



HEAVY PHOTON SEARCH

AT JEFFERSON LAB

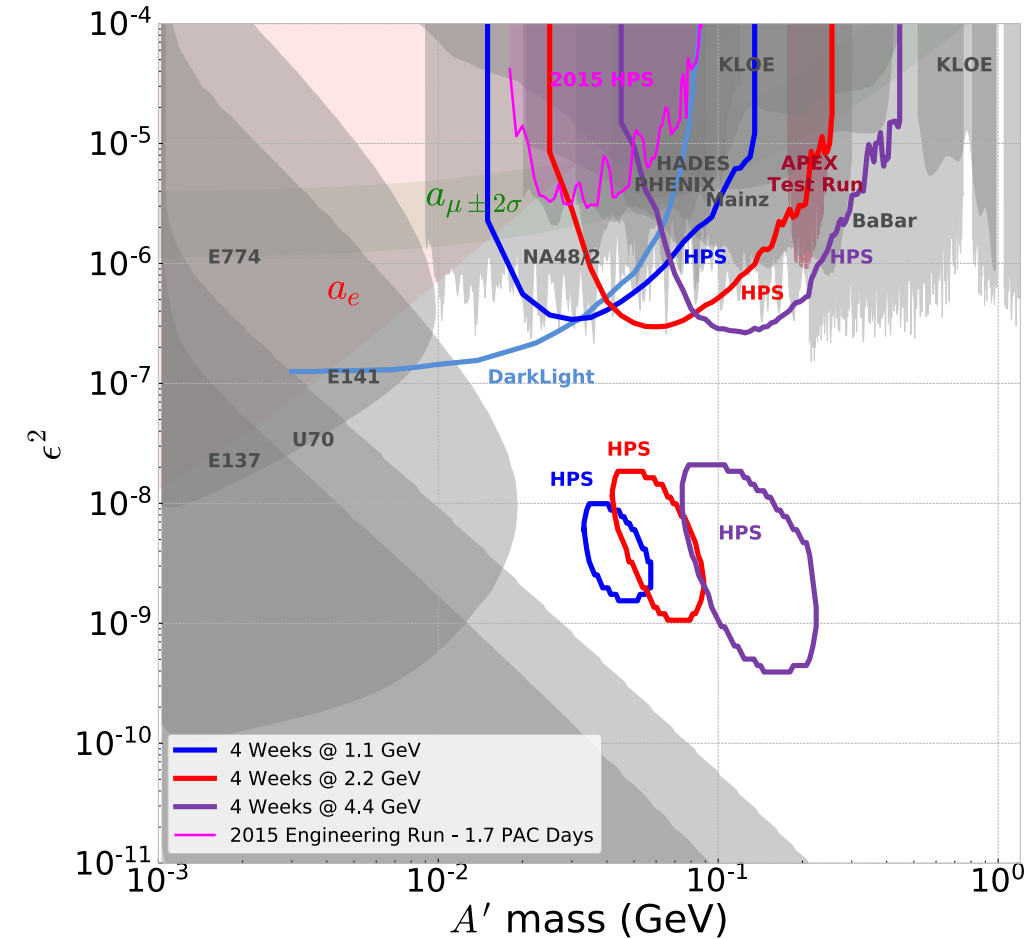
DM

Overview of the first physics run

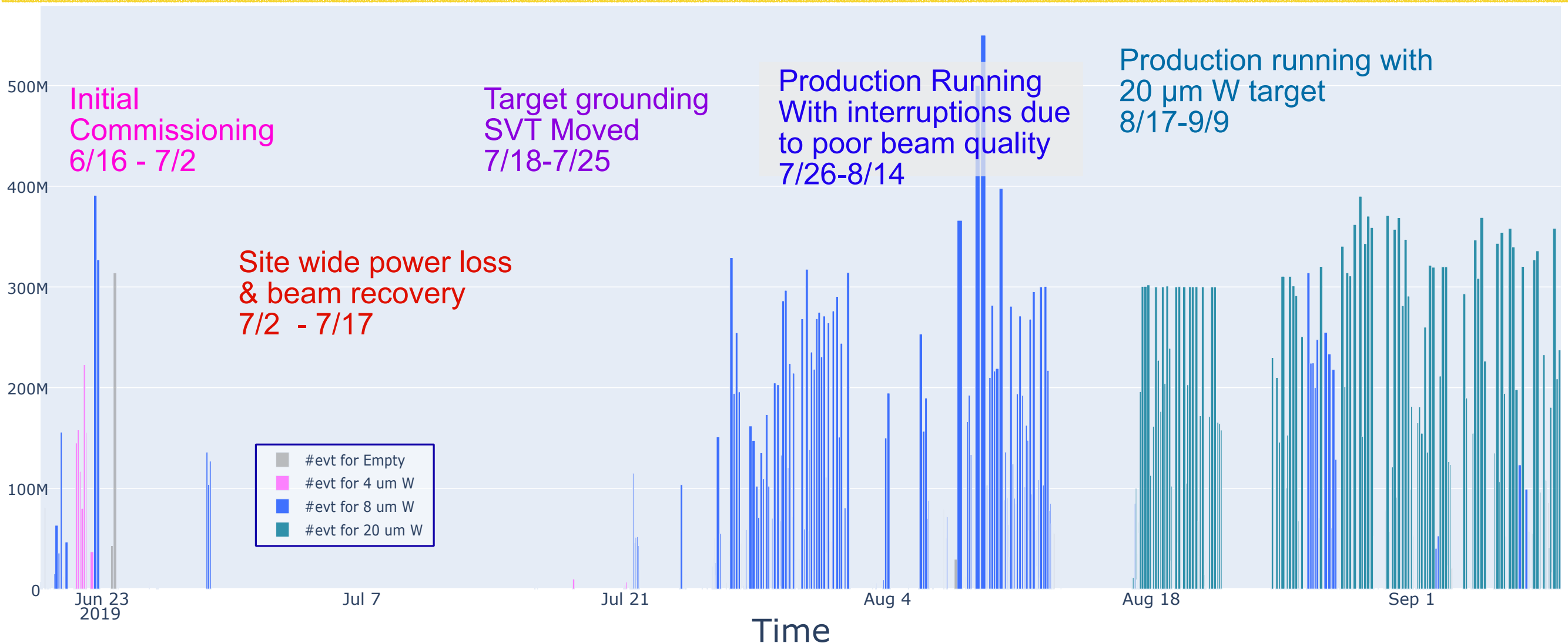
HPS Collaboration Meeting, JLab Nov 18, 2019

The 2019 Run

- Plan for 2019 run:
 - 4.5 PAC weeks =
9 weeks running, 63 days
8 weeks production, 56 days
 - Wanted: 4 weeks production with
4.4 GeV beam at 300 nA on 8 μm W
 - Total expected charge = 725 mC (4.5×10^{18} e^- on target)
 - Upgraded detector: Extra SVT layer (L0) + Hodoscope



