



TRIUMF Beam Physics Note
TRI-BN-17-BL1A-T2
Apr.04, 2017

BL1A T2 Issue

Y.-N. Rao

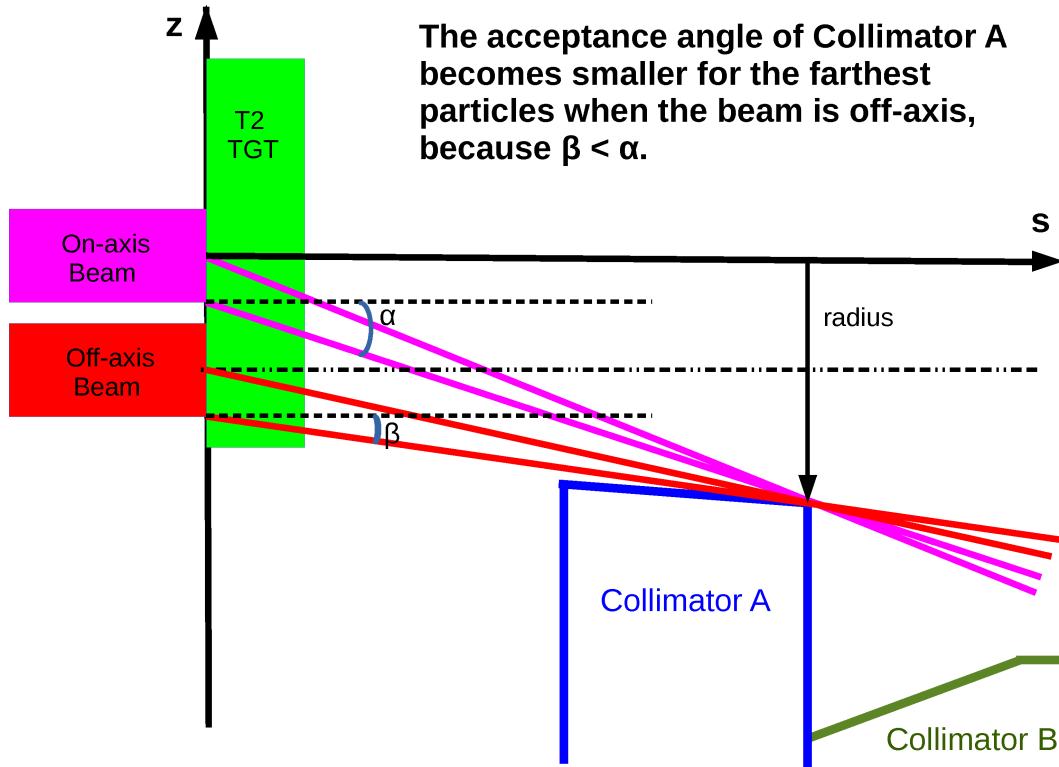
TRIUMF

Abstract: In this note we review the changes in the elevations of BL1A T2 target and its protect monitor over the last four years, with goal to pinpoint the primary misalignment that causes the reduction of TNF neutron flux.

1 What is the issue?

Since 2013, the neutron flux as monitored by the TNF neutron monitor has been fluctuating during every year's production run. These fluctuations were partly related to the fact as to whether or not there were any targets installed in the TNF. When there were no targets installed in the TNF, the neutron flux was deemed to be close to 10 cps per μA BL1 adjusted current. But when the TNF had a number of Moly targets installed, they reduced the proton energy producing fewer neutrons. This part is not the issue with argument. The issue is that the neutron flux had a reduction of about 20% even if there were no Moly targets installed in the TNF. This was evidently observable during the last 4 years particularly during the 2015 and 2016 production runs.

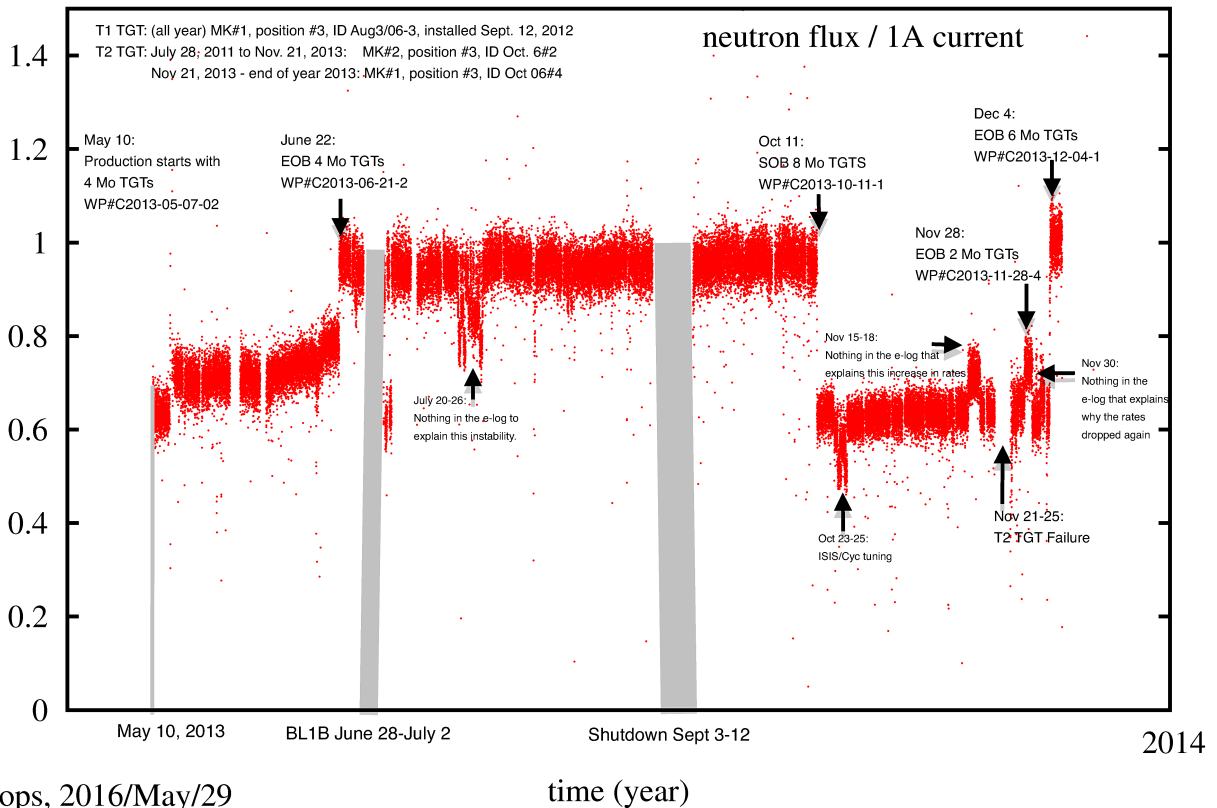
It was suspected that the proton beam was being forced off axis by the T2 Protect Monitor, as a result, a larger fraction of the beam was scraped by Collimator A which has a 1 cm radius entrance aperture. In terms of the REVMOC simulation result (see TRI-DNA-82-3), about 35% of the beam hitting T2 is normally lost on the Collimator A before entering TNF, as the beam size becomes largely blown up due to multiple scattering and nuclear scattering after passing through a 10 cm long T2 target (Be). The scattering angle is about 15 mrad (rms). If the beam enters the T2 target with an offset from Collimator A axis, then the acceptance angle of Collimator A is reduced, thus the furthest off-axis protons are scraped by the Collimator A, leading to the TNF neutron flux reduction. This is sketched below.



In order to pinpoint the primary misalignment that causes the neutron reduction, here I have to put together all the information of the last 4 years about the elevations of T2 Protect Monitor, T2 target, and Collimator A. According to Isaac Earle, the Collimator A has never been shifted intentionally since 2009, and its current elevation is supposed to be 1834.7 mm, measured from the collimator flange. Keep in mind that the magnitude of misalignment we are searching for here is merely about 2 to 3 mm, instead of in a centimeter range.

2 Year 2013

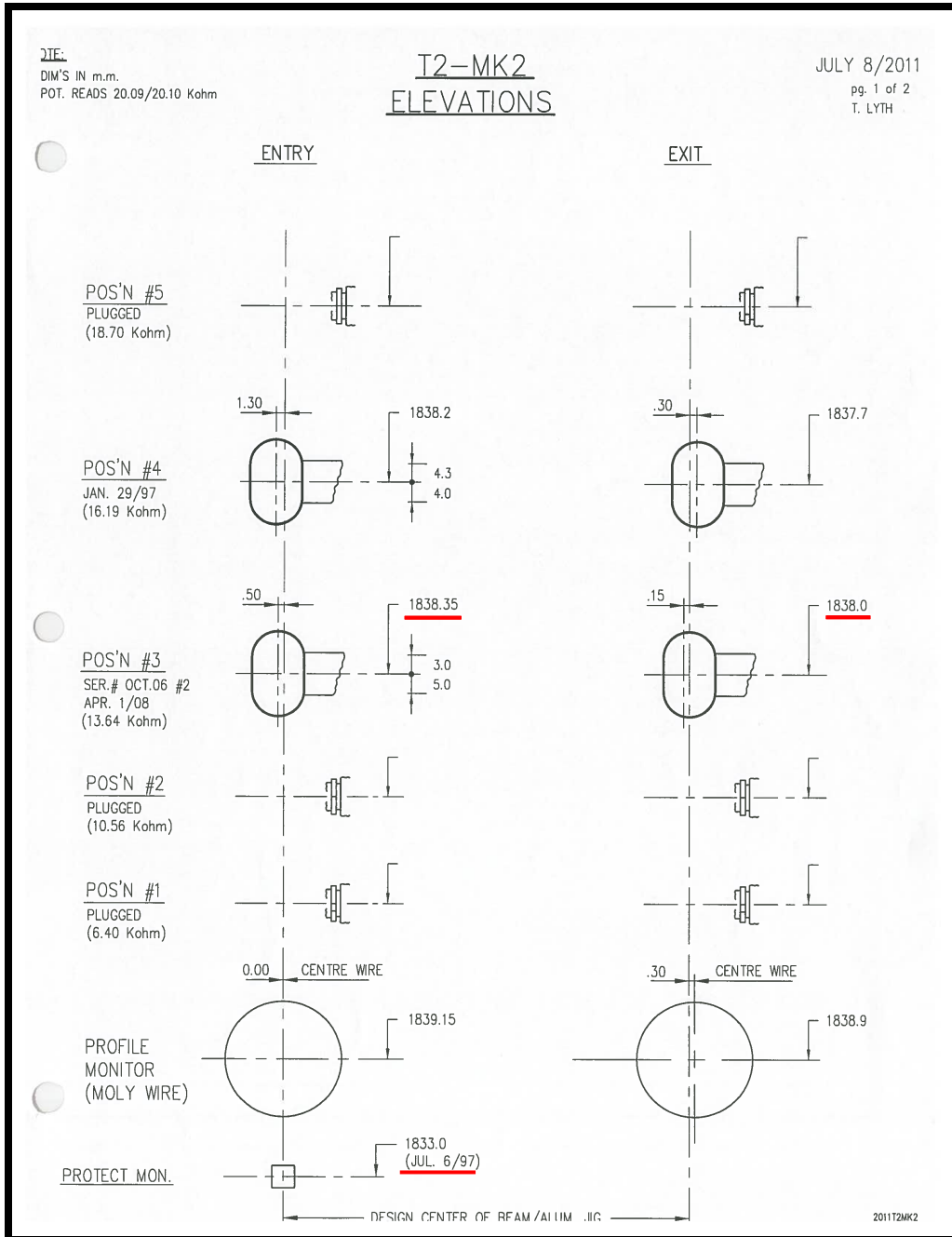
TNF Flux Rate 2013



There were no Moly targets installed in the TNF during the period from 2013-Jun-21 to 2013-Oct-11, over which the TNF neutron flux was reading as high as ~ 1000 counts (which corresponds to the 1 in the above plot) and was almost constant. And then from 2013-Oct-11 to 2013-Nov-28, there were 8 Moly targets installed in the TNF, thus the neutron flux dropped to ~ 650 counts (which corresponds to 0.65 in the plot). This drop was due to the energy reduction of proton beam passing through the Moly targets. Until 2013-Dec-04 when the Moly targets were removed, for a brief time the neutron rate came back to 1000 counts level.

