Purity monitors, gain calibration and grid transparency

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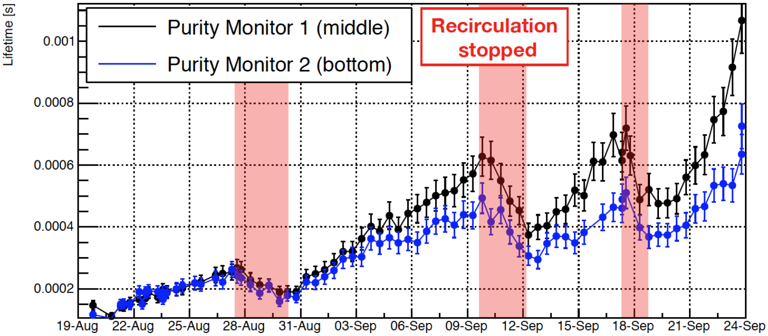
Introduction

- At the collaboration meeting we showed a plot of the lifetime measured by our 2 purity monitors in ProtoDUNE.
- That plot showed that the two PrMs measured a different lifetime, but it was not clear to us whether our uncertainties covered the differences
- Taking additional measurements we found two correction factors:
  1. Electronics gain calibration correction factor
  2. Grid transparency correction factor

The plot in question

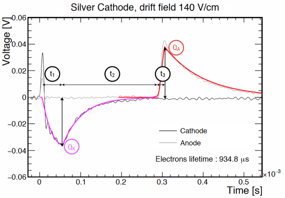


Correction factors

- As the lifetime is calculated as

$$\tau_{lifet} \approx -\frac{1}{\log\left(-\frac{Q_A}{Q_K}C\right)}\left(t_2 + \frac{t_1 + t_3}{2}\right) \qquad (1)$$

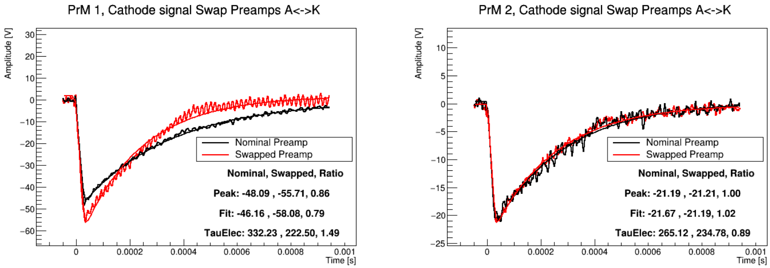
- C is the correction factor
- if $C > 1$ lifetime gets bigger, if $C < 1$ lifetime gets smaller



PREAMPS GAIN CALIBRATION

Gain calibration test

- A couple of weeks ago myself, Stephen and Fernando took data swapping preamp A and K within same purity monitor
- This dataset is used to find the relative gain calibration between the anode and the cathode of the same purity monitor



Preamps gain correction factor

- Correction factor for PrM1 is now set to 0.80 with a 0.05 uncertainty for now
- Correction factor for PrM2 is now set to 1 with an uncertainty on 0.05
- Note also that the two different electronics decay times of the preamps used in PrM1 were already accounted for.

GRID TRASPARENCY

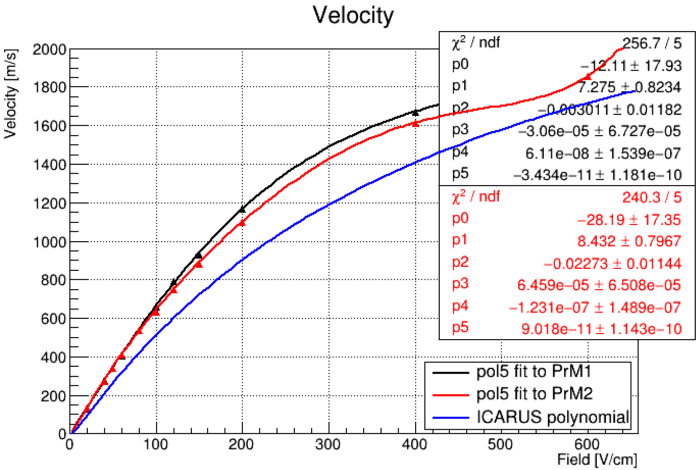
What fields are we really applying?

