Charles University Prague

Digitizers, First Round of Reconstruction

PXD Cluster Shape Correction in DEPFET Pixel Detector

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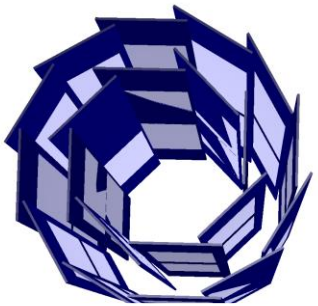
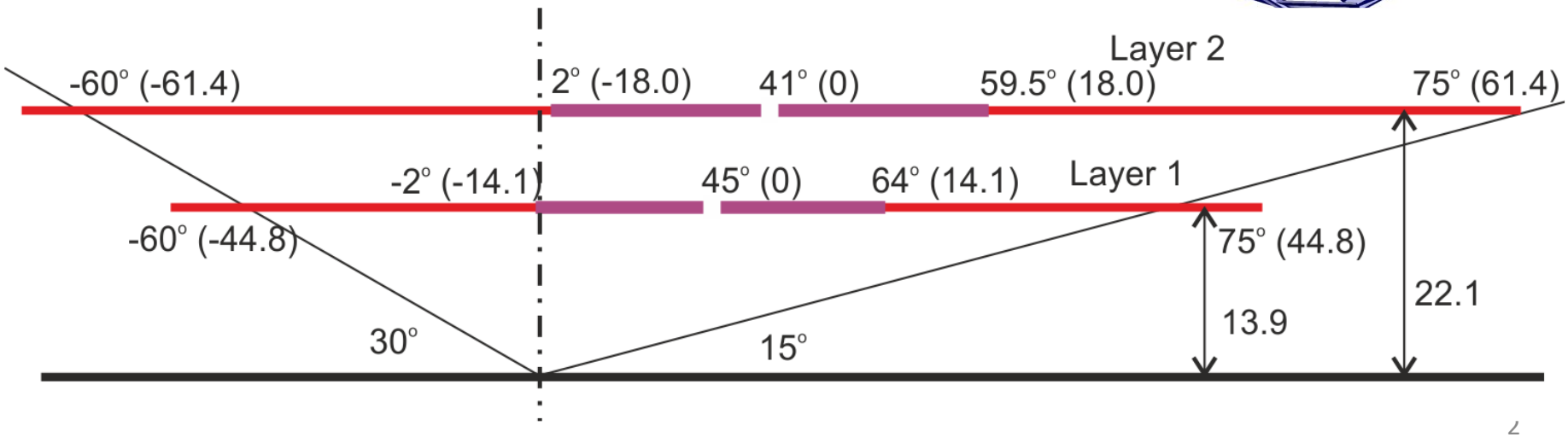
	Inner Layer	Outer Layer
Modules	8	12
Thickness	75 microns	75 microns
Length	90 mm	123 mm
Sensitive	44.8 x 12.5 mm	61.44 x 12.5 mm
Pixel Size	55,60 x 50 μm^2	70,85 x 50 μm^2
Pixels	3.072 x 106	4.608 x 106
Frame Rate	50 kHz	50 kHz





Using cluster shape to improve of hit position and error estimation

- There are five basic types of clusters for four different pitch in v direction: single, double and triple pixel clusters, rest of symmetrical and nonsymmetrical clusters.

- In Belle II geometry for particles shot of 0.05 – 3.0 GeV electrons and positrons in uniformly distributed directions from the interaction point and in range phi 17 – 150 deg, with magnet

- In Belle II: 25 % form single-pixel clusters, 15 % form 2-pixel clusters along the R-phi coordinate, and 26 % along the z-coordinate. 12 % form non-symmetric "L"-shaped three-pixel clusters, 16 % form larger non-symmetrical clusters, and rest 6 % form symmetrical clusters (like 2x2 clusters).

1-pixel 2-pixels 3-pixels non-symmetrical symmetrical

Categorization of cluster shapes

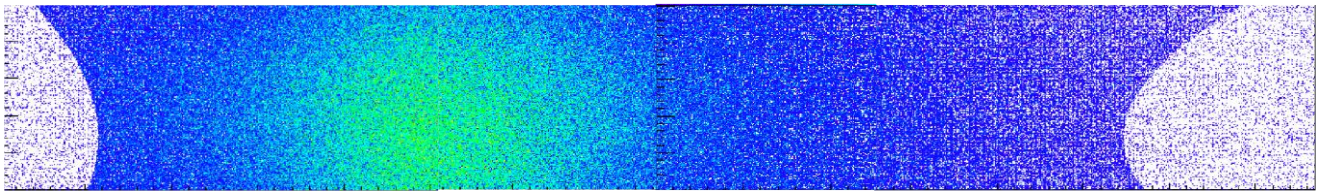
Using cluster shape to improve of hit position and error estimation

- For single-pixel clusters, the obvious hit position estimate is the center of the pixel, error estimation improve for only expecting in-pixel region.
- For single-pixel clusters, hit position uncertainty is given by the area where a given energy deposition is mostly contained within the single pixel - it therefore depends on pixel charge and clustering threshold.
- For larger clusters, hit position is estimated separately for the u- and v-coordinates, using center-of-gravity estimates for clusters size 2 and the analog head-tail method for size 3 and more. Generally, the average resolution is best for small clusters of size 2 and 3.
- With particles arriving at different (and unknown) directions, the standard eta-correction algorithms are not usable. Therefore, simple bias-correcting methods for center-of-gravity and head-tail estimates are desirable, that would only use measurable quantities to correct for bias and set realistic error estimation.

Simulation condition for Belle II geometry

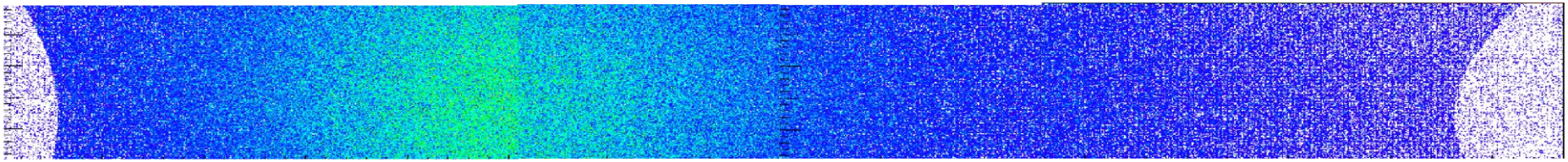
- For single-pixel clusters, the obvious cluster position estimate is the center of the pixel.
- Position of clusters on ladders is on perpendicular to interaction point

Layer 1 89.6 x 12.5 mm^2 PXD in Belle II – all clusters distribution

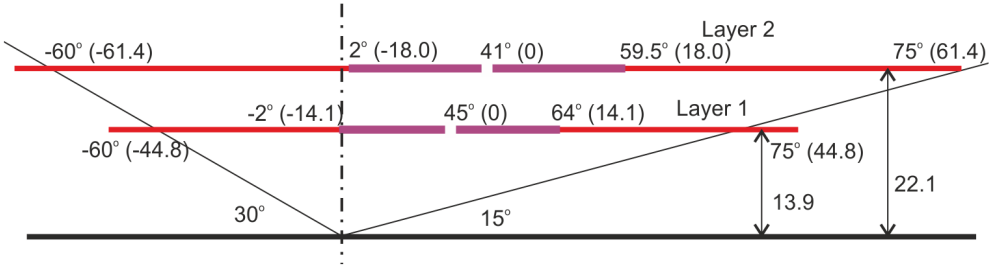


Pixel size: 60 x 50 55 x 50 55 x 50 60 x 50

Layer 2 122.88 x 12.5 mm^2 PXD in Belle II – all clusters distribution



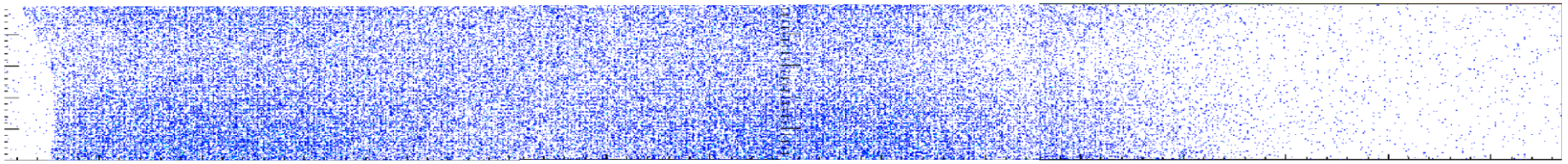
Pixel size: 85 x 50 65 x 50 65 x 50 85 x 50



Simulation condition for Belle II geometry

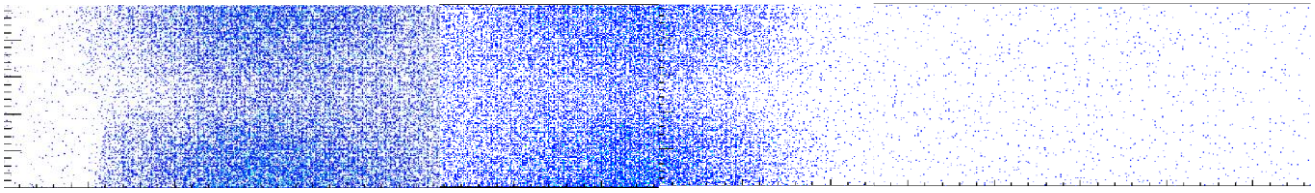
- For L-shape clusters, the obvious cluster position is bit out of the calculation.

