PSA Performance Analysis and Optimization

DPG Frühjahrstagung 2014 Frankfurt

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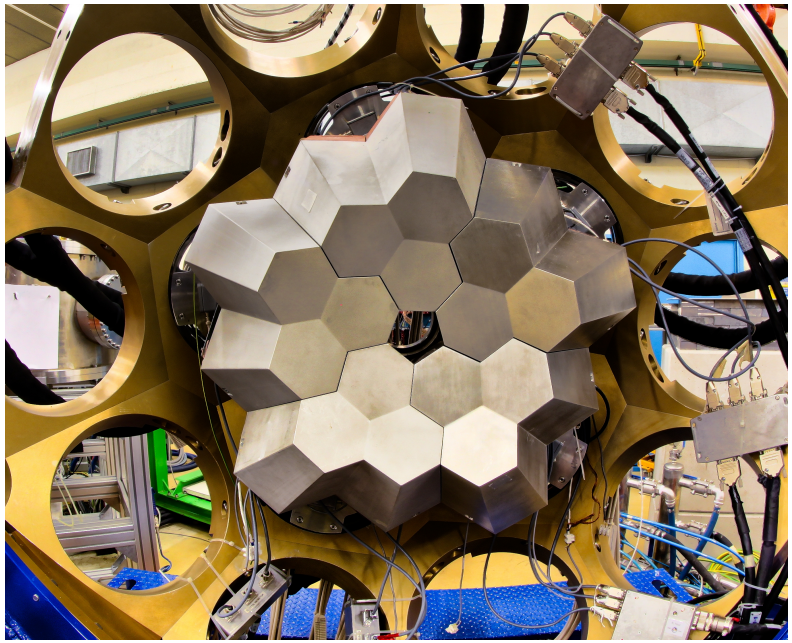
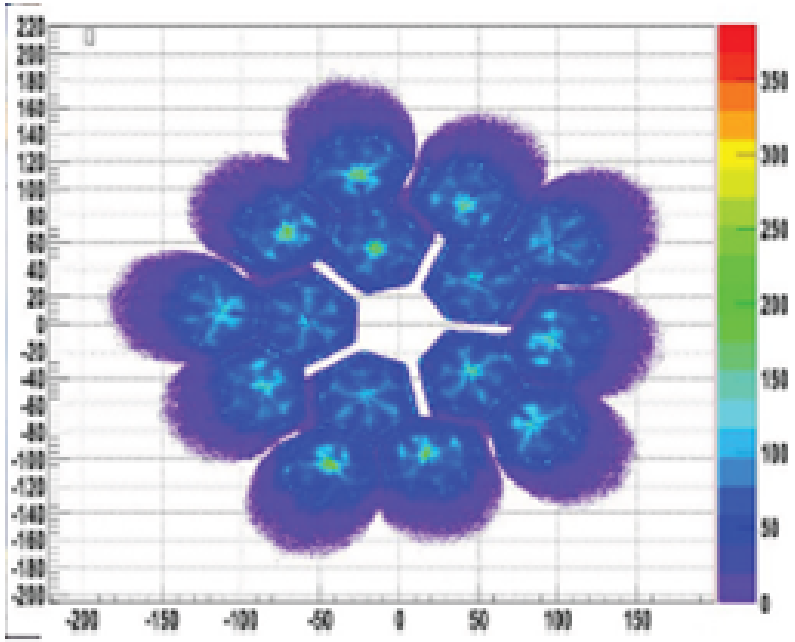
Content

