BCAL gain Calibration using π^0s

Karthik Suresh

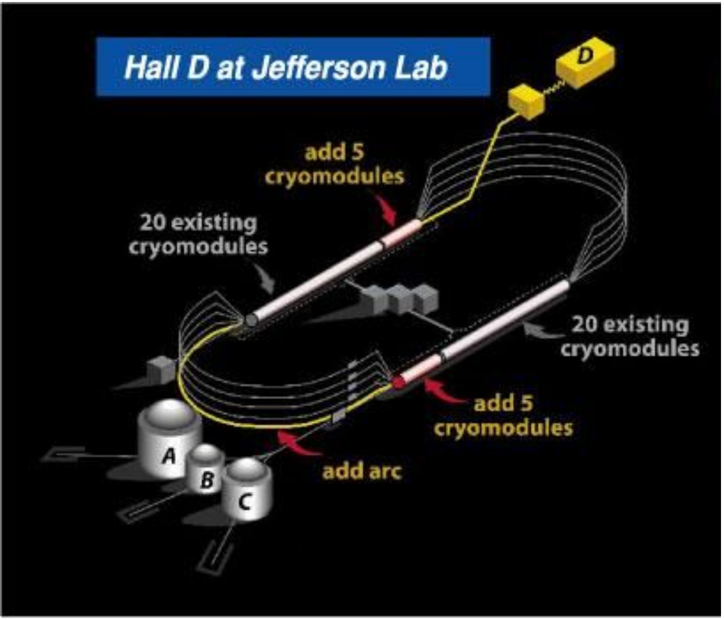
Outline

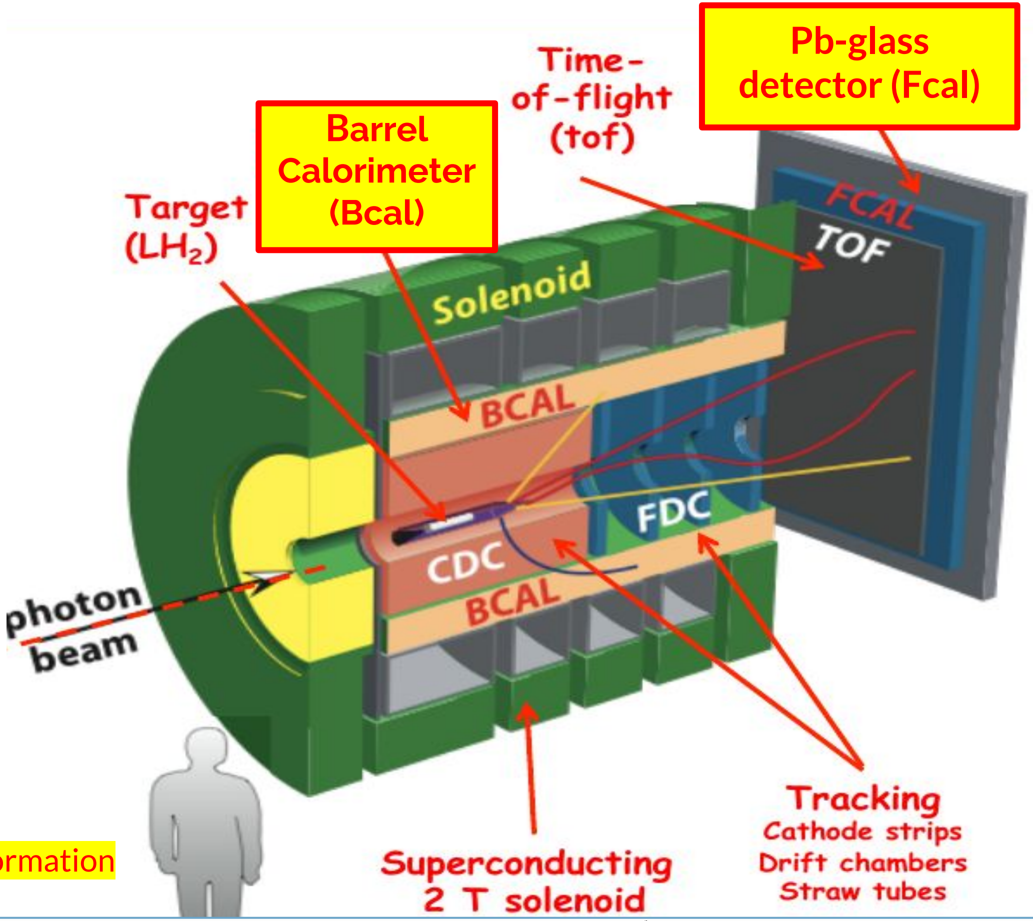
WNPPC-2019

1. Detectors in GlueX
2. BCAL- design and working principle
3. BCAL Gain Calibrations
   a. Energy determination algorithm
