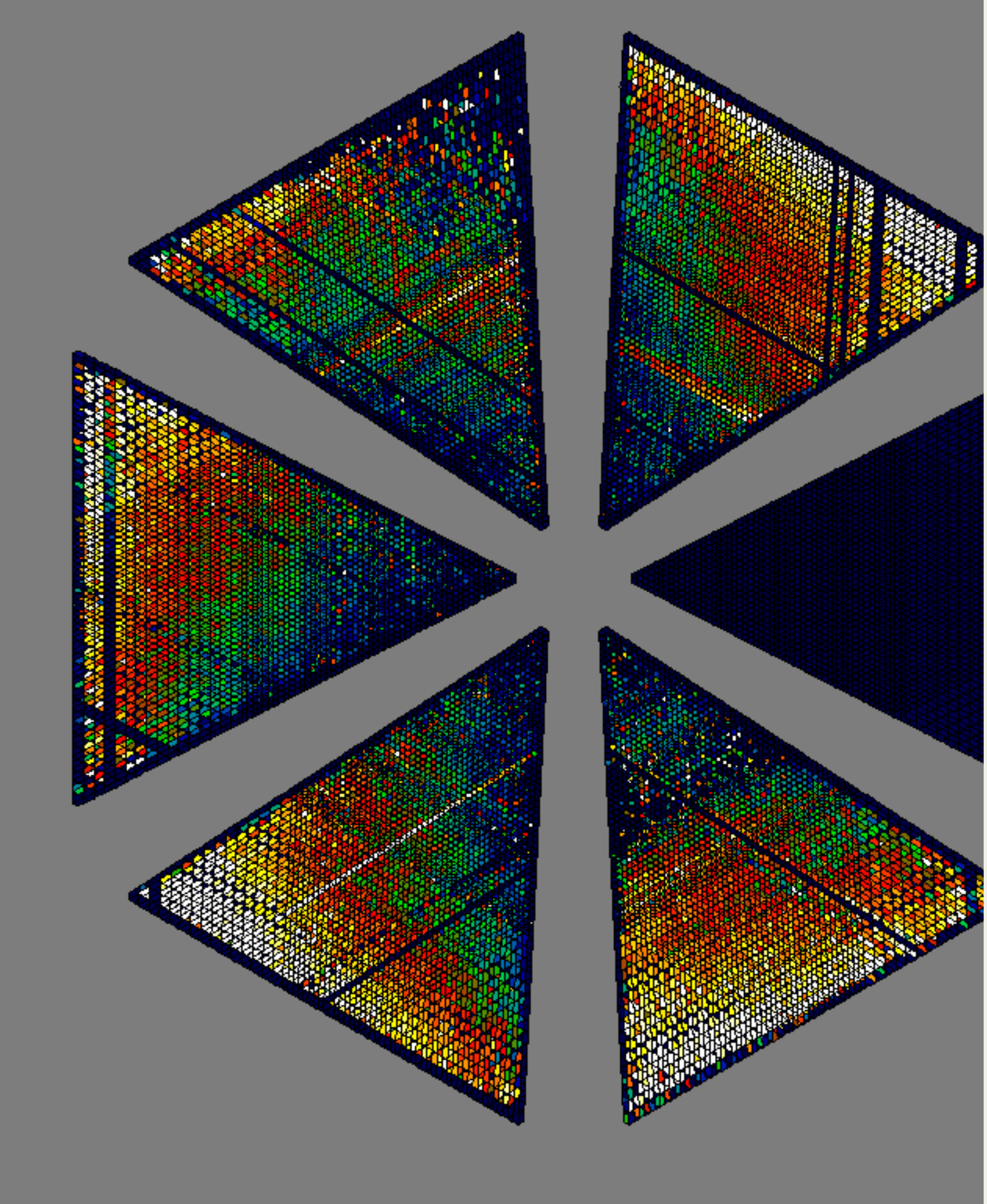


ECAL Status

Cole Smith

Contributors

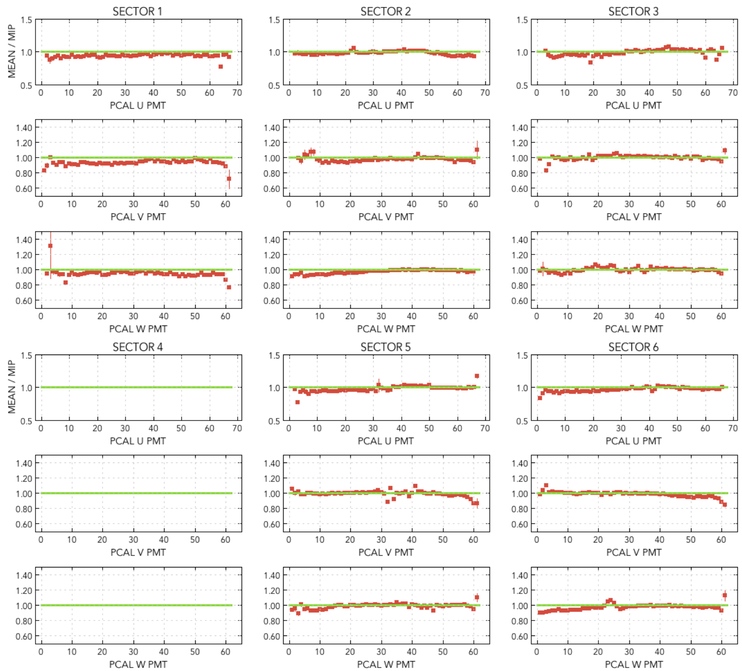
Taya Chetry
Nick Compton
Andrey Kim
Josh Tam

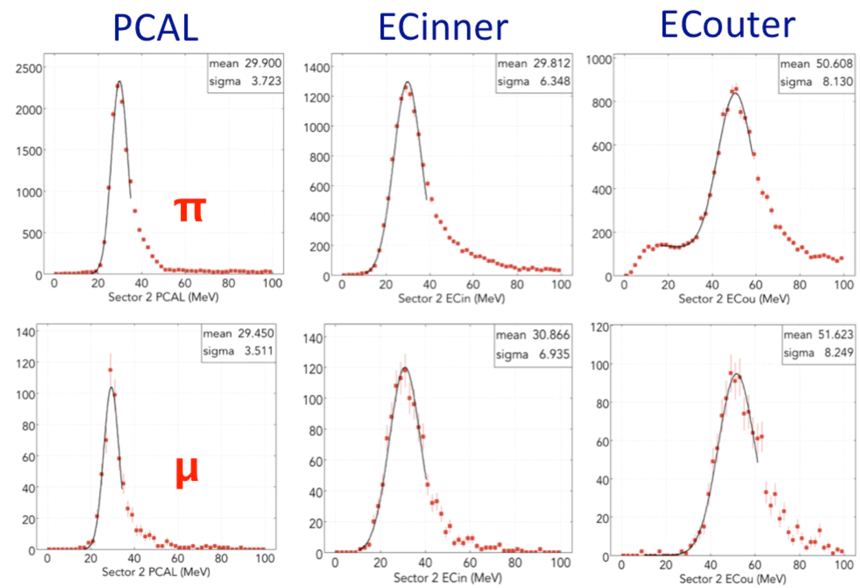
CLAS 12 Workshop
June 13 2017

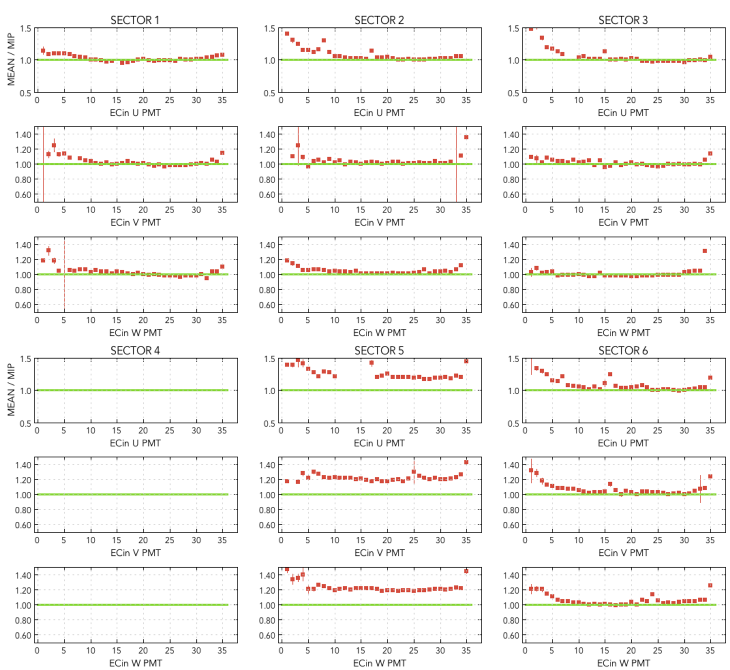
Outline

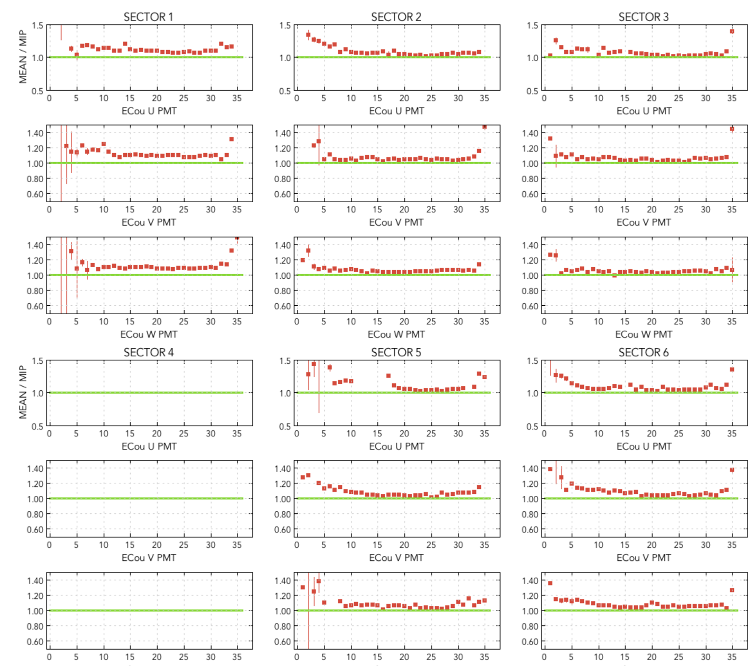
- KPP Triggers and Thresholds
- KPP Sector 1 New EC Calibrations (Pass 5)
- ECMON Monitoring GUI: New Features
- Remaining Work

KPP RUN 761 PION CLUSTER ENERGIES (PASS 5)









Summary of ECAL Triggers

- Hit-based: DISC based, PCAL strips, U.V, Nu=Nv=1.
  - Used for cosmic muon calibration runs since 2014.
  - Prior to April 2017 Sector 1 used EC U.V.W Nu=Nv=Nw=1 (thresholds were too high!)
  - After April 2017 all sectors use identical PCAL based trigger.

- Cluster trigger: FADC based, PCAL+EC, energy and position reconstruction.
  - Ultimately will provide total energy trigger for CLAS12
  - EC Inner cluster tested in KPP with various thresholds (Sector 1,5 thresholds too high!).
  - Trigger timing in KPP was determined from W strip (latest, max energy?).
  - Did not use most current attenuation constants.

- Pixel trigger: FADC based, PCAL+EC, single pixel, no energy corrections.
  - Used to increase efficiency and reduce data rate for cosmic runs.
  - Study bias/efficiency/systematics of more complex cluster finding algorithm.

NOTE: Cluster trigger does not currently implement PMT gain factors. Therefore trigger hit and cluster thresholds must compensate for sector variations in overall gain. This was not done in KPP for Sectors 1 and 5.

