

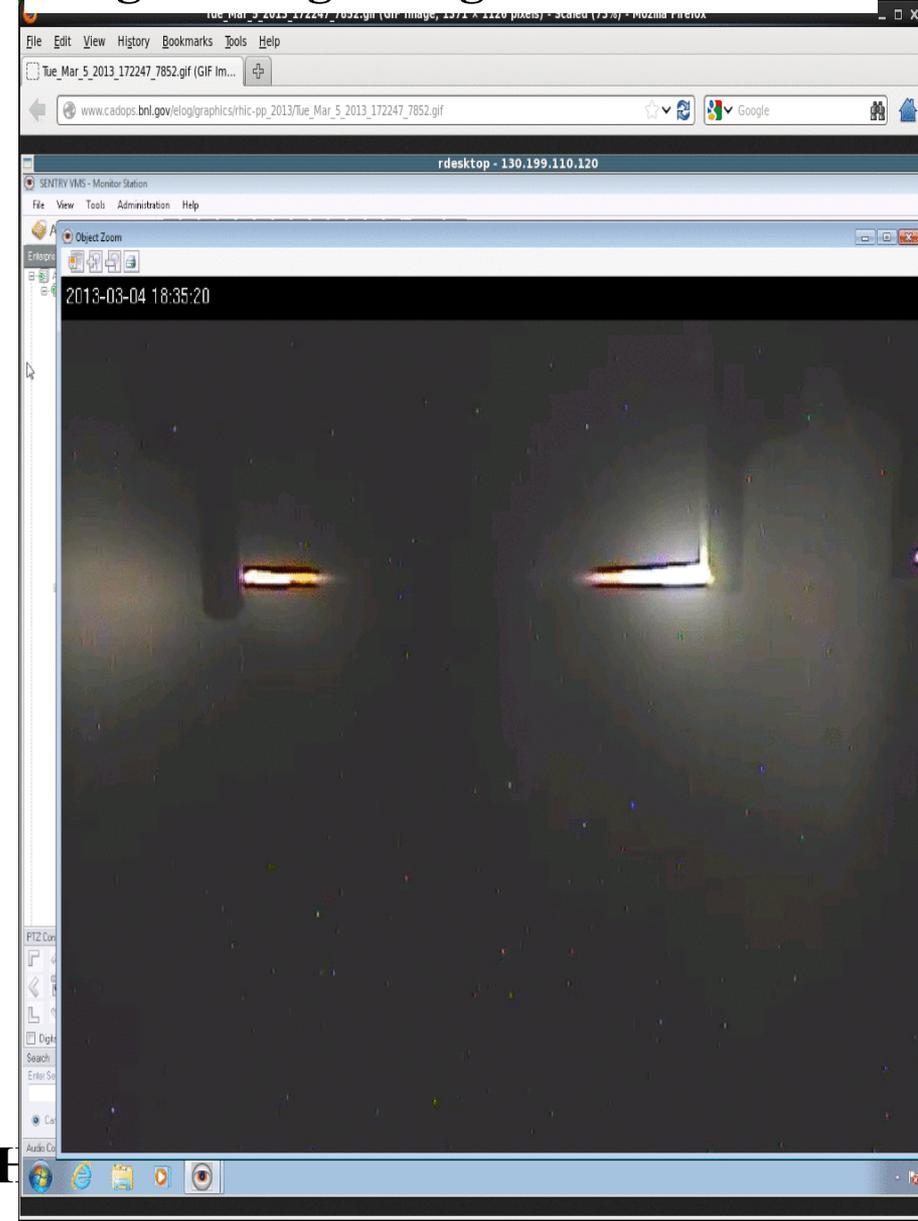
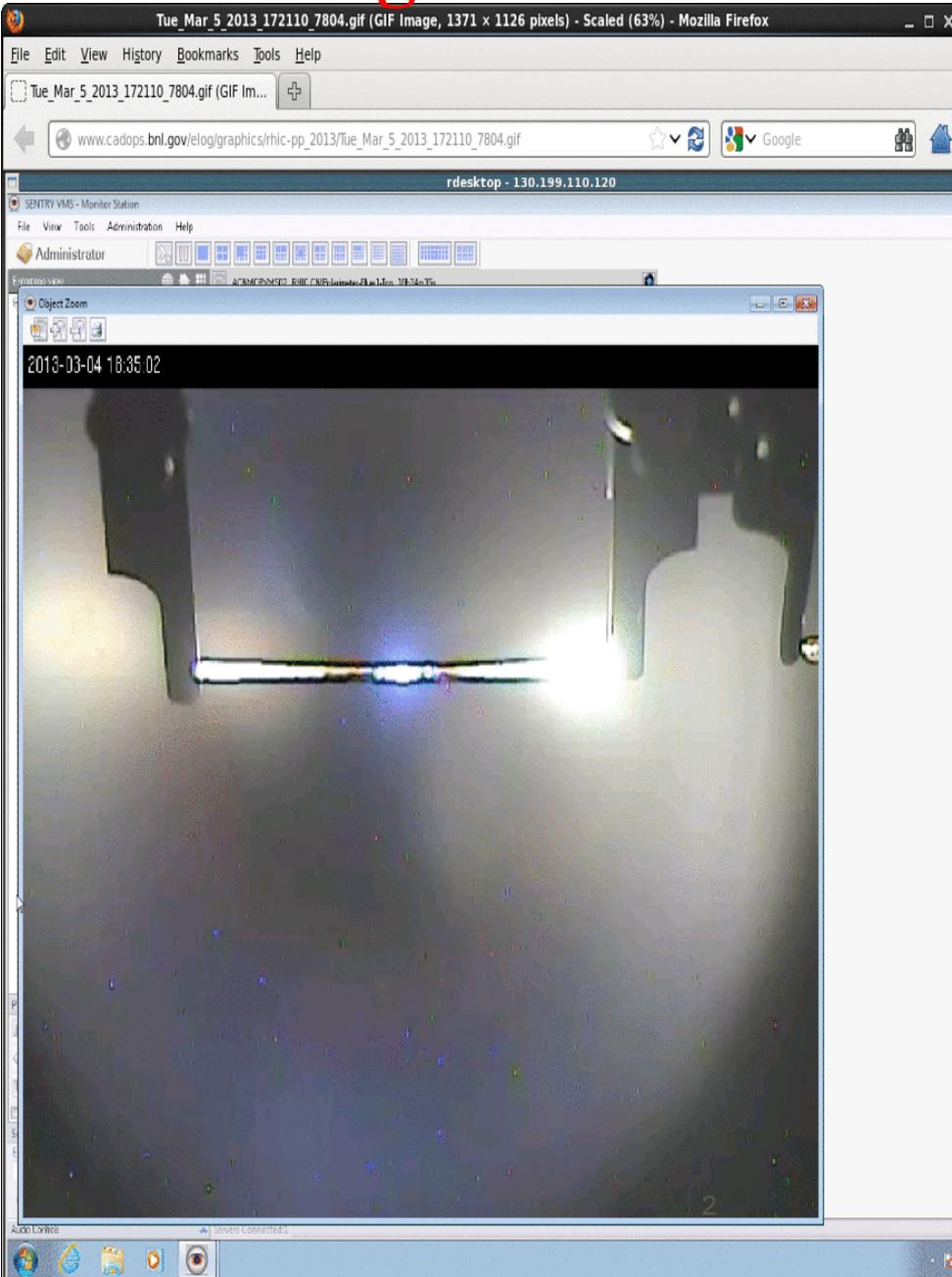
RHIC Polarimeter Target Frame Test

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T. Tsang, A. Zelenski

August 6, 2014
Polarimeter Group Meeting

B1H1 Target in Proton Beam Last Run

Target tails glowing when off beam



Motivation

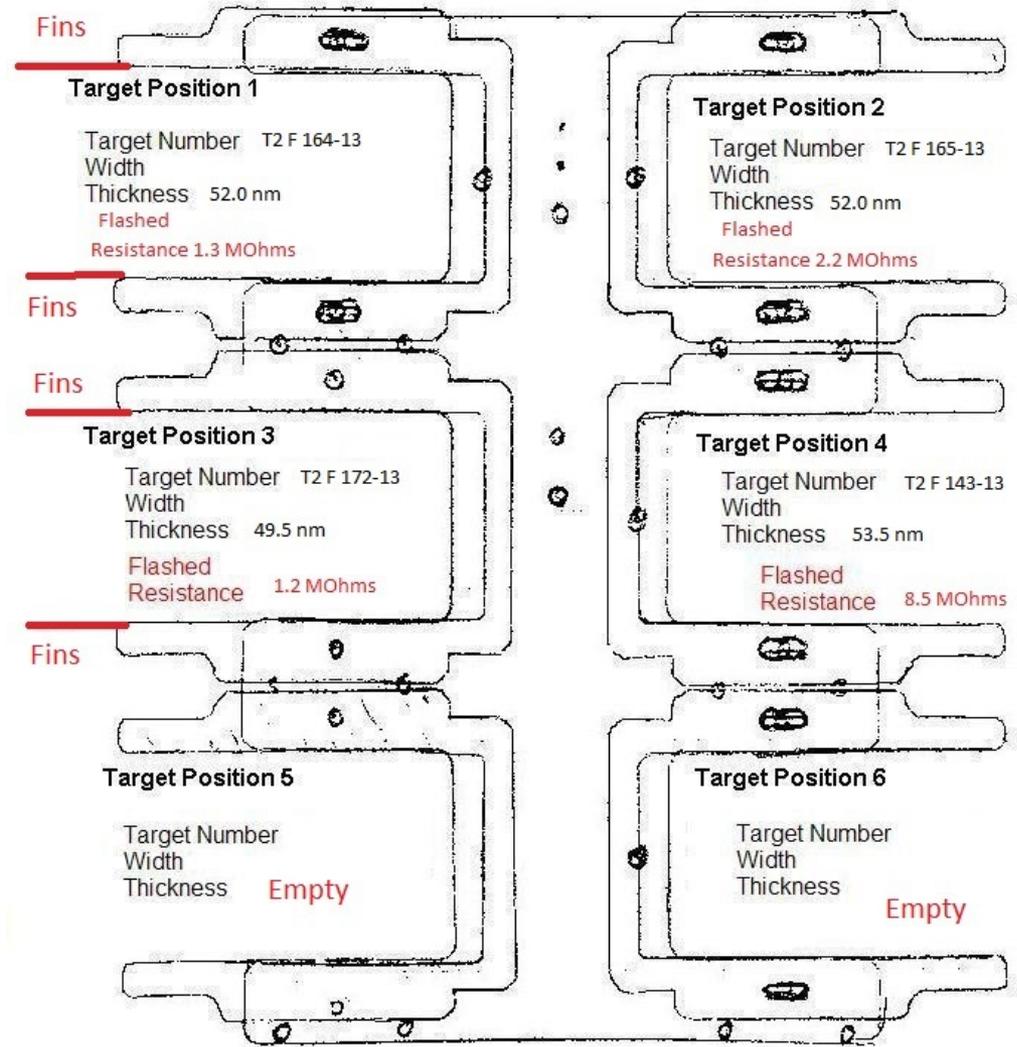
- Target life time was poor in run13 with higher bunch intensity ($1.6-2*10^{11}$) at 255GeV. We had to replace targets twice.
- We may have another 510GeV run in 2016.
- Jorg carried out simulation with micro-studio which showed that the electric-magnetic fields at the edges can be greatly reduced with added flips (fins).
- It is assumed that the high frequency fields induce electrons moving back and forth, which in term heats the target tails and makes them glowing.
- About 2/3 targets are broken near the ends, which supports the idea that the EM fields (and heating) is one possible reason for shorted lifetime.

Experiment Setup

- Due to the clearance concern, we did not install targets at target5 and target6 positions. We installed five targets in blue1 with fins. These fins are on both sides of a target, so a factor 10 reduction is expected according to Jorg's simulation. This will make the effect easier to distinguish.
- Anatoli redesigned the fins and Jorg approved the change. In total, we have 12 targets without fins on blue2, 8 targets on blue1 (five with fins, no targets at 5-6 positions).
- Limitation of this test: we removed all Si detectors. So there is no way to determine the beam position by target scan from Si detectors. The only information we have is the logged beam decay and target positions, in addition to the recorded videos. The time stamps on videos are wrong by a few minutes. We rely on the recording time to synchronize with logged target positions.

Blue1 Horizontal Targets

- Targets 1-4 were used for Au beam.
- Only target1 had chance to be used for He3 beam.
- Targets 2 and 4 were lost during target switch.
- Note that Target4 resistance is much higher than others: 8.5MOhms vs. 1-2 MOhms.

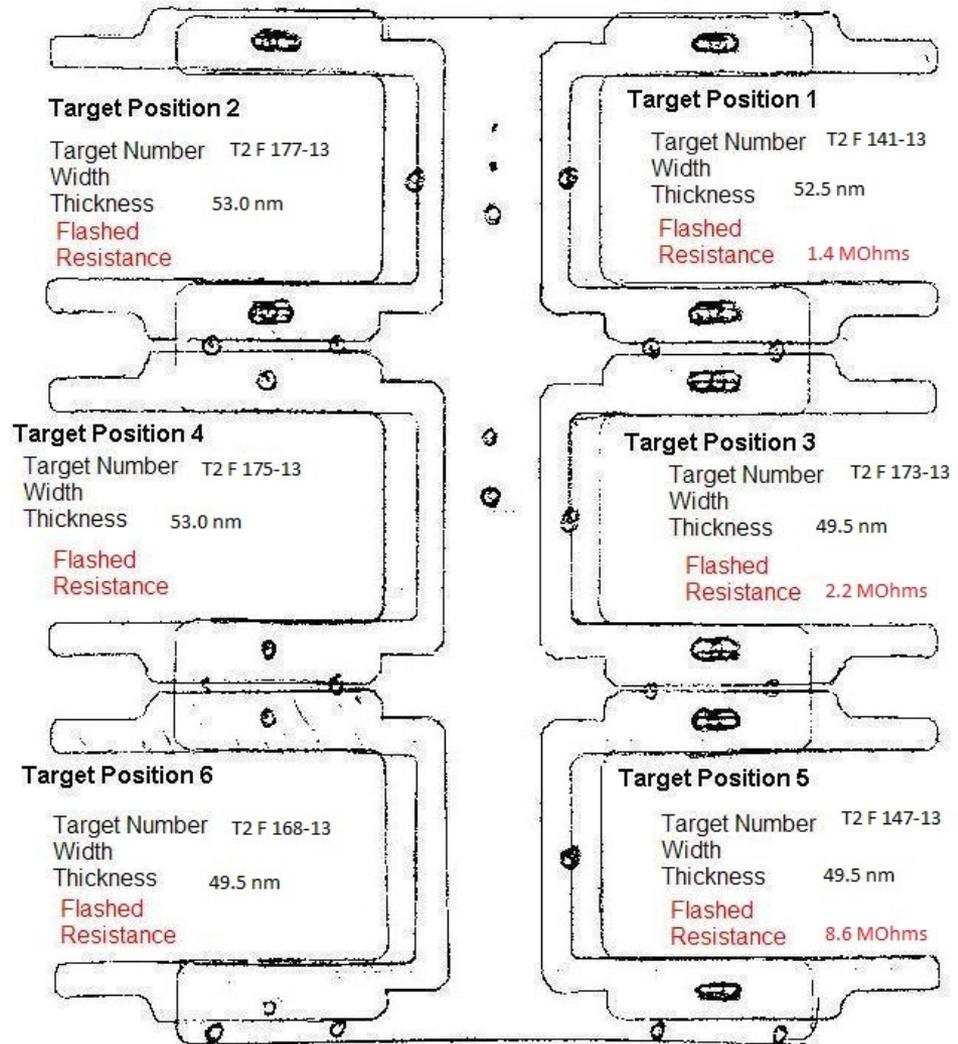


Blue 1 Horizontal
Upstream

Installed 01-28-14

Blue2 Vertical Targets

Targets used for He3 beam.
No resistance info for
targets 2 and 4.

