

HV Items from Long Bo

MicroBooNE R&D Meeting
April 25, 2014

Slides by S. Lockwitz

Motivation & Outline

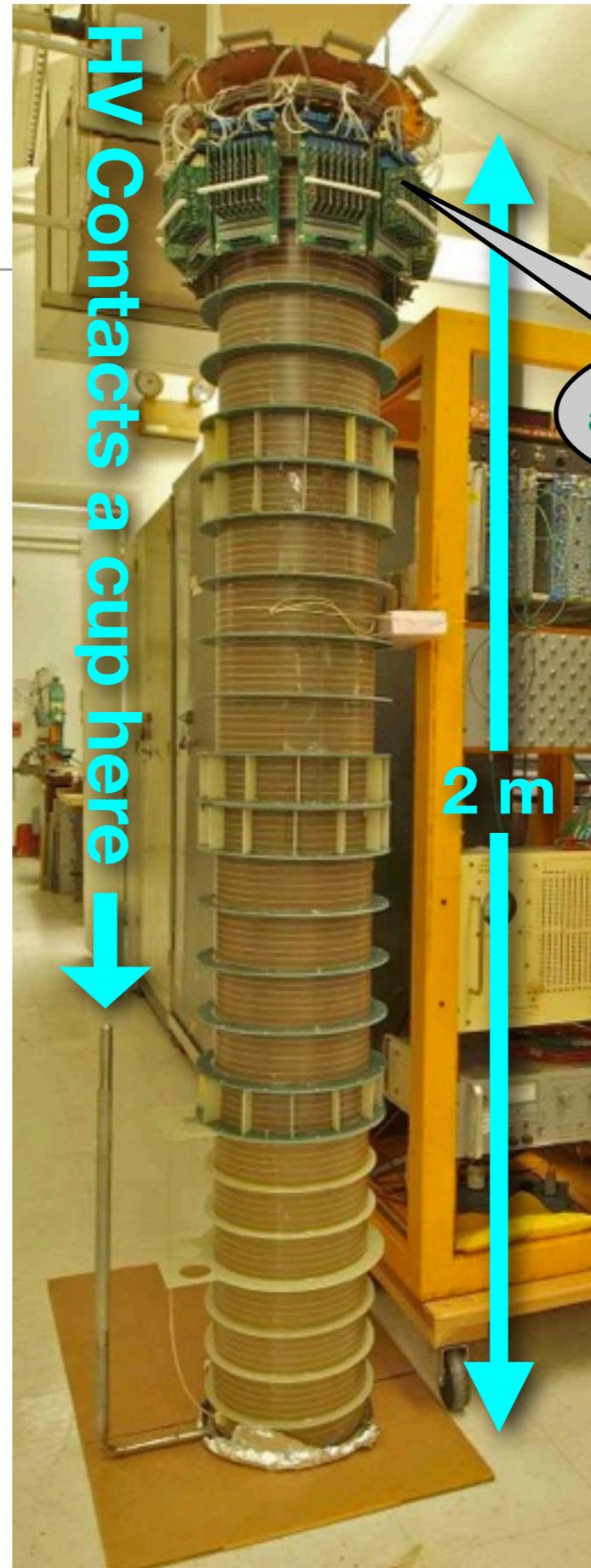
- Time
- I realized some of our experiences at LAPD/Long Bo in HV had not been shared with this group

- Long Bo intro
- Operation of HV
 - Hints at purity relationship (the plot some dislike)
- Cosmic shower study
- Light relationship
- A fixed distance test

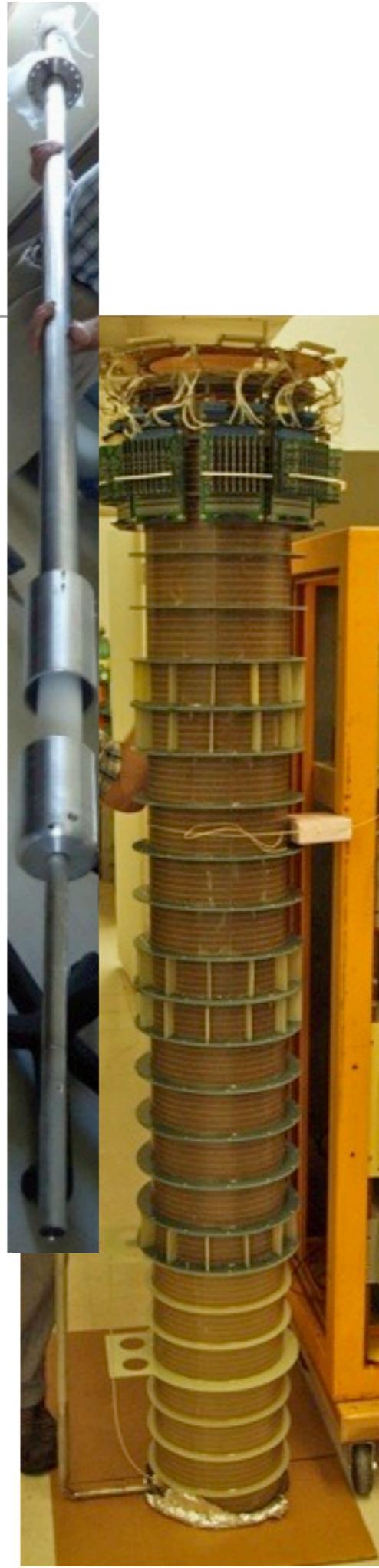
- Autopsy

Long Bo Introduction

- It was/is a TPC put in LAPD to drift cosmic tracks “long” distances
 - 2 meters in the drift direction, 25 cm diameter
- Ran from Jan to ~Sept. 2013
- T. Yang has done lifetime measurements with the data (uB docDb 2710 among others)



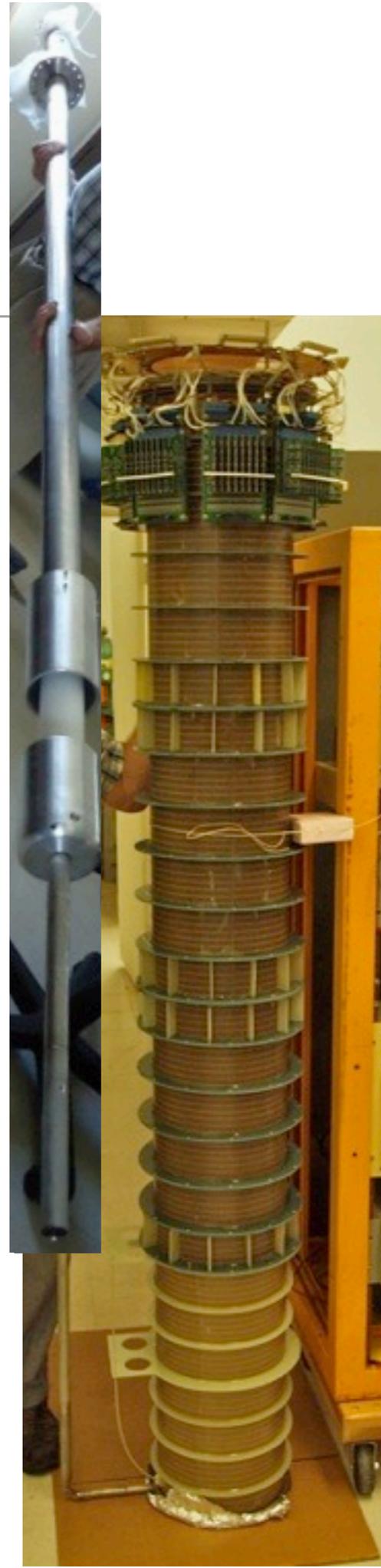
Operation



Not to scale or proper location by any stretch of the imagination

Operation

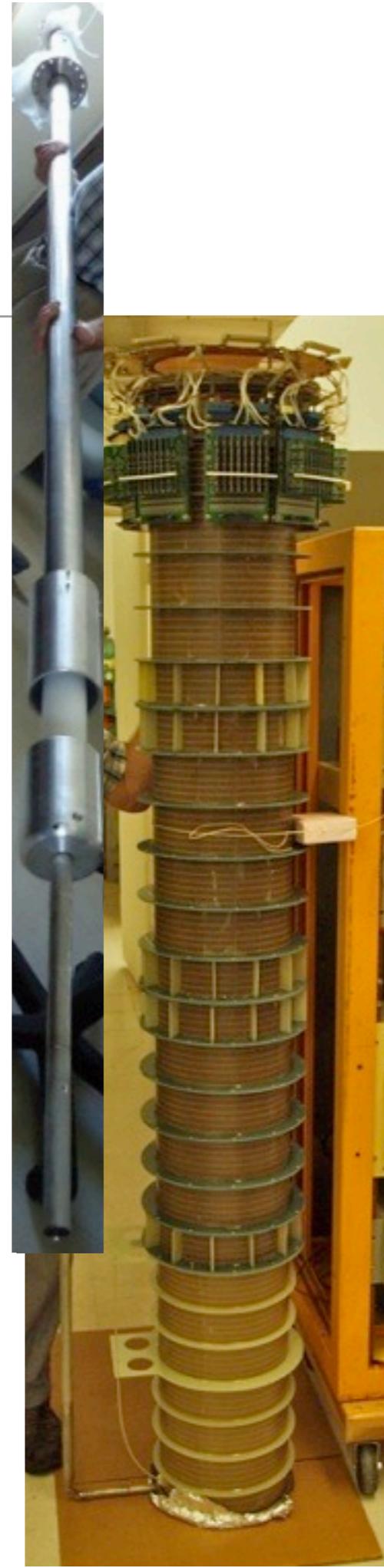
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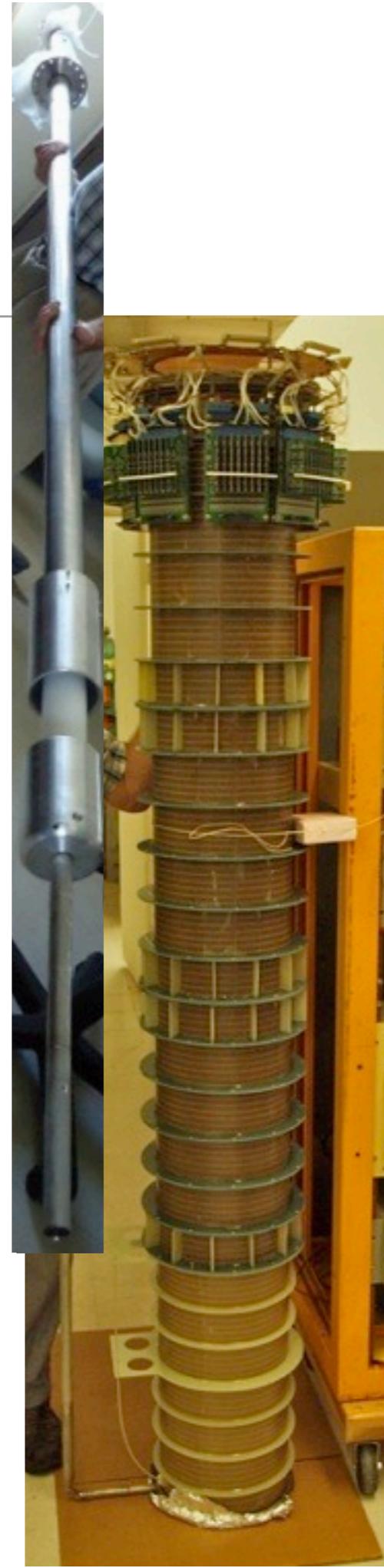
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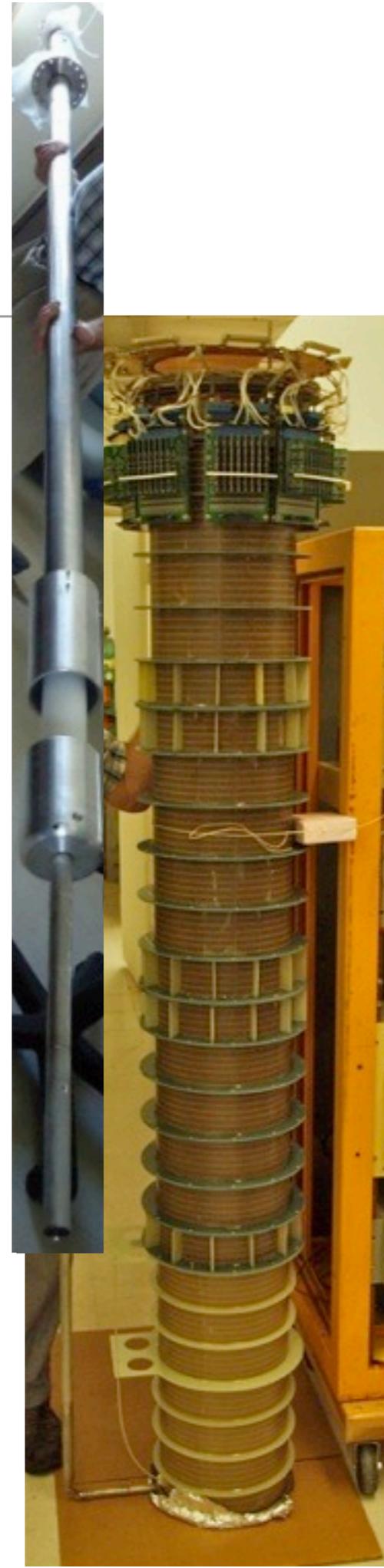
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- The HV never held 100 kV for more than a few seconds after that



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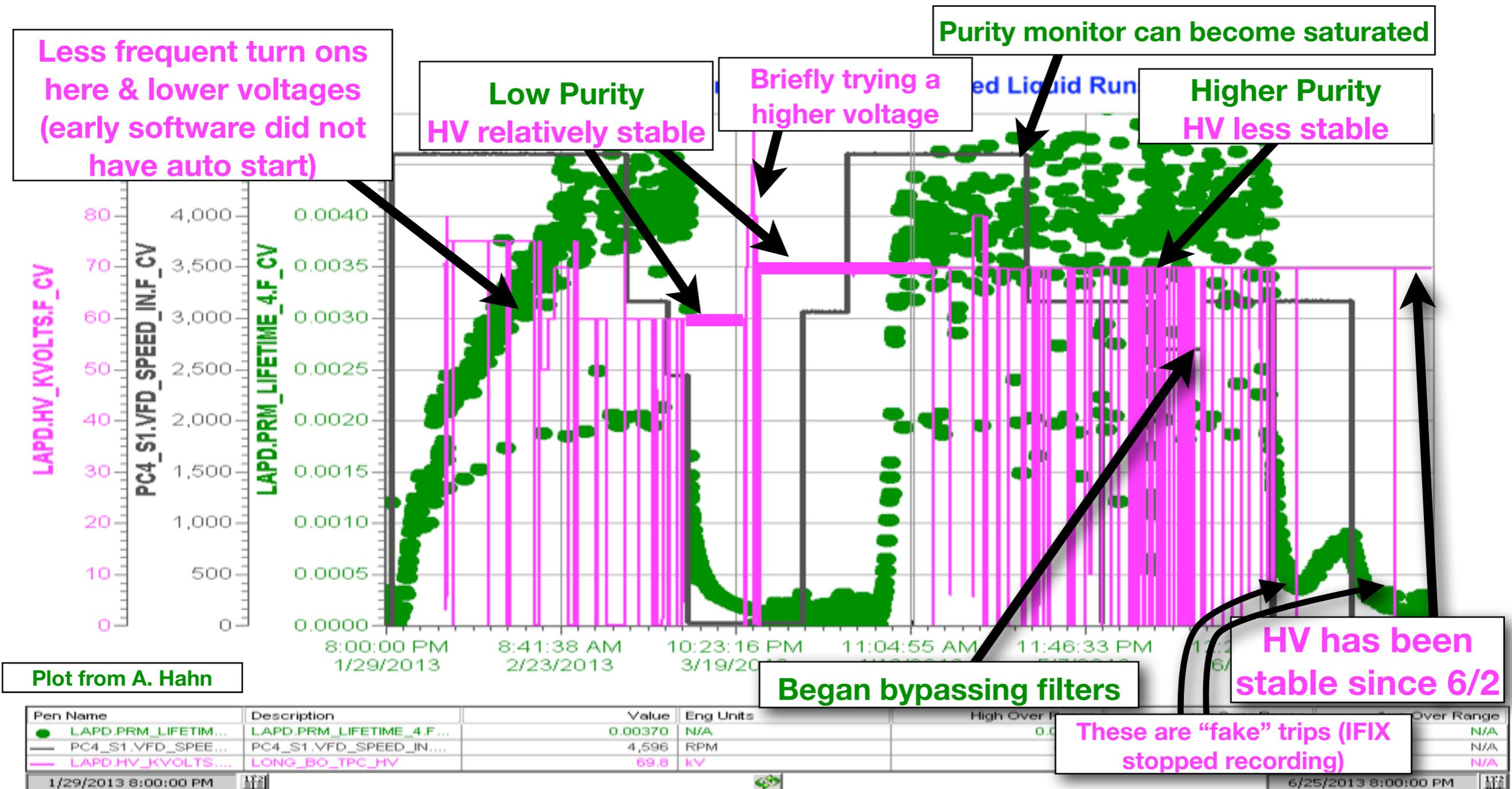
- We had a problem with Long Bo HV
- There was an incident the first time it was turned on (not the fault of the HV)
- The HV never held 100 kV for more than a few seconds after that
- We operated at lower voltages but still saw a trip every day or so



