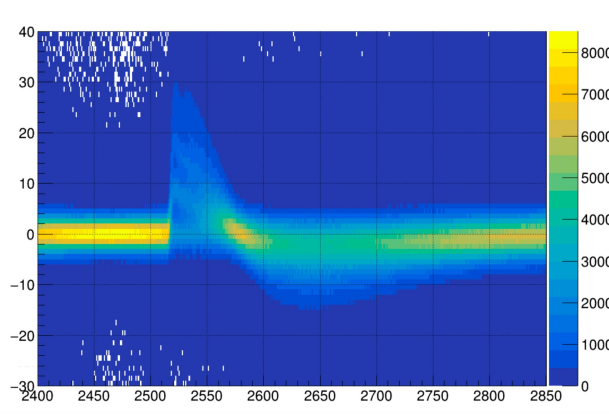


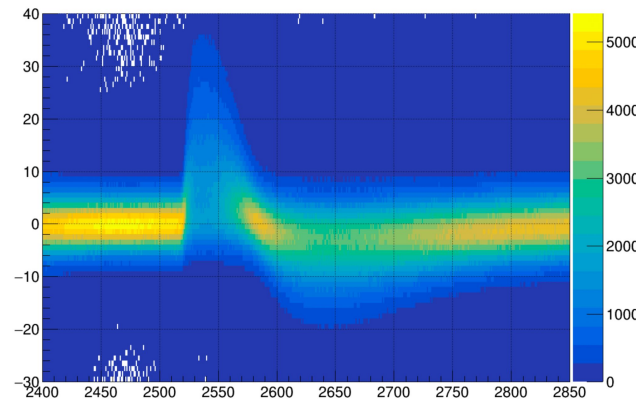
ColdBox membrane detectors

Ajib paudel
March 8, 2024

Optimizing integration window:

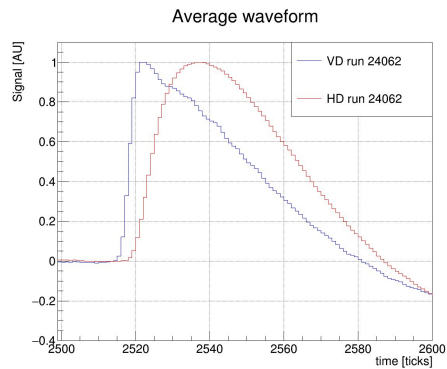


VD 24062 HD



Rising edge starts 2516

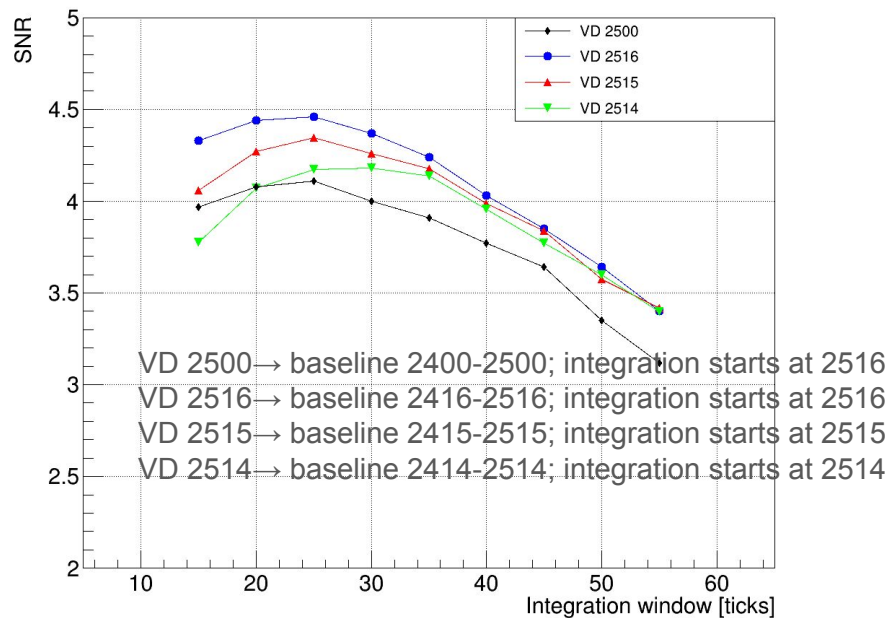
Rising edge starts 2520



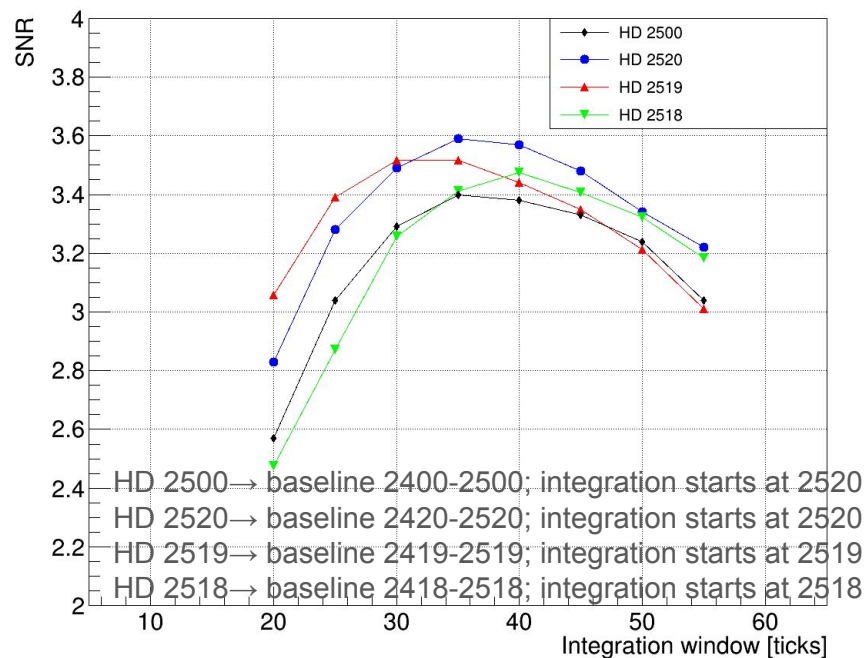
Integration is started from the rising edge (2516 for VD and 2520 for HD) for different t window:

I tried different integration start point and baseline is calculated using 100 points until integration start point:

SNR vs integration window width

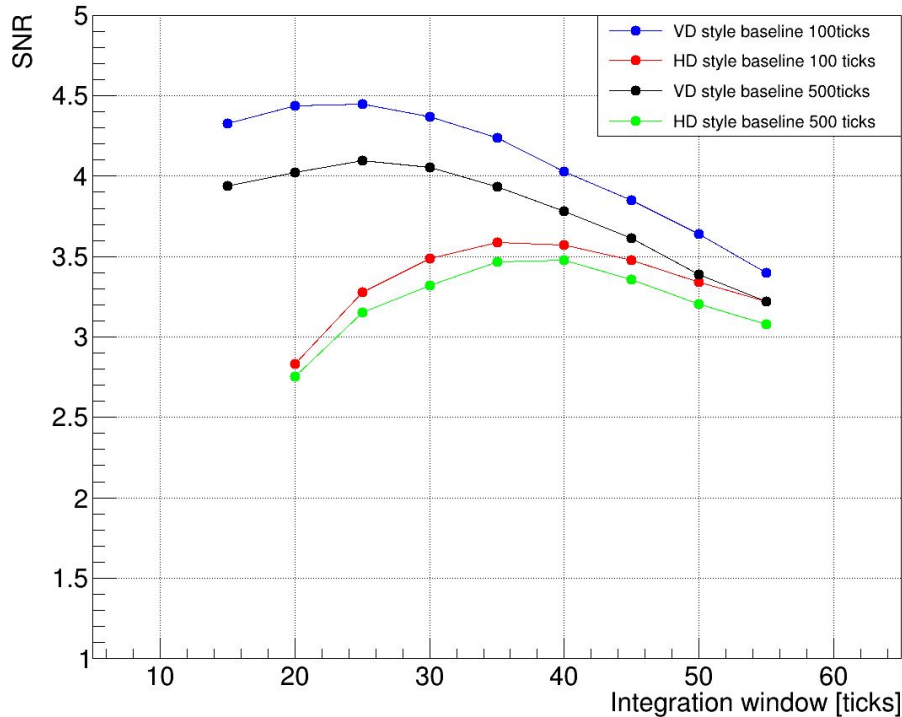


SNR vs integration window width



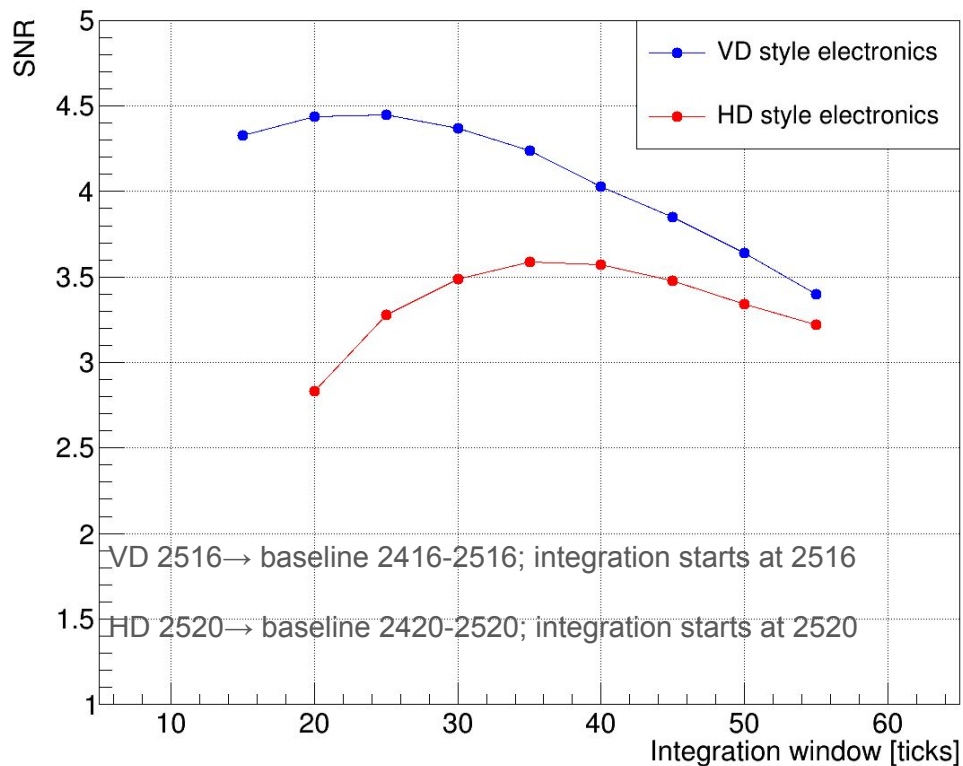
100 ticks (1.6 micro-sec) vs 500 (8 micro-sec) ticks baseline

