Systematic Studies for the π^0 Calibration of the Crystal-Ball Detector

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The Process

$$\gamma + p \rightarrow \pi^0 + p \rightarrow p + \gamma_1\gamma_2 \tag{1}$$

$$m_{\pi^0} = \sqrt{2E_1E_2(1 - \cos(\alpha))} \tag{2}$$

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- How can it be checked if there is a energy dependency in the CB?
  $\rightarrow |E_1 - E_2| < 25\,\text{MeV}$
- What are the reasons for the dependency?

Crystal-Ball-Function / Reduction of the Underground

- Gaussian Fit Function $\rightarrow$ Crystal-Ball Fit Function

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- Check if the registered particles are charged
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- Gaussian Fit Function → Crystal-Ball Fit Function
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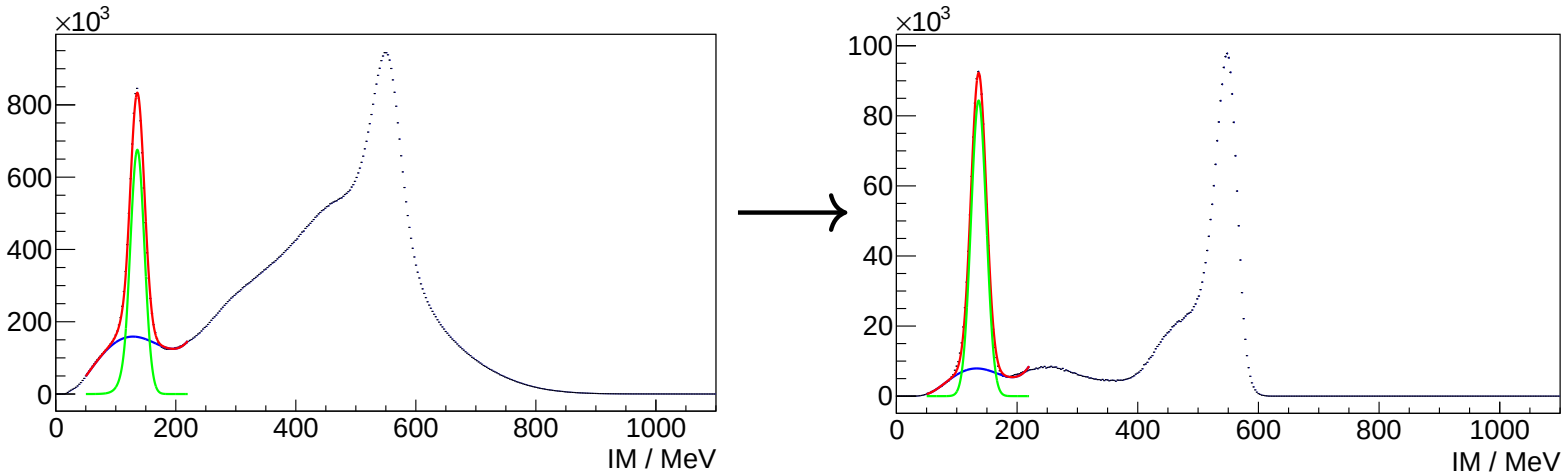

Abbildung: Beamtime: Example for not reduced and reduced underground

Event Generator

Reasons for a new event generator:

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- The condition $|E_1 - E_2| < 25\,\text{MeV}$ is a strong cut
  $\rightarrow$ There is no package with enough events
- Creating a new package with enough events would take to much time (multiple days on blaster)
- It would be better if the same generator is used for all studies
  $\rightarrow$ The generator should be able to simulate MAMI-Beam and isotropic decay

