No.
T-475

TEST REQUEST

Title: LC Beam 2 **Date:** June 11, 2004
Linear Collider - synchrotron stripe energy spectrometer

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Purpose of Test: Develop synchrotron stripe energy spectrometer for the Linear Collider

Description of Test Apparatus: **see attachment**

Beam Requirements: **see attachment**
Momentum: 28 GeV
Particles: 10^{10} single bunch
Rep. Rate: 10 Hz
Δ **p/p:** 1%

Space requirements (include sketch): see attachment

Special power requirements: see attachment

Duration of test and shift utilization: 1 week (can be simultaneous with LC-Beam 1

Desired calendar dates: June 2005

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Test Beam Coordinator____________________Date: __________
Radiation Physicist____________________Date: __________
Chairman, SOC____________________Date: __________
Area Manager____________________Date: __________
Accelerator Dept. Physicist____________________Date: __________

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Program Coordinator
Action: Approve/Disapprove/Defer Signature____________________Date: __________
Remarks:

Position-sensitive synchrotron radiation monitor using Quartz fibers for LC spectrometry

Eric Torrence

June 11, 2004

1 Purpose of Test

A Linear Collider spectrometer based on the WISRD design must be able to make precise measurements of the centroid and shape of the synchrotron radiation stripe which is used to image the primary electron beam. In the WISRD, this synchrotron radiation detector was composed of an array of 75 μm wires spaced on a 100 μm pitch. An alternate detector technology which may be feasible is to use Cherenkov light produced by secondary electrons traversing 100 μm Quartz fibers. This technology has several potential advantages over the wire array, including lower cross-talk, better background rejection due to the higher Cherenkov threshold, and simplified high-speed readout made possible by multi-anode PMTs.

The purpose of this beam test is to validate the Monte Carlo simulation of the Cherenkov light production and detection efficiency expected in the quartz fibers, while also directly comparing the signal-to-noise ratio seen in the quartz fibers with that observed in a traditional wire array detector.

A secondary purpose of this test is to look for unexpected operational or design issues which could compromise the performance of the quartz fiber detector. This could include backgrounds from stray particles, light induced in the fibers between the detector head and the shielded PMT, or excessive cross-talk between detector channels. Due to the small active area present in the 100 μm fibers, this detector technology is extremely difficult to test in a non-accelerator environment.

A final purpose of this test is to attempt to measure the beam energy distribution of a disrupted electron beam produced by scattering from a thin target.

2 Description of Test Apparatus

This beam test will consist of three separate position-sensitive detectors of synchrotron radiation, as shown in Figure 1. The primary detector is an array of eight 100 μm Quartz fibers and eight 600 μm Quartz fibers spaced on a 1 mm pitch inside a light-tight aluminum box. This combination of thin and fat fibers, and the 1 mm pitch, was chosen to ensure that a signal would be seen with this device without precise alignment while minimizing the total channel count. The fibers are read out using a multi-anode PMT enclosed in its own light-tight box attached to the main detector by way of a flexible conduit of approx. 1 meter length. The intent is to place the PMT enclosure on the tunnel floor shielded by lead bricks. To allow some control over the production of secondary electrons from the primary synchrotron photons, it is envisioned to also include a set of removable pre-radiator plates directly in front of the fiber array.

A secondary detector will be a wire array similar to the WISRD detector. The exact wire diameter and pitch is still to be determined, but a geometry similar to the WISRD is envisioned. It is possible that the WISRD wire array can be directly used. The purpose of this detector is to provide a baseline to which the quartz fiber performance can be compared. It is intended to mount both of these detectors on a moveable stage to avoid the need for precise positioning at installation, and allow for cross-channel calibration.

A third diagnostic detector is envisioned which deflects the visible synchrotron light out of the vacuum pipe using a thin mirror where it can be imaged by a CCD camera. This detector is inspired by the existing gated CCD camera installed in the A line. The primary purpose of this detector is to provide alignment and targeting information as well as to monitor the 2D profile of the synchrotron spot.

Additional detectors, if available, could also be easily mounted on the detector stand for testing. One interesting possibility would be a diamond detector with 100 μm pitch readout. Testing the reliability of this device in the intense synchrotron radiation environment expected would be very useful.

3 Beam Requirements

In principle, to test the Quartz fiber detector all that is needed is a source of $\simeq 1$ MeV photons, as the Cherenkov threshold for electrons in Quartz is at 700 keV total energy. To match as well as possible the beamline foreseen at the Linear Collider, the synchrotron radiation should be produced from a wiggler sitting immediately after a dipole bend of around 5 mRad as shown in Figure 2. The detectors sit some 10s of meters downstream where a reasonable separation can be achieved between the synchrotron radiation detectors and the primary electron beam. Using 10D45 dipoles, a separation of five centimeters from the outside of a 2 inch radius beampipe can be achieved at a distance of 20 meters downstream from the second dipole.