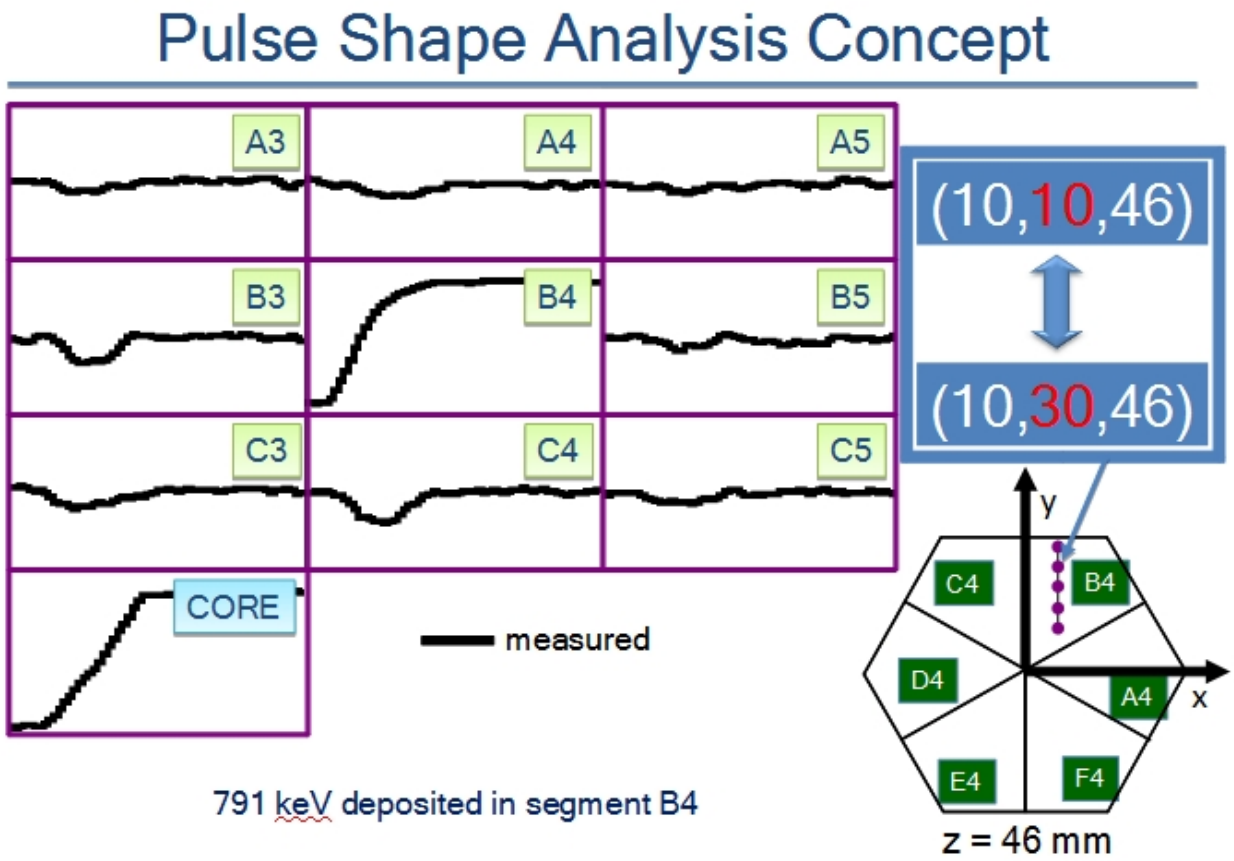
Introduction



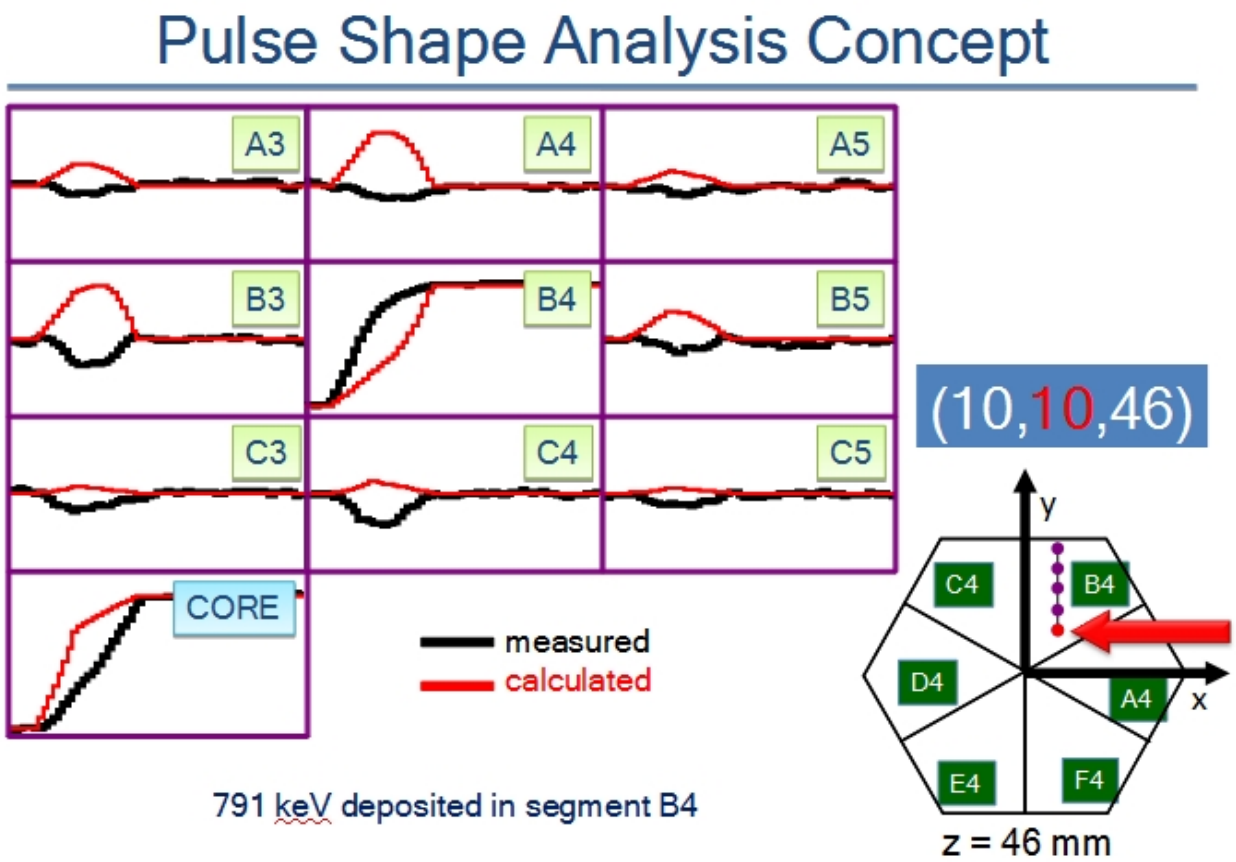


- No Compton veto detectors ⇒ tracking
- Position resolution necessary for tracking and Doppler correction
- ⇒ Pulse Shape Analysis (PSA)

