University of Glasgow

DIRC MCP tests

@UofG

Andrew Cheyne - 23rd April 2026

University of Glasgow

Testbench Setup

Developing methods and testbench with Photonis MCP-PMT

Readout Capabilities Update

- We have experienced a series of unfortunate events, but are on the recovery
- Failure of Tektronix (MSO64B BW6-4000) high resolution oscilloscope
  - Previously used for Gain curve data and timing resolution measurements
  - Resolution better with oscilloscope than digitiser
  - Repair very expensive. In process of sending it back, Same thing happened at BNL twice
  - Surge protection on oscilloscope not good. Even though we were using single PE level signals.
- Digitiser (VX1742) (and VME crate) also suffered a hardware power failure. We do not understand this, potential power surge in building overnight - but the fuses on the modules are ok. Need to send to CAEN for repair. Hardware failure.
- At the moment all we have is a CAEN v1742 Digitiser on loan from another project in Glasgow
- Purchased new Keithley picoammeter upon recommendation from Photek. Our existing one was tailored more for SiPM settings
- Working out the cables and Keithley schematic for connecting to MCPs - it would be useful to cross check our circuit/ connection diagram with someone who has Keithley experience

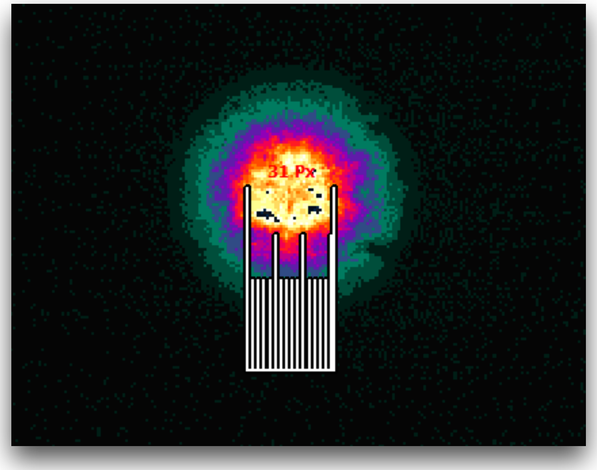
Software Update

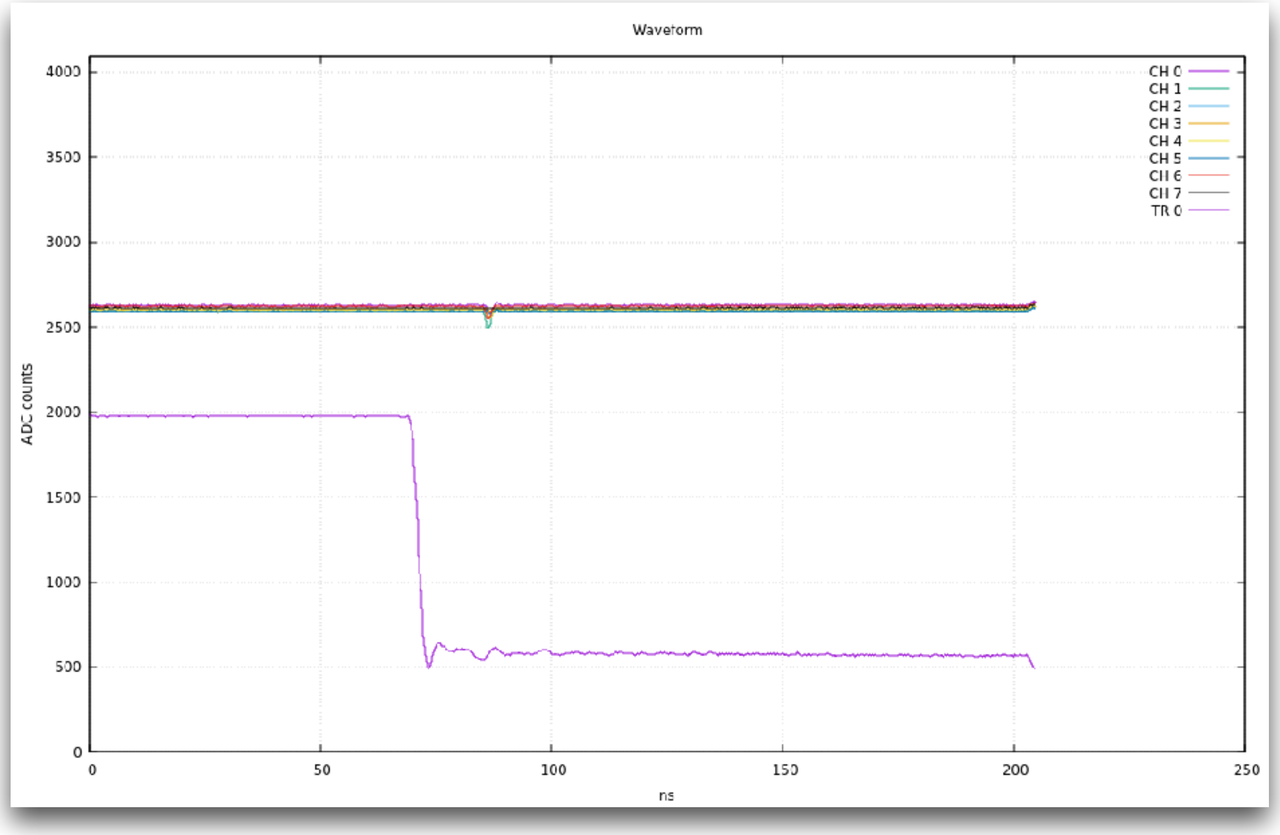
- Software for scanning and analysis ready
- Recently upgraded digitiser readout capabilities to go from 200Hz to 1.2kHz -> should make scans go quicker
- Can be improved by optimising record length further if needed.

New laser info

Pilas DX

- New blue laser procured
- From now on using blue one rather than red PiLAS
  - peak wavelength: 406.5nm
  - spectral width: 1.5nm
  - timing jitter: 1.6ps
  - optimal tune: 50%
- Measured laser focal plane (below)
  - Beamspot ~31 pixels (6.45 micros/px) = 0.2mm



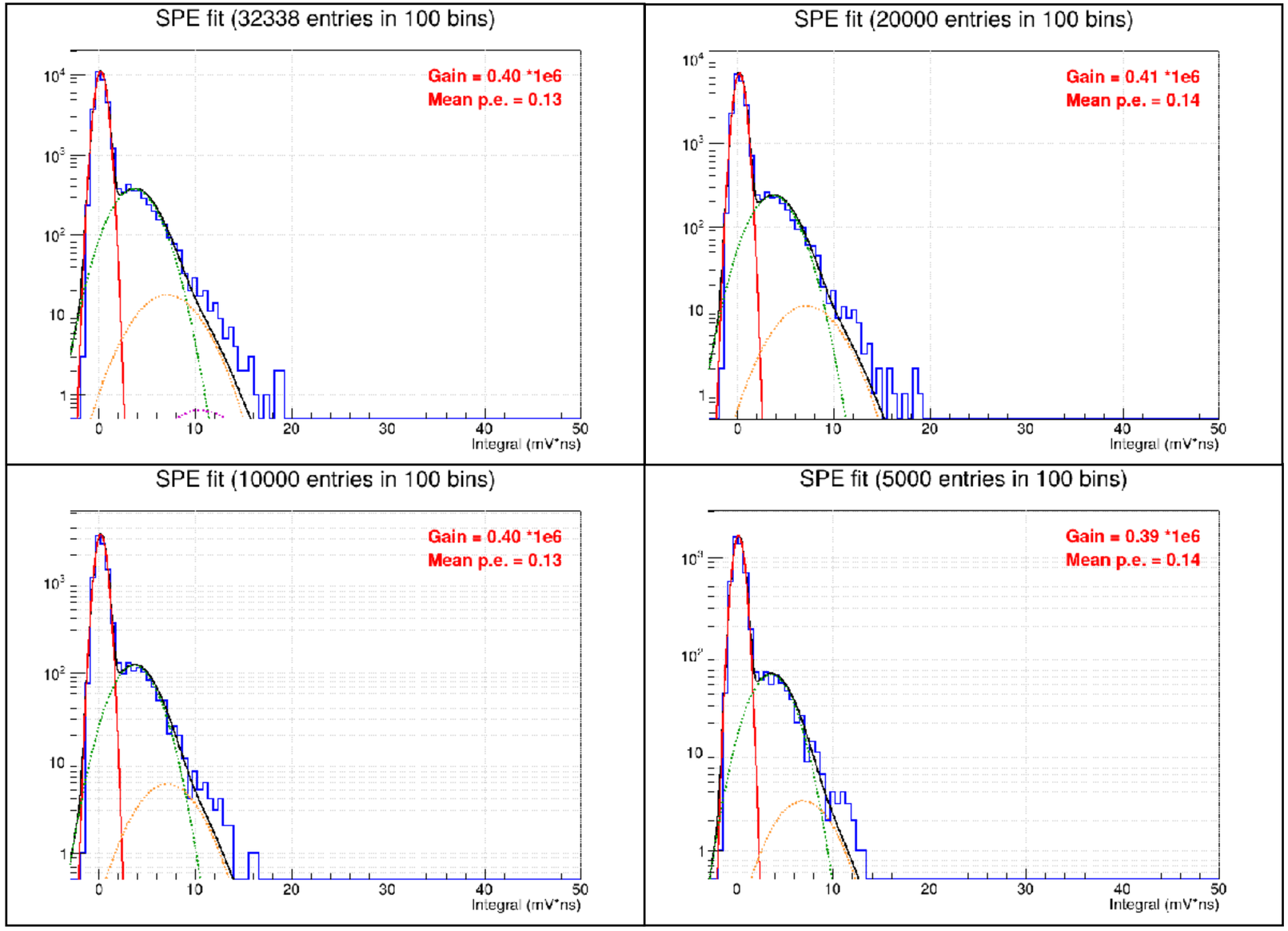


Wavedump signal from Photek MAPMT at ND4.6

Checking light level

New Laser & MCP

- **Yordanka method**
  - step-through ~100 pulses on scope from laser trigger
  - count pulses on channel of interest
  - aim for <10% of triggers
- Scope hardware failure, unusable under 100mV/div
- Changed to digitiser and saw ~100% pulses from triggers at ND4.6
- ND 5.6 showed ~20 pulses in 200 triggers
- Also recorded data for ~1min and checked fitting at various n_entries to estimate scan time.

