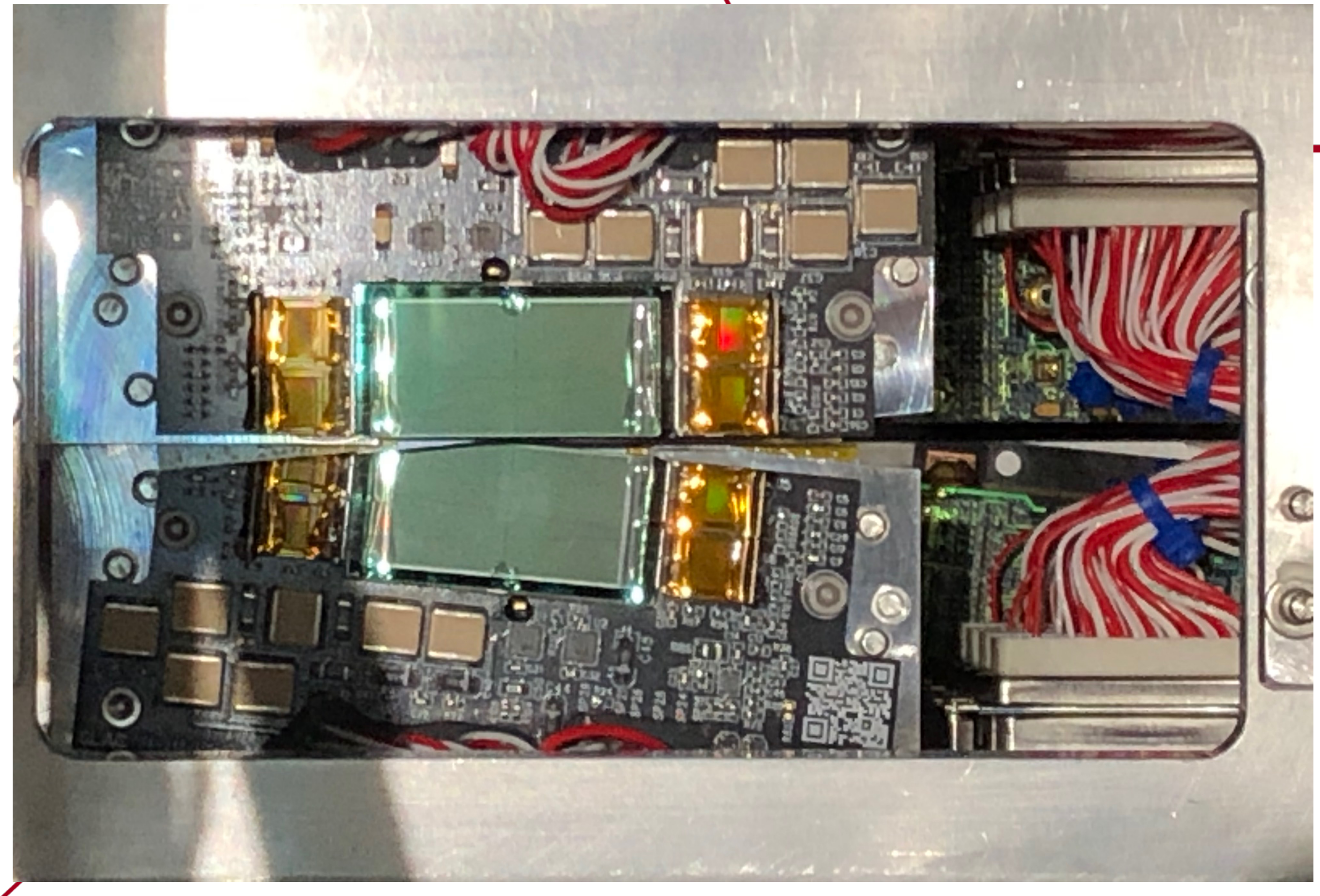
HPS SVT: 2019 Run and beyond

Tim Nelson - SLAC

HPS Collaboration Meeting

JLab - November 18, 2019



U.S. DEPARTMENT OF ENERGY
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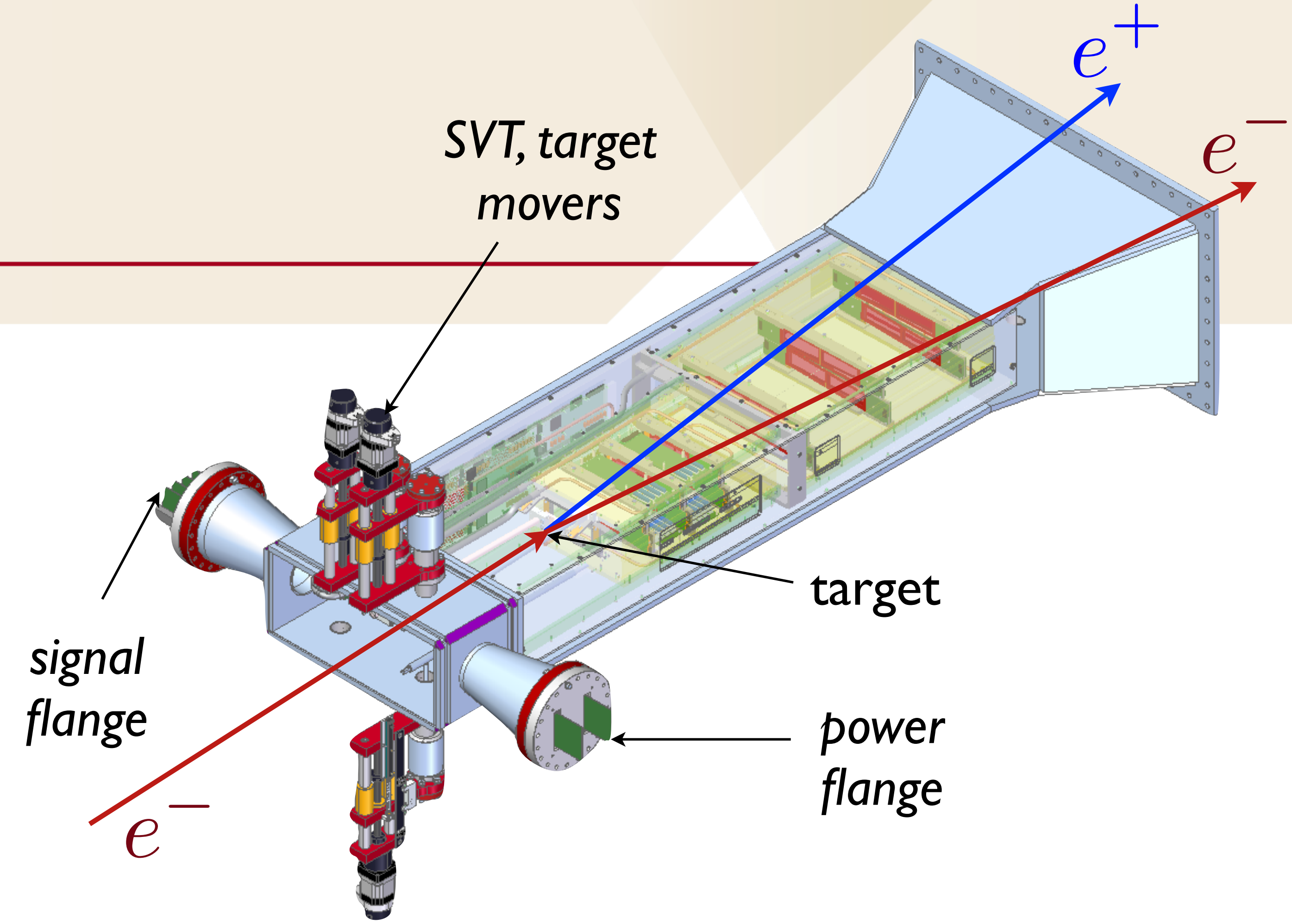
SLAC NATIONAL ACCELERATOR LABORATORY

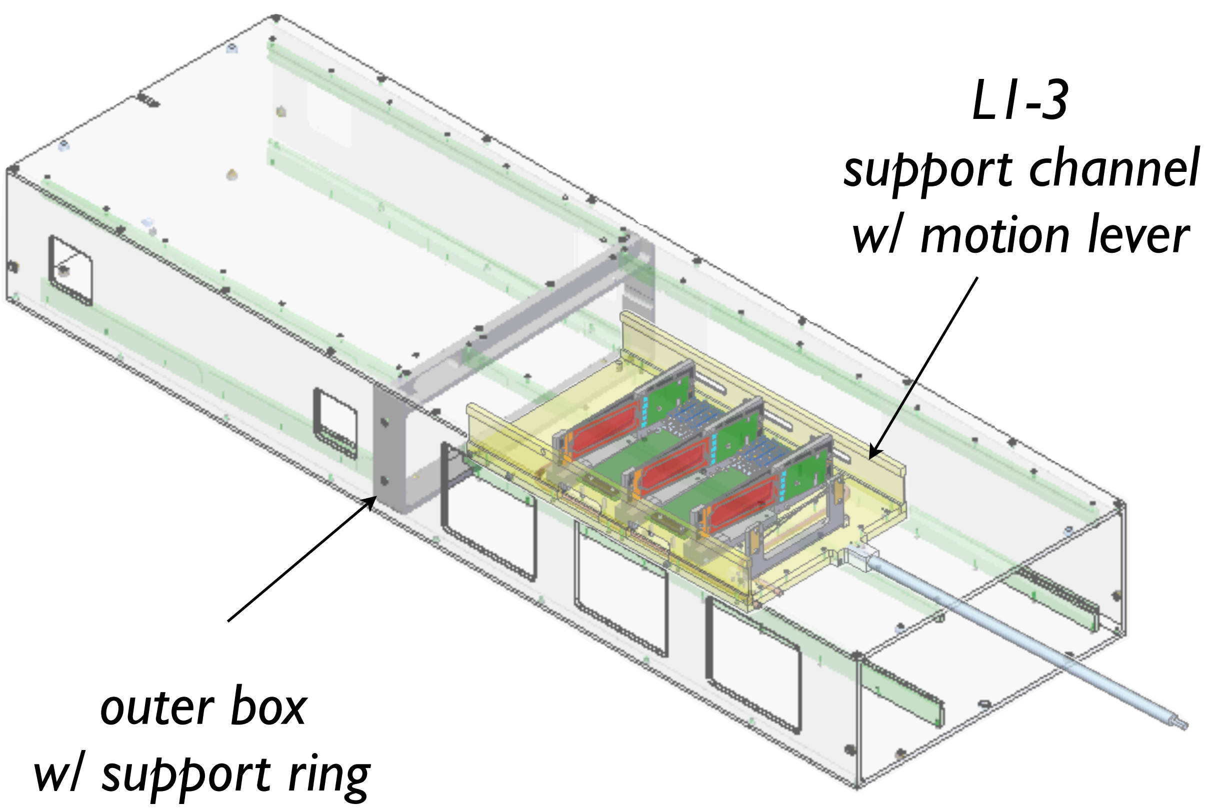
The HPS SVT for 2015-2016

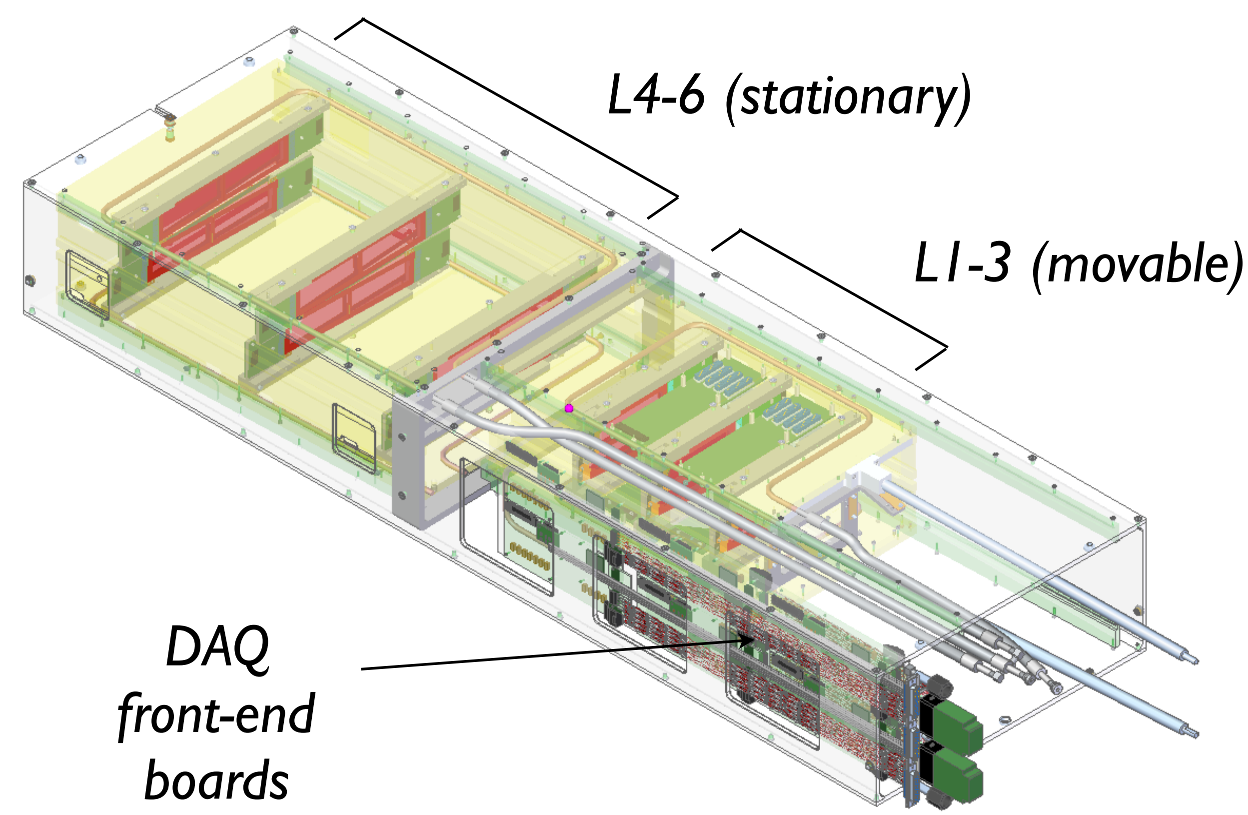
6 layers of silicon strips, each measures position (~6 μm) and time (~2 ns) with 0.7% X_0 / 3d hit.

Must operate in an extreme environment:

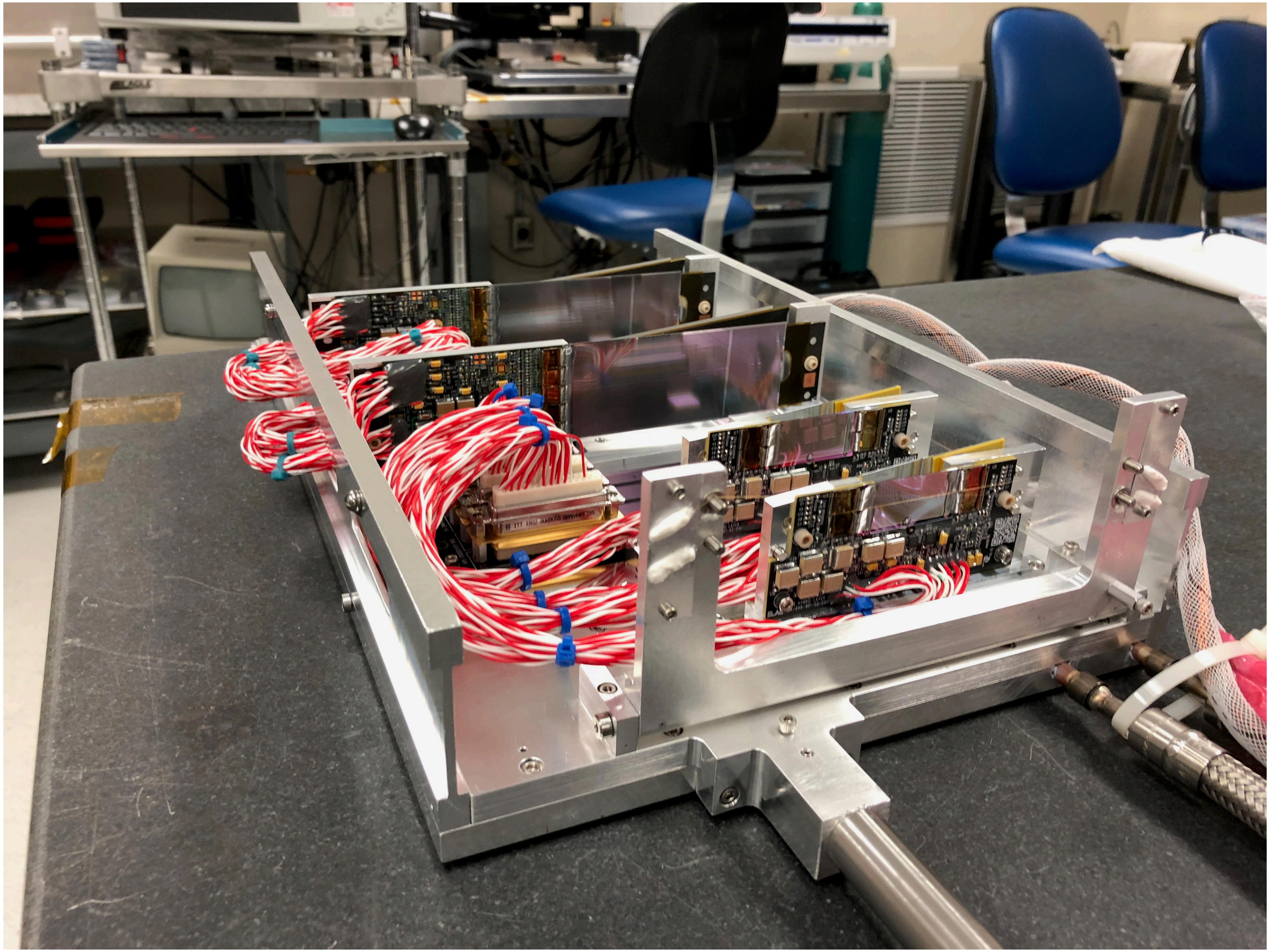
- beam vacuum and 1.5 Tesla magnetic field
  ⇒ constrains materials and techniques
- sensor edges 0.5 mm from electron beam in L1
  ⇒ must be movable, serviceable
- sensors see large dose of scattered electrons
  ⇒ must be actively cooled to -20 °C
- 23004 channels can output >100 gb/sec
  ⇒ requires fast electronics to process data