RUN::config Sector Trigger Word

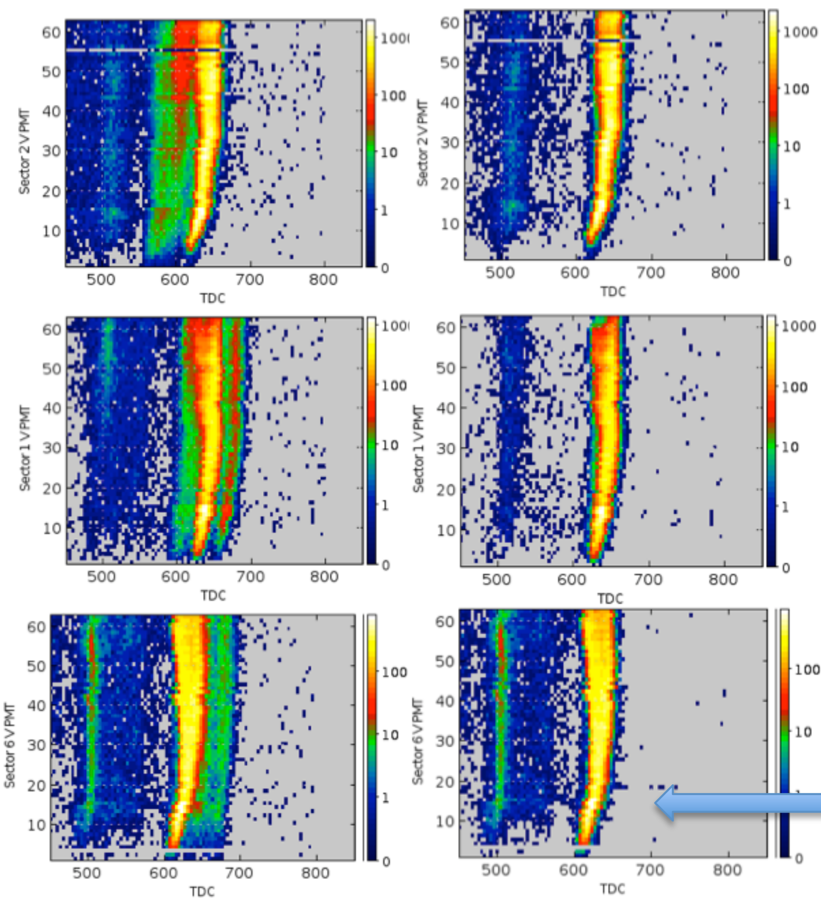
<bank content="bank" data_type="0xe" tag="37(0x0025)" padding="0" num="1" length="92" ndata="90">
<uint32 data_type="0x1" tag="57610(0xe10a)" padding="0" num="0" length="7" ndata="5">
0x39010004 0x1 0x1ae2a49e 0x5 0x1000000

Useful for rejecting contributions from other sector triggers

On first line, tag 37 is the trig1 Trigger Supervisor Crate header.
On second line, tag 57610 is the TS event data bank header.
On third line, TS event data. The last 32bit word is the trigger pattern:

32bit word 0: TI header
32bit word 1: event number (lower 32bits)
32bit word 2: trigger time (lower 32bits)
32bit word 3: 15:0=trigger time high, 31:16=event number high 16bits
32bit word 4: trigger bit pattern:
- 0x1000000 - sector 1 (really VTP_GT_TRGBIT 8 in trigger file)
- 0x2000000 - sector 2 (really VTP_GT_TRGBIT 9 in trigger file)
- 0x4000000 - sector 3 (really VTP_GT_TRGBIT 10 in trigger file)
- 0x8000000 - sector 4 (really VTP_GT_TRGBIT 11 in trigger file)
- 0x10000000 - sector 5 (really VTP_GT_TRGBIT 12 in trigger file)
- 0x20000000 - sector 6 (really VTP_GT_TRGBIT 13 in trigger file)

Trigger bit ignored　　　Trigger bit checked




```
if(event.hasBank("RUN::config")){
    DataBank bank = event.getBank("RUN::config");
    timestamp = bank.getLong("timestamp",0);
    trigger   = bank.getInt("trigger",0);
    evno      = bank.getInt("event",0);
    int phase_offset = 1;
    phase = ((timestamp%6)+phase_offset)%6;
    app.bitsec = (int) (Math.log10(trigger>>24)/0.301+1);
}
```

KPP: EC Inner Hit and Cluster Trigger Thresholds

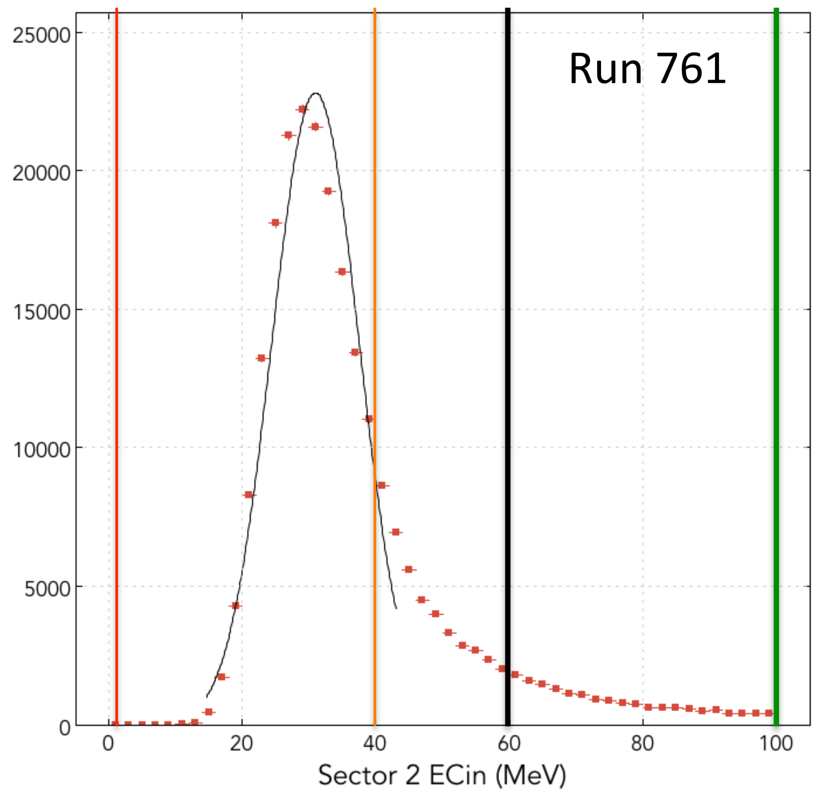
evio2xml cache/clas_000809.evio.0 | grep ECALIN_CLUSTER_EMIN

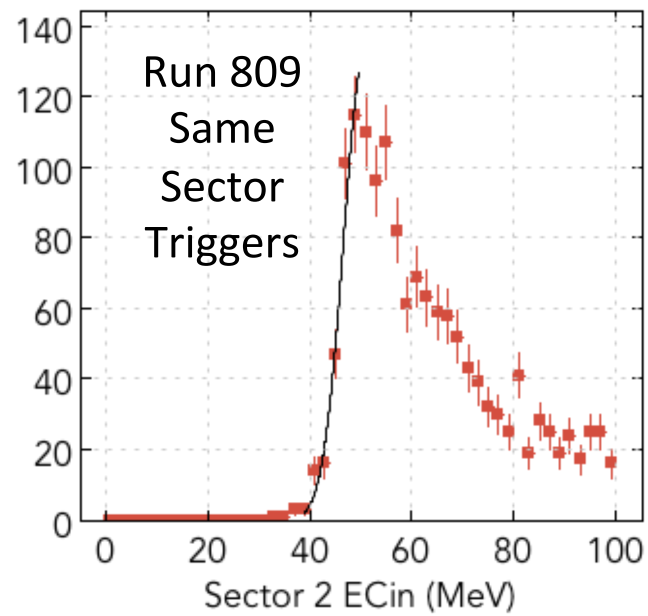
VTP_ECINNER_HIT_EMIN 100

SSP_GT_STRG_ECALIN_CLUSTER_EMIN 0 2000

Threshold (MeV) = EMIN x 2 / 100

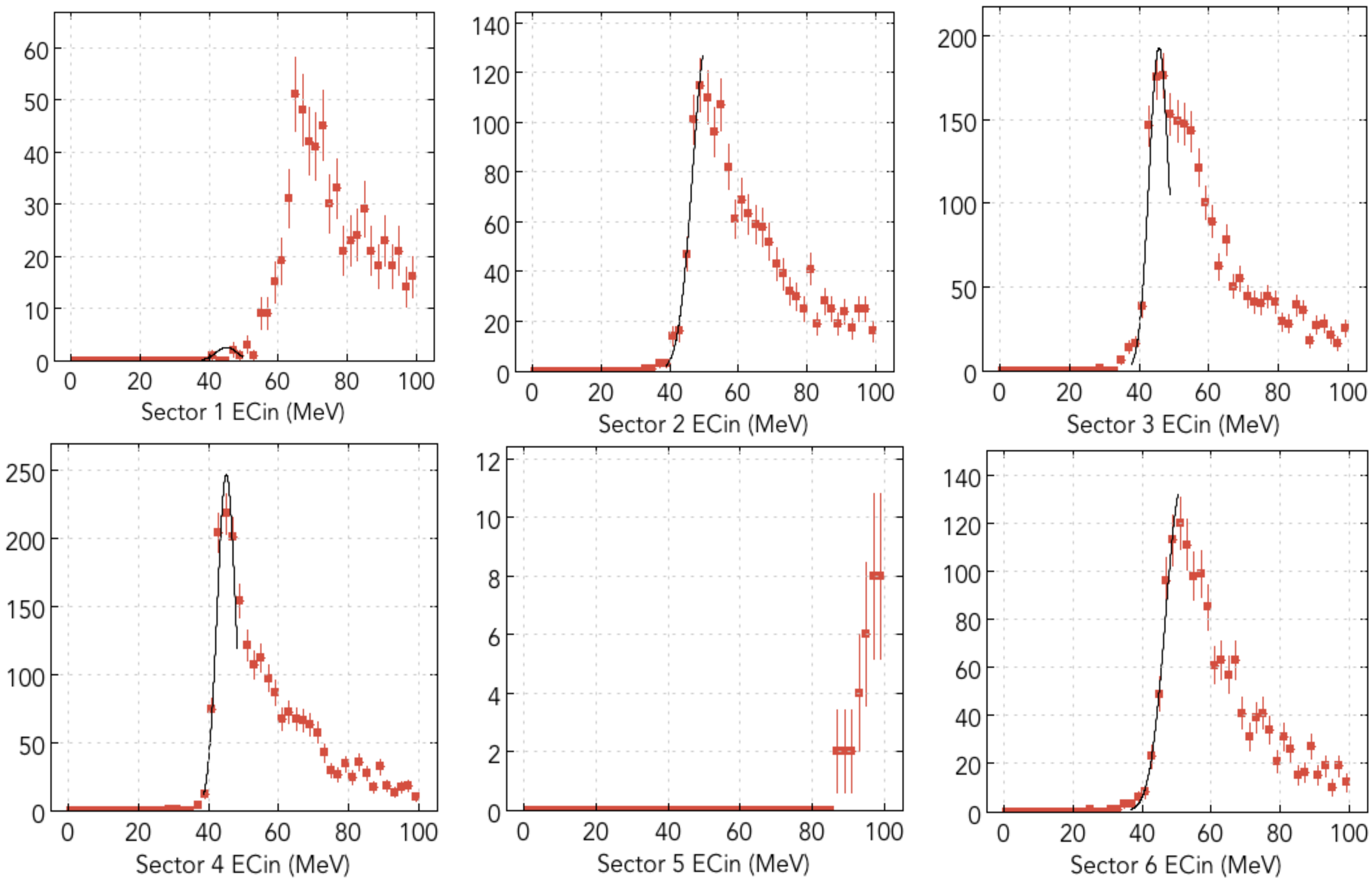
RUN	Threshold (MeV)
708-763	0-0.02
764	40
765	60
767	100
809-810	40