Clearly, during each period, either with or without Moly targets installed in the TNF, the TNF neutron flux could increase or decrease for some reason. Nevertheless, it is making sense for the neutron user to consider the 1000 counts as their reference and desired value for the case without Moly targets.

During 2013, there were 2 targets used at T2, namely, from the beginning of May to Nov.21, and then from Nov.21 to the year end. Their elevations are shown below.



★ Note that during the 1st target period, the Protect Monitor was higher than the target by about $1838.0 - 1833.0 = 5.0$ mm, and also **HIGHER** (not lower) than the Collimator A by about $1834.7 - 1833.0 = 1.7$ mm.

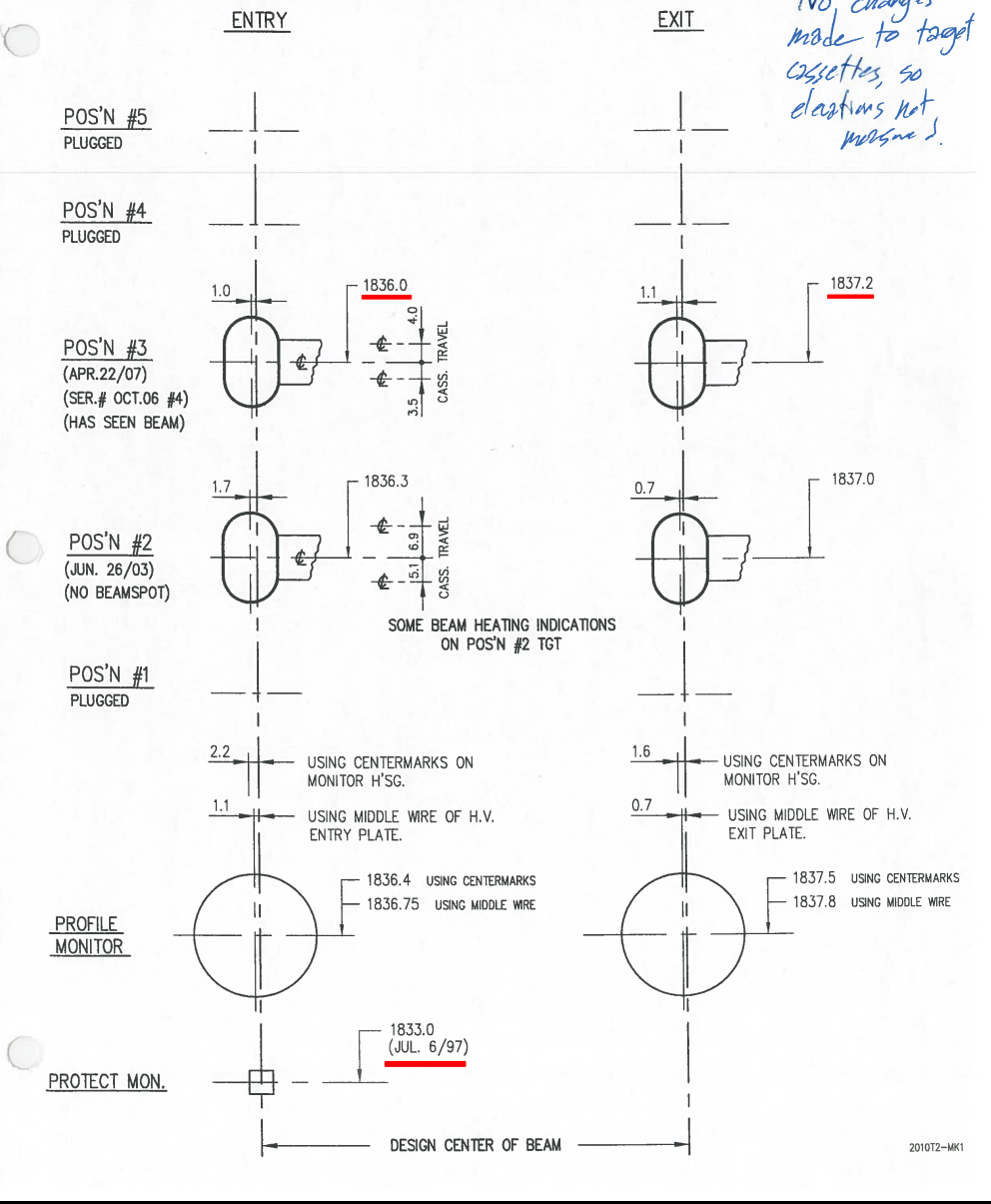
NOTE:

- DIM'S IN m.m.
- POT. READS 20.19/20.20 Kohm
- METERMAN 33XR METER.

T2-MK1
ELEVATIONS

JAN. 5/10
pg. 1

No changes made to target cassettes, so elastins not measure!



★ During the 2nd target period, the Protect Monitor was higher than the target by about $1836.6 - 1833.0 = 3.6$ mm, and also **HIGHER (not lower)** than the Collimator A by about $1834.7 - 1833.0 = 1.7$ mm.

3 Year 2014

★ Over the weekend from 2014-Apr-25 to 2014-Apr-27, the T2 target was situated at position #4, taking 15 μ A. The beam was kept centered vertically on the T2 Protect Monitor. See Eric Chapman's entries on the CycOps e-log.

2014-04-25 18:05:00	Summary: Remove 1AMT2 Detail: DT 2 mins	Make Comment - Eric Chapman
2014-04-25 18:14:00	Summary: Beam off to move T2 back to position 4 Detail: (No additional detail)	Make Comment - Eric Chapman
2014-04-25 18:17:00	Summary: Beam on to 2A and 1A Detail: (No additional detail)	Make Comment - Eric Chapman
2014-04-25 18:18:00	Summary: BL2A back up to 30uA, production resumes. Detail: (No additional detail)	Make Comment - Eric Chapman
2014-04-25 18:18:07	Summary: BL1A current limit set to 20uA. Issac Earle has requested we run 15uA down BL1A over the weekend. On Monday T2 will be pulled for inspection. Detail: (No additional detail)	Make Comment - Eric Chapman
2014-04-25 19:31:40	Summary: Please keep beam vertically centered on the T2 protects. Detail: (No additional detail)	Make Comment -- Eric Chapman
2014-04-25 18:57:14	Summary: Retired Defeat 7011: MHESA B1 collective zone 02-001-001 Detail: Visual check of the area confirmed no personnel and all smoke detectors in place. Collective zone re-armed	Make Comment - David Bandiera

★ On the following Monday 2014-Apr-28, the T2 target was removed from the beamline and then transported to the hot cell for measurements. A clear spot was visible on the entrance and exit windows of the target. See Isaac's e-mail and photos that follow.

Subject: T2 Beam Spots

From: Isaac Earle <iearle@triumf.ca>

Date: 04/29/2014 05:15 PM

To: Yuri Bylinski <bylinsky@triumf.ca>, Jamie Cessford <cessford@triumf.ca>, Thomas Planche <tplanche@triumf.ca>, Rick Baartman <krab@triumf.ca>, Yi-Nong Rao <raoyn@triumf.ca>

CC: Scott Kellogg <kellogg@triumf.ca>, Ron Kuramoto <kur@triumf.ca>, Grant Minor <gminor@triumf.ca>

Hello All,

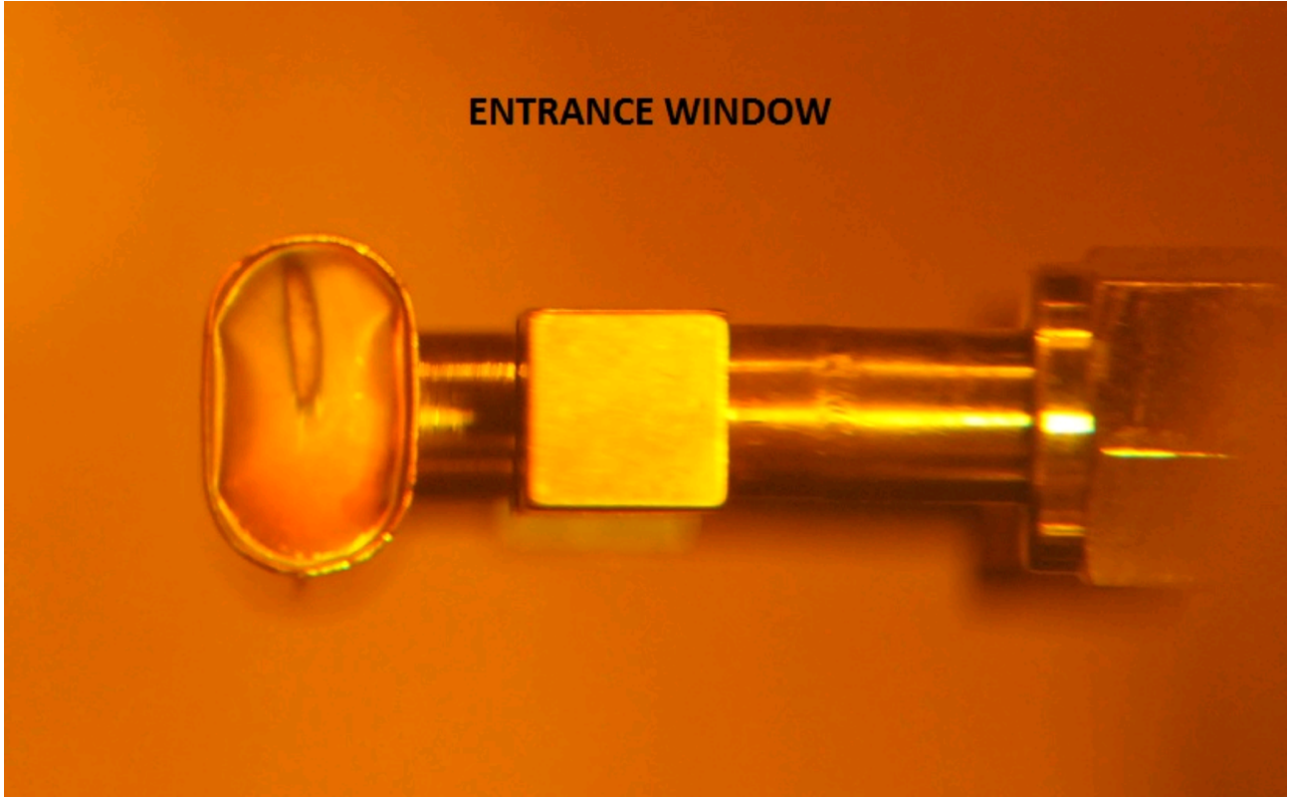
The T2-MK2 target was removed from the beam line yesterday afternoon and transported to the hot cell. A clear beam spot is visible on the entrance and exit windows of the target (photos below). The beam spot confirms where the beam was suspected to be and what the profile monitor was telling us (approximately 6mm high).

