CLAS12 Event Reconstruction

Veronique Ziegler

CLAS12 Collaboration Meeting

06/14/2017

GEMC Updates

M. Ungaro

• problem in geant4 inclusive electroproduction. Investigating, may report to developers.

• new geometries / digitization for:

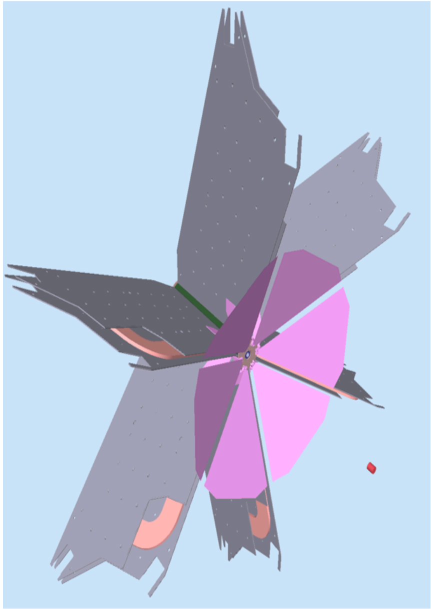
- dc
- micromegas
- rich
- beam line
- torus

• cad import mechanism working very well

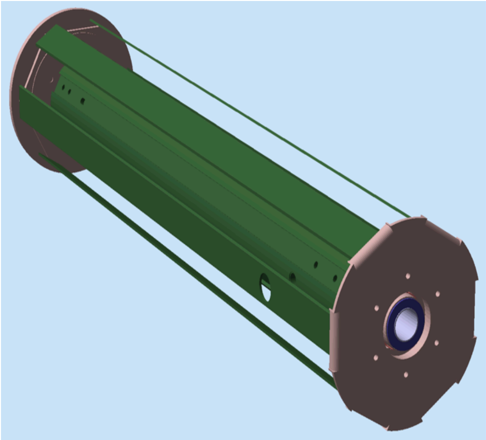
• gemc 3.0 will:

- take advantage of geant4 event multithreading
- have better memory management
- be optimized
- ready for new geant4 goodies

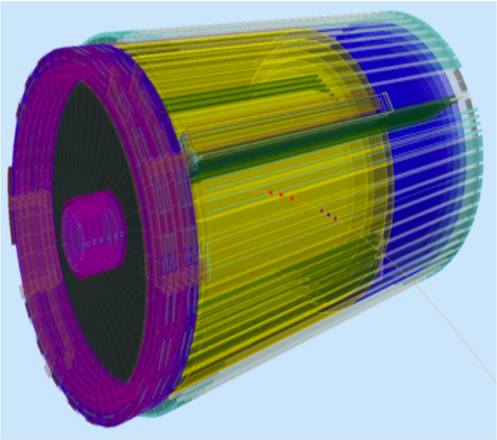
Torus and DC mounts from CAD



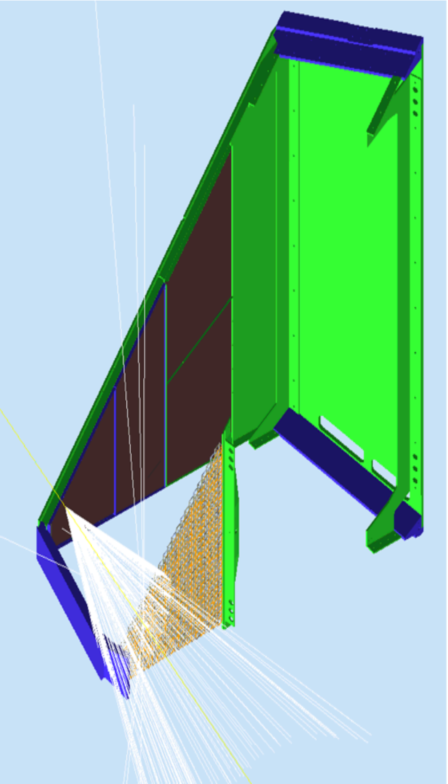
Torus hub from CAD



New Micromegas and digitization



RICH is a combination of CAD and native geant4 volumes



Reconstruction Services

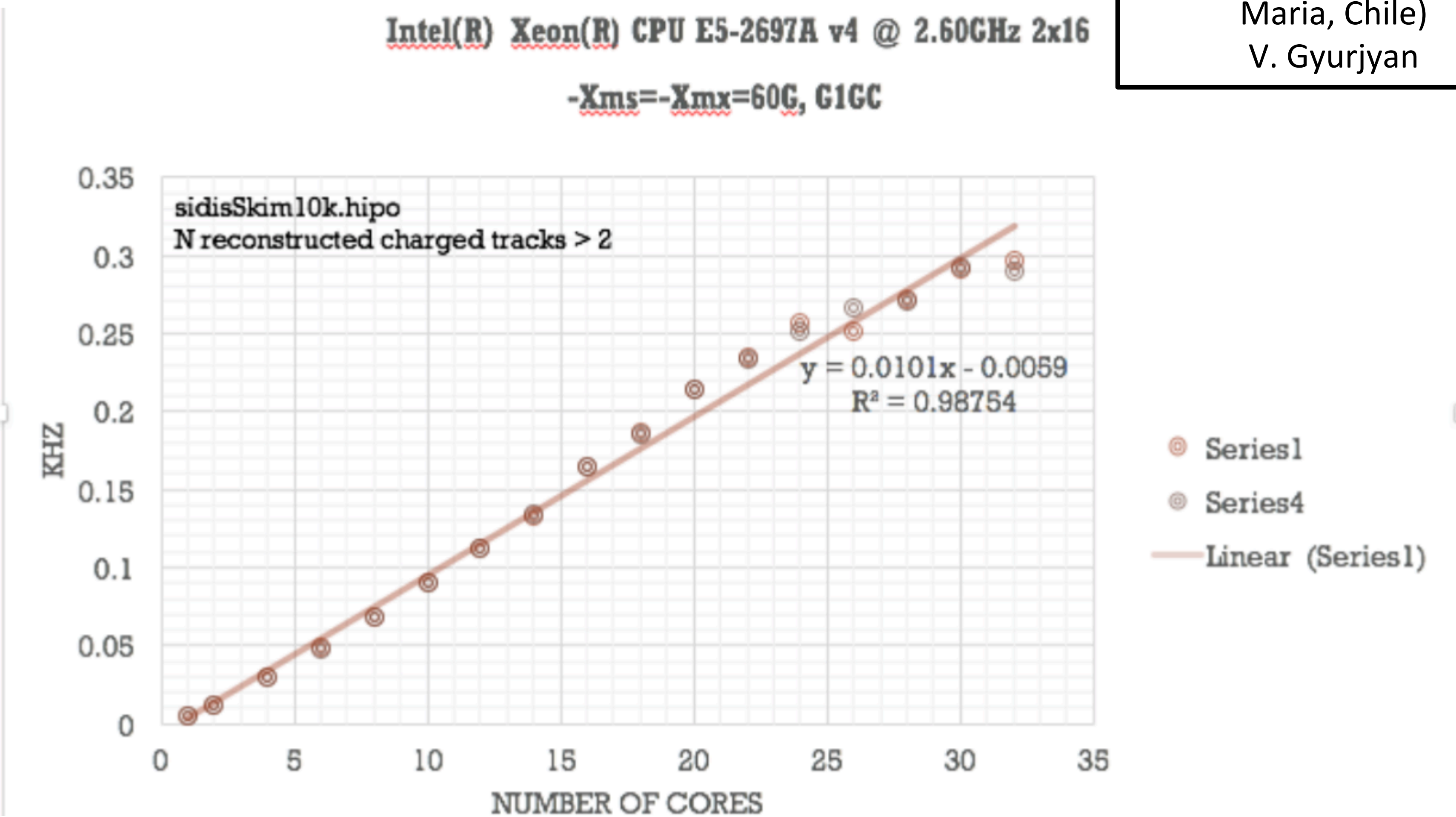
First Experiment
Workshop
G. Gavalian

- Significant improvements to the code were done (mainly tracking) to improve reconstruction performance.
- Reconstruction was tested on new Haswell nodes with 2 track event sample and 300 Hz reconstruction rate was achieved.
- Scaling curve shows that all services work well (without thread contention)
- Further work is needed to improve performance (500 Hz possibly)

- Pulse bit packing algorithm was developed to reduce event size while writing full FADC pulses. Significant reduction in size up to 7 times.
- Possible to take data in RAW pulse mode (at least some times).
- Partial waveform bit packing will increase by ~25% (over mode 7)

