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Memo

date: *April 11, 2012, (UPDATED-April 25, 2012)*

to: *RSC*

from: *D. Beavis*

subject: *ERL Beam Dump Review*

The review of the design of the ERL beam dump and shield has been an open RSC checklist item[1] for ERL. The shield has been submitted for review. Several people have examined aspects of the electron beam dump. The beam dump is designed for 1MW of electrons at 3.5 MeV. This is the maximum beam energy for the electron gun. The ASE for ERL is written for 3.5 MeV and 1.5 MW although the beam dump is not expected to have more than 1 MW of beam.

Although the text of this review is written for 1 MW the results can be scaled to 1.5 MW, which is the ASE limit. The conclusions are that there will be no radiological issues related to the beam dump at the ASE limit. This conclusion will be confirmed by radiological surveys and air sampling.

External Dose Rates from the Beam Dump

The dose rates in areas adjacent to the ERL shielding have been estimated. Kin Yip[2] used MCNPX to estimate the dose rate at the east entrance gate and near 90 degrees at the closest location a person can stand. The dose rate near the power supply house was estimated to be $7.5*10^{-2}$ mrem/hr for 1 MW. The dose rate at the gate is 100 times lower. Analytic approximations were used[3] to estimate the dose rate near the concrete wall inside the power supply room at 1 mrem/hr. The dose rates in the isle way near the power supply building were estimated[4] to be 0.7 mrem/hr for 1MW.

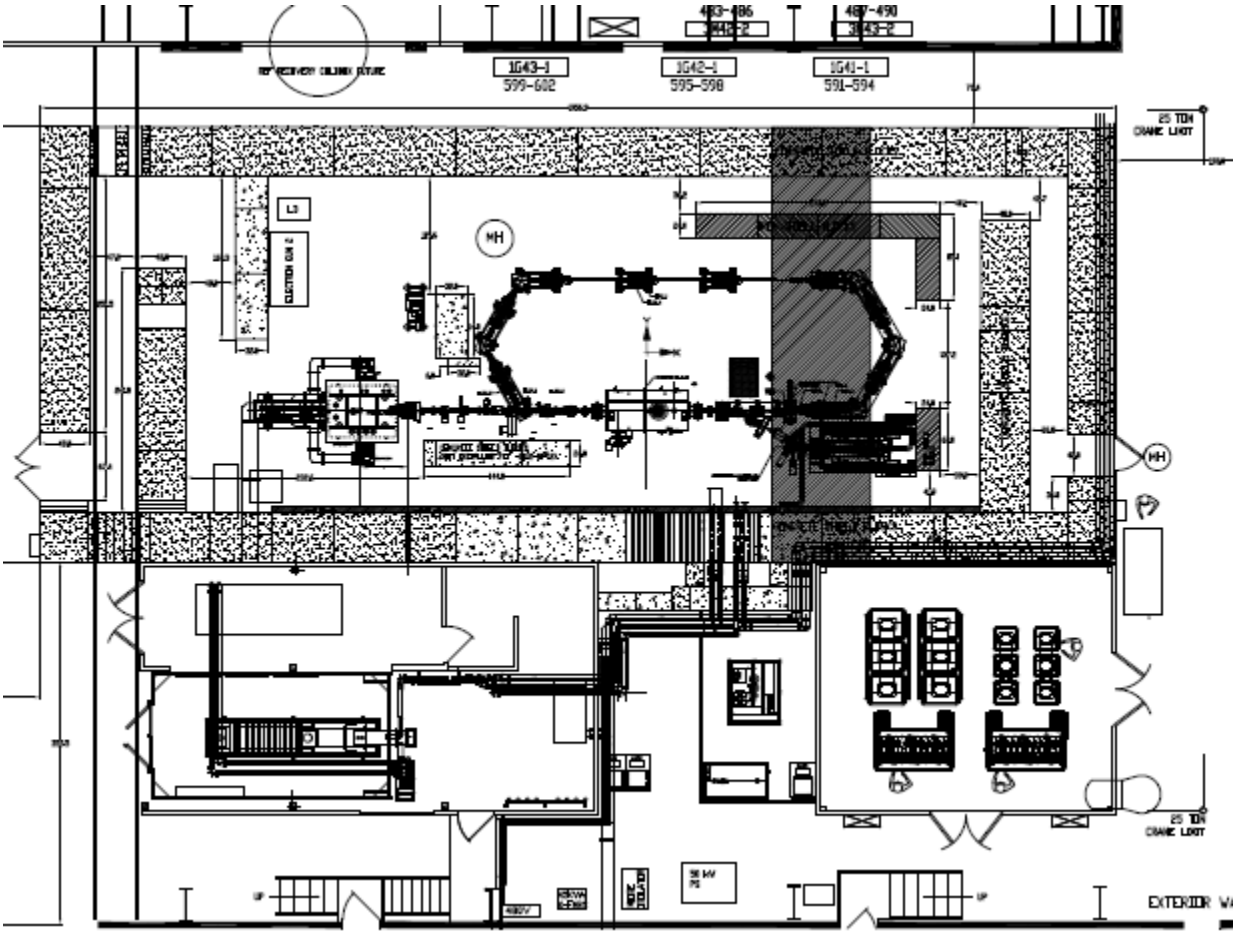
The steel shield on the side of the beam dump is 6.1 inches thick, 3 inches on top, 4 inches at the back, and 6.1 inches on the bottom. In the forward direction a two-foot free standing block of steel is used to shadow the entrance door from the beam line and the beam dump. The beam dump in the ERL layout is shown below. In addition, various views of the beam dump and the removable shield are shown in a series of views.

