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Memo

Date: *April 6, 2015*

To: *J. Skaritka, M. Fedurin, I. Ben-Zvi, and C. Folz*

From: *D. Beavis*

Subject: *Design Request for the ATFII Linac Tunnel and EH1*

This memorandum is to ensure that the design conditions for ATFII have been properly communicated and to provide the RSC with a heads-up on pending reviews for the facility.

The ATFII project has requested design for the linac tunnel and Experimental Hall[1] 1 (EH1). The Linac tunnel will have two beam lines branch off using 20^{o} dipoles. A long straight section exists between the beam line dipoles to accommodate machine equipment and potentially future Linac modules. The shielding has been requested to be designed so that the machine can operate up to 4 micro-amps of beam with a maximum energy[2] of 160 MeV. The 160 MeV is above the physical capability of the machine to prevent possible ASE violations. The Linac tunnel long straight section may allow future upgrades to energies of 500 to 1000 MeV for the electron beam. The Linac tunnel may be extended in the future to accommodate experiments at the higher energy.

The Project has requested that experimenters be allowed in EH1 while the Linac operates to full power to the beam safety shutters located in front of EH1. Two beam shutters, associated shadow shielding, and wall shielding will protect users in EH1 while beam tuning is conducted to the energy slits just upstream of the safety shutters in the beam line. About 90-95% of the experimental program operates well below the maximum capability of the machine. The project desires that the users not be required to ware TLD badges but should establish a machine threshold in power above which the posting of areas could change to either Controlled Area-TLD required or Radiation Area without a large impact. It is desirable that areas which may require changes in posting for infrequent high-power operations be limited to shielded enclosures and very limited areas outside the enclosures.

The Gun typically operates with an electron beam energy of 5 MeV. The shielding should be designed to allow the gun to operate at its routine parameters with beam to the energy slits at the gun or into a Faraday cup also near the gun. This is important to allow tuning of the gun before acceleration begins. The shielding should be designed for these operations with all nearby external areas posted as Controlled Areas. This excludes the shielding roof and small areas near

[1] Experimental; Hall 2 (EH2) will have similar requirements but the design will follow after the completion of the Linac tunnel and EH1.
[2] This is the maximum energy to the dipole for the extraction to EH1.

penetrations. If necessary, shadow shielding can be used at the energy slits and Faraday cup to reduce dose rates external to the shielding.

The Linac has two accelerating modules each provide up to 70 MeV of energy increase to the beam. Typically the energy will be less than 150 MeV. The shielding has been requested to be designed for a localized beam loss of 1% of the maximum beam at an arbitrary location with acceptable dose rates outside the shielding for the Controlled Areas. The Linac tunnel shielding and interlock system should be designed to handle the entire energy range from the gun energy to the maximum of 160 MeV. EH1 should be designed for a maximum energy of 160 MeV.

The energy slits and safety shutters should have shielding that allows for 100% beam losses at maximum beam power. The energy from the Linac to the first dipole is not well determined[3] without using one of the beam line dipoles to conduct an energy measurement. Tuning both the beam energy and bunch characteristics is one of the motivations for not having the dipole as a critical device.

Initial tuning of the Linac beam will use instrumentation that is thin but causes a long distributed beam loss. Details are required to determine where the perturbed beam will scrape either by calculations or beam studies at low beam power. Localized shielding can be used at locations that are identified as loss point when intrusive instrumentation is used. It is recommended that the end wall of the Linac tunnel be designed to handle 100% beam loss or studies[4] be conducted to verify that this is not necessary. will be subjected to bremsstrahlung generated by 100% of the beam and the thickness should take this into account.

The Linac tunnel will have one personnel labyrinth that is five feet wide to accommodate large pieces of equipment. The other personnel labyrinth will be narrower so that it requires a smaller amount of floor space.

In addition to the shielded enclosures for the linac and experimental halls there will be areas for Klystrons, racks for accelerator equipment, laser rooms, and a small experimental room for the Ultrafast Electron Diffraction (UED) experiment.

A series of radiation detectors will be distributed around the facility in locations to be sensitivity to beam faults and coupled with the shielding will provide an integrated design that meets the C-AD shielding policy[5]. It is expected that existing chipmunks will be used for most or all of these radiation detectors. The committee usually requires one radiation monitor for beam faults up to 1000 mrem/hr and additional monitors for higher dose rates. These monitors typically cause the beam to stop (interlock) in less than 9 seconds.

An incomplete and incorrect layout of ATFII in Building 912is shown below to give readers some idea of what the layout may look like in the future. It should not be assumed that any of the

[3] It can be crudely determined using by measuring the effect of quadrupoles or small correctors.
[4] Either design simulations or low power beam studies.
[5] http://www.c-ad.bnl.gov/esshq/snd/opm/Ch09/09-01-12.PDF

shielding walls, labyrinths etc. are correct. The beam layouts for the experimental beam lines was just updated a few days ago. However, construction of the walls for the upstream section of the Linac tunnel has started since the design is nearly complete. It is expected that the RSC will be asked to review the Linac tunnel to the EH1 extraction dipole in the near future. In addition, the UED will begin operations within six to eight months and a review will soon be scheduled. The design documents are presently being prepared for the RSC reviews.

