

Study of the relative timing accuracy among PMTs on protoDUNE-DP

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DPPD consortium

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GOBIERNO
DE ESPAÑA

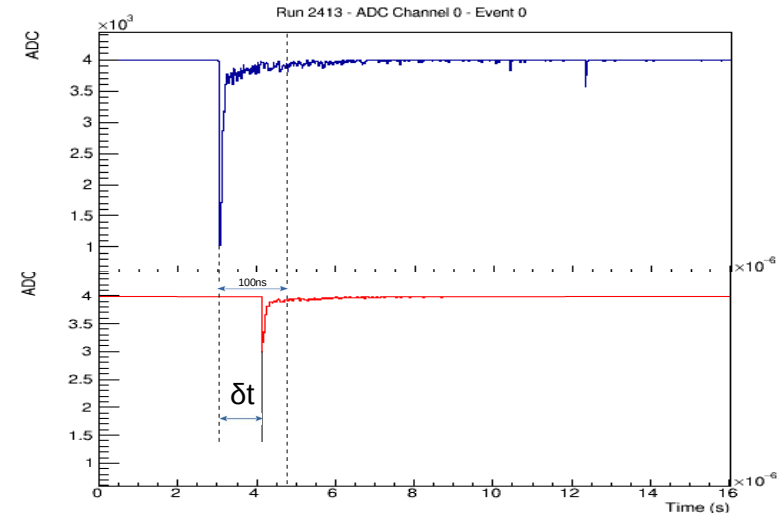
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Introduction

- TDR requirement: timing accuracy $<100\text{ns}$ among PMTs.
- This is needed to be able to group signals originated by the same track in different PMTs
→ Flash reconstruction.
- To test this requirement:
 1. Using different trigger runs (CRT and PMT trigger).
 2. Applying different cuts to be sure we select signals originated by the same track in all PMTs.
 4. We take the bin with the minimum of the signal.
 5. We compute the δt among PMTs, w.r.t channel 20 as a reference.
- Then we will discuss results.



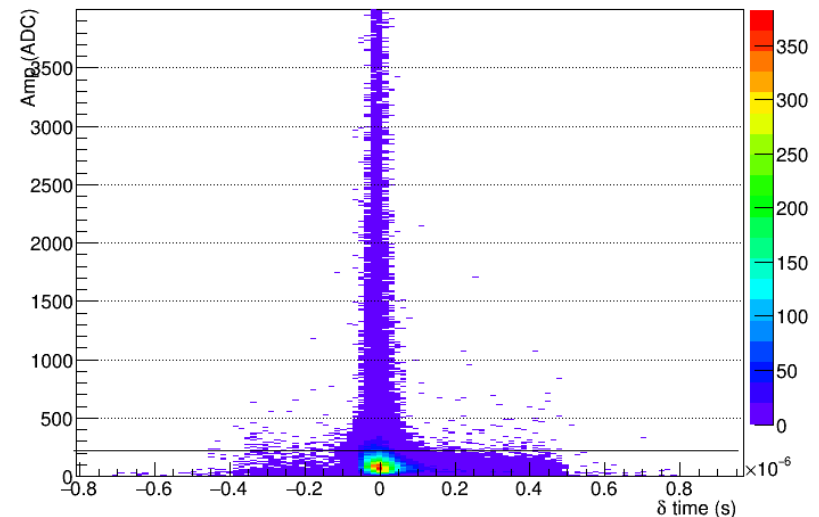
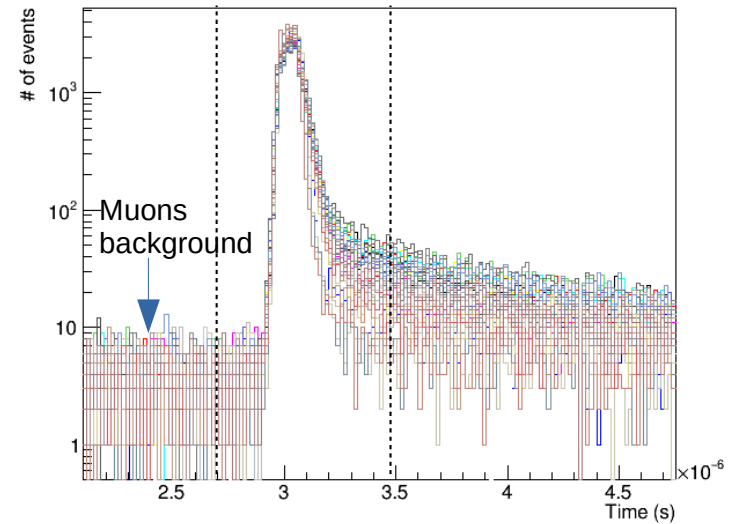
* Manually shifted

