Source runs dip profile

Processed and prepared by Gabby Gelinas
Data collected by Ben Scully

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Data was collected using a radioactive source positioned above the trigger setup at various points along paddle 58, measured as a proportion of the paddle along the scintillator from board 5. Measurements were taken 1/4, 1/2 and 3/4 of the way down the paddle both with and without a 99 mm space placed between the two paddles. Results are presented here grouped by the time difference of interest.

1 Time Difference Examination

For each type of time difference measurement (each paddle end pairing examined), a distinct dip in the plot was only observed when the source was placed 1/4 and 1/2 of the way along scintillator 58, if at all. When examining the t3-t2 time difference no sharp dips were observed with any of the source positions and the plots for the 1/4 and 1/2 along 58 with no spacer we the most rectangular of all datasets, although they had a large amount of noise at the peak. The curious feature lies in the difference between data collected with and without using a spacer. Since we are only calculating time difference along the board and not time-of-flight, we should not expect to see a significant difference between data examining the same time difference with the source at the same position along the board when comparing using versus not using a spacer. However, in all cases the plot with the spacer takes the form of a significantly more smooth Gaussian than its no spacer counterpart. At this time I do not have a physical explanation for this phenomenon but would like to note that all of the data with the spacer was collected after the data without the spacer, and the last run without the spacer in all cases except the t3-t2 time difference more closely resembled the plots with the spacer than any of the others without. This makes me suspicious that the data acquisition system's behaviour or the physical setup changed during the course of data collection for this set or there was a strong background presence for the first two runs (1/4 and 1/2 on 58, no spacer), although the second situation seems unlikely. More thorough details may need to be collected about the setup of each run during data collection in the future. For example, to my knowledge the height of the source above the trigger system is not measured. It may be possible that there was a significant enough difference between the height of the source in the first two runs versus the last four (higher in the first two) to cause a noticeable effect.

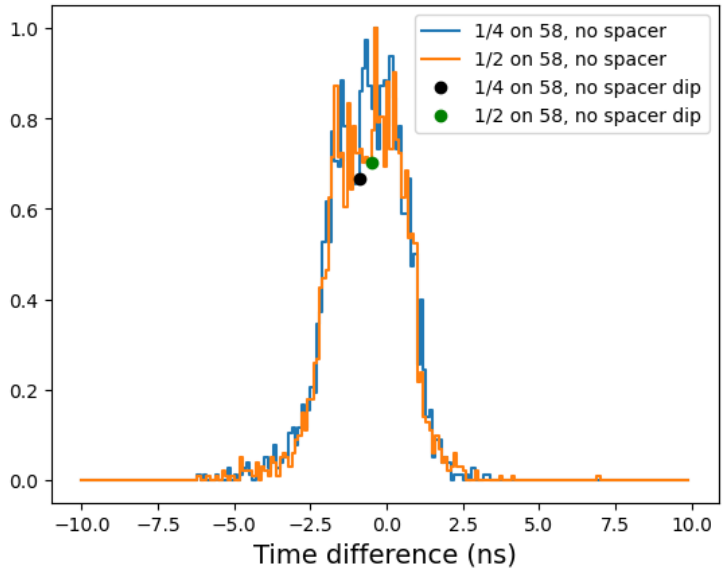

Figure 1: Paddle 1 time difference, t4-t1 (ns) when the source was 1/4 and 1/2 of the way along scintillator 58 (no spacer). Data showed a distinct dip with the minimum marked on the plot. When the source was 1/4 of the way down scintillator 58 the dip was found at (-0.9,0.667), and when the source was 1/2 of the way down scintillator 58 the dip was found at (-0.5,0.703).

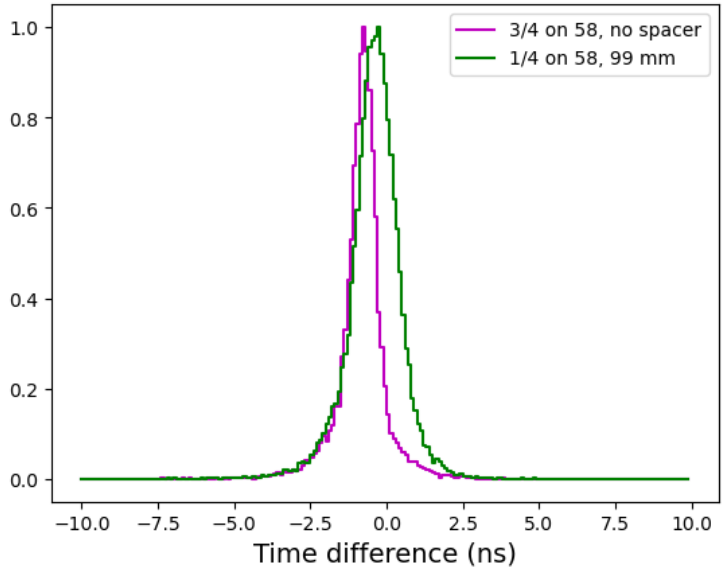

Figure 2: Paddle 1 time difference, t4-t1 (ns) when the source was 3/4 of the way along scintillator 58 (no spacer) and 1/4 of the way along (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

