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Validation of pulse shape simulation

for segmented germanium detectors

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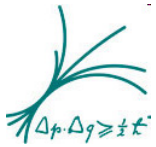


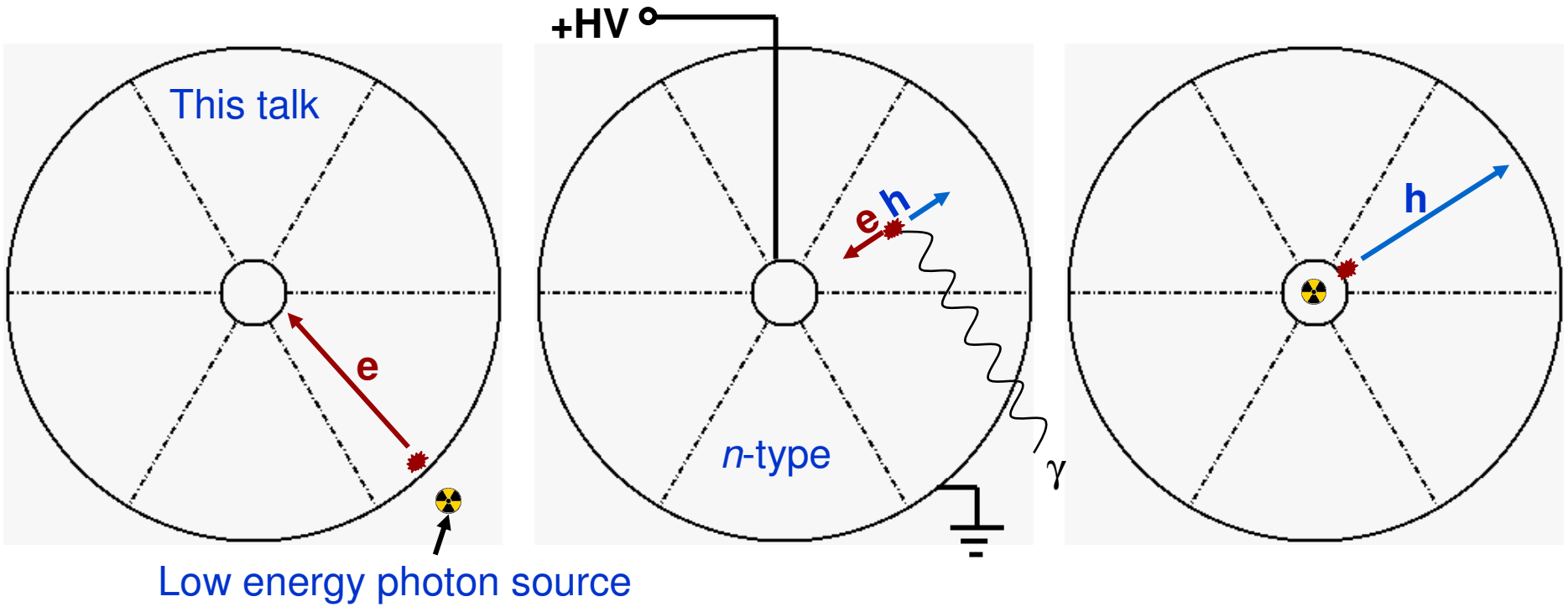
* Jing Liu @ DPG2009, Munich

Introduction

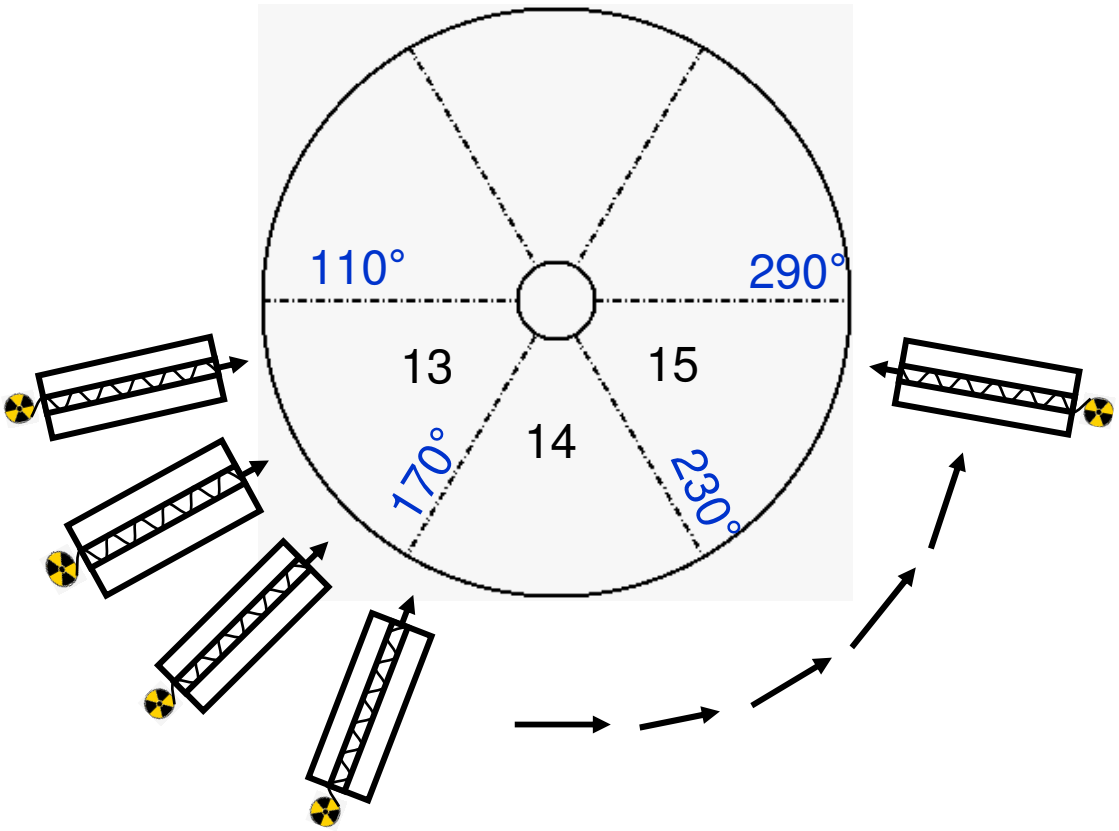
- Pulse shape analysis (PSA):
  - Complementary method to segmentation for identifying background
  - Important to reach background level down to 10^{-3}count/(keV•kg•y)

- Pulse shape simulation (PSS):
  - Estimate the efficiency of pulse shape analysis
  - Complicated process: need to be validated!
  - Validation of PSS: understand the detector meanwhile

