Energy Calibration of the $\bar{P}$ANDA Electromagnetic Calorimeter

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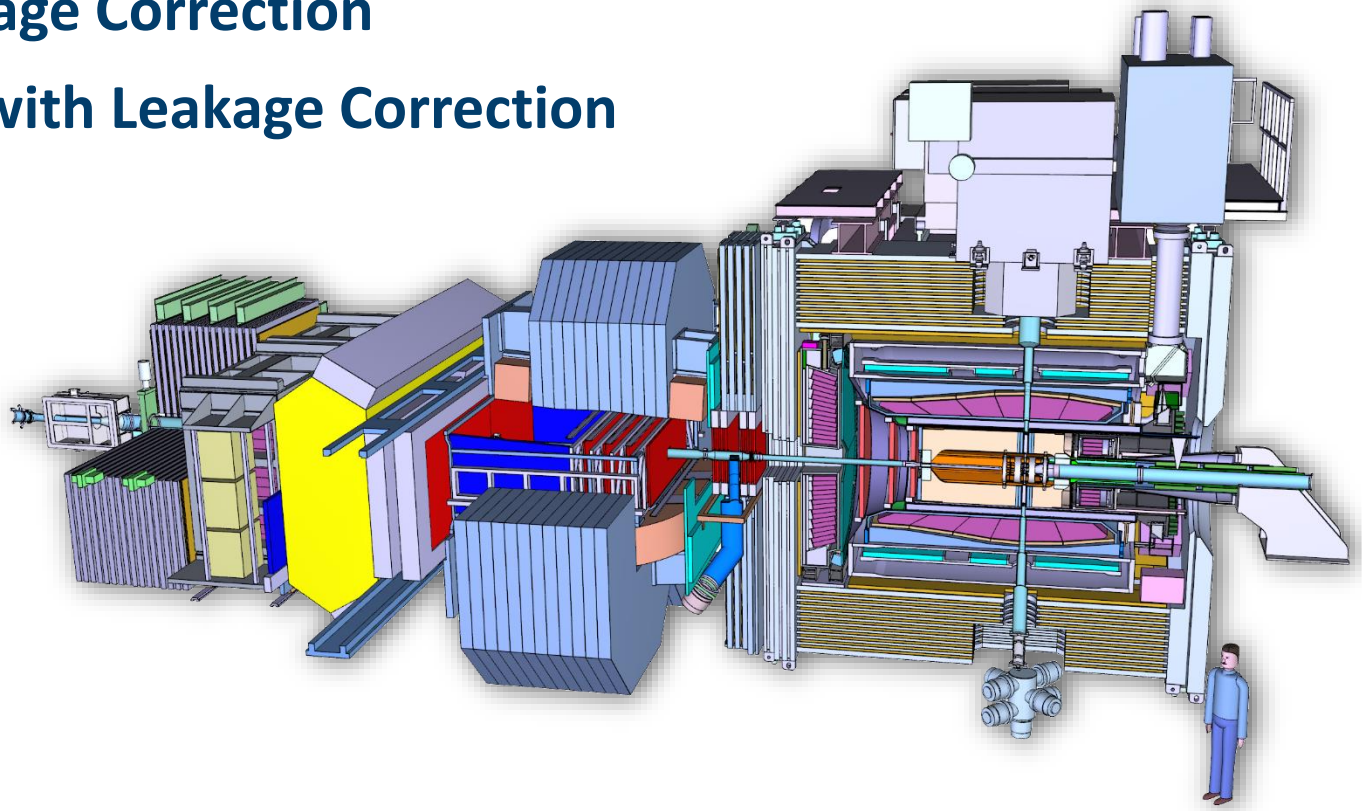
PANDA Collaboration Meeting 23-1 at Bochum University

Outline

- PANDA EMC-Barrel
- Energy Calibration
- Energy Leakage Correction
- Calibration with Leakage Correction
- Summary

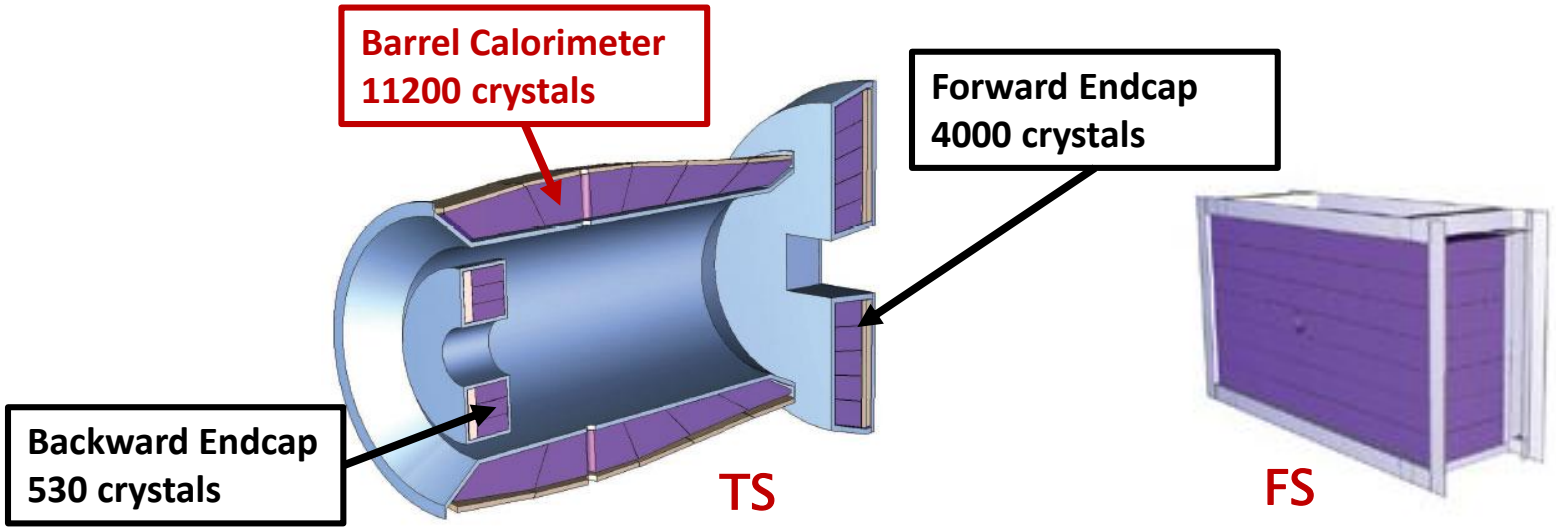


PANDA EMC-Barrel

- Energy measurement
- Position measurement
- Shower shape measurement
- Separation of γ/e and hadrons

PWO-II crystal:

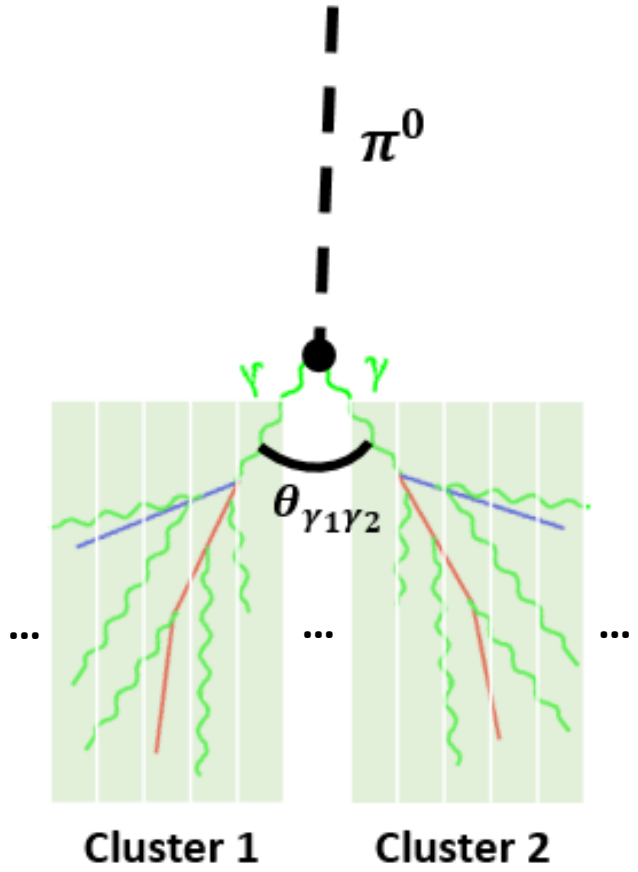
- Width ~ 2-3 cm (R_M ~ 2 cm)
- Length ~ 20 cm (X_0 ~ 1 cm)



Energy Calibration ($\pi^0 \rightarrow \gamma\gamma$)

- Detection unit uniformity
- Pre-shower and Leakage
- Light yield non-uniformity
- …

