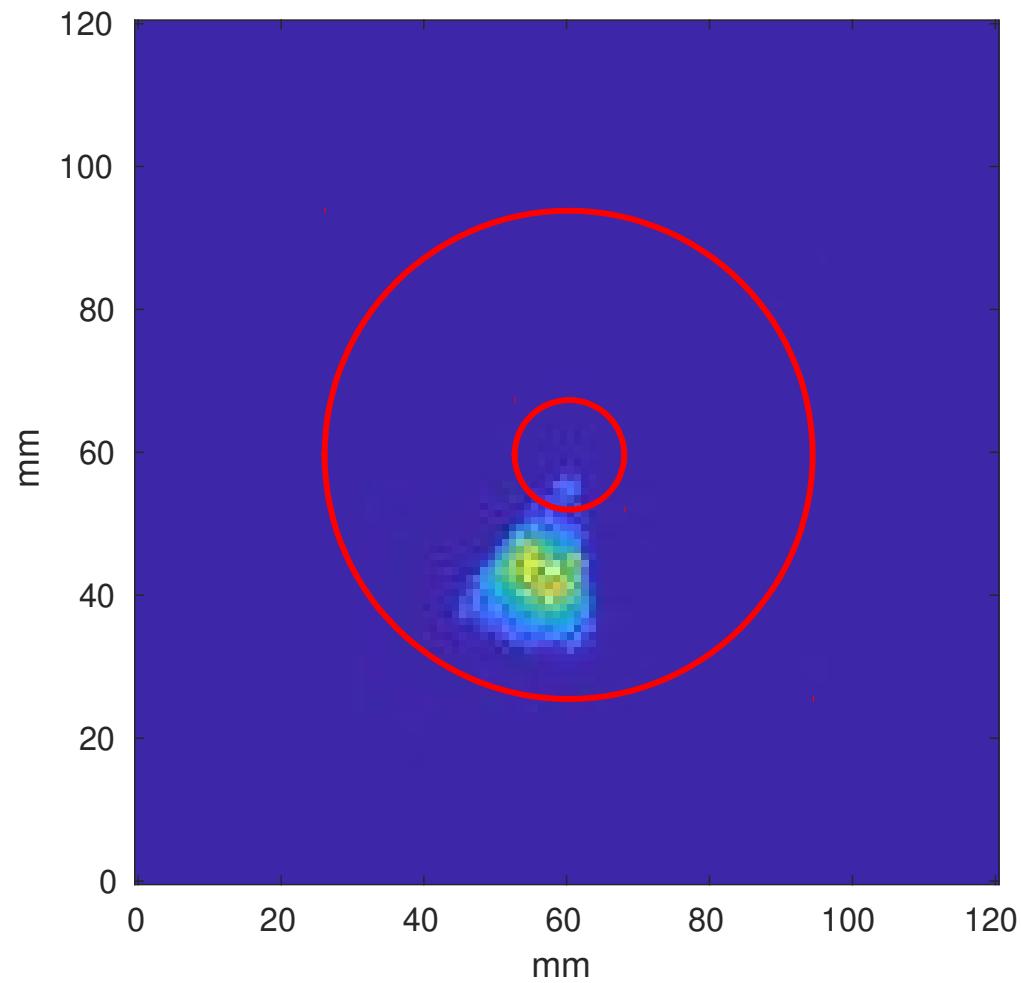
Segment 1



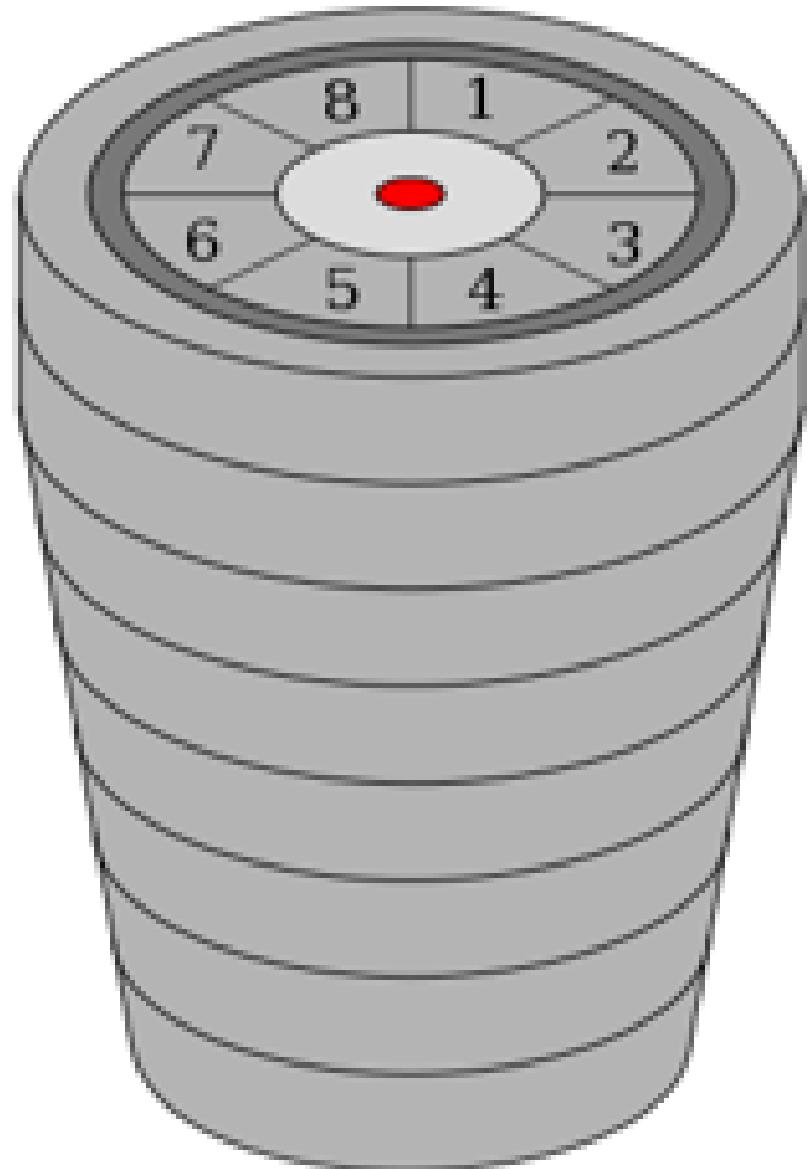
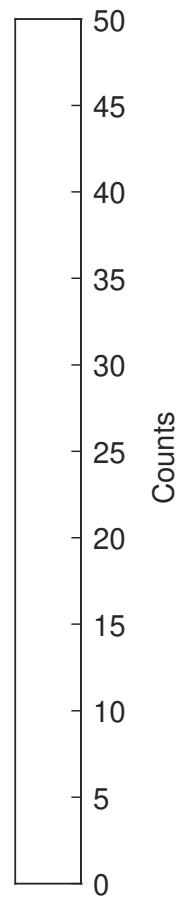
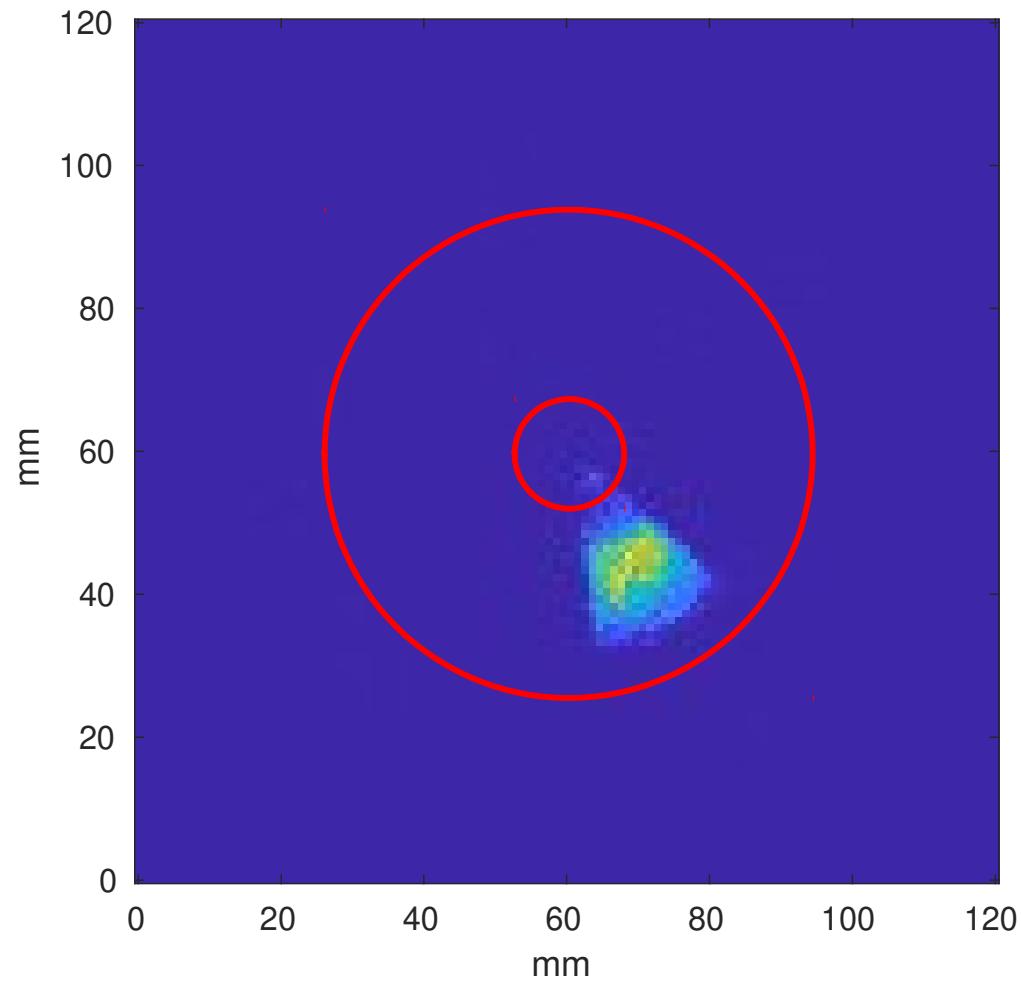
Segment 1



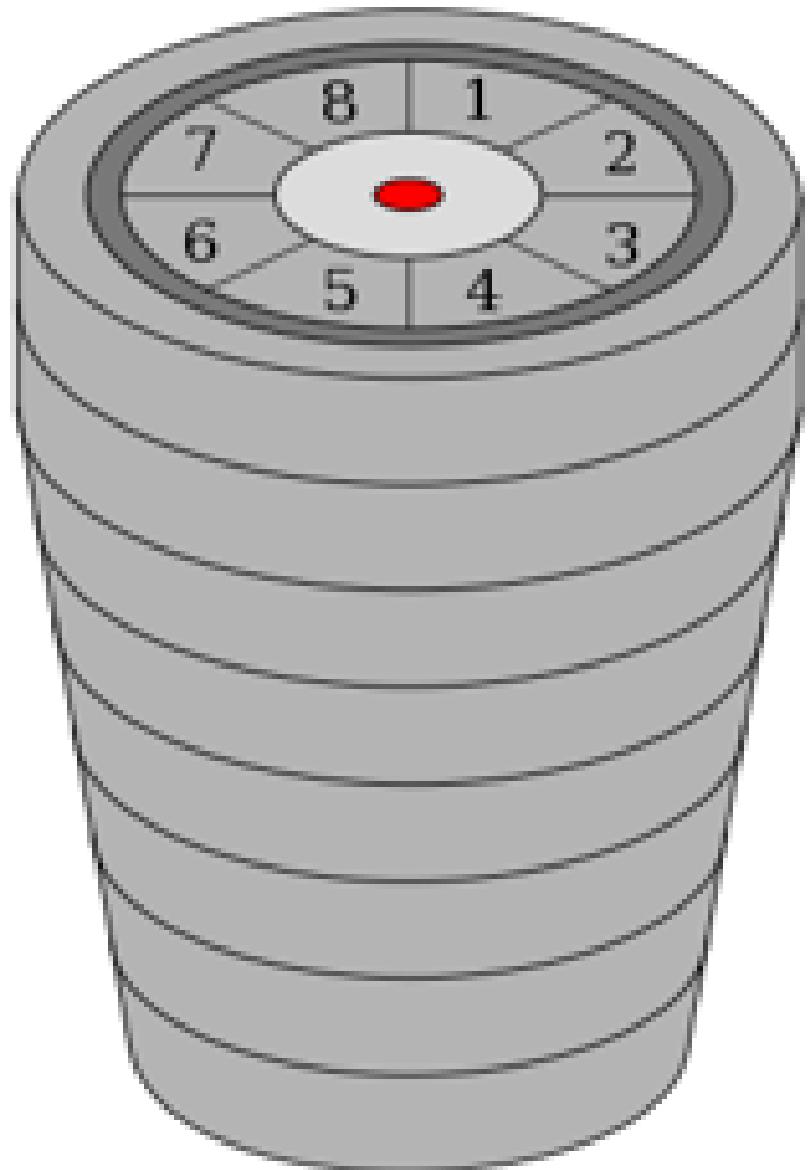
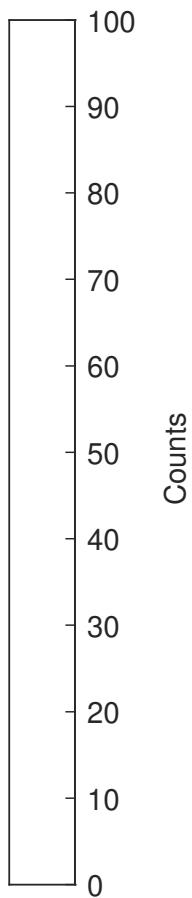
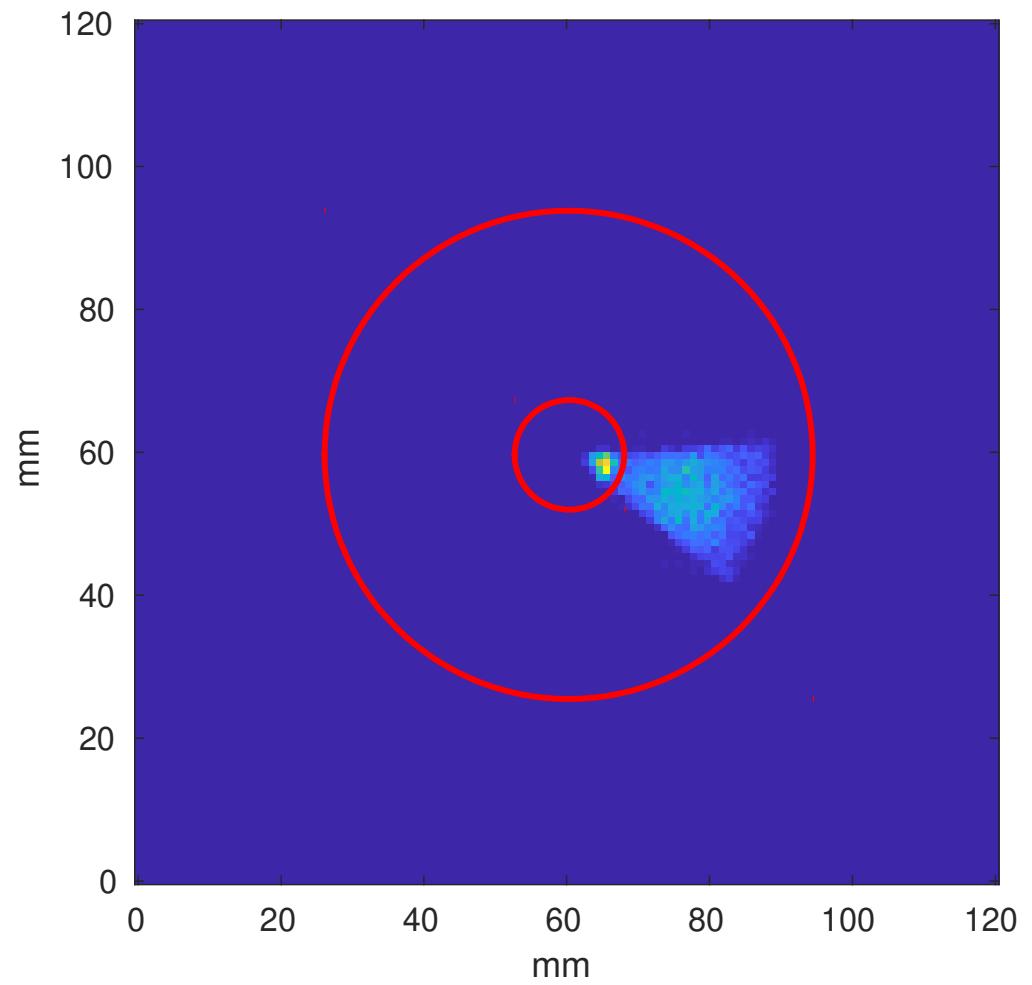
Segment 2



