protoDUNE DP light data analysis
Cathode scan

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Cathode voltage scan

Goal: To observe the dependence of the light yield and the scintillation time profile with the drift field.

Runs: (taken on 04/12/2019):
https://pddpelog.web.cern.ch/elisa/display/848

- Different gains for PEN and TPB PMTs to equalize their response: PEN5e7_TPB6e6_20191126
- 16us window and 16ns sampling.
- 7 voltage values: (0kV, 5kV, 10kV, 20kV, 30kV, 40kV, 50kV).
- **7 Runs with PMT trigger: Trigger on channel 20 @ 3950ADC**
- 7 Runs with random trigger using the LCS (still to be analysed)
- 200k evts per run.

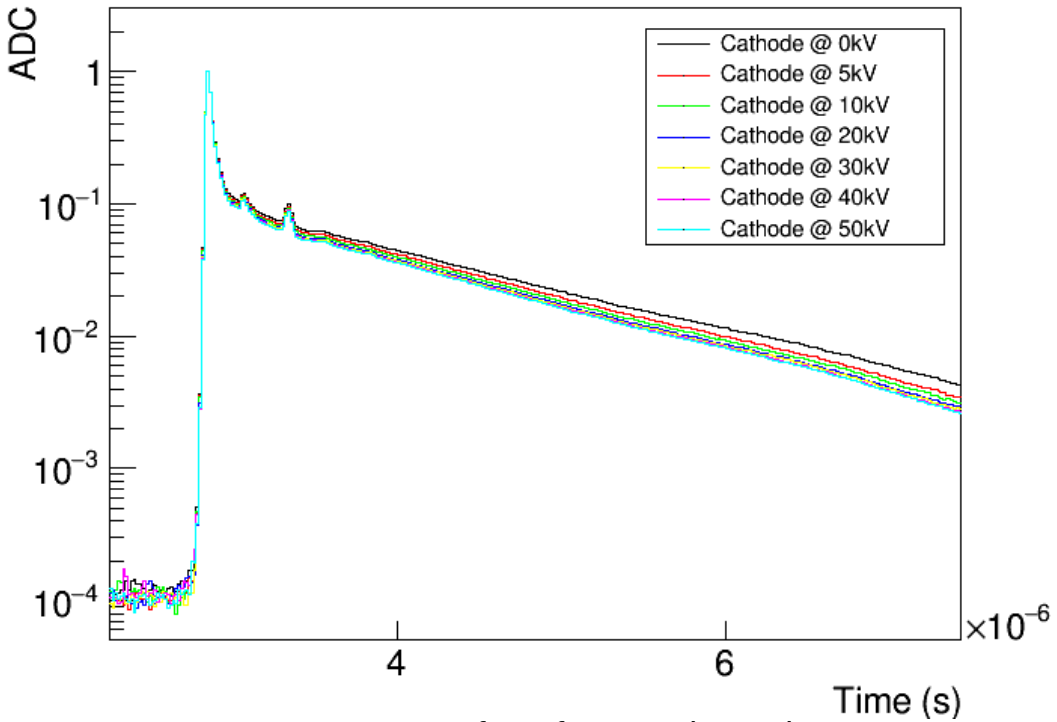
Scintillation light profile

- Similar analysis to the monitoring of the tau slow analysis:

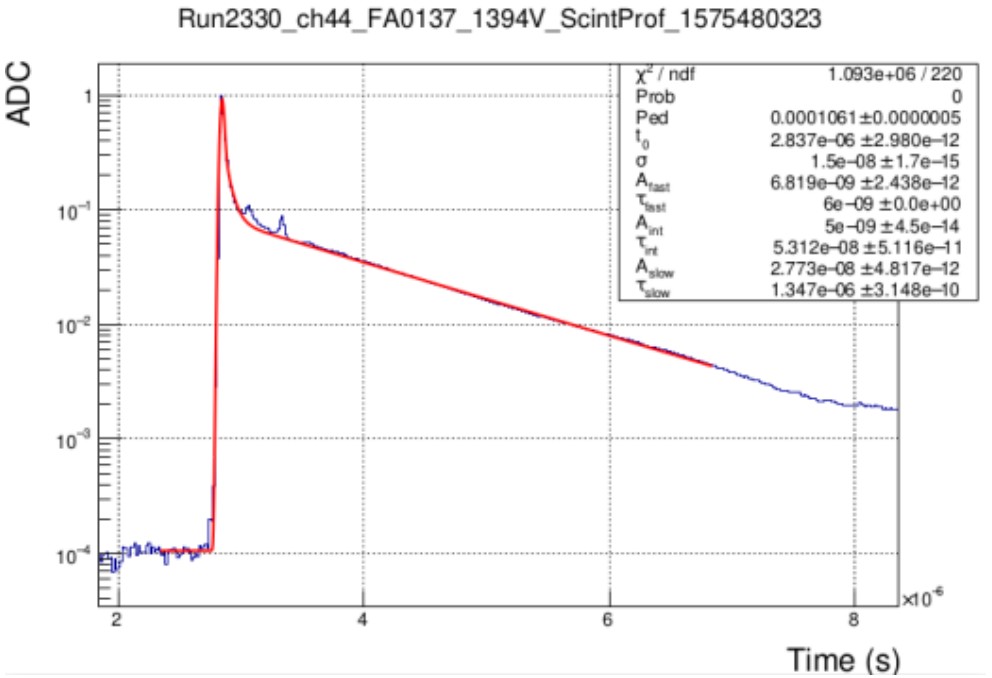
  → Apply cuts to avoid ADC and PMT saturation.

  → Add waveforms to obtain the average signal.

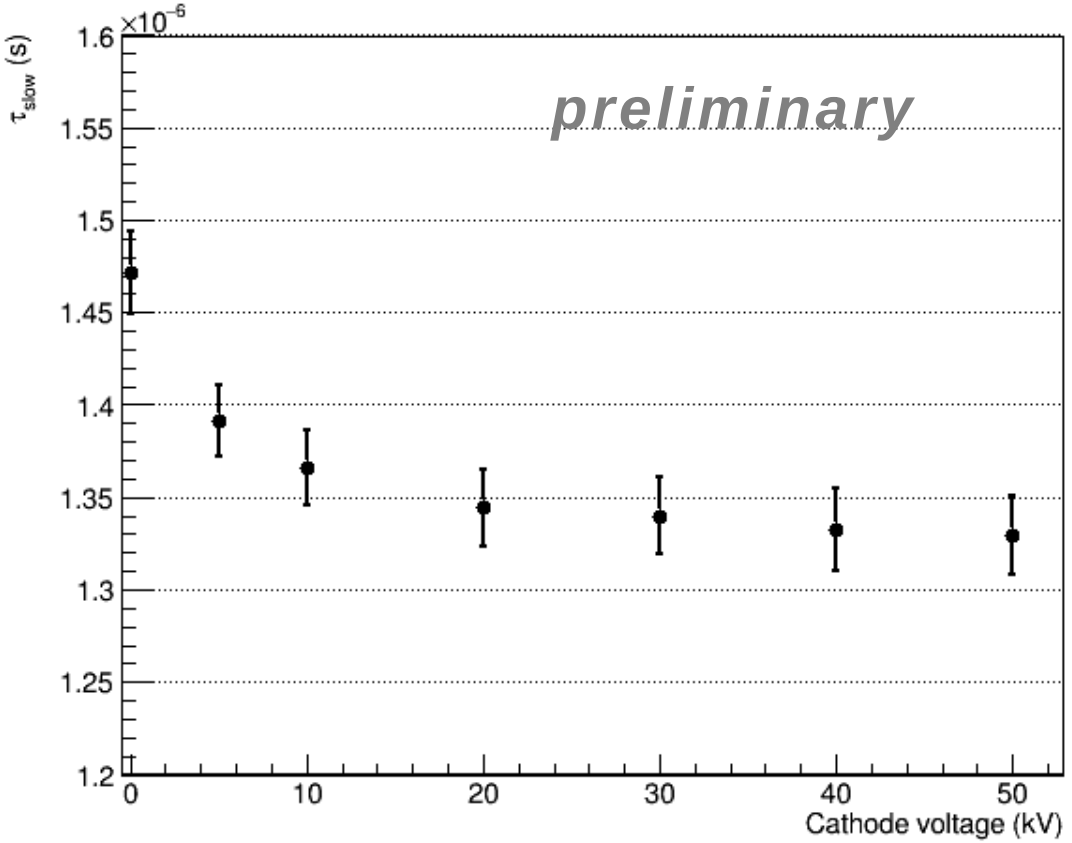
  → Normalize and fit the scintillation function.

