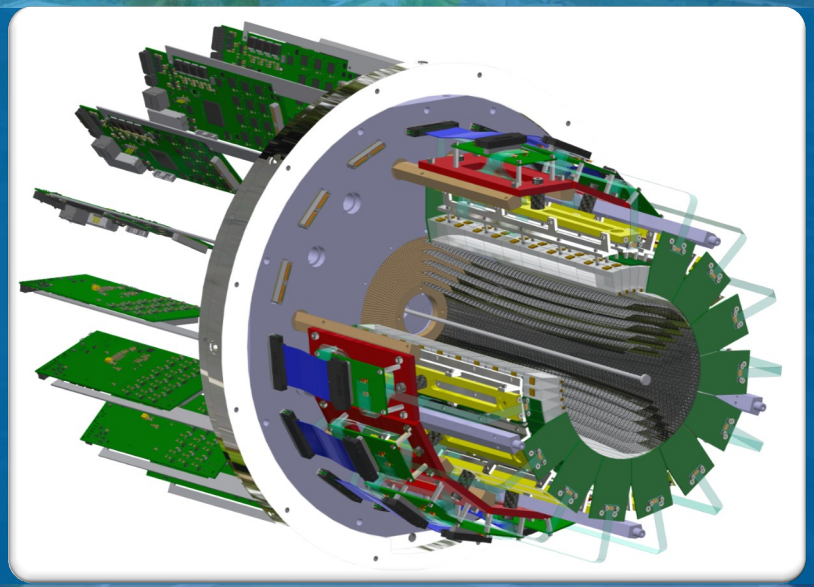
ALERT ATOF Calibration



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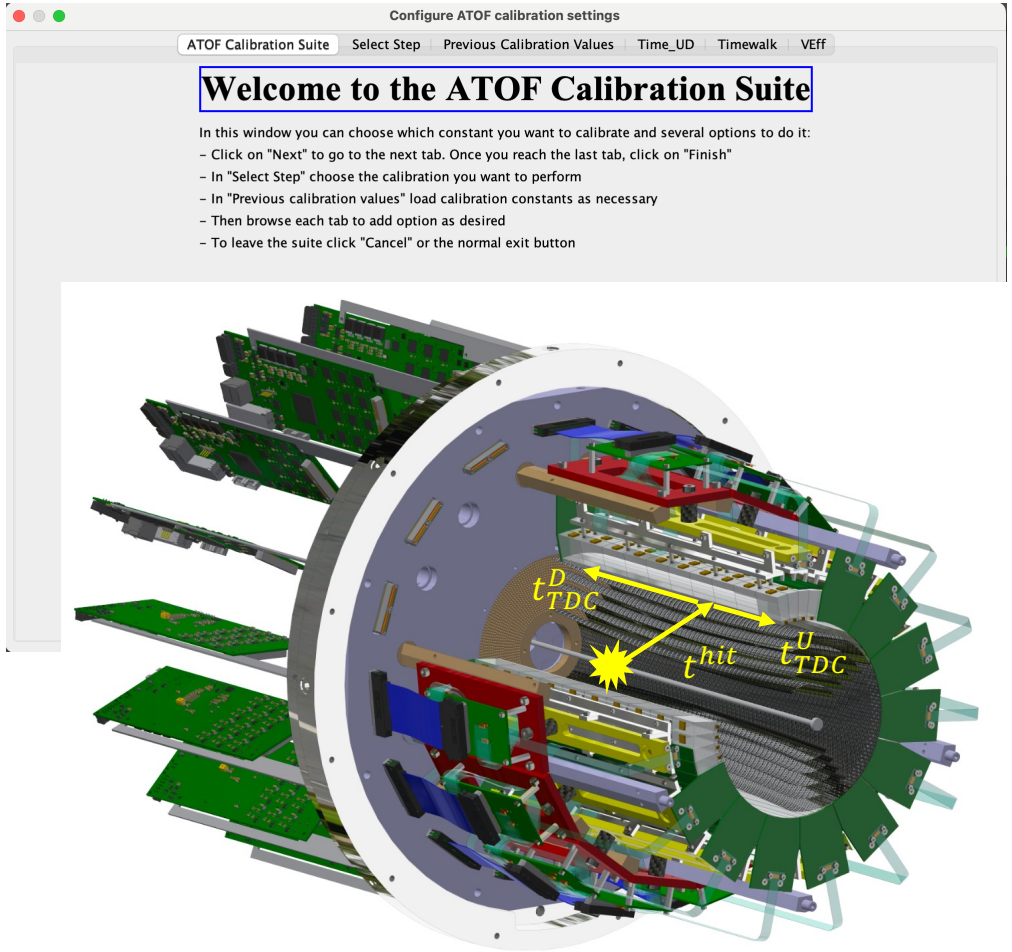
11/19/2025

ATOF Calibration

Ready in calcode: https://code.jlab.org/hallb/clas12/calibration/calcode/-/tree/main



- Bar hit time (t^{hit}) from Up/Downstream end (✓):
  - $t^{D/U} = t^{D/U}_{TDC} - t_{vertex} - t^{D/U}_{TW} \mp t^{UD} - \frac{L-z}{v_{eff}}$
  - $t^{hit} = \frac{1}{2}(t^U + t^D) + c_{b2b}$
- Wedge hit time (t^{hit}) has better resolution (✓)
  - $t^{hit} = t^w_{TDC} - t_{vertex} - t^w_{TW} - \frac{h}{v_{eff}} + c_{w2w}$

ATOF Calibration

Bar

- Event selection on t^{sum}
- Bar Phi Alignment:
  - $t^{UD} = \frac{\Delta t}{2}$, $c_{b2b} = \frac{t^{sum} - t^{sum}_{S0L0}}{2}$