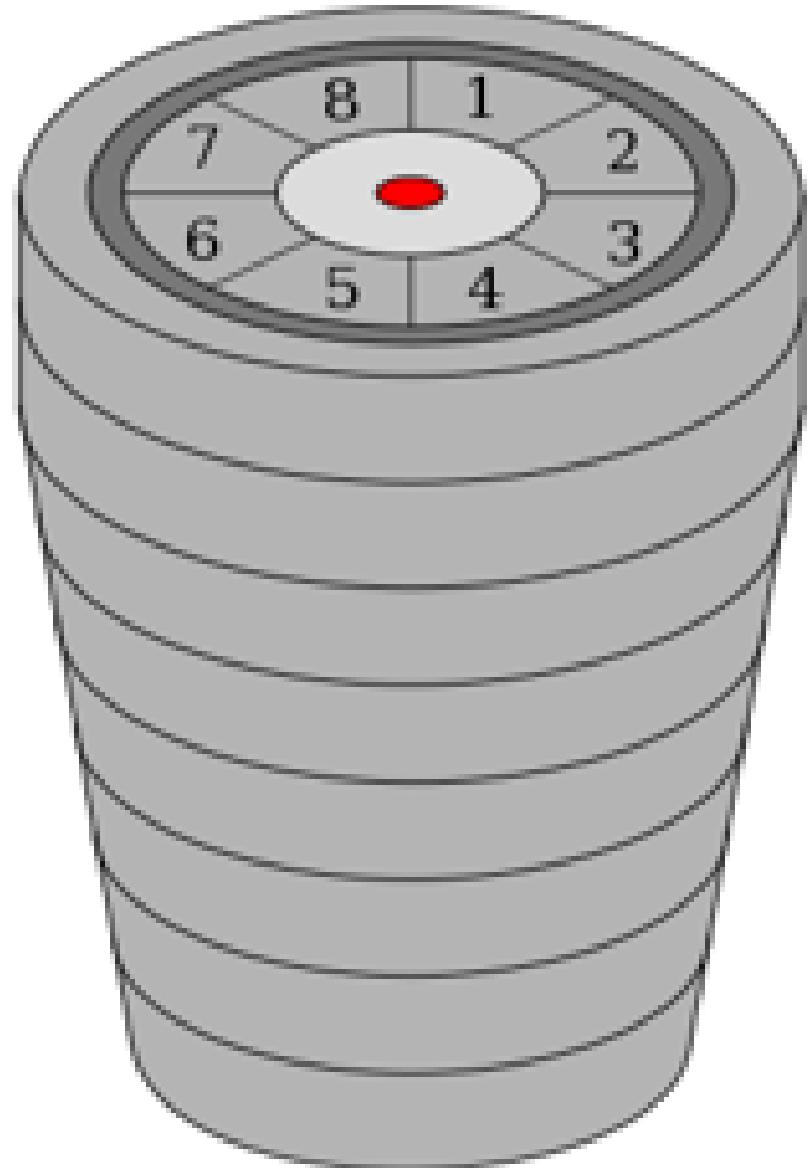
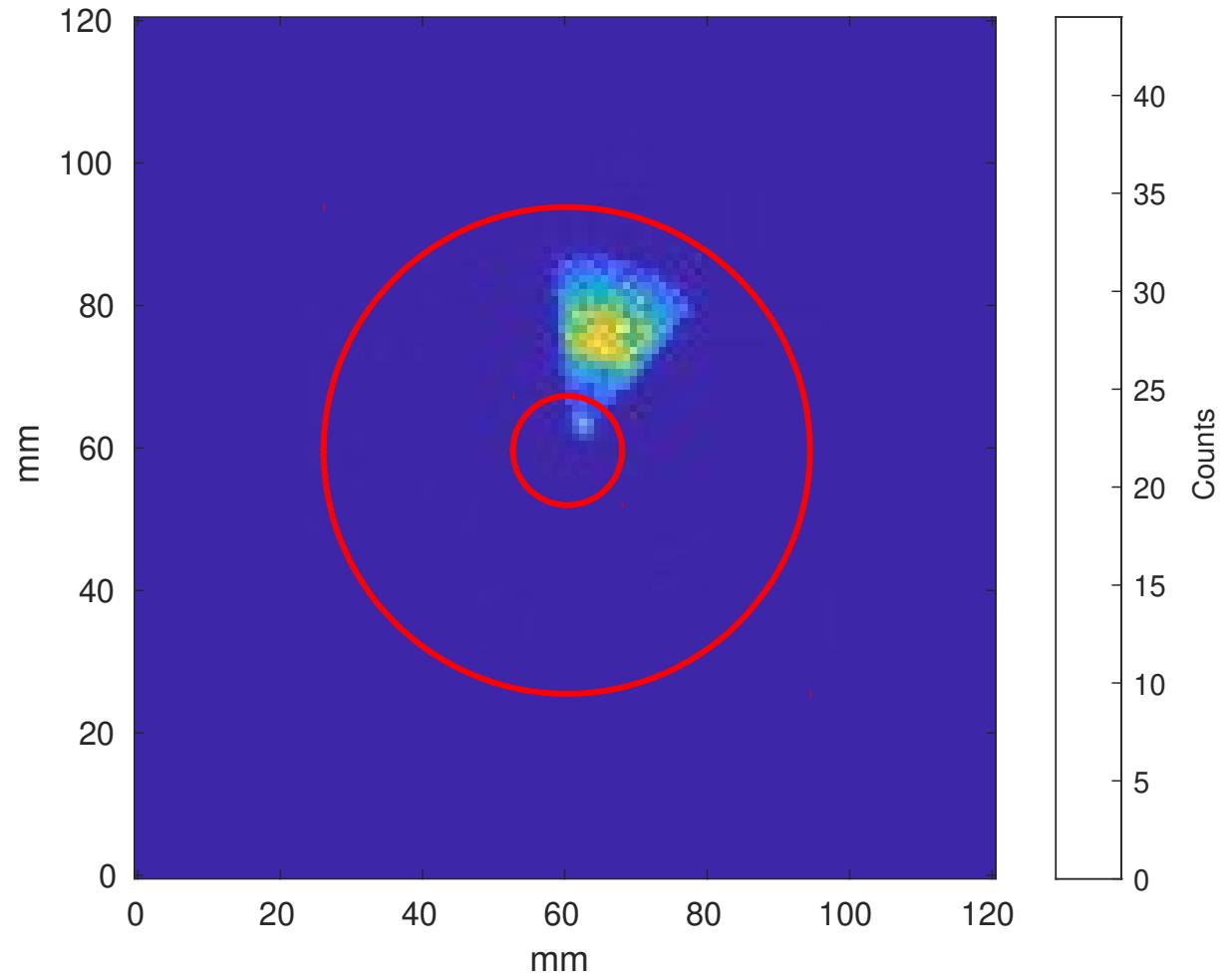
Segment 3



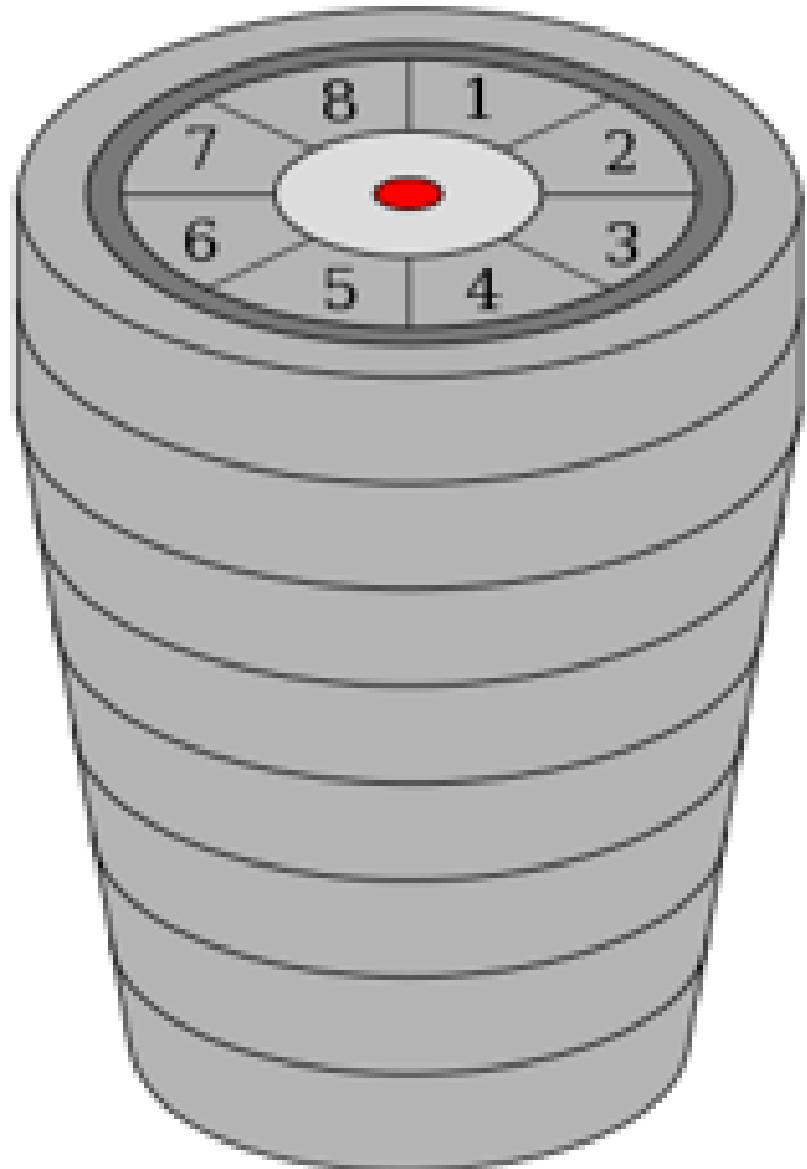
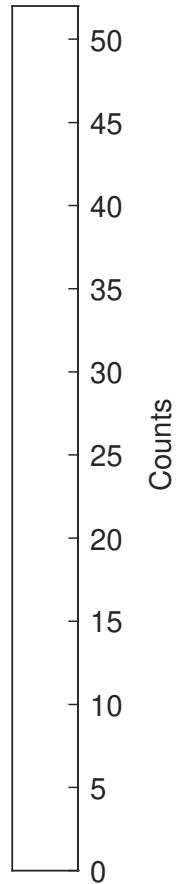
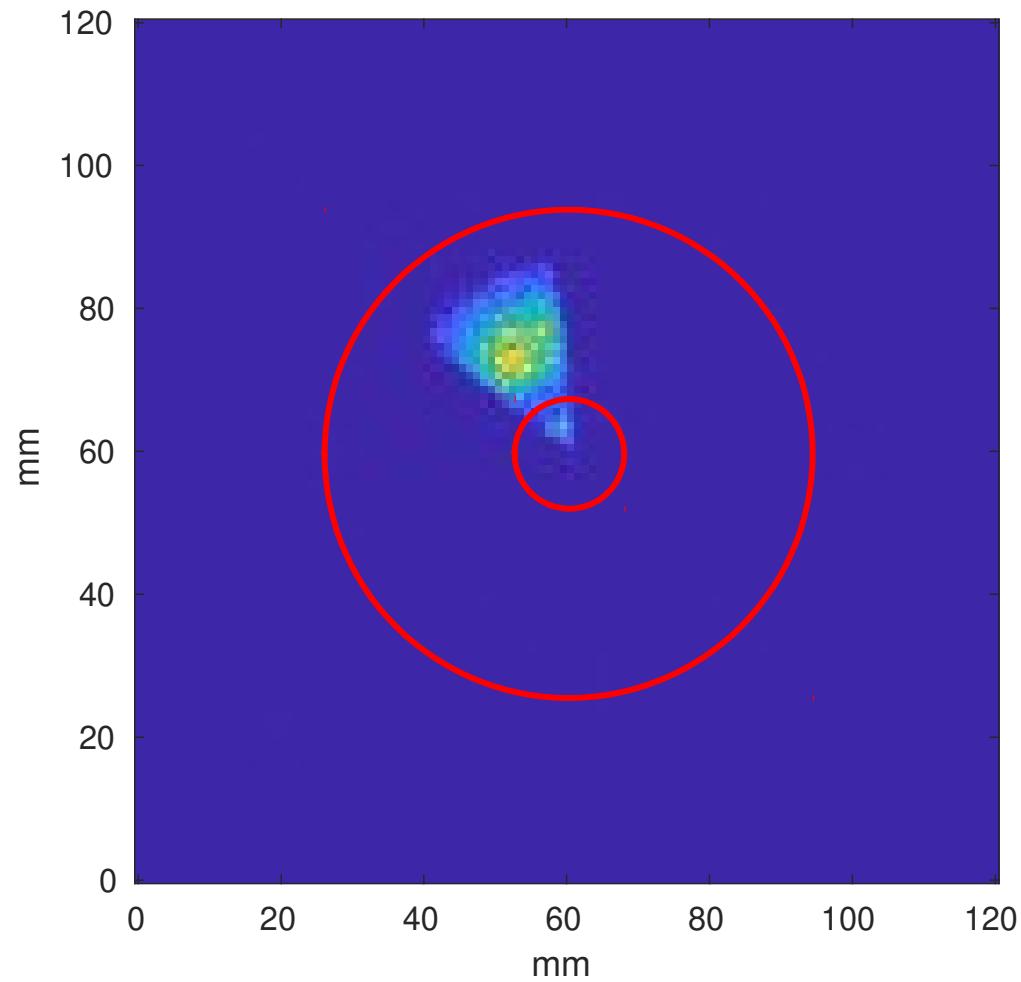
Segment 4



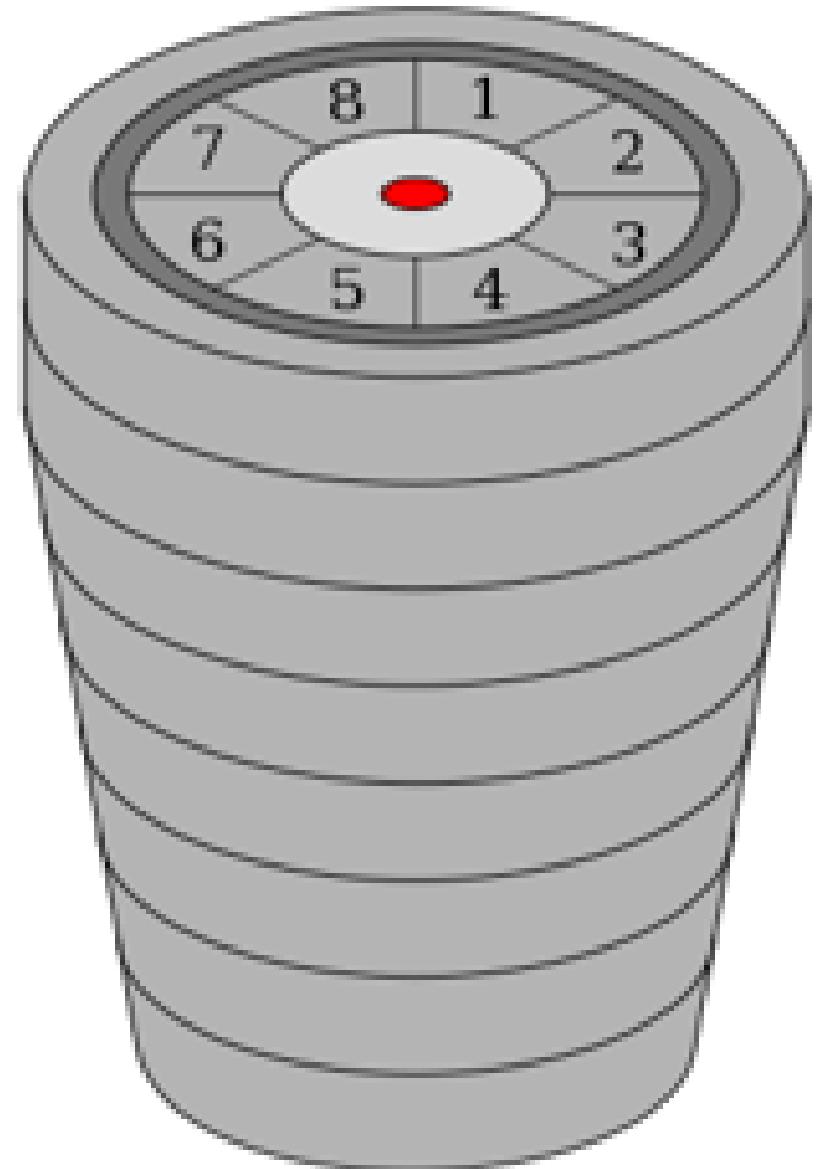
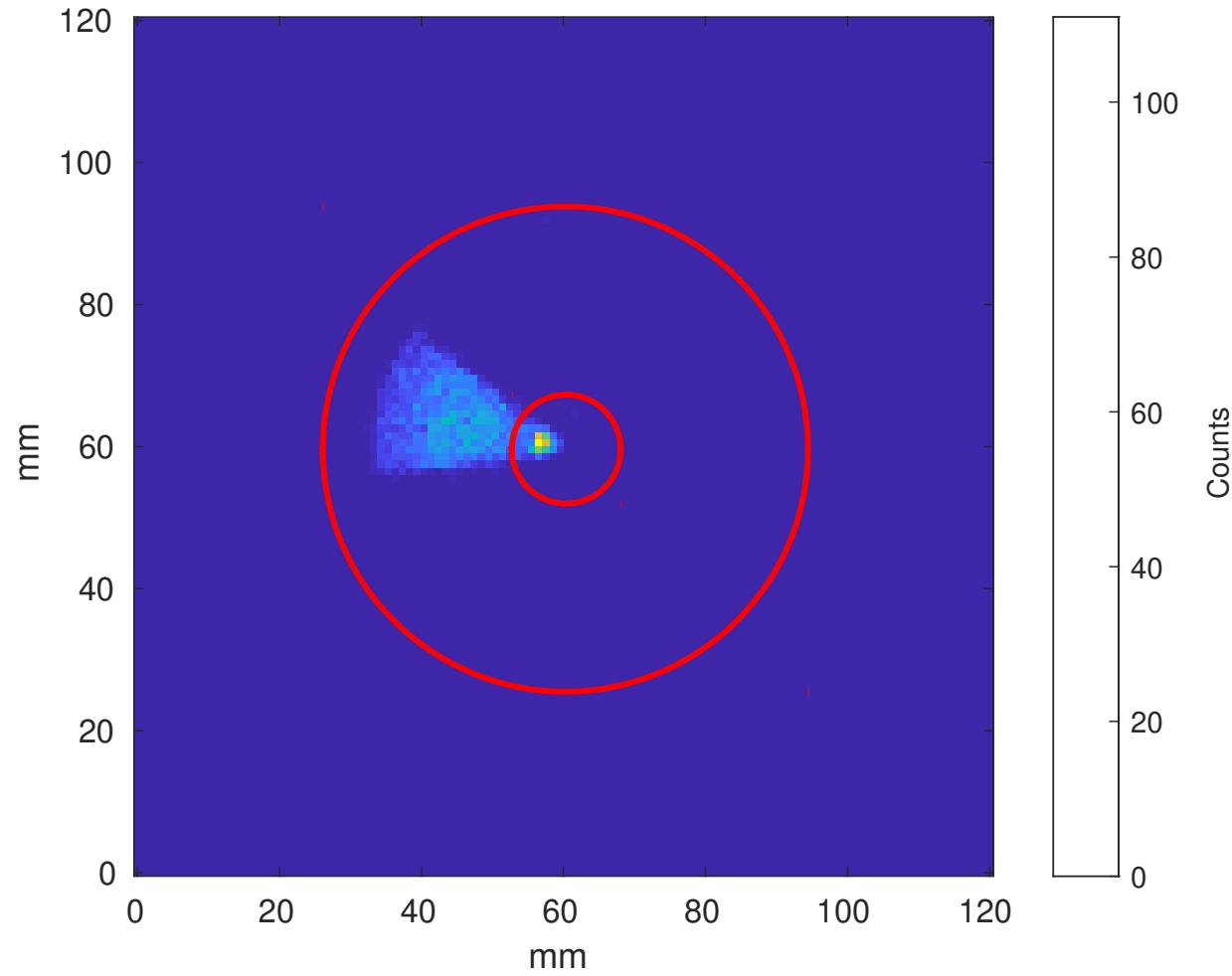
Segment 6



