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Loss and Residual Radiation at MI400 for 2010 Shutdown Preparation

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Abstract

In preparation for the 2010 Fermilab Facility Shutdown, radiation exposure estimates will be used for ALARA planning for work in the Main Injector. The task of completing the installation of the Gap Clearing Kickers in the MI400 region will require cable connections and related work to complete the installation of these devices. It will involve working the same area in which the mechanical installation and vacuum work was done in the 2009 shutdown. We will use the Residual Radiation measurements, the BLM loss records, and the fits which relate these as described in Beams-doc-3568[1] to establish expectations for the radiation levels for this work. With current loss rates and residual radiation levels combined with the lower loss levels expected during the two week Booster power reduction, we believe that radiation levels for 2010 will be comparable or lower than the 2009 levels during the shutdown. Limits on the per pulse loss for BLM's in this area will be imposed.

Introduction

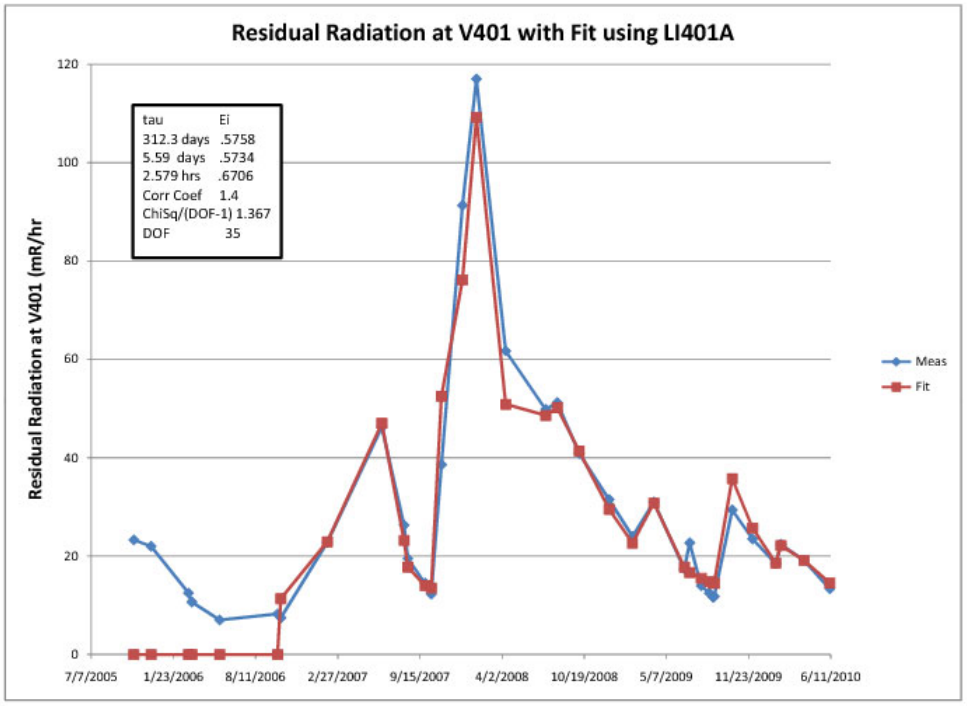
The kickers for aborting the MI beam are located just downstream of Q400. Two modules, KM400A and KM400B provide this kick. To clear beam from the injection gap, seven additional gap clearing kicker (GCK) modules were installed downstream of KM400B and extending to near V401 which is just upstream of Q401, an F Quad. This installation involved extensive cable tray and cable manipulations during the 2009 Fermilab Facility Shutdown. Tunnel penetrations were also created at this time with cables inserted but not terminated. For this work, lead shielding was installed on magnets LAM40A, LAM40B, and LAM40C. Residual radiation measurements at the Lambertson magnet locations were hindered by the lead blankets but the most interesting region for 2010 planning is upstream where we have good cooldown measurements at V401. A major Main Injector task for the 2010 Fermilab Facility Shutdown is to complete the cable installation for the GCK system.

