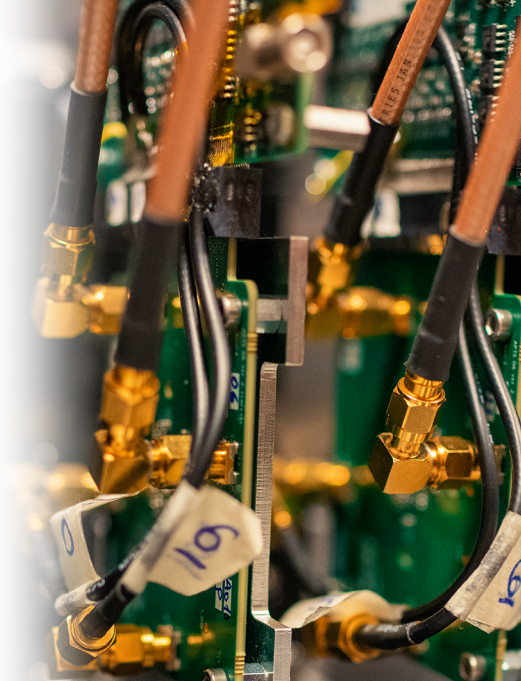
Study on Digital-Constant Fraction Disriminator



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Digital Constant Fraction Discriminator (CFD)

Digital CFD

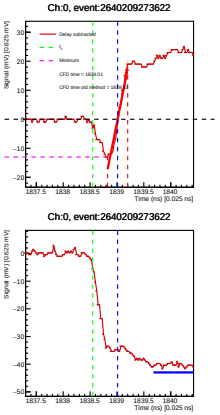


Figure 1: Top: S'_i CFD Trace, Bottom: S_i Sampled Data

- Reference: [1], CAEN AN3251
- CFD Trace computation:
  - $S_i \rightarrow S'_i = \Sigma_{j=1}^{L}\{k \cdot S_{i-j} - S_{i-j-d}\}$
  - S_i: Sampled data point, S'_i: CFD Trace
  - L: Length of the running average, d: Delay, k: Fraction
  1. Set a threshold to arm the search of the zero crossing
  2. Find the zero crossing identifying the two consecutive samples across it.
  3. Compute a linear interpolation using the two points and find the intersection with the zero axis.
  4. k, d, L values can be chosen based on the time resolution obtained.
- Benefits:
  - No signal amplitude dependence on a computation.
  - Therefore, no baseline / underline dependence.
  - Used in many applications.

Δt distribution from DCFD

- Stable Δt distribution obtained on combination with:
  - Delay d: [0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0] ns
  - Fraction k : [0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0]
  - Length L : [1, 2, 3, 4, 5] points
- Fitting spectra
  - Obtained Δt distributions are fitted with a Gaussian function.
  - QA plots of fitting parameters (μ, σ), P and number of entry (N) are shown in the next slides.

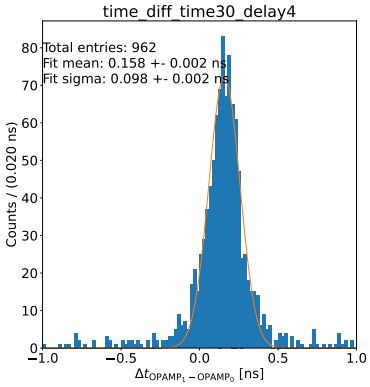


Figure 2: Δt distribution ($d = 0.4$ns, $k = 0.3$, $L = 2$)

Examples of Δt distribution from DCFD

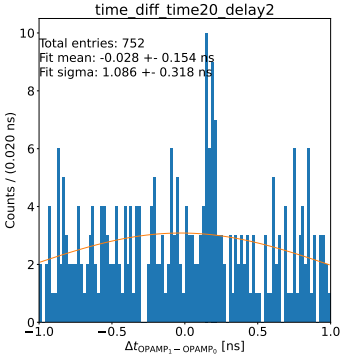


Figure 3: Δt distribution ($d = 0.2\mathrm{ns}$, $k = 0.2$, $L = 2$)

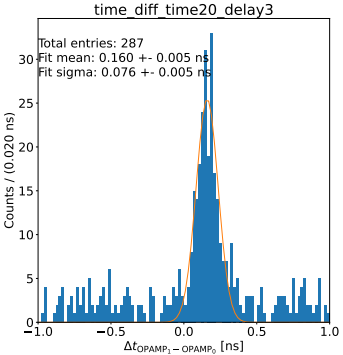


Figure 4: Δt distribution ($d = 0.3\mathrm{ns}$, $k = 0.2$, $L = 2$)