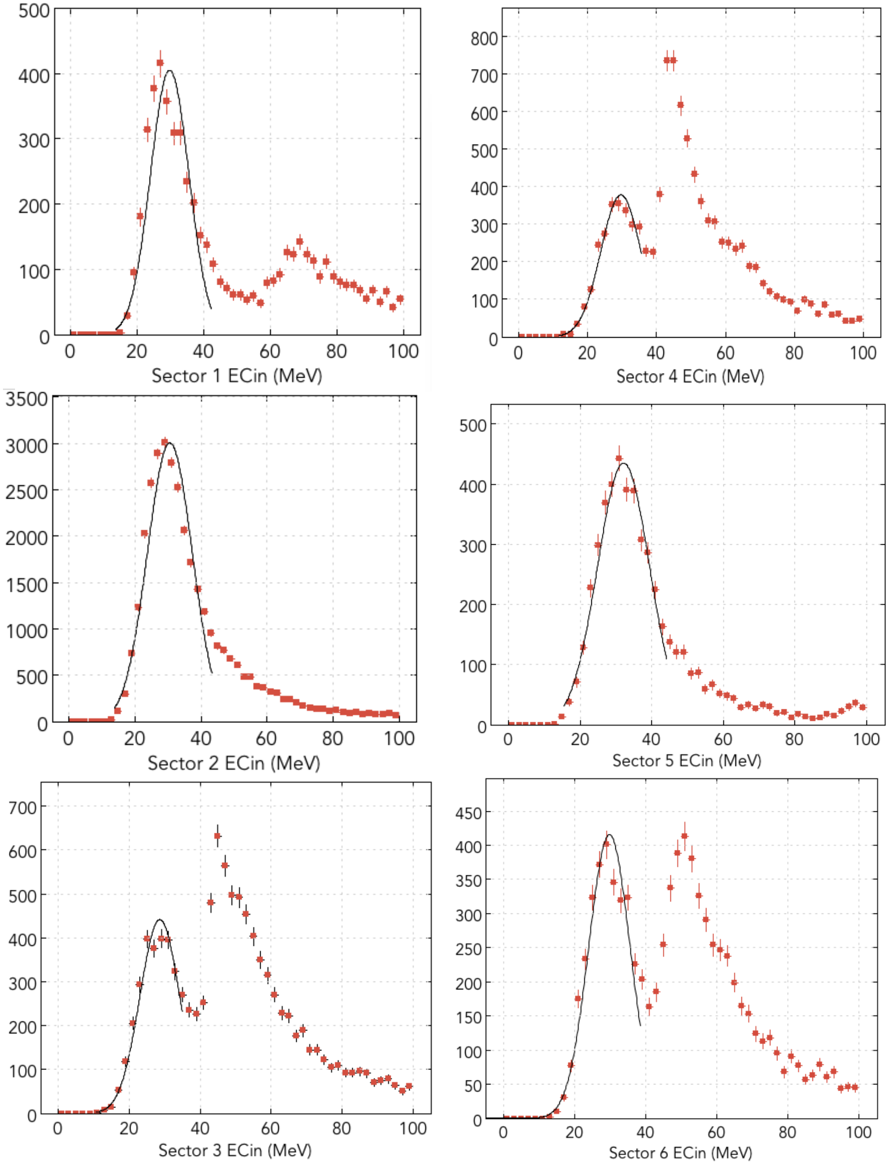


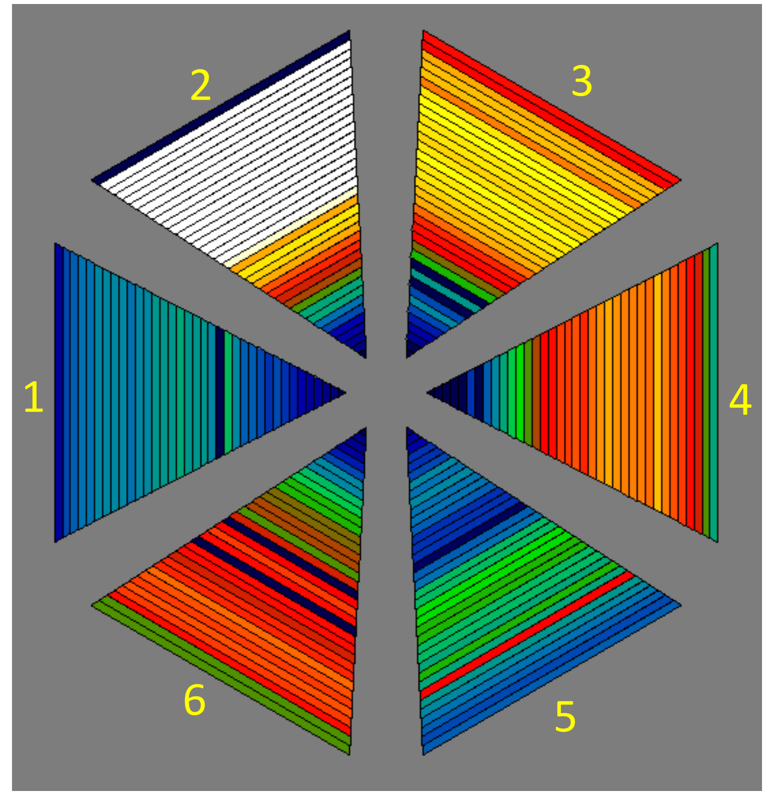
EC Inner Cluster Energies: Same Sector Triggers – Run 809

- Threshold shifts in S1 and S5 due to lower intrinsic PMT gains not compensated for in trigger cluster thresholds.



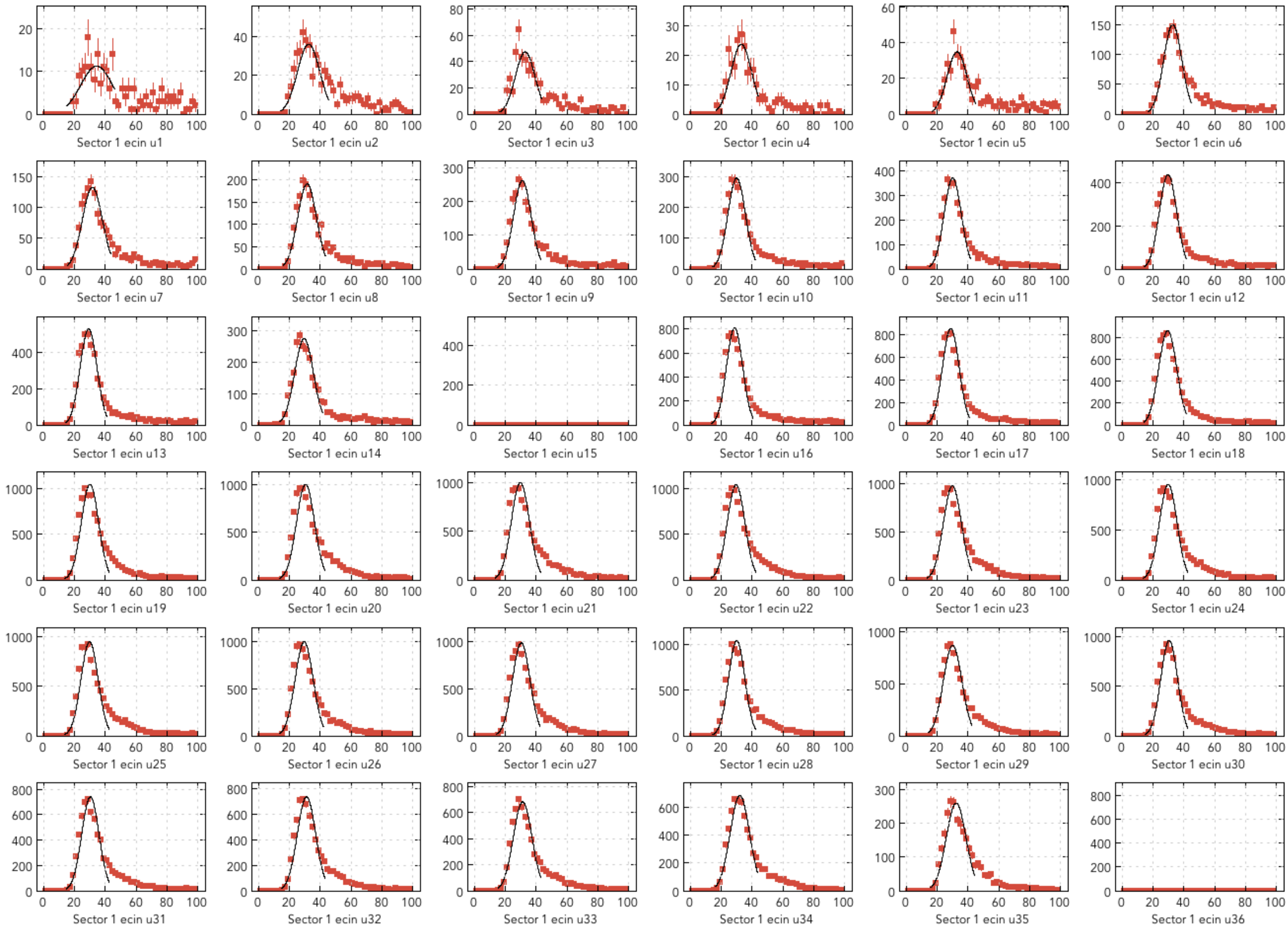
EC Inner Cluster Energies: All Sector Triggers – Run 809



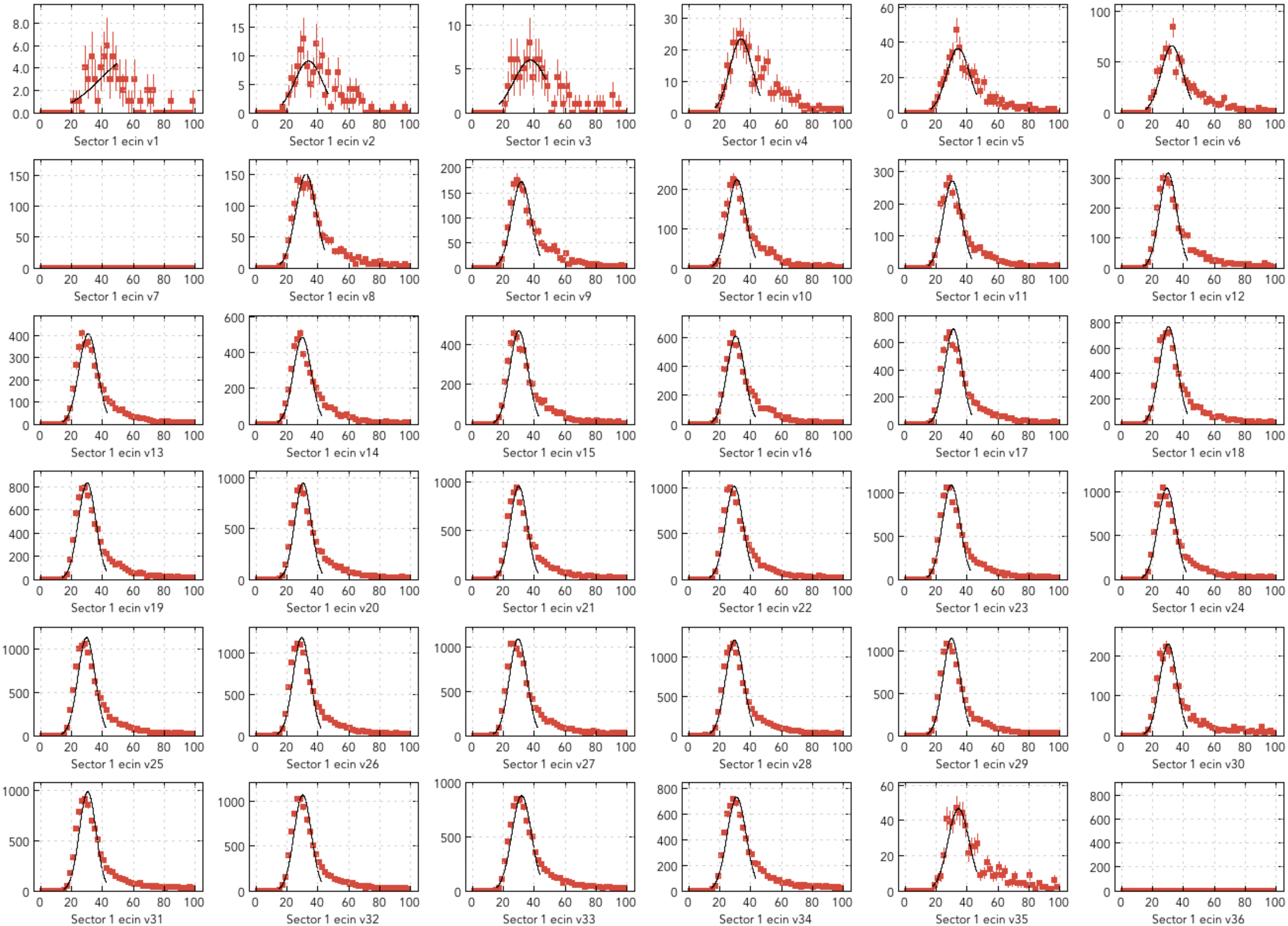


- Both cluster and hit-based trigger active in Sector 2, giving 7.5x cluster trigger rate.
- Other sector triggers (E<40 MeV) show MIP peak with overall equal yield. Suggests sector dependence of absolute yield may be small.