Event Generator

No Additional Cut

- Beamtime October 2014
- No additional cut

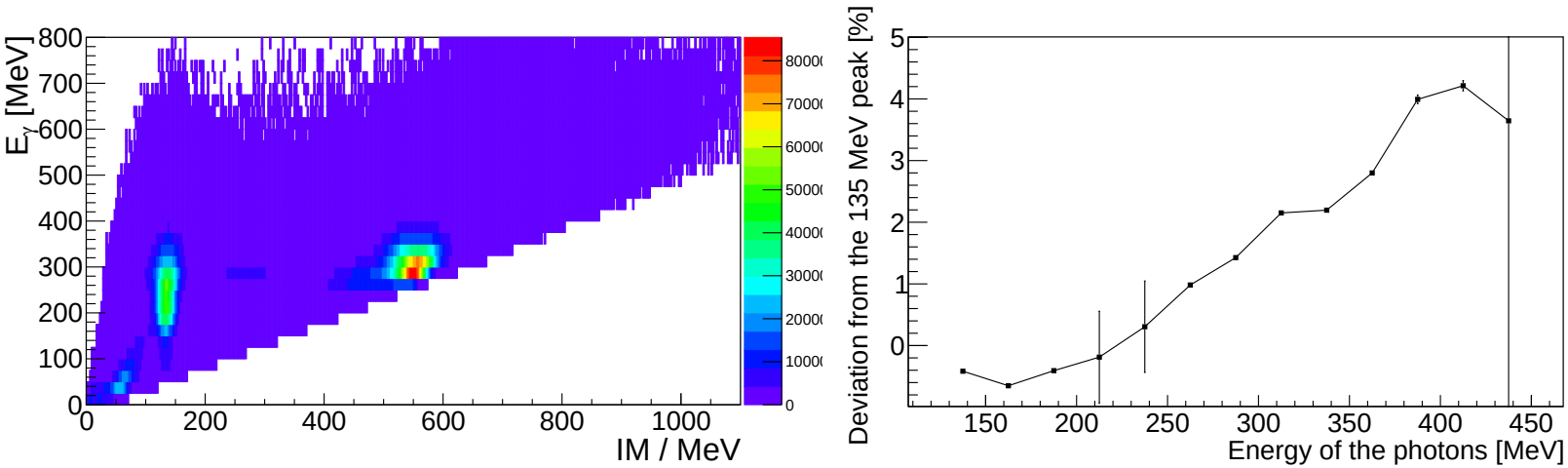

Abbildung: Beamtime: No additional cut

Detectors on the Edge

- Beamtime October 2014
- Neglect the detectors at the edge

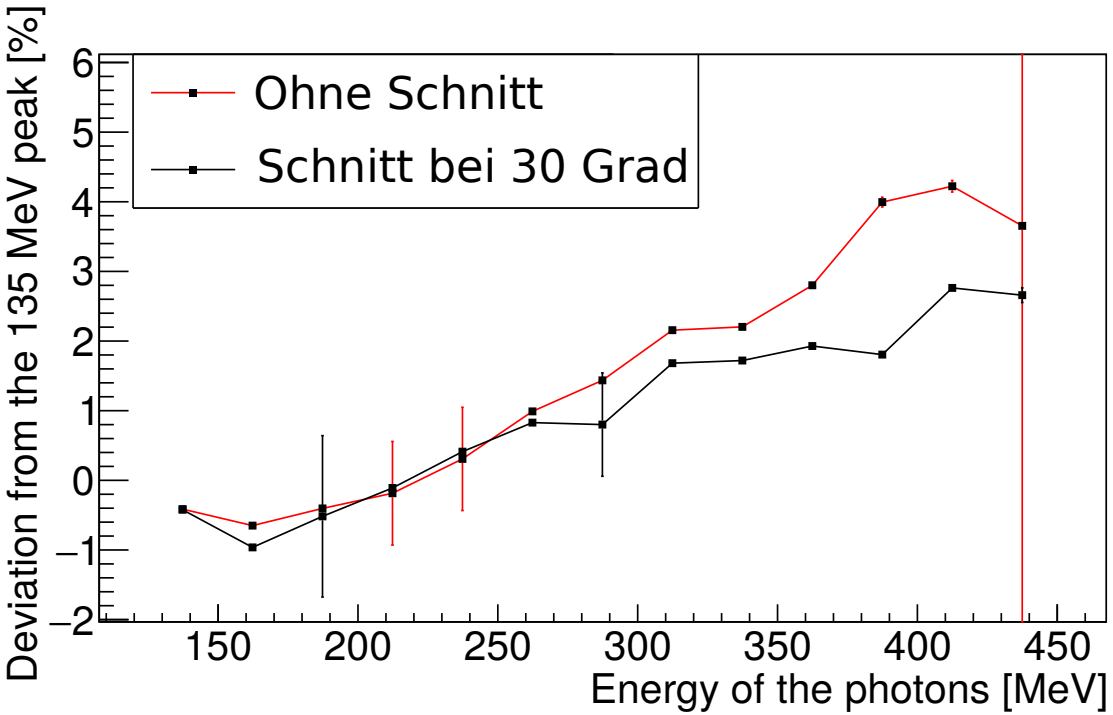

Abbildung: Beamtime: With and without considerations of the detectors on the edge of the beam entrance and exit