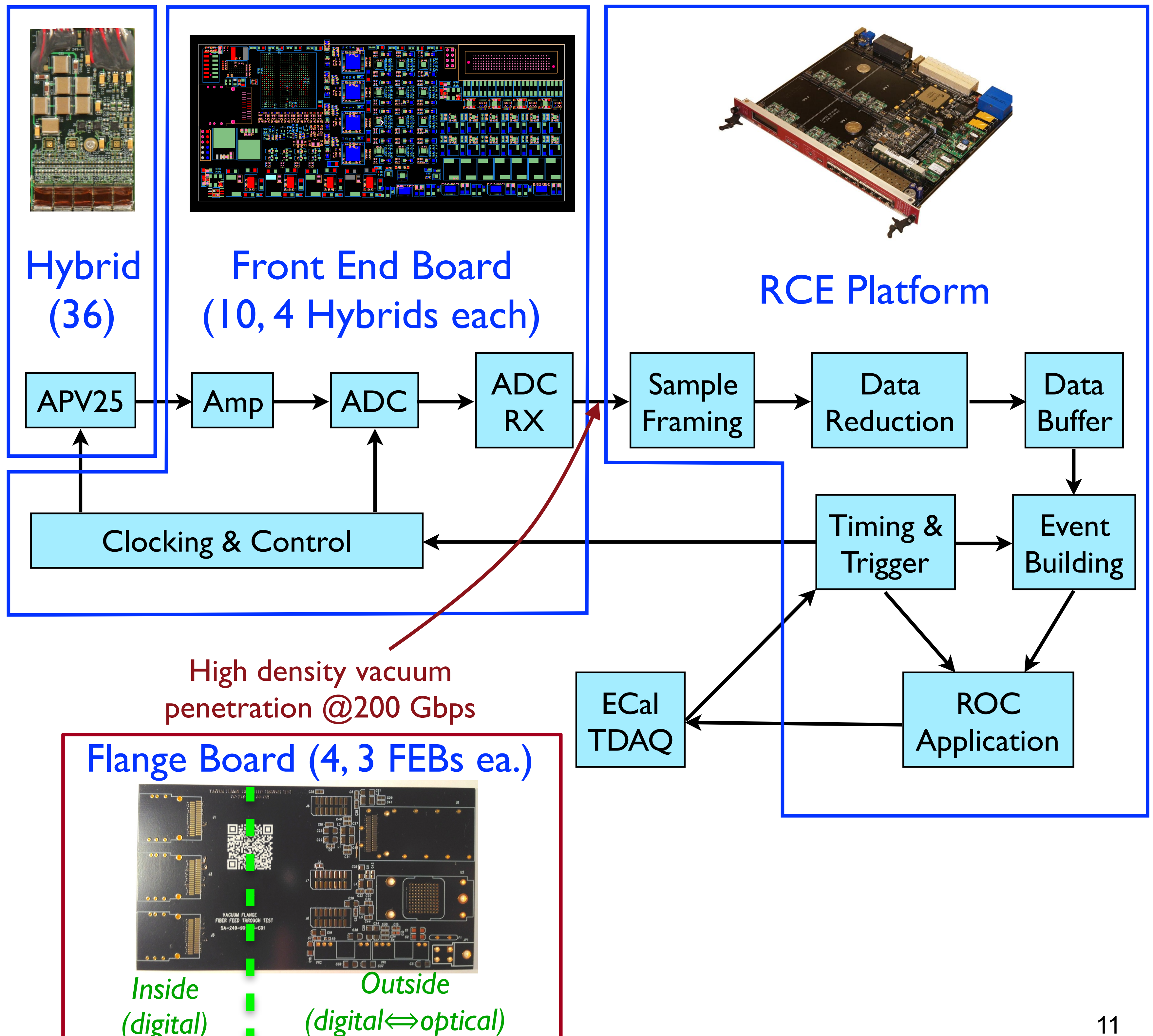
U-channel Lever Block and Layer 1 Replacement



HPS SVT DAQ for 2015-2016

- Hybrids hosting
  5 CMS APV25 each
- In-vacuum ADC, voltage generation and power distribution/control on Front End Boards
- Penetration for digital signals via high-density PCB through flange. Optical conversion on outside of flange.
- Firmware support for APV25 burst trigger mode (50 kHz trigger rate for 6 samples)
- Wiener MPOD power supplies

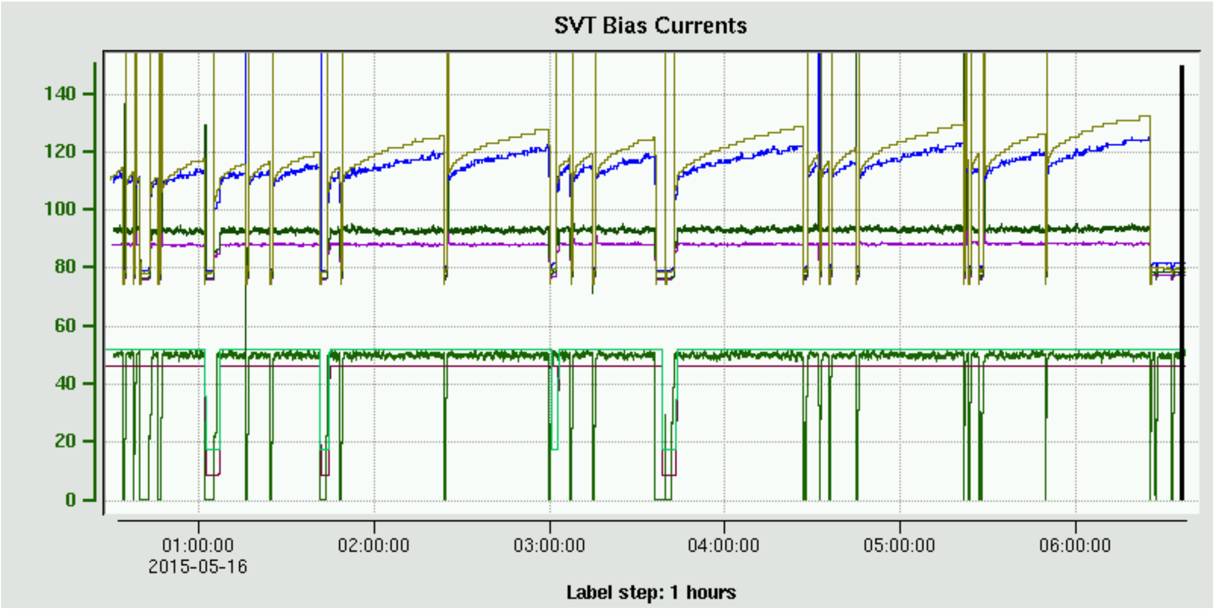
Much more powerful and flexible than test run DAQ.



2015 and 2016 Operations

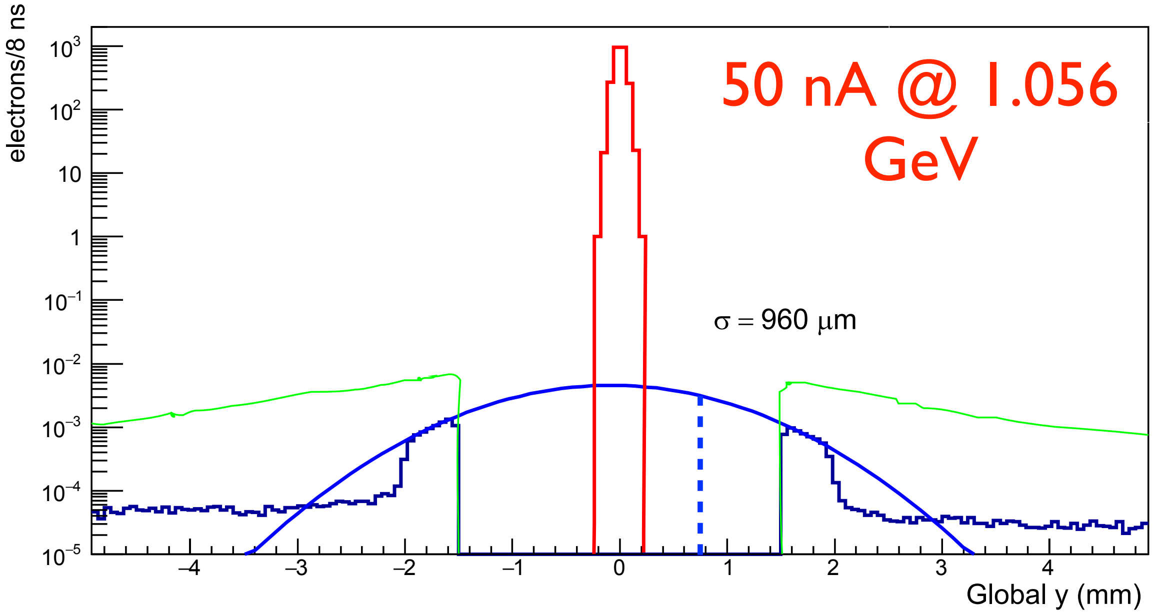
Expected observations

- increases in bias currents from bulk damage
- SEU counts in FEB FPGA monitors, but no clear instances of data corruption



Unexpected observations

- surface currents from x-rays in L1 front side.
- beam tails
- low-charge hits (from high noise) in samples acquired during readout of header (observed at CMS also)
- Problems w/ corruption of SD cards in RCE. *Mitigated by DAQ updates.*



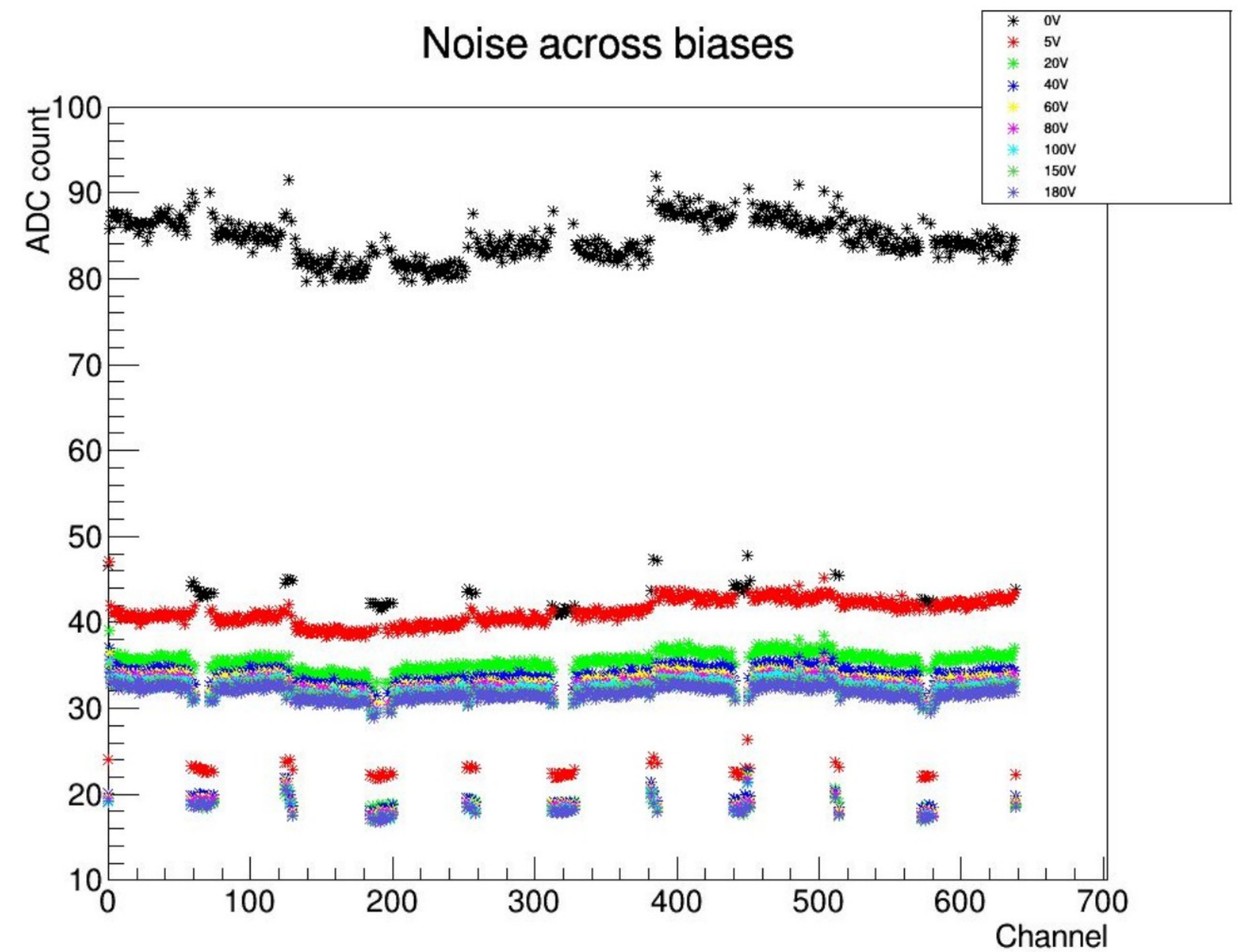
Issues Between 2015 and 2016 Runs

After 2015 run, detector warmed up and put on nitrogen purge for beamline work

A few months later, cooled down again, tested, and put on hibernation at ~0C with switch to HFE7500 to minimize reverse annealing of radiation damage.

Some sections of low-noise channels observed, only on back side of Layer 6 (facing ECal), in the middle of each APV and between APVs.

Those remained stable during/after 2016 run, but some additional similar channels in L1-3, away from beam, again after 2016 run.



study by To Chin You

Wirebond Damage

Cameron's investigations indicate wire bond damage

- Removed Sylgard and wire bonds from one sensor and re-bonded.
- Channels are recovered.

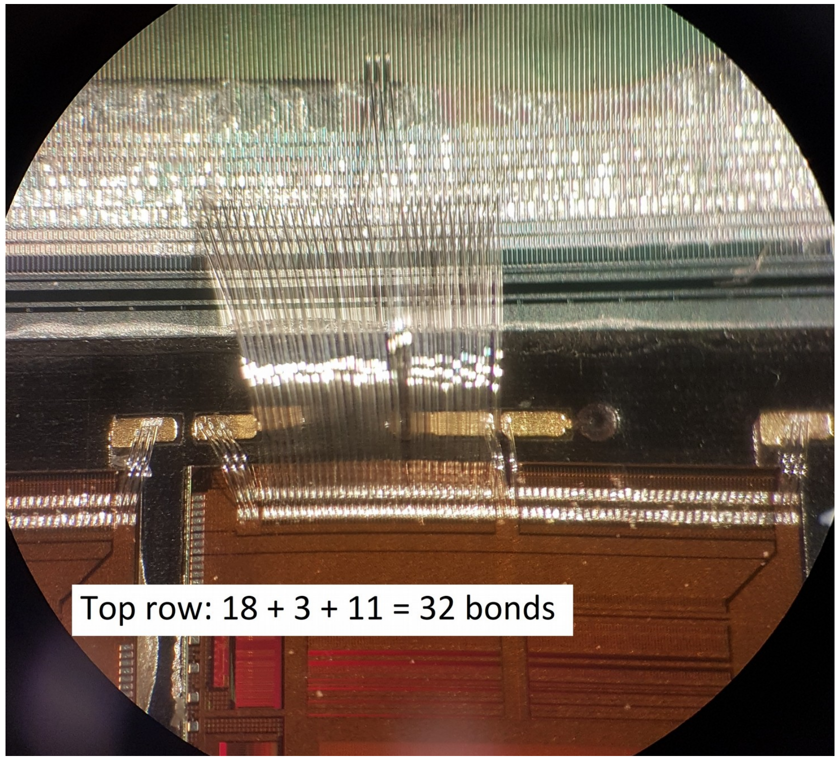
Less clear exactly what caused this

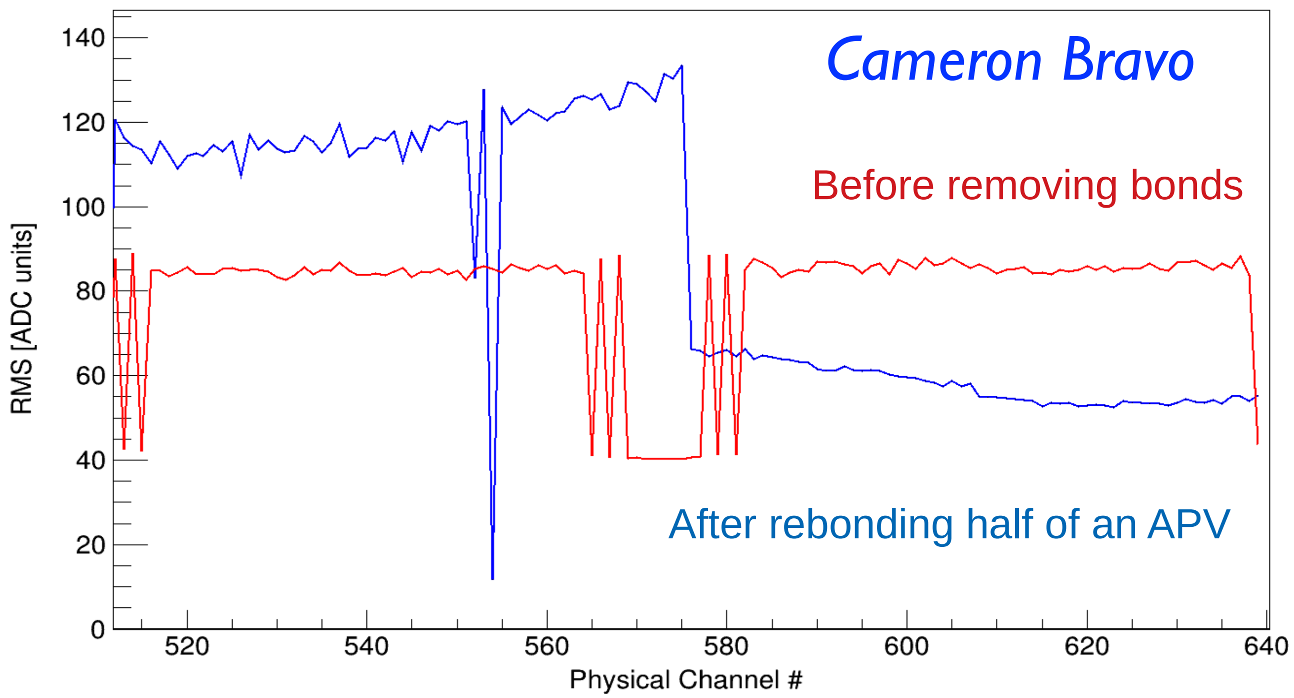
- Sylgard (esp. 186) is tried-and-true material for >30 years. Problems have been rare and involved unusual geometries (not like ours)
- CMS and ATLAS ***had*** recently decided that Sylgard was 100% trusted solution for upgrades.
- Everyone now looking at this more carefully
- CMS starts to see problems with 80C swings.

Localization suggests more than one causative agent

- Entire back of L6 - pump oil contamination? (crude test show ~1% swelling)
- Occasional outer edges of L1-3 - CTE stress (40 C swing gives ~1% differential)

Al-1%Si bond wire breaks at about 1% elongation…

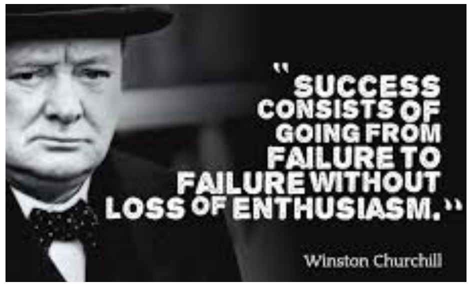




Outline of 2019 Operations and Beyond

Installation
(a reprise)

Operations
(victory of the indefatigable)

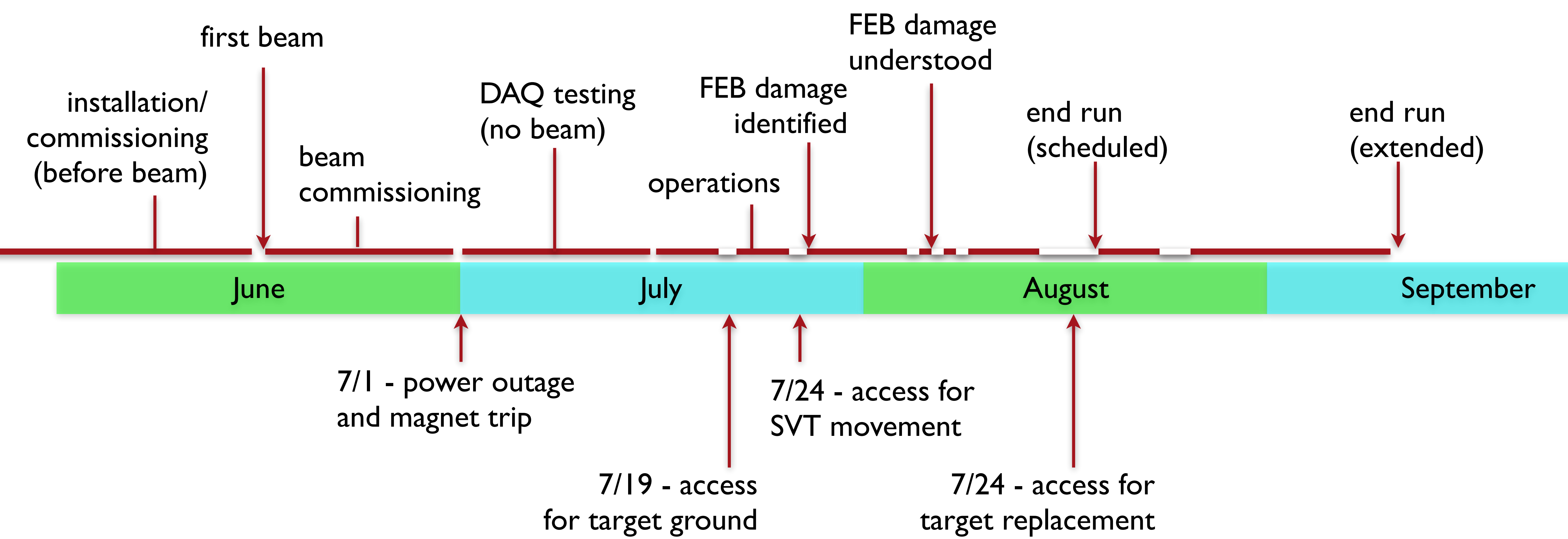


Post-operational assessment of the SVT
("It's just a flesh wound.")

