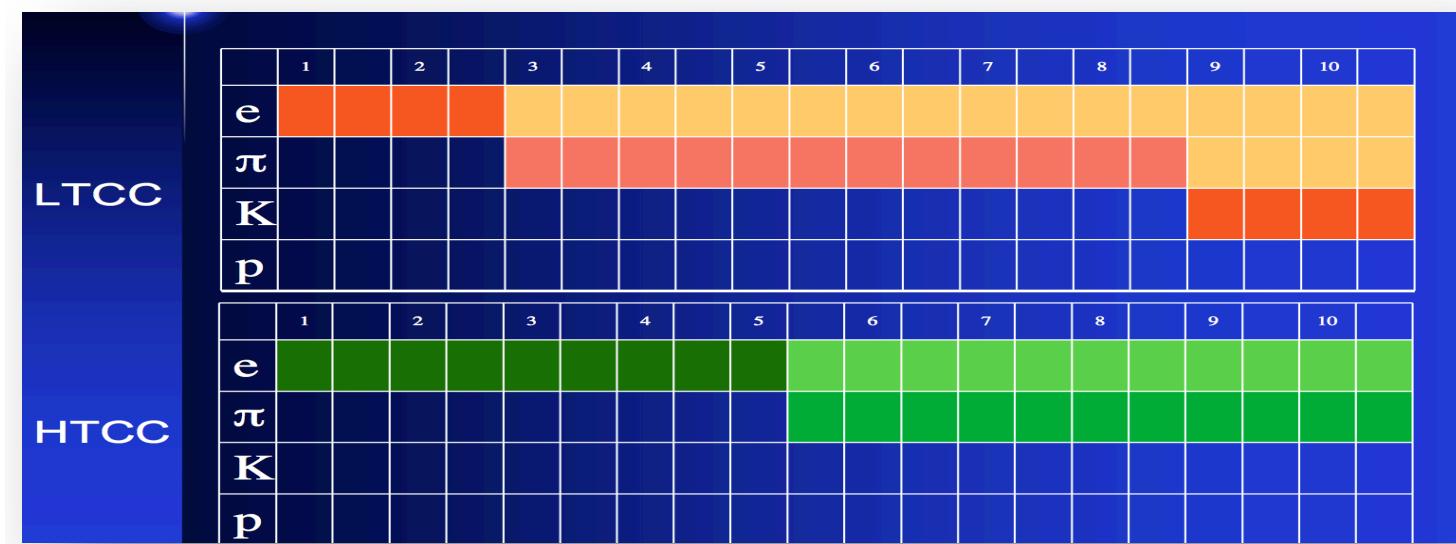


# CLAS12 Low Threshold Cherenkov Counter

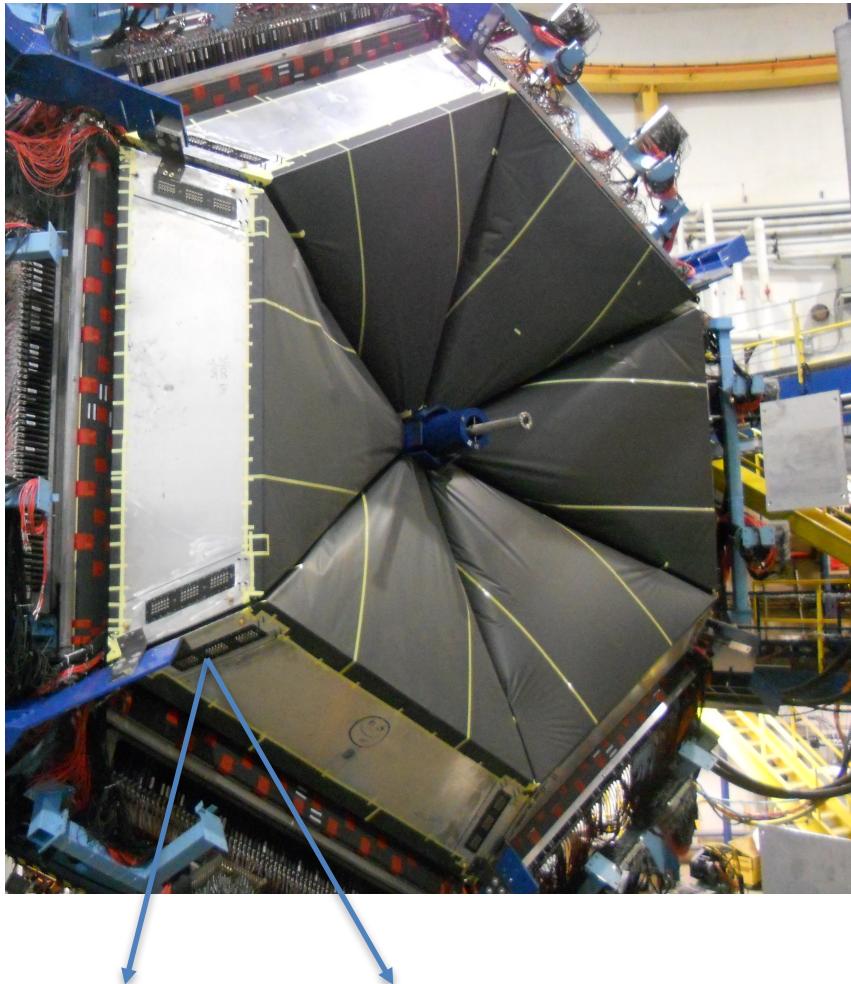
## Project Scope:

1. Decrease inefficient regions
2. Increase PMT gain, split output (FADC, TDC)
3. Better mirrors support to maintain alignment
4. **Increase light yield for  $\pi$ : Refurbish mirrors, WC, PMTs**
5. **Fit between DC and FTOF (box is too large)**



# LTCC Overview

*LTCC is installed in the Forward Carriage*



TDC

FADC

The **LTCC** system is part of the forward CLAS12 detector and will be used to for pions/kaons discrimination. The LTCC consists of 6 sectors of lightweight mirrors, light collecting cones, 5" PMTs and magnetic shields. The sectors are filled with C<sub>4</sub>F<sub>10</sub> gas, providing pion/kaon discrimination from 3.5 to 9 GeV/c.

- 648 lightweight mirrors
- 216 Winston Cones
- 216 5" PMT
- 216 Magnetic Shields

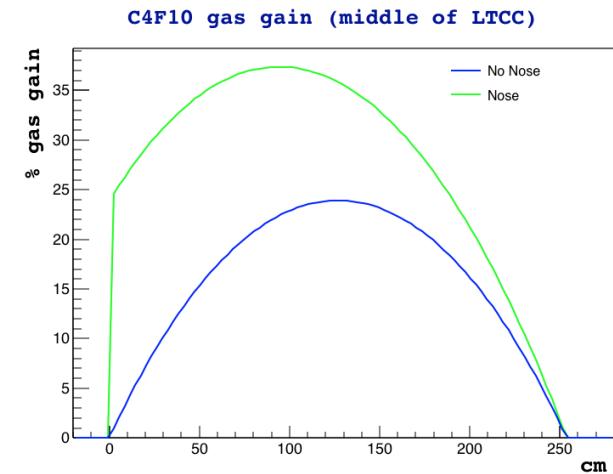
PARAMETER	DESIGN VALUE
<b>Mirrors</b>	
Support Structure	3 kevlar layers sandwiched with vinyl foam
Elliptical	Length = 6" to 55", Width = 8" to 11"
Hyperbolic	Length = 12" to 30", Width = 8" to 9.25"
Mirror Coating	Al/MgF2
Reflectivity	90% from 250 to 650 nm
<b>C<sub>4</sub>F<sub>10</sub> Gas</b>	
Refraction Index	1.00134
Transparency	100% above 220nm
Density	9.94 Kg/m <sup>3</sup>
Window Material	tedlar/mylar/tedlar composite
<b>PMTs</b>	
200	Photonis XP 4500B
16	Photonis XP 4508 (Quartz Window)
<b>Magnetic Shields</b>	
Material	Eagle AAA: 80% Ni, 4.20% Mo, and 15% Fe
Field Attenuation Factor	85 Axial, 390 Transverse
<b>PID:</b>	
π/K Separation	3.5 to 9 GeV/c

# Back-wall, Connectors, Nose

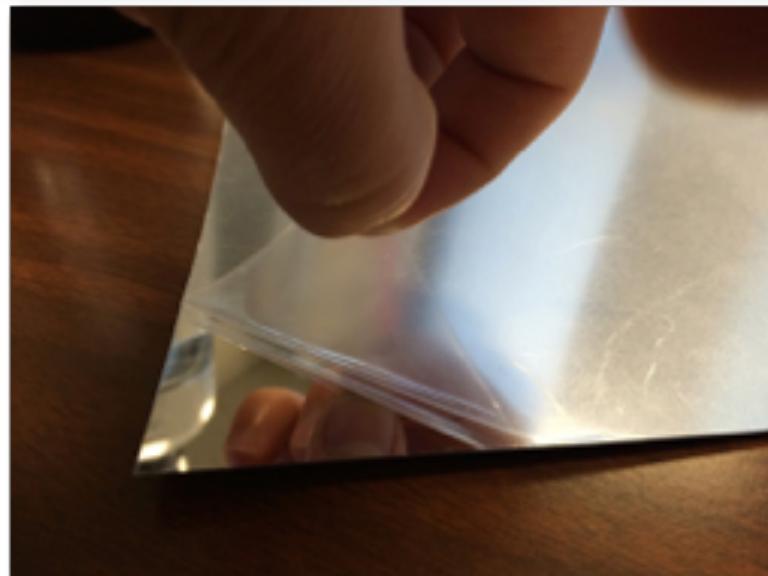
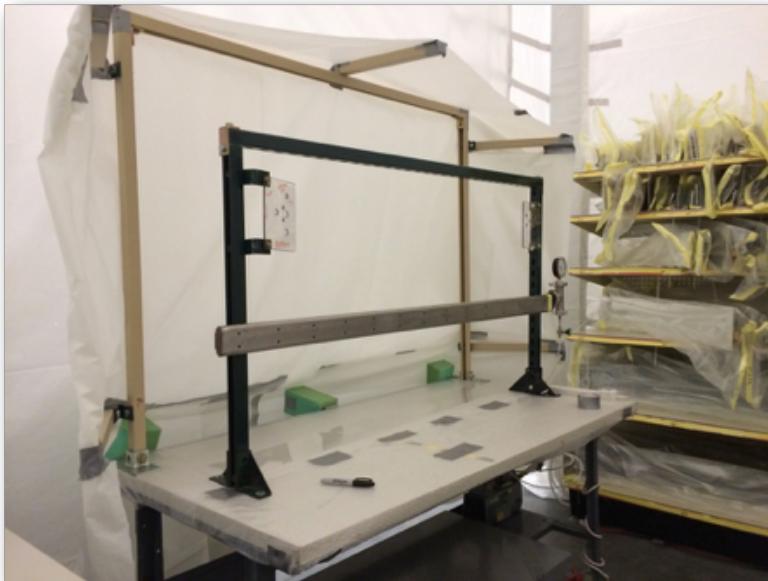