The four-foot thick concrete roof is an area that is not allowed to be occupied during ERL operations. The dose rates on the roof over the beam dump will be about a factor of 20 higher than out the side wall due to the thinner steel shield and the smaller distance. This should not create any issues. The beam dump is downstream of the ODH vent, which is a weak portion of the roof shielding[5]. The photons must penetrate two feet of concrete to enter the port and require at least two scatters to exit the port. Scaling the G5 beam dump results, using the TVL for light

concrete, and two scatters for the photons an estimate of less than 1 mrem/hr is expected out the ODH port.

The 50 kW waveguide is another close large penetration in the shielding. The expected dose exiting the port is estimated to be 6mrem/hr. There is a shadow block after the port[6] to further reduce the radiation exiting the port. The dose to occupied areas is expected to be satisfactory.

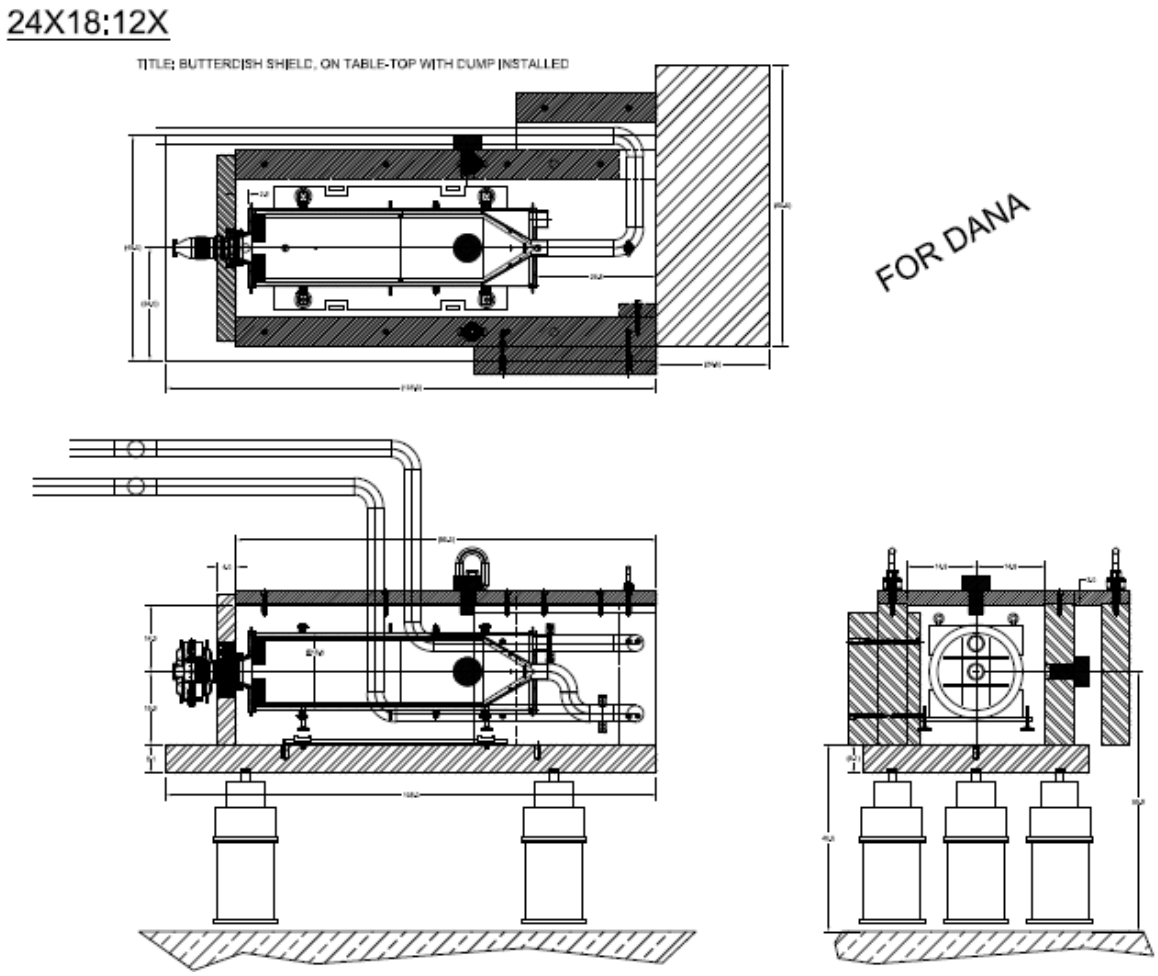
Most other penetrations are smaller and farther away and not expected to be an issue to the beam dump shield design. The beam dump will be a substantial source of x-rays inside the shielding for routine operations. This is a departure from the initial design philosophy[5] to make the dump no larger than expected routine losses. However, this design change does not create a dose issue for personnel outside the shielding and makes the dump shield design more economical. Initial surveys of the ERL facility will verify the design of the shielding and the penetrations.



