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Facility for Advanced Accelerator Experimental Tests (FACET) at SLAC and its Radiological Considerations

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FACET in SLAC will be used to study plasma wakefield acceleration. FLUKA Monte Carlo code was used to design a maze wall to separate FACET project and LCLS project to allow persons working in FACET side during LCLS operation. Also FLUKA Monte Carlo code was used to design the shielding for FACET dump to get optimum design for shielding both prompt and residual doses, as well as reducing environmental impact.

I. INTRODUCTION

Facility for Advanced Accelerator Experimental Tests (FACET) will be an experimental facility that provides short, intense pulses of electrons and positrons to excite plasma wakefields and study a variety of critical issues associated with plasma wakefield acceleration [1]. This paper describes the FACET beam parameters, the lay-out and its radiological issues.

II. PLASMA WAKEFIELD ACCELERATION

Plasma wakefield acceleration is a technique that helps particles get "up to speed" in a much shorter distance than conventional accelerators require, by driving them through ionized gas, also known as plasma. As a bunch of electrons passes through these free-floating ions, the bunch's negative charge pushes the similarly-charged plasma particles out of its path. The remaining positive ions are attracted to the negatively charged electron bunch and form a tail behind it. Now, the displaced negative free ions are attracted back to this wake of positively-charged particles, causing them to gather behind the original electron bunch. The negative charges repel, giving the bunch an extra push.

III. FACET BEAM PARAMETERS AND LAY-OUT

FACET will produce 23 GeV, 2.2-kW electron or positron beams. The facility includes: the first two kilometer of the existing SLAC Linac; the sector-10 chicane, the sector-20 chicane, experimental area and FACET dump. Linac Coherent Light Source (LCLS) uses the last kilometer of the SLAC Linac (Figure 1).

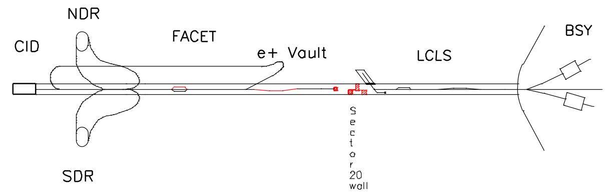

Fig. 1 Lay-out of FACET and LCLS

IV. FACET RADIOLOGICAL ISSUES

Three Radiological issues have been studied:

IV.A. Maze wall shields FACET side for LCLS operation

It is designed that access to FACET is allowed during LCLS operation, but no access to LCLS line except LCLS injector vault is allowed during FACET operation.

A maze-type wall was designed to separate FACET and LCLS (Figure 2).

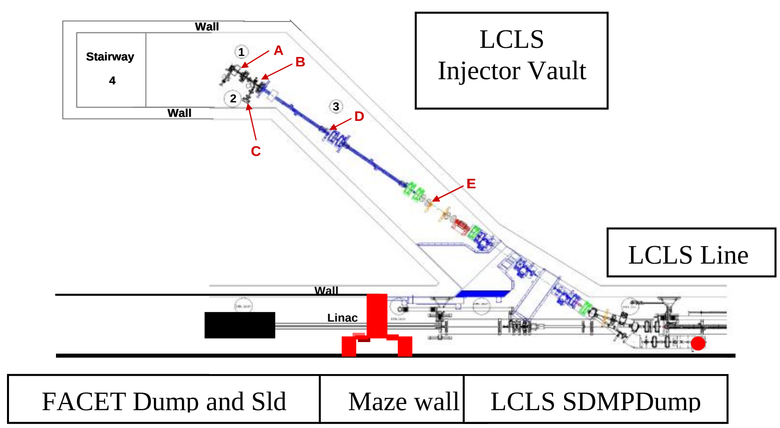

Fig. 2. FACET and LCLS separation

The dose limits used in SLAC to protect personnel are listed in Table 1.