Layer 2 122.88 x 12.5 mm^2 PXD in Belle II – “L” shape hits distribution

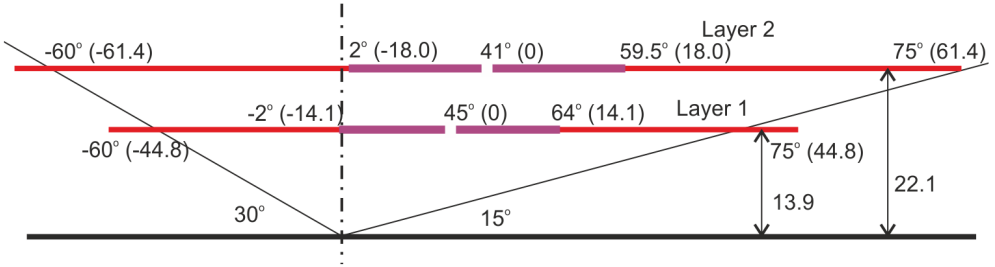


Pixel size: 85 x 50 65 x 50 65 x 50 85 x 50

Layer 1 89.6 x 12.5 mm^2 PXD in Belle II – “L” shape hits distribution

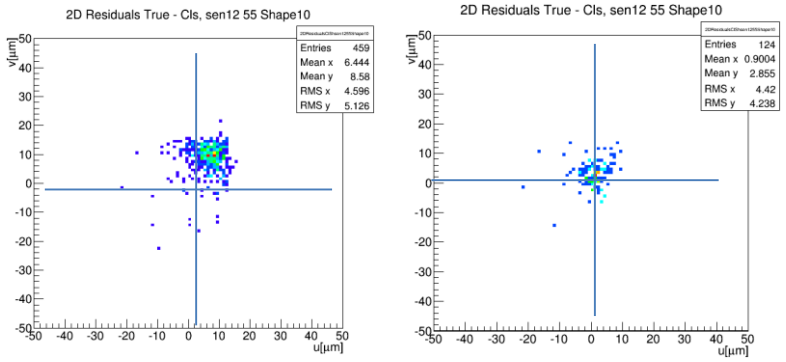


Pixel size: 60 x 50 55 x 50 55 x 50 60 x 50

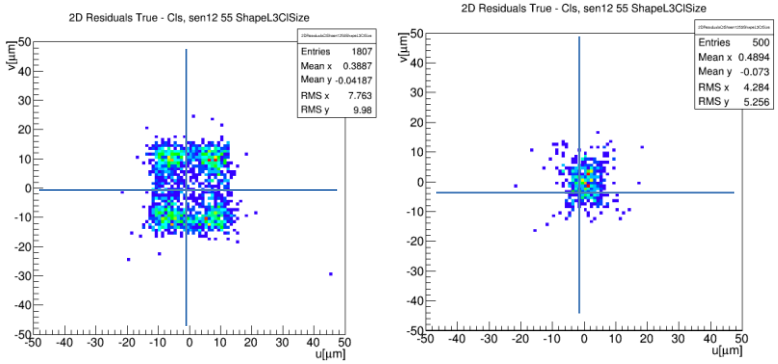


Simulation condition for Belle II geometry

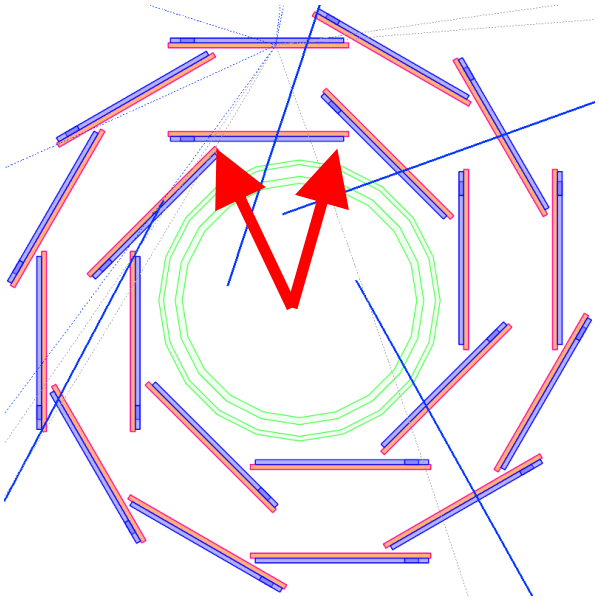
- u (r-phi) direction: -10 .. +35 deg
- v (theta) change: -10 .. +10 deg
- Than bias is on both direction and correction works better



Residual plot of “L” shape in one orientation before (left) and after (right) correction



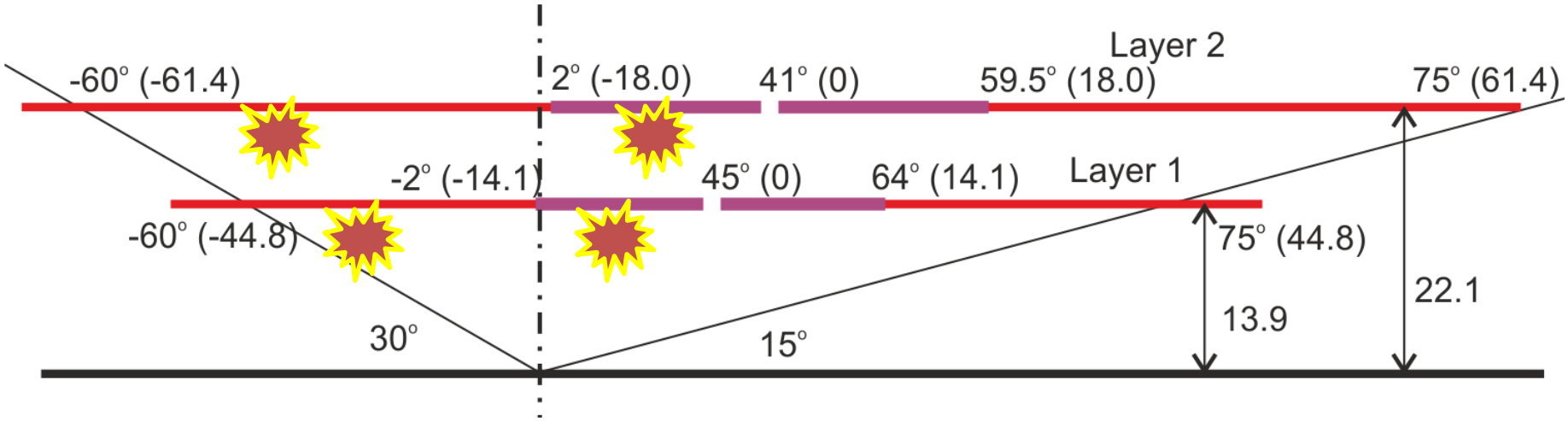
Residual plot of “L” shape in all orientation before (left) and after (right) correction



Cut of incident angle range in r-phi

Simulation condition for Belle II geometry

Simulation for source independent position



Simulation condition for Belle II geometry

Following slides show examples of shape filter properties

More is on backup

Full set is in disposition on request

Cl. Shape: 0 - Large

(pixel size 0)

From σ–electrons mostly…

1a – 24% of all events
16 – 0.4% of all events
17 – 1% of all events

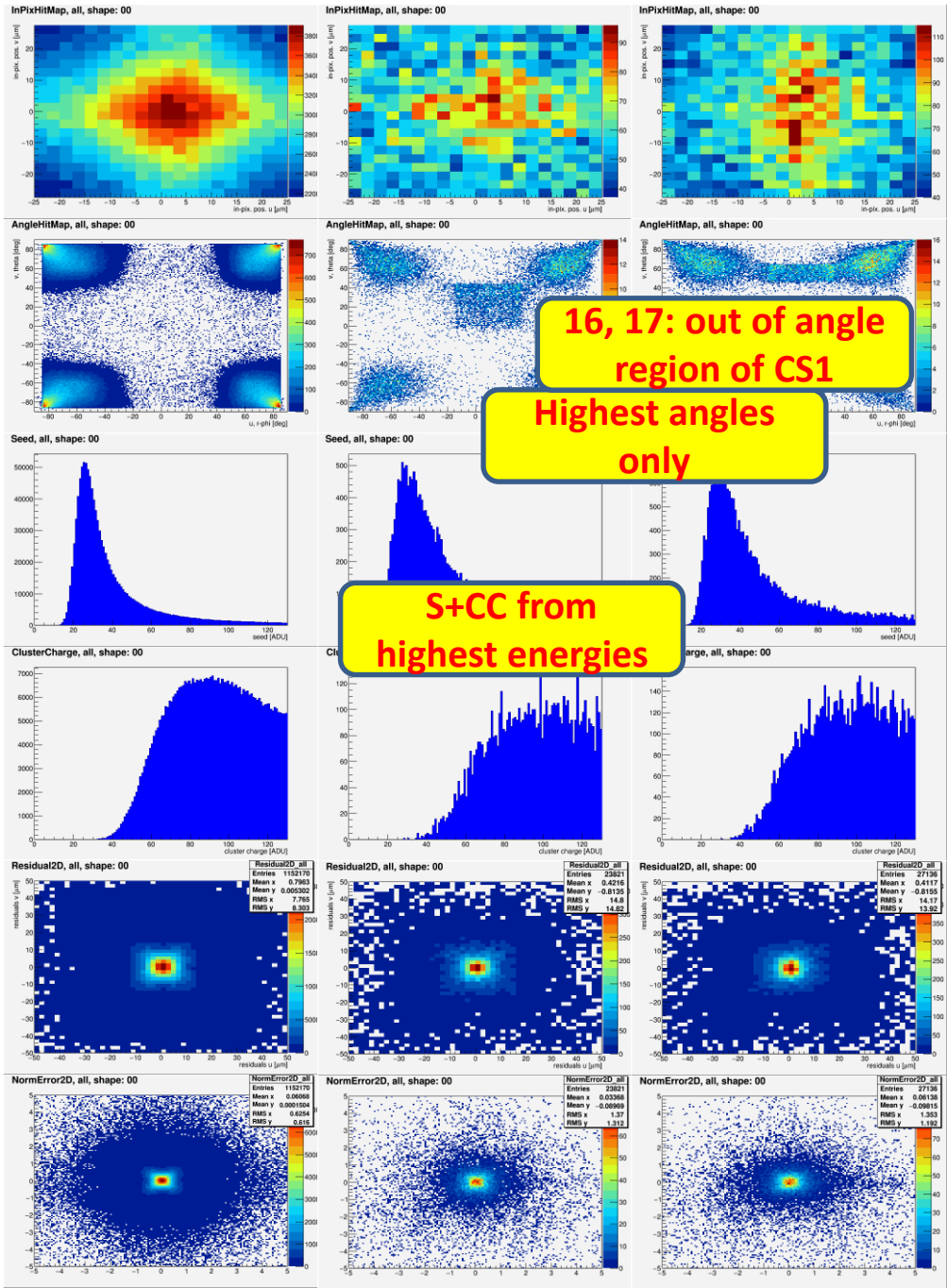
From σ–electrons mostly than error is larger -> underestimated

Seed – similar
Cluster charge – max shifted

Normalised error

Norm. Error (pix0)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,6254	0,616	1,37	1,312	1,353	1,192

Over estimated for 1a
Under estimated for 16, 17



Cl. Shape: 0 - Large
(pixel size 3)

