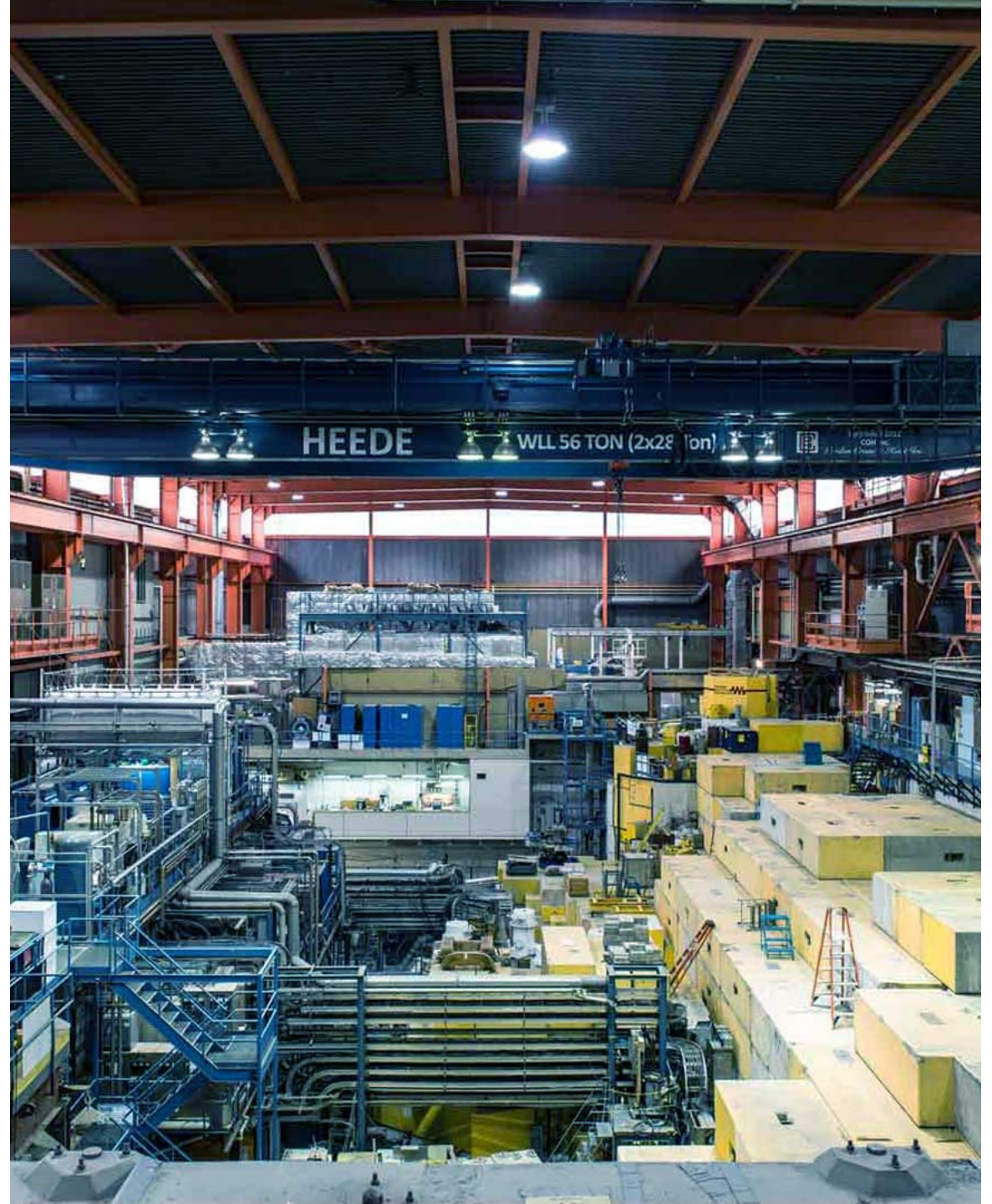


DarkLight Trigger System Status

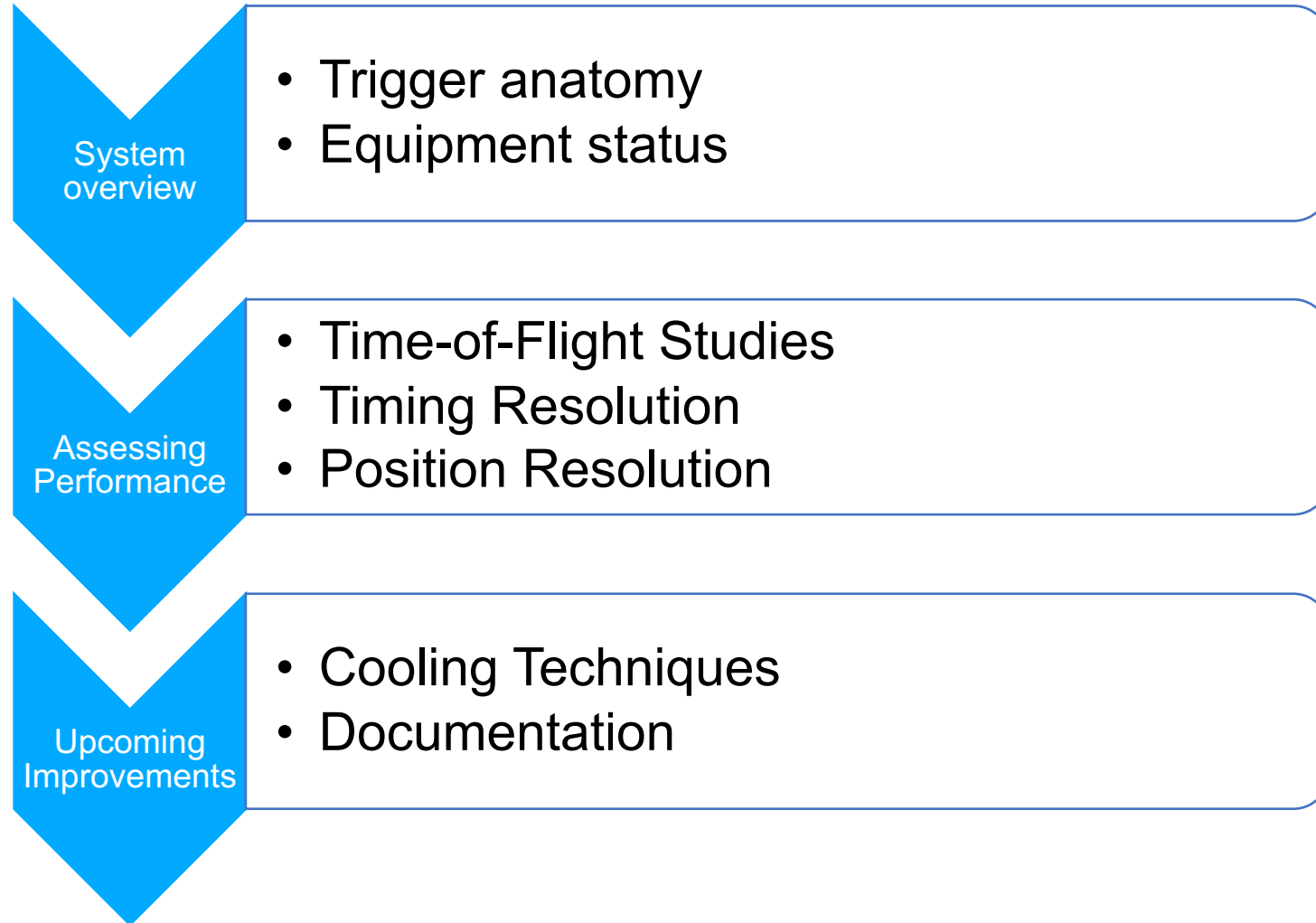
Gabby Gelinas

DarkLight Collaboration Meeting

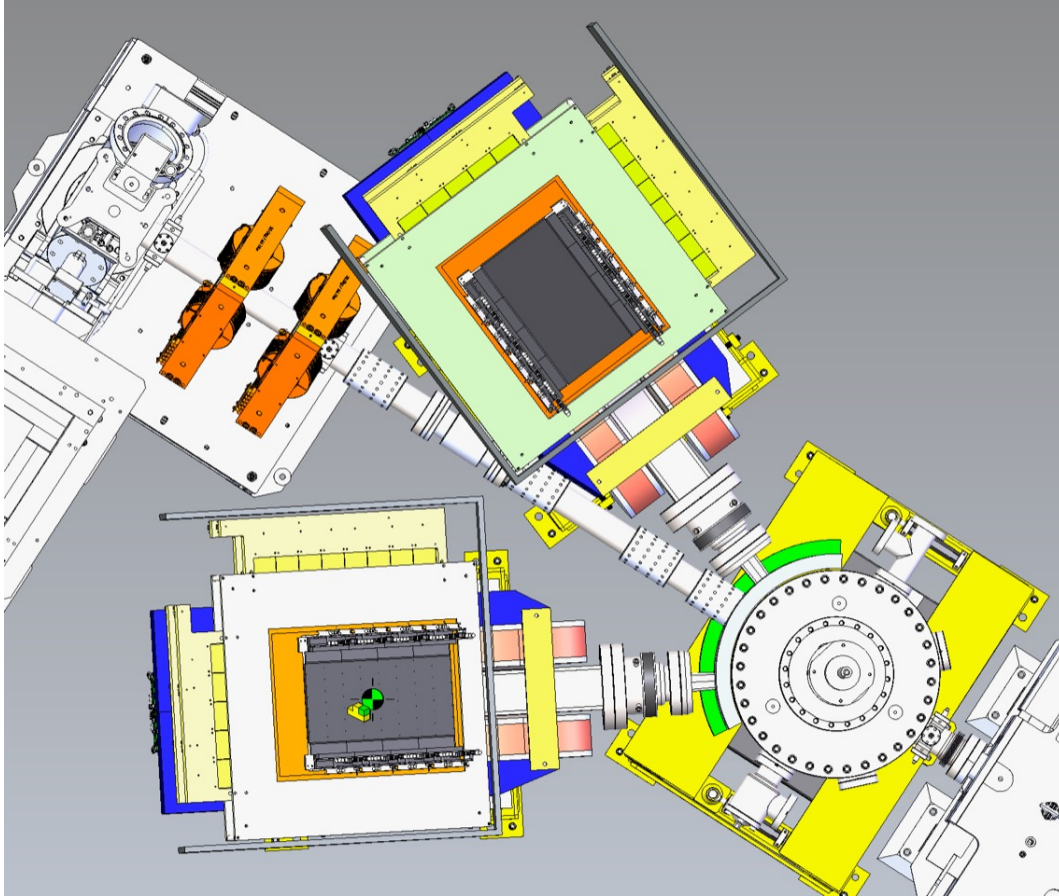
2024-07-10



Roadmap



Trigger System Overview



Goals:

- Prompt data collection in the GEMs → requires better than 200 ps timing resolution
- Provide additional accuracy verification in hit position determination

Trigger Anatomy



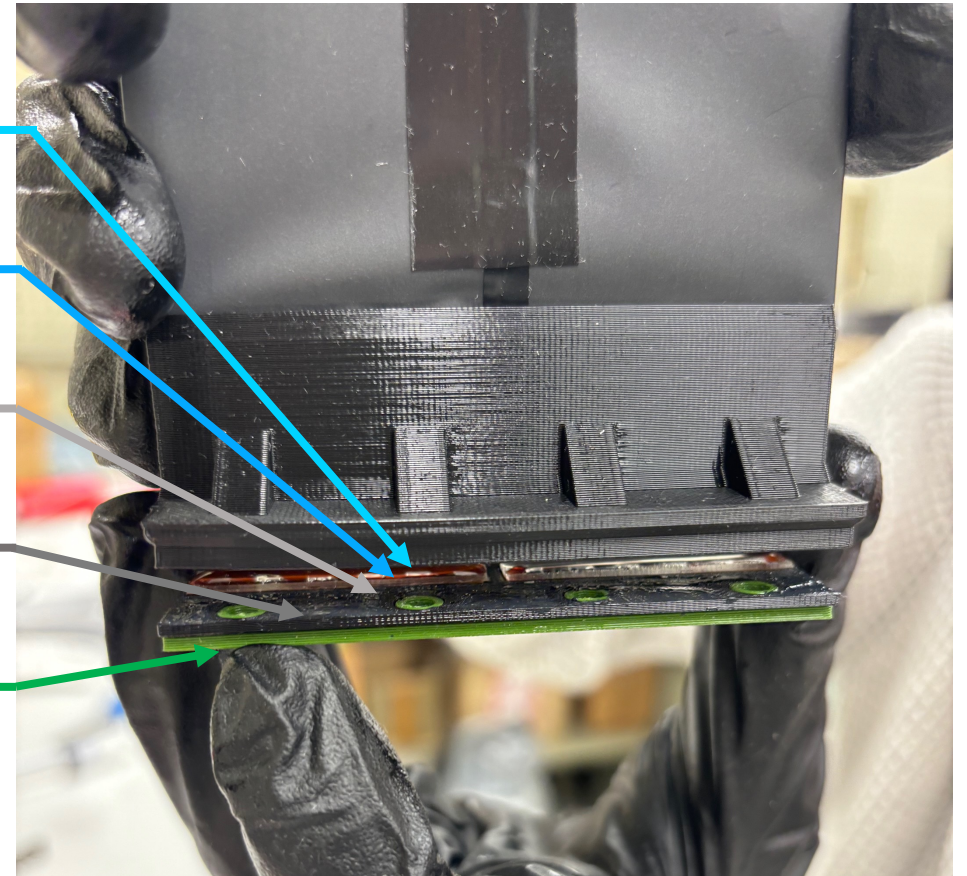
Fresh silicone

Cured silicone cookie

Foam

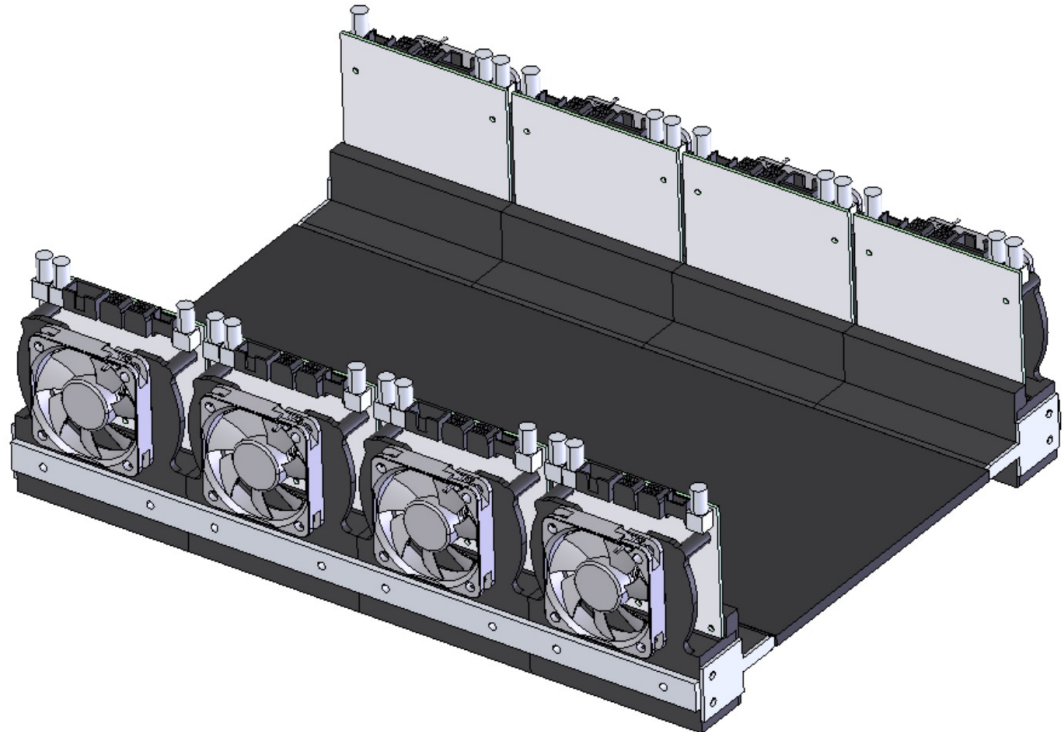
Plastic plate

SiPM board



Equipment Status

- 3/4 prototype paddles assembled
 - 2 will remain as is
 - 2 to be used in making the experiment's paddles
- 11 scintillators available
 - 7 wrapped and ready
- All SiPM boards ready and at TRIUMF
- Underway: small scale design improvements