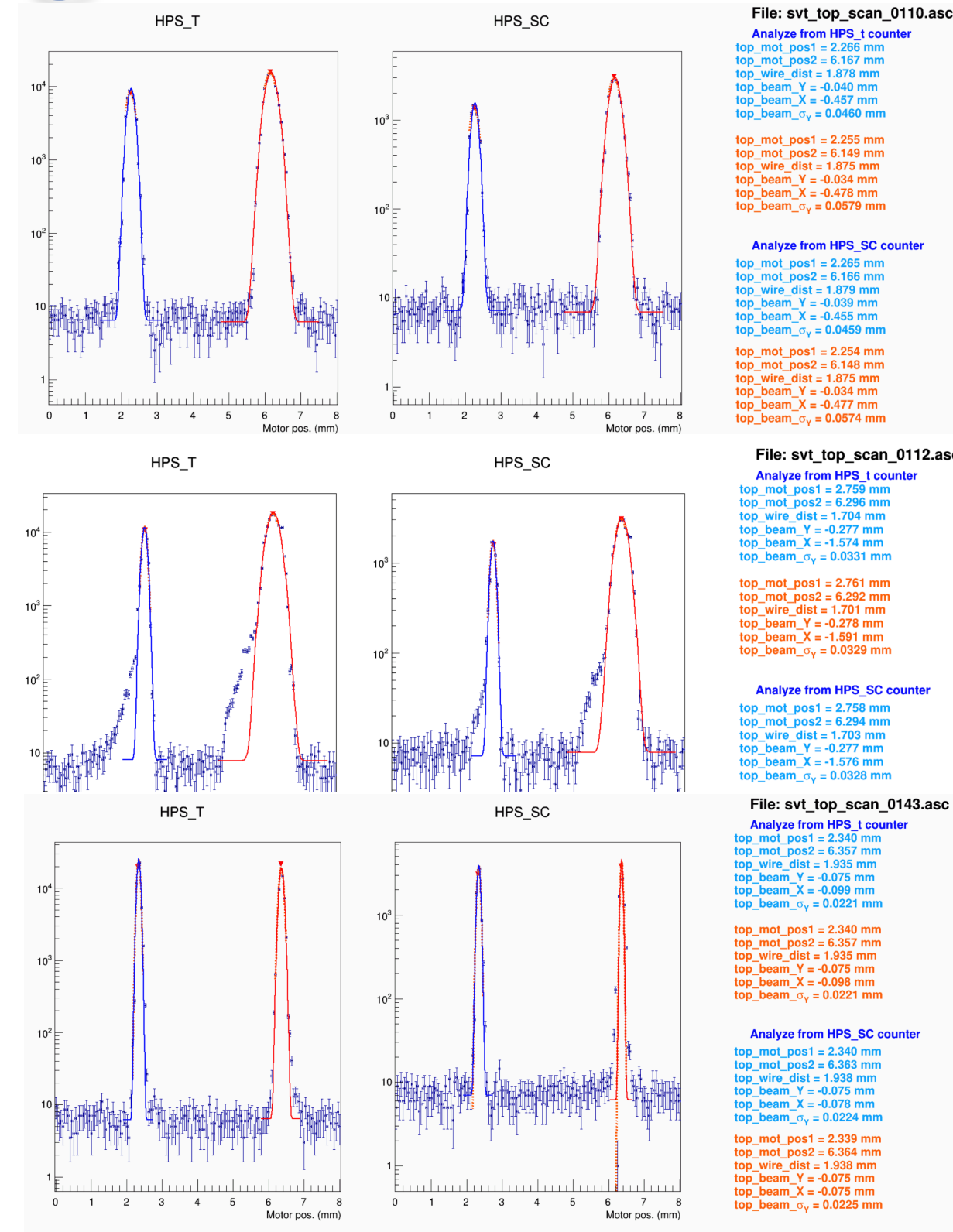
Overview of run



- Run started 6/17
- Production running started 7/26
- Thicker target install 8/17
- Total number of ABUs collected was 727.7 (30.3 days)
- Total charge ~ 400 mC, just over 50% of expected charge.

Commissioning 6/16-7/2

- RC: Matt Graham, Tim Nelson
- Establish good beam
- SVT and Trigger timing
- SVT and DAQ debugging.
- DAQ stress testing revealed some issues (max 15 kHz)
- SVT brought in to 0.5 mm towards end of this period.
- Study of occupancies.
- From RC report:
“The beam developed a tail in the middle of the week that held up data taking. After extensive retuning, a very good beam was provided that only lasted for a few hours until the beam was taken away for a Hall C pass change. After that point the beam tune in the upstream beamline is not good enough to allow sending it to the Faraday cup.”



Power event: No Beam 7/2 - 7/17

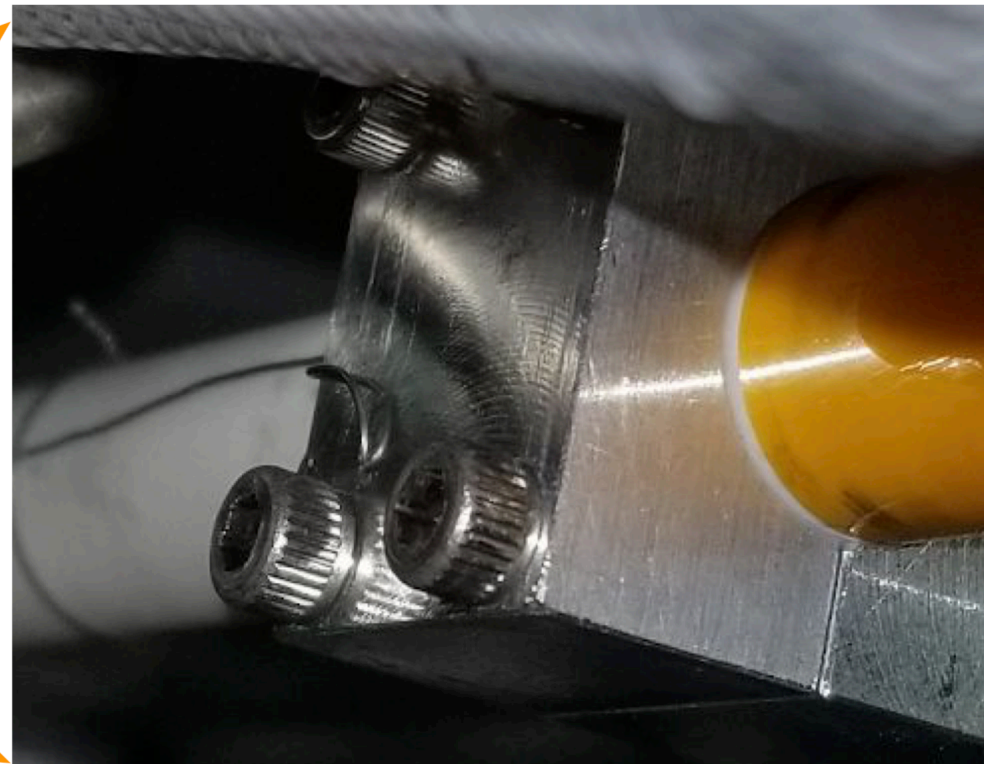
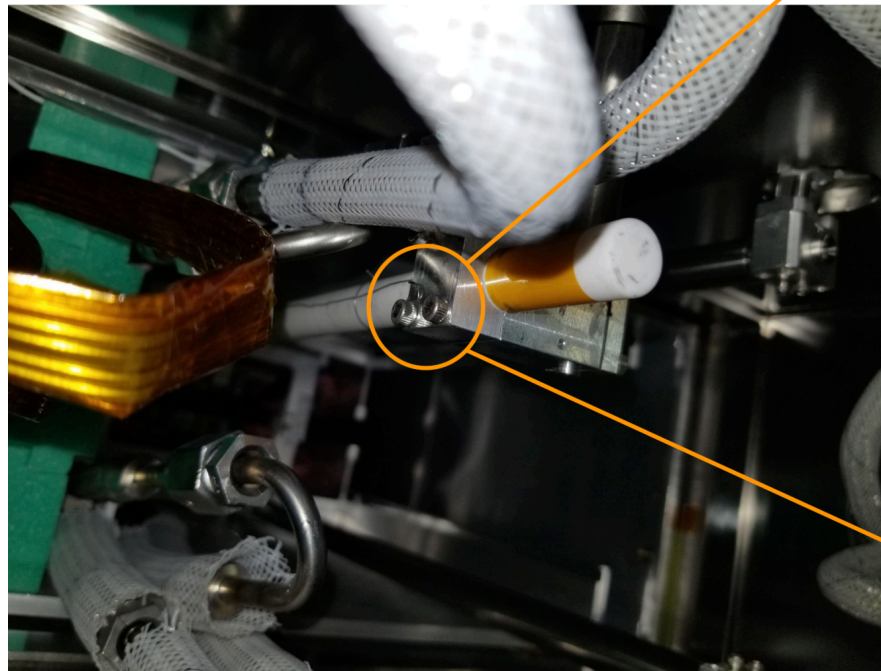
- RC: Takashi & Stepan
- 7/2 @ 18:40 - Site wide power lost to lab.
- Accelerator takes about 1 week to restore.
- Beam delivery to Hall-B is difficult
 - It was found the magnets had faulty trim cards that do not restore the magnets to exactly where they were before.
- DAQ optimizations studies during the down time.
- 7/17 - First good beam with small profile.

More Trouble: 7/18 - 7/22

- RC: Rafo
- Good beam to the hall.
- DAQ became very unstable and would crash at random times, but frequency would scale with luminosity.
- It was found the grounding wire to the target was broken.

It was noticed immediately upon opening the upstream flange of the vacuum box, that the grounding wire of the target was broken!