I performed horizontal and vertical measurements on the position 4 target and profile monitor, and also measured beam spot size/shape/location on the entrance and exit windows. These figures will be supplied to Ops once an elevation measurement has been taken of the new protect monitor.

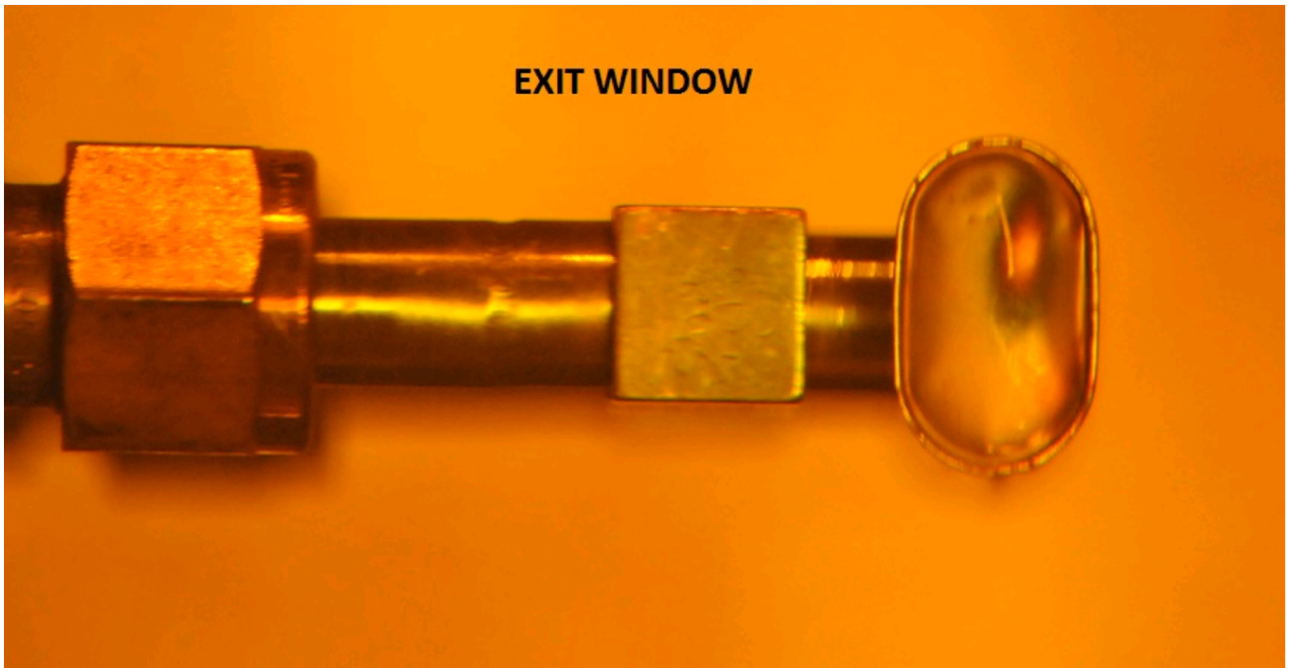
The T2-MK2 target is ready to be returned to the beam line tomorrow morning.

Isaac

ENTRANCE WINDOW



EXIT WINDOW

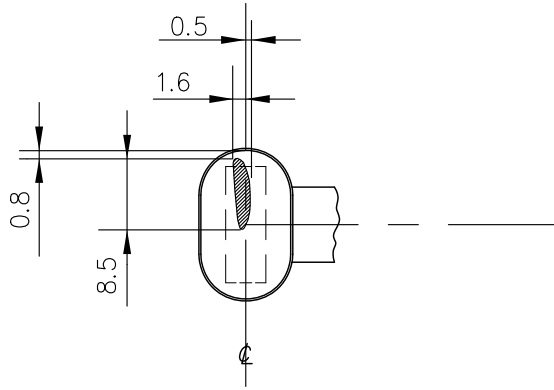


T2-MK2 BEAMSPOTS

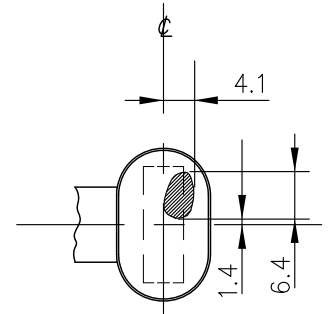
ENTRY

EXIT

POS'N #4



VIEWED FACING DOWNSTREAM

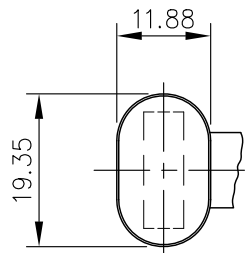


VIEWED FACING UPSTREAM

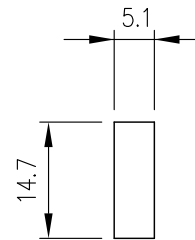
BEAM SPOT MEASURED MAY 2, 2014

FIRST BEAM ON TARGET: APRIL 2014

HIGH BEAM SPOT CAUSED BY MISALIGNED PROTECT MONITOR – CORRECTED MAY 1, 2014



OUTSIDE DIM'S



Be TGT

★ In terms of Isaac's photos and measurements, the beam spot centroid was upward displaced from the target centre-line by roughly $8.5/2=4.2$ mm at entrance.

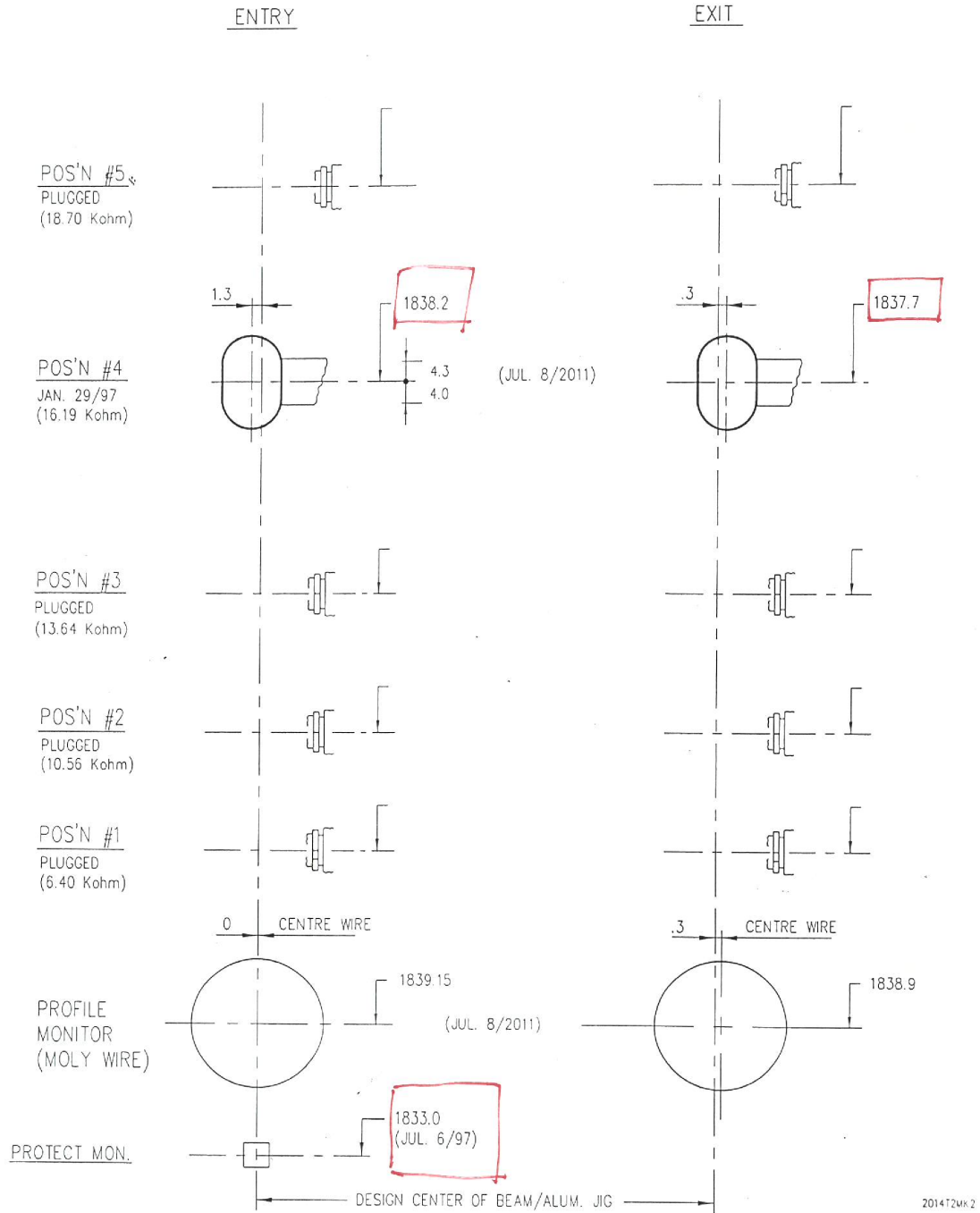
The displacement is roughly the same at the exit window. This indicates that the beam was pretty leveled through the target.

But remember that this beam was kept balanced up and down on the T2 Protect Monitor. **Thus, this means that the target centre-line was misaligned by ~ 4.2 mm, too low relative to the Protect Monitor centre-line. This is consistent with the elevation info that Isaac provided, as shown next page, where the target was indicated to be $(1838.2+1837.7)/2-1833.0=5.0$ mm lower than the Protect Monitor.** Note that the bigger number here means a lower elevation as the zero value is on the top.

T2-MK2 ELEVATIONS



JAN 27, 2014

pg. 1 of 2
I. EARLE



It indicates that the target was lower than the protect monitor by $(1838.2+1837.7)/2-1833.0=5.0$ mm.

★ On 2014-May-14, the T2 target was returned to position #4 and 2 mm above the nominal position. See Grant Minor's entry on the RH e-log of 2014-May-14.

