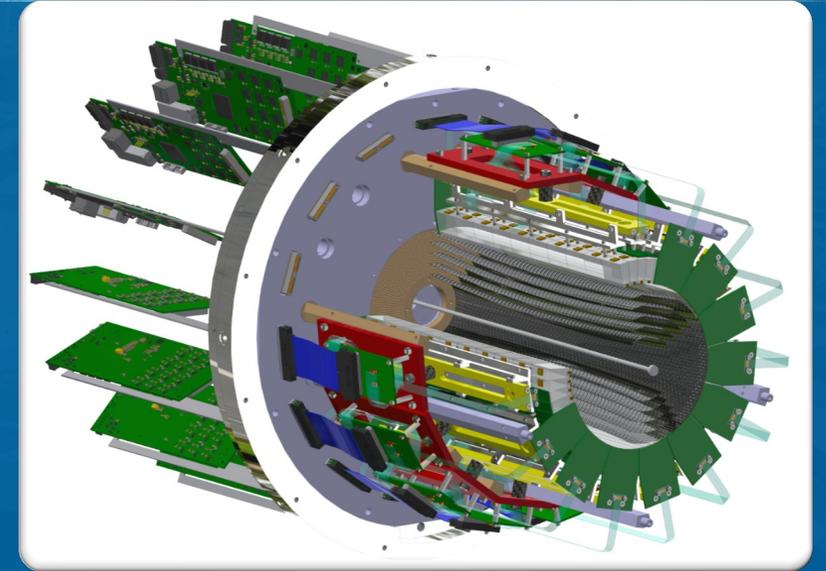


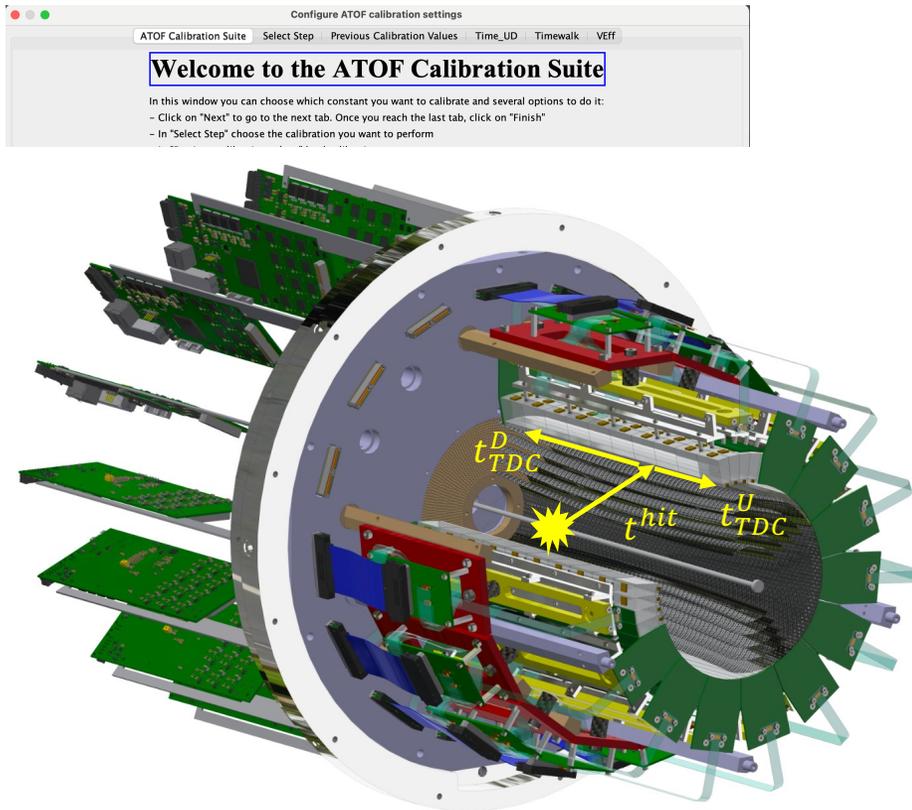
ALERT ATOF Calibration Update



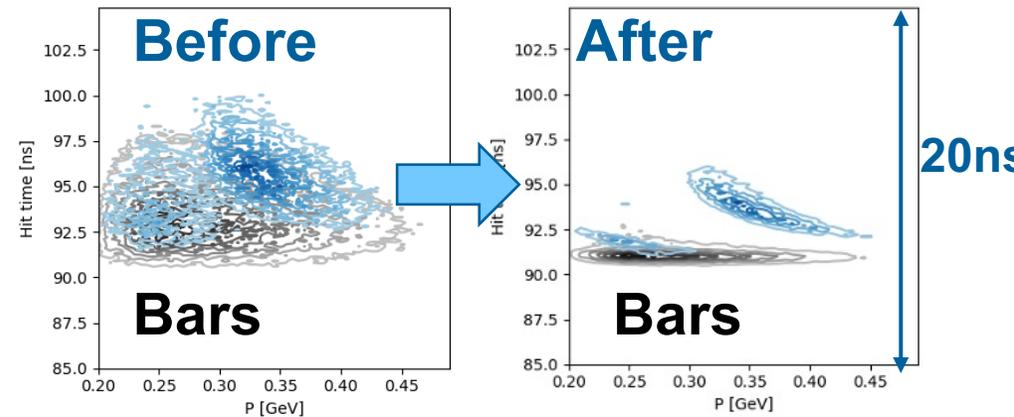
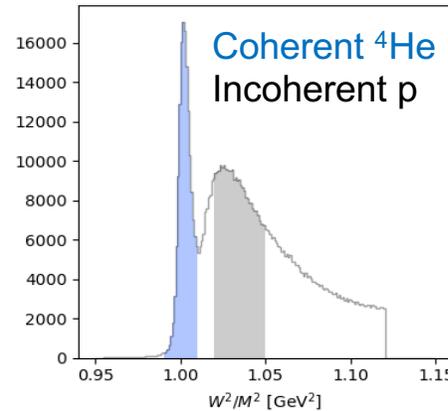
Zhiwan Xu for ALERT/Run Group L
zhiwan.xu@anl.gov
Argonne National Laboratory
03/11/2026

ATOF Calibration

calcode: <https://code.jlab.org/hallb/clas12/calibration/calcode/-/tree/main>



- Bar hit time (t^{hit}) from Up/Downstream end (✓):
 - $t^{D(U)} = t_{TDC}^{D(U)} - t_{vertex} - t_{TW}^{D(U)} \mp t_{U2D} - \frac{L-z}{v_{eff}}$
 - $t^{hit} = \frac{1}{2}(t^U + t^D) + c_{b2b}$
- Wedge hit time (t^{hit}) has 10 z components:
 - $t^{hit} = t_{TDC}^W - t_{vertex} - t_{TW}^W - \frac{h}{v_{eff}} + c_{w2w}$
- Timeline update with CCDB.
- Wedge to wedge calibration along z components.

