CLAS12 Offline Software Tools

G.Gavalian (Jlab)

CLAS Collaboration Meeting (June 15, 2016)

Overview

- **Data Formats:**
  - RAW data decoding from EVIO.
  - Reconstruction output banks in EVIO.
  - Reconstruction output convertor to ROOT (coming soon).
  - Data preservation format (HIPO), compression and fast random access.
    - Fast indexing and error recovery
    - Used to produce small data samples (and DSTSs)
- **Calibration Framework:**
  - Powerful 2D detector visualization framework.
  - Data analysis library for plotting, fitting (most of the plots in presentations today).
  - Interface to constants database, and translation tables.
  - Pulse fitting toolkit (database aware).
  - Automated calibration constants visualization and analysis.
- **Reconstruction:**
  - Modular reconstruction framework (CLARA based)
  - Event Builder for full event reconstruction
  - ROOT convertor for particle ID and physics analysis

Data Input/Output

✓ **Raw DAQ Data**

- standard CCDB tables for pulse parameters (NSA,NSB, TET).
- standard tables for Translation Tables (CCDB).
- tools for reading FADC tables and Translation tables.
- visualization and constrain highlighting.
- simple interface to interact with data (independent of the source)

✓ **Raw Detector Pulse viewer**

- interface for pulse FADC visualization
- fitting for FADC pulse (integration)

✓ **Event Decoder**

- decoder for compact data structures
- pedestal subtraction/pulse fitter
- creating reconstruction detector banks

A	A	A	pedestal	nsb	nsa	tet
1	3	0	93.8	3	15	10
1	3	1	137.5	3	15	10
1	3	2	94.6	3	15	10
1	3	3	125.4	3	15	10
1	3	4	96.3	3	15	10
1	3	5	110.5	3	15	10
1	3	6	138.3	3	15	10
1	3	7	112.0	3	15	10
1	3	8	116.1	3	15	10
1	3	9	101.2	3	15	10
1	3	10	90.7	3	15	10
1	3	11	106.5	3	15	10
1	3	12	87.8	3	15	10
1	3	13	134.6	3	15	10
1	3	14	113.1	3	15	10
1	3	15	109.3	3	15	10
1	4	0	113.5	3	15	10
1	4	1	114.7	3	15	10
1	4	2	119.5	3	15	10
1	4	3	125.4	3	15	10
1	4	4	98.8	3	15	10

```
D [FTOF1A ] C/S/C [  11   4  13 ] S/L/C [  2   1  16 ] ORDER =  0 -->>> TYPE = ADCPULSE  SIZE =   100
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---------------> event  # 7
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```
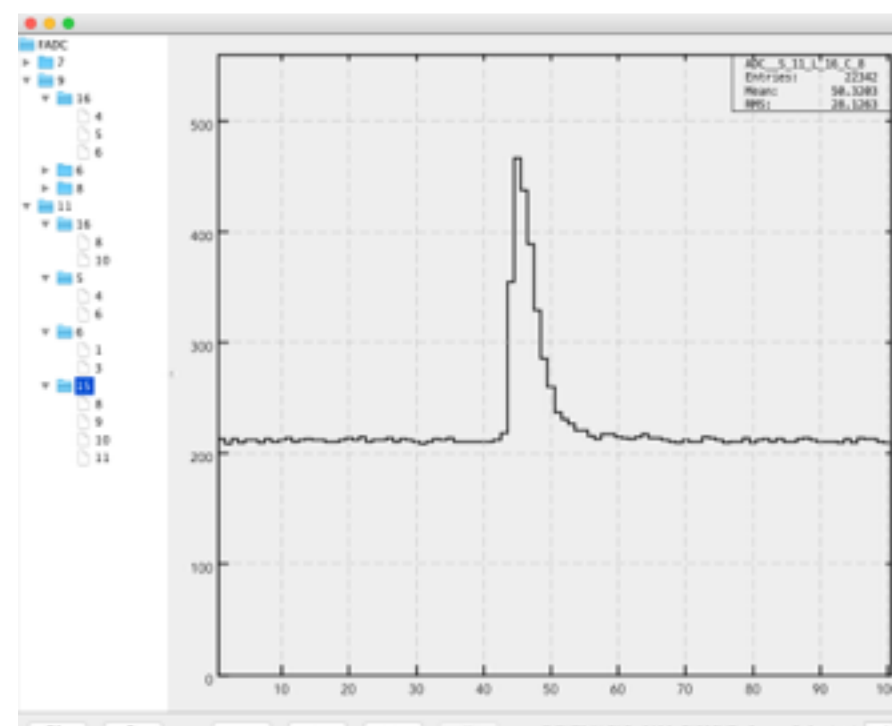
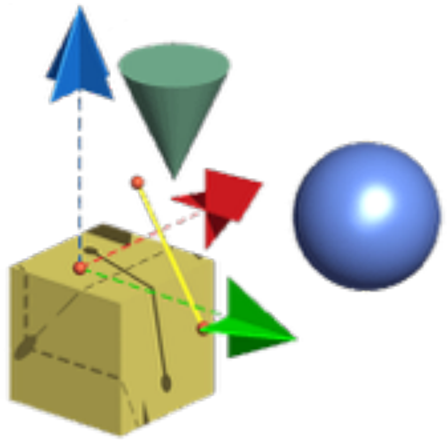



Geometry & Calibration Tools

✓ **Standard Detector Geometry Package Implements:**

- Forward Time of Flight
- Electromagnetic Calorimeter
- Forward Tagger
- Drift Chambers
- Silicon Vertex Tracker
- Central Neutron Detector