CLARA Scaling Tests

S. Mancilla (Universidad Tecnica Federico Santa Maria, Chile)
V. Gyurjyan



DC Software Development

DC Readiness for First Experiment
M. Mestayer

- **Monitoring** (Olga Cortes, Michael Kunkel, Latiful Kabir)
  - Standard plots, exploratory package (ntuple)
- **Calibration** (Krishna Adhikari, MK, LK)
  - Fit time as function of (doca, beta, B, local angle)
    - Write calibration constants to CCDB
    - **Same function** used for **reconstruction** and **simulation**
- **Simulation**
  - Distance to time (KA, Daniel Lersch)
    - non-linear function, time walk correction, random walk smearing
  - Efficiency (DL, Michael Kunkel)
    - intrinsic inefficiency, background inefficiency, malfunction-related inefficiency
- **Corrections** (No one yet!)
  - Time-of-flight, signal propagation, alignment, wire sag, endplate bowing
- **Torus Mapping** (Joseph Newton)
  - Compare sector to sector, measurement to model
  - Fit to individual misplacement, distortion

DC simulation: distance → time; time smearing; efficiency

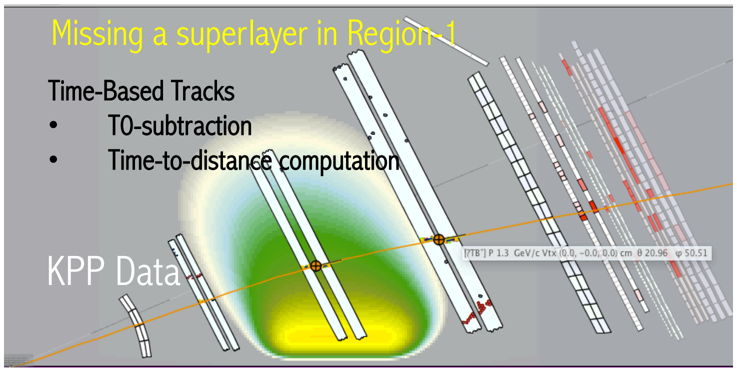
DC Readiness for First Experiment
M. Mestayer

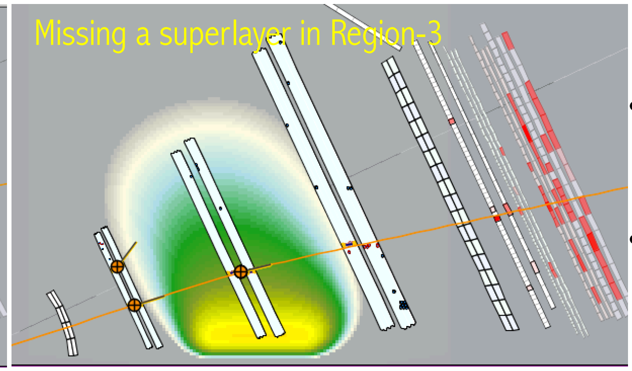
- Simulate distance → time (including smearing)
  - non-linear distance to time function (SAME as for calibration)
  - time-walk (beta-dependent) time smearing
  - random walk smearing

- Simulate wire-hit efficiency
  - intrinsic efficiency (distance dependent)
  - malfunction related (run dependent)
    - malfunction table in MySQL (date, wire-list, statchange)
    - translation table (equipment → wire)
    - → run-dependent wire status table in CCDB
  - background related
    - on-track (handled by GEMC)
    - out of time (need to merge events)

DC Tracking Status

5-Out-Of-6 superlayers tracking

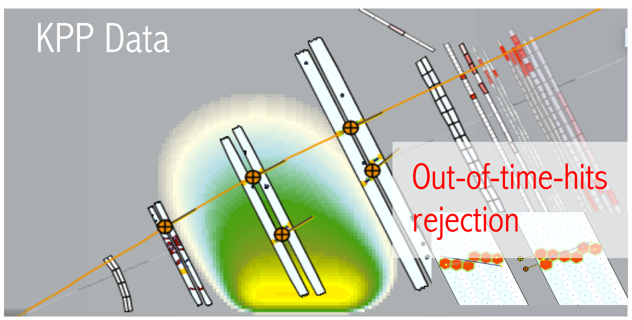


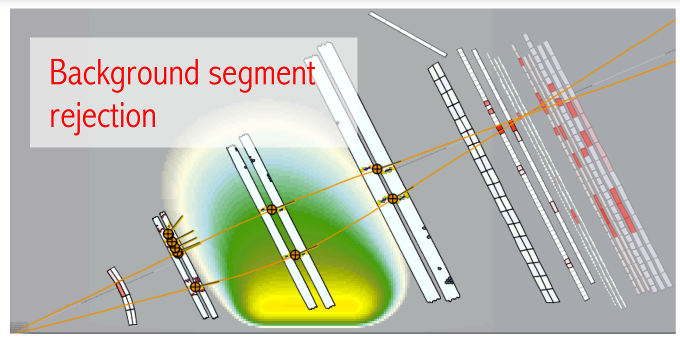


<u>MC Studies</u>

- Loosing a superlayer has a minimal effect on tracking resolutions
- Inefficiencies due to missing SL: 5% for SL1, 10% for SL2, less than 3% for all other SLs

Noise rejection algorithms validation on KPP data

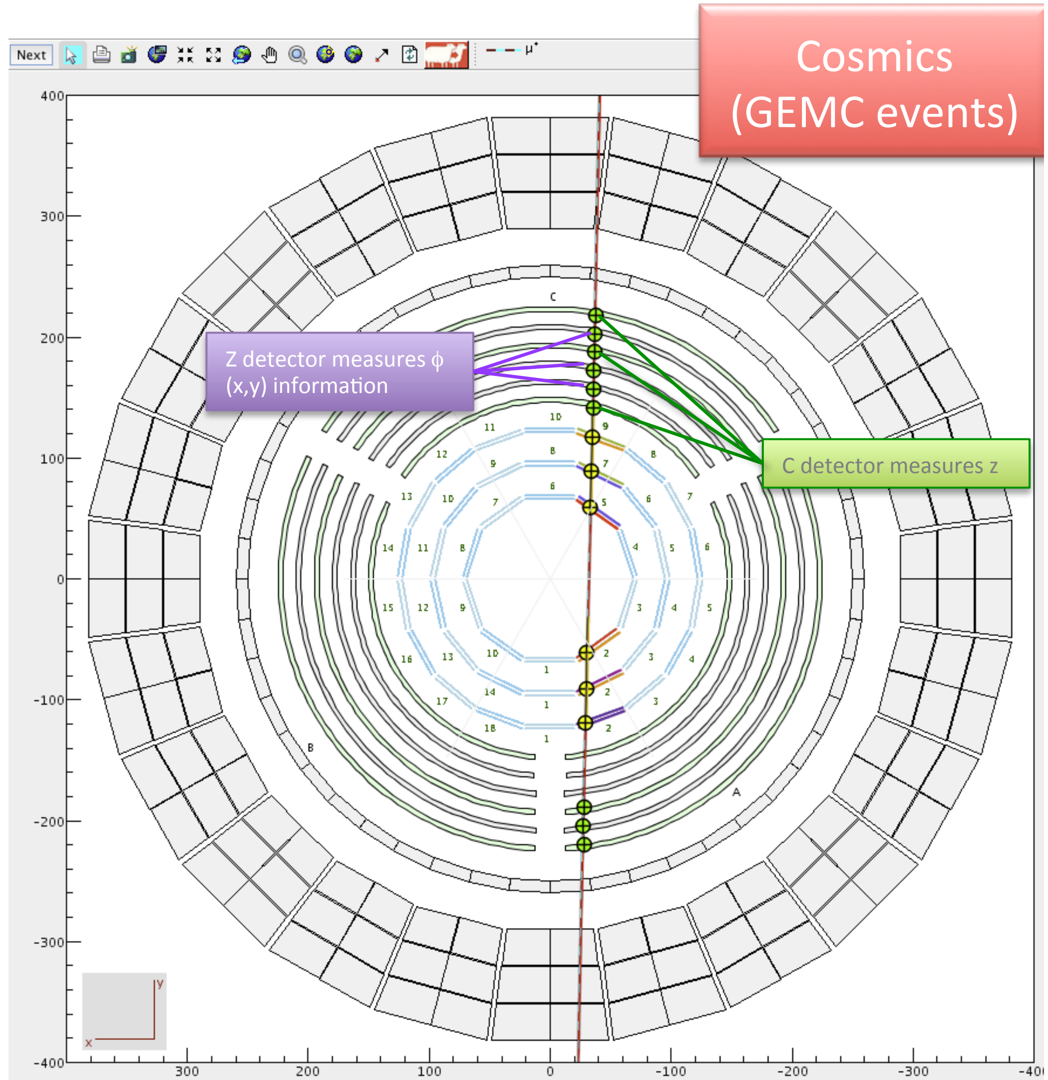




* FMT in simulation (Maxime) → after geometry validation use FMT points to refit the track

Barrel Micromegas Tracker (BMT) Pattern Recognition

1. Pattern recognition in BMT
   1. Reconstruct clusters of strip (todo: energy-weighted centroid)
   2. Obtain pseudo crosses
      1. Z detectors P=(x,y), C detector P=(r,z)
2. Store information in fit arrays:
   1. extract helix parameters (2-step fit: 1. x,y projection fit to extract $\mathbf{d}_0$, ϕ_0, ρ; 2. r,z projection fit to extract $\mathbf{z}_0$, $\tan\lambda$)
   2. HT to select straight track candidate (use XY projection, check coincidence in r.z projection)

