Project name

Studies of the Use of Scintillating Fibers for an Intermediate Tracker which Provides Precise Timing and Bunch Identification

Classification (accelerator/detector:subsystem)

Detector: Tracking

Institution(s) and personnel

Indiana University (Bloomington), Department of Physics:
Richard J. Van Kooten (associate professor), t.b.a. (50% LC postdoc)

University of Notre Dame, Department of Physics:
Barry Baumbaugh (engineer), Michael Hildreth (assistant professor), Randy Ruchti (professor), Mitchell Wayne (professor), Jadzia Warchol (research professor)

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Project Overview

The performance and capabilities of the charged particle tracking in either a TPC-based large LC detector or silicon-based detector can be enhanced by the presence of an intermediate tracker at radii just below the inside radius of the TPC, or in a silicon strip device, particularly with long strips, either inside or outside the central tracker. In the case of a TPC-based detector, such a device would link tracks between the vertex and central tracking detectors, improve pattern recognition, and provide a reliable and stable measurement points close to the TPC for use in the calibration of the TPC and monitoring variations of its characteristics with time. An intermediate tracker built from scintillating fibers has the advantages of very compact radial extent, simplicity of operation, and good single-hit resolution (80-100 μm). Possibly most importantly, in both tracking scenarios a scintillating fiber tracker can offer high-precision timing of tracks in events.

The current NLC/JLC machine design provides beams composed of trains of many (>100) bunches with bunch spacings of 1.4 ns. Large rates (10's of nb) of two-photon interactions are expected both from interactions of virtual photons from each beam and virtual photons with real photons from beamstrahlung. During the crossing of each bunch train one expects many of these two-photon interactions that result in "mini-jets" of particles spraying into the detector. The overlap in the tracking devices of the much more prevalent "mini-jets" with the e^+e^- interaction events of interest can be a problem if bunches are not identified in time which would allow the removal of extraneous particles from the analysis. Simulation studies already performed show

significant impact on Higgs events with missing energy when two-photon events from prior or subsequent bunches are overlaid on top of the event of interest[1]. The planned resolution of a TPC tracking subdetector would result in integration of these two-photon events over 4–5 bunches, whereas a system with sub-nsec timing could identify from which individual bunch the tracks have originated.

A scintillating fiber intermediate tracker coupled by clear fiber to visible light photon counters (VLPC'S, Si:As devices manufactured by Boeing[1] with a fast response time of less than 100 ps) read out by the SVXIIe (or more recent versions such as the SVXIV) chip can achieve time resolutions less than 1 ns to associate tracks with individual bunches as well as complement time measurements in the TPC or silicon tracker. Using the resources and expertise developed within our groups from working on the Scintillating Fiber Tracker[2] on the DØ experiment, we propose to demonstrate the feasibility of sub-ns timing in a scintillating tracker device.

Description of first year project activities

We propose to investigate the potential for precision system timing using an intermediate scintillating fiber tracker. Using an existing cosmic ray test stand[3] at Lab 3 at FNAL, layers of prototype scintillating fiber ribbons from DØ will be mounted on carbon fiber scintillators approximating the inner radius carbon fiber structure of a TPC. External precision position measurements will be provided by existing layers of proportional drift tubes. Front-end electronics and DAQ will be modified as needed to be able to allow faster readout of the VLPC's present in the prototype set-up to approach desired time precisions. Tests will be made using cosmic ray samples to confirm overall system time and position resolutions.

Accompanying simulations incorporating an intermediate layer of scintillating fibers both at the inner radius and outer radius of a TPC in a LC detector will be continued as well as an outer layer of fibers in a silicon tracking based detector to determine impact on track parameter resolutions. For the TPC option, initial studies have shown[2] that the measurement points offset the addition of material of the fibers and neither the momentum resolution nor impact parameter resolution is degraded. More complete simulations will be attempted to investigate its impact on track pattern recognition. Finally, physics analysis simulations will be continued to compare results obtained when integrating and overlaying events over several bunches to results when bunch identification is available.

Both the Indiana and Notre Dame groups have experience with scintillating fibers, VLPC's, the related DAQ components, and the cosmic ray test stand through their work on the central scintillating fiber tracker of the DØ upgrade detector. They have also

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[1] Boeing Electronic Systems, 3370 Miraloma Ave., Anaheim, CA 92803; M.D. Petroff *et al*., Appl. Phys. Lett. **51** (1987) 406.

[2] A. Bross et al., *The D0 scintillating fiber tracker*, published in Proceedings of Notre Dame 1997: Scintillating Fiber Detectors, World Scientific.

[3] Described in P. Baringer *et al*., *Cosmic Ray Tests of the DØ Preshower Detector*, Nuc. Inst. and Meth. **A469** (2001) 295.

collaborated in the past as part of this subdetector in the fabrication of clear fiber optic waveguides carrying the light from the scintillating fibers to VLPC's. Personnel will work part-time on the project, and 50% of the Indiana postdoc is dedicated to linear collider R&D.

The funding request is shown below and is for the first year only. Results from the studies of the first year will determine the direction of research the following years when different scintillating fiber formulations, different versions of VLPC sensors, and improved electronic and DAQ readout could be pursued. Finally, the embedding of such scintillating fibers into calorimeter systems allowing precise timing of neutral clusters as well could be considered in the future depending on the success of this R&D direction.

Budget (First Year)

Institution	Item	Cost
Indiana	Modification of existing prototype ribbons (3 layers, 128 fibers each, 60 cm long)	$2,000
Indiana	Re-use of clear fibers, optical connectors	$2,000
Notre Dame	Refurbished VLPC readout system: modified analog electronics	$12,000
Indiana	Consumables for cosmic ray test stand (gas for PDT system; LNHe, LN for VLPC cryogenics)	$4,000
50% Indiana 50% Notre Dame	Faster DAQ components, partial instrumentation with 32 channels of fast TDC	$10,000
Indiana	Test equipment, fast digital storage oscilloscope	$9,500
	Total	**$39,500**

[1] R. Van Kooten, *Studies of Event Overlap in Higgs Events: Need for Bunch ID*, presented at Chicago Linear Collider Workshop, Gleacher Center, Chicago, IL, 8 Jan. 2002 and available at `http://hep.physics.indiana.edu/~rickv/nlc/overlap_chicago.pdf`.

[2] Using `LCDTRK` (`http://www.slac.stanford.edu/~schumm/lcdtrk20011204.tar.gz`), author B.Schumm.