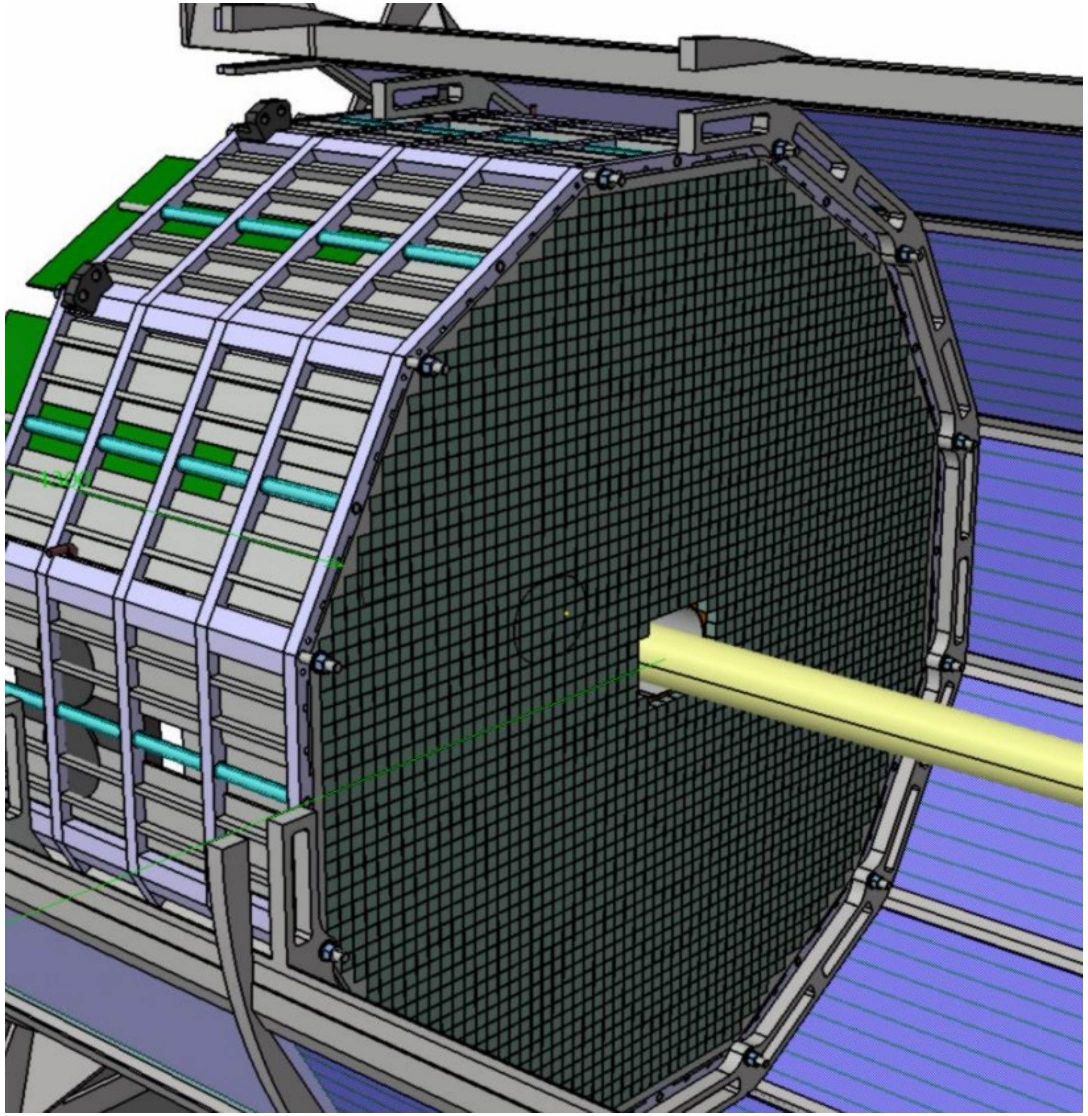

Backward ECAL (EEEMCAL) Calibrations

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Backward Ecal Overview

Goals:

- Electron/pion separation
- Improve electron resolution at large $|\eta|$
- Measure photons with good resolution
- Separate 2-γ from π^0 at high energy

