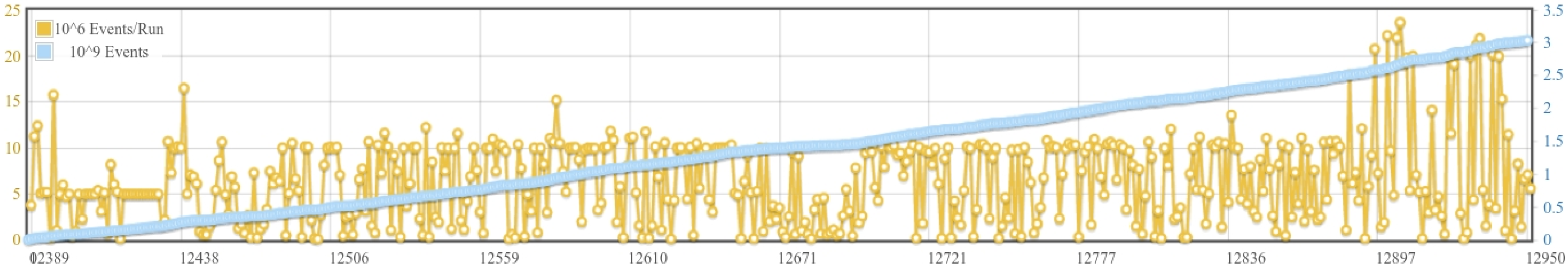
OLD DOMINION UNIVERSITY

BONuS12-RTPC Calibration For RG-F

M. Hattawy
(On behalf of RG-F)

RG-F Pass1v2 Readiness Review, June 17th, 2022, JLab

Data Scope



Showing runs: 12389 - 12951. 472 runs per page. Total runs: 472

Data Range:

- Summer run:

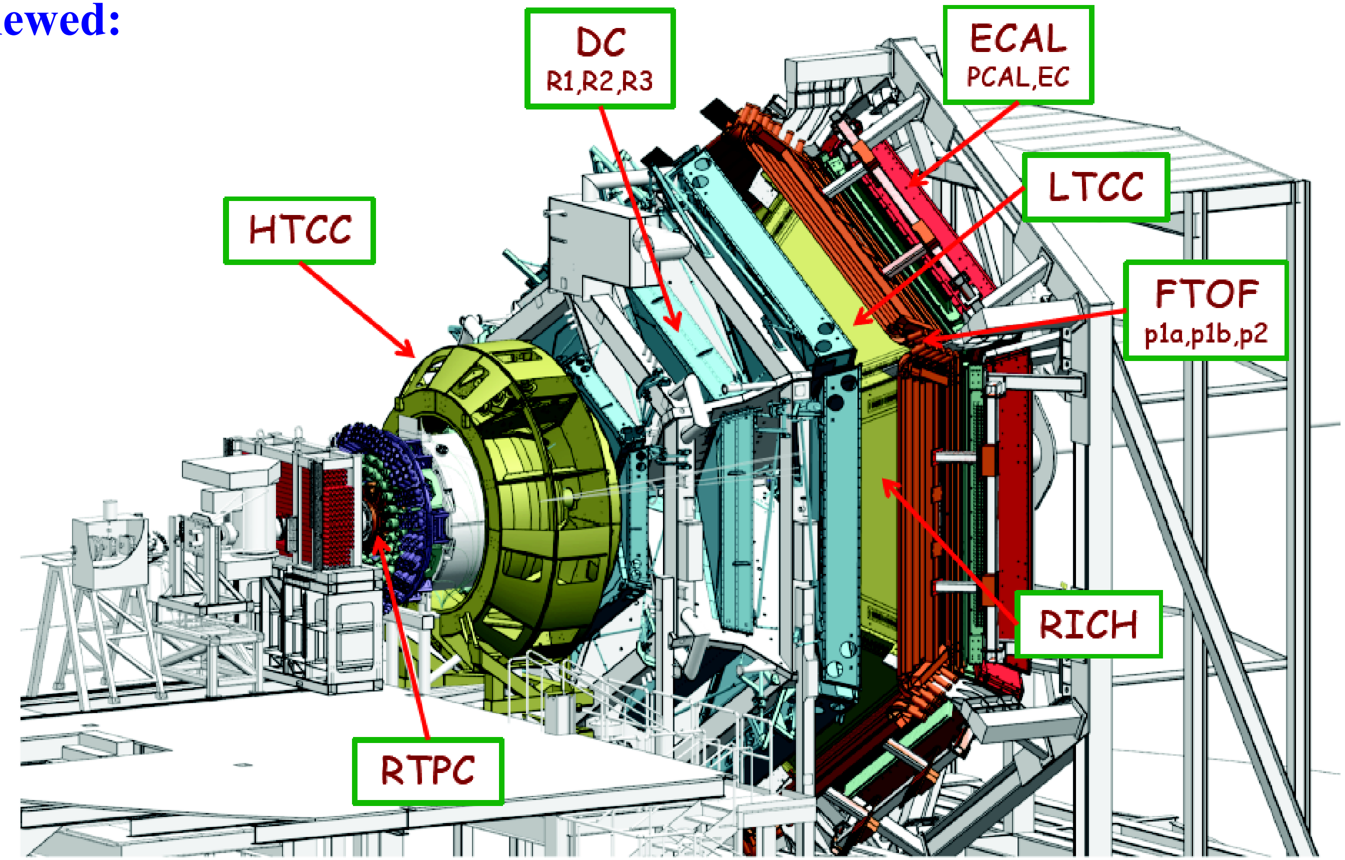
12389 – 12434 (Out-bending 1 pass)
12435 – 12443 (In-bending 1pass)
12447 – 12951 (In-bending 5 pass)

Beam Energy	Target	Summer 2020
1 Pass Data	H2	185M
	D2	45M
	4He	44M
	Empty	22M
5 Pass Data	H2	266M
	D2	2355M
	4He	51M
	Empty	45M
		3013M

Calibration Scope

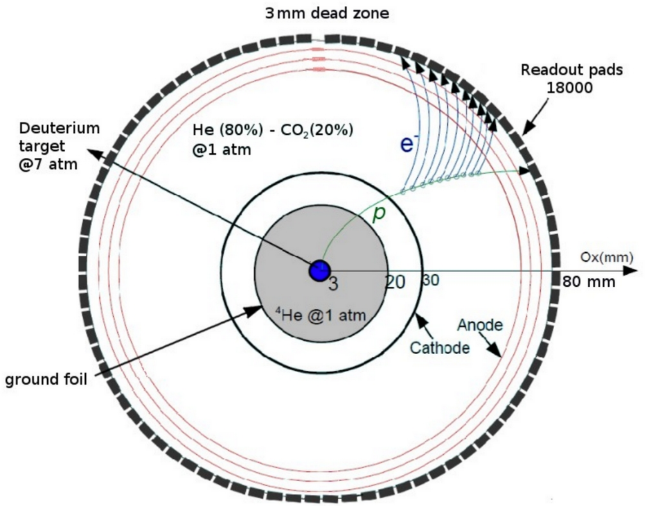
*** Detectors calibration to be reviewed:**
- RTPC
- HTCC
- DC
- LTCC
- RICH
- FTOF
- EC

*** Detectors to be later calibrated (pass2):**
- FMT (3 layers)
- CND + CTOF



RTPC Calibration

RTPC Calibration



- Work principle:

Charged particle ionizes the gas atoms

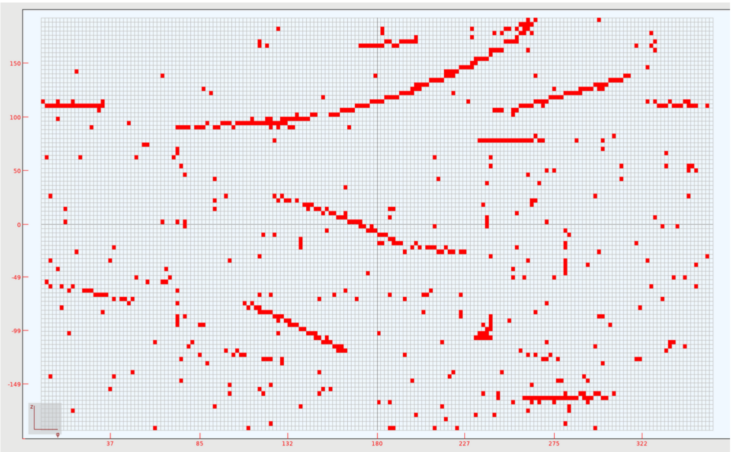
→ Under EM field, released electrons follow their drift paths at a certain drift speed

→ Amplifications via the 3 GEM layers

→ Readout board → MVT FEU electronics →

Recorded info
- Pad # → Pad (x,y,z) - Time - Signal height

- Offline reconstruction:



* Time and Pad location

→ 3D reconstruction of track

→ vector p/q, vz, vertex time

* Signal height —Pads' gain (G_i)→

$$\left\langle \frac{dE}{dX} \right\rangle = \frac{\sum_i \frac{ADC_i}{Gi}}{vtl}$$

RTPC Track Reconstruction

1. Track Finding: Hits chaining into contiguous collections, i.e. tracks
2. Time shifting: Each chain of hits for a track is shifted in time, such that the first ionization starts at the cathode.
3. Reconstructing the hit position:

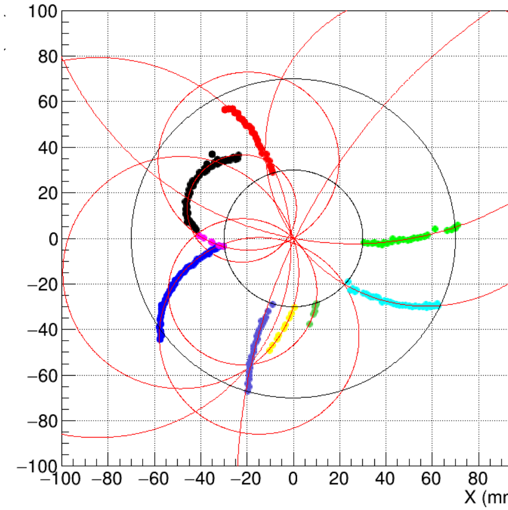
(Pad # → Pad (x,y,z), Time) → The original location of the ionization can be determined as:

$$r(t,z) = \sqrt{r_{max}^2(1-x) + r_{min}^2 x}$$

$$x = \frac{t - a_t}{b_t}$$

$$\Delta\phi(r,t,z) = a_\phi + b_\phi \ln \frac{r_{max}}{r}$$

→ Hit (r, ϕ, z)
* at the ionization point in the drift region

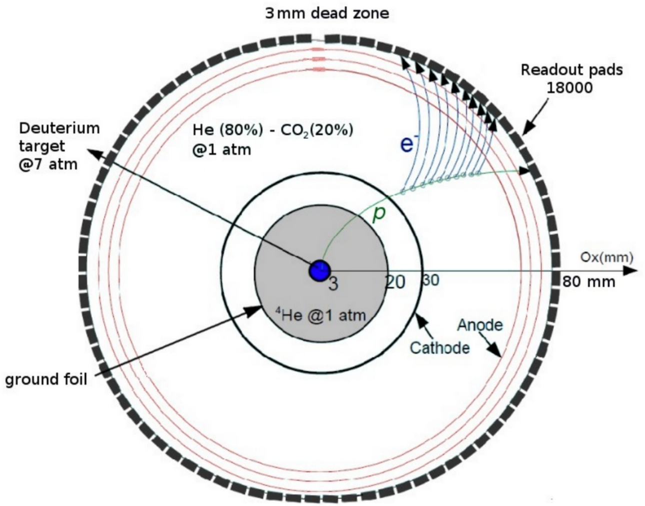


* a, b, parameters are z-dependent parameters initially calculated by a simulation of the magnetic field in Garfield++ and re-tuned using real data (next slide).