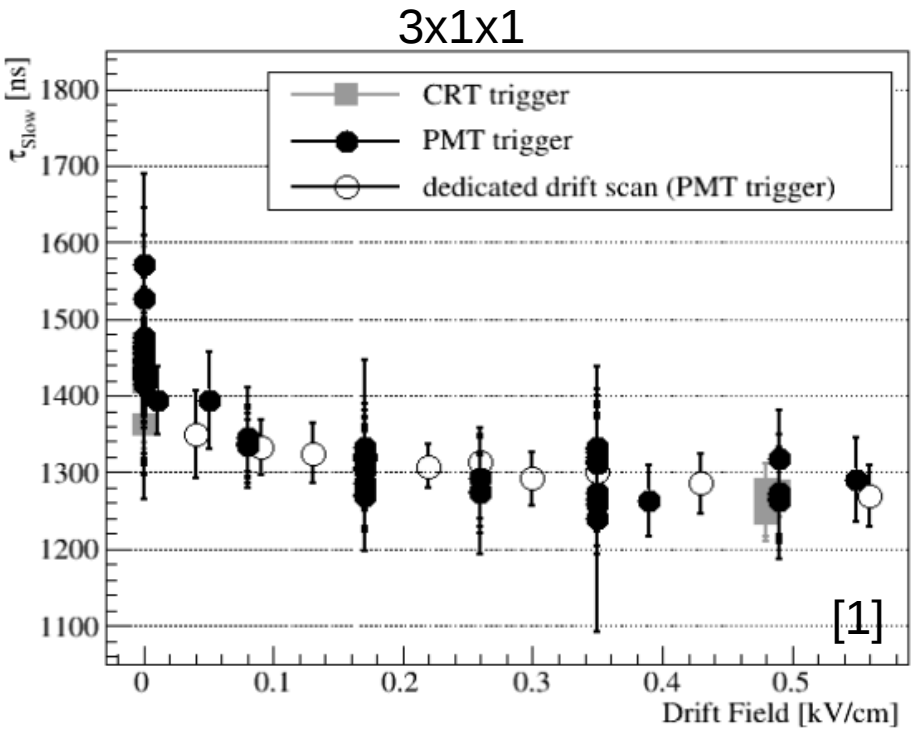


Average waveform for one channel
at several cathode voltages



Tau slow dependence with the drift field





- Above: Average tau slow among PMTs. Error bars show the STD variation among PMTs. No free-riders PMTs have been included.
- We observer a similar behaviour as the 3x1x1.

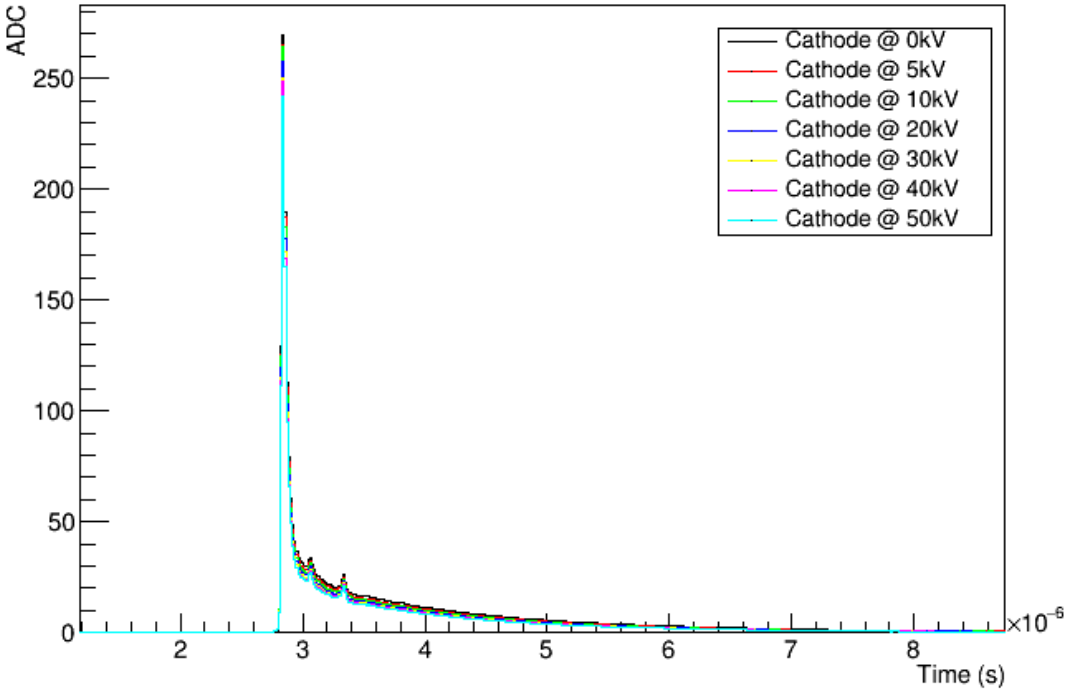
[1] Lastoria arXiv:1911.06880

Light yield dependence with the drift field (Birk's law).