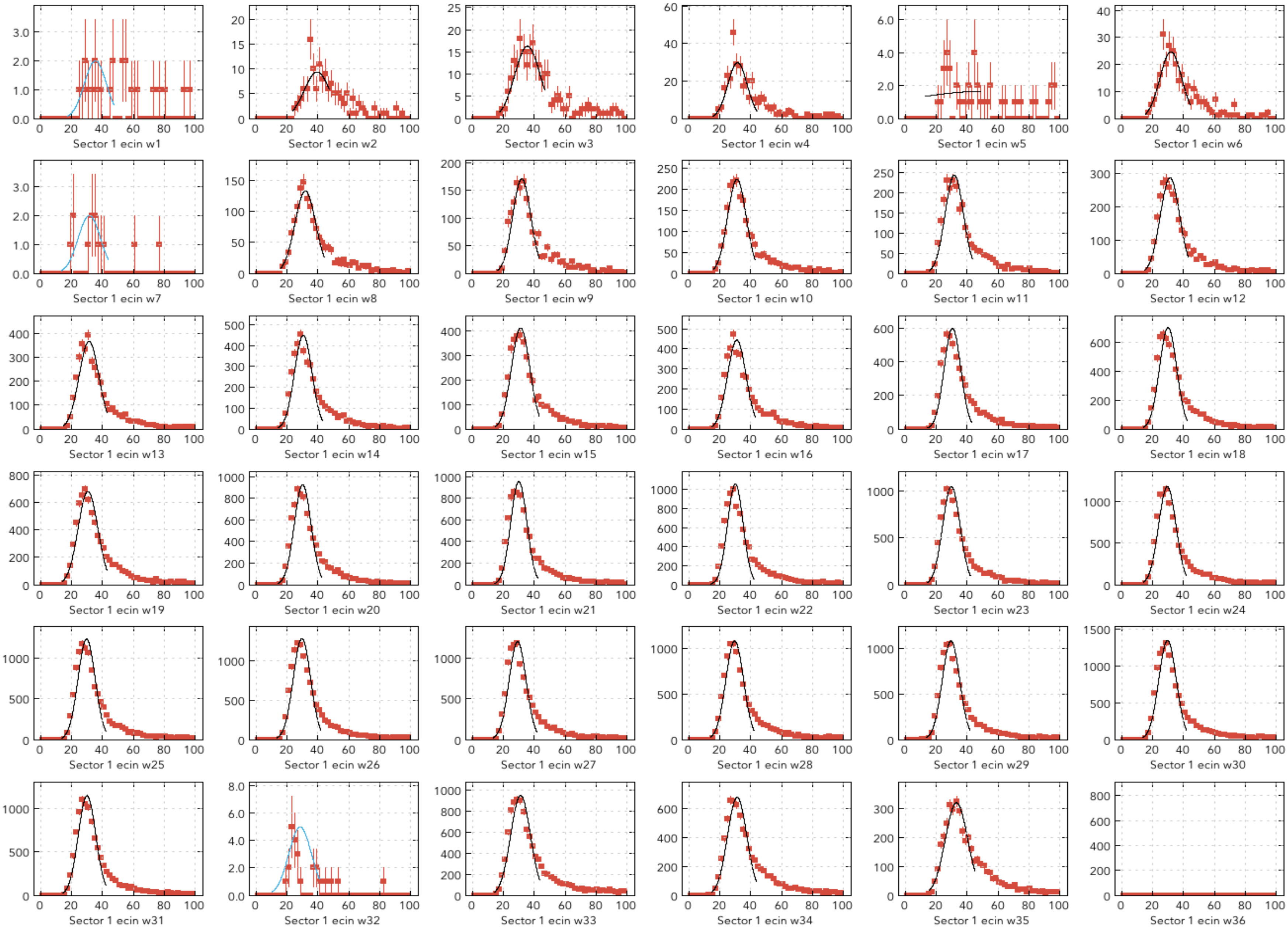
Sector 1 EC Inner Cluster Energy: U Strips (Pass 5)



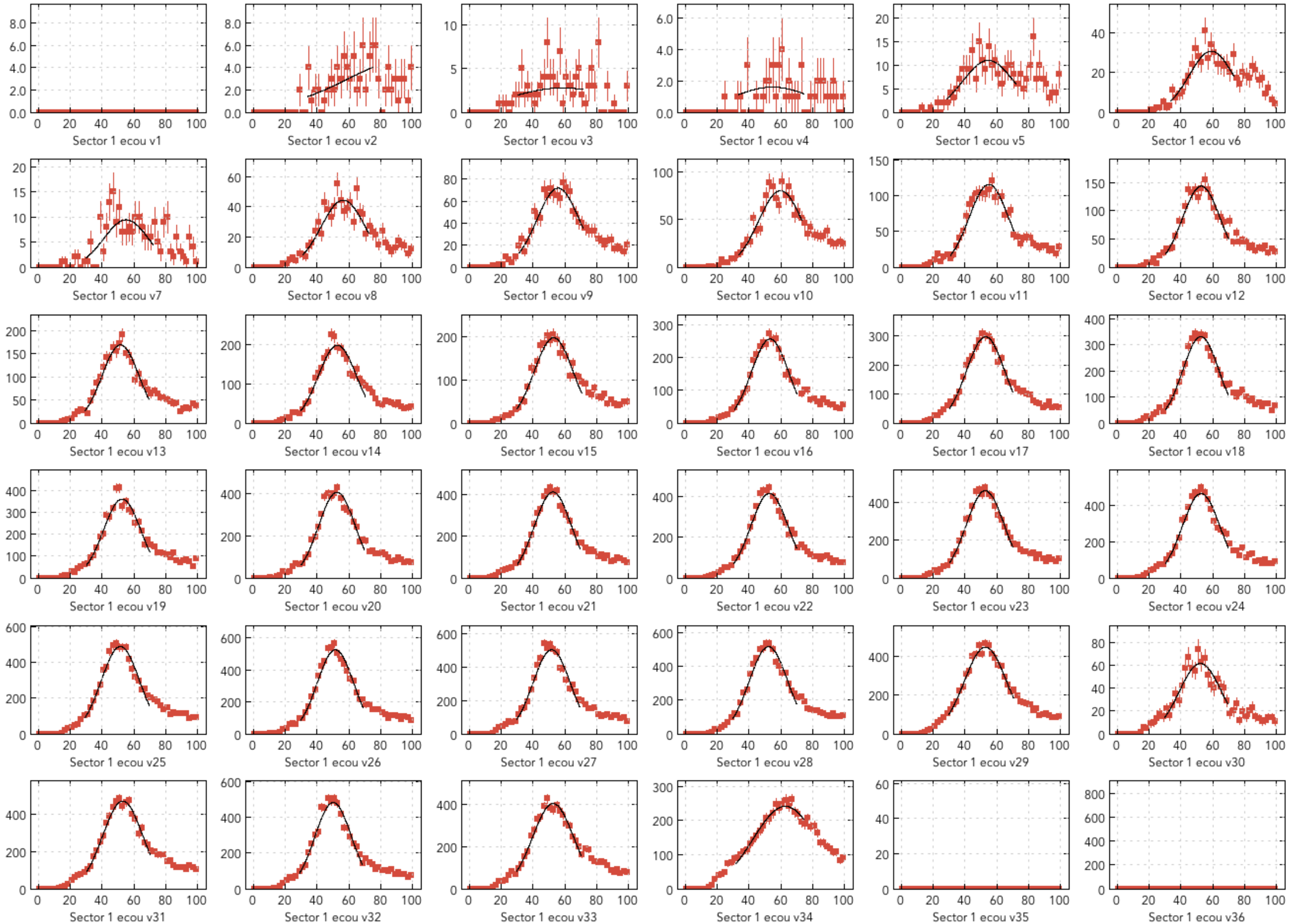
Sector 1 EC Inner Cluster Energy: V Strips (Pass 5)



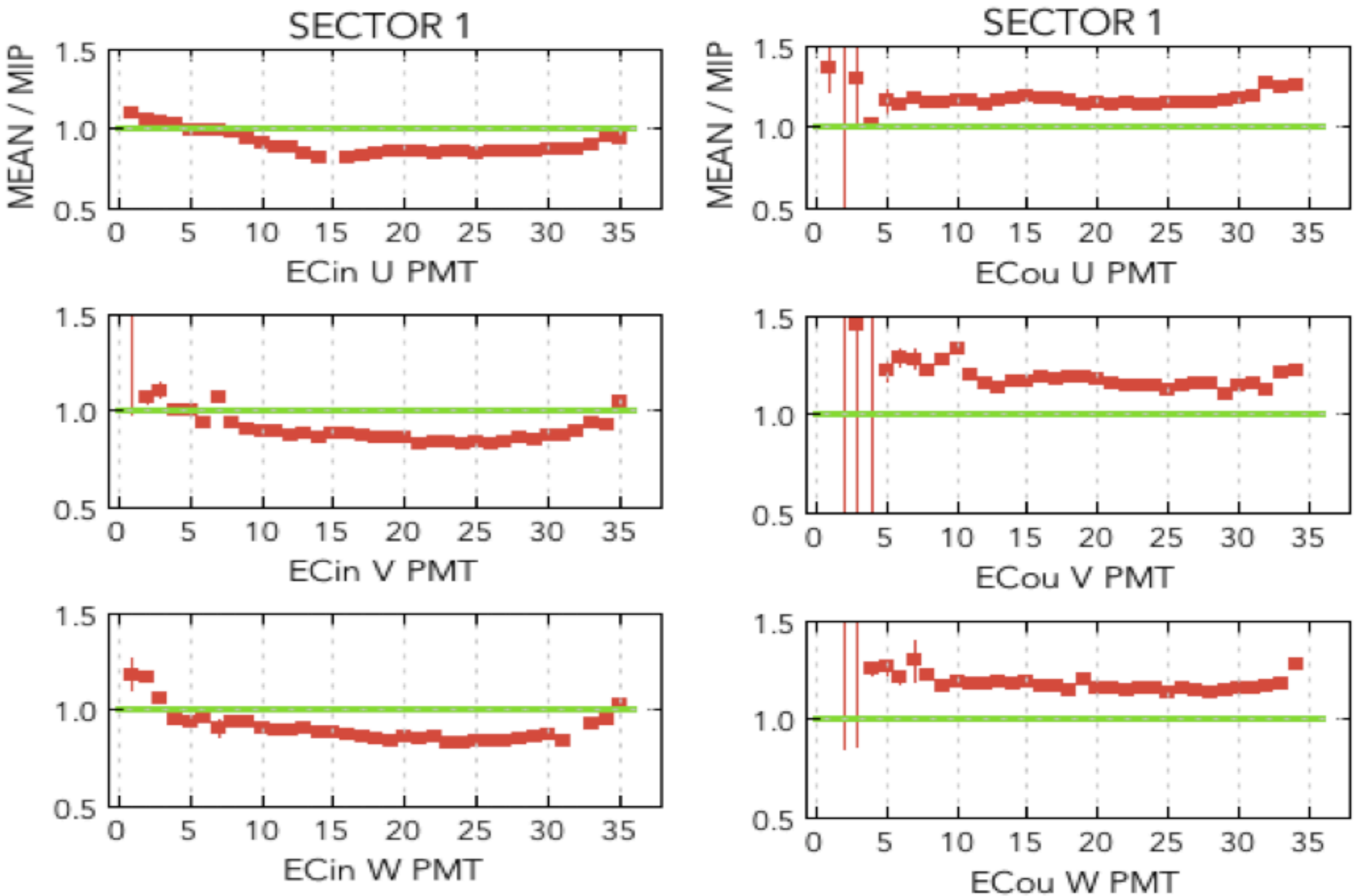
Sector 1 EC Inner Cluster Energy: W Strips (Pass 5)