Wedge

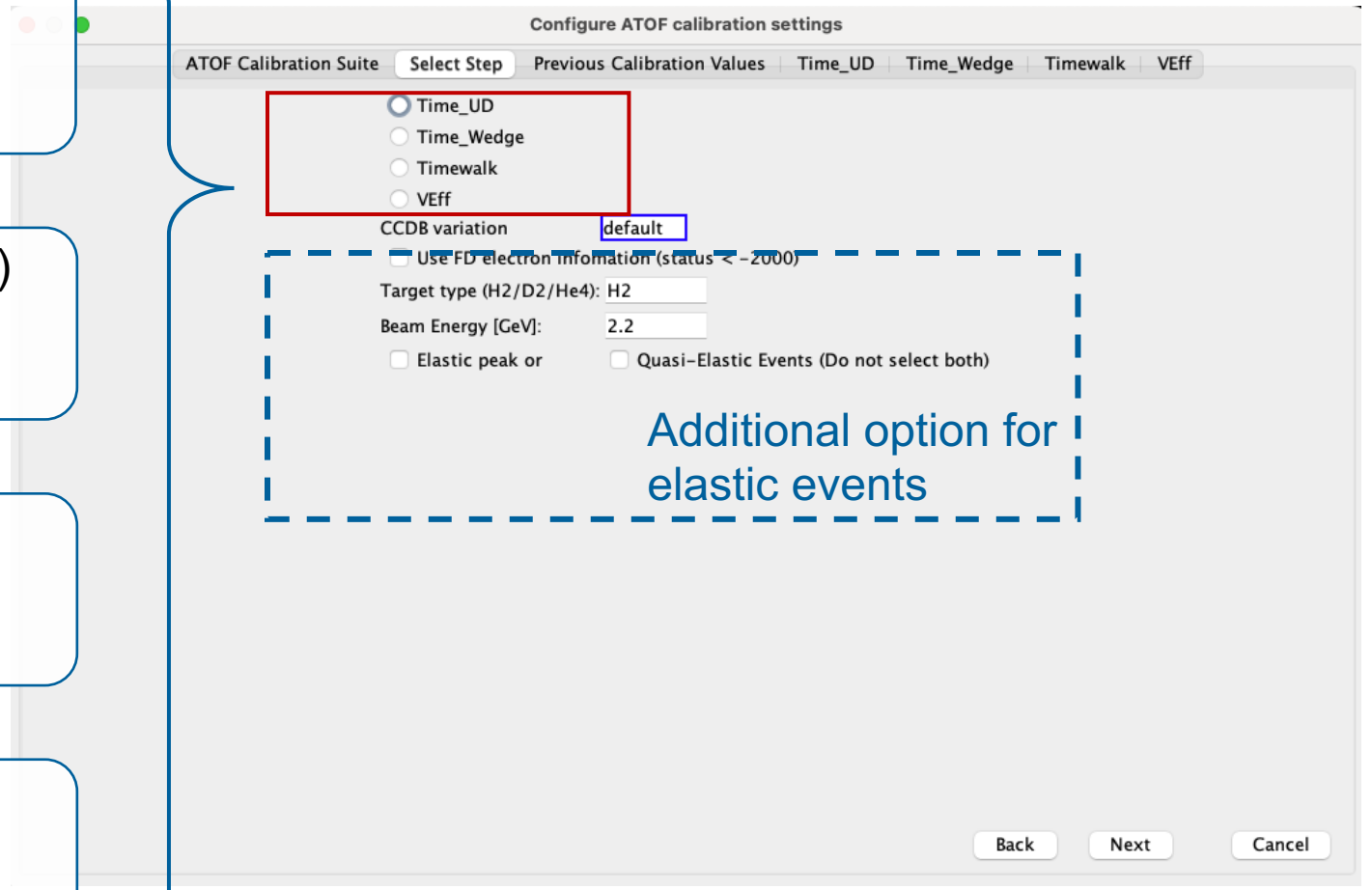
- Clean wedge selection (2 options)
- Wedge Phi Alignment
  - $c_{w2w} = t - t_{S0L0}$

Effective velocity

- Bar hit z position (2 options)
  - $v^{eff} = \frac{2}{slope}$

Time Walk

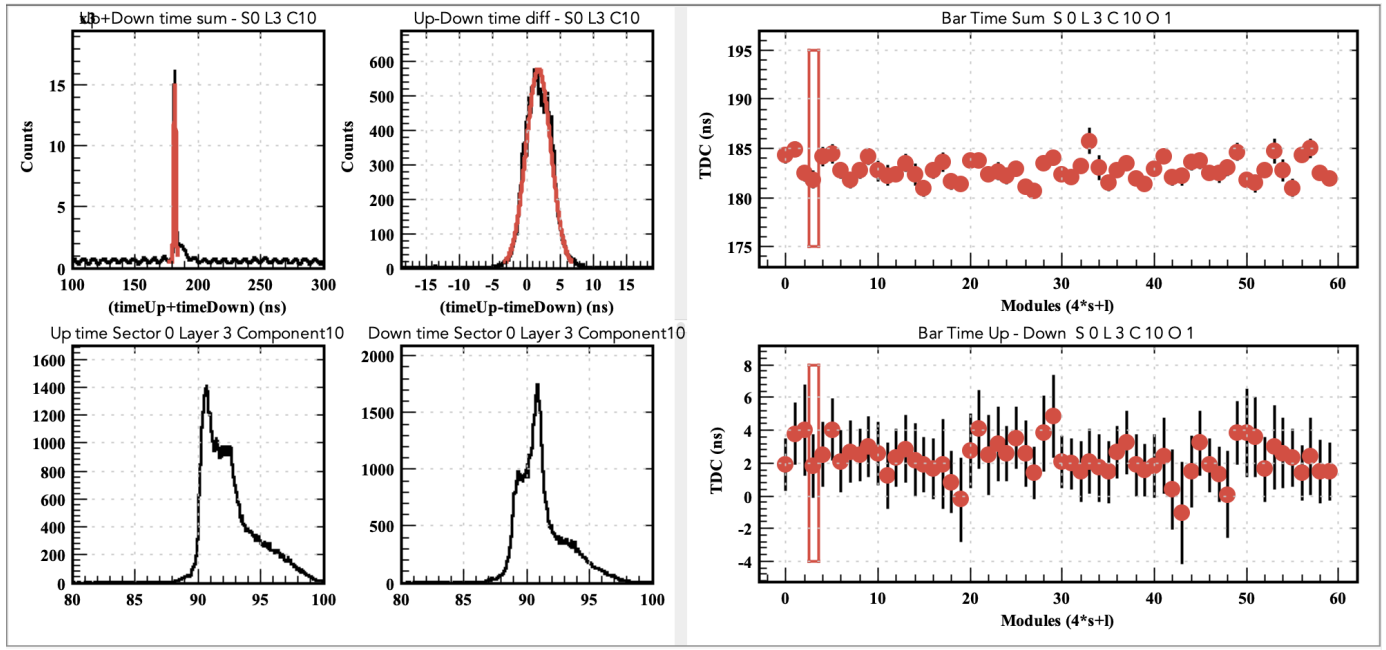
- TDC vs TOT [ns]: $f = a + be^{c\,x}$
  - $t^{w/U/D}_{TW} = f(x) - f(x = 30ns)$



ATOF Calibration

Bar timing

- Bar $t^{sum} = t^U + t^D$
- Bar $\Delta t = t^U - t^D$ with hits on central wedges.
- RF time (periodic 4ns) observed in t^{sum} - also provide event selections ±5σ.
- $t^{UD} = \frac{\Delta t}{2}$
- $c_{b2b} = \frac{t^{sum} - t^{sum}_{S0L0}}{2}$



/calibration/atof/TimeUD

sector	layer	component	order	time_sum_UD	time_offset_UD	time_2D_proj	time_sum_UD_err	time_offset_UD_...
0	0	10	1	184.266	1.914	0.000	0.602	1.551
0	1	10	0	184.882	3.796	0.000	0.629	1.777
0	1	10	1	184.882	3.801	0.000	0.629	1.778
0	2	10	0	182.431	3.972	0.000	0.654	2.703
0	2	10	1	182.431	3.977	0.000	0.654	2.688
0	3	10	0	181.834	1.788	0.000	0.748	1.855
0	3	10	1	181.834	1.789	0.000	0.748	1.859
1	0	10	0	184.145	2.531	0.000	0.819	1.879
1	0	10	1	184.145	2.525	0.000	0.819	1.881
1	1	10	0	184.484	4.026	0.000	0.823	1.809

Show ..