First looks at data integrity
("it's alive!")

Making the SVT whole again
("I love the smell of solder in the morning.")

The Long March



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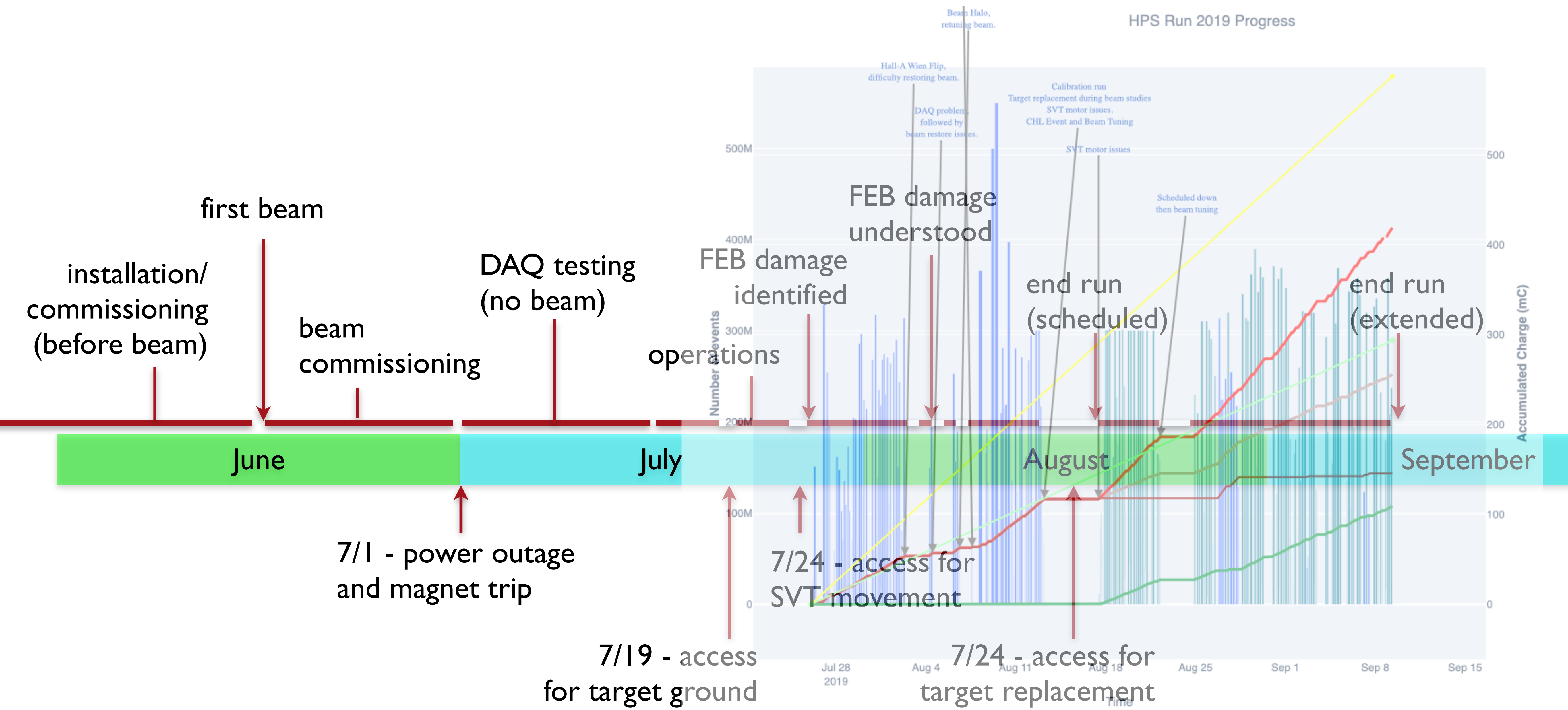


The SVT on the Eve of Operations

Installation turned out to be a significant trial

- Upgrade completed late due to sensor delivery/quality issues
- Unexpected FEB failures (2×)
- Weiner MPOD failure
- Bad power in alcove for SVT chiller
- FEB cooling system fouled with algae
- One hybrid in L4 (1/8 of L4) begins acting flaky in post-installation testing

Significant issues remaining with ~2 weeks before first beam

- Integration of SVT DAQ with JLab DAQ
- Understanding of survey and positioning of the SVT
- Lack of updated EPICS control/logging
- Lack of detector model for track reconstruction and updated online monitoring

SVT group overextended trying to cover everything, so work on these was still ongoing at start of beam operations.

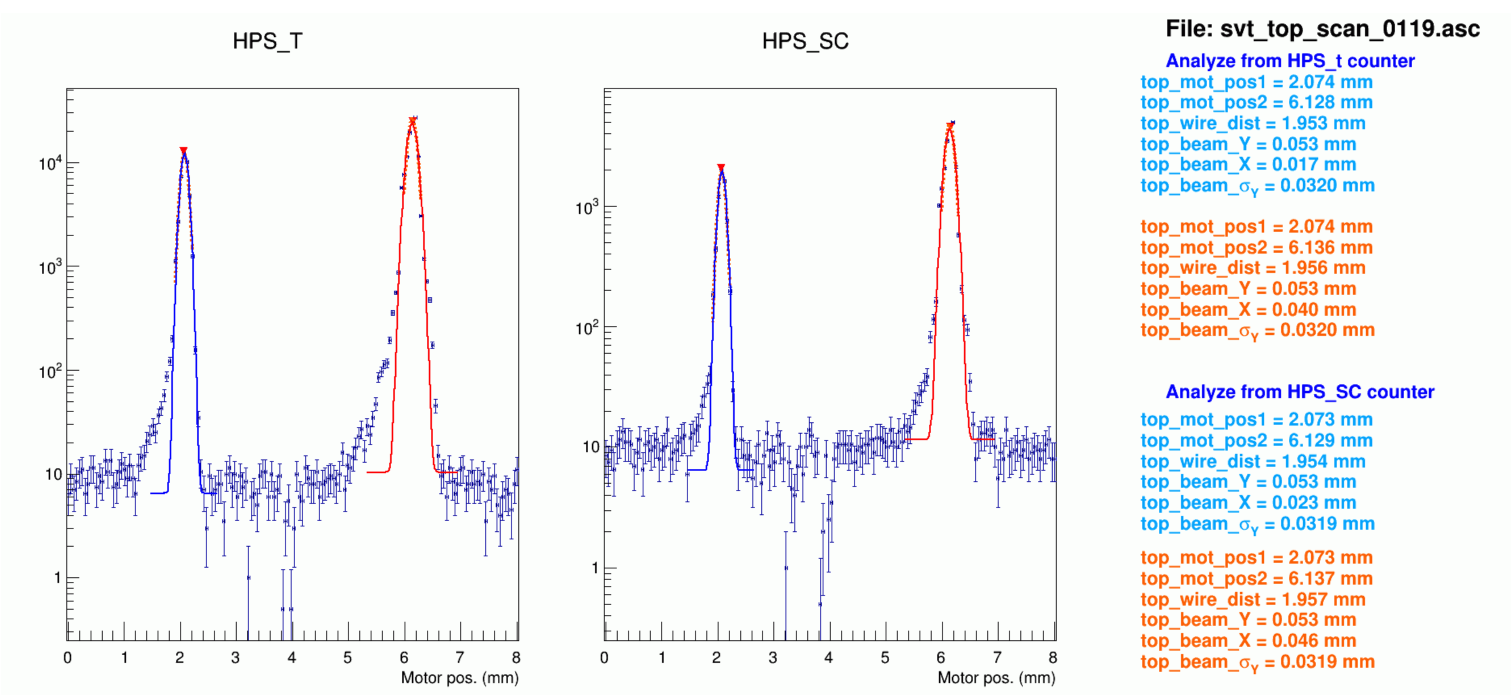
Beam Commissioning

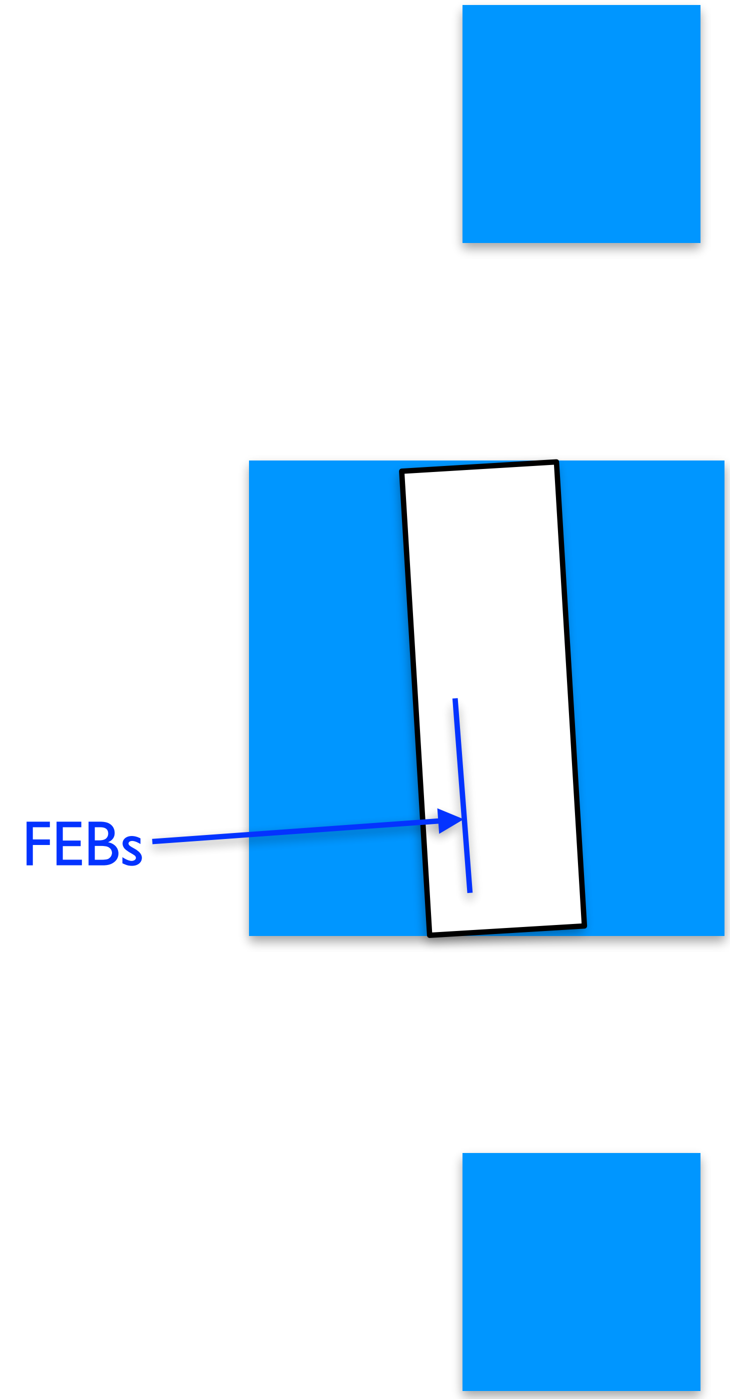
Issues with beam quality were quickly apparent.

- Difficulty tuning beam to tagger dump and subsequently transporting to the Faraday Cup

  ⟹ Likely we were doing significant damage to the FEBs during long tuning sessions without realizing what was happening.
- Long tails in y, so we could not close the SVT, but tried to do early commissioning anyway.

  ⟹ Likely we were doing significant damage to the FEBs during commissioning runs also.





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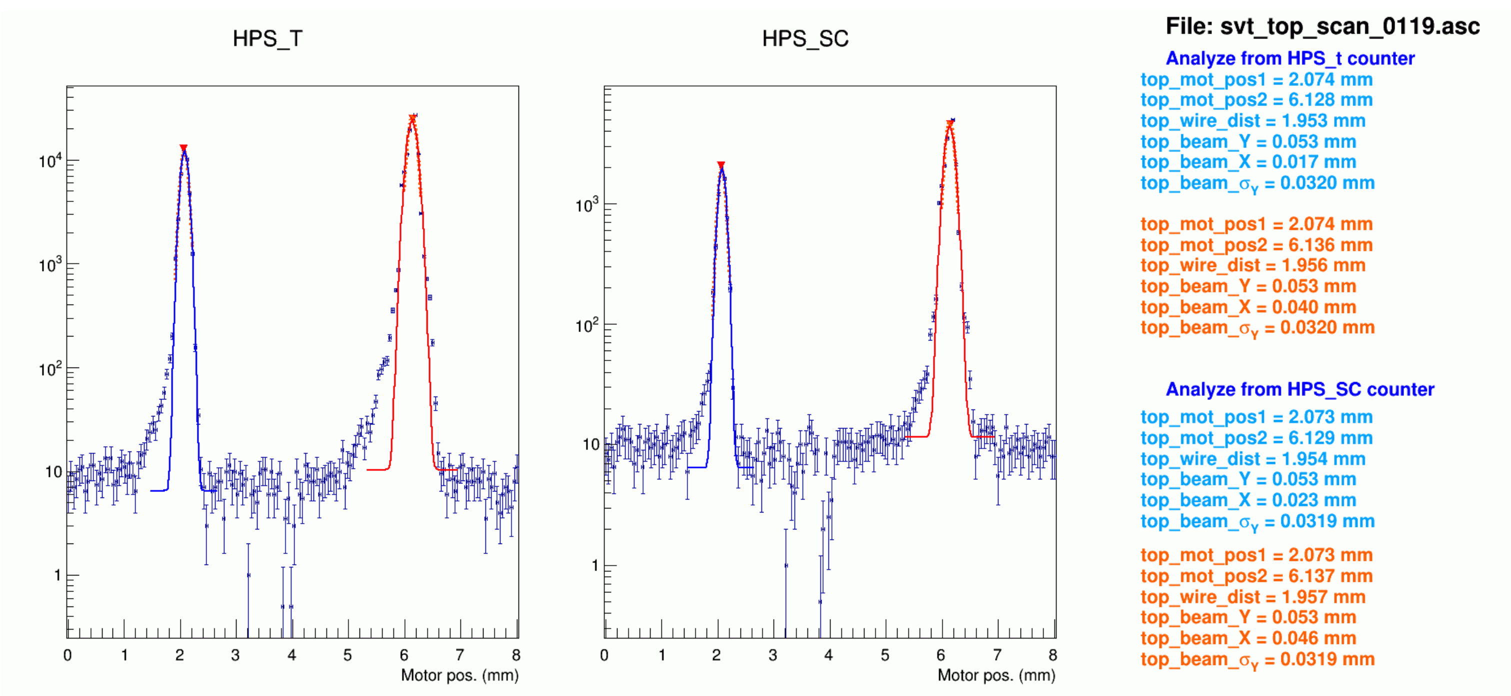

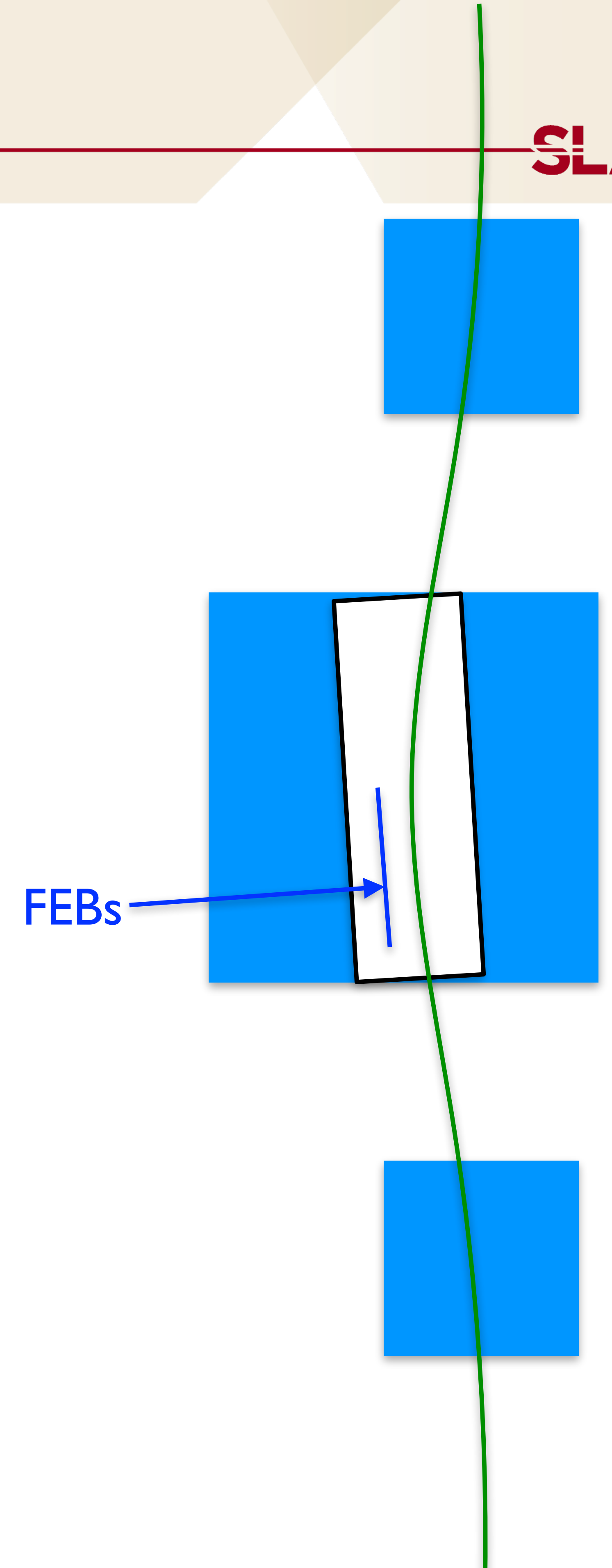

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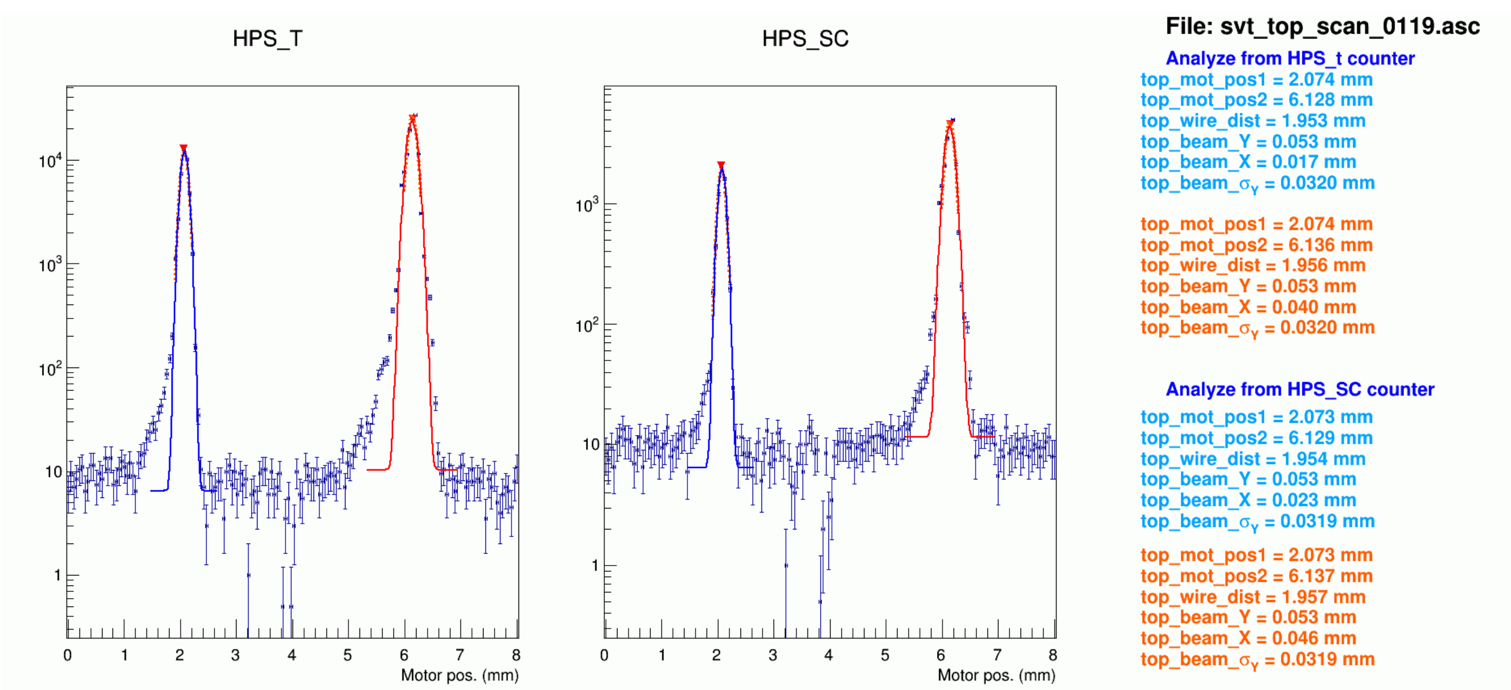

