C-AD

Radiation

Safety

Committee

Issued: September 18, 2015

Minutes of RSC Subcommittee of September 16, 2015

Subject: Deuterons from EBIS and CeCPoP Radiological Issues

Present: I. Pinayev, J. Tuozzolo, D. Beavis, R. Karol, R. Michnoff, M. Minty, J. Alessi, H. Kahnhauser, C. Naylor, C. Gardner, W. Fischer, and J. Reich

The committee was asked to review two distinct topics:

1. Final configuration for operation of deuteron beam from EBIS.
2. Unreviewed Issues related to the Final Configuration of CeCPoP at IR2 of RHIC

Deuteron Beams from EBIS

C-AD is requesting Management and DOE remove the restriction on deuteron beams from EBIS. Faults studies were recently conducted to provide information on determining the final configuration. J. Alessi conducted the fault studies[1] and a provided a written summary[2] of the results. A brief Powerpoint presentation[3] covered the dose rates for intrusive instrumentation and beam faults, along with suggested recommendations. The worst case beam fault at full intensity and assuming a "quality factor" of 20 is 240 mrem/hr. Routine levels are much lower but the use of intrusive instrumentation could create potential exposure of greater than 5 mrem in an hour.

There is potential exposure in the Booster enclosure whenre the EBIS beam is injected with similar levels expected as measured for the EBIS area.

D. Beavis proposed[4] several modifications that would be done for deuteron operations. These are:

1.The area within 5 feet of the beam transport be posted as a Radiation Area for deuteron operation. **This was recommended by the committee.** The area on the service isle side will be the only area that requires posting. The other side of the EBIS transport has the building wall. The posted area will run from the EBIS Linac to the end of the transport. The posting will be checked as part of a deuteron RSC check-off list. Otherwise the area will remain a Controlled Area- TLD required. **(Ck-EBIS-deuterium-P. Bergh& J. Alessi-946)**

[1] C-AD FS 242 logbook II page 37-45.

[2] J. Alessi, " Summary of Fault Study 242 (Deuterium beam from EBIS", July 24, 2015; http://www.c-ad.bnl.gov/esfd/RSC/Memos/7_24_15_EBIS.pdf

[3] D. Beavis, PowerPoint file, "Deuterons from EBIS"

[4] D. Beavis; http://www.c-ad.bnl.gov/esfd/RSC/Memos/9_11_15_EBIS.pdf

2.Place the chipmunks into the monitor system with an appropriate alarm level but do not interlock. **This was recommended by the committee.** This work is in progress. There are three chipmunks distributed along the transport located at the EBIS Linac, near the buncher cavity, and near the beam stop. These chipmunks will be checked on the EBIS check-off list. **(Ck-EBIS-all-J. Alessi& D. Beavis-947)**

3.Post the entrance of the Booster that there can be elevated levels near the beam pipe due to deuteron injection from EBIS. **This was rejected by the committee.** The committee did not think this was as helpful and as clear as it could be. **Instead the committee recommended that the area along the injection line in the Booster enclosure will be posted at a five foot offset like the EBIS transport in the Linac service building.** Routine operations would have the beam terminate in the Faraday cup and produce a dose rate of 7 mrem/hr at a foot for full deuteron current. The demarcation at five feet is to provide a factor of 25 reduction for potential beam faults. The Booster is a High Radiation Area so the demarcation only needs to provide a warning that there may be radiation from EBIS injection and to contact MCR. The committee did not discuss whether to require a work permit to work inside the designated area in the Booster or near the EBIS transport in the Linac service building. **(Ck-EBIS-D-P. Bergh and J. Alessi-948)**

The committee also recommended that surveys be conducted for deuterons along the EBIS transport inside the Booster. (Ck-EBIS-D-P. Bergh and J. Alessi-949)

Before the meeting it was suggested by P. Bergh and H. Kahnhauser that the "quality factor" be measured to ensure that the correct factor is applied for these low energy neutrons. H. Kahnhauser will examine the procedure to measure the quality factor, FS-CAD-209, to determine if any assumptions used as a technical basis need to be revised. Even if EBIS does not operate with deuteron it is possible to conduct this measurement at the tandem. It is believed that the factors used in the analysis are conservative. **The committee recommended that such a quality factor measurement and procedural evaluation should be made. (Ck-EBIS-all-P. Bergh and J. Alessi-950)**