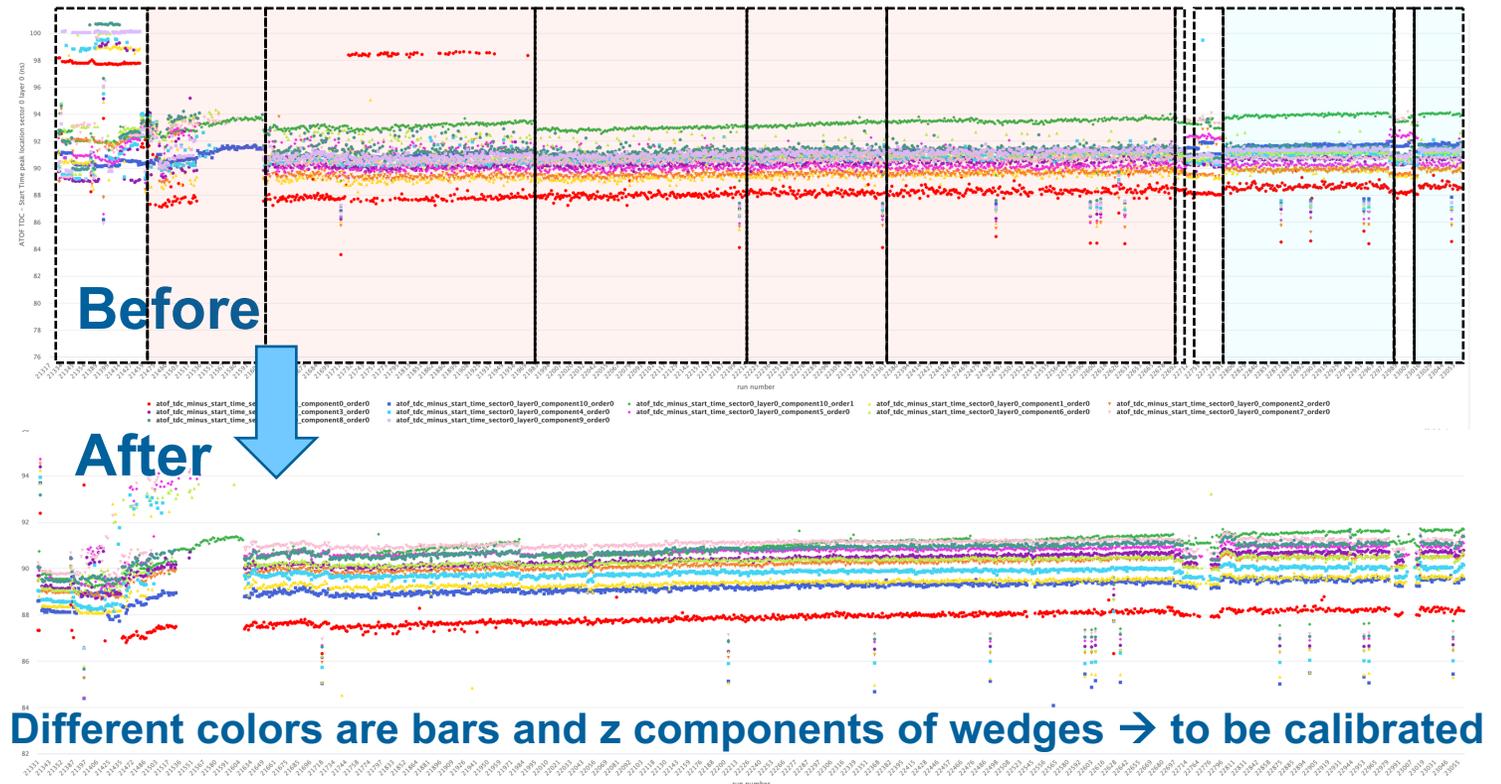


ATOF Calibration

Timeline and CCDB constant

- The RGL ATOF timeline is divided into **11 run periods**, each with its own set of CCDB constants.
- In reconstruction, we implemented the **ATOF::time** bank for t^{hit} with CCDB constants
 - provide a rough alignment for bars and wedges in azimuthal slices to the first slice (reference).
 - In the latest CJ version, we change the reference to 0

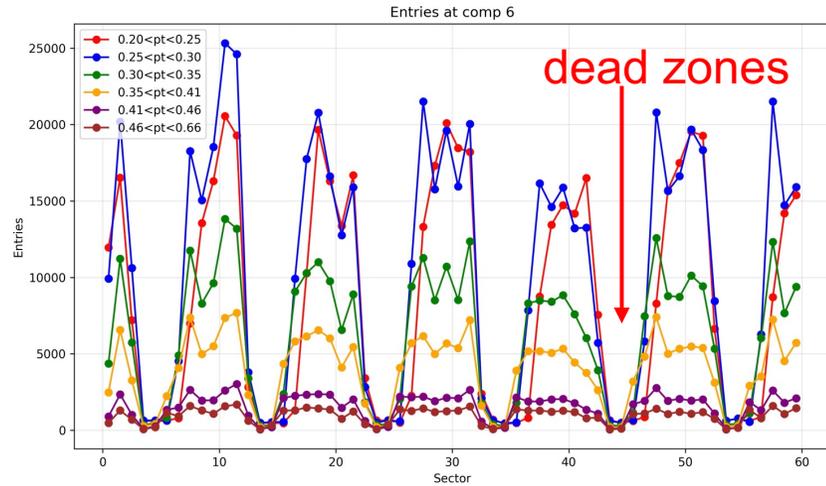
	Start	End	CCDB data
1	21310	21435	Full 21347, 21348 (H2)
2	21436	21611	21520-21602 (He4)
3	21612	21978	21649-21731 (D2)
4	21980	22204	22006-22060 (D2)
5	22205	22358	22231-22276 (D2)
6	22359	22693	22541-22610 (D2)
7	22694	22708	22697-22708 (H2)
8	22709	22791	Full 22784 (H2)
9	22792	22980	22795-22804 (H2)
10	22981	23015	Full 23012 (H2)
11	23016	23065	23028-23056 (He4)



