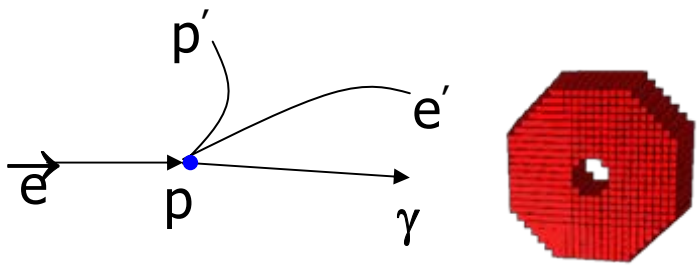
Inner Calorimeter in CLAS/DVCS experiment

- ✓ Motivation
- ✓ E1-DVCS run Configuration
- ✓ Inner Calorimeter Performance
- ✓ Summary

Exclusive Reactions Workshop R. Niyazov(JLAB)

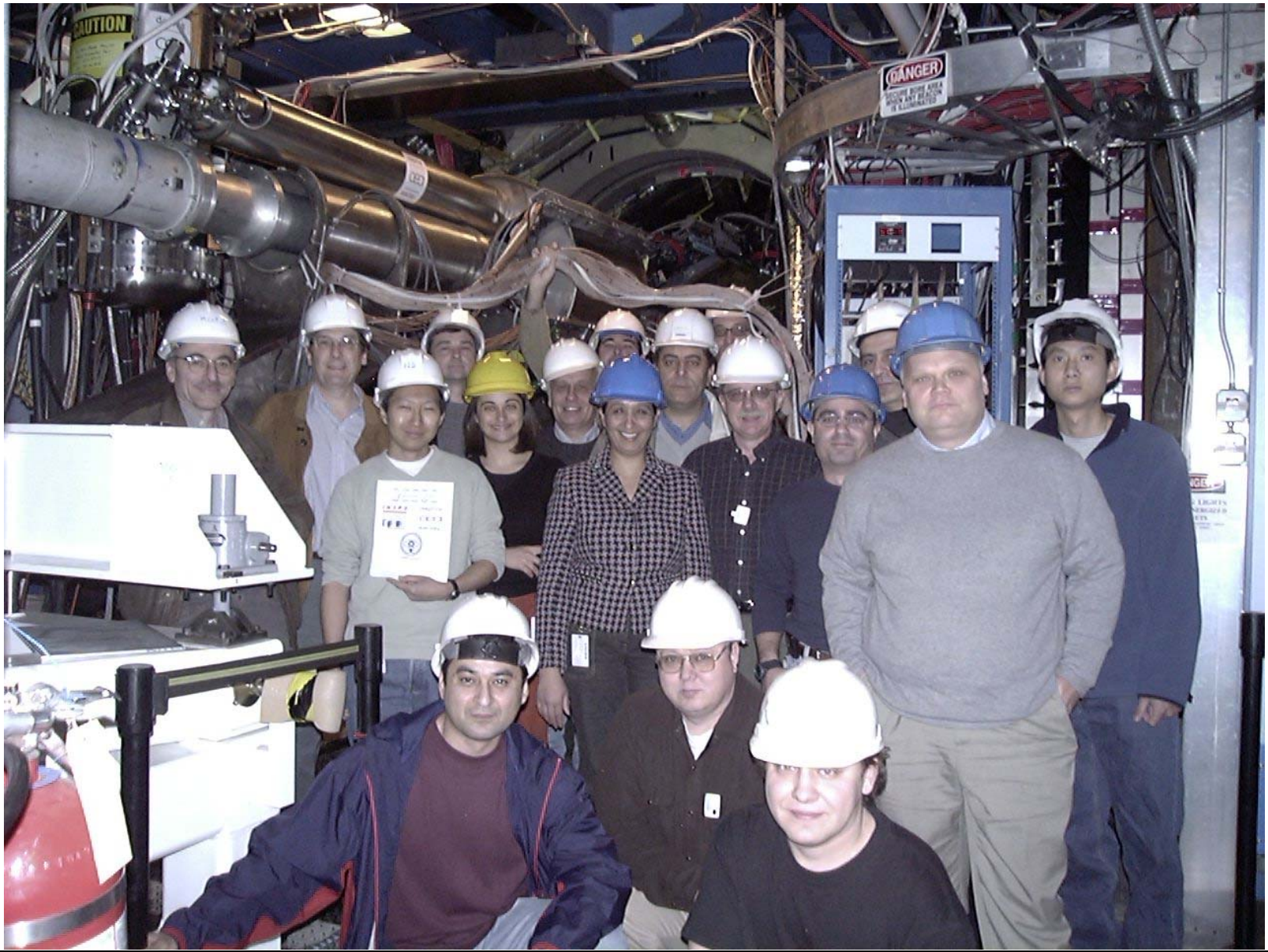
e1-dvcs run Physics Goals

- DVCS Beam Spin Asymmetry: $ep\gamma$
- DVCS cross sections
- Exclusive π^0 and η Beam Spin Asymmetry $ep\gamma\gamma$
- Exclusive π^0 and η cross sections
- $e\gamma\pi^+ (\rho^+)X$, $e\gamma\pi^0 (\rho^0)p$, $e\pi^0\pi^0 p$
- Exclusive pion pair production
- Semi-inclusive π^0 production



Need high precision calorimeter to detect photons at small angles

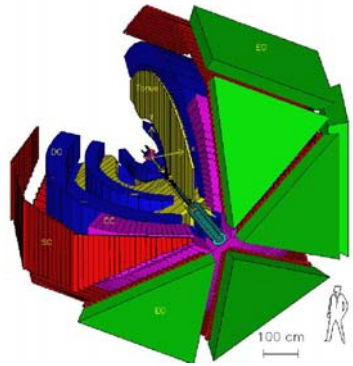
Dedicated DVCS Experiment With CLAS

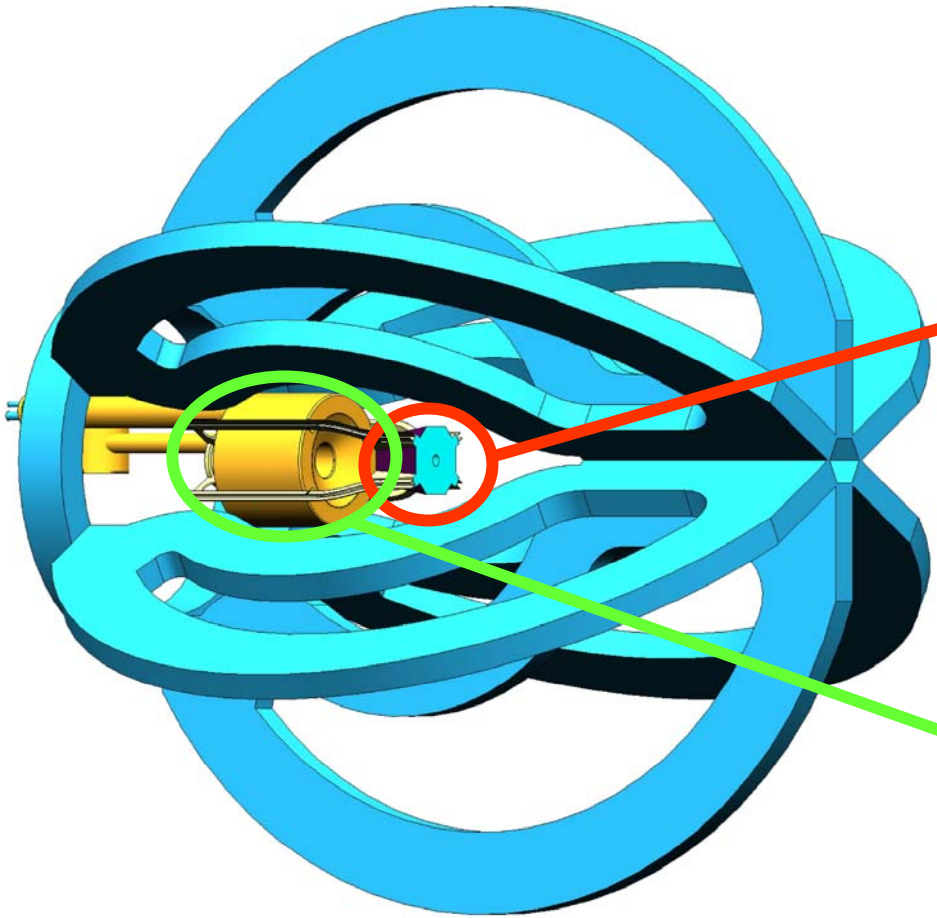


CLAS+Solenoid+Inner Calorimeter

- CLAS and
  - ✓Super-conducting solenoid magnet to shield detectors from Møller background (field=4.5 T)
  - ✓2.5 cm Hydrogen target (upstream of CLAS Center -66 cm)
- Inner Calorimeter (IC)
  - ✓424 $PbWO_4$ crystals, 16 cm long, 1.3x1.3 cm^2
  - ✓High resolution calorimeter to detect photons at small angles (4-15°)
  - ✓Light read-out via APDs (avalanche photo-diodes)
  - ✓Low-noise fast preamplifiers
  - ✓Temperature stabilization for high precision energy measurements (< 0.1°)
  - ✓Laser Monitoring System

