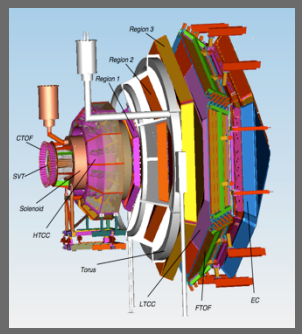
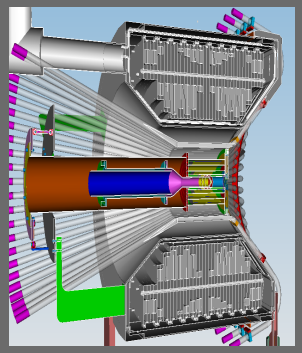
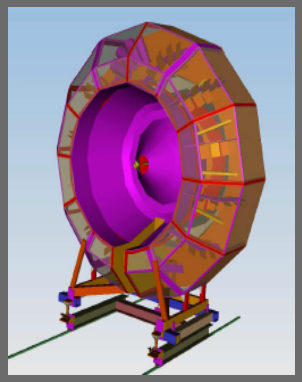
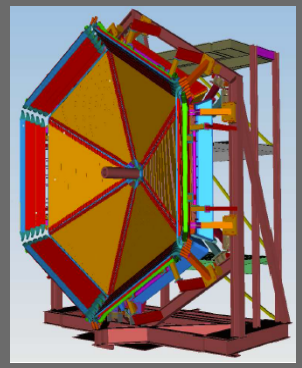


CLAS12 Calibration

R. De Vita

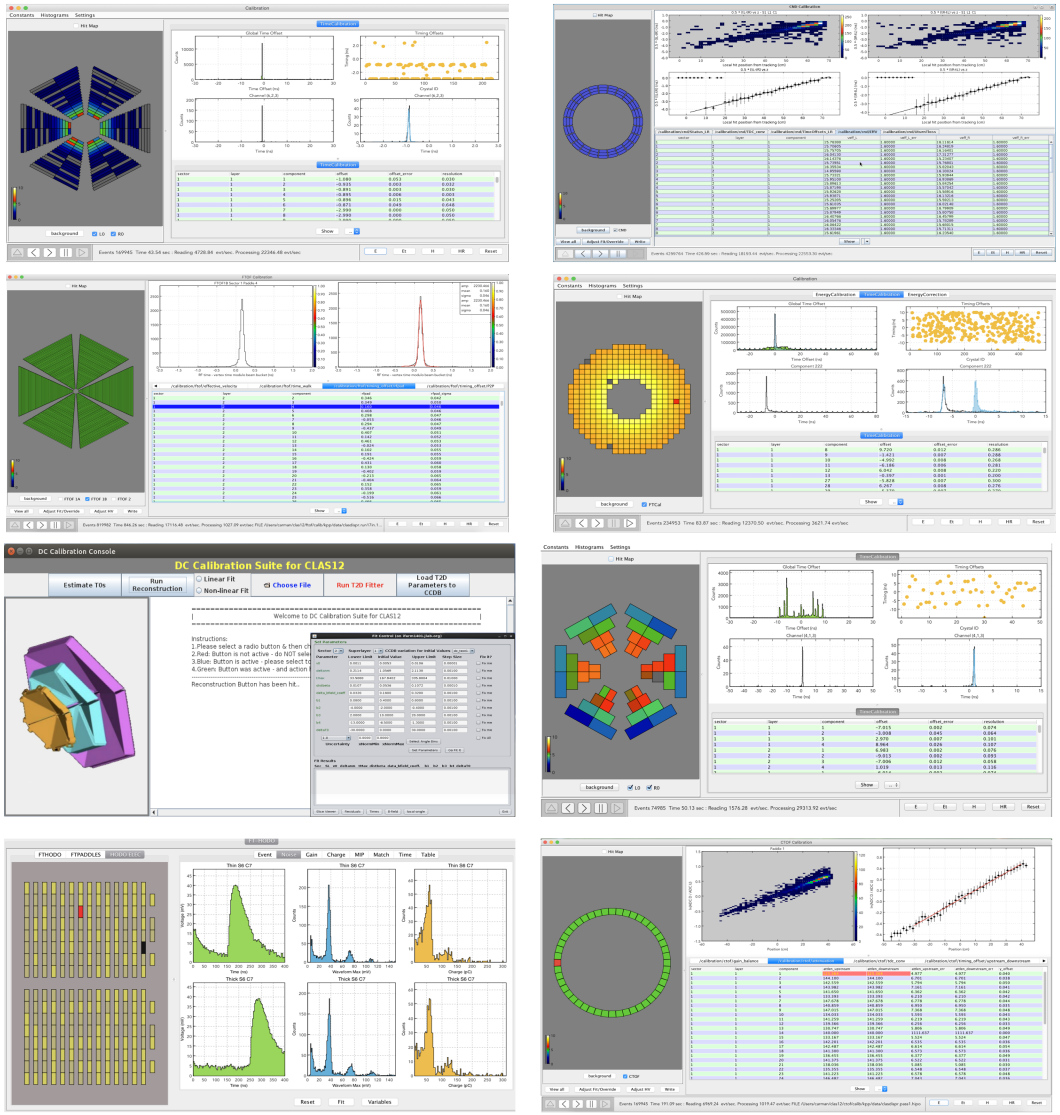
First Experiment Workshop

October 3, 2017

Calibration Software

Development of calibration and monitoring applications in an advanced stage for both baseline and ancillary CLAS12 subsystems:

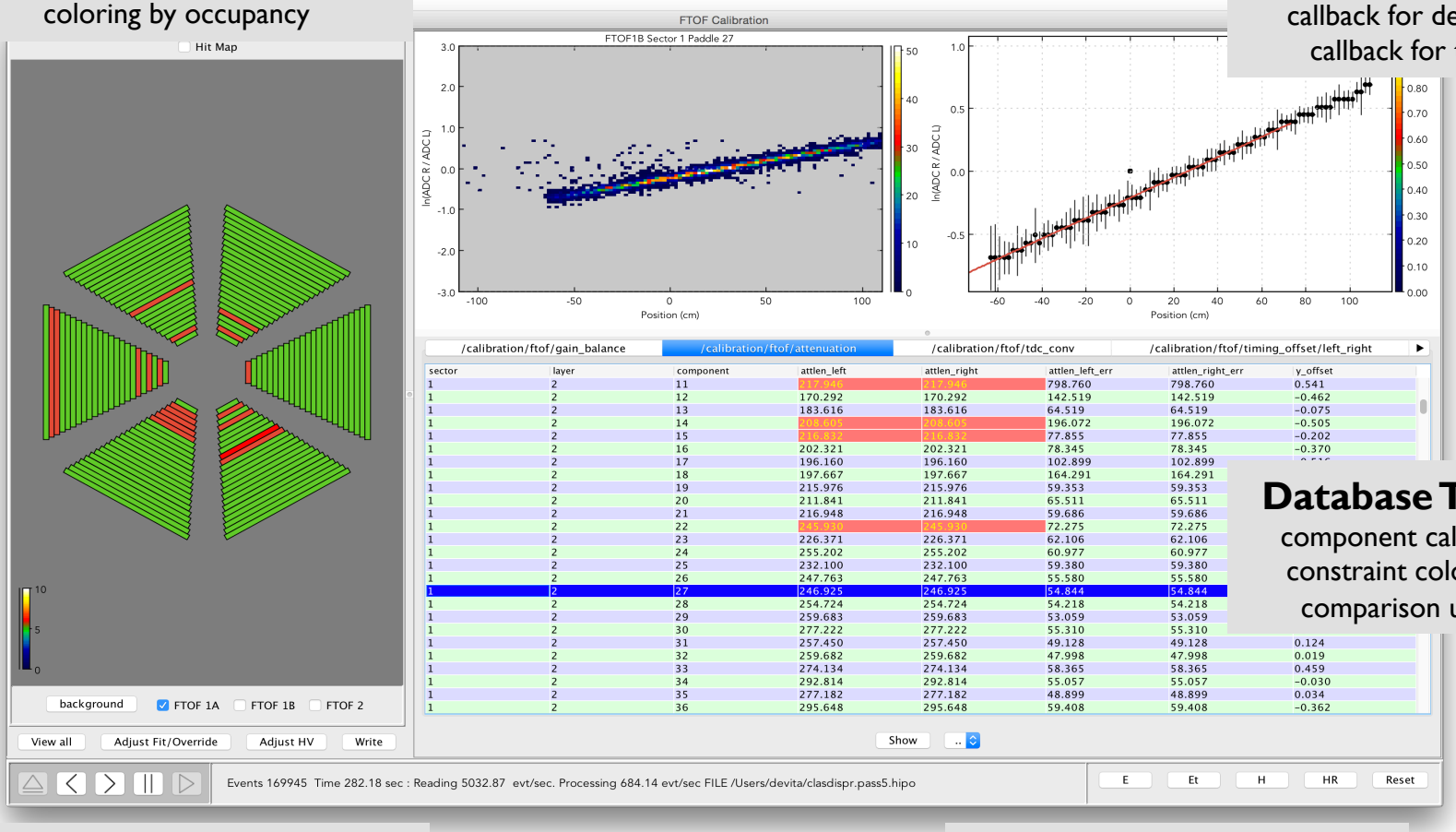
- Calibration software based on CLAS12 Common Tools (COATJAVA):
  - Full integration with CLAS12 software tools and reconstruction packages
  - Optimization of resources, high uniformity and maintainability
- Algorithm development supervised by the CLAS12 calibration & commissioning group (CALCOM)
- Implementation supervised by the software group
- Tests on both cosmic ray, KPP and simulated data



Calibration Suites

Detector Visualization
callback on clicks
coloring by occupancy

Data Canvas
callback for detector
callback for table

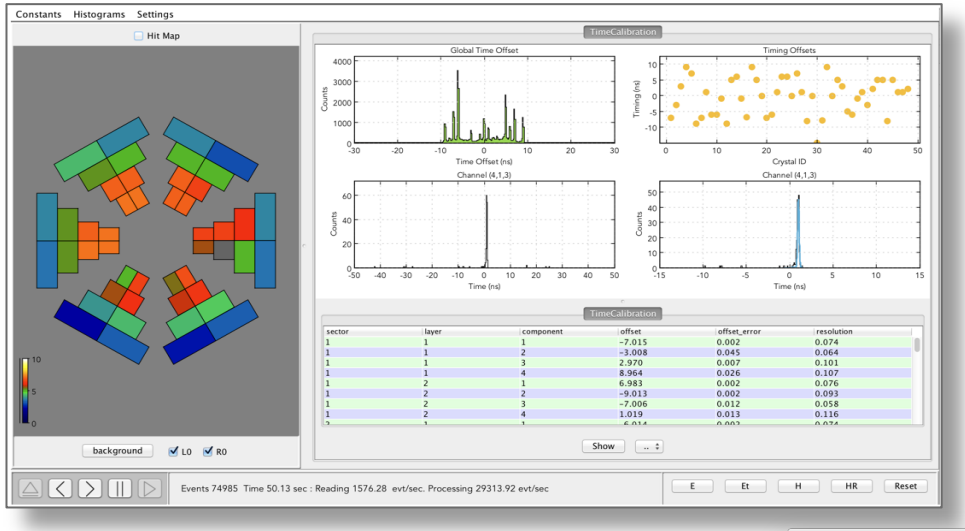


Database Table
component callback
constraint coloring
comparison utils

Detector Visualization
Layers

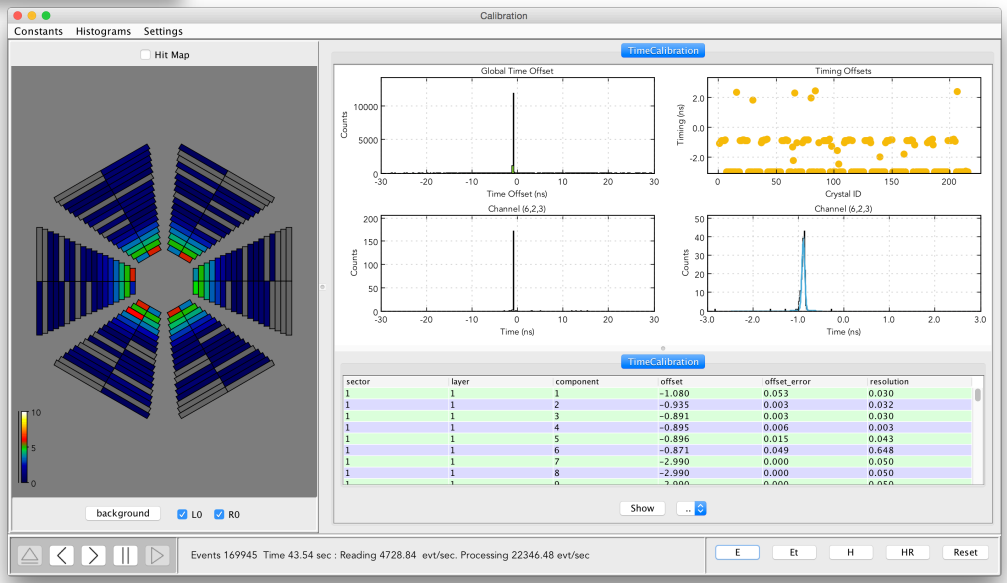
Event Processing Panel
event by event, or whole
opens: File, ET ring, EVIO or HIPO

Latest additions



- New HTCC and LTCC GUI for timing calibrations
  - Developed based on same "design" starting from COATJAVA calibration engine
  - Used successfully in recent calibration challenge