SNR vs integration window width



Optimal VD and HD SNR:

SNR vs integration window width

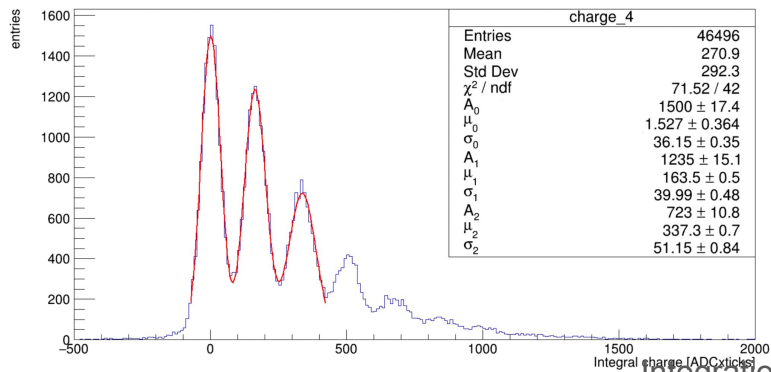


SNR dependence on the fit start (noise)

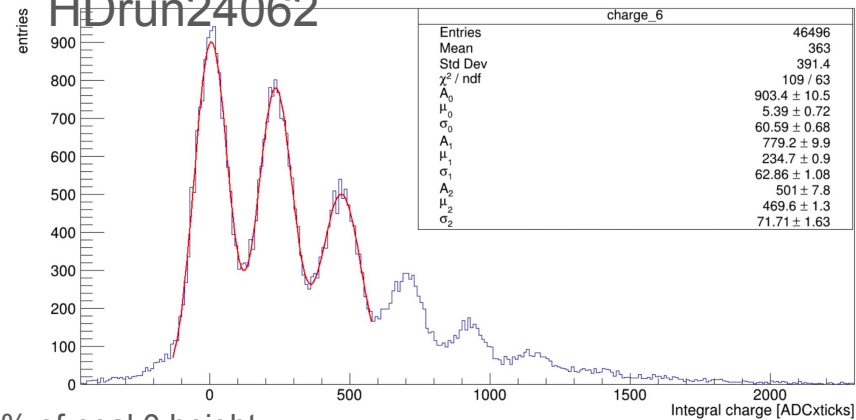
Fits:

Integration starting at 10 % of peak0 height

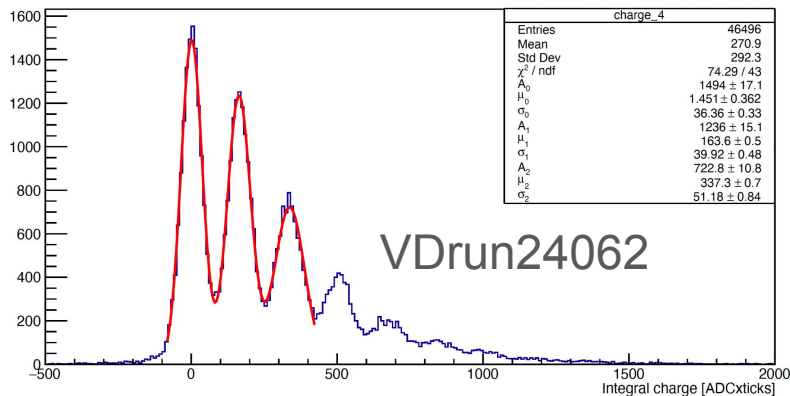
VDrun24062



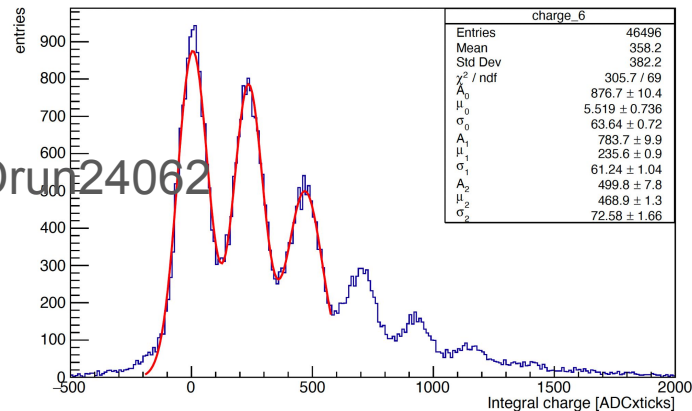
HDrum24062



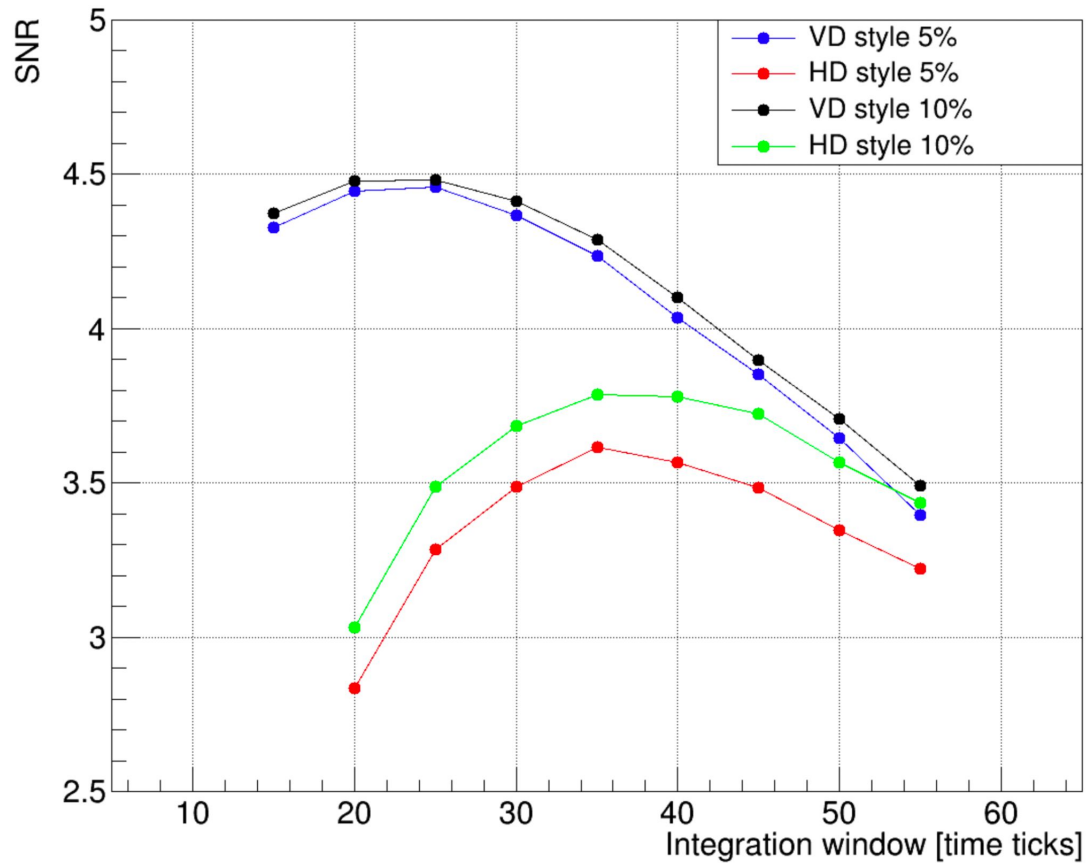
Integration starting at 5 % of peak0 height



HDrum24062

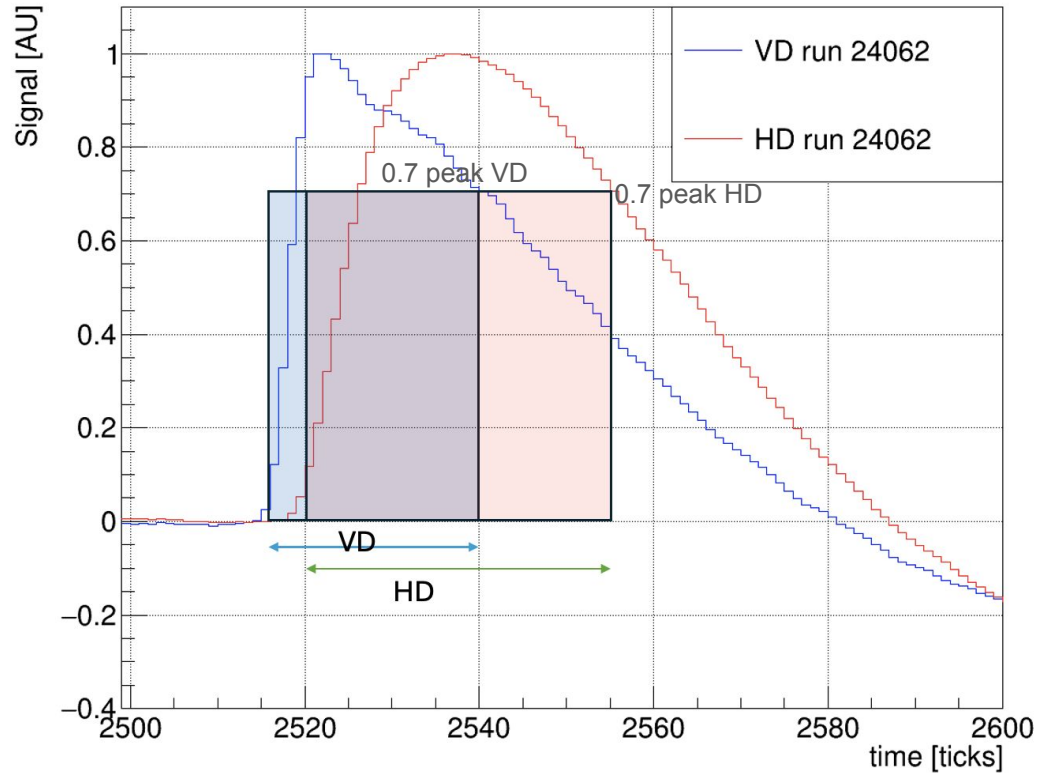


Dependence on Fit start point:

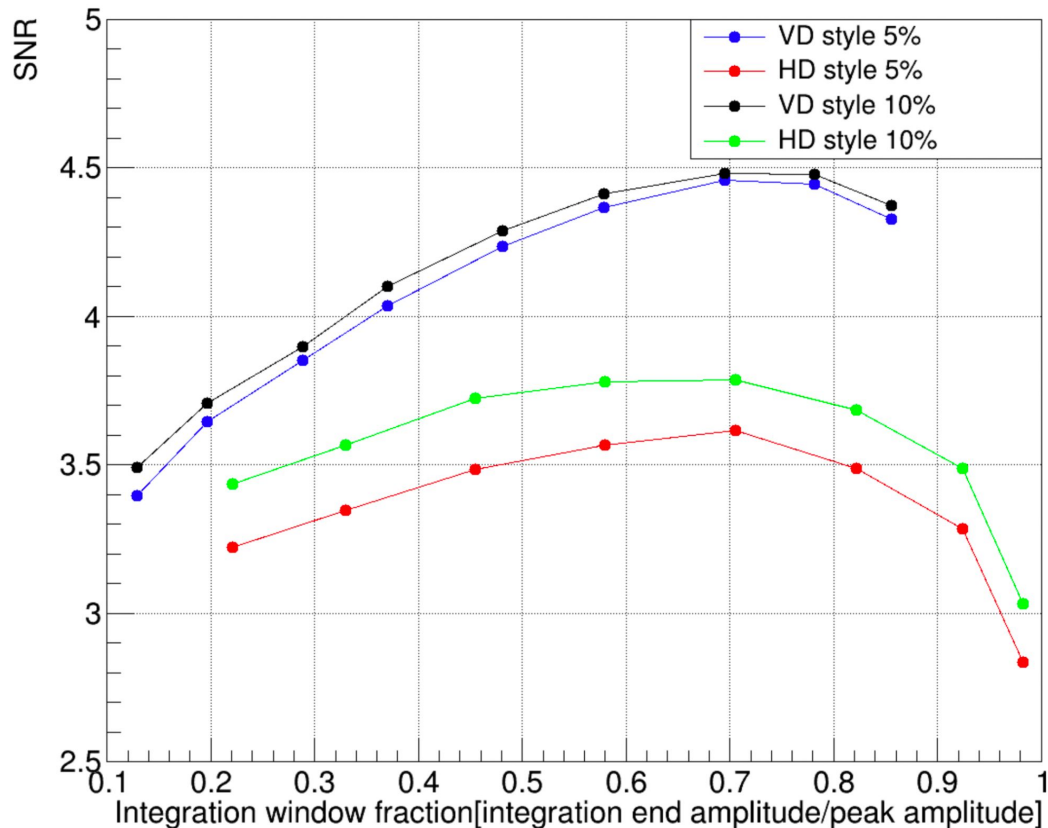


Selecting integration window

Average waveform

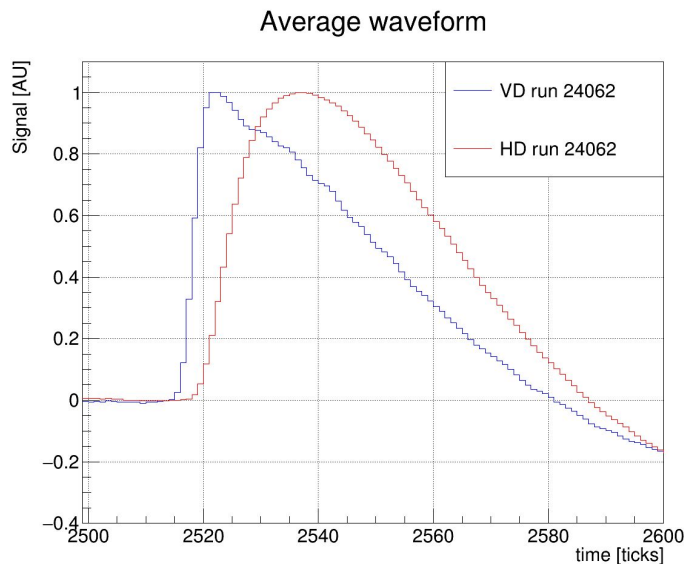


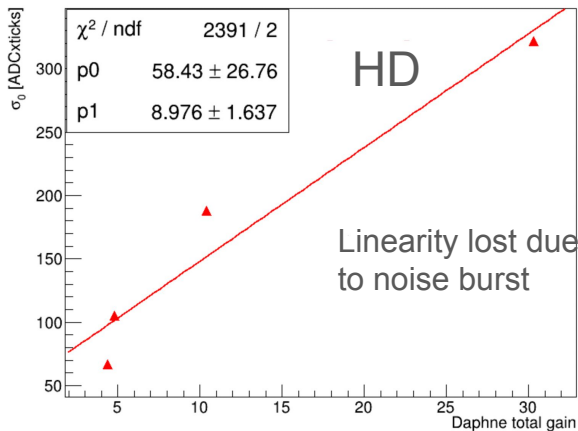
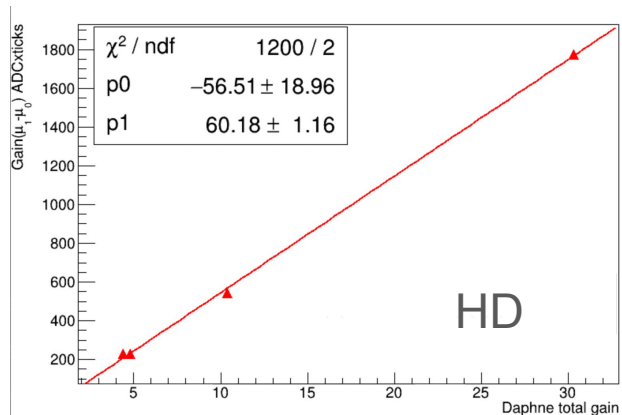
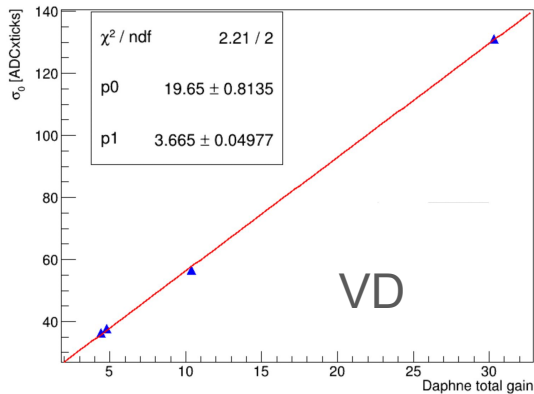
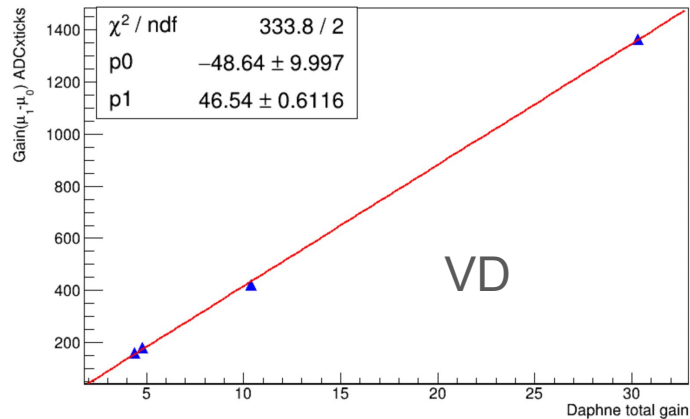
Effect of fit range:



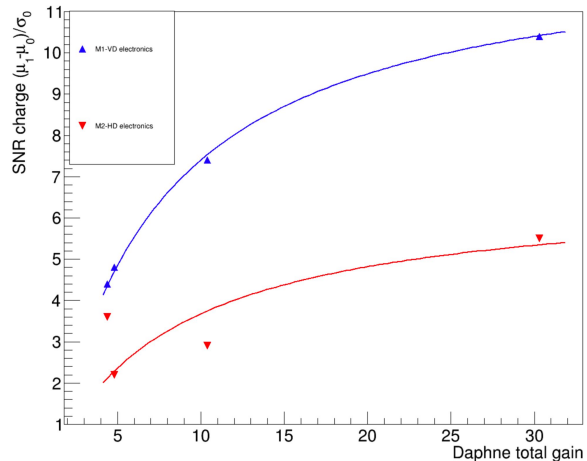
5% → fit starting at 5% of 0 peak height for charge histogram (next slide)

10% → fit starting at 10% of 0 peak height for charge histogram (next slide)





SNR charge summary plots:



BLUE CURVE =
 $\text{signal}(p_0 + p_1 * x) / \text{noise}(p_0' + p_1 * x)$ (top 2 fits)

