Collider-Accelerator Department

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Memo

Date: *April 13, 2016*

To: *RSC, D. Phillips, C. Folz, J. Tuozzolo, and A. Fedotov*

From: *D. Beavis*

Subject: *Laser Penetration for IR2*

There has been a request for initial guidance on the future design of a laser penetration that may be drilled though the existing IR2 shield wall. This penetration may be constructed during the FY2016 summer shutdown. The penetration will have the following three beam sources for radiation:

1. CeCPoP beam losses at either 2 MeV or 25 MeV.
2. LeREC beam losses at a maximum of 3 MeV.
3. RHIC Beam losses.

For access allowed near the exit of the penetration the maximum allowed dose in a beam fault should be less than 100 mrem. Ideally, the design should reduce the potential dose to less than 20 mrem in a beam fault. Simple parameters will be used for this analysis of the penetration. As details of the location of the penetration, the location of components of LeREC, and other parameters become available then the penetration design can be iterated to meet the committee's recommendations.

The distance from the beam loss point to the penetration is one of several important parameters that determine the leakage radiation. It will be assumed that the LeREC loss point is 10 meters away, the RHIC beam loss point is 7 meters, and CeCPoP beam loss point is 7 meters away. These distances will be used for $(1/r)^2$ scaling of the dose rate to the entrance of the penetration.

The radiation source terms for full beam losses are:

- CeCPoP[1] $\rightarrow 7*10^3*8.5$ $6*10^4$ rem/hr at one meter
- RHIC[2] $\rightarrow$ $3*10^3$ rem at a meter
- LeREC $\rightarrow 1*10^4*50$ $5*10^5$ rem/hr at a meter

[1] For the electrons see NCRP Report No. 144, Figure 3.5.
[2] The 38,800 rem for a full beam fault has been adjust to ½ beam fault, factor of 2 for neutrons reduced to 1.5, and scaled from $2.28*10^{13}$ protons to $5*10^{13}$ protons per ring.

The dose rate challenging the penetration will be:

- CeCPoP → 1200 rem/hr
- RHIC → 61 rem/fault
- LeREC→ 5000 rem/hr

For this initial guidance we will make several additional assumptions. lt is assumed that a maximal beam fault can only last for 12 minutes. This does not impact the RHIC beam fault and is expected to be very conservative for the electron machines. The shield wall will be approximated as 240 cm thick and the diameter of the penetration is set to 10cm. A design goal of 20 mrem in a fault would suggest that an attenuation of $2*10^{-5}$ must be achieved for the LeREC beam losses. A simple analysis of straight penetrations is given[3] by A.H. Sullivan. Using section 2.4.2 of Footnote 3 the desired reduction is essentially not possible. It is likely not possible for any change in the penetration parameters. This means that either the source terms need to be reduced or shadow shielding needs to be used. If the source term for LeREC can be reduced by more than a factor of 10, then the present concept of a straight through penetration can be used.

A more careful analysis will be conducted once initial understanding is achieved of the LeREC operating parameters and beam loss locations.

[3] A.H. Sullivan, A Guide to Radiation and Radioactivity Levels Near High Energy Particle Accelerators, Nuclear technology Publishing, 1992.