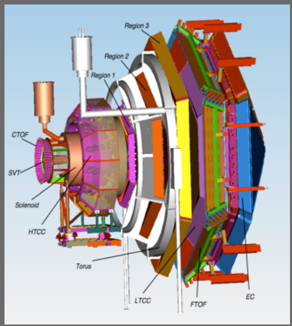
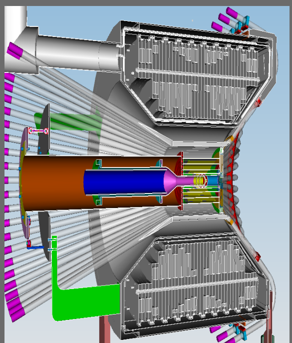
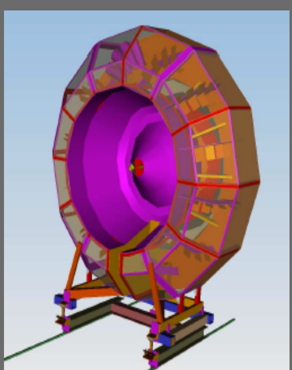
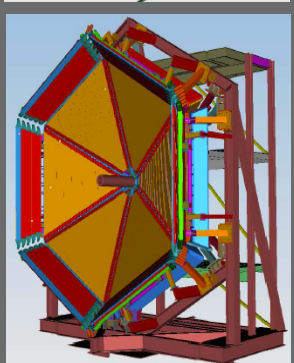


CLAS12 CalCom Status Update

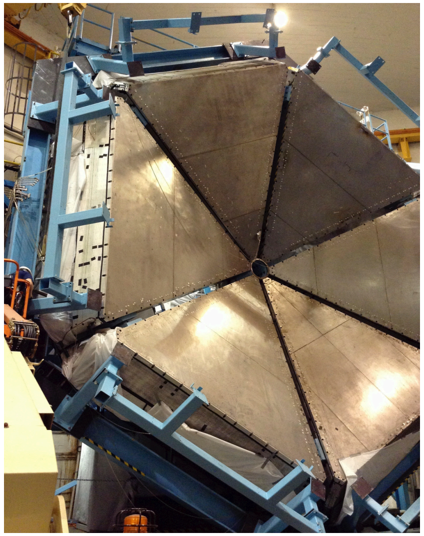
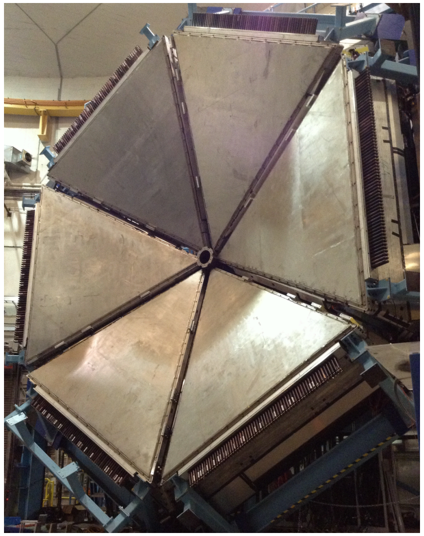
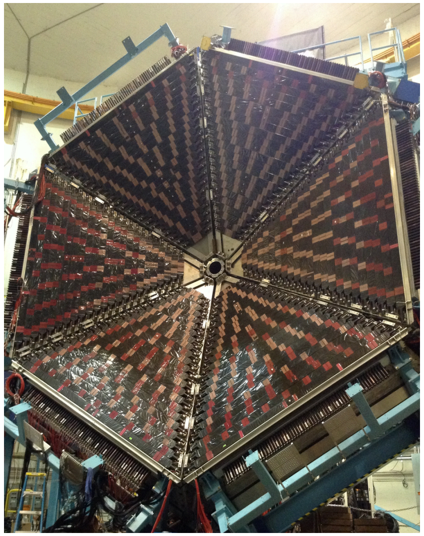
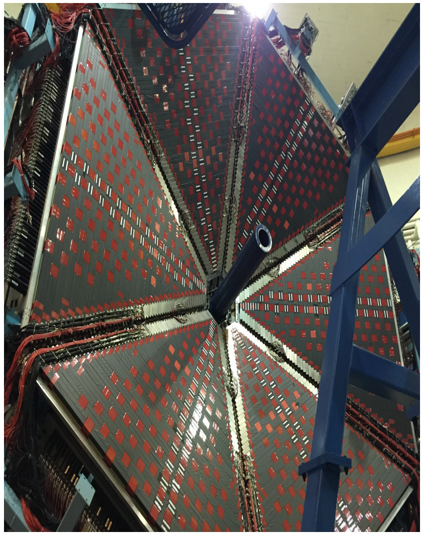
CLAS Collaboration Meeting

October 21, 2015

Outline

- Detector commissioning and calibration:
  - Status update and upcoming work for CLAS12 subsystems (EC-PCAL, FTOF, LTCC/HTCC, DC, SVT, CTOF, CND, FT,…)
  - Software development and calibration tools
- Commissioning with Beam Plan
  - Revision of CWB plan
  - Path forward

Forward Carriage Commissioning

			
EC	PCAL	FTOF Panel 1A	FTOF Panel 1B

Detector Status

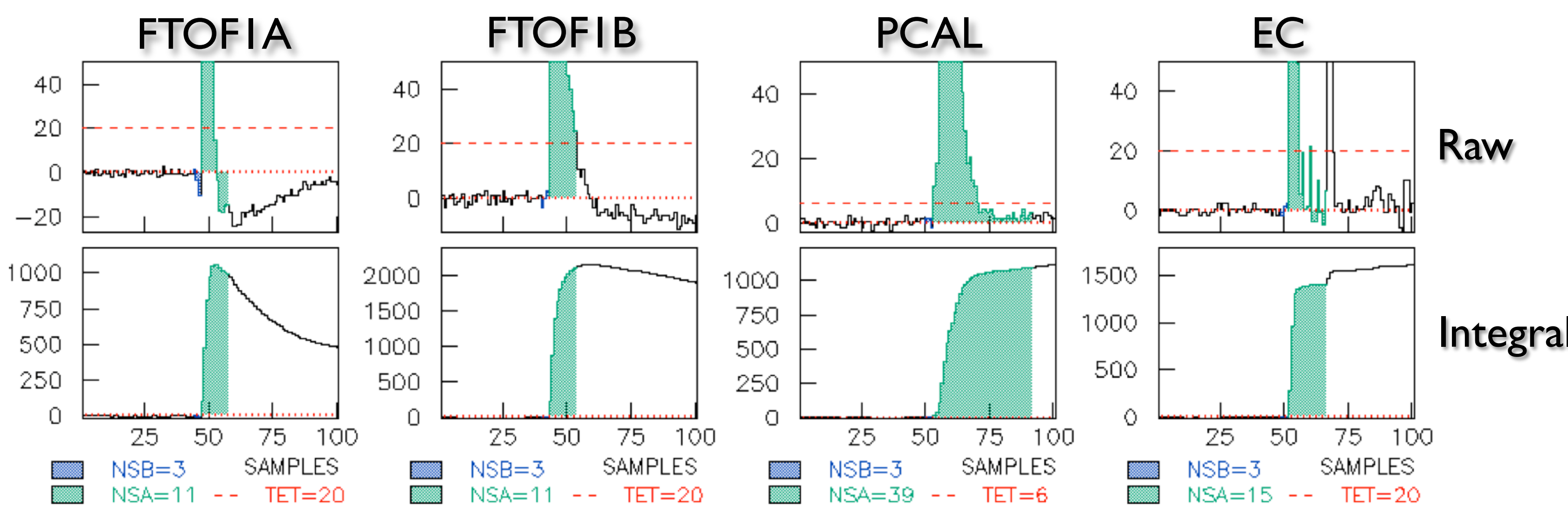
- PMT gains and occupancy of PCAL and FTOF largely stable after 1½ years of running.
- EC issues:
  - Light leaks opened up due to disturbance of taped seams during cable installation.
  - CAEN HV repairs (5 boards and a power supply returned).
  - Some electronics cabling was postponed until patch cables were available. This work is mostly finished and full checkout of EC should be completed by end of 2015.
- Next major goal is development of energy sum / cluster trigger in Central Trigger Processor (CTP) when hardware becomes available in early 2016.
- "Final" EC/PCAL cosmic calibration will use CTP-based trigger for greater flexibility and efficiency studies of both detectors and trigger.

Forward Carriage Commissioning

Up to now cosmic data taken with FADC raw mode (mode 1) with pedestal subtraction, thresholds and peak summing performed in event decoder and DST ntuples written to disk

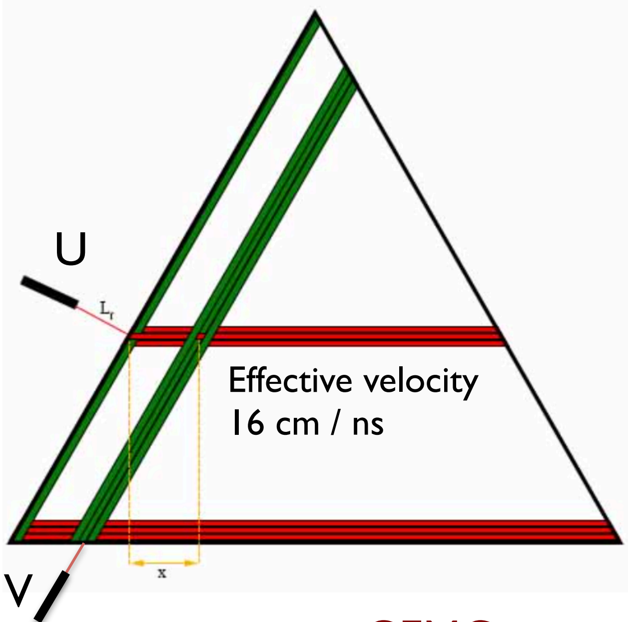
Currently we are evaluating pulse mode (mode 3) to enable better data compression and write EVIO files for testing COATJava calibration suites

This requires fine tuning fADC NSA, NSB window parameters and TET thresholds to take into account different pulse shapes in PMTs and optimize pulse integral



Zero crossing at NSA=7 | Zero crossing at NSA=17 | Slow pulse, long tails | Fast pulse, afterpulses, reflections

EC-PCAL Simulation



GEMC now includes time propagation of light along strips for EC and PCAL

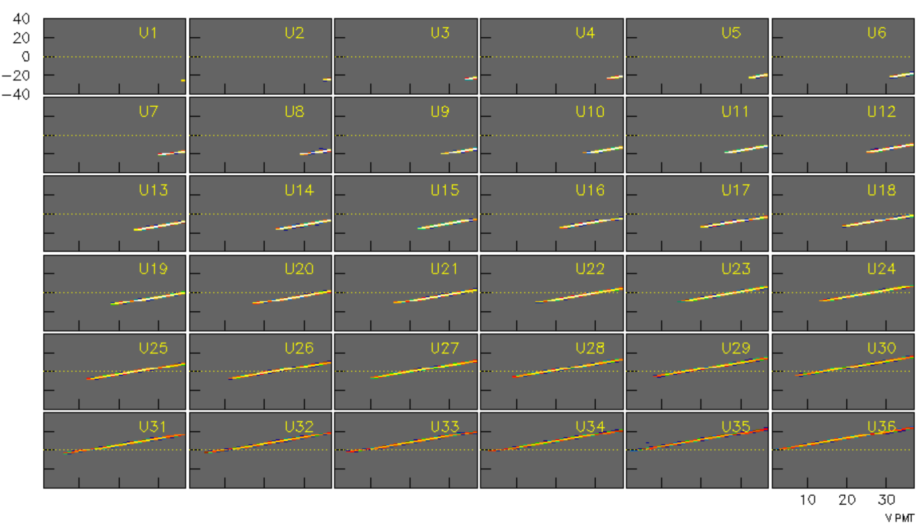
DGTZ banks: Raw counts x 24 ps/count to simulate both V1190 / V1290 TDCs

Simulation checked against data using time differences between cosmic muon hits in different U,V,W layers (below)

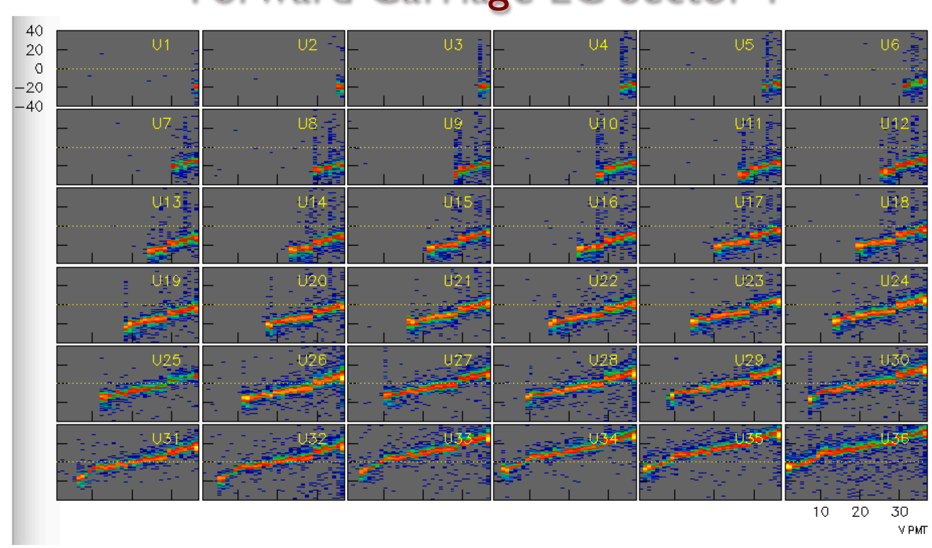
Forward Carriage data show effect of different cable and light guide lengths and provide estimate of time resolution for simulation