Red CURVE =
 $\text{signal}(p_0 + p_1 * x) / \text{noise}(p_0' + p_1 * x)$ (bottom 2 fits)

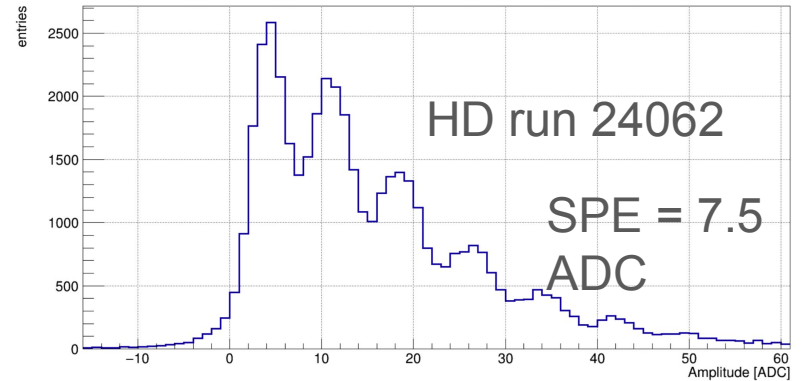
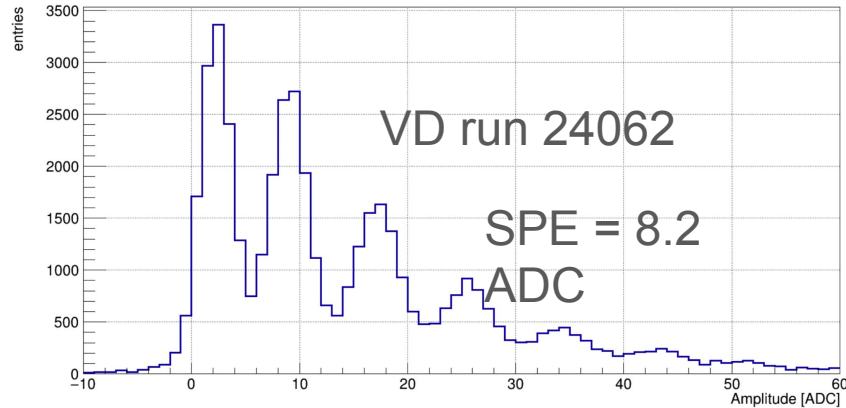
SNR Amplitude

SNR study using DAPHNE data:

For threshold based trigger logics, SNR in terms of signal amplitude is relevant.

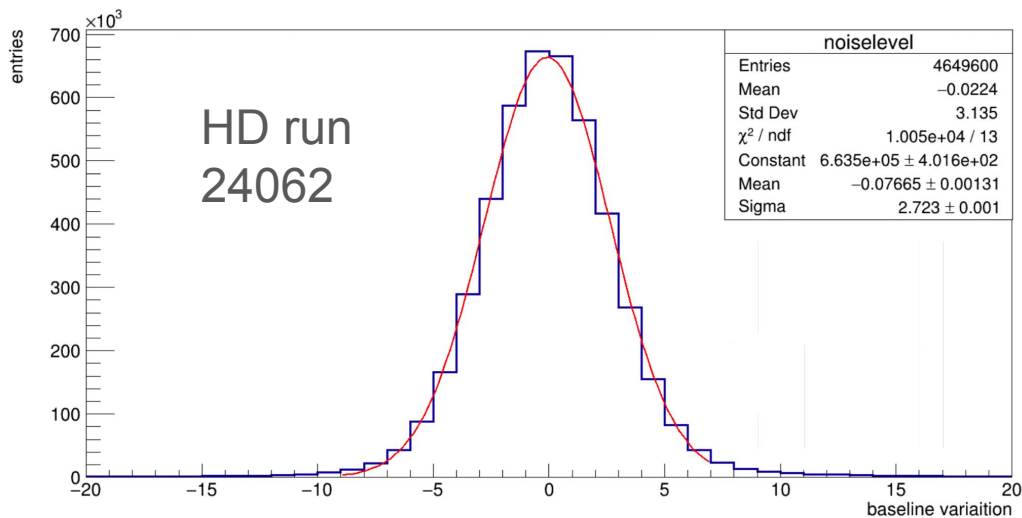
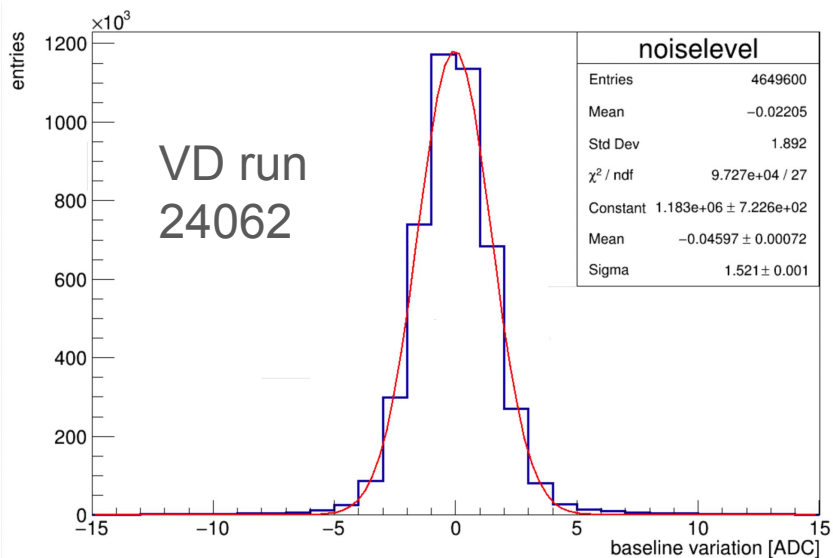
SNR_A (amplitude based signal to noise ratio) for the moving average of 7 points, equivalent to a bandwidth filter of 10 MHz.

Amplitude: Baseline is calculated using mean value of 100 ticks (1600 ns) immediately before rising edge. A plot of maximum amplitude in the region between rising edge and 50 ticks thereafter is estimated (below). Distance between fitted mean for peak2 and peak3 is the SPE amplitude.



Baseline noise:

Plots below shows the waveform of moving average involving 7 points after baseline subtraction; for 100 ticks immediately before the rising edge (all waveforms in a run)



SNR_A = Amplitude/Baseline noise sigma

Run 24062

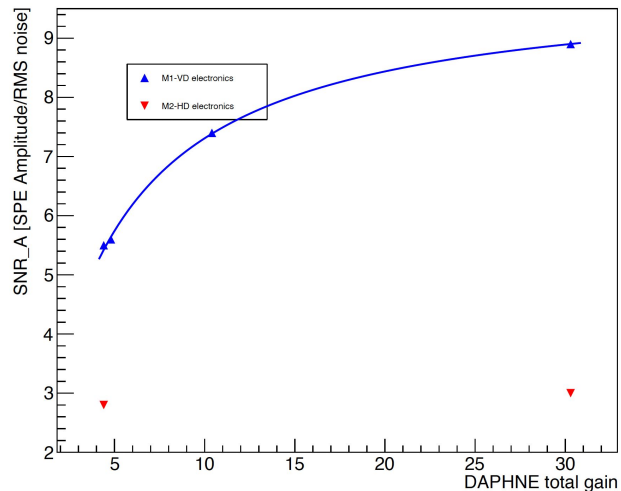
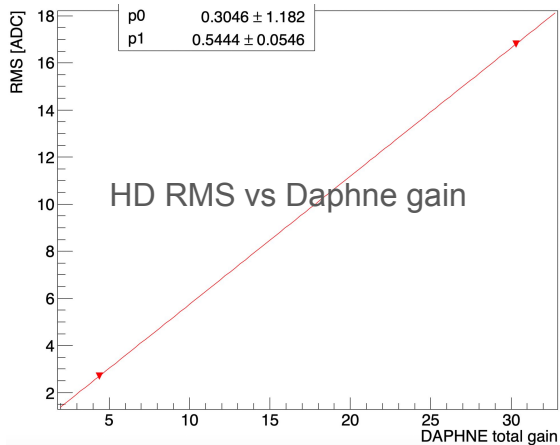
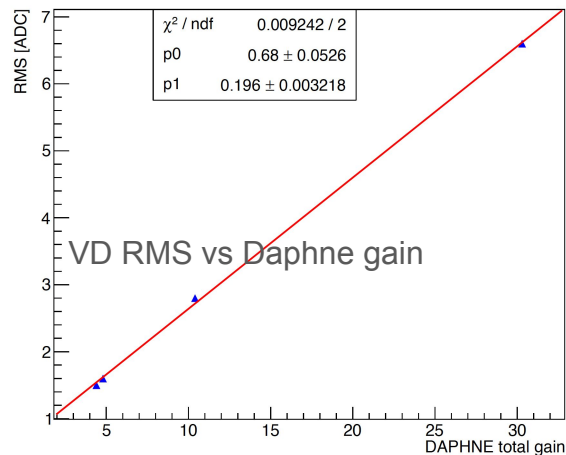
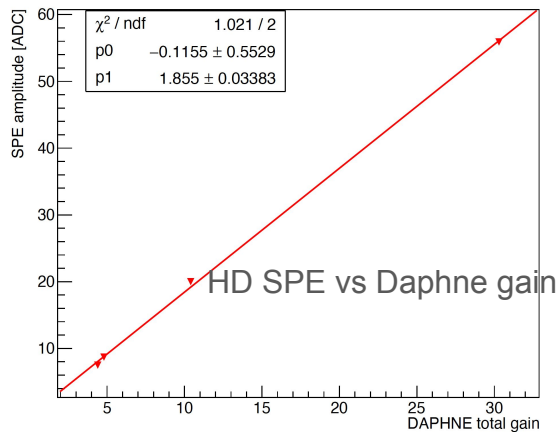
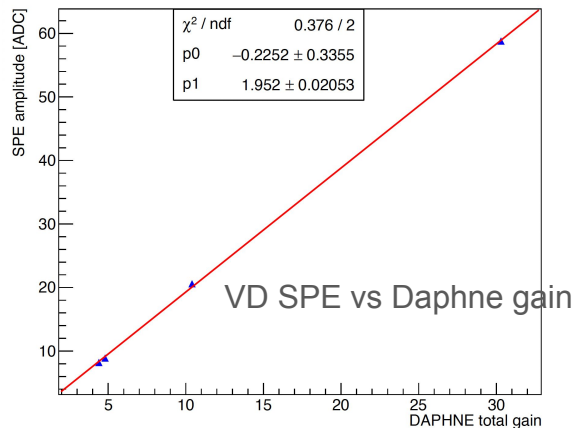


Fig : VD, HD SNR amplitude. Blue curve represents the ratio of two linear functions defining SPE amplitude vs daphne gain and RMS vs Daphne gain for M1-VD electronics.

