Subject: Booster Trench, LEReC Penetrations, and CeC


Several items were presented to the committee. A Powerpoint presentation\(^1\) by D. Beavis provided a framework for the discussion.

Booster Trench

Sandbags were removed from the booster trench that runs under a portion of the access labyrinth from building 914 to the Booster enclosure. The issues have been discussed in a memo\(^2\) by D. Beavis. The committee found that the removal was appropriate. There are sandbags still in the bottom portion of the trench as the removal team found them difficult to remove and they were not in the way of pending work. The committee felt that the plug door chipmunk was placed in the most sensitive location at the time the fault studies were conducted.

The committee does NOT recommend moving the plug door chipmunk.

The committee recommends that when protons of intensity of 10\(^{12}\) or higher are transferred to the AGS that a simple fault study be conducted similar to one of the Booster fault studies conducted in the past. This will provide a relative measure of the trench to the gates and the plug door chipmunk. (CK-protons-Booster-Gardner&Beavis-957)

The effort to place a chipmunk with scaler readout in the labyrinth should be determined and then the RSC can decide whether the effort is worthwhile. (CK-protons-Booster-Minty&Beavis-958)

The trench should be inspected to ensure that with the sandbags removed that a small person could not violate the perimeter of the Booster. If it is possible to get into the Booster enclosure than a barrier with posting needs to be installed in the trench. (CK-protons-Booster-Mahler&Gardner-959) closed on 10/22/15-no possible access through the trench.

LEReC Penetrations

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\(^1\) D. Beavis, Oct. 16, 1015 Powerpoint file; Meeting Minutes 10/16/2015
There are 4 16 inch-diameter pipes planned for installation through the berm to allow utilities to be routed from outside to the LEReC devices in the tunnel. A discussion of the radiation sources and potential dose outside the penetrations on the berm were analyzed in a memo\(^3\) by D. Beavis. These pipes exit the berm inside a locked-fenced area, which is swept and secured for RHIC beam operation, operation of the RGDs, and electron beam inside the two O’clock intersection region (IR2).

Due to a change of the installation technique the four pipes have been moved relative to the positions discussed in footnote 3. The pipes have moved north into the twenty foot tunnel. This means that the potential sources in IR2 create lower exit dose from the penetrations but some LEReC sources inside the twenty foot diameter tunnel will have increased exit dose. The sources that will increase have been estimated. Table 1 lists the sources and the estimated dose rate (dose) out the exit of the pipe. The area is classified as a Controlled Area which requires that dose rates not exceed 5 mrad/hr. The ground outside the penetration and before the fence will be prepared to support shielding, if needed. The reduction of dose from dispersion to the fence boundary has not be calculated. Due to limited space inside the tunnel it is desired to limit the shielding in the tunnel. The dose rates (dose) do not include self shielding or reduction due to materials in the pipes.

Table 1: Source Locations and Potential Exit Dose from the Planned LEReC Penetrations

<table>
<thead>
<tr>
<th>Source Location</th>
<th>Old design (dose)</th>
<th>New Design (dose)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHIC Q2</td>
<td>5 mrem</td>
<td>80 mrem</td>
</tr>
<tr>
<td>LEReC dump</td>
<td>2 mrads/hr</td>
<td>11 mrads/hr</td>
</tr>
<tr>
<td>1% routine loss</td>
<td>2 mrads/hr</td>
<td>19 mrads/hr</td>
</tr>
<tr>
<td>LEReC gun</td>
<td>Lower than tuning dump</td>
<td>Lower still</td>
</tr>
<tr>
<td>LEReC tuning dump (60kW)</td>
<td>125 mrads/hr</td>
<td>lower</td>
</tr>
<tr>
<td>CeCPOp dump</td>
<td>130 mrads/hr (n=1.5 mrem/hr)</td>
<td>lower</td>
</tr>
<tr>
<td>CeCPOp 1% loss at 22 MeV</td>
<td>1.3 mrads or less</td>
<td>lower</td>
</tr>
</tbody>
</table>

The Q2 fault dose in a Maximum Credible Incident that is below the original RHIC design criteria for uncontrolled areas. The area outside the fence is a Controlled Area when RHIC is operating. It was noted for RHIC beam losses these penetrations are similar to the ones that were installed for PHOBOS at 10 O’clock years ago.

