4th LAPPD Workshop (remote)
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Plans for LAPPD#153 ageing studies at INFN

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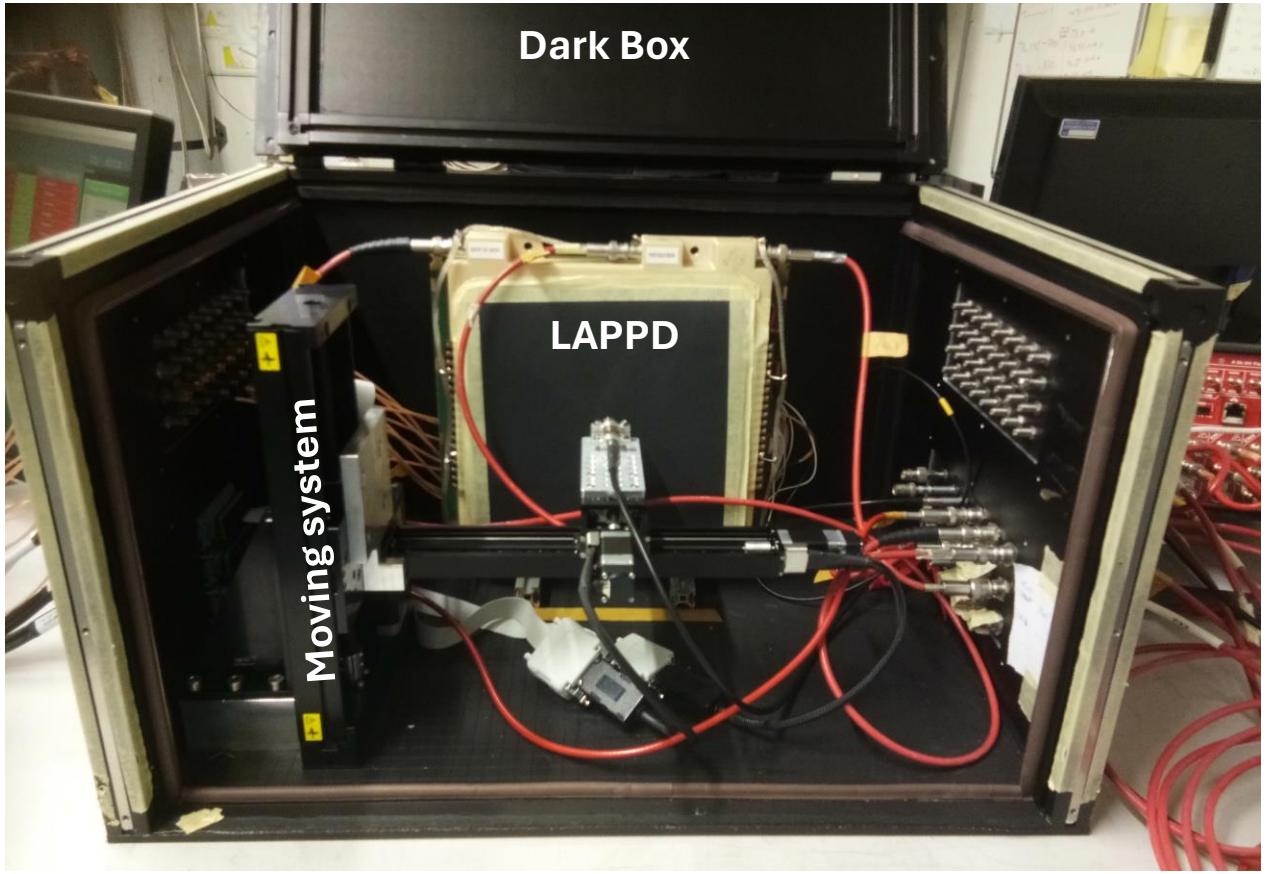
INFN
Istituto Nazionale di Fisica Nucleare

LAPPD and Instruments

- LAPPD#153 (Gen-II)
- Dark box
- Laser light introduced inside dark box by a fibre with focalising lens
- Software-controlled Moving Arm System (Zaber)



➢ Daisy Chain HV Power Supply (CAEN DT1415)
(as for our timing studies with test beams at CERN)

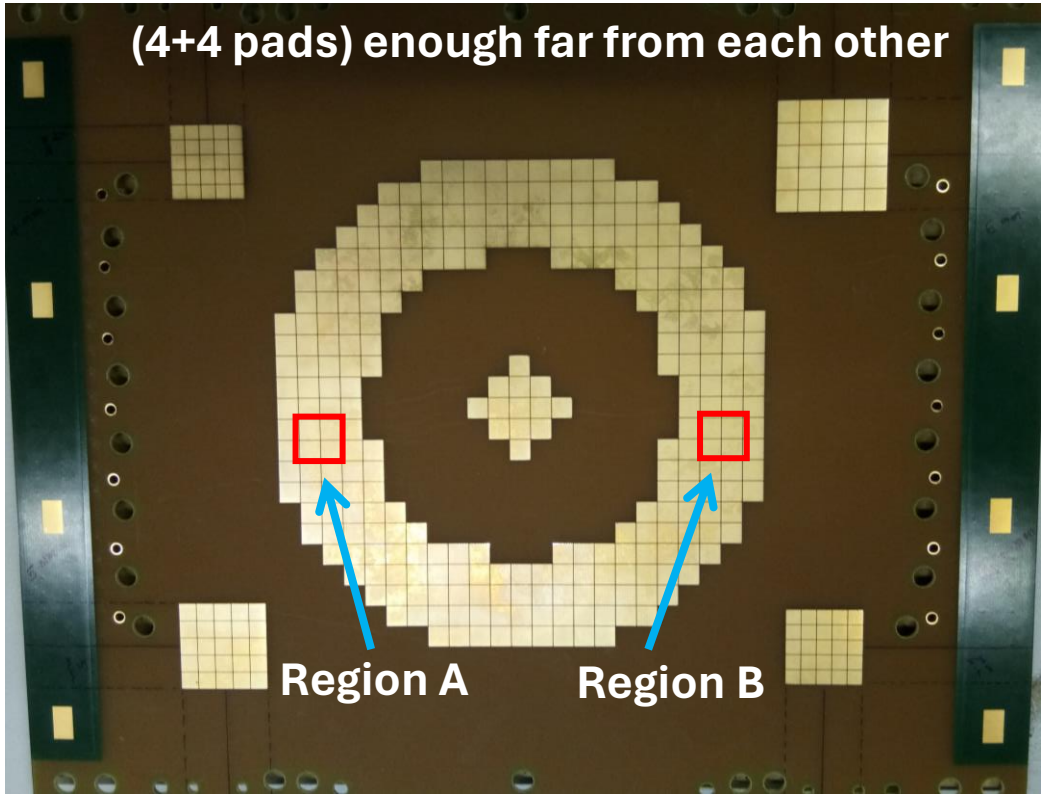
➢ Light source
- Laser Diode Head (Pulsed - 405 nm) and controller