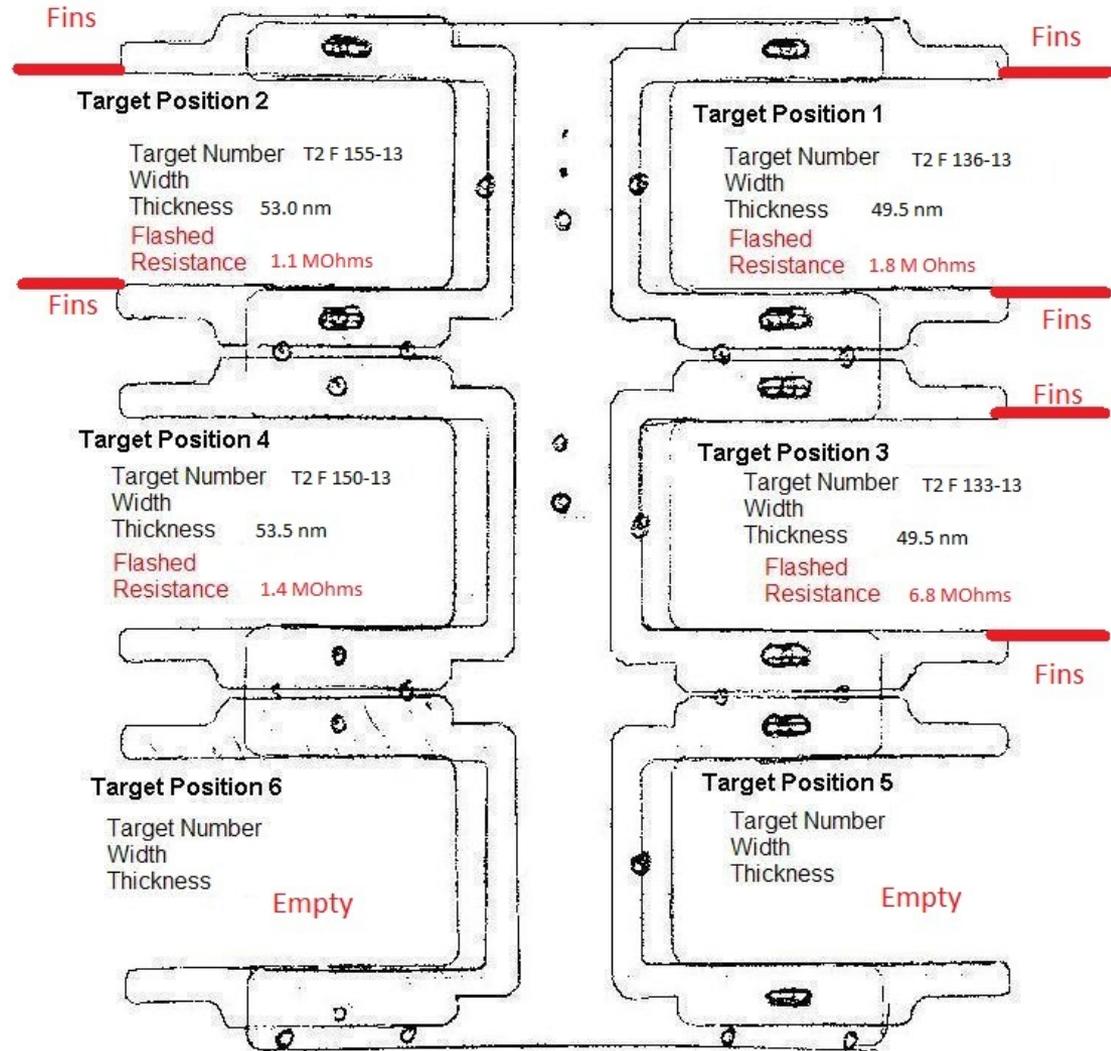


**Blue 2 Vertical
Downstream**

Installed 01-28-14

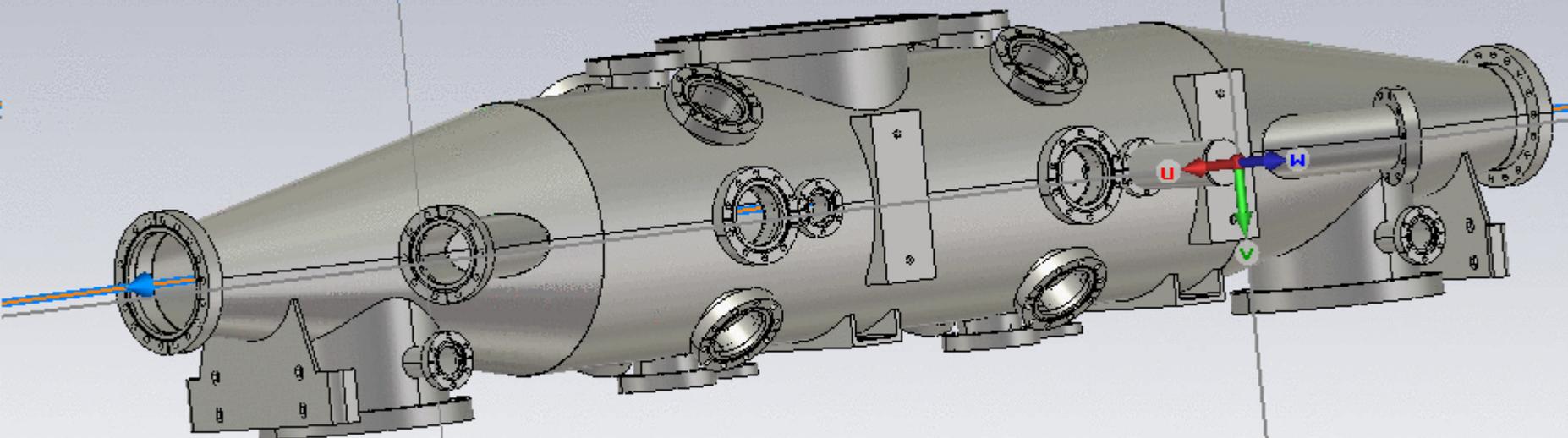
Blue1 Vertical Targets

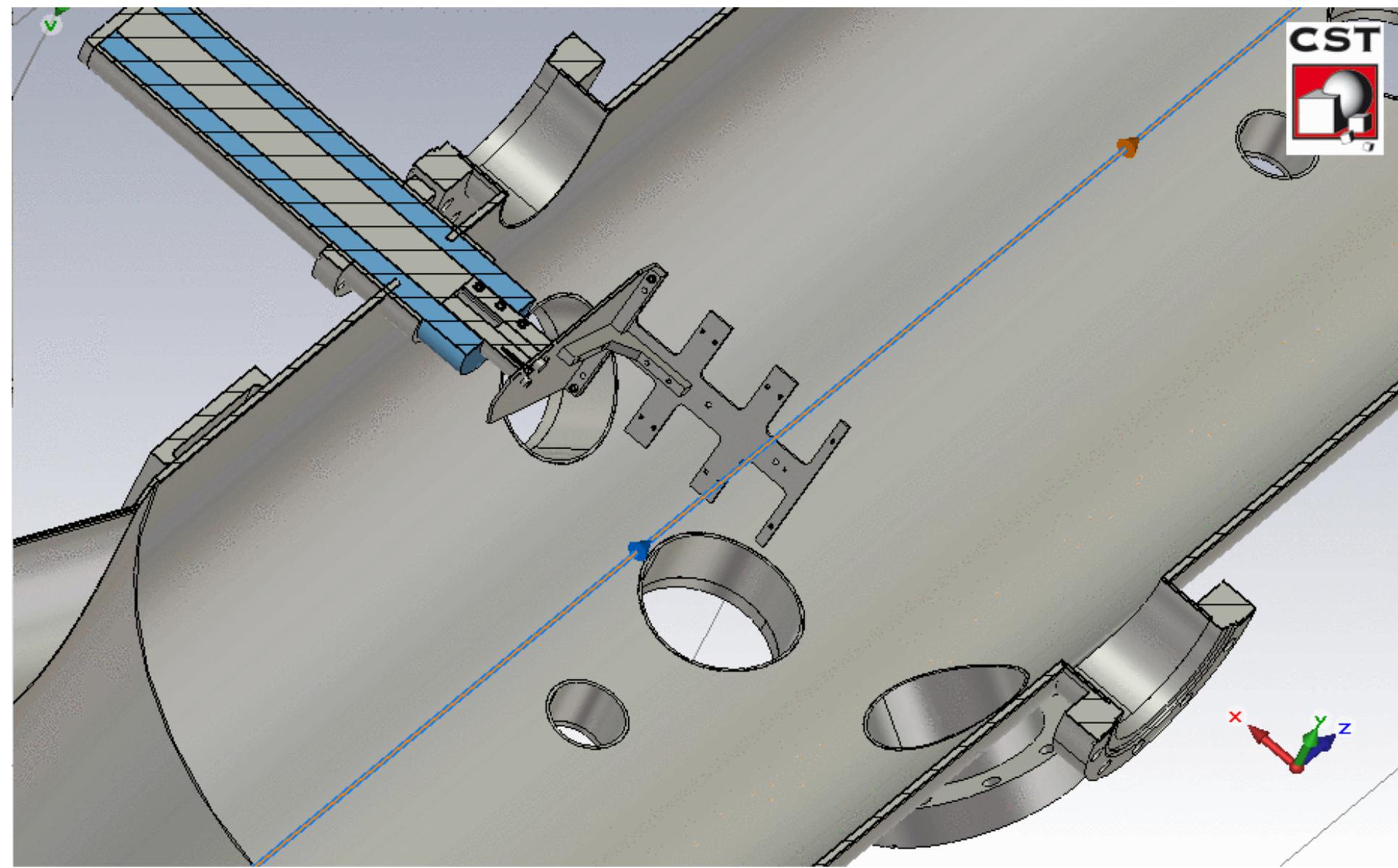
Targets used for He3 beam but no video recorded. Target 3 was gone (no beam loss generated); much higher resistance for this target: 6.8M Ohms vs. 1-2M Ohms.



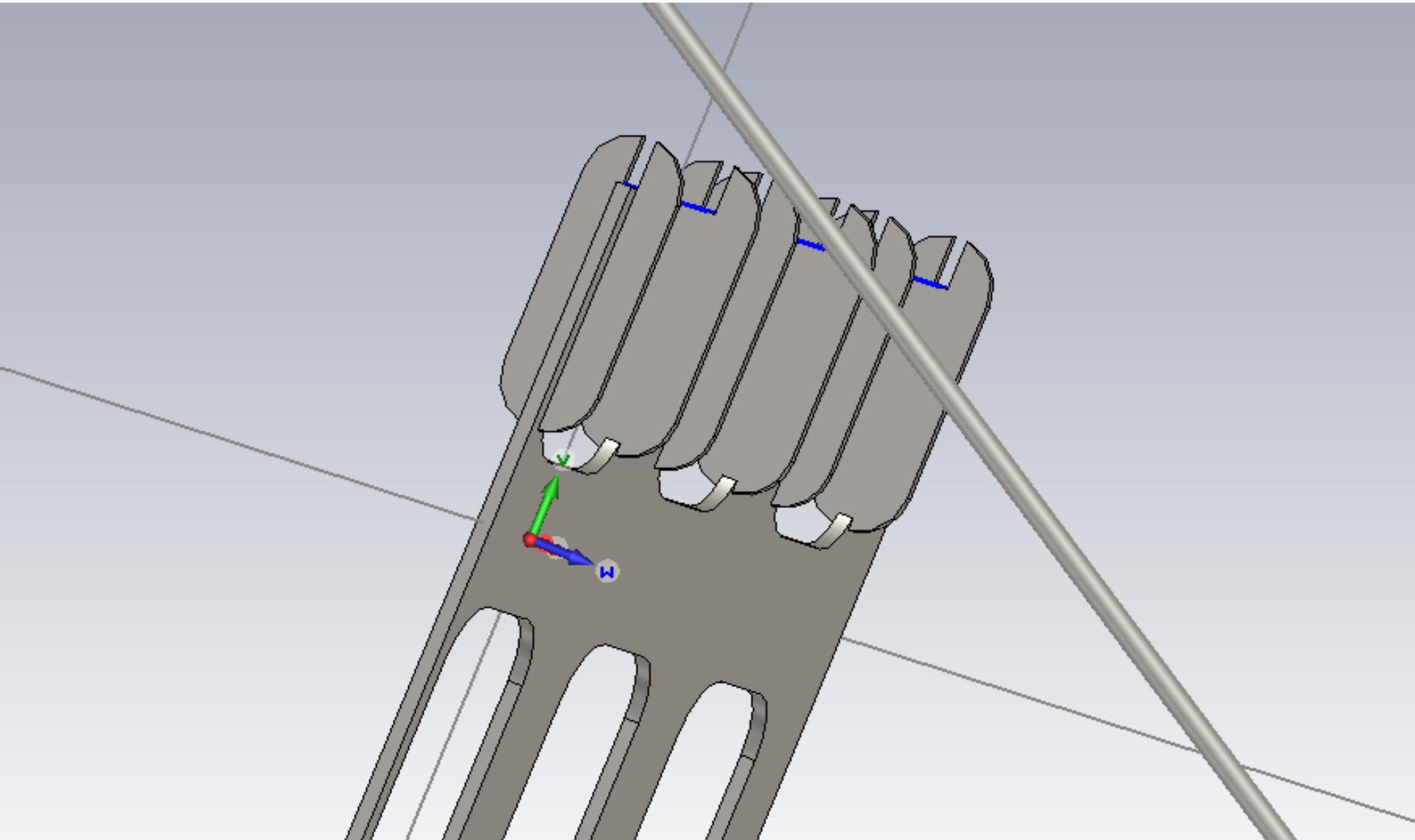
Blue 1 Vertical
Upstream

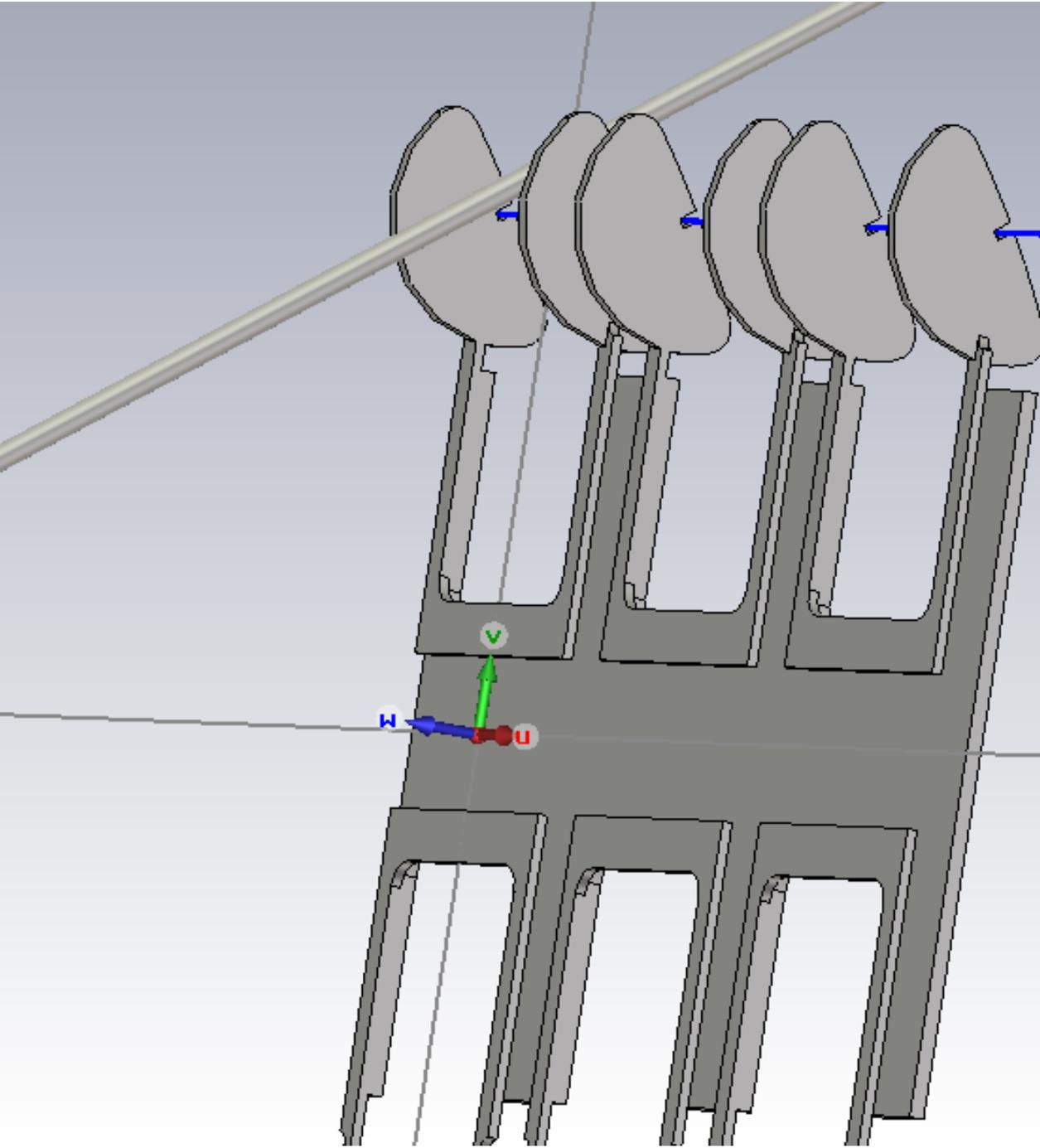
Installed 01-28-14





Provide surface for the field lines to “spread out”