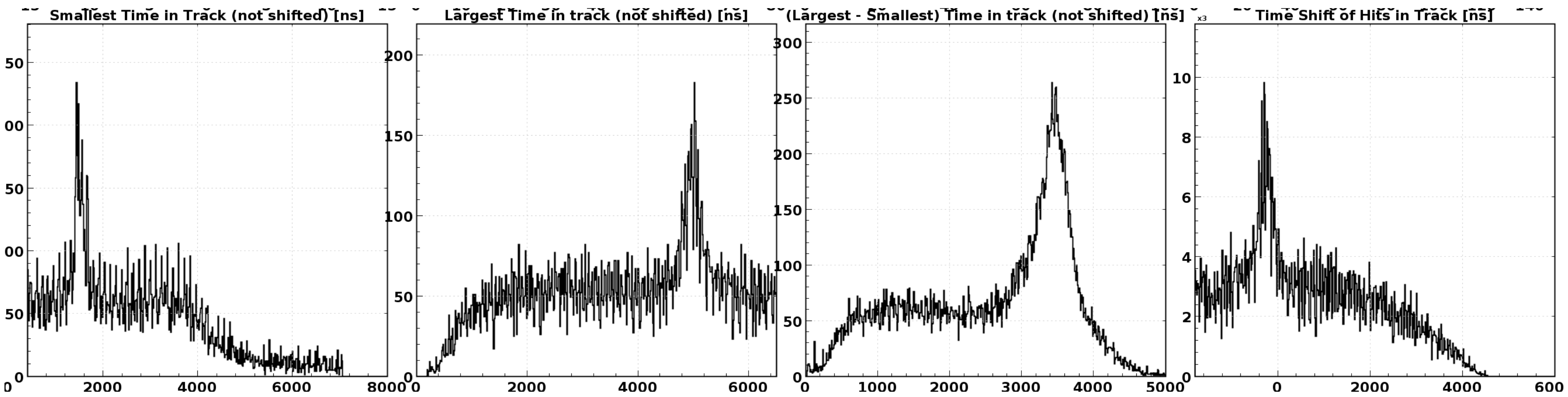
a_t = "Smallest Time" = time offset
b_t = the max. drift time (Largest time - Smallest Time)
a_ϕ (comes entirely from the GARFIELD++, the drift between GEM1 and Padboard)
b_ϕ = tan(θ_Lorentz)

4. Helix Fitting → Track's p/q, vz, ...

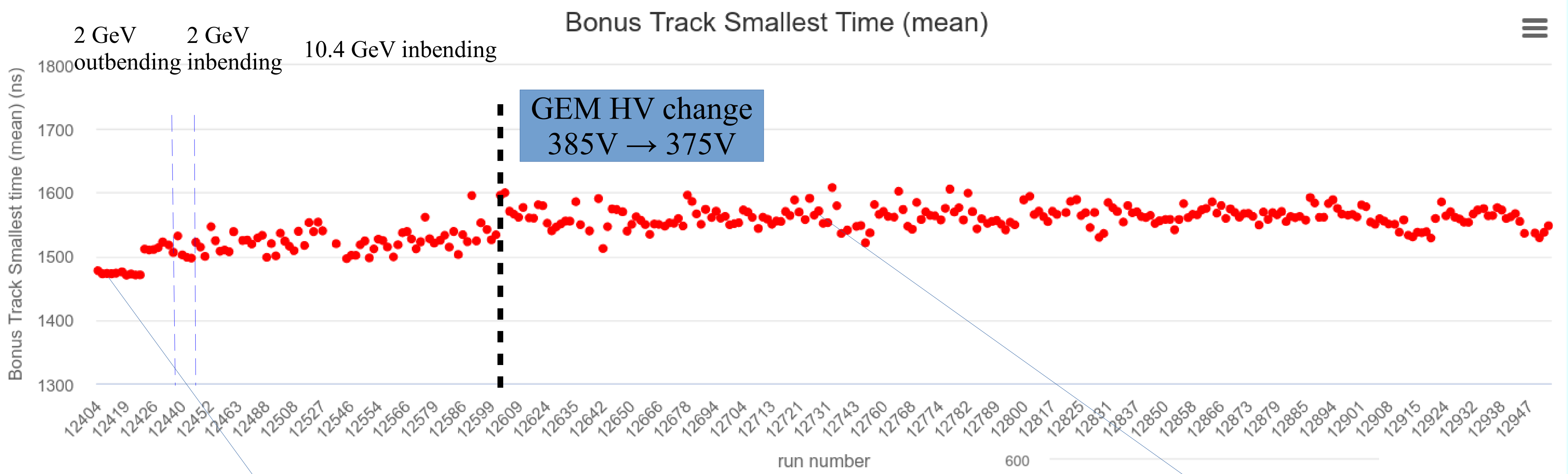
BONuS - Timing

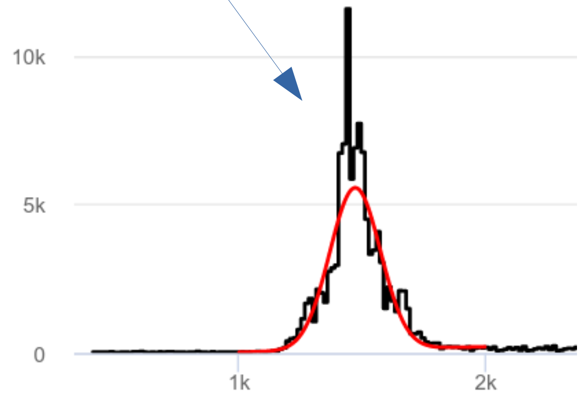


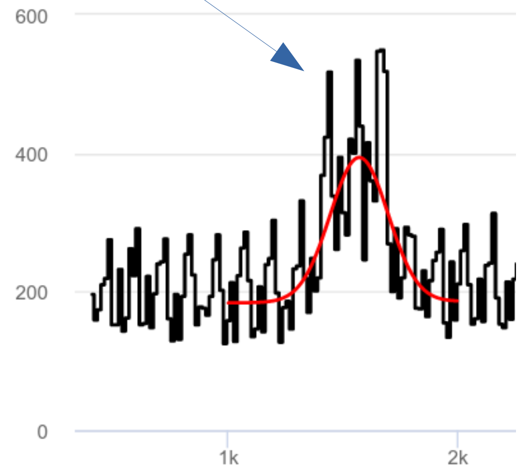
- Smallest time → Timing offsets between the trigger and the RTPC.
- Largest time → Sum of offset + maximum drift time
- Largest - Smallest time → maximum drift time from cathode to GEM1
- Time shift → Difference between measured largest time within a track and that expected for an in-time track



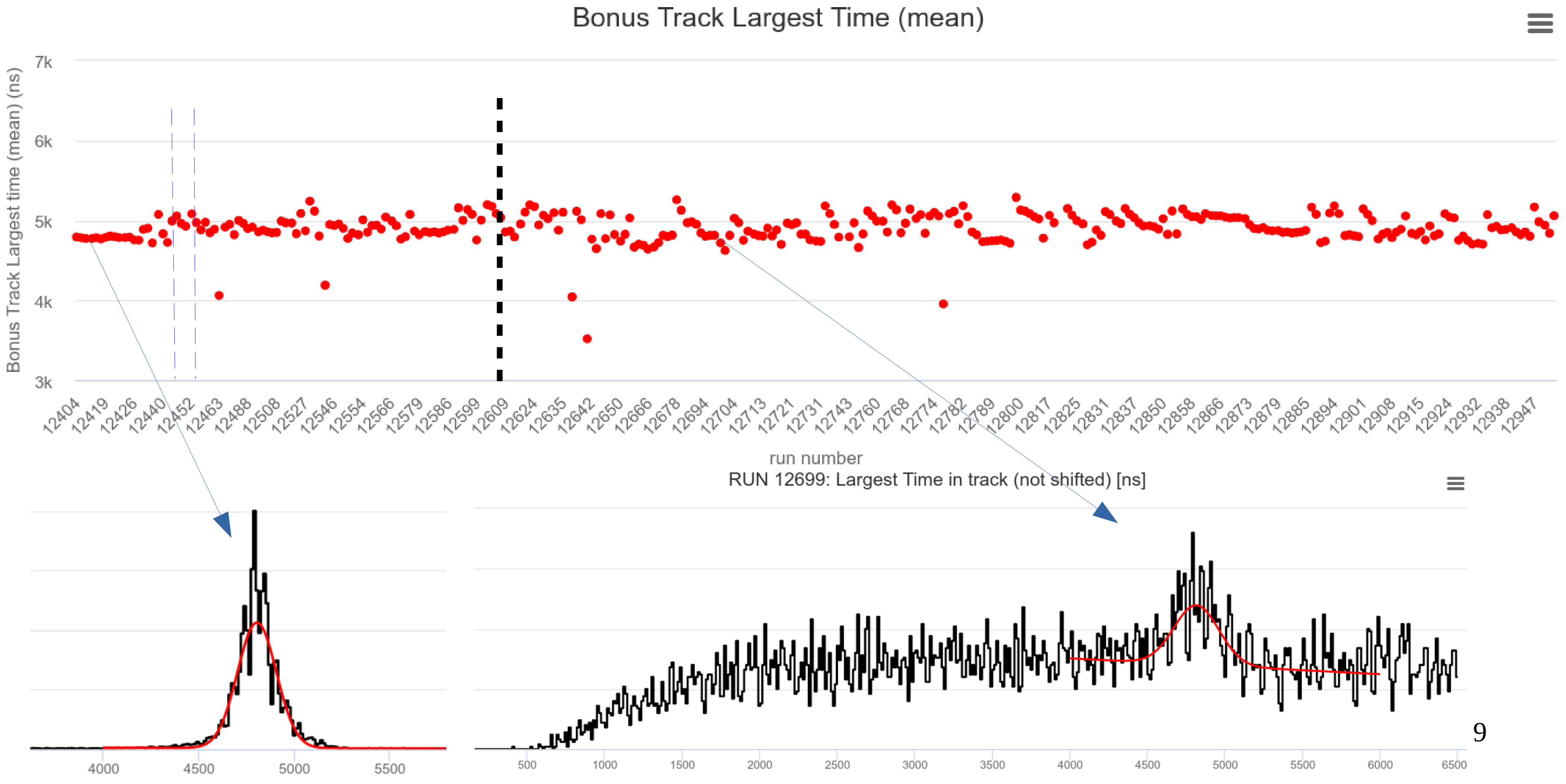
BONuS – Timing (Smallest Time)



