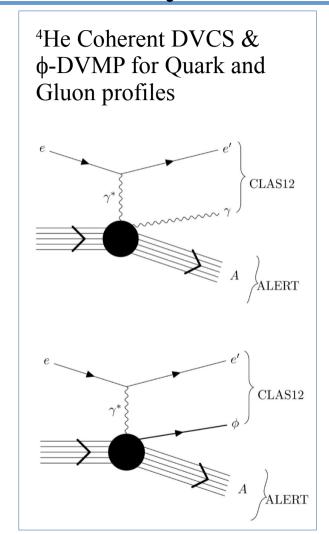


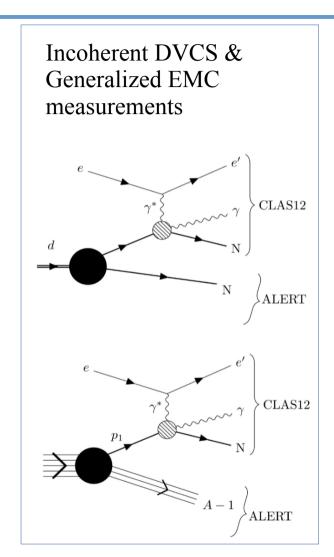
#### **RG-L** Ready for Calibration Review

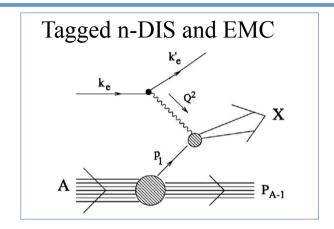
#### M. Hattawy

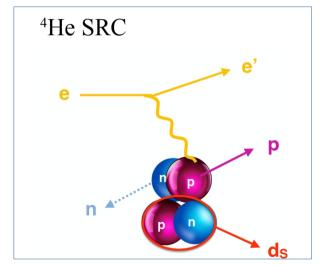
- Physics Motivations
- Experimental Setup
- Data Scope
- Review Charges
- Manpower & Plans
- ALERT Calibration

# **RG-L Physics Case**









and many more ..

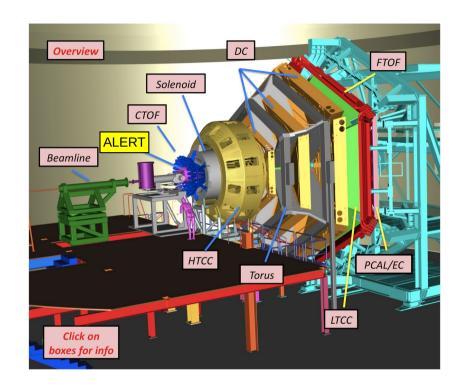
#### **Experimental Setup**

#### - CLAS12 Forward Detector:

- → Superconducting Torus magnet.
- $\rightarrow$  6 independent sectors:
  - $\rightarrow$  HTCC: identifying e<sup>-</sup> (p < 5.0 GeV/c).
  - → 3 regions of DCs: tracking charged particles.
  - $\rightarrow$  LTCC and RICH:  $\pi$  identification (p >3.0 GeV/c).
  - → FTOF Counters: identifying hadrons.
  - $\rightarrow$  PCAL and EC: detecting  $\gamma$ , e and n [5°,40°].
- $\rightarrow$  **FT**: detecting  $\gamma \& e^{-}$  [2.5°,4.5°].

#### - Central Detector:

- **Target:** <sup>4</sup>He, D, gas @ 5.8 atm, 293 K
- ALERT: Detects low energy recoils, replacing the CVT.
- Solenoid
- CTOF & CND
- **BAND Detector:** For backward n detection.

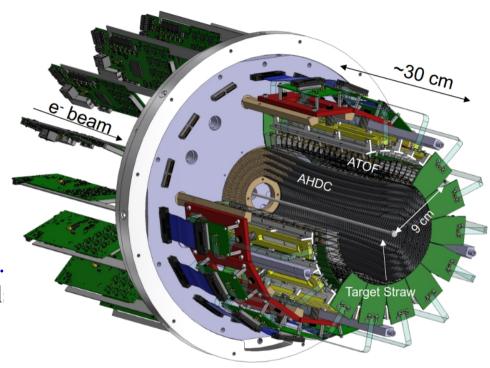


#### **ALERT Detector**

#### **◆** Cylindrical target:

- 30 cm active length
- 6 mm outer radius.
- Target at 5.6 atm pressure.
- 60µm target wall (Kapton).
- ◆ A clear space filled with helium to reduce secondary scattering from the high rate Moller electrons (R<sub>out</sub> = 30 mm).
- ◆ Hyperbolic drift chamber (32 mm < R < 85 mm). Detects the trajectory of the low-energy nuclear recoil
  - 8 circular layers of 2mm hexagonal cells.
  - 10° stereo-angle to give z-resoluation.
  - Total of 2600 wires, < 600 kg tension.
  - Maximum drift time  $\sim 250$  ns.
- ◆ Two rings of plastic scintillators:

Total thickness of 20 mm, SIPMs directly attached ToF (< 150 ps resolution) and deposited energy measurements.



### **Review Charges**

- Charge #1: Is the full list of runs to be calibrated defined with all known issues or special conditions that may affect the calibration documented and available for calibrators?
- Charge #2: Is the list of calibrated runs for each detector subsystem along with their applicable run ranges documented as a starting point for the calibration effort?
- Charge #3: Are the calibration QA specifications for each subsystem defined and reasonable?
- Charge #4: Are the plans to monitor the calibration quality for each QA timeline for each detector subsystem defined and reasonable?
- Charge #5: Has a defensible and realistic calibration timeline for the dataset been presented with trackable milestones up to the "ready for cooking" review? Has an acceptable plan for tracking the progress of the calibration work been provided?
- Charge #6: Is the manpower adequate for the proposed effort and are all Run Group leadership roles fully defined for each step in the process?