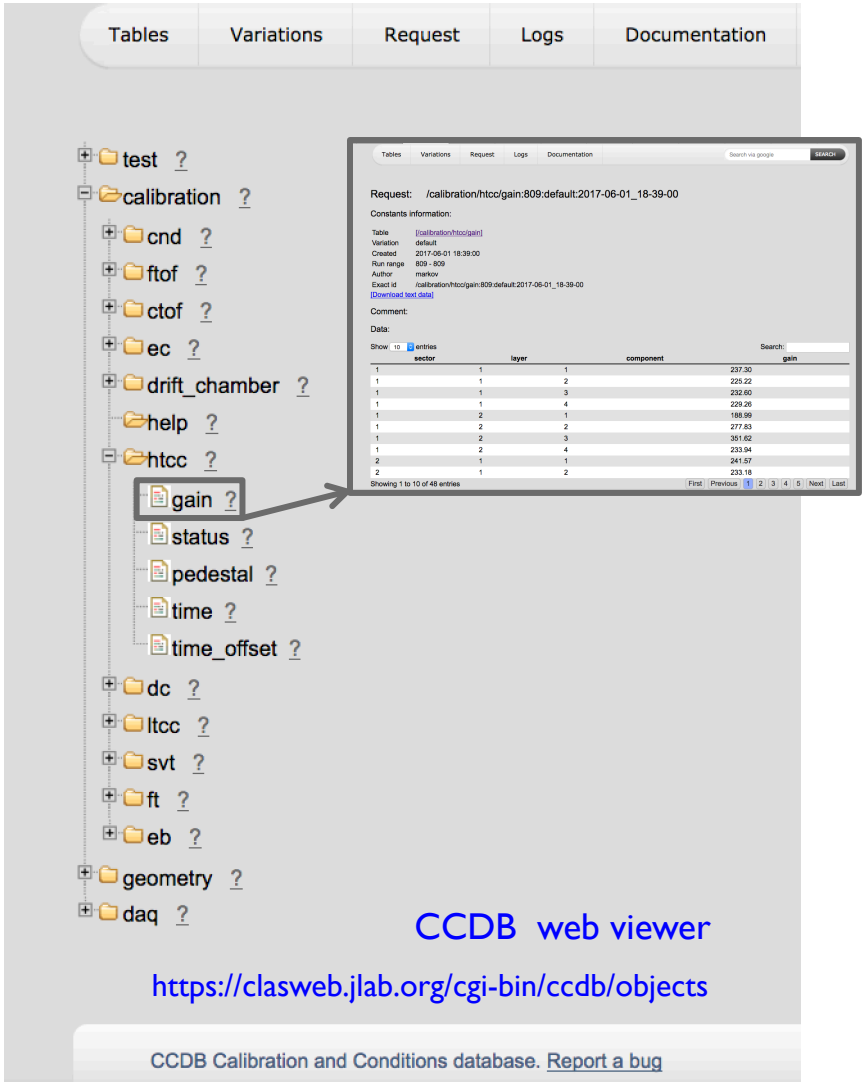
- Further development and tuning now in progress by detector "calibrators"
  - HTCC: Nick Markov
  - LTCC: Burcu Duran



Calibration Constants DB

- Based on CCDB
- Entries organized according to:
  - Variation
  - Run range
  - Time stamp
  - ID
- Used to store:
  - Calibration parameters
  - Geometry parameters
  - DAQ parameters
- Tables:
  - Organized in "detector" folders
  - Common indexing convention by sector, layer, component
- Accessible via Common Tools
- Used by both simulations and reconstruction software
- Presently, all tables for detector calibrations created and filled

https://clasweb.jlab.org/wiki/index.php/CLAS12_Geometry,_Calibration,_Reconstruction_and_Monitoring_Documents



Calibration strategy

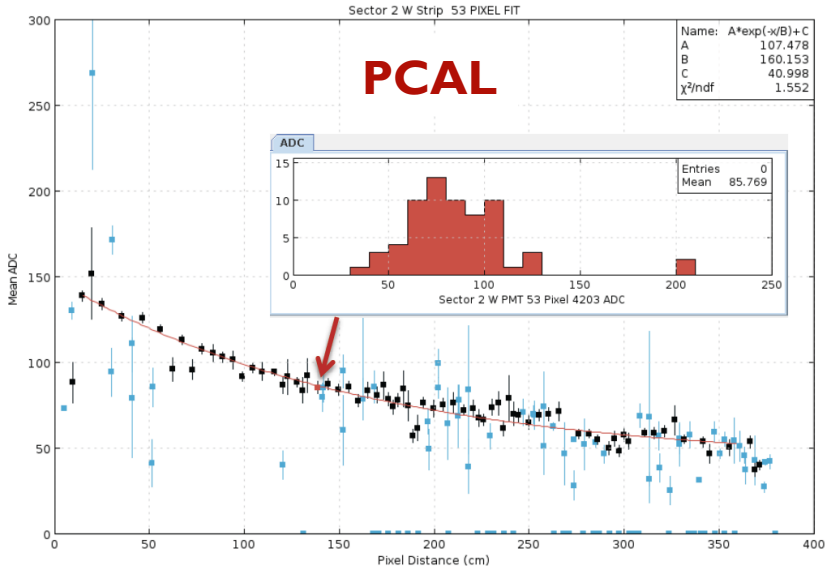
Development and validation of calibration algorithms and tools based on:

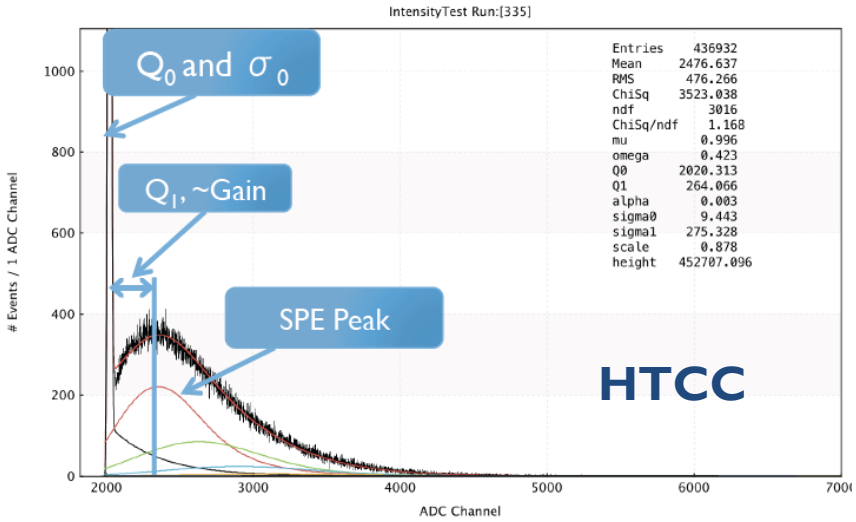
- Non beam data:
  - Light sources (LED or Laser systems for Cerenkov Counters, FT-Cal LMS, …)
  - Noise, pedestals, …(SVT and MM trackers, Cerenkov Counters gain calibration via SPE measurements, …)
  - Cosmic ray data
- KPP data:
  - Energy and time calibration of forward detectors (DC, HTCC, FTOF, ECAL)
- Simulated data:
  - Use of realistic simulations (GEMC) to exercise calibration procedures
  - Calibration challenges