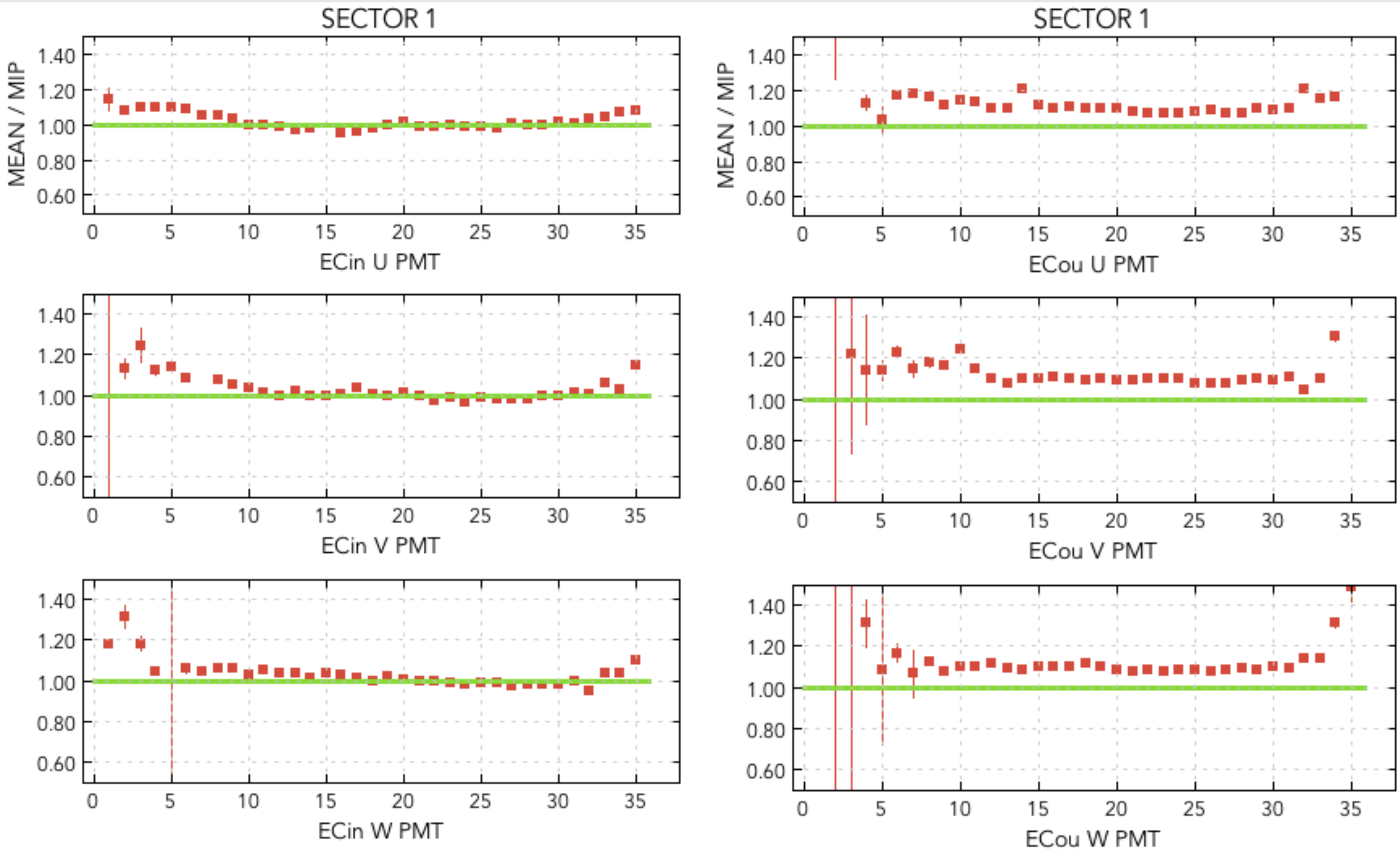
Sector 1 EC Outer Cluster Energy: V Strips (Pass 5)



Sector 1 EC Pion MIP Clusters (Passes 1-4)

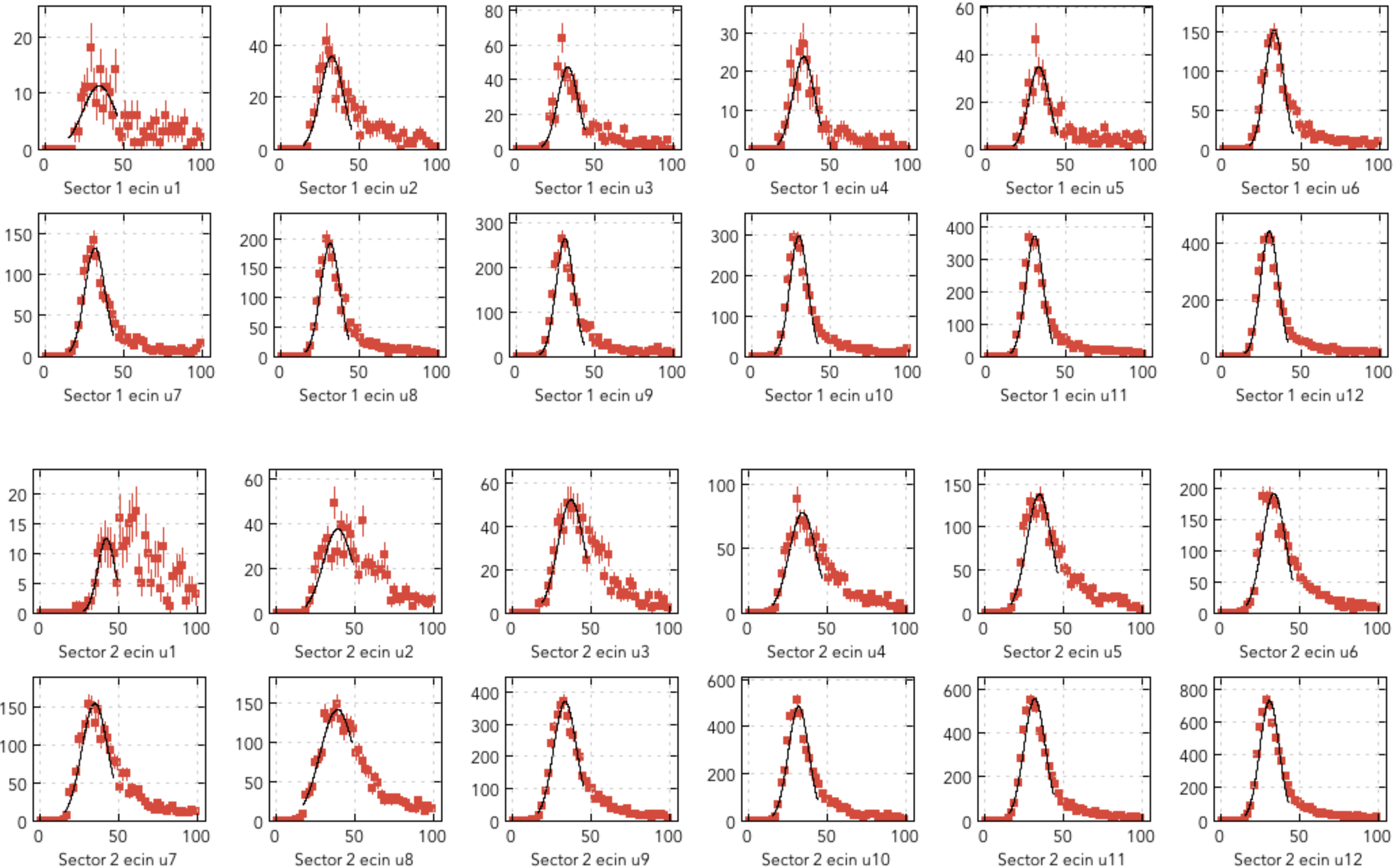


Sector 1 EC Pion MIP Clusters (Pass 5)

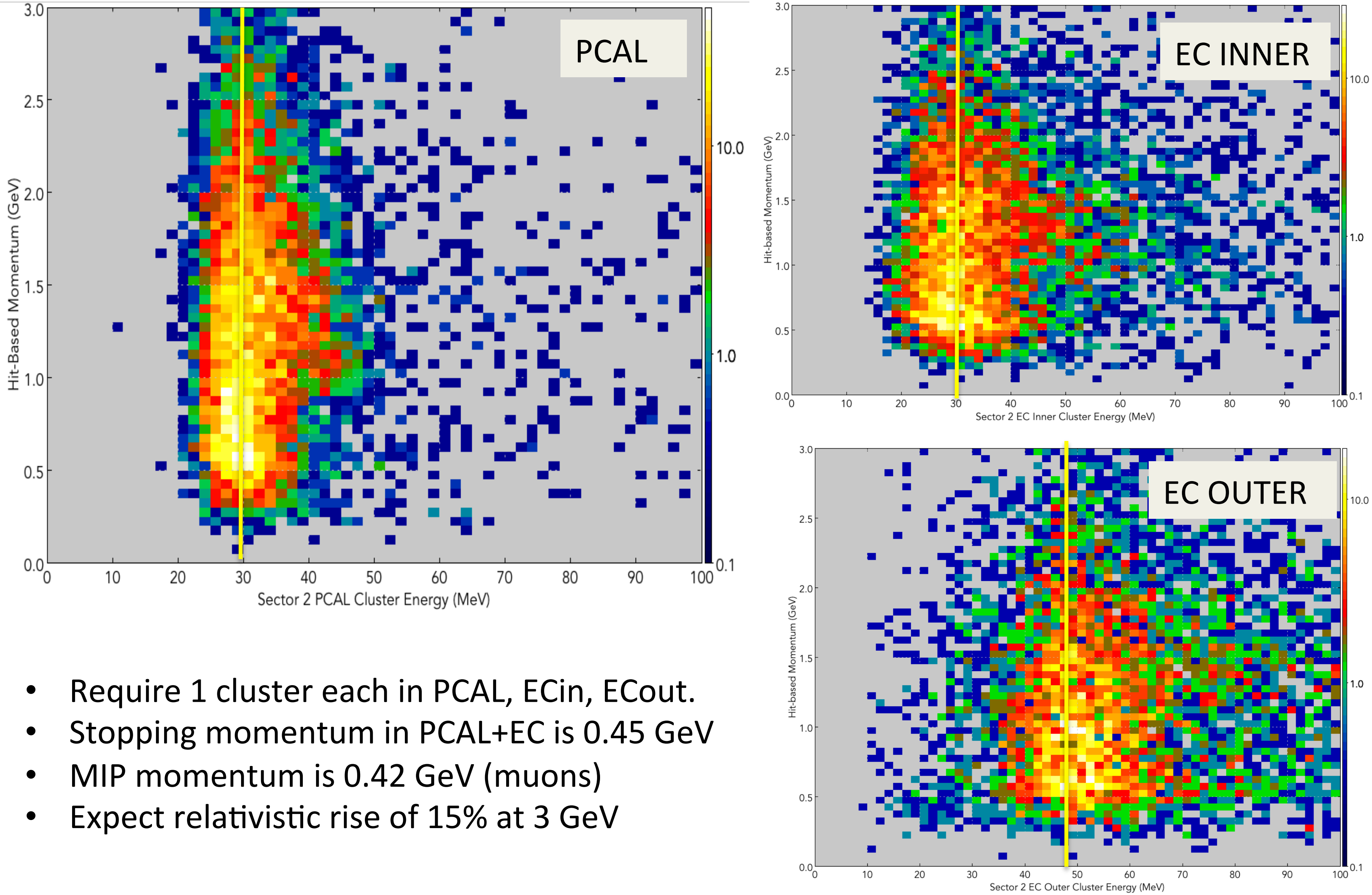


EC Pion MIP Clusters: First 12 U PMTs

Some systematics in calibration may arise from MIP shape changes in corners of EC Inner.



Momentum Dependence of Cluster Energy



- Require 1 cluster each in PCAL, ECin, ECout.
- Stopping momentum in PCAL+EC is 0.45 GeV
- MIP momentum is 0.42 GeV (muons)
- Expect relativistic rise of 15% at 3 GeV

ECMON: Calibration and Monitoring Suite. What's New?

- Timing calibration development started by Josh Tam and Andrei Kim.
- Phase corrections to displayed TDCs to remove TDC/FADC clock phase skew.
- Common visualization of FADC, TDC timing to better understand backgrounds, multi-hits, threshold settings. This was only possible after phase corrections were implemented.
- Enable/Disable button for using trigger bit to plot same sector trigger data.
- EVIO/ET to HIPO decoding implemented in GUI to save time and conserve disk space for cosmic runs.
- Added low range ADC histograms to document light leaks below thresholds.
- CCDB Status tables to record run-dependent occupancy issues (ADC, TDC, CABLE, HV, NOISE).