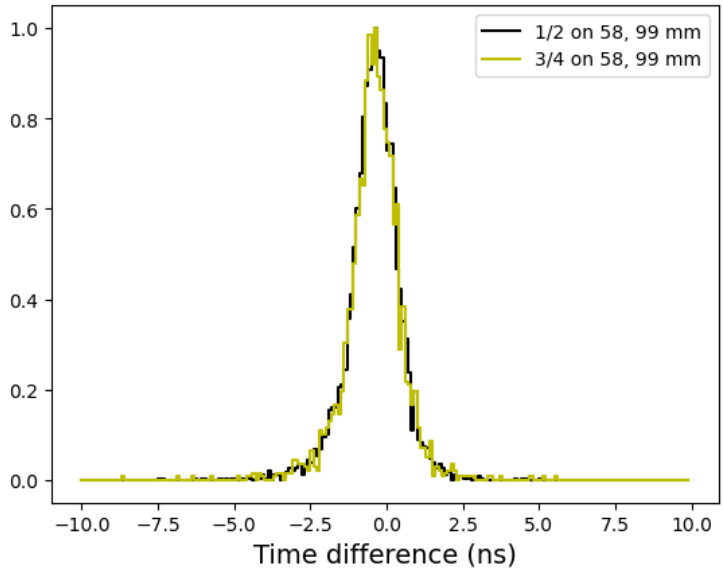

Figure 3: Paddle 1 time difference, t4-t1 (ns) when the source was 1/2 and 3/4 of the way along scintillator 58 (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

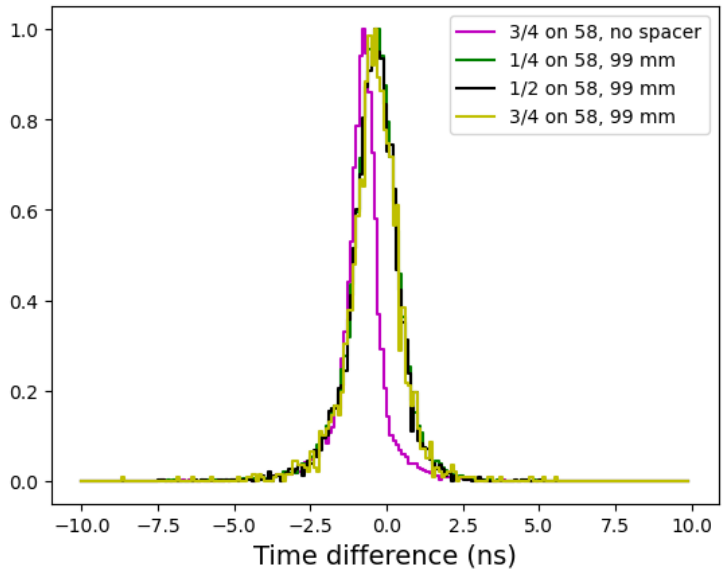

Figure 4: Paddle 1 time difference, t4-t1 (ns), compilation of all sharp Gaussian peaks without a dip.

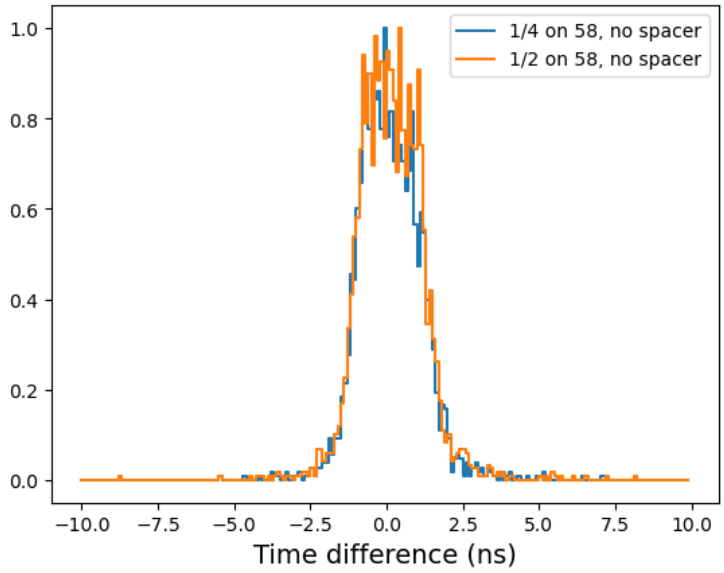

Figure 5: Paddle 2 time difference, t3-t2 (ns) where the source was 1/4 and 1/2 of the way down scintillator 58. No sharp dip was observed in any of the plots for this time difference. This data was the most rectangular of any data collected out of all data presented here.