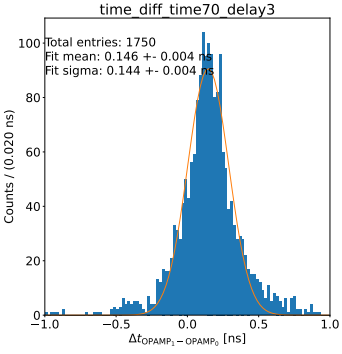
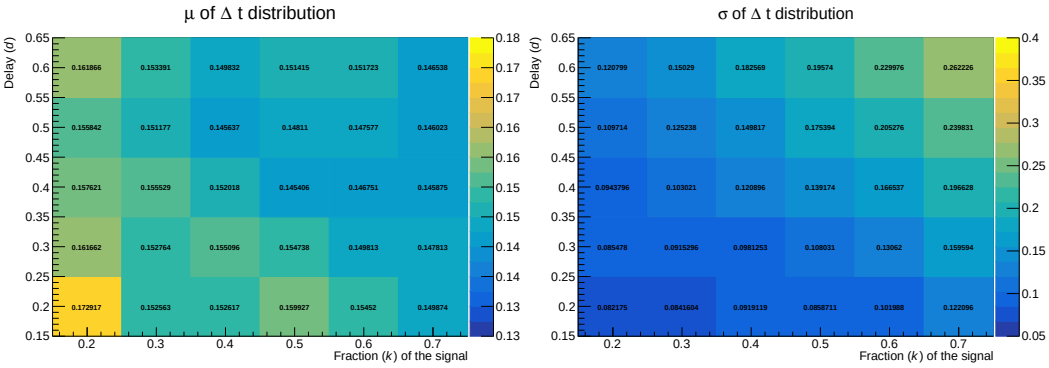


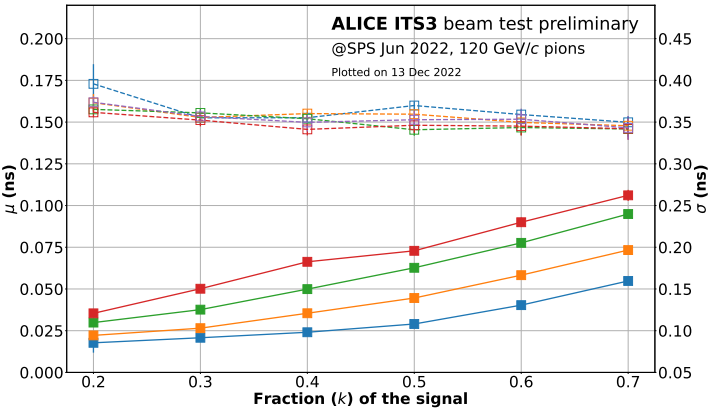
Figure 5: Δt distribution ($d = 0.3\mathrm{ns}$, $k = 0.7$, $L = 2$)

QA plots from fit result of Δt distribution #1



- Left: μ of the Gaussian fit, Right: σ of the Gaussian fit

QA plots from fit result of Δt distribution #2



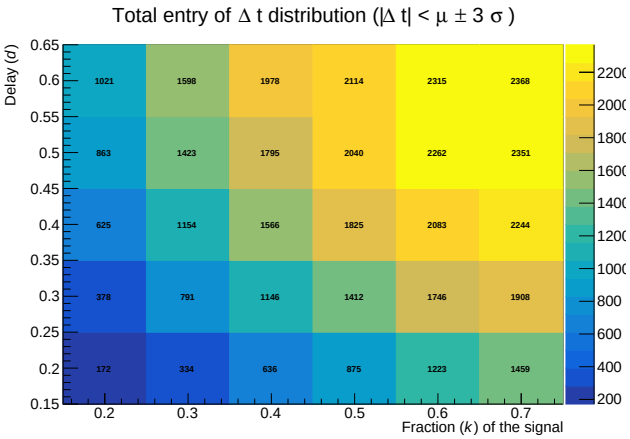
APTS-OAW 22AO10 (not irradiated)
setups..

APTS-OAW 22AO10 (not irradiated)
setups..