RUN::Config Timestamp

<bank content="bank" data_type="0xe" tag="37(0x0025)" padding="0" num="1" length="92" ndata="90">
<uint32 data_type="0x1" tag="57610(0xe10a)" padding="0" num="0" length="7" ndata="5">
0x39010004 0x1 0x1ae2a49e 0x5 0x1000000

Correction for time phase skew between 41.67 MHz TDC and 250 MHz trigger clocks

On first line, tag 37 is the trig1 Trigger Supervisor Crate header.
On second line, tag 57610 is the TS event data bank header.
On third line, TS event data. The last 32bit word is the trigger pattern:

32bit word 0: TI header
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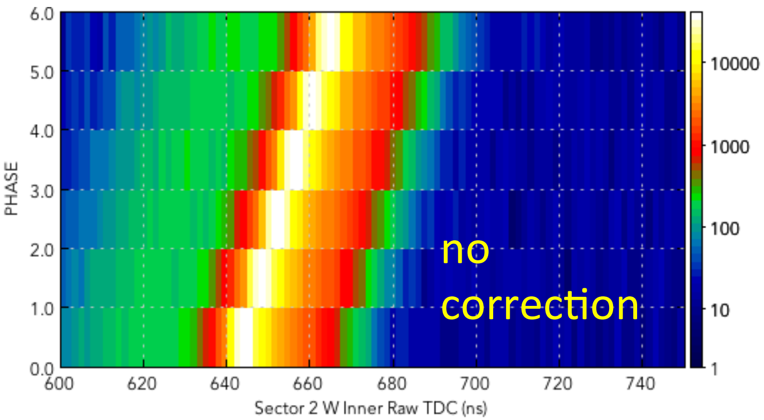
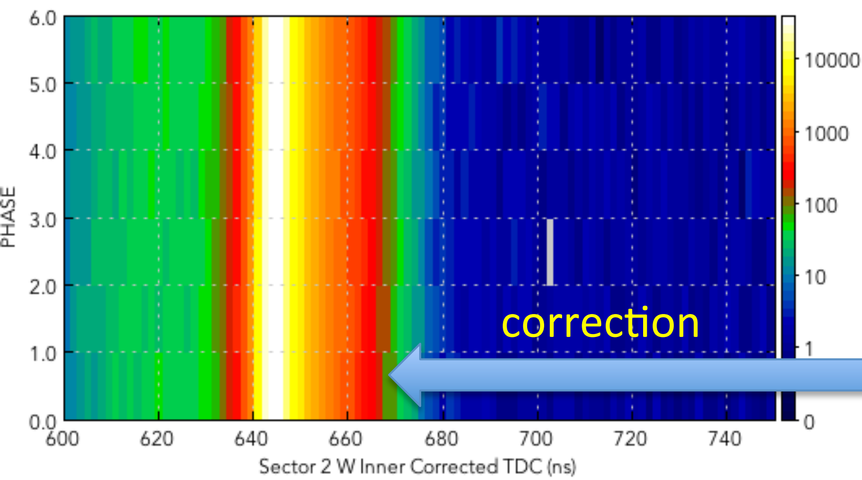
- 0x20000000 - sector 6 (really VTP_GT_TRGBIT 13 in trigger file)

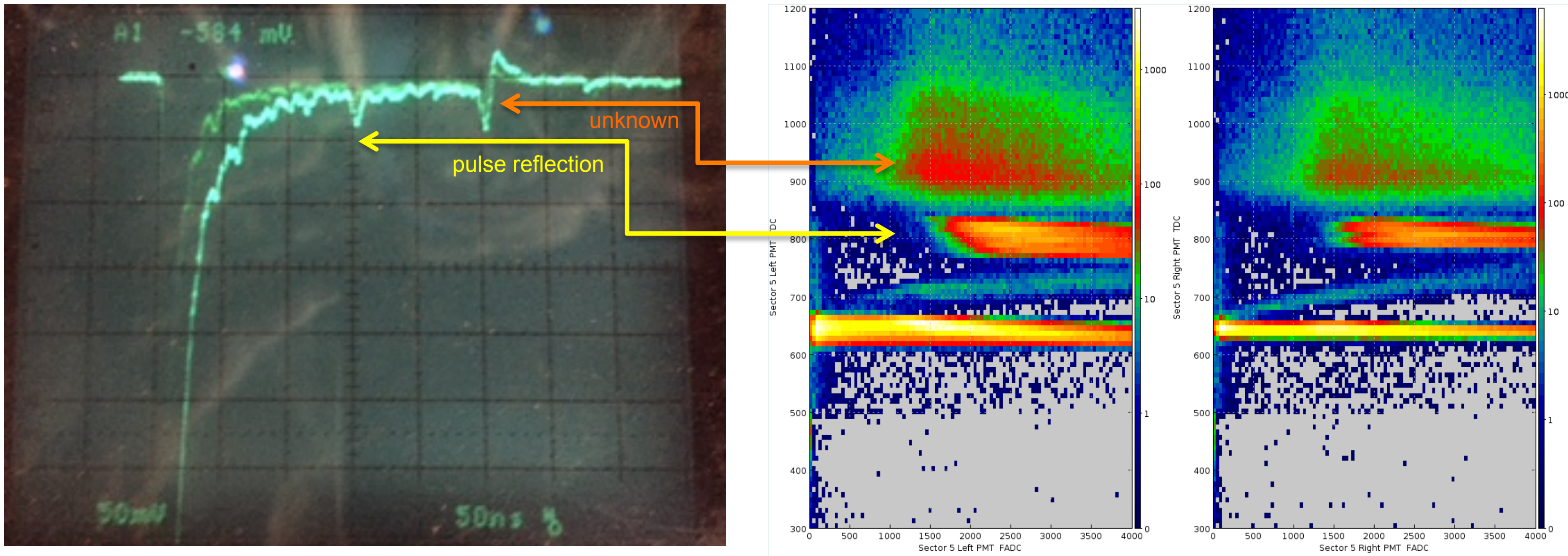


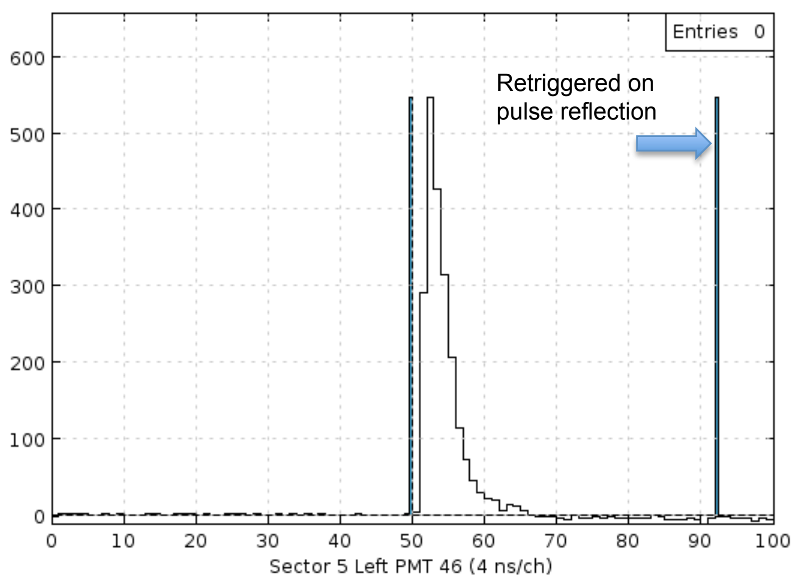


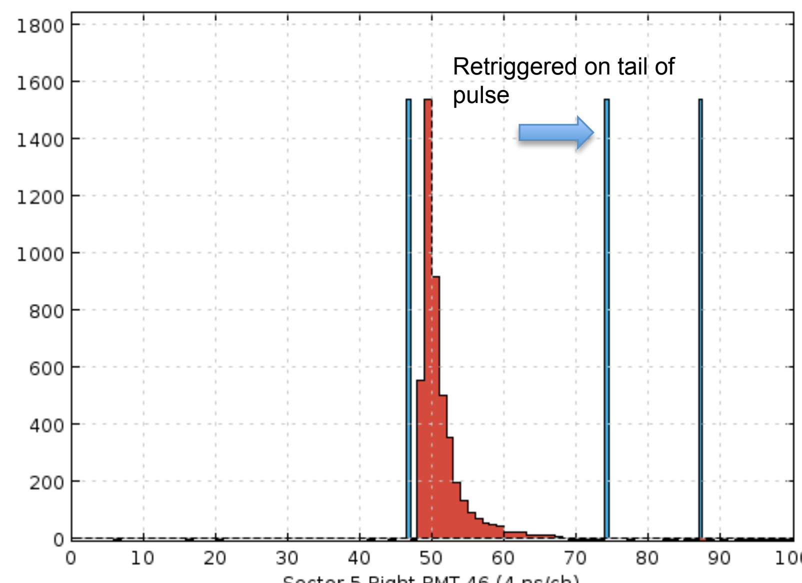

```java
if(event.hasBank("RUN::config")){
    DataBank bank = event.getBank("RUN::config");
    timestamp = bank.getLong("timestamp",0);
    trigger   = bank.getInt("trigger",0);
    evno      = bank.getInt("event",0);
    int phase_offset = 1;
    phase = ((timestamp%6)+phase_offset)%6;
    app.bitsec = (int) (Math.log10(trigger>>24)/0.301+1);
}
```