Calibration without beam

Calibration with cosmic ray, light sources, "noise" (SPE, …):

- In progress since detector assembly completion or installation
- Main means of calibration for Cerenkov detectors, SVT, and MicroMegas detectors
- Provide initial calibrations for energy loss and HV/gain calibrations for several detectors:
  - **CND:** full calibration before installation
  - **CTOF**: full calibration before installation
  - **ECAL**: gain and attenuation length
  - **FT**: gain and energy calibrations for calorimeter and hodoscope
  - **FTOF**: full calibration before installation; gain, attenuation length and left-right time offsets after installation
  - **HTCC** and **LTCC**: gain calibrations
  - **MM**: noise and pedestals measurement
  - **SVT**: noise and pedestals measurement
- Crucial for the success of the KPP run

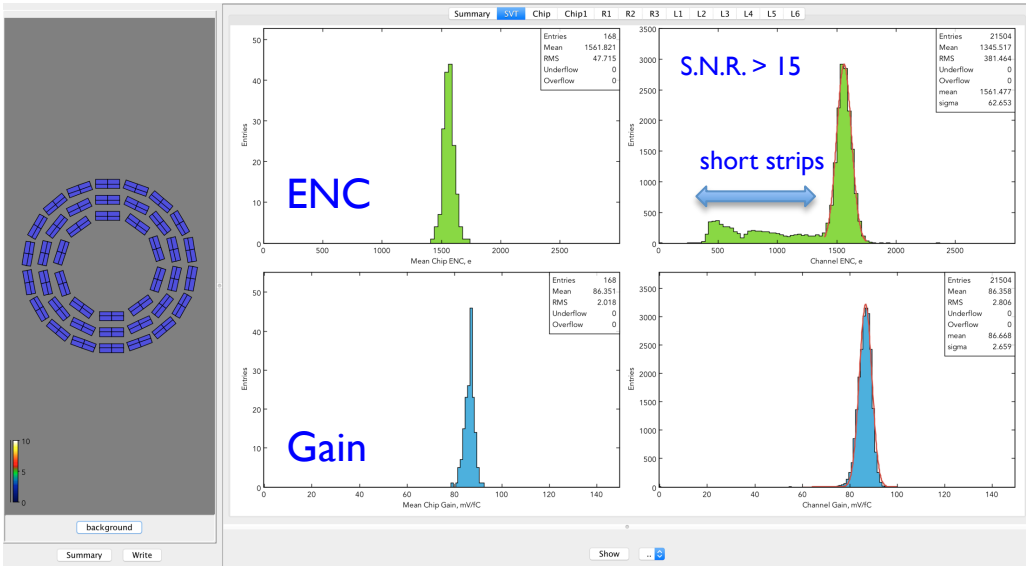


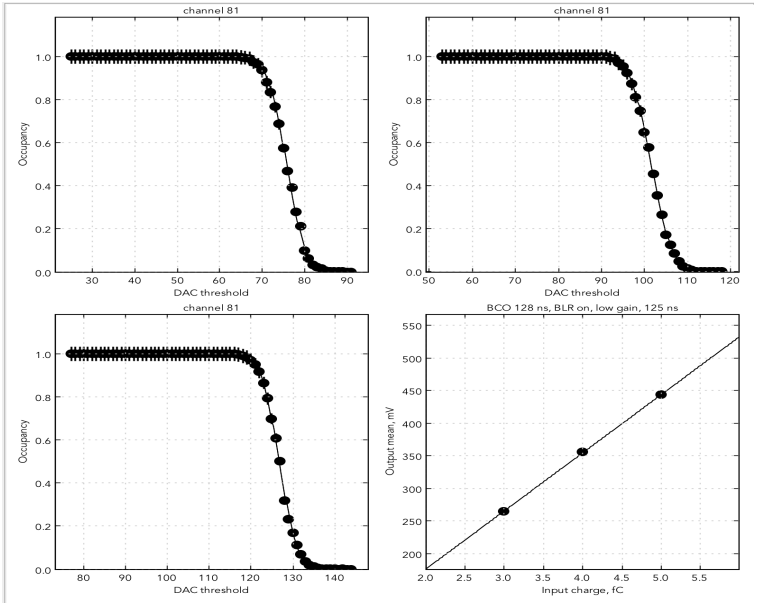


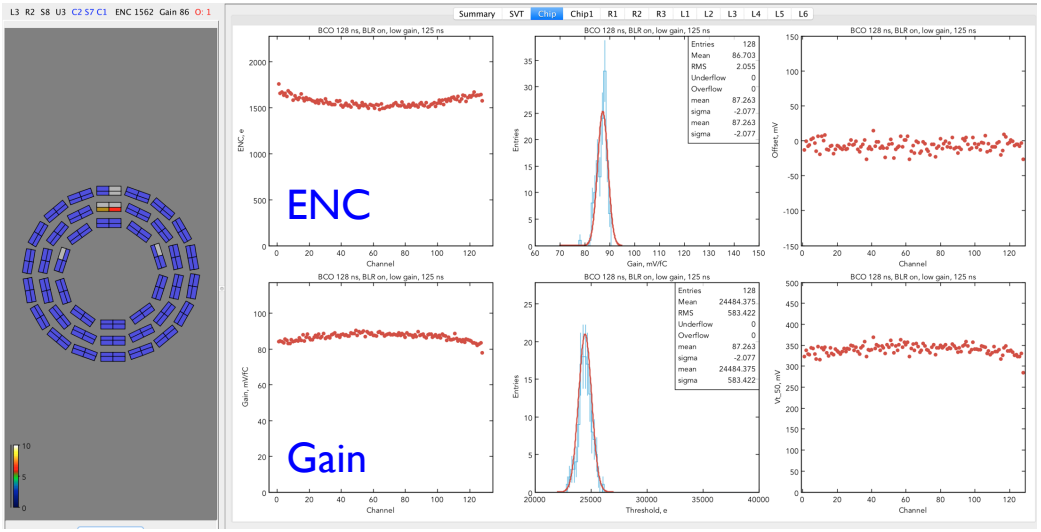
SVT calibration suite

Suite developed to monitor detector parameters (gain, ENC) from global level down to individual channels

- Regular calibration scans
- Calibration data in elog
  https://logbooks.jlab.org/book/hbsvt
- Documentation & tutorial at
  https://www.jlab.org/Hall-B/cvt/svt/doc/calib/svt/introduction.html?highlight=ccdb#calibration-software