The wiggler needs to be oriented to produce a synchrotron radiation stripe transverse to the stripe from the dipole bends with a transverse angular divergence of order 1 mRad. To provide this sort of radiation pattern, one needs a "wiggler" with long wavelength and high pole-tip field. These specifications are well matched by the original SPEAR wiggler described in SLAC-PUB-2289. This wiggler would produce synchrotron light with critical energy of 0.88 MeV at 28 GeV beam energy and a pole tip field of 1.7 Tesla. The synchrotron radiation and location of the detectors is shown in Figure 3. The critical energy for a 10D45 and 10D90 dipole are 0.34 and 0.17 MeV with a bend angle of 8 mRad.

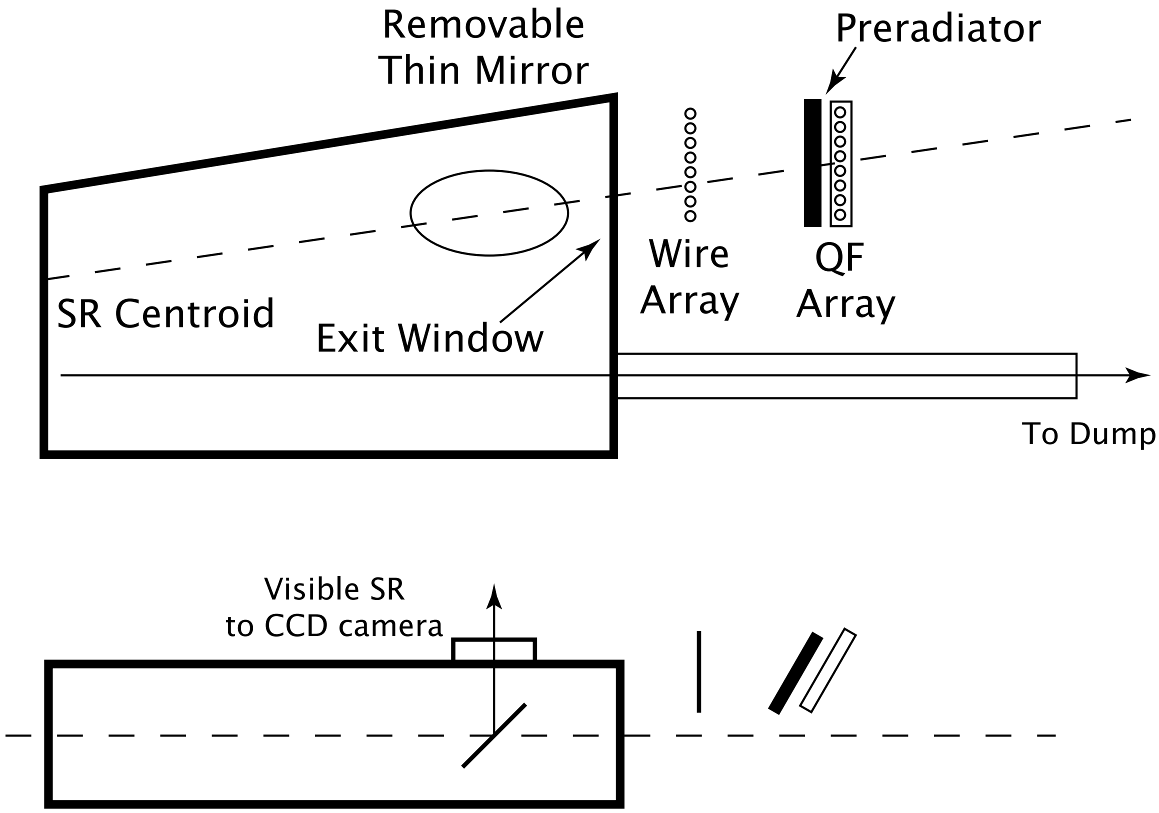

Figure 1: Detector configuration

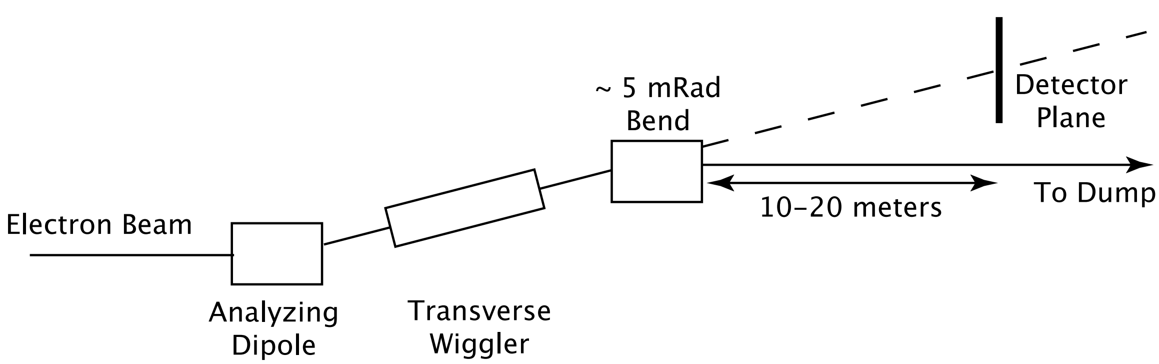

Figure 2: Beamline layout

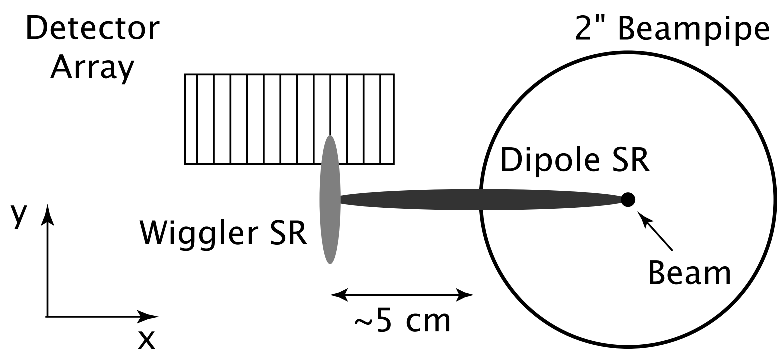

Figure 3: Synchrotron radiation pattern at the detector plane

Any beam energy is acceptable as long as (with the chosen wiggler field) it can provide $\simeq 1$ MeV photons. A beam energy of 30 GeV appears to be acceptable for this, although tests at higher beam energy would be desirable to test the detector response as a function of the critical energy. Increasing the beam energy to 35 GeV, for example, would raise the critical energy of the wiggler photons to 1.37 MeV. For this test, a slow repetition rate (10 Hz) and any bunch