How to make life easier



Surface scanning

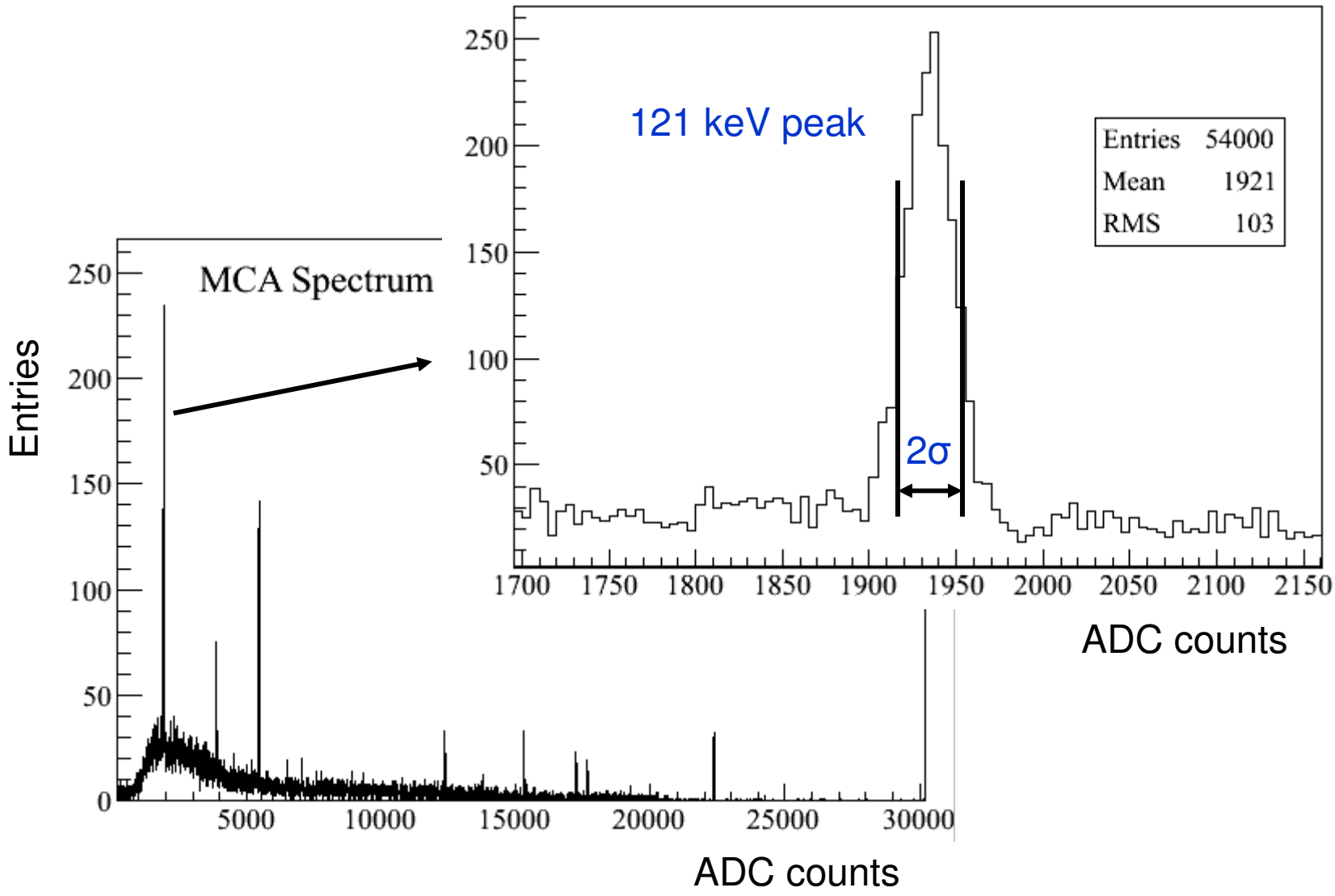


Start point: 120°
Stop point: 280°

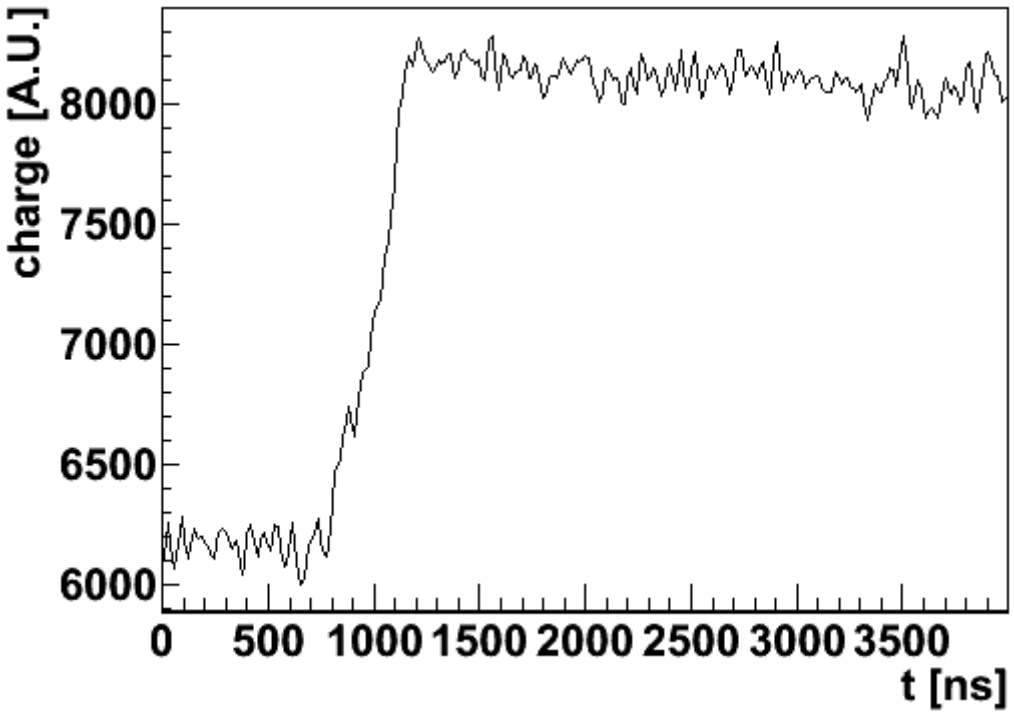
Step:

- 10° in segment 13, 15
- 5° in segment 14

Event selection (taking 140° scanning data as an example)