The routine dose rates from the two electron machines appear to have potential dose rates above 5 mrads/hr. However, it is expected that with the pipes being approximately 50% full, that the dose rates will be substantially smaller. Several of the larger dose rates are due to routine full power operations to beam dumps. It is suggested that the dose rates out the penetrations could be measured during low power testing or early in the machine commissioning phase of the electron machines and avoid adding shielding inside the fence.

\(^3\) D. Beavis, Oct. 9, 2015; [http://www.c-ad.bnl.gov/esfd/RSC/Memos/10_09_15_LEReC.pdf](http://www.c-ad.bnl.gov/esfd/RSC/Memos/10_09_15_LEReC.pdf)
Measure radiation leakage from penetrations during early operations of CeC and determine if changes in posting and shielding are required. (CK-electrons-CeCPoP-Pinayev&Bergh-960)

Measure radiation leakage from penetrations during early operations of LEReC and determine if changes to shielding and posting are required. (CK-electrons-LEReC-Fedotov&Bergh-961)

Place monitor TLD on fence adjacent to the exit of the penetrations(CK-electrons-RHIC-Bergh&Beavis-962)
This will be done at RHIC startup before either electron machine is operational.

The analysis of the penetrations will be updated when the as-built drawings are available. (CK-electrons-RHIC-Phillips&Beavis-963)

The committee recommends that shielding be avoided unless the effort is relatively small. The shielding, if placed, should be inside the fence but other options will be considered.

CeCPoP

The review of the CeCPoP low power beam dump analysis was completed by R. Karol and C. Schaefer. A few arithmetic errors were found but the conclusions remain the same. The report will be updated. (CK-electrons-CeCPoP-Beavis-964)

Losses in the beam line to the first bending magnet or the low power dump can cause photons to travel substantially down the tunnel. It was recommend that shielding be place downstream of the low power dump to shield the forward direction from losses in the transport. (CK-electrons-CeCPoP-phillips&Beavis-965)

Chipmunks were used last year to measure the x-rays from the gun and cavities. These measurements help the project protect the machine while they develop their machine protection instrumentation and provide area dose rates inside the IR2. The gun (1.3 MV) measurements when scaled for distance are a few hundred rads/hr at a foot during conditioning. The warm-buncher cavities with their lower voltage (300kV) were tens of rads/hr at a foot but under 50 rads/hr at a foot. Both have dual interlocks and the committee thought it was prudent to leave the buncher cavities with dual interlocks.

A cable pulling crew is working at the IR. It is a good time to determine the number of chipmunks that the Project and RSC would like in the IR for 2016 operations. The following list was developed:

1. Keep the one near the gun.
2. Remove the one for the buncher cavities (After the meeting it was decided that this chipmunk would remain. If not used for the warm cavities it can be used to characterize the radiation inside the IR.
3. Place one near the linac.
4. Place one along the outside wall across from the low power beam dump with extra cable so dose rates can be measured from the dump and at penetrations in the shielding wall.
5. Place one on the inside wall near the dump with sufficient cable to be moved to the labyrinth.
6. Place a second one at the dump with extra cable for measurements including into the labyrinth.

A total of six chipmunks are desired inside the IR with computer read out. None of these chipmunks will be will be interlocking. The RSC Chair will work with the instrumentation group to determine the locations.  