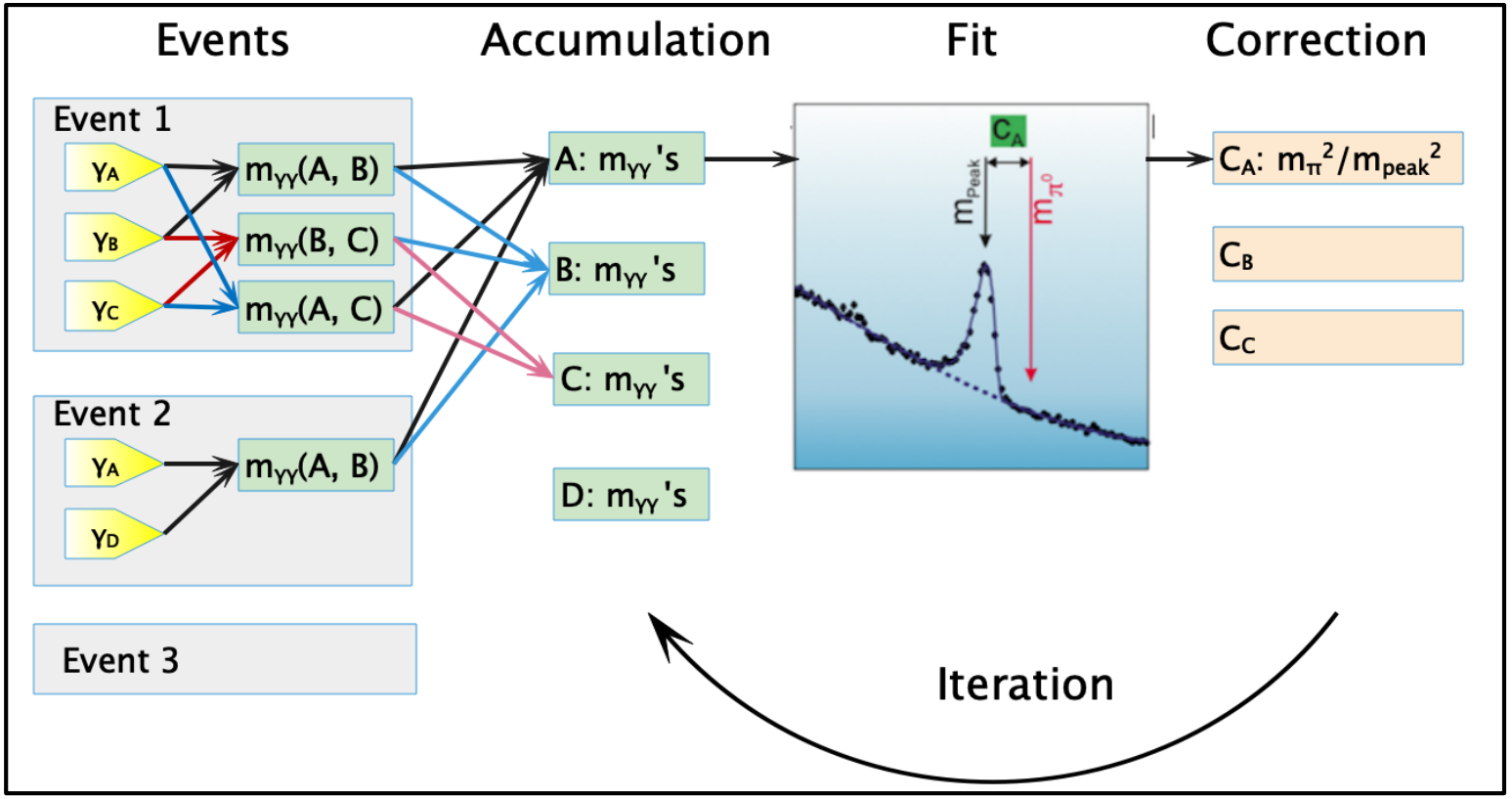
The calibration will improve the energy resolution and correct the reconstructed energy to the true energy which can be used in physics analysis.



Energy Calibration ($\pi^0 \rightarrow \gamma\gamma$)

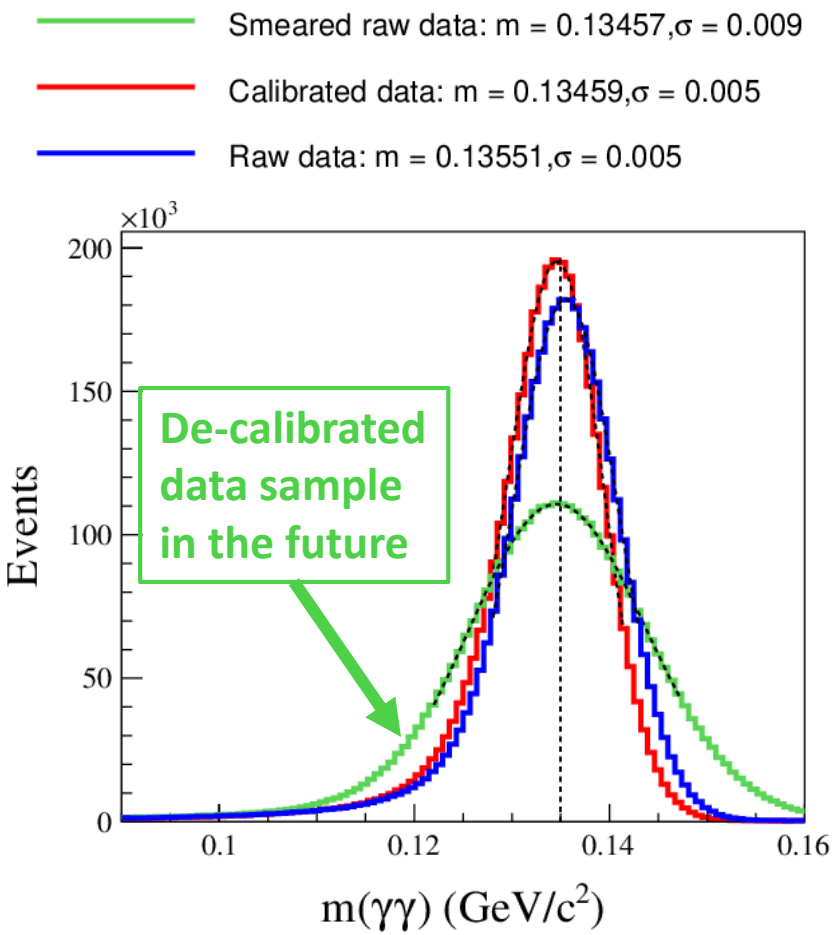
- **Monte Carlo simulated sample of $\pi^0 \rightarrow \gamma\gamma$**

https://indico.gsi.de/event/1226/contributions/2378/attachments/1960/2472/Steinke_EmcCalibration.pdf

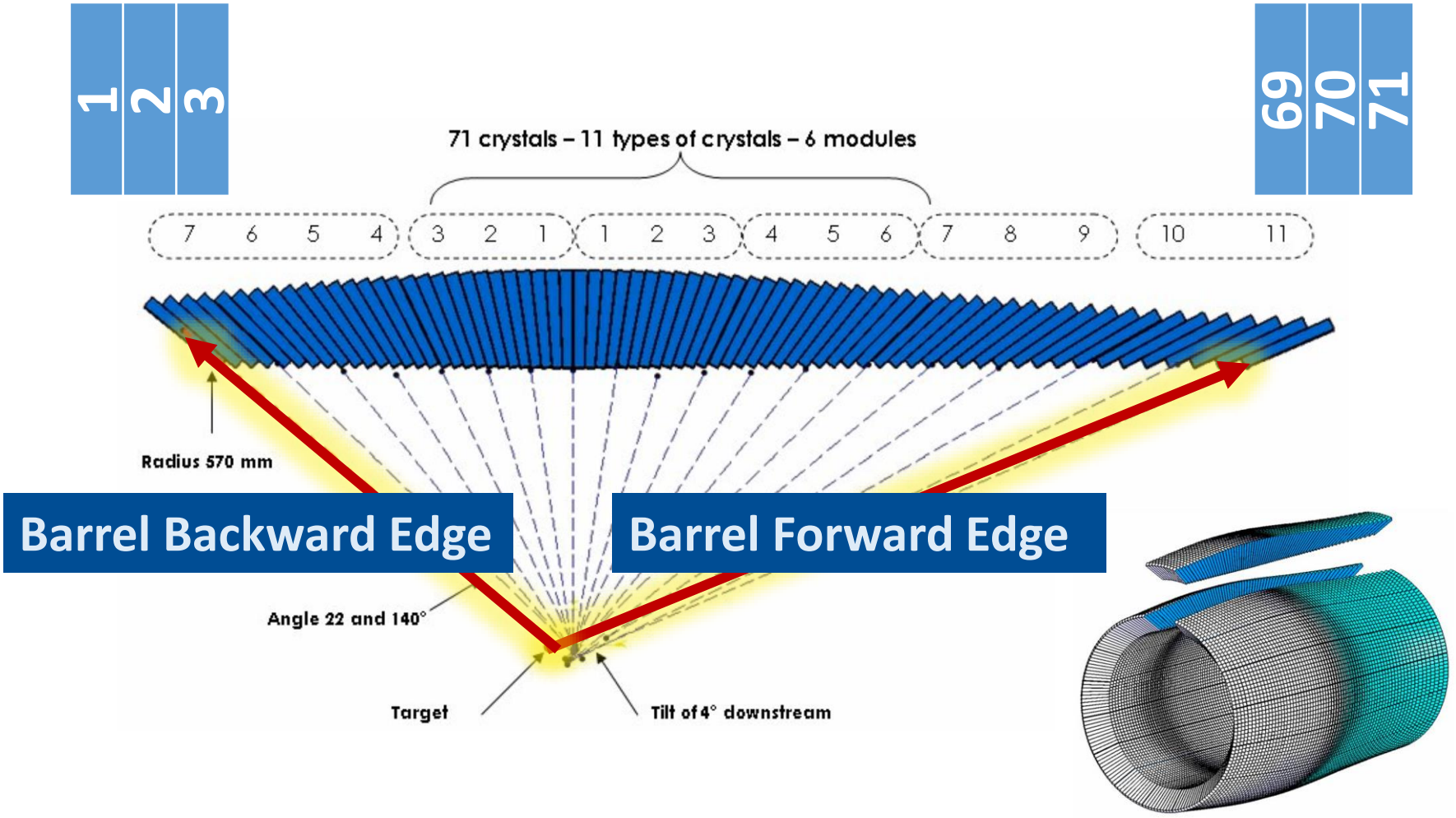


Energy Calibration ($\pi^0 \rightarrow \gamma\gamma$)

- The calibration algorithm can be applied to those crystals in the inner region of the calorimeter, and perfectly satisfy the requirement of PANDA experiment
- However, the calibration algorithm will suffer the energy leakage problem when applied to crystals in the edge region
- The energy leakage problem must be solved before doing calibration



