The Electromagnetic Calorimeter of the Babar Detector

Vancouver

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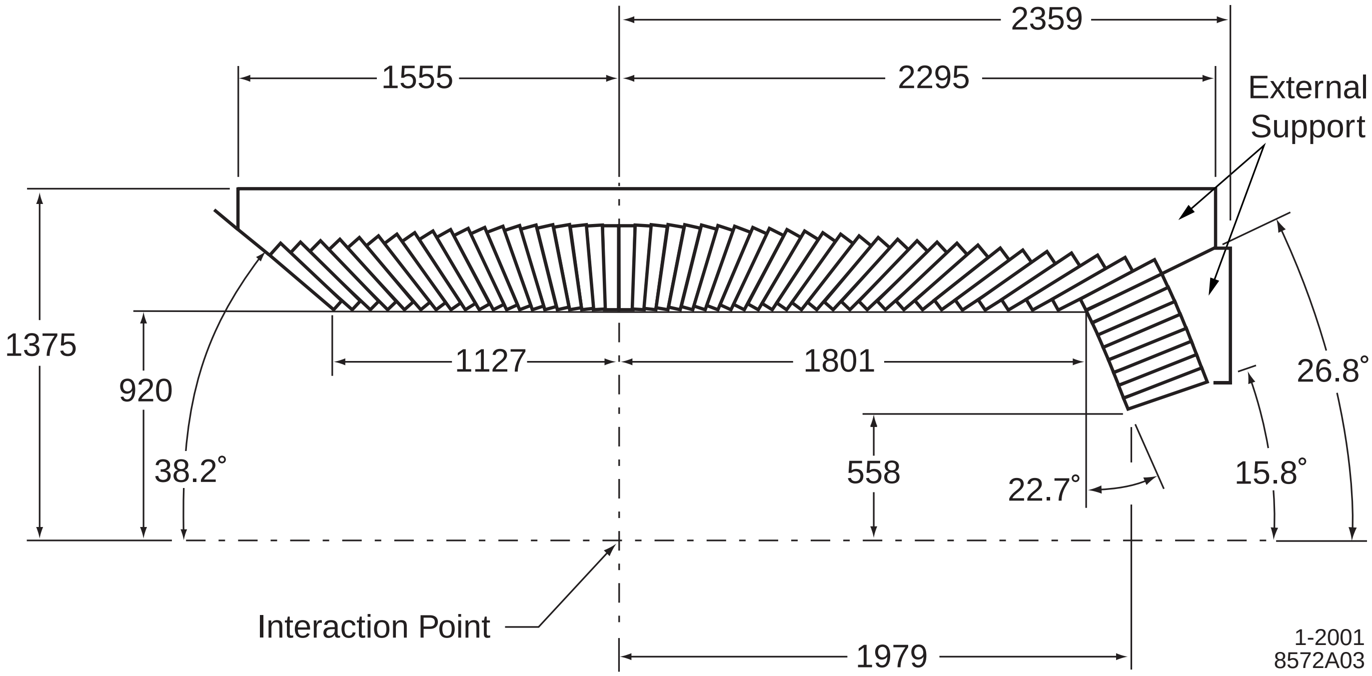
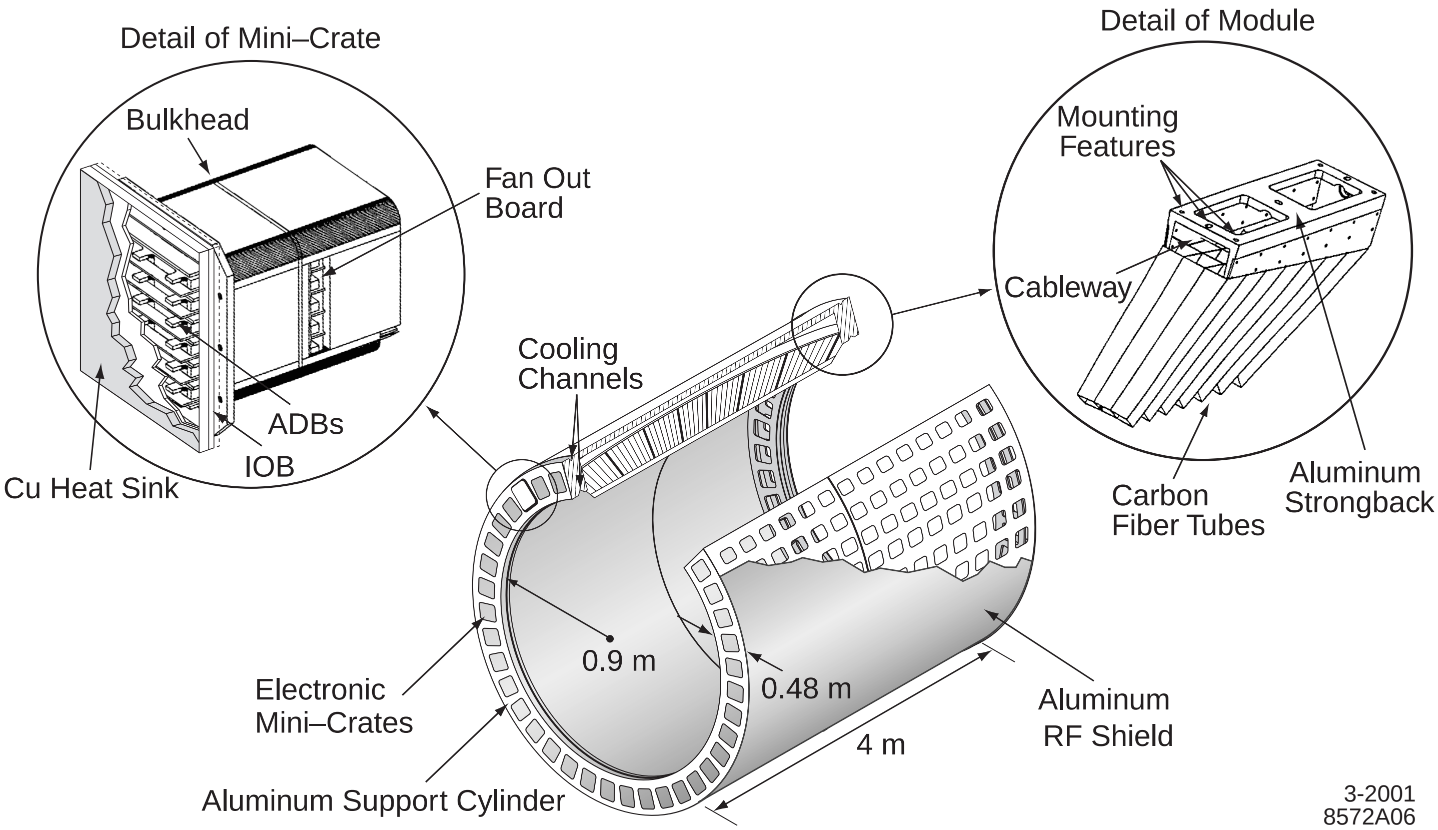
(SLAC)