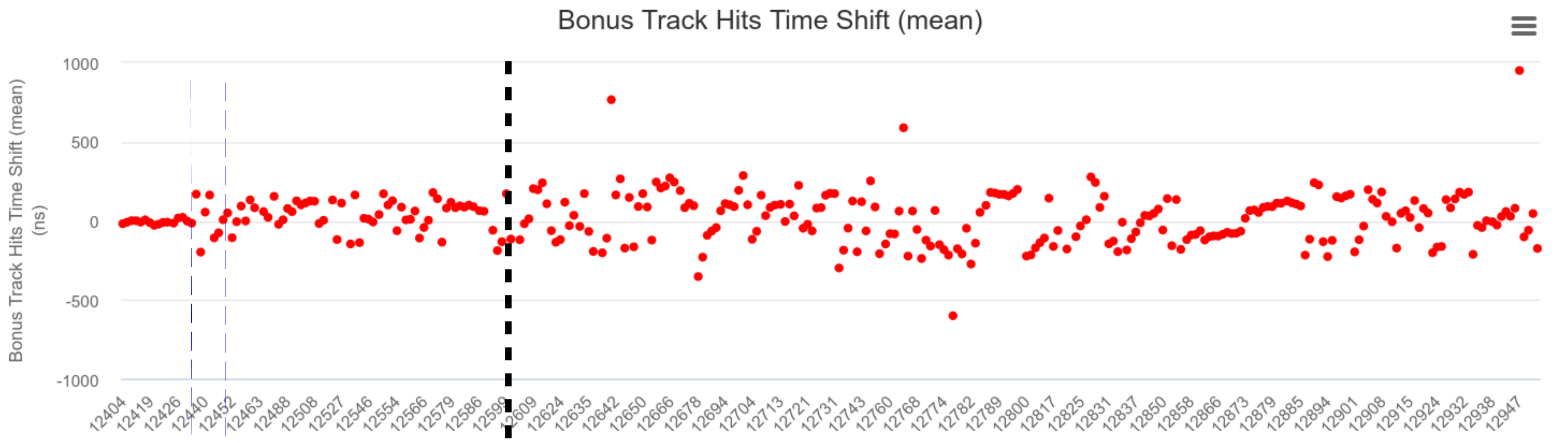


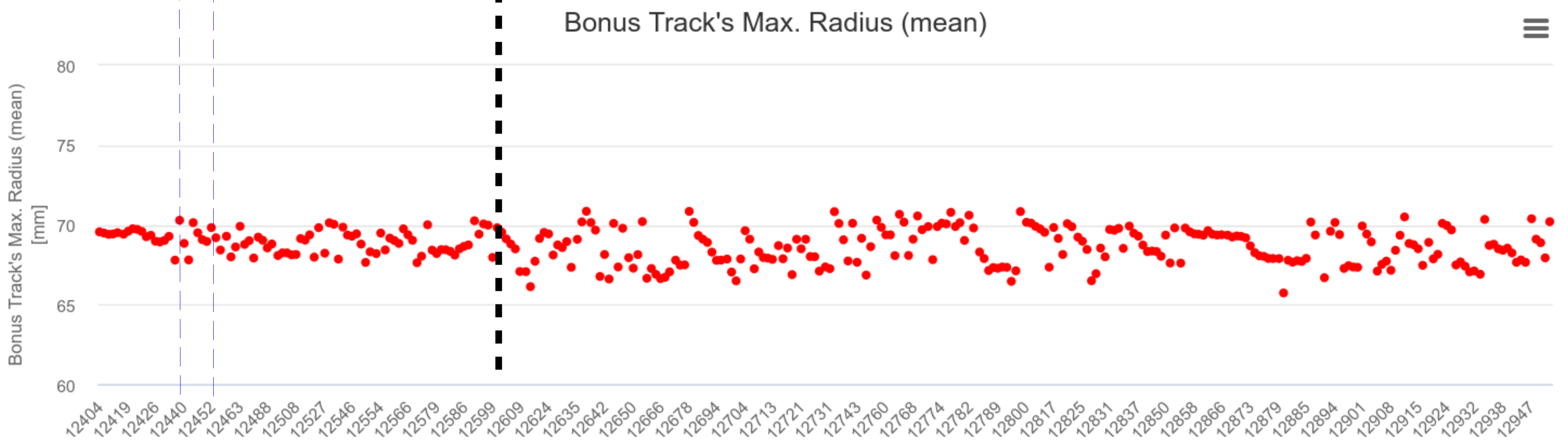


BONuS – Timing (Largest Time)



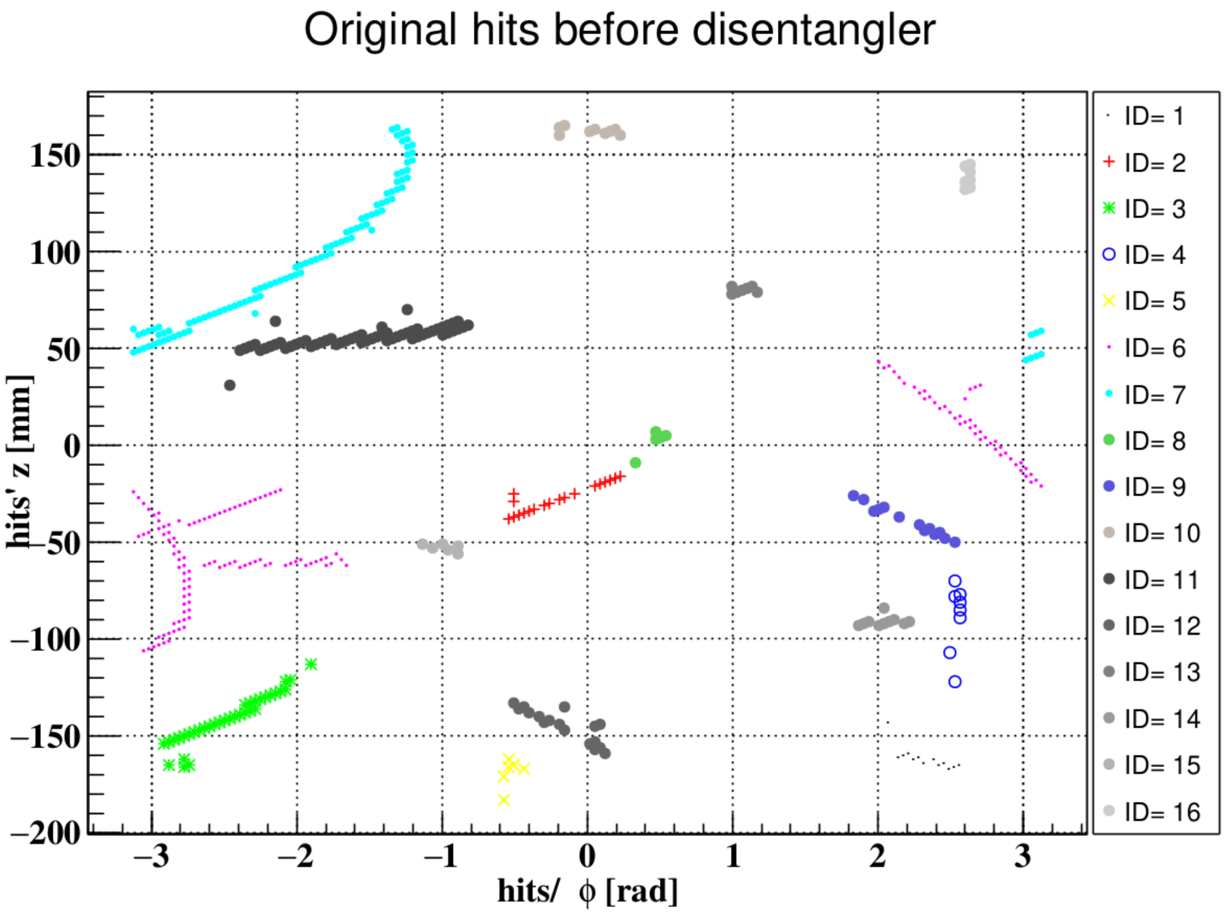
BONuS – Timing Quality Timelines





Updates on the RTPC Track Reconstruction

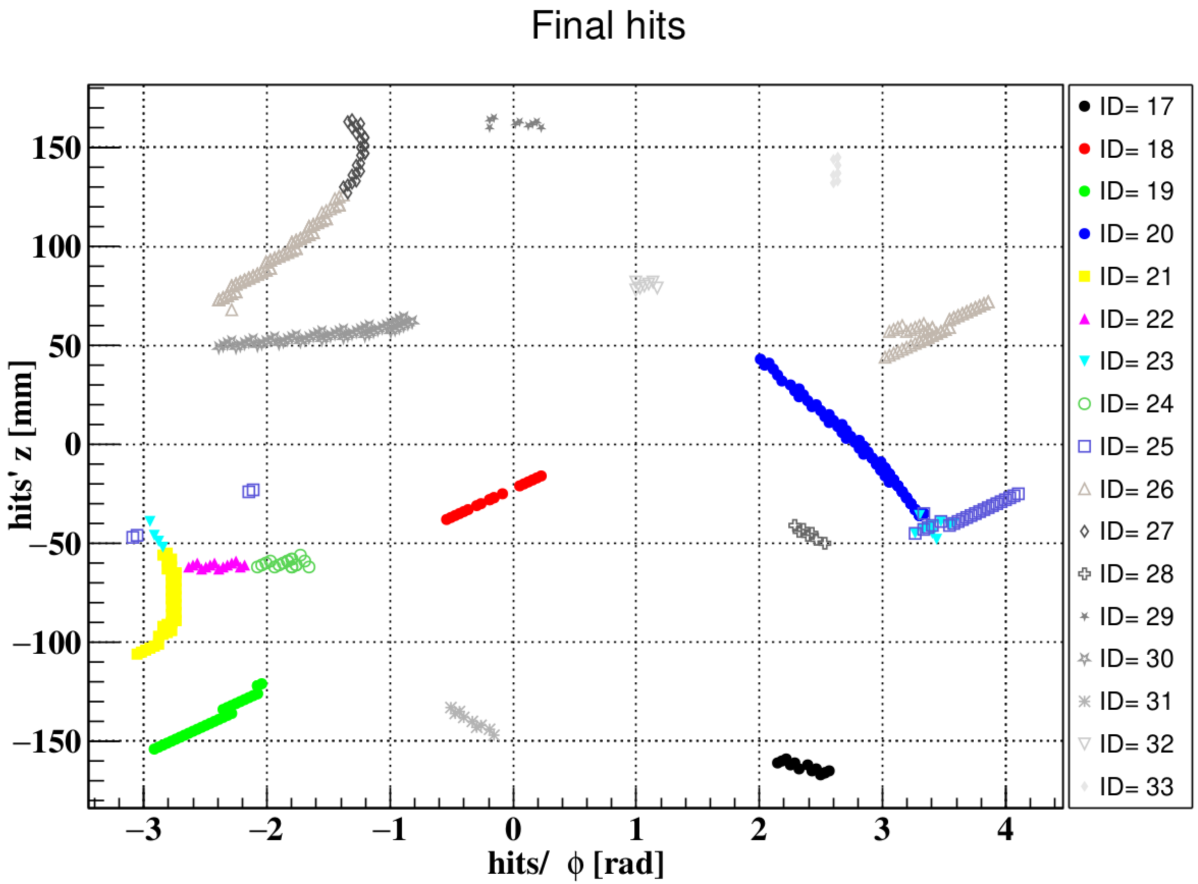
Tracks' Disentangler: Distinguishing the crossing tracks.



Updates on the RTPC Track Reconstruction

Tracks' Disentangler: Distinguishing the crossing tracks.

