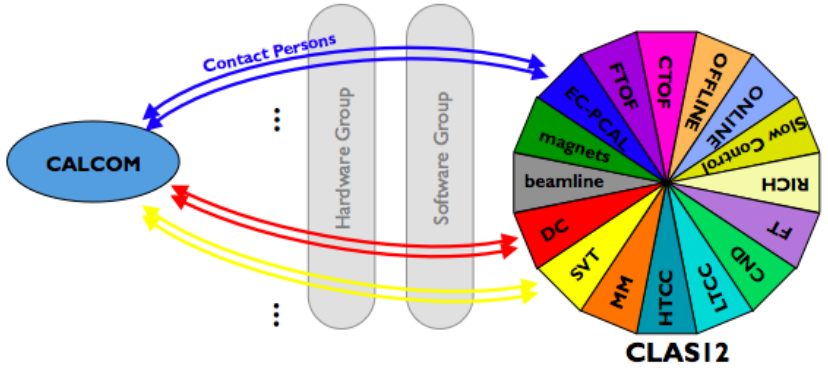
# CALCOM STATUS AND PLANS

Topics:

- Calibration status - RG-L
- Pass-3 preparations
- High luminosity commissioning
- Summary




DANIEL S. CARMAN

CLAS COLLABORATION MEETING

NOVEMBER 17-20, 2026

# Active Run Groups in Calibration Mode – November 2026

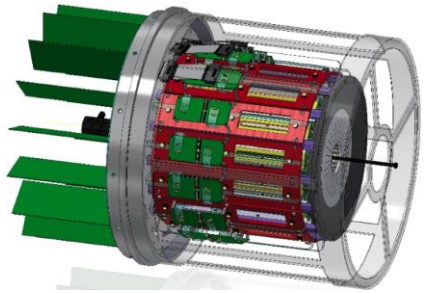
| # | Run Group | Dataset | Conditions | Run Range | Stage |
|---|---|---|---|---|---|
| 1 | RG-L | Spr25 | D2, 4He 2.2, 6.6, 10.7 GeV | 21310 - 23065 | Calibrating |
| 2 | RG-E | Spr27 | Nuclear (D, C, Al, Cu, Sn, Pb) | - | Upcoming online |

A single dataset now being calibrated

| | Analysis Coordinator | Chef |
|---|---|---|
| RG-L | Mohammad Hattawy | Zhaozhong Shi |

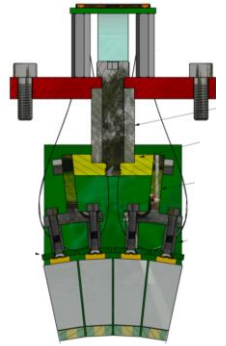
Other tasks in progress:

- Gearing up for return to CLAS12 operations
- "Online" calibrations will be part of RG-E run



# RG-L - Status

RG-L – Pass-1 Calibration Review
Nov. 14, 2025



## CLAS12 subsystems -- where do things stand?

- DC alignment finished
- Beam offset calibrations done
- Calibrations for all FD detectors done
- DC AI network training in progress
  - Denoising, track finding, track fitting
- Hardware status tables filled for FD detectors
- Calibration of CTOF and CND (procedure TBD)

## ALERT subsystems – where do things stand?

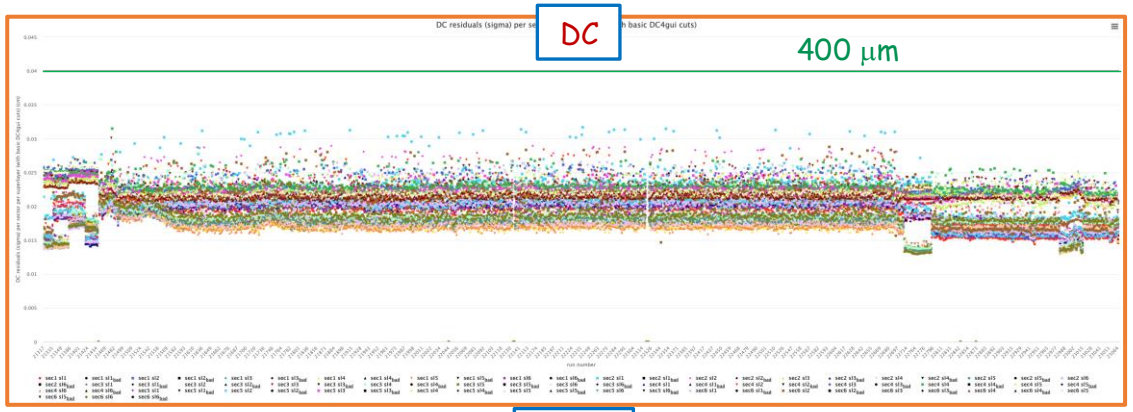
- Development/validation of ATOF and AHDC algorithms & suites in progress
- ATOF calibrations in progress:
  - Global time offsets advanced
  - Energy loss calibrations ongoing
- AHDC calibrations in progress:
  - Initial $t_0$ calibrations done
  - Initial time-to-distance calibrations in progress with layer dependence and time-walk corrections
- ALERT alignment (layer, wire-to-wire, $\Delta z$) in progress

Difficult to predict when cooking of dataset will begin – projecting now for summer 2027 (??)