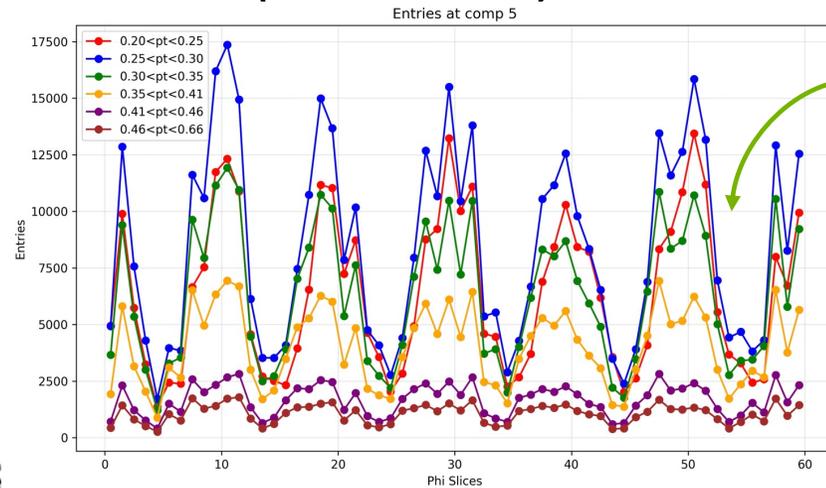
ATOF Calibration

Finer alignment

23012 (H2 + elastic cut)

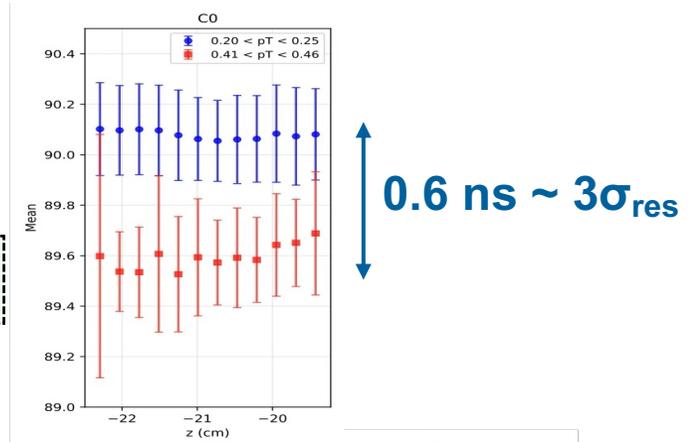


22991 + 22994 (D2 + elastic cut)

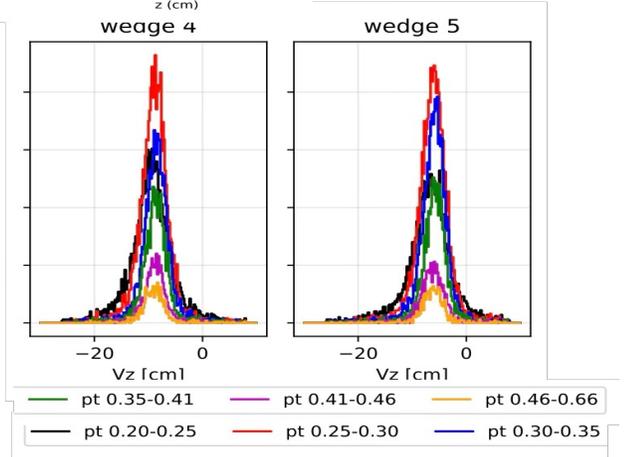


- Elastic data use FD reconstructed electrons show acceptance dead zones. Partially recovered in D2 runs.
- With a tight V_z and p_T cut, we minimize path-length differences, with durable statistics

p_T Bin [GeV/c]	θ_p [°]	θ_e [°]
0.20-0.25	80.1	5.9
0.25-0.30	77.9	7.3
0.30-0.35	75.7	8.7
0.35-0.41	73.2	10.3
0.41-0.46	70.6	12.0



