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: *September 28, 2012*

to: *RSC*

from: *D. Beavis*

subject: *ATF Linac Tunnel Penetrations*

The ATF has several penetrations in the Linac tunnel that were not analyzed in the SAD or the original analysis has been lost. There are four cableways on the west side of the Linac tunnel. The penetrations provide pathways for cables and small water pipes. The penetrations will be analyzed using simple techniques that have been used at C-AD for RHIC and the ERL.

Analysis

The linac tunnel penetrations have dimensions 3.5 inches high by 7 inches wide and are 46 inches long. Three of the four penetrations have direct line of site to the Linac beam pipe. The fourth has a Pb shield blocking the direct line of sight. The source term for transverse radiation of photons for an 85 MeV electron beam can be estimated[1] to be $5*10^3$ Rads/(hr-kW) at one meter. Using a measured distance of 40 cm the photon dose is estimated to be 31,250 rads/(hr-kW) at the entrance of the penetration into the tunnel.

The attenuation of an empty one-legged penetration can be estimated[2] to be $9*10^{-3}$. Photons exiting the penetration would produce 281 rads/kW of lost electrons at 85 MeV. ATF is allowed via the SAD to operate at 60 nano-amps of 85 MeV beam. This is 5.1 W of beam power. **Assuming a 100% beam loss in the vicinity of the penetration the dose immediately outside the hole would be 1400 mrads/hr.** The ATF has never operated near this beam power. It has been proposed[3] that a series of hardware and administrative controls be put in place to limit the beam to 0.14W at 85 MeV. **Using this low power option would reduce the fault dose to 39 mrad/hr.**

Several of the penetrations have direct line of sight to a quadrupole. The SAD discusses that a routine loss in a quadrupole could be expected to be 1% of the beam. **The routine dose outside a penetration would be 0.4 mrads/hr for low-power operations.** This does not include the self shielding of the quadrupole.

There are other factors that should be considered in evaluating the exposure risk. The area of the penetration is substantially smaller than what would create a whole body exposure. Typically a 1000 cm^2 has been used for a whole body exposure. A 1000 cm^2 exposure area would occur about 15 cm from the exit of the penetrations and if used would provide a dose reduction of 0.16. In addition, based on operating experience it is not expected that a fault would occur for more 15 min. Incorporating these factors leads to a dose estimate of:

Low Power Estimates at 0.14 Watts of 85 MeV Electrons

Operating condition	Estimated Photon Dose (mrads in an hour)
Routine 1% loss	0.06
100% beam loss	1.5

The neutrons can be estimated in the same manner. The initial dose of neutrons is substantially[4] lower. The curve for attenuation of neutrons[5] in a one legged penetration is nearly identical so that the neutron dose outside the penetration will be less that the photon dose.
There is also a penetration for one of the waveguides. The penetration appears to go down vertically in the wall about half-way down the acceleration section. There are no measurements available for this penetration, but it is suspected not to be an issue. A portion of the mezzanine may exist above the penetration. The distance from the exit point to above the mezzanine deck would reduce the dose substantially.

A penetration has been added for the x-band. This penetration enters the ceiling where the access door to the tunnel is on the east side of the tunnel. The hole appears to be made by removing one vertical stack of blocks. It will be assumed that the hole is 7.5 inches by 7.5 inches. The x-rays from the beam line travel through the 90 cm of light concrete. Most appear to miss the heavy concrete. It will be assumed that there is no attenuation provided by the hole. An estimate of 250 mrads/hr from photons is estimated at the exit of the hole at 5.1 Watts. **For 0.14 Watts the estimate is reduced to 6 mrads/hour.** Additional reduction will occur from the hole exit to the floor above. This should cause another factor of 2-4 reduction. The analysis of this hole is crude but a fault study should be conducted to verify the risk of exposure is small. This is a fault dose for 100% of the beam on a thick target. The routine dose will be several orders of magnitude lower.

Conclusions

The penetrations appear to be sufficiently low in potential dose for low power operations.

It is recommended:

1. Several routine surveys should be conducted with beam to the zero degree dumping area immediately downstream of the 20 degree dipole.
2. The dipole should be locked off pending analysis of the experimental area and the ability of the plug to protect personnel in the experimental area.

References

1. NCRP Report No. 144. See figure 3.5
2. A.H. Sullivan, A guide to radiation protection and Radioactivity Levels Near High Energy Particle accelerators, 1992. See figure 2.26 and associated text.
3. Private communication.
4. See ATF Appendix.
5. Reference 2 above. See figure 2.25