# RG-L – Calibration Timelines

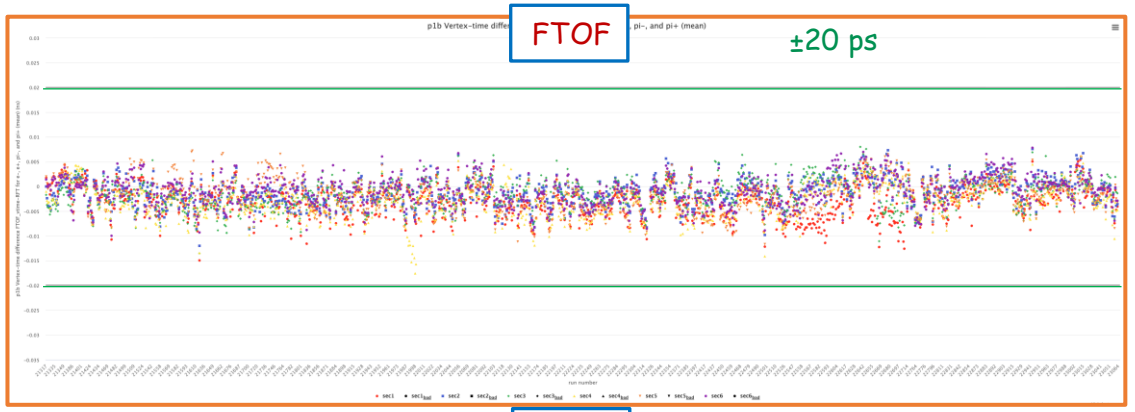
DC

400 μm



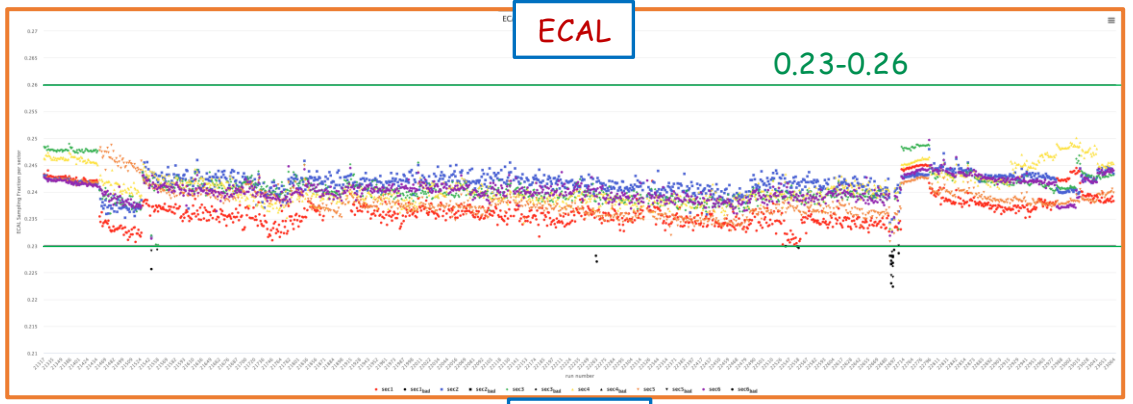
FTOF

±20 ps



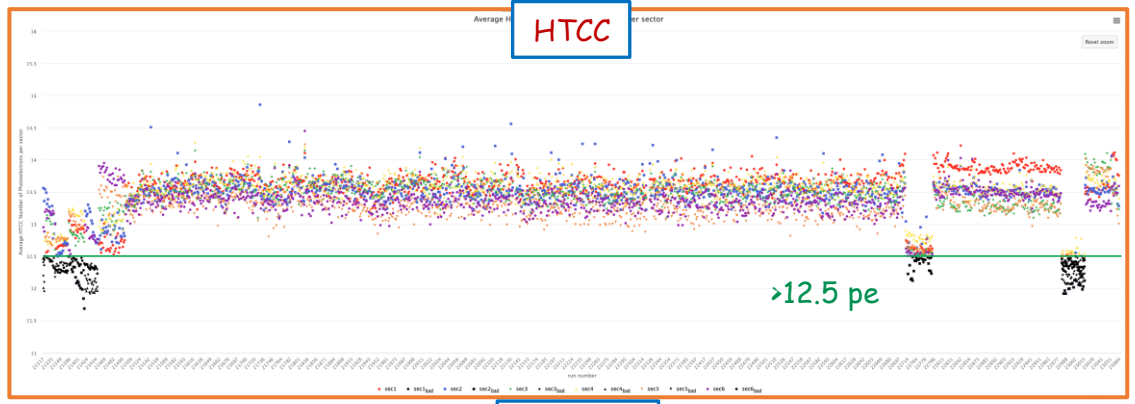
ECAL

0.23-0.26



HTCC

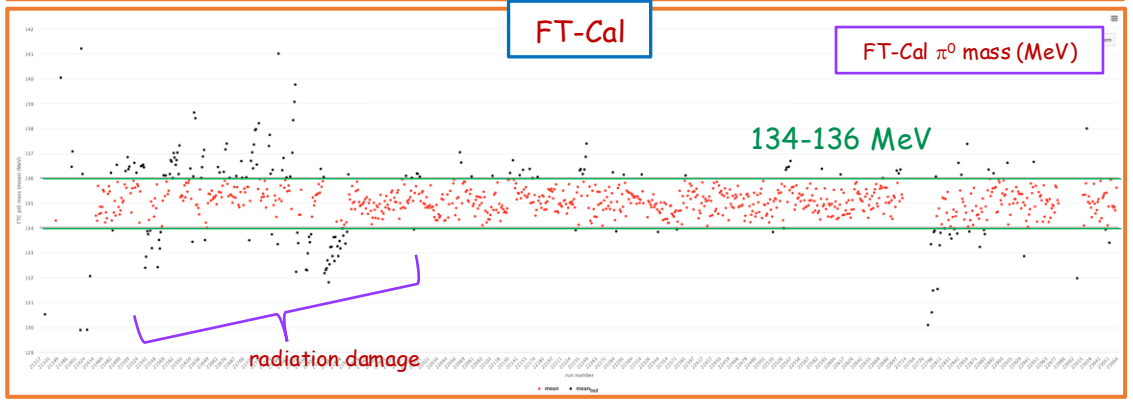
>12.5 pe



FT-Cal

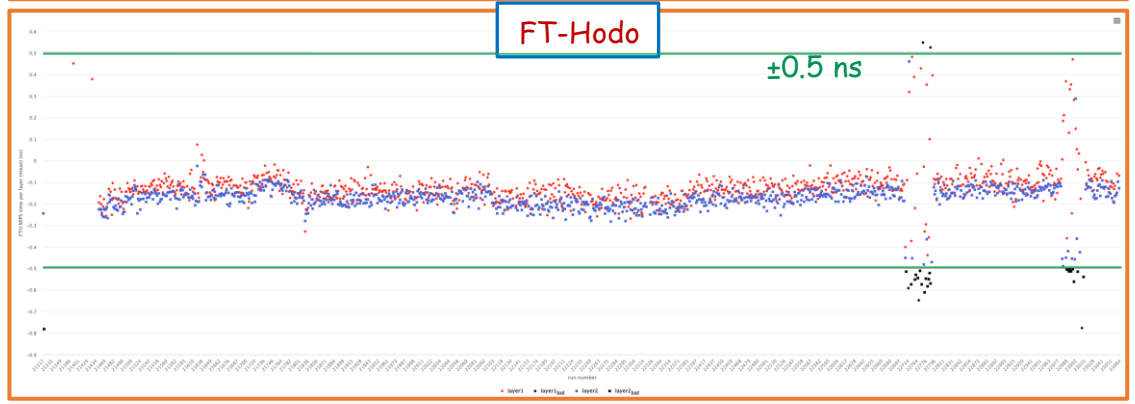
FT-Cal $\pi^0$ mass (MeV)

134-136 MeV



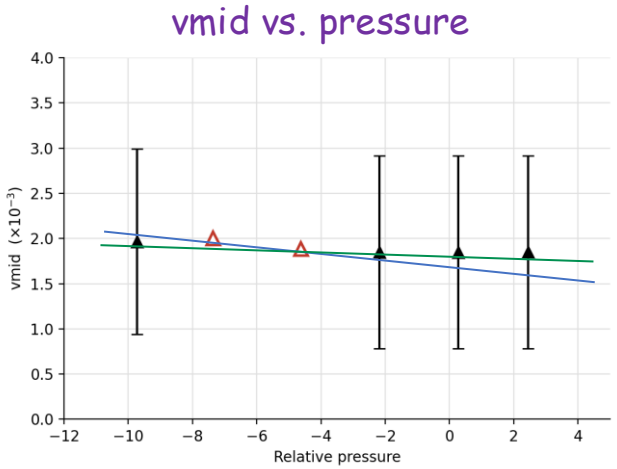

FT-Hodo

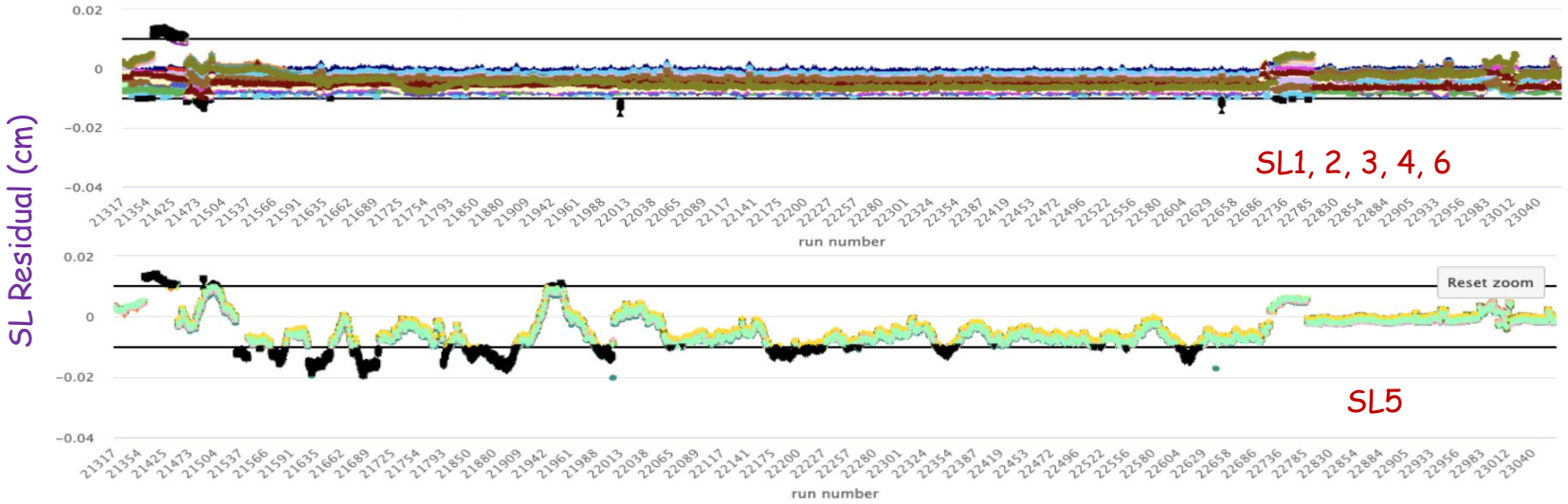
±0.5 ns



# DC Updates

Aron Kripko




| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global time offset (T00) | | | | | | | | | | | | | | |
| T00 check | | | | | | | | | | | | | | |
| TDC window cuts | | | | | | | | | | | | | | |
| T2D Round #1 | | | | | | | | | | | | | | |
| T2D #1 Check | | | | | | | | | | | | | | |
| T2D Round #2 | | | | | | | | | | | | | | |
| T2D #2 Check | | | | | | | | | | | | | | |
| T2D Round #3 | | | | | | | | | | | | | | |
| T2D #3 Check | | | | | | | | | | | | | | |

calibration

cooking

RG-L DC Calibration Timeline

Florian Hauenstein

# RG-L CTOF/CND Calibration without CVT: A Path Forward

Anchor CTOF/CND timing to reactions fully predicted by the FD – bootstrap technique