- fit mean (μ)
- fit sigma (σ)
- delay (d) = 0.2 ns
- delay (d) = 0.3 ns
- delay (d) = 0.4 ns
- delay (d) = 0.5 ns
- delay (d) = 0.6 ns

- μ (dashed line) and σ (solid line) of the Gaussian fit

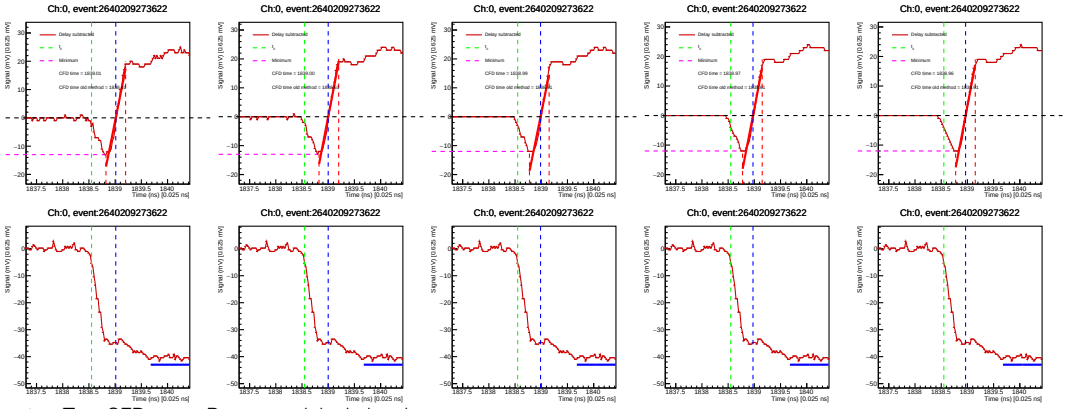
QA plots from fit result of Δt distribution #3



- Total number of entries in the Δt distribution with in the range of $\mu \pm 3\sigma$.

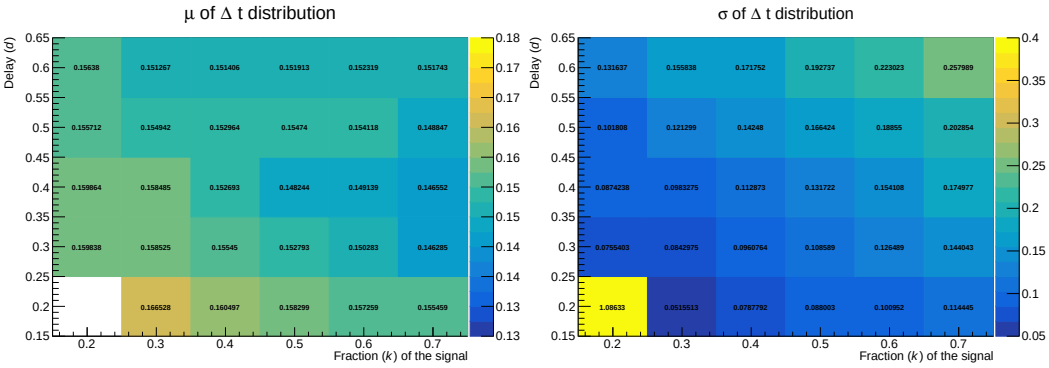
CFD Trace with different running averages (L)

CFD Trace with different running averages



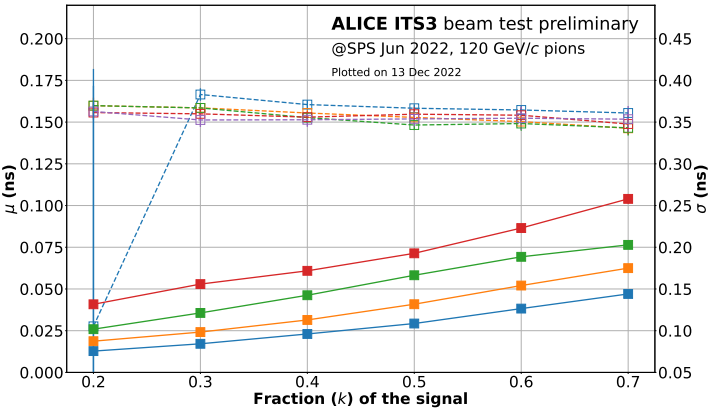
- Top: CFD trace, Bottom: original signal
- From left to right: L = 1, 2, 3, 4, 5 bins
- Note that the trace becomes smoother as the running average increases

QA plots from fit result of Δt distribution #1 ($L = 2$)



- Left: μ of the Gaussian fit, Right: σ of the Gaussian fit

QA plots from fit result of Δt distribution #2 (L =2)



