Observation of light seen by PMTs in coincidence with Drift HV “event”

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11/4/2015

Drift HV “events”

- DocDB-4998 summarizes recent drift HV (current) fluctuations
- Elog #10495 shows a fluctuation in the pick-off voltage in coincidence with a current spike on a PMT HV (see below)
  - This occurred on 11/3/2015 at 8:25:25 pm CST

Reading out PMT data

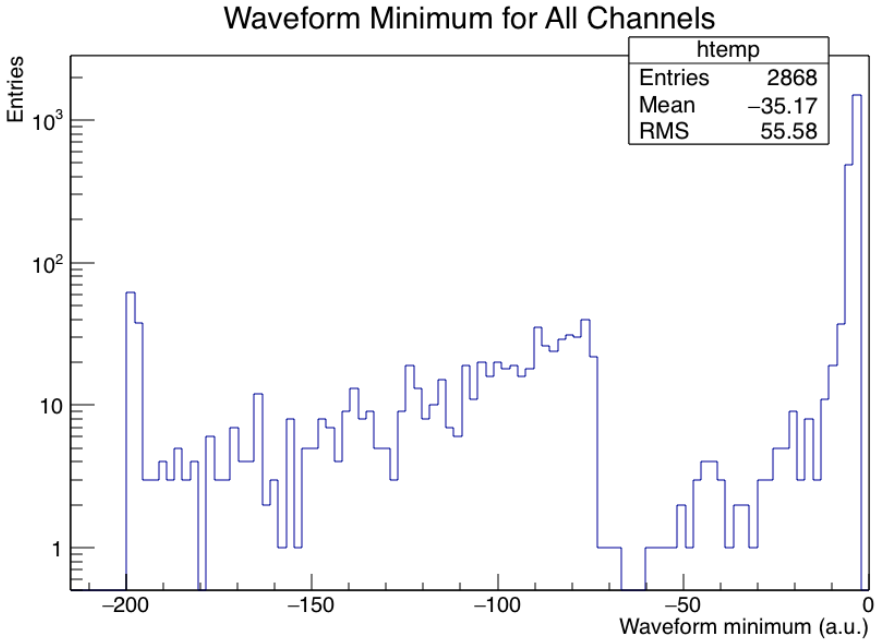
- We only trigger on BNB (5 Hz), NUMI (0.6 Hz), and a fixed rate function generator (0.1 Hz)
  - Therefore, the probability for light information from a drift HV event to be read out due to an accidental coincidence with our trigger is 5.7 Hz x 6.4 ms = 3.6%
- However, per Stephen's original suggestion, copies of the low gain outputs from the four "paddle PMTs" were also plugged into an oscilloscope that is triggering on a large signal in the most downstream paddle PMT (Ch. 1) to monitor possible drift HV discharge events
  - We have been reading out the data from this oscilloscope starting 11/3/2015 at 4:52 pm thanks to our slow monitoring team