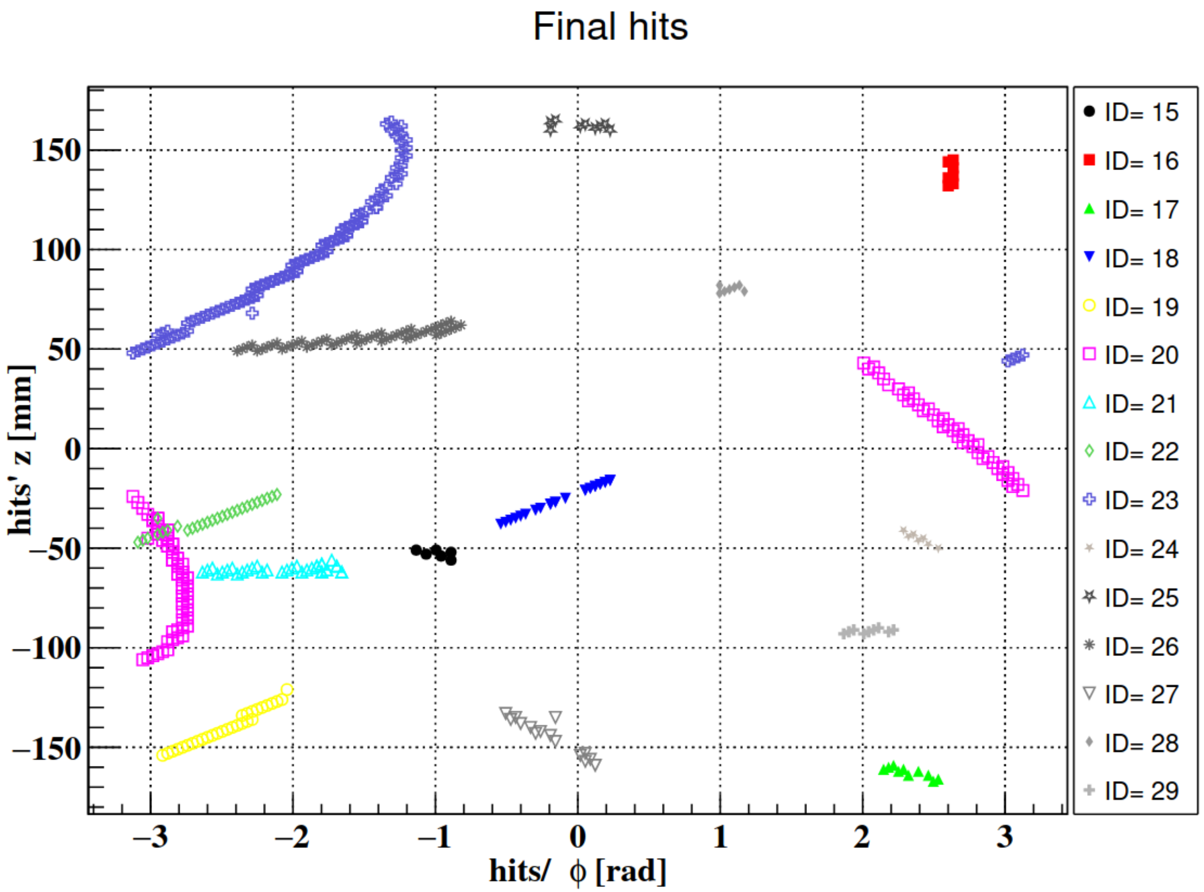
Old Disentangler



Updates on the RTPC Track Reconstruction

Tracks' Disentangler: Distinguishing the crossing tracks.

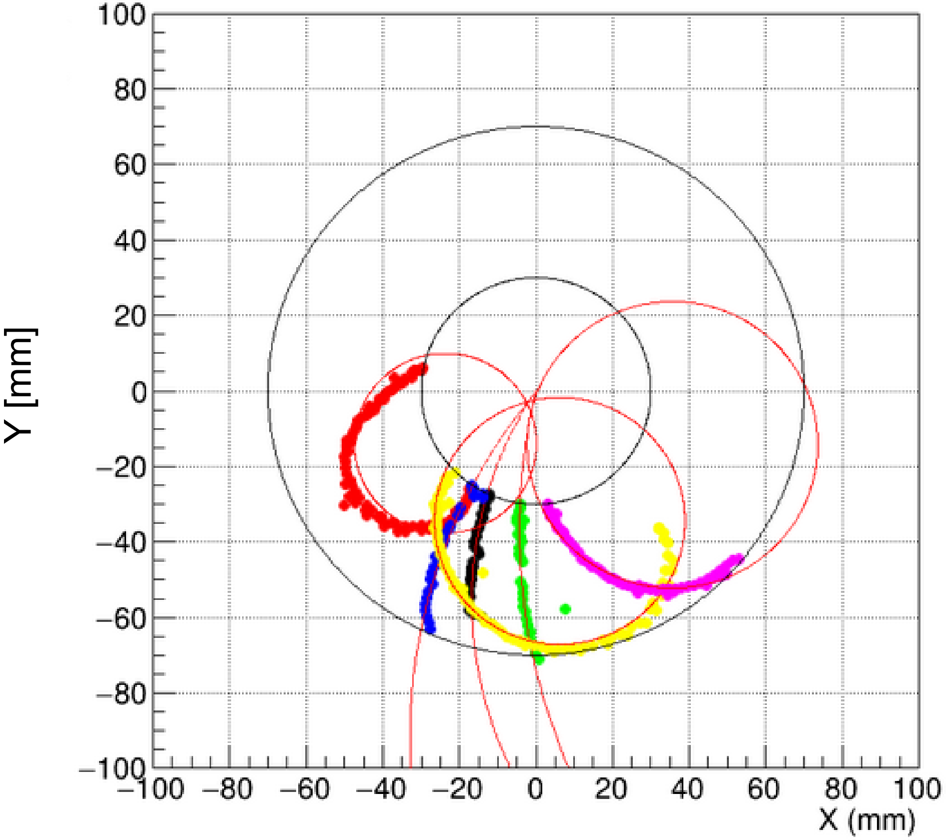
Updated Disentangler

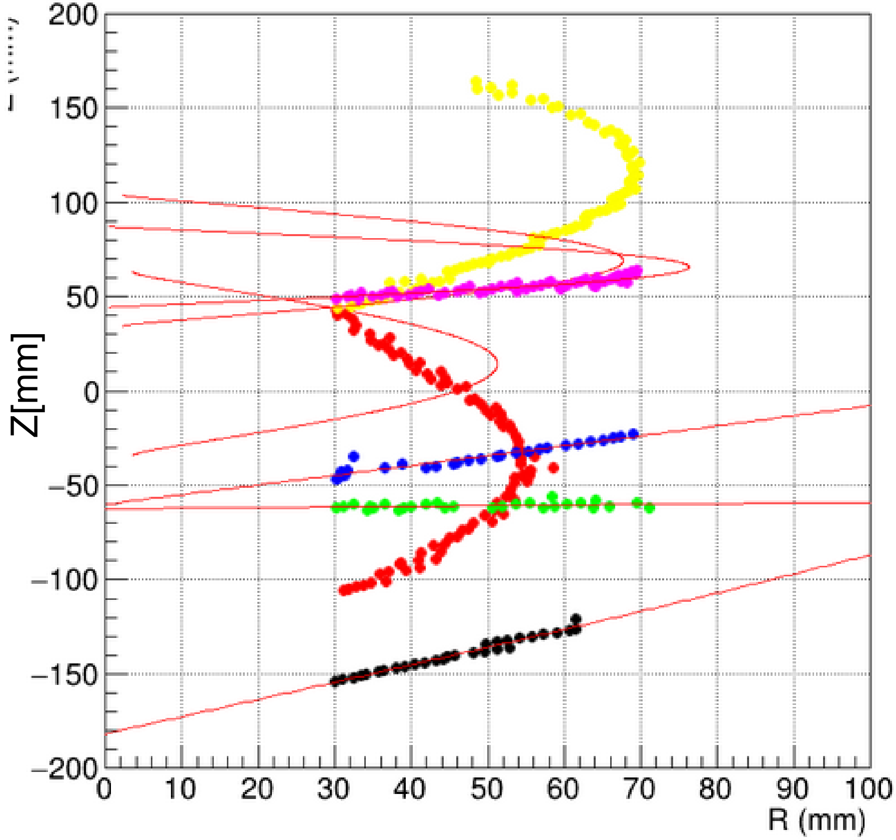


Updates on the RTPC Track Reconstruction

Back-benders and tracks crossing the seam of the RTPC:

Old Helix Fitter

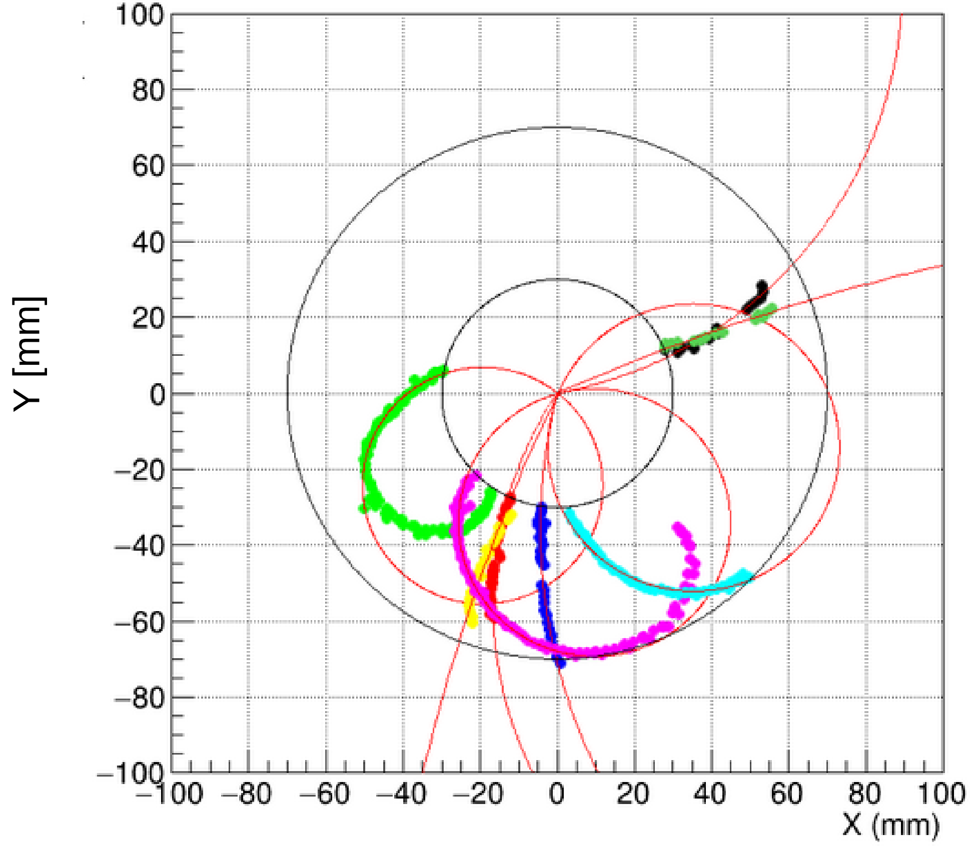


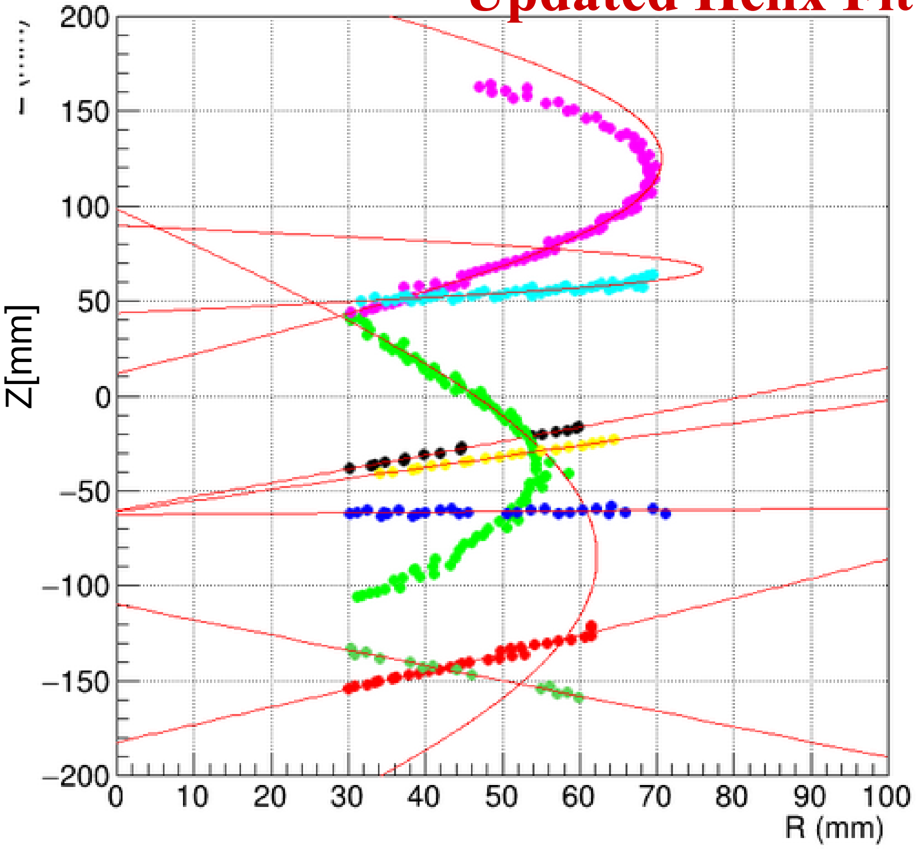


Updates on the RTPC Track Reconstruction

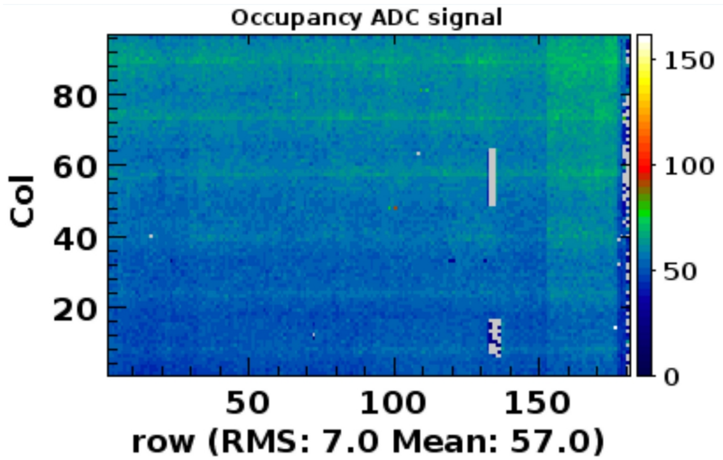
Back-benders and tracks crossing the seam of the RTPC: (+40% more tracks were reconstructed)

Updated Helix Fitter





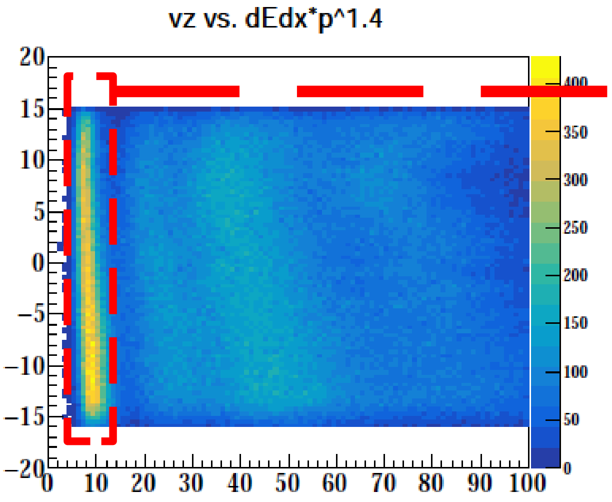
BONuS – Improving Gain Calibration

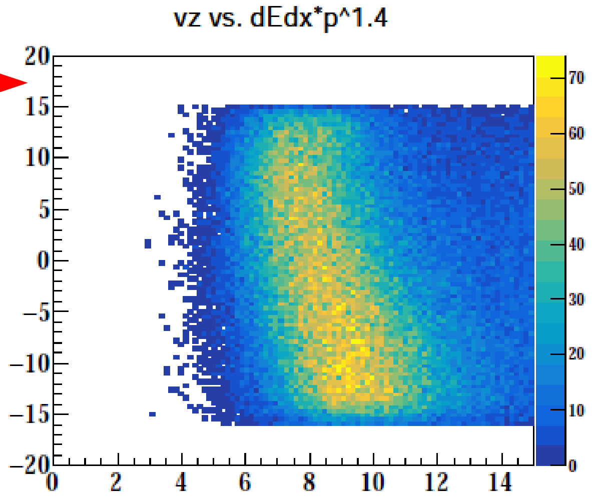


Signal height —Pads' gains (G_i)→ $$\left\langle \frac{dE}{dX} \right\rangle = \frac{\sum_i \frac{ADC_i}{Gi}}{vtl}$$

→ Using real data pads' occupancy info, each pixel gives the ratio of the ADC sum for a given pad divided by the number of hits on that pad, which defines a pad "gain".

→ This method **did not correct** for an observable dependence of dEdx of the recoils on the longitudinal position along the target.





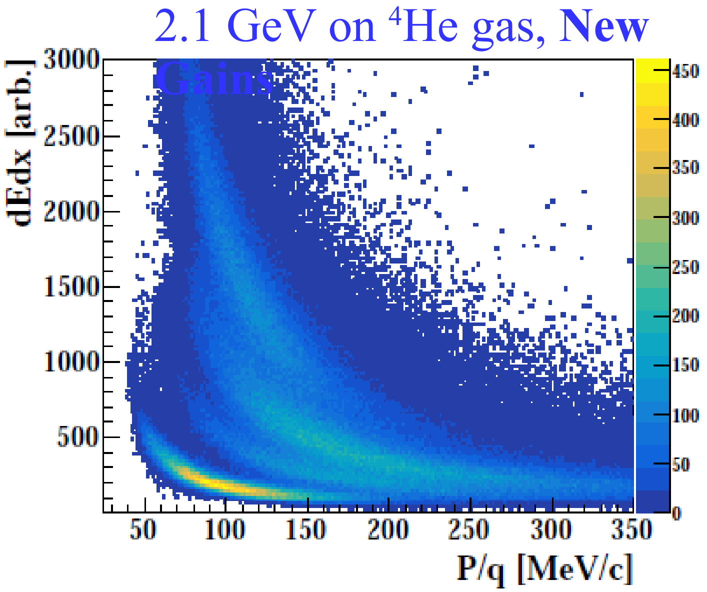
BONuS – Improving Gain Calibration

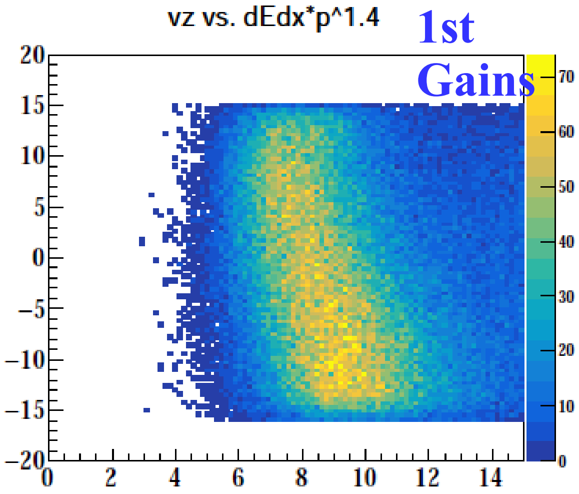
→ Using On-time reconstructed tracks (that spans the full drift region from the Cathode to the Anode)

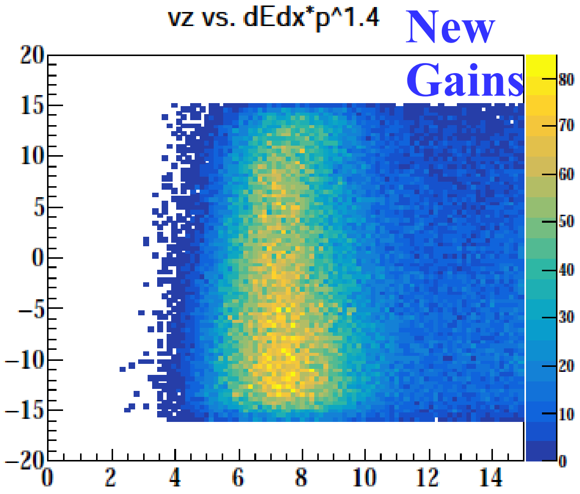
→ Comparing every pad's collected charge (ADCs) in a track to the median full track's collected charge.

→ Average this ratio (pad's gain) over enough statistics for every pad.

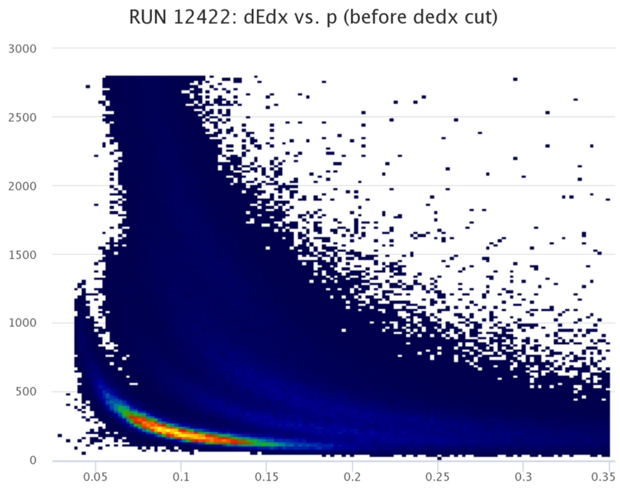
→ This method **has corrected** for the vz-dependance.

