Collider-Accelerator Department

BROOKHAVEN NATIONAL LABORATORY

Building 911B – P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344 7124
Fax 631 344 5568
beavis@bnl.gov
www.bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: *December 29, 2008*

to: *RSC*

from: *D. Beavis*

subject: *Labyrinth 8GE2 at RHIC*

It has recently been proposed[1] that the interlock function for most of the RHIC be removed. The chipmunks would remain to provide active monitoring of dose and provide dose rate alarms to operations. The 8GE2 labyrinth is the only access labyrinth that has a well defined source nearby, the blue beam primary beam collimator. This labyrinth has both a chronic dose and the dose related to maximal beam faults. Therefore, this labyrinth and its associated chipmunk should be reviewed more carefully.

The labyrinth will have two contributions to the dose at the gate that is located at the end of the third leg. The first contribution is from low energy neutrons scattering down the three legs of the labyrinth. This contribution was documented[2] in the RHIC SAD to be 21 mrem for a maximal beam fault. Recently, a punch-through contribution was estimated[3] for this labyrinth that is not part of the contribution formulated in the RHIC SAD appendix 15, and given in reference 3 as 40 mrem for a maximal beam fault. Reference 3 used an equation based on appendix 15 of the RHIC SAD that gives the dose due to a full beam fault as

$$38800*\exp(-d/2.2)/(rt*rt) \text{ (in rem-ft}^2\text{)},$$

where rt is the transverse distance from the machine component to the labyrinth gate in feet, d is the thickness of the soil shield for the first leg in feet. The punch-through calculation has been recalculated using the labyrinth dimensions found in reference 4 and a result of 28 mrem for a maximal beam fault is obtained.

The 8GE2 labyrinth had an updated calculated documented for the blue primary collimator. This update was not in the RHIC SAD but referred to in RHIC SAD Appendix 16 as forthcoming. This calculation uses the planned geometry of the collimator and LAHET to calculate the dose at the exit gate. The result is based on the beam loss scenario of $1.1*10^{14}$ Au ion equivalents at 100 GeV scrapped on the primary collimator per operating year. The estimated dose at the gate was 4200 mrem per operating year.

There are several factors to consider. The chronic loss on the collimator corresponds to 456 times the maximal beam loss. Reference 4 has the location of the blue primary collimator as 2.1 meters downstream of the labyrinth opening. The present location is approximately .6 meters upstream of the opening. This change in position should at least double the expected dose into the

labyrinth. This new location also means that the punch-through dose will contribute to the labyrinth exit dose for beam losses on the collimator. A polyethylene door of thickness 1cm was added to the labyrinth to decrease the dose due to low energy neutrons. This should reduce the low energy neutron dose by a factor of 0.53 based on the calculation[5] of RHIC SAD Appendix 43. This reduction was not included in the estimate of 4200 mrem per operating year.

A new estimate can be calculated using the results of the previous estimates and adjusting for changes. The estimate is:

1. High energy punch through will contribute 28 mrem*456 = 12,800 rem per operating year. No reduction has been credited to the polyethylene.
2. Using the dose formula above along with labyrinth attenuation formulas the dose for low energy neutrons is 24.5 * 456 = 11,800 mrem.
3. The total dose would be expected to be 24,000 mrem per year.

This should be compared to the 2200 mrem per year from reference 4 scaled by the 0.53 for the polyethylene door. Half the difference is associated with the punch-through contribution. This contribution from the collimator would be non-existent if it were located in the position used for reference 4. A good portion of the remaining difference can be attributed to the change in position, which increases the dose into the labyrinth. Finally, the formula used does not use an actual simulation of the collimator as was done in reference 4.

The dose at the 8GE2 gate is monitored with a TLD as well as a chipmunk, NMON312. The neutron dose recorded on the TLD for the run in 2007 was 142 mrem. This area is a controlled area with low occupancy. The large difference between the recorded dose and the estimated dose is attributed to substantially lower beam scrapped on the collimator than used for the estimates and the conservative nature of some of the estimates. Future operations may scrap more beam on the collimator and **it is recommended that shielding be added to decrease the shine into the labyrinth and the punch-through contribution. (CK-FY2008-RHIC-573).**

As already recommended in reference 1 the interlock function on this chipmunk can be removed. Routine operations of 20% lost over 4 hours at 4 times design intensity would put the estimated dose rate a 2.5 mrem/hr without the shielding. The maximum dose in an hour would be associated with a full beam loss on the collimator and would be 53 mrem based on the estimates above. In either case an interlocking device is not required[6]. If shielding is added then these numbers will be decreased substantially.

References

1. D. Beavis Memorandum, "Proposal to Remove RHIC Chipmunk's Interlocking Function", Dec. 23, 2008.
2. RHIC SAD Appendix 16, May 1999.
3. D. Beavis Memorandum, "Labyrinth Calculations in RHIC SAD", Dec. 16, 2008
4. A. Stevens Memorandum, "8 O'clock Labyrinth Simulation, Oct. 27, 1997.

5. S. Kahn and A.J. Stevens, “Estimates of Dose Equivalent Associated with Penetrations in the Phenix Shield Wall”, June 1998.
6. See CA-OPM 9.1.11c.

CC: RSC
A. Pendzick
A. Drees
RSC RHIC file