LCLS Newsletter 24-April-2000

Project Management *Lowell Klaisner, Max Cornacchia*

Plans for the LCLS experimental area.

We have been struggling with trying to fit everything we need between the muon shield and the road at the back of the Research Yard. This problem came up again with at the Scientific Advisory Committee meeting.

Basically, the problem is not enough space along the beam. It might be possible to shorten the electron beam diagnostics but this will not generate enough space. The undulator was 112 meters long in the design study report. This left no space for expansion or contingency. The space left for x-ray diagnostics is barely adequate and we have been trying to tweak the spacing of the dump, etc. to create enough space. The experimenters are concerned about the limited length of the hall, which is getting shorter if we move the dump downstream.

We are investigating alternatives. We are thinking of moving the experimental hall to the backside of the hill at the back of the Research Yard. If we put the hall at the "possible site" shown at 2250 feet on Figure 9.3-2 of the LCLS Design Report, this would put the hall approximately 1000 feet from the end of the undulator. We would microtunnel through the hill, which would give us a small-bore (say 2 feet diameter) tunnel for a vacuum pipe. We would not have any devices in the tunnel. The tunnel would be about 750 feet long. This would leave about 250 feet in the research yard for lengthening the undulator and x-ray diagnostics.

We are looking into microtunneling but these dimensions seem readily doable and should cost less than $500K. The FFTB tunnel would be extended using the same construction techniques as the existing tunnel.

Are there any downsides to this approach? For example, all user experiments will be at least 1000 feet away from the undulator. The SAC did not identify any experiments that needed to be close but we should consider this.

LCLS General Seminar

The next LCLS seminar will take place on April 24 at 3:00 PM in the LOS 2nd floor conference room. Paul Emma will present an algorithm for the optimization of undulator section lengths.

FEL Physics Section Report *C. Pellegrini, H-D Nuhn*

The LCLS physics group is presently studying the problems listed below.

1. VISA experiment. The main goals are reaching saturation, studying the gain as a function of emittance and other beam parameters, analyze the data and benchmark existing FEL codes. Understanding the beam transport and alignment in a strong focusing undulator, as well as understanding how to separate and use the beam, FEL and background signals in the intra-undulator detectors, is another area where VISA is providing useful information for LCLS.

2. Analysis of data obtained in other SASE experiments from the point of view of their relevance to LCLS design.

3. Carl Schroeder is reexamining the quantum theory of SASE to see if there is any effect that might become important as we move to the 0.1nm region.

4. Sven Reiche is completing the development of a code to evaluate the spontaneous undulator radiation, in a given solid angle and frequency interval, at any point in the undulator, using the Lienard-Wiechert fields. When complete this code will be useful to the design of the diagnostics and x-ray optics.

5. Carl Schroeder is studying a "beam slicer" system to examine the possibility of inserting a beam line and collimators between the injector and the main linac. This would allow us to change the electron bunch charge and emittance to optimize the FEL performance, and reduce the wake fields and coherent radiation emission in the linac and compressors. The possibility of inserting such a beam line would greatly increase the flexibility of LCLS, and would be particularly important during commissioning.

6. Claudio Pellegrini is working, in collaboration with Roman Tatchyn and the X-ray optics group, on an X-ray pulse compressor, to reduce the X-ray pulse duration to the level of about 10fs.

Photoinjector R&D News *J. Clendenin*

GTF Status.

With the f=-2.5 m convex mirrors, the mode size in the regenerative amplifier was too small (1.8 mm diameter, cf. 2.0 mm at ANL). After switching to –1.5 mm mirrors, the mode size at 2.5 Hz is about 2.3 mm. The beam is stable, but perhaps just barely so. Mirrors with f=-2.0 m have been ordered.

Some damage is seen on one of the rod faces. It is not known when this occurred: perhaps it was during the period when the mode size was <2 mm. Jeremy West (President of Positive Light) and Bill White will be at SLAC April 25th to evaluate the damage on the rod face.