ECMON:Mode1App

Now displays TDC and FADC data together in sync

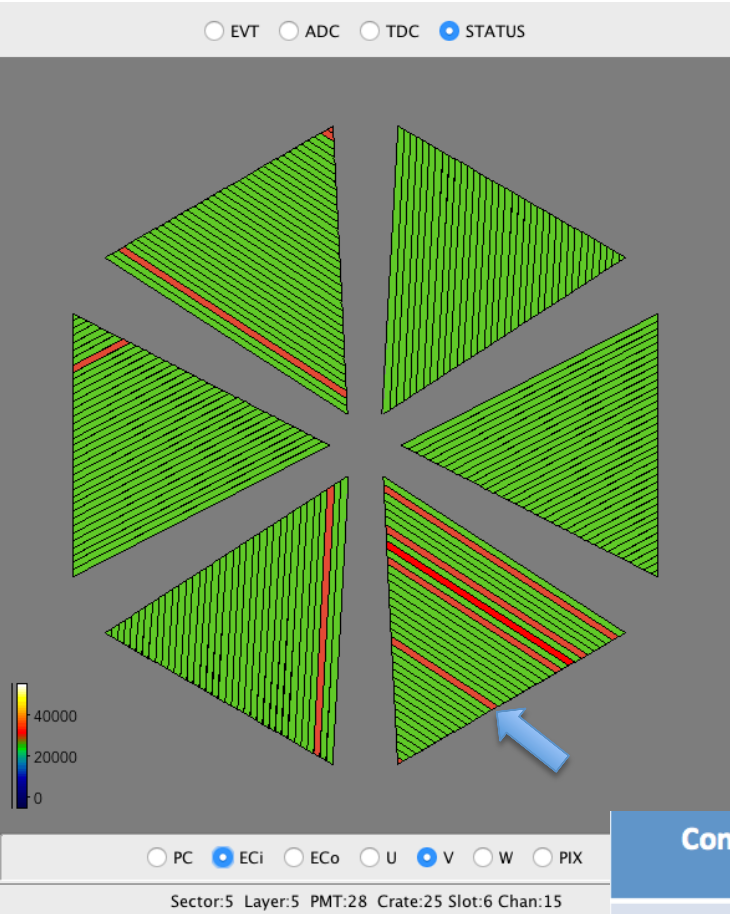


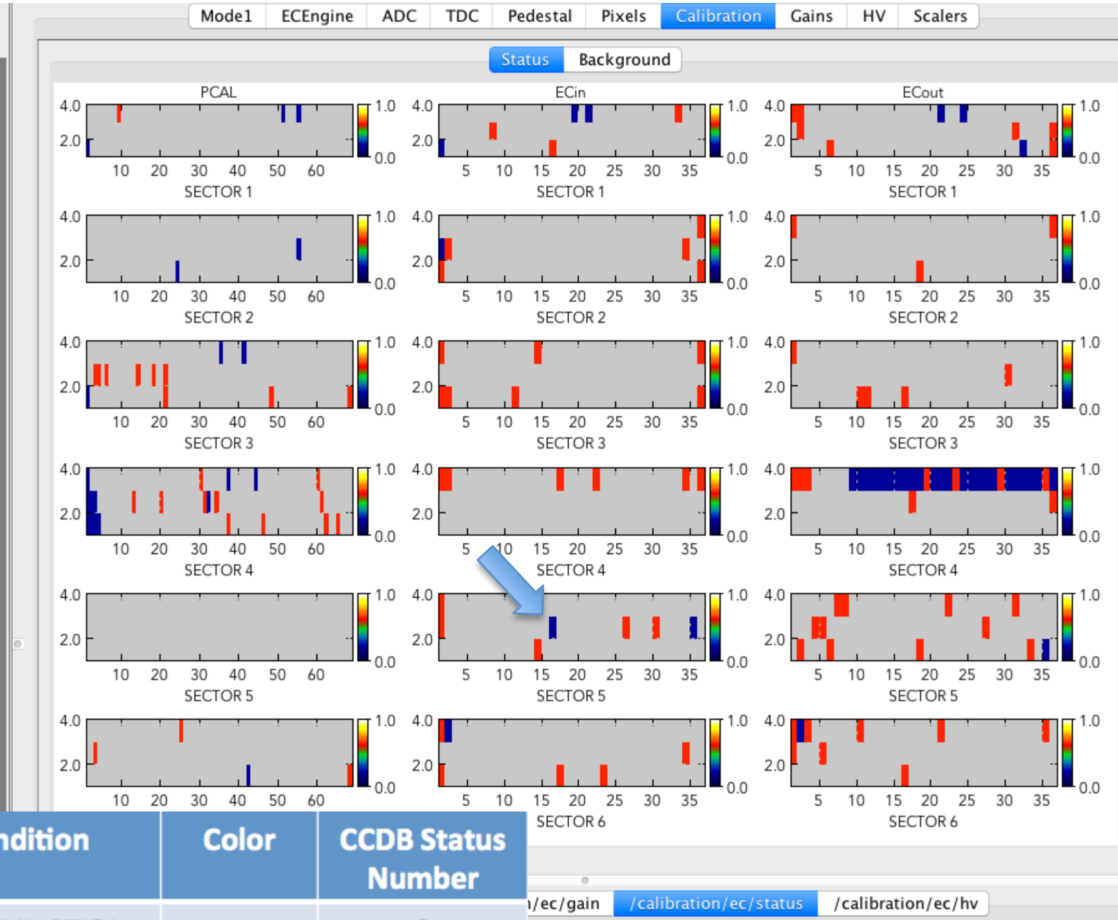




ECMON:CalibrationApp

Status Tab shows occupancy issues



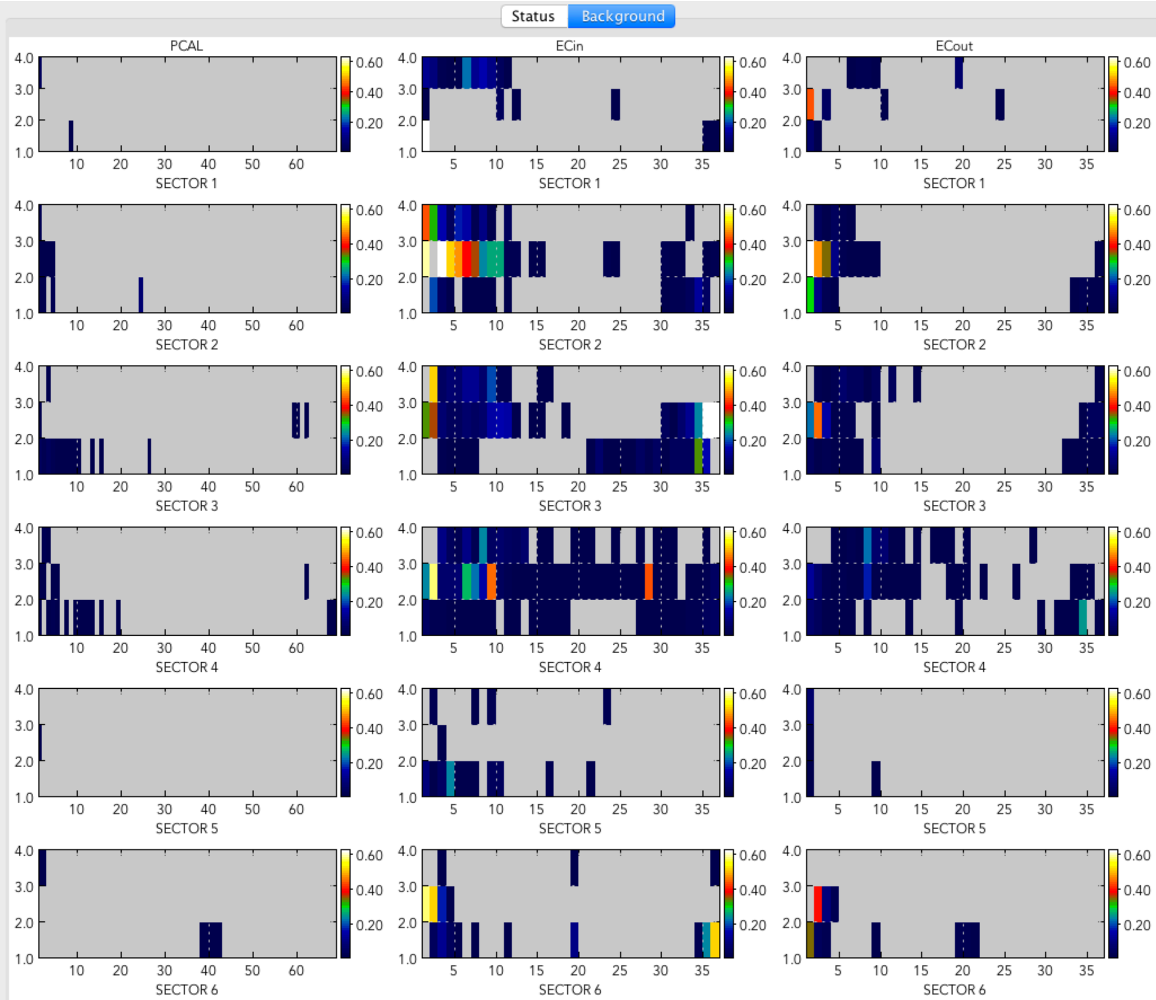


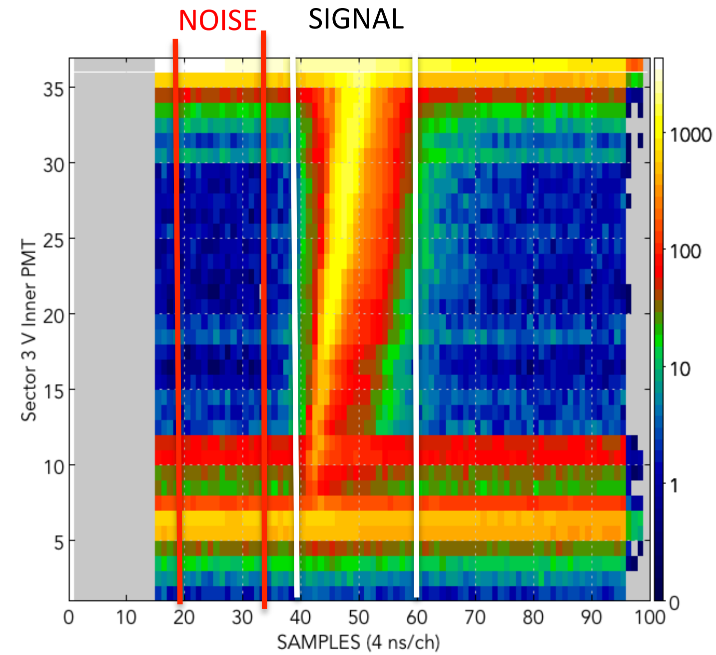
Condition	Color	CCDB Status Number
FULL FUNCTION		0
TDC=1 ADC=0		1
TDC=0 ADC=1		2
TDC=0 ADC=0		3
HV=1 IB=0		4
HV=1 IB=low		5
HV=0		6

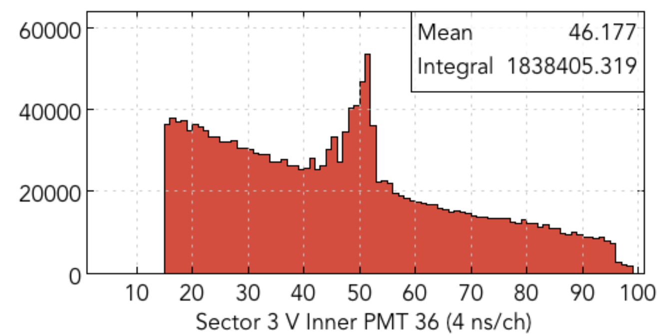
Detector view allows crate,slot,channel ID

Goal is for monitoring GUI to flag conditions for quick repair. Store in CCDB long term issues

ECMON:CalibrationApp







Background Tab shows light leaks, accidentals.

Plots show noise/signal defined by cuts on FADC samples (top right).

Other metrics based on absolute rate from scalers, energy weighted ratios, etc.

Plot at bottom right shows excessive noise due to light leak.

EC Timing Calibration Scheme

Event Selection
- ✓ Event Filter
- ✓ Hit Strip Identification
- ✓ ADC and TDC Reading

Expected Time Calculation
- ✓ ToF Calculation
- ✓ New Geometry Implementation
- Effective Velocity Parameterization

Model Time Calculation
- ➢ Definition of Calibration Constants

Calibration Constants Calculation
- Fitting
- Temporary Constant Storage

Iteration
- Event Rejection
- Recalculation/Refitting

Calibration Constant Selection
- Refitting with Rejected Events
- Finalization

Joshua Tam

Fitting a highly overconstrained system (pixels, Dalitz) to determine constants

$$\chi_j^2 = \sum_{i=1}^{N_j} \frac{\left|T_{expected_i} - T_{model_i}\right|^2}{\sigma_{j,i}^2}$$

Time walk correction term

Constant term

Reference time

$$T_{model_i} = a_0 + a_1 TDC_i + a_2 \frac{1}{\sqrt{ADC_i}} + a_3 l_i^2 + a_4 l_i^3 - T_{vertex}$$

TDC conversion term

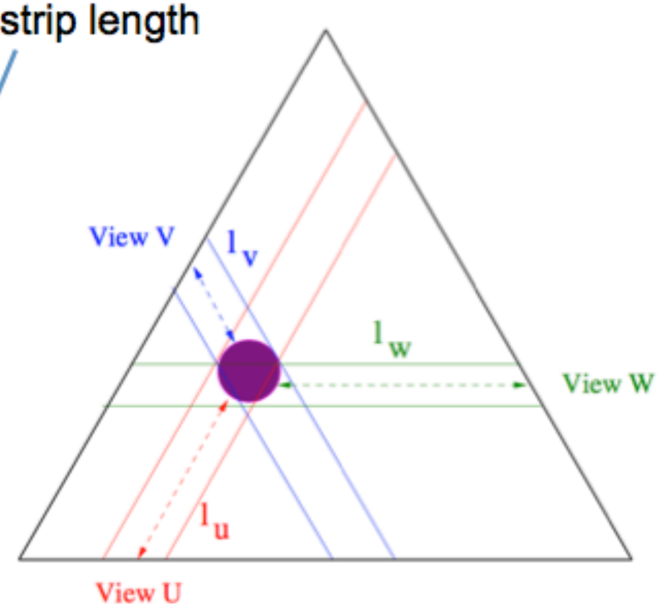
Attenuation terms

Effective strip length

Particle path length

$$T_{expected_i} = \frac{L}{c} + \frac{l_i}{v}$$

Effective velocity



Summary

- KPP run exposed some faults in the cosmic calibration/trigger settings for Sectors 1 and 5.
- Need sector dependent thresholds and gain factors for trigger.
- Goal is to have TDC calibrations ready for testing in Challenge by end of July.
- Many light leaks in EC and occupancy holes to be repaired (mainly cables and connectors). Will take several more months.
- Final voltage adjustments and calibrations will follow in time for Engineering run in October.

