mPMT Electronics Poland

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Hardware Status

- HV status
  - Few modifications by INFN related to part availability
  - Arrived (1500 pcs.); remaining 500 pcs. Possible for Oct/Dec 2022.
- Automated HV tester
  - Design ready, components purchased, expecting commissioning in August
  - Firmware is partially written (for STM32 on Nucleo boards)
- FE status
  - Schematic and layout complete, Parts ordered and confirmed, PCB for Prototype delivery this week.
  - Critical parts purchased for 620 pcs.
  - Delayed MCU delivery for remaining 1400 pcs. (was Sept. 2022, now June 2023)
  - Firmware complete
    - Some fixes related to debugging comm issues with Rev. 1 mainboard
- Mainboard status
  - Two mainboards in Poland to taking data
  - Additional information by M. Nurek
  - Remote access to the board is working

MCC status

Hardware:

- we finished the specification describing the MCC elements and their connection with each other

https://docs.google.com/document/d/1MGmCEbf3xMTG_4EMxsDc7Y85fvLZdGxe/edit

- we are currently working on the electrical diagram and PCB

Software:

- the main function of MCC will be to transfer data between ports, similar to Ethernet hub or switch

- hardware development board will test 2 connections of mPMT to one aggregation. Prototype, 2 to 1 communication, two mPMT "input ports" to one data aggregation "output port" (these are not exactly inputs/outputs - communication is two-way).

- like in an ethernet hub or switch, data from mPMT 1 and 2 goes to the aggregation port, and data from the hub to both mPMT 1 and 2 as in an ethernet hub.

- we purchased ethernet phy, a development board ready to use + a typical board with FPGA

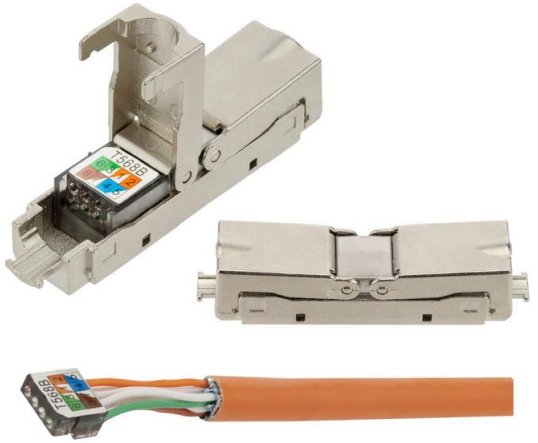
- adding more mPMT channels will be a copy of the second mPMT

Cable and Connectors

- Underwater cable:
  - We have a project and quotation for 9.2 mm CAT 6A S/FTP with an HDPE High-Density Polyethylene, We have a sample to do a soak test Benjamin will provide results
  - VIIT presented the solution of bending radius of cable (L shape) – can stay on a current project of cable.
  - We have to order cable in the first week of August.
- Ribbon cables to PMTs:
  - Ribbon cable 15 rolls of 300ft was ordered with a specified length between twisted and flat sections (13'' repeat and 1,5'' flat) – delayed September
  - Micro-Match connectors, 2k female, 4k male (both delivered)
- Connection to the mainboard and at feed-through
  - Want to avoid RJ45
  - Options:
    - DIGITUS connector (approx. 8 USD)
      - Got samples – not sure if it is fine
    - Neku (approx. 12 USD)
      - Possibly fine, but not detachable
    - M12 X-code connector (approx. 35 USD) - recommended
      - Tested and believe that it will work OK
      - Assembly requires more work