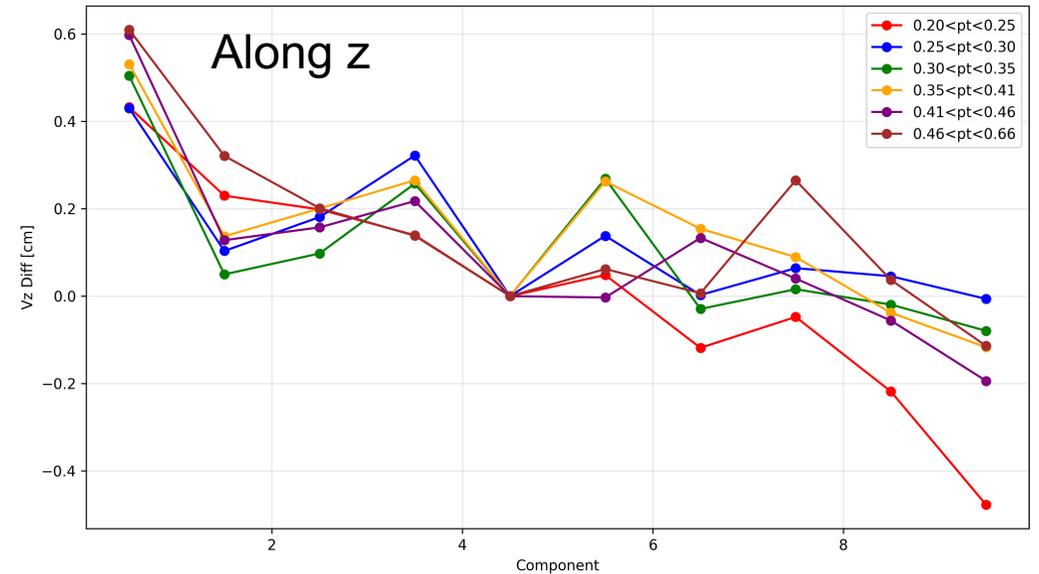
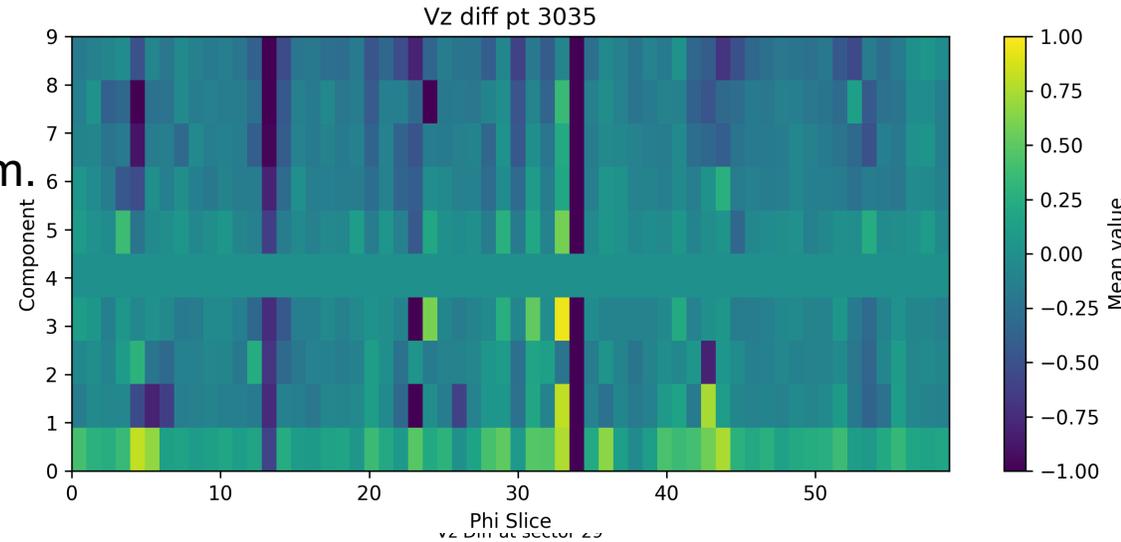
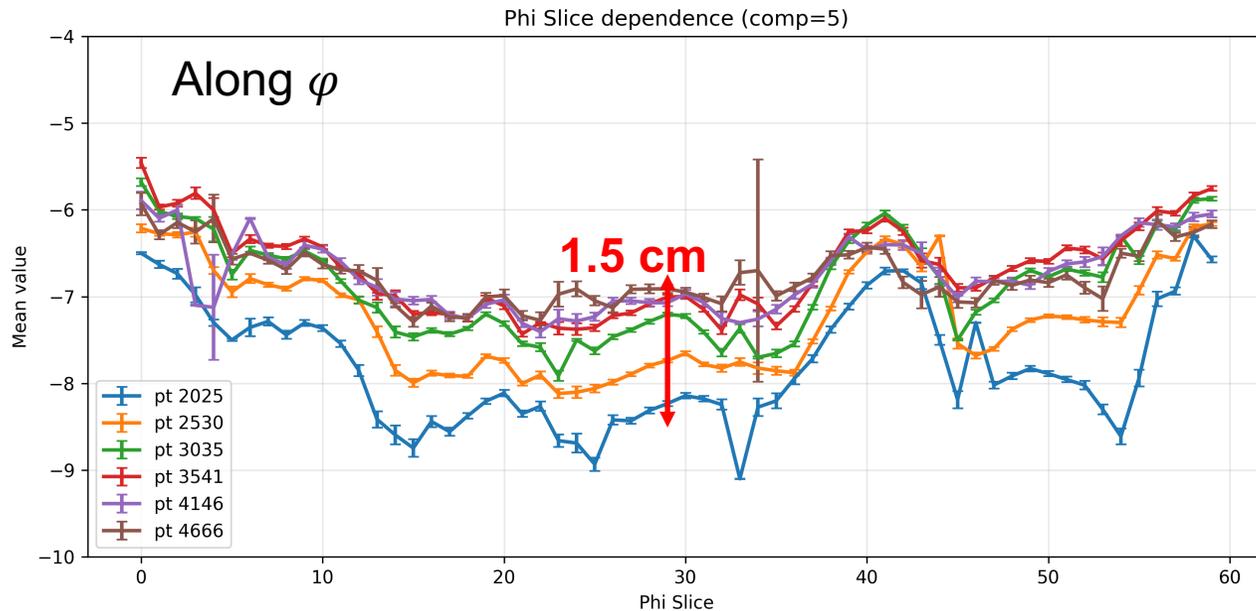
V_z Bin	Range [cm]
Upstream	[-1.35, -0.75]
Center	[-0.3, +0.3]
Downstream	[+0.75, +1.35]



ATOF Calibration

Finer alignment: D2 run 22991+22994

- Electron V_z show p_T shift. θ from $80^\circ \rightarrow 70^\circ$, roughly ~ 1.5 cm.
- V_z shows φ -dependence. Fine alignment is calculated and applied per local slice.
- A small z dependence.