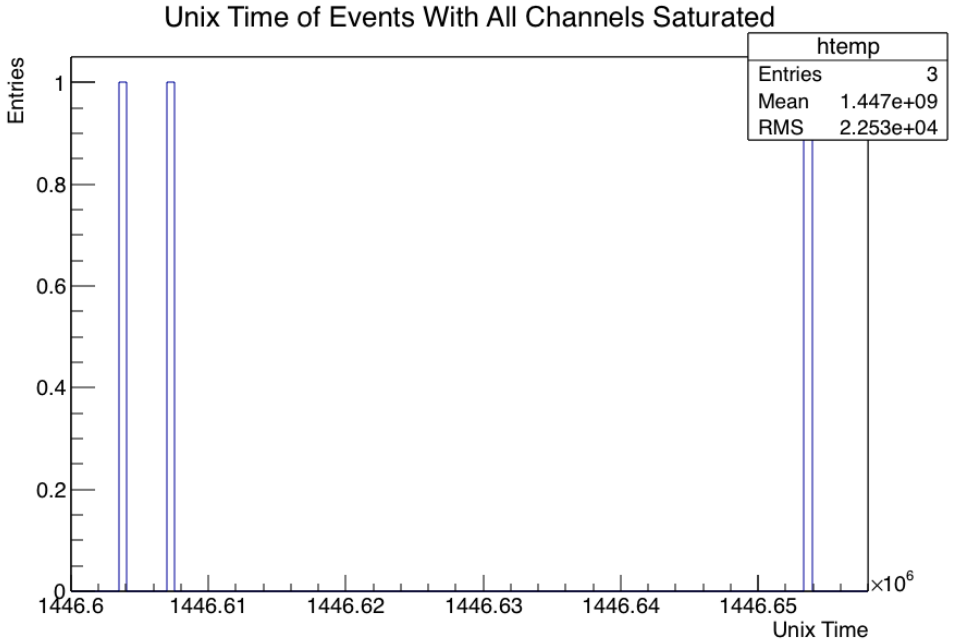
Oscilloscope paddle PMT data

- The trigger rate is ~0.6 triggers/minute
- The precision of the timestamp associated with oscilloscope data is ~5 sec (the polling frequency)
- For each channel, we collect 10,000 samples at 2.5 GS/s
- For each channel, the range of the 8-bit ADC has been set to 160 mV

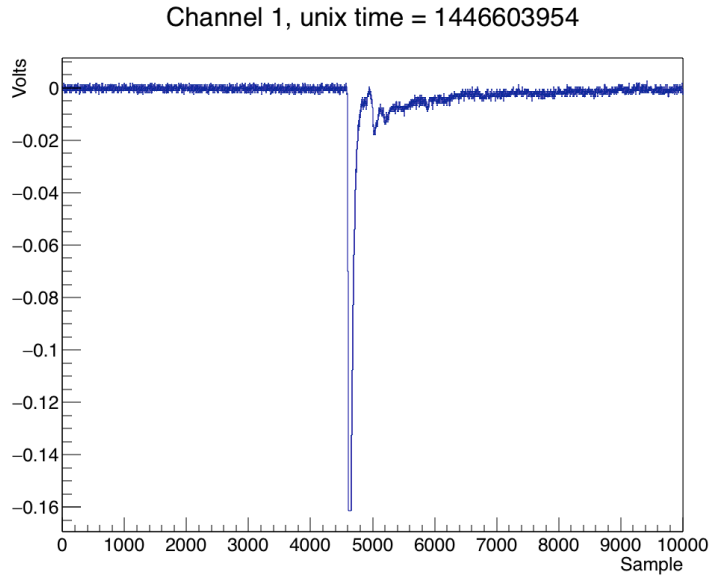
Oscilloscope Data From Glenn (Thanks!) Spanning ~19 hours

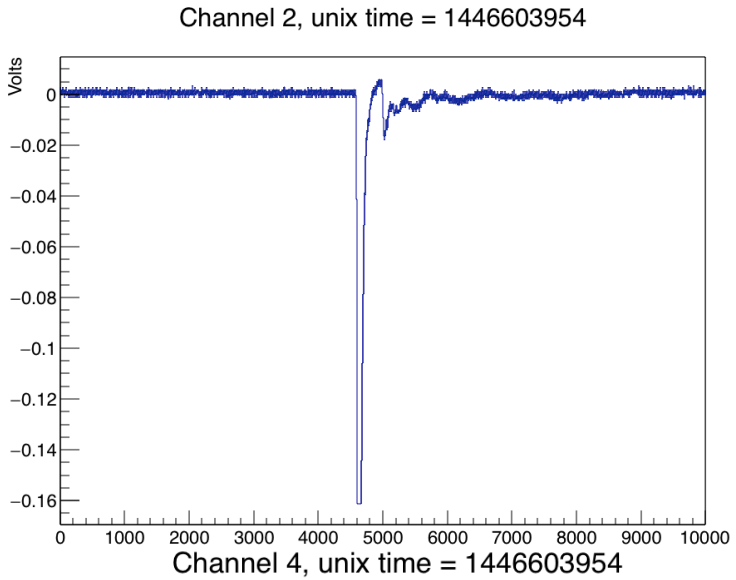
- Distribution of all waveform trace minima shows a population of saturated waveforms
- Three events contain saturated waveforms on all 4 channels
- The first of these events occurs 3 seconds after the drift HV event mentioned in Elog #10495