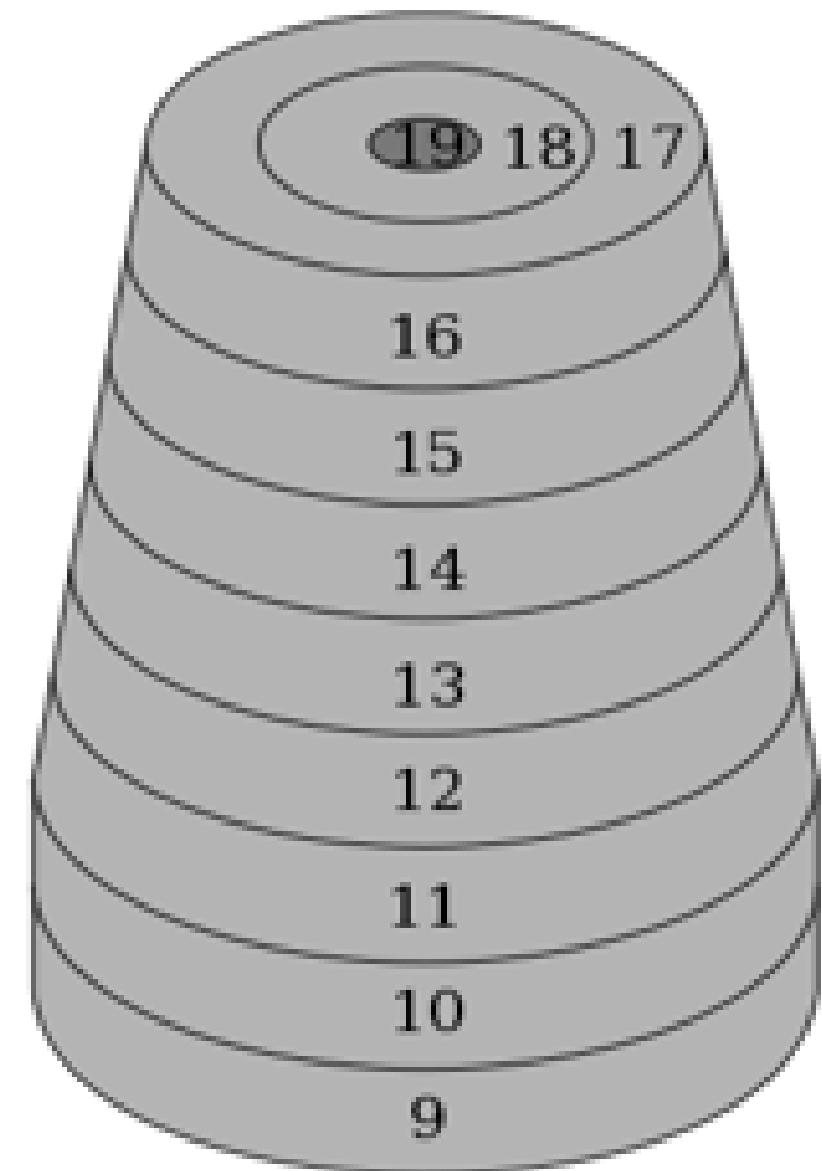
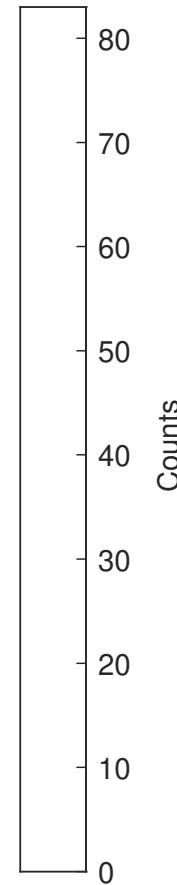
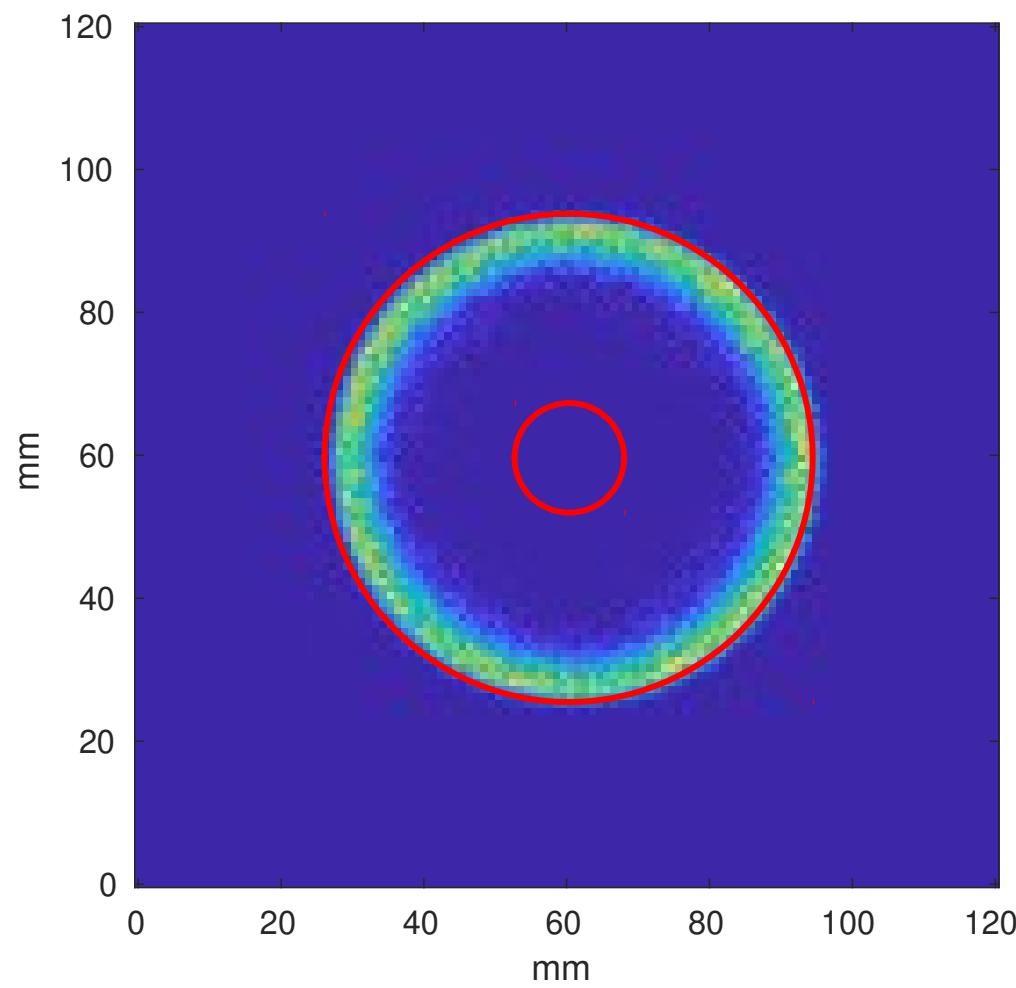
Segment 7



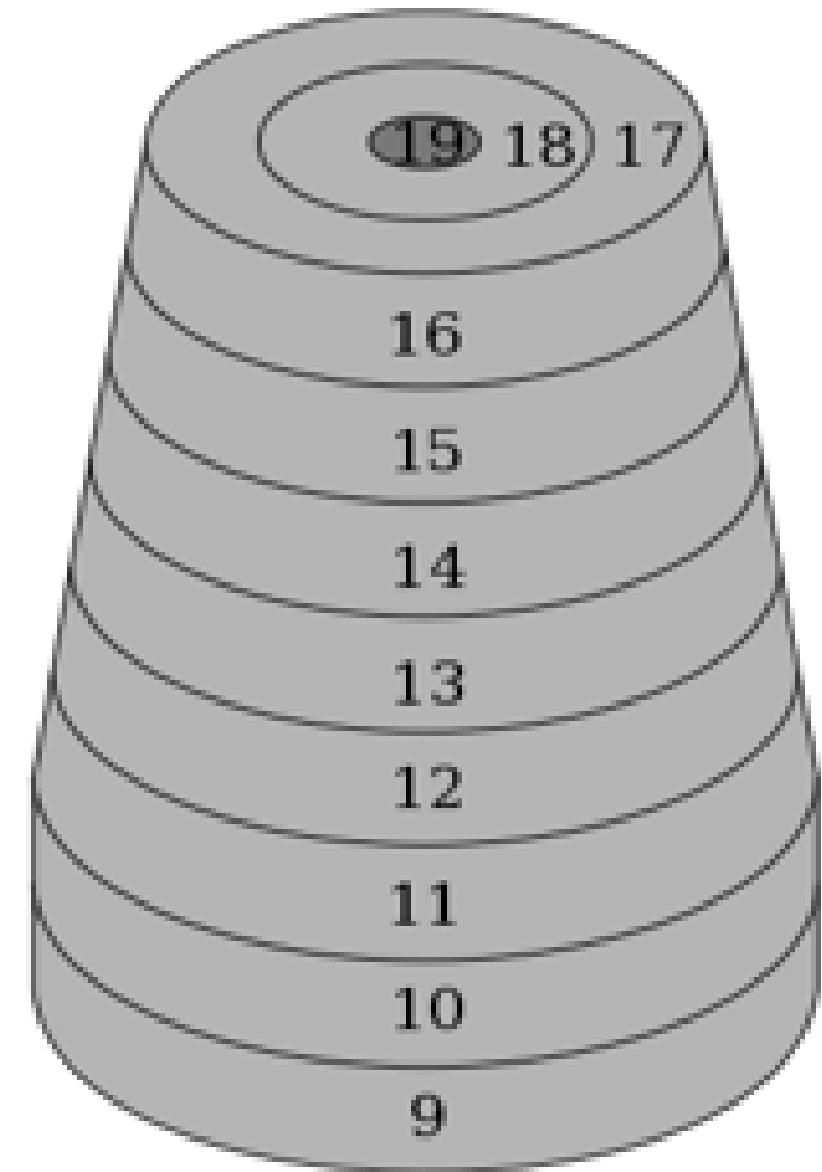
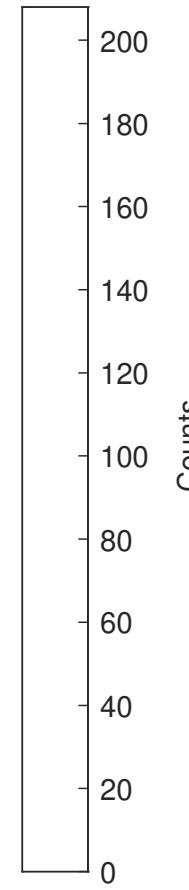
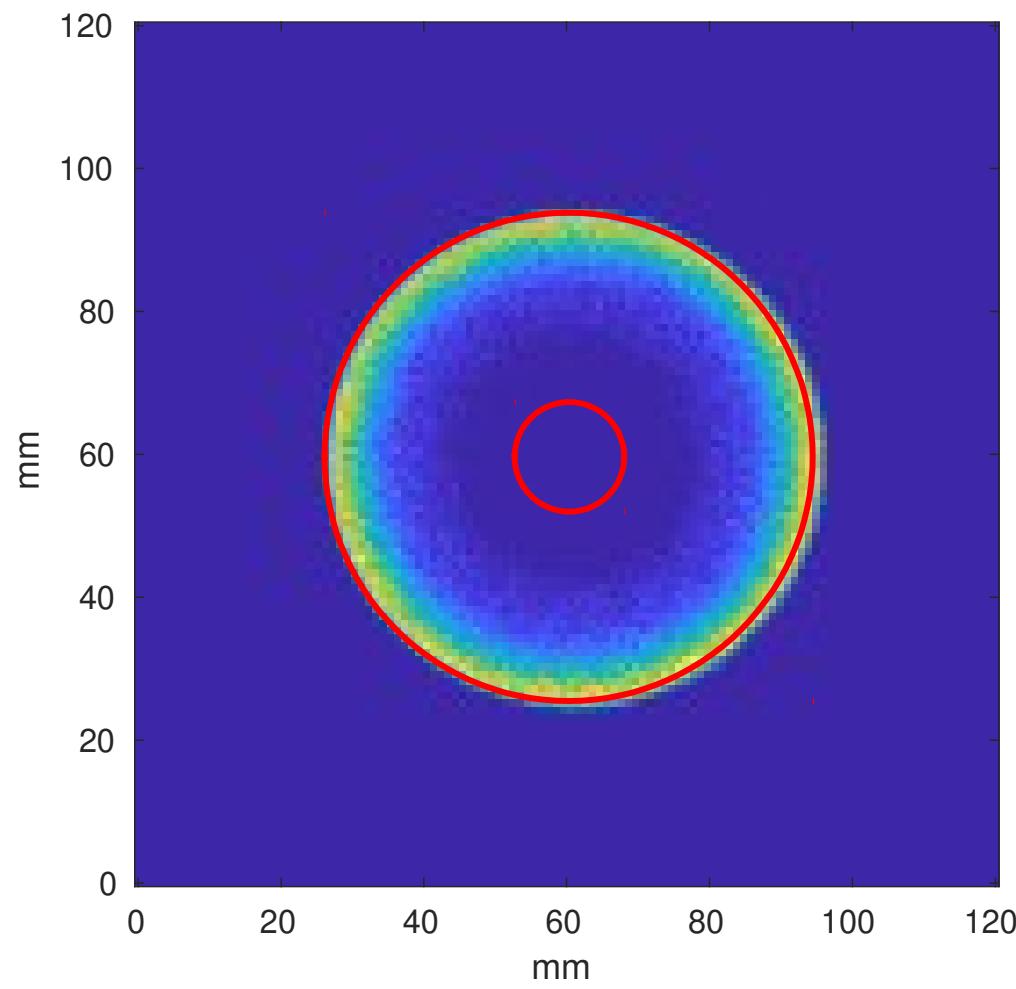
Segment 8



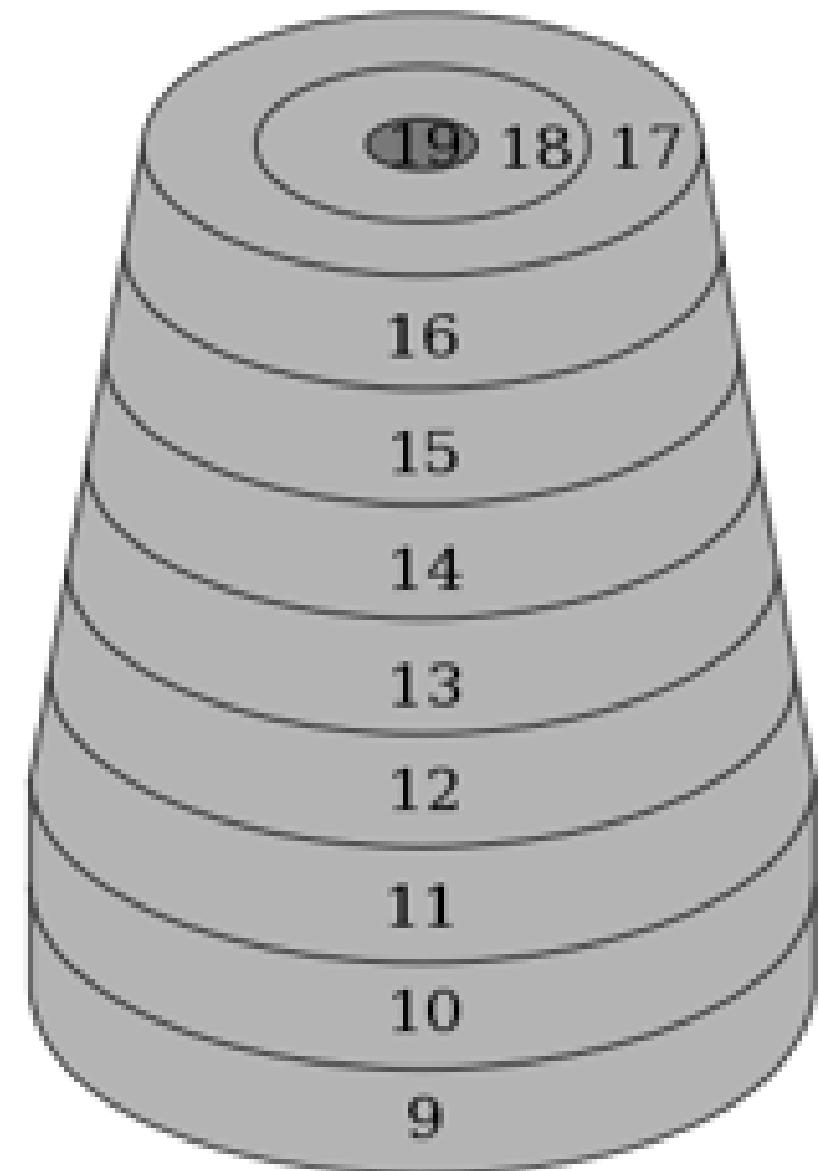
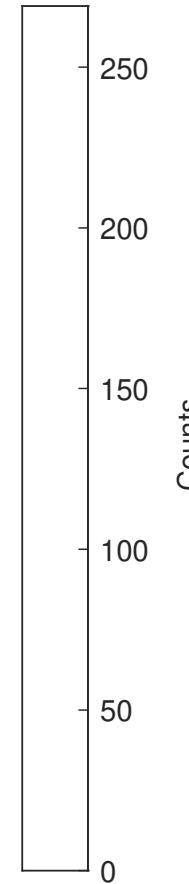
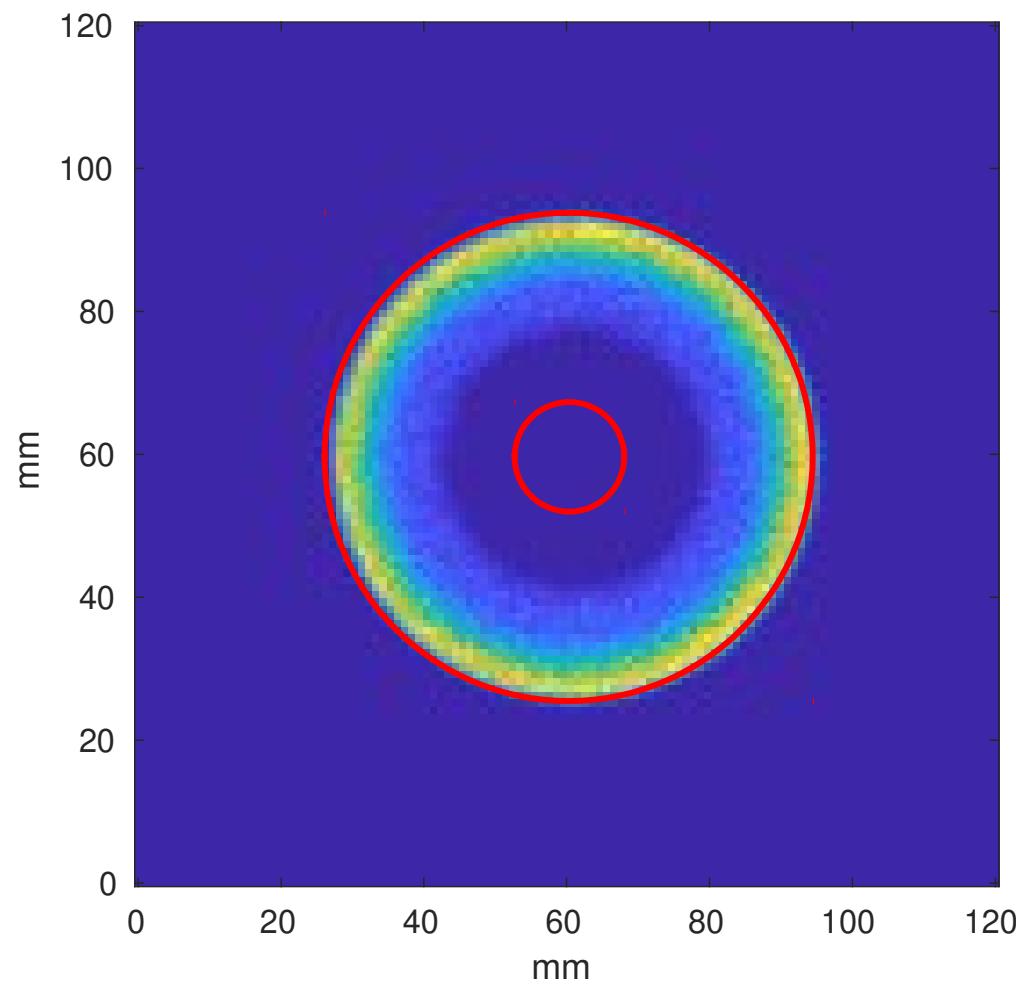
Segment 9