ATOF Calibration

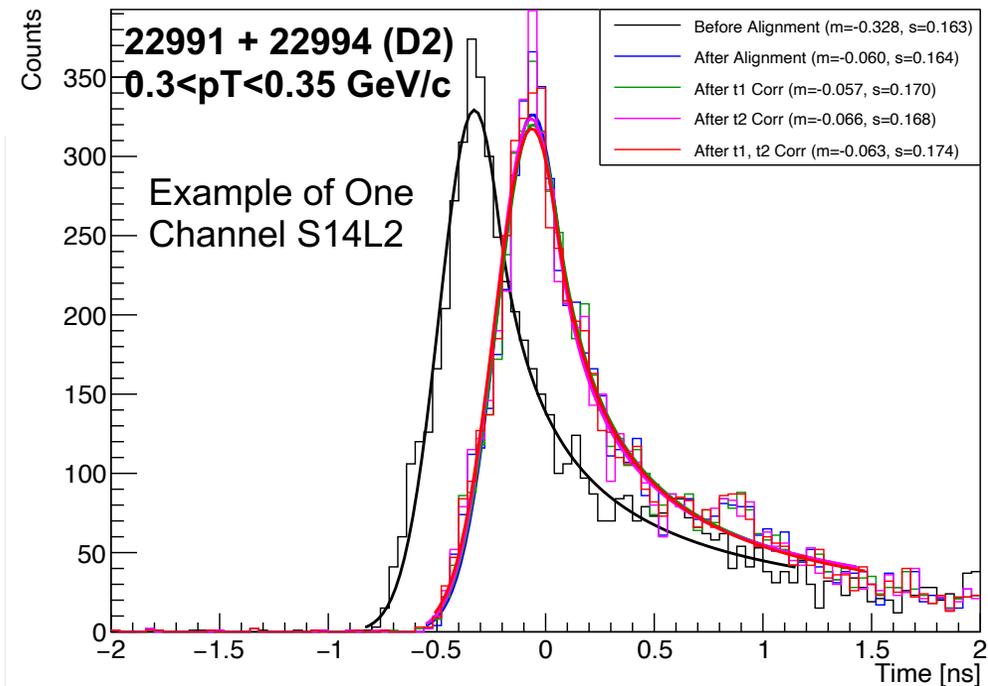
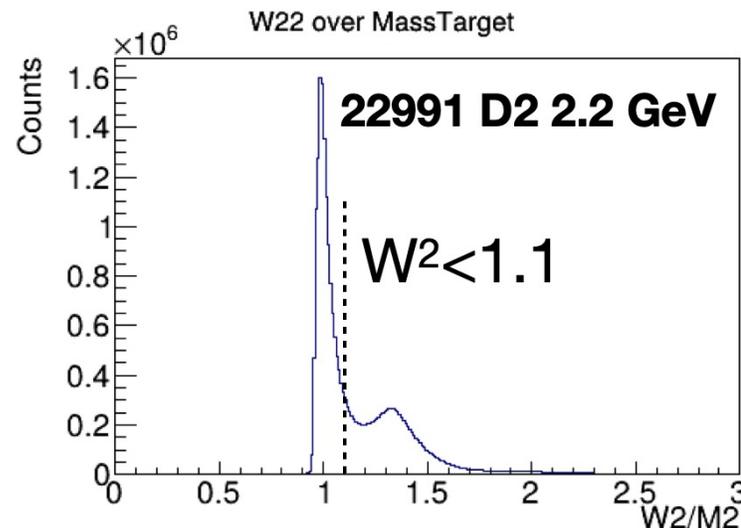
Alignment + Correction

- Step 0. Alignment: Use time (t_c) at central V_z to align at $t = 0$ ns. Fit with Crystal-Ball function.

- Step 1. Electron timing correction $t_1 = (V_z - V_z(0))\frac{1}{c}$, at $\frac{L}{2} \approx 47$ ps

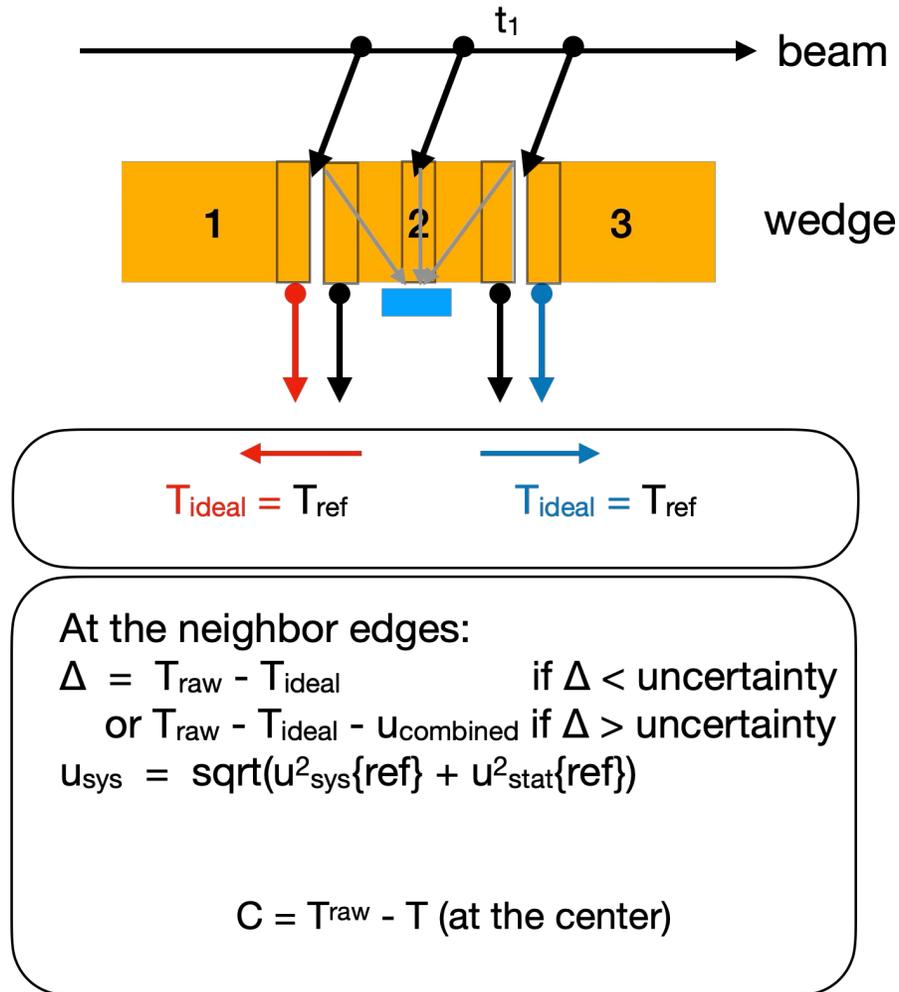
$L = 2.8$ cm, $h = 1.975$ cm, and $n = 1.58$.

- Step 2. Photon propagation $t_2 = \frac{\sqrt{h^2 + (V_z - V_z(0))^2} - h}{c/n}$, at $\frac{L}{2} \approx 24$ ps