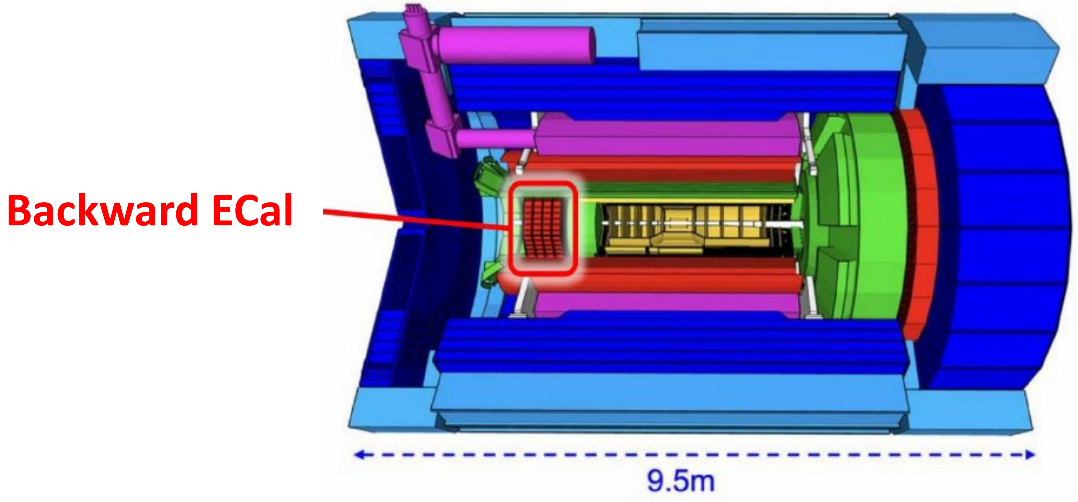
Technology choice:

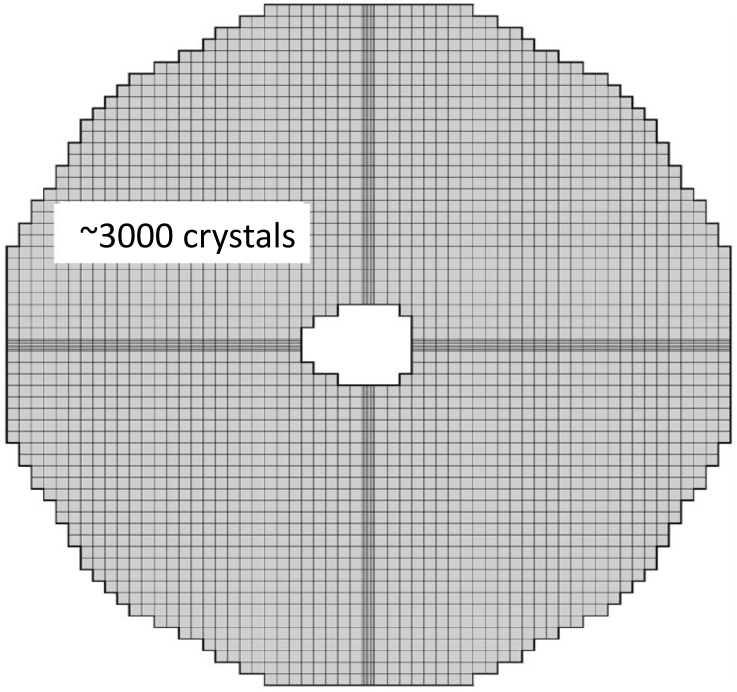
- PWO crystals (2x2 cm^2) – passed FDR in 2023
- High-density SiPM readout – passed FDR in 2023

Requirements:

- Energy resolution: $2\%/\sqrt{E} + (1\text{-}3)\%$
- Pion suppression: $1{:}10^4$ (together with other PID detectors)
- Minimum detection energy: > 50 MeV

High resolution in the backward endcap can only be achieved with homogeneous materials like crystals





$PbWO_4$ specifications are similar to those achieved for JLab Projects (NPS, FCAL)

