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Memo

date: *September 23, 2009*

to: *RSC*

from: *D. Beavis*

subject: *AtR Low Energy Operations – Potential Dose*

The potential for dose exposure along the AtR will be examined for low energy operations. The RHIC Analysis for the AGS to RHIC Transfer (AtR) line assumed conditions for the beam parameters, integrated beam intensity, and loss locations. Details of that analysis can be found in reference 1. Details of the radiation analysis can be found in reference 2. It will be concluded that dose exposure outside the AtR tunnel will not be an issue for low energy operations. Dose exposure inside can be keep ALARA with appropriate surveys and access procedures.

The AtR is enclosed in a locked fence from the thick berm near the V-block house until the end of the W beam dump. Since access during beam operations is prevented except by special consideration, the issue of exposure directly on the berm will not be discussed in this note.

For the present planning purposes it will assumed that the low energy losses[3,4] will be 5% of the beam extracted into the transfer line with half the loss concentrated in one location. The estimated weekly losses for low energy operations can be compared to the total annual losses considered by the RHIC Project. The table below makes such a comparison:

Beam Energy (per nucleon)	Localized 1 wk loss-Au 10.4 GeV Equivalents	Annual localized Loss in RHIC SAD in AtR for 10.4 GeV Au
3.85 GeV Au	$6.25*10^{11}$	
5.75 GeV Au	$1.4*10^{11}$	
9 GeV Au	$1.2*10^{11}$	
10.4 GeV Au		$1.0*10^{12}$

Based on this simple comparison, several weeks of low energy operations should not be an issue. There are no exposure limits that were close to being reached for the losses assumed in the RHIC SAD. The limits will be examined more carefully below and it will be shown that low energy operations are not an issue for exposure outside the tunnel.

SkyShine

The AtR reports estimated skyshine for two locations, Building 1005 and the site boundary. The annual dose from skyshine estimated in reference 2 was:

Annual Skyshine Dose

Building 1005	0.0055 mrem
Site Boundary	0.0002 mrem

A factor of 20 increase in annual AtR losses than considered in the RHIC SAD would raise the expected dose in Building 1005 to 0.1 mrem. At the estimated 5% low energy loss this would be equivalent to 32 weeks of operations at 3.85 GeV in one year.

The skyshine dose was also compared to the direct dose for locations on the side of the AtR at a distance of 20 meters from the beam center where the skyshine contribute is equal to the direct contribution. The annual dose was estimated to be 1.2 mrem from each source. To maintain a limit of 100 mrem/yr for these areas the annual losses in AtR would need to be less than 40 times the limit used in the RHIC SAD. Provided the losses are kept at a reasonable level there should be no issue for dose along the sides of the AtR.

Entrance Labyrinths

All entrance labyrinths for the AtR have radiation monitoring devices, chipmunks. These devices alarm in MCR for operators to respond to via written procedures if a high dose rate is detected. The chipmunks will turn the beam off (interlock) if the dose rate exceeds a predetermined level.

Special Locations

Several special locations are mentioned in section VI of reference 2. The location where the shielding over the transfer line may be as thin as 10.5 feet is inside the enclosed barrier and not an issue. The roof over the beam switching enclosure was upgraded to 13 feet as part of the shielding increase over the W dump. This area is also inside the locked fence. The power supply house, building 1000P, is estimated to have an annual dose of 4.3 mrem/yr (normal losses). For many weeks of low energy operations the posting on this building should be considered to be upgraded to “controlled Area- TLD required” or have surveys conducted to ensure exposure levels are sufficiently low.

Thompson Road

Thompson Road crosses over the injection arcs downstream of the W dump. During the initial design reviews this area was envisioned to be an uncontrolled area. The area was upgraded to a “Controlled Area TLD Required” due to the risk of large beam faults under the road and has been closed to road traffic during beam transfer operations to RHIC. There has been analysis[5] that supports opening Thompson Road during normal operations. It will be assumed that for low energy operations this area will have its present posting which is “Controlled Area-TLD Required”. Monitor TLDs have been used in this area during past operations and are consistent with background for an annual exposure. Even with the higher losses and total injected beam this area is not expected to have exposure issues. The potential exposure due to a beam fault is lower at low energy than at high energy operations and therefore satisfies existing requirements.

W Beam Dump

Section IX of reference 2 discusses the radiation from the beam dump. It should be noted that after reference 2 was written the shielding was increased from an elevation of 86 feet to 94 feet providing an extra eight feet of soil shielding. In addition, a cap (membrane) was placed over the area to prevent leaching of activated soil. The extra shielding reduces the estimated maximum hourly dose rate over the dump from 52 mrem/hr to 1.4 mrem/hr. The dose rate over the dump is not of concern since it is inside the locked area.

The skyshine from the dump to several locations was estimated in reference 2. These numbers are presented below taking credit for the reduced radiation with the additional shielding. The new estimates do not take into account the potential change in the radiation pattern due to the change in the shielding.

Location	Distance (m)	Annual Dose (mrem)
Thompson Road	14	0.1
Building 1000P	17	0.08
Building 1005	365	0.0003
Site boundary	1060	0.00001

These numbers correspond to the equivalent of $2.*10^{14}$ 10.4 GeV/nucleon Au ions into the dump in a year. The weekly estimate for beam in the AtR assuming 50% uptime[4] for 3.85 GeV operations was $2.5*10^{13}$ Au-10.4 equivalents per week. Naturally there is no intent to operate for weeks with the beam into the dump. However, the numbers given in the table above demonstrate that a factor of a 100 increase in beam into the dump will still have acceptable skyshine contributions to dose.

Estimates of water activation, air activation, and residual activity have not been made. Present operation experience is that these are all very low for the present beam losses. Several of the access procedures and monitoring procedures should be updated for the low energy operations to catch any increase potential dose due to activation.

The magnet cooling water for AtR is tested every year for radioactivity. The water system had an increase of 560 pCi/l of ^3H from the FY09 proton operations[6]. The total amount of proton beam transported through AtR for FY09 is equivalent to $1.6*10^{14}$ Au ions at 10.4 GeV. If losses are 50 times higher for low energy running and these losses are responsible for the water activation then we can expect a factor of 8 increase in water activity per week or 4500 pCi/l 3H per week from low energy operations. It is not clear if the water activity should scale in this manner. The factor of 50 times higher losses is expected to be conservative. Monitoring during the run should be conducted.

Comments

The following should be considered for low energy operations of AtR:

1. Upgrade the posting on building 1000P to "Controlled Area-TLD Required".
2. Have the area over Thompson Road posted as "Controlled Area-TLD Required" for initial low energy operations.
3. Modify access procedures to the U line to require surveys or make estimates of residual activity and air activation doses to ensure present access procedures are acceptable.
4. Monitor the activity of the magnet cooling water during the low energy operations and conduct surveys at the heat exchanger.

References

1. M. Harrison and A.J. Stevens, "Beam losses in RHIC", AD/RHIC/RD-52, Jan. 1993, Appendix 8 of the RHIC SAD.
2. A.J. Stevens, "Analysis of radiation Levels Associated with Operation of the RHIC Transfer Line", AD/RHIC/RD-83, Dec. 1994, Appendix 17 of the RHIC SAD.
3. T. Satogata, "RHIC Low Energy Beam Loss Projections", Sept. 9, 2005.
4. D. Beavis, "Low Energy Operations of AtR—Soil Activation", Sept. 22, 2009.
5. Minutes of the RSC, February 3, 2009.
6. J. Scott, e-mail to D. Beavis, Sept. 23, 2009.

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