VD – HD Comparison

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SETUP

Vertical-Drift Coldbox – January 2024

- CAEN DT5730SB (500 MHz - 2 ns/tick)
  - VD: DVDM and warm stage
  - HD: DMEM and warm stage
- DAPHNE V2 (62.5 MHz - 16 ns/tick)
- LED: 365 nm and 275 nm
  - The 365 nm shows a spread in time when plotting an average waveform -> broader rise and fall times
- SiPM: FBK TT operated at 32.5 V (5.5 over-voltage)
- VD Coldbox @ Neutrino Platform

Breakdown Voltage

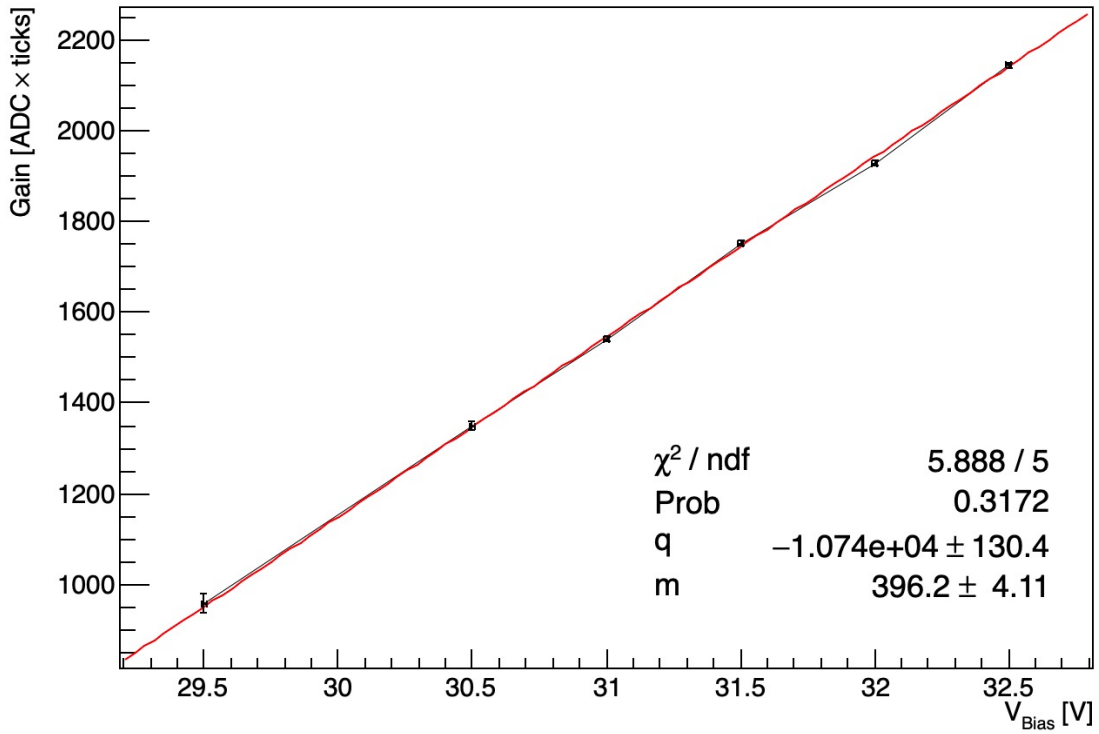
SiPM: FBK TT

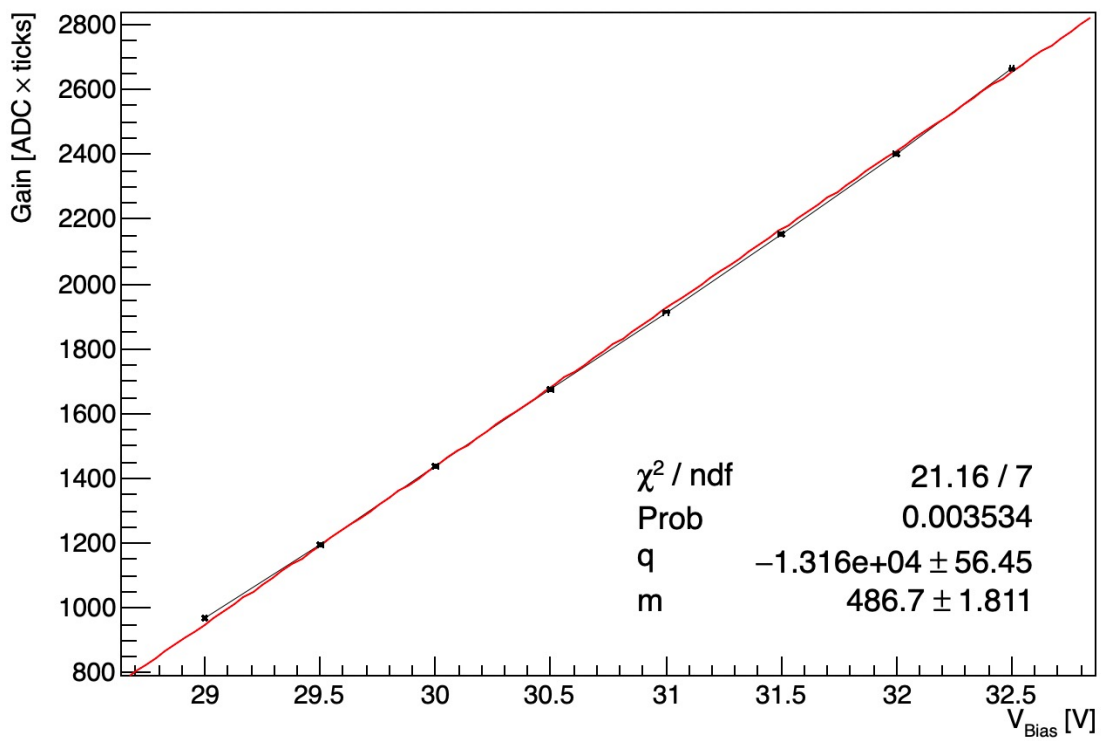
To compare the gain of the two boards we have to guarantee that the SiPMs are working at the same overvoltage.

In the following, M1-VD plots are on the left and M2-HD ones one the right.

- Fit : $G = m \times V_{Bias} + q$
- VD : $V_{br} = 27.0 \pm 0.6$ V (left)

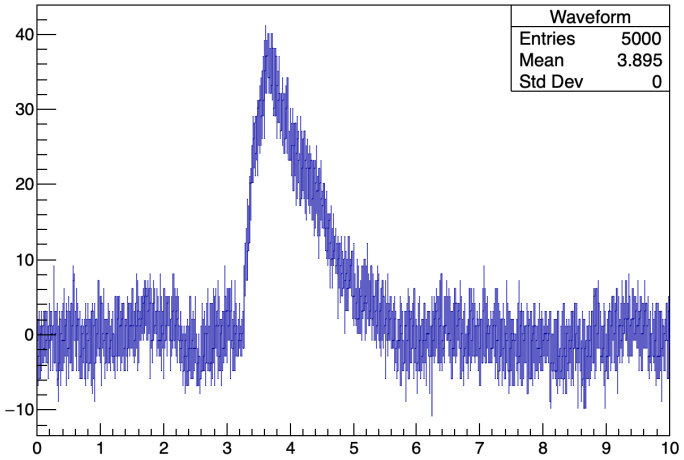
HD : $V_{br} = 27.0 \pm 0.2$ V (right)