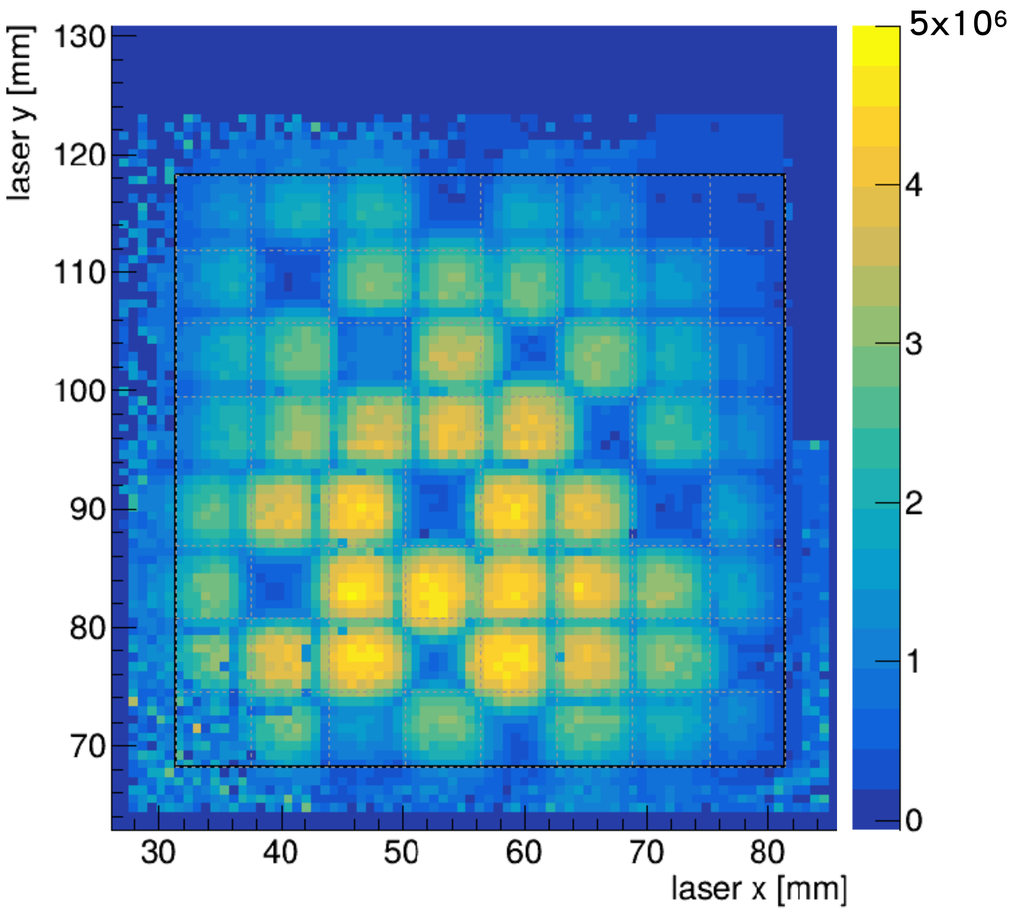


Photonis

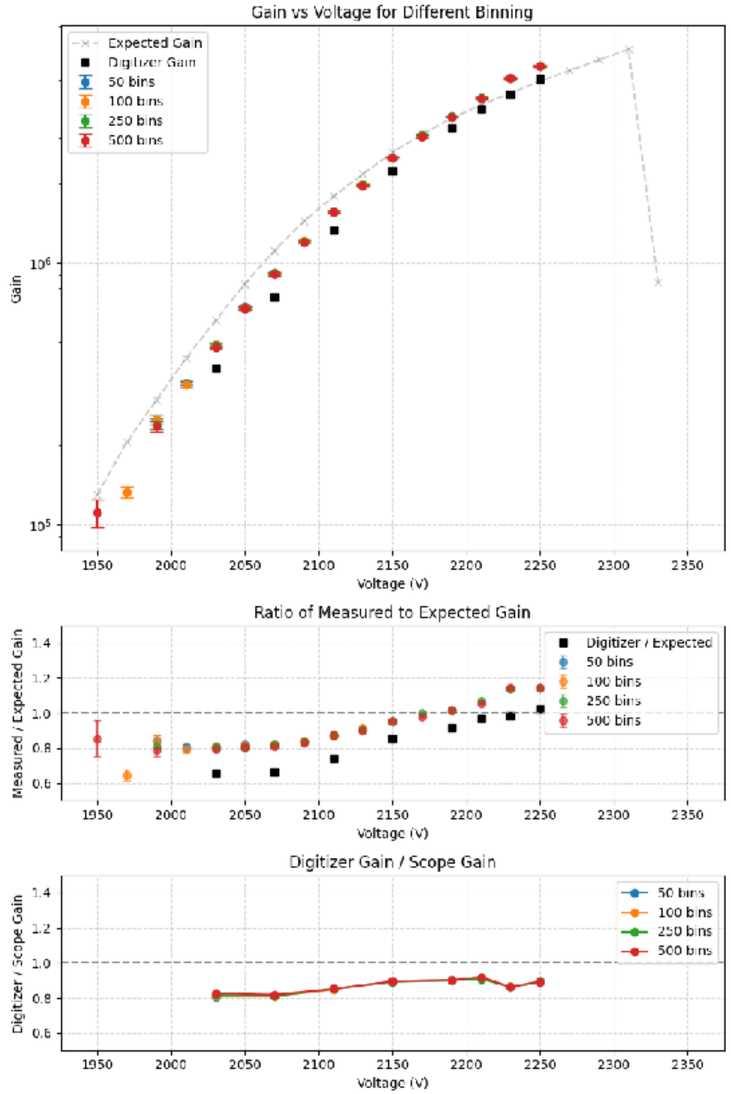
Status

- Gain curve performed previously
- Compares digitiser & scope data (at various binnings) to that measured at GSI (dotted line)
- Gain Map is from digitiser scan at 0.75mm step sizes in x and y.
- Single PE level
- Some channels are clearly missing - believe this is cables on the readout cards
- 2230V

Gain Map



Gain Curve



QE measurement setup

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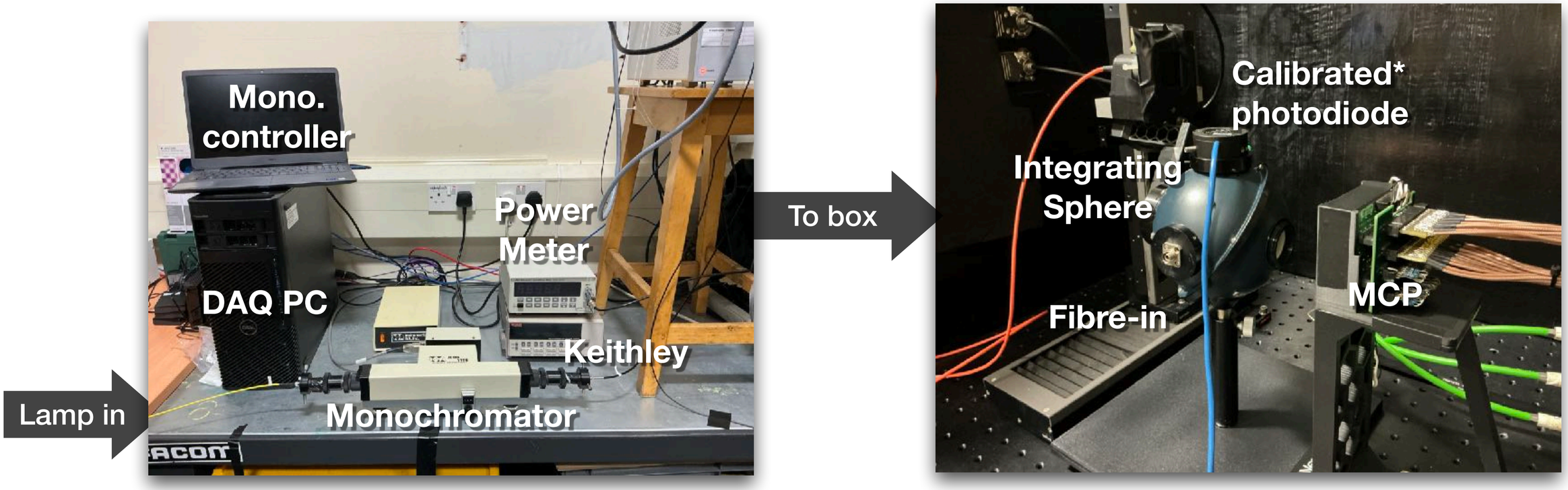
Current measurement *(between MCP in and photocathode)*

- Detector dark current
- Detector current with known light source
- Subtract dark count (I_photo = I_light - I_dark)
- N_electrons = I_photon/e^-

Photon measurement *(diode with known sensitivity, S_ref)*

- Calculate incident optical power P_opt = I_ref/S_ref
- Calculate photon flux
- N_photons = P_opt/E_photon = P_opt/(hc/lamda)

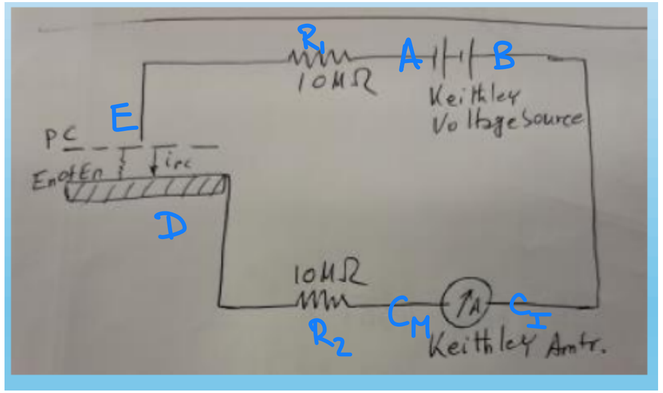
QE = N_electrons / N_photons

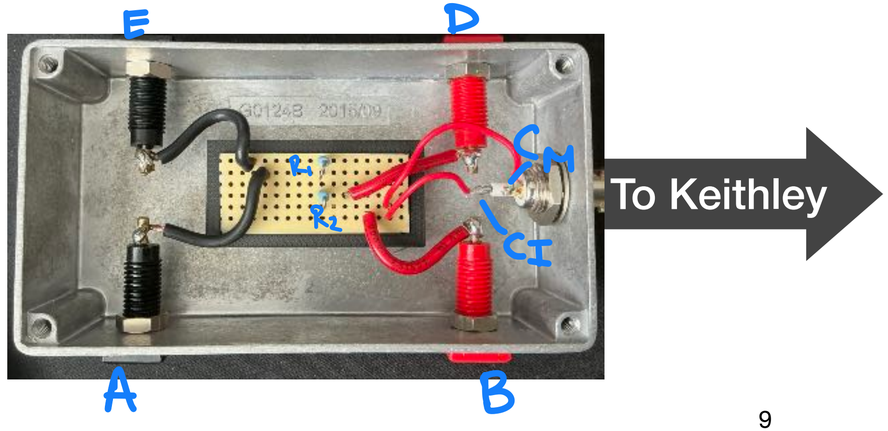


Additionally we can scan with either blue LED, or Blue Laser at high rate

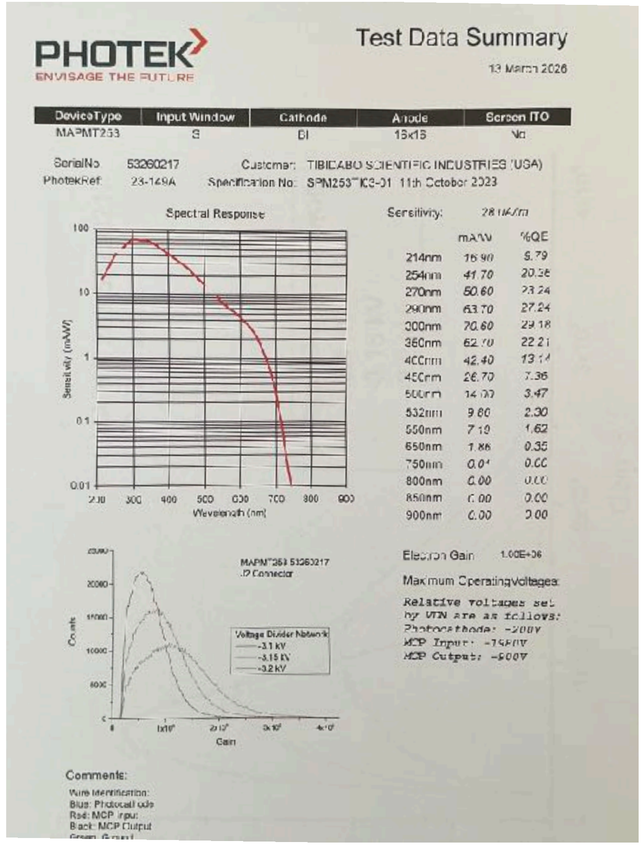
QE measurement next steps

- Figure out connection of Keithley to MCP (advise welcome, eg any protection resistances, grounding etc?)
- Currently making cables and circuit box for this connection
- Trying to figure out fibre connection between monochromator and integrating sphere (have emailed Newport) - Different fibre connectors on each device and need to convert