Back-wall re-designed:

- New frame
- Old back-wall fitted on new frame, sealed
- New hermetical connectors
- One more PMT output
- Nose extension for more gas volume



# Elliptical, Hyperbolic Mirrors

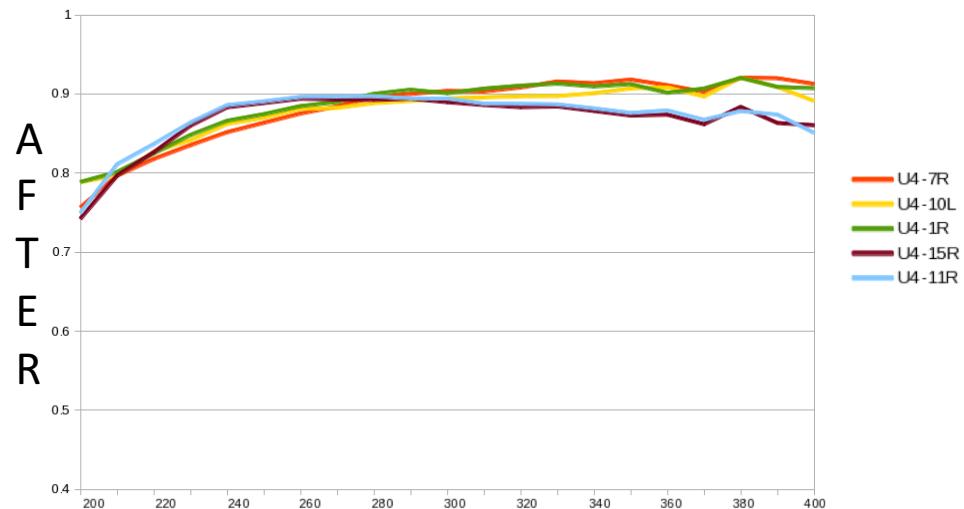
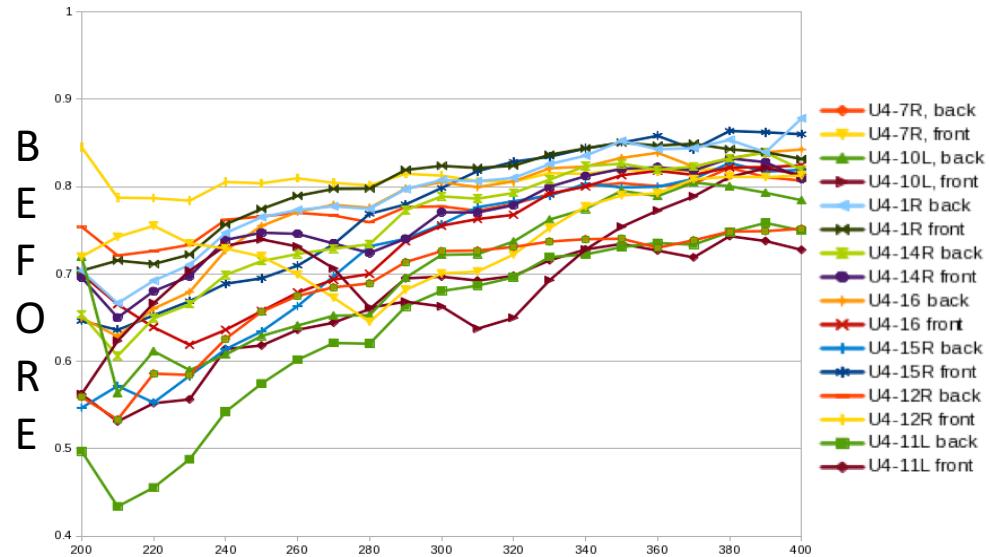


- Clean room environment
- Spray glue pumped outside
- Mirrors vacuum-held
- Lexan Strips rolled on mirror

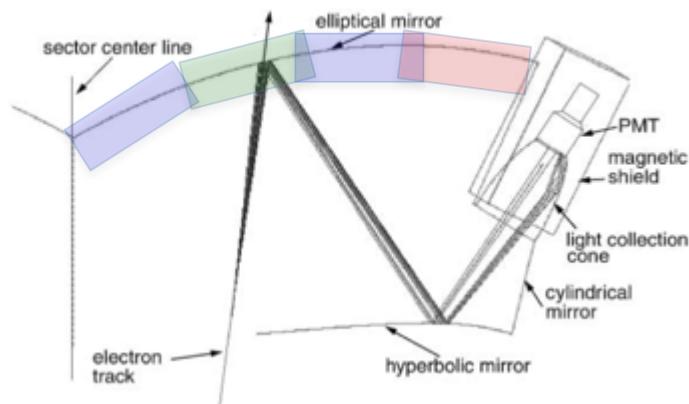
# Reflectivity Improvements



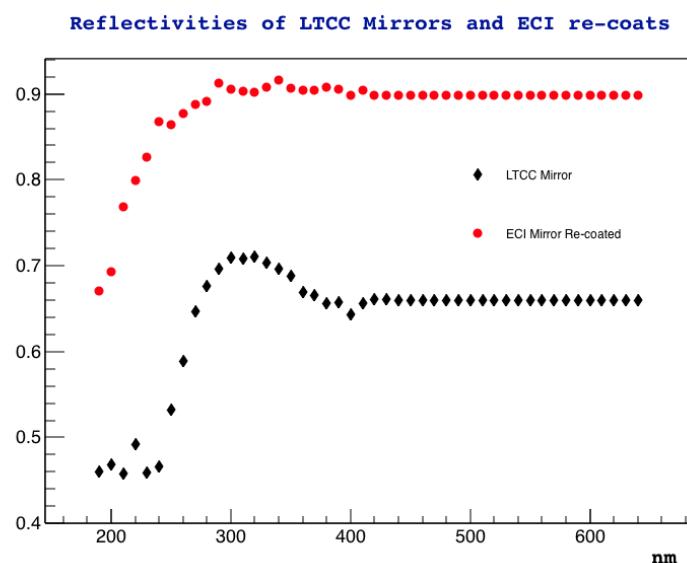
648 Mirrors, ~100 Winston Cones Re-coating



# Reflectivity Improvement



- 2 reflections only: 30% of the time
- 3 reflections ~40% of the time
- 4 reflections ~30% of the time



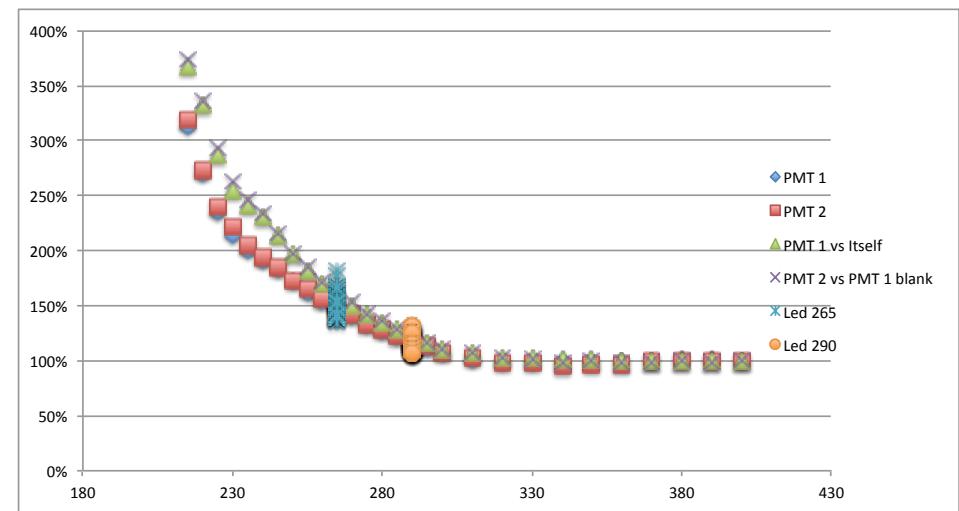
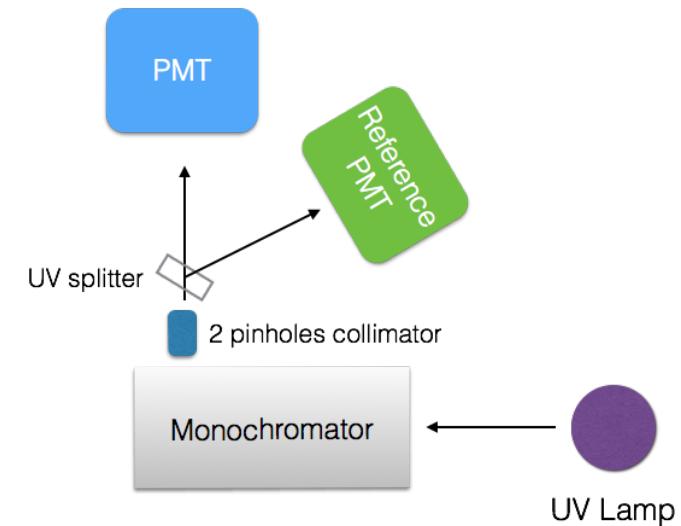
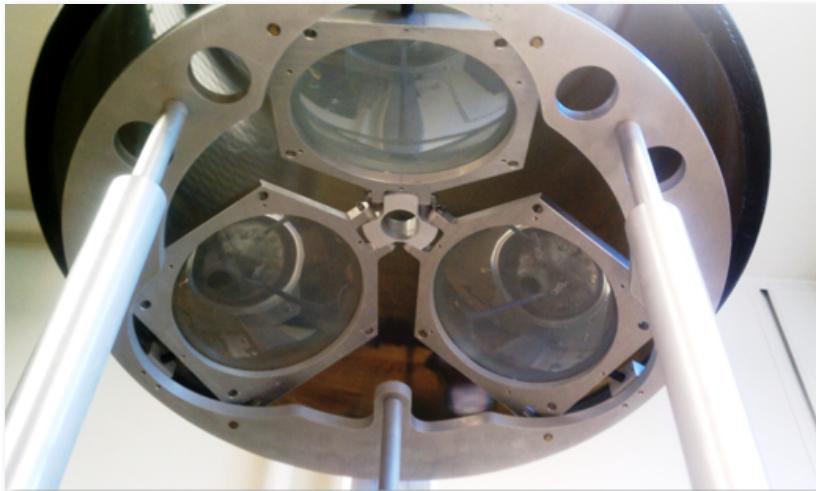
3 reflections visible:

~27.5% (original, 65% 1 reflection)  
~68.1% (recoated, 88% 1 reflection) } X ~2.4 better

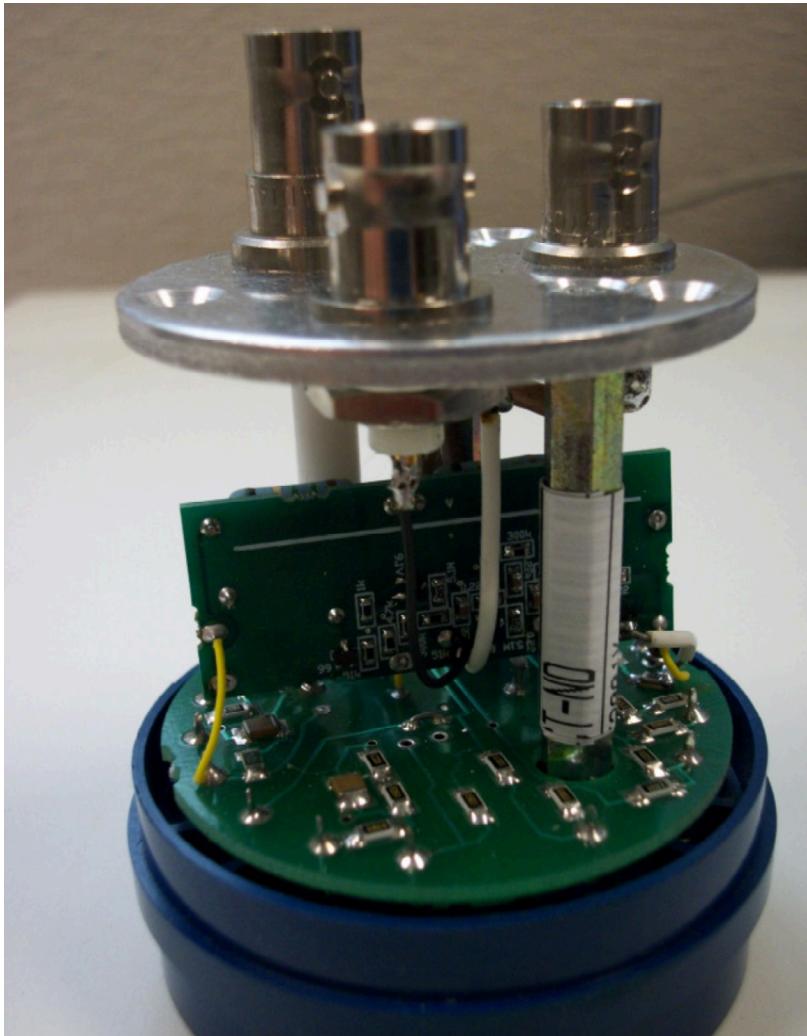
3 reflections UV:

~9.1% (original, 45% 1 reflection)  
~31.3% (recoated, 70% 1 reflection) } X ~3.7 better

# PMTs Wave-length Shifter



# PMT Divider

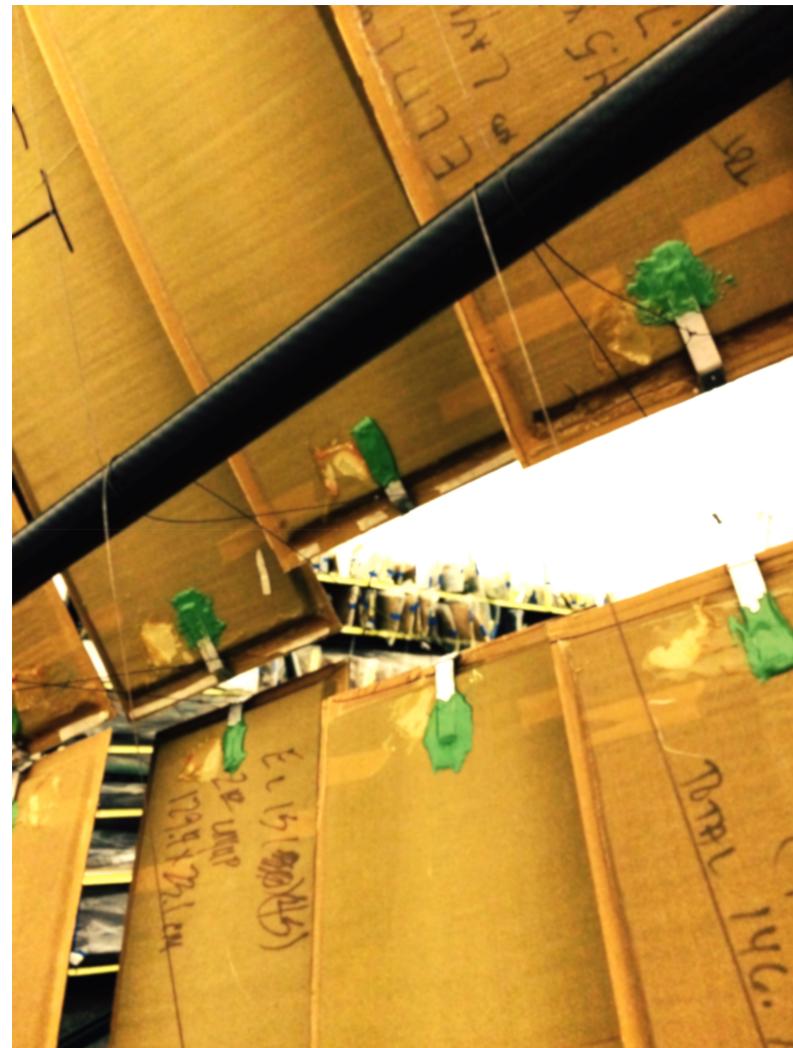
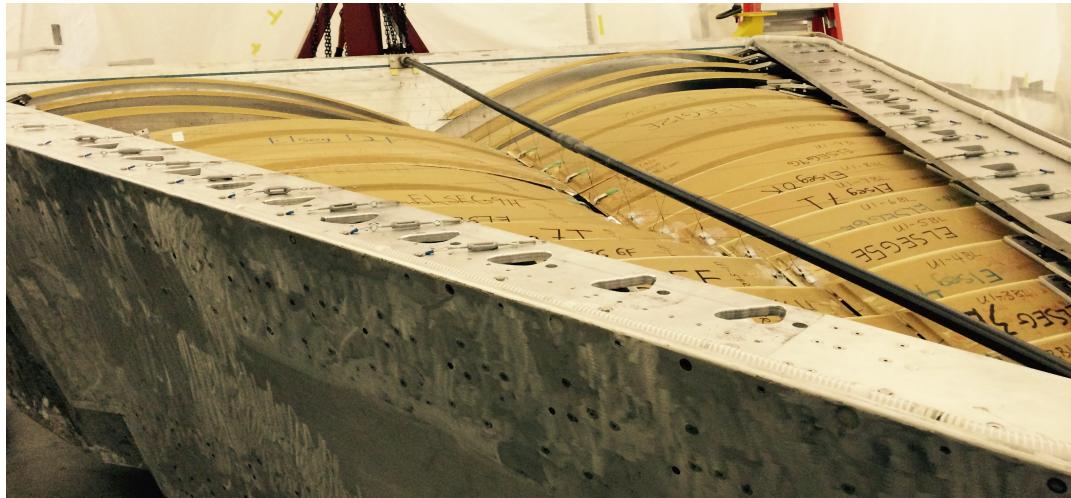


*CLAS: PMT signal was divided and amplified by UVA electronics modules no longer available.*

*Popov's modification can be used instead*

- Vladimir Popov Design (Photonis wanted it!)
- Provides 2 identical signal: X10 amplification (no penalties)
- 240 pcp boards populated by Flextron Circuit Assembly
- 200 divider modifications at JLab, work done by DSG