Fix was relatively easy, even target was not removed

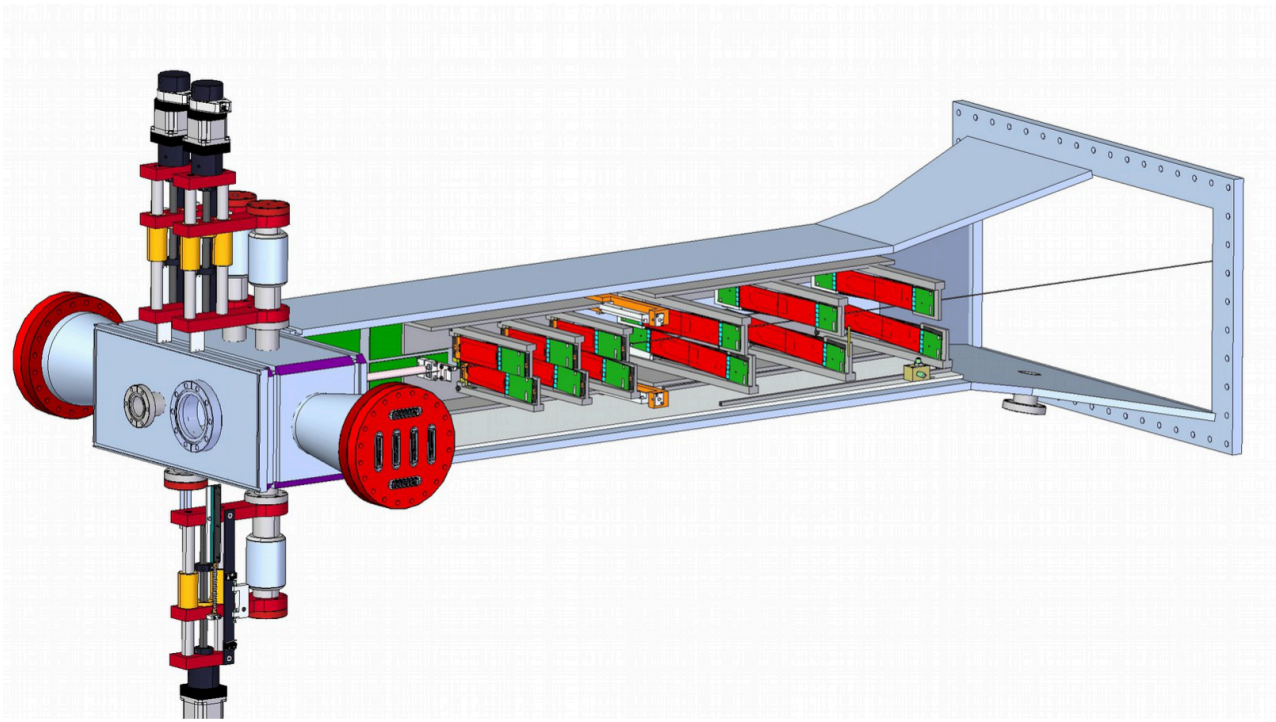


In about 14 hours since the controlled access, we were ready to take a beam!

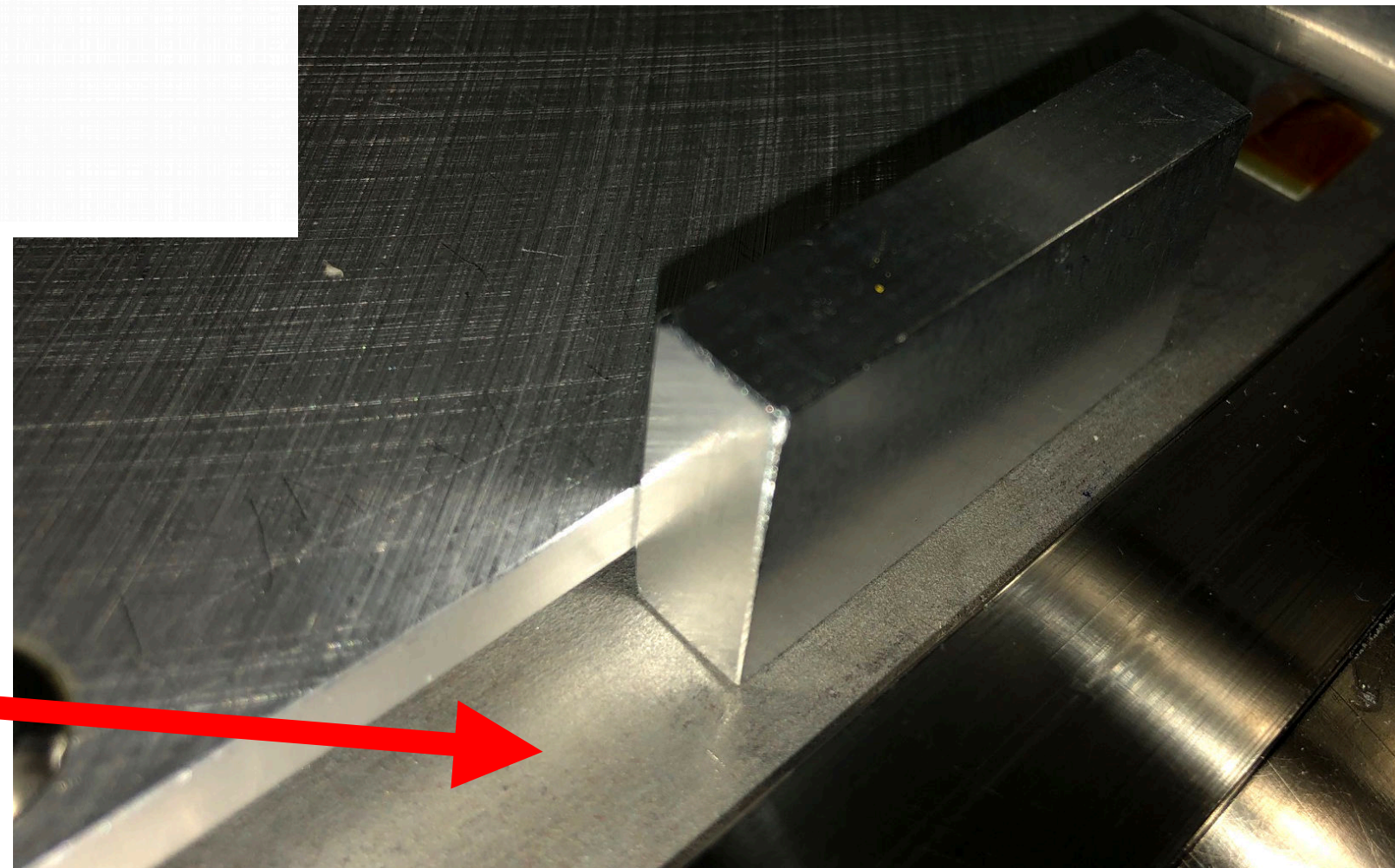
7 / 22-7 / 29

- RC: Maurik
- 7/23 - After LCW water leak fixed, HPS running again.
 - Tuning beam, but SVT wire scans don't make sense. Top and Bottom scan disagree by $> 200\mu\text{m}$ and are inconsistent.
 - Taking some data to diagnose issue using tracks. Results don't make sense either.
 - Hypothesis: The top SVT is not sitting properly in the groove that forms the downstream hinge of the first 4 sensor layers.
- 7/24 - 3pm - We decide the only thing to do is open the detector, again.
 - Detector was found to have moved $\sim 1\text{cm}$ downstream.
 - This must have happened when the magnet crashed when power was lost.

Detector Moved!