Calorimeter Overview



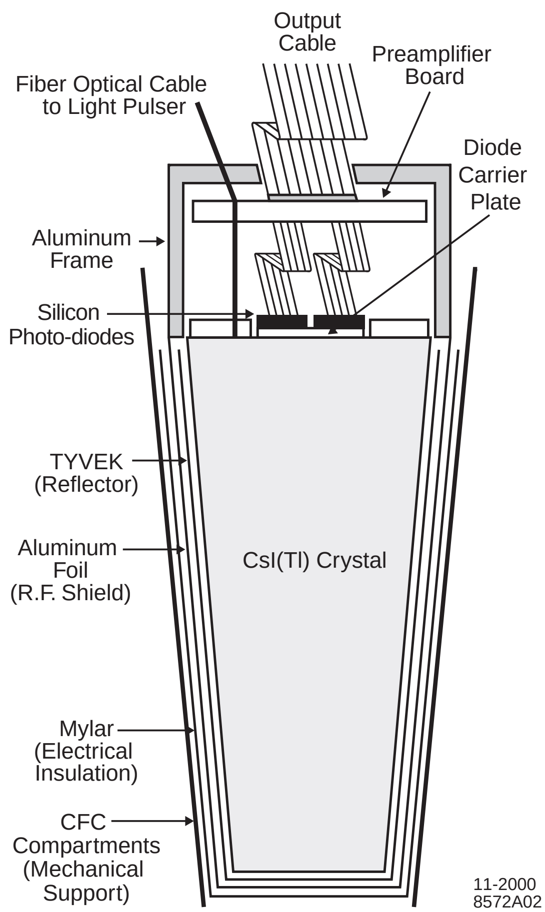
- 6580 CsI(TI) crystals
- Barrel: 48 rings in θ, 120 crystals per ring
- Forward Endcap: 8 rings in θ, 80/100/120 crystals per ring
- Angular coverage: 126 $^\circ$ in θ, 360 $^\circ$ in ϕ

Calorimeter Support Structure



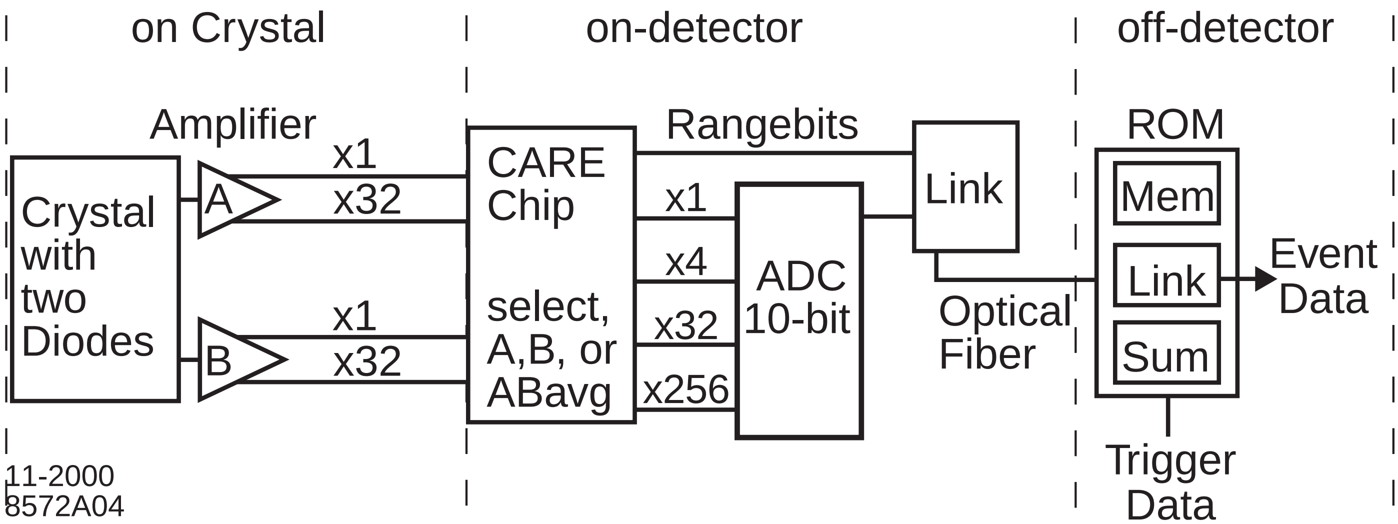
- Barrel
  - 280 carbon fiber modules
  - 7 modules along θ, 40 along ϕ
  - 7 crystals in θ, 3 in ϕ per module
- Endcap
  - 20 carbon fiber modules
  - 41 crystals per module (8 in θ, 4/5/6 in ϕ)