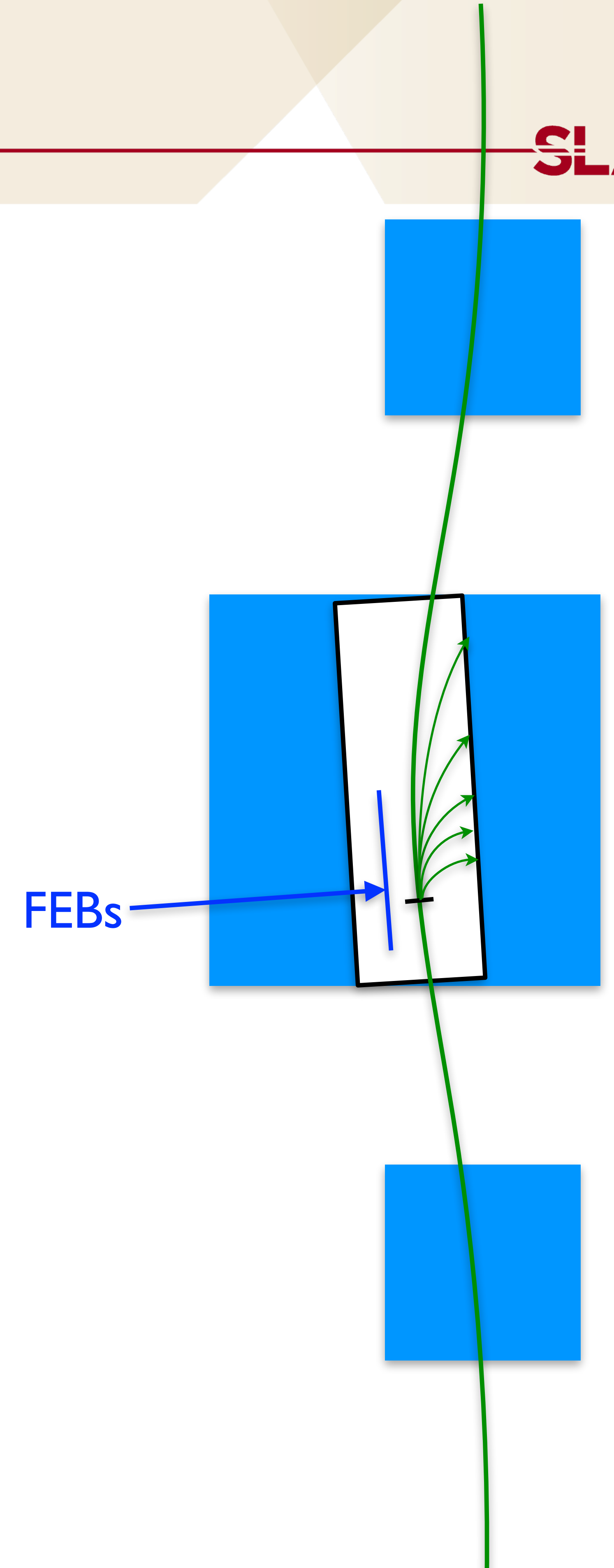

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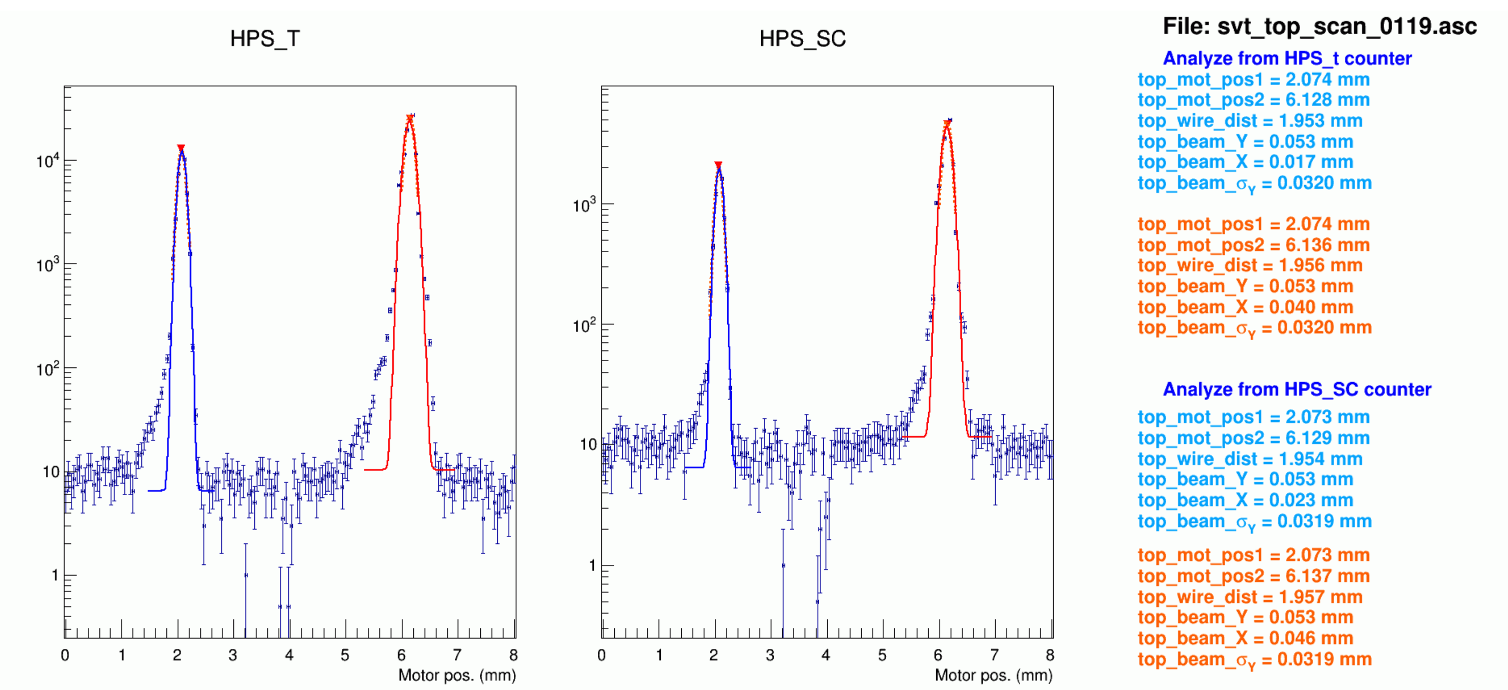

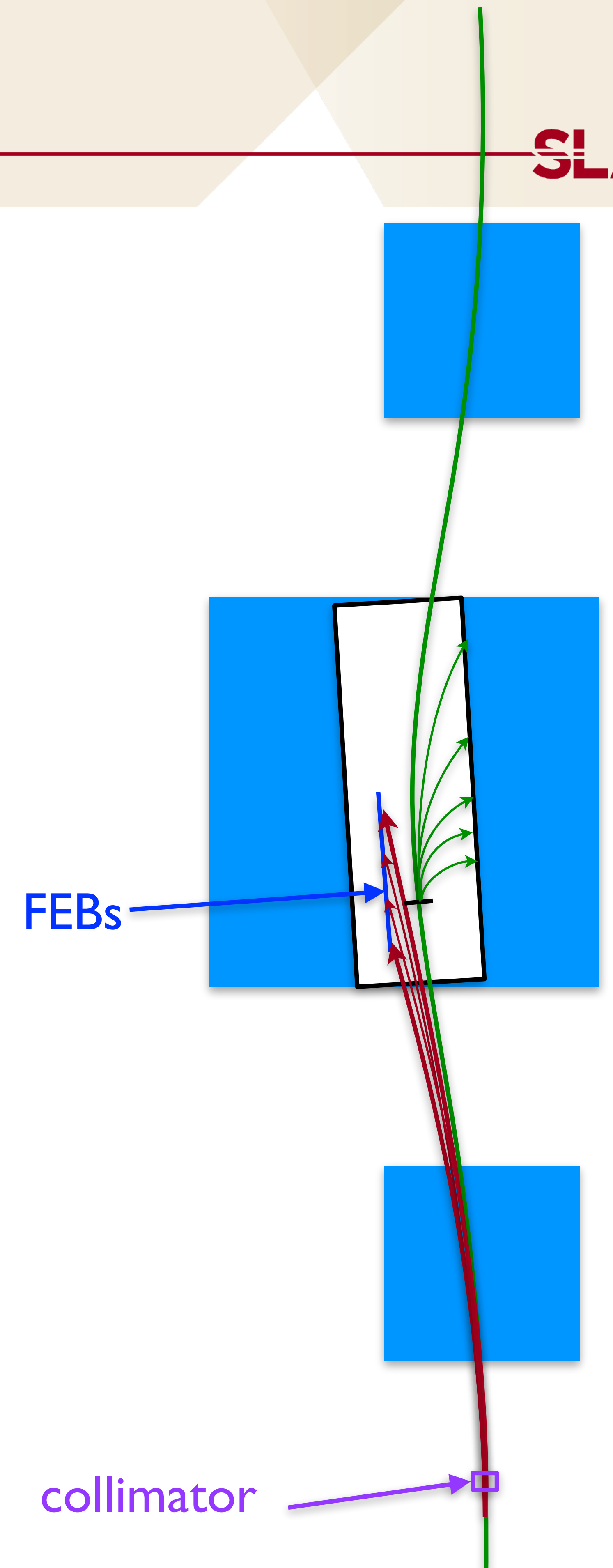

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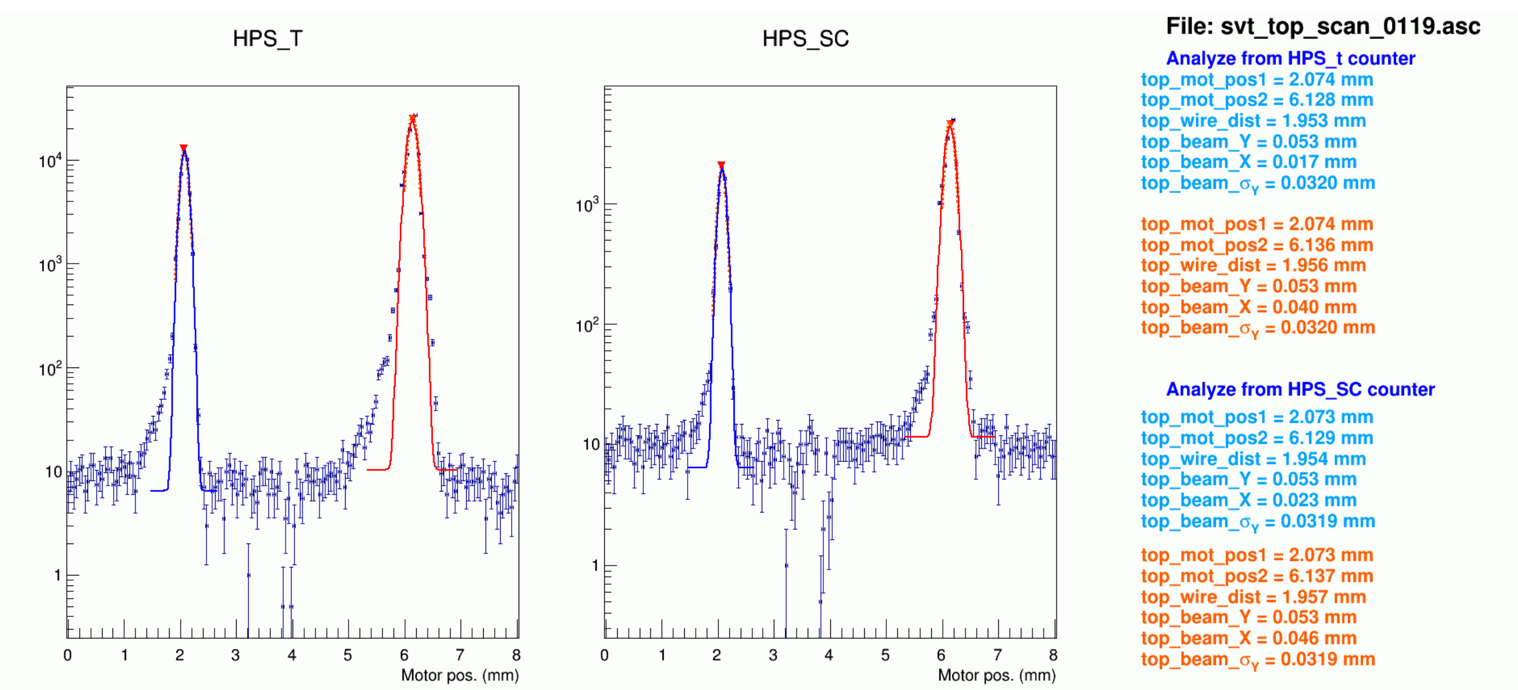
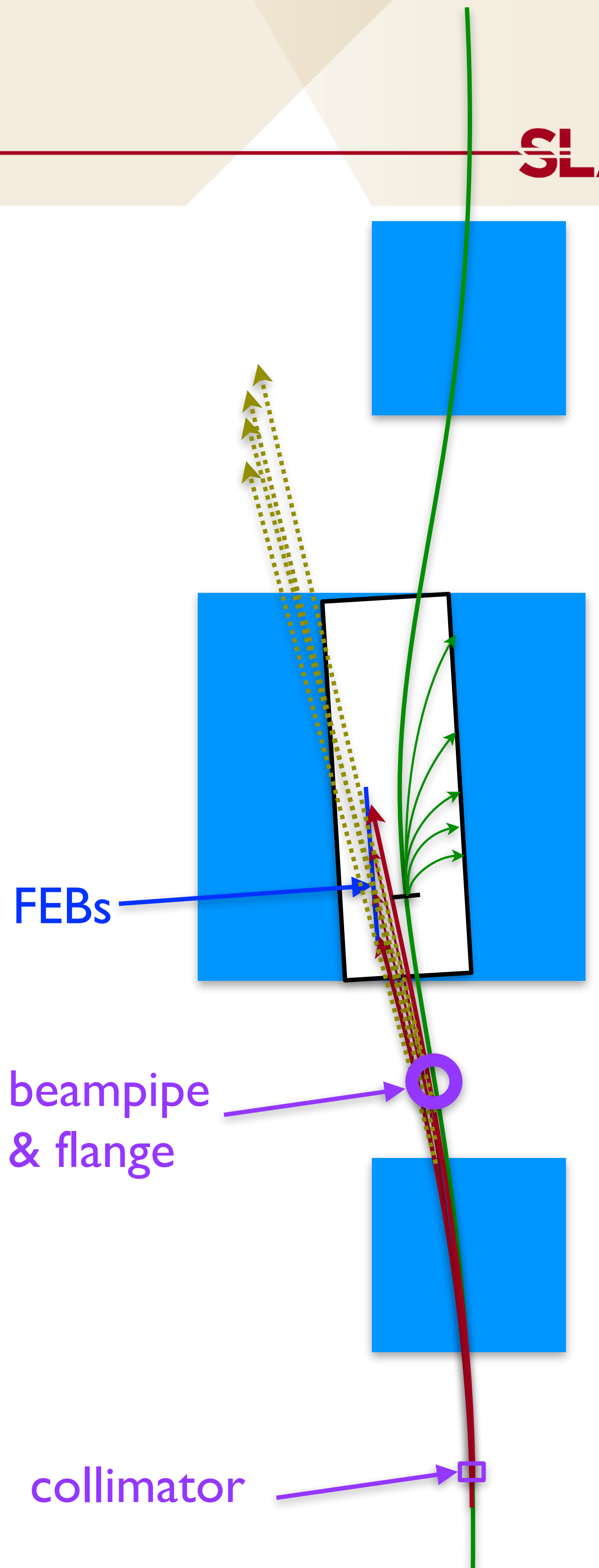
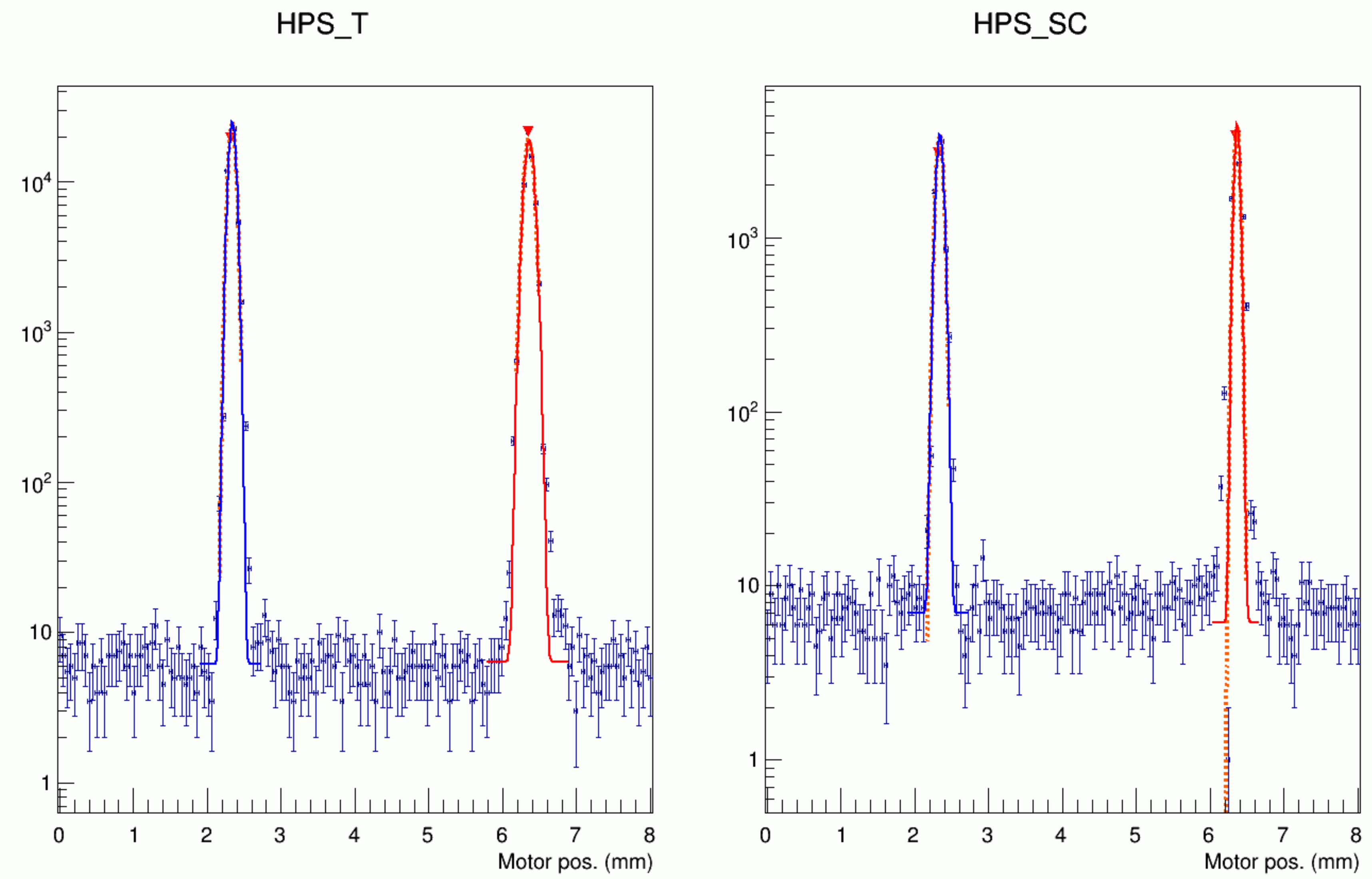




Beam Commissioning

However, when beam tuning successful, quality was excellent!!!