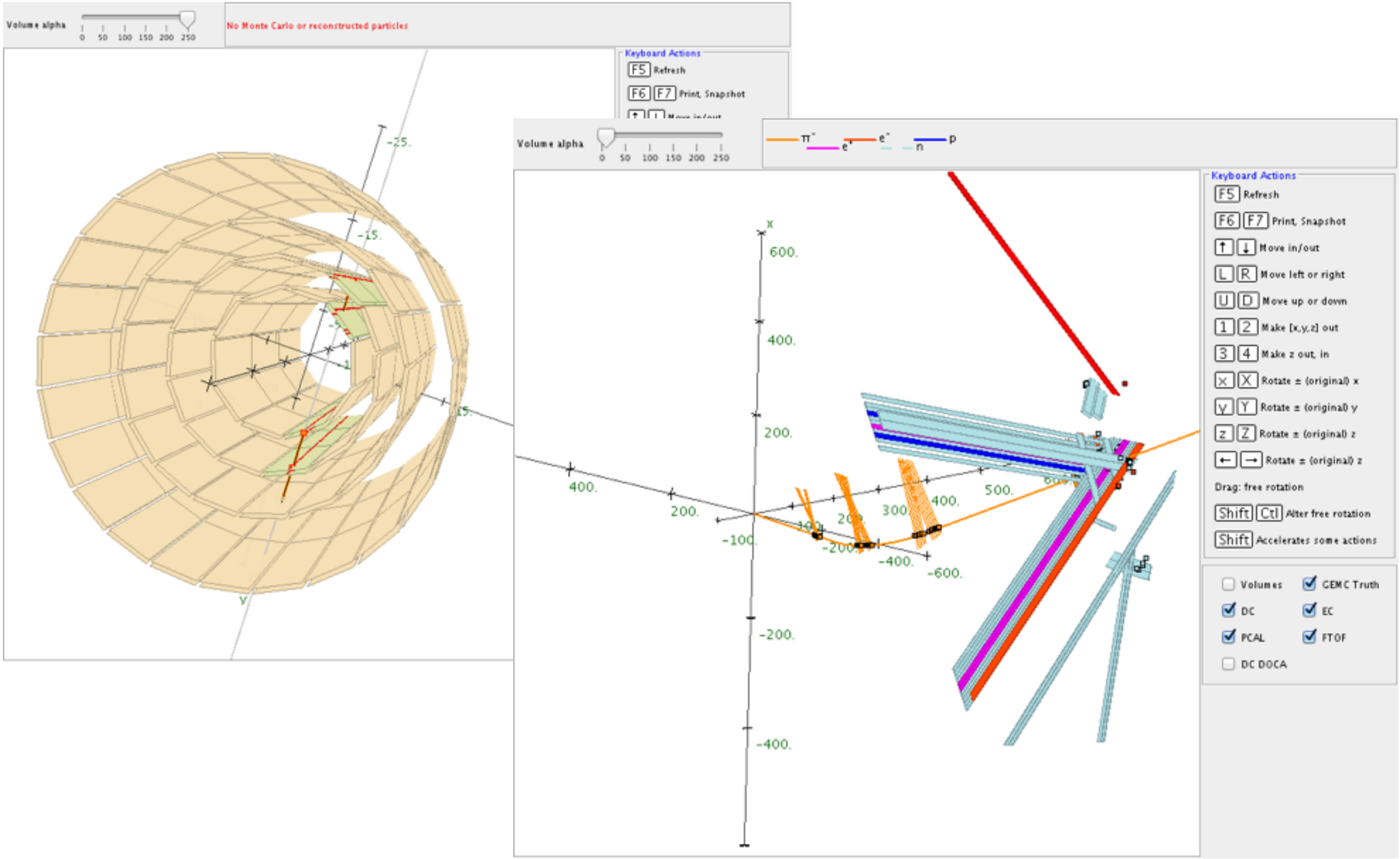
✓ **Geometry Tools and Utilities:**

- Drawing package for 2D detector representation
- 3D shapes for CED-3D viewer
- Detector component tracker for Fast Monte-Carlo

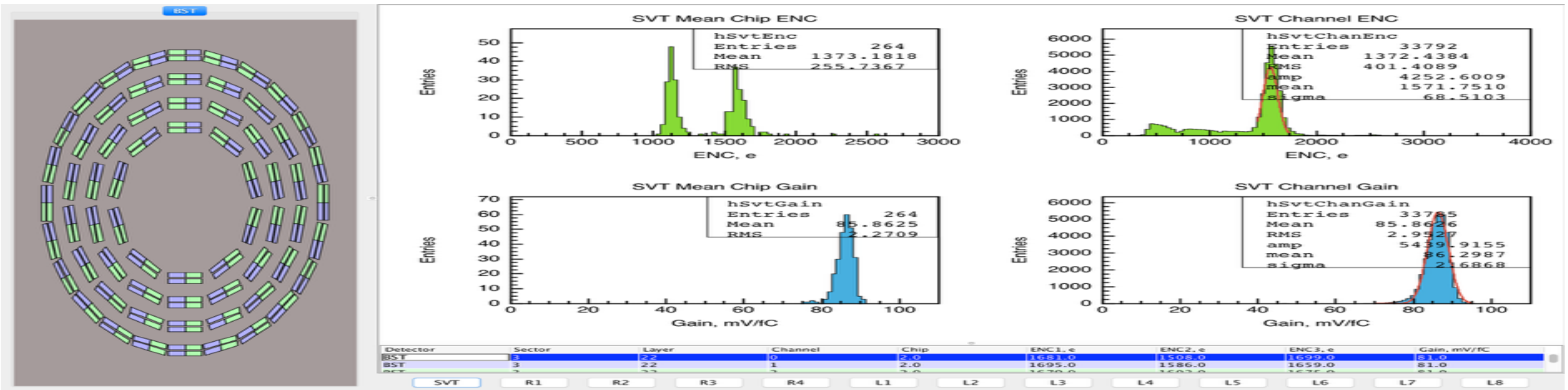
✓ **Calibration UI:**

- new UI for developing Calibration code
- data stream implementation for EVIO files and ET-ring
- reasonable drawing and fitting package

Geometry 3D in CED

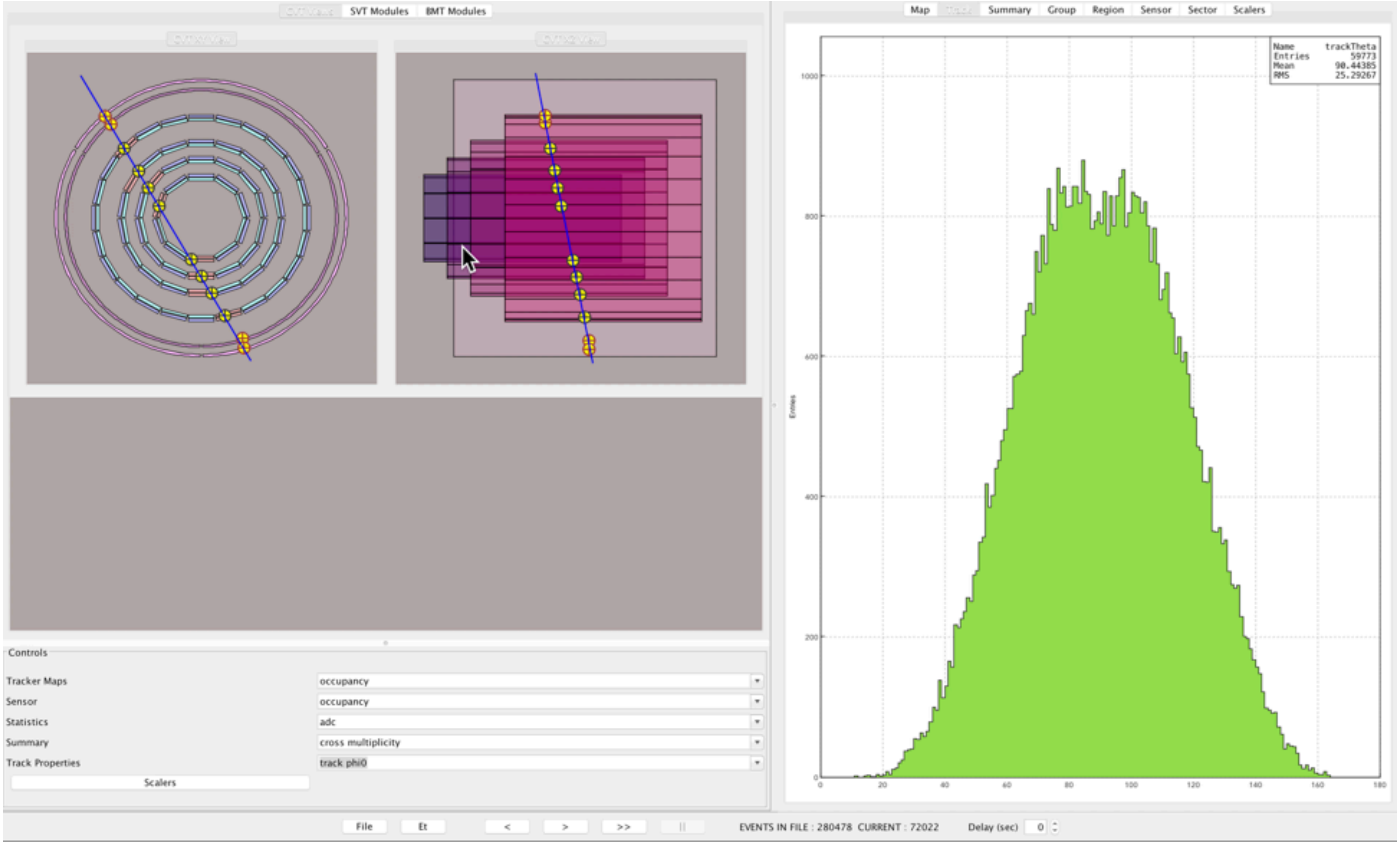


Calibration Examples (SVT)

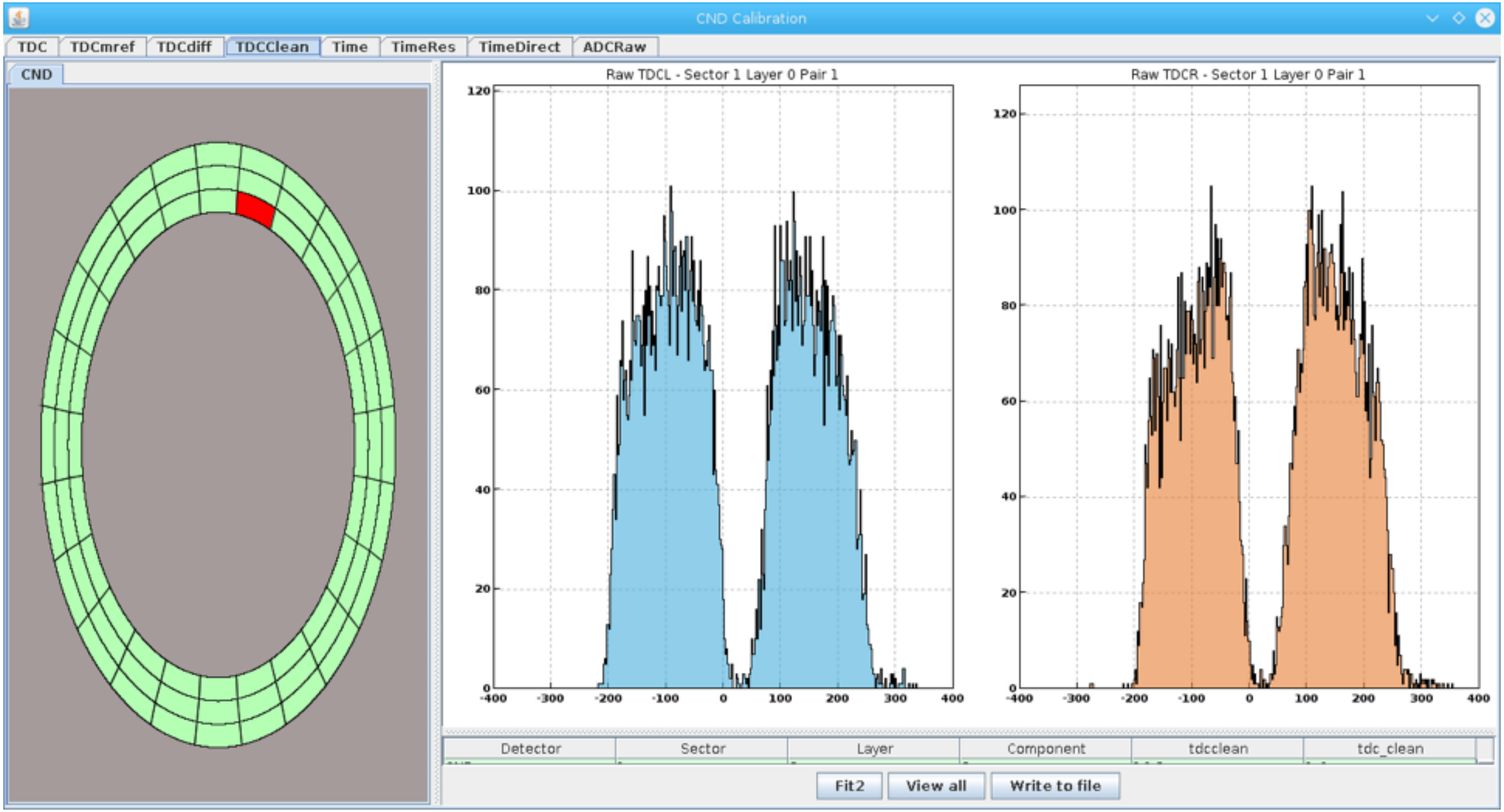


Detector	Sector	Layer	Channel	Chip	ENC1, e	ENC2, e	ENC3, e	Gain, mV/fC
BST	3	22	0	2.0	1681.0	1508.0	1699.0	81.0
BST	3	22	1	2.0	1695.0	1586.0	1659.0	81.0
BST	3	22	2	2.0	1679.0	1602.0	1675.0	81.0
BST	3	22	3	2.0	1679.0	1583.0	1652.0	81.0
BST	3	22	4	2.0	1681.0	1650.0	1686.0	80.0
BST	3	22	5	2.0	1663.0	1634.0	1641.0	81.0
BST	3	22	6	2.0	1689.0	1607.0	1668.0	81.0
BST	3	22	7	2.0	1650.0	1562.0	1633.0	81.0
BST	3	22	8	2.0	1650.0	1496.0	1651.0	83.0
BST	3	22	9	2.0	1669.0	1599.0	1640.0	83.0
BST	3	22	10	2.0	1642.0	1469.0	1655.0	82.0
BST	3	22	11	2.0	1649.0	1558.0	1603.0	82.0
BST	3	22	12	2.0	1640.0	1539.0	1611.0	84.0
BST	3	22	13	2.0	1642.0	1465.0	1638.0	83.0
BST	3	22	14	2.0	1676.0	1489.0	1642.0	83.0
BST	3	22	15	2.0	1617.0	1545.0	1582.0	83.0
