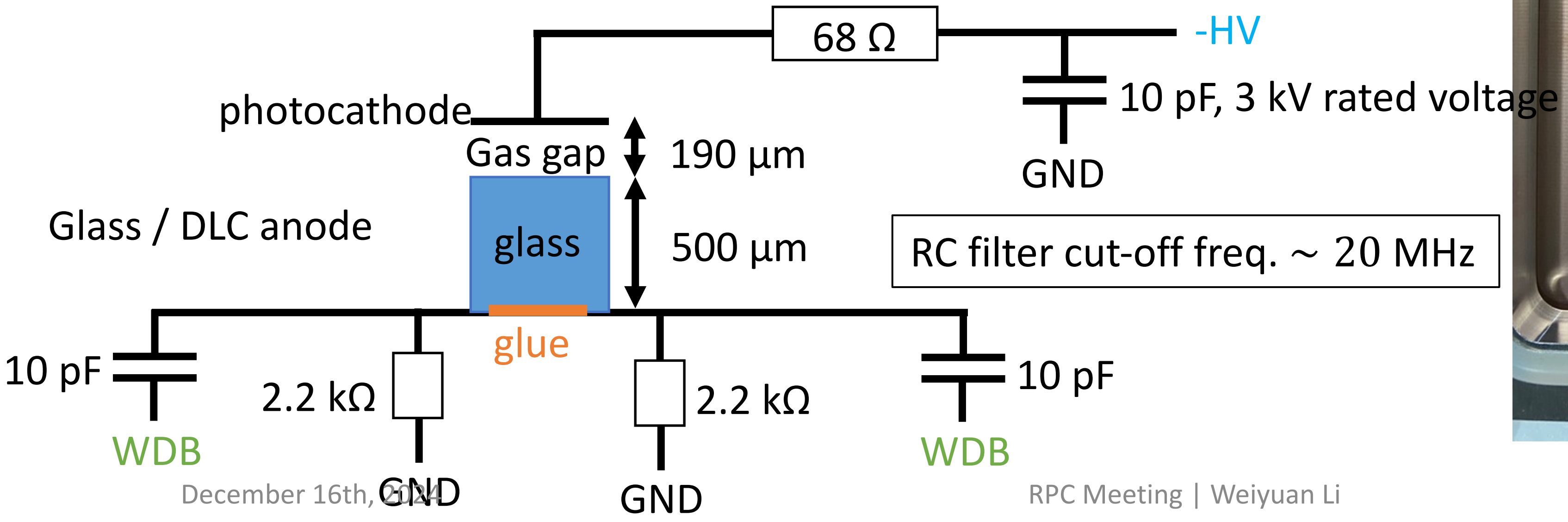
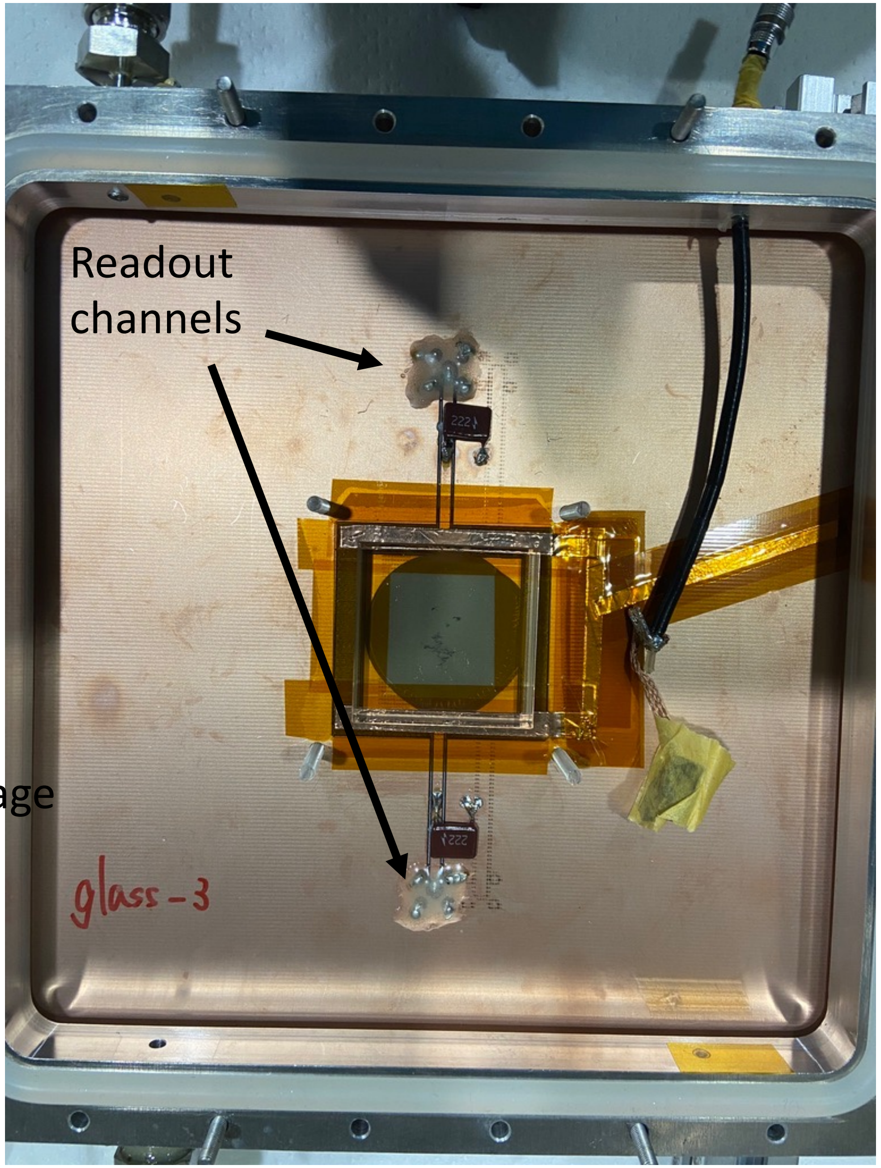
Status report

Weiyuan Li

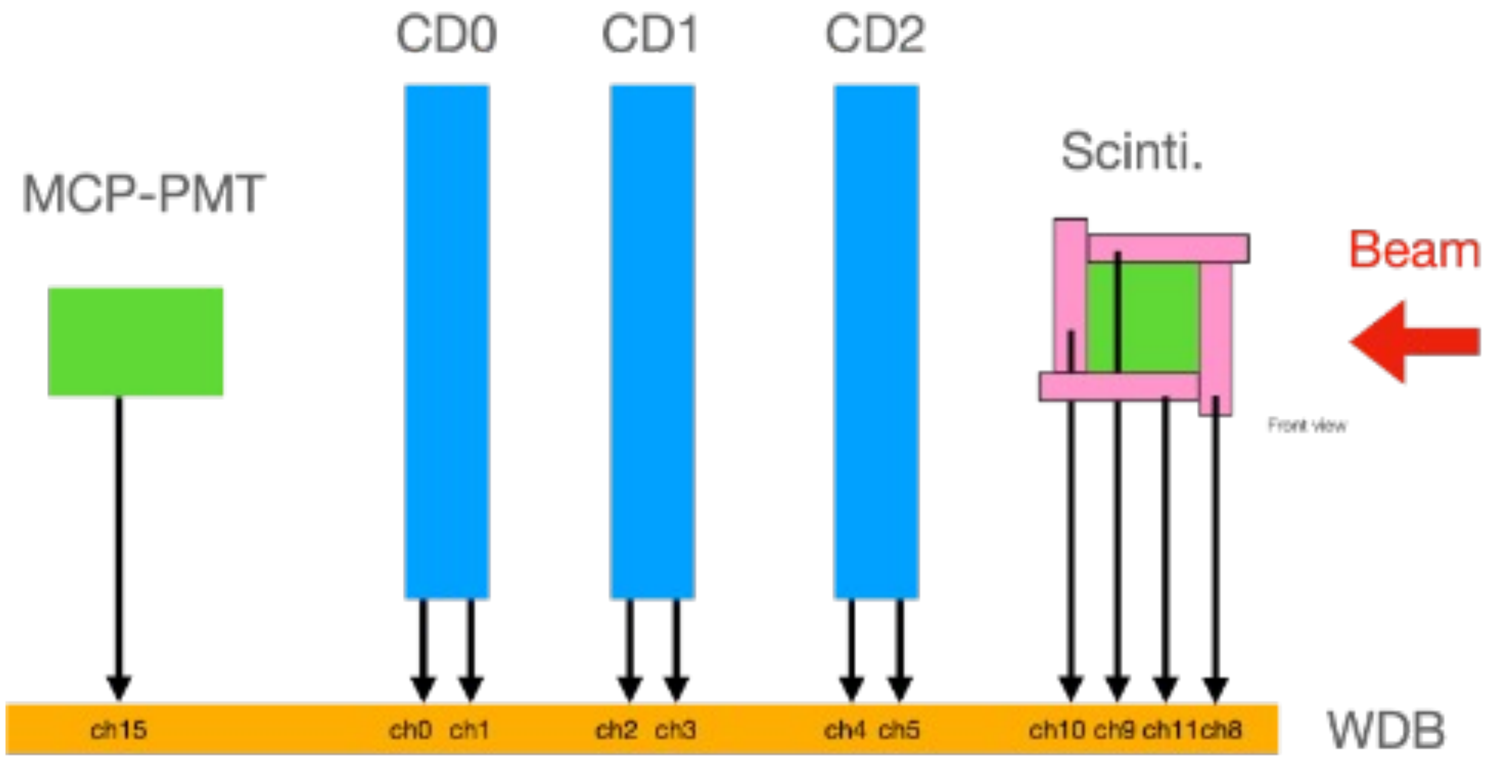
Cherenkov detector reminder

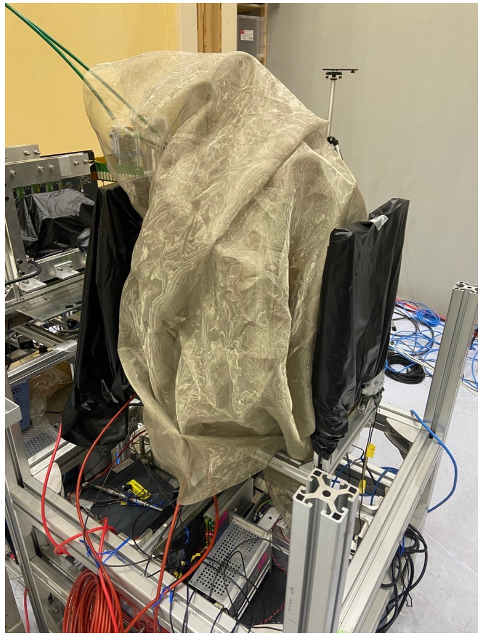
- Two readout channels per chamber
- Each channel has HP-filter to avoid HV-origin low freq noise, made by …
  10 pF multilayer ceramic capacitor
  2.2 kΩ metal oxide film resistor
  → cut off freq. ~ 14 MHz
- Anode electrode: 0.5 mm-t soda-lime glass (thinnest available), directly connected to readout electrode with conductive glue
- Gas gap thickness: 190 μm (55 μm Kapton x 2 + 80 μm Cu)





Beamtest setup





CDs are shielded by a metal mesh curtain

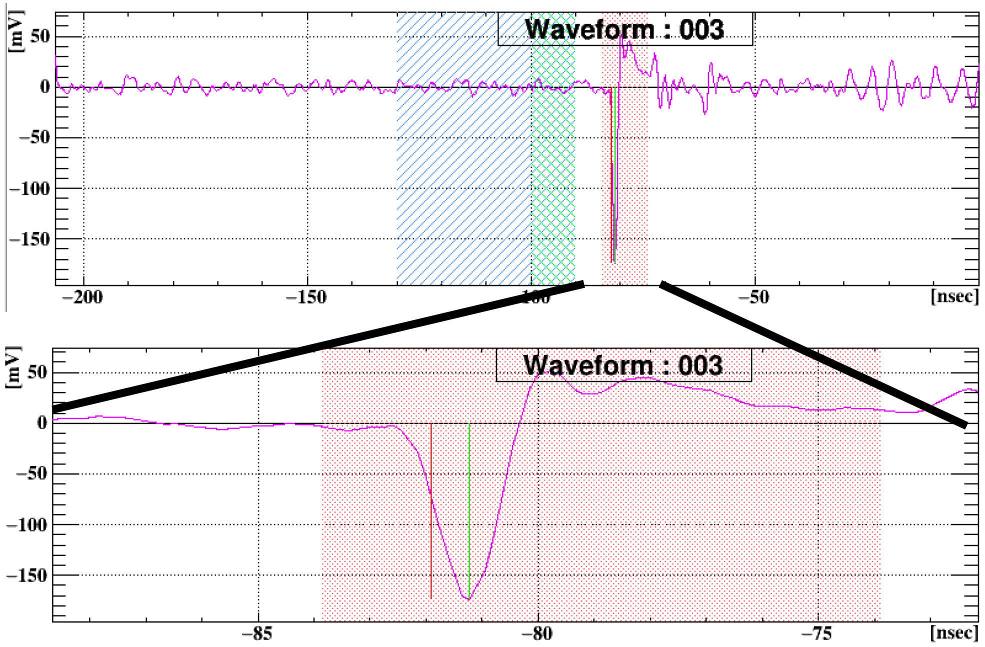
Datasets

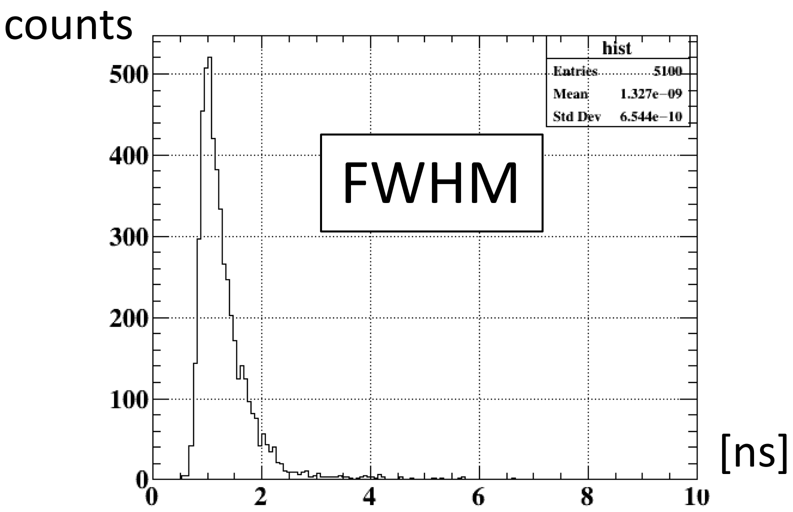
	CsI photocathode	DLC photocathode
MgF2 2.4 mm-t	✅	✅
MgF2 5.0 mm-t	✅	❌
MgF2 10.0 mm-t	✅	✅

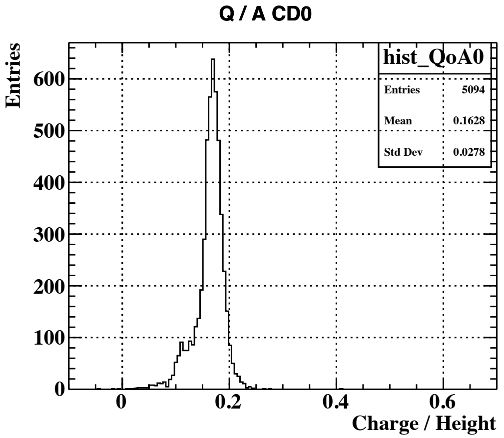
What to start?