File: svt_top_scan_0143.asc

Analyze from HPS_t counter

top_mot_pos1 = 2.340 mm
top_mot_pos2 = 6.357 mm
top_wire_dist = 1.935 mm
top_beam_Y = -0.075 mm
top_beam_X = -0.099 mm
top_beam_σ_Y = 0.0221 mm

!!

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Analyze from HPS_SC counter

top_mot_pos1 = 2.340 mm
top_mot_pos2 = 6.363 mm
top_wire_dist = 1.938 mm
top_beam_Y = -0.075 mm
top_beam_X = -0.078 mm
top_beam_σ_Y = 0.0224 mm

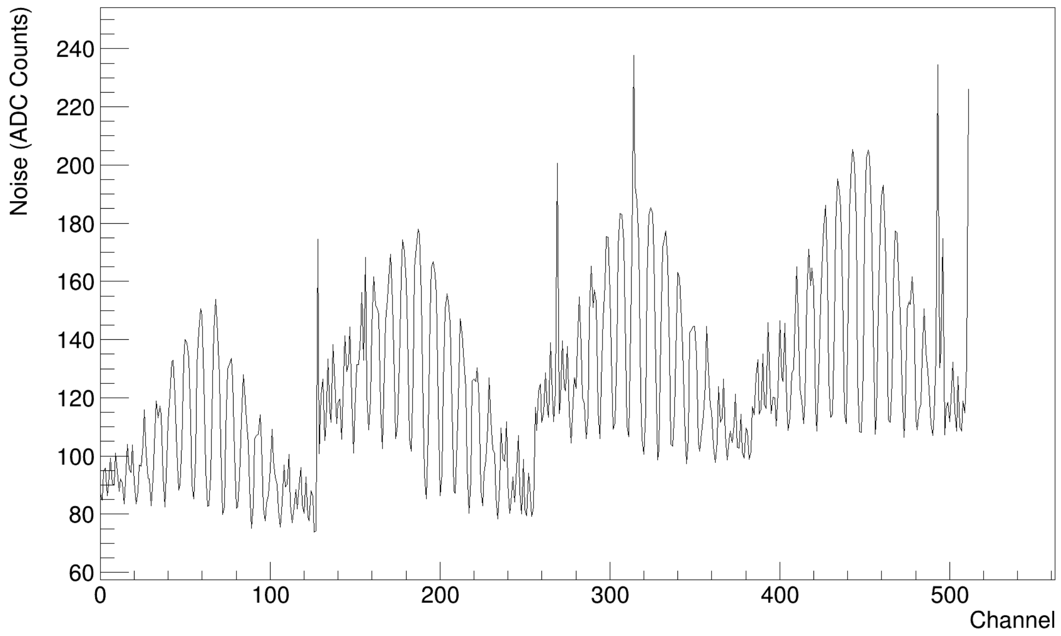
top_mot_pos1 = 2.339 mm
top_mot_pos2 = 6.364 mm
top_wire_dist = 1.938 mm
top_beam_Y = -0.075 mm
top_beam_X = -0.075 mm
top_beam_σ_Y = 0.0225 mm

With good beam, centered on SVT, tails were outside of the active silicon

Detector Commissioning

Early runs highlighted/uncovered other problems too

- livetime vs. trigger rates
- data throughput capacity
- sporadic sync errors / DAQ crashes
- simultaneous system-wide loss of sync
- higher than expected occupancies in all layers



- all modules on FEB8 suddenly become noisy, unless one (of four) is disabled. Then FEB5 (which coincidentally also had flaky hybrid after installation).

Learned in 2015 that FEBs experience data corruption even tuning to the tagger dump, 30 m upstream of the SVT, so FEBs always off during tuning.

- DAQ issues difficult to study while CEBAF struggling with beam.
- Pressure to take data prevents investigation during very brief periods (an hour here or there) of acceptable beam.

Power Outage and Aftermath

Major area-wide outage caused by equipment failure at nearby utility substation causes hours-long site-wide power outage

CEBAF loses cryo and damages relief valve: many days to repair and refill.

SVT DAQ takes advantage of downtime to resolve issues and do stress testing. Major improvements made:

- New JLab TI board modified to output high-quality clock signal. Huge improvement to overall DAQ stability
- New stability exposes problem with event header format which caused event building to crash when run exceeds 2^28 events: fixed, DAQ stable for many hours.
- Discovery that FEB degradation manifests as inadequate internal 5V supply which is sensitive to temperature. Lowering FEB cooling temps recovers entire SVT (including flaky hybrid in Layer 4).

Despite clever stress testing before TI board modification, unable to reproduce system-wide loss of sync observe with beam. Suspect there will be more to this story…

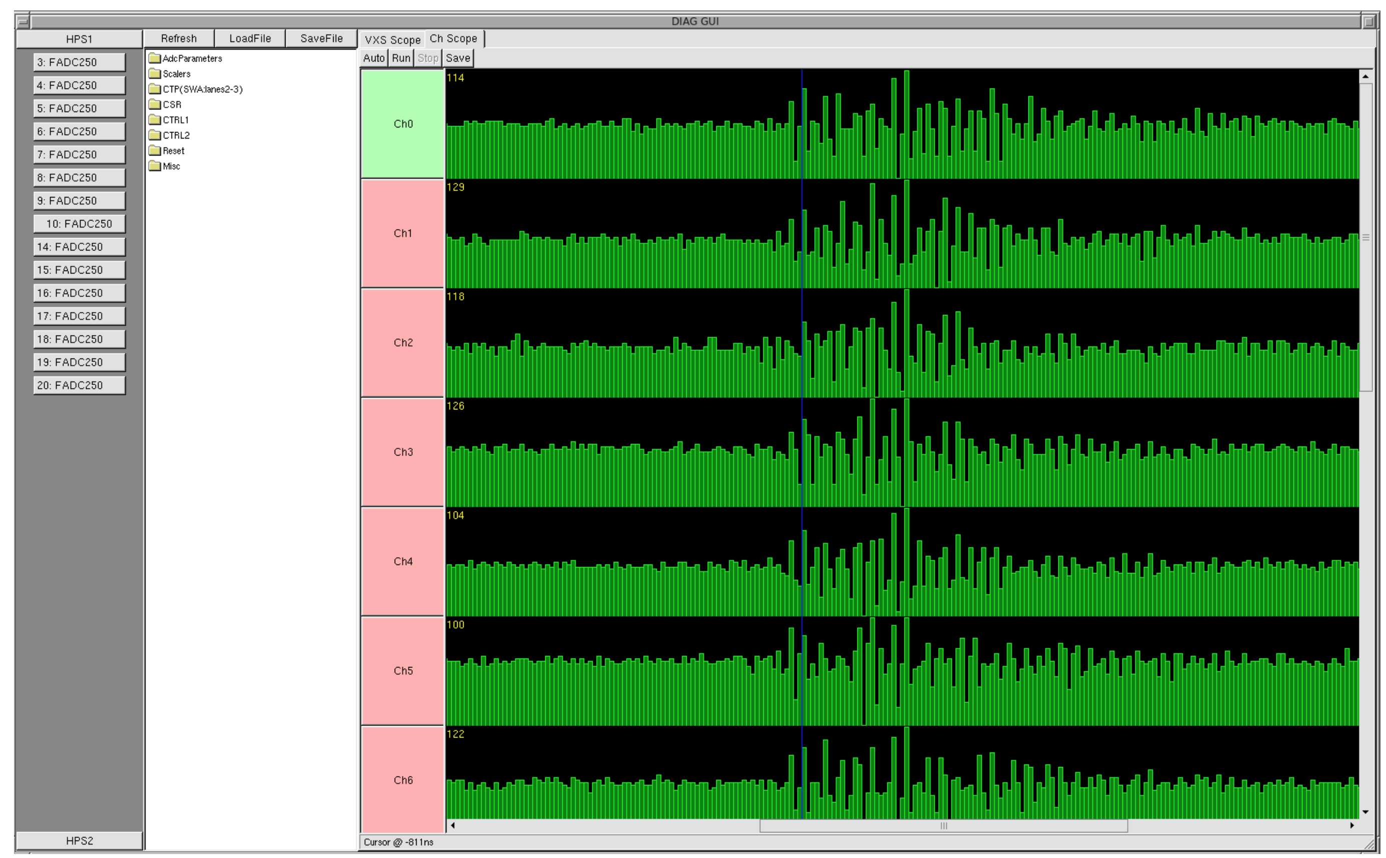
The Mystery of the Sparking Target

Within hours of first beam after power outage, system-wide loss of sync occurs regularly. With stable beam over several hours, real study is possible:

Sync is lost everywhere simultaneously, but DAQ does not crash, indicating system-wide, simultaneous interruption of communications.

Sync loss is not only regular, but periodic. Testing shows that…

- sync only lost with target in
- period depends on beam current (higher current = shorter period)
- period depends on position of SVT (closer to target = shorter period)

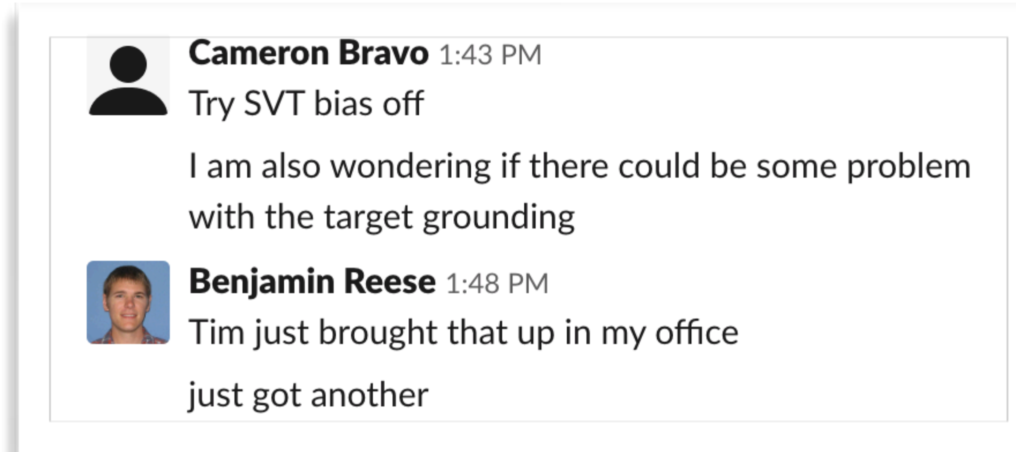


Radiation? But, no single-point failure can cause system-wide sync loss!

Then… observation of ECal FADC pulses coincident with sync loss

The Mystery of the Sparking Target

About 12 hours after first beam, two people with the same crazy thought achieve resonance…



- Using an SVT scan wire as a target, no "events" are seen.

- Pulses observed even when entire SVT is OFF $\Longrightarrow$ source is not inside the SVT!

- Opening the detector reveals a break in ground wire for the target.

Wire is re-connected and detector closed. Beam back within 8 hours.

Setting the SVT Straight

Also during first operations after the outage, there are signs of new inconsistency between the top/bottom SVT wire scans.

After the outage, they disagree at the level of ~0.3 mm: top and bottom "see" a greater distance to beam than during early scans.

In one instance, this leads to hitting a Layer 0 sensor with the beam!

We become convinced that something is wrong with the detector position, but can't account for what or how. Photos taken during target work are interesting, but not convincing.

Arriving at JLab, and talking to Clive, the pieces fall into place: the possibility that the magnet trip from the power outage somehow moved the SVT!

Quickly conclude that there is no choice but to open the detector again.

Setting the SVT Straight

Inside the vacuum chamber, carnage

- SVT box moved downstream ~7.5 mm
- Motion apparently limited by flex pivots
- Although eddy currents were certainly at work, seems likely vibration played a role.
- Tool fabricated to pull SVT back into place.
- Care taken not to alter flex pivot connections to target motors that would change opening position calibration of SVT

Turnaround ~18 hours.

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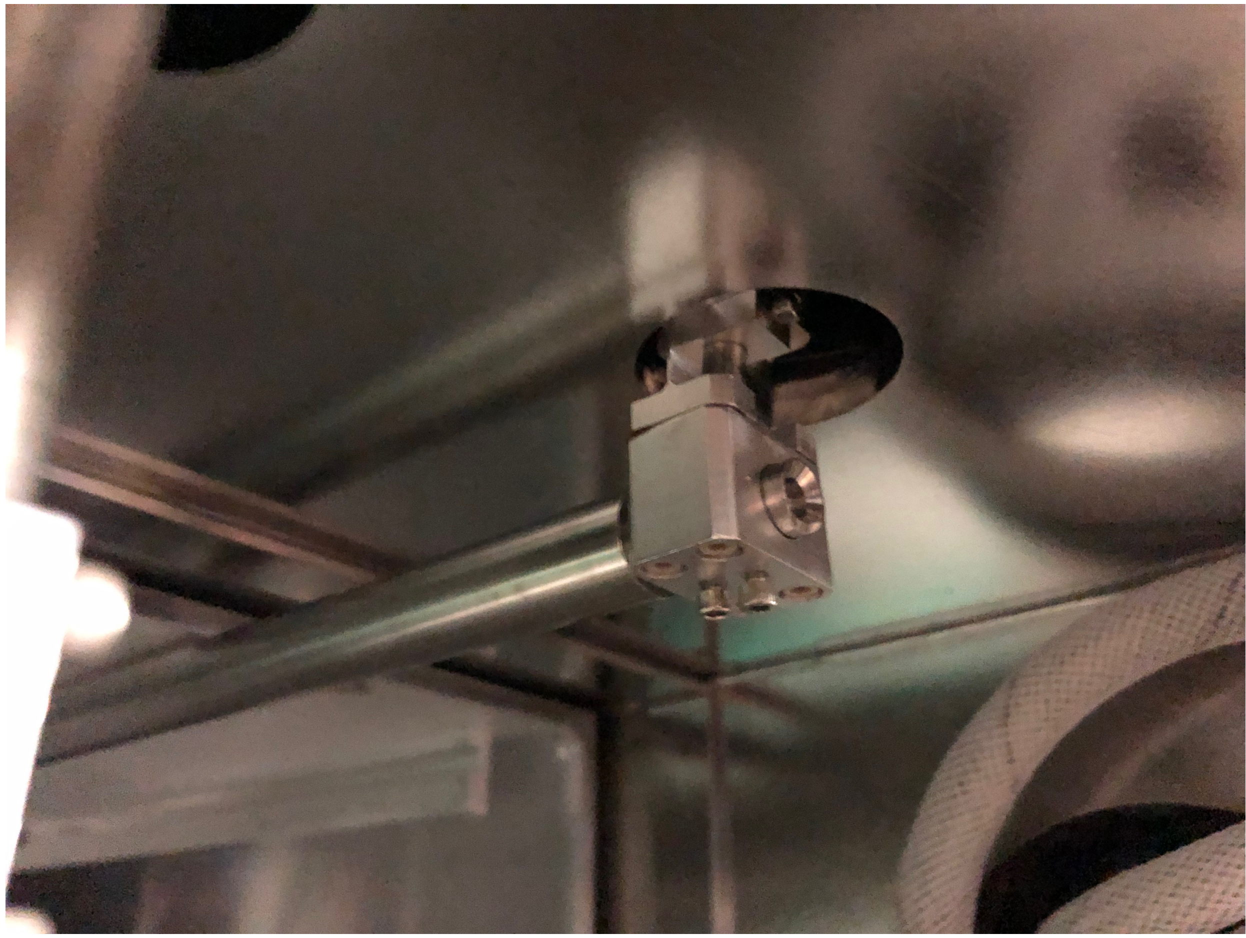

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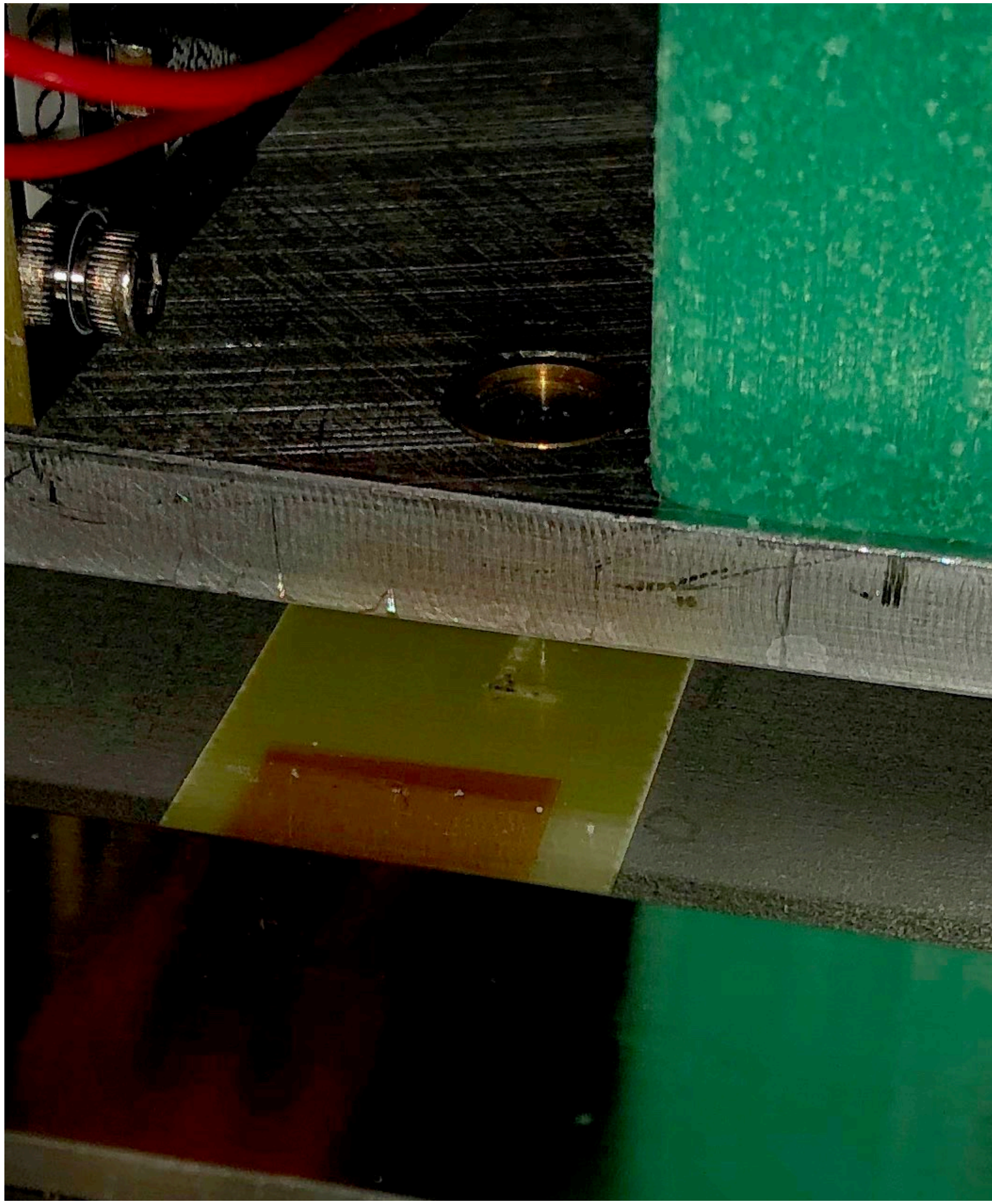