Δt (U-V) vs. V PMT

GEMC



Forward Carriage EC Sector 1



FTOF Simulation

GEMC now properly simulates gain matching algorithm for FTOF

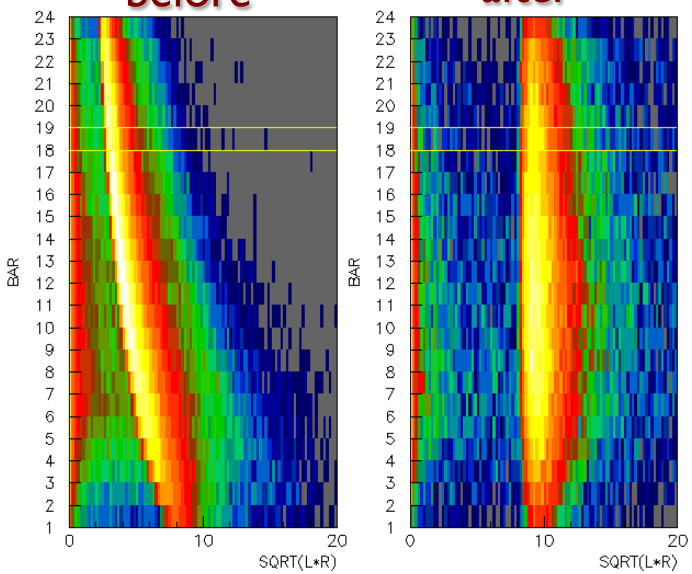
PMTs are not gain matched to each other, but Left, Right adjusted so geometric mean (sqrt L×R) is independent of counter length z

Overall attenuation factor of exp(- 0.5 z/ λ) is built into HV adjustment, in addition to L,R gain balancing

This factor was added to ftof_hitprocess.cc in GEMC

sqrt(L×R) from GEMC

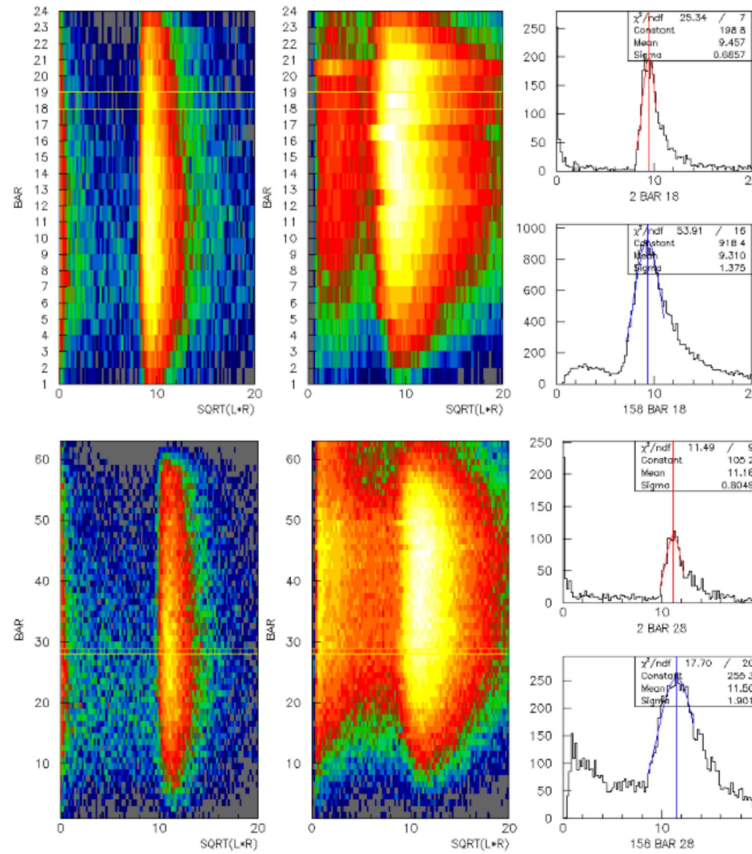
before after



GEMC Data

Panel 1A

Panel 1B

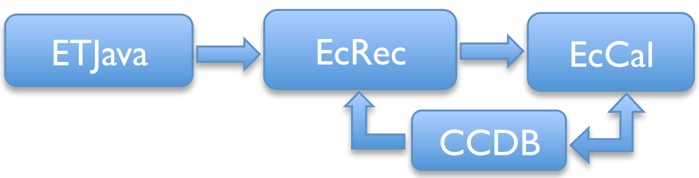


EC-PCAL Calibration

COATJava GUIs developed to display raw and filtered data relevant to EC / PCAL energy and timing calibration

GUIs currently use legacy code for isolating suitable muon tracks (pixel cut). Plan is to replace this code with online ECReconstruction service (EcRec)

EC Calibrator (EcCal) will perform fitting and display of calibration results (gains, attenuation lengths, timing offsets and other constants)



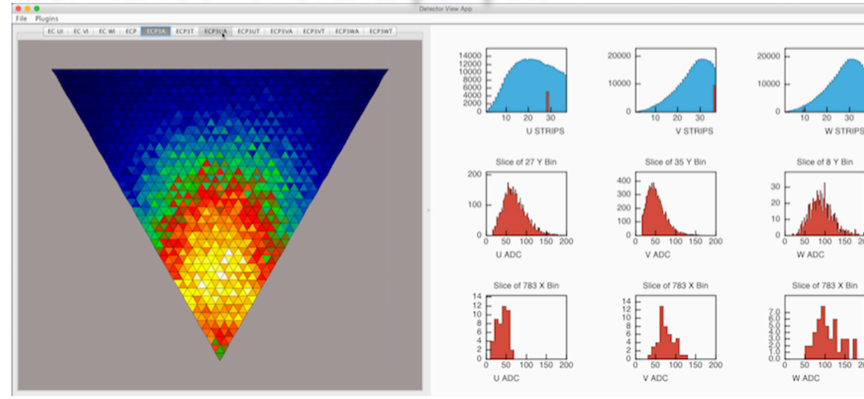
Work in progress:

- ETJava service, DAQ/CLON prep (Gagik, Sergei)
- EcRec, CCDB tables (Cole)

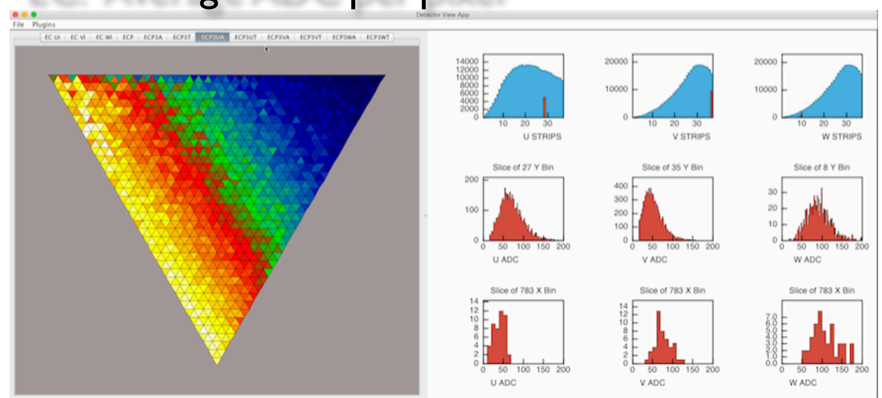
Schedule:

- Oct-Nov: Forward Carriage testing of ETJava + event decoder + EcRec
- End of 2015: EcCal ready for testing service chain outlined above. Needs to be in place for testing CTP trigger (EcRec vs. FPGA based cluster finding) in 2016

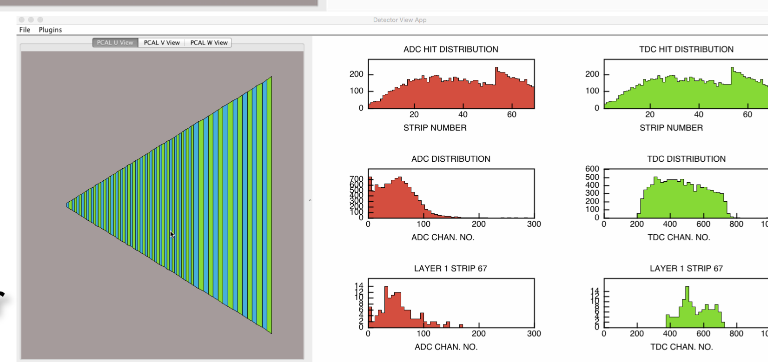
EC: Number of events per pixel



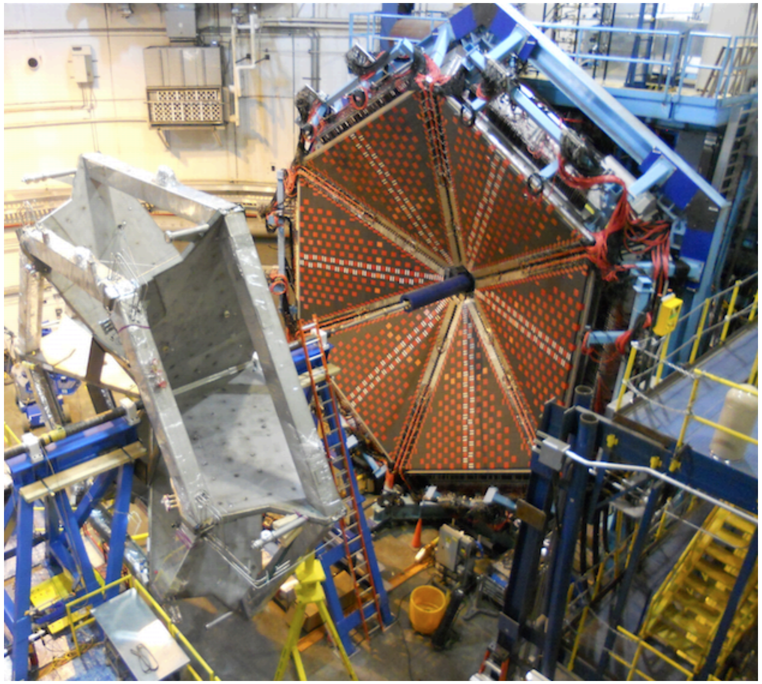
EC: Average ADC per pixel



PCAL: Browser



FTOF Calibration



Calibration Run History:

(as of October 2015)

S1: last run June 12, 2015

S2: last run June 13, 2015

S3: last run July 13, 2015

S4: last run April 10, 2015

S5: last run March 21, 2015

S6: last run April 4, 2015

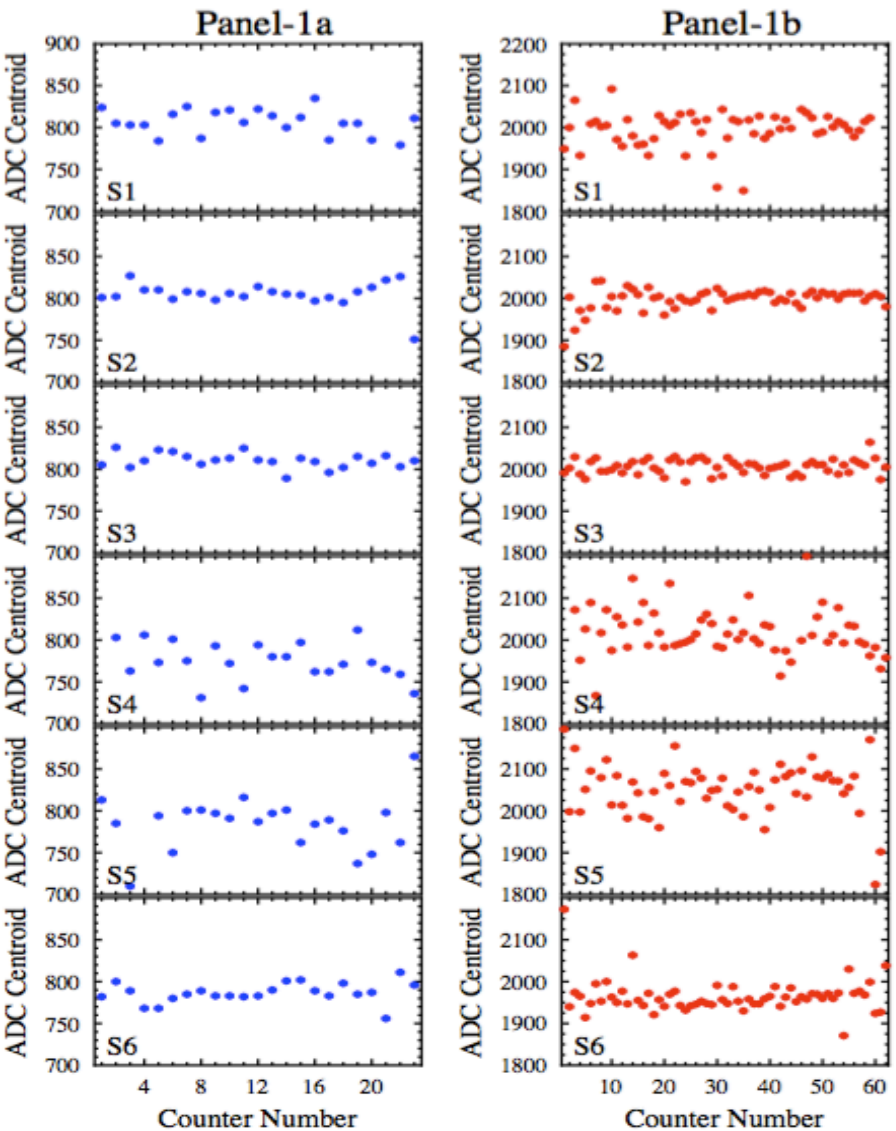
Calibration runs:

- *Checked signal connectivity*
- *Checked signal inverters (panel-1b)*
- *Calibration HV (gain matching)*
- *Checked for swapped cables*
- *Checked counter functionality*
- *Note: TDCs not fully functional*

Known Problems:

- *S4b #7R (high PMT current)*
- *S6a #21L (bad voltage divider)*
- *S5a #4R (bad voltage divider)*
- *S6b #54L (high PMT current)*

FTOF Calibration



- FTOF gain calibrations complete; monitoring system long-term stability
- Using data to develop FTOF calibration suite
  - *code development in progress by H. Lu (Iowa) & L. Clark (Glasgow)*
- Gearing up for PCAL/EC/FTOF1a+1b geometry matching and FTOF efficiency measurements using cosmic rays
  - *Initial studies complete for S5 (CLAS12-Note 2014-006)*
  - *Waiting for completion of PCAL setup (in progress – C. Smith)*

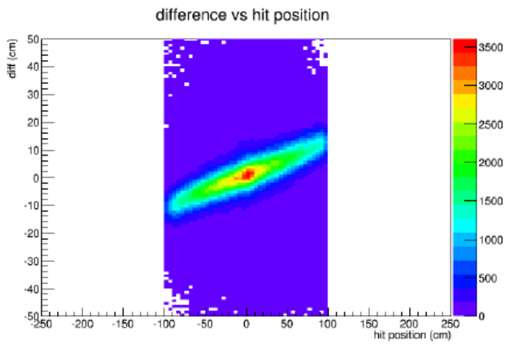
FTOF Calibration

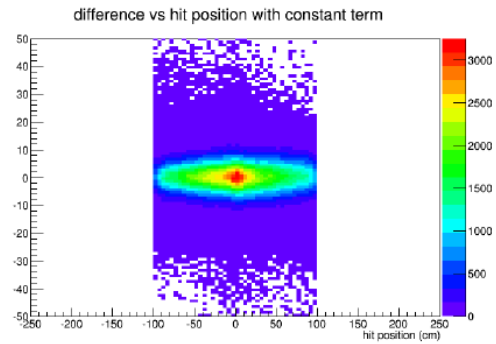
Algorithm development

Haiyun Lu (Iowa U.)

