PSA uncertainties estimation via bootstrap technique

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CONTENTS

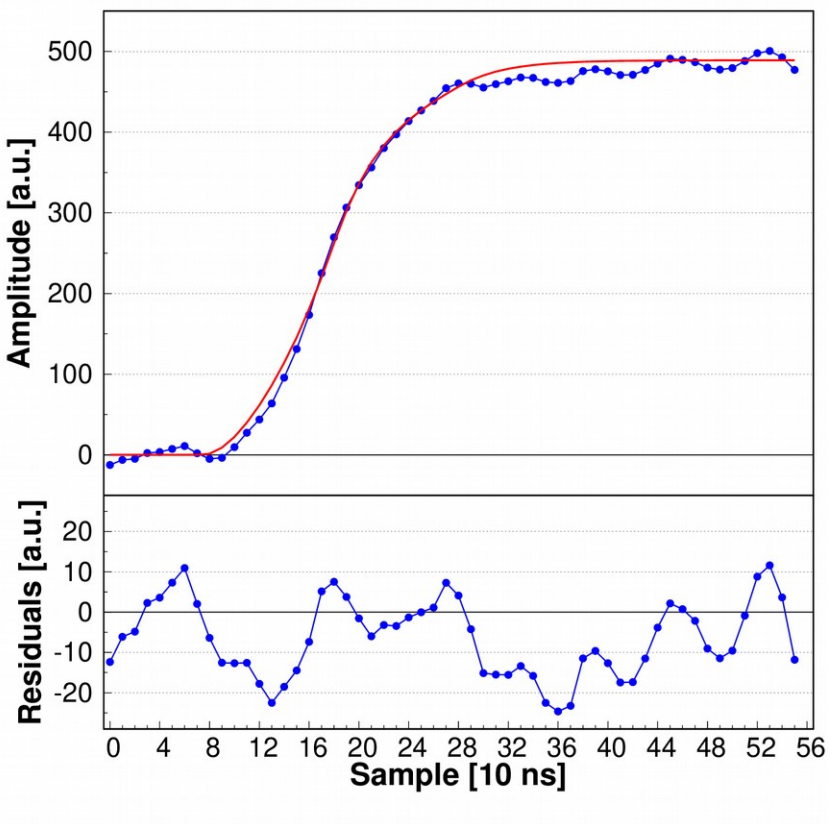
The **bootstrap method** is a resampling technique used to estimate statistics on a population by sampling a dataset with replacement.
It allows to estimate some properties of AGATA Pulse-Shape Analysis.

- Bootstrap on AGATA
- PSA uncertainties estimation
  - Definition?
  - Energy dependence
  - Position dependence
- Issues?

BOOTSTRAP

By comparing the original (short) trace with those from the database, the γ-ray interaction point position is identified inside the segment.

$$(E_i, x_i, y_i, z_i)_{OR}$$



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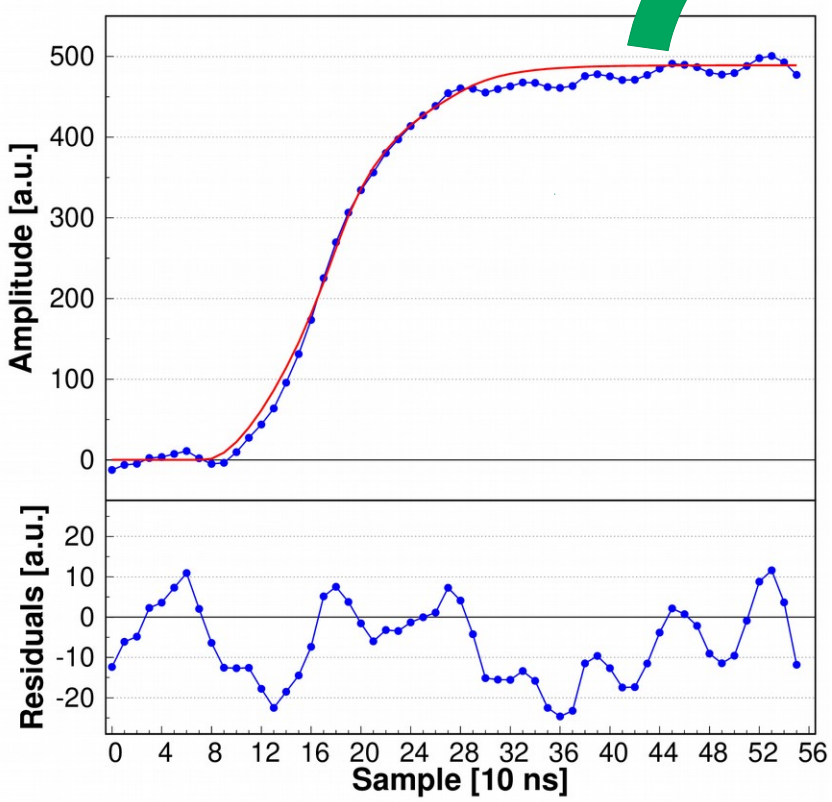
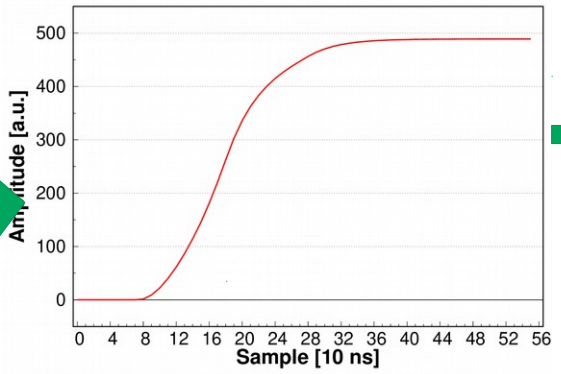
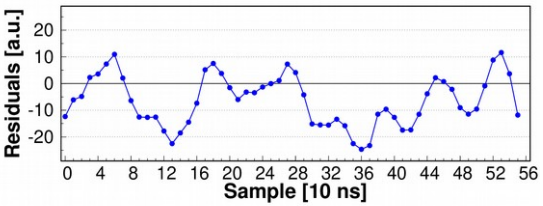




+ (RANDOM)



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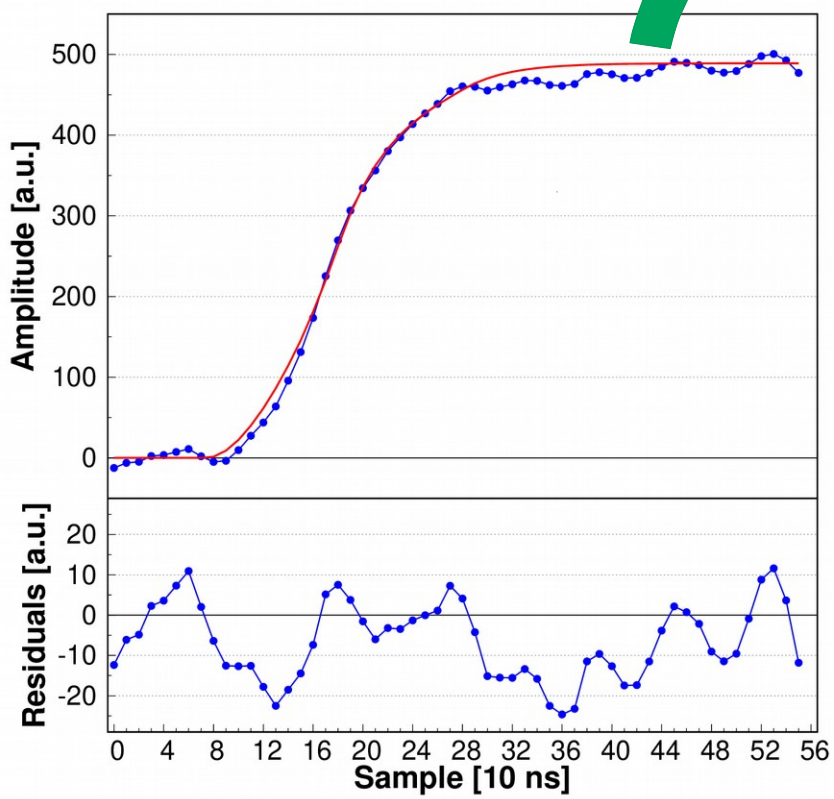