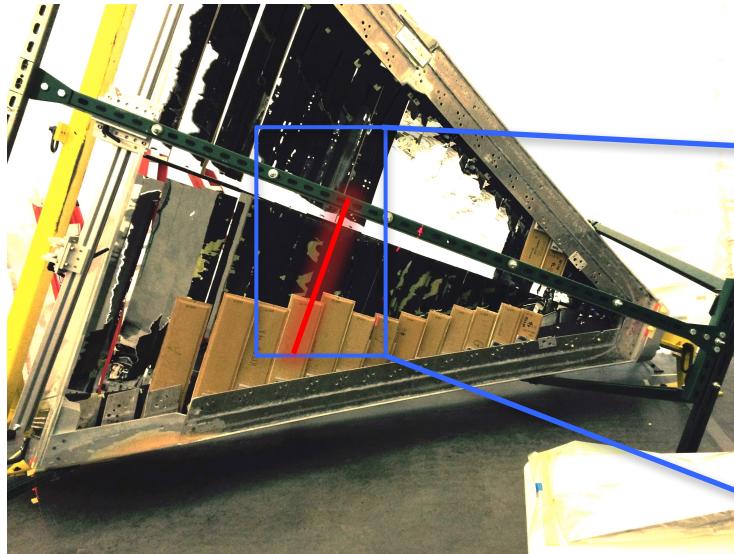
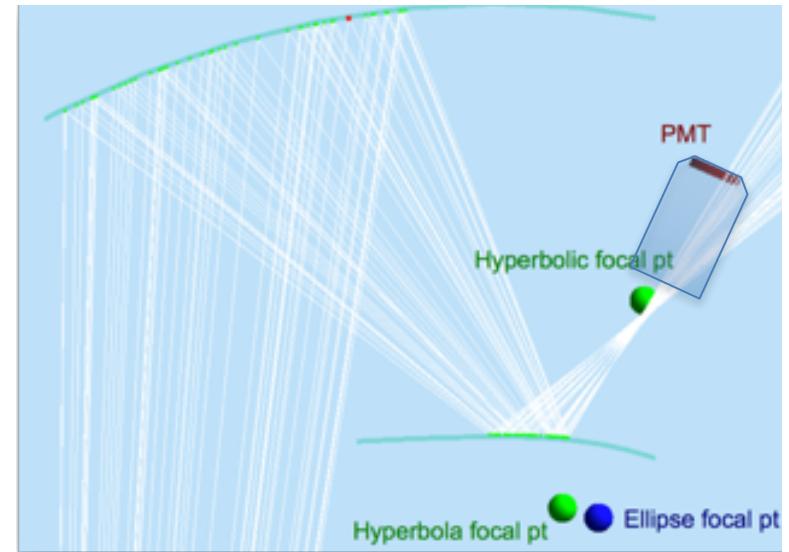
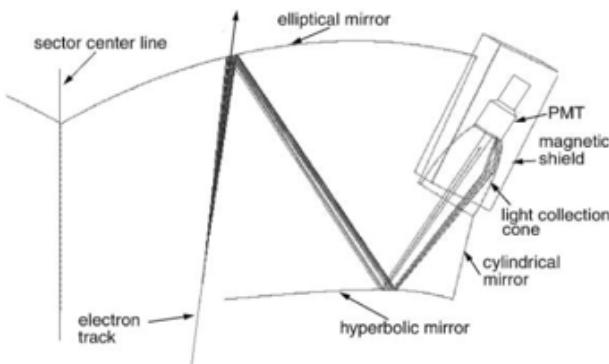
# Mirrors Support



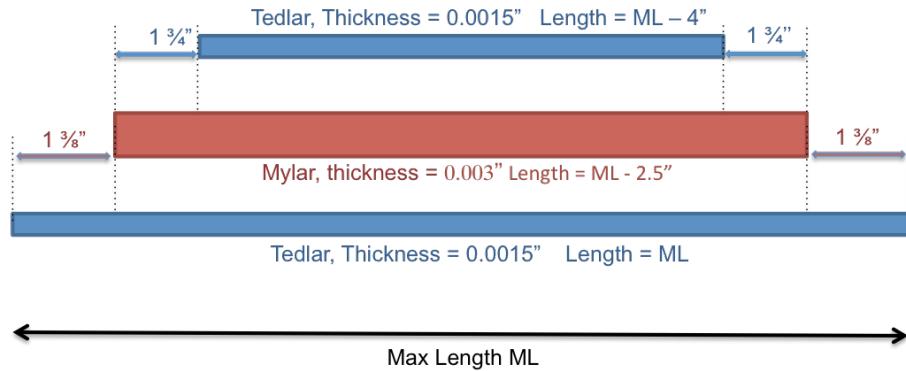
*New Spine, design by Bob Miller, David Anderson*

- 1" diameter, 1mm thick carbon fiber
- 22 mils stainless steel cabling to the box sides
- Adjustment buckles, springs
- Spine is “free to move” inside tube bolted on wall, 1/2" free space to allow for the 8mm movement of the back-wall

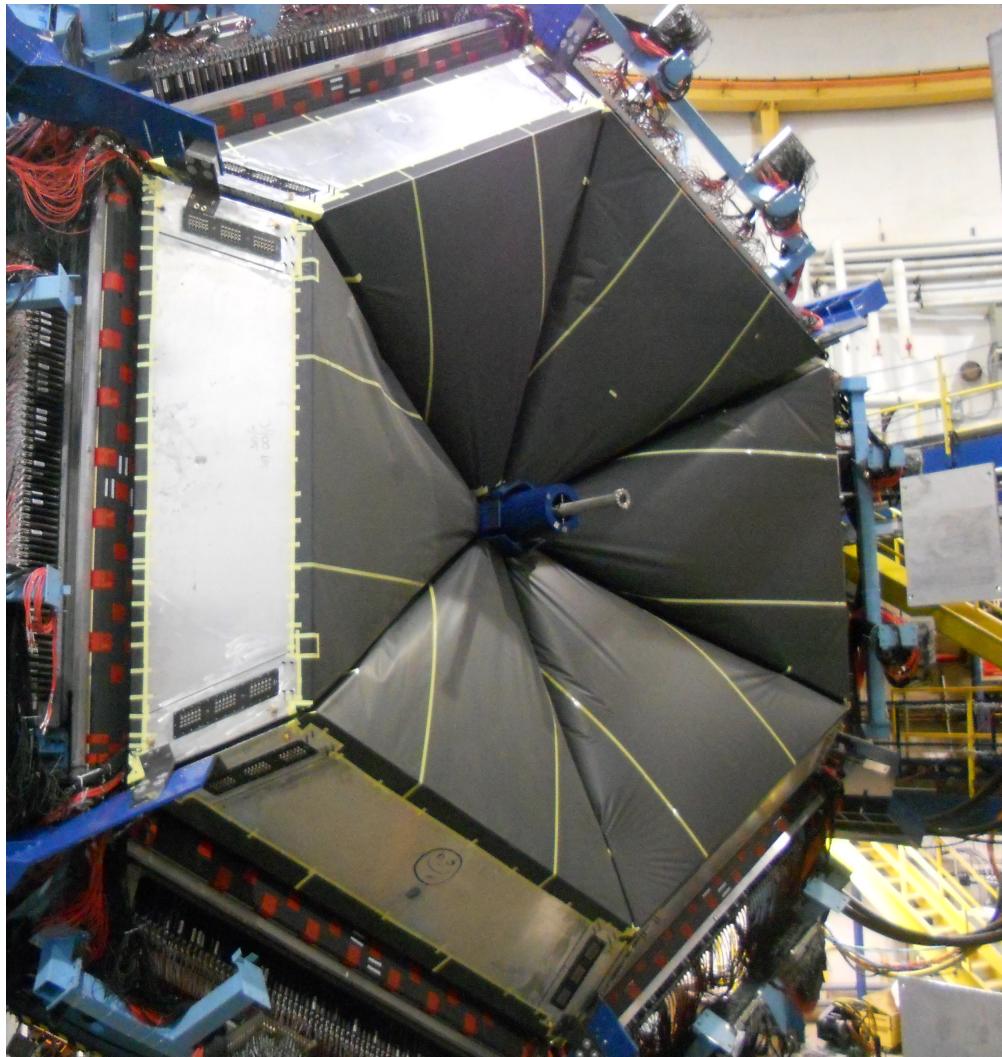
# Mirrors Alignment



# Window On LTCC



# Installation Completed



All sectors completed,  
installed

Now:  
Sector 4 out as of 8/23/2017

# Leaks

## Pre-installation Leak Checks:

- Using r134 + sniffer
- Pressure drop test (~24h)
- Results:
  - ✓ (Rare) leaks found on window / wall: fixed
  - ✓ Most leaks from nose: fixed
  - ✓ No sniffer alarm after box is fixed, even at lower settings

TODO:

Locate leaks for sector 3,5

**Current C4F10 price: \$140 / Kg**

Sector	C4F10 / day	C4F10 Kg / Day	Price / Week
1	95	1.06	1038.8
2	32	0.36	352.8
3	118	1.32	1293.6
4	38	0.43	421.4
5	27	0.3	294
6	101	1.13	1107.4
			4508

Price / week, all sectors:

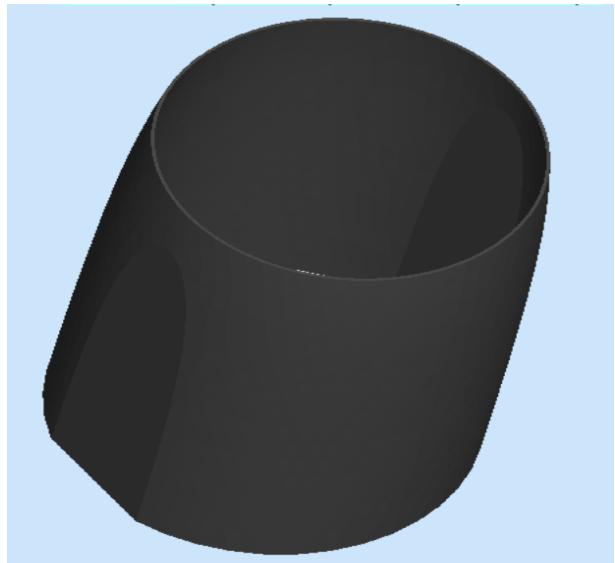
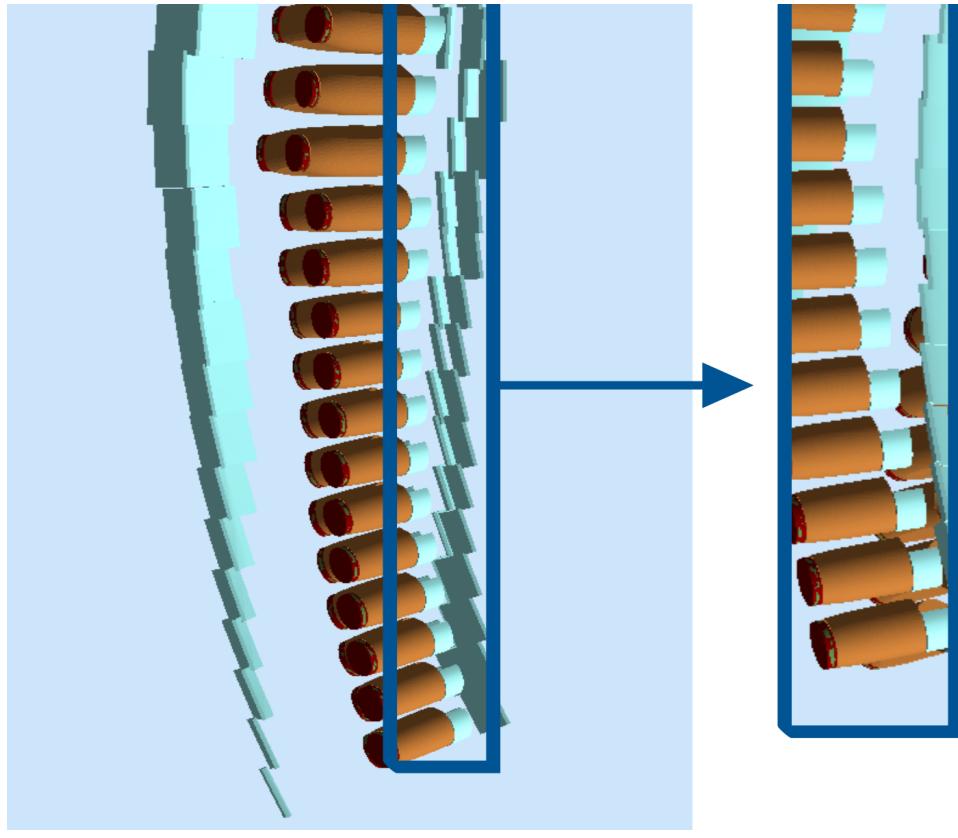
**\$1470** / week all 5 sectors assuming  
sector 5 leak rate for all

**\$4508** assuming current leaks

Note: these rates are extrapolated to C4F10. In reality leak location plays a major role due to the gas weight.

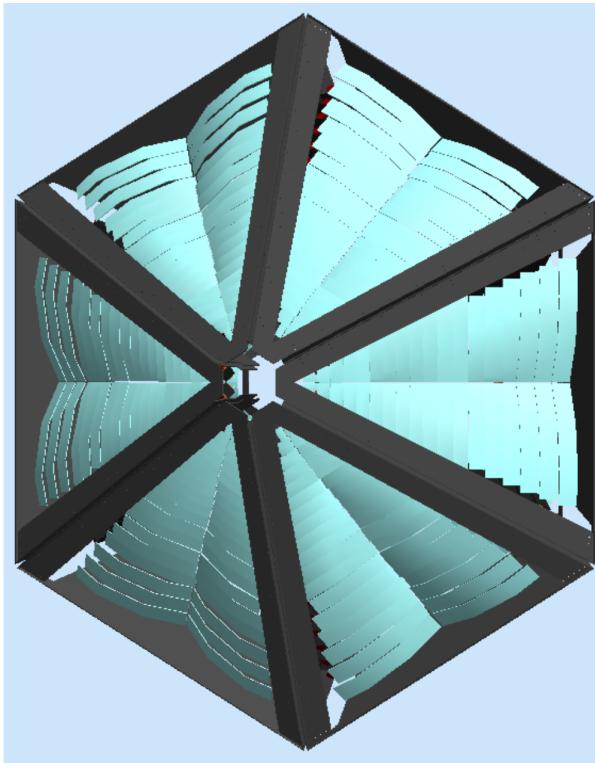
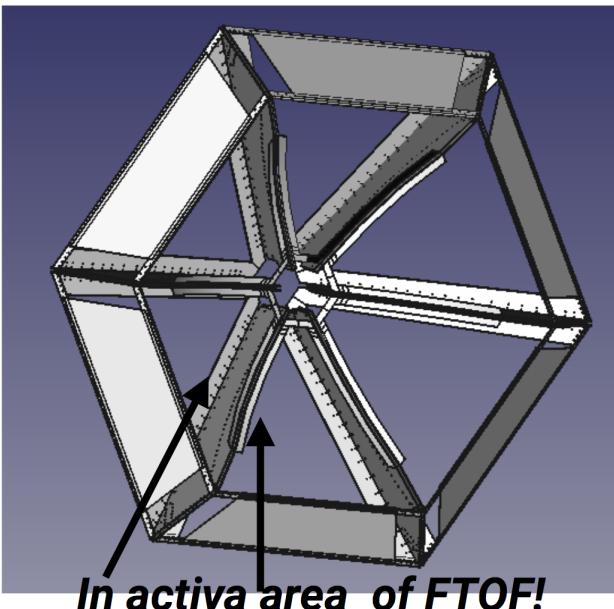
# Simulation

**Correct “flattened” Winston cone shape  
modeled in CAD Directly imported into genc  
Elliptical, Hyperbolic and Cylindrical Mirrors.**



# Simulation

- Aim: accurate representation of passive material in LTCC frame
- Started from engineering drawing
- Removed the non-essential components
- Simplified the shapes
- Import resulting CAD file in genc directly



- Working full simulation!
- Ongoing: effort to simplify meshes even further for reduced load times

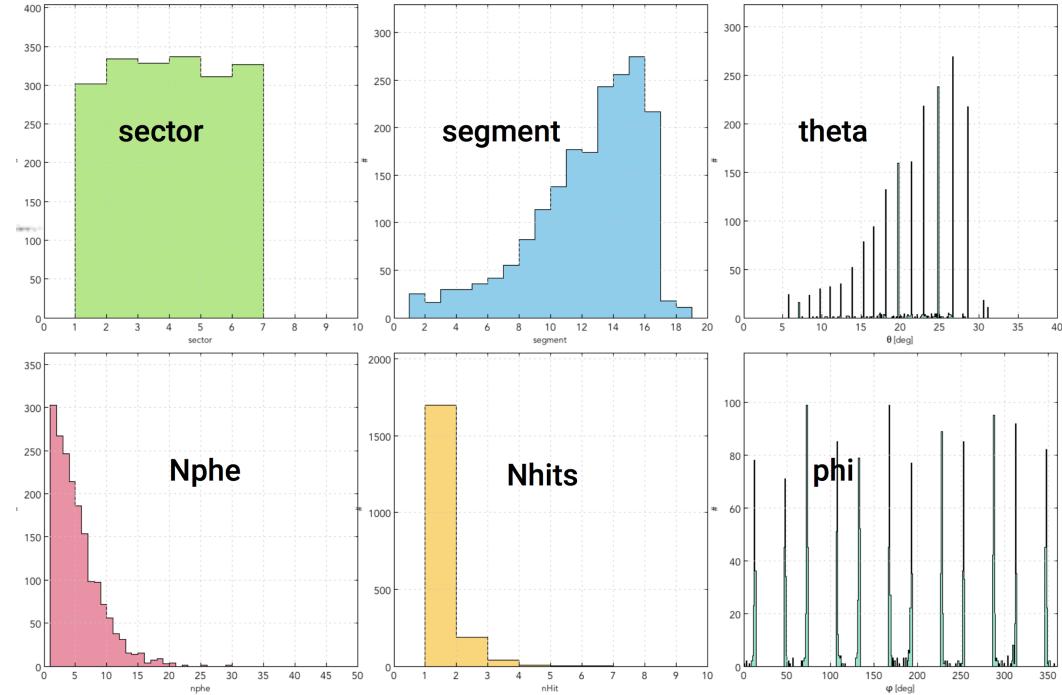
## Digitization:

- Measured PMT Quantum Efficiency
- Measured Mirrors, WC Reflectivity
- CCDB Calibration Constants, ADC Output

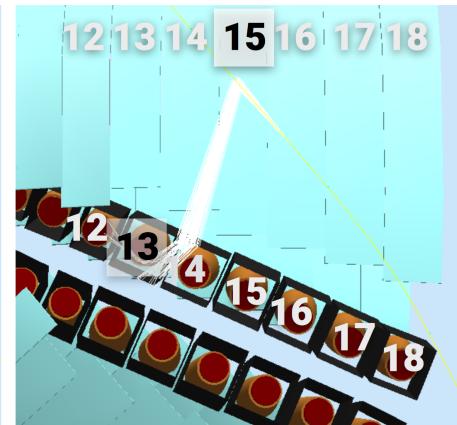
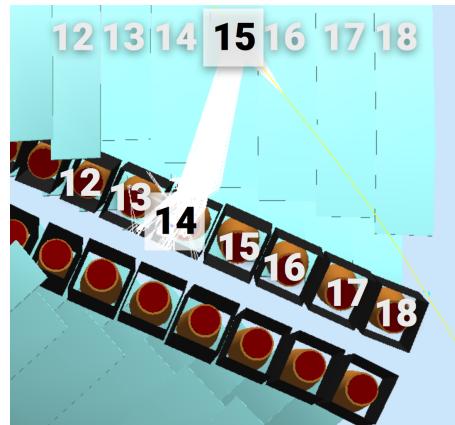
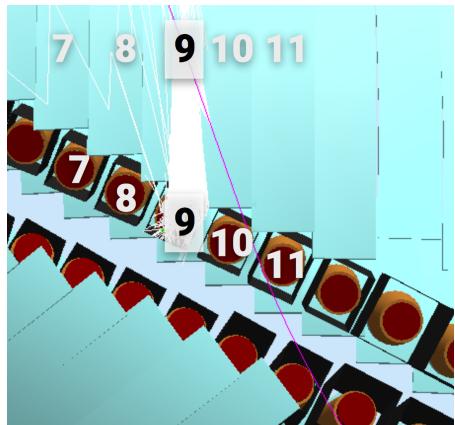
# Reconstruction