Summary table:

AFE Gain & Attenuation Settings and VD-style, HD-style CE results Summary Table

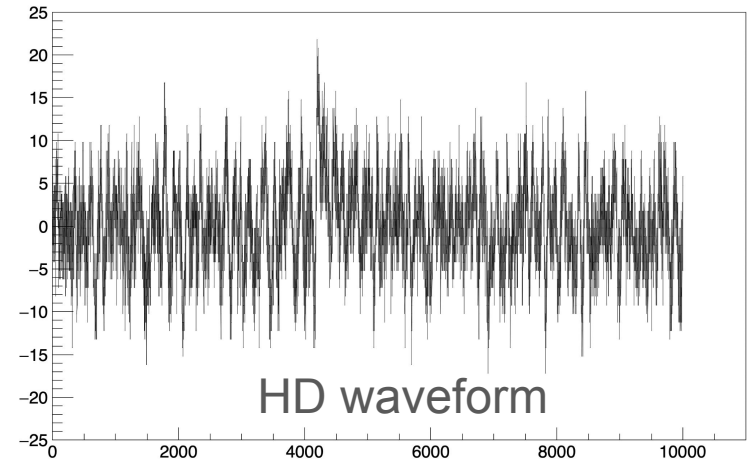
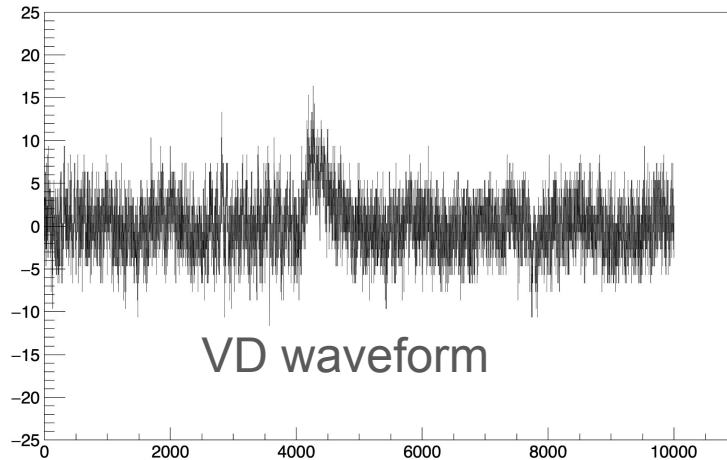
Run #	AFE-VCAT setting VGAIN [DAC]	VCAT Atten [db]	LNA+VCAT+PGA Tot Gain [A_out/A_in]		SPE A [ADC] 1PE-(Max A) (Mov Avg N=3, n_tTick=7)	Noise RMS [ADC] $\sqrt{S^2}$ Baseline window: immediate 100 tTicks	SNR_A (Amplitude/ RMS)	Nominal Dynamic Range [14-bit*/ SPE A]	SPE Ch ($\mu_1-\mu_0$) from fit [ADC x tTick] Int window: $\Delta tTick$ [0%LE,70%TE]	Noise Ch (σ_0) from fit [ADC x tTick] Int window: $\Delta tTick$ [0%LE,70%TE]	SNR_C ($\mu_1-\mu_0$)/ σ_0
24037	600	-6.4	30.3	VD-style CE	58.8	6.6	8.9	223	1365.2	131.0	10.4
				HD-style CE	55.9	16.8	3.0	217	1773.0	321.9	5.5
24089	1330	-15.6	10.4	VD-style CE	20.6	2.8	7.4	637	419.7	56.5	7.4
				HD-style CE	~20	>11	Undefined	~592	543.2	188.2	2.9
24097	1860	-22.4	4.8	VD-style CE	8.9	1.6	5.6	1480	180.9	37.6	4.8
				HD-style CE	~8.7	>5	Undefined	~1395	230.6	104.9	2.2
24062	1925	-23.2	4.4	VD-style CE	8.2	1.5	5.5	1598	162.2	36.4	4.4
				HD-style CE	7.5	2.7	2.8	1618	230.1	66.6	3.6

CAEN digitizer data amplitude SNR analysis for membrane modules:

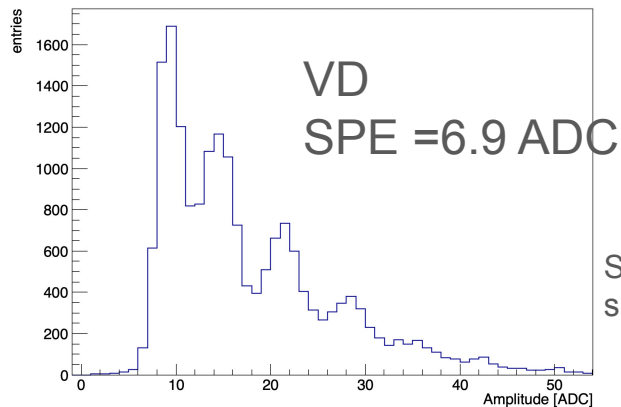
File analyzed:

Run170 (HD and VD) LED→275nm width-→20ns (4V70)
→hd_low_gain_no_transformer
Sampling time: 2 ns

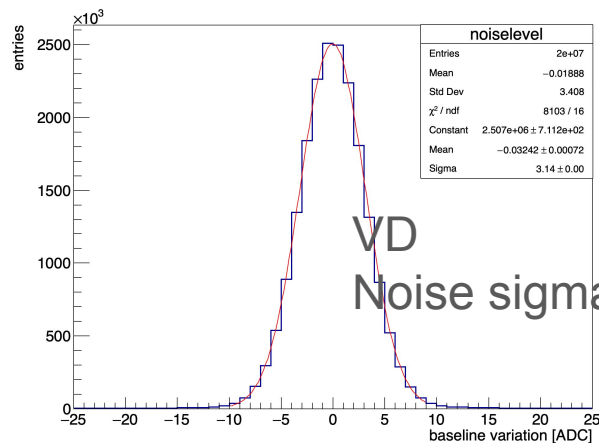
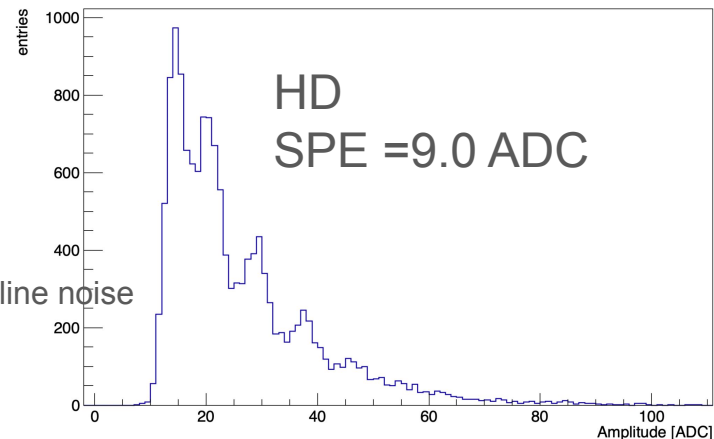
For the baseline calculation, moving average filter (15 points) is used;
After determining baseline;
Raw waveform is used for amplitude and RMS estimate.



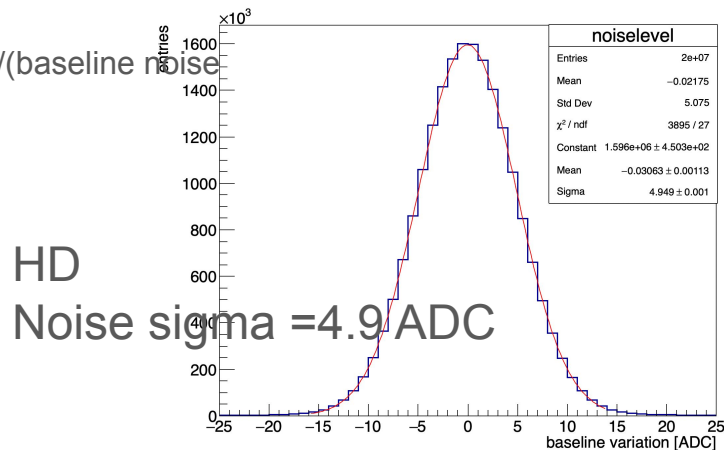
SPE amplitude = difference in fitted mean values of 3rd and 2nd peak in amplitude distribution plot



$$\text{SNR}_A (\text{VD}) = \text{SPE amplitude} / (\text{baseline noise sigma}) = 2.2$$



$$\text{SNR}_A (\text{HD}) = \text{SPE amplitude} / (\text{baseline noise sigma}) = 1.8$$