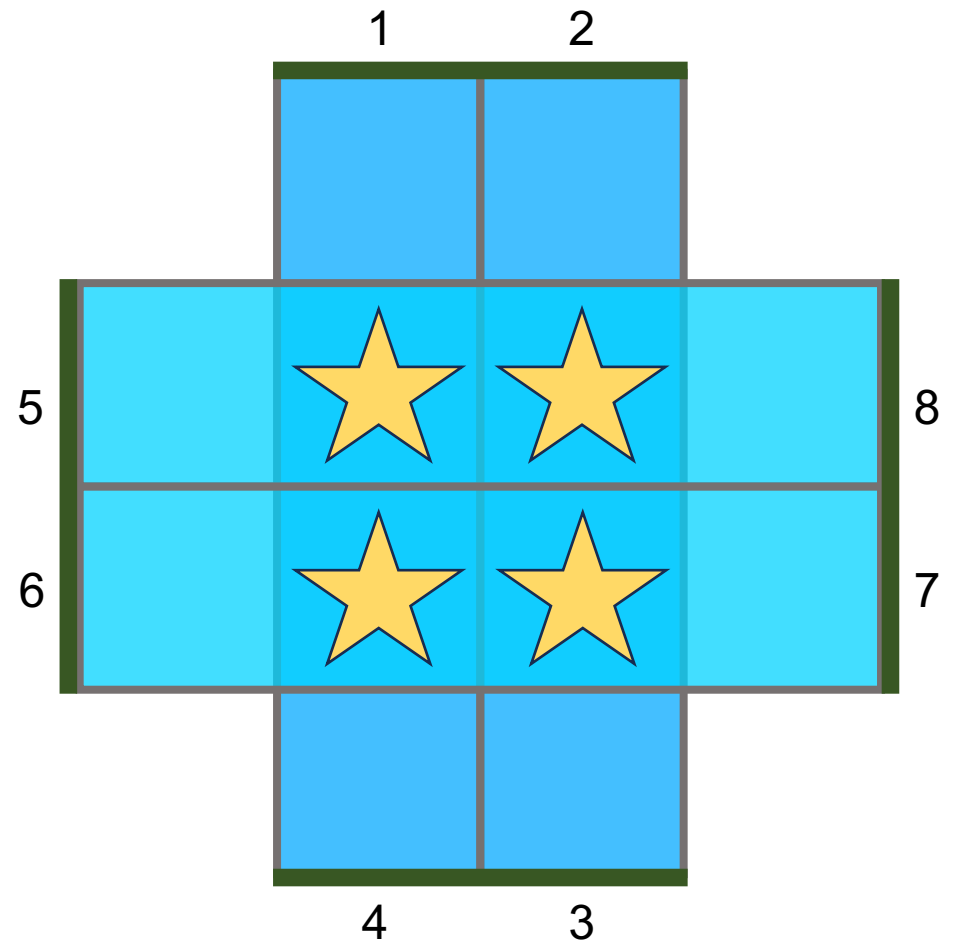
Paddle

Assessing Trigger Performance

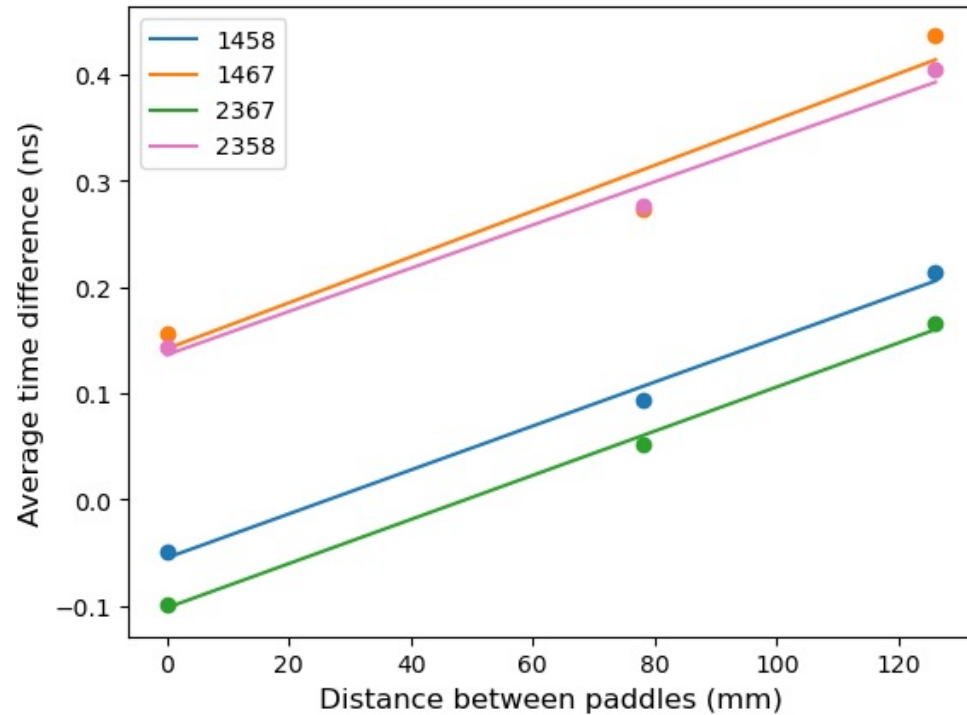
Time-of-Flight Studies

- Goal: prove the system can accurately measure time
- Measuring average arrival difference between the paddles with a variety of vertical spacings between the two paddles

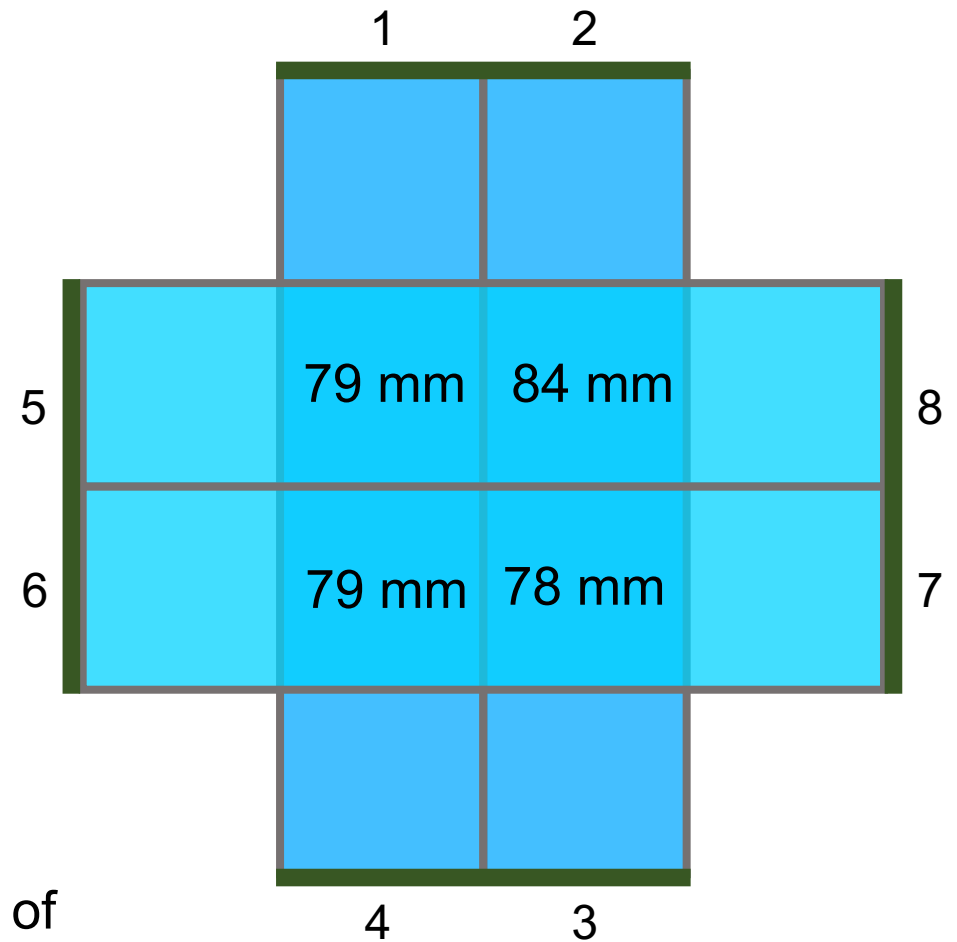
$$\frac{t_8 - t_5}{2} - \frac{t_4 - t_1}{2}$$



Time-of-Flight Studies

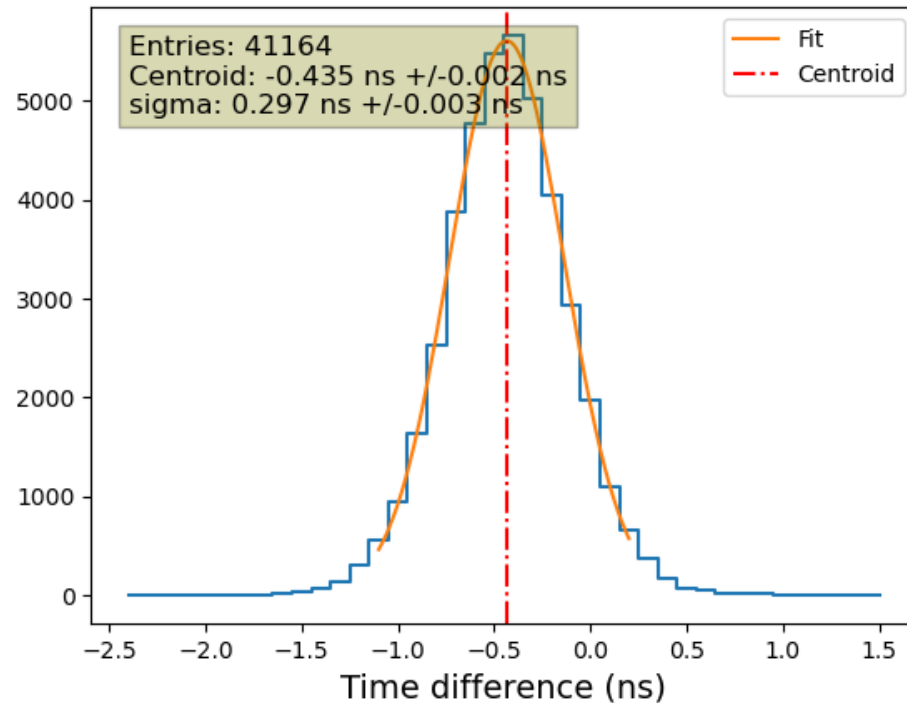


- Apparent gap distance ~67 % of physical distance
- Difference due to uncertainty in the system's definition of one second

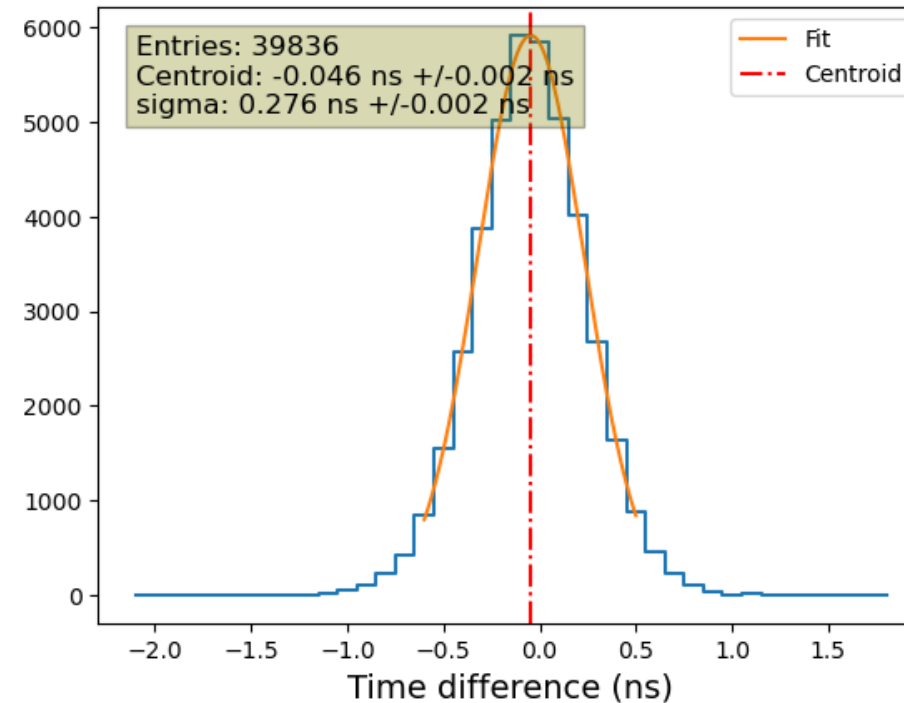


Timing Resolution

$t_4 - t_1$, TWC, coincidence hits [ns]



$t_1 - \frac{1}{2}(t_5 + t_8)$, TWC, coincidence hits [ns]



- Typical for time difference measurements ~ 320 ps
- Typical for absolute time measurements ~ 270 ps
- Best timing resolution so far: 243 ps (absolute time) and 228 ps (TOF)