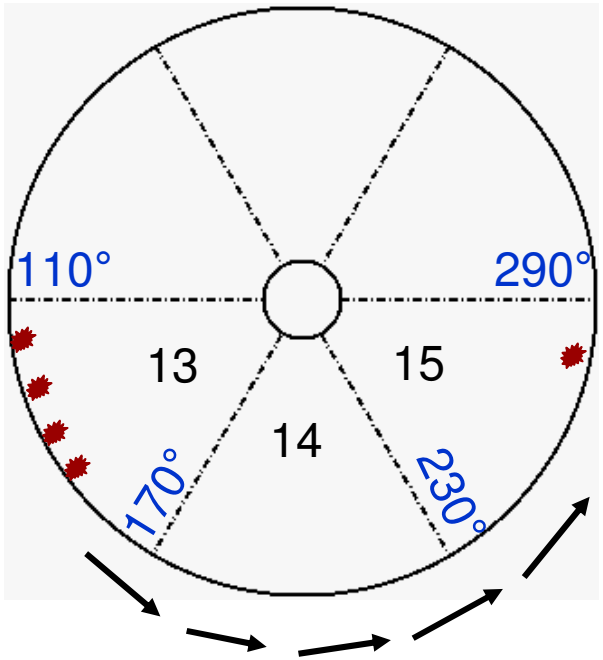


A real pulse seen by the core of the detector

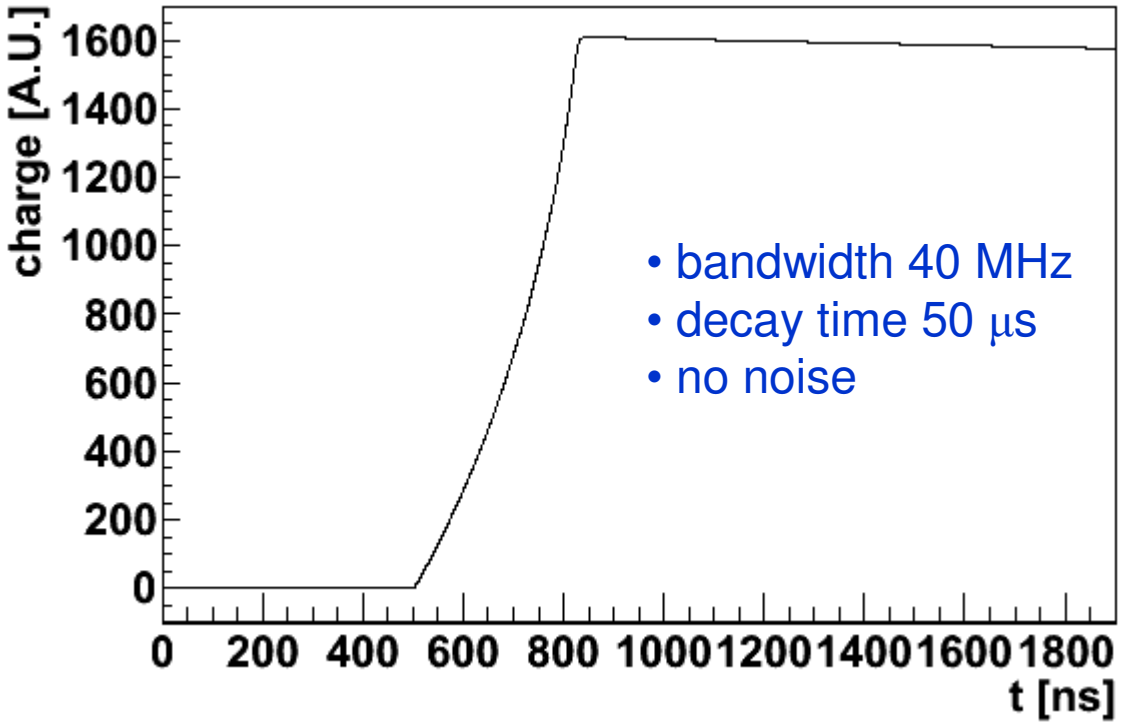


Pulse shape simulation

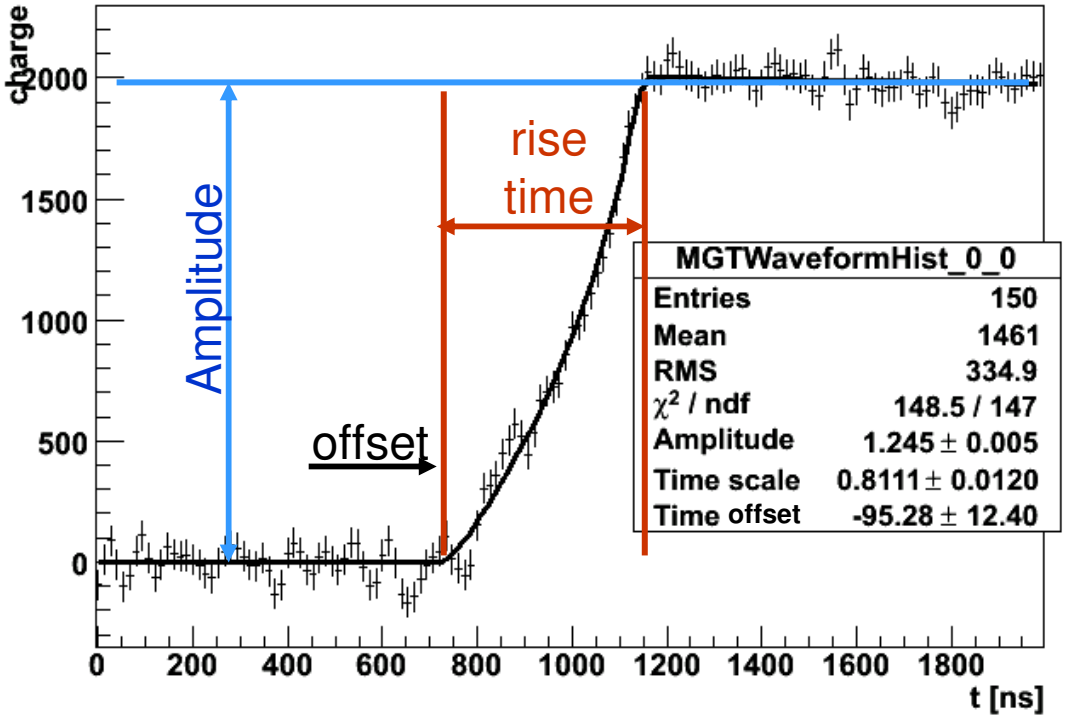
- One hit at each scanning point
  - from 120° to 280°
  - right on the outer surface