❑ Readout Chain
- Inverting Amplifier (Custom-made)
- Digitizer (CAEN V1742)
- Oscilloscope (2.5 GHz, Teledyne Lecroy waverunner 9254)
- Picoammeter (Custom-made) – Photocathode Current
- Picoammeter from Keithley (6485) - One Ground Connection - Anode Current

Strategy – Ageing Study

Two well separated regions for light illumination → Each region : Four sensor pads → Illumination
- HIGH for Ageing
- LOW for SPE

→ One of these two regions (**let's call Region A**) will face HIGH illumination



↓

During high illumination (**Region A**), rest of the window **protected with black screen**

↓

Region A
SPE measurements before and after high illumination

←

Region B
SPE measurements for comparison and stability check

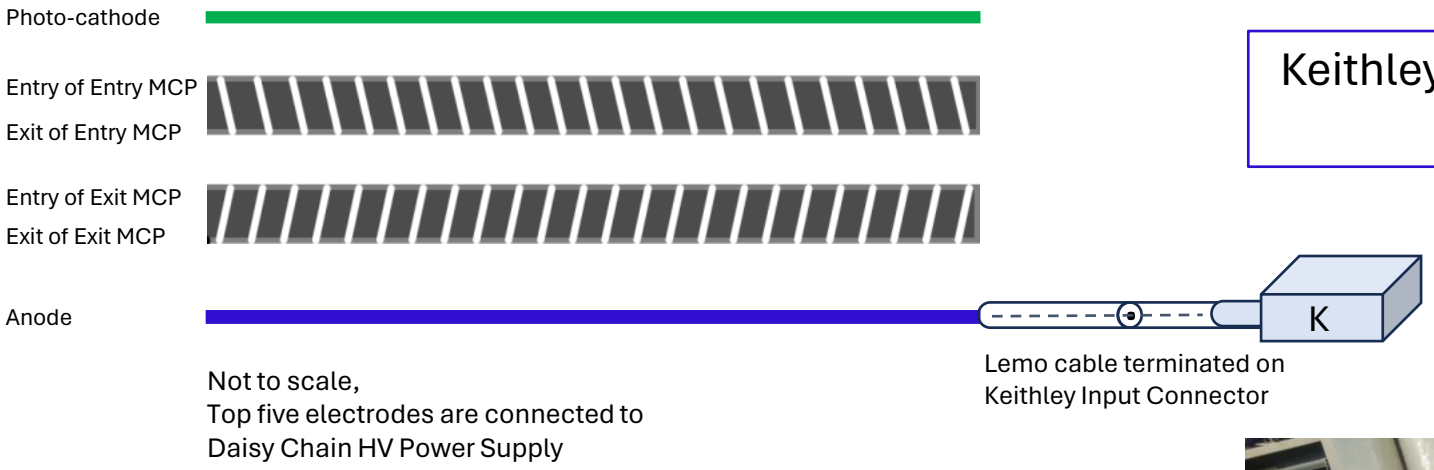
What to Measure?

Quantities of interest:

- Efficiency
- Effective gain
- Photocurrent at Anode/Photocathode

  - Hardware intervention on the LAPPD performed for getting a connection point to measure **Integrated Charge on Anode**

Keithley Picoammeter – Anode Current



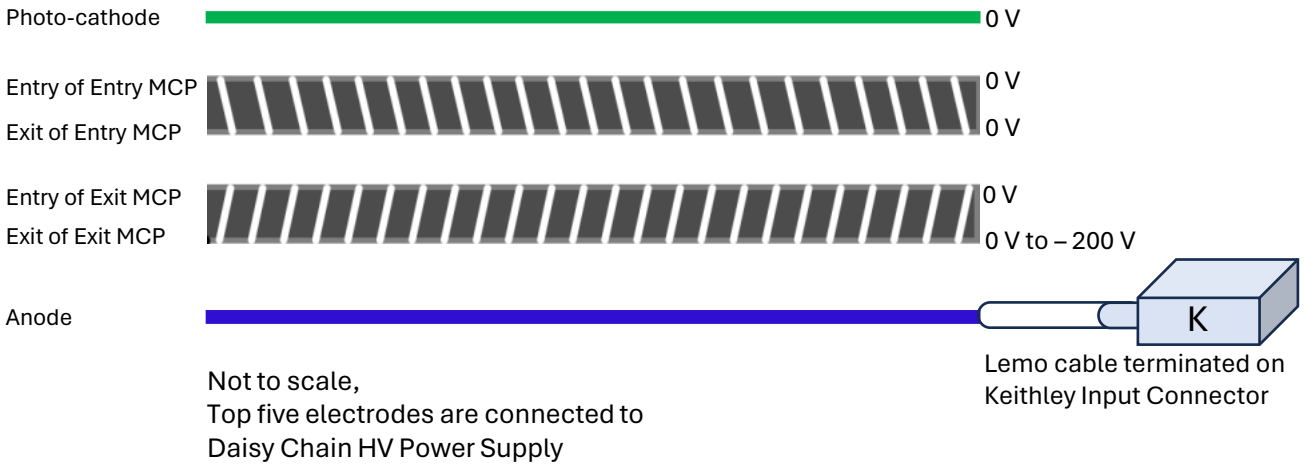
Keithley Picoammeter between Anode and Ground
Resolution: 10 fA

