Estimate of electron lifetimes during and after filling in the 35T Phase 1 run

Alan Hahn

8/20/14

Phase 1 Filling Details

- First (~70% partial fill) on 12/18/2014
- LAr taken from LAPD, passed through Purification Filters and into 35T cryostat.
- PrMs were running, initially setup in GAr mode of running
  - PrM1 located at bottom of tank—short PrM
  - PrM2 also at bottom of of tank---long PrM
  - PrM3 located just above PrM1 on same string
  - PrM 4 located at top of tank, not covered in this fill
  - PrM 1&3 lost anode signals during cooldown.

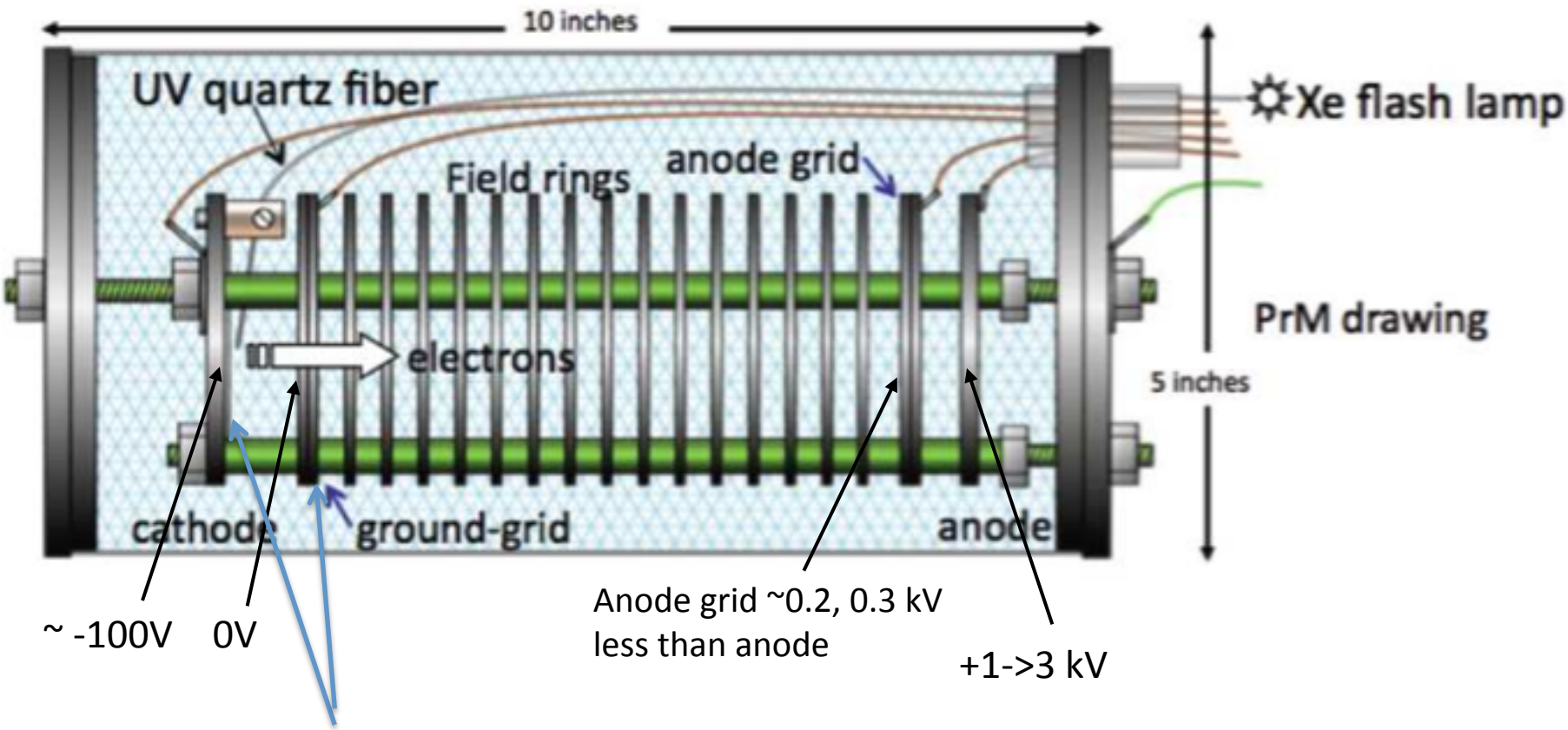
PrM Cathode Signal details

- Flashlamp illuminates Au photocathode with UV light, which liberate electrons.
- Electrons drift towards a grid (~1.8cm away) under the influence of an electric field (30-130V/cm depending on setup).
  - Drift time is on the order of 25-40 μs.
  - Cathode signal is developed as the electrons drift towards the cathode grid. If electrons are captured by an impurity, that part of the current stops.
  - Full signal is developed as the electrons pass the grid.
    - Electronics integrates this signal, so that peak height is representative of the total electron charge
- In order to see a cathode signal, the electron lifetime must be at least on the order of this drift time.
  - Is a means to get an estimate of electron lifetime early before the lifetime is good enough for electrons to make it to the anode.
    - Note that the only working anode during this first fill was in PrM2, a long PrM where the drift time was >1ms.
  - Is not as clean as the normal Anode/Cathode ratio since we lack an absolute normalization of the cathode pulse height
    - I try to use the plateau of the cathode signal as a normalization, but this doesn't account for changes in the flashlamp or cathode itself over time.
    - As mentioned, PrM1, the only short PrM which might have been able to measure short lifetimes (<100 μs) in the "normal" manner, was having a problem with its anode signals.