## LTCC Clustering plugin:

- Implemented in COATJAVA
- simple clustering algorithm:
  - (1) scan for highest multiplicity hit
  - (2) add neighbors (in space and time)
  - (3) Repeat until done

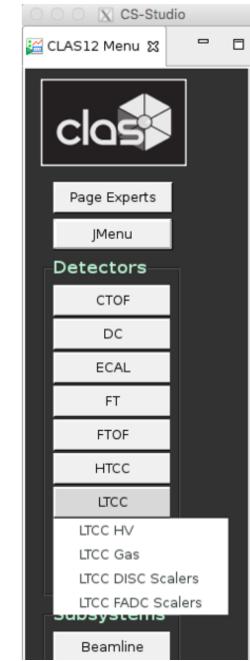
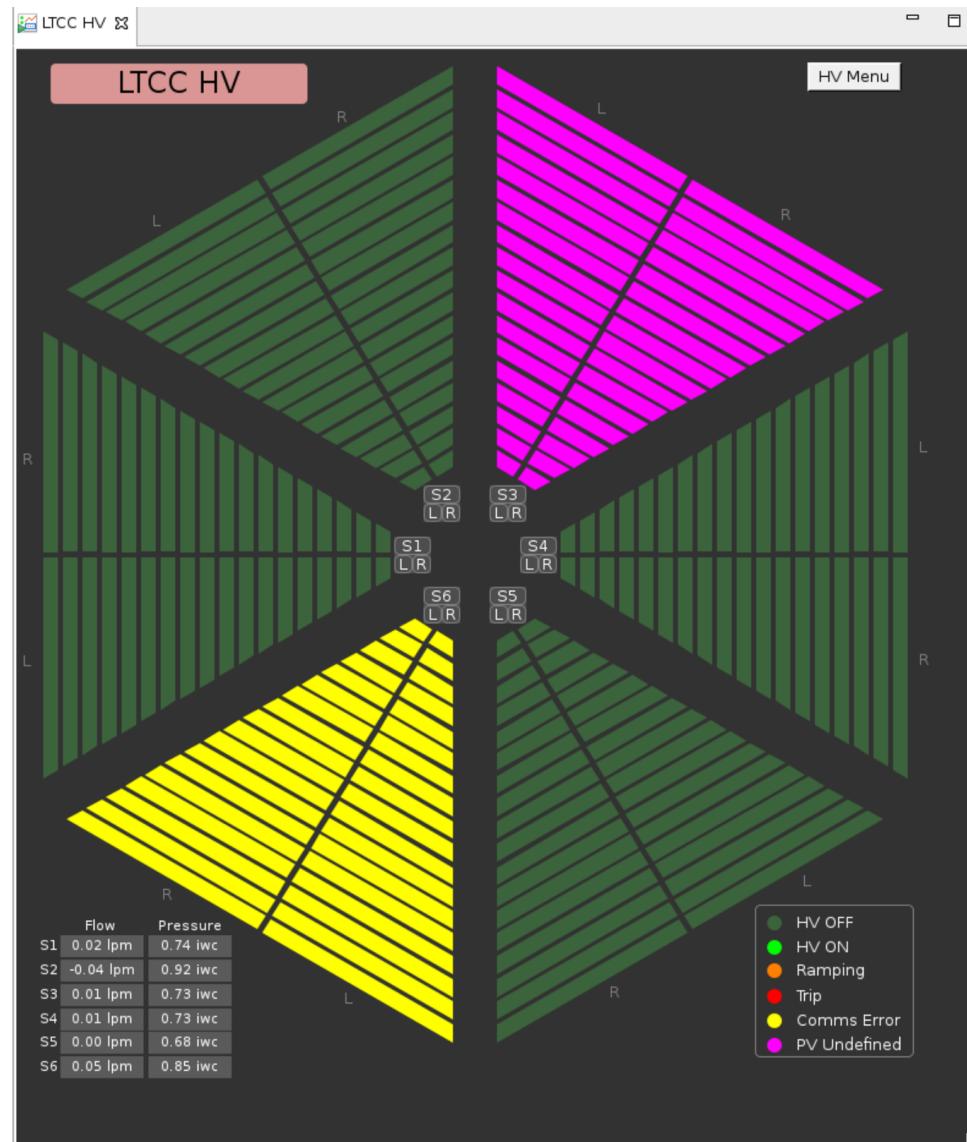


Same Segment



Different Segment

# Slow Controls



**HV SEC1 LTCC**

#	Description	Pw	Vmon	Imon	Status	Vset (V)	Iset (uA)	Vmax (V)	Up (V/s)	Down (V/s)
1	LTCC_HV_SEC1_R_E01	<input checked="" type="radio"/> OFF	1.000	0.00	OFF	1450.000	1450.000	1000	1000	1500
2	LTCC_HV_SEC1_R_E02	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1300.000	1300.000	1000	1000	1500
3	LTCC_HV_SEC1_R_E03	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
4	LTCC_HV_SEC1_R_E04	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
5	LTCC_HV_SEC1_R_E05	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
6	LTCC_HV_SEC1_R_E06	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
7	LTCC_HV_SEC1_R_E07	<input checked="" type="radio"/> OFF	1.000	0.00	OFF	1400.000	1400.000	1000	1000	1500
8	LTCC_HV_SEC1_R_E08	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1350.000	1350.000	1000	1000	1500
9	LTCC_HV_SEC1_R_E09	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
10	LTCC_HV_SEC1_R_E10	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1300.000	1300.000	1000	1000	1500
11	LTCC_HV_SEC1_R_E11	<input checked="" type="radio"/> OFF	1.000	0.00	OFF	1450.000	1450.000	1000	1000	1500
12	LTCC_HV_SEC1_R_E12	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
13	LTCC_HV_SEC1_R_E13	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1350.000	1350.000	1000	1000	1500
14	LTCC_HV_SEC1_R_E14	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1300.000	1300.000	1000	1000	1500
15	LTCC_HV_SEC1_R_E15	<input checked="" type="radio"/> OFF	1.000	0.00	OFF	1400.000	1400.000	1000	1000	1500
16	LTCC_HV_SEC1_R_E16	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500
17	LTCC_HV_SEC1_R_E17	<input checked="" type="radio"/> OFF	1.000	0.00	OFF	1400.000	1400.000	1000	1000	1500
18	LTCC_HV_SEC1_R_E18	<input checked="" type="radio"/> OFF	0.500	0.00	OFF	1400.000	1400.000	1000	1000	1500

Gas, HV, IOC, Alarms  
(Nathan Baltzell)

# Manual

## Low-Threshold Cherenkov Counter Operations Manual

M. Ungaro, Jefferson Laboratory  
*ltcc\_manual.tex - v1.0*

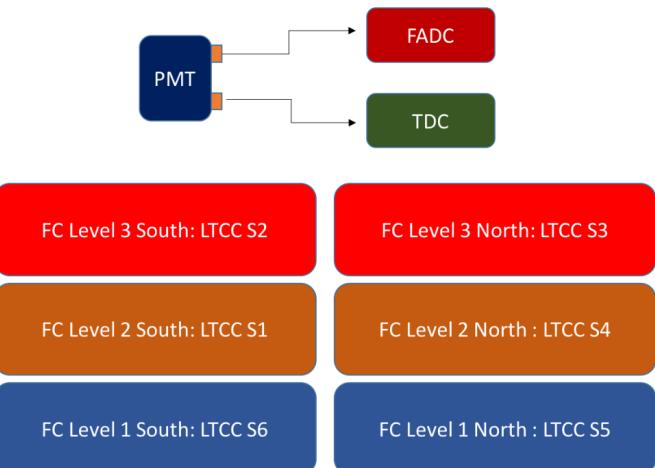
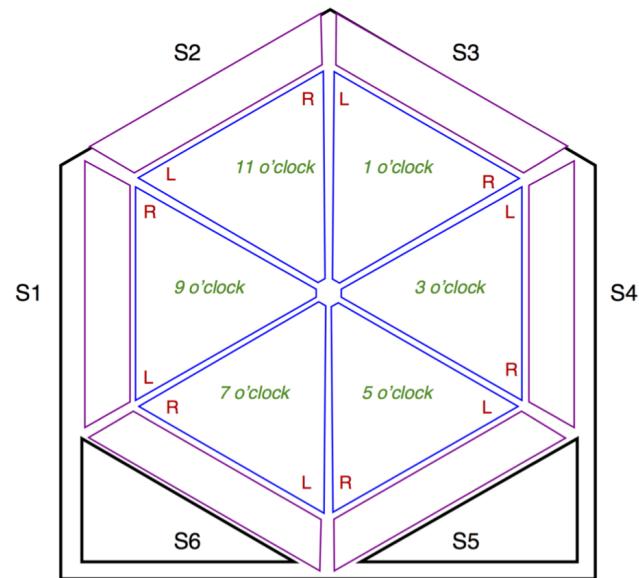
January 31, 2017

### Abstract

This document provides an overview of the CLAS12 Low-Threshold Cherenkov Counter (LTCC) and serves as an Operations Manual for the detector. Instructions are provided for shift workers related to basic steps of operating and monitoring the HV controls, monitoring the detector system and responding to alarms, and knowing when to contact the on-call personnel.

