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Memo

date: *February 5, 2010*

to: *RSC*

from: *D. Beavis*

subject: *Potential Dose near RHIC IRs*

Introduction

The potential doses near RHIC Intersection Regions (IRs) are discussed. The estimated doses from the RHIC SAD and supporting documents are tabulated. Scaling will be used to demonstrate that low energy operations this year and in the future should be acceptable. Radiation surveys and operational experience will provide for ALARA operations in future longer low-energy runs. Scaling will be used to estimate doses for higher intensity and energy operations that may occur in the future.

The methods used for Maximum Credible Incidents (MCI) and chronic loss conditions have been discussed in a series of memorandums[1] on RHIC operations and will not be discussed here.

Dose near the RHIC IRs

The results for the six IRs are given in Table I.

Table I. Doses Near IR Shield Walls

Area	Full Energy MCI mrem	Upgrades MCI mrem	Chronic[2] Low Energy (mrem/hr)	References
2 O'clock- ground level	340	850	3	3
2 O'clock- high above ground	2630	6600	23	3
2 O'clock- 3 feet above ground	475	1200	4.1	3
4 O'clock- excluded area	3800	9500	33	4
4 O'clock Accessible area	223	560	2	4
6 O'clock	267	670	2.3	5
8 O'clock	339	850	3	6
8 O'clock- South Shield wall	650	1625	6	13

8 O'clock-North shield wall	330	825	2.9	14
10 O'clock	NA	NA	NA	7
12 O'clock-excluded area	18,500	46,000	160	8
12 O'clock-fence	355	890	3.1	8

For low energy operations all the accessible areas for personnel standing at ground level are sufficiently low that radiation surveys should be adequate to detect and post any area with elevated levels. It is expected that the beam loss rate used for the IRs is conservative and that the actual radiation surveys will show lower levels consistent with the Controlled Area postings. The area where ladders can be used to elevate a person above ground level at 2 O'clock and receive increased exposure potential is posted that ladders are not to be used.

The high levels inside the fence at 4 O'clock are due to the magnet ports in the walls which allow the wall to be exposed to forward radiation from the source. Many locations at IRs have weak locations at elevations high above the floor due to the reduction of shielding and potential penetrations. The large dose values at 2 O'clock are the result of reduced shielding at the higher elevations. In addition, there are cryogenic penetrations on both sides of the shield wall. Both STAR and PHENIX have weak locations high above the floor level.

For future intensity upgrades some of the potential radiation levels become quite large. As an example the 46,000 rmem noted at 12 O'clock is for a person standing on the ground. The levels at beam height are a factor of 1.7 higher or 78,000 mrem. Some of the areas near the operating experiments are approaching 1000 mrem for an MCI. It has been suggested by an RSC subcommittee[9] that these areas be designed for 100 mrem in the future.

The roof tops were not considered in the RHIC SAD since they were and still are exclusions areas. It is worthwhile to consider what the expected dose rates are on the IR roofs. The dose for MCIs and the chronic dose rate for low energy operations are given in Table II.

Table II: Dose on IR Roofs (Access not allowed except at 10 O'clock)

IR Roof	MCI for Full[10] energy Dose in mrem	MCI for upgrades Dose in mrem	Chronic low[2] energy Dose rate in mrem/hr	References
2 O'clock	3,400	8,500	60	11
4 O'clock	7,200	18,700	130	
6 O'clock	1,200 (3,100)	3,000 (78000)	21	12
8 O'clock	380 (1,900)	950 (4,800)	7	12
10 O'clock-berm	34	85	0.6	
12 O'clock	8,300	21,000	150	

Recommendations and Comments

The potential dose levels are sufficiently small for low-energy operations that surveys conducted early in the stores should identify locations that require extra precautions. Most of the areas have occupancy levels that substantially reduce the risk of integrated exposure. I would recommend:

- Where there is expected to be personnel that the area have precautionary posting until surveys establish routine operational dose rates. **(CK-FY2010-RHIC-677)**
- The area outside the PHENIX south shield wall should be posted as TLD required until the surveys are conducted. PHENIX should be informed that the gas house may have elevated dose rates. **(CK-FY2010-RHIC-678)**

The potential doses for intensity and energy upgrades have potential exposure levels that are high. It is recommended that:

- Additional shielding be considered to reduce potential exposures in an MCI. **(CK-FY2010-RHIC-679)**
- Even without upgrades some of the potential doses should be reduced with shielding. **(CK-FY2010-RHIC-680)**

References

1. See for example: D. Beavis, "Potential Dose on RHIC Berm", Dec. 30, 2009; D. Beavis, "RHIC Labyrinths" , January 14, 2010
2. The Chronic dose for an IR at low energy is obtained by scaling the full energy MCI to 3.85 GeV and assuming that 25% of each injected beam (10^9 Au ions) scrapes equally near the six IRs with three fills per hour. This is expected to be conservative. The locations that have contributions in the forward direction will scale differently from the $E^{.8}$ that has been used for the energy scaling. For low energy operations it is conservative.
3. A.J. Stevens, "BRAHMS Shield Wall Calculations", RHIC/DET Note 24, Oct. 1997.
4. A.J. Stevens," RSC Meeting on Shield Design and Access Restrictions at 4 O'clock", March 25, 1998. These levels are from forward radiation and are probably smaller for low energy operations.
5. A.J. Stevens, "Estimate of Dose Through Cracks in the STAR Shield Wall", RHIC/DET Note 23, Aug. 1997. This estimate assumes that the STAR magnet and detectors are in place. The numbers present here does not include cracks.
6. RSC Minutes of Meetings held on Sept. 10, 1996 and Oct. 20, 1997. This number is for the movable shield wall and does not include any cracks.
7. The 10 O'clock IR is enclosed by the berm and not a shield wall. The dose rates on top of the berm have been discussed in the memorandum on the RHIC berm.
8. RSC minutes of July 28, 1998. A.J. Stevens, "Dose Equivalent rates at the 12 O'clock IR", July 1998.
9. RSC Minutes of August 25, 2009, "Fault Dose design Criteria for RHIC upgrades".
10. For the full energy MCI half of one beam is assumed to hit an aperture near the IR.
11. A simple empirical formula is used to calculate the dose on the IR roof surface. Dimensions of the concrete and distances have been taken from the archived drawings. The double neutron factor that was common in the previous memorandums and the RHIC Project documentation has been used.

12. The numbers in parenthesis are estimates with the detectors at STAR and PHENIX removed. The detector system at PHENIX has a substantial difference in material that shields the side walls verses the roof. The roof numbers for the PHENIX IR are probably too small.
13. A.J. Stevens, "Improved Estimates of fault Dose Exterior of the PHENIX South Shield Configuration", AD/RHIC/RD-128, Sept. 1999. It should be noted that the potential dose rates in the PHENIX gas house may be 50% of the rates at the fence.
14. A.J. Stevens, "Evaluation of the Current Counting House Shielding Design at 8 O'clock", memorandum of Sept. 17, 1996.

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