WFD timing

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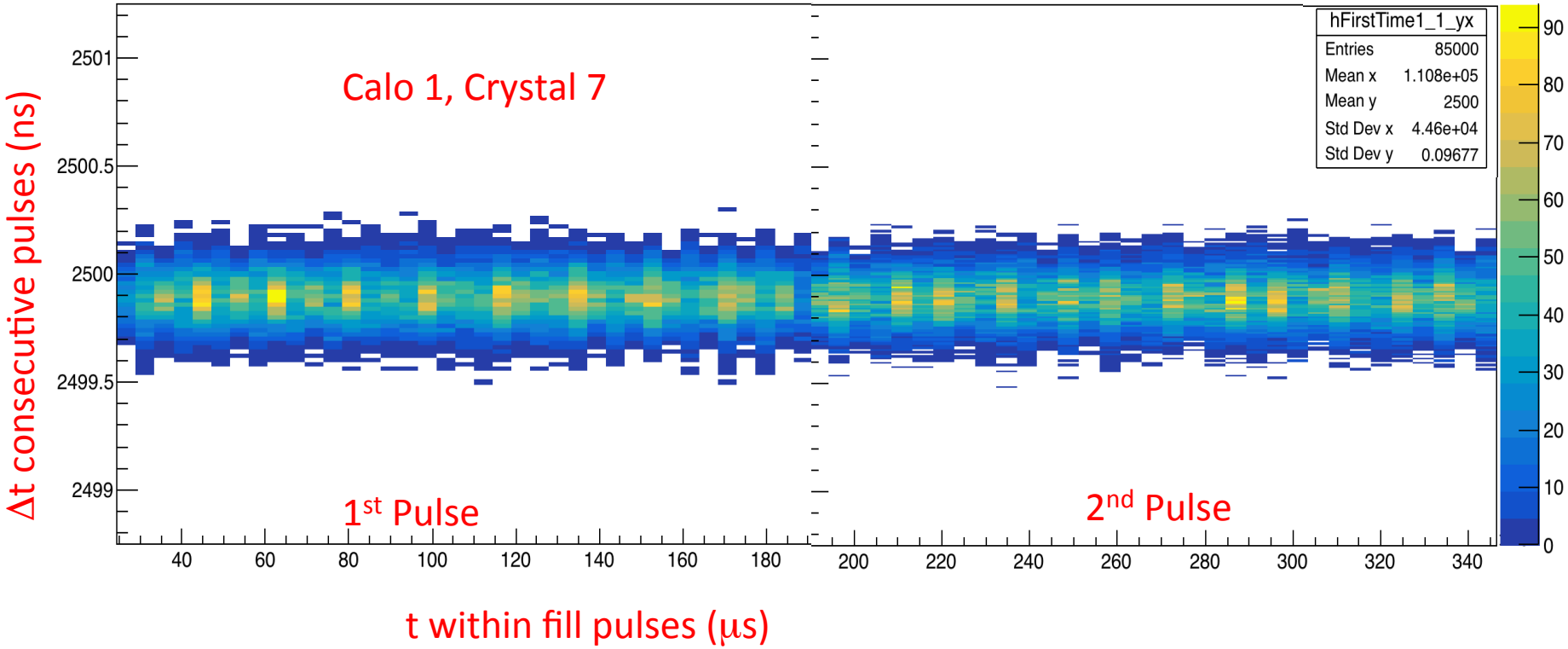
How to get time stability within fill with picosecond precision

1. Check Δt between consecutive pulses
   - consecutive pulses belong to different fills → subtract SYNC
   - shift between consectuive pulses is set in 2.5 μs steps → must collect large statistics
2. Use Short Time Double Pulse
   - STDP (0-100 ns) is normally taken in 4 or 5 moments during fill at distances ~100-150 μs → this is done to increase statistics
   - comparison of the Δt set by the Delay Generator with the one measured by the WFD

Δt between consecutive pulses

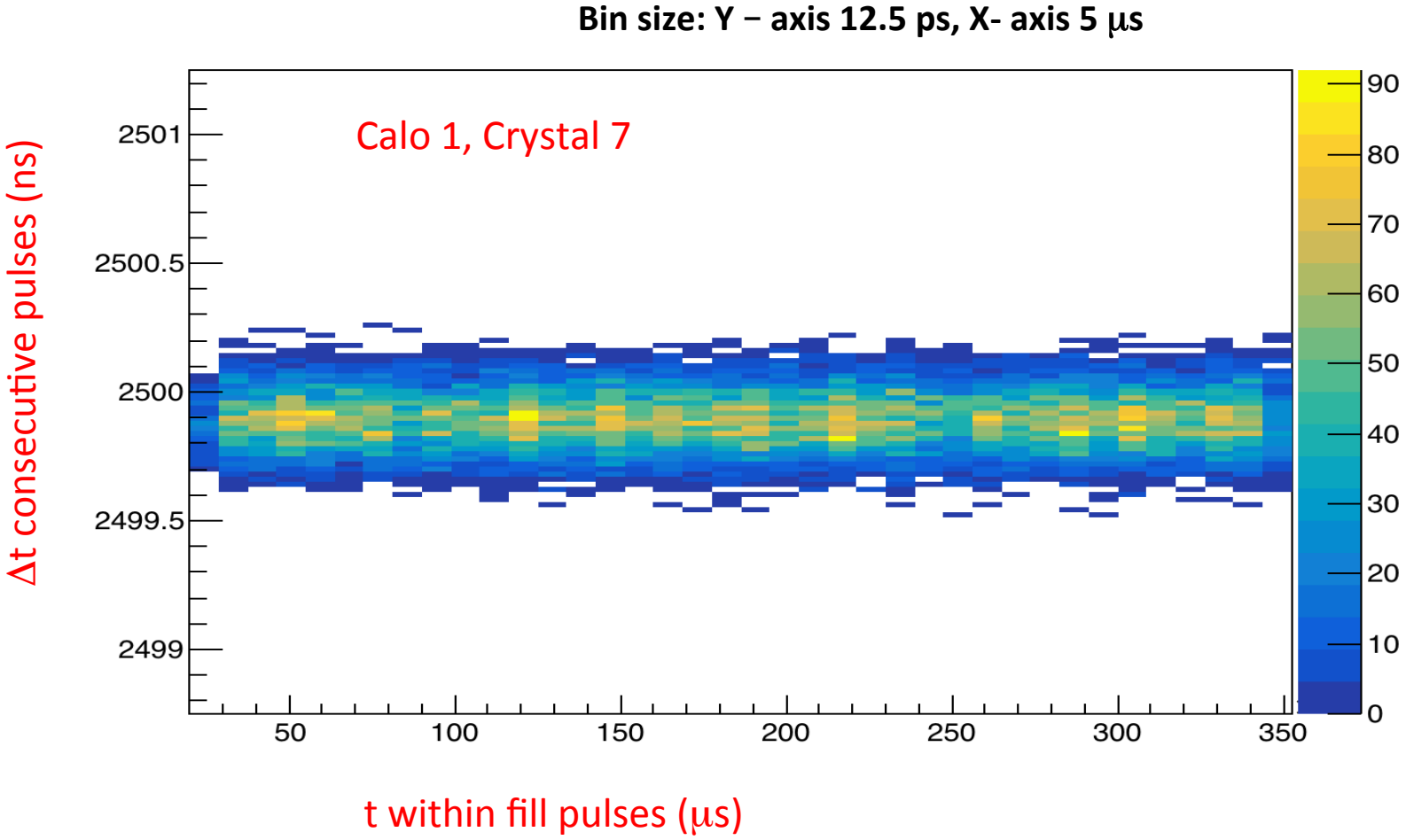
- The time between consecutive pulses is set in 2.5 μs steps → many events required to reach ps precision − used 60 hr dataset
- Preliminary result:

