中国科学技术大学
University of Science and Technology of China

Energy calibration for EMC

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On behalf of IHEP/USTC group

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Outline

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- EMC
- Calibration algorithm
  - Sample preparation
  - Input and output
  - Fitting
  - Iteration
- Calibration Result
- Calibration with single cluster
- Summary

EMC

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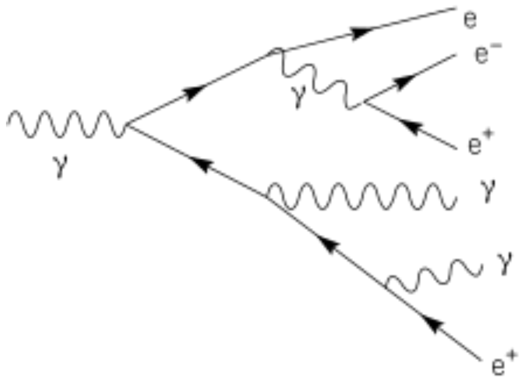
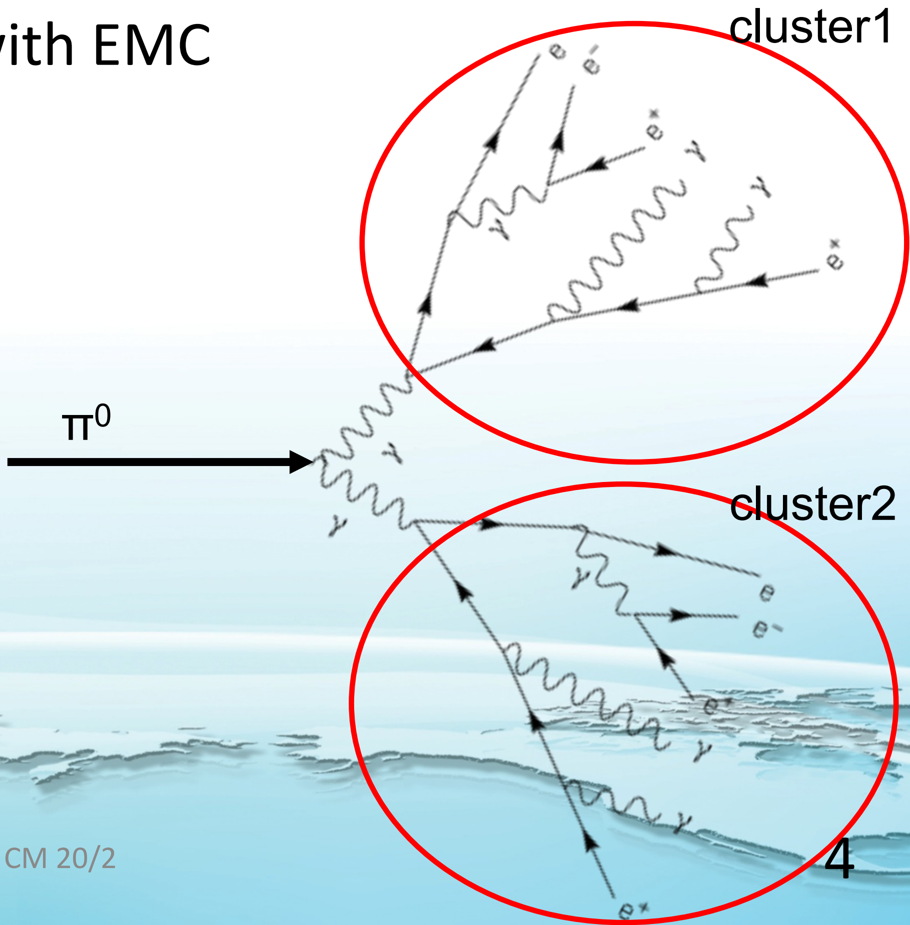
- Functionality
  - Energy measurement of γ, e and part of hadrons
  - Separation of γ/e and hadrons
  - Position measurement
  - Shower shape measurement



- Calibration
  - Detection unit uniformity
  - Leakage
  - Preshower
  - Light yield non-uniformity
  - Energy response non-linearity
  - Electronics

Calibration

- Calibration sample
  - Abundance
  - Accurate quantity as standard value
  - Well understand interaction with EMC
- π^0 / η → γγ
  - Abundantly produced
  - Known mass and small width
  - Energy coverage