CLAS + Solenoid + IC





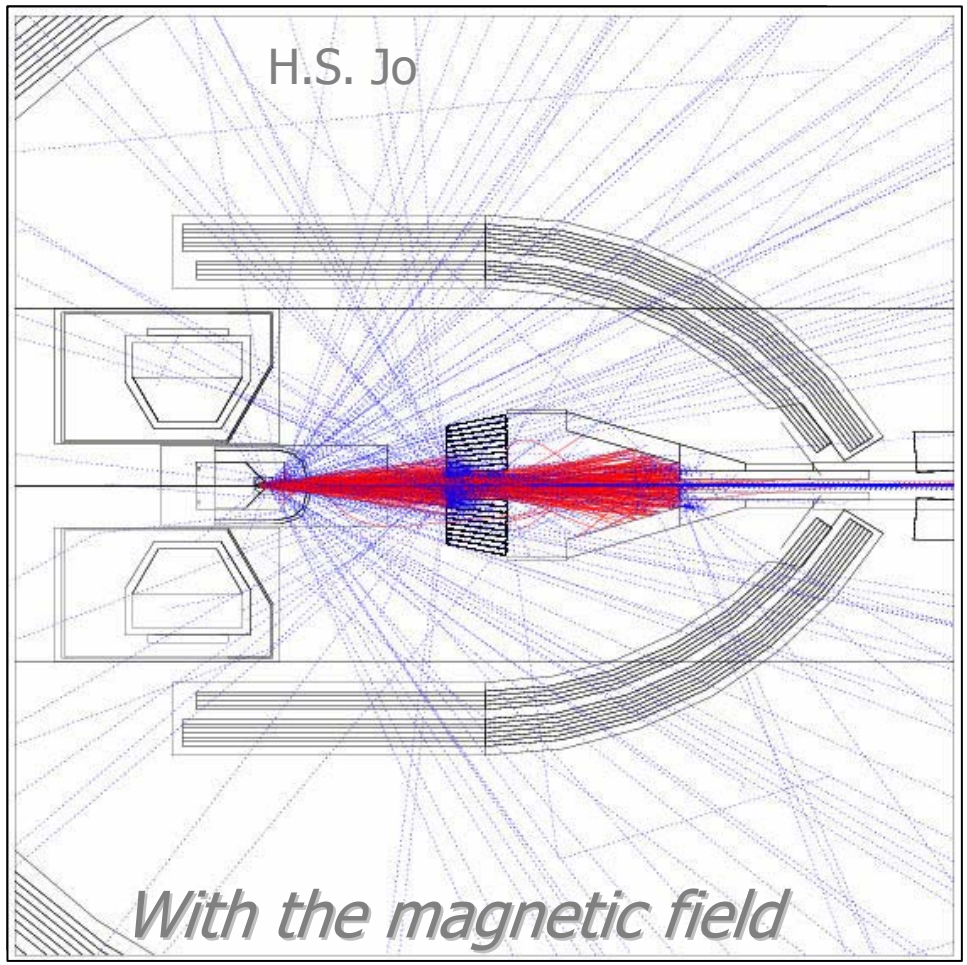
Inner Calorimeter

- Higher luminosity
- Larger acceptance for γ

Superconducting solenoid magnet

The Superconductive Solenoid

Simulation of the magnetic shielding

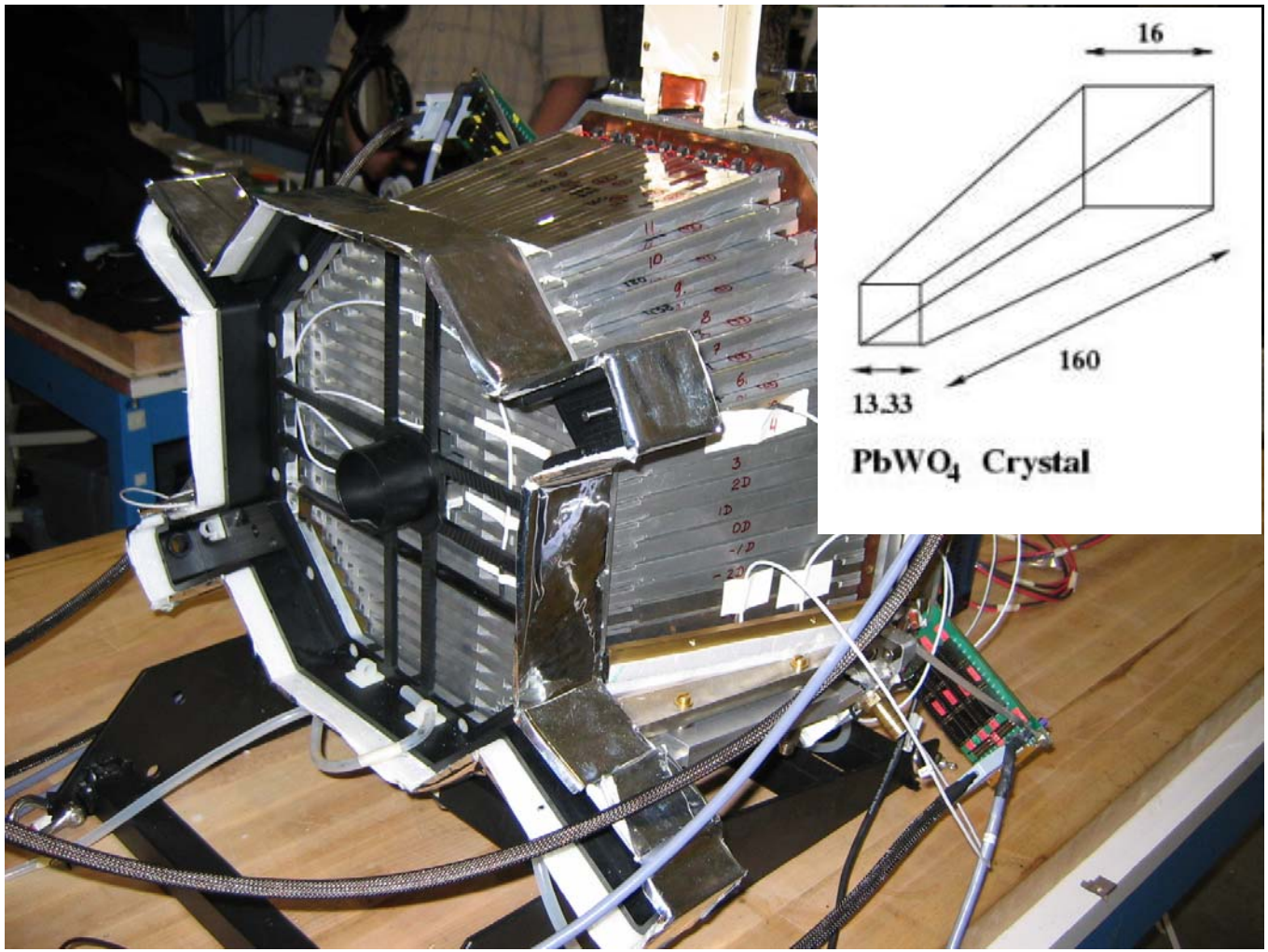


Møller electron energy – 1-10 MeV

The e1-dvcs Run Summary

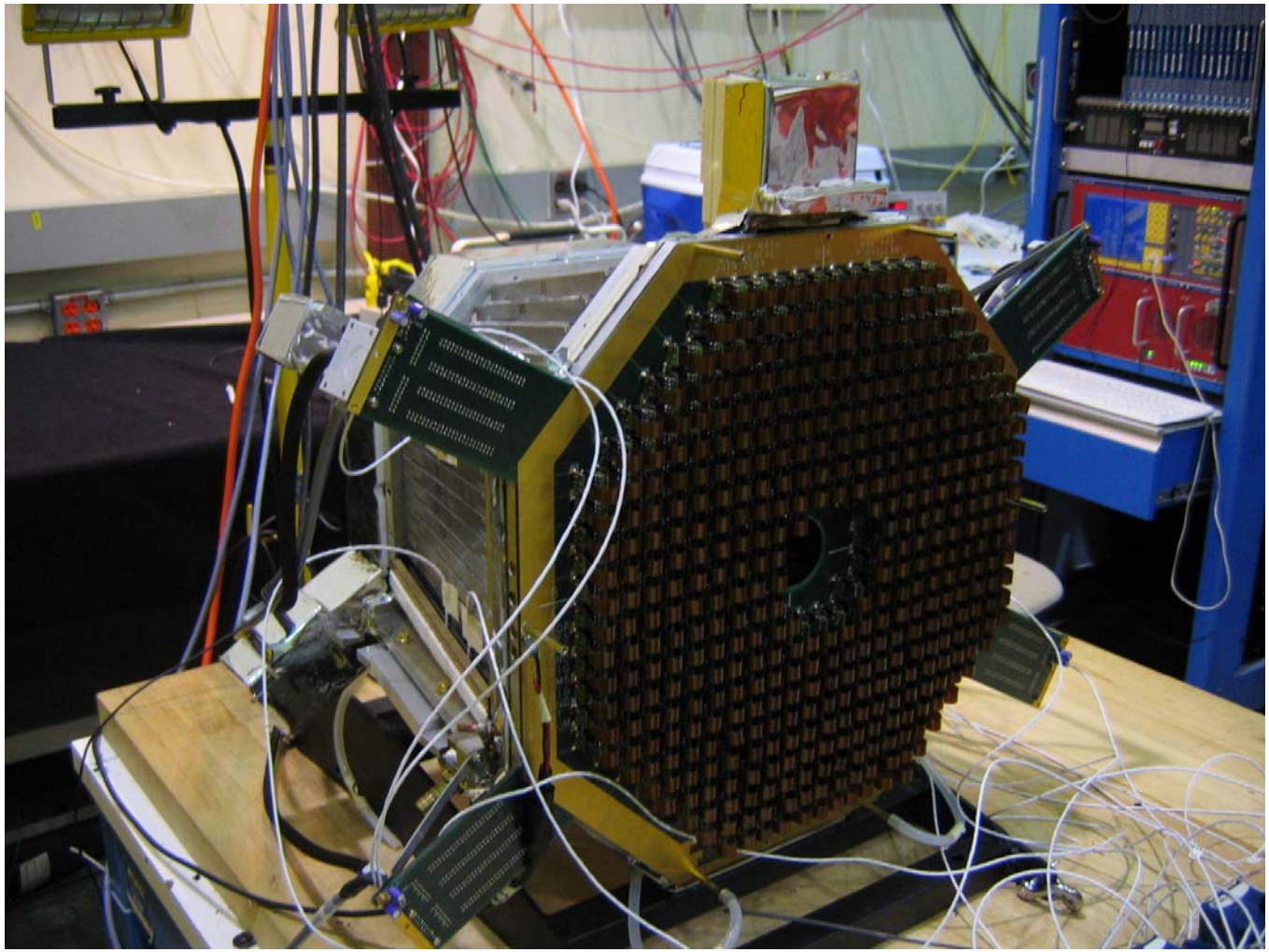
- ✓ DVCS run; 67 days (March 17-May 27, 2005)
- ✓ E_0=5.8 GeV; Luminosity=1.7×10^{34} $cm^{-2}s^{-1}$
- ✓ Average Beam Polarization = 80%
- ✓ Average Beam Current 25 nA
- ✓ Number of production triggers = 7.5×10^9
- ✓ 7 Tb of production data (440 runs)
- ✓ FC charge=58.9 mC

