Task 8.2 Purification and monitoring

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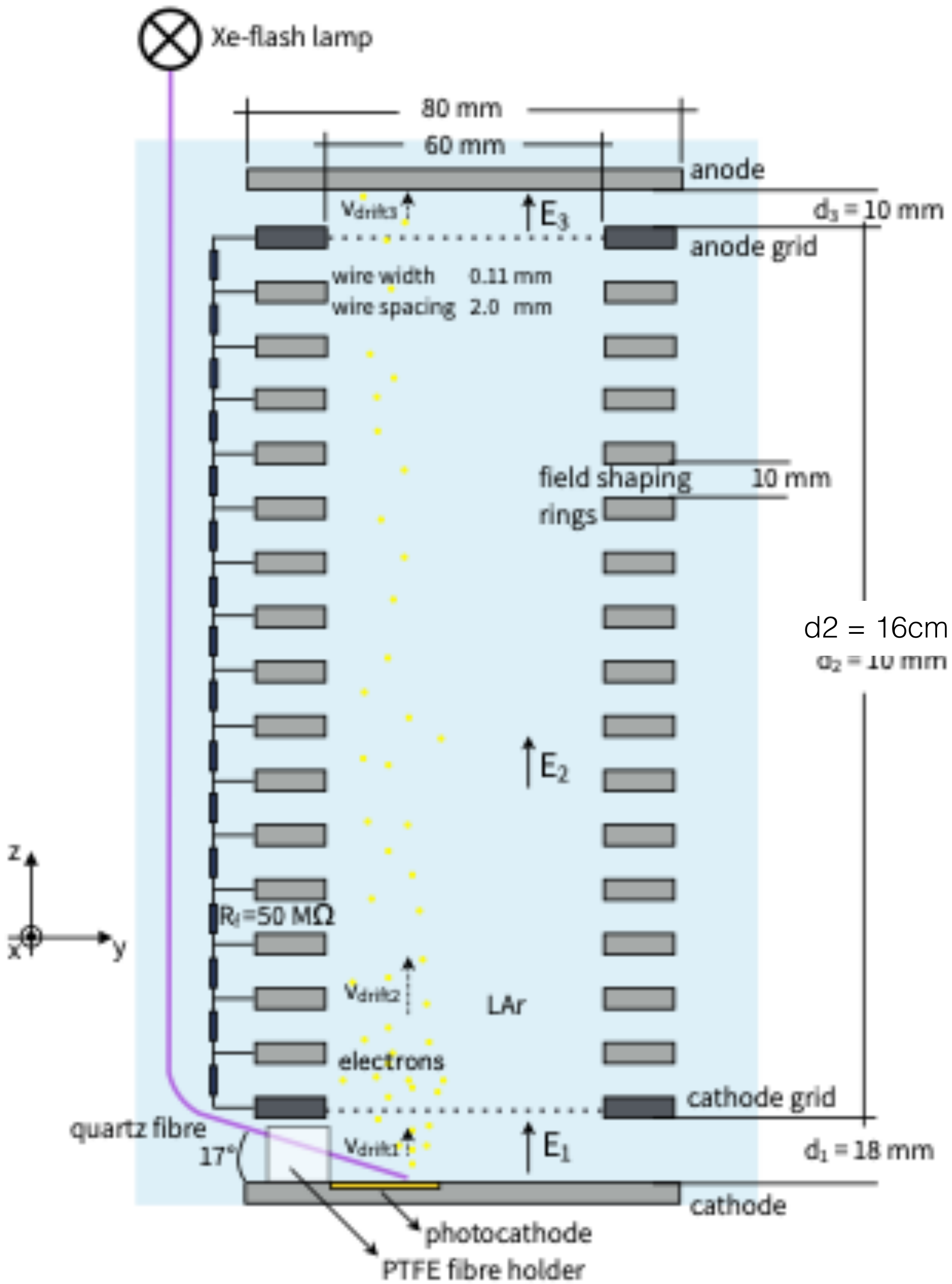
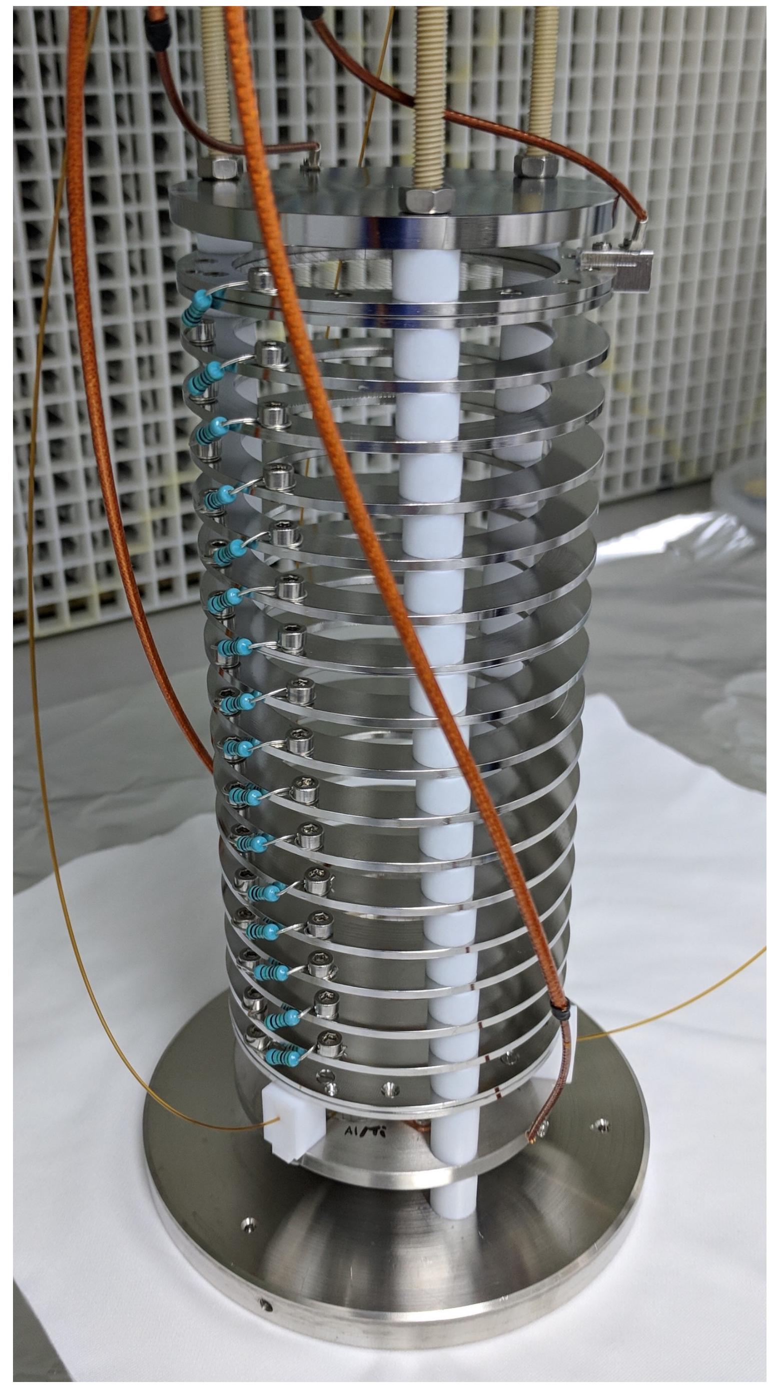
Introduction