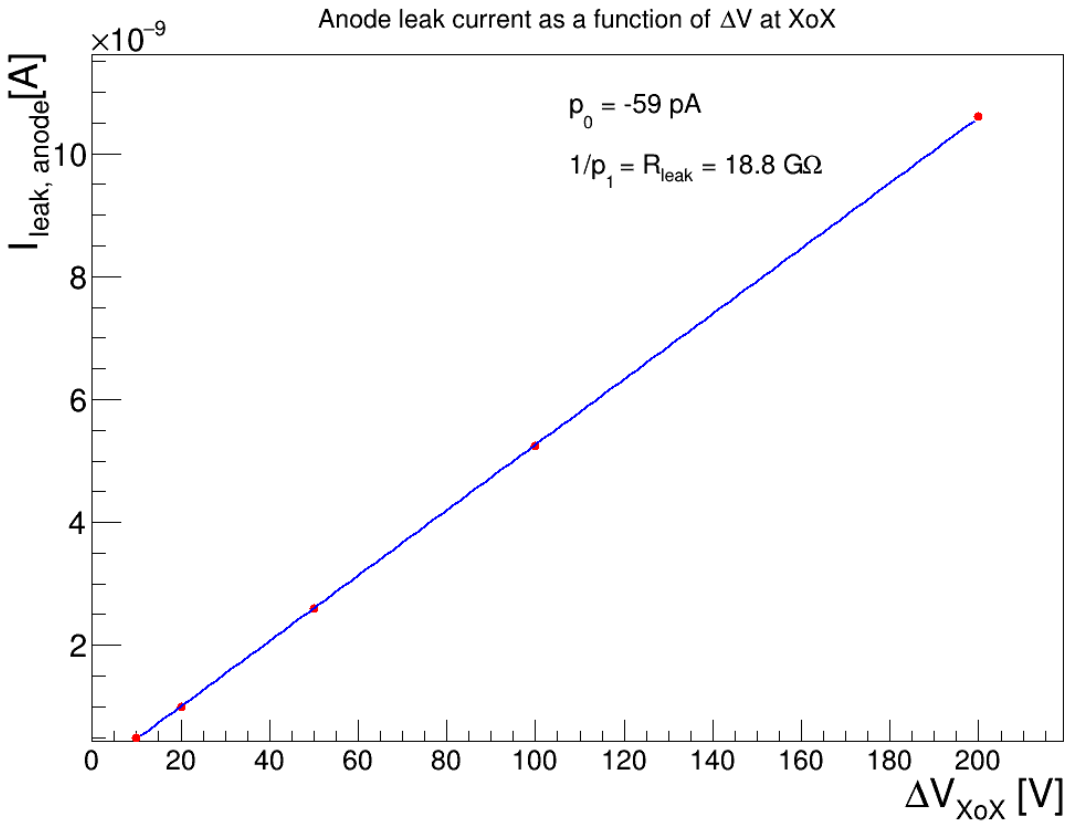
Two working configuration

- Normal: lemo terminated (with 0 Ω) on patch panel
- Keithley (K): lemo terminated on Keithley Input Connector

Lemo (via the HV cable) is terminated on Keithley input

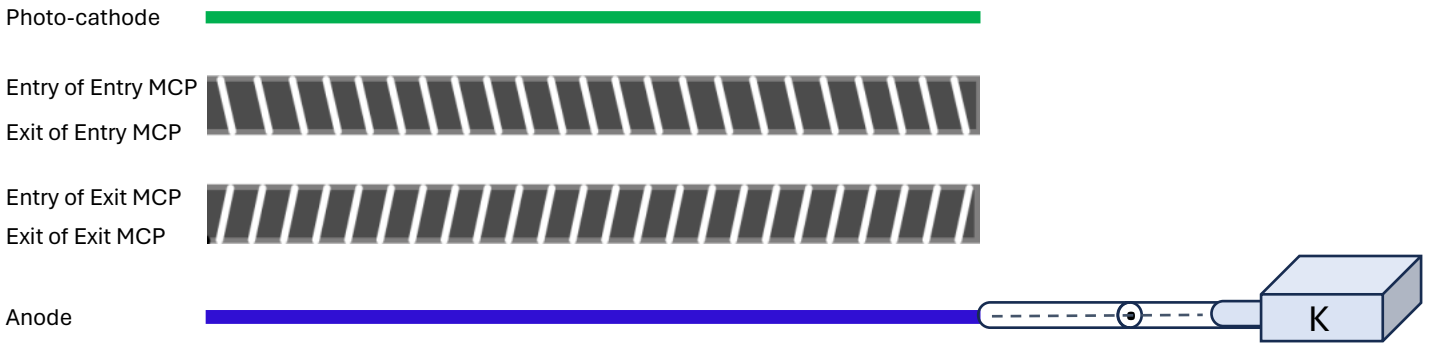
Anode Leak Current





- Anode current measured (light source OFF)
  - as a function of voltage at Exit of Exit
  - with all other electrodes kept at zero bias voltage
- **Ohmic Leak Resistance** between Exit of Exit and Keithley Input via the Anode: **~19 GΩ**
- Only Entry of Exit MCP has some significant contribution to this leak current

Anode Leak Current



Not to scale,
Top five electrodes are connected to
Daisy Chain HV Power Supply

Lemo cable terminated on
Keithley Input Connector

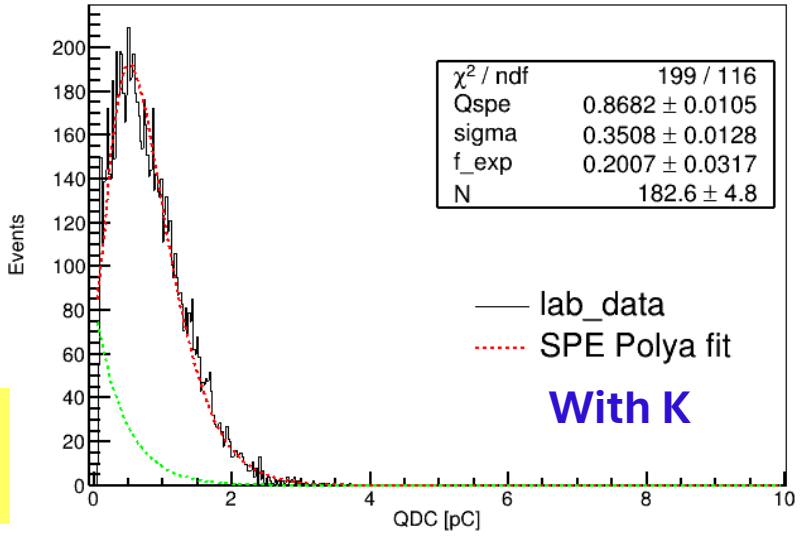
Config.	Efficiency [%]	Mean of Pulse Height Distribution [pC]
Normal	7.3	0.85
K	7.6	0.87
K + 10 MΩ	7.4	0.56
10 MΩ	7.2	0.62

