C-AD

Radiation

Safety Minutes of RSC Subcommittee of October 28, 2015

Committee

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Subject: 100 TW Laser and ATF-II introduction

Present: D. Beavis, I. Pogorelsky, K, Kusche, Y. Makdisi, R. Karol, E.T. Lessard, M. Fedurin, P. Pile, P. Cirnigliaro, J. Sandberg, M. Benmerrouche, C. Schaefer, C. Folz, J. Reich, M. Babzien, H. Hartman, I. Ben-Zvi, and P. Sullivan

The committee reviewed two aspects of the Future ATF II facility:

1. The 100 TW laser and the potential radiation issues related to its operation. The high power laser represents a means to produce radiation that the committee has not reviewed before.
2. An introduction to the layout, scope, and future expansion of the ATF II facility in Building 912. The main purpose was to provide the committee with an overview and also provide a beginning basis for the design of the access control system.

The committee has already reviewed a small exempt accelerator, UED, that will be operated as part of the ATF II facility. It will be the first operating component of the facility.

100 TW Laser

I. Pogorelsky lead the discussion with a Powerpoint presentation[1] of the 100 TW laser and the potential radiation issues associated with its operation. The ATF group presently operates a 2 TW CO2 laser as part of the ATF facility. The main purpose of the laser is to provide research opportunities with photon-electron interactions in experimental hall 1 (EH1) and study laser acceleration of ions. The laser may also be used in the future expansion of the facility with a second Linac experimental hall (EH2).

The 100 TW laser has many components that are distributed in a large area. Figure 1 shows a preliminary layout of the laser along with EH1. The laser will deliver light to EH1 and the ion accelerator. One delivery path for the CO2 laser to EH1 has been designed, see Figure 2. Future routing paths may use the trench to deliver CO2 laser light to EH1 and EH2. Access to the 100 TW laser devices/rooms can be limited to appropriately trained personnel. It is not expected that users will need access to this area. Users will need access to the ion accelerator vault. This area should be designed to be classified as Controlled Area-TLD required. Residual activity may eventually require this area to be posted as a Radiation Area. **Analysis will be conducted to determine the posting requirements, potential activity created, shield walls, air acvtivation,**

[1] I. Pogorelsky, "100-TW CO2 Laser as a Source of Ionizing Radiation", Oct. 28, 2015

water activation, and ozone production. (CK-ATFII- Dec. 1, 2015-D. Beavis-984)

The 100 TW laser facility has several locations where radiation will be generated. The initial 6 meter amplifier in Figure 1 has 100 kV electron guns to ionize gas via bremsstrahlung photons. The electrons strike an aluminum plate, which creates the bremsstrahlung radiation and is a potential source for x-rays external to the vessel. A pre-ionizer electron gun is shown Figure 3. The ionized gas discharge occurs in 10 Atmospheres of CO_2:N_2:He and is not a source of ionizing radiation. The next location where ionizing radiation can be an exposure issue is at the non-linear compressor. The highest radiation levels in the laser system will occur in the ion accelerator and that area is shown with a preliminary layout of shielding. Finally, the laser can create ionizing radiation in EH1. The shield design for the Linac beam is expected to be sufficient for the radiation created by the laser[2]. The access controls for EH1 must assure that the CO_2 laser is off[3] for staff and experimenters to access EH1.

The 100 TW CO_2 laser parameters are[4]:

Table 1: Main Parameters of the ATF-II CO2 Laser

Parameter	**Value**
Laser wavelength	9-10 □m
Peak power	100 TW (25TW)
Pulse energy	10 J (50J)
Pulse duration	100 fs (2 ps)
Repetition rate	0.2 Hz
Gas content	CO_2:N_2:He
Gas pressure	10 atm
Internal x-ray preionizer	100 kV, 3 Roentgen

An amplifier is presently in use at ATF. There is no evidence from personnel TLDs that exposure from the is an issue. The chipmunk has shown no evidence of radiation from the pre-ionizer but is too far away to be sensitive to the x-ray intensity from the gun. The chipmunks begin to lose sensitivity to x-rays as the x-ray energy is decreased below 100 kV with the response being about 50% at 50 keV. The 22.5 mm of stainless steel around the pre-ionizer represents almost 4 Tenth-Value-Layers (TVLs) of shielding and the internal housing will add additional material. There are three amplifiers side by side as shown in Figure 1. The final analysis may need to take into account various ports on the 22 mm thick tank as well as having three guns side by side. The 22 mm wall thickness of the tank will reduce external x-ray dose by almost 10^{-4}. The analysis of 3,000 mrads of x-rays was not presented but is most likely in the discharge region which is close to the x-ray source.