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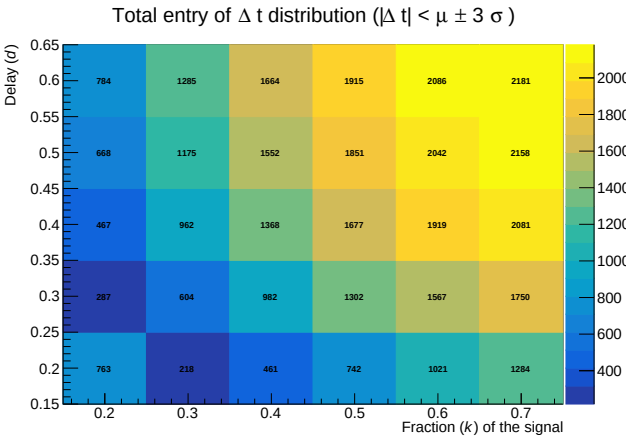
- delay (d) = 0.6 ns

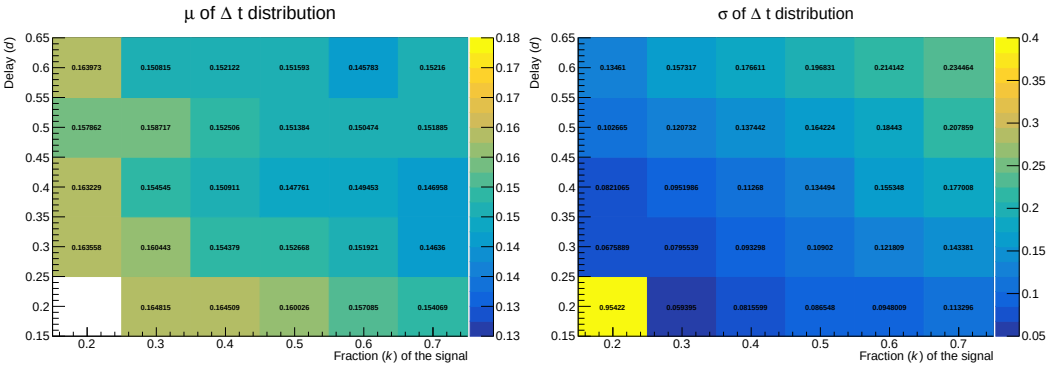
- μ (dashed line) and σ (solid line) of the Gaussian fit

QA plots from fit result of Δt distribution #3 (L =2)



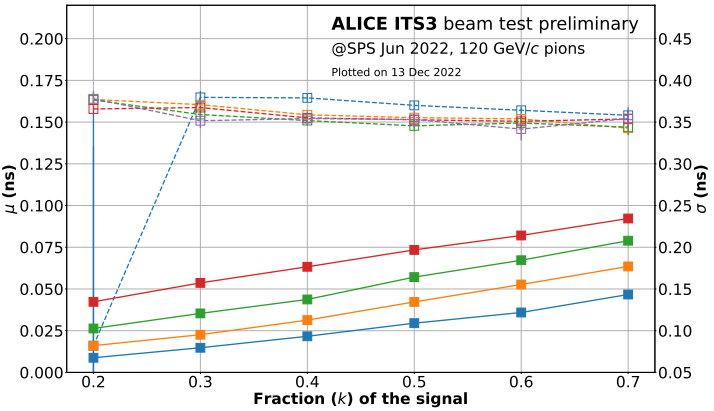
- Total number of entries in the Δt distribution with in the range of $\mu \pm 3\sigma$.

QA plots from fit result of Δt distribution #1 ($L = 3$)



- Left: μ of the Gaussian fit, Right: σ of the Gaussian fit

QA plots from fit result of Δt distribution #2 (L =3)



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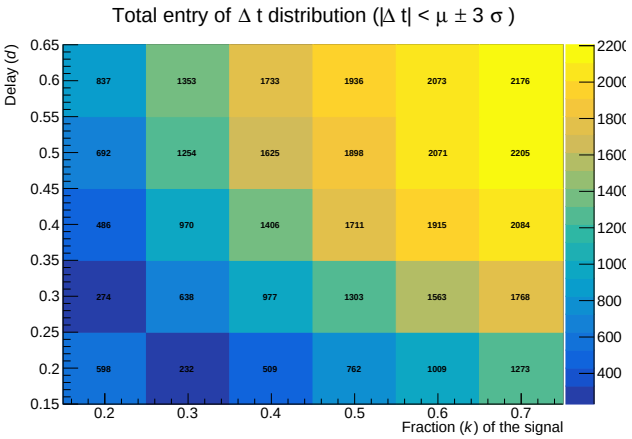
- delay (d) = 0.4 ns
- delay (d) = 0.5 ns
- delay (d) = 0.6 ns

