Scintillator Fibers for Intermediate Tracking and Bunch Identification

OUTLINE

- The problem
- Planned work: simulations, hardware
- Current status, some results

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Fermilab

Alan Bross (staff physicist)

Request

First year, $39.5k

Mostly equipment and DAQ modifications,
also parts, consumbables for test stand
Effects of Bunch Overlap

NLC Bunch Structure:

- Many bunches per train
- Trains at 120 Hz, msec between trains
- 1.4 nsec spacing between bunches
- High luminosity per bunch

Design luminosity = $2.2 \times 10^{-34}$ cm$^{-2}$s$^{-1}$

$$\mathcal{L}_\text{bunch} = \frac{2.2 \times 10^{-34} \text{ cm}^{-2}\text{s}^{-1}}{190 \times 120 \text{ s}^{-1}}$$

$$\int \mathcal{L}_\text{bunch} \sim 1.0 \mu\text{b}$$

**Problem:** Physics process with largest cross section gives largest contribution to event-event overlap

- Multiple interactions in single bunch (but not spread out in z like at Tevatron!)
- Hadrons from $\gamma\gamma$ interactions of the beamstrahlung photons
- Multiple bunch collisions within the integration time of detector components (same luminous region in z, slightly out-of-time depending on bunch)
Scintillating fiber tracker, $\sigma \sim 1 \text{ nsec}$

system wide should be possible, resolve single bunches

"Strawman" for L detector:
Two axial layers, two 3 degree stereo layers
Half-length of 29.5 cm, average radius of 48 cm
(mounted on inside of inner layer of TPC)

~15,000 channels

Single-hit resolution of 80–100 $\mu$m ,
has been checked using Bruce S.'s programs that extra material does not degrade impact parameter resolution

Some physics studies already performed of Higgs events overlapped with 2-photon events
detector simulations, adding 0.7% $X_0$ at this radius; extra material, but more measurement points

almost a "wash"; at least no degradation (same is true for impact parameter resolution)

new: student started with work implementing to check effects on pattern recognition/track-finding
- Largest effects on channels involving invisible energy and missing mass

- e.g., measurement of $WW$-fusion production cross section: $\sigma(\nu\nu h)$:

- Potentially large relative systematic effect (use same templates, 2.0% effect) if background level not known well,

- New: contributions $\sim 60\%$ charged particles, $\sim 40\%$ neutrals for $\cos(\theta) < 0.97$ cut

Changes depending on forward tracking and forward calorimetry,  
$\Rightarrow$ want timing in forward region too

- TPC still has decent timing, integrates over a few bunches. Maximum impact of above overlapping multiple events with Poisson distribution being studied.
Existing Test Stand, Lab 3, Fermilab

Carbon Fiber Cylinder for sci. fiber ribbon mounting

Scintillator

30cm

x

y

z

Iron

VLPC readout, cryostat, DAQ

Frontend board

Cryostat

VME Crate

PC

Ethernet

SGI
- Modify DAQ for fast timing

- Piggy-back on D0 tests for using fast timing (MCMII, "Trip Chip", discriminator) from one end for $z$ measurement; modify readout for both ends

- Measure system timing resolution, compare to MC simulations. IU student with light path/response MC verifying time resolutions

![Graph showing time resolution](image)

- Bross, MC predictions (single end)

- Fibers in hand, faster fluorescence
• Notre Dame/FNAL: SBIR/STTR collaborations for scint. fibers more light yield, faster decay?

• Continue Higgs simulations for timing impact

Future (following years)

• Continued optimization of fiber formulation and VLPC version (multi-anode PMT's as anode count continues to increase...?)

• R&D for integration with a TPC

• Collaboration with calorimeter groups? (e.g., silicon/tungsten calorimeter, time resolution of ~10 nsec...) Embedding of scintillator fibers into calorimeter systems – precise timing of neutral clusters also