1a – 22% of all events
16 – 1% of all events
17 – 3% of all events

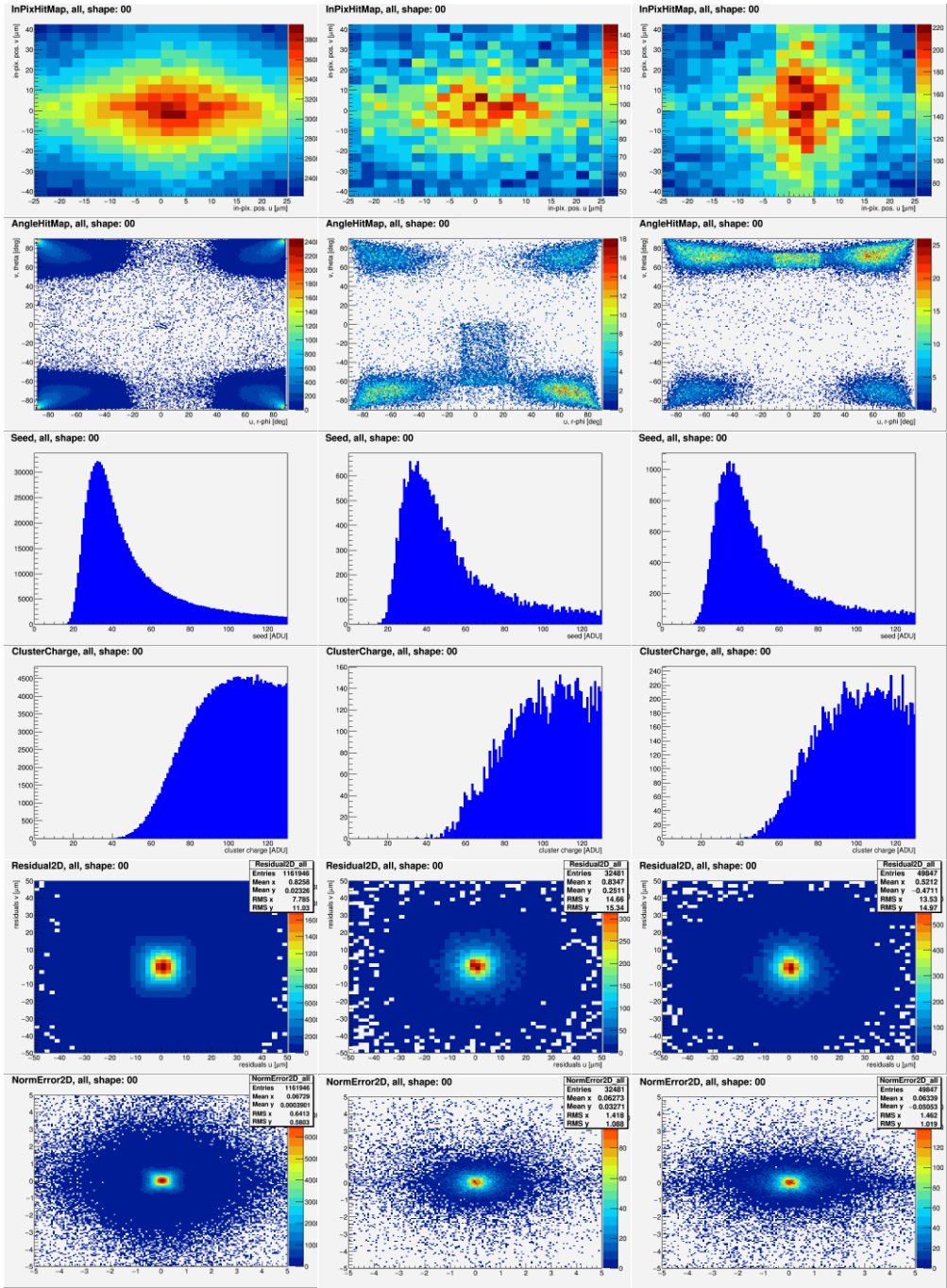
Reco position is appointed to the center of the pixel

Seed – similar
Cluster charge – max shifted

Normalised error

Norm. Error (pix3)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,6413	0,5803	1,418	1,088	1,462	1,019

Over estimated for 1a
Under estimated for 16, 17



Cl. Shape: 10 - L

(pixel size 0)

1a – 3% of all events
16 – 4% of all events
17 – 4% of all events

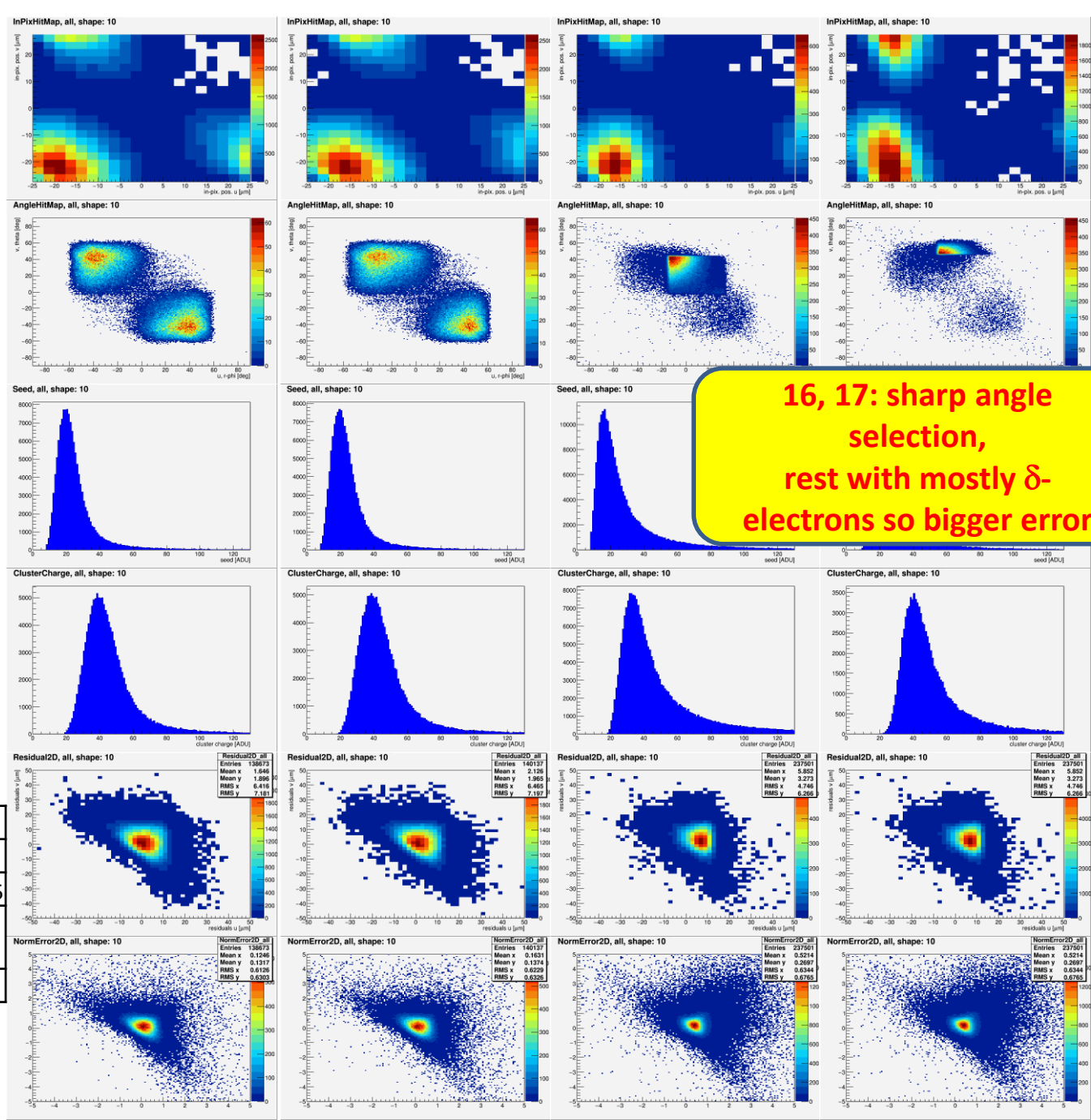
Reco position is appointed to three corners of the pixel

Seed – similar
Cluster charge – similar

Normalised error

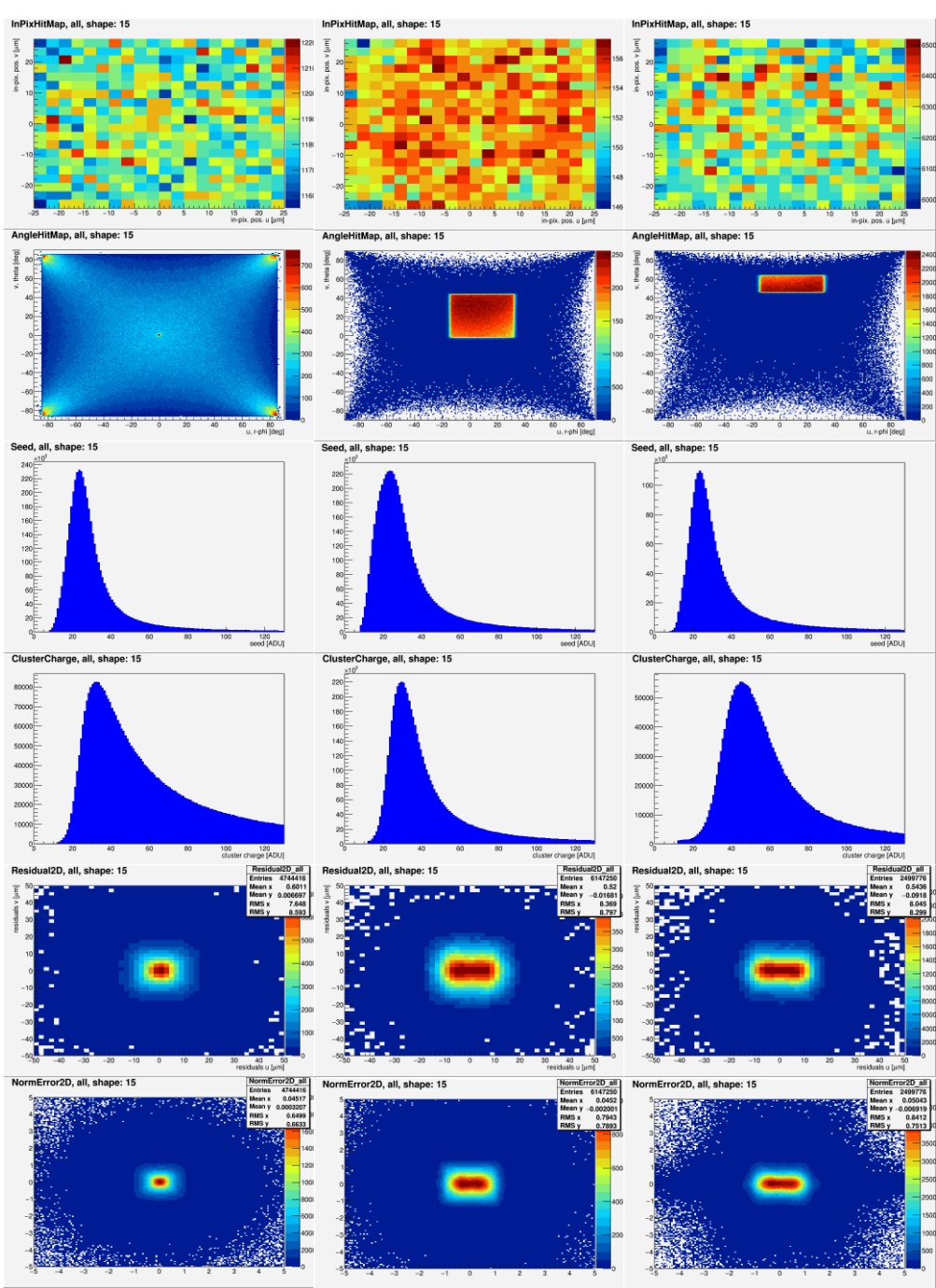
Norm. Error (pix0)			
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v
0,6229	0,6326	0,6344	0,6765
17-Sigma u	17-Sigma v		
0,5303	0,7552		