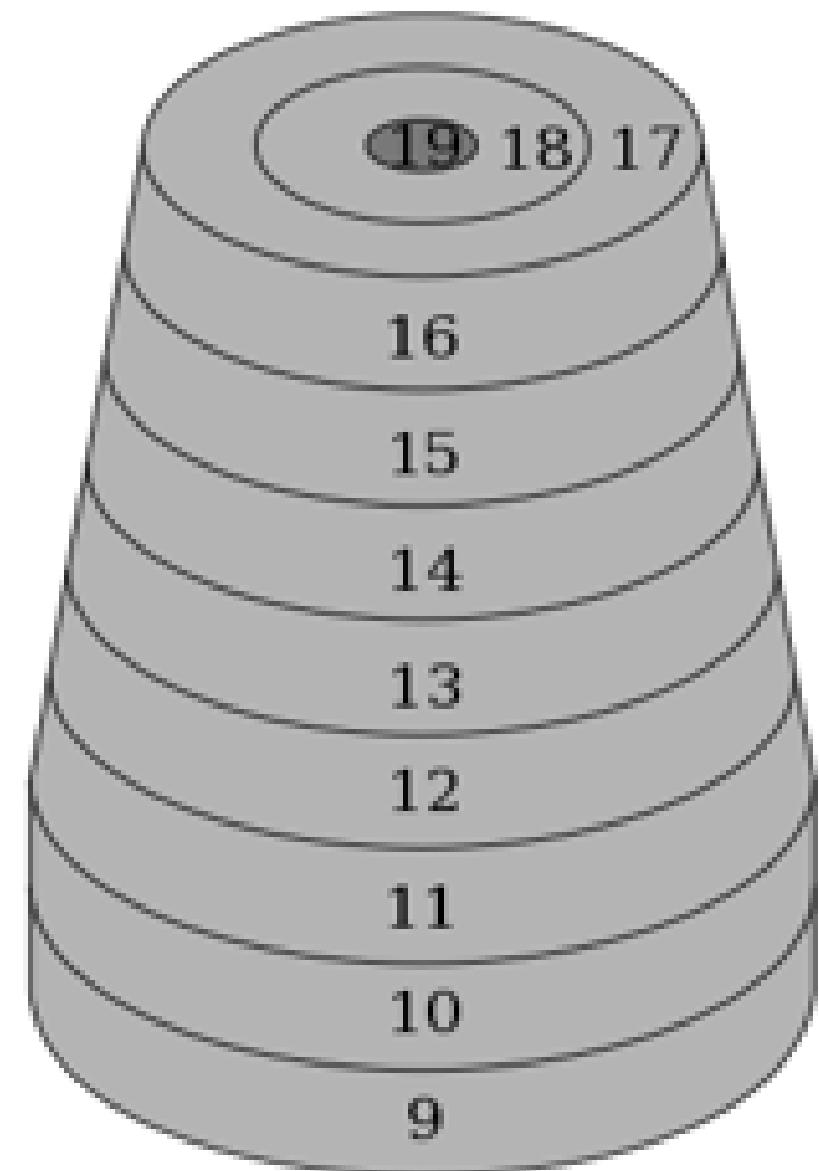
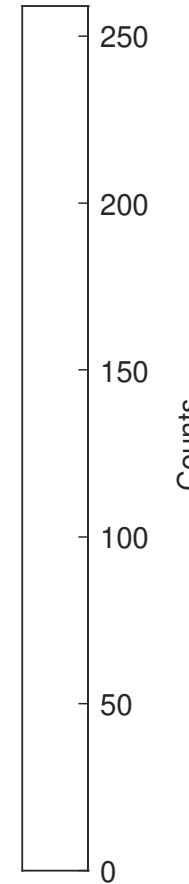
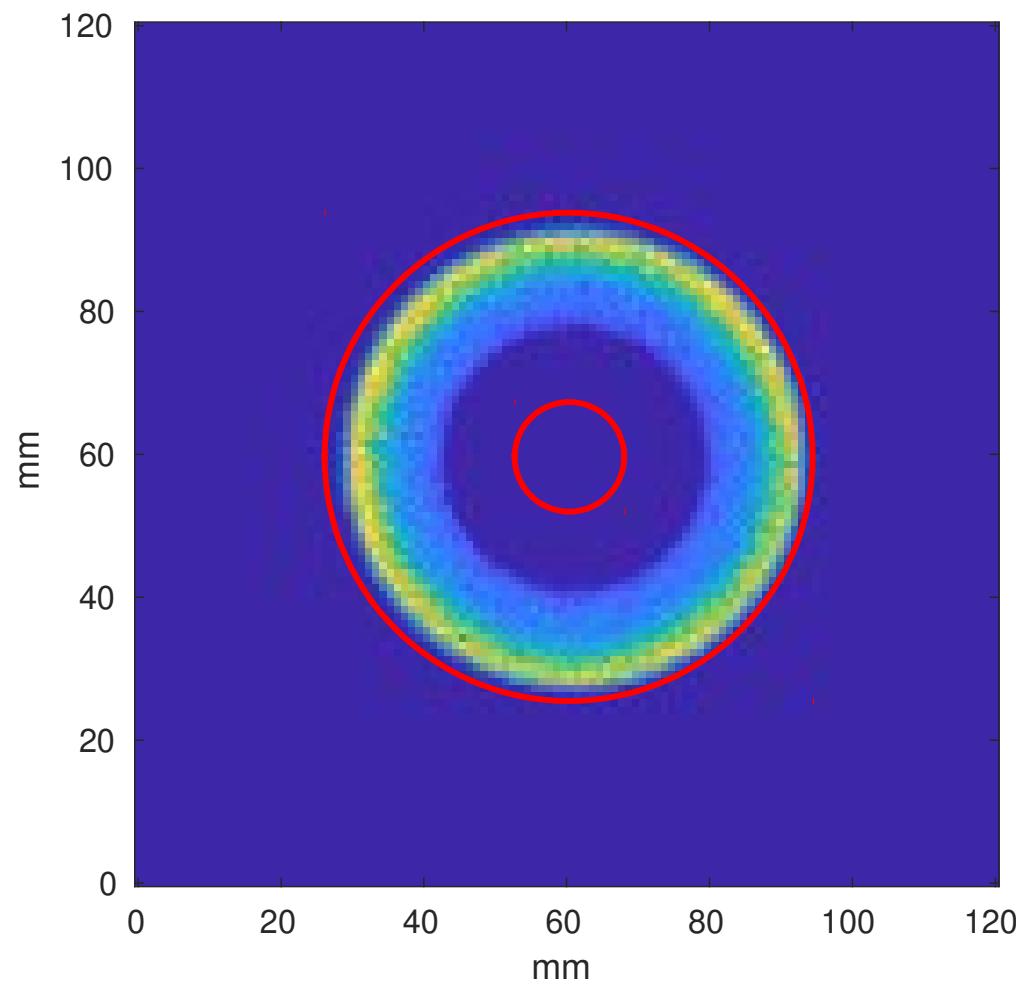
Segment 10



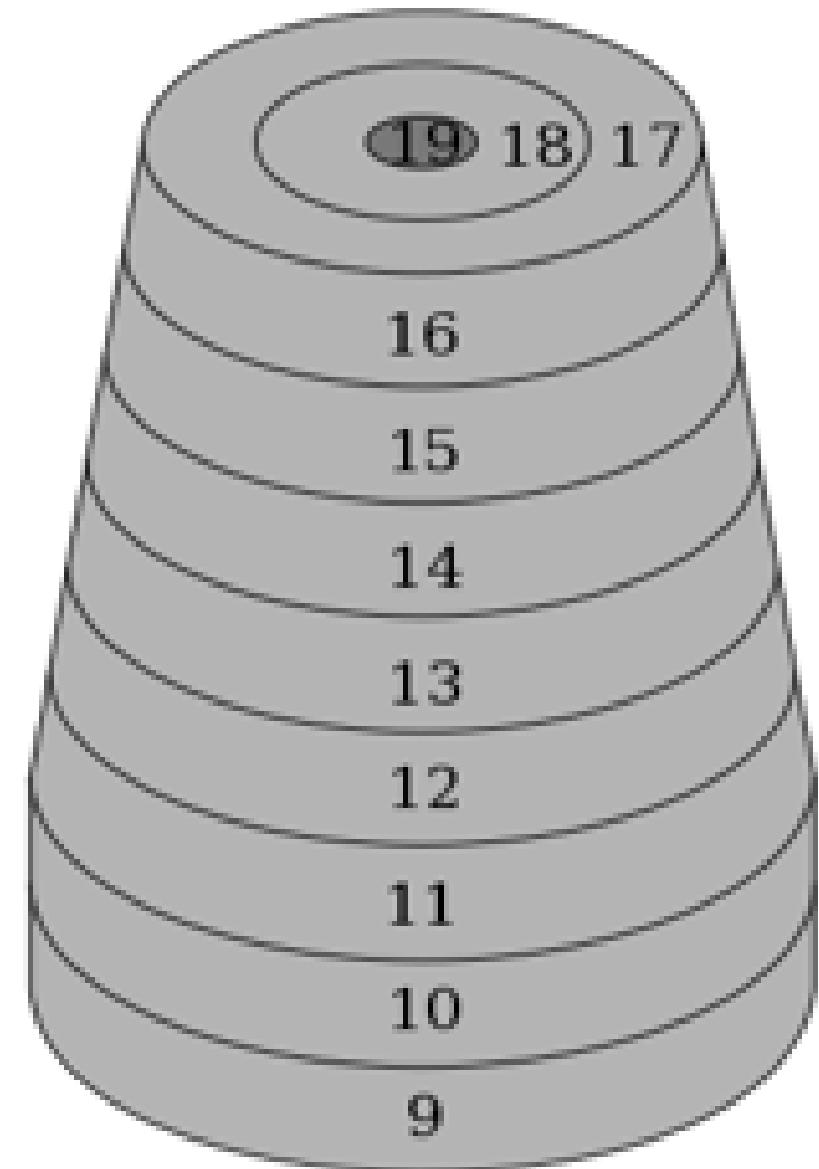
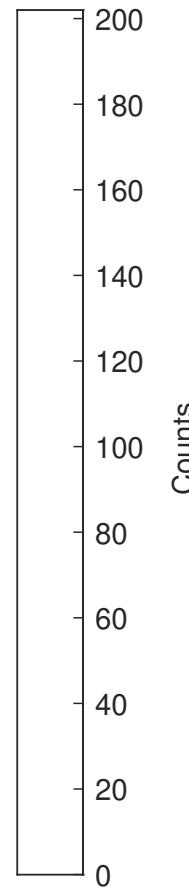
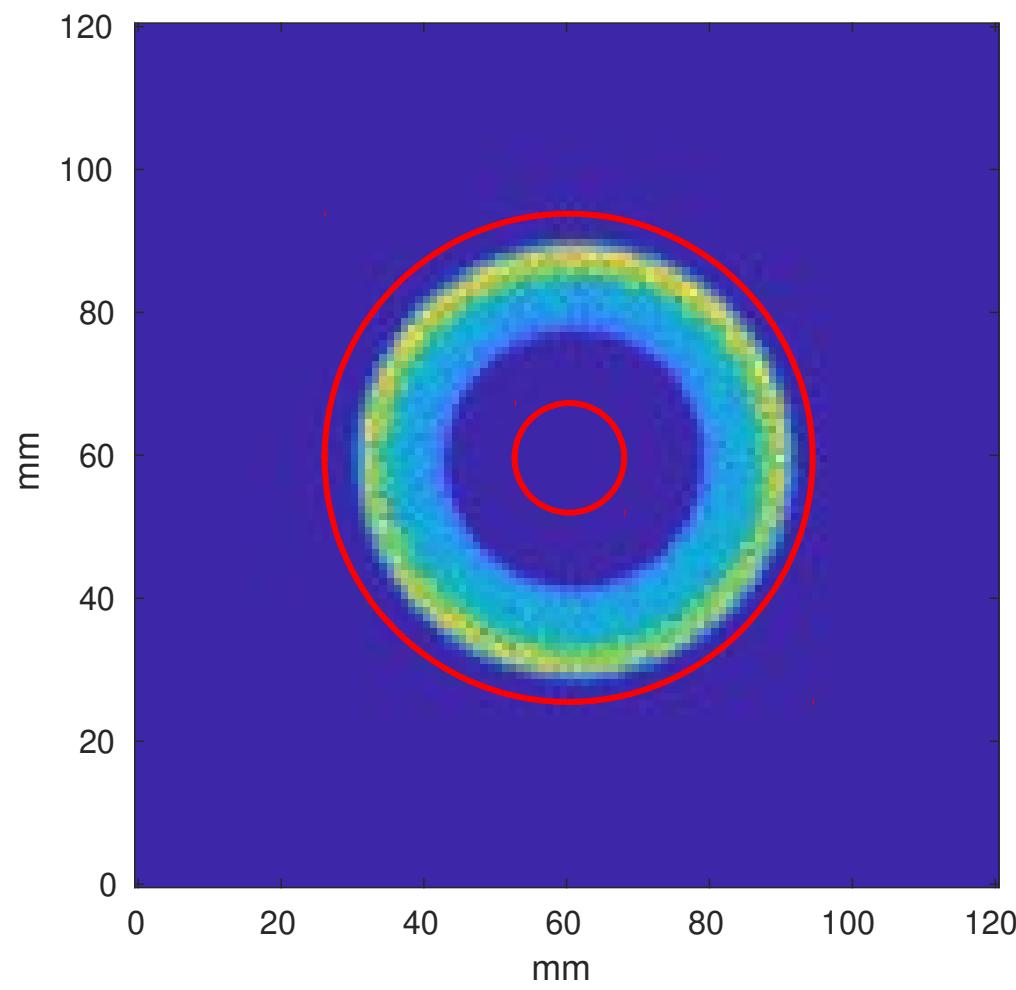
Segment 11