Inner Calorimeter



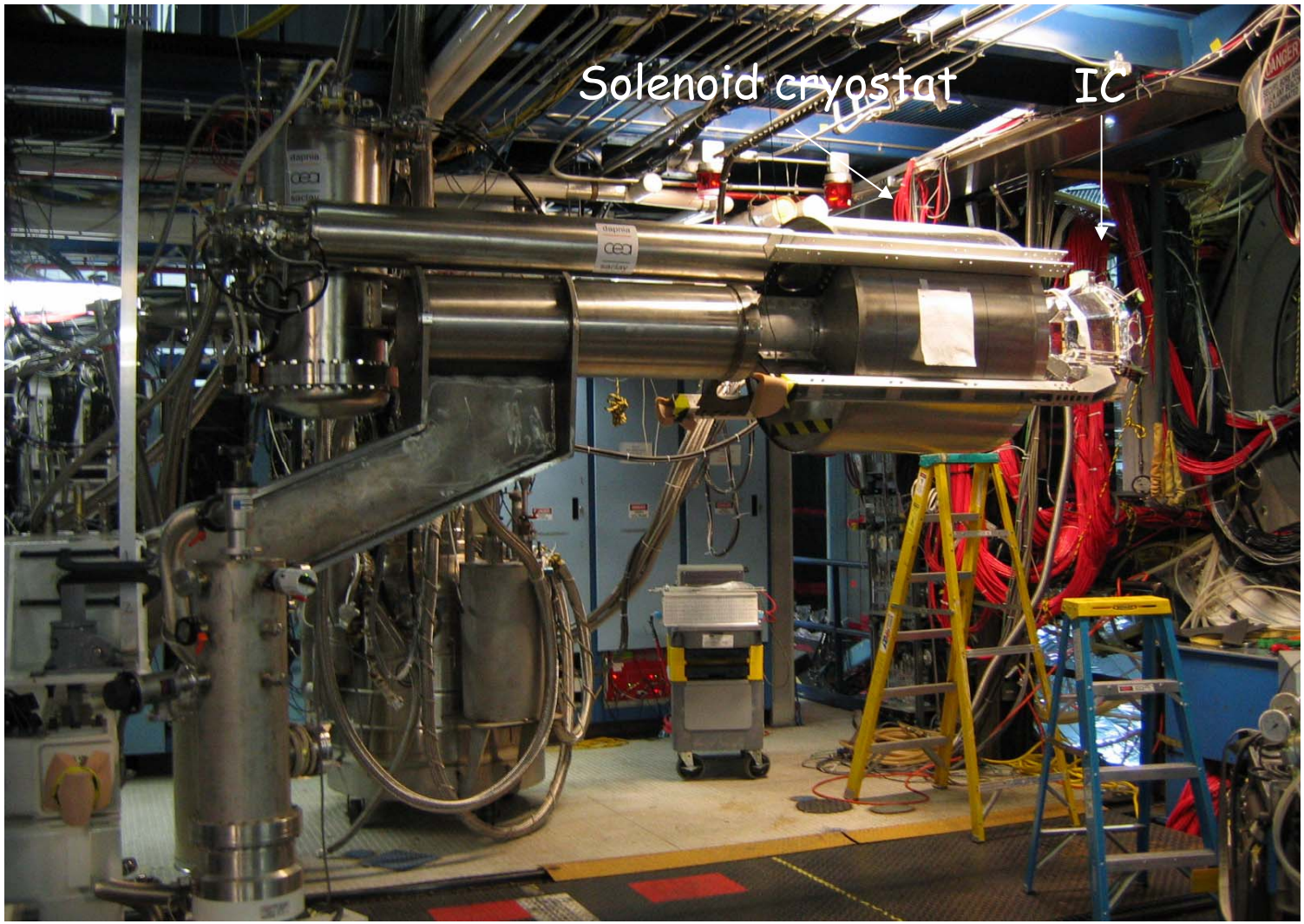
IC assembly/Front View

Inner Calorimeter



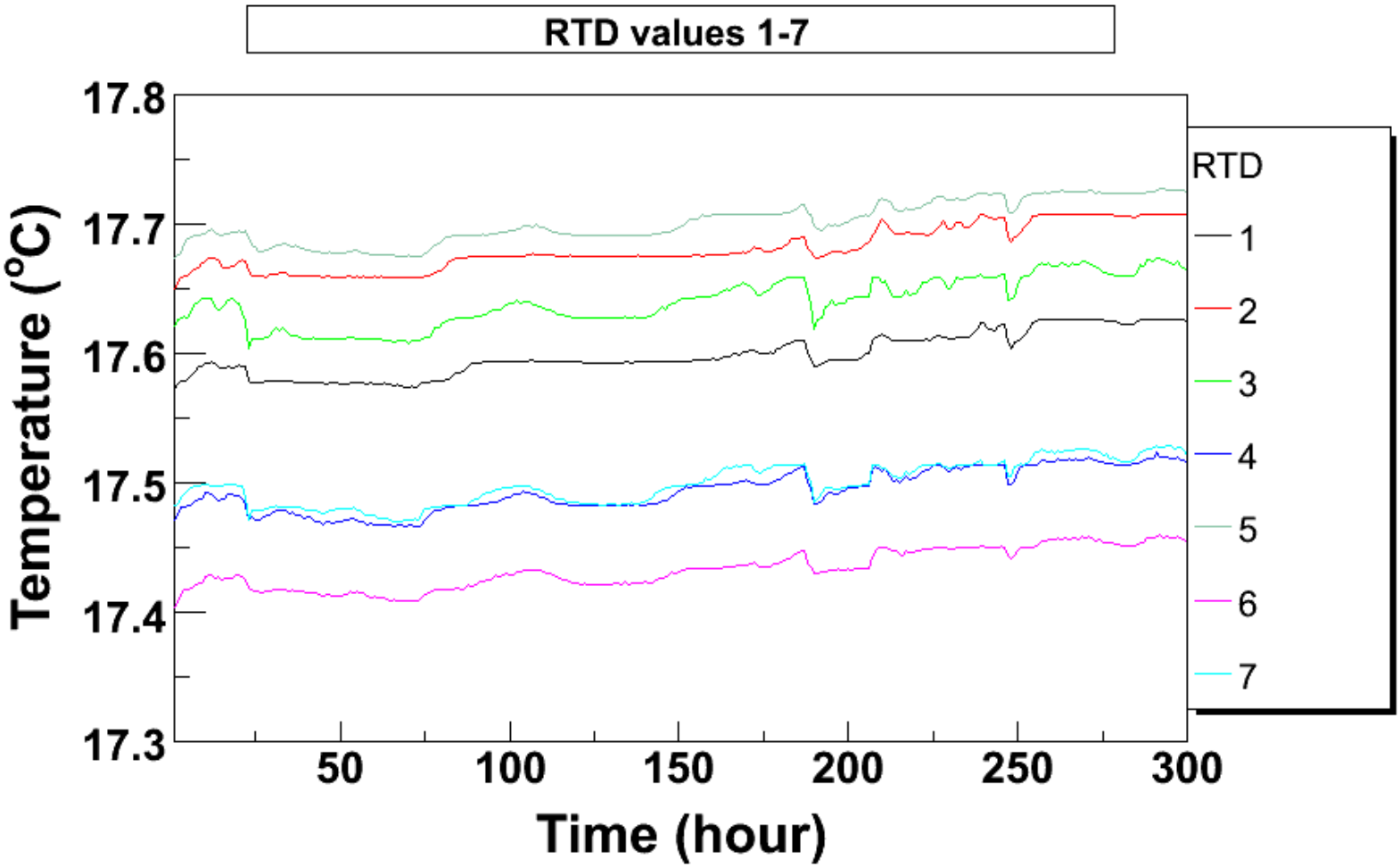
IC assembly/Back View

Solenoid Magnet + IC Installation



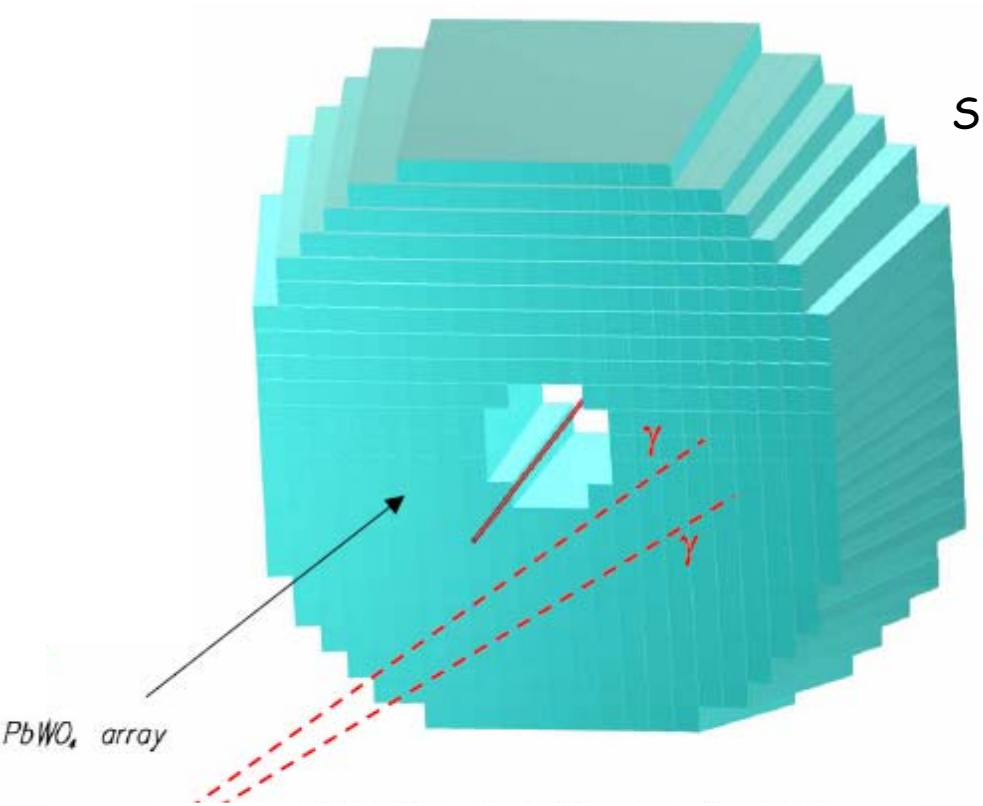
IC insertion in CLAS

Temperature Stability



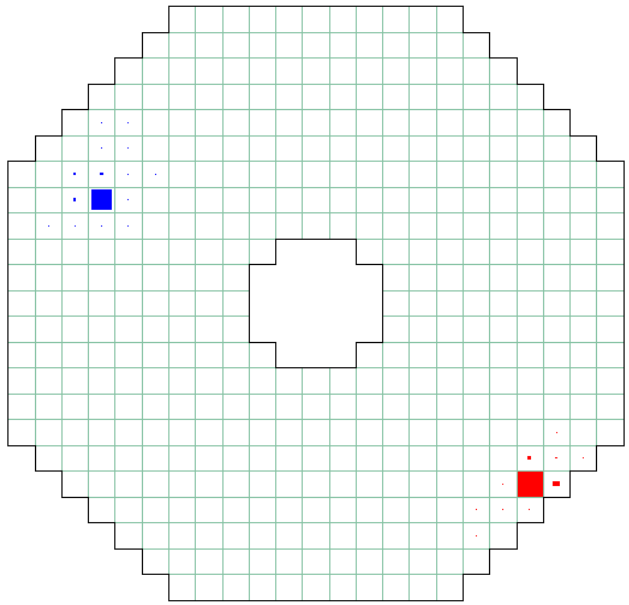
Temperature fluctuations ~ 0.02° in 12 days

