Subject: CeCPoP and LEReC Radiation Measurements and 2 GHz Cavity Reach-backs


The meeting was called to discuss the radiation measurements conducted at IR2 for CeCPoP and LEReC. A brief discussion occurred on the reach-back for 2.1 GHz cavity.

A brief presentation in Powerpoint was presented\(^1\) to the committee regarding the issues.

**Radiation Measurements**

A group of chipmunks have been placed at IR2 to characterize the x-ray sources from x-ray devices and beam loss. These devices have been located to determine the magnitude of the x-ray generation from devices being conditioned; measured radiation levels from cavities are typically much lower than predicted by using the power and energy limits of the power supply. This was not the topic at this meeting but should be used to allow de-rating factors for the potential dose from the x-ray devices. Chipmunks were located to also determine the dose rate challenging penetrations and provide a measurement of the attenuation of the penetration or shielding.

The labyrinth attenuation was measured using chipmunk MN265 and MN324. MN265 is a required configuration chipmunk for IR2. Originally it was located inside the BRAHMS fast electronics hut (FEH). When the FEH was relocated to IR4 the chipmunk was placed in a location outside but closer to the shield wall. The placement of this chipmunk was to monitor potential dose to personnel inside the FEH. No dose was ever detected at the locations outside the shield wall. There are no specific weaknesses to the shielding in this area for RHIC operations that this chipmunk would have been sensitive to. The RSC approved the relocation\(^2\) of NM265 to the end of the 2GE1 labyrinth in Sept. 2016 to detect both neutrons (RHIC) and photons (CeCPoP and LEReC) with a quality factor of 2.5.

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\(^1\) D. Beavis, Sept. 14, 2014; [http://www.c-ad.bnl.gov/esfd/RSC/Minutes/References/CeCPoP and LEReC.pptx](http://www.c-ad.bnl.gov/esfd/RSC/Minutes/References/CeCPoP and LEReC.pptx)

NM324 is not a required chipmunk but was located near the LEReC dipole to bend beam to the gun diagnostic dump. It was relocated near the roll-up door to measure the radiation directed towards the 2GE1 labyrinth. As the attenuation of the labyrinth has been measured it is likely that this device will be relocated or removed.

The determination of the Labyrinth attenuation is discussed in a memorandum\(^3\) that has been distributed to the committee. The Labyrinth attenuation was measured as \(3.8 \times 10^{-5}\) and predicted\(^4\) to be \(6 \times 10^{-5}\). There is agreement is good. The dose rate seen on the chipmunks was predicted to be 16 rad/hr and was measured as 11 rad/hr. The actual dose rate for the source term was in good agreement with predictions which should add confidence for the estimated dose rates that were calculated for the IR penetrations.

A shielding wall shadows the new and old penetrations on the inside of the IR as seen in the figure below. The outer shield wall was modified to accommodate the RF waveguides (through old cableway), co-axial cable (New drilled penetration), and a laser port (new drilled port). The outer shield wall is the same thickness of light concrete as previous but is wider and taller. The inner shield wall is thicker than the original design that the calculations were conducted for (now 60 cm of heavy concrete inside of 45 cm of heavy concrete).

Two chipmunks were used to measure radiation near the penetrations and shadow shield. MN320 is located on the top of the shadow wall on the edge closest to the RHIC beam line to avoid being shadowed by the shield wall itself. NM268 is located near the cable way penetration. The ratio of the two chipmunks was \(1.4 \times 10^{-3}\). The reduction in radiation is

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\(^3\) D. Beavis, Updated Sept. 1, 2017; [http://www.c-ad.bnl.gov/esfd/RSC/Memos/06_30_17_CeC.pdf](http://www.c-ad.bnl.gov/esfd/RSC/Memos/06_30_17_CeC.pdf)

\(^4\) D. Beavis, August 26, 2016; [http://www.c-ad.bnl.gov/esfd/RSC/Memos/8_26_16_LEReC.pdf](http://www.c-ad.bnl.gov/esfd/RSC/Memos/8_26_16_LEReC.pdf); The dose rate must be adjusted for the fact it is not at the gate and the quality factor.
attributed to x-rays scattering off the main shielding wall and ceiling and not penetrating through the shadow wall. The radiation expected from shielding albedo was of the order $1 \times 10^{-4}$. The expected radiation levels out of the penetration should be lower that the calculations conducted for the initial design. It is concluded that the design is sufficient.

Surveys were conducted for routine operations to the high power beam dump for 14.1 MeV beam with beam powers of 60 and 160 Watts. Only the minimum detectable level of 0.01 mrad/hr was measured at the penetrations. Scaling to 8kW would imply that operations at 8kW would produce less than 0.5 mrad/hr. Details are given in Footnote 3.