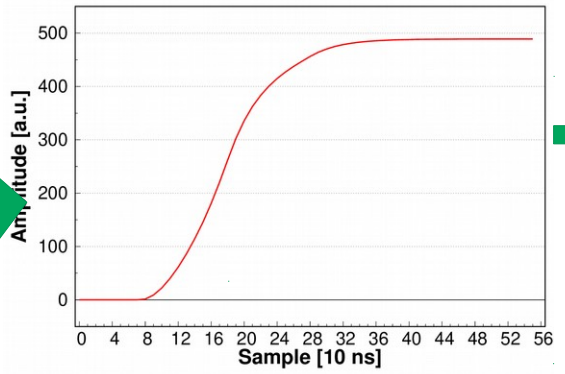

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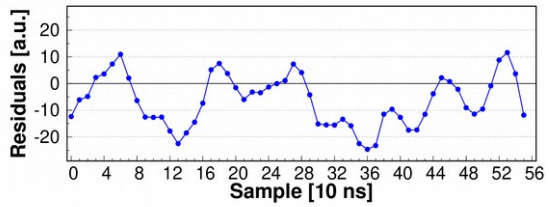
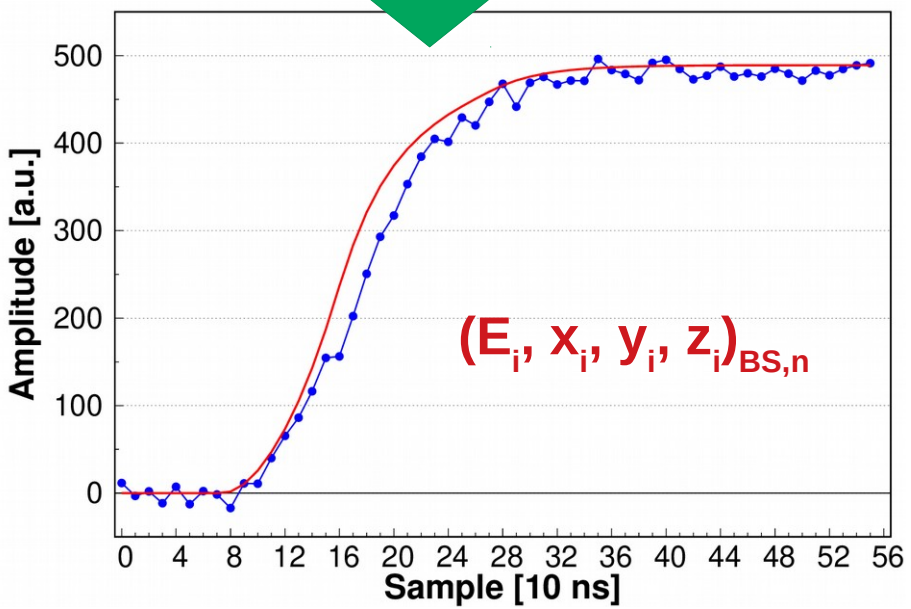
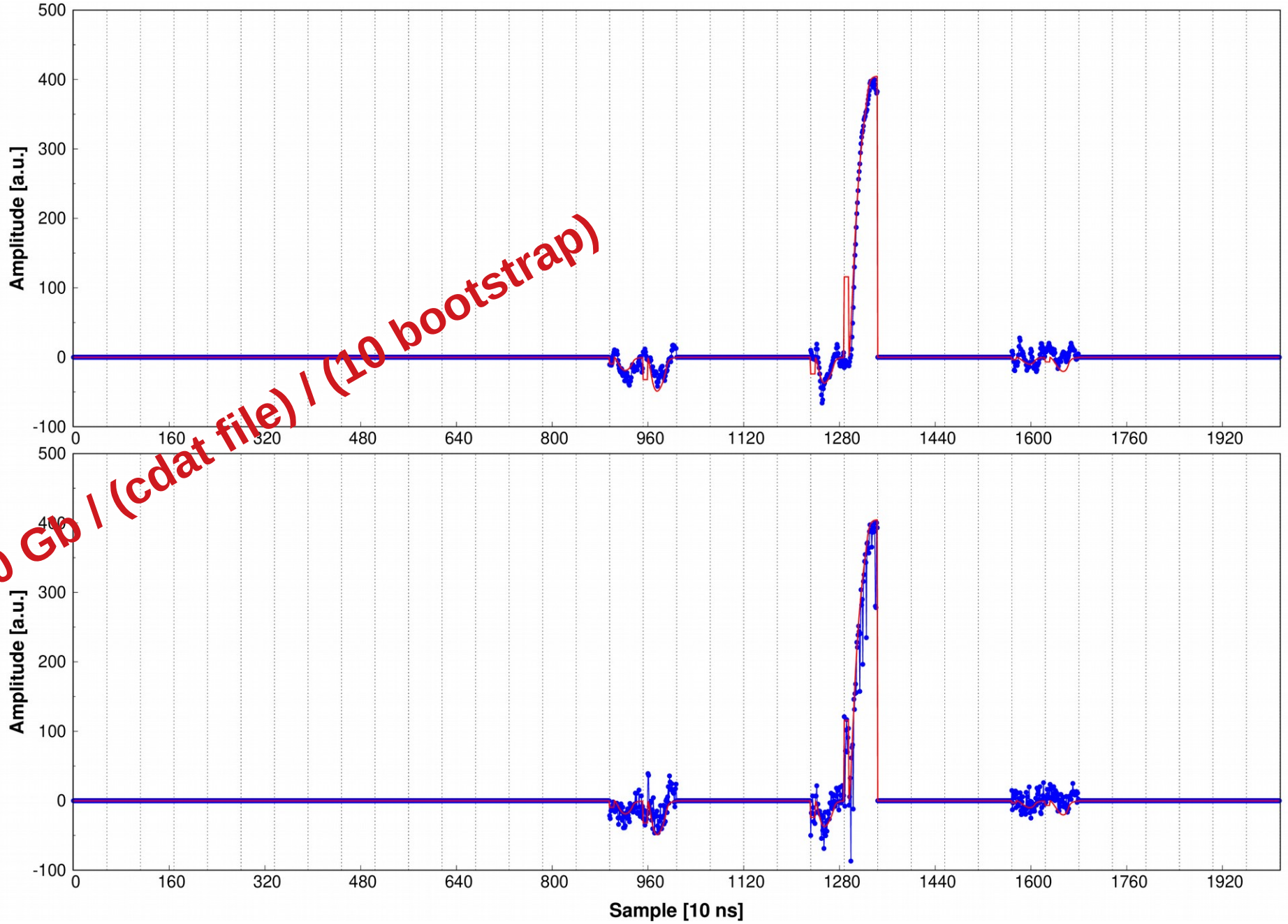