Over estimated for all



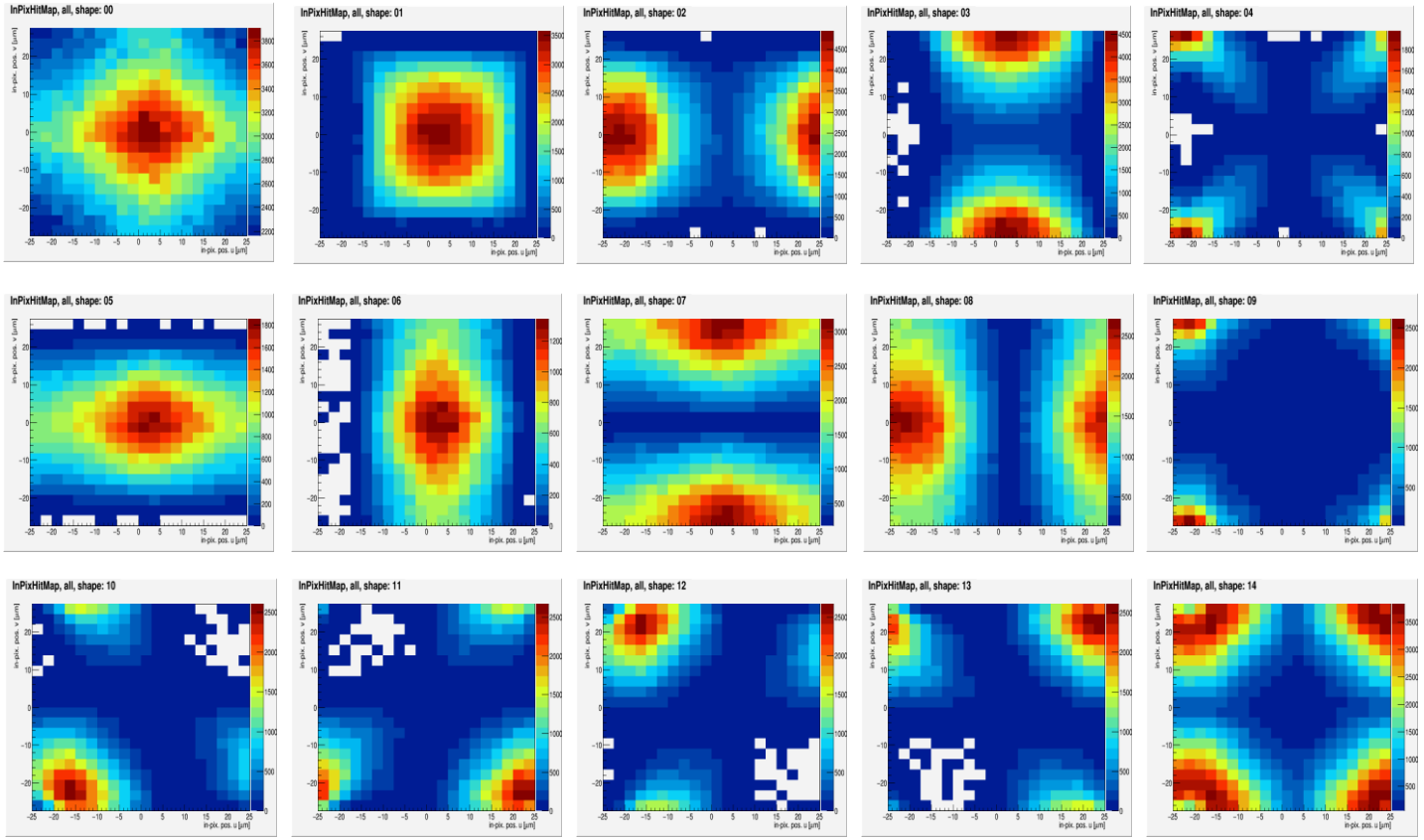
Cl. Shape: 15 - All shapes
(pixel size 0)

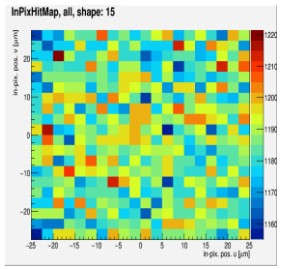
Norm. Error (pix0)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,6499	0,6633	0,7943	0,7893	0,8412	0,7513



In Pixel Position – pix0 – 1a

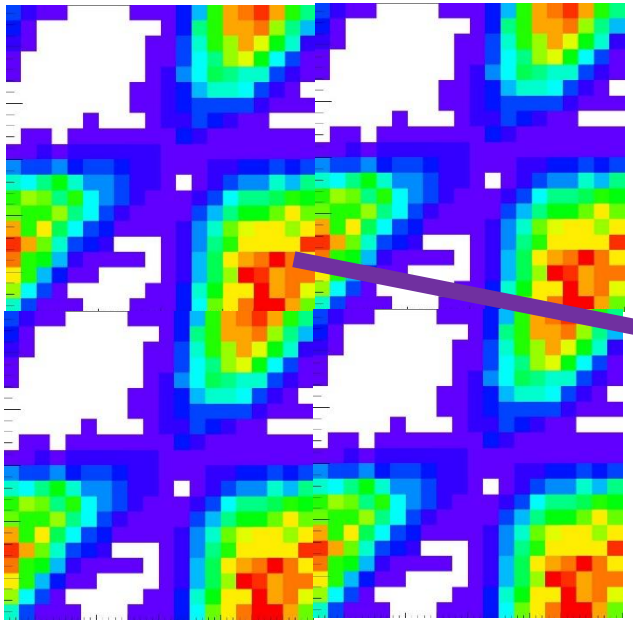
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All





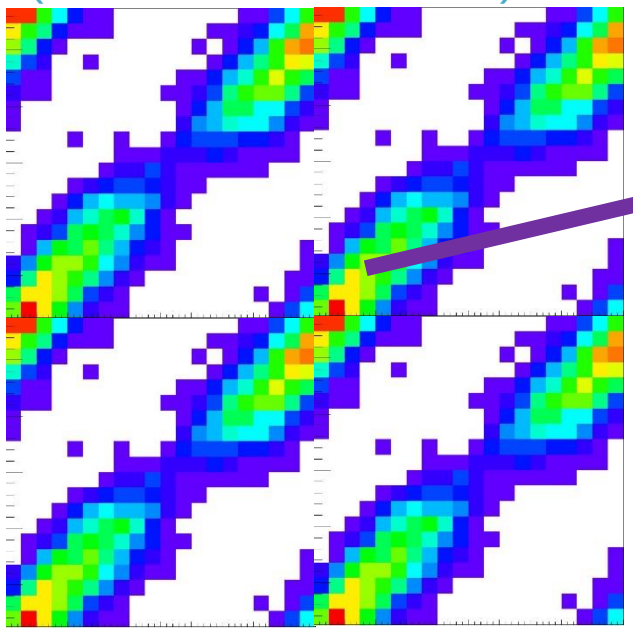
Toy simulation/validation

1a



Cl. Shape:
10 - L
(pixel size 0)

(The same color scale)

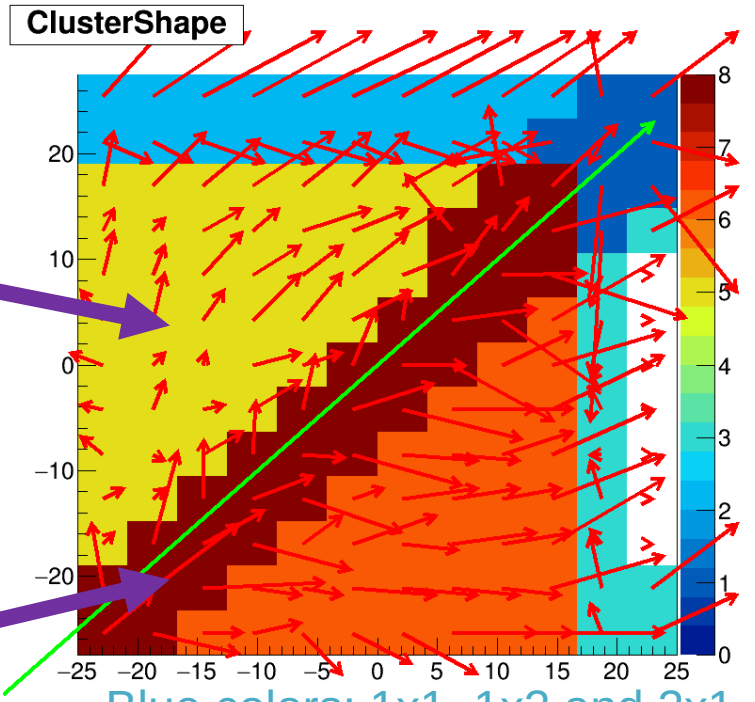


Cl. Shape:
4 - 2x2 diag
(pixel size 0)

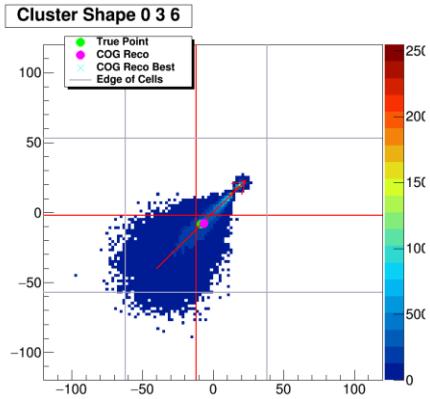
Angle range: 33 – 55 deg

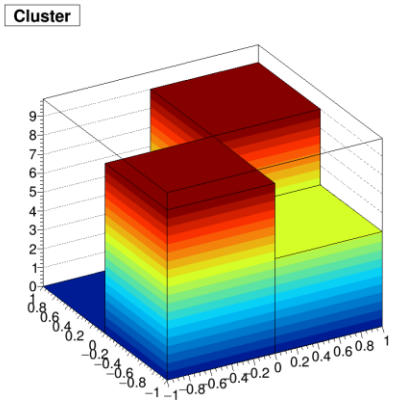
Angle: 40 deg

Map of corner position



Blue colors: 1x1, 1x2 and 2x1





Implementation to basf2

For bias correction and error realistic estimation is useful to know following information:

- Shape of cluster
- Angle of path of particle with respect to sensor plane
- In-pixel position of particle in sensor plane
- Direction of particle flight with respect to sensor plane

Full this information we have in fitting time so we can apply

Applying will be on reco hit position and error estimation

Hot candidates for bias correction:

- cluster 2x2 (u,v) three pixels: (L, mirror in u, v and u+v)
- cluster 2x2 diagonal (u,v) pixels
- cluster 2x2 anti-diagonal (u,v) pixels

Plan

- Write a code to basf2 for shape recognition
- Write code for correction of bias and error estimation
- Calculate/simulate corrections
- Add it to database (?)
- Prepare validation of corrections

- Term: this year (with respect of reorganization of clustering code)

Thank you for your attention

Follow backup slides…

Cl. Shape: 1 - 1x1
(pixel size 0)