π^0 Reconstruction and Calibration



$$\pi^0(\eta) \rightarrow \gamma\gamma$$

Size of the box is weighted by hit energy

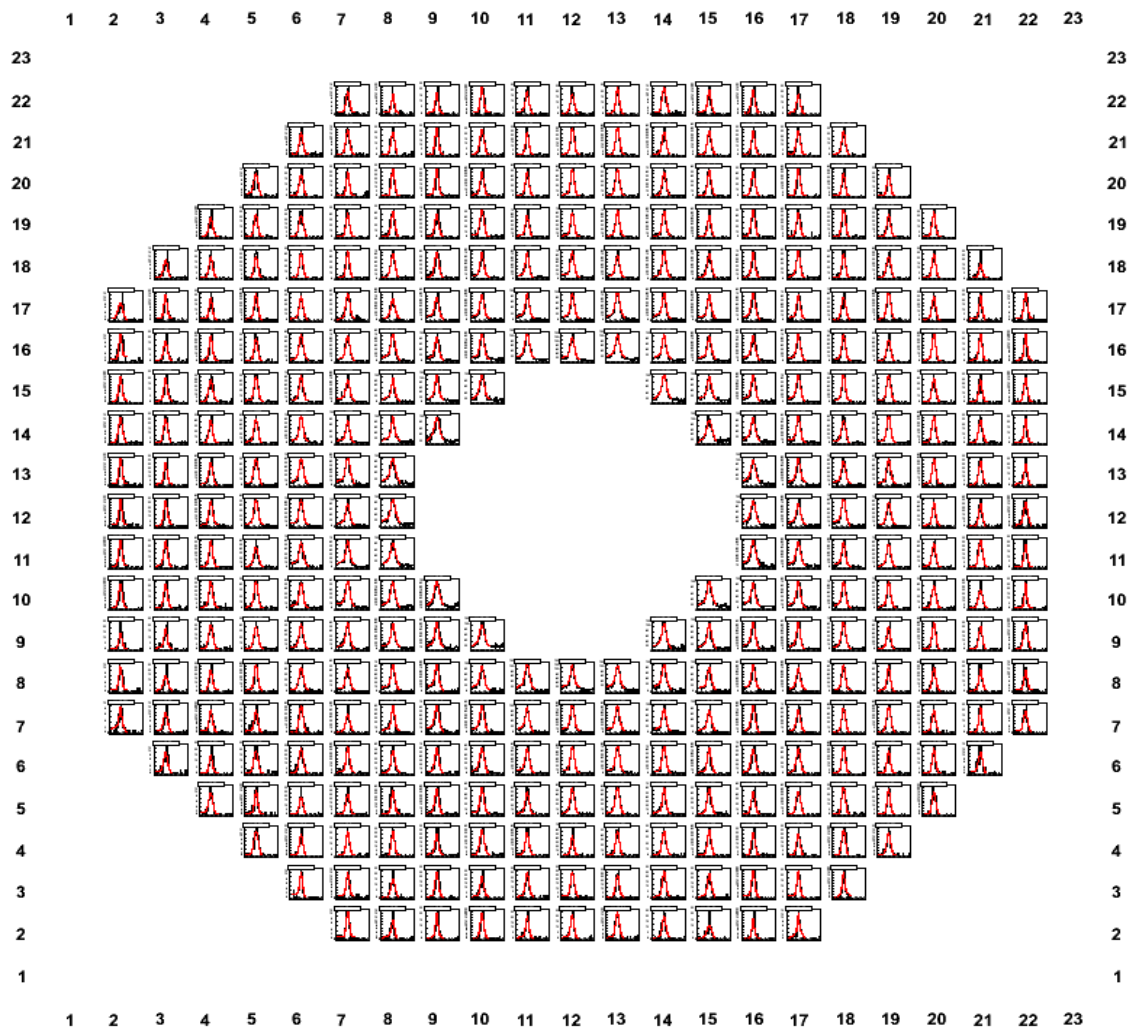


π^0 Calibration is based on 2 photon reconstruction and correction of channel Gains by fitted $M_{\gamma\gamma}$ value

$$M_{\gamma\gamma} = \sqrt{2E_{\gamma 1}E_{\gamma 2}(1-\cos\theta_{\gamma\gamma})}$$