Difference between hit position and calculated from two TDCs in dependence of hit position

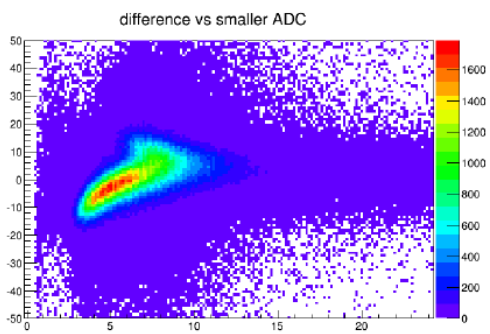
Before time-walk correction

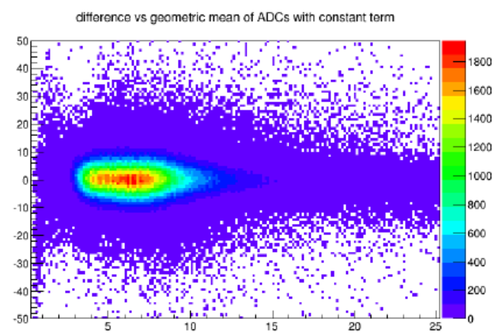




after time-walk correction

in dependence of smaller ADC



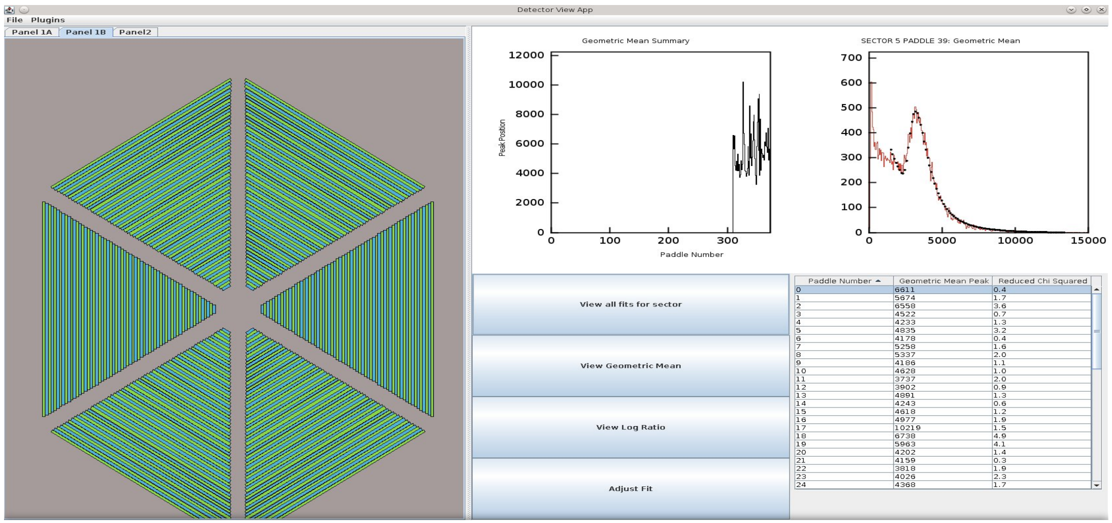


FTOF Calibration

Software implementation

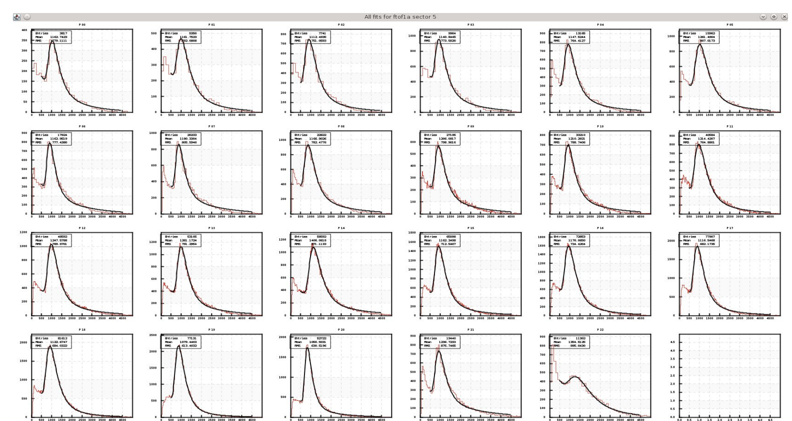
Louise Clark (Glasgow U.)

Development of FTOF calibration plugin for detector monitoring interface



Paddle Number	Geometric Mean Peak	Reduced Chi Squared
0	6611	0.4
1	5674	1.7
2	6558	3.6
3	4522	0.7
4	4233	1.3
5	4835	3.2
6	4178	0.4
7	5258	1.6
8	5337	2.0
9	4186	1.1
10	4628	1.0
11	3737	2.0
12	3902	0.9
13	4891	1.3
14	4243	0.6
15	4618	1.2
16	4977	1.9
17	10219	1.5
18	6738	4.9
19	5963	4.1
20	4202	1.4
21	4159	0.3
22	3818	1.9
23	4026	2.3
24	4368	1.7

- View individual plots and table of calibration values
- Adjust fits
- View all plots for sector



- Write constants to file
- Color code graphic to indicate success of calibration algorithm (planned)

FTOF Calibration

Software development status

Louise Clark (Glasgow U.)

Work in progress

- Conversion of calibration algorithms to COATJAVA framework
- Integration of calibration plots and fits with standard monitoring GUI

Work planned

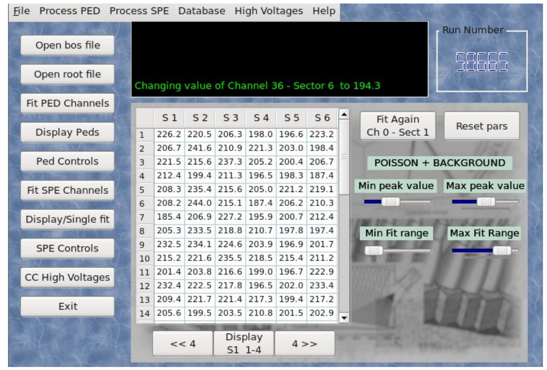
- Conversion of remaining calibration algorithms to COATJAVA framework
- Full functionality within GUI for each calibration area

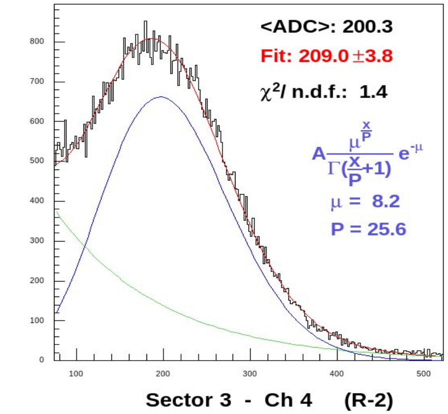
Calibration area	COATJAVA development status
Geometric mean / Log ratio	In progress
Effective velocity	In progress
Left-right adjustment	In progress
Attenuation length	In progress
Time-walk correction	Planned
Counter status	Planned
TDC	Planned
RF offset	Planned
P2P constants	Planned

Cerenkov Calibration

CLAS Calibrations:

- HV Matching
- Pedestals
- SPE calibration
- CALDB I/O
- ROOT Output

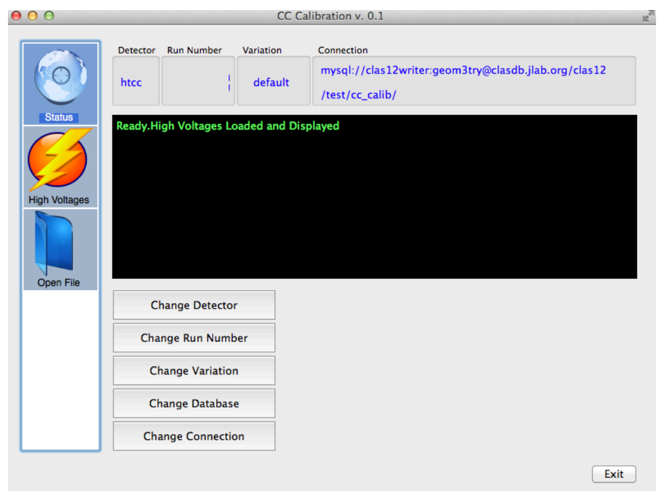


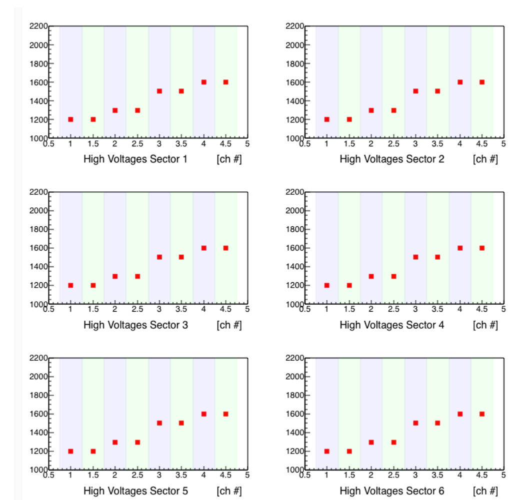


CLAS12 Calibrations

- HTCC and LTCC
- HV Matching
- SPE analysis
- CCDB I/O
- CAEN SY4527 HV I/O
- ROOT Output

M. Ungaro and
N. Markov





Status

- GUI started
- CCDB I/O
- Working on CAEN I/O
- Starting actual FADC acquisition, HTCC and LTCC calibrations
- Will also use Java Framework

HTCC Commissioning and Calibration

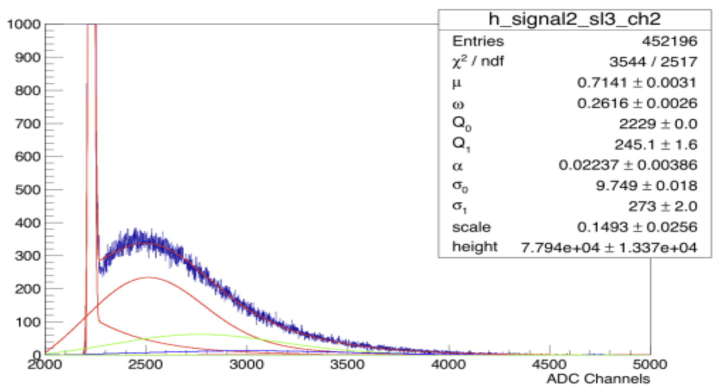
Status

N. Markov, W. Phelps

- New driver for the Light Source (LED) providing faster signals adjustable in wide range has been developed and manufactured
- Module to operate remotely the LED driver has been developed, manufactured
- PMT gain equalization software has been developed
- Tests of all components successfully completed
- LMS components installed
- Test of installed PMTs and bases in progress

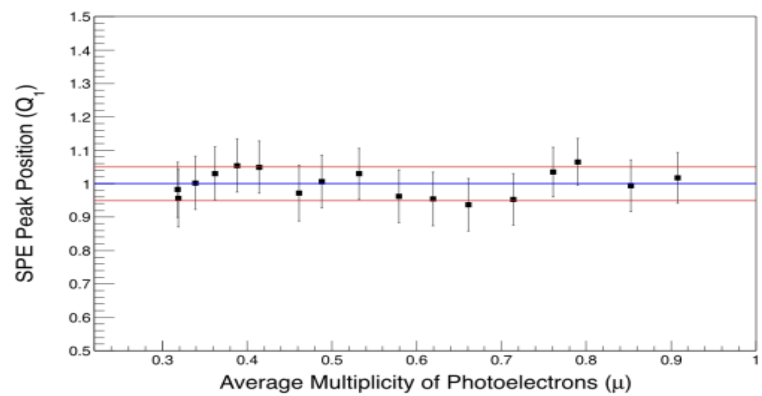
Calibration

Individual fit:



- Typical Fit Result at low intensity of LED light

Fitting with Different Intensities :



- Fitting function is stable across a wide range of intensities
- Fit function accurately describes PMT response at low intensities ($\mu<1.0$)
- Position of the Peak stays within 5% of mean

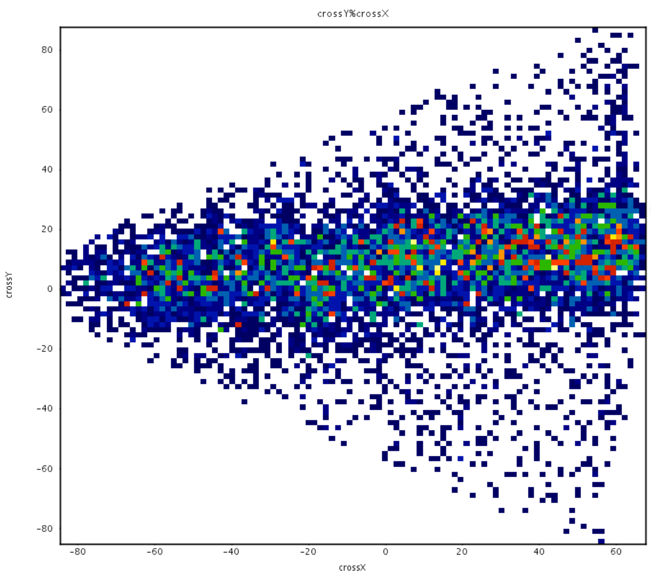
DC Calibration

DC Calibration Categories:

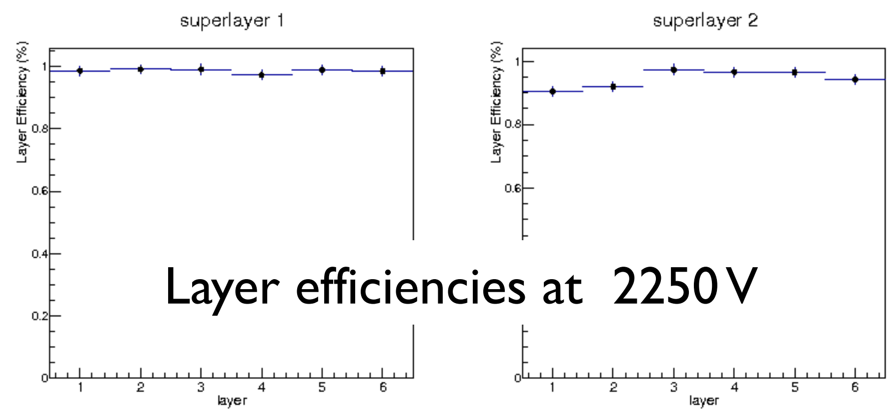
- **Translation Tables** – …WELL UNDERWAY…
  - associate each wire with its electronics; STB → DCRB; CAEN → HVTB, etc.
- **Geometry** –
  - ideal wire positions …DONE…
  - misalignment … Procedure established…
- **Time Delays** – … Procedure established…
  - cable delays
  - signal velocity along wire
  - time difference between DCRB and FTOF
- **Status Tables** –
  - keep time history of HV, lv, wire status …GUI's, Maps built…
- **Drift Velocity** –
  - parameters to determine DOCA as a function of time … Studies begun…

Krishna Adhikari, Olga Cortes, Johann Goetz, Brook Byrd

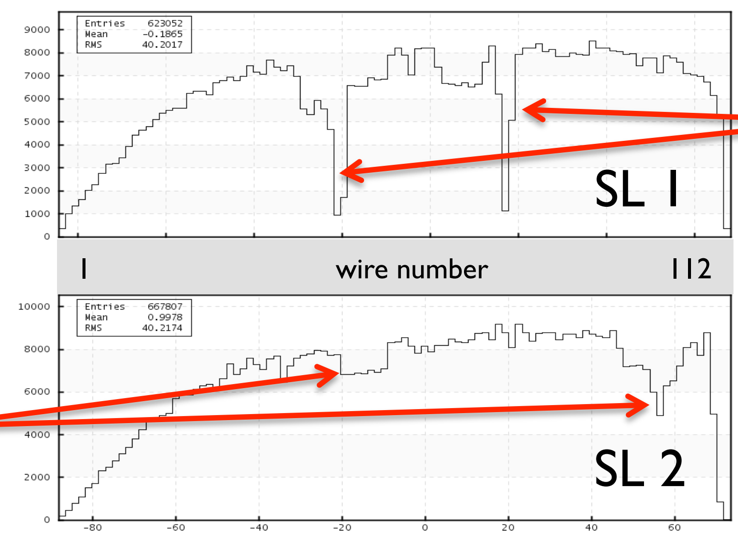
DC Cosmic Studies: Efficiency



Location of 2-superlayer 'crosses'
→image of scintillator paddle
→reg.1 chamber



Layer efficiencies at 2250 V

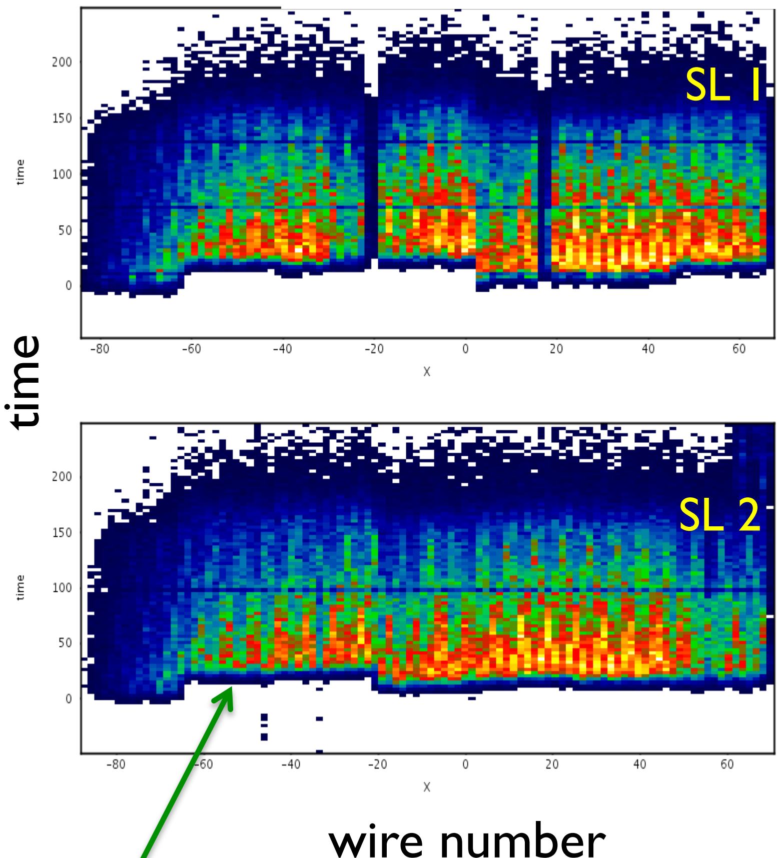


unplugged connectors ?

swapped connectors ?

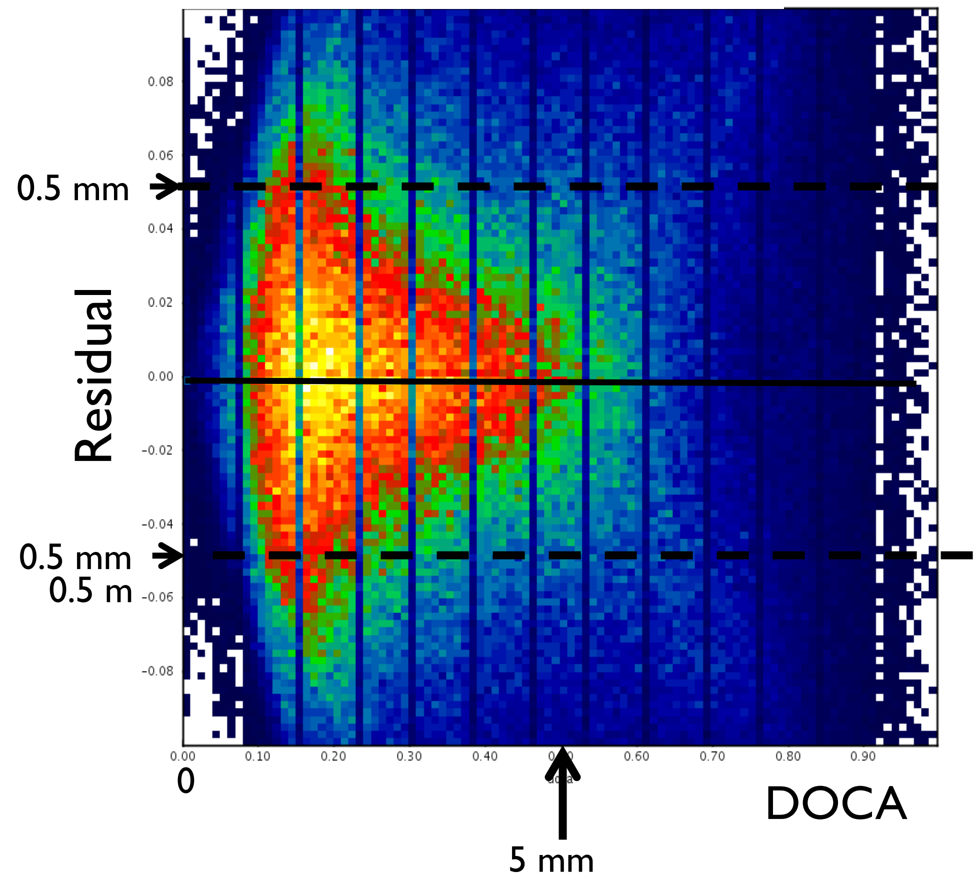
DC Cosmic Studies: Timing

Time delays



different length cables:
~ 5 – 10 ns diff.

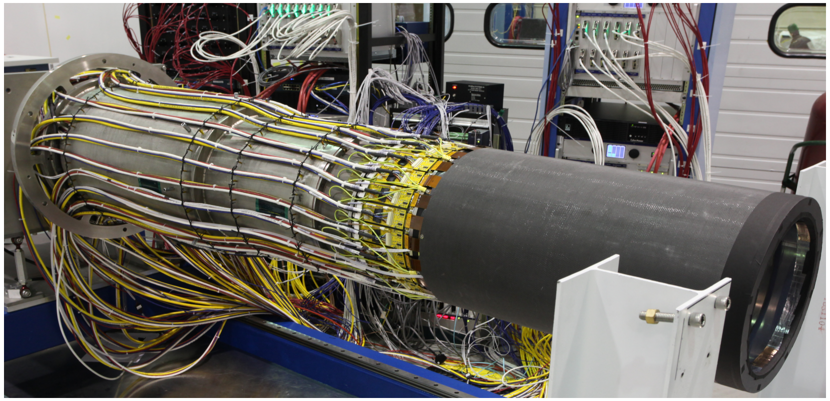
X vs T calibration

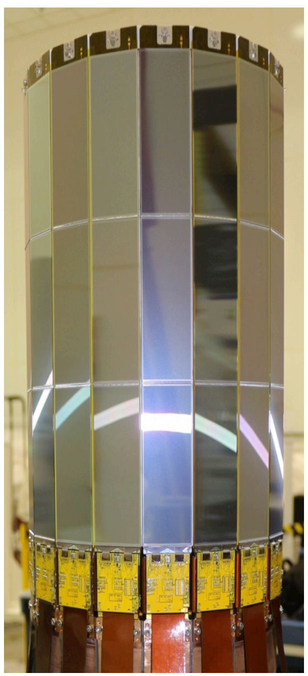


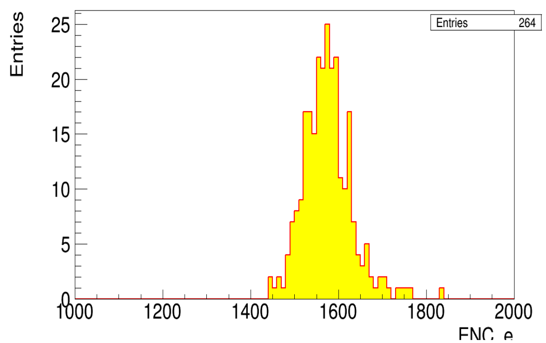
Residuals from un-calibrated data using same T → X curve as GEMC !

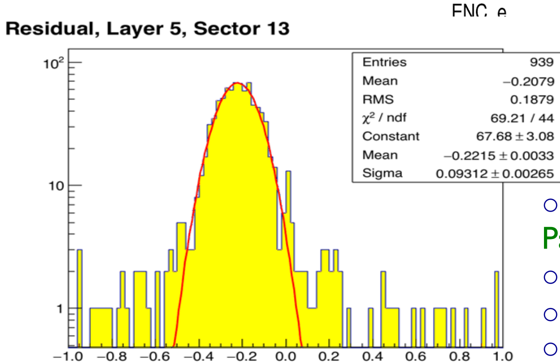
SVT Commissioning

- SVT is fully integrated, surveyed and calibrated









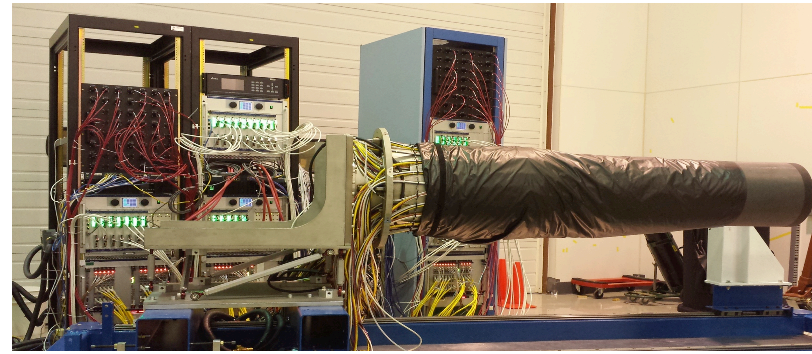
- Checkout of the cooling system complete
- Checkout of gas purging system complete
- Checkout of detector safety system complete
- IOC based software interlock commissioned
- Compact RIO based hardware interlock system commissioned
- Checkout of the slow control and monitoring system complete
- EDM based EPICS GUI implemented
- Monitoring parameters are continually written to the MYA DB
- Checkout of HV system and distribution complete
- Checkout of LV system for readout electronics complete
- Checkout of FrontEnd electronics complete
- Checkout of DAQ and trigger complete, trigger parameters configured
- Validation of data integrity and reconstruction chain complete
- Calibration and commissioning procedures documented
- Absolute gain calibration with r/a sources complete
- Signal-to-Noise measurements with protons and cosmic muons complete
- C++ ROOT calibration package with automated logbook posting in use
- CoatJava based calibration suite development at the final stage
- Development of the data validation and monitoring suite in progress
- System is running stable, performance constantly monitored
  - Cosmic data taking in progress 24/7, collected sample of over 30 M muons
  - Validation of local and track reconstruction in progress
  - Monte Carlo tuning on the cosmic data in progress
  - Geometry database complete, analysis of mechanical survey data in progress
- SVT alignment using Monte Carlo and cosmic data in progress

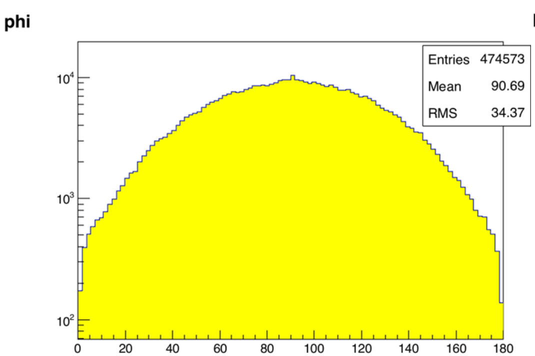
Path forward

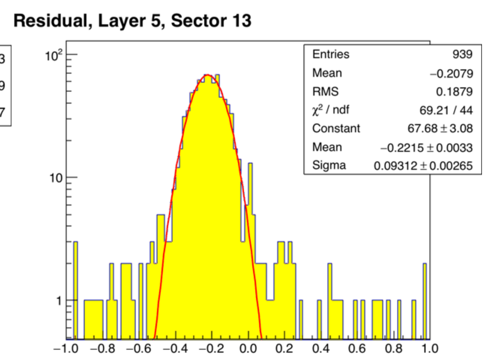
- Central Tracker integration (November-December) and commissioning
- Profiling, benchmarking and batch processing
- Databasing (run, config, conditions)