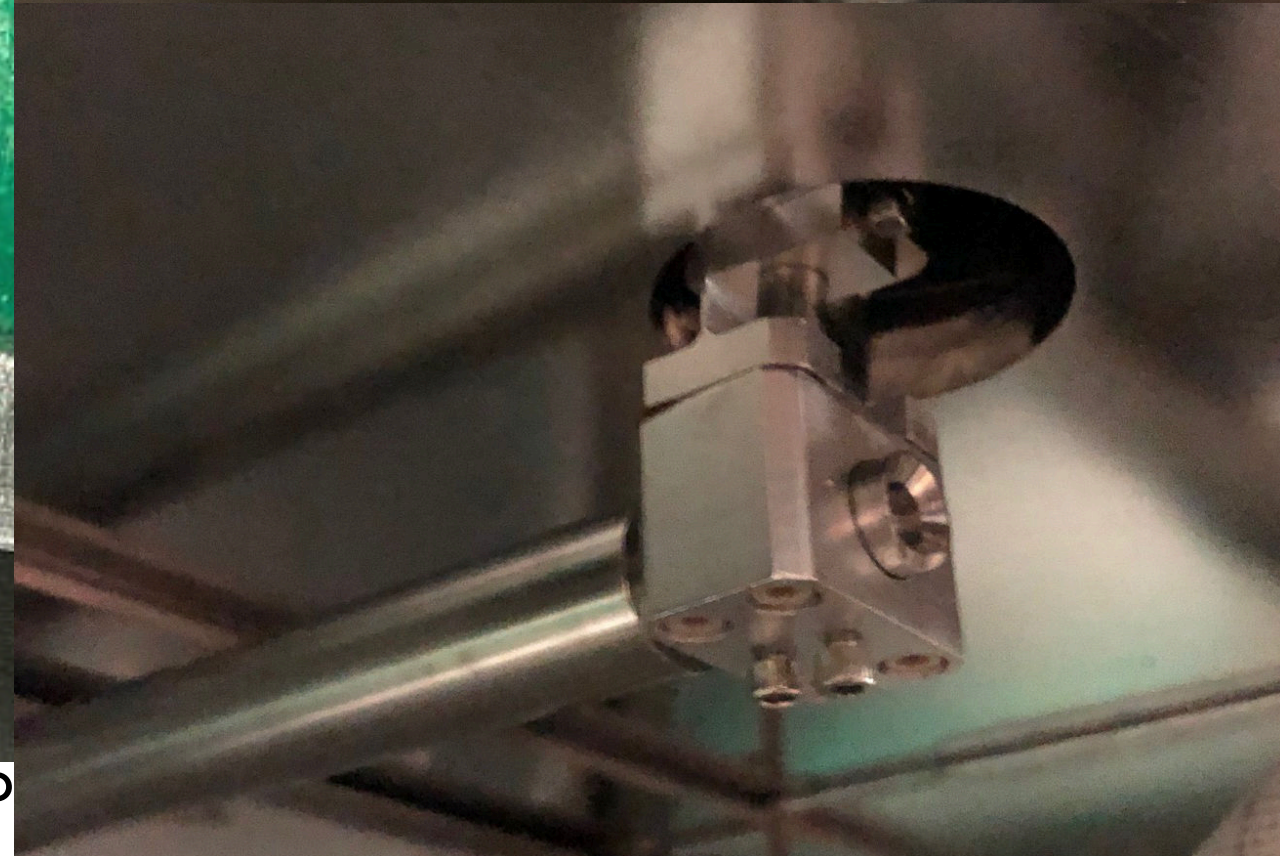
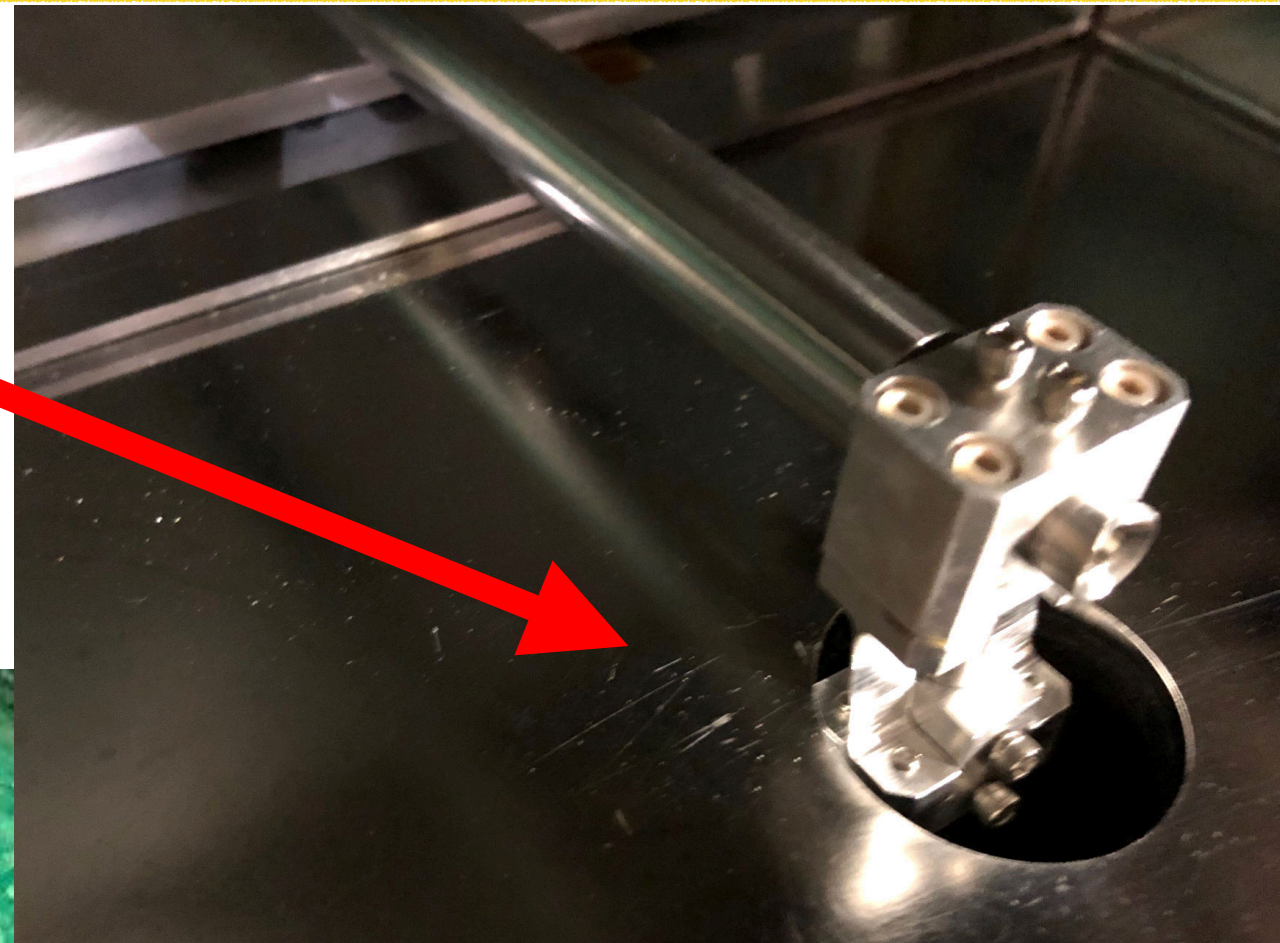
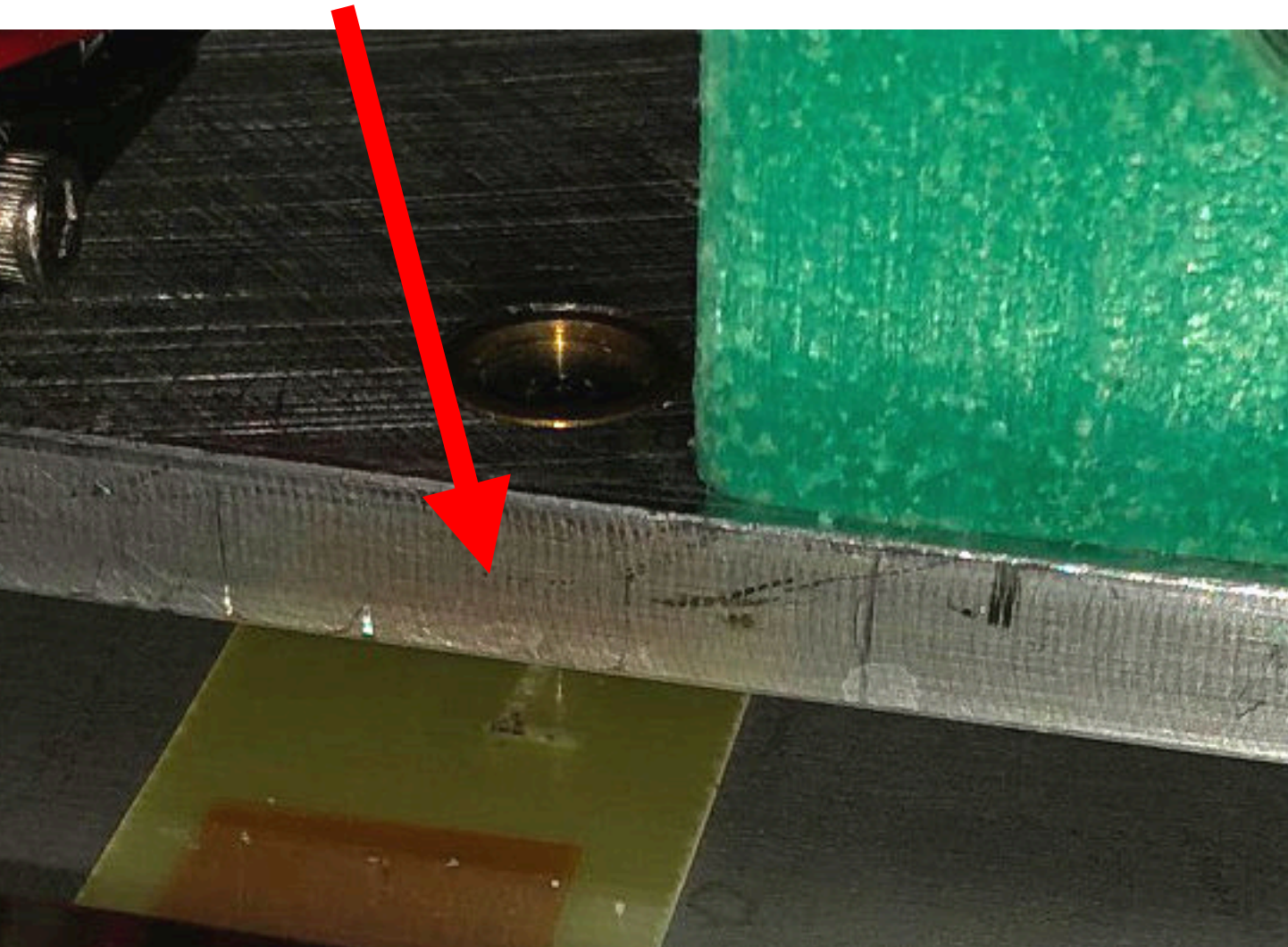
Gap between SVT assembly
and vacuum box “ridge”
should be 0.5 inch.
(Width of the block)