(CK-electrons-CeCPoP-Minty&Beavis-966)

I. Pinayev noted that they would routinely do tuning and use destructive instrumentation with beam up to 5 micro-amps. This is 110 watts at 22 MeV. This is a somewhat larger than the 1% of 8500W used for evaluating the shielding penetrations. The numbers can be adjusted in the future. The 110W of 22 MeV beam will be the maximum expected routine loss in the IR except for the water cooled beam dump. The experiment does not expect to operate for more than 100 hours of full power into the water cooled beam dump during a four day test. Small amount of beam will be delivered when RHIC operations allow windows for development. The Project needs to provide an estimate of the total beam used in the IR so that external radiation and environmental issues can be addressed. These issues typically deal with integrated beam rather than just instantaneous. (CK-electrons-CeCPoP-Pinayev&Beavis-967)

The Project needs to provide an overview of commissioning effort to the RSC along with issues related to credible beam faults, locations of beam destructive instrumentation, and under what conditions the beam will be allowed into the RHIC transport. There will be no intentional electron ion collisions but if they are possible then the risk needs to be understood as a fault condition. This can be avoided if electrons are not allowed in the RHIC transport with blue beam. The energy range of the yellow beam relative to the electron beam needs to be addressed. The Project will need to explain restrictions on the beam parameters and how the limitations are maintained.

Presently low power testing plans and high power commissioning plans are being developed. Radiation measurements and beam fault studies should be part of this planning. (CK-electrons-CeCPoP-Pinayev-968)

The Project has examined the issue of electron capture by co-moving ions.

The displacement of the RHIC beam by the LEReC 45 degree dipole is small. The dipoles are in pairs to keep the ion beam parallel to the beam axis. If one magnet shorts and the other is operating the beam is displaced about 3 mm on the other side of the IR. If there is a turn to turn short the ion beam displacement would be substantially smaller. Failure of the CeCPoP magnets common with the RHIC transport are only expected to cause beam losses issues in the IR for the electron beam.

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4 Powerpoint presentation by A. Fedotov, June 18, 2008
5 I. Pinayev, Electron Capture Calculations for CeC Experiment, June 5, 2014
There was a discussion on whether a full magnet short was credible. Typically a complete short causes a fire due to the resistance at the point of contact causing the short. The committee did not decide on whether to consider full magnet shorts as credible. Therefore, analysis of a single magnet dropping out needs to be considered in the fault analysis. More common are turn to turn shorts which cause a partial decrease in a magnets bending power. These shorts would most likely cause a distributed scraping loss downstream of the element with the short. A complete short would create a localized loss. For the electron beam a decreased bend at the first dipole causes or towards the tunnel. Beam aimed at the back wall will be a machine protection issue provided the shielding is sufficient for faults of the full beam. The second bend being too small or zero will again cause the beam to be aimed at the back wall and only be a machine protection issue. The last electron dipole under bending will send the beam down into the tunnel. This could be an issue for the penetrations in the tunnel.

Examine the penetrations for under bending last dipole, beam aimed down the tunnel from the first dipole, and that the shielding policy is met for full beam fault in the IR. (CK-electrons-CeCPoP-Pinayev&beavis-969)

The committee recommended that shielding blocks should be placed in the forward direction to reduce air activation and the amount of radiation potentially sent down the tunnel. (CK-electrons-CeCPoP-Phillips&Beavis-970)

The possibility of reverse polarity was discussed for the dipoles. The power supply is unipolar but leads anywhere along the magnet train could be reversed. The first dipole in reverse polarity could aim the bremsstrahlung cone towards the labyrinth. Either a calculation needs to be conducted or a shield block installed near the first dipole. (CK-electrons-CeCPoP-Phillips&Beavis-971)

The committee recommends that the Department develops a standard procedure that involves polarity checks of appropriate dipoles after installation or cable removal. The procedure may include checking by low power beam transmission rather than tests of the field direction. (CK-electrons-CeCPoP-Phillips&Hammonds-972)

The accelerator division has considered the issue of the RHIC beam hitting the apertures in the IR2 area. They have advised the committee chair that the appropriate beam loss to use for an MCI is 50% of one beam. This is the value used in previous analysis so no additional calculations are necessary.

The committee noted to the Project that systems such as the undulators with permanent magnets are not tolerance of large radiation doses. The Project is aware of these issues and considering ways to protect the undulators.

A series of questions were answered6 by the Project and all may not have been discussed in the meeting. The entire list may not have been discussed during the meeting. Members should read footnote 6.

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6 See e-mail from I. Pinayev to D. Beavis; First Set of Answers[pdf]
CC:
  Present
  RSC
  RSC Minutes File
  A. Fedotov
  V. Litvinenko