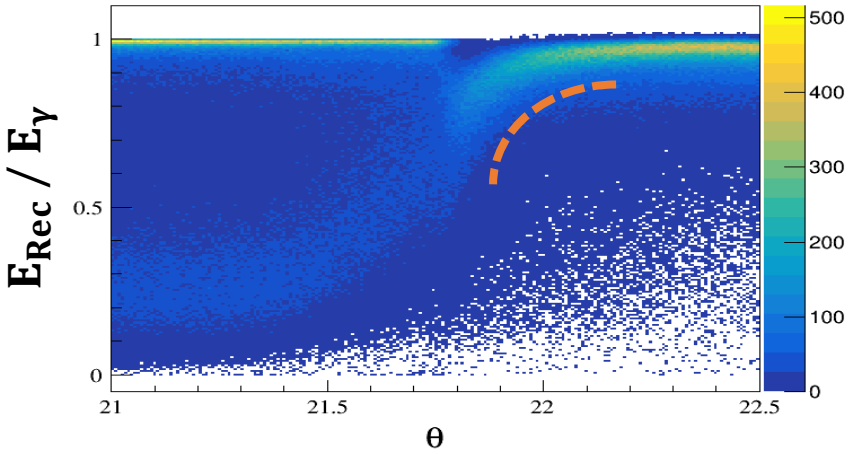
Energy Leakage Correction

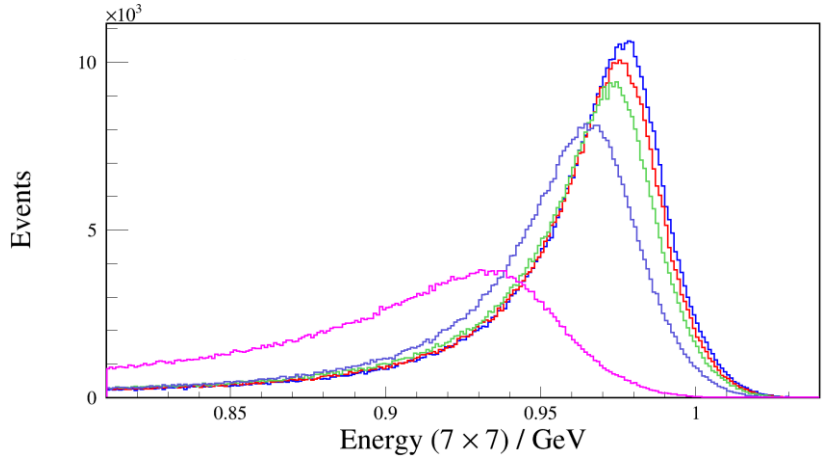


Energy Leakage Correction

- Influences of energy leakage :
  - Shower lost → energy shift
  - Statistics lost → bad resolution
  - …
- Solutions:
  - MPV shift
  - Estimate the leakages based on some features of the shower lateral development, such as the shape of the shower…

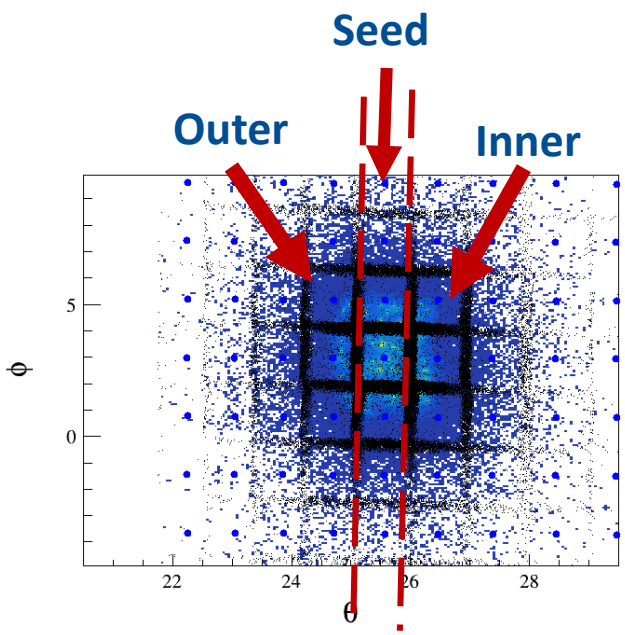
Monte Carlo simulated sample of single γ



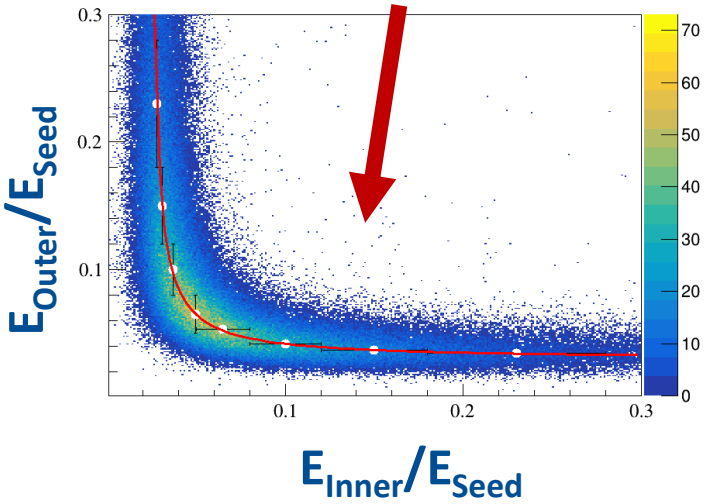


Energy Leakage Correction

- When a coming particle hit the edge of the EMC, the energy deposited in the outer side will not be detected.



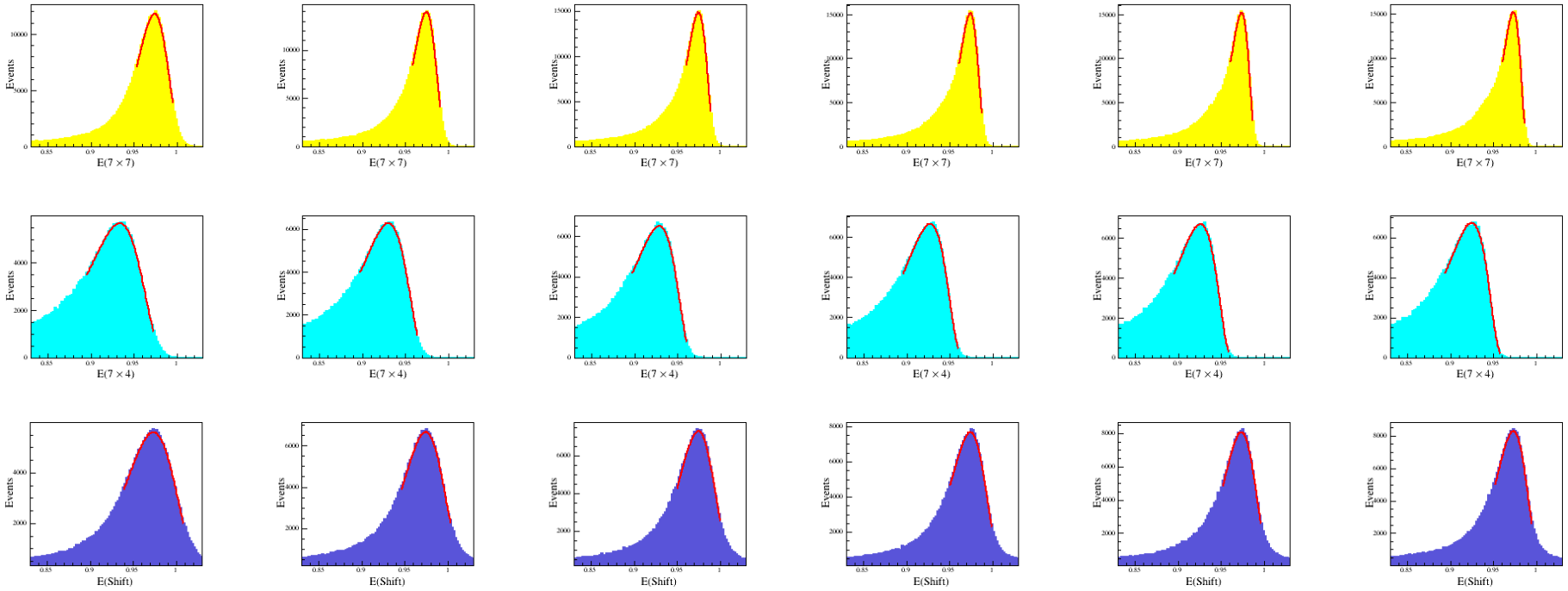
The energy deposited in the outer side (E_{Outer}) is missed for edge condition, but the ratio E_{Outer}/E_{Seed} can be obtained according to E_{Inner}/E_{Seed}