Backward Ecal Calibration Methods

Different methods available

- Light Monitoring system – can be used to calibrate the SiPM gain for the calorimeter, strongly depends on the design of the LM system and material used for light transport, e.g., plexiglass (GlueX FCAL)
- Cosmic muons – considers the variations between crystals, wrapping, optical coupling, etc., requires a straight track (for which one should observe a peak ~15 MeV in PWO) using the coincidence with other detectors
- Physics processes – clear signal, does not require external information (from trackers) and can be run online/offline

We will use physics processes for the best determination of calibration coefficients and their evolution with time

Single electrons

- Relies on tracker (calibration, accuracy…)
- May not be possible for all crystals

Neutral pion decays: $\pi^0 \rightarrow \gamma\gamma$

- Very clear signal – no need for other detectors
- Invariant mass of π^0 used for calibration, but non-linear procedure (two clusters per event)

MIP:

- Wide signal distribution
- Relies on simulation (or independent measurements) for absolute calibration

Calibration with Neutral Pions - Principle

Methods successfully used with EMCals at JLab

- Based on NIM A **566** (2006) 366
- Most recently used for PWO NPS calibration at JLab (2024++)

Basic principle:

optimize calibration coefficient to constrain the π^0 invariant mass position and minimize its width

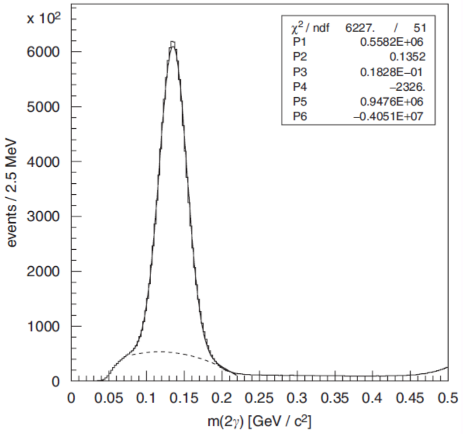
$$F = \sum_{i=1}^{N_{events}} (m_i^2 - m_0^2)^2 + 2\lambda \sum_{i=1}^{N_{events}} (m_i^2 - m_0^2)$$

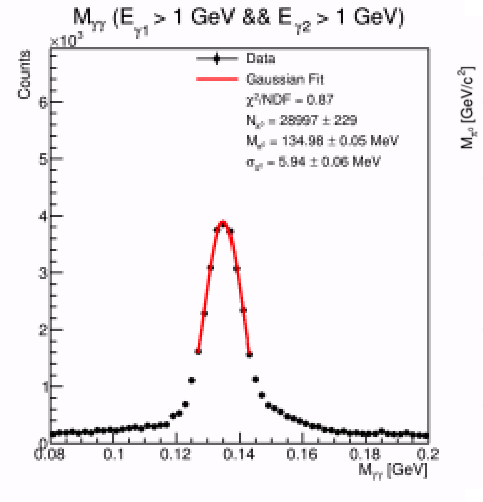
resolution term to optimize

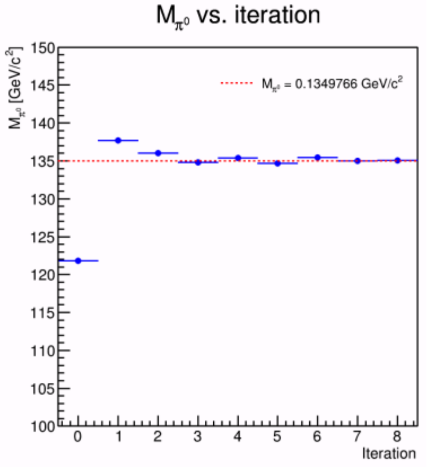
constraint $\langle m_i^2 \rangle = m_0^2$

$m_0 = M_\pi = 0.1349766$ GeV
m_i: reconstructed $M_{\gamma\gamma}$
λ: Lagrange multiplier