Two working configuration

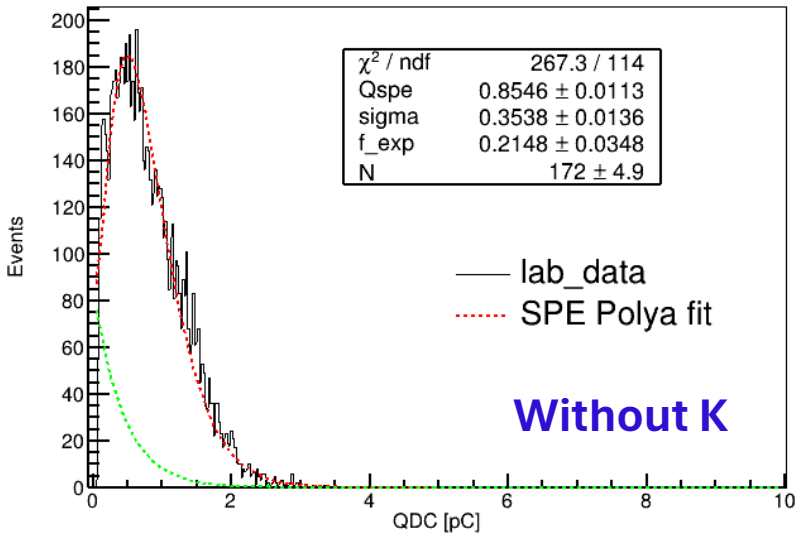
- Normal
- Keithley

➢ No evidences for Keithley presence modifying the results

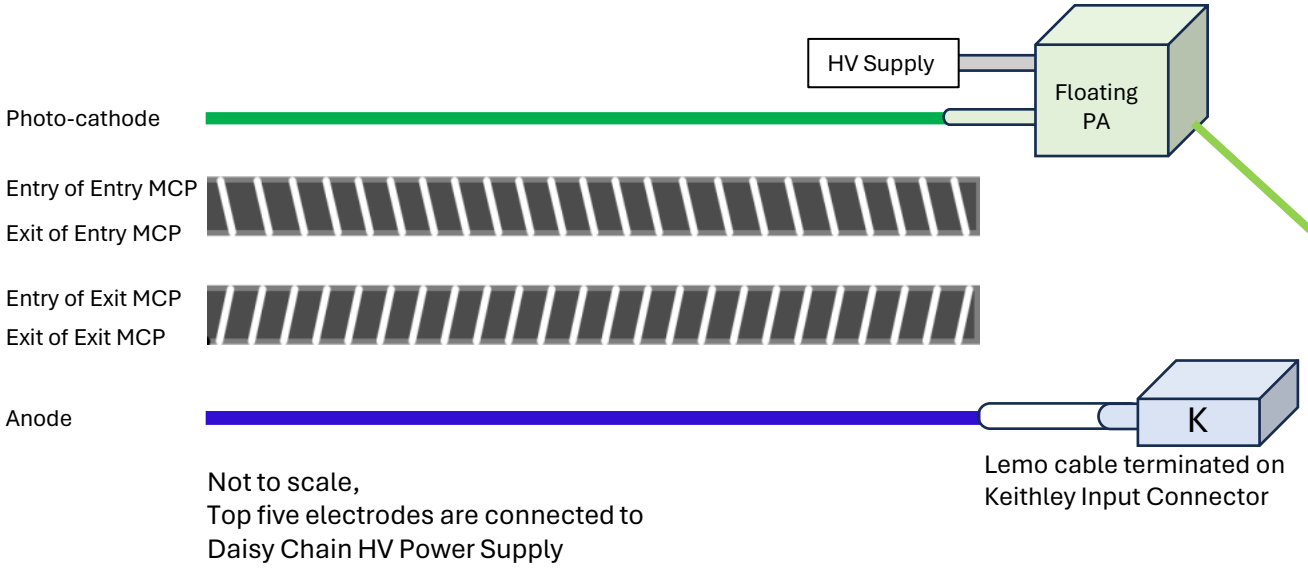
PHDist_K_test



PHDist_N_test



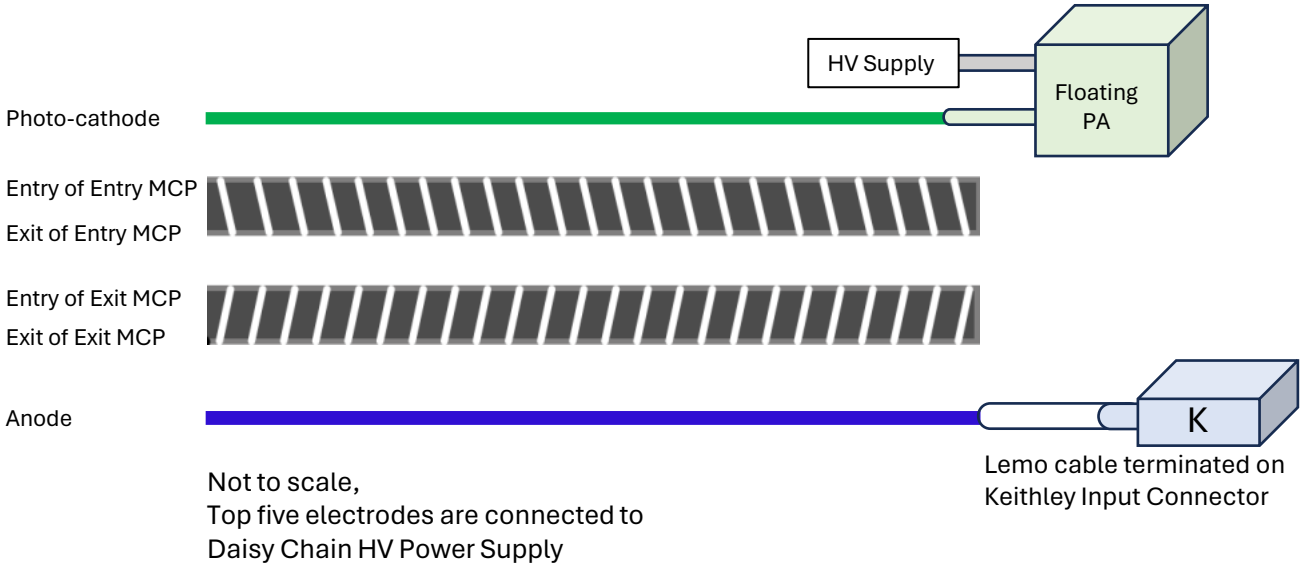
Photocathode leak current