CRT trigger run

Cuts

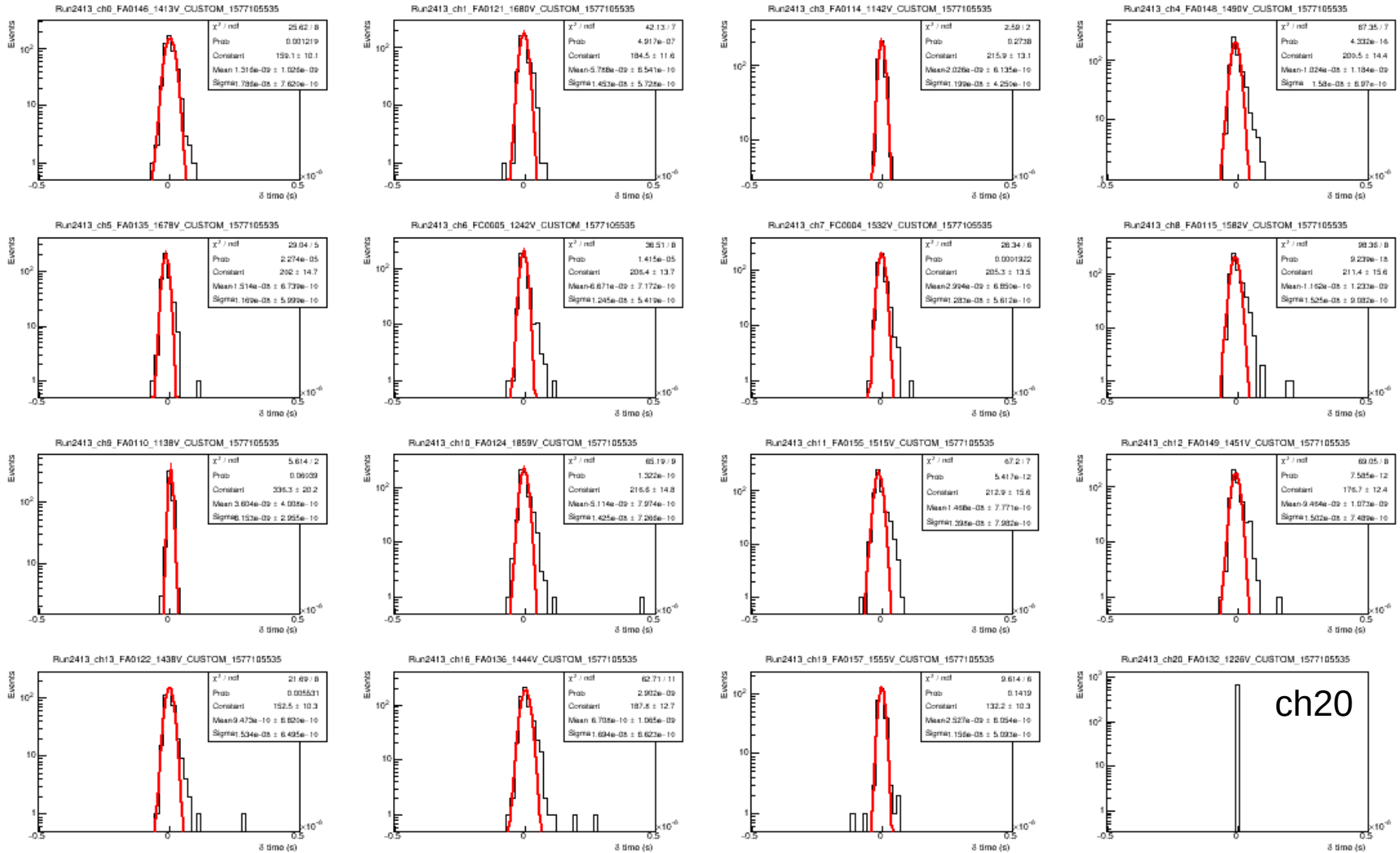
- Using Run #2413: CRT Trigger, HV OFF (no S2), equalized gains (PEN5e7_TPB6e6). 25K events.
- Remove ADC saturated signals (~4%).
- CRT reco cut applied, to be sure it is a crossing-muon (9800 events after cut, ~38%).
- We take the bin with minimum of the waveform within the trigger range (from 2.7 μ s to 3.5 μ s, defined by look at the plot in the top-right).
- Also, to remove background muons in coincidence with our signal we ask for a minimum signal amplitude of 200ADC \rightarrow To be sure the muon we are selecting is producing the largest signal in all PMTs (defined by looking at the bottom-right plot).
- This cuts reduces the statistics to just ~500-1000 events per PMT.

PeakTime (minimum of the waveform)