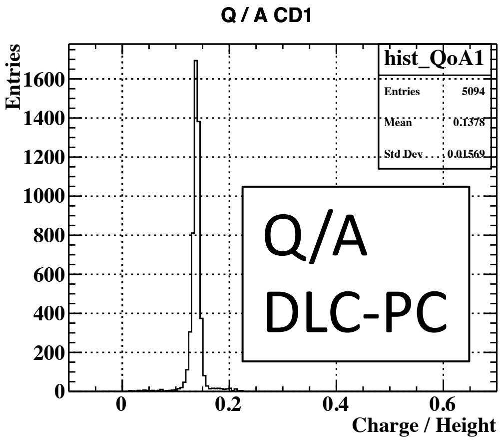
- DLC photocathode signals seem to be the easiest to handle
  - No big variation in pulse width (FWHM)
  - Sharp Q/A distribution
  - This should suggest that the effect of PFB is not big
  - And also it has the best result so far

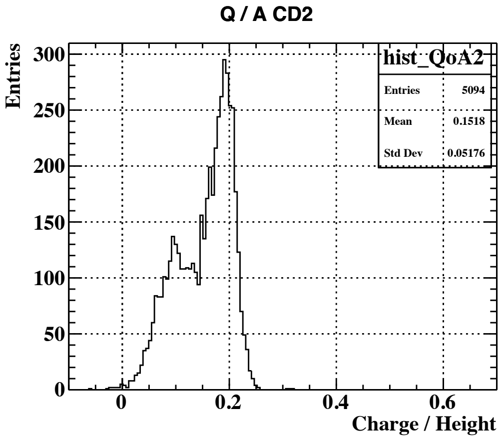
Run 5408 (HV 2800 V, R134a:C4H10=1:1), event 6











Let’s begin with one of the most promising data

- Run 5408 (almost at the end of the beamtest: after quit a lot of irradiation), 5100 events

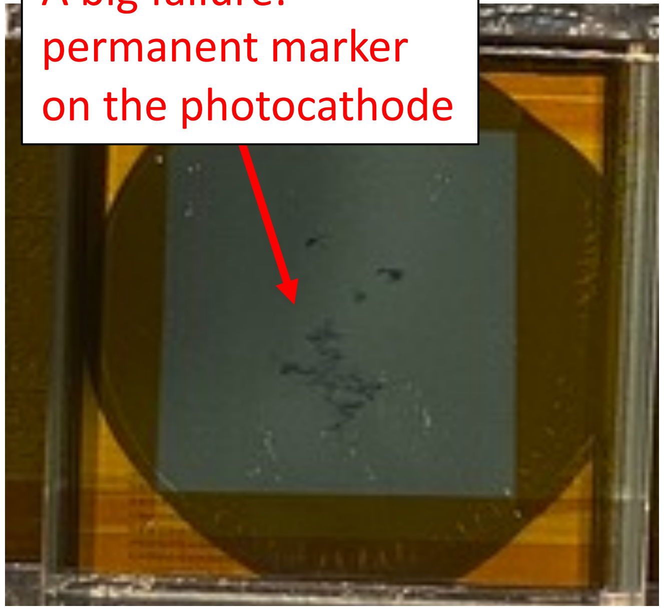
[photocathode] DLC 3 nm-t

[radiator] MgF2 10 mm-t

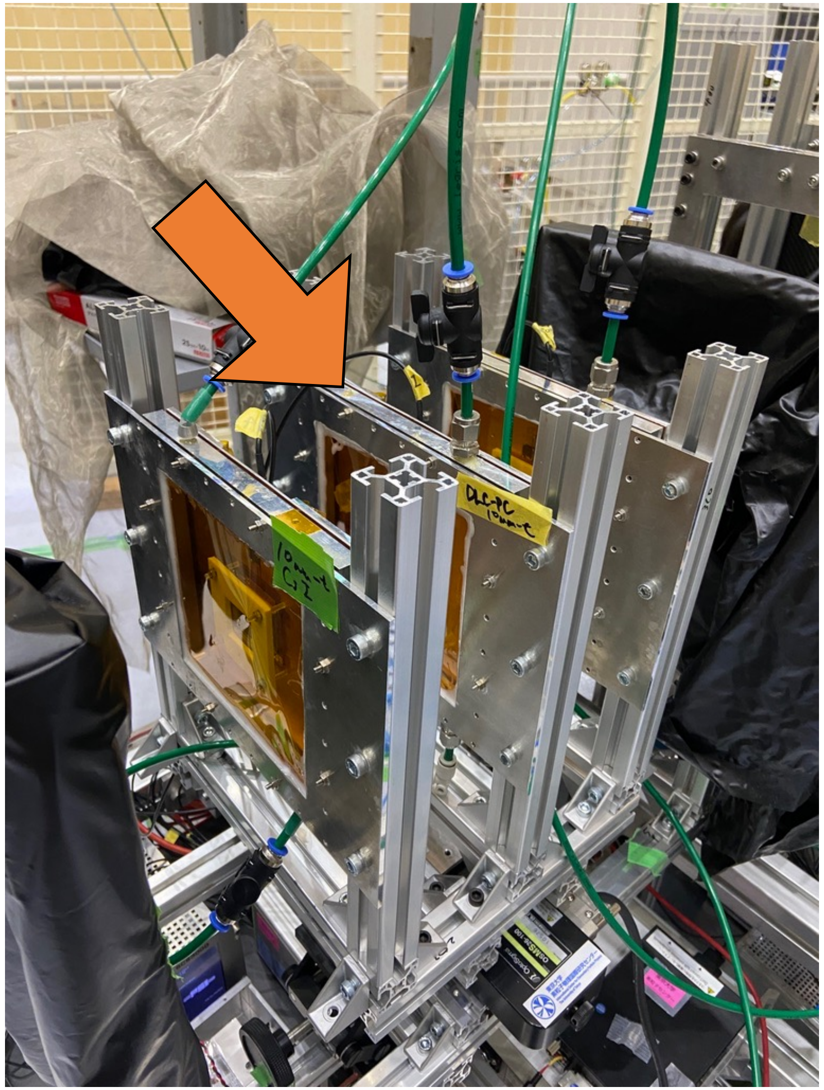
[HV] 2800 V (applied on photocathode)

[Gas mixture] R134a : SF6 : C4H10 = 1 : 0 : 1 (40 mL/min in total)

[Beam rate] Low (trigger rate: 2-3 Hz)

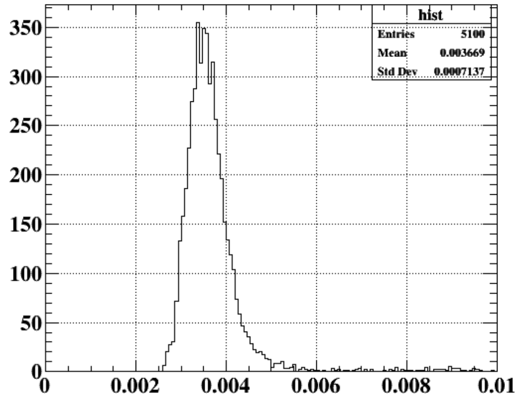


A big failure: permanent marker on the photocathode



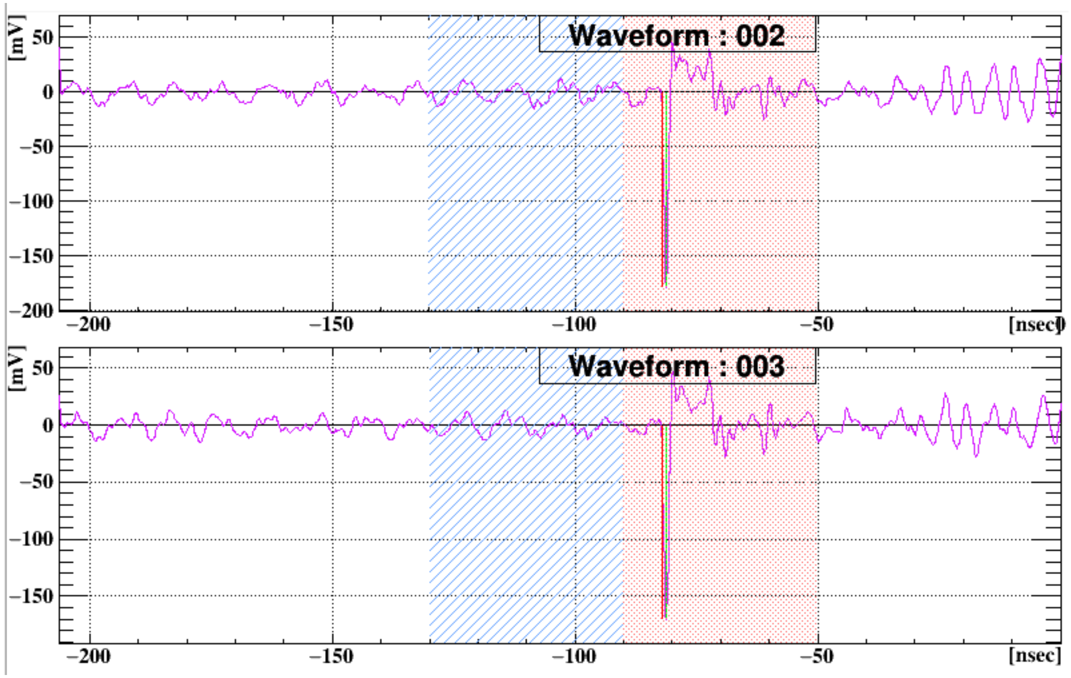
Clock noise subtraction

Noise RMS after subtraction
@baseline region
~ 3.5 mV

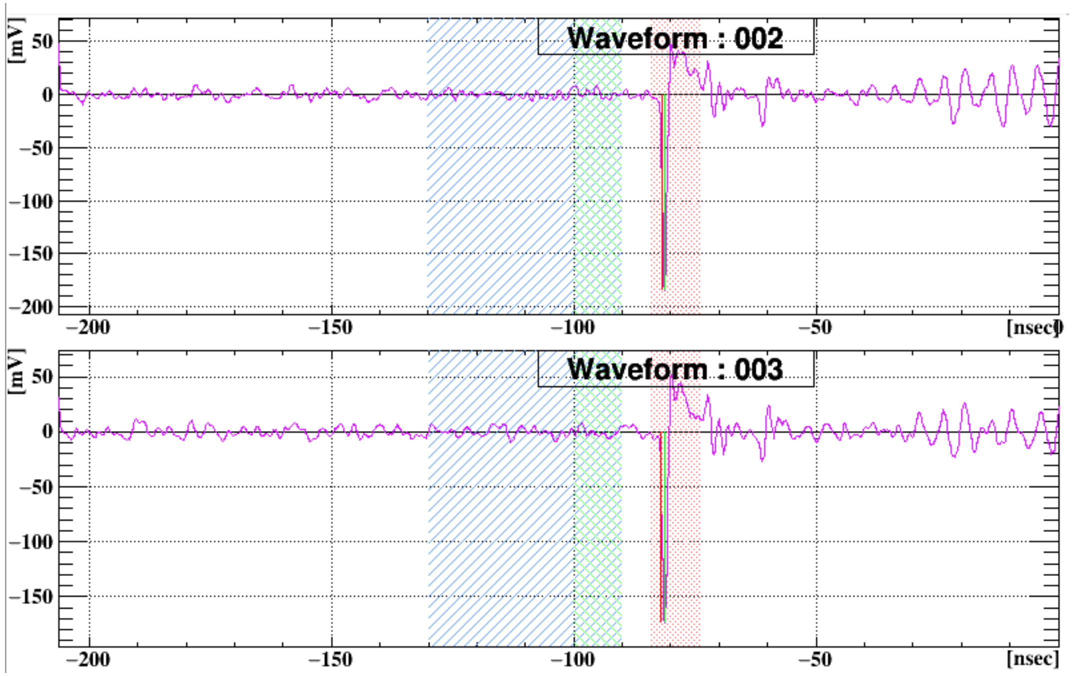


- Process the raw waveform by LP-filter (11 point moving average)
- Fit "baseline region" by sine wave $a \cdot \sin(2\pi f(x - x_0)) + b$
  - Frequency fixed to the clock
  - Fit phase (x_0), amplitude (a), and baseline (b)
- Subtract the fitted function from raw waveform