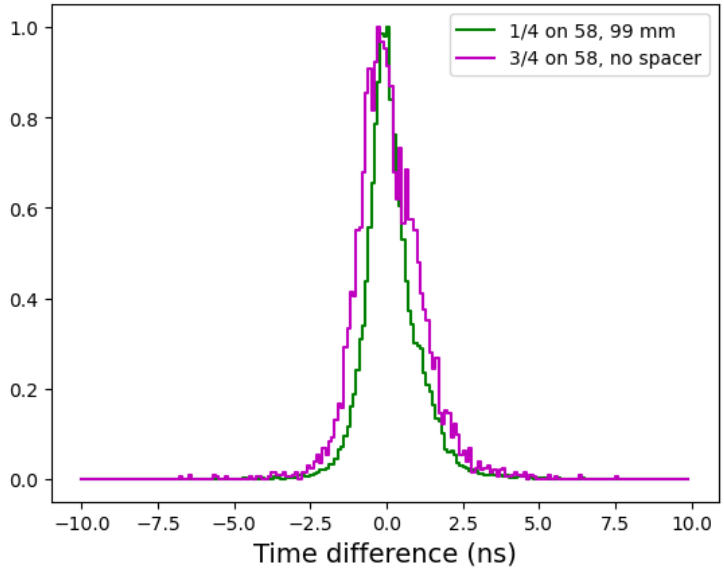

Figure 6: Paddle 2 time difference, t3-t2 (ns) when the source was 3/4 of the way along scintillator 58 (no spacer) and 1/4 of the way along (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

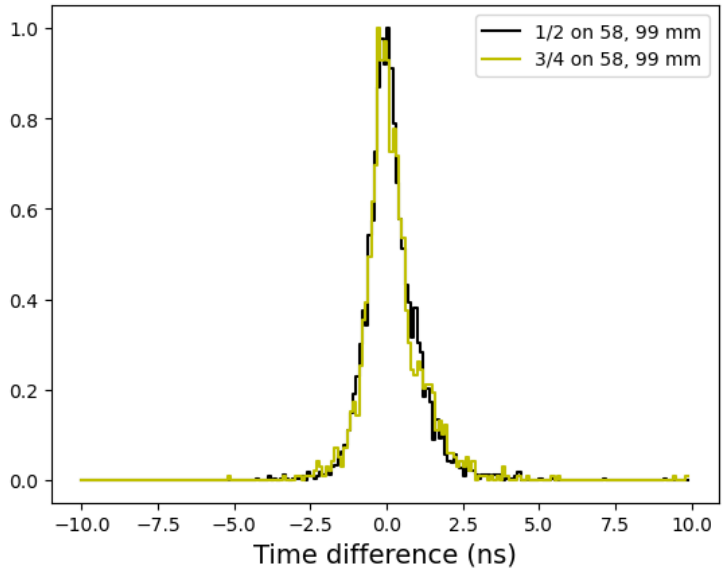

Figure 7: Paddle 2 time difference, t3-t2 (ns) when the source was 1/2 and 3/4 of the way along scintillator 58 (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

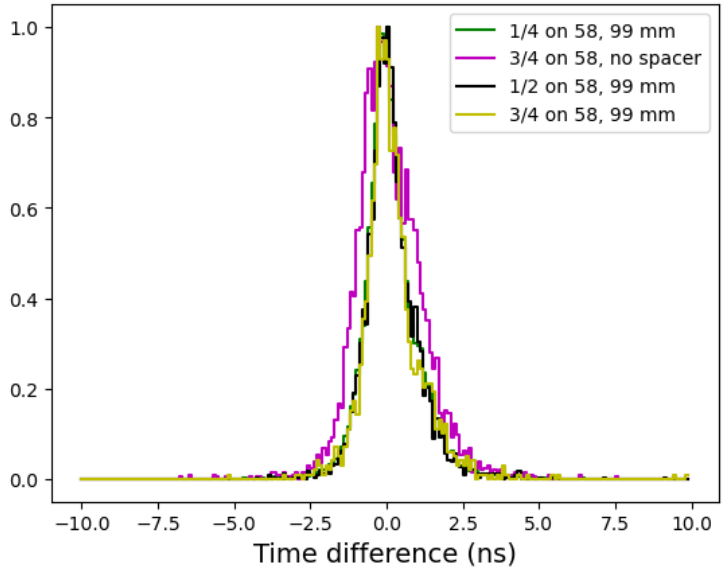

Figure 8: Paddle 2 time difference, t3-t2 (ns), compilation of all sharp Gaussian peaks without a dip.