[2] This will need to be examined more carefully when more details of the laser interaction in the EH1 are understood.
[3] This is a requirement for radiation exposure. All lasers will need to be examined against the requirements to protect against exposure to laser light.
[4] I. Pogorelsky, "ATF_II CO_2 Laser", Oct. 21, 2015

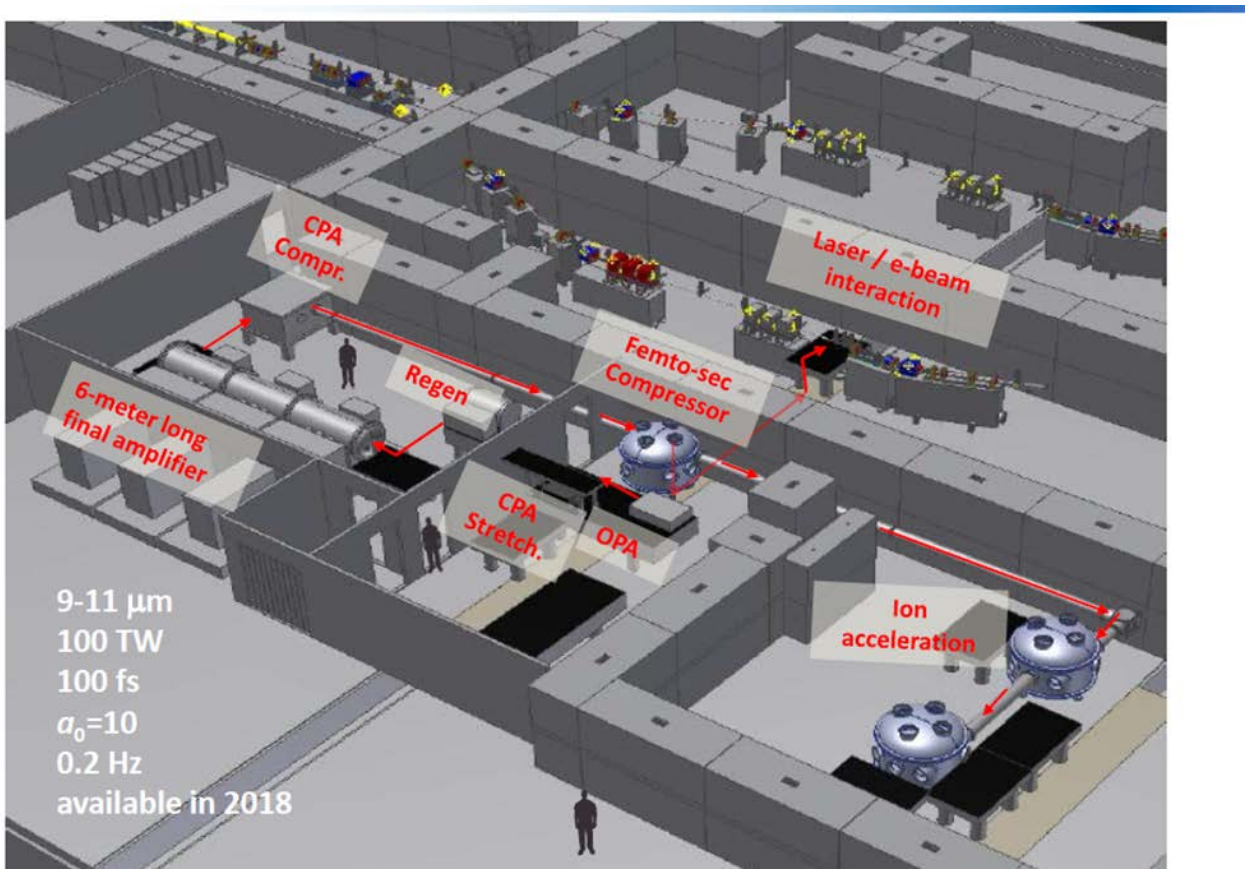

Figure 1: Depiction of the 100 TW CO2 laser adjacent to EH1 of the ATF II Linac in Building 912. Optical paths of the laser system are shown with red lines. The ion accelerator is in a shielded room on the right side.

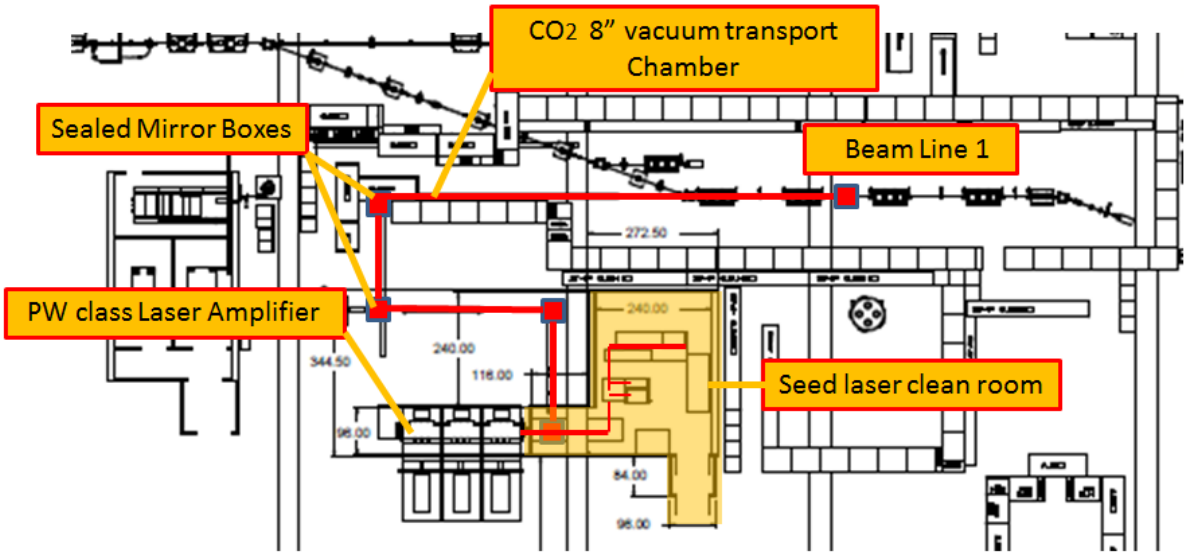

Figure 2: Day one laser delivery path to EH1. The EH1 layout is the presently under construction.