To Keithley


PHOTEK
ENVISAGE THE FUTURE

Test Data Summary

13 March 2026

DeviceType	Input Window	Cathode	Anode	Screen ITO
MAPMT253	S	BI	15x15	No

SerialNo 53260217 Customer: TIBIDABO SCIENTIFIC INDUSTRIES (USA)
PhotekRef: 23-149A Specification No: SPM253"K3-01 11th October 2023

Spectral Response

Sensitivity: 281A/m

Sensitivity (mA/W)

Wavelength (nm)

	mA/W	%QE
214nm	16.90	9.79
254nm	41.70	20.36
270nm	50.60	23.24
280nm	53.70	27.24
300nm	70.60	29.18
360nm	62.70	22.21
400nm	42.40	13.14
450nm	26.70	7.36
500nm	14.00	3.47
532nm	9.80	2.30
550nm	7.10	1.62
650nm	1.86	0.35
750nm	0.01	0.00
800nm	0.00	0.00
850nm	0.00	0.00
900nm	0.00	0.00

MAPMT253 53260217
.D Connector

Voltage Divider Network
-3.1 kV
-3.15 kV
-3.2 kV

Counts

Gain

Electron Gain 1.00E+06

Maximum Operating Voltages:

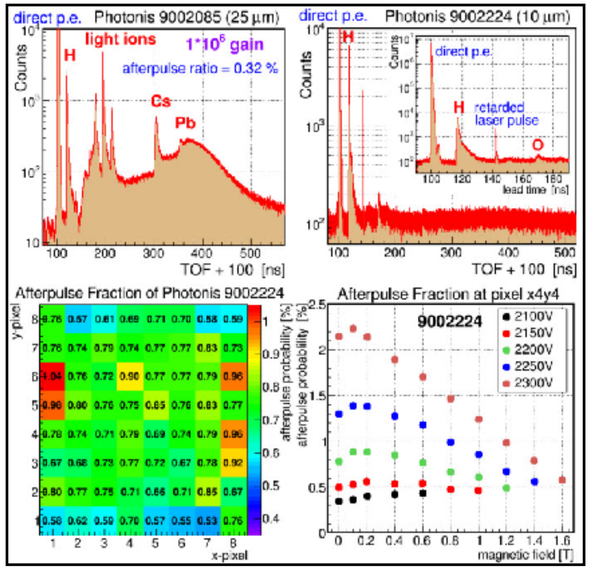
Relative voltages set by VTN are as follows:
Photocathode: -200V
MCP Input: -1.4kV
MCP Output: -500V

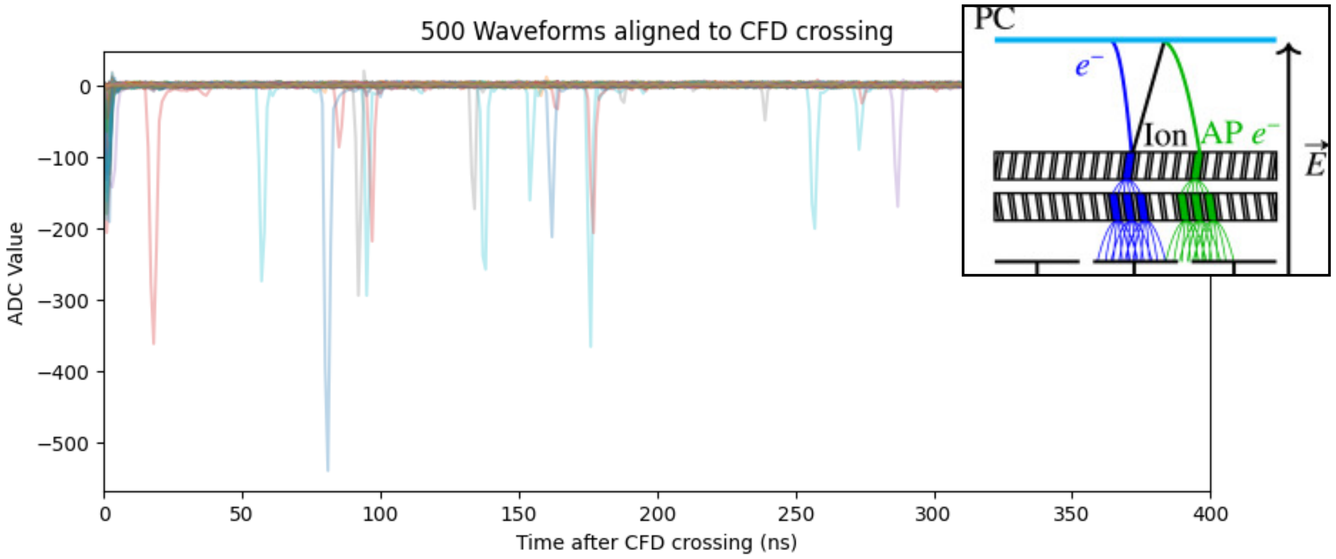
Comments:
Wire Identification:
Blue: Photocathode
Red: MCP Input
Black: MCP Output
Green: Ground

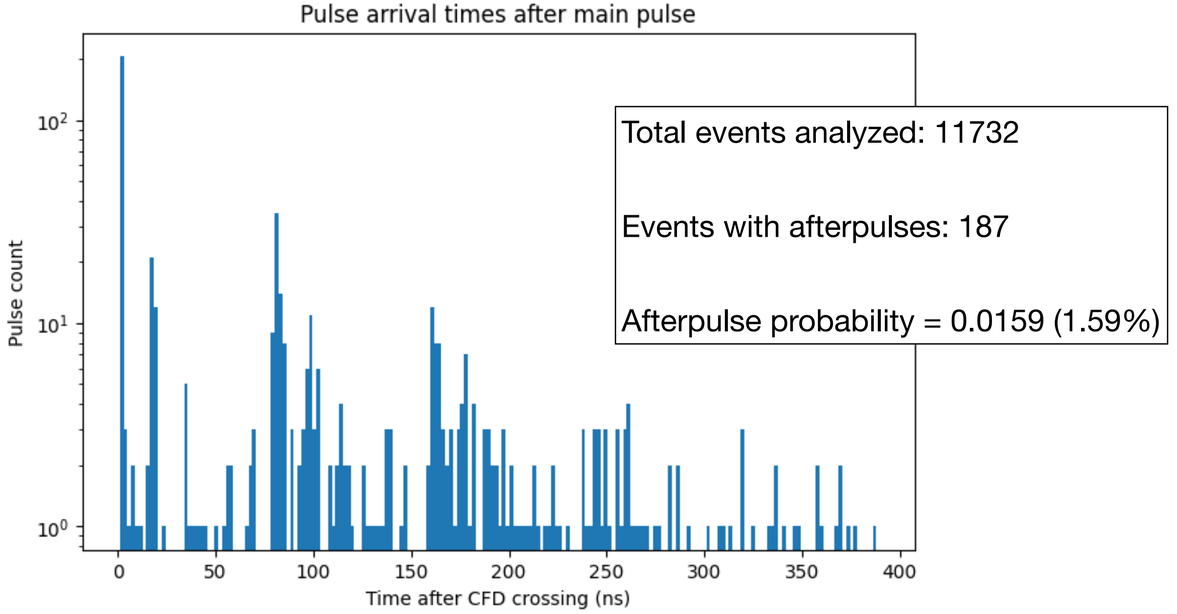
Photonis - Afterpulsing

Method

- Drop rate ~factor 5 to have large window (1 GS/s while no scope))
- Record for 20seconds at each pixel (2230V)
- Align waves to 50% CFD crossing time. Fill hist with afterpulse times.
- Tested with a **single** file (12193 events from file pos_57.50_83.50_Ch__23.dat) to reproduce spectrum below
- Note, single channel, so not expecting afterpulses. value seems high.



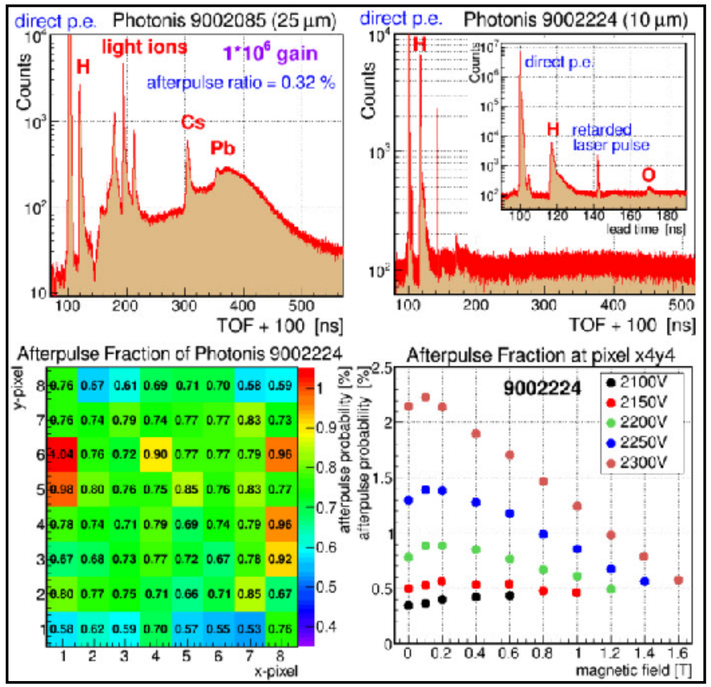


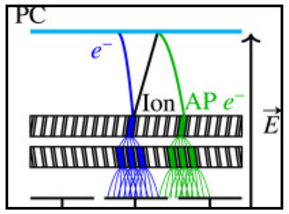


Photonis - Afterpulsing

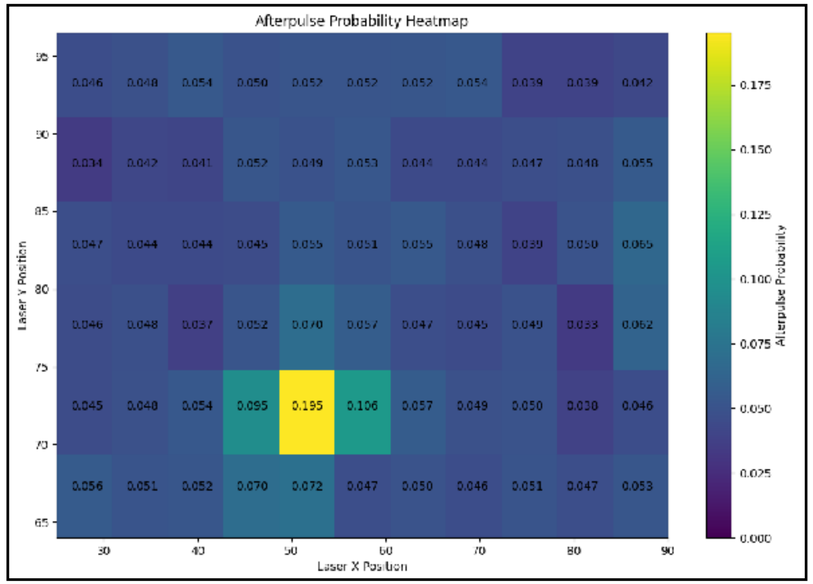
Status

- Same as before, but now looping over all channels and positions.
- Results highly threshold dependent (see right)
  - Defining Ratio as N_afterpulse / N_direct_p.e.
  - How to define thresholds on R to be consistent with below?