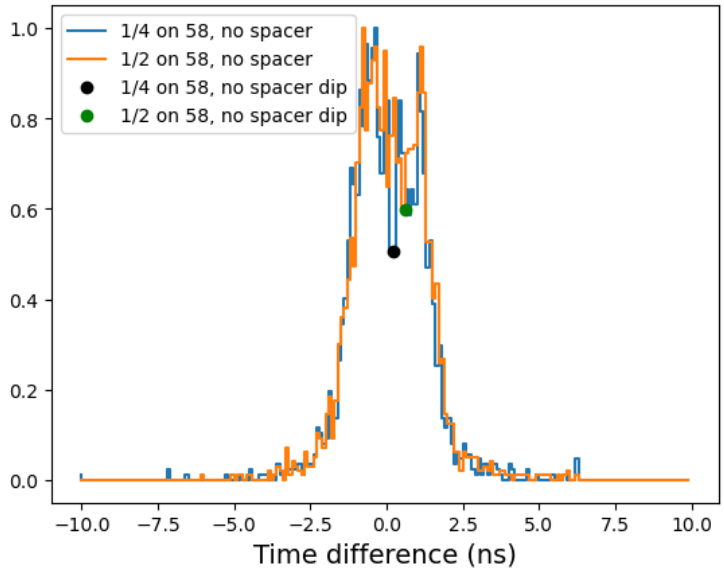

Figure 9: Paddle 3 time difference, t8-t5 (ns) when the source was 1/4 and 1/2 of the way along scintillator 58 (no spacer). Data showed a distinct dip with the minimum marked on the plot. When the source was 1/4 of the way down scintillator 58 the dip was found at (0.200,0.506), and when the source was 1/2 of the way down scintillator 58 the dip was found at (0.600,0.598).

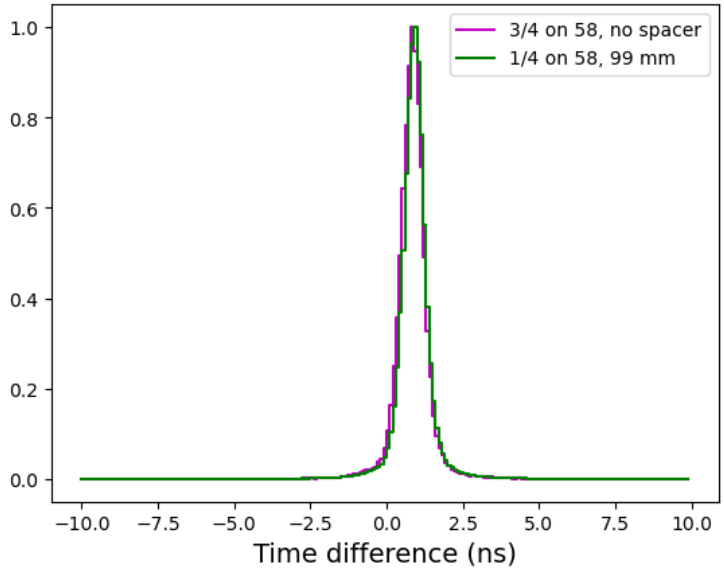

Figure 10: Paddle 3 time difference, t8-t5 (ns) when the source was 3/4 of the way along scintillator 58 (no spacer) and 1/4 of the way along (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

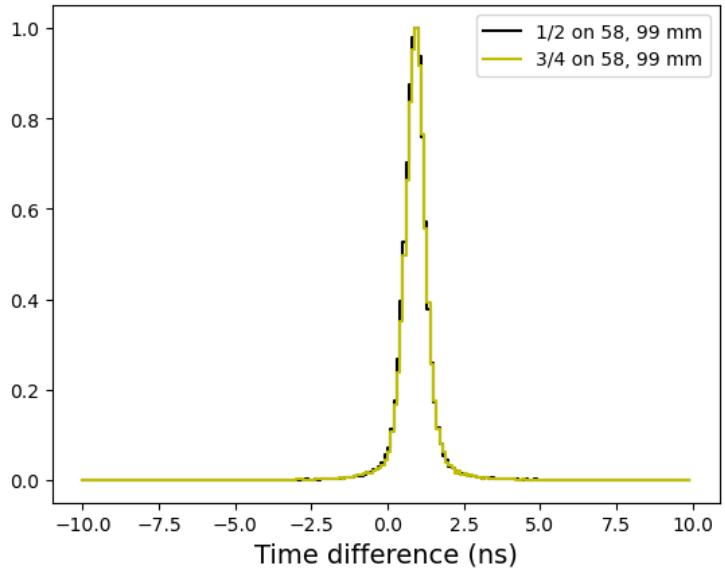

Figure 11: Paddle 3 time difference, t8-t5 (ns) when the source was 1/2 and 3/4 of the way along scintillator 58 (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

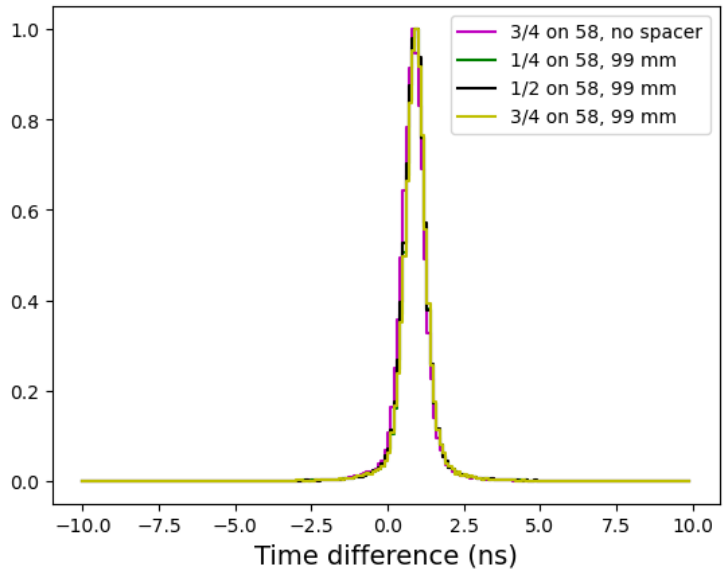

Figure 12: Paddle 3 time difference, t8-t5 (ns), compilation of all sharp Gaussian peaks without a dip.