A simulated core pulse

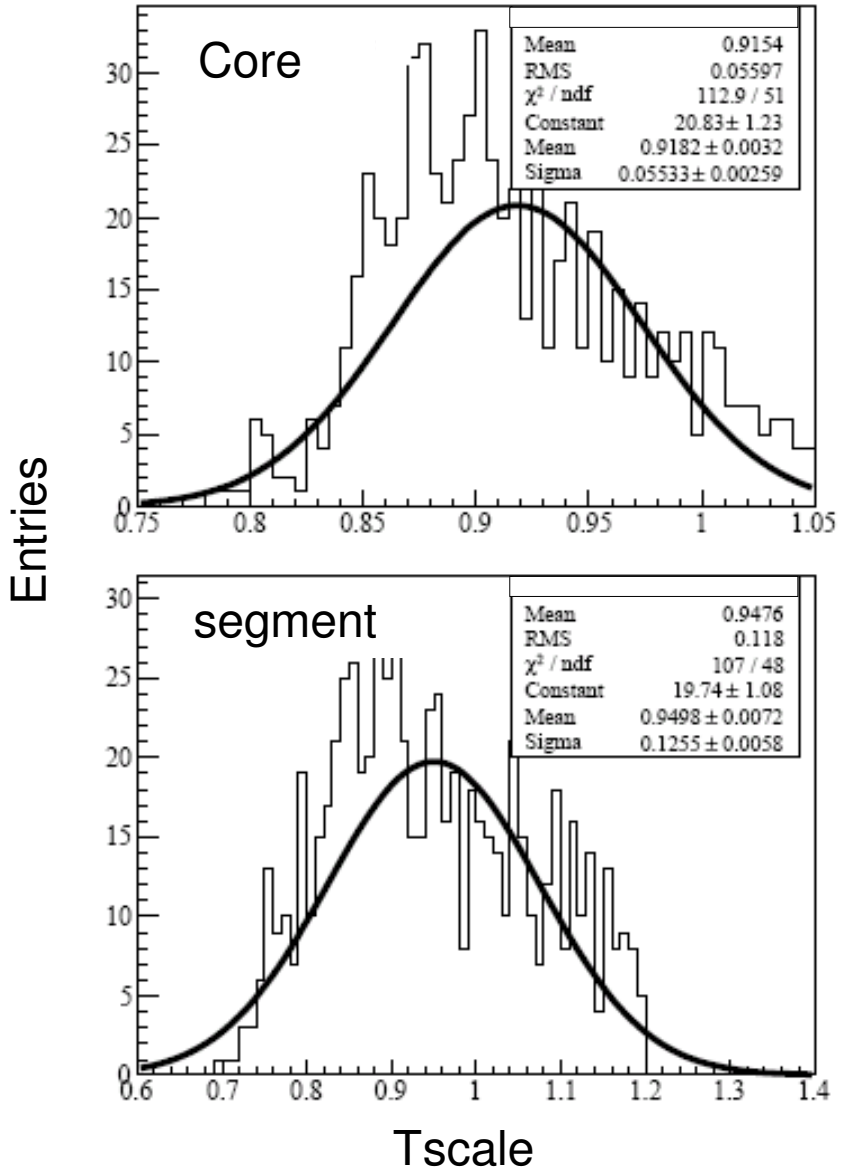


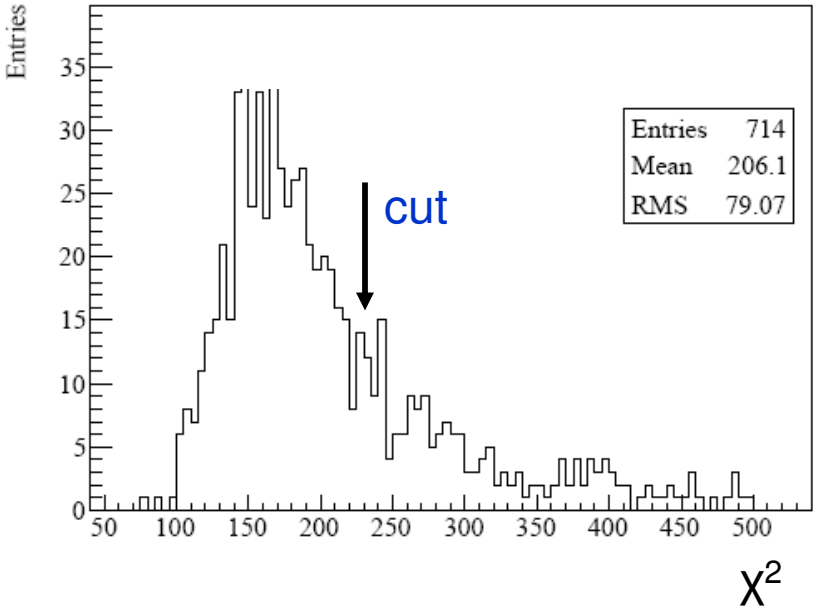
Fit simulated pulse to a real one



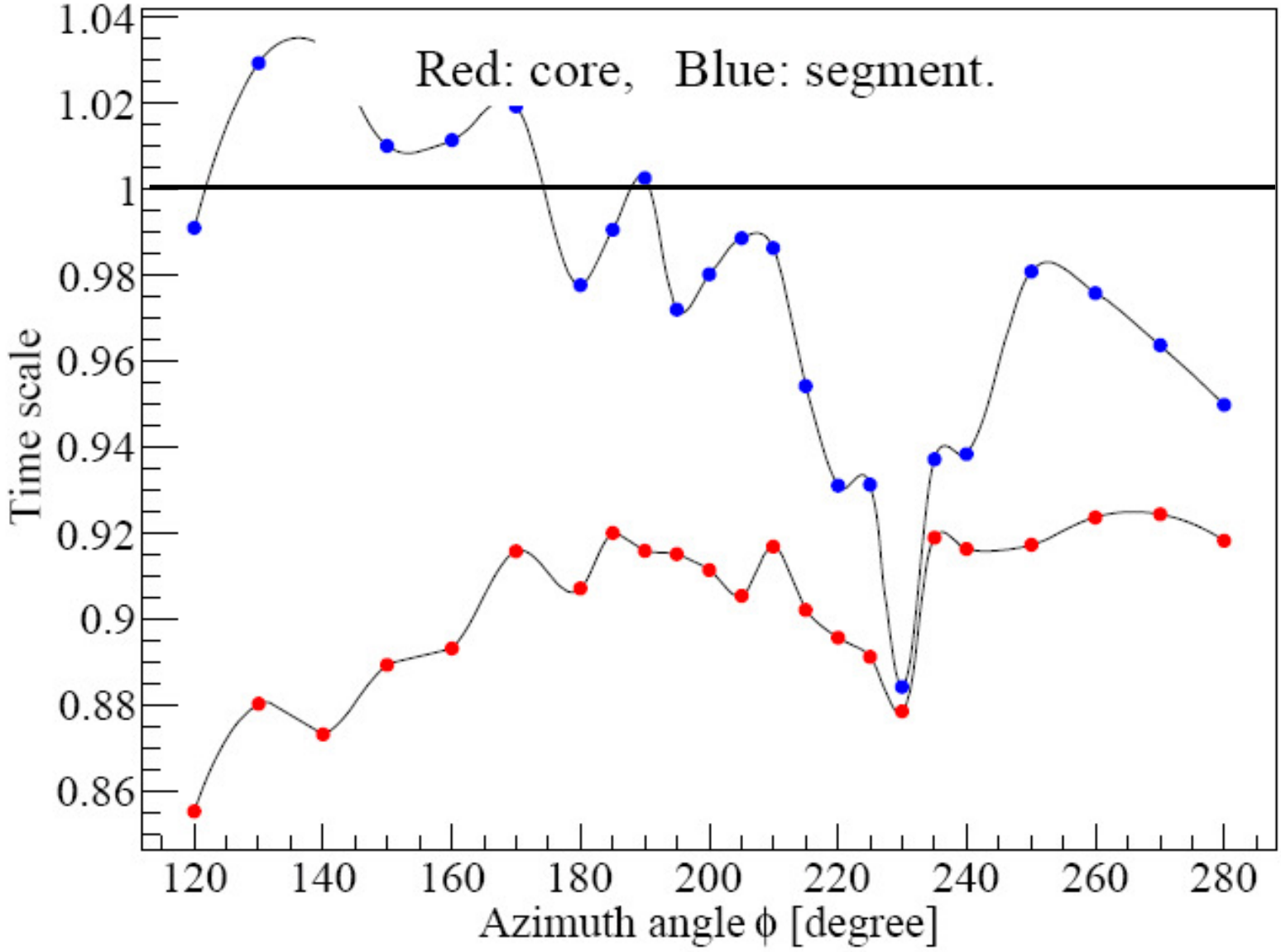
- real pulse:
  - dots with error bars
  - error is set according to noise
- simulated pulse:
  - smooth line
  - three free parameters:
    - Amplitude
    - Time scale
    - Time offset