Logbooks General Evaporator 1 Evaporator_2 Laser cutter Target Production Test-Stand RH-ISAC RH-Cyclotron RH-Meson Hall RH-Beamlines RH-ARIEL		
RH-Meson Hall	Not logged in	
 List		
Message ID: 116 Entry time: Wednesday, May 14, 2014, 20:36		
Author:	Grant Minor	
Category:	Development	
Type:	Target 2	
Specific:	Target	
Subject:	Target exercised to position 0, then back to 2.0 mm above position 4	
<p>The T2 target was exercised to position 0 around 6:15pm so that the T2 profile monitor could be used by operations. The T2 water package was re-enabled when the target was in position 0, however this resulted in some trips of the cooling package.</p> <p><u>Operations called around 7:45 to request return of the target to about 2mm above position 4.</u></p> <p>The target position was re-set so that the position reading fluctuated roughly between 2.7 and 1.6 mm above position 4 (hovering roughly around 2.0 mm), and so the potentiometer reading was hovering roughly between 0.801 and 0.798.</p> <p>The cooling package was re-started, and called operations to confirm the system was OK.</p>		
ELOG V2.7.5-2130		

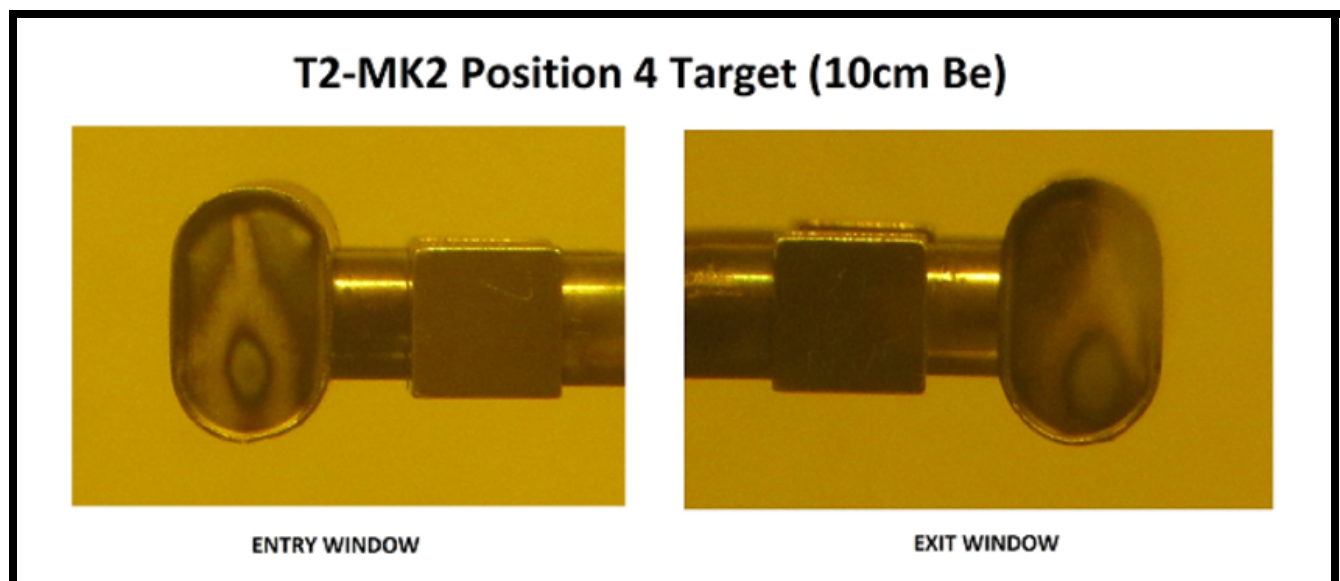
But this 2 mm upward fine adjustment did not help, because the Protect Monitor was still too low, that is, the beam entered the target section too low.

★ **The problem persisted, causing a lot of beam trips.** We could not lower the beam position at T2 and TNF both to solve the trouble because we were limited by the beamline optics; the steerer SM11A,B was already maxed out and still wanted to go to higher setting.

There was no chance to re-align the T2 Protect Monitor before the 2014 Christmas shut-down. A provisional action taken was to lower the beam at TNF to make the TNF Protect Monitor balanced up and down and therefore to reduce the beam trips due to the TNF. We could not do this until we got a new power supply installed on the asymmetric quad Q16 to have more steering capability available for the steerer SM11A,B. We ended up getting chance to do the online adjustment on 2014-Oct-16. I had this well done within 15 minutes; it went straightforward. During that exercise, I did not try to lower the beam position at T2 at all.

★ **But, 5 days later, that is, on the beam development shift of 2014-Oct-21,** Yuri asked to lower the beam at T2 to make the T2 Protect Monitor look balanced. I warned him that this would be risky to the T2 target. Indeed, the beam appeared to be too lower on the target. Look at Isaac's messages and pictures in the following pages.

Note that Isaac's these info were produced on 2015-Feb-27, after the full 2014 running period.



Subject: Re: T2-MK2 Beam Spot Photographs

From: Isaac Earle <iearle@triumf.ca>

Date: 02/27/2015 01:03 PM

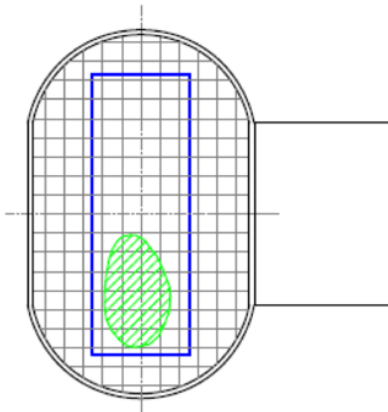
To: bylinsky <bylinsky@triumf.ca>

CC: Yi-Nong Rao <raoy@triumf.ca>, Rick Baartman <krab@triumf.ca>, Thomas Planche <tplanche@triumf.ca>, Scott Kellogg <kellogg@triumf.ca>

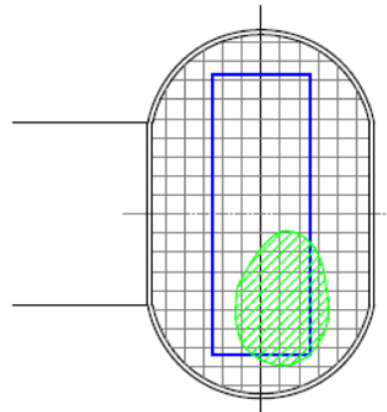
Hi Yuri,

Here are plots of the entry and exit window beam spots with the outline of the beryllium material shown in blue. The grid spacing on the target window is 1mm. As you suspected, part of the beam is missing the target at the exit.

T2-MK2 POS'N 4 BEAM SPOT AS MEASURED FEB 27, 2015



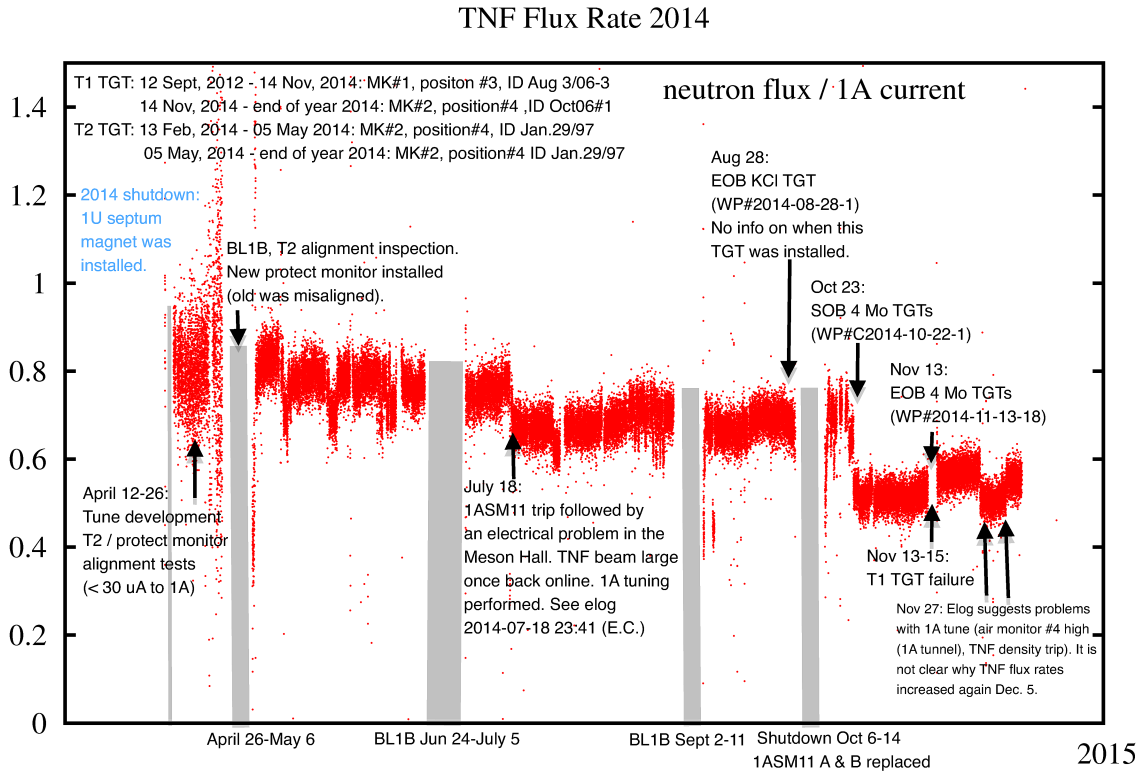
ENTRY WINDOW



EXIT WINDOW

For the full 2014 running period the T2 target ladder was 2mm higher than the nominal position, to try to compensate for steering issues (the issue was corrected in October 2014, but the ladder position was not changed). The plot below shows the beam spots shifted up 2mm. This is what I would expect if the target ladder was set at the nominal position and beam tune was not changed. In the plot below the beam spot centers seem to be about 2.5mm below the target center, this indicates to me that the T2 protect is 2.5mm too high.

★ As a result of that, the TNF neutron flux dropped below 600 counts. This drop was very significant, starting from 2014-Oct-22, even until 2014-Nov-13 when the Moly targets were removed. See the following plot.





(c) ops, 2016/May/29

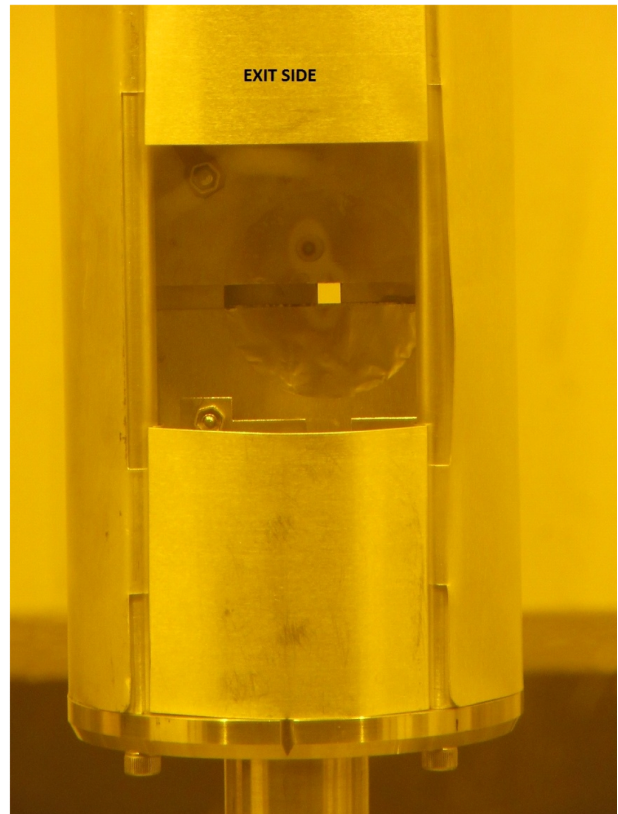
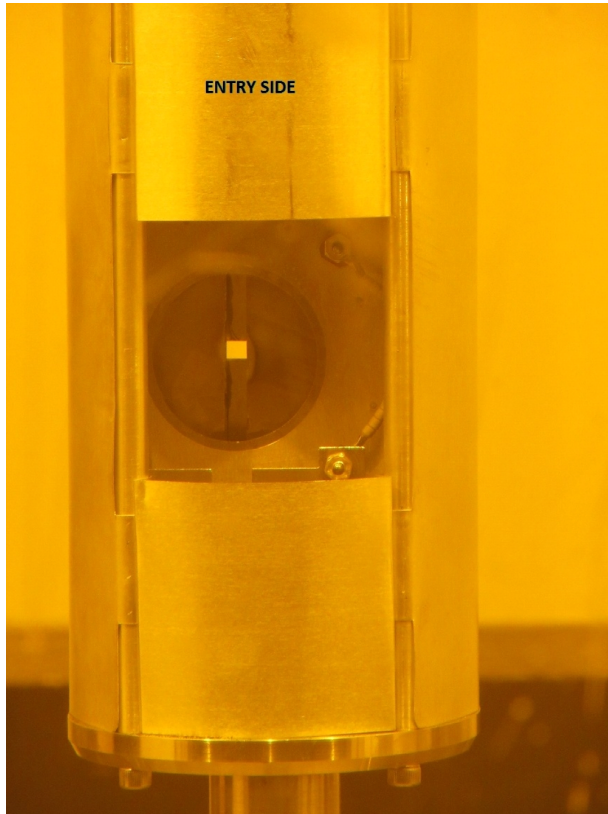
★ In conclusion, from 2014-Oct-21 to the end of 2014, the T2 Protect Monitor which was sitting at elevation of $1833.0+6.8=1839.8$ mm was lower than the Collimator A which was sitting at 1834.7 mm by 5.1 mm. This was responsible for the neutron flux getting significantly dropped below 600 counts.