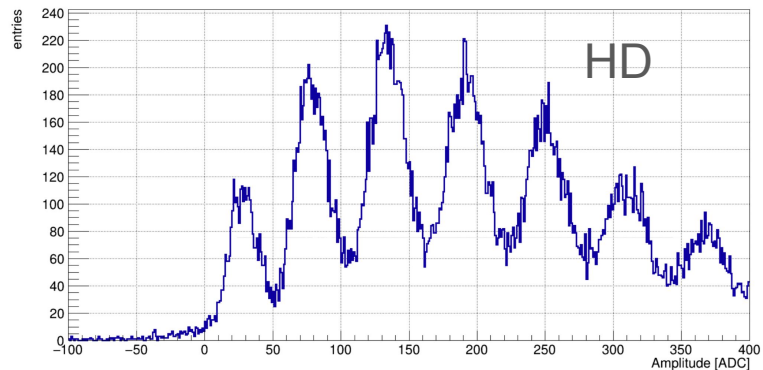
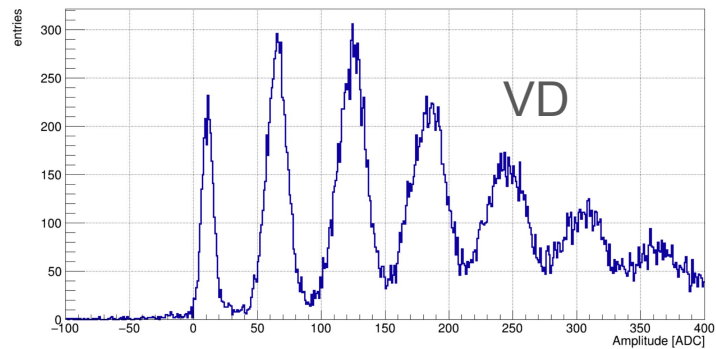
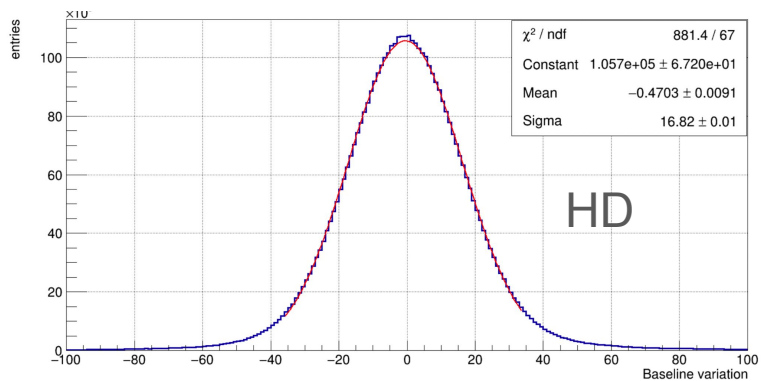
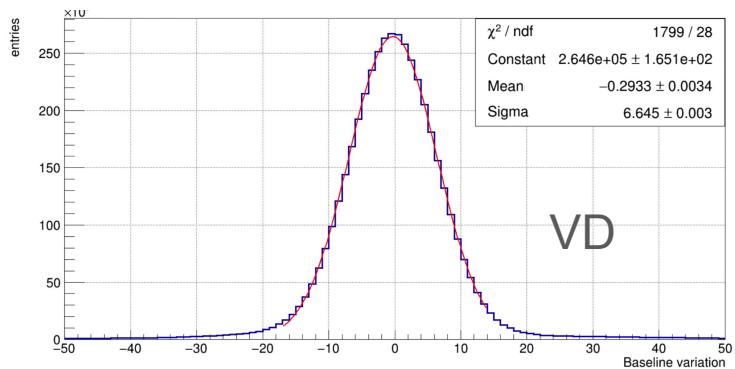


Summary

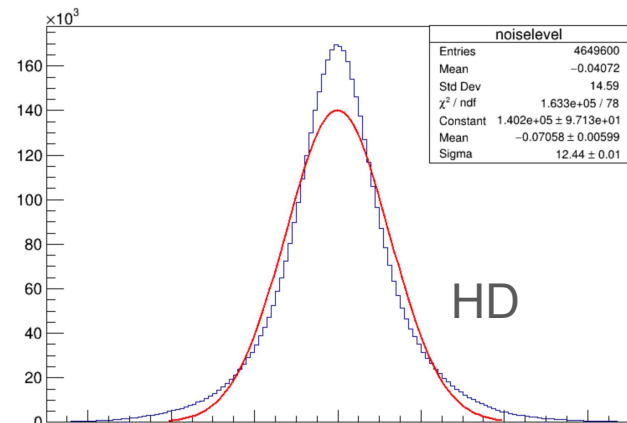
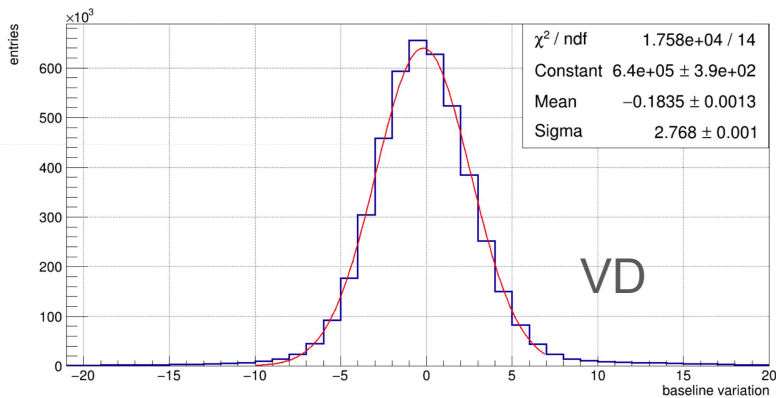
1. Different parameters (baseline range, integration start, fit start, common integration window) varied to possibly understand the differences between the results from Federico's study.
2. Some parameters affect both SNR estimates for VD and HD, but in some cases one more than the other; e.g. fit start point on noise 0-peak makes a bigger difference to HD compared to HD.
3. Overall the trend in the SNR is similar, for all cases, and maximizes for the integration window starting at the rising edge and ending at 70% of peak amplitude.

Backup:

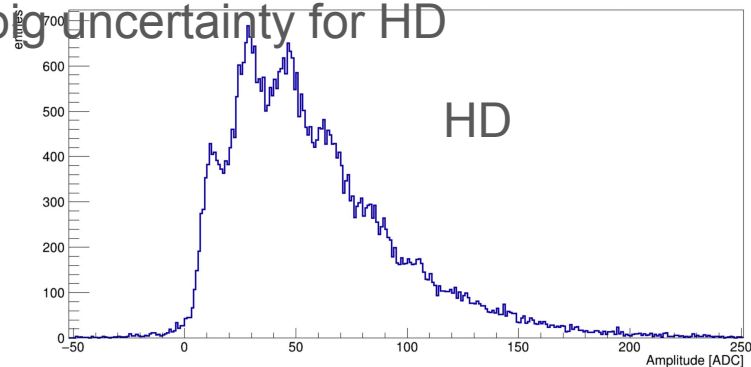
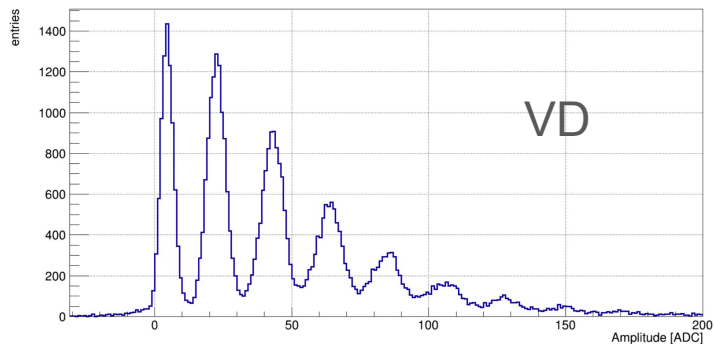
DAPHNE NOISE RMS, Amplitude (7 points moving average)(24037):



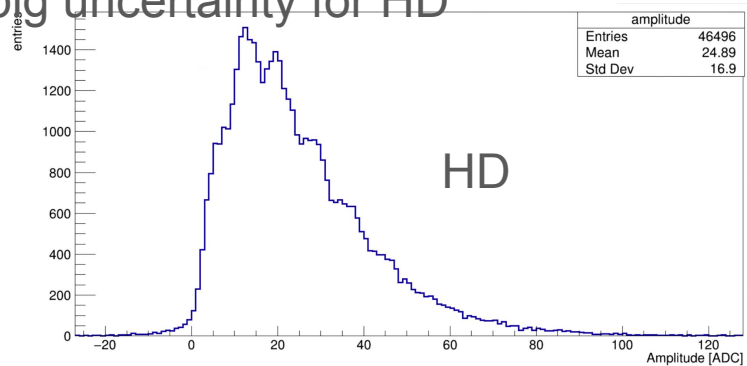
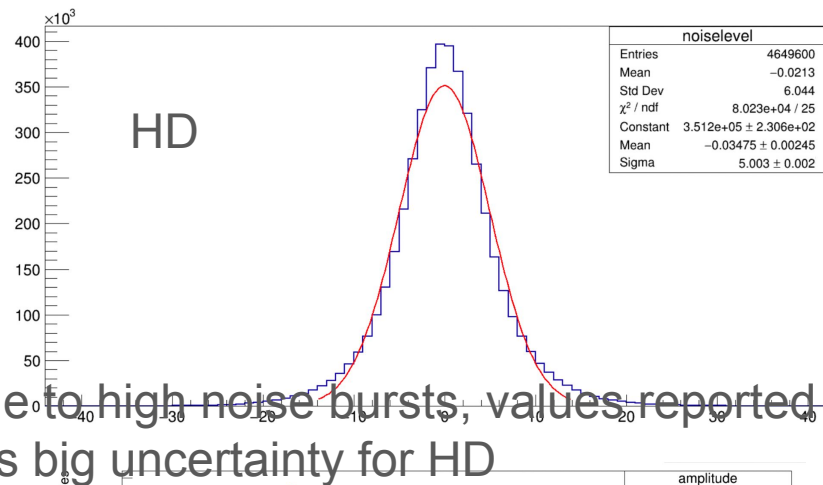
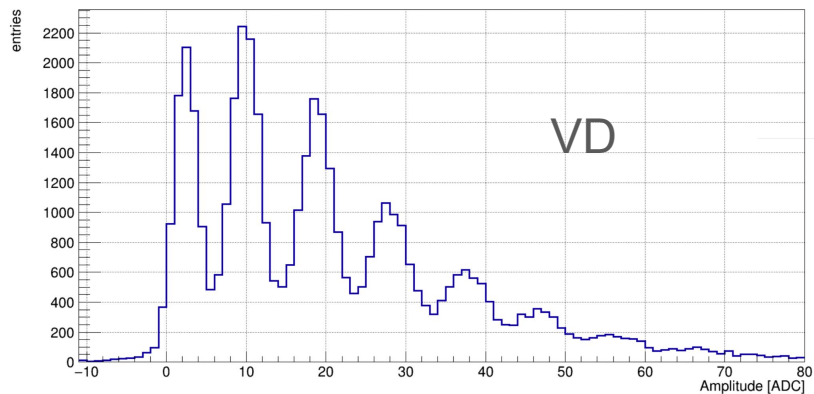
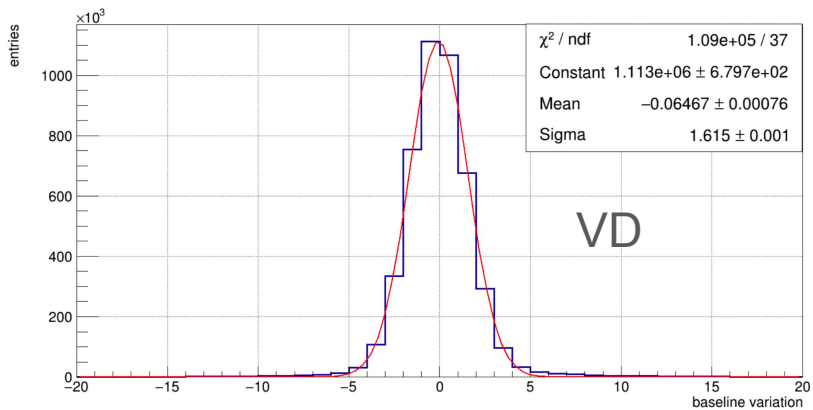
DAPHNE NOISE RMS, Amplitude (7 points moving average)(24089):