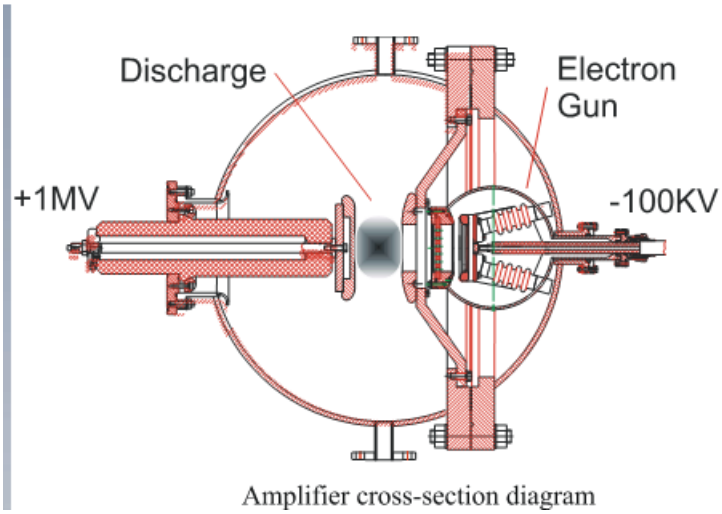

Figure 3: The elevation view of the amplifier showing the 100 kV electron gun that generates x-rays to ionize the gas. The gun has an internal housing inside the tank which is stainless steel with a wall thickness of 22.5 mm. The electrons strike a thick Al plate that is 10 cm high and a meter long.

A calculation based on thick target formulas[5] provides a simple and quick estimate for the radiation for the pre-ionizer electrons. The dose rate at a meter for 100 keV electrons is given as 6 Rads/hr*P. P is the power of the 100 keV electron beam in kW. The TVL of iron[6] is 6.35 mm providing a reduction of $2.9*10^{-4}$. The dose rate at 1 meter is expected to be 1.7 mrads/(hr-kW). Additional reduction is dose rate is expected to come from the internal gun shield. The value of P was not known when the minutes were written. If it is assumed that P=10 J/pulse then the power is 10J/p*720P/hr*1hr/3600s = 2 Watts. The external dose rate would be a few microrads/hr at a meter.

The committee recommends:

(CK-ATF-Nov. 15, 2015-K. Kusche&P. Bergh-985) Obtain radiation surveys at the present location of the internal x-ray pre-ionizer at the first opportunity.

(CK-ATF-Nov. 15, 2015-D.Beavis & I. Pogorelsky-986) Perform radiation analysis of the x-ray pre-ionizer at the ATFII 100 TW laser.

When the CO_2 laser light is focused to high power densities it can create a "thermal" bath of electrons[7] if the high power density light strikes material. The first location where this occurs as part of routine operations and potentially under fault conditions is the non-linear compressor (see Figure 1). The next location where this will occur routinely is at the ion accelerator. The third location is in EH1, where the shielding[8] and access controls for the electron beam will be sufficient for any radiation created by the CO2 laser light.

[5] See for example NCRP Report 49. This number is extrapolated for curve E.1.
[6] See NCRP 49 curve E.15.
[7] To a lesser degree light ions are also created.
[8] The EH1 side wall shielding may need to be thicker if the laser can target materials as discussed for the ion accelerator below. This could be handled by local shielding near the interaction point of the laser and the targeted material.

The CO_2 laser can create radiation (see footnote 4) at the focus location in the non-linear compressor. The laser light is focused through a pinhole with a diameter of about 100 microns. During routine operations with well aligned beam there will be a 20% loss of laser light on the material forming the pinhole. The power density at the edges of the aperture is 10^{15} W/cm^2 during the laser pulse. If a misalignment occurs before the pinhole the entire laser light can strike the aperture material with a power density of 10^{16} W/cm^2. Table 2 provides a summary of the operating parameters of the laser and characteristics of the created hot electrons and light ions produced in the non-linear compressor.

Table 2: Operating Parameters for the Non-linear Compressor

Parameter	Routine	Maximum	Comments*
Laser energy	2 J	10 J	
Laser intensity	10^15 W/cm^2	10^16 W/cm^2	
Laser repetition rate	500/h	20/h	
Primary hot electrons			isotropic
Laser deposition to hot electrons	10%	100%	
Electron temperature	<300 keV	1 MeV	
Secondary gammas			isotropic
Electron energy conversion	<1%	10%	
Temperature	400 keV	1 MeV	
Secondary ions	10 nC	100 nC	isotropic
Electron energy conversion	negligible	10%	
Temperature	negligible	1 MeV	

* Maximum regime in this situation corresponds to laser misalignment resulting in higher energy deposition on a target. This is a fault condition that can be spotted and corrected. That is why the accumulated number of shots per hour is substantially reduced to compare with a routine operation where most of the laser radiation propagates through a hole in the target without producing ionizing radiation.