   b. Calibration using pi0
   c. To address the presence of nonlinearity after the calibration.

GlueX experiment

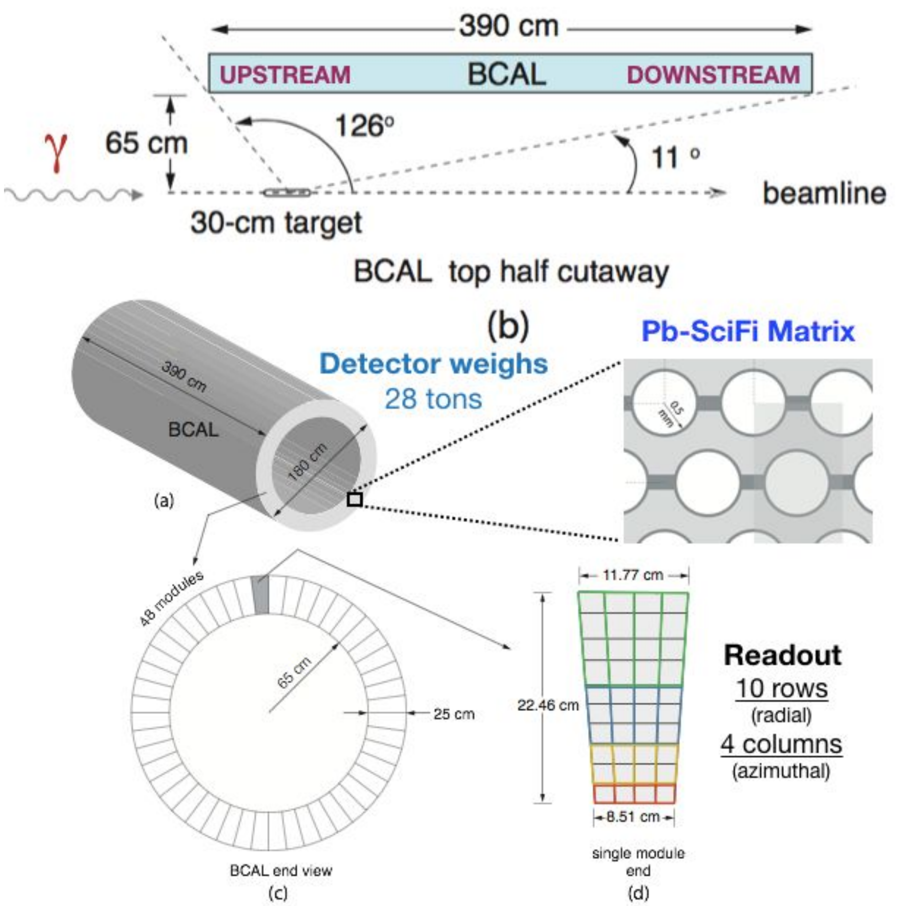
Detector setup





- BCAL detects -> n, γ, p,π^+,π^-
- BCAL along with tracking chambers gives the PID information