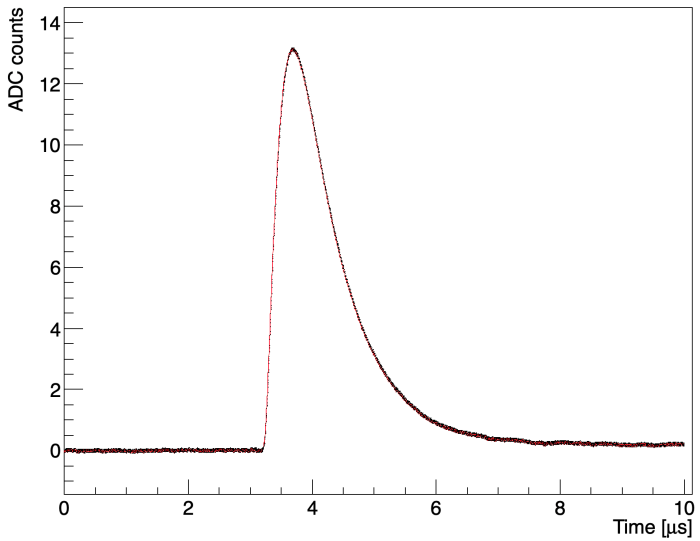




CAEN digitizer

Waveforms: how they look like





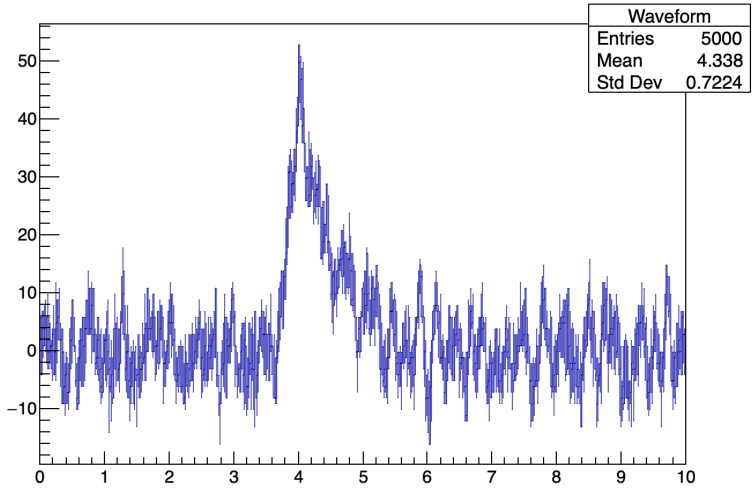
M1-VD

DVDM – cold and warm stages

Undershoot: 1.3%

Rise time: 140 ns

Fall time: 1’420 ns



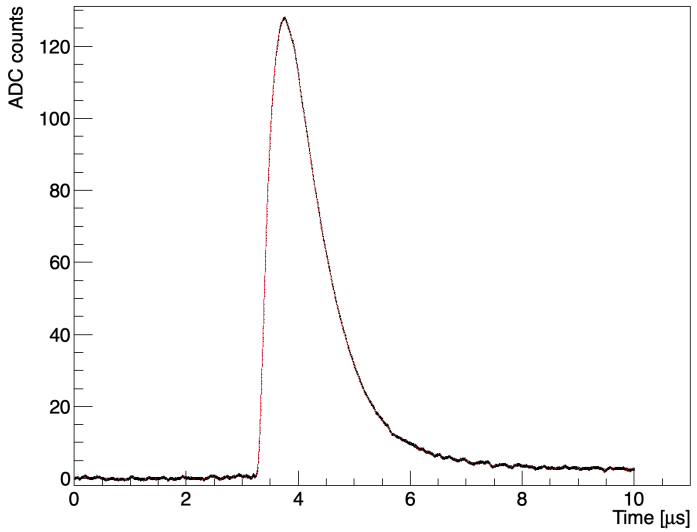
M2-HD

DMEM – cold and warm stages (bypassing the transformer of the warm board)

Undershoot: 1%

Rise time: 142 ns

Fall time: 1’480 ns



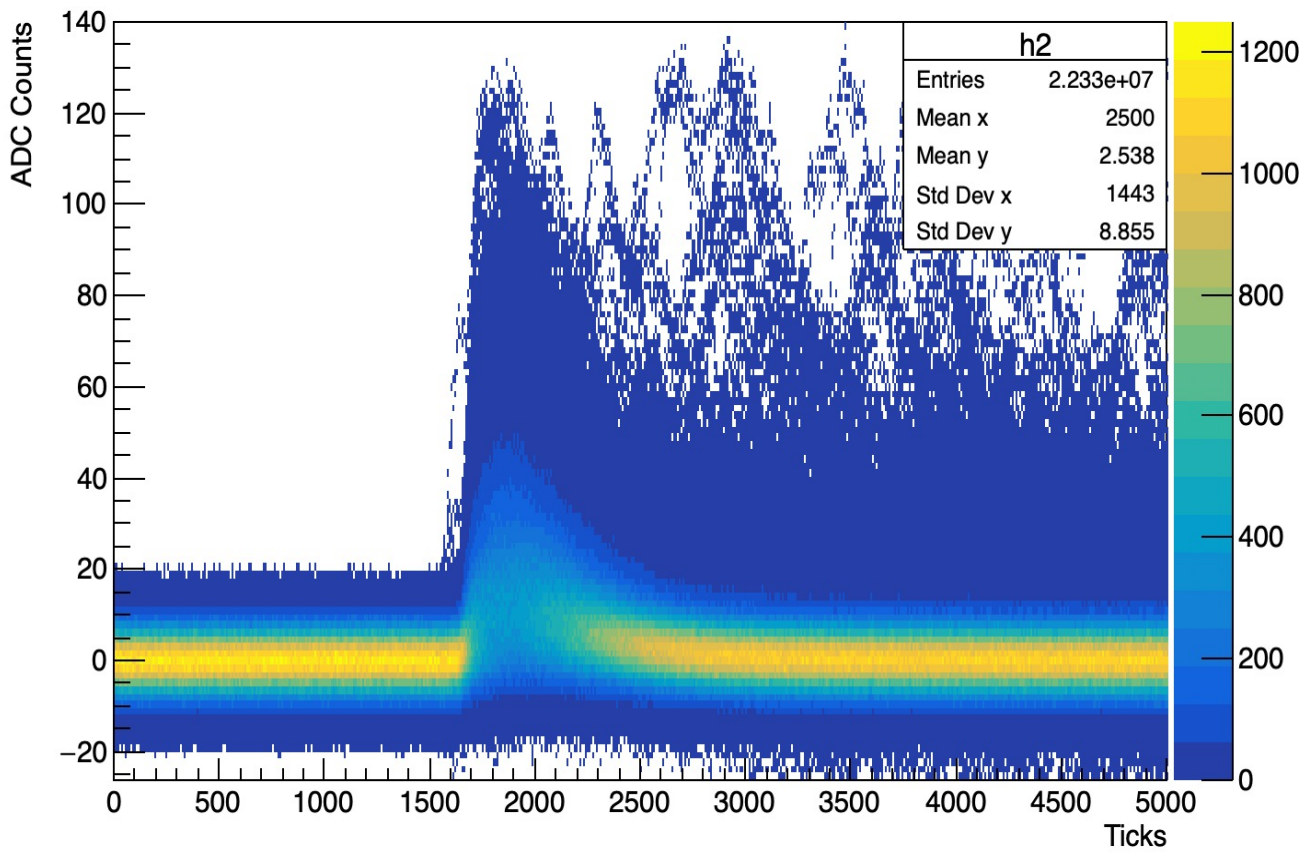
Waveform selection

Calibration

I select waveforms with no light in the pre-trigger and with an amplitude within the range of the LED pulses.

In this way I lose around the 6% of the statistics, mostly in the tails of the calibration spectrum

- ➔ Irrelevant for SNR estimations
- ➔ Useful to compute the RMS of the noise



Signal to Noise ratio

Bias 32.5 V – LED 275 nm – run 170

The SNR strongly depends on the integration window's width (see plot).

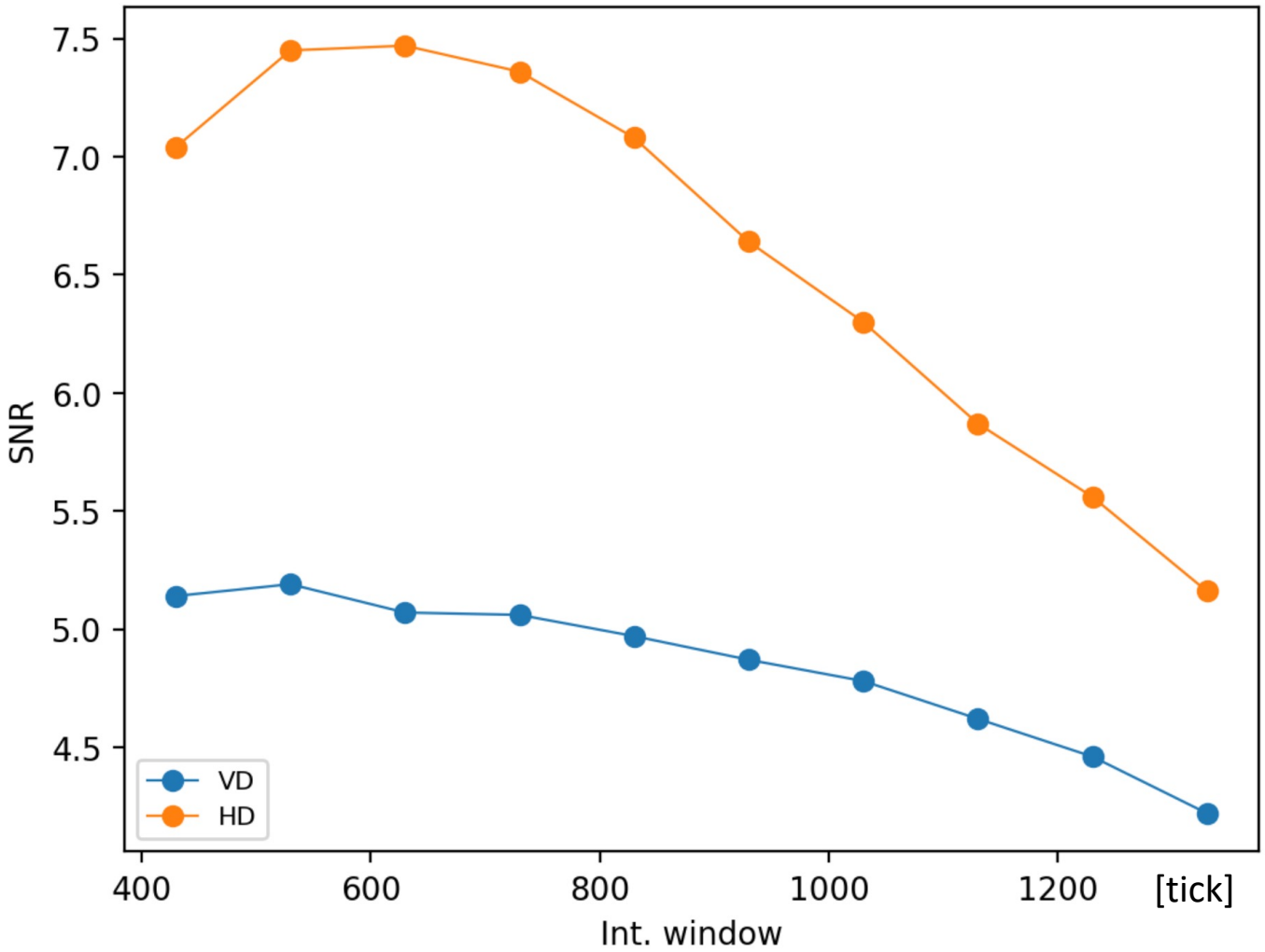
➔ The X-axis of the calibration spectrum is not the total amount of charge of the signals!