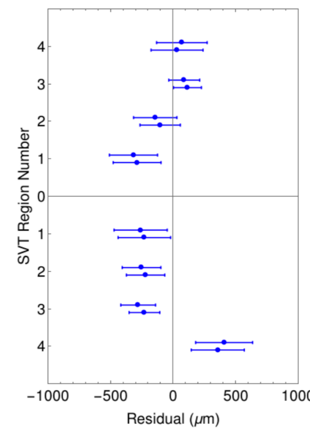
SVT Cosmic Ray Commissioning

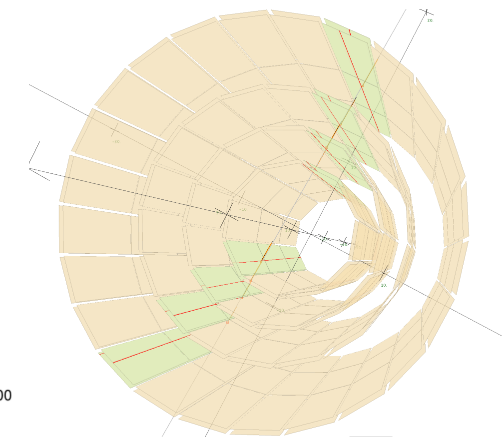
- All three SVT VXS crates are in sync
- Trigger window and latency are set
- SVT 2D and 3D event displays functional
- Reconstruction chain validated
- Data monitoring and validation ongoing
- Monte Carlo tuning on data in progress
- Alignment studies started

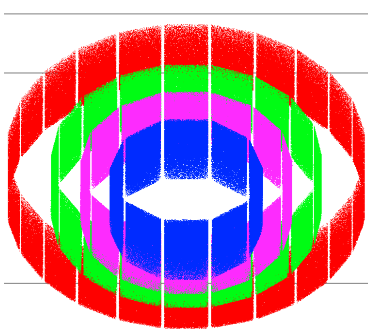


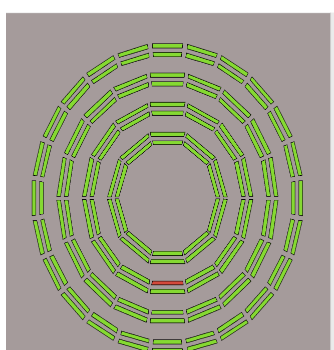


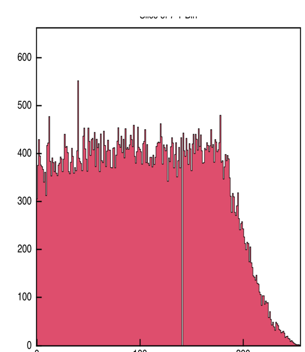


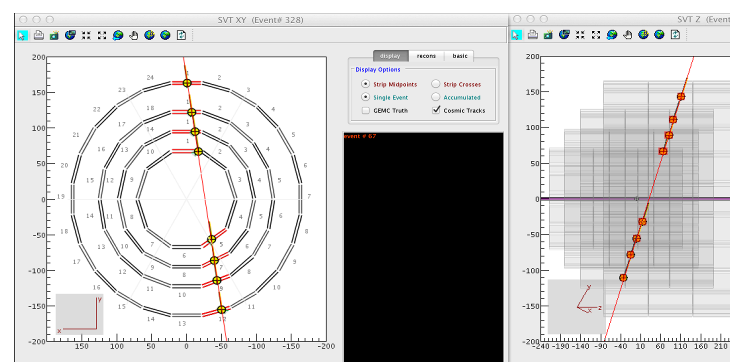












SVT Calibration: Path Forward

Work before installation

- Complete Java based SVT calibration suite
- Periodic calibration runs on SVT barrel using SVT Calibration Suite
- Design SVT calibration DB
- Develop an interface from the CLARA to the SVT calibration DB

Development of the SVT calibration suite

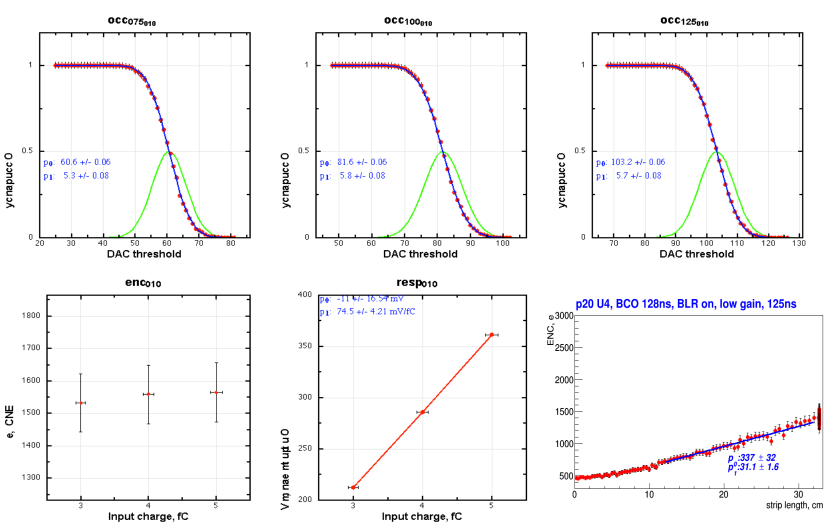
- A c++ ROOT based calibration package with automated logbook posting in use (takes 4 hours to scan the SVT)
- Parallel calibration data scans from VSCM readout boards (20 min run for the barrel)
- CoatJava based analysis package using multi threading being developed (1 min to make the plots)
- Developer (grad student) left at the final stage of the project, Jlab engineer is taking over, ETC 1 month

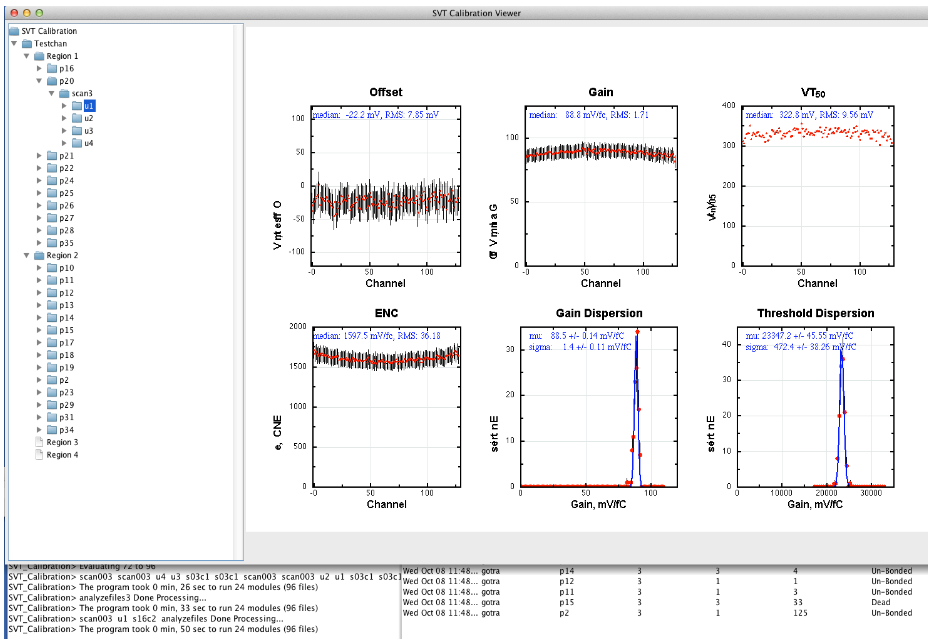
Post-installation plans

- Periodic calibration runs on SVT barrel using SVT Calibration Suite
- Automated filling of the SVT calibration DB used in reconstruction