Timing Resolution

	Top		Bottom	
	$t_4 - t_1$	$t_3 - t_2$	$t_8 - t_5$	$t_7 - t_6$
Mean pulse width [ns]	39.3	38.5	49.3	48.2
Timing resolution [ns]	0.299	0.310	0.388	0.402

	Left scintillators (1 4/5 8)	Right scintillators (2 3/6 7)
Mean pulse width ratio	0.80	0.80
Timing resolution ratio	0.77	0.77

Top scintillator/bottom scintillator

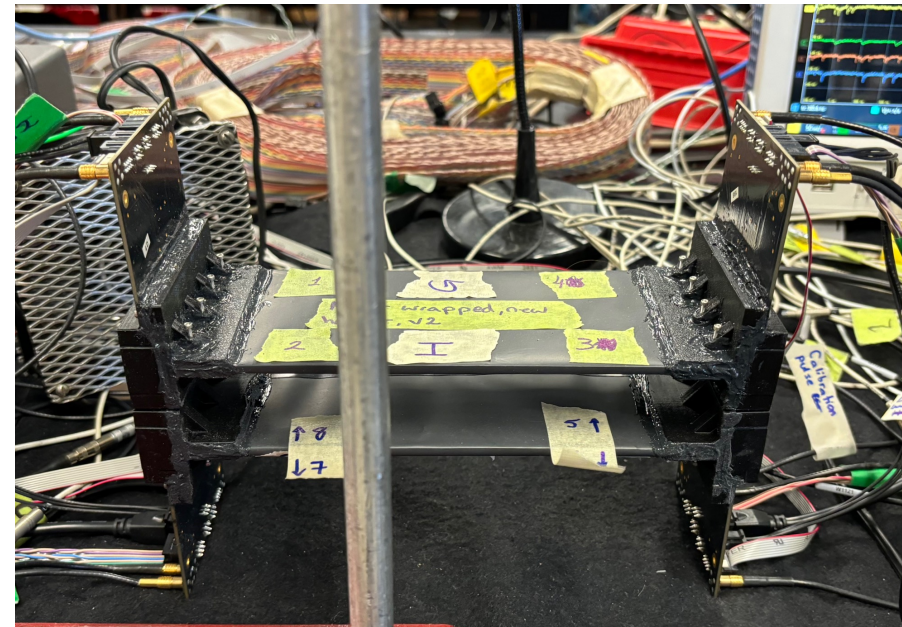
All time differences are restricted to coincidence events between the upper/lower scintillator

Position Resolution

Goal: Support GEMs hit location identification by providing an additional verification system

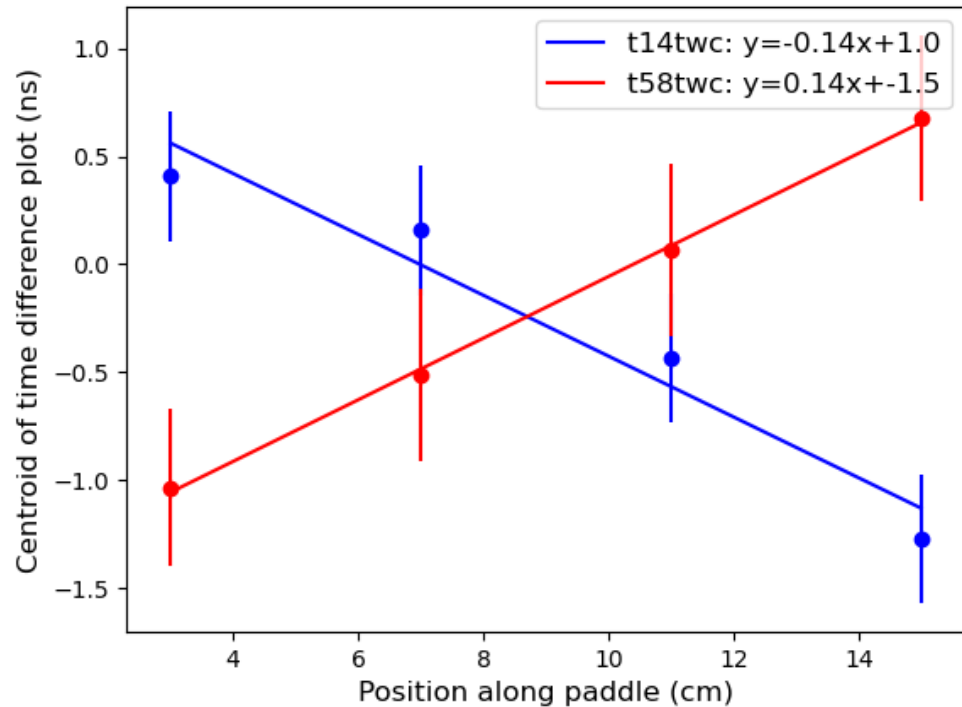
- Improves background filtering

Examined by stacking paddles to enable coincidences and varying a Sr-90 source over the length of a scintillator

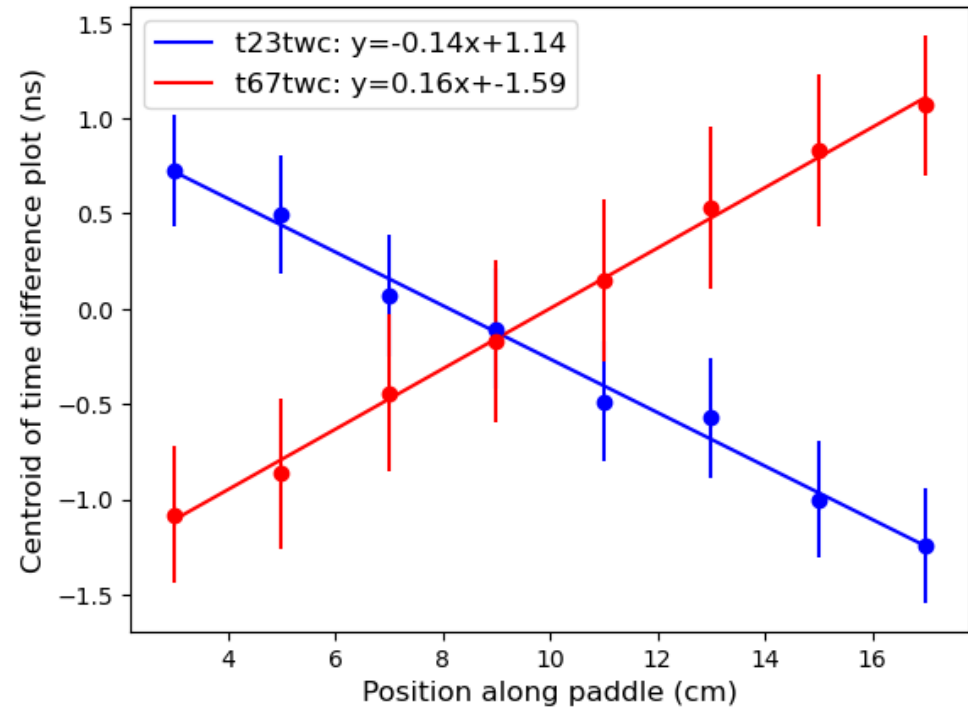


Position Resolution

Position Resolution of Paddle CD with source over 14 14twc*58twc coinc



Position Resolution of Paddle CD with source over 23 23twc*67twc coinc

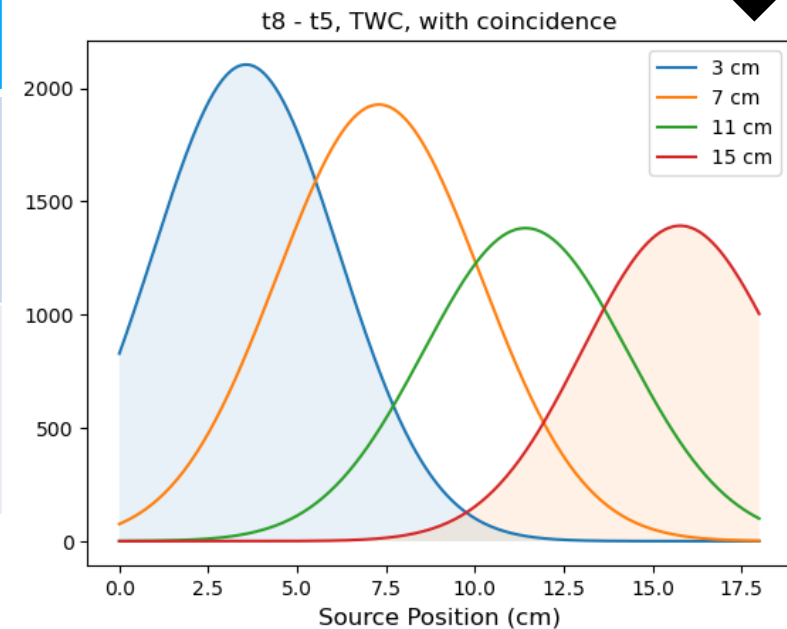
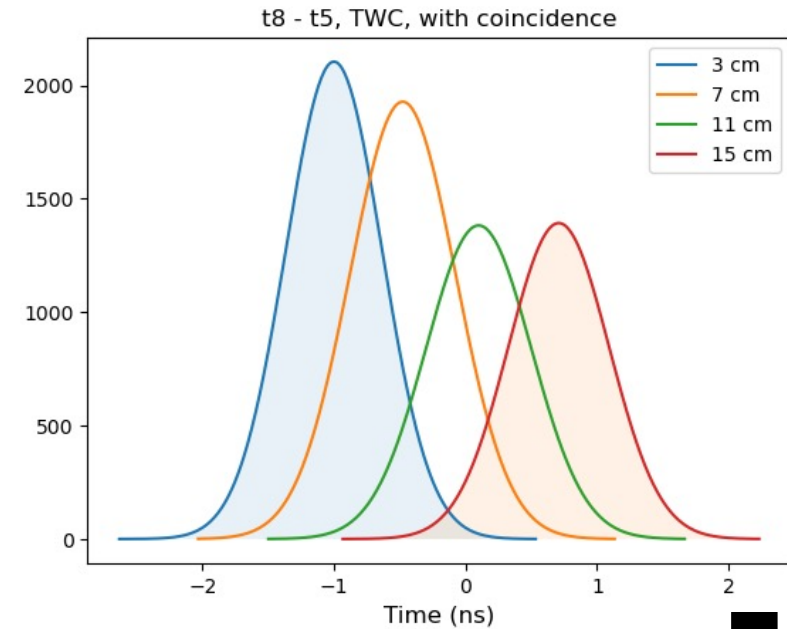