Crystal Housing



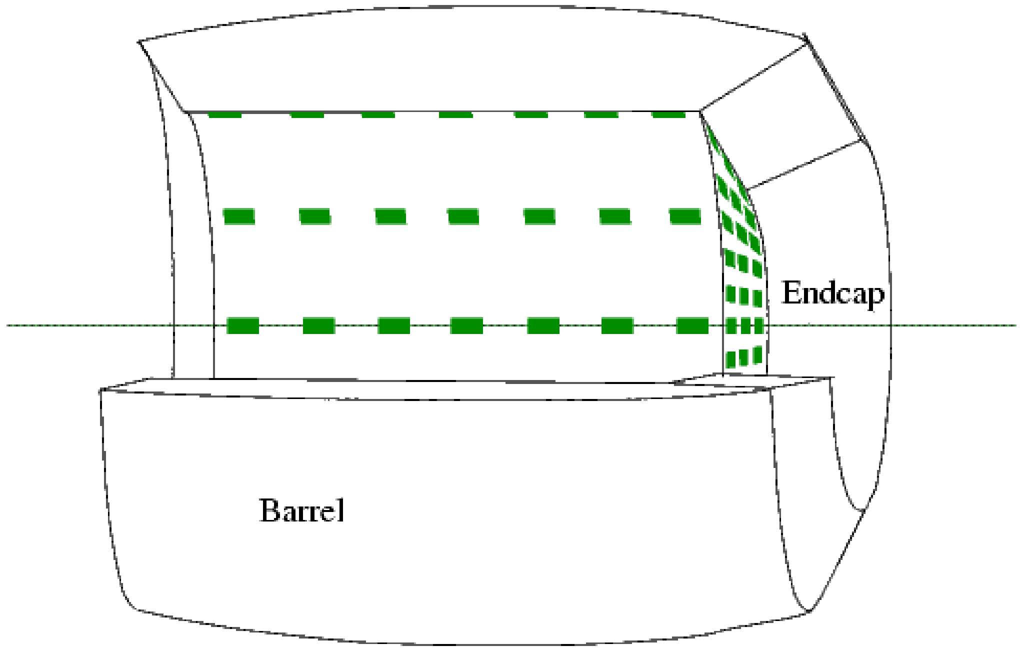
- Trapezoids: Front 4.7 x 4.7 cm^2, back 6.1 x 6.0 cm^2
- Length between 16.0 X_0 (bwd) and 17.5 X_0 (fwd)
- Tyvek wrapping for reflection and tuning
- Aluminum foil/Mylar wrapping
- Lightyield typically 7300 photoelectrons/MeV
- 2 photodiodes glued onto the crystal via a polystyrene coupling plate
- Preamps in readout box above crystal

Readout Electronics



- Short shaping-times of 800/250/250 ns to reduce the impact of beam background
- 2 readout chains per crystal provide redundancy
- Auto-ranging amplifier (CARE) with 4 gains (1, 4, 32, 256) allows for high resolution at low energies, needed for calibration at 6.13 MeV
- 10-bit ADC
- Sampling frequency 3.7 MHz
- 100 Readout modules (PPC) to process untriggered data
- Calibration circuit to linearize electronics response

Radiation Monitoring



- 116 radfets measure the integrated radiation dose
- Maximum dose is about 500 rad after 2.5 years
- Highest dose is in the endcap

- PIN diodes on the inside of the endcap measure instantaneous radiation
- The injection rate is limited if the radiation level goes above threshold

⇒ Steven's talk

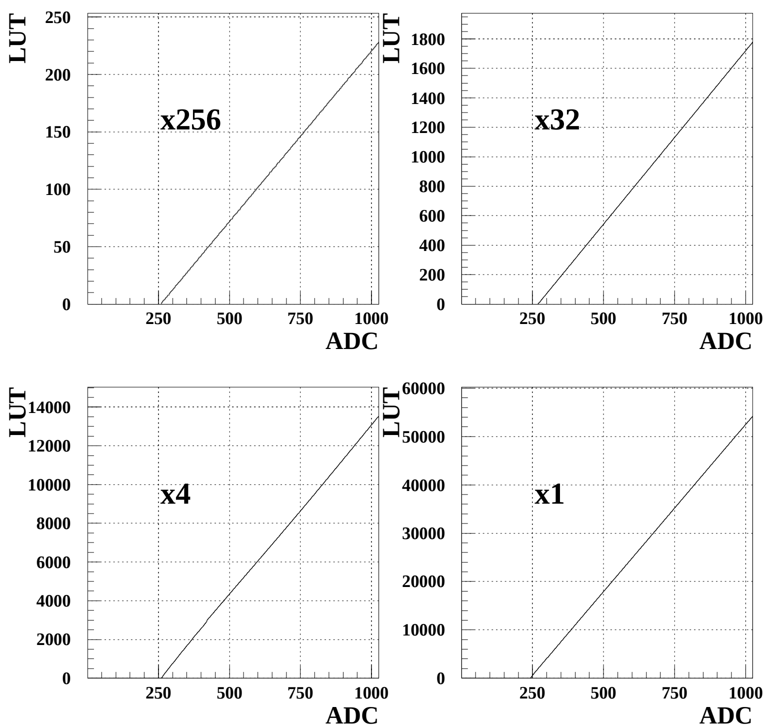
EMC Calibration Overview

Properties of the different calibrations

	Duration	Energy scale	Single Xtal	Absolute
Source	1/2 h	6.13 MeV	✓	✓
Bhabha	12 h	3-9 GeV	✓	✓
Rad Bhabha	1 - 2 days	0.3 - 9 GeV	–	✓
Pi 0	2 h	30-3000 MeV	–	✓
Electronics	15 min	0 - 13 GeV	✓	–
Light Pulser	3 min	0 - 13 GeV	✓	–

- The lightpulser connects the very low energy range of the source calibration with the high energy range of the Bhabha calibration.
- The lightpulser injects light into the crystal whereas the electronics calibration injects charge only into the preamp.