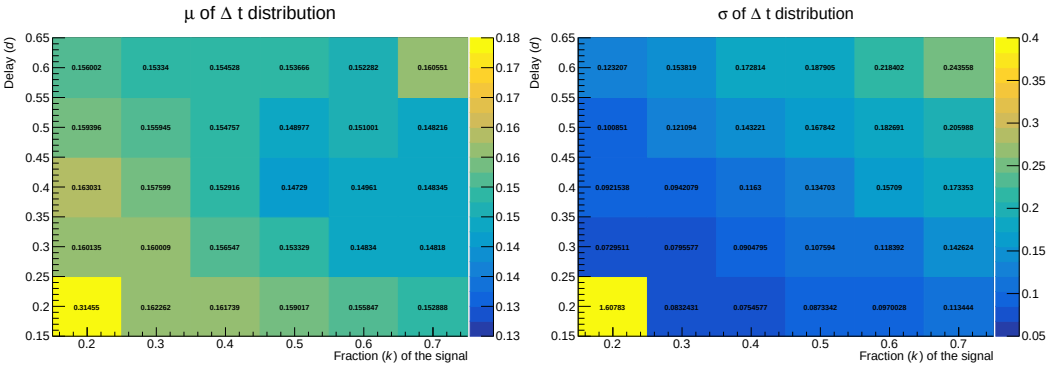
- μ (dashed line) and σ (solid line) of the Gaussian fit

QA plots from fit result of Δt distribution #3 (L =3)



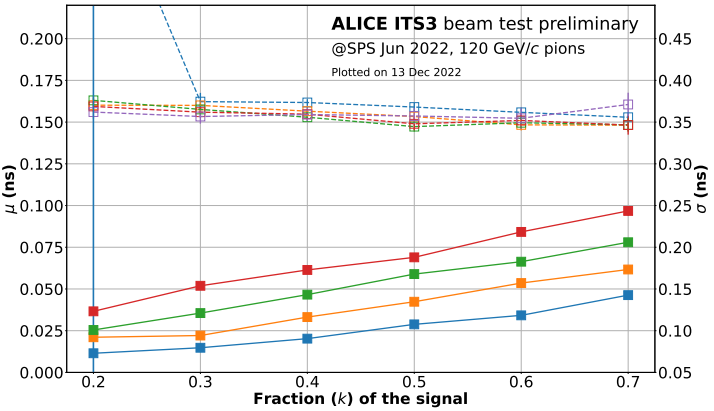
- Total number of entries in the Δt distribution with in the range of $\mu \pm 3\sigma$.

QA plots from fit result of Δt distribution #1 (L =4)



- Left: μ of the Gaussian fit, Right: σ of the Gaussian fit

QA plots from fit result of Δt distribution #2 (L =4)



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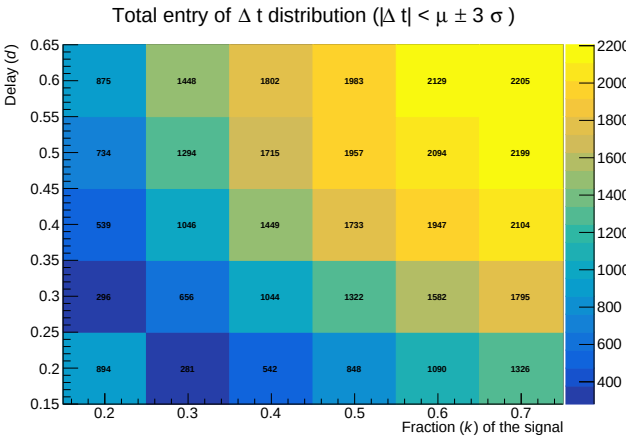
- delay (d) = 0.5 ns
- delay (d) = 0.6 ns