Energy Leakage Correction

No leakage Leakage Corrected

Crystal ID: 1

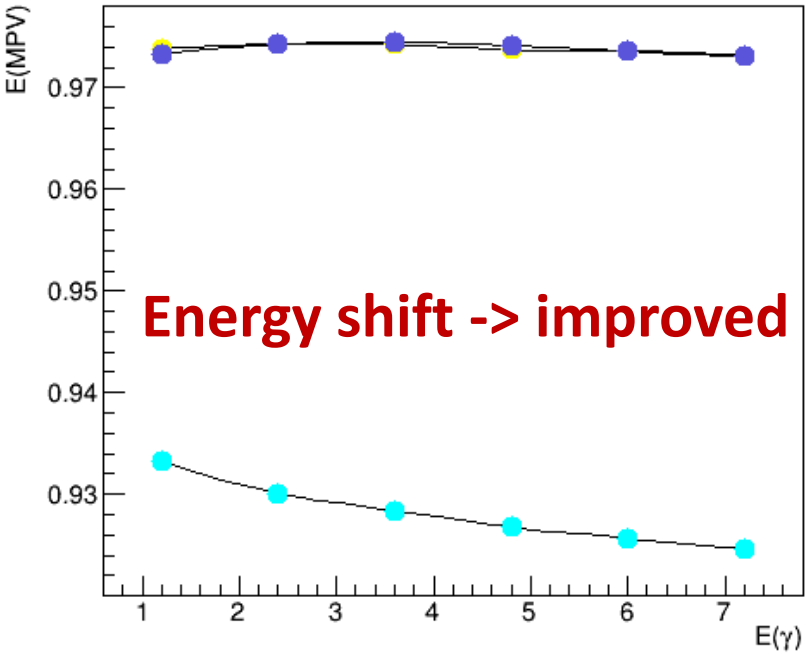


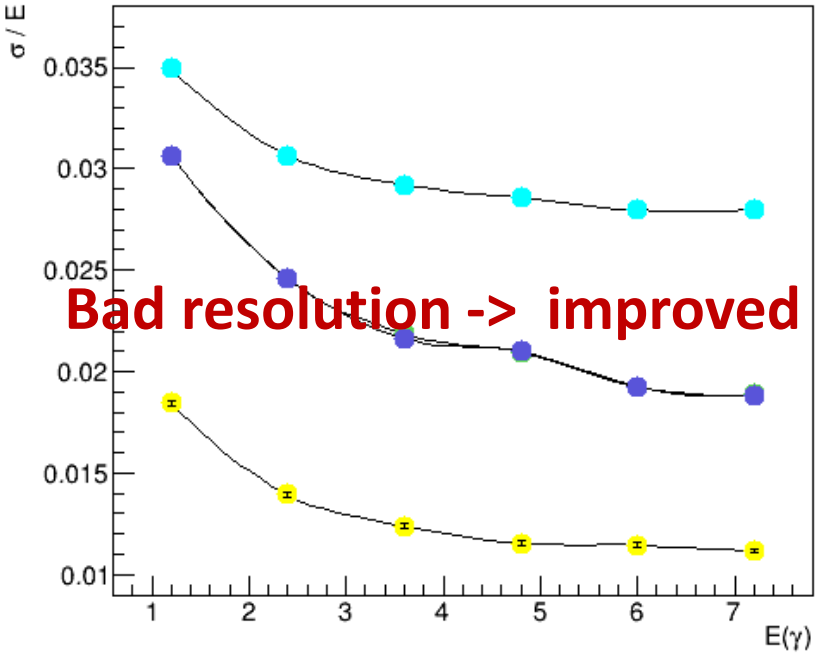
1.2GeV 2.4GeV 3.6GeV 4.8GeV 6.0GeV 7.2GeV