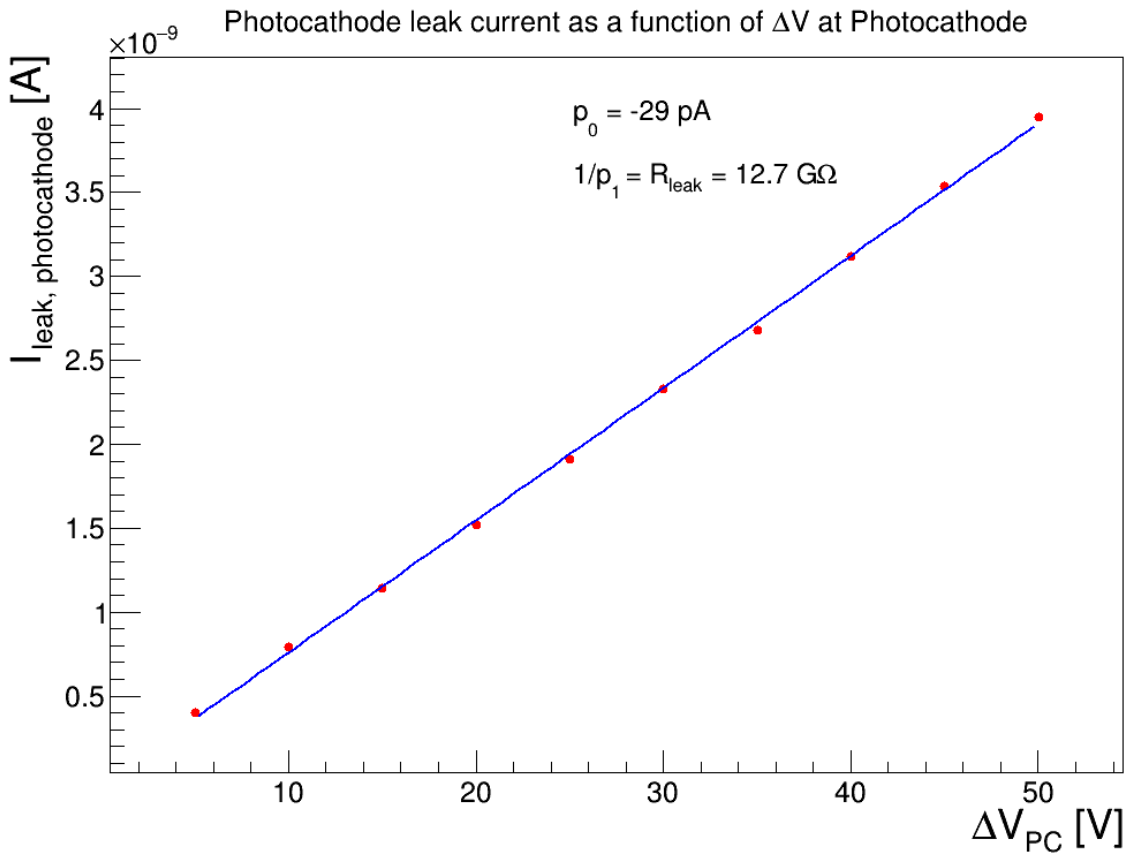


- Custom-made Picoammeter
- Resolution 1 pA
- Amplifier circuit
- Made in Trieste

Silvia Dalla Torre, et al., RHIP, a Radio-Controlled High-Voltage Insulated Picoammeter and its usage in studying ion backflow in MPGD-based photon detectors. (2018) 068. 10.22323/1.322.0068.

