

## Memo

*date:* December 16, 2008

*to:* E.T. Lessard and R. Karol

*from:* D. Beavis 

*subject:* Labyrinth Calculations in RHIC SAD

I was examining the RHIC SAD for the analysis of the labyrinths and noticed that there was a component of radiation not included in the analysis for the three legged labyrinths. For three legged labyrinths with short first legs the radiation that travels through the shielding can penetrate (punch-through) the shield wall directly into the third leg of the labyrinth. This component was not included in the analysis that provided the basis of Table 4-G-2 of the RHIC SAD.

On December 11 and 12 I measured the dimensions of the three-legged personnel access labyrinths and checked several of the escape labyrinths. I measured the distance from the beam elements to the wall of the tunnel and also determined the type of source. The analysis for a design basis accident used for the SAD assumed that most of the RHIC ring could have a localized fault of one-half the beam in a ring (such as yellow) and apertures could have the full beam lost locally. I have 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. If the labyrinth was treated in more detail I would suspect that the dose would be somewhat smaller than this simple scaling, but this then provides a conservative estimate. A more detailed analysis could be conducted using either MCNPX or MARS. This estimate does not include the contribution calculated in the documents for the RHIC SAD Table 4-G-2.

The results of the punch-through contribution are compared with the numbers given in the SAD in the table below. Only the relevant three-legged labyrinths are given here.

<b>Labyrinth</b>	<b>Source Rem at one ft</b>	<b>At wall</b>	<b>mrem at Gate</b>	<b>Table 4-G-2 mrem</b>
8GE2	38752	387.52	40	21
6GE3	19376	452.9087	40	36
6ED1	38752	351.4921	131	24
5GE1	19376	478.4198	49	not listed
4GE3	19376	917.2071	0.2	13
4GE2	19376	387.52	82	16
2GE2	38752	151.375	190	19

It can be seen when a labyrinth has a long first leg such as 4GE3 then the punch-through is negligible. When the first labyrinth leg is short such as the case of 2GE2 then the punch through contribution can dominate. The source numbers have the factor of two used for increased quality factor as was done in the RHIC SAD. These numbers are well below the guidelines that were used for the RHIC design. The SAD may describe many of these labyrinths as exiting into uncontrolled areas but now the entire area where the labyrinths exit are Controlled Areas for RHIC operations.

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