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Table 1
Dose limits at SLAC

Condition	Dose
Normal operation	1 mSv/y (2000 hr/year) 5 µSv/hr
Mis-steering conditions	4 mSv/h
Maximum Credible Incident	250 mSv/h 30 mSv (integrated)

The main radiation source during LCLS operation and FACET access is LCLS beam parking on LCLS spectrometry dump SDMP. The beam losses for different conditions are listed in Table 2.

Table 2
Beam Losses during LCLS Operation

Condition	Beam Losses
Normal operation	135 MeV and 16 W
Mis-steering conditions	135 MeV and 100 W Limited by Long Ionization Chambers
Maximum Credible Incident Maximum charge could be extracted from LCLS gun	135 MeV and 5 kW

FLUKA Monte Carlo code [2][3][4][5] was used in the design of the maze wall. The results are listed in Table 3 [6].

Table 3
Beam Losses during LCLS Operation

Condition	Calculated dose rates
Normal operation 135 MeV and 16 W	5 µSv/hr
Mis-steering conditions 135 MeV and 100 W Limited by Long-Ionization Chambers	0.03 mSv/hr
Maximum Credible Incident Maximum charge could be extracted from LCLS gun	1.5 mSv/hr

IV.B. Radiation Shielding for FACET Dump

FACET dump is located three meters upstream of the maze wall (Figure 2). 23-Gev and 2.3-kW FACET beam will park on the dump.

It is allowed to access to LCLS injector vault during FACET operation. The shielding around the FACET dump was designed to minimize the prompt dose to personnel working in the LCLS injector vault during FACET operation, also to limit the residual dose to personnel working around the FACET dump after the FACET beam is off. FLUKA Monte Carlo code was used in the design and dose calculations. The shielding around the FACET dump consists of blocks made by different materials, include steel, tungsten, borated polyethylene, lead and concrete. The different materials were used in different layers to get optimum design for shielding both prompt and residual doses, as well as reducing environmental impact [7][8].

1. Prompt dose to personnel working in the LCLS injector vault during FACET operation [7][8]

The resulting maximum dose rate is ~13 µSv/hr in a very small area of the LCLS injector vault. The design limit of annual dose rate is 1 mSv/ or 5 µSv/hr. Dose will be collected in the injector vault only when the following three conditions are simultaneously fulfilled:

a. LCLS is not running (rarely)
b. FACET is running (not all the time)
c. The injector vault needs access (rarely)

Therefore, the shielding design for prompt dose is adequate. The vault is posted as Radiological Control Area.

2. Residual dose to personnel working around the FACET dump after the FACET beam is off [7][8]

The residual dose rates after the beam shut off depends on the beam power on the dump, the time of the beam-on, and the cooling time. One-hour cooling time is good practice used in SLAC to reduce the air activation. Thirty days of irradiation was used in the simulation. An experimental area is located upstream of the dump. The design goal is the minimize to residual dose to be around 5 µSv/hr in the experimental area and less than 1 mSv/hr around the dump area. The access control to the area with dose rates below 1 mSv/hr is much easier than those above 1 mSv/hr. The shielding requirements are based on SLAC ALARA guidance. The simulation results showed about 7 µSv/hr in the experimental area. A small fence needs to be installed in the front of the dump to get dose rate below 1 mSv/hr.

3. Soil activation

The Soil activation depends on the beam power on the dump and the time of the beam-on. Five years of irradiation was used in the simulation. ^{3}H activity around the dump in a 1m^3 of soil is about 6 pCi/g [7][8], which meets the SLAC limit of 20 pCi/g.

V. CONCLUSUION

Full 3D simulations of the prompt and residual dose around FACET dump have been performed with a Stat-of-the-art Monte Carlo code. The prompt dose rates in the LCLS injector vault meets SLAC design limit. The residual dose rates around the dump meets SLAC ALARA guidance. Preliminary environmental impact study meets SLAC goal.

ACKNOWLEDGEMENT

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