Collider-Accelerator Department

BROOKHAVEN NATIONAL LABORATORY

Building 911B – P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344 7124
Fax 631 344 5568
beavis@bnl.gov
www.bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: *May 11, 2015*

To: *C. Schaefer (ERL IRR* Team Leader), RSC, D. Kayran, and I. Ben-Zvi*

From: *D. Beavis*

Subject: *IRR Pre-start Finding 7.3.4*

Introduction

The IRR prestart finding 7.3.4 " Complete the ARR Gun-to-Dump Post-Start Action 2: " To assure availability of the shielding calculations to others for continuity of operations, the preparation of a comprehensive shielding assessment for ERL should be prepared and made readily available."

The ERL is an R&D facility with several of the present components expected to be used elsewhere within two years. Each time the configuration is changed in the future the person examining the changes should examine the QA1 shielding prints and QA1 Interlock State Tables. Then with appropriate field inspection a qualified person should be able to design the changes without reference to the notes written in the past. Therefore, I find this request somewhat out-of–place for this R&D facility. Naturally, having the previous methods and calculations to evaluate the shielding may make evaluation of the changes more efficient.

I believe that the ARR Team was unaware of some of the documents that are easily available online inside the BNL firewall. It was unfortunate more of these documents were not transferred to the special website that was created for the ARR Team. However, a better method would be to give them access to the BNL sites and avoid transferring documents to multiple websites.

I will provide a brief history of the evolution of the ERL radiation protection design and then follow it with a road map to most of the design documents for radiation protection.

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ERL Shielding and Operational History

ERL shielding construction started in early May 2004. The C-AD shielding physicist was working with the Liaison Engineer to design the shielding for the facility construction. The initial construction was allowed to begin without an RSC review, as the RSC Chair was confident the shielding physicist should be able to support the design without initial review. The RSC reviewed the initial design[1] on May 27, 2004. The review determined that the forward Bremsstrahlung dose had not been considered in the design. Additionally, a myriad of other issues had not been addressed such as penetrations, full beam faults, and neutrons. There was no plan in place on how to address the integrated design of the shielding. The side walls had been constructed and the initial design is shown in Figure I. The shielding physicist was encouraged to work with the project to develop in-close shielding to provide adequate protection.

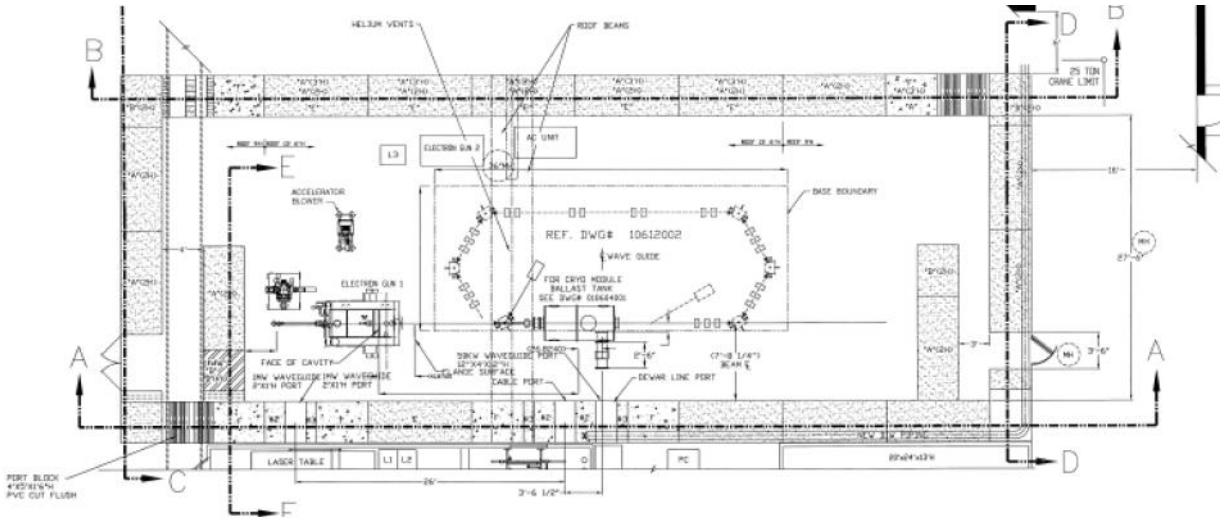

Figure I: ERL shielding design at time of first RSC review.