View all | Adjust Fit/Override | Write

Events 91000516 Time 770.03 sec : Reading 42... | E | Et | H3 | H4 | Reset

ATOF Calibration

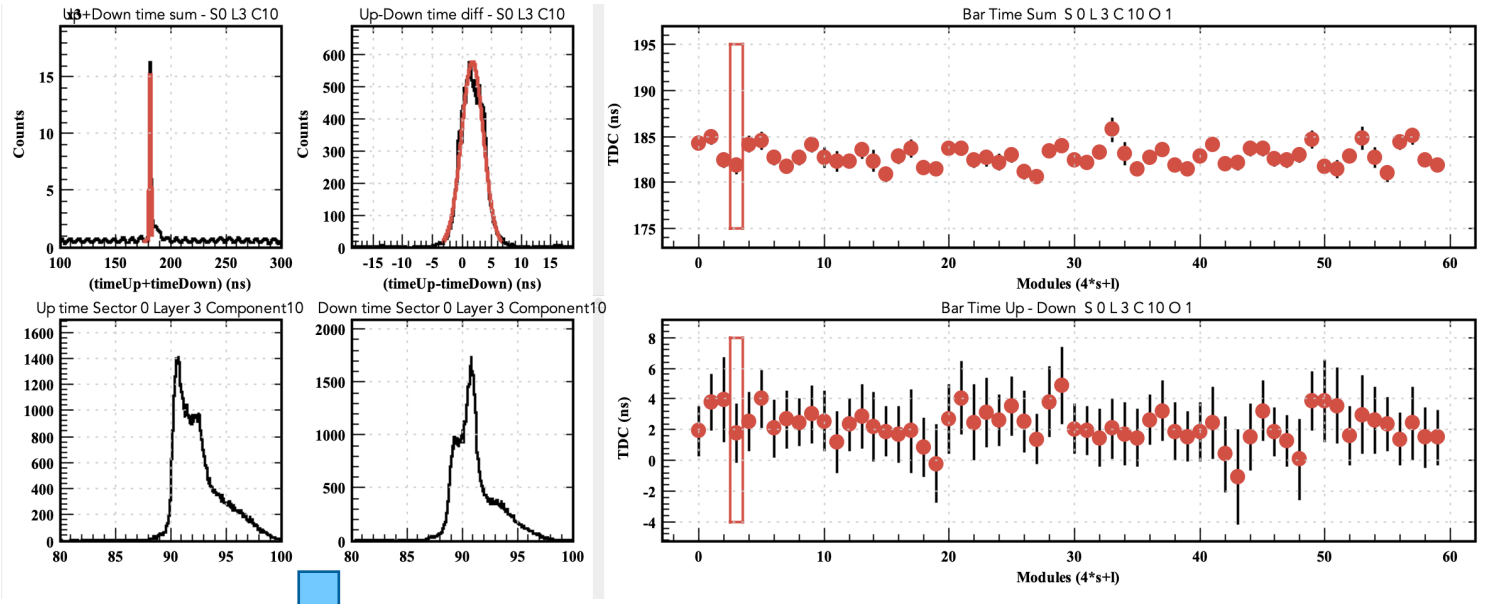
Bar timing
– 2.2 GeV H2 run

Bar Phi Alignment:

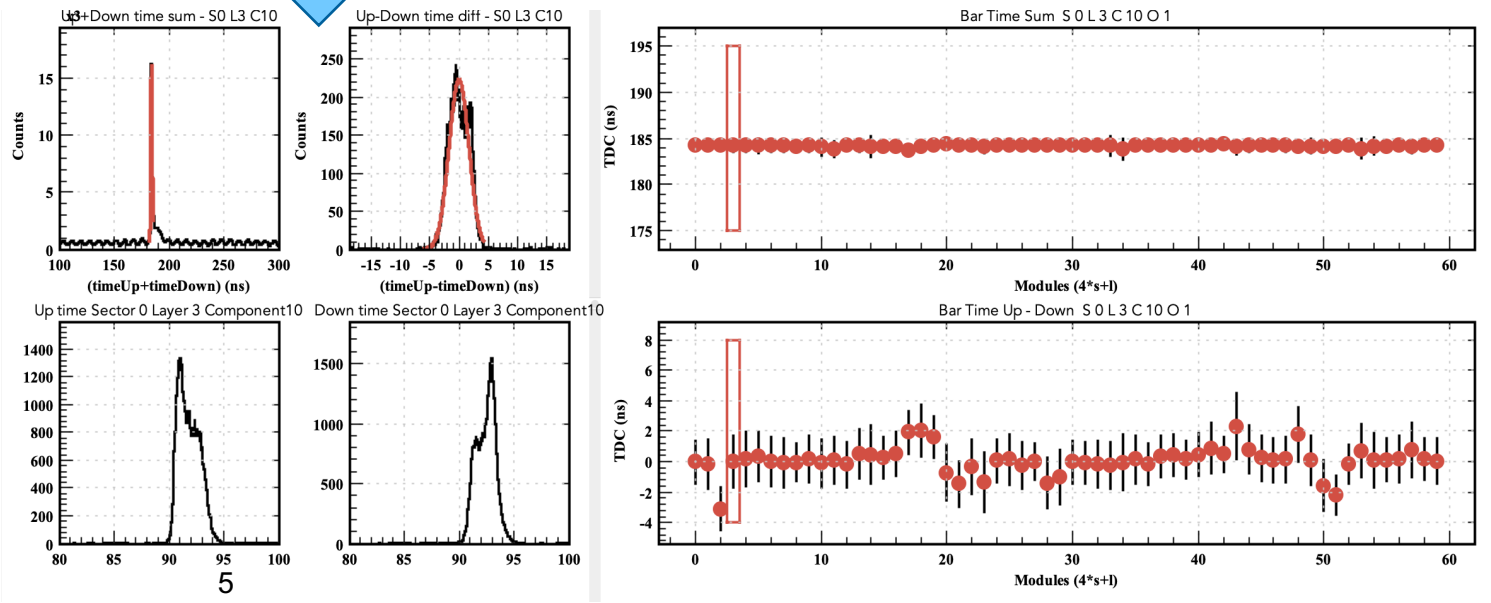
- $t^{UD} = \frac{\Delta t}{2}$, $C_{b2b} = \frac{t^{sum} - t^{sum}_{S0L0}}{2}$

- Bar sum is aligned well
- Few modules' bar time difference is offset - will be absorbed in the effective velocity fitting