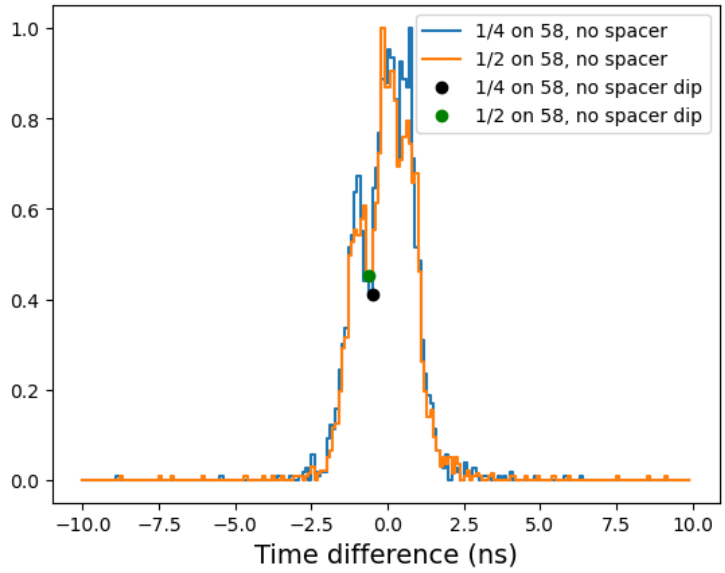

Figure 13: Paddle 4 time difference, t7-t6 (ns) when the source was 1/4 and 1/2 of the way along scintillator 58 (no spacer). Data showed a distinct dip with the minimum marked on the plot. When the source was 1/4 of the way down scintillator 58 the dip was found at (-0.500,0.411), and when the source was 1/2 of the way down scintillator 58 the dip was found at (-0.600,0.453).

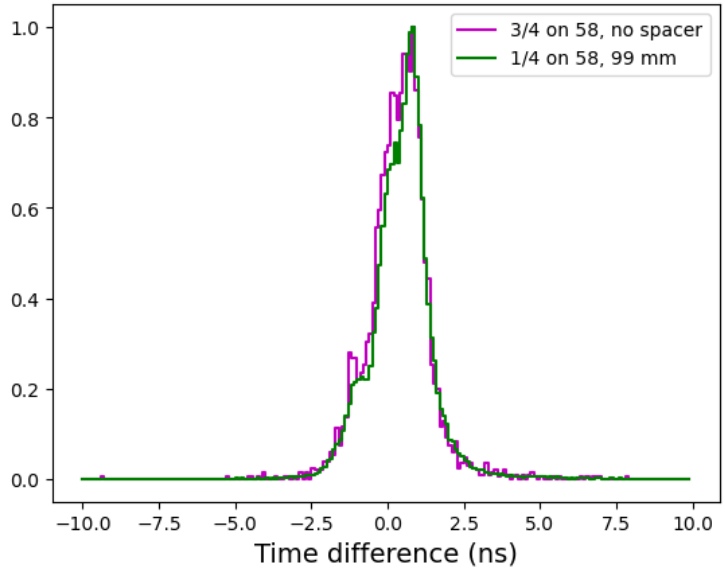

Figure 14: Paddle 4 time difference, t7-t6 (ns) when the source was 3/4 of the way along scintillator 58 (no spacer) and 1/4 of the way along (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

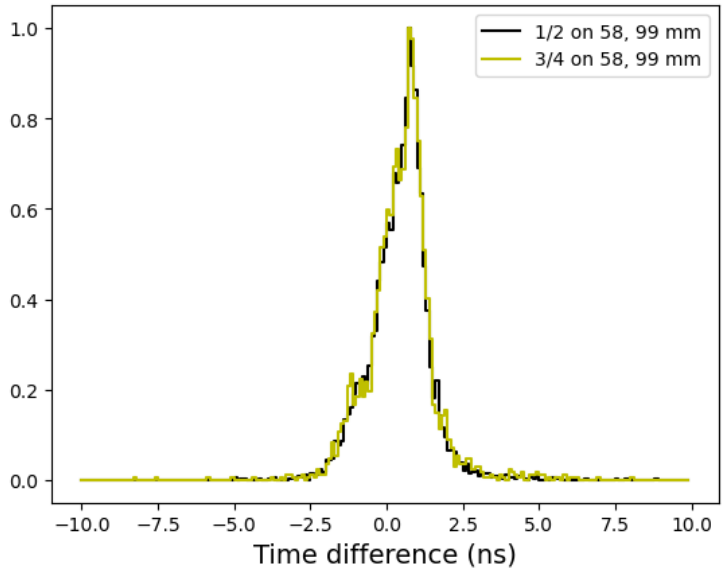

Figure 15: Paddle 4 time difference, t7-t6 (ns) when the source was 1/2 and 3/4 of the way along scintillator 58 (99 mm spacer). Neither dataset showed a sharp dip and instead resemble a narrow Gaussian.