Manpower

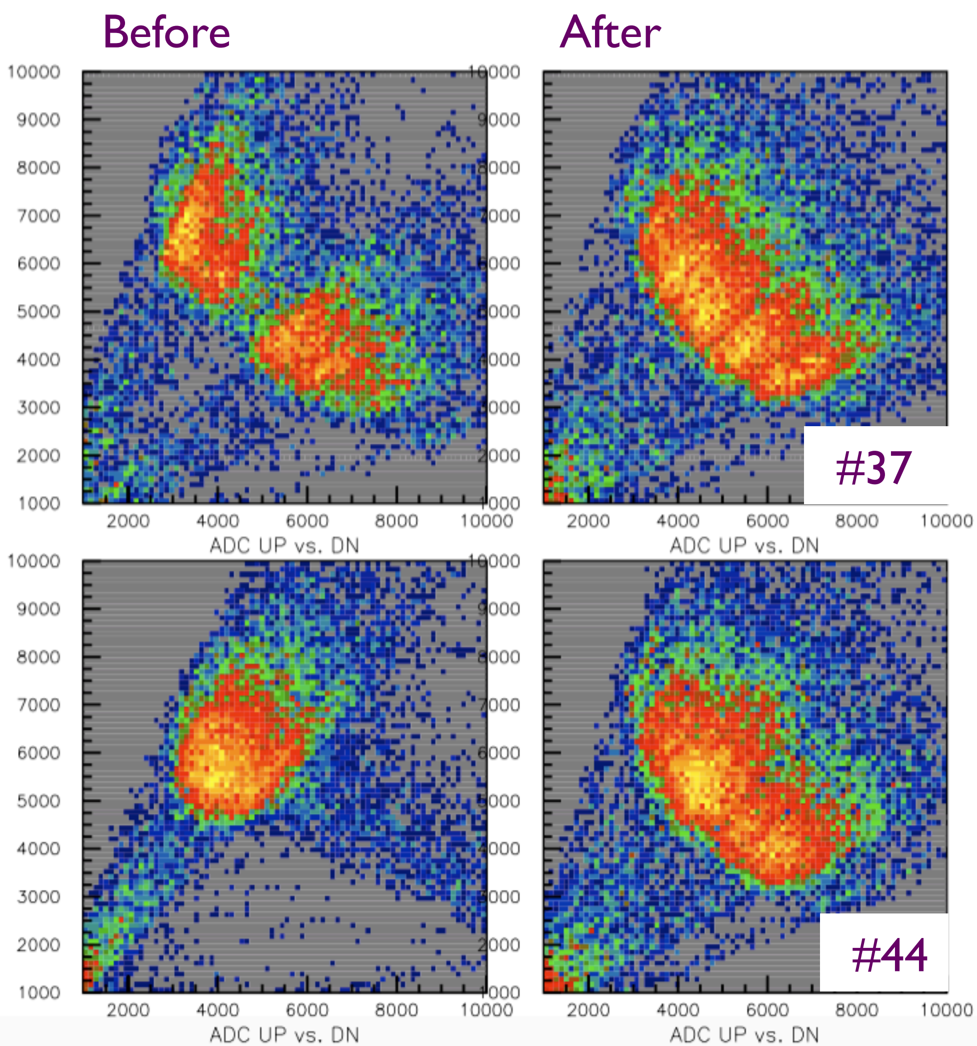
- 1 scientist, 1 engineer

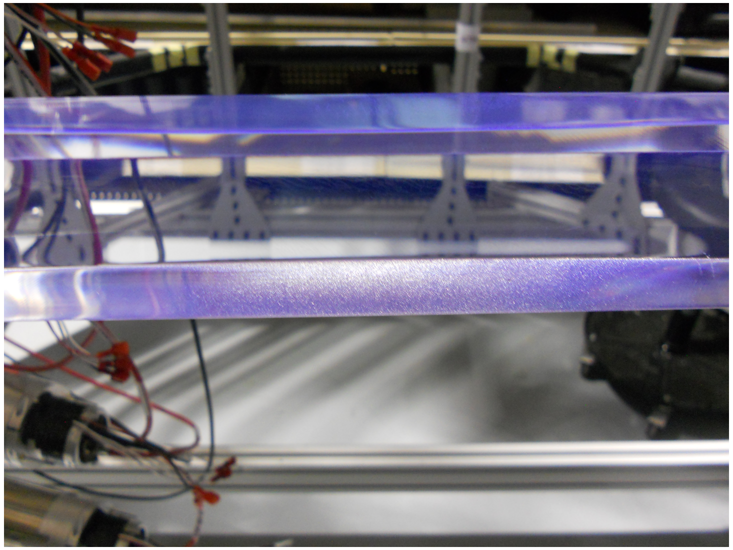




CTOF Commissioning

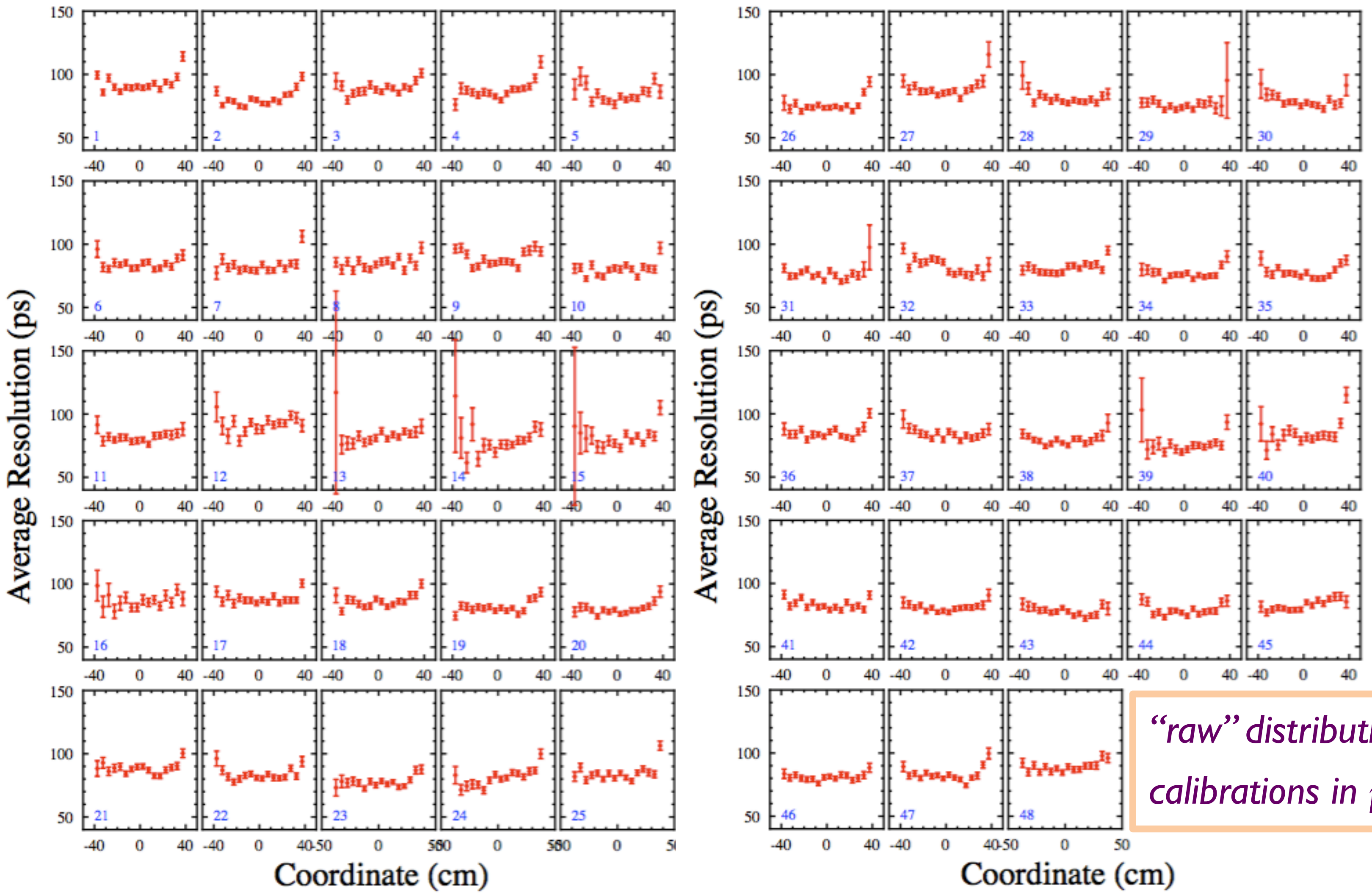
Surface Quality Issues





- Clear issues found with *"crazing"* on multiple bars.
  - *8 counters required re-surfacing and re-polishing*
  - *The before/after comparisons show good improvement in counter performance*
  - *Monitor counter response to see if problems return*

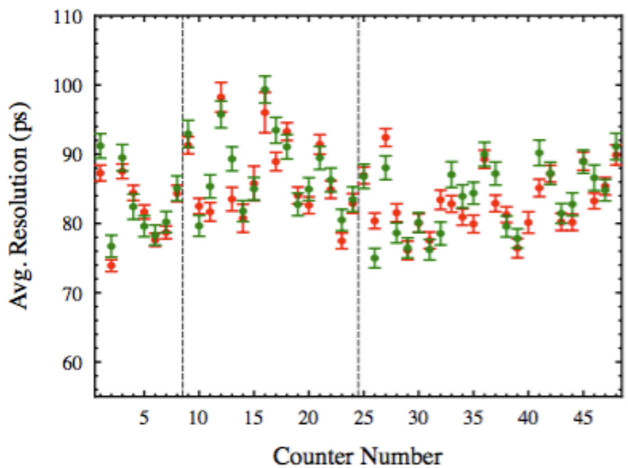
CTOF Resolution vs. Coordinate

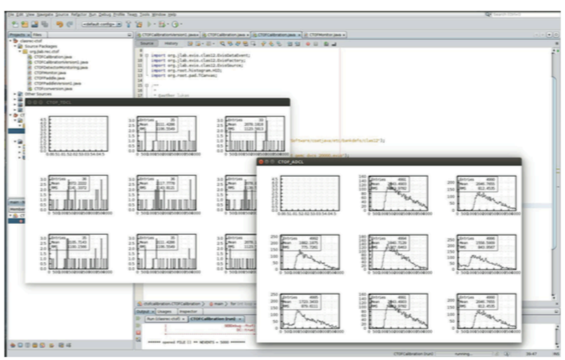


"raw" distributions

calibrations in progress

CTOF Work Remaining





Light Monitoring System:

- *PR submitted for fiber assembly*
- *Fiber attachment blocks and cutting templates delivered; blocks being mounted to light guides*

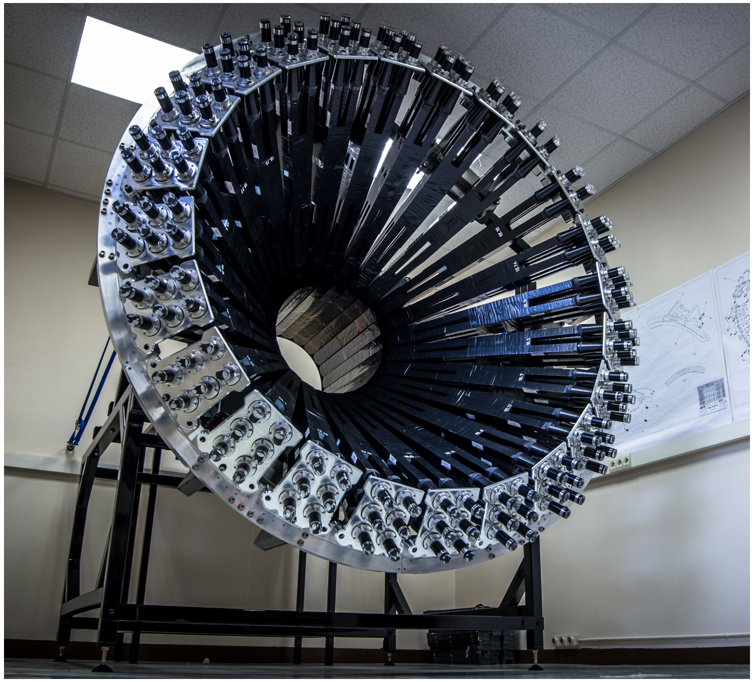
System Calibration and Monitoring:

- *Optimize time resolution of system*
- *Develop time-walk corrections; compare LED to CFD performance*
- *Monitor stability over next 6 months*

Calibration Software Suite:

- *Calibration software developed by A. Ni (KNU)*
- *Continue development and testing over next 6 months*
- *Develop integrated system for CTOF, FTOF, CND*

CND Commissioning



CND scintillator barrel:
- 3 radial layers
- 48 bars per layer
- coupled two-by-two downstream by a "u-turn" lightguide
- 144 PMTs upstream

Recent achievements:

- CONSTRUCTION COMPLETED
- Detector shipped to JLab (air+truck):
  - 9 boxes (2.5 tons)
  - 24 3x2 blocks
  - mechanical support structure
  - PMT shieldings
  - electronics (TDCs, splitters, CFDs)
- HV calibrations of PMTs completed
- Simulations for radiation dose
- Strength tests for glue
- In-field tests for shieldings
- Cosmic data analysis: σ_t ~150 ps for all blocks
- Assembly in mechanical structure done
- Development of calibration and reconstruction software ongoing

CND Calibration

Calibration parameters:

- Effective velocity in scintillator
- Attenuation length in scintillator
- Gain
- TDC slope and offsets
- ADC slope, offsets and pedestals
- Time of propagation through u-turn
- Light loss in u-turn

Procedure similar to that of CTOF, but complicated by the u-turn geometry of the CND:

Cosmic ray data taken in Orsay is being used to develop calibration algorithms: at this stage stand-alone functions, in ROOT.

Plan:

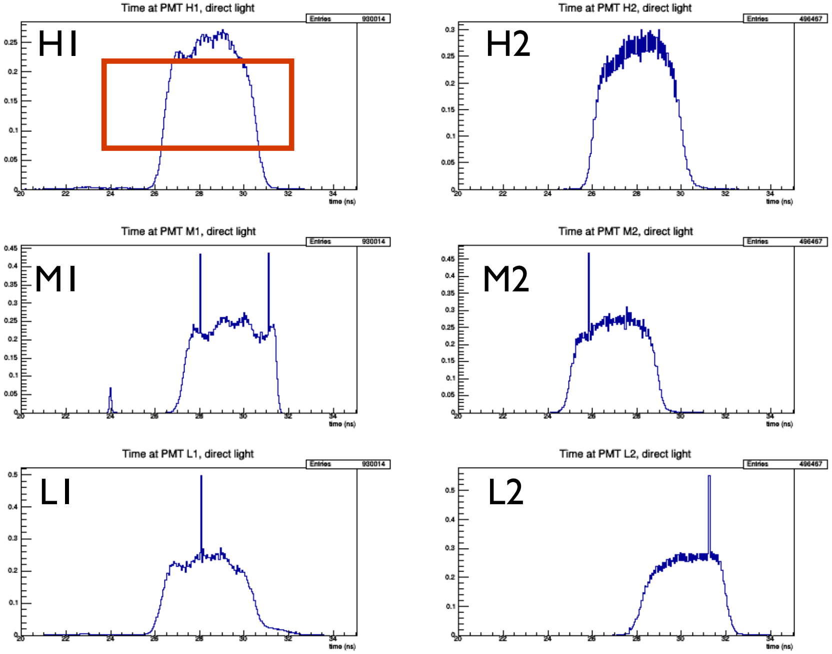
- optimise algorithms (by end of year)
- implement the methods within the COATJAVA framework (early 2016)
- test on GEMC simulated data (early 2016)
- calibrations on cosmic and laser pulse data, to be acquired in JLab in spring 2016.

Daria Sokhan, Gavin Murdoch (Glasgow)

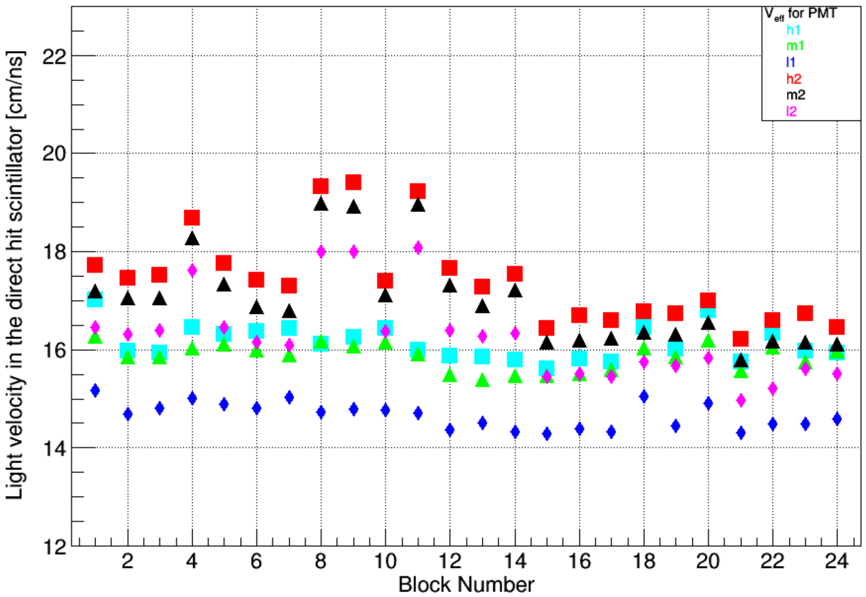
CND Calibration Example: v_{eff}

Time for light to travel the entire length of the paddle = width of the time distribution of hits in the paddle.

TDC channels for cosmic ray hits in a single block



Imperfect distributions, algorithm is designed to take the average width of the central part of the distribution, avoiding the tails at the bottom and the uneven data-spread at the top.

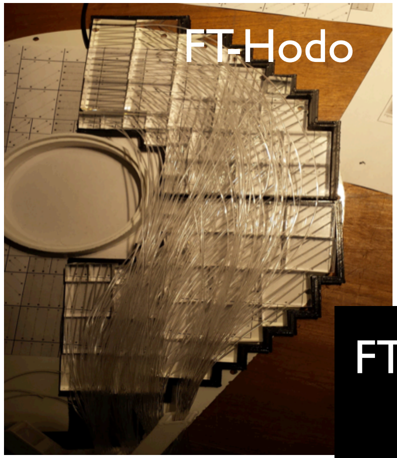


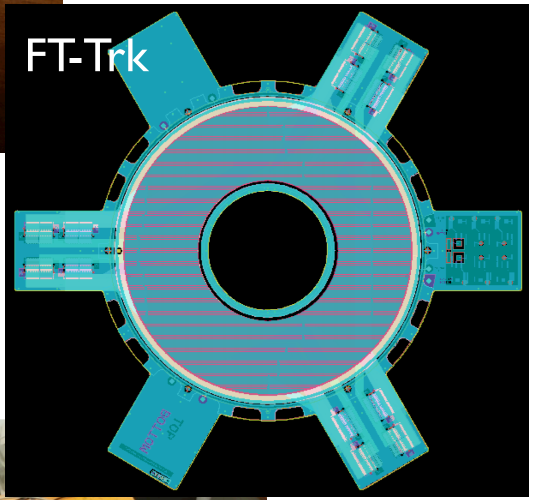
Results show a systematic difference between the top, middle and bottom layers of each block, and between the left and right paddles — possible issues with normalisation of the histograms, under investigation.

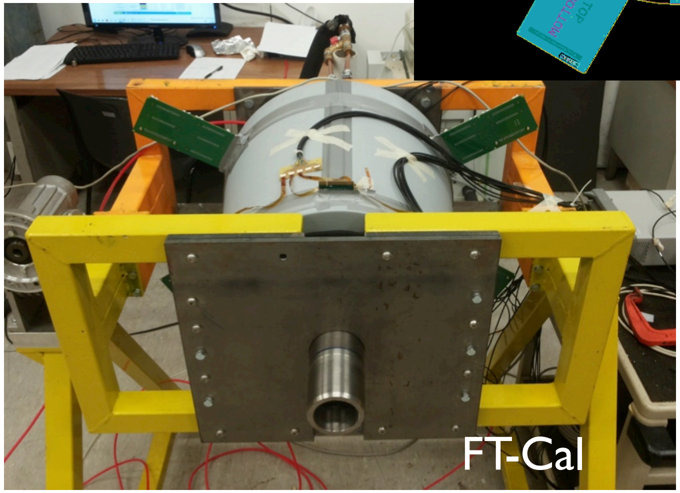
Gavin Murdoch (Glasgow)

FT Status

Coordination: INFN-Genova
Contributors: CEA, INFN-Ge, INFN-Roma2, U. Edinburg, U. Glasgow, JLab, James Madison U., Norfolk State U., Ohio U.