Charge #1: Run List

### **Data Scope**



#### **Data Scope**

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21354, 21352, 21351, 21350, 21349, 21348, 21347, 21346, 21345, 21344, 21343, 21342, 21341, 21349, 21343, 21334, 21334, 21334, 21331, 21329, 21312, 21326, 21325, 21323, 21322, 21317
```

# **Data Scope**

Target\E <sub>b</sub>	5 Pass	3 Pass	1 Pass
H <sub>2</sub>	1.34E+08	4.02E+08	1.25E+09
$D_2$	1.76E+10	4.08E+07	1.25E+09
<sup>4</sup> He	3.73E+10	4.73E+09	1.36E+09
Empty	4.03E+07	8.84E+07	0.00E+00
Total	5.51E+10	5.26E+09	3.86E+09

Run Ranges	Beam Energy	Solenoid	Torus
21317 – 21435	2.239	-0.5,-0.8,-1	1
21458 - 22708	10.676	-1	-1
22709 – 22791	2.239	-1	1
22795 – 22980	6.474	-1	-1
22981 – 23015	2.239	-1	1
23016 – 23061	6.474	-1	-1

- Charge #2: Is the list of calibrated runs for each detector subsystem along with their applicable run ranges documented as a starting point for the calibration effort?
- Charge #3: Are the calibration QA specifications for each subsystem defined and reasonable?
- Charge #4: Are the plans to monitor the calibration quality for each QA timeline for each detector subsystem defined and reasonable?