Before



After

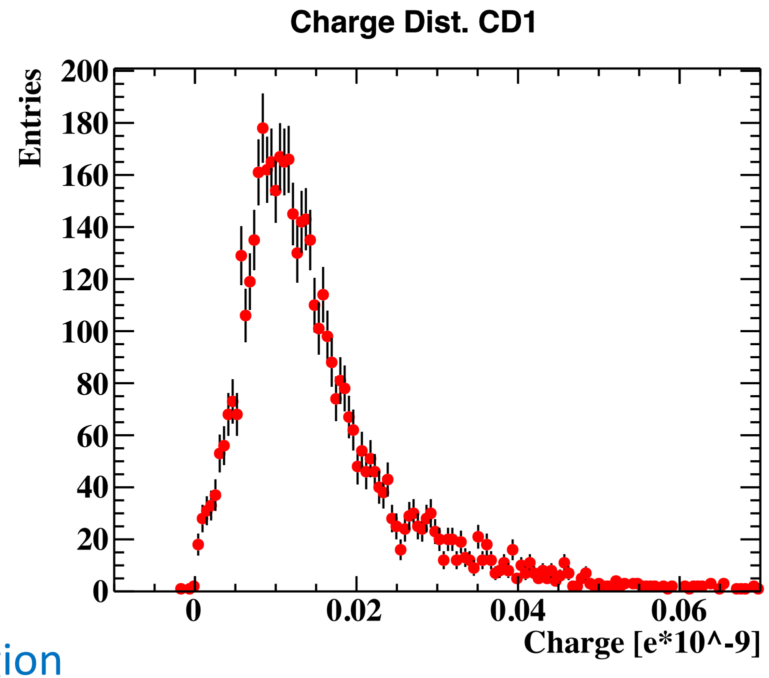


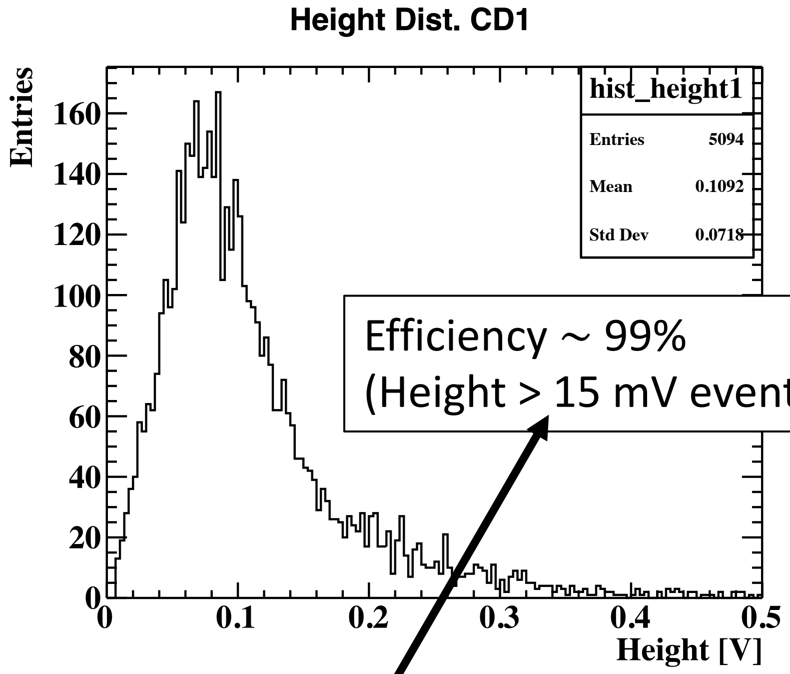
Can it be even better by subtracting another empty channel?

⇨ No (just by a naive subtraction)

- It needs timing arrangement?
- Maybe timing information from the previous clock noise fitting would be useful

Height/Charge





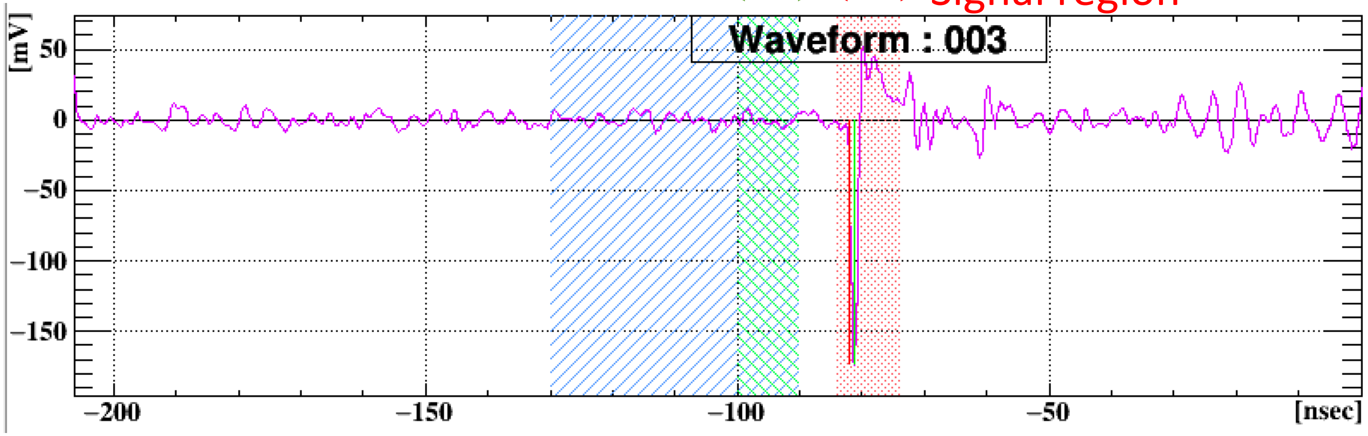
Efficiency ~ 99%
(Height > 15 mV events)

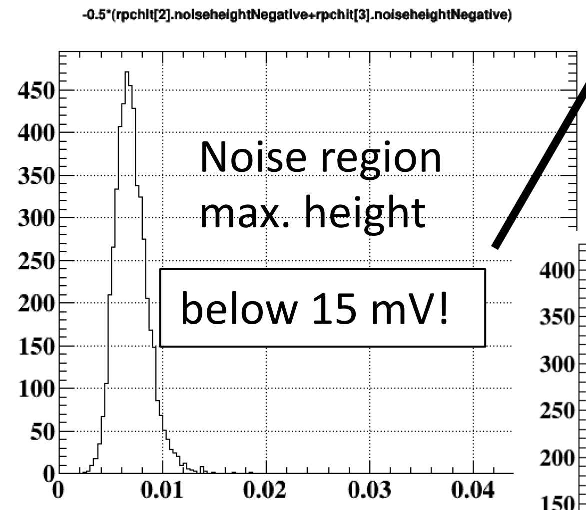
Baseline region

Noise region

Signal region

Clock noise subtracted

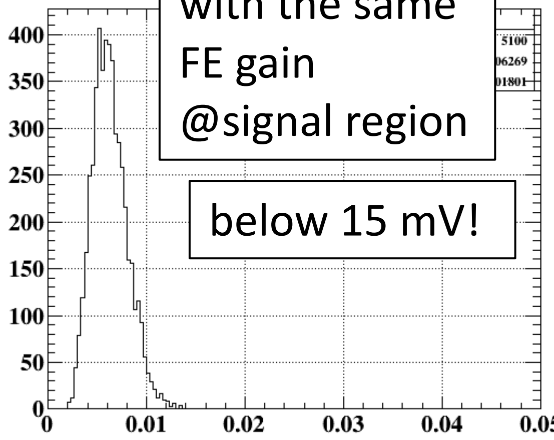




Noise region max. height

below 15 mV!

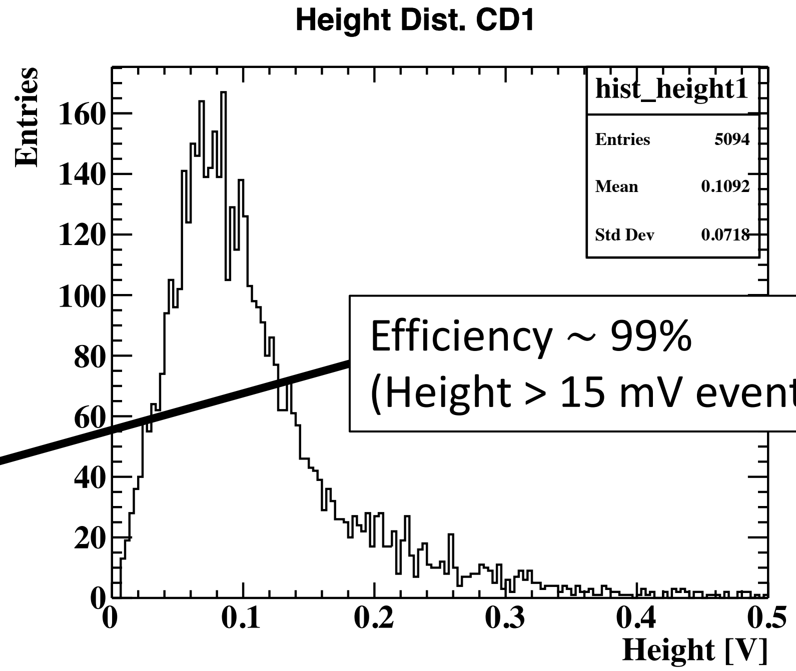
(maybe it’s not fair because clock noise is fitted at baseline region)



Empty channel with the same FE gain @signal region

below 15 mV!

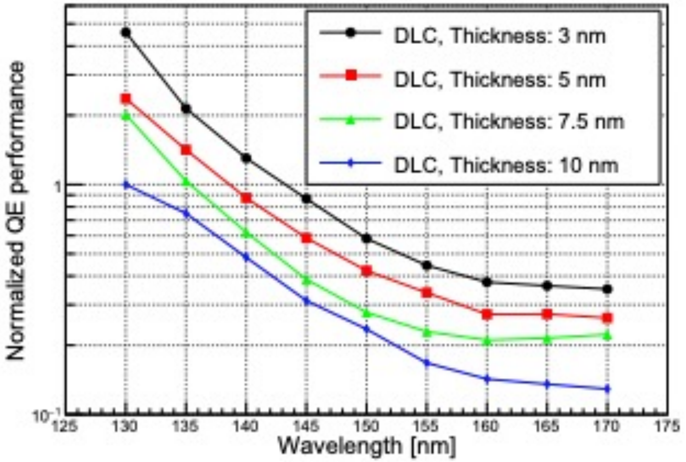
Height/Charge



Efficiency ~ 99%
(Height > 15 mV events)

If it follows Poisson distribution: $P(X = k) = \frac{e^{-\lambda}\lambda^k}{k!}$,

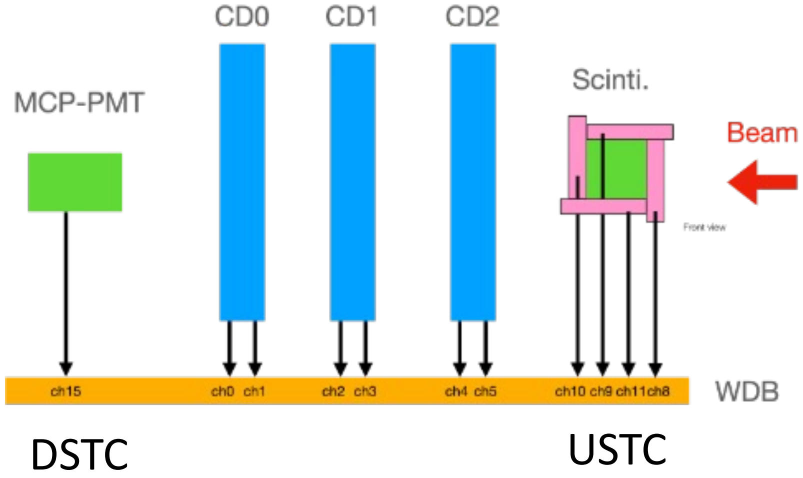
$\lambda = -\log P(X = 0) > 4.6$



By the way, PICOSEC Collab. have already studied the QE of 3 nm DLC
→ Able to calculate the average pe from this result and cross-check

Timing

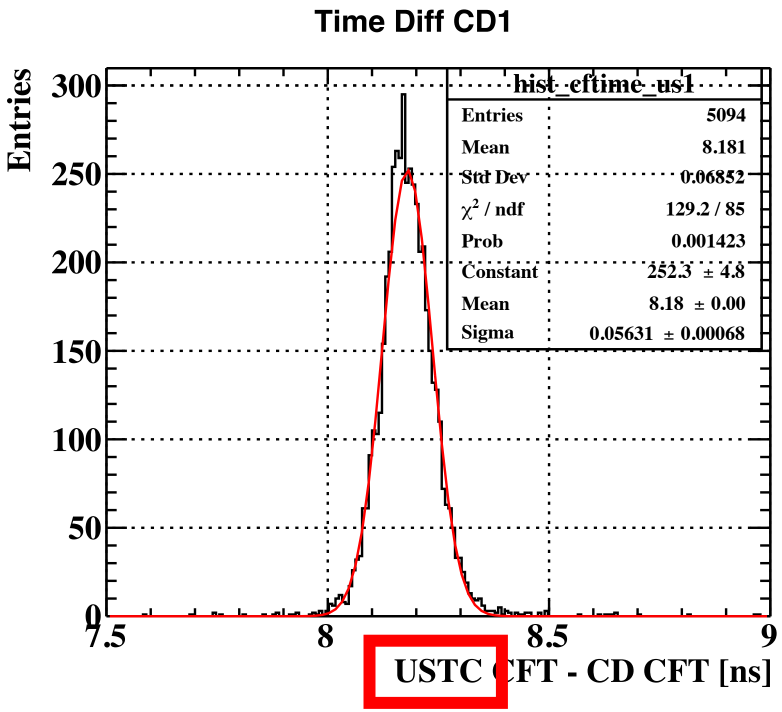
- CD constant fraction @0.4
  - not fully optimized, but should be not bad
  - Almost the same timing w/ differential waveform peak
- USTC only uses ch8 and ch10 (because ch9 is somehow dead)
- CD: average of two channels, USTC: average of ch8 and ch10