Detector Moved!

Motor control rods are bent against the side of the hole. Flex joints are stressed. Scrapings found on plate.

Scrape mark on the G10 board below the set screw.



Detector Moved!

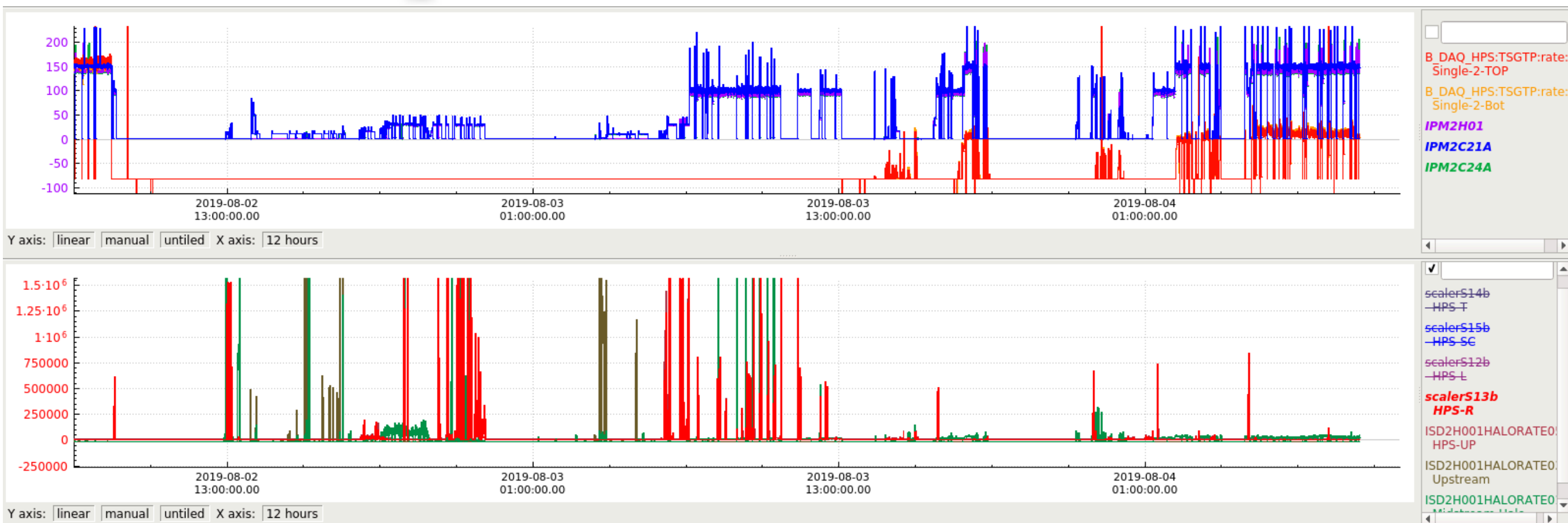
- Bob Miller created a “grabber” on a threaded rod that allowed us to pull the SVT detector box forward by ~1cm.



7 / 25-7 / 29 - 8 / 5

- RC: Maurik
- 7/25 - beam restored.
- **7/26 start of PRODUCTION RUNNING**
- Production running started with $I=150$ nA on $8\mu\text{m}$ W.
- Beam quality was quite good, with frequent trips due to Hall-A (high current parity experiment.)
- 8/2 8:30am Beam off for Hall-A “Wien filter” spin flip.
 - Accelerator has beam again at 12:30pm to Halls A & C
 - Our beam is terrible, and it is Friday afternoon....
 -the entire weekend is spend tuning.... with just a little bit of good beam.
- JLab management agrees to extend run to 9/9.

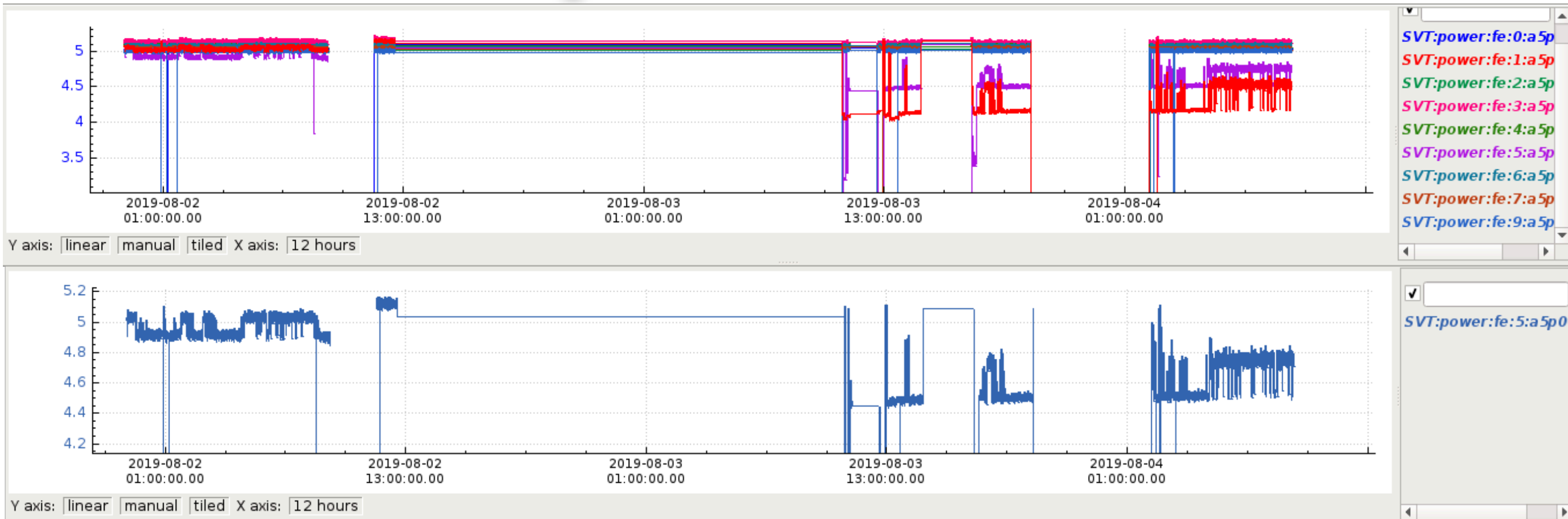
Consequences of bad beam.