Photocathode leak current

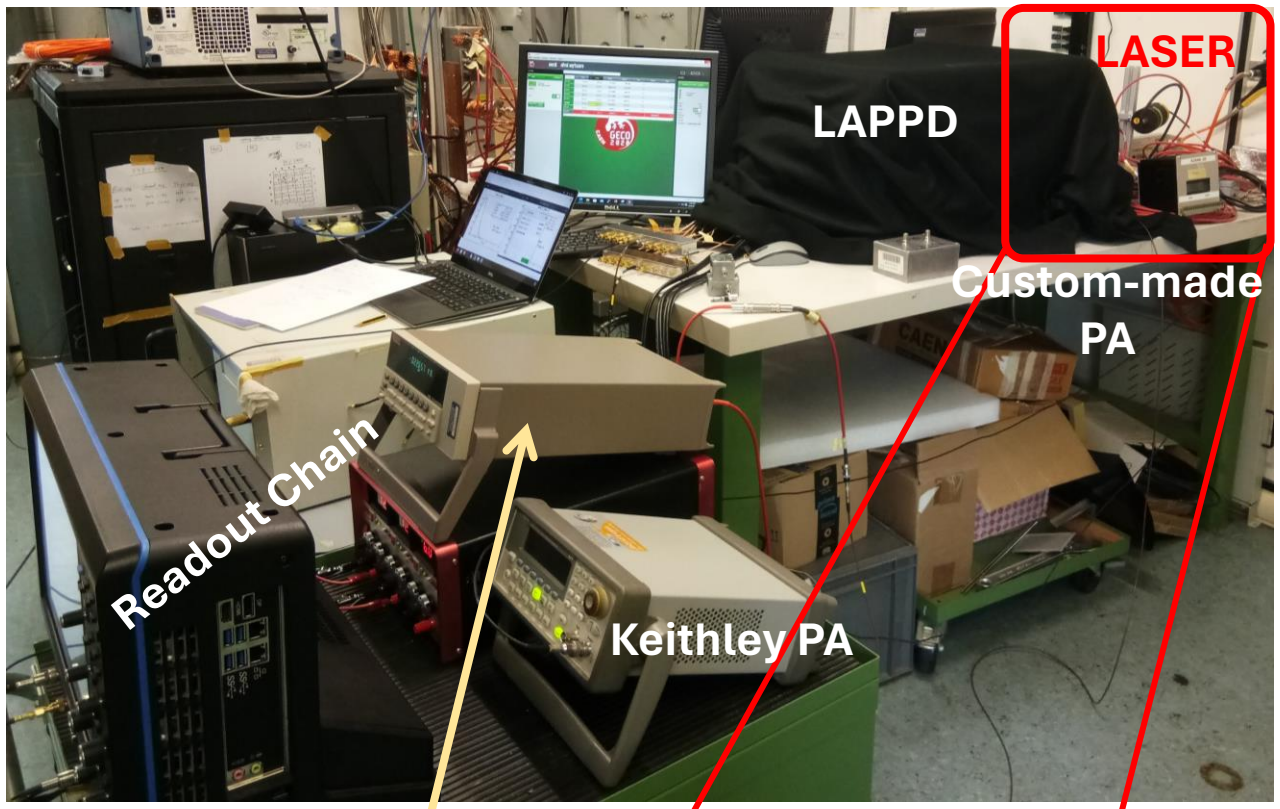


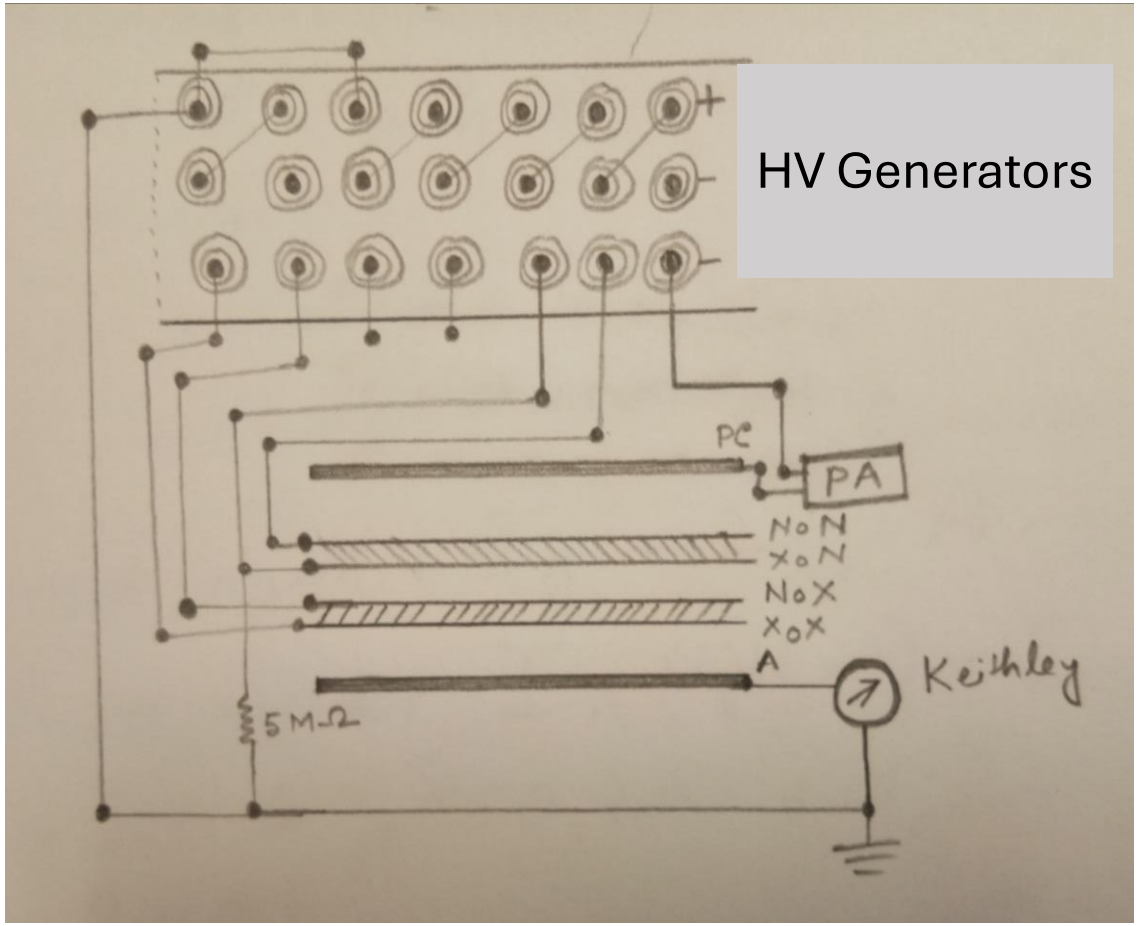


- Photocathode current measured (light source OFF)
  - as a function of voltage at Photocathode
  - with all other electrodes kept OFF (not powered)

- **Ohmic Leak Resistance** between Photocathode and Entry of Entry MCP: **~13 GΩ**