- Similar analysis to the previous one, but avoiding any cuts that may affect the ligh yield:

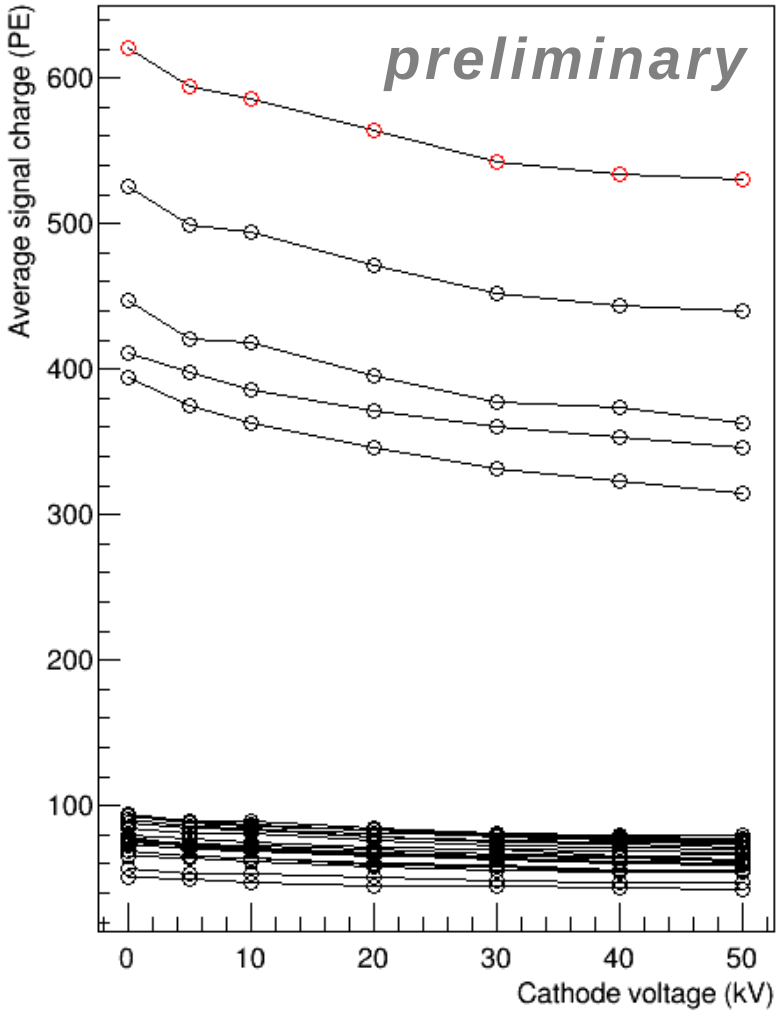
  → Add waveforms to obtain the average signal without applying any cut (in the case of a PMT or ADC saturation, the shape of the waveform would be affected, but we avoid a larger bias on the area of the waveform), and divide by the number of added waveforms.

  → Integrate the average signal from (-100ns,1.5us) around the maximum.