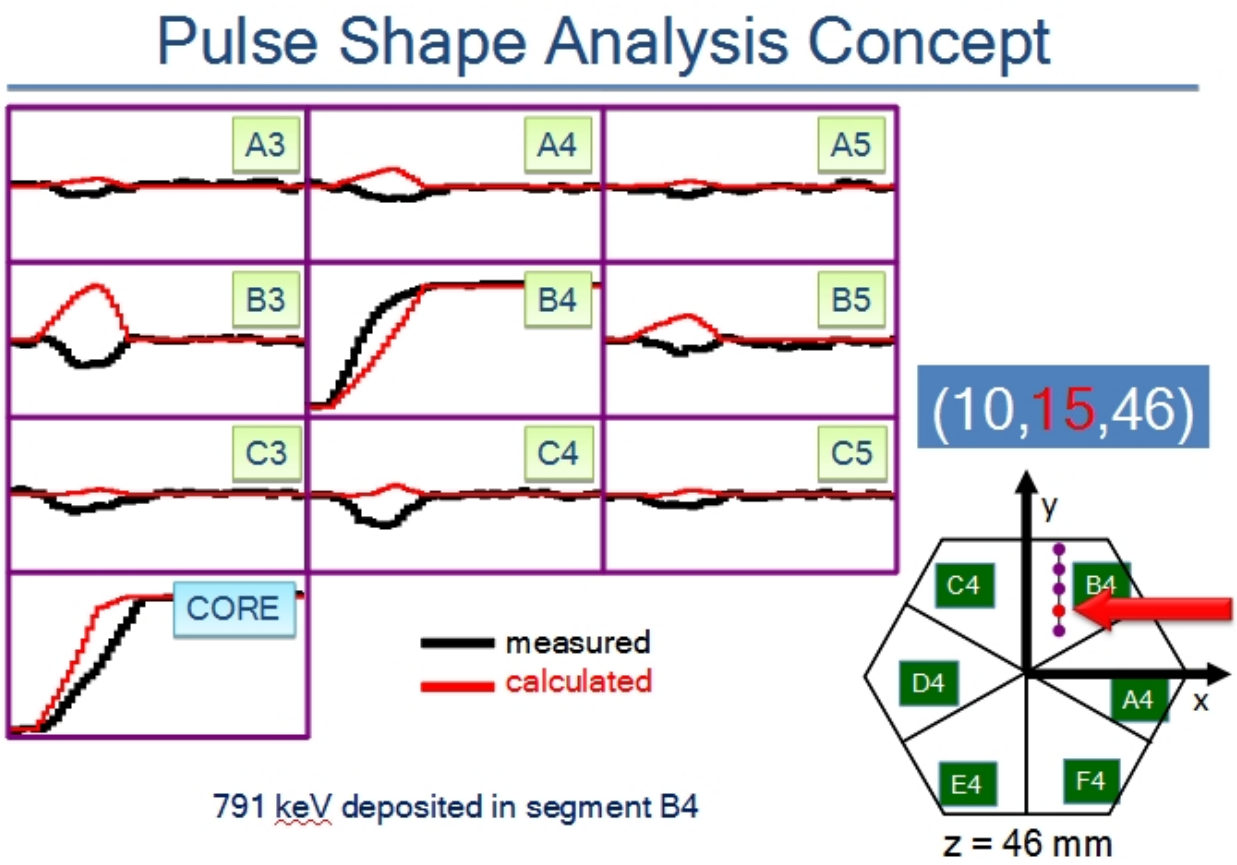
PSA working principle



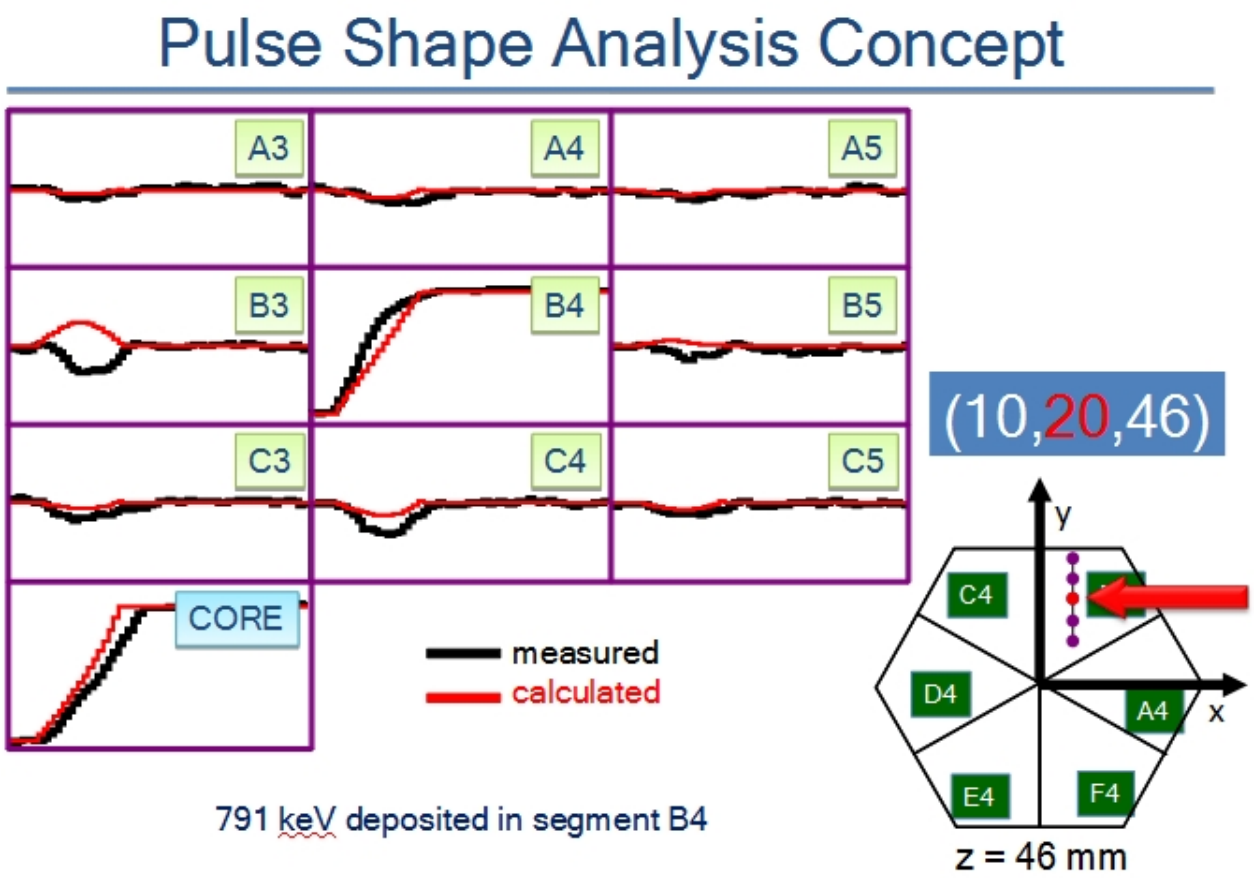
PSA working principle



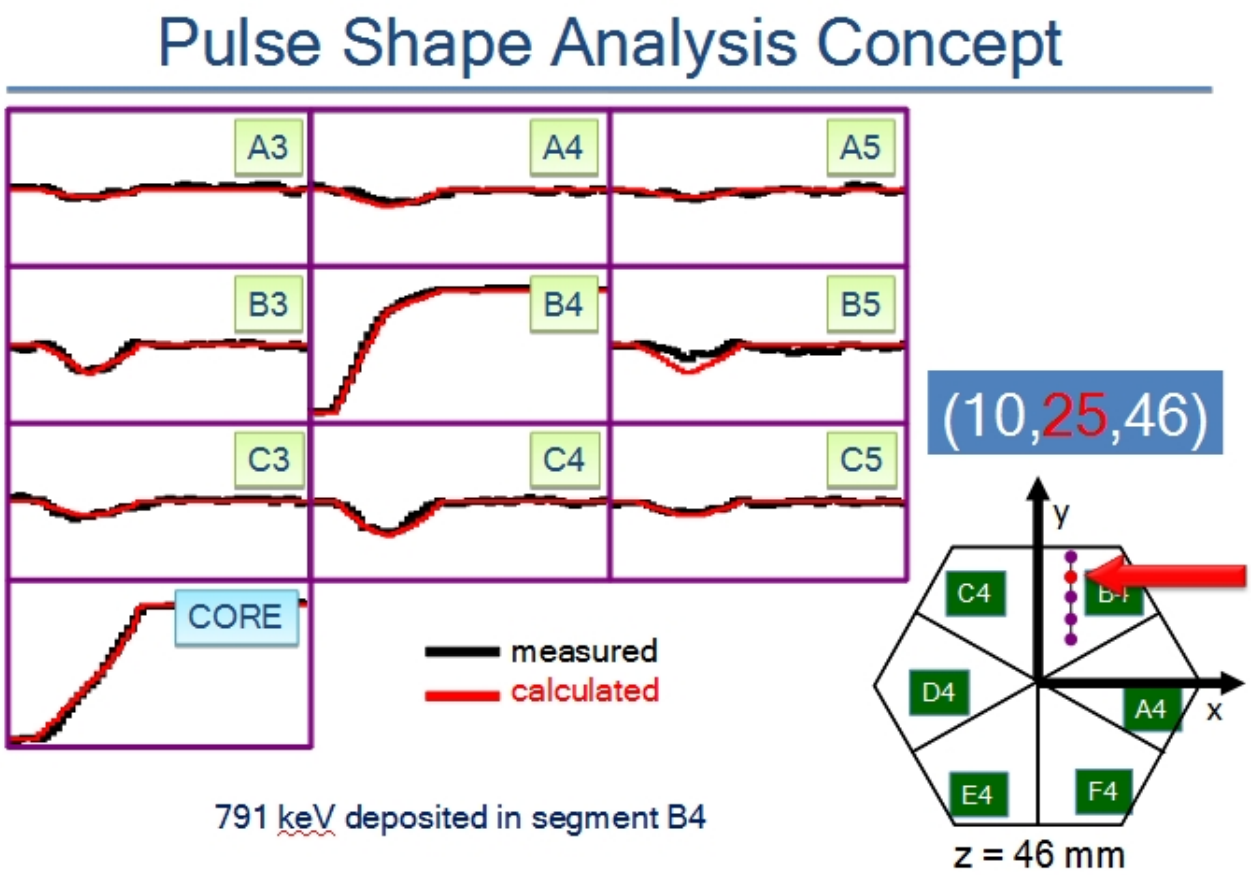
PSA working principle



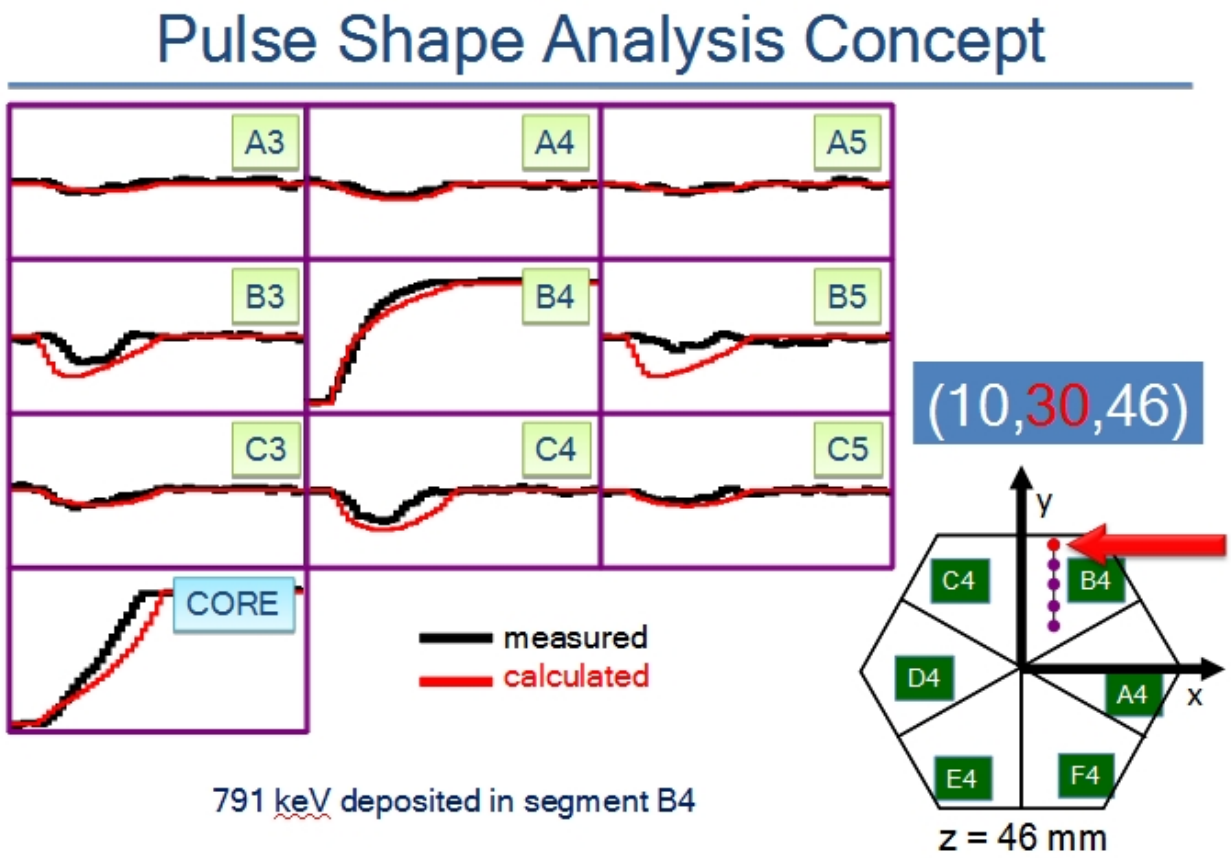
PSA working principle



PSA working principle

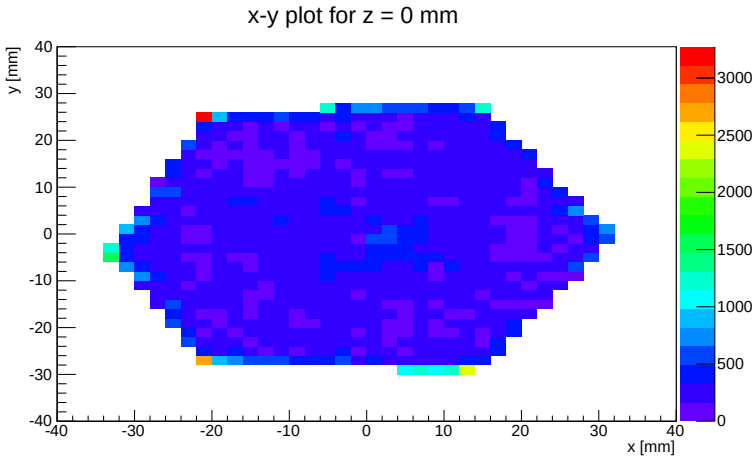


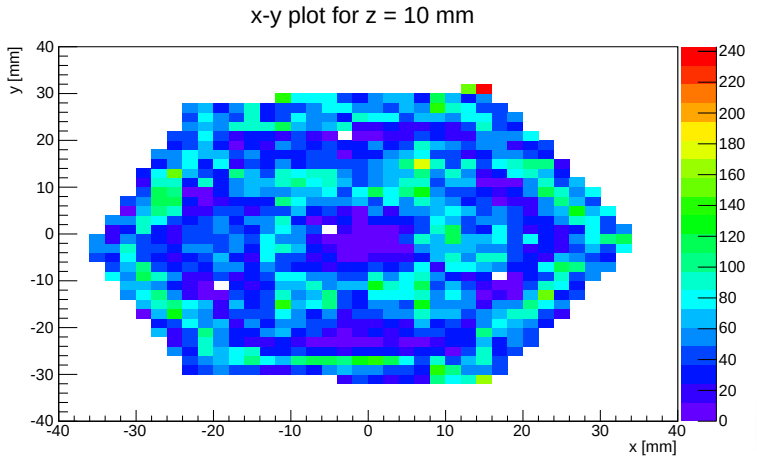
PSA working principle



Introduction

- Isotropic radiating single source
- PSA favors certain areas of the detector
- Structure of Segments visible





Optimization method

- Choosing the Distance Metric
- Preamplifier Response function
- Differential Crosstalk

Methods and observables

- Doppler correction and FWHM
- Homogeinity of distribution of hits
- Correlation of neighbouring grid points ($\Rightarrow$ Clustering)

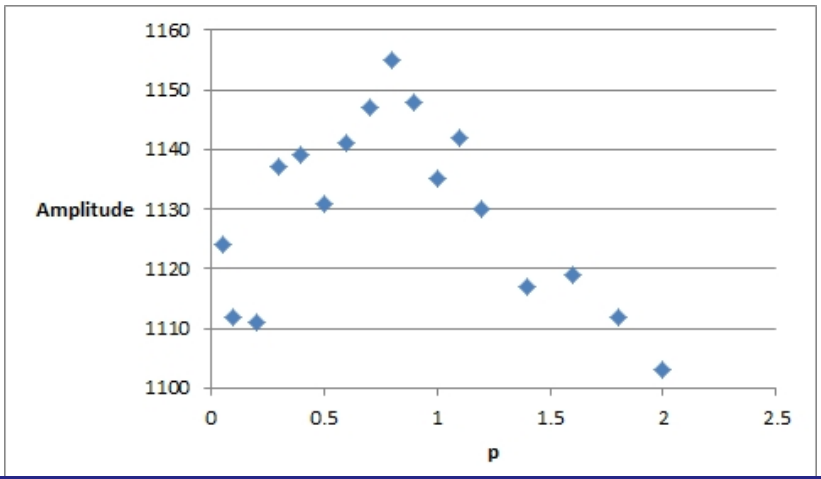