During the beam tune, very high rates are seen on the HPS-R halo counter (red), and the upstream (brown) and midstream (green) FSD counters.

This wasn't brought under control until Saturday midday.

The consequences of bad beam

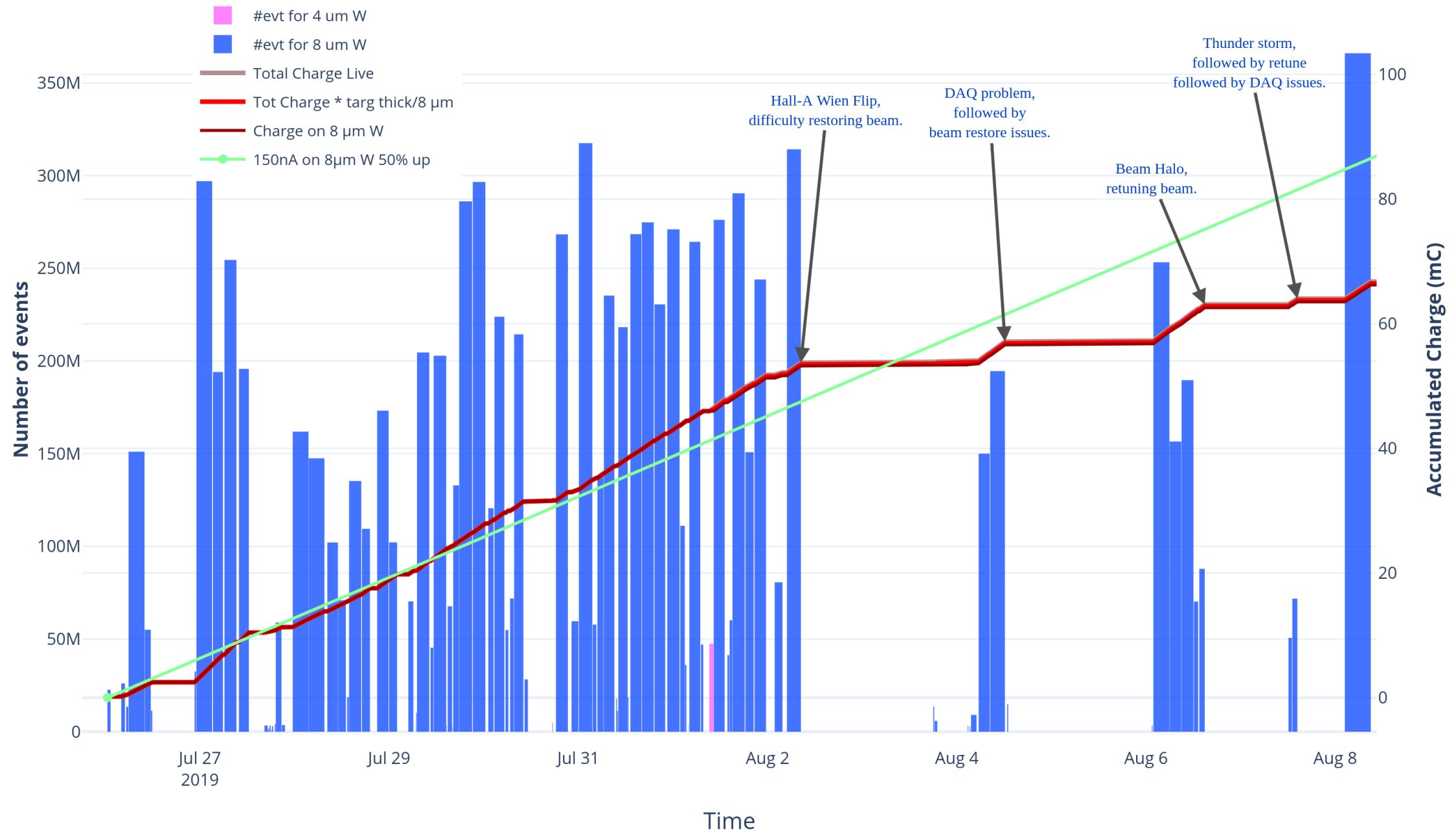


The Front End Boards (FEBs) of the SVT show a clear degradation in the 5V power to the analog section of the board, which powers the amplifiers. When the 5V power drops to 3.8, one or more of the 4 hybrids on that FEB need to be turned off, causing us to loose one SVT.

More this afternoon: Tim Nelson "SVT: performance, lessons learned, plans for repair and upgrades"

7/25 - 8/5

HPS Run 2019 Progress

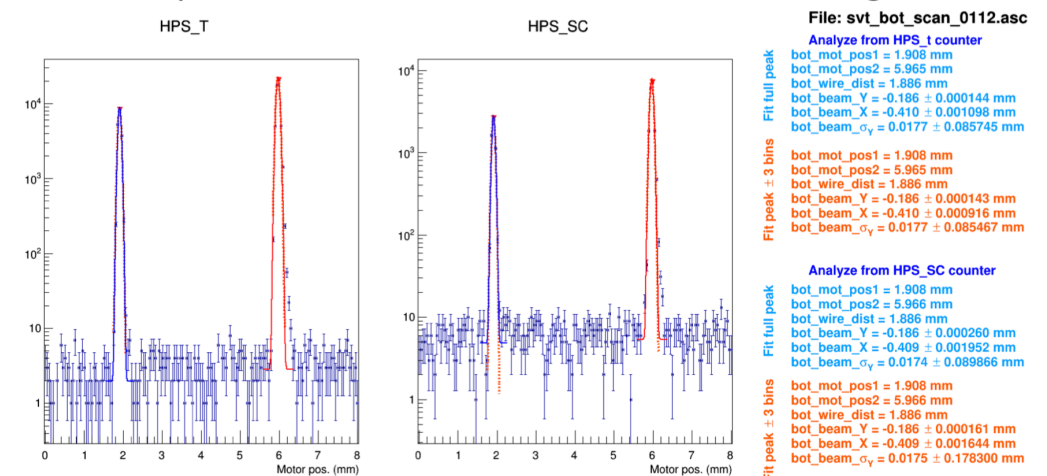


8 / 6-8 / 22

- RC: Raphaël Dupré, Stepan
- Improved beam tuning agreement with MCC to attempt to get beam to hall cleanly.
- Still a lot of beam tuning: Thunderstorm, “Spontaneous Machine Change”.
- DAQ instability.
- Still some good running.
 - Decision to make runs not too long.