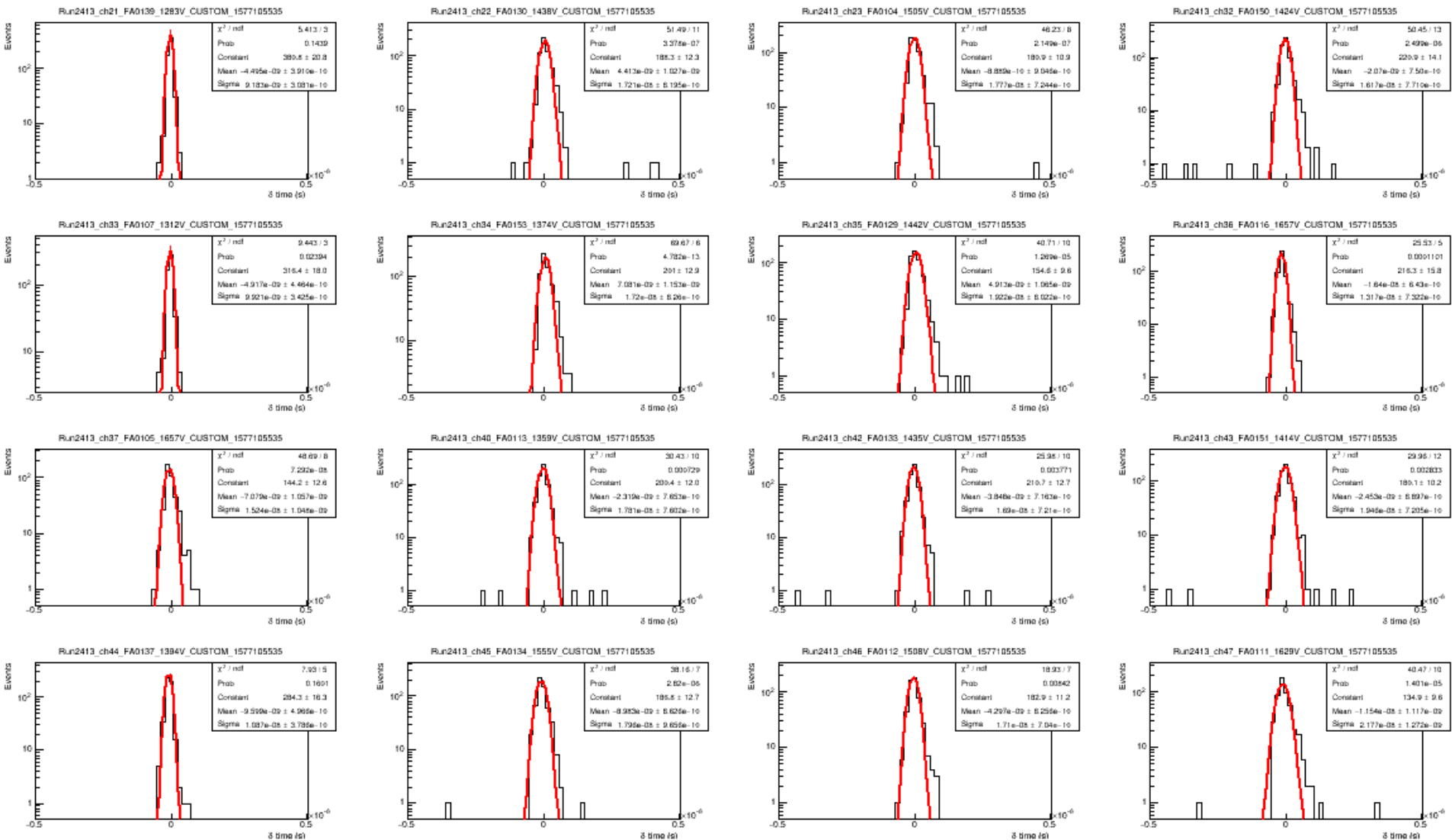
CRT trigger run

δt distributions per PMT



CRT trigger run

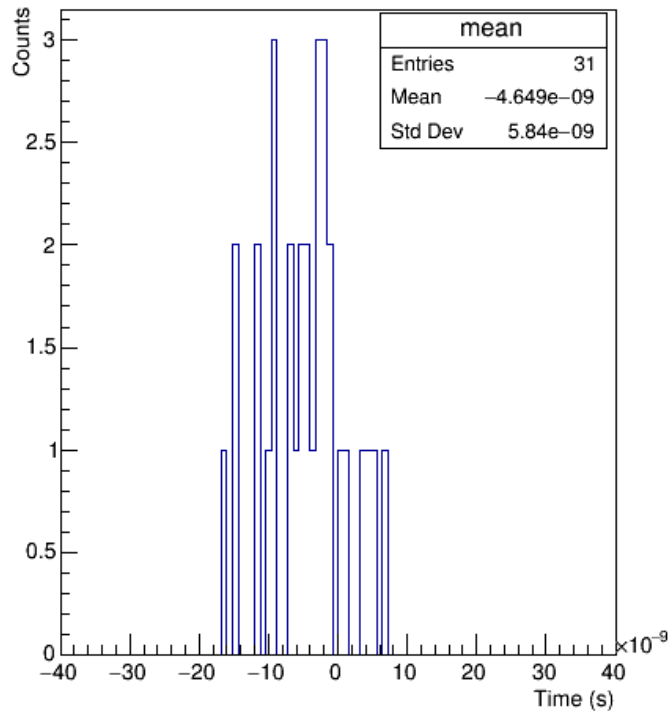
δt distributions per PMT



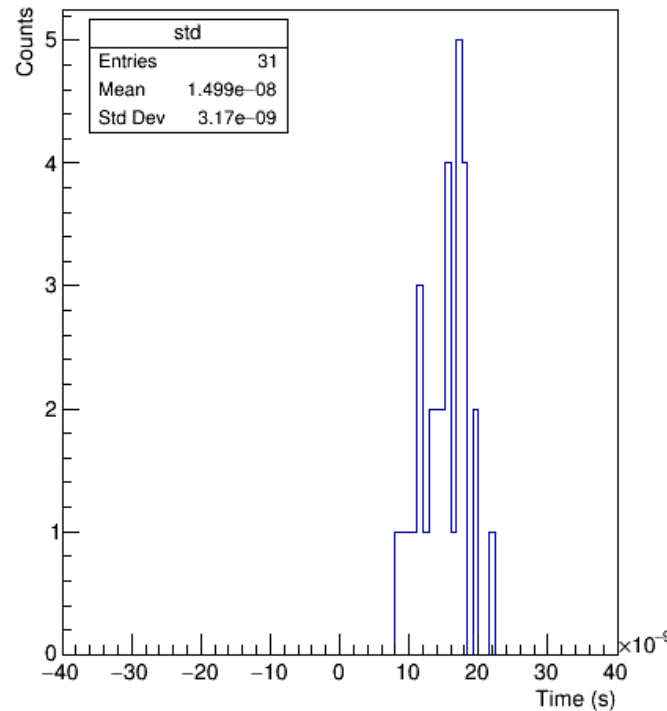
CRT trigger run

δt distributions

δt - Average



δt - STD

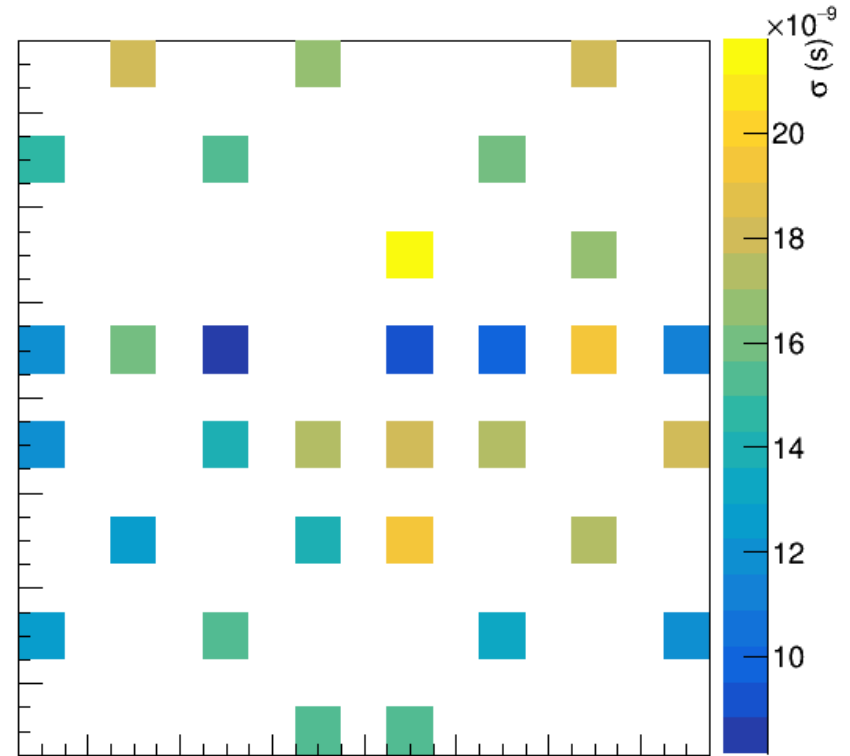
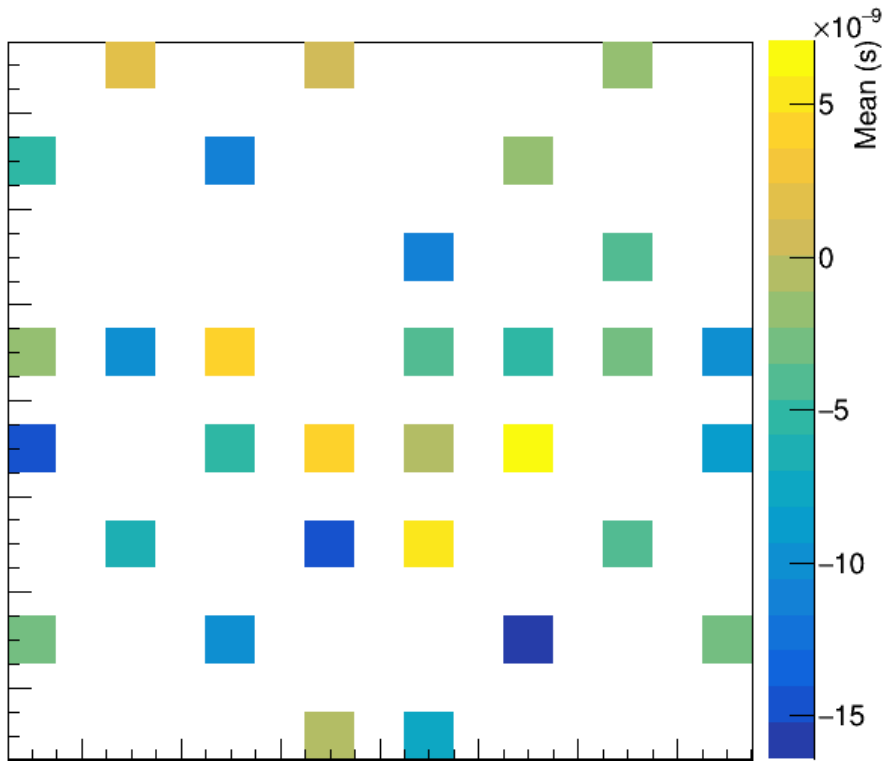