Before

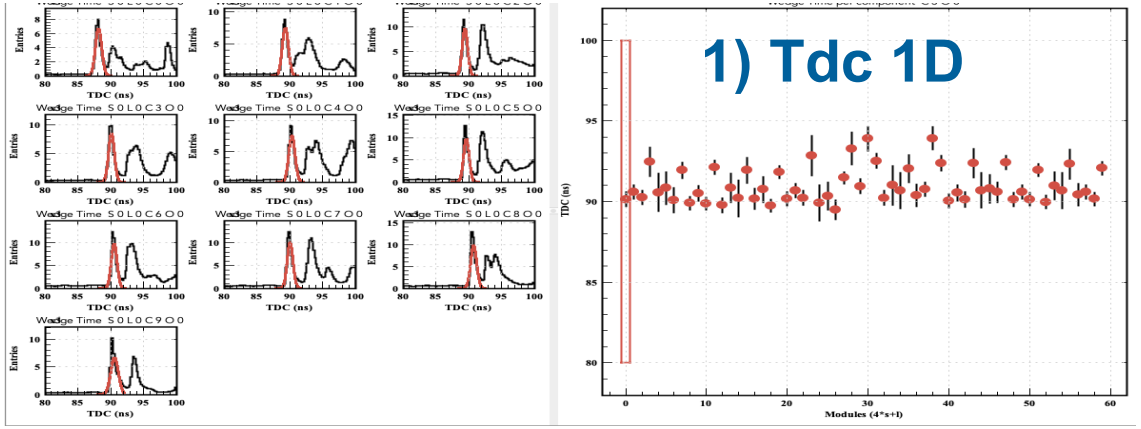


After

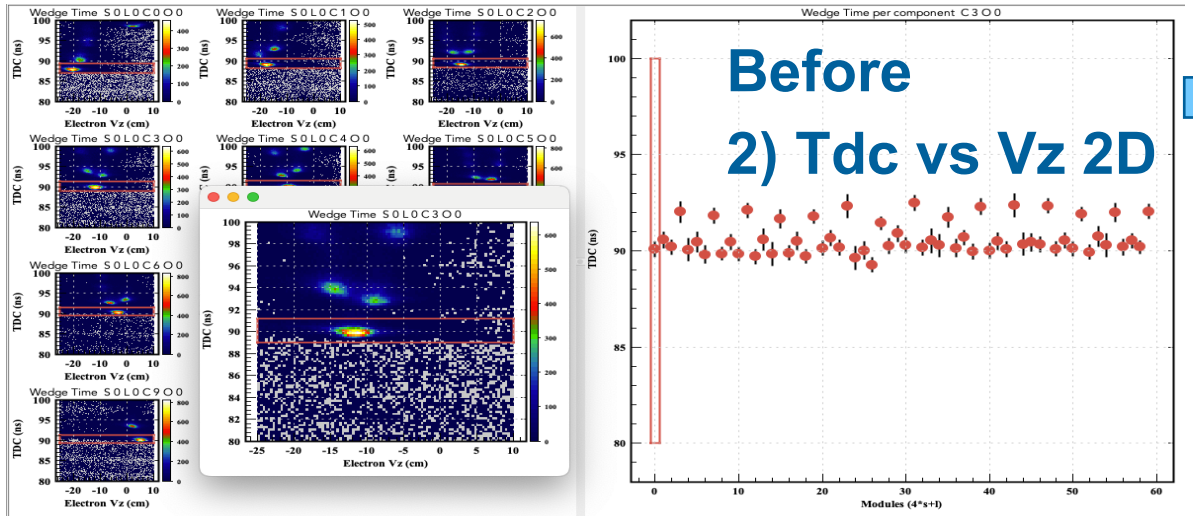


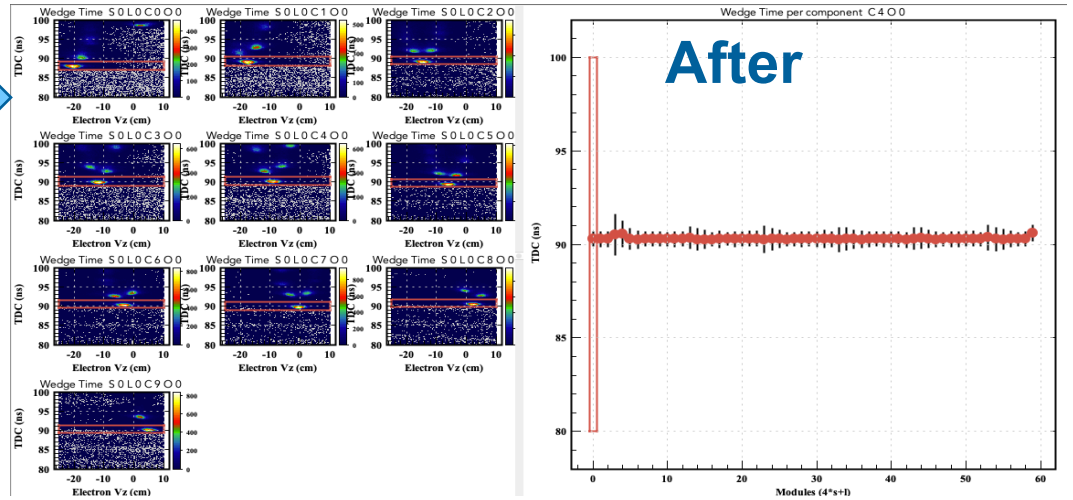
ATOF Calibration

Wedge timing – elastic data 2.2 GeV H2



- Clean wedge selection with Vz from scattering electron
- Wedge Phi Alignment for each component
  - $c_{w2w} = t - t_{S0L0}$