Energy Leakage Correction

No leakage Leakage Corrected

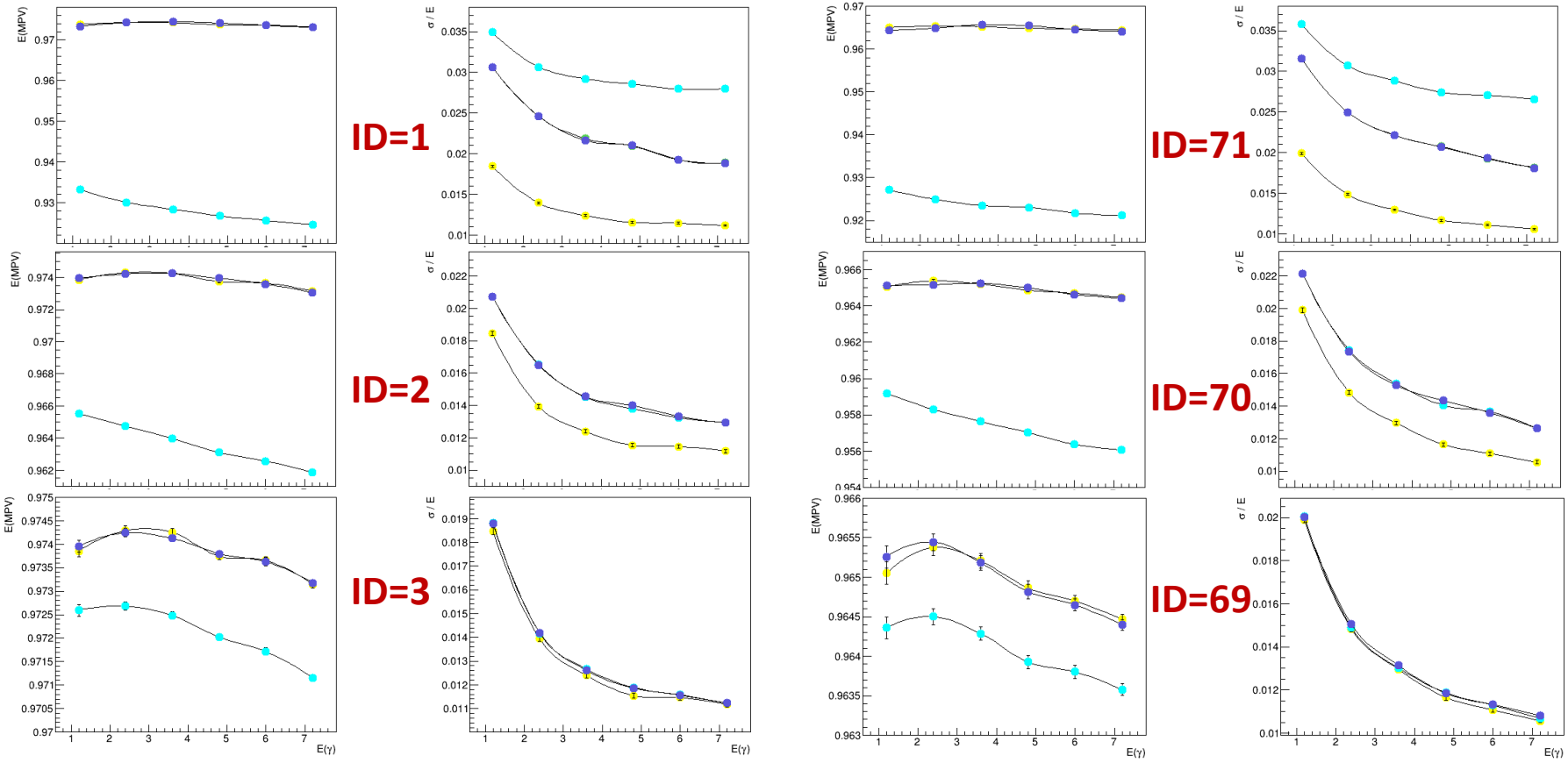
Crystal ID: 1



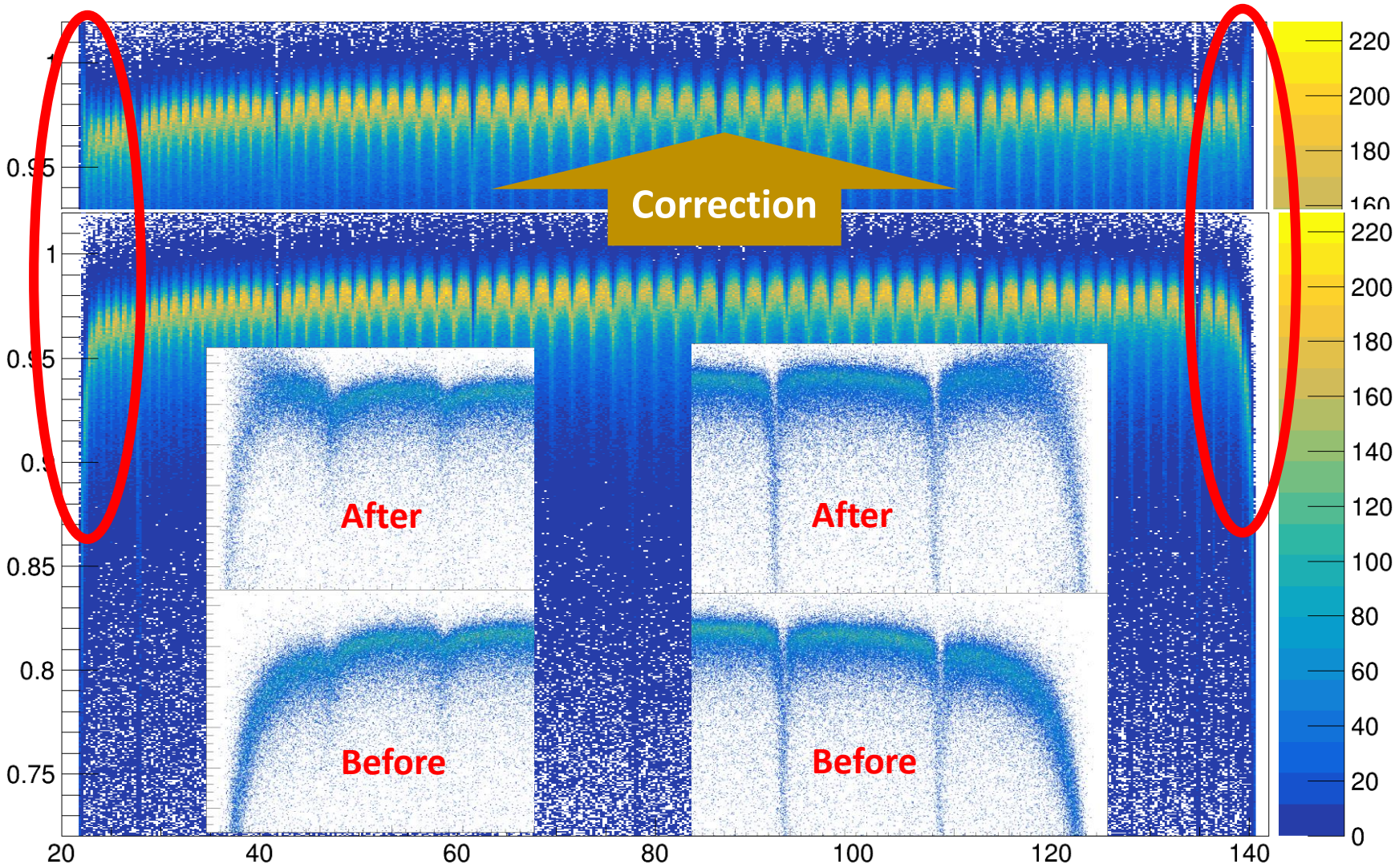


Energy Leakage Correction

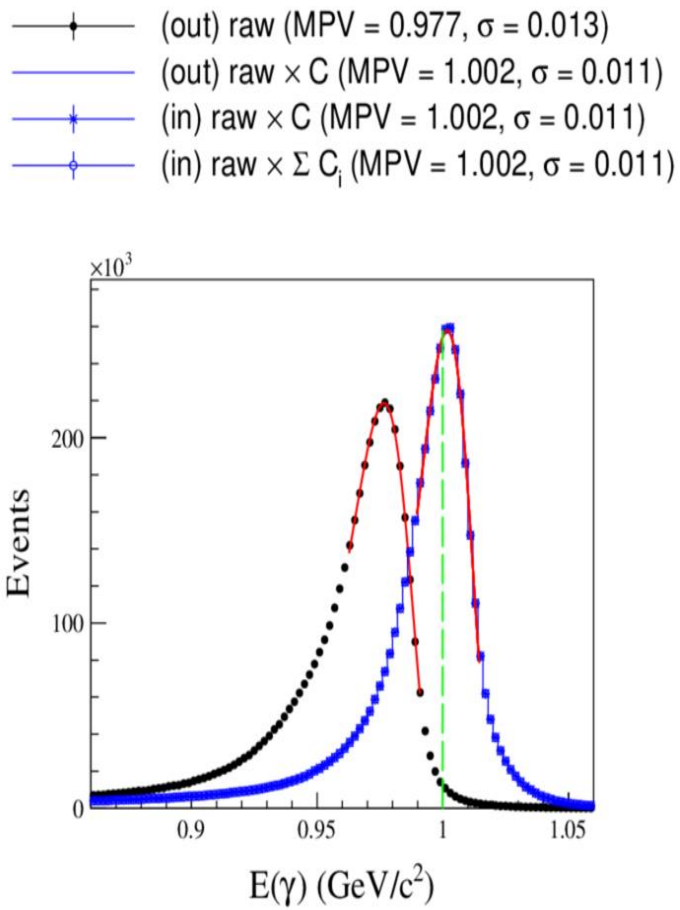
outer 1 2 3 … No leakage Leakage Corrected … 69 70 71 outer