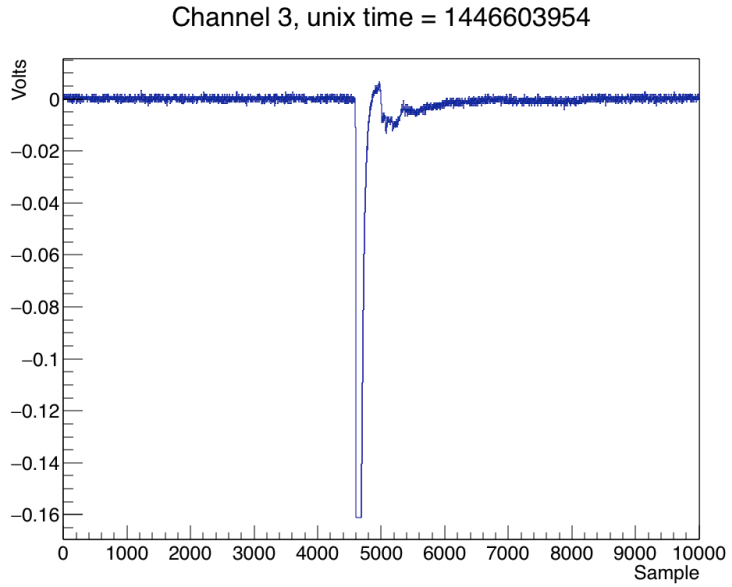


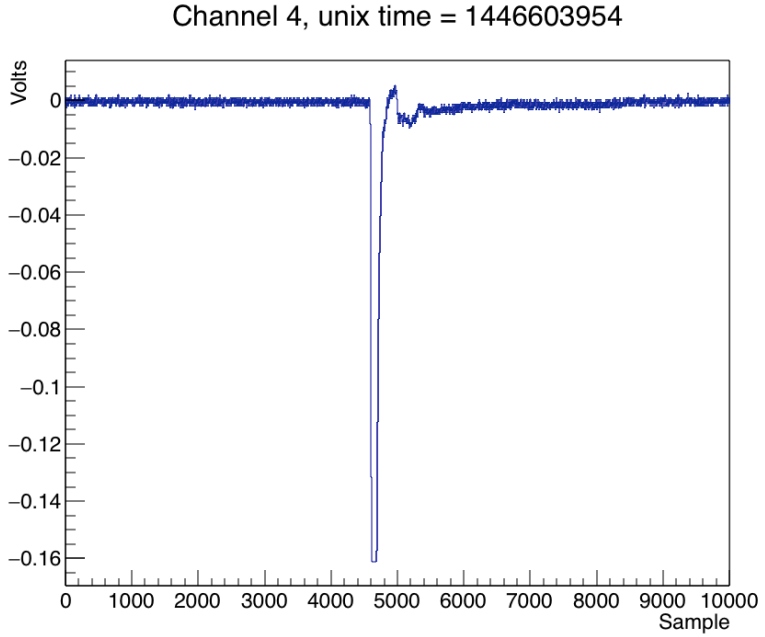


Traces From All Four Channels For Drift HV Event

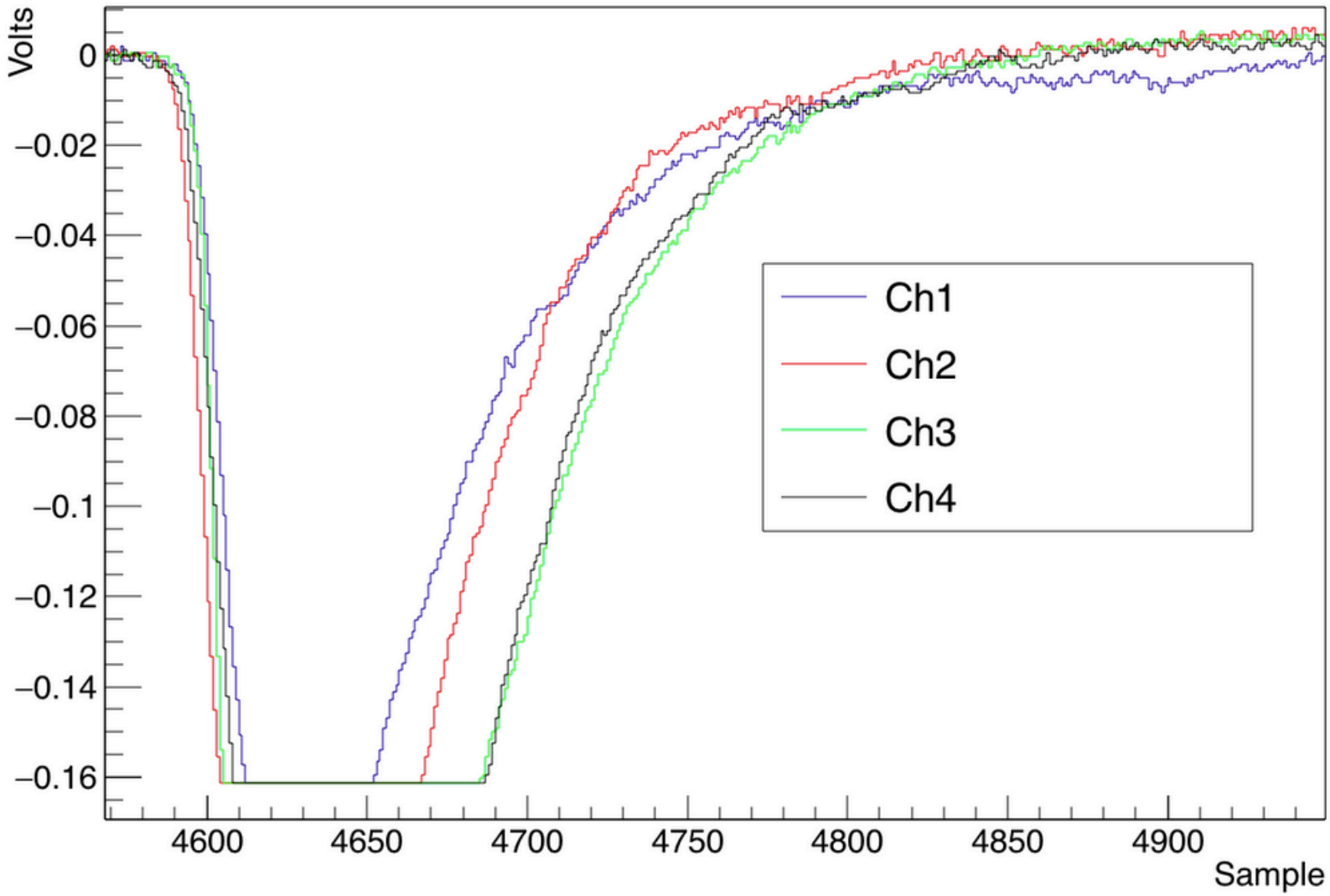








Zoomed in Traces, Overlaid

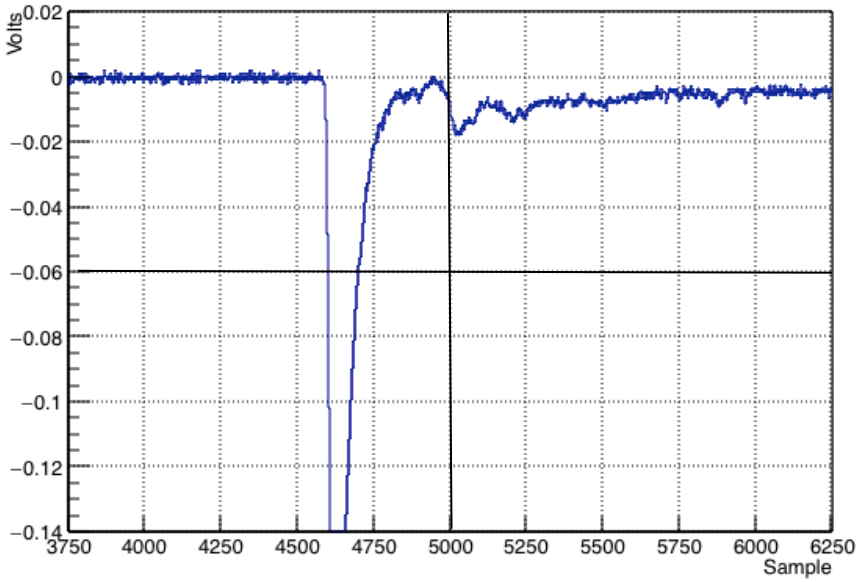


Observations

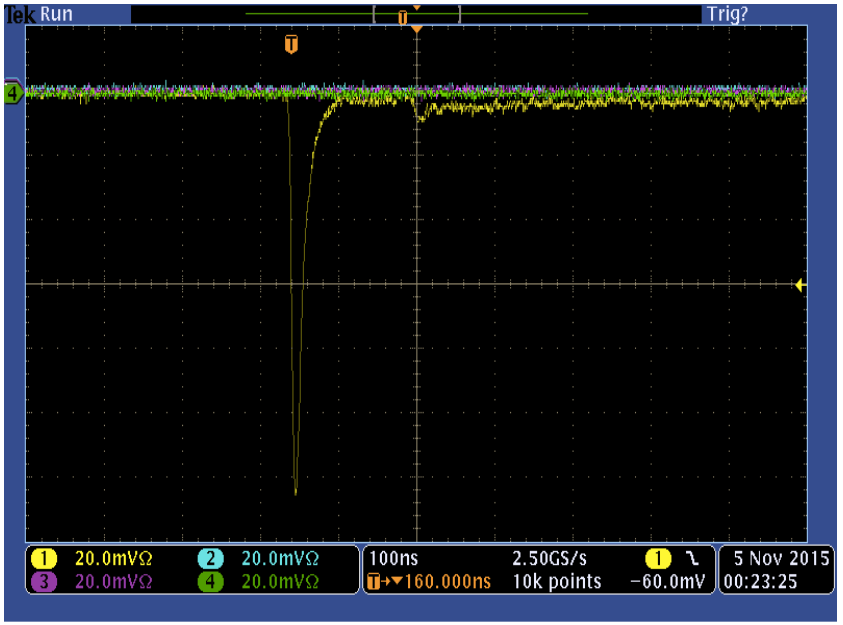
- Pulses appear to start within a few ns of one another
  - Points to the distance traveled by first photons being much larger than the horizontal distances separating the paddle PMTs, which are 6', 3', and 6', respectively perhaps due to reflections
- Channel 1 pulse width is smallest
  - Points to channel 1 seeing less light and the HV event being more upstream rather than downstream
- Pulses have different undershoots and recoveries to baseline
- These observations appear to depend on the HV event
  - Could be an indication of the variability of the HV event (e.g. location)
    - Other HV events appear to be more downstream (see backups)
  - Need larger dataset with larger dynamic range so pulse peaks visible