CeCPoP Radiation Issues

D. Beavis made a brief Powerpoint presentation[5] outlining the items that the committee needs to review over the next few weeks so that the analysis is documented and reviewed and ready to support the USI submission to the Laboratory Safety Committee for review and recommendation. Items to review include:

- Beam Operations scenarios for 2 and 22 MeV
- Beam fault scenarios
    - Electron beam at both energies
    - Ion beam in the IR with the new equipment
- Radiological issues for the Low power dump
- Radiological Issues for the water cooled dump
- Some plots of the CeCPoP at IR2 are shown at the end of the minutes to aid in understanding some of the discussion

[5] D. Beavis, PowerPoint File, "CeC Issues"

The low power beam dump has been evaluated[6] for a series of radiological issues for 1 Watt of beam at 2 and 22 MeV. These include beam dump heating, ozone production, air activation, soil activation, and residual activity. The results are well below any exposure or environmental limits. External shielding and penetrations were not evaluated. The report contains a description of the analysis and it was **recommended by the committee that two members carefully review the report.** This is important since the same methods will be used for the full power beam dump at 8500 W. R. Karol and C. Schaefer will conduct the review. **(Ck-CeCPoP-R. Karol & C. Schaefer-951)**

I. Pinayev noted that the expected mode of operations will be low power operations to the straight ahead beam dump (low power dump) with 0.1 W of 2 MeV beam and 1.0 W of 22 MeV beam. He expects that the beam size for 2 MeV will be 1mm. The thermal analysis was conducted for 3mm and 1 Watt. These two factors differences should compensate and the expected temperature in the window would be 56^{o} C. The area of the beam for 22 MeV is expected to be 10 times smaller and at 1 Watt the window could be as hot as 300^{o} C. This is based on the same energy deposition but over a smaller area. This is a machine protection issue since it the window fails the machine turns off and is potentially damaged. It is expected that when beam is transported to the low power beam dump the vacuum valve between the 2 MeV beam transport and RHIC vacuum will be closed. No exposure are ALARA issues are expected for such a failure.

The ASSRC has not reviewed the Machine Protection System (MPS) for CeCPoP operations. The RSC does not typically take credit for such systems except for short durations or small increments in radiation hazards. Typically the MPS provides defense-in-depth.

The Project does not intend to deflect the low energy beam (2 MeV) with the first dipole. The Project has not requested reviewing the transport of 2 MeV beam to the water cooled beam dump. However, except for possible over-bending by magnets the radiation hazards are higher for the 8500W 22 MeV beam. If the CeCPoP decides to bend the beam with the bending magnet then a short review will need to be conducted.

The committee chair has requested a written but brief operations scenario be provided to the RSC. This will be important for evaluating yearly issues, potential exposure for access, and also review by other committees. The present information is:

- as much low power running to the straight ahead beam dump as needed to tune the gun and Linac
- A total of 100 hours of full power running to the water cooled dump distributed over several short runs and one longer run
- A total of 50 hours of continuous operations in a dedicated full power run

A profile monitor exists in the beam transport that is common with the RHIC beam. **If this intrusive instrumentation moves off the out switches the beam permit shall be pulled. (Ck-CeCPoP-A. Drees & I. Pinavey-952)**

There are two bending magnets at each end of the straight section. One is intended to inject the electron beam onto the RHIC axis and at the other end to extract the electron beam. The other two magnets are intended to keep the RHIC beam on axis. The rigidity of the RHIC beam is more than a

[6] D. Beavis, " Radiation Issues related to the CeCPoP Low Power Beam Dump', Sept. 14, 2015; http://www.c-ad.bnl.gov/esfd/RSC/Memos/rsc%20memos/main%20pages/rsc_memos.htm