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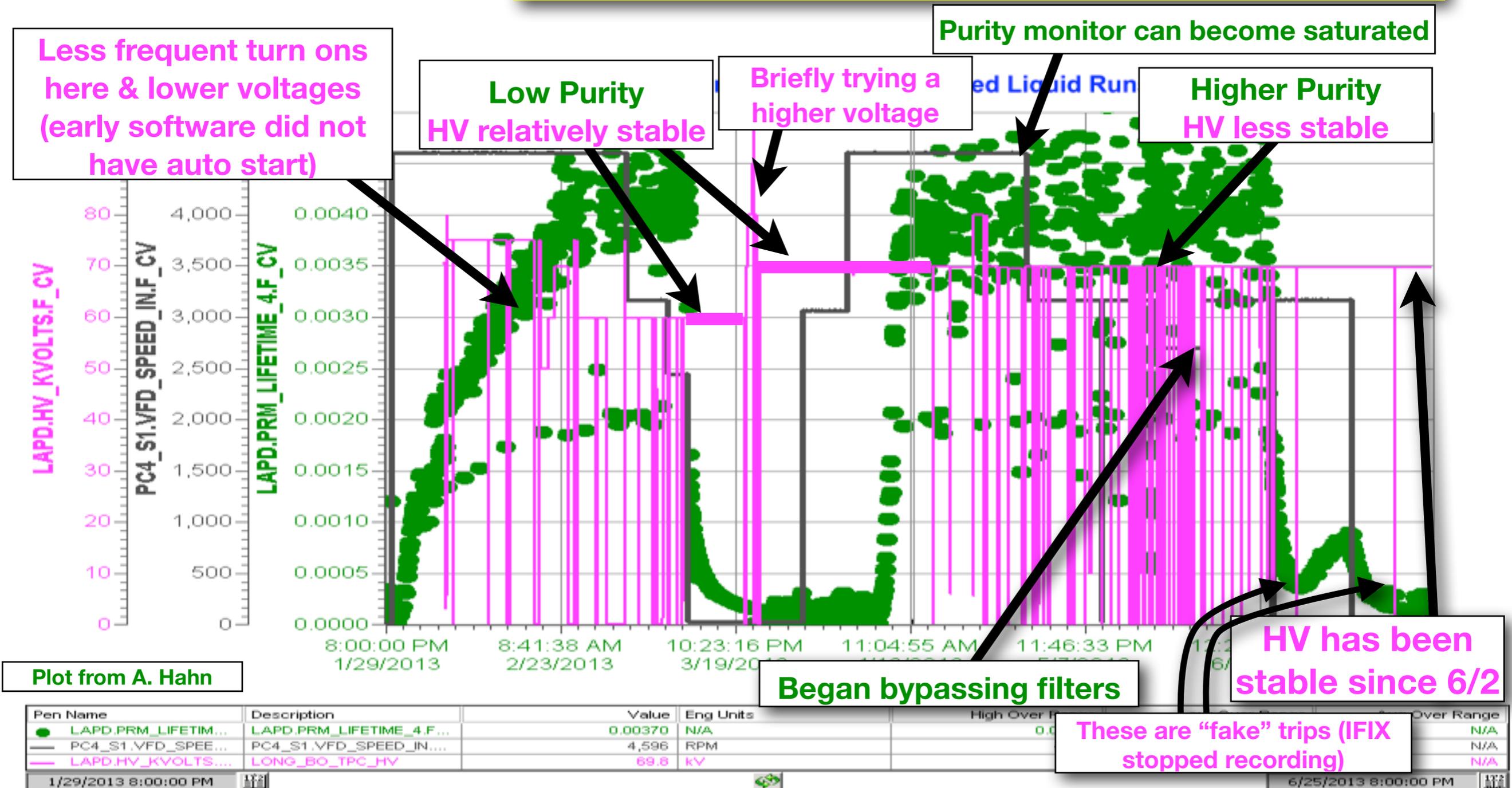
Our Experience: Long Bo HV

- After a pump failure, we noted HV stability
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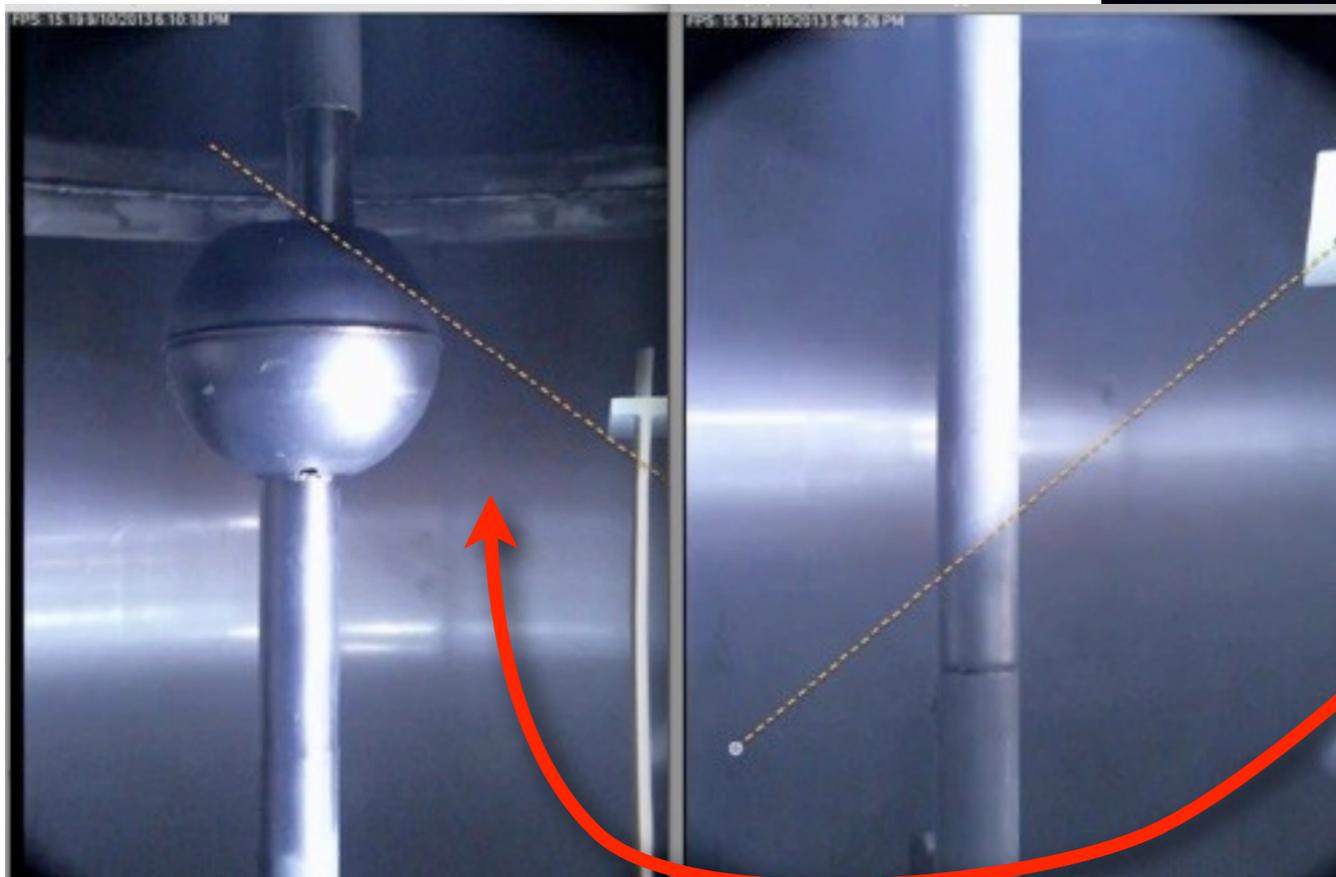
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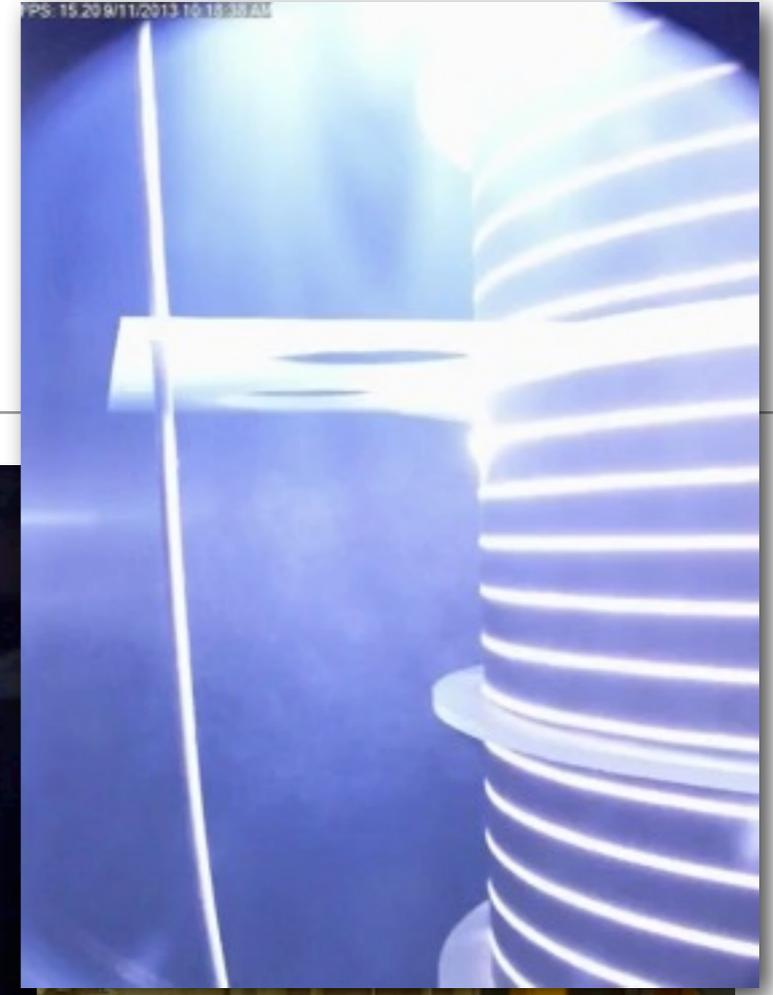
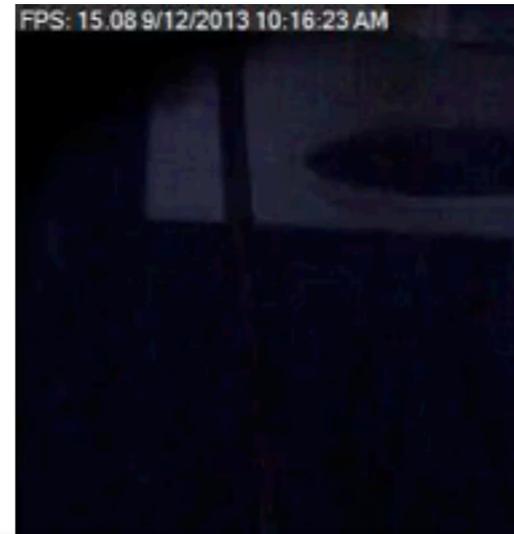
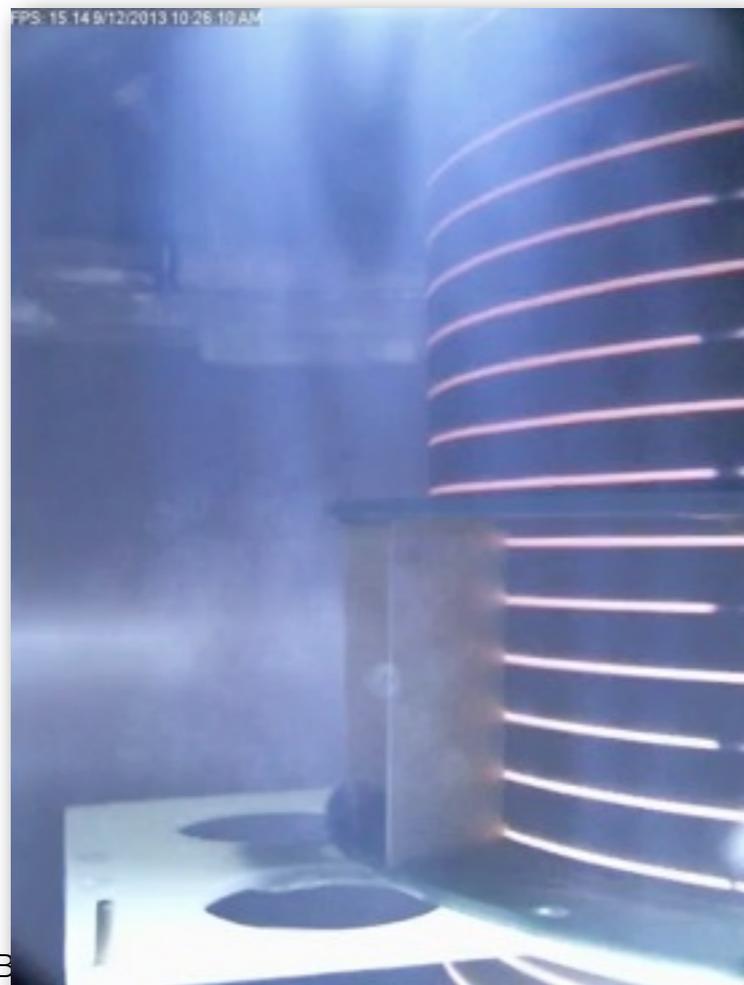


This is here



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- We eventually put a camera in LAPD (provided by BERN)
- Amazing photos...