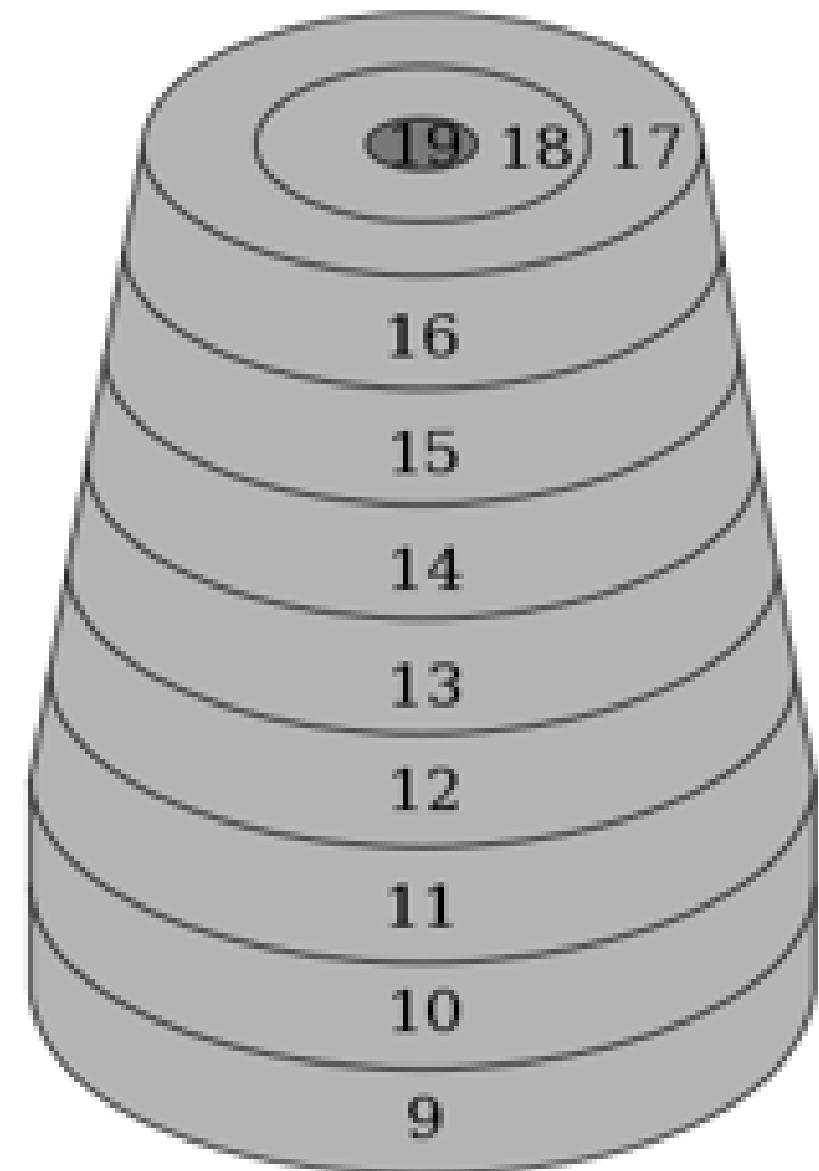
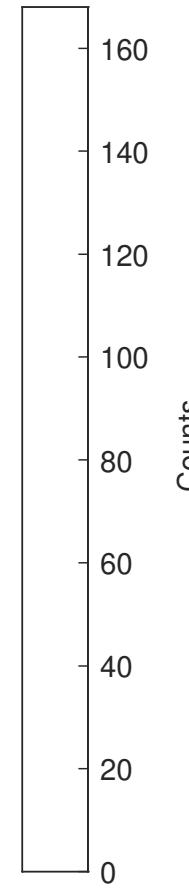
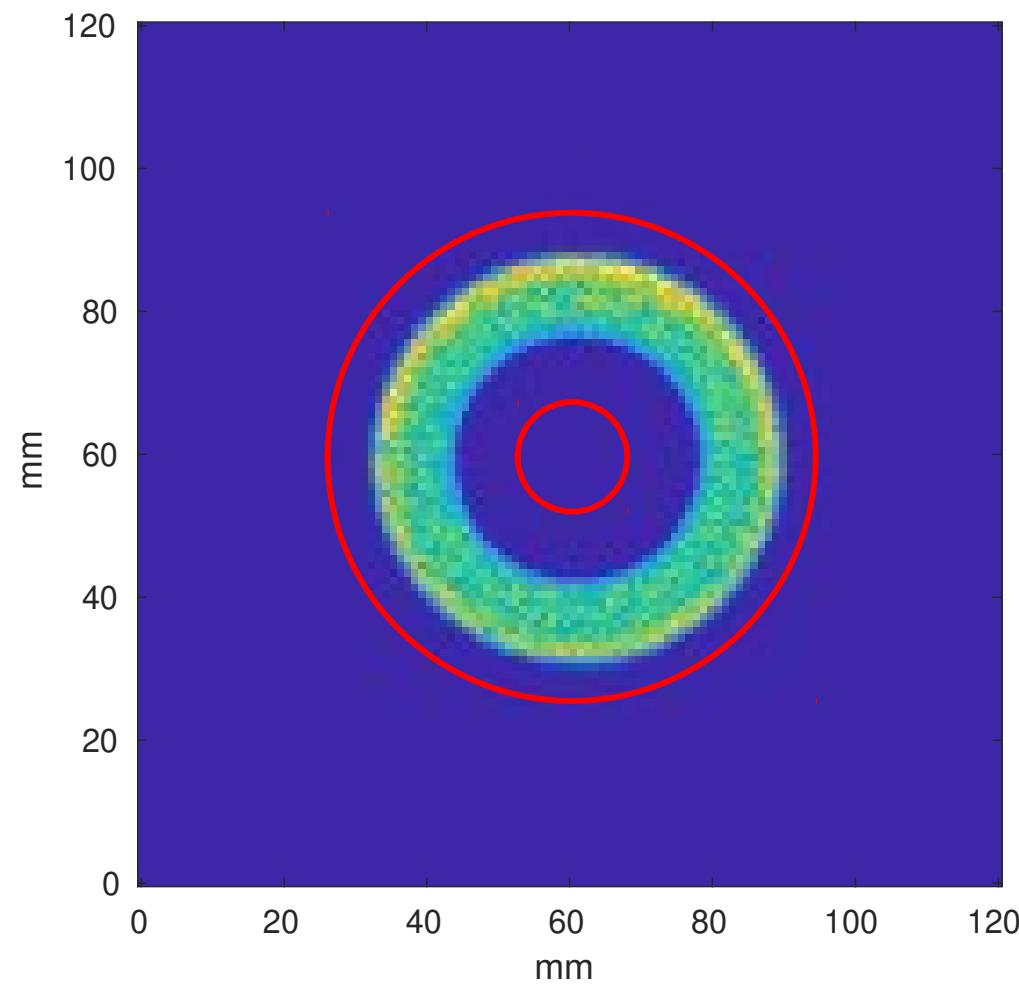
Segment 12



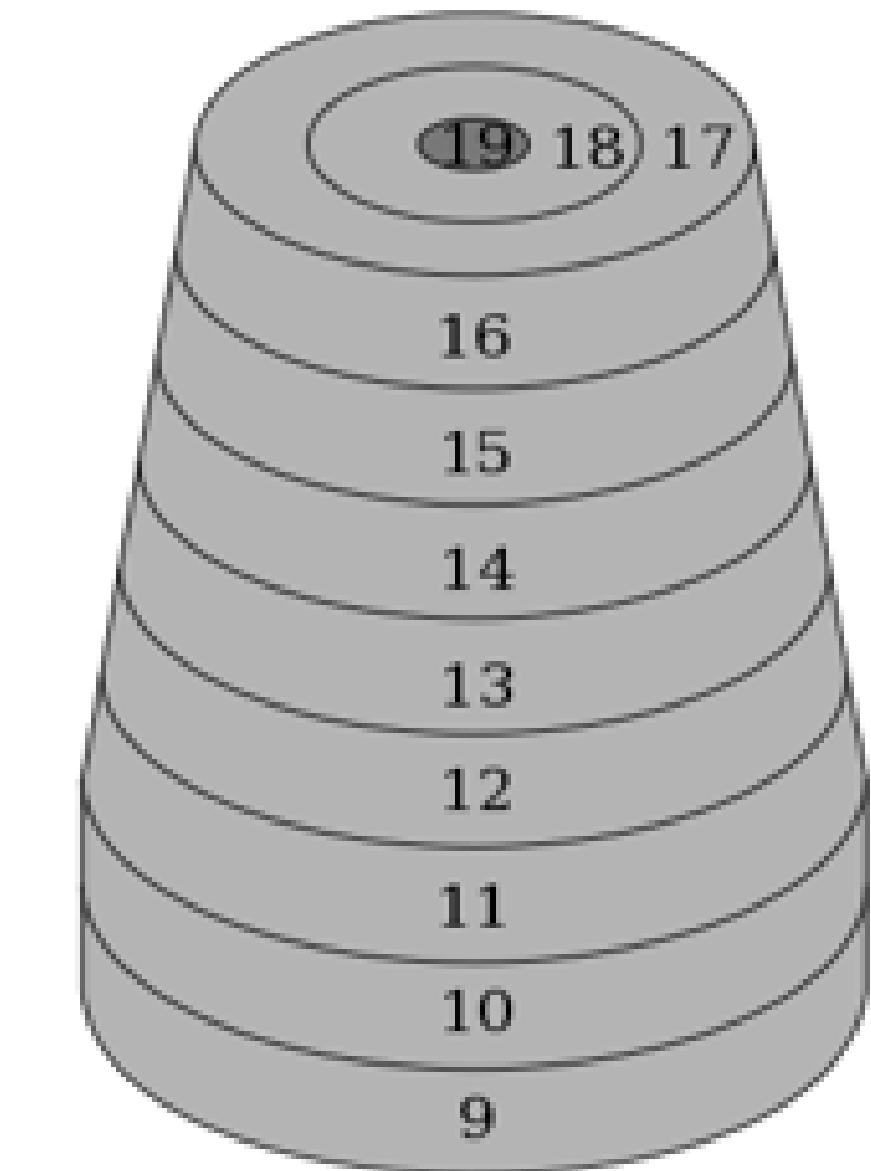
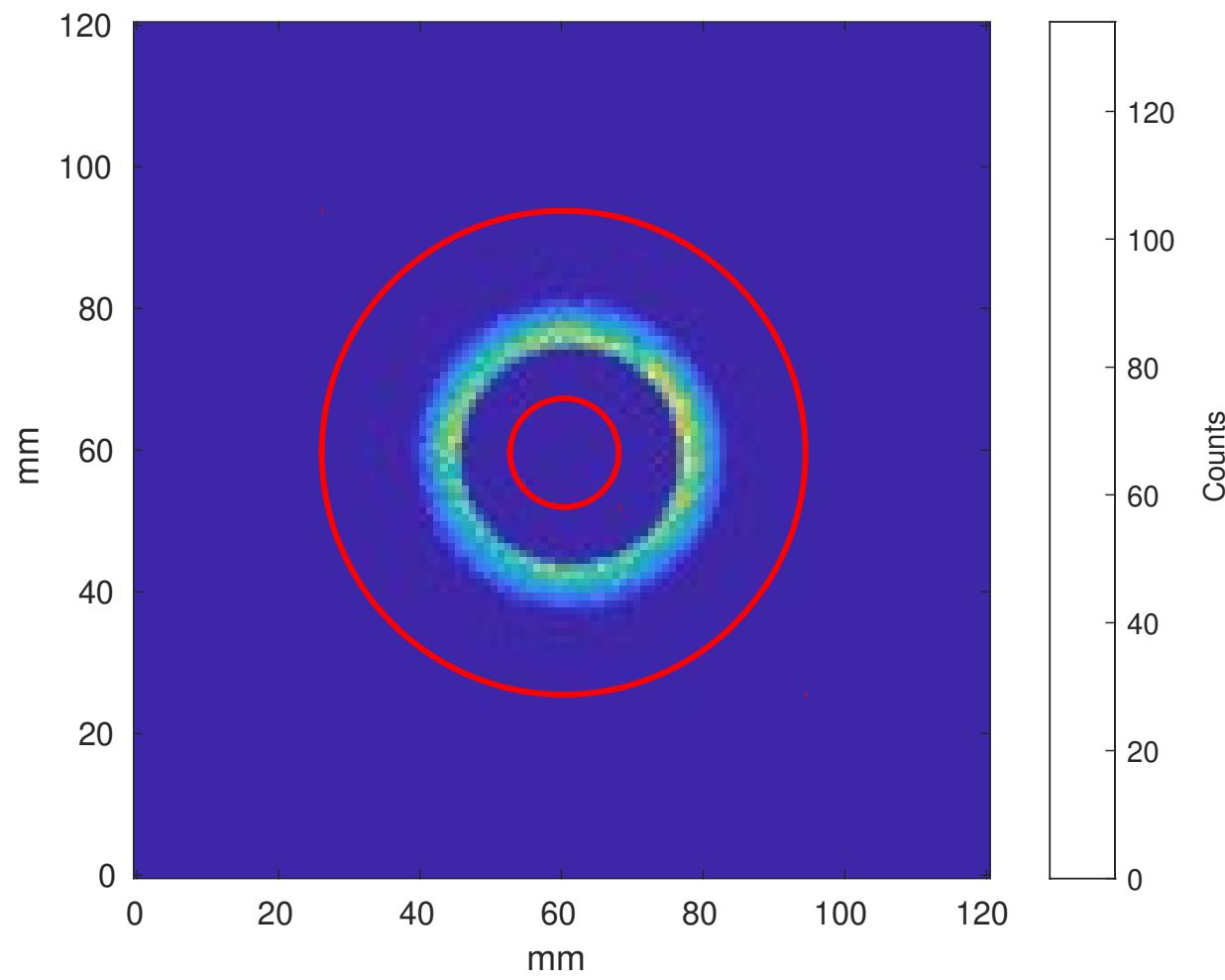
Segment 13



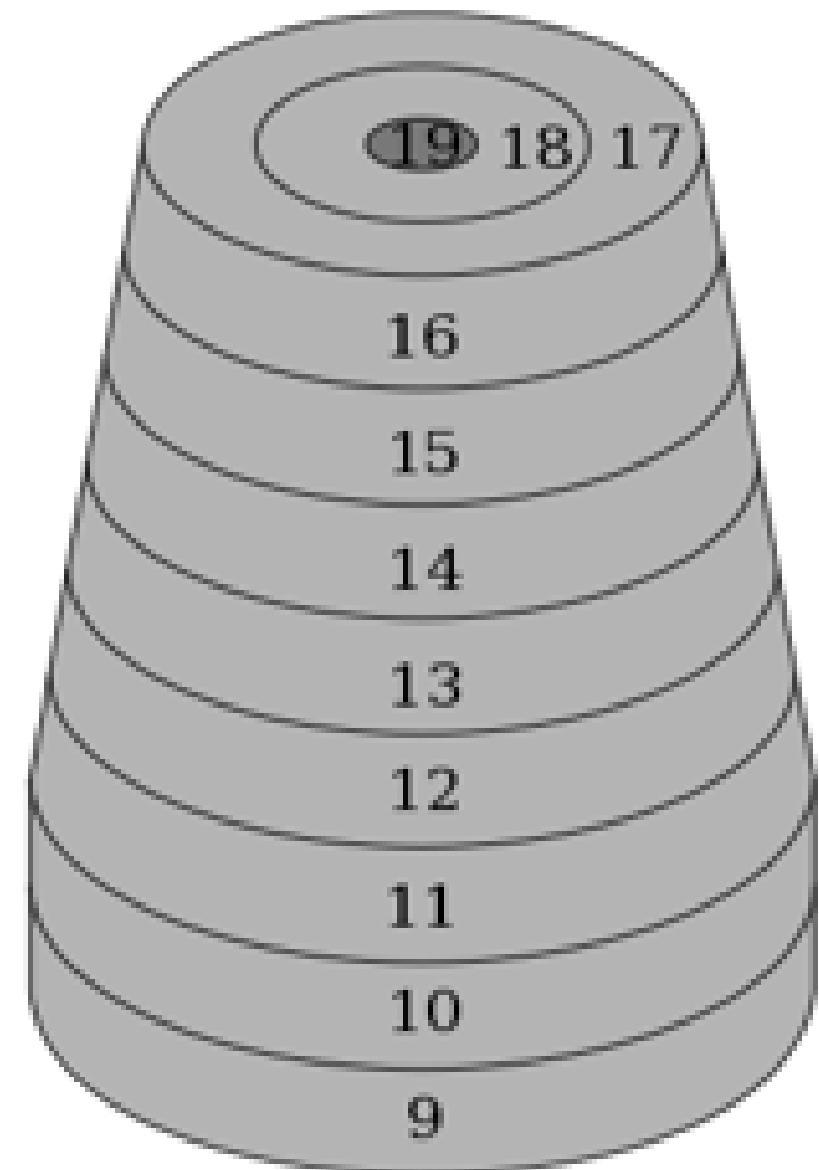
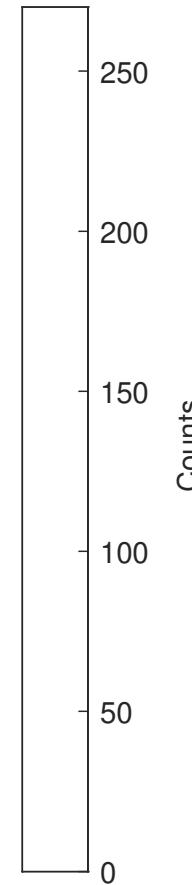
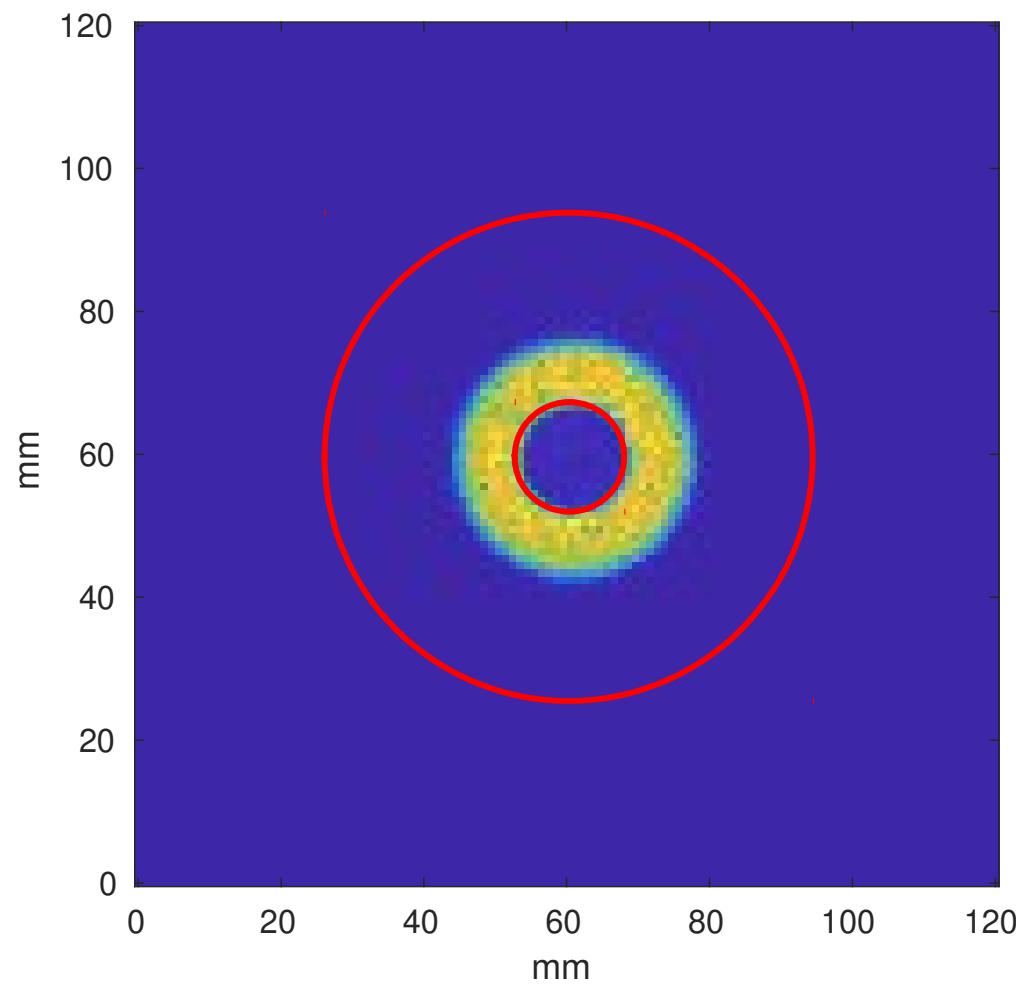
Segment 14