Operations following the 2009 shutdown included use of improved anti-damping of beam in the extraction gap which was achieved by driving a kicker module at MI103. It was found that some of this loss was being captured on the downstream GCK modules since they have less aperture than the standard two inch Main Injector beam pipe. Adjustments of the vertical collimation at C301 was made on 25 March 2010 in order to avoid activation of these devices. See Appendix A for further discussion of loss measurements related to this issue.

Predicting the residual radiation from BLM measurements, as described in Beams-doc-3568, assumes that the loss geometry is constant. The loss geometry changes due to the GCK installation is unlikely to limit this analysis. We will note that the loss patterns downstream of the abort Lambertsons were greatly improved when we discovered and rectified beam pipe misalignment between LAM40C and V403 but since this was during the 2007 Fermilab Facility Shutdown (beginning on 05-Aug-2007) we can deal with that for understanding current loss and residual radiation patterns.

Fit Results

Using the losses measured with LI401A, we can fit the measured residual radiation at V401 to the losses weighted by appropriate isotope half lives. Performing this using the full set of losses and with residual radiation measured through 6/8/2010, we find the result shown in the figure.

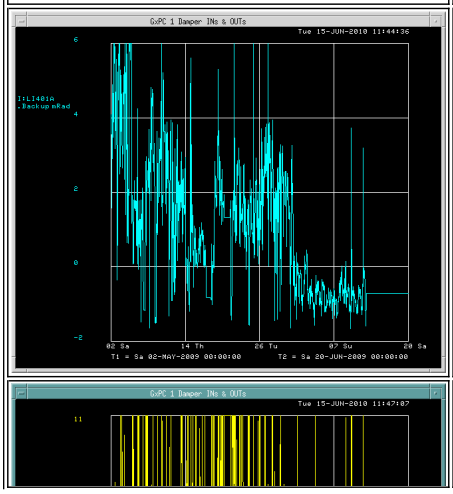
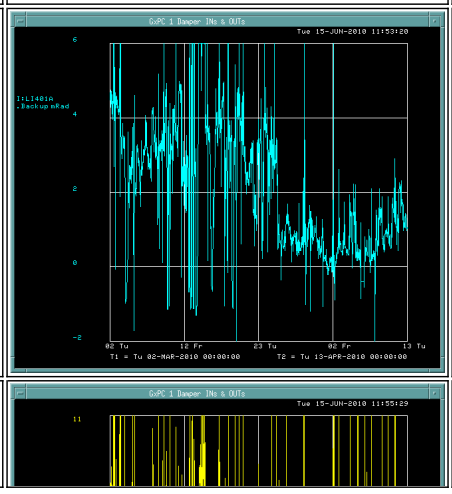
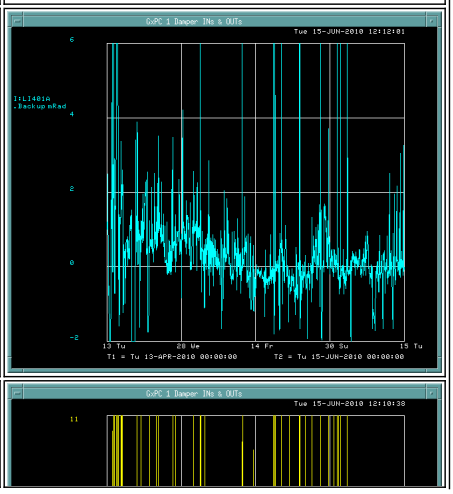