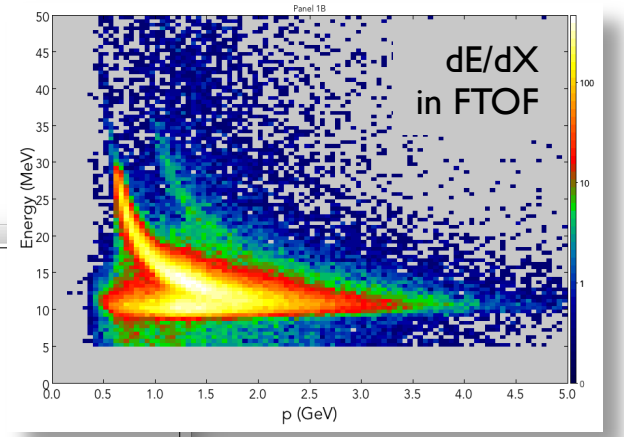


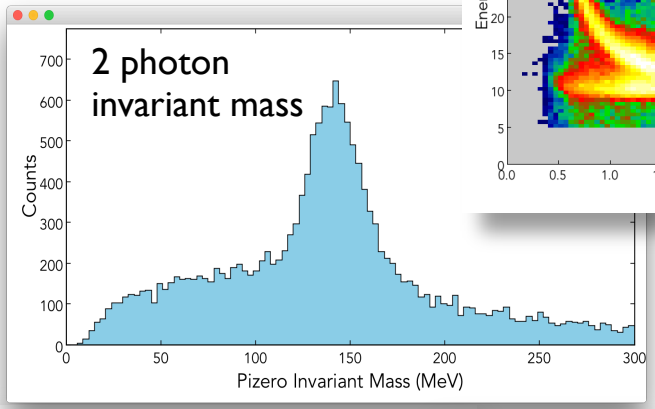


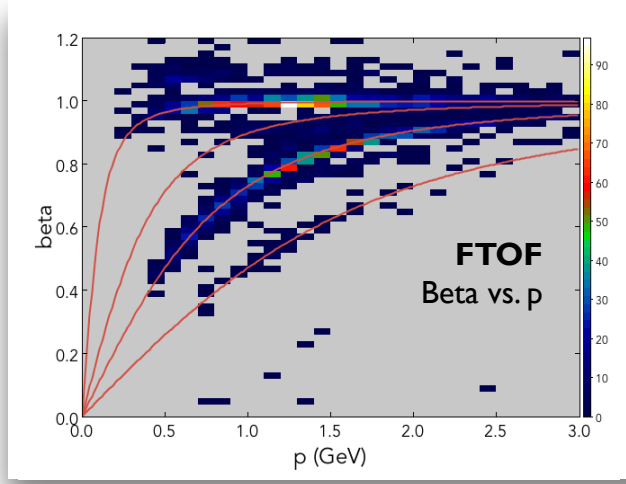


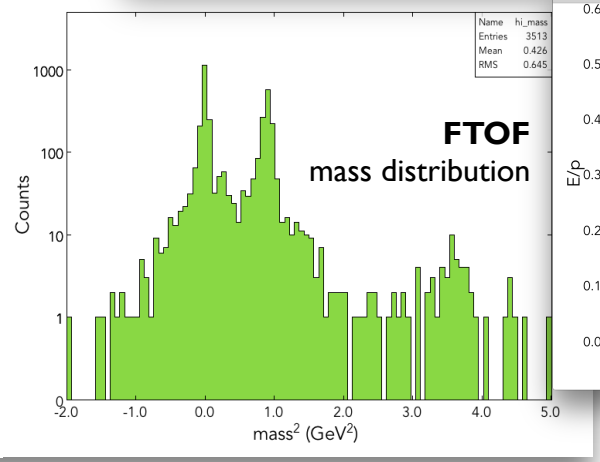
Calibration of KPP Data

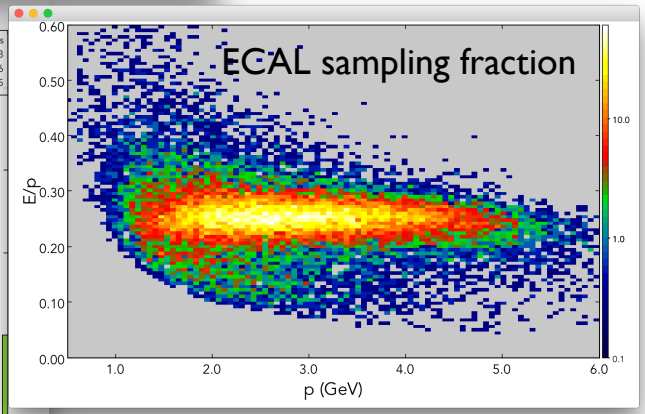
- First opportunity to perform full detector calibrations based on real data:
  - ECAL cosmic gain calibration cross checked with pions, timing calibration started
  - Full calibration of FTOF done, improvements to reach ultimate resolution in progress
  - DC calibration step sequence developed and implemented
  - HTCC calibration extended to include timing







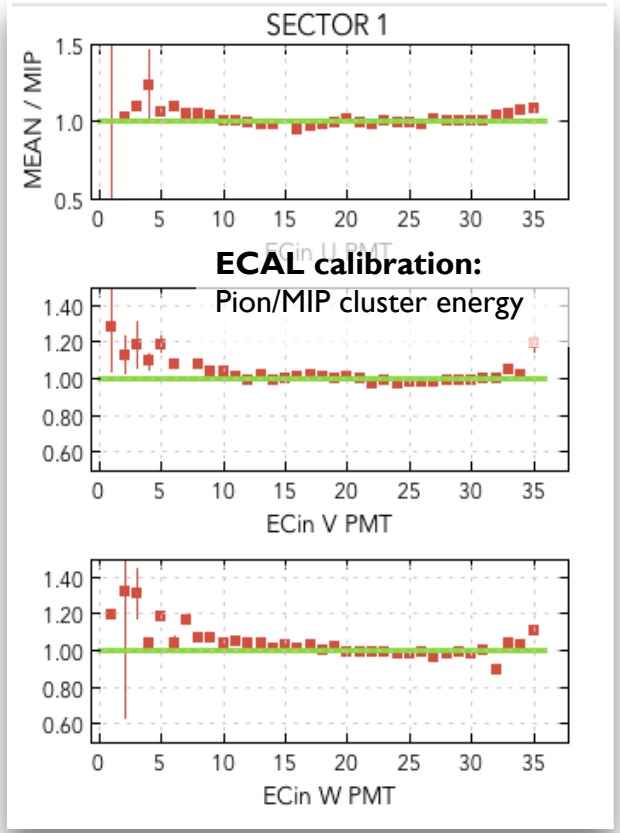




ECAL energy calibration

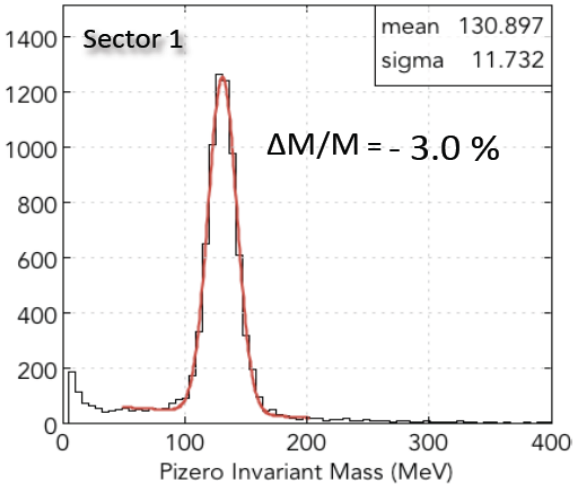
Crucial system for CLAS12 electron trigger:

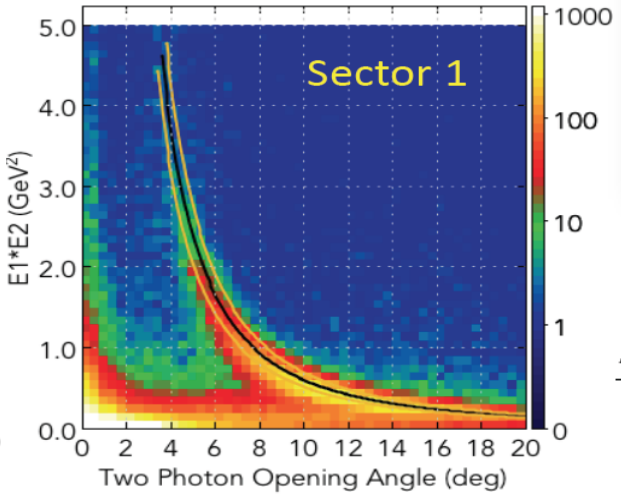
- Initial energy calibration based on comic ray data
- Calibration cross checked with pions in KPP: more uniform six-sector coverage
- Calibration results validated via analysis of pi0 mass spectrum from two-photon events



ECAL calibration:
Pion/MIP cluster energy

$$M_{\pi^0}^2 = 2\,E_1^\gamma\,E_2^\gamma\left(1-\cos\vartheta_{12}\right)$$



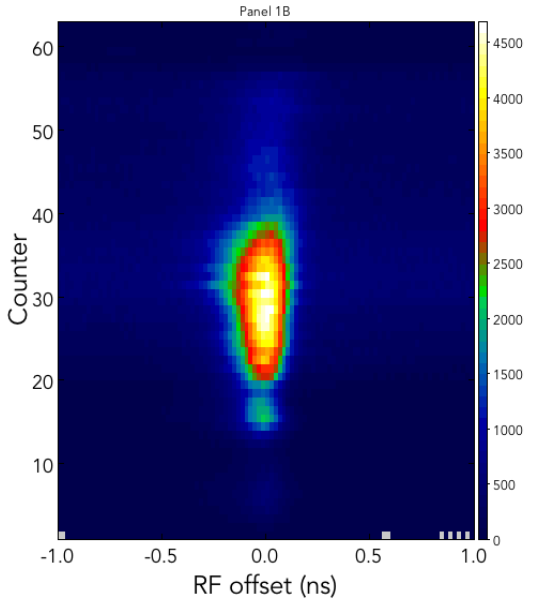


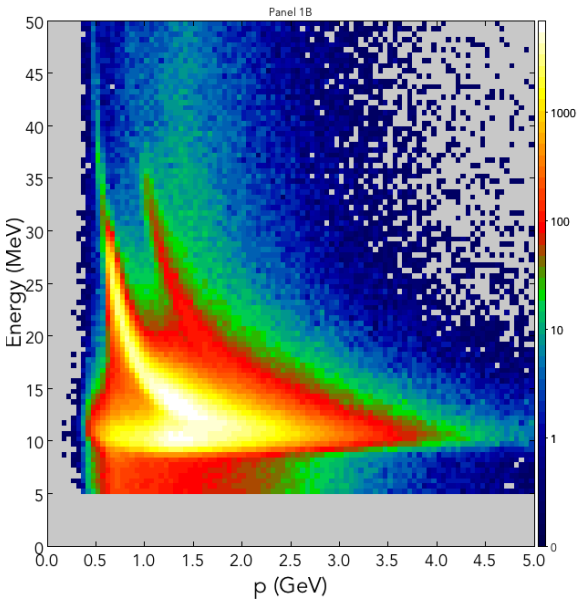
$$\frac{\Delta M}{M} = \frac{1}{2}\left[\frac{\Delta E_1}{E_1} + \frac{\Delta E_2}{E_2}\right]$$

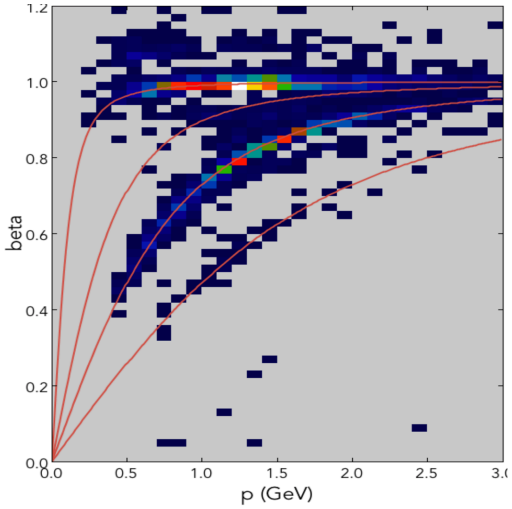
FTOF calibration

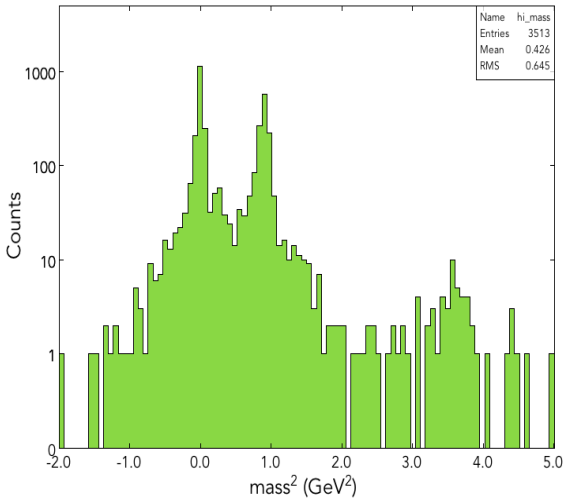
HV/Gain Calibration	
Step #	Action
✓ 1	Gain Calibration
Timing Calibration	
✓ 1	PMT Timing Diff.
✓ 2	Attenuation Length
✓ 3	Effective Velocity
✓ 4	Time-Walk
✓ 5	P2P
✓ 6	RF Offset

While the KPP data is limited (low statistics, S2 only), it has allowed for important developments and verifications related to the FTOF calibrations