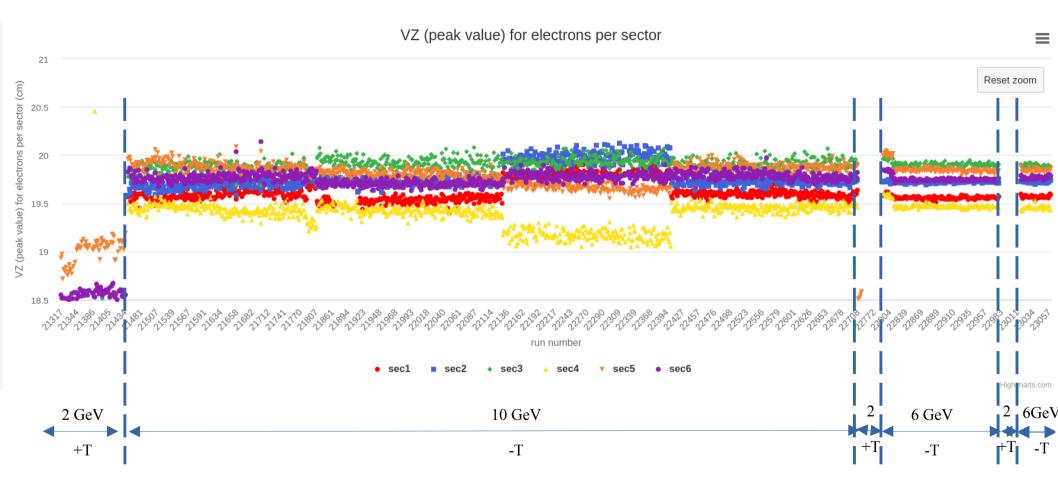
https://clas12mon.jlab.org/rgl/pass0 v7/tlsummary/

# **Sub-Systems Standard Quality Constraints**

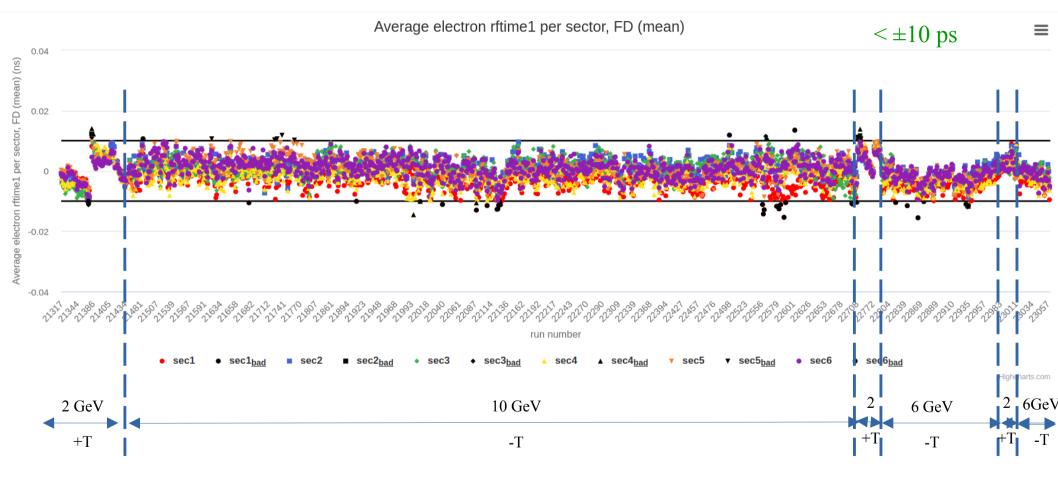
Subsystem	Timeline	Constrains
RF	rftime electron FD mean	<±10 ps
	rftime electron FD sigma	< 70 ps
FTOF	ftof edep pla midangles	8.75-10.75 MeV
	ftof edep p1b midangles	10.5-12.5 MeV
	ftof edep p2	8.75-10.75 MeV
	ftof time pla mean	< ±30 ps
	tof time pla sigma	< 135 ps
	ftof time p1b mean	< ±20 ps
	ftof time p1b sigma	< 75 ps
	ftof time p2 mean	< ±70 ps
	ftof time p2 sigma	< 350 ps
ECAL	ec Sampling	0.23-0.25
	ec gg m mean	129–133 MeV
	ec gg m sigma	15 MeV
	ec pim time mean	< ±40 ps
	ec pim time sigma	< 200 ps
	ec pip time mean	< ±40 ps
	ec pip time sigma	< 200 ps

Subsystem	Timeline	Constrains
DC	dc residuals sec mean	±0.010 cm
	dc residuals sec sl sigma	R1,R3 < 300 µm, R2 < 400 µm
LTCC	ltcc elec nphe sec	11–14
HTCC	htcc nphe sec	11–13
CTOF	ctof edep	5.6-6.4 MeV
	ctof time mean	±20 ps
	ctof time sigma	< 115 ps
CND	end dEdz mean	1.75-2.25 MeV/cm
	end dEdz sigma	< 0.30 MeV/cm
	end time neg vtP mean	±100 ps
	end time neg vtP sigma	< 300 ps
	end zdiff mean	< 0.4 cm