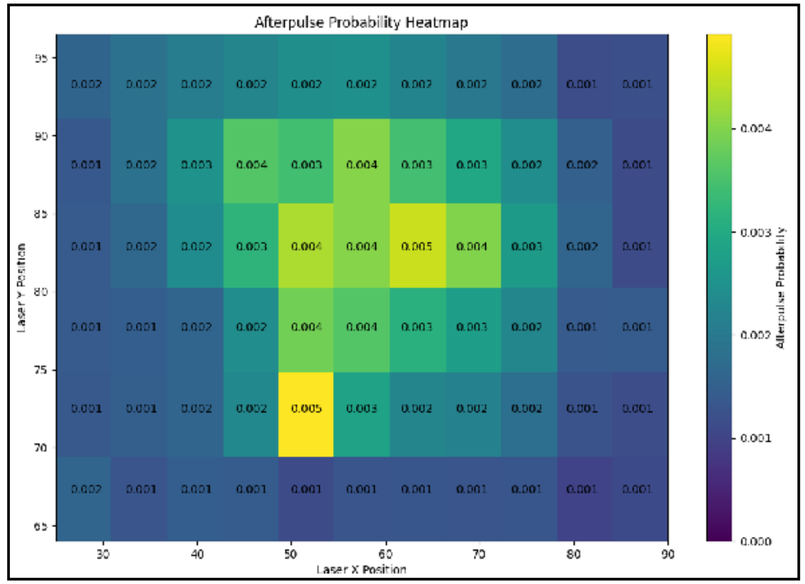




- Threshold on direct p.e. peak value < -8mV
- R up to ~20%



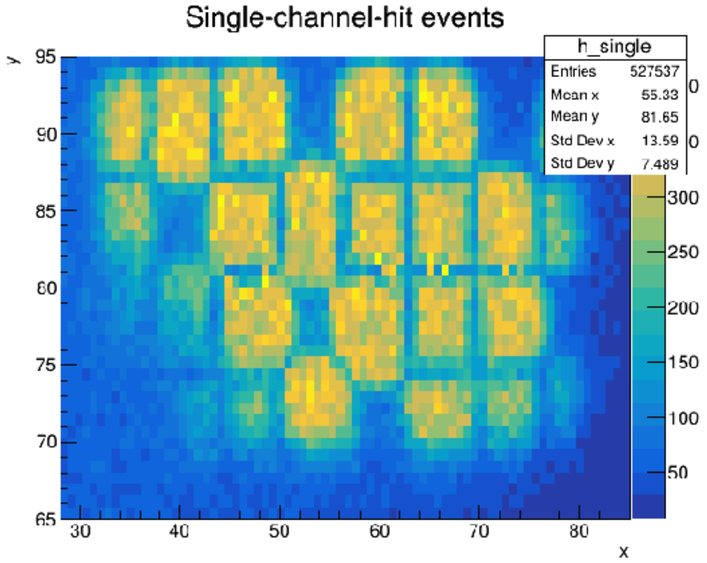
- Very low threshold (-2mV) *(i.e. many baseline hits in denominator*
- R up to 5%

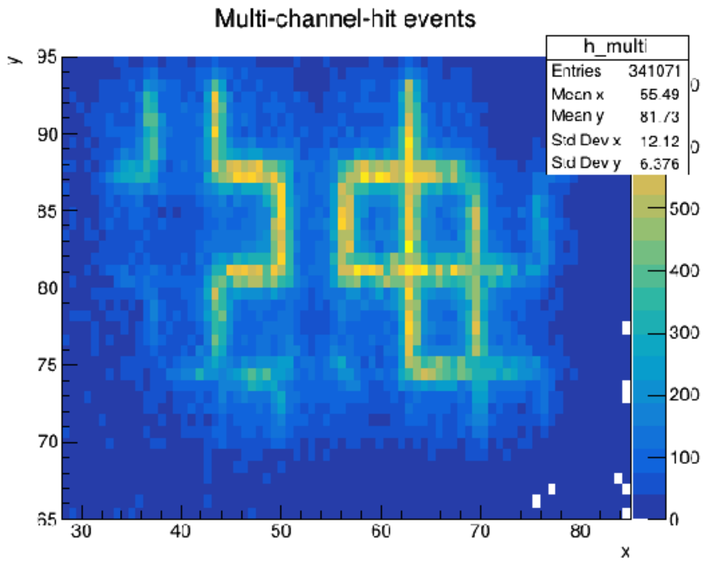


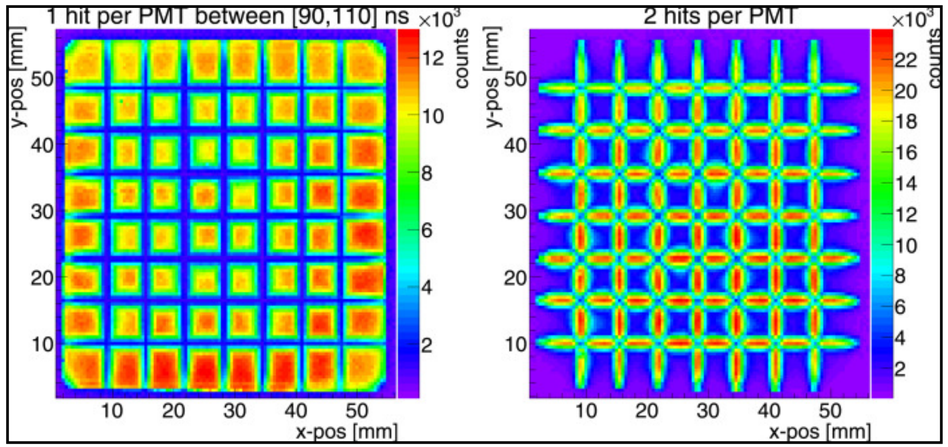
Photonis - Charge sharing & recoil electrons

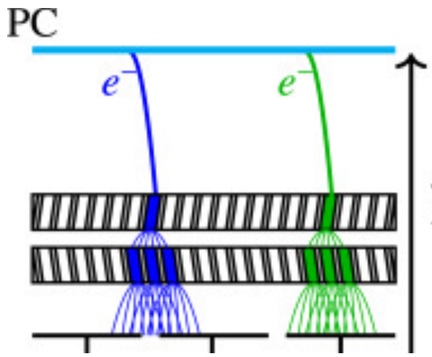
2D hit maps with multi-channel-hit cuts

- Time cut around direct p.e. (23.5-25.5ns)
- Pulse height cut above pedastal (-5mV)
- top half of the detector
- Looking to reproduce plots below









Photonis - Charge sharing & recoil electrons

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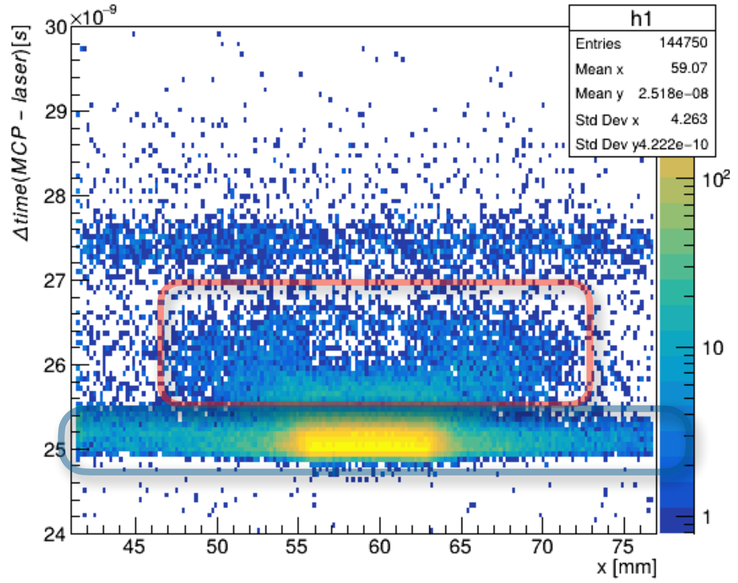
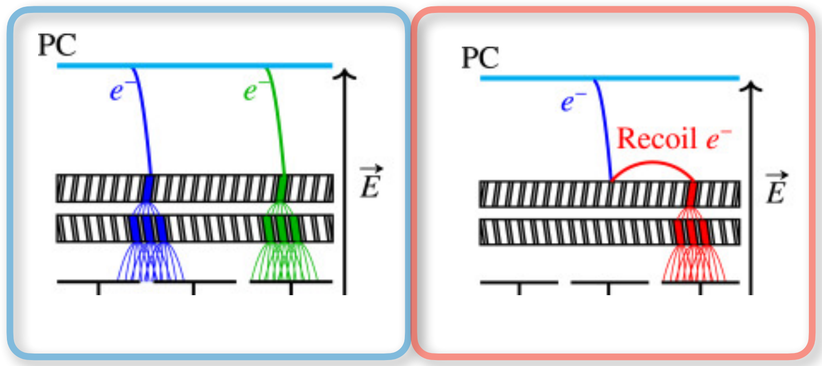
Single channel x vs time

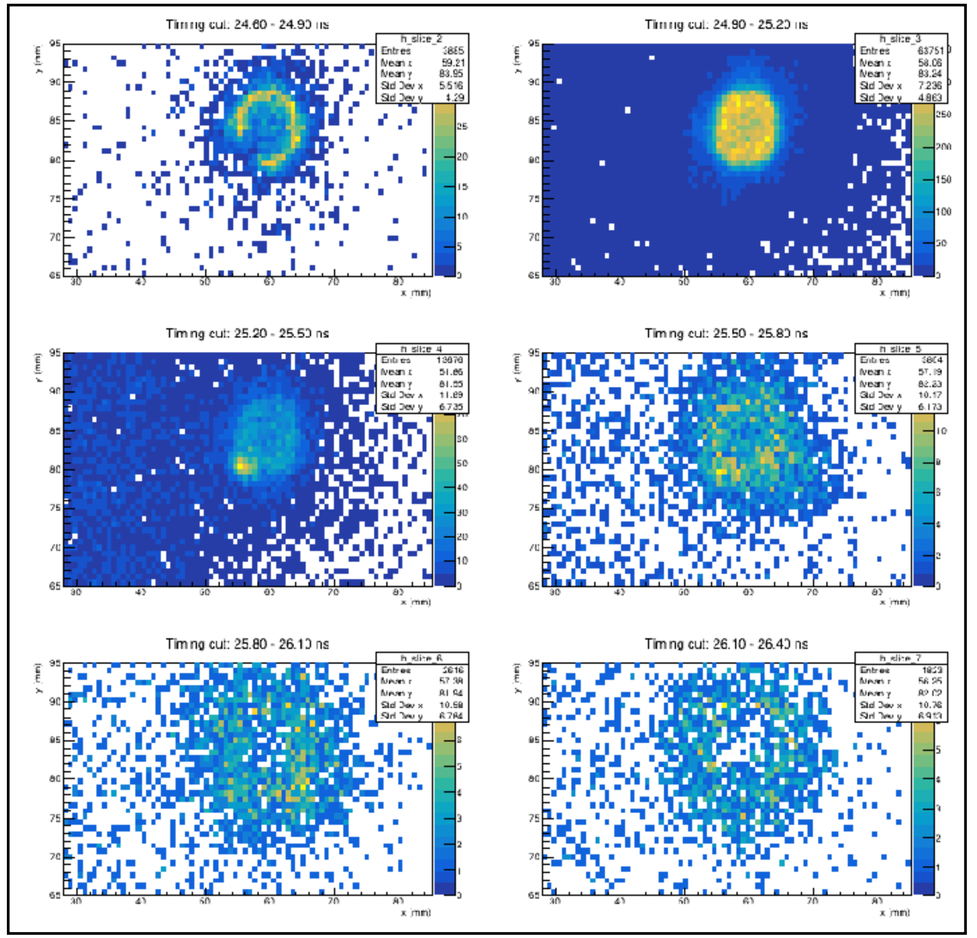
- Sweep 35mm in x over fixed y in 0.2mm steps