Comparison with “typical” paddle PMT cosmic pulse candidate on same scales

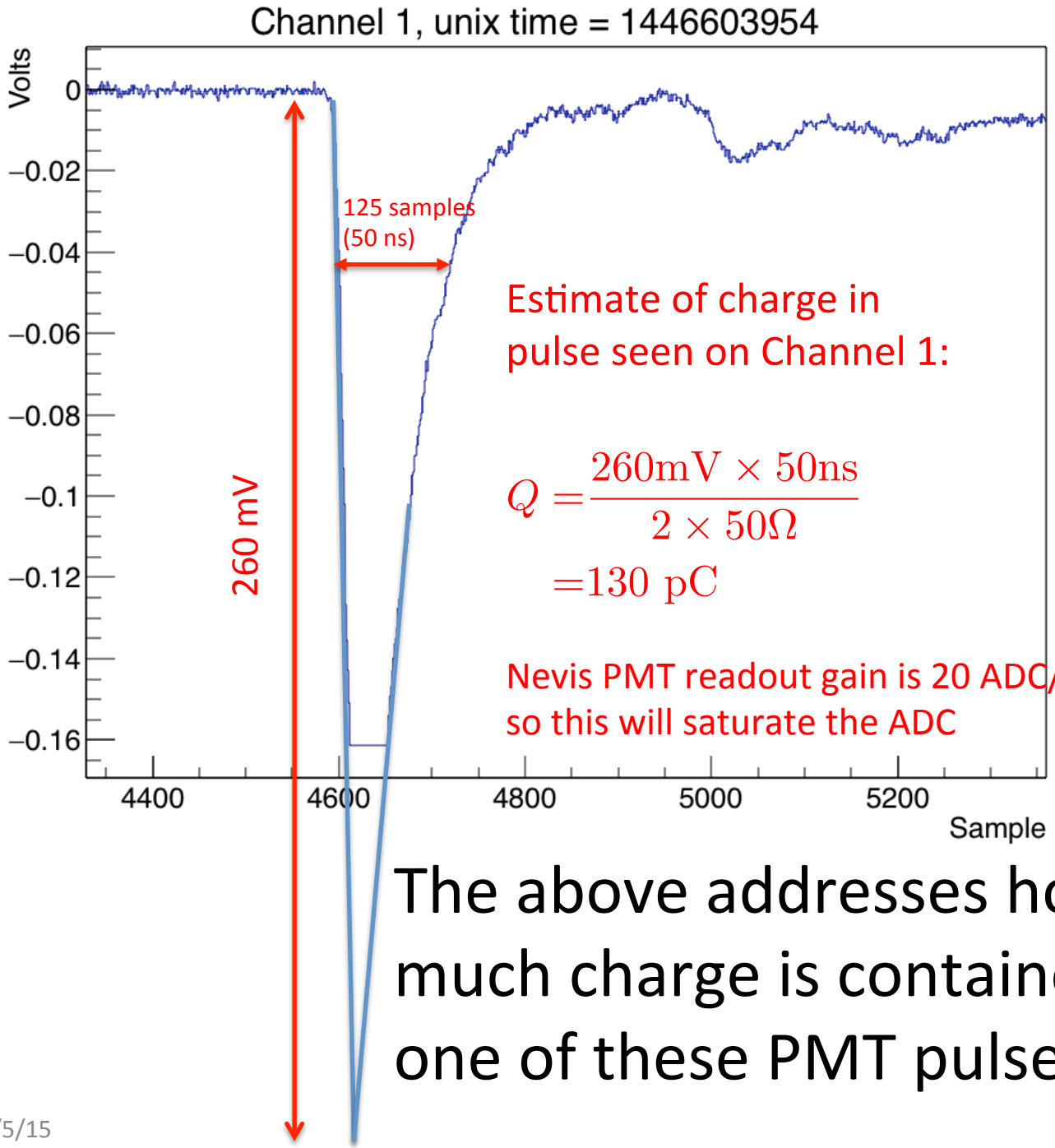
Channel 1 pulse coincident with HV event



Typical paddle PMT cosmic pulse candidate



- In principle, pulse shape may contain information about the duration of the light source (prompt pulse width) and the spectrum of light seen (late light is an indication of a source of VUV LAr scintillation light rather than visible light)
- Difficult to make solid conclusions about differences in pulse shape (e.g. prompt pulse width, late light, etc.) from this rough comparison



