DUNE VD - Cold Box Dec 2024 run

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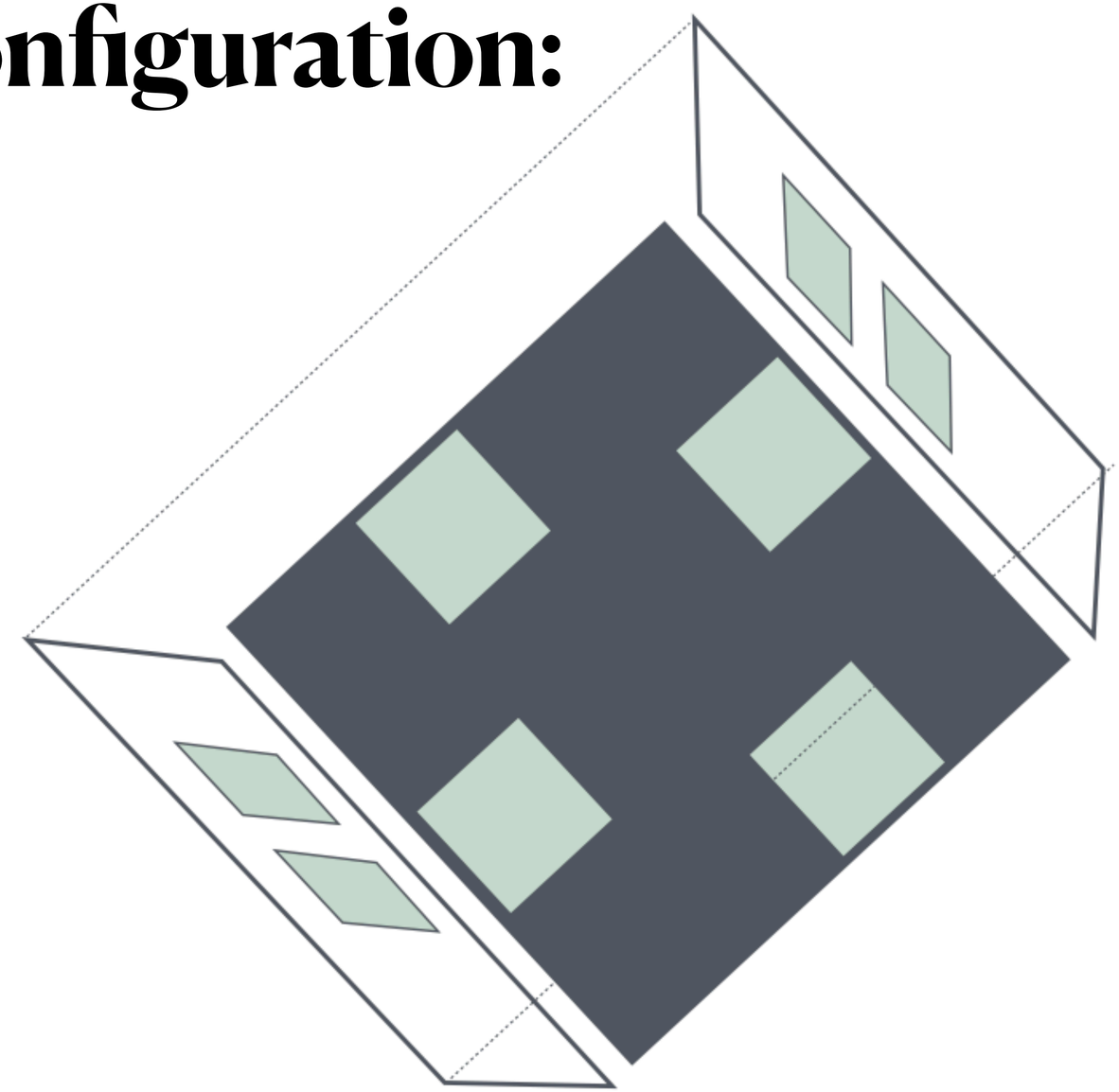
Dec 10th, 2024

Dec. 2024 Cold Box configuration:

Proposal: 8x X-Arapuca modules

- 4x cathode moduel
- 4x membrane modules

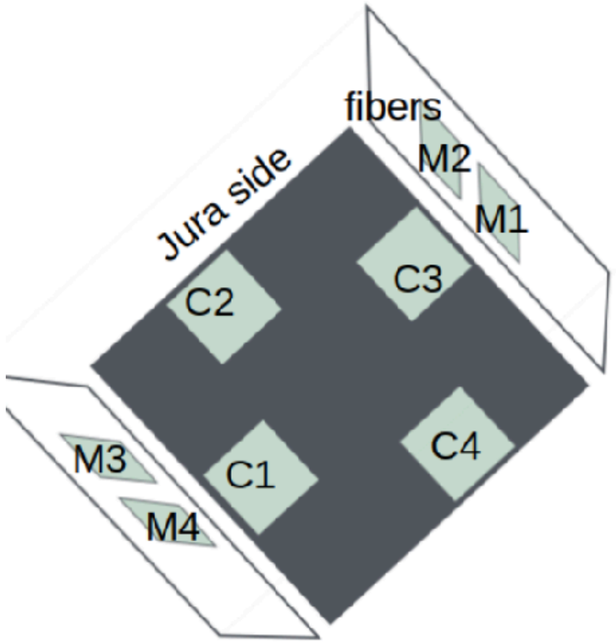
= 1/2 of Module 0 setup



Cold Box configuration details

https://docs.google.com/spreadsheets/d/1N9xcb2VVlzzDcNfBjlj_buhH9LiBTdG8-cnisb-orsI/edit?gid=0#gid=0

Module Name	Module Position	Frame Version/ID	WLS	backplane	Filters brand	ID	SiPMs model number	Nominal Bias voltage	Cold Electronics	DCDC ID / V_w / V_c
Nov24M-A	M1	V.M1- April CBM1	40mg/kg 2023P001S001-FD2T40B (April CBC3)				HPK (4new MiB + 4 Old FNAL) - 3x in ch1 and 3x ch2	47V	VD-style - DVDM 2.0 - 1k	-
Nov24M-B	M2	V.M1- April CBC3	40mg/kg 2024P001S001-FD2T40A (new)	vikuiti	ZAOT		HPK (from April CBC3)	47V	VD-style - DVDM 2.0 - 2k	-
Nov24M-C	M3	V.M1- New Prod.	40mg/kg 2024P002S001-FD2T40B (new)				FBK - TT (New_10%+)	32.5V	HD-style	-
Nov24M-D	M4	V.M1- New Prod.	40mg/kg 2024P002S001-FD2T40A (new)				FBK - TT (New_10%+)	32.5V	HD-style	-
Nov24C-A	C2	V.M1 April CBC1	40mg/kg 2023P001S001-FD2T40C (April CBC1)	vikuiti	ZAOT (April CBM1)		FBK - TT (New from MiB)	32.5V	DCEM 1.31 LMH - 2.4k / 3.3 Ohm	IA36 / 39.0V / 32.61 V
Nov24C-B	C3	V.M1-April CBM2	40mg/kg 2023P001S001-FD2T40E (April CBM2)	vikuiti	ZAOT		FBK - TT (from April CBM1-M2)	32.5V	DCEM 1.31 LMH - 2.4k / 3.3 Ohm	IA33 / 39.1 V / 32.75 V
Nov24C-C	C4	V.M1-New Prod.	24mg/kg 2023P001S001-FD2T24E (April CBM1)		Old CBC1-top		FBK - TT (from old M0_C3) - 3x in ch2	32.5V	DCEM 1.31 LMH - 2.4k / 3.3 Ohm	IA34 / 40.0V / 32.46 V
Nov24C-D	C1	V.M1-New Prod.	40mg/kg 2024P002S001-FD2T40C (new)		dichroics/substrates mix		FBK - MT (from April CBC1)	31.5V	DCEM 1.31 LMH - 2.4k / 3.3 Ohm	~~from April CBC1~~ Modified IA37 / 36.5V / 31.1 V