Calibration algorithm

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- Based on π^0 mass

From Bernhard Roth & Marc Pelizaeus, Ruhr University

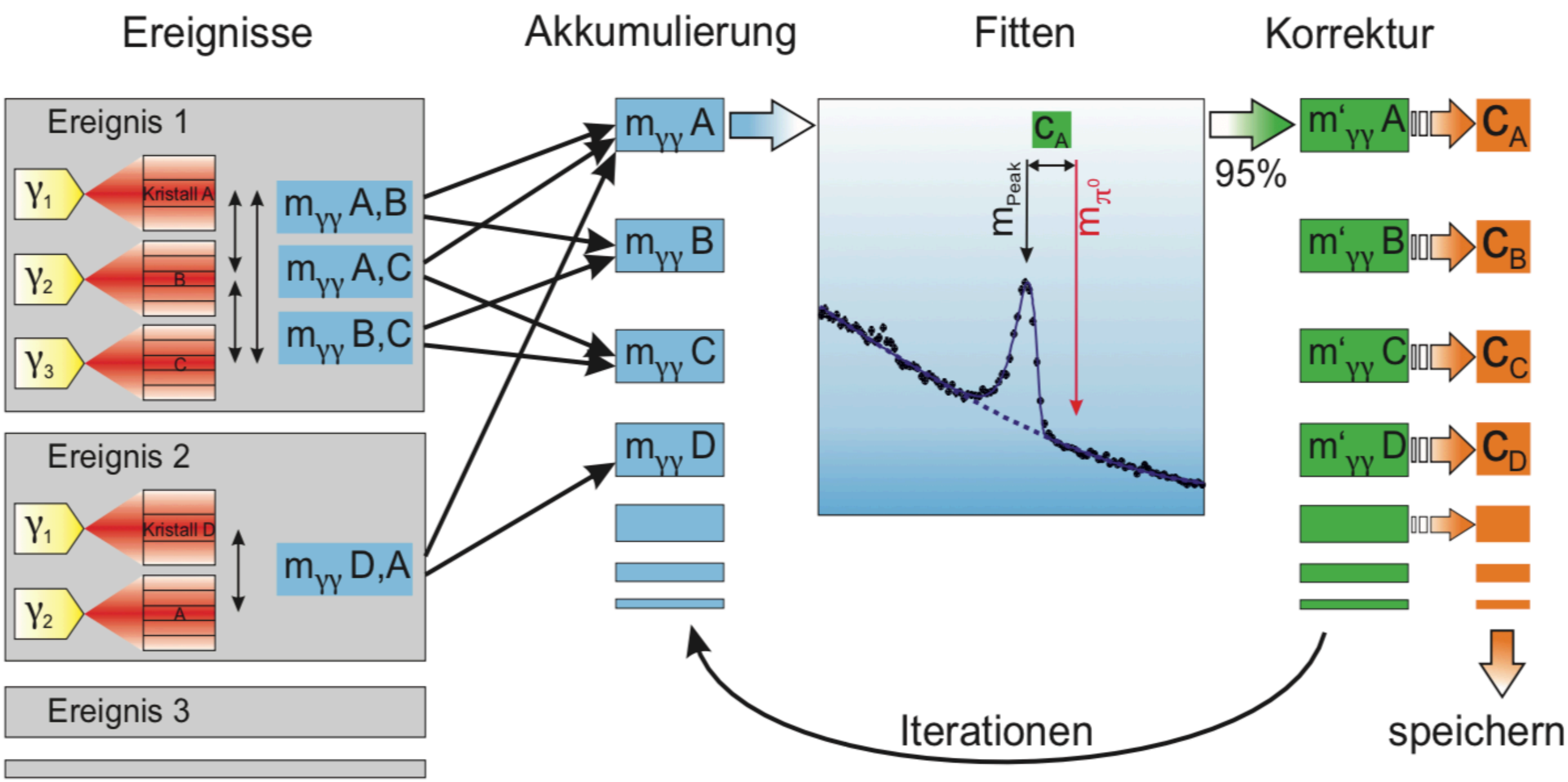

Abbildung 6.1: Schematische Darstellung des iterativen Verfahrens zur Kalibrierung des elektromagnetischen Kalorimeters.

Calibration algorithm

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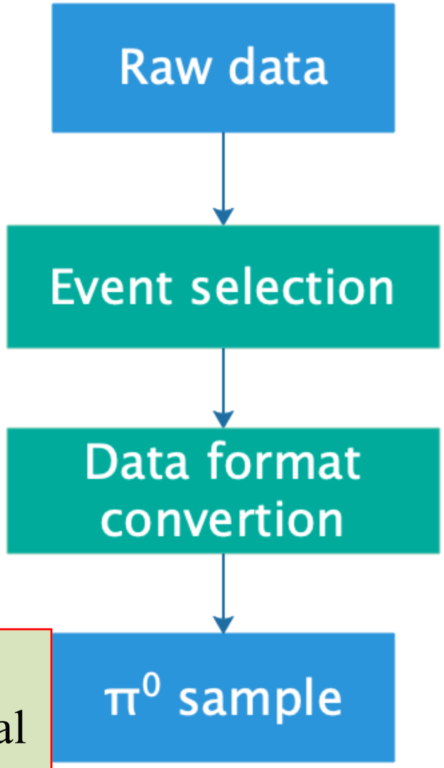
- Implementation
  - Sample preparation
    - Raw data from beam test, physical run or MC simulation
    - π^0 candidates are saved in root file in a specific format (simplified data)