- UCL team is building **two purity monitors** for ProtoDUNE Dual Phase
- Design is same as the ICARUS purity monitors, with 16 cm between the two grids
- First purity monitor has been constructed and extensively tested at UCL

Purity monitor design





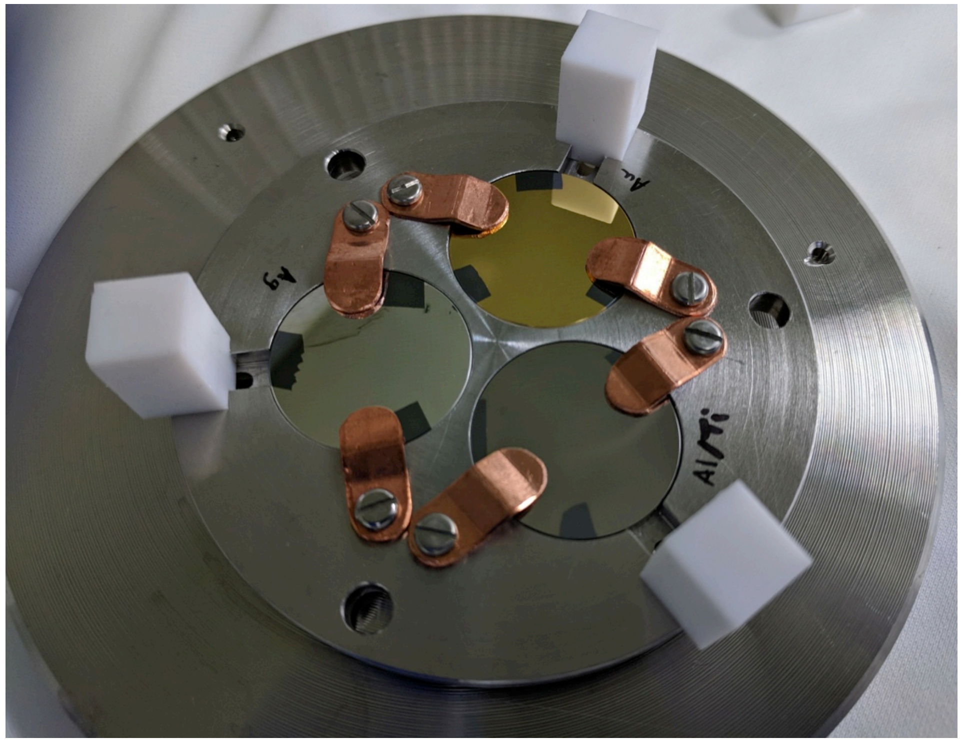
- Based on design of ICARUS purity monitors
- Adjustable height, nominal distance between grids 16 cm
- Typical fields for operation:

  K -> GK: 50 V/cm
  GK -> GA: 100 V/cm
  GA -> A: 200 V/cm

- Maximum fields reached:

  K -> GK: 10 V/cm
  GK -> GA: 200 V/cm
  GA -> A: 400 V/cm

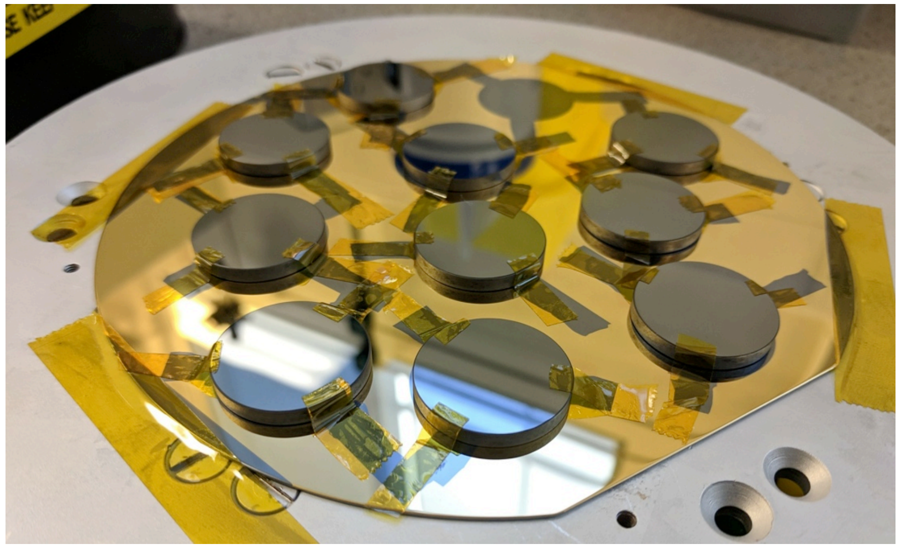
Three cathode design

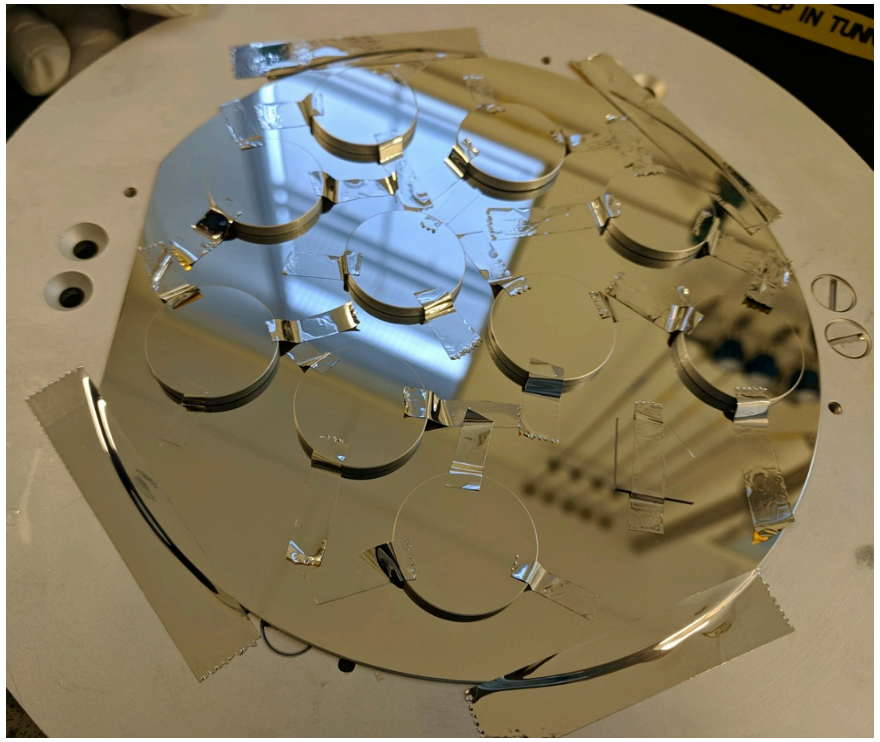


- New design allowing placement of three different photocathodes at a time
- Photocathode materials studied: **gold**, **silver**, **aluminium**, **titanium**