BST	3	22	16	2.0	1629.0	1483.0	1629.0	84.0
BST	3	22	17	2.0	1631.0	1561.0	1586.0	84.0
BST	3	22	18	2.0	1603.0	1460.0	1637.0	83.0

Calibration Examples (SVT) (Y. Gotra)



CND Calibration (G. Murdoch)



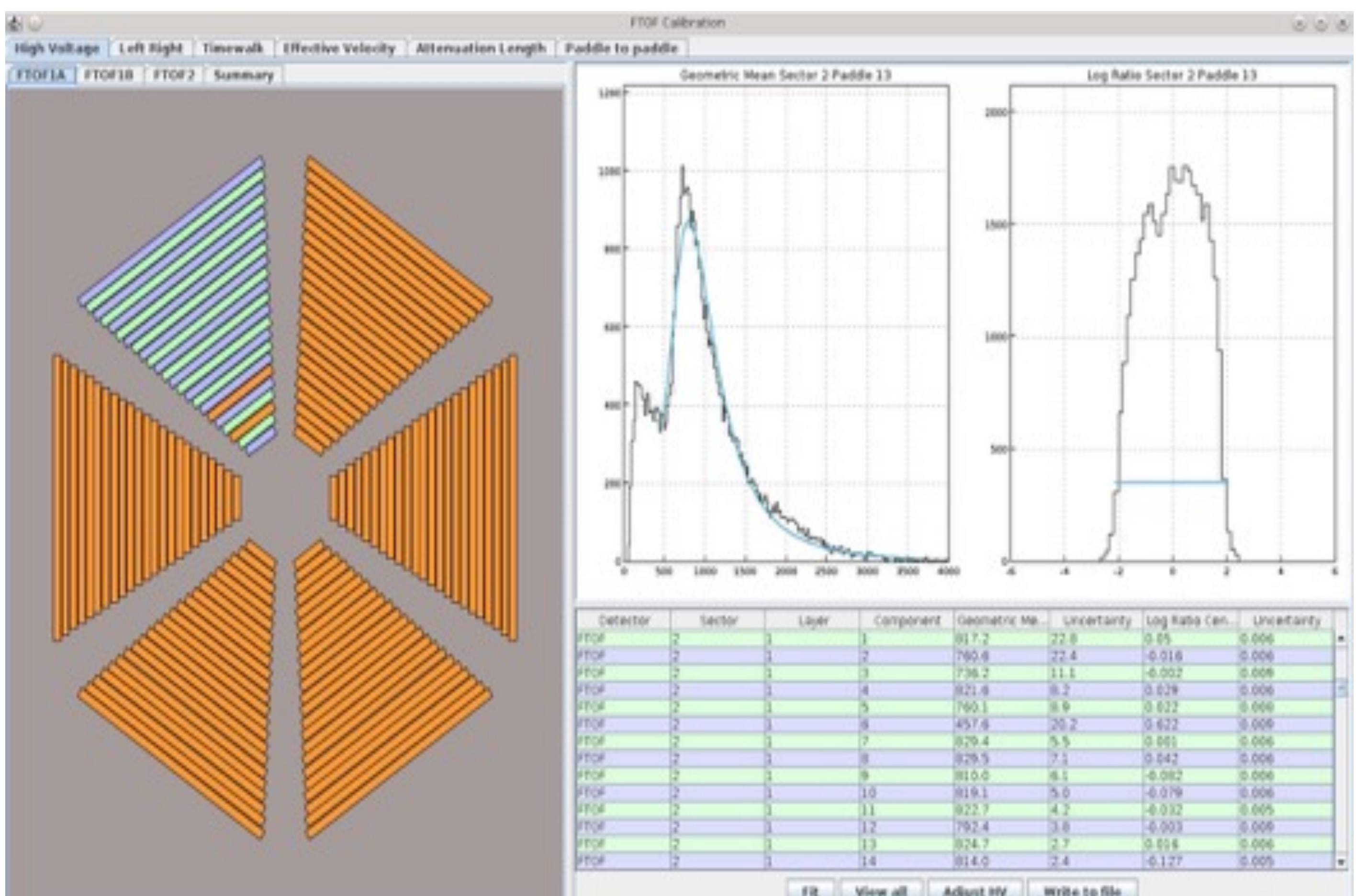
FTOF Calibration (L. Clark)

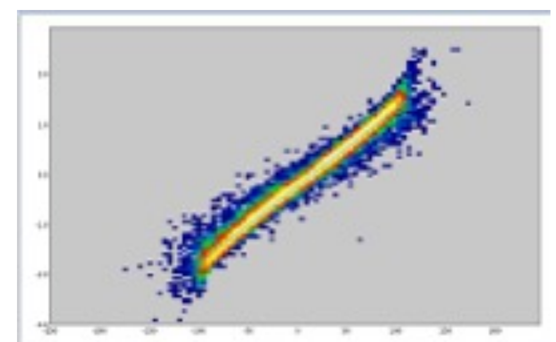
Work completed / in progress

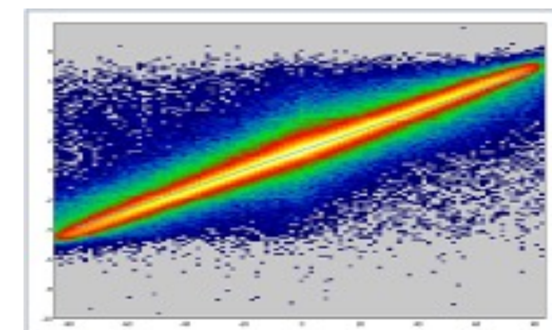
- Conversion of calibration algorithms to COATJAVA framework for high voltage, attenuation length, effective velocity, timewalk, paddle to paddle offsets
- Script generation for high voltage adjustments
- Output file of calibration constants for transfer to calibration database
- Summary graphs of calibration values
- FTOF calibration GUI

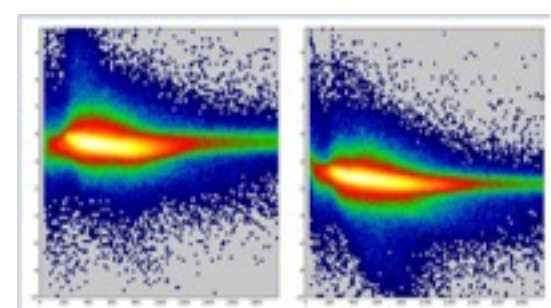
Work planned

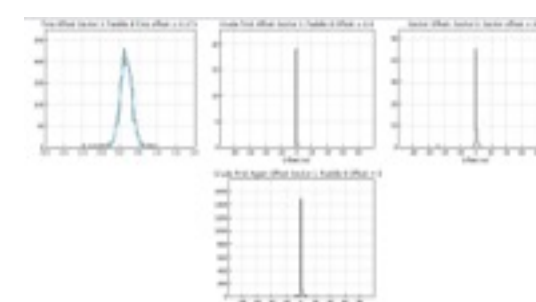
- Conversion of calibration algorithms for RF offsets and counter status
- Full functionality within GUI for each calibration area
- Testing

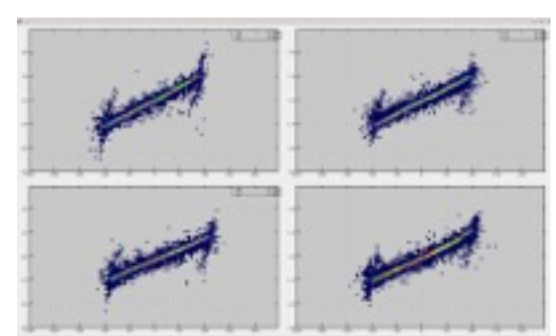


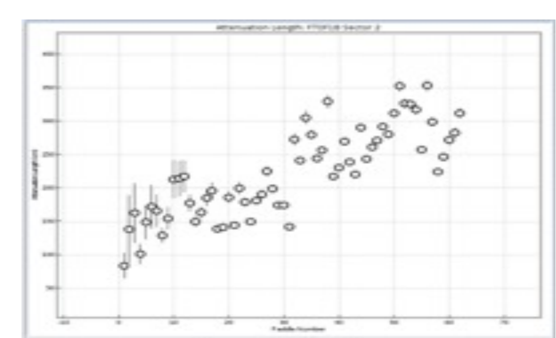










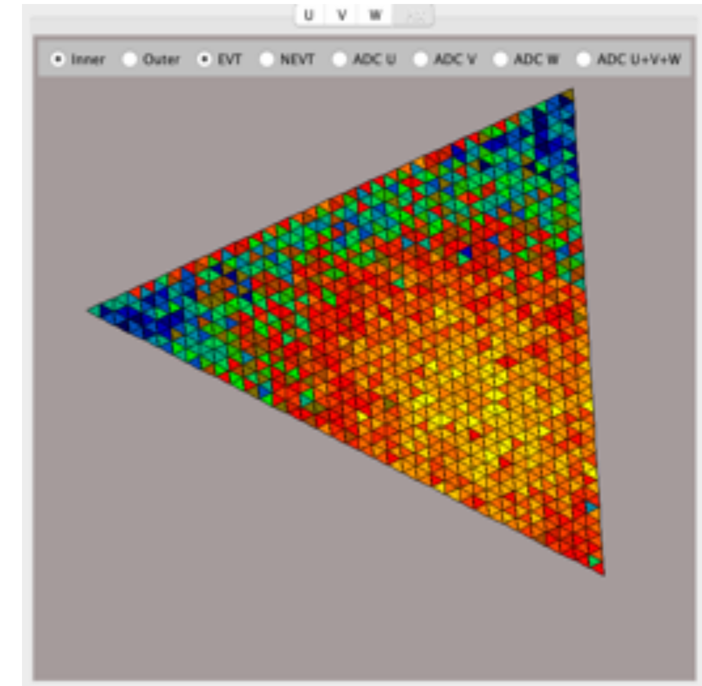


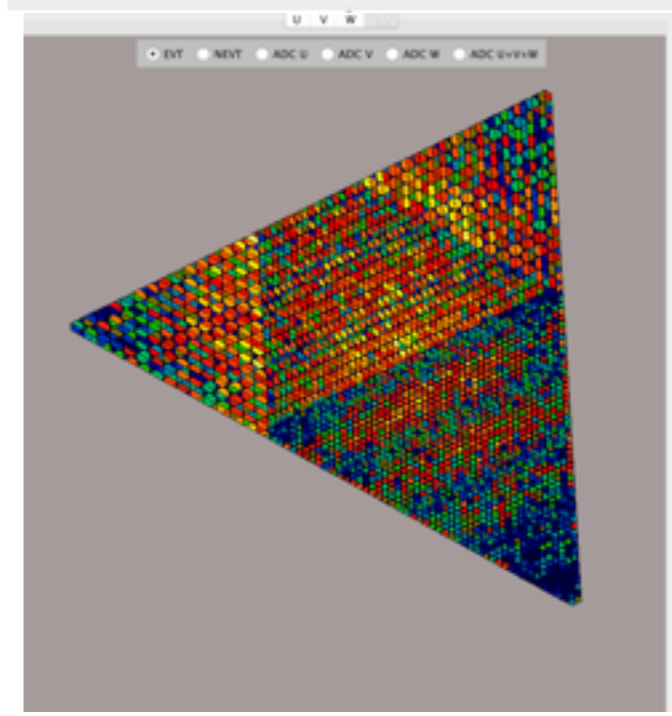
Data Visualization (EC) (C. Smith)

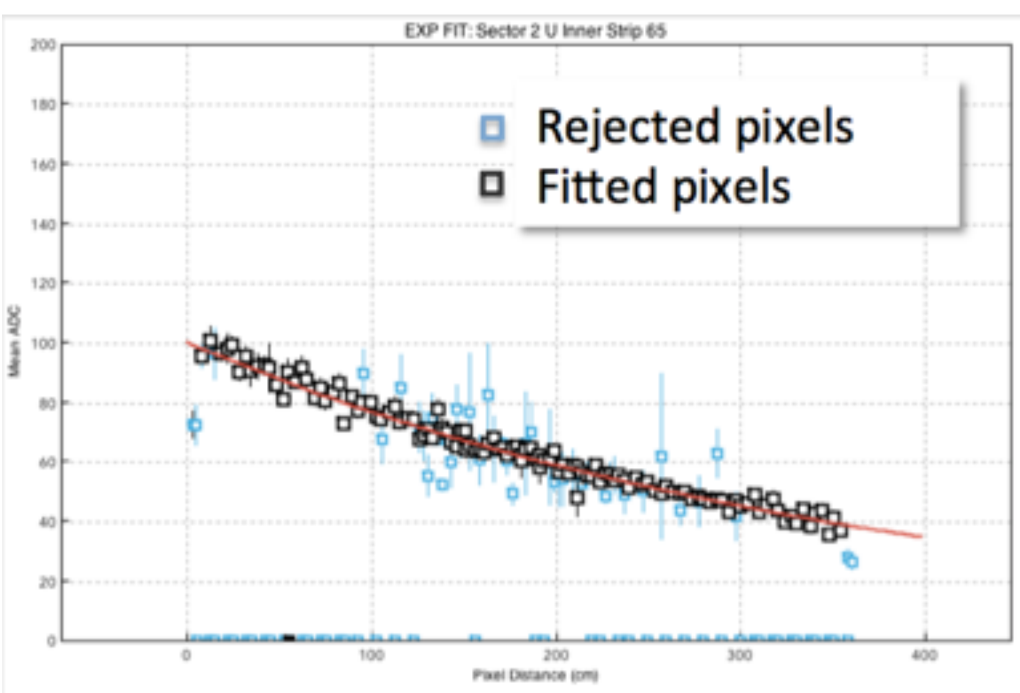
Current Features
- Common framework for PCAL and EC.