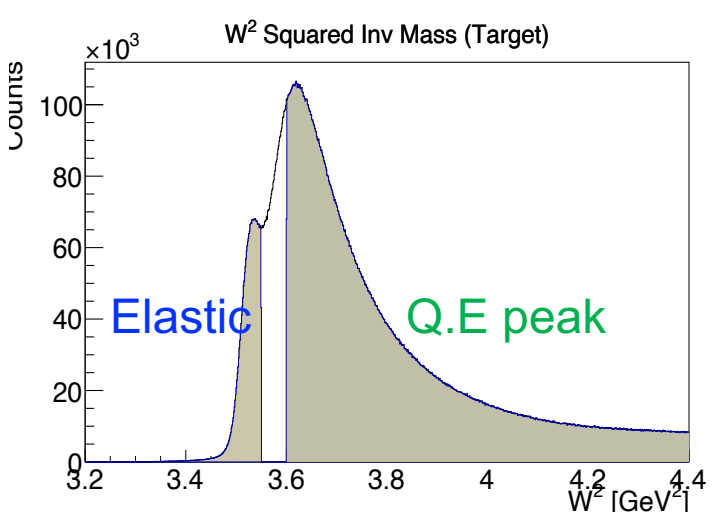
ATOF Calibration

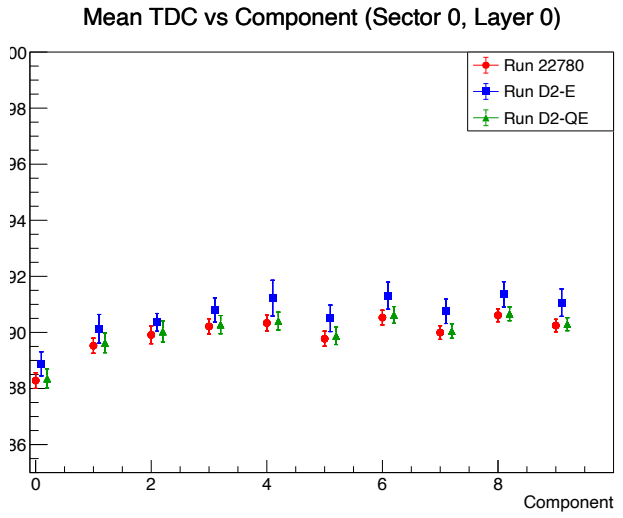
Wedge timing - test H2 / D2 target

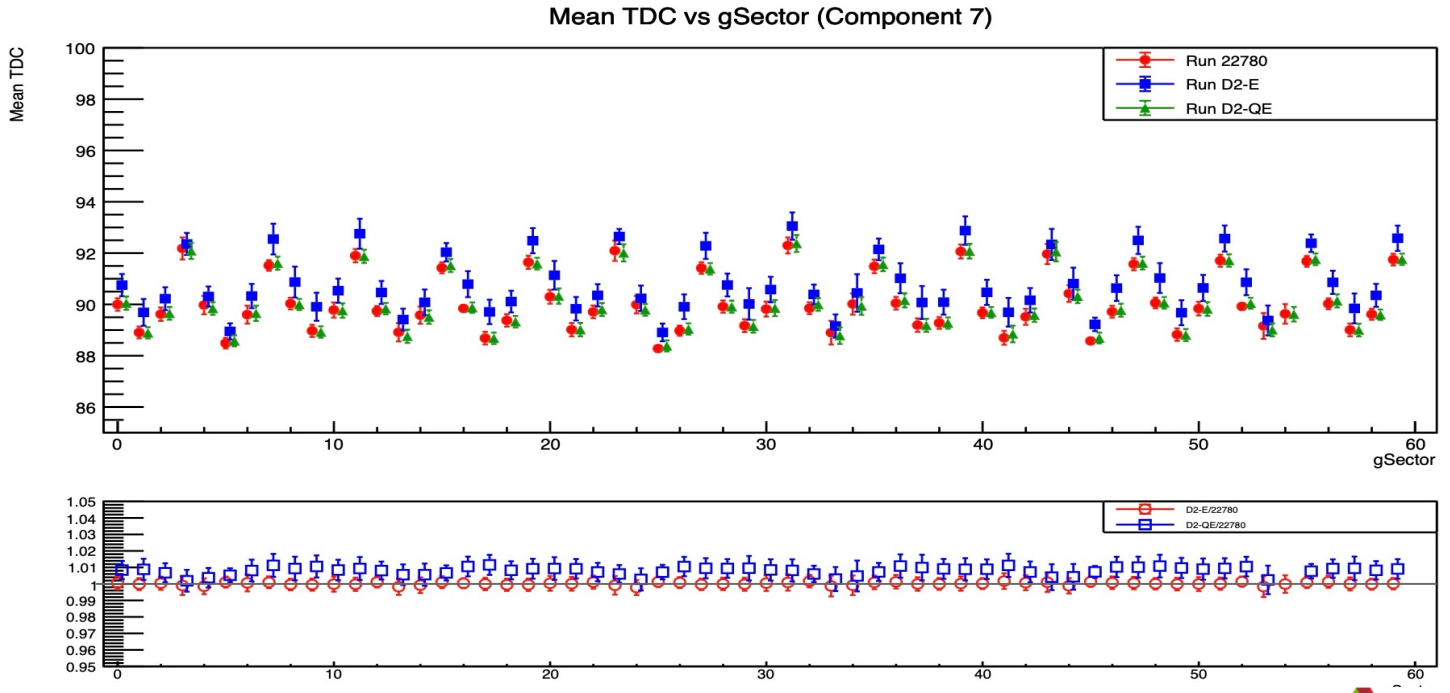
- To understand the 1st peak, we compared the H2 run, coherent D2, and incoherent protons from D2 run.

- Same phi pattern.
- Same tdc value for the H2 and incoherent protons in D2

- Observe coherent D2 slower than incoherent protons ~ 1ns





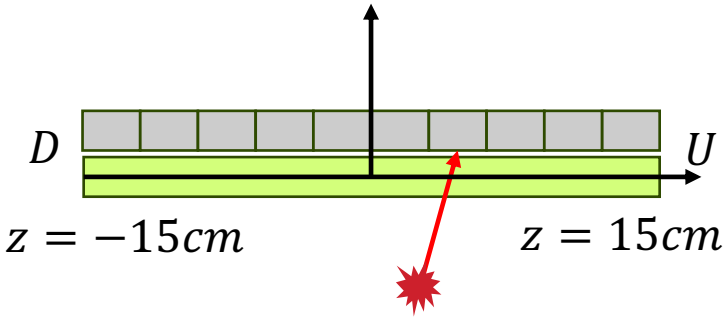


ATOF Calibration

- Bar effective velocity

1) Tdc 1D

- Bar time difference t^{UD} with hits on each wedge component (from 1st peak). Fit the 10 cases by Gaussian
- Fit linearly on the 10 peaks vs z (wedge)
- $v^{eff} = \frac{2}{slope}$



2) Tdc vs Vz 2D

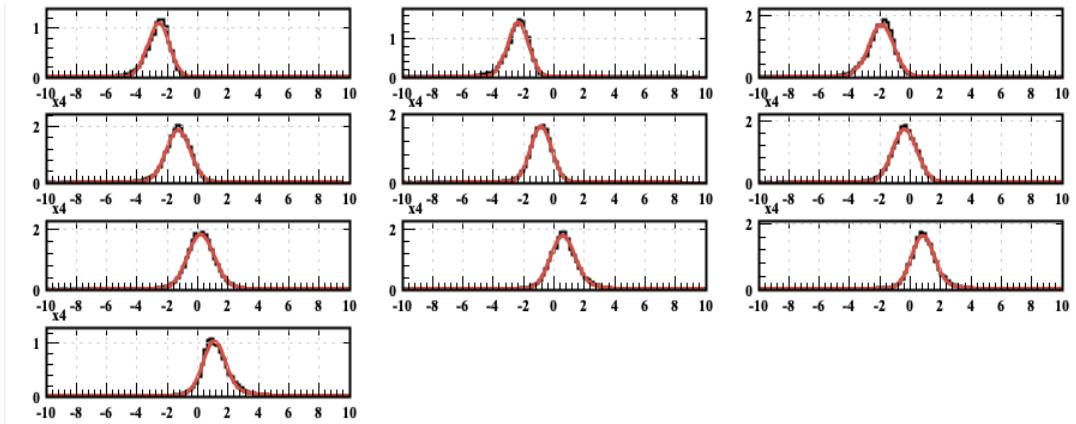
- Individual bar time vs vertex (Vz) from scattered electron
- Notice: the vertex would be different from geometry z
- Fit the 2D histo linearly
- $v^{eff} = \frac{1}{slope}$

