Collider-Accelerator Department

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Memo

Date: *June 17, 2016*

To: *RSC, J. Li, M. Palmer, M. Montemagno, M. Babzien, and C. Folz*

From: *D. Beavis*

Subject: *Radiation Surveys of UED*

Radiation surveys have been conducted during the commissioning process of the UED in Building 912. These surveys were conducted during the conditioning process of the RF system to ensure that the radiations levels were at or below anticipated levels. Predominately the radiation detected was from the concrete floor which has minor activation from past proton operations. The RF system was fully commissioned on May 23, 2016. At this time a fault study plan was written to provide for a set of baseline radiation surveys with the RF operating to the gun with no laser beam to excite the cathode.

Fault study plan[1] no. 244 was implemented on May 24, 2016. The results of the measurements are given in Appendix II. All radiation levels were consistent with background. After sufficient data were obtained it was decided that it was pointless to continue the fault study. Instead an RCT and D. Beavis were secured inside the gate and the machine turned on. A series of measurements were taken inside the enclosure 1 foot from the beam line. All values were consistent with background and the minimum detectable level. The radiation measurements were terminated. The operating parameters of the UED were 2.95 MW of RF power to the gun at 1 Hz. The instrumentation to image the dark current was not functional. It was decided that additional radiation measurements would be made when the beam instrumentation and laser were ready.

On June 15, 2016 the UED was available with stable laser beam and working instrumentation to continue the radiation measurements. The UED had 0.74 pC per bunch of pulsed electrons and 2 bunches per second. The RF power at the gun was 3.27 MW. The total beam power was 5 micro-Watts. An initial measurement with the fluke meter and the HPI 1010 were taken at the rear gun position and the two instruments consistently measured 0.2 mrads/hr. This is essentially the same as the original surveys. With the laser operating it is not practical to have personnel go inside the UED enclosure. Instead, the chipmunk was moved to be one foot from the pop-in screen in the middle of the beam transport. The chipmunk did not register any dose above its 0.2 mrad/hr background level. During this time frame the instrumentation was inserted and removed to witness the impact on the beam current measurements and screen image.

[1] See Appendix I.

The measurements suggest that either the dark current is substantially lower than originally thought or the dark current electrons achieve much lower energy than the pulsed beam before striking a surface. The laser induced electron beam had 5 micro-watts or beam power. Using $5*10^{3}$ rads*m^2/(hr-kW) and the 5 $*10^{-9}$ kW one would expect 0.25 mrad/hr for the chipmunk. Although this was not detected it is probably within the uncertainty of the simplicity of the calculation method and the instrumentation used for the measurement.

A chipmunk was installed in the UED area on April 5, 2016. The records for the chipmunk were scanned from that date to the present. The three highest readings are shown in Appendix III. The RF power was in excess of 6 MW for April 29 and May 24. Other times were not checked. Based on a $(1/r_t)^2$ scaling the reading can suggest short periods of time where the dose rate exceeded 100 mrads/hr. However, there were no times during conditioning that the dose rate exceeded 100 mrads in an hour. There a several examples where the chipmunk registered a few tenths of a mrad/hr for 5-10 minutes. These measurements suggest that during the commissioning process the UED area is not a high radiation area. During routine operations with beam or RF the UED enclosure does not reach radiation area levels.

Based on the chipmunk data and radiation surveys the following changes are being made or suggested:

1. Repost the UED gate as a Radiation Area with beam on. After additional operating experience this could be further reduced if data warrants. P. Bergh has agreed to change the gate posting within a few days.
2. The requirement of locking of the gate and coupling of the gate key to the modulator HVPS could be relaxed to times of RF conditioning. The experiment and operators should determine how desirable this would be. If desired the experiment can request the RSC to review the change.

Appendix I

Fault Study Plan for UED Dark Current

Prepared by: D. Beavis
Reviewed by: [signature] 5/24/16
Date: May 23, 2016
FAULT STUDY No. 244

Goal: To provide baseline radiation measurements for the UED operating in several configurations some of which are routine and others which are fault conditions.

Method: The RF for the UED should be placed at the normal status for operating the RF for UED beam.

The laser should be prevented from exciting the cathode. 99% of the radiation is expected to be from the dark current. There should be no Pb shielding along the beam line.

The configurations to measure are:

1. Aperture installed and solenoid off.
2. Aperture installed and solenoid on at operating value.
3. Aperture removed and solenoid installed
4. Aperture removed and solenoid off.

With the aperture in the main source is expected to be the aperture. With the aperture is out the loss point is expected to be the Faraday cup if the beam is tuned to the dump.

RCT instrumentation: Appropriate for x-rays with a quality factor of 1. There are no neutrons. RF interference should be considered.

Surveys conducted under RCD RWP for surveys. This covers the entrance into the enclosure. TLDs are required for the areas and inside the enclosure a SRD is also required.