Slope uncertainty: ~ 0.03 ns/cm
y-intercept uncertainty: ~ 0.3 ns

Position Resolution

- Studied four runs with the source position varied by 4.0 cm
- Convert time axis of time difference plot to position

	Left scintillator (14-58)	Right scintillator (23-67)
σ upper scintillator [cm]	2.1	2.2
σ lower scintillator [cm]	2.8	2.5

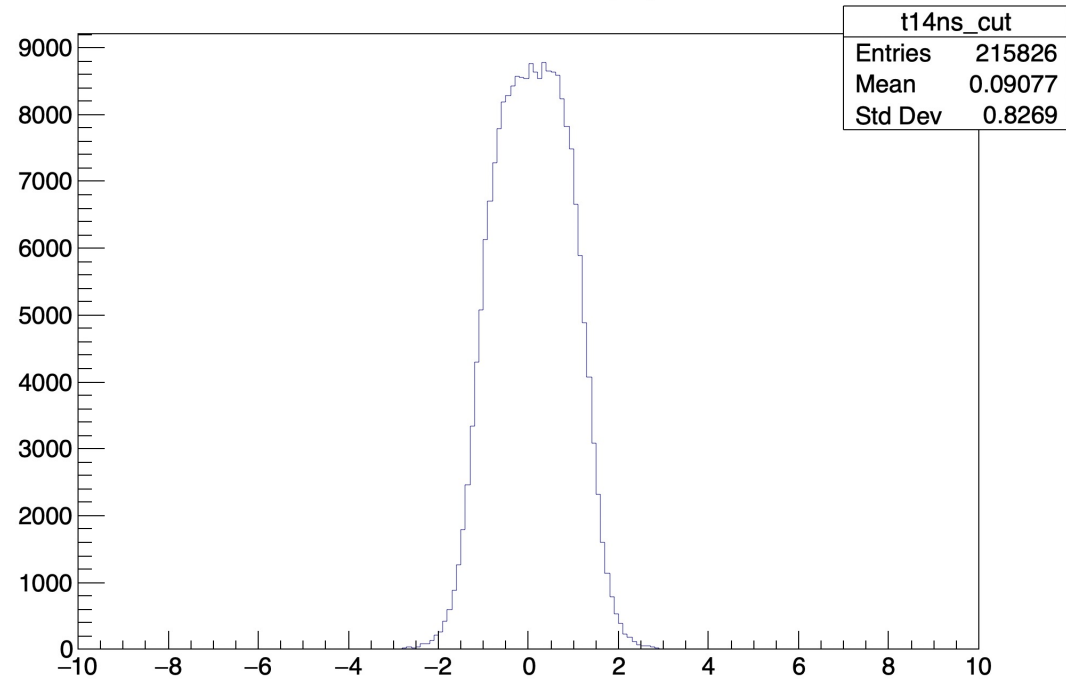


Conversion from previous slide

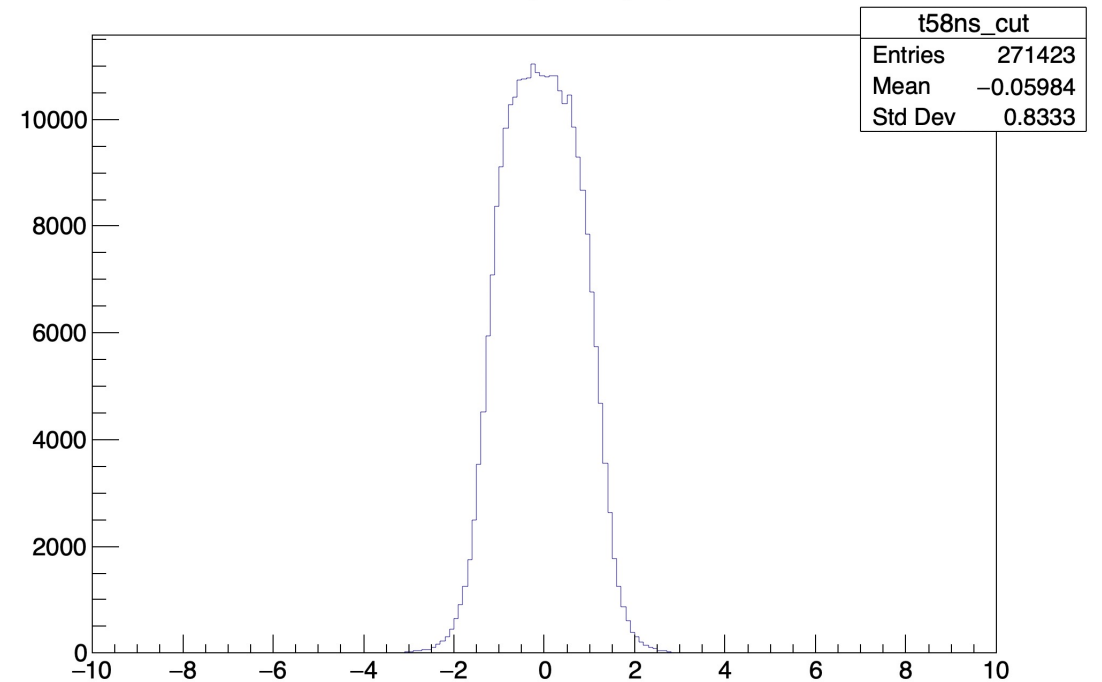
$$x = \frac{1.5 + t}{0.14}$$

Currently Investigating: Cable Length Effect

Paddle 1 time difference, t_4-t_1 (ns) with cut Run 49

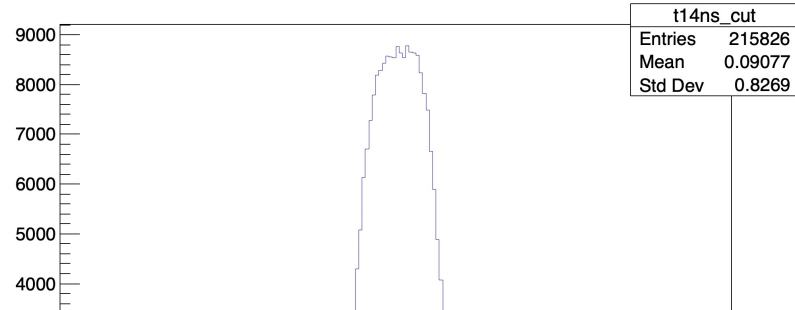


Paddle 3 time difference, t_8-t_5 (ns) with cut Run 49

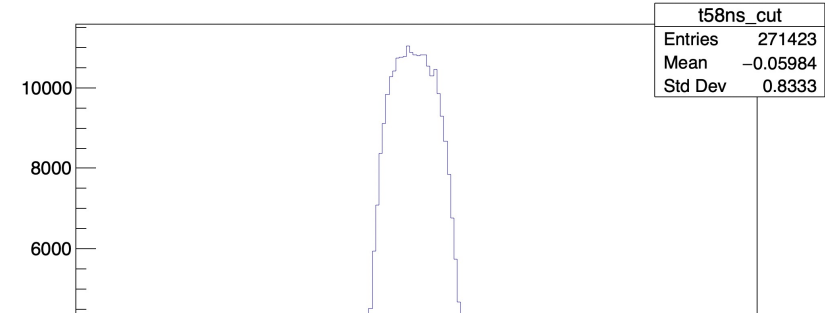


Currently Investigating: Cable Length Effect

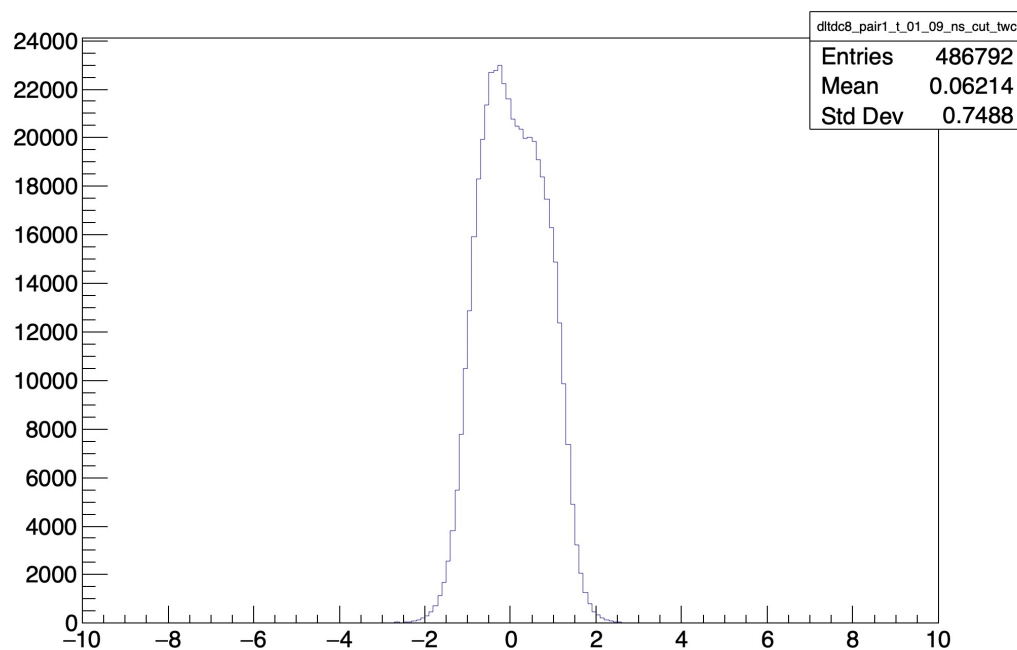
Paddle 1 time difference, t_4-t_1 (ns) with cut Run 49