[1] See http://www.c-ad.bnl.gov/esfd/RSC/Minutes/05-27-04%20minutes.pdf

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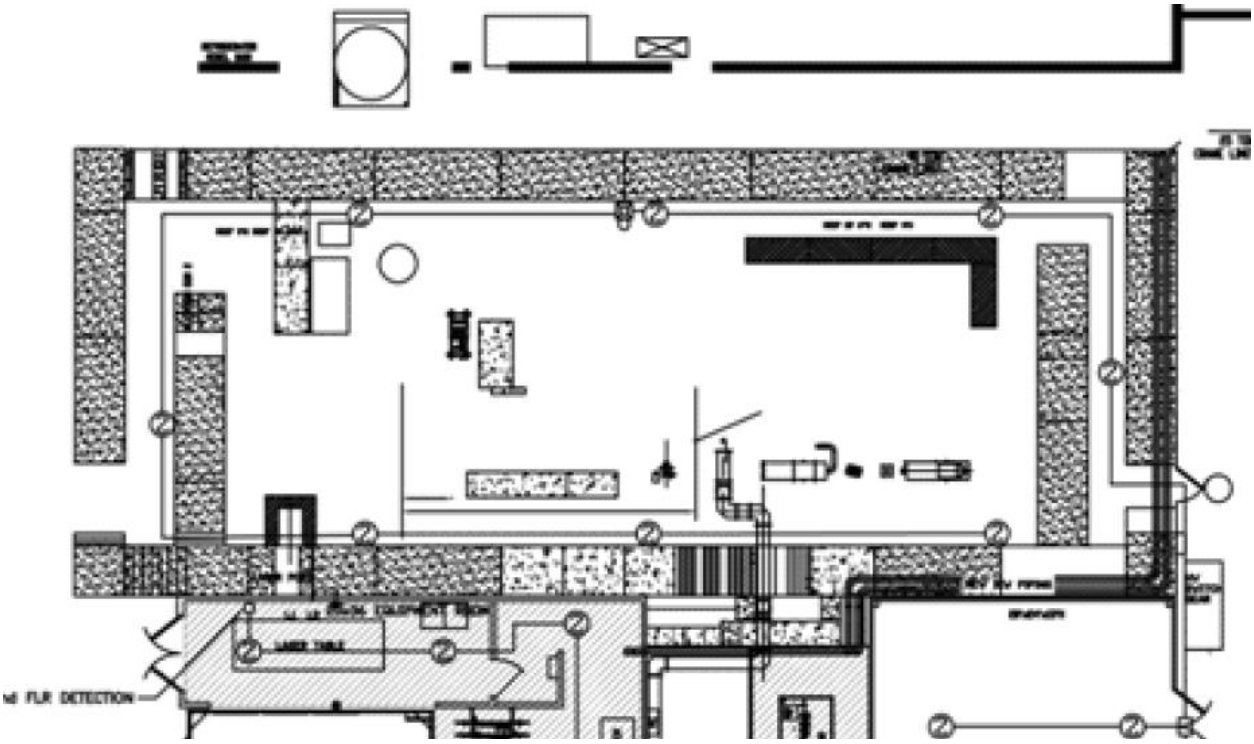

Figure II: ERL shielding after changes in late 2006 and early 2007.

It became apparent in mid to late 2006 that there were difficulties in developing the ERL shielding design in a systematic manner. In August of 2006 the first of several memorandums were written to support changes in the bulk shielding design and address penetrations. Some of these changes are reflected in Figure II and were reviewed by the RSC[2] on Jan. 18. 2007. By this time exterior support buildings had been added and the shielding plan needed to accommodate their existence. Some minor changes to water pipes and cable tray were conducted and additional shielding was added where possible. By early 2008 most of the shielding issues for ERL had been addressed. Since that time most of the documents reflect comparing as built to design and more detailed treatment of specific issues and running modes.

A series or Radiation Generating Device (RGD) tests have been conducted at ERL. The first was testing the Klystron in 2008 followed by a series of five-cell cavity testing beginning in April 2009. Since April 2009 there have been at least ten operational tests of the five cell cavity. Beginning in March 2011 a series of tests on the gun have been conducted as an RGD with means in place to prevent electron beam. April 2014 was the first attempt for low power beam from the gun. Low power beam was successfully produced from the gun on Nov. 18, 2014 with approximately 0.5 Watts of 1.3 MeV beam to the first Faraday cup. Two fault studies were

[2] RSC Minutes; http://www.c-ad.bnl.gov/esfd/RSC/Minutes/01_18_07%20Minutes.pdf

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conducted and a third attempted but not run as the cathode failed. The next test with gun beam is expected after the May ARR and the first loop tests sometime in July 2015.

During RGD testing and beam tests Radiological Control Technicians have been dispatched to conduct radiation surveys. No radiation has been detected[3] outside the shielding enclosure.

Documentation Roadmap for ERL

The Prototype Energy Recovery Linac, Building 912 Safety Assessment Document (SAD) is dated June 30, 2008[4]. This document is a summary of the shielding and radiation protection design of ERL. After this date the primary changes have been examining the as built to the design, calculating specific penetrations in more detail, addressing specific operational modes, and addressing the issue of the seams in the shielding. Since 2008 the overall scheme has remained the same, which is to reduce the largest sustainable faults to less than 15,000 mrem/hr outside the shielding and to satisfy the C-AD shielding policy. It is expected that the Machine Protection System (MPS) will provide additional defense in depth. The routine dose rate outside the shielding is trivial.

The main basis for the bulk shielding design was reviewed by the RSC in August 2006[5] and (see Footnote 2) January 2007. These minutes address a simple TVL treatment of the bulk shielding for beam faults using the combination of four-foot thick light concrete shielding walls coupled with additional shielding that reduces the dose rate for 50 kW of zero degree 25 MeV beam losses to less than 15,000 mrem/hr outside the external bulk shield. A plan view of the final shielding with the beam dump and outline of the machine is shown in Figure III.