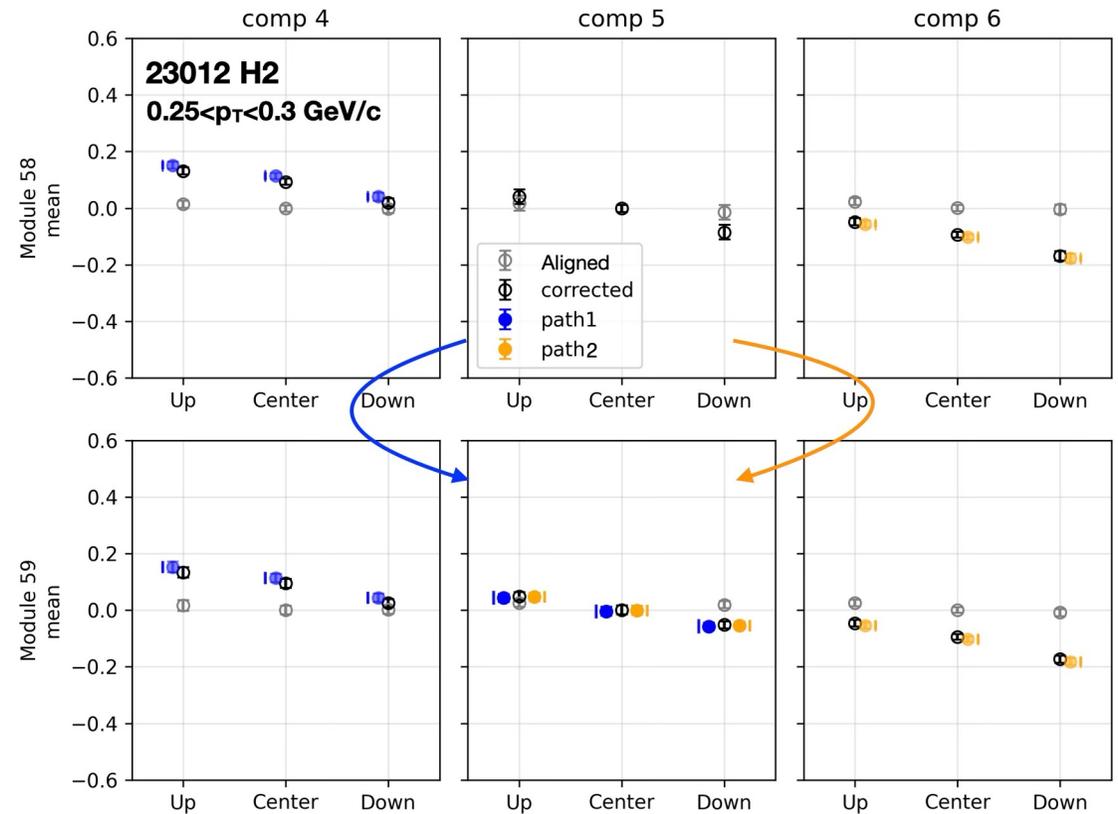


ATOF Calibration

Wedge to wedge calibration

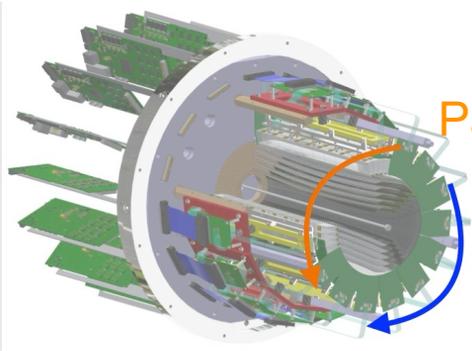


- Propagation algorithm: Align the wedge to reference wedge; then, that one became the new reference.
- A test using 2 close loops returns the same value.



ATOF Calibration

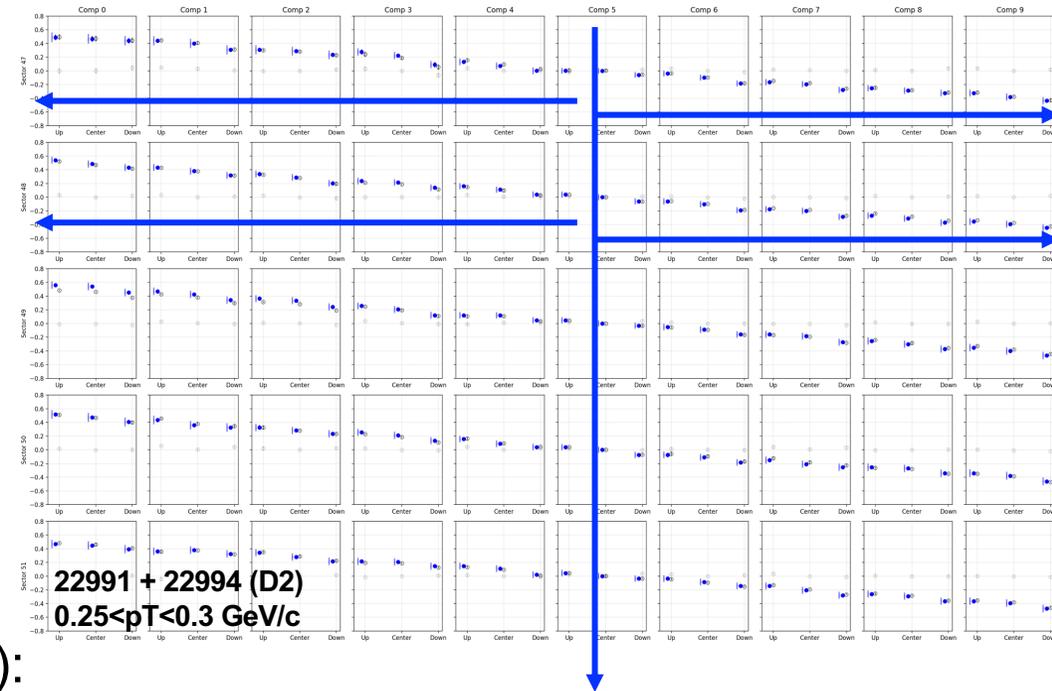
Wedge to wedge calibration: full ATOF



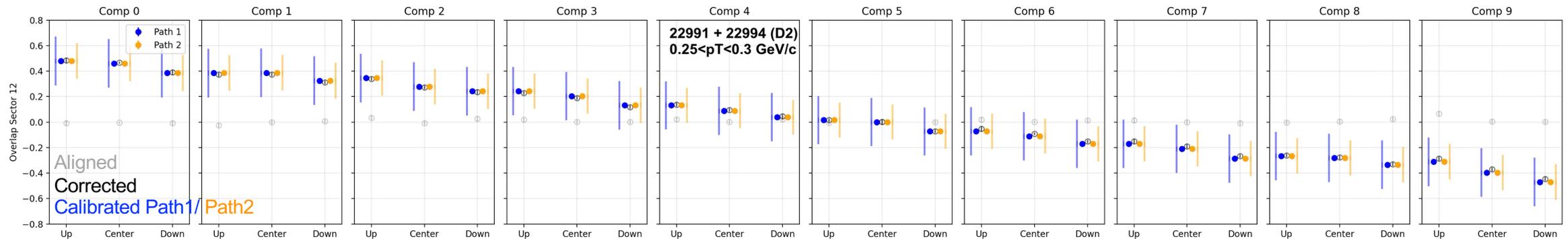
Path 2: S -> S-30

Path 1: S -> S+30

Example of Propagation

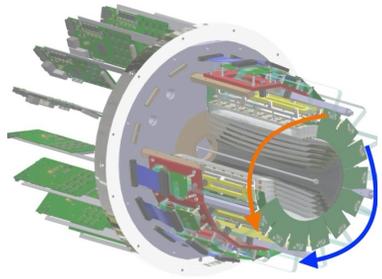


- Check result at the overlap channel (start from 42 → 12):
 - Two paths return the same constant value
 - Accumulated systematic uncertainties are close