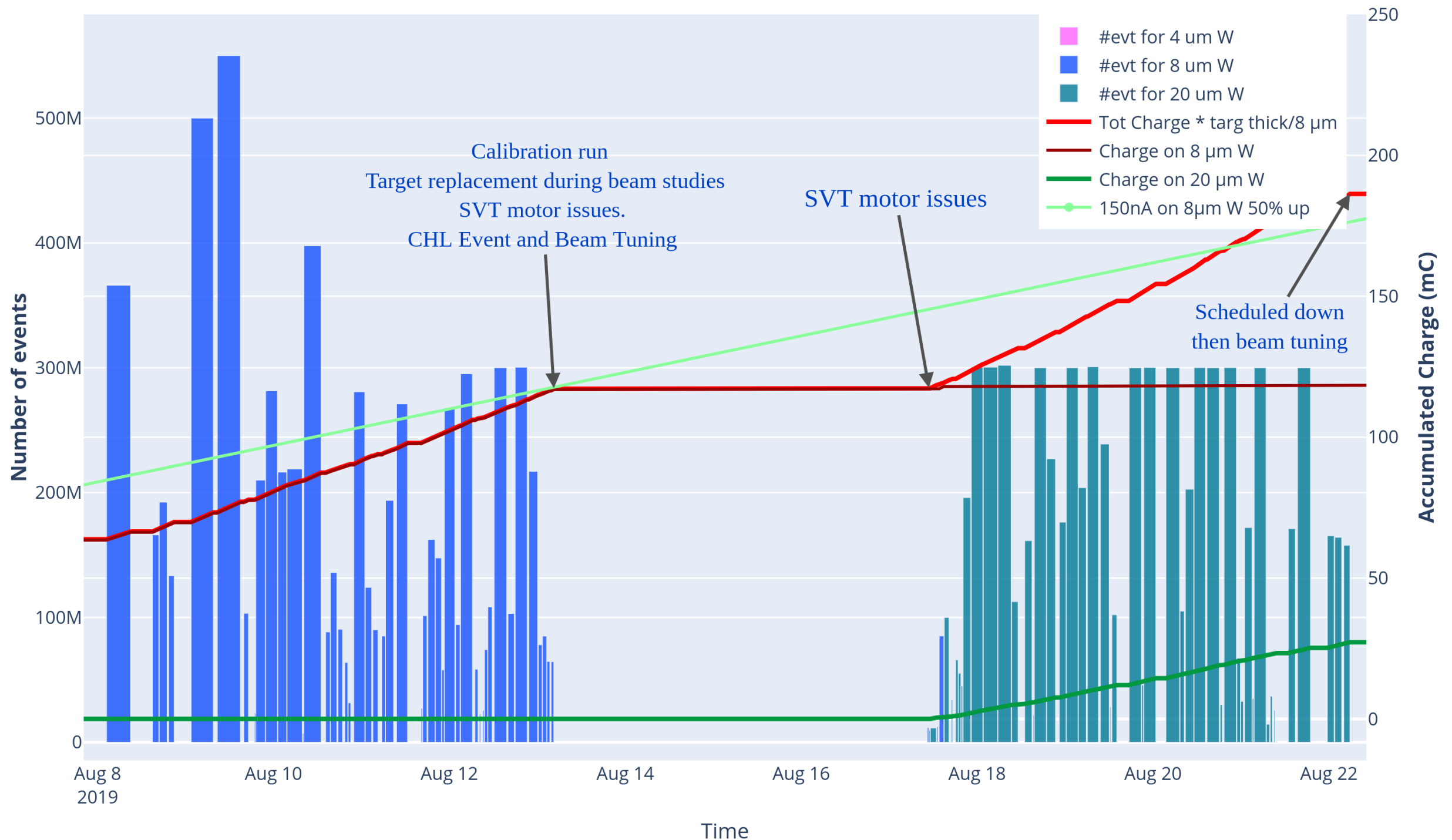
8 / 6-8 / 22

- 8/13 - During beam down for beam studies and Hall-A polarization change, we installed a new target ladder with a 20 μm W (plus 8 μm and 15 μm) target.
 - While measuring target position relative to SVT, the top horizontal SVT scanning wire was broken.
 - Additional shielding added to protect FEB boards.
 - Connector to the bottom SVT positioning motor broke, and was subsequently repaired.
- Beam recovery difficult due to halo and Hall-A bleed through.
- 8/16 CHL crashed, bringing machine down.
- 8/17 Hall-B priority to restore. Beam Back at 9am!!
- New production: 150 nA on 20 μm W
- Requires trigger tune to improve live time.



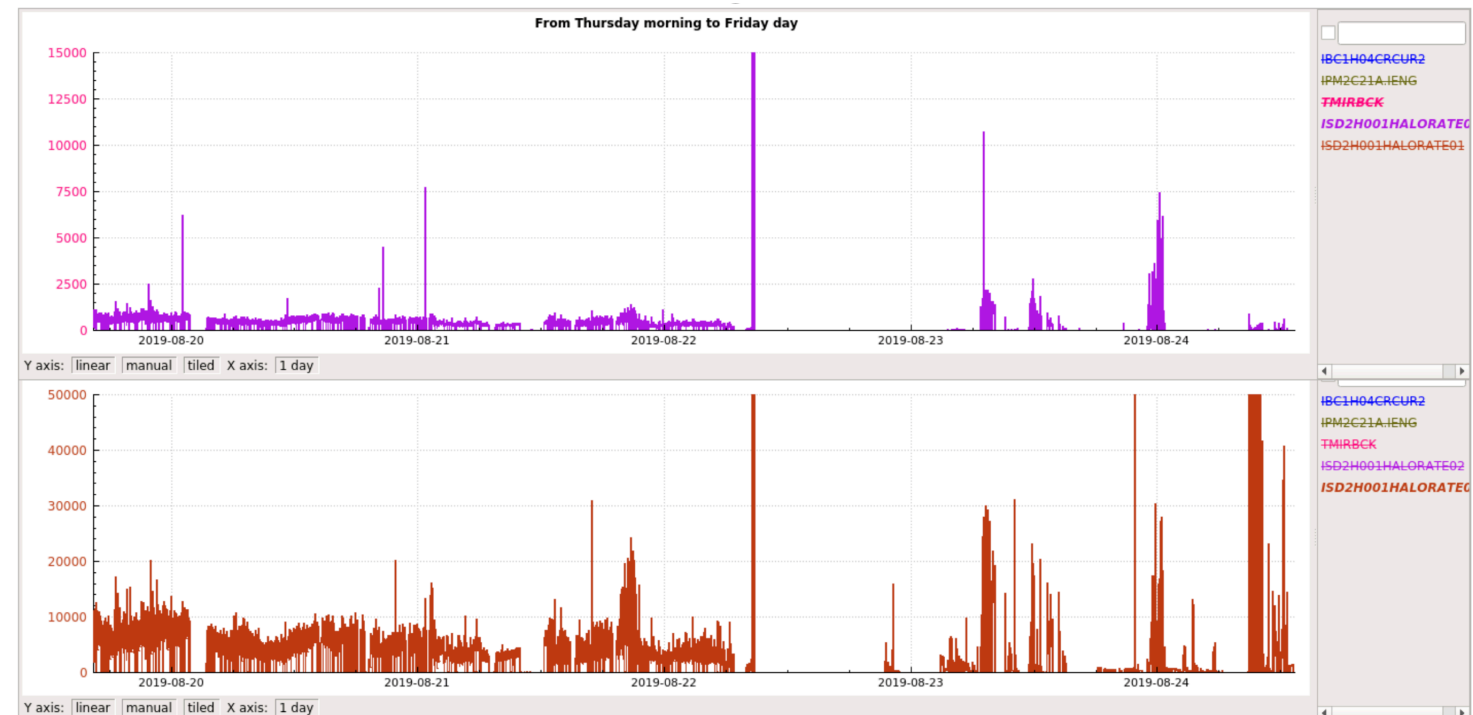
8/6 - 8/22

HPS Run 2019 Progress



8 / 23-9 / 9

- Production running $I=120\text{nA}$ on $20\text{ }\mu\text{m W}$.
- Still issues recovering beam to Hall-B after changes to accelerator to accommodate Hall-A.
- Issues with halo rates: excessive bleedthrough from other halls (usually manageable while on the tagger)
- mis-steering, dumping the beam in the hall (before or after CLAS12). This is the most common issue when establishing beam to FC