Experimental set-up



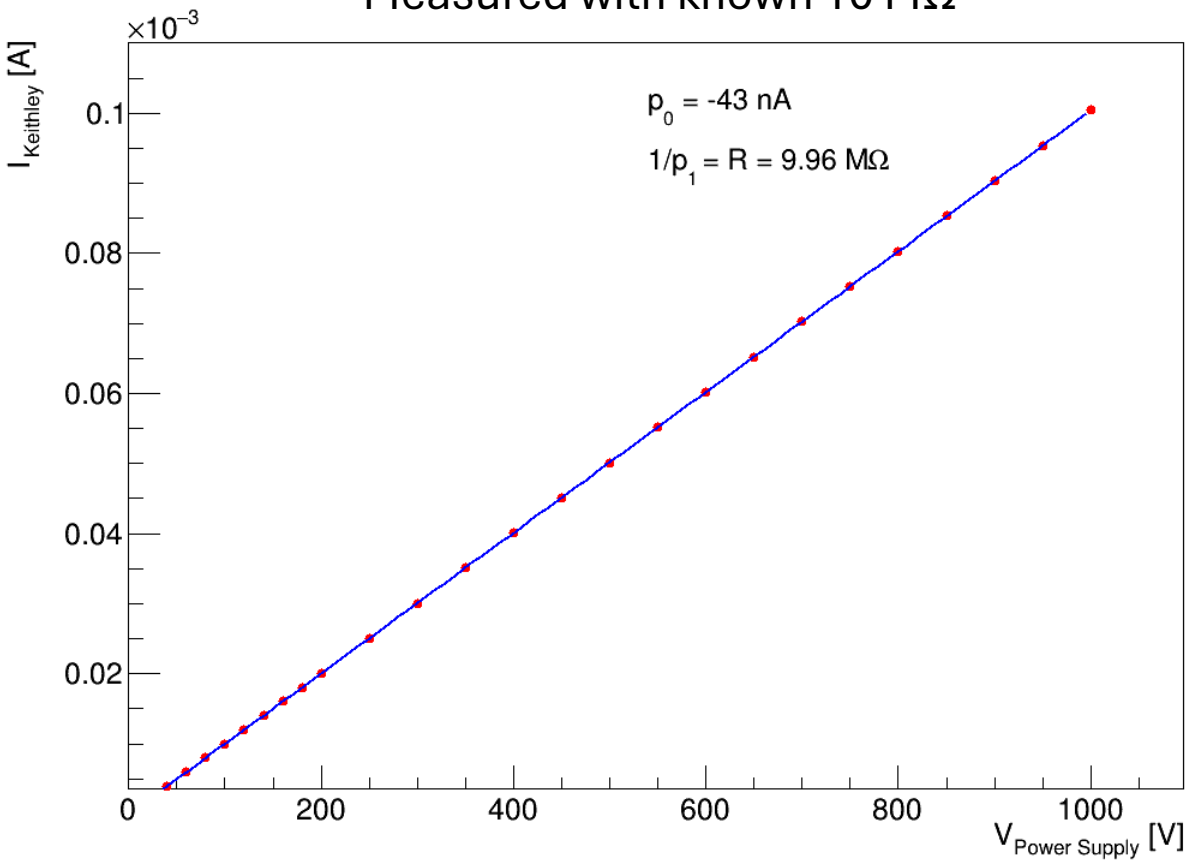


Electrical circuit

Calibration of Picoammeters

Keithley Picoammeter

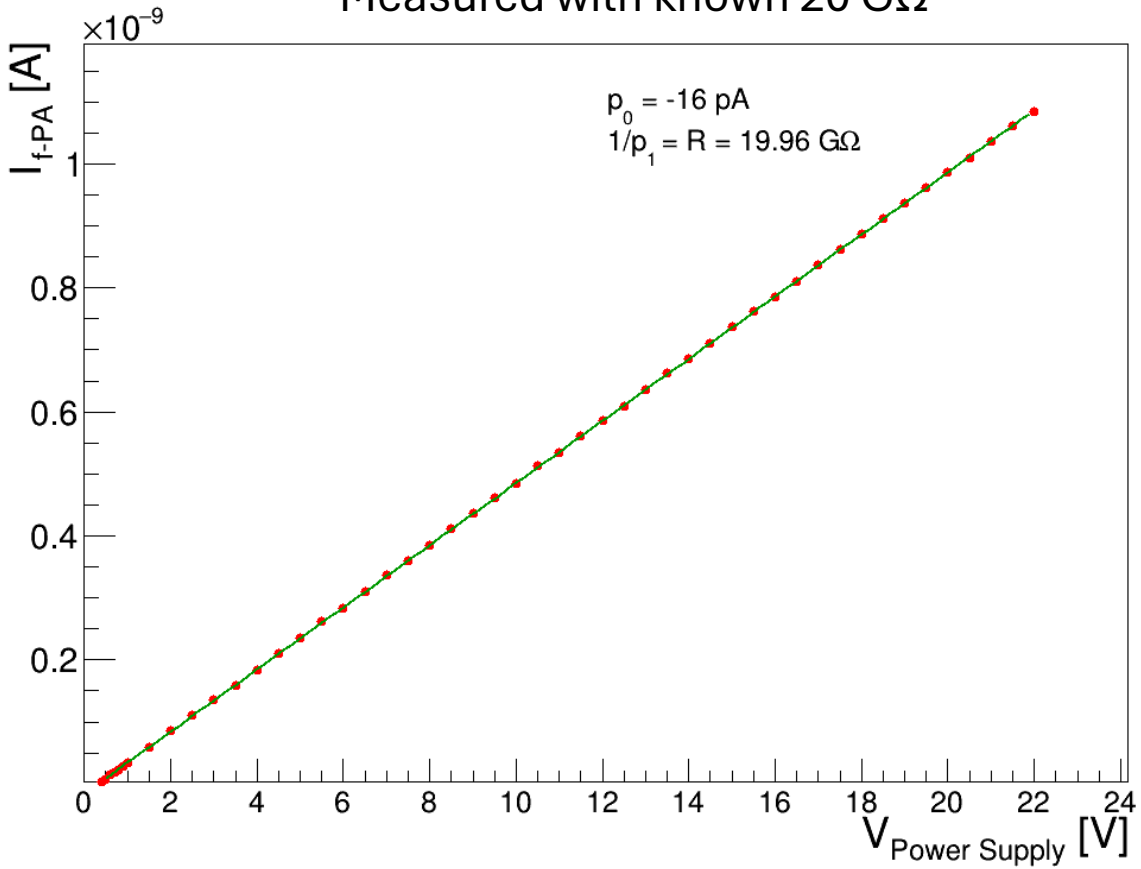
Measured with known 10 MΩ



Range of Interest: 20 μA – 100 μA

Custom-made Picoammeter

Measured with known 20 GΩ

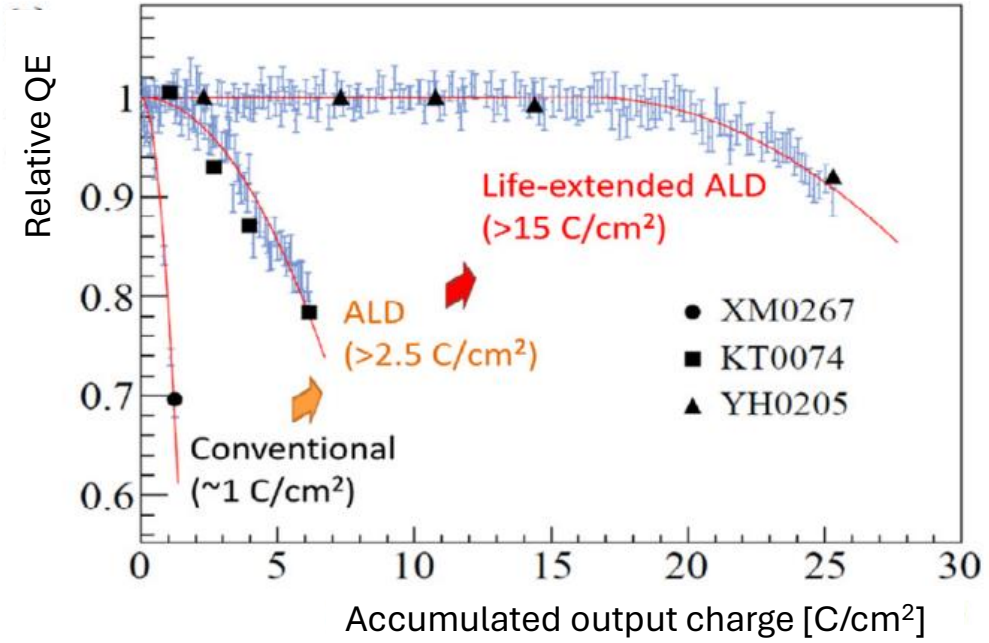


Range of Interest: 10 pA – 1 nA

Photocurrent and timing for ageing

From literature:

- QE relative to the initial value as a function of the accumulated output charge on PMT anodes
- Does NOT provide measure of accumulated charge on Photocathode



K. Inami, et al., MCP-PMT production for Belle II TOP detector and further R&D. NIMA, 936 (2019), pp. 556-557

We can measure accumulated charge on Photocathode too!

$I_{Photocurrent} = \langle I_{total} \rangle - \langle I_{leak} \rangle$

- For Ageing (**conventional PC**), ~ 1 C/cm^2 at Anode

$$\frac{1\ C/cm^2 * 0.36\ cm^2}{(1.6 * 10^{-19})\ C/e^- * 10^6}$$

~ 10^{13} p.e.