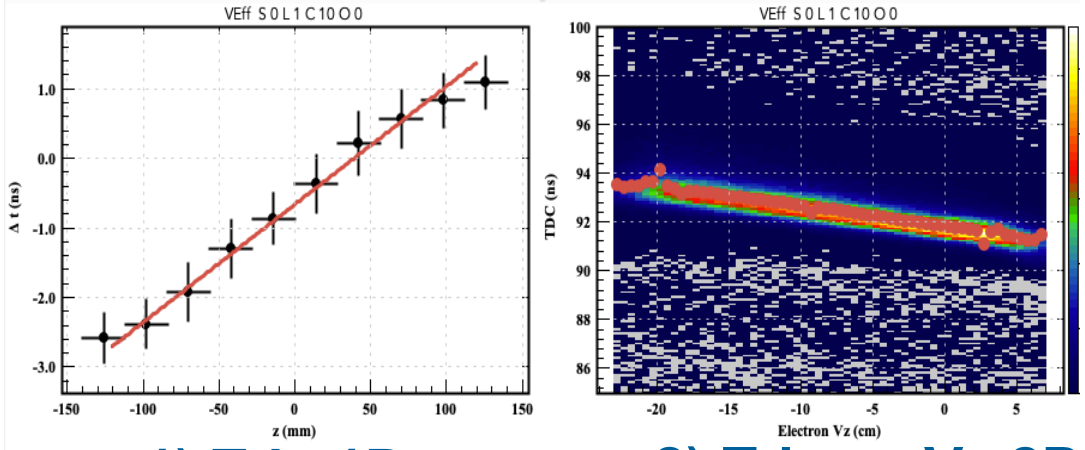
ATOF Calibration

Bar effective velocity

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

Before

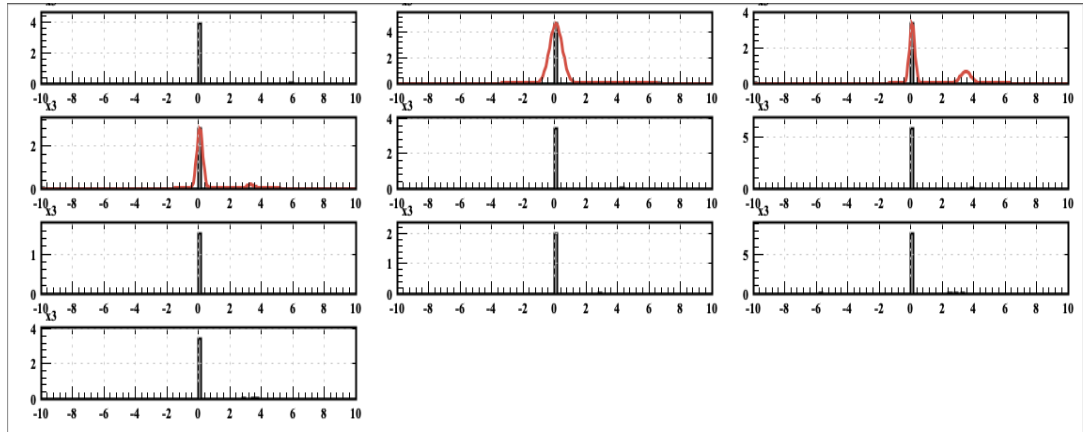


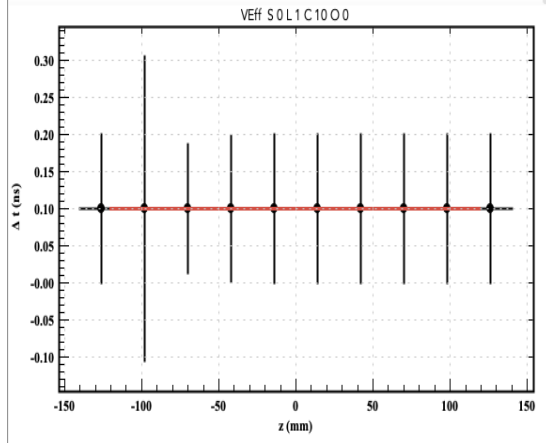


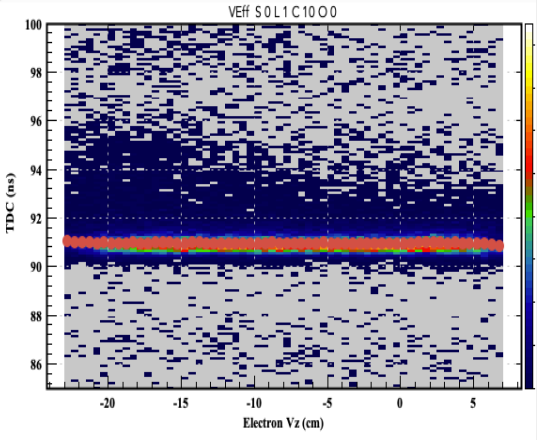
1) Tdc 1D

2) Tdc vs Vz 2D

After



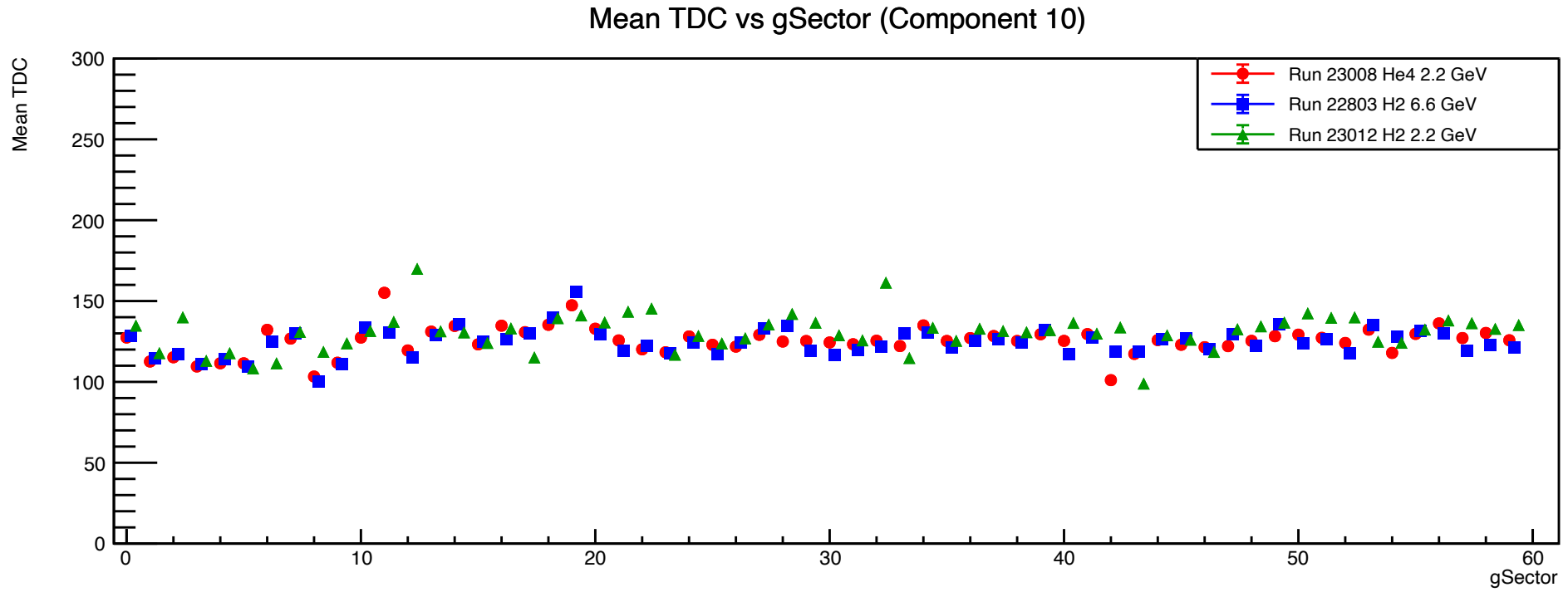




ATOF Calibration

Bar effective velocity – test at different targets

- We compared Veff calculated from H2 runs at 6.6 GeV, 2.2 GeV, and incoherent protons from He4 run at 2.2 GeV.
- Bar wedge alignment required.
- Similar phi pattern.