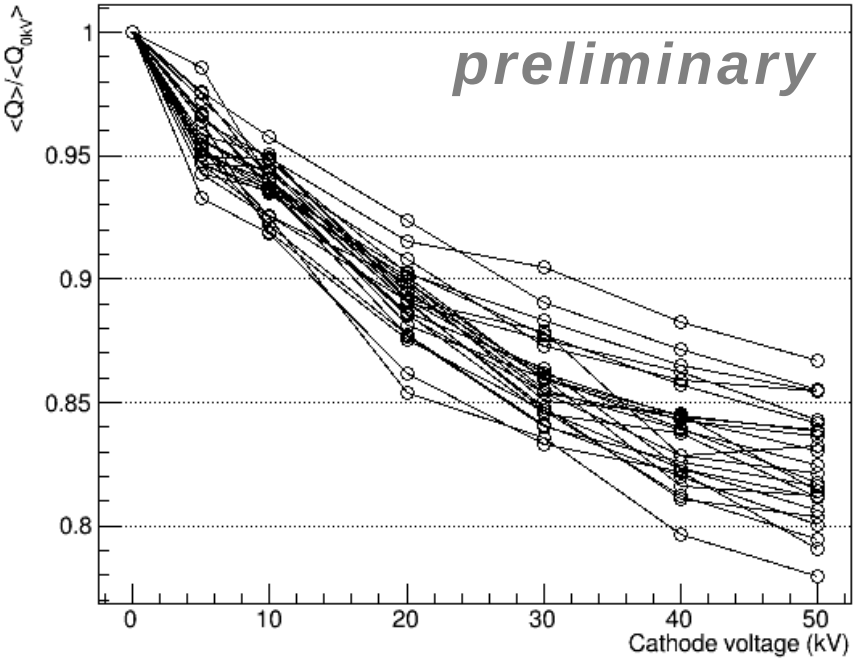


Average signal for one pmt
at different cathode voltages

Light yield dependence with the drift field (Birk's law).



*PMT trigger in red



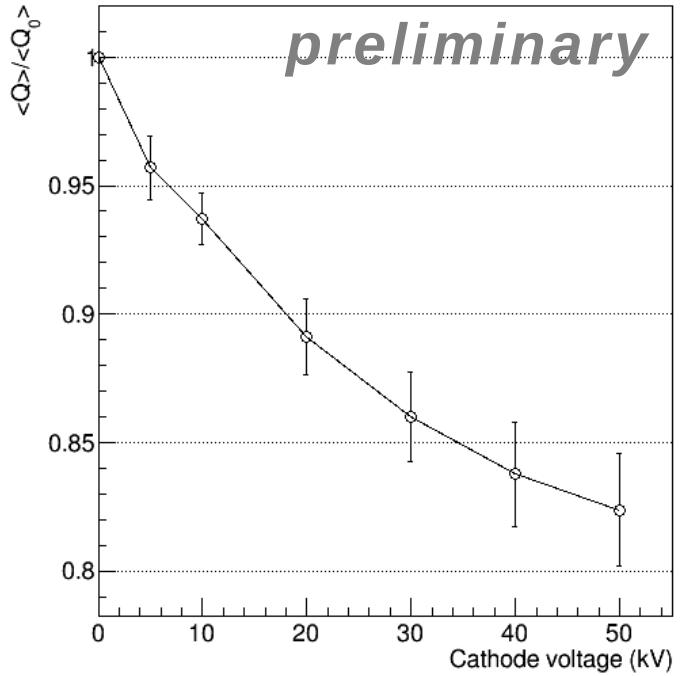
- Left: Integrated charge of the average waveform for every PMT at different cathode voltages. Since we are triggering on an specific PMT, not all channels see the same amount of light.
- Above: Ratio of the integrated charge w.r.t the integrated charge at 0kV.

  All PMTs observe a decrease in the light yield with the drift field as expected.

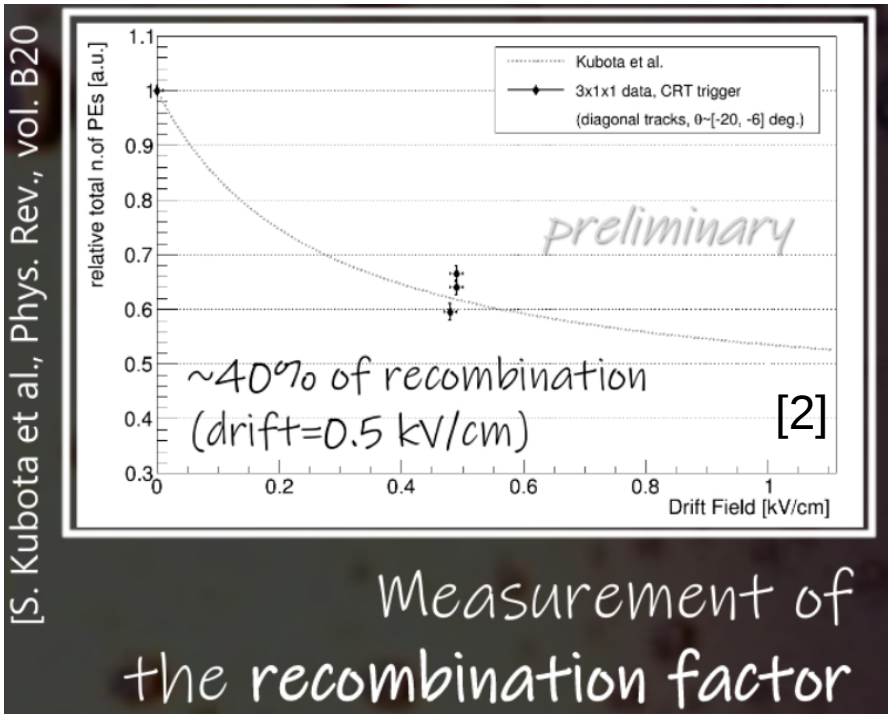
Light yield dependence with the drift field. Comparison with 3x1x1.