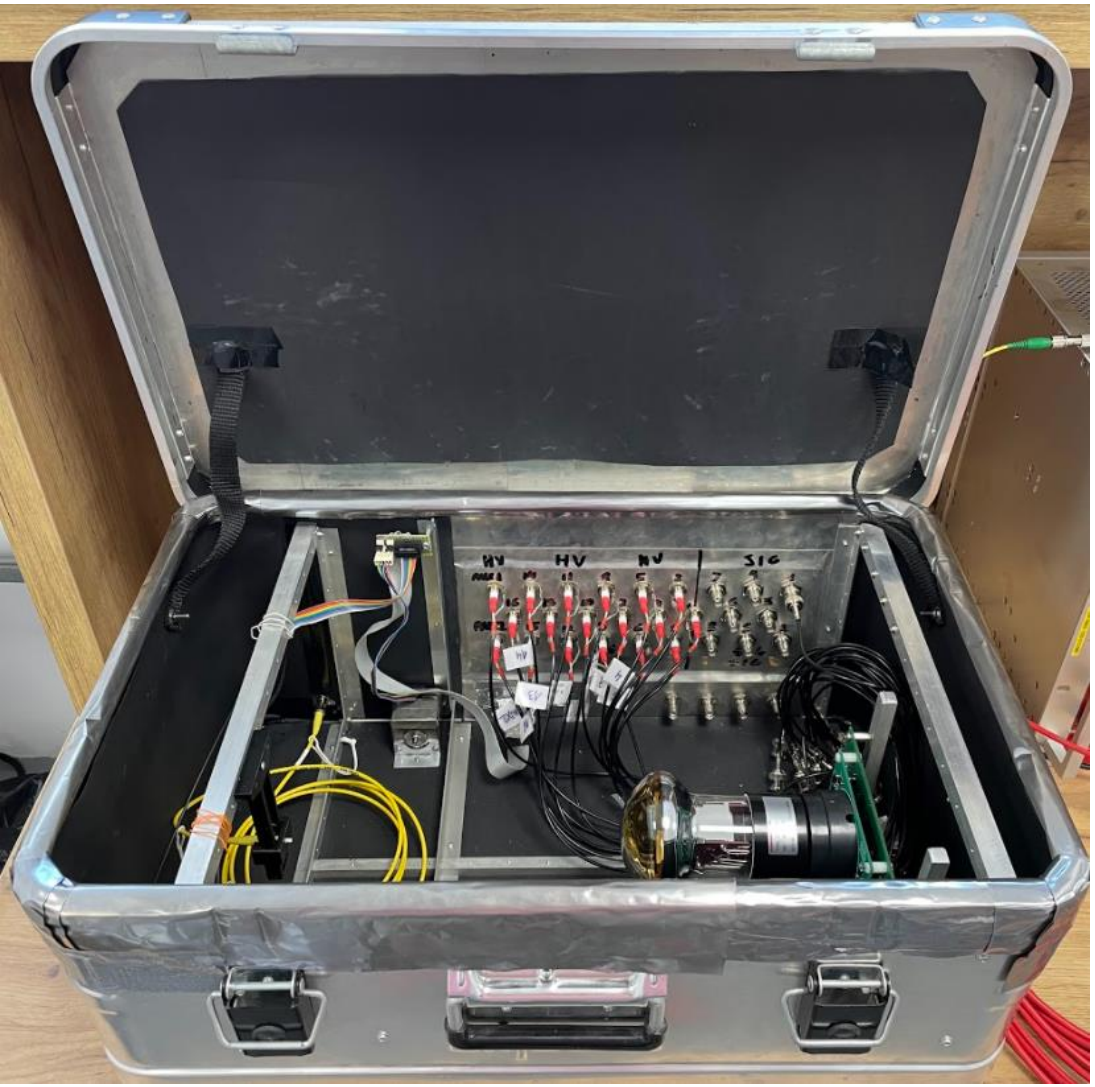
DIGITUS

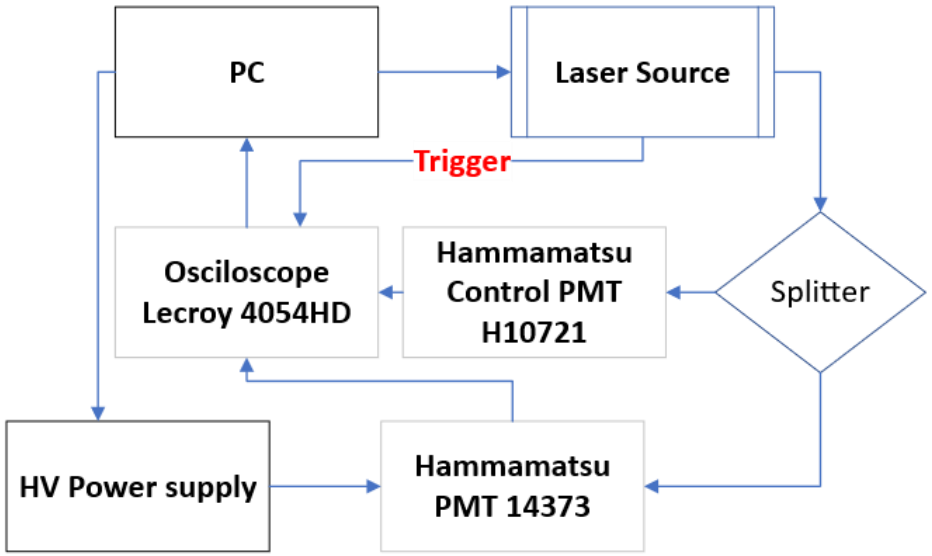
NEKU

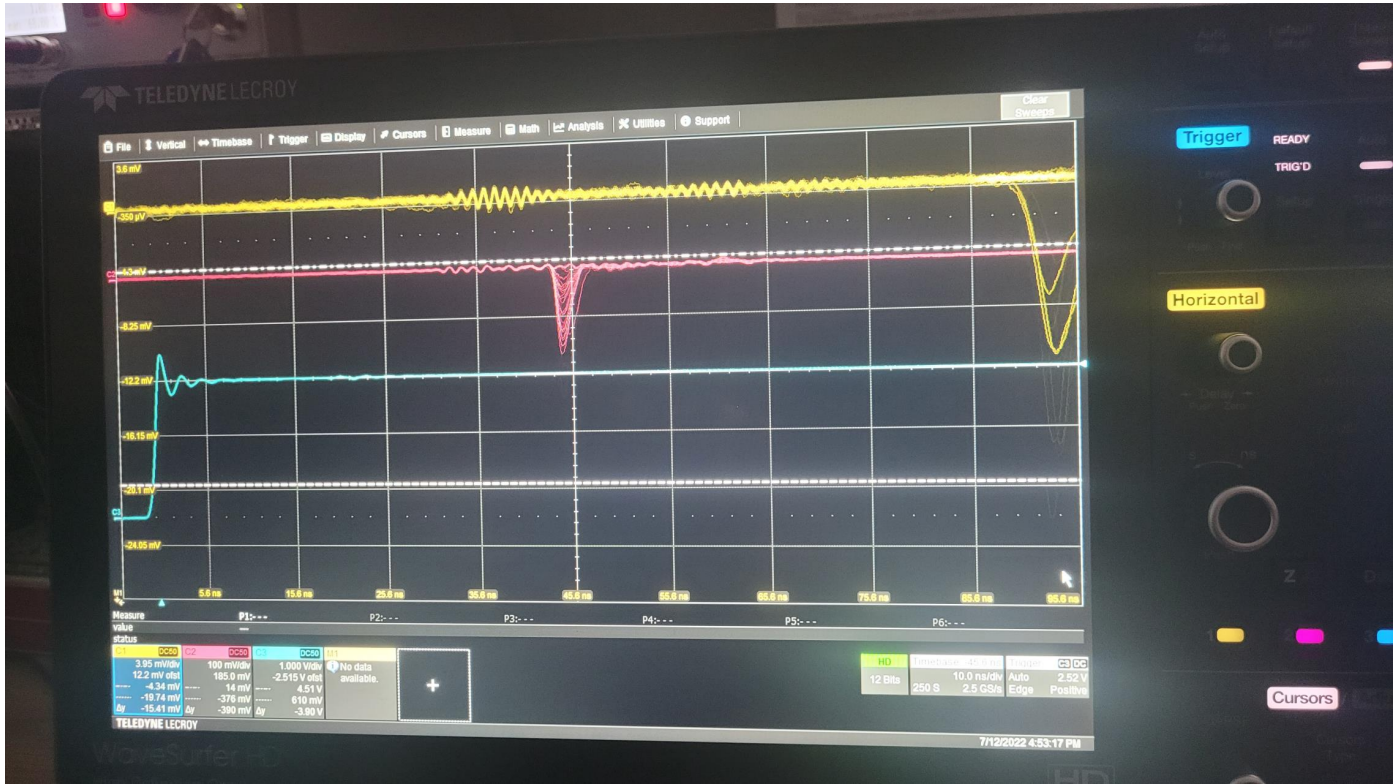


M12 X-CODE

PMT characterization setup

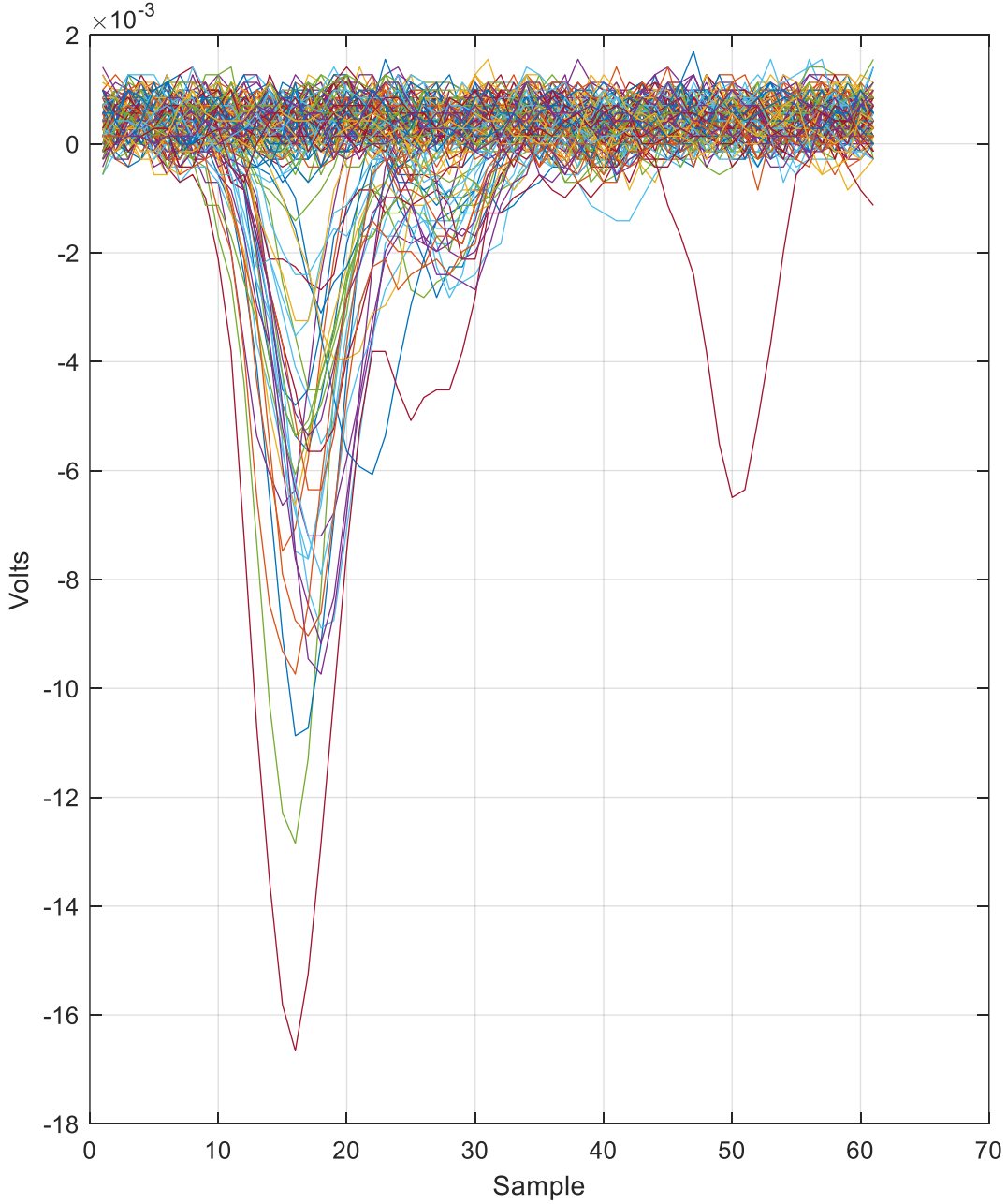




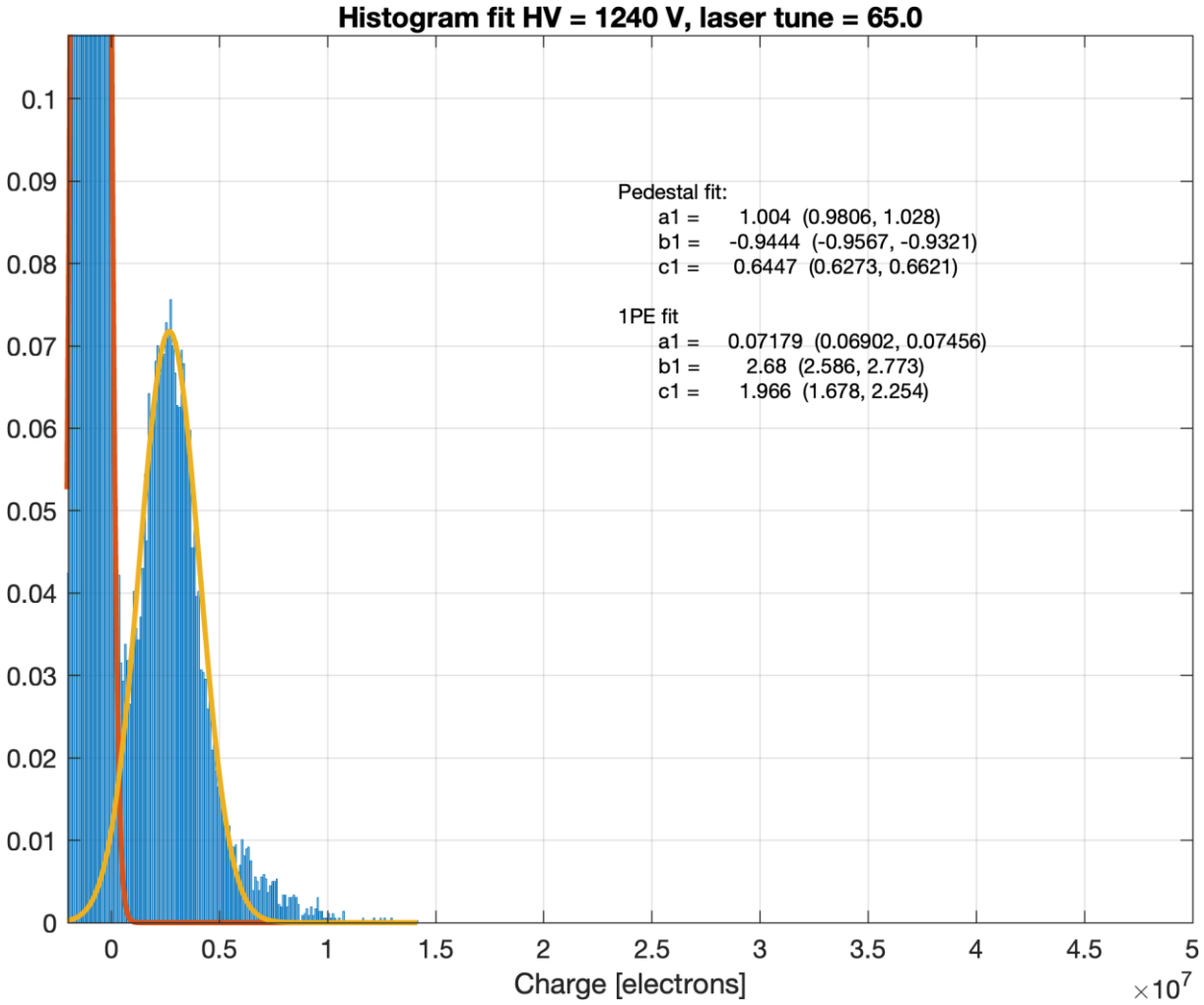


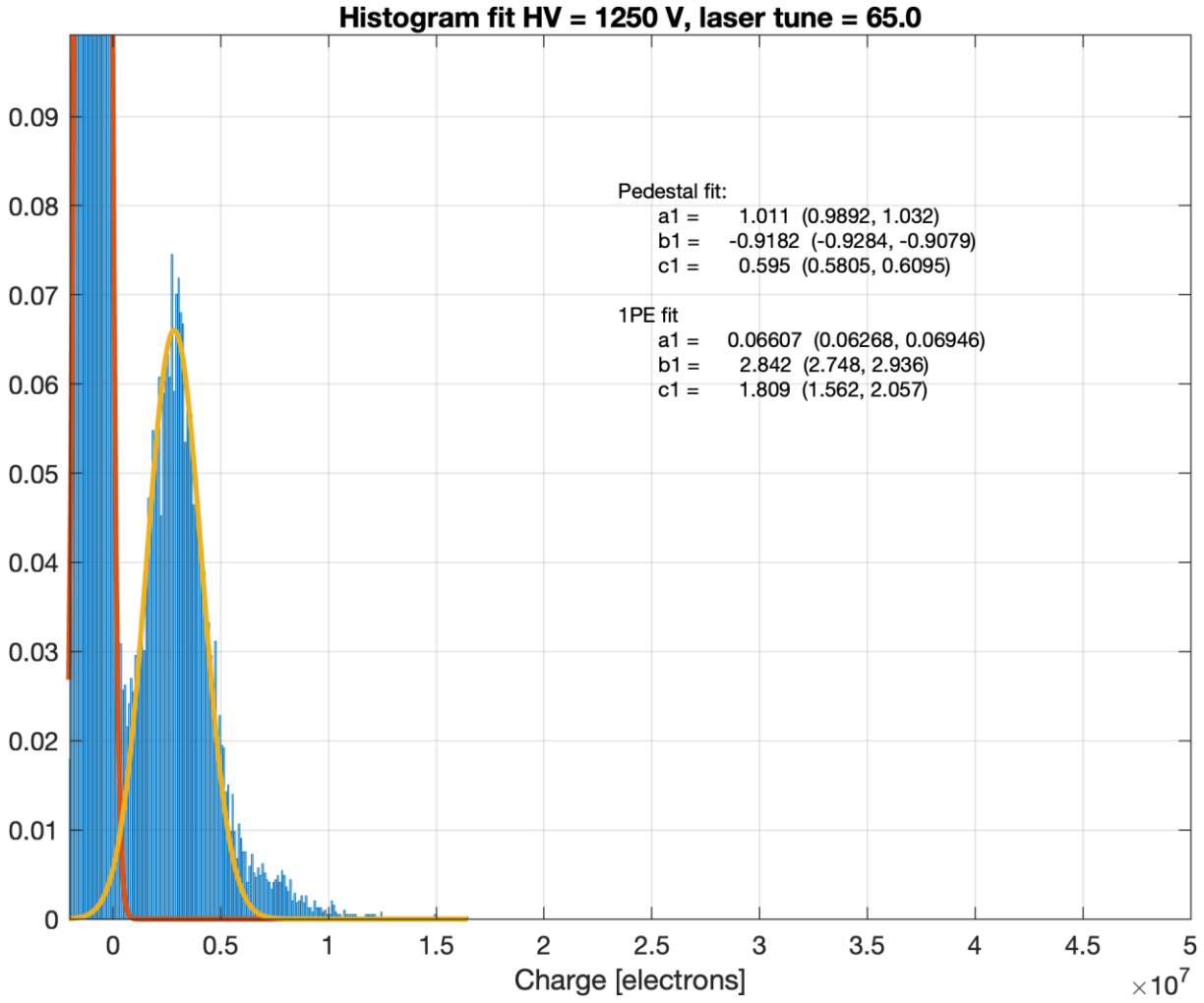
Purpose of analysis

- Shape of pulse rise time, fall time, FWHM
- Use correlation analysis to extract a model of pulses
- Need 1 PE pulse to check gain dependency on voltage
- We need to determine what are the pulse shape parameters
  - simulate analog filters with Laplace inverted transform (finalize shaping)
  - Check if shape is constant (possibility to determine timing using matched filtering)