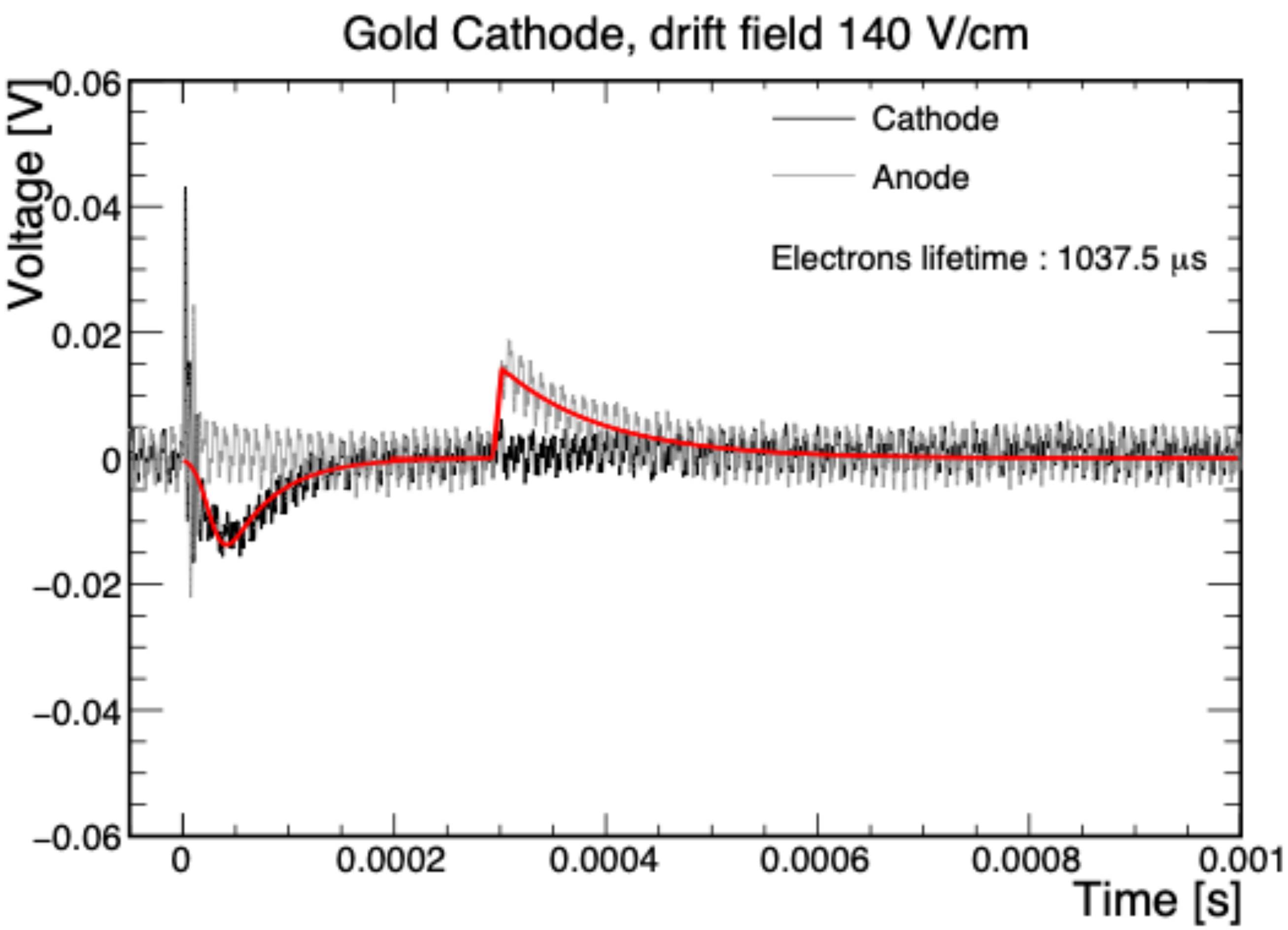
Study of different photocathodes

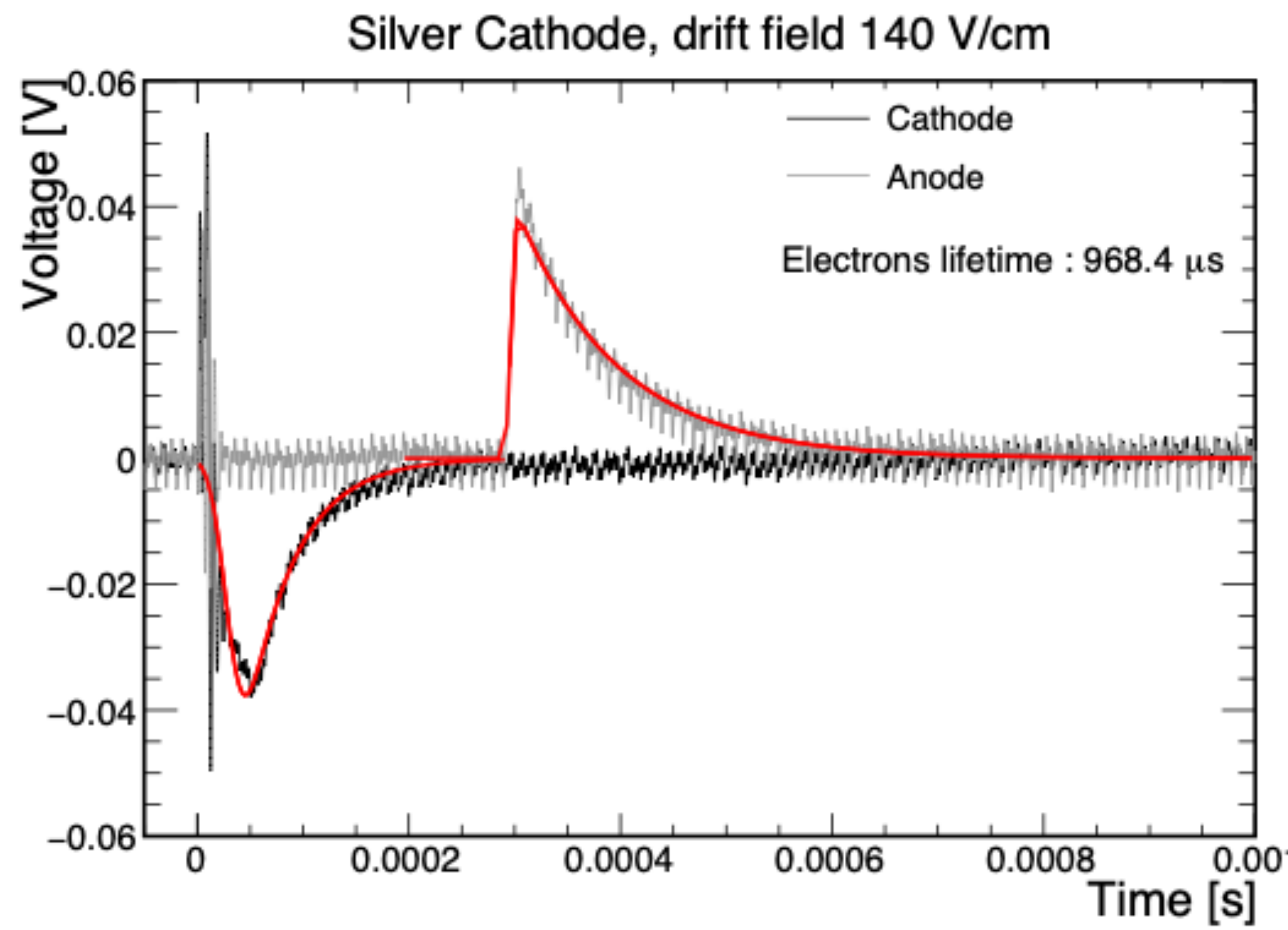
- New photocathodes made at London Centre of Nanotechnologies:
    - Gold (Au), silver (Ag), aluminium (Al) and titanium (Ti)
- Al, Ti and Ag have lower work functions than Au
- Al, Ti and Ag may oxidise, unlike Au
- Al and Ag have been tested in vacuum
- Ag has also been tested in LAr
- Ti still to be tested





Measuring the purity: gold vs silver



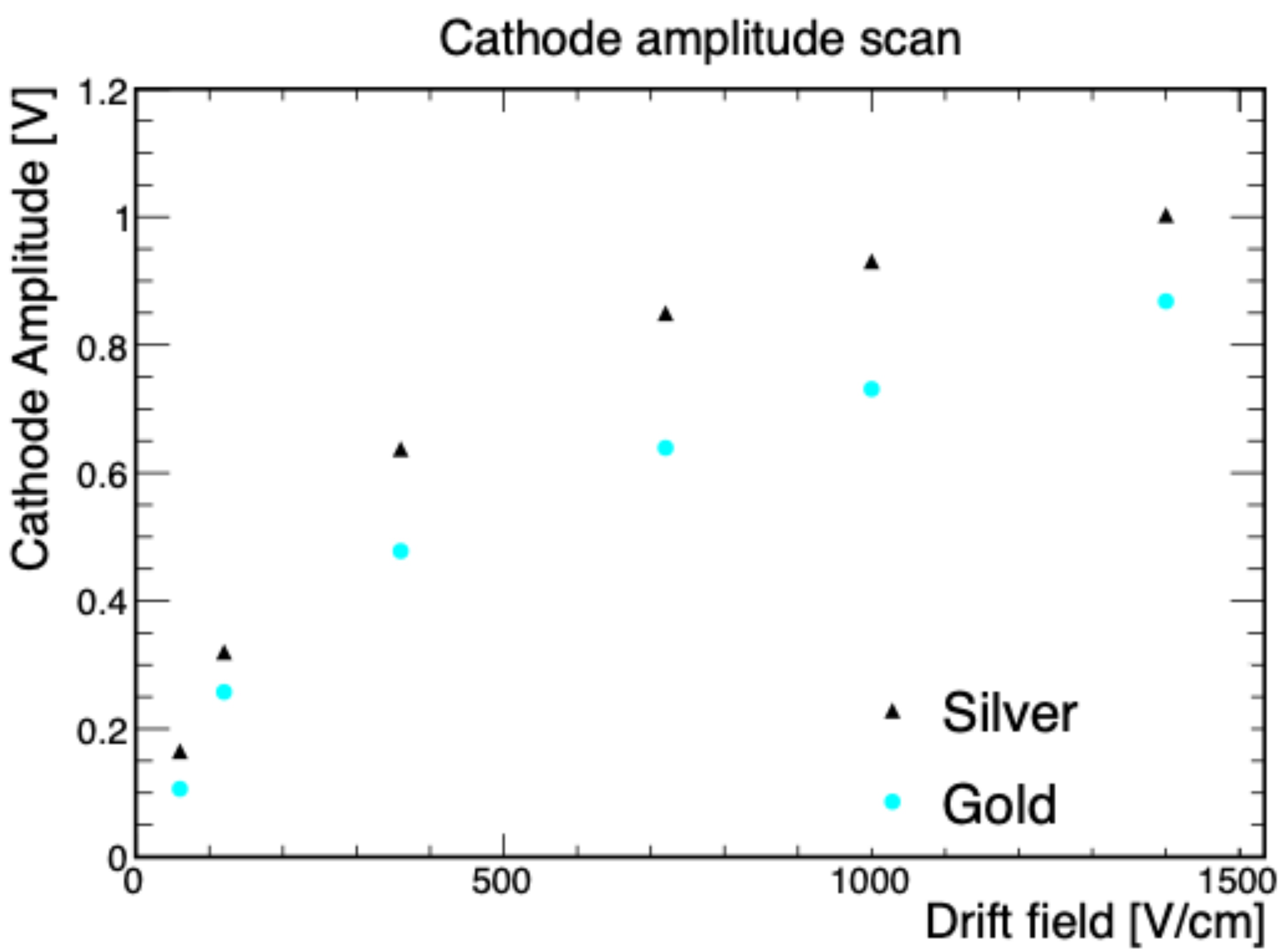


- Tests in **liquid argon at UCL**
- Drift field:

  K -> GK: 70 V/cm
  GK -> GA: 140 V/cm
  GA -> A: 280 V/cm

- Lifetime of **1 ms** at UCL even without a recirculation system
- Lifetime measurement consistent for the two, but silver signal larger than gold

Cathode amplitude: gold vs silver



- Tests in **liquid argon**
- At all drift fields cathode amplitude for silver is larger than for gold
- → For Dual Phase ProtoDune purity monitors use a mix of 1 gold and 2 silver cathodes

Installation plans

- First purity monitor already at CERN

- Second purity monitor is being refurbished at CERN
  - Silver and gold cathodes being brought from UCL

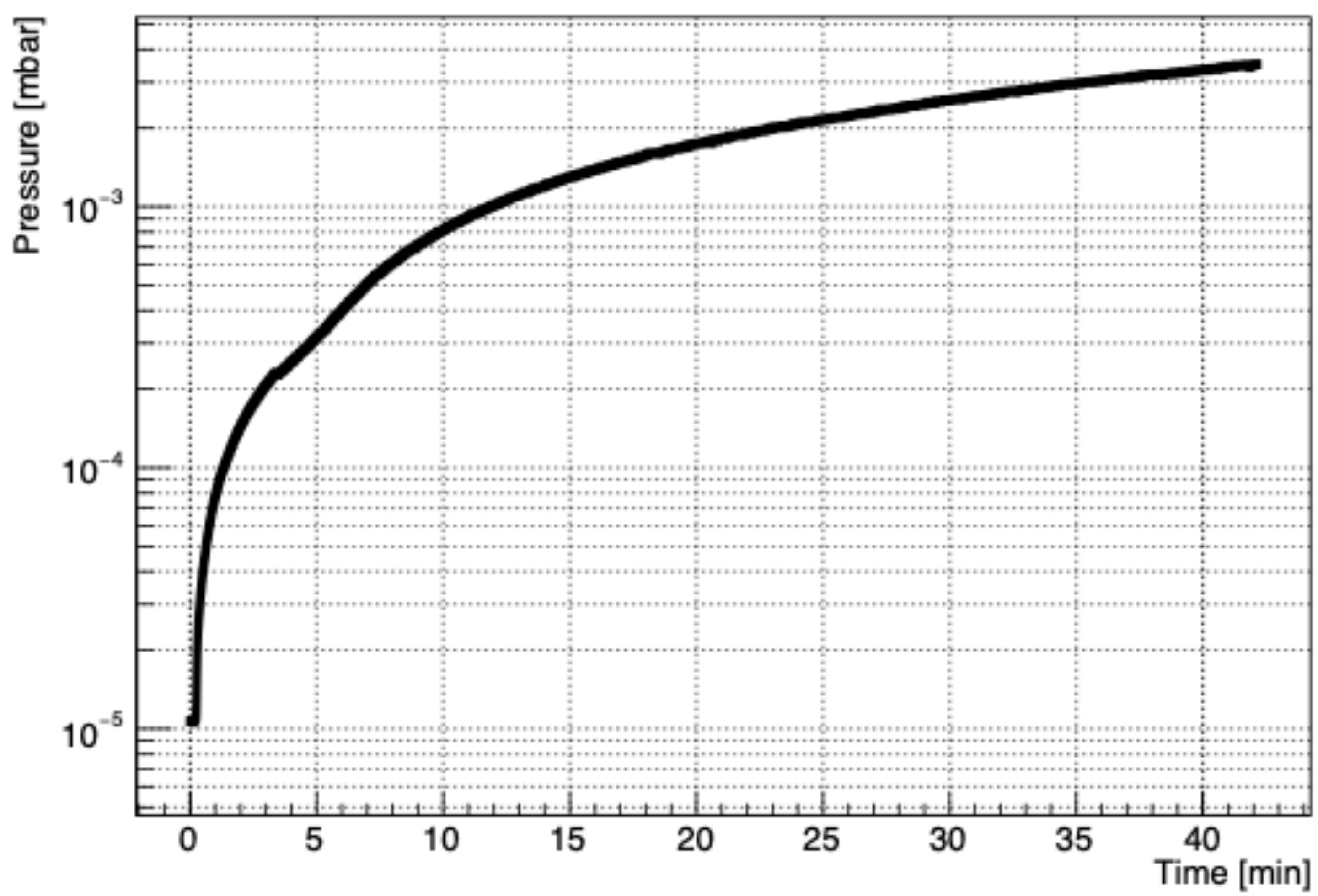
- **First 2 weeks of April**: test the 2 purity monitors **simultaneously** at CERN
  - Test both purity monitors in same chamber to check systematic differences between the two purity measurements

- Installation after TCO closure (23/04 – 18/05), **end of May/beginning of June**
  - 2 identical purity monitors 2 m apart, one directly above the other

