# CLAS12 PCAL/EC

Settings – Calibration - Performance Status and Plans

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### **Energy Calibration: Minimum Ionizing Cosmic Muons**

- Use pixel cut to define normal incidence muon track on a single pixel (U,V,W intersection).
- Measure MIP energy vs pixel readout distance to obtain gain (A+C) and attenuation (B,C) parameters.
- MIP energy = 10 MeV (PCAL,ECi) 16 MeV (ECo).
- High statistics cosmic muon runs were taken in weeks prior to ER-A.



#### **ECAL HV Adjustments**

# **Final Adjustments to EC HV**

Lognumber 3496037. Submitted by lcsmith on Thu, 11/23/2017 - 17:51.

Last updated on Thu, 11/23/2017 - 17:58

Logbooks: HBECAL

PMT HV for ECAL sectors 1-6 was adjusted using cosmic muon pixel trigger data from Run 1574. Plot below from Run 1577 shows measured MIP energy per pixel for U,V,W layers of inner and outer portion of ECAL (not corrected for light attenuation). Nominal MIP energy per layer is 10 MeV and 16 MeV in inner and outer respectively.



#### **CCDB Updates**

Lognumber 3496957. Submitted by lcsmith on Tue, 11/28/2017 - 13:10. Last updated on Tue, 11/28/2017 - 23:09

Logbooks:

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Following databases are being updated:

/calibration/ec/attenuation

/calibration/ec/gain

11/28 13:00 - EC (inner,outer) entries were updated using cosmic run 1586 after EC HV adjustments following run 1574. Note Hall B dome lights were turned off for run 1586.

11/28 22:23 - PCAL entries were updated using run 1419 except for sectors 1 and 4.

## Quick checks on calibration uniformity

EC: Dalitz sum





#### PCAL: MIP cluster reconstruction

**Final CCDB energy calibration** 

constants loaded on Nov. 28

## **Optimization of fADC and TDC Settings**

- Start of Engineering Run
  - fADC TET=20 bits fADC window=100 samples TDC threshold = 1 mV
  - PCAL energy threshold ~10/150\*10 MeV = 0.67 MeV
- Dec 17 2017
  - Run 2128: TET raised from 20 to 60. PCAL energy threshold ~30/150\*10 MeV = 2 MeV.
- Feb 14 2018
  - Run 3203: Reduce fADC window 100 samples -> 74 samples.

Reduce TDC window from 800 ns to 500 ns.

Run 3204: fADC window time offset changed by 10 samples (7608 uS to 7568 uS).

TDC timing shifted in Sector 2 by 40 ns to match other sectors.



## Spot Checks of MIP Calibration using Cosmic Runs



100

0.4

10 15 20 25 30

10 15 20 25 30 35

Vinner PMT



#### ECAL Cosmic Run 3231

Lognumber 3532676. Submitted by lcsmith on Fri, 02/16/2018 - 00:26. Last updated on Fri, 02/16/2018 - 01:37

Logbooks:

#### HBECAL HBLOG

Config: FC Trigger: EC/trigger\_lcs.trg (ECInner Cluster) Started: Feb 15 20:59 Ended: Feb 15 01:35 Event Rate: 1632/s Data Rate: 12 MB/s

- Sporadic changes in PMT gains, origin unknown.
- Attenuation measurements mostly stable.
- No systematic or follow up studies possible due to long duration required.

#### **Calibration Run 2109 – PION MIP Cluster Reconstruction in PCAL**



#### **Calibration Run 2109 – PION MIP Cluster Reconstruction in PCAL**



### Reconstructed Energy vs Strip Number in PCAL Negative Pions (top) Positive Pions (bottom)



# **FTOF Based MIP trigger**

- FTOF x PCAL x ECAL (10 MeV)
- S1 and S4 only (for PCAL).
- Prescale 2^9
- Rate 130-160 Hz at 38 nA

Results were suspicious due to non-uniform distributions of events and suggestion of non-MIP energy deposition at large angles (protons?).