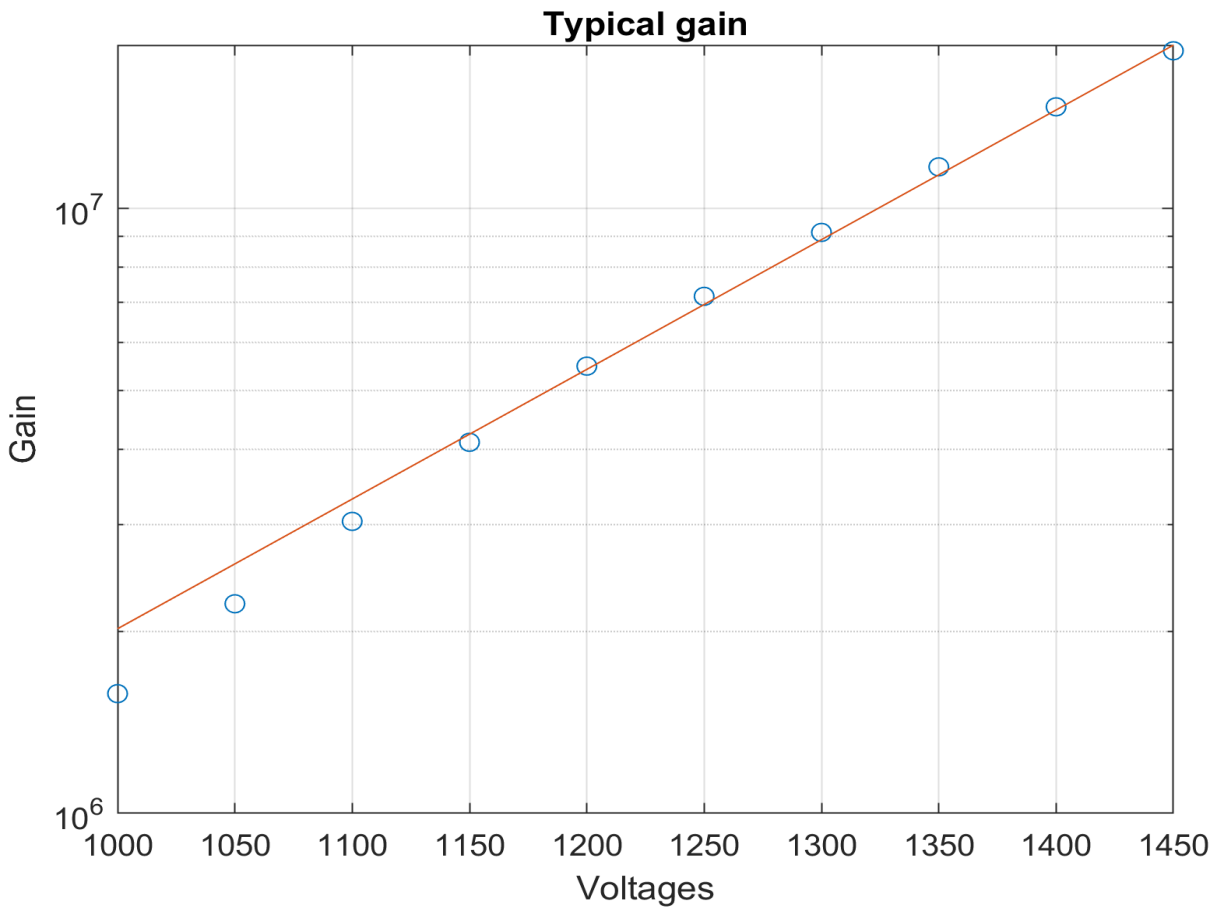


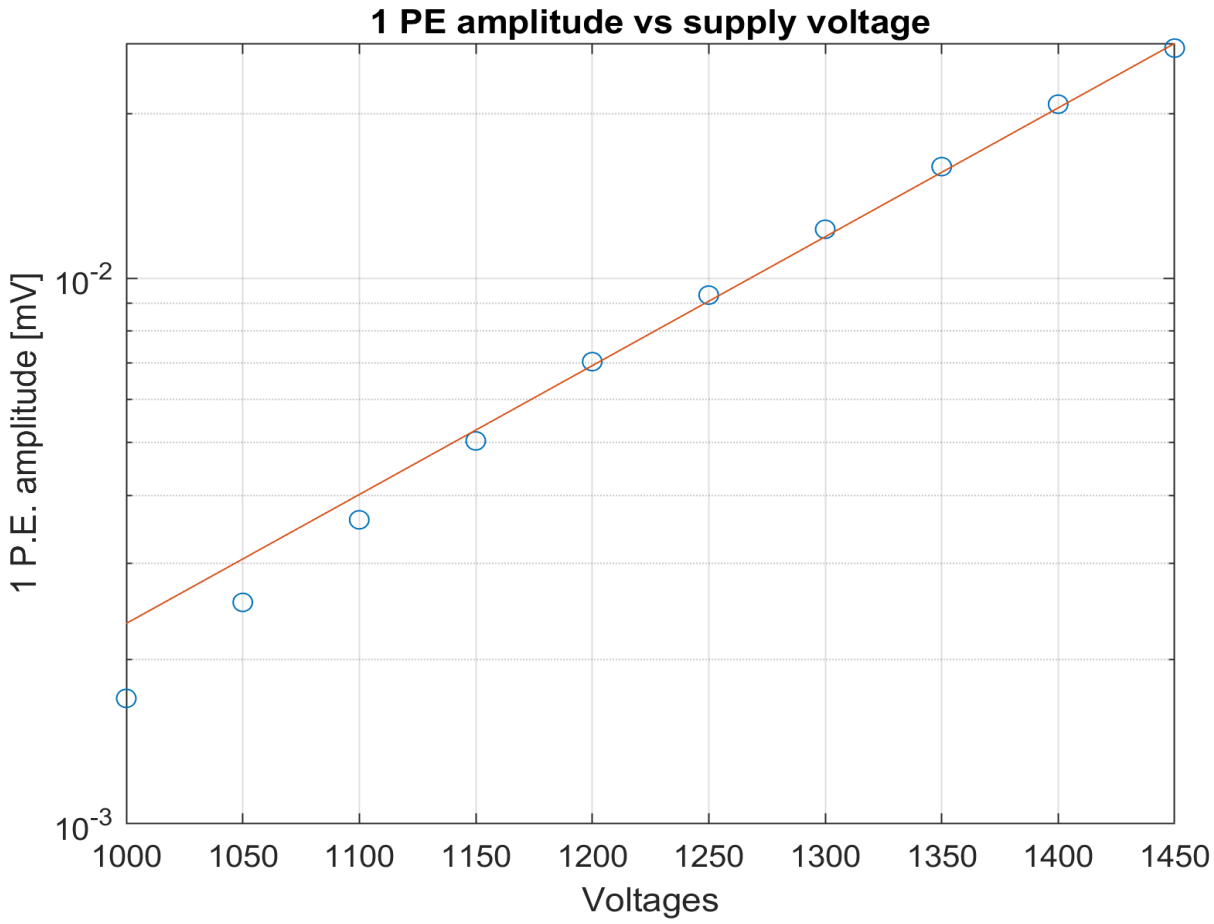
Pulse analysis – histograms of charge





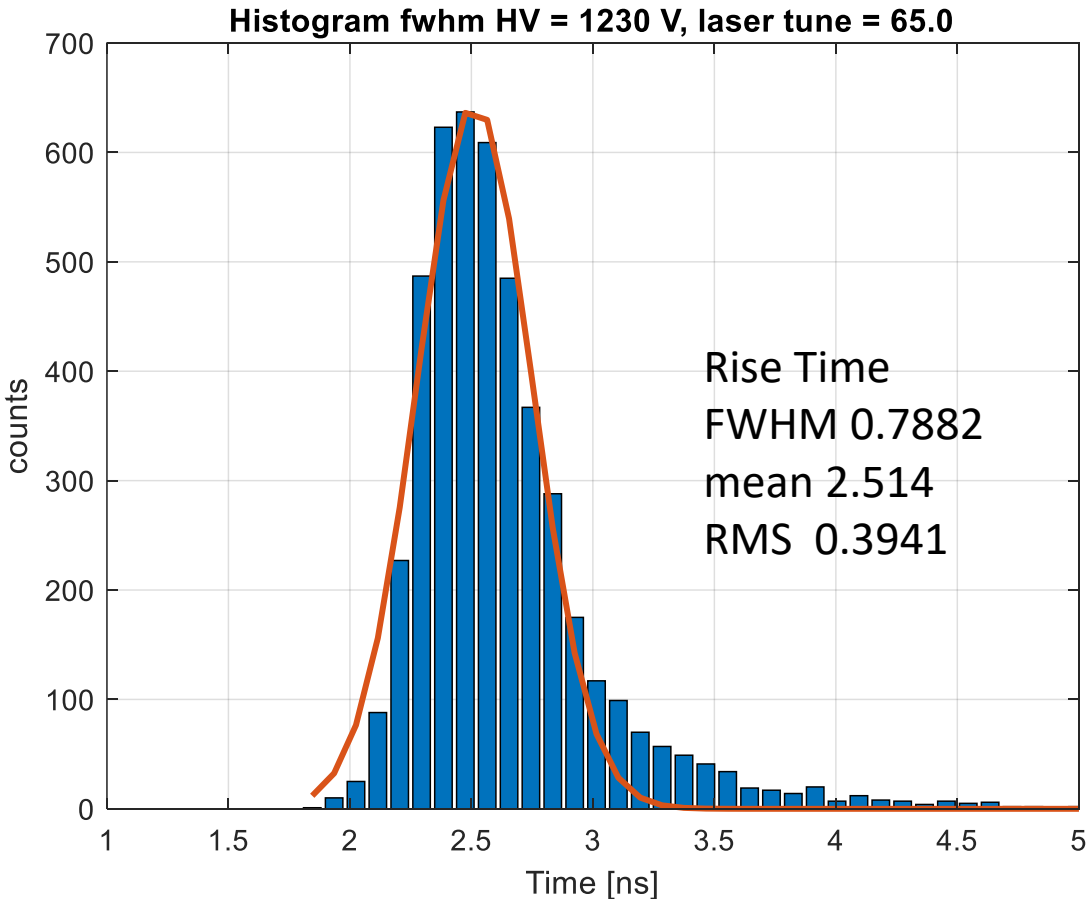
Measured PMT performance

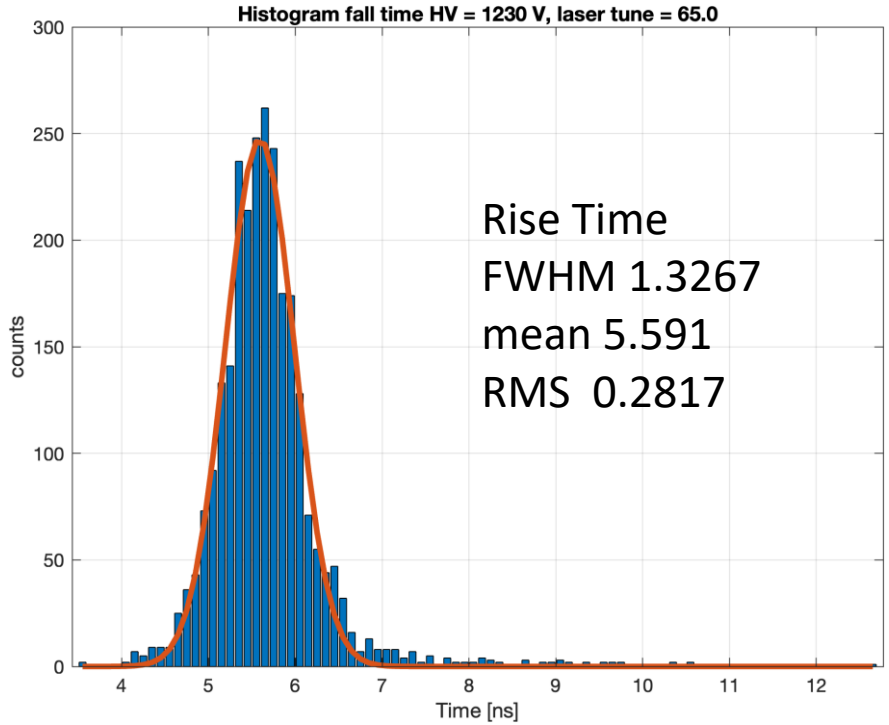


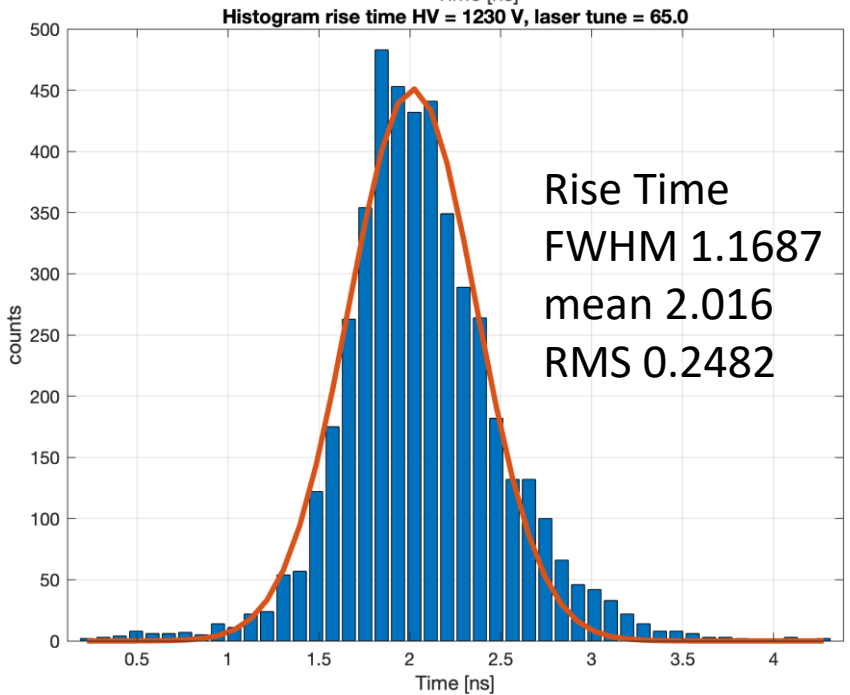


Pulse shape parameters

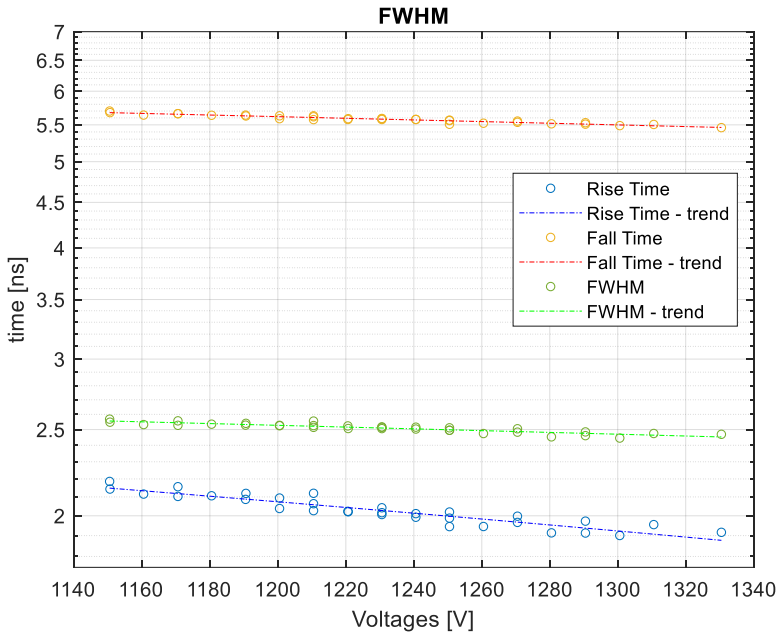
Parameters seem steady for now – need additional data and measurements