- From our cathode scans in the previous week we noticed that:
  - when running in standard field conditions of E:2E:4E (e.g. 50.100.200 V/cm) t_1 observed is much faster than the prediction from the ICARUS polynomial (roughly factor of 2)
  - when running in cathode only field conditions of E:0:0 (e.g. 50.0.0 V/cm) t_1 agrees well with the ICARUS polynomial prediction
- This led us to think that our "effective" field between the cathode and the cathode grid is higher than we think (possibly a factor of 2)
- In the next slides I will show 2 datasets used to understand the effective field between the cathode and the cathode grid

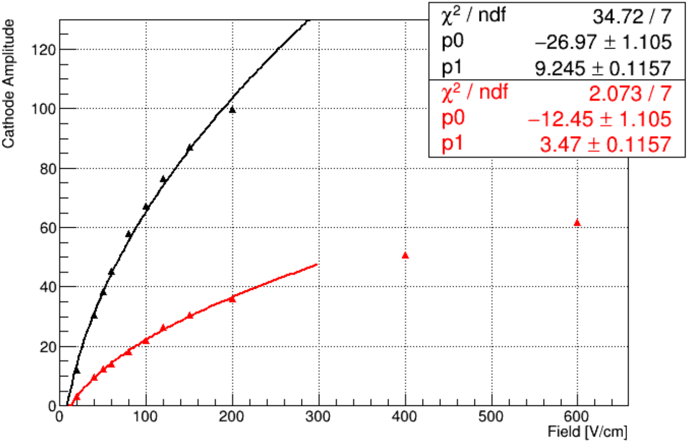
Cathode scan data

- Cathode only field scans (ie E1:0:0 V/cm)
- This dataset is used to find 2 fit for each purity monitor:
  1. velocity as a function of E1 (pol5)
  2. QK as a function of E1 (Schottky $[0] + [1] * \sqrt{x}$)

Cathode scans: velocity



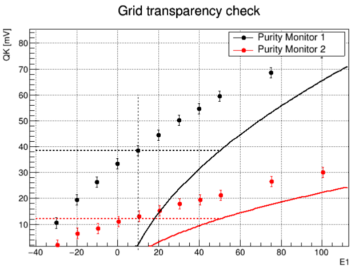
Cathode scans: Q_K

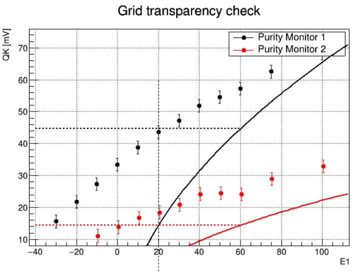


Cathode grid transparency scan data

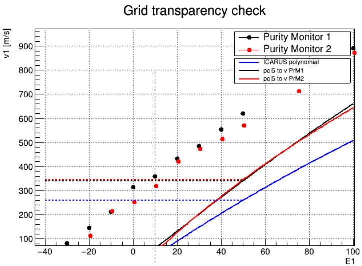
- Cathode grid transparency scan data (ie E1:100:200 V/cm, and E1:120:240 V/cm)
- Using the two fitted functions found with the previous dataset we find:
  - at what value of E1 the field is effectively 50V/cm or 60 V/cm
  - the relative correction factor to apply to our past datasets

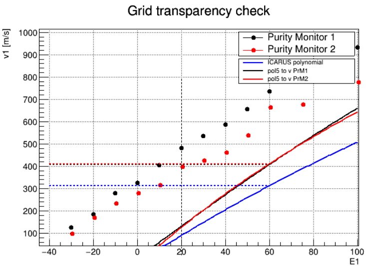
Q_K (corrected)



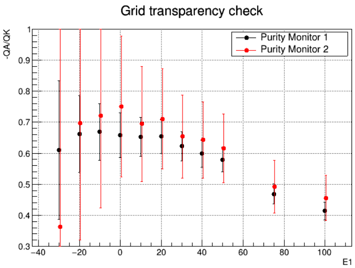


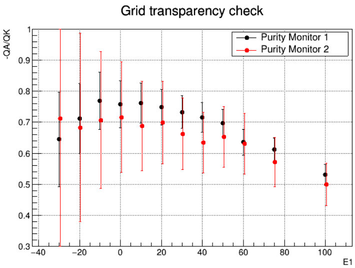
v1


Grid transparency check
v1 [m/s]
E1
Purity Monitor 1
Purity Monitor 2
ICARUS polynomial
pol5 to v PrM1
pol5 to v PrM2