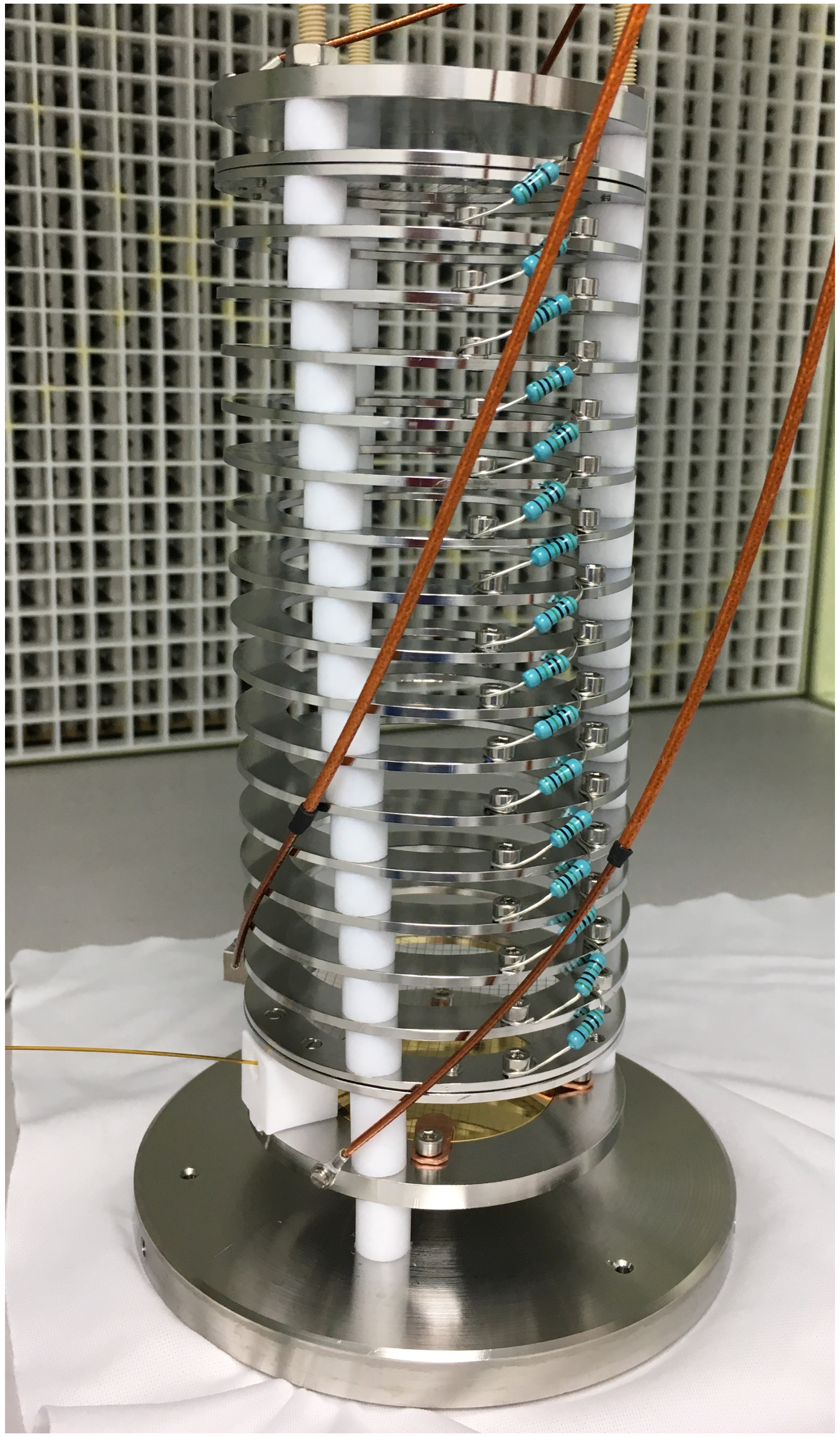
Back up slides

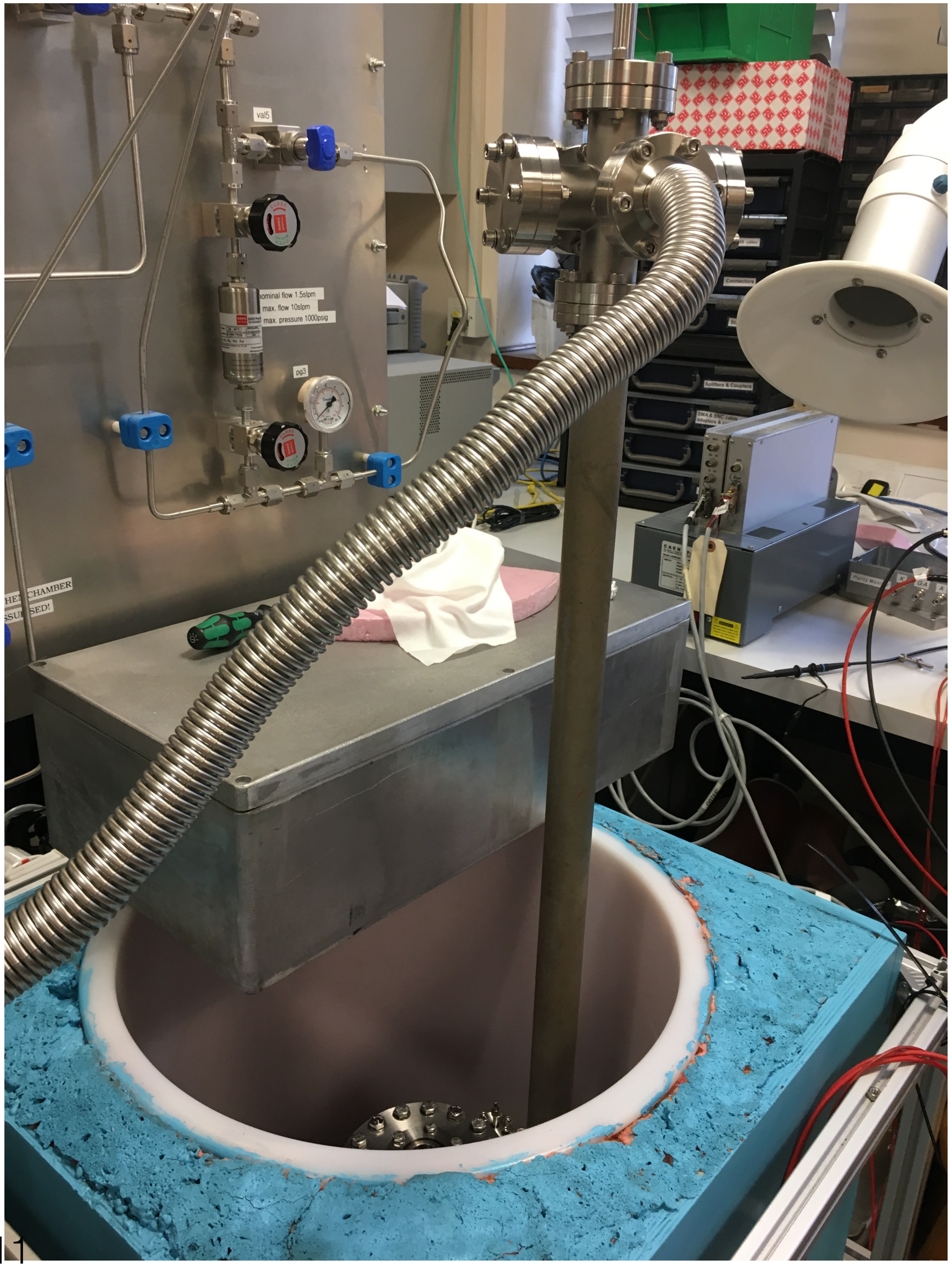
Leak rate

- System He-leak checked with RGA
- Leak rate is ~1.3E-05 mbarL/s (as measured in the first 20 mins)
- This roughly corresponds to a contamination ratio of 1.8ppt w/V of O_2 per s
- Before liquefying the chamber is flushed through a back pressure regulator (BPR) at 7 stdL/min
- After flushing, low-grade LAr is added to bath hosting the chamber
- Once the pressure starts dropping, the BPR is closed. It is kept closed during the entire liquefaction and data taking.