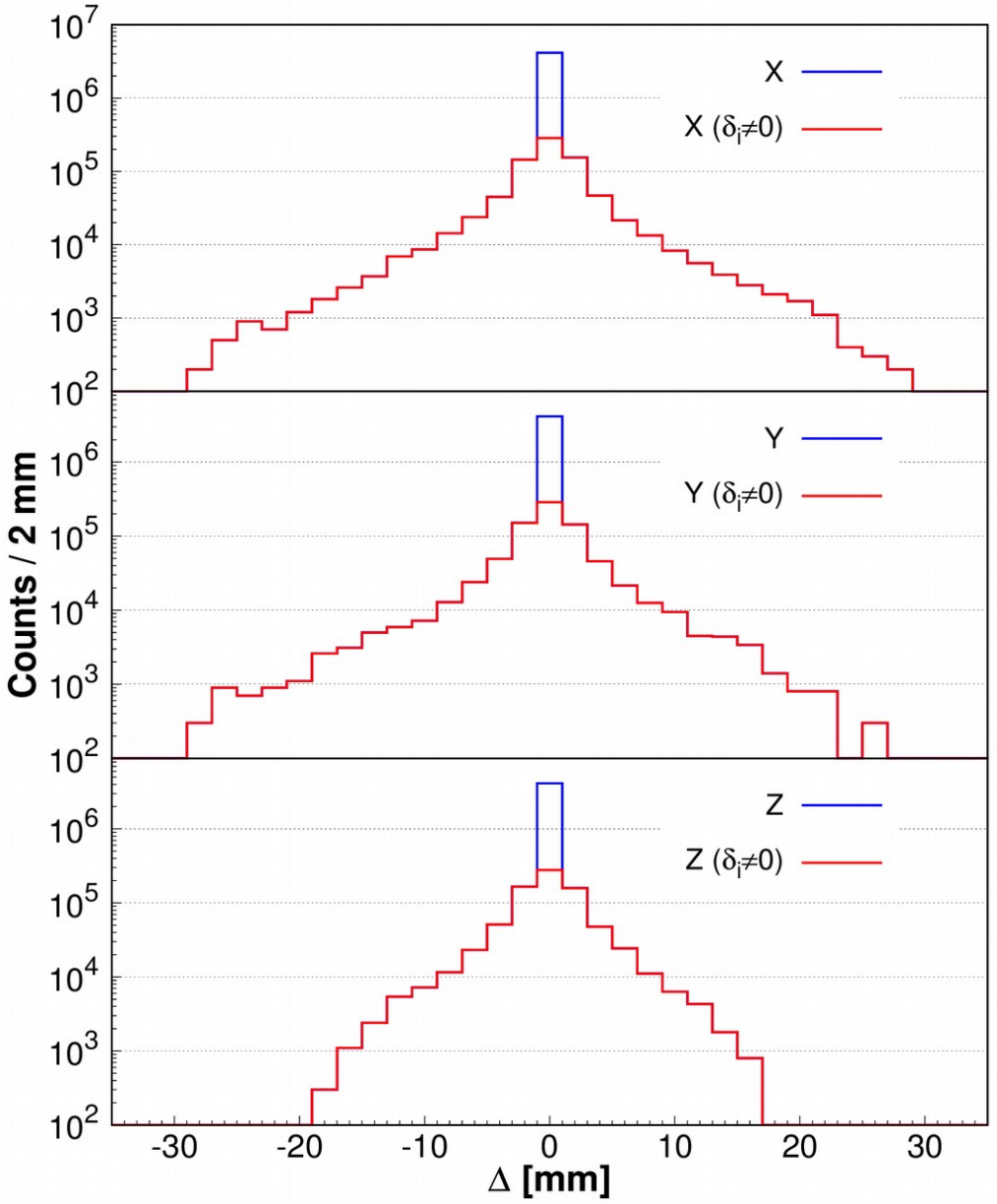
$(E_i, x_i, y_i, z_i)_{BS,n}$

BOOTSTRAP



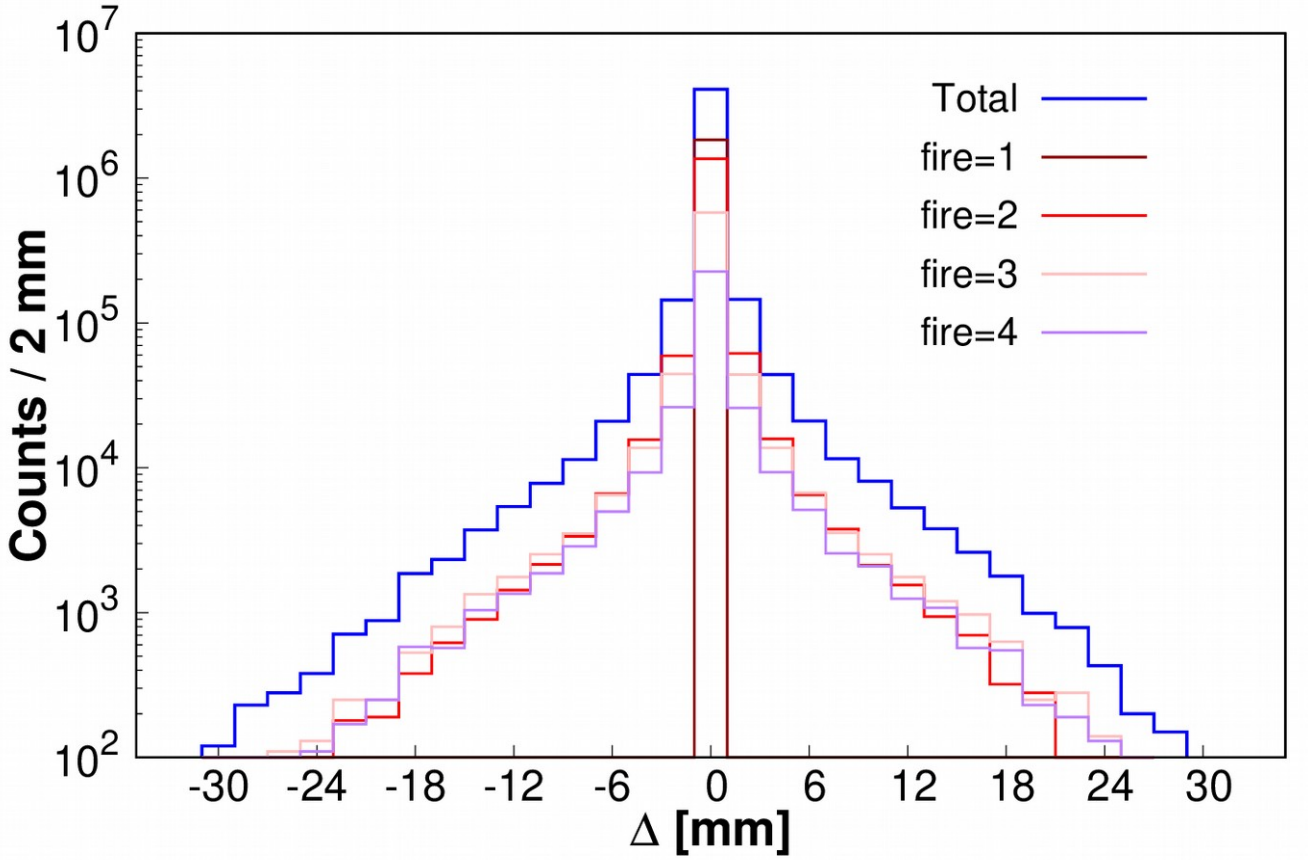
100 Gb / (cdat file) / (10 bootstrap)

RESULTS
PSA error



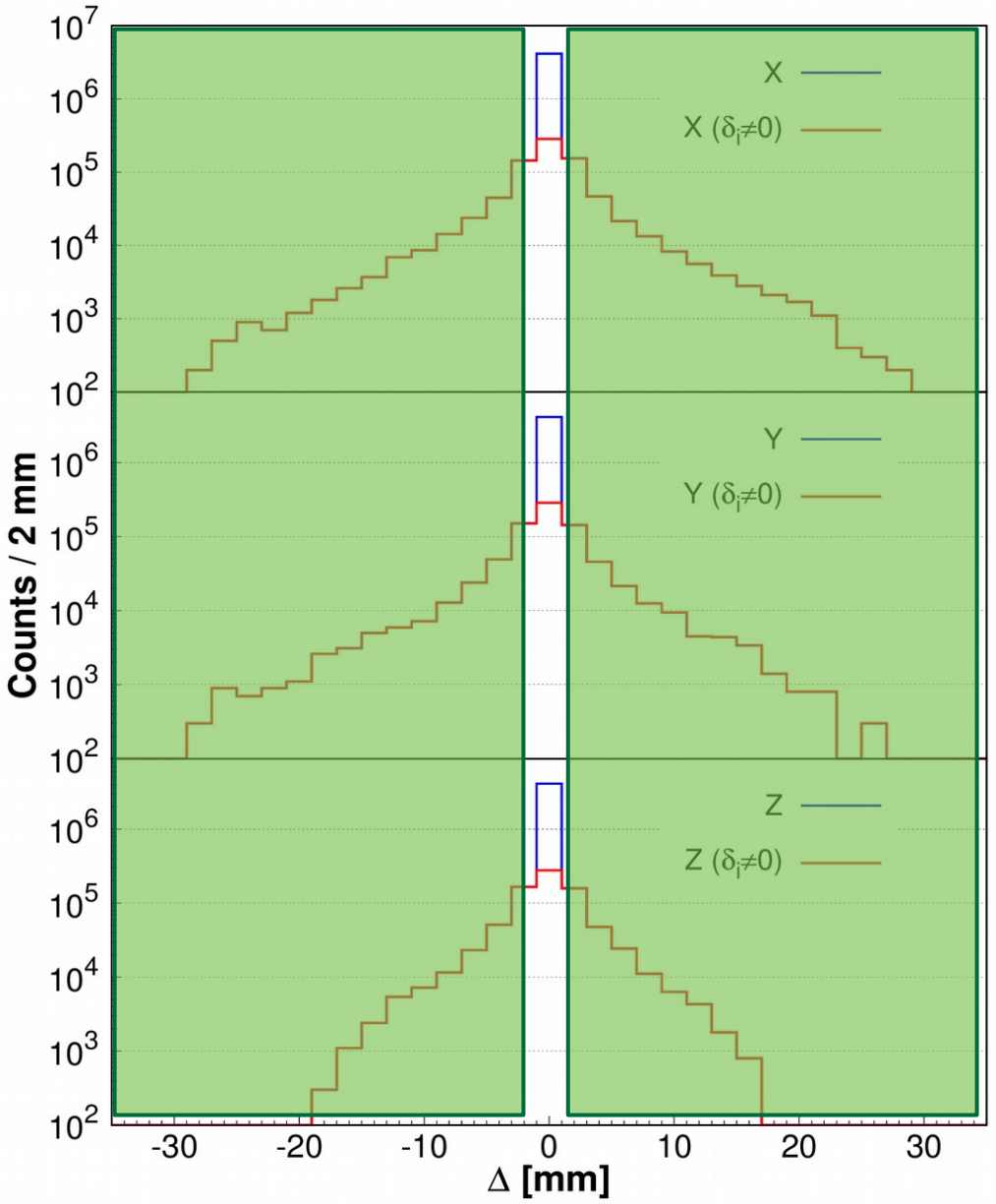
- In adaptive grid search, the PSA distinguishes the bootstrapped traces 17%
- Asymmetric distribution requires the definition of positive/negative error
  - Fluctuations distribution is position dependent
  - Fluctuations distribution is energy dependent

RESULTS
PSA error



- Overall standard deviation 1.85 mm (2.36 mm for *fire>1* condition)
- Standard deviation increasing (from 1.6 to 4.4 mm) as a function of the number of firing segments
- When only one segment is firing (~40%), PSA does not distinguish the bootstrap traces
  - Neighboring positions χ^2 largely different?