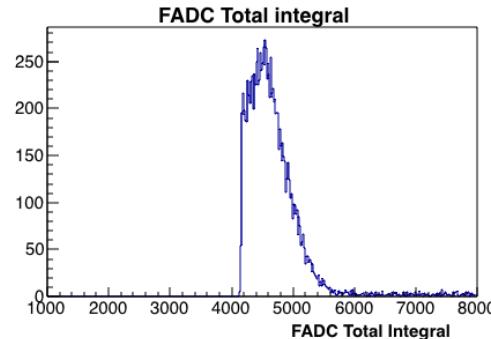
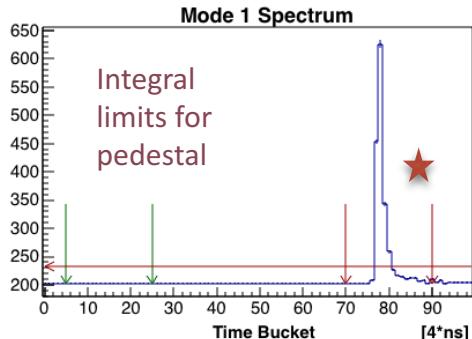
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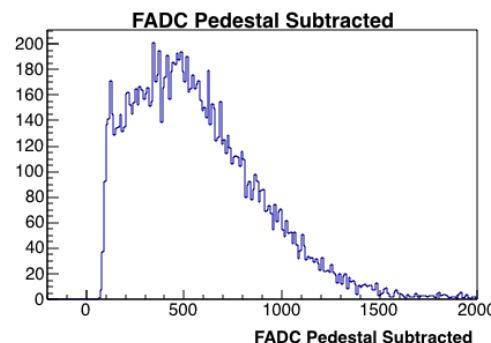
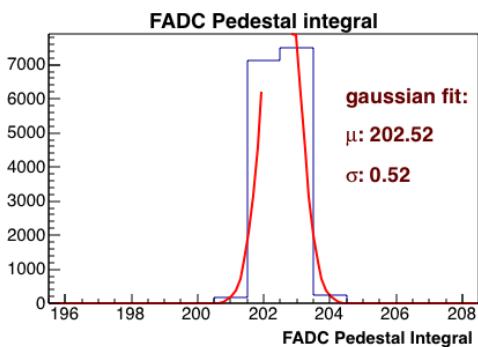


# Mode 1 Data

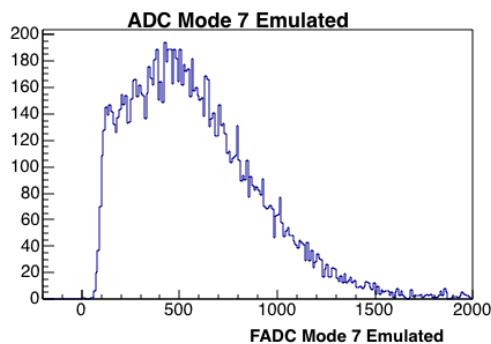
## Sector 1 Channel 1 Left



Total integral beneath  
signal



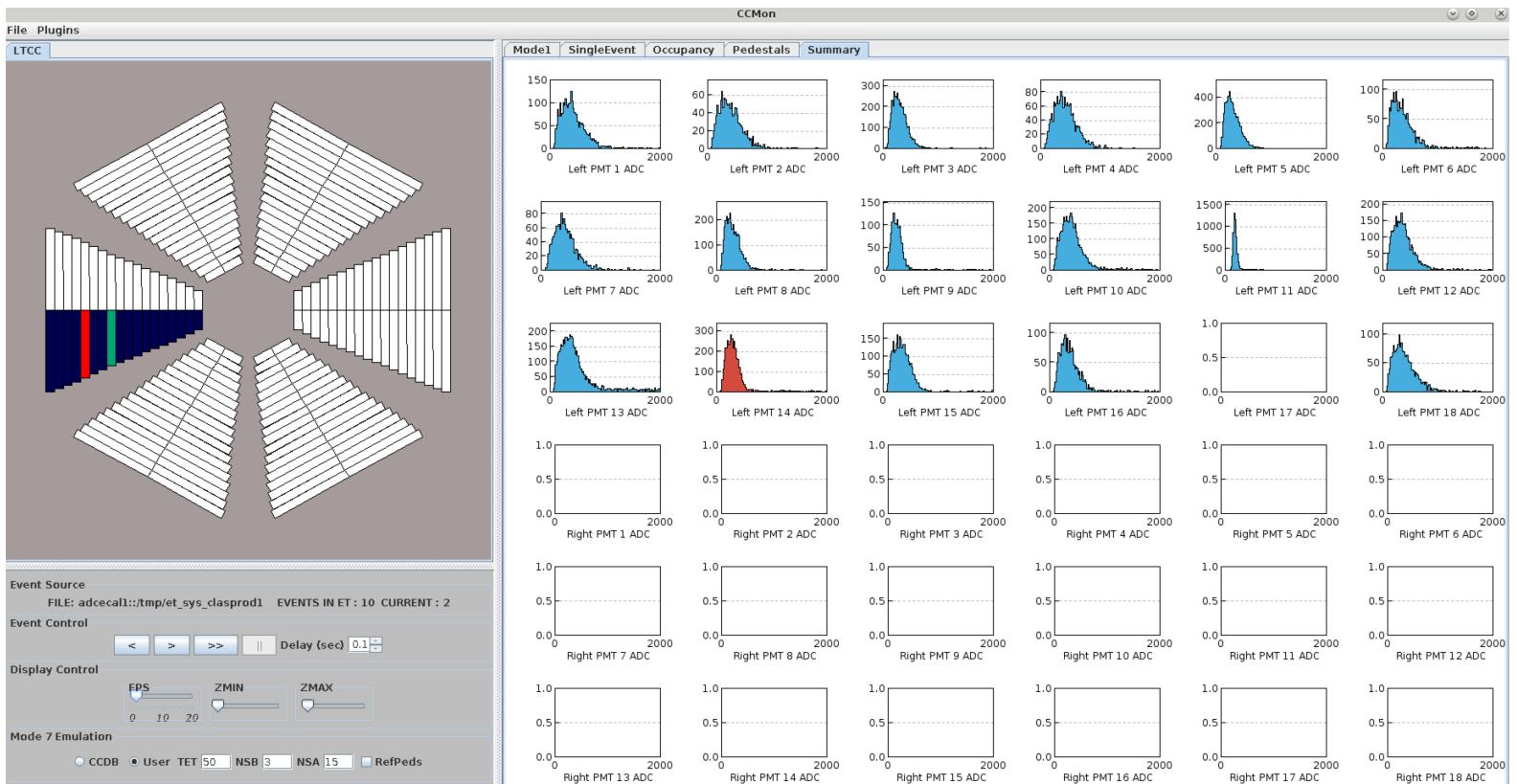
Total Integral -  
Pedestal  
EVENT BY EVENT



Number of hits: 15004  
Pedestal: 202.5  
Pedestal min t: 5  
Pedestal max t: 25  
Signal min t: 70  
Signal max t: 90  
Mode 7 Emulation Threshold: 30

# Online Calibration, Monitoring

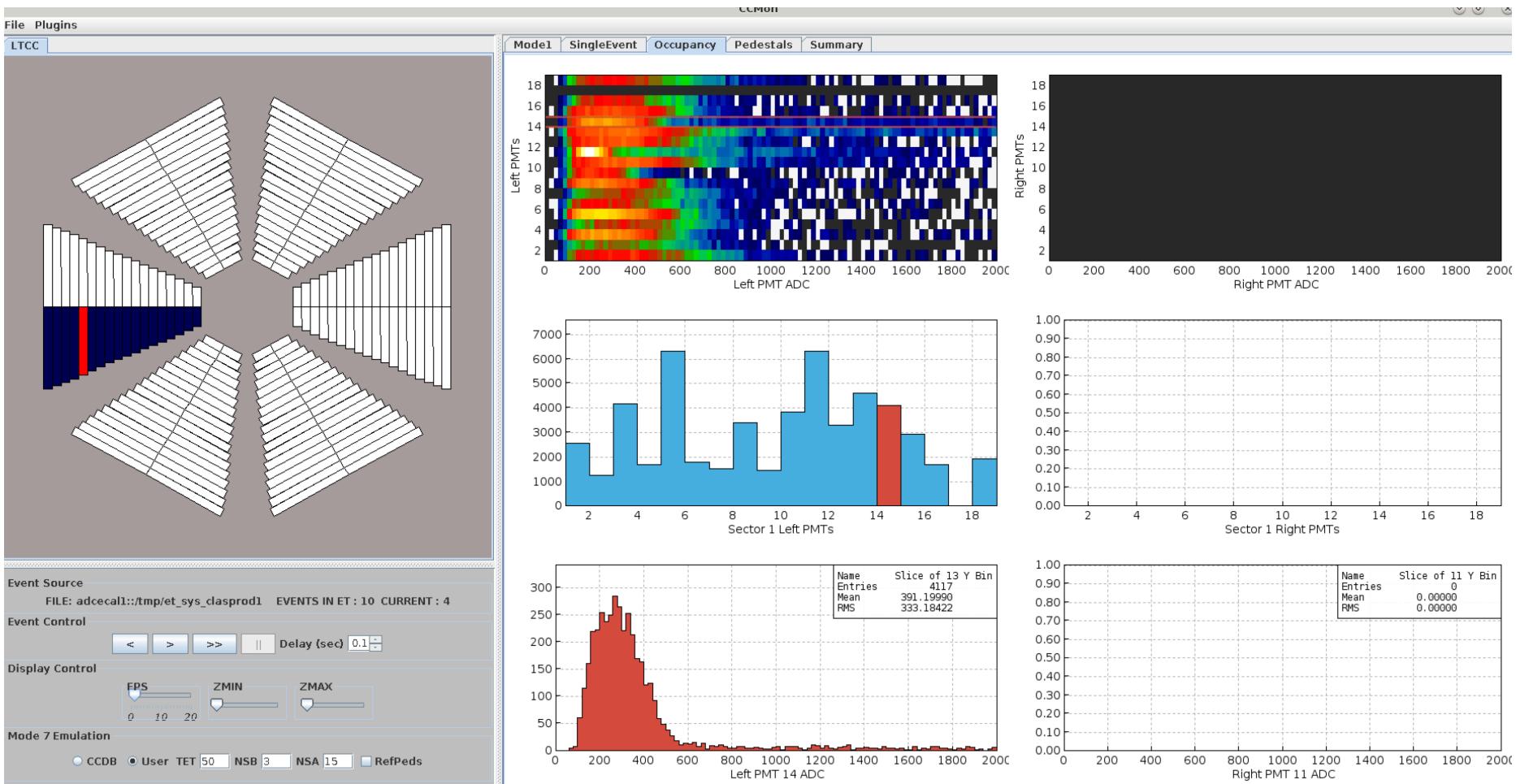
- Real time histograms, mode 1
- Mode 7 emulation
- Single events, Accumulated events
- Summary 1D, 2D plots
- Select individual channel, all sectors
- Very fast!
- Small CPU overhead