Detectors on the Edge

- Simulation
- Red: No additional cut
  Black: Neglect the detectors on the edge

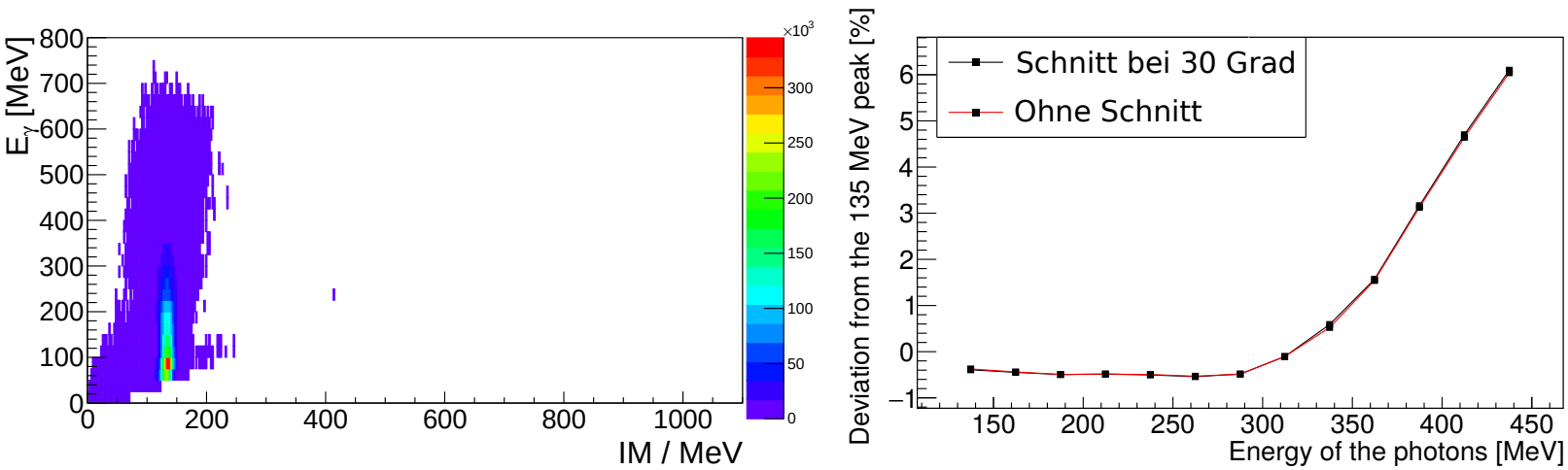

Abbildung: Simulation: Left: Example for the two dimensional histogram with simulated data. Right: Deviation with and without the detectors on the edge

Minimum Opening Angle

- Simulation
- Opening angle α has to be bigger than $30°$ degree
- $m_{\pi^0} = \sqrt{2E_1E_2(1-\cos(\alpha))}$ with $E_1 \approx E_2$
  $\rightarrow E_{max} \approx 250\,\text{MeV}$