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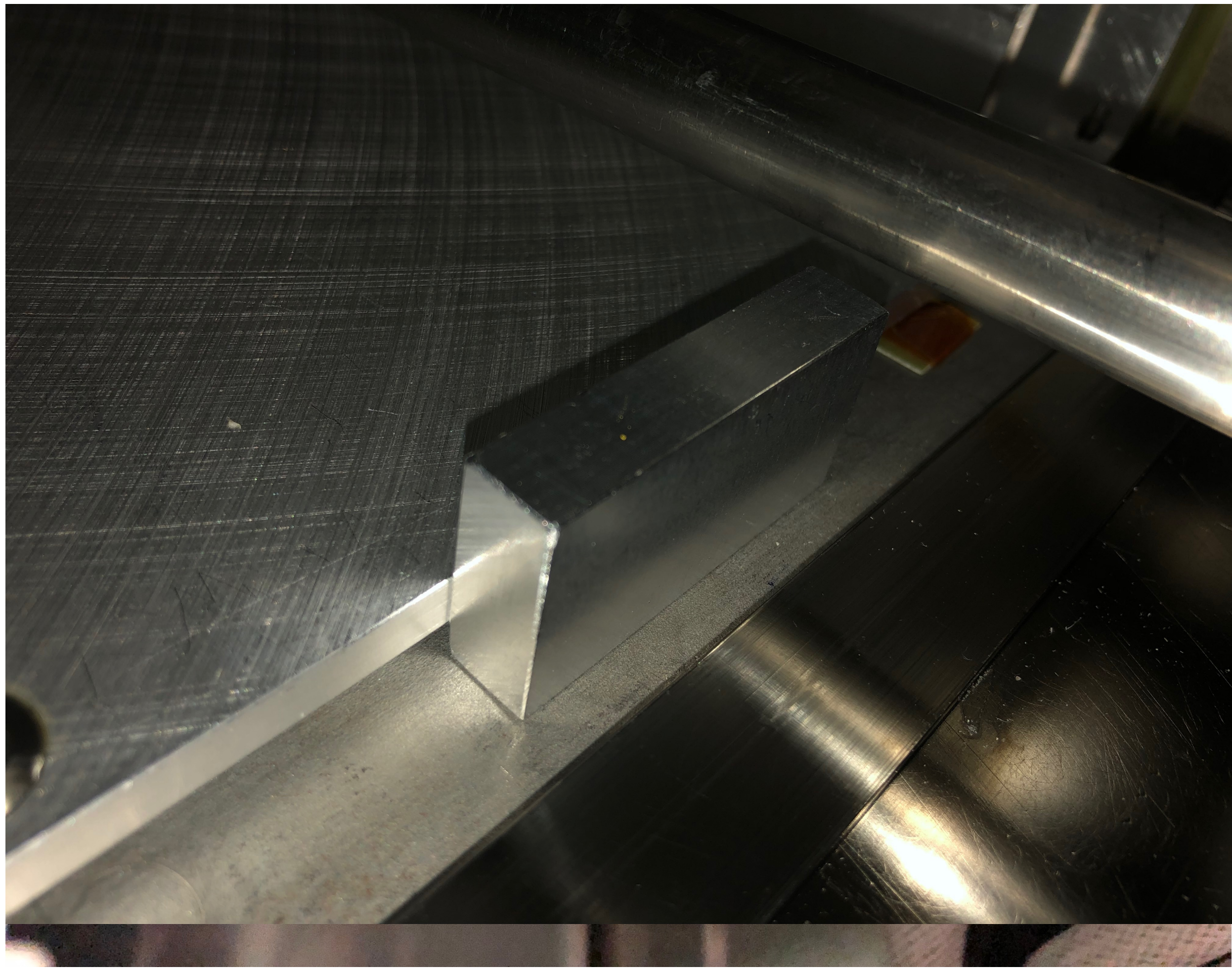

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Realizing FEB Degradation

SLAC

FEB degradation manifests as drooping 5V / 500 mA regulator, which supplies:

- 24 preamps for APV before ADCs (10 mA each)
- bias voltage for 12 regulators that supply voltages to the hybrids (5 mA each)

No current monitoring and voltage not exported to EPICs, but hand logging showed two devices degrading steadily. A third was seen to be affected at higher temperatures.

- With only 3/10 symptomatic, geographically diverse, numerology favors problem w/ current draw.
- Temperature sensitivity favors a regulator problem. (known susceptibility of LDO control/monitoring).

Damage required turning off L6T and second sensor in L4b.

F5, F8 - no triggers
=====
7/25: 5.0?, 4.2
7/26: 5.0?, 4.0
7/27 12:00: 4.85, 3.32
7/27 16:00: 4.85, 3.27

7/27 12:00 @23 kHz, 5.0, 4.0

7/27 16:30 @11.5kHz, 4.87 (one off), 3.54 (cannot operate 3 hybrids cleanly)
7/27 16:30 @23 kHz 4.85 (one off), 3.8 (barely operates, and then doesn't)

7/27 20:30 @ 11.5kHz, 4.94 (one off), 4.45 (two off)
7/27 21:00 @ 0kHz, 4.877 (one off), 4.240 (two off)
7/27 23:00 @ 11.5kHz, 4.95 (one off), 4.47 (two off)

7/28 11:00 @ 11.5 kHz, 4.97 (one off), 4.30 (two off)
7/28 11:00 @ 0 kHz, 4.88 (one off), 4.05 (two off)
7/28 13:00 @ 0 kHz, 4.90 (one off), 4.01 (two off)
7/28 15:00 @ 14 kHz, 4.97 (one off), 4.275 (two off)
7/28 15:20 @200 Hz 4.90, 3.98
7/28 15:20 @200 Hz 4.90, 3.98

7/28 17:00 @0 Hz 3.94, 4.90
7/28 17:00 @19kHz 4.98, 4.28
7/28 18:00 @15kHz 4.98, 4.25

F8, F5
=======
7/28 20:00 @0Hz 4.91, 3.89

7/29 15:30 @18kHz 4.99, 3.85
7/29 15:40 @200Hz 4.90, 3.41

7/30 15:30 @0 Hz 4.90, 4.00 (three off)
7/30 17:30 @ 0Hz 4.90, 3.96

7/31 12:50 @ 0Hz 4.90 (3.85 none off), 3.38 (4.46 all off)

Identifying FEB Damage Mechanism

Changes made to log ~3000 operational parameters of FEB to allow plotting of FEB5V.

Logging during operations demonstrated that degradation only occurred with beam

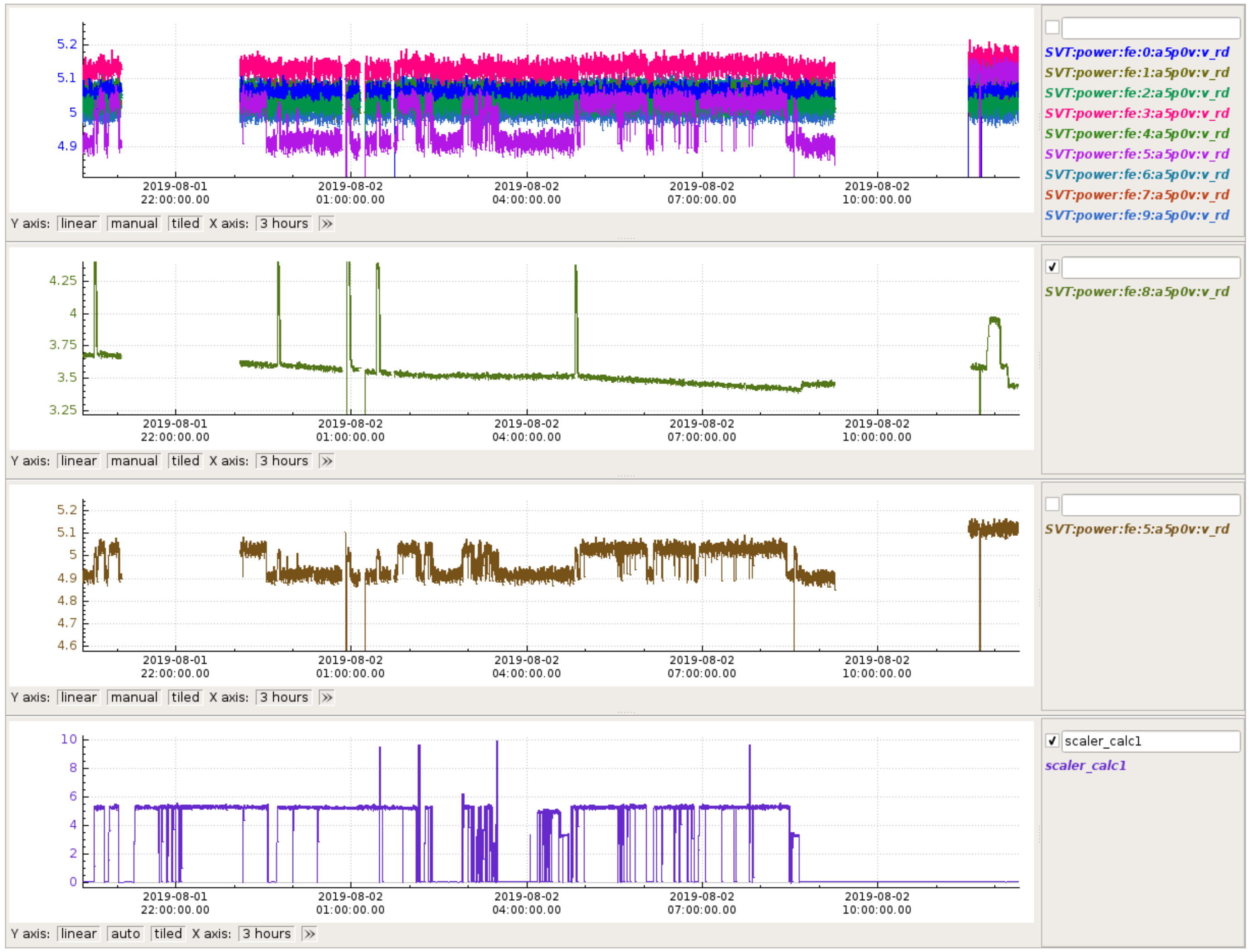
Then, during one tuning session, profound damage, corresponding to weeks at this rate.

Clearly radiation was responsible: radiation from target or elsewhere?

With next beam, requested 30 minutes of running with no target

When beam returned, there was no degradation when running with the target.

Still unclear exactly where scraping was taking place that was doing steady damage.



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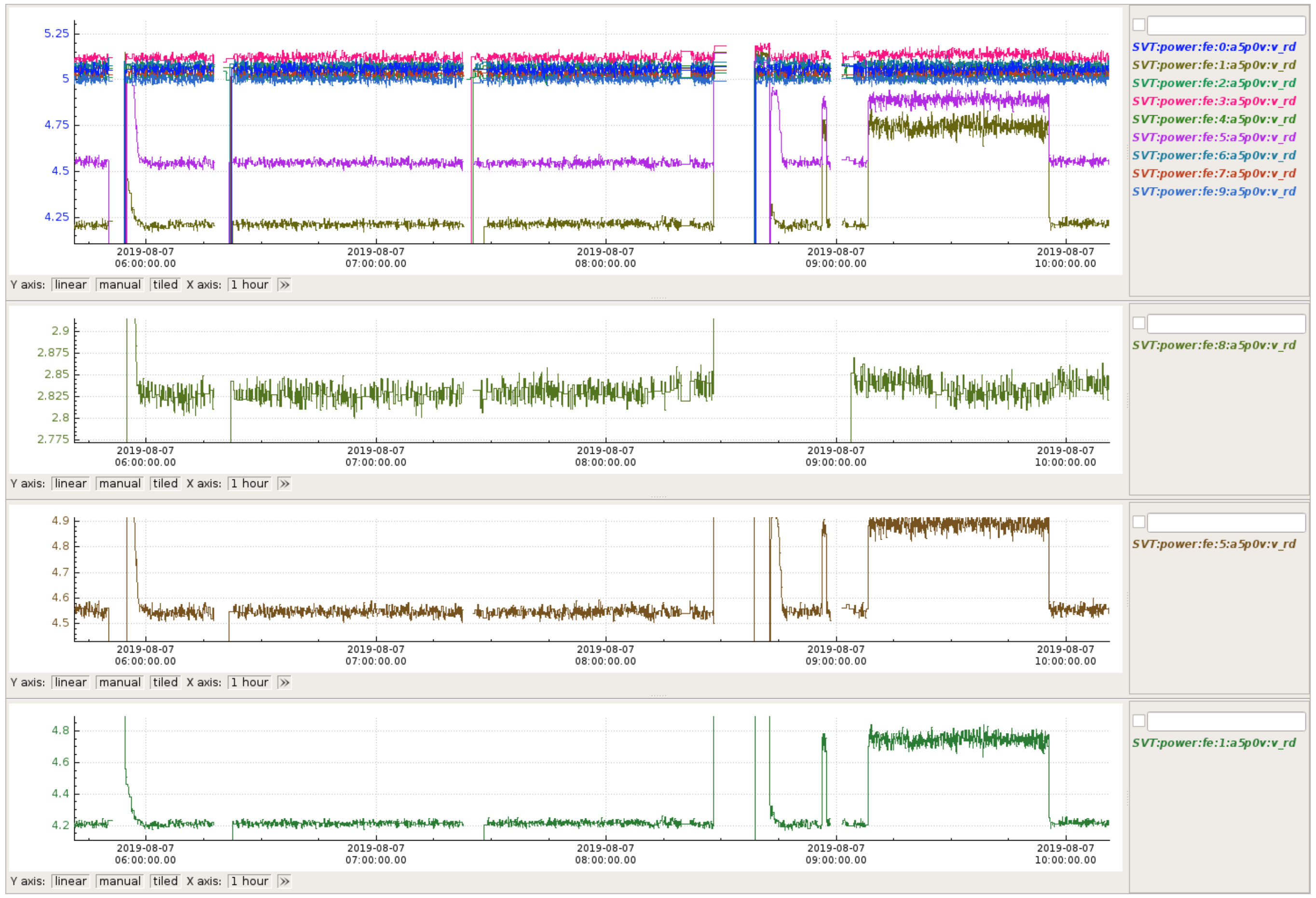

Managing FEB Degradation

A plan was developed to intervene and replace FEBs. However, given lack of perfect spares, better to complete the run if no more degradation.

- For the rest of the run, FEB5V carefully monitored.
- Little or no degradation for next three weeks.
- Some degradation after final Wien flip and beam tune.

Decision not to attempt replacements appears to have been sound.

FEB planning:
==========

1. FEB8 is gone
2. FEB5 holds at 4.90 with one off, but underlying capacity may be degrading

1. Rework only happens at SLAC
2. Rework requires diagnostic work at SLAC
3. opening and FEB removal - ~12 hrs
4. FEB installation - ~8 hours
5. FEB insertion

Non-invasive actions
1. Turn off ADC for F5.H3 (get more overhead)
2. Explore voltage spikes
3. Check 5V when FEBs warm
4. make FEBs colder

Invasive actions
1. Swap L0/1 F0/F1 assignment
2. Swap L4 F4/F5 assignment
3. Extract FEB8
4. Send FEB8 to SLAC to ID failing components
5. Replace FEB8?
6. Replace more?
7. Swap FEB9 somewhere?

=================================

FEB0 - holding, but critical
FEB1 - problem with H3. serious?
FEB5 - missing two sensors. One recoverable. H3 also?
FEB8 - fried

=================================

FEB replacement plan:
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Priorities:
1. Good data in L0/1 (FEB 0, FEB 1)
2. Good data in L4B (FEB 5)
3. Good data in L6T (FEB 8)

Materials:
1. SN 15 (perfect)
2. SN 10 (missing chip) - WHICH?
3. SN 9 (status unknown)
4. Thermal pad

Supplies:
1. Gloves (M or L)
2. Sleeves
3. Small parts boxes
4. VCR gaskets
5. Long 1/4″-20 screws (3) for neutron shielding
6. copper gasket for FEB cooling feedthrough
7. clean foil (for wrapping flanges
8. Thermal compound
9. zip ties (need more vac compatible ties?)
10. Kapton tape to mark SAS cables
11. Paper/pen and/or computer for recording information

Tools:
1. nut drivers (toolbox)
2. Thermal pad template
3. Caliper (for target measurement)
4. Target placement tool
5. FEB cooling plate feet

Workspace setup:
1. Table in front of vacuum box
2. Good lighting (big LED light hung up)

FEB plate removal process:
==================

- Warm up FEBs and SVT (1.0 hour)
- Measure FEB5V on way up
- Disconnect FEB cooling (0.25 hours)
- Open vacuum chamber (0.5 hours)
- Measure target position (0.5 hours)
- Remove target and store safely (0.25 hours)
- Remove neutron shielding (0.5 hours)
- Reconnect FEB cooling and set above dew point. (0.5 hours)
- Test F0.H3 / F1.H3 with FEB swap. Power only H3. (1.0 hour)
- Remove cable dressing ring (0.25 hours)
- Disconnect FEB power cables (0.25 hours)
- Disconnect L0-3 SAS cables and dress back to vacuum box (0.25 hours)
- Disconnect L0-3 from FEBs, set aside hardware. (0.25 hours)
- Move cooling plate for L4-6 disconnection. (0.25 hours)
- Disconnect L5 and L6 SAS cables and dress back to vacuum box. (0.
- Reconnect L4-6 LV supply
- Test F4.H3/F5.H3 swap. Power H3 only.
- Disconnect L4-6 LV supply
- Disconnect L4 SAS cables and dress to vacuum box
- Disconnect L4-6 from hybrids, set aside hardware.
- Dress mezzanines to SVT box.
- Remove FEB cooling plate

FEB plate rework - in hall but not alcove?
===============================

depends on test results and status of FEB9

Scenario 1 - Replace FEB1, FEB5 and FEB8
- SN15 in FEB1
- SN10/SN9 in FEB5/FEB8

Scenario 2 - Replace/shuffle FEB0, FEB1, FEB5 and FEB8
- SN15 in FEB0
- Leave FEB1? Replace with SN9 if perfect?
- SN10/SN9 in FEB5/FEB8

or...

- SN15 to FEB1
- SN9 to FEB0?
- FEB5 to FEB8
- SN10 in FEB5

or?

Extra considerations:
=================

Module replacement of F0.H3?

FEB plate testing:
=============

1. spare L4-6 module
2. LV supplies
3. HV supply
4. spare data flange
5. LV mezzanine cable
6. HV mezzanine cable
7. spare SAS cable
8. spare L4-6 hybrid cable

Managing Surface Currents

As in previous runs, observed large surface currents from ionizing radiation (x-rays) from target

Due to some combination of proximity to beam and sensitivity of sensor technology, these currents were higher than in previous runs (5-10 uA instead of 2-3 uA).

To mitigate risk of damage from high-current breakdown, we imposed a limit of 10 uA on L0 surface currents.