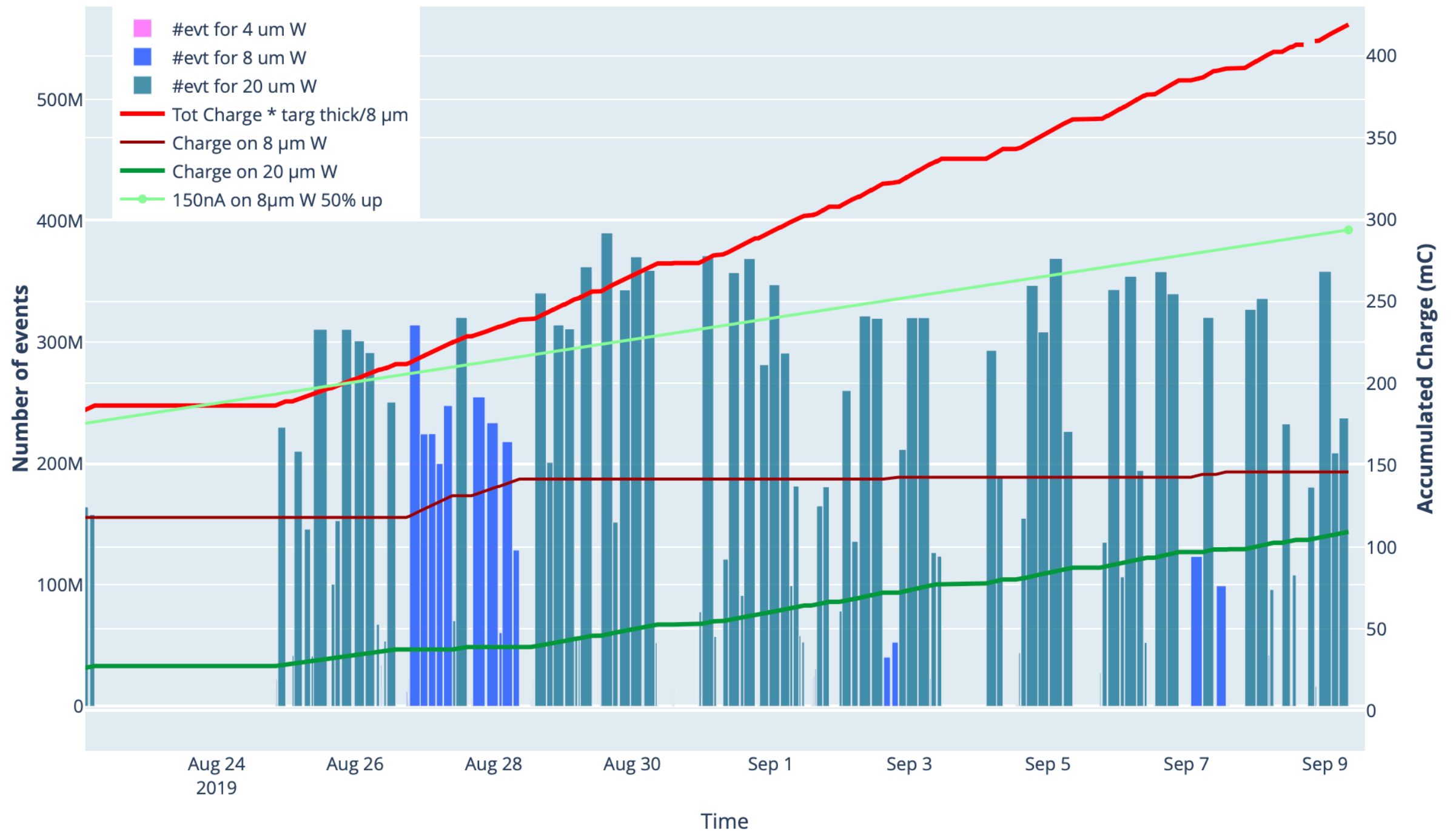


S. Stepanyan, RC report, 08/19 - 08/26 2019

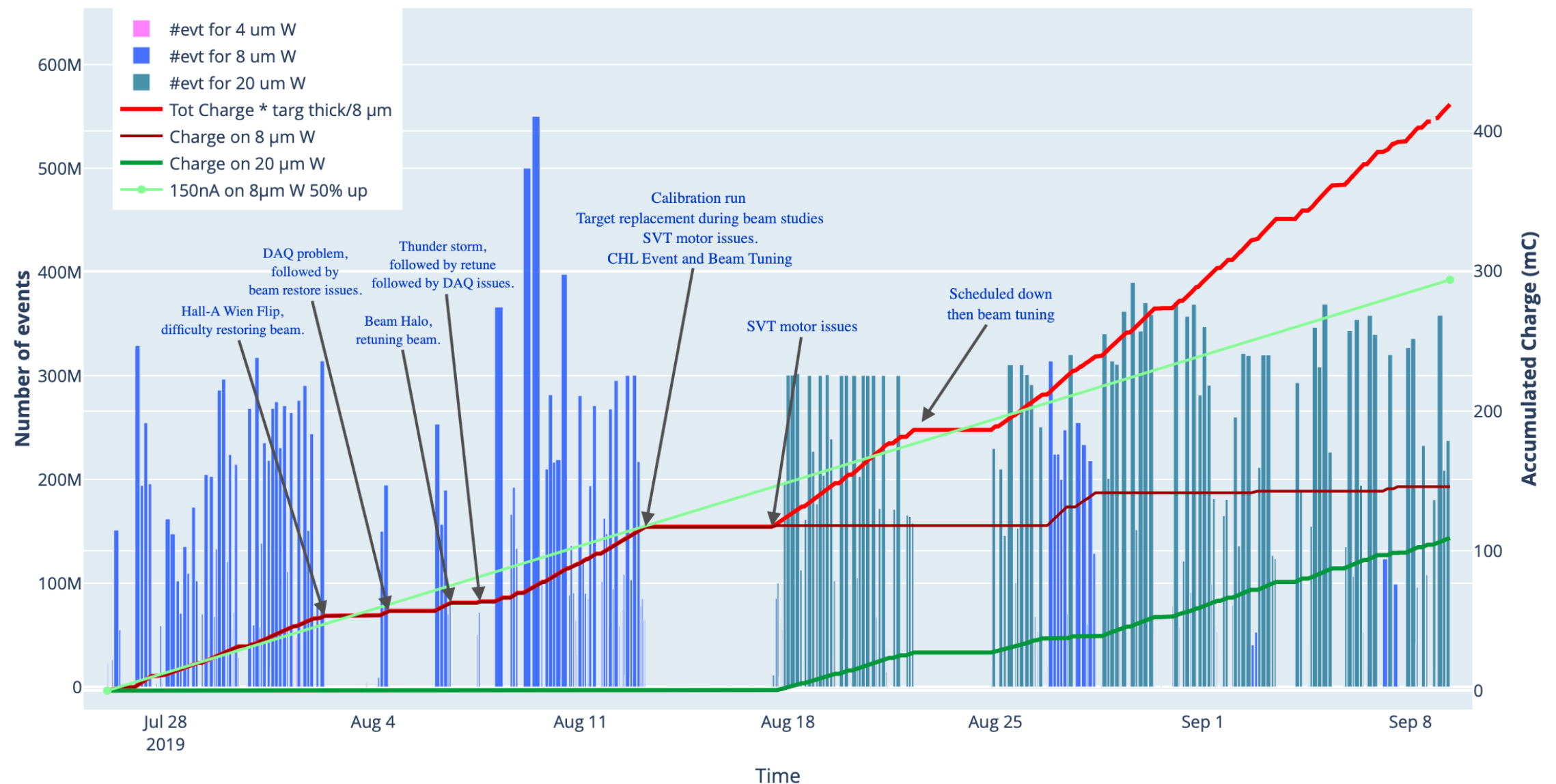
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8/23-9/9

HPS Run 2019 Progress



Production Running: 7/26 - 9/9



Total calendar days of production running period: 45 (expected 56, on floor 84)
Total charge on target, scaled to 8 μm W: 400 mC (expected 725 mC)

Lessons from the 2019 run

- The CEBAF accelerator is capable of delivering very high quality beam to Hall-B.
 - Beam quality depends on the entire accelerator working correctly.
 - Changes upstream (i.e. Wien flip, injector reconfiguration, change in orbit locks) can negatively affect the Hall-B beam.
 - Beam recovery (i.e. after thunderstorm, or other extended down) is not “push button”.
 - Beam tuning has to be done in careful steps, first establishing good beam to the tagger dump, then to the FCup, to minimize radiation exposure to the HPS electronics.

Lessons from the 2019 run

- The SVT
 - Layer redundancy we have is not a luxury. We need it.
 - The FEB boards were more vulnerable than expected to radiation during beam tuning, but seemed to be fine during running with quality beam.
 - A magnet crash seemed to have moved the detector. Is there a simple way to prevent this?
 - Replacing SVT layers and/or FEB boards is tricky, requiring a super-expert. More spares, and starting the run with perfect boards would be great.
 - X-rays limit beam current on thin targets, so a thicker target was used.

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 - X-rays limit beam current on thin targets, so a thicker target was used.
 - “Monster events”?

Lessons from the 2019 run

- DAQ, Trigger, ECAL, Hodoscope
 - DAQ seems to always be more work to get working, but finally worked really well.
 - Trigger also worked well, but we can use far better, more insightful online diagnostics.
 - ECAL is starting to show some aging, as is everything else.
 - Hodoscope had higher rates than expected (?), still e^+ trigger worked well.
- I am looking forward to more comprehensive studies of the trigger, the trigger efficiency, the overall detector efficiency.

Concluding

- Despite getting 50% of what we hoped for, we now have **a whole lot of data** to process.
 - Lots of hard work by everyone made this run a success.
 - It all (still) worked, but we cannot take that for granted.
- We will need a concerted effort by students, postdocs, and staff to calibrate, understand and process this data rapidly.