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Loss History in Main Injector: LI619A-LI621 and LI101C-LI107

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Abstract

Various beam instrumentation devices have been or will be installed in the Main Injector near the Main Injector and Recycler injection regions from 101 through 104 and in the 620 straight section. The failure of one piece of electronics has alerted us to issues of radiation damage. Preparations are underway for documenting the radiation at locations where electronics currently exists or where additional electronics may be placed. Using the tools available, a summary of the Beam Loss Monitor (BLM) data for some of the loss monitors in the area is provided. Features of these losses are dominated by various changes in the configuration of the Main Injector and Recycler so these items will be documented.

Introduction

We have activation and radiation damage concerns for existing and new beam instrumentation for the Main Injector and Recycler. Since we document the BLM readings on every machine cycle, we have a good record of the history of radiation in the areas of interest. Of course, the installation of new devices and the removal of old ones will require analysis and interpretation of the data. We expect to make measurements with Al Tag activation which requires 3 to 7 kRad of exposure and perhaps with some more sensitive techniques so an overview of the area radiation is appropriate.

Measurements

There is a Beam Loss Monitor located just downsteam and above the quadrupoles in each Main Injector half cell. Additional loss monitors are installed near transfer locations. Using the electronics system installed in 2006, we record the loss sum (in Rads) for each BLM on each Main Injector cycle into the D43/D44 datalogger system. For this analysis, we employ the data summary features of I130 (pa4178). This program sums the losses in QD sums and weights the sums for various decay half life values. We will use the QD results averaged for weekly intervals and reported in Rad/sec. This is in lieu of employing D44 directly as we have experienced the deleterious effects of various data anomalies such as a long series of high values during a shutdown. I130 has cleaned up this data and we believe we can take it as well measured. Using the output files from I130 we have populated worksheets for each loss monitor considered in the Spreadsheet LossAtInstrStuff.xlxs (included in this Beam-doc). In addition to the data worksheets, we have included a Plots worksheet where each loss monitor is plotted vs. weeks since October 16, 2006 using the default scale (which shows all the data) and for some cases, an expanded scale to emphasize the more recent lower loss rate. The Notes worksheet has some tables which summarize the loss rate (average Rads/sec) and loss sum (Rads) for several time ranges of interest. Plots for the average rates are included here.

Remarks and Analysis

In part, this effort will guide the placement and removal of Al Tags for activation studies. We need to understand how long we should leave tags to obtain a useful measurement. Fluences from 3 - 7 kRad produce sufficient activation for our analysis system. We see that for operation in the Recycler Proton Stacking era we have accumulated 3 kRad or more in the year from 8/1/2013 through 8/1/2014 only at 621, 102B, 103 and 104. At other loss monitors, we will accumulate activation more slowly. However, other locations of interest including the present locations of IPM detectors and IPM amplifiers may well have higher doses than the nearby loss monitors. While we plan to employ more sensitive measurements in future, placing tags now will allow us to gather important data.

This document should be read in conjunction with the accompanying spreadsheet where data is available for each BLM as well as plots and summary tables. Figures 1 and 2 provide some overview.

Figure 1. Average BLM reading in various time periods in MI Injection Area.

See Spreadsheet for time interval description.

Figure 2. Average BLM reading in various time periods in MI620 Region.

See Spreadsheet for time interval description.

The specific dates can be found on the worksheets for each loss monitor. Significant modifications in the Main Injector configuration or operation are listed in spreadsheet MIColNlossTimeLine. A few comments are appropriate. The operation after the 2012-13 shutdown begins in week 360 - 15 July 2013. The following are directed to comment on the plots for each loss monitor:

MI101 - MI107

LI101C - Losses varied In the 2006 - 2012 running with tuning of the injection from MI8 line. 1581 rads were accumulated from 1 August 2013 thru 1 August 2014.

LI102B (loss monitor at usual location downstream of Q102 on wall). Loss was low until startup in Week 353 (July 2013) when we started having loss at RR injection (LAM102 aperture issue). May be improved by alignment during 2014 shutdown.

Injection Gap Losses in 103 - 106 grow with slip stacking intensities. Commissioning of Gap Clearing Kickers after 2010 shutdown eliminated this loss in 103 - 106 area. Very little loss got to 107.

LI103 - Gap loss quite noticeable until commissioning of the Gap Clearing Kickers in week 200 (January 2011). They rise again as we turn on in Week 353 (July 2013). This is mix of MI and RR injection issues.

LI104 - Gap loss quite noticeable until commissioning of the Gap Clearing Kickers in week 200 (January 2011). Little loss here in 2013-14 era - lower by x5.

LI105 - Gap loss drop at about week 25 (April 2007) as we commission the MI Collimators but then remain unacceptable until commissioning of the Gap Clearing Kickers in week 200 (January 2011). Little loss here in 2013-14 era - lower by x10.

LI106 - Gap loss drops at about week 25 (April 2007) as we commission the MI Collimators but then remain unacceptable until commissioning of the Gap Clearing Kickers in week 200 (January 2011). Little loss here in 2013-14 era but more variable.

LI107 - Saw very little loss from Gap. Still low in 2013-14.

MI619 - MI621

LI619A - This location has always shown very little loss.

LI620A, B, C - Loss at 620 Lambertsons reflected issues with slip stack loss which didn't get fully addressed until the vertical collimation orbit fix in July 2008. The steady progress in collimation performance is most obvious by looking at the average loss for various periods as shown in the table (Average Radiaion at Selected Loss Monitor (Rads/sec) ) in the Notes worksheet. The Lambertsons were removed in the 2012-13 shutdown. Loss in the 2013-14 period remained low but is up to twice the loss in the last year with the Lambertson.

LI620D, LI621 - When the 620 Lambertsons were in place, we never achieved a really low loss orbit at their downstream end which resulted in losses at these two BLM's. LI620D loss was typically 15 times the loss at LI620C and LI621 was a further two times higher. In 2013-14, the loss at LI620D dropped 30 times to become lower than the loss at LI620C. We still have not fully achieved low loss at LI621 but the loss did drop three times lower than in previous periods. We can be glad that the electron beam scanner is upstream of this location.

Aluminum tags have been placed during the 2014 shutdown and will be analyzed when data from the BLM's indicates that the sensitivity of the analysis tools will allow us to make a measurement.

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