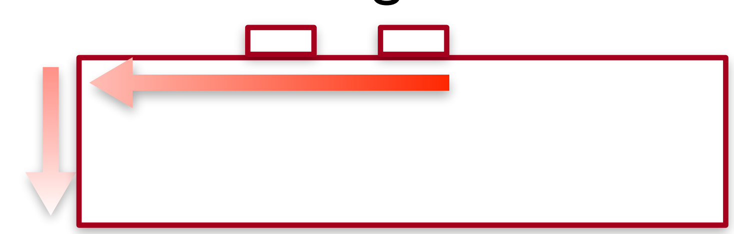
Required ~10 minute break - beam and HV off - every few hours if no other long trips to allow surface charge density to dissipate.

Ultimately, decided to replace target to allow operation with lower currents since only x-ray generation from back of a thicker target escapes the back side.

conventional sensor

potential decreases between guard and edge

slim-edge sensor



potential decreases between guard and backside (including edge)

Broken Wirebonds

Various theories have been advanced for wirebond damage, but it has correlated with changes in temperature and/or vacuum.

We were very rough on the SVT in both respects during this run

Not surprisingly, we observed the same effect again: some broken wirebonds, mostly in places not critical for physics

- in middle and at chip edges in back side of Layer 6
- at outer edge of 1 or two specific Layer 2 sensors

The similarity with the previous pattern is remarkable. Given the symmetries in the design, especially difficult to understand the specificity to the damaged locations in Layer 2.

Low-charge Hits (AKA Monster Events)

SLAC

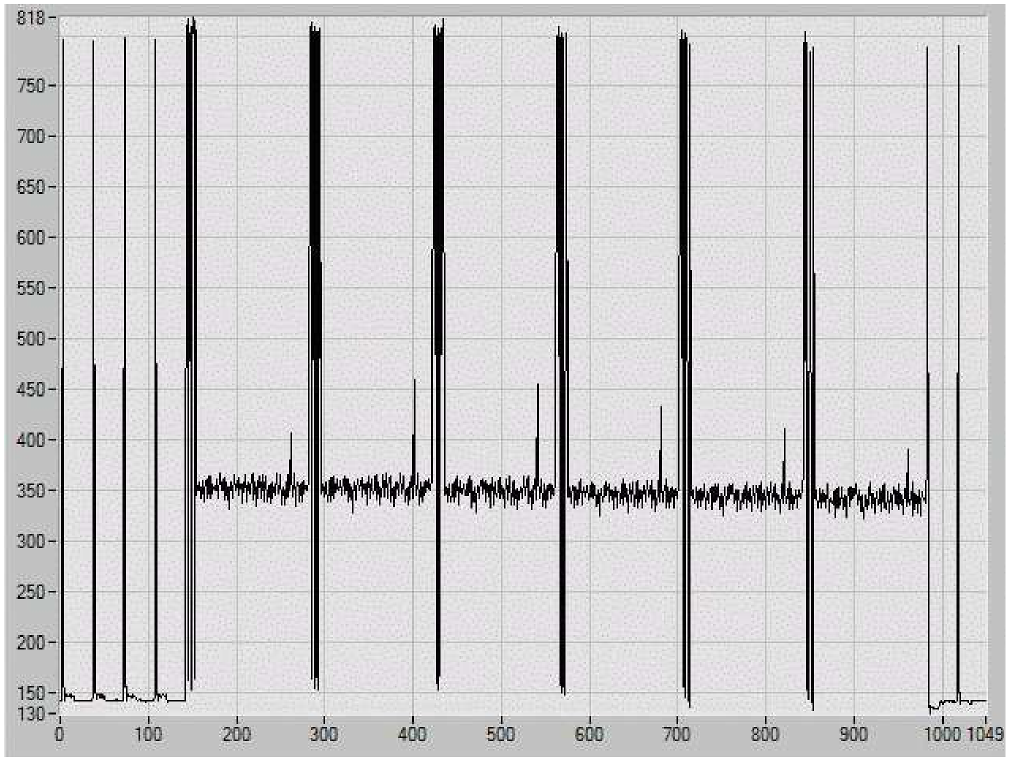
As in previous runs, reading out stacked triggers - necessary at high trigger rates - gives rise to events with large number of low-charge hits.

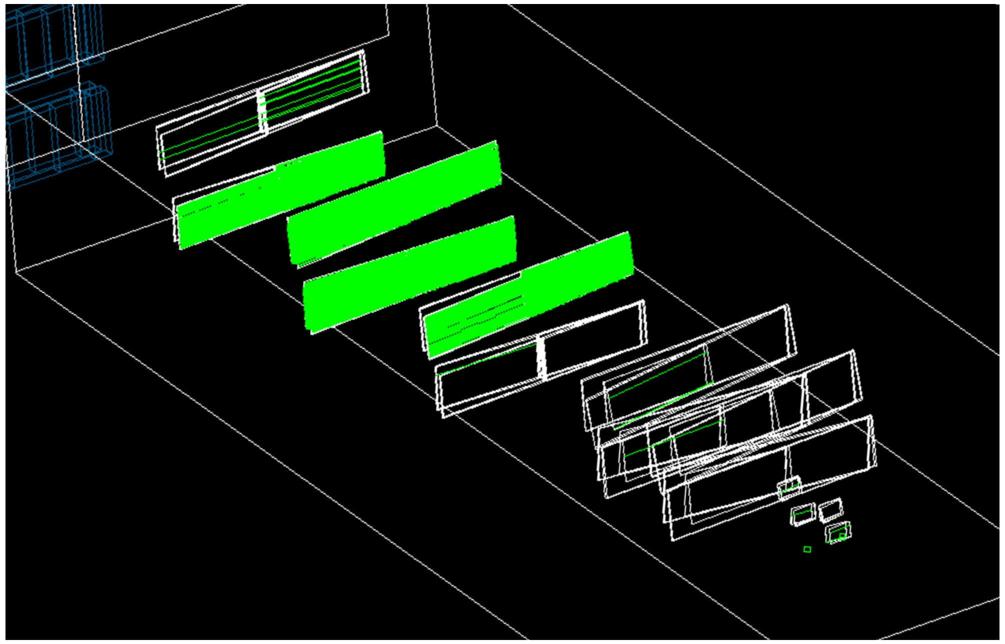
Coming at it from a different angle — per event occupancy rather than hit amplitude — these get renamed "Monster Events"

One new observation: the rate at which readout header noise noise produces a large number of low-charge hits varies from device to device.

Not clear whether this relates the specific bit pattern in the header or differences in intrinsic noise (lower noise devices have lower absolute thresholds).

Previously, we have simply filtered out these events - a few percent in 2016.





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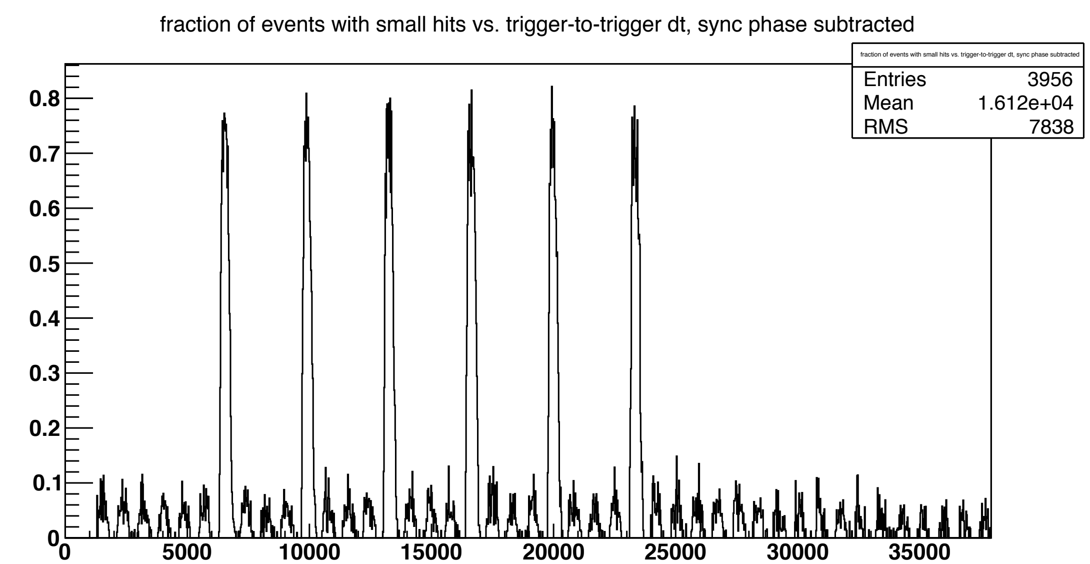
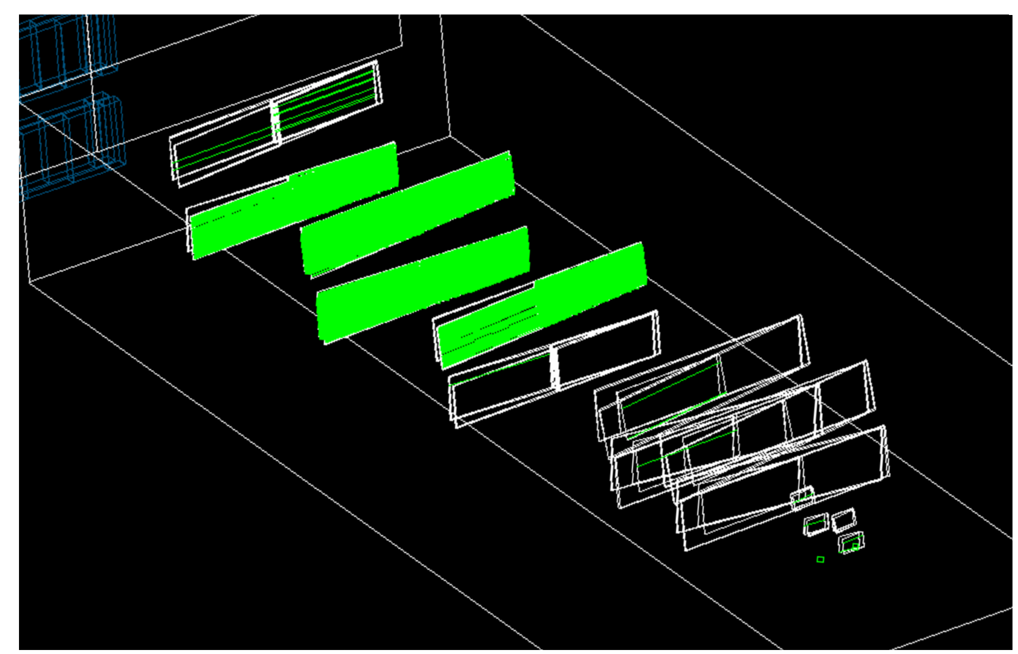


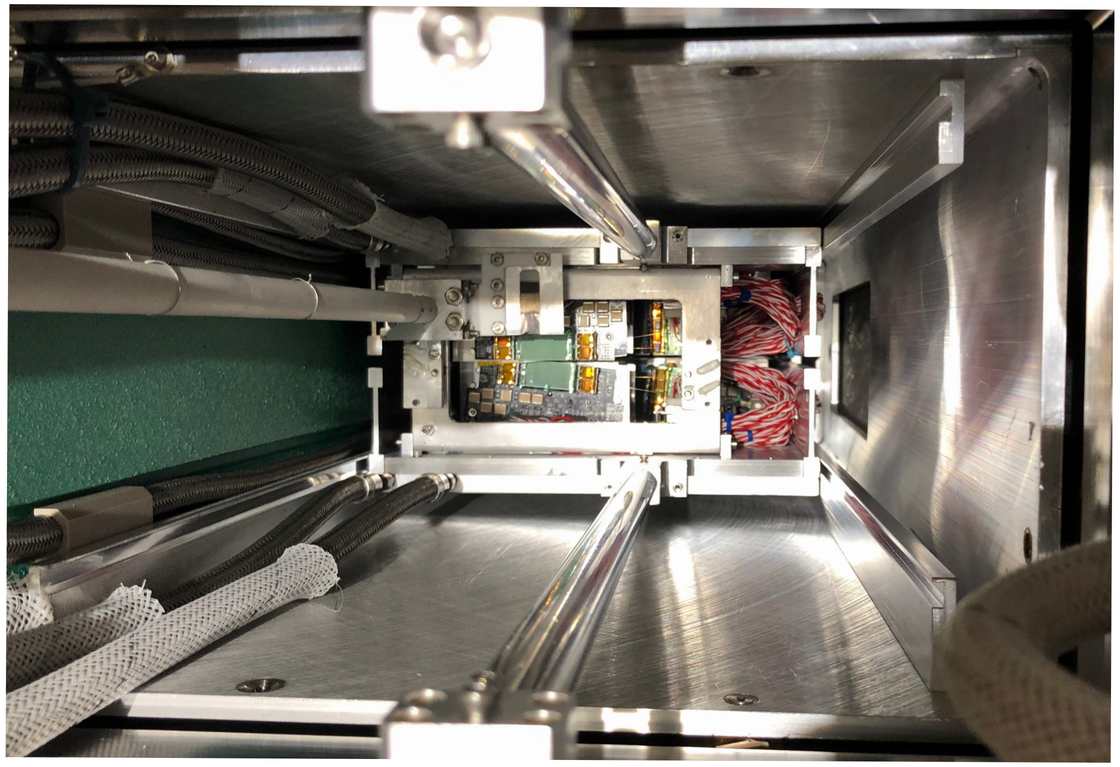


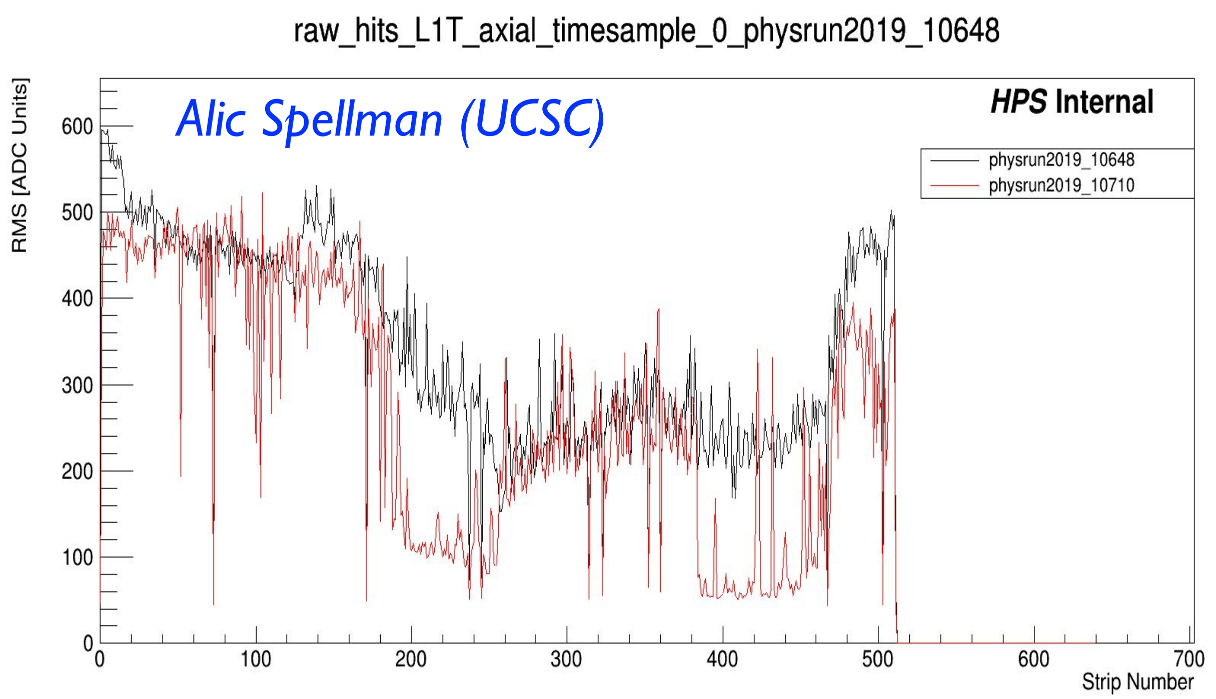
Damage to L0/L1 Modules

HV trips in the SVT have been rare, but not unheard of in previous runs.

- On a few specific days, experienced a large number of HV trips in Layers 0/1.
- No obvious problems with beam, but was unusual activity /tuning for other halls
- On one occasion, a section of channels damaged in Layer 0, mostly outside acceptance.
- Late in the run (during straight-throughs?), a Layer 1 sensor also damaged.

Mechanism not well understood — will need access to modules to determine whether similar to damage observed in beam tests at SLAC





SVT Chiller Issues

Fluid loss from the SVT cooling system (uses highly volatile HFE7500):

- Loss rate decreased by factor of three after testing and attempts to make tighter connections.
- For operations at -10C and above, switched from HFE7000 to lower-volatility HFE7500: no significant change in loss.

➡ Solution was just to pour in more coolant. (thanks Stepan!)

The chiller — always somewhat temperamental — became much more so. Radiation in alcove seemed to aggravate instability.

- Early in the run, the SVT chiller tripped roughly once daily.
- After similar problems with the ECal chiller, both were moved upstream which appeared to improve reliability.

➡ We got better at quick recovery after trips.

These interruptions cost us ~1-2 hours/week of data: problem should be addressed

Back End DAQ

After a slow start, very few problems with the off-detector DAQ

Most disruptive issues with the DAQ stemmed from the problems with the FEBs: some FEBs / FEB channels were fussy to bring up.
$\Longrightarrow$ *starting up the DAQ after tuning remained a task for experts.*

The other issue requiring attention was improving the performance of copying SVT data during event building to increase livetime at high trigger rates
$\Longrightarrow$ *addressed with optimization of the event building code*

In the end, we ran at higher trigger rates than we ever had before over relatively long periods and without hiccups.

Post Assessment of SVT Condition

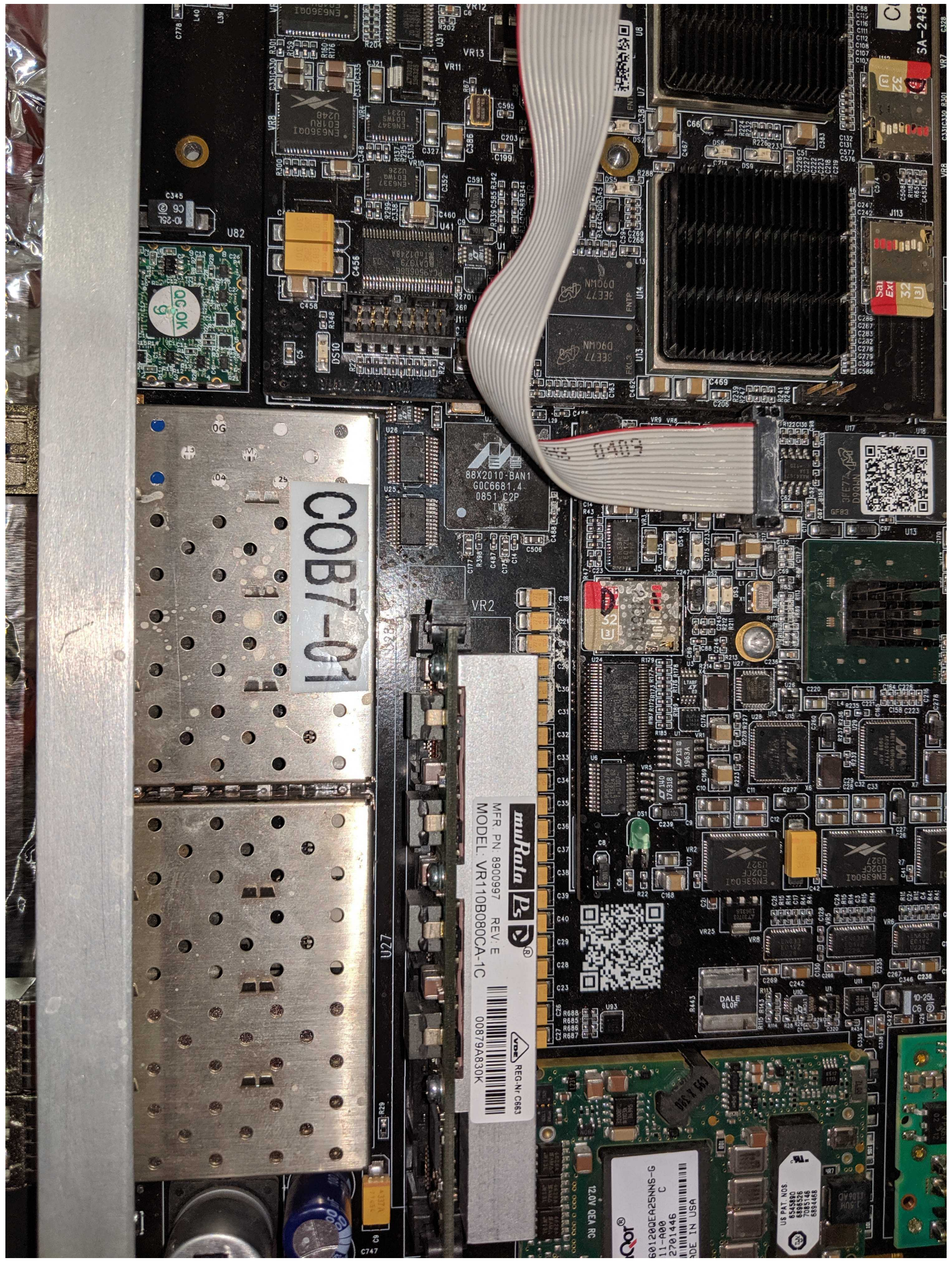
IV/breakdown tests after the run indicate that L0/L1 have suffered enough damage that they should be replaced.