Examples from JLab EMCal calibrations

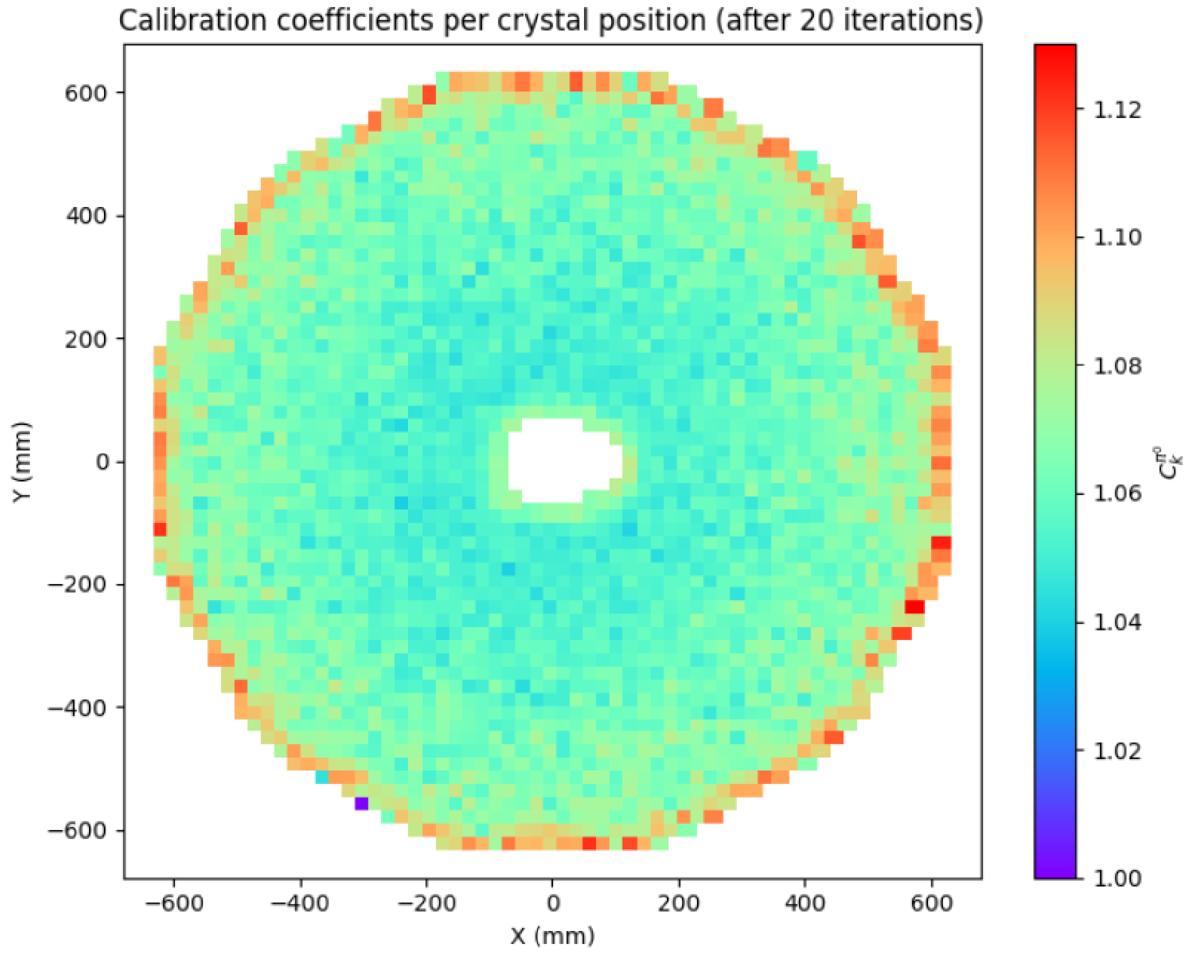


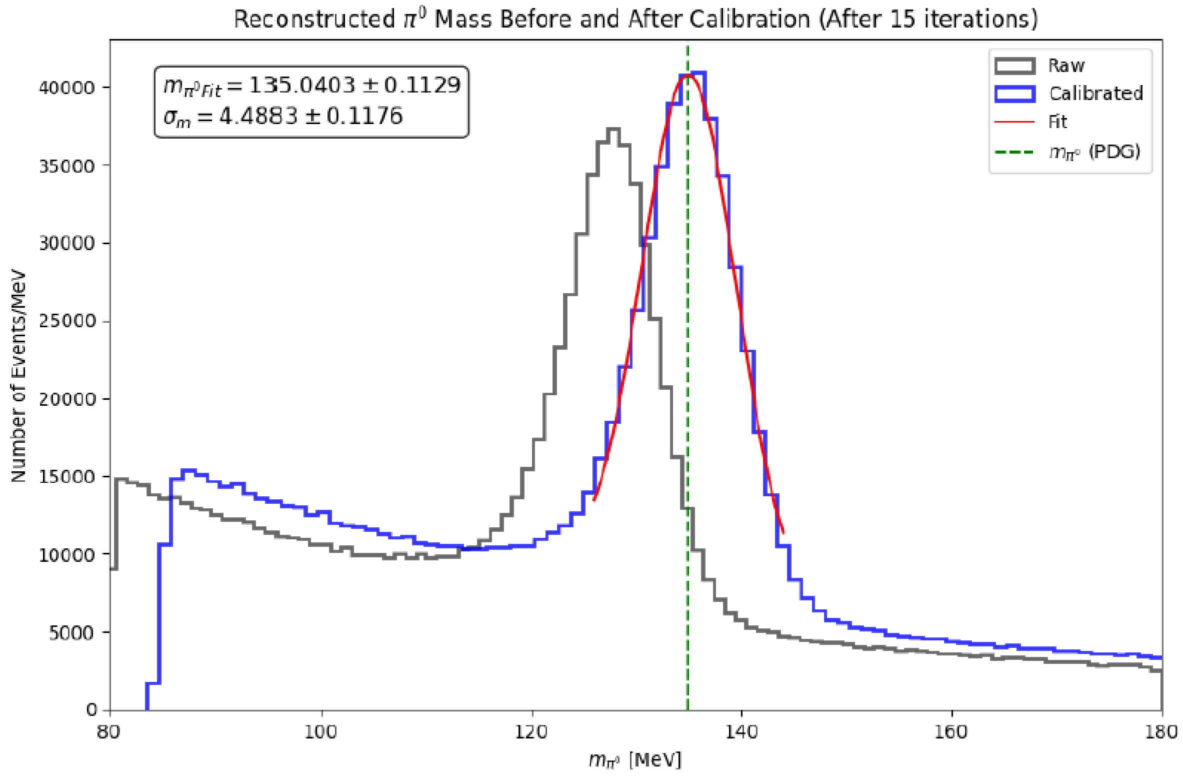




Calibration with Neutral Pions – at EIC

SIDIS simulation at 18 x 275 GeV