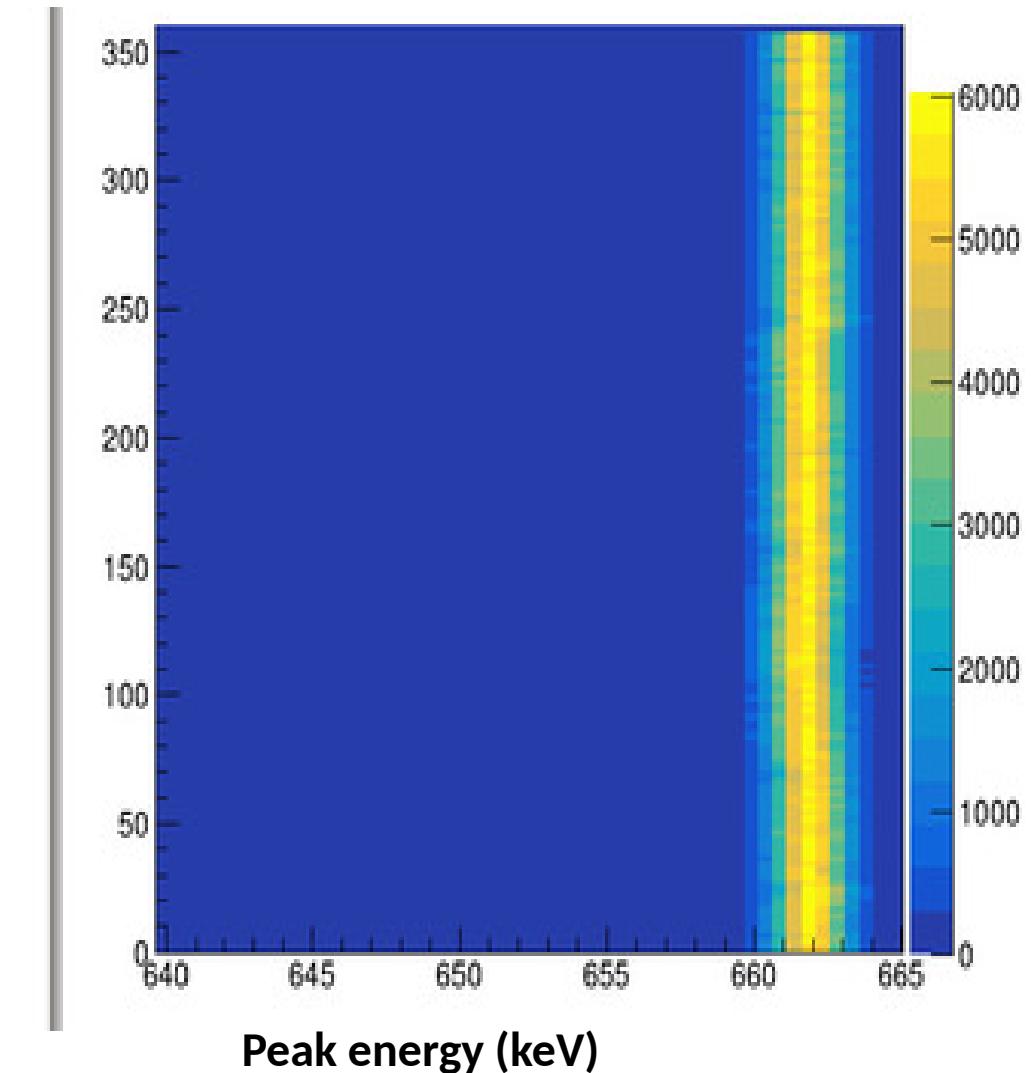
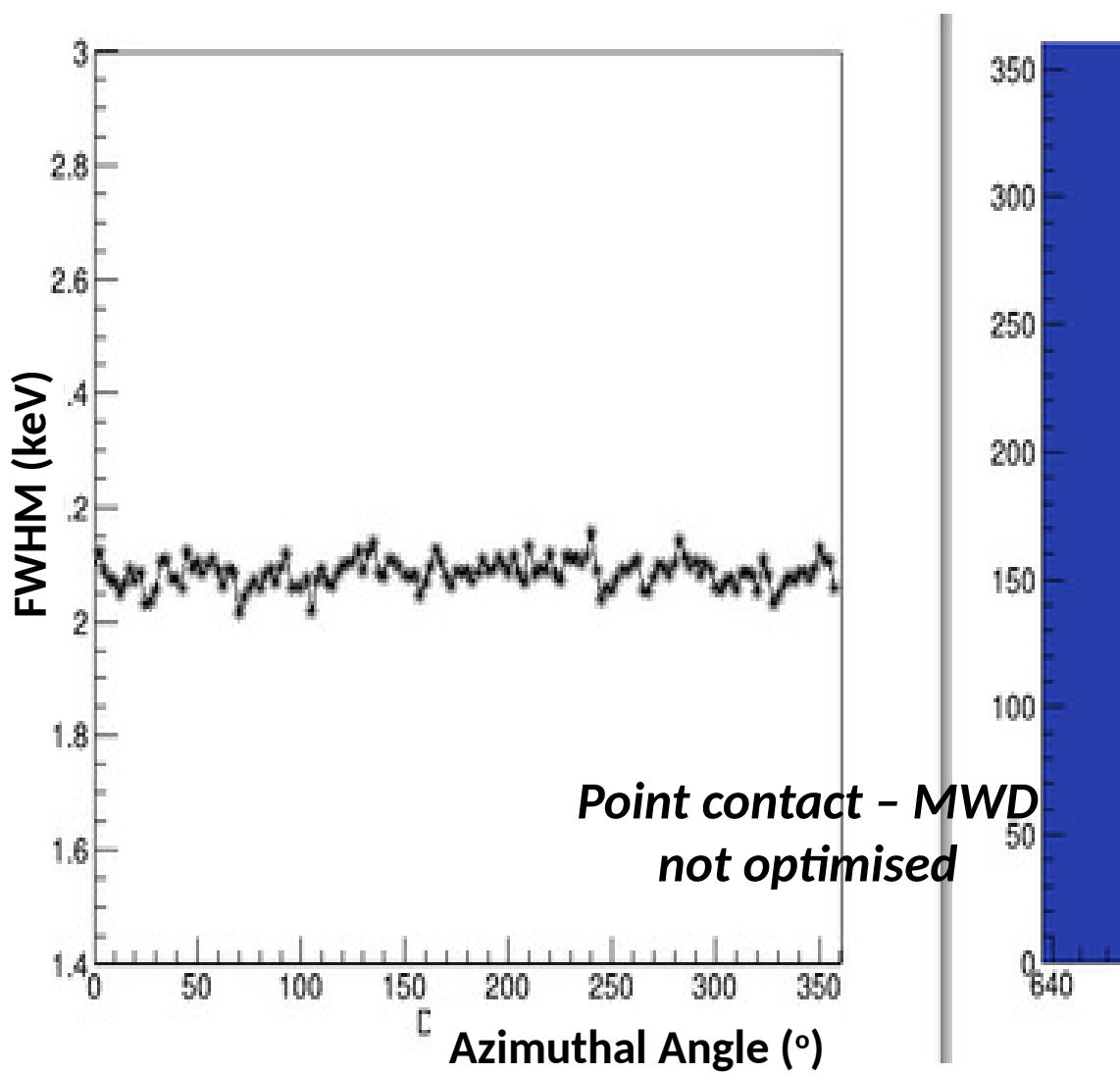
Segment 17



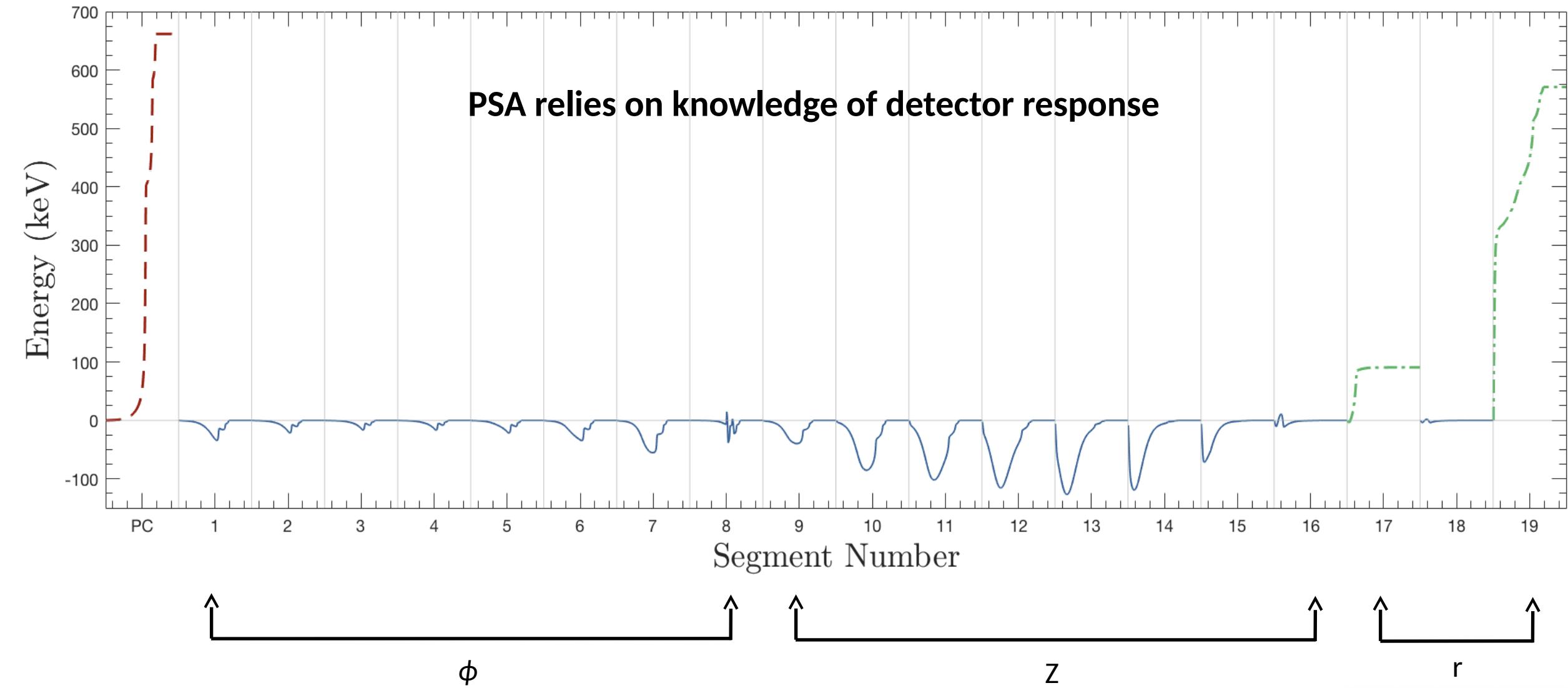
Segment 19



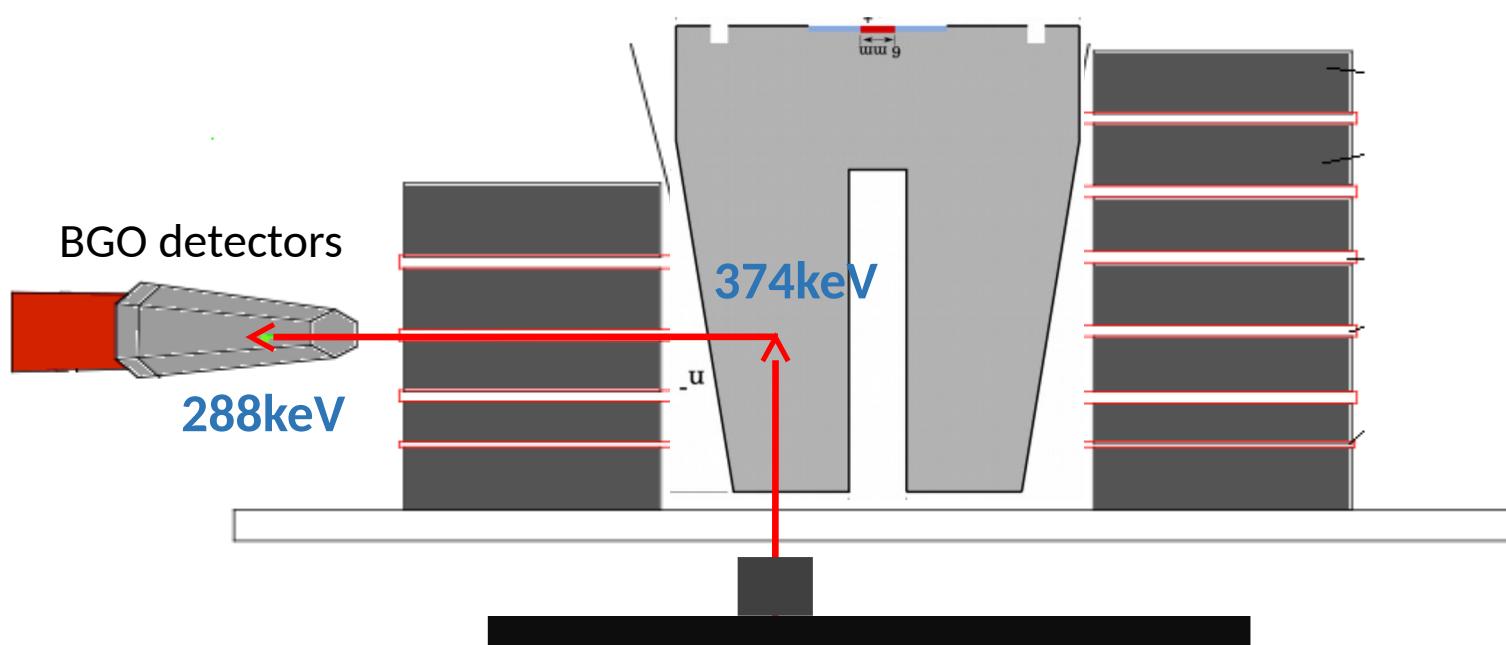
Energy as a function of azimuthal angle



Position Identification



Building a signal database



- 4 rings of collimated BGO detectors
- Only photons which scatter at 90° collected
- 374keV in SIGMA and 288keV in BGO detector