The above addresses how much charge is contained in one of these PMT pulses

Proposal

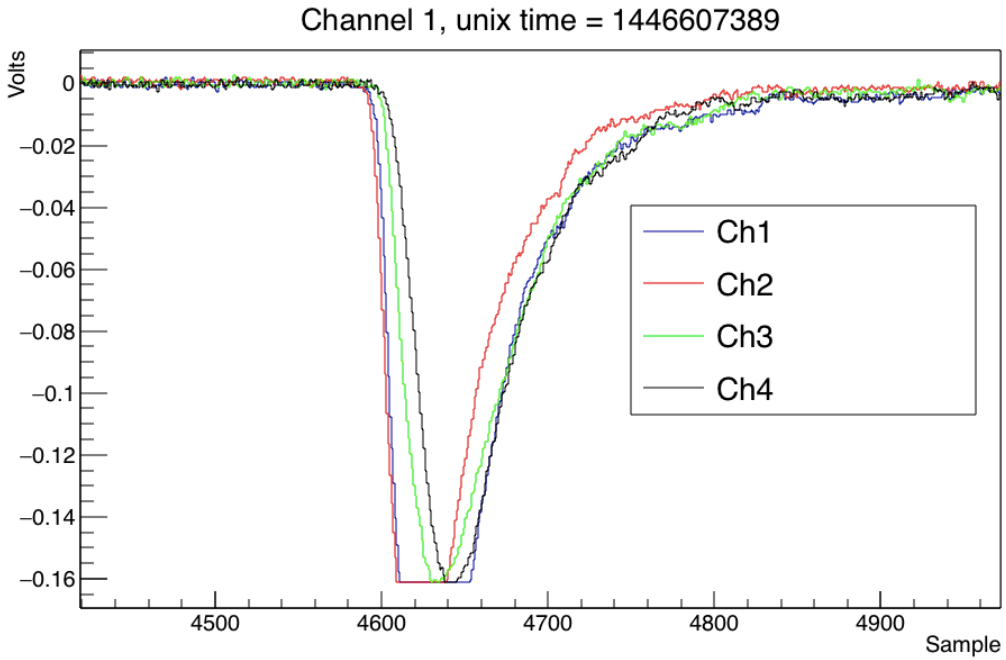
- Implement an off-beam PMT trigger, which looks for at least 4 low gain PMTs to be saturated within 50 ns of each other
  - Hardware is capable of this, but low gain FEM needs to be connected to trigger board
  - Firmware is capable of an off-beam "cosmic" trigger, but can the PMT trigger condition outlined above be implemented in the current version of the firmware?
- Trigger rate is ~4 day^{-1}, which is a negligible contribution to our trigger rate
- This will allow us to read out all the PMTs when there is an HV event and get a much better handle on where it is occurring
- We may also learn something about the HV event from the TPC data read out using this trigger

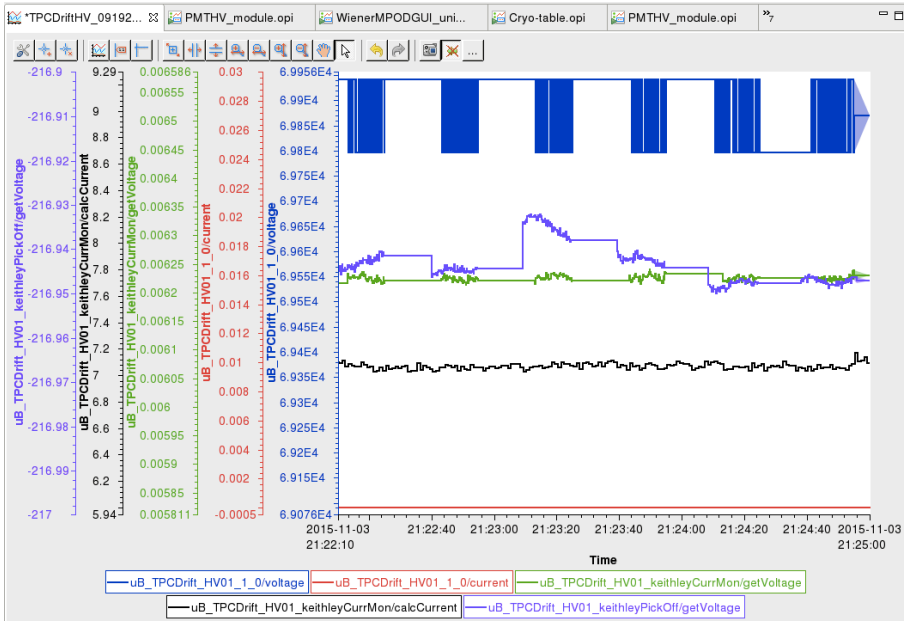
Conclusion

- We see light in coincidence with HV events
- This work should be extended to systematically look for correlations between all HV events and all oscilloscope triggers for which all four PMT channels are saturated (see backups)
- An off-beam PMT trigger should be implemented as soon as possible to read out the entire detector when these HV events occur