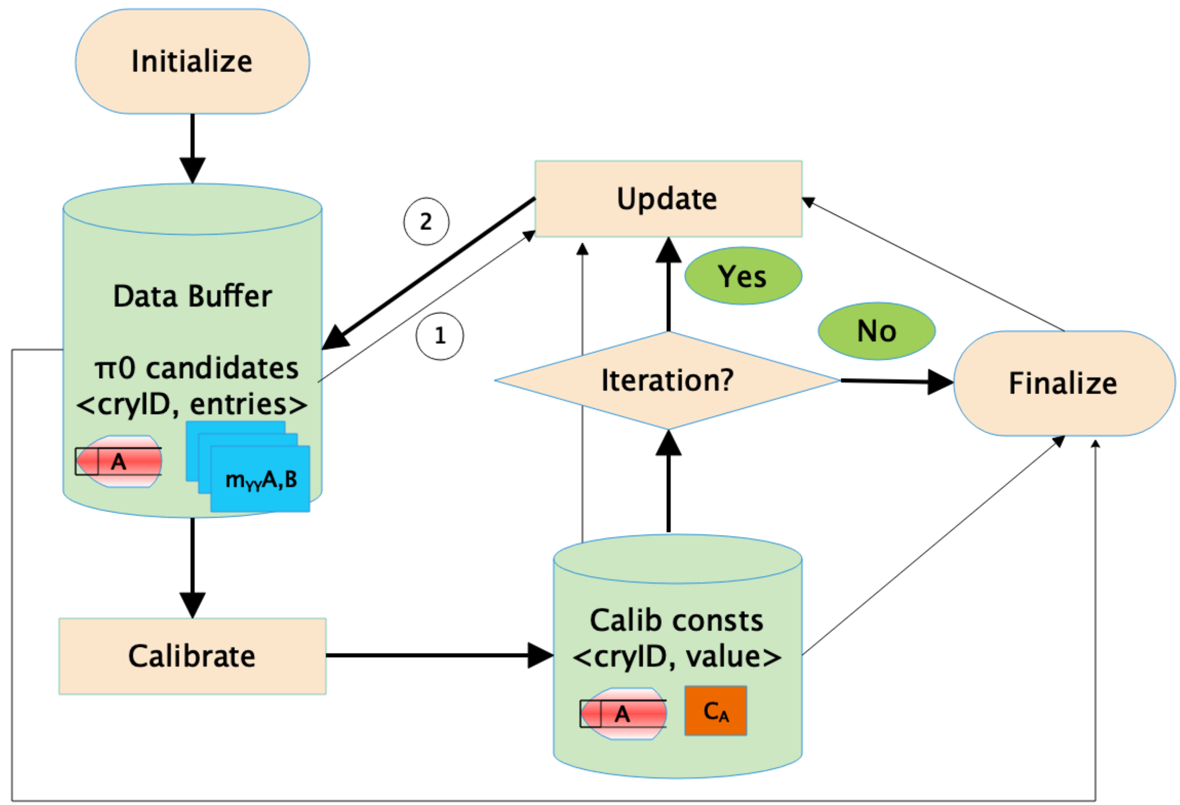

```
class entry{ // pi0 candidate
  float m_gg;  // invariant mass of two γ
  int cpnr2;
  float fraction;
  float fraction2;
  float angle; // opening angle

  std::vector<hit> this_bump; // gamma
  std::vector<hit> associated_bump;
}
```

```
class hit{ // single crystal
  int cpnr; // index of a crystal
  float E_dep;
  float X;
  float Y;
  float Z;
}
```



Calibration algorithm

- Implementation
  - Calibration
    - Initialize
    - Calibrate
    - Update
    - Iteration
    - Finalize



Calibration algorithm

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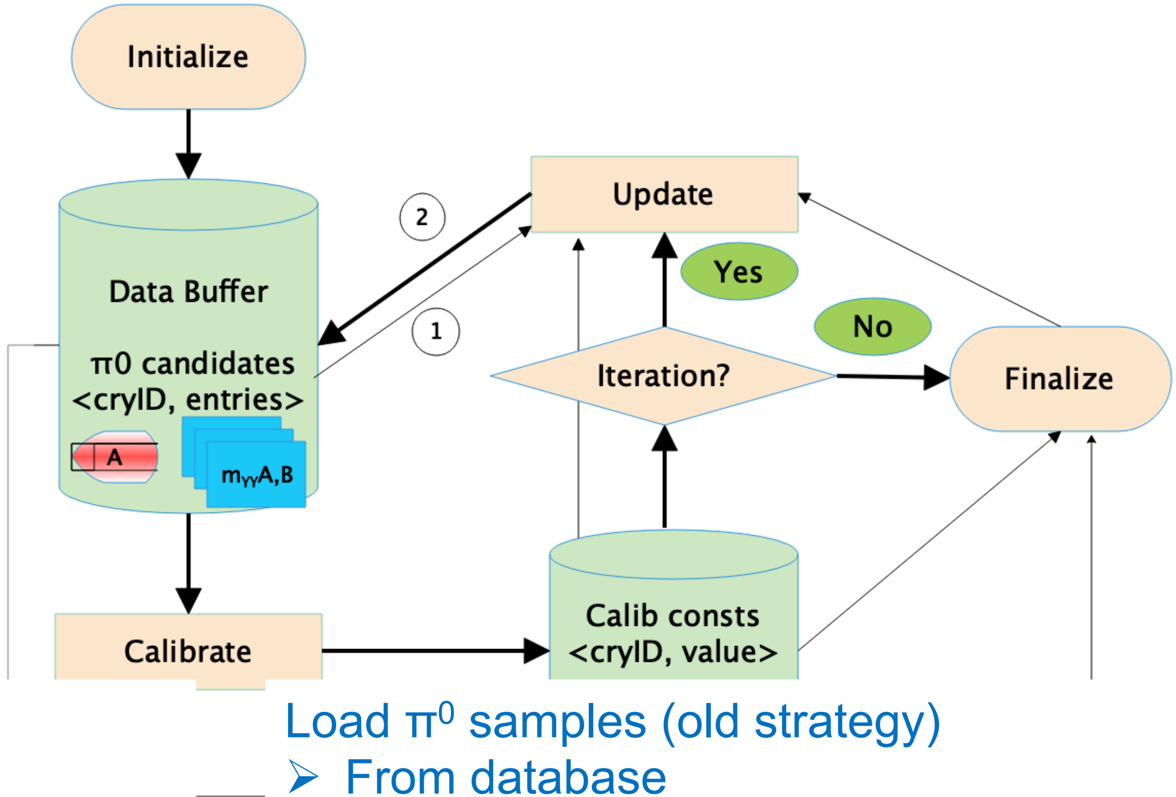
- Implementation
  - Calibration
    - Initialize
      - Set parameters
      - Load/Initialize calibration map
      - Load crystal map
      - Load π^0 samples



Load π^0 samples
- From root file
  - Readable format with ROOT
  - Ability to deal with large amounts of data
- Cache sample in memory
  - High performance for later usage
  - 5M π^0 need ~1G memory

Load π^0 samples (old strategy)
- From database
  - Multi-threaded design, locally or network connected threads
- Cache in database