Survey Locations:

1. Laser port
2. Gate
3. Over south shield wall
4. Through south shield wall
5. Over end wall shielding
6. Through endwall shielding
7. In middle of laser room at waist height.

8. At gap between north shield blocks and environmental room.
9. At back behind the gun
10. On roof over beam loss point.

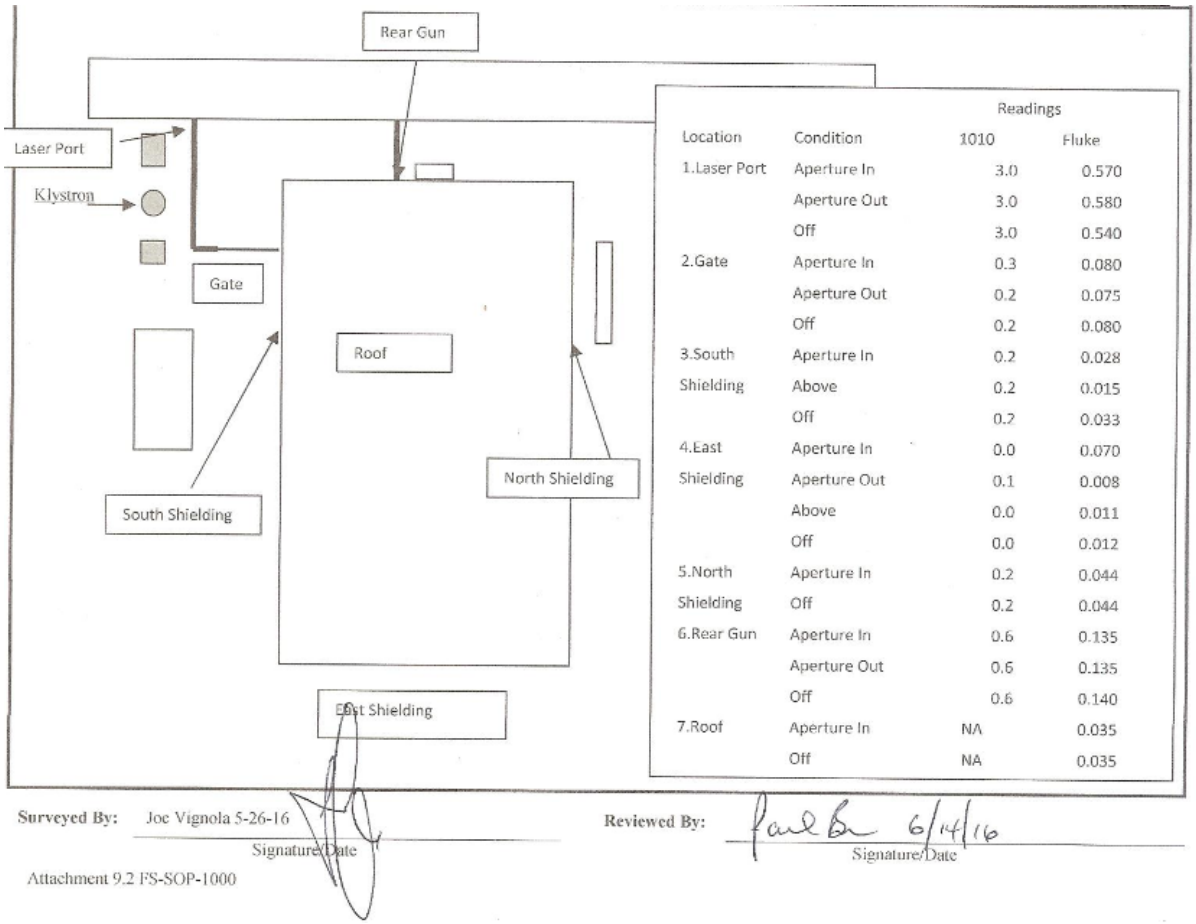
Expected dose rates:

Table 1: Summary of UED dose rate at location near the UED.

Location description	Dose rate (mrads/hr)
Entrance gate	0.029
Laser port	Less than 0.500
ATFII shielding roof	0.500
ER roof (two feet above)	1.
Through south wall 30 cm away	0.010
Max. in Radiation Area	6.
Laser room 30 cm from concrete wall	0.016
General area skyshine from UED	0.008-0.015
Over top of side wall (south)	1.0
Through end wall	0.032
Over top of end wall (10 feet above floor)	0.8

When the external surveys are completed and appear to be reasonable then the RSC Chair or designee can enter the area with the RCT to conduct surveys inside the enclosure near the UED to obtain source point near the machine. The RSC Chair will obtain the spare key from the safety office. One configuration checked should be the aperture in and one with the aperture out.