A decrease of ~20% due to recombination (instead of 40%) seems reasonable.

→50kV at the cathode means a drift field of 0.5kV/cm in the first meter below the CRPs, and a lower field in the rest of the active volume.



Relative variation of the light yield w.r.t the cathode voltage.
* Error bars show the variation among PMTs.
* Free rider PMTs have been removed.

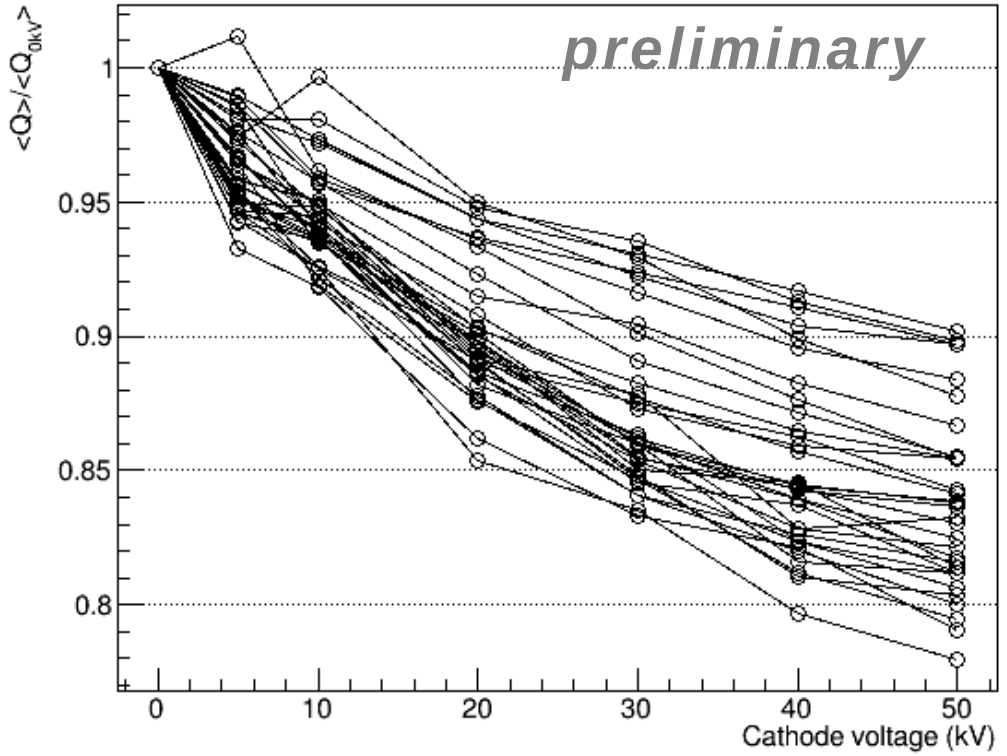


[2] Lastoria (2019) LeptonPhoton Poster.