To cross-check the results, Dante and I agreed on a set of windows to use.

The integration starts at tick #4070*, a bit before the trigger.

- 1 tick = 2 ns

*In this run we took 10k tick waveforms

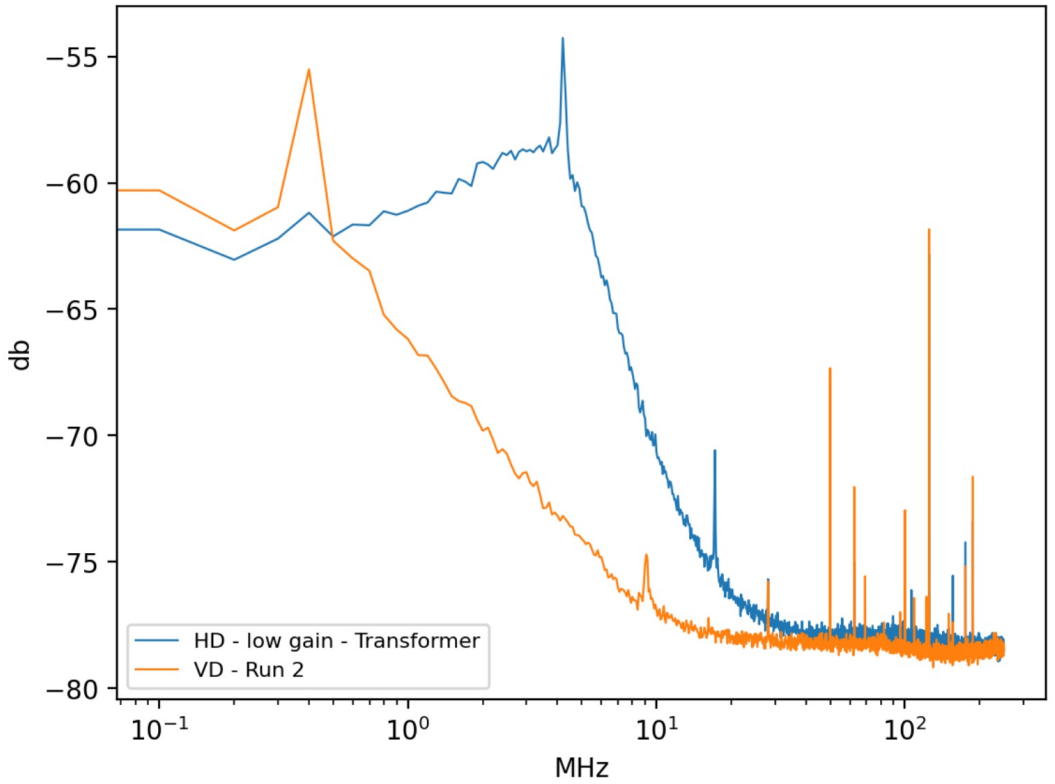


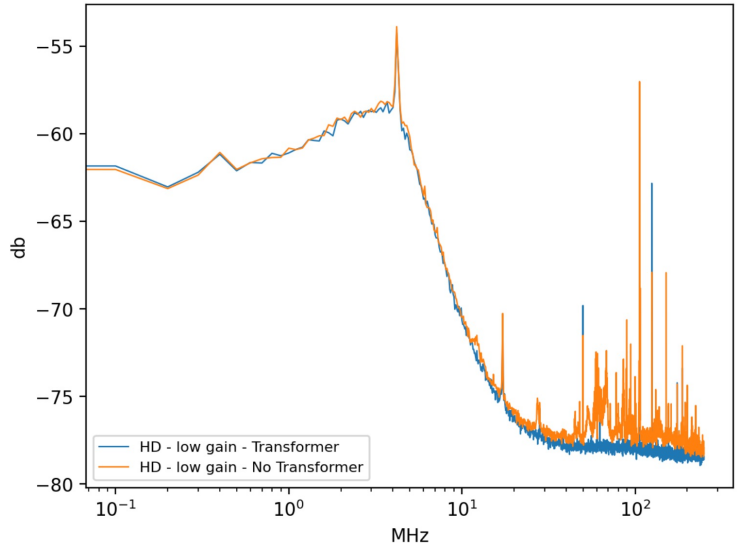
Noise

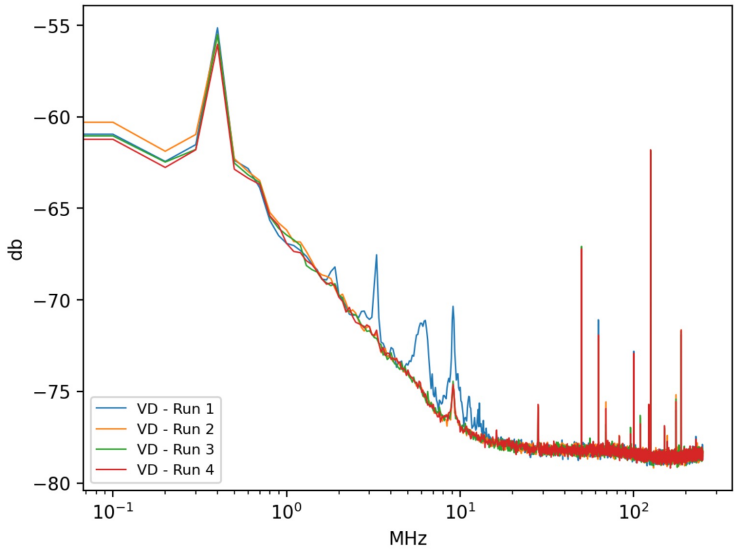
RMS and FFTs

HD: baseline RMS = 4.8

VD: baseline RMS = 3.0





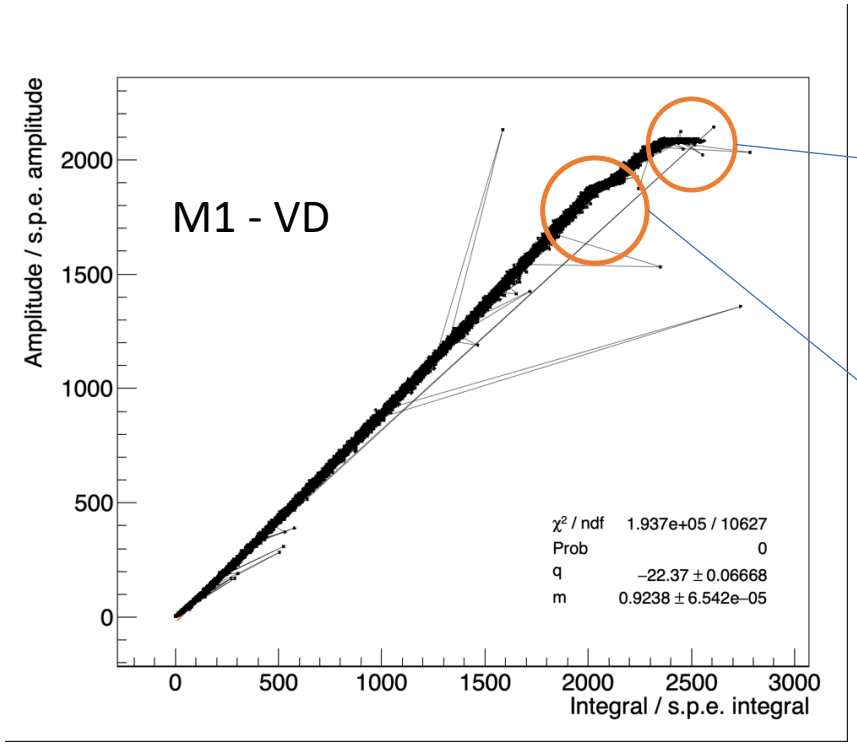


Linearity

Amplitude vs Integral

Analysis to have a more reliable estimation of the dynamic range:

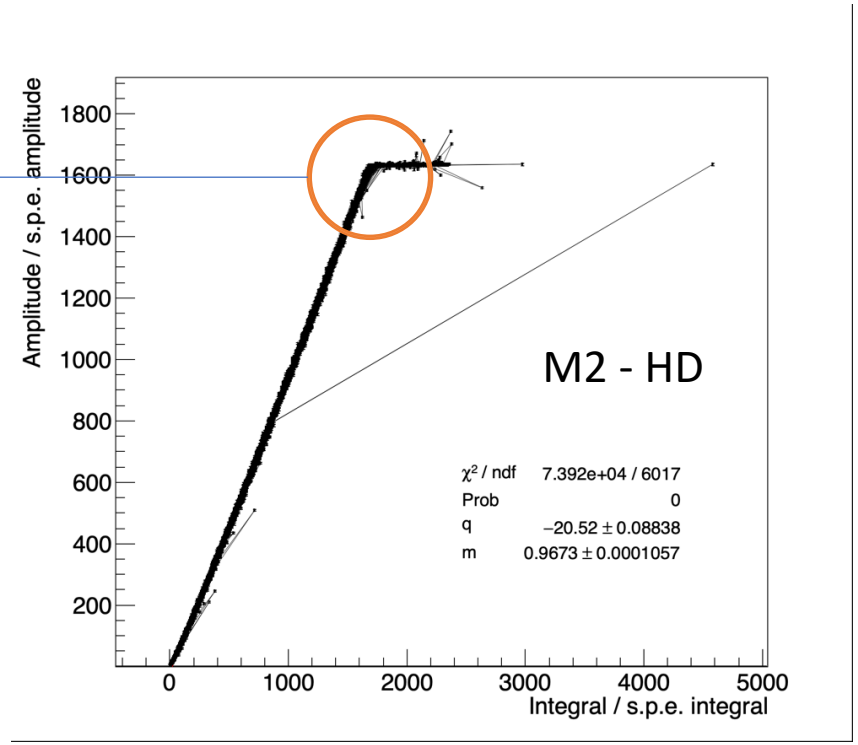
- Plot the amplitude of the waveforms vs. their integrals (#photons vs. #photons)
- Linear fit in the intermediate range
- Discard the point that too far away from the fit function …



Saturation

Due to the second stage

Beginning of distortions

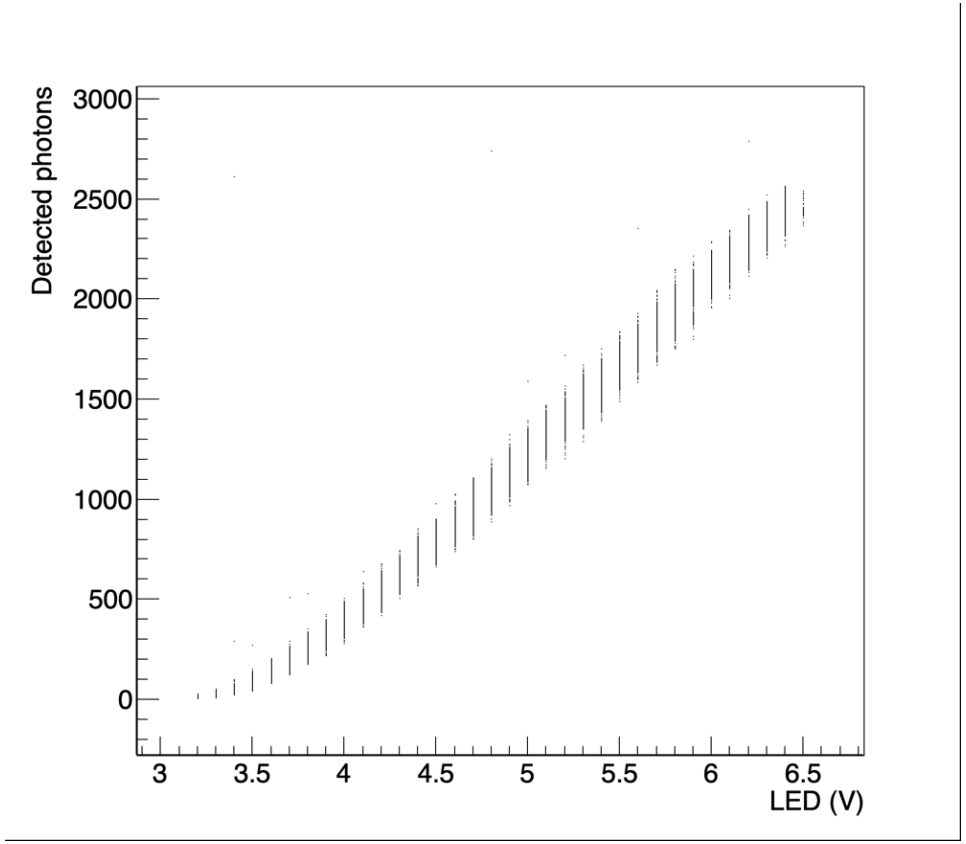


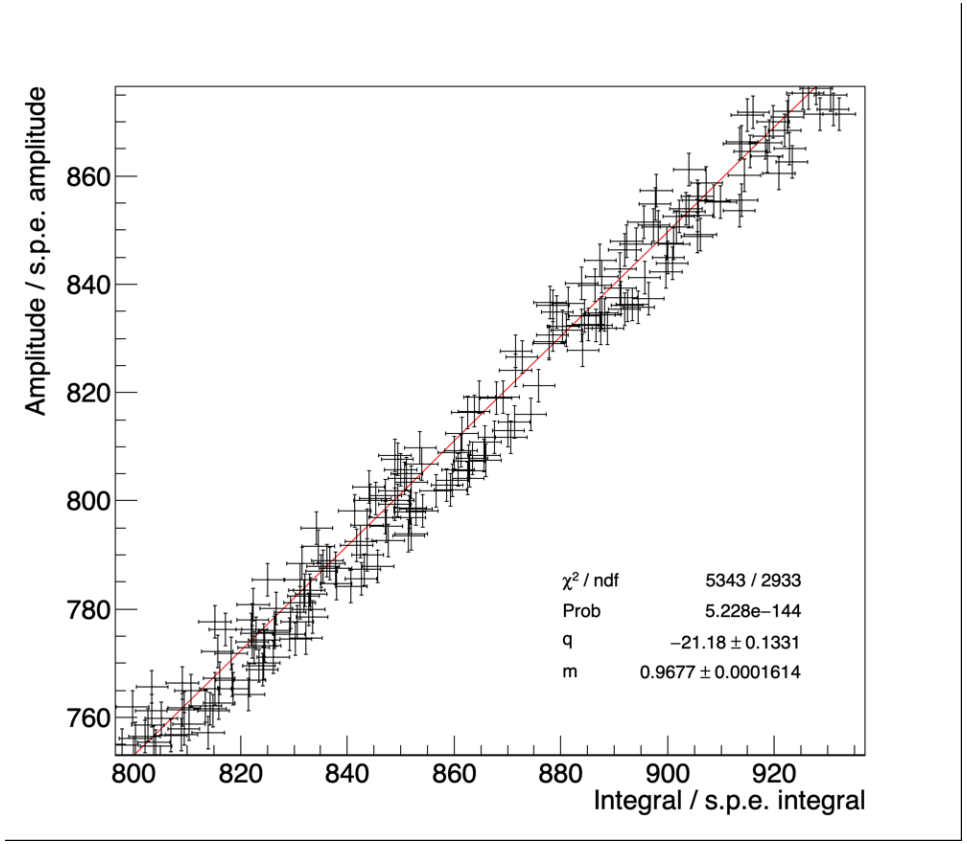
LED and linearity

Scan in LED intensity and zoom

The number of detected photons vs the LED voltage is not linear -> no way to use it as cross-check

The fitting procedure looks reasonable





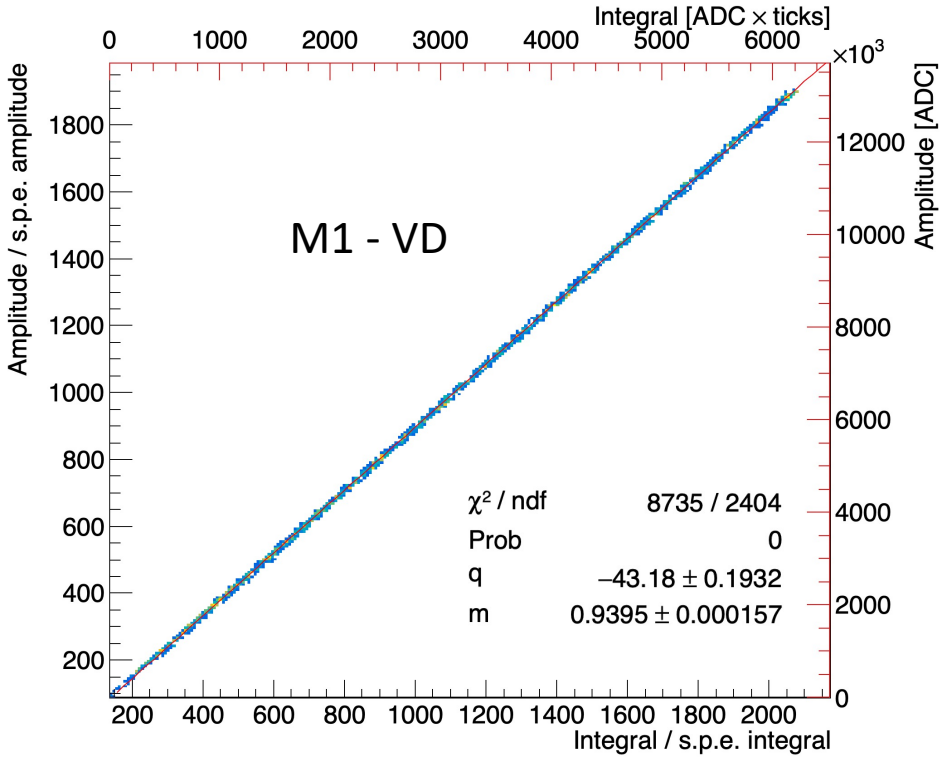
Dynamic range

Updates

Dynamic range estimated as $\frac{Saturating\ wf's\ amplitude}{s.p.e.amplutide}$ -> VD = 2140 ph. | HD = 1630 ph.