Synchronization of GlueX Timing Systems

Kei Moriya
Arizona State University
Mark M. Ito
Thomas Jefferson National Accelerator Facility

GlueX Note 2686-v5

July 21, 2015

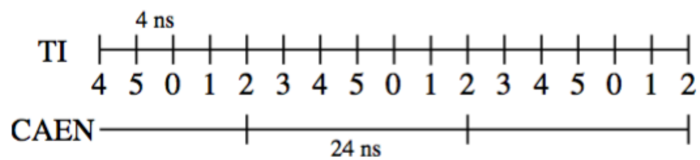


Figure 1: Global system clock vs. CAEN TDC clock. The global system clock is represented by the TI counter and is shown modulo 6. The trigger can come on any edge of the global system clock.

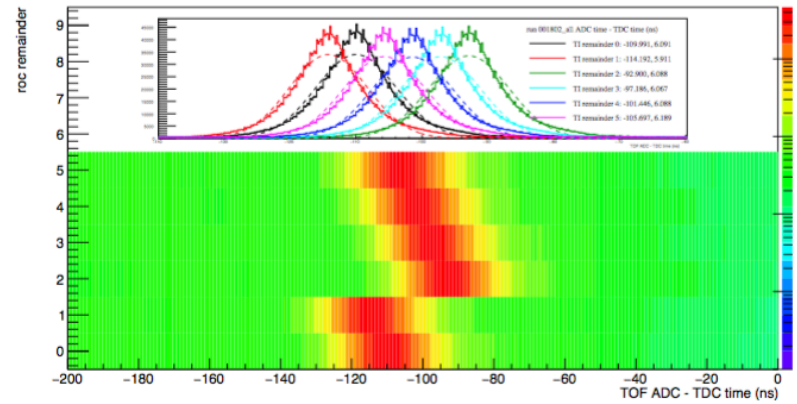


Figure 3: Time difference between CAEN TDC and FADC-250 for a given channel, summed over all channels, and divided into values of $n_{\mathrm{TI},6}$. The timing can be seen to shift for increasing values of $n_{\mathrm{TI},6}$, and takes minimum shift values for $n_{\mathrm{TI},6} = 2$. The figure is for run 1802 of the fall 2014 run, summed over all files.

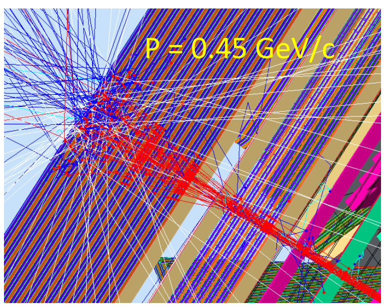
- Trigger comes on edge of 4 ns clock.
- TDC not stopped until next edge of 24 ns clock.
- Introduces random (n x 4 ns, n=0-5) delay between trigger and TDC stop for each event.
- Trigger Interface (TI) board keeps count of 250 MHz clock.
- TI counter is reset at beginning of each run by sync signal from TS.
- TS fixes phase of 24 ns clock w.r.t. 4 ns clock at sync time.
- Six-fold phase ambiguity can be corrected after fixed phase is determined empirically.

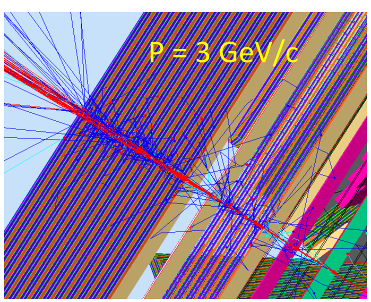
Muons in polyvinyltoluene [$(2\text{-}CH_3C_6H_4CHCH_2)_n$]

$\langle Z/A\rangle$	ρ [g/cm^3]	I [eV]	a	$k = m_s$	x_0	x_1	$\overline{C}$	δ_0
0.54141	1.032	64.7	0.16101	3.2393	0.1464	2.4855	3.1997	0.00

T	p [MeV/c]	Ionization	Brems	Pair prod [MeV cm^2/g]	Photonucl	Total	CSDA range [g/cm^2]
10.0 MeV	4.704×10^1	7.917				7.917	6.971×10^{-1}
14.0 MeV	5.616×10^1	6.171				6.171	1.275×10^0
20.0 MeV	6.802×10^1	4.816				4.816	2.389×10^0
30.0 MeV	8.509×10^1	3.734				3.734	4.780×10^0
40.0 MeV	1.003×10^2	3.187				3.187	7.698×10^0
80.0 MeV	1.527×10^2	2.388				2.388	2.266×10^1
100. MeV	1.764×10^2	2.237				2.237	3.133×10^1
140. MeV	2.218×10^2	2.082				2.082	4.996×10^1
200. MeV	2.868×10^2	1.992				1.992	7.954×10^1
300. MeV	3.917×10^2	1.957			0.000	1.957	1.303×10^2
325. MeV	4.171×10^2	1.956			0.000	1.956	*Minimum ionization*
400. MeV	4.945×10^2	1.962			0.000	1.962	1.814×10^2
800. MeV	8.995×10^2	2.033	0.000		0.000	2.034	3.817×10^2
1.00 GeV	1.101×10^3	2.066	0.000		0.000	2.067	4.792×10^2
1.40 GeV	1.502×10^3	2.120	0.000		0.001	2.121	6.702×10^2
2.00 GeV	2.103×10^3	2.179	0.000	0.000	0.001	2.181	9.489×10^2
3.00 GeV	3.104×10^3	2.246	0.001	0.001	0.001	2.249	1.400×10^3

http://pdg.lbl.gov/2016/AtomicNuclearProperties/MUE/muE_polyvinyltoluene.pdf





GEMC muons:

p < 0.10 stop in Panel 1A

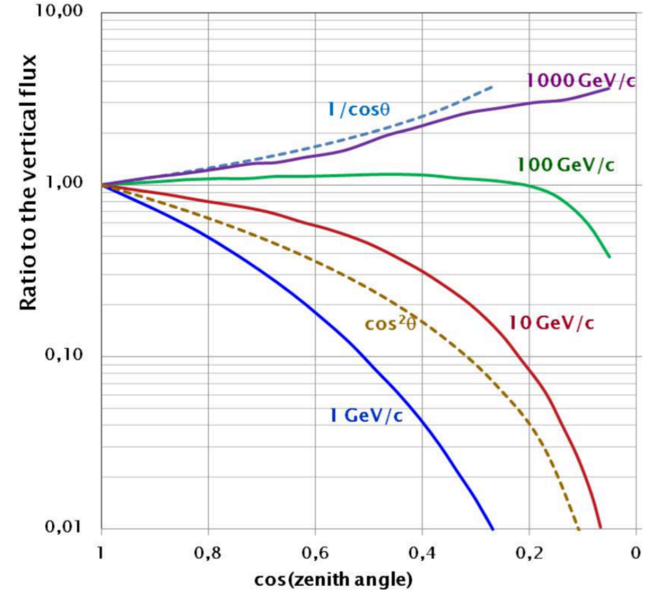
p < 0.23 stop at rear of PCAL

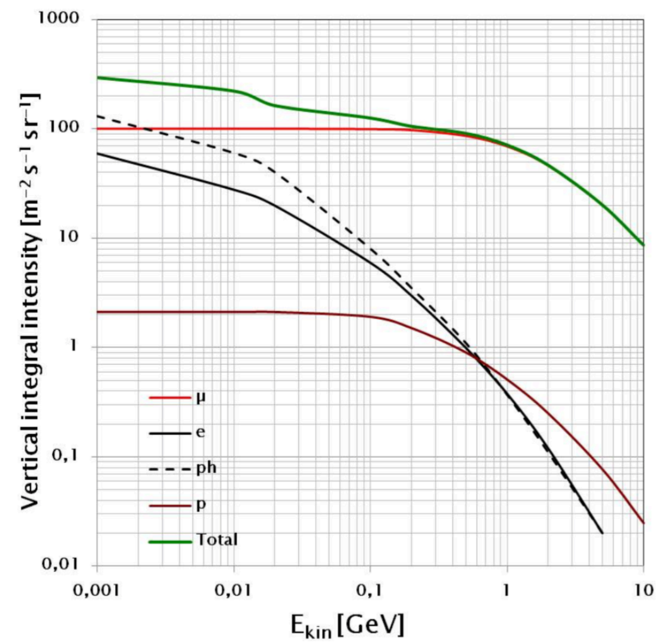
p < 0.31 stop between EC inner, EC outer

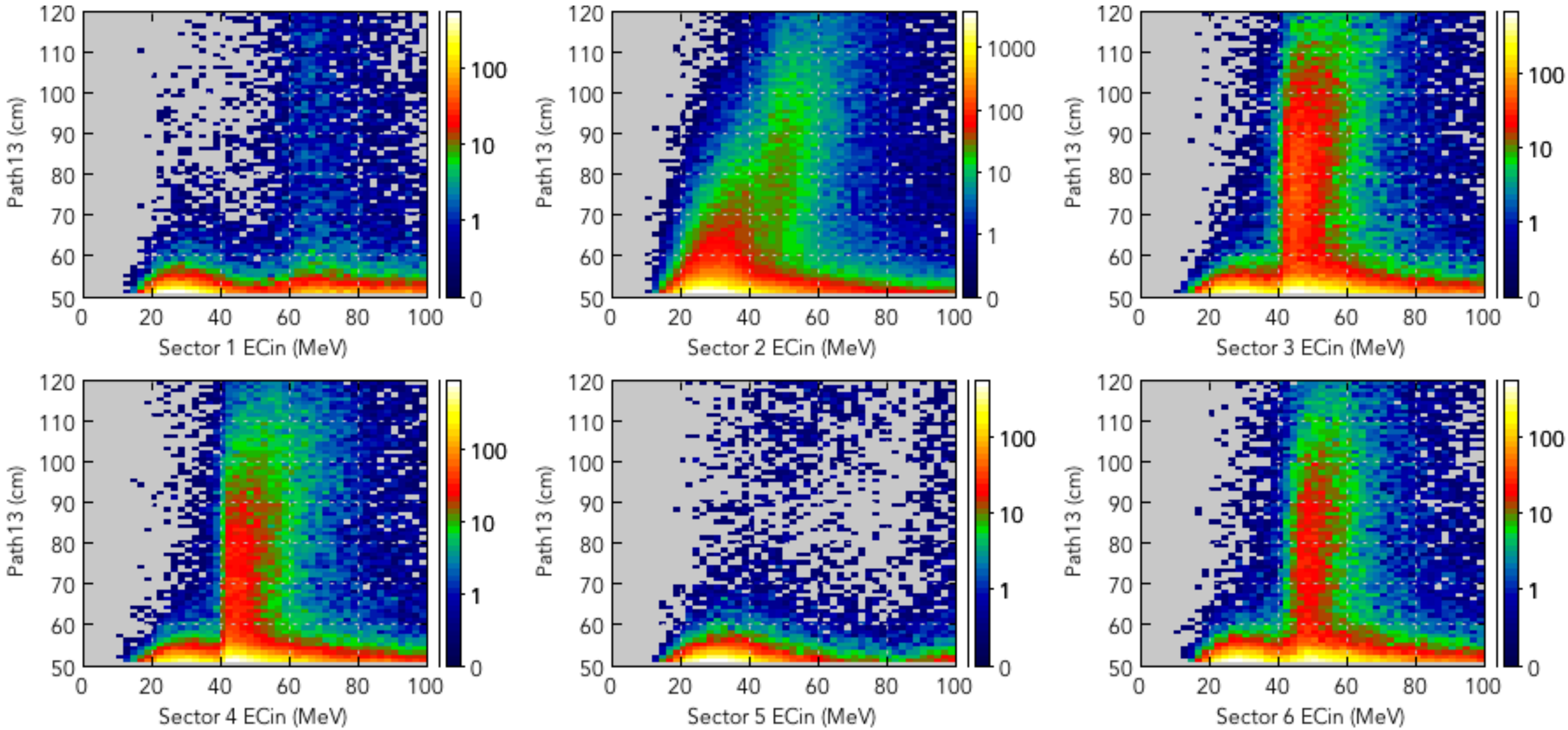
p > 0.45 exit rear of EC (large multiple scattering)

p = 3 GeV (insignificant multiple scattering)

- Mean incident muon energy depends on zenith angle.
- Mean ionization energy loss depends on coincidence requirements and pixel cuts used to constrain minimum incident energy.







Path13 (cm)
Sector 1 ECin (MeV)
Sector 2 ECin (MeV)
Sector 3 ECin (MeV)
Sector 4 ECin (MeV)
Sector 5 ECin (MeV)
Sector 6 ECin (MeV)