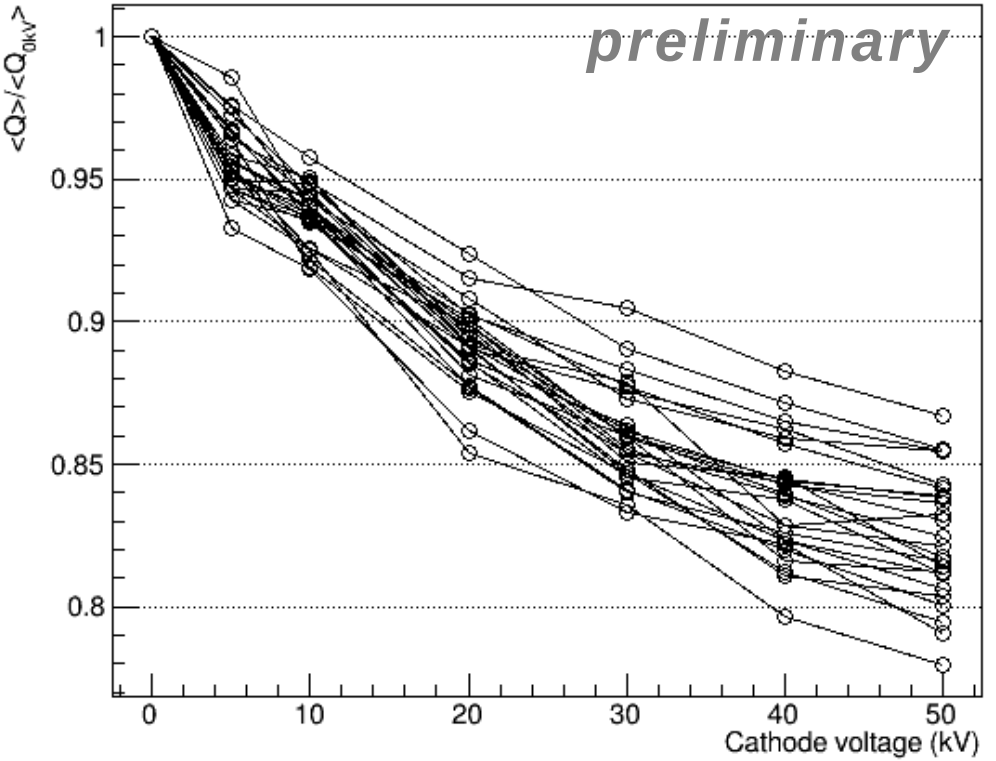
Summary

- The dependence of the light yield and the tau slow with the drift field has been shown using protodune dual phase data.
- We observe a similar behaviour as in the 3x1x1 demonstrator.
- Since our drift field is not uniform, the comparison is tricky and it will need further studies.