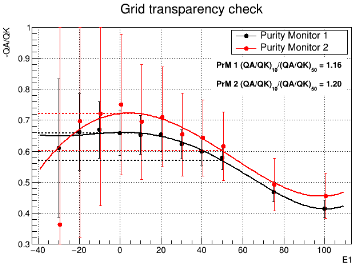

Grid transparency check
v1 [m/s]
E1
Purity Monitor 1
Purity Monitor 2
ICARUS polynomial
pol5 to v PrM1
pol5 to v PrM2

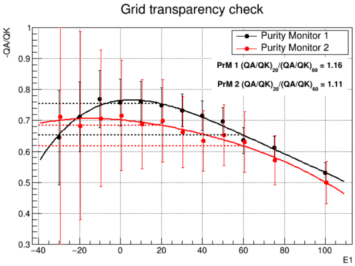
Q_A/Q_K (corrected)





fitted Q_A / fitted Q_K





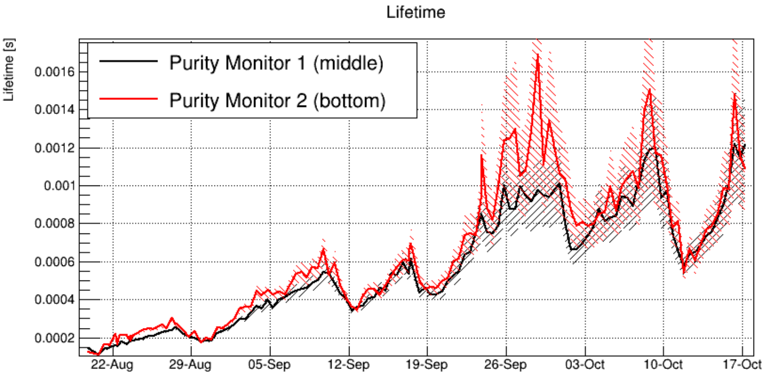
Correction factor for reduced grid transparency

- In both cases the correction factor seems to be 1.16 (I trust PrM1 more than PrM2 as it has higher signals, hence lower uncertainties)
- Laura ran a comsol simulation and found that for a E:E:2E case (similar to what we are using) the correction factor should be 1.14
- At the moment we are using a correction factor of 1.15 with again 0.05 uncertainty
- A full translation map between the fields we set and the effective field is currently under construction and it will be used to define the operations of the purity monitors from now on

Caveats

- I want to stress that these are first rough estimation of these correction factors that allow us to measure more believable lifetimes in NP02
- A more detailed analysis of the various datasets and uncertainties will take longer, and once that's done we will report to the group and update these numbers again
- Short aside: the latest datasets are compatible with Stephen's measurement of the lifetime with his long purity monitor (1-1.2ms)

NP02 electron lifetime



BACK-UP SLIDES

Possible explanation

PrM1 / MIDDLE

	V0 Set	I0 Set	VMon	IMon	On/Off	HW Flt	On/Off Set		Trip Time	OVC
A	1222.00	5.00	1222.00	0.00000	ON	none	Off	On	5	
GA	985.00	10.00	985.00	2.00000	ON	none	Off	On	5	
GK	985.00	10.00	984.75	1.60000	ON	none	Off	On	5	
Cathode	1095.00	5.00	1095.00	0.00000	ON	none	Off	On	5	

PrM2 / BOTTOM

	V0 Set	I0 Set	VMon	IMon	On/Off	HW Flt	On/Off Set		Trip Time	OVC
A	1330.00	5.00	1330.50	0.00000	ON	none	Off	On	5	
GA	1050.00	10.00	1049.75	1.80000	ON	none	Off	On	5	
GK	1050.00	10.00	1049.25	2.00000	ON	none	Off	On	5	
Cathode	1176.00	5.00	1175.75	0.00000	ON	none	Off	On	5	

- Francesco thinks it is due to the difference in current measured at the two grids, and that this excess currents goes through our filters (lots of resistors in series)

Old plots from 182 (with and without filters on grids, t_1 changes)