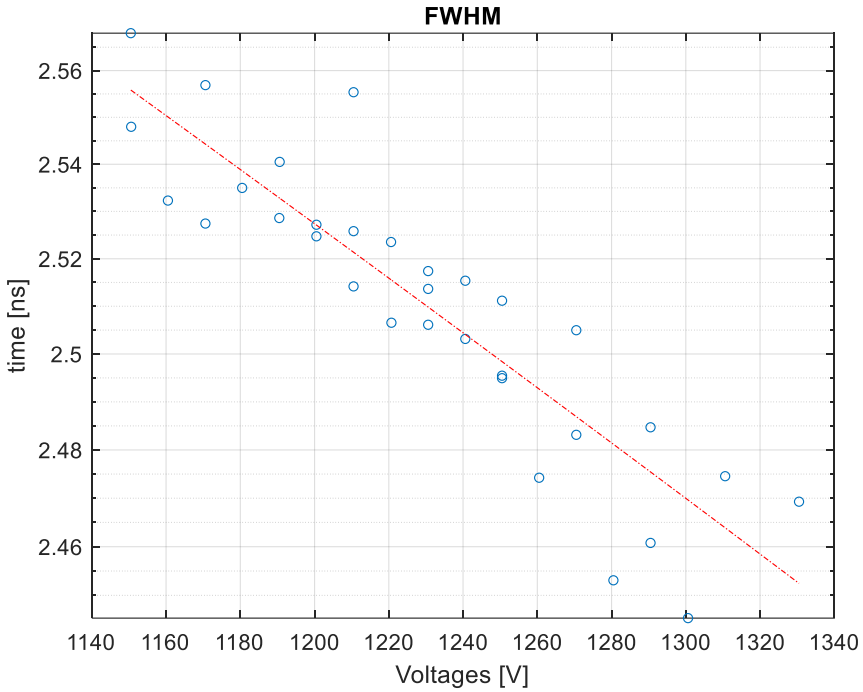


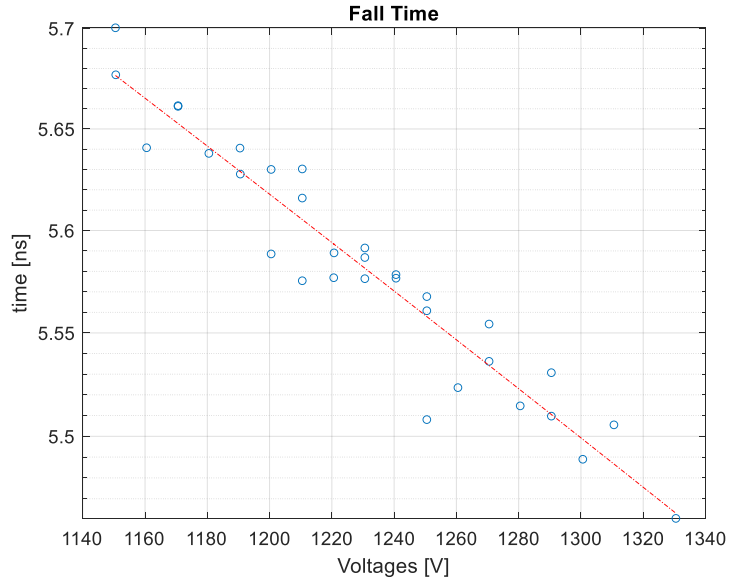


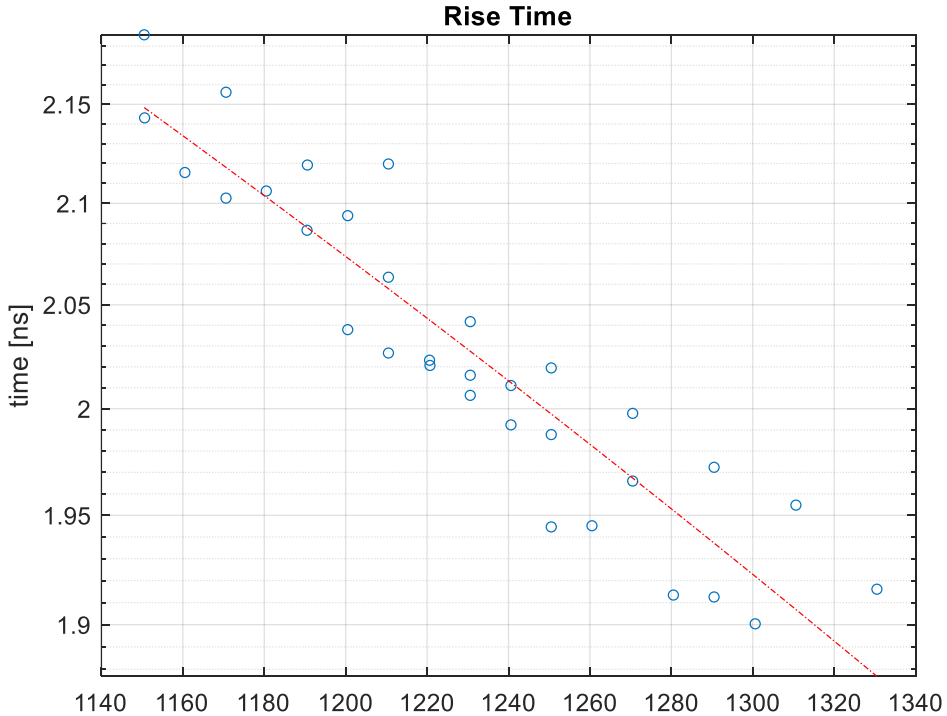


Pulse shape vs HV









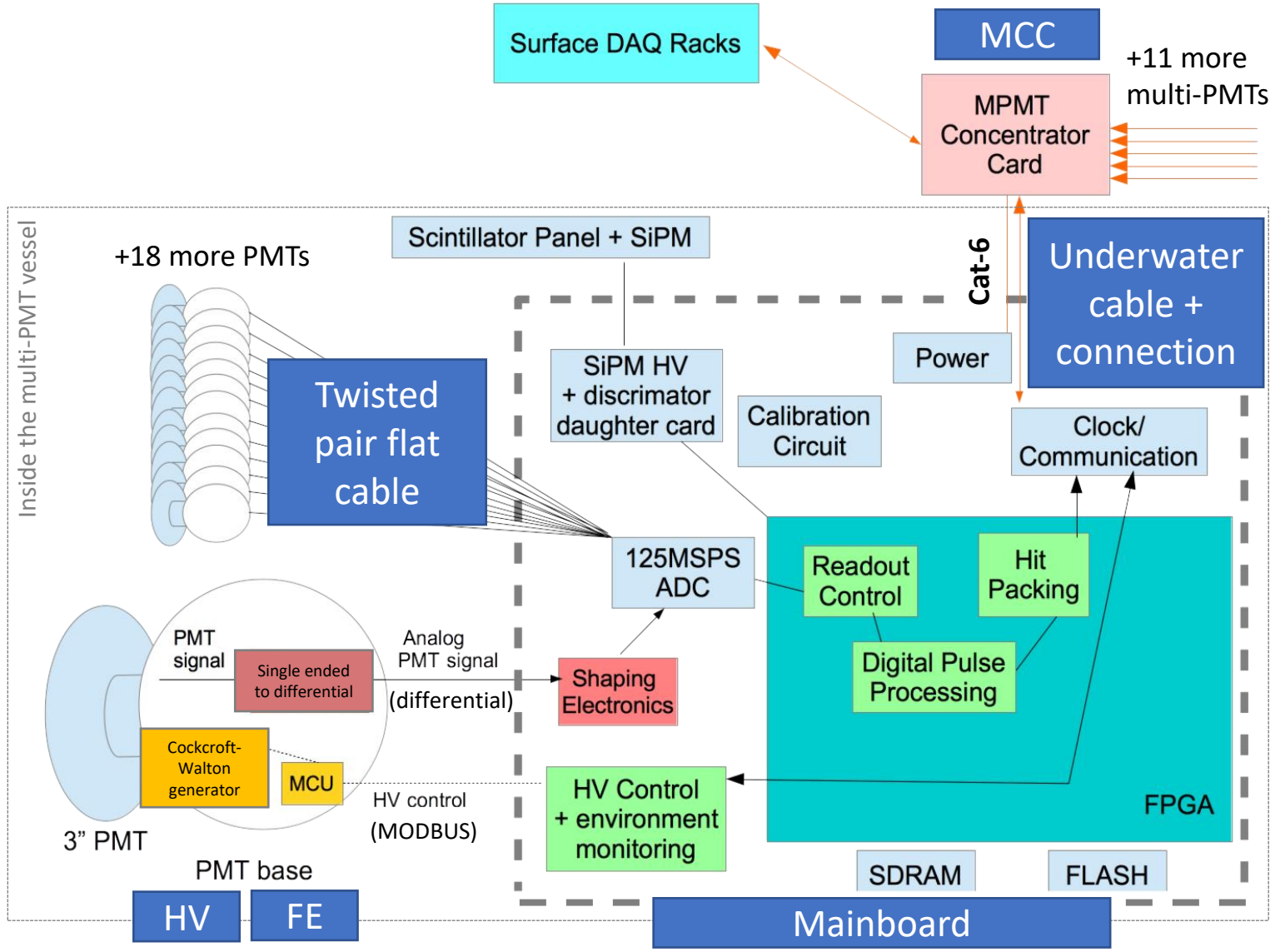
Summary

- Need to decide on connector. Recommend M12.
  - Price manageable, allows for disconnecting
- Flat cable ordered; underwater cable to be ordered soon.
- HV boards
  - Arrived 1500 pcs. for WCTE; Automated tester soon to be commissioned.
  - Additional circuits possible in Oct-Dec.
- FE boards
  - Schematic done – now in final checks; first prototype arriving next week
  - Can manufacture 620 pcs. MCU delivery for the remaining pieces delayed till June 2023.
- General comment: struggling with component availability.
- Need an additional analysis of Pulses – for now, we see we can use pulse correlation techniques

Backups

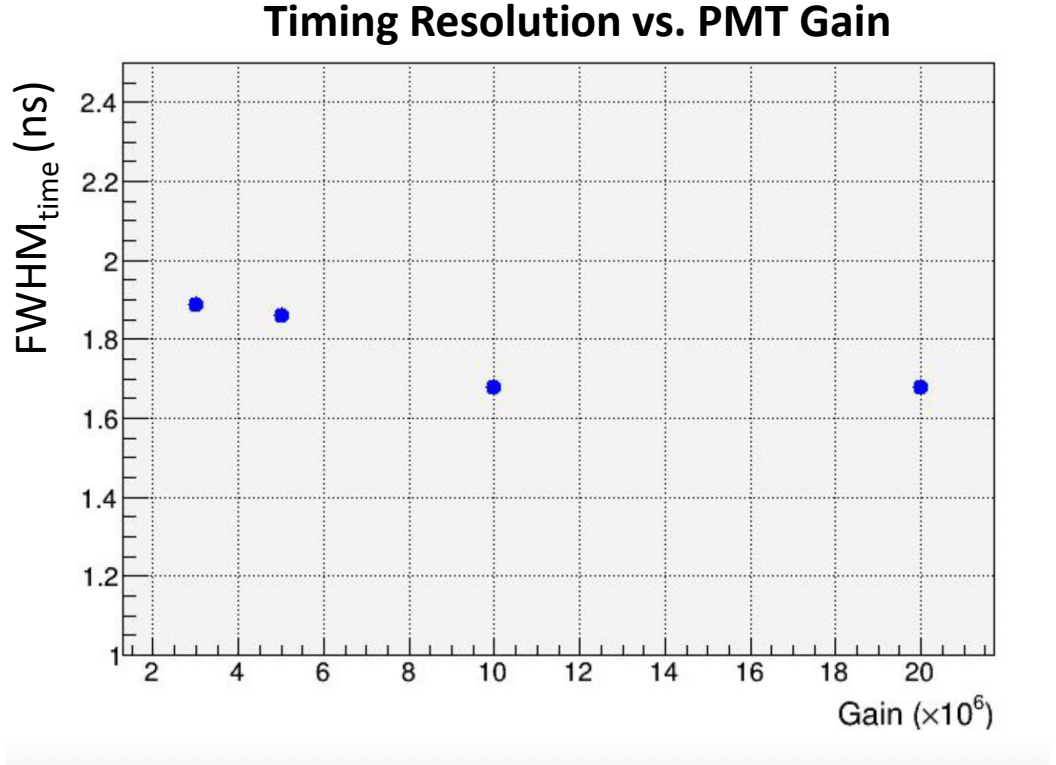
Reminder

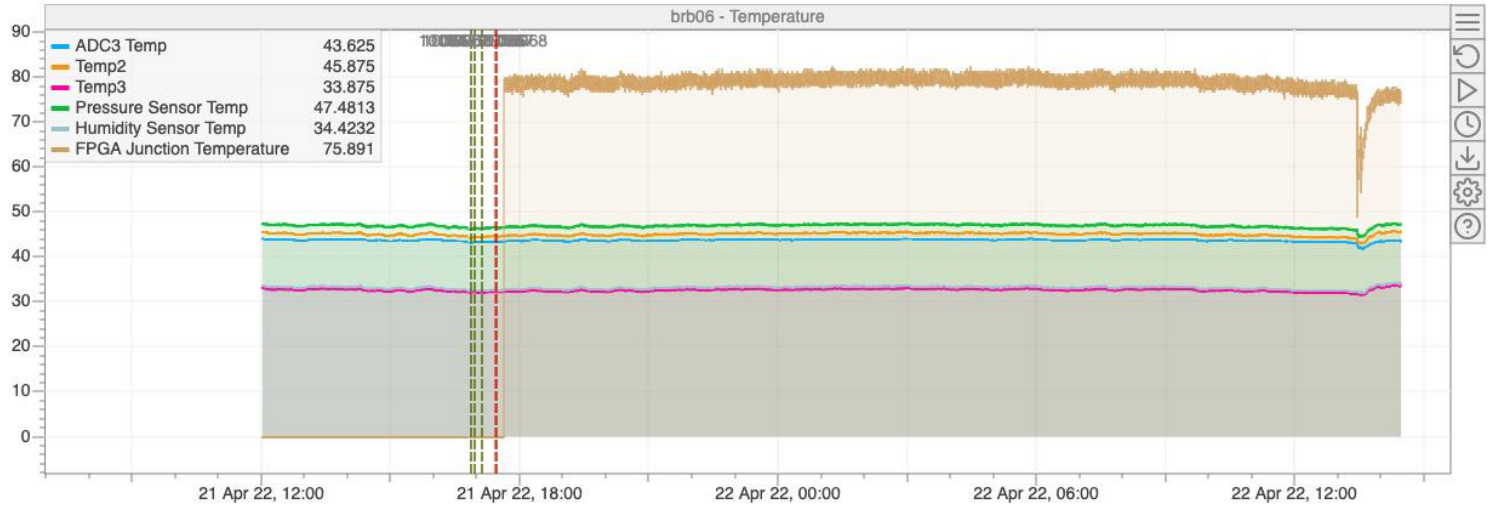
- Design based on commercial components
- Good reliability
- Target power limit: 10W
- Dynamic range: 100 p.e.
- Self triggering system
- Dead-time free system
- Use waveform digitizer:
  - Separate hits from different bunches
  - Ideally separate pulse pile-up in the same bunch
- Use concentrator modules for multi-PMTs, to have architecture similar to the far detector
- Maintain performance of the photo-sensor
- On-the-fly feature extraction and estimation of the quality of the estimates; if unsatisfactory, compress waveform and send full buffer to the DAQ



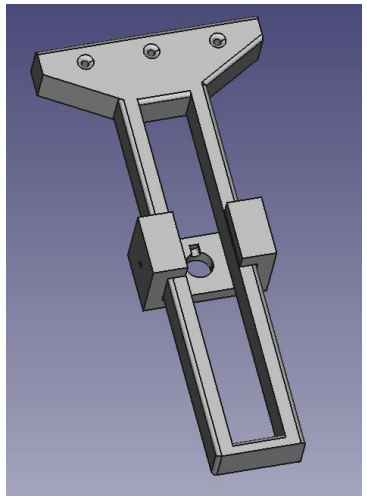
mPMT Mainboard

- Fully working readout of all ADCs using the rev-1 Xilinx mainboard.
- Readout of Xilinx FPGA junction temperature sensor
  - Currently sitting around 75-80C. Within specs, but would be nice to try to reduce that temperature (better reliability)
- Have started measurements of timing resolution to help finalize shaping circuit and dynamic range
- Currently doing tests with circuit with op-amp gain=4.
- Will do tests with another op-amp gains in order to disentangle intrinsic PMT dependence of TTS on gain vs worsening TTS because of signal to noise ratio.