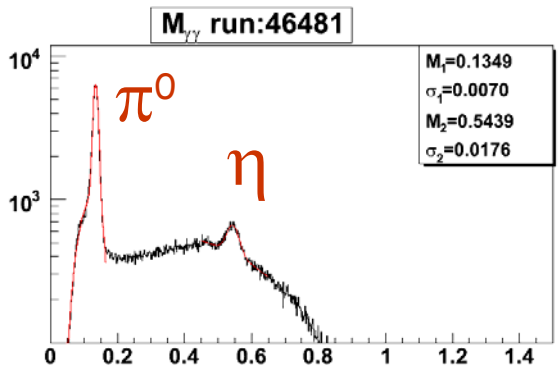
Two cluster single data event from π^0

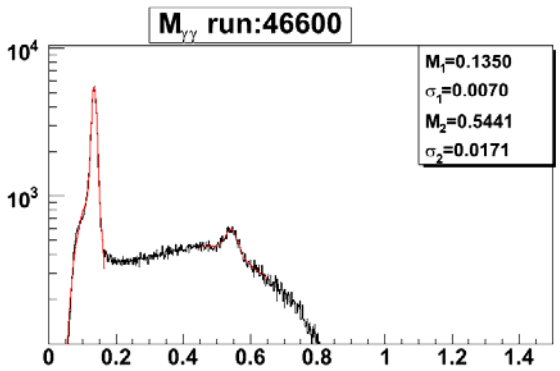
Gains by fitting $M_{\gamma\gamma}$

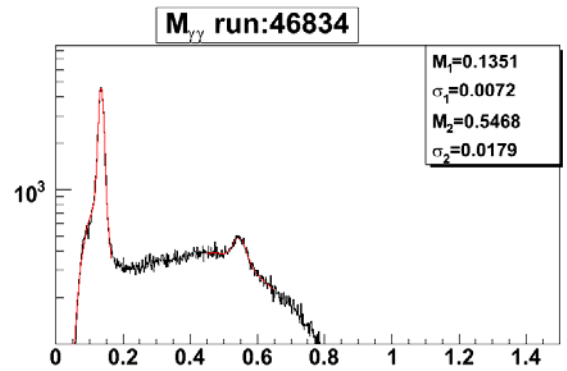


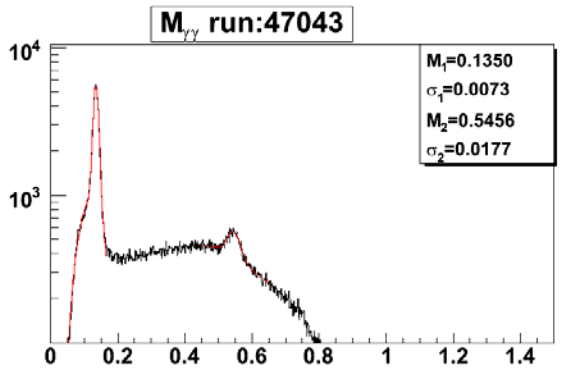
One of the gain correction iterations

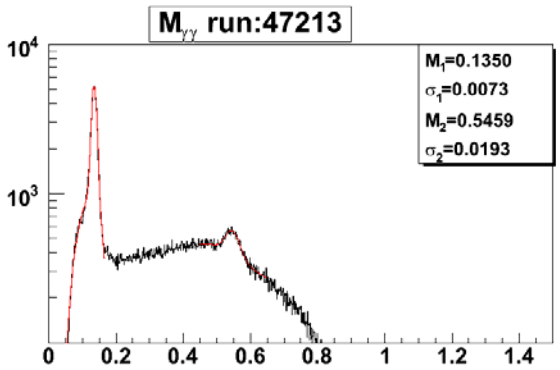
IC Calibration Results

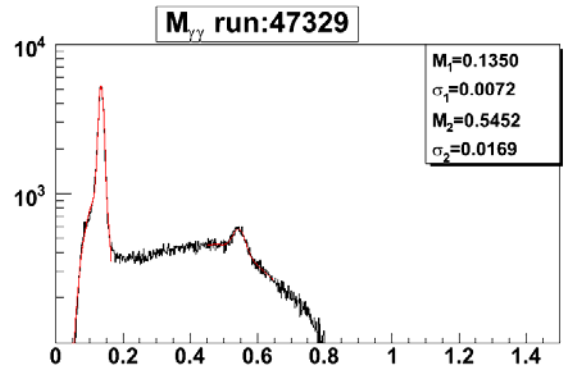












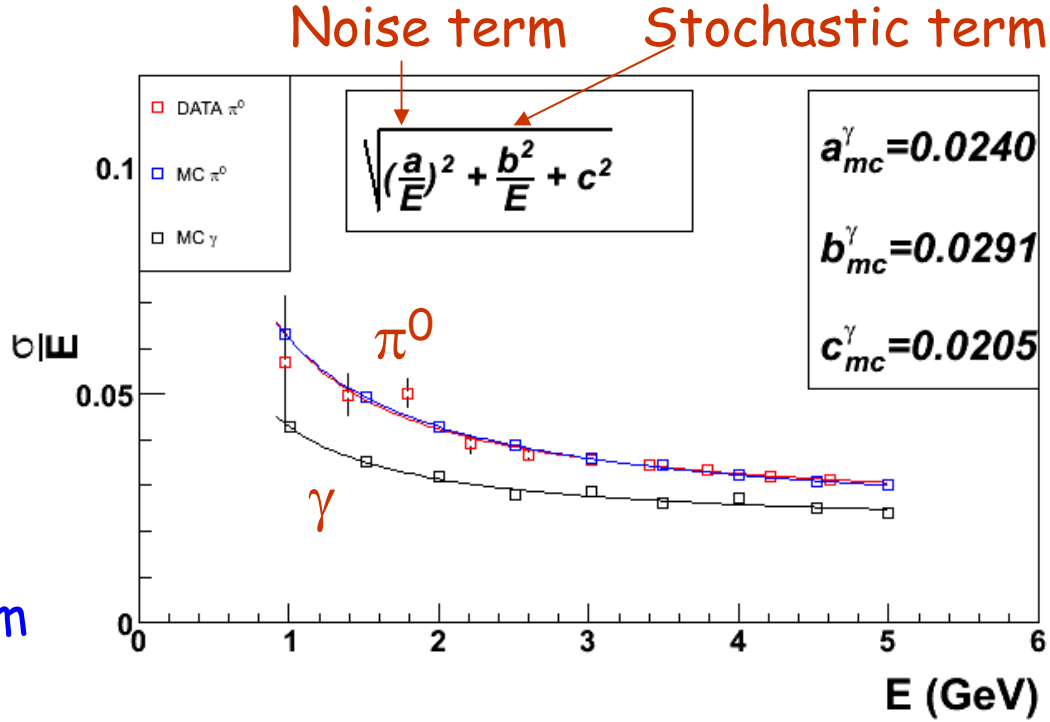
6 special π^0 calibration runs (no CLAS involved)

$\sigma_{M\pi^0} \sim 7.2$ MeV

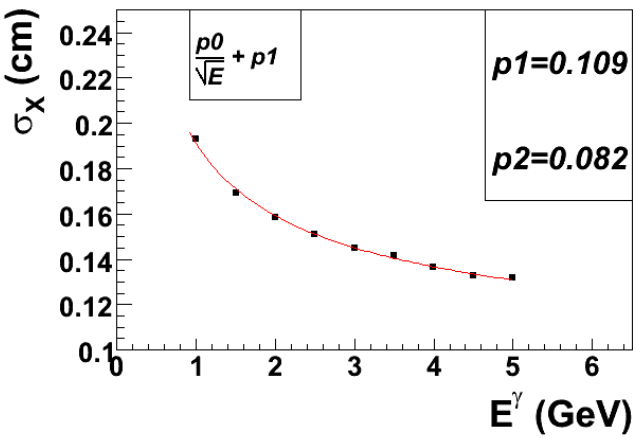
Comparable with $\sigma_E/E \sim 4\%$ at E_γ=1 GeV

IC Energy and Position Resolution

$\Delta E/E$ = 4% at 1 GeV



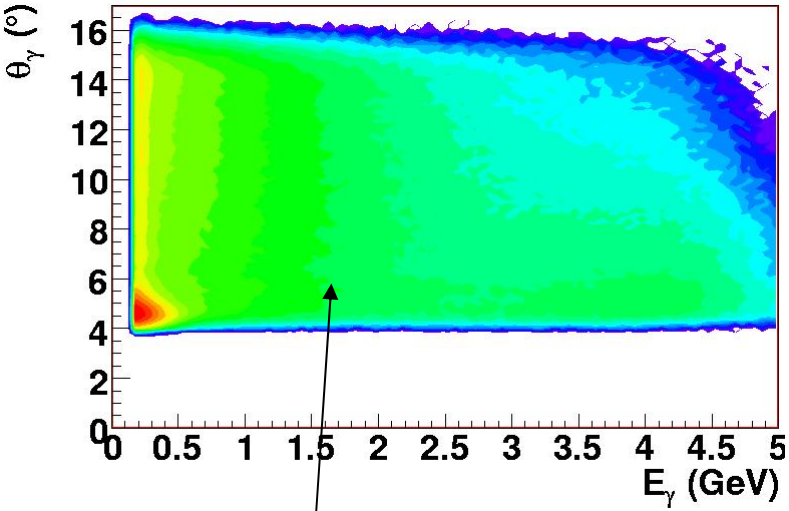
Position resolution – <2mm



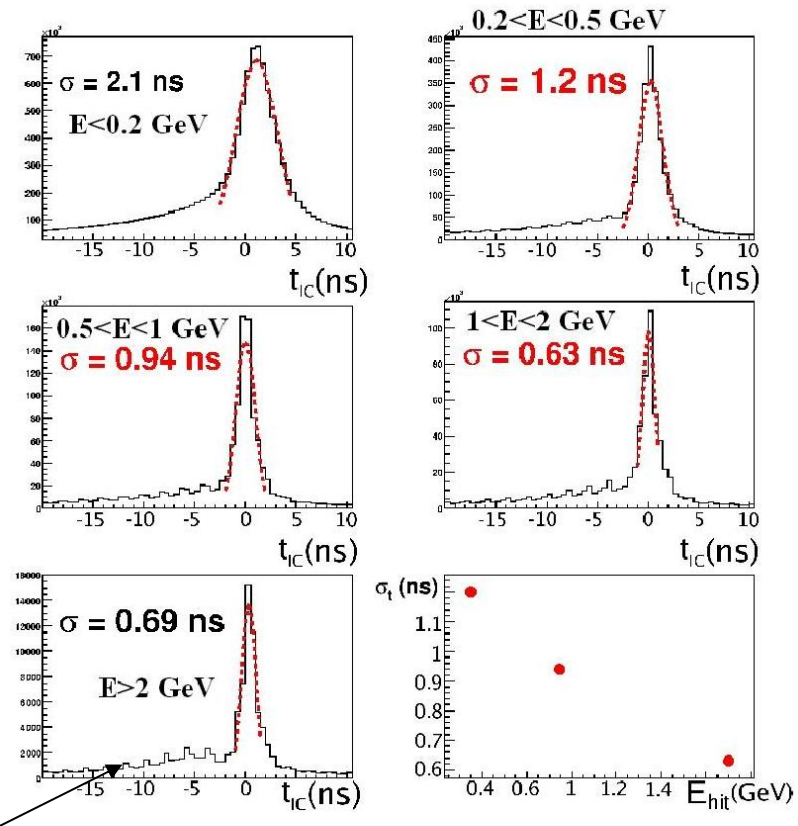
Noise & stochastic terms are consistent with expected values based on
- 7 MeV preamplifier noise and
- 2 phe/MeV photostatistics