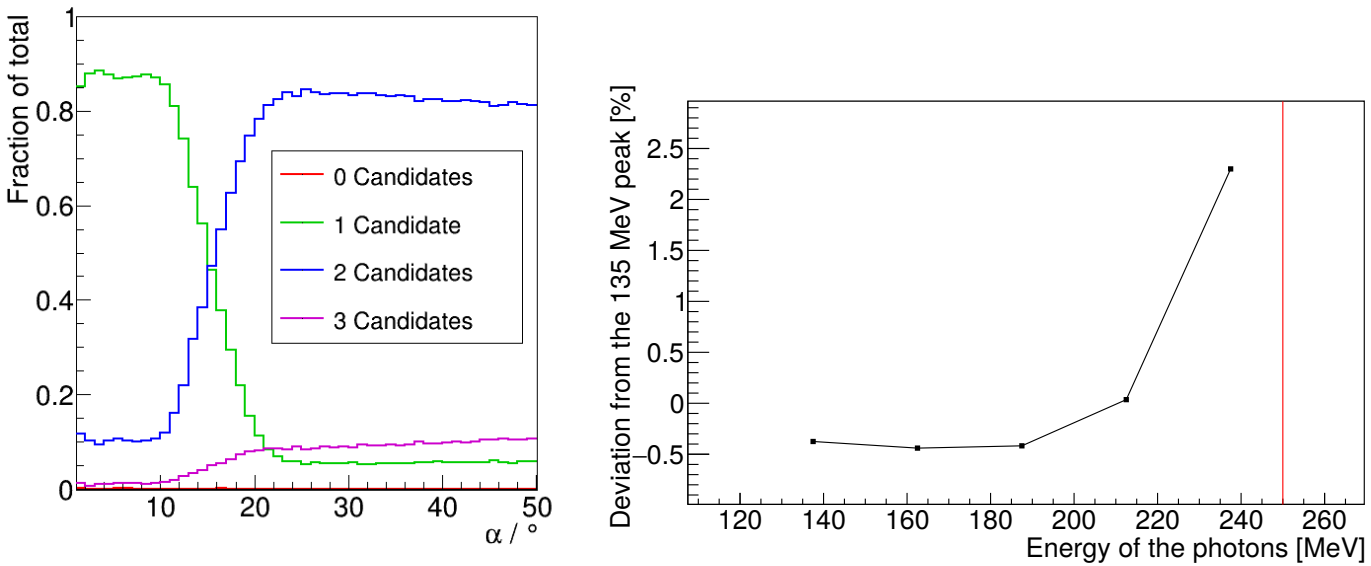

Abbildung: Left: Number of reconstructed candidates for different opening angles. Right: Deviation with $\alpha > 30\,\text{MeV}$

Isotropic Decay

- Simulation
- π^0 decay in the origin of the target
- π^0 are boosted isotropic with an energy of $1420\,\text{MeV}$ to $1580\,\text{MeV}$

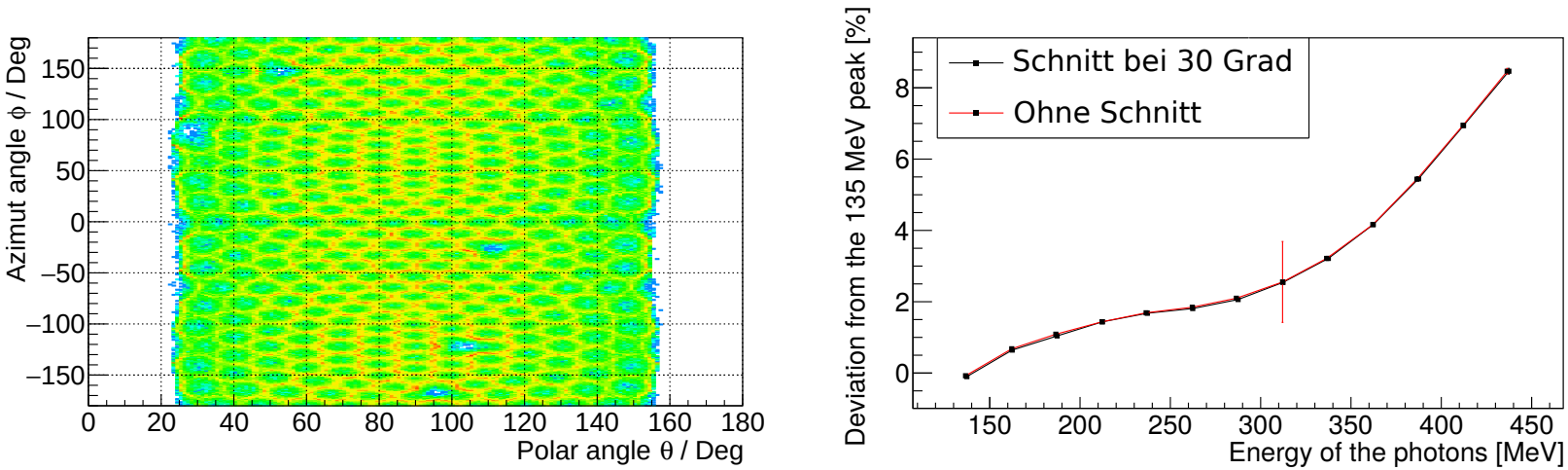

Abbildung: Simulation: Isotropic decay in the origin of the target

z-Vertex Dependency

- Simulation
- Neglect the detectors on the edge
- Devide the target in smaller sections of $1\,\mathrm{cm}$