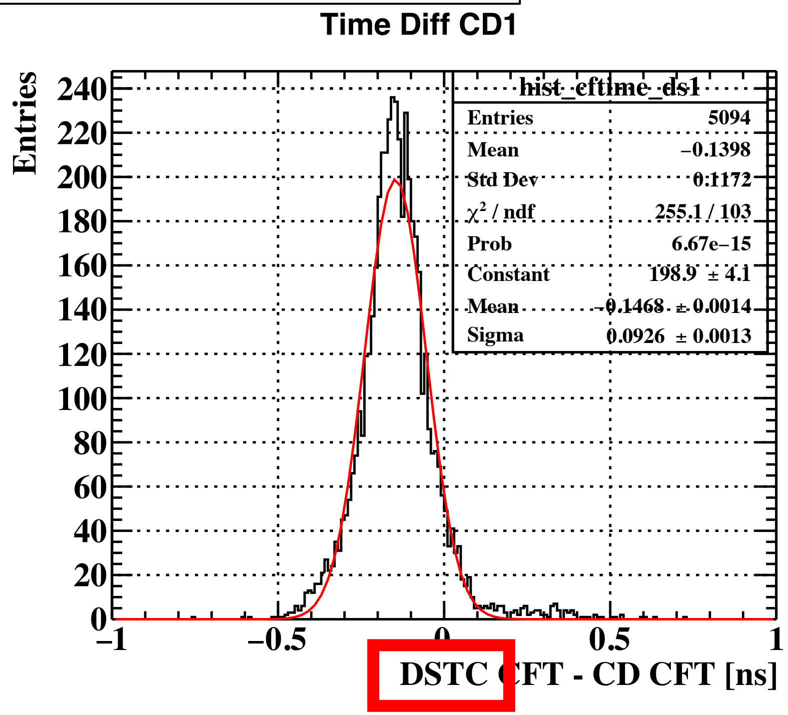


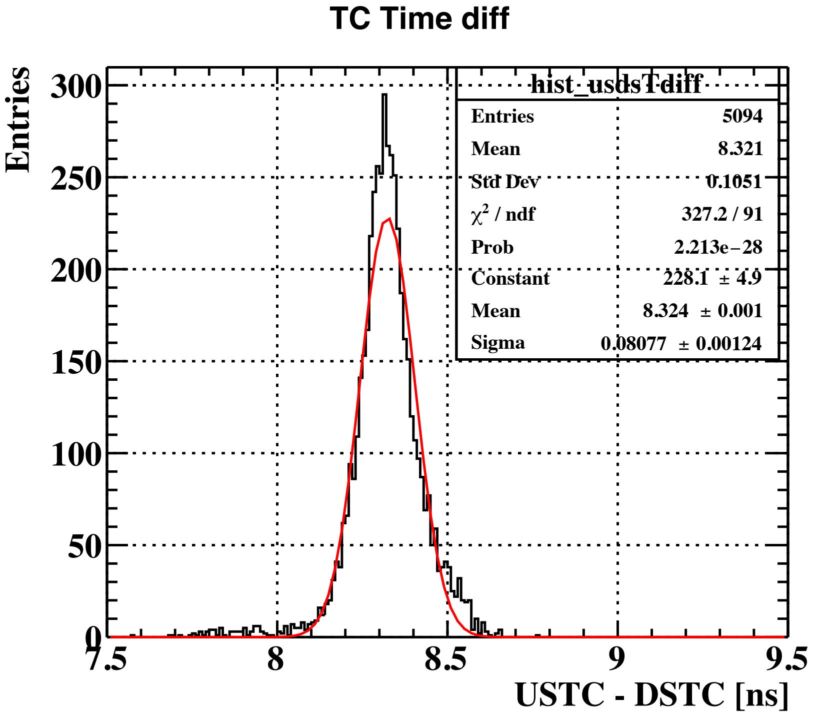
- $\sigma(US - CD) = 56.3 \pm 0.7$ ps
- $\sigma(DS - CD) = 92.6 \pm 1.3$ ps
- $\sigma(US - DS) = 80.8 \pm 1.2$ ps

⇒

- $\sigma(CD) = 51.1 \pm 1.6$ ps
- $\sigma(US) = 23.7 \pm 3.4$ ps
- $\sigma(DS) = 77.2 \pm 1.0$ ps







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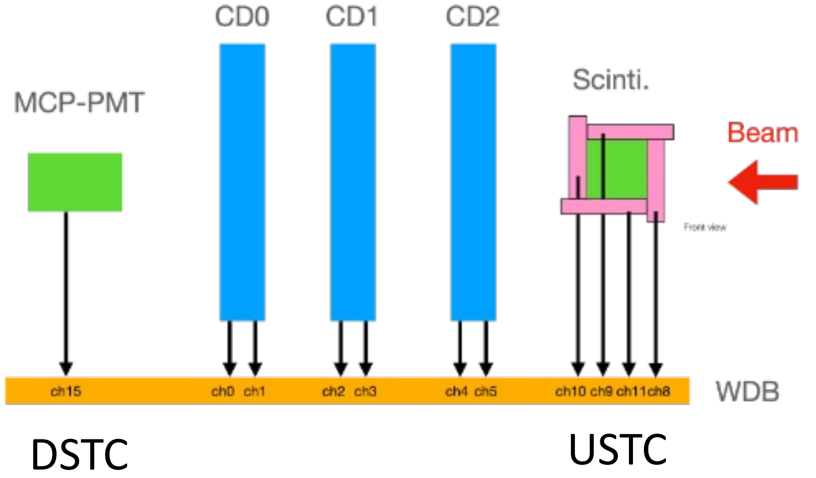

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⇨

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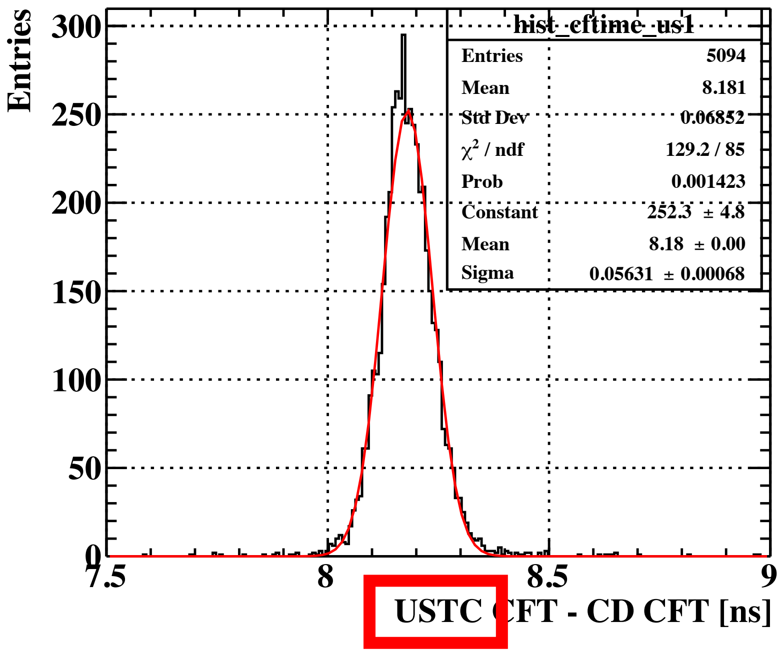
- $\sigma(US) = 23.7 \pm 3.4$ ps
- $\sigma(DS) = 77.2 \pm 1.0$ ps

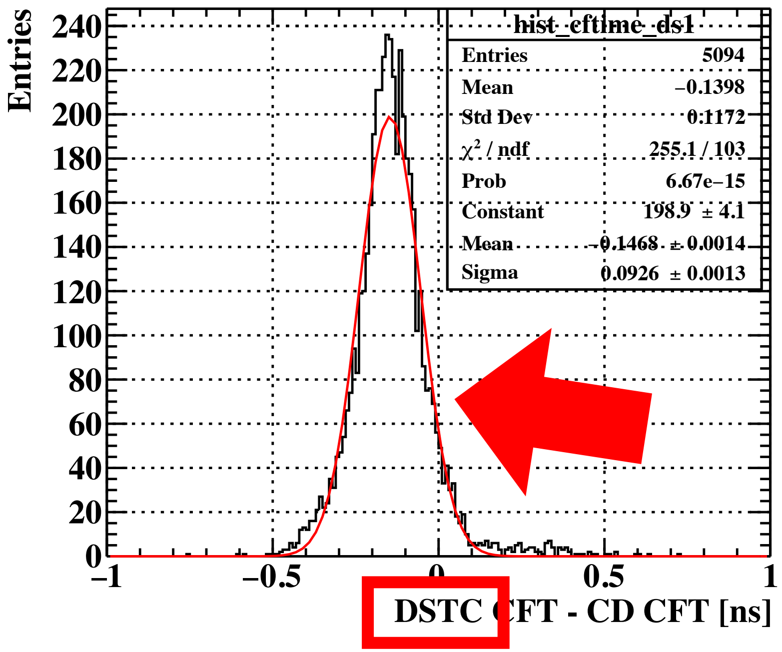
???