The beam's incident angle seemed to be small, as the centroid of beam spot on the entrance window was at an elevation of $\sim(1838.2-2.0+4.0)=1840.2$ mm (where the 1838.2 mm was the nominal position of target centre-line, the 2 mm was the upward fine adjustment of the target ladder during the full 2014 running period, whereas the 4 mm was the downward displacement of the beam spot centroid w.r.t. the target centre-line.). This was about the same elevation as the Protect Monitor's centre-line of 1839.8 mm.

★ On 2015-Apr-23 (during the winter shutdown), Isaac took photos of the old Protect Monitor. See his e-log entry and photos below.

RH-Meson Hall		Not logged in			
 List					
Message ID: 154 Entry time: Thursday, April 23, 2015, 13:40					
Author:	Isaac Earle				
Category:	Development				
Type:	Target 2				
Specific:	Other				
Subject:	T2 Protect Monitor Elevation Adjustment				
<ul style="list-style-type: none"> - T2 Protect Monitor moved from the beam line to the hot cell on Monday April 20th - <u>Elevation of the plate center measured at 1839.0mm from the base of the vacuum flange</u> - <u>Old monitor cassette photographed (attached). Heat mark noticed on exit side approximately 10mm above and 5mm south of plate centers (cause unknown, and no matching mark on entrance side)</u> - <u>Old monitor cassette removed, new one installed. New elevation 1836.1mm (2.9mm upward shift - 3.0mm was requested)</u> - Electrical check performed by Probes Group on April 22 - They reported that it looks normal - <u>T2 Protect Monitor returned to the beamline April 22 in the evening.</u> Cables plugged in and flange bolts installed - Vacuum pumped down normally on April 23 in the morning - Probes group repeated the electrical check after installation from the 1A mezzanine - They reported that it looks normal - The old monitor cassette will be left in the hot cell for possible future use 					
Attachment 1:	Old_T2_Protect_Monitor_(removed_Apr_22_2015)_-_Entry_Side.jpg 222 kB Hide Hide all				
Attachment 2:	Old_T2_Protect_Monitor_(removed_Apr_22_2015)_-_Exit_Side.jpg 229 kB Hide Hide all				
ELOG V2.7.5-2130					

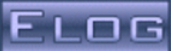

Photos of the Protect Monitor used for the 2014 production run.



Clearly, there were 2 heat marks noticed on the exit side: one was significantly above the plate centre, the other was flush with the gap.

4 Year 2015

★ On 2015-Apr-23, a new Protect Monitor was installed with its elevation upward adjusted by 2.9mm relative to the old one used over the previous year from 2014-May-05 to 2014 Christmas shutdown.

RH-Meson Hall		Not logged in			
 List					
Message ID: 154 Entry time: Thursday, April 23, 2015, 13:40					
Author:		Isaac Earle			
Category:		Development			
Type:		Target 2			
Specific:		Other			
Subject:		T2 Protect Monitor Elevation Adjustment			
<ul style="list-style-type: none">- T2 Protect Monitor moved from the beam line to the hot cell on Monday April 20th- Elevation of the plate center measured at 1839.0mm from the base of the vacuum flange- <u>Old monitor cassette photographed (attached). Heat mark noticed on exit side approximately 10mm above and 5mm south of plate centers (cause unknown, and no matching mark on entrance side)</u>- <u>Old monitor cassette removed, new one installed. New elevation 1836.1mm (2.9mm upward shift - 3.0mm was requested)</u>- Electrical check performed by Probes Group on April 22 - They reported that it looks normal- <u>T2 Protect Monitor returned to the beamline April 22 in the evening.</u> Cables plugged in and flange bolts installed- Vacuum pumped down normally on April 23 in the morning- Probes group repeated the electrical check after installation from the 1A mezzanine - They reported that it looks normal- The old monitor cassette will be left in the hot cell for possible future use					
Attachment 1:		Old_T2_Protect_Monitor_(removed_Apr_22_2015)_-_Entry_Side.jpg 222 kB Hide Hide all			
Attachment 2:		Old_T2_Protect_Monitor_(removed_Apr_22_2015)_-_Exit_Side.jpg 229 kB Hide Hide all			
ELOG V2.7.5-2130					

Also, look at the following sheet that Isaac documented about the “T2-MK2 ELEVATION”.

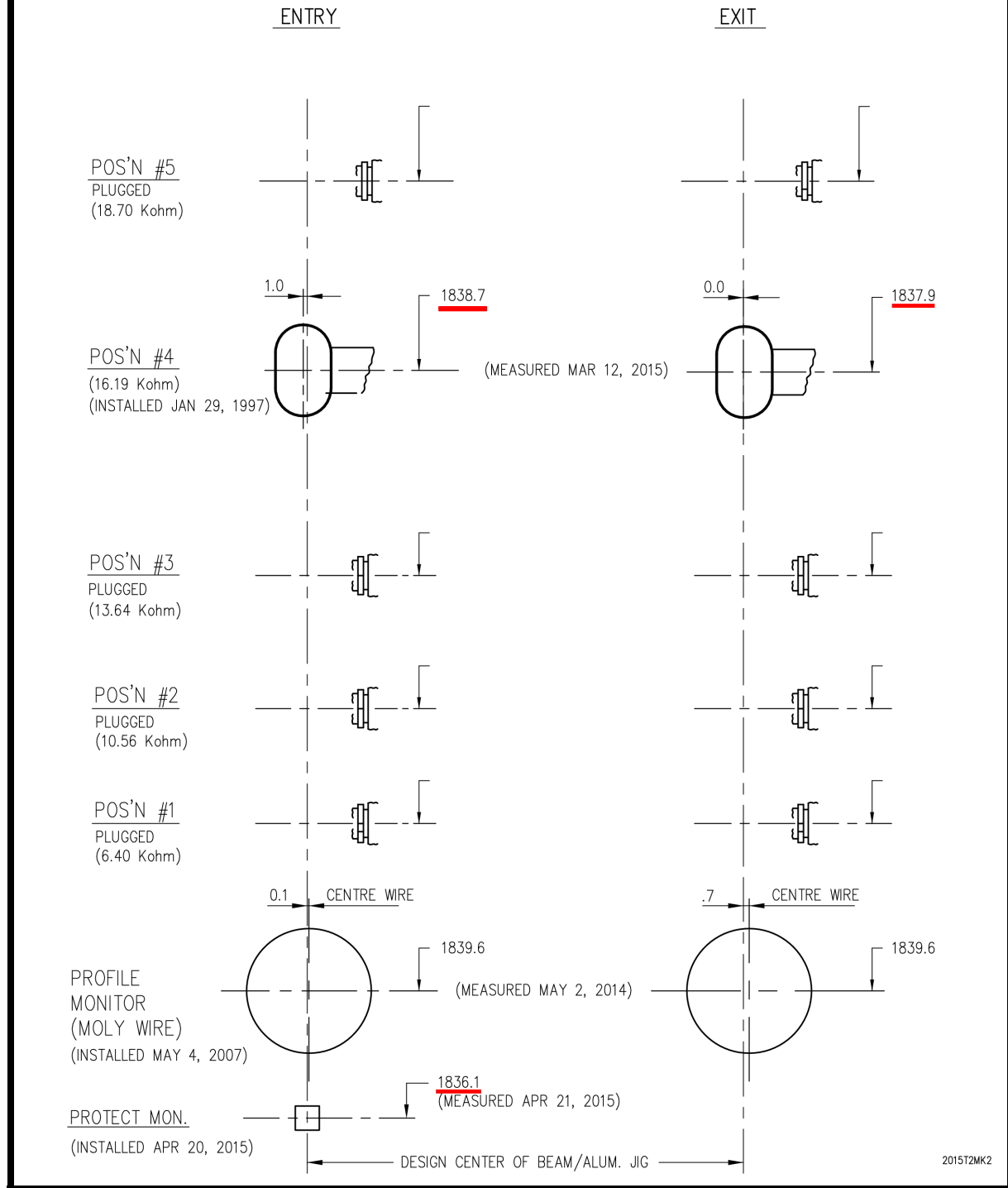
NOTE:

-DIM'S IN m.m.
-POT. READS 20.09/20.10 Kohm

T2-MK2
ELEVATIONS

APRIL 24, 2015



pg. 1 of 2
I. EARLE



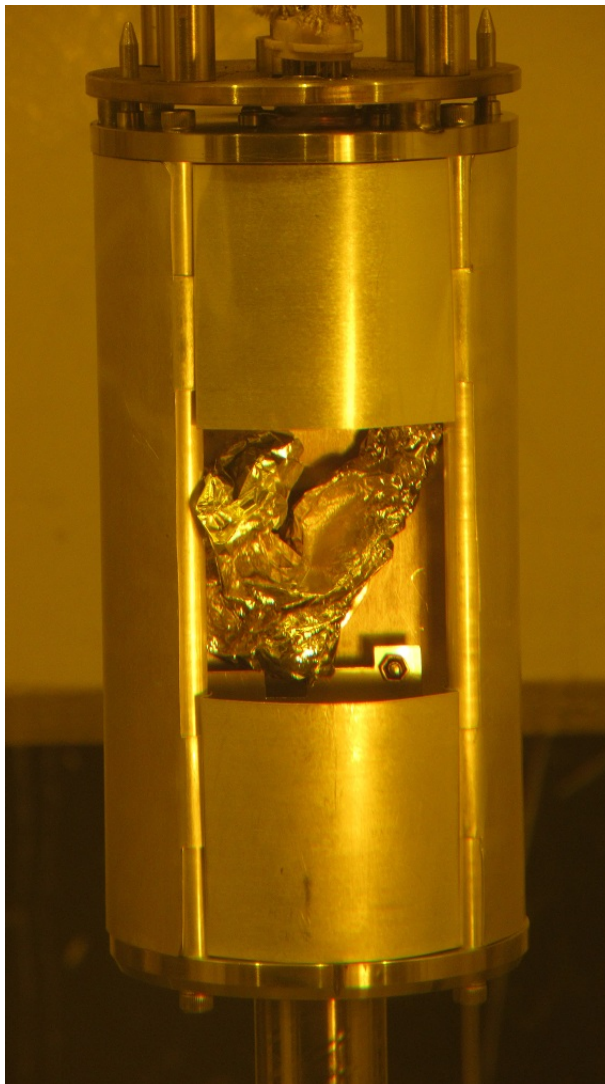
It indicates that the Protect Monitor was higher than the target by $(1838.7+1837.9)/2-1836.1=2.2$ mm.