The angular distribution of hot electrons is isotropic. Using the numbers for routine operations[9] for 720 pulses/hr one get that the power in the "electron beam" is 2J/pulse*.1(conversion)*720 pulses/hr =0.2 W. At 300 KeV the photon dose rate is 0.4 mrad/(hr-W) at 1 meter. The routine dose rate at one meter is 0.08 mrad/hr. With the stainless steel vessel for the non-linear compressor this would be reduced to levels sufficiently low for an uncontrolled Area for routine operations.

Errors[10] in operating condition can allow the full intensity laser light to strike the aperture material. Assuming that there are no controls to limit this condition for one hour the expected dose rate at 1 meter is 10J/p*720P/hr*1hr/3600s*3000 rads/hr = 6 rads/hr. The TVL for steel at 1 MeV is 5cm. The dose from a single pulse is 8.3 mrads which would be sufficient to interlock a chipmunk before the next pulse five seconds later. This is low enough to satisfy the C-ADs shielding requirement for less than 20 mrad per fault. However, this is intended for infrequent faults. The Projects states the potential fault rate at 20 times an hour. This fault rate should be clarified. For fault rates of this frequency the area would need to be a Controlled Area-TLD required and mitigation strategy to prevent exposure to many such faults.

[9] The pulse rate has been increased to 720 to be the same as the amplifiers. These numbers were provided by D. Beavis after the meeting for future reviews.

[10] This analysis was provided by D. Beavis after the meeting to provide guidance and information towards the next review.

The committee recommends for the non-linear compressor:

(CK-ATF-Nov. 15, 2015-I. Pogorelsky& K. Kusche-987) The Project will clarify the beam fault rate at the aperture and what mitigates the fault rate.

(CK-ATF-Dec. 1, 2015-I. Pogorelsky& K. Kusche-988) The Project will provide details of the non-linear compressor vessel so a more detailed analysis can be conducted including potential leakage out ports and the laser transport tubes, as required.

(CK-ATF-Jan. 1, 2016-D. Beavis& R. Karol-989) A more detailed analysis and fault protection scheme should be presented to the RSC. Shielding may not be needed if an interlocking chipmunk, shielding provided by the vessel, well defined mitigation of the faults, and the access needs of the Project are understood.

The energy of the hot electrons scales with the laser power density. Figure 4 shows the hot electron temperature as a function of the laser energy density in W/cm^2. The non-linear compressor is in region 1, 100 keV to 1 MeV. The experimental hall and the ion accelerator are expected to operate in region 2, 10^{18} W/cm^2, the hot electrons are expected to have a temperature of 100 MeV. The operating parameters for the ion accelerator are given in Table 3. The angular distribution of hot electrons that creates the Bremsstrahlung photons is isotropic. Although for an individual electron the bremsstrahlung distribution will be forward peaked, the isotropic angular distribution of the electron directions creates a photon distribution that is isotropic. The energy distribution will be a convolution of the thermal energy distribution convoluted with the bremsstrahlung energy distribution.

A simple estimate[10] of the radiation created by the isotropic distribution of hot electrons in the ion accelerator can be made in a similar manner as was done for the non-linear compressor. The 100 MeV electrons are 30 times more effective at creating photons. Thus the isotropic distribution at a meter should be 30*6rad/hr = 180 rads/hr of photons. This would be a routine dose rate for the laser targeting in the first vessel shown in the ion accelerator vault (see Figure 1). The laser beam terminates in this first vessel. Initial planning of the ion accelerator area should use dual interlocks for high hazard areas[11] and have shielding designed to reduce the dose rates outside to 50-500 micro-rm/hr from photons. There will also be neutrons created from the 100 MeV electrons as well as the accelerated light ions.

[11] Refined analysis may demonstrate that the dose rates in the area fall below 50 rads/hr. However it would be prudent to have redundant interlocks for the area around the targeting chamber.

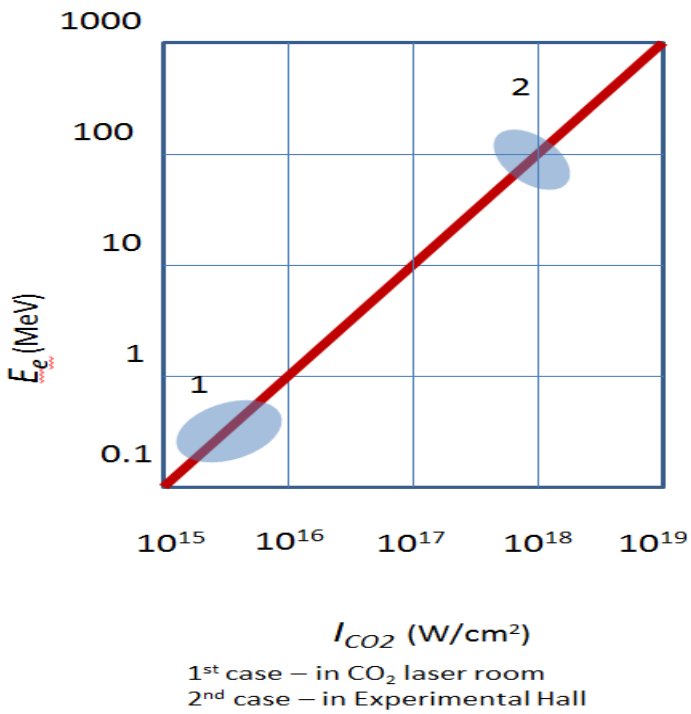

Figure 4: Electron temperature as a function of the laser power density.