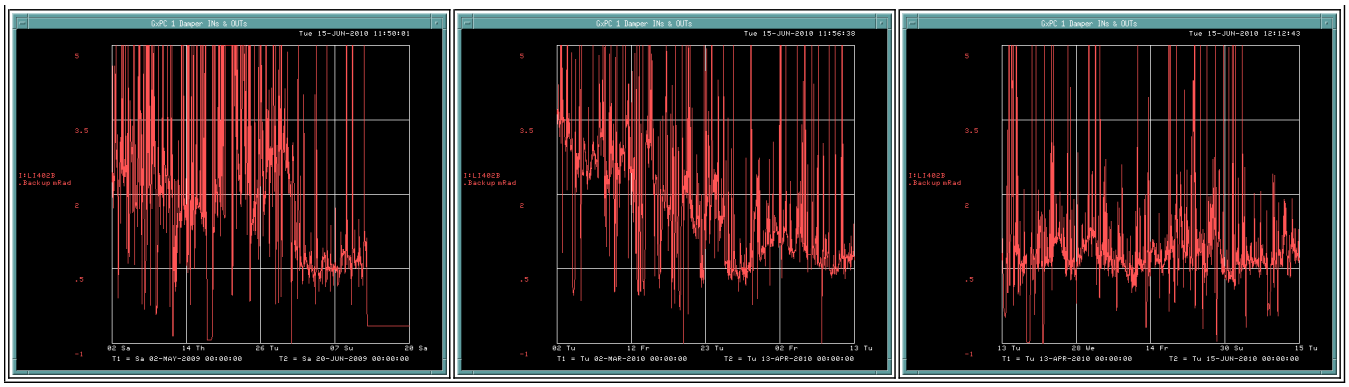
We note that the measurement on 6/19/2009 (beam off on 6/13/2009) found V401 at 17.4 mR/hr while the measurement on 6/8/2010 was 13.4 mR/hr and the beam had been off only for about 6 hours.

Losses in 2009 and 2010

In due course, we will add output features to I130 so that cooldown results from the fit can be provided based on all existing loss data or for future assumptions. At this point, we will simply document the D44 averages and sums for losses at LI401A, LI401B and LI402B for relevant periods for 2009 and 2010. In the figure below, we show losses in three periods: leading up to the 2009 shutdown; Spring 2010, through the collimation changes in March; and up to time of this writing (see label at top of each column). In the first column, we see the impact of the intensity reduction before the 2009 shutdown. In the second column we see the sharp drop in losses at LI401A when C301DV was placed closer to the beam to capture more of the 'fuzzer' (anti-damping) losses. The third column shows the losses for recent high intensity operation. The losses are well below the losses during 2009 high intensity operation. The plan to reduce Booster intensity prior to the 2010 shutdown is expected to further reduce the losses. As noted above, residual radiation at V401 is lower than it was early in the 2009 shutdown. It should be noted that the pedestal of BLM measurements may be significant and for these measurements, the loss as reported my be low due to a negative pedestal. For readers looking at printed versions of this document, we note that the electronic version will allow one to see single graphs with more detail by selecting 'view image' from the browser.

Plots of Losses near MI400 in 2009 and 2010 --- LI401A in blue; LI401B in yellow; LI402B in red

02 May thru 20 June 2009	02 March thru 13 April 2010	13 April thru 15 June 2010
		



It is helpful to see numbers as well as plots. However, we find that the BLM results stored in the datalogger (as reported by D44) have sufficient difficulties as to make it hard to easily provide what we would expect. In the following table, we have used the 'average' feature of D44 to examine weekly losses in 2009 and 2010. We see that no data was entered for the week of 5/18 - 5/25/2010 and only Average values (which were not for the full week) are shown for 4/13 - 4/20. This was due to brief periods of faulty data which made the full week sums and averages to be too large by many times the real values. Note also that when low losses are achieved, the averages and sums may be negative (despite the appearance of the graphs above). The trends noted in the paragraph above the loss graphs are still evident. The efforts which are underway to cleanse the BLM data log are expected to allow more detailed conclusions in the future. Multi-week averages would be more helpful and we attempted to provide them but the data quality issues made this quite difficult. Appendix B shows some results of this effort.