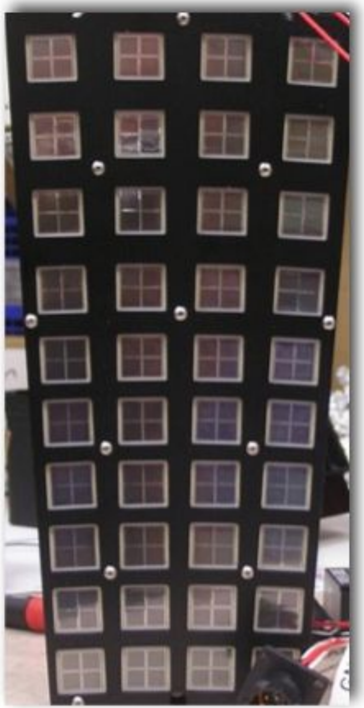
Barrel Calorimeter (BCAL)



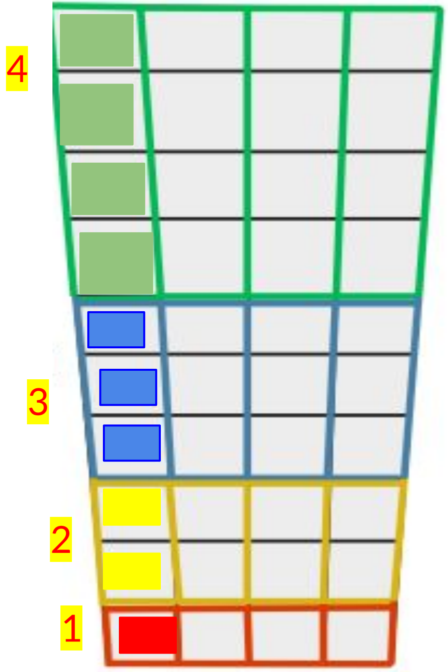
- 4 m long detector with $r_< = 65$ *cm* and $r_> = 90$ *cm*
- Polar acceptance $12^\circ < \theta < 126^\circ$
- Segmented into 48 azimuthal modules with each module containing 40 SiPMs. Provides almost 2π coverage
- 1 module has 185 layers of Pb sheet with 184 layers of double clad scintillating fibres.
- Total 685000 fibres connected to 3840 SiPMs (Resistant up to 2T) with 1536 readouts

BCAL (continued)