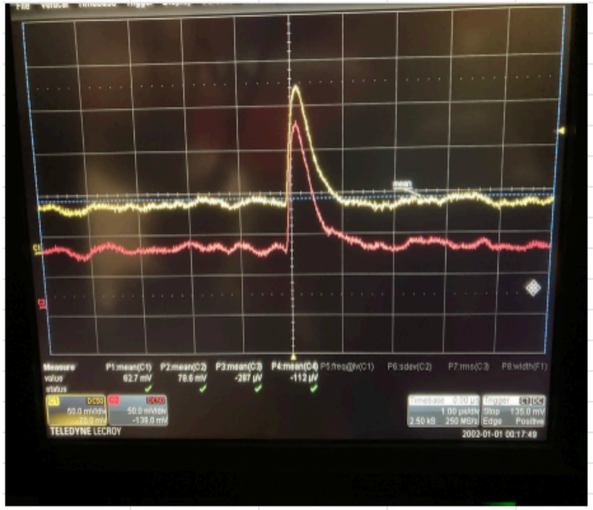
- X-Arapuca modules M1 frame style
- Thick WLS (5.5 mm, 40mg/kg)
- Dichroic /substrate mix

- 4x cathode moduel equiped with:
  - PoF/SoF, DCEM (bipolar style, larger gain)
  - (3+1) x8 ~~HPK~~ FBK Flexes
- 4x membrane modules equiped with:
  - 2x HD-style CE and 2x VD-style 2.0 CE.
  - 2x8 New FBK Flexes and 2x8 HPK Flexes

End of November we had 4+4 X-Arapuca modules in the Cold Box

Warm test after roof closure (Nov. 28th 2024)

C1



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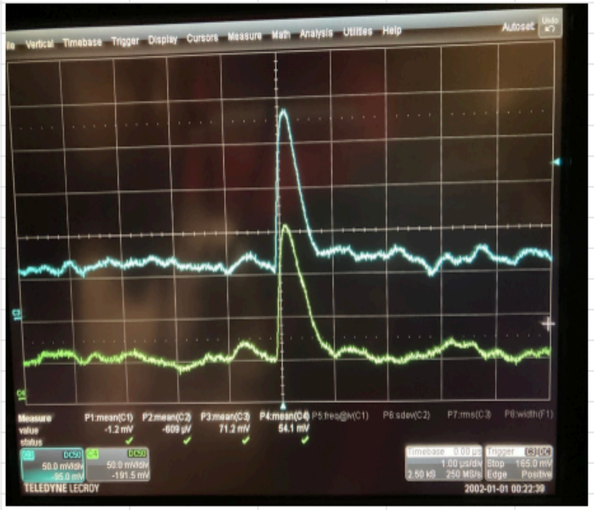

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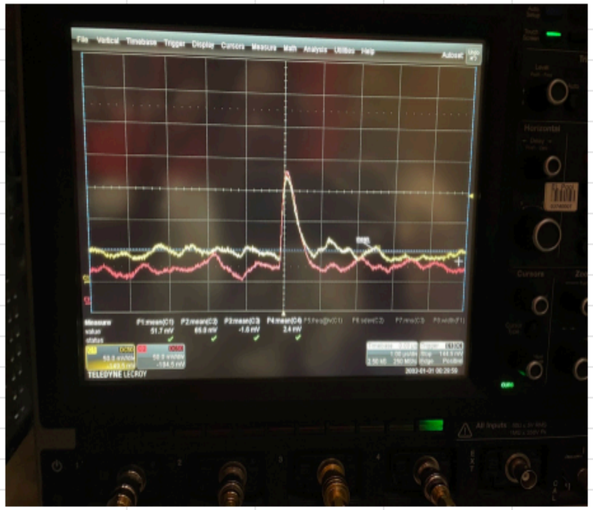

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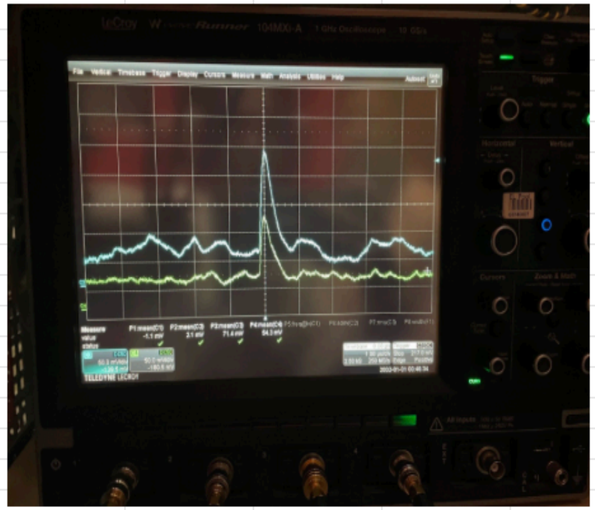
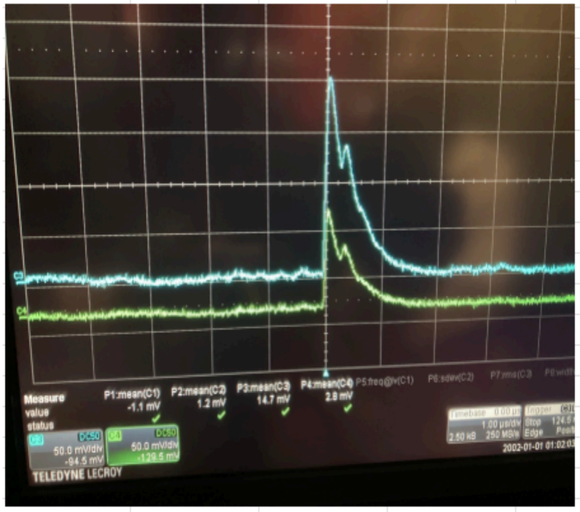