1a – 9% of all events
16 – 30% of all events
17 – 2% of all events

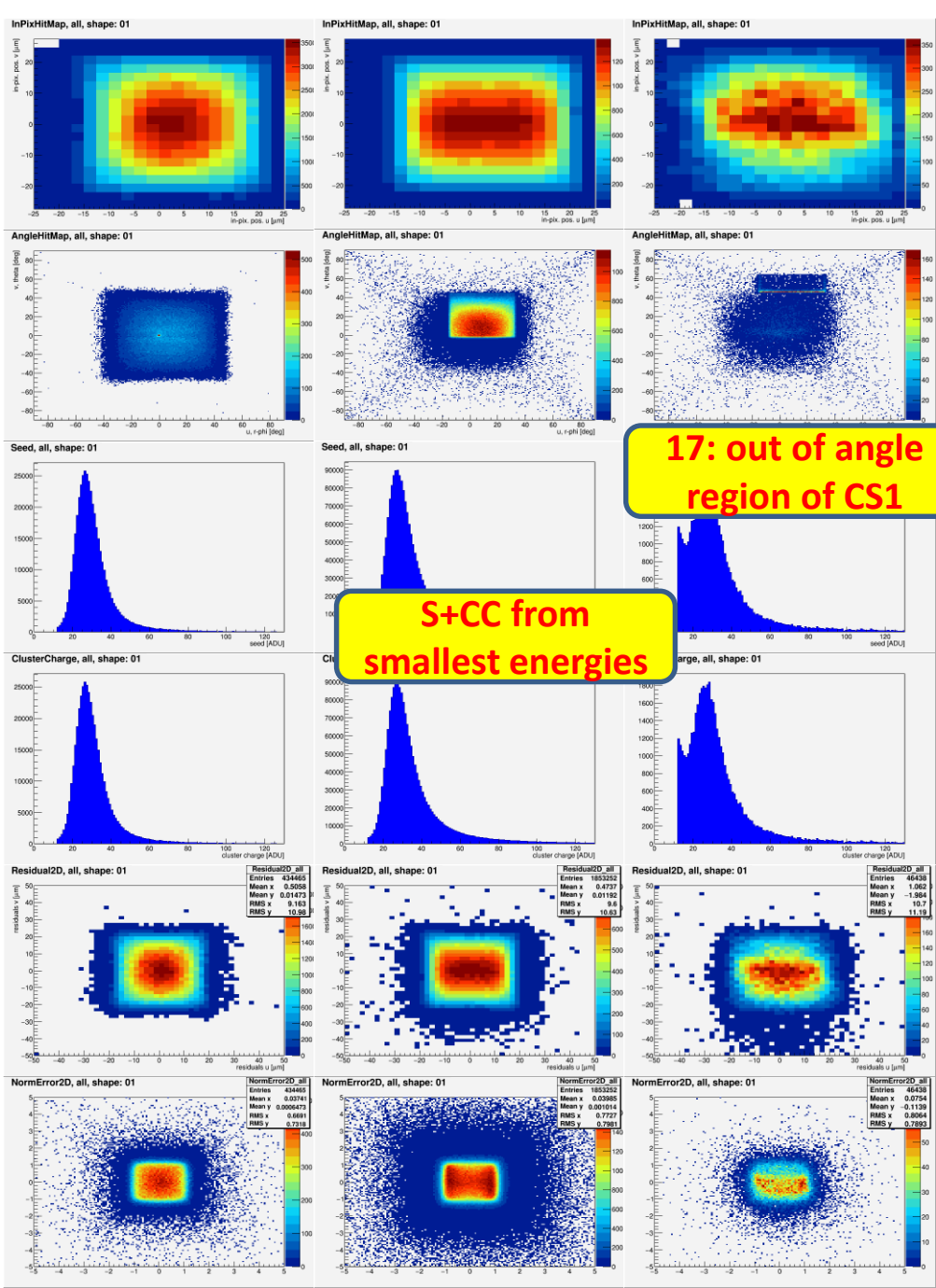
Reco position is appointed to the center of the pixel

Seed – similar
Cluster charge – similar

Normalised error

Norm. Error (pix0)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,6691	0,7318	0,7727	0,7981	0,8064	0,7893

Over estimated for all



Cl. Shape: 4 - 2x2 diag

(pixel size 0)

1a – 2% of all events
16 – 1% of all events
17 – 0.4% of all events

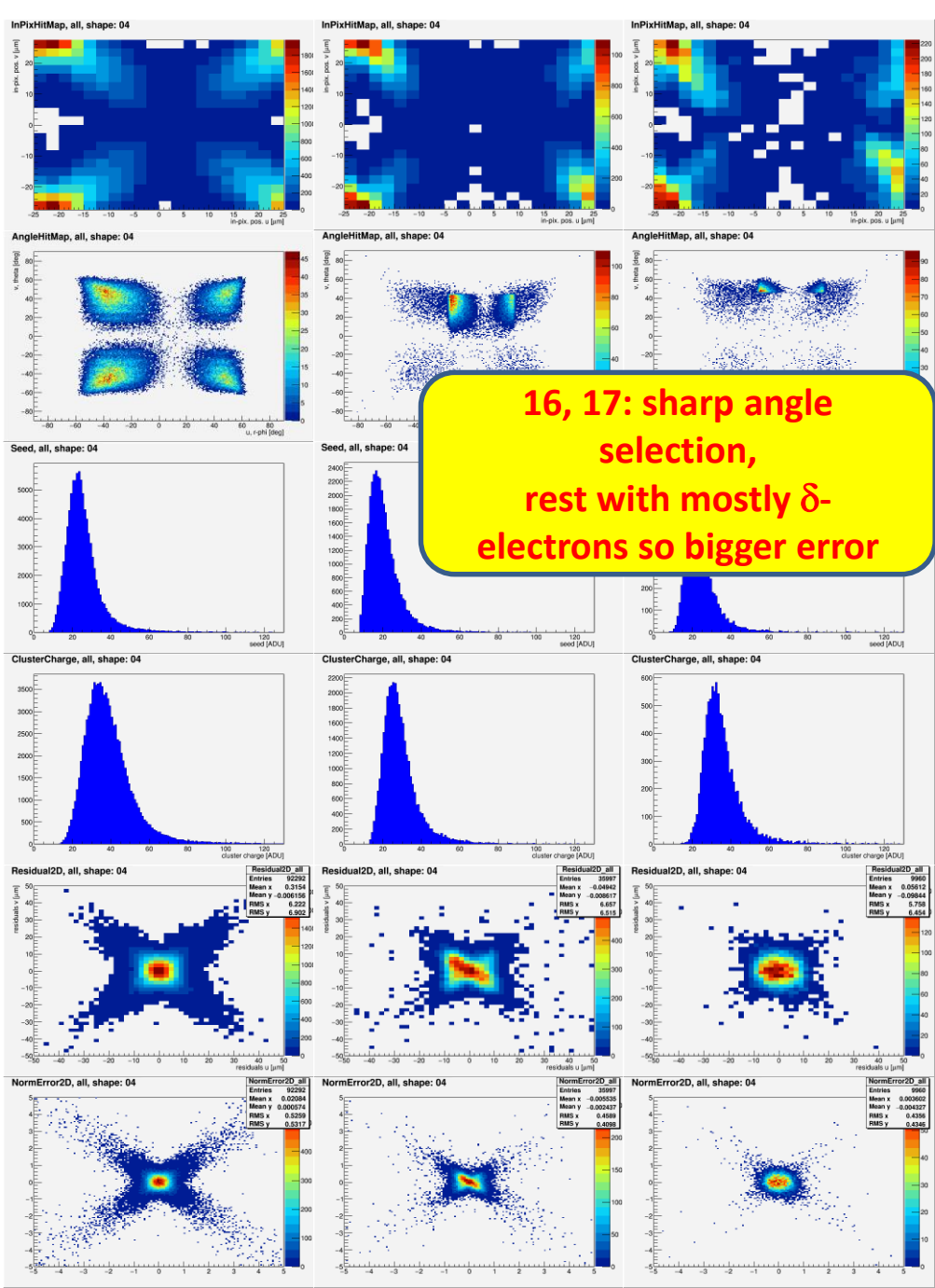
Reco position is appointed to the corners of the pixel

Seed – similar
Cluster charge – similar

Normalised error

Norm. Error (pix0)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,5259	0,5317	0,4589	0,4098	0,4356	0,4346

Over estimated for all



Cl. Shape: 14 - All L

(pixel size 0)

1a – 12% of all events
16 – 14% of all events
17 – 14% of all events

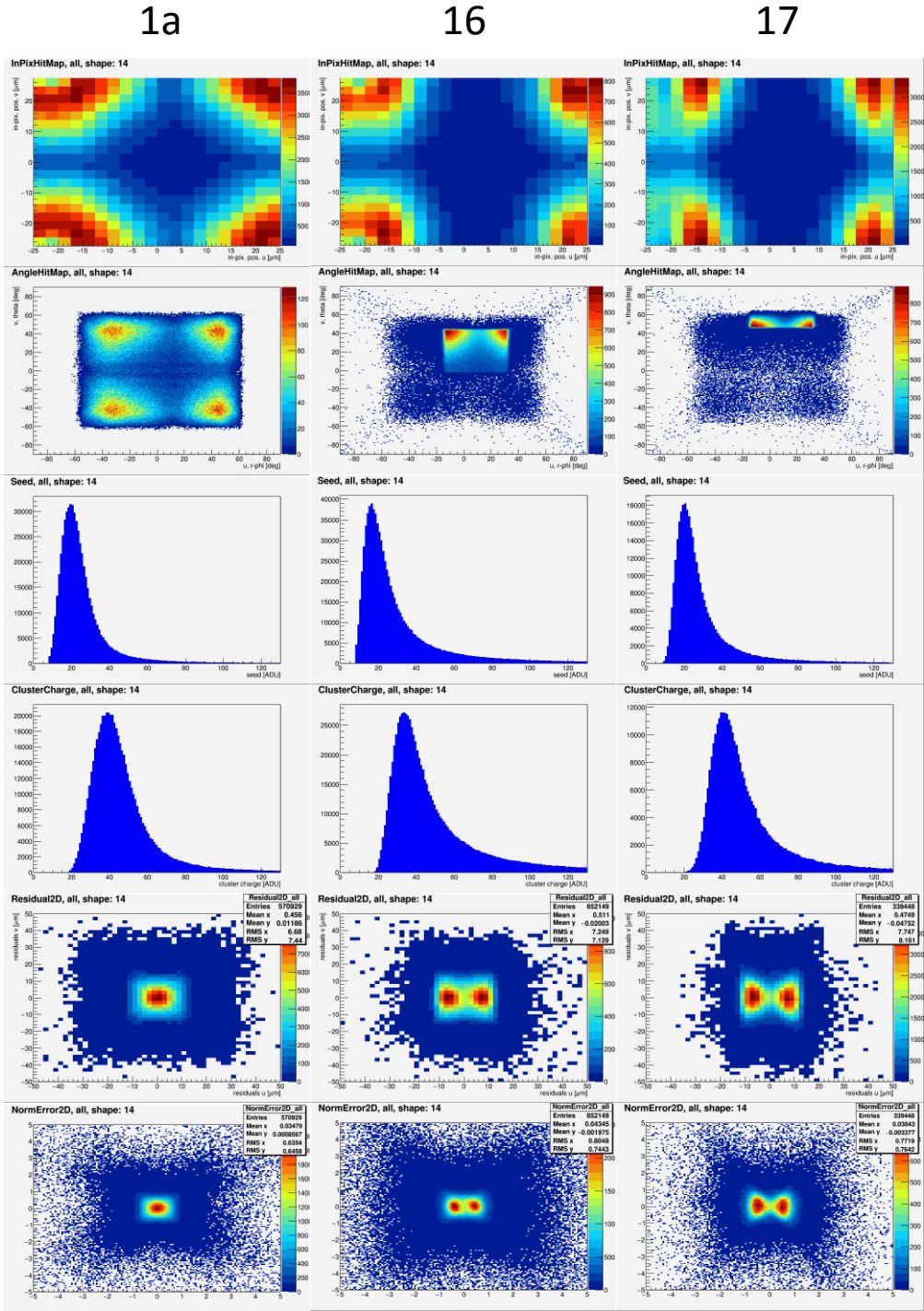
Reco position is appointed to the corners of the pixel