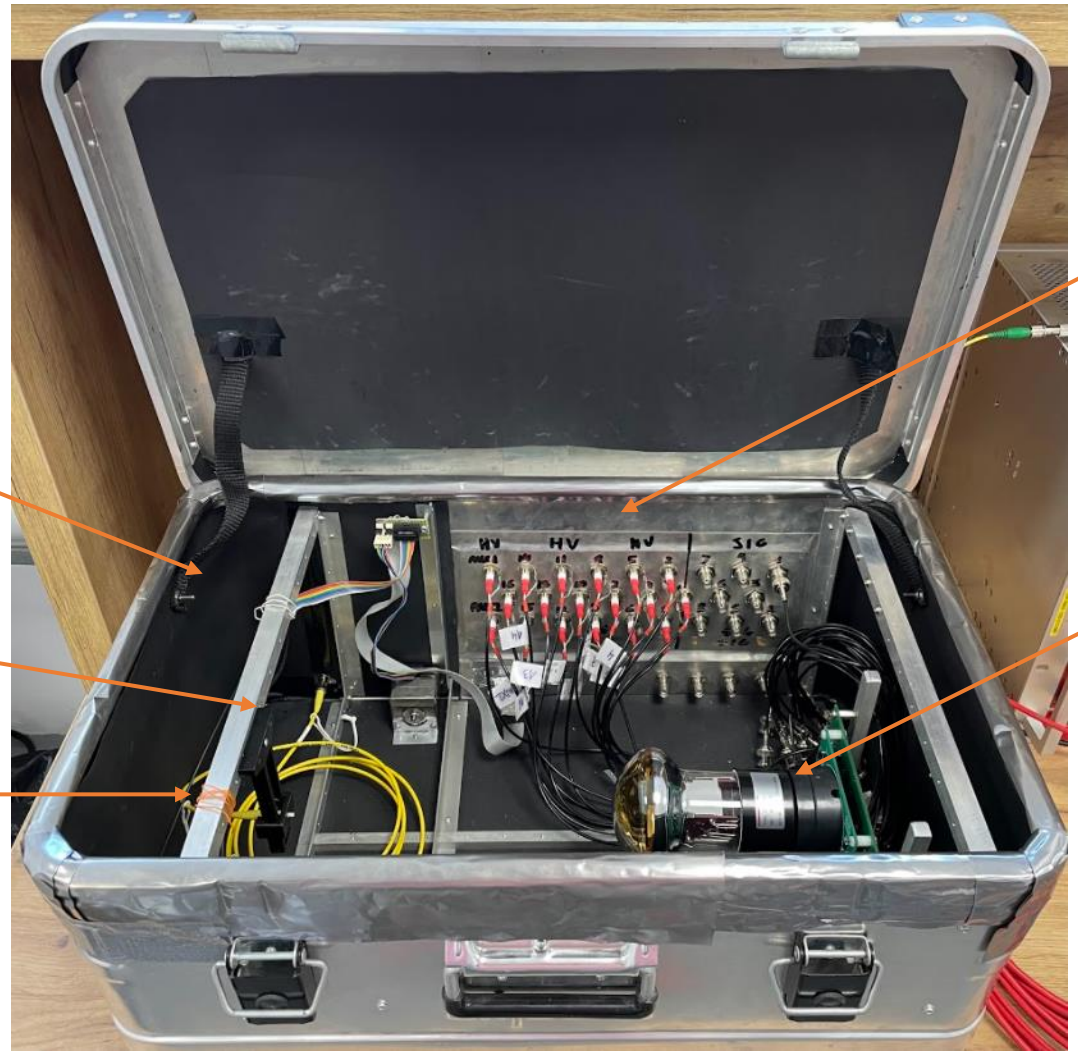
PMT characterisation - setup



Box covered with mumetal foil

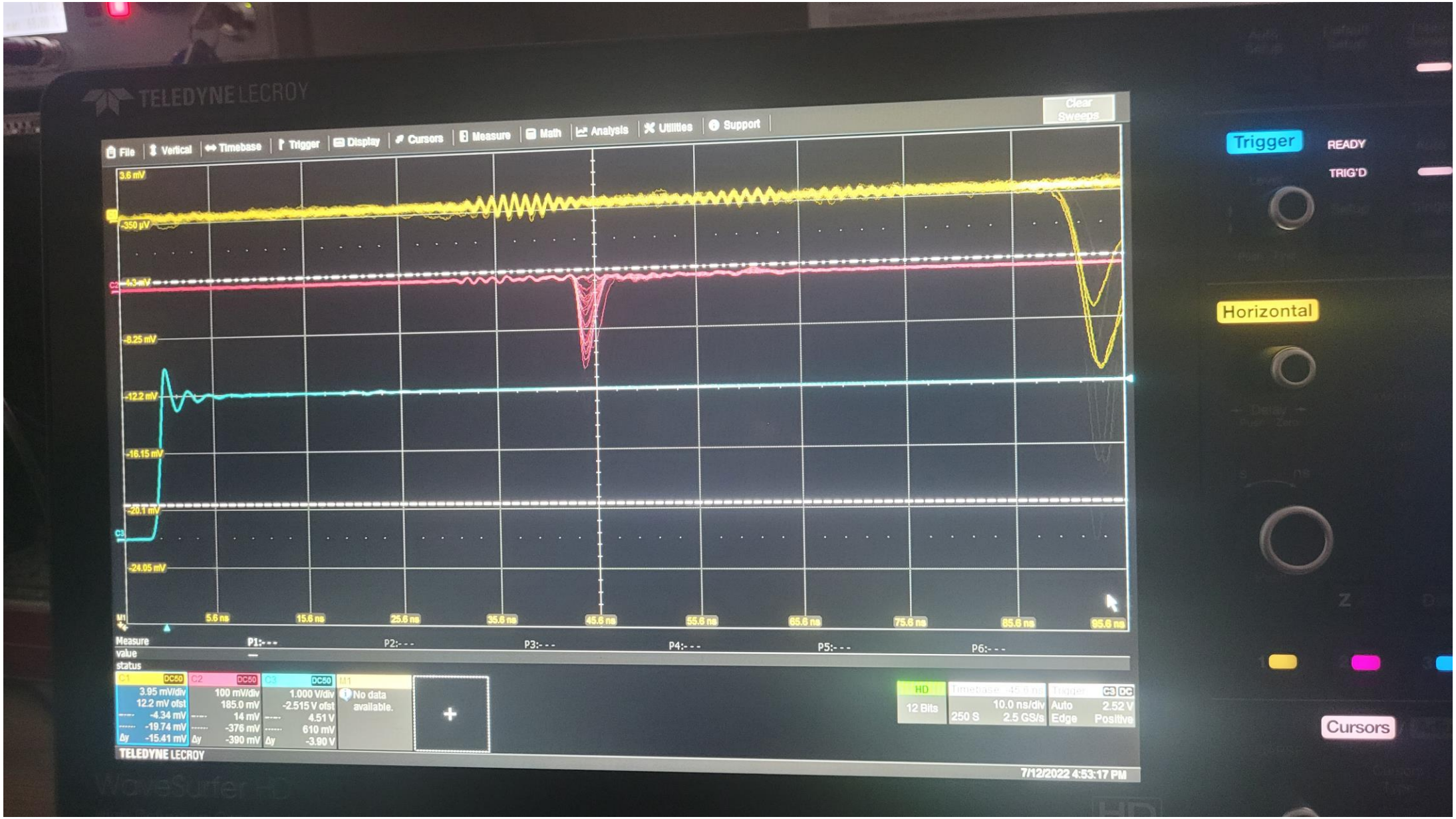
Optical fiber

Optical fiber holder



HV connections

Photomultiplier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Vertical
Timebase
Trigger
Display
Cursors
Measure
Math
Analysis
Utilities
Support
Clear Sweeps
3.6 mV
-350 µV
-4.3 mV
-8.25 mV
-12.2 mV
-16.15 mV
-20.1 mV
-24.05 mV
5.6 ns
15.6 ns
25.6 ns
35.6 ns
45.6 ns
55.6 ns
65.6 ns
75.6 ns
85.6 ns
95.6 ns
Measure
value
status
P1:- - -
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