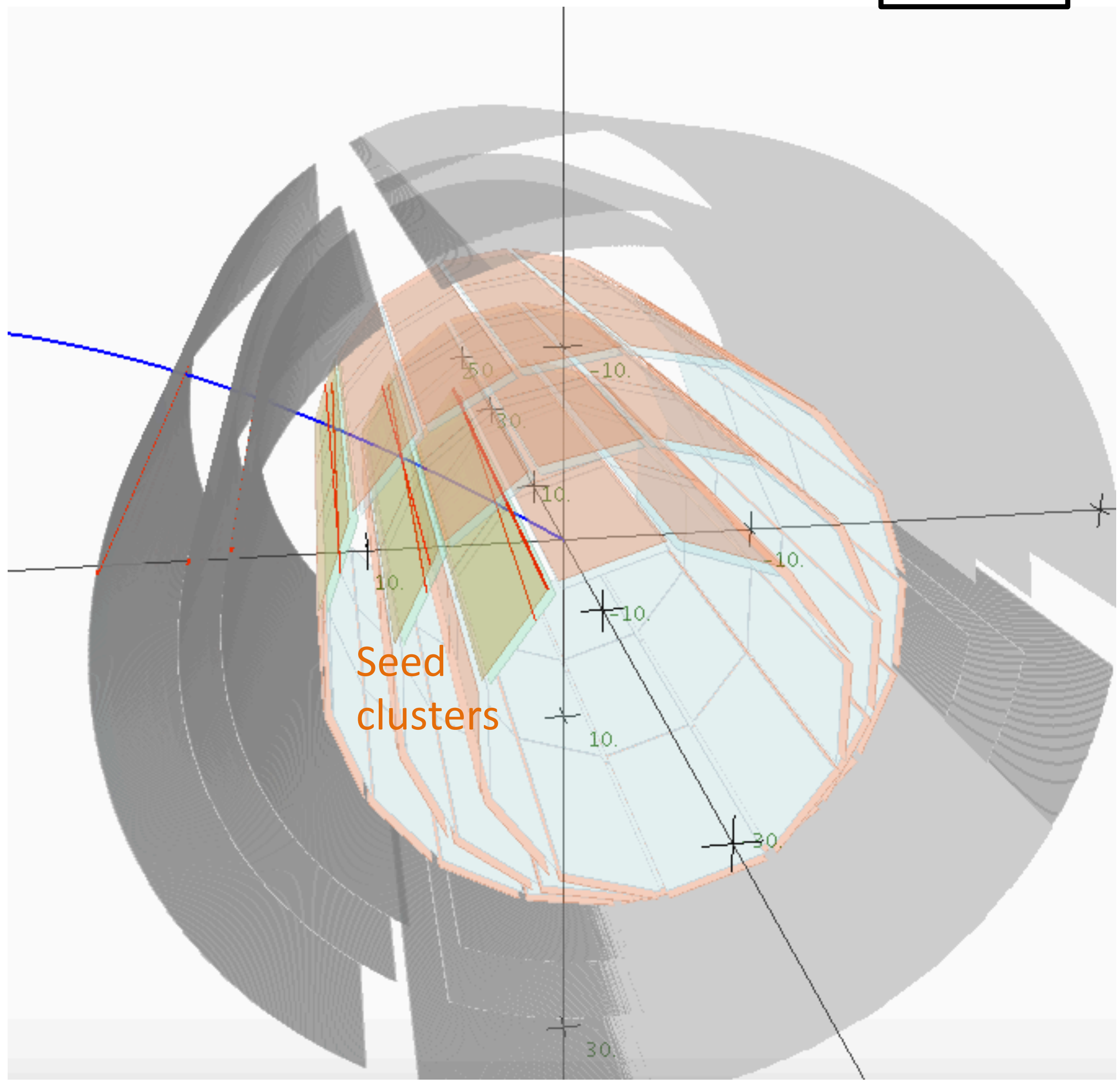


CVT (SVT+BMT) Reconstruction Algorithms

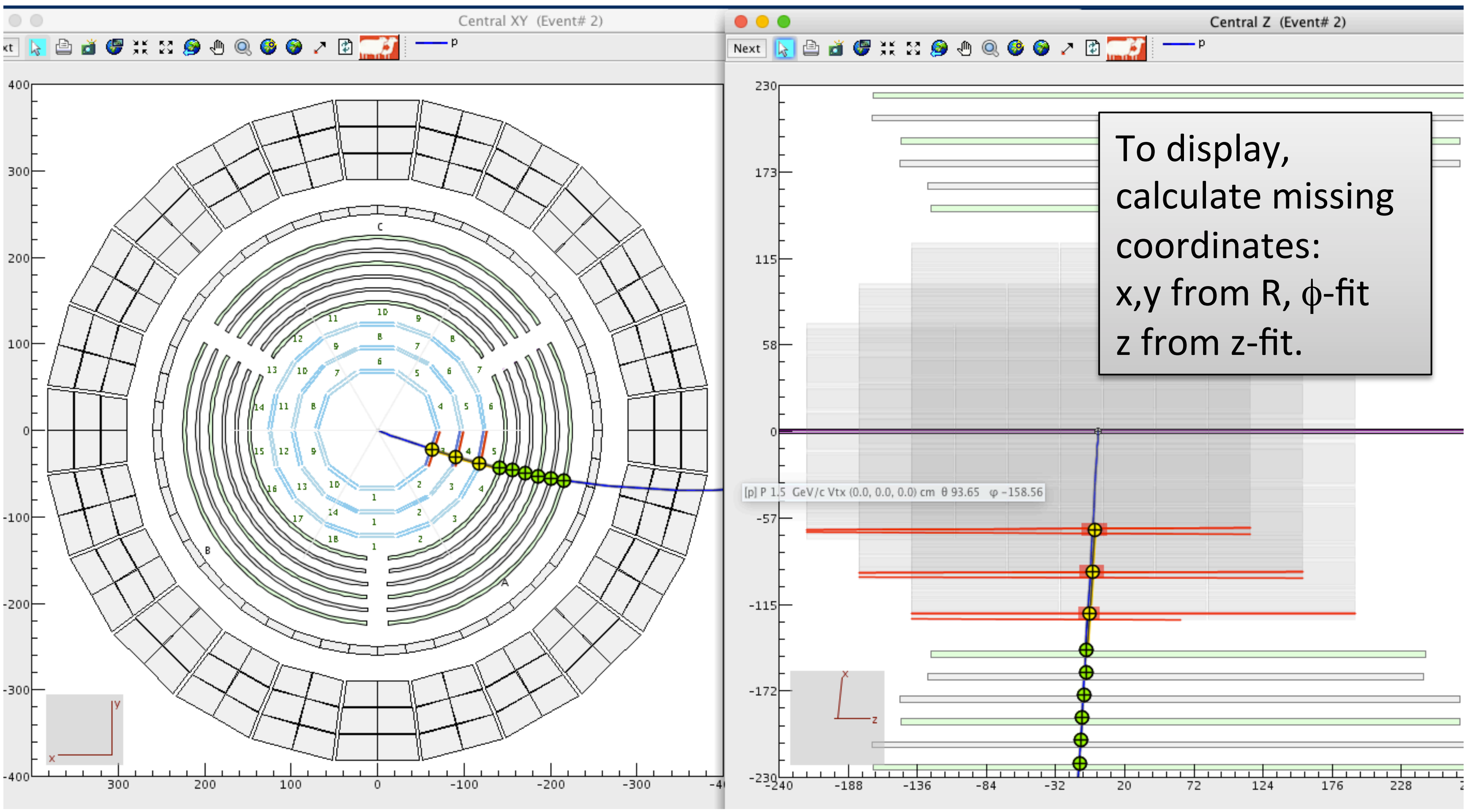
1. Use SVT as a track seeder
    1. Reconstruct clusters of strip and compute energy-weighted centroid
    2. Obtain position of these centroid wrt lab frame
    3. Fit cluster endpoints (upstream side) XY projection to a circle after HT-type selection to select clusters belonging to a track candidate.
    4. Find crosses and refit to match to BMT crosses
    5. Refit using all SVT and BMT crosses

- This is the track ***seed***, it contains SVT clusters + BMT pseudo-crosses

ced 3-D



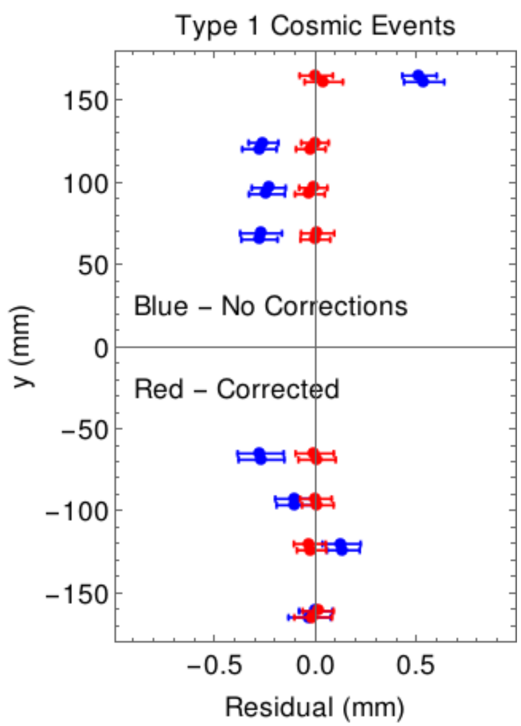
Validation using single track events simulated within acceptance for Central Tracks