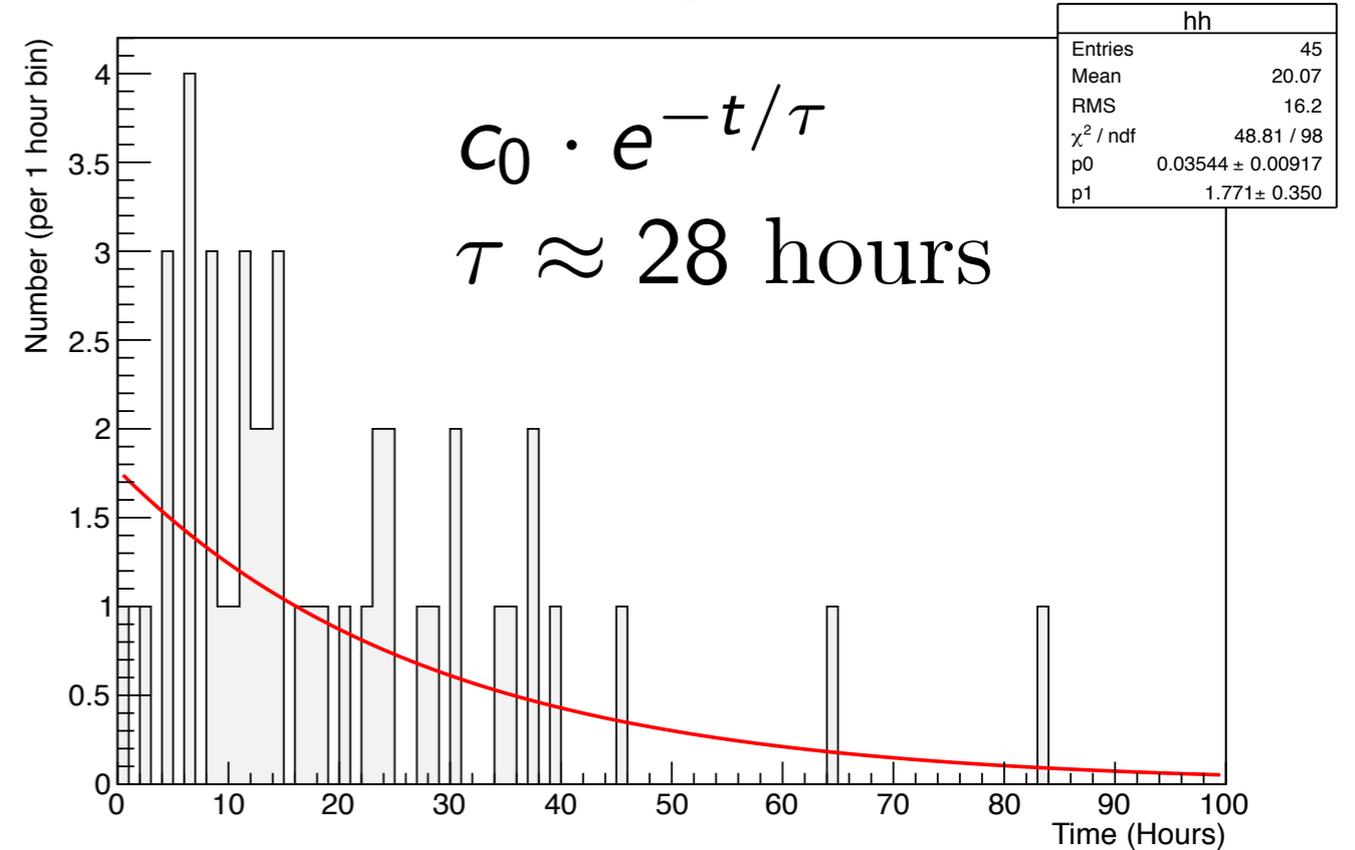


Are The Delayed Discharges Random?

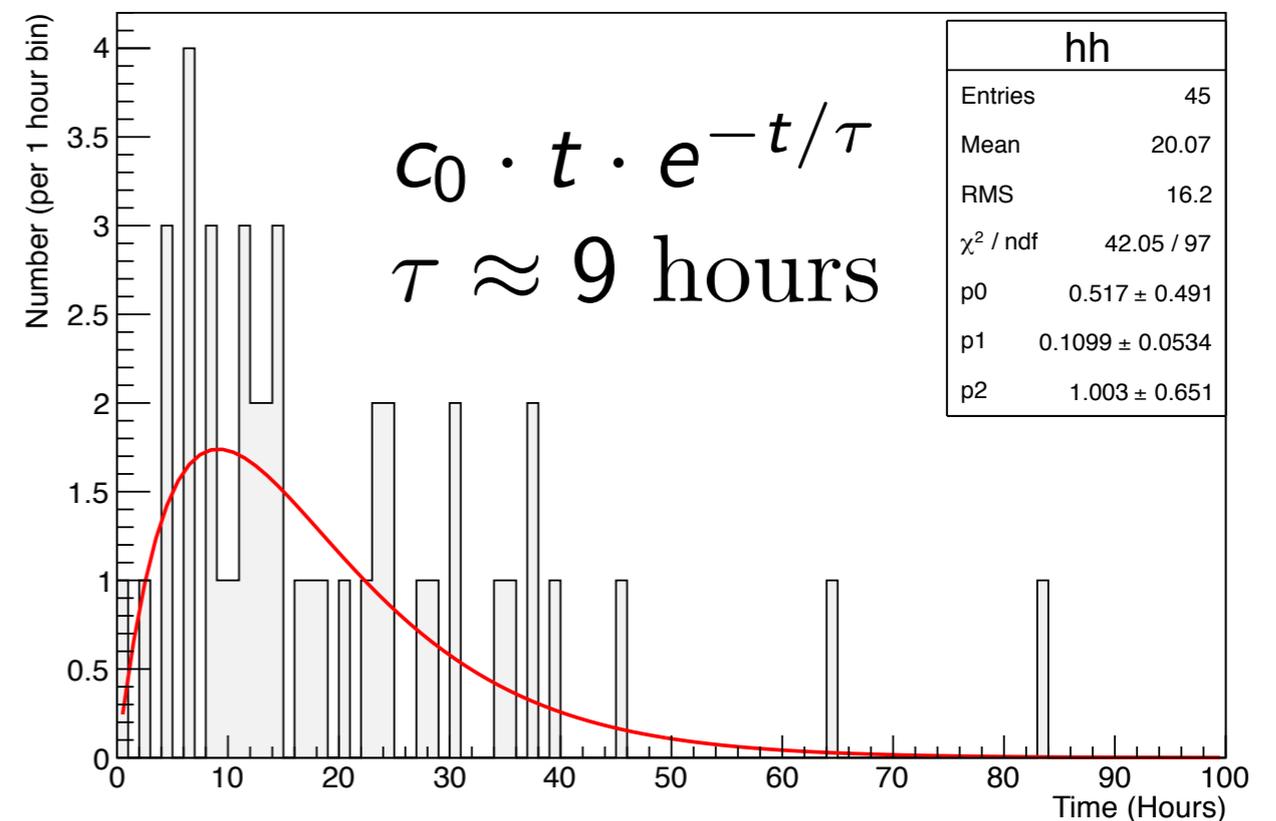
- If this was a Poisson process, the time between occurrences should be a decaying exponential
- This instead seems to have a time constant associated with it.

- Pretty low statistics

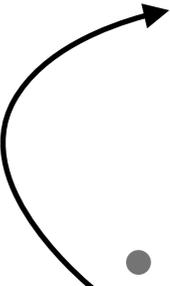
Period of Holding HV (4/25-6/2)



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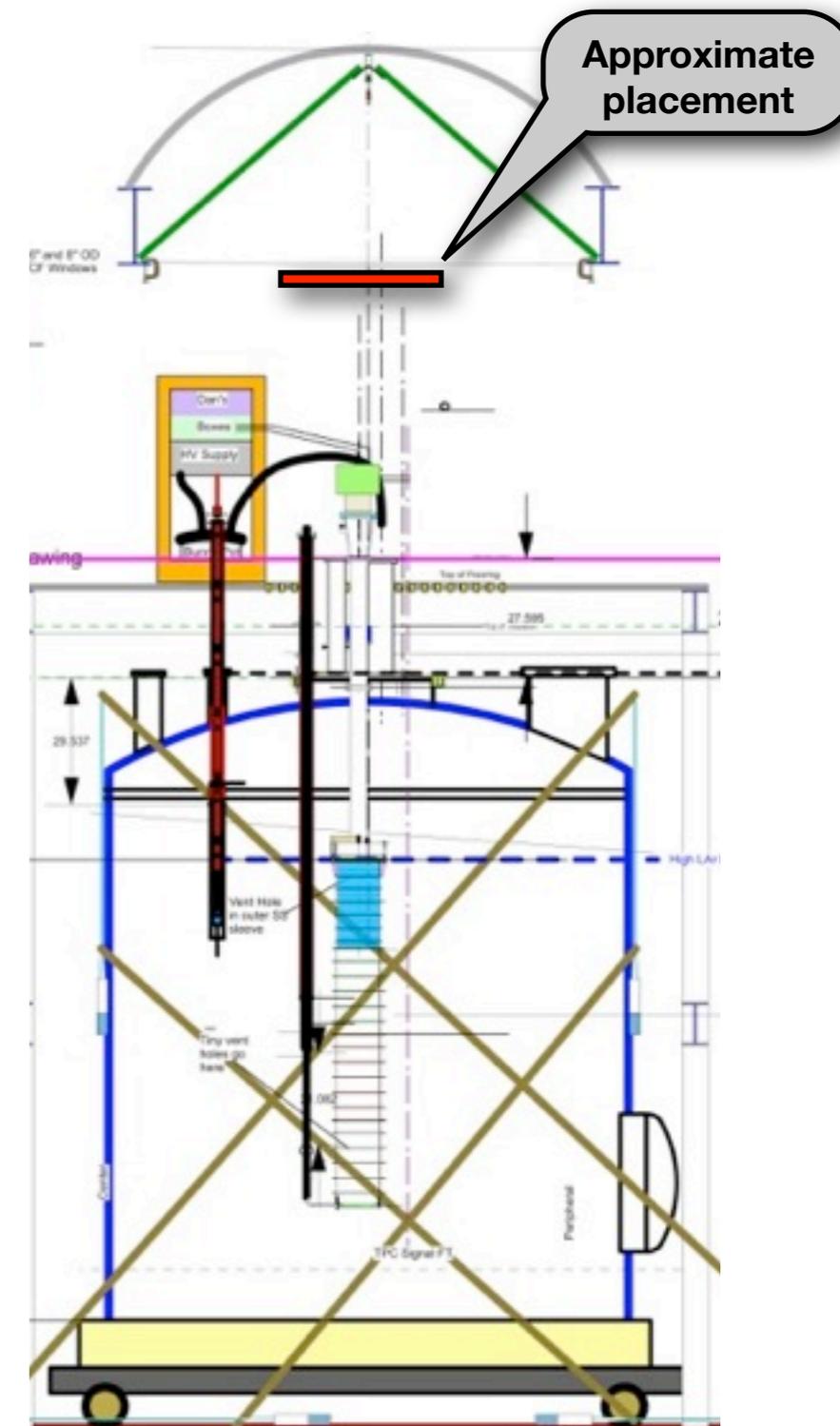
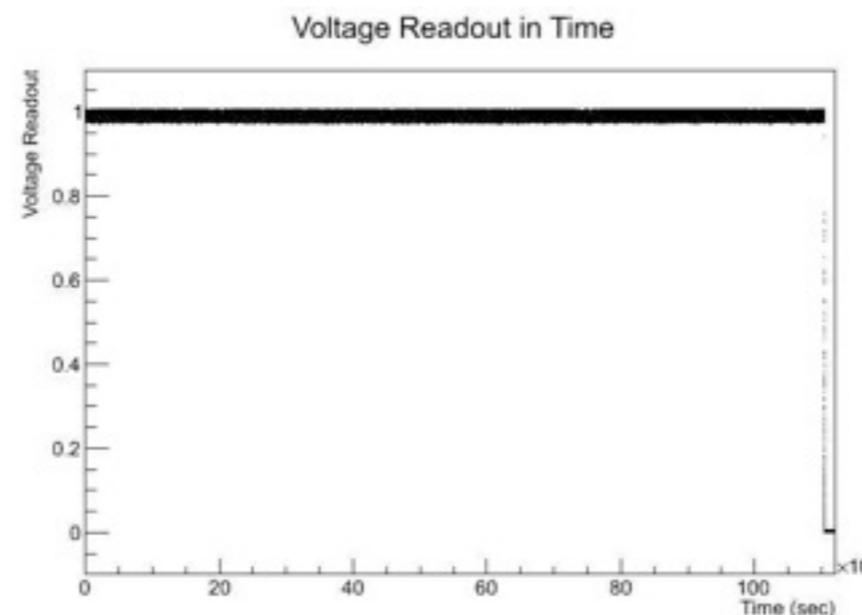


What Causes These Delayed Breakdowns?

- Seemed to be something charging up
 - Could be triggered by avalanches from:
 - A heavy particle from a cosmic ray interacting with a nucleus finding its way to a high field region.
 - A single cosmic muon passing through a high field region.
 - A discharge from surfaces being charged up by a constant flux of cosmic rays.
 - Large shower liberating many electrons in a high field region.
 - Or
 - We investigated this with Tom Badman & Michelle Morris (& lots of help from Alan Hahn)
- 

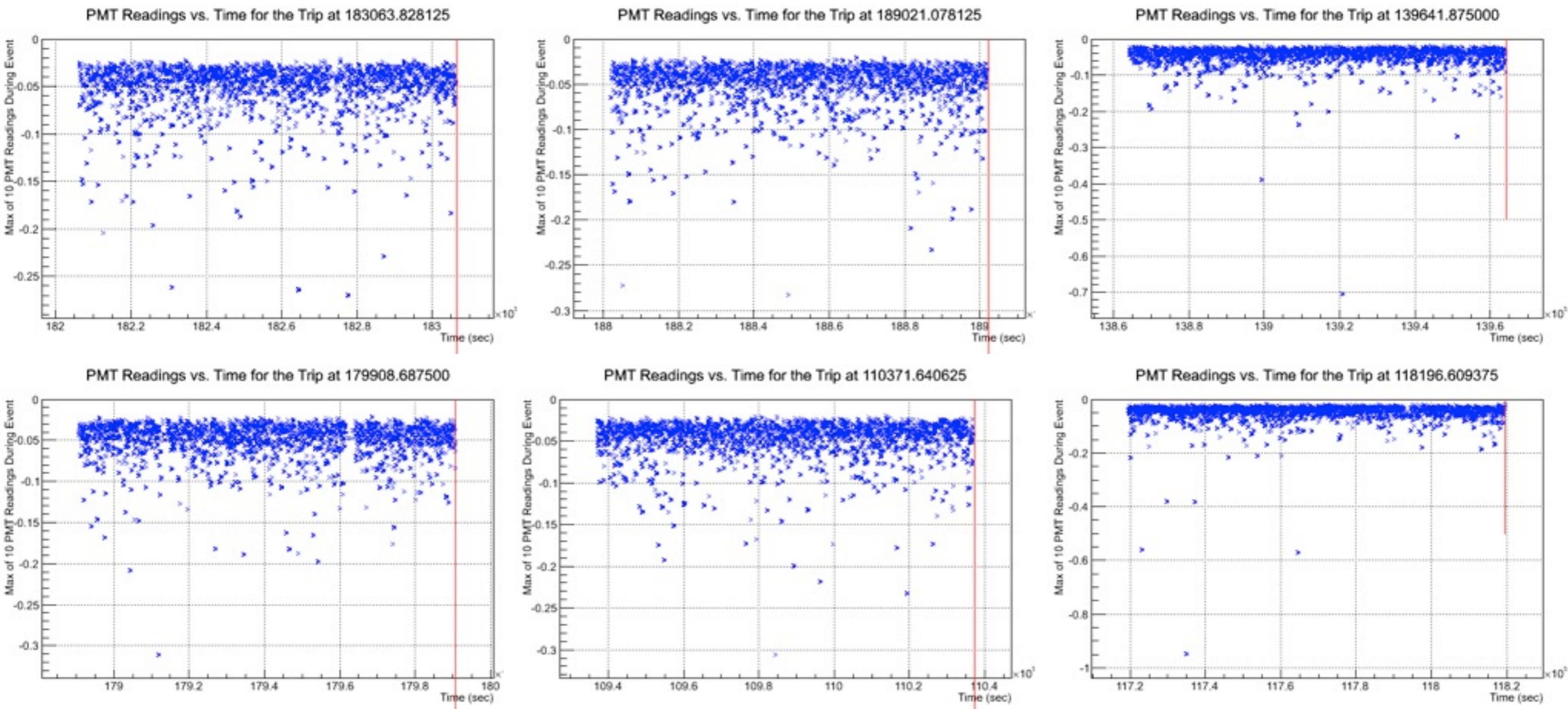
HV Breakdown Shower Test at LAPD

- We put a $\sim 34.5'' \times 34.5'' \times 2''$ counter above the TPC (about 8' above the platform).
- Two PMTs read out the counter. We used one as a trigger, and recorded the value from the other
- Used A. Hahn's NI 6035 card to record the signal in LabView (200 kHz sampling)
 - Recorded 10 PMT values per trigger, and 10 power supply voltage readings (100 kHz sampling each)
- Trips were relatively easy to spot:



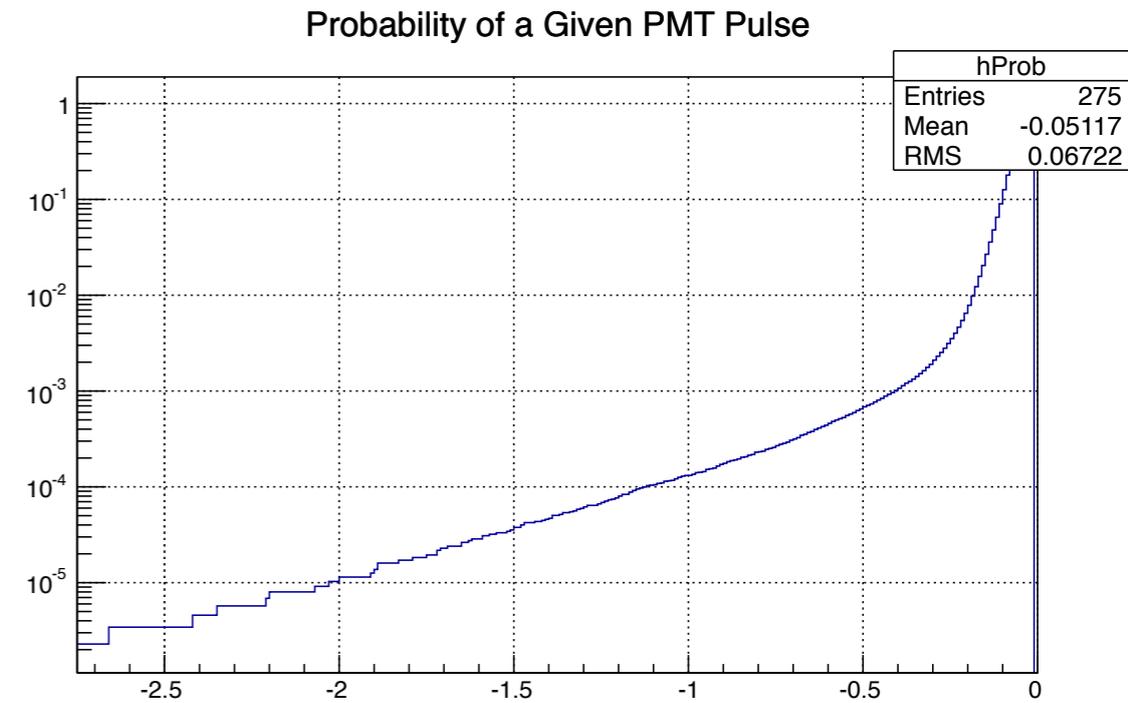
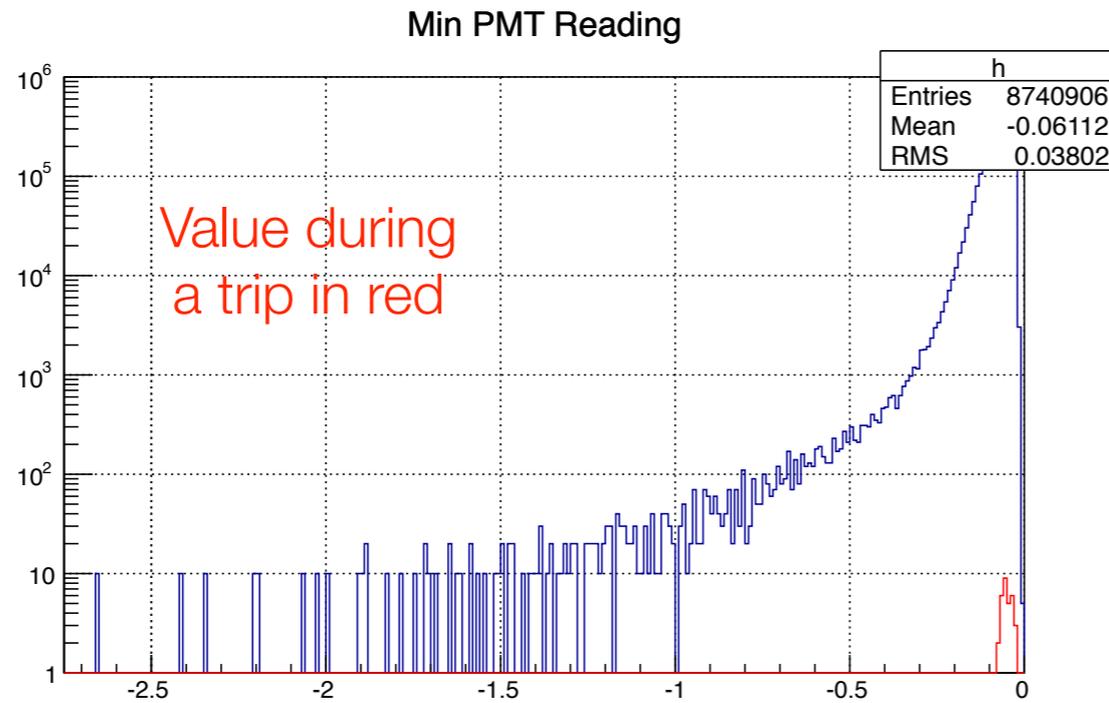
Shower Test: PMT Values Before Trips

- Random subset of trips from September 3rd. No obvious correlation.

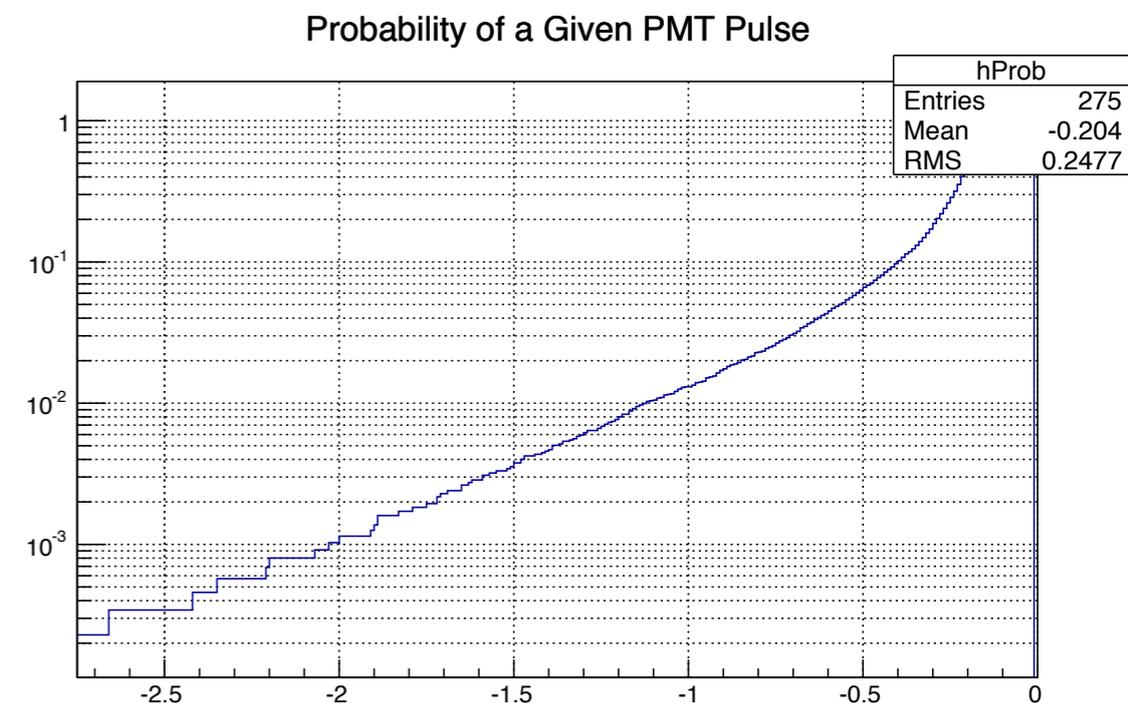
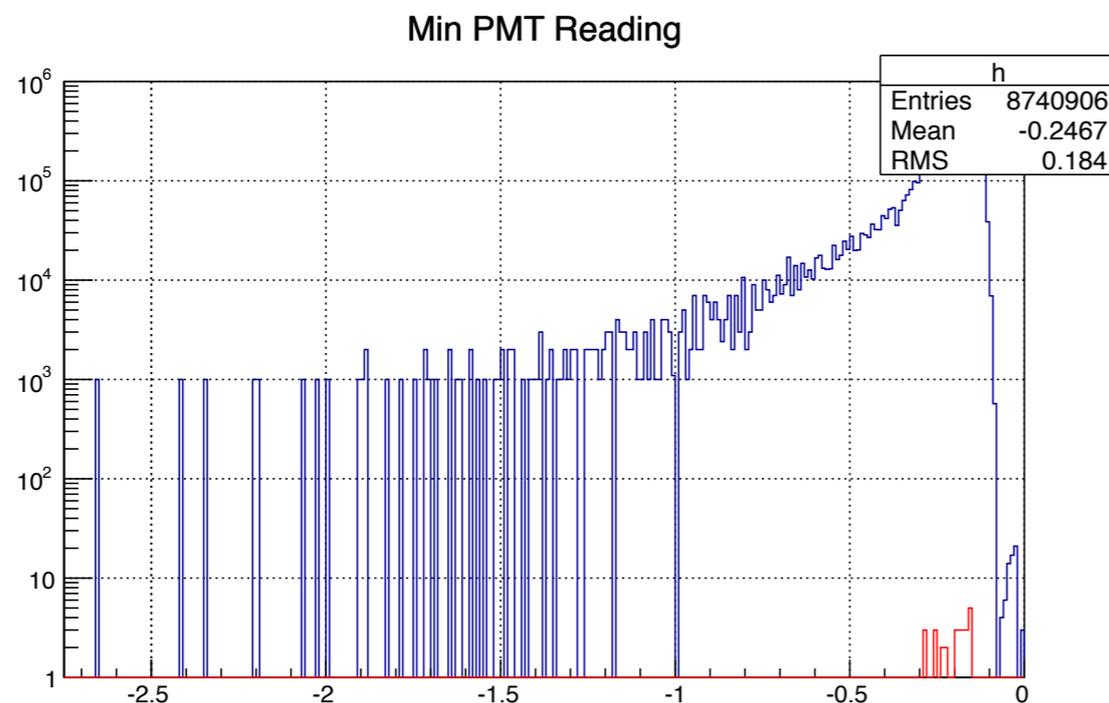


Shower Test: PMT Values & PDFs

- Minimum out of the 10 values recorded for a triggered event:



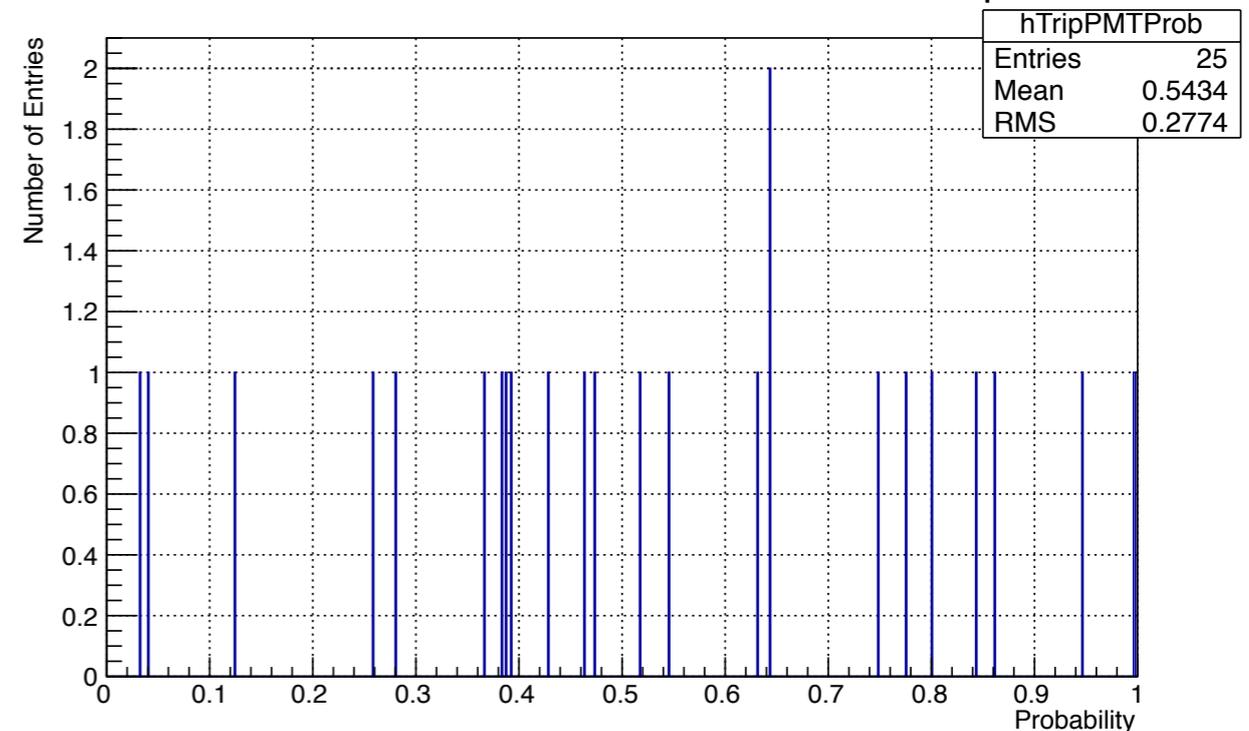
- Minimum of the last 100 triggered events (1000 values):



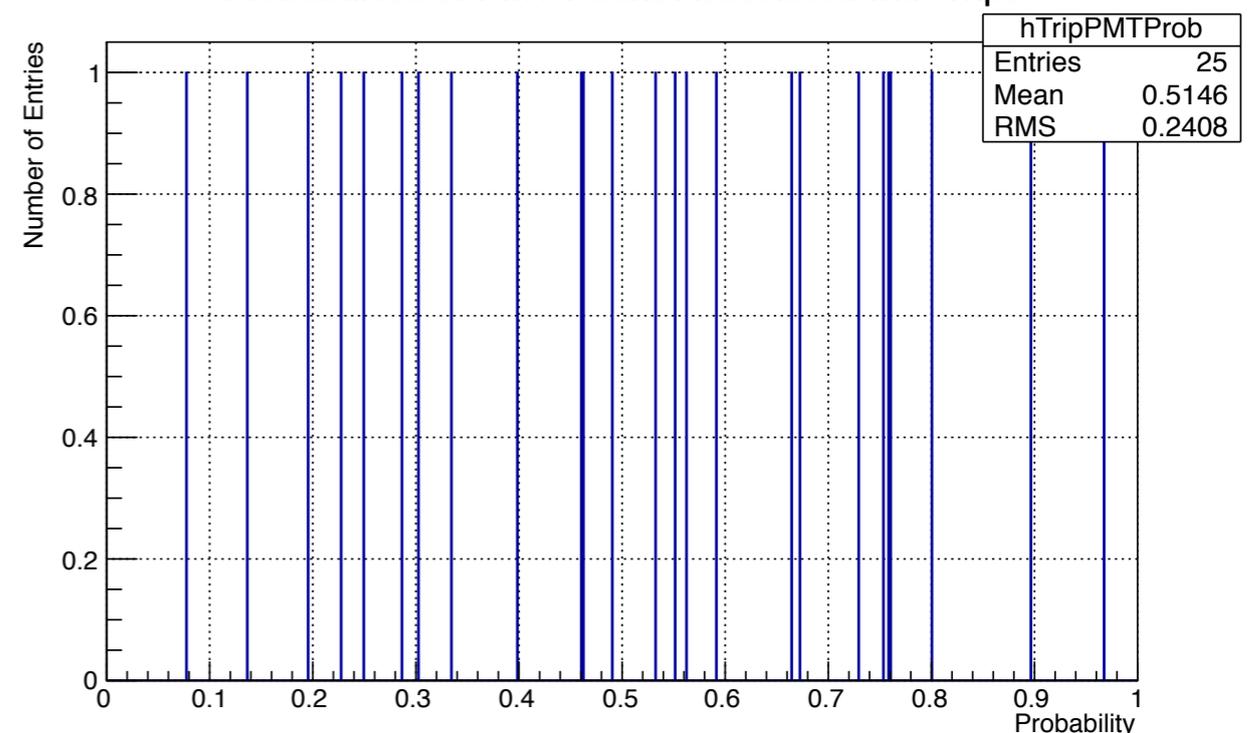
Shower Test: Probabilities

- Probabilities of getting a given PMT pulse near a trip:
 - **Top** is considering the minimum value of the 10 recorded per triggered event
 - **Bottom** is considering 100 triggered events (99 before the trip)
- They are flat; **the discharges are not correlated with triggered events in the counter above the TPC**