## CD for RG-L:

- Rely on CD for neutron detection – CND with CTOF charged particle veto
- < 1 ns - CTOF timing: sufficient for veto
- ~0.5 ns - CND timing: measure from prompt-$\gamma$ peak
- Neutron efficiency: d(e,e'$p_s$)n with spectator p in ALERT

Cross-checks: independent reactions should be used to study calibration corrections, e.g. elastic vs. QE protons, protons vs. pions, neutrons and photons in the CND.

Software: the existing CTOF/CND calibration suite and reconstruction must be modified to use predicted (swum) tracks in place of CVT tracks.

Work plans: work not yet started but needs to be completed for pass-1 cooking review

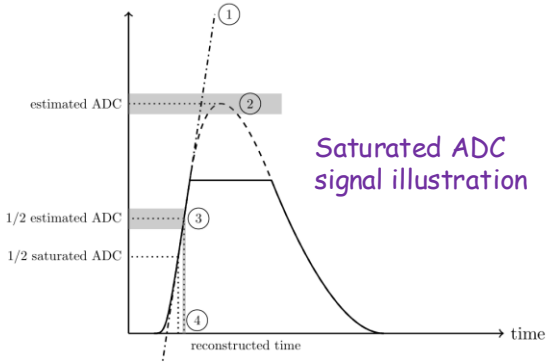
## Procedure:

1. Start: RG-E constants applied to RG-L; event start time from calibrated FD
2. 2 & 6 GeV: elastic/QE ep on $H_2$, $D_2$, $^4$He; swim predicted p to CTOF/CND → time shift per bar
3. 10.6 GeV: ep → e'p$\pi^+\pi^-$; CD hadron predicted from missing momentum
4. Gains: energy deposit with swum path → connect to RG-E calibration + time walk parameters

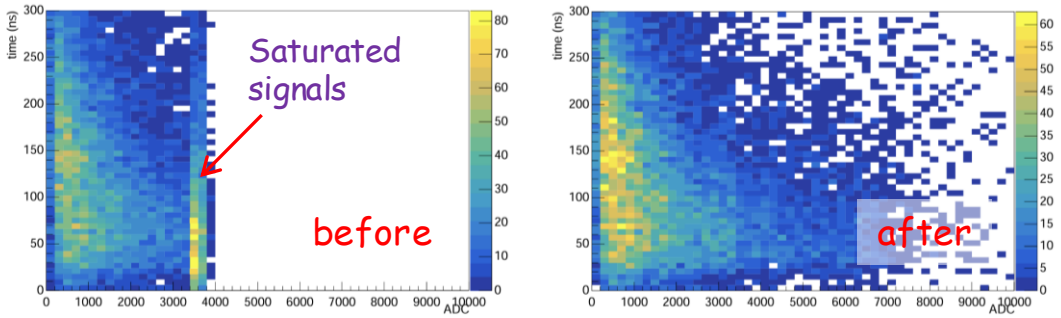
CTOF/CND Calibrations for ALERT

Mohammad Hattawy, Florian Hauenstein
CALCOM
03/21/25

# RG-L ALERT AHDC Calibration Status



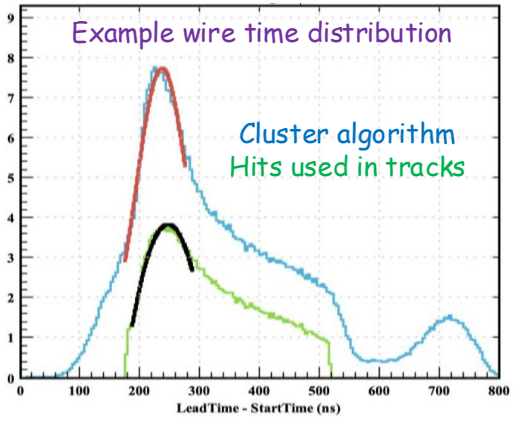

Time vs. ADC

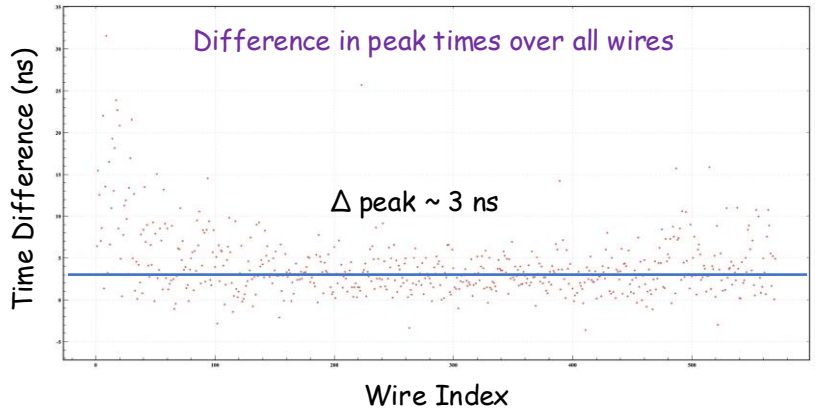



## ADC Saturation:

By evaluating the waveform shape, saturated ADC values have been recovered with more accurate pulse times. (Completed)

Felix Touchte-Codjo




## AHDC T0:

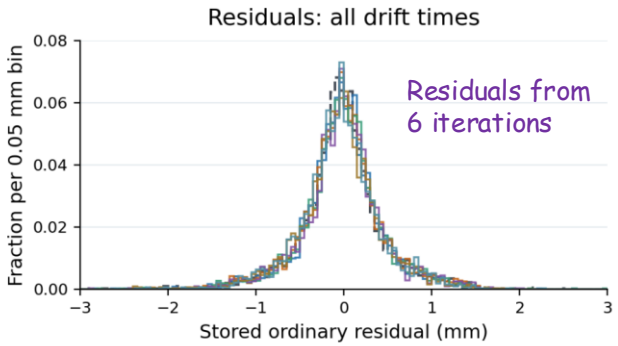
Investigating timing fits between cluster samples and hits used in tracking.T0 values close to being finalized.

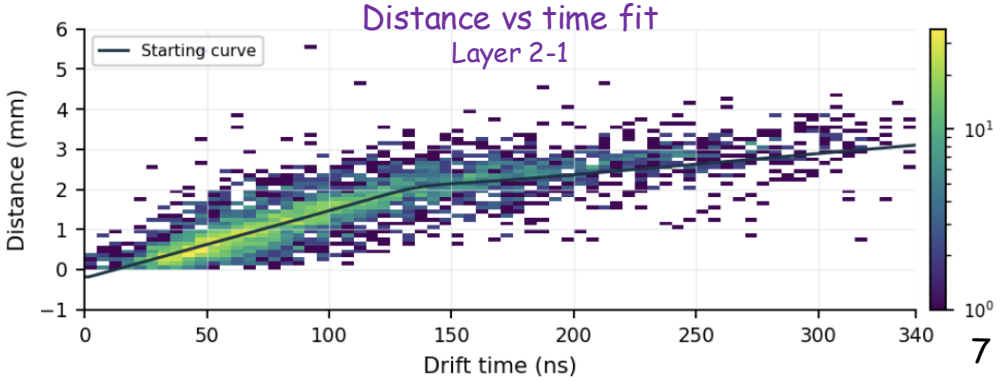
Akshit Mehta

## AHDC T2D:

Iterative fitting procedure has been developed, but early results show no improvement in residuals. More work needs to be done to reach goals.