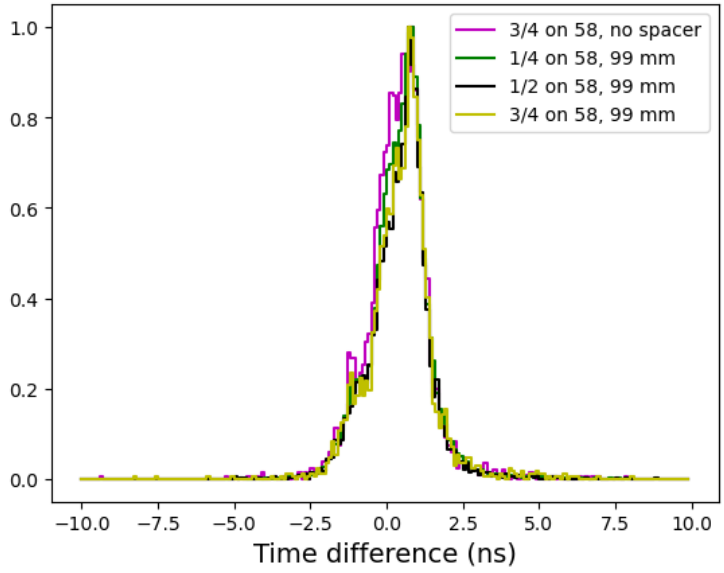

Figure 16: Paddle 4 time difference, t7-t6 (ns), compilation of all sharp Gaussian peaks without a dip.

1.1 1/4 and 3/4 Comparison

Another point of interest is in how the plots when the source was 1/4 of the way along the 58 scintillator compare to those when it was 3/4 of the way along the same scintillator. I would expect these two plots to be mirror images of each other, reflected about x=0. This, however, is not what is observed and part of the reason why may be due to where the focus was applied in each run. Both with and without the spacer, when the source was in the 1/4 position it was focused on 1458 and when the source was in the 3/4 position it was focused on 2358. Though this setup difference is present in runs both with and without the spacer, the results are vastly different.

In runs without the spacers the plot corresponding to the source in the 1/4 position is consistently wider than the plot for the 3/4 position. It is reasonable to expect a better resolution for the 1/4 position in Figure 17 than the 3/4 position since the

1/4 position run was focused on 1458, where 14 is the time difference of interest. Likewise, observing the faster narrowing of the 3/4 position plot and broadening of the 1/4 position plot in Figure 19 since the 3/4 position run was centered on the 2358, with 23 being the time difference of interest. The more interesting plots are Figure 21 and 23. Consider Figure 21: both plots were focused on 58 (the time difference of interest) and the 3/4 position plot appears like up nearly perfectly with the rightmost peak of the 1/4 position plot. This makes me suspicious of the leftmost peak in Figure 21 and curious if it is a result of an equipment concern (NOTE: unsure how to confidently interpret this in more detail since they are not both focused on exactly the same position, would like to discuss). Though the alignment of the 3/4 position peak and rightmost 1/4 position peak is not as strong in Figure 23 as it is in Figure 21, I expect the same effect is at play where the additional spreading and imperfect overlap is due to the two runs not being focused at the same point or the time difference of interest.

When examining the data collected with the spacer in use, we unexpectedly consistently see a near perfect overlap between the two plots. The reason for the discrepancy between the data with the spacer and without it not clear to me as I would expect them to behave in the same way. I expect there was another (likely unnoticed after discussions with Ben) change to the system between the first two and remaining runs.

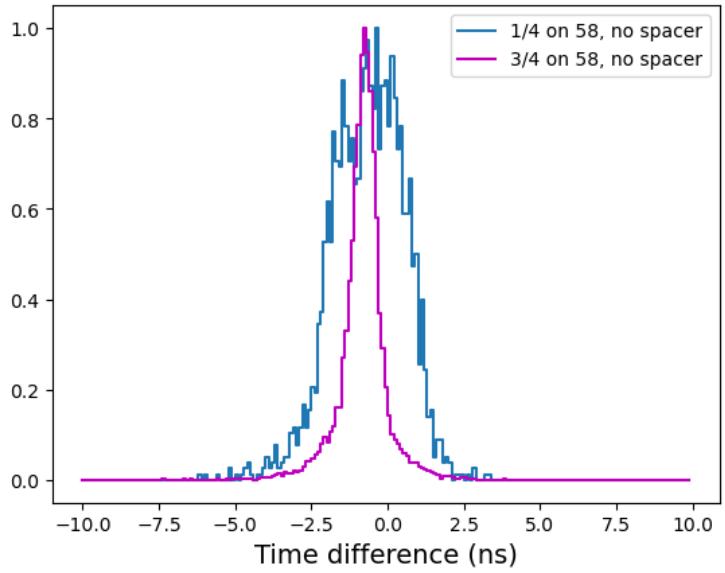

Figure 17: Paddle 1 time difference, t4-t1 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (no spacer).