Bin size: Y − axis 12.5 ns, X- axis 5 μs



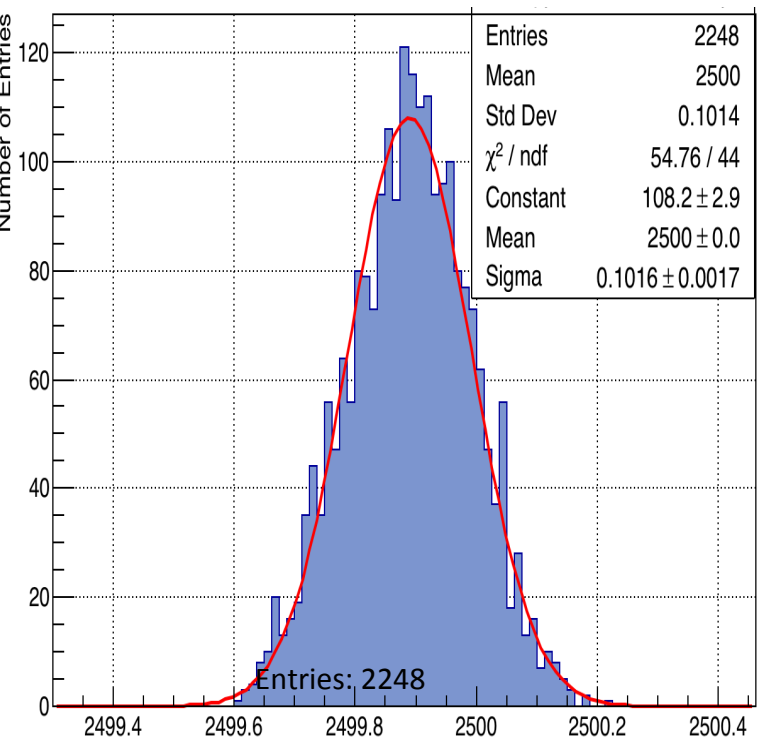
Δt between consecutive pulses

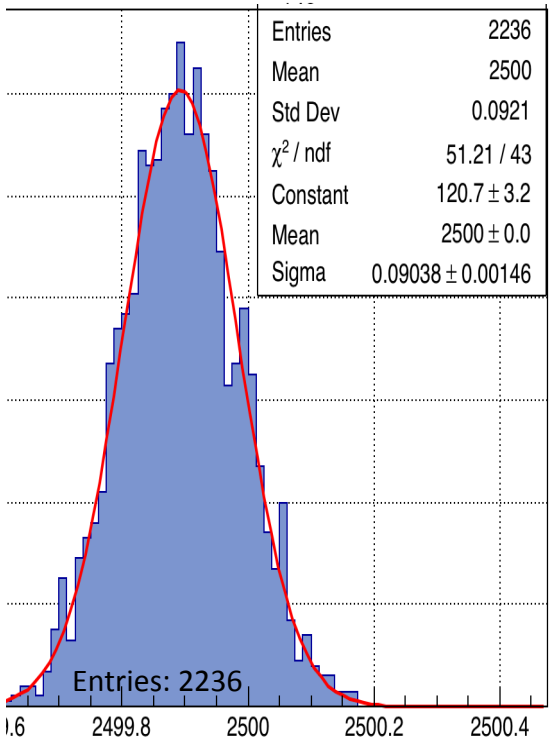
- Combined the Δt between consecutive pulses (both first pulse and second pulse in a fill) in a single plot