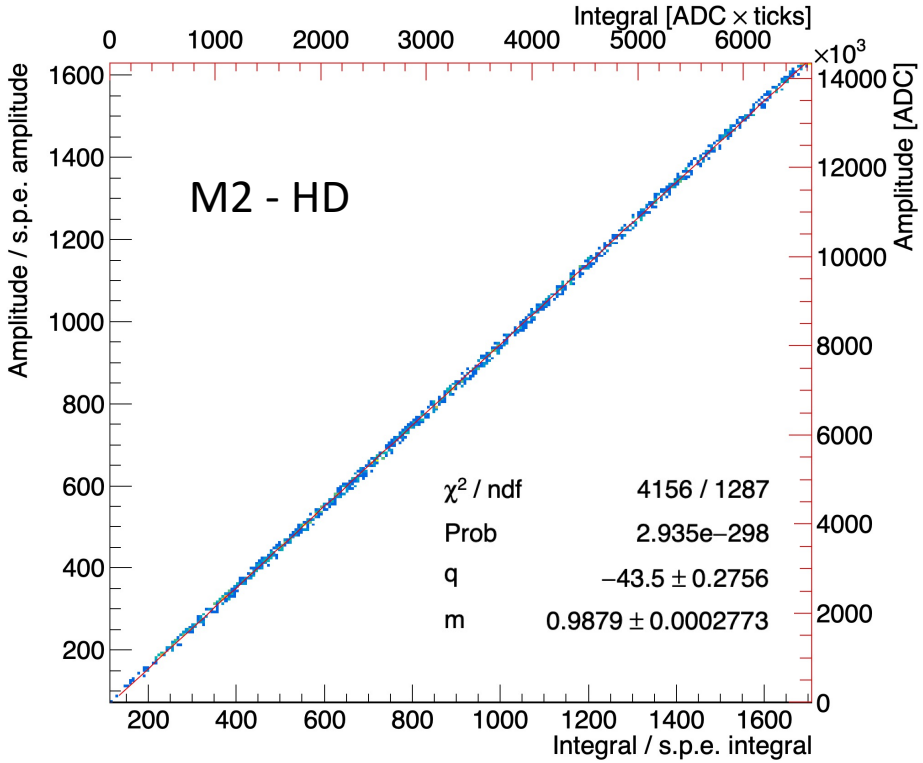
- ➔ This methond doesn't take into account distortions and could be affected by an over/under estimation of the s.p.e. amplitude (done by averaging s.p.e. waveform candidates)

New estimations -> VD = 2050 ph. | HD = 1700 ph.



The slope < 1 indicates an overestimation of the spe ampl

- ➔ This is why I prefer the new method



DAPHNE

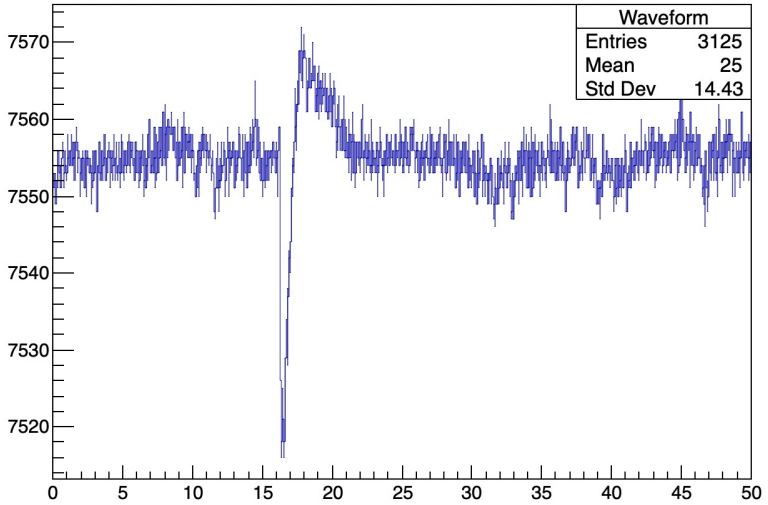
Intro

We had a fistfull of run where membrane modules were read using DAPHNE.

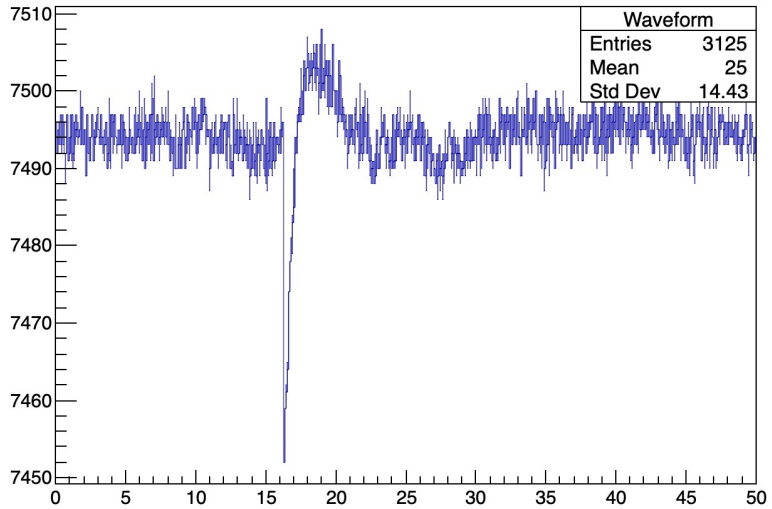
- No fine tuning
- Few runs with reasonable dynamic range
- No LED scans
- Large noise in HD channel in the last runs
- …