- Pixels dynamically generated from geometry database.
- Mouse-over navigation of detector elements.
- Live updating of detector response and calibration results.

Monitoring
- Occupancy: strips, pixels, fADC and TDC data.
- fADC data: pulse shape, noise, fitter settings.
- Single event: visualize hits and showers.
- Pedestals: event-by-event, noisy channels.

Calibration
- GUI isolates single pixel cosmic muon hits (Dalitz).
- Optimization of pixel selection (statistics, geometry).
- Fits to pixel data: PMT gains and light attenuation.
- Validation using GEMC simulations.

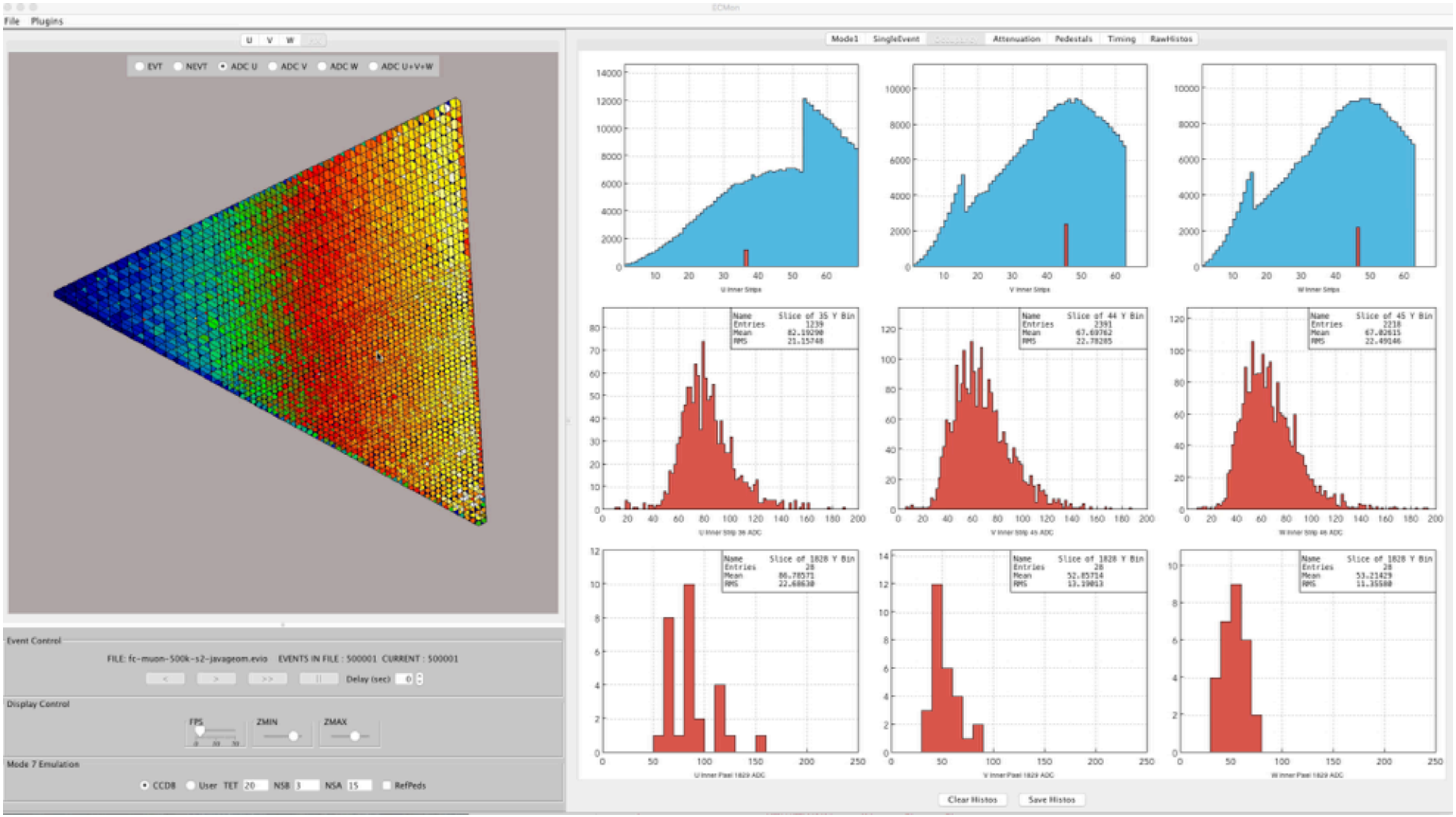






Further Development
- Incorporate EPICS data (scalers and HV) for status monitoring.
- Energy cluster reconstruction and trigger debugging support.