M1



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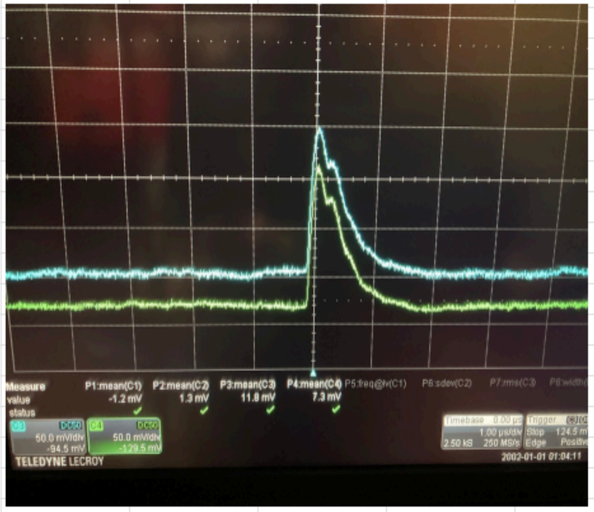
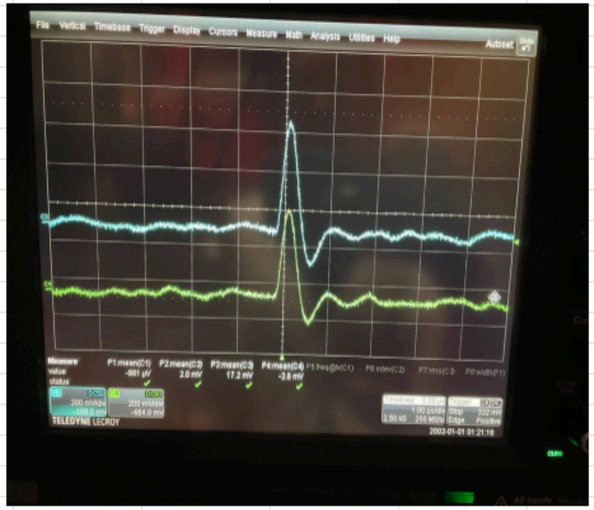
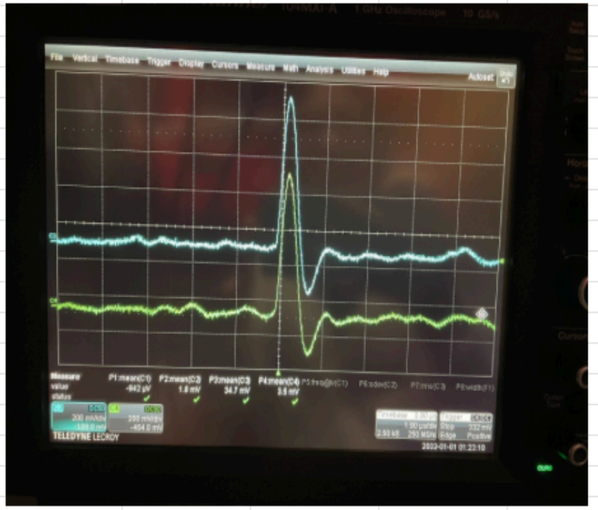