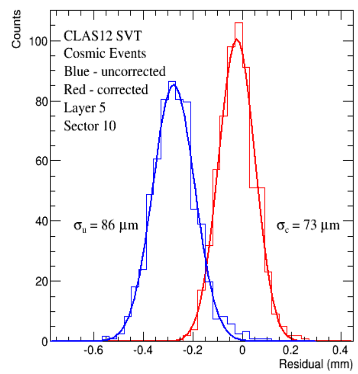


Alignment of the SVT using Millepede

J. Gilfoyle

Reconstruction of cosmic events with millepede misalignments incorporated

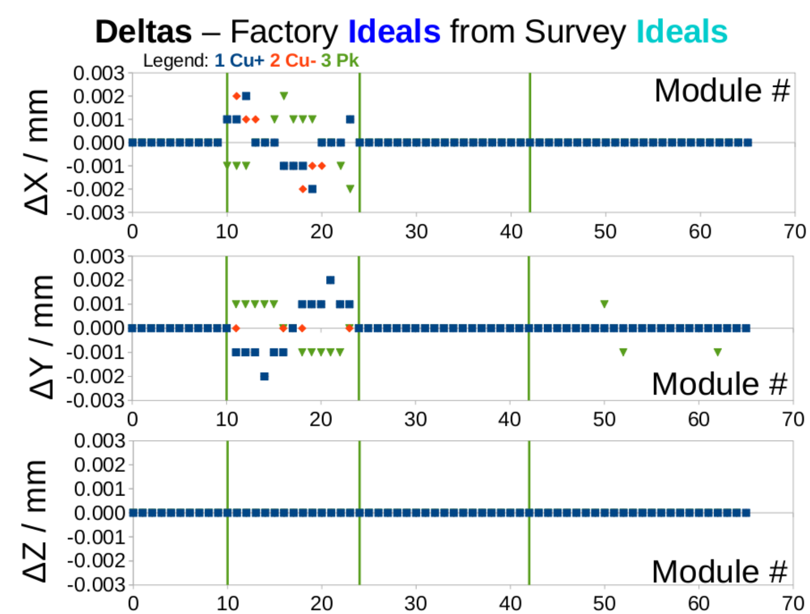




Fit residual and resolution improve

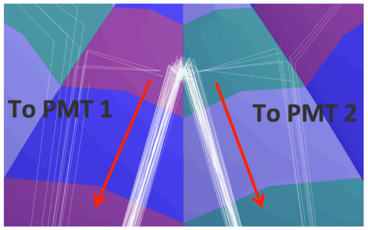
Validations

- Ideal Geometry Validation and Testing.
  - Corrected differences between engineering drawings and ideal geometry – 100 μm down to 3 μm.
  - Developing API for reconstruction – completed one for gemc.
  - **Platt (Surrey masters), Johnston (ANL postdoc).**

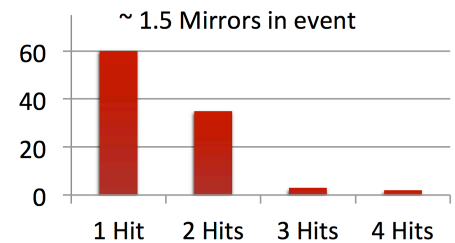


HTCC Reconstruction

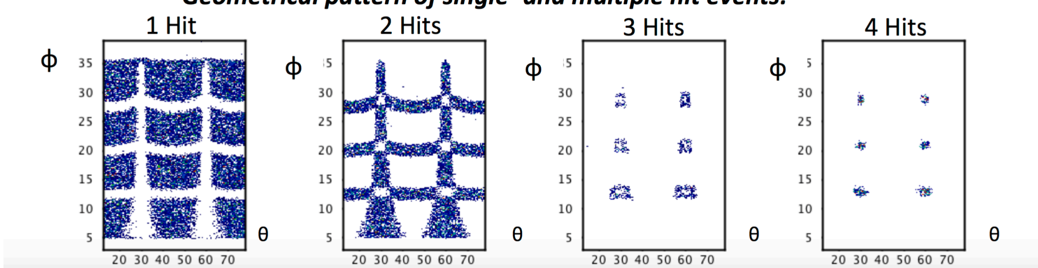
N. Markov [U. Conn]

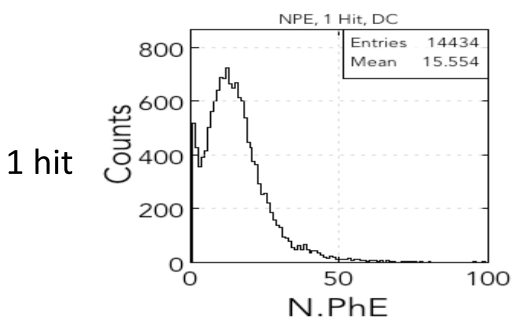


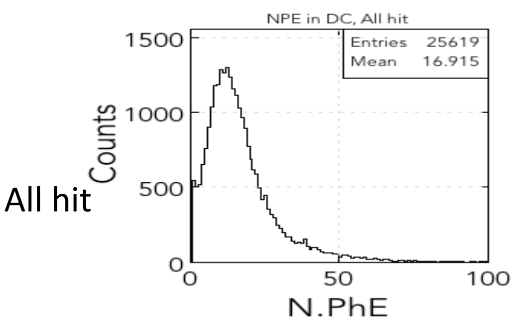
Cerenkov radiation from single electron may split between mirrors and is collected by different PMTs



Geometrical pattern of single- and multiple hit events:







Increase in average number of Nphe; spike at very low Nphe is significantly reduced.

- Cluster reconstruction

performed and events with 1, 2, 3, or 4 hits are properly reconstructed

- Large statistics, access to spectrum of all 48 PMTs.

- Calibration and PMT tests in the Hall and TEDF are under way.

- Time correction

Uses LED data to eliminate time shifts between different PMTs

- PCAL Fiducial cuts

Uses Cerenkov light geometry to cut out innermost region of the HTCC where part of the Cerenkov radiation is lost to the center hole

TOF reconstruction

TOF reconstruction code determines:

- hit times (t_L, t_R, <t>)

$$t_{L,R} = (\mathcal{C}_{TDC} \cdot TDC_{L,R}) - t^{walk}_{L,R} \pm \frac{C_{L,R}}{2} + \mathcal{C}_{p2p}$$

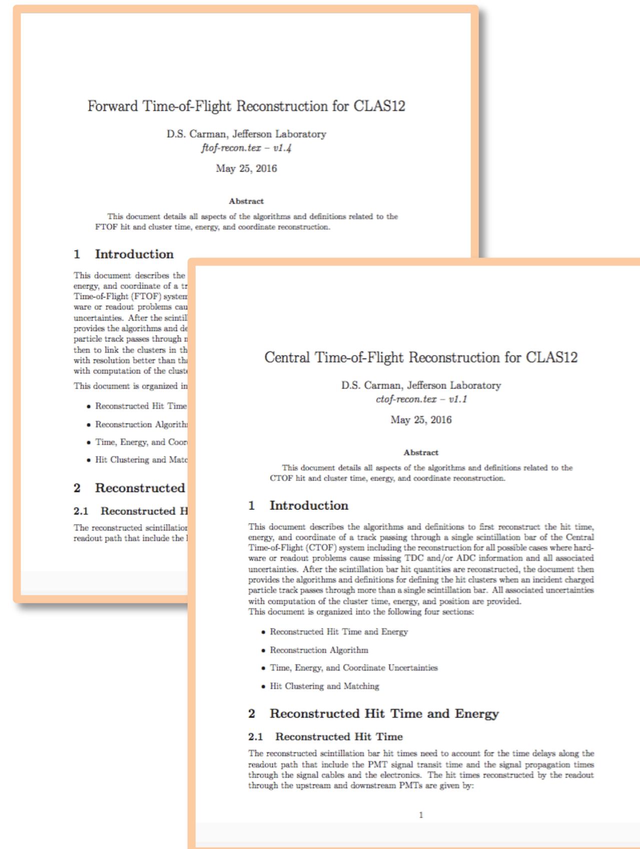
- hit coordinates (x)

$$x = \frac{v_{eff}}{2}(t_L - t_R)$$

- deposited energies (E_L, E_R, <E_{dep}>)

$$E_{L,R} = (ADC_{L,R} - PED_{L,R}) \left[\frac{(\frac{dE}{dx})_{MIP} \cdot t}{ADC_{MIP}} \right]$$

- associated time, coordinate, and energy uncertainties
- performs hit clustering and matching
- combines hit times from panel-1a and panel-1b



Forward Time-of-Flight Reconstruction for CLAS12

D.S. Carman, Jefferson Laboratory
ftof-recon.tex – v1.4

May 25, 2016

Abstract

This document details all aspects of the algorithms and definitions related to the FTOF hit and cluster time, energy, and coordinate reconstruction.