CeCPoP beam losses were conducted for the gun beam before the 704 MHz cavity. The radiation appeared non-existent or very low for the 0.5 micro-amperes of 1 MeV beam on the profile monitors. I. Pinayev checked that the profile monitors were in the beam. It was noted during the discussion that the most likely explanation was that the solenoids were providing local shielding. They have a thickness of approximately four inches of copper, which would provide two orders of magnitude in dose reduction if shadowing the detectors. This would be sufficient to reduce the radiation to levels from the beam loss such that it could not be detected from the other sources of radiation in the IR.

Measurements conducted with the LEReC beam at 0.3 MeV are discussed in two memorandums. The first was to ensure the numbers were sufficiently understood to approve increasing the gun beam from 1 mA to 10 mA. The second examined the radiation for 10 mA of 0.3 MeV beam. Where possible the results from CeCPoP and LEReC were compared and found to be in agreement. The absolute dose rates were in agreement with the used source terms.

The conclusion of these studies is that the shielding should be sufficient for full CeCPoP operations and LEReC gun operation to full energy and power. However, until the LEReC is approved for operations to the high power dump there is no location to dump high power beam without damaging the machine. There are no radiation protection issues to limit the LEReC gun current. The table below summarizes some of the estimates for radiation out of penetrations for the various machines.

The data for the shield wall is sufficient that the chipmunk behind the wall, NM268, could be used for other purposes. It may get moved to monitor the x-ray levels from the LEReC booster cavity. The chipmunk on the shield wall, NM320, will remain for monitoring the radiation levels from the electron machines. An alarm level could be established for NM320 to provide alarms concurrent with RHIC operations. If the alarm level can be set high enough RHIC losses would not generate an alarm. The highest alarm level for

5 The Power point file has $9 \times 10^{-4}$ but the calculations are not conducted with sufficient precision to be better than a factor of 2 or more. The measured radiation was essentially the amount predicted for 45 cm of heavy concrete but with the change in design the radiation penetrating the shield wall should be a factor of 10 lower. See the discussion in footnote 3.
6 D. Beavis, August 8, 2017; http://www.c-ad.bnl.gov/esfd/RSC/Memos/08_08_17_LEReC.pdf
8 Copied from Footnote 4.
chipmunks is 998. After the meeting the RSCC requested the chipmunk software be modified to have 9999 represent no alarm status. This will allow chipmunks used inside the machine enclosures to alarm at a much higher dose rate.

The chipmunk at the B-alcove barrier is the closest location in the tunnel that personnel can approach the LEReC and CeCPoP. As a precaution for initial commissioning without RHIC beam the chipmunk will have an alarm level of 1 mrad/hr. This may need to be modified or set to no-alarm with RHIC beam present.

The committee was comfortable with the results from the radiation measurements. The radiation measurements will also be examined by the IRR for LEReC. This will provide an “independent” review of the conclusions.

The committee is comfortable with using exemptions to start early development work of these new accelerators or accelerator modification until an IRR and/or ARR can be performed. The committee is ready to assist the Department in supporting such staged approaches. However, the committee is not as committed as the RSCC that some of these reviews are unnecessary and that the system does not take into account situations such as occurring at IR2.

Any suggestions for improvement for the exemption request for LEReC conditioning and gun testing in the Fall, prior to the IRR in December, should be sent to E. Lessard, A. Fedotov, and the RSCC.

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9 999 in the database signifies no alarm status. The software does not allow levels above this value.
10 This modification has been completed. This is a mode of use that was not envisioned for the chipmunks when the software was developed decades ago.
Reach-back for 2.1 GHz

Several members expressed reservations on the removal of the reach-back on the 2.1 GHz interlocks. This is the only RF system where the removal of reach-backs is being considered. The members expressed concerns about reducing safety for undocumented issues of potential device performance. It was expressed that the appropriate approach would be to choose a switch that did not provide an impedance mismatch. It was expressed that such switches should be available to remove possible signal degradation. Therefore, without additional information the reach-back will remain in the system. Future reconsideration may occur if preferred by the RF group.

Reach-back for 2.1 GHz Cavity will remain in the ACS.

An RSC meeting will be scheduled in early October to review the calculations that have been conducted for the portions of LEReC in the tunnel. There are few issues related to radiation safety and most of LEReC is under an area which is excluded of personnel when RHIC or the electron machines are operated.

CC:
Present
RSC
RSC Minutes File
A. Drees