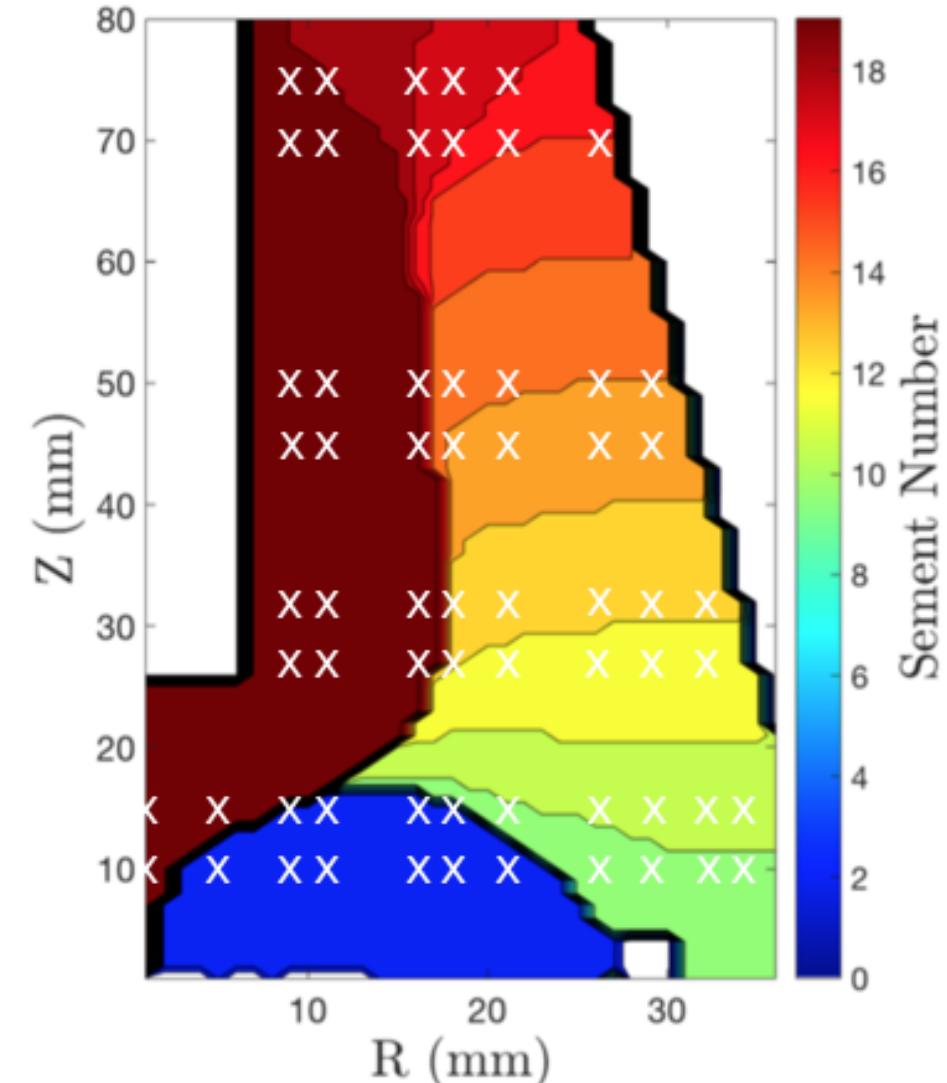
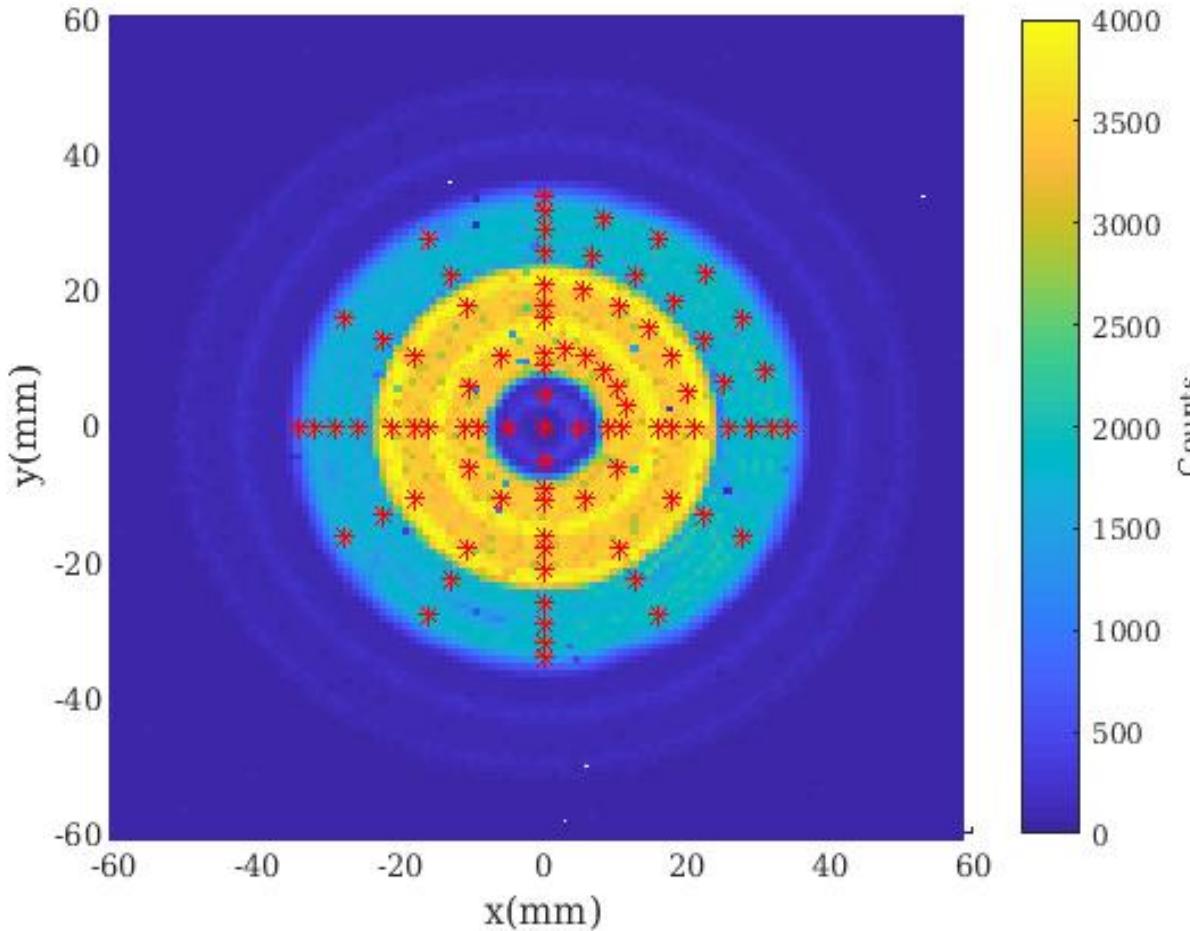


uilding a signal database



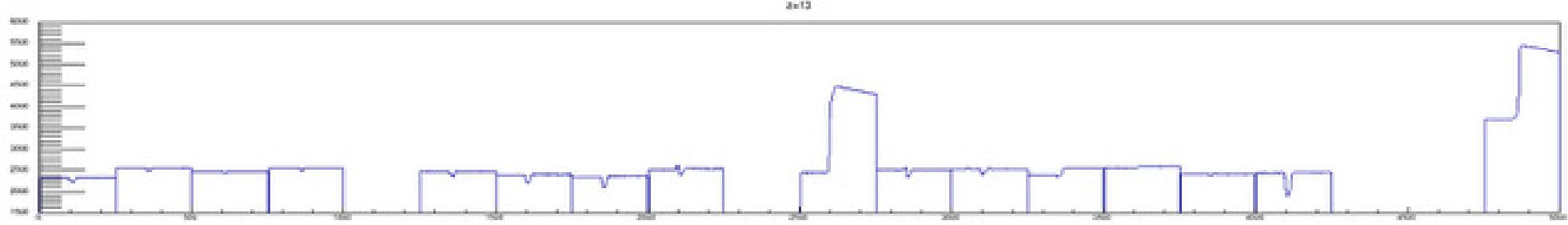
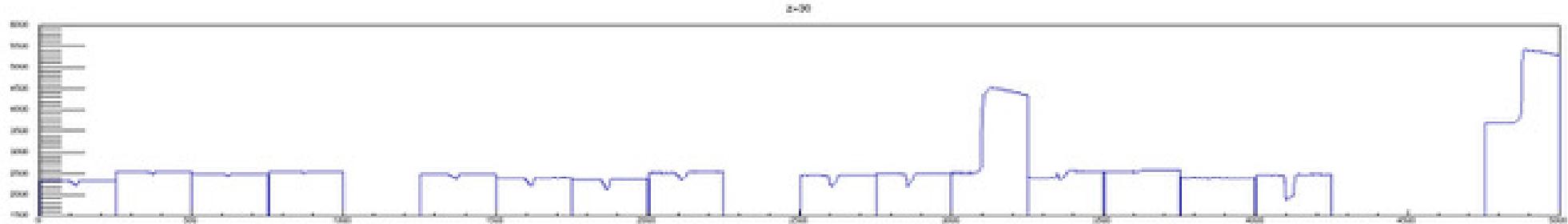
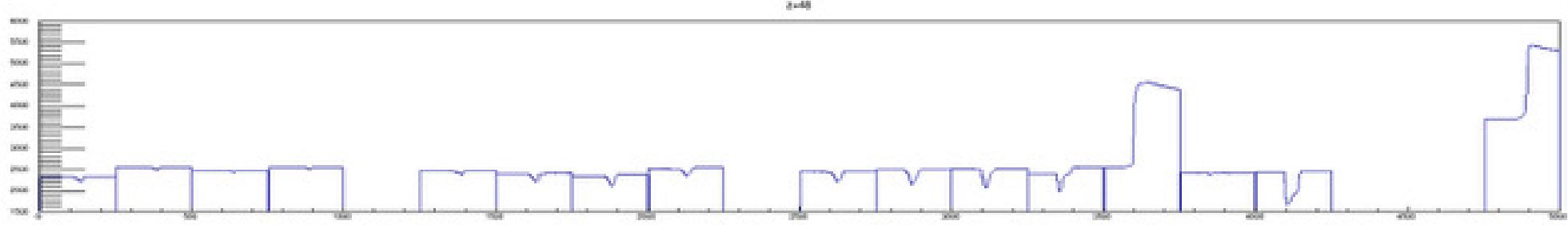
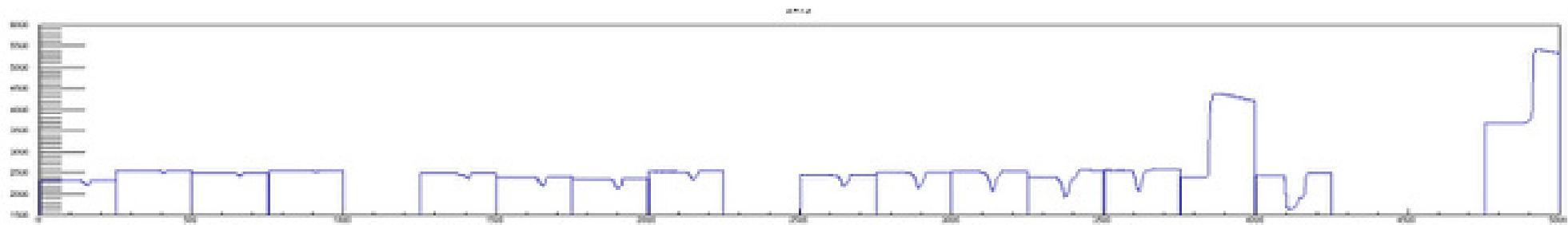
- Existing scanning equipment has been upgraded significantly since the last Agata data was taken
 - Old scanning system based around Gretina digitisers + analogue trigger
 - Now uses Caen 14-bit 100MHz V1724 digitizer (each 8 x channel) + V1495 digital trigger or software trigger
 - V1724 digitisers Data: timestamp, energy, digitised trace
- New custom designed BGO's
- New detector support frame with easily adjustable height
- New 3d printed secondary detector mountings
- New lead shielding around source
 - Easier to align source with collimator
- New 3d-printed 0.5 mm tungsten collimator
- Commissioned with SIGMA detector

uilding a signal database

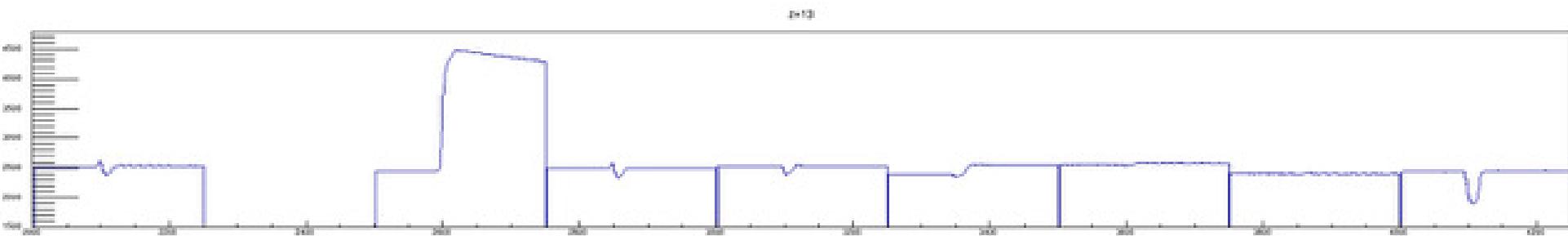
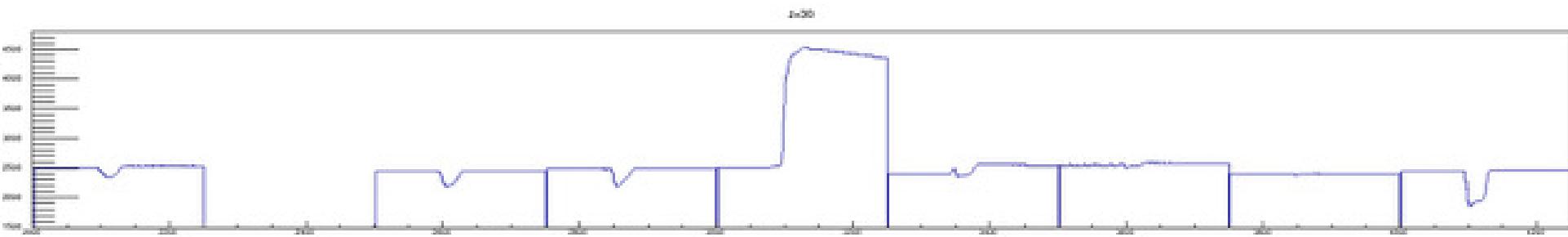
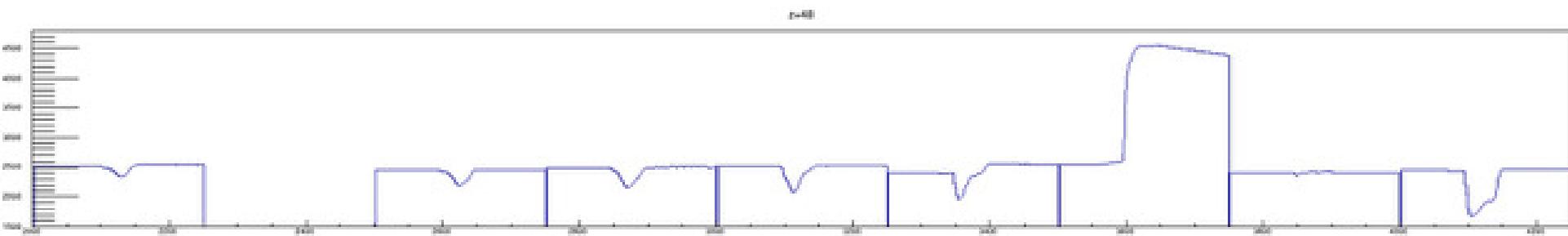
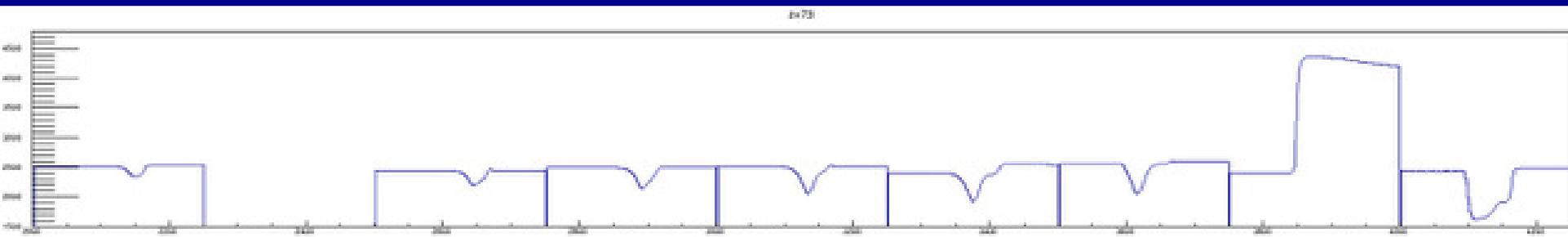


- Data acquired for 6 h at each (x,y) position (8 BGO depths)
- Positions chosen to study segment boundaries and crystallographic axis

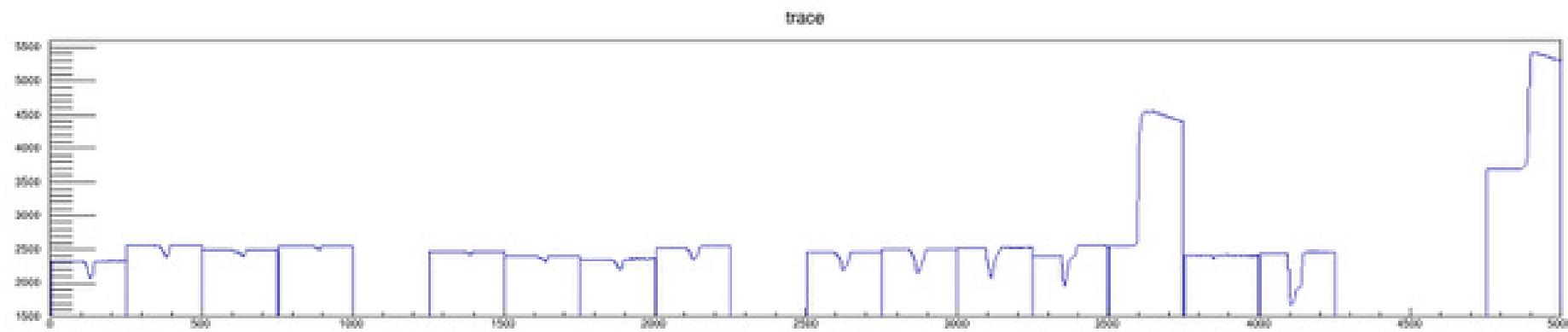
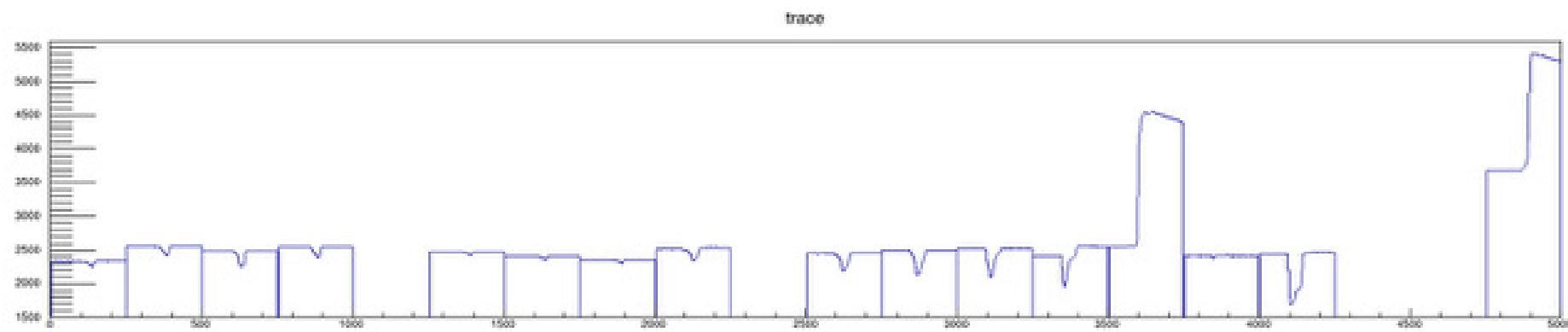
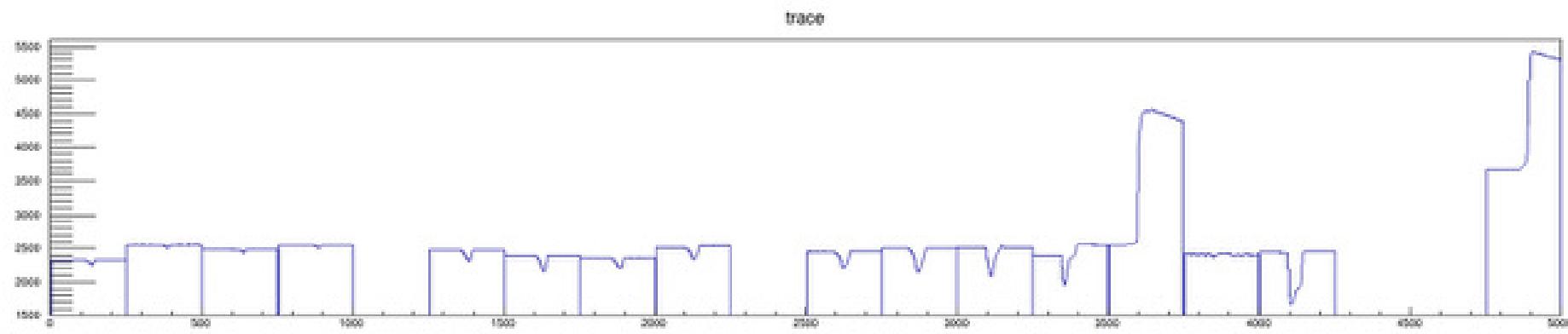
Same x-y position, different BGO depths