Seems to be good for using only two channels

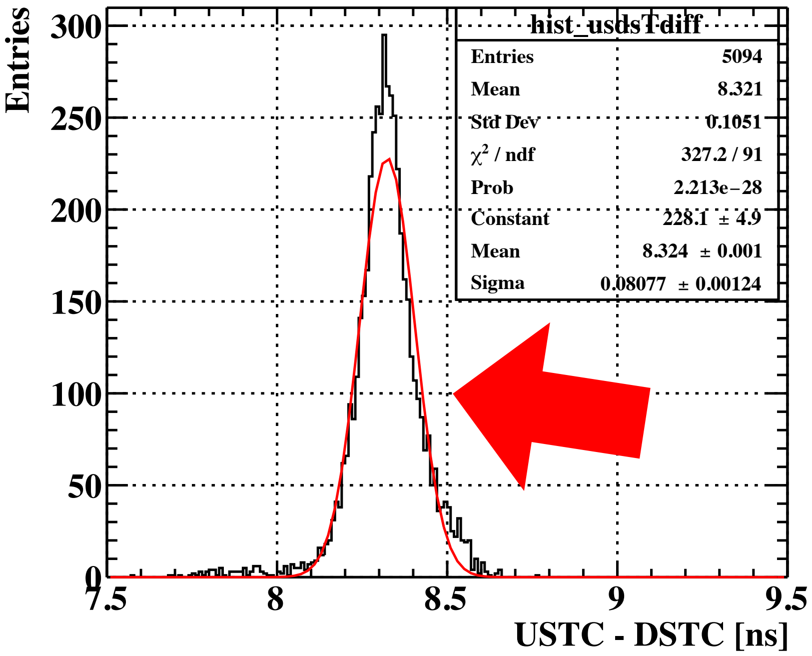
Time Diff CD1

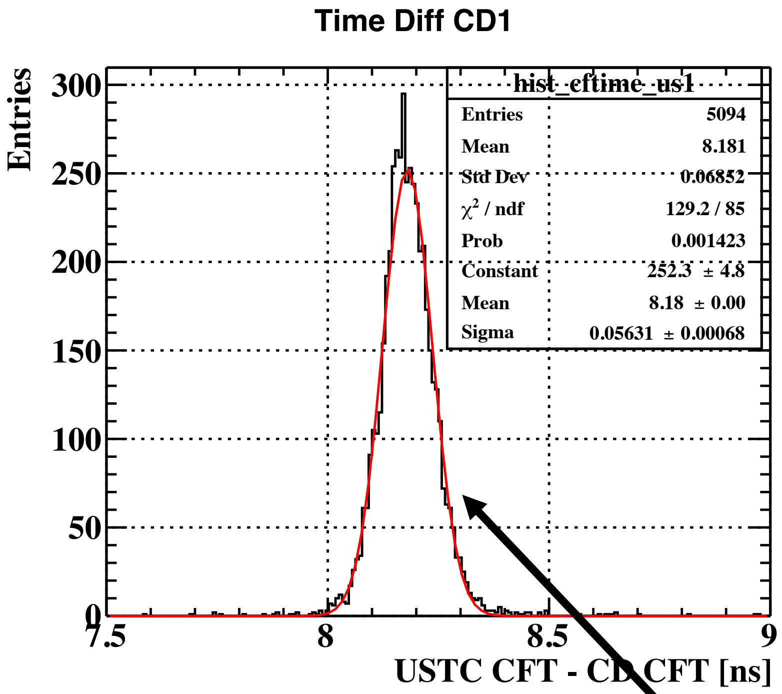


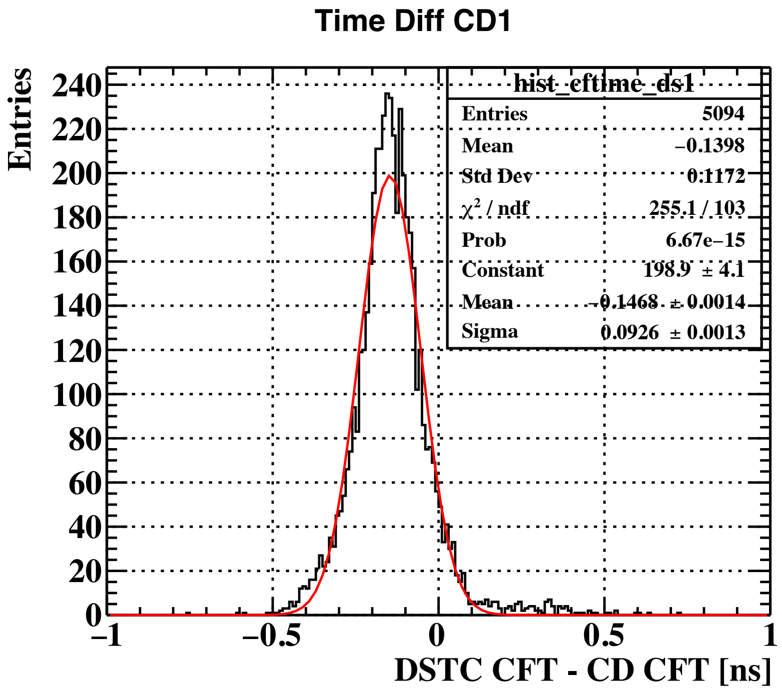
Time Diff CD1

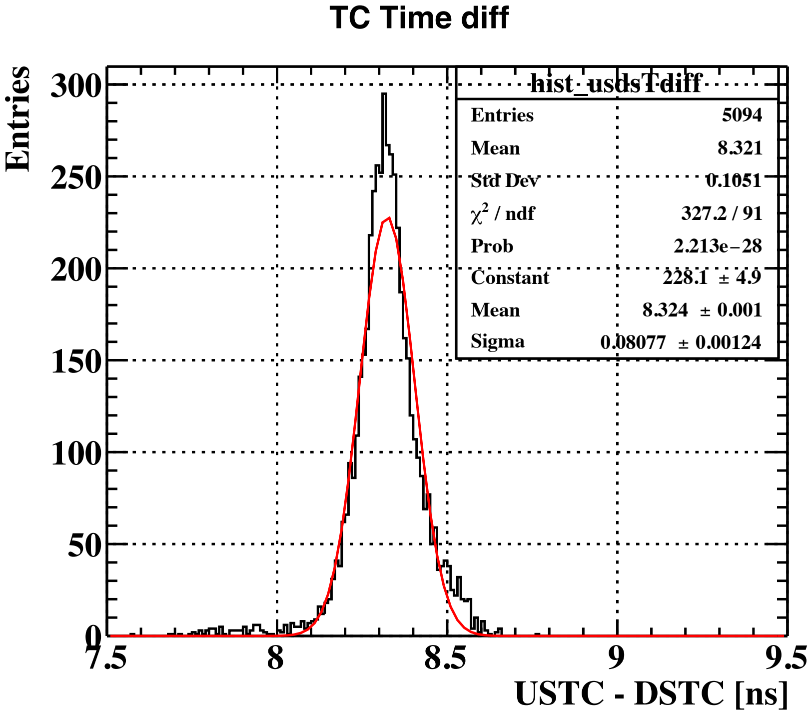


TC Time diff

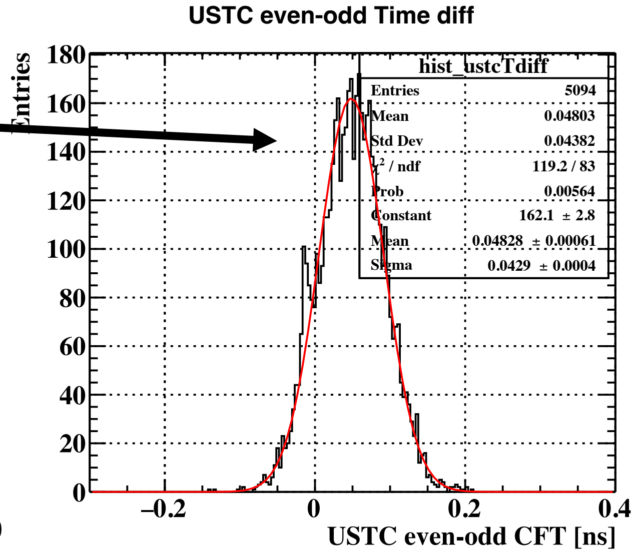








- USTC – CD has a clean gaussian shape
- Histograms relevant to MCP do not fit very well
- If we use even-odd method by USTC itself, USTC time resolution can be estimated to be $\sigma\left(\frac{ch8+ch10}{2}\right) \sim \sigma\left(\frac{ch8-ch10}{2}\right) = 42.9 \pm 0.4$ ps
- In reality, even-odd method yields better results = underestimate the real resolution
- But it do not overestimate the time resolution of CDs

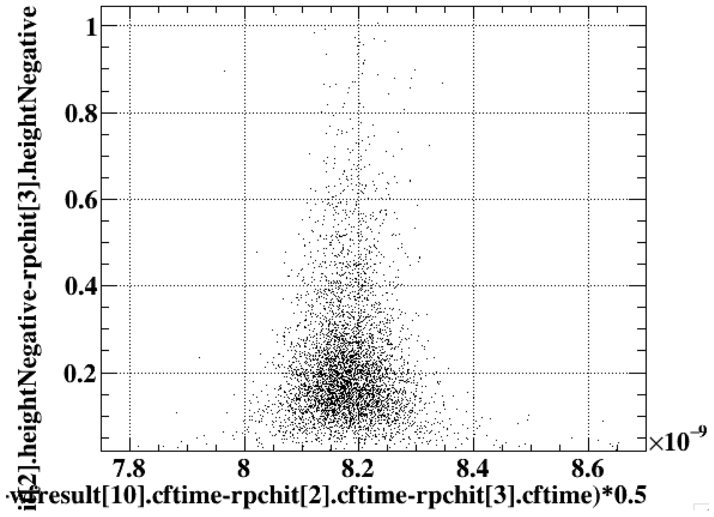


Something wrong with MCP??

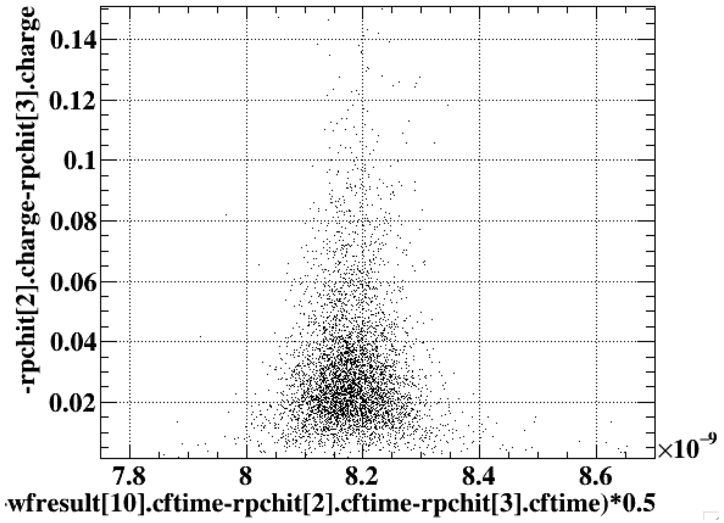
$\sigma(US - CD) = 56.3 \pm 0.7$ ps
$\rightarrow \sigma(CD) < 36.5$ ps
To me, this is more trustworthy
Now, the USTC has worse resolution
$\rightarrow$ maybe adding one more active channel would help

Check if any correlation b/w other parameters

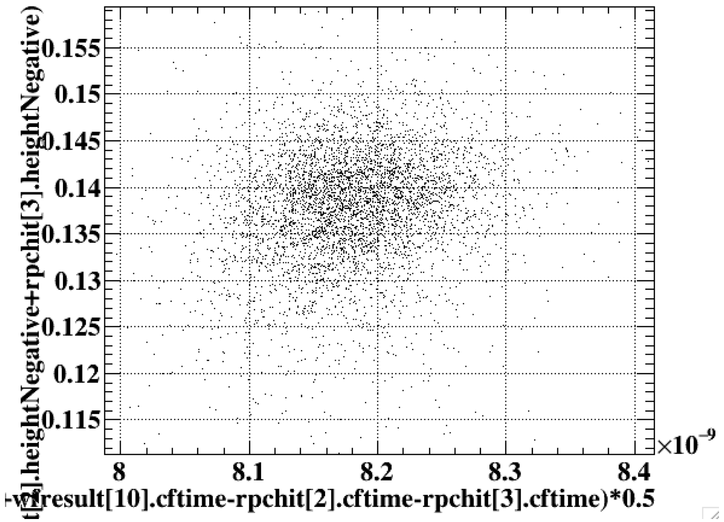
Height vs Tdiff



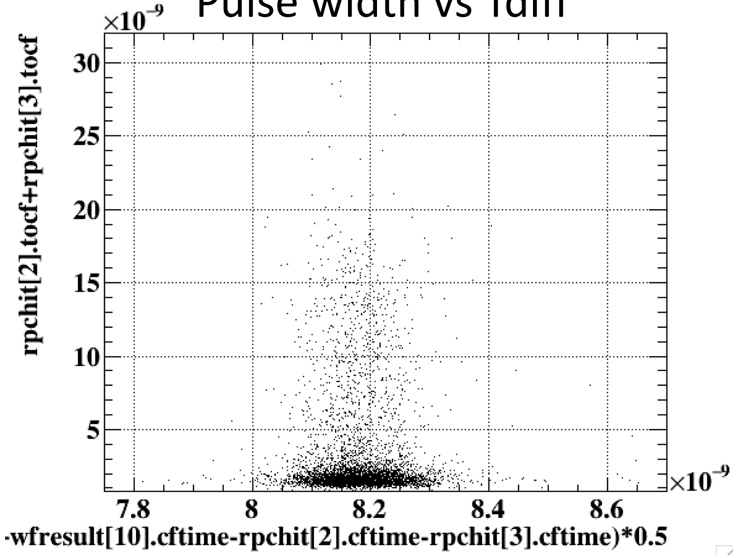
Charge vs Tdiff



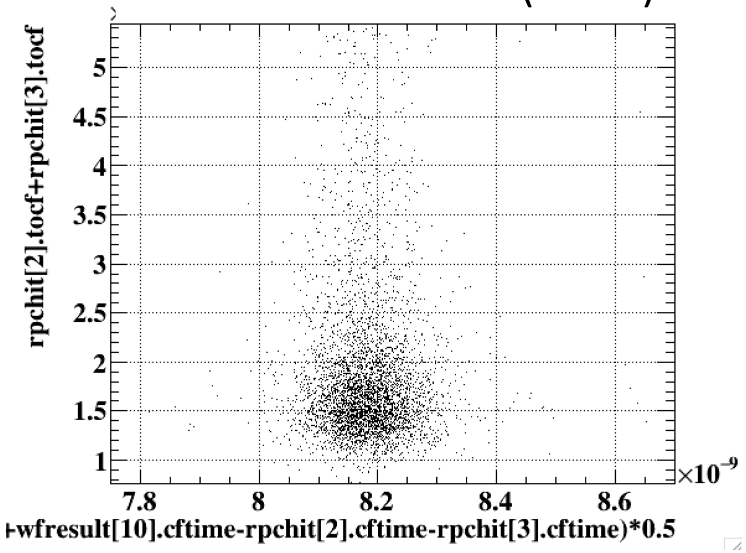
Q/A vs Tdiff



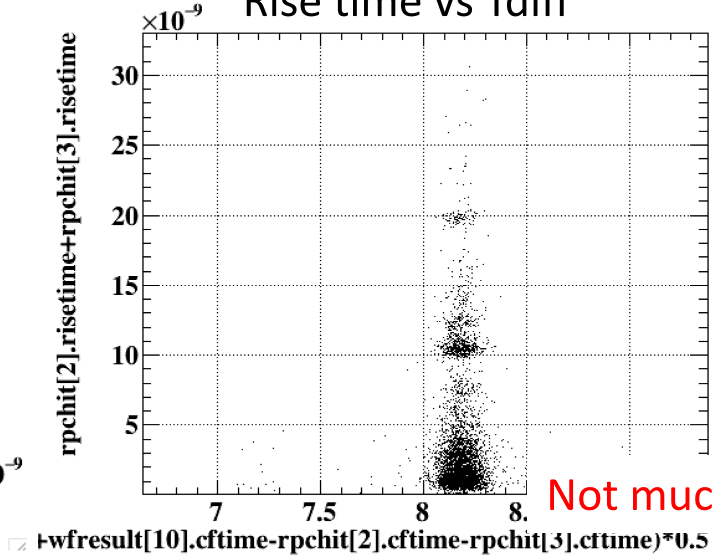
Pulse width vs Tdiff



Pulse width vs Tdiff (zoom)



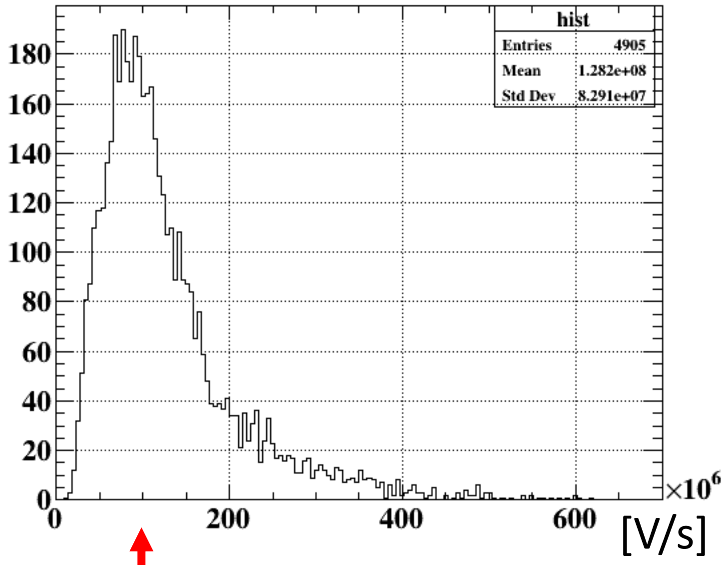
Rise time vs Tdiff



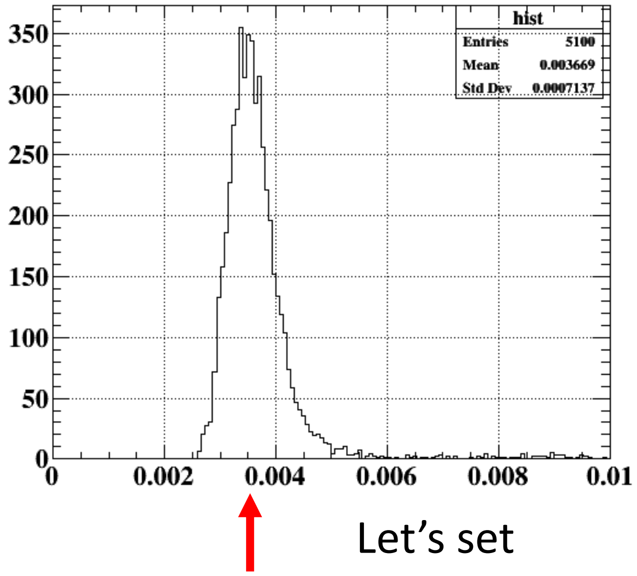
Not much can do…

How much does noise jitter effect?