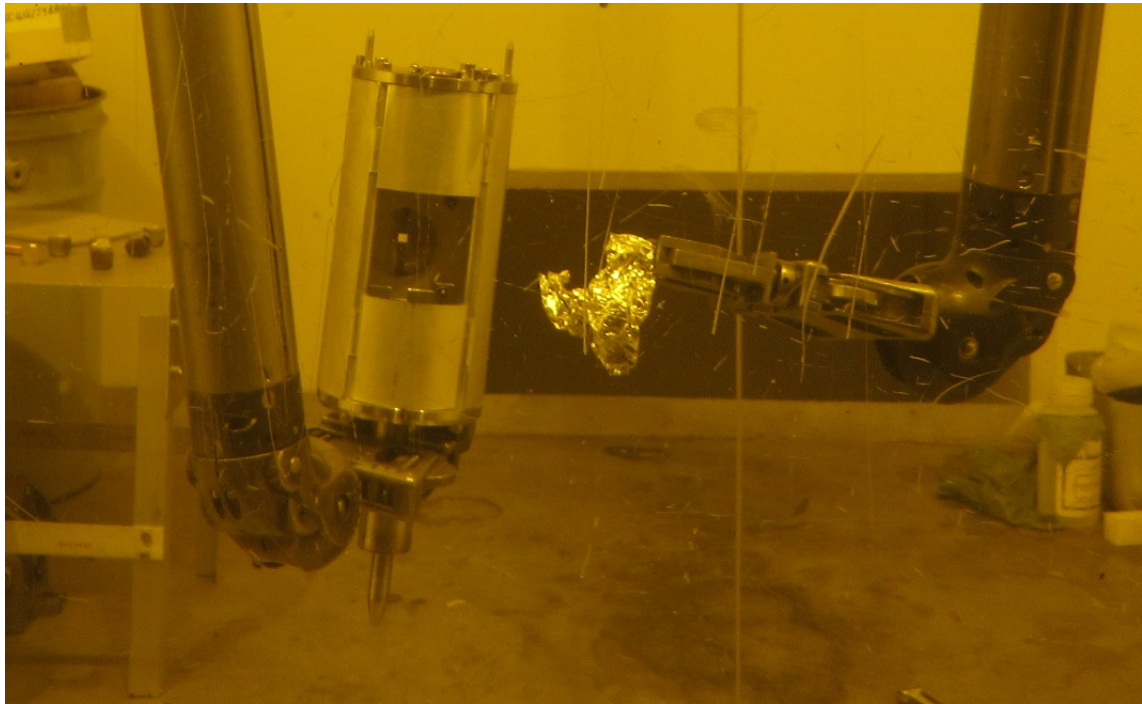
★ This newly installed Protect Monitor ran under these conditions until 2015-Sept-21 mini shutdown started. Coming out of this shutdown, it had been reading wrong and becoming worse and worse over time.

Thus, on 2015-Oct-05 a decision was made to uncover and remove the T2 Protect Monitor for inspection. See Isaac's e-log entry of 2015-Oct-09 and pictures below for details.

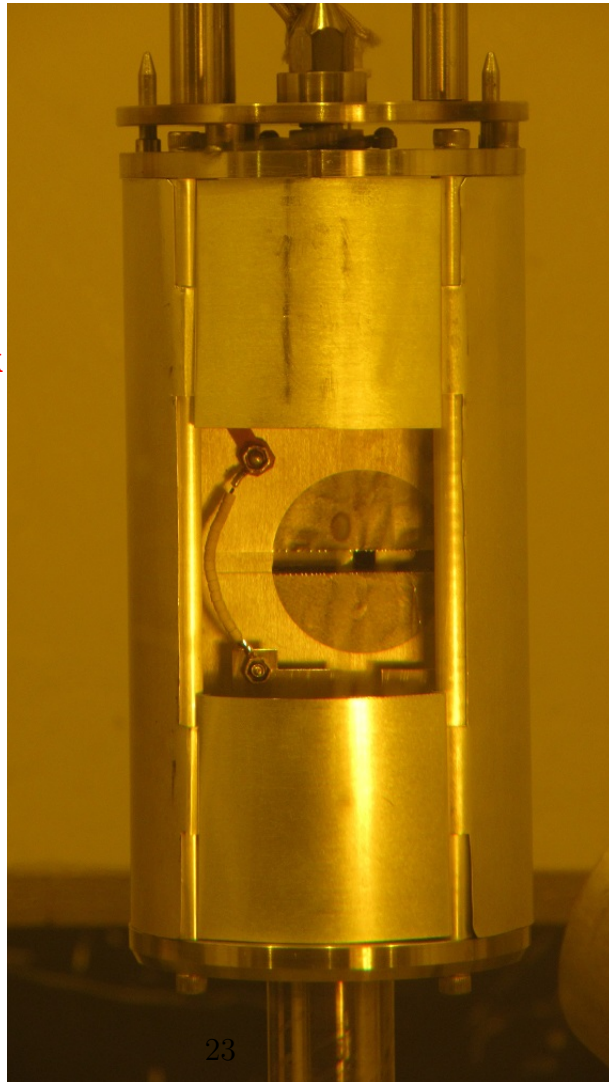
RH-Meson Hall		Not logged in			
					
Message ID: 179 Entry time: Friday, October 09, 2015, 14:56					
Author:	Isaac Earle				
Category:	Repair				
Type:	Target 2				
Specific:	Other				
Subject:	T2 Protect Monitor Replacement				
<p>On Monday Oct 5th a decision was made to uncover and remove the T2 Protect Monitor due to faulty readings. The monitor had been behaving strangely since the September shutdown, and had been getting worse over time.</p> <ul style="list-style-type: none"> - Blocks were removed over T2 starting Monday afternoon. It is necessary to remove the narrow 12' block and two 6' blocks west of the T2 plug block in order to fit the flask frame in for protect monitor removal - The monitor was moved to the hot cell by 7pm on Monday. Pierre was operating the crane and there were no issues with the move. (monitor measured 15mSv/hr at 0.5m) <p>Oct 6:</p> <ul style="list-style-type: none"> - Monitor inspected: a thin piece of foil was found jammed into the entrance side of the monitor (see photos) & a heat or burn mark was seen on the exit side above and to the south of the plate gap. It is suspected that this material traveled down the beamline at high speed when there was a vacuum burst during the September shutdown. In light of this information it was decided to remove the T2 target and T1 target as well (see following e-logs) - <u>Monitor elevation measured: 1835.8mm (april 2015 measurement was 1836.1 --> ok)</u> - <u>Old monitor cassette removed, new one installed.</u> Elevation checked: 1832.2mm - did not match, removed, decontaminated, and returned to Probes for adjustment - <u>Adjusted monitor installed, elevation checked: 1835.8mm --> ok</u> - Electrical check done by Probes group at hot cell: found left plate shorted to ground - Cassette removed, decontaminated, and repaired by Probes Group - Cassette reinstalled, and electrical check repeated --> ok <p>Oct 7:</p> <ul style="list-style-type: none"> - <u>Monitor elevation re-checked: 1836.2mm --> ok</u> - <u>T2 protect returned to beamline, bolts installed, cables connected</u> 					

A thin piece of foil was found jammed into the entrance side of the monitor :





**And a heat or burn mark
was seen on the exit side
above and to the south of
the plate gap. ==>**



To replace the damaged protect monitor, a new one was put in.



★ And then, Isaac checked the T2 target beam spots on the entrance and exit windows. See following entry and photos.

RH-Meson HallNot logged inELOG

[List](#)

Message ID: **180** Entry time: **Friday, October 09, 2015, 15:18**

Author:	Isaac Earle
Category:	Repair
Type:	Target 2
Specific:	Target
Subject:	T2-MK2 Check at Hot Cell and Motor Drive Cable Replacement

While the T2 monolith was uncovered for T2 Protect repair (see previous e-log), it was decided that the T2 target should be moved to the hot cell to address issues discovered last week with target ladder movement (see e-log #175)

Oct 7:

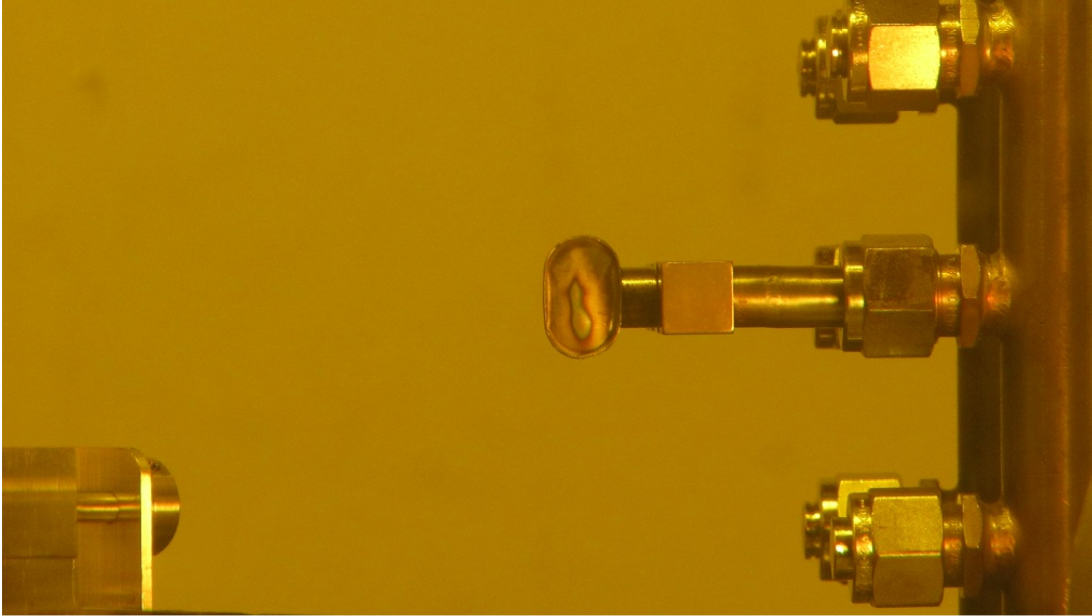
- T2-MK2 target was moved from the beamline to the hot cell after the T2 protect was reinstalled (the target measured 896mSv/hr at 0.5m)
- The target was inspected in the hot cell: profile monitor looked normal, two beam spots (one higher, one lower) were observed on the entrance window (see photos), the spot on the exit window was low but not quite touching the weld
- T2 profile monitor was checked by probes group at the hot cell --> ok
- Ladder movement was checked by cycling through all target positions twice using the portable control box. This revealed that the drive motor is actually functioning properly and the fault lies elsewhere
- Tested T2 motor drive cable from 1A racks to beamline with Dave Cameron. Found Pin B has 190kOhm short to building ground. Attempts to fix the cable at both ends were unsuccessful and spare wires in the bundle could not be used because there is a break in the cable at an unknown location and use of wire colours in both sections is inconsistent
- Checked entrance side elevation: 1839.0mm with potentiometer at 16.19kOhms. This is consistent with previous measurement of 1838.7mm. This confirms that pot, motor, and drivetrain for ladder movement are all ok.