Time scale distribution





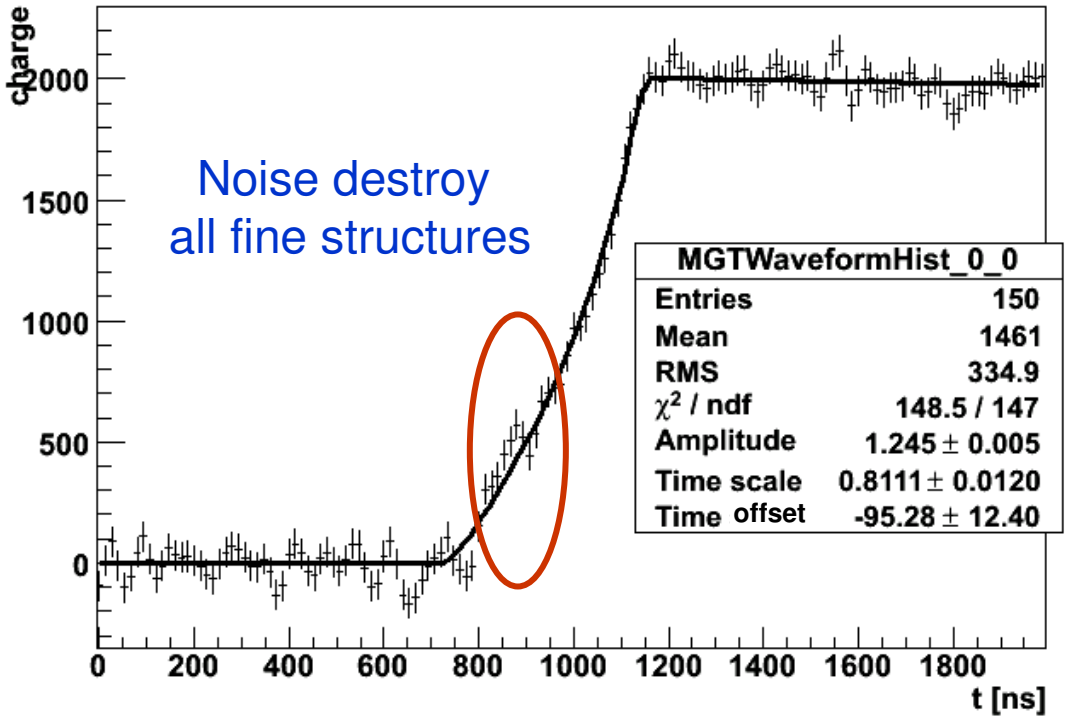
Mean time scale distribution along azimuth angle



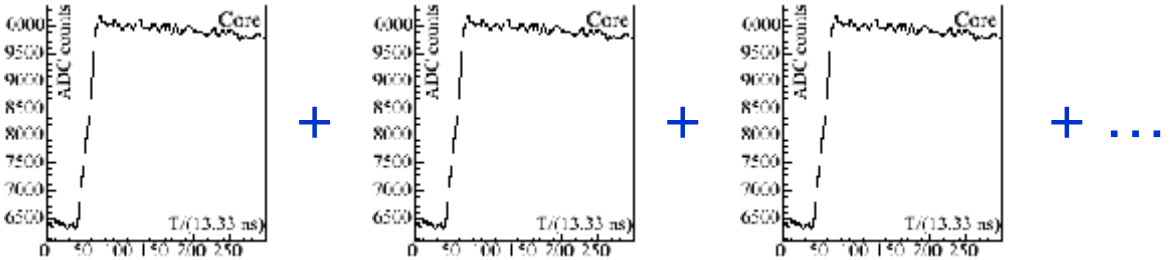
Possible explanation of the time scale distribution

- Input parameters for physics models
  - Shouldn't change from detector to detector
  - Checked by AGATA collaboration
- impurity density distribution, geometry
  - Change from detector to detector
  - Geometry is simple in our case
  - Inhomogeneous impurity distribution inside detector

How to compare the fine structures



Average out the noise



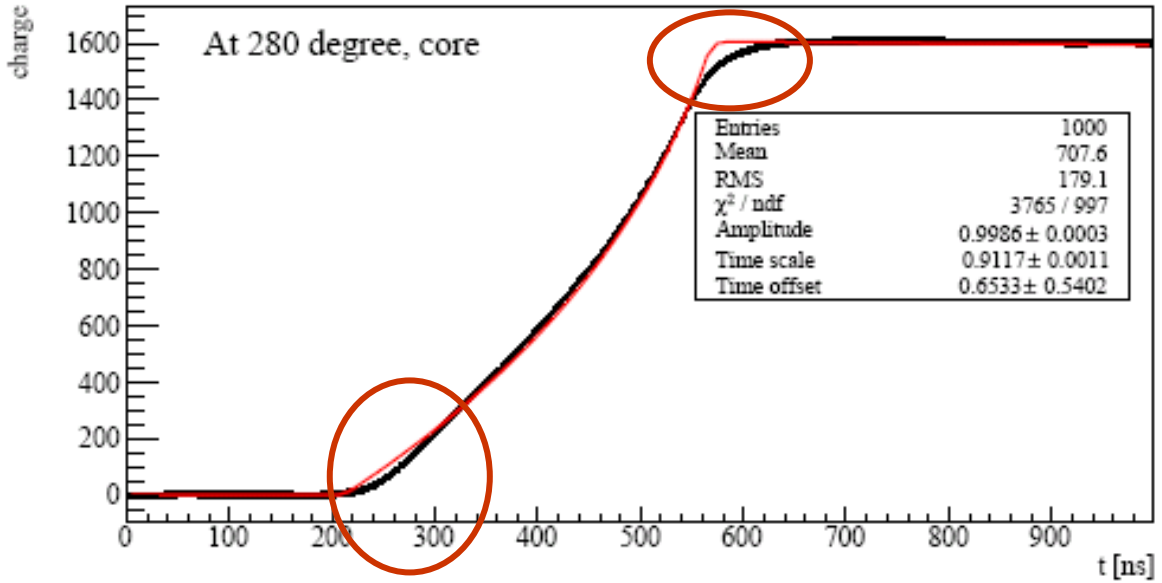
+ + + …

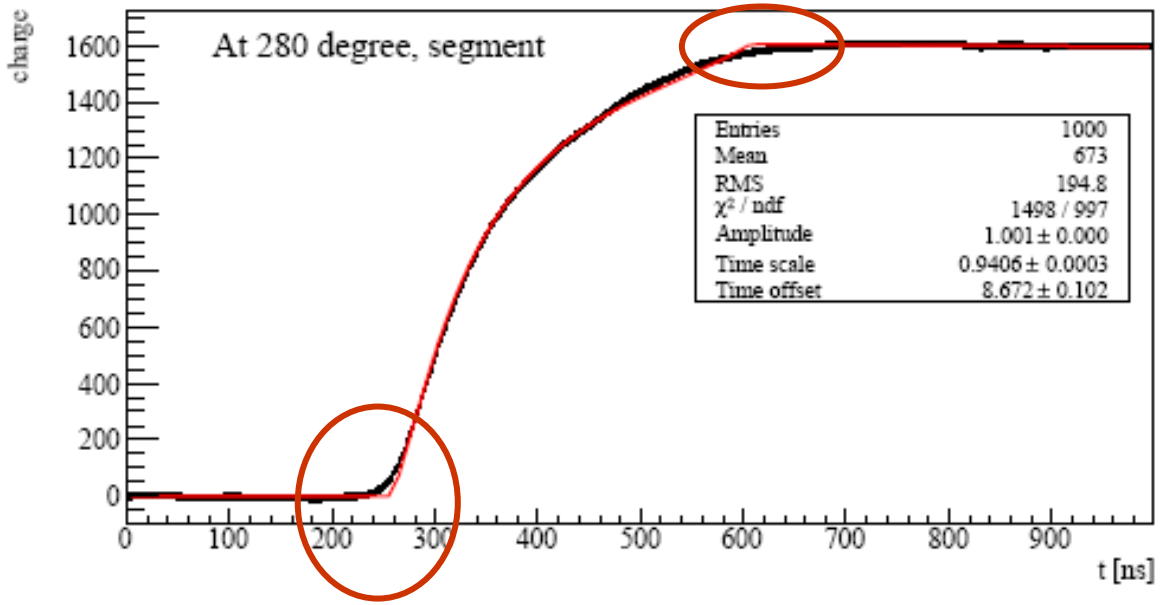
Total number of pulses

= averaged pulse

(noise averaged out!)