Peak value of ch2 differential waveform



Noise RMS after subtraction
@baseline region
~ 3.5 mV



$$\sigma_t^2 = \left(\frac{\sigma_S}{(dS/dt)_{\text{trig}}}\right)^2 + \left(\frac{\sigma_n}{(dS/dt)_{\text{trig}}}\right)^2 + \sigma_{\text{arrial}}^2 + \sigma_{\text{dist}}^2 + \sigma_{\text{digit}}^2$$

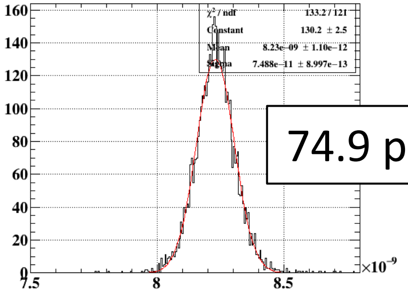
Let's set
$\sigma_n \sim 3.5\times10^{-3}$ V, and
$(dS/dt)_{\text{trig}} \sim 1\times10^{8}$ V/s
→ second term ~ 35 ps
Pretty dominant!!!
It might suggest that it will be important to make a low noise readout…

Consistency check

Calculated by single channel
CD (36.5) subtracted

xxx ps

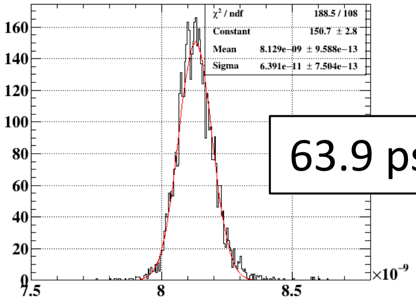
ch8 - CD



65.4

74.9 ps

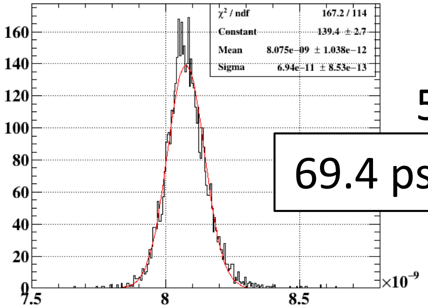
ch10 - CD



52.4

63.9 ps

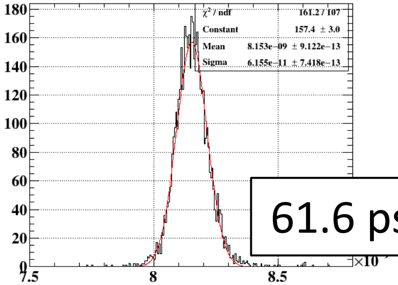
ch11 - CD



59.0

69.4 ps

(ch8+ch11)/2 - CD

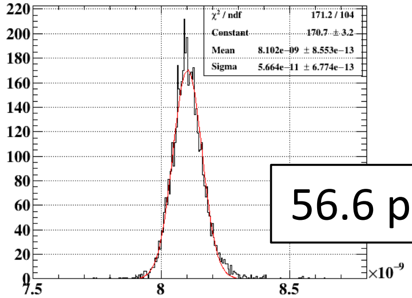


44.0

49.6

61.6 ps

(ch10+ch11)/2 - CD

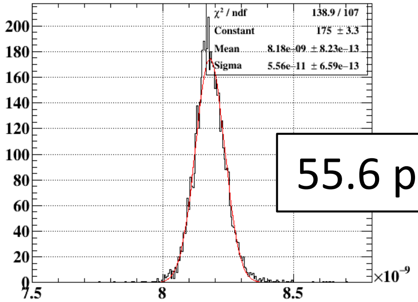


39.5

43.3

56.6 ps

(ch8+ch10)/2 - CD

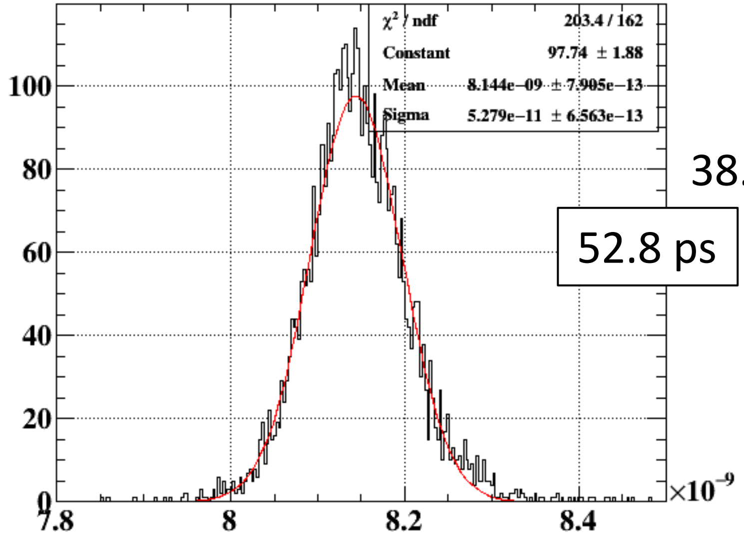


41.9

41.9

55.6 ps

(ch8+ch10+ch11)/3 - CD

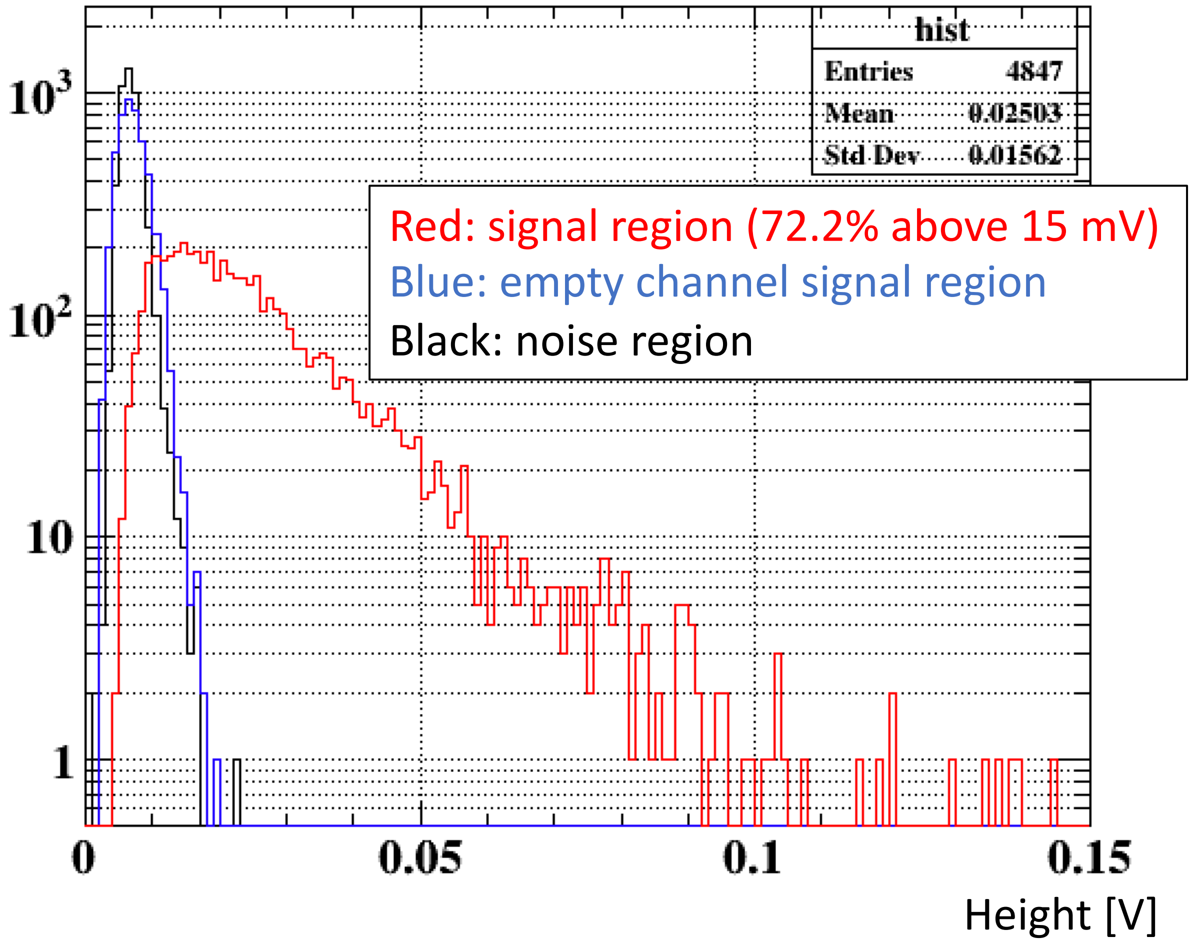


34.2

38.2

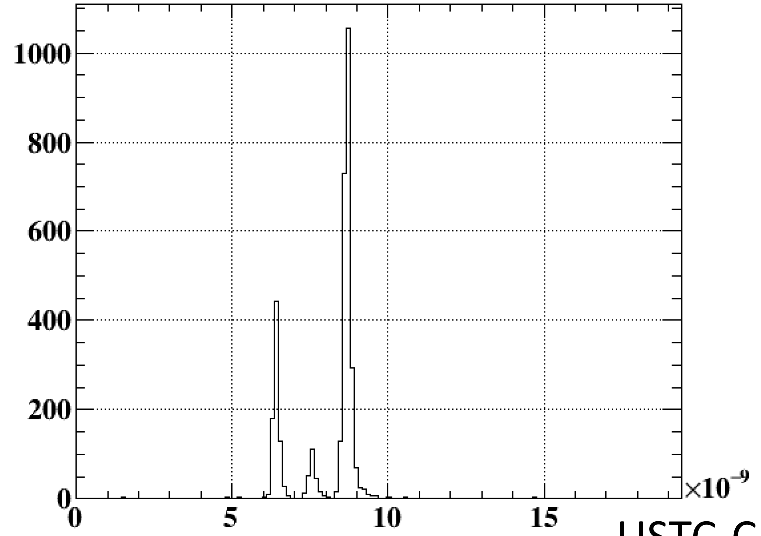
52.8 ps

DLC-PC, MgF2-2.4mm-t

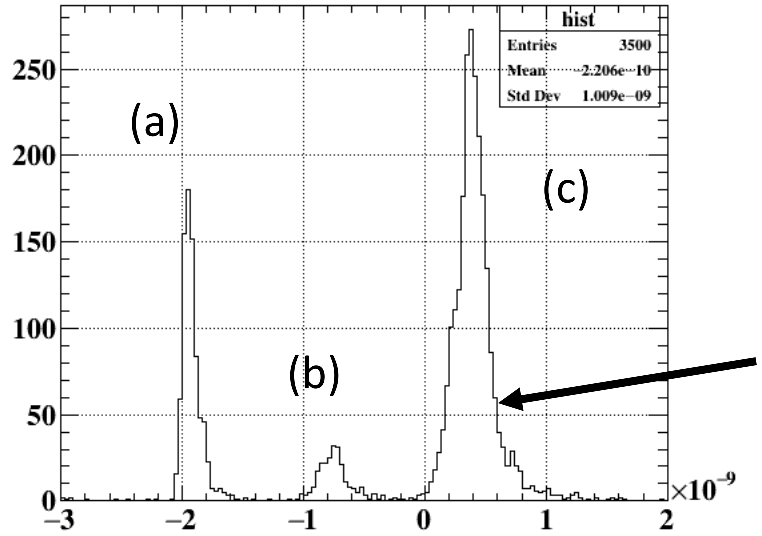


*Note that it has been mistakenly filpped

DLC-PC, MgF2-2.4mm-t

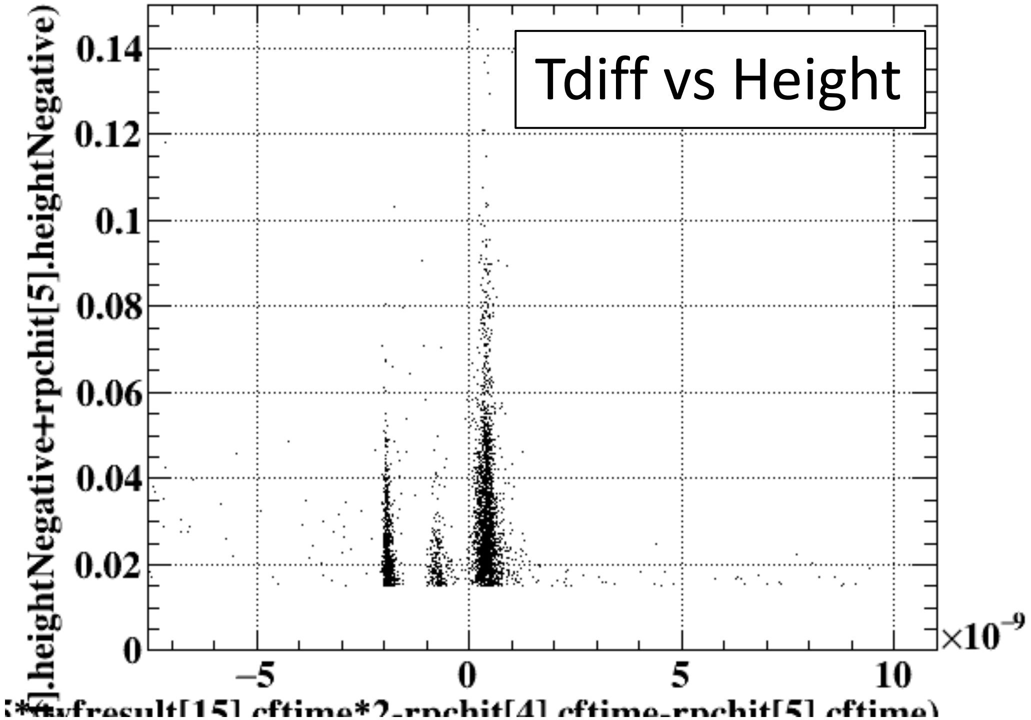


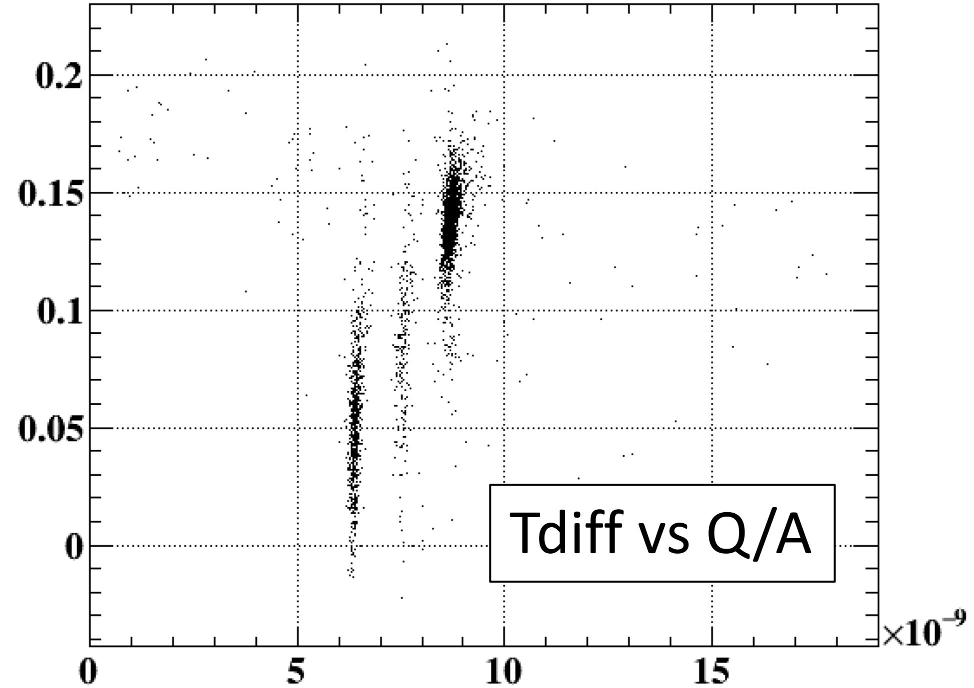
USTC-CD (Tdiff)