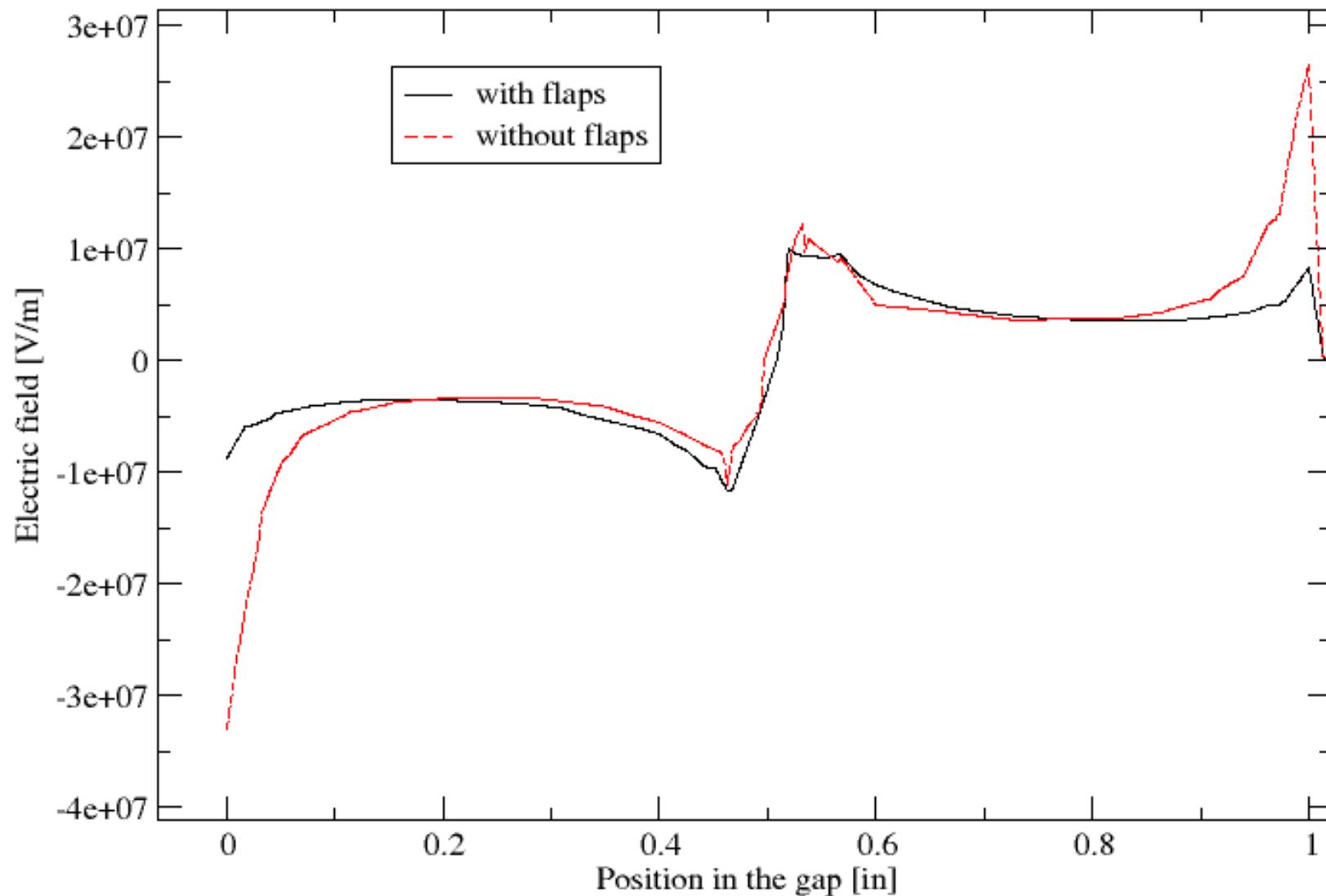




Must fit into the t

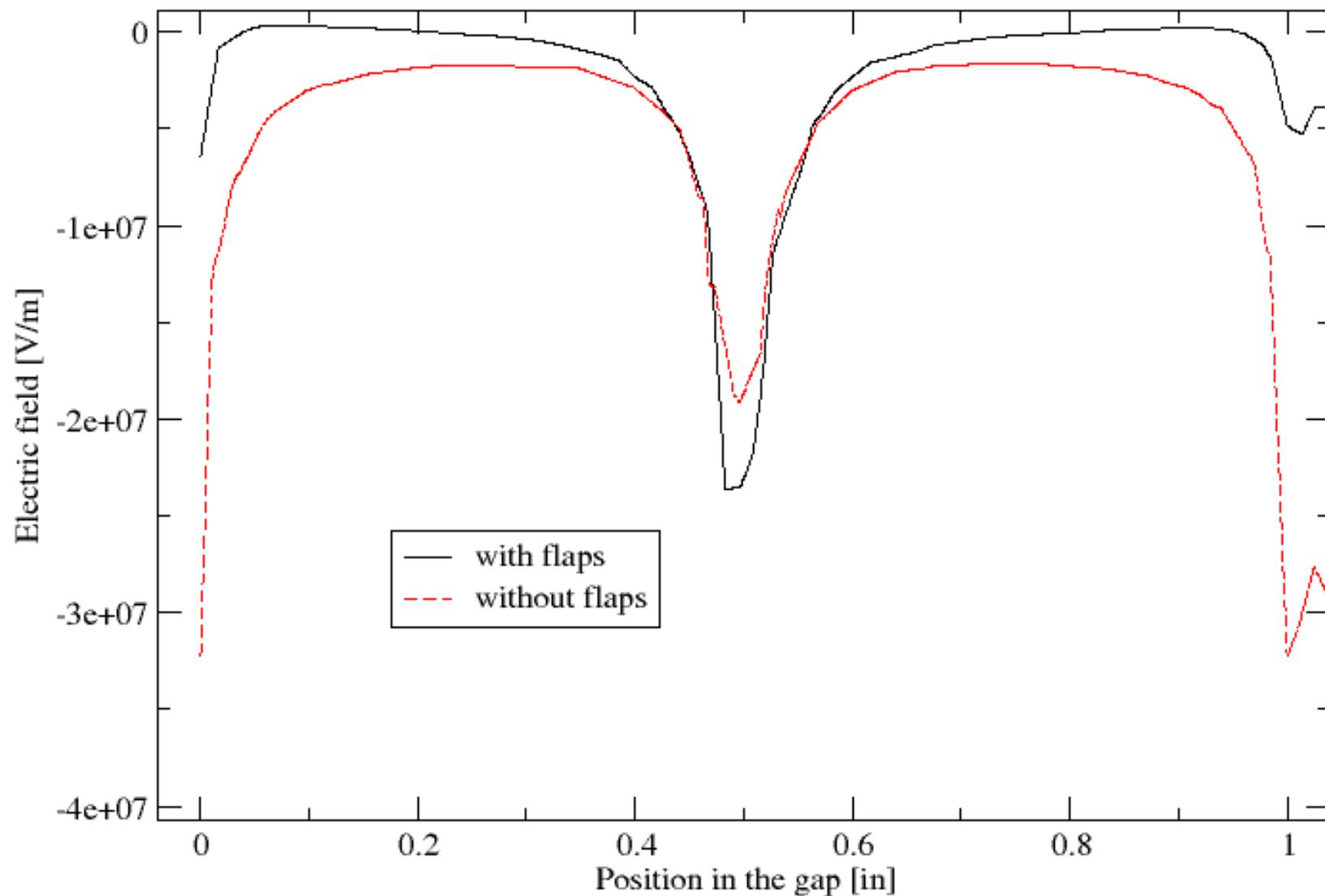
Beam next to the wire

x direction

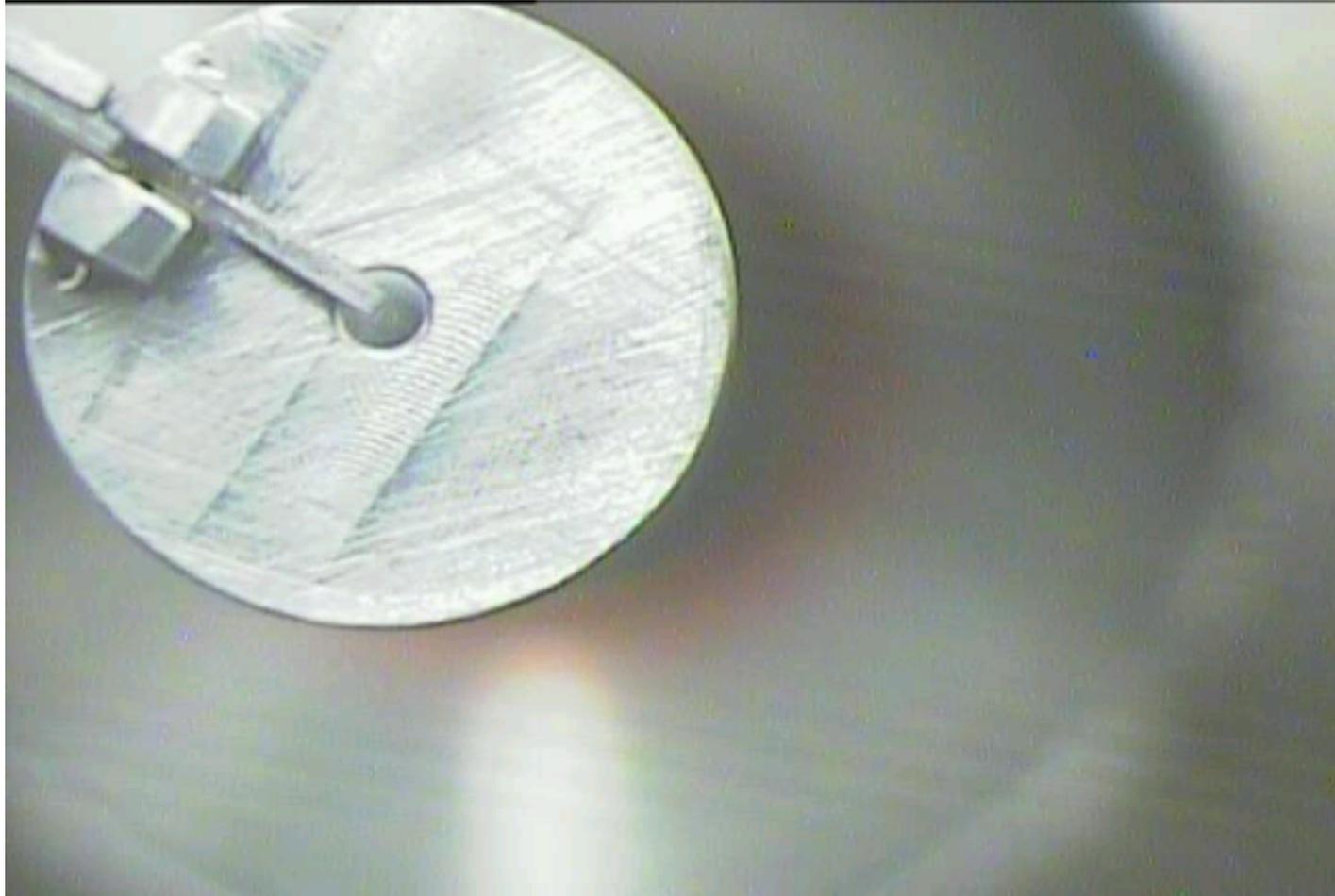


Beam next to the wire

y direction



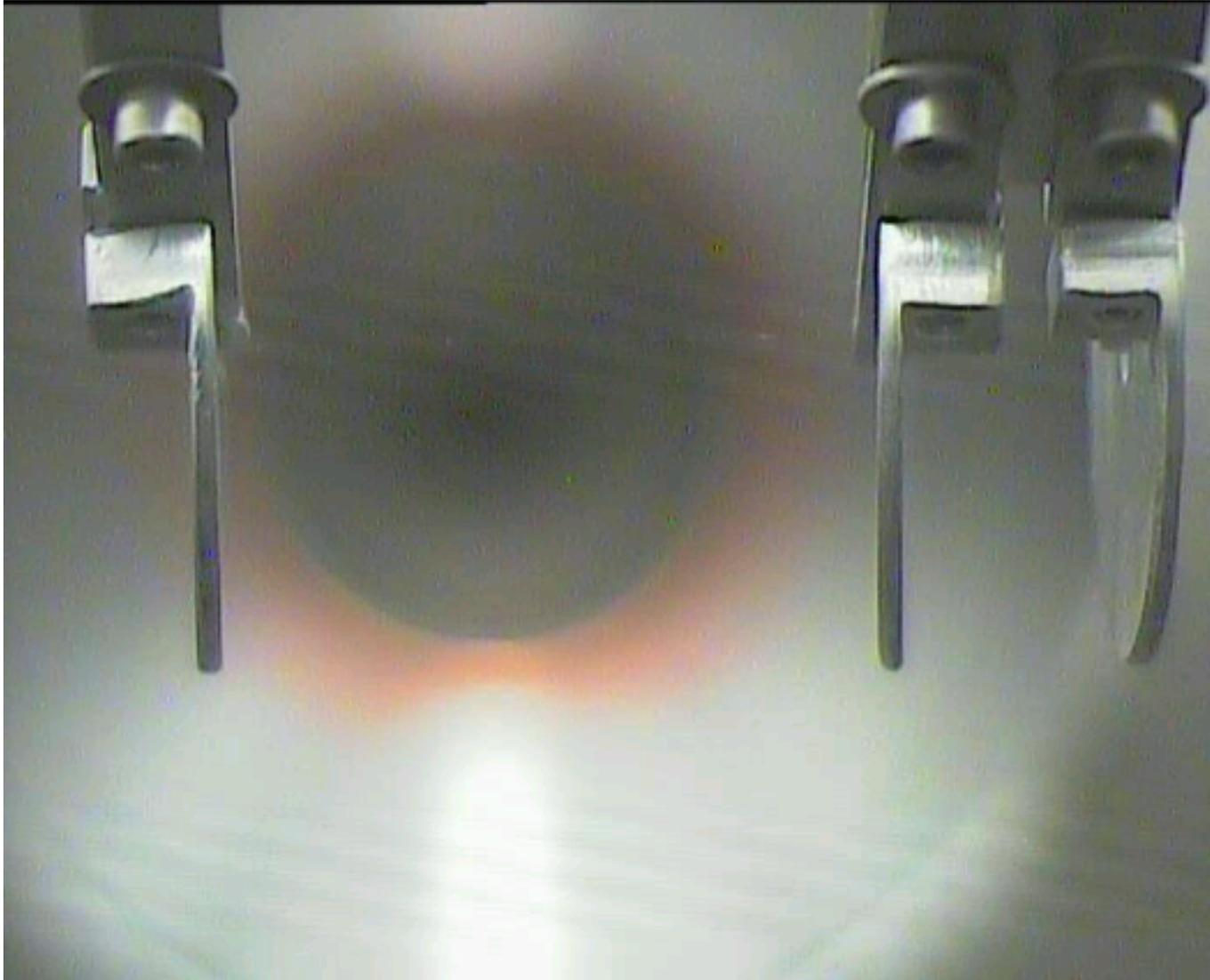
B1V1 Target (with Fins) from Top Camera



With modified design, so the reduction should be 10 times, instead of 4-5 times.

B1H1 Target (with Fins) from Top Camera

Target is visible



B1H2 Target (without Fins) from Top Camera

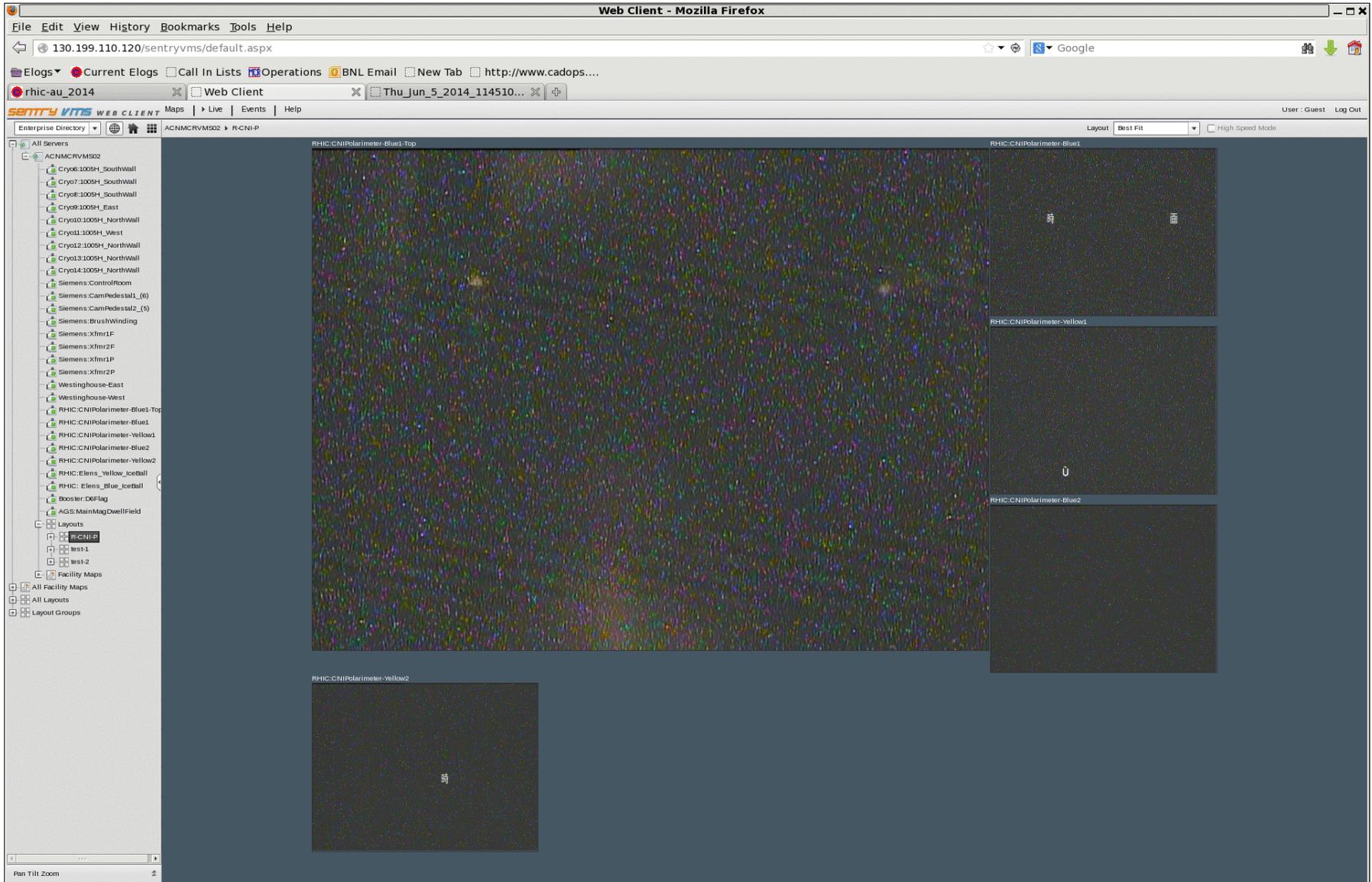


Target is visible

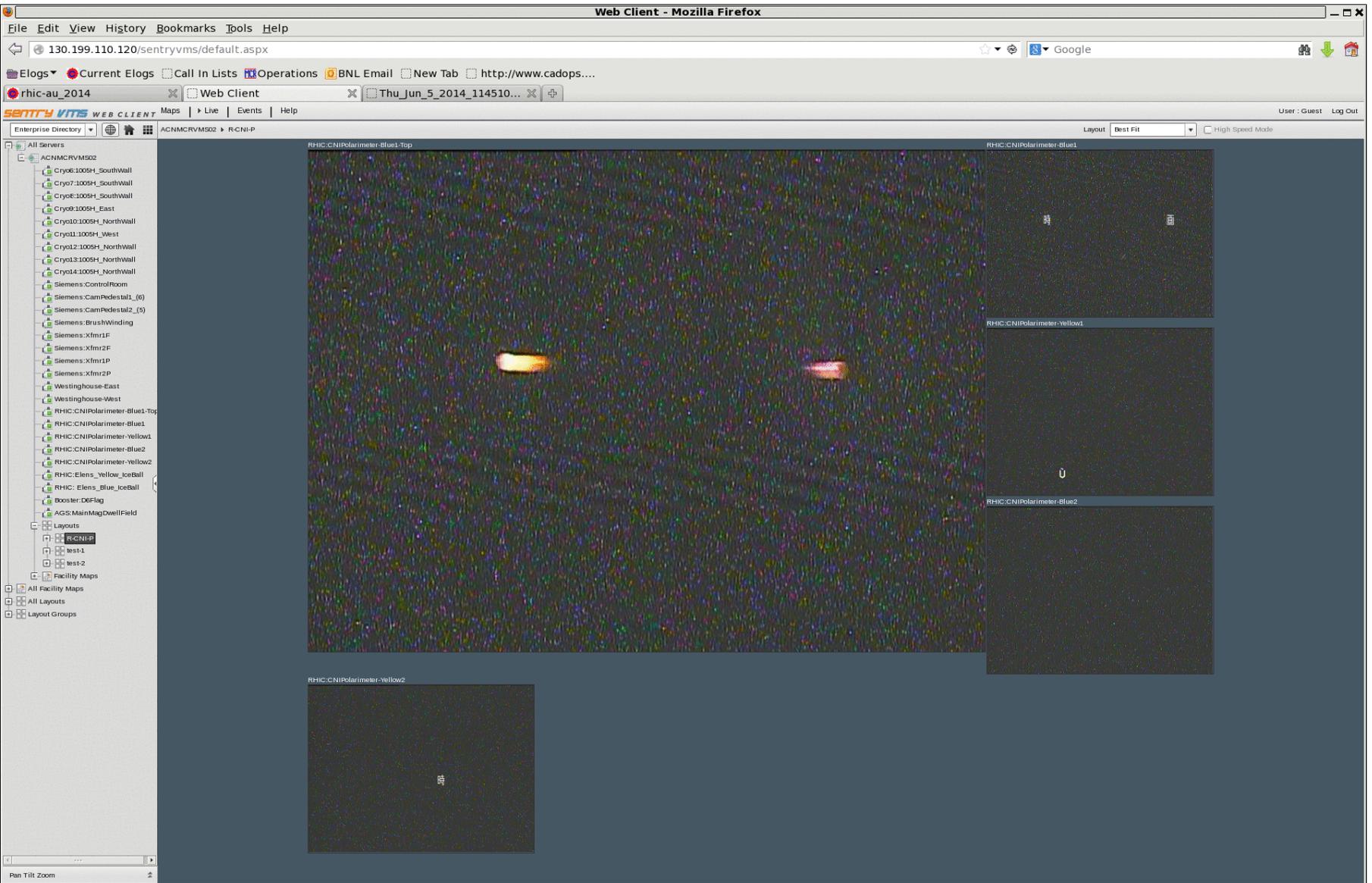
Beam Test Done with Au Beam

- June 5, 11:41-11:45. Tested B1H1 (with fins) and B2V (no fins). Target tail glowing were visible for both targets. Au intensity 65×10^9 .
- June 6, 14:05-14:10. Tested B1H1 then caused beam abort (human error). Au intensity 59×10^9 .
- June 10, 11:38-11:45. Tested B1H1 (with fins) and B1H2 (without fins). The glowing light is definitely stronger for target frame without fins. we tried a few times and it is reproducible. Au intensity 66×10^9 (peak current 1.4A).
- June 12, 17:52-17:58. The Au total intensity was 67×10^9 (peak current 0.75A). Tested B1H3 (with fins) and B1H4 (without fins). Overall, the light from this pair is dimmer than B1H1 and B1H2. But the light from frame without fins is still brighter. We also ramped down the RF voltage from 650kV to 100kV in 20 sec. The light disappeared for the no-fins target frame. Then when we switch back to B1H3 (with fins), there is no visible light either. The correlation of light with RF voltage is also established.