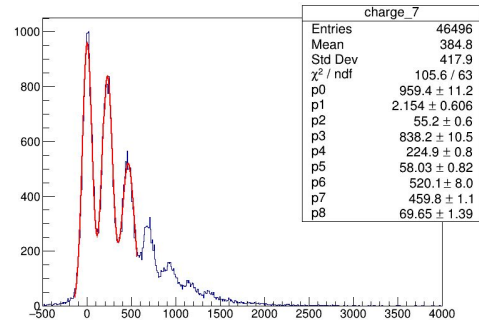
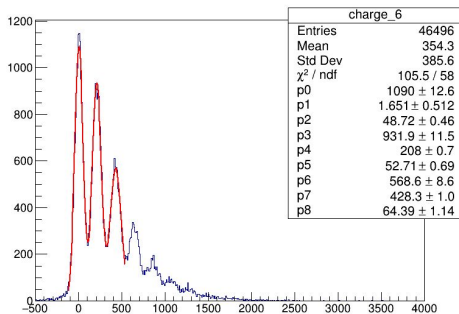
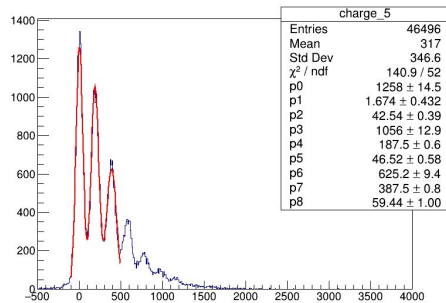
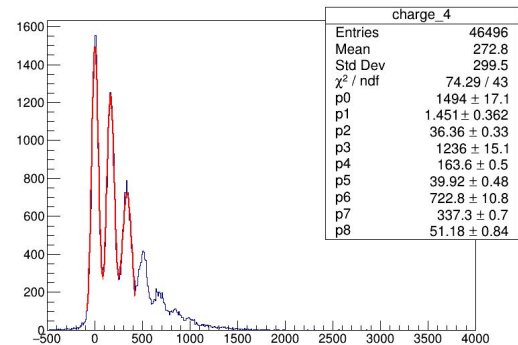
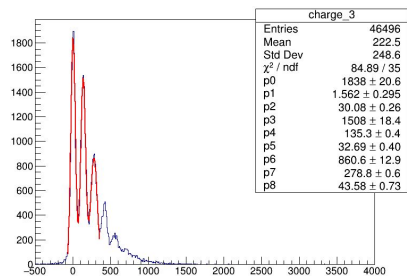
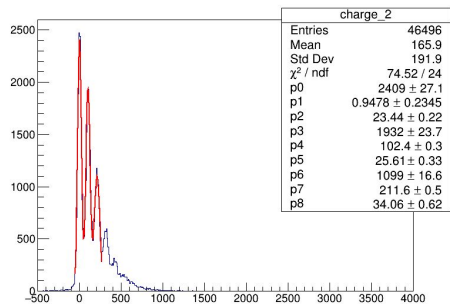
Due to high noise bursts, values reported has big uncertainty for HD



DAPHNE NOISE RMS, Amplitude (7 points moving average)(24097):

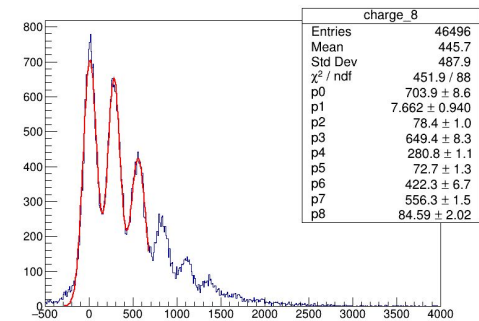
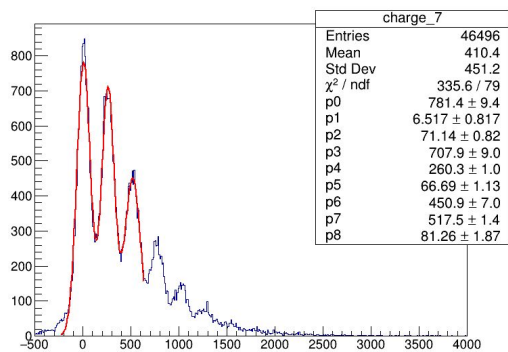
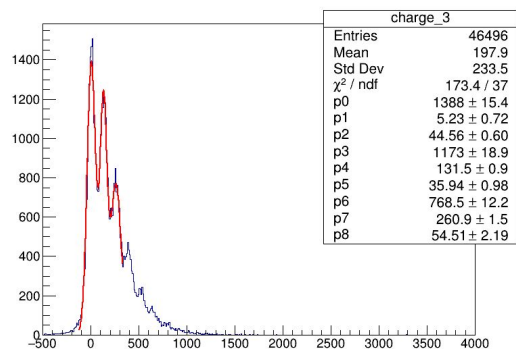
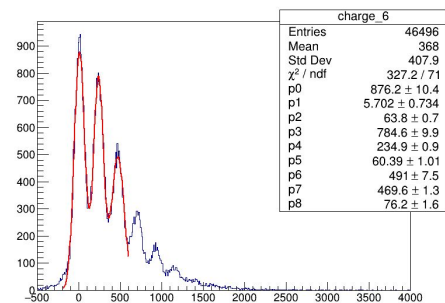
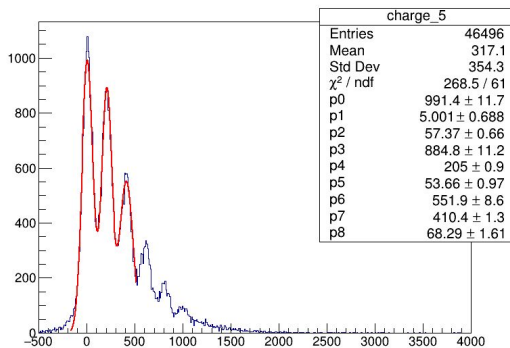
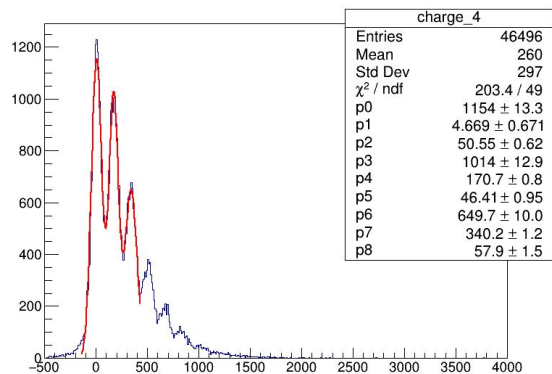


VD fits (5% start):



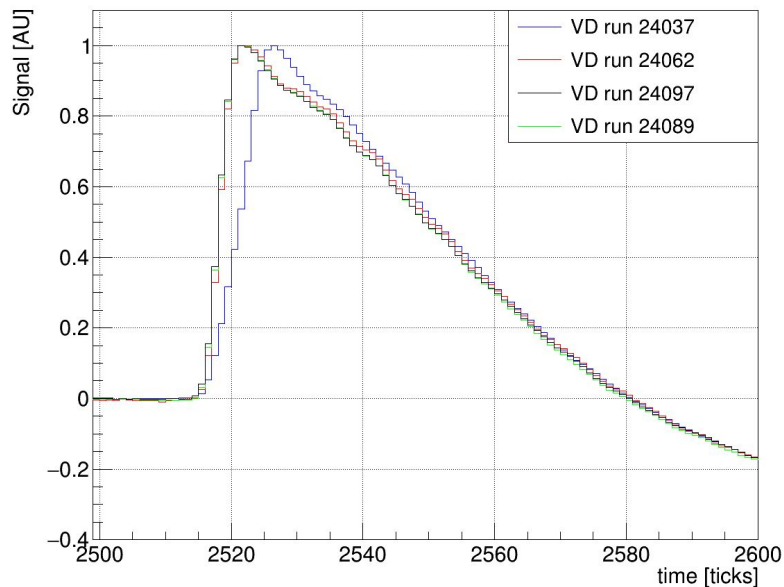
HD fits:

HD fits (5% start):

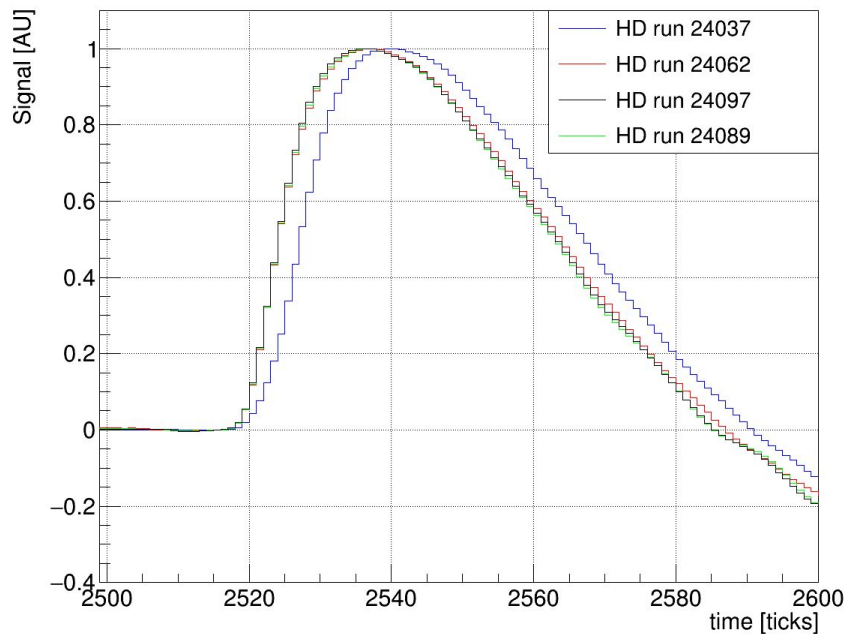


Average waveforms (LED pulse width for run 24037 was 100 ns while for all other runs was 20 ns):

Average waveform

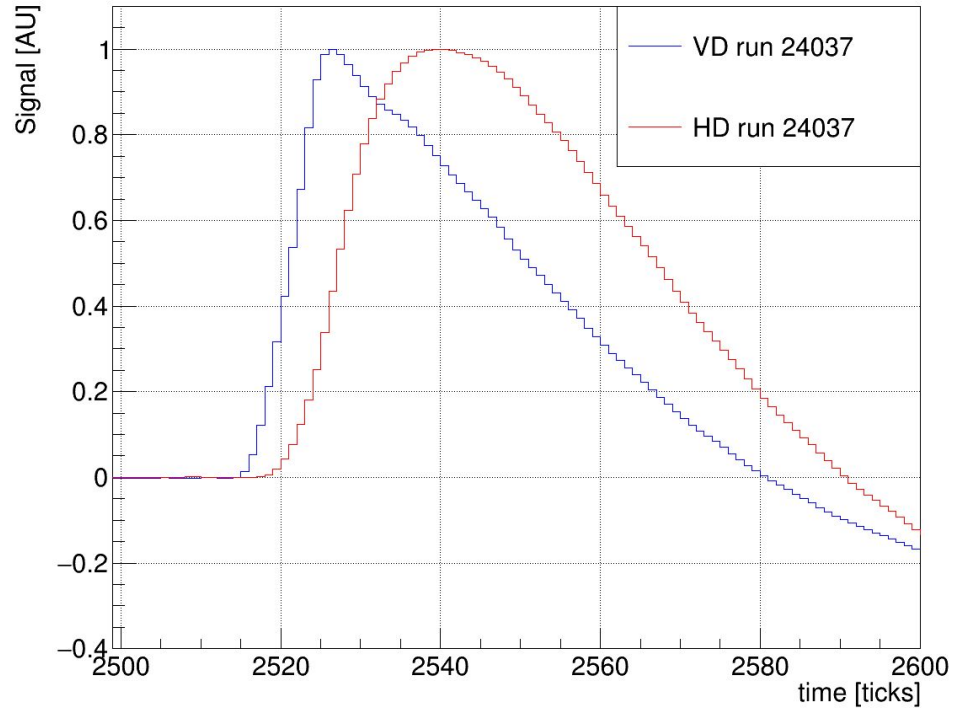


Average waveform

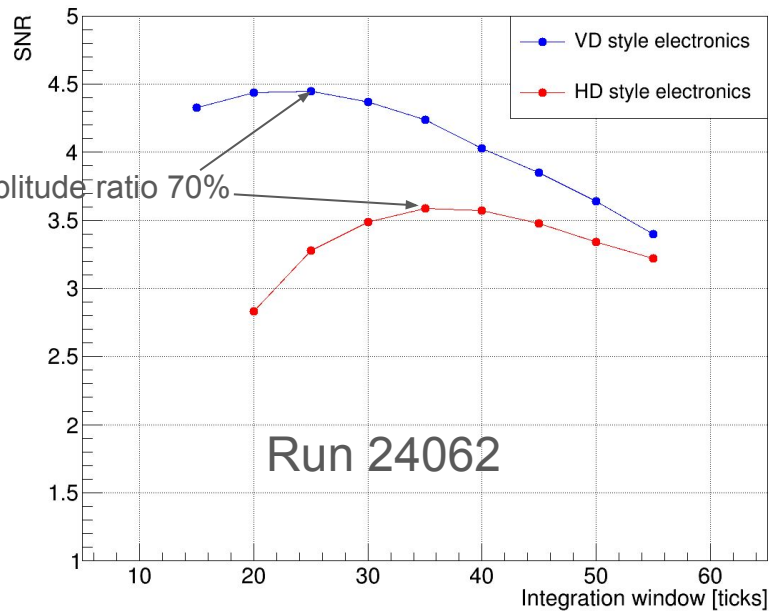


Run 24037 zoomed

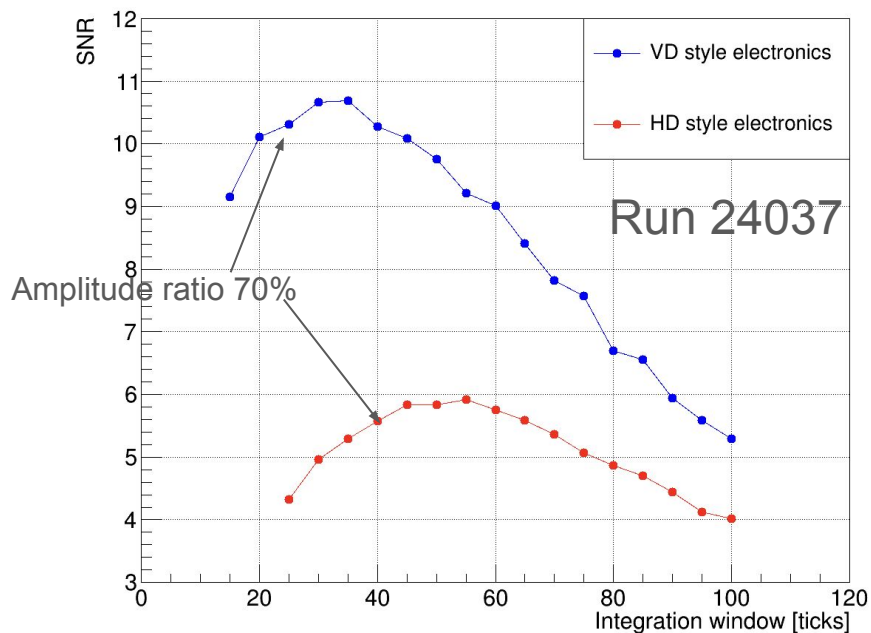
Average waveform



SNR vs integration window width

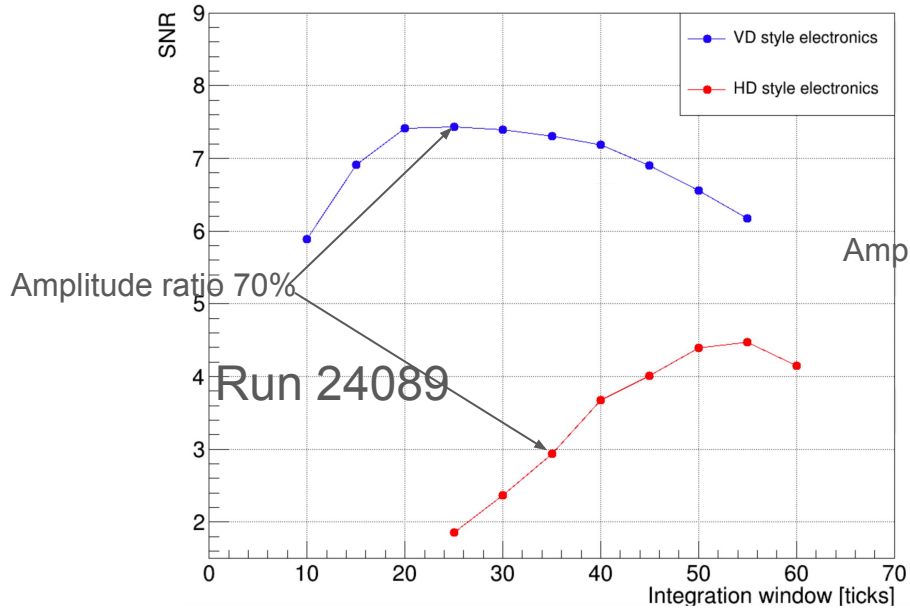


SNR vs integration window width



These runs had noise burst for HD electronics:

SNR vs integration window width



SNR vs integration window width