structure is acceptable. In future tests it may be desirable to demonstrate fast (1.4 ns) performance of this detector. No particular demands are made on the momentum bite of the A-line for this current test. A planned upgrade for a future test would be to install a finer pitched detector and attempt to resolve a double-peaked energy distribution from the linac similar to that expected at an X-band LC. A possible end station A layout is shown in Figure 4 which includes the BPM installation for the complimentary BPM test, the thin target to the left, and an additional pair of quads to focus the beam on the detector plane with the target inserted.

4 Equipment

The user can potentially provide a beamline insertion of appropriate length which contains the exit window and mirror box, although this work might be more expeditiously done at SLAC. The detectors themselves and front-end electronics (including the phototubes) will be provided by the user. Equipment required from the lab include all magnets, collimators, and other beamline components, along with mounting stands for the detectors and a translation stage for the detector table. Cabling and DAQ readout for at least 32 channels of fast, PMT-style signals will also be required, although this could also be provided by the user if necessary.

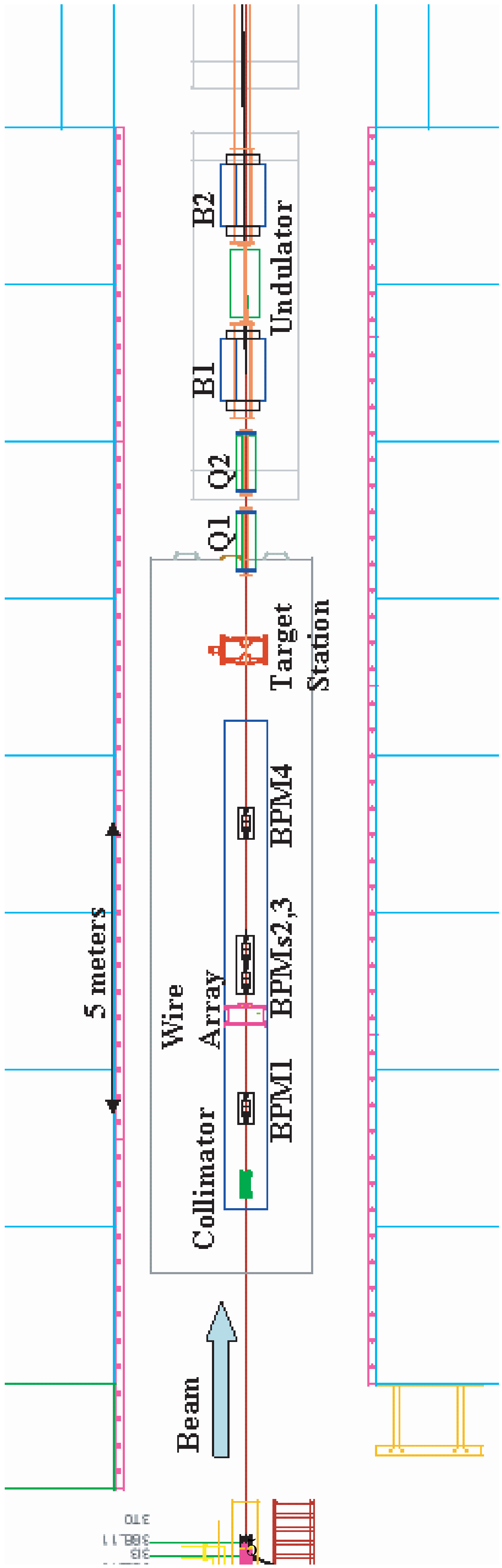

Figure 4: Layout of end station A including magnets for this test.