B1H1 with Fins Near Au Beam (1.5cm away)



B1H2 without Fins Near Au Beam (1.5cm away)



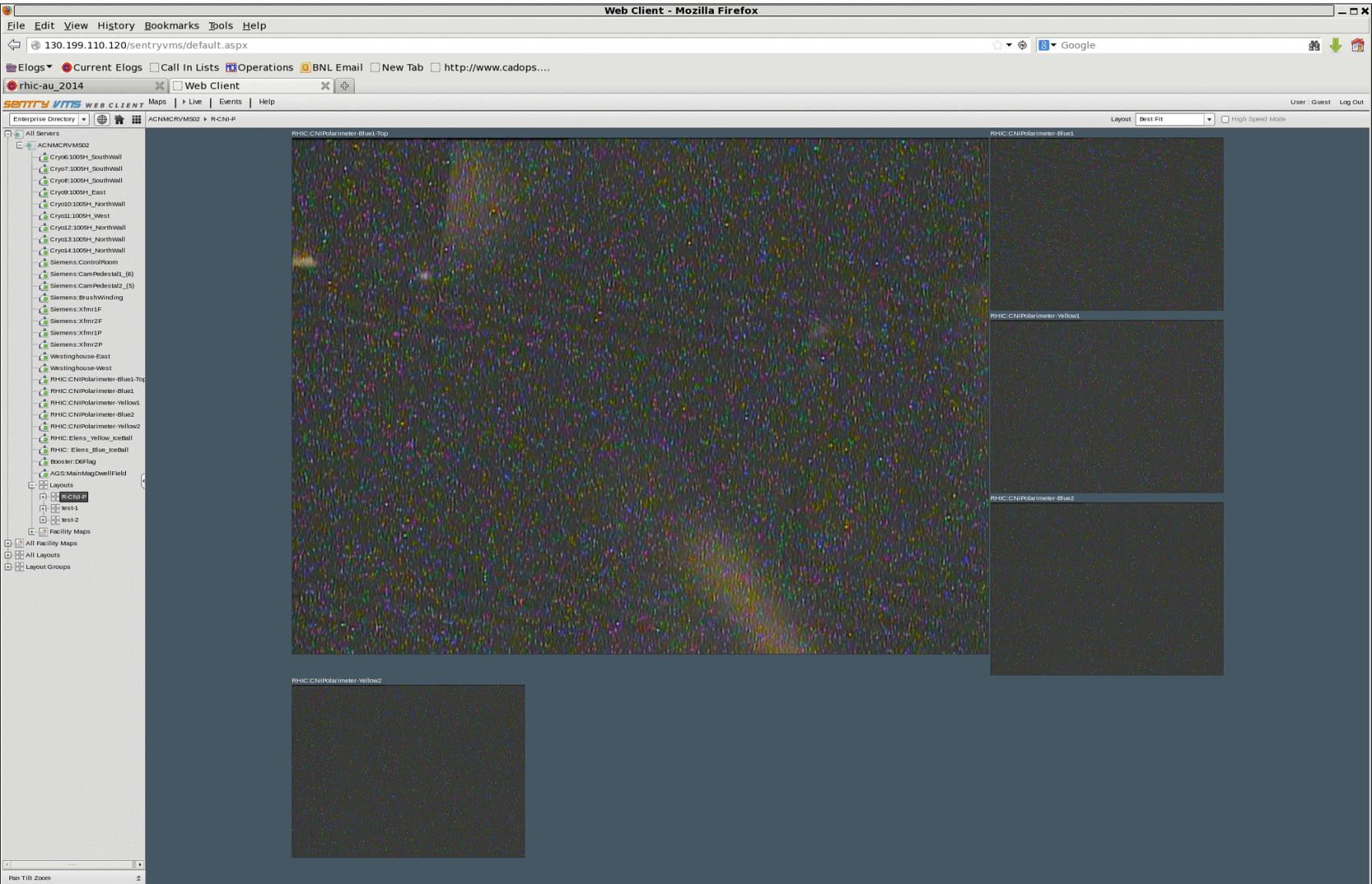
Brighter light than with fins.

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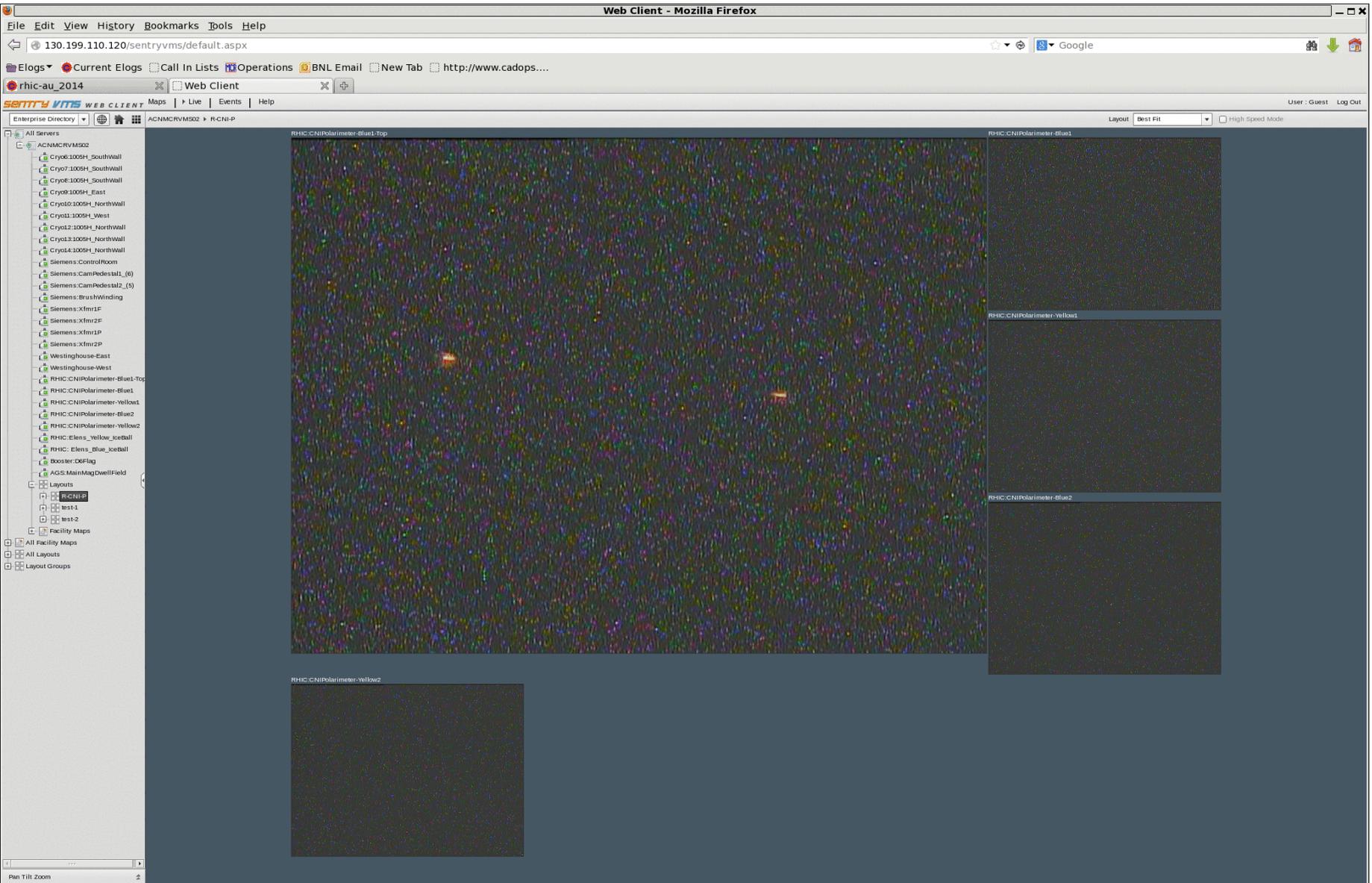
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B1H3 with Fins Near Au Beam (1.5cm away)



The light from the B1H3 is dimmer than B1H1 (only shown partially).^{RY}

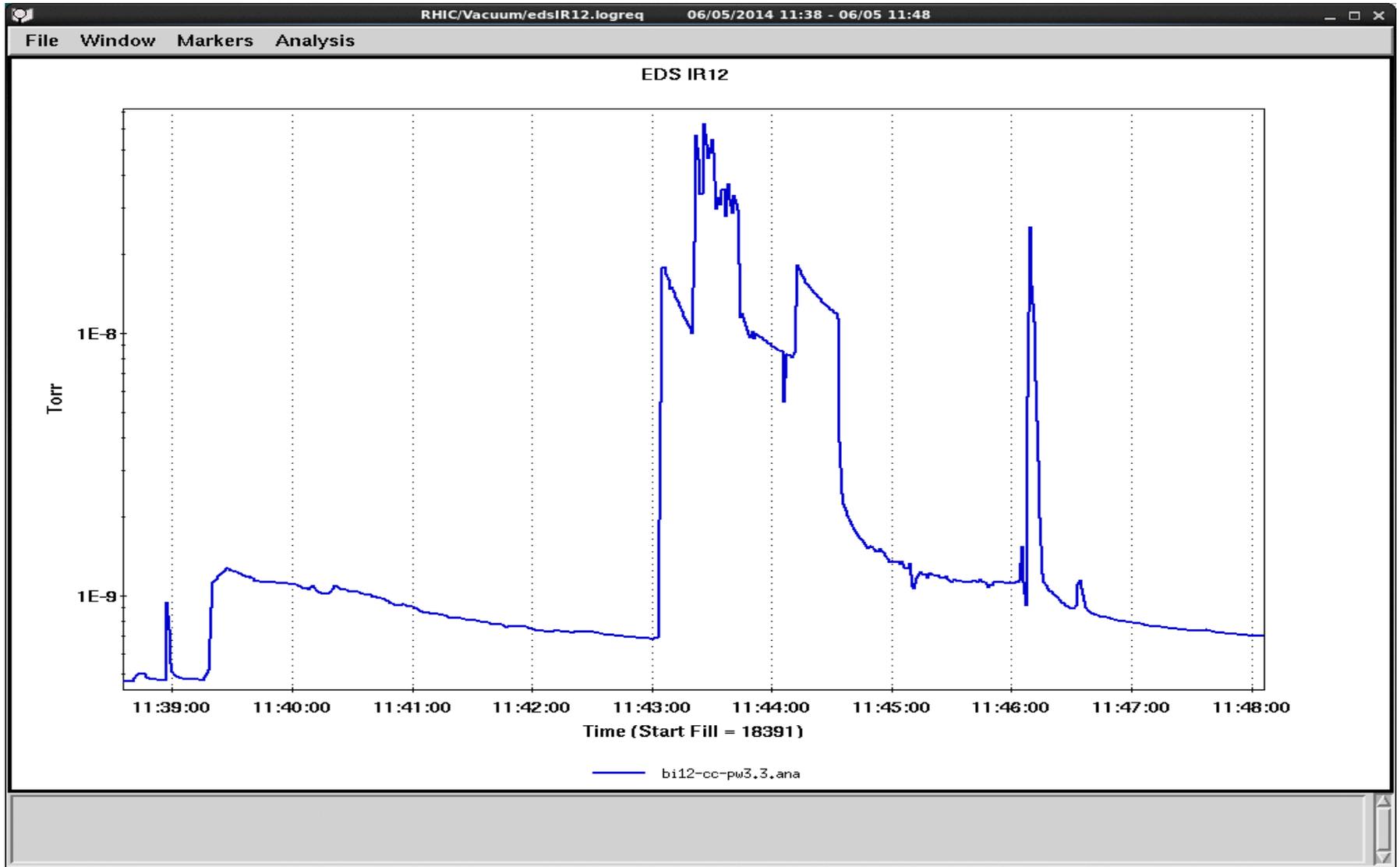
B1H4 without Fins Near Au Beam (1.5cm away)



Brighter light than with fins.²¹

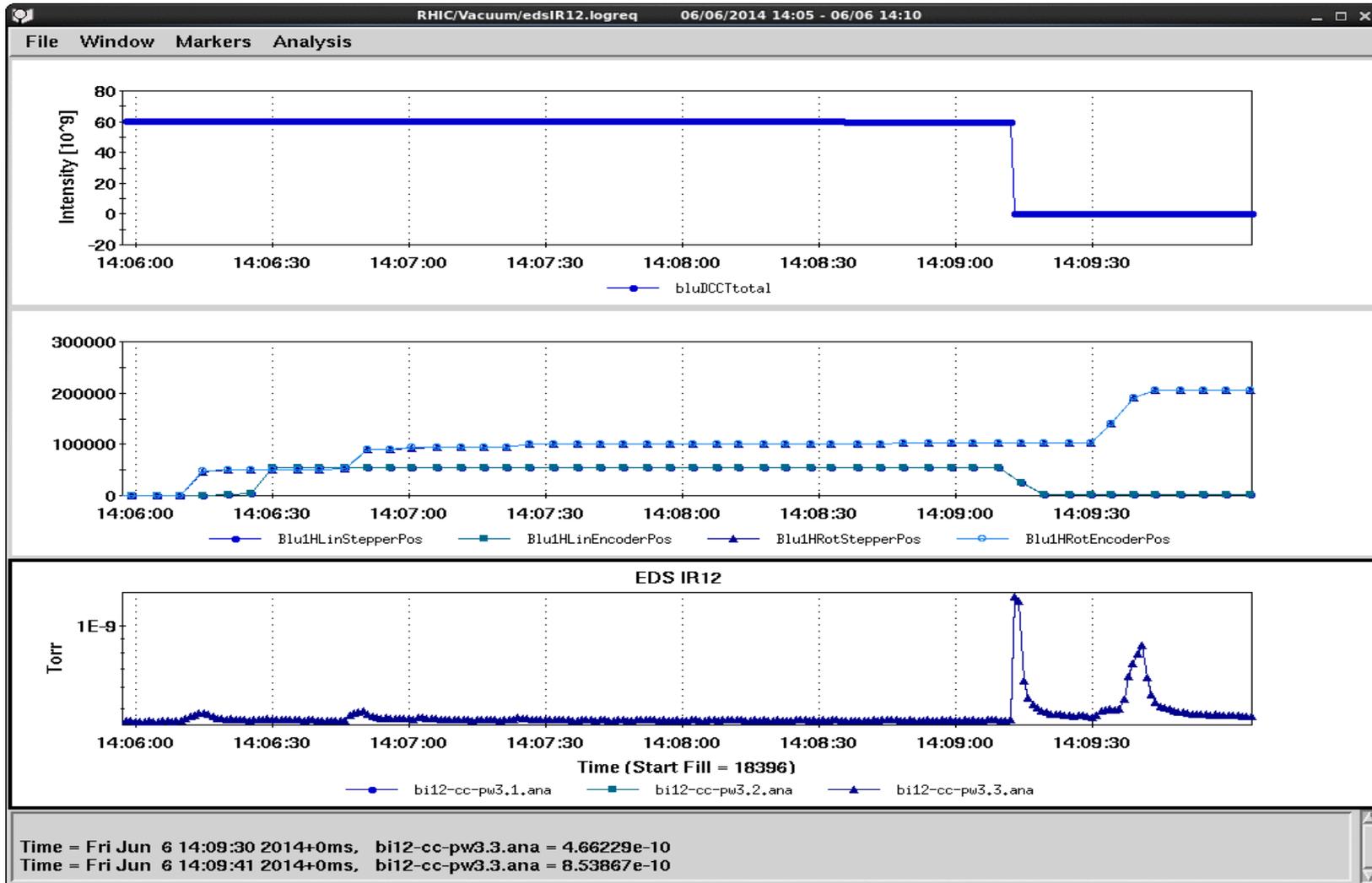
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Vacuum Pressures(6/5), No Target Position Logged



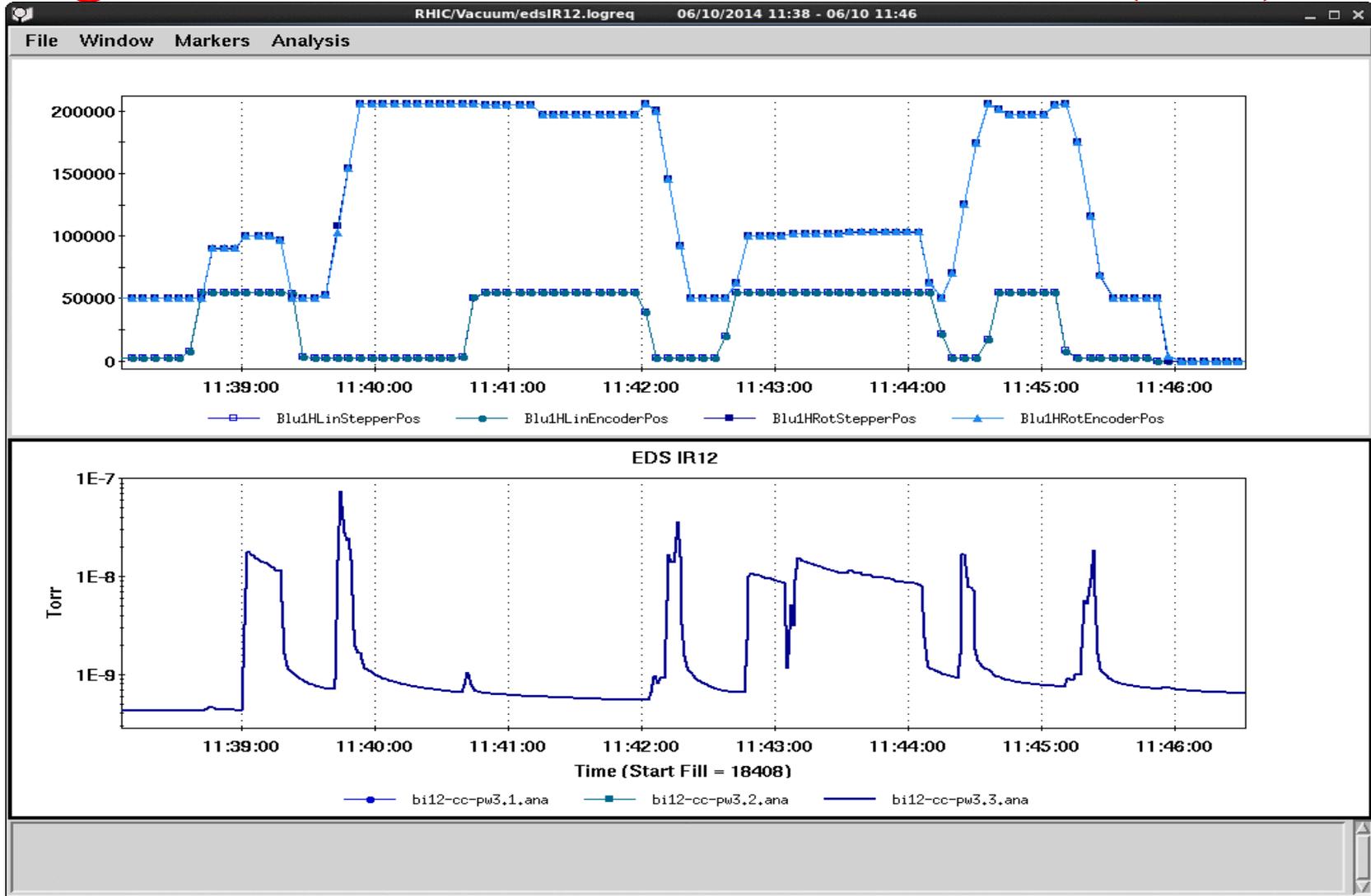
No target positions were logged for the first day. But the vacuum spikes were associated with every target motion. They are quite large spikes compared to later time. They were caused by gas in the bellows. Since they have not been moved for awhile, the vacuum spikes are quite large compared to the spikes at later time. It also takes longer time to recover.