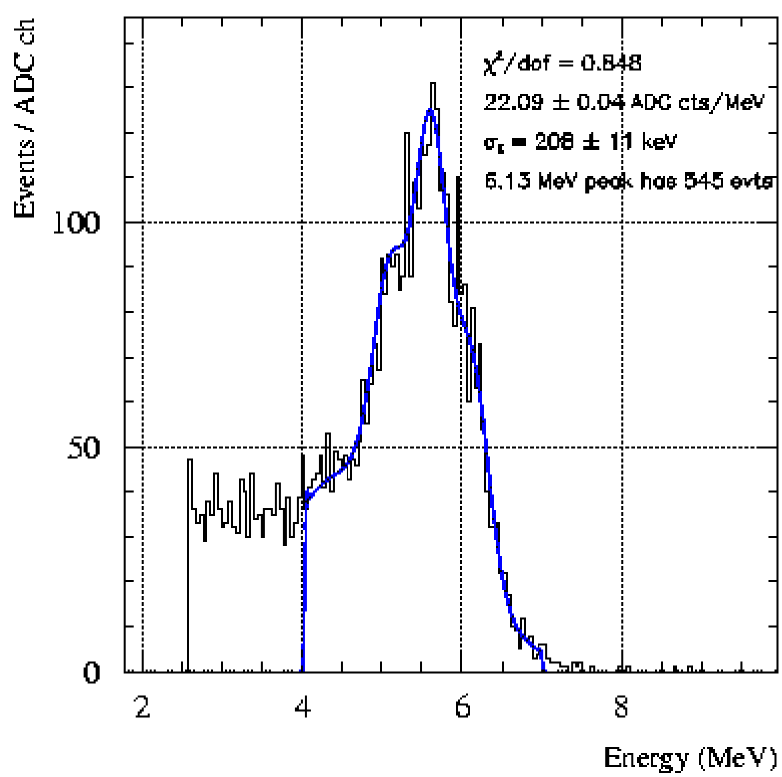
Electronics calibration



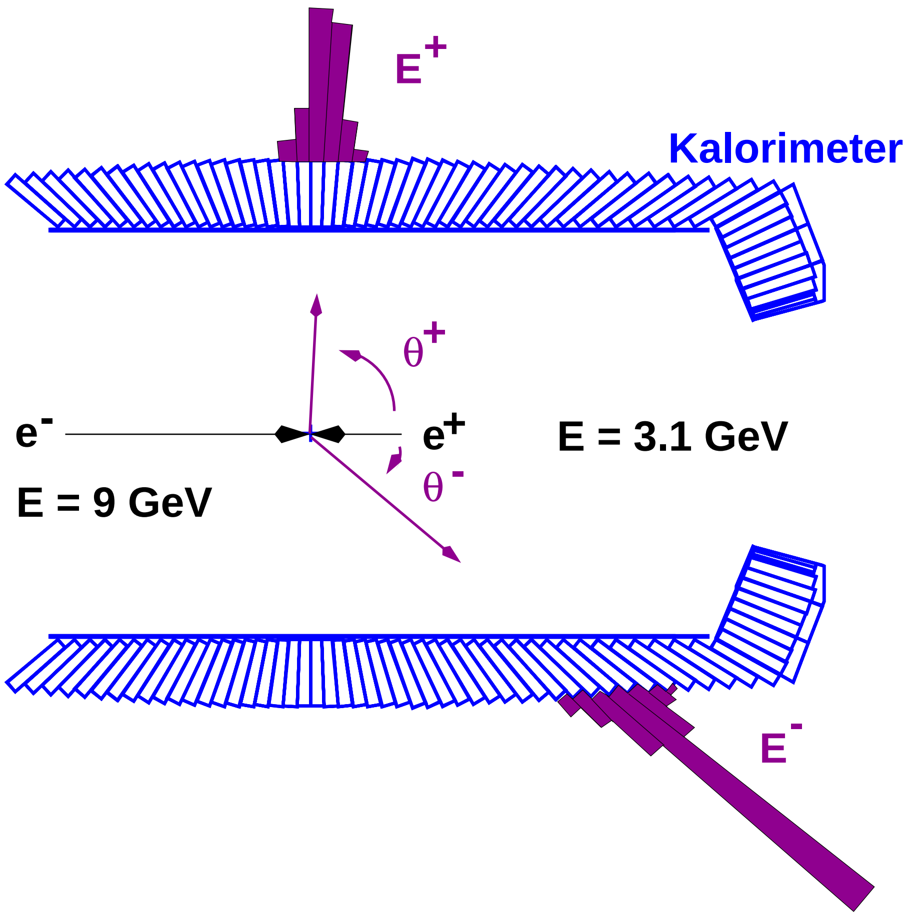
- Charge injection with two capacities (ratio 1:35)
- Lookup tables correct non linearities individually for each crystal
- Noise in the calorimeter without beam :
  - Raw: 440 keV
  - With digital filter applied: 380 keV
- Noise in the calorimeter with beam :
  - Raw: 680 keV
  - With digital filter applied: 560 keV

Source Calibration

- Calibration uses 6.13 MeV photons from $^{16}N \rightarrow^{16} O^* \rightarrow^{16} O\gamma$
- ^{16}N has a lifetime of 7 seconds
- The activated fluid circulates through a system of hoses in front of the crystals
- Resolution of the constants: 0.33 %
- Source spectrum with two escape peaks:



Bhabha Calibration I



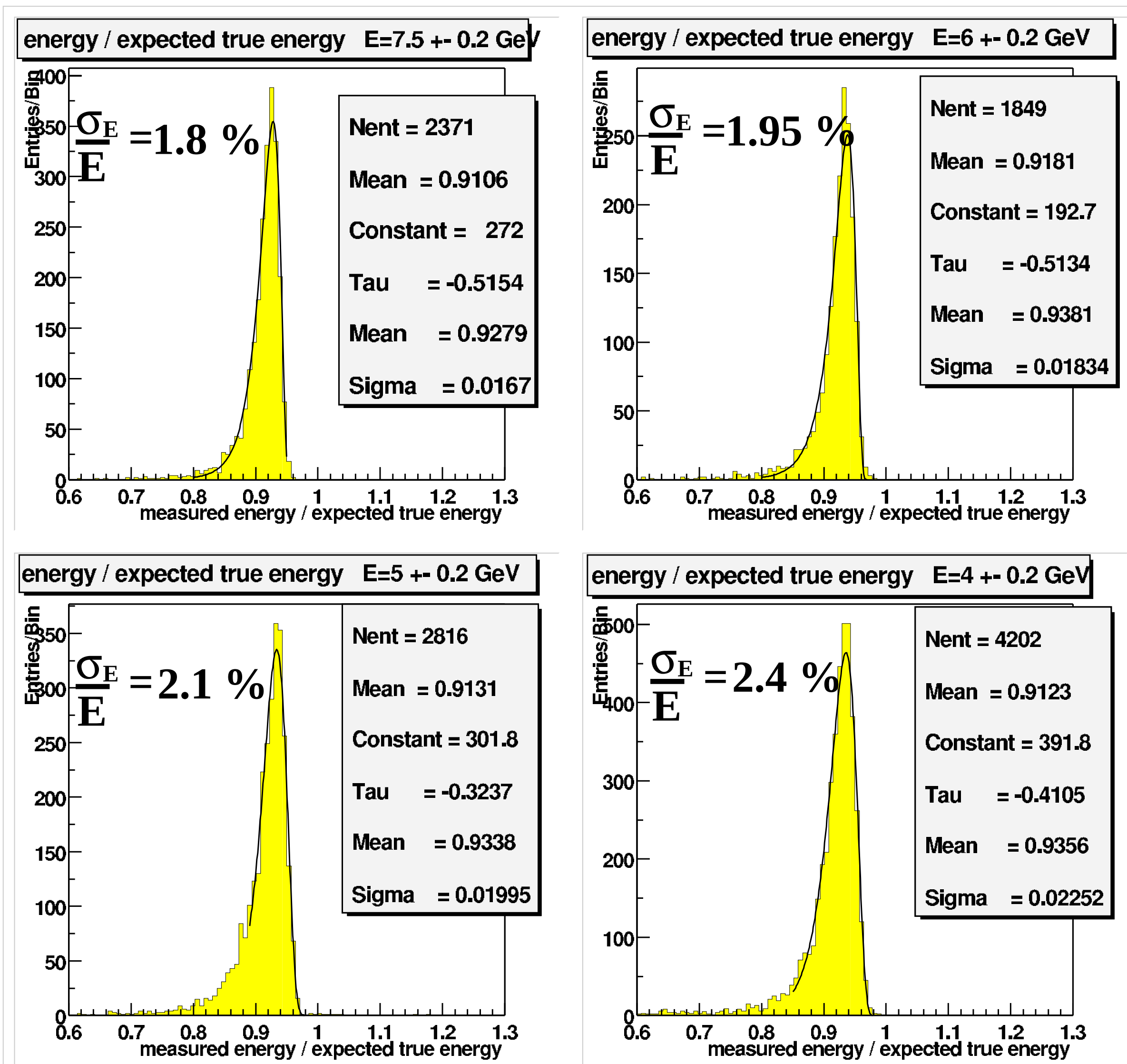
- Single crystal calibration to $E_{deposited}$ (from MC)
- Find constants c_i so that