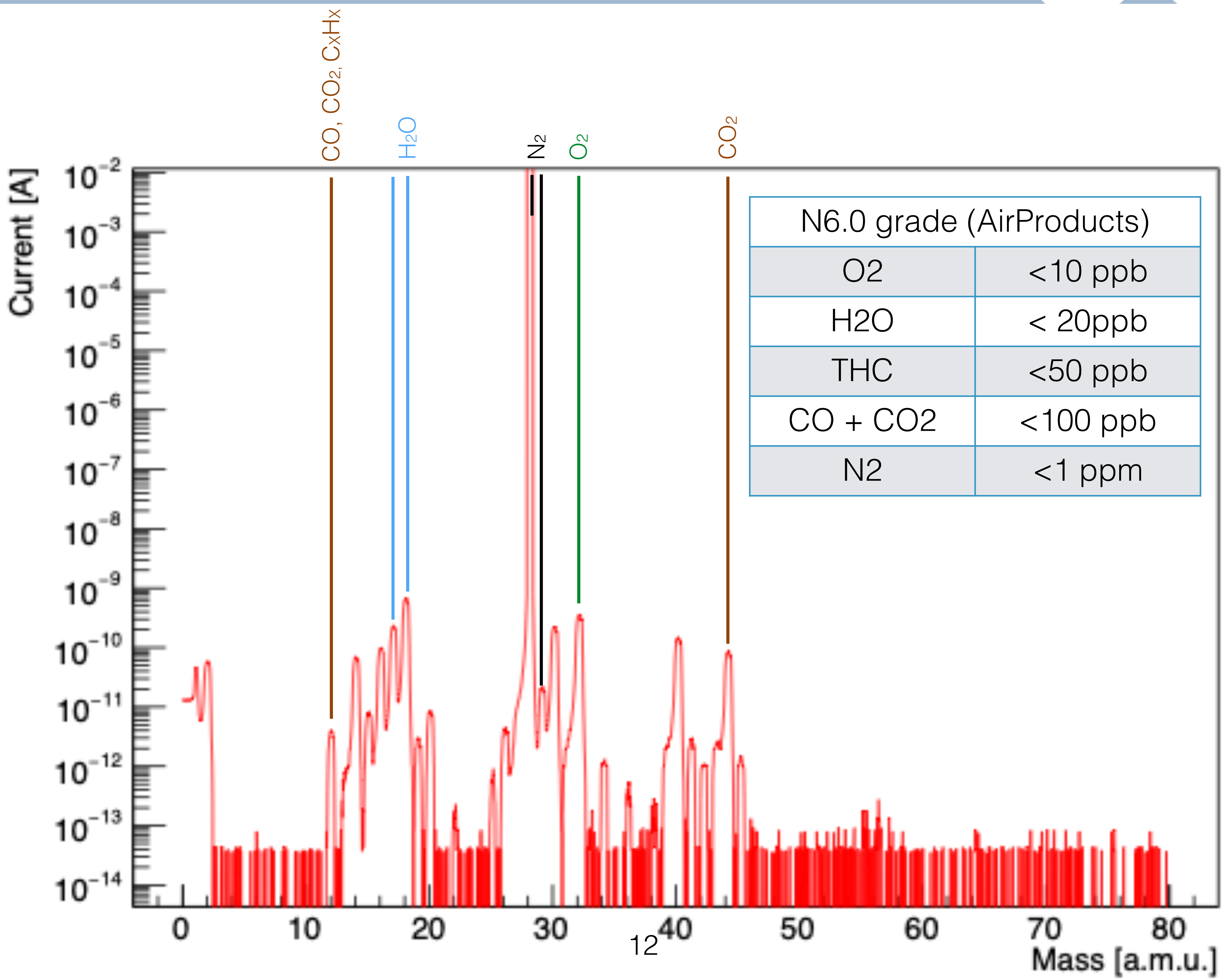


PrM and “LARA” system at UCL



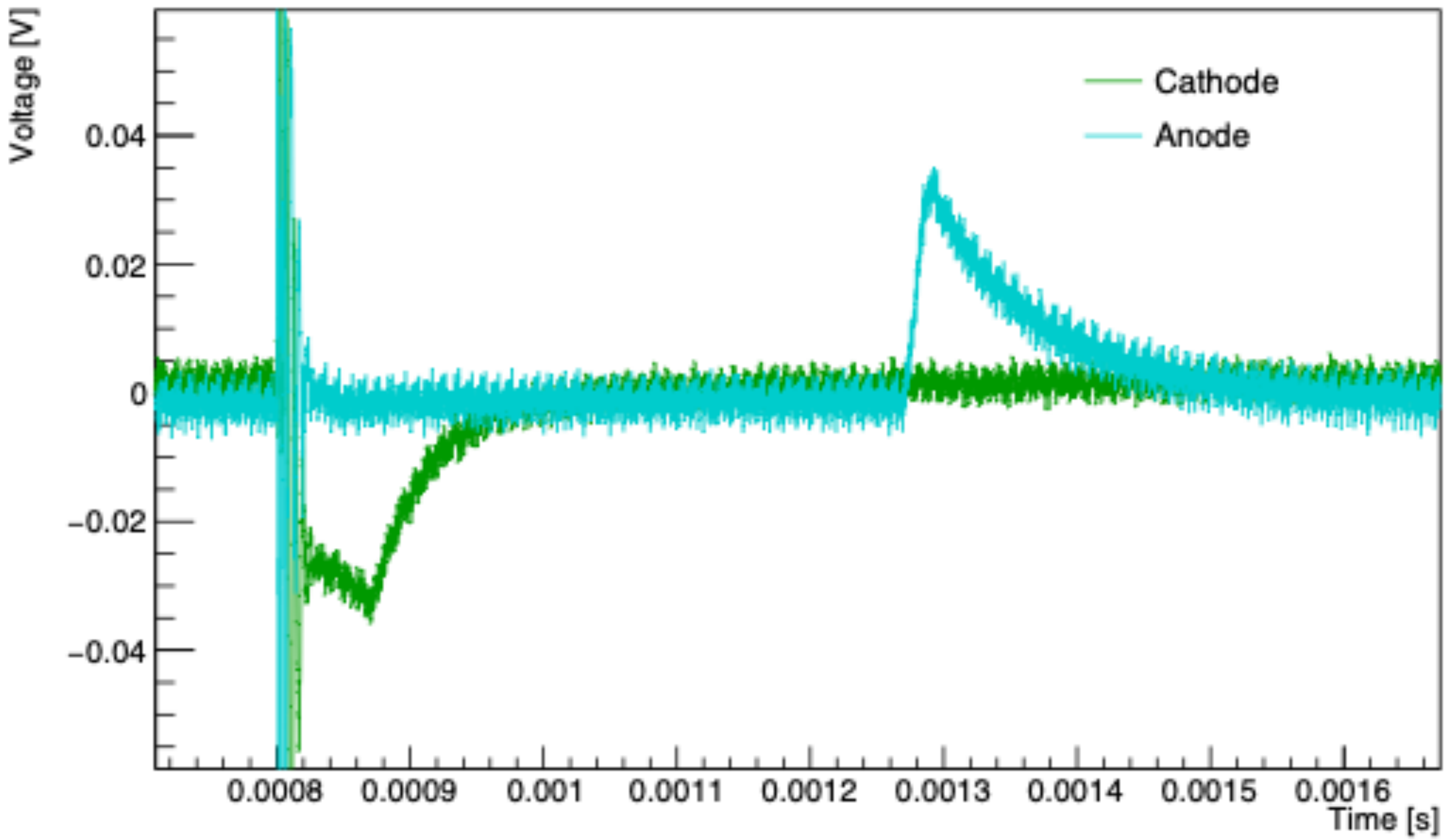


Sampling GAr to RGA



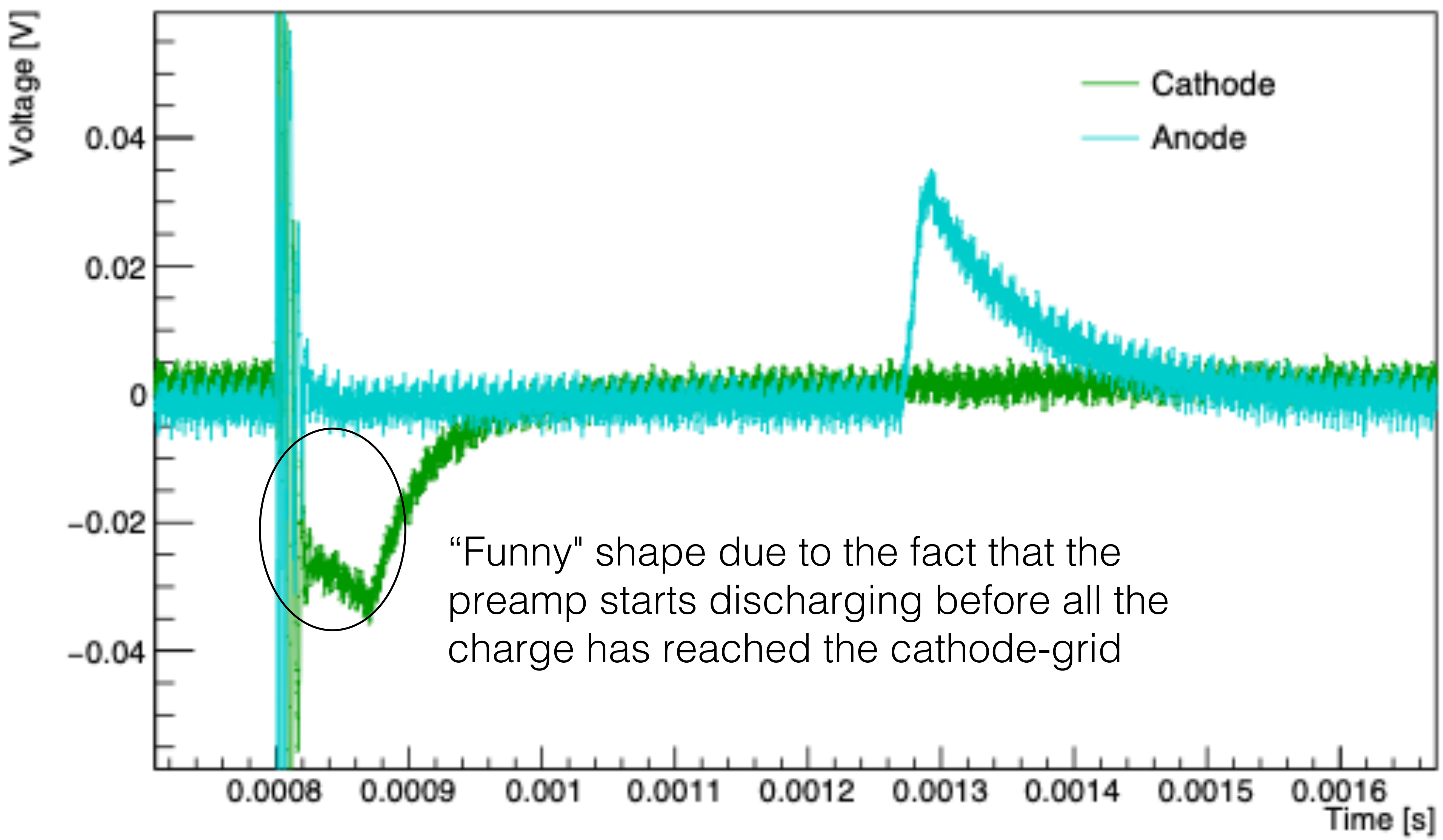
N6.0 grade (AirProducts)	
O2	<10 ppb
H2O	< 20ppb
THC	<50 ppb
CO + CO2	<100 ppb
N2	<1 ppm

Cathode and anode signal in LAr



Field configuration is 40, 80, 160 V/cm (in between K-GK, GK-GA, GA-A).
Both cathode and anode represent the average of 1000 waveforms collected.

Cathode and anode signal in LAr



"Funny" shape due to the fact that the preamp starts discharging before all the charge has reached the cathode-grid

Correction factor

$$V_{out}(t) = \int dt' G(t-t')I(t') \quad (1)$$

$$G(t) = G_0 \Theta(t) e^{-\frac{t}{\tau_{el}}} \quad (2)$$

$$I(t) = \begin{cases} \frac{Qv_e}{d} & 0 \leq t \leq t_{drift} \\ 0 & t > t_{drift} \end{cases} \quad (3)$$

$$V_{out}(t) = G_0 Q \frac{\left(e^{-\frac{t}{\tau_{el}}} - e^{-\frac{t}{\tau_{life}}}\right)}{\frac{t_{drift}}{\left(\frac{1}{\tau_{life}} - \frac{1}{\tau_{el}}\right)^{-1}}} \quad (4)$$

measured voltage output

true voltage output

Correction factor is a function of the preamp decay time and the electron lifetime.