Oct 8:

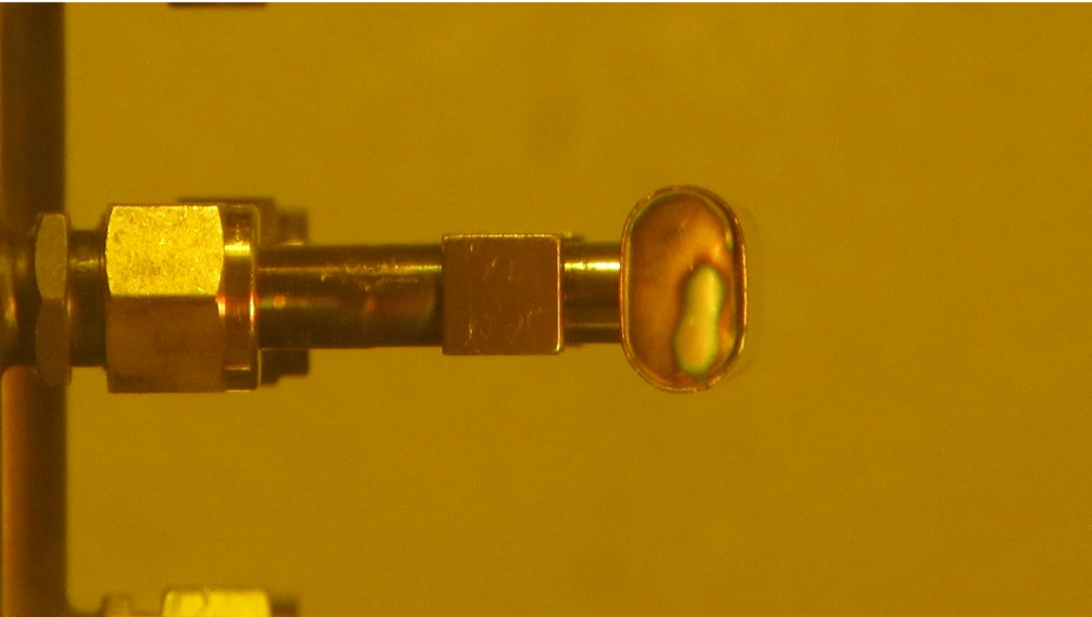
- Decided to run new cable for target motor drive (already had on hand for T1/T2 controls upgrade in 2016 shutdown). The cable is labeled T2TGMTTR-DRV. It was first tested at the hot cell and then installed by Doug and Ron
- The T2-MK2 target was returned to the beamline. A camera and monitor setup was used to watch the target entering the hole remotely which greatly reduced dose (inserting the target requires multiple iterations to get alignment correct, so dose is typically higher than when removing devices from the monolith)
- T2 profile and protect monitors checked by Probes Group from the mezzanine --> both ok
- Pumping on T2 volume began late morning, leak was found at T2 protect flange (see previous e-log), after correcting this the vacuum pumped down normally. A helium leak check was performed on all flanges on the T2 monolith --> no leaks found

Photographs were taken on 2015-Oct-07 of

beam spot on the T2 entrance window :

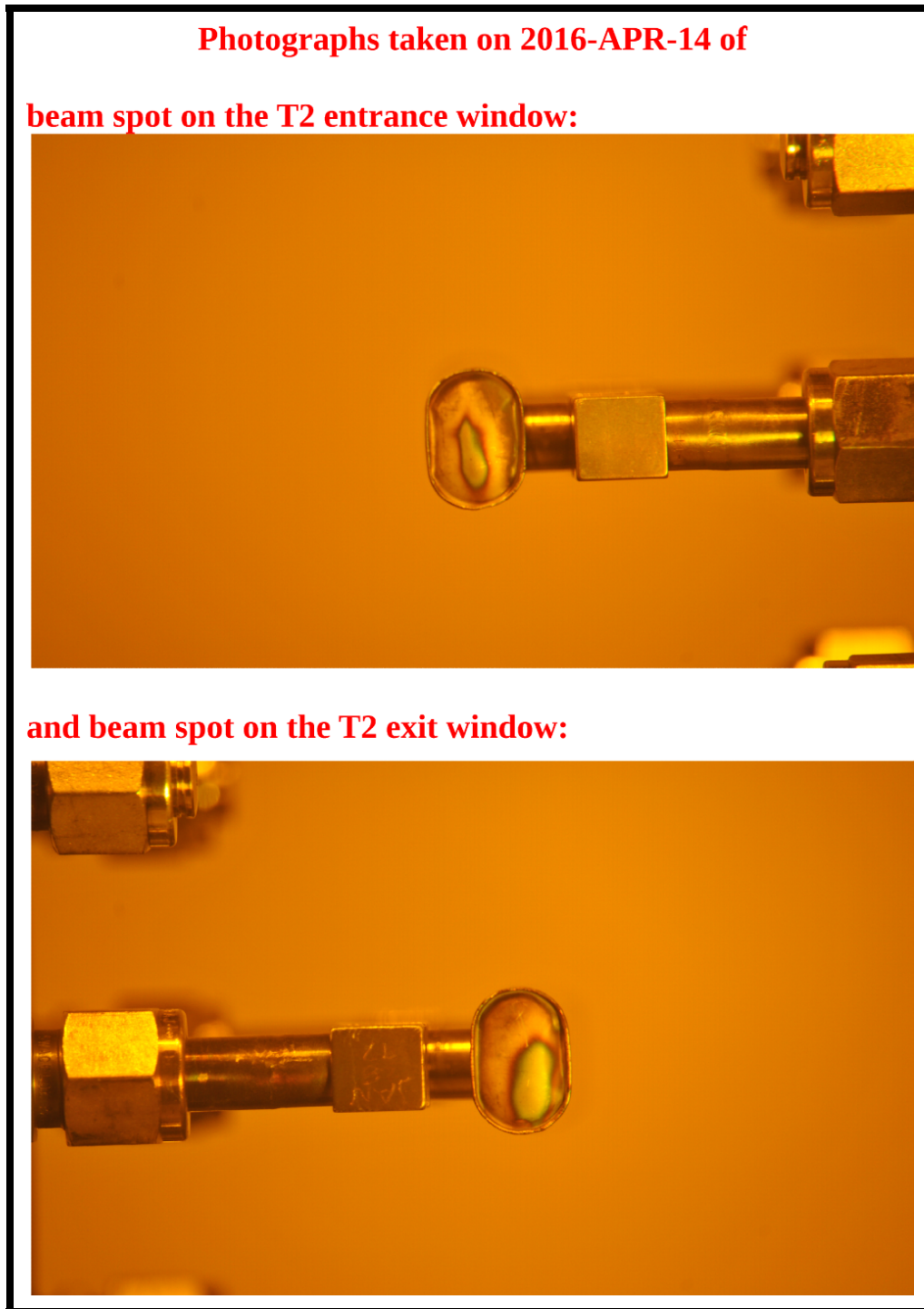


and beam spot on the T2 exit window:



★ Clearly, there were 2 spots visible on the target, but shifted up and down.

★ On 2016-Apr-11 (during the winter shutdown), the T2-MK2 target was photographed as well. Shown below.



Similar to the pictures of Oct. 2015, overall the spots were low on the target.

★ Here we take the elevations of the T2 Protect Monitor and T2 target **during the 2015 production run** as a reference, which were:

1836.2 mm for the Protect Monitor centre-line,

$(1838.7+1839.0)/2=1838.9$ mm for the T2 target entrance,

1834.7 mm for the Collimator A.

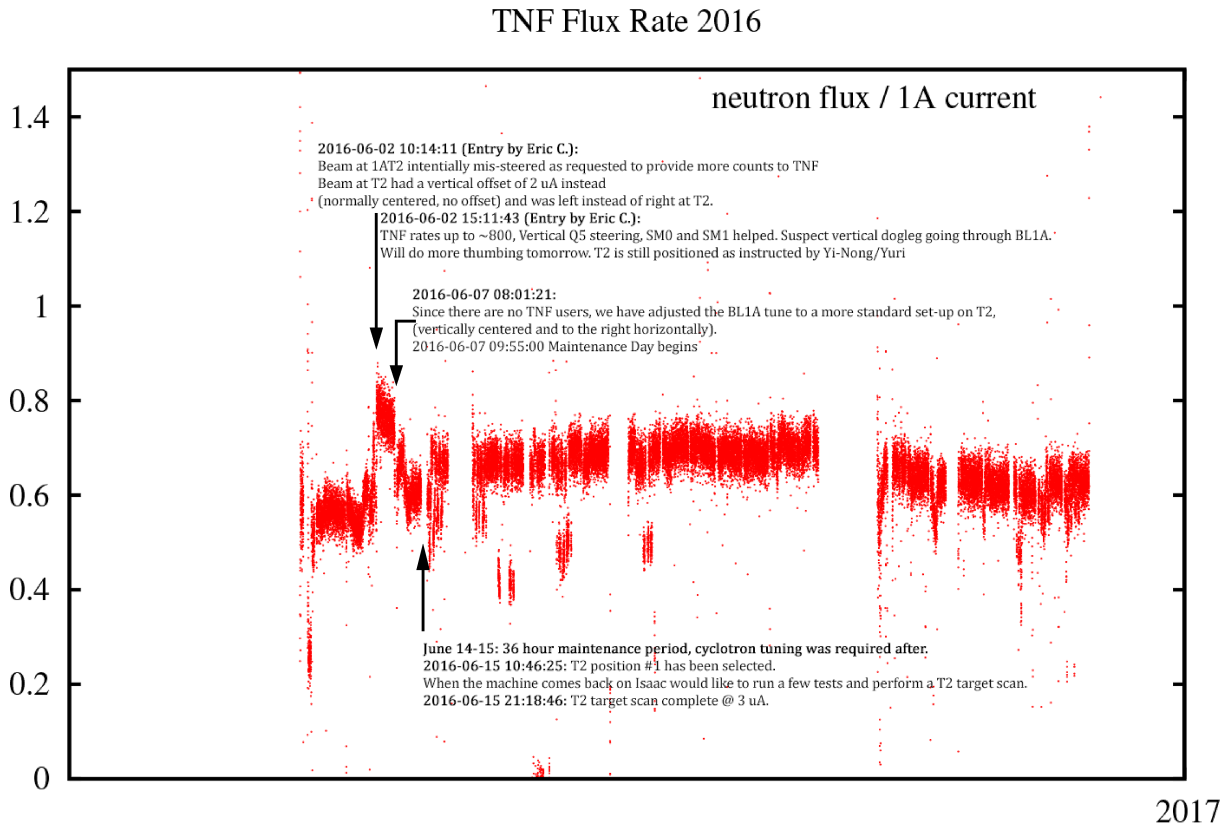
Note that the Protect Monitor was higher than the target by about 2.7 mm, but still LOWER (not higher) than the Collimator A by about 1.5 mm.