$$\chi^2 = \Sigma_{events} \frac{(\sum_i c_i \varepsilon_i - E^{expected})^2}{\sigma^2}$$

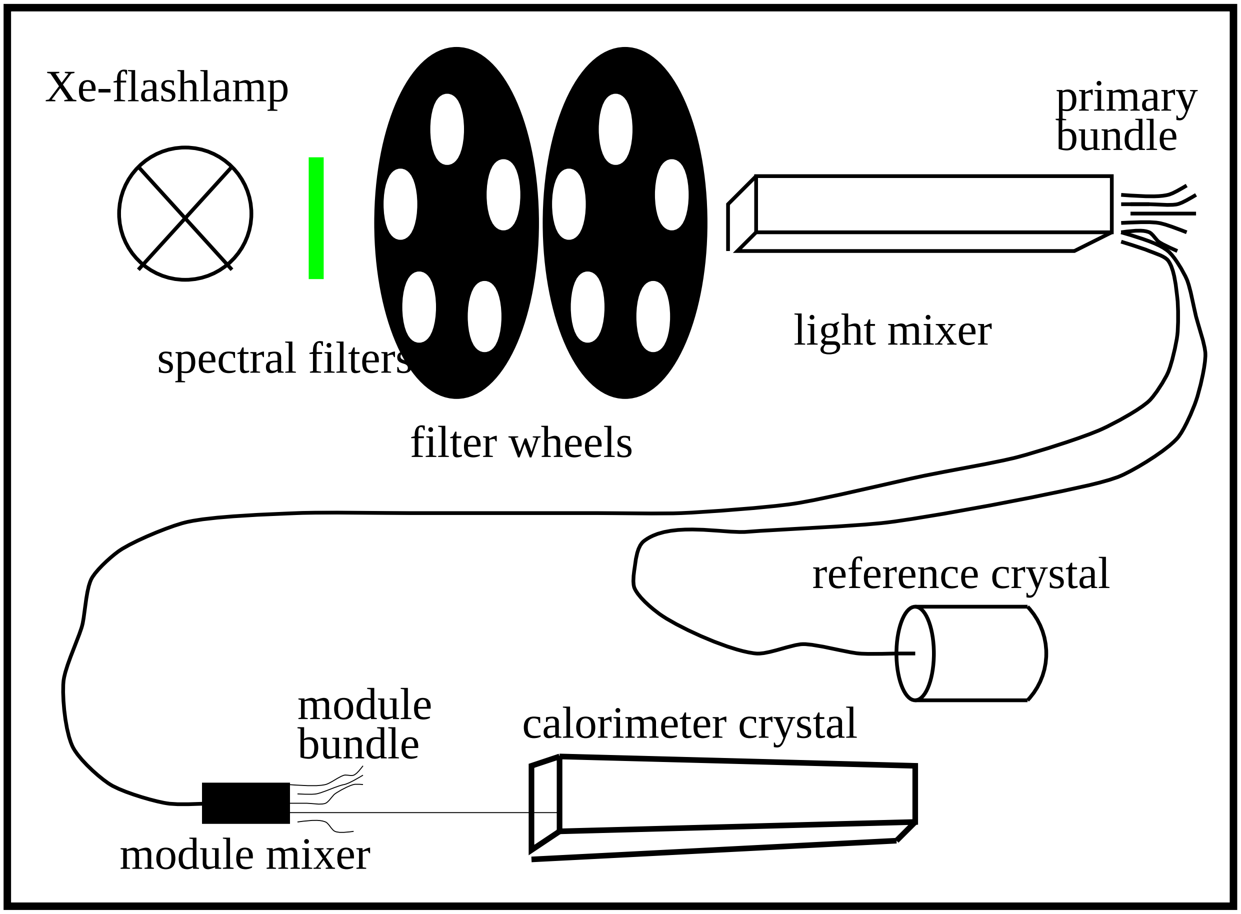
becomes minimal

Bhabha Calibration II

- Minimization of χ^2 yields a system of linear equations with a 6580 x 6580 matrix
  $\longrightarrow$ numerical solution
- Fit with Novosibirsk function