Calibration algorithm

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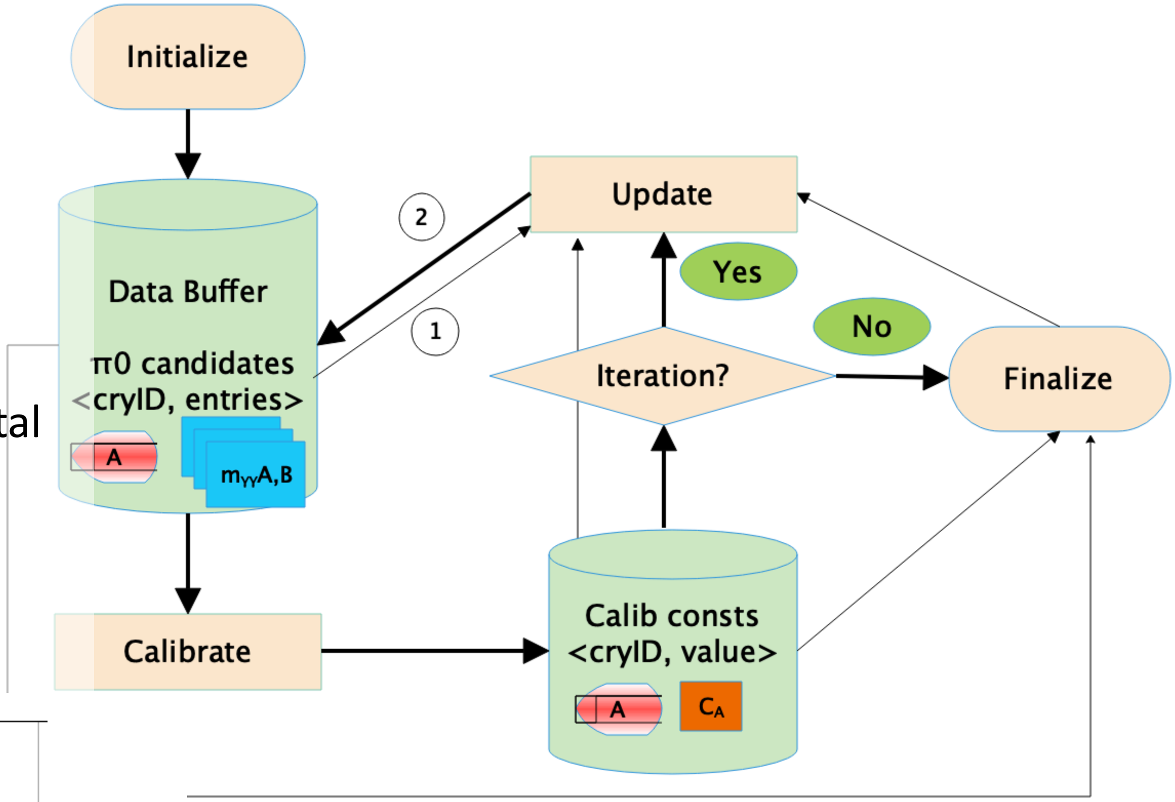
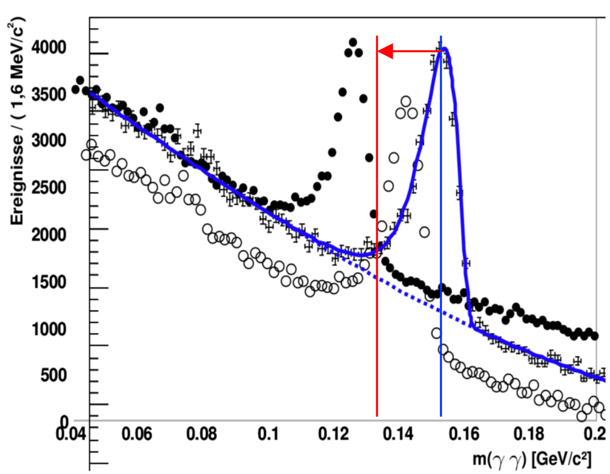
- Implementation
  - Calibration
    - Initialize
    - Calibrate
      - Load sample from cache for each crystal
      - Fit to $m_i(\gamma\gamma)$
      - Determine C_i
      - Save in calib_map





$$c_i = \frac{m^2_{\pi,PDG}}{\langle m^2_{\pi,i} \rangle},$$

Calibration algorithm

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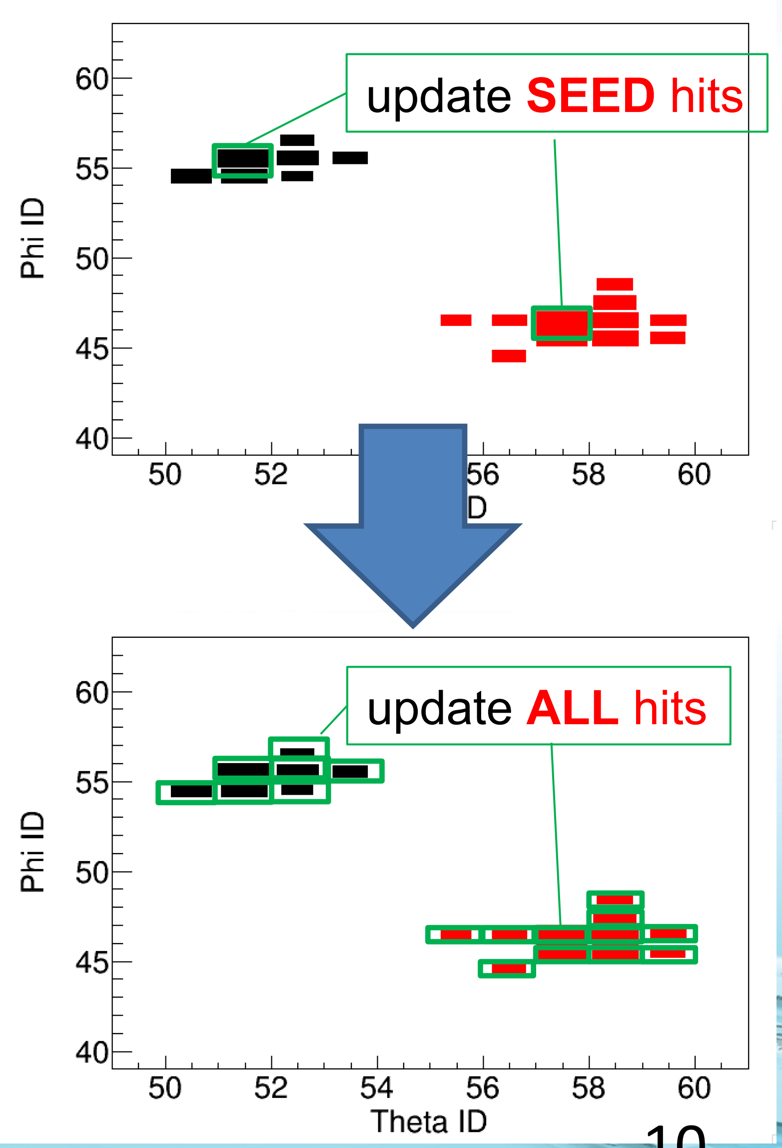
- Implementation
  - Calibration
    - Initialize
    - Calibrate
    - Update
      - Load sample from cache for each crystal
      - Update hit energy
      - Update E_γ, $m(\gamma\gamma)$ for each candidate