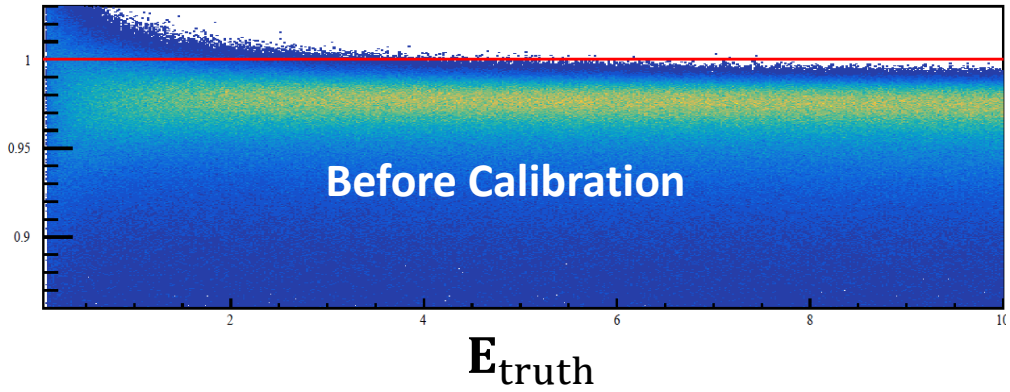


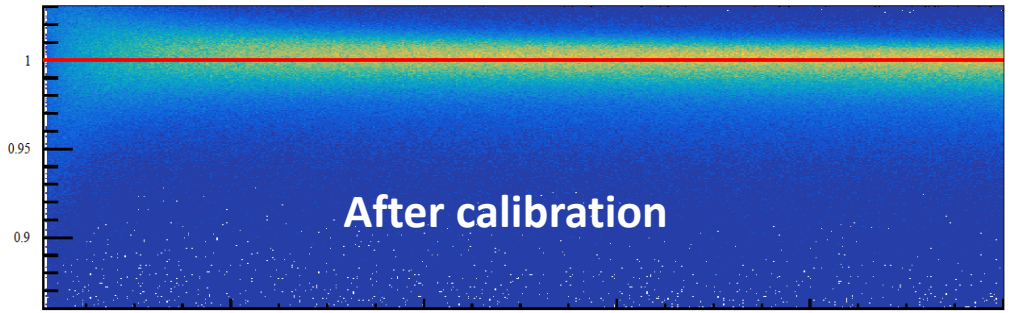
Energy Leakage Correction



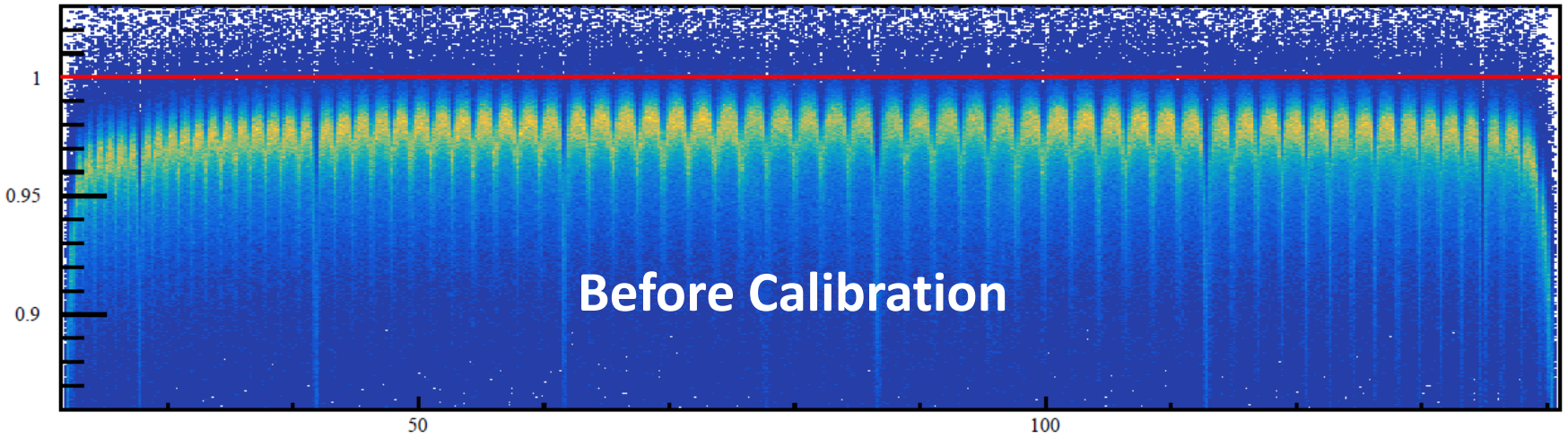
Calibration with Leakage Correction



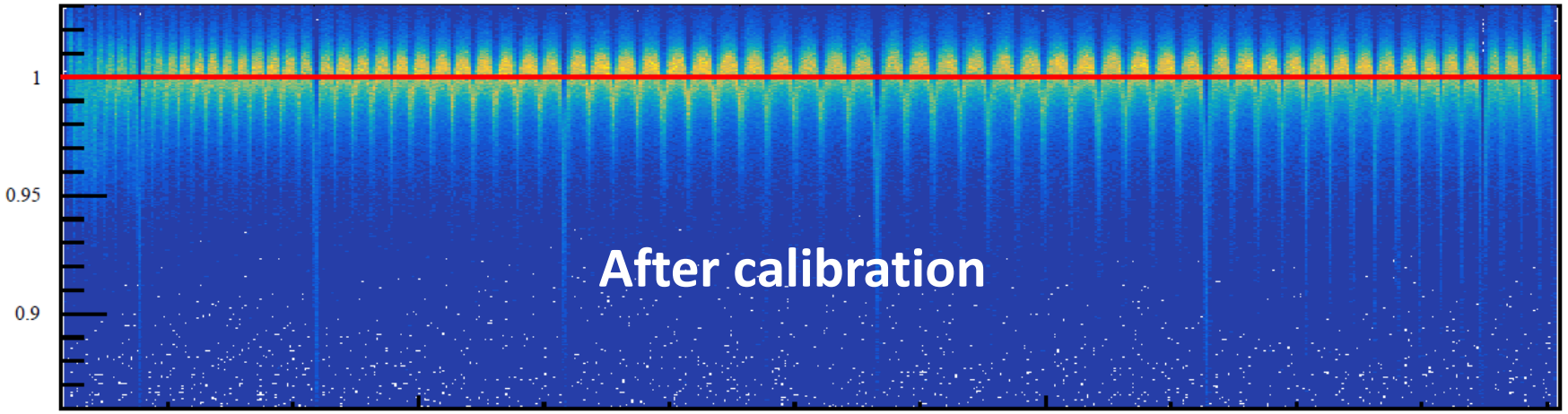




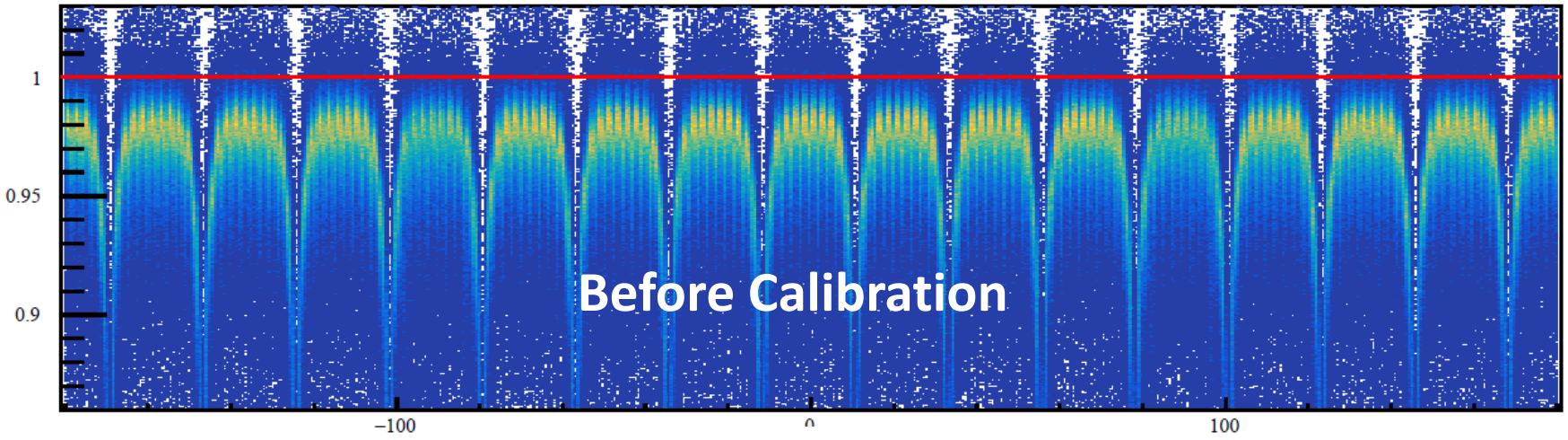
Calibration with Leakage Correction



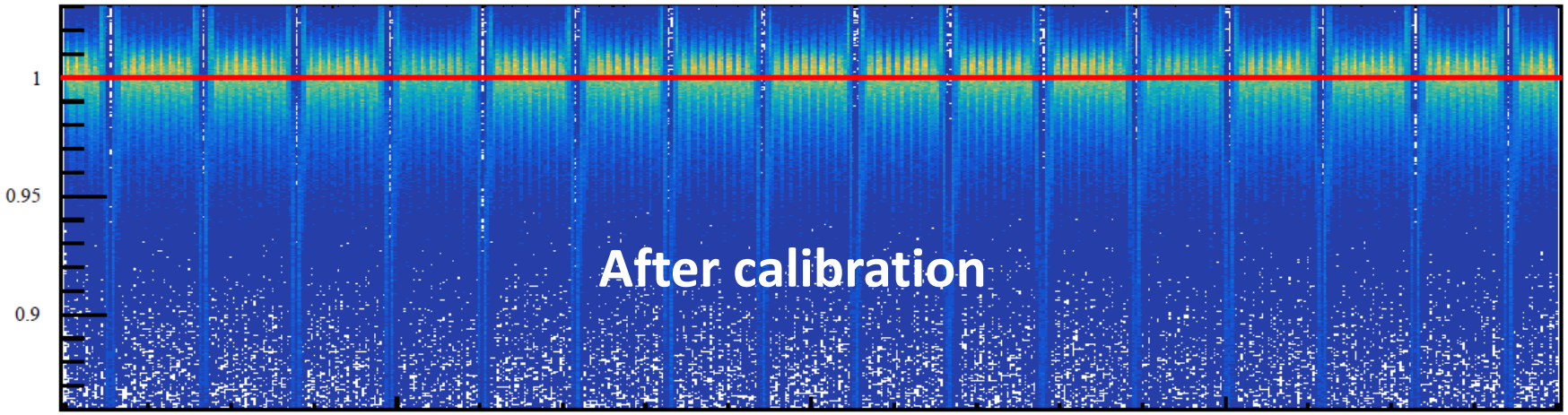
θ



Calibration with Leakage Correction

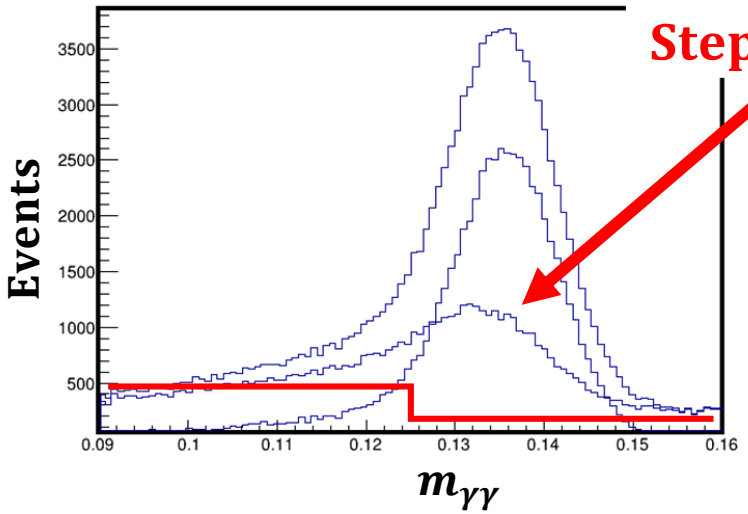


ϕ



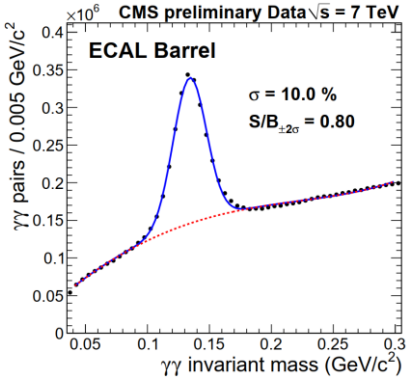
Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)

- The calibration algorithm has been tested with single γ/π^0 particle from particle gun.
- Calibration with real physics events is the final goal.
- Process like $p\bar{p} \rightarrow \pi^0\pi^0\pi^0$ is an ideal control sample.



PANDA:
Bkg shape ?
Real data ?
Inclusive MC ?
Inclusive π^0 ?

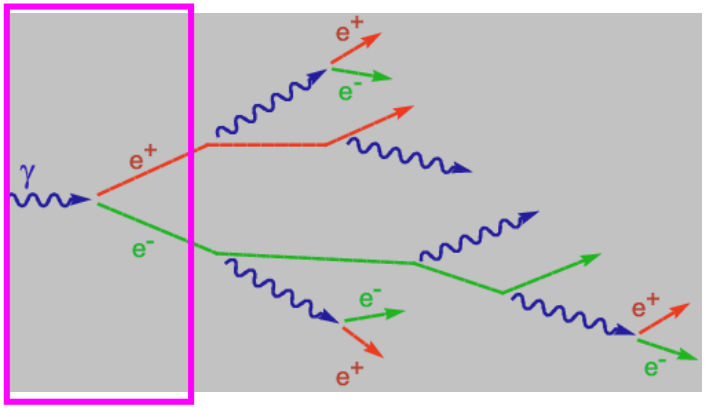
CMS data (2010)
π^0 from QCD events

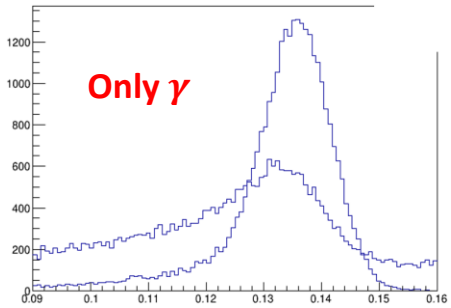


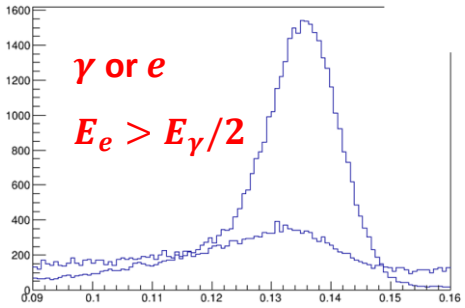
Energy Calibration ($p\bar{p} \to \pi^0\pi^0\pi^0$)

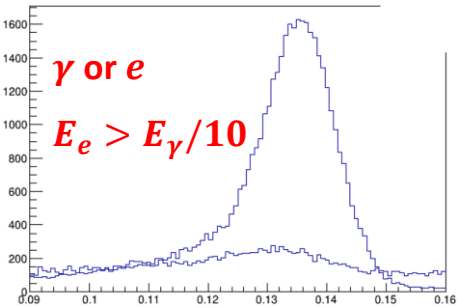
- γ: the cluster match with the γ from π^0 decay
- e: the cluster match with the $e^{\pm}$ from γ_{π^0}
- Match with further secondary particles are not considered here
- The peaking BKG and the higher tail in low mass side comes from the “leakage” events