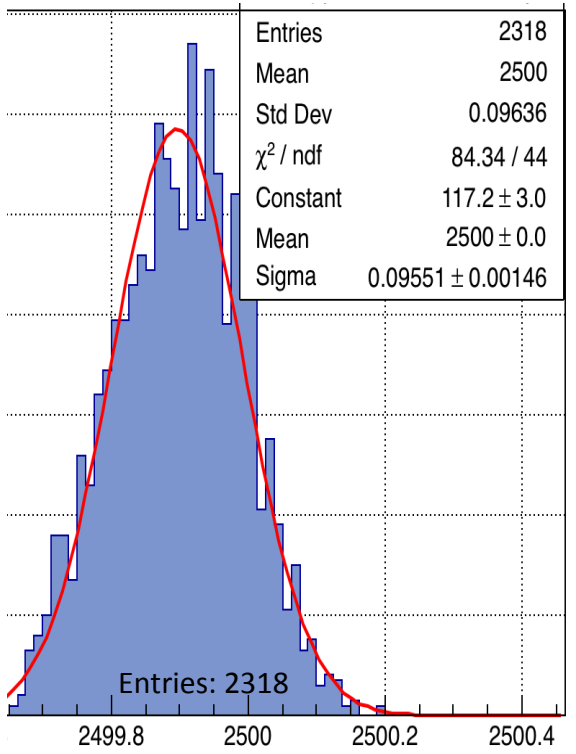


Δt between consecutive pulses

Δt consecutive pulses (ns) for 1 bin – three consecutive bins shown

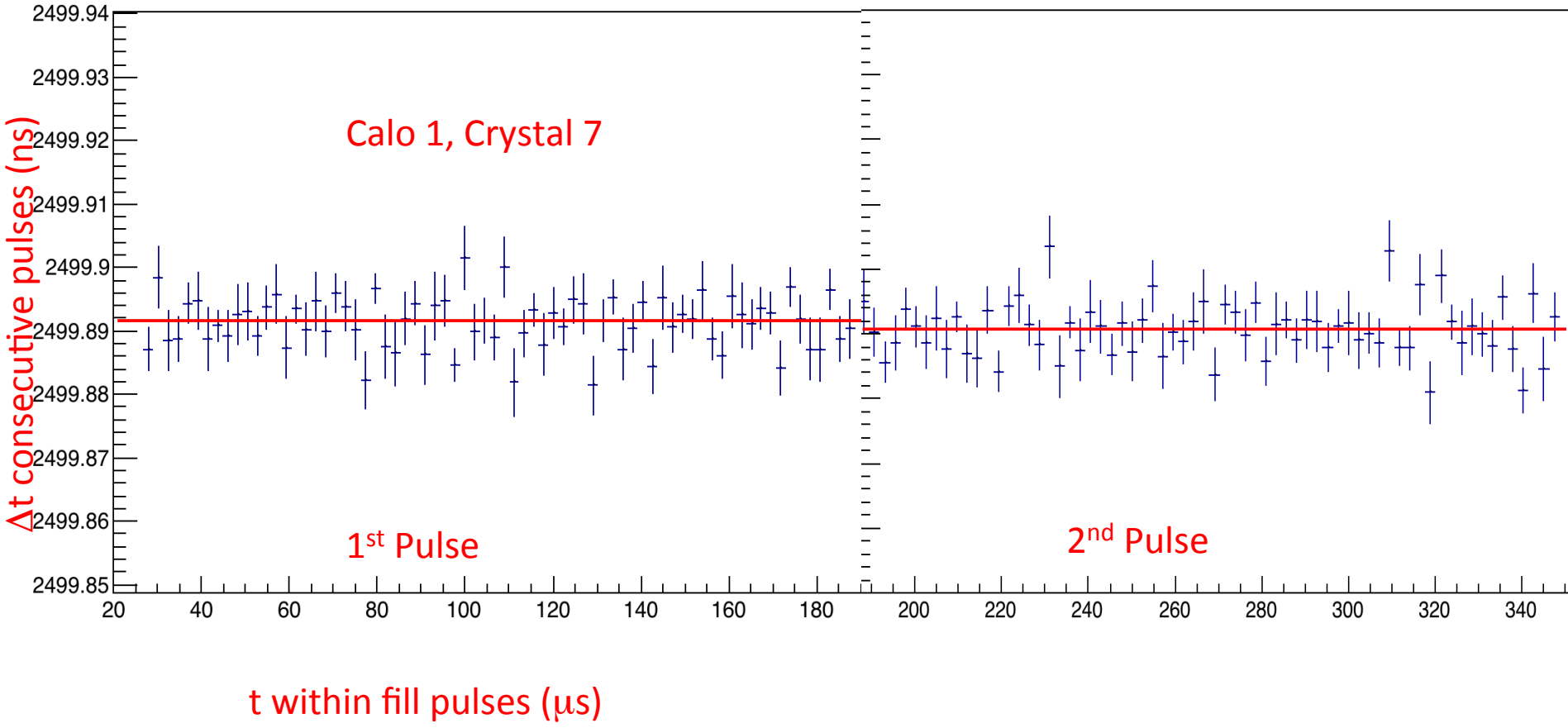






Δt between consecutive pulses

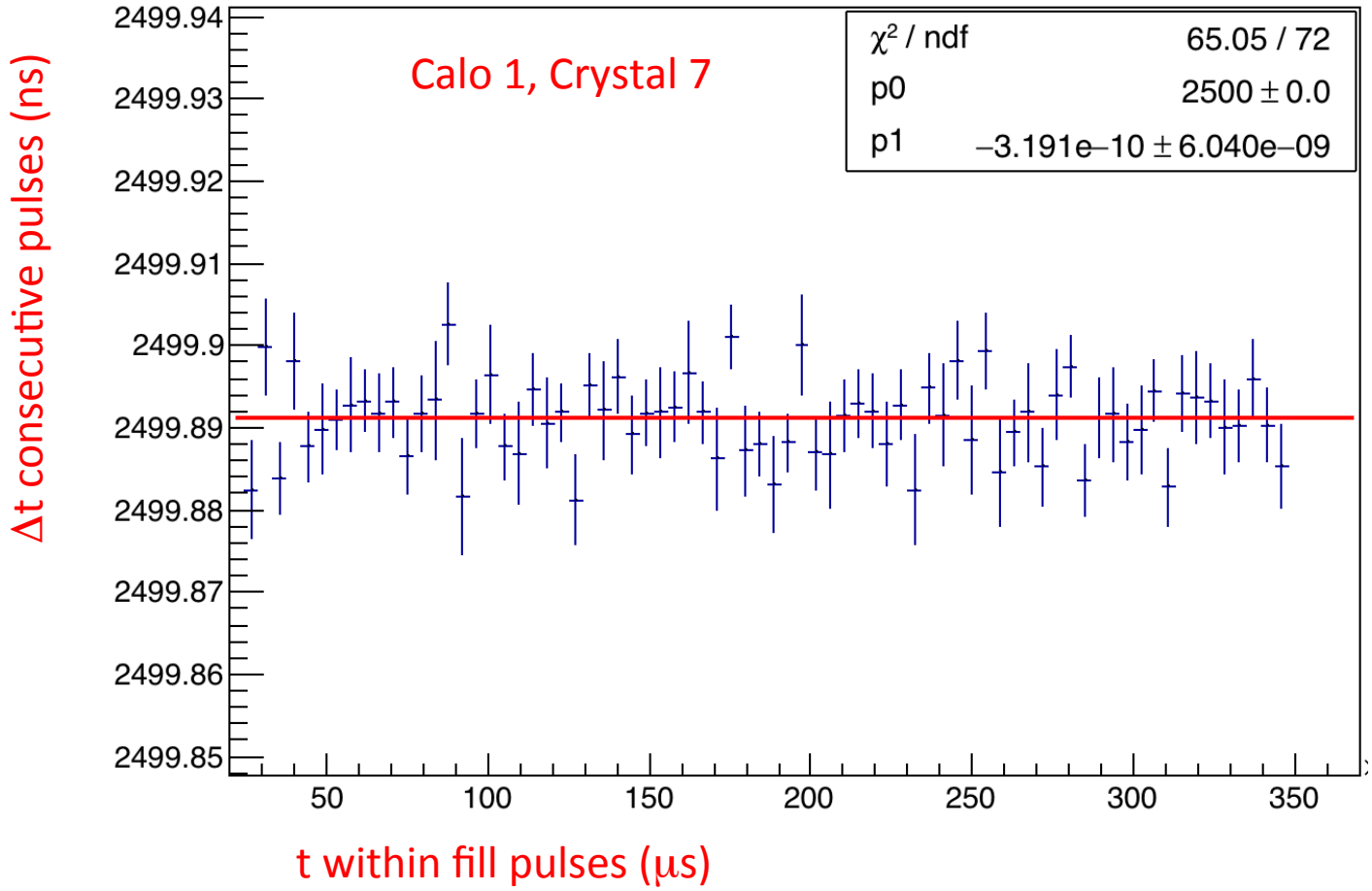
Profiles with linear fit − Mean 2499.891 ± 0.00045 ns