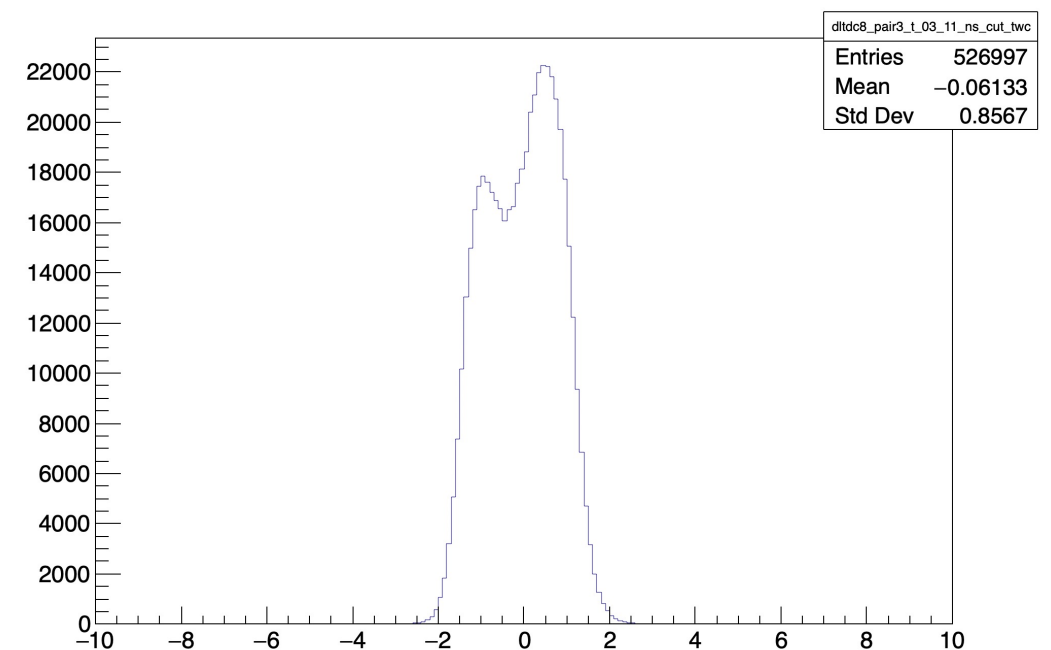
Paddle 3 time difference, t_8-t_5 (ns) with cut Run 49



pair 1 time difference chan 9 minus 1, ns, with cut on width and time walk correction



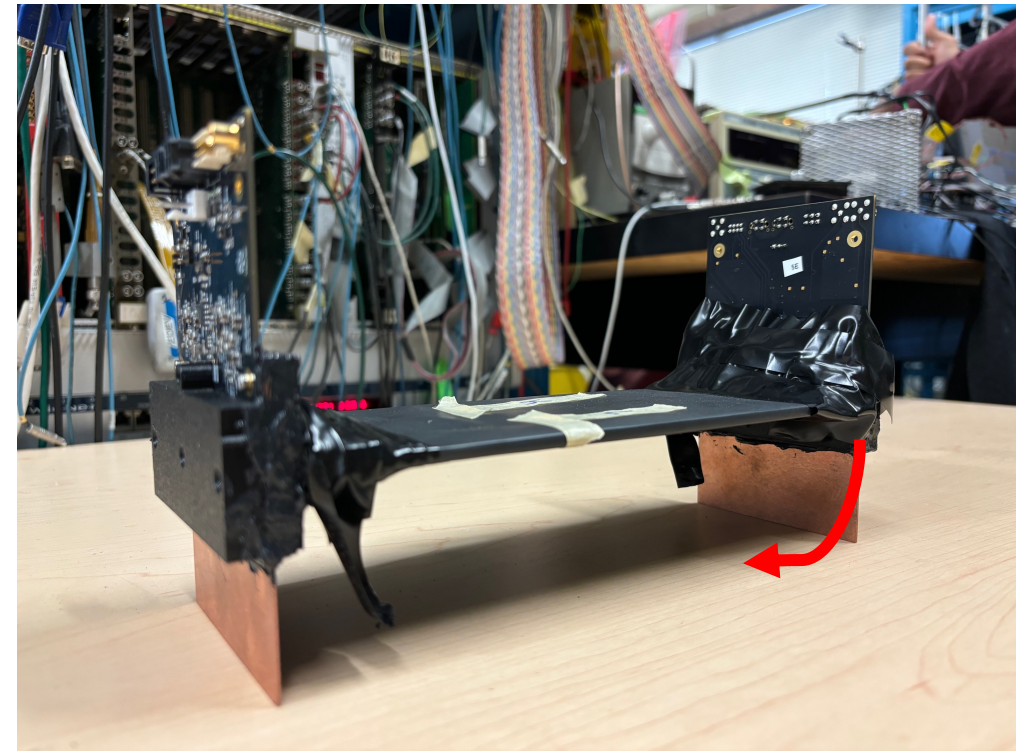
pair 3 time difference chan 11 minus 3, ns, with cut on width and time walk correction



Improving Trigger Performance

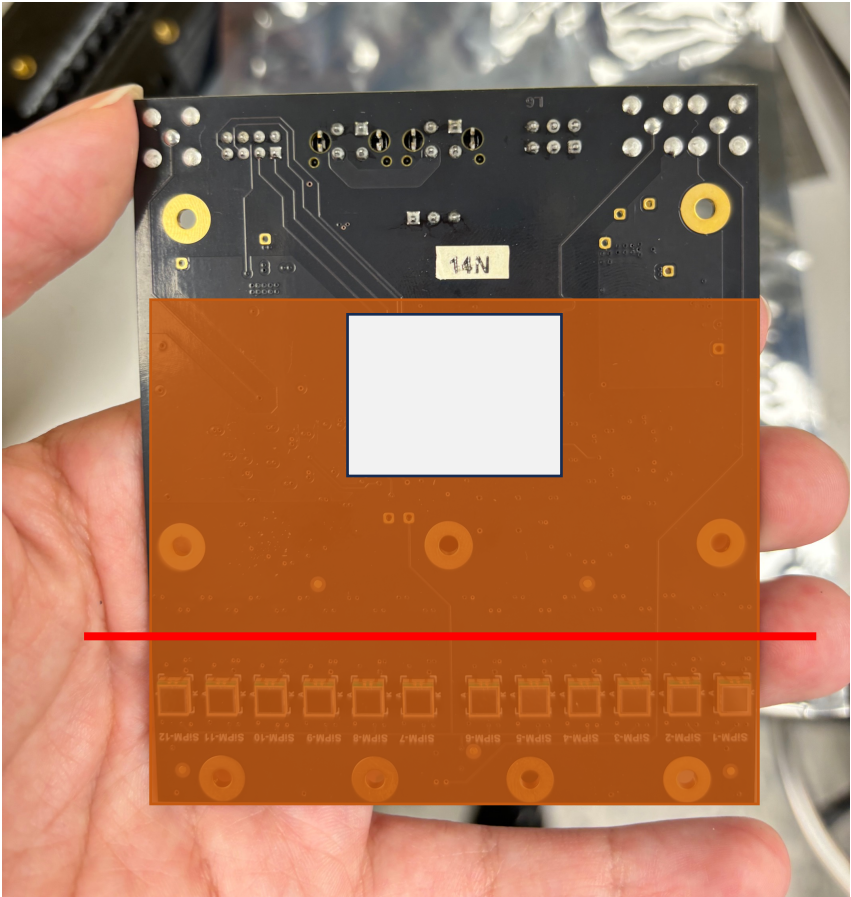
Cooling Techniques

- Replaced plastic spacer with a copper spacer
- Cooled the SiPMs from 36°C to 30°C
- Adds significant height to the system, we are actively investigating solutions

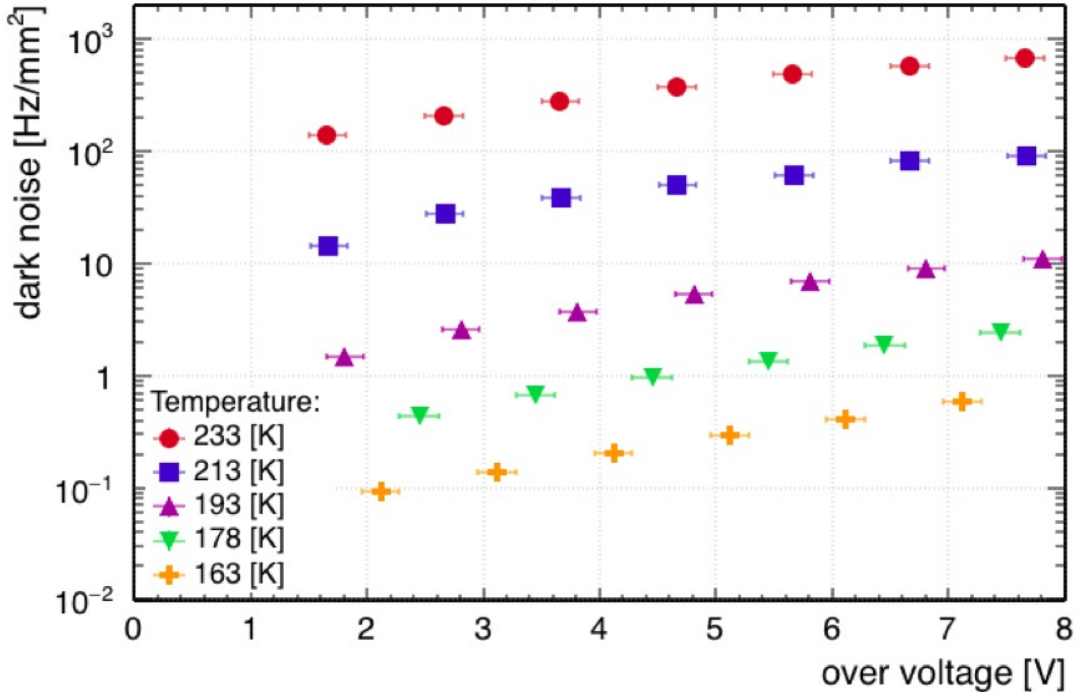


— 3 - 5 mm height addition

Next Steps: Peltier Introduction



— Heat source



Gallina, G., Giampa, P., et al, 2019. Characterization of the Hamamatsu VUV4 MPPCs for nEXO. <https://arxiv.org/pdf/1903.03663>