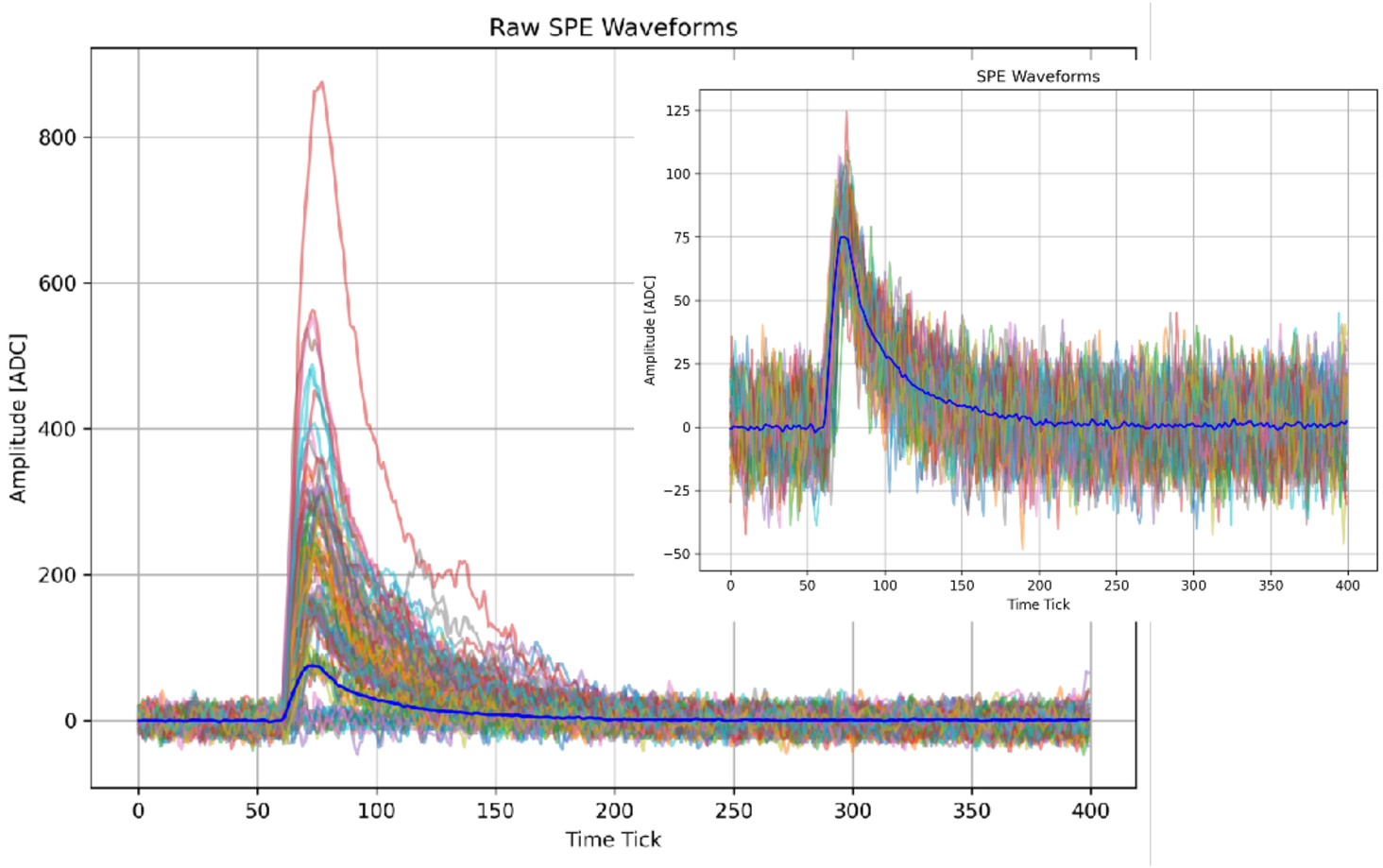
M3

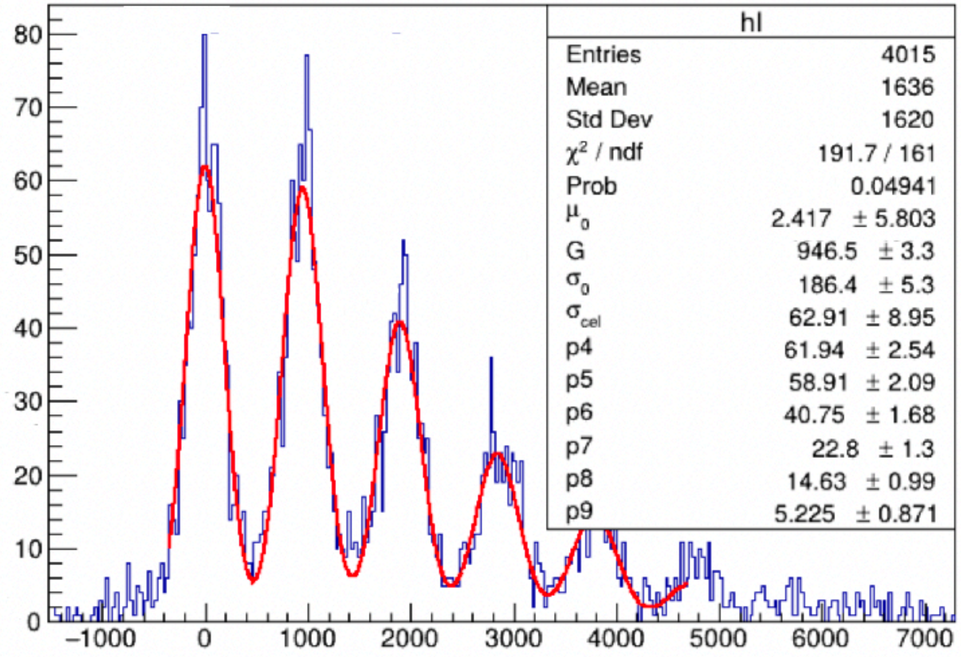


M4



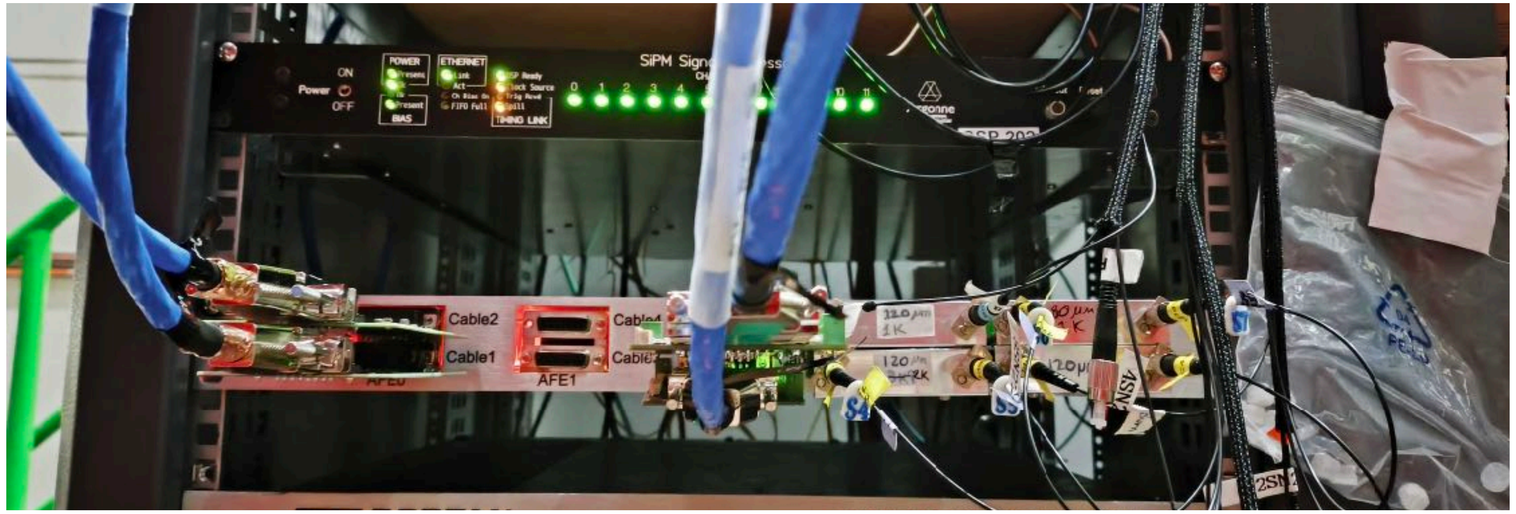
Snaps of preliminary analysis





Plot form Federico and Dante

Warm electronics



- All the modules are read through a Daphne integrated into the DAQ
- An SSP is used to drive the calibration LED system
- Remote acquisition is ongoing (see data-taking plan)

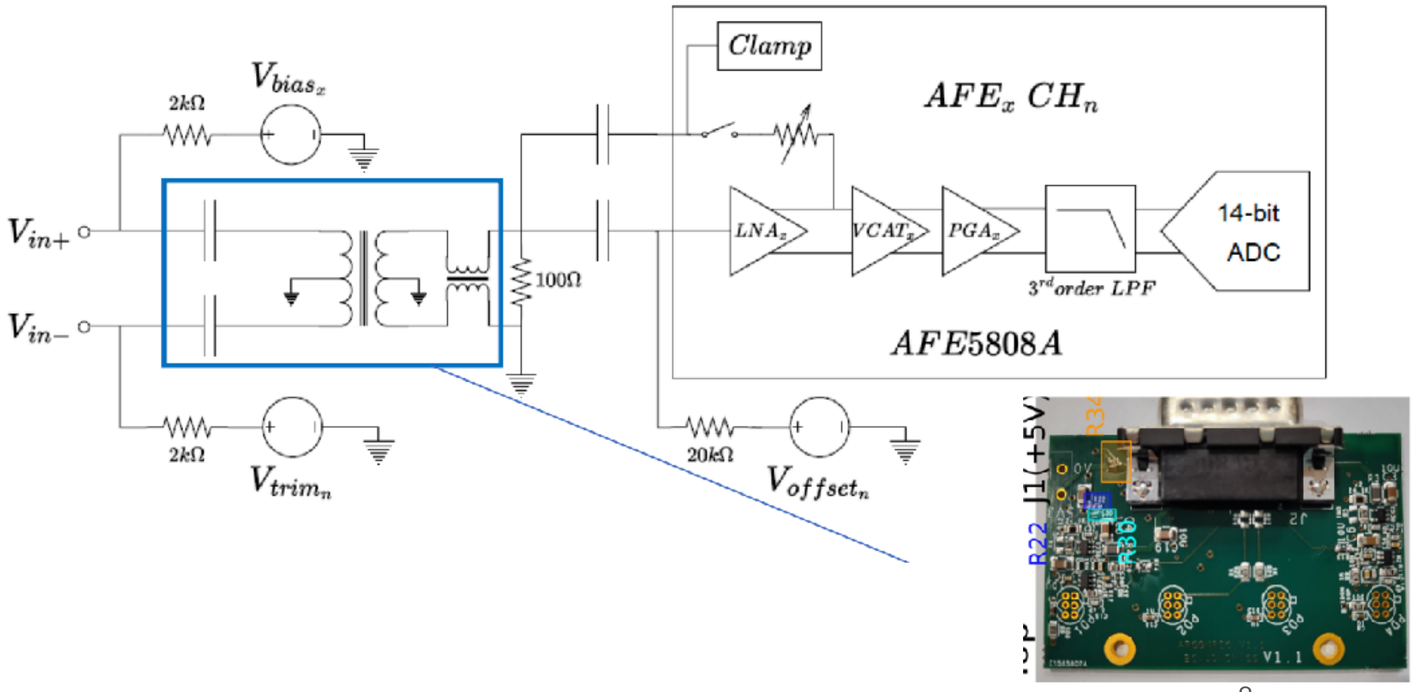
Initial runs were also taken stand-alone using:

- Oscilloscope (mainly for WF's screenshot) + external LED driver
- CAEN + external LED driver
- stand-alone Daphne (spy-buffer + laptop) + external LED driver

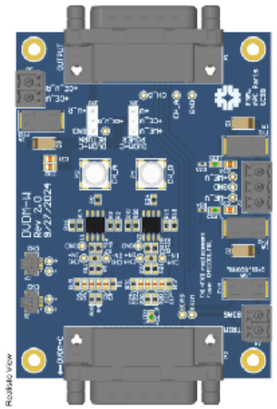
Daphne and Warm stages

All three solutions use dedicated warm stages, bypassing the Daphne transformer:

- Full-differential to single-ended for membrane modules
- SoF to single-ended for cathode models



Warm stages will be moved inside Daphne as mezzanine boards.