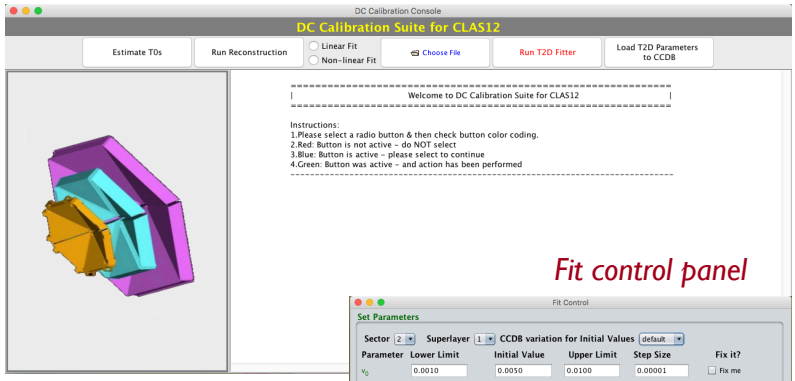




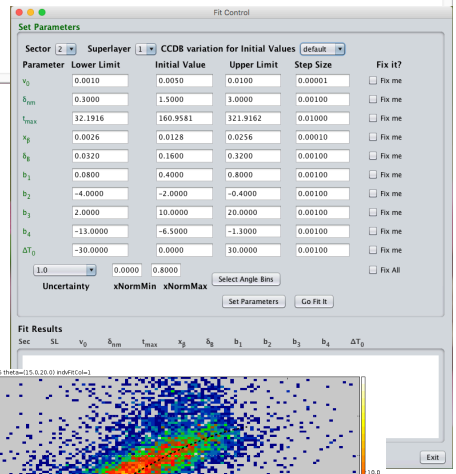
DC calibration

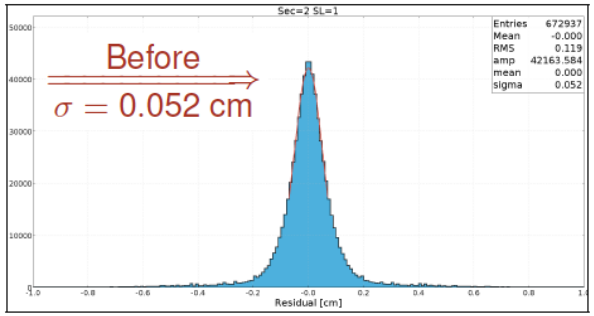
- GUI driven complete calibration suite for DC
- Tested with both MC and KPP data for convergence, stability and improved resolution

DC calibration main GUI

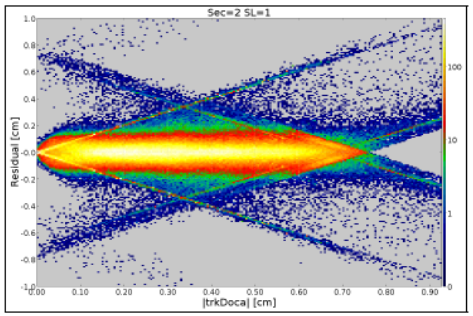


Fit control panel

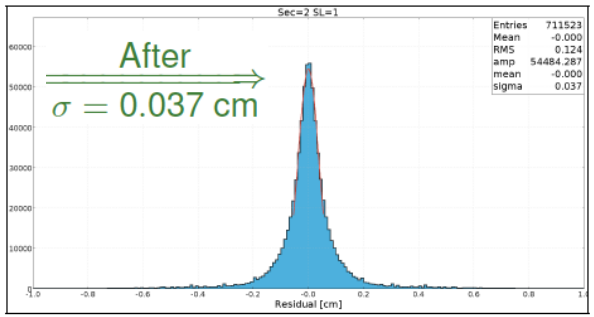




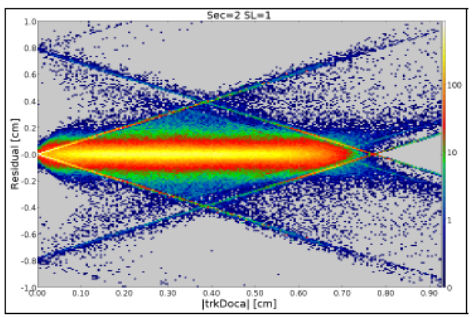
(a) Residual distribution



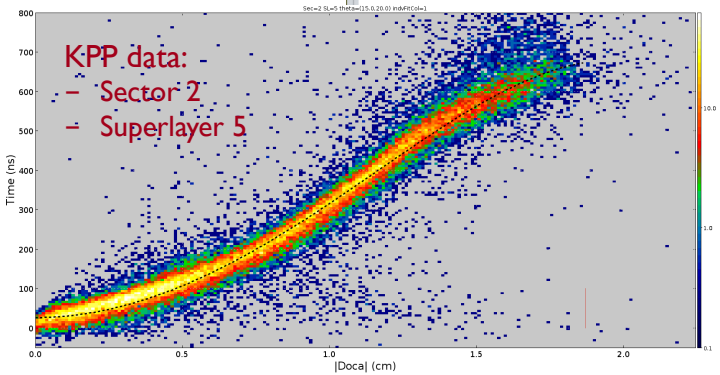
(b) Residual vs trkDoca



(a) Residual distribution



(b) Residual vs trkDoca



Typical fit for time-to-distance function

Calibration Challenge

Test of the full calibration procedure:

- Generate pseudo-data with "wrong" calibration constants
- Run calibrations for different systems in appropriate sequence
- Extract calibration constants and save them to DB
- Evaluate calibration quality by:
  - looking at monitoring plots
  - comparing reconstruction output with extracted and original constants

- First challenge in December 2016, second challenge in August 2017 involving all detectors

- Who:
  - Analysis Coordinator
  - Calibrator team
  - DB manager
  - "Chef" for data processing
- When:
  - December 12-19 2016
  - August 28 – September 8 2017

    (1 week -10 days)
- How:
  - Generate pseudo-data with Pythia and 10^{34} luminosity background
  - 1 shift (8 h) worth of data
  - Daily meetings and milestones for coordination and progress tracking

Calibration Challenge

System	Calibration	Calibrator(s)
CND	Energy & Time	G. Murdoch (Glasgow)
CTOF	Full	D. Carman (JLab), L. Clark (Glasgow)
DC	Time	L. Kabir (Mississippi)
ECAL	Time	J.A. Tan (KNU)
FTCal	Time	R. De Vita (INFN)
FTHodo	Energy	N. Zachariou (Edinburgh) S. Hughes (Edinburgh)
FTOF	Energy & Time	D. Carman (JLab), L. Clark (Glasgow)
HTCC	Time	N. Markov (UCONN)
LTCC	Time	B. Duran (Temple) M. Ungaro (JLab)

Calibration challenge goals, strategy, organization and results documented in CLAS12-Note 2017-010

1 week

Day #1: Pass-0 data made available
- FTOF calibrations completed

Day #2: First iteration of calibrations completed
- Detector component status for all subsystems
- Energy/gain calibrations for FT and CND
- DC time-based tracking calibration started
- Pass-1 data made available to calibrators
- CTOF calibrations completed

Day #3: Second iteration of calibrations
- Time calibrations for CND, FT, HTCC, LTCC, ECAL
- Refinement of DC time-based tracking calibrations
- Pass-2 data made available to calibrators
- Unblind calibration constants to calibration teams

Day #4: Third iteration of calibrations
- Recooked data sample with DC reconstruction and calibration fixes made available
- Refinement of ECAL and HTCC timing calibrations