Probabilities of PMT Peaks Associated with Trips

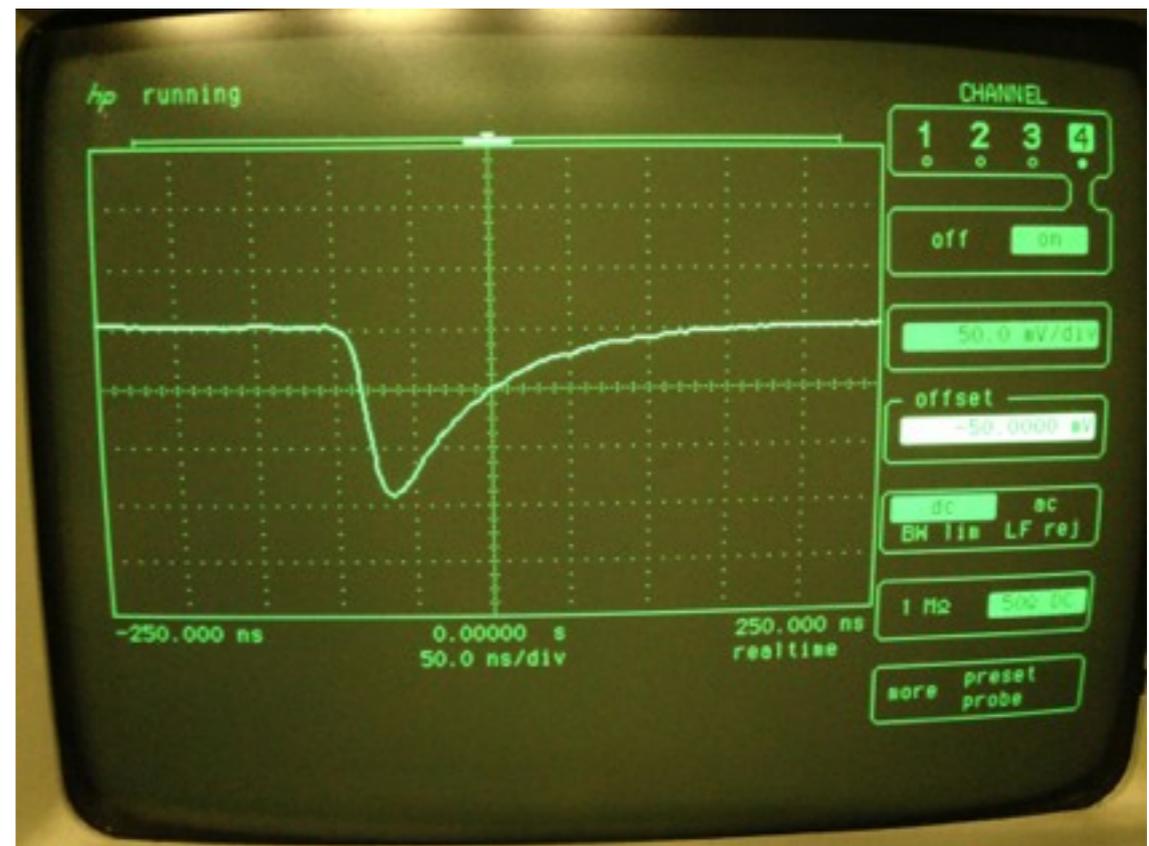


Probabilities of PMT Peaks Associated with Trips



A Relationship to Light: Evidence for Microsparks

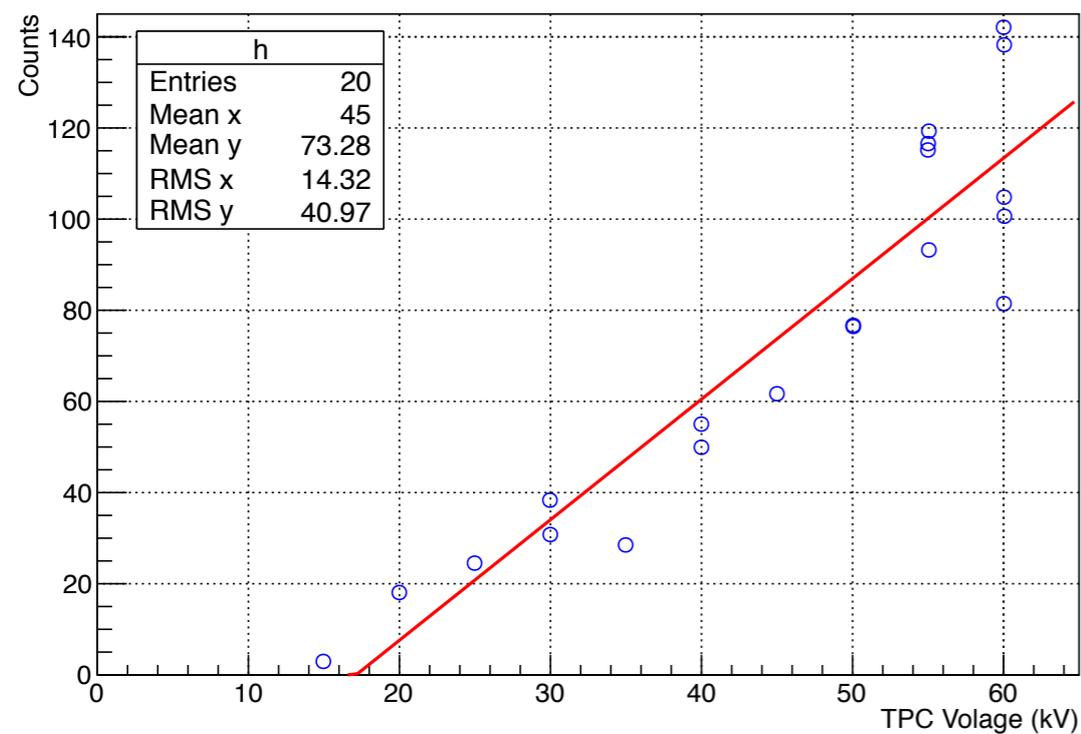
- H. Jostlein had an idea:
 - Very frequent breakdowns across resistors act like a current
 - If this is true, there should be little sparks
- He put a PMT on a flange window (blocked out the other)
- Yes! There were sparks:



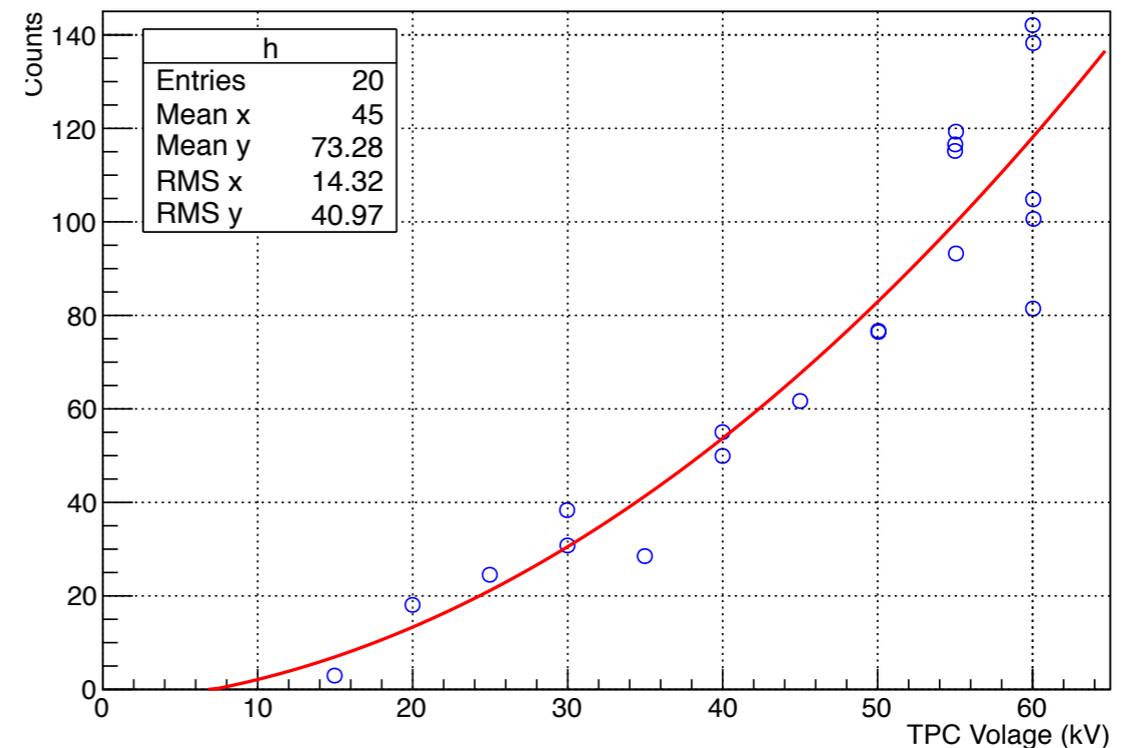
Micro-Sparks

- These are not unrelated light pulses
 - The frequency varies with TPC HV (these are counts per 60 sec):

PMT Counts vs. TPC Voltage



PMT Counts vs. TPC Voltage

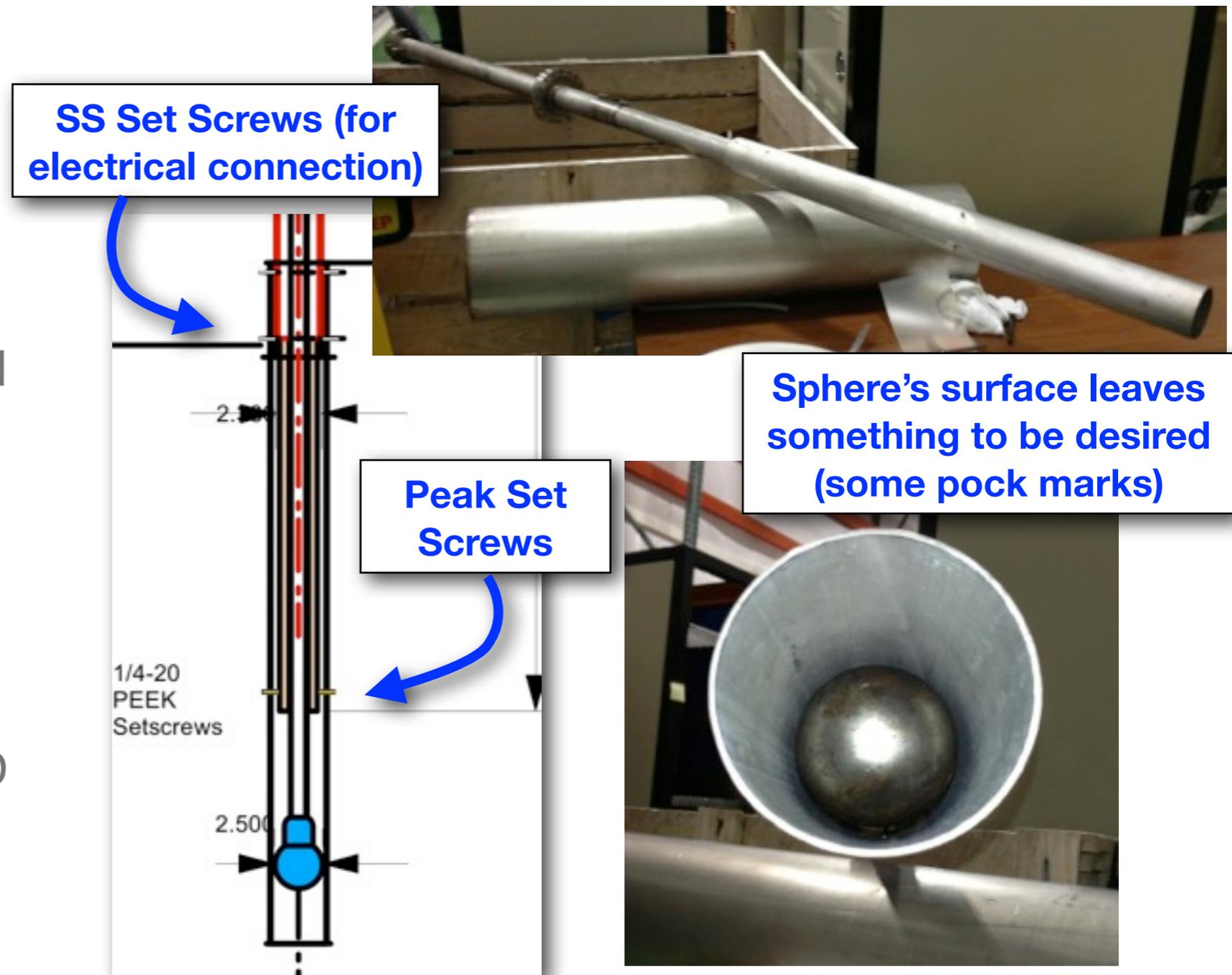


```
Chi2 = 4756.48
Ndf = 17
p0 = -45.3043 +/- 12.328
p1 = 2.64492 +/- 0.260971
```

```
Chi2 = 4230.07
Ndf = 16
p0 = -3.09886 +/- 32.2218
p1 = 0.221855 +/- 1.73583
p2 = 0.0299626 +/- 0.0212342
```

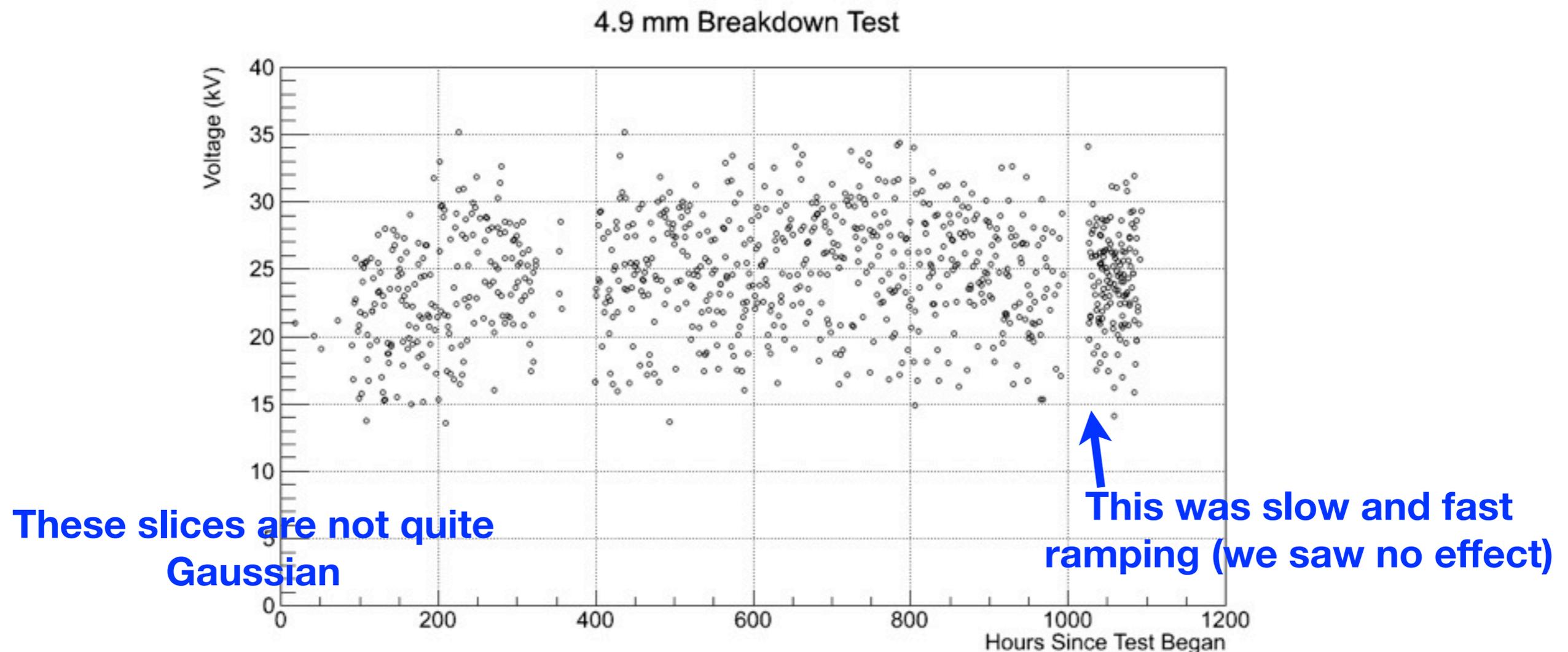
Fixed Distance Breakdown Test

- The idea was to use the MicroBooNE prototype feedthrough for a fixed distance test at LAPD
 - While we couldn't vary the distance, we would be able to see the effect of purity on immediate breakdown voltage
- We placed a grounded cylinder around the 2.5" D HV tip of the FT:



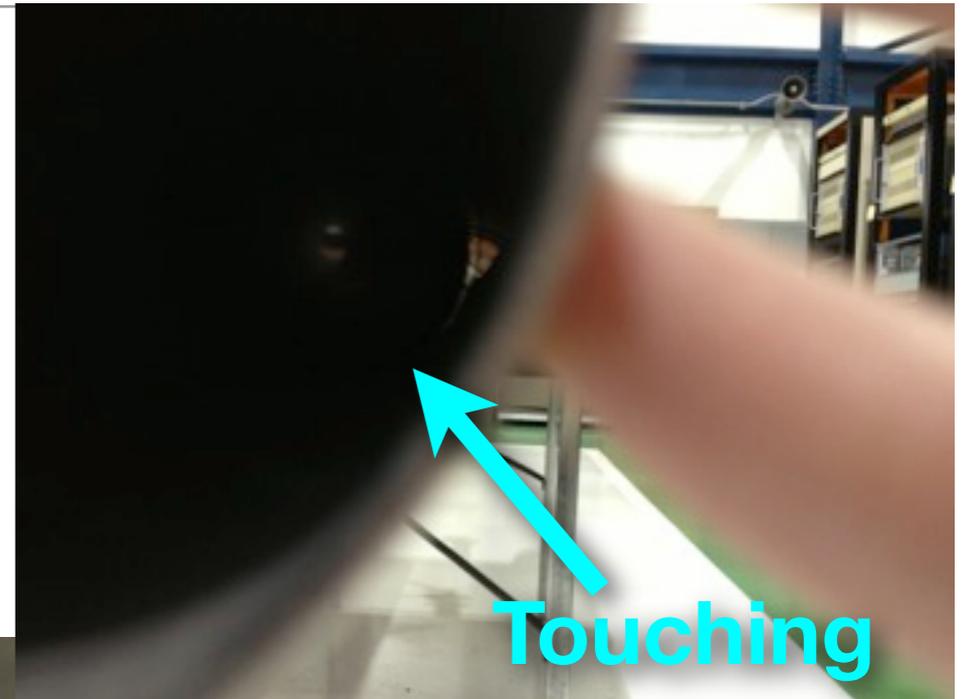
Fixed Distance Breakdown Test

- We mostly tested every hour ramping up slowly (0.1 kV/s) to discharge (this value was recorded)
- The data seemed a bit scattered and low (DAB BDT would project something like 50 kV, but that's in dirty Ar)

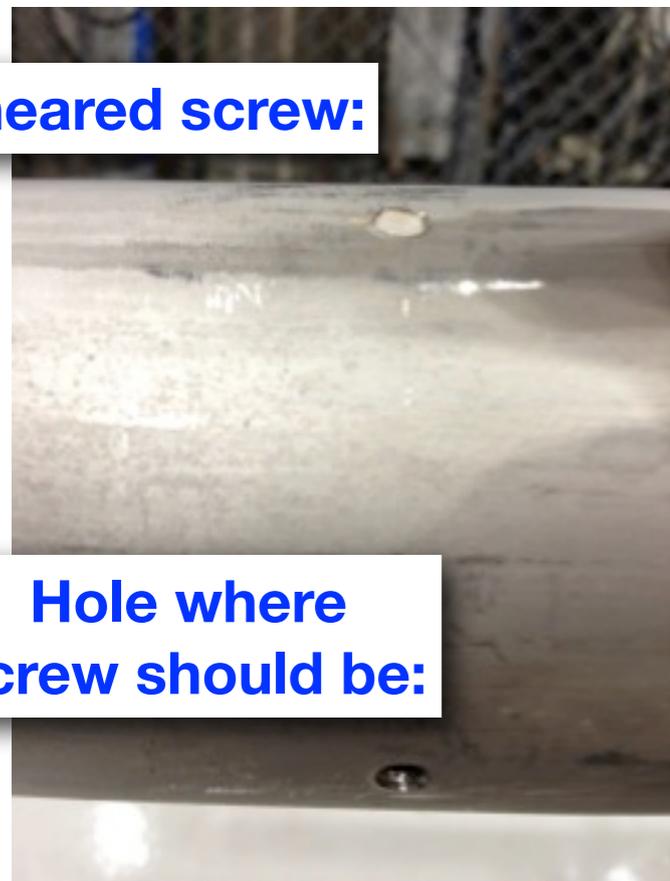


Fixed Breakdown Test

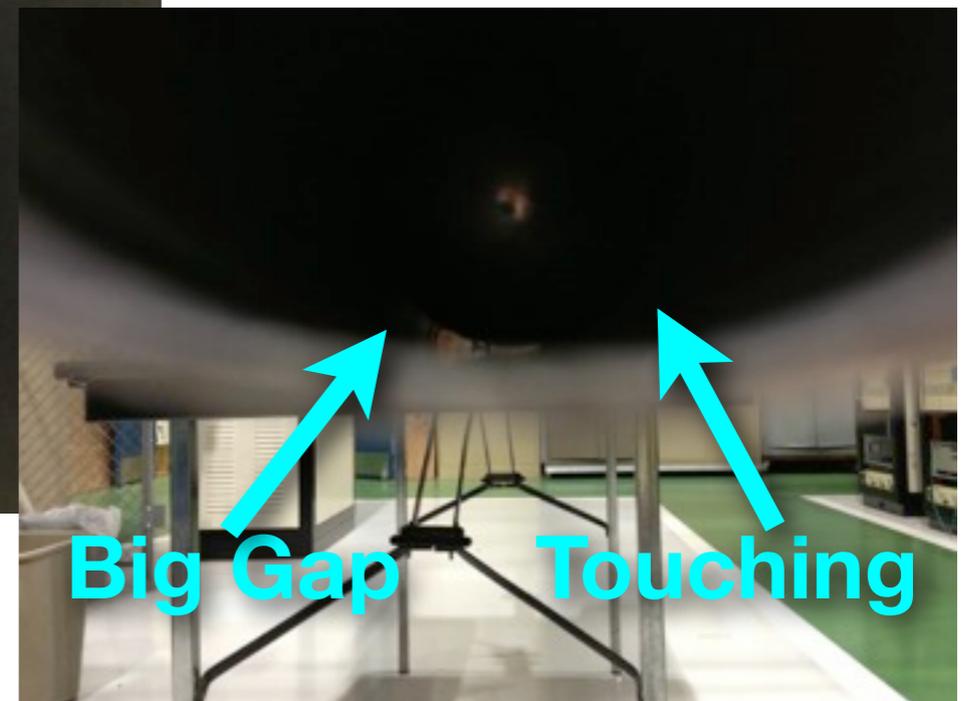
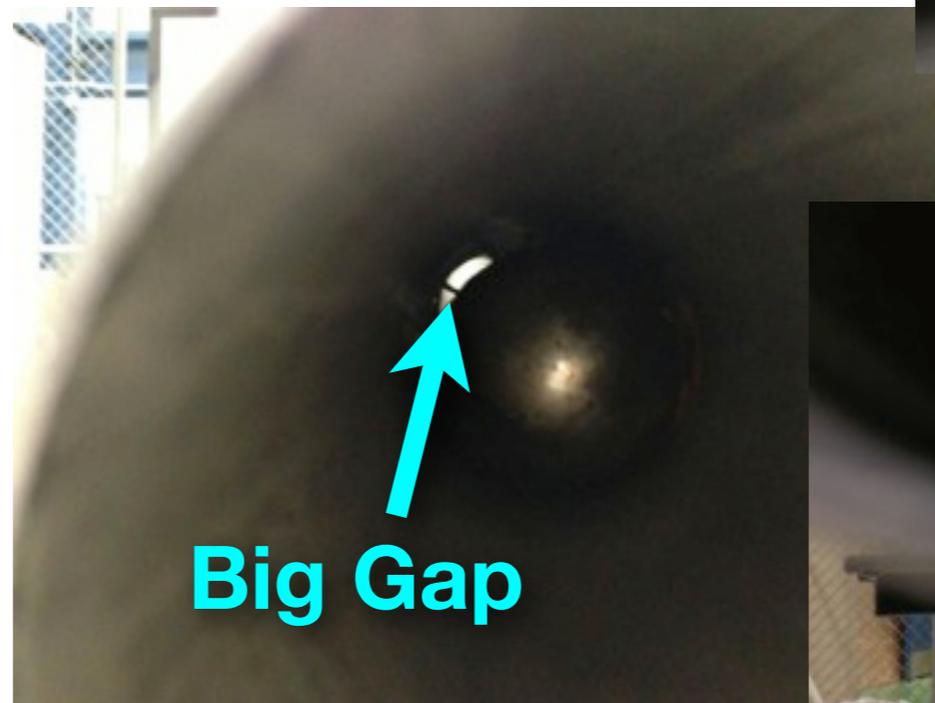
- Unfortunately, when we pulled the FT, the setup was damaged
 - The peak screws were sheared and the distance during testing cannot be known
 - Bummer



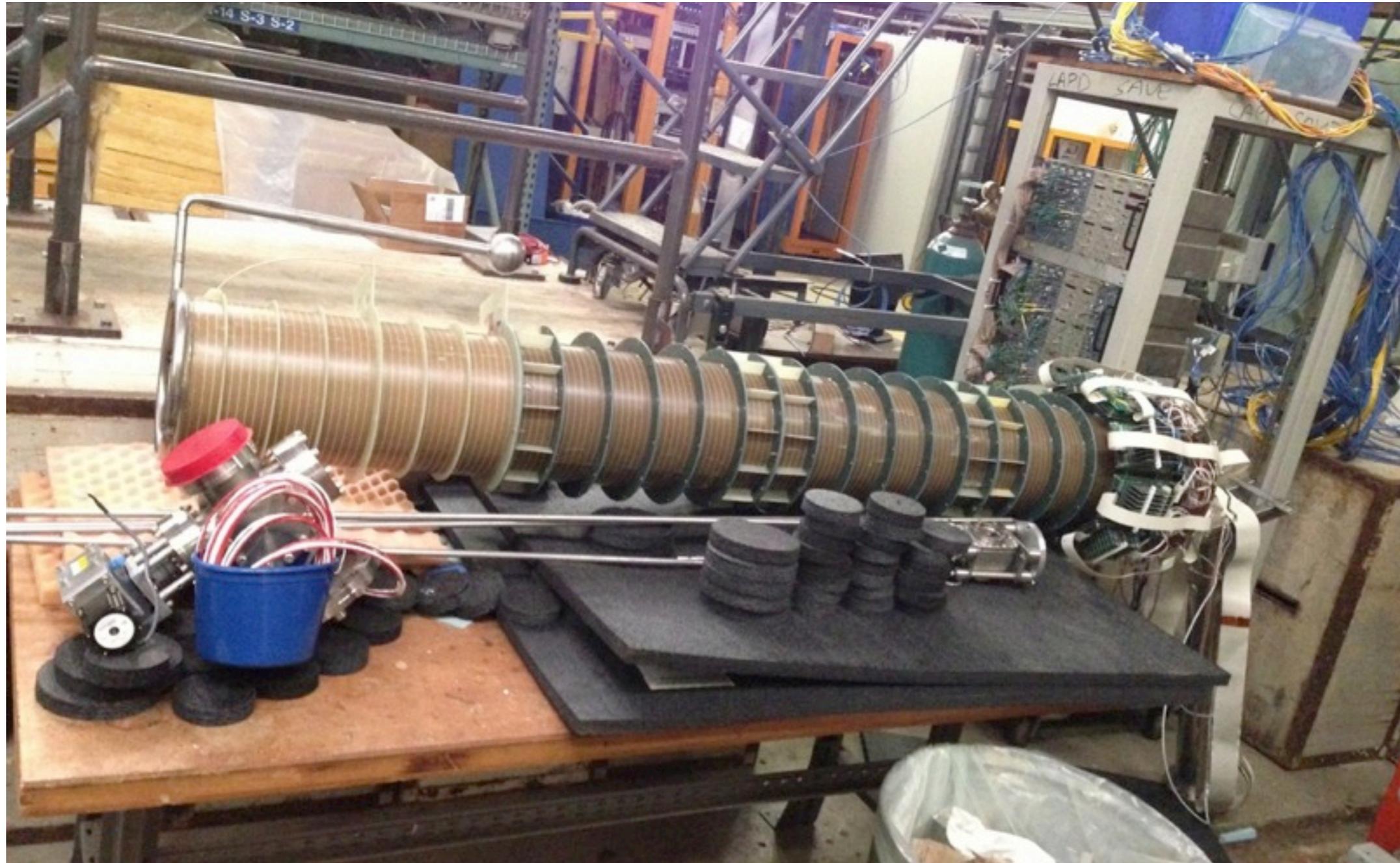
Sheared screw:



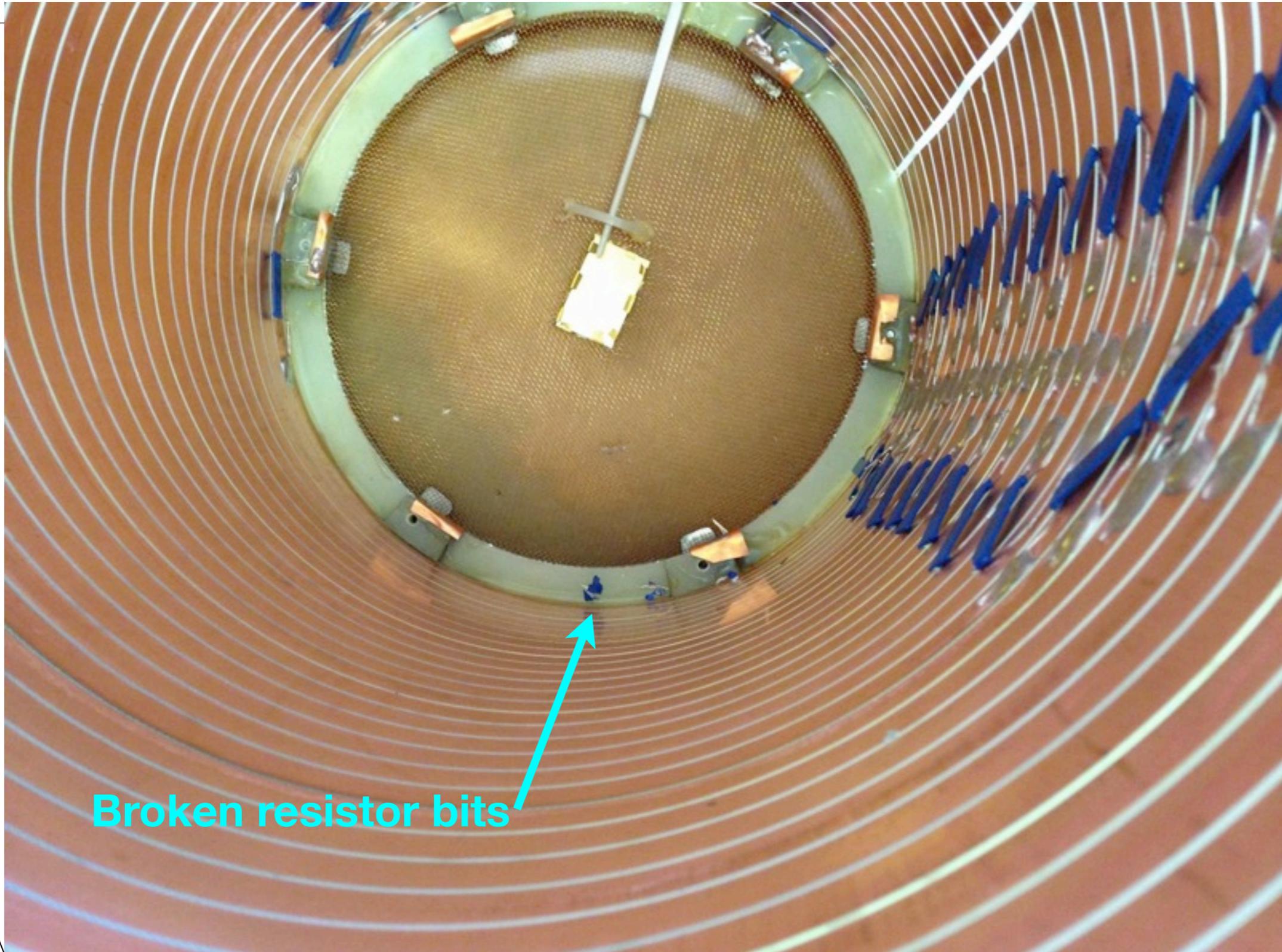
Hole where screw should be:



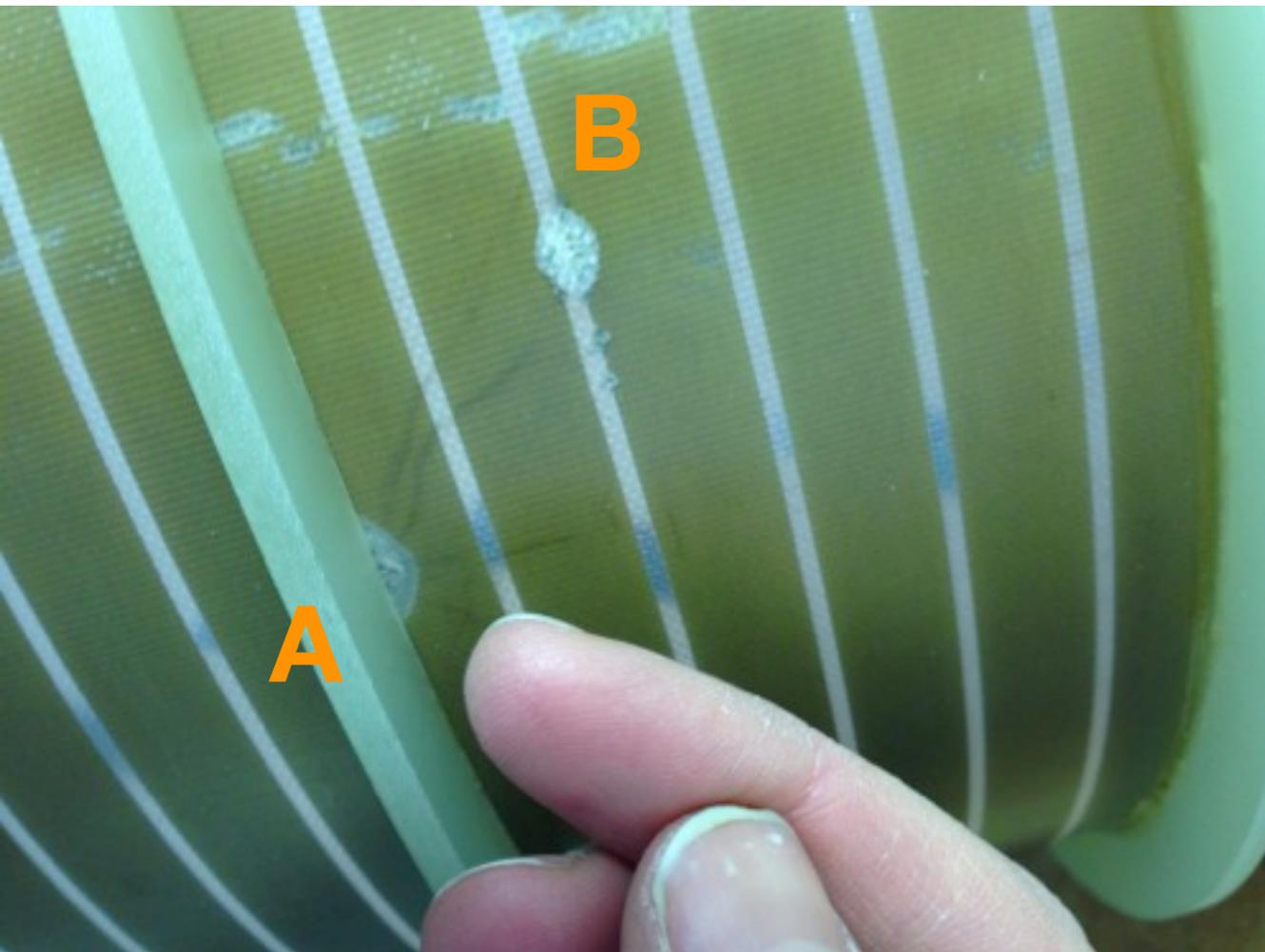
A Quick Long Bo Autopsy in Pictures



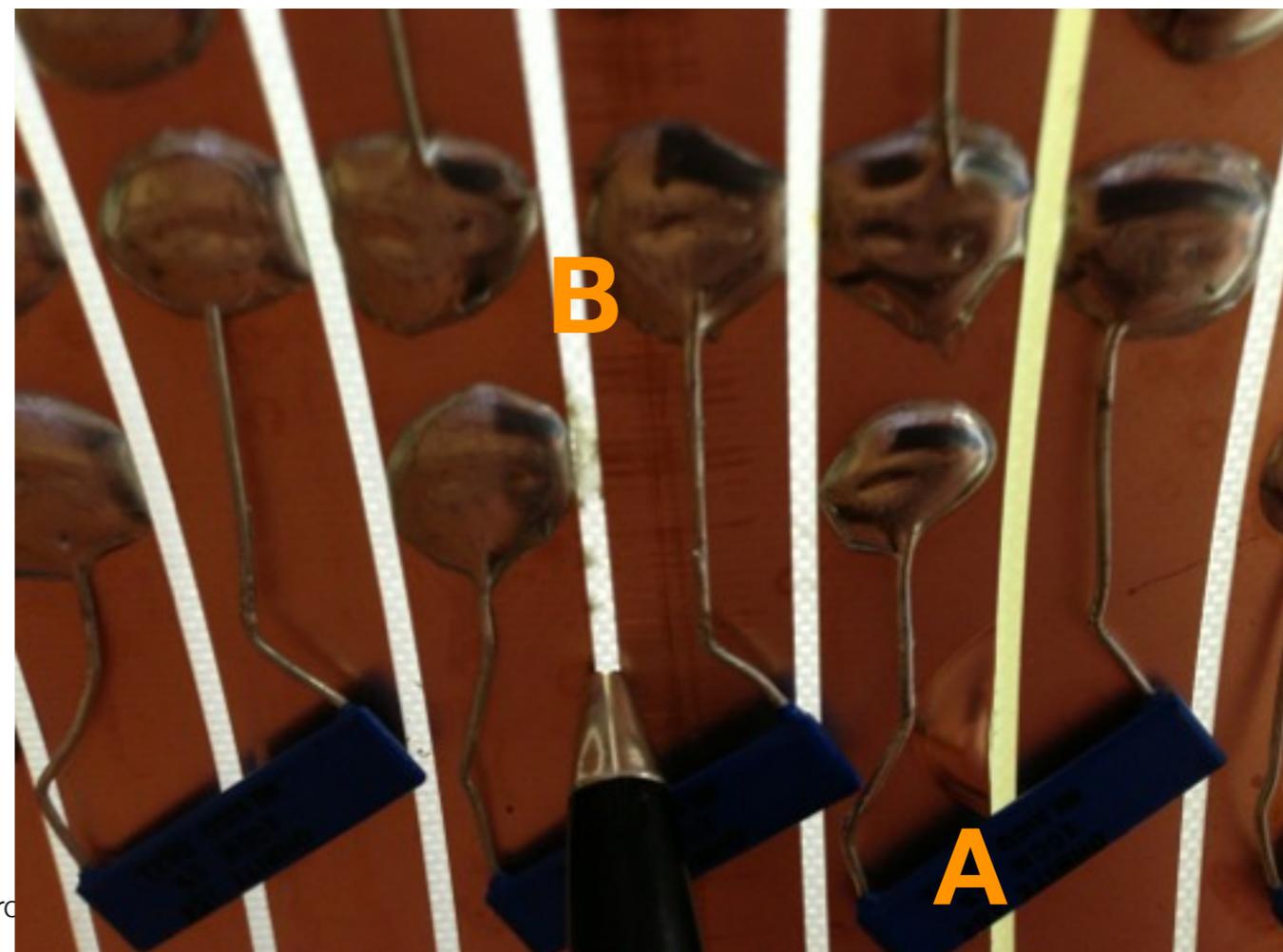
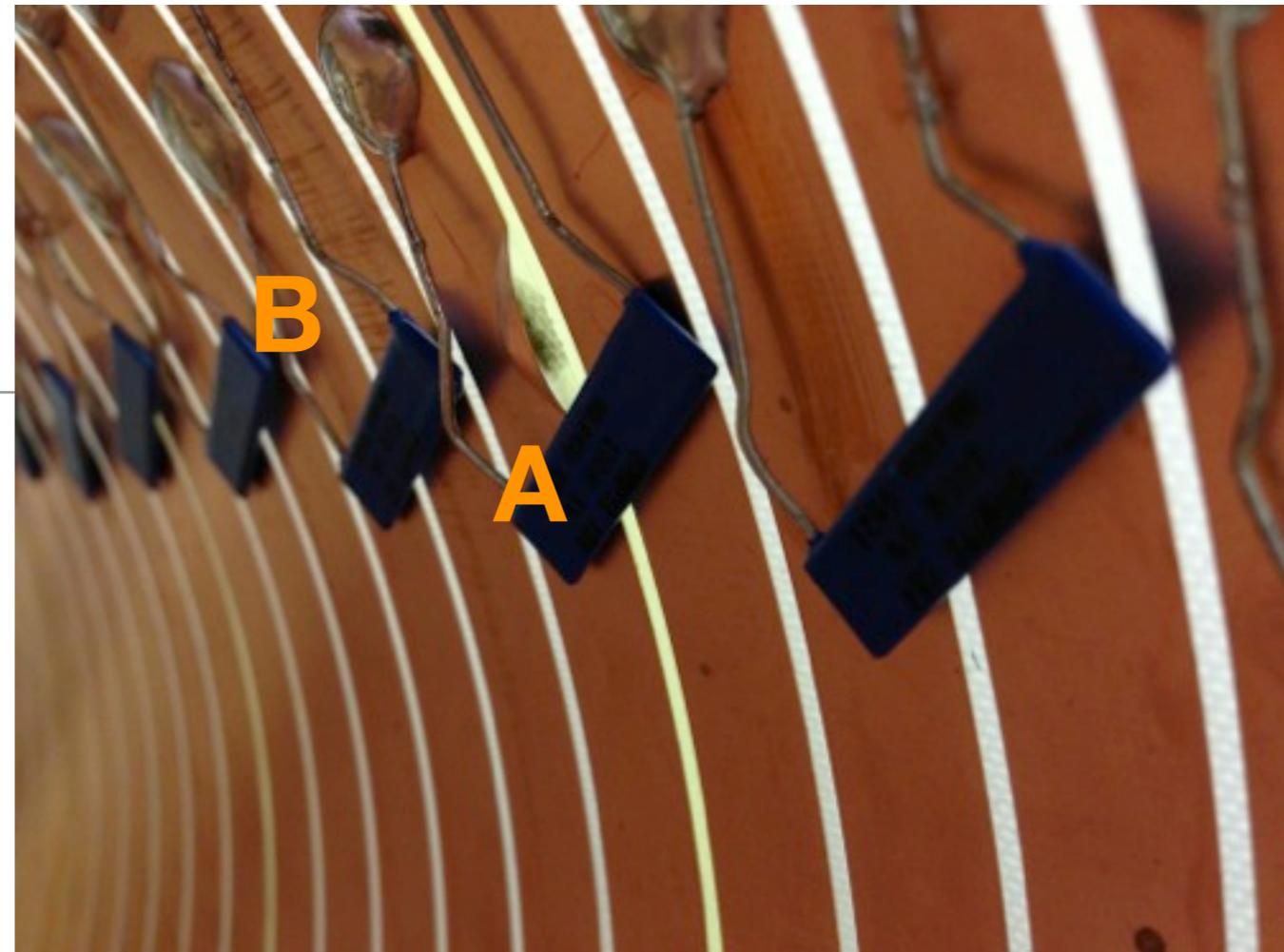
Looking Inside (Lowest section)