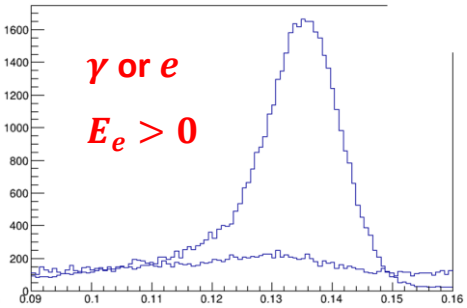
Match range



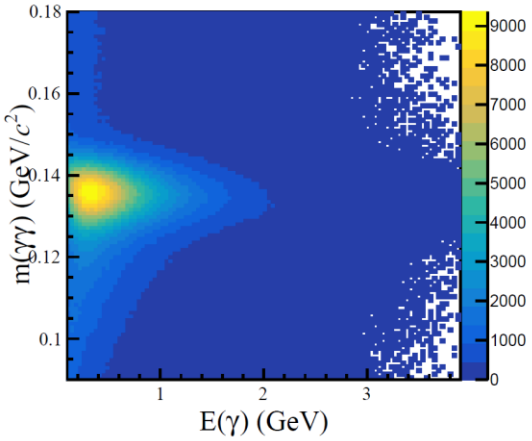


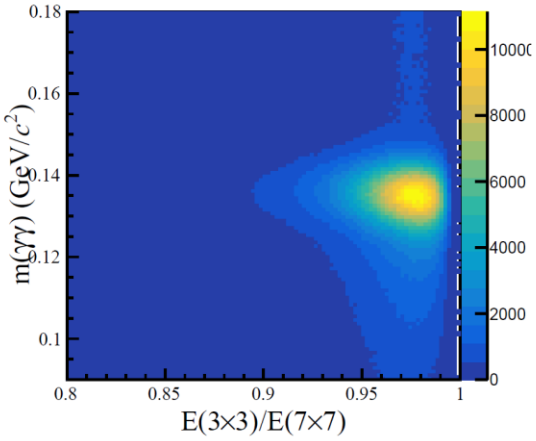


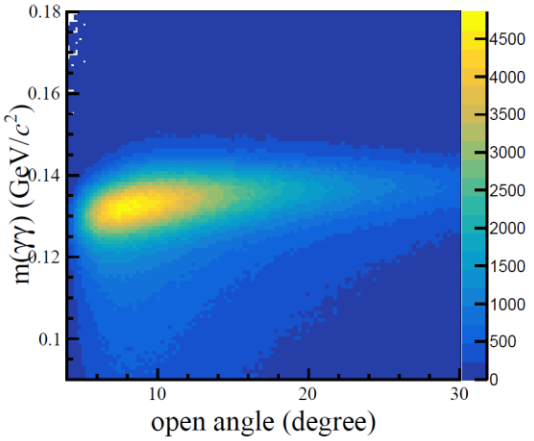


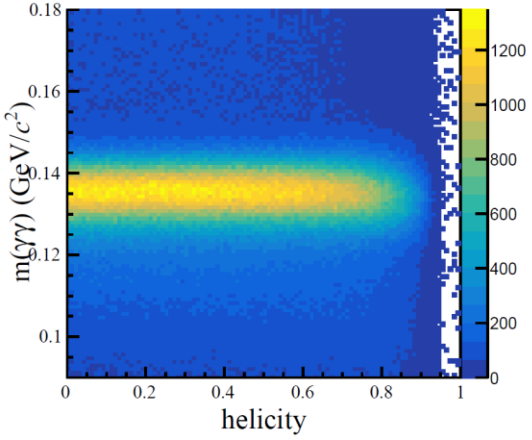


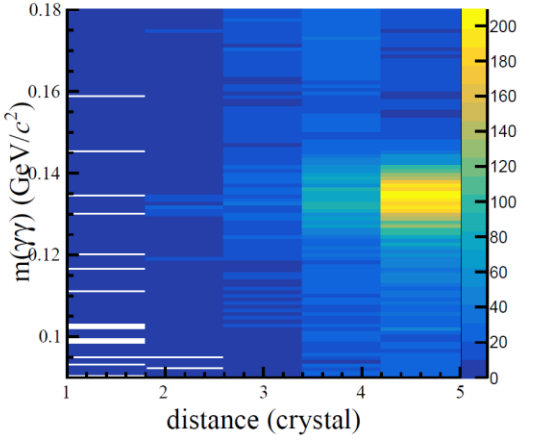
Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)

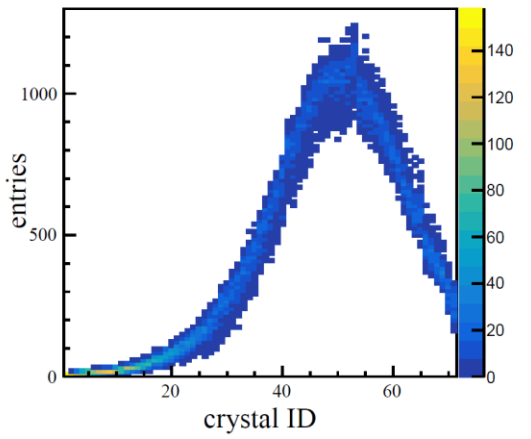




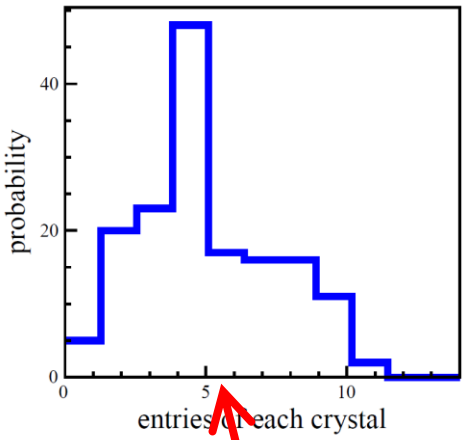


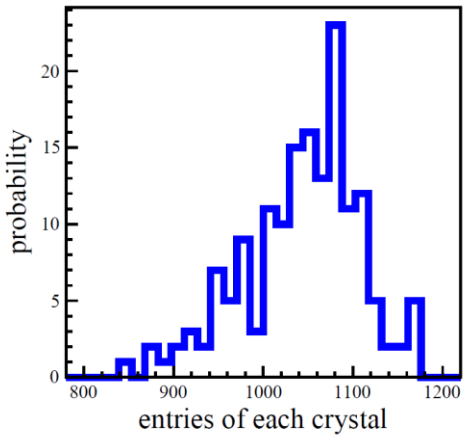


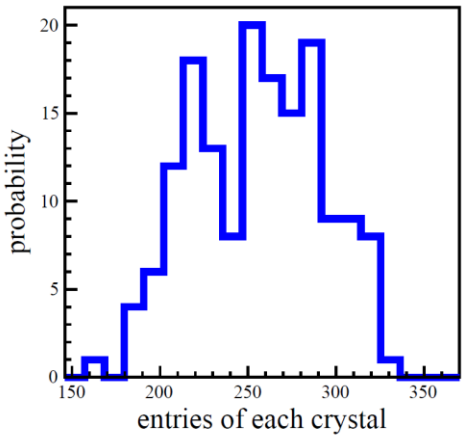




Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)







in the electromagnetic calorimeter. The channels $\overline{\mathrm{p}}\mathrm{p} \rightarrow \pi^0\pi^0\pi^0$ and $\overline{\mathrm{p}}\mathrm{p} \rightarrow \pi^0\pi^0\eta$ have a cross section of about 30 μb, thus producing 4200 events per second at a luminosity of $10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ ($\eta \rightarrow \gamma\gamma$ only).

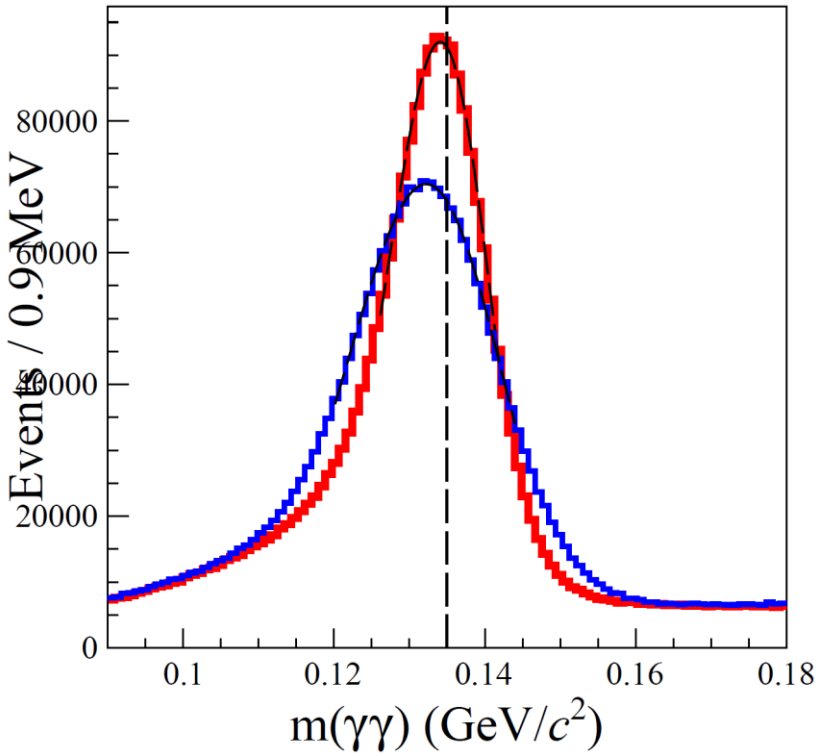
Current statistics: 5×10^6

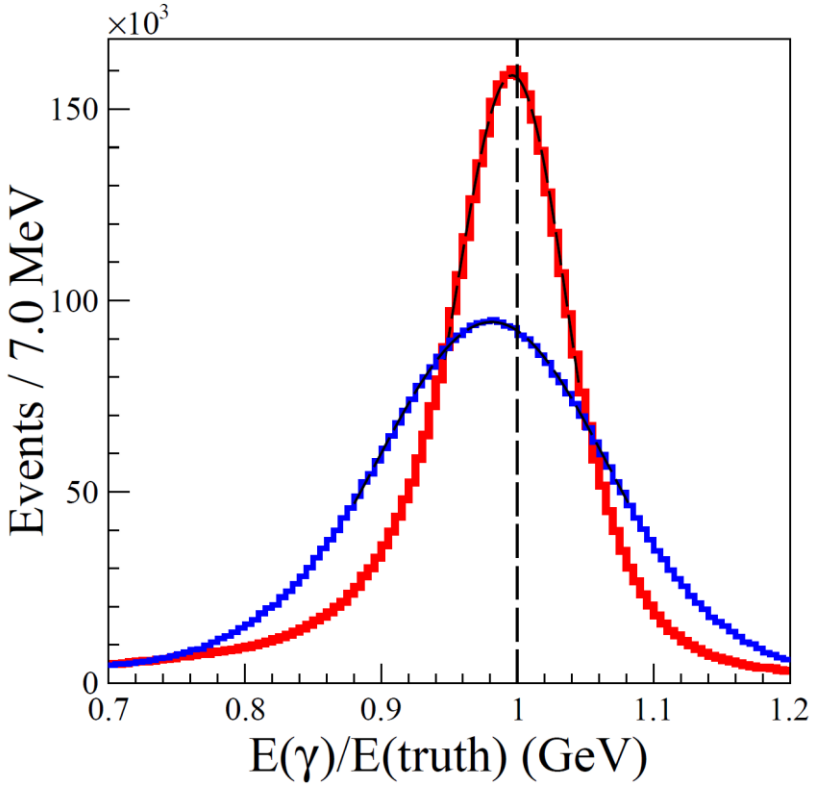
If require $\times 10^2$ more, ~ 30 hrs is needed to collect the calibration sample

Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)