Meanwhile, the downstream optics is being retuned and the finishing touches are being applied to the IR FROG.

Cathode Testing.

UV optics was taken to LLNL. Laser can produce 25 mJ in UV.

Cathode holder diameter is being reduced to eliminate tendency to short to the 6-way cross that is to be used as the test chamber.

AFEL SASE Experiment.

The RF system is now fixed, but the laser needs work. The present plan is to continue the SASE experiment beginning 1st week of May.

CDR Progress.

A detailed layout of the injector tunnel has been started. The beamline will be laid out at 45° to the linac, about 2.5 feet from the NE tunnel wall. The matching section generated by Mark Woodley is in place. Radiation Physics has started on a shielding design.

Steve Gierman is now working on the diagnostics list and a plan for placement in the beamline.

The tunnel will be extended along the beamline axis by about 6 feet to give adequate room for the load-lock in addition to space for people and equipment to move around the back end of the gun.

Linac *Vinod Bharadwaj/Paul Emma*

Michael Borland (ANL) spent the week at SLAC helping to get the start-to-end simulations going. We now have a representation of the entire accelerator (1270 meters) from injector output at 150 MeV to undulator entrance at 14.35 GeV. Mark Woodley (SLAC) did much of the work involved in generating a detailed and realistic accelerator lattice (using MAD and a MAD-2-Elegant converter program), which includes the new compression parameters. Many parameter scans were done using the accelerator simulation code Elegant, to study jitter, error sensitivities and slice emittance preservation. The simulation uses six-dimensional particle tracking with wakefields, misalignments (BPMs, quads and structures) and a steering algorithm. The preliminary results show that the slice emittance is well preserved (<5% growth) through the 1270-meters of beamline. The projected emittance, however, can be increased by as much as a factor of two. We expect empirical corrections, not included yet, to reduce this projected emittance.

Injector timing jitter and charge jitter were studied, as were transverse betatron oscillations starting at the injector. Some of these tests were positive confirmations of earlier studies and some were new tolerance studies. As is fairly well known, there are many challenging stability tolerances such as <1 psec injector timing, <0.1 degree S-band RF phase, <4% charge, and <20%-of-beam-size transverse centroid oscillation tolerances. The effects of coherent synchrotron radiation were also studied with typically larger emittance growth results than previously calculated by Torsten Limberg (DESY). The results are still being compared.

Some agreement was also reached as to how to supply sufficient particle densities, from Elegant output to the FEL codes (e.g. Ginger). This is not tested yet but might be done fairly soon.

Parmela input files have been used (such as supplied by Jamie Rosenzweig) as input to Elegant, but so far we do not have a realistic Parmela file which includes the thermal emittance and the required slew on the temporal bunch distribution.

Undulator *Efim Gluskin/Liz Moog*

Gain lengths obtained using the code RON have been consistently longer than those reported in the LCLS Design Study Report. It was believed that this was due to a different transverse distribution in the beam - the RON calculations assumed a waterbag model, whereas results from other codes assumed a Gaussian transverse distribution. This belief was tested. RON was used to do calculations on a beam with a Gaussian transverse distribution. The result was that the gain length became even longer. Tests of the code are underway to find the reason for the discrepancies with other codes.

Calculations will be made to choose the optimal length for the undulators in the FODO lattice. In order for these calculations to be most meaningful, it is important to establish the validity of the codes used for the calculations. A code that gives a consistently wrong gain length will probably not give the best results for the undulator length either.

Calculations are now being made for a homogeneous undulator, so that comparisons can be made with analytical results and with other codes that handle the effect of separate quadrupole focusing differently.

X-Ray Optics *Art Toor/Roman Tatchyn*

We have continued our analysis of a windowless gas-filled X-ray attenuation cell under the assumption that a working gas is Xenon. Gas loads on the vacuum line of sight will be brought to a very low level (~10^{12} atoms/s) by using differential pumping. For a cell with a 1-mm diameter aperture the total length can be made as short as 1 m, with the X-ray attenuation coefficient up to 10^4. A feature of this design that helps to bring the length down is a tilted Laval nozzle in the first stage of the differential pumping system. For a cell with a 1-cm diameter aperture the length is 4 m with the X-ray attenuation coefficient up to 10^2. Honeycomb-type limiters or ion pumps will be used in the last stage of the large-aperture system to ensure a low level of gas loads on the Vacuum system. Possible ways of calibrating the system at large attenuations have been identified.

