

Memo

date: September 29, 2012

Updated: October 8, 2012

Updated: October 10, 2012*

to: RSC

from: D. Beavis 

subject: Simple Analysis of W Beam Plug at ATF

A movable beam plug having a length of 18cm of W is located inside the beam transport between the Linac tunnel and the experimental area. Personnel are typically allowed in the experimental area with beam on the beam plug. The experimental area is posted as a Controlled Area. The dose from neutrons and photons will be estimated at the position of the first dipole in the experimental area and at the transverse location along the side of the beam plug. The shielding does not allow a person to go past this dipole, although a portion of the beam line is exposed from the top before the dipole.

Experimental Area

The same methods used in previous notes and in the appendix of the SAD have been used for this estimate. For W (assuming 97% W) the radiation length was used to obtain a TLV of 3.4 cm. The photon dose at 1 meter is estimated to be 12,750 rads/hr for 5.1 Watts (85 MeV). The plug is 17.8 cm long providing 5.2 TVLs of gamma reduction. The closest location a person can stand is beside the dipole in the experimental area. The distance is 2.3 meters. **Using the distance and gamma attenuation the gamma dose in the beam pipe at 2.3 meter is 14 mrad/hr.**

The neutron yield¹ is 2.35×10^{12} neutrons/sec per kW. Thus the total yield of neutrons is 4.3×10^{13} neutrons/hr for 5.1 W of beam at 85 MeV. Using a neutron attenuation length 8.61 cm for the W and assuming an effective length of 14 cm the neutrons are reduced by a factor of .197 by the downstream plug material. A neutron fluence to dose conversion factor² at 3 MeV is 2.65×10^{-5} mrem/(n/cm²). **A neutron dose rate of 340 mrem/hr is obtained³ in the beam pipe at the dipole for 5.1 W of 85 MeV electrons striking the plug.**

The estimates above do not include the dose that can bounce through the penetration around the beam pipe. The beam pipe has a small area so that even if the pipe is open downstream of the dipole the whole body exposure would be small.

A survey taken on Feb. 18, 2011 found 2 mrem/hr to the left of the chipmunk which sits on the top of the dipole. The electron beam had an energy of 70 MeV with a power of .084 Watts. Scaling to 5.1 Watts would suggest a dose rate of 120 mrem/hr.

The total dose at the low power testing (0.14 W) would be 9 mrem/hr., inside the beam pipe.

The West Wall

The radiation outside the west wall can be estimated. The lead is 8 inches thick on the side of the beam plug. The shielding has 40 inches heavy concrete, which has not been verified. It will be assumed to be light concrete to be conservative. Self shielding from the W plug will be ignored. **The photon dose outside the concrete is estimated to be 0.03 mrad/hr.** This is a conservative estimate so the actual dose is expected to be smaller.

The neutron dose outside can be estimated as above for the forward direction. The lead and the concrete will provide a dose reduction of 8.8×10^{-4} . **The neutron dose outside the light concrete will be less than 3.5 mem/hr.**

A same survey discussed above detected 0.2 mrem/hr near TLD 80. Scaling to 5.1 Watts would suggest⁴ a dose rate of 12 mrem/hr. The calculation above would be about a factor of 3-4 smaller due to the increased distance to TLD 80 location, which is on the opposite side of the hallway. If 60% of the concrete wall is heavy concrete the calculated number would be decreased another factor of 5.

At the proposed low power testing the survey results would predict 0.8 mrem/hr.

Conclusion and Recommendations

The plug provides sufficient shield to allow low power running.

A survey should be conducted before the area is released to users and include the following points:

1. Directly on top of the beam pipe in front of the dipole. Additional transverse points can be taken to obtain the falloff with distance.
2. Where the building seam penetrates the shield on the west side.
3. Along the hallway to examine for possible neutron leakage.

References

1. See NCRP Report No. 144, Fig. 3.12
2. See J. Donald Cossairt and Kamran Vaziri, Fermilab-pub-08-244-esh.
3. An isotropic distribution has been used.

The concrete has been assumed to be all light concrete. Based on the instruments used almost all the dose is neutrons and the HPI-1010 has a quality factor of