During this period of production run (from 2015-Oct-10 to the year end), the beam was kept balanced on the Protect Monitor vertically. **This suggests that the beam was entering the target section with an angle. This angle was roughly $2.7\text{mm}/(32-5)\text{cm}=10.0$ mrad downward.**

★ On 2016-May-13, the T2-MK2 target Position #4 started to take beam. From the start to June 1, the neutron flux was constantly reading as low as 600 counts.

★ On June 2, Eric Chapman intentionally mis-steered the beam as requested to provide more counts to TNF. Eric had to let the beam position be high vertically and be left horizontally on the T2 Protect Monitor in order to increase the TNF counts up to 800.

Should be pointed out that during the 2016 production run there were no Moly targets installed at TNF.



(c) ops, 2017/Mar/01

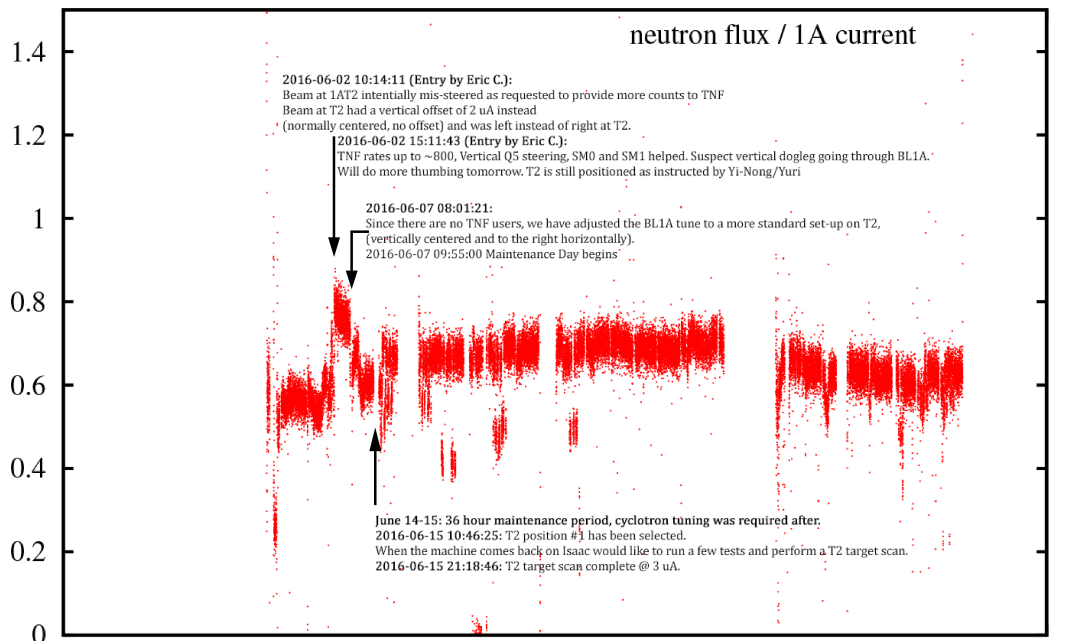
Time (Year)

★ On 2016-June-15, the T2-MK2 target was moved to Position #1 from the previous Position #4, because the Position #4 target had reached the maximum beam time. This new target, namely, the Position #1 target, was used for the remainder of the 2016 running period. See Isaac's e-log below.

RH-Meson Hall		Not logged in	ELOG
Message ID: 201	Entry time: Wednesday, June 15, 2016, 11:00		
Author:	Isaac Earle		
Category:	Standard Operation		
Type:	Target 2		
Specific:	Target		
Subject:	T2-MK2 Target Moved to Position #1		
<p><u>Position #4 on the T2-MK2 target has now reached the maximum beam time. The target was moved to Position #1 at the nominal elevation.</u> This target should be used for the remainder of the 2016 running period.</p>			

But, from 2016-June-15 to the end of 2016, the TNF neutron flux constantly stayed below 800 counts. During this period, the beam was kept balanced vertically and to the right horizontally on the T2 Protect Monitor.

TNF Flux Rate 2016



2017

(c) ops, 2017/Mar/01

Time (Year)

★ On 2017-Jan-09 (during the winter shutdown), the T2-MK2 target in Position #1 was photographed and measured for the spots, shown below.

Message ID: 213 Entry time: Thursday, January 12, 2017, 09:21
Author: Isaac Earle
Category: Standard Operation
Type: Target 2
Specific: Target
Subject: T2-MK2 Position 1 Beam Spot

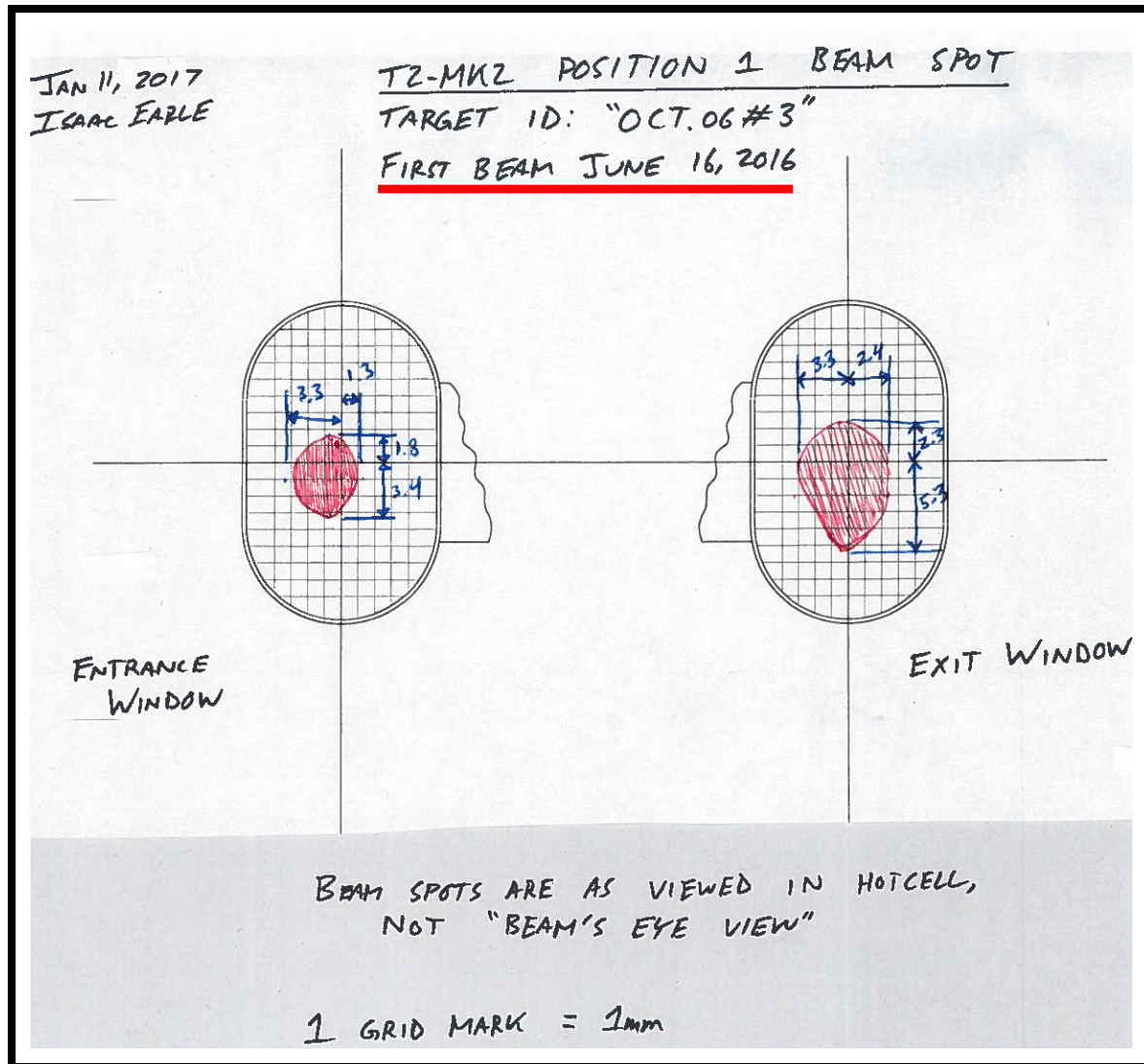
The beam spot on the 10cm beryllium target in Position 1 on T2-MK2 (Target ID: "OCT.06#3") was measured and photographed yesterday. A fairly well centered spot was measured to be approximately 4.6mm wide x 5.2mm tall on the entrance window and 5.7mm wide x 7.6mm tall on the exit window using the Nikon micrometer level. This target first saw beam on June 16, 2016.

A PDF scan of the beam spot measurements and photographs of the beam spots are attached.

T2-MK2 Position 1 Beam Spot

Target ID: "OCT.06#3", 10cm Beryllium
First beam June 16, 2016, Photo taken Jan 11, 2017





★ Use Isaac's figures as a rough estimate, vertically the beam centroid was at

$$(1.8+3.4)/2 - 3.4 = -0.8 \text{ mm at entrance,}$$

and

$$(2.3+5.3)/2 - 5.3 = -1.5 \text{ mm at exit.}$$

The offset was about 0.7 mm downward, suggesting that the beam was angling downward by 7 mrad onto the T2 target as the target was 10 cm long. At least in terms of the angling direction being downward, this angle was consistent with the elevation difference between the Protect Monitor and the target, which was $(3.5+0.8)\text{mm}/(32-5)\text{cm}=16 \text{ mrad}$.

6 Conclusions

★ Over the last 3 years from the beginning of 2014 to the end of 2016, the T2 Protect Monitor's elevation has been lower than that of Collimator A by about 1.5 to 5.1 mm.

★ There were evidences showing that the beam was angling downward onto the T2 target. This angle was roughly 10 mrad. This angle could explain the 2 observations consistently: one was that the beam spot was seen to be higher on the target entrance window than on the exit window; the other was that when the beam was kept balanced up and down on the Protect Monitor, it was seen to be more or less centered on the target entrance window. But remember that the Protect Monitor was ~ 3 mm higher than the target which is at ~ 30 cm downstream from the Protect Monitor.

When the beam was angling onto the target, the TNF neutron flux could hardly reach 800 counts level, no matter it was centered on the target entrance window or shifted downward. The downward shift produced even less (significantly less!) neutron counts.

★ Since we have no real-time measurements about the position and incident angle of beam entering the target, and bear in mind that the beam just wanted to be higher on the Protect Monitor to produce > 800 neutron counts, **we've decided to elevate both the Protect Monitor and the target by 3 mm from where they are. Specifically, they shall be set to the following elevations:**

T2 Protect Monitor centre-line: 1833.5 mm, w.r.t. the T2 target flange.

T2 target centre-line: 1836.5 mm, w.r.t. the T2 target flange.

The T2 profile monitor shall be set to the same elevation as the T2 target centre-line.

The current elevation of Collimator A is at 1834.7 mm, w.r.t the T2 target flange.

We're going to try with these new settings to recover the neutron flux of > 800 counts.

Even though OPS might tune the beamline to get, by chance, the beam more leveled through the target section and the Collimator A that follows, that would be even easier for the beam to pass through the Collimator A, because the Collimator A has a full aperture of 20.0 mm at minimum which is way larger than the remaining offset of 1.2 mm vertically between the Collimator A and the T2 Protect Monitor.

7 Acknowledgement

The author thanks Isaac Earle for providing the target elevation info, and appreciates Kathleen Genge for making the nice plots of neutron rates with notation.