$$E_{Cluster} = \sum_{i=1}^{n} c_i A_i$$



Calibration algorithm

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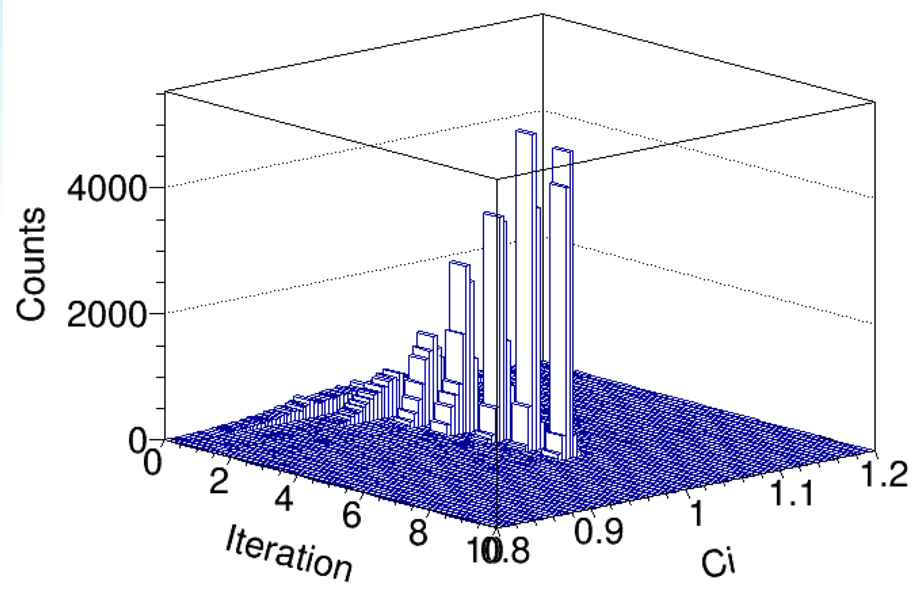
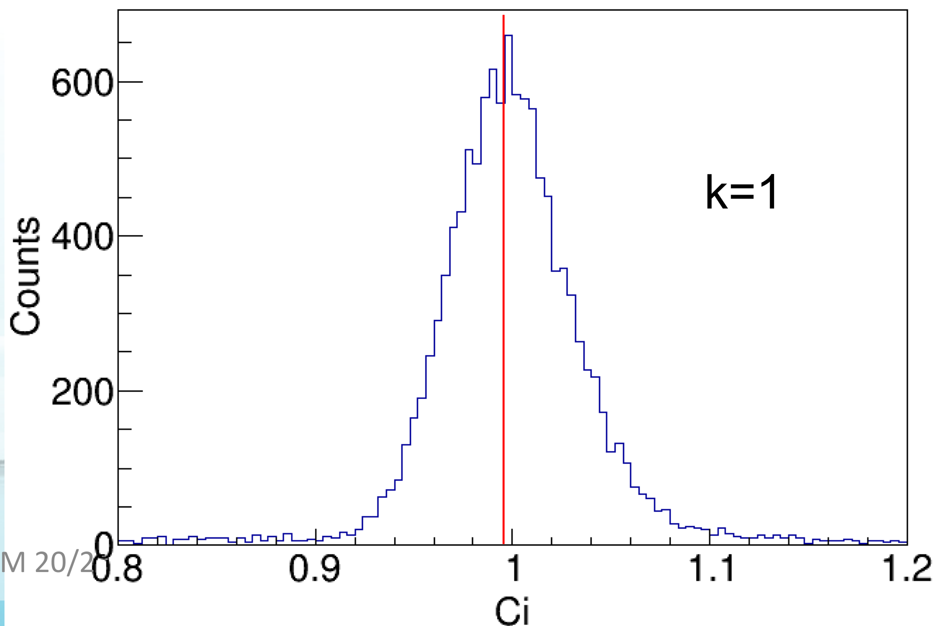
- Implementation
  - Calibration
    - Initialize
    - Calibrate
    - Update
    - Iteration
      - After iterations, $\lim_{k \to \infty} C_{i,k} = 1$
      - Iteration k < maxIteration
      - C_i close enough to 1
      - C_i closer to 1 than last iteration
      - Width of C_i narrower than last iteration