Losses near MI400 in 2009 and 2010

Dates		LI401A		LI401B		LI402B	
Begin	End	Sum	Average	Sum	Average	Sum	Average
6/6/2009	6/13/2009	-4.61E+05	-0.765	2.59E+06	4.3	2.43E+06	4.02
5/30/2009	6/6/2009	5.82E+04	0.0964	6.38E+05	1.06	8.18E+05	1.35
5/23/2009	5/30/2009	1.11E+06	1.84	6.93E+06	11.5	3.68E+06	6.10
5/16/2009	5/23/2009	6.28E+05	1.04	6.78E+06	13	3.78E+06	6.27
5/9/2009	5/16/2009	1.00E+06	1.66	2.99E+06	4.97	2.88E+06	4.78
5/2/2009	5/9/2009	1.77E+06	2.93	4.39E+06	7.27	2.33E+06	3.86
6/8/2010	6/15/2010	-7.59E+04	-0.126	3.59E+05	0.545	4.43E+05	0.74
6/1/2010	6/8/2010	3.85E+05	0.638	3.67E+06	6.09	8.14E+05	1.35
5/25/2010	6/1/2010	4.52	0.75	1.72E+06	2.85	1.34E+06	2.22
5/18/2010	5/25/2010						
5/11/2010	5/18/2010	-4.16E+04	-0.069	-3.35E+05	-0.557	4.54E+05	0.75
5/4/2010	5/11/2010	1.40E+05	0.232	-2.94E+05	-0.488	4.14E+05	0.69
4/27/2010	5/4/2010	4.83E+05	0.796	1.52E+06	2.5	1.33E+06	2.19
4/20/2010	4/27/2010	4.39E+06	0.724	9.97E+05	1.64	1.22E+06	2.01
4/13/2010	4/20/2010		0.21		0.995		1.96
4/6/2010	4/13/2010	5.17E+05	0.851	3.61E+06	5.94	1.40E+06	2.31
3/30/2010	4/6/2010	3.64E+05	0.601	6.70E+05	1.1	1.27E+06	2.10
3/23/2010	3/30/2010	1.13E+06	1.86	1.02E+07	16.7	9.75E+06	16.10
3/16/2010	3/23/2010	1.79E+06	2.95	7.04E+06	11.6	2.15E+06	3.54
3/9/2010	3/16/2010	2.28E+06	3.78	3.63E+06	6.03	2.28E+06	3.78
3/2/2010	3/9/2010	3.38E+06	5.57	2.78E+07	46.1	1.86E+07	30.60

Expectations

The residual radiation measurements at V401 on 6/8/2010 are well fit by half life weighted loss measurements. Since the residual is lower than was experienced after the start of the 2009 shutdown, we believe that the loss reduction associated with the Booster intensity reduction can be sufficient.

Conclusions

In preparation for the 2010 Fermi lab Facility Shutdown, operation of the Main Injector can continue at normal high intensity until the Booster intensity reduction, currently planned for the two weeks prior to the start of the shutdown. Tight loss limits on the loss monitors in the region of MI400 will be imposed to be sure that no extended periods of loss due to mistuning can produce high residual radiation levels in the area of the GCK installation work.

References

[1] Bruce C. Brown, Predicting Residual Radiation using Beam Loss Data - Early Results Beams-doc-3568-v1

Appendix A

Appendix B

Losses at MI400 in 2009 and 2010

Dates	LI401A		LI401B		LI402B	
	Sum	Average	Sum	Average	Sum	Average
9 May - 30 May 2009	2.74E+6	1.51	17.7E+6	9.78	10.3E+7	5.71
23 May - 13 Jun 2009	7.04E+5	.388	10.3E6	5.67	6.95E+6	3.83
01 Mar - 21 Mar 2010	7.53E+6	4.37	36.9E+6	21.4	21.7E+6	12.2
23 Mar - 13 Apr 2010	2.01E+6	1.11	14.7E+6	8.11	12.6E+6	6.97
13 Apr - 4 May 2010	2.61E+6	1.44	9.38E+6	5.18	6.39E+6	3.53
4 May - 25 May 2010	0.999E+6	.551	138E+6 ???	76.2 ???	33.0E+6	18.2
18 May - 08 Jun 2010	1.70E+6	0.94	141E+6 ??	77.9 ??	33.6E+6	18.5