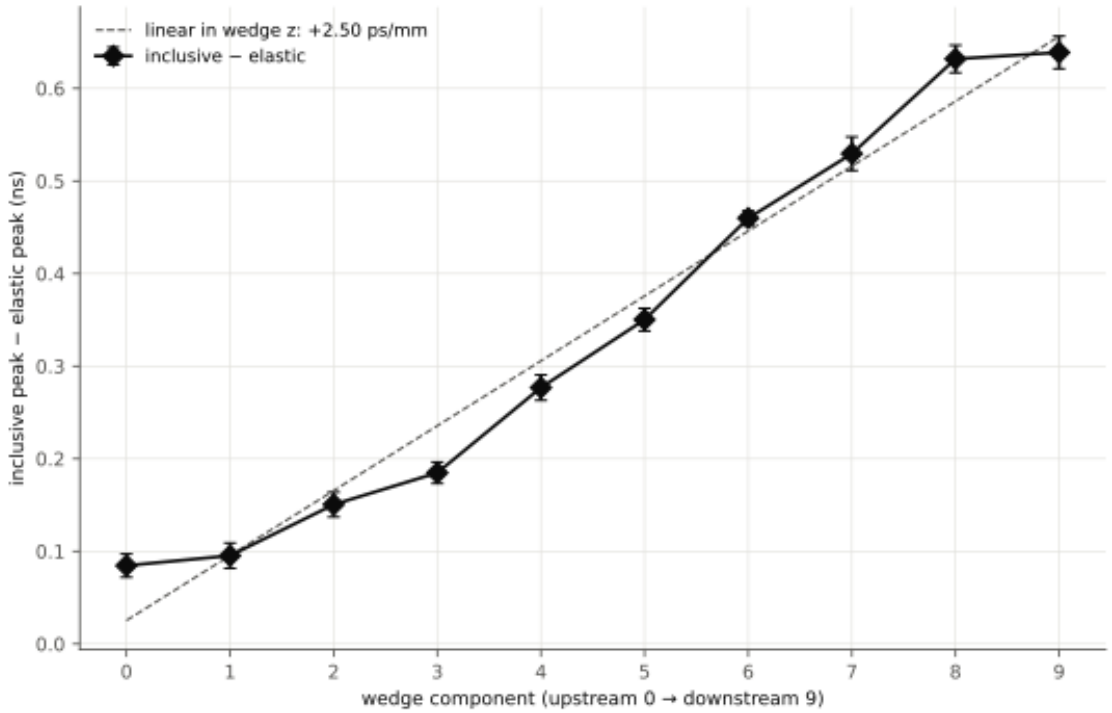
Amitabh Biswas

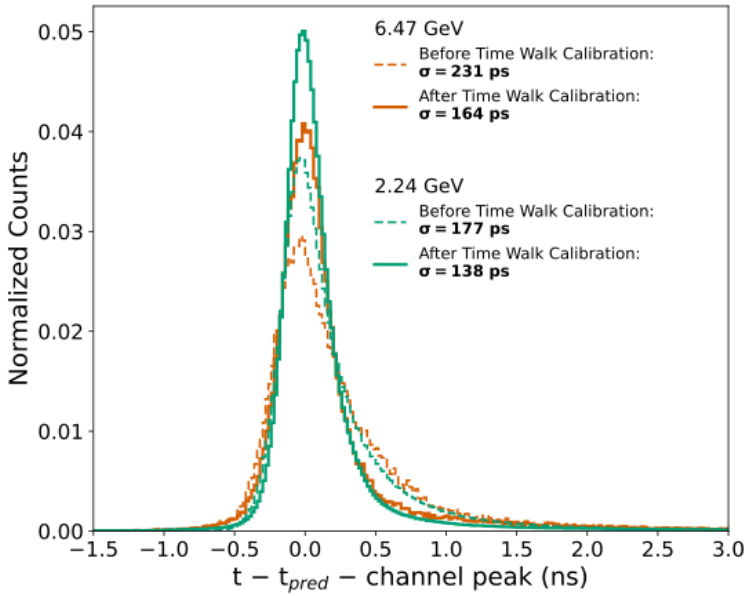


# RG-L ALERT ATOF Calibration Status

- Use 2.2 and 6.6 GeV elastic recoils to pin down absolute time calibration
  - Had previously aligned channels with inclusive TDC peak, now determining the channel-by-channel offset required to get absolute time




- Exploring correlation between elastic time and TOT to correct for time walk
  - TOT shapes still not totally understood, but does show a time-dependence that can be used to define a "time-walk"

Even before time walk correction, ATOF time resolution seems good enough for physics!

Zhiwan Xu, Noemie Pilleux, Whitney Armstrong, Henry Klest

# Pass-3 Recalibration/Recooking

Goal: Improve procedures to speed-up time to calibrate a given dataset

- This is not tied to pass-3 but for all future calibrations!

Pass-3:

- The goal is to gain the improvements from the DC tracking updates and other tracking bug fixes/improvements that have been realized since the pass-1/pass-2 cooking
- The hope for all of CLAS12 data is to improve the CVT tracking efficiency, track purity, and resolution based on improved algorithms

Reconstruction Studies:

- Investigate anomalies in FD reconstruction showing vertex-dependence in tracks of opposite charge

Suite Automation:

- The work to develop the infrastructure to enable calibration suites to run on the batch farm has made good progress – several suites (RF, FT-Cal) operate in this batch mode
- Other suites will be/could be developed in this model over the next months (e.g. CTOF, CND, HTCC, LTCC), but some suite that require iterations or more "hands-on" control (e.g. FTOF, DC) will take longer to incorporate (need to automatically handle fit failures based on known pathologies)

Path Forward:

- The plan is currently to begin pass-3 work on the Spr19 datasets (RG-B and RG-A) for baselining – this work will focus only on the FD calibrations while development work on the CD continues

# Pass-3 Preparation Status

1. Suite and calibration development:
   - ✅ Implementation of subsystem calibration banks (smaller disk size, faster processing) (Raffaella)
   - WORK IN PROGRESS DC benchmarking and validation (Florian)
   - ✅ Suite batch compatibility – includes save histogram feature (Nathan/Chris)
   - 🚧 WORK IN PROGRESS Calibration suite updates/streamlining/automation (Developers/Nathan/Raffaella)

2. Workflow and data processing improvements:
   - ✅ Simplification to YAML configuration files (Nathan/Raffaella)
   - ✅ Code speed-ups (decoding and reconstruction) (Nathan)
   - ✅ Workflow simplification (decoding and denoising in CLARA) (Nathan/Raffaella)
   - ✅ Single chef model (Nathan)

3. Reconstruction software development:
   - ✅ New DC denoising, track finding, HBT "fitting" (Tongtong)
   - 🚧 WORK IN PROGRESS Improvements to conventional CVT tracking (Veronique/Tongtong)
   - 🚧 WORK IN PROGRESS Implementation of AI tracking finding/denoising for CVT (Richard/Mathieu/Tongtong)