Calibration algorithm

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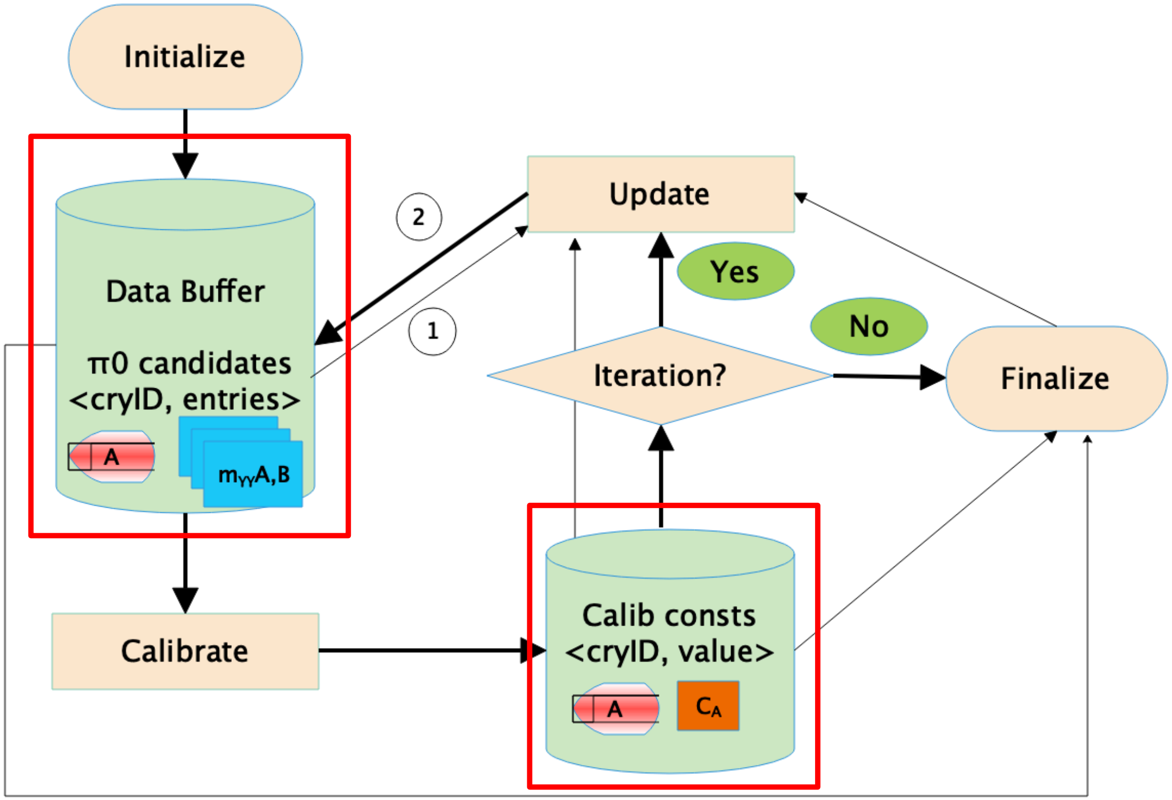
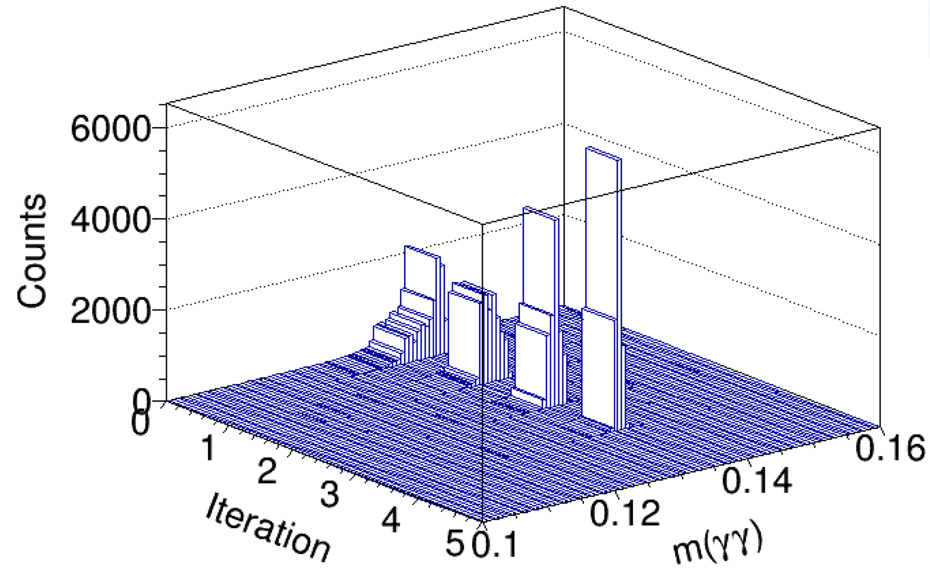
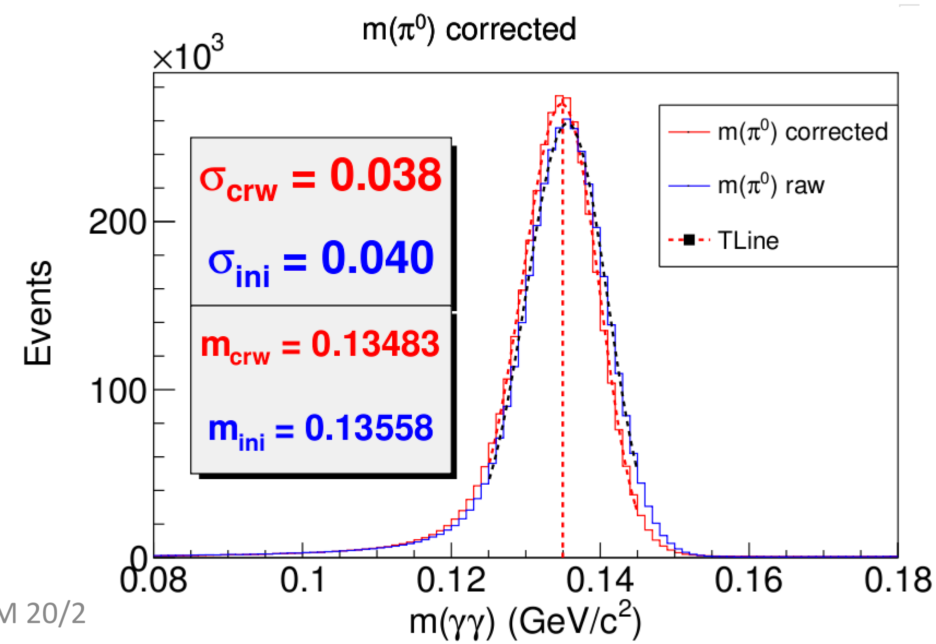
- Implementation
  - Calibration
    - Initialize
    - Calibrate
    - Update
    - Iteration
    - Finalize
      - Save calibration constants
      - Save calibrated candidates