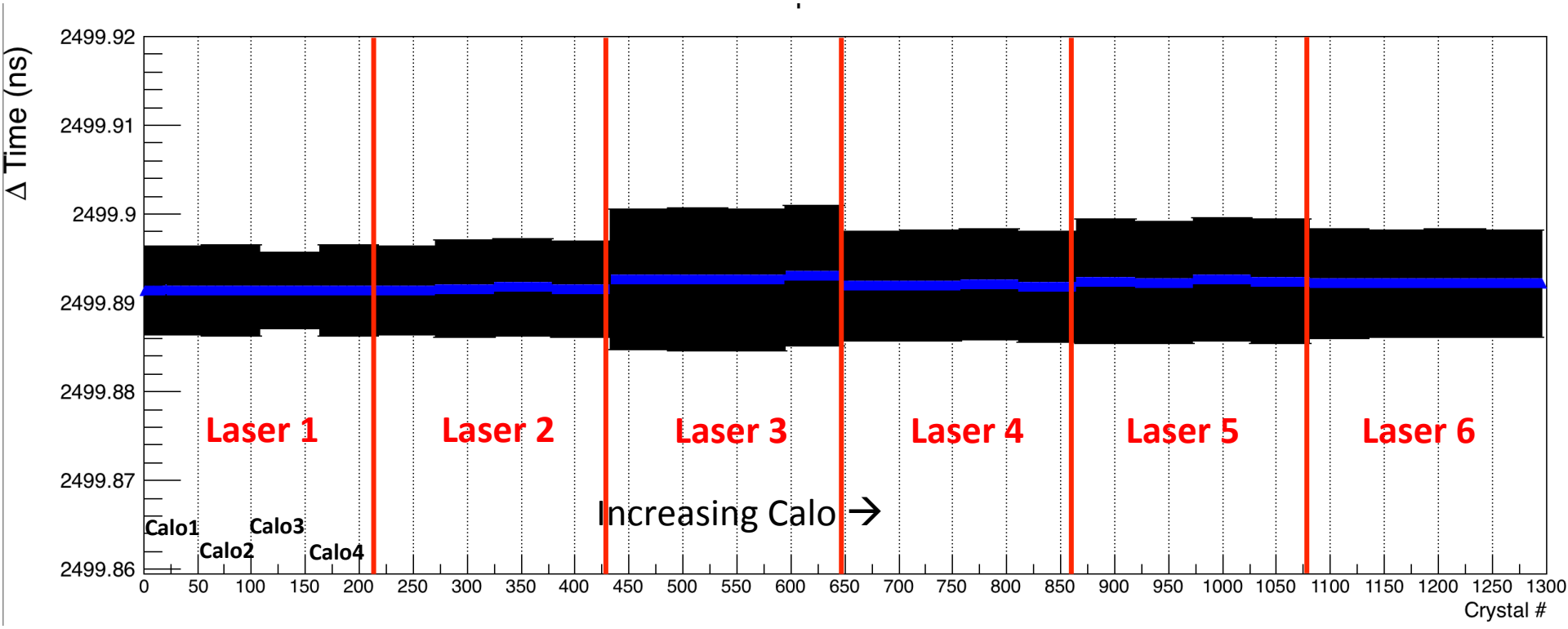
Δt between consecutive pulses

Combined the Δt between consecutive pulses (both first pulse and second pulse in a fill) in a single plot