By timing, (c) should be the true pulse (2413 events, 49.9%)

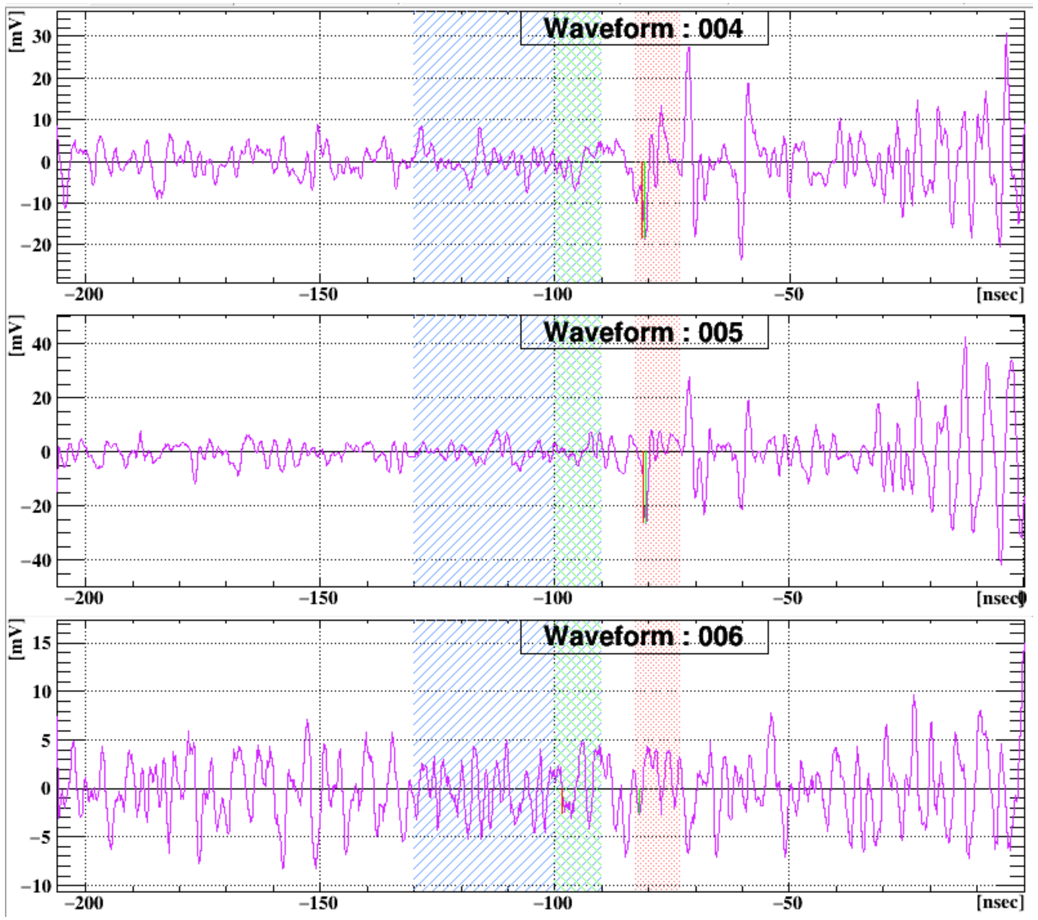
DSTC-CD

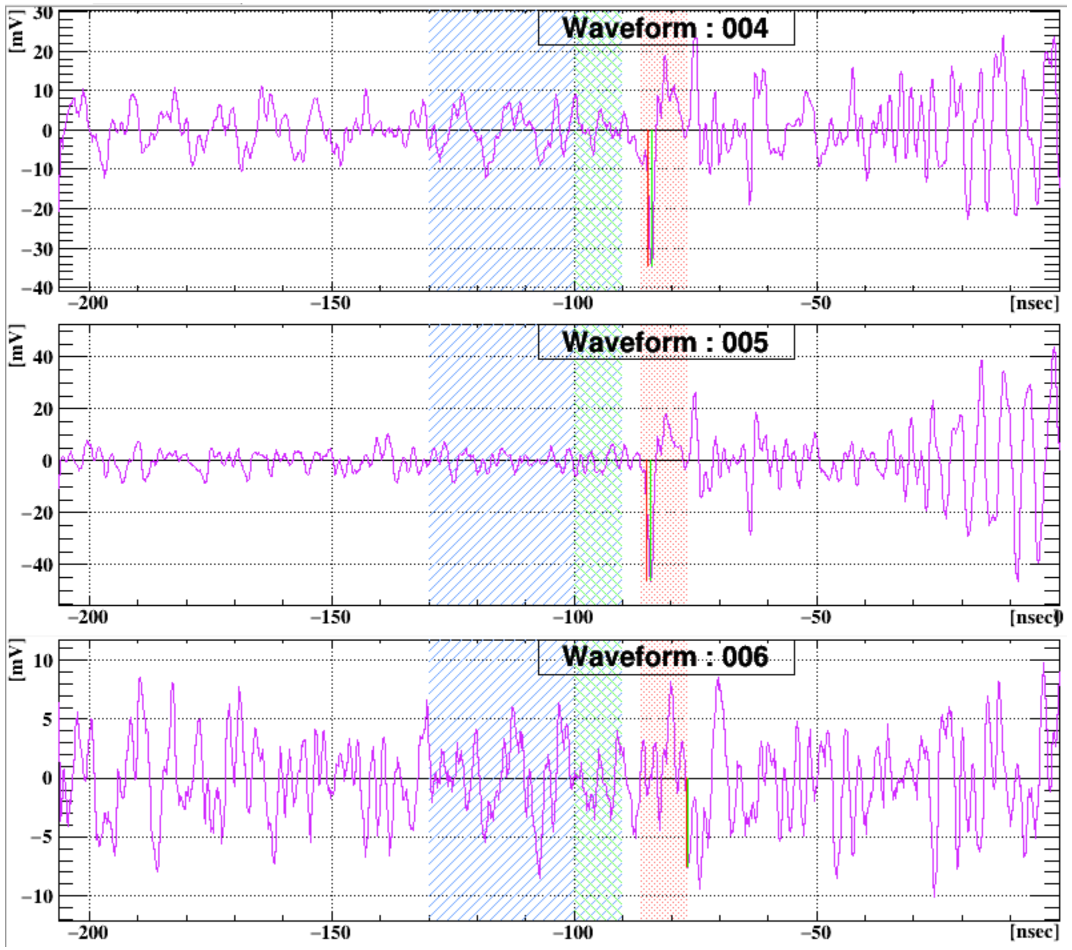




(c)

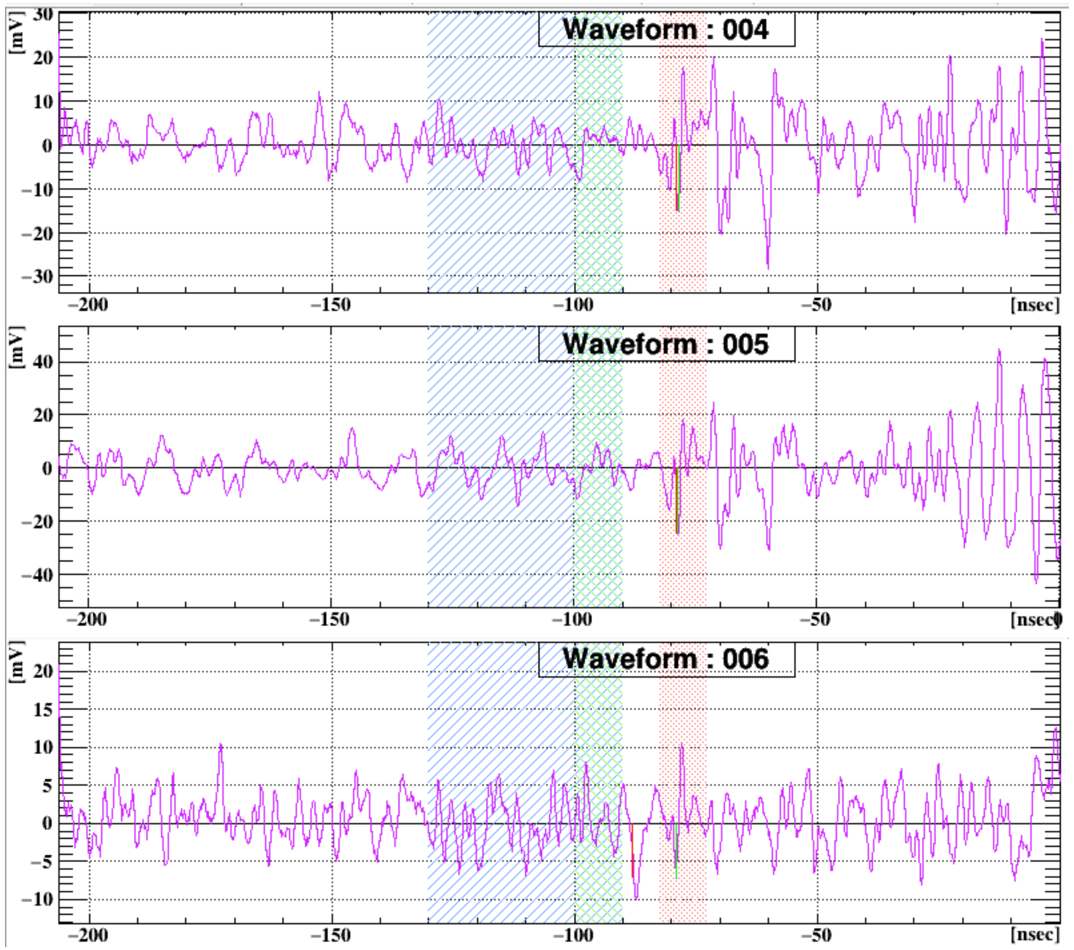
Run5410, event17



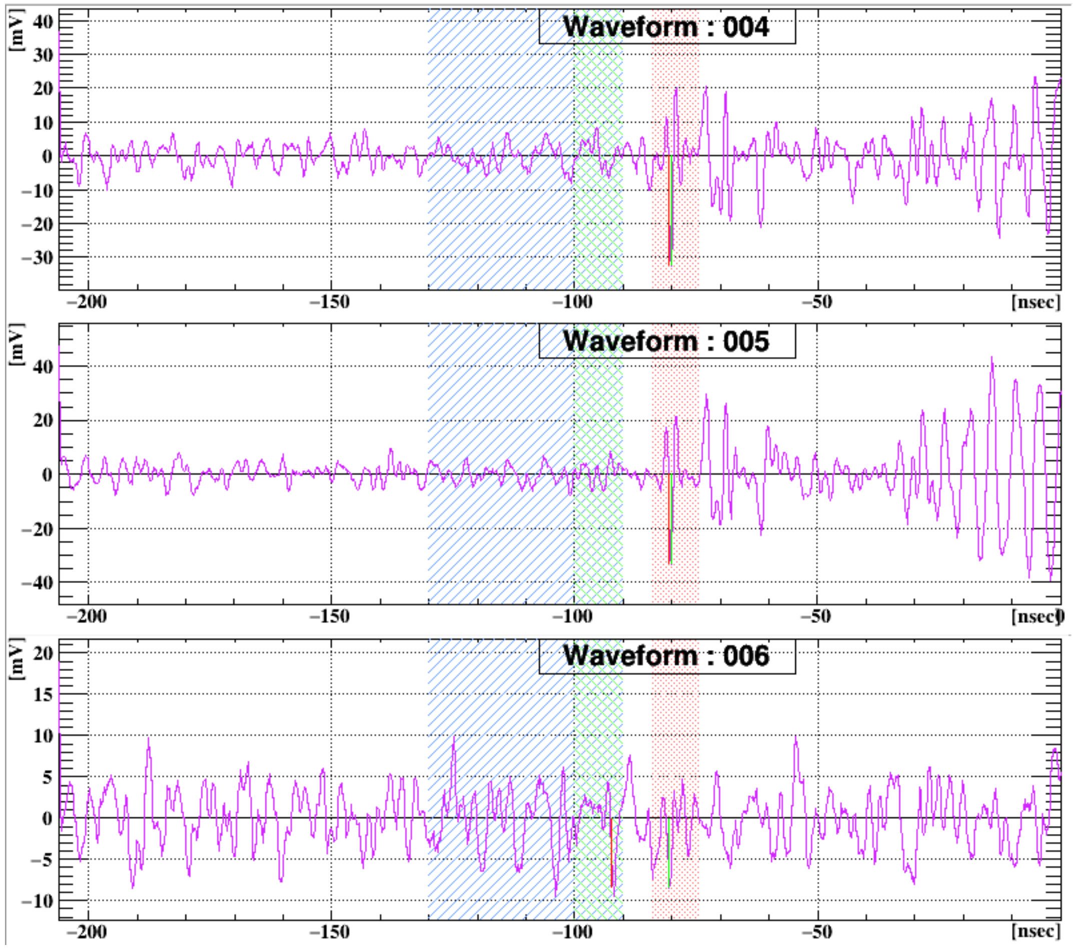


(a)