IC Resolution Timing

- ✓T_0 time corrections
- ✓Vertex time corrections
- ✓Time walk corrections



Very few accidentals with good electron trigger

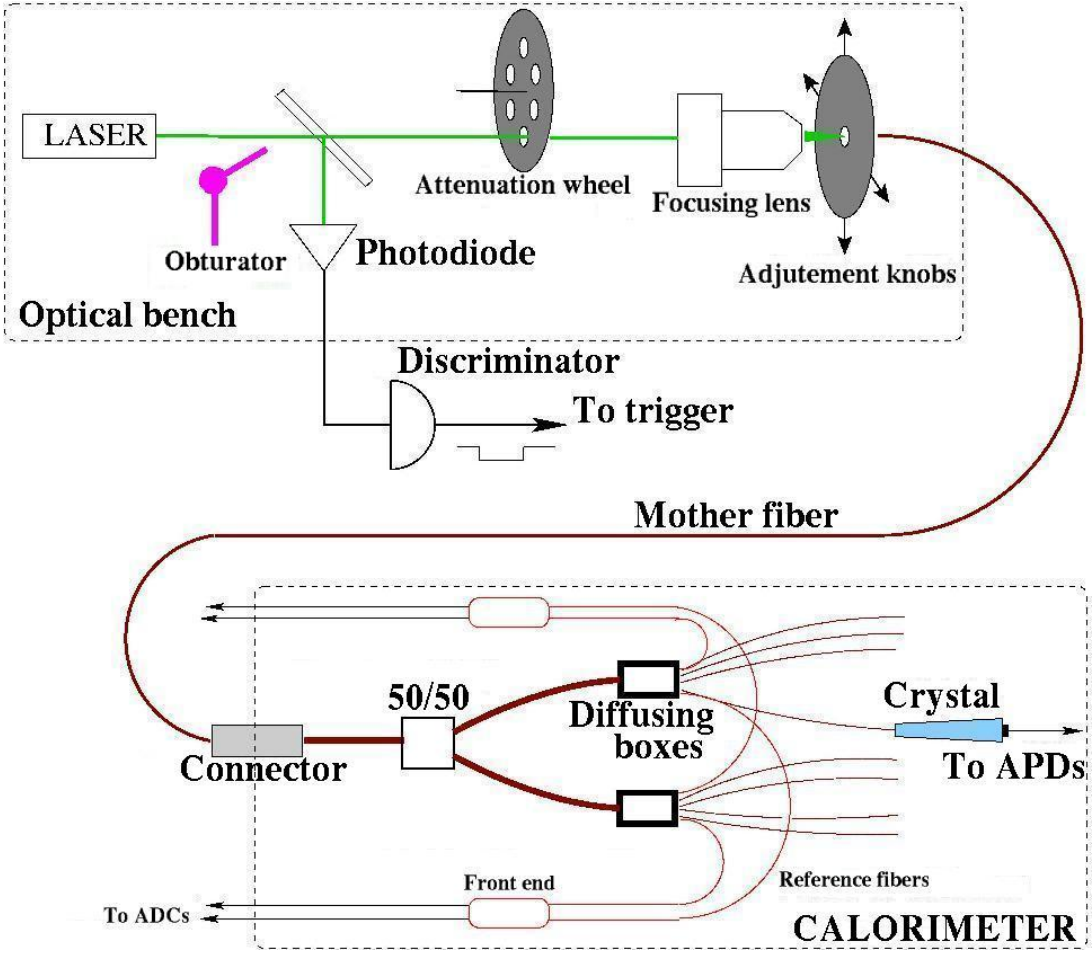


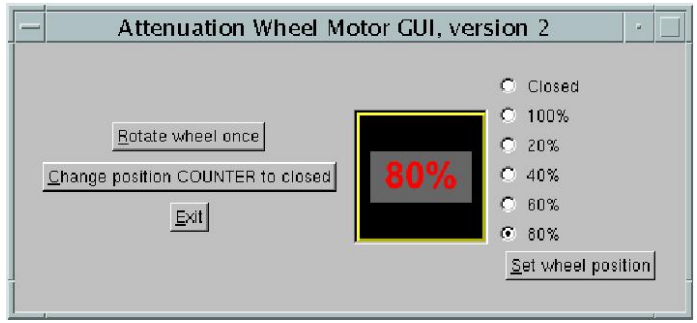
Beam packet structure

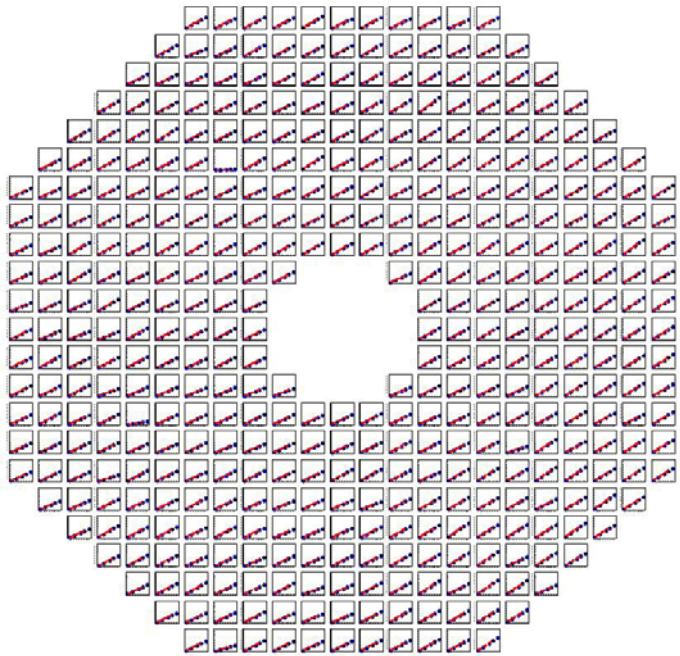
Time spectra for several deposited energy bins

Higher the energy – better resolution and lower background

Laser Monitoring System

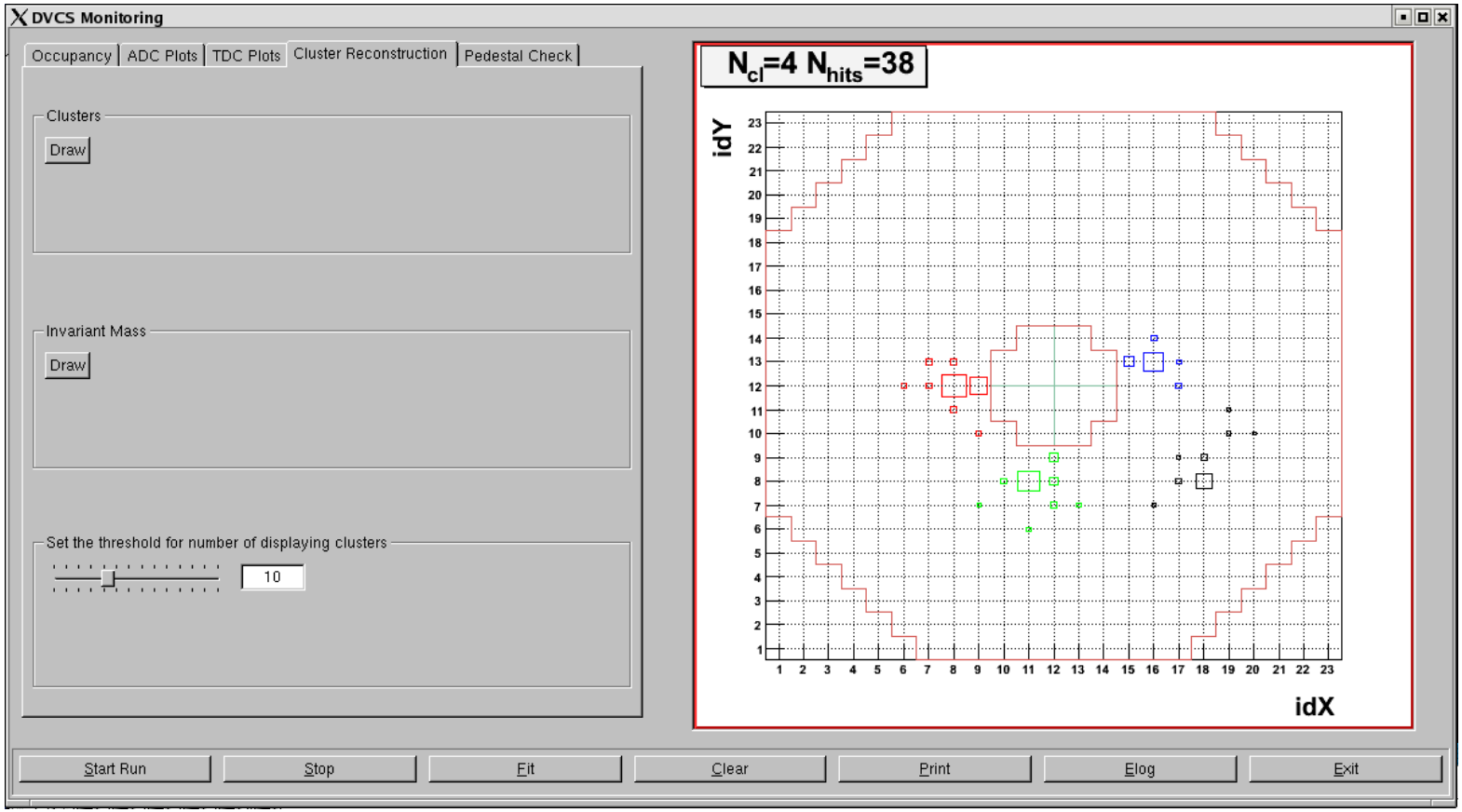






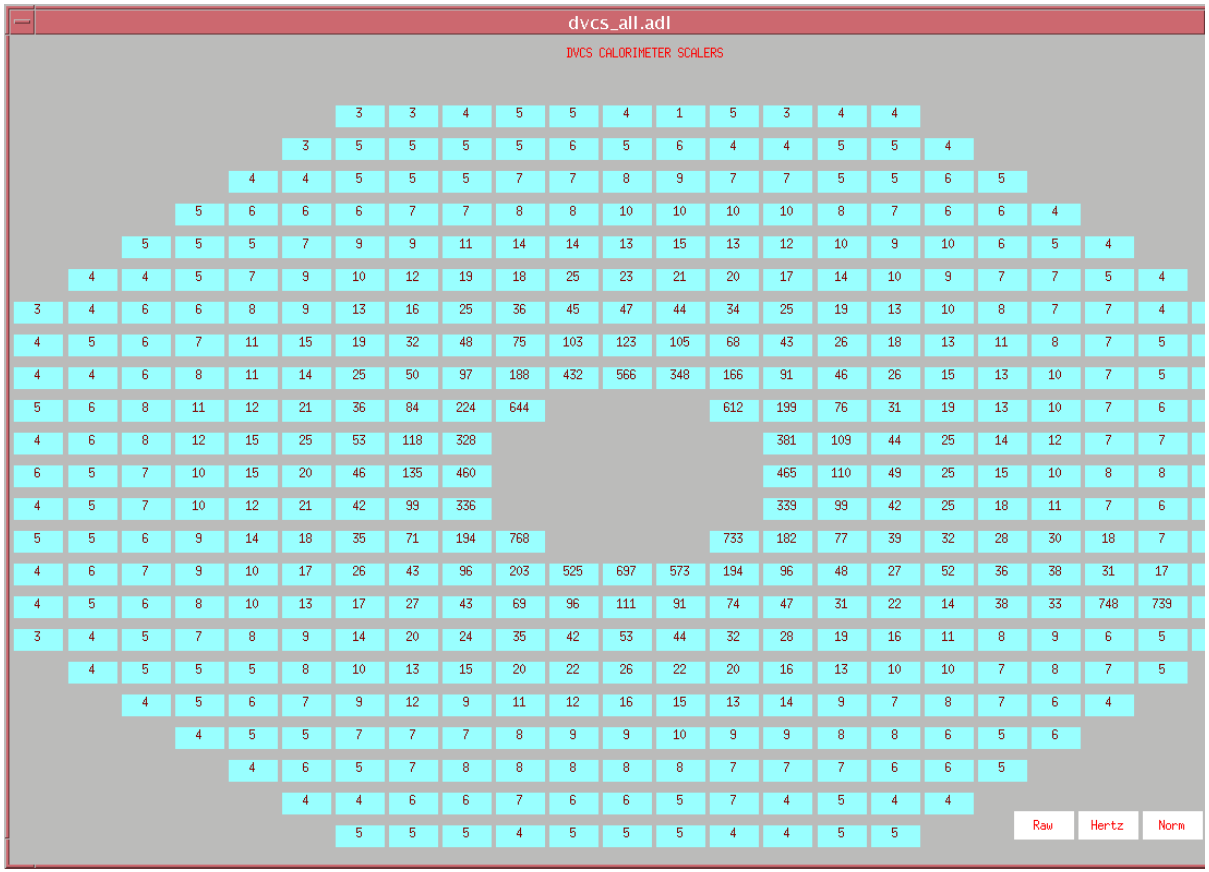
Linearity checks and gain monitoring during the run