Profiles with linear fit (pol1) for entire range− Mean 2499891.35 ± 1.26 ps

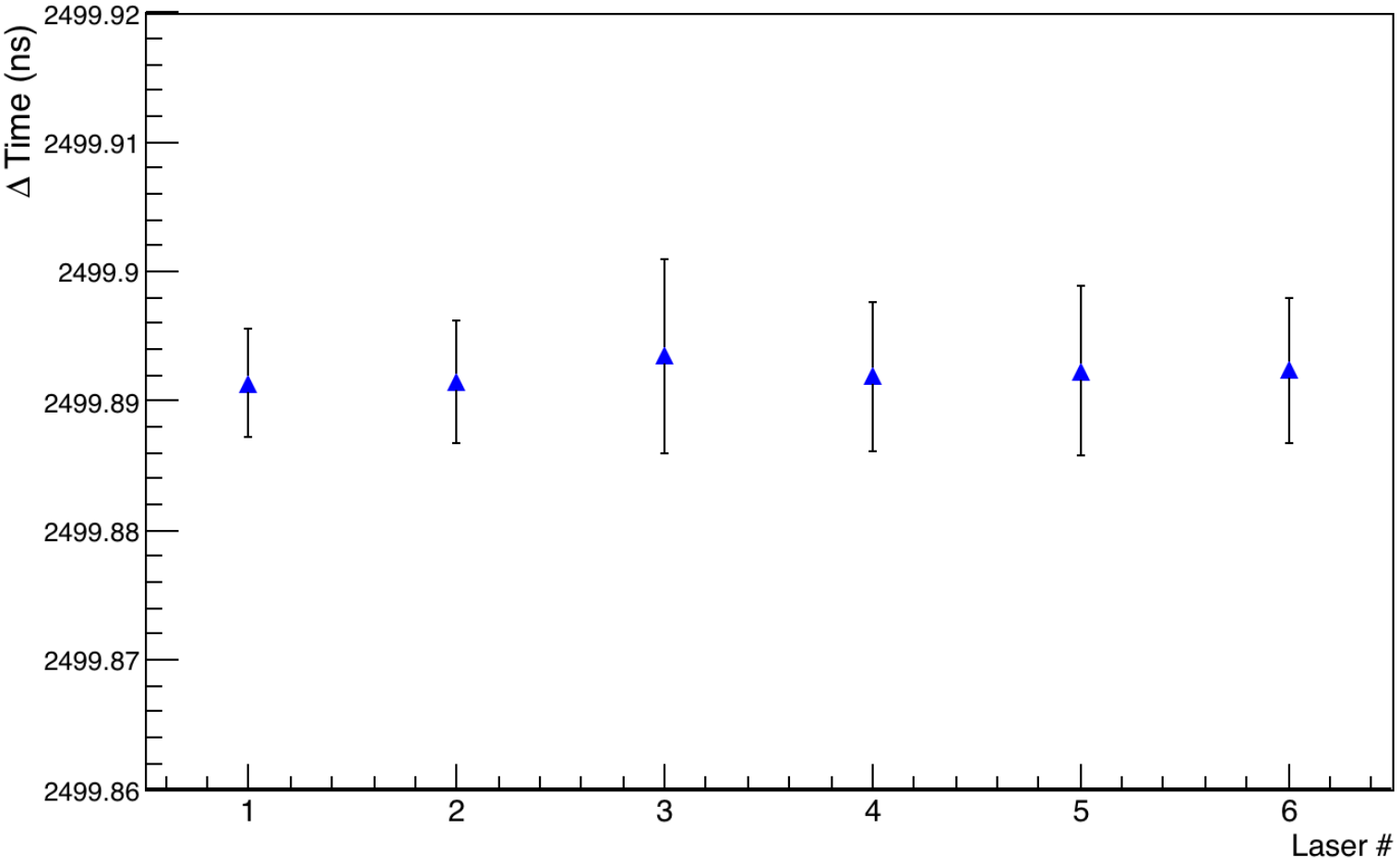


Δt between consecutive pulses – all 1296 xtal



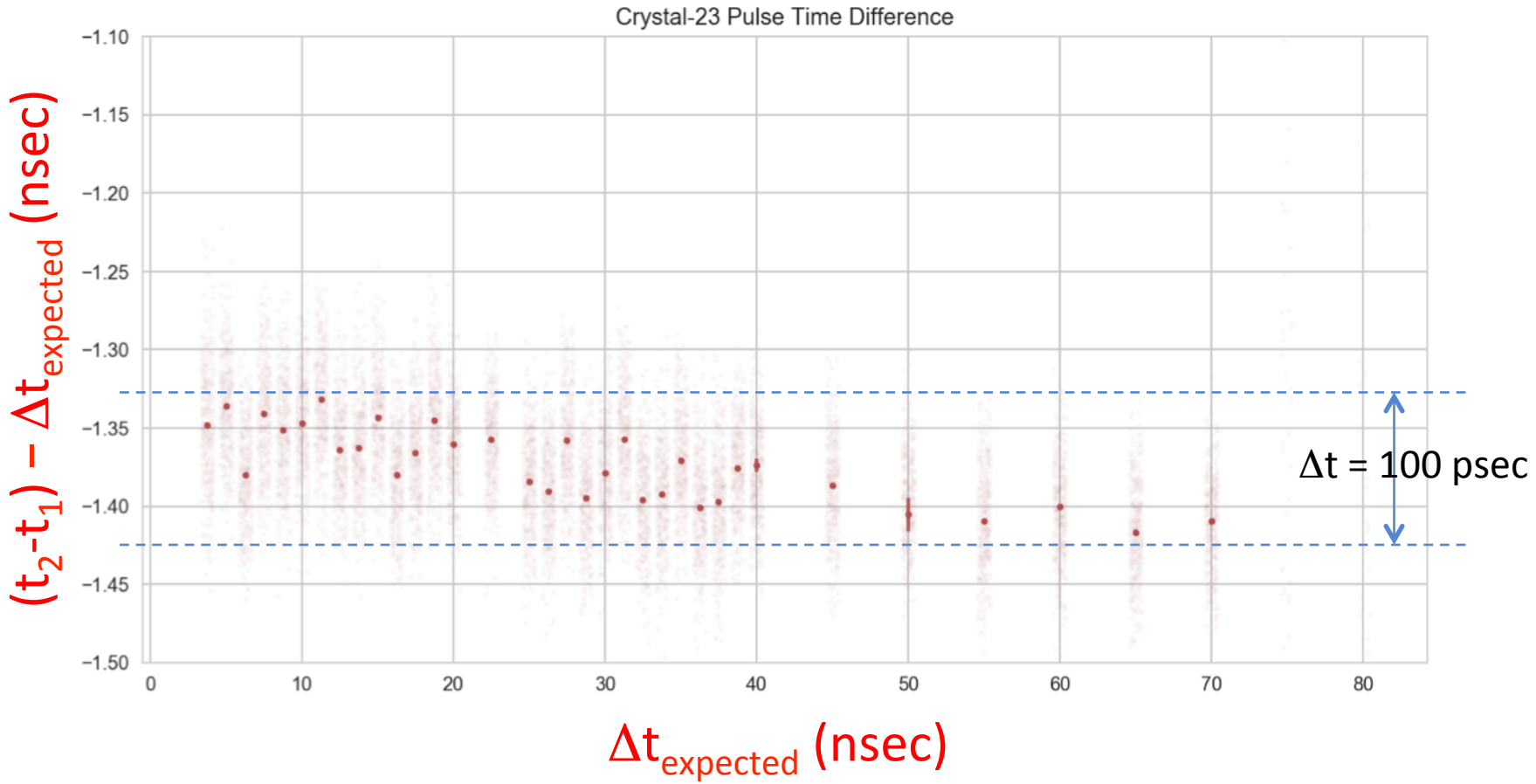
Obtained by Gaussian fit of Y projection with sigma/sqrt(NDF) as errors.
Error bars of ~10 ps