4. Calibration procedure tracking:
   - ✅ Calibration dashboard checklist (Chris/Daniel)

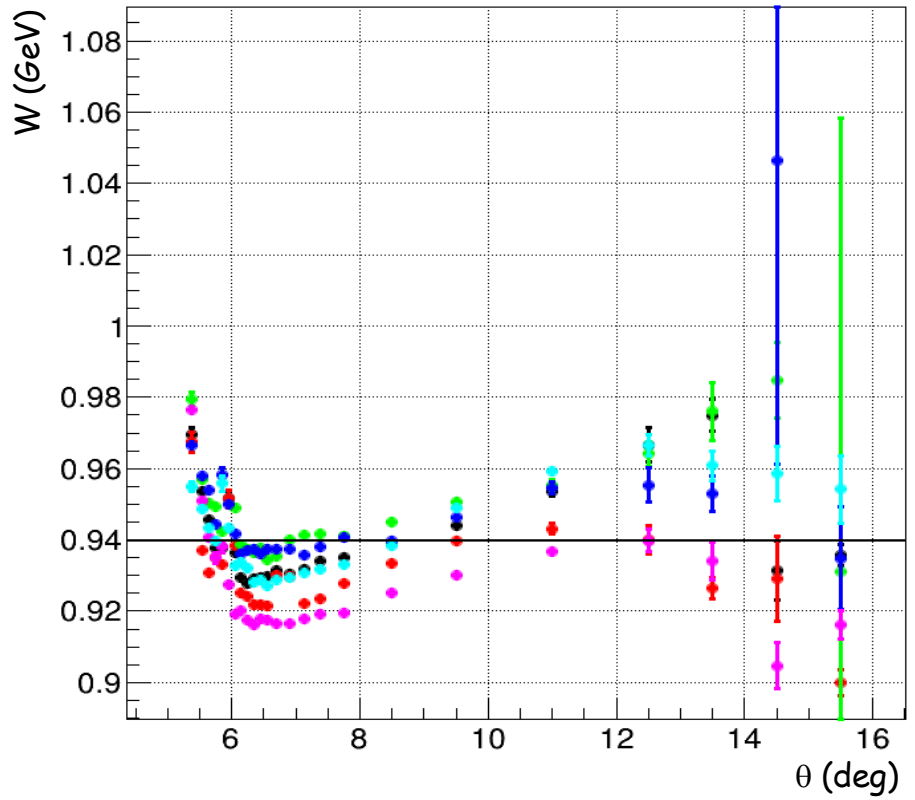
5. Miscellaneous studies:
   - 🚧 TO BE DONE Study of FD track z-vertex biases (Raffaella)
   - 🚧 TO BE DONE Study CVT global alignment (i.e. tilts/rotations) (Yuri)



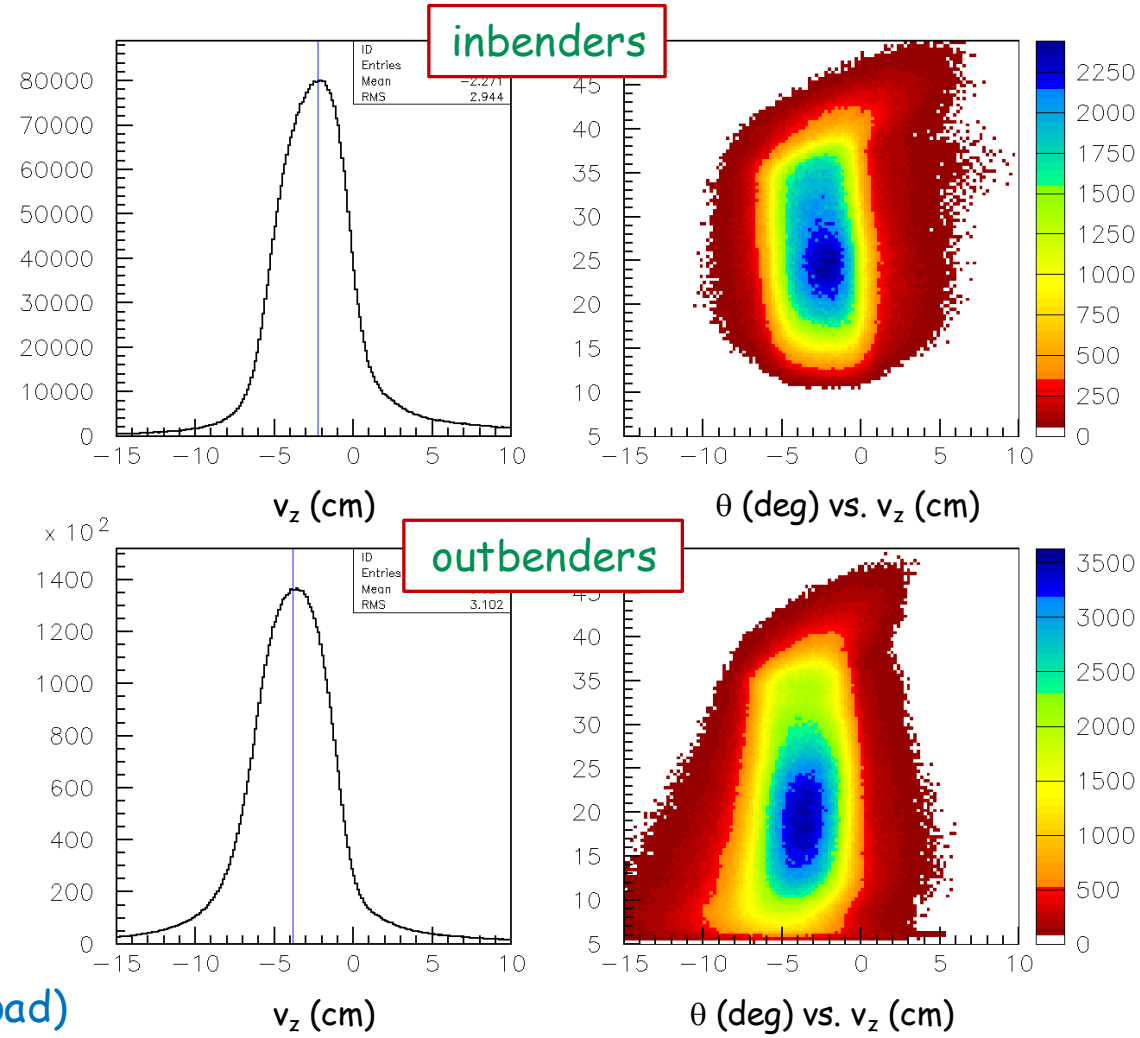



# Investigations of Track Biases

## Elastic peak dependence on angle




## Charge-dependent vertex reconstruction



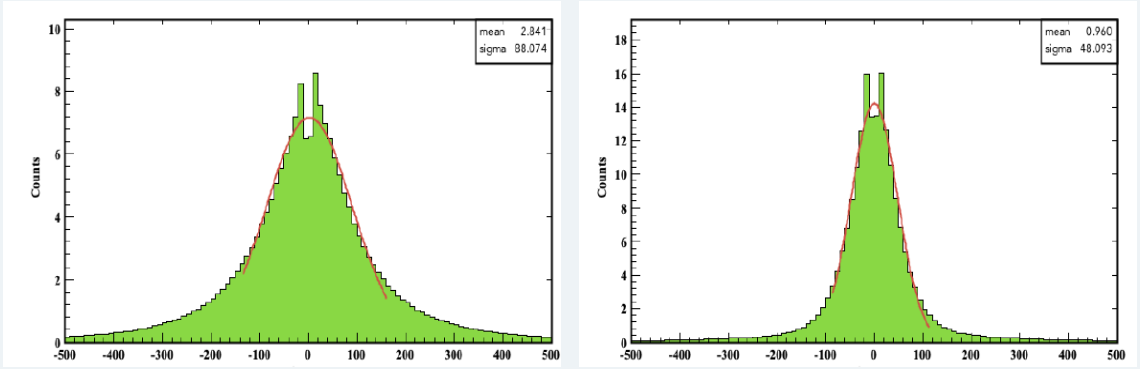

CHECK:

- DC geometry issues (e.g. endplate bowing due to wire tension load)
- Magnetic field issues
- R2 DC calibration (based on straight line segment in SL3, SL4)

# CVT & FMT Alignment with Millepede

Synthesis of Y. Gotra, CVT and FMT alignment talks (Nov. 6+13, 2026)

## CVT: Kalman projector fix + Millepede



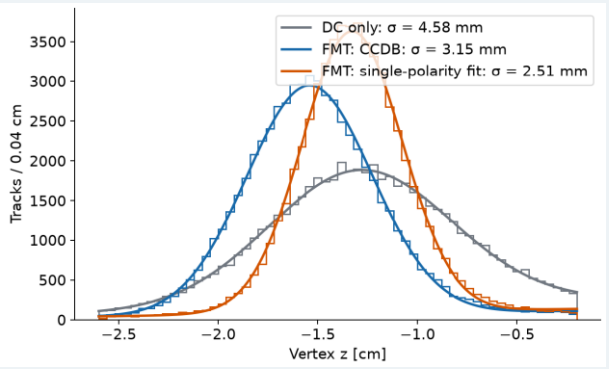

Before: σ = 88 μm

After fix: σ = 48 μm

*SVT residuals [μm], run 19060, same events*

- Bug in production CVT track fit: Kalman derivatives used the wrong SVT/BMT surface → failed fits, wrong $\chi^2$, and correct alignment looked worse than ideal geometry.
- Millepede + full-field data: further 1–4% residual narrowing.
- Effect of improved CVT alignment still to be tested on data.