- **Observed photocurrent at PC** (laser intensity setting: 2.16), bias: ΔV_Gaps-MCPs-PC: **200-850-50 V**

~8 pA

~ $5 * 10^7$ p.e. per sec

➢ With laser intensity setting: 2.16 to accumulate 10^{13} p.e. we need **~ 60 h of illumination**

Summary of the status

- We plan to perform LAPPD#153 ageing studies at INFN Trieste.
- We have set-up high resolution (10 fA and 1 pA) Picoammeters to measure accumulated charge both on Anode and Photocathode. Devices are calibrated, show good linearity.
- For high illumination (ageing) we will also explore a fibre-coupled, collimated LED with an USB-controlled, constant current LED driver (upLED™ from Thorlabs).
- Automatic recording of currents using computer and software - work in progress.
- Preliminary measurements are performed and we will start the measurements in next weeks.

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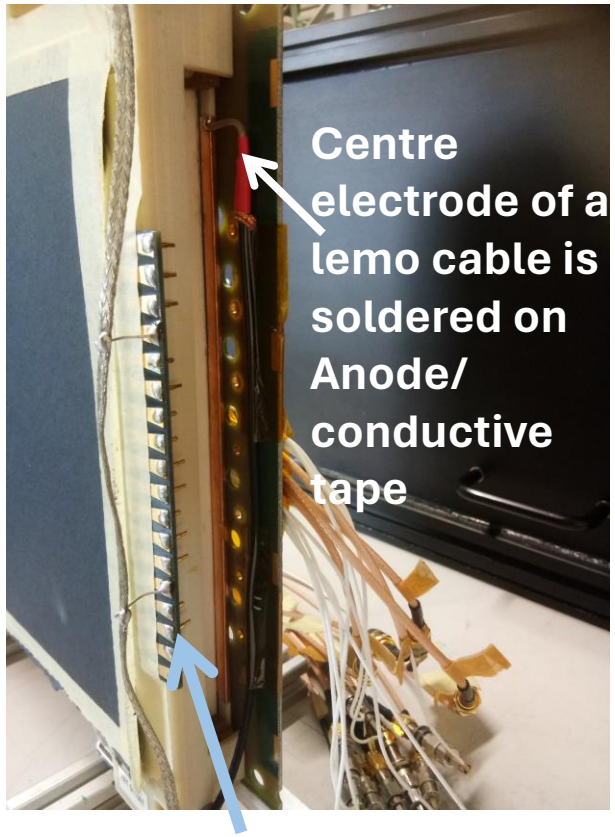
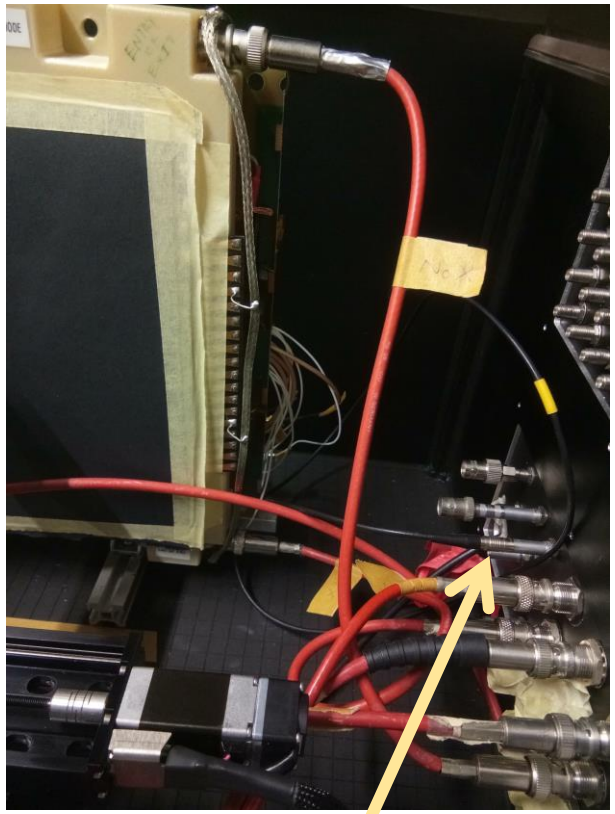
Thank you!

Back Ups

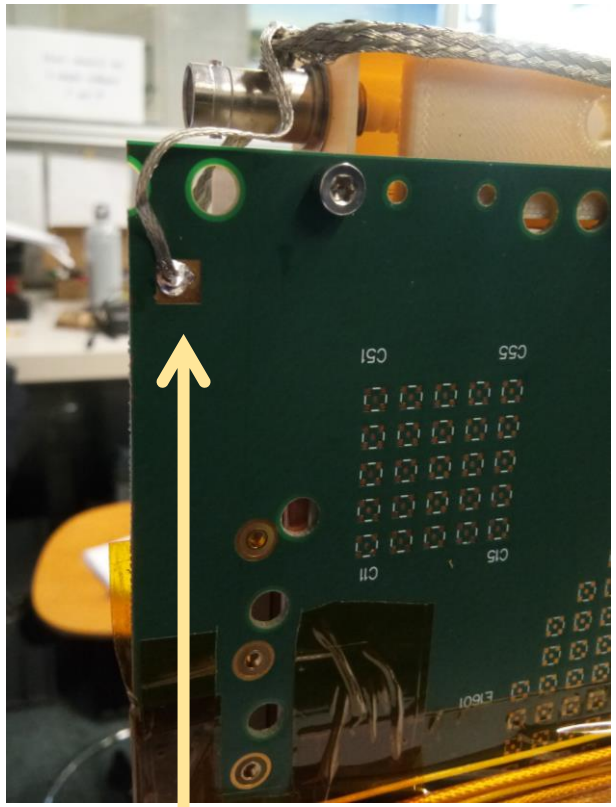
Hardware Intervention



Common grounding via pogo pins removed on both sides (before: pogo pins were touching the conductive tape on the LAPPD ground)



lemo going to patch panel



Common grounding

Photocurrent measurement

With enough light photocurrent is clearly visible in Picoammeters

- Laser Diode
- Repetition frequency: 80 MHz
- Internal Mode

Pico-Ammeter readings (total): leak current + photocurrent

- Bias: ΔV_Gaps-MCPs-PC : **200-850-50 V**
- Laser intensity setting: **2.16**

$I_{photocurrent,\ P.\ Cathode}$ = 8 pA

Laser intensity: **2.16**
Data taken (100kevts) with the digitizer for the central pad
ε = 0.35 (**Assumption: Poisson Distribution**)

$\varepsilon = 1 - P(0) = 1 - e^{-\lambda}$
λ = 0.43 expected number of photoelectrons per pulse

$I_{photocurrent,\ P.\ Cathode} = 80\ MHz * \lambda * 1.6 \times 10^{-19} \sim 6\ pA$

Consistent picture between expected (6 pA) and measured (8 pA)