Single channel xy plots in 0.3ns time bins

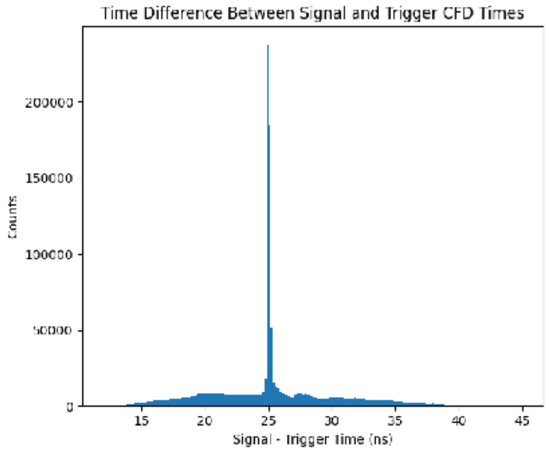
- Data from gain scan, 0.75mm step size in x and y

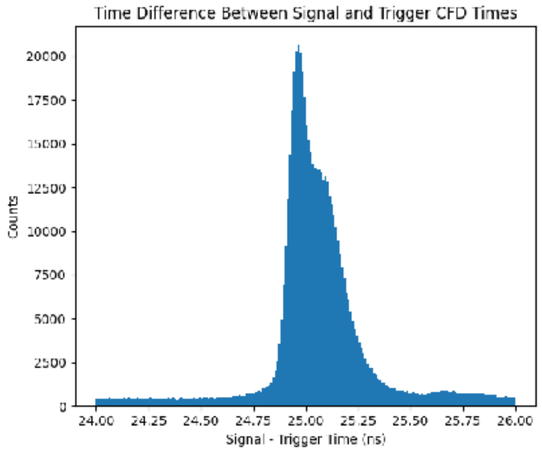


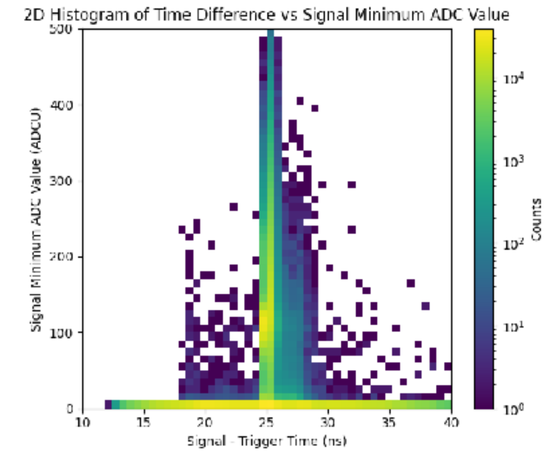
Photonis - Timing

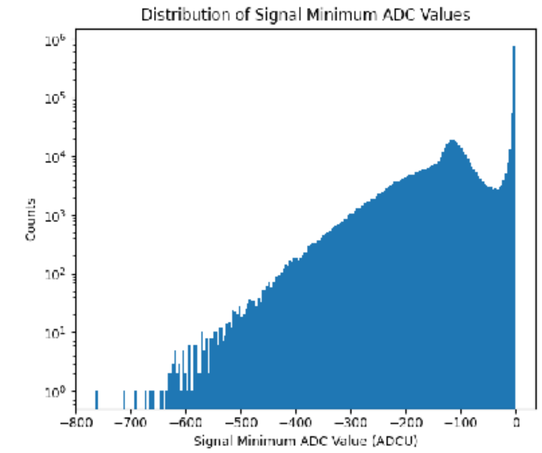
Measurement

- Measure on fixed position for an extended time, same laser and V as previously
- Filter on very small ADC value to remove events random in time window