Daphne undershoot mitigation

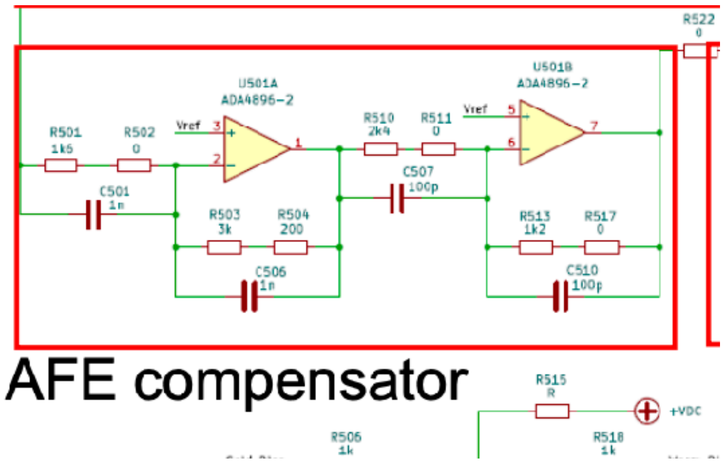
The transformer used by Daphne to perform the full-differential to single-ended conversion introduces a huge undershoot: ~25%.

In the VD PDS readout solution, the Daphne transformer is bypassed:

- SoF converts light in the single-ended signal (no need for the transformer)
- The two membrane CE solutions (HD-style and VD-style) use dedicated active stages for the full-differential to single-ended conversion

Although the undershoot has significantly decreased, a notable contribution of approximately 5-6% remains, due to the AFE chip.

To mitigate the remaining undershoot, an analog compensator has been developed by E. Cristaldo, C. Gotti (see here).

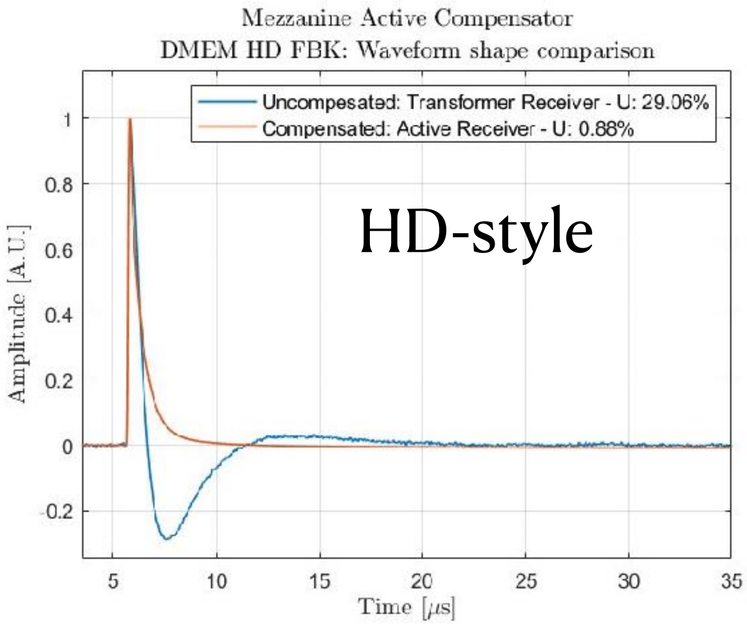


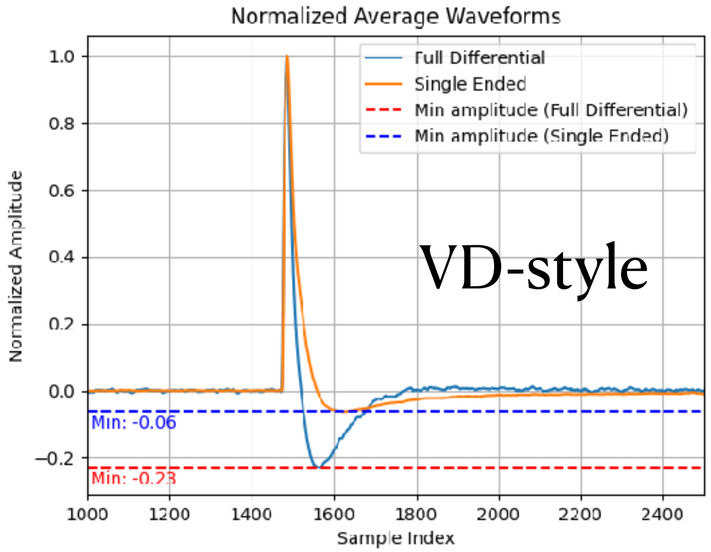
AFE compensator

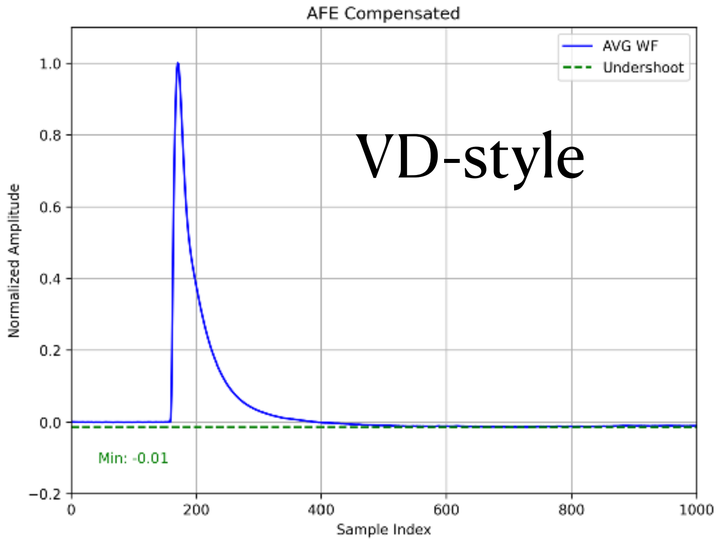
Daphne undershoot mitigation

Active receivers + AFE compensator show signals with an undershoot $\lesssim 1\%$

Both HD-style and VD-style see similar signals







The reduced undershoot allows:

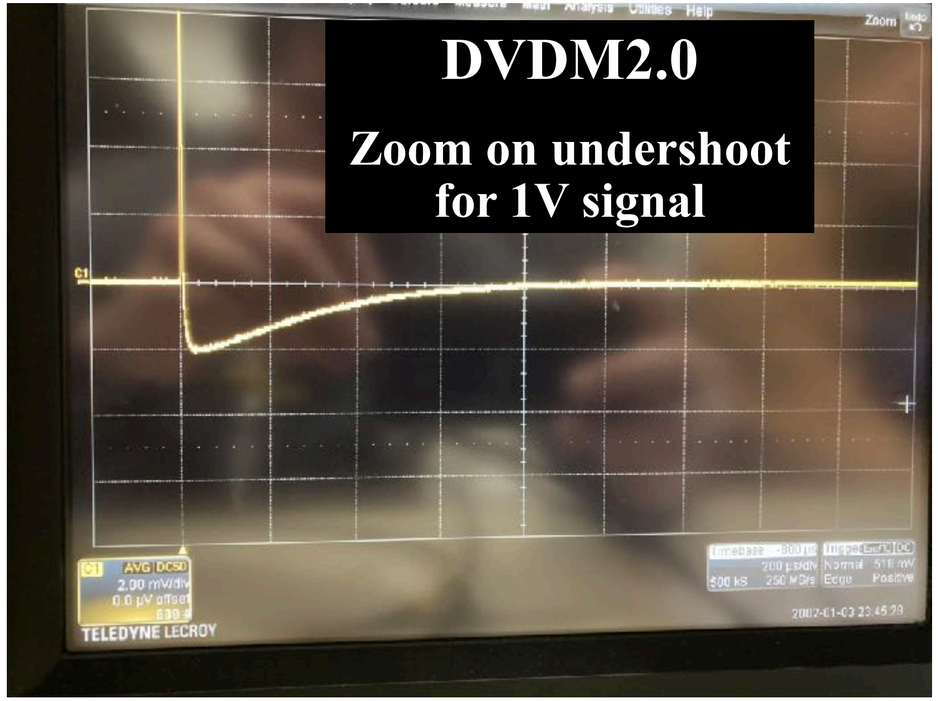
- **for a reduction of Daphne attenuation (larger SNR) while maintaining the ADC dynamic range.**
- **for the offset to be configured at a minimum level to have a single-sided full dynamic range.**