Δt between consecutive pulses – Average for all Lasers



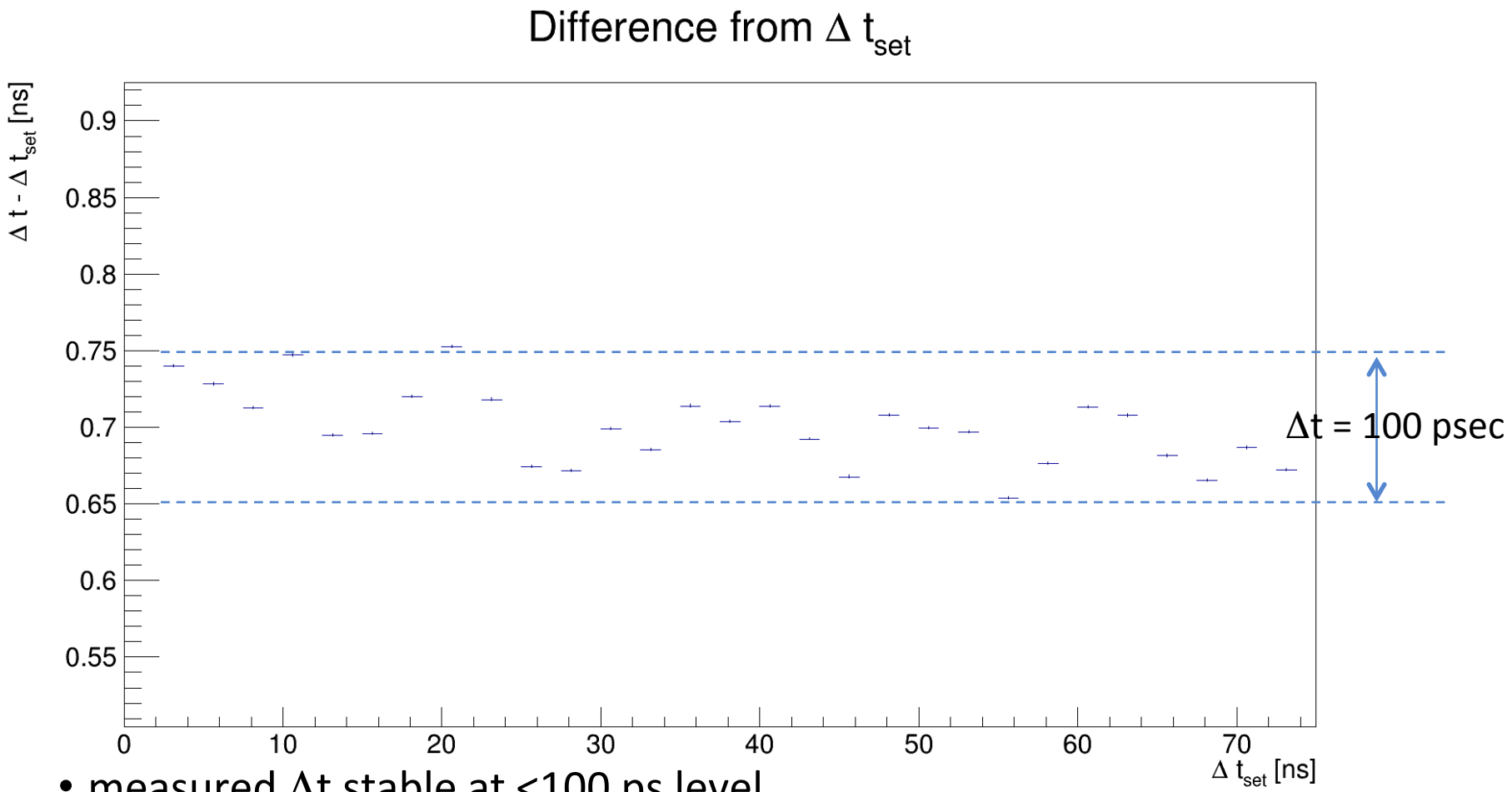
This is the average Δt of all crystals of a single laser (from previous slide).

Short Time Double Pulse



- measured Δt stable at <100 ps level
- shift due to different light path of the two lasers
- residual trend at 5 ps level