Target Position and Vacuum Pressures(6/6)



The vacuum spikes were smaller this time. The biggest one was due to beam abort event.

Target Position and Vacuum Pressures(6/10)



Some vacuum spikes took longer time to go away.

Video file names

11h43m23s.avi June 10, 2014

11h44m58s.avi June 10, 2014

17h53m10s.avi June 12, 2014

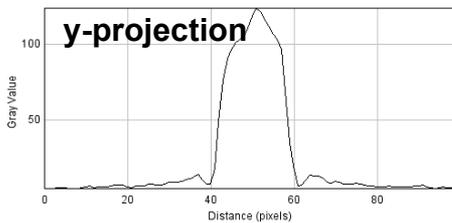
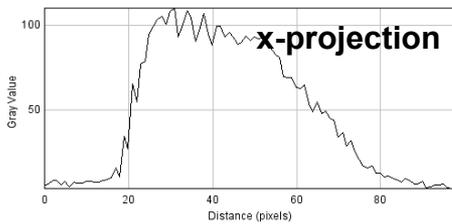
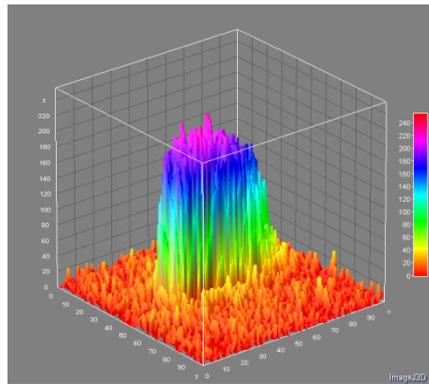
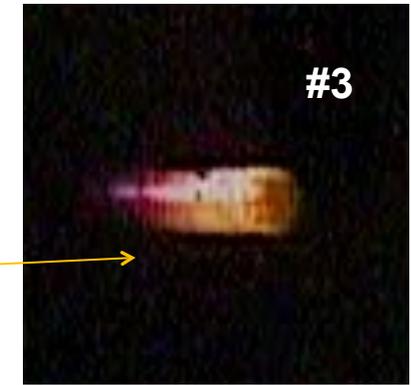
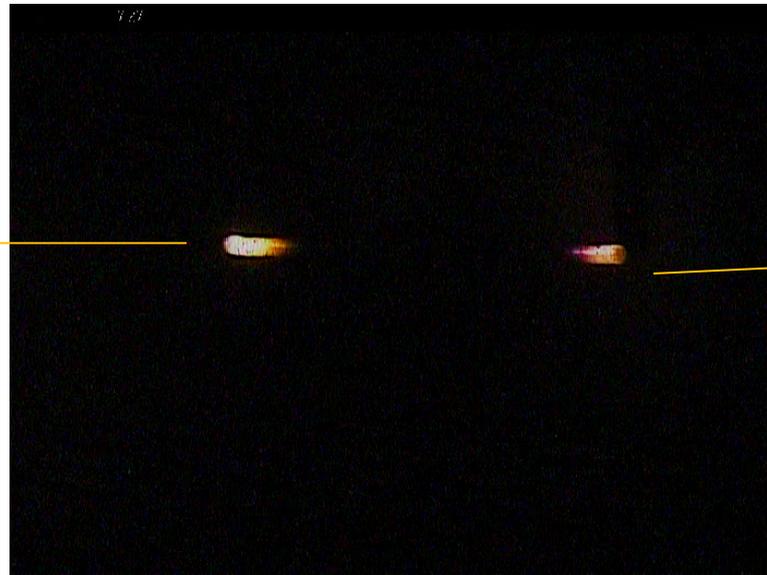
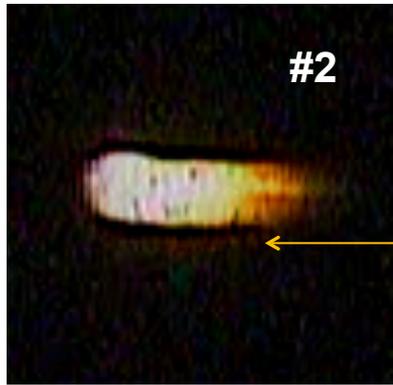
17h54m40s.avi June 12, 2014

All images & calculations processed by ImageJ Software

Image pixels size: 704x528

Image color: RGB color, 8-bit/color

Analysis done by Thomas Tsang. We only have two comparable cases for Au beam. The targets with no-fin on blue1 horizontal broke during target switch in He3 beam. The last attempt on July 4 failed to record image on blue1.

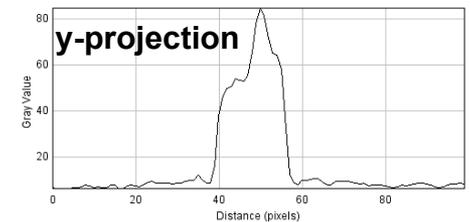
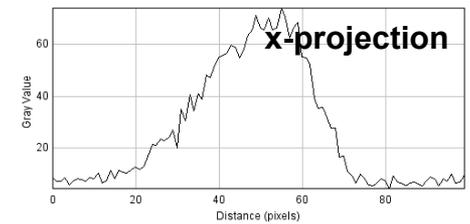
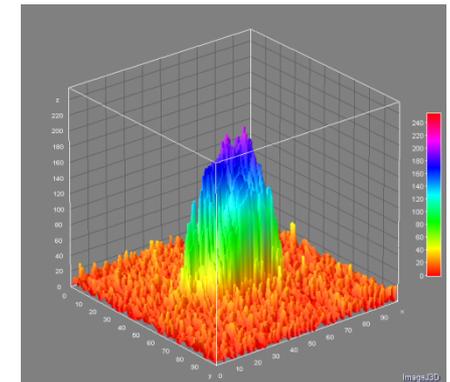


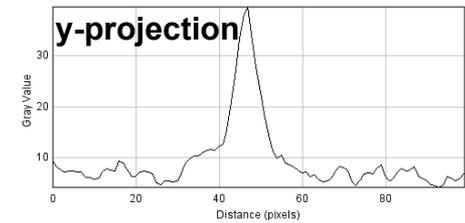
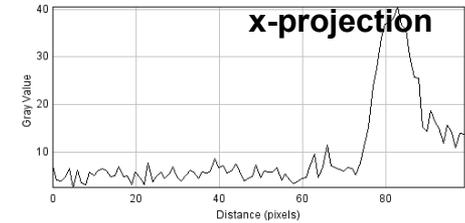
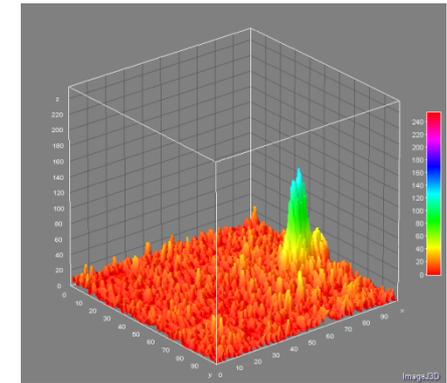
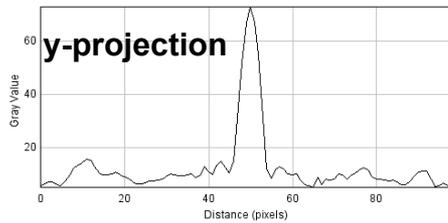
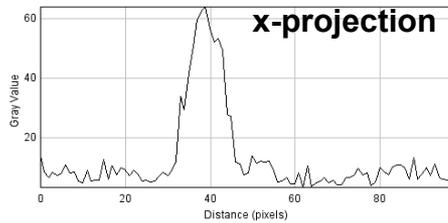
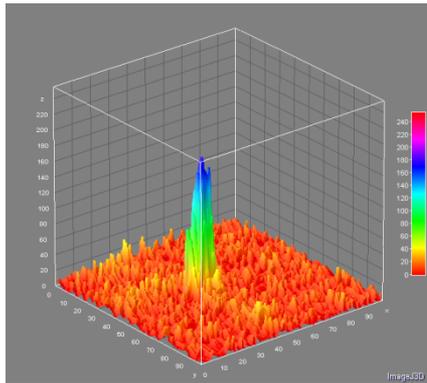
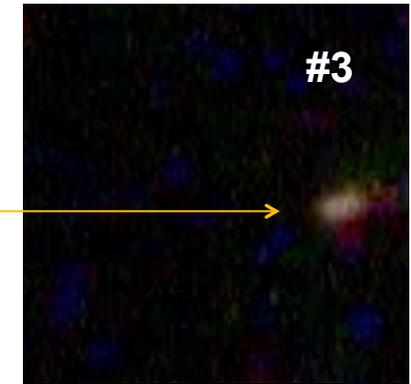
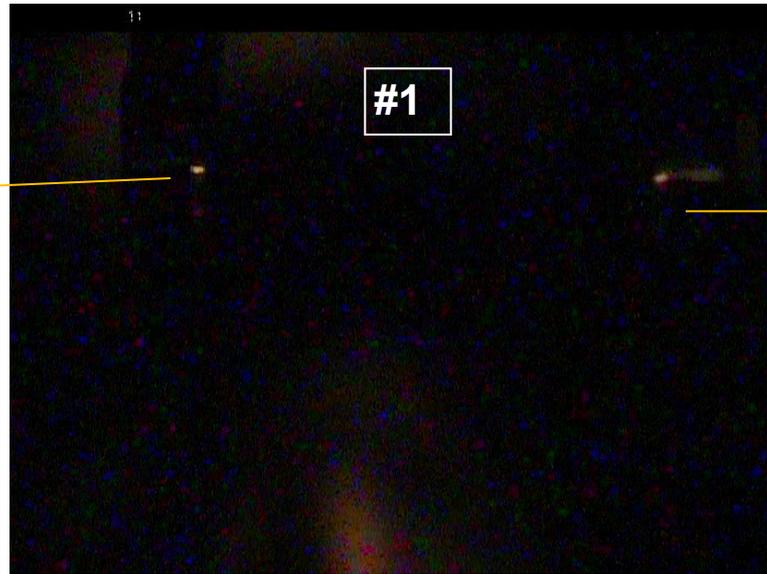
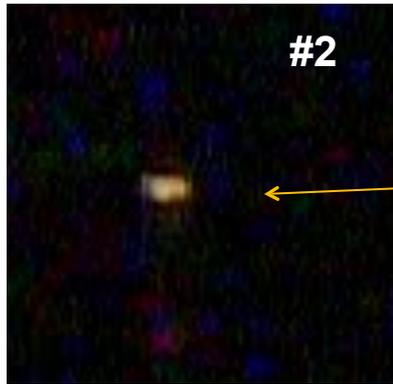
Numerical calculated
volume = intensity

2 8.6×10^4

3 9.4×10^3

intensity ratio #2/#3 ~ 9





Numerical calculated
volume = intensity

2 3.4×10^3

3 1.2×10^3

intensity ratio #2/#3 ~ 3

Video file name: 11h44m58s.avi June 10, 2014

Numerical calculated
volume = intensity

2 8.6×10^4

3 9.4×10^3

intensity ratio #2/#3 ~9

Video file name: 11h43m23s.avi June 10, 2014

Numerical calculated
volume = intensity

2 3.4×10^3

3 1.2×10^3

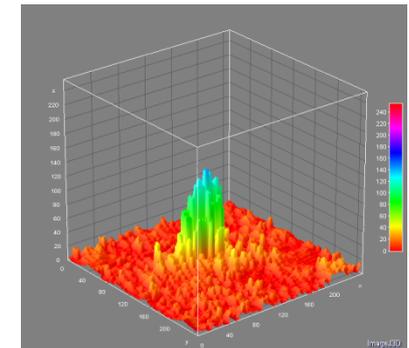
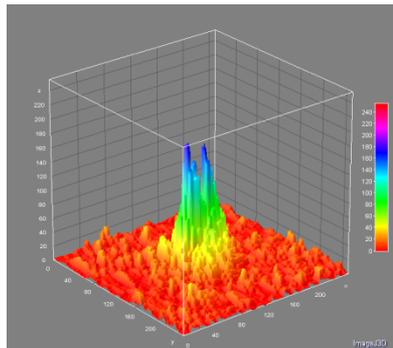
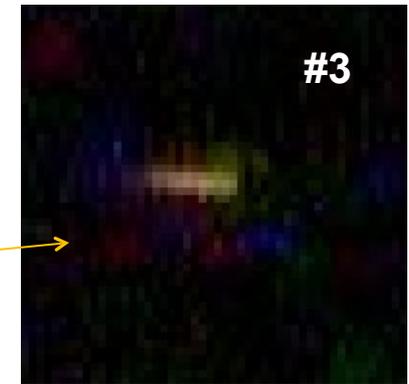
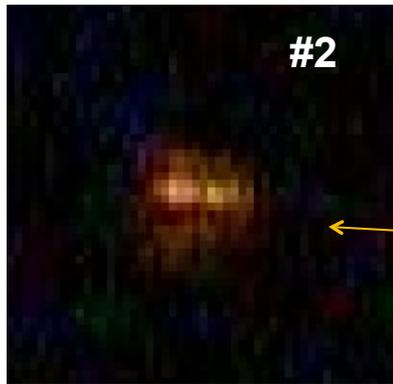
intensity ratio #2/#3 ~3

intensity ratio 11h44m58s.avi to 11h43m23s.avi

#2 >25

#3 ~8

Average of #2 and #3 is >10

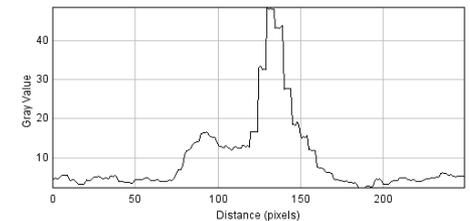
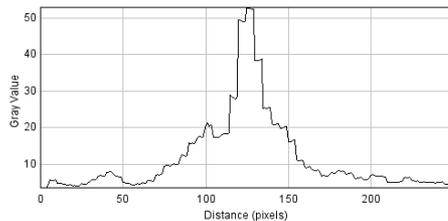
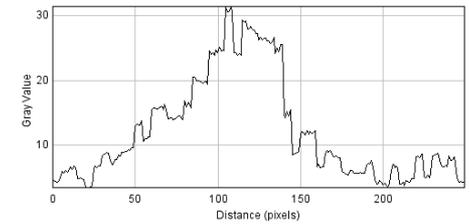
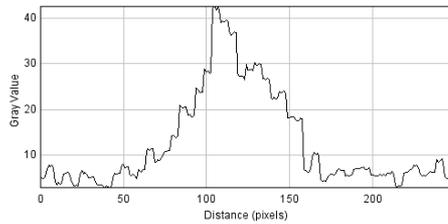


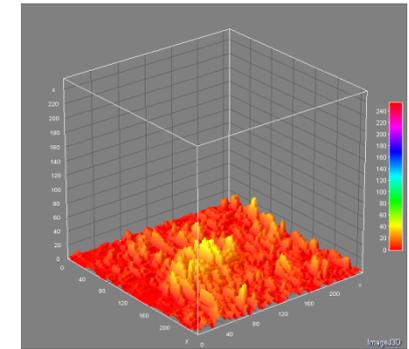
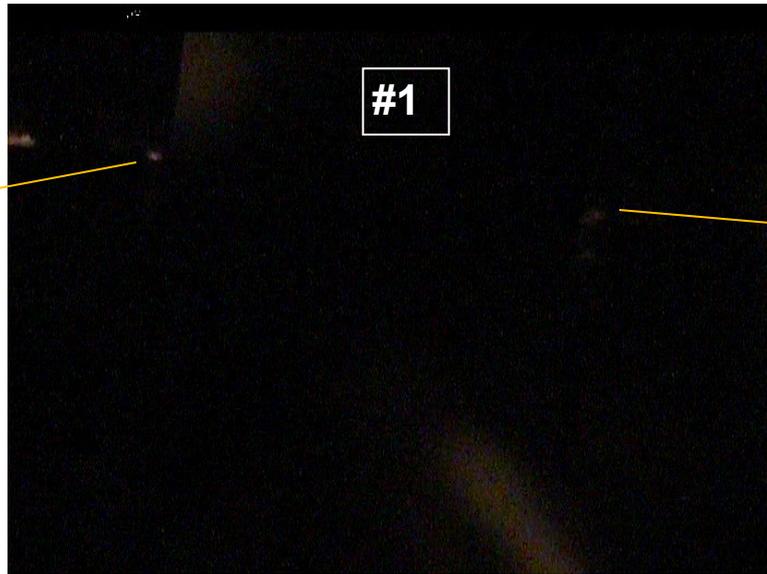
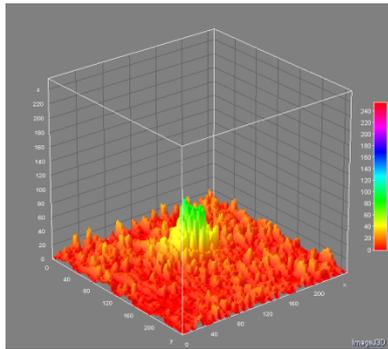
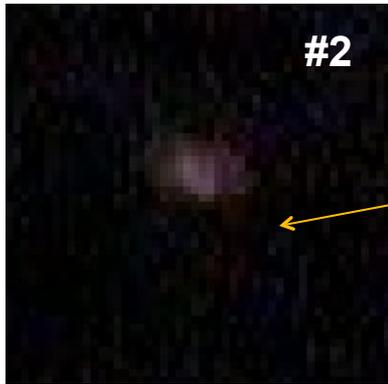
**Numerical calculated
volume = intensity**