Seed – similar
Cluster charge – similar

Normalised error

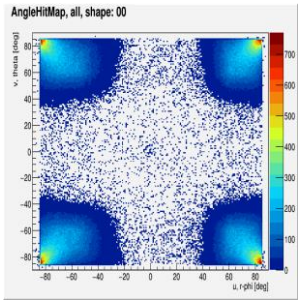
Norm. Error (pix0)					
1a-Sigma u	1a-Sigma v	16-Sigma u	16-Sigma v	17-Sigma u	17-Sigma v
0,6354	0,6458	0,8048	0,7443	0,7719	0,7642

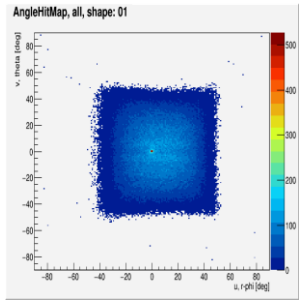
Over estimated for all

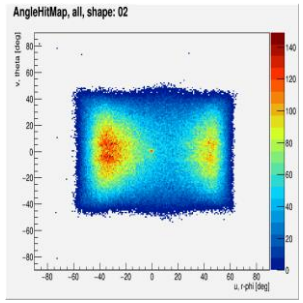


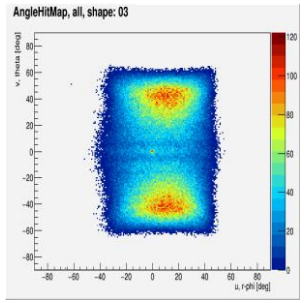
Angle hit map for tracks – pix0 – 1a

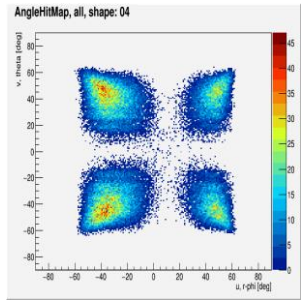
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All

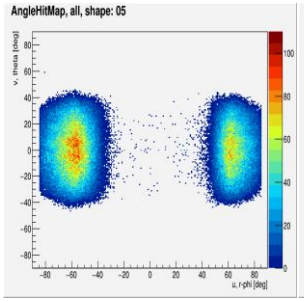


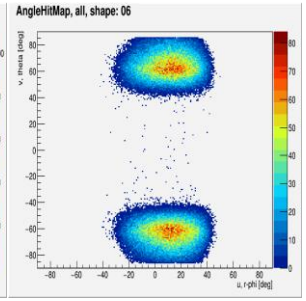


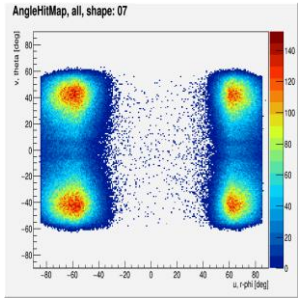


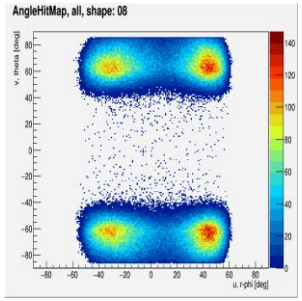


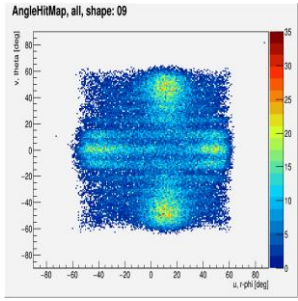


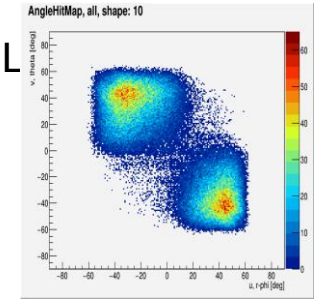


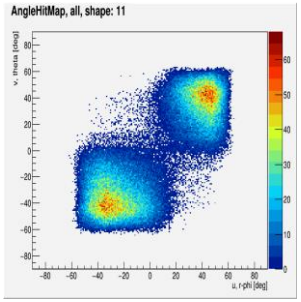


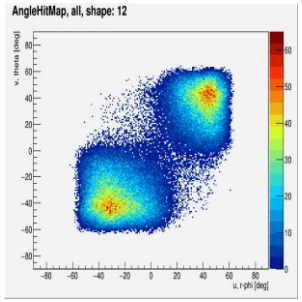


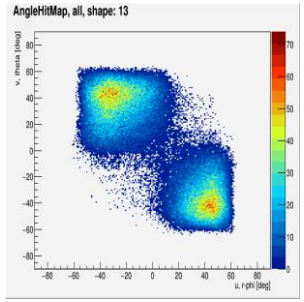


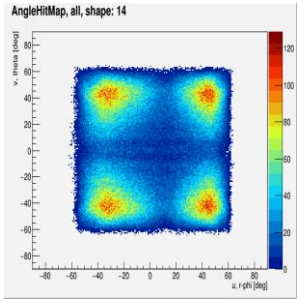


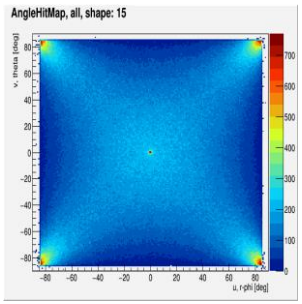






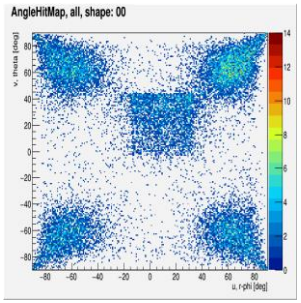


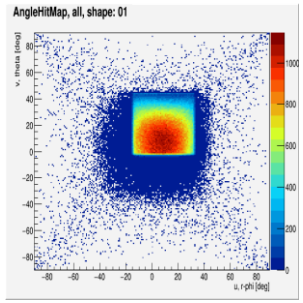


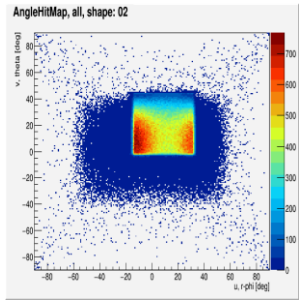


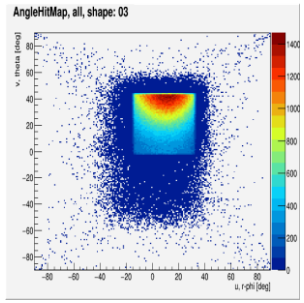
Angle hit map for tracks – pix0 – 16

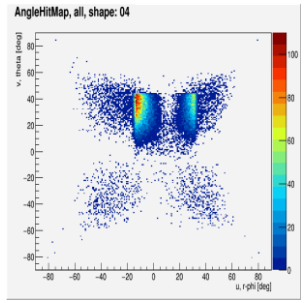
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All