RESULTS
PSA error



- In adaptive grid search, the PSA distinguishes the bootstrapped traces 17%
- Asymmetric distribution requires the definition of positive/negative error
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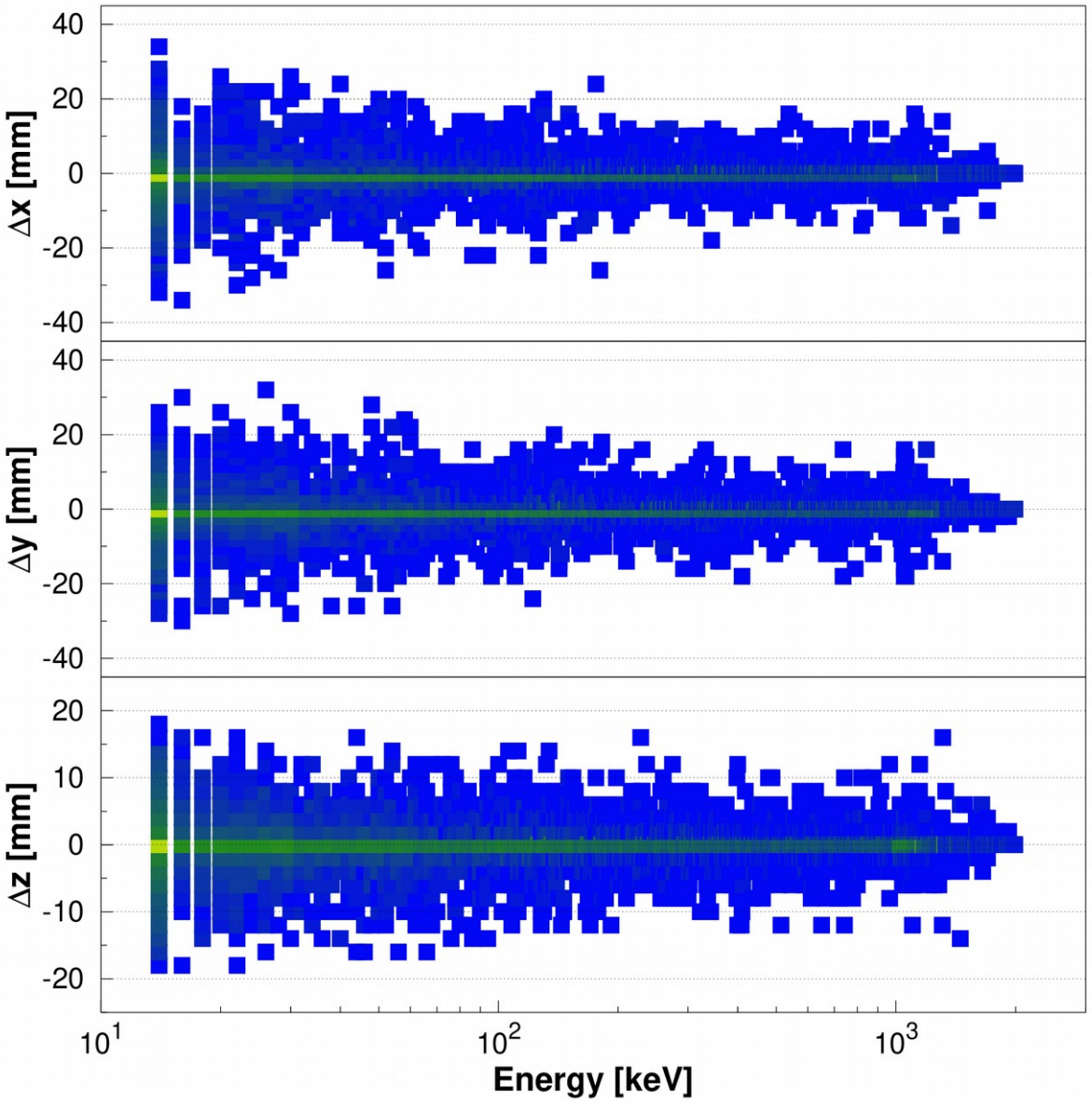
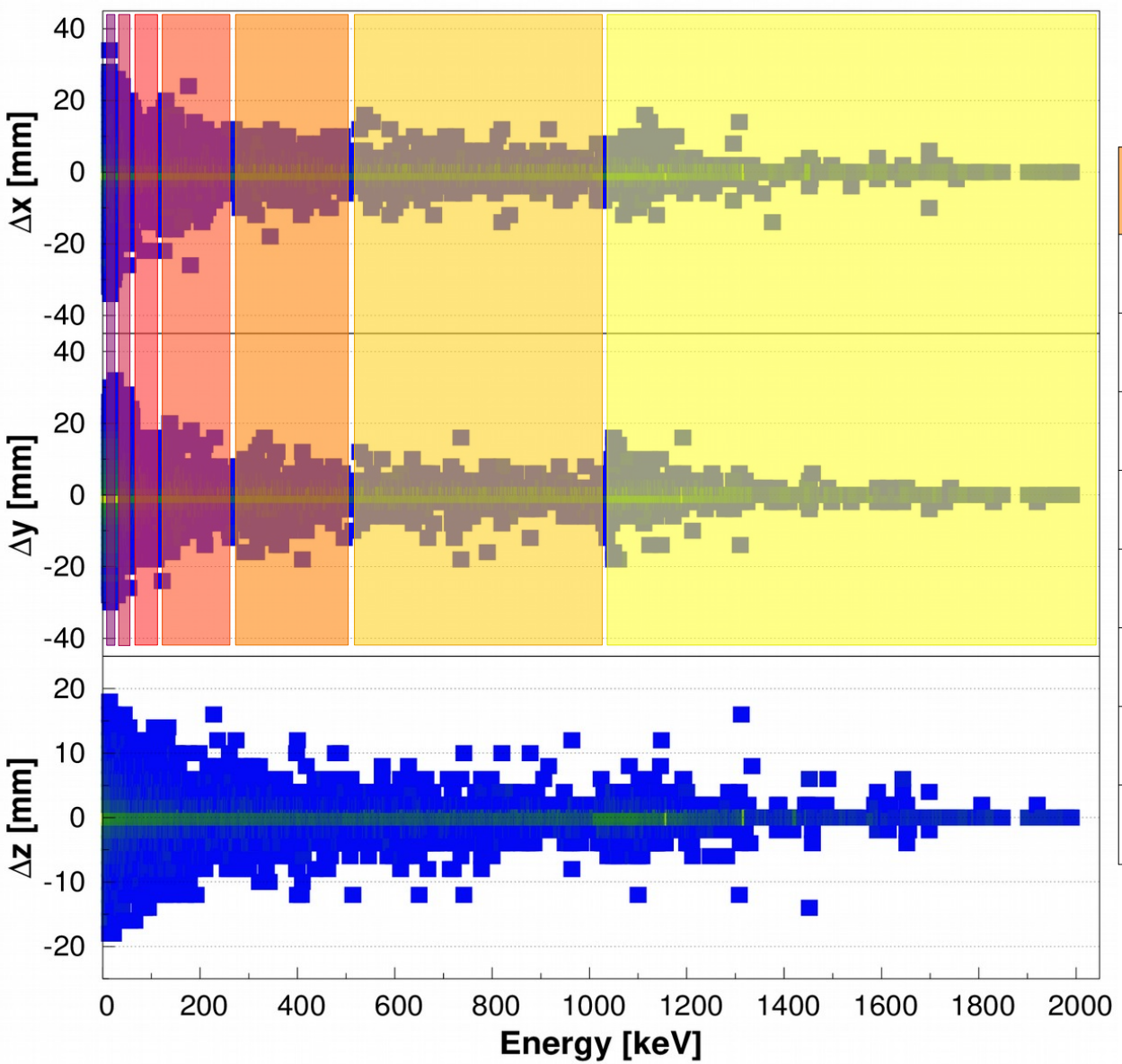
How do we define the error on PSA position?