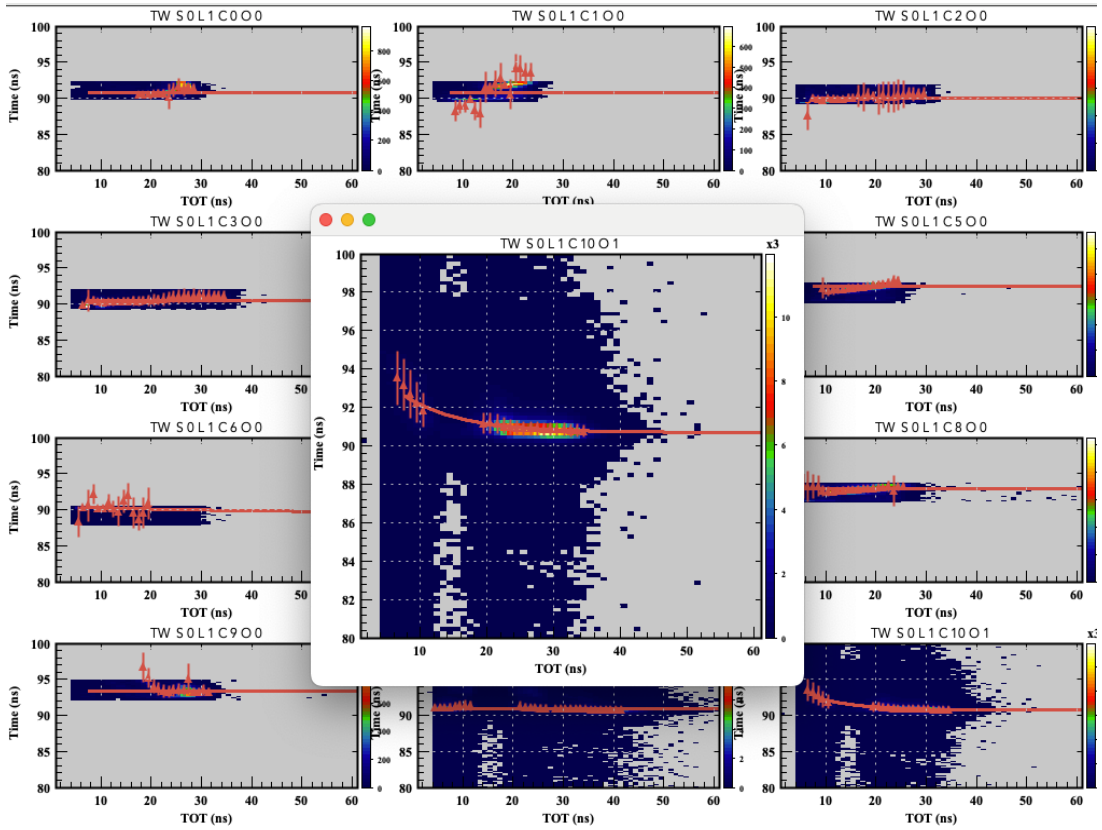


ATOF Calibration

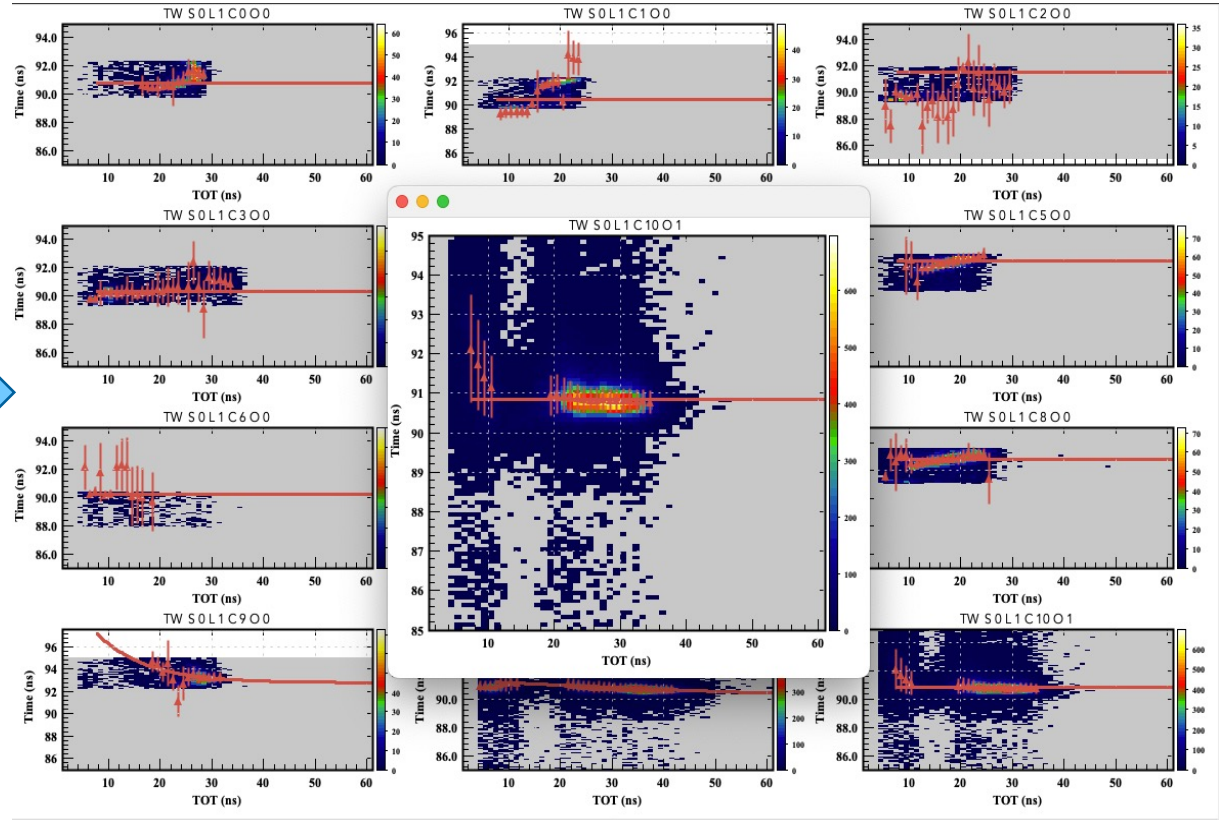
Time walk

- Bar or wedge (from the first peak) TDC vs TOT [ns]. Fit with $f = a + be^{c\,x}$
- Plan: only apply for ToT < 2000 (x~30) regions: $t_{TW}^{w/U/D} = f(x) - f(x = 30ns)$

Before

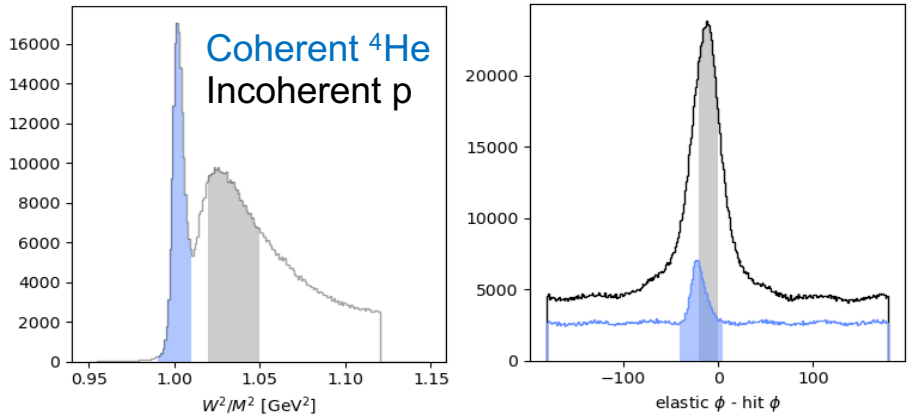


After



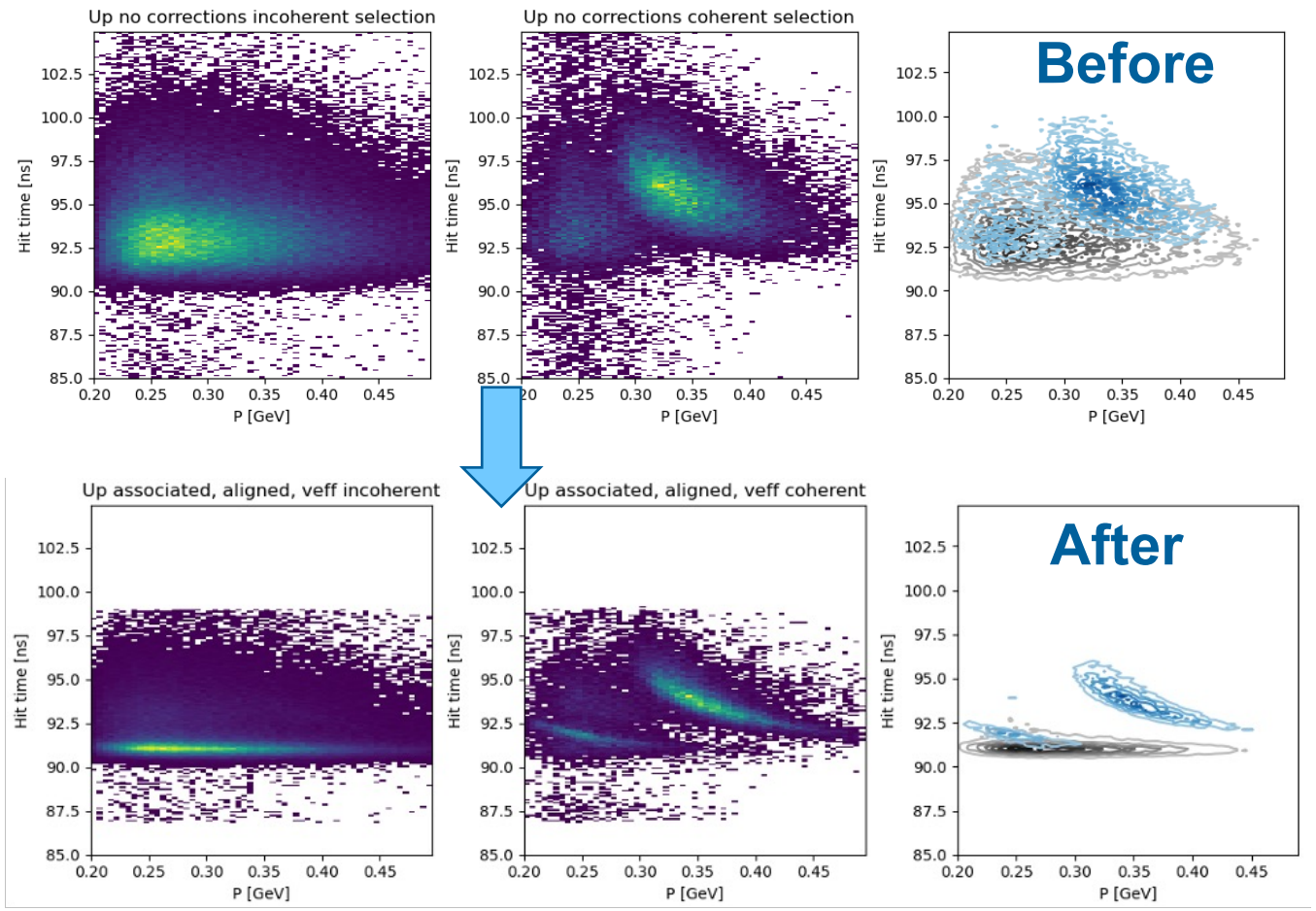
ATOF Calibration

First glance PID (by Noémie Pilleux) - elastic data, 2.2 GeV ^{4}He run



Showing upstream end of the double-sided 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



Conclusion

- We have developed the ATOF calibration suite and generate the first set of constants.
- First test of ^{4}He data at 2.2 GeV shows good results.

- Plan for future: 1) Head for the timeline calibrations, provide QA for different run period. 2) Require propagation time to better understand time-walk calibration.

THANK YOU