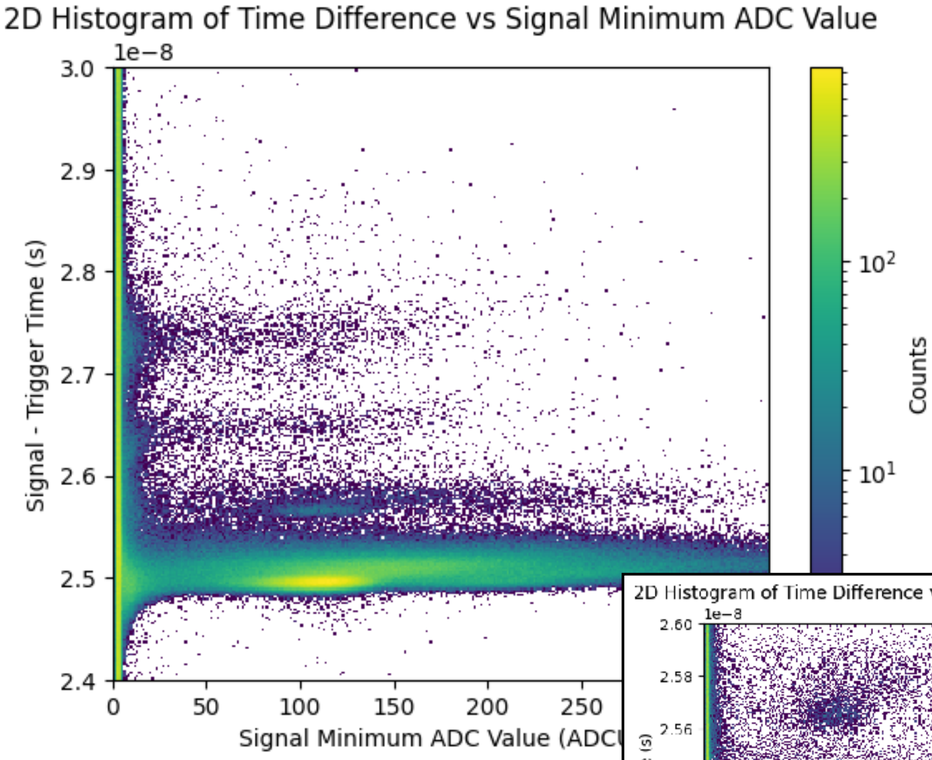


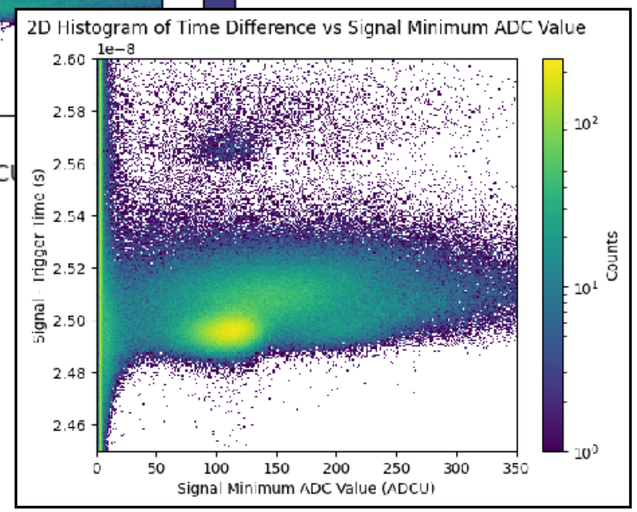






Check for Timewalk in CFD method

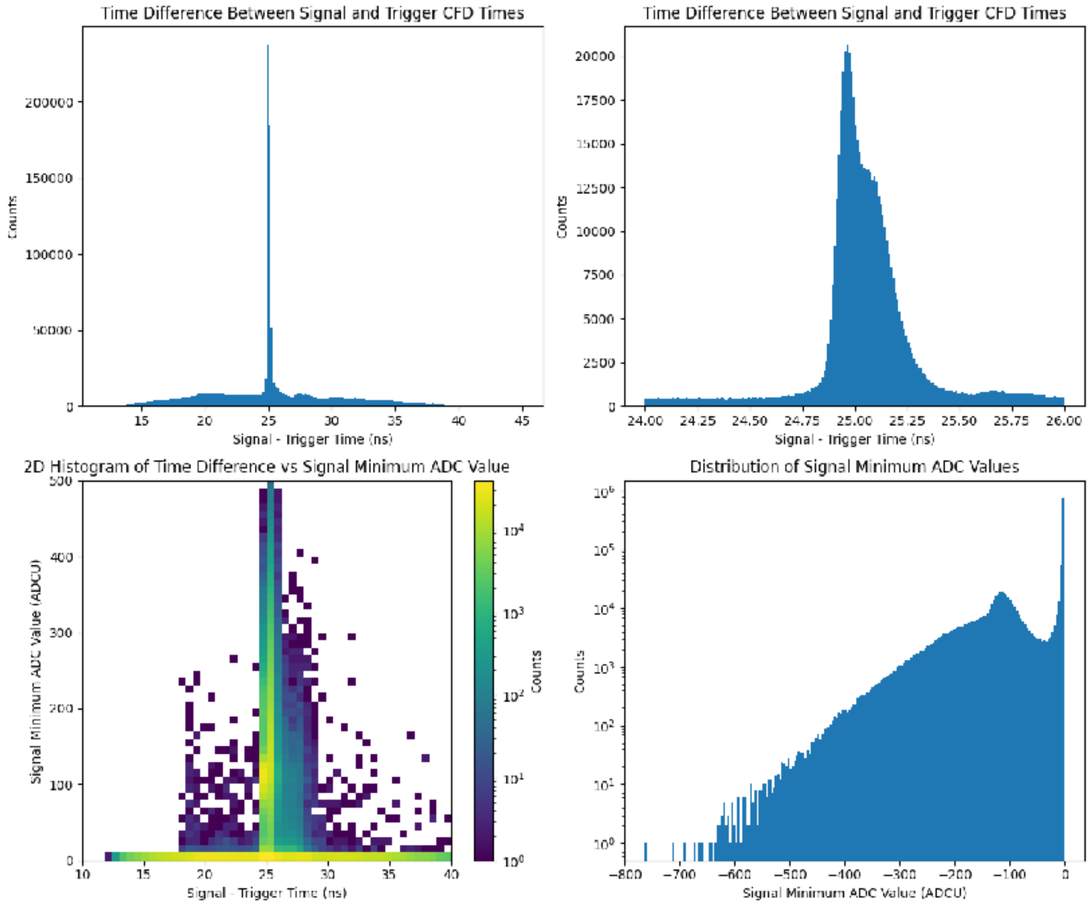




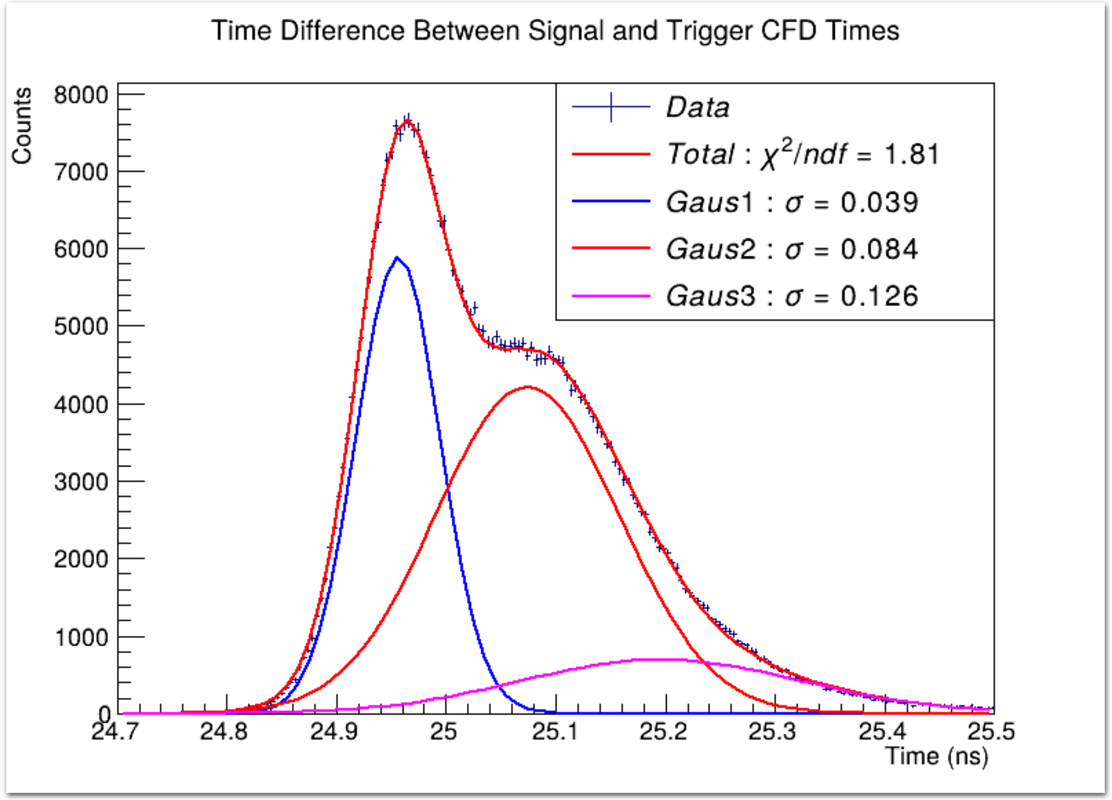
Photonis - Timing resolution

Status

- Measure on fixed position
- Filter on very small ADC value to remove events random in time window



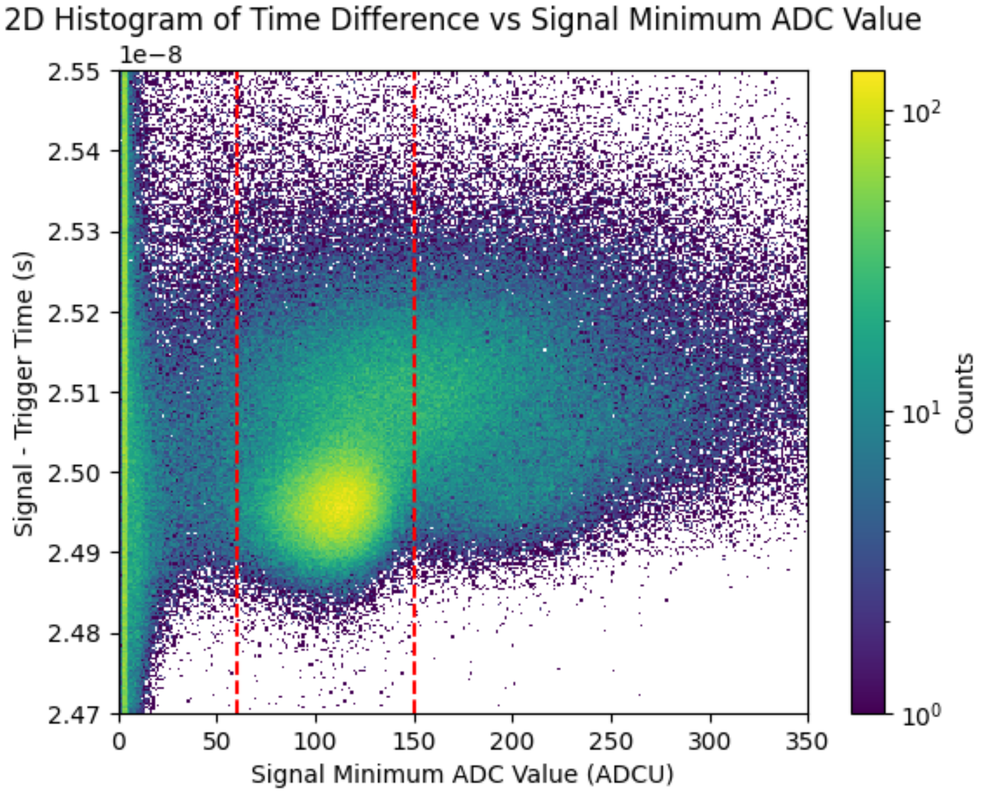
Time resolution

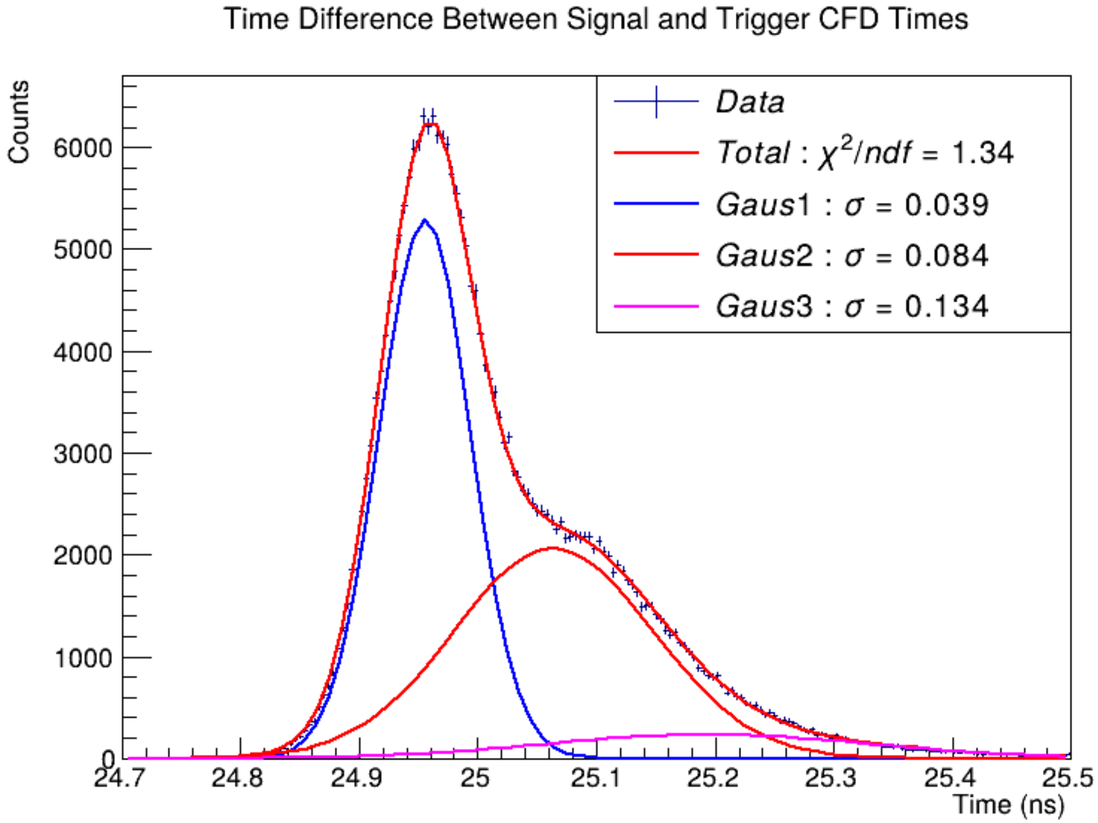


Photonis - Timing resolution

Status

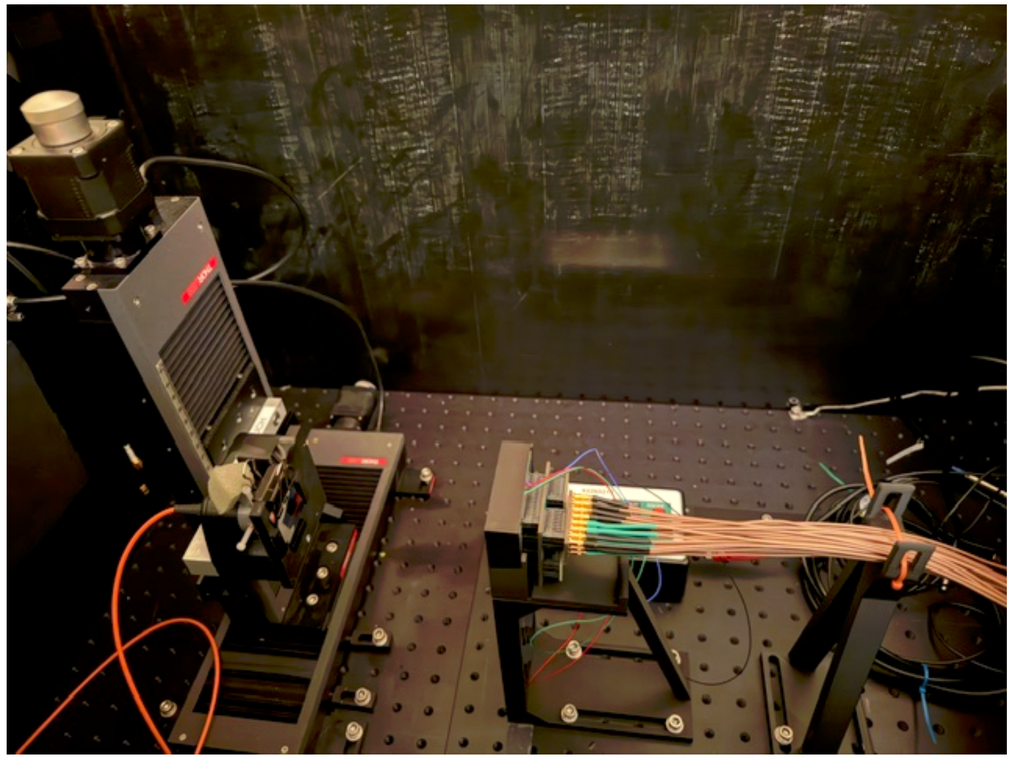
- Measure on fixed position
- Filter on ADC value 55 to 150 to reduce RMS peak