RESULTS
PSA error vs Energy



- Fluctuations decrease with the increasing gamma-ray energy
- Fluctuations are almost symmetric with respect to 0
- PSA defines the interaction-point position withing the firing segment, so the coordinates are limited
  - For *x* and *y* coordinates, fluctuations have similar trend
  - For *z* coordinate, fluctuations distribution is narrower

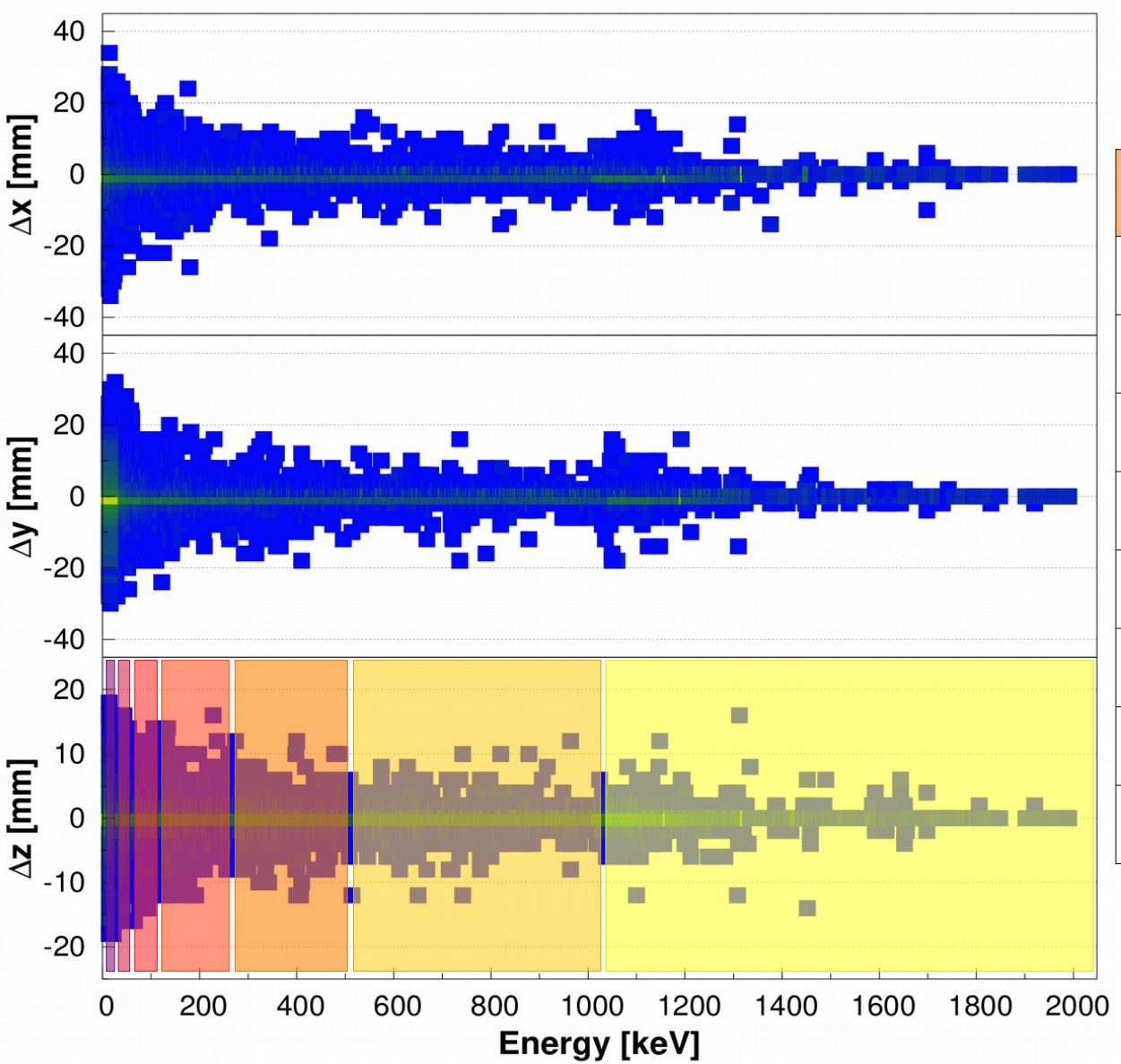
RESULTS
PSA error vs Energy



PSA position error for *x* and *y* coordinates as a function of the energy:

Energy range [keV]	-Δ [mm]	+Δ [mm]
8-16	6	8
16-32	6	6
32-64	4	6
64-128	4	4
128-256	4	4
256-512	4	2
512-1024	2	2
1024-2048	2	2