Distribution of the average and STD of the delta t gaussian fit for each PMT. 31 entries (36 PMTs – 4 connected to the scope – 1 taken as reference).

- δt distribution is centered in -5 ± 5 ns, with an STD of 15 ± 3 ns.

CRT trigger run

δt distributions

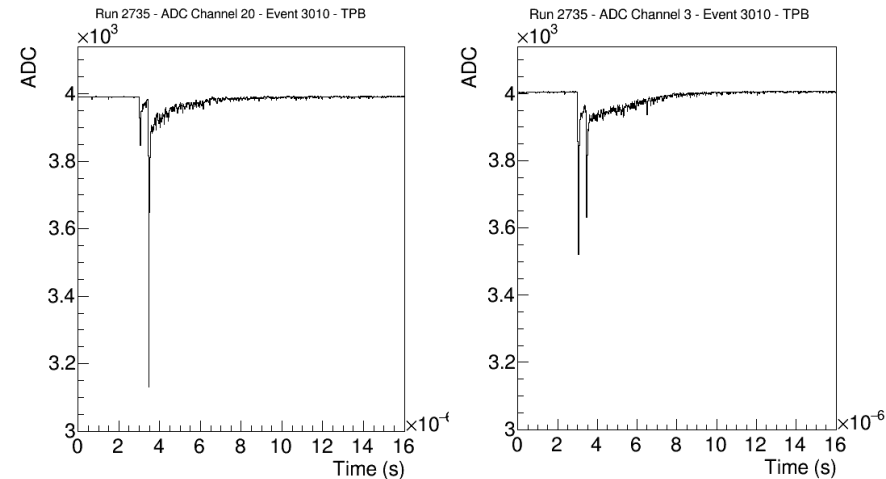
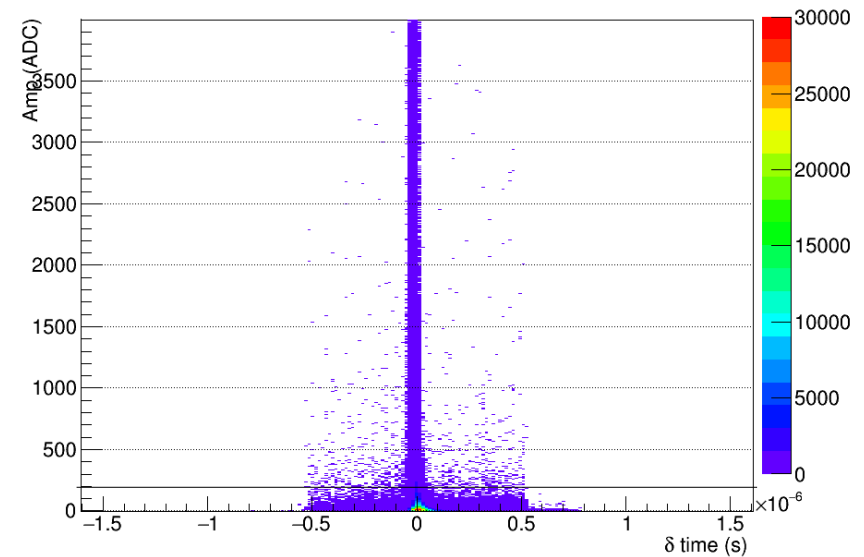


- Layout of the δt mean and sigma from the fit as the PMTs are placed within the detector.