[3] Radiation was detected only once during a five-cell test with incomplete shielding for the 1 MW waveguide.
[4] ERL Archival SAD; http://www.c-ad.bnl.gov/ESSHQ/SND/ERL/ERL%20SAD%20June%202008.pdf
[5] RSC Minutes and references therein; http://www.c-ad.bnl.gov/esfd/RSC/Minutes/08_10_06%20Minutes.pdf

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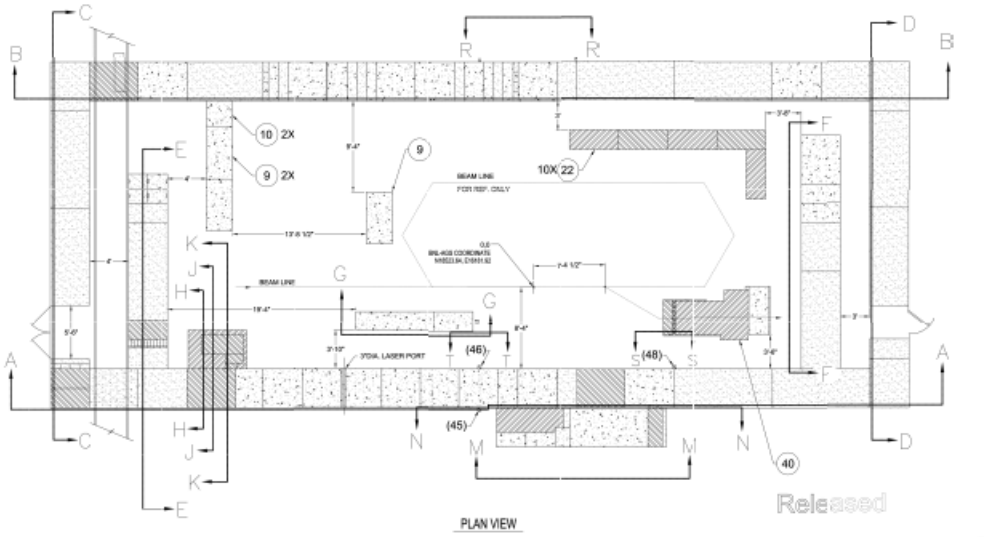

Figure III: Plan view of the approved shielding.

Other documents that address ERL bulk shielding are:

G5 Beam Dump Simulation http://www.c-ad.bnl.gov/esfd/RSC/Memos/G5%20Beam%20Dump%20Simulation.pdf

Dose outside the ERL room *http://www.c-ad.bnl.gov/esfd/RSC/Memos/kin_dump.pdf*

ERL Beam Dump Review *http://www.c-ad.bnl.gov/esfd/RSC/Memos/erl_dump_review.pdf*

Radiation due to 3.5 MeV electron beam *http://www.c-ad.bnl.gov/esfd/RSC/Memos/Kin_Radiation_MeV_10_1_12.pdf*

ERL Roof Transition *http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_1_13_14.pdf*

The documents that address penetrations and updates include:

Dose Rate Estimates for ERL Penetrations:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL-Penetrations3.pdf

An Updated Table for the ERL penetrations can be found at:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/5_13_15_ERL.pdf

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Estimate of the Radiation Exiting Penetrations for the ERL 50 KW Wave Guide, Cable Buss Block, and Water Pipes: http://www.c-ad.bnl.gov/esfd/RSC/Memos/holes_1_040912.pdf

Both were used in the SAD. Updates include:

ERL Shielding Holes, Seams, and Penetrations for 3.5 MeV Beam:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_Holes_5_27_14.pdf

Dose Calculations for ERL Seams using FLUKA:
http://www.cad.bnl.gov/esfd/RSC/Memos/07_08_14_Memo%20on%20ERL%20Seams%20rev1.pdf

ERL Roof Shims: *http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_6_19_14.pdf*

Documents that cover miscellaneous items including bulk shielding, penetrations, etc.

Hydrogen Generation in ERL Beam Dump Water:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/kin_dump_water.pdf

Examination of Miscellaneous Shielding Changes at ERL:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_7_14_14.pdf

ERL Chipmunk Locations: *http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_7_15_14.pdf*

ERL Dipole Power supplies: *http://www.c-ad.bnl.gov/esfd/RSC/Memos/ERL_7_23_14.pdf*

ERL Shielding Changes: *http://www.c-ad.bnl.gov/esfd/RSC/Memos/10_24_14_ERL.pdf*

Comparison of MCNPX with ERL Fault Study 232:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/12_18_14_ERLFaultStudy.pdf

ERL Beam Fault Studies and Maximum Beam Power:
http://www.c-ad.bnl.gov/esfd/RSC/Memos/5_11_15_ERL.pdf

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IRR shielding Findings: *http://www.c-ad.bnl.gov/esfd/RSC/Memos/4_22_15_IRR.pdf*

A set of documents and minutes for all RSC activities can be found on the website: http://www.bnl.gov/cad/esfd/ where there are subheadings for Radiation Safety.

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