BCAL before inserting into the bore magnet



SiPM attached readout module



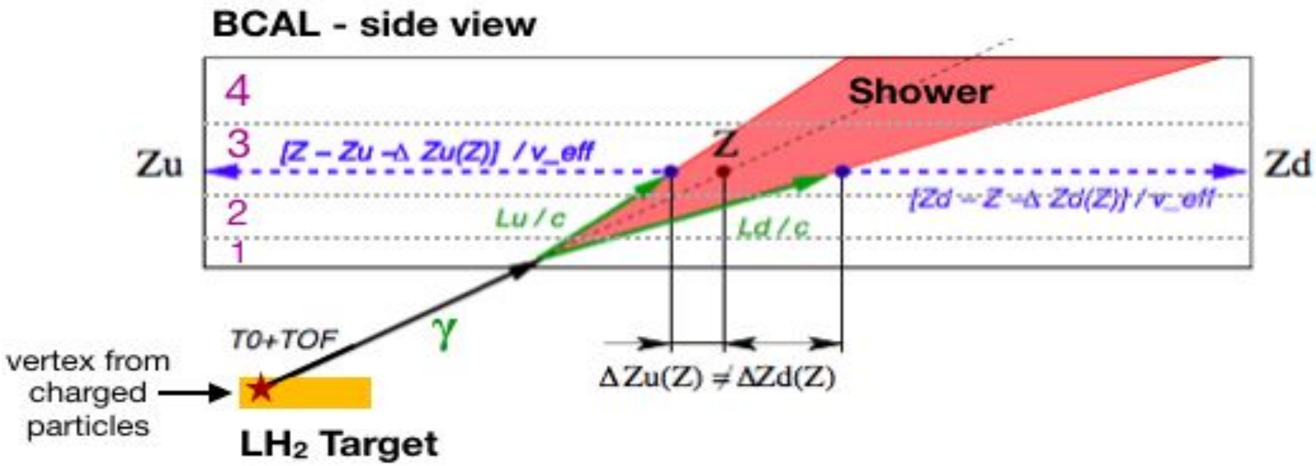
Summing scheme

$$\frac{\sigma(E)}{\sqrt{E}} = \frac{5.2\%}{\sqrt{E}} \oplus 3.6\% \qquad \sigma(z) = 3cm \qquad \sigma(t) \approx 200ps\ @1GeV$$

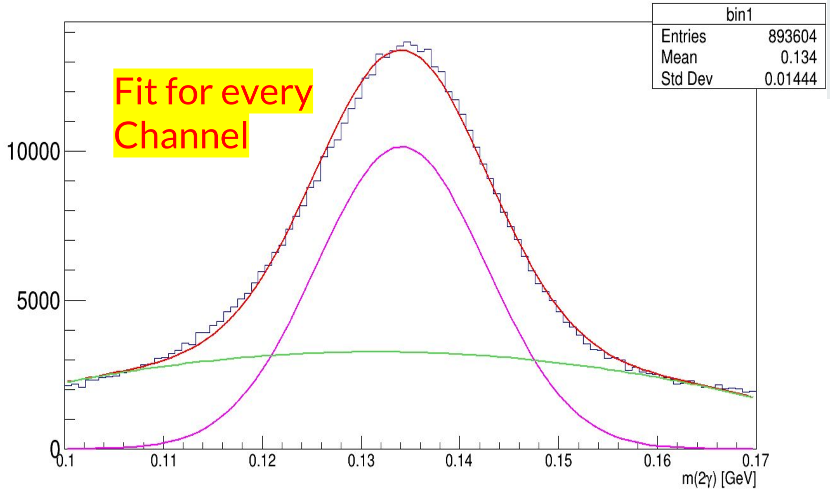
Determination of energy and calibration using π^0 in BCAL

$$\gamma p \rightarrow \eta p \rightarrow 3\pi^0 p \qquad \pi^0 \rightarrow \gamma_1 \gamma_2$$

- Energy of photons are determined by the SiPM's attached at the end of the Sci-Fibres.
- The position of photon shower is reconstructed using the timing information. The vertex of reaction is calculated from charged particle.
- π^0 s offer large statistics in the energy range of interest (0.5-3 GeV)