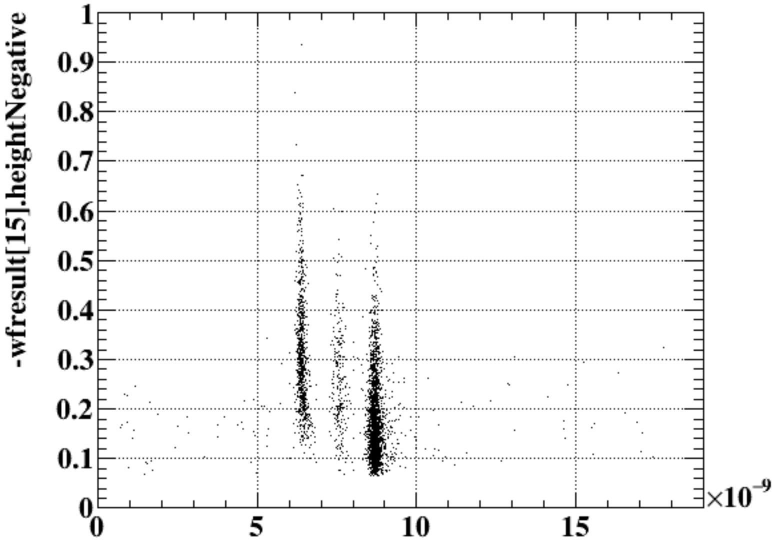
Run5410 event18



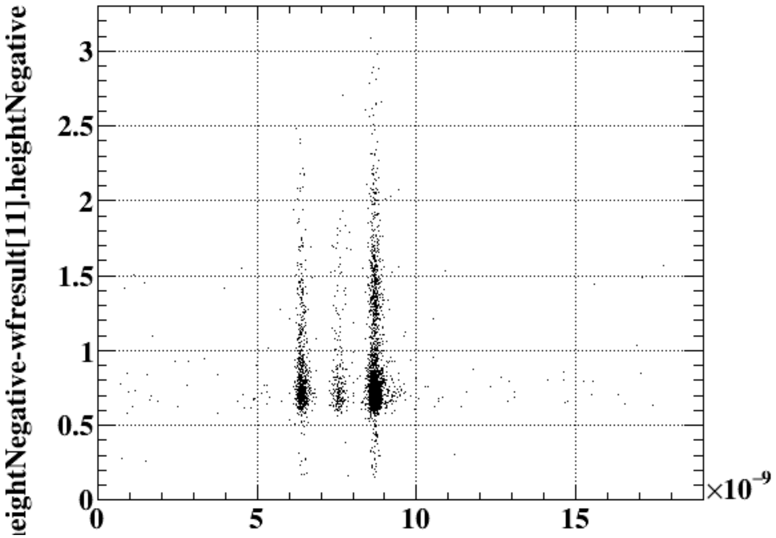
Run5410, event22



MCP

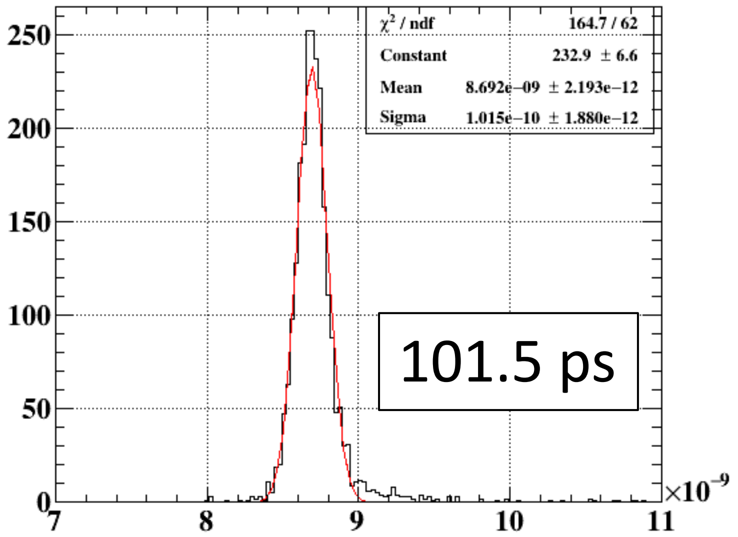

-wfresult[15].heightNegative
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
×10^{-9}

MPPCs

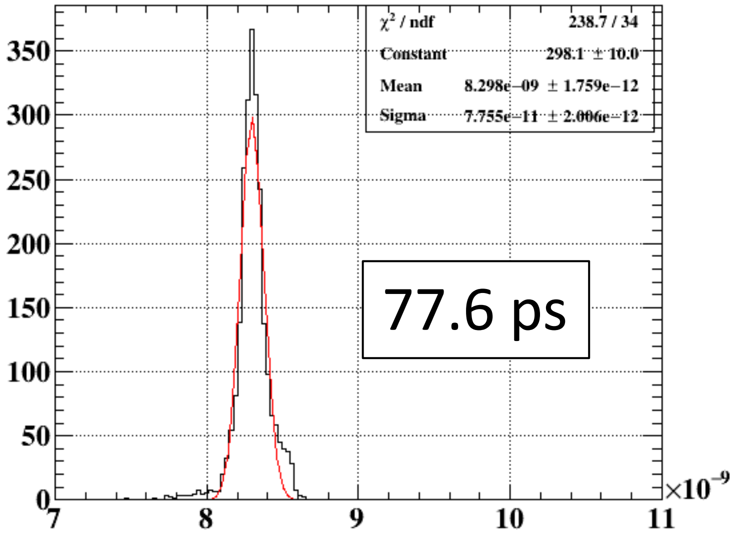

eightNegative-wfresult[11].heightNegative
3
2.5
2
1.5
1
0.5
0
0
5
10
15
×10^{-9}

DLC-PC, MgF2-2.4mm-t timing

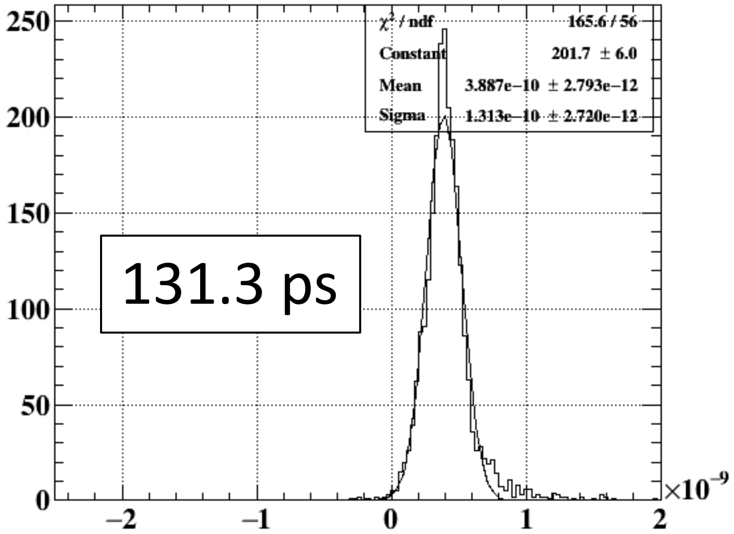
USTC - CD



USTC - DSTC



DSTC - CD

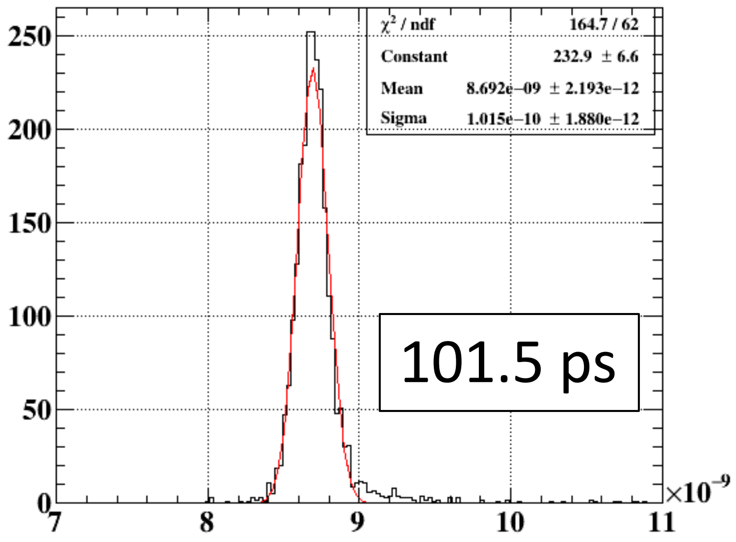


Not even able to calculate it!

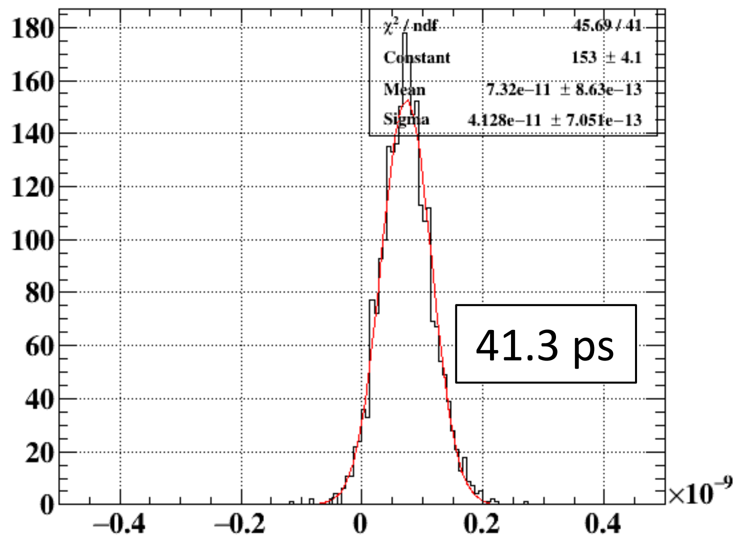
```
sig(DSTC) = 80.49596263167489+-2.685746584017667
sig(USTC) = nan+-nan
sig(DSTC) = 103.73085365502398+-2.084160585279863
```

How about only using USTC?

USTC - CD



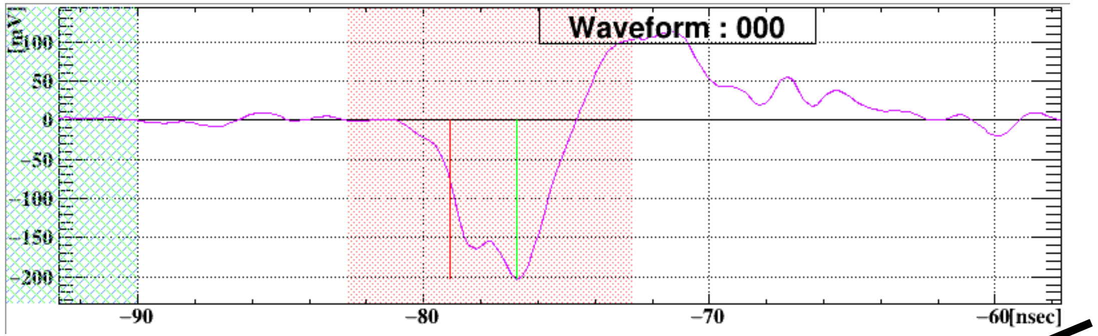
USTC even-odd



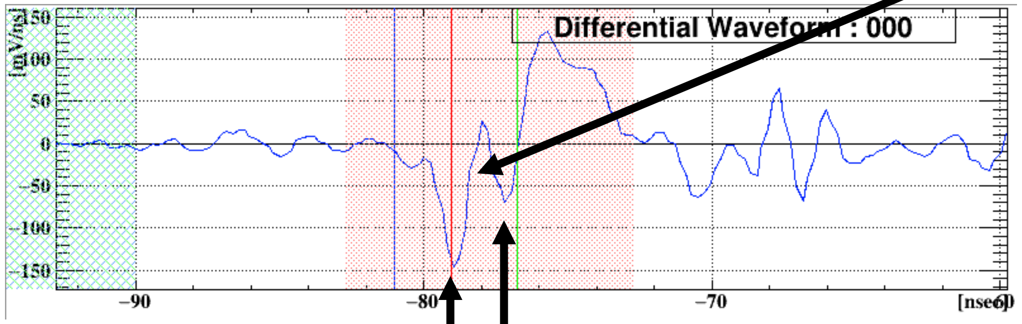
92.7 ps for CD

Strategy for CsI photocathode signal analysis

Original waveform (Clock noise subtracted)



Differential waveform



signal maximum height

Delayed falling max

Signal falling max

- Pos and Neg Peak search @differential wf from leading-edge time in original wf to end of signal region
- find the signal maximum point and calculate constant fraction time
- It might not work for those wf that doesn't cross baseline in the differential wf
- We might want a wf digitizer that has wide band-width and more sampling rate (such as 10 GSPS <- picosec used a oscilloscope that has this value)

Presentation

- Platform A
  - 12/26-27 imminent!
  - Diff. b/w last time will be too much?
    → mainly show the preliminary result?

- JPS
  - Let's slowly but keep on analyzing the beamtest data
  - Summary of the beamtest results