Results using Doppler corrected Peaks

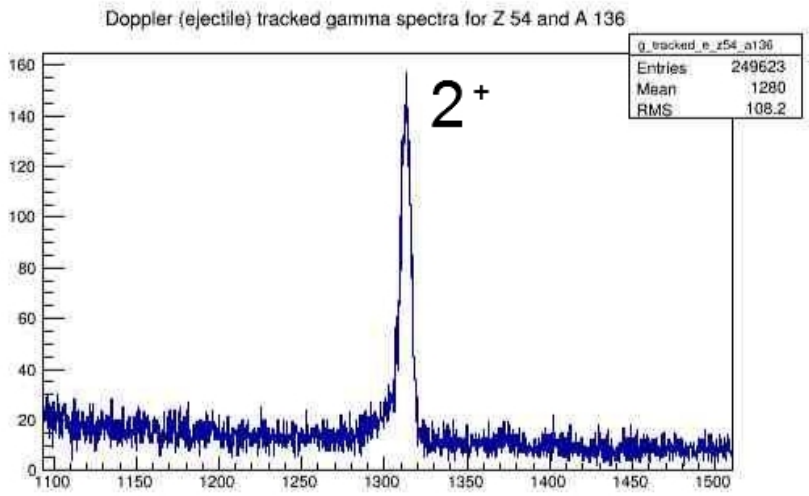
Distance Metric

$$\text{Figure of Merit} = \sum_{\text{Segments } j} \sum_{\text{Timesteps } t_i} |A^m_{i,j} - A^s_{i,j}|^p$$

Behaviour of $A^m_{i,j} - A^s_{i,j}$ gaussian?

Doppler correction for ^{136}Xe(Benedikt Birkenbach and Andreas Vogt)





Analysis

- New Method: Deviation from the mean
- Bin content of grid points
- Mean bin content $Mean = \sum_{i,j}^{N} BinContent_{i,j} \cdot \frac{1}{N}$
- N number of bins

Error of single Measurement

$$\sigma = \sqrt{\frac{\sum_{i,j} (BinContent_{i,j} - Mean)^2}{N - 1}}$$

For comparison the Error has to be normalized by the Mean value.

Correlation Coefficient

- Consider Clustering

Correlation Coefficient

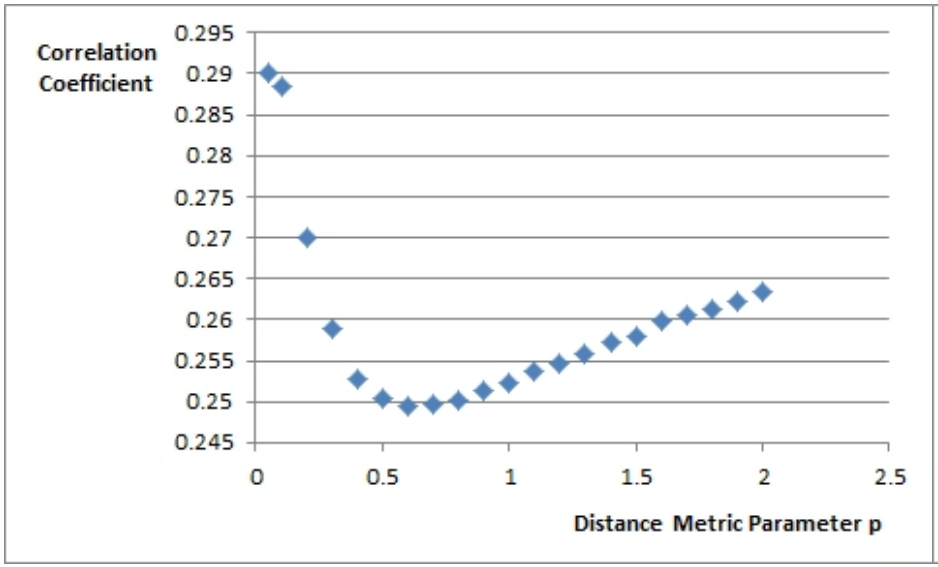
BC = Bin Content, $E(BC_{i,j})$ = Expectancy Value for the bin (i,j)