C1 DC50
3.95 mV/div
12.2 mV ofst
-4.34 mV
-19.74 mV
Δy -15.41 mV
C2 DC50
100 mV/div
185.0 mV
14 mV
-376 mV
Δy -390 mV
C3 DC50
1.000 V/div
-2.515 V ofst
4.51 V
610 mV
Δy -3.90 V
M1
No data available.
HD
12 Bits
10.0 ns/div
250 S
2.5 GS/s
Auto
Edge
2.52 V
Positive
TELEDYNE LECROY
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Trigger
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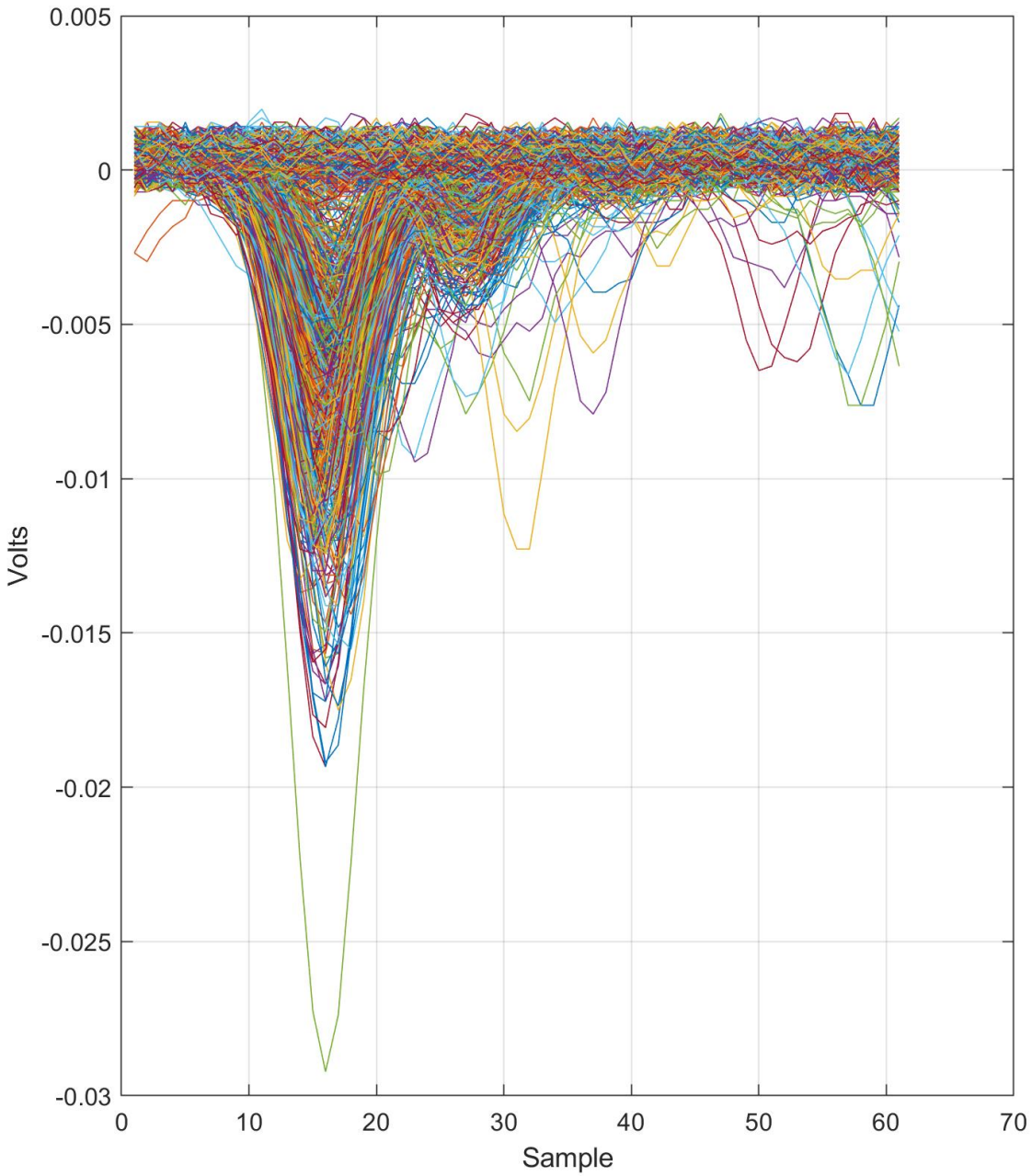
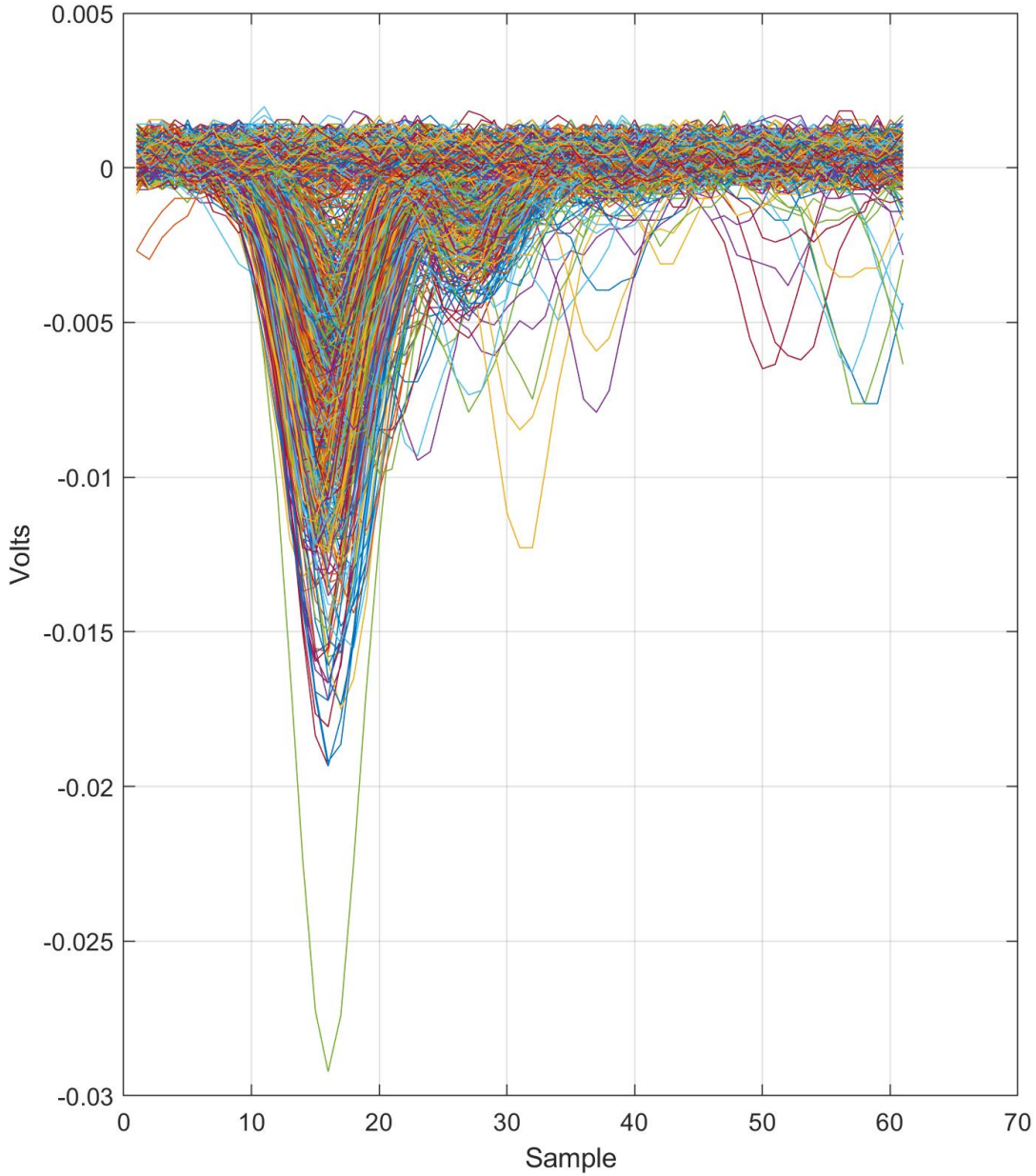
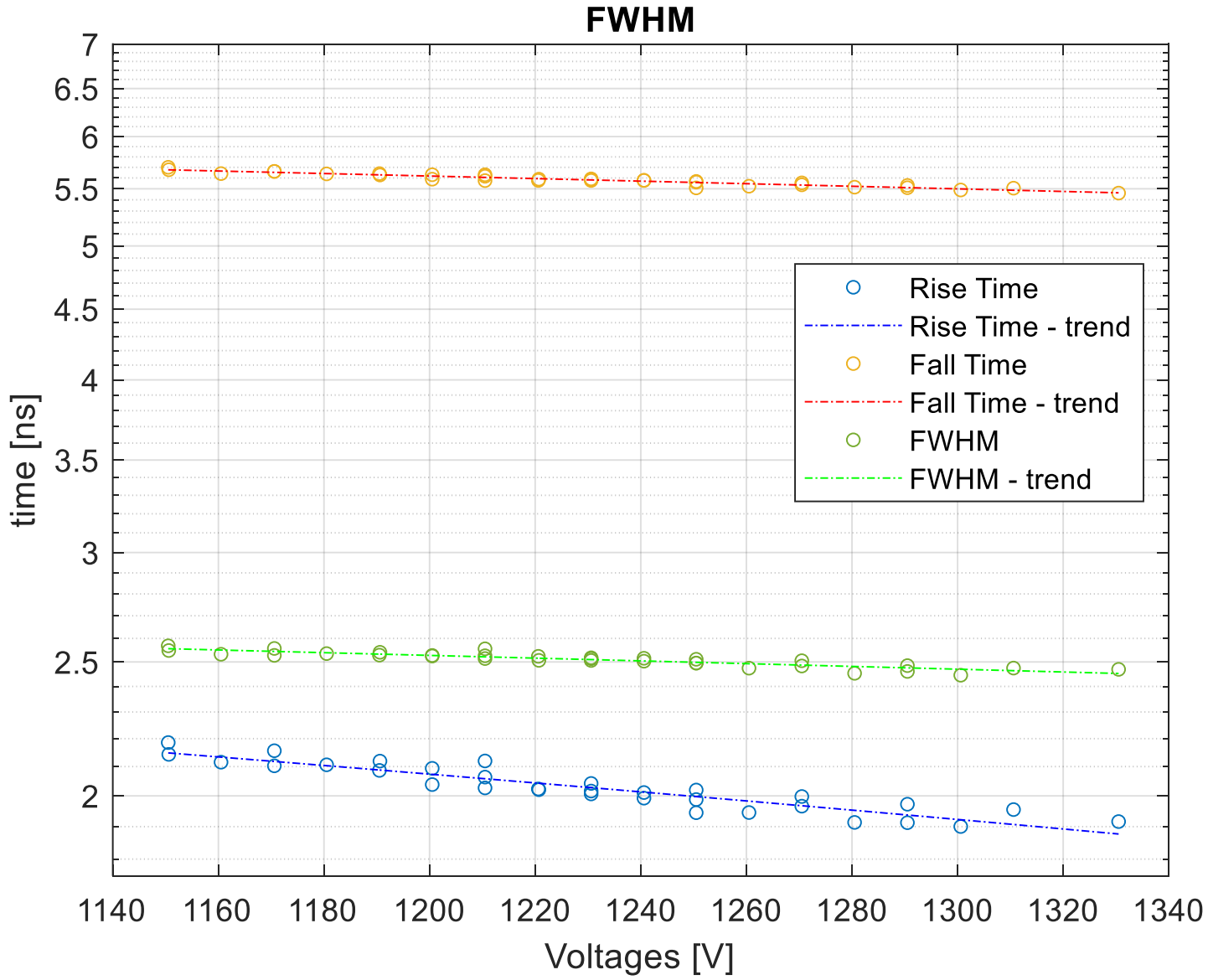
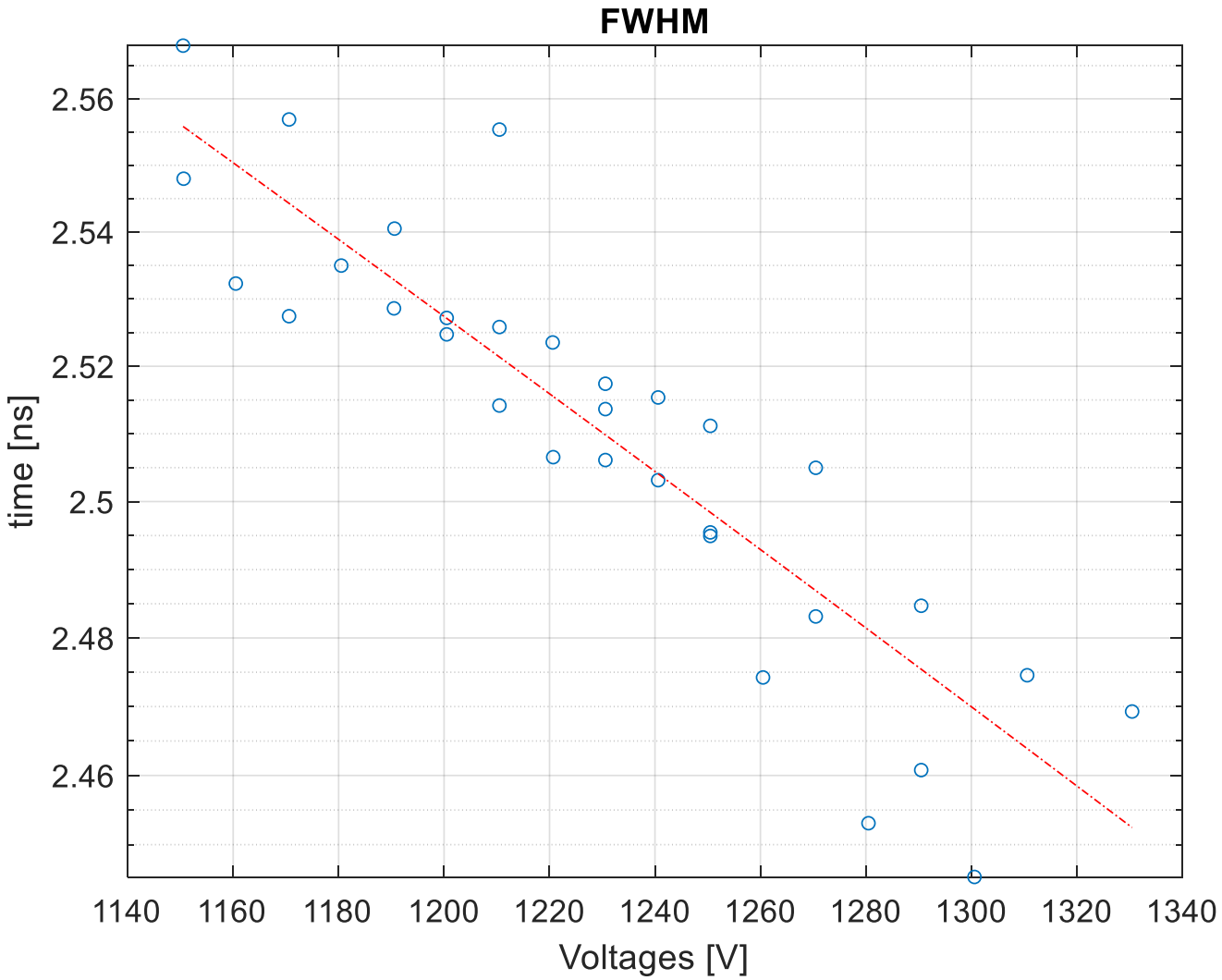