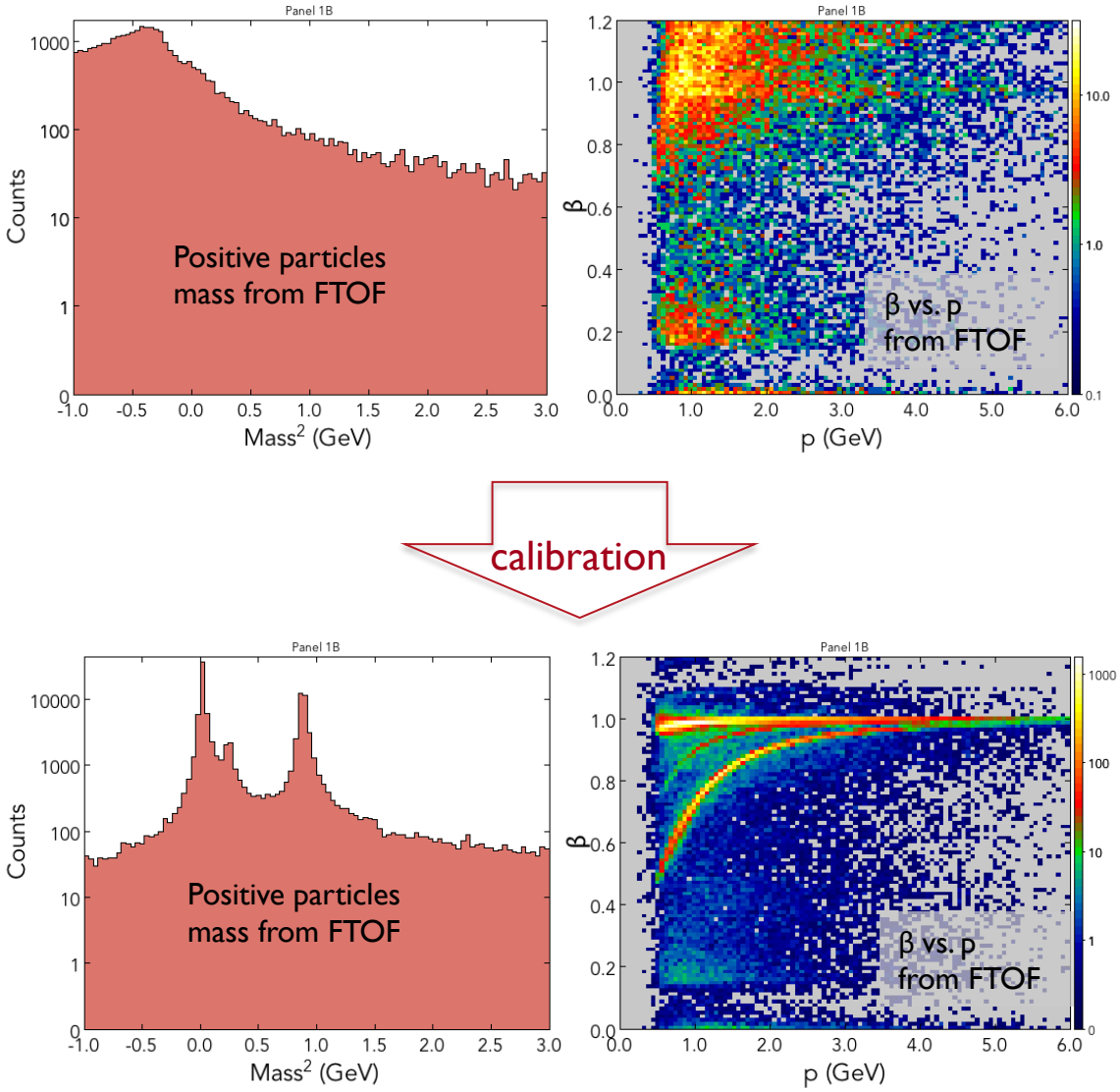
Day #5: Fourth (and final) iteration of calibrations

Days #6 - #12: Complete calibration constant comparisons and preparation of reconstruction plots

Calibration Challenge

System	Calibration	Calibrator(s)
CND	Energy & Time	G. Murdoch (Glasgow)
CTOF	Full	D. Carman (JLab), L. Clark (Glasgow)
DC	Time	L. Kabir (Mississippi)
ECAL	Time	J.A.Tan (KNU)
FTCal	Time	R. De Vita (INFN)
FTHodo	Energy	N. Zachariou (Edinburgh) S. Hughes (Edinburgh)
FTOF	Energy & Time	D. Carman (JLab), L. Clark (Glasgow)
HTCC	Time	N. Markov (UCONN)
LTCC	Time	B. Duran (Temple) M. Ungaro (JLab)

Calibration challenge goals, strategy, organization and results documented in CLAS12-Note 2017-010



Overall Calibration Status

Done In progress To be started

System	Calibration algorithm	Calibration Suite	Monitoring Suite	Documentation & Tutorials
DC	Done	Optimization in progress (10/31/2017)	Done	Suite documentation (10/31/2017)
ECAL	Done	Timing (10/31/2017)	Done	In progress (11/15/2017)
FTOF	Done	Done	Done	Done
HTCC	Done	Merging of gain and time (10/31/2017)	Done	In progress (10/31/2017)
LTCC	Done	Merging of gain and time (10/31/2017)	Done	To be started (11/15/2017)
FT	Done	Upgrade to Coatjava 4.0 (10/15/2017)	Tracker implementation (10/31/2017)	In progress (11/15/2017)
SVT	Done	Done	Done	Done
MVT	Lorentz angle correction (10/31/2017)	Done	Done	In progress (10/31/2017)
CTOF	Done	Done	Done	Done
CND	Attenuation length (10/15/2017)	Done	In progress (10/31/2017)	To be started (11/15/2017)
RICH	Global timing (11/15/2017)	In progress (10/31/2017)	In progress (10/31/2017)	Software documentation (11/31/2017)

Calibration Team
for CLAS12 Engineering Run

Task		Name
Analysis Coordinator		N. Baltzell (JLab), R. De Vita (INFN)
Data Chef(s)		F. X. Girod (JLab), N. Harrison (North Georgia)
DB manager		H. Avakian (JLab)
Calibrators	CND	G. Murdoch (Glasgow), S. Niccolai (IPN)
	CTOF	D. Carman (JLab), L. Clark (Glasgow)
	DC	L. Kabir (Mississippi)
	ECAL	C. Smith (JLab), J. A. Tan (KNU)
	FT	A. Celentano (INFN), L. Lanza (Roma TV), N. Zachariou (Edinburgh)
	FTOF	D. Carman (JLab), L. Clark (Glasgow)
	HTCC	N. Markov (UCONN)
	LTCC	B. Duran (Temple), M. Ungaro (JLab)
	MVT	G. Christiaens (CEA), M. Defurne (CEA)
	RICH	A. Kim (UCONN), M. Turisini (JLab/INFN)
	SVT	Y. Gotra (JLab)

Summary

- Further progresses on detector calibration development and validation since last collaboration meeting
- Combined use of non-beam, KPP and simulated data
- Successful completion of second calibration challenge from August 28 to September 8
- Remaining calibration development tasks on track for completion in October-November
- Calibration team and organization for the upcoming Engineering Run in place