An estimate of the potential radiation for an 85 MeV electron hitting a target was conducted. This estimate is intended to provide guidance on the exposure risk related to the shielding at ATF. The estimate has been conducted using two methods. The first method used simple figures provided in NCRP Report No. 144, which should provide a conservative estimate of the external dose for photons. This method is similar or identical to the analysis in the ATF SAD. The second method was to establish a simple model in MCNPX shielding code to provide a more accurate estimate, which has some of the conservatism by using the actual transverse energy distributions and cross-sections provided for the shielding the code provides. However, the geometry has been severely approximated as cylinders to estimate the dose at the smallest appropriate dimension. This should provide a reasonable estimate of the potential dose along the uniform shield at the weakest point. The first method provides an estimate the potential dose quickly while the second can provide accurate estimates depending on the level of detail put into the model.

Analysis

NCRP Report No. 144 recommends using $5 \times 10^3$ rads/hr per kW at one meter. Scaling this to 140 mW of beam power which is the proposed low power limit becomes 7.5 rads/hr at a foot. The TVL for light concrete is 53.2cm for 85 MeV electrons hitting a target. The west wall is 116 cm thick providing an attenuation of $6.5 \times 10^{-3}$. The distance is 4.7 feet from the beam to the outside of the shield. **Combining all the factors a photon dose of 2.2 mrem/hr is estimated with no local shielding for a full beam fault at 0.14 Watts.** The opposite side has a thinner wall with one layer of heavy concrete. The distance to the outside wall is 5.87 feet and the TVL for heavy concrete is approximately 35.7 cm. A **potential dose rate for a full beam loss of .14W at 85 MeV is 3.4 mrem/hr.** We expect that these numbers are probably a factor of ten on the conservative side.

The Monte Carlo program MCNPX was used to estimate the dose for 85 MeV electrons striking a cylinder of copper. Cylindrical geometry was used to obtain a rapid estimate of the dose outside 120 cm of concrete. A **dose rate of 0.08 rads/hr was obtained outside the shield for a full beam fault at low power.** This dose rate should be a reasonable approximation at beam height. There are several factors that contribute to the factor of 30 between the two methods, but at least a factor of 10 was expected before the MCNPX code was run. The use of attenuation
factors for broad beams and the high–z target source terms are known to provide substantial overestimates in the external dose for transverse radiation.

The MCNPX model had photo-neutron production turned on and followed the neutrons in the geometry. The statistics of the run were too low to provide the dose outside the shield, but did provide the dose on the inside surface of the concrete. Using NCRP No. 144 the external dose rate was estimated at 30 micro-rem/hr for .14 W lost on copper. A Pb target would yield about a factor of 2 more neutrons. There is a substantial amount of Pb distributed near expected beam loss points and it would probably wise to use 60 micro rem/hr for a full low power beam loss for the neutron dose. The neutron dose is essentially equal to the photon dose external to the shield.

These dose rates suggest that there is little risk of exposure for low power operations outside the external shield for transverse radiation. The total transverse radiation for a full beam loss at the low power limit is 0.15mrem/hr with no local shielding accounted for. It is not reasonable to expect that the ATF operators would allow the faults to occur for an hour unless it was a special test. A fault of 15 minutes seems possible if the operators become distracted. The Linac bulk concrete shielding appears to be sufficient for the low power operations. Examination of the bulk concrete shielding has shown that the amount of concrete shielding shown in the prints is accurate. The shielding prints show most if not all of the existing penetrations. The analysis of the penetrations will be presented in another note. The concrete walls in the experimental area are farther way then the walls forming the linac tunnel. Thus the dose outside will be lower for the bulk shielding of the experimental area. The roof is a special case that will be treated in a separate note.

There are only minor differences that would not impact the analysis of the bulk shield. The photon dose in the forward direction can be 1000 times higher than the transverse dose. The distributions of forward local shields will need to be examined to determine if there is a risk for forward faults that could cause exposure. These local forward shields also act to prevent mistuned magnets from deflecting the beam past the distributed forward shielding. This will at least need a preliminary examination to assure that it is not likely. A more careful examination will need to be conducted to assure that it is not a serious risk. This type of fault is primarily an issue for the experimental area where there are substantial bends (20 degrees at 85 MeV).

**Conclusions and Recommendations**

The existing shielding prints provide a good representation of the actual shield. Any differences should not impact the expected dose for external radiation. The risk of exposure for external transverse radiation appears to be low for the linac tunnel and the experimental areas.

The risk is low for low power operations in the linac tunnel.

Before beam is introduced into the experimental area the experimental area shielding needs:

1. Be examined for forward faults especially those introduced by miss-steered beam.
2. Have penetrations in the shield analyzed.
3. Roof analysis completed and controls implemented.