Ongoing: Improving Documentation

- Trigger user manual development underway
- Four task specific assembly manuals ready
- Cabling diagram under revisions

DarkLight - Trigger Prototype Signals & Systems Diagram

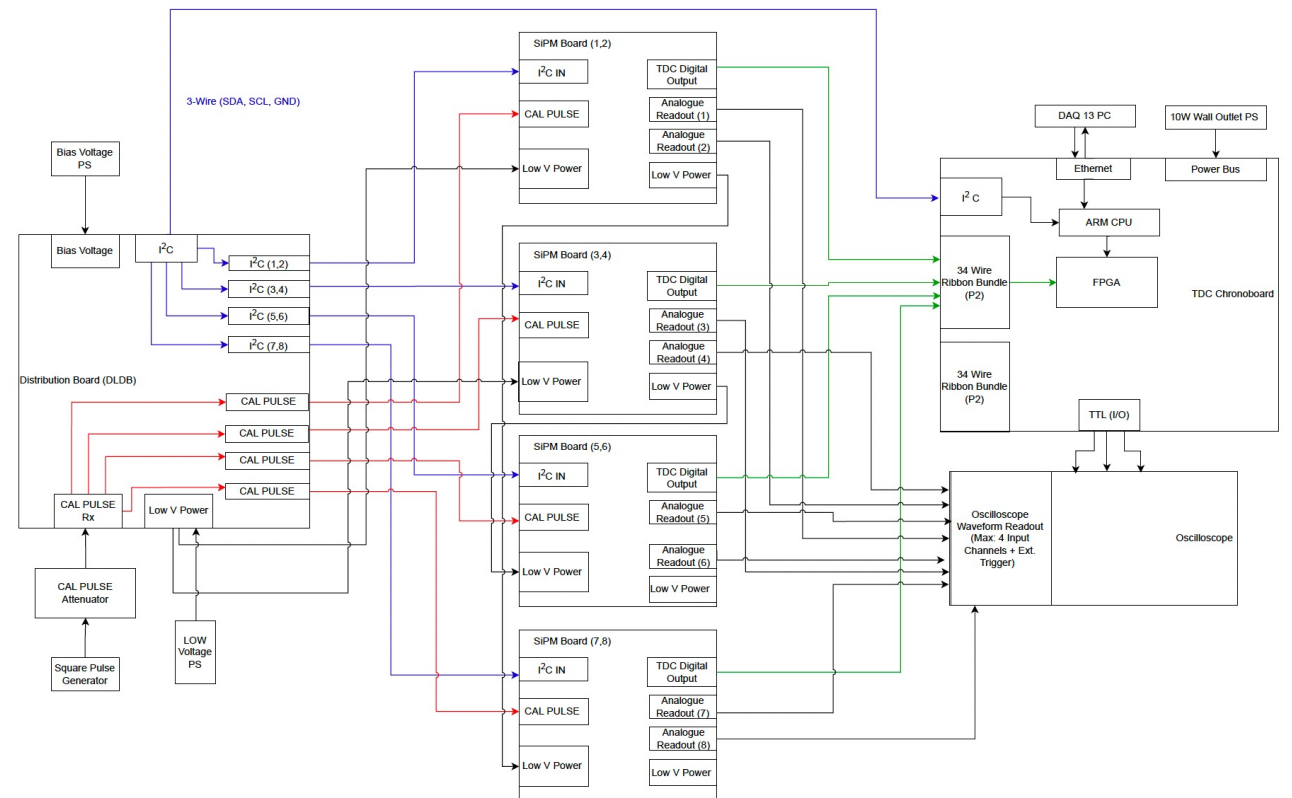


Diagram courtesy of Karm Gill

Thank you
Merci

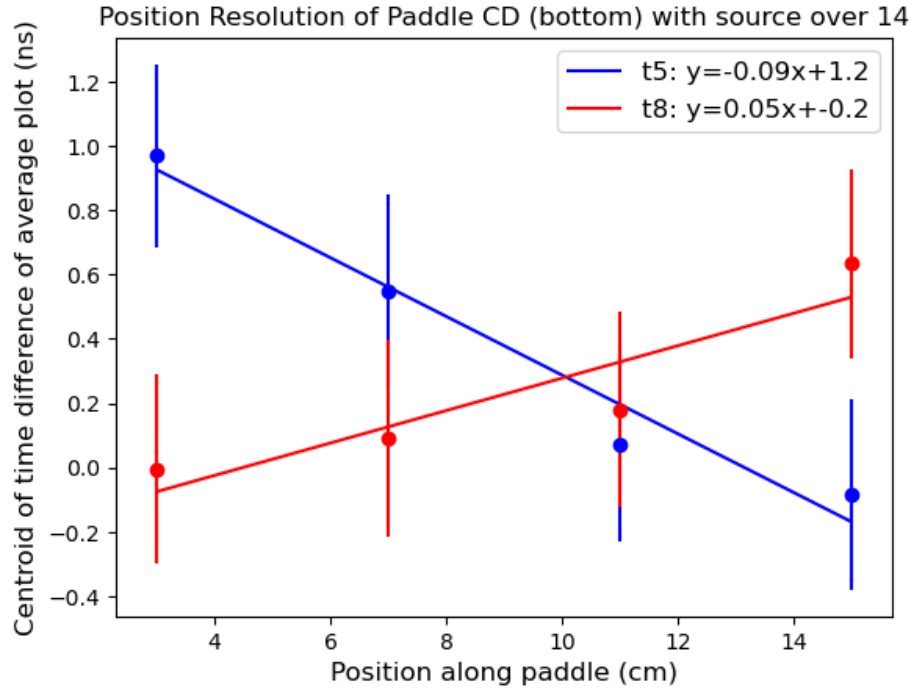
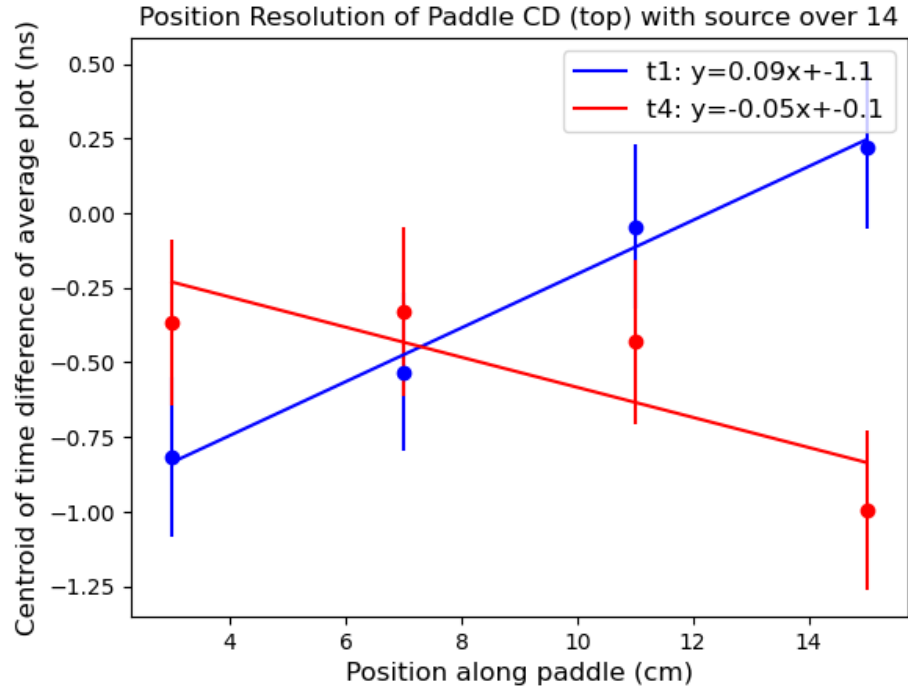
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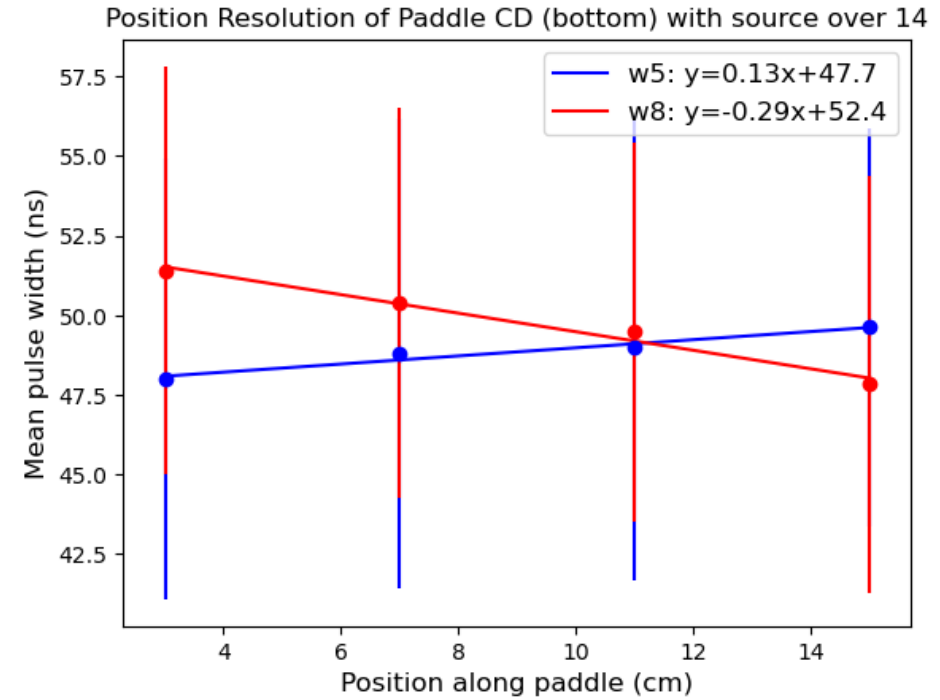
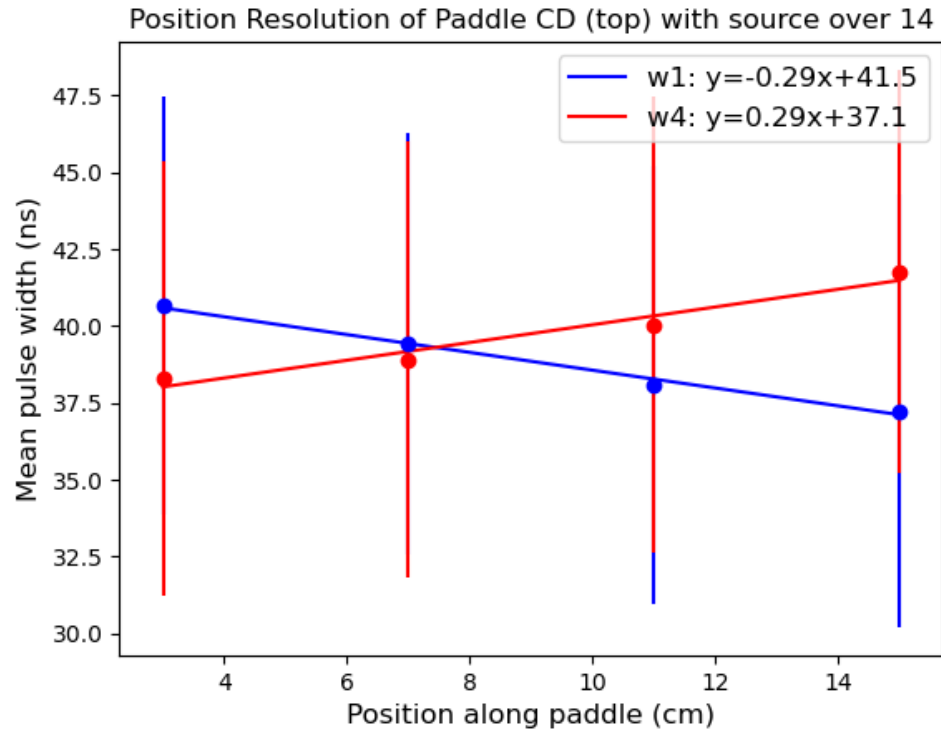