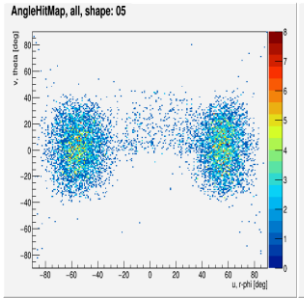


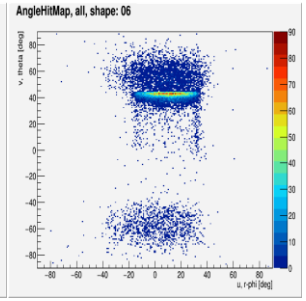


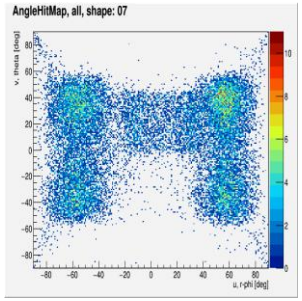


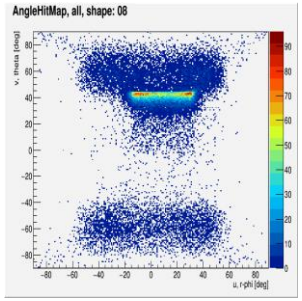


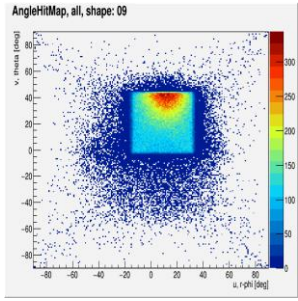


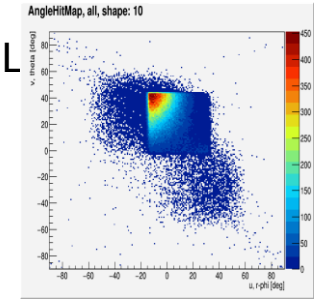


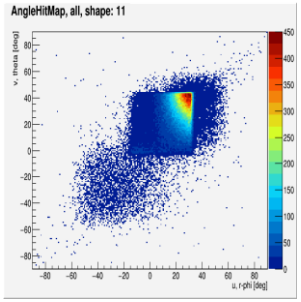


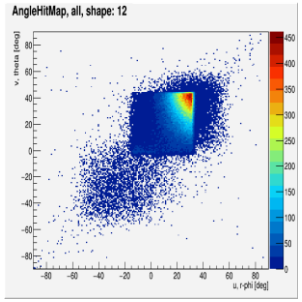


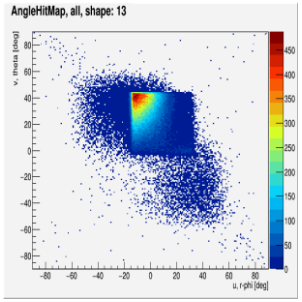


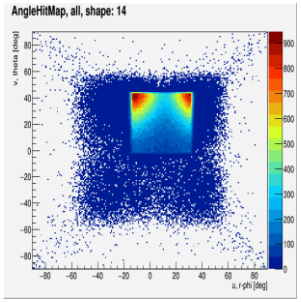


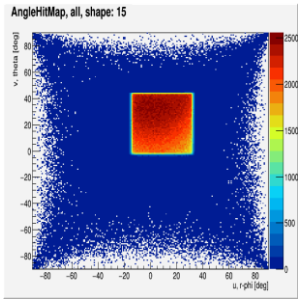






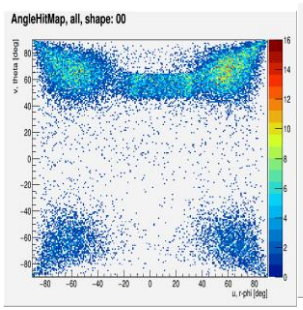


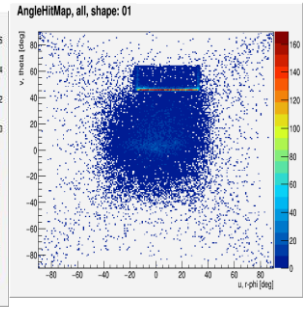


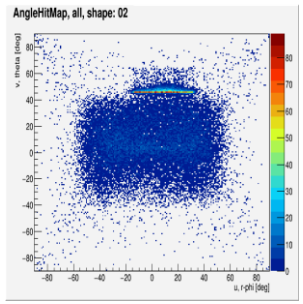


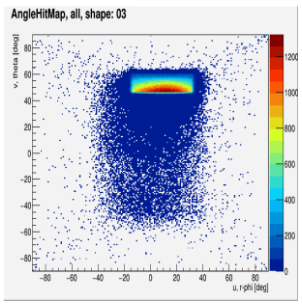
Angle hit map for tracks – pix0 – 17

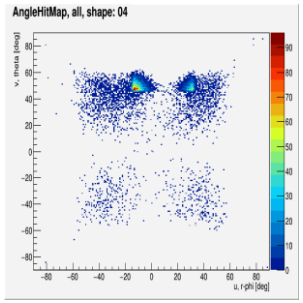
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All