Hover on CC segment to display signal

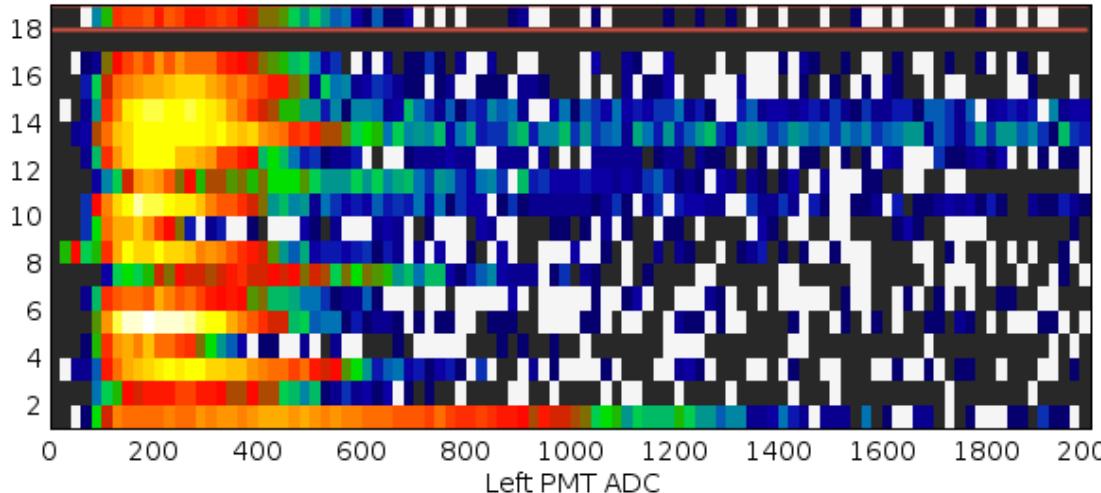
# Online Calibration, Monitoring

Summary Screen: 1 and 2D occupancies, single segment plot



# Preliminary HV Matching

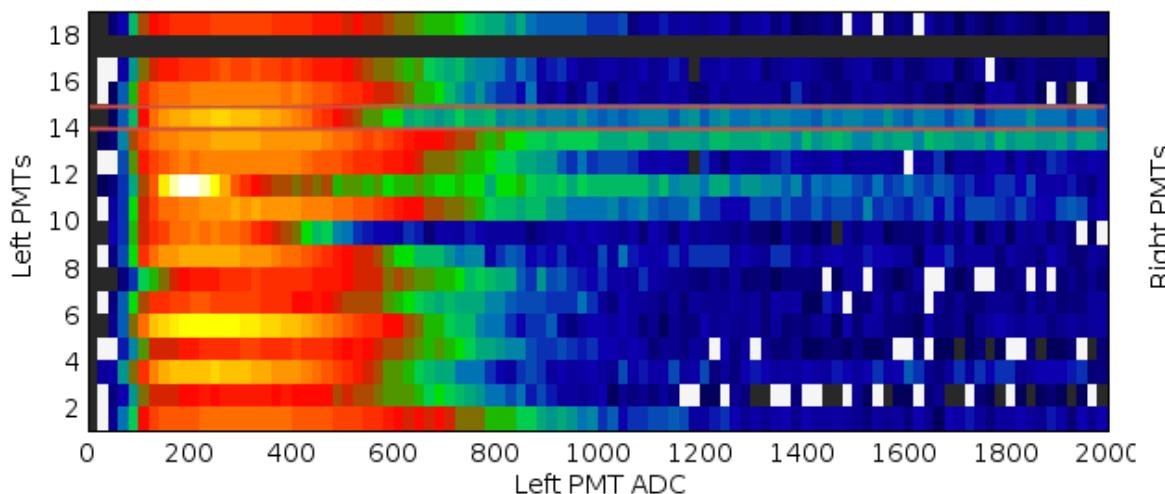
Model | SingleEvent | Occupancy | Pedestals | Summary |



Preliminary gain  
matching  
Before/After

Full calibration  
SUITE:  
Temple University,  
Fall 2017

Model | SingleEvent | Occupancy | Pedestals | Summary |



# OSP, THA, Documentation, Team

- OSP & THA: Submitted and Approved ✓
- LTCC Shift Workers Manual : Completed ✓
- LTCC Shift Experts Manual : In progress
- LTCC GAS System Operation Manual: Completed (G. Jacobs) ✓

LTCC Construction Team:

Tech Team: David Anderson, Morgan Cook

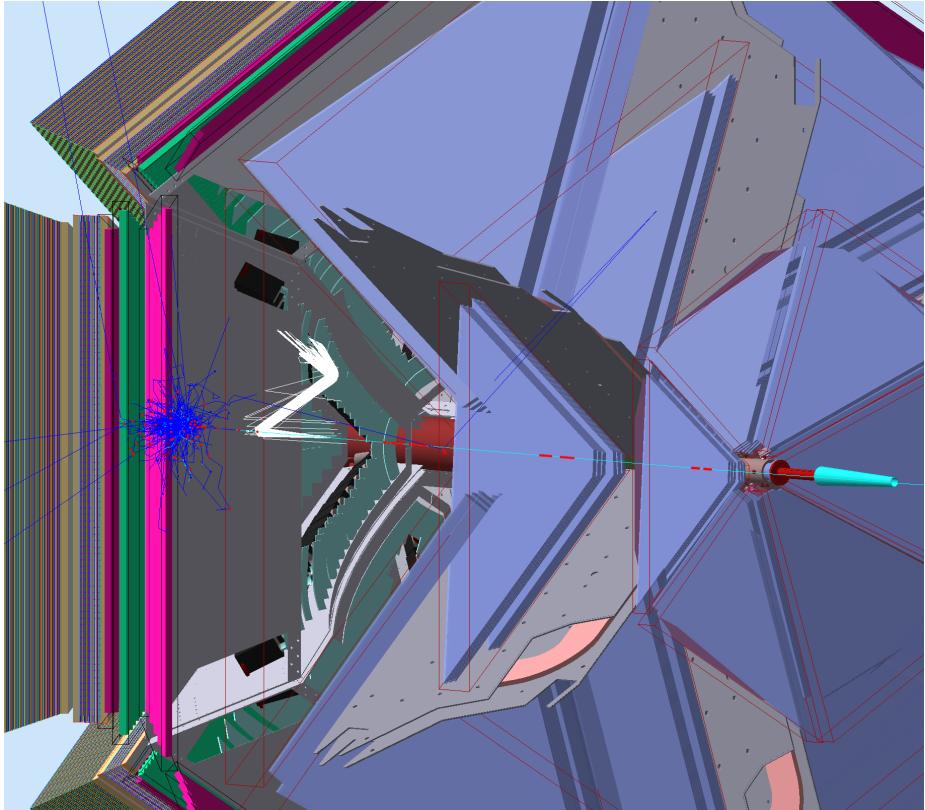
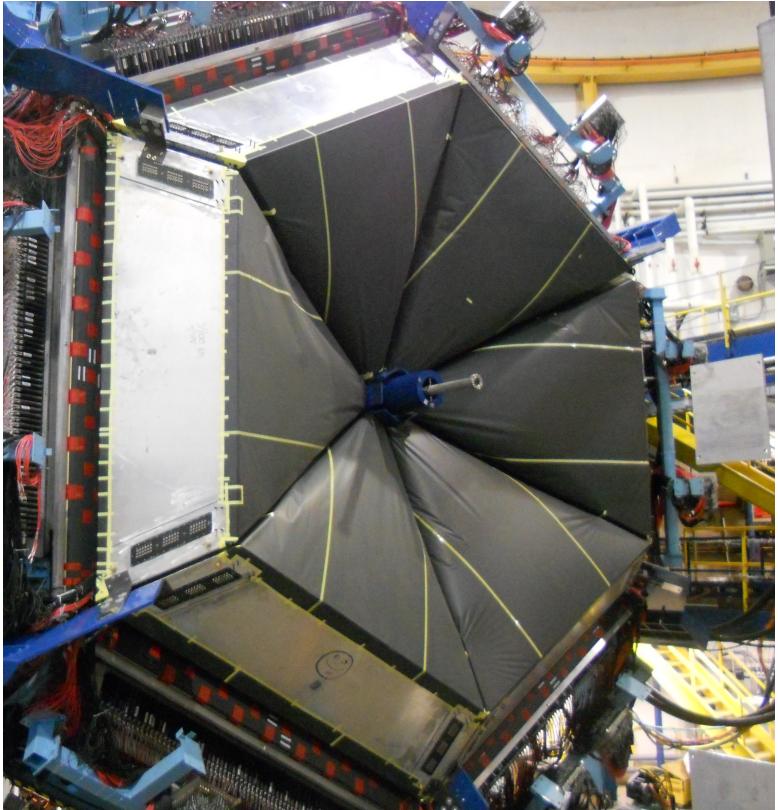
Designer Team: Bob Miller, Joe Guerra

- Window: Steve Christo, D. Anderson
- PMT Mod: Vladimir Popov
- Mirror Recoating:
  - D. Anderson, M. Cook
  - Company: ECI
- WC Refurbish, Recoating: ECI, DSG
- Mirror, WC reflectivity measurements: DSG
- Spine Refurbish: Bob Miller, D. Anderson
- PMT Wavelength Shifter: Temple U.
- Installation: Hall-B Tech Team.

LTCC Current Team:

- Gas System: G. Jacobs, D. Insley, DSG
- Monitoring Software: Cole Smith
- Slow Controls: Nathan Baltzell
- Reconstruction, Calibration: TEMPLE U.

# Summary



- 12CBLT closed. \$1.2M Project completed
- Leaks at clas6 level but should be lower.  
Investigating.
- LTCC HV matching, SPE simulations, calibration,  
reconstruction and monitoring ongoing