	end zdiff sigma	< 4 cm
BAND	band adcCorr	Comb1: 1700-1800, Comb2: 1850-1950
	band meantimeadc	
	band meantimetdc	
RICH	rich time fwhm max	< 1 ns

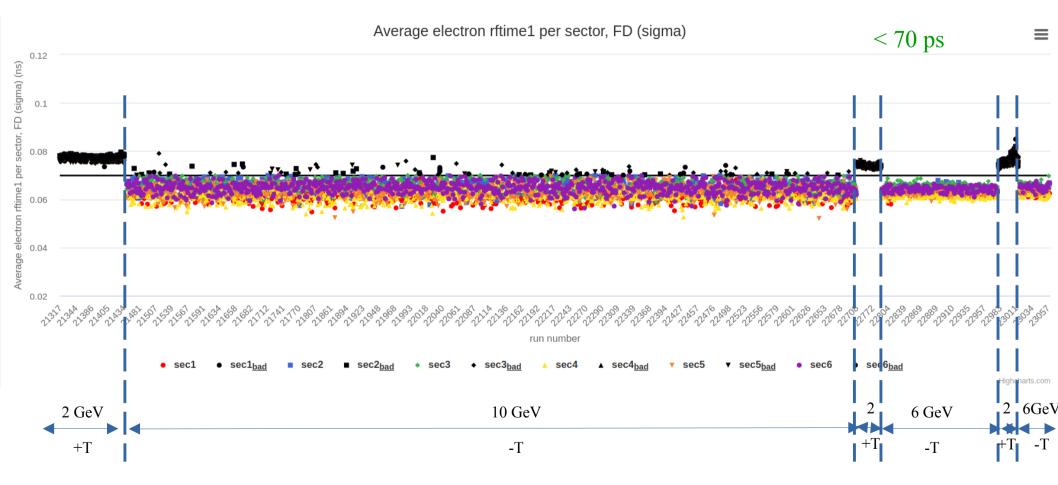
#### **Beam Offset**



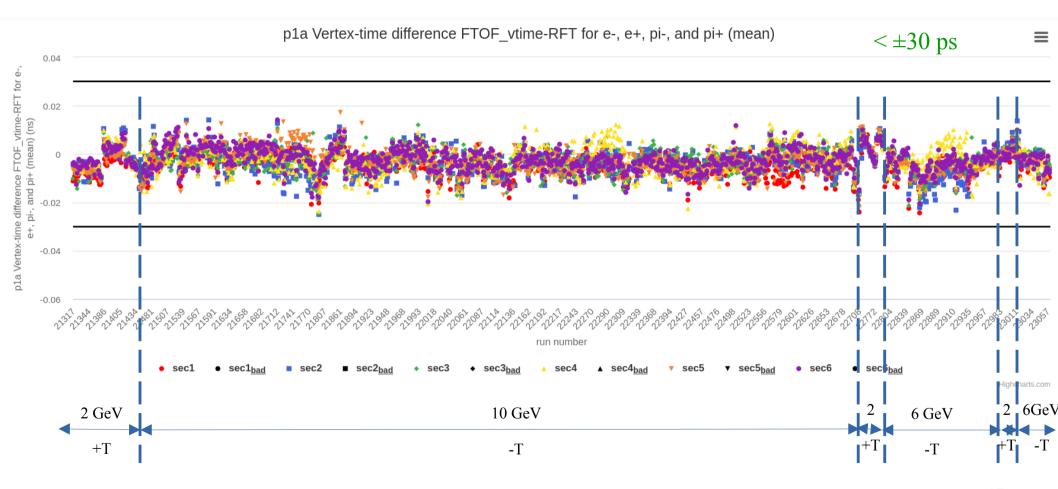
#### RF



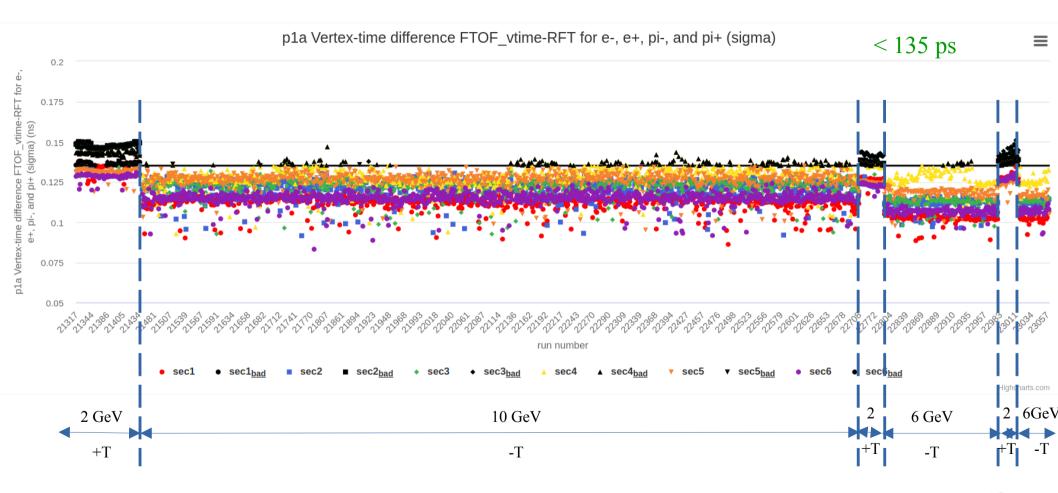
#### RF



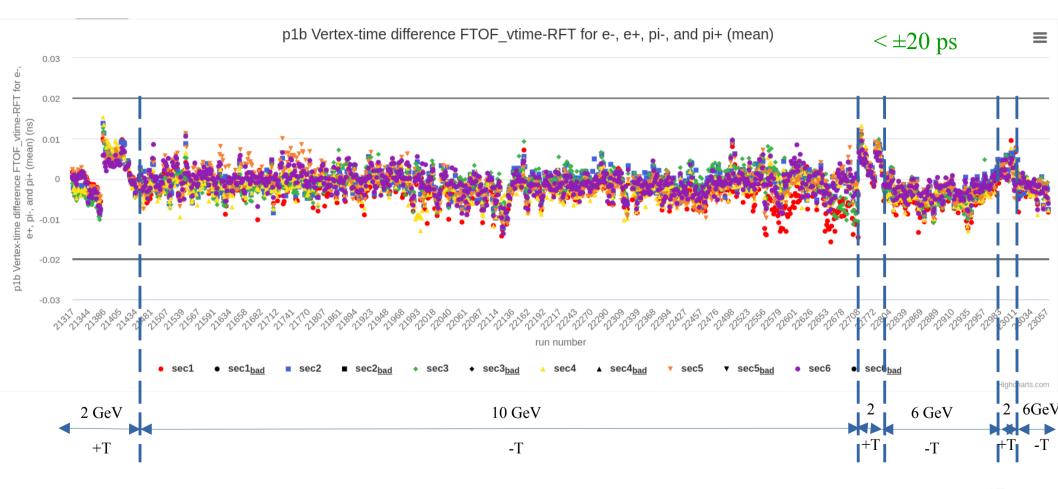
# FTOF – p1a (Timing Calib.)



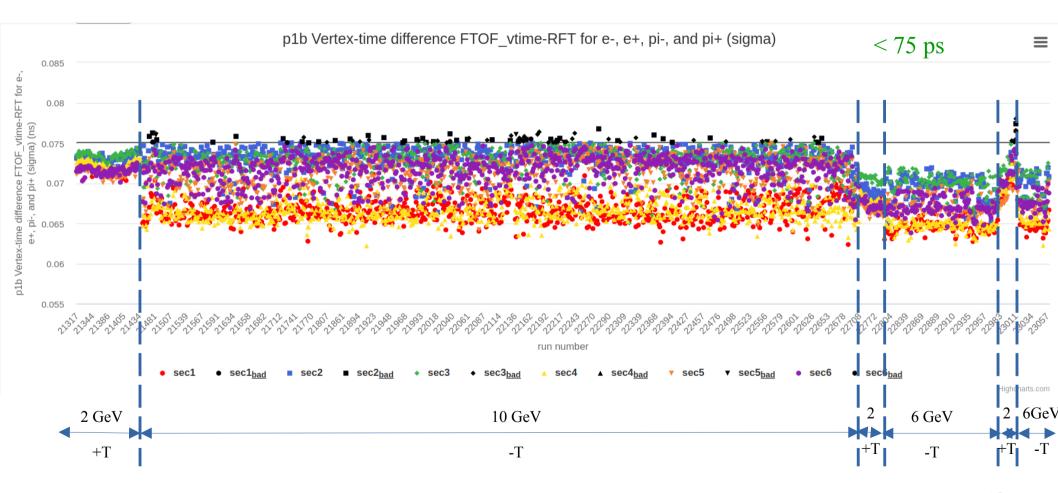
# FTOF – p1a (Timing Calib.)



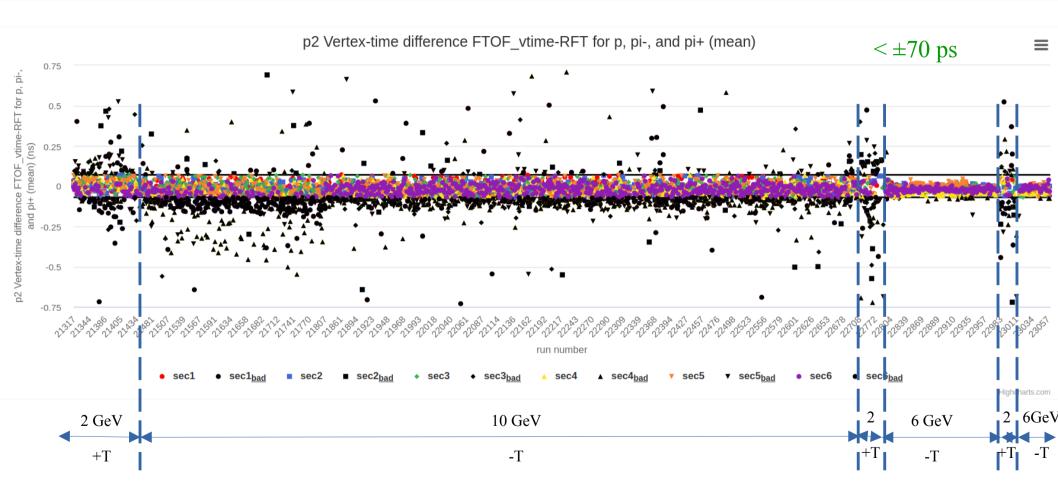
# FTOF – p1b (Timing Calib.)



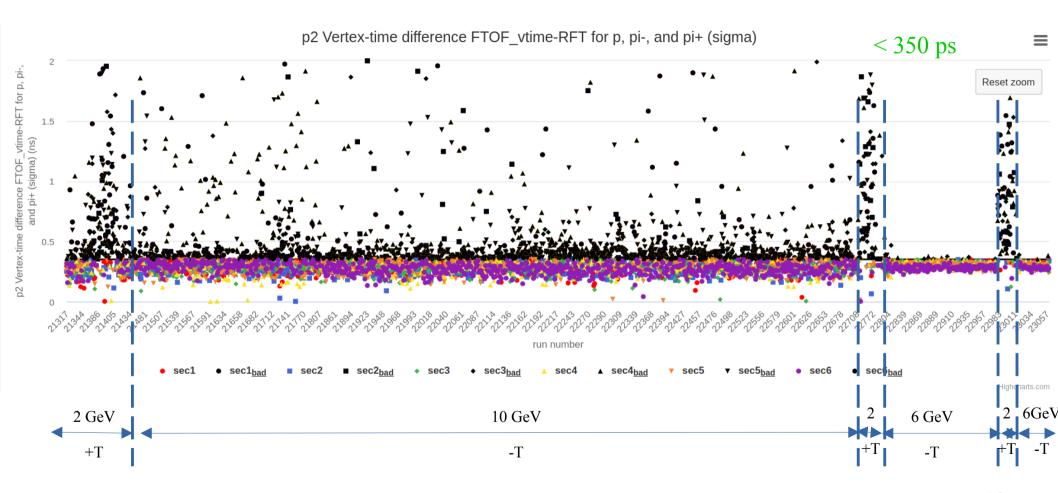
# FTOF – p1b (Timing Calib.)



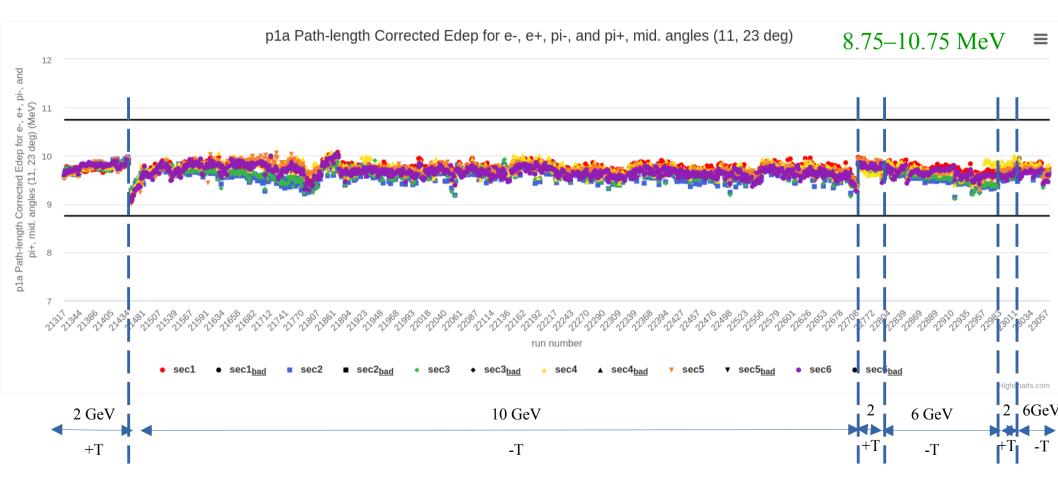
# FTOF – p2 (Timing Calib.)



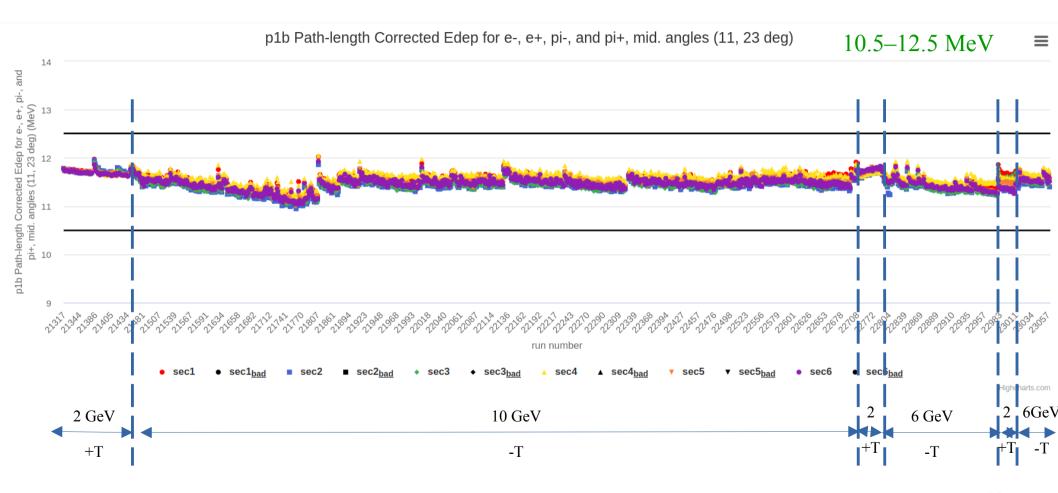
# FTOF – p2 (Timing Calib.)



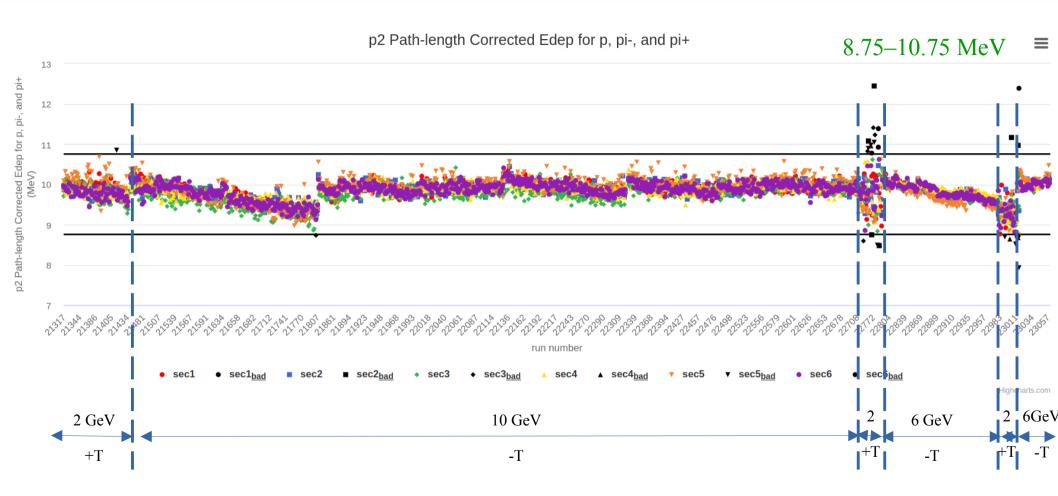
# FTOF – p1a (Energy Calib.)



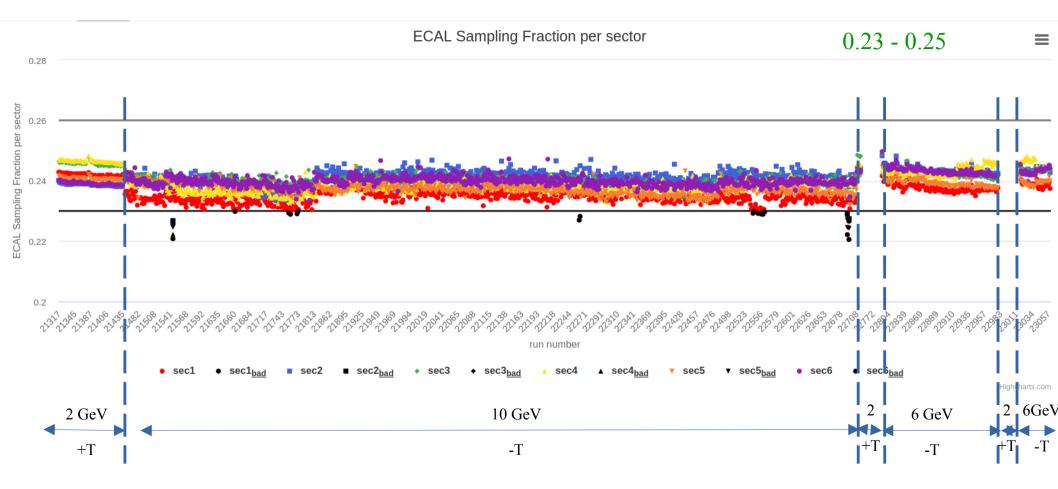
# FTOF – p1b (Energy Calib.)



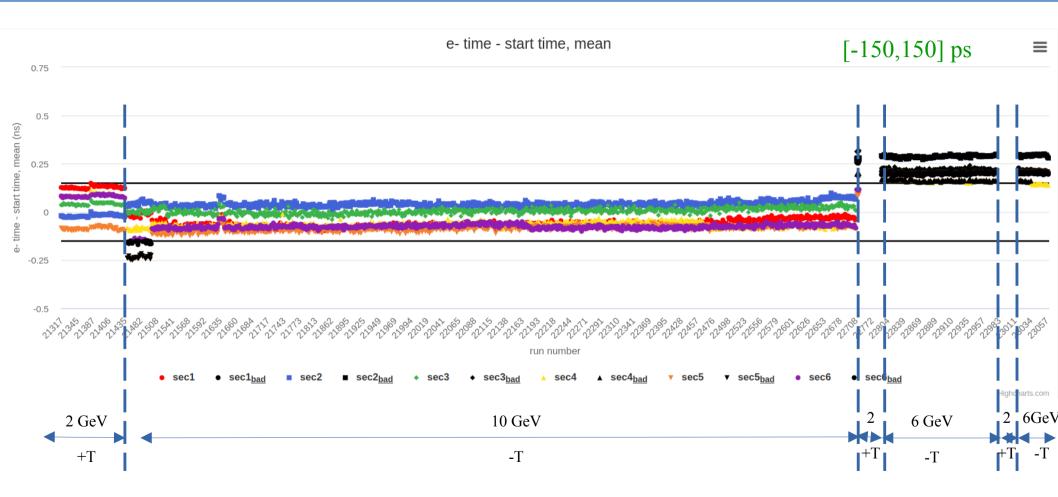
# FTOF – p2 (Energy Calib.)



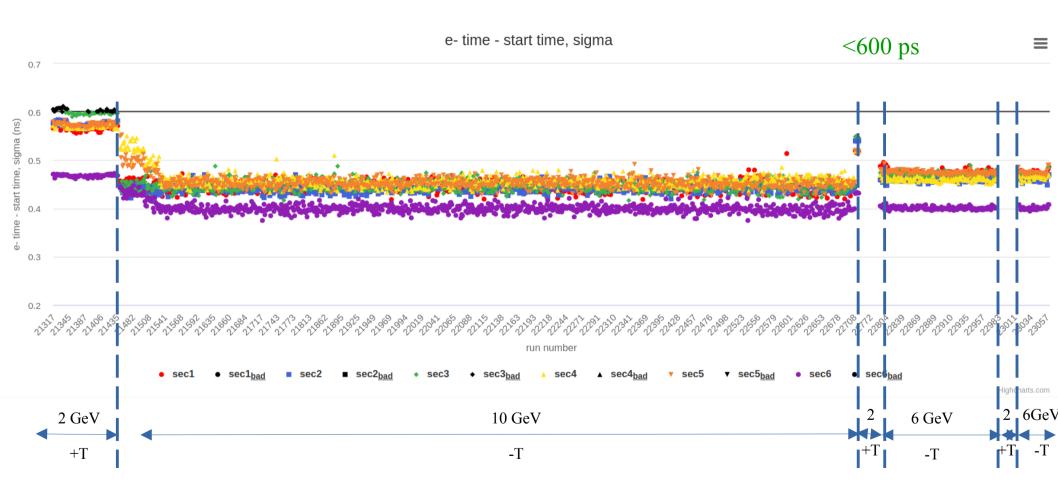
#### ECAL - SF



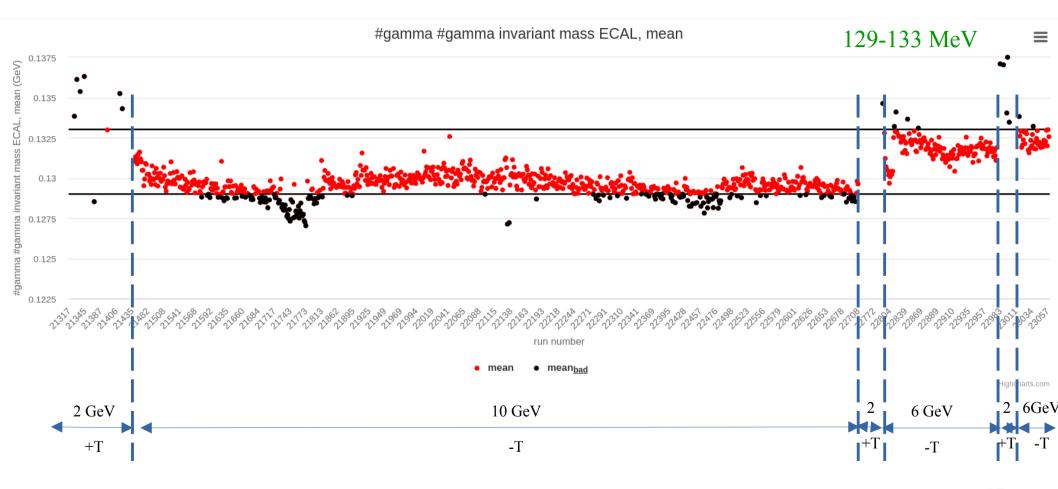
## **ECAL** - timing



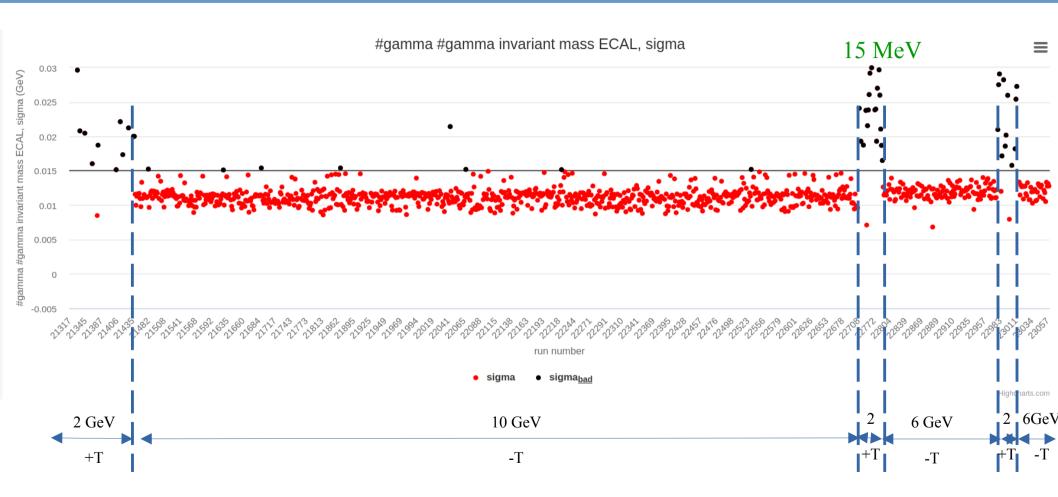