IC Monitoring



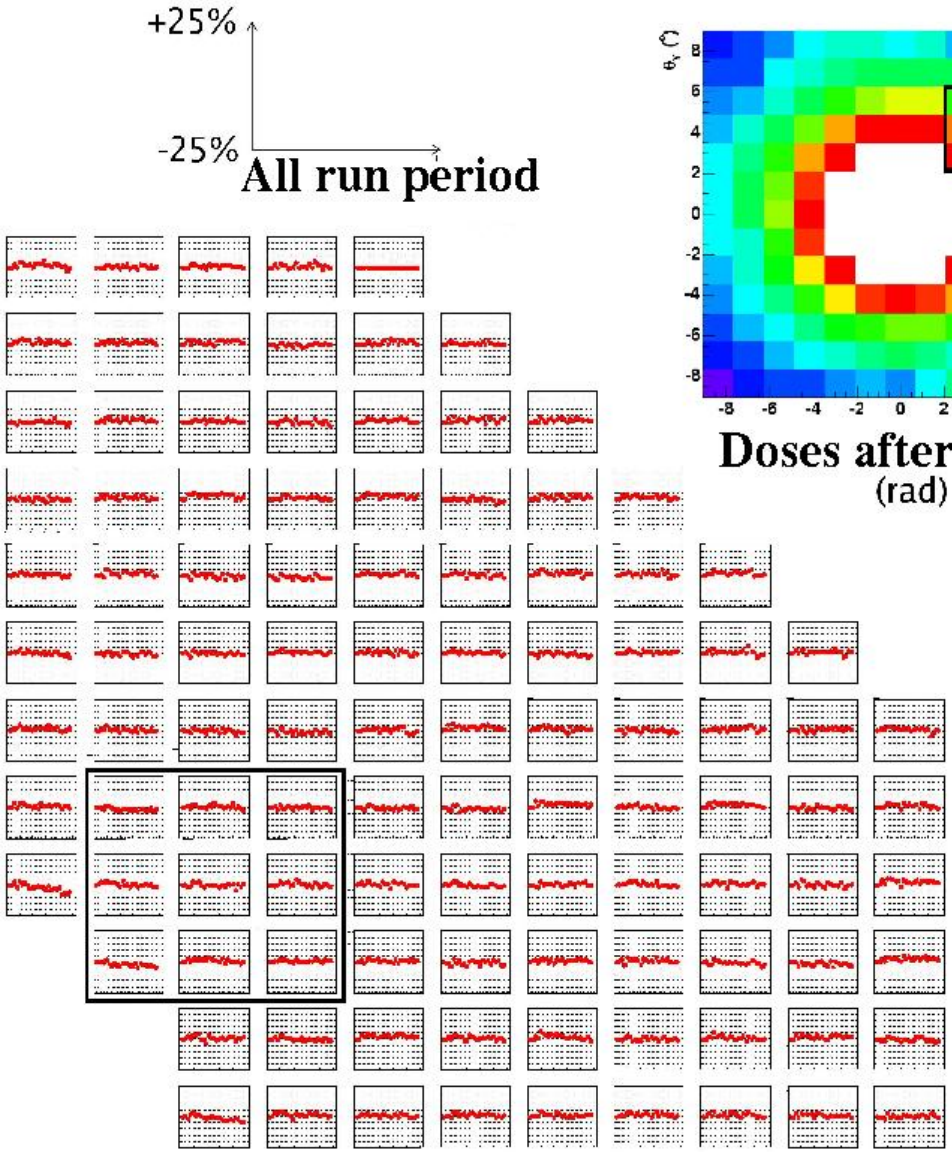
Monitor channel occupancy, ADC,TDC,cluster reconstruction

IC Monitoring



IC Scalers

Radiation Doses in IC



Doses derived from pedestal runs with beam ON

Agrees with Møller electron simulation

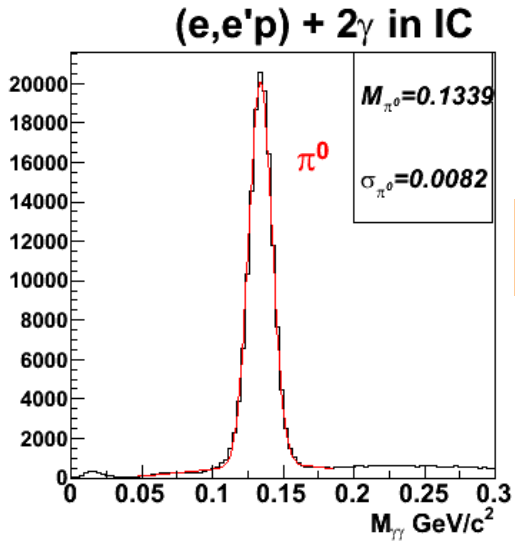
The light output of the crystals depend on dose rate and accumulated dose.

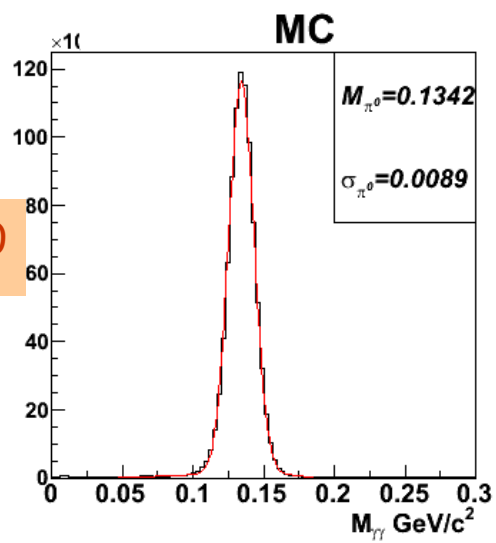
← Relative gains from LMS
For the whole run period