Waveforms

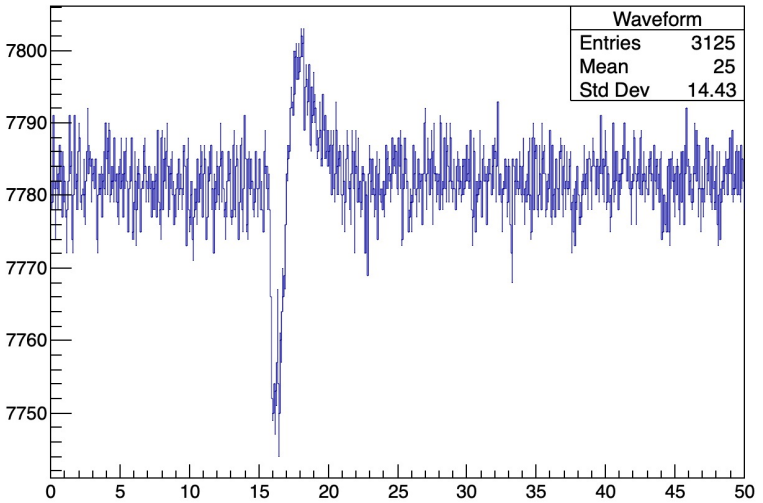
How they look like



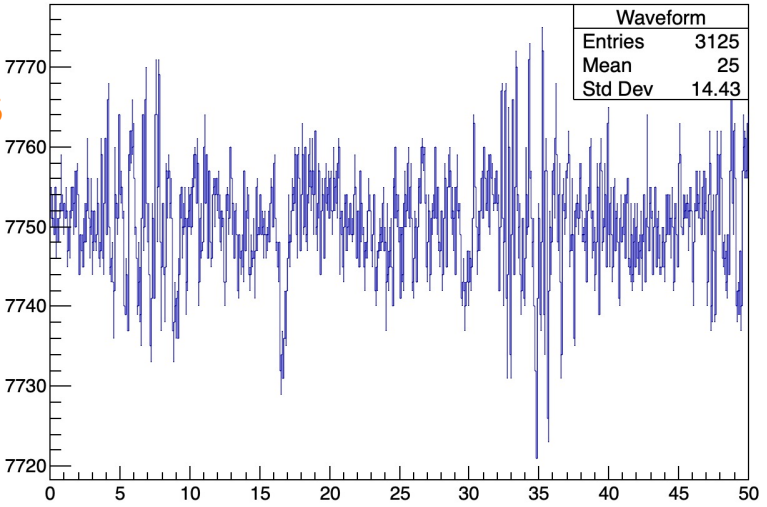
Run 24062 - VD: baseline RMS = 2.4



Run 24062 - HD: baseline RMS = 3.6



Run 24097 - HD: baseline RMS > 6.5



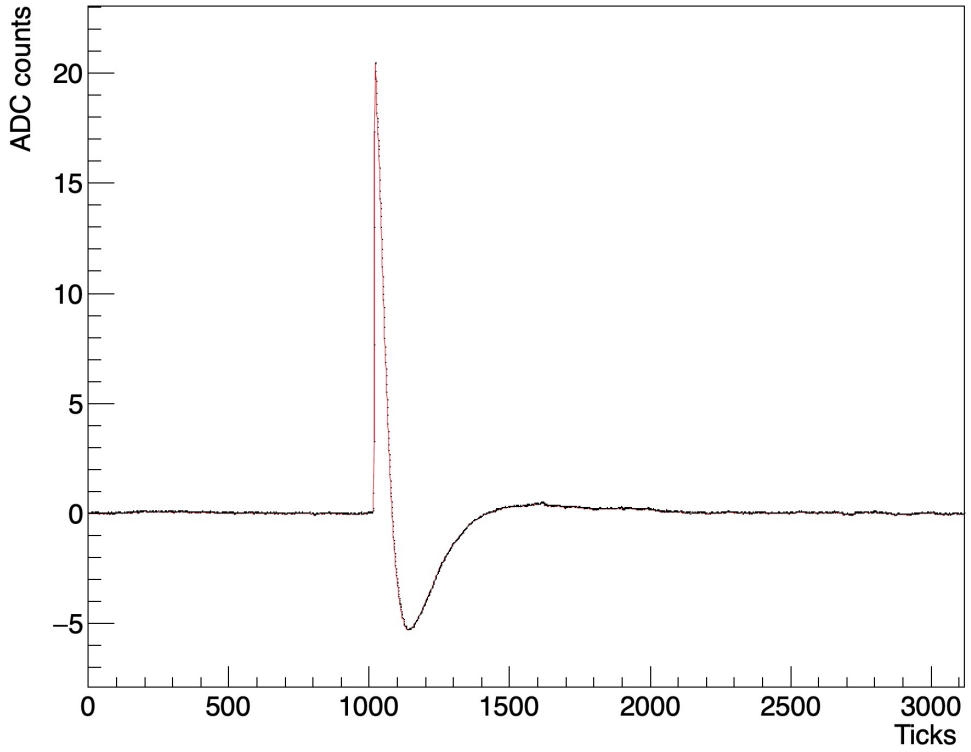
Run 24097 - VD: baseline RMS = 2.6

Average and undershoot

LED data

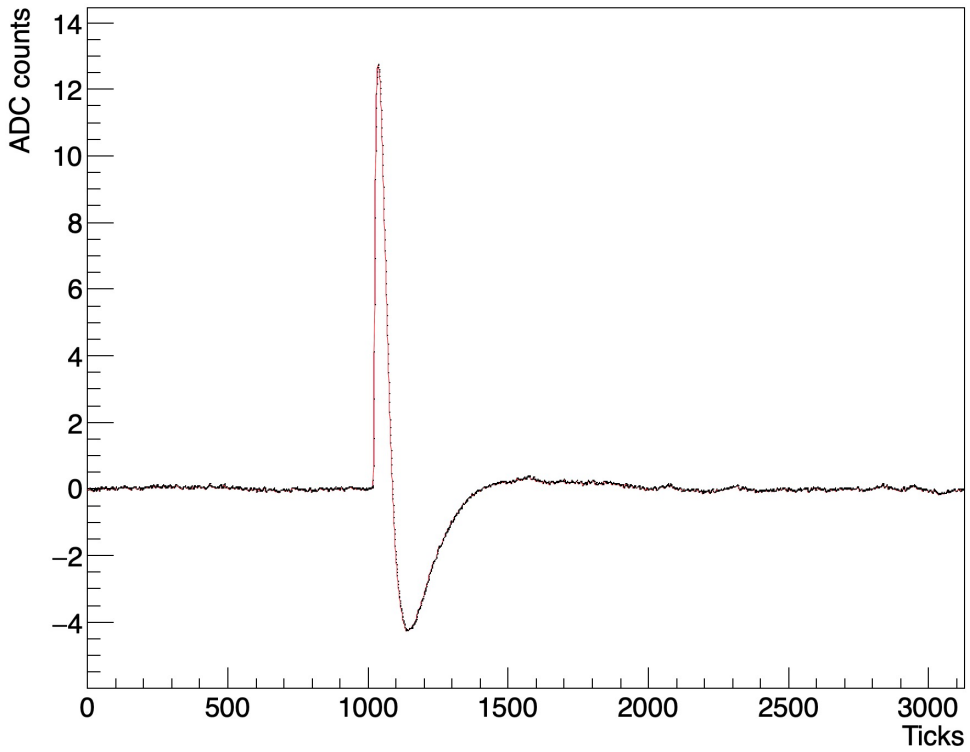
M1 –VD

- Undershoot: 25-26%
- Rise time: 65 ns
- Fall time: 752 ns



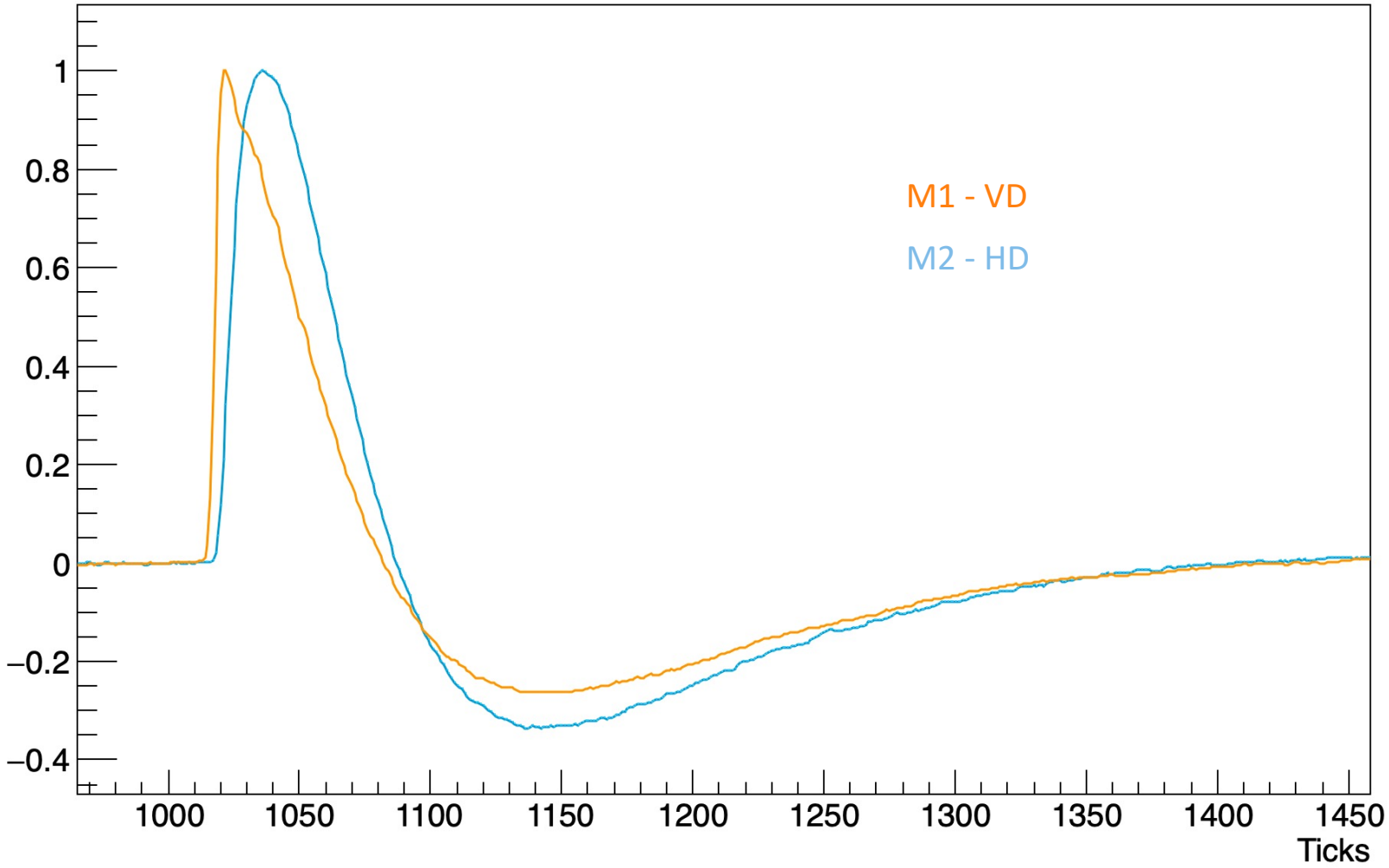
M2 – HD

- Undershoot: 34-35%
- Rise time: 150 ns
- Fall time: 560 ns



Averages and undershoot

Zoom



Noise

FFT and RMS

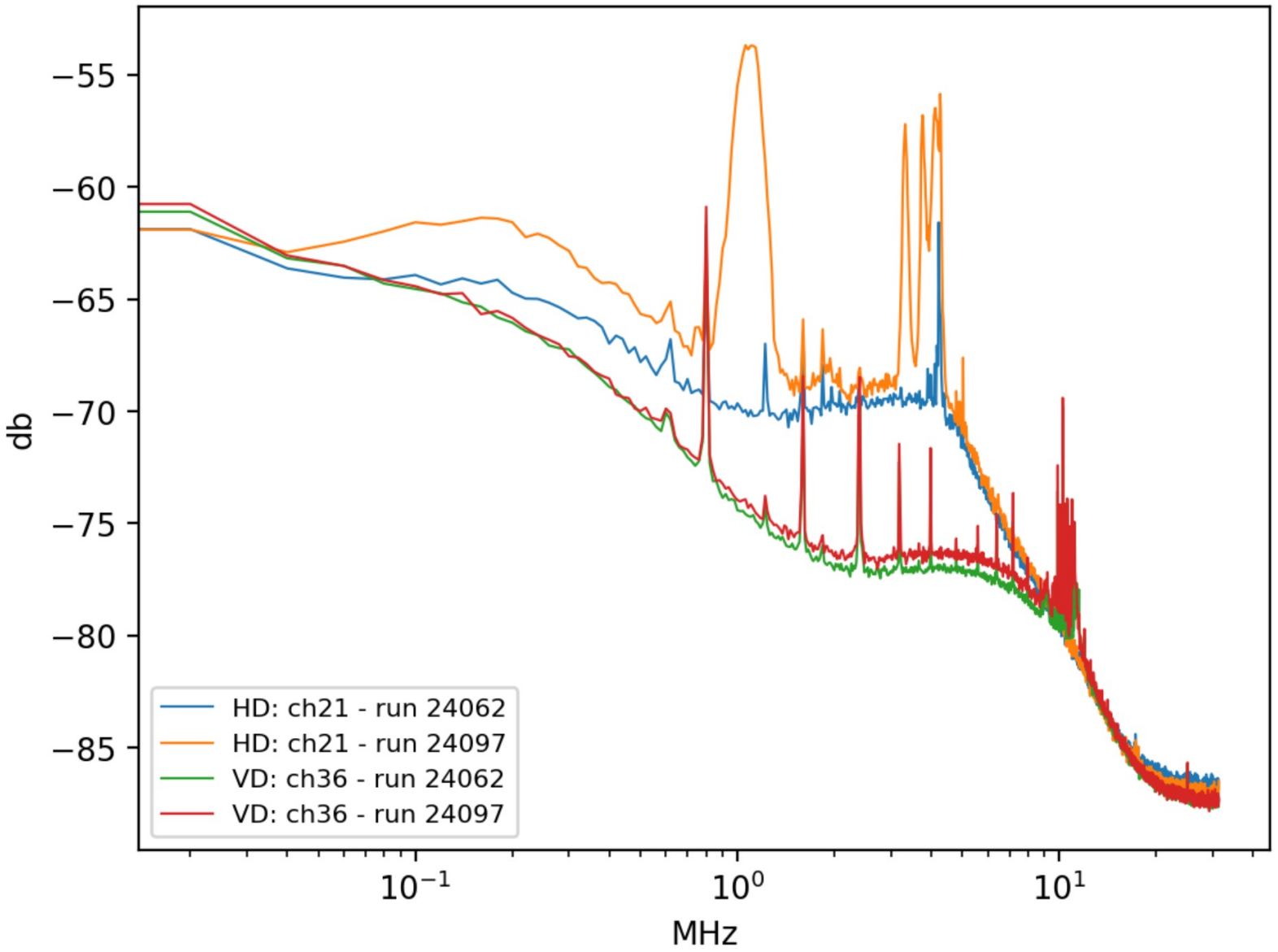