Backups

Second Event With All paddle PMT Oscilloscope Channels Saturated

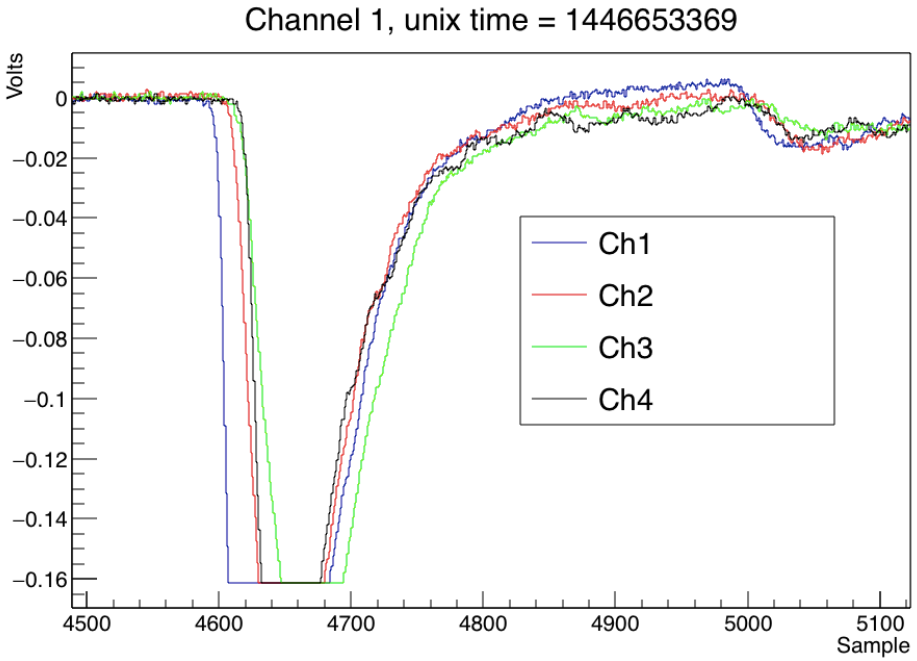


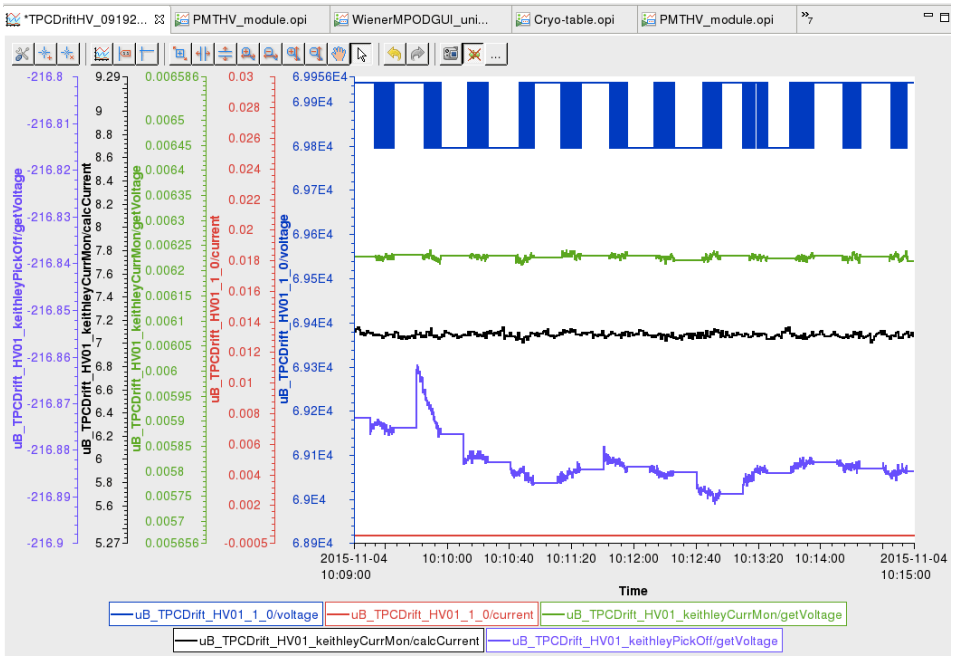


Unix time corresponds to 11/3/2015 21:23:09 CST

Small fluctuation in pick-off point seen on 11/3/2015 at 21:23:09 CST

Third Event With All paddle PMT Oscilloscope Channels Saturated





Unix time corresponds to 11/4/2015 10:09:29 CST

Small fluctuation in pick-off point seen on 11/4/2015 at 10:09:30 CST