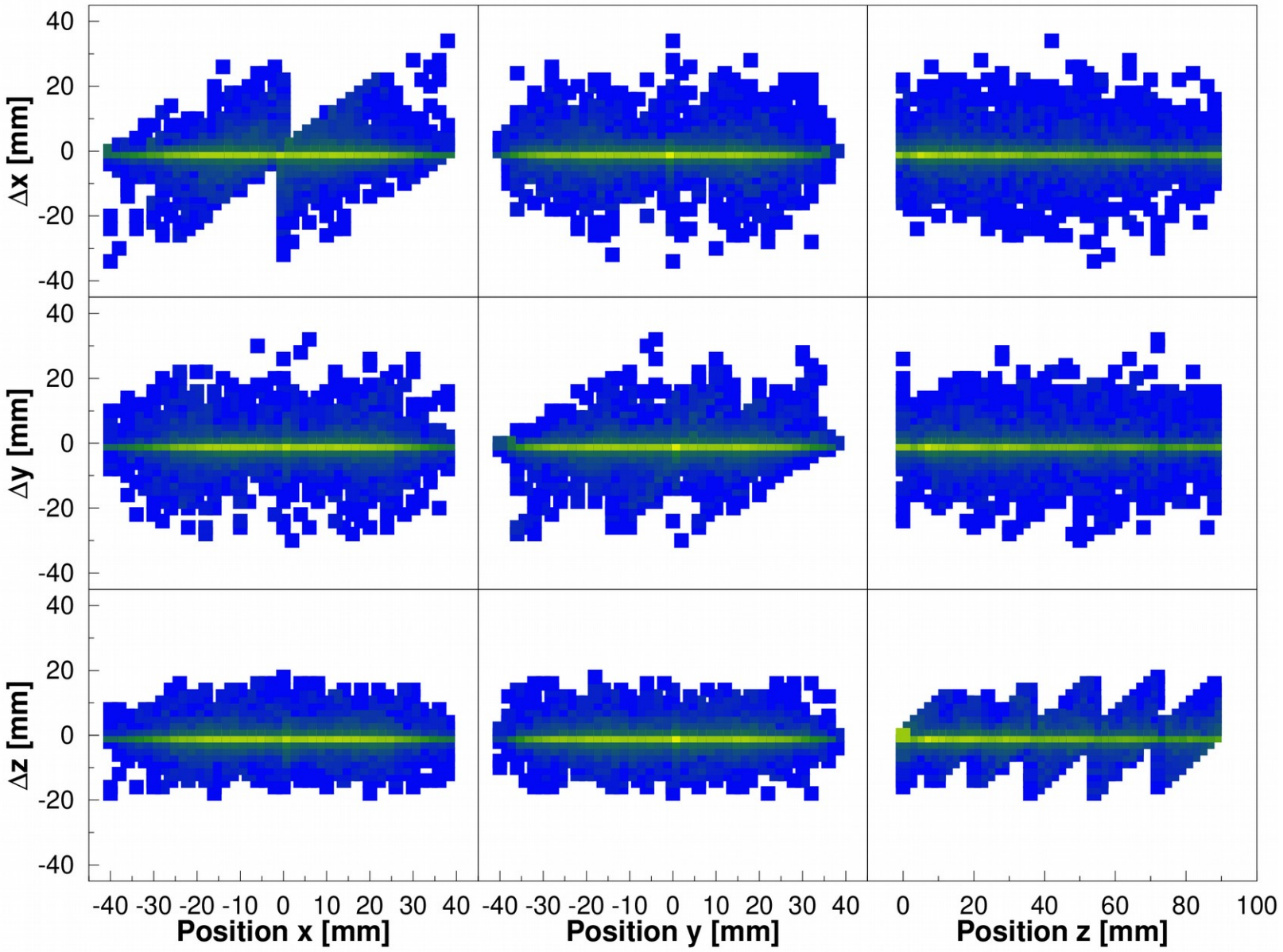
RESULTS
PSA error vs Energy



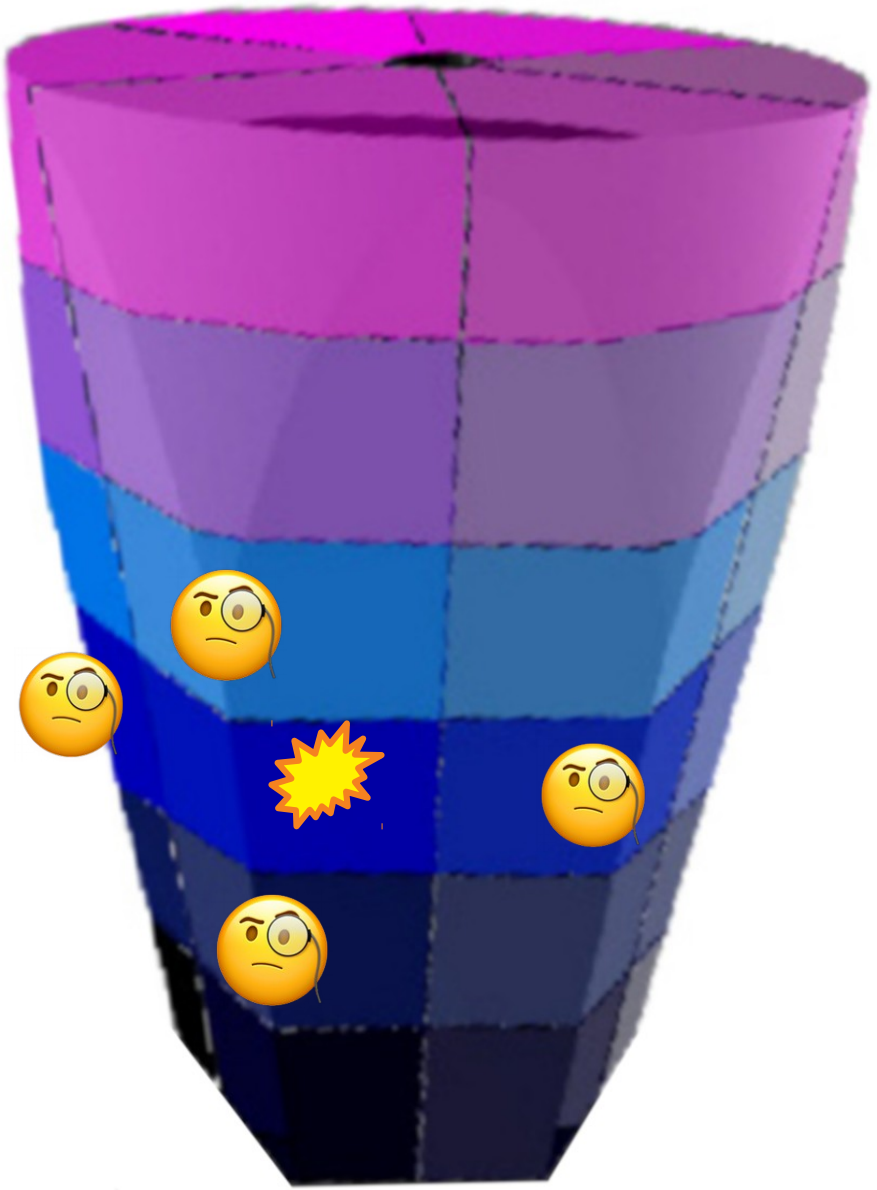
PSA position error for *z* coordinate as a function of the energy:

Energy range [keV]	-Δ [mm]	+Δ [mm]
8-16	6	6
16-32	6	4
32-64	4	4
64-128	4	4
128-256	4	4
256-512	2	2
512-1024	2	2
1024-2048	2	2

RESULTS
PSA error vs Position



PROBLEMS
Local Mask



In the case of an electrically segmented detector, charges are induced also on the neighboring electrodes

- *Net-charge signal* in the firing segment(s)
- *Tansient signals* in the neighboring segments

Usually for each firing segment, 4-6 signals are taken into account by the PSA.

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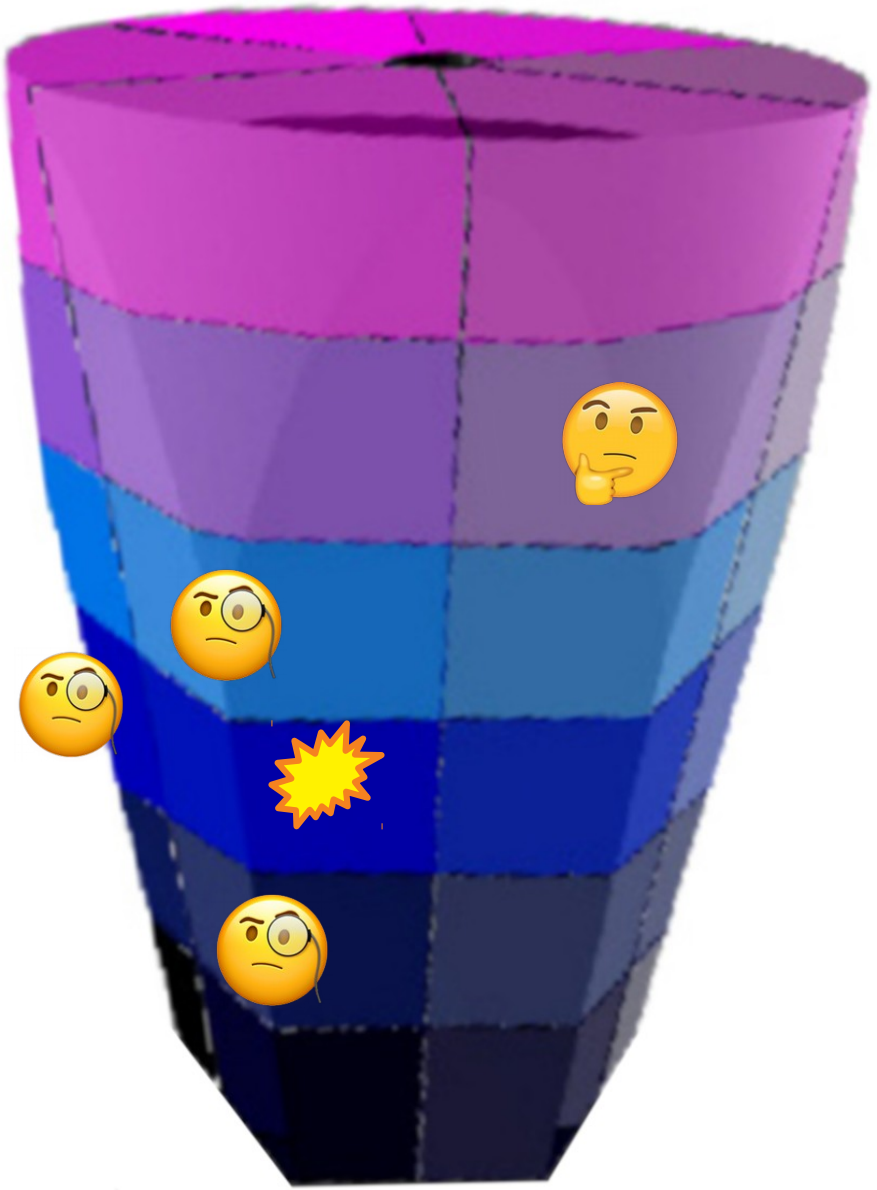

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- *Net-charge signal* in the firing segment(s)
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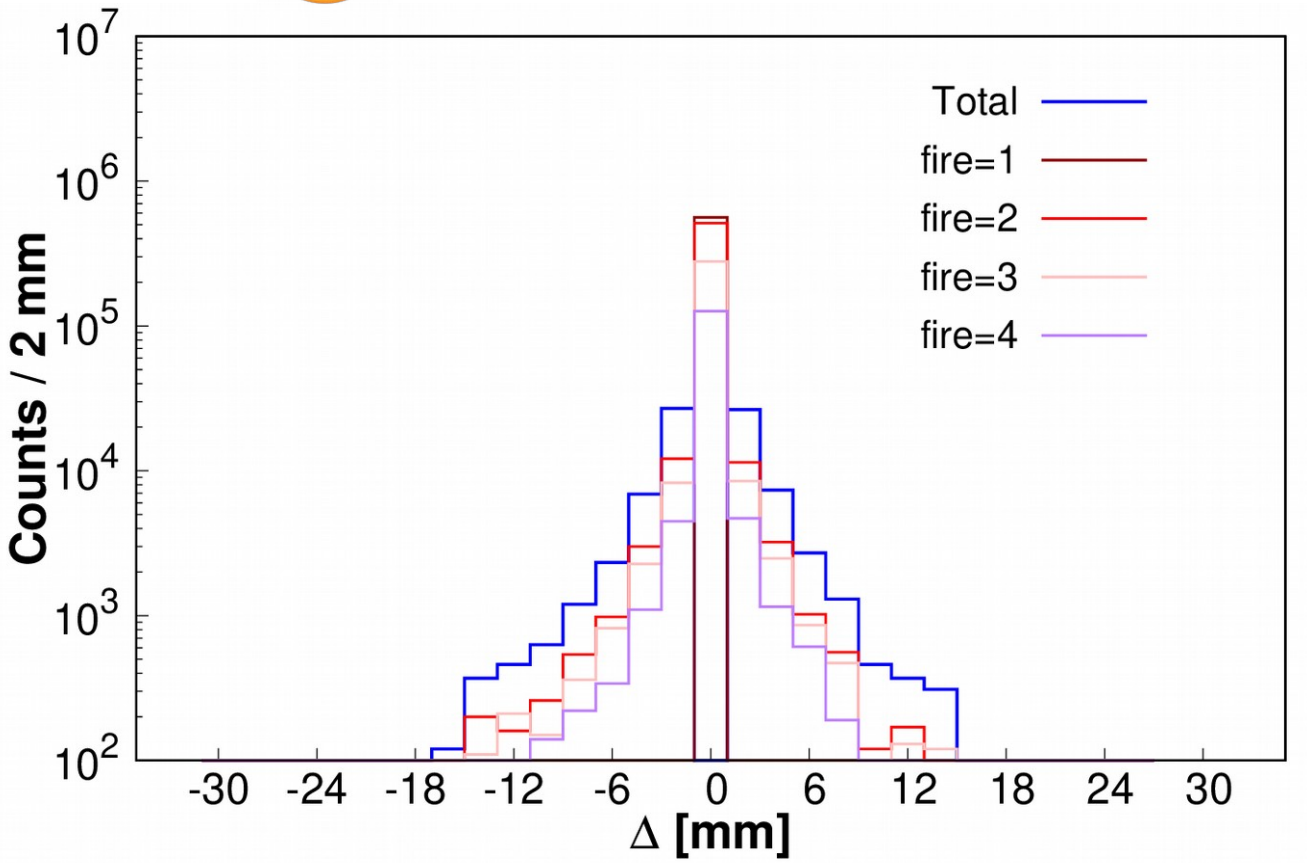
Usually for each firing segment, 4-6 signals are taken into account by the PSA.