Layout showing the beam dump and surrounding facilities.

Ozone Production in Air near the Beam Dump

The production of ozone in the air surrounding the beam dump was estimated[2] to be 1.6 PPM per hour with no shielding. At that time the beam dump shield was estimated to be 0.25 meter thick and the ozone production would have been reduced by about 10^{-4}. The shield has been designed to be about 6 inches thick on the sides and 3 inches on top. A distance of 10 meters was used for the estimation of the concentration, which may be too large a value. The concentration will depend of air circulation, incidental venting, etc. The air quality will be sampled for the first few operations to provide an empirical measure of the ozone production and concentration. **(Ck-FY2012-ERL-804)**



Various views of the beam dump and shield. The shield has counter weights for rigging.

Hydrogen Generation in the Cooling Water

The electron beam will deposit energy in the cooling water. Hydrogen can be generated in the water and has been examined by K. Yip[7] using MCNPX and I. Ben-Zvi[2] using analytic techniques. Their results were 4.8 liters/hr (K. Yip) and 5.6 liters/hr (I. Ben-Zvi). There are no expected radioactive products in the cooling water since the beam energy is below most thresholds. Therefore, the plan is to vent the gases from the cooling water to a safe location outside. At higher beam energies the radioactive products can make venting the gases an issue.

The venting method and area must be reviewed by the safety section before beam is put into the dump. **(Ck-FY2012-ERL-805)**

References

1. RSC Minutes of May 27, 2004; http://www.c-ad.bnl.gov/esfd/RSC/Minutes/05-27-04%20minutes.pdf
2. Kin Yip memorandum of Feb. 27, 2012; http://www.c-ad.bnl.gov/esfd/RSC/Memos/kin_dump.pdf
3. I. Ben-Zvi, C-AD AP note, March 2012.
4. D. Beavis memorandum of Jan. 12, 2012; http://www.c-ad.bnl.gov/esfd/RSC/Memos/rsc%20memos/main%20pages/rsc_memos.htm
5. D. Beavis Memorandum of March 28, 2008; http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL-Penetrations3.pdf
6. D. Beavis Memorandum of Dec. 6, 2006; http://www.c-ad.bnl.gov/esfd/RSC/Memos/holes_1_040912.pdf
7. Kin Yip memorandum of Feb. 15, 2012; http://www.c-ad.bnl.gov/esfd/RSC/Memos/kin_dump_water.pdf

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