Short Time Double Pulse



- measured Δt stable at <100 ps level
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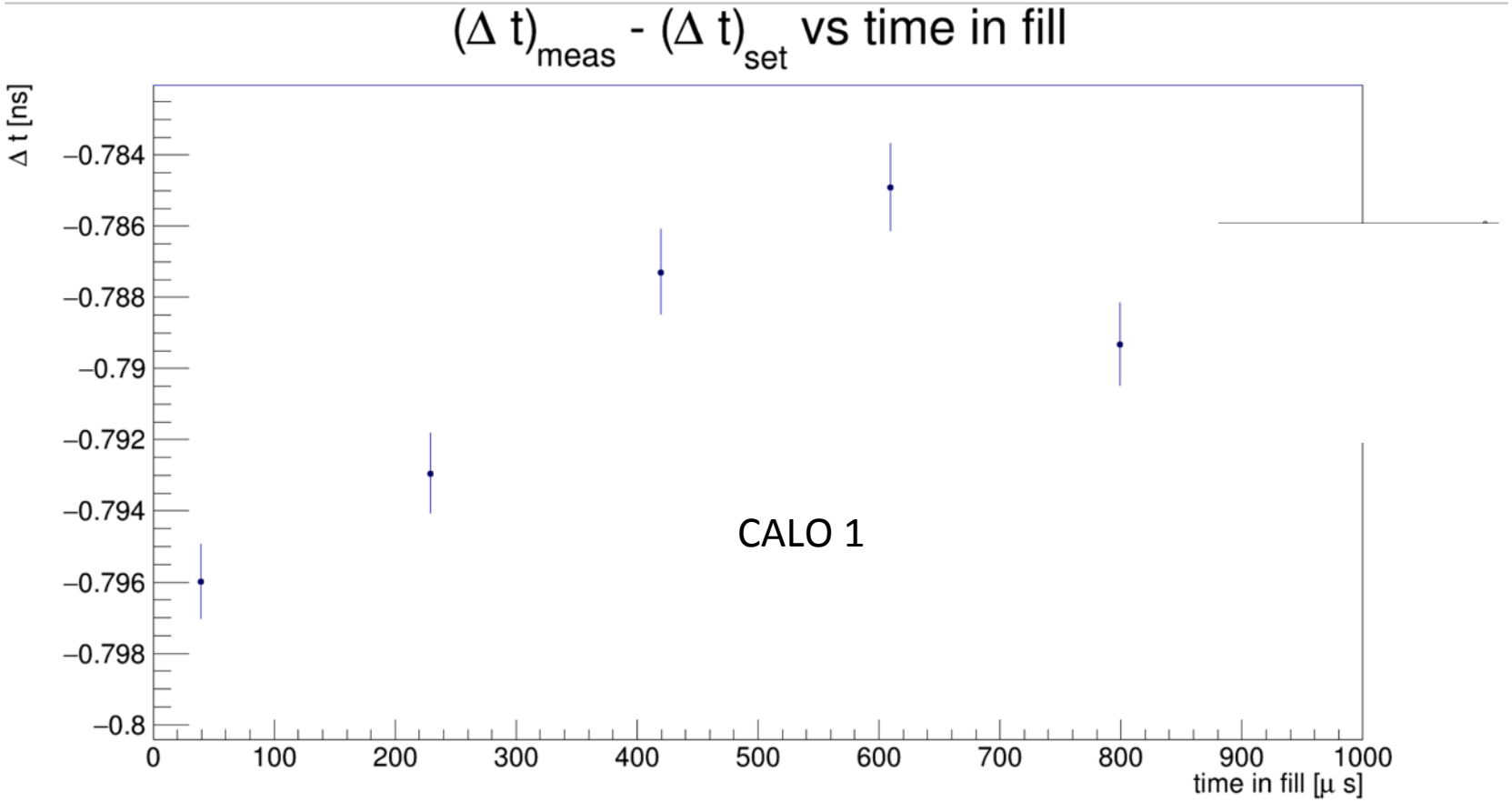
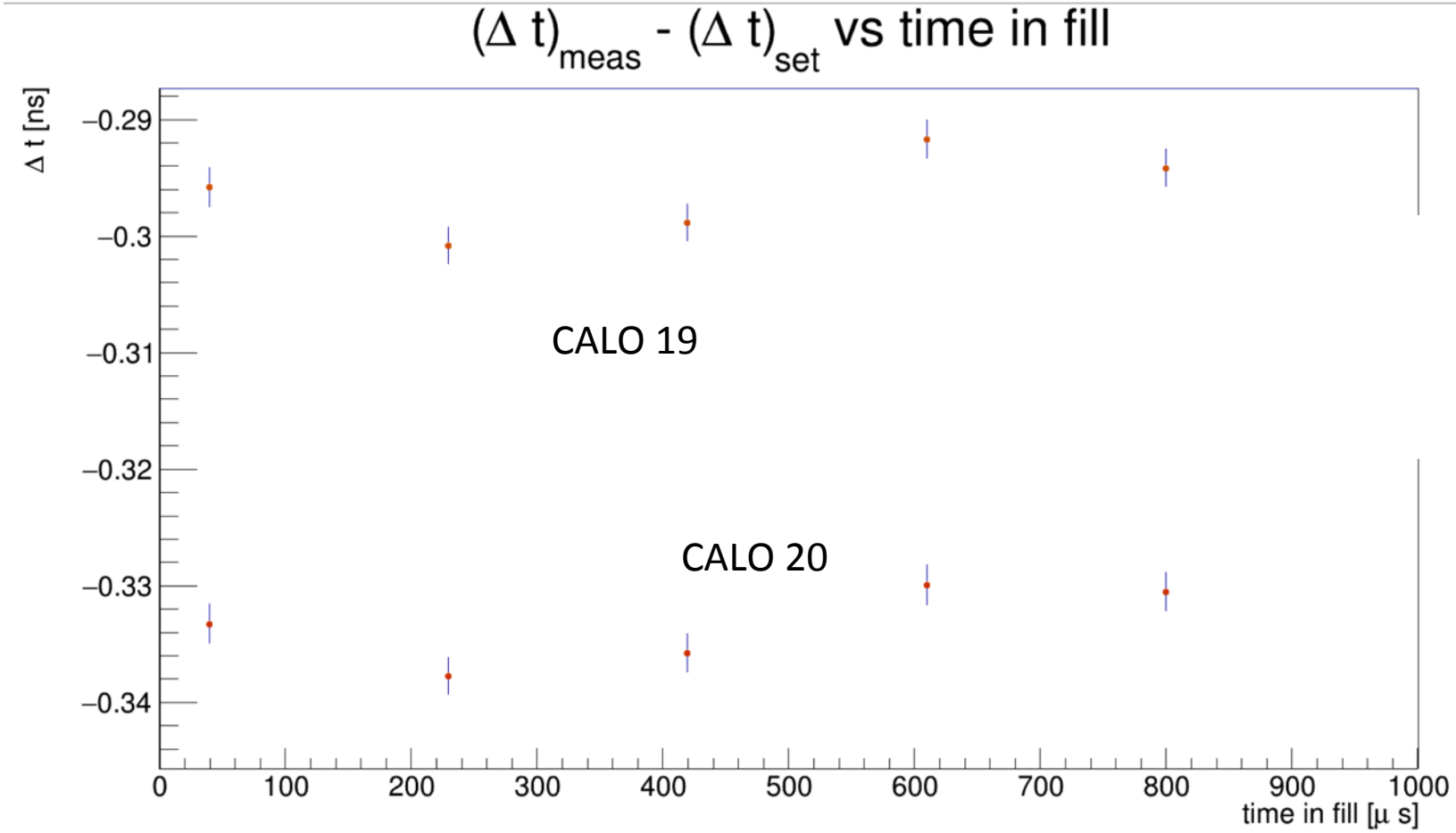
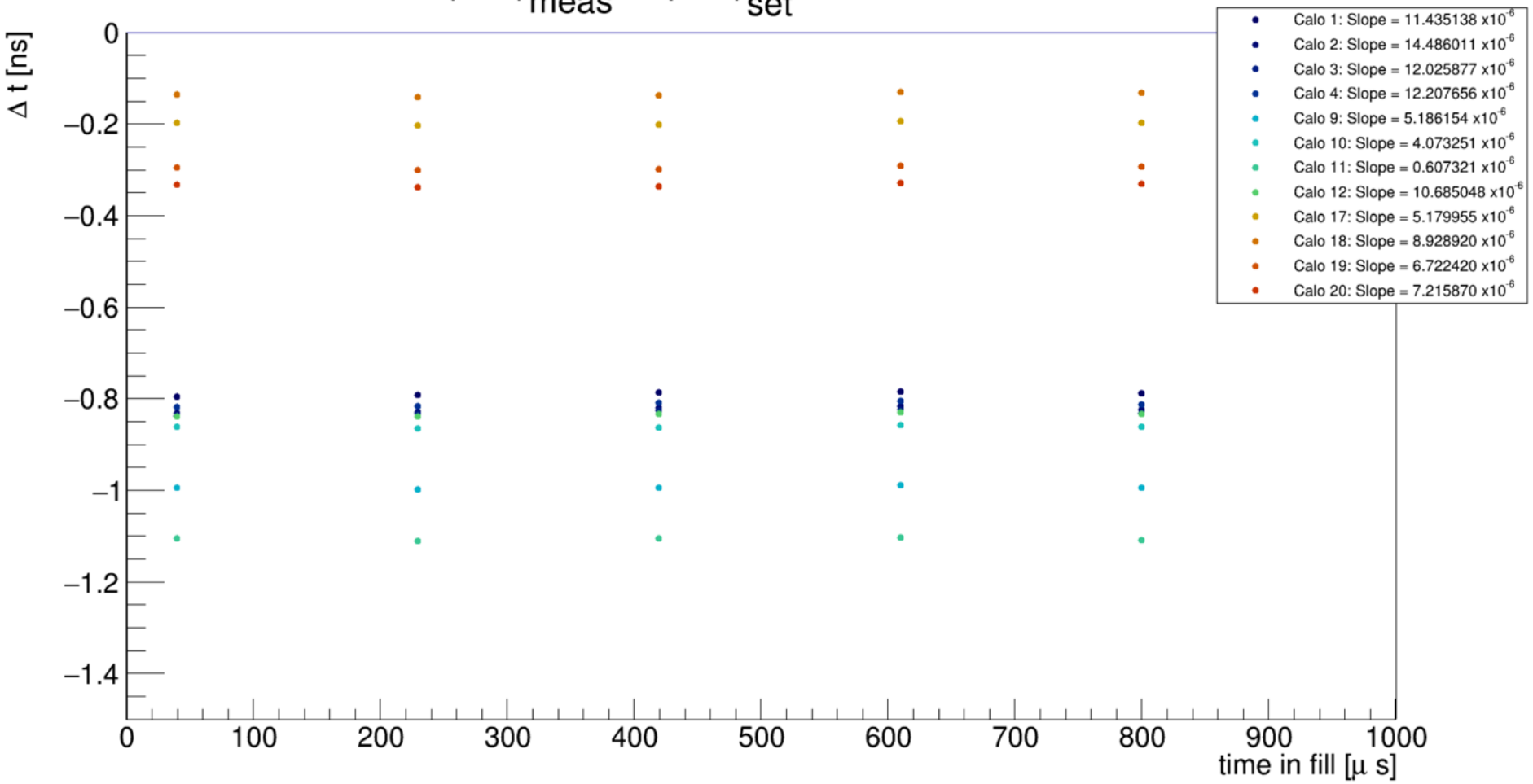
- residual trend at 5 ps level