- Energy calibration using physics data (e-, pi-zero and MIP pions).
- Timing calibration (offsets, time-walk).
- EC, PCAL relative alignment using cosmic muon pixel events.

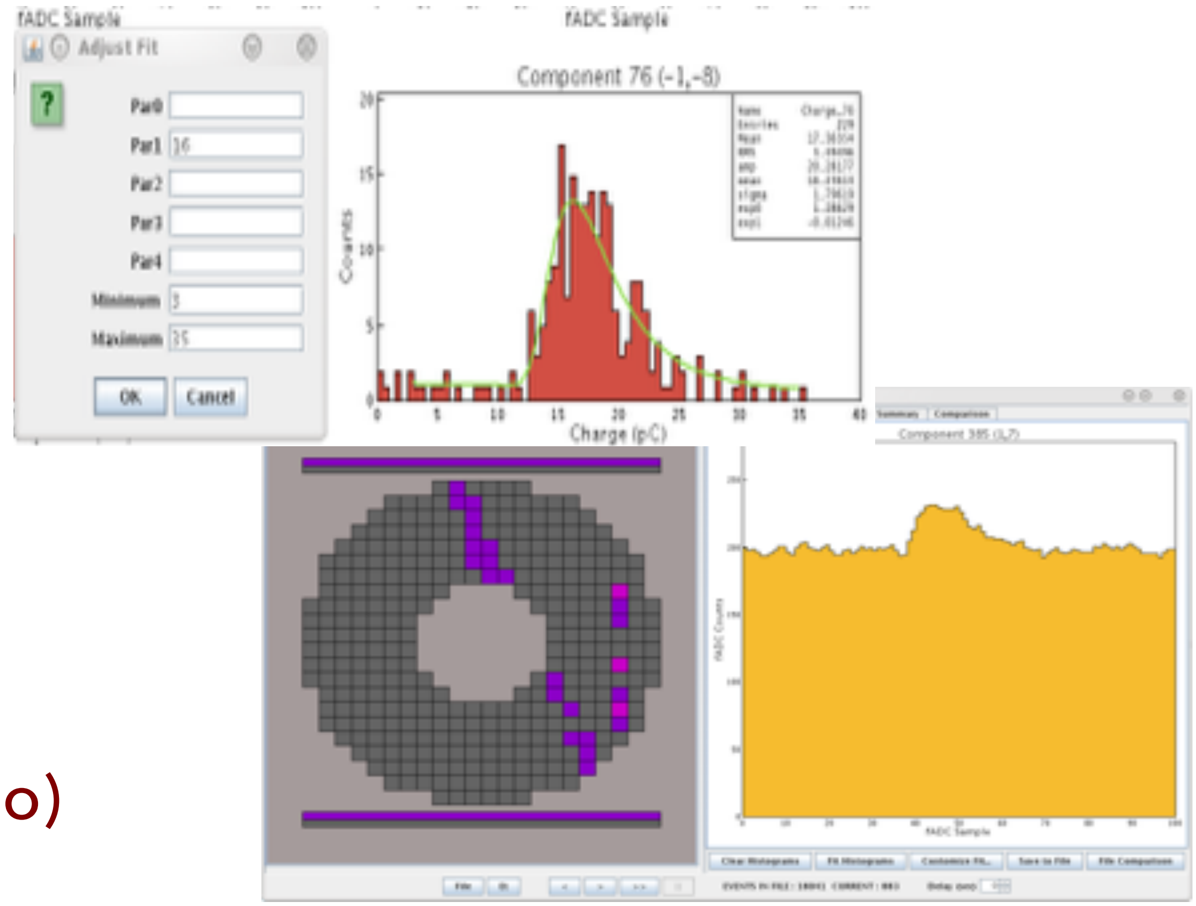
Calibration EC

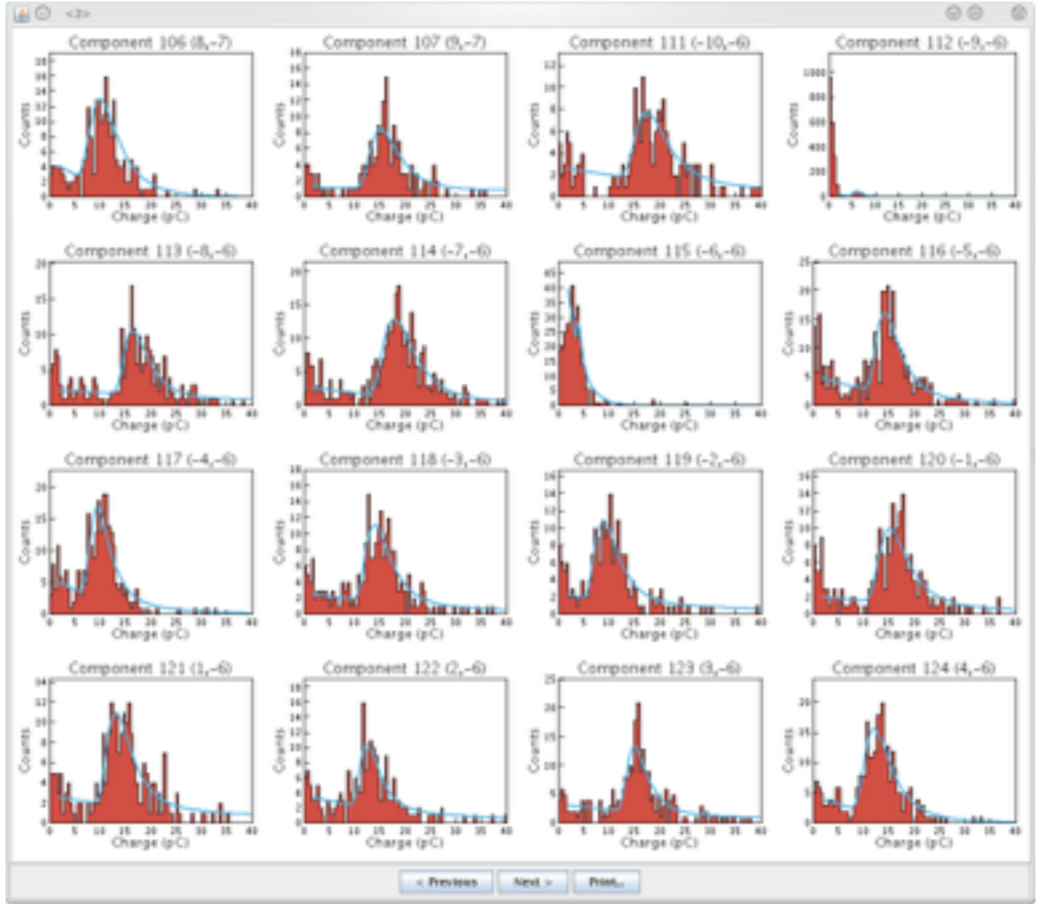


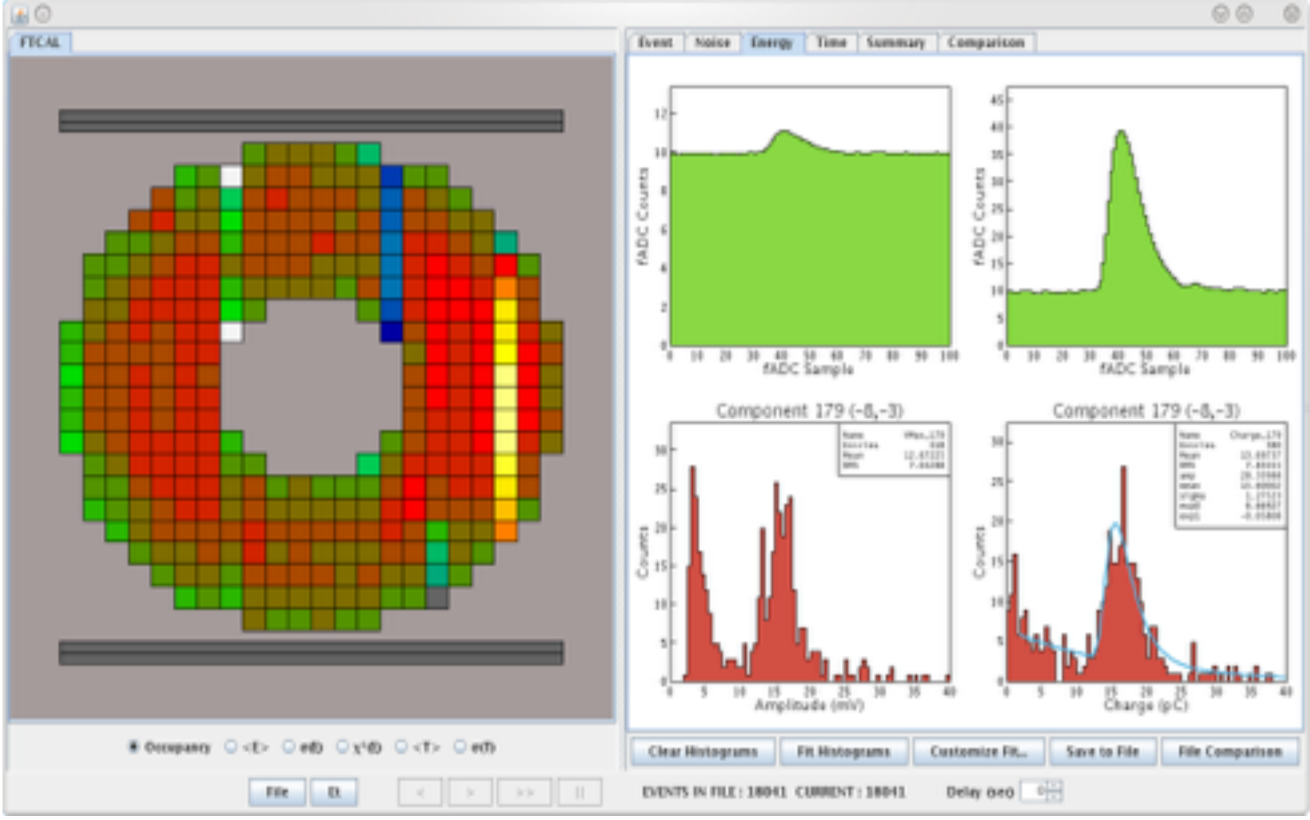
Calibration&Monitoring (FTCAL) (E. Fanchini)

- ***Modular software:***
- project organized in subroutines (app) to be re-used
- ***Runs:*** online and offline data analysis
- ***Selections:*** Tabs and buttons to select analysis and variables to display
- ***Comparison:*** distributions compared with a reference or an offline run
- ***Summary panel:*** window displaying channel distributions and fits

- ***Refit panel:*** user function fit optimization