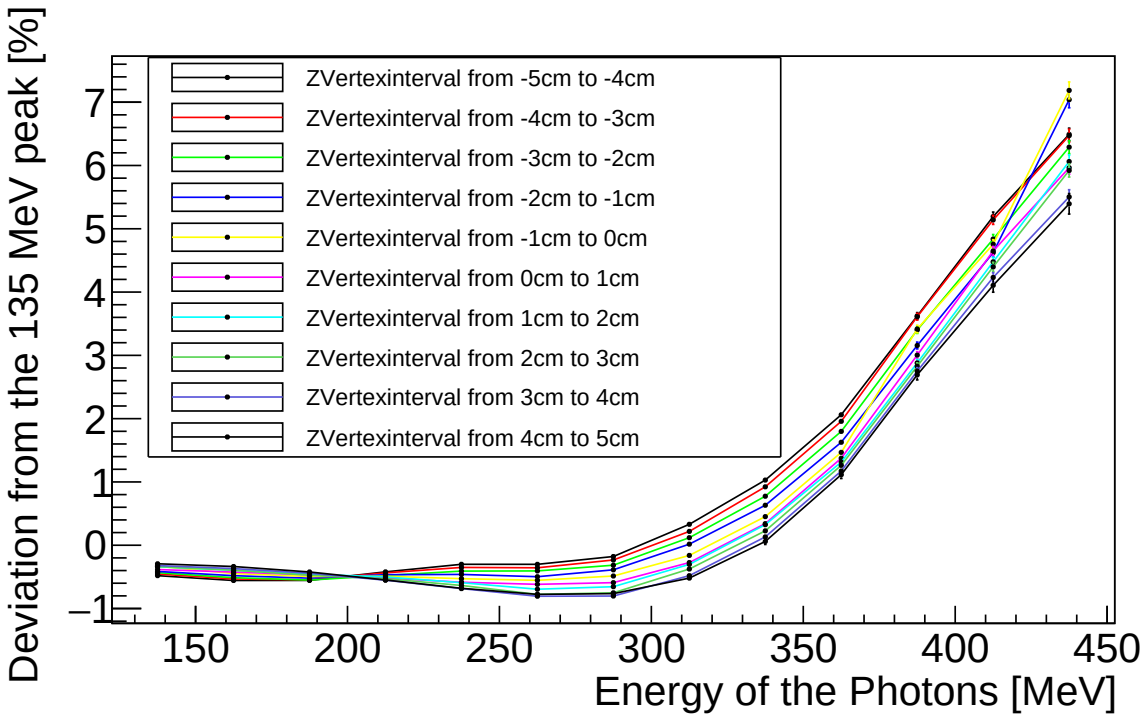

Abbildung: Simulation: Deviations for different z-Vertices

Angle between Generated and Reconstructed Candidates

- Simulation
- The angle between generated and reconstructed candidate is calculated