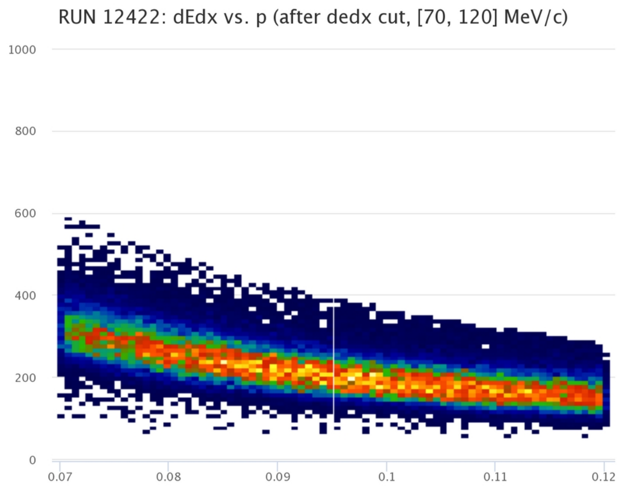


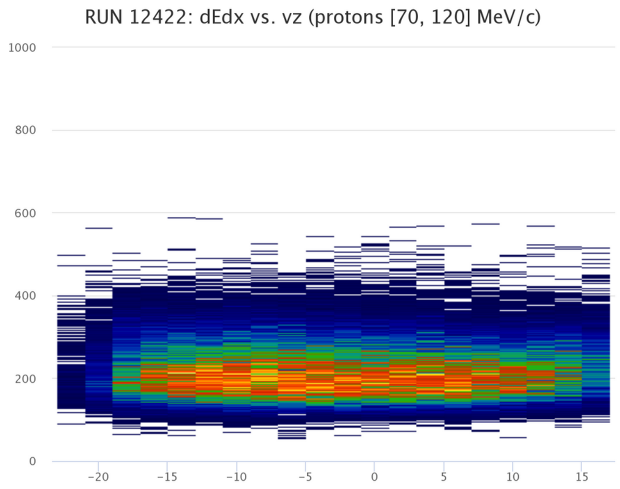


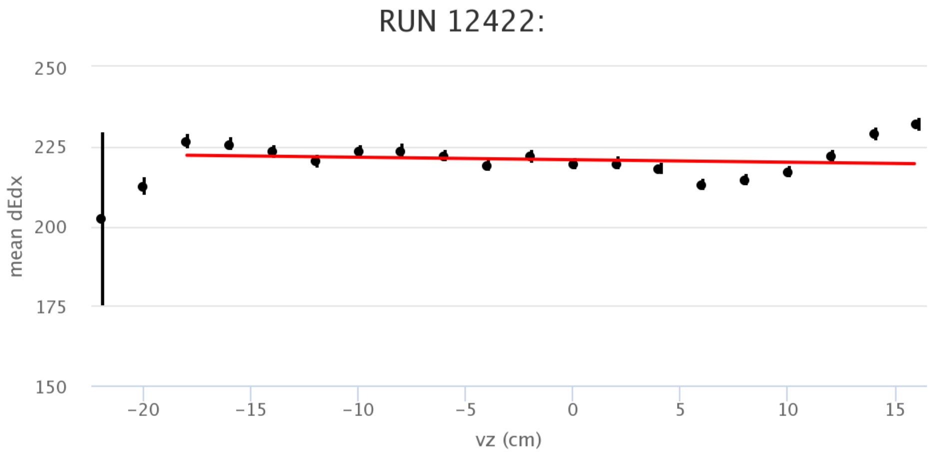


BONuS – dEdx Timelines





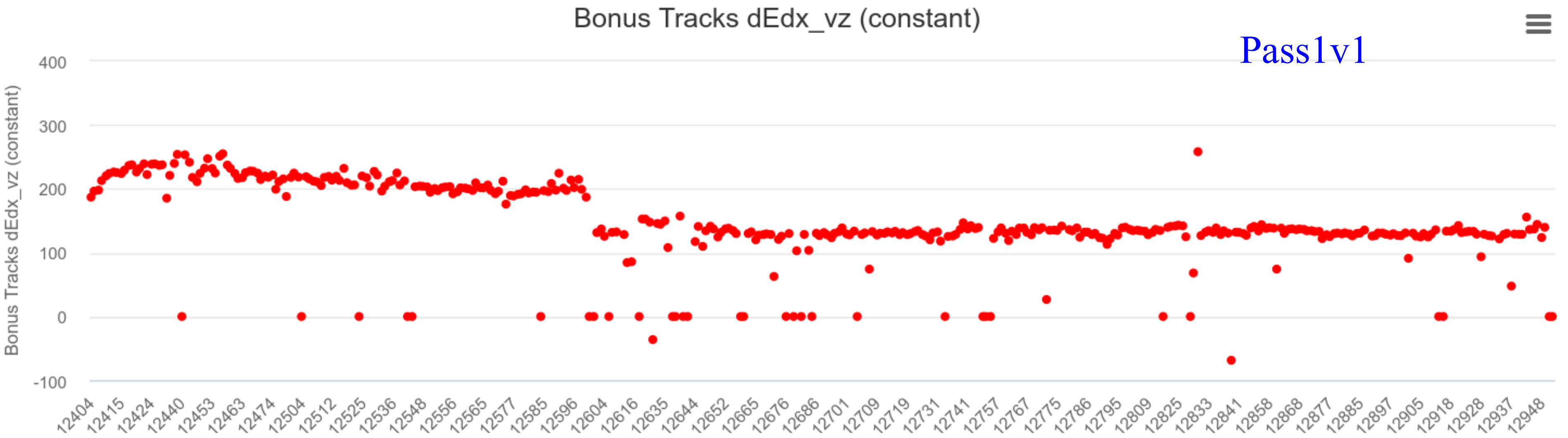


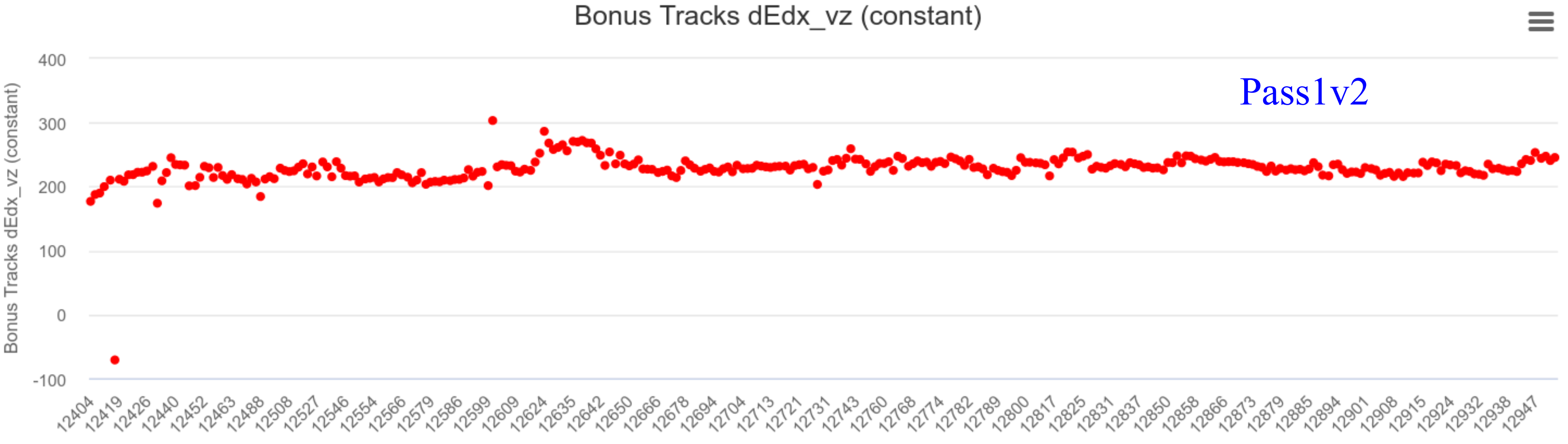


dEdx timelines Observables: using protons from all the target types:

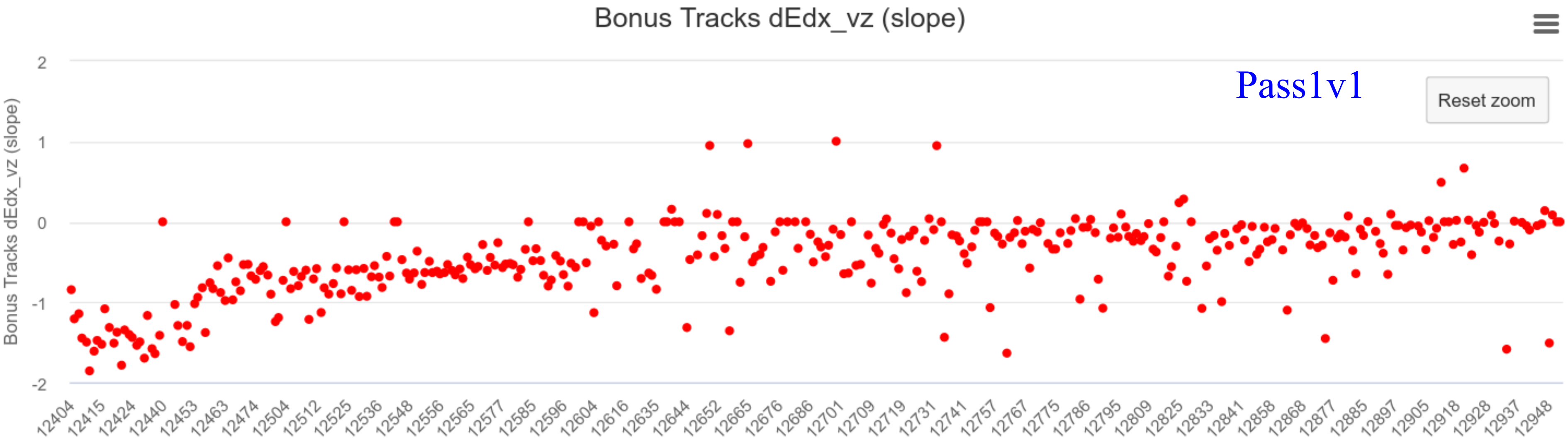
- dEdx amplitude: the constant of the fit.
- dEdx slope vs. vz: the slope of the fit.
- dEdx percentage ratio:
  = target_length*slope/constants