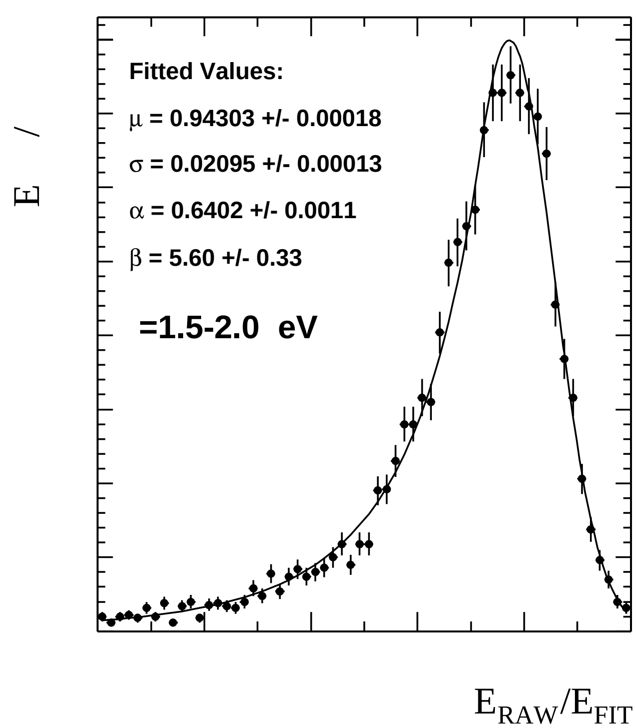
Lightpulser system

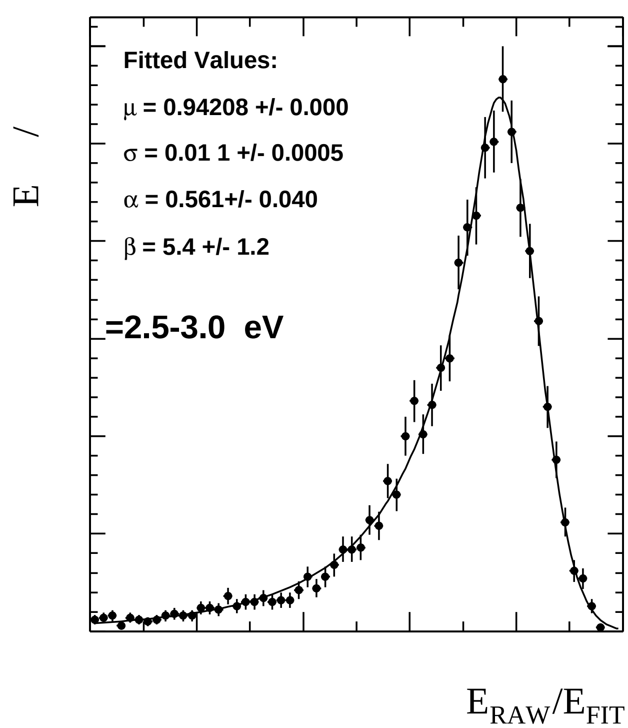


- 2 Xenon flashlamps (barrel/endcap)
- attenuation filters
- 300 primary fibers 400 μm HPCS
- airgap module light mixer
- module bundles with 200μm HPCS fibers
- reference crystal
- EMC channel check, radiation monitor, linearity check

Radiative Bhabhas

- Radiative Bhabhas can be used for cluster corrections in the region above 1 GeV
  - Use energy and position information from tracks
  - Use position information for the neutral cluster
  - Do a constrained fit to the cluster energy
  - Binning in θ, ϕ, E
  - Use the ratio of fitted and measured cluster energy as a correction

