Project name

Quartz fiber Çerenkov detector for precision beam energy spectrometer

Classification

Beam Instrumentation (Luminosity, Energy, Polarization)

Institution(s) and personnel

University of Oregon, Department of Physics:
Eric Torrence (professor), Paul Csonka (student)

Contact person

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Project Overview

A measurement of the absolute beam energy with a precision approaching 10^{-4} is needed for many of the physics analyses foreseen at a future LC. One possible scheme to realize this precision is to improve upon the WISRD spectrometer built and operated at the SLC. In this scheme, two horizontal dipole magnets produce stripes of synchrotron radiation which are detected at a downstream target. The separation between these stripes, provided by the bending of a third vertical dipole magnet, is then inversely proportional to the beam energy. One of the dominant systematic errors in the SLC WISRD design was the absolute alignment accuracy of the copper wire arrays used as the downstream synchrotron radiation detector.

We propose to develop a different detector technology for position sensitive detectors using the Çerenkov light produced in an array of fused quartz fibers read out by multi-anode photomultiplier tubes (PMTs). While quartz fibers have been used as the sensitive material in calorimeters for some time, the application of this technique as a position sensitive detector is less common. The advantages of this technology over traditional solid-state detectors like silicon strips are threefold. First, the fused silica fibers are very radiation hard. Second, the Çerenkov threshold of electrons in quartz at $E \sim 0.7$ MeV provides some tolerance to backgrounds from very soft photons. Third, the PMT readout can in principle be fast enough to keep up with the 1.4 ns bunch spacing of the NLC bunch train allowing for pulse-to-pulse measurements. With typical fiber diameters of ~100 microns, a very finely segmented fast detector can be designed which can operate in the hostile environment near the LC beam line.

This research is currently motivated by the needs of a beam energy spectrometer, but a similar detector could also be useful in various other applications, for example a precision position measurement of the kinematic endpoint in the Compton polarimeter, or imaging synchrotron radiation for other machine diagnostics.

Description of first year project activities

An excellent undergraduate student (Paul Csonka) is currently working with the Oregon group to characterize a pair of Hamamatsu H6568 multi-anode PMTs. With 16 channels per tube, sub-nanosecond rise time, and a very compact profile, these tubes appear to be a suitable solution for the readout of a Quartz fiber Çerenkov detector. This current study will provide a full characterization of the gain, linearity, crosstalk, and stability characteristics of these tubes.

In the coming year, Paul is interested in pursuing the design, construction, and testing of a small prototype fiber array detector as a senior honors research thesis. The idea is to produce a 32 fiber prototype with four detector planes of eight fibers each which will provide a four-fold coincidence for 'tracking' incident particles. It is envisioned to use low energy O(1 MeV) electron sources to characterize the performance of this detector.

Since this detector is intended to be sensitive to O(2 MeV) photons rather than electrons, it will also be important to optimize the amount of material used to convert the photons while maintaining a reasonable detection efficiency. We also intend to test a variety of mechanical designs for the fiber array itself to improve the accuracy and stability of positioning the fibers themselves. At the end of his work, Paul will be required to produce a thesis documenting this project.

Most of the equipment needed for this project including shop facilities, data acquisition infrastructure, and the PMTs are available already at the University of Oregon. Support is requested for the student's salary, some miscellaneous optics supplies, and enough channels of ADC to read out the full prototype module.

Beyond the first year, future work is likely to include a refinement of the prototype design to optimize the performance and cost of a full scale detector. A beam test of this detector in the A-line at SLAC where a large bending dipole produces a synchrotron radiation stripe comparable to that needed for a WISRD-style spectrometer is also desirable. Eventually, the development of a fast data acquisition system capable of handling the ~1 ns NLC bunch structure will also be required.

First Year Budget

Institution	Item	Cost
Oregon	Summer + academic year undergraduate salary	$6,500
Oregon	CAEN V792 32ch VME Charge ADC	$4,325
Oregon	Other materials (fibers and assorted optics tools)	$1,000
Oregon	Indirect costs (26%)	$3,074
	Total	$14,899