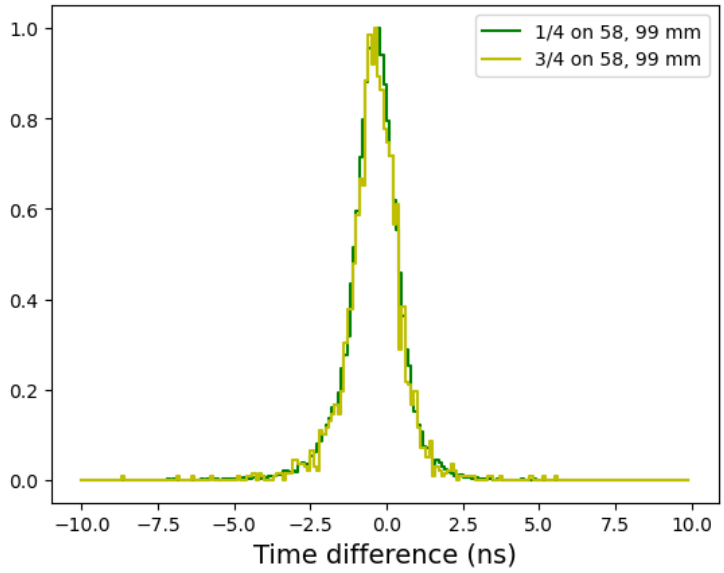

Figure 18: Paddle 1 time difference, t4-t1 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (99 mm spacer).

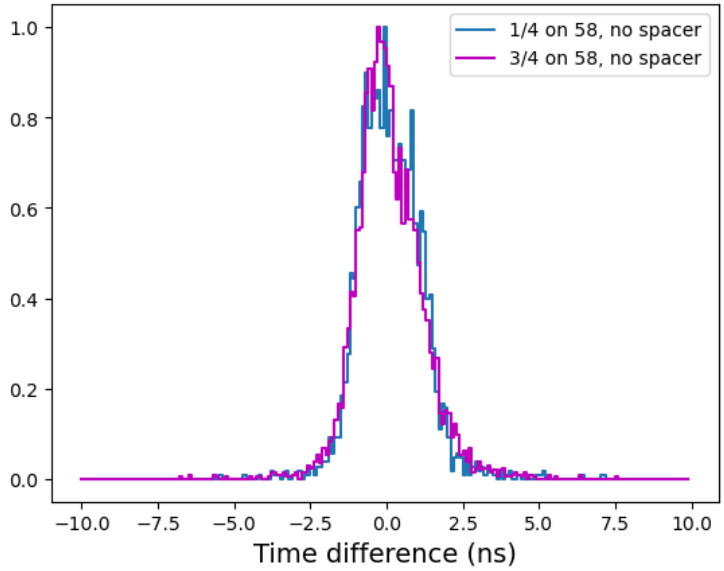

Figure 19: Paddle 2 time difference, t3-t2 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (no spacer).

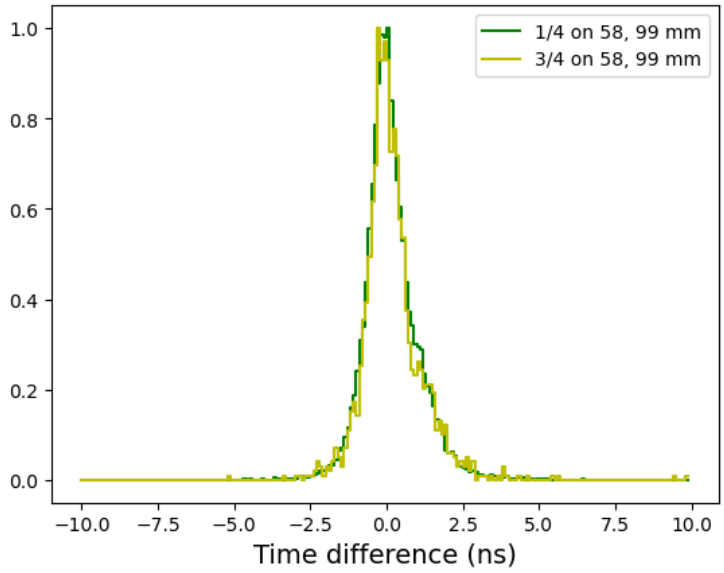

Figure 20: Paddle 2 time difference, t3-t2 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (99 mm spacer).

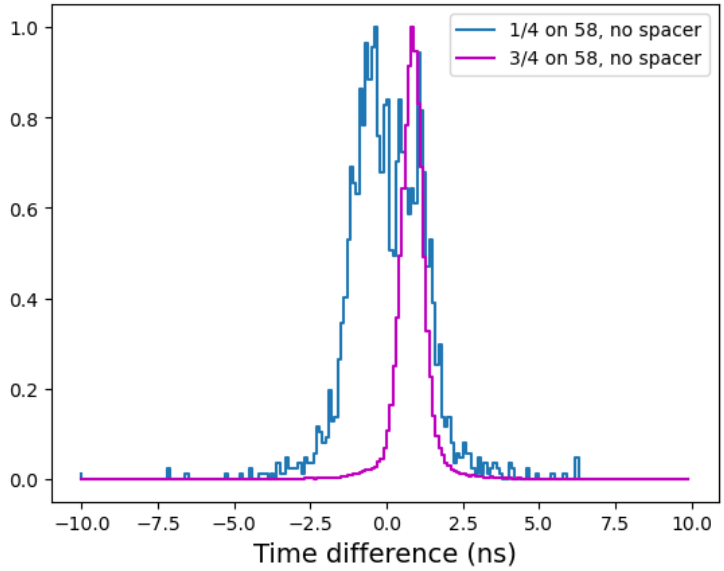

Figure 21: Paddle 3 time difference, t8-t5 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (no spacer).