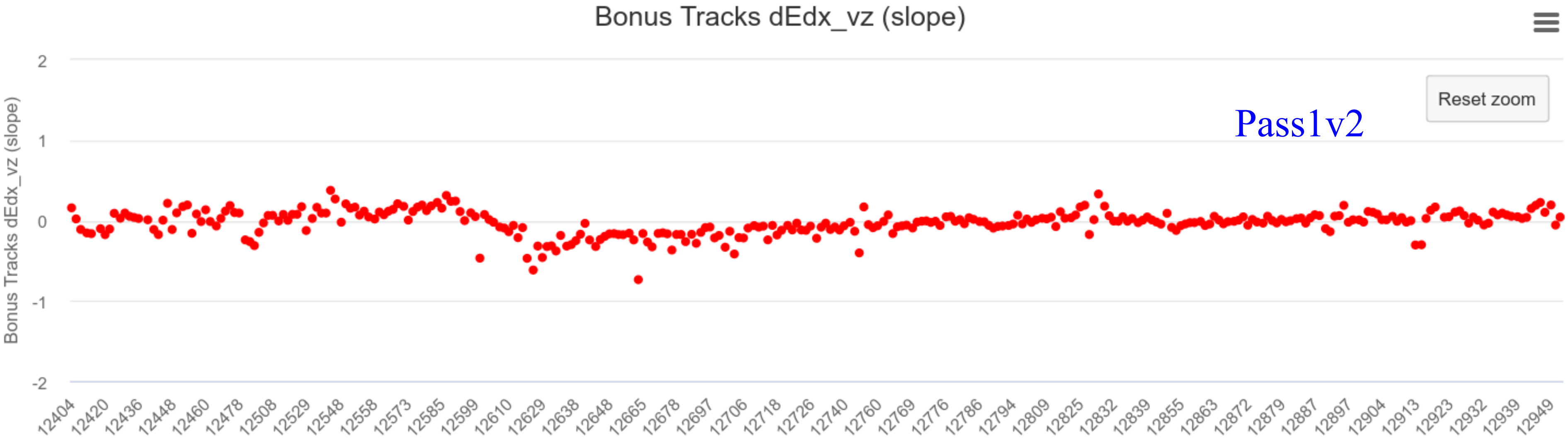
BONuS – dEdx Amplitude Timeline



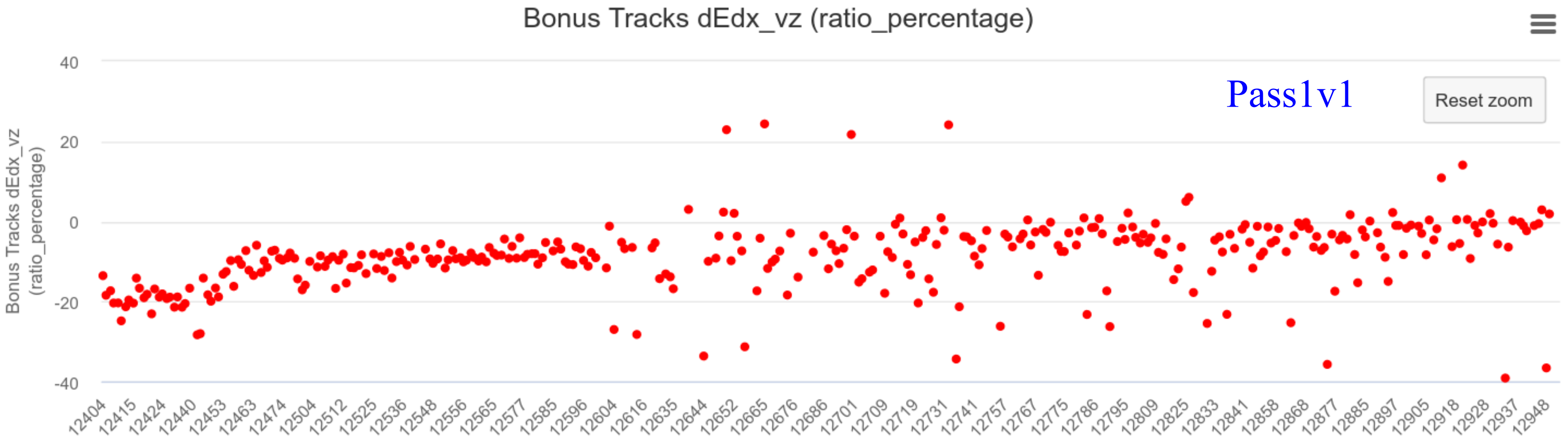


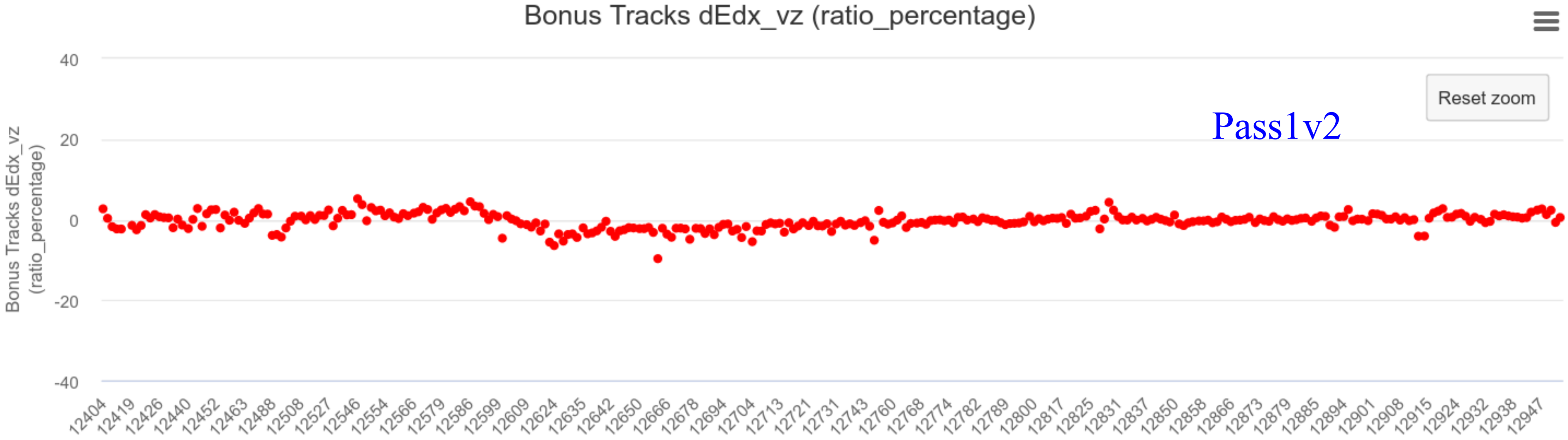
BONuS – dEdx vs. vz Slope





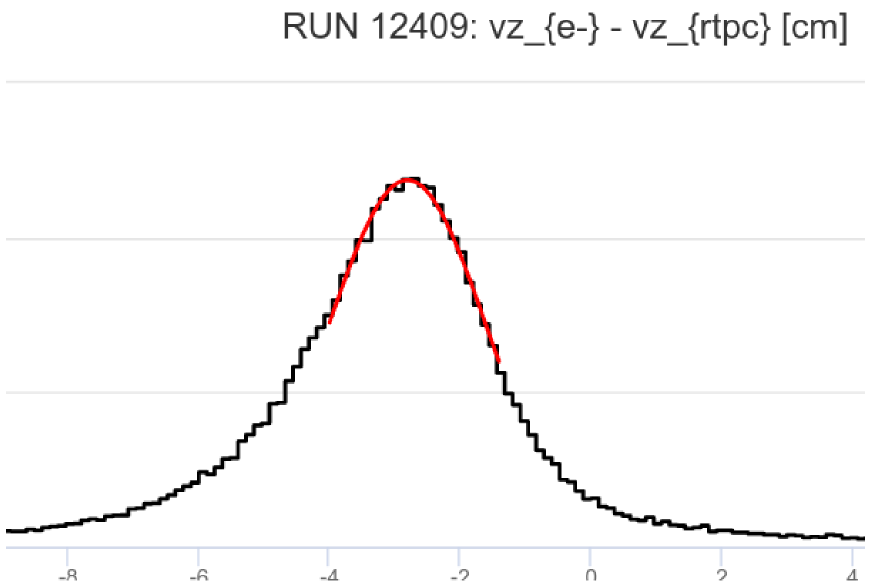
BONuS – dEdx Percentage Ratio Timelines



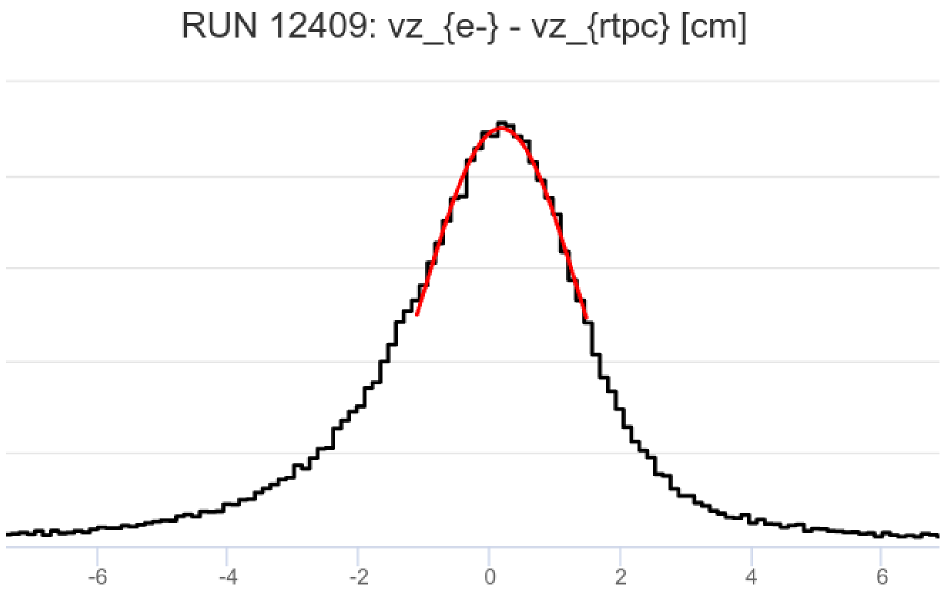


CLAS12-RTPC z alignment

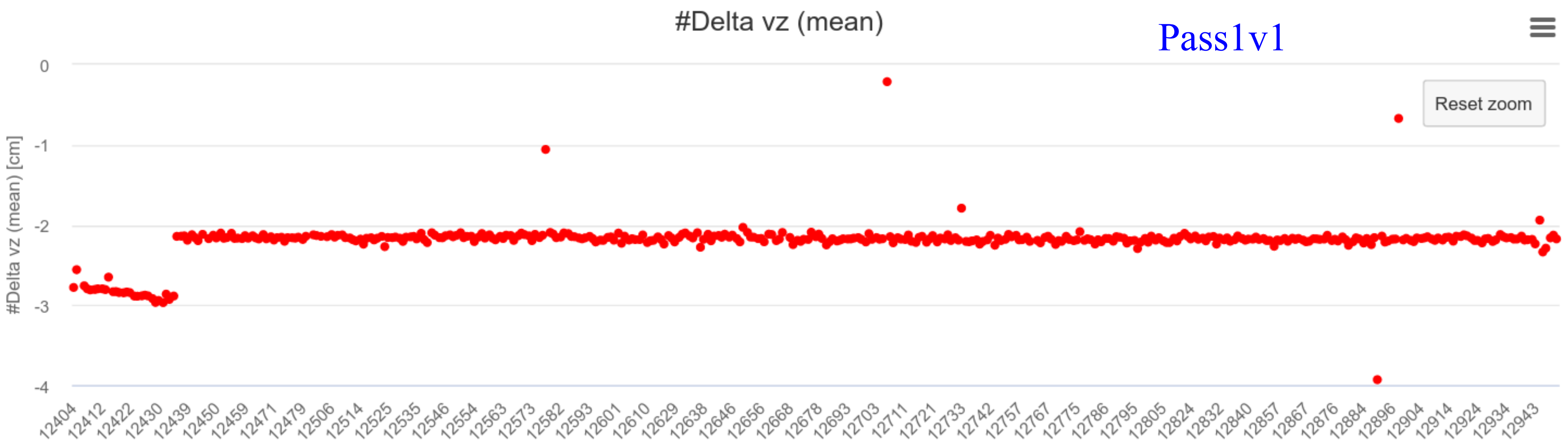
Pass1v1

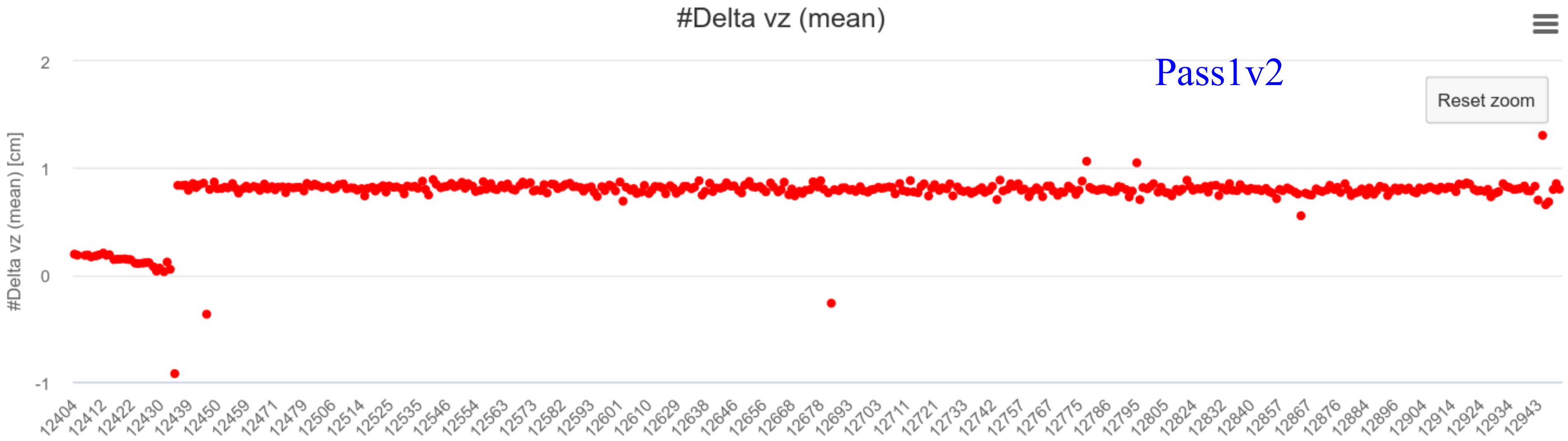


Pass1v2



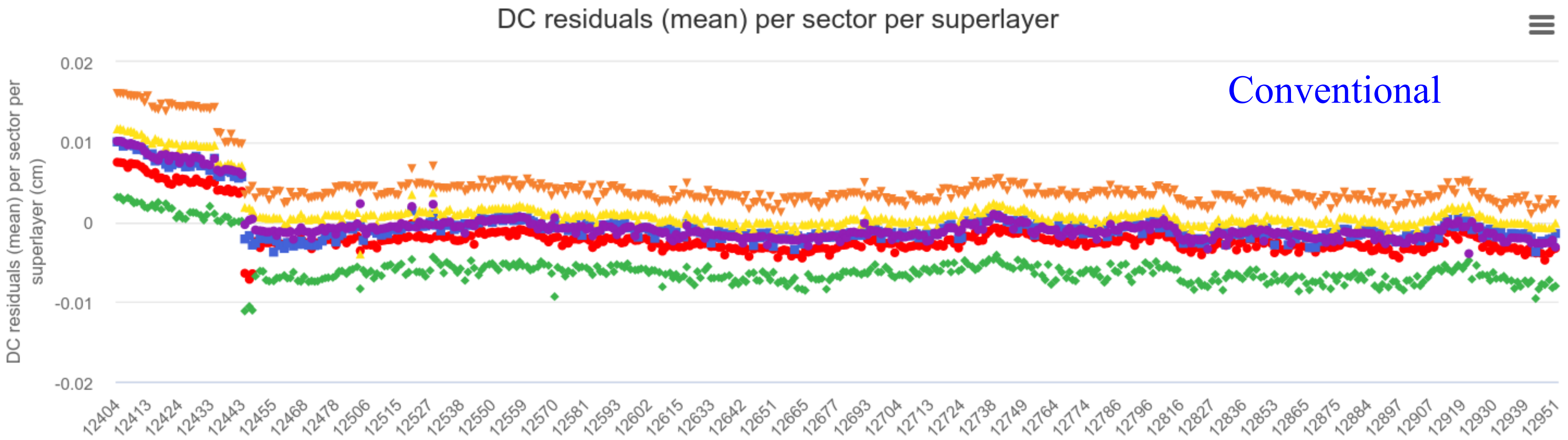
CLAS12-RTPC z-Alignment Timeline

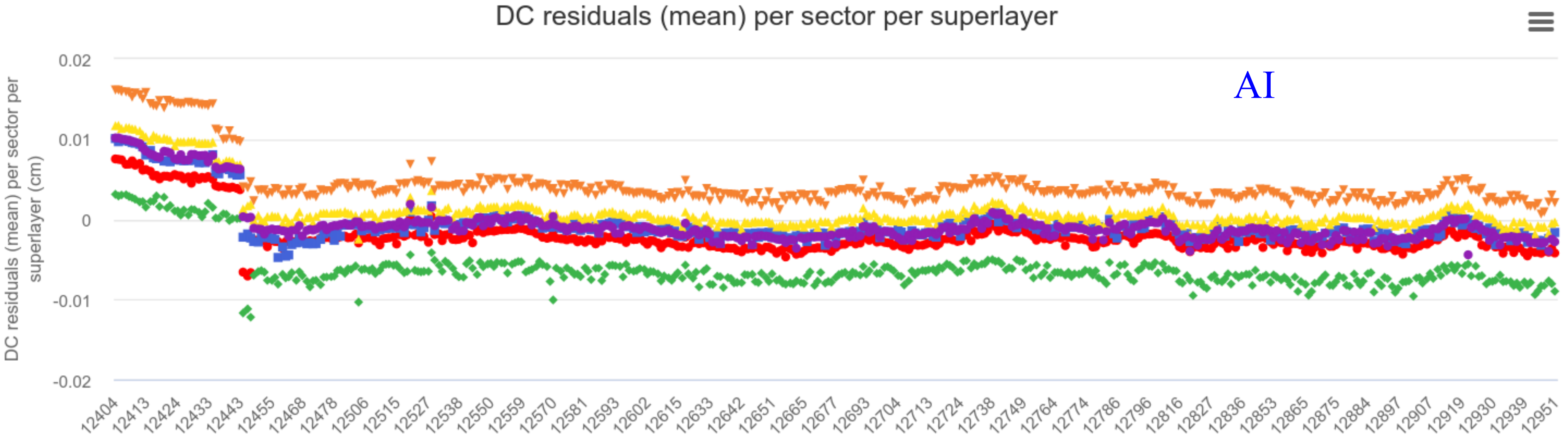




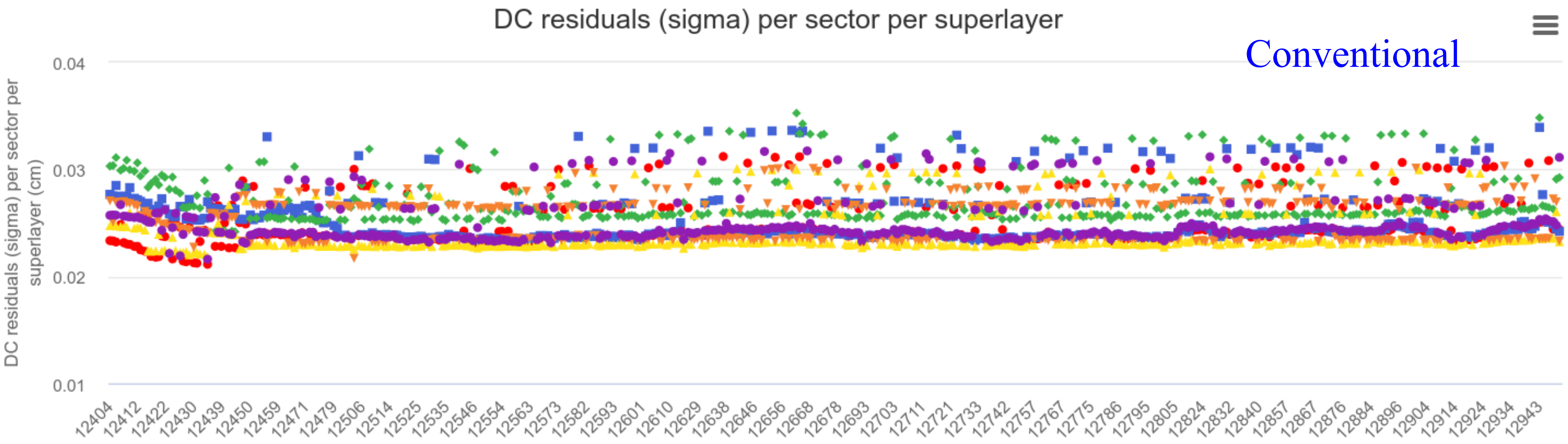
AI vs. Conventional DC Tracking

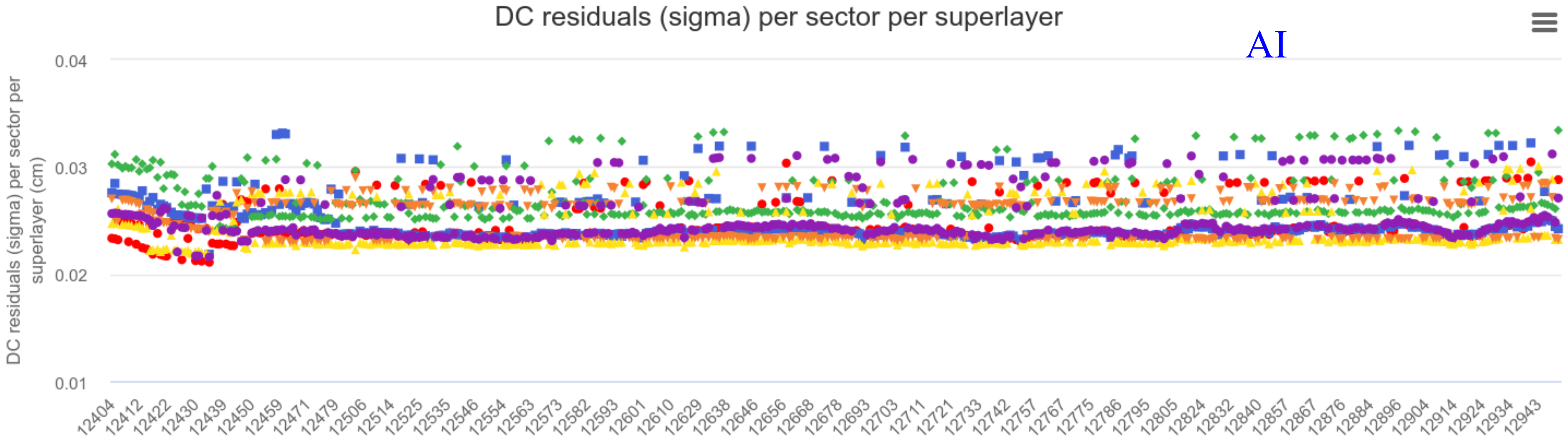
DC Residuals: Conventional vs. AI Tracking





DC Residuals: Conventional vs. AI Tracking





Summary

Subsystem	Timeline	Constraint (RG-B)	Constraint (RG-F)
RF	rftime electron FD mean	< ±10 ps	< ±10 ps
	rftime electron FD sigma	< 70 ps	< 70 ps
LTCC	ltcc elec nphe sec	12-14	5-20
HTCC	htcc nphe sec	11-13	10-13
FTOF	ftof edep p1a midangles	9.25-10.5 MeV	9.25-10.5 MeV