Obvious advantages of this scheme of attenuator are: 1) absence of moving parts; 2) the ease of controlling the attenuation coefficient in a very broad dynamical range; 3) Absence of windows or other elements that could suffer from high X-ray power density.

The definition of the layout for the Experiment Hall is proceeding. Existing drawings and survey data show the distance between the downstream face of the muon shielding and the access road is 285 m. The baseline distances for the major beam line components are:

Muon shield to undulator	68 m
Length of undulator	112 m
Undulator to beam dump	12 m
Shielding after beam dump	6 m
Experiment Hall	87 m
Total required length:	285 m

This leaves no margin. We need to look at the possibility of reducing some of these distances in order to provide the option for adding additional length to the undulator in the future, if required. The next X-ray Optics / Health Safety Meeting will review the operations safety protocol for the Experiment Hall floor plan as defined in early March.

The X-ray Optics Group met March 29 and Bill Fawley gave an excellent seminar on the physics and algorithms in the polychromatic FEL simulation code GINGER. His description for the rational of adopting SVEA and KMR wiggler averaging and the discussion of the underlying assumptions for each was helpful and informative and provided a better understanding on how Ginger applies slippage.

Roman Tatchyn gave a brief description of a beam compression concept that uses a structure consisting of a number of discrete LSMs made in such a way that each has a slightly different period and each has a slightly different angle with respect to the incident beam. This concept and a compression scheme proposed by Claudio Pellegrini involving two gratings and its variant using crystals will be discussed in more detail at our next X-ray Optics Meeting on April 12.

Slava Shlyaptsev continued design studies for LiH plasma lenses. At high currents (~8 kA, 2 μs) his simulations using the RADEX magnetohydrodynamic code show radiation collapse leading to high electron density contours that focus a 6Å LCLS beam to < 1000 Å. Other MHD codes (Lasnex and TRAC-II) will be used to independently study the details of the radiation collapse and the possible onset of instabilities.

Richard Bionta continued working on a time slicing technique using transmissive optics. The efficiency of his original design, which used a grating to sweep the chirped beam and a zone plate to focus onto a slit, was vastly improved by combining the two optics into a single optic that both sweeps and focuses. A practical point design, utilizing a 5 m focal length amplitude modulating zone plate in conjunction with a 5 micron slit, produces a

40- fs pulse (FWHM) downstream of the slit with a peak intensity of 2.3 x 10^{20} v^2/m^2. Further improvements in efficiency and slice length are expected.

Richard London, Roman Tatchyn, and Alberto Fasso are continuing with work on the development of algorithms to enable the code FLUKA to simulate the interaction of X-ray beams with grazing-incidence mirrors. The effect of reflectivity and the penetration depth of the inhomogeneous wave into the mirror surface can be represented within FLUKA by an effective reflectivity and an effective incidence angle. Conversions between the actual reflectivity parameters and the effective parameters for FLUKA are underway for several low-Z materials, angles of incidence, and energies spanning 6 - 14 keV.

VISA Report from ATF Newsletter *Ilan Ben-Zvi, Aaron Tremaine*

Here are the results from last week's run in PDF format:

http://www.nsls.bnl.gov/AccTest/R0/4_21_VISA.pdf

(Credit to the drawing of the undulator/magnets are to go to the great Alex "Kandinsky" Murokh!). For our next two run days, we are going to solely study the trajectory and how to improve it by correction algorithms using the two upstream steering magnets. We believe we have a good plan for separation of the spontaneous from the OTR in the BPMs using polarizers and filters. The transport is still being installed and should be finished once again, by Monday.