- ***Outputs:*** output files for offline analysis (txt, hipo)

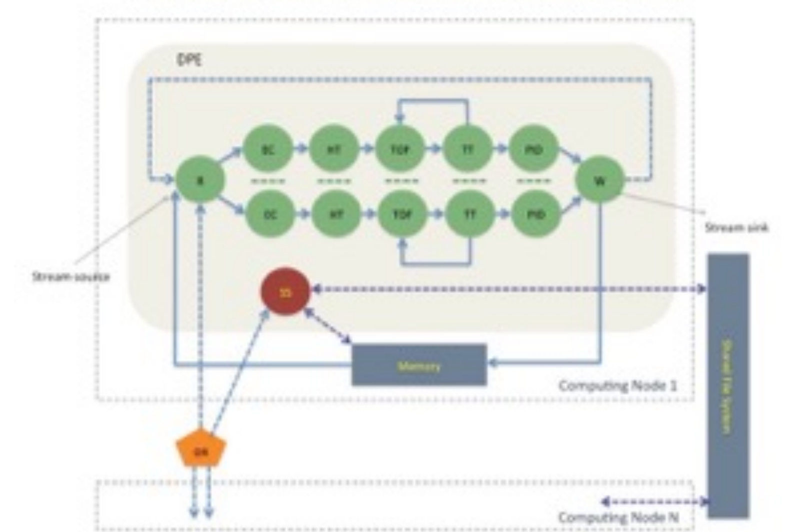


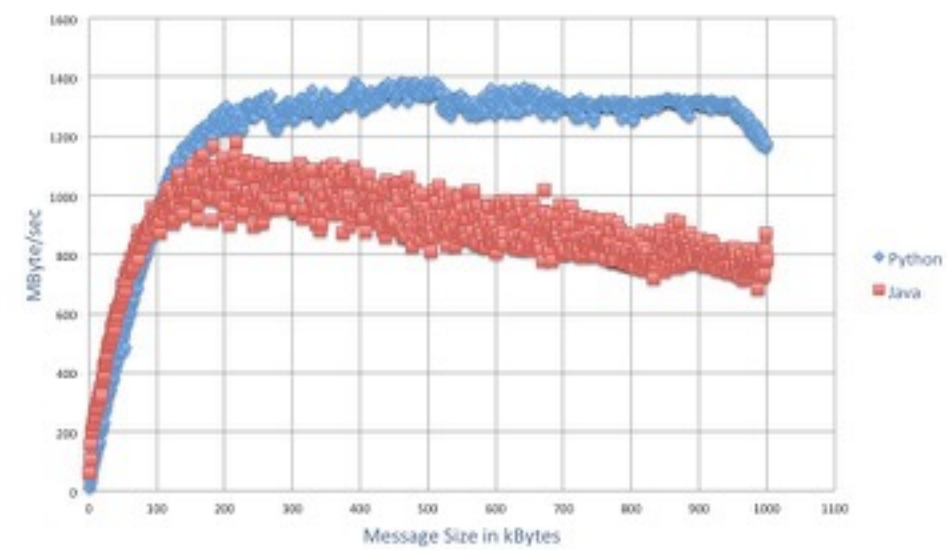




Reconstruction CLARA 4.3

Clas12 Reconstruction Application



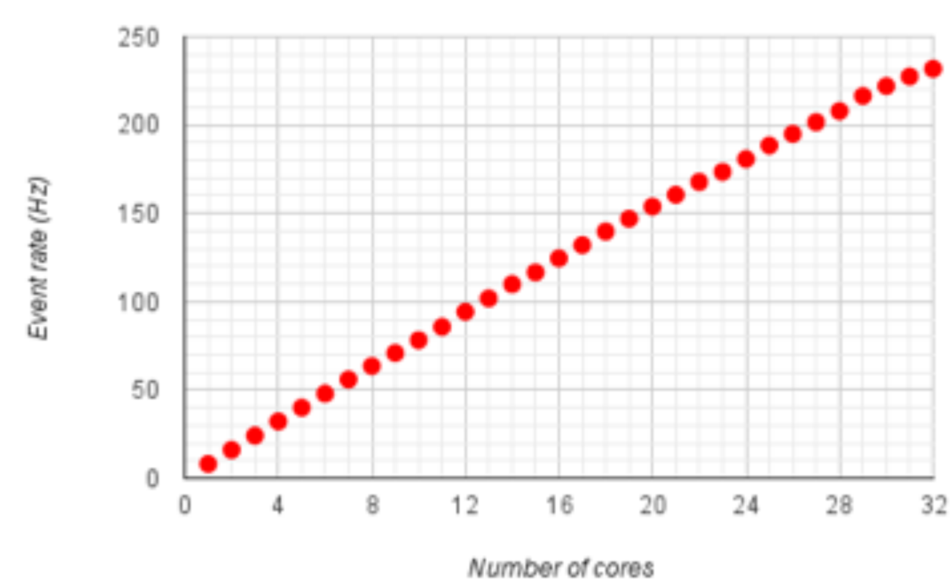


- ✓ **xMsg CLARA service bug**
  - general purpose public subscribe MPI
  - utilizes zeroMQ socket libraries
  - Sockets that carry messages across various transports
    - In-process
    - Inter-process
    - TCP
    - Multicast
  - Sockets can be connected N-to-N with patterns
    - Fan-out
    - Pub-sub
    - Task distribution
    - Request-reply
  - Java, C++, Python bindings

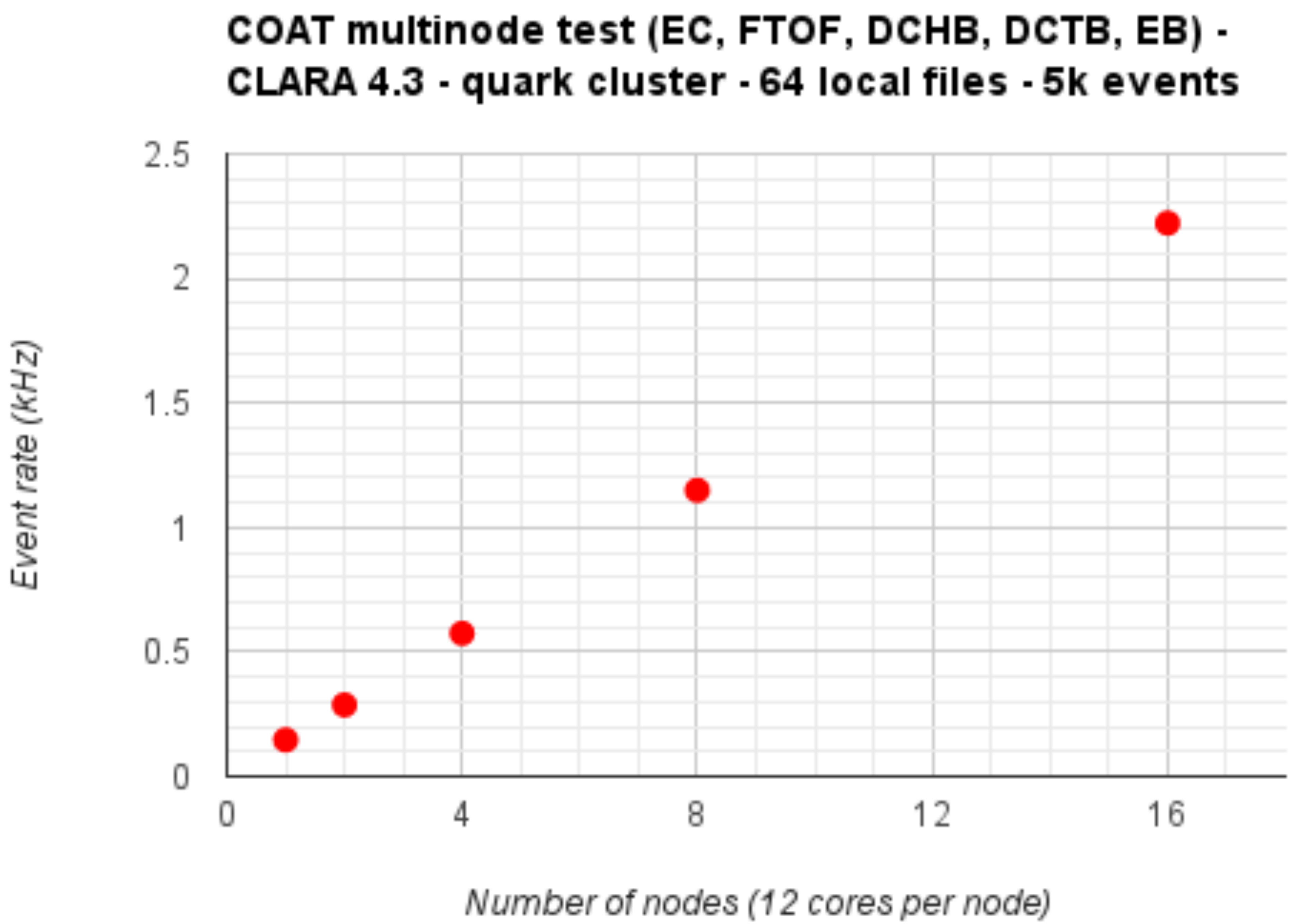
- ✓ **Reconstruction Framework**
  - reconstruction framework reads GEMC generation parameters.