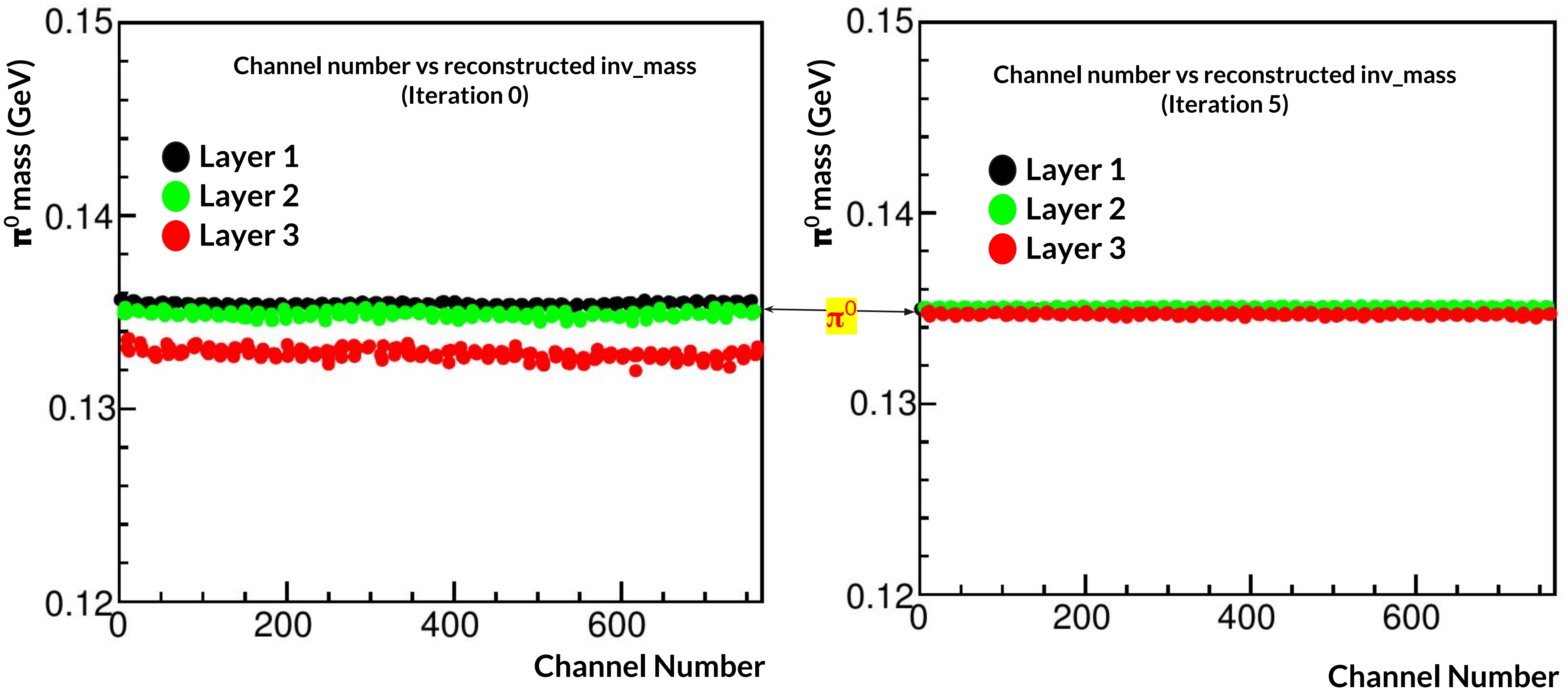
The Calibration Algorithm



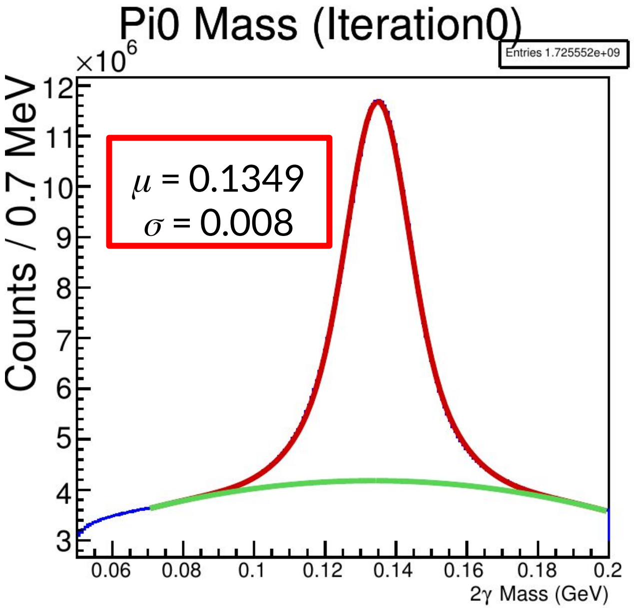
1. Events with **π**° ->2 ***γ*** with at least 2 charged particles.
2. Determine photon energies ($E\gamma_1$,$E\gamma_2$)
3. Find event vertex using the charged particles.
4. Select channels in layer 1 and 2 having more than 50% of the deposited energy ($E\gamma_1$ and $E\gamma_2$)
5. Reconstruct invariant mass of π^0 using the E***γ***'s and the vertex[1], and fit it. $m^2 = 2E_1E_2(1 - \cos(\psi))$
6. Form ratio with PDG invariant mass (0.135 GeV) to the measured mean of invariant mass and use to adjust gains for each channel
7. The entire procedure is iterated till tolerance is less than 1%