1 Introduction

This document describes the ...

Central Time-of-Flight Reconstruction for CLAS12

D.S. Carman, Jefferson Laboratory
ctof-recon.tex – v1.1

May 25, 2016

Abstract

This document details all aspects of the algorithms and definitions related to the CTOF hit and cluster time, energy, and coordinate reconstruction.

1 Introduction

This document describes the algorithms and definitions to first reconstruct the hit time, energy, and coordinate of a track passing through a single scintillation bar of the Central Time-of-Flight (CTOF) system including the reconstruction for all possible cases where hardware or readout problems cause missing TDC and/or ADC information and all associated uncertainties. After the scintillation bar hit quantities are reconstructed, the document then provides the algorithms and definitions for defining the hit clusters when an incident charged particle track passes through more than a single scintillation bar. All associated uncertainties with computation of the cluster time, energy, and position are provided.
This document is organized into the following four sections:

- Reconstructed Hit Time and Energy
- Reconstruction Algorithm
- Time, Energy, and Coordinate Uncertainties
- Hit Clustering and Matching

2 Reconstructed Hit Time and Energy

2.1 Reconstructed Hit Time

The reconstructed scintillation bar hit times need to account for the time delays along the readout path that include the PMT signal transit time and the signal propagation times through the signal cables and the electronics. The hit times reconstructed by the readout through the upstream and downstream PMTs are given by:

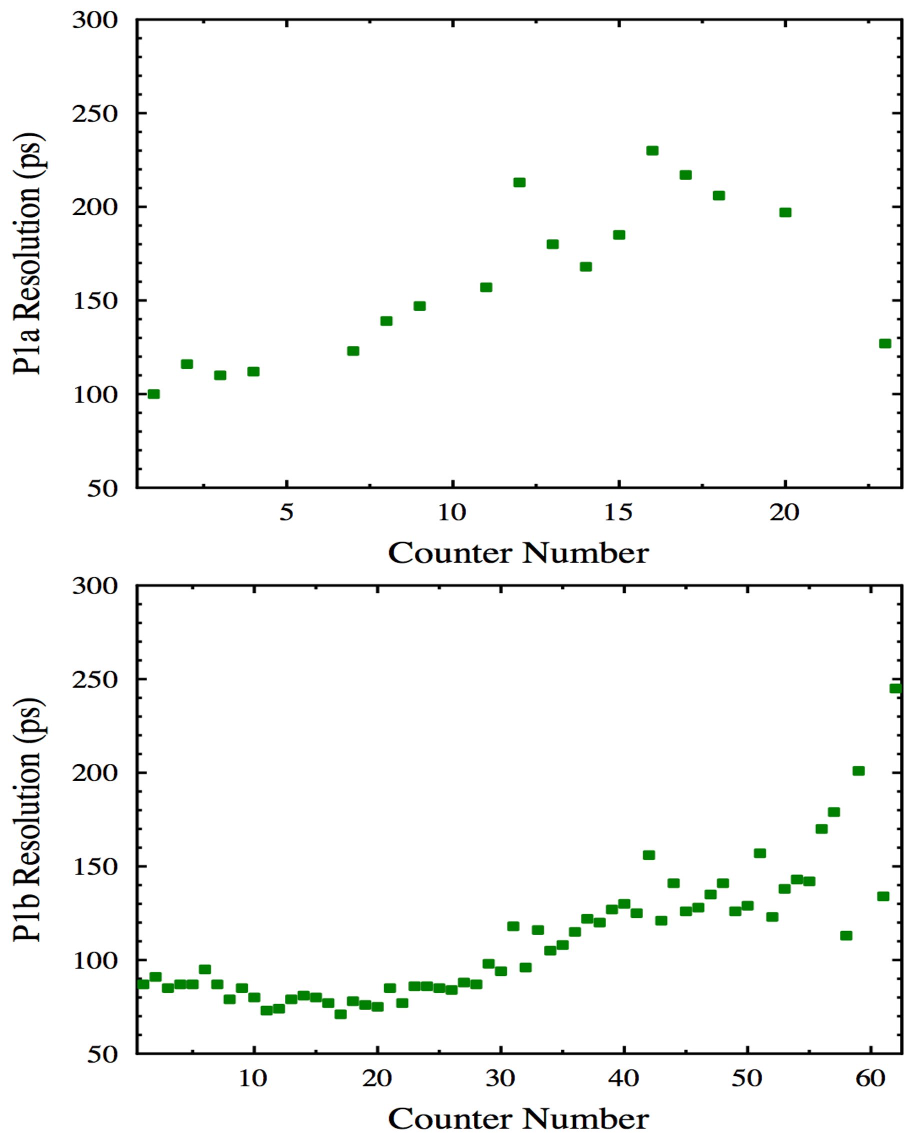
1

- Code designed to function for all “allowable” hardware conditions

- Most of the code validated in detail; work remains on combining hit times

FTOF Timing Resolutions

D. Carman



- Counter timing resolutions still higher than values determined from cosmic ray bench tests:
  - *P1a: 80 – 150 ps*
  - *P1b: 30 – 80 ps*
- However, timing resolutions are still limited by:
  - *TW corrections*
    - *Position-dependent TW*
  - *TDC calibrations*
  - *TDC non-linearities*
  - *Non-optimized tracking*
  - *Geometry offsets*

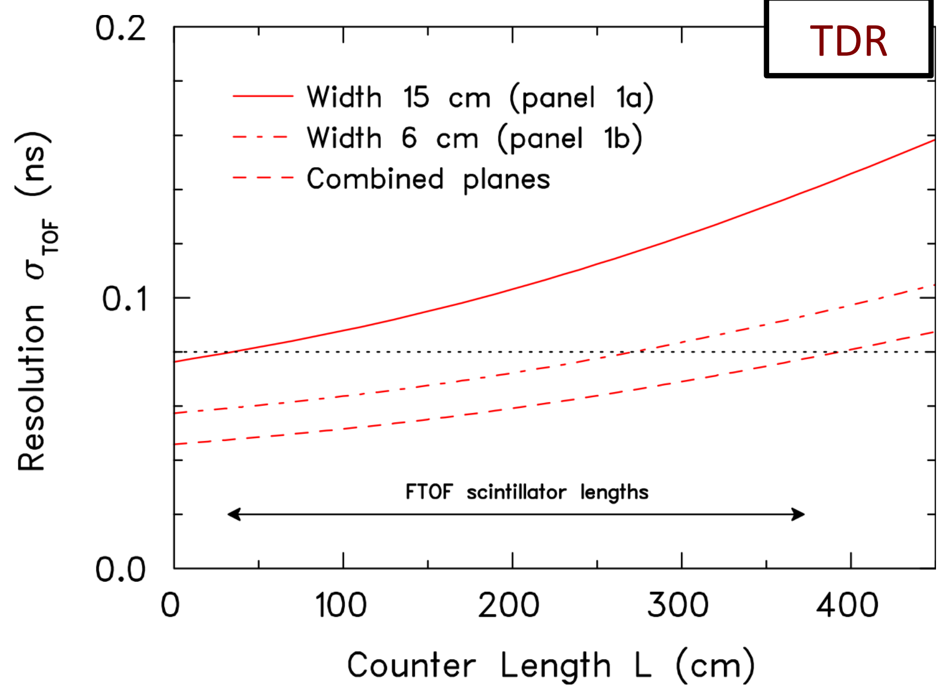
Optimizing System Time FTOF Resolution

Combine the measured times from the FTOF panel-1a and panel-1b to optimize the resolution

$$t_{corr} = \frac{\dfrac{t_{1b}^{cluster}}{\delta_{1b}} + \dfrac{(t_{1a}^{cluster} - \Delta r/\beta)}{\delta_{1a}}}{\left(\dfrac{1}{\delta_{1b}} + \dfrac{1}{\delta_{1a}}\right)}$$

D. Carman

TDR



Algorithms for cluster > 1:

- *use hit with t_{min}*
- *use hit with E_{max}*
- *use weighted average*

Evgeny Golovach

GEMC Studies with cluster = 1

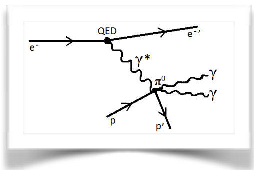
(20% gain)	e	p	π^+	π^-
FTOF 1A	152 ps	164 ps	160 ps	151 ps
FTOF 1B	62 ps	67 ps	65 ps	61 ps
FTOF 1A+1B	49 ps	54 ps	54 ps	51 ps