Damage



Note: Carbon traces

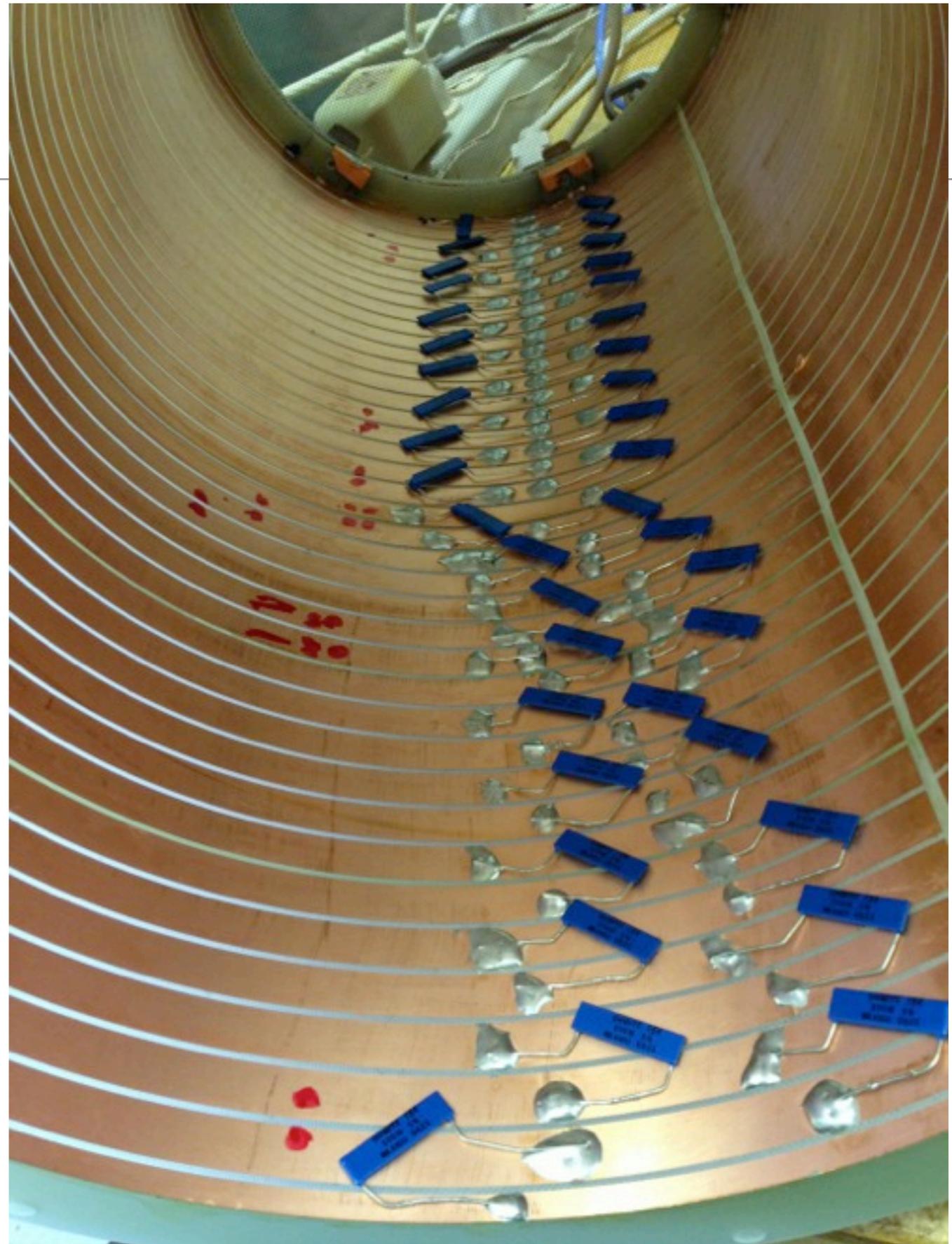


Measuring the Resistance



Measuring the Resistances

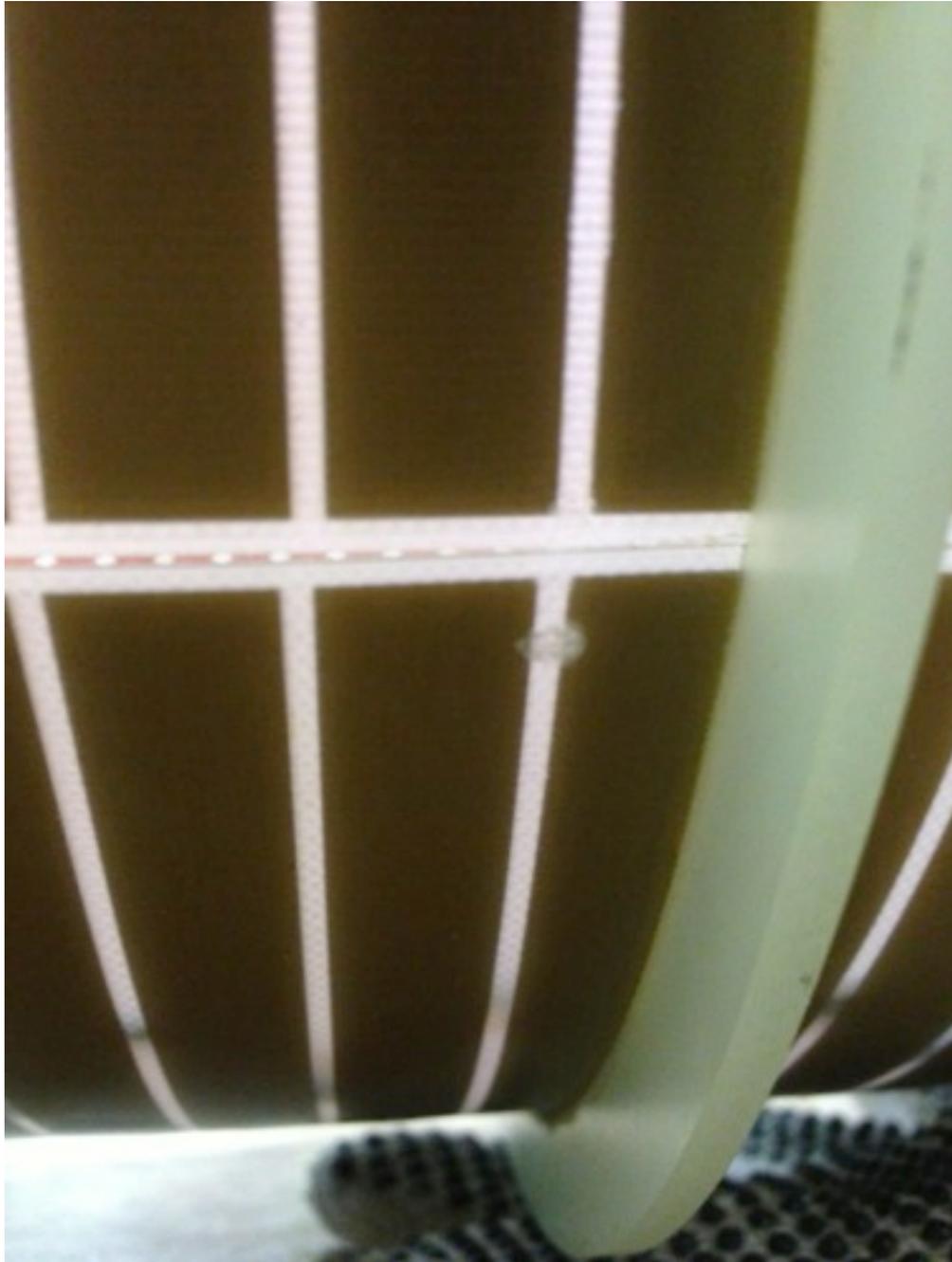
- This is the lowest section
- Red dots are failures
- **Six single resistor failures between rings** (4-5, 16-17, 19-20, 22-23, 23-24, 26-27, 38-39)
- **One double resistor failure** (open between rings 21-22)
- (Resistance between rings 27-28 was 80% of what it should be)



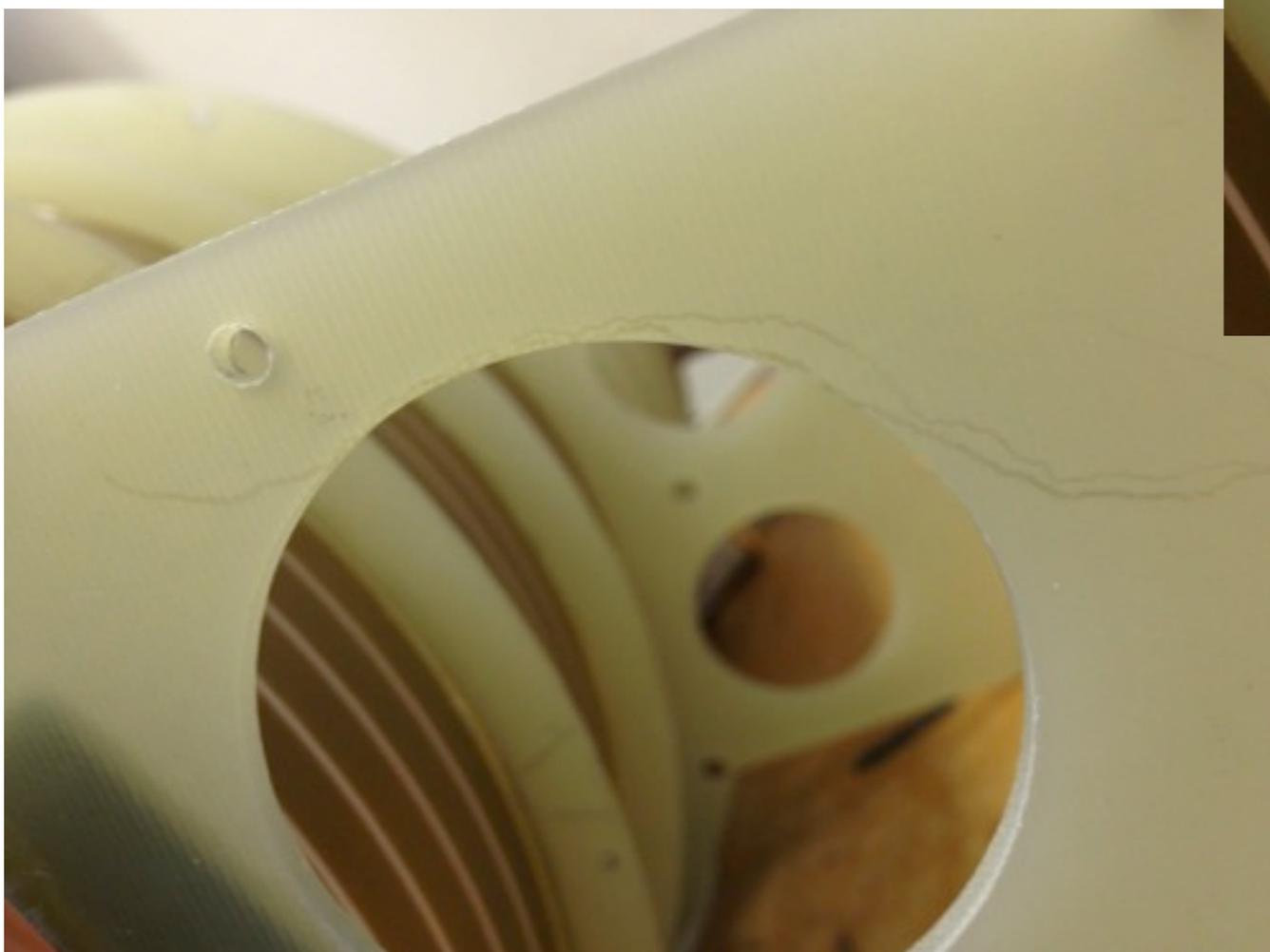
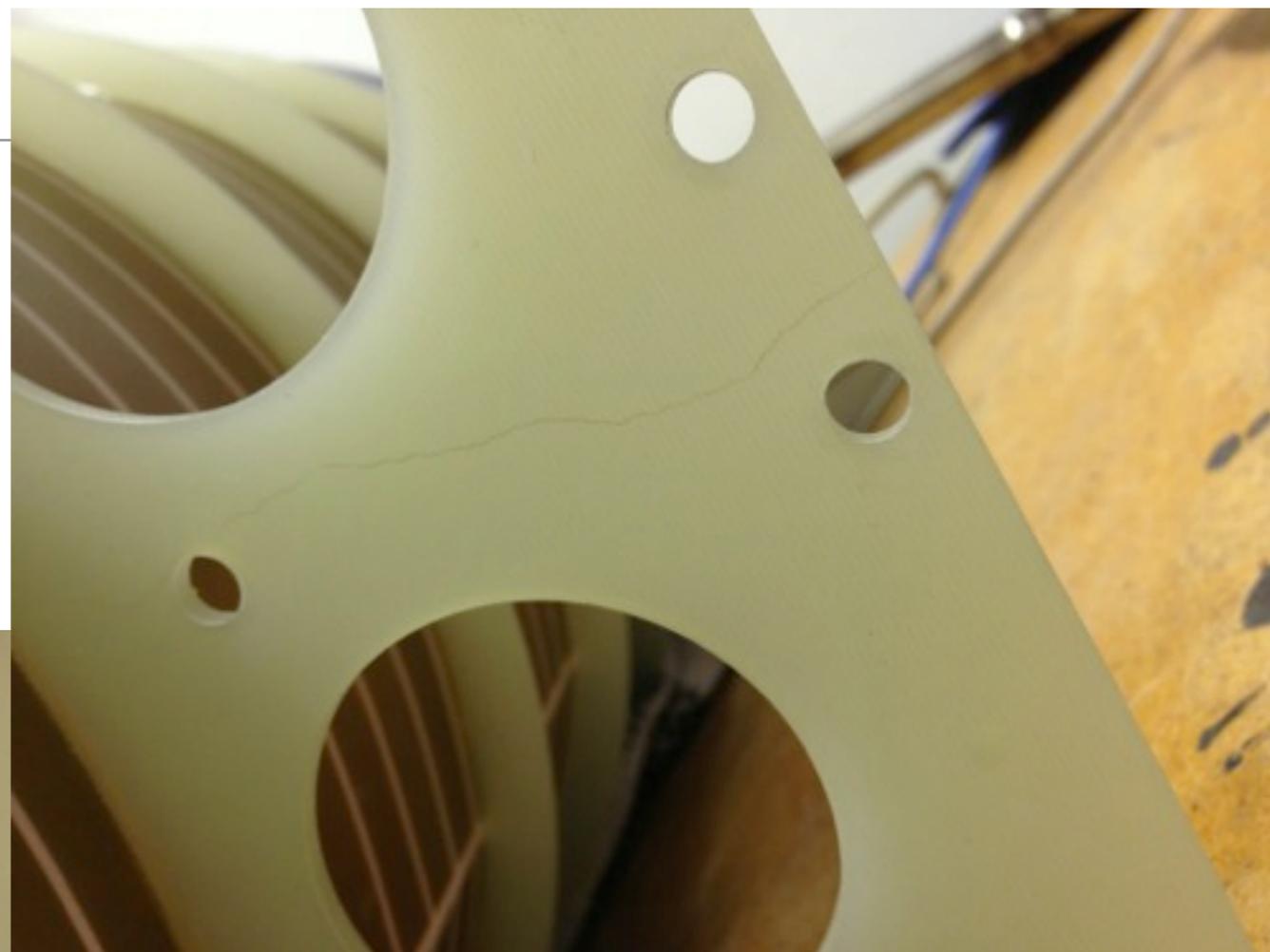
- Fail points from “Damage” slide are up here
- Those points did **not** have broken resistors on the rings



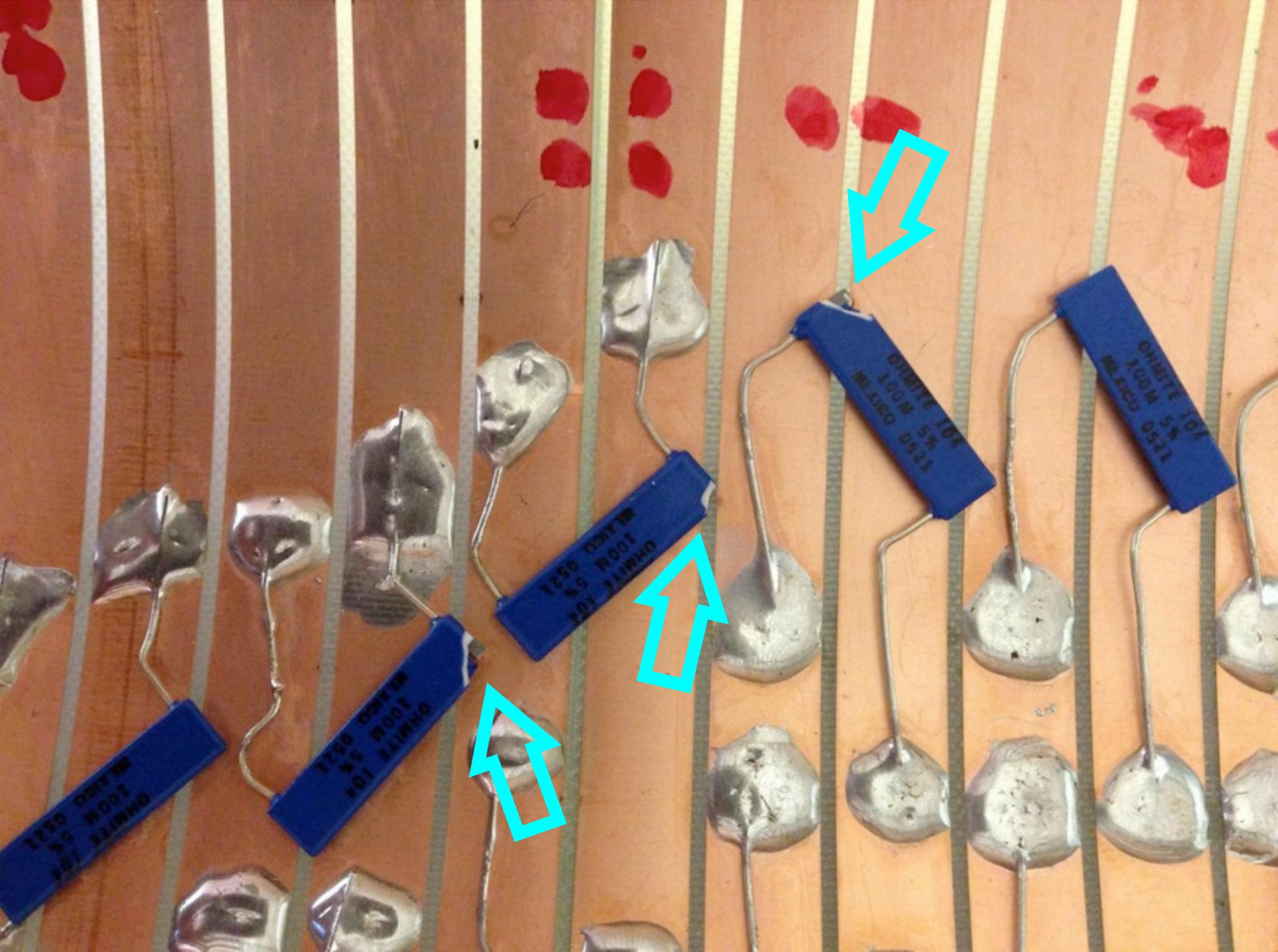
An Impact Point (outside and inside)



Traces on G10



Broken Resistors:



Zoom in of Middle Failure (from previous photo)