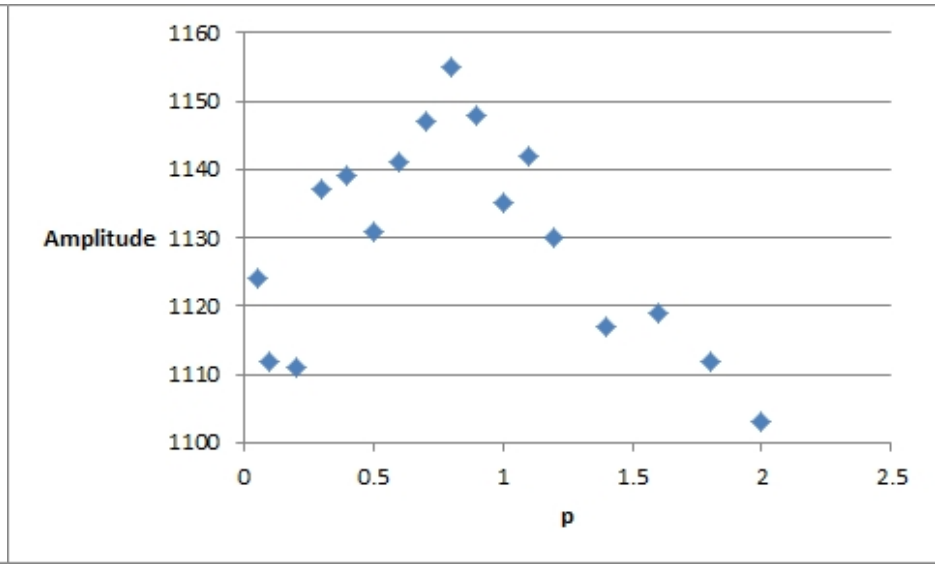
$$Cov = E[(BC_{i,j} - E(BC_{i,j}))\,(BC_{i,j+1} - E(BC_{i,j+1}))]$$

To get a comparable Correlation Coefficent one has to normalize the Covariance

$$Corr.Coeff. = \frac{Cov}{\sigma_{i,j}\sigma_{i,j+1}} = \frac{Cov}{\sigma^2}$$

Distance Metric with the Correlation Coefficient



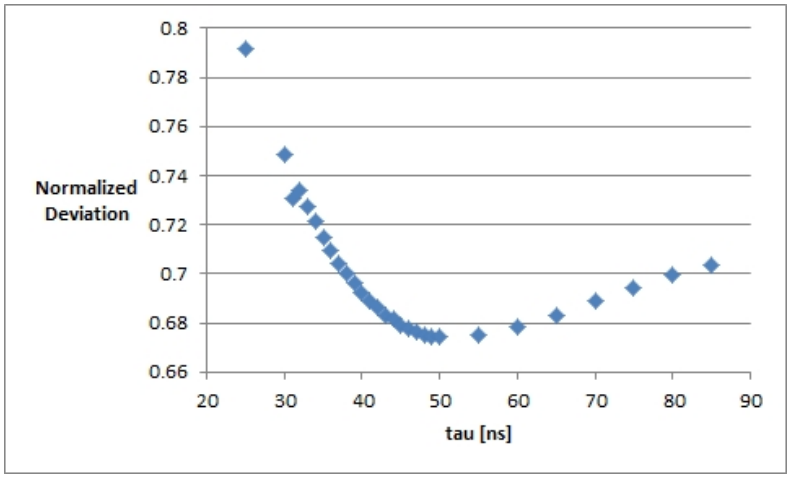


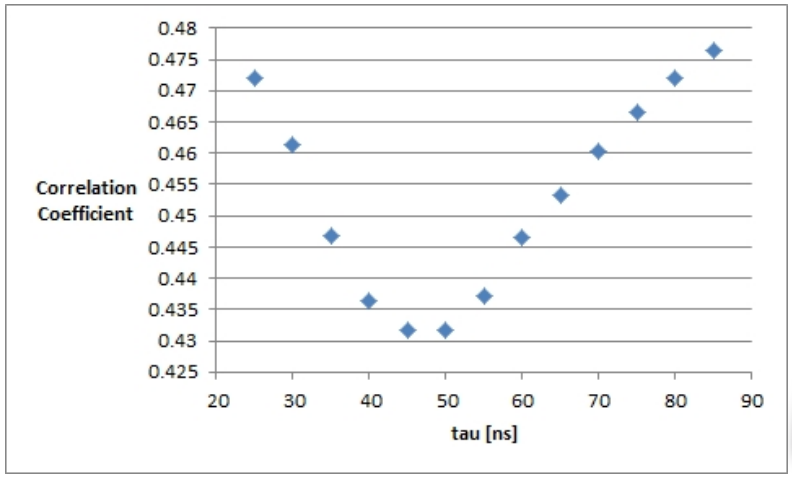
- Consistent behaviour with Doppler correction method
- More accurate

Response Function

Convolution of real signal and detector response

- Preamplifiers and digitizers smear out measured signal
- Deconvolution with exponential decay parametrized by decay parameter τ
- Older value 35 ns



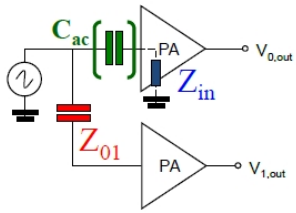


Differential Crosstalk

With $Z_{in} = 1/sAC_{fb} + (1/sC_{ac}) + R_{cold}$

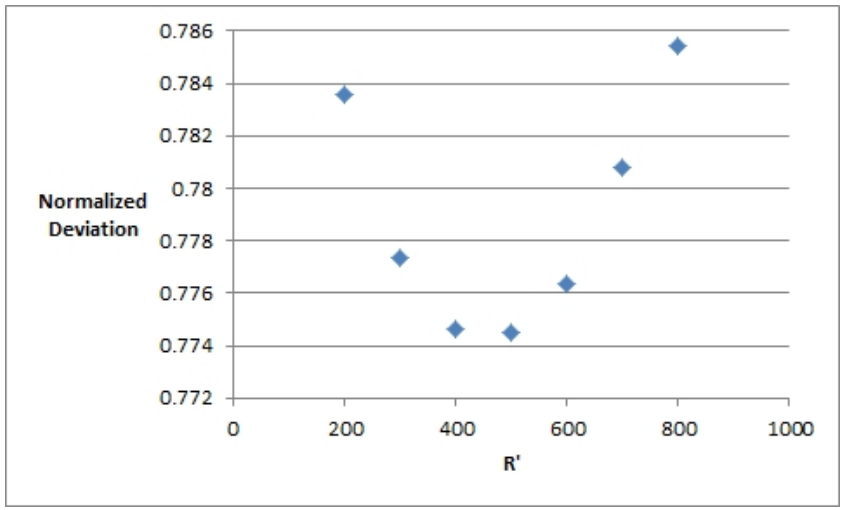
Xtalk ~ Z_{in} / Z_{01}

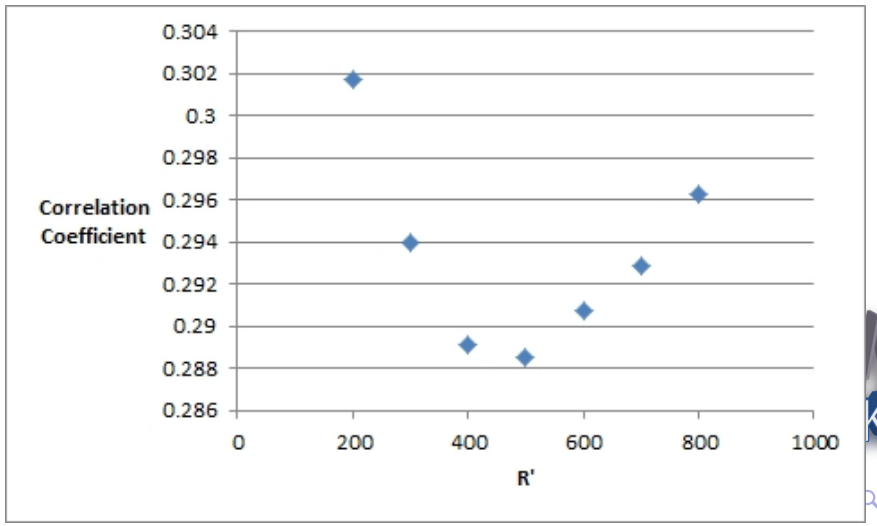
~ $\underbrace{C_{01}/AC_{fb} + (C_{01}/C_{ac})}_{\text{Proportional}} + \underbrace{s \cdot R_{cold} C_{01}}_{\text{Differential Xtalk}}$



