BEAM LOSS AND RESIDUAL ACTIVATION TRENDING*

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Abstract

The SNS Front End, the Drift Tube Linac, and most of the Coupled Cavity Linac have been operated during commissioning. Beam loss data were taken with differential Beam Current Monitors, and Beam loss Monitors during commissioning. Residual activation data were taken at various times during and after the run. An analysis of beam loss trending, beam loss monitor data and residual activation will be shown.

INTRODUCTION

The SNS Front End, the Drift Tube Linac (DTL) and most of the Coupled Cavity Linac (CCL) have been operated during commissioning. Beam loss data were taken with differential Beam Current Monitors (BCM), Beam Loss Monitors (BLM), and Chipmunks during commissioning. Residual activation data were taken at various times during and after the run. An analysis of BLM data and Chipmunk data was conducted.

Beam loss monitors measure the instantaneous beam loss as the beam is transported through the accelerator. Differential beam current monitors measure the difference in the beam current between BCMs. The DTL and CCL contain a total of 33 BLMs and 7 BCMs. Chipmunks are Personnel Protection Safety devices that are capable of disabling the beam should activation exceed a specific limit. Chipmunks are located throughout the accelerator.

WHY BEAM LOSS TRENDING?

The main sources of beam loss in the Linac are ionization and magnetic stripping as well as halo growth due to mismatch and space charge. Beam loss trending is utilized to determine if the losses exceed the simulated values, to address gradual increases in the beam loss pattern, and to address issues raised by previous fault studies. The operations procedure governing beam loss trending calls for a radiological data survey, a comparison of BLM data to the radiological survey data, a comparison of the actual beam loss data to the calculated beam loss data, and an analysis of chipmunk data.

PREDICTED LOSSES

Models and simulations have been conducted to determine the amount of controlled and uncontrolled beam loss in specific areas. Most of the SNS has been designed for hands-on-maintenance. Under normal operation, that is, 60 Hz and 1000 μsec pulse width, losses throughout the Linac are not expected to exceed 1-2W/m, except in specific locations such as the beam dumps.

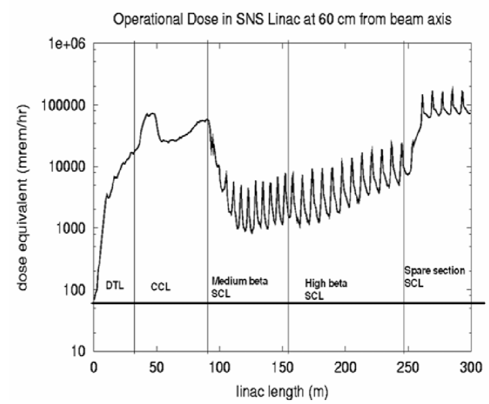

Figure 1: Dose at 60 cm distance from the Linac beam axis due to beam losses in normal operation [1]

The prompt doses at 60 cm distance from the beam axis are shown in figure 1. Localized losses may occur at the beginning of the DTL, at the end of the CCL, and at the transition between the CCL and the SCL. From the experience at other accelerator facilities, it is known that beam losses typically occur at locations where a change in transverse focusing or RF frequency introduces a mismatch. In the SNS Linac, above average losses are predicted to occur in the transition between the DTL and the CCL because of a frequency transition.

BLM AND CHIPMUNK ARCHIVED DATA

One aspect of the beam trending data analysis is to compare the actual beam loss to the predicted loss. The BLM data are stored in an archive. The data can then be extracted and plotted in a variety of time constraints to see the loss patterns. In reviewing the BLM archived data, it was found that at a beam intensity of 38 mA, and the machine parameters at optimum condition, both for the RF cavity power, and for the beam steering and beam focusing devices, the instantaneous beam losses through the warm Linac were negligible accept at the beam stop at the end of the CCL.

For this beam commissioning run, the archived Chipmunk data were plotted and reviewed, and found to be insignificant.