Not-neighboring segments are considered in the comparison

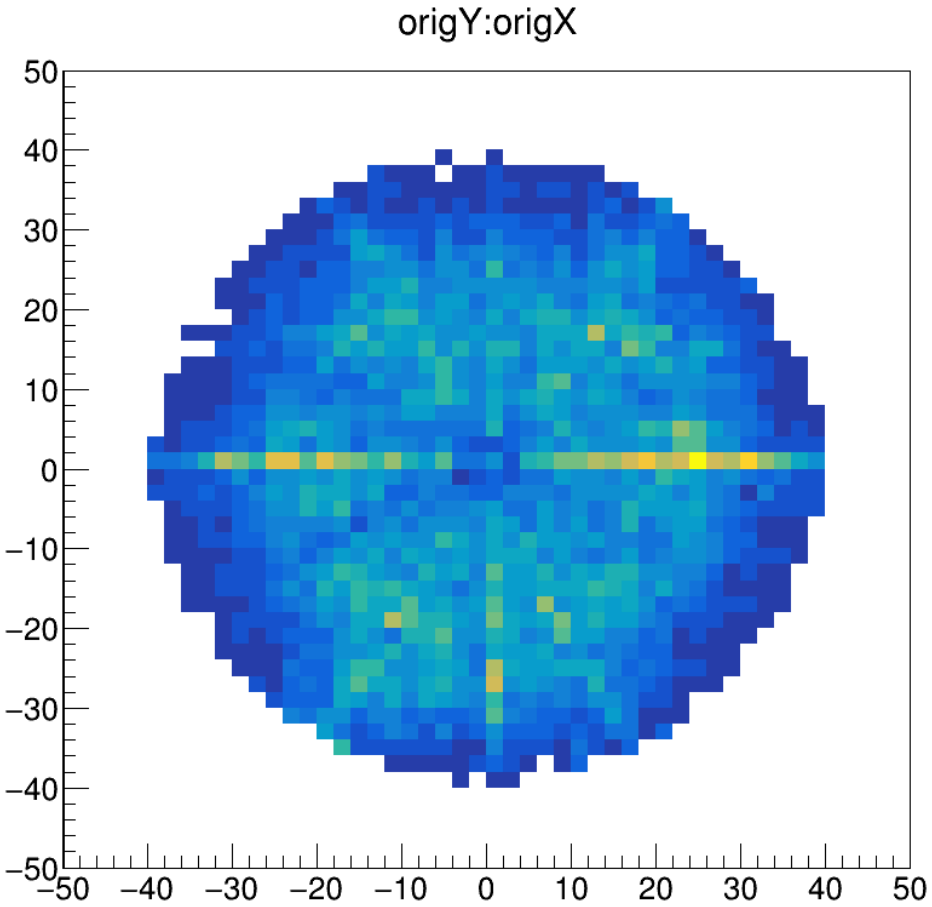
PROBLEMS
Local Mask

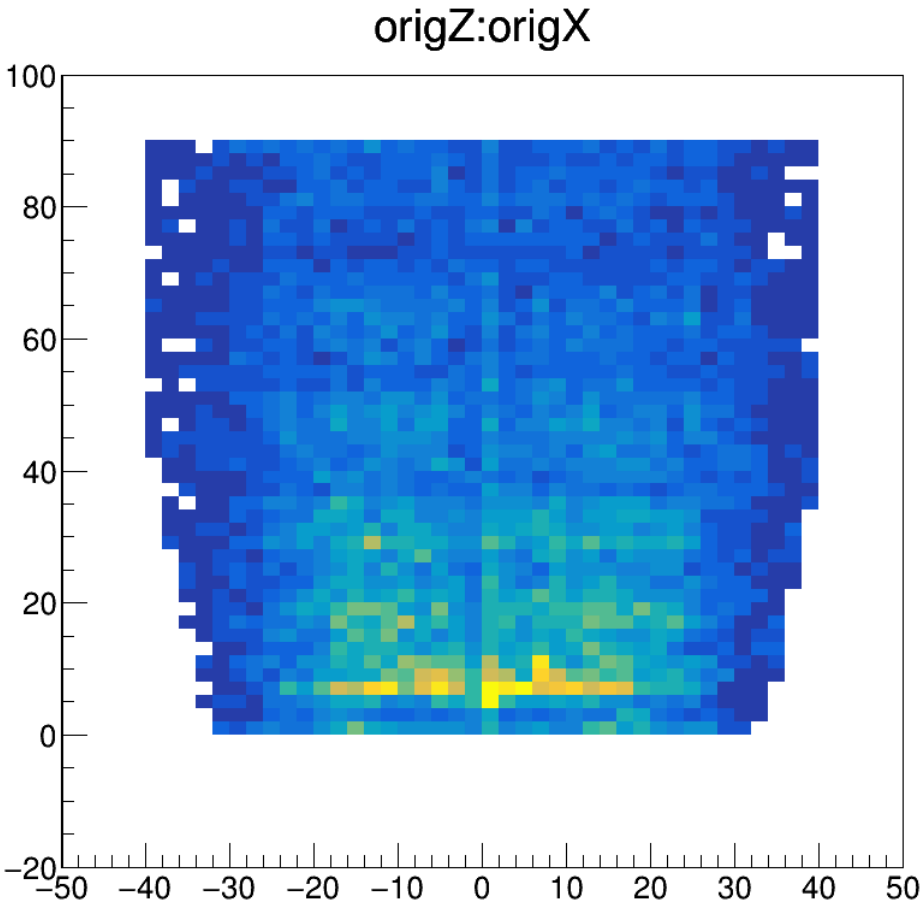
190 Gb / (cdat file / 20) / (10 bootstrap)



- Overall standard deviation is half of the "normal" PSA-comparison procedure
- Standard deviation is rather constant as a function of the number of firing segments
- When only one segment is firing, PSA does not distinguish the bootstrap traces

PROBLEMS
Accumulation Areas?





- Some detectors present accumulating areas for X=0 and Y=0
  - Twice the intensities of the closest coordinates

In the ADL bases
different segments have same coordinates

PROBLEMS
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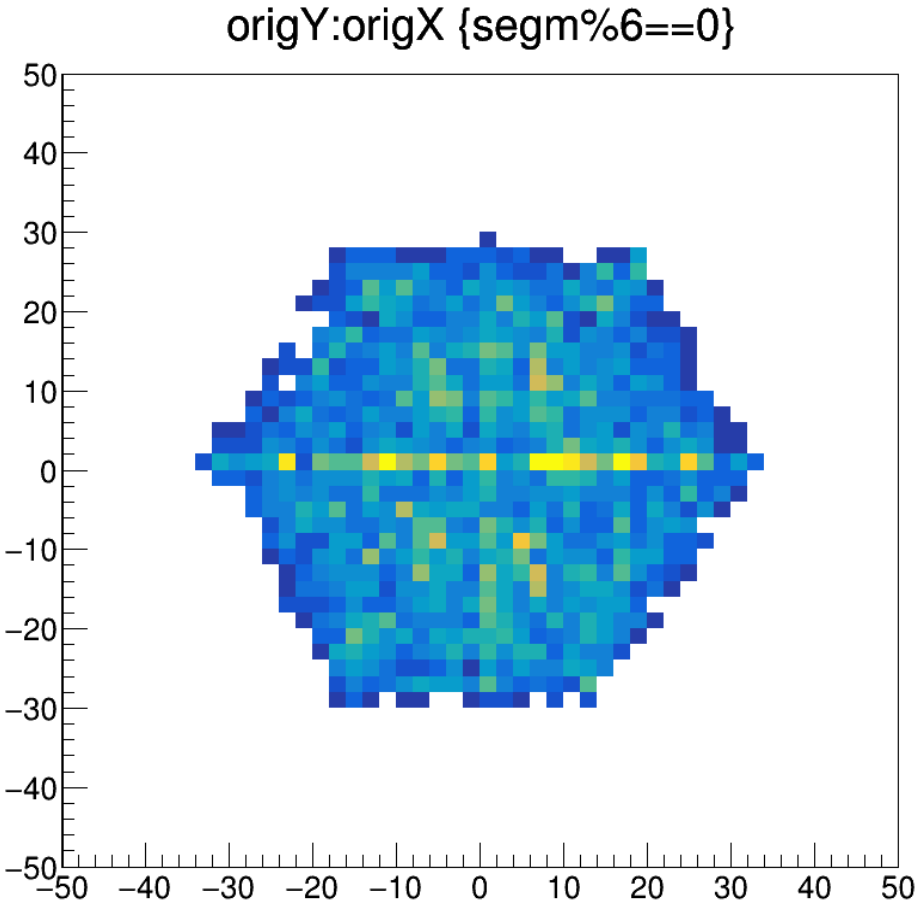