Fit simulated pulses to averaged pulses

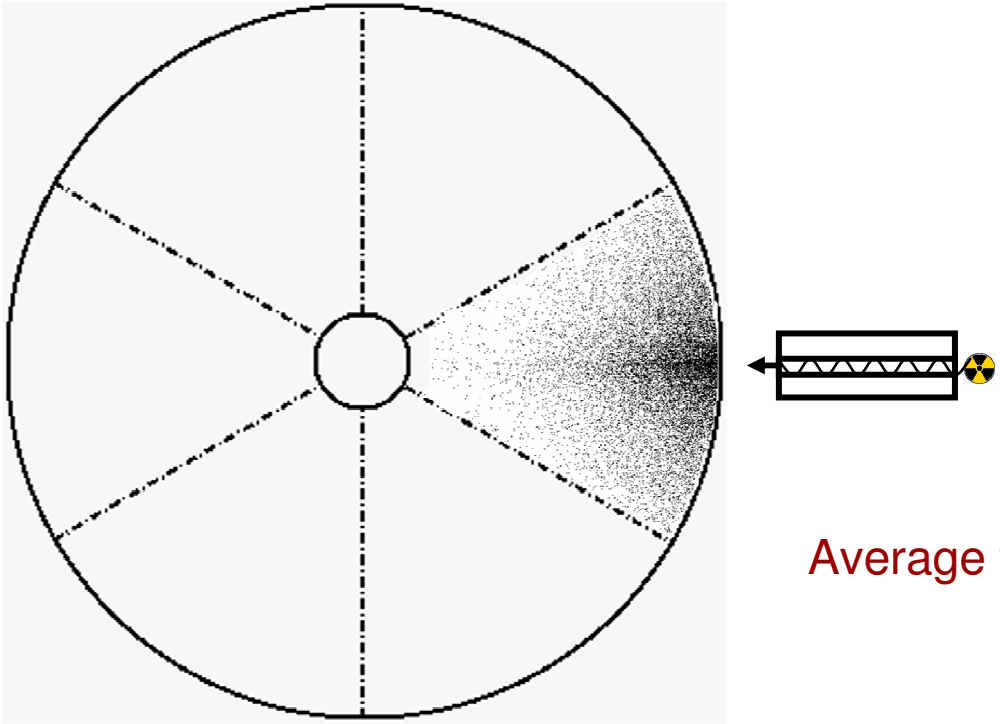




Red: simulated

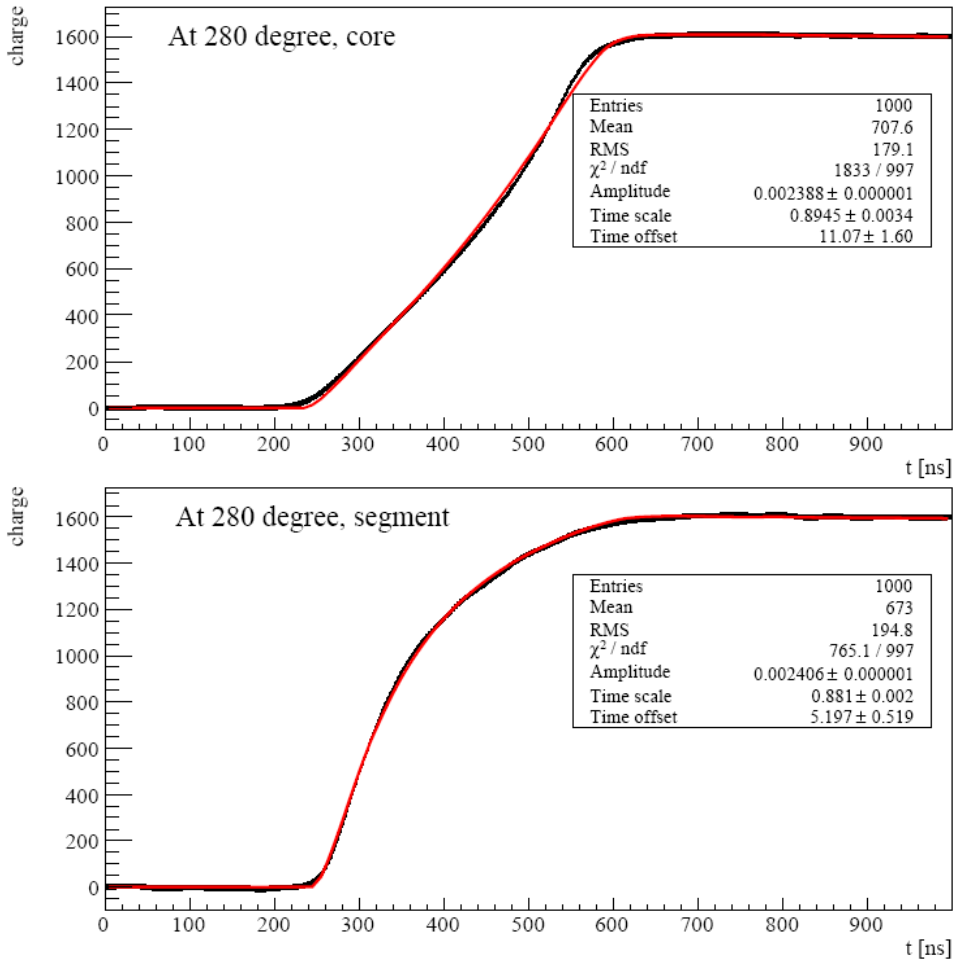
Black: data

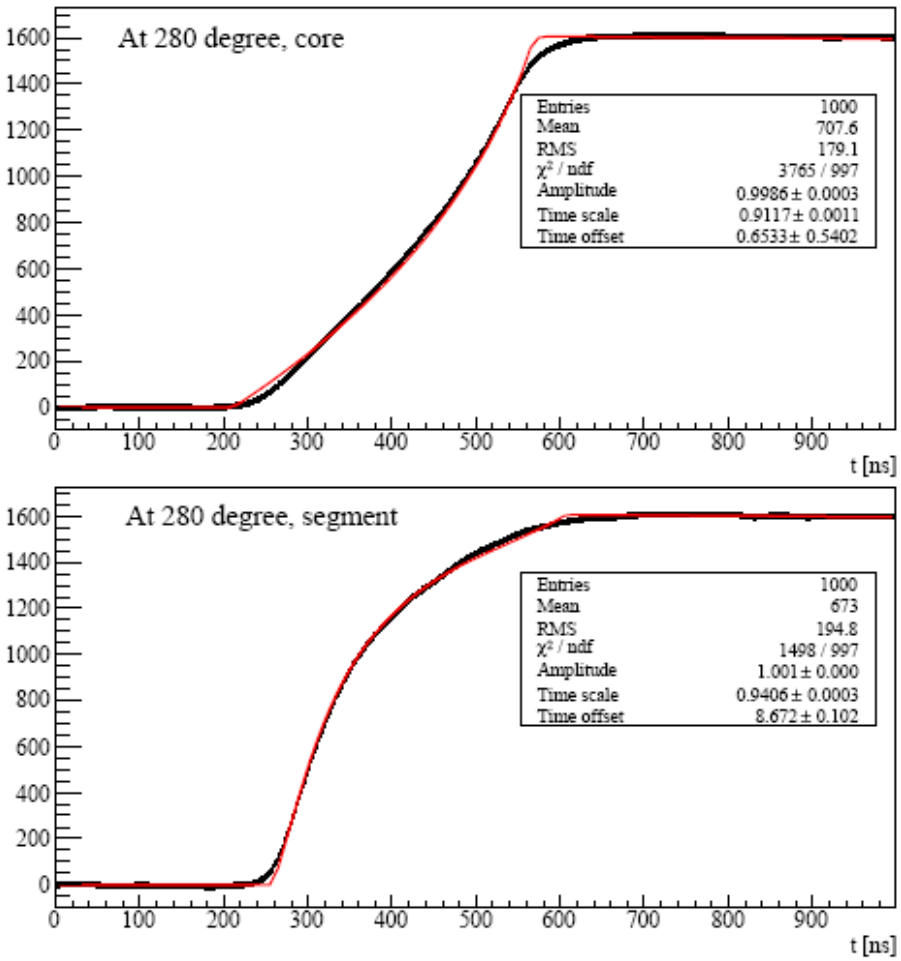
Distribution of hits from 121 keV photons



Hits have a distribution!

Average the simulated pulses as well!