Purity Measurements

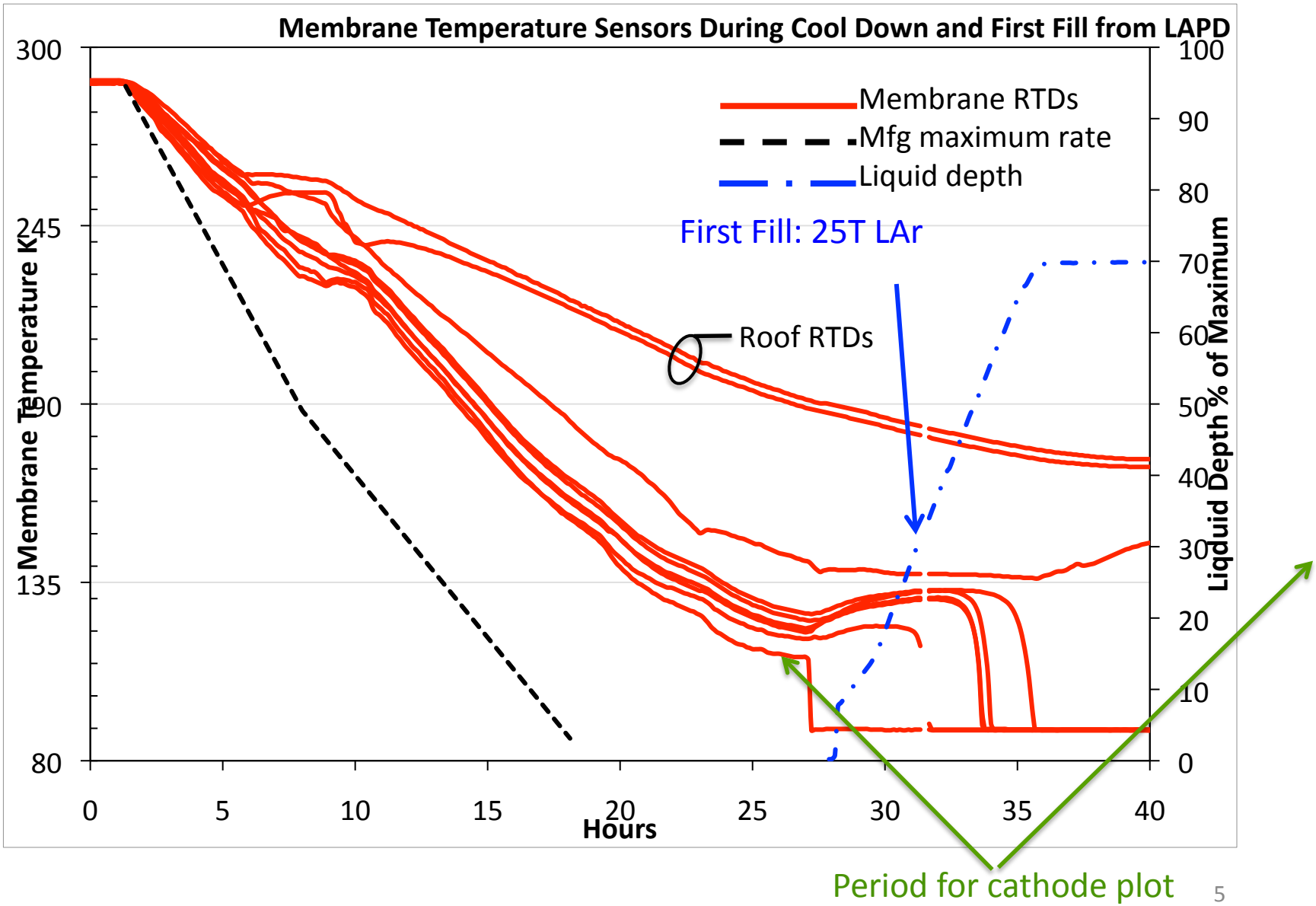
Drawing of Short PrM

(ICARUS Design, FNAL-Provided infrastructure)