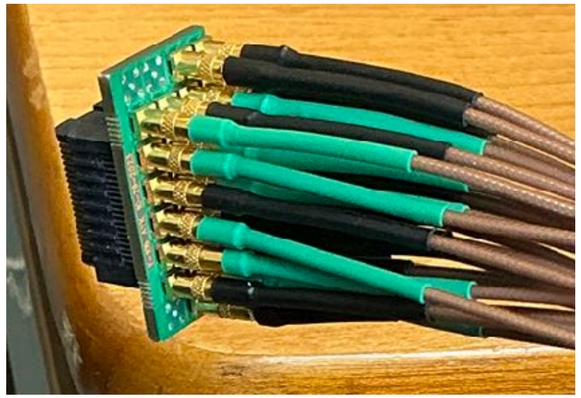




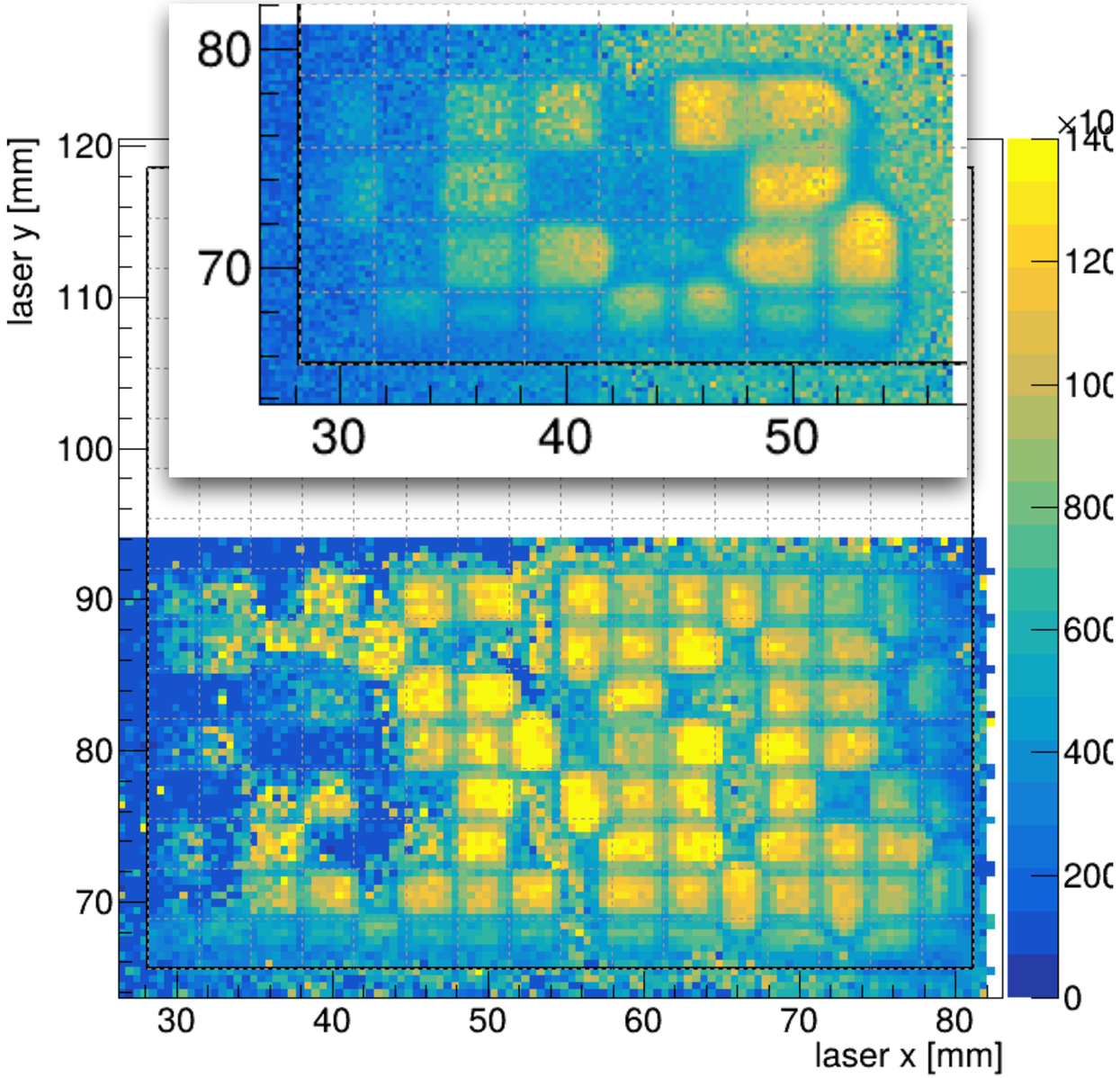
Photek

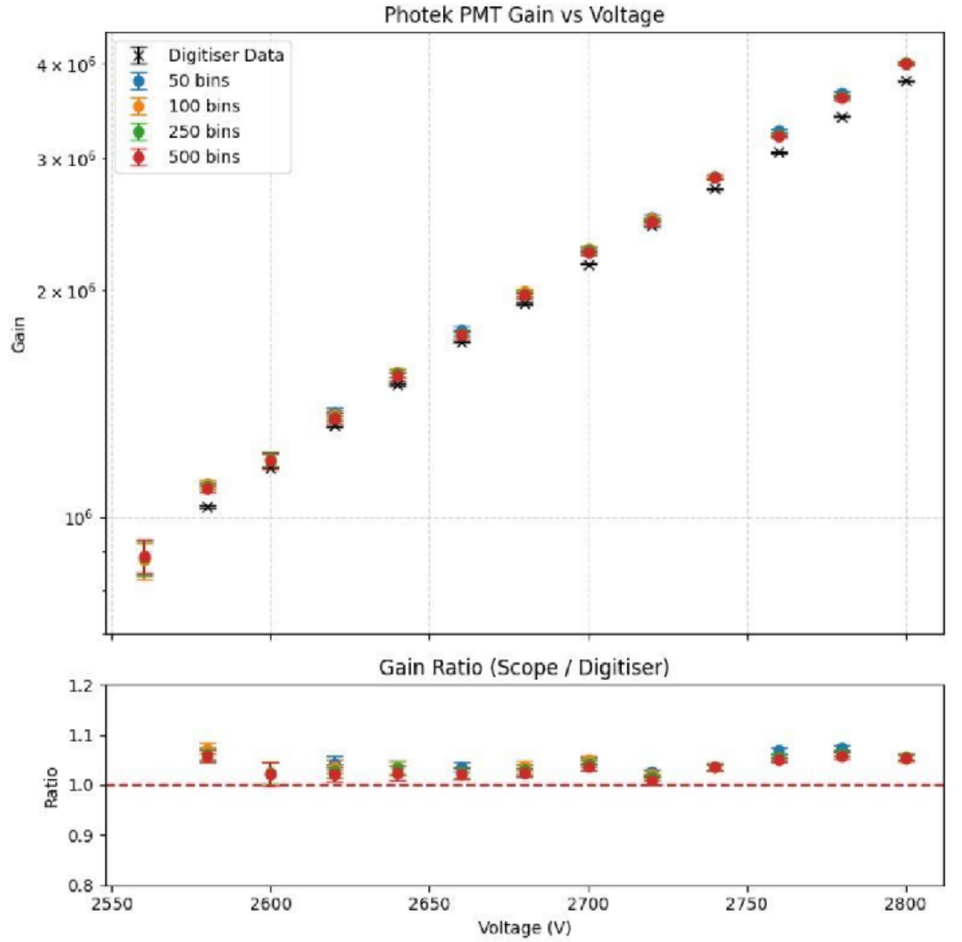
- New Photek Tube in Glasgow
- Requested us to ship back old one (done)
- Started scanning device
- Noticed several missing channels in readout
- Combination of gold MMCX connectors falling off adapter board (4 channels) and some cables being faulty
- Now:
  - Making replacement cables
  - Trying to get a quote to purchase more readout boards
  - Question for collaboration? Is current channel failure rate ok? If so we will proceed with missing channels to finish characterisation the photek tube
  - See next slide for missing channel rate

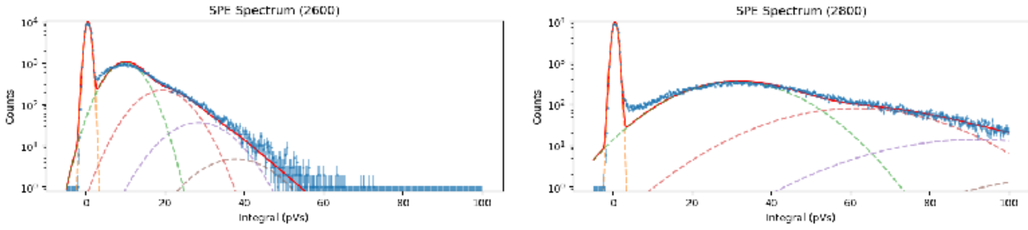




Photek

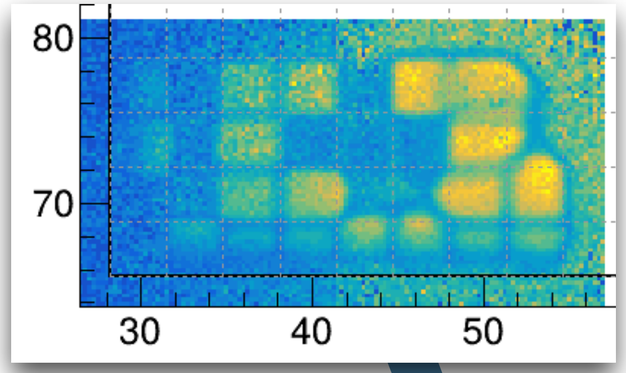

laser y [mm]
laser x [mm]
×10
120
110
100
90
80
70
30
40
50
60
70
80
140
120
100
80
60
40
20
0

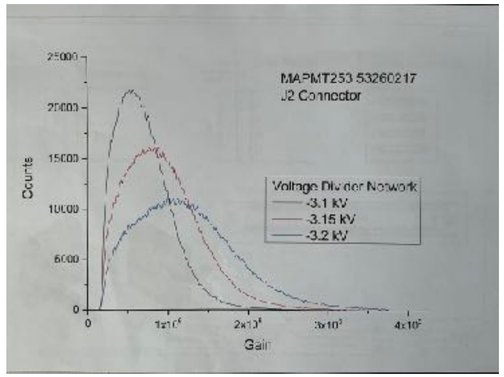

Photek PMT Gain vs Voltage
Digitiser Data
50 bins
100 bins
250 bins
500 bins
Gain
Gain Ratio (Scope / Digitiser)
Ratio
Voltage (V)