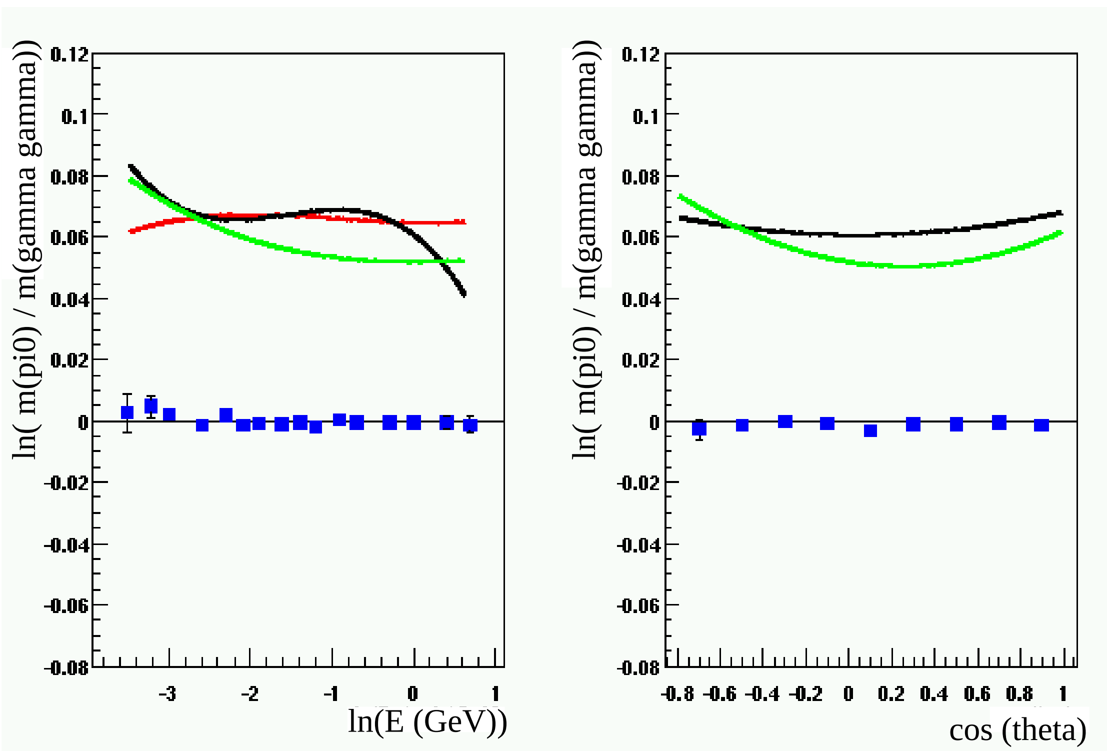




π^0 Calibration

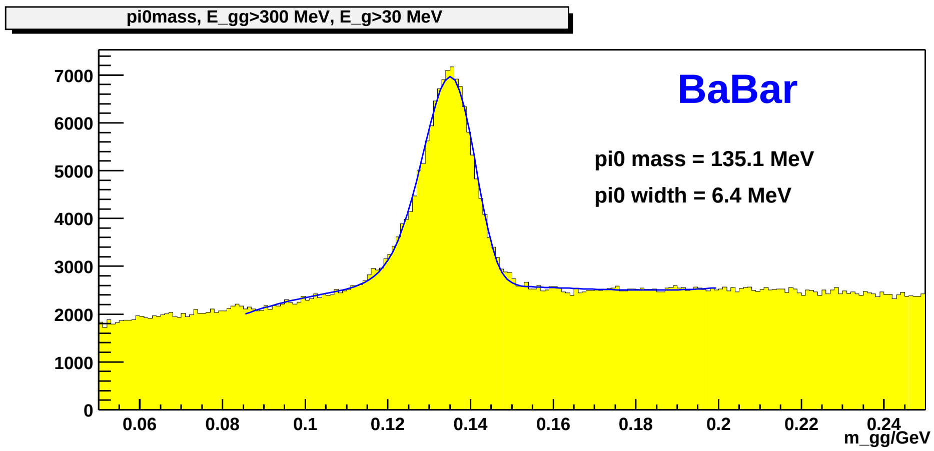
- Use known π^0-mass to do cluster corrections to the photon energies E_1 and E_2

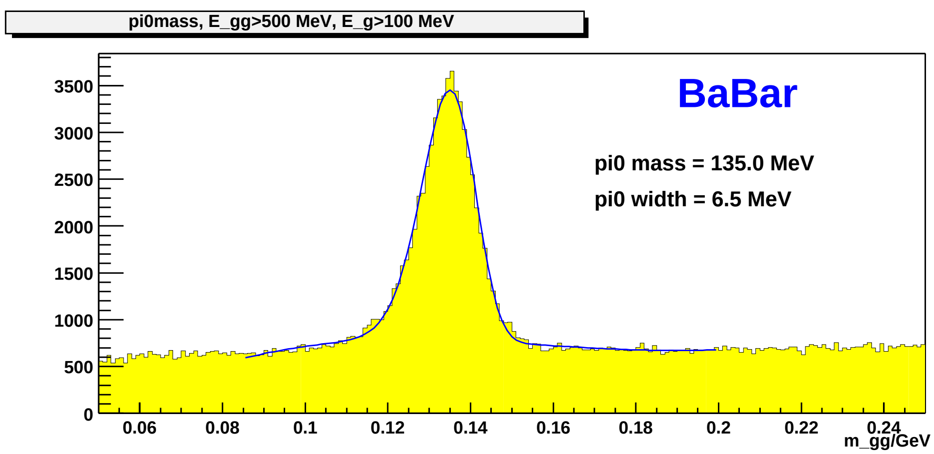
  $m_{\pi^0} = \sqrt{E_1 E_2 (1 - \cos\theta)}$, θ:angle between photons
- Calibration function is a polynomial of third order in $\log(E_\gamma)$ and second order in $\cos(\theta)$
- Iterative procedure until convergence is achieved

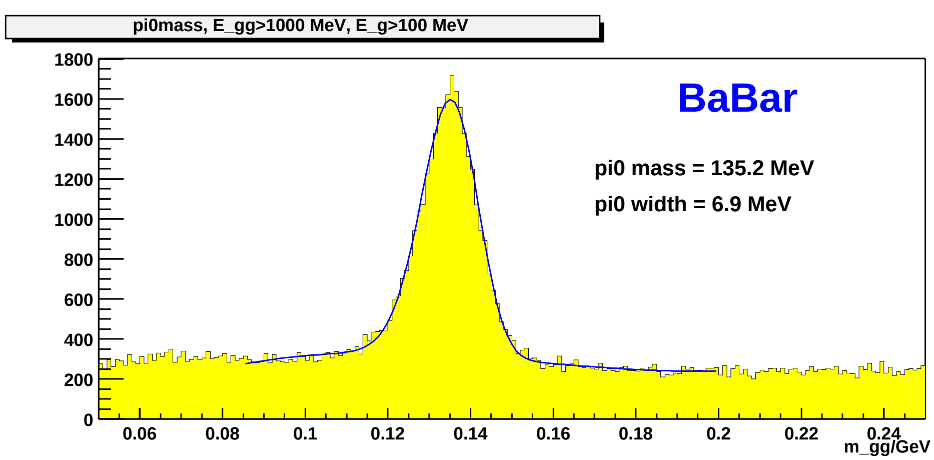


- Calibration function Monte Carlo (Run 1 reco cuts)
- Calibration function data Run 1
- Calibration function data Run 2
- Data points after correction Run 2