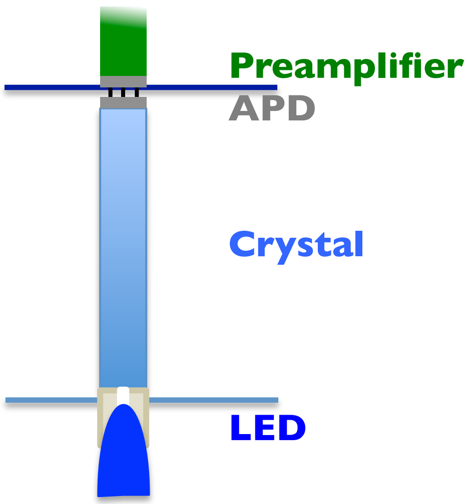






- Construction of FT detectors in final stage
- FT-Cal assembled and tested in Genova with light source and cosmic
- FT-Hodo in final assembly stage
- FT-Trk detector elements in production stage
- Detectors to be transferred at Jlab Nov. - Dec. 2015
- Full system to be reassembled and tested at Jlab by end of 2015, beginning of 2016

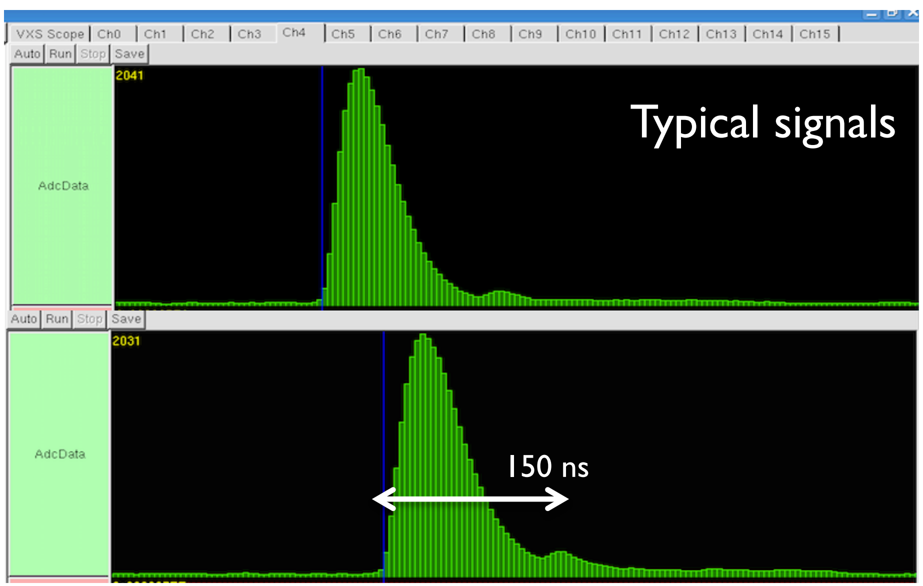
FT-Cal Checkout

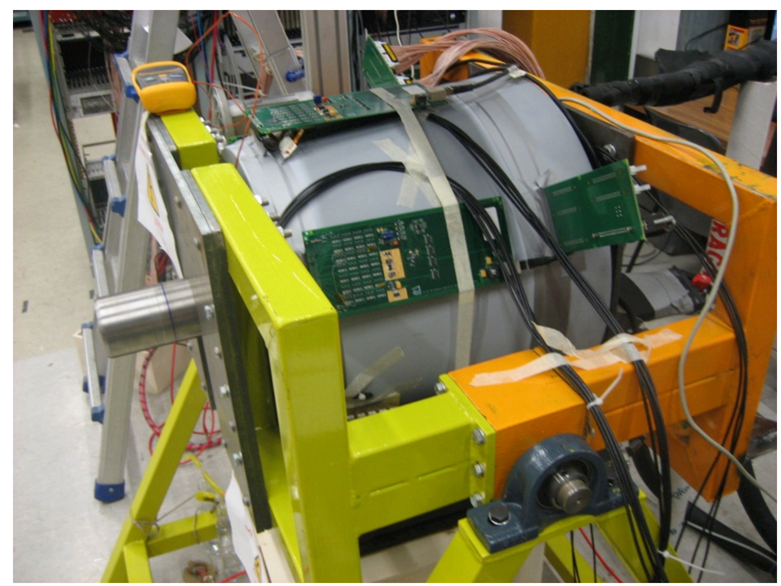


FT-Cal checkout at 20° and 0°C using the LED monitoring system:

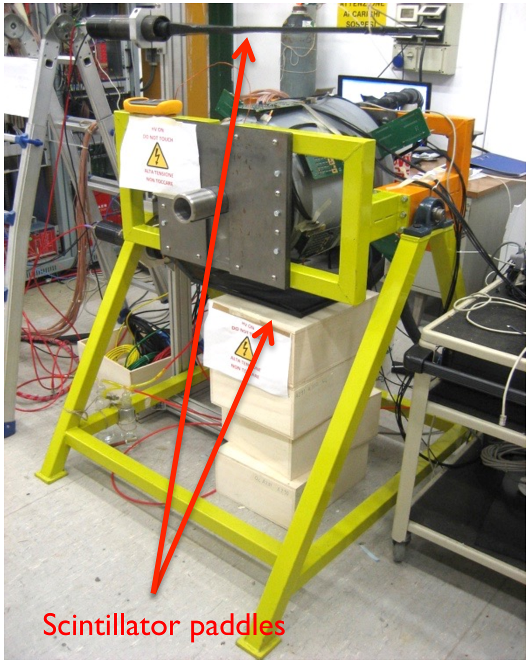
- 332 blue LEDs (one LED per crystal) placed on the front face of the calorimeter
- Independent control of each LED using 6 driver boards
- Capability of varying pulse light intensity and pulse frequency
- Useful to identify cable swaps, faulty channels

Summer students:
Max Camp (Ohio)
Ian Davenport (JMU)
Harkirat Singh-Manns (JMU)
Marys Yates (JMU)

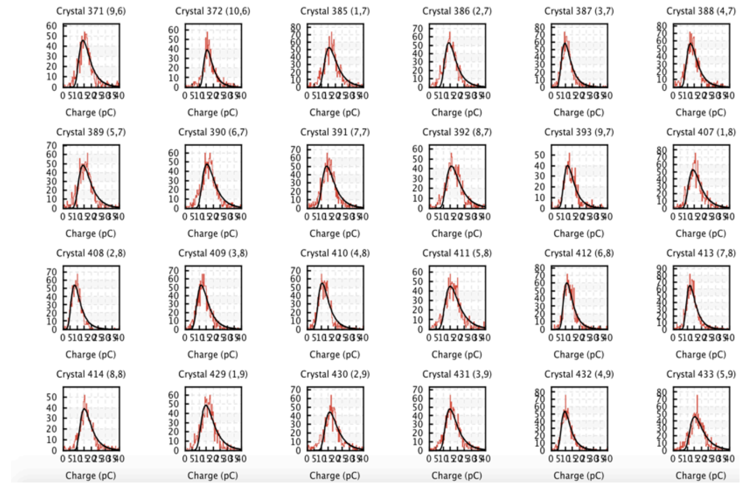




FT-Cal Cosmic Ray Calibration

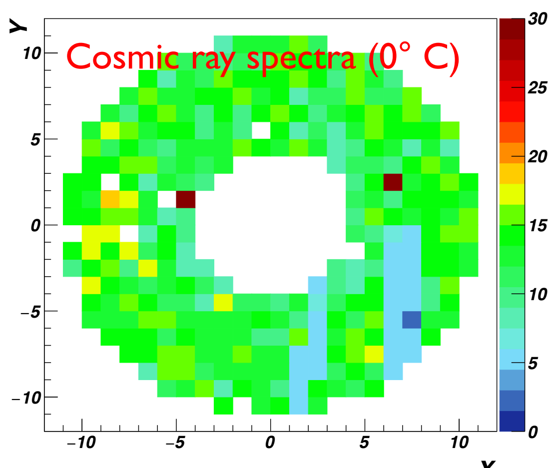


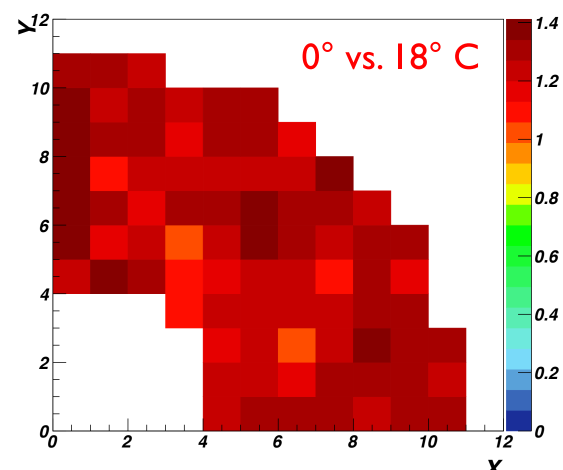
- Data collected for each quadrant with the calorimeter in horizontal (production) position
- External trigger given by scintillator paddles placed above and below the calorimeter
- Charge spectra built for each crystal



- Distribution fitted with Landau function to evaluate mean values
- Analysis repeated for each quadrant at 0° C and for quadrant 1 both at 0°, 10° and 18° C

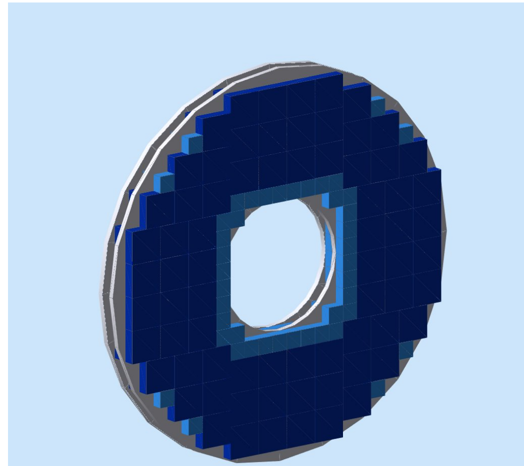
- Cosmic rays can be used for initial FT-Cal energy calibration!!
- Response uniformity consistent with expectations (~20%)
- Increase of LY at low temperature in agreement with prototype tests



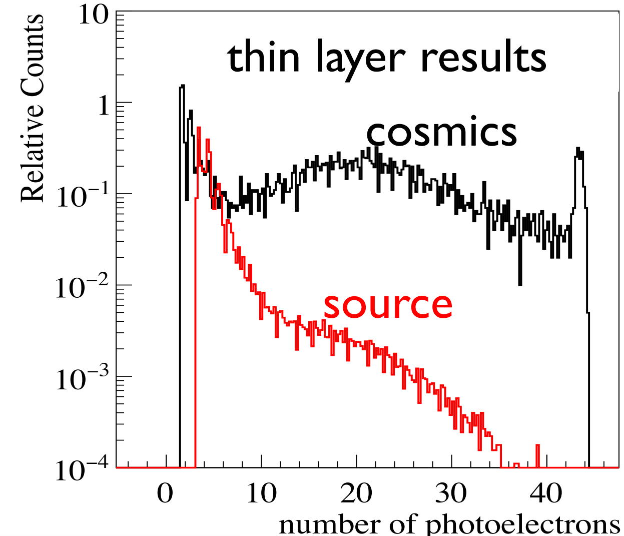


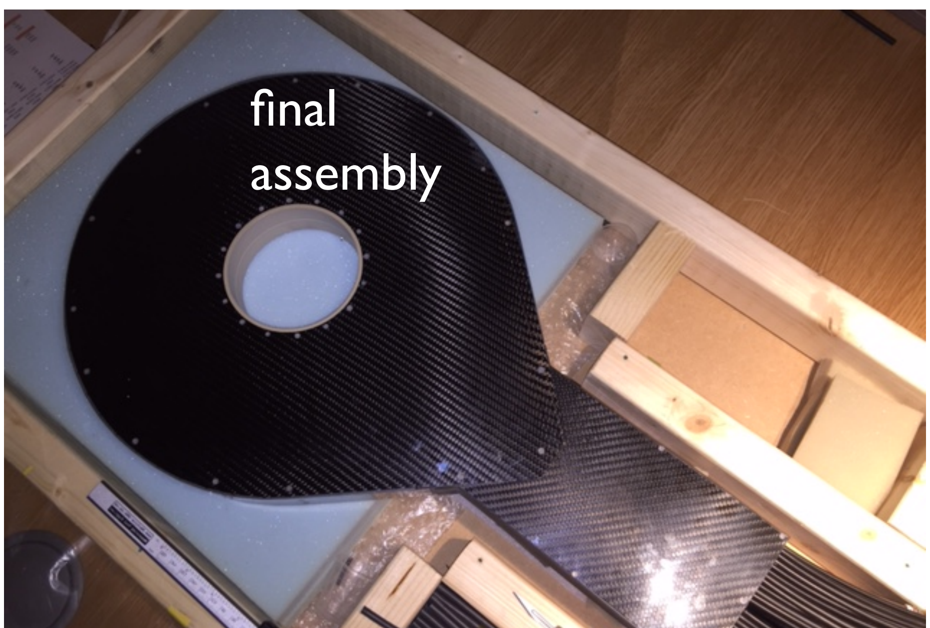
FT-Hodo Checkout

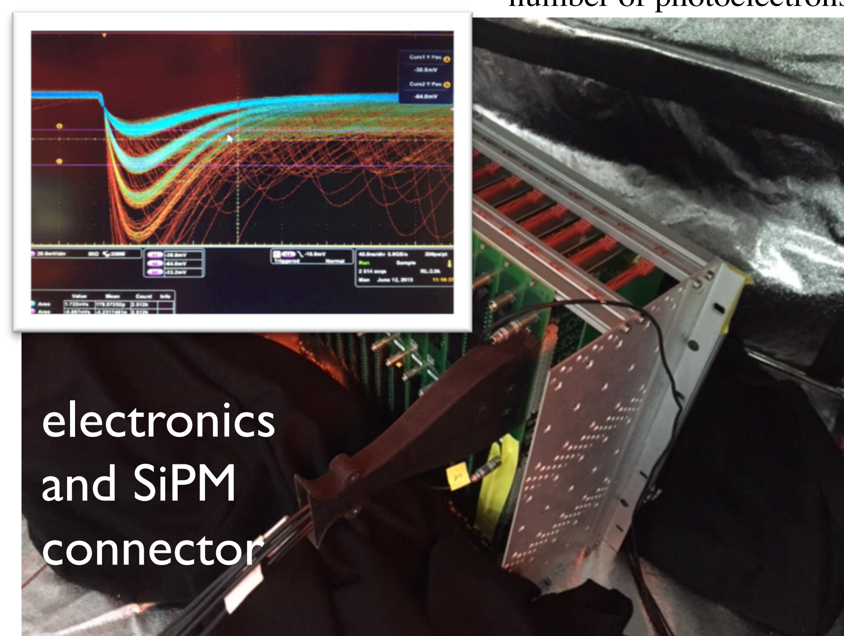
- photon / electron discriminator
- two layers of scintillator arrays with timing and position resolution to match FT-Cal
- ship to Jlab to arrive in November