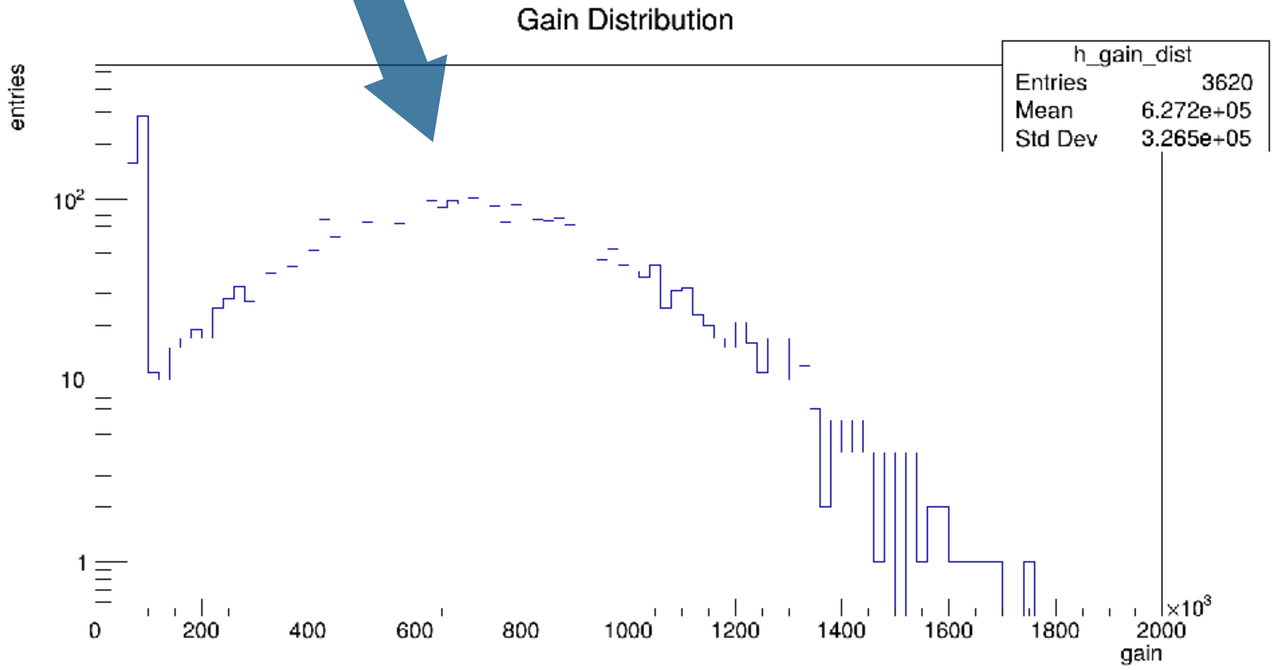

SPE Spectrum (2600)
SPE Spectrum (2800)
Counts
Integral (pVs)

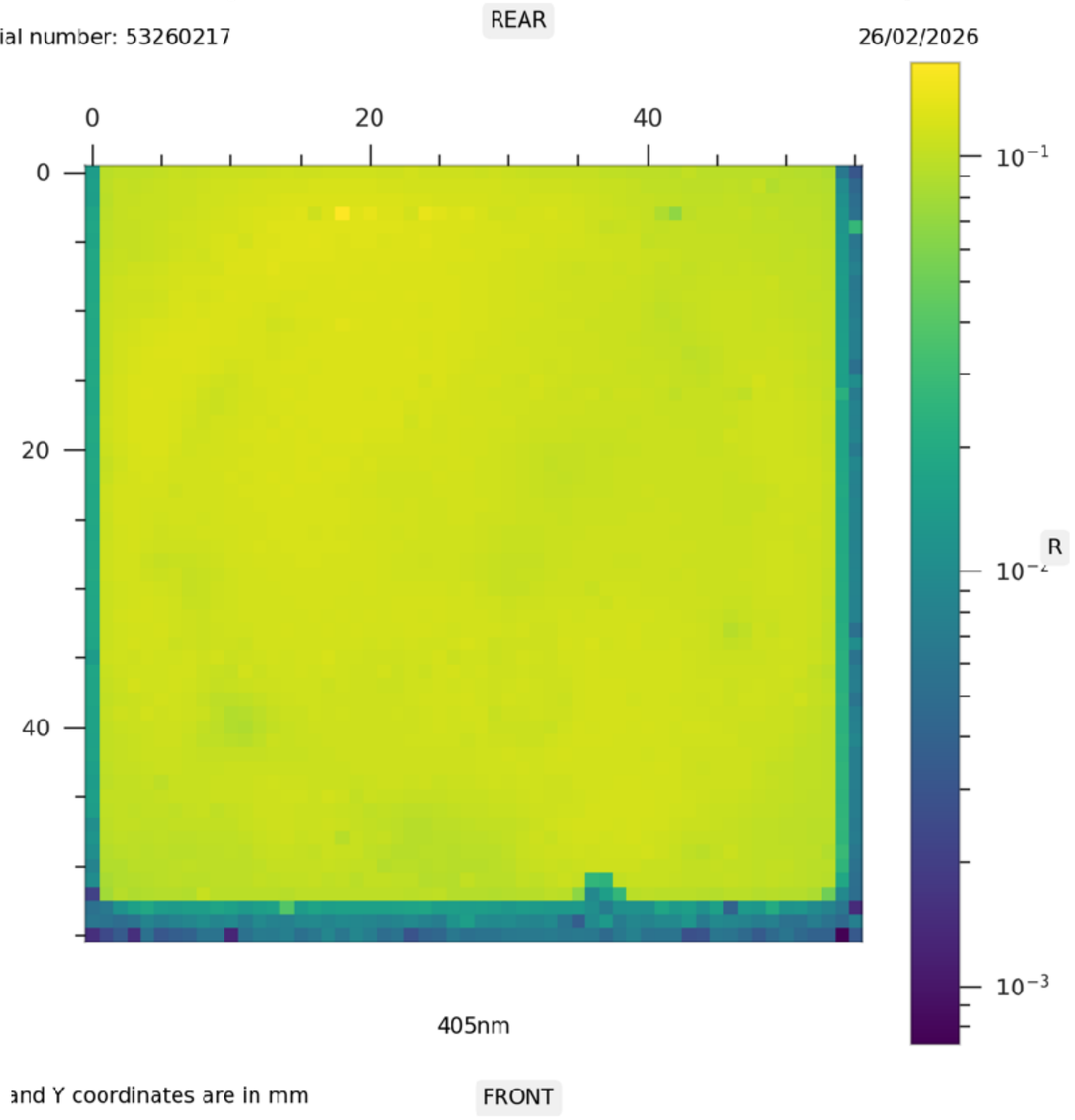
Photek

QE uniformity scan for 405 nm from photek









Summary

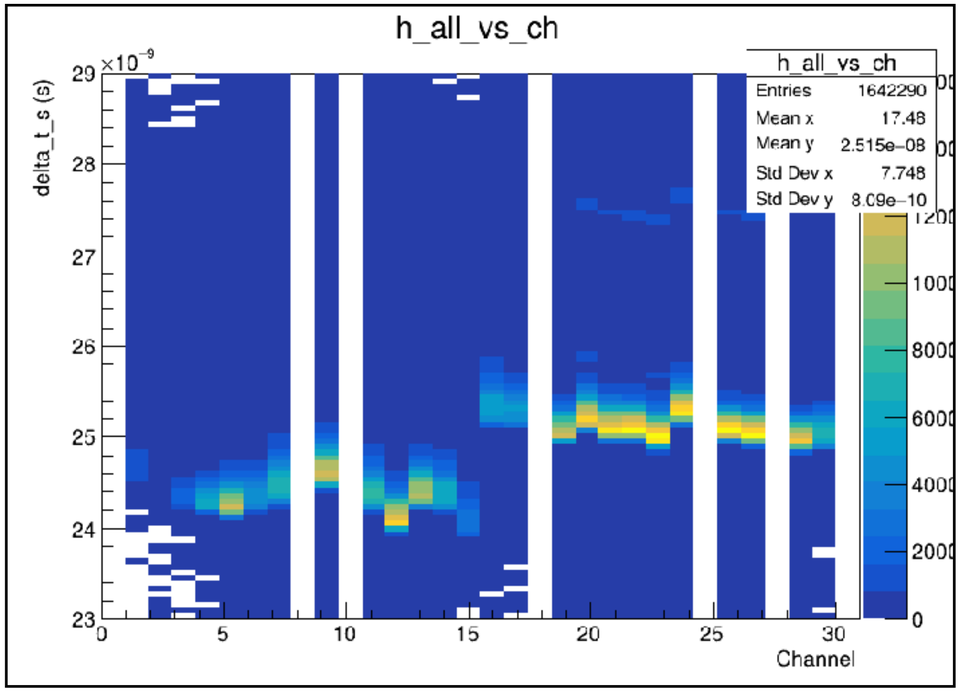
- Experienced some recent hardware set backs
- Would like to understand what fraction of missing channels is acceptable to collaboration for the studies?
- Regaining all channels is more timely than moving on as is, although we are currently trying to recover as many channels as we can and will continue to do so in parallel
- Photonis
  - Single PE gain scan complete
  - Timing resolution under study (but do not have like for like result for this S/N and divider set up from GSI)
  - Need to do QE and crosstalk (please remind us the photon level for crosstalk/ringing checks)
- Photek
  - Partial single PE gain scan performed, but several channels missing
  - Need to perform other measurements
- HRPPD
  - Need to perform all measurements
- Note: Kathleen and Andrew at pfRICH testbeam for a couple of weeks

Backups

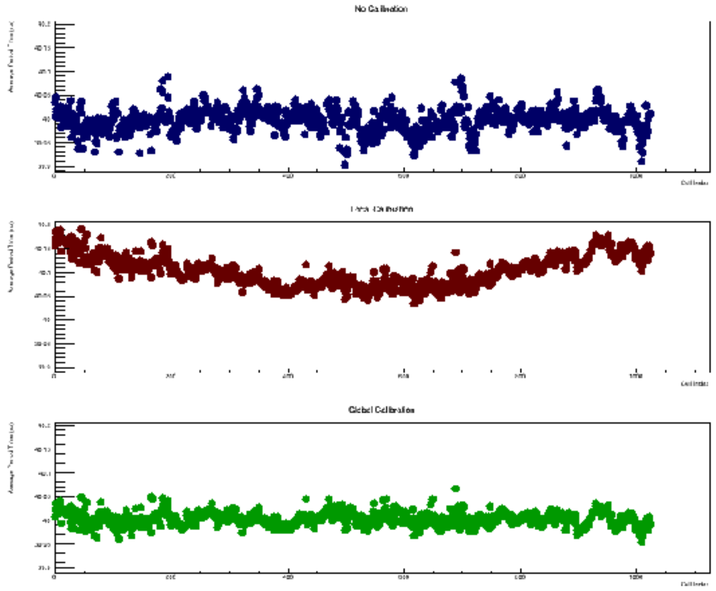
DRS4 calibration

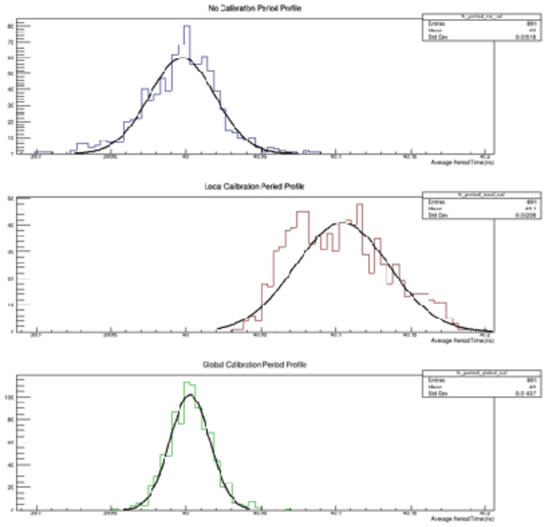
First look

Performed DRS4 calibration using signal generator on 1 channel to test procedure.



0.218ns





DRS4 calibration

First look

nhits plots with larger time (+/- 10ns) window
(similar to paper)