Pulse shape vs from HV



FWHM



Coefficients

p1 = -0.0005742 (-0.0006794, -0.0004691)

p2 = 3.216 (3.087, 3.346)

Goodness of fit:

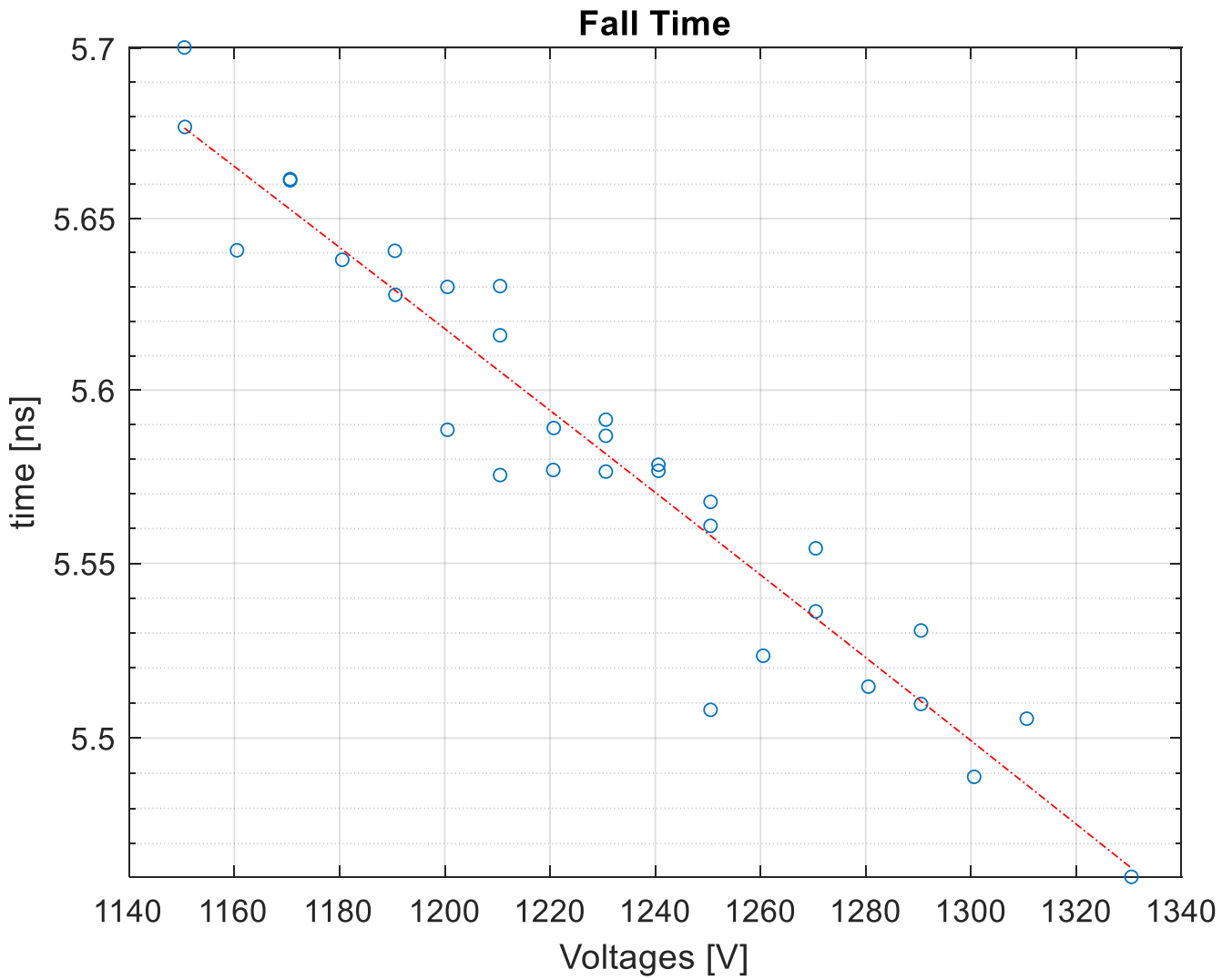
SSE: 0.005589

R-square: 0.8057

Adjusted R-square: 0.7992

RMSE: 0.01365

Fall time



Coefficients

p1 = -0.001186 (-0.00132, -0.001052)

p2 = 7.041 (6.876, 7.205)

Goodness of fit:

SSE: 0.009046

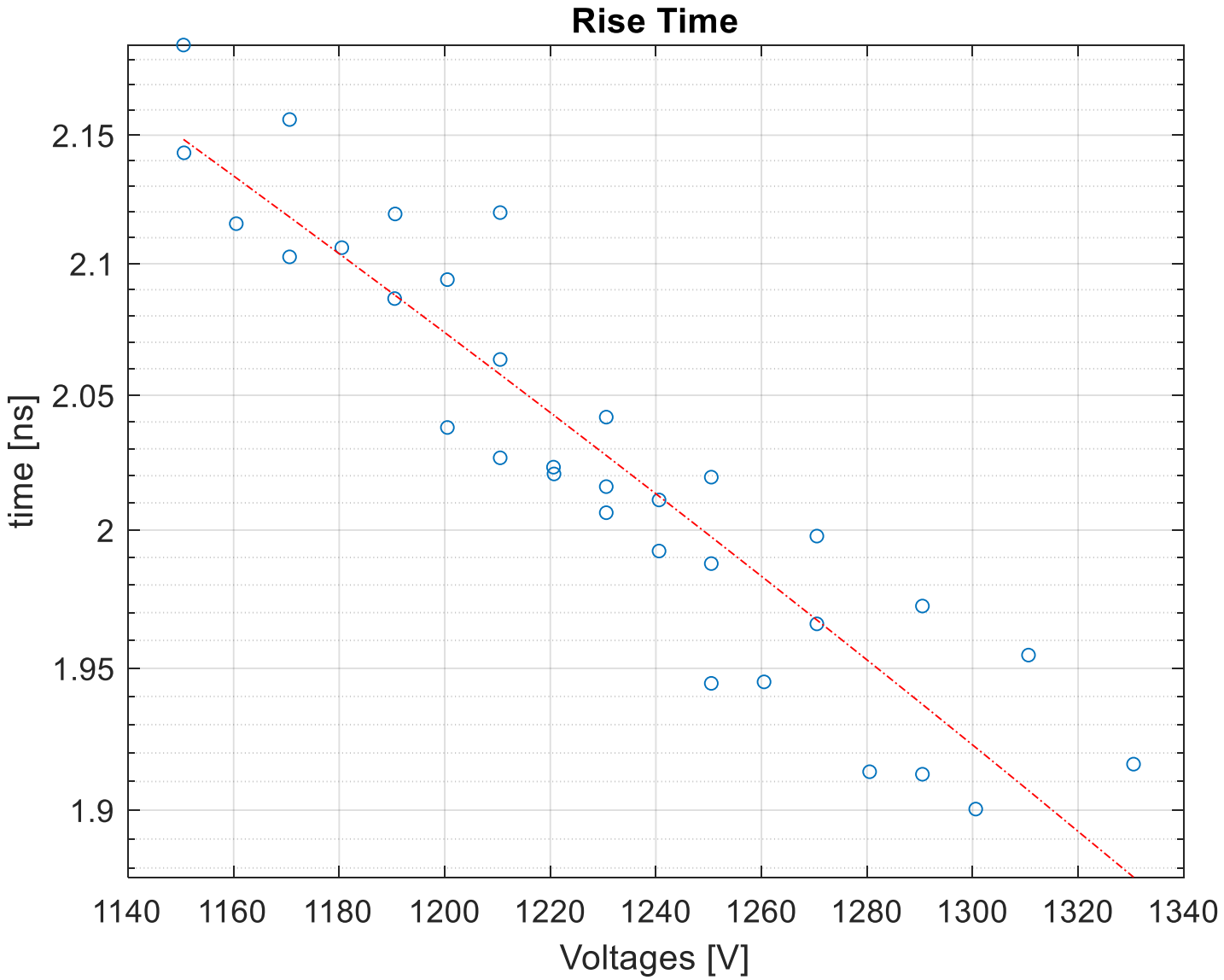
R-square: 0.9161

Adjusted R-square: 0.9133

RMSE: 0.01736

Pojedyncze punkty x error barami

Rise Time



Coefficients

- p1 = -0.001508 (-0.001736, -0.00128)
- p2 = 3.884 (3.603, 4.165)

Goodness of fit:

- SSE: 0.02631
- R-square: 0.8587
- Adjusted R-square: 0.854
- RMSE: 0.02962