Two layers of scint. tiles

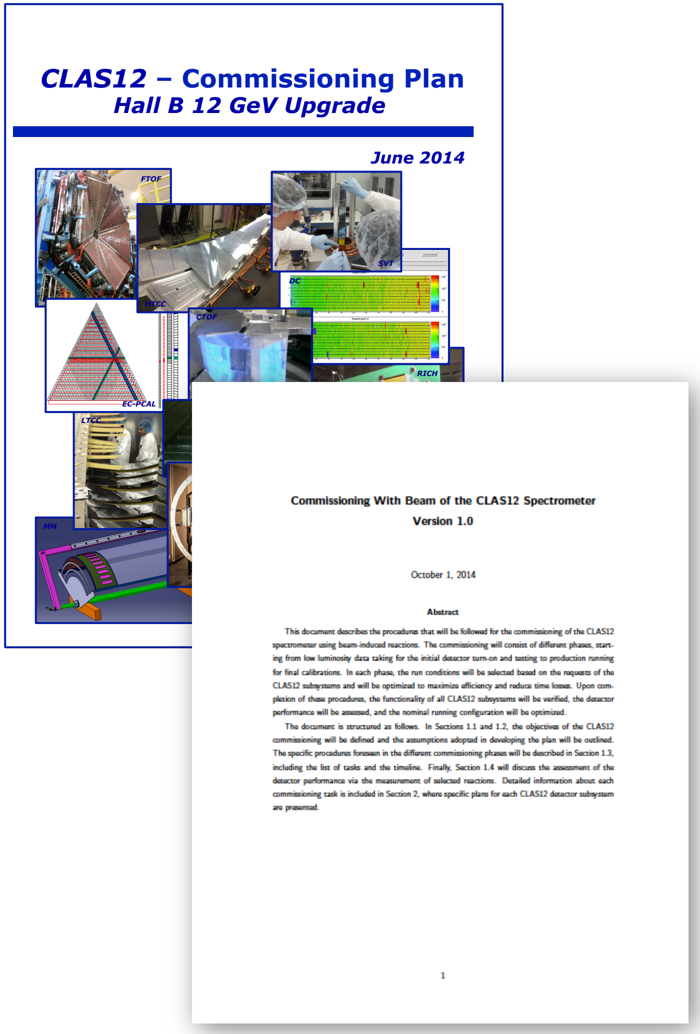






Commissioning with Beam

- Revision of initial Commissioning with Beam (CWB) plan started
- Commissioning With Beam:
  - 15 calendars days with full CLAS12 detector
  - Establishing beam
  - Detector checkout with particles from beam interaction
  - Initial calibrations
  - Proof of detector functionality
- Jan. 15 CWB review outcomes:
  - 15 days CWB period at pass 3 (6 GeV) to possibly exploit photon tagger and past CLAS experience at same energy
  - Main focus on achievement of Key Performance Parameters (KPP) to reach 12 GeV project milestones
  - Commissioning at 11 GeV to follow in extended period


CLAS12 – Commissioning Plan
Hall B 12 GeV Upgrade
June 2014

Commissioning With Beam of the CLAS12 Spectrometer
Version 1.0

October 1, 2014

Abstract

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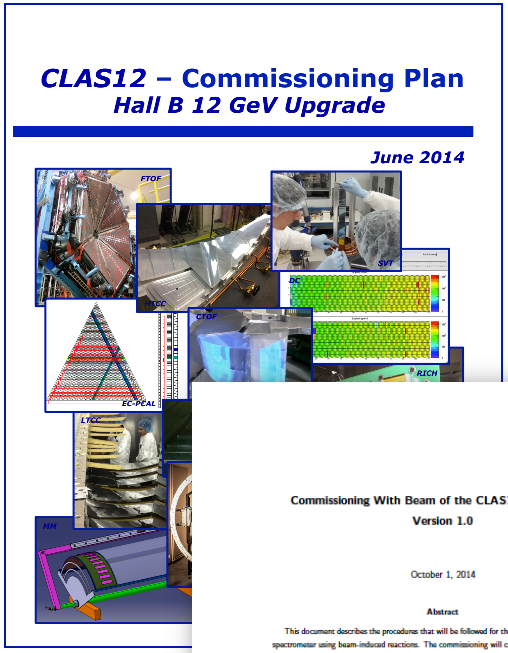
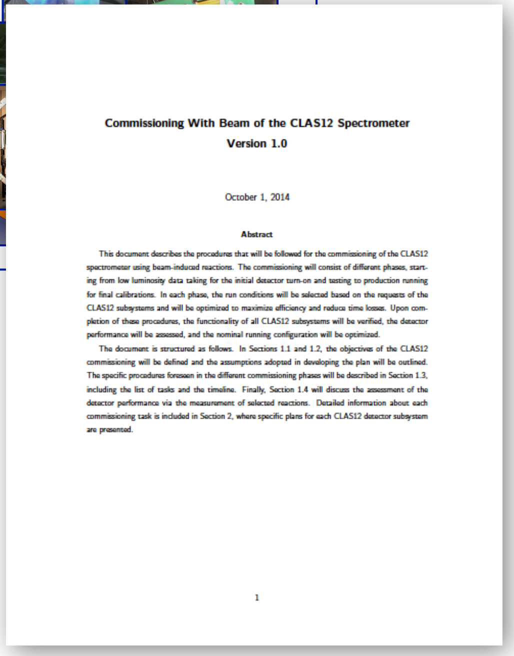
The document is structured as follows. In Sections 1.1 and 1.2, the objectives of the CLAS12 commissioning will be defined and the assumptions adopted in developing the plan will be outlined. The specific procedures foreseen in the different commissioning phases will be described in Section 1.3, including the list of tasks and the timeline. Finally, Section 1.4 will discuss the assessment of the detector performance via the measurement of selected reactions. Detailed information about each commissioning task is included in Section 2, where specific plans for each CLAS12 detector subsystem are presented.

1

CWB - Workplan

- Estimate particle rates at 6 and 11 GeV to better define configuration and time allocation for the different tasks
  - Inclusive electrons
  - Hadron rates for detector calibrations
- Prepare for detailed simulation studies of backgrounds and hadronic events using GEMC:
  - Consolidate detector geometry description including passive materials
  - Update/complete digitization routines
- Determine expected backgrounds in all detector systems for different CWB phases
- Optimize target configuration
- Define trigger configuration and commissioning procedure
- Present (analysis) strategy to achieve KPPs

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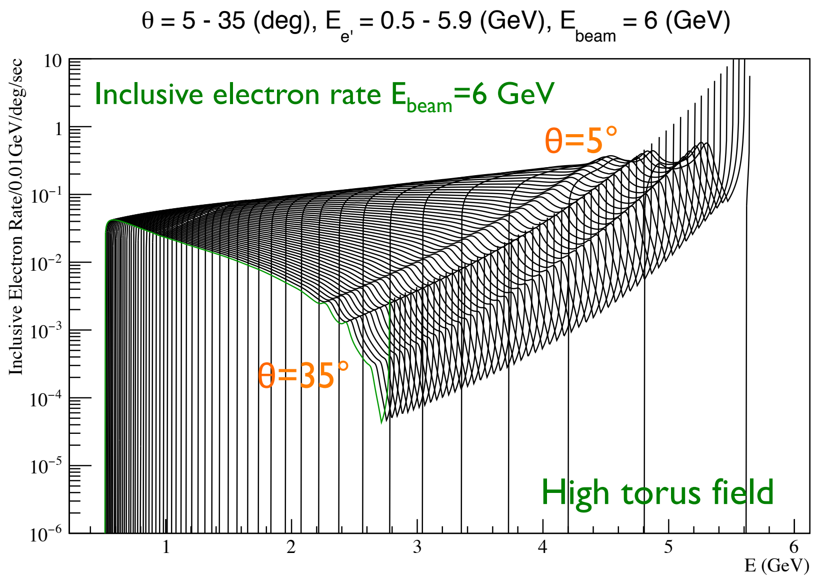
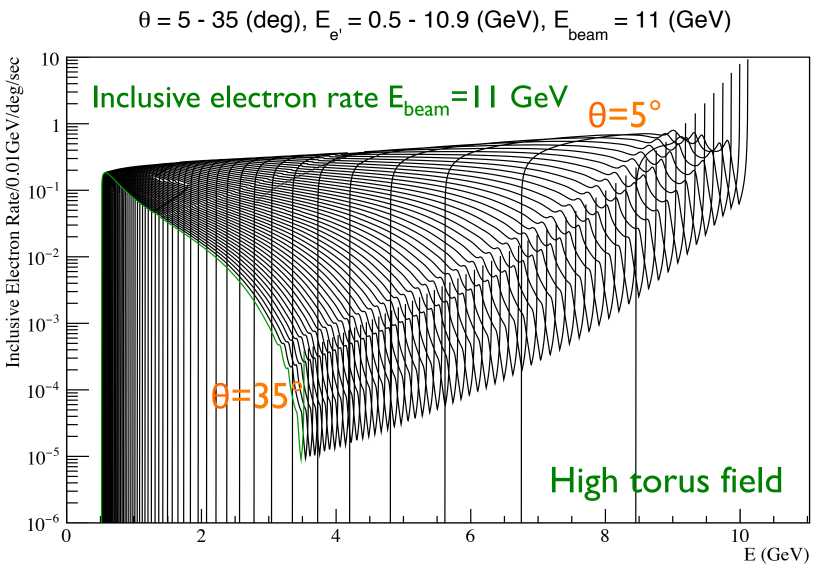
1

Rate Estimates

- Initial estimate based on inclusive electron-scattering radiated cross section from M. Sargsyan, CLAS-NOTE 90-007 (already used for rate estimates) and fastMC acceptance for different torus fields
- Further studies for both electron and hadron rates with GEMC+CLAS12 reconstruction based on event generators (clasDIS)
- Final output:
  - Expected trigger rate during the different commissioning phases
  - Optimization of running conditions (magnetic field, target, …) for detector calibrations
  - Estimates of necessary beam time for different commissioning tasks

Work by S. Pisano

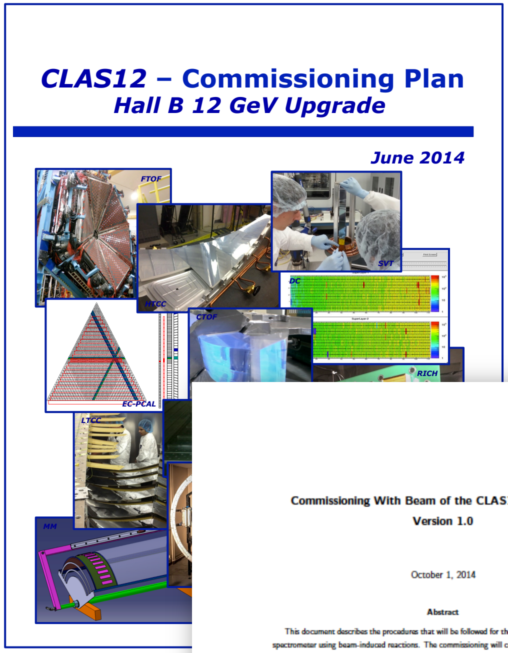


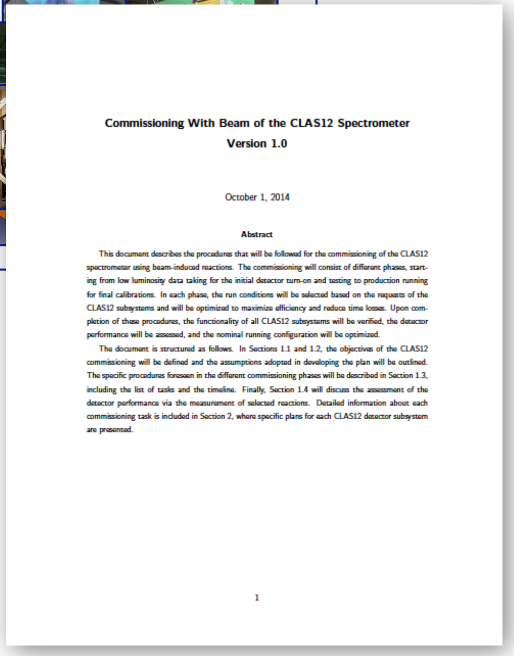


CWB – Path Forward

- Complete rates studies and background simulations (in progress) by end of 2015
- Revise CWB plan based on study results and review recommendation with focus on achieving KPP parameters during the allocated 15 days; new plan release by Spring 2016
- Identify/estimate resources needed for tasks completions:
  - Tools: monitoring, calibration, analysis
    - Development
    - Documentation
    - Test and validation
  - Manpower: experts and shift takers (online/offline shifts)
    - Training
    - Organization
  - Time:
    - Fixed beam time allocation
    - Offline analysis
    - Data processing
- Periodic revisions to monitor progress and optimize planning

Will need cooperation of the whole collaboration





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1

Summary

- Detector commissioning and calibration
  - Continuous progresses for all systems systems
  - Advanced stage for forward carriage detectors and SVT
  - Important results for other systems including non-baseline equipment
  - Aiming at first version of calibration suites by Spring 2016 to allow for at least 6 months of validation, improvements, documentation, tutorial and training

- Commissioning With Beam (CWB)
  - In progress:
    - Revision of CWB plan
    - Evaluation of particle rates at 11 and 6 GeV
    - Simulation of detector backgrounds
  - Focus of next months:
    - Tools: documentation and test
    - Manpower: task assignments and organization
    - Time: detailed scheduling for online and offline work