2 7.8×10^4

3 5.4×10^4

intensity ratio #2/#3 ~ 1.4



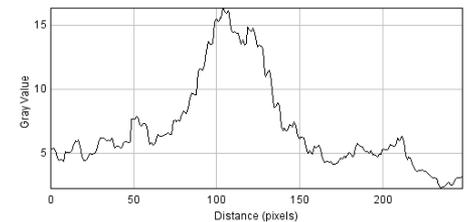
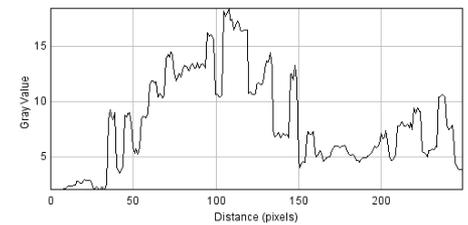
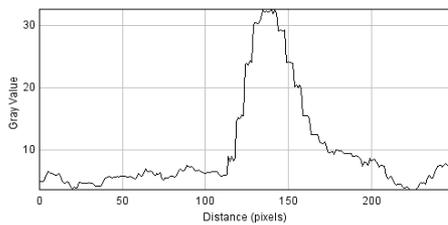
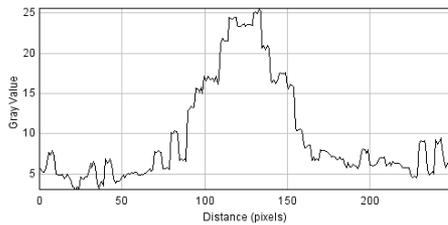


**Numerical calculated
volume = intensity**

2 4.9×10^4

3 4.2×10^4

intensity ratio #2/#3 ~ 1



Video file name: 17h54m40s.avi June 12, 2014

Numerical calculated	intensity ratio #2/#3	~1.4
volume = intensity		
2 7.8×10^4		
3 5.4×10^4		

Video file name: 17h53m10s.avi June 12, 2014

Numerical calculated	intensity ratio #2/#3	~1
volume = intensity		
2 4.9×10^4		
3 4.2×10^4		

intensity ratio 17h54m40s.avi to 17h53m10s.avi

#2 ~1.6

#3 ~1.3

Average of #2 and #3 is about 1.5

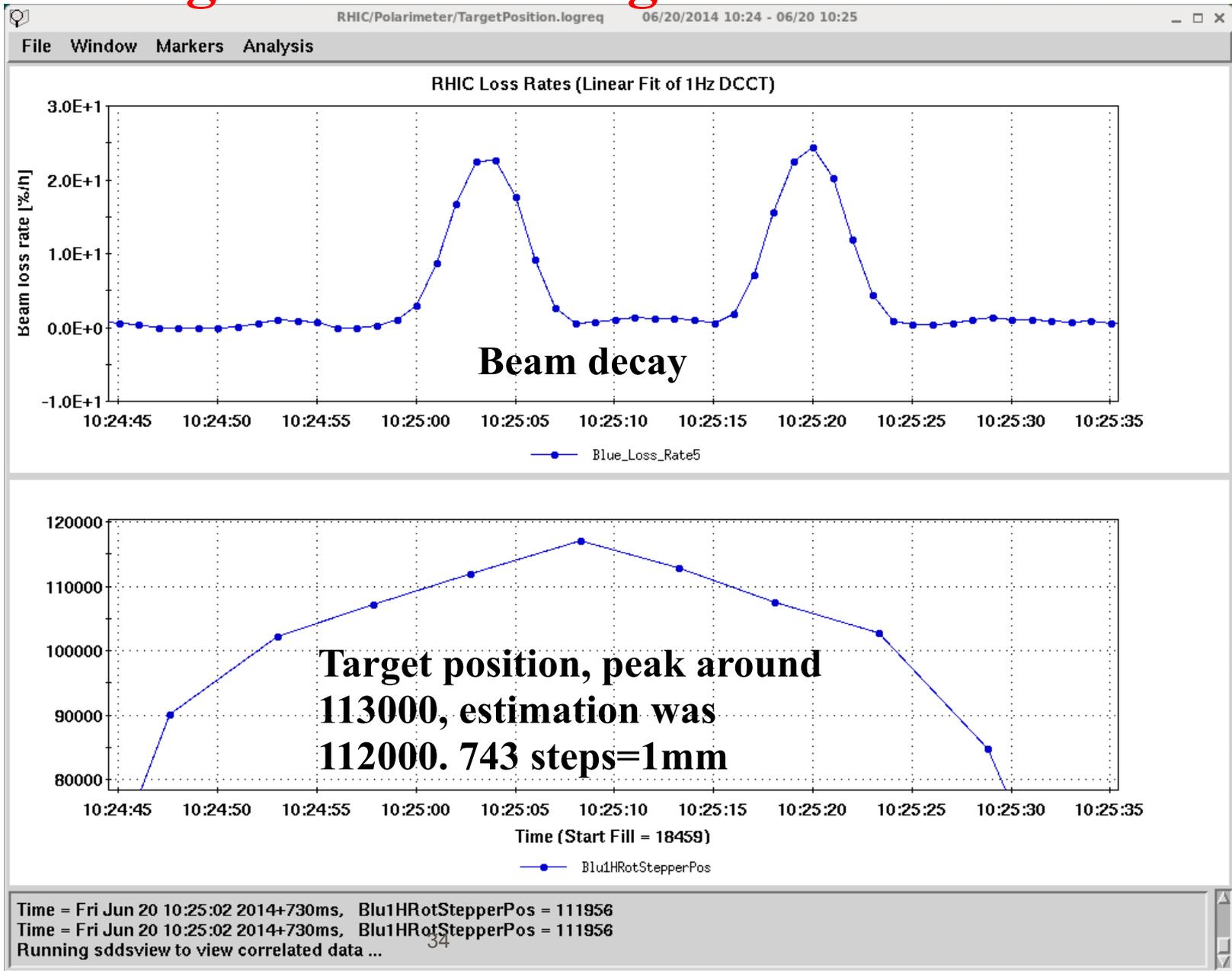
Beam Test Done with He3 Beam

- June 20, 10:23-10:37. Tested B1H1, B1H3 (with fins) and B1H2, B1H4 (no fins). He3 intensity 344×10^9 .
- The two targets without fins were lost when I switched from 1-3-5 side to 2-4-6 side. A big flash happened in the process but without beam loss. Only the broken target tails were visible. Same exercise with Gold beam also showed brighter light at the time, but did not break target.
- The target with fins were tested before and after. They were not lost during the switch. In both cases there were no glowing light at both ends (unlike the Au case).
- July 4, 11:20-11:40. Tested B2V1, B2V3, B1V1(with fins0, B1V3(with fins), B2V2, B2V4. But blue1 camera didn't record any videos. So the test has not much use.

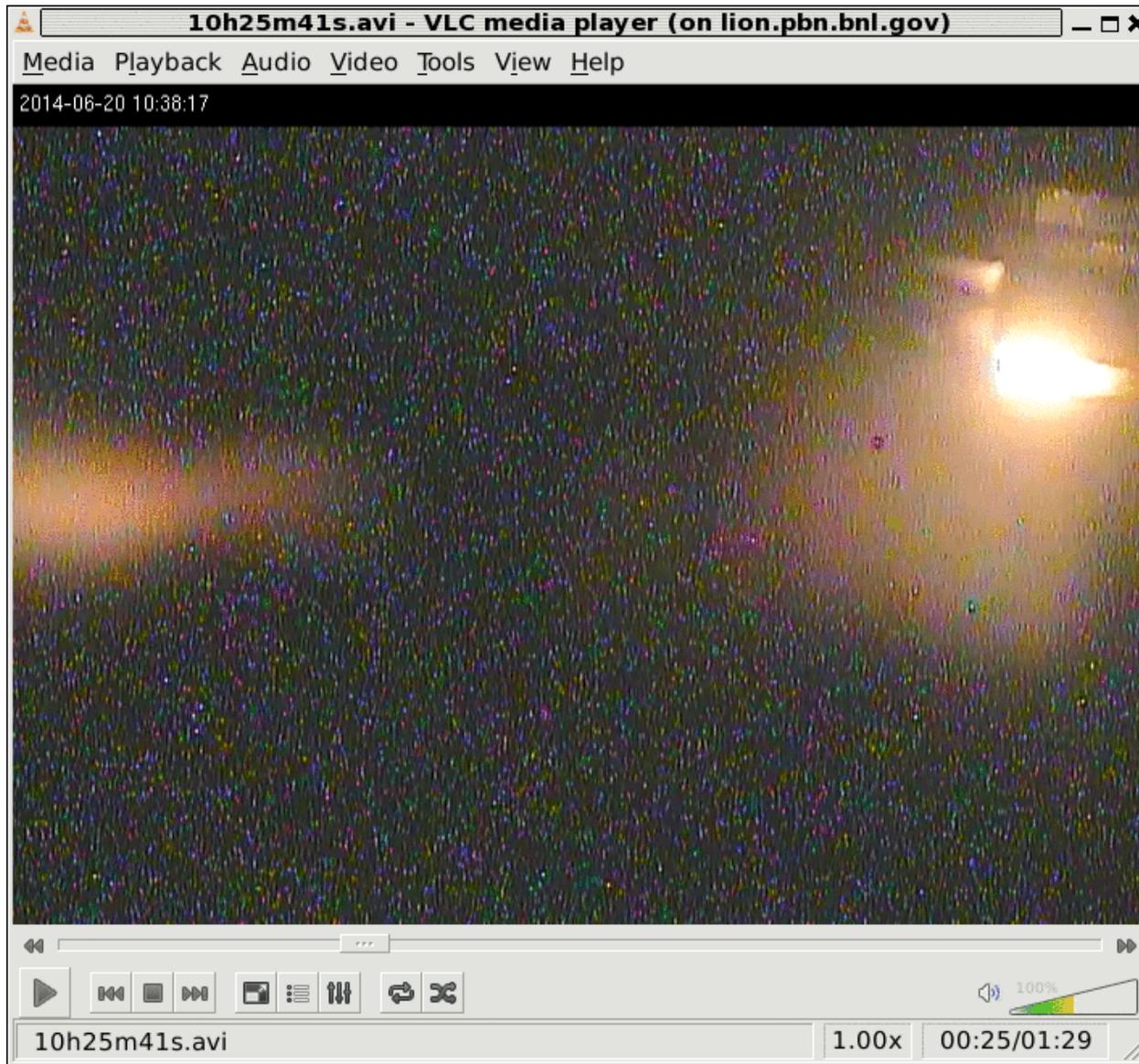
B1H1 (with Fins) Crossing He3 Beam



B1H1 Target Scan crossing He3 Beam



Big Flash When Switching to No-fin Targets



Six Seconds Later.....



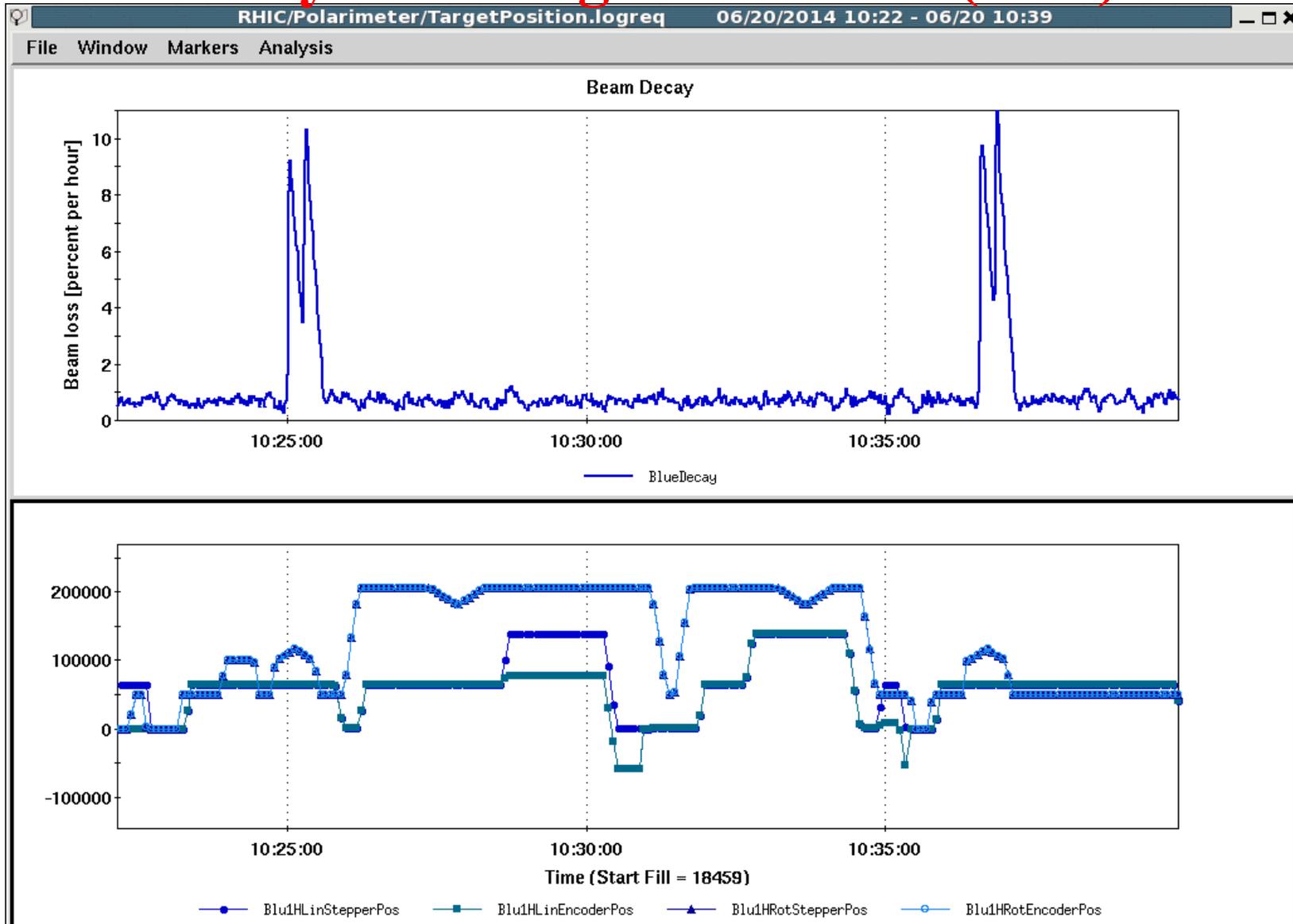
We lost the two targets.

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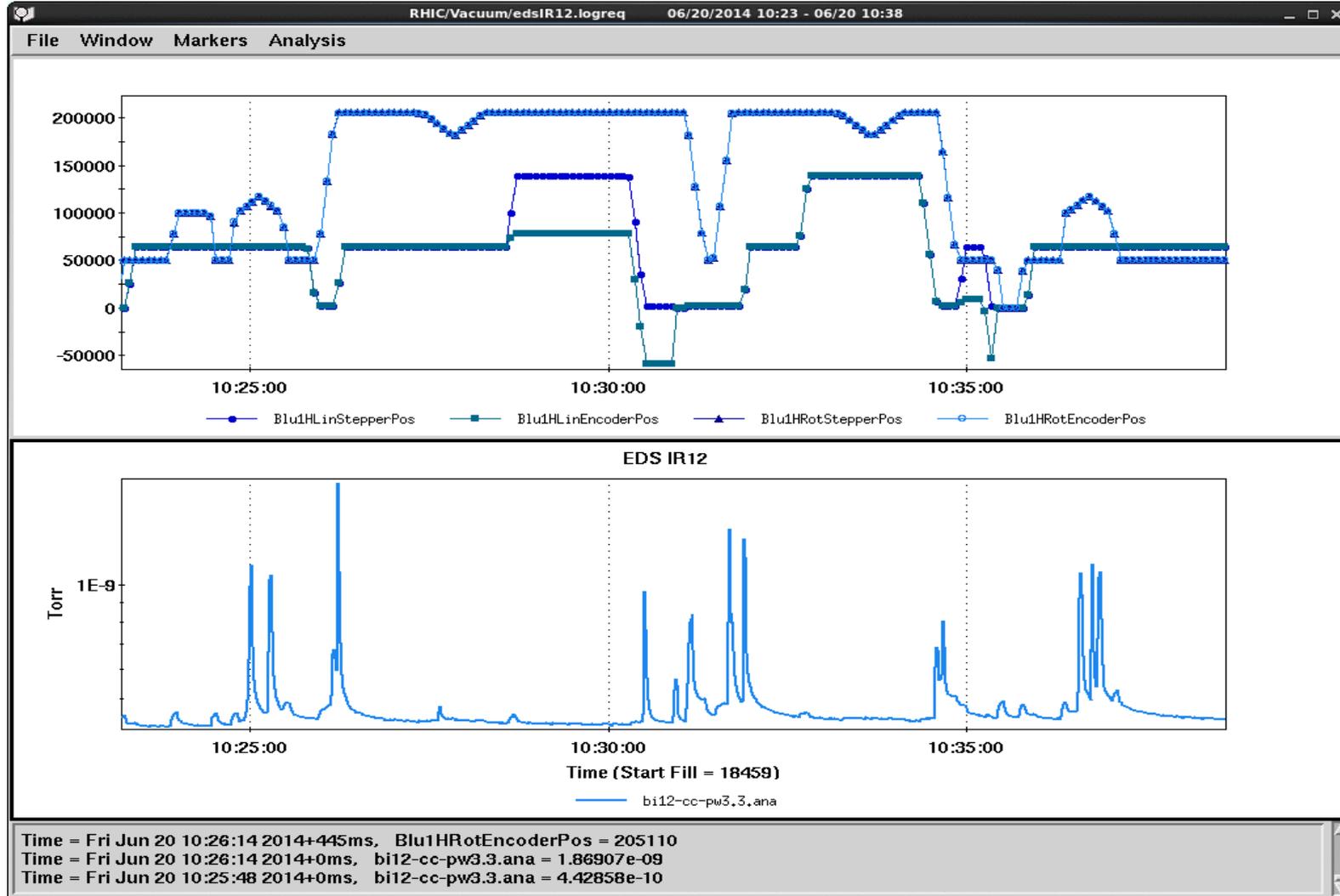
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Beam Decay and Target Positions (6/20)