	ftof edep p1b midangles	11.25-12.25 MeV	11.25-12.25 MeV
	ftof edep p2	9.2-10.2 MeV	9.2-10.2 MeV
	ftof time p1a mean	< ±25 ps	< ±25 ps
	ftof time p1a sigma	< 125 ps	< 125 ps
	ftof time p1b mean	< ±15 ps	< ±15 ps
	ftof time p1b sigma	< 70 ps	< 70 ps
	ftof time p2 mean	< ±50 ps	< ±50 ps
	ftof time p2 sigma	< 325 ps	< 325 ps
ECAL	ec Sampling	0.24-0.26	0.22-0.25
	ec gg m mean	131-134 MeV	128 -142 MeV
	ec gg m sigma	< 15 MeV	< 15MeV
DC	dc residuals sec mean	< ±0.005 cm	< [-0.03,0.01] cm
	dc residuals sec sl sigma	R1,R3 < 300 um, R2 < 400 um	< 450 um
RICH	rich time fwhm max	< 1 ns	<1ns

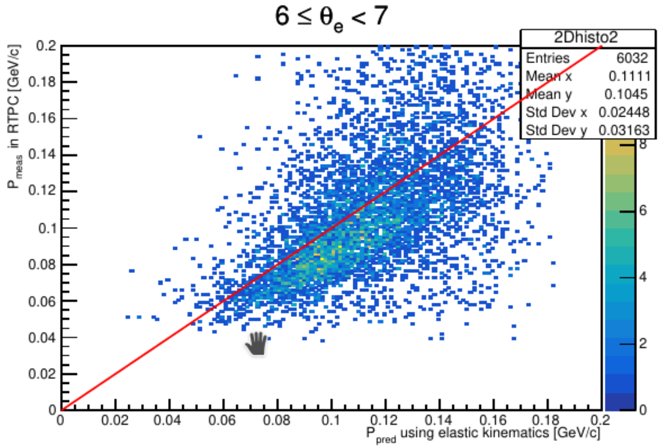
Lorentz Angle Calibration

→ Use radiative e-p elastic scattering (beam bremsstrahlung) at 1-Pass to calibrate the RTPC (θe- [5°,8°]).

→ Then calculate the energy of the gamma simply ASSUMING that the event was elastic.

→ Simple, first estimation for energy loss applied, but will be refined in the future.

→ Modify the Lorentz angle until we get the best agreement between the measured and the predicted momentum for protons in H(e,e'p)γ.



2.14 GeV on H_2 target