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Beam Instrumentation Tests for the Linear Collider using the SLAC A-Line and End Station A Update on SLAC LOI-2003.2

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The Linear Collider will be the next frontier accelerator facility for particle physics, providing exceptional resolving power and precision for exploring the TeV energy scale. New discoveries are expected in one or more exciting areas: Higgs and the explanation of particle masses, supersymmetry, dark matter, extra dimensions, unification of fundamental forces, … The luminosity at this facility will be a factor 1000 greater than that achieved at LEP and 10,000 times greater than achieved at the SLC.

Precise knowledge of the initial state is a distinct advantage for an e^+e^- collider for making precision measurements and for uncovering new physics. This advantage can only be fully realized if there is adequate instrumentation available to measure the beam properties at the interaction point (IP). Additionally, IP beam instrumentation is critical for achieving design luminosity.

During the engineering design phase for the LC over the next 5 years, we envision and are proposing to mockup key components of the IR region. The aim is to demonstrate the IR beam instrumentation that is required to achieve design luminosity and measure properties of the beam and beam-beam interaction to the precision required for LC physics.

A new feature at the LC is the large beam disruption and beamsstrahlung resulting from the intense electromagnetic fields during collision. Roughly 5% of the (MegaWatts of) beam power will be radiated into beamsstrahlung, far more than at the SLC. A test beam experiment at SLAC's ESA can mimic the beam disruption and beamstrahlung present at the LC, with multiple scattering and bremsstrahlung in a thick (~5% X_0) target. The performance of beam diagnostics planned for the LC *extraction line* (for example: BPMs for luminosity optimization, components for an energy spectrometer and a polarimeter) can therefore be tested in ESA downstream of a thick target.

We will take advantage of the high power beam and shielded beamline in ESA that were developed for the recent E-158 experiment, where the charge and time structure beam properties were similar to those for the warm X-band LC design. A wide range of beam properties are also possible: from single bunches of the right charge for either the warm or cold LC designs, to a bunch train closely resembling that planned for the warm LC or 2 bunches separated by 337 ns as in the cold LC design.

We are initially focusing on 4 independent beam tests:

1. **IP BPMs and kickers**. We want to demonstrate that the fast IP BPMs and kickers, located 4 meters downstream of the IP can work to the required precision, especially in the presence of the intense beam-beam interaction. This system has been identified as one of the highest risks to delivering design luminosities for both the warm and cold LC designs. This system must be robust against stray rf pickup from the beam and the beamsstrahlung. It must also be rad hard and robust against the intense background of low energy e+e- pairs in this region.
2. **BPM energy spectrometer**. Both the warm and cold LC designs envision a BPM energy spectrometer located upstream of the IR with a goal to measure the beam energy to 100 parts per million. This requires achieving 100 nanometer position accuracy and stability over lever arms of 10 meters and time scales of minutes to hours. We plan to carry out beam tests demonstrating the necessary BPM resolution and the required mechanical and electronics stability.
3. **Synchrotron light energy spectrometer**. Downstream of the IR, we plan to implement an independent energy spectrometer that would measure the separation between two synchrotron stripes with the separation determining the beam energy. We plan to carry out beam tests for the synchrotron detectors, the imaging techniques and the use of an undulator magnet for generating the synchrotron stripes.
4. **Forward calorimeter** for fast luminosity monitoring and 2-photon physics veto. The calorimeter at 5-40 mrad polar angle sees a high flux of low energy e+e- pairs from the beam-beam interaction and will be used for fast luminosity monitoring and beam tuning. It also serves as an important physics detector to identify low angle high energy electrons that arise in 2-photon physics events. Such electron ID is important for supersymmetry physics analyses that may be relevant for predicting the amount of dark matter in the Universe.

Other beam tests may include studies of rf pickup for LC Detector subsystems, such as the vertex detector. An IP girder test to demonstrate nanometer stabilization of the IP quads is also being done independently and it may be useful to incorporate that into an ESA beam test in the future.

A Letter-of-Intent for LC Beam Instrumentation Tests was submitted to SLAC's EPAC in November 2003 and received a very positive response from the committee and from the laboratory. Collaborators for the LOI included 27 physicists from 10 institutions, most of whom are involved in LC R&D proposals to the DOE and NSF. It also included collaborators from the UK and we are pursuing further European and Asian involvement in these tests. We plan to submit 2 or 3 test beam requests to SLAC by mid-June for some of the tests described above. The first phase of beam tests could be carried out in a 3-week run in June 2005.