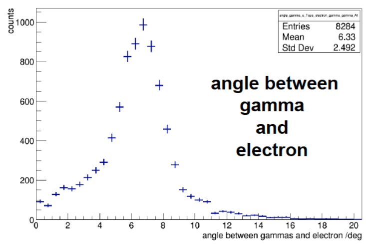
FT Reconstruction Status

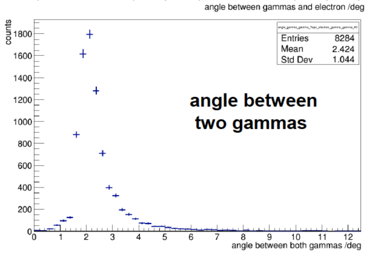
M. Battaglieri
INFN, Genoa

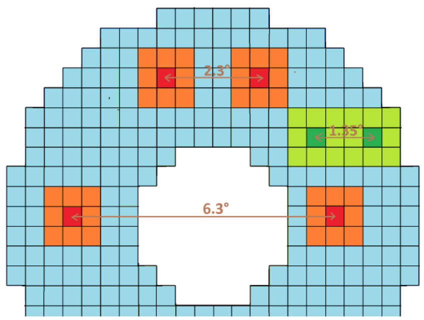
e p → e' p π0 (γ p → p π^0)

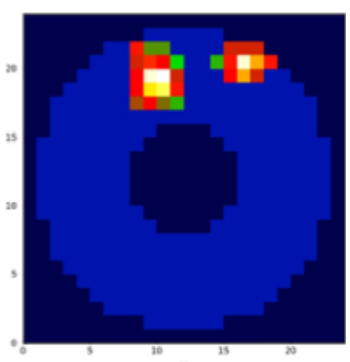
- **S.Diehl (U Giessen)**
- Full CLAS12 (+FT) GEANT4 sim/rec
- JPAC e-production amplitudes (V.Mathieu)
- AMPTOOLS

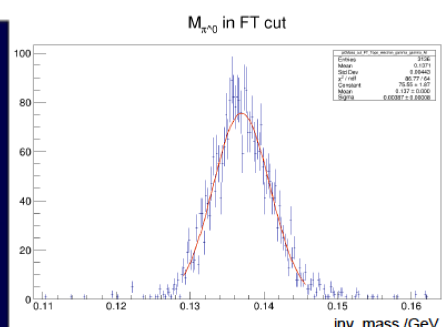












137 MeV/c² reconstrcuted (lit.: 134,98 MeV/c²)

Resolution: 3.9 MeV/c²

FT-Cal:
- Read raw hits from hipo bank
- Read calibration constants from DB
- Create hits, converting from digitized info to E and T
- Reconstruct cluster and determine cluster E, T and pos

FT-Hodo:
- Read raw hit from evio bank
- Read calibration constants from DB
- Create hits, converting from digit info to E &T
- Match hits in the hodoscope layers

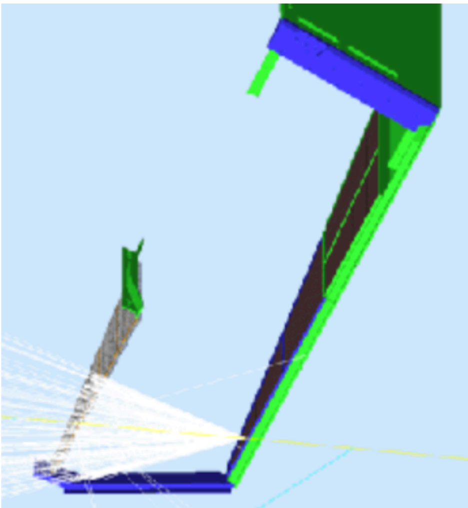
FT-Track:
- started based on algorithm developed by G. Charles

FT-Match:
- Match reconstructed clusters with hits in hodoscope
- Output of final reconstructed particles

Code available in present COATJAVA distribution
FT Trigger simulation (S.Diehl at the HSWG meeting on Thur)

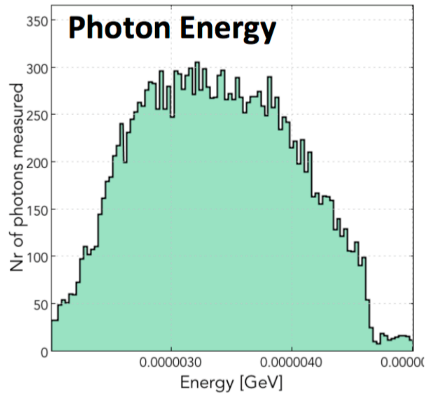
RICH Simulation and Reconstruction

M. Contalbrigo
INFN, Ferrera

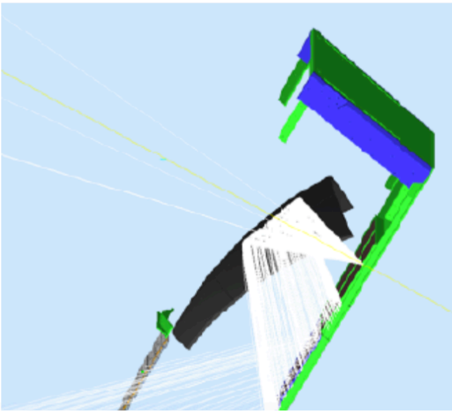


- a detailed, consistent and updated description of the detector can be obtained
- simulation and reconstruction shared the same database

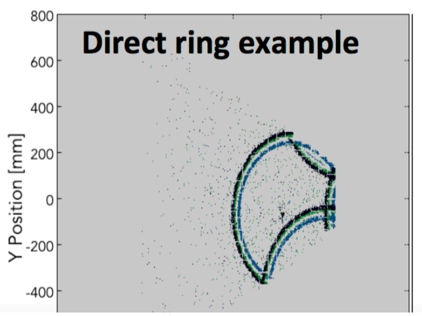
Possible conflicts with optical photon tracking not yet solved
(mother volume, spherical mirror)



Digitization of the MAPMT response:
- calculate the pixel ID
- interface to CCDB
- apply efficiency
- simulated ADC and TDC spectra



Event reconstruction started
- match with DC information in coat-java
- photon tracing algorithm
  (tested with prototype and cosmic runs)
- event display



Strong crew: Matteo, Ilaria, Marco, Giovanni,

Event Builder Status

J. Newton (ODU), R. DeVita (INFN), N. Baltzell

- Geometrical matching between HTCC hits and DC tracks
- Particle Identification
- CCDB parameters access
- New Output Banks
  - REC::Cherenkov = All Cherenkov Hits and their positions and number of photoelectrons
  - REC::Tracks = All Tracks Found at Hit-Based and Time-Based levels
  - REC::Event = Contains event-by-event information such as the event start time
  - matching of CVT tracks and CTOFhits
  - FT particles added to REC::Particles

Event Builder

First Experiment Workshop
J. Newton

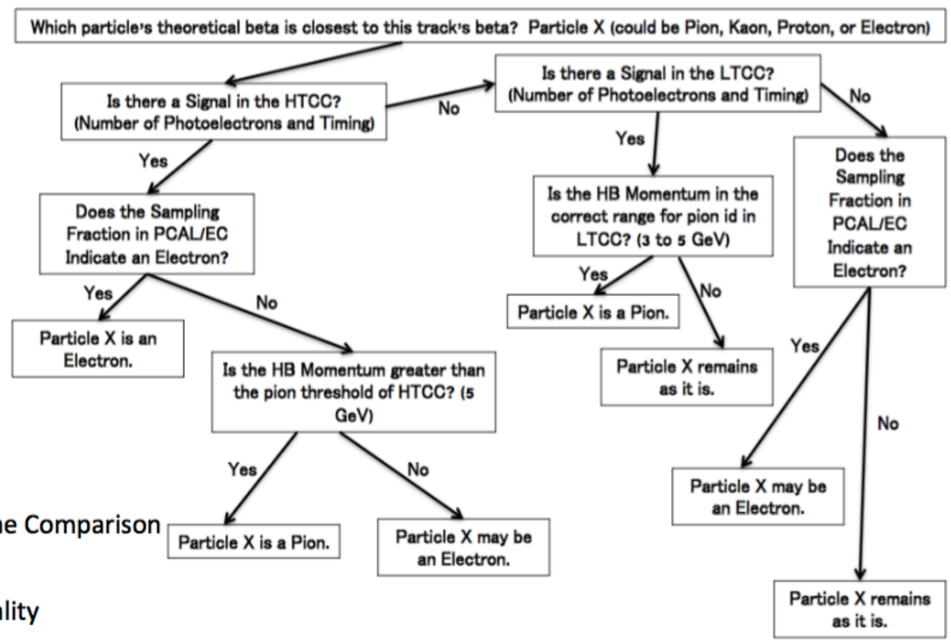
Event Builder Particle Identification

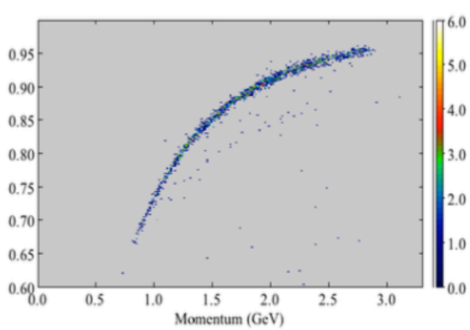
- After time-based tracking, particle identification for non-electrons will be primarily based on a comparison between the particle's projected vertex time and the event start time.
- The quality of the particle id will be based off of the time-of-flight detector's resolution