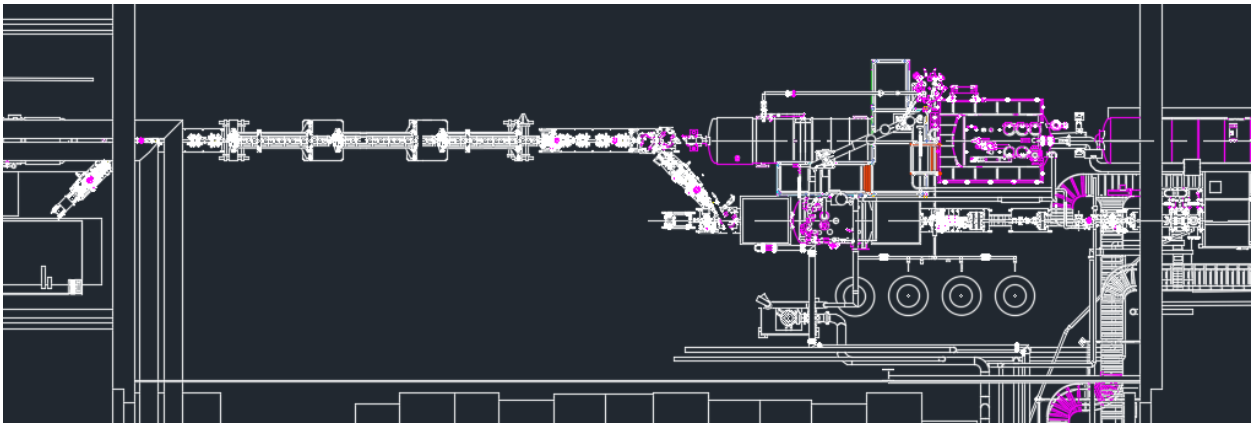
factor of 500 to 5000 that of the electron beam. The electron beam is bent 45^{o} which means the maximum kick to the RHIC beam is 0.09 degrees before being bent back on axis by the partner dipole. All five dipoles are operated in series and have the same bending power. If the Power supply drops off or changes current it does not appear to cause beam loss issues for RHIC.
It is intended that the power supply for these dipoles will be monitored by the MPS.

With the dipoles in series the most likely faults are a turn-to-turn short in one magnet or mistakenly placing a magnet in the wrong polarity by reversing the cables during installation or maintenance. The power supply in unipolar. This will be examined at the next meeting. **(Ck-CeCPoP-J. Tuozzolo&I. Pinavey-953)**

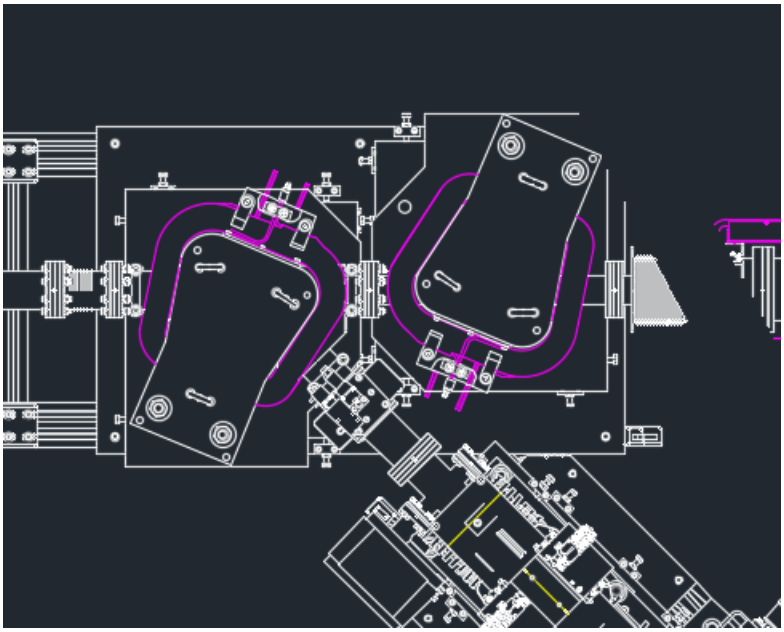
The committee needs the Accelerator Division to provide what they believe is the maximum credible beam loss that can occur at IR2 with this new equipment in place. Most of RHIC is evaluated with 50% of the beam in one ring lost at a single location. It may be that at this IR with the CeCPoP in place it could be 100% of both beams. The RSC needs to know what to use as a credible beam fault. **(Ck-CeCPoP-A. Drees & W. Fischer-954)**