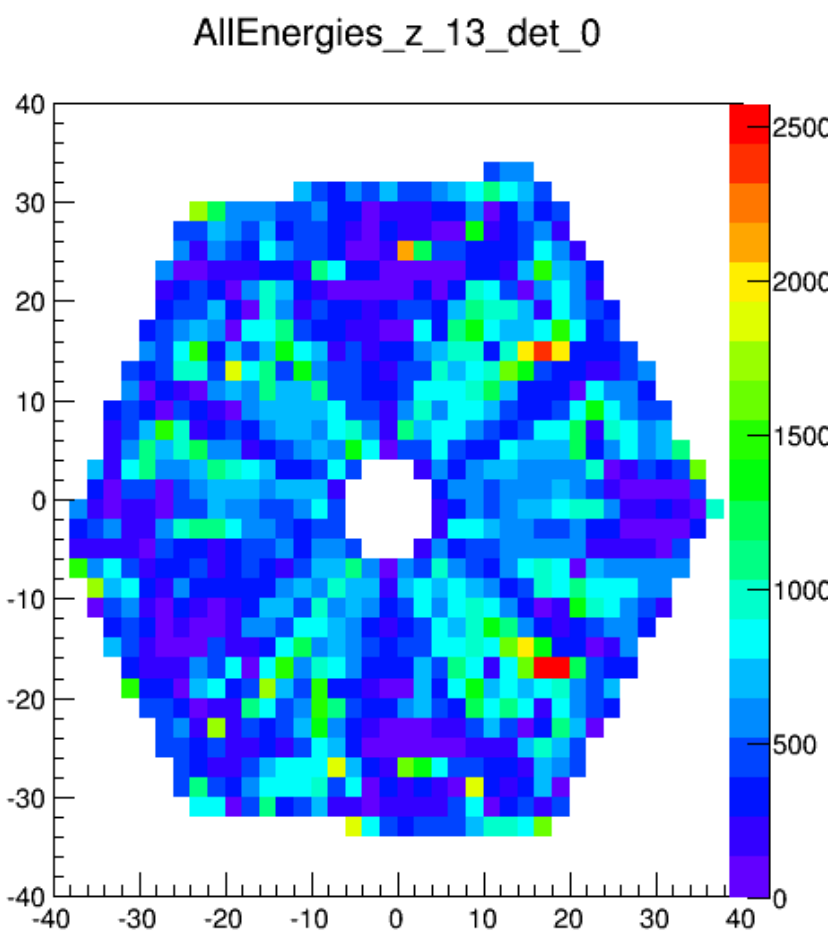
Crosstalk

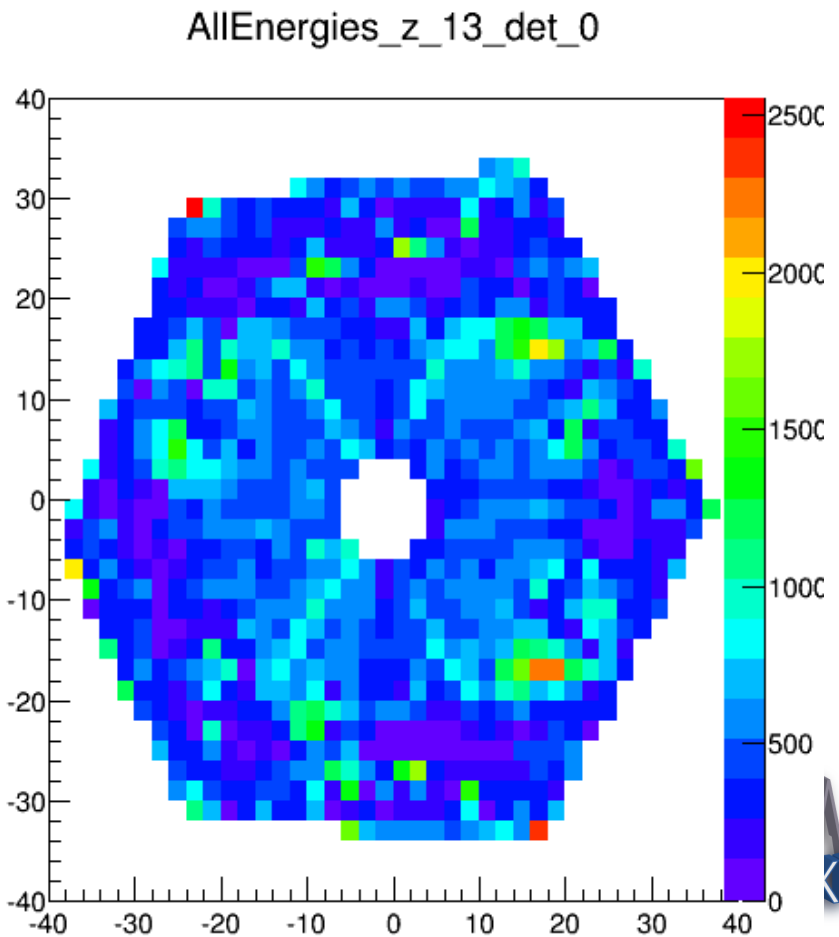
- Differential Crosstalk derived from Prop. Crosstalk
- One free parameter





Comparison


AllEnergies_z_13_det_0
40
30
20
10
0
-10
-20
-30
-40
-40 -30 -20 -10 0 10 20 30 40
2500
2000
1500
1000
500
0


AllEnergies_z_13_det_0
40
30
20
10
0
-10
-20
-30
-40
-40 -30 -20 -10 0 10 20 30 40
2500
2000
1500
1000
500
0