PMT trigger run

Cuts

- Using Run #2735:
 - PMT Trigger on ch20@3900.
 - PMT Gain = 5e6.
 - CRP1/2 LEMs at (3.1,3.4) kV across.
 - Grids at 4.5 kV.
 - 200keVts.
- Remove ADC saturated signals (~0.1%)
- We take the bin with minimum of the waveform within the trigger range (from 2.7us to 3.5us).
- Also, to remove background muons in coincidence with our signal we ask for a minimum signal amplitude of 200ADC → To be sure the muon we are selecting is producing the largest signal in all PMTs (defined by looking at the bottom-right plot).
- This cuts reduces the statistics to just ~10k-100k events depending on the PMT.

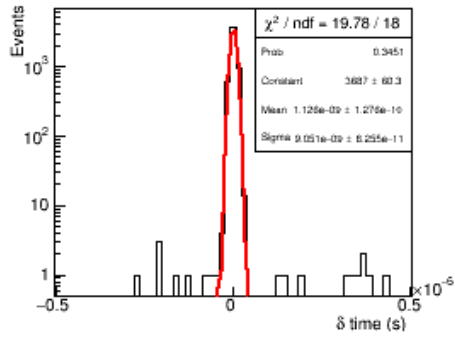


Example of background event: We mismatch the timing of two muons in coincidence.

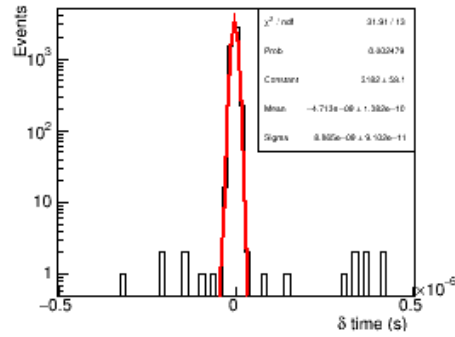
PMT triggered run

δt distributions per PMT

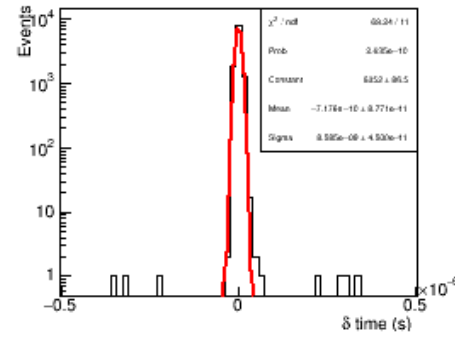
Run2735_ch0_FA0146_1153V_CUSTOM_1583164051



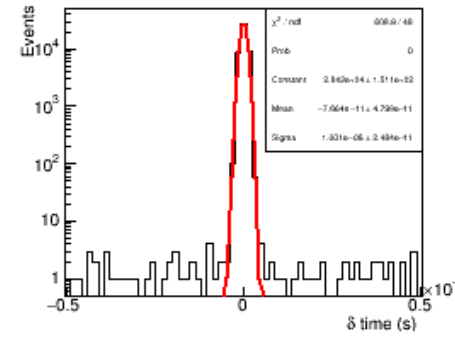
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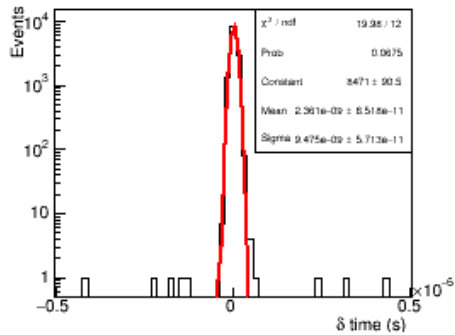
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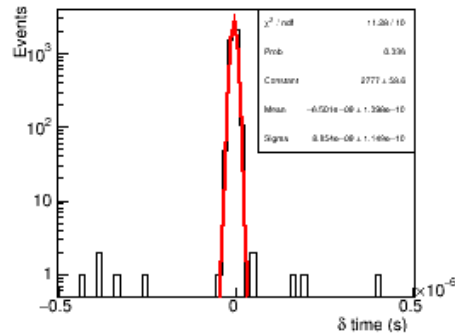
Run2735_ch3_FA0114_1125V_CUSTOM_1583164051



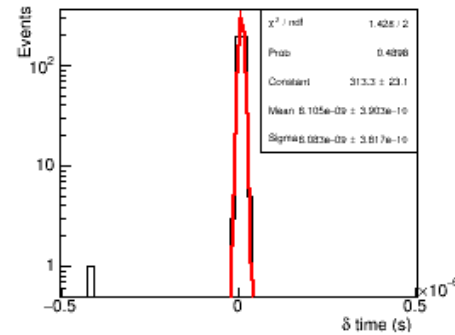
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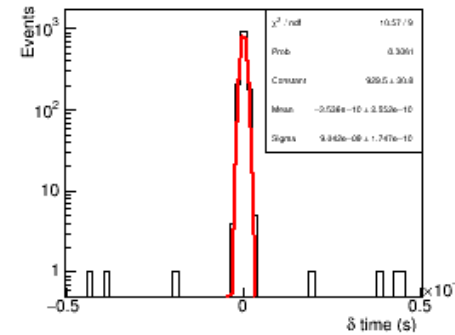
Run2735_ch5_FA0135_1256V_CUSTOM_1583164051