Other items to review are: **(Ck-CeCPoP-D. Beavis-955)**

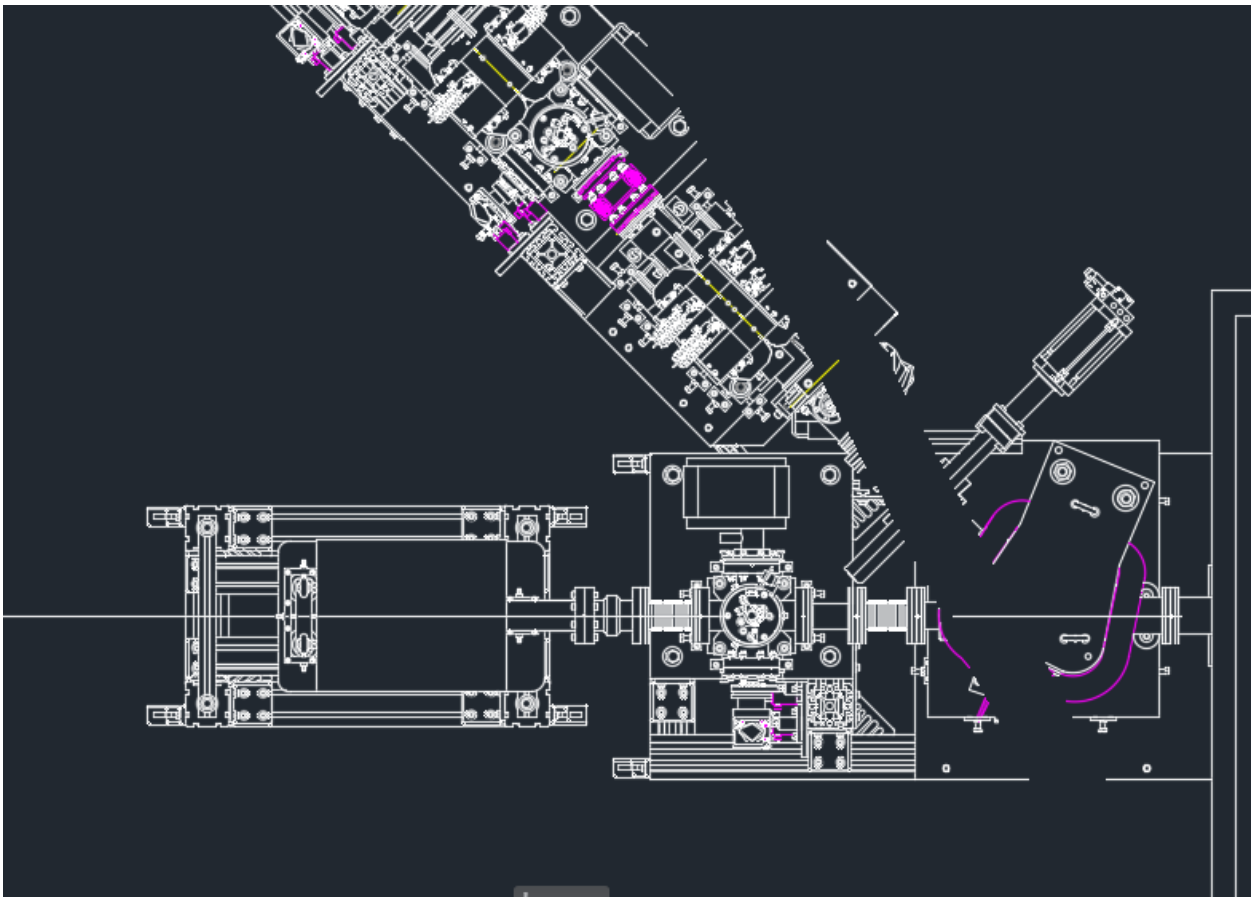
- *High Power beam dump*
- *Shielding and penetrations for 22 MeV losses*
- *Beam Faults*
- *Routine losses at 22 MeV*
- *Commissioning issues*