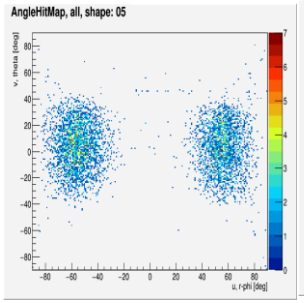


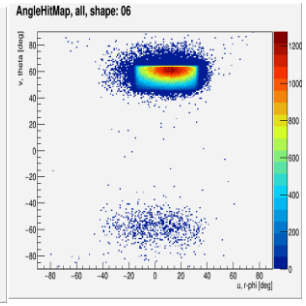


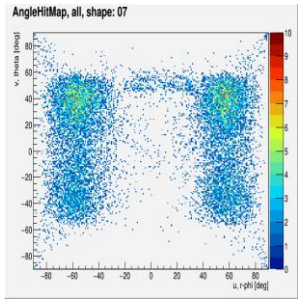


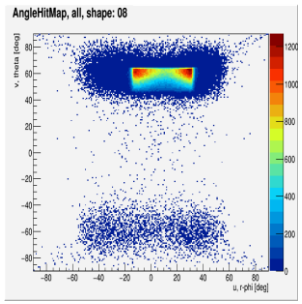


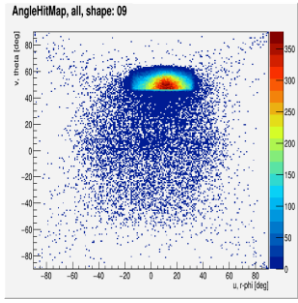


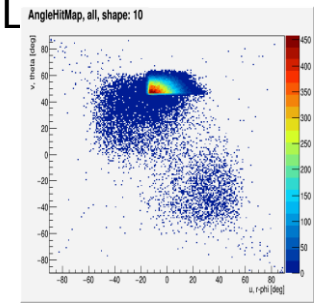


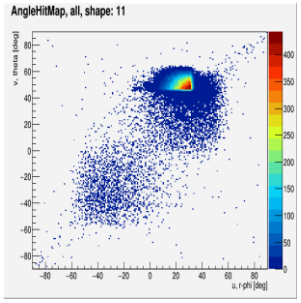


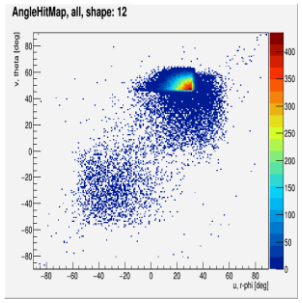


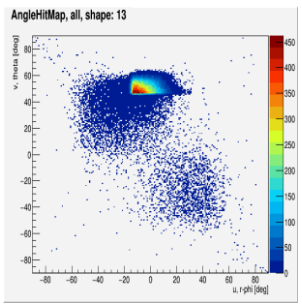


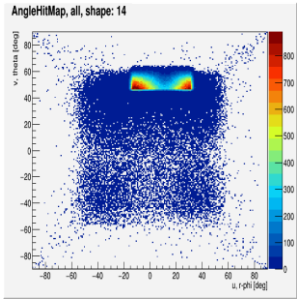


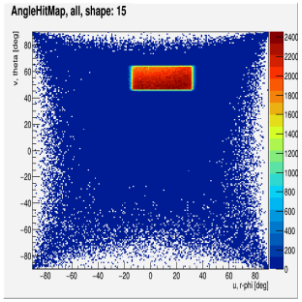






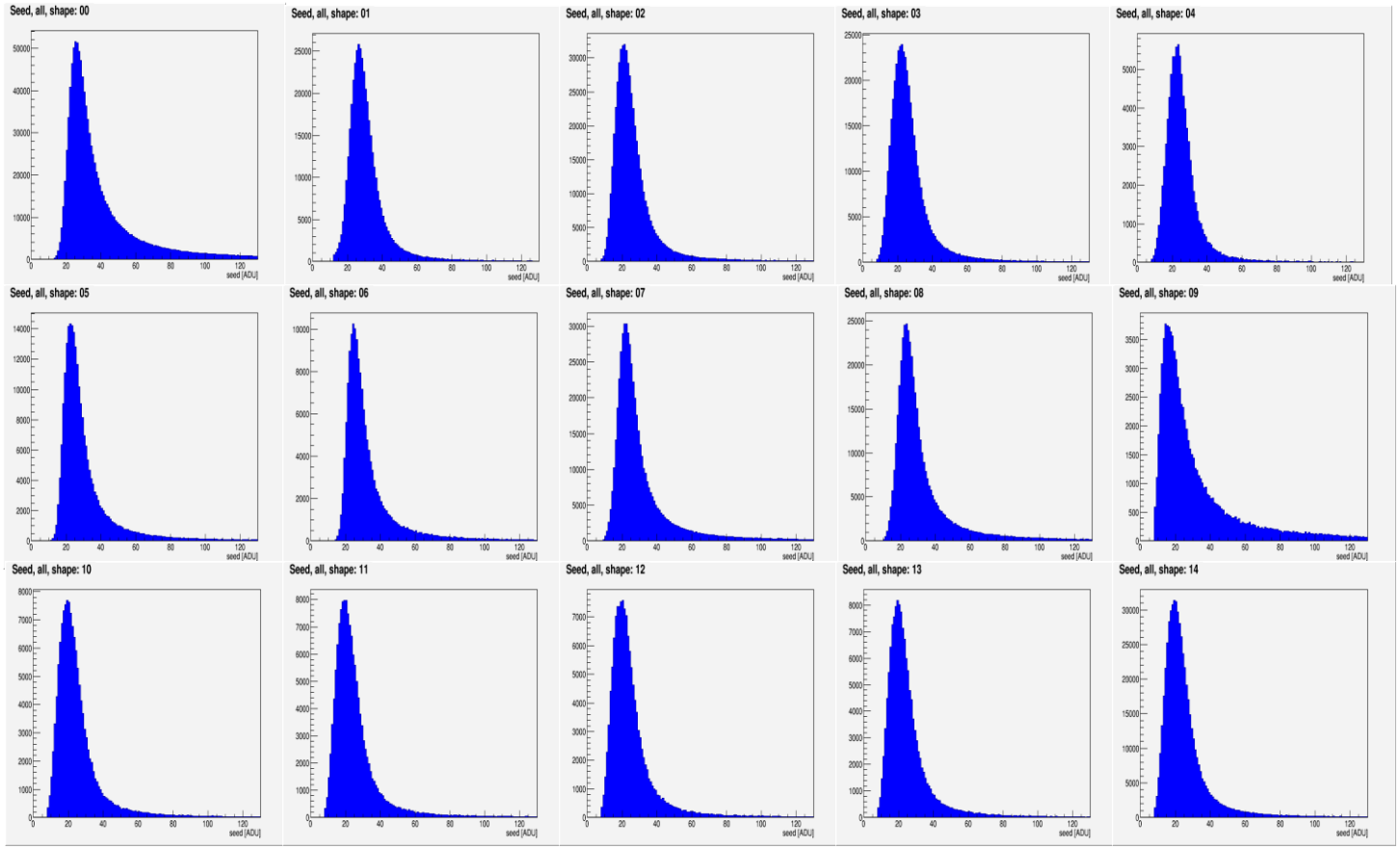


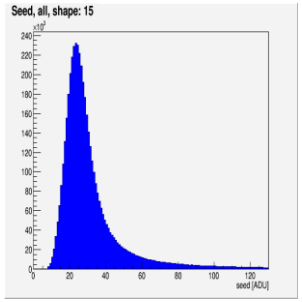




Seed – pix0 – 1a

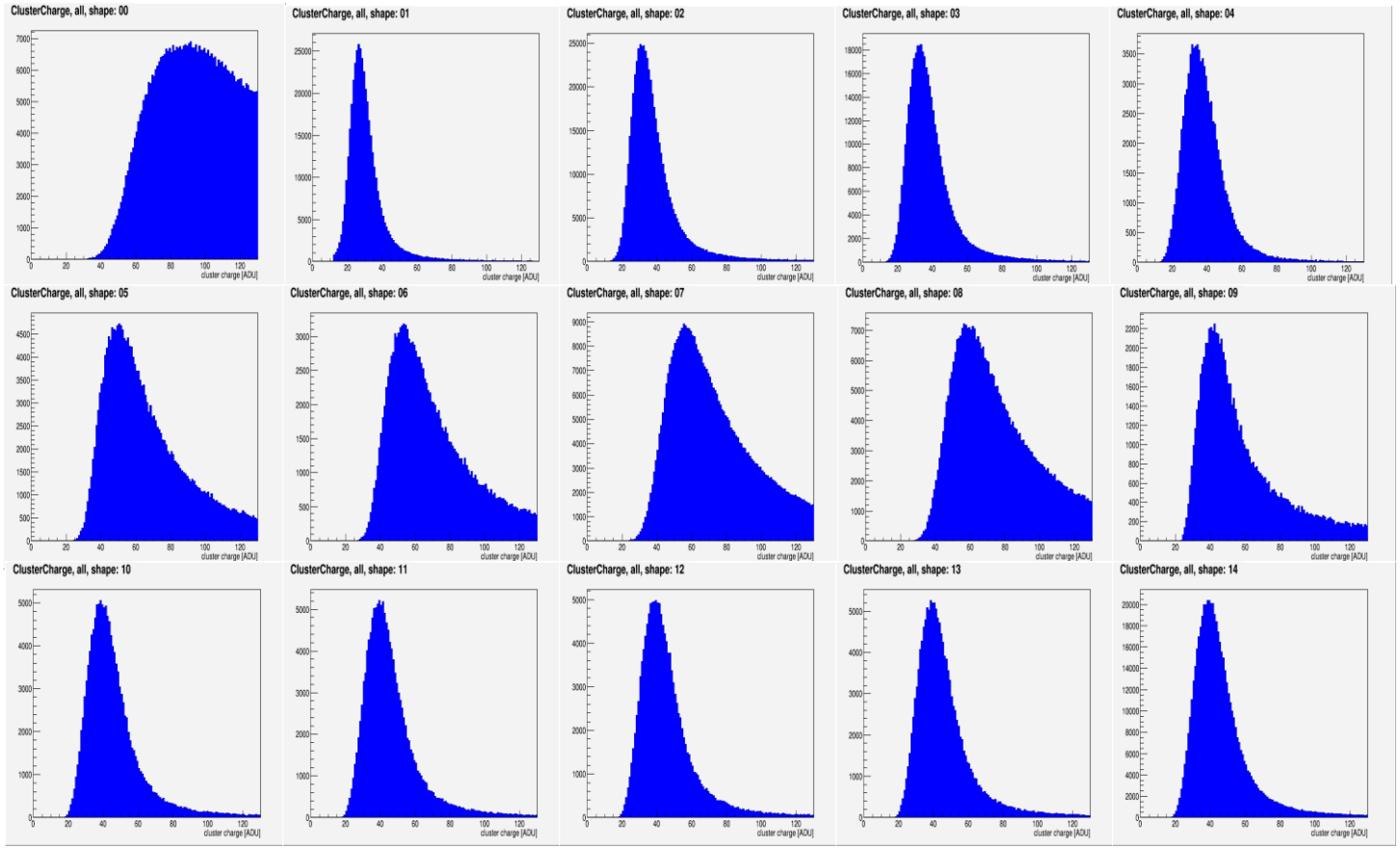
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All

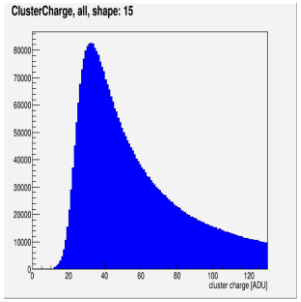




Cluster Charge – pix0 – 1a

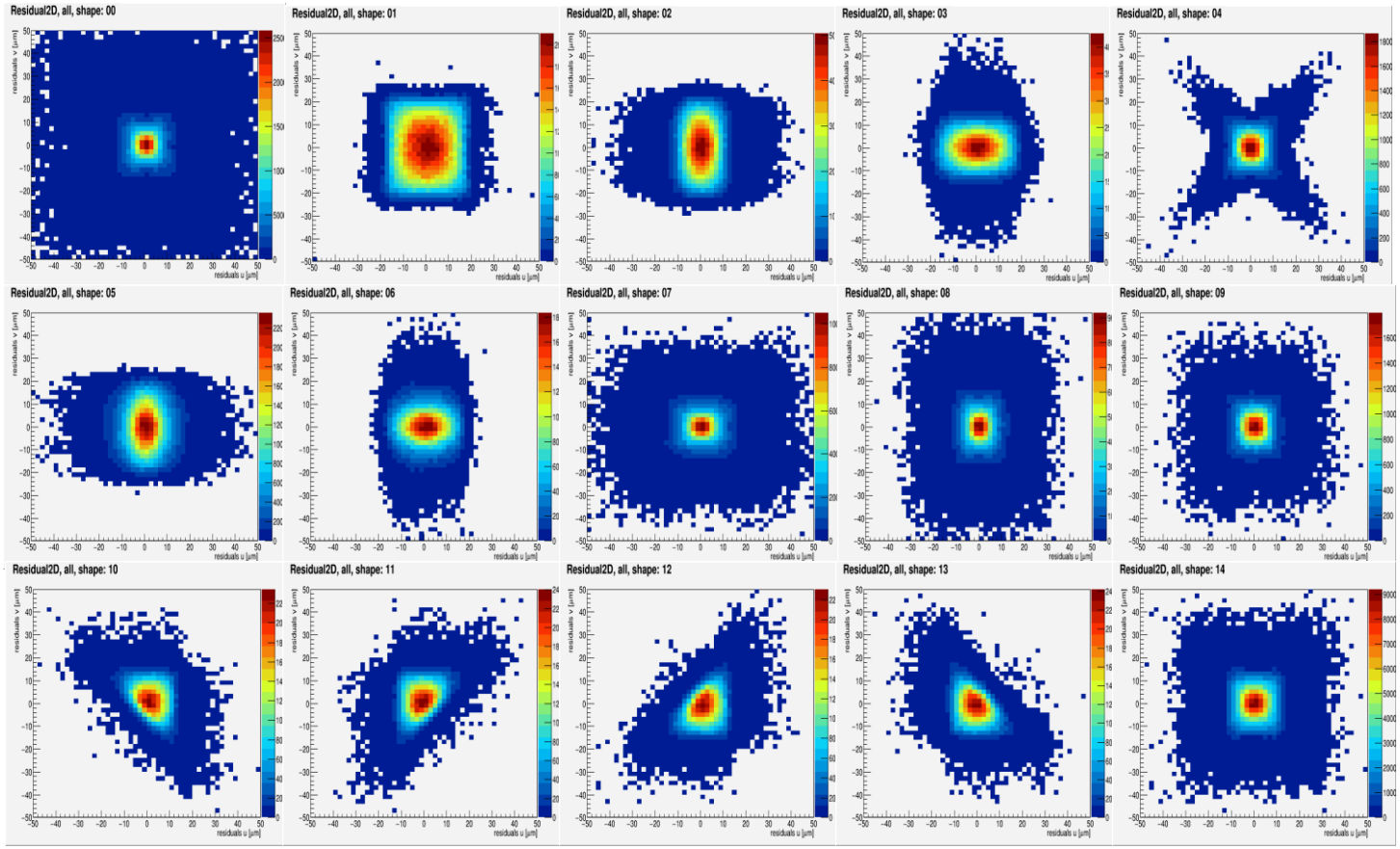
0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All

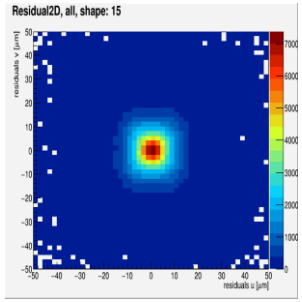




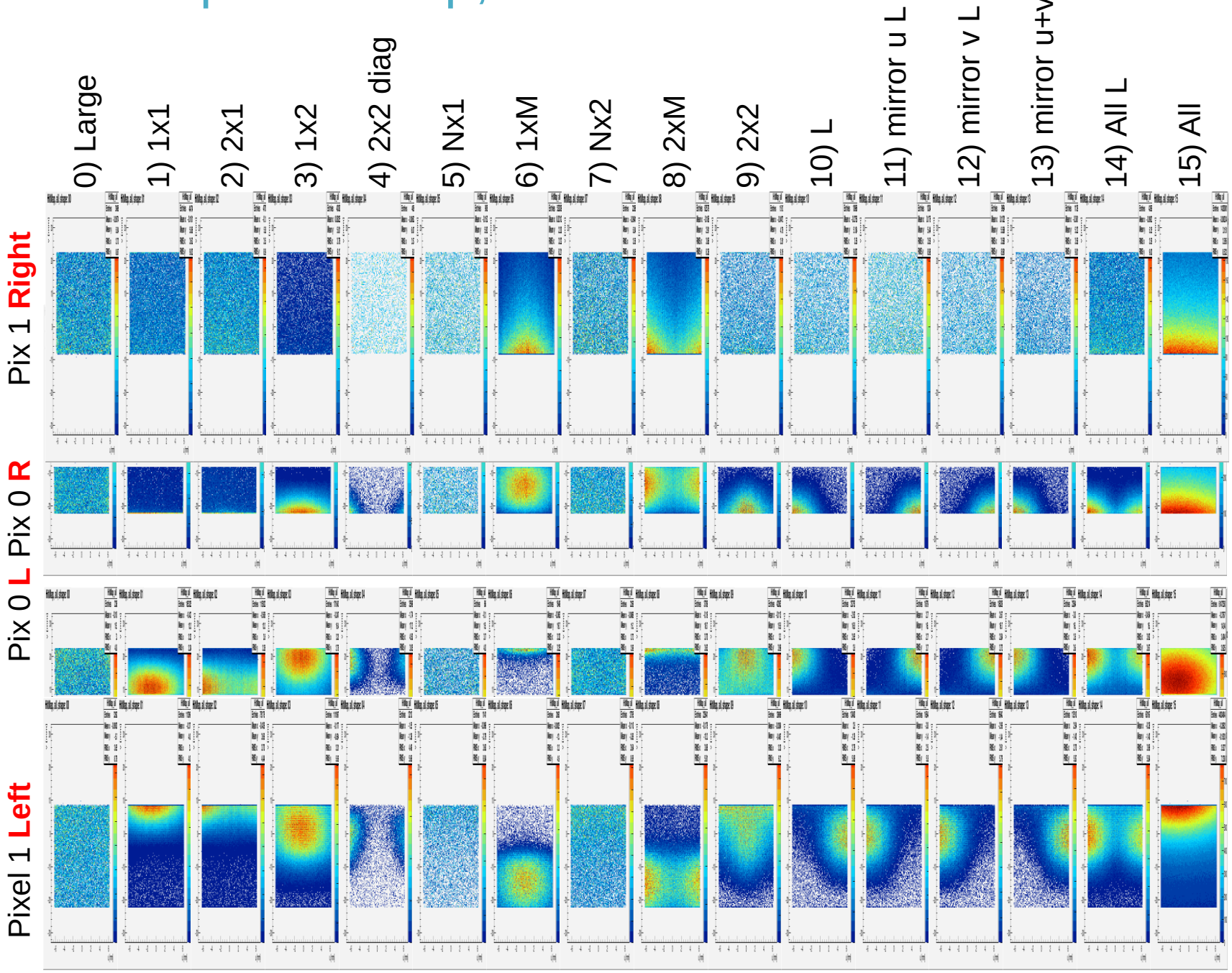
Residual – pix0 – 1a

0) Large
1) 1x1
2) 2x1
3) 1x2
4) 2x2 diag
5) Nx1
6) 1xM
7) Nx2
8) 2xM
9) 2x2
10) L
11) mirror u L
12) mirror v L
13) mirror u+v L
14) All L
15) All





Cluster Shape: Hit Map, Pixel 0/1



Cluster Shape: Hit Map, Pixel 2/3