### **ECAL** - timing



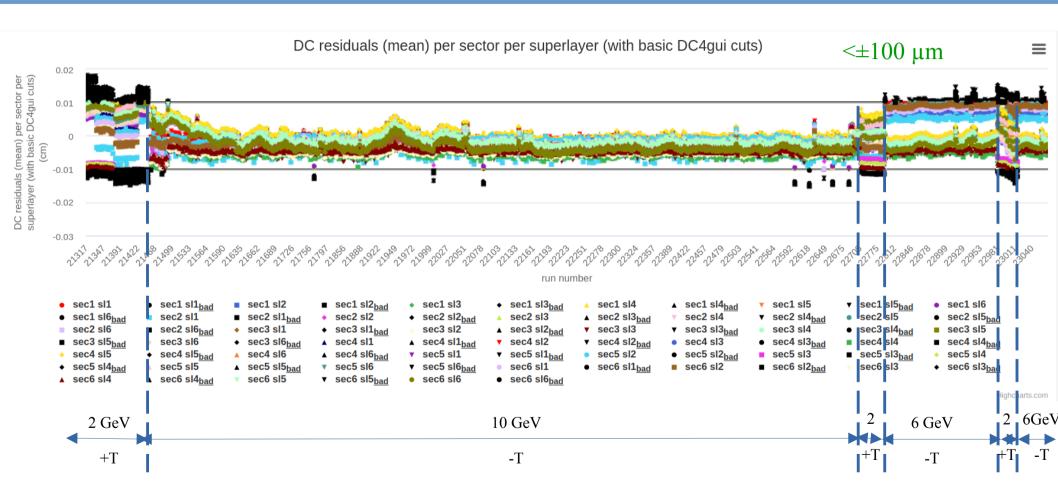
### ECAL - $\pi^0$



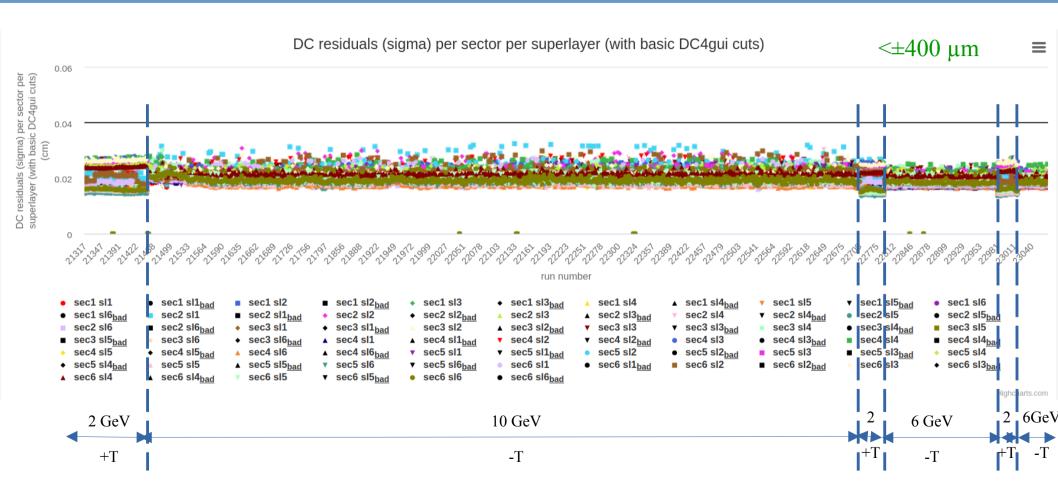
### ECAL - $\pi^0$



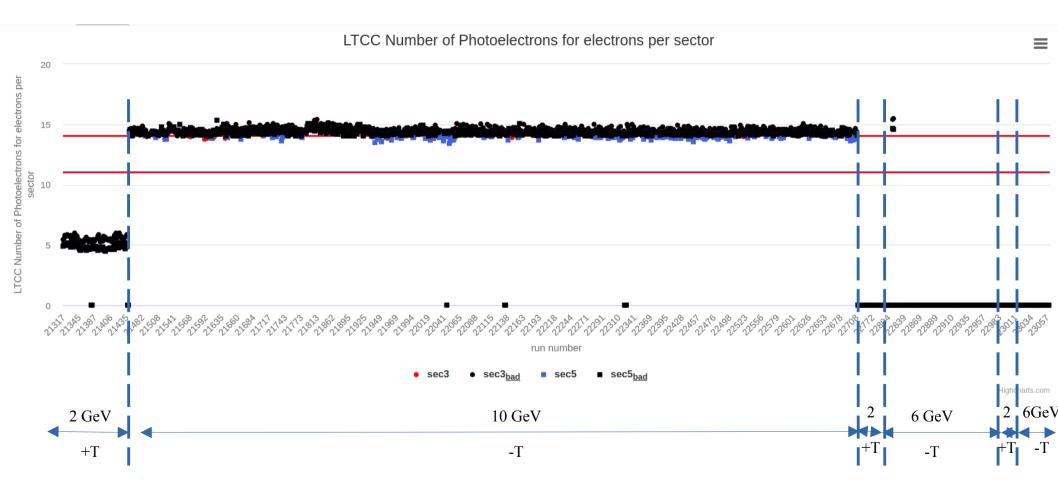
#### DC - Residuals



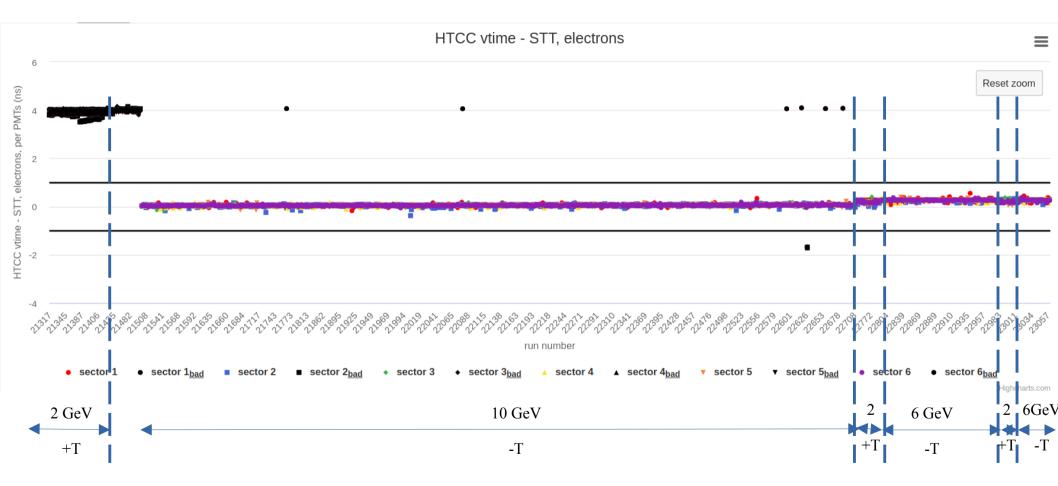
#### DC – Residuals



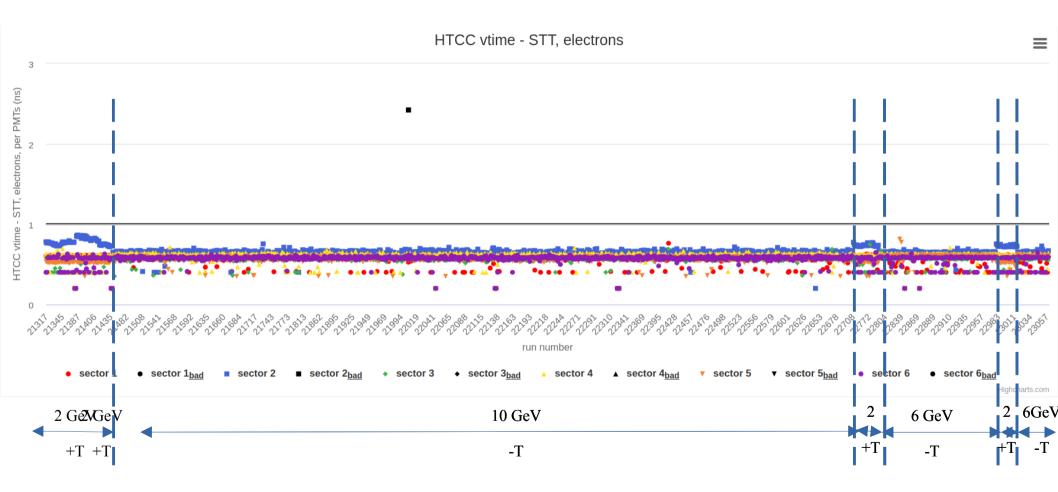
#### **LTCC**



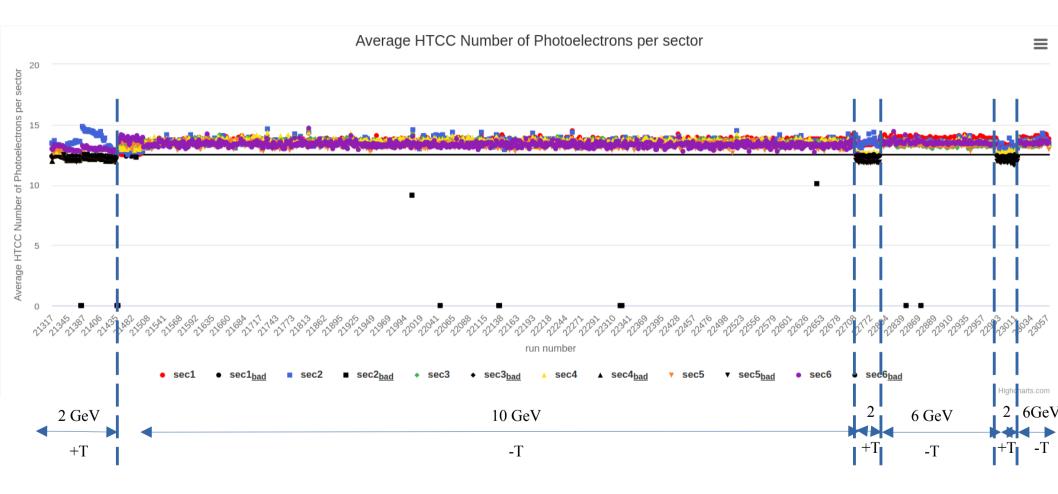
# **HTCC** - timing



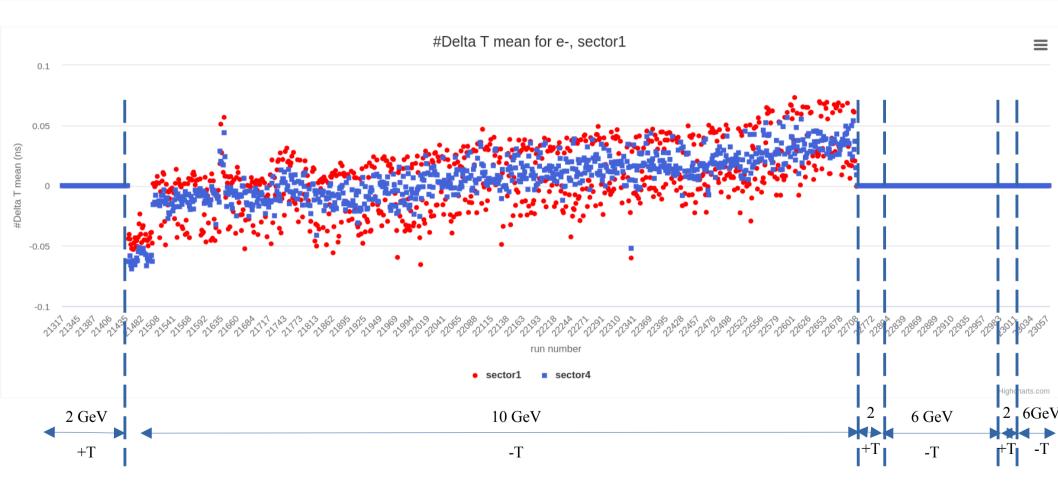
### **HTCC** - timing



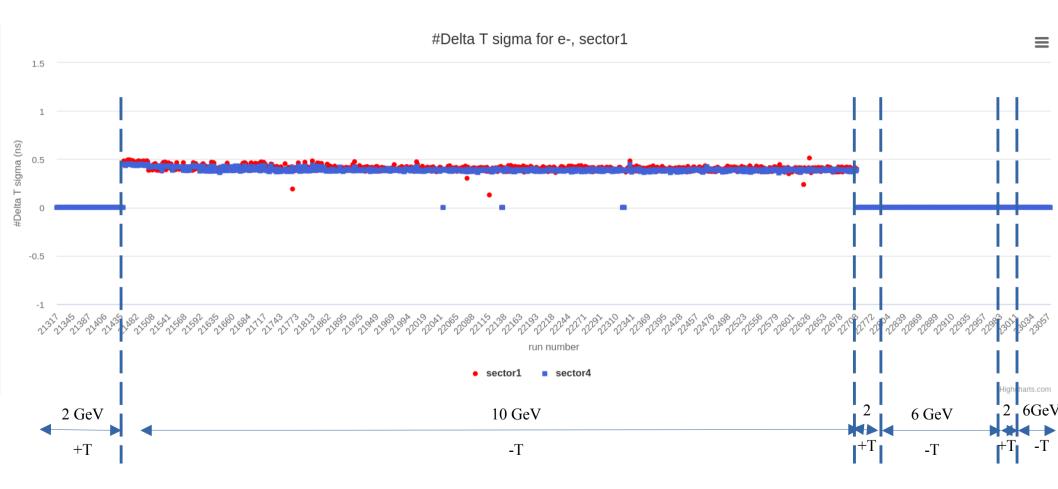
### HTCC - nphe



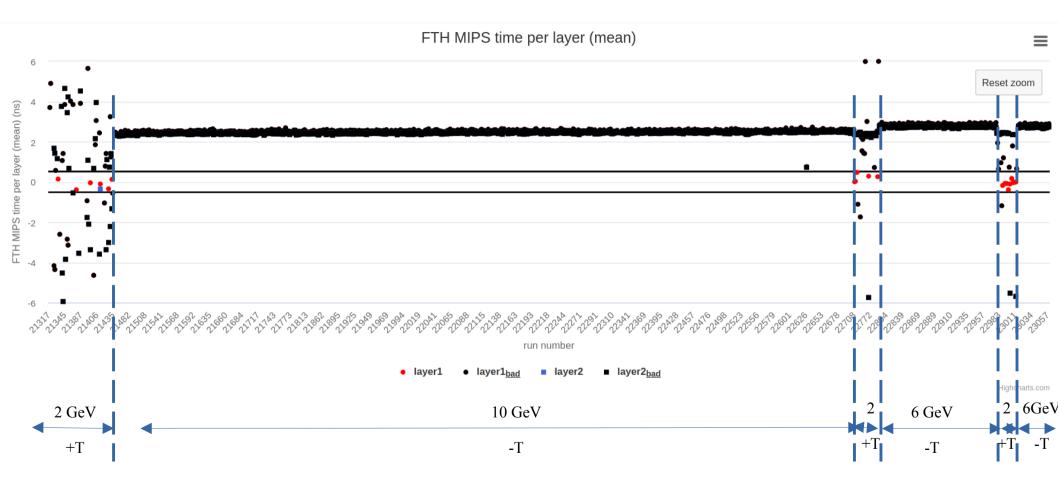
## **RICH - timing**



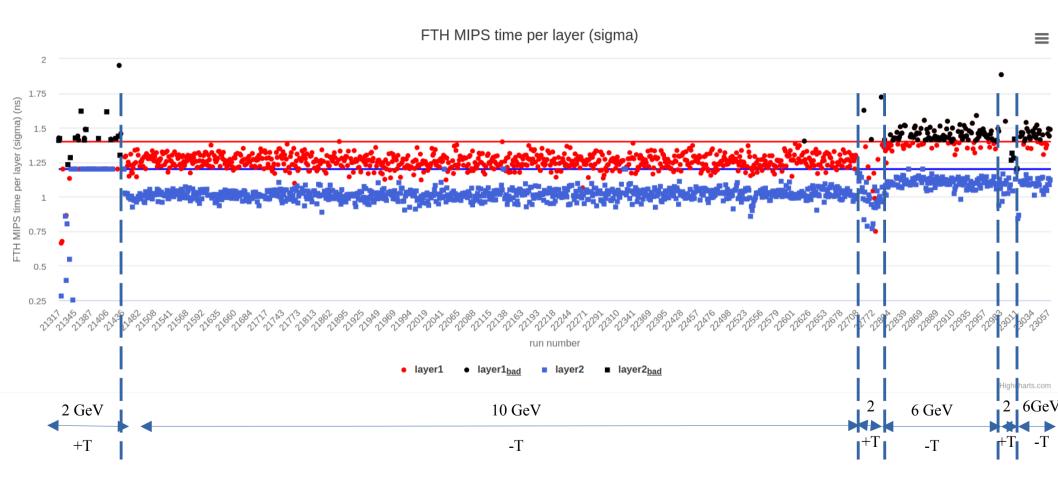
# **RICH - timing**



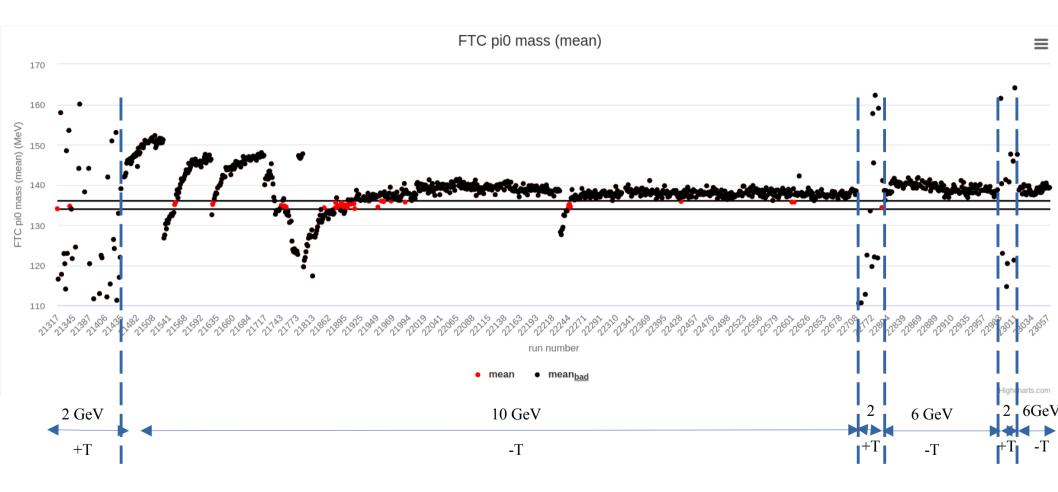
FT - timing



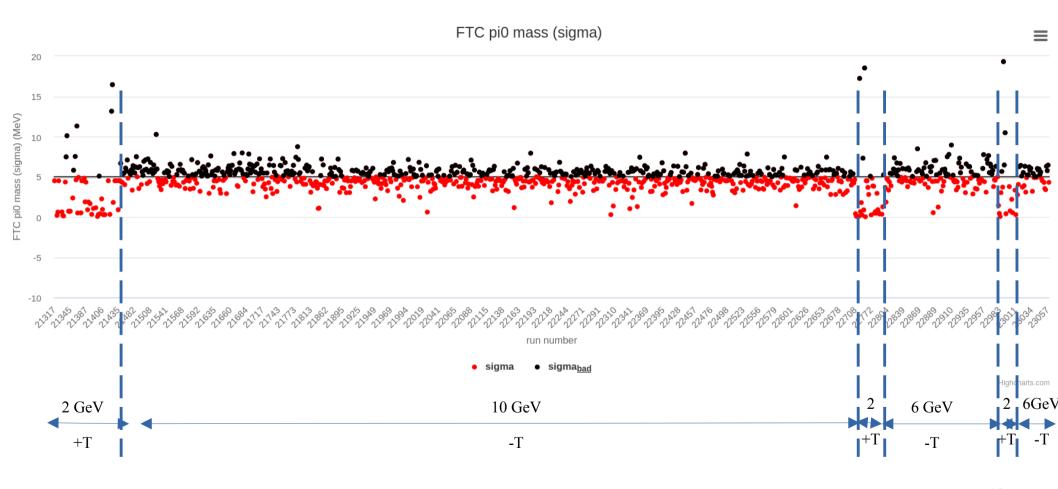
FT - timing



 $FT - \pi^0$ 



FT -  $\pi^0$ 



# **Charge #5 - Calibration timeline and milestones**

#### Calibration sequence:

- o Beam offset Completed
- FTOF calibration Completed
- RF calibrations Ongoing
- o DC calibration Ongoing
- Other CLAS12 Subsystem Calibration → ECAL, HTCC, LTCC, RICH, FT, BAND & ALERT
- Detector Alignment: DC, ALERT
- HW status tables: HTCC (done)
- AI network training/validation