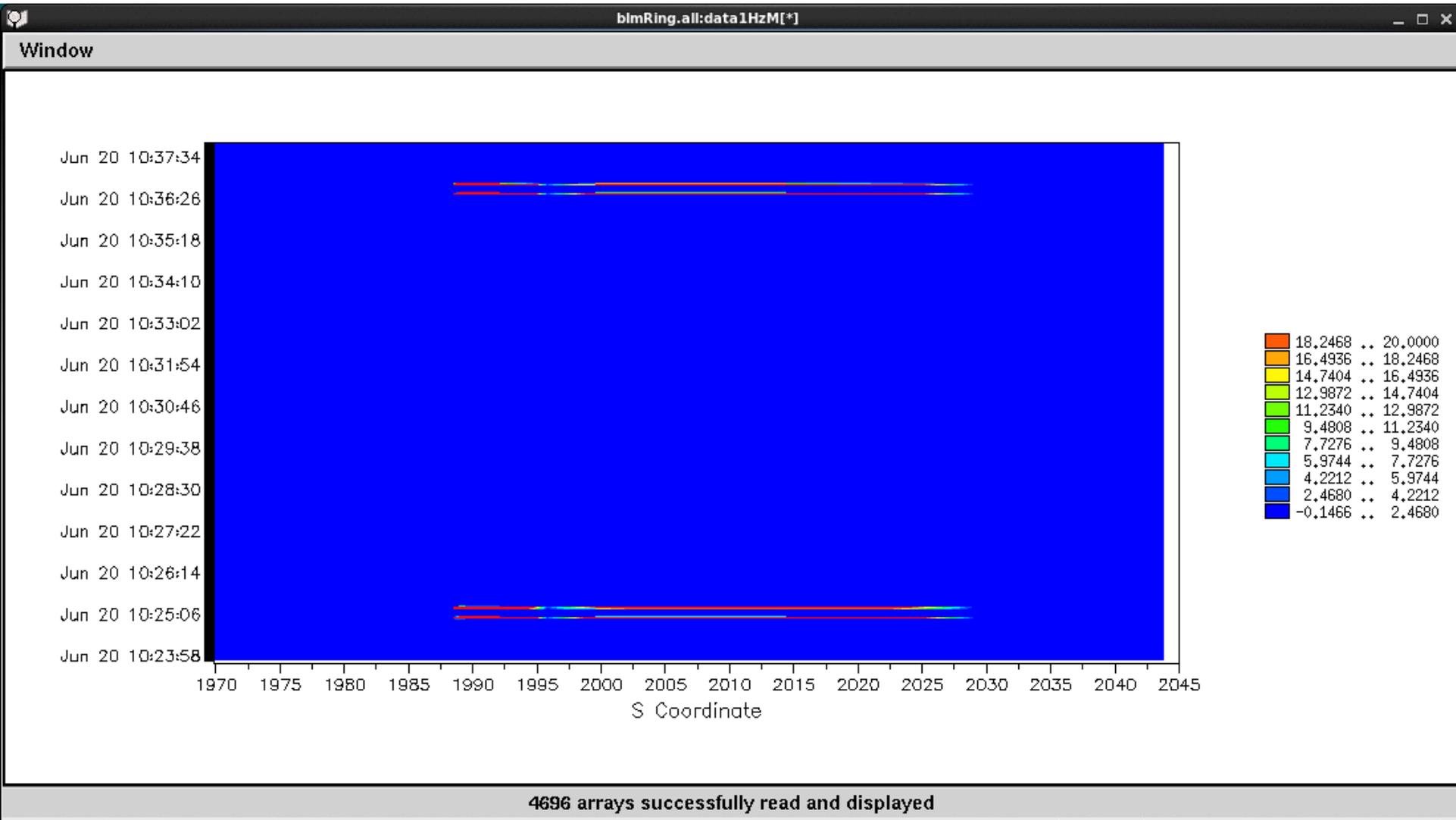
Beam decay and target position. Note that there is no beam decay spike around 10:26:06. There is also no decay around 10:27 and 10:32 when scanning no-fin targets into the beam. They were gone by then. Repeated target with fin again at 10:37 confirmed that target was still there. So only the no-fin targets were affected.

Target Positions and Vacuum Pressures(6/20)

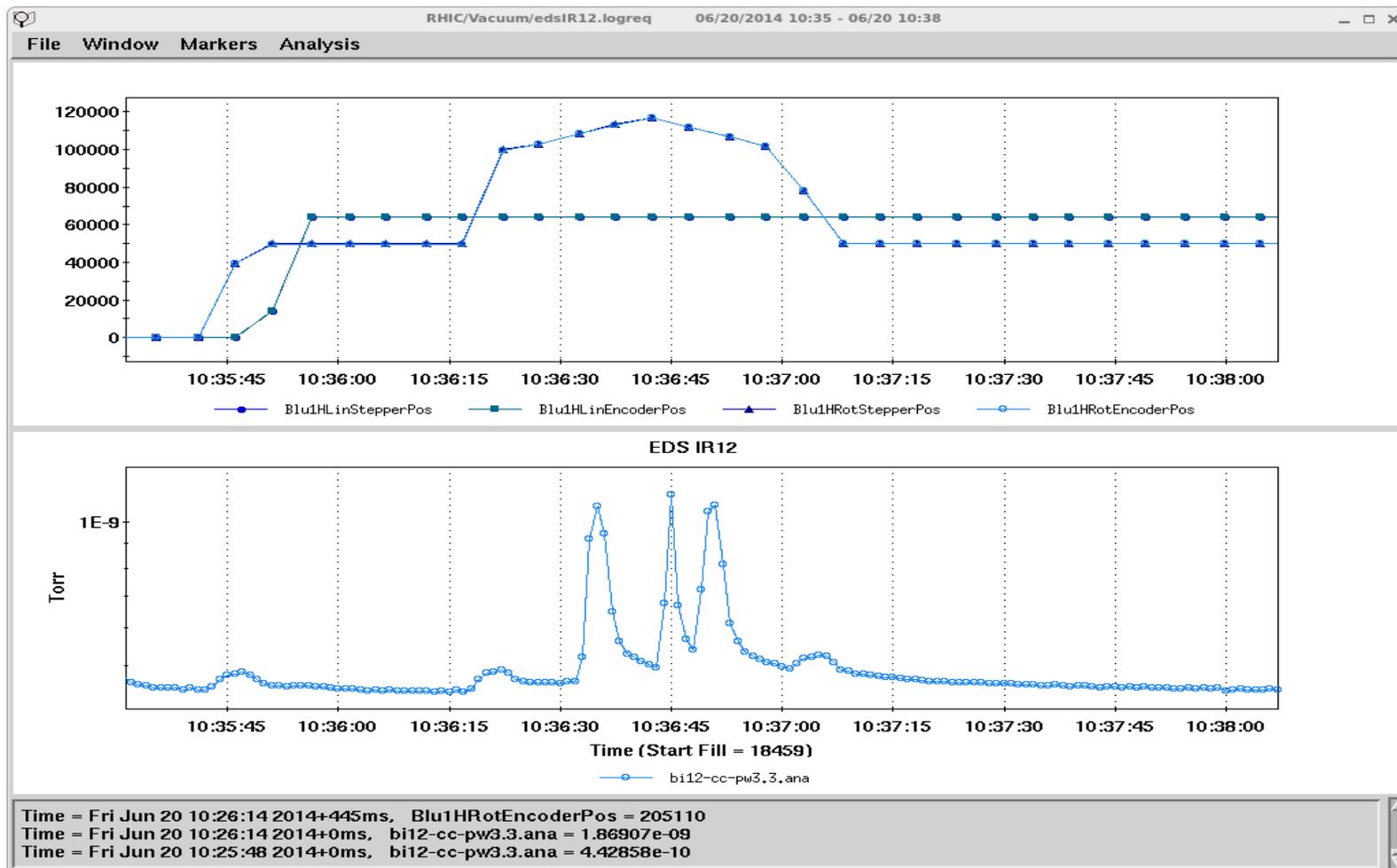


Beam decay and target position. Note that there is no beam decay spike around 10:26:06. There is also no decay around 10:27 and 10:32 when scanning no-fin targets into the beam. They were gone by then. Repeated target with fin again at 10:37 confirmed that target was still there. So only the no-fin targets were affected.

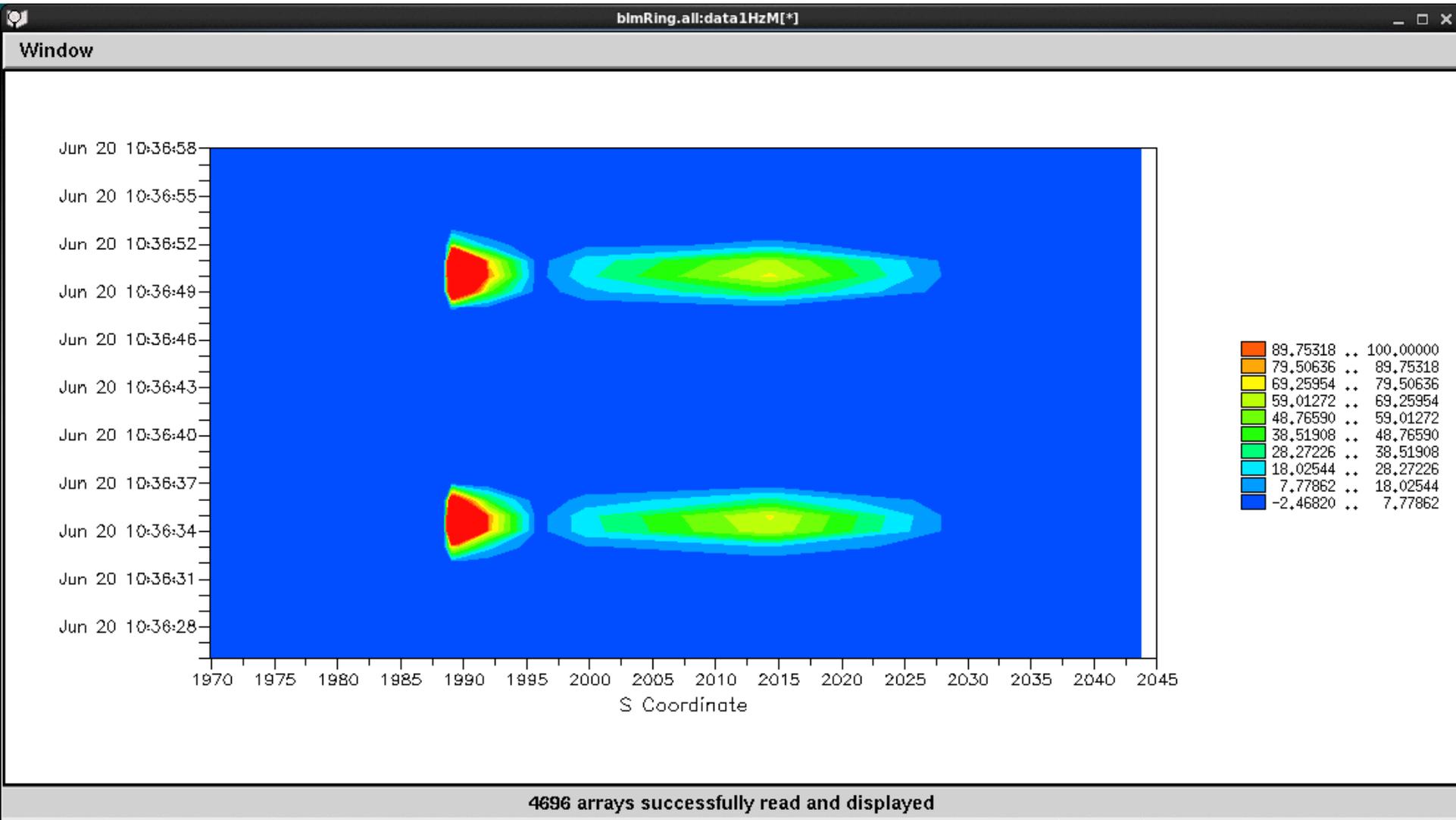
Beam Loss At Polarimeter(6/20)



Target Positions and Vacuum Pressures(6/20), zoomed in



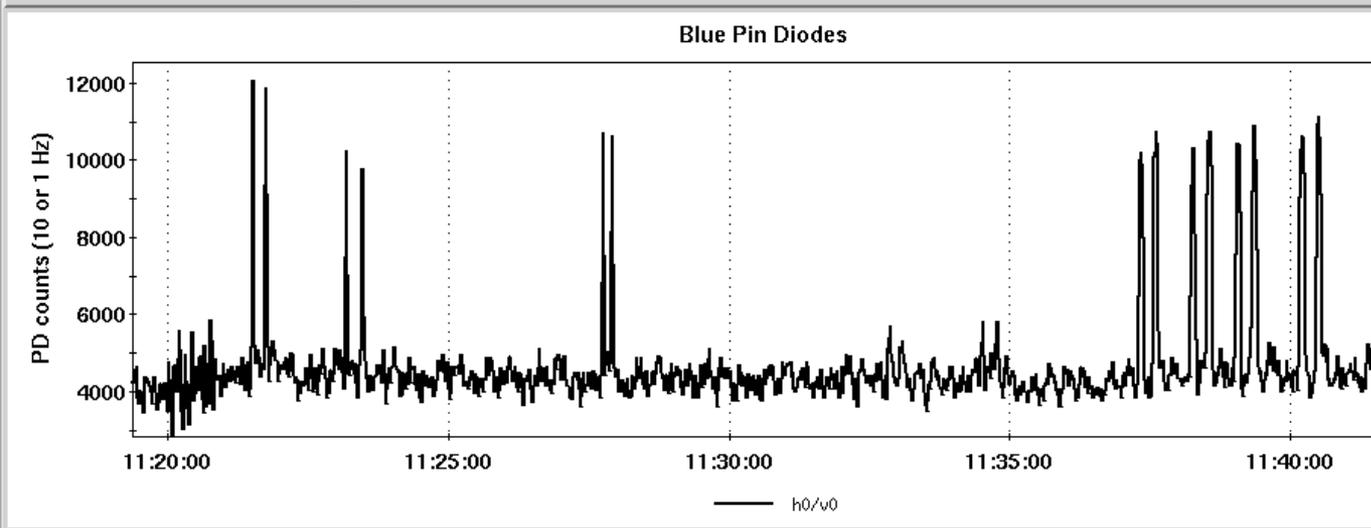
Beam Loss At Polarimeter Zoomed in(6/20)



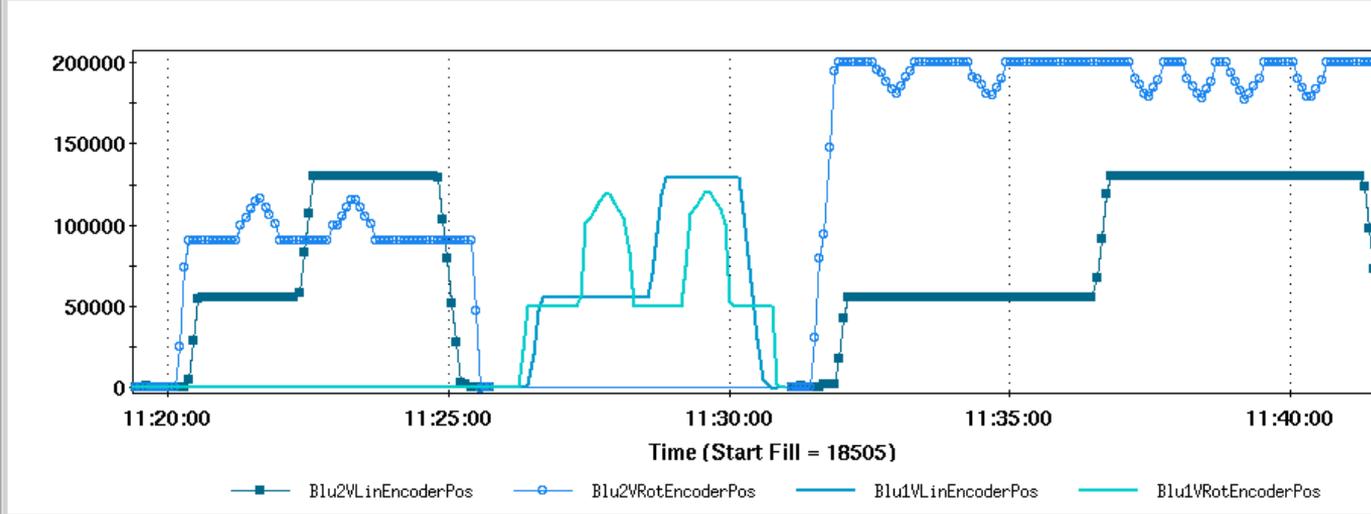
July 4 Beam Test with Vertical Targets

RHIC/Polarimeter/TargetPosition.logreq 07/04/2014 11:19 - 07/04 11:42

File Window Markers Analysis

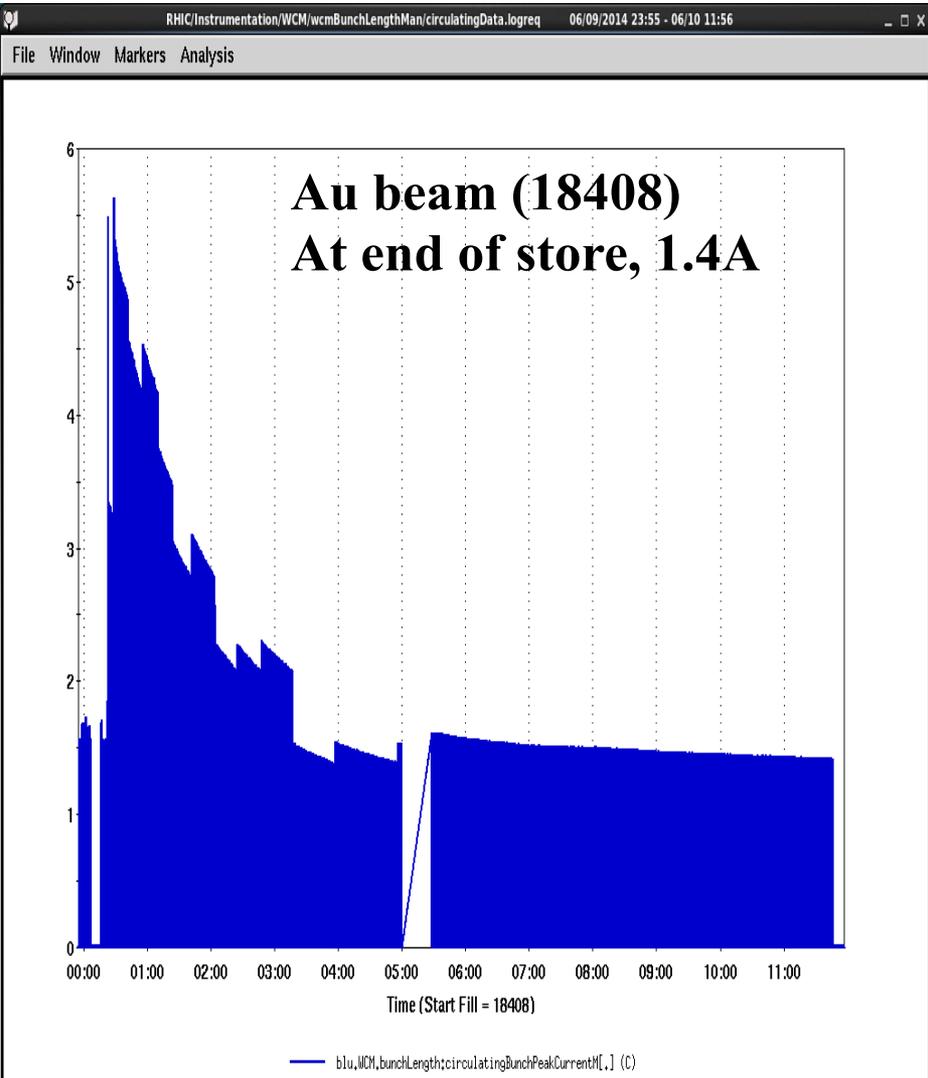


- Idea was to compare B1V (with fins) and B2V (without fins). But the blue1 camera did not work.
- Target B1V3 (with fins) is not there.
- Quite different target size for B2V2.

