Collider-Accelerator Department

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Memo

date: *March 10, 2014*

to: *RSC*

from: *D. Beavis*

subject: *Radiological Issues of Orbit Bumps for Blue and Yellow Kicker Pre-fires*

The plan to prevent most of the beam that would aperture near experiments during a kicker pre-fire has been changed[1]. The current plan is to place an orbit bump in the middle of the IR10 to IR12 arc for the blue beam. In the event of a blue abort kicker pre-fire the beam will scape near the 11B alcove. An orbit bump in the yellow beam will be placed in the middle of the arc between IR10 and IR8. The total amount of beam lost in the region of the orbit bump is expected to be 10-20% of the beam in the ring with the kicker pre-fire. A typical fill will have less than $2*10^{11}$ Au ions or less than $4*10^{13}$ nucleon equivalents.

A local loss limit of $5*10^{13}$ 100 GeV nucleon equivalents should be used unless additional review occurs. This should be sufficient to cover the numbers of kicker pre-fires in each ring anticipated in a year of operations.

Issues:

Residual activity→ not expected to be an issue and can be examined by radiation surveys. **On a ring opening after a pre-fire the area should have an RCT conduct a survey, if there is access into the region of the arc near the orbit bump location.**

Air activation→ not considered to be an issue. (no explicit calculation done)

Soil activation(ground water)→ A local loss of $5*10^{13}$ nucleon equivalents at 100 GeV would correspond to the BNL action limit for tritium if the beam fault occurs at a specific spot. It is assumed that the soil is six feet from the beam. If the beam is sprayed over a 10 meter section[2] of the arc then 10^{14} nucleon equivalents could be lost. **(ATS-RHIC-Beavis-Drees-2014).**

Dose on berm→ Using the analysis for MCIs[3] the dose would be less than 12 mrem kicker pre-fire. TLDs will be located on the berm along the beam direction, on the ventilation shaft, and at

[1] http://www.c-ad.bnl.gov/esfd/RSC/Memos/Scraping_1_17_14.pdf
[2] Private communication from C. Montag to D. Beavis; 10 meters is probably an appropriate distance for the beam to smear on the magnet.
[3] http://www.c-ad.bnl.gov/esfd/RSC/Memos/RHIC_berm_052312.pdf

the exit of the labyrinth. The LP for RHIC will monitor the amount of beam lost in the two orbit bumps and the TLD results will be normalized to provide a measurement of the berm shielding (effectively a passive fault study). **(ATS-RHIC-July 2014_Beavis and Drees)**

Penetrations→ The penetrations of the berm have been evaluated for $2.5*10^{13}$ protons at 250 GeV relating to a potential MCI, which would correspond to $6.25*10^{13}$nucleon equivalents at 100 GeV. A single kicker pre-fire loss would be equivalent to a 6-12% MCI event. This would result in a potential dose[4] out the vent of 10-30 mrem per pre-fire event. The dose out the labyrinth[5] would be much smaller.

The examination of the emergency ventilation shaft revealed[6] that there may be a small solid angle of radiation that has lower than normal soil shielding. The soil thickness is 2.04 meters with a distance of 10.2 meters. Comparing to the shorter distance and thicker soil for the typical berm it is expected that the dose could be a factor of 10 times higher or 1100 mrem in an MCI. However, it is likely that the source is longer than this weak spot resulting in a reduction of potential dose and the angles that challenge the weal location have to be close to 90 degrees to the beam which would give an additional reduction. It would be anticipated that these reductions would cause at least a factor of 3 decrease in the potential dose. For 100 GeV Au we also have a factor of two reduction due to the energy per nucleon and less stored beam. It is recommended that the machine be allowed to have an orbit bump but more careful analysis be completed before next year. The work permit system and limited access for work near weak areas on the RHIC berm will be emphasized to appropriate personnel overseeing work at RHIC. **ATS-RHIC-Sept.1, 2014-(Beavis& Yip)**

Muons→ The muons generated in the beam interactions inside the magnets will not be aimed at the muon lobes. A calculation has been done to estimate the dose due to muons that exit out the berm. The muons will not set the limit on allowed losses. The calculation will be presented in another note.

Skyshine→ The following was done to provide a rough estimate for skyshine at the site boundary. The skyshine calculations for the beam dumps[7] were examined and the formula used. The formula requires an estimate for the total number of neutrons emerging from the berm with energy greater than 20 MeV. The z-distribution of neutrons emerging through a typical berm section was presented in the calculations[8] for increasing the proton intensity. It will be assumed that an average of $4.5*10^{-8}$ n/cm^2 per lost proton emerge over an area of 8 meters long by 4 meters wide. Scaling for energy, and using 130 meters to the site boundary[9], and assuming all

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[4] http://www.c-ad.bnl.gov/esfd/RSC/Memos/RHIC_low_E_ducts.pdf; A factor of 1/1.5 has been used to reduce the neutron weighting factor used in the report.
[5] See http://www.c-ad.bnl.gov/esfd/RSC/Memos/RHIC_labys.pdf
[6] See drawing A3001B0603 sheet 3 of 6.
[7] http://www.c-ad.bnl.gov/esfd/RSC/Memos/RHIC_dump_082310.pdf, The formula was divided by 1.5 to remove some of the conservatism introduced by using a factor of 2 for the neutron dose. The blue value is lower and the two locations are far apart so there is no superposition of dose. $5*10^{13}$ nucleons at 100 GeV were used.
[8] http://www.c-ad.bnl.gov/esfd/RSC/Memos/RHIC_berm_052312.pdf
[9] This distance is for the yellow beam. For the blue beam the distance would be 150 meters.

the nucleons interact at a single location than a dose of 0.009 mrem/yr is estimated at the site boundary for the kicker pre-fire losses at the orbit bumps.

It is concluded that the pre-fire losses from the orbit bump will not create any radiation exposure or environmental issues.

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