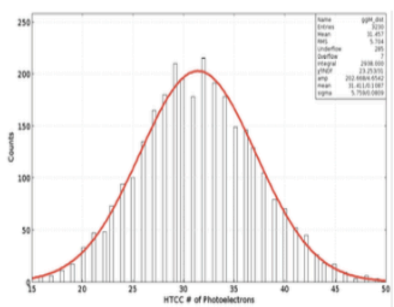
$$\Delta t_i = t_0 - \left[t_{FTOF,i} - \frac{R_{FTOF_i}}{\beta_i}\right]$$ ← Vertex Time Comparison

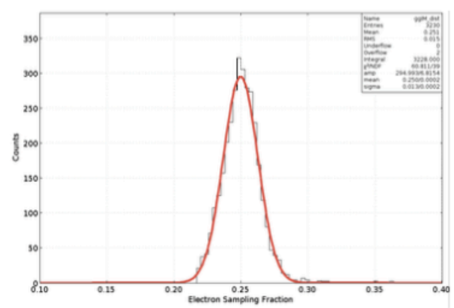
$$\chi^2 = \left(\frac{\Delta t_i - 0}{\sigma_i}\right)^2$$ ← PID Quality

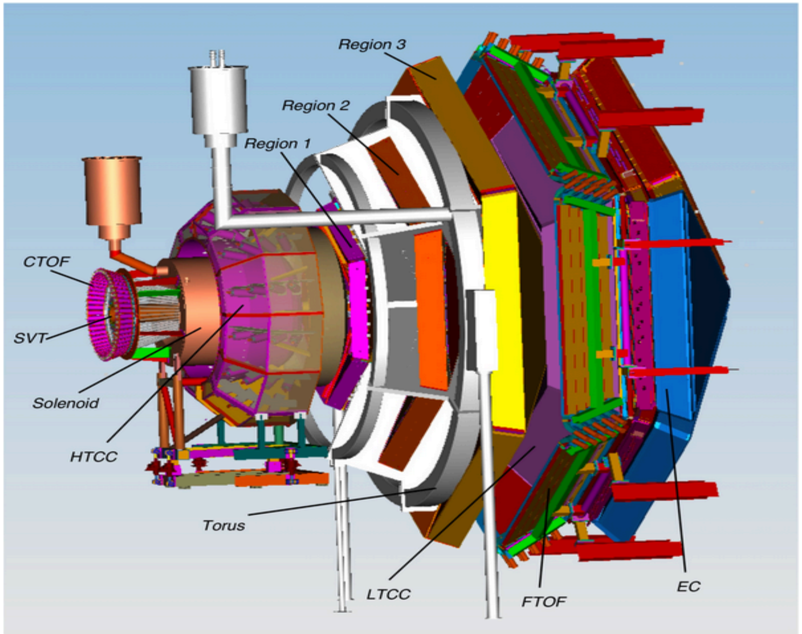
Particle ID for Charged Particles











H. Avakian

Link to CLAS (6 GeV) Wiki

Link to CALCOM Wiki

Link to CLAS12 Operations Documentation

https://clasweb.jlab.org/wiki/index.php/CLAS12_Wiki

Physics

- Physics Experiments

Deep Processes

- Deep Processes Working Group

Hadron Spectroscopy

- Hadron Spectroscopy Working Group

Nuclear Physics

- Nuclear Physics Working Group

Common Analysis Tools

- Analysis Committee of Experts

CLAS12 Run Groups

- Run Group A

Hardware

- Detector Subsystems Hardware
- Safety and Quality Assurance Procedures
  - Technical Control Board
  - Engineering and Design
  - Safety and Quality Assurance Procedures
  - CLAS12 Longitudinally polarized H and D target

Baseline Equipment

- Beamline
- Silicon Vertex Tracker (SVT)
- Central Time-of-Flight (CTOF)
- Torus
- Solenoid
  - Torus and Solenoid Field Maps

Software

General

- Software Documentation Page
- Software (on/offline) **OLD!**
- JLab's GitHub home page
- CLAS12 SVN Repository
- Software FAQs
- Forums
- CLAS Offline Software CVS to SVN Transition
- CLARA: The CLAS12 Analysis and Reconstruction Framework
- CLAS12 Constants Database (ccdb)
- CLAS12 Online Database (rcdb)
- CLAS12 Software Workshops

https://clasweb.jlab.org/wiki/index.php/CLAS12_Constants_Database

https://clasweb.jlab.org/wiki/index.php/CLAS12_Run_Condition_Database

served by a MySQL server on clasdb.jlab.org

Development: D. Romanov
CC support: M. Wise, S. White
Hall-B: H. Avagyan

Some policies with ccdb/rcdb

H. Avakian

- Simulation and reconstruction programs should use sets of geometry and calibration constants and online info from ccdb/rcdb ONLY!
- Production cooking use run group “frozen” variations from ccdb (under development)
- The run information from online provided by the offline mirror of the online rcdb
- Database access programs should be from official ccdb/rcdb library of programs (API).
- Monitoring of integrity of constant sets→ rungroup responsibility

Policies of “who can write what and where” not enforced yet.

Basic Information about the CLAS12 Constants Database

mysql server host: clasdb.jlab.org

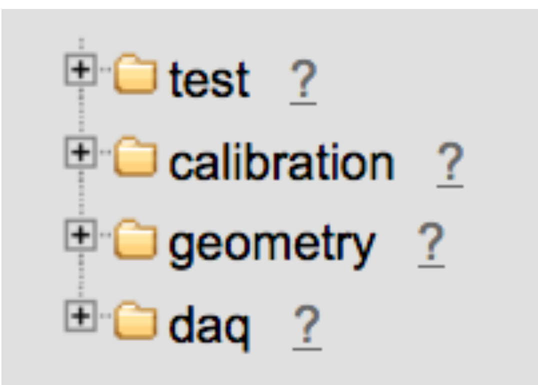
user: clas12reader

database: clas12

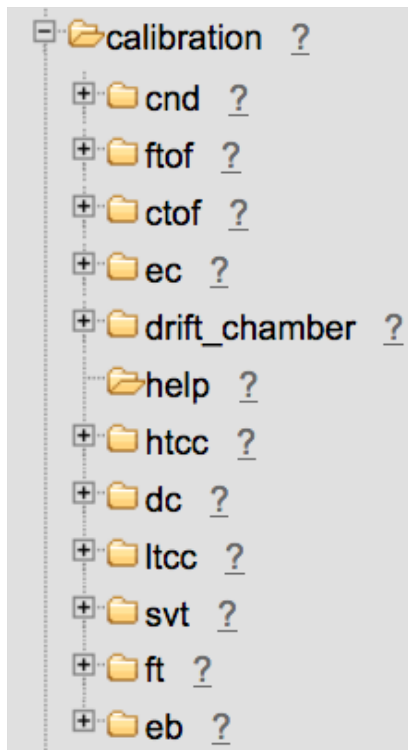
web viewer: https://clasweb.jlab.org/ccdb

ccdb (calibration constants database)

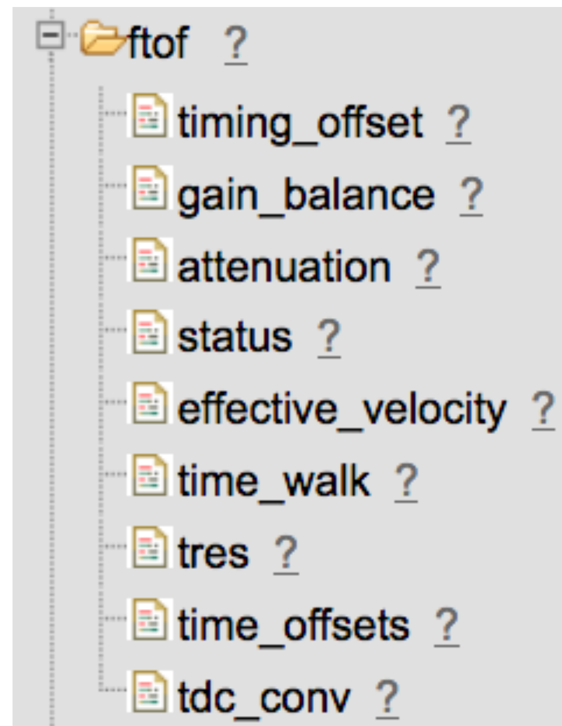
Directory structure (level 0)