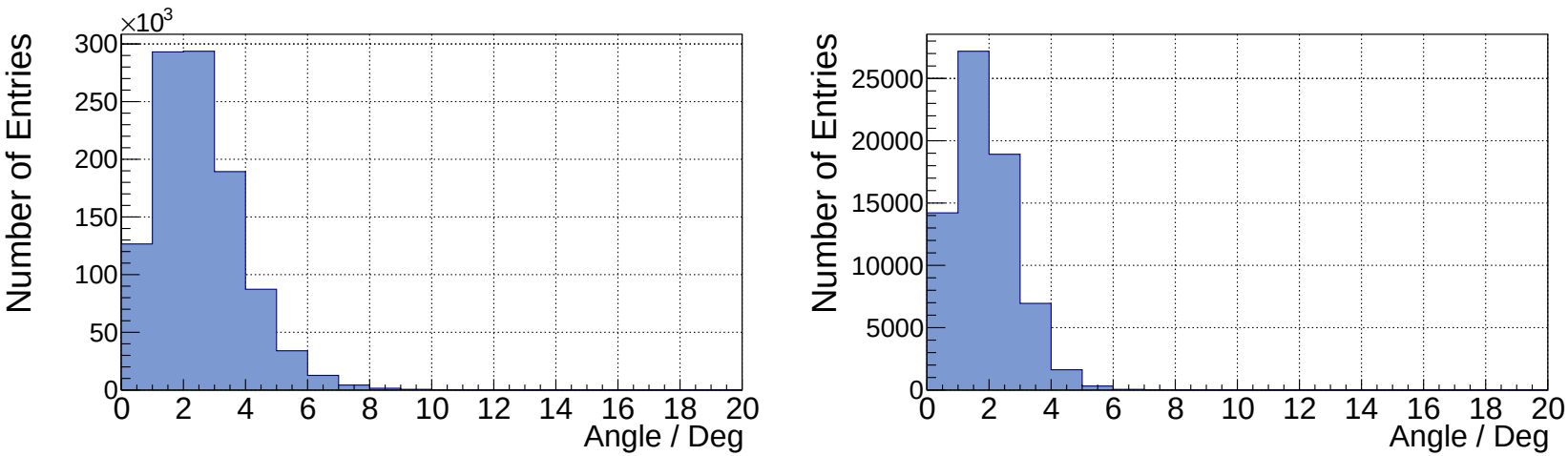

Abbildung: Simulation: Angle between gen. and rec. candidates. Left: Photon energy between $125\,\text{MeV}$ and $150\,\text{MeV}$. Right: Photon energy between $425\,\text{MeV}$ and $450\,\text{MeV}$

Difference between Generated and Reconstructed Opening Angle

- Simulation
- $\Delta\alpha = \alpha_{rec} - \alpha_{gen}$

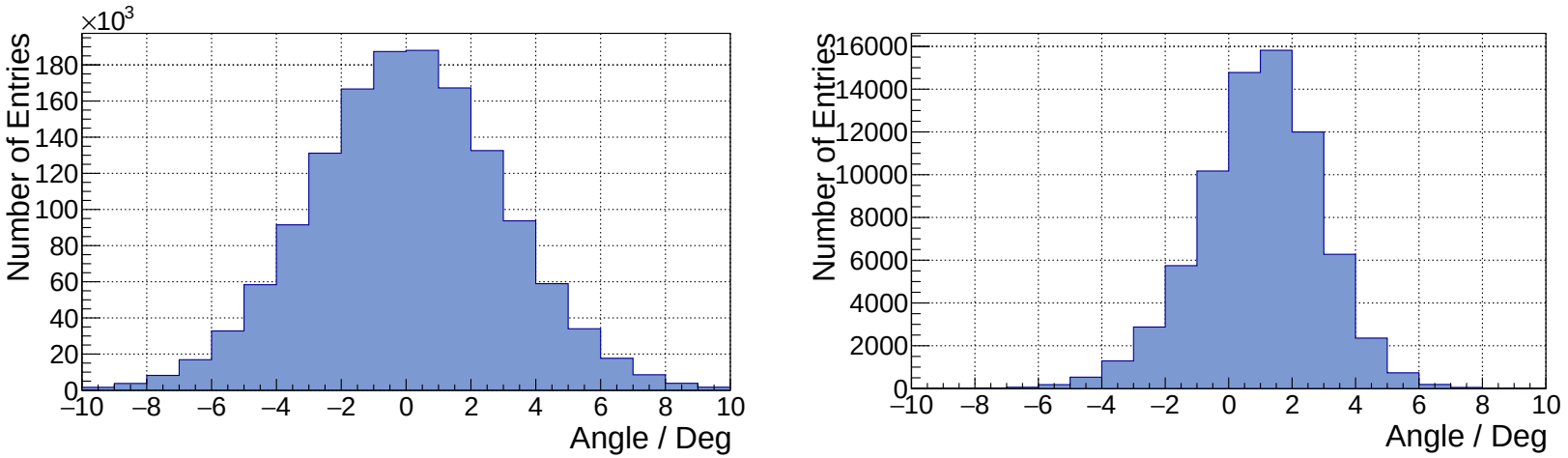

Abbildung: Simulation: $\Delta\alpha$ for different photon energies. Left $125\,\text{MeV}$ to $150\,\text{MeV}$. Right from $425\,\text{MeV}$ to $450\,\text{MeV}$