Table 3: Operating Parameters for the Ion Accelerator

Parameter	Routine*	Maximum*	Comments
Laser energy	10 J	10 J	
Laser intensity	10^18 W/cm^2	10^18 W/cm^2	
Laser pulse length	100 fs	100 fs	
Laser repetition rate	60/h	720/h	
Primary hot electrons			isotropic
Laser energy deposition to hot electrons	100%	100%	
Electron temperature	100 MeV	100 MeV	
Secondary gammas			isotropic
Electron energy conversion	50%	50%	
Temperature	100 MeV	100 MeV	
Secondary ions	1000 nC	1000 nC	30^0 cone
Electron energy conversion	30%	30%	
Temperature	100 MeV	100 MeV	

*

Light concrete or heavy concrete shielding will be used for the side walls except where space is at a premium. The TVL for light concrete at 100 MeV is 48 cm. Based on the preliminary layout it is assumed that the ion accelerator vessels have a radius or 4 feet, the distance from the vessel to the concrete wall is 8 feet, and the shielding is at least 4 feet thick. The total of 16 feet minimum to the outside of the shielding provides a dose rate reduction of 0.042. The shielding must provide a reduction of 0.05 mrad/hr/(0.042*180,000 mrem/hr) = $6.6*10^{-6}$. This requires that the shielding be 250 cm thick (8.2 feet), if light concrete is used. The shield wall would only be required to be this thick for the section near the targeting vessel. Increased distance and effective thickness due to the angle will decrease the requirements of the rest of the wall. Denser materials can be used for shielding if it is desired to reduce the footprint for the shielding.

(CK-ATF-Jan. 1, 2015-I. Pogorelsky& Beavis-990) The Project will provide details of the ion accelerator vessel and targets inside so a more detailed analysis of photon shielding can be conducted if deemed appropriate by the committee.

The dose rate from neutrons can be estimated[12] using simple techniques. There are 7,200 J/hr of produced hot electrons. The Giant Dipole Resonance (GDR) neutron dose is 0.27 mrem*m^2/J. The High Energy Neutron (HEN) dose is 0.043 mrem*m^2/J. The dose rate at a meter is 1,940 mrem/hr for GDR neutrons and 310 mrem/hr for HEN. The attenuation length for GDR neutrons in light conctere is 17 cm and for HEN the attenuation length is 27.7 cm. At a distance of 16 feet outside a 250 cm light concrete wall the dose rates are 0.00003 mrem/hr for GDR neutrons and 0.00015 mrem/hr for HEN.

A simple estimate of the shielding requirements for protons can be made using formulas and figures provided by K. Tesch[13] and Sullivan[14]. Most of the 1000nC of protons per pulse are at low energy. A conservative estimate[15] is to assume all 1000 nano-C of ions are 100 MeV protons. This would result in $4.5*10^{12}$ 100 MeV protons per hour. The lateral radiation at 1 meter for $4.5*10^{12}$ protons per hour is 375 mrem/hr. The forward radiation is expected to be about 1,100 mrem/hr at a meter[16]. With the ions contained in a 30 degree cone only a portion will reach the downstream detector chamber. The downstream shielding will need to provide shielding for the x-rays from the target chamber and the light ions. If a shield wall exists between the two vessels if may be possible to build a limited shield wall and radiation barrier around the detector chamber. It is expected that a more careful treatment will decrease these shielding thicknesses.

(CK-ATF-Jan. 1, 2015-I. Pogorelsky& Beavis-991) The Project will provide additional details of the detector vessel and beam transport downstream of the target vessel for the ion accelerator. Additional radiation calculations may be necessary if deemed appropriate by the committee.

The layout of the CO_2 laser system appears to be spread over an area larger than necessary. There was no discussion on whether there were optical or timing issues that required various transport sections to be the length chosen. To the non-expert it would seem more natural to have the ion accelerator on the other side of the non-linear compressor. The laser light needs to be transmitted in this direction to get to EH1. This may eliminate some transport pipes for the laser to the ion accelerator.

The 100 TW CO_2 laser is expected to be operational at the end of 2017.
(CK-ATF-Jan. 1, 2015-I. Pogorelsky& Beavis-992) The Project should provide to the RSC a series of milestone dates for the installation especially for areas that need access controls, shielding design, and authorization documents.

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[12] See P.K. Job and W.R. Casey, "Preliminary Radiological Condierations for the Design and Operation of NSLS II Storage Ring and Booster Synchrotron", NSLS II Tech. Note 13, July 15, 2006. Minor reductions in the neutron production based on the lower energy of 100 MeV will be ignored.
[13] K Tesch, "A Simple Estimation of the lateral Shielding for Protons Accelerators in the Energy Range 50 to 1000 MeV", Radiation Protection Dosimetry, Vol 11, No. 3 pg 165-172 (1985).
[14] A.H. Sullivan, A Guide to Radiation and Radioactivity Levels Near High Energy accerleators, Nuclear Publishing Technology, 1992.
[15] A more careful treatment is expected to produce substantially lower dose rates as thinner shielding requirements.
[16] A factor of 3 has been used for forward dose relative to lateral (Fig. 2.14 of footnote 14) and an attenuation length of 26.6 cm has been used based (fig. 2.16 footnote 14).