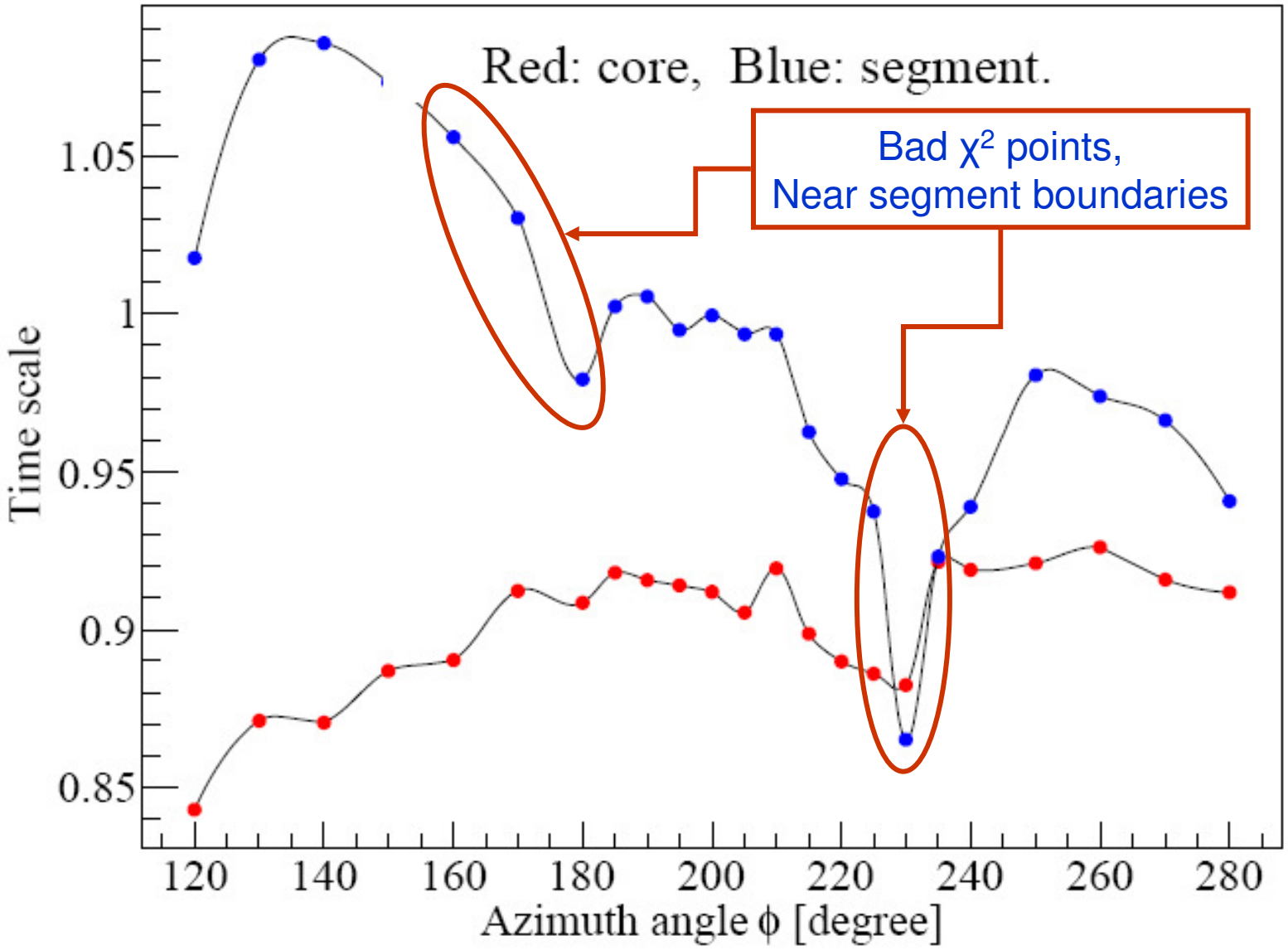
After averaging

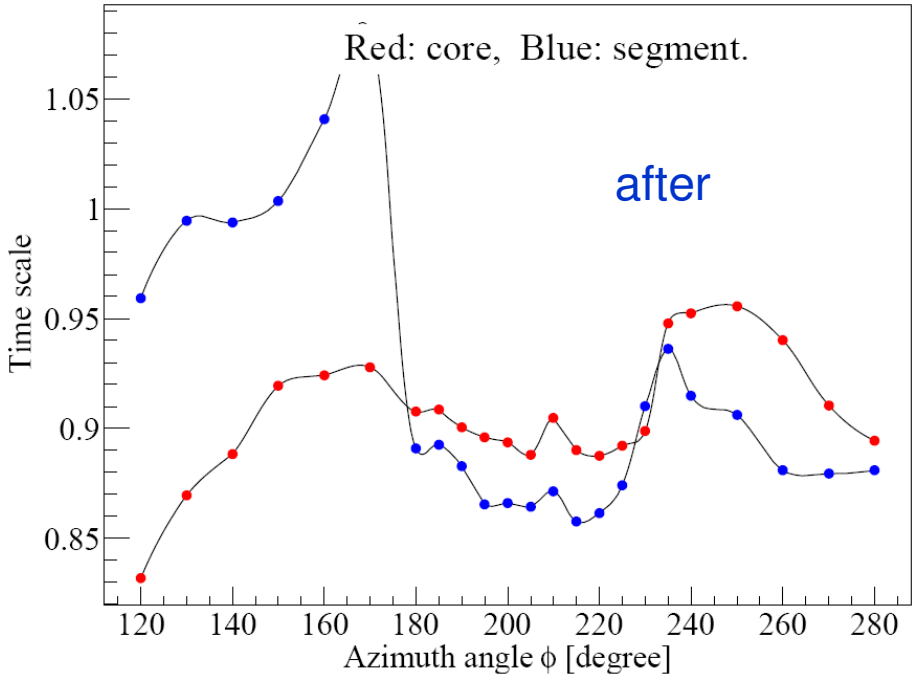
Before averaging

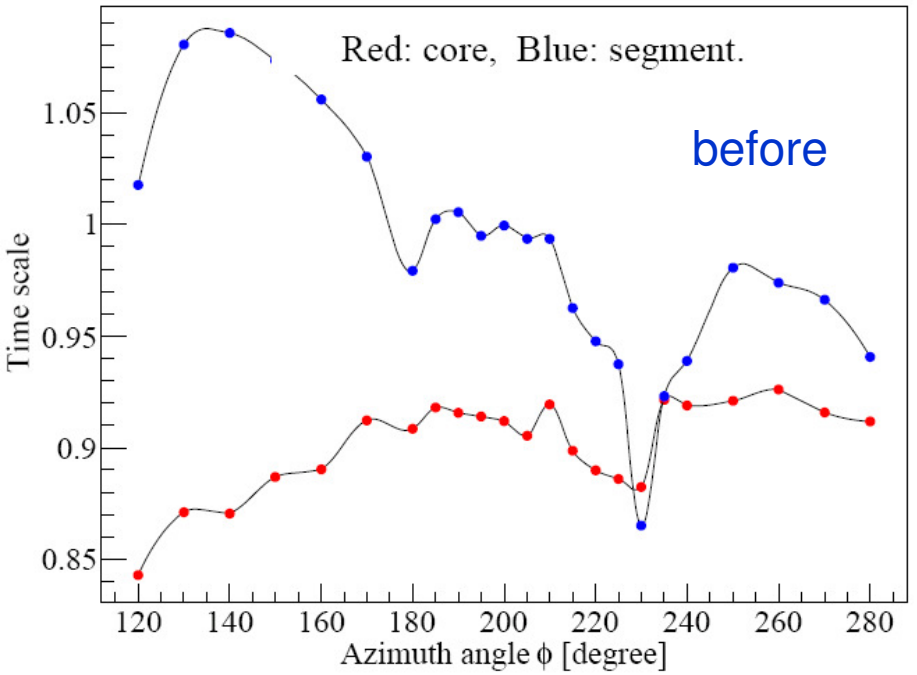
Summary

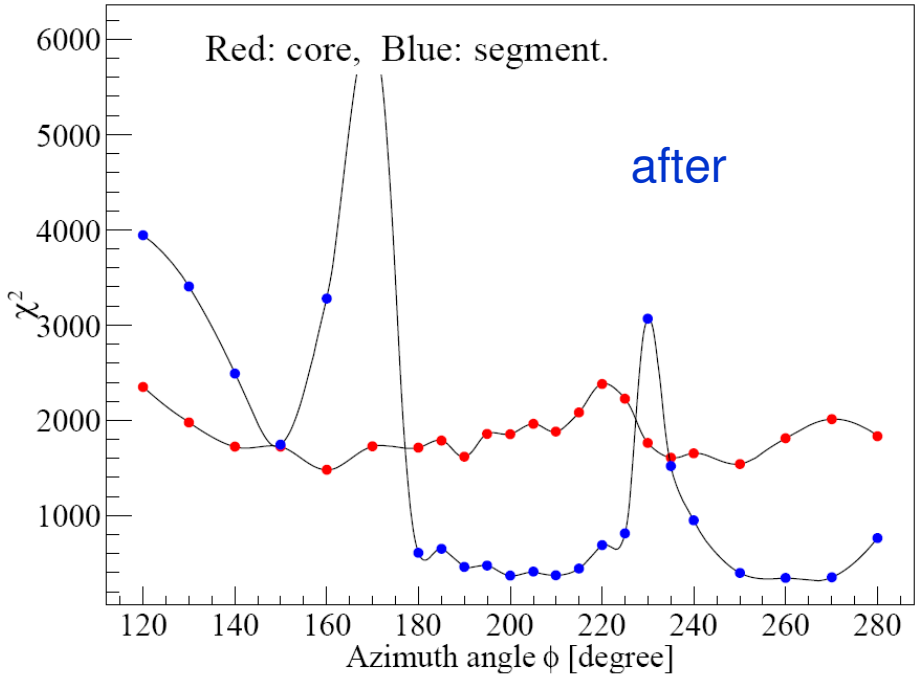
- Pulse shape analysis helps to reject background events
- Pulse shape simulation helps to estimate the efficiency
- Pulse shape simulation must be validated
- Different methods were used to compare simulated pulse to real ones
- Rise time as well as fine structures of the pulses were compared