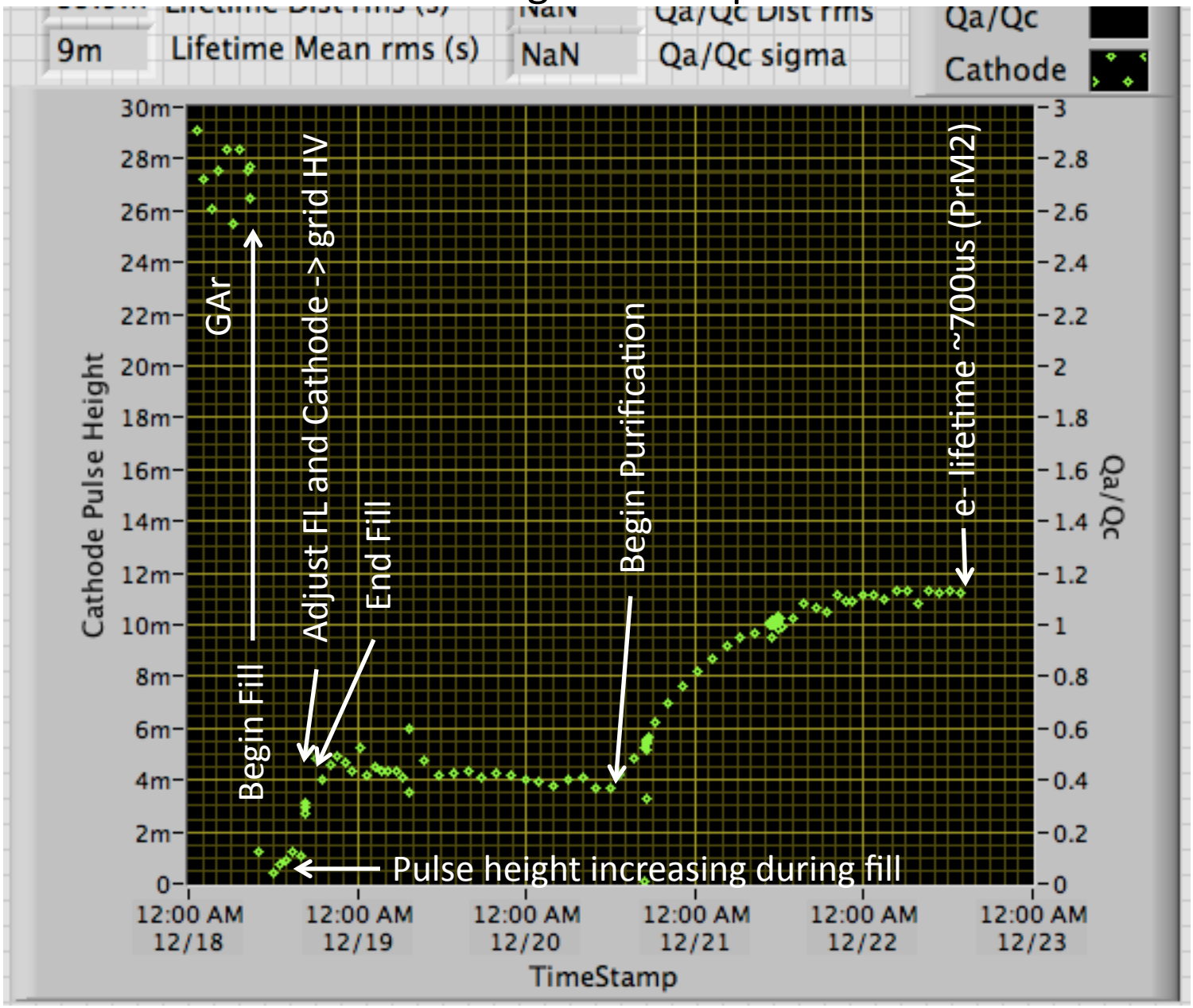


Cathode signal is developed between these two electrodes

Cooldown: A mixture of gas and liquid Ar is sprayed across bottom of tank to cause a turbulent mixing, cooling surfaces and (any) structures inside cryostat



PrM 1 Cathode Peak height, (12/18 -> 12/22/2013)
First fill through start of purification



Comments on previous Plot

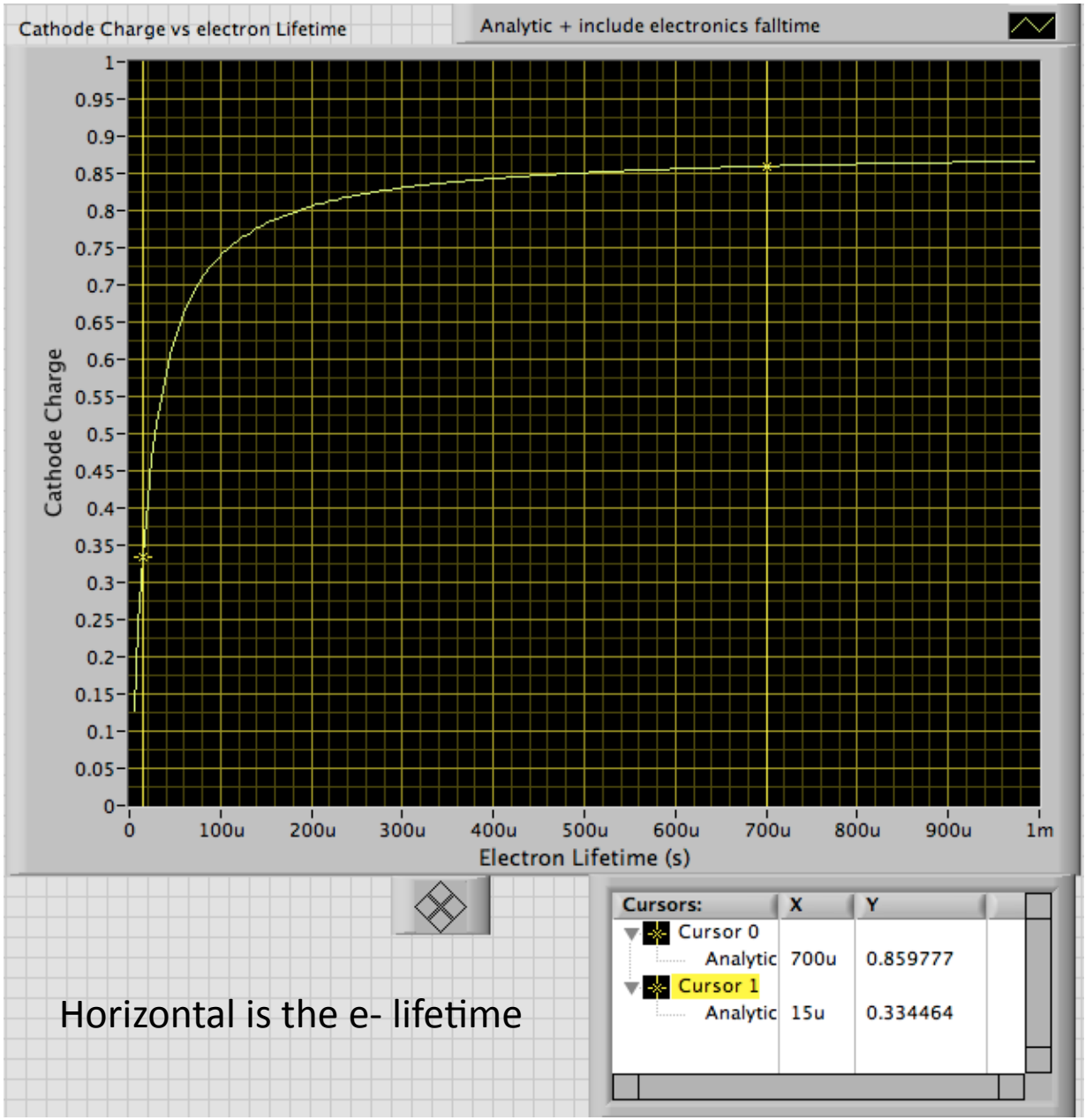
- Start of plot is when 35T is in cooldown state with cold GAr (~1 AM on 12/18)
- LAr fill begins at ~9 AM on 12/18.
  - Drop in Cathode pulse height when PrM1 cathode becomes covered in LAr (~9:53 AM)
  - First obvious cathode signal LAr seen at ~noon.
  - Signal increases over the fill. See slide 11 in extra slides.
    - Presumably due to GAr contaminants being diluted by pure LAr fill.
  - At ~16:00 I increased both the flashlamp intensity and the cathode-cathode grid voltage—this causes the big jump in cathode signal height at this point.
  - At 17:00, fill is over, LAr is at 70% level in cryostat.
- LAr sits in cryostat during 12/19 while we commission the pumps.
  - Note Cathode pulse height is decreasing, at least partially due (I think) to outgassing in ullage
- LAr Purification starts at noon on 12/20
  - Note that cathode signal increases as function of time, more or less plateauing on 12/22 (as seen on this scale).