An Introduction to the ATF II Electron Accelerator

M. Fedurin lead the discussion with a Powerpoint presentation[17] of the ATF II electron accelerator and experimental areas. This introduction was intended to expose the committee to generally planning of the ATF II electron machine without reviewing technical details of the machine. More technical reviews by the committee are expected to occur soon.

The ATF II project is in the process of re-scoping and preparing for a major review by DOE in March 2016. The facility is using a substantial number of existing components. The present baseline is:

- Laser excited 5 MeV gun
- 150 MeV Linac comprised of two 75 MeV modules
- A beam current of 4 micro-amps
- A horizontal chicane between the two accelerating modules
- An environmental room for two lasers and the UED. The room has partitions.
- An Experimental Hall (EH1)
    - A diagnostic beam line with a beam dump
    - A beam line with several experimental stations
    - A spectrometer at the end of the beam line with a beam dump.
    - Access port for the 100 TW laser beam for experiments
    - Access port for a YAG laser beam for experiments (in room with other laser)
- Klystron Area for the gun and linac modules
- Rack area for power supplies and controls.
- Both the laser vault and the EH1 must be swept for the 5 MeV beam to be accelerated by the Linac modules. The critical devices must be determined or else the gun beam must be off.

A series or de-scoped items or planned upgrades may include:

- Two critical devices between the Linac and EH1 enabling workers to be in EH1 while the electron beam is accelerated and transported to the Linac beam dump or another experimental hall.
- The addition of a second Experimental Hall (EH2) which is essentially a copy of the EH1. EH2 may be designed for 500 MeV electron beams.
- Additional Linac modules downstream of the dipole for EH1 that can accelerate the beam to 500 MeV.
- Possible expansion of the Linac vault downstream of EH1.
- The transport of the 100 TW CO_2 laser to EH2
- Transport of the 100 TW CO_2 laser to allow acceleration of the electron beam to 10 GeV.

The project is designing the present baseline system so these future options do not become too costly to implement or substantially interrupt the operations of the base program. Figure 5 shows an overall layout of the ATF II facility. Some of the shielding has been placed and the design will be presented to the RSC. The overall shielding design concept is to construction the walls with two layers of concrete blocks, avoiding seams that go through the entire shield.

[17] M. Fedurin, "Introduction to ATF II e-beamlines", Oct. 28, 2015

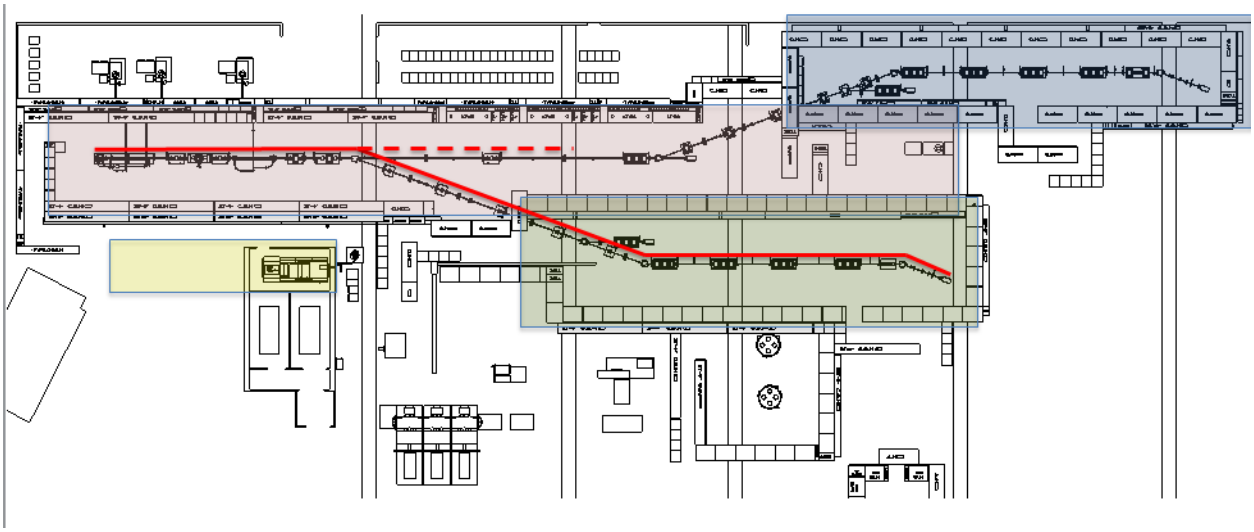

Figure 5: General layout of the ATF II facility. The 100 TW CO2 laser is shown at the bottom. EH1 is adjacent to the 100 TW laser. A second experimental area (EH2) is planned for the future and shown at the top right of the figure.