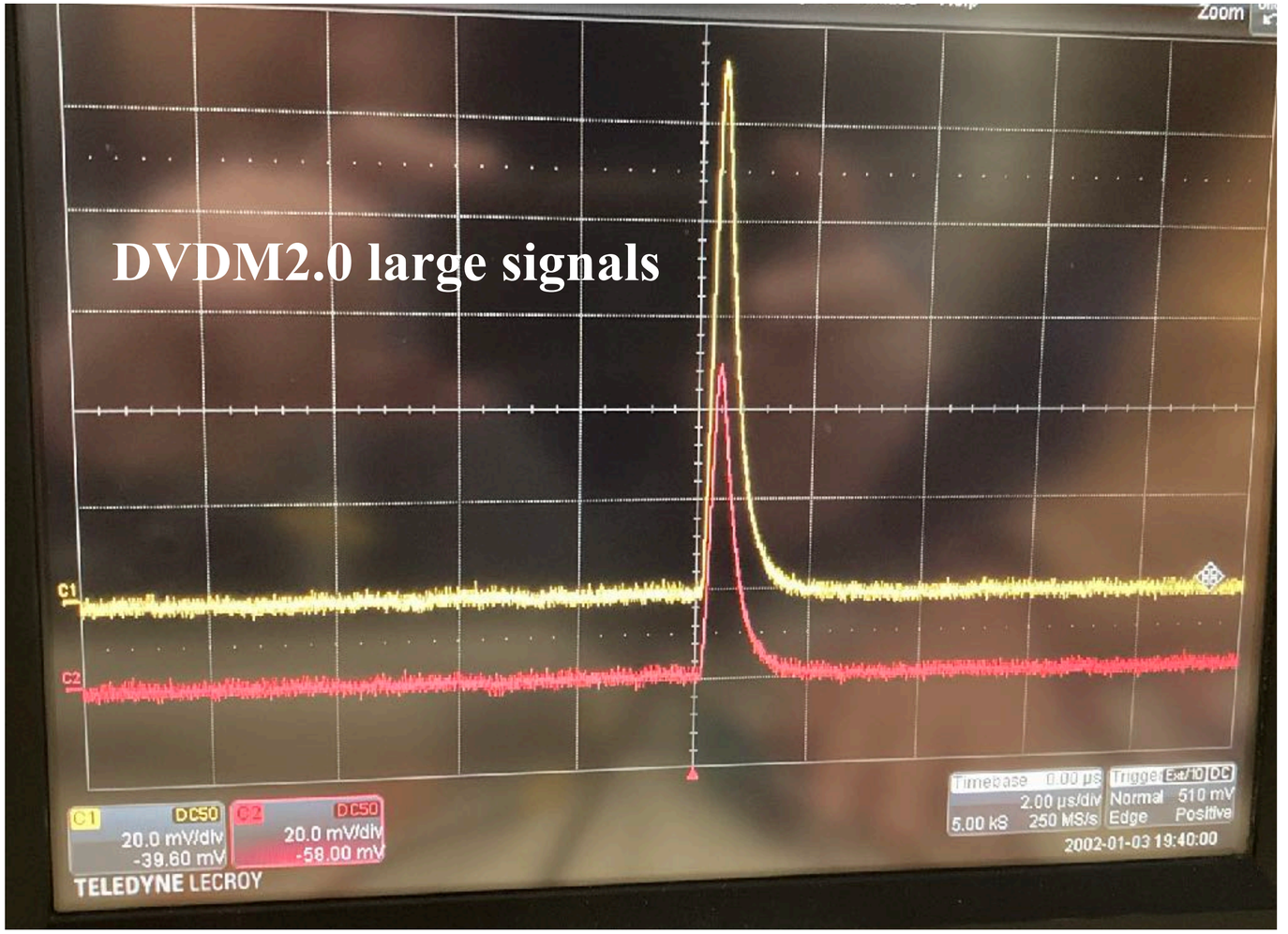
Plot form Esteban and Dante

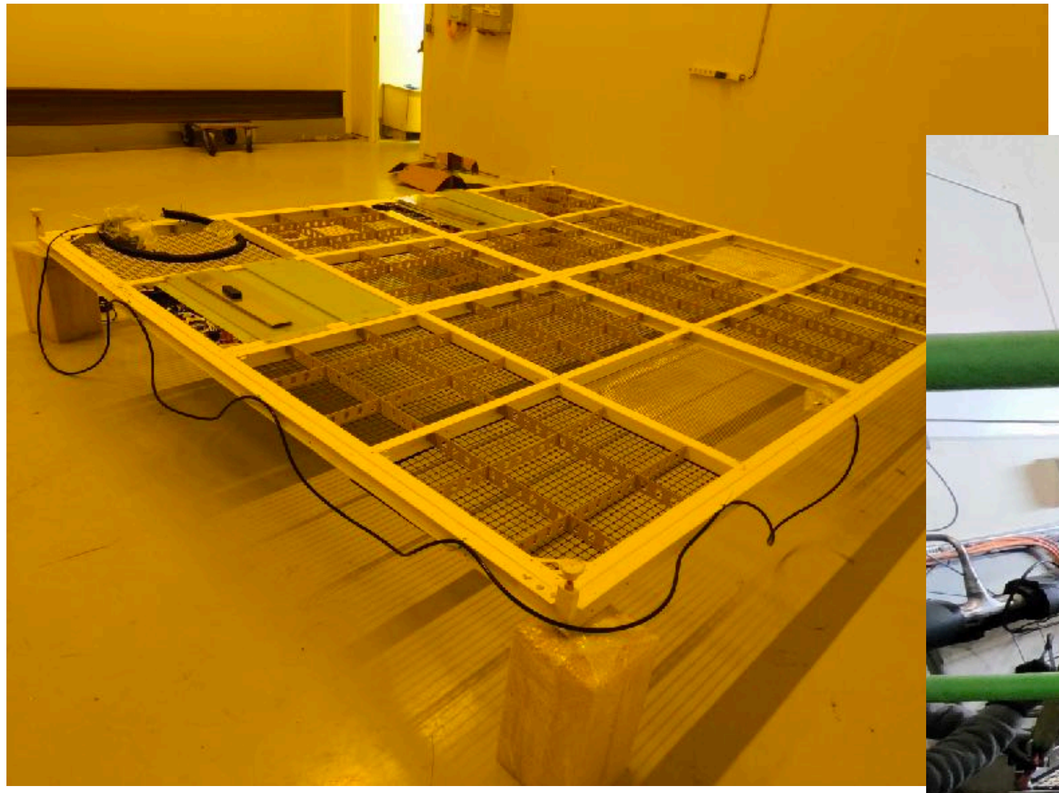
Example from DVDM_2.0 C+W oscilloscope

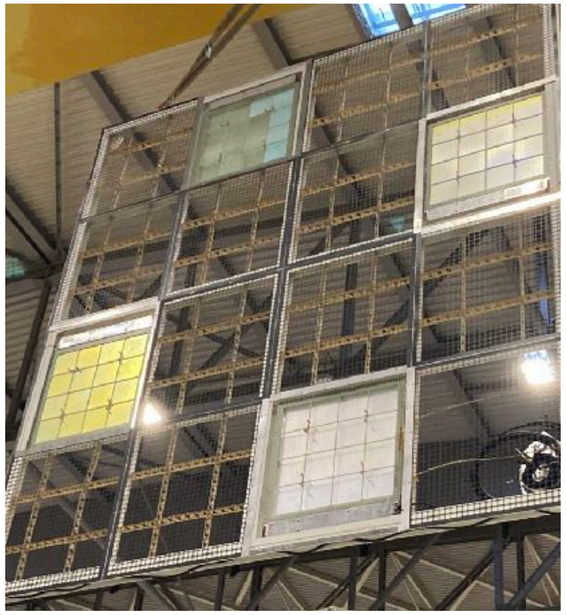
DVDM 2.0 C+W stage shows an undershoot of **0.2%** when read through an oscilloscope

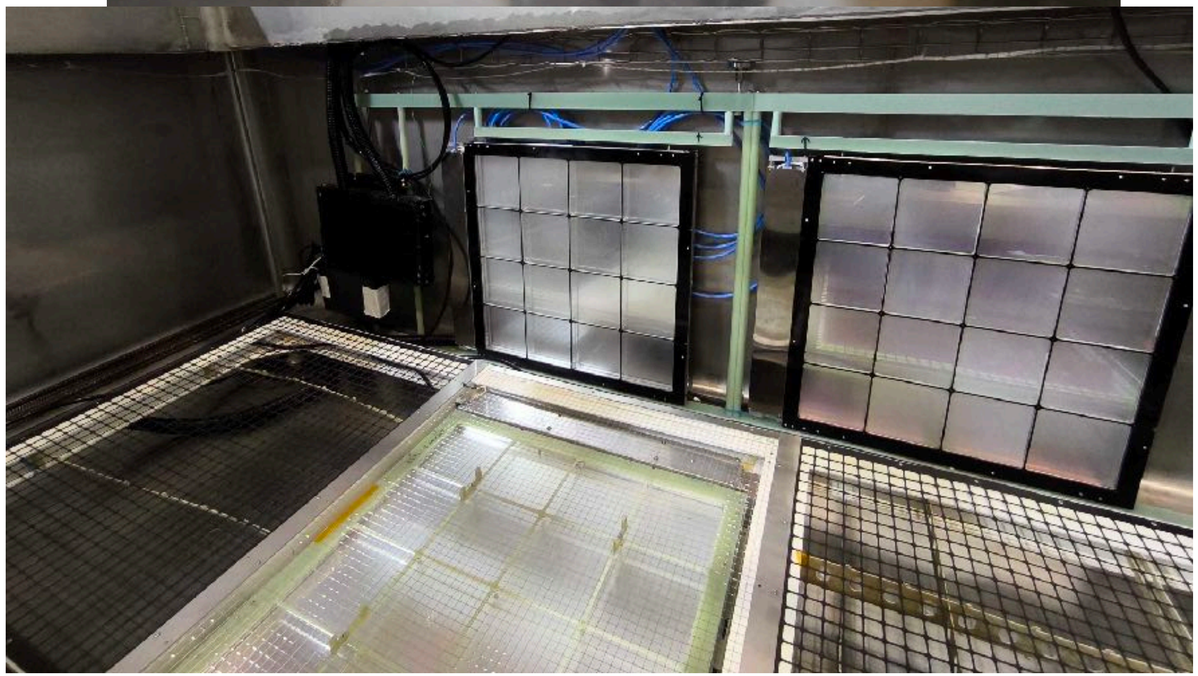
Further tuning of the compensator can reduce the remaining undershoot

