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Memo

date: *February 16, 2012*

to: *RSC*

from: *D. Beavis*

subject: *High intensity Proton Transfers in the RHIC ARCs for APEX Studies in February*

The RSC has reviewed the issue of increasing the intensity limit on bunches of protons to RHIC. The limit is presently established as $2*10^{11}$ protons per transfer. The final upgrades for RHIC may require transfers up to $5*10^{11}$ protons. With this limit the road is allowed to be posted as an uncontrolled area.

It is proposed that for short tests, such as a one day test presently proposed for Feb. 22, that the road remain uncontrolled.

- **A TPL is recommended to ensure an operator is assigned to monitor transfer efficiency.**
- **Allow several pre-approved 24 hour windows for high intensity transfers.**
- **For routine operations at high transfer intensities additional reviews are required.**
- **An RSC check-off list will be generated for each high intensity transfer test.**

Justification

The dose history for Thompson road[2] has been discussed in previous meetings. The RSC has adopted[3,4] the use of 1.5 micro-rem per 10^{10} protons lost under Thompson Road. Protons are transferred in single bunches. The present limit is $2*10^{11}$ protons per bunch and the analysis here will assume $5*10^{11}$ protons per bunch which is the requested future limit.

A single bunch faulting under the road would produce 0.075 mrem in the dose distribution peak and 120 bunches would produce an exposure of 9 mrem. Chipmunks are sited on each side of the road for the X and Y arcs. The distance between the Y-arc chipmunks is 47 feet (14m) and the X-arc chipmunks are 74 feet (23m) apart. The radiation distribution on the surface for the big bends (X&Y arcs) was presented in Fig. 5 or reference 5. The loss location with the least sensitivity is determined by the fault occurring at a location between the chipmunks where both detect equal dose. For the Y-arc this occurs when the fault is located 1 meter downstream of the first chipmunk. The two chipmunks would register 5% of the peak dose. Neglecting details of the time response of the chipmunk and assuming 4 seconds between bunches then one would get that

the chipmunks would register 3.4 mrem/hr and interlock almost immediately, for the $5*10^{11}$ limit per bunch. The present alarm limit of 1 mrem/hr would alert operators to beam faults at the location where the chipmunks are least sensitive.

The increased distance between chipmunks over the X-arc makes the detection of a fault less likely for a few meters of transport under the road. Using the same analysis the chipmunks would register .32% of the dose at the peak of the distribution. The chipmunks would register 0.22 mrem/hr. A small section of beam transport under Thompson road about 3-4 meters in length may not create alarms.

Losses in the X and Y arcs are maintained below a threshold limit by an active alarm process[6] with C-AD OPM 2.5.2.1. An alarm is generated[7] at a loss threshold of 50% of $3.3*10^{13}$ protons lost in the arc. Usually the losses are near the RHIC injection magnet and not near Thompson Road. At 90% the procedure requires[8] that the operators stop injection until the hourly average drops sufficiently. The maximum dose for the 90% alarm limit would be equivalent to 60 bunches of $5*10^{11}$ protons corresponding to a maximum dose of 4.5 mrem. The alarm limit would correspond to a maximum dose of 2.5 mrem.

OPM 2.5.2.1 uses the same loss limits and loss percentages for the RHIC ring and the injection arcs. In the future it may be possible to use different limits for the different regions. For this run it will be assumed that the procedure and its support software are unchanged.

To remove the potential weakness in the arc protection for high intensity transfers it is recommended that a temporary procedure be established which requires an operator to monitor the transfer efficiency and ensure that losses under Thompson Road are kept to a minimum. The BLMs (Beam Loss Monitors) in the X and Y arcs should be able to provide additional information in addition to the current transformers.

It is suggested that the TPL be allowed to be used for pre-approved one day intervals. This allows operations to use high intensity transfers several times if required for machine operations and advancement.

The magnets that are under Thompson Road in the X-arc are XD9, XD10, XD11, XD12, and XD13. The magnets under Thompson Road in the Y-arc are YD6, YD7, and YD8.

The B15 dual current transformers prevent large pulses from being accelerated and extracted past the 20-degree bend in the transfer line. It may be possible for one large pulse to get through the system and be transported to the area under Thompson Road. This is expected to be unlikely but worthwhile to examine the size of the potential fault. The largest amount of beam accelerated in one pulse is about $1*10^{13}$ protons. One such bunch could create 1.5 mrem of dose at the peak of a radiation distribution.

The dose history registered by the chipmunks and the monitor TLD has been reviewed in the past and shown that the area is essentially at background levels. There is no evidence of beam losses creating dose to people on Thompson Road.

For the long term routine operations methods to use BLMs or the equivalent on the tunnel roof are being investigated. If possible a set of special BLMs would be created that have thresholds appropriate to terminate beam operations above a level that would increase dose rates exterior to the shielding. These would be calibrated yearly and configuration controlled as part of the Access Control System (ACS).

References

1. RSC Minutes of June 14, 2011; http://www.c-ad.bnl.gov/esfd/RSC/Minutes/6_14_11_Minutes.pdf
2. RSC Minutes of Nov. 20, 2008; http://www.c-ad.bnl.gov/esfd/RSC/Minutes/Nov_20_08Minutes.pdf
3. Fault studies 28 for Au and Fault Study 30 for protons; N. Tsoupas, Oct. 20, 2000, " Results from beam-Fault Studies performed along the Y-Arc of the AtR Using Polarized Proton Beam,"
4. The 1.5 micro-rem was recommended by a sub-committee; J.W. Glenn and A.J. Stevens, " Recommended Design Value for Fault Conditions at Thompson Road",
5. A.J. Stevens, "Analysis of Radiation Levels Associated with Operation of the RHIC Transfer Line", AD/RHIC/RD-83, Dec. 1994;"
6. C-AD OPM 2.5.2.1, "procedure to Monitor the Intensity Limit Portion of the RHIC ASE",; http://www.c-ad.bnl.gov/ESSHQ/SND/OPM/Ch02/02-05-02-01.PDF
7. See section 5.3.2 of OPM 2.5.2.1 .
8. See section 5.3.2.2 of OPM 2.5.2.1 .