ATOF Calibration

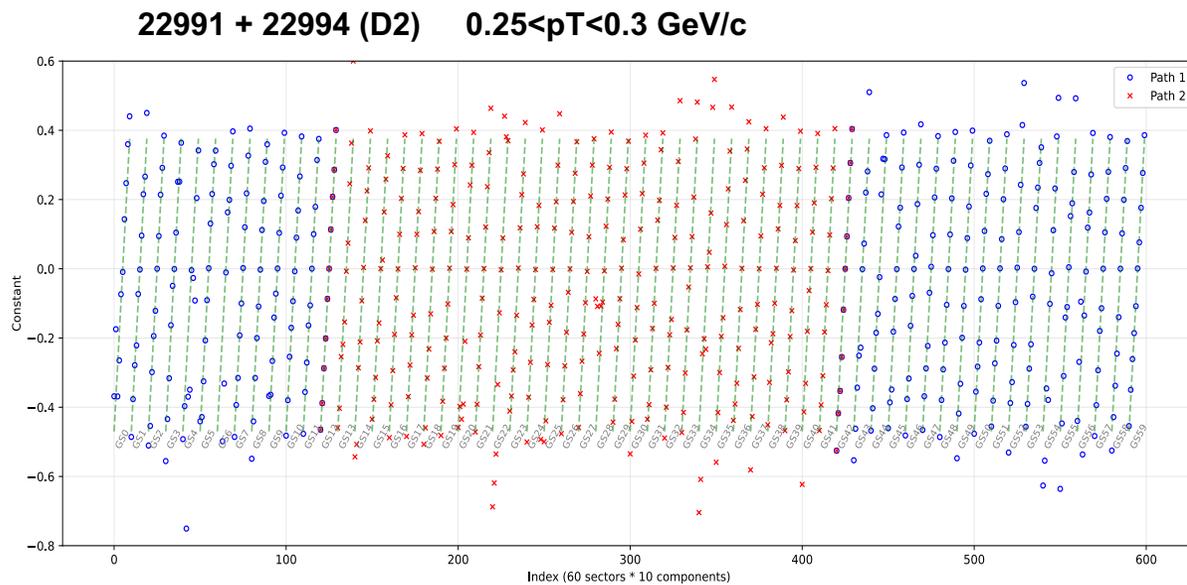
Wedge to wedge calibration



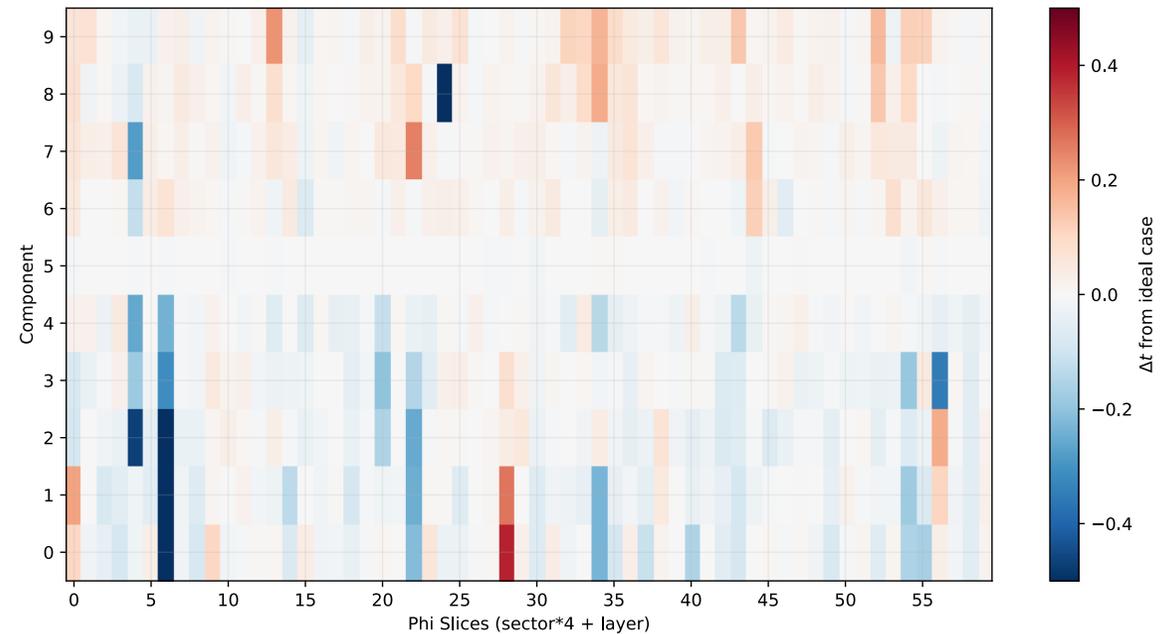
Path 1: S -> S+30

Path 2: S -> S-30

- Example Constant Table
 - Green line: t^{ideal} from electron timing correction
 - Time difference $\Delta t = C - t^{\text{ideal}}$ is small, proving detectors performance is in general good.
- Change to different wedge returns same constants