Test

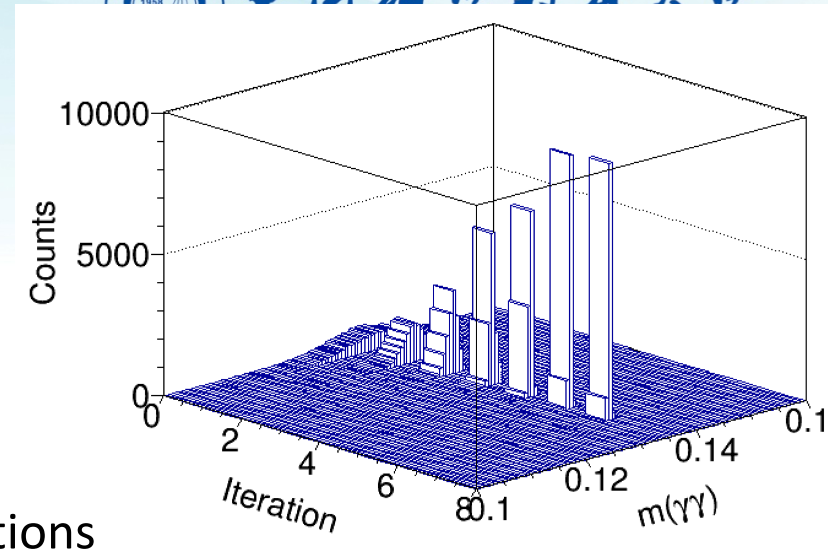
- MC sample as input
  - 1 GeV π^0, 5 M, ~400/crystal
  - Cover the barrel region
  - Uniform distribution
- Result check
  - Function
    - Novosibirsk function for π^0
    - 3rd Chebyshev for bkg
  - Performance
    - Memory usage, ~ 1G
    - Time usage, ~30min/iteration

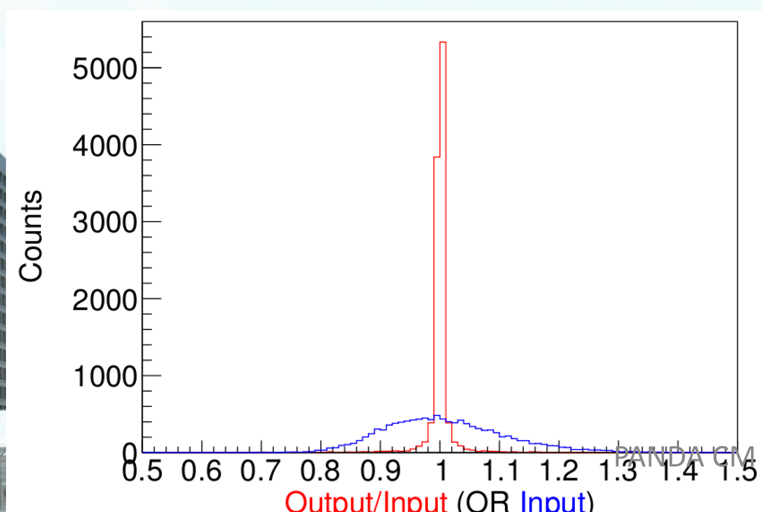


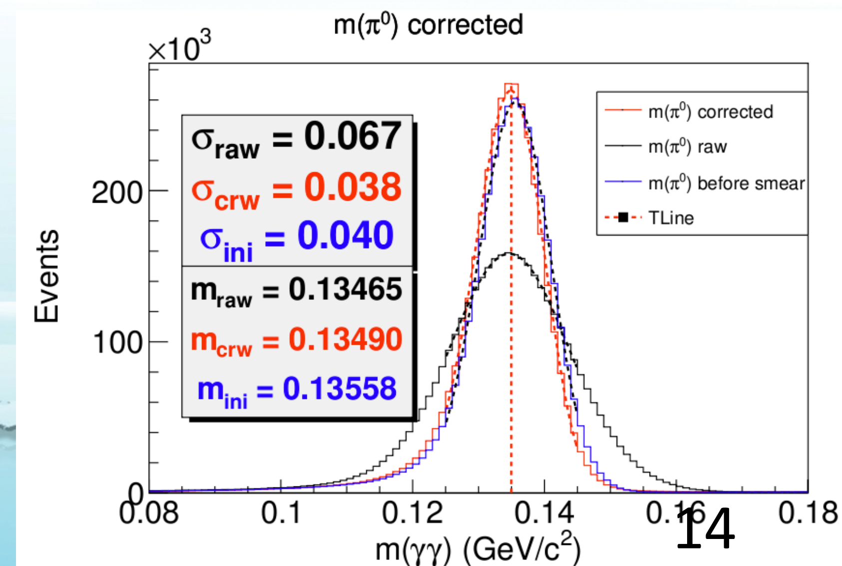


Validation

- Input/output check
  - Gain fluctuations are assigned to crystals, $C_i=1 \rightarrow C_i = \text{Gaus}(1, 0.1)$
  - Hit energies are scaled with C_i
  - Use scaled sample to do calibration
  - Output consistent with input gain fluctuations
  - The calibration algorithm can recover gain fluctuations