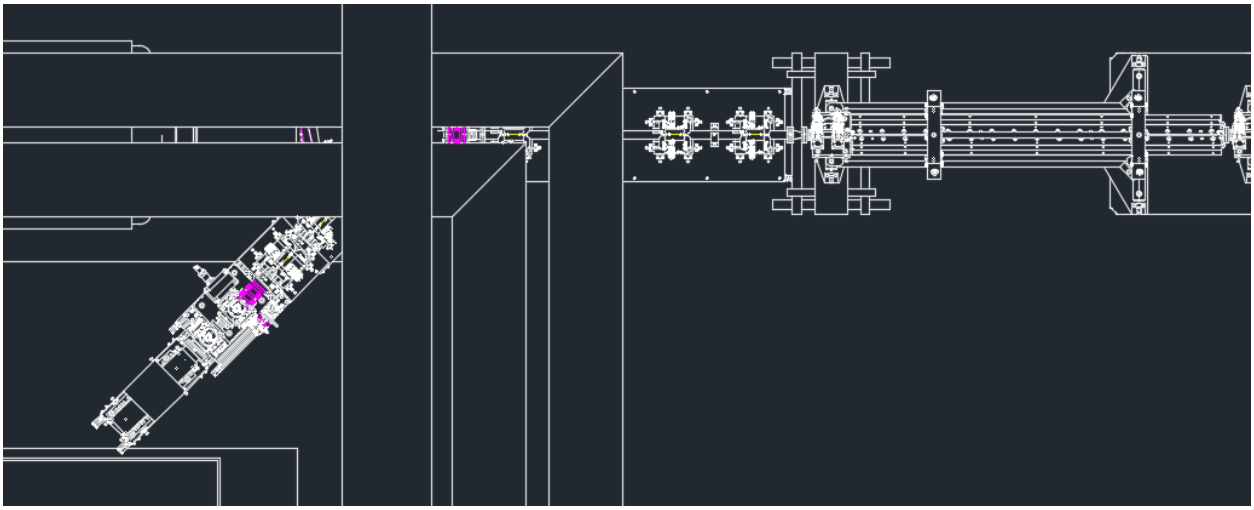
CeCPoP at IR2.



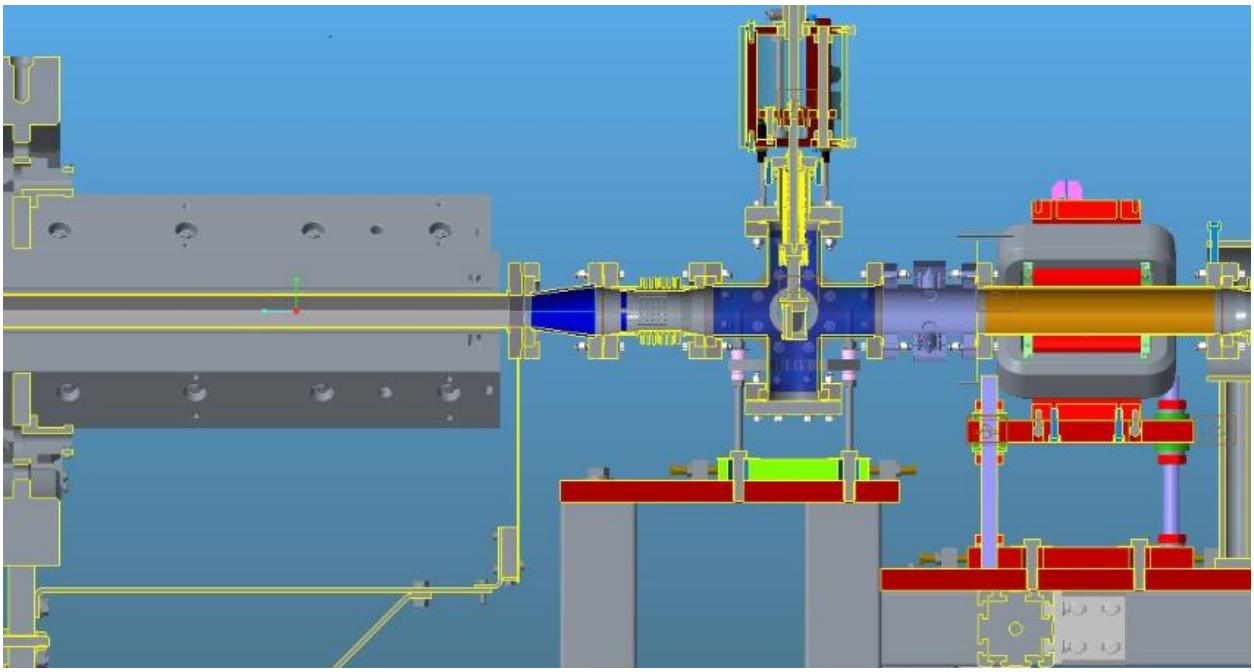
Electron Injection into RHIC and the pair of dipoles.



Low Power beam dump and first 45 degree bending magnet.



Extraction to the water cooled beam dump. Some items are obscured by overhead trays and pipes.



Decrease in aperture at the undulator is shown in side view.

CC:

Present
RSC
RSC Minutes File
W. Fischer
A. Drees