## FMT: Millepede alignment




*Target-foil vertex z, RG-E run 20506 (inbending), same tracks*

- Full Millepede workflow implemented for the FMT using DC tracks traced back to the vertex; fit takes minutes vs. days of manual scans.
- New table from inbending data narrows the FMT vertex peak by ~20% on identical tracks; also improves outbending and zero-field data.
- Next: understand remaining sector-dependent vertex structure

**Work in progress**

# CVT Reconstruction Status

See talks:
Mathieu Ronayette
Tongtong Cao

Inefficiencies in CVT reconstruction due to noise and track finding:

- Background leads to fake tracks and lost or contaminated true tracks
- Current track finding uses rough helix fitting

Main Machine Learning (ML) work has targeted denoising:

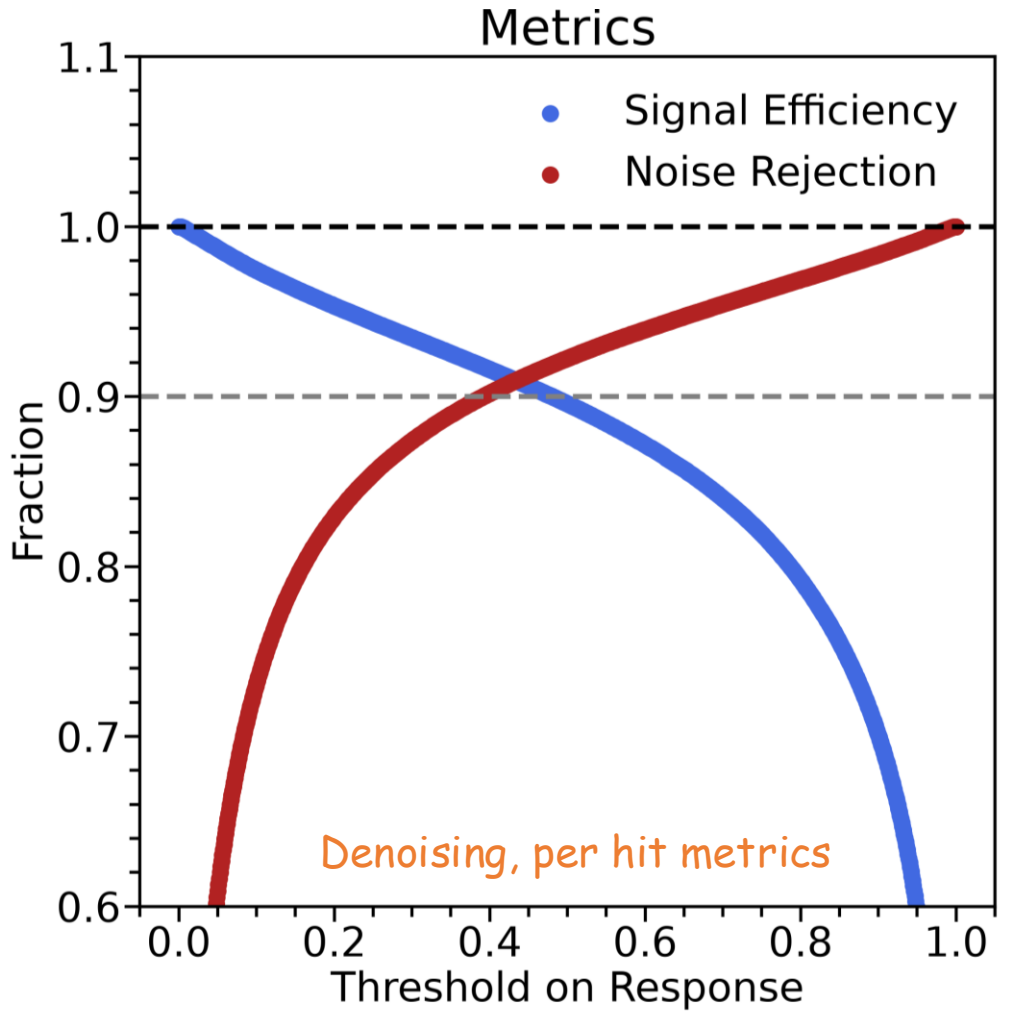
- Model trained and validated on simulated data
- Model inference implemented in COATJAVA
- Validation on real data ongoing
- Some future optimization (e.g. MC vs. CLAS12 training data)
- Future validation with exclusive reactions

Future ML work:

- ML-enhanced track finding (similar to FD): Classifier trained to ID real from fake cluster combinations
- ML-track state predictor (similar to FD): Model trained to estimate initial track state
- For both, initial testing looks promising, need more detailed algorithm optimization, validation, implementation in COATJAVA

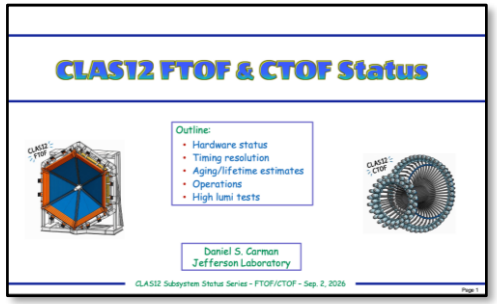
Expected Timeline:

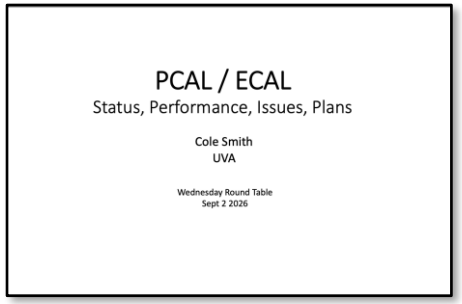
- Updated conventional reconstruction – early 2027
- Full ML assisted reconstruction – late 2027



# High Luminosity Discussions

| | | |
|---|---|---|
| FTOF/CTOF | Daniel Carman | Sep. 2 |
| ECAL | Cole Smith | Sep. 2 |
| CND | Silvia Niccolai | Sep. 4 |
| CVT/FMT | Yuri Gotra | Sep. 4 |
| Slow Controls | Nathan Baltzell | Sep. 9 |
| RICH | Valery Kubarovsky | Sep. 9 |
| DAQ | Sergey Boyarinov | Sep. 16 |
| Beamline | Eugene Pasyuk | Sep. 18 |
| Forward Tagger | Raffaella De Vita | Sep. 18 |
| BAND | Florian Hauenstein | Oct. 2 |
| DC | Florian Hauenstein | Oct. 2 |
| Physics Program with High-Luminosity Facilities | | Oct. 5 - 9 |