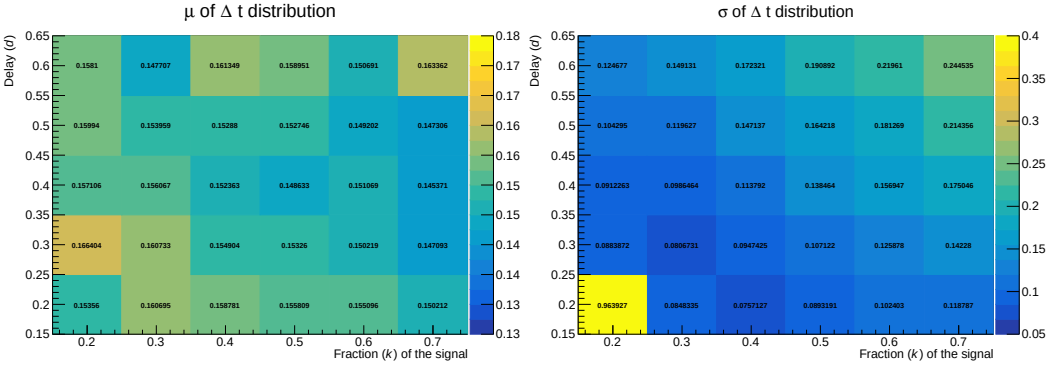
- μ (dashed line) and σ (solid line) of the Gaussian fit

QA plots from fit result of Δt distribution #3 (L =4)



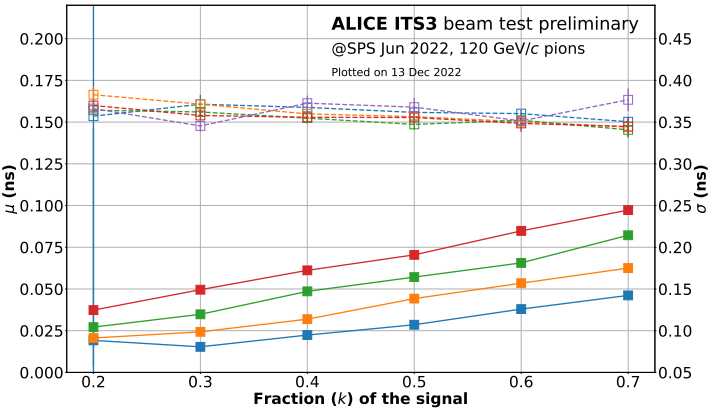
- Total number of entries in the Δt distribution with in the range of $\mu \pm 3\sigma$.

QA plots from fit result of Δt distribution #1 (L =5)



- Left: μ of the Gaussian fit, Right: σ of the Gaussian fit

QA plots from fit result of Δt distribution #2 (L =5)



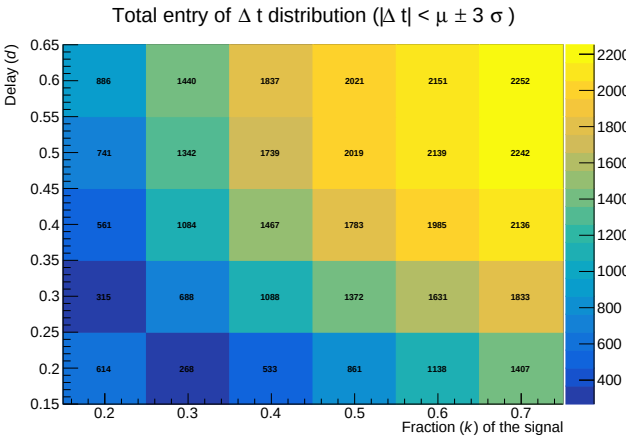
APTS-OAW 22AO10 (not irradiated)
setups..

APTS-OAW 22AO10 (not irradiated)
setups..

- fit mean (μ)
- fit sigma (σ)
- delay (d) = 0.2 ns
- delay (d) = 0.3 ns
- delay (d) = 0.4 ns
- delay (d) = 0.5 ns
- delay (d) = 0.6 ns

- μ (dashed line) and σ (solid line) of the Gaussian fit

QA plots from fit result of Δt distribution #3 (L =5)



- Total number of entries in the Δt distribution with in the range of $\mu \pm 3\sigma$.

Summary of the update

- DCFD method
  - Very promising approach.
  - Tested with several different combinations of the parameters.
  - Suitable result from $k = 0.4$, $d = 0.3\mathrm{ns}$
  - running average method did not affect the result significantly.
- Outlook:
  - Apply this method to the TB data from November
  - Correlate with the output from the Corryvreckan

Backup

References I

[1] A. Fallu-Labruyere et al. “Time resolution studies using digital constant fraction discrimination”. In: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectro 579.1 (2007). Proceedings of the 11th Symposium on Radiation Measurements and Applications, pp. 247–251. ISSN: 0168-9002. DOI: https://doi.org/10.1016/j.nima.2007.04.048. URL: https://www.sciencedirect.com/science/article/pii/S0168900207006213.