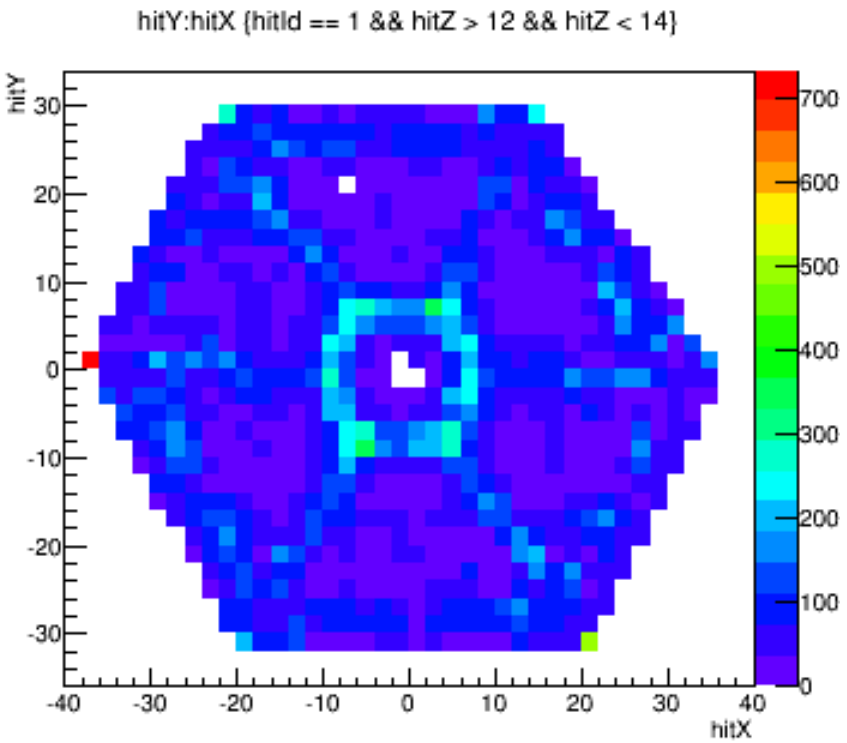
Outlook

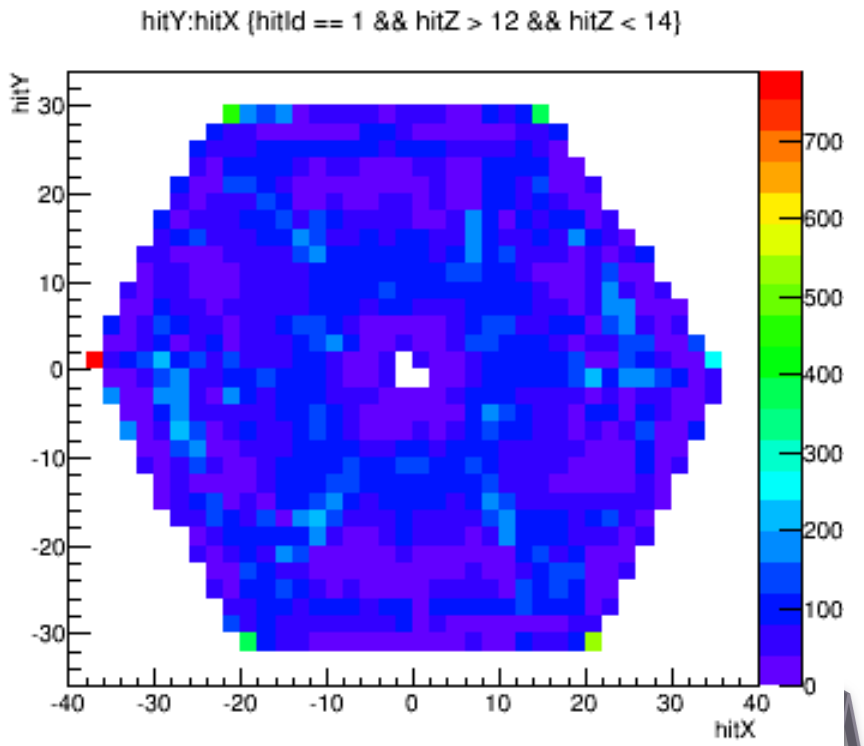
- PSA performance was investigated and optimized
- Optimization of distance metric, preamplifier response, differential crosstalk
- Clustering still exists. Exclude investigated parameters
- Investigate the ADL bases - use scanning table data?

Outlook

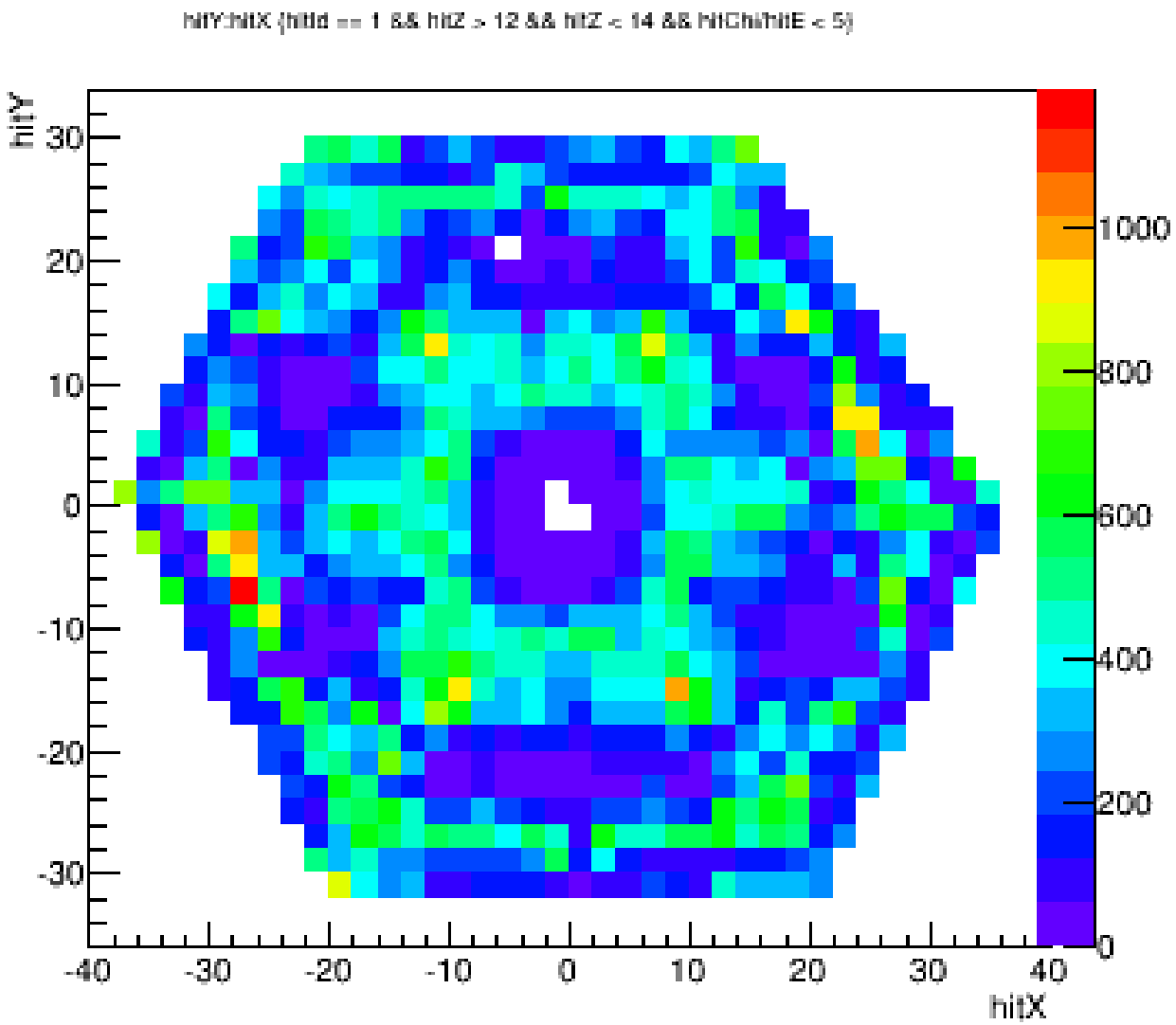
Thank you for your attention

Appendix

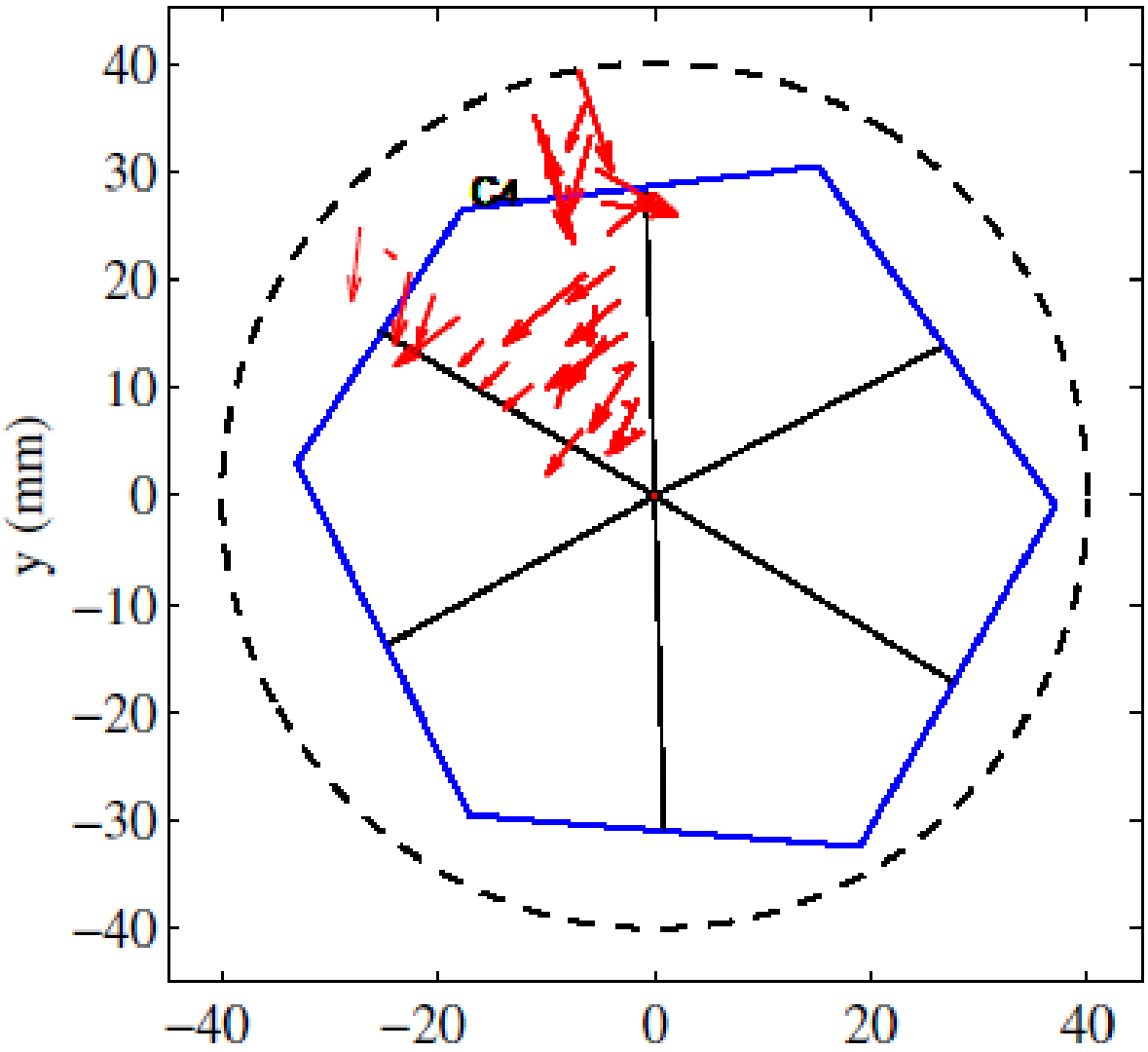

hitY:hitX {hitId == 1 && hitZ > 12 && hitZ < 14}
hitY
hitX
30
20
10
0
-10
-20
-30
-40
700
600
500
400
300
200
100
0