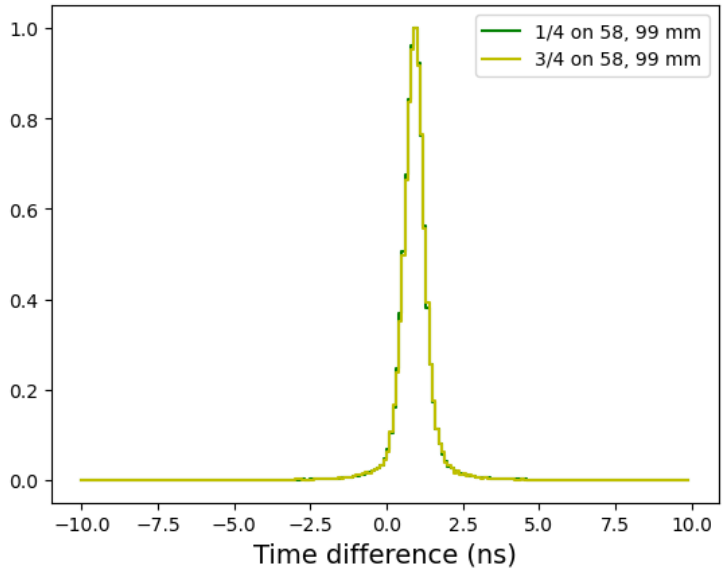

Figure 22: Paddle 3 time difference, t8-t5 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (99 mm spacer).

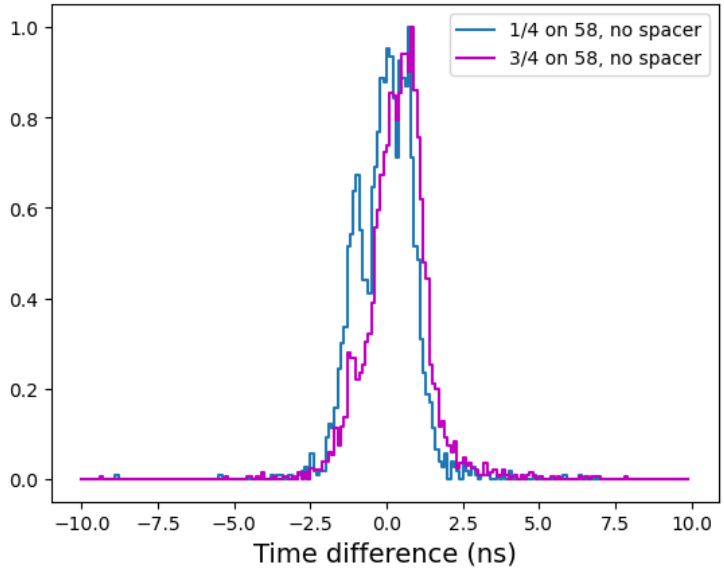

Figure 23: Paddle 4 time difference, t7-t6 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (no spacer).

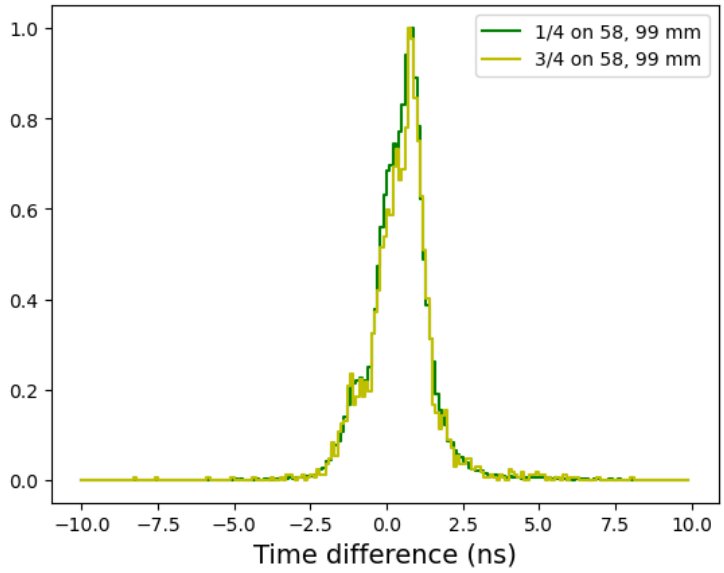

Figure 24: Paddle 4 time difference, t7-t6 (ns), plot for the source positioned 1/4 and 3/4 of the way along scintillator 58 (99 mm spacer).

2 Pulse Width

Excluded due to insufficient counts to make a meaningful heat map.