FEB/hybrid testing with cable swaps determined that with the exception of the "flaky L4b hybrid" all problems with on-detector DAQ are in the FEBs.

Some installation-related damage to cables observed that could explain flaky L4b hybrid, but needs closer investigation to determine the problem.

The FEB cooling plate was removed and shipped back to SLAC for diagnostics.

One of the COBs has large water spots, probably condensation from temporary cooling installed in the rack. COBs also removed for return to SLAC, where they will be needed for testing.



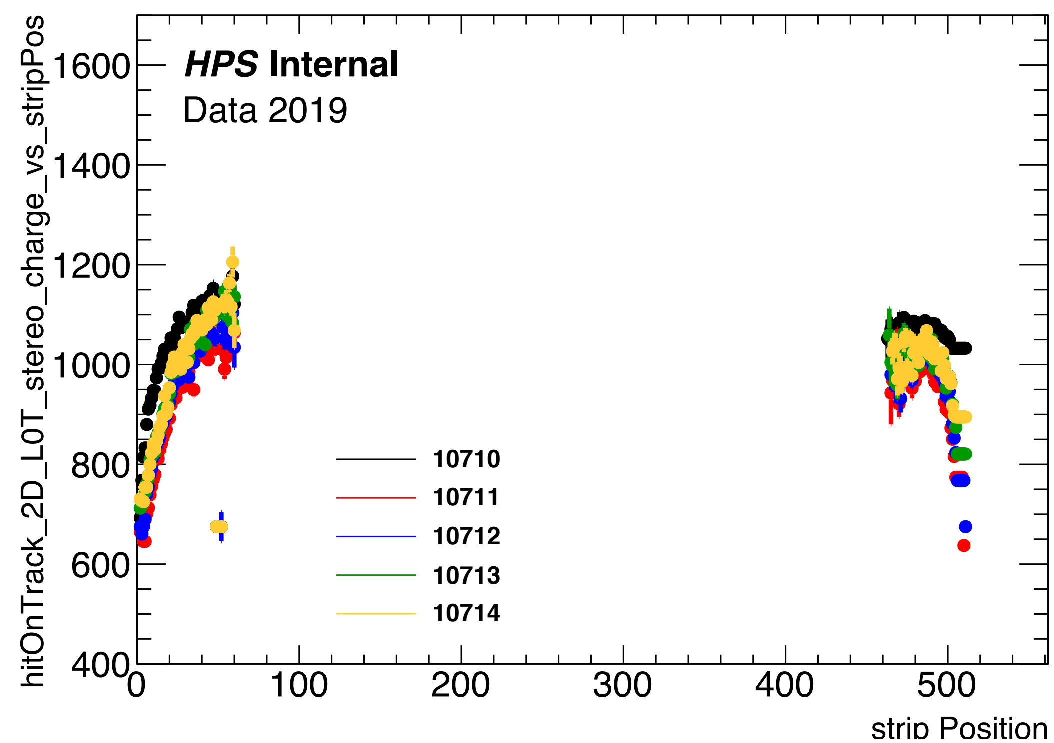
Low-level Data Integrity Checks

Checks of the data are ongoing

Analysis of bias scans at end of run suggest that charge loss from radiation damage was minimal.

Pierfrancesco Butti

Run	Lumi	L0/1 V
10710	120A 8um	60
17011	120A 20um	40
17012	120A 20um	50
17013	120A 20um	60
17014	120A 20um	70

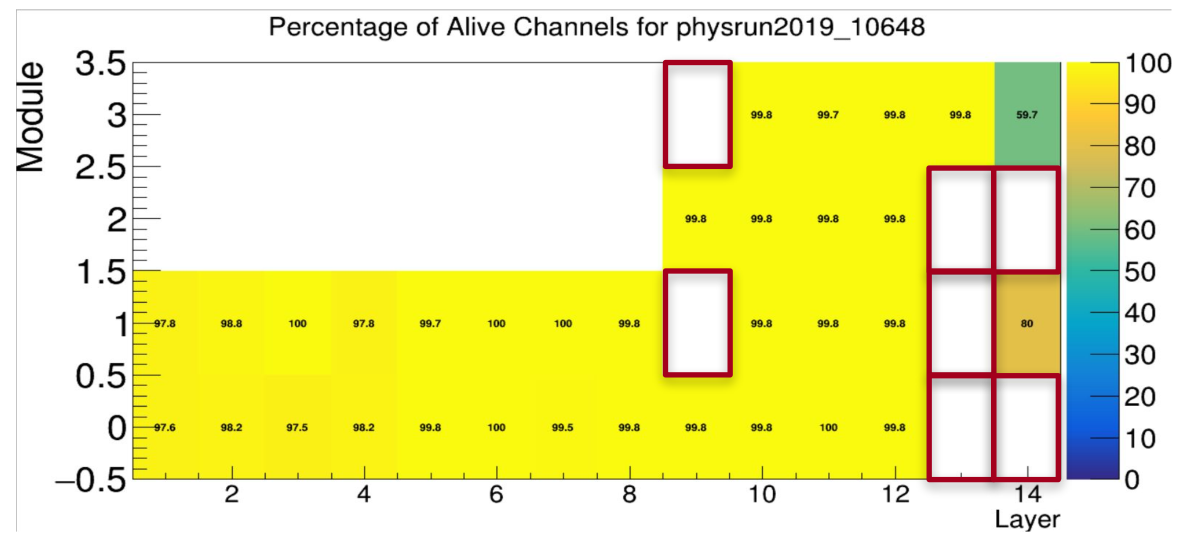


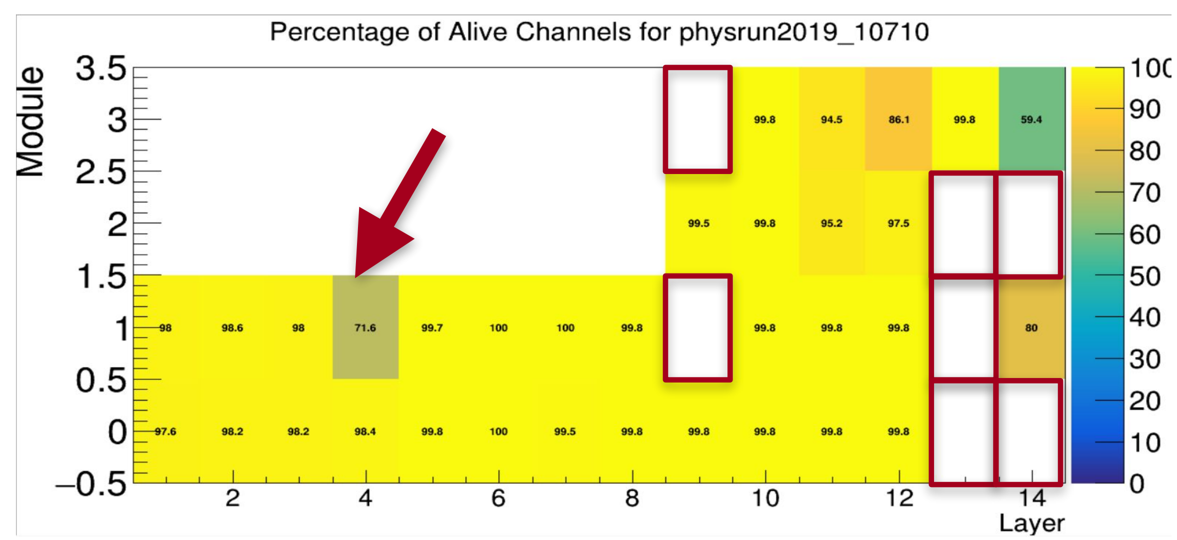
Low-level Data Integrity Checks

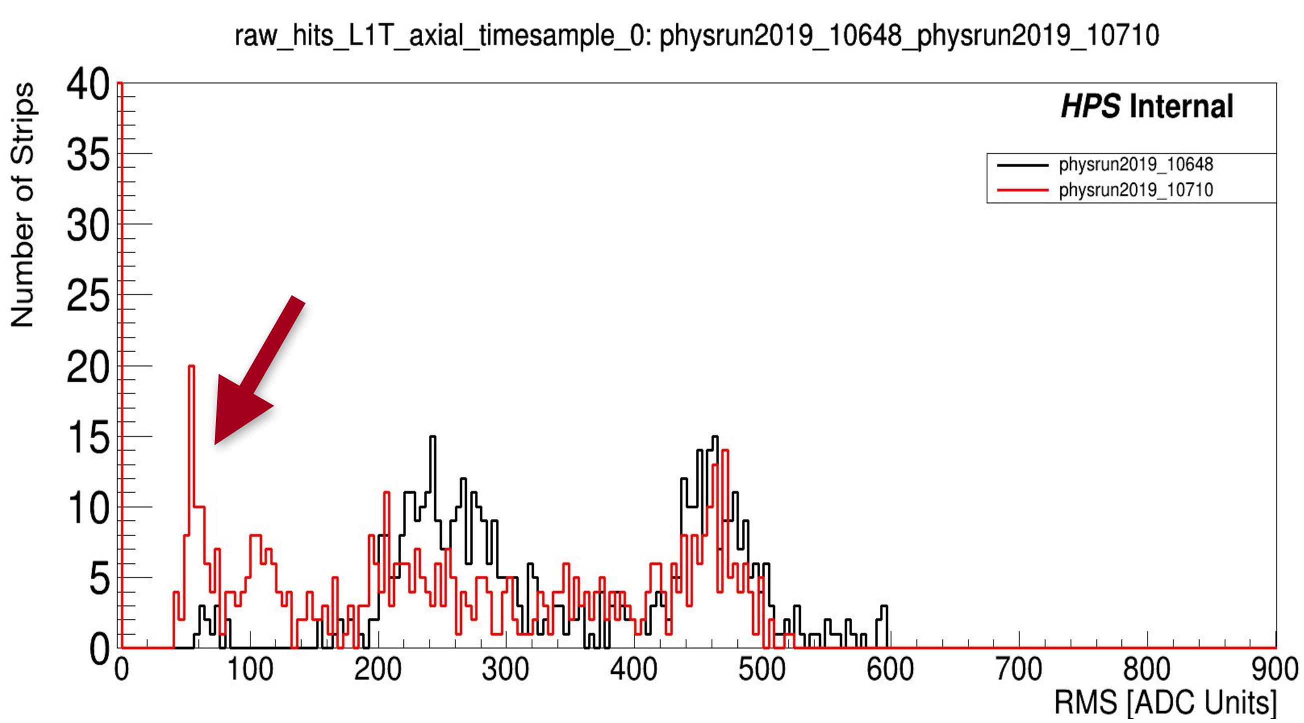
Checks of the data are ongoing

Tools a being developed to crawl the data and identify bad channels on a run-by-run basis.

Alic Spellman (UCSC)

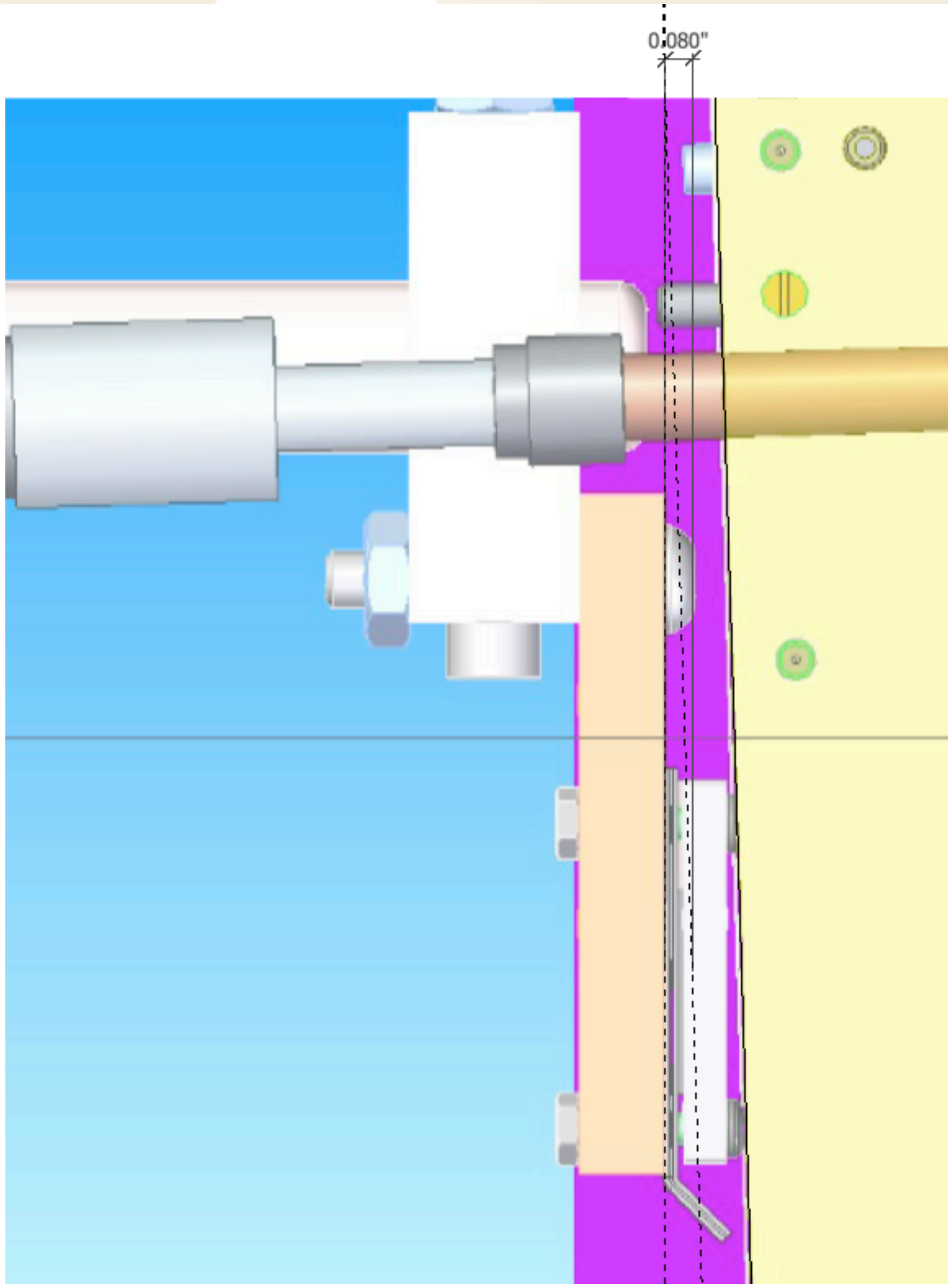






SVT Position 2016

With 2016 data, offline alignment produced z_{target} = -4.3 mm.



This had been a mystery as hand measurements — together with information from drawings — were roughly consistent with z=0.

During installation I *measured* the key components. When I got around to checking against the drawings, I found…

- *that the as-built target assembly does not match the drawings.*
- *that the target assembly was (inexplicably) designed to be aligned with the magnet axis, instead of the beam axis at the target — makes measuring target position by hand very tricky*

When I finally got around to estimating the effect of this, I put the following into Google for distance to L1:

(3.13 + 5/16 - 0.502 - .140 + 1.23 + 0.080) inches in mm = 104.41 mm

mystery finally solved: a triumph of following the data!

SVT Position 2019

After manipulating the SVT box during installation, similar hand measurements produced the estimate target = -5.1 mm

After repositioning the SVT box post power outage, similar hand meaurements indicated that the SVT box was still about 0.1” = 2.54 mm downstream of where it was when we installed.

Comparison of pre/post run JLab surveys of the SVT box measure this shift to be 2.71 mm — pretty good agreement.

We can expect the target to be at approximately -7.8 mm give or take a hundred microns or so. Understand this is roughly consistent with data.

One effect of this: our angular acceptance will be better than what we designed, about 12.5 mrad instead of 15 mrad: Good for physics, bad for the detector (30-50% occupancy increase is expected, along with more radiation.)

Planning for SVT Repairs

SLAC

FEB Status:

- 15 built, 10 needed. After replacements during installation no perfect spares.
- 3 now show symptoms of damage in 5V supply
- 1 has some kind of damage to V125 control for one hybrid
- other evidence for damage to ADCs (e.g. bad temperature data)

Repair or replace?

Repairing these complex boards has proven to be a time sink. time = $

Turnkey quote for 10 new FEBs is $26K + a few parts and additional labor - call it $3K each: equivalent to 1.5 days of AIRENG (2.5 days of AIRTECH).

Labor costs for repair likely exceed M&S for new boards by a large factor.

Given historical problems with these boards, likely that there were initial quality problems (cracked vias) that a new spin is likely to solve.

Replacement allows opportunity to make design more robust against failure modes.

Need to assess damaged boards and develop design changes - hopefully minimal.

Planning for SVT Repairs

SLAC

Module Status

- Layer 0/1 modules no longer hold bias voltage for operation to much higher radiation doses. A limited supply of sensors and use in Layer 1 means only a single spare module is available.
- Minor damage to Layer 2-3 modules may not require replacement, but spares exist.
- Wirebond damage to Layer 4-6 modules probably motivates some swaps, but may not be possible to make Layer 6 perfect again. Not a big deal

Building more Layer 0/1 modules

- Hybrids and components are easy and relatively inexpensive
- Plenty of spare support structures
- Assembly infrastructure still in place.
- Sensors will be less expensive - can address quality issues with new run…
- *… But, there is a long sensor lead time to consider - must begin soon!*

Planning for SVT Repairs

Other things to consider:

SVT chiller has become very grumpy, possibly leaking somewhere.
$\Longrightarrow$ Chiller needs to be removed to EEL for service.

FEBs can be fully tested at SLAC but the rest of the SVT needs testing and repairs also.
$\Longrightarrow$ SVT will also need to be removed to EEL for testing and repairs, including the DAQ, power supplies, and cable plant.

With the entire system back in the EEL, we can arrive at Hall B next time with a fresh and fully tested SVT to install.

Summary and Outlook

I’ve had some rough rides over the years of building and operating silicon trackers. This was the roughest.

We persevered and got precious data.

We broke some stuff that will need to be fixed to run again. Figuring out how to make that happen is a top priority.

“Money and effort that would go into an overly conservative design might better be used elsewhere.... A major component that works reliably right off the bat is, in one sense, a failure — it is over-designed.”
- Robert Wilson

“Fermi is reported to have said that the perfect experiment falls apart right on completion of data taking (otherwise it was overdesigned). At least he’d approve.”

“Yes, there have been a lot of problems, but you never know when the current problem will be the last problem.”
- John Jaros