Backups

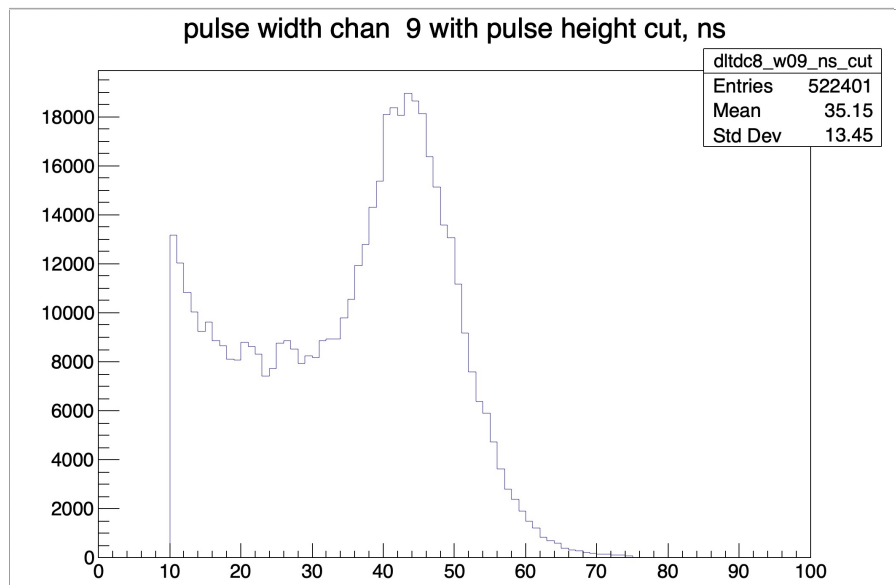
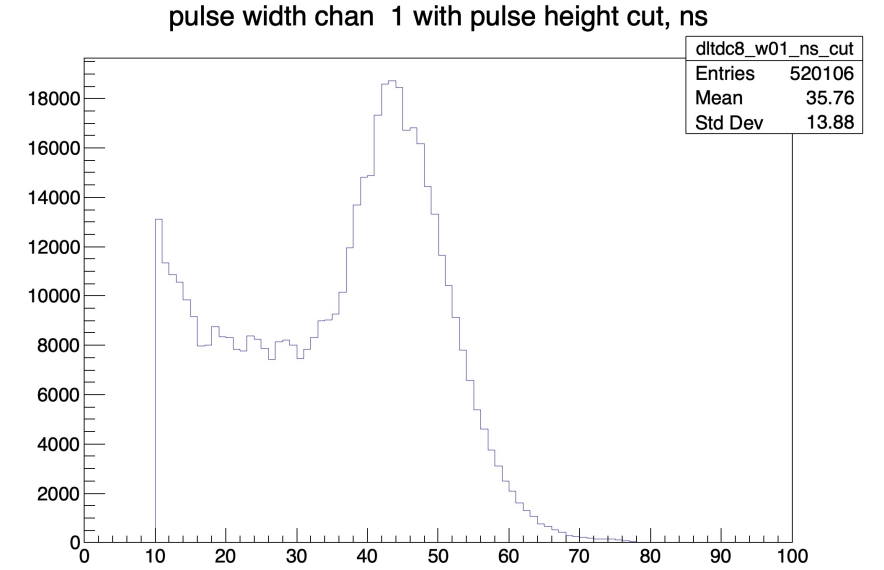
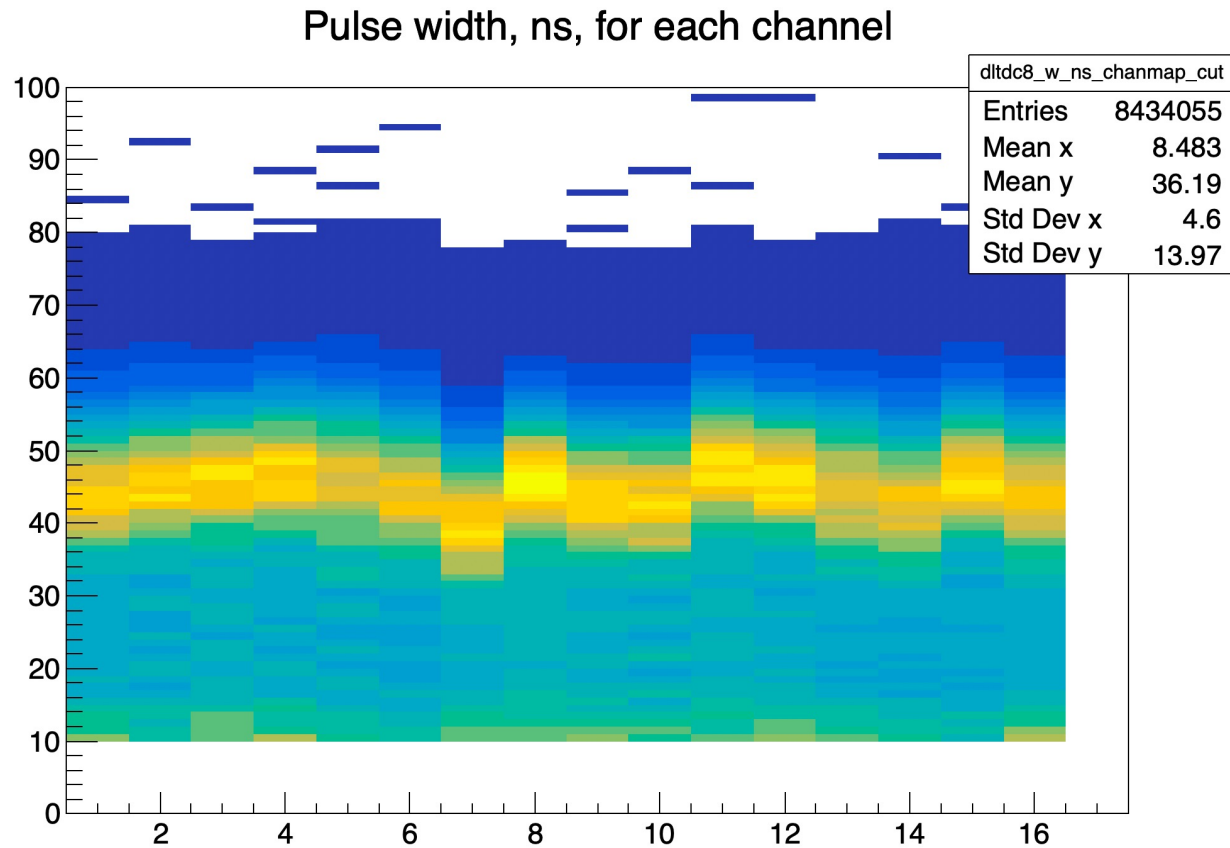
Position Resolution – Absolute Time



Position Resolution – Widths



Cable length investigation: gains



Cable length investigation: gains