Single cluster calibration

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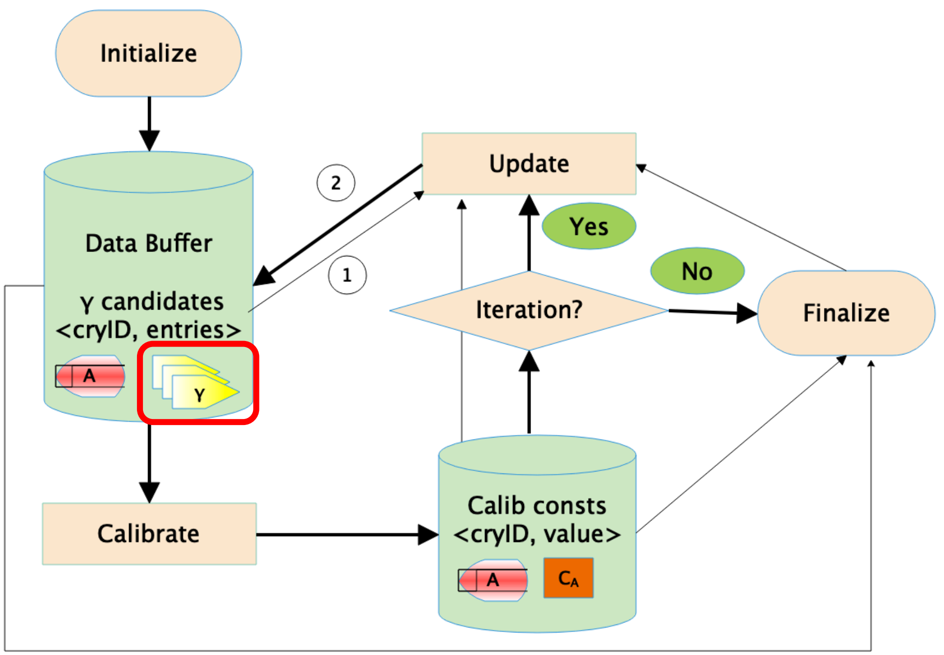
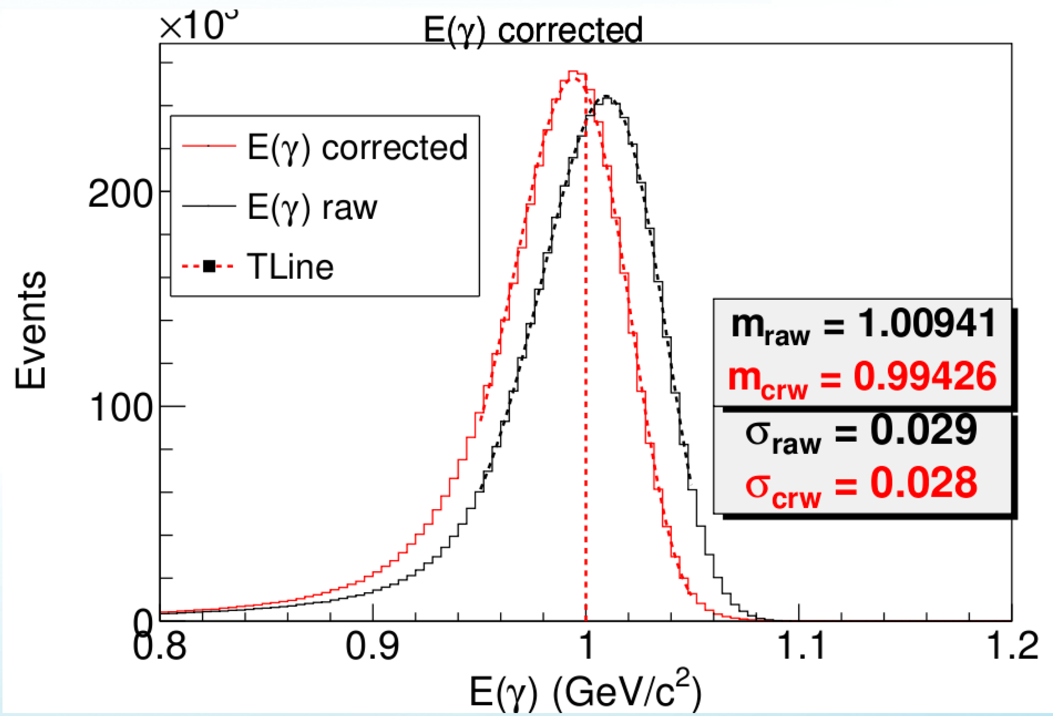


- Single cluster mode
  - γ or e with specific energy
  - One cluster per candidate
- Implementation
  - Same data format,
    but only use one bump
  - Add a flag to mark sample type
  - Set the calibration goal from pi0 mass to the specific energy
  - Recalculate the energy of the cluster with constants

Test

- Gamma sample
  - 5M, 1GeV γ
  - Barrel region
- Result
  - Closer to 1 GeV
  - Slightly narrower
  - Works fine



Summary

- Run and test the calibration algorithm
  - Calibration samples preparation
  - ROOT file as input, cached in memory
  - Calibrate
  - Update all hits
  - Validation
- Extend to single cluster case
  - Same data format
  - Change calibration goal
- Work to do
  - Optimize the algorithm
  - Test with MC closer to physics events
  - Multi-threads implementation and test
  - Database
  - PandaRoot