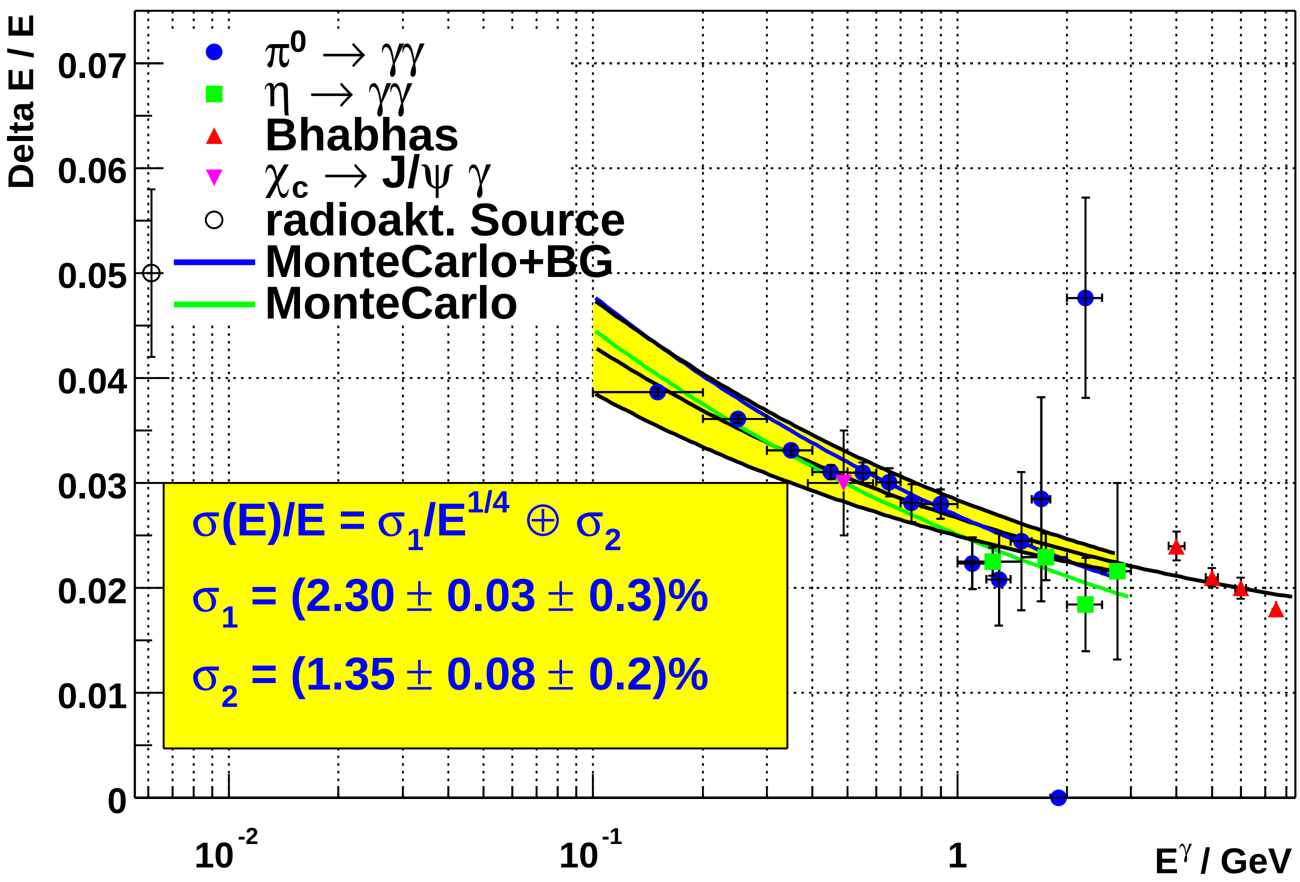
π^0 resolution



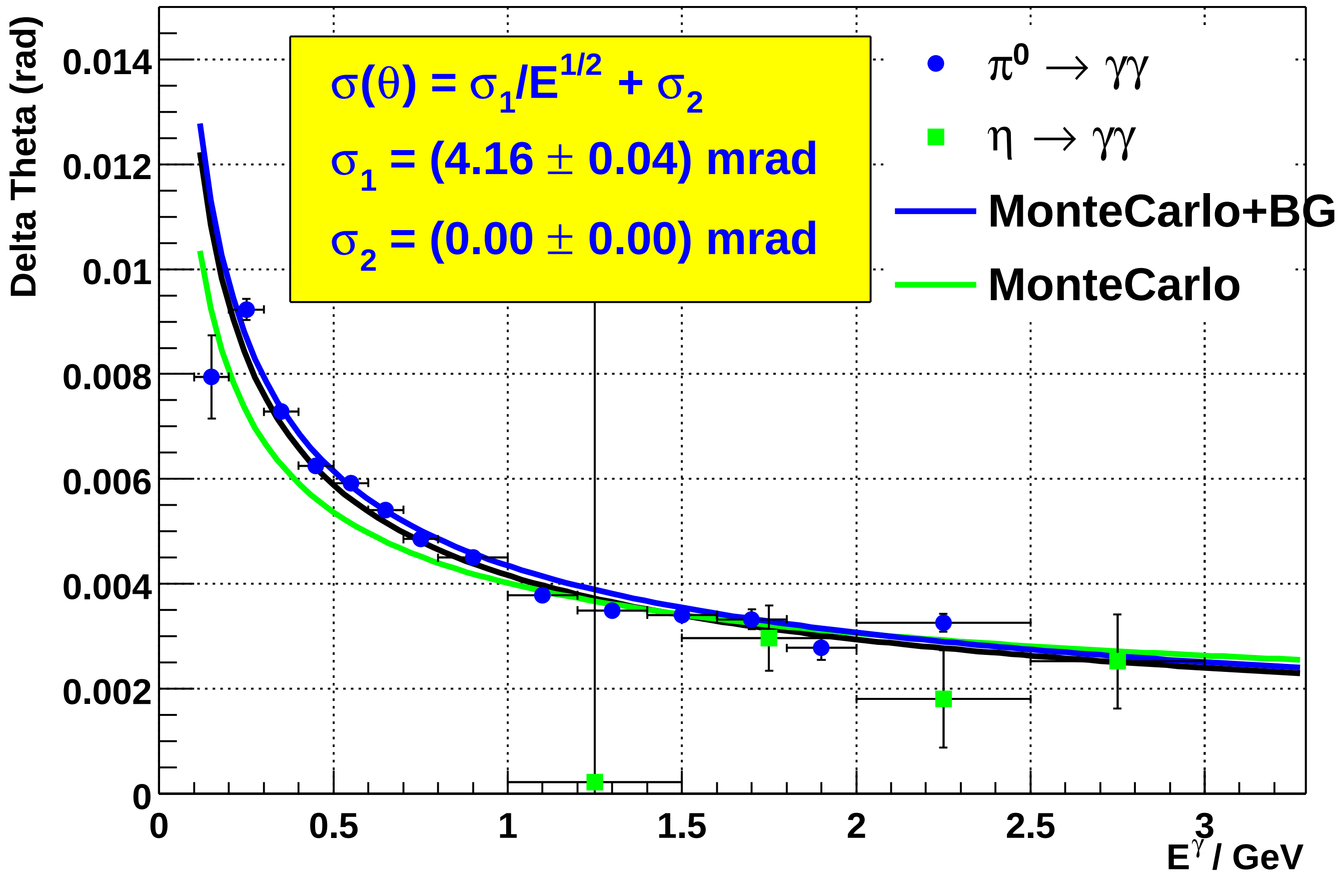




Energy resolution



Angular resolution



Conclusion

- Calorimeter performance is close to expectations
- Frequent calibration is necessary to compensate for changes in lightyield
- Calibration algorithms are working and still being improved
- Additional studies are being done (Virtual Compton scattering, DIRC preshower corrections, etc.)