Note the difference between two runs of HD channel

Run 24062 - HD: baseline RMS = 3.6

Run 24097 - HD: baseline RMS > 6.5

Run 24062 - VD: baseline RMS = 2.4

Run 24097 - VD: baseline RMS = 2.6



Results in a nutshell

M1 VD – M2 HD comparison

The best we observed (short integration window)

The best we achieve having set the offset according to the undershoot

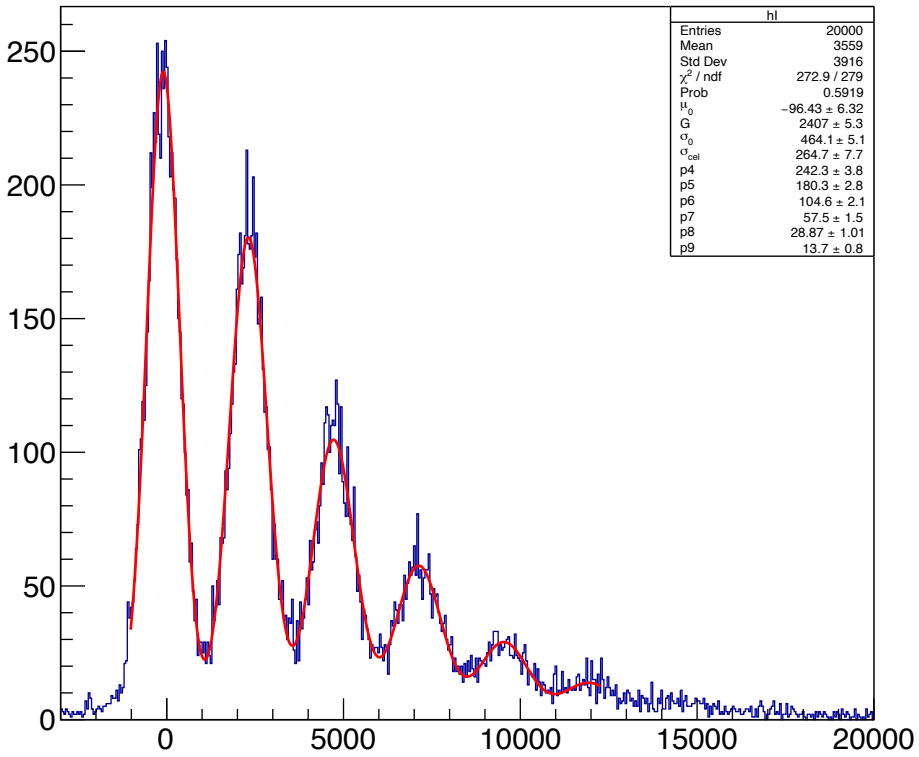
RUN	Digitizer	Module	RMS [ADC]	SNR	SPE Ampl [ADC]	DR	DR ideal
170	CAEN	M1 – VD	3.0	5.2	6.9	2050	| |
170	CAEN	M2 – HD	4.8	7.4	8.8	1700	| |
24062	DAPHNE	M1 – VD	2.4	3.7	8.2	920	1590
24062	DAPHNE	M2 – HD	3.6	4.0	7.5	1040	1630