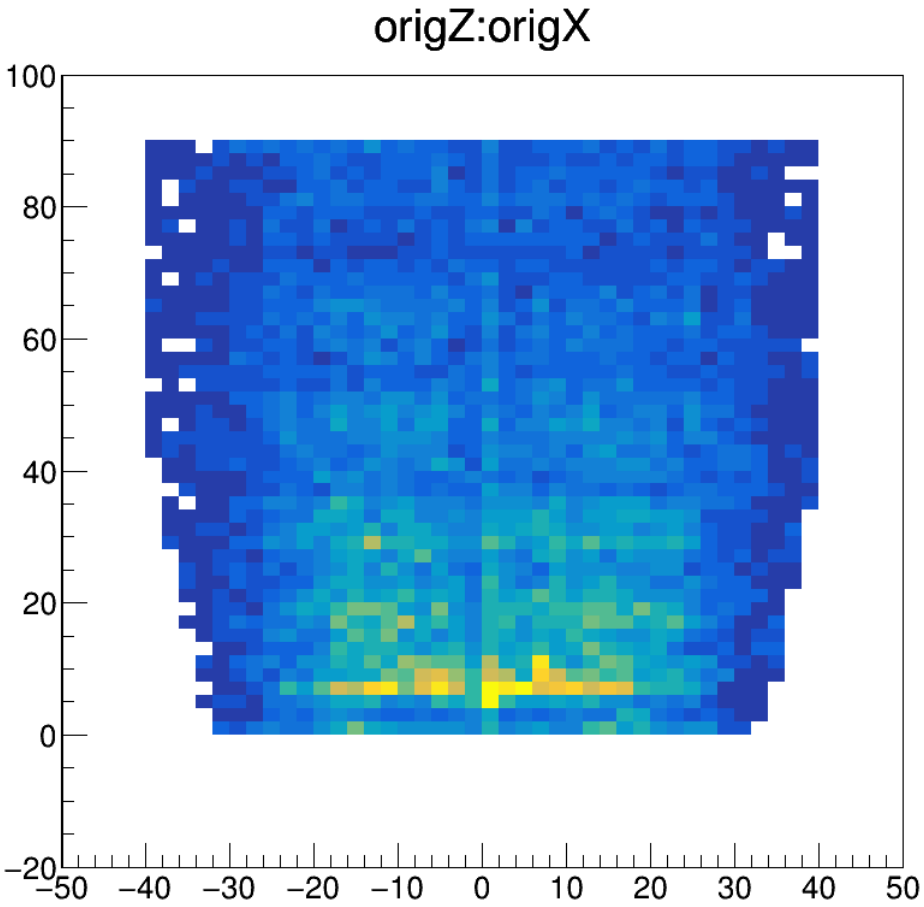

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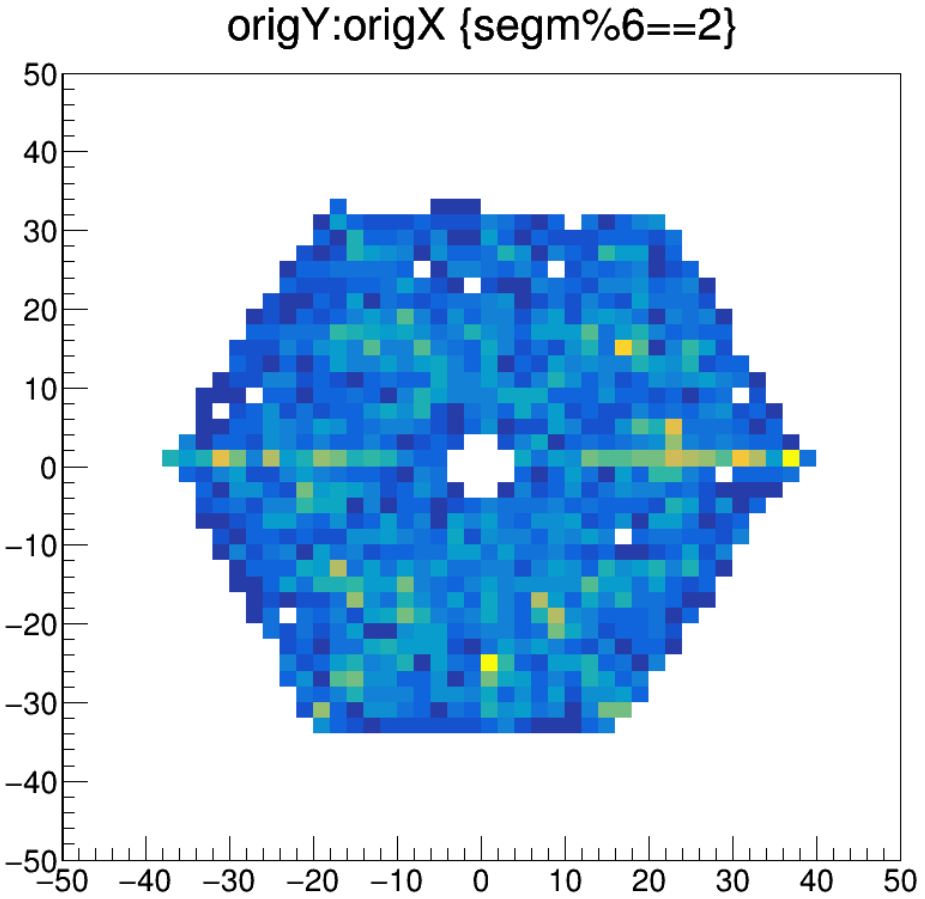

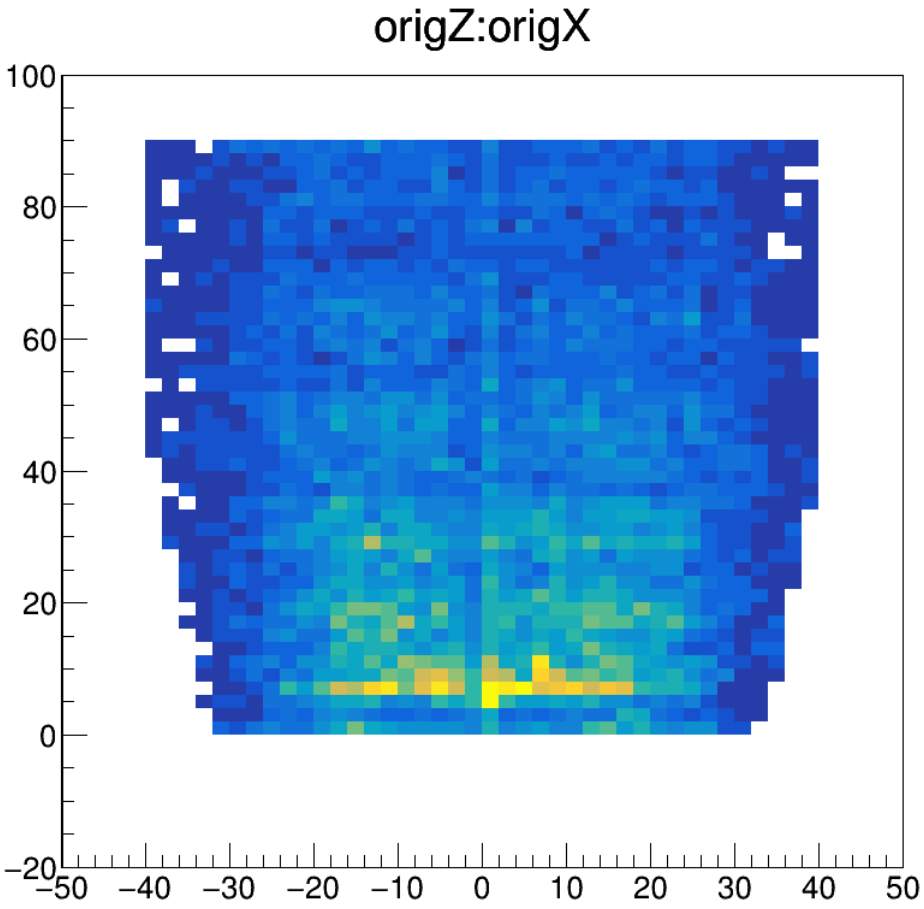

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CONCLUSIONS

- Bootstrapping is an established procedure that can help in identifying PSA features
  - **PSA code is a jungle!**
  - In order to have enough statistics, the procedure requires large disk space
- Problems in defining the error on the position (?)
- **Preliminary results** highlight the expected energy dependence of PSA-position fluctuations
- **Preliminary results** highlight that fluctuations are position dependent
  - Defining a map of uncertainties
- By knowing uncertainties dependencies, the PSA procedure can be simplified and it would make the online/offline data process much faster