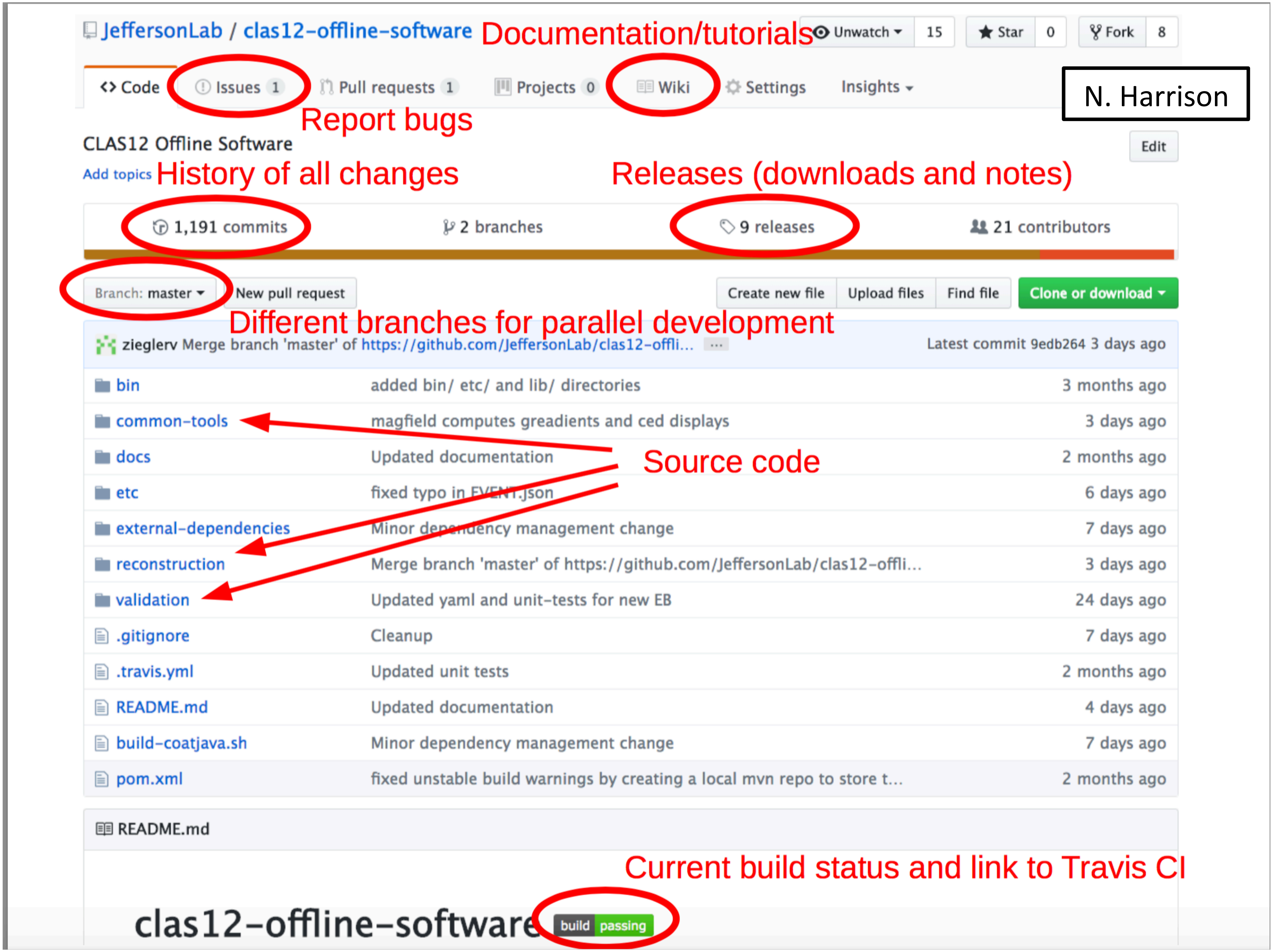
structure (level 1)



structure (level 2)

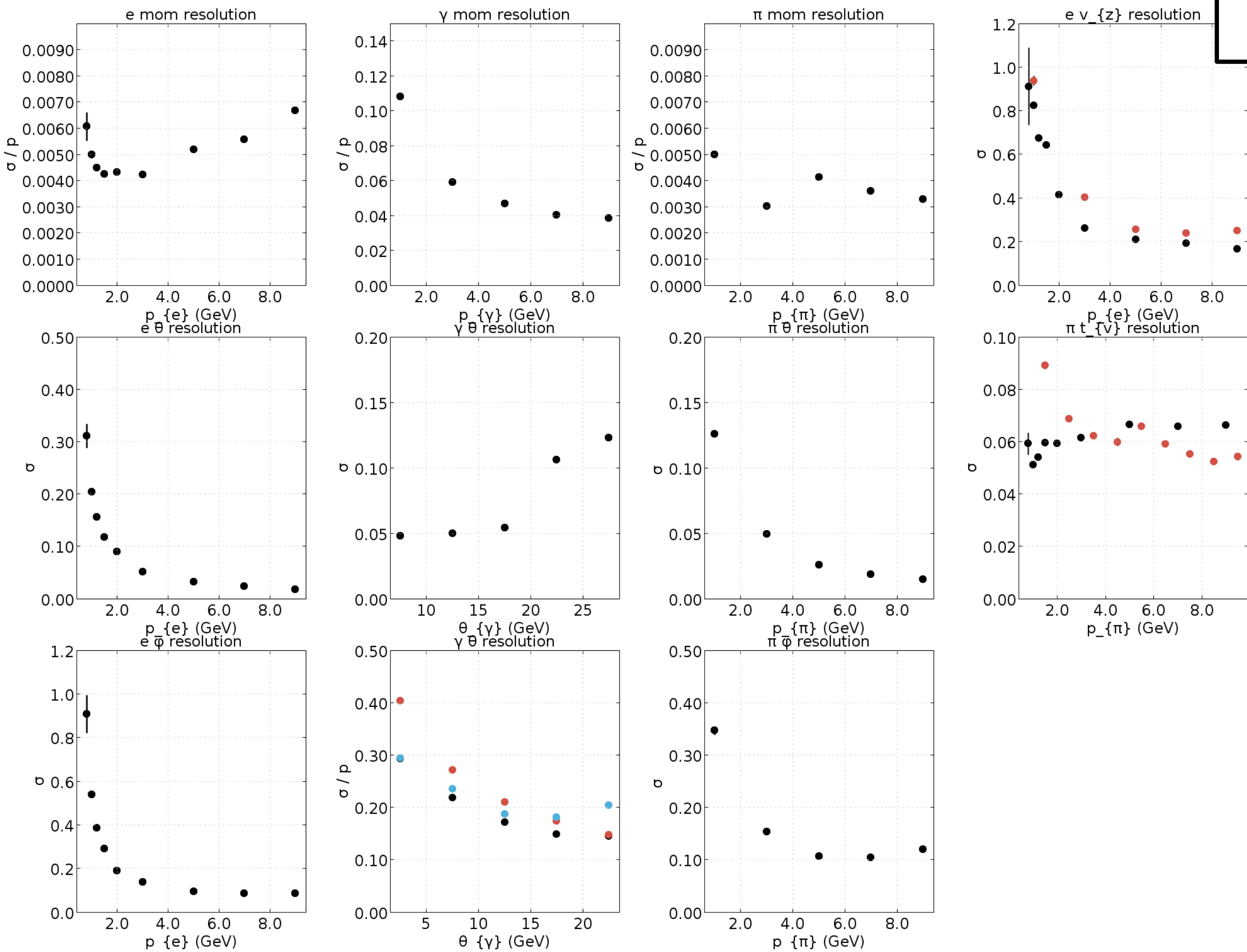


https://clasweb.jlab.org/wiki/index.php/CLAS12_Constants_Database


JeffersonLab / clas12-offline-software
Documentation/tutorials
Unwatch 15
Star 0
Fork 8
Code
Issues 1
Pull requests 1
Projects 0
Wiki
Settings
Insights
N. Harrison
Report bugs
CLAS12 Offline Software
Edit
Add topics
History of all changes
Releases (downloads and notes)
1,191 commits
2 branches
9 releases
21 contributors
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download
Different branches for parallel development
zieglerv Merge branch 'master' of https://github.com/JeffersonLab/clas12-offli...
Latest commit 9edb264 3 days ago
bin
added bin/ etc/ and lib/ directories
3 months ago
common-tools
magfield computes greadients and ced displays
3 days ago
docs
Updated documentation
2 months ago
Source code
etc
fixed typo in EVENT.json
6 days ago
external-dependencies
Minor dependency management change
7 days ago
reconstruction
Merge branch 'master' of https://github.com/JeffersonLab/clas12-offli...
3 days ago
validation
Updated yaml and unit-tests for new EB
24 days ago
.gitignore
Cleanup
7 days ago
.travis.yml
Updated unit tests
2 months ago
README.md
Updated documentation
4 days ago
build-coatjava.sh
Minor dependency management change
7 days ago
pom.xml
fixed unstable build warnings by creating a local mvn repo to store t...
2 months ago
README.md
Current build status and link to Travis CI
clas12-offline-software
build passing

Validations

First Experiment
Workshop
F.X. Girod



Concluding Remarks

- Code used to cook & recook (after calibration) KPP data
  - * Code in github (see Nathan's talk on CLAS12 organization at First Experiment Workshop)
- KPP data used to improve reconstruction, find issues that are better revealed under realistic conditions with backgrounds
- Monitoring suites advanced stage
- Reconstruction in good shape
  - * Significant reconstruction speed improvements
  - * Further work to be done for development and tuning of algorithms for nominal configuration including MM, CND.
- On track for engineering run