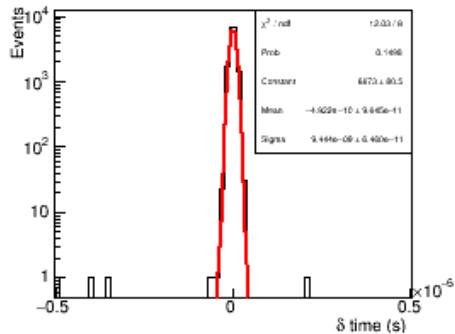
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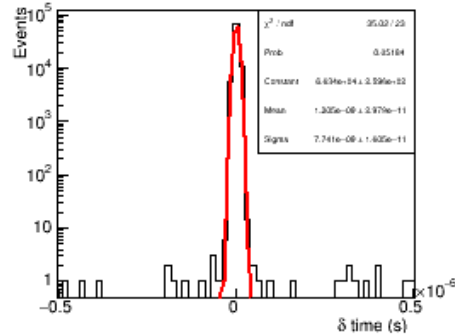
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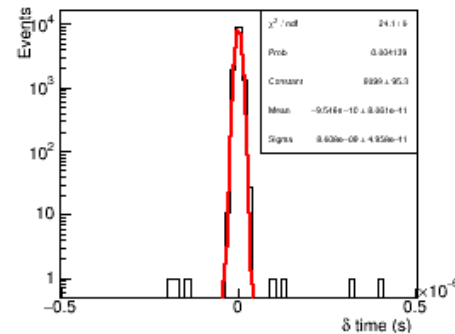
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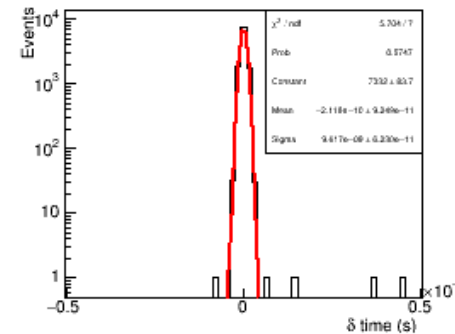
Run2735_ch9_FA0110_1142V_CUSTOM_1583164051



