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Memo

date: *September 2, 2009*

Updated: *November 20, 2009*

to: *RSC*

from: *D. Beavis*

subject: *Low Energy RHIC Operations: External Dose from Collimators – Updated*

The issue of external dose from the RHIC primary beam collimators is discussed in the context low energy beams. The external dose from the RHIC collimators was documented by A.J. Stevens[1] for the RHIC Project. The issues that will be examined for low energy RHIC beams are soil activation, dose on the berm, and skyshine to adjacent facilities and off-site.

The radiation issues for beam on the collimators were evaluated[1] for $1.1*10^{14}$ Au ions at 100 GeV/u per year and $2.85*10^{10}$ Au ions at 100 GeV/u per hour per collimator. Since the issues that will be discussed are due to transverse radiation the results given in reference 1 can be scaled[2] by $E^{.8}$, where E is the kinetic energy per nucleon of the beam. The table below lists the equivalent loss of gold ions that the evaluation of reference 1 corresponds:

Au loss	Equivalence to Reference 1 loss		
Energy of Au ion	100 GeV/u	9.0 GeV/u	2.5 GeV/u
Au ions per year	$1.1*10^{14}$	$6.7*10^{14}$	$2.1*10^{15}$
Au ions per hour	$2.85*10^{10}$	$1.7*10^{11}$	$5.4*10^{11}$
FY10 Projection per hour (ref. 3)		$(1.7\text{-}2.1)*10^{10}$	$(7.5\text{-}29.)*10^{10}$

The hourly loss rates for low energy operations in FY10 are given in the table and detailed in reference 3. The numbers for the projected low energy operations have a lower value which is the result of store losses on the collimator. The upper value for the projected loss is the store losses supplemented with 70% of the injection losses. No estimate has been made on the upper limit for injection losses but 70% seems like a reasonably conservative value. The hourly losses on the collimators approach but do not exceed the hourly rates used in the RHIC SAD. The external dose rates related to higher hourly loss for low energy running are therefore lower than presented in the RHIC SAD. However, if the hourly losses exceed the values in the RHIC SAD the dose rates in the associated external areas would not exceed their posting.

The yearly rates impact both the evaluation of soil activation and yearly exposure levels to adjacent non C-AD area and off site. Reference 1 has the following dose in a year for the closest off sire location and bldg 1101:

Location	Collimators mrem/year
Wm. Floyd Parkway	0.9
Bldg 1101	1.0

It can be noted that building 1101 is a C-AD storage building. The closest building that is used by non C-AD personnel is building 1005. This building is twice as far away from the collimators as the site boundary. The yearly dose at building 1005 will be nearly $1/10^{th}$ (0.13) of the yearly dose at the site boundary. Reference 1 noted that if the thickness of shielding was increased over the collimators than the dose at the site boundary would be 0.4 mrem/year. Based on the projections of reference 3 it would take about 300 days to reach this limit with 2.5 GeV beam with a 100% duty factor. It is concluded that the primary beam collimators are not an issue.

The groundwater estimate given in reference 1 was 48 pCi of ^{22}Na per cc of water, which is above the 20 pCi per cc limit established in the BNL SBMS[4]. A liner was added to the design of the RHIC facility. The liner has a width of 45 feet. The liner will prevent leaching for at least 10 feet beyond the tunnel wall. Every foot of soil will reduce the transverse radiation about 1/e so that after 10 feet we would expect concentrations to be 0.002 that of the tunnel wall or about 0.1 pCi of ^{22}Na. It would require 280,000 fills with the entire beam lost on the collimator for the leachate at the edge of the liner to approach the limit established in reference 4. In the forward direct the length of the liner is sufficiently long that the curvature of the tunnel terminates the need for a liner. The soil activation near the primary collimators for low energy operations is not an issue.

Removable soil samples are presently used to monitor the potential exposure of the soil near the collimators. This practice will continue during the future low energy operations.

It should be noted that the issues of residual activation near the collimators or the energy deposition in the collimator are not addressed here.

Note

The Nov. 20 update corrected minor typos, and 2 numerical errors in the table and added injection losses to the estimate on the collimators.

References

1. A.J. Stevens, "Radiation Safety Considerations Near Collimators", AD/RHIC/RD-113, April 1997.
2. D. Beavis, "Extending Routine Operations of RHIC and AtR to Low Energies", August 28, 2009.
3. T. Satogata, "RHIC Low Energy Beam Loss Projections", August 25, 2005.
4. https://sbms.bnl.gov/sbmsearch/subjarea/40/1r09e011.pdf

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