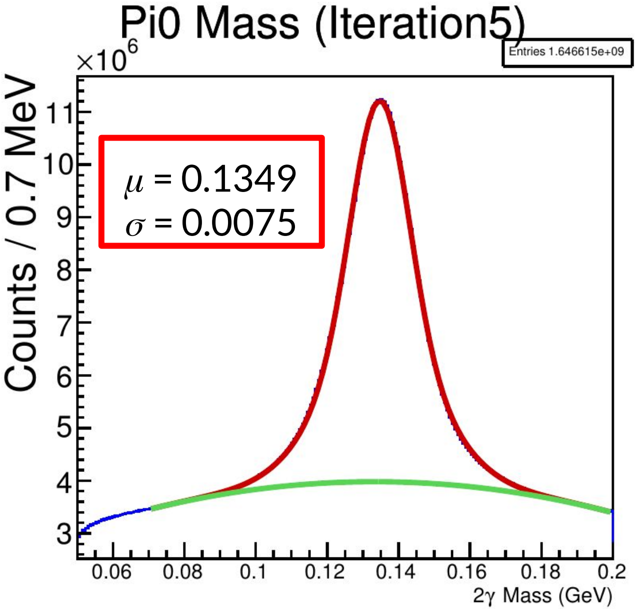
[1] https://doi.org/10.1016/j.nima.2018.04.006

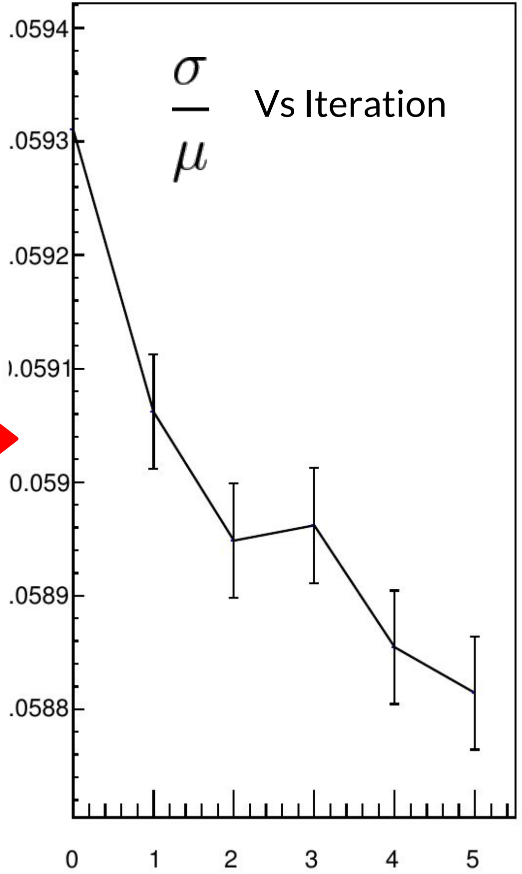
Calibration plots



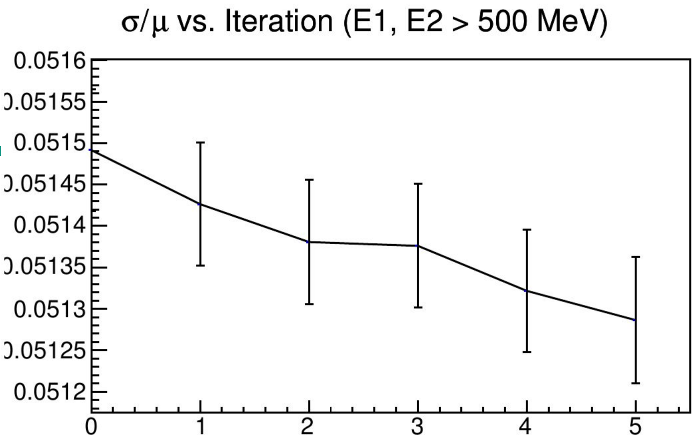
Calibration plots (continued)