Run2735_ch10_FA0124_1496V_CUSTOM_1583164051

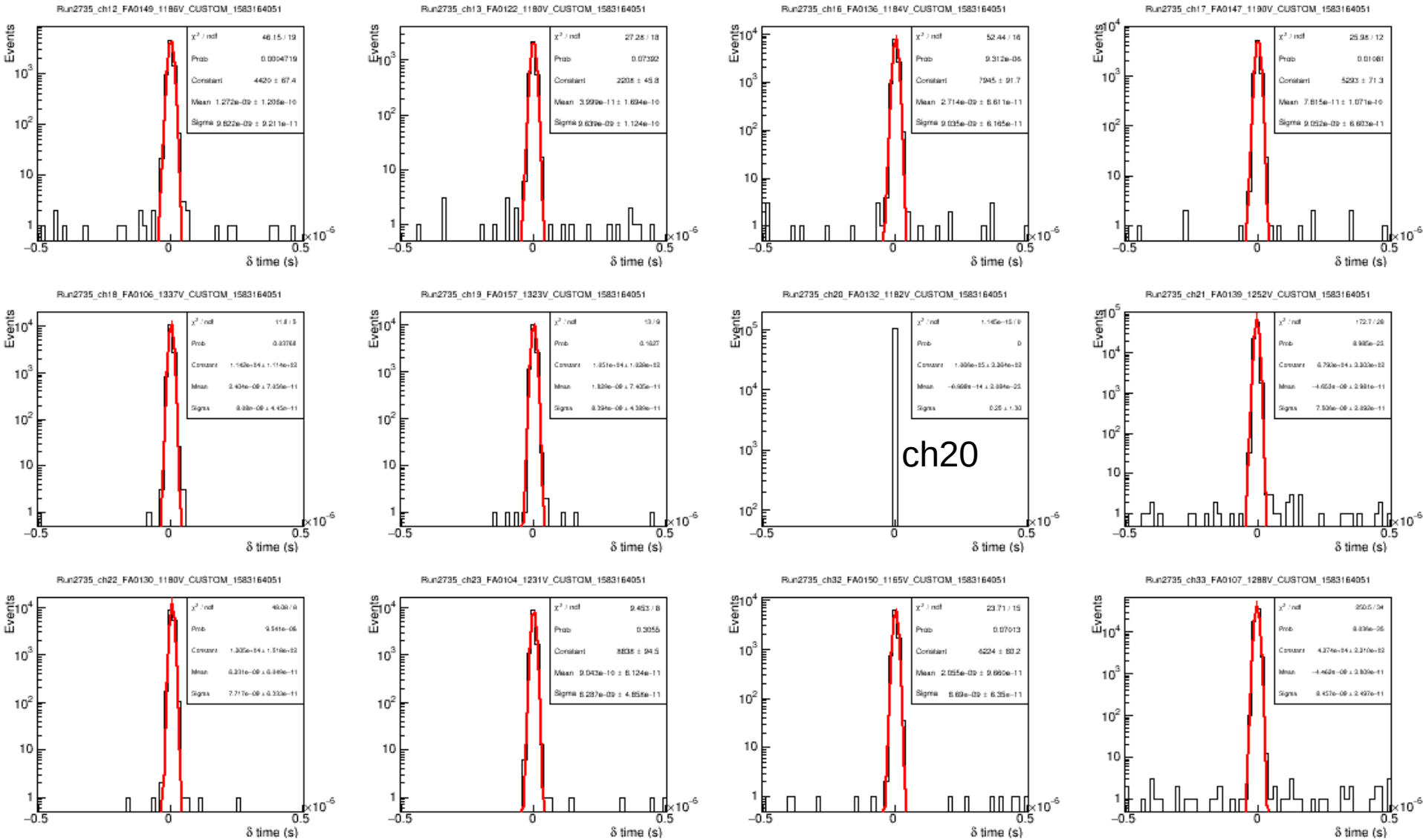


Run2735_ch11_FA0155_1234V_CUSTOM_1583164051



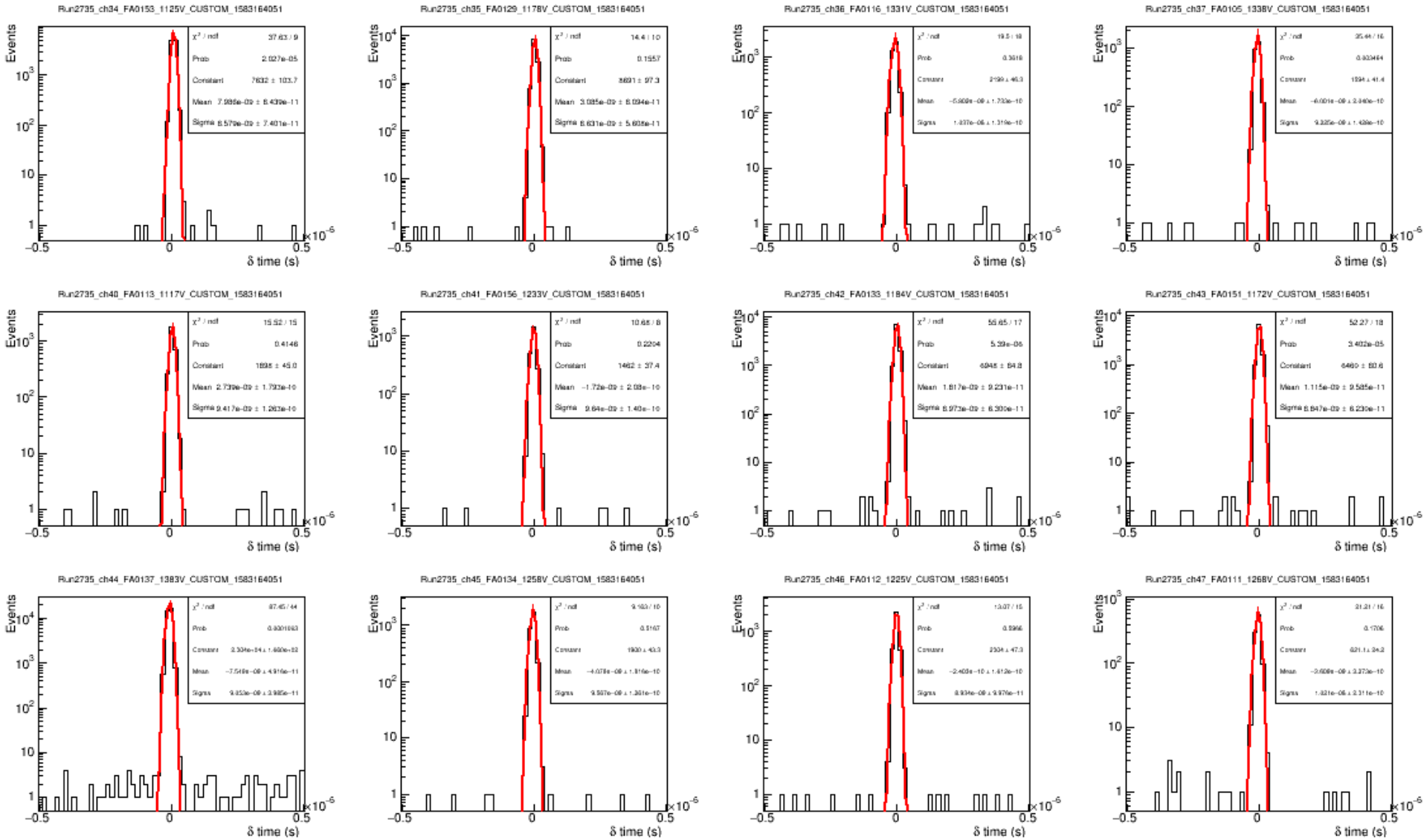
PMT triggered run

δt distributions per PMT



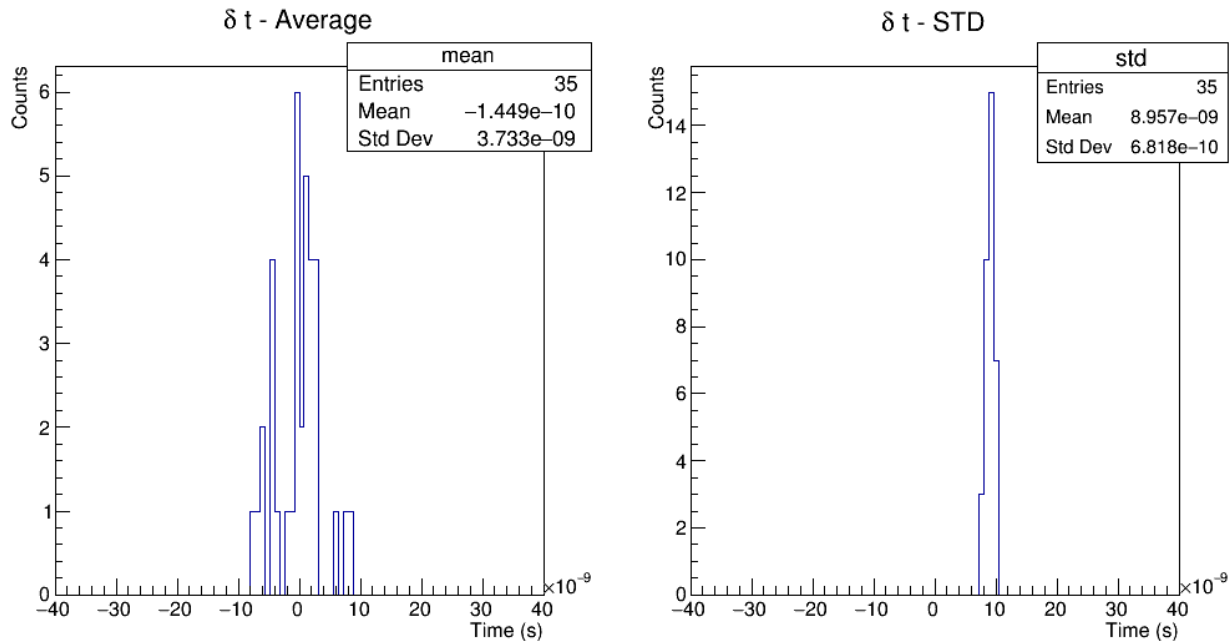
PMT triggered run

δt distributions per PMT



PMT triggered run

δt distributions

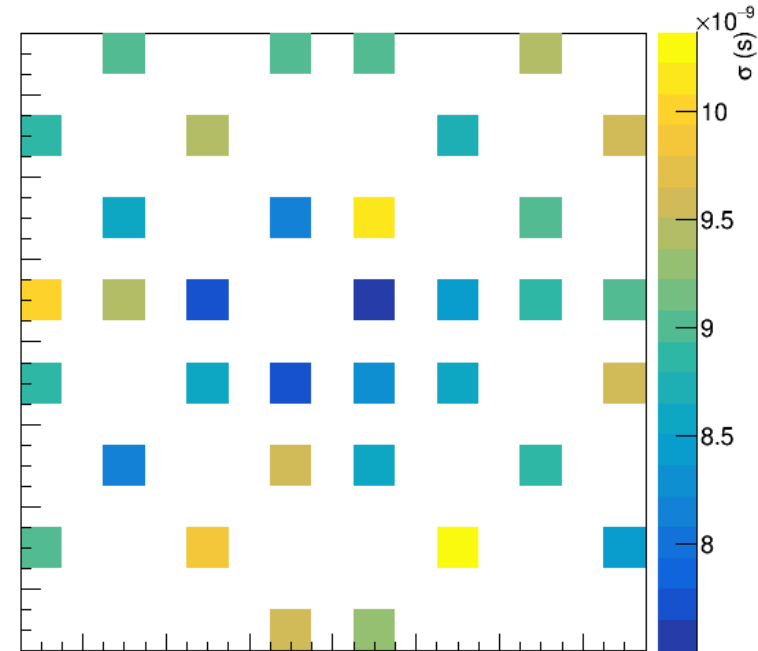
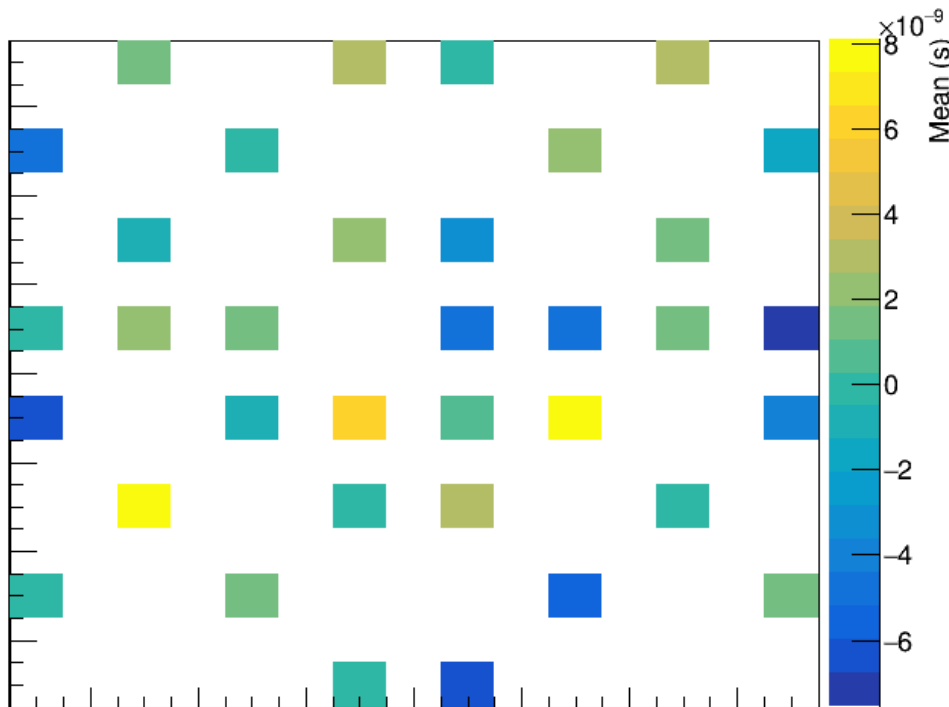


Distribution of the average and STD of the delta t gaussian fit for each PMT. 35 entries (36 PMTs – 1 taken as reference).

- δt distribution is centered in $0 \pm 4\text{ns}$, with an STD of $9 \pm 1\text{ ns}$.

PMT triggered run

δt distributions



- Layout of the δt mean and sigma from the fit as the PMTs are placed within the detector.

Results

- Relative timing accuracy δt is required to be below 100 ns, as stated in the TDR.
 - Using a CRT trigger run, δt distribution is centered in -5 ± 5 ns, with a sigma of **15 ± 3 ns**
 - Using PMT trigger run, δt distribution is centered in 0 ± 4 ns, with a sigma of **9 ± 1 ns**.
- This two values are below the 16ns binning, our systematic uncertainty.
- **The relative timing accuracy among PMTs is limited by the sampling frequency (16ns), it might be even better.**

Backup

PMT trigger run