- $\Delta(\Delta t)$ stable within 10 ps in 5 different time slices within fill
- This technique is more precise than InFill pulses, but less points within fill available



- Calorimeters from same laser have similar, but not necessarily identical $\Delta(\Delta t)$.

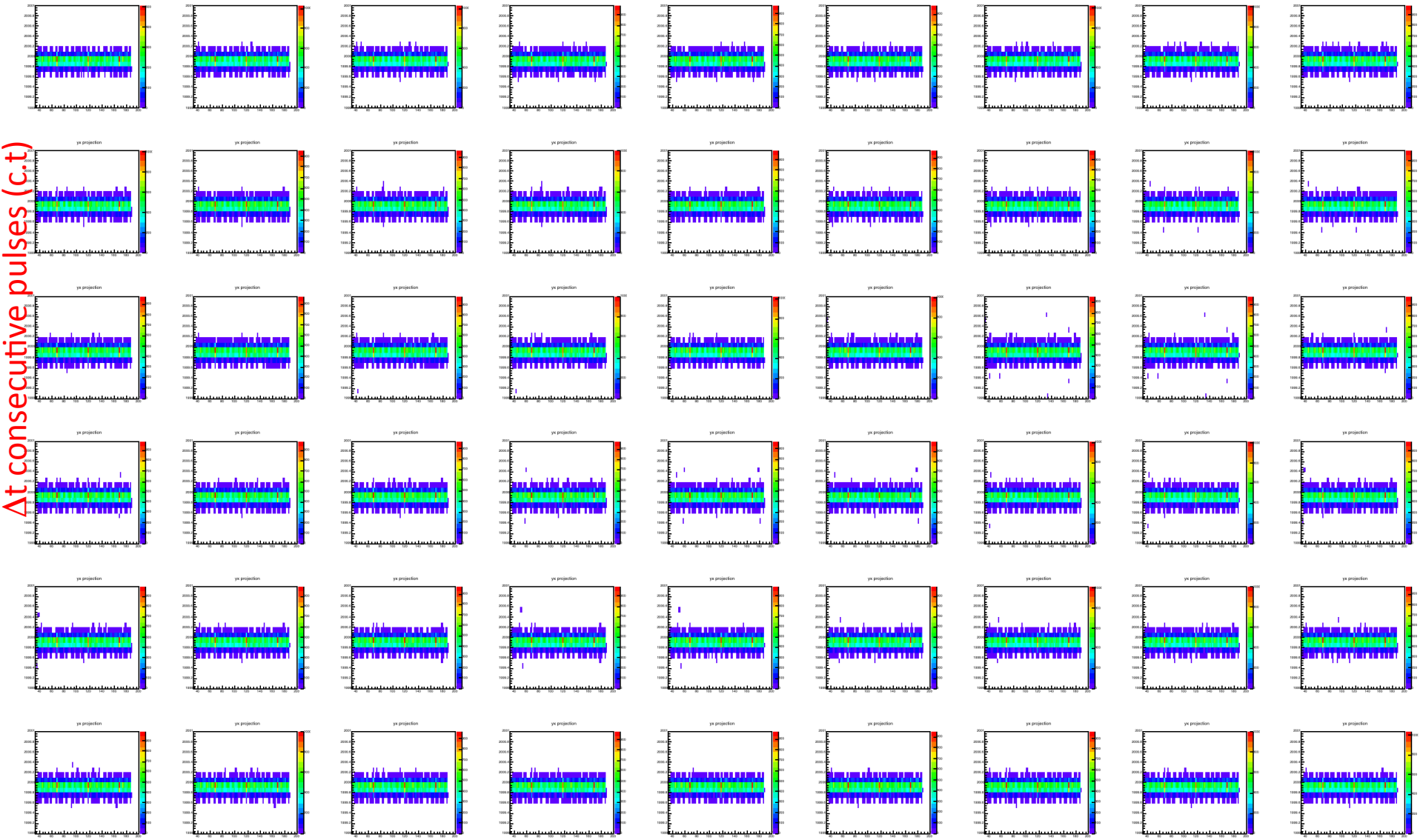

$(\Delta t)_{meas} - (\Delta t)_{set}$ vs time in fill
Δ t [ns]
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
0
100
200
300
400
500
600
700
800
900
1000
time in fill [μ s]
Calo 1: Slope = 11.435138 x10^-6
Calo 2: Slope = 14.486011 x10^-6
Calo 3: Slope = 12.025877 x10^-6
Calo 4: Slope = 12.207656 x10^-6
Calo 9: Slope = 5.186154 x10^-6
Calo 10: Slope = 4.073251 x10^-6
Calo 11: Slope = 0.607321 x10^-6
Calo 12: Slope = 10.685048 x10^-6
Calo 17: Slope = 5.179955 x10^-6
Calo 18: Slope = 8.928920 x10^-6
Calo 19: Slope = 6.722420 x10^-6
Calo 20: Slope = 7.215870 x10^-6

Conclusions

- The WFD timing can be evaluated both with InFill and STDP events.
- InFill pulses are more numerous, but less precise than STDP.
- Both show a stability within ~10 ps over the Fill (conclude from the errors).
- All 1296 crystals show a similar (and consistent) behaviour.

Back up Slides

Δt between consecutive pulses – Calo 1, all xtals



Shows consistent behaviour of all xtals.

Bin size: Y – axis 0.1 ct, X- axis 2 μs
X, Y Ranges same as before

Δt = Difference between 2nd and 1st pulse for a fill