$\Delta\alpha$ for Different z-Vertices

- Simulation
- $\Delta\alpha$ for different z-Vertices

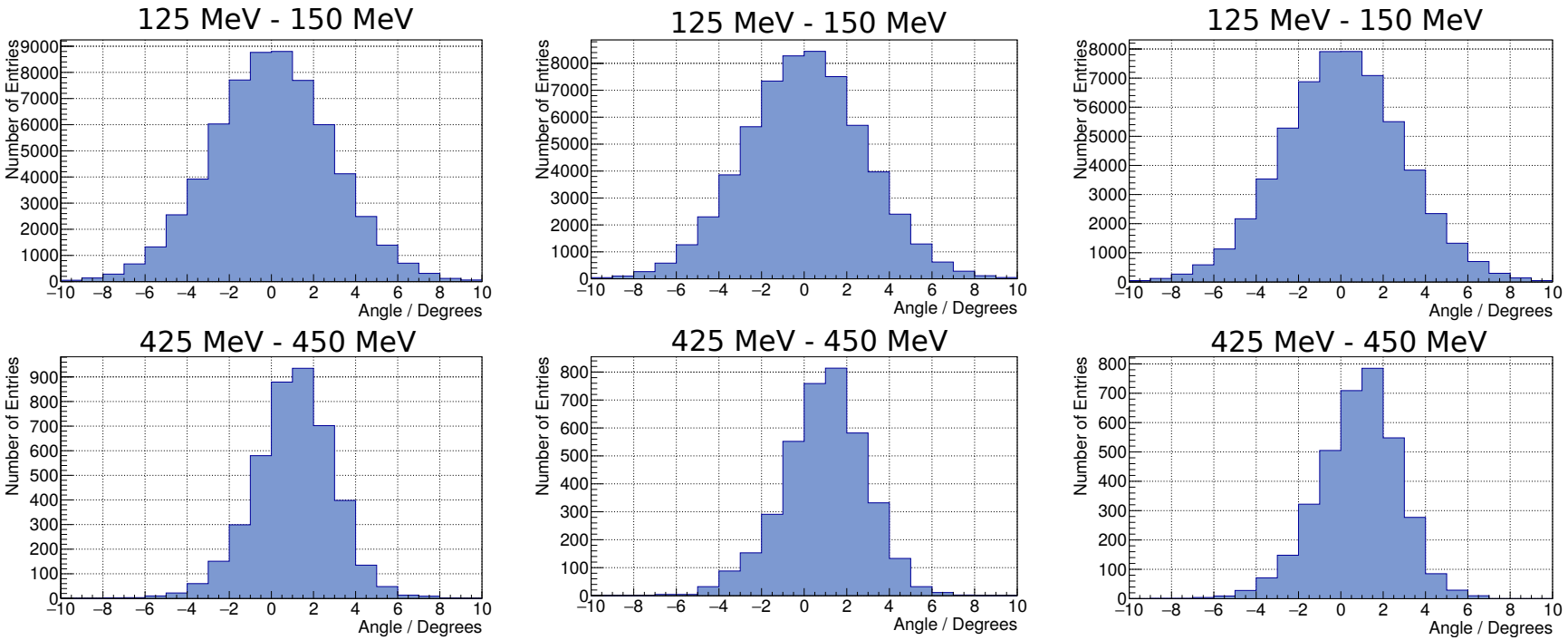

Abbildung: Simulation: $\Delta\alpha$ for different photon energies. Decay at different z-Vertices

Hot and Dead Crystals

Conclusion

- There is a energy dependency in the detector
- The reconstructed opening angle is too big for high energies
  $\rightarrow$ wrong reconstruction of the photon impact position is probably the reason for the dependency (Clustering Algorithm)
- The hardware of some PIDs has to be checked (too few events)
- There is a strange ϕ distribution in the detector
  $\rightarrow$ reason for this has also to be determined