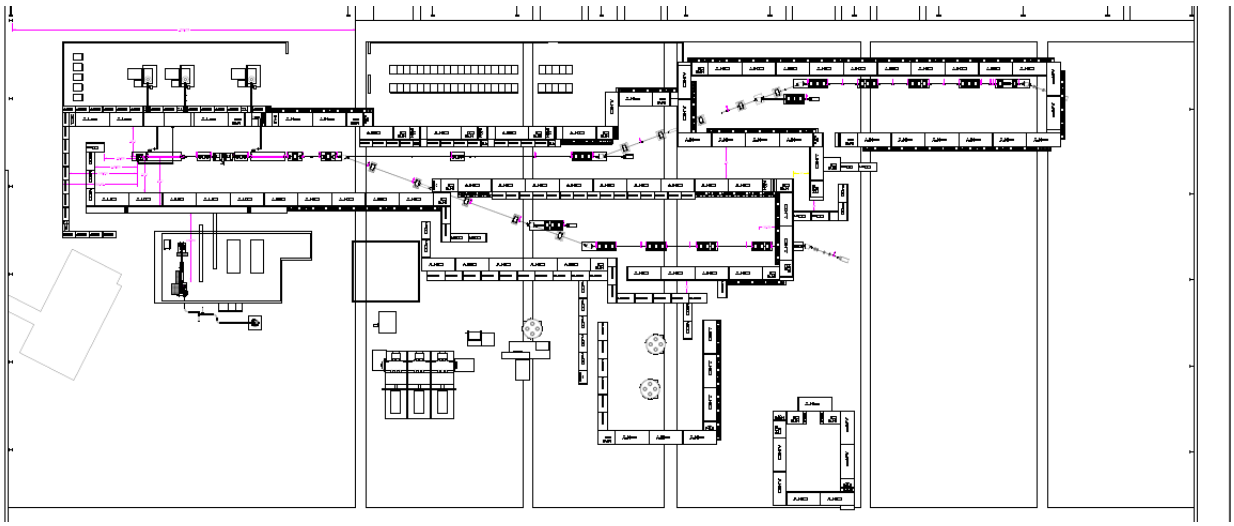

Figure 1: Preliminary layout of ATFII with errors.

The RSC will want to review both the routine and fault conditions for the Linac and the experimental halls. A few simple questions and comments are listed below which should be addressed as much as possible before the reviews. The answers may impact the designs of shielding and interlock.

1. Are the two beam line dipoles in EH1 and EH2 on a transfer switch or operated by separate power supplies?
2. Is the Linac extraction Linac operated in series with the dipoles in EH1?
3. Which dipole power supplies are unipolar and which are bipolar?
4. To limit potential large beam faults can the current of the dipoles be monitored and a window placed on the allowed range. For ERL a 5% reference was recommended and then lowered to 3%. Preventing mis-matched dipoles can reduce the potential parameter space of beam faults and potentially help reduce shielding.
5. What is the maximum field and Bdl for the dipoles?
6. What provides the limiting BdL of the dipole?
7. The large laser port for EH1 needs to be located for the shielding design. The request is for a 14 inch diameter hole if the pipe is placed through the shielding or a 12.5 inch diameter hole if the shielding is built around the large laser tube. This penetration is centered at beam height.
8. All intrusive instrumentation should be defined by location and material into the beam.
9. To properly complete the UED area and interlocks a person who understands the machine sufficiently to discuss potential beam faults such as steering the electron beam out of the vacuum system should be involved in the final design before the RSC review.
10. The limitations on the Klystron that drives the UED need to be determined.

11. Are additional penetrations needed for the Linac tunnel upstream of the extraction dipole for EH1? The defined penetrations are:
    a. 3 Klystron dog-legged penetrations up high
    b. Straight through laser tube penetration for the gun on the floor
    c. EH1 beam port
    d. Five foot wide personnel labyrinth
    e. Second smaller labyrinth
    f. Several buss blocks on the west side for cables.
    g. The west side of the trench downstream of the dipole will have a buss block for cables, water pipes etc.
    h. The east side of the trench requires a specification of required space for cables etc. or it will be completely blocked to minimize radiation leakage.
12. Are there know large loss point in EH1 such as a mask at the front end?
13. Are the experiments expected to create large beam losses or induce large energy changes in the electron beam in EH1?
14. Is there a zone in the front end of EH1 where users without TLDs can be excluded? It is often hard to prevent leakage through beam ports.
15. Do you have devices for the RF gun and laser that you would like to specify as critical devices? Sometimes slamming a device off is not a very good method to treat a sensitive instrument so it pays to think about the method the device is turned off. Please keep in mind that the RSC prefers not to share devices as much as is practicable to prevent inadvertent errors by personnel. However, we do often have devices fitted with one set of contacts for the Access Control System (ACS) and another set of contacts for the controls system. A likely example is the RSC would want a laser shutter dedicated for the ACS as a means to stop beam if high radiation levels are detected outside the shielding.
    a. Specify two devices to turn the HV on the gun off. It is assumed that the gun can create radiation levels greater than 50 rem/hr at a foot. If this is not the case then please provide the documentation.
    b. One critical device to tur the laser off for radiation protection, preferably a dedicated laser shutter.
    c. Please specify potential reachback devices should a primary device fail. For example if the laser shutter fails to close the AC power for the laser could be turned off.
16. Piping systems which transport fluids into and out of the shielding enclosures must be defined. The enclosures are potential activation areas.

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