Menu CLAS12 VTP Trigger 02/20/2018 04:06:42							
B	eam Current 37.6 nA	Alarm 1-6: FT:	s NO_ALARM NO_ALARM	1-6 Tolerance:	0.4 9 Hear	etime 4.0 % rtbeat: 🔵	
Dit	Description		Totals (Hz) 363250	13971 Proscoled (Hz)	Fraction (%)	Broscolo	ln Tatala
0	Electron - OR of 1	-6	6276	6276	44.0	0	
1	Sector 1	_	914	914		0	
2	Sector 2		1023	1023		0	
3	Sector 3		1130	1130		0	
4	Sector 4		1187	1187		0	
5	Sector 5		1188	1188		0	
6	Sector 6		866	866		0	
7	FTOFxPCALxECAL	S1	32177	125	0.9	9	
8	FTOFxPCALxECAL	S4	40040	156	1.1	9	



#### Sector Dependence of Pi-Zero Reconstruction

Lognumber 3515385. Submitted by lcsmith on Wed, 01/17/2018 - 10:41. Last updated on Wed, 01/17/2018 - 10:46

Logbooks:

CLAS12ANA

#### PCAL/EC Pizero Invariant Mass vs Sector

- Based on cosmic muon MIP calibrations from Nov. 2017
- From calibration run 2319 (not recalibrated).
- Mostly low energy pizeros (E1\*E2 < 2 GeV).</li>
- Requires matched neutral clusters in PCAL/EC, no MIP in FTOF.
- Low mass in Sector 1 probably due to poor muon based calibration for PCAL.
- Currently evaluating effect of EM background noise on pion MIP calibrations needed to improve PCAL gain/attenuation constants.



#### Sector and Momentum Dependence of Total Sampling Fraction E/P



Run 3222 (Out-bending)

# **Summary of Gaussian Fits to Outbending Sampling Fraction**



Decreased SF with large momentum seems unlikely for outbenders.

Problem with high momentum reconstruction?



- Sector 2
- Sector 3
- Sector 4
- Sector 5
- Sector 6

Resolution (sigma) should drop by factor of  $sqrt(10/2)^{\sim} 2.2$  over this energy range

#### Sector and Momentum Dependence of Total Sampling Fraction E/P



Run 3432 (In-bending)

#### Sector Dependence of PCAL Sampling Fraction EPC / P vs. Detector Theta



Run 3432 (In-bending)





## **Spatial Distribution of Total Sampling Fraction**

- Net effect of LTCC causes loss of SF at edges of S2,3,5,6.
- For all sectors boundary of usable SF clearly evident.



# Spatial Distribution of PCAL Sampling Fraction

- Electrons do not interact with LTCC sidewalls. No edge effects visible.
- Fiducial cuts may be unnecessary for outbending e-.
- Lower PCAL SF in forward regions probably due to higher e- energy.



## Spatial Distribution of Total Sampling Fraction

- Impressive uniformity with exception of several miscalibrated PMTs.
- High spatial resolution of PCAL should be exploited to precisely define fiducial cuts for electron and photon acceptance.



Out-bending



Out-bending



Out-bending



**Out-bending** 



**Out-bending** 



Out-bending

# Summary and Future Plans

- Spot checks of PCAL/EC energy calibration using cosmic runs and various trial MIP triggers have been performed during ER-A,B and RG-A. Code to perform pass0 runbased calibration analysis currently being developed.
- MIP calibration appears mostly stable when using standard low threshold cluster or pixel triggers.
- Systematic shifts in S1 and S4 not consistent with other MIP triggers are seen using FTOF.PCAL.ECAL trigger. There are S2 and S3 trigger data yet to be analyzed.
- Both pizero and e- reconstruction look reasonable, validating the use of MIP based energy calibration. Luminosity studies and investigation of systematics of using beam data vs. cosmics to monitor calibration are in progress.
- Final calibration of PCAL S1 and S4 may require special calibration trigger runs, possibly with lowered torus field to permit small angle penetration of tracks.
- Reconstruction of cluster timing using fADC and TDC data requires modification of EC reconstruction engine (hit matching, calibration constants). This is planned to occur before pass0 cooking begins. Josh Tan will perform the timing calibration.