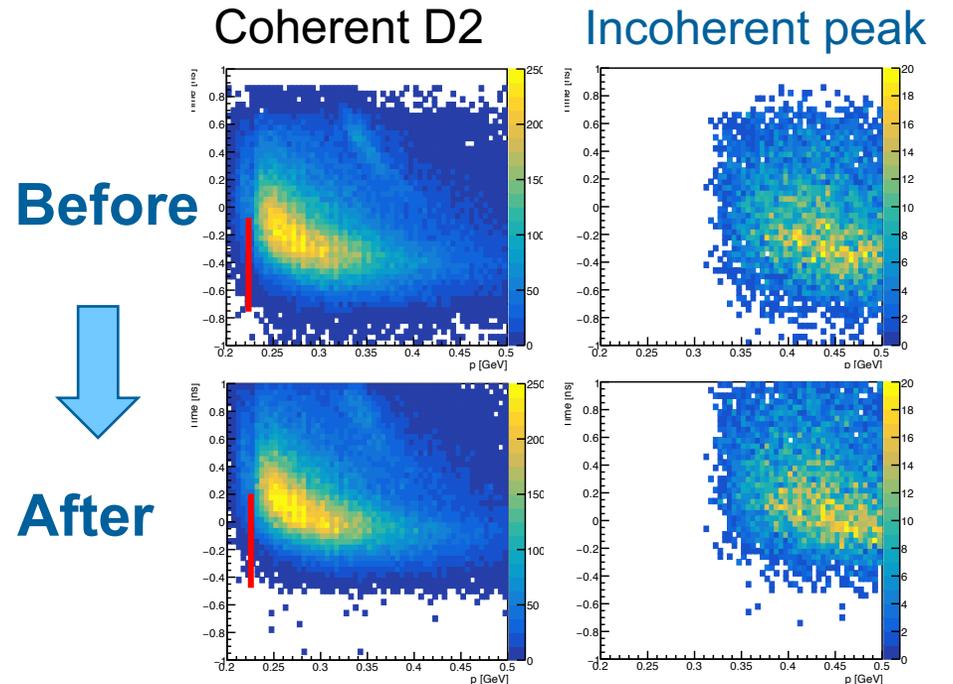
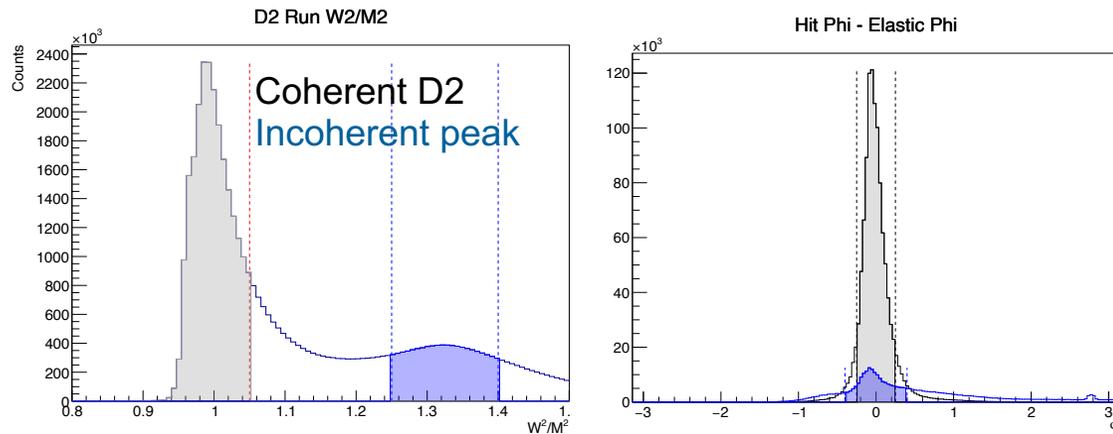
Constant Table



Constant Δt from ideal case

ATOF Calibration

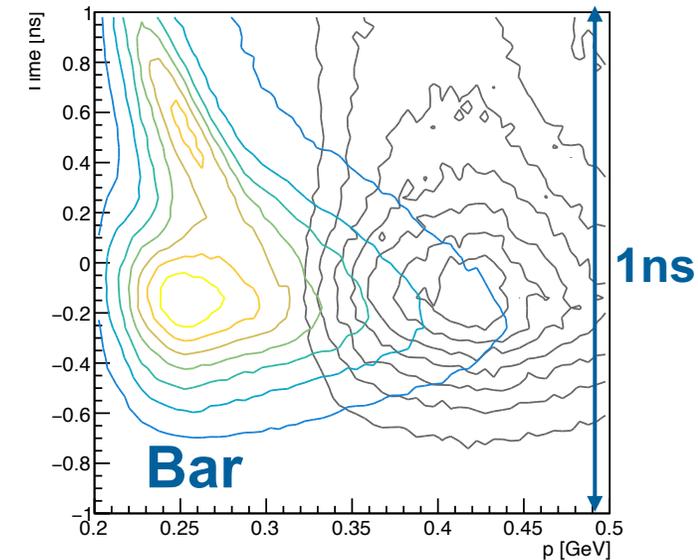
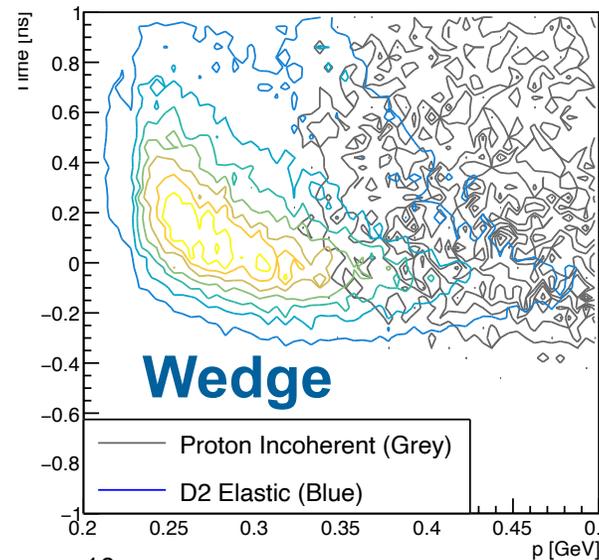
Wedge to wedge calibration: PID at D2 2.2 GeV



- Show the component 5 wedge (at central of ATOF).
- **Before:** with CCDB calibration constant, that has a rough φ alignment
- **After:** with finer φ alignment + wedge to wedge calibration

PID Comparison (Wedge c=5)

PID Comparison (Bar c=10)



Conclusion

- Updated CCDB calibration constants for 11 run period in the timeline.
- Developed wedge-to-wedge calibration propagation code and validated the constants.
- Next step: incorporate tracking-based path length calculation to further improve ATOF timing calibration.



THANK YOU



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