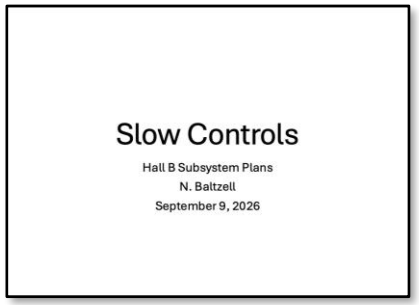




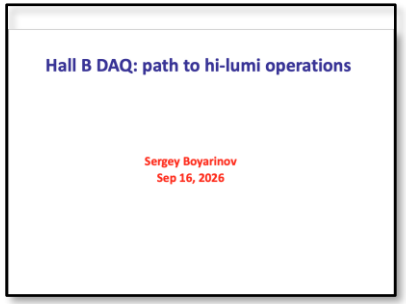


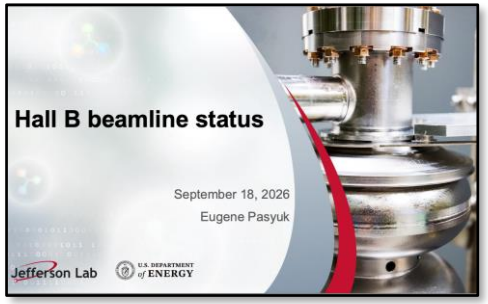


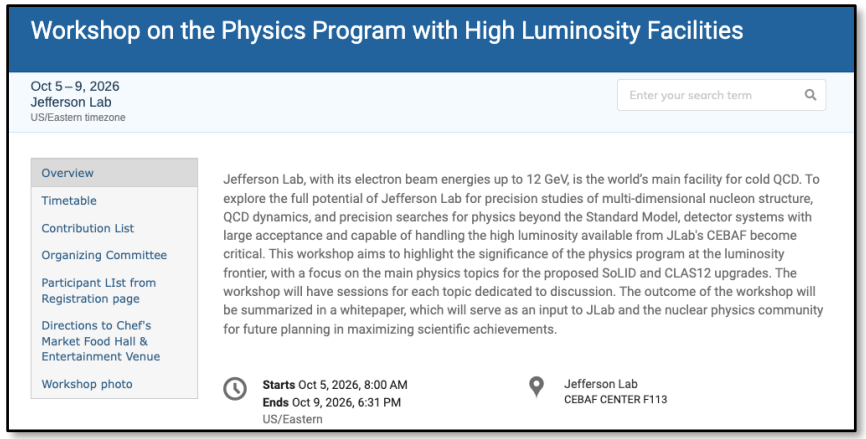



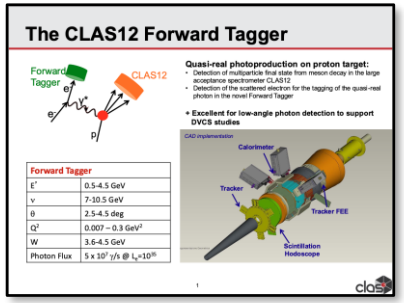


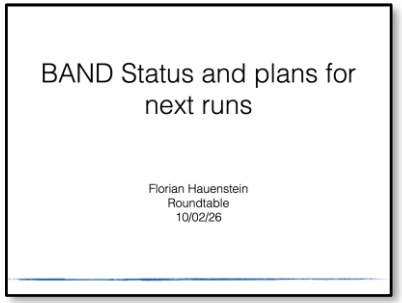


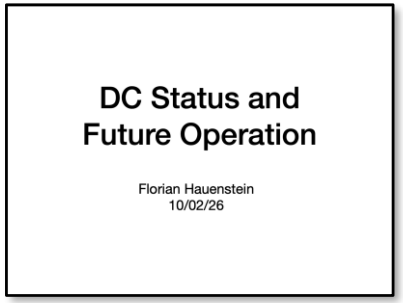


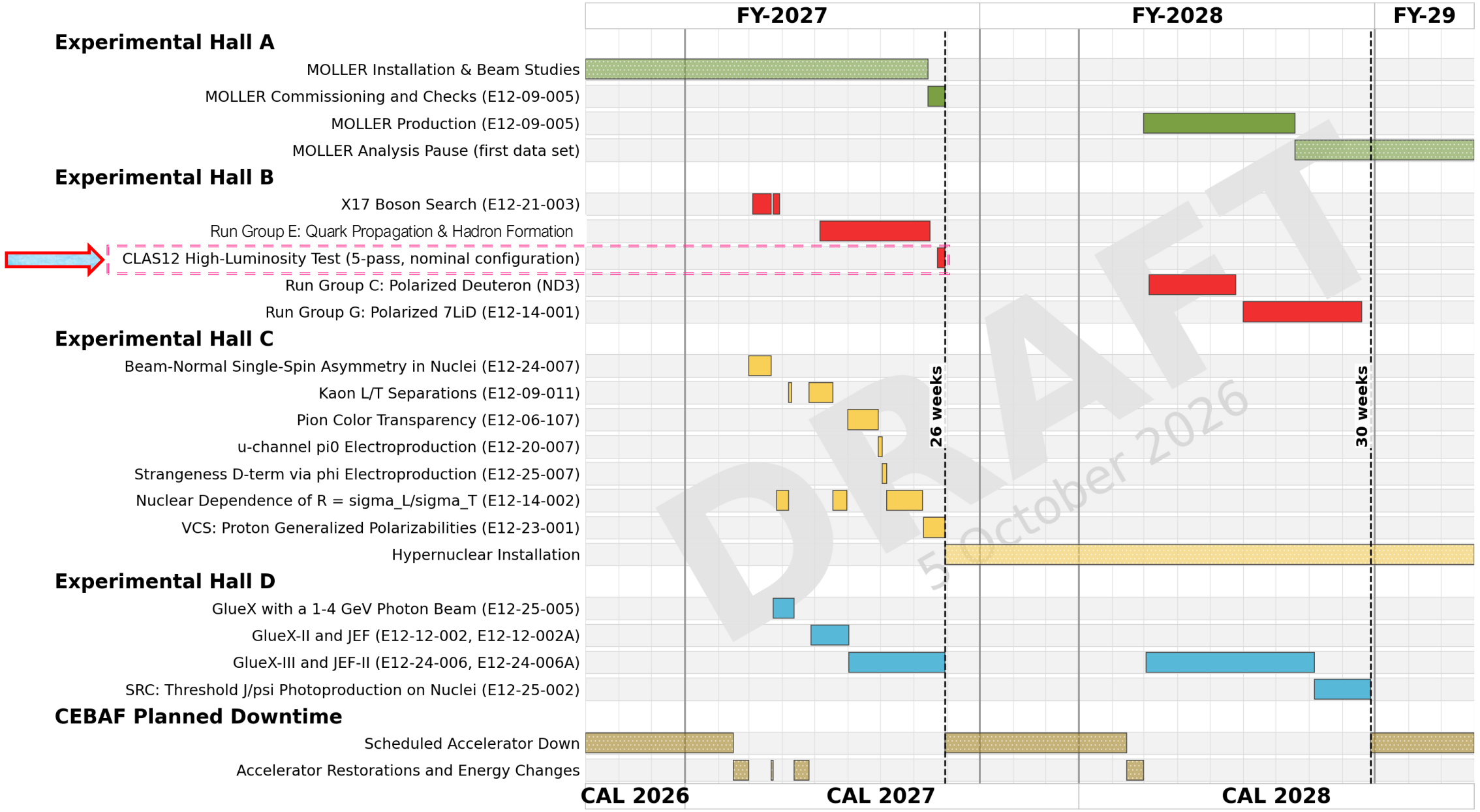



# Run Schedule for Hall B



# High Luminosity Test Plan

GOAL Establish the operating envelope for 2-3x nominal luminosity and identify what limits performance

Luminosity: 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0

At each point collect 100M triggers and calibrate CLAS12 subsystems

## Subsystem Test Matrix

### DETECTORS

| | |
|---|---|
| FTOF/CTOF | rates & timing • calibration vs. L • PMT HV/anode linearity • pile-up/multi-hit • gain/aging |
| CND/ECAL /HTCC | rates & occupancy • calibration/gain stability • PMT linearity • pile-up • efficiency |
| DC/CVT | dark & leakage currents • HV stability • occupancy • efficiency/tracking • calibration stability (DC) |
| FT | gain/calibration stability • radiation effects • rates/pile-up • performance at highest current |
| RICH | PID efficiency/separation • occupancy & backgrounds • stability vs. L |

### TRIGGER / DAQ

| | |
|---|---|
| TRIGGER | rate capability • purity/efficiency • DC-road requirements • optimization |
| DAQ | throughput • dead time/linearity vs. current • buffering/event building • SEU probability |
| SYSTEM | HV/current monitoring • alarms/trips • synchronization • online monitoring & automated QA |

### HIGH-RATE / NEW SYSTEMS

| | |
|---|---|
| μRWELL | commissioning • efficiency/gain • discharge/HV stability • software/DAQ integration |
| CTOF RATE TEST | ~500 kHz/PMT non-linearity: compare modified vs. stock dividers |
| PMT GAIN SCANS | repeat selected luminosity points with gain stepped from G toward ~0.5G, as needed |
| RECOVERY | return to nominal conditions and verify calibration/gain/stability recovery |

Deliverable: luminosity-dependent performance map for every subsystem: operating range vs. emerging limitation vs. hard limit

Sustained operation: calibration drift vs. time -- sensitivity of energy/time/distance calibrations to sustainied elevated beam current