No damage from radiation found

π^0 and η Reconstruction in IC

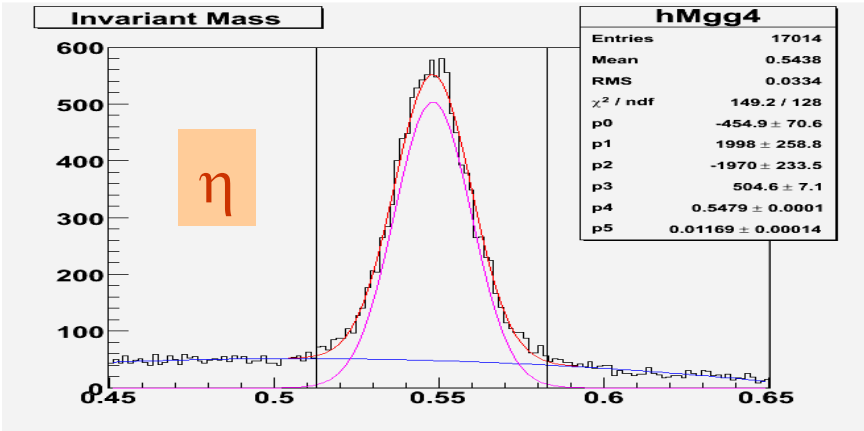
Invariant Mass of two photons





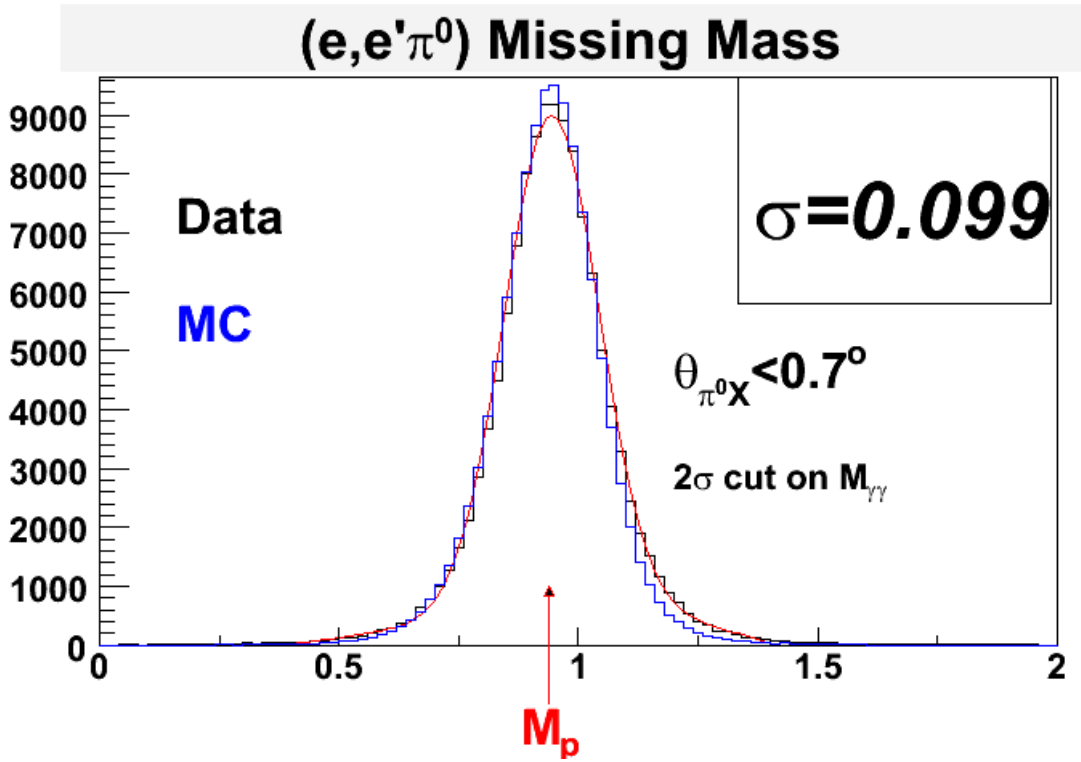
π^0

8 MeV sigma



12 MeV sigma

CLAS+IC Measurements



Match Data and Simulation proton peak

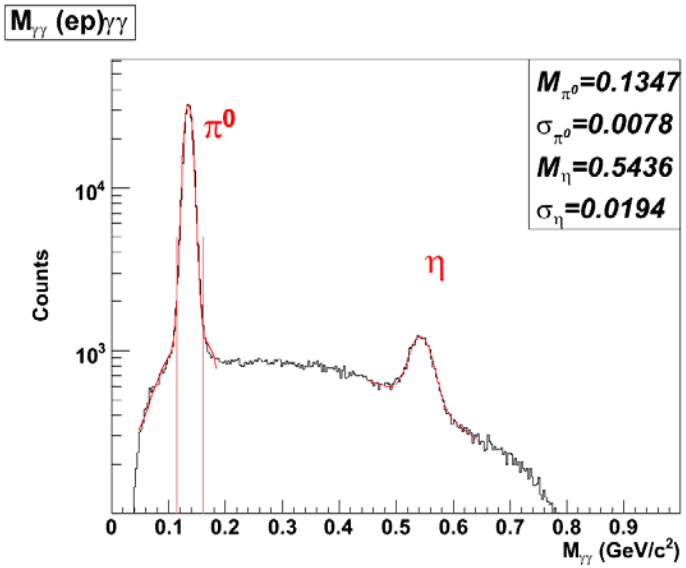
select $e\pi^{\upsilon}p$

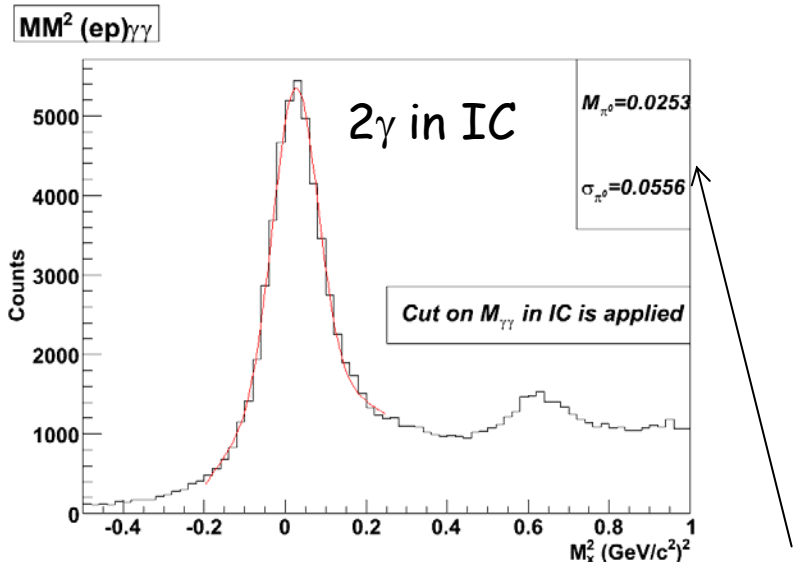
Clean Proton peak

Summary

- IC Performance was very good during the run
  First functional $PbWO_4$ calorimeter with APD readout
  Resolution is better than anticipated
- DVCS, π^0 and η BSA results were already reported
  Cross-sections are still in progress
- Will be used in the second part of the e1-dvcs run + several new experiments were already approved
  ER-07-009 Meson Spectroscopy in the Coherent Production on 4He with CLAS
  ER-05-113 Semi-Inclusive Pion Production with Longitudinally Polarized Target at 6 GeV
  ER-05-114 DVCS at 6 GeV with Polarized Target and Polarized Beam using the CLAS
- Calorimeter may be used in conjunction with polarized target

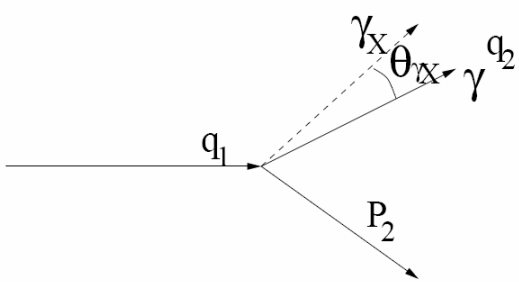
CLAS+IC Measurements

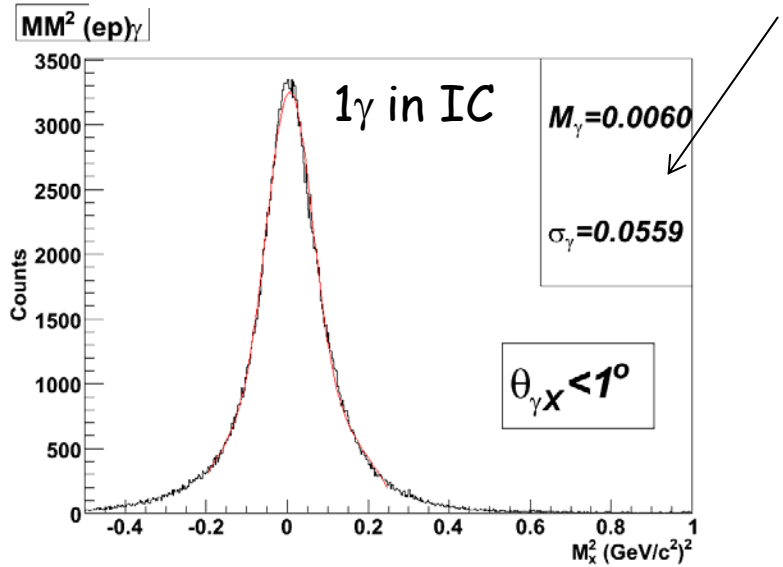




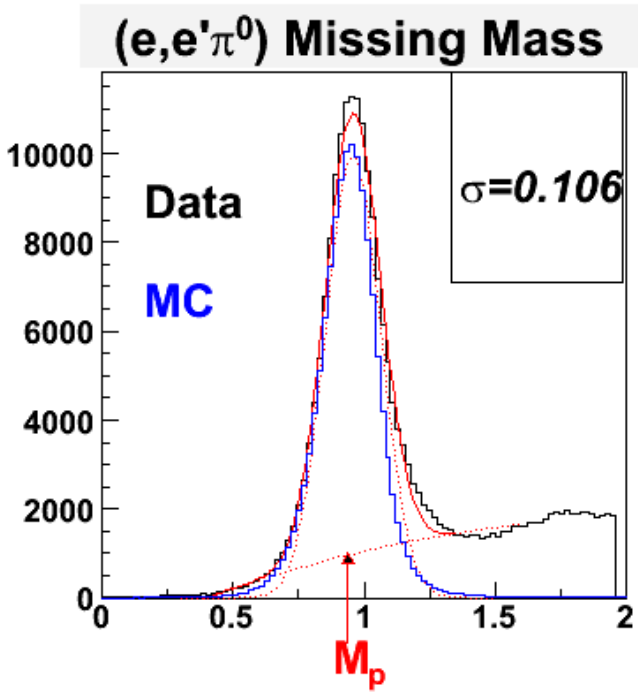
Consistent peak position and width

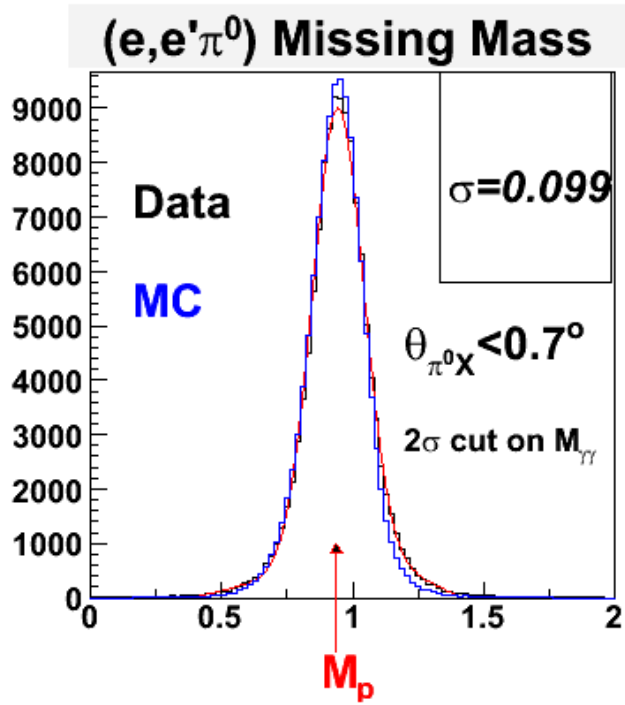
Cut on direction of the measured photon to select epγ





CLAS+IC Measurements





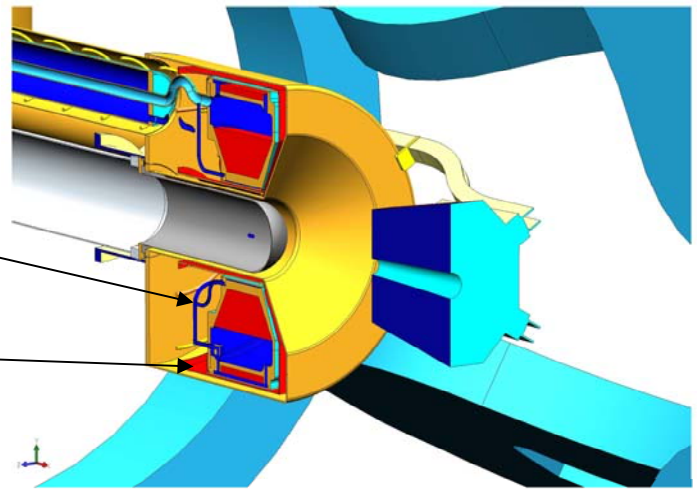
Cut on direction of the measured π^0 to select $ep\pi^0$

The Superconductive Solenoid

- ✓ Magnetic shielding of the Møller electrons

Superconductor solenoidal magnet:

- ✓ Cu+Nb/Ti composite at 4.3 K
- ✓ Original cryogenic system
- ✓ Additional coil to compensate fringe field



Average field at the target location - 4.5 T at 534 A