  - modular, runs as separate services.

- ✓ **CLARA 4.3**
  - CLARA switched from using cMsg to xMsg (version 4)
  - easy transfer from 2.2 interface to 4.3
  - tests run on CLARADM machine show 250 Hz event reconstruction

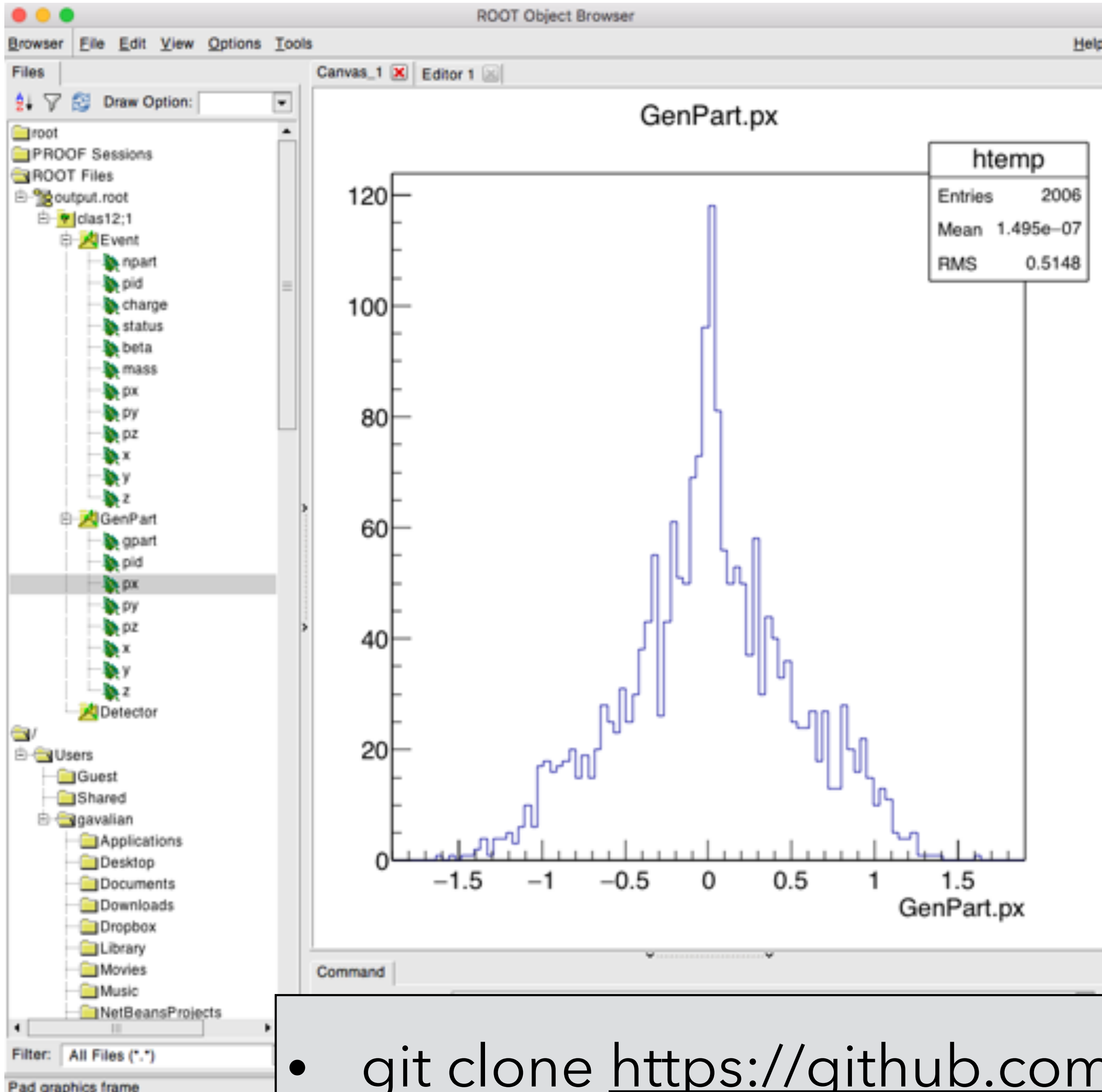
COAT scaling test (EC, FTOF, DCHB, DCTB, EB) - CLARA 4.3 - claradm - ramdisk - 20k events



S. Mancilla


COAT multinode test (EC, FTOF, DCHB, DCTB, EB) -
CLARA 4.3 - quark cluster - 64 local files - 5k events
Event rate (kHz)
2.5
2
1.5
1
0.5
0
0
4
8
12
16
Number of nodes (12 cores per node)

ROOT (migration to comfort zone)



- output to ROOT tree
- flat NT10 structures
- includes generated particles
- reconstructed particles
- combined detector responses

- git clone https://github.com/gavalian/evioRoot
- cd evioRoot
- scons
- ./bin/evio2root   badfile.evio   goodfile.root

SEB

*****>>>>> BANK EVENTHB::particle >>>> SIZE = 12

status	(int) :	100	100	100	300
charge	(int) :	1	-1	1	0
pid	(int) :	0	0	0	22
chi2pid	(float) :	0.00000	0.00000	0.00000	0.00000
mass	(float) :	0.00000	1.02744	-0.04474	0.00000
beta	(float) :	0.00000	0.99369	1.11434	0.00000
px	(float) :	-0.18433	-3.37997	-0.04721	0.05070
py	(float) :	0.43621	-0.95739	0.08271	0.40868
pz	(float) :	1.35398	8.26402	0.46983	0.81477
vx	(float) :	-1.68993	-0.01706	89.54659	0.00000
vy	(float) :	-9.39006	-0.01128	-229.40326	0.00000
vz	(float) :	4.18556	-0.00932	-113.52102	0.00000

Particle Index

EC

FTOF

*****>>>>> BANK EVENTHB::detector >>>> SIZE = 15

pindex	(int) :	3	3	3	1	-1	1	2
index	(int) :	0	1	2	3	9	10	11
detector	(int) :	16	16	16	16	17	17	17
sector	(int) :	2	2	2	4	2	4	6
superlayer	(int) :	0	0	0	0	0	0	0
layer	(int) :	1	4	7	1	2	2	2
X	(float) :	39.47684	37.39711	38.86332	-248.39410	38.15368	-239.08804	89.78727
Y	(float) :	318.21198	332.02527	344.10800	-88.25842	298.47241	-82.55210	-268.66174
Z	(float) :	634.41272	645.85968	661.12976	656.29370	607.72925	625.66974	607.72925
hX	(float) :	39.47684	0.00000	0.00000	-249.49568	0.00000	-239.30841	88.61828
hY	(float) :	318.21198	0.00000	0.00000	-88.72266	0.00000	-83.83494	-269.44305
hZ	(float) :	634.41272	0.00000	0.00000	655.82739	0.00000	625.41614	607.55542
path	(float) :	710.84229	0.00000	0.00000	707.38593	0.00000	674.96979	748.87653
time	(float) :	0.00000	0.00000	0.00000	26150.00000	28.11775	22.64188	22.40115
energy	(float) :	0.04108	0.03902	0.16640	0.91186	16.06812	11.30349	9.94297

Live Demo

Summary

- **Calibration:**
  - Unified framework for calibration seems to work for everyone.
  - All detector systems are using unified tools (visualization and analysis).
  - More work has to be done to unify data analysis
- **Data Formats and preservation.**
  - Transition to reading translation tables from DB is underway.
  - ADC pulse parameters are being read from database.
  - Raw bank decoders implemented for all detectors.
  - Transitional data structures are implemented (HIPO) for data compression.
  - Work is being done to optimize bank structures to save space.
- **Reconstruction:**
  - Reconstruction release 2.4 is ready to use.
  - Includes all detectors (Forward, Central and FTCAL)
  - CLARA Sand-Box available for CLAS12 reconstruction
- **Future Developments:**
  - Conversion from EVIO to ROOT for final reconstruction files.

Analysis Software Framework