The three Klystrons for the gun and Linac modules are situated in an area on the south east side of the facility (see Figure 5). This area is expected to be posted as a Controlled-Area TLD required. The Klystrons are self-shielded to reduce x-rays to low levels. Users are not expected to need access to this area. **(CK-ATF-Jan. 1, 2015-J. Skaritka&P. Bergh-993) Obtain existing surveys of these Klystrons in operation or obtain surveys when they are commissioned.**

The rack area to the north of the Klystrons will mainly support electronics and power supplies for the accelerator. Areas assigned for experimeter's electronics, gas systems, prepararion stations, and workstations should be depicted for the committee to consider exposure. The control room for the facility needs to be defined. **(CK-ATF-Jan. 1, 2015-J. Skaritka&Folz-994) Define user support areas, facility control room, and the occupancy.**

Figure 6: Left hand side shows the construction of the Linac vault with the actual Linac components. The 20 degree bend to EH1 is in the middle of the photograph. The right hand

side shows the laser/UED room and portions of EH1 transport elements.
Figure 6 shows the upstream section of the Linac tunnel. This section is primarily light concrete A blocks[18] backed with two-foot thick roof beam. The downstream section has heavy concrete A blocks backed with two-foot thick roof beams. The south end of the Linac vault has a labyrinth that is five feet wide to accommodate bringing in equipment. The Linac tunnel is sufficiently long as to require two egress paths. An exit labyrinth[19] is shown at the north end of the tunnel. It is suggested that the committee request the Linac tunnel downstream labyrinth be moved 60-70 feet upstream to avoid unnecessary space in a primary area and an extend space for beam faults. This frees up 1200-1400 ft^2 that could be used for experiment prestaging, accelerator component staging or other purposes.
(CK-ATF-Dec. 1, 2015-Beavis&Karol-995) Consider moving Linac downstream labyrinth closer to EH1 dipole.

The EH1 shielding construction is similar in design concept to the Linac tunnel. There are two labyrinths into EH1 due to the length of the experimental hall. The downstream labyrinth will be sized to accommodate moving limited sized equipment into EH1. Making the labyrinth too wide requires more floor space and shielding. The roof is removable in the present design so a limited number of roof beam lifts are required to lift equipment in/out of EH1 with the building crane. The same comment can be applied to the Linac and future EH2 enclosures.

Both the Linac tunnel and EH1 will have numerous small penetrations for utilities, RF waveguides, and lasers. The design of the penetrations will be presented at a future meeting.

A conceptual design for the roof exists but has not been finalized. At present the roof will be two layers of roof beams overlapped so that no seams go completely through the roof. The present design has the roof beam lapped on the side with shielding to prevent cracks directly into the shielding enclosure. At present the plan is to have personnel excluded from the roof. However, it may be possible to have some sections of the roof occupied by personnel if required. Areas where this may be desired should be identified early in the project.
(CK-ATF-Dec. 1, 2015-Skaritka&Folz-996) Define shielding roof areas where occupancy by personnel may be desires.

The shielding end walls shown in Figure 5 are simple representations of preliminary locations for the end walls. End walls have to be substantially thicker than the side walls to handle the forward bremsstrahlung radiation.

The present criteria for the Linac tunnel shielding is that a localized beam loss of 1% can occur anywhere along the transport. Higher local losses will be prevented by the appropriate distribution of radiation detectors, chipmunks. The shielding is designed to reduce the radiation to occupied areas to between 0.05mrem/hr and 0.5 mrem/hr. Locations where personnel are expect to spend substantial time will be designed to 0.05, whenever possible. It should be noted that the shielding and floor have residual activity related to their previous use in the high energy physics program. The areas outside the shielding will initially be posted as Controlled Area-TLD required until there is sufficient evidence to warrant a lower classification.

Intrusive instrumentation can be inserted into the beam for tuning and characterizing the beam. This type of operation may cause 100% of the beam to be lost in a distributed pattern. A means to rectify this with a local 1% loss needs to be understood. The first dipole bends the beam to EH1

[18] An A block is four feet thick, ten feet long, and 4.5 feet high.
[19] This labyrinth has not been design for radiological purposes yet.

and an energy slit downstream of the dipole will be used to trim the beam and make energy measurements. Local shielding will be used to augment the sidewall shielding assuming continuous 100% beam loss at the slit.
(CK-ATF-Dec. 1, 2015-M. Fedurin& D. Beavis-997) A better understanding of tuning losses and the use of intrusive instrumentations needs to be developed in regards to the shielding and radiation detector placement.

The Linac beam can be transported past the EH1 dipole to a small beam spectrometer and beam dump. The area near the beam dump will have local shielding to accommodate continuous 100% beam losses.

The electron gun will have a Faraday cup designed for continuous beam at full gun power Local shielding may be need to reduce the dose into the upstream labyrinth or into penetrations.

Local shielding may exist in the tunnel to protect against beam faults. A few examples are the EH1 dipole miss-matched with the Linac beam energy, improperly set horizontal chicane, and power supplies to magnets that trip off or put at a wrong set-point.