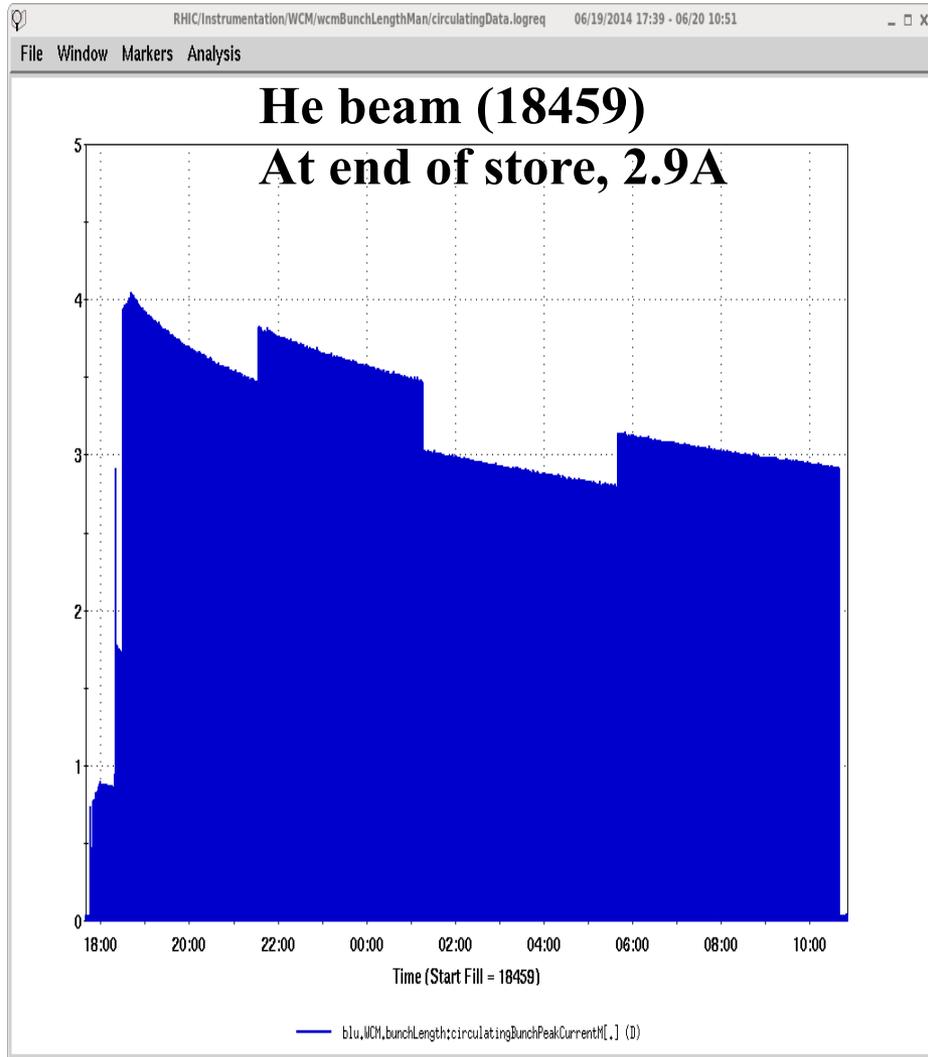


Time = Fri Jul 4 11:31:47 2014+246ms, Blu2VRotStepperPos = 147436
Time = Fri Jul 4 11:37:18 2014+585ms, Blu2VRotStepperPos = 185818
Time = Fri Jul 4 11:41:44 2014+269ms, Blu2VRotStepperPos = 200121

Higher Current at End of Store for He Beam was Likely the Reason for the Target Break



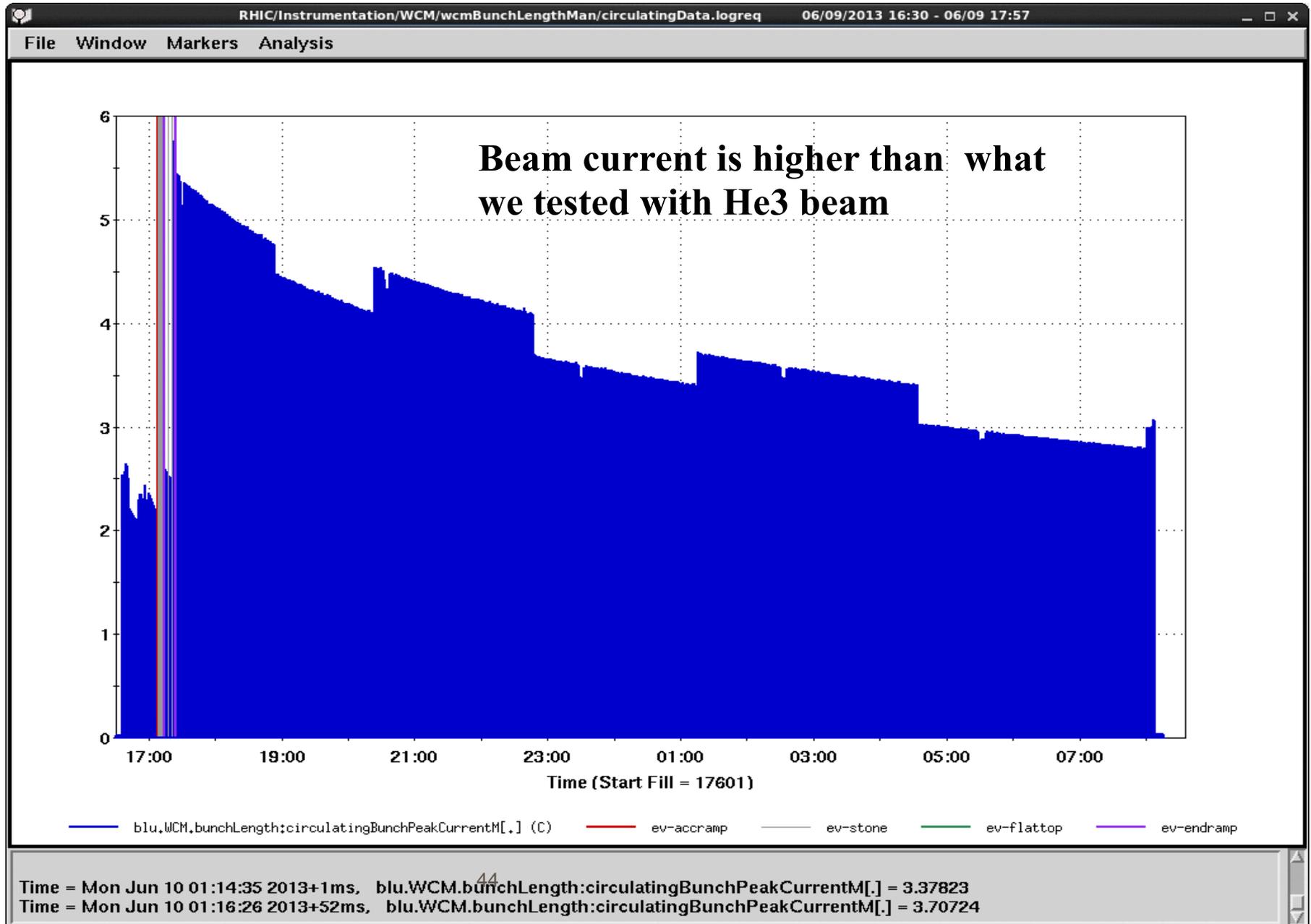
Time = Tue Jun 10 11:44:27 2014+304ms, blu.WCM.bunchLength:circulatingBunchPeakCurrentM[,] = 1.4178



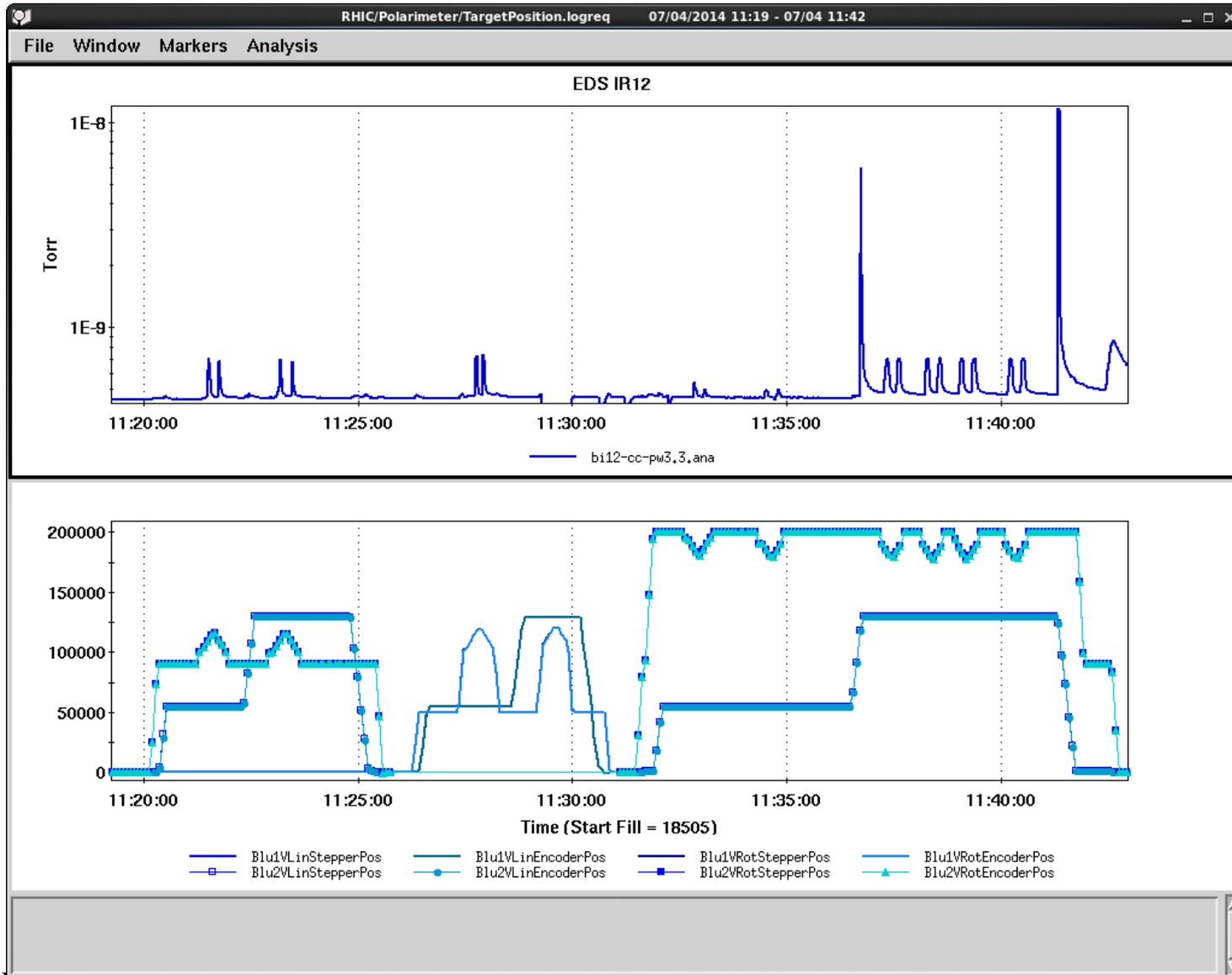
Time = Fri Jun 20 05:35:03 2014+285ms, blu.WCM.bunchLength:circulatingBunchPeakCurrentM[,] = 2.7868
Time = Fri Jun 20 05:41:48 2014+285ms, blu.WCM.bunchLength:circulatingBunchPeakCurrentM[,] = 3.12302
Time = Fri Jun 20 10:40:00 2014+285ms, blu.WCM.bunchLength:circulatingBunchPeakCurrentM[,] = 2.90825



Proton Beam Current from Run13 (17801)

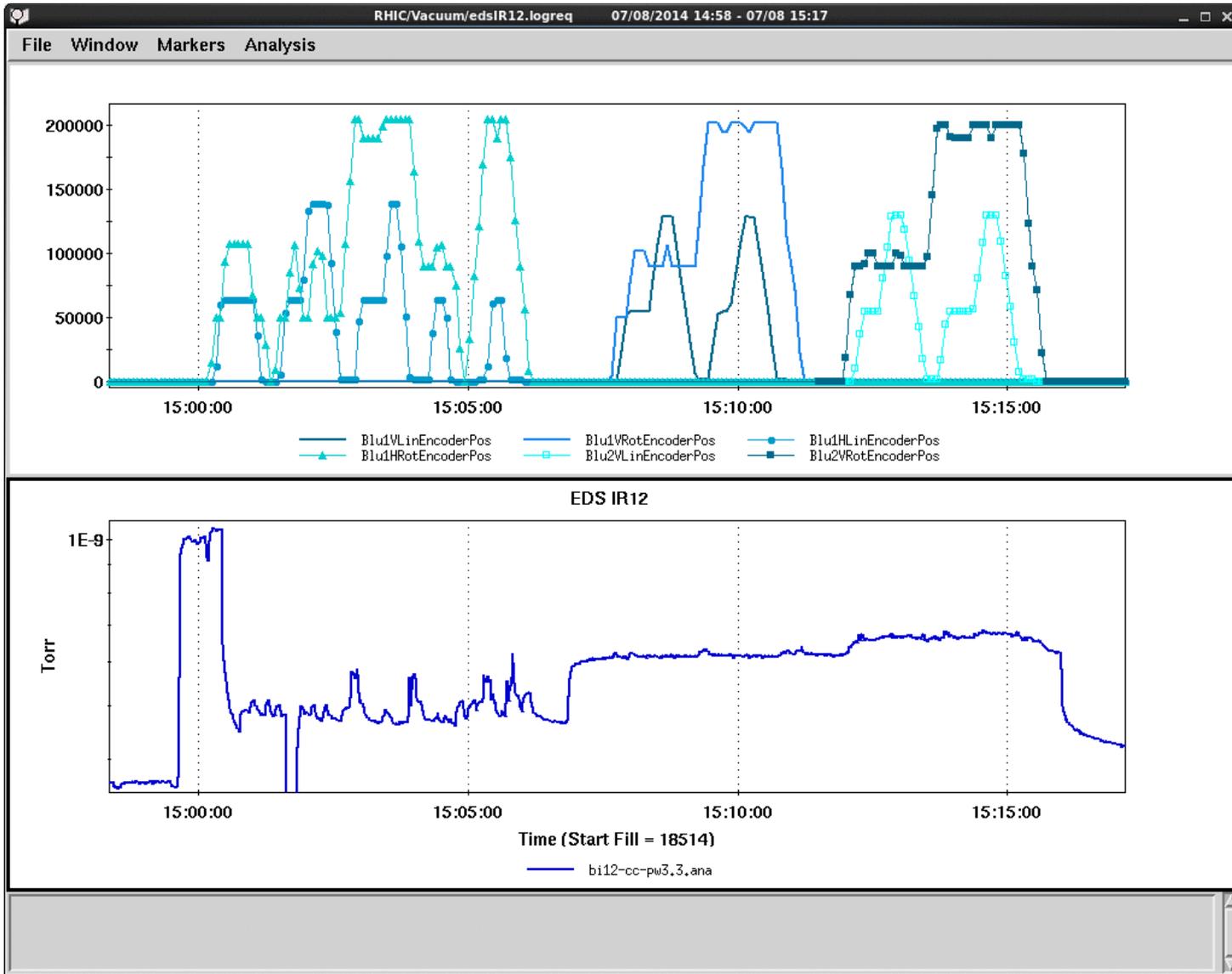


Target Position and Vacuum Pressures(7/4)



Some vacuum spikes took longer time to go away.

Target Position and Vacuum Pressures(7/8)



Vacuum spike structures are different from with beam. Probably some pumps were turned off?

Haixin Huang

What We Have Learnt So Far

- With fins, the glowing light is dimmer in all cases. The large difference of two pairs of target (B1H1/B1H2 and B1H3/B1H4) could be due to many factors. The light brightness is dependent on the beam peak current, target relative size, target resistance, and the relative positions to the camera, etc.
- Target broken during switch in He3 instead of Au beam is believed due to the peak current difference. But why that position is a dangerous spot is not understood.
- With 200MHz RF voltage ramped from 600kV down to 100kV, the glowing light disappeared. This means that the ramping down RF voltage has the similar effect as the added fins.
- If the targets can be parked far enough and 200MHz cavity can be ramped down when targets are in use, we don't have problem.
- However, there is not enough space on 2-4-6 side to park target far away. These targets indeed have shorter lifetime. In addition, the big flash when switching targets underneath the beam is a real concern. This means that targets far away from beam are still affected by the beam EM fields. The fins as protection are needed.

Why Targets Broke During Switching?

- The distance to beam is quite far.
- Some speculations: there is a big viewport above horizontal targets. This is the difference between horizontal and vertical.
- The simulations Jorg done are for target1 in and out of beam. No simulation for other targets or park positions. In addition, the viewport was not in the simulation either.

How about Proton Run?

- In Proton operation, the target switch from 1-3-5 to 2-4-6 side was rarely at store with full RF voltage.
- It mostly happened without beam, with beam but at injection, or with beam at store but with ramped down RF voltage at store.
- Only one exception: April 23, 2013 in store 17417. B2V2(not flashed, broken after 2 store measurements) was broken, and the target was moved to park position between measurements once. The B2V4 (flashed, 4.5MOhms) was used for next three stores. But this is vertical.

Plan (1)

- We need to understand the reason for the target break during switch on June 20.
- Simulation is too slow and probably can not be done easily: large mesh won't be able to show the details, but small mesh may take too long.
- A test with the chamber in Bldg. 930 may be viable. We need spectrum analyzer to see the resonance frequency of the chamber. Mike Brennan offered help for the setup.

Plan (2)

- The fins are helpful in reducing target glowing. Furthermore, it did protect targets in one case. There is no indication of any effect on beam, other than the beam loss when crossing beam as before.
- We have shown enough fin clearance for targets 1-4 with current design. There seems some clearance issue for the current fin design for the 45 degree detectors. This needs to be checked both on drawing and reality check. The design probably should be modified a little bit.
- How many should we install? Here are options we have (I would prefer 2 or 1):
 1. Add for all possible ones (except 5 and 6 positions).
 2. Add for half of all possible ones.
 3. Add for all 2,4 targets.
 4. Add just a few to continue the test (comparison).
 5. Do nothing.