Attempt to extract electron lifetime before purification starts.

- Use the plateau, and a toy model of cathode signal development
  - When the purity gets substantially better than a few 100 μs, the cathode pulse height "plateaus, or changes only at a slow rate.
- First good measurement of e- lifetime (~700 μs) was at noon of 12/22 using PrM2
  - Recall the PrM1 anode signal wasn't giving signals.
  - Last points on the plot (slide 6) are at this time
  - Cathode was ~11.5mV at end of plot, compared to 3.8mV just before purification was turned on.
    - This ratio is ~0.33
- Have a simple model of cathode signal (see next slide) as a function of e-lifetime and with a nominal drift field.
  - Includes charge attachment, electronic RC falltime, and drift speed
  - Using this model, a 700 μs lifetime would give 0.86 of the original electron charge that came off the cathode (primarily the fall time of the electronics).
  - Measured Cathode pulse height = 1/3 *0.86 = 0.29 gives from the plot, an electron lifetime of 14 μs—estimate of lifetime just before purification starts.
    - Errors are most likely large (estimate 2-300%, probably asymmetric to the longer lifetime side).
    - Lifetime just after completion of filling ~ 17 μs using same calculation.

Toy model of Cathode Signal vs e^- lifetime

Vertical axis is the measured (relative) cathode pulse height, (including the electronics falltime)