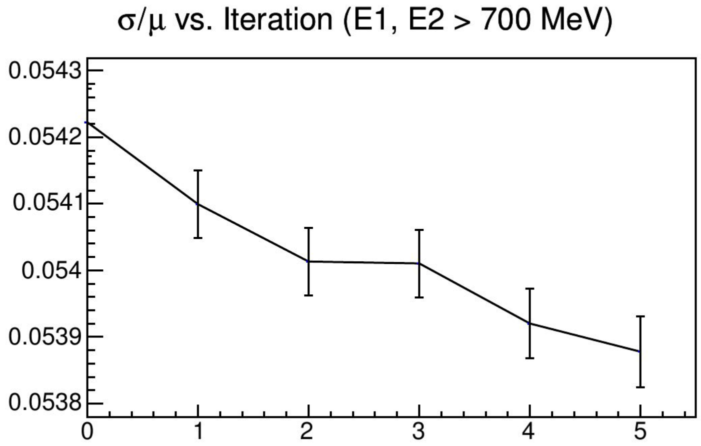


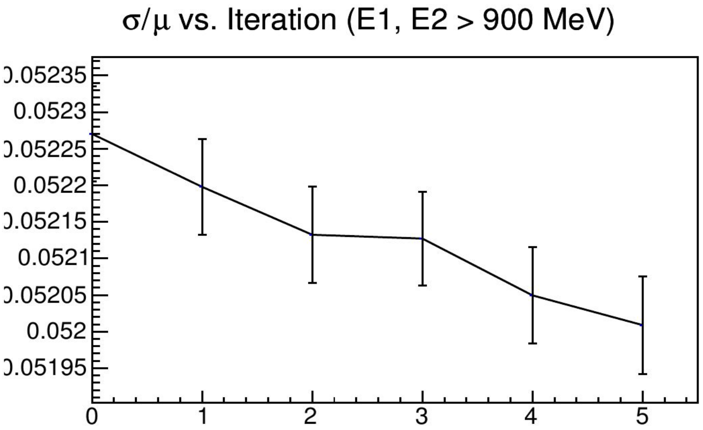


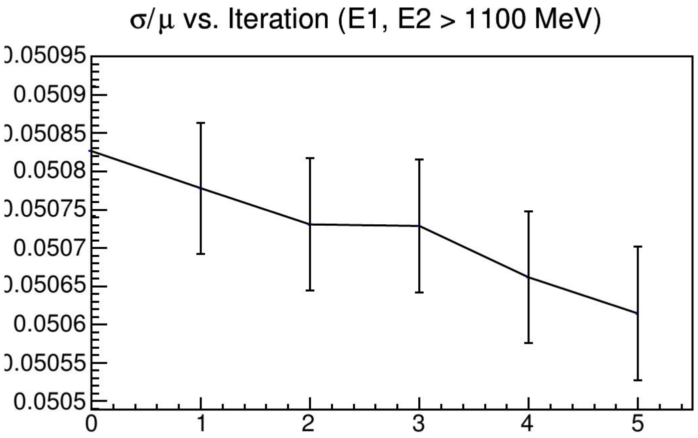


Checks in Different energy ranges



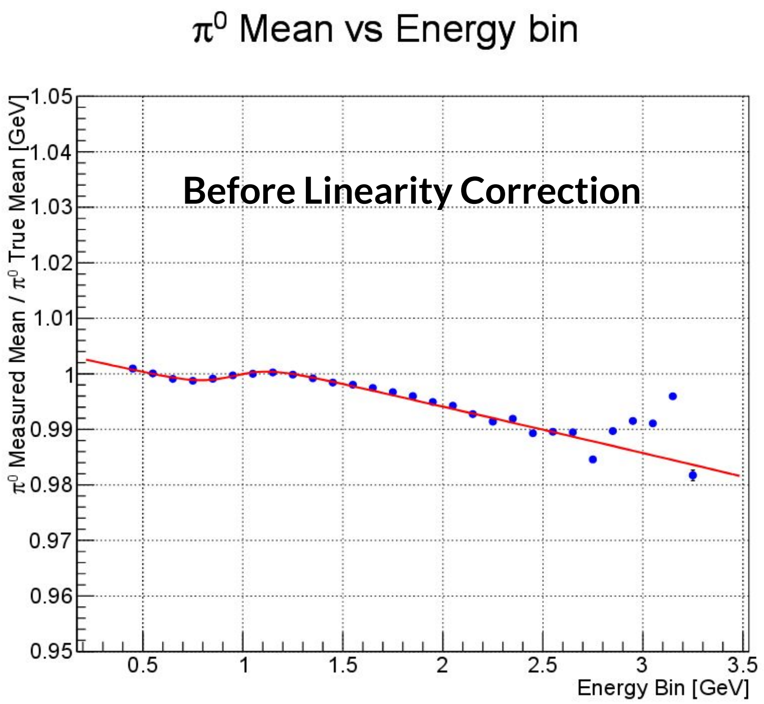


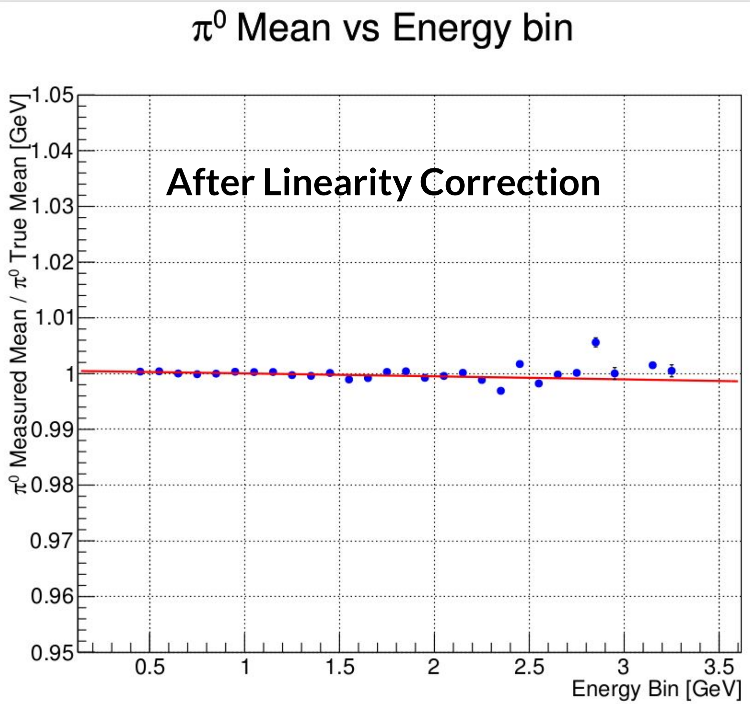




Nonlinearity after the calibration

- SiPM and FADC Saturation: FADC->Constant pulse shape normalisation: SiPM No correction
- An empirical nonlinear function is fit to the plot and is used to correct for nonlinearity





Conclusions

- BCAL is a key detector in the GlueX experiment.
- The BCAL performance is monitored online.
- A new gain calibration for the BCAL is needed for every run period BCAL is necessary. The π0 method shown here works well.
- SiPM saturation at high energies have also been employed.

References

- T. Beattie et al , NIMA 896 (2018) 24-42 https://doi.org/10.1016/j.nima.2018.04.006
- E.Smith "Note on Saturation in BCAL SiPMs" GlueX-doc-3737-v4

Thank you


GlueX Collaboration Meeting
May 15-17, 2017
Jefferson Lab • Newport News, VA