hitY:hitX {hitId == 1 && hitZ > 12 && hitZ < 14}
hitY
hitX
30
20
10
0
-10
-20
-30
-40
700
600
500
400
300
200
100
0

Appendix


hitY:hitX (hitId == 1 && hitZ > 12 && hitZ < 14 && hitChi/hitE < 5)
hitY
30
20
10
0
-10
-20
-30
-40
-30
-20
-10
0
10
20
30
40
hitX
1000
800
600
400
200
0

Appendix

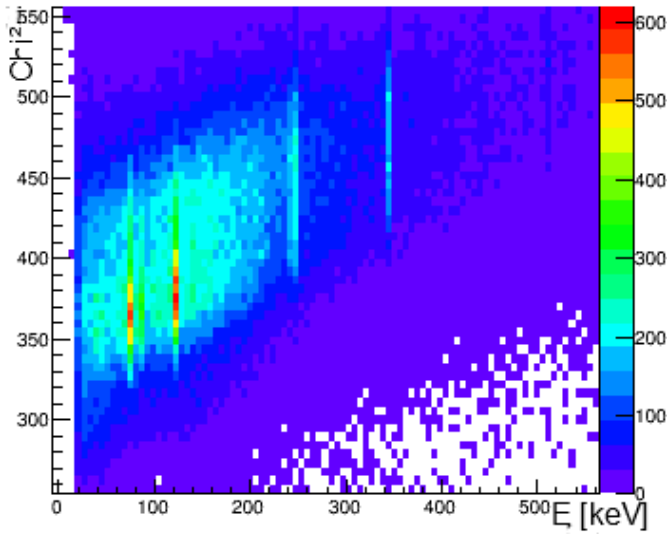


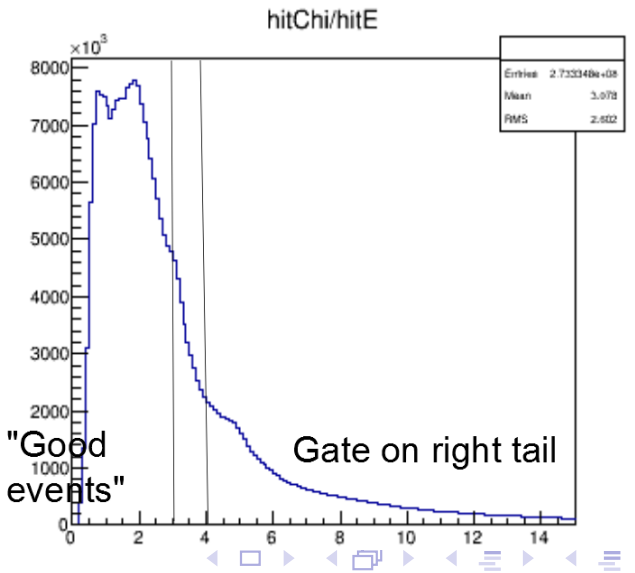
Further Quantization

Minimization

$$\text{Figure of Merit} = \sum_{\text{Segments } j} \sum_{\text{Timesteps } t_i} |A^m_{i,j} - A^s_{i,j}|^p$$

- $\chi^2 = \chi^2(E)$
- $\Rightarrow$ distinguish between good and bad matching of traces

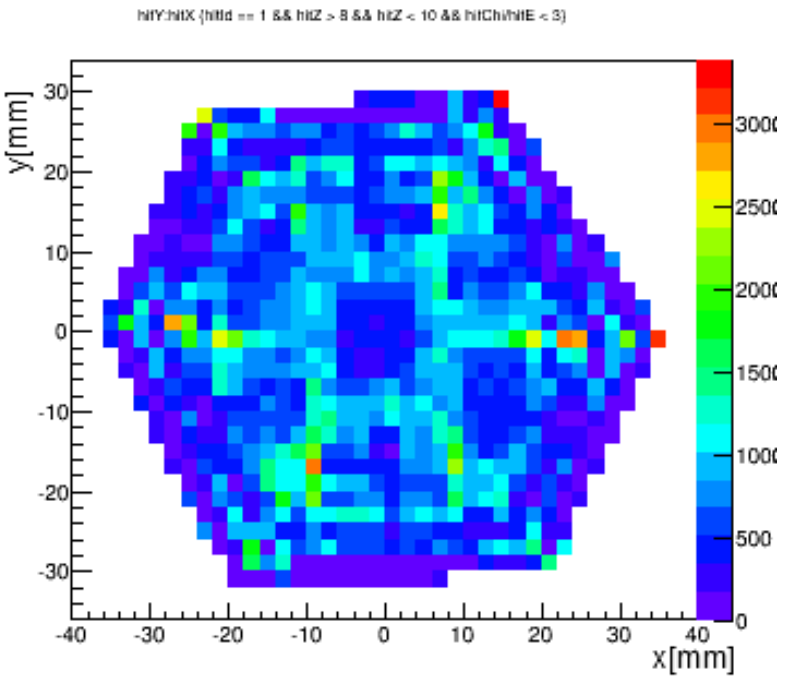


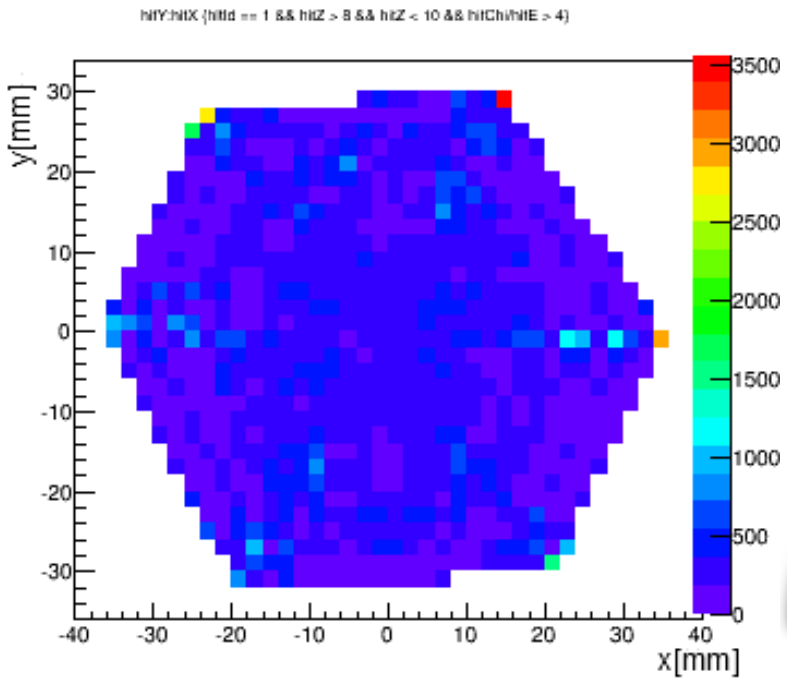


Further Quantization

Gate on χ^2/E

- On the right: 40% statistics
- Local Minimum





Bibliography I

[1] Bart Bruyneel CEA Saclay France. Electronics. *EGAN School, Liverpool*, 2011.

[2] Francesco Recchia. In-beam test and imaging capabilities of the agata prototype detector. *Universita degli studi Padova*, 2008.