- Luminosity scan studies data/MC

→ Monitor timelines, recook and reiterate if needed for specific run ranges or subsystems

### **Charge #6 - Manpower**

Run Group Contact: Raphael Dupre

Analysis coordinator: Mohammad Hattawy

Chef: Mathieu Ouillon (Former Noémie Pilleux)

Monitoring/Timelines: Mathieu Ouillon, Sangbaek Lee, Support from: Chris Dilks

FD Calibrators: Provided by CALCOM

#### **ALERT Calibrators:**

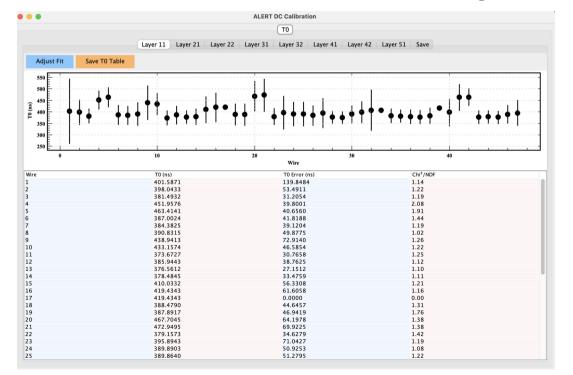
- AHDC: Raphael Dupre, Michael Paolone, Felix Touchte Codjo, Eric Fuchey, Akshit Mehta, Churamani Paudel.
- ATOF: Henry Klest, Zhiwan Xu, Noémie Pilleux, Whitney Armstrong

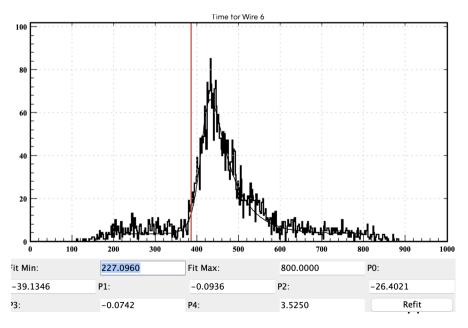
### **ALERT Calibration**

### **AHDC Timing Calibration**

#### AHDC T<sub>0</sub> calibration procedure:

- 1. Apply basic "good" wire cuts: reasonable AHDC ADC, ToT, pedestal, and waveforms are selected.
- 2. Apply tracking independent clustering cuts (see next slide).
- 3. Subtract event start-time
- 4. Fit to an exponential\*dipole function to identify rising edge.
  - -- In cases where statistics are too low to provide adequate fit: find max value 50ns as estimate.