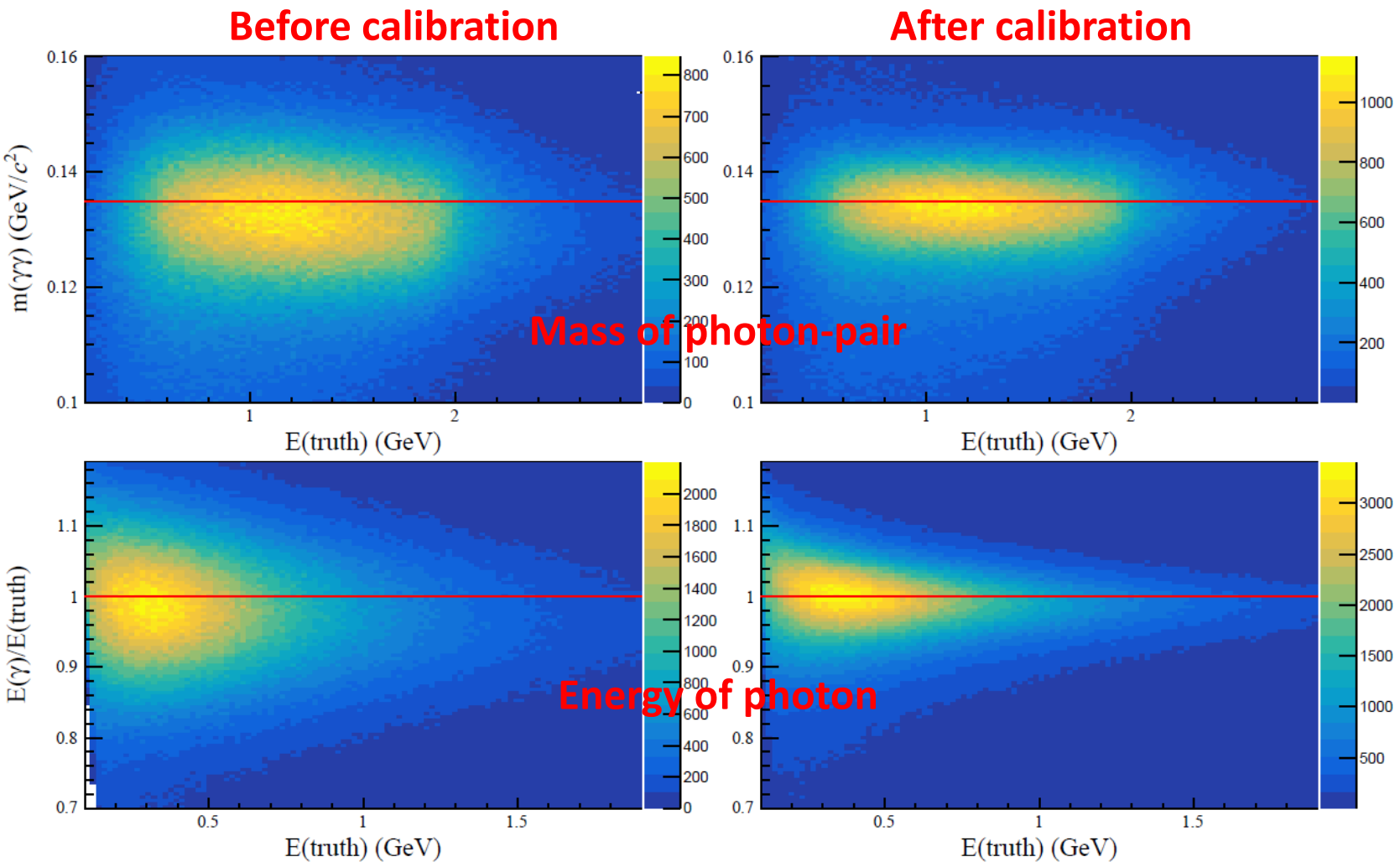
m = 0.13222, σ = 0.010 (raw) E = 0.98113, σ = 0.085 (raw)

m = 0.13409, σ = 0.007 (cor) E = 0.99611, σ = 0.043 (cor)

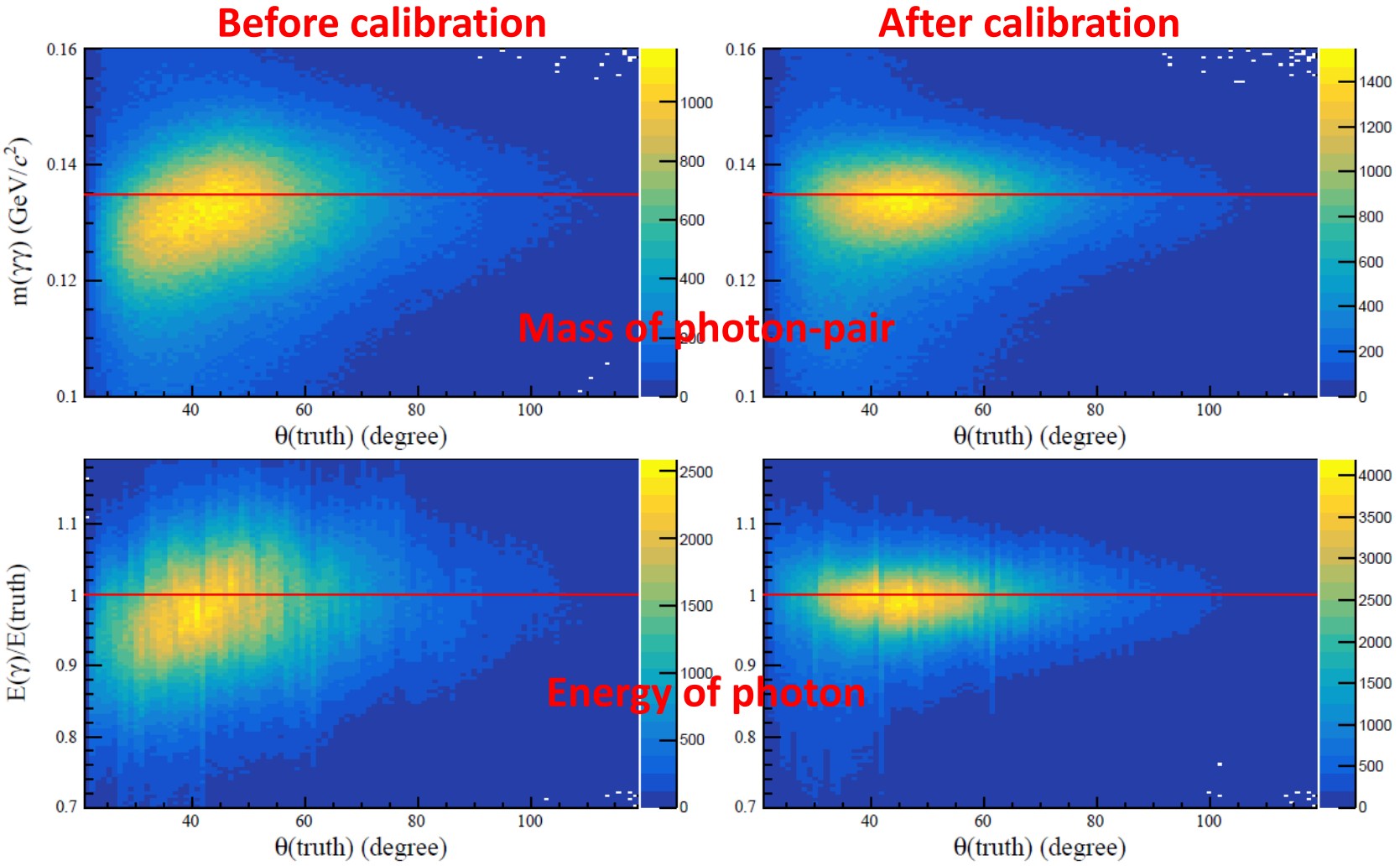




Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)

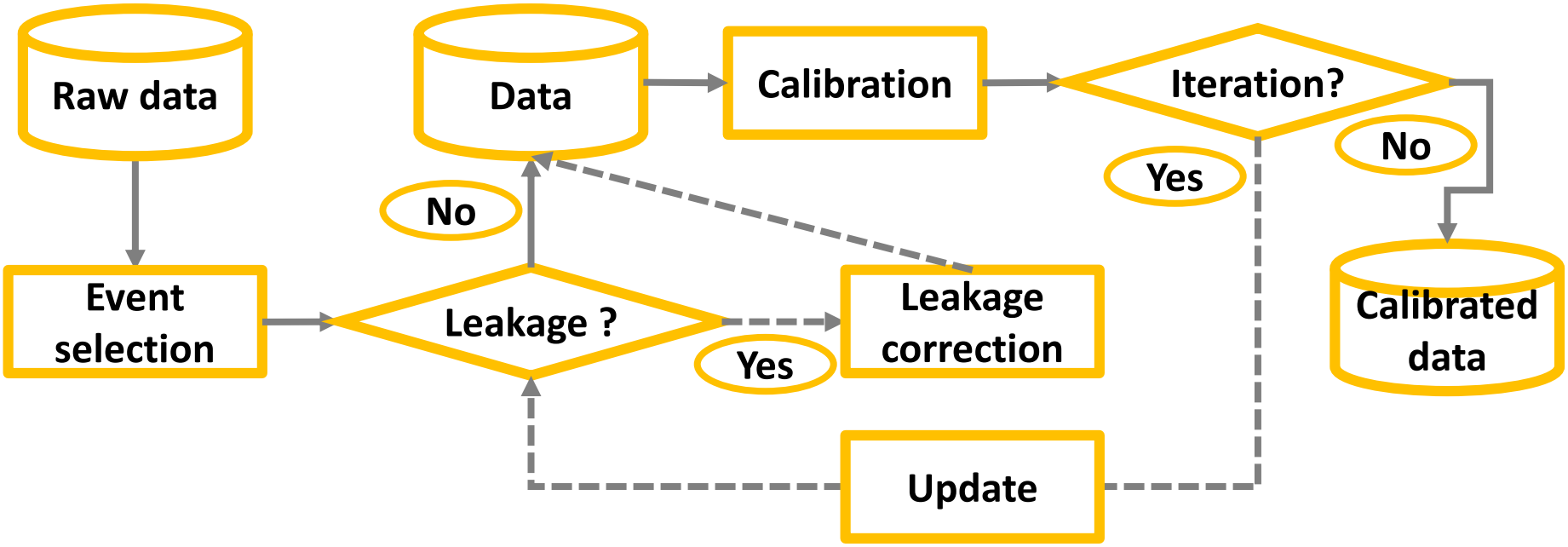


Energy Calibration ($p\bar{p} \rightarrow \pi^0\pi^0\pi^0$)



Summary

- A dedicated calibration algorithm is developed for the PANDA EMC
- The correction of energy leakage is included in the calibration
- The calibration method is tested with γ/π^0 from single particle events and π^0 from physics events. Better accuracy and precision can be achieved (merge?).



Thank you for your attention!