Figure 7 shows a depiction of EH1 with specified experimental stations distributed along the beam. Some experiments at these locations may create 100% beam losses. The losses may be local or distributed depending on the experiment. At the end of the beam line is a small spectrometer and beam dump. The spectrometer at the end of the beam line is shown in different directions in Figure 7 and Figure 5. Changes to both the spectrometer and shielding layout are being considered. The potential simultaneous use of EH1 by multiple users needs to be presented for the committee so that potential interferences that impact potential radiation issues can be considered.
(CK-ATF-Dec. 1, 2015-M. Fedurin& D. Beavis-998) Multiple users in EH1 needs to be understood.

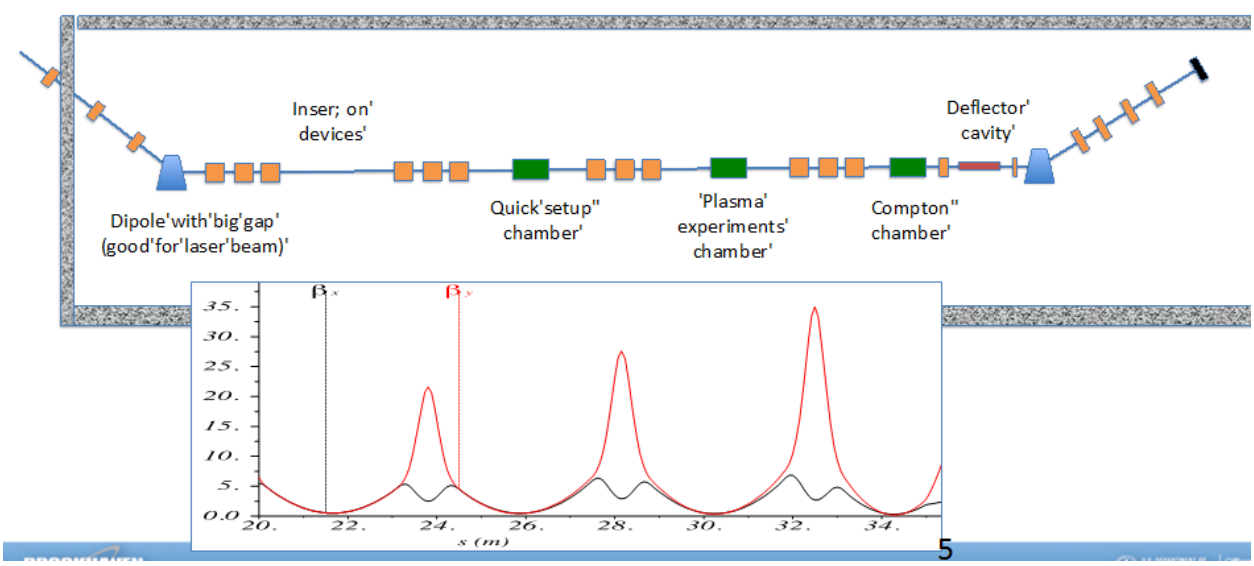

Figure 7: Layout and uses expected for EH1. The beta functions for the beam are shown in the lower portion of the figure. The short diagnostic bean line is not shown.

The Project is interested in obtaining a cost a schedule for the access controls system.
(CK-ATF-Dec. 1, 2015-Pogorelsky&Skaritka-999) The access controls group needs to be

given a timeline for both the 100 TW CO_2 laser and the electron machine. Also which items are costed to which device as it is not clear if these are two separate projects.

The Linac tunnel, EH1 and the ion accelerator vault will require high hazard interlocks. The two systems may use the same redundant PLCs if desired. However, this may create issues depending on the time lines of the two efforts. The laser room will need to be examined for potential interlocks and any interlocks required be incorporated into the ACS design.

Should the perimeter of the Linac enclosure be broken then all radiation sources must be interlocked off. This includes the three Klystrons. This is for both beam hazard and x-ray hazard. It is not clear what the dark current from the gun is if the laser is off but the RF stays on. The RF off must be redundant unless it is clear that this hazard is not above 50 rads/hr at a foot. The gun laser must have a separate shutter and the laser turned off if the Linac enclosure is entered[20].

The Linac tunnel and EH1 will have a series of chipmunks to prevent excessive dose rates or dose exterior to the shielding. The chipmunk interlock will shut the close the laser shutter. If the radiation decreases in a sufficiently short time then the RF can stay on. For downstream radiation detectors putting the gun Faraday cup into the beam would be another option. The ACS design should group the chipmunks into being Linac tunnel chipmunks, EH1 chipmunks and CO2 area chipmunks. A simple guess is that the Linac tunnel will have five to eight chipmunks depending on the length of the tunnel. The EH1 may have two or three. The CO_2 area would be expected to have two of three chipmunks[21].

The design of the access control system should take into account the possible expansion of the facility in the future. This includes the introduction of two critical device between the Linac and EH1 so that experimenters can work in EH1 with the Linac operating.

Each electron beam shielding enclosure will have an access gate and escape gate. The access gate will have a BNL badge reader to check if the person is cleared for entering the enclosure. If possible this portion of the system should not be mixed with the QA1 portion. All sweeps will be unidirectional. The RSC does not allow multiple sweep patterns for an area. Both the Linac tunnel and EH1 will need to be secured for beam operation. Only the Linac tunnel needs to be secured to operate devices that generate x-ray hazards and operation of the gun to the first Faraday cup.

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[20] If determined to be required by a laser review.
[21] One would be for the non-linear compressor and the other two for the ion accelerator.