- Simulation can be very good if corrected
- We have to understand our detector to improve the simulation

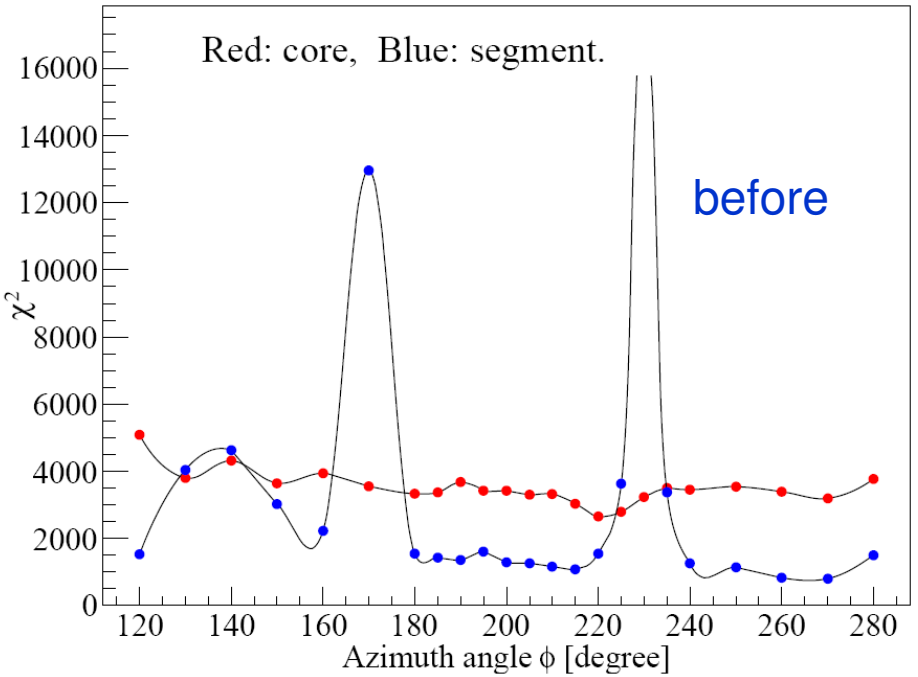
Time scale distribution along azimuth angle




Red: core, Blue: segment.
after
Time scale
Azimuth angle ϕ [degree]


Red: core, Blue: segment.
before
Time scale
Azimuth angle ϕ [degree]


Red: core, Blue: segment.
after
χ²
Azimuth angle ϕ [degree]


Red: core, Blue: segment.
before
χ²
Azimuth angle ϕ [degree]