# Summary

- CALCOM has been overseeing the detector calibrations of the different CLAS12 datasets:
  - In Progress: RG-L calibrations for FD finished; ALERT team advancing calibrations for ATOF/AHDC
  - RG-K Spr24: CCDB not updated with final CVT geometry before data processing; RG-K is considering reprocessing due to $\phi$-dependent shifts in CVT.
- Laying the groundwork for "pass-3" recalibrations/recooking:
  - Updated code suites for improved speed and automation
  - Improved/streamlined calibration protocols (including for DC alignment)
  - Implemented calibration dashboard for tracking
  - New DC tracking software development (DC denoising/hit selection)
  - Investigation of AI methods for CVT tracking
- Working on considerations for higher-luminosity operations
  - Developing "commissioning" list for a high-luminosity test run (continuing the nuclear target test completed in 2020)
- Lots of folks are part of this work: CALCOM, coordinators, chefs, timeline crew, subsystem leaders, calibrators, alignment team, Software Group, data validators, …

FD work commencing in spring 2027, CD work commencing in fall 2027

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# Backup Slides

# CLAS12 Calibration and Commissioning

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1 CALCOM Committee
2 CLAS12 Subsystem Contact Persons
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## CALCOM Committee

The role of the CALCOM (Calibration and Commissioning) Group is to be responsible for the development of the tools/algorithms to calibrate the CLAS12 detector and to help ensure that the design performance specifications are met. In addition the CALCOM group is responsible for developing the CLAS12 commissioning plan and overseeing its execution.

The committee is composed by:

- Daniel Carman (chair / hardware)
- Raffaella De Vita (software / hardware)
- Gagik Gavalian (common tools)
- Maurizio Ungaro (simulation)
- Veronique Ziegler (reconstruction)




## CLAS12 Subsystem Contact Persons

| System | Subsystem | Contact Person(s) | Software Contact Person |
|---|---|---|---|
| **Calorimeters** | ECAL | *C. Smith* | *C. Smith* |
| **Central Tracker** | SVT | *Y. Gotra* | *V. Ziegler* |
| | MM | *Y. Gotra* | *F. Bossu, M. Defurne* |
| | RTPC | *M. Hattawy* | *M. Hattawy* |
| **Cerenkov Counters** | HTCC | *Y. Sharabian* | *I. Illari, W. Phelps* |
| | LTCC | *M. Ungaro* | *V. Mascagna, M. Ungaro* |
| | RICH | *M. Contalbrigo* | *M. Mirazita* |
| **Forward Tagger** | FT-Cal | *R. De Vita* | *R. De Vita* |
| | FT-Hodo | *N. Zachariou* | *R. De Vita* |
| | FT-Trk | *R. De Vita* | *V. Ziegler* |
| **Forward Tracker** | DC | *F. Hauenstein* | *V. Ziegler* |
| | FMT | *Y. Gotra* | *V. Ziegler* |
| **RF** | | *R. De Vita* | *R. De Vita* |
| **Scintillation Counters** | FTOF | *D.S. Carman* | *D.S. Carman* |
| | CTOF | *D.S. Carman* | *D.S. Carman* |
| | CND | *S. Niccolai* | *S. Niccolai* |
| | BAND | *F. Hauenstein* | *F. Hauenstein* |

## CLAS12 Calibration

**Ready for Calibration Reviews:**

- RG-A: Spr18, F18, Spr19
- RG-B: Spr19, F19/W20
- RG-C: Sum22, F22, W23
- RG-D: F23
- RG-E: Spr24
- RG-K: W18, Spr24
- RG-L: (TBD)
- RG-M: F20/W21

**CLAS12 Dataset Information:**

- CLAS12 Dataset Run ranges
- Run Group QADB information (Jan. 2025)

**Information for Analysis Coordinators:**

- Calibration sequence [1]
- Calibration overview [2]
- Calibration and Software Development Teams: [3]
- CCDB Tables and Usage Policies
- CLAS12 Hardware Status Word Definitions




**Calibration Suite Documentation:**

- Alignment: DC and FMT
- BAND: suite
- Beam Offset: suite
- Cherenkov:
  - HTCC: suite, tutorial
  - LTCC: suite
  - RICH: suite, Time calibration, Cherenkov angle calibration, Monitoring histograms and timelines, Scaler calibration runs
- CND: suite, tutorial, algorithms
- CTOF: suite, tutorial, algorithms, ccdb, geometry
- CVT:
  - MM:
  - SVT: suite
- DC: suite, tutorial, calibration wikipage
- ECAL: suite
- FT:
  - FT-CAL: suite, tutorial
  - FT-HODO: suite, tutorial
- FTOF: suite, tutorial, algorithms, ccdb, geometry
- RF: suite, tutorial
- RTPC: geom, ccdb

### Meetings and Minutes

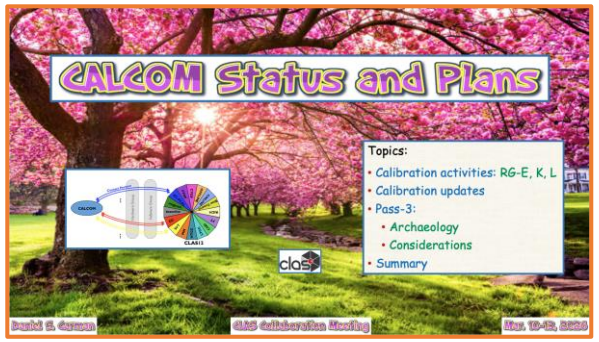
- Zoom meeting connection: [4]
- 2011 Meetings
- 2012 Meetings
- 2013 Meetings
- 2014 Meetings
- 2015 Meetings
- 2016 Meetings
- 2017 Meetings
- 2018 Meetings
- 2019 Meetings
- 2020 Meetings
- 2021 Meetings
- 2022 Meetings
- 2023 Meetings
- 2024 Meetings
- 2025 Meetings

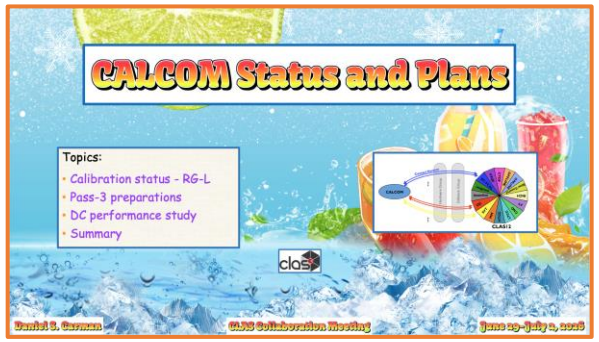
clas12_calcom@jlab.org






https://clasweb.jlab.org/wiki/index.php/CLAS12_Calibration_and_Commissioning




# Pass-3 Considerations

1. DC realignment efforts to account for the thermal contraction of the cryotarget
   - Includes improved zero-field DC calibration protocols and improved alignment software since pass-2 work
   - Includes updates to DC geometry after extensive review
2. Application of new protocols for DC time offsets and time-to-distance calibration
   - New TDC jitter corrections, time window cuts, multi-hit effects
3. Updated calibration protocols for subsystems – DC, FT, FTOF, RICH
4. Improved tracking algorithms – DC and CVT
5. Investigations of tracking anomalies
   - Attempt to explain angle and charge dependence of forward track reconstruction
6. Run-by-run hardware status tables
7. New RICH alignment and calibration procedures
8. Matching Monte Carlo to data

# Data Calibration Periods

pass-1
pass-2

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| RG-A Spr18 | | | | | | | |
| RG-A F18 | | | | | | | |
| RG-K F18 | | | | | | | |
| RG-B Spr19 | | | | | | | |
| RG-A Spr19 | | | | | | | |
| RG-B F19 | | | | | | | |
| RG-B W20 | | | | | | | |
| RG-F Spr20 | | | | | | | |
| RG-F Sum20 | | | | | | | |
| RG-M Win21 | | | | | | | |
| RG-C Sum22 | | | | | | | |
| RG-C F22 | | | | | | | |
| RG-C W23 | | | | | | | |
| RG-D F23 | | | | | | | |
| RG-K Spr24 | | | | | | | |
| RG-E Spr24 | | | | | | | |