The only one with reasonable noise, attenuation and dynamic range

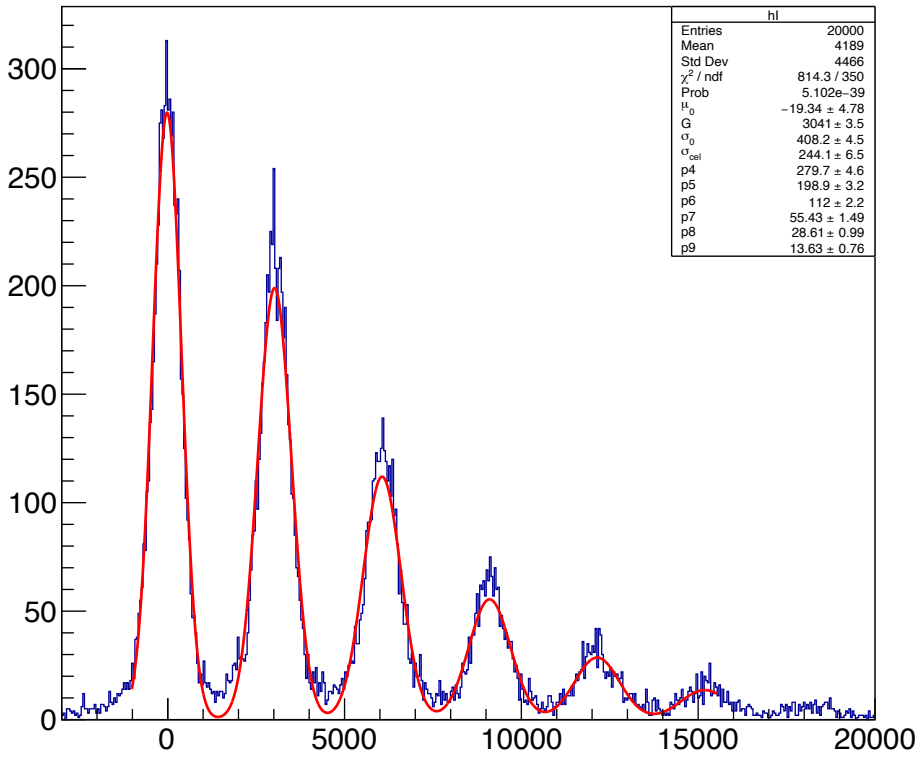
Results in a nutshell

M1 VD – M2 HD comparison SPECRTRA

M1-VD Digitizer
Inttegration window 4070-4600 ticks



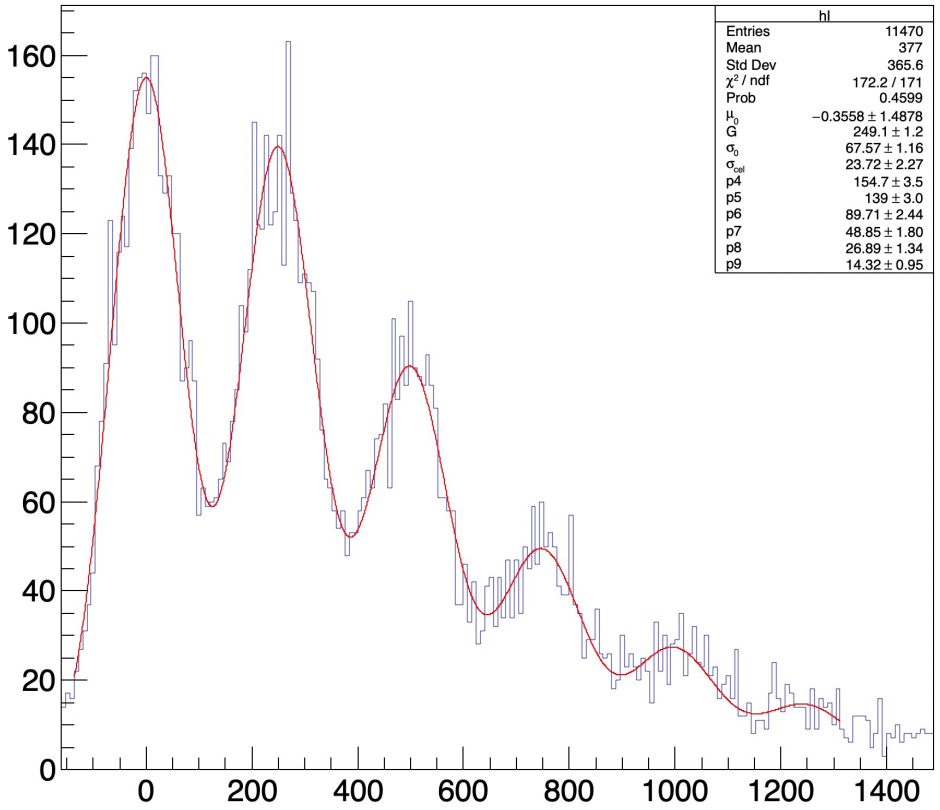
M2-HD Digitizer
Inttegration window 4070-4600 ticks



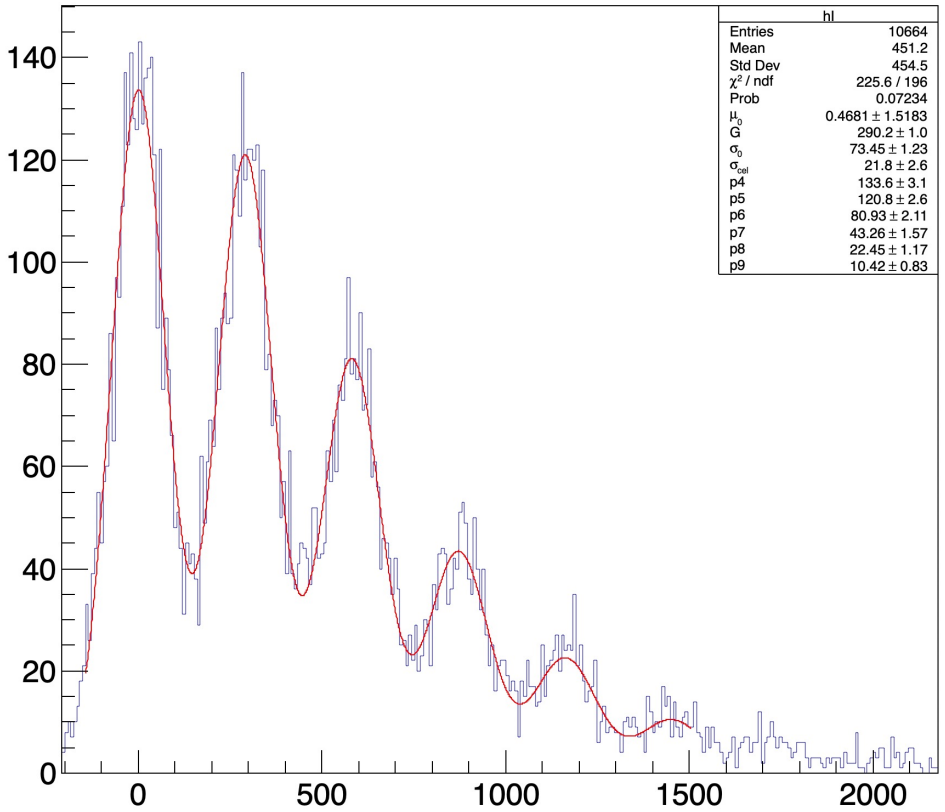
Results in a nutshell

M1 VD – M2 HD comparison SPECRTRA

M1-VD Daphne - Attenuation 1925
Integration window 1015-1065 ticks



M2-HD Daphne - Attenuation 1925
Integration window 1020-1070 ticks



Big big table

M1 VD – M2 HD comparison

RUN	Digitizer	Module	Attenuation	RMS [ADC]	SNR	SPE Ampl [ADC]	DR	DR ideal
170	CAEN	M1 – VD	||	3.0	5.2	6.9	2050	||
170	CAEN	M2 – HD	||	4.8	7.4	8.8	1700	||
24062	DAPHNE	M1 – VD	1925	2.4	3.7	8.2	920	1590
24062	DAPHNE	M2 – HD	1925	3.6	4.0	7.5	1040	1630
24089	DAPHNE	M1 – VD	1330	4.4	8.6	21.4	310	606
24089	DAPHNE	M2 – HD	1330	>16	4.4	20.5	350	592
24097	DAPHNE	M1 – VD	1860	2.6	3.7	9.4	800	1390
24097	DAPHNE	M2 – HD	1860	>6.5	3.5	8.7	890	1390
24098	DAPHNE	M1 – VD	1330	4.7	7.7	20.5	320	635
24098	DAPHNE	M2 – HD	1330	>15	4.8	20	360	610

Big big table

M1 VD – M2 HD comparison

HD	Run	Int win	erase	V Bias	Attenuation	mu0	emu0	Gain	eGain	s0	es0	SNR	SPE	U %	Baseline	DR	DR Ideal	RMS	Rise	Fall
CH 1	24037	2515-2570	0	?	600	-14	8	2103	4	306	11	6.872549	62	34	5275	85.080645	197.20751		176	560
		2519-2590	0	?	600	-7	9	2312	4	346	12	6.6820809	62	34	5275	85.080645	197.20751		176	560
CH 21	24062	1020-1070	1500	32.5	1925	0	2	290	1	73	1	3.9726027	7.5	34	7782	1037.6	1630.2488	3.6	144	560
		1010-1085	1500	32.5	1925	1.5	2.8	308	2	95	2	3.2421053	7.5	34	7782	1037.6	1630.2488	3.6		
	24089	1020-1070	1500	32.5	1330	2.9	3.7	709	2	162	3	4.3765432	20.5	35	7180	350.2439	592.01445	16 ?	144	560
		1005-1085	1500	32.5	1330	14	6	741	4	214	5	3.4626168	20.5	35	7180	350.2439	592.01445	16 ?		
	24097	1020-1070	1500	32.5	1860	0.6	2.3	309	1	88	2	3.5113636	8.7	35	7745	890.22989	1394.9766	6.5 ?	160	560
		1010-1085	1500	32.5	1860	0.8	4.5	331	2	118	3	2.8050847	8.7	35	7745	890.22989	1394.9766	6.5 ?	160	560
	24098	1020-1070	1500	32.5	1330	2.4	3	706	2	146	3	4.8356164	20	35	7190	359.5	606.81481	15	144	544
		1010-1085	1500	32.5	1330	16	6	752	3	191	4	3.9371728	20	35	7190	359.5	606.81481	15	144	544
VD	Run	Int win	erase	V Bias	Attenuation	mu0	emu0	Gain	eGain	s0	es0	SNR	SPE	U %	Baseline	DR	DR Ideal	RMS	Rise	Fall
CH 26	24037	2515-2570	0	?	600	-23	5	1790	2	141	5	12.695035	62	25.806452	3950	63.709677	210.05128		112	672
		2510-2580	0	?	600	-24	5	1820	2	153	5	11.895425	62	25.806452	3950	63.709677	210.05128		112	672
CH 36	24062	1015-1065	1500	32.5	1925	0	1.5	249	1	67	4	3.7164179	8.2	25.609756	7555	921.34146	1590.6796	2.4	64	752
		1010-1080	1500	32.5	1925	4	3	259	2	88	2	2.9431818	8.2	25.609756	7555	921.34146	1590.6796	2.4	64	752
	24089	1015-1065	1500	32.5	1330	-1	1.6	632	1	73	1	8.6575342	21.4	26.3	6635	310.04673	606.18169	4.4	64	752
		1010-1080	1500	32.5	1330	0	2	654	1	80	2	8.175	21.4	26.3	6635	310.04673	606.18169	4.4	64	752
	24097	1015-1065	1500	32.5	1860	1.3	2.4	286	1	86	1.6	3.3255814	9.4	25.3	7495	797.34043	1391.0445	2.6	64	752
		1010-1080	1500	32.5	1860	0.6	2.7	287	2	92	5	3.1195652	9.4	25.3	7495	797.34043	1391.0445	2.6	64	752
	24098	1015-1065	1500	32.5	1330	-2.3	1.5	627	1	81	1.3	7.7407407	20.5	25.8	6645	324.14634	635.30963	4.7	64	752
		1010-1080	1500	32.5	1330	0.7	1.9	650	1	97	1.5	6.7010309	20.5	25.8	6645	324.14634	635.30963	4.7	64	752