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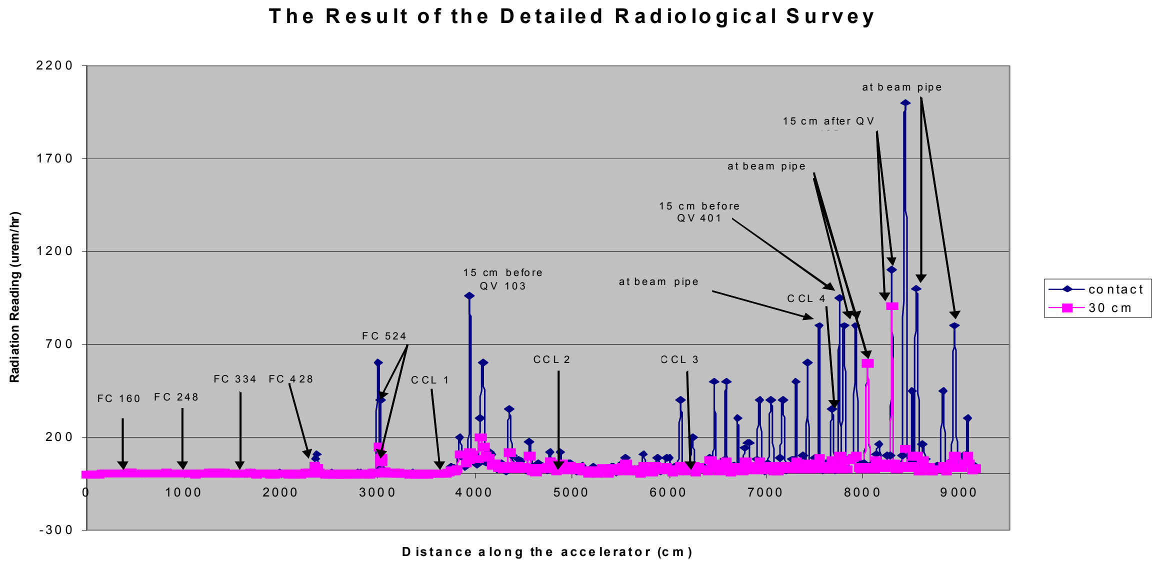

Figure 2: Detail Radiological Survey

RADIOLOGICAL SURVEY DATA

Radiological surveys are routinely done prior to allowing personnel access to the tunnel. Those surveys are not for beam loss trending analysis but for radiological posting.

As part of beam loss trending, a detailed radiological survey was conducted because it gives residual activation information throughout the machine and more accurately depicts changes over time in activation due to location and other factors. The result of the detailed radiological survey is presented in figure 2.

The intent was to make a measurement every 30 cm along the accelerator from the beginning of DTL1 to the end of CCL4. However, because of the shielding wall, access to the beginning of DTL1 was unavailable and the first reading was taken at 150 cm from the beginning of the DTL. In order to maximize shielding, prior to taking the readings, the faraday cups were inserted. In the warm Linac, the background reading was determined to be 8-10 urem/hr.

At each location, using a Bicron Microrem Meter, the residual activation data at contact (where possible) and at 30 cm were recorded. In addition to taking readings at every 30 cm along the accelerator, readings at the faraday cups were also taken.

CONCLUSION

Radiological Survey

Activation at the faraday cups was expected to be higher than the surrounding areas. Usually the readings at contact at the faraday cups were higher than the readings at 30 cm. However, for the areas upstream and downstream of the faraday cups, sometimes the readings at 30 cm were higher than at contact for that same “Z” location. The reason for the higher reading at 30 cm was due to the “shine” from the faraday cup whereas the contact reading did not see the same shine due to the tank shielding. This same observation was also made at some of the exposed beam pipe locations in the CCL.

In the CCL, there were many areas where the beam pipe was exposed. At these locations, actual contact readings on the beam pipe were made or readings were made as close to the beam pipe as possible. As expected, the readings at the areas of exposed beam pipe were much higher than the surrounding area. The readings at the quadrupoles were also higher than the surrounding areas.

In many cases, following a commissioning run, beam losses and subsequent activation result from various and sundry beam tuning exercises that are conducted to explore the parameters of the accelerator. Through much digging in the electronic logbook and in the beam accounting data, one can sometimes reconstruct the accelerator’s operating conditions. However, because these reconstructions are somewhat inaccurate (over the entire beam commissioning run), one has to be cautious as to how one interprets the detailed survey data.

Prior to opening up the enclosure for personnel access following a beam run, it may also have been useful to ask the Radiological Control Technicians to conduct a detailed radiological survey (perhaps not as thorough as taking data every 30 cm, because of a desire to minimize

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exposure to the workers) for beam loss trending analysis in addition to conducting a survey for radiation posting. Conducting this type of detailed survey closer to the time in which the beam is shut off may yield more meaningful data. However, investing much time in detailed surveys while the machine parameters are still being explored may be somewhat premature, in addition to needlessly exposing to radiation the workers conducting the survey.

Activation measured in the precision-detailed radiological survey is cumulative. The cumulative activation resulted from the different experiments conducted to explore the beam's characteristics, diagnostic devices being inserted into the beam, and RF and beam steering and focusing devices being at the wrong value. These cumulative effects on the beam and subsequent activation make comparison to predicted losses and beam loss trending somewhat impractical at this time.

Beam Trending Data Analysis

The optimum operating condition of the accelerator has not yet been established. The majority of the times, during commissioning, the accelerator is operated at significantly lower values of beam current and duty factor. At those lower operating values, the residual activation in the accelerator enclosure was found to be higher than predicted. This higher activation was due to beam commissioning activities. Until normal operating conditions have been established, the beam loss and chipmunk data trending analysis should be cautiously interpreted.

REFERENCES

[1] N. Catalan-Lasheras (Ed.), J. Galambos, N. Holtkamp, D. Raparia, R. Shafer, J. Staples, J. Stovall, E. Tanke, T.Wangler, and J.Wei, "Accelerator physics model of expected beam loss along the SNS accelerator facility during normal operation," March 29, 2001

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