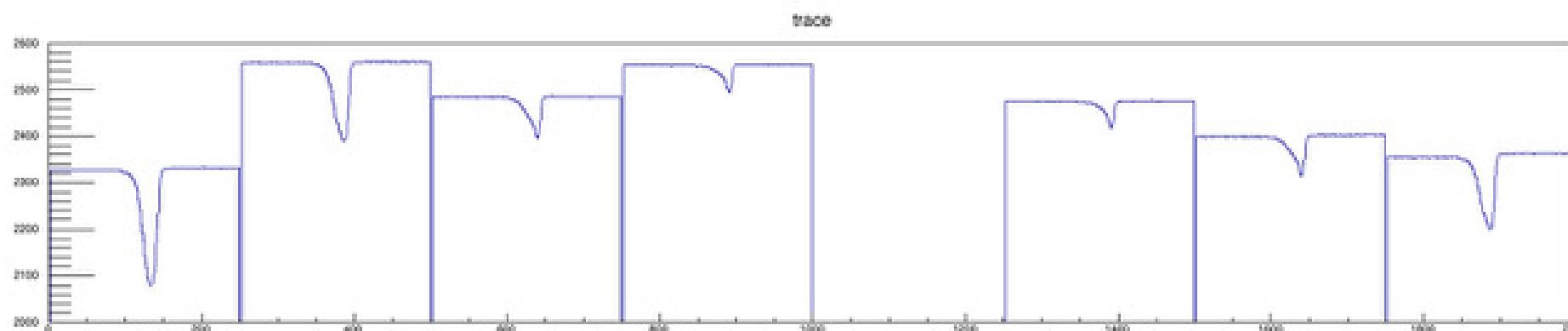
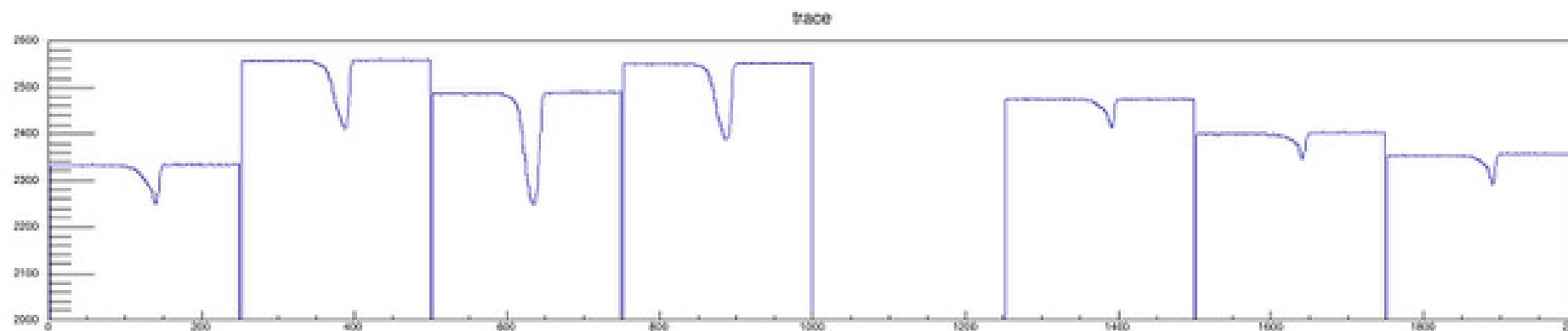
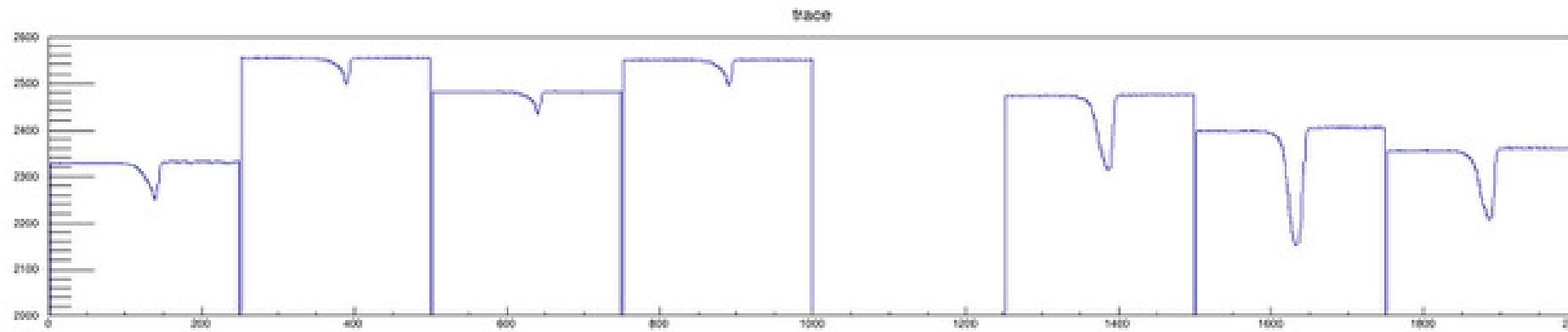
e x-y position, different BGO depths (rings only)



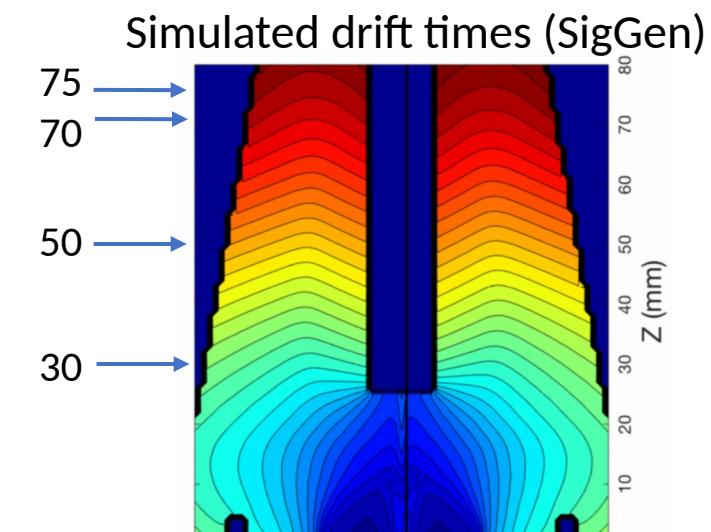
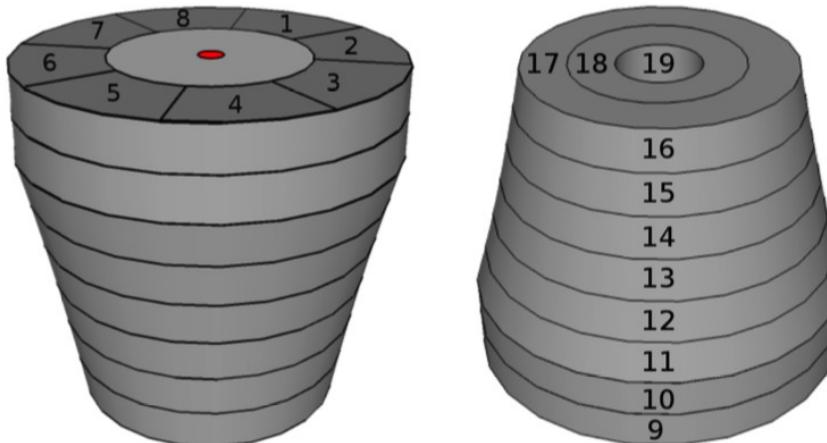
Same BGO depth, different x,y positions



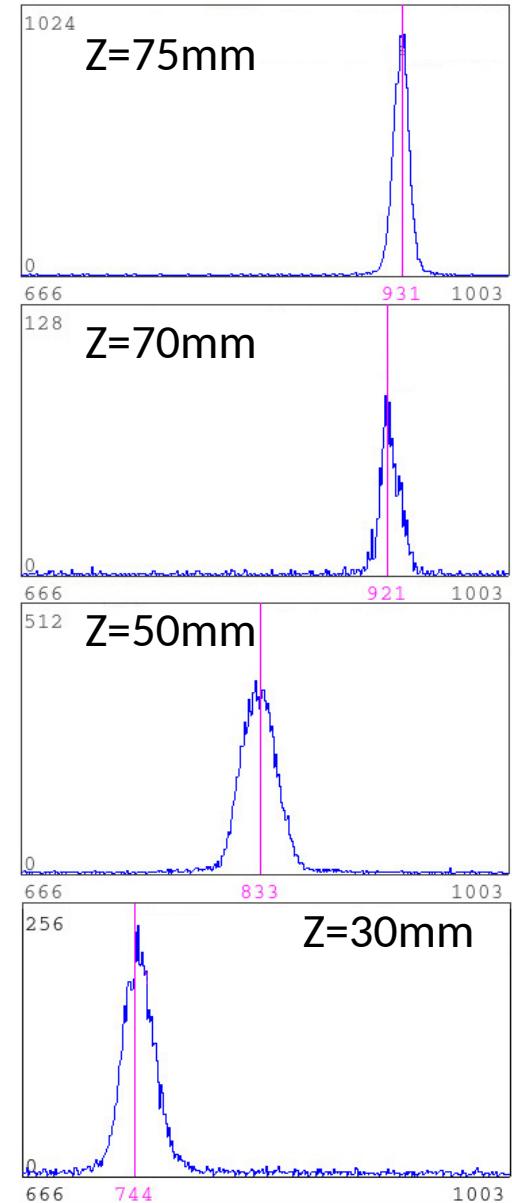
BGO depth, different x,y positions (azimuthal only)



uilding a signal database



J.P. Wright et.al. NIM A892, P84, 2018



Ongoing and Future work

- Create an average superpulse response for each location
- Compare experimental measurements with simulated database
- Make any necessary adjustment to the simulation
- Evaluate position resolution of detector
- Confirm using experimental lab pencil beam and Compton images
- Evaluate cross-talk data that has been collected

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Unsworth

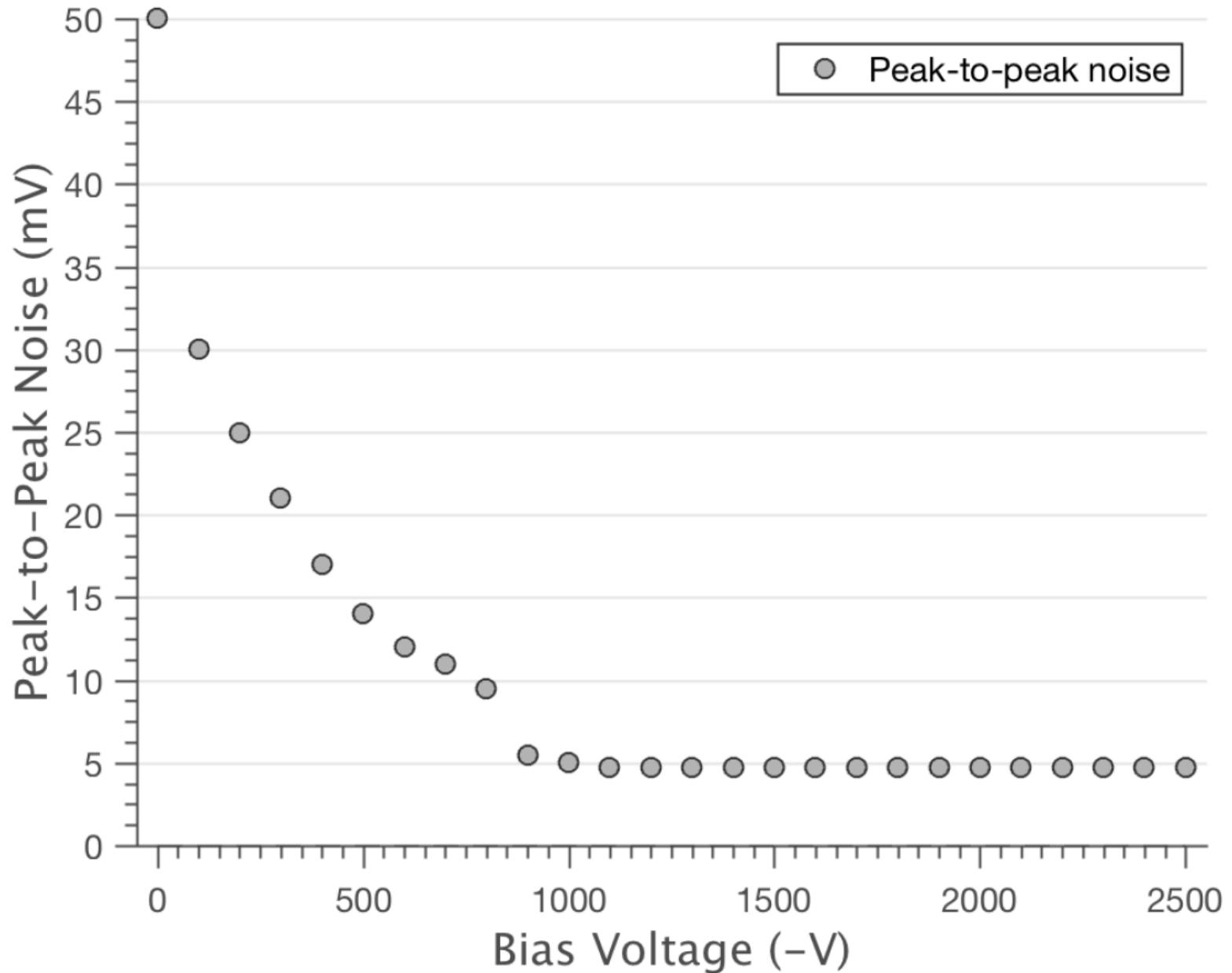
Oak Ridge National Laboratory: David Radford

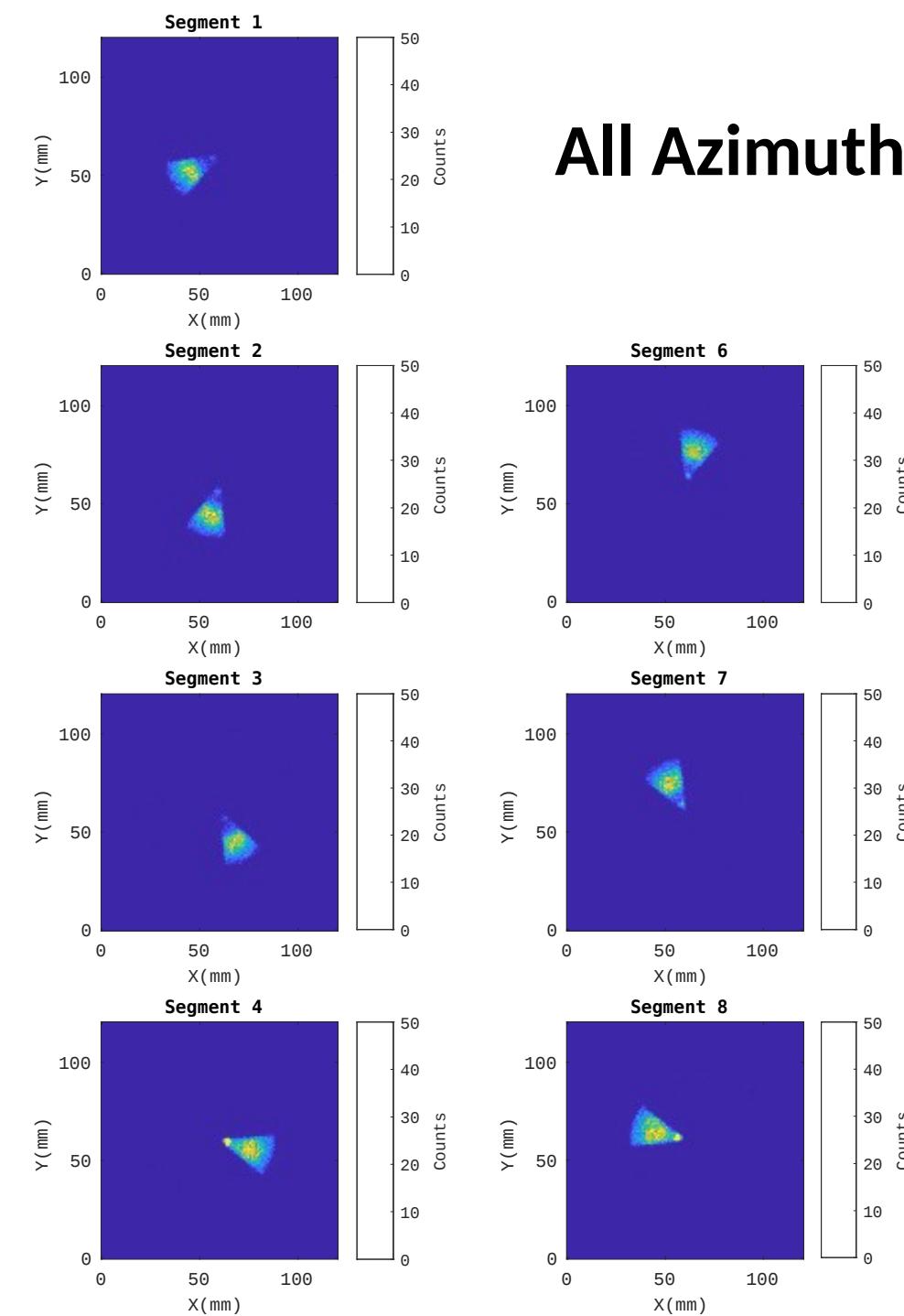
Thanks to STFC for Project Funding

Thanks for listening

Any Questions?







All Azimuthal Segments