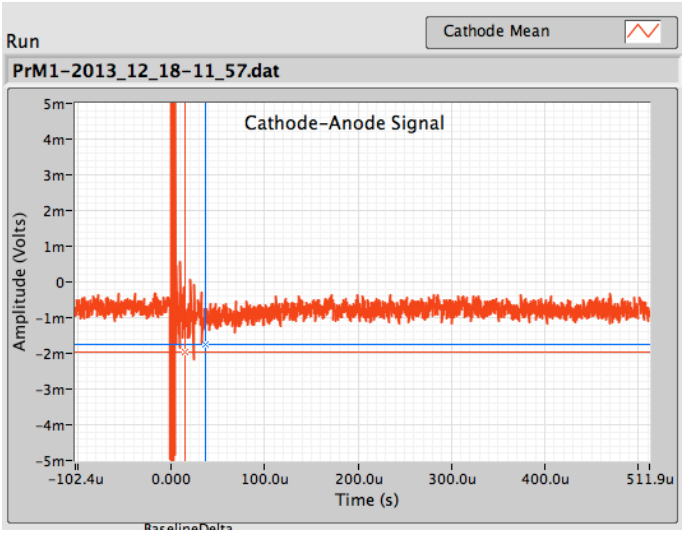
Horizontal is the e- lifetime

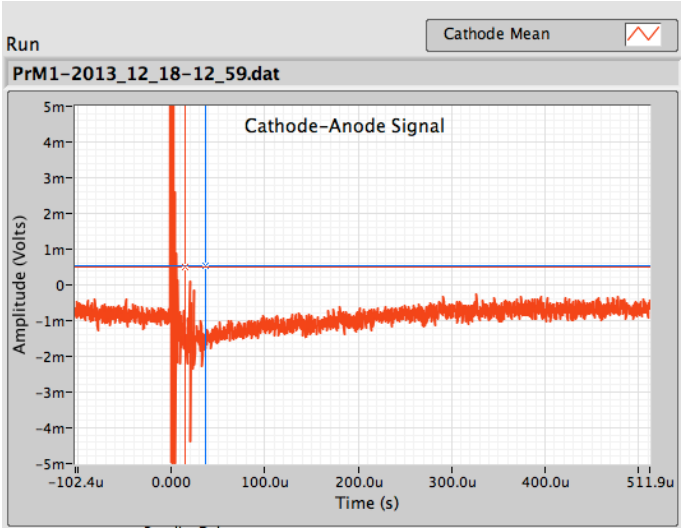
Curve shows how the measured cathode signal depends on the e^- lifetime in the LAr.

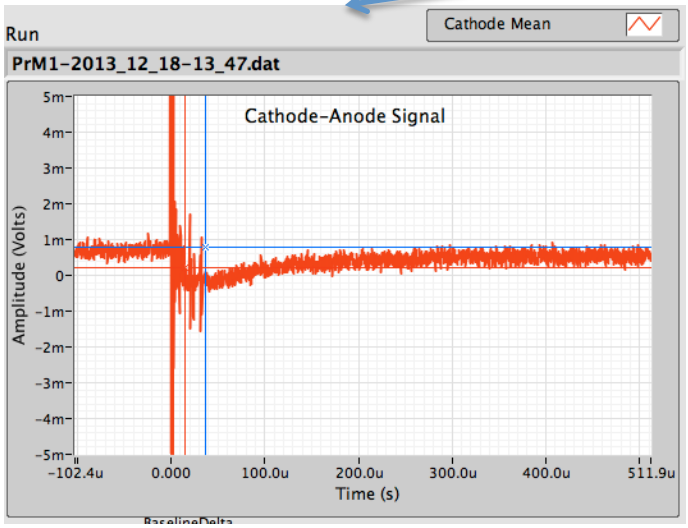
Cursors are on 700 μs and 15 μs lifetimes

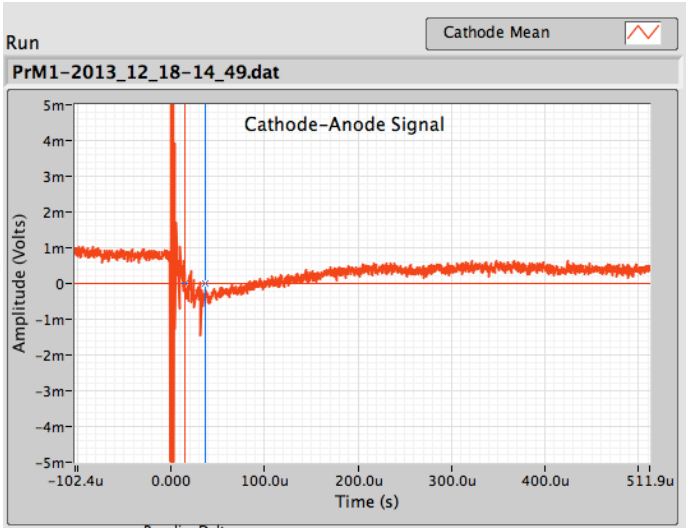
Extra slides

Cathode signal development during LAr fill (~1 hr apart), starting at ~noon on 12/18









End of First Fill ~17:00

(these traces are before I increased the Flashlamp intensity and Cathode-grid drift field)