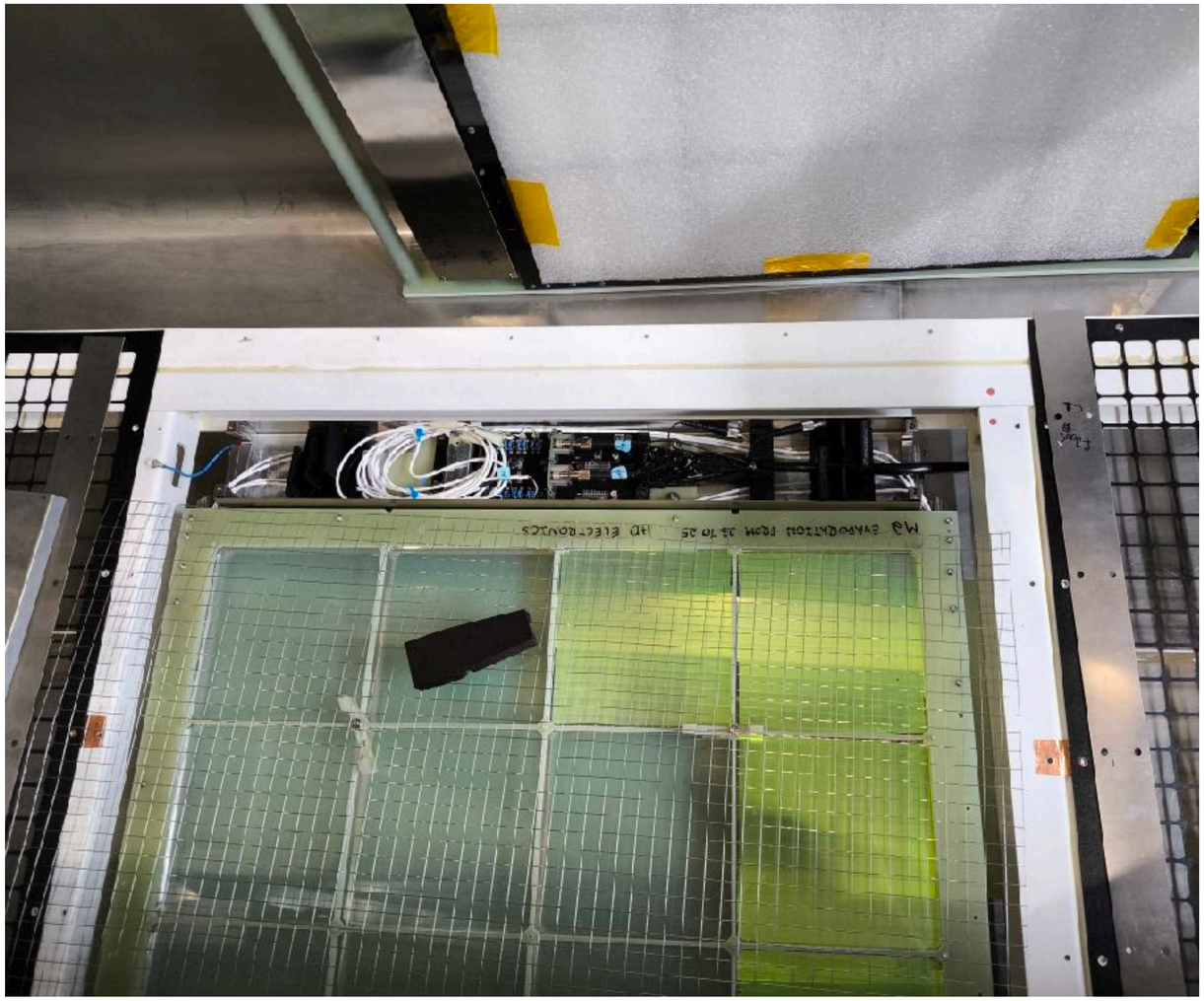






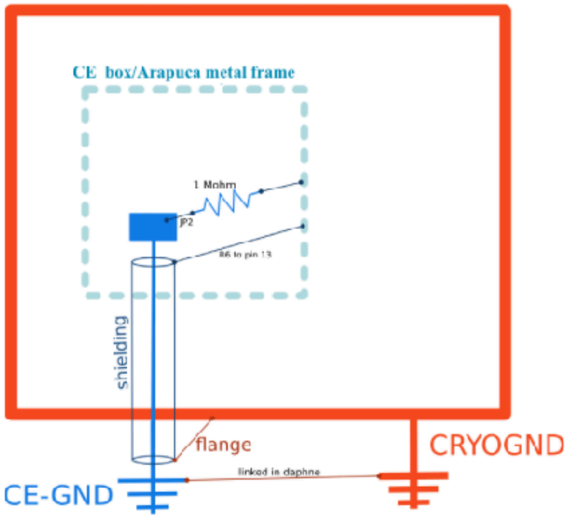






Membrane module grounding check

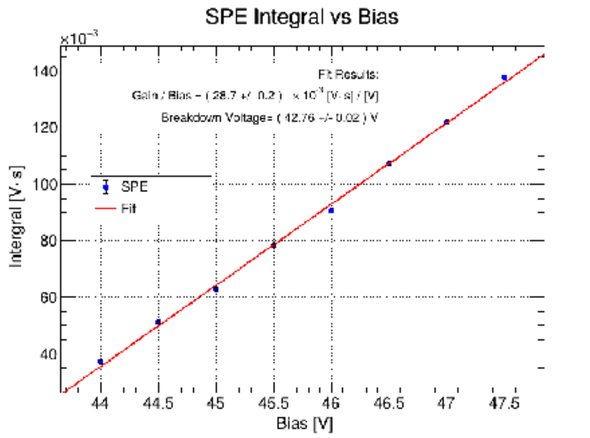
Grounding scheme recommendation
for protoDUNE VD (module 0)

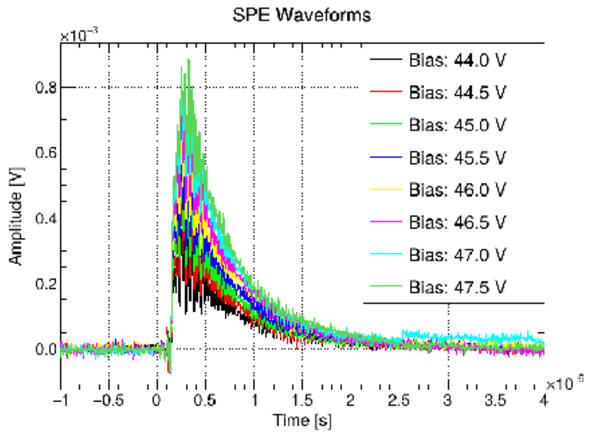


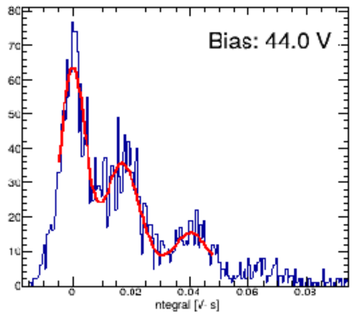
Module Name	Module	Style	Groundin g	Check before installation:		Check after module installation before cable plugged (M) / Wire connected (C)	Check after cable plugged (A) / Wire connected (C)	
	Position		Scheme	Frame / CE Box	A_GND	Frame/CE Box	Frame/CE Box	Analog_GND
				DB15 Shielding (M) /Mesh pin (C)	CE Box	Cryostat Wall (M) / Cathdoe Frame (C)	Cryostat Wall (M) / Cathdoe Frame (C)	CE Box/Frame/ Cryostat Wall (M) / Cathdoe Frame (C)
Nov24M-A	M1	Membrane VD	standard	0 Ohm	1 MOhm	open	0 Ohm	1 MOhm
Nov24M-B	M2	Membrane VD	standard	0 Ohm	1 MOhm	open	0 Ohm	1 MOhm

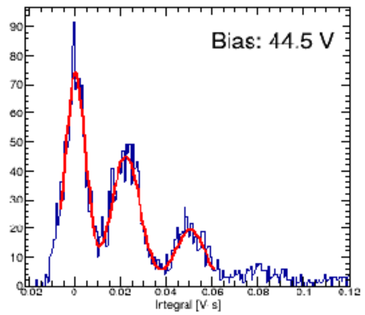
Snaps from TestStand Analysis

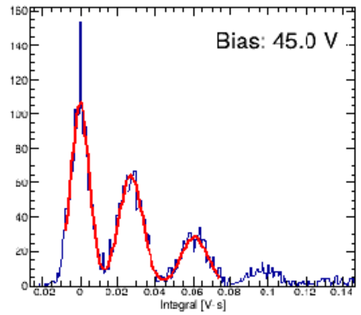
https://indico.fnal.gov/event/67146/contributions/304172/attachments/183441/252172/DVDM 2.0 TestStand@CERN Nov24.pdf

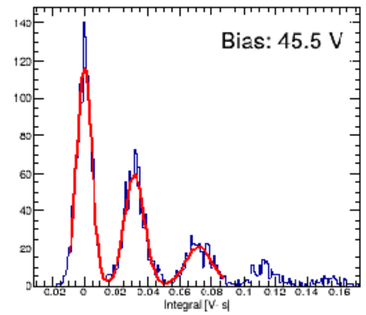


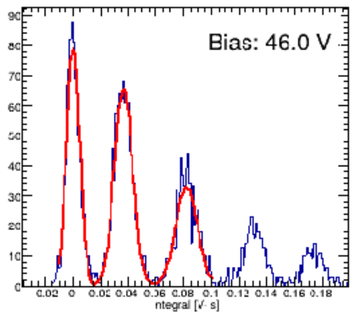


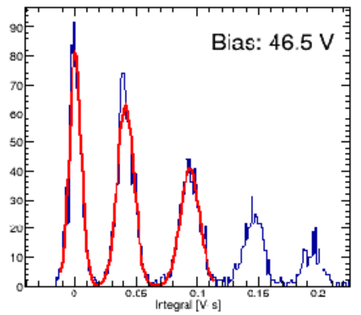


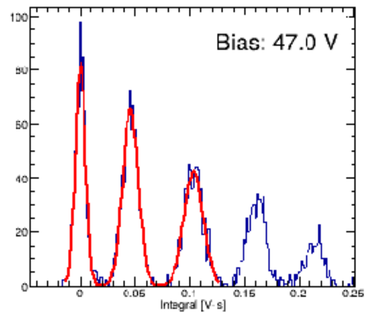


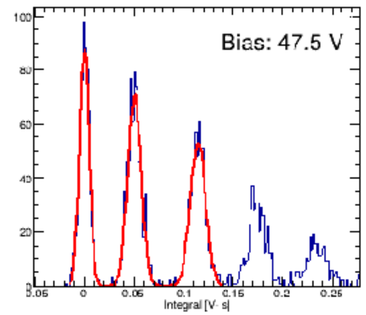












Plots from Francesca