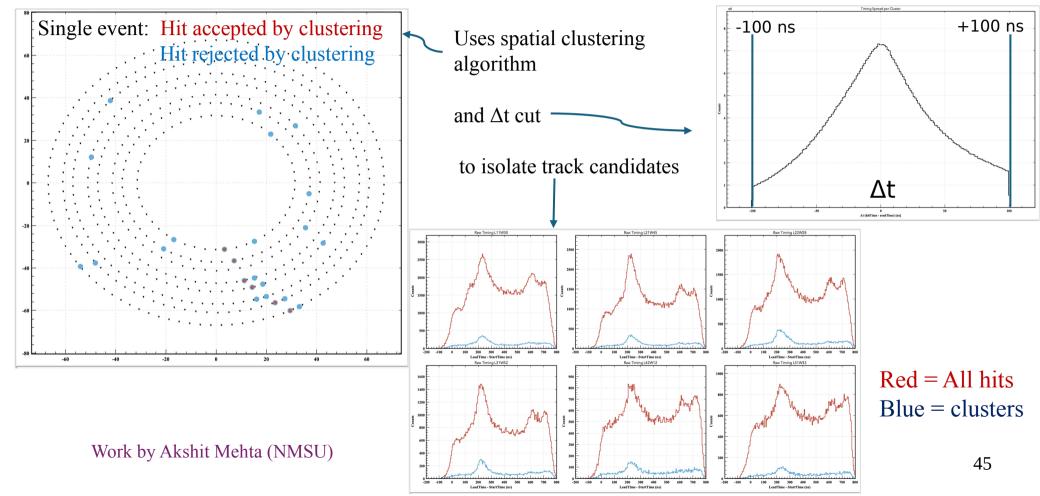




 $\frac{\exp(B - Ct)}{1 + \exp(D - Et)}$ 

# **AHDC Timing Calibration**

Developing tracking independent clustering algorithms to reduce timing background.

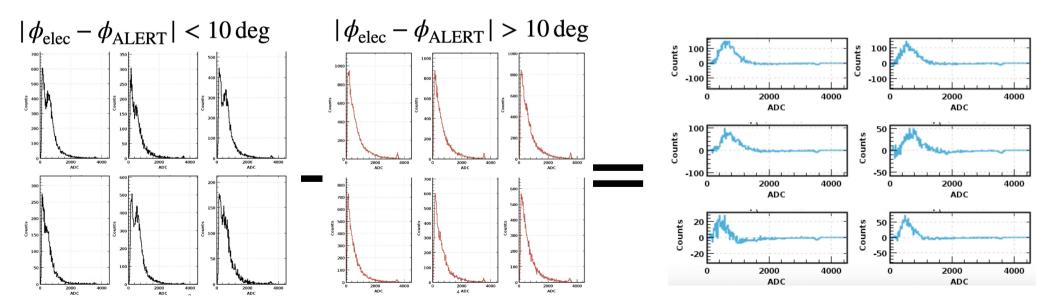


#### **AHDC Gain Calibration**

#### Procedure:

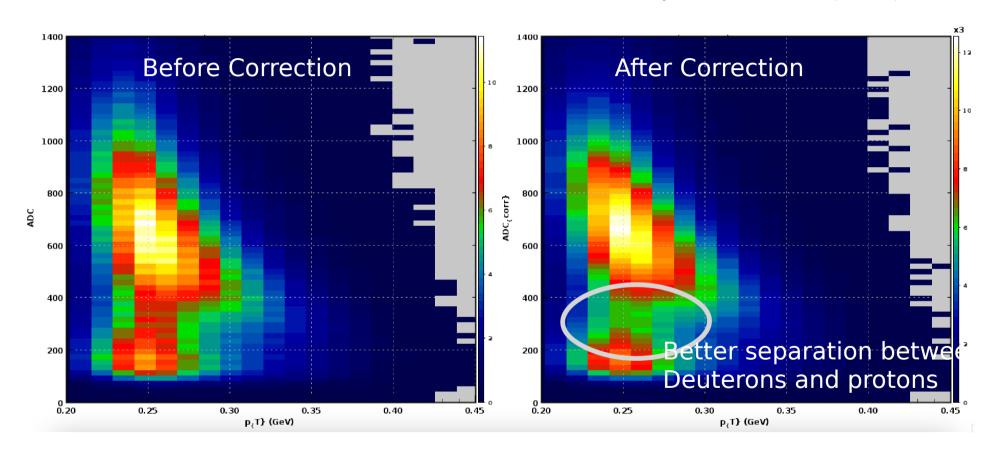
Work by Churamani Paudel (NMSU)

- 1. Apply basic "good" wire cuts: reasonable AHDC ADC, ToT, pedestal, and waveforms are selected.
- 2. Identify elastic deuteron events (with quasi-elastic contamination) via phi-cut.
- 3. Identify quasi-elastic proton events via anti-phi cut.
- 4. Subtract quasi-elastic distribution from deuteron + contamination distribution.
- 5. Fit to a Landau function.
- 6. Scale Landau peak to mean value.
  - In cases where statistics are too low to provide adequate fit: skip calibration.



### **AHDC Gain Calibration**

#### Work by Churamani Paudel (NMSU)

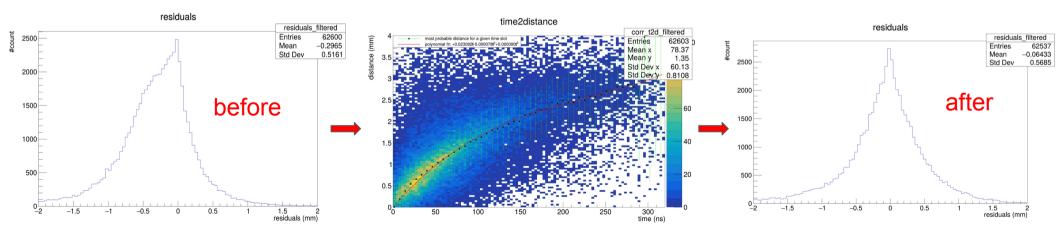


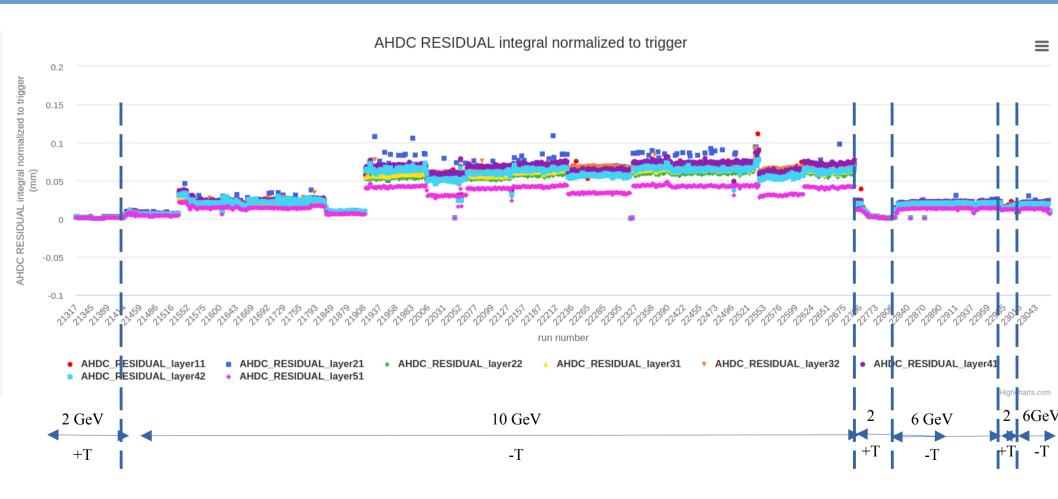
#### A new time2distance in real data

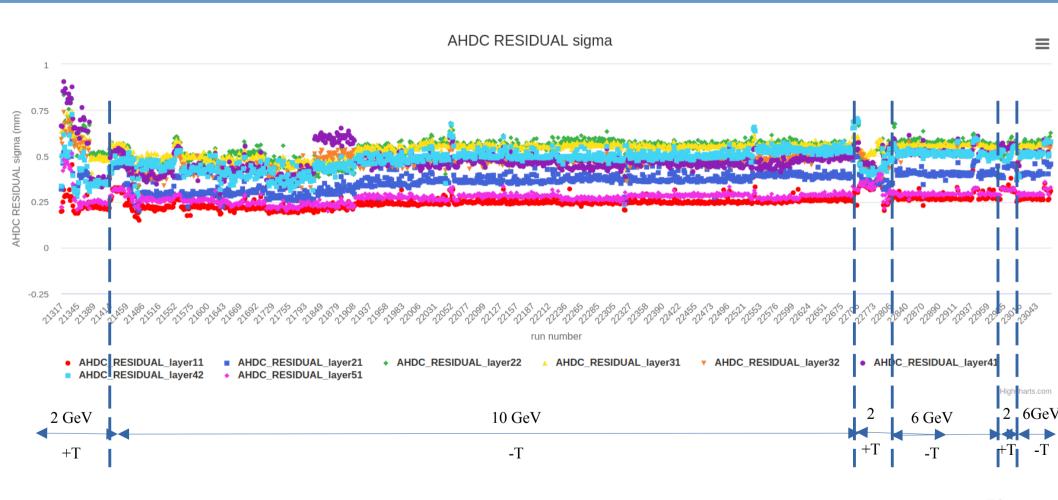
$$\mathrm{t2d} = \sum_i p_i \cdot x^i$$