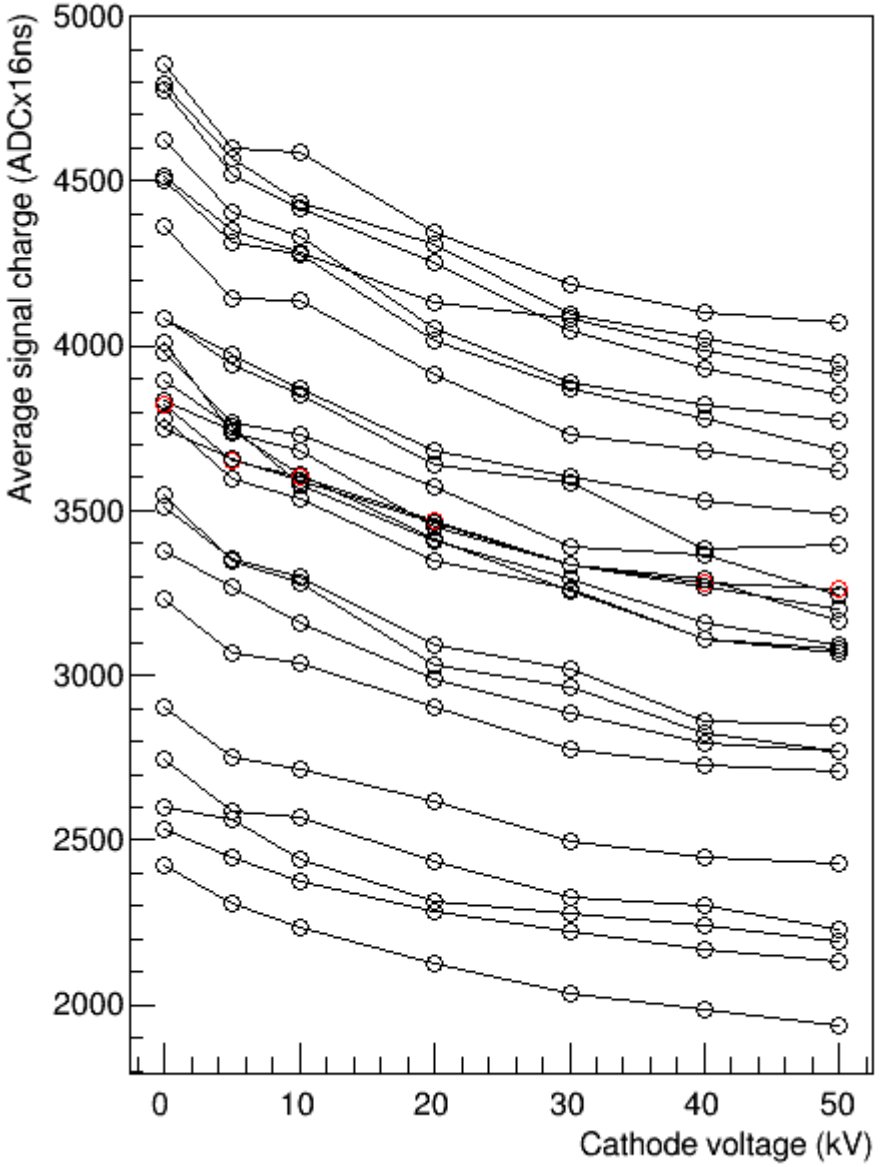
Backup

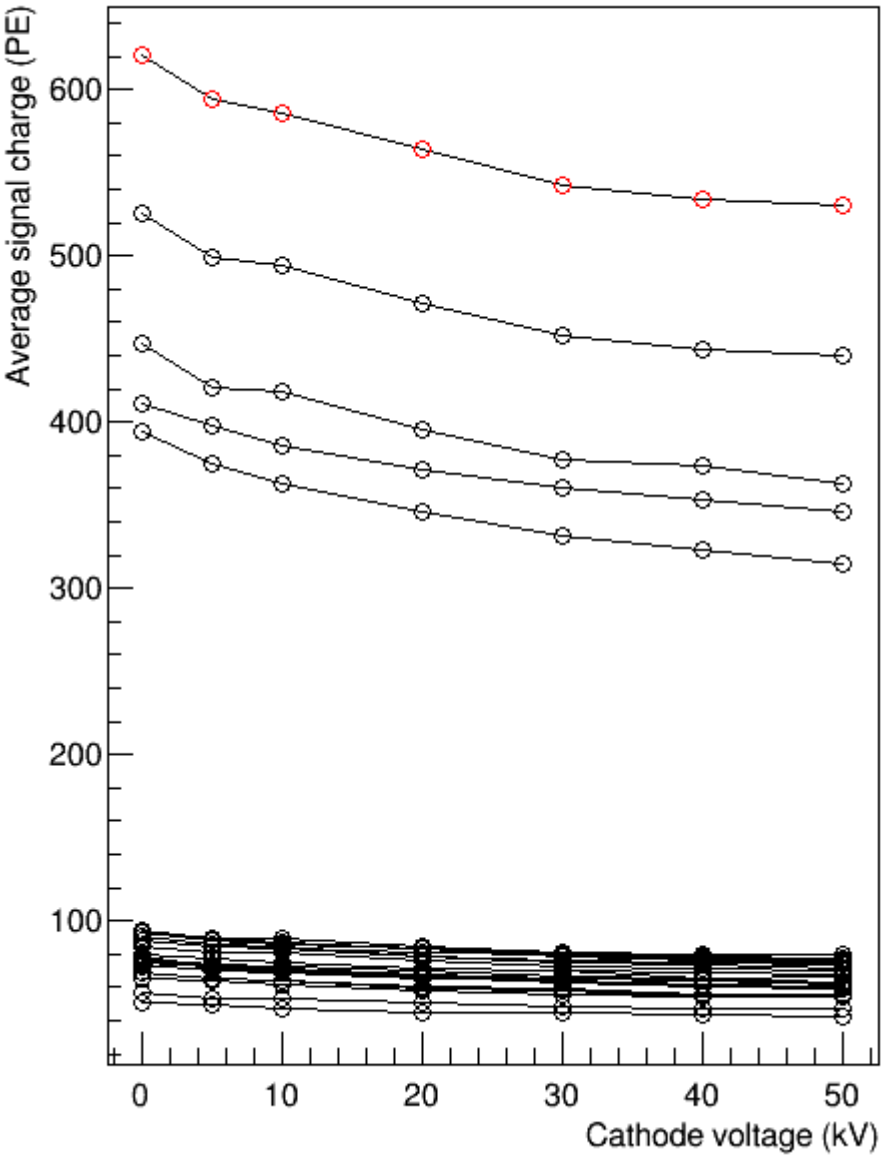


Relative variation of the light yield w.r.t the cathode voltage.
* All 32 PMTs.



Relative variation of the light yield w.r.t the cathode voltage.
* Free rider PMTs have been removed.





PMT trigger in red