Appendix II



Location	Condition	Readings 1010	Fluke
1.Laser Port	Aperture In	3.0	0.570
	Aperture Out	3.0	0.580
	Off	3.0	0.540
2.Gate	Aperture In	0.3	0.080
	Aperture Out	0.2	0.075
	Off	0.2	0.080
3.South Shielding	Aperture In	0.2	0.028
	Above	0.2	0.015
	Off	0.2	0.033
4.East Shielding	Aperture In	0.0	0.070
	Aperture Out	0.1	0.008
	Above	0.0	0.011
	Off	0.0	0.012
5.North Shielding	Aperture In	0.2	0.044
	Off	0.2	0.044
6.Rear Gun	Aperture In	0.6	0.135
	Aperture Out	0.6	0.135
	Off	0.6	0.140
7.Roof	Aperture In	NA	0.035
	Off	NA	0.035

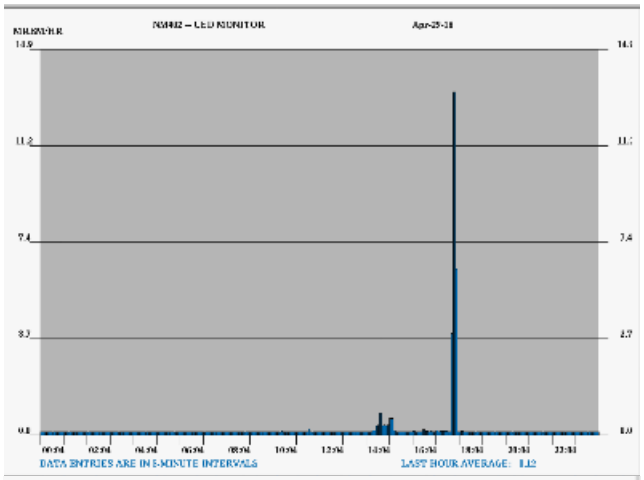
Surveyed By: Joe Vignola 5-26-16
Signature/Date

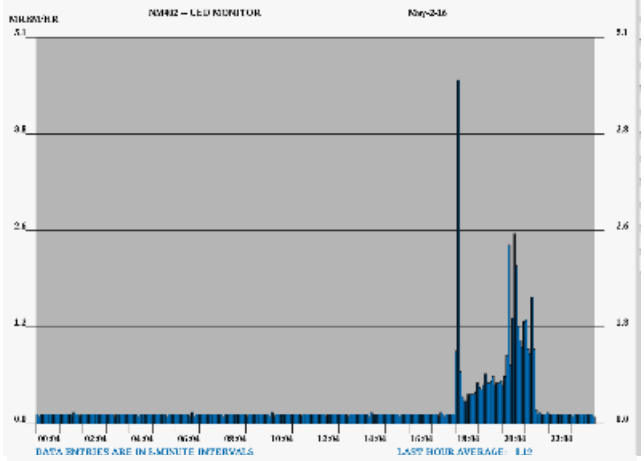
Reviewed By: Paul Bu 6/14/16
Signature/Date

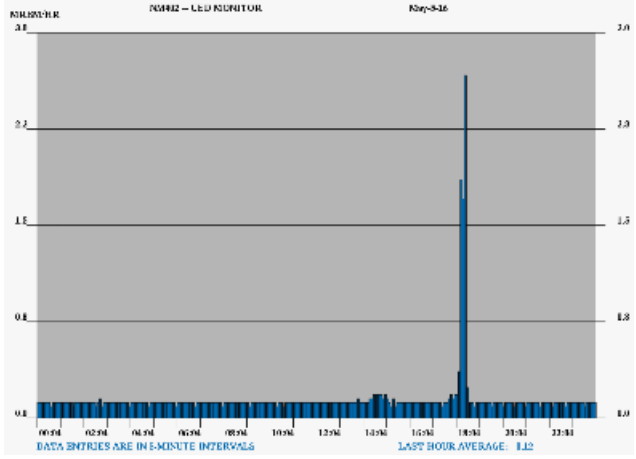
Attachment 9.2 FS-SOP-1000

Appendix III (Chipmunk data)

The following three chipmunk viewer charts show the three largest detected spikes in the UED chipmunk. The chipmunk is located approximately five feet transverse from the beam line. The time buckets are for five minutes averages. All events occurred during the RF conditioning process when higher than normal RF power was being operated to the gun.


NM402 – LED MONITOR
Apr-25-16
MR/HR
14.9
11.2
7.4
3.7
0.0
14.1
11.7
7.4
3.7
0.0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
DATA ENTRIES ARE IN 5-MINUTE INTERVALS
LAST HOUR AVERAGE: 11.2


NM402 – LED MONITOR
May-2-16
MR/HR
5.1
3.8
2.6
1.3
0.0
5.1
3.8
2.6
1.3
0.0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
DATA ENTRIES ARE IN 5-MINUTE INTERVALS
LAST HOUR AVERAGE: 1.2


NM402 – LED MONITOR
May-3-16
MR/HR
3.0
2.3
1.5
0.8
0.0
3.0
2.3
1.5
0.8
0.0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
DATA ENTRIES ARE IN 5-MINUTE INTERVALS
LAST HOUR AVERAGE: 1.2