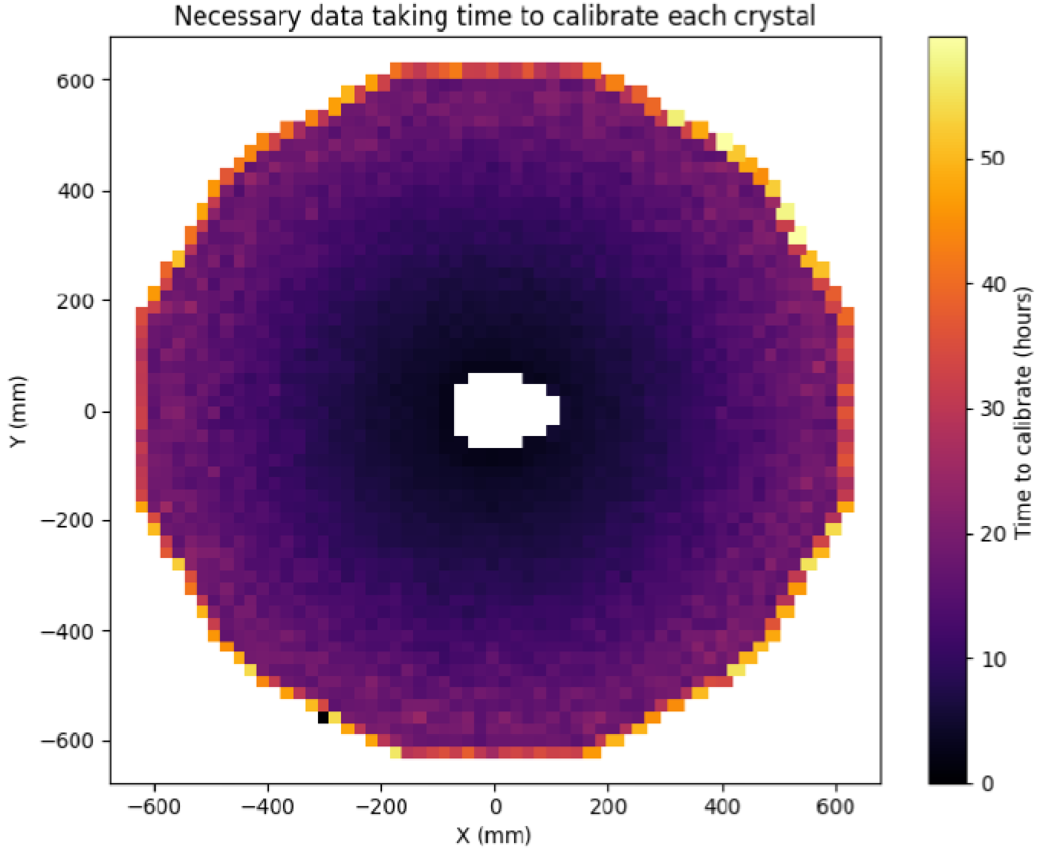




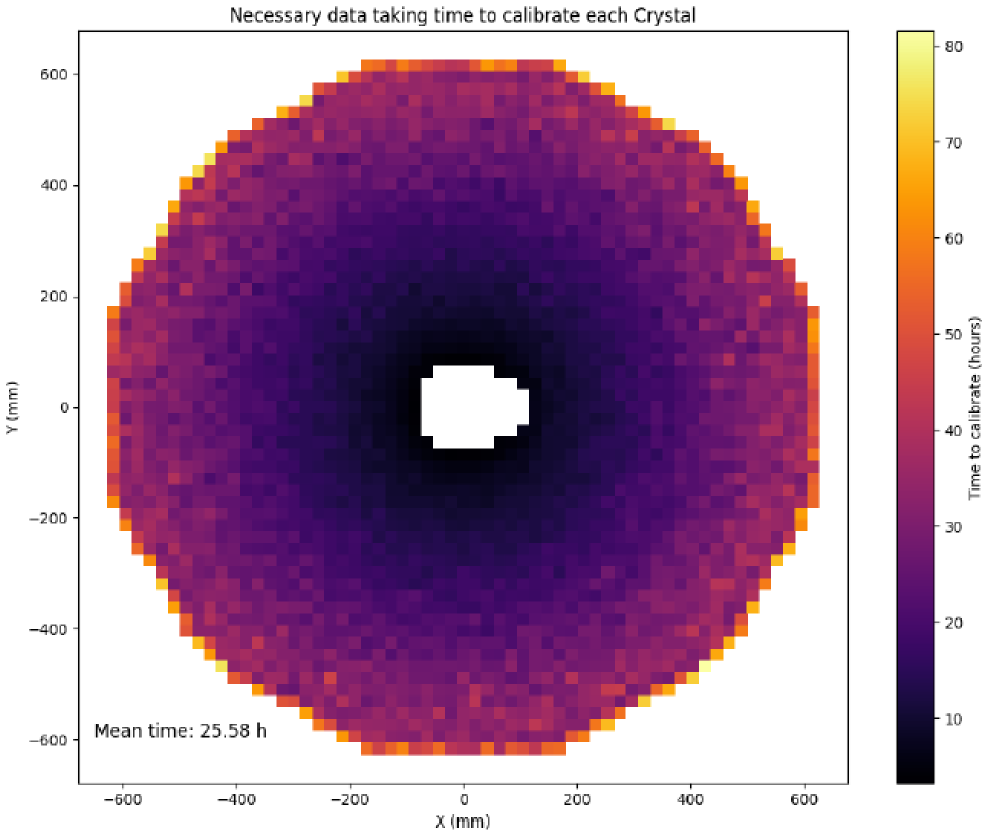
Analysis by Axel Perez Ruiz (IJCLab)

Calibration with Neutral Pions – Time Estimate

SIDIS simulation for number of hours needed for 100 events/crystal



18x275 GeV



5x41 GeV

Analysis by Axel Perez Ruiz (IJCLab)

Based on this: 1-2 days of such data should be sufficient