```
p0 = 0 p1 = 0.0230817
p2 = -7.79242e-05 p3 = 1.13299e-07
p4 = 0 p5 = 0
```

- Elastics data from run 22712 on D2
- We made a fit to have an estimate of the time2distance. Then we re-cooked the data. We made 3 iterations. The resulting residual is better.
- The CCDB parameters of the t2d have been updated on 2025-10-29\_14-37-59 https://clasweb.jlab.org/cgi-bin/ccdb/show\_request?request=/calibration/alert/ahdc/time\_to\_distance:0:default:2025-10-29\_14-37-59







#### **AToF Calibration**

Ready in calcode: <a href="https://code.jlab.org/hallb/clas12/calibration/calcode/-/tree/main">https://code.jlab.org/hallb/clas12/calibration/calcode/-/tree/main</a>



• Bar hit time  $(t^{hit})$  from Up/Down stream end  $(\checkmark)$ :

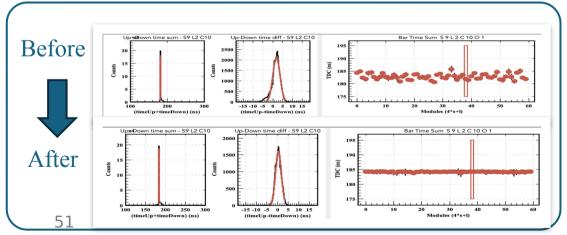
$$\circ t^{D/U} = t_{TDC}^{D} - t_{vertex} - t_{TW}^{D} \mp t^{UD} - \frac{L-z}{v_{eff}}$$

$$\circ t^{hit} = \frac{1}{2}(t^U + t^D) + c_{b2b}$$

• Wedge hit time  $(t^{hit})$  has better resolution  $(\checkmark)$ 

$$\circ t^{hit} = t_{TDC}^{w} - t_{vertex} - t_{TW}^{w} - \frac{h}{v_{eff}} + c_{w2w}$$

Example: the bar timing



#### **AToF Calibration**

Bar

- Event selection on
- Bar Phi Alignment

Wedge

- Clean wedge selection (2 options)
- Wedge Phi Alignment

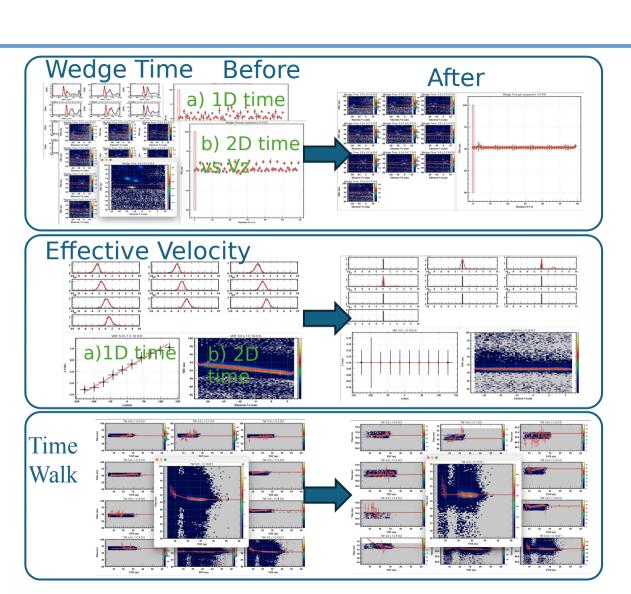
Effective velocity

Bar hit z position (2 options)

Time Walk

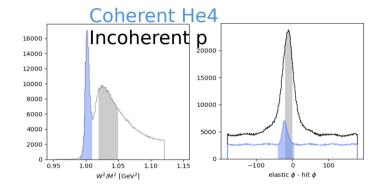
• TDC vs TOT [ns]:

Work by Zhiwan Xu & Noemie Pilleux (ANL)



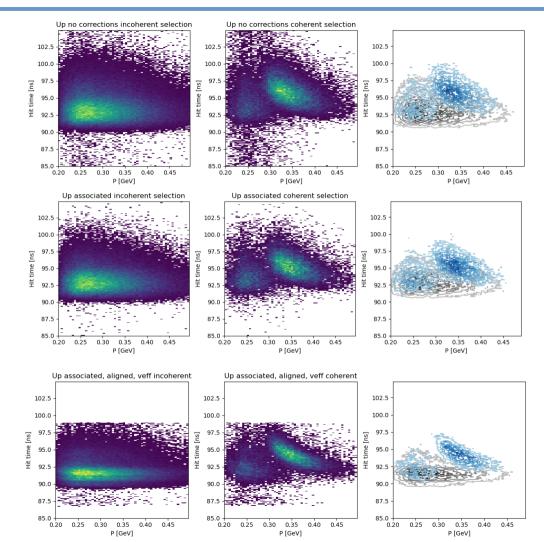
### **AToF Calibration**

Effect of ATOF calibrations – test with elastic data, 2.2 GeV <sup>4</sup>He run



Showing upstream end of the doublesided bar readout

- **Associated** = selecting hits with a matching hit, in time, in the downstream end
- Aligned: all bars are time aligned against reference bar
- **Veff**: effective velocity correction



# ALERT – Plans & Manpower

	В	C	D	E	F	G	Н	1
	Task	Implementation	Fine tuning / Al	Maintenance	Validation	Comments and future possible addition		Color code
	AHDC Decoding (incl. implementation of calibration constants)	Félix		Félix				No plan
	ATOF Decoding (incl. implementation of calibration constants)	Noémie		Noémie				Not ready
	AHDC Adv. Decod. (Time walk, non linearities etc.)							Need some
	ATOF Adv. Decod. (Time walk, non linearities etc.)	Noémie ?					1 1	Attributed
	AHDC Noise Treatment	Félix	Noémie	Félix			1 1	Ongoing
	ATOF Noise Treatment	Noémie ?						Done
;	AHDC Clustering	Mathieu	Mathieu	Mathieu				
	AHDC + ATOF Clustering		Mathieu	Mathieu				
	Track + ATOF Clustering	Noémie						
	Helix Fit (do proper helix fit or AI based reconstruction, and use e- vertex)	Mathieu				Needs a new version with actual helix fit to the wires, then time based, then include e-		
	Check clustering (verify if some hits need to be reconsidered based on the helix fit)					Needs better helix fit to start		
	PID pass 1		Uditha			Base PID using dE/dx and times is missing		
	Kalman Filter base	Mathieu / Éric	Éric	Éric				
	Kalman Filter with e- and ATOF information	Éric		Éric		ATOF hit integration option would be great		
	Kalman Filter accounting for PID pass 1					Allow the Kalman filter to treat different PIDs		
	Check clustering (verify if some hits need to be reconsidered based on the helix fit)					Allow dropping some hits during the tracking		
	PID pass 2					The state of the s		
	Kalman filter refined fit (and alternate PIDs)							
	Output production (with covariance matrix)					We need to fill a new bank with full recon (PID and covariant M)		
	AHDC Gain calibration	Churamani / Esteban	With run selection			We might want to have constants for ADCmax, ToT, and noise level		
	ATOF Gain calibration	Noémie / Zhiwan	With run selection			We might want to have constants for Abolitax, 101, and holse level		
C A	AHDC Time calibration	Michael	With run selection					
	ATOF Time calibration bars	Noémie / Zhiwan	With run selection					
	ATOF Time calibration lears  ATOF Time calibration wedges	Noémie / Zhiwan	With run selection					
	AHDC Pile-up treatment	NOETHIE / ZHIWAH	With run selection			This needs some specific analysis		
			With run selection					
	ATOF Noise Treatment	Mahammad				This needs some specific analysis		
	Beam position	Mohammed	With run selection			would be conful for an an artificial to		
O N	AHDC Alignment (x,y / z / phi / tilts)		With run selection			Would be useful for CLAS calibration		
	ATOF Alignment		With run selection			Can be done with elastics to calibrate z and phi position with CLAS12		
	ALERT CLAS Alignment (mostly in z but maybe in other directions)			- 111				
N	AHDC Digitization	Félix	Félix	Félix				
	ATOF Digitization							
	AHDC Noise Merging							
	ATOF Noise Merging							
	AHDC Dead channels							
	ATOF Dead channels							
	Geometry adjustment to calibration							
	Reconstruction validation							
	Documentation					We need to renew the software installation documentation (probably redirect to CLAS doc now)		
N E	Timelines	SangBaek						
	Cooking (making the standard and specialized yaml files)	Mohammad				Need to be made available somwhere		
A L	Run list (define golden runs, run periods, etc.)							
	Polarization summary							

# **Backup slides**

#### Use the same time2distance for real data and simulation

simu deuteron p = 250 ± 50 MeV

- ♣ The CCDB T2D is inverted in the simulation
- We have a good agreement between the reconstructed distance and the doca.

