Scintillator Fibers for Intermediate Tracking and Bunch Identification

OUTLINE

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

Rick Van Kooten
Indiana University

Mike Hildreth
Univ. of Notre Dame

ARLINGTON LINEAR COLLIDER WORKSHOP

UTA

American Linear Collider Physics Group

University Texas, Arlington
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People

- Indiana University

  RvK (faculty),
  50% postdoc (other 50% D0), starting
  1 Jan. 2003, Daniela Bauer
  Keith Turpin (undergrad)

- University Notre Dame

  Mike Hildreth (faculty), Randy Ruchti (faculty)
  Mitch Wayne (faculty),
  Jadzia Warchol (research scientist),
  Barry Baumbaugh (engineer)

- 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

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

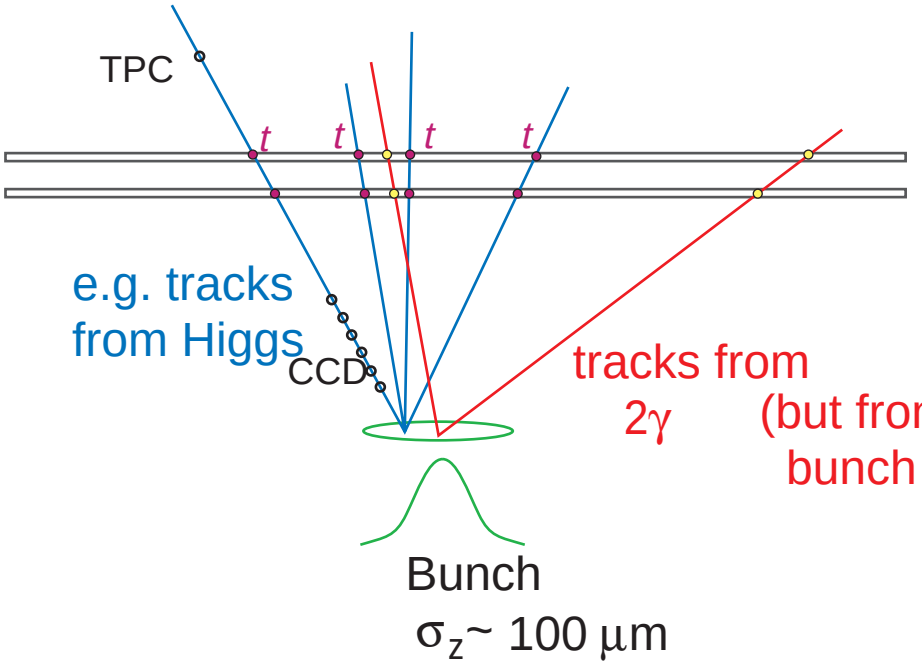
$$\mathcal{L}_{\text{bunch}} = \frac{2.2 \times 10^{-34}\ \text{cm}^{-2}\text{s}^{-1}}{190 \times 120\ \text{s}^{-1}}$$

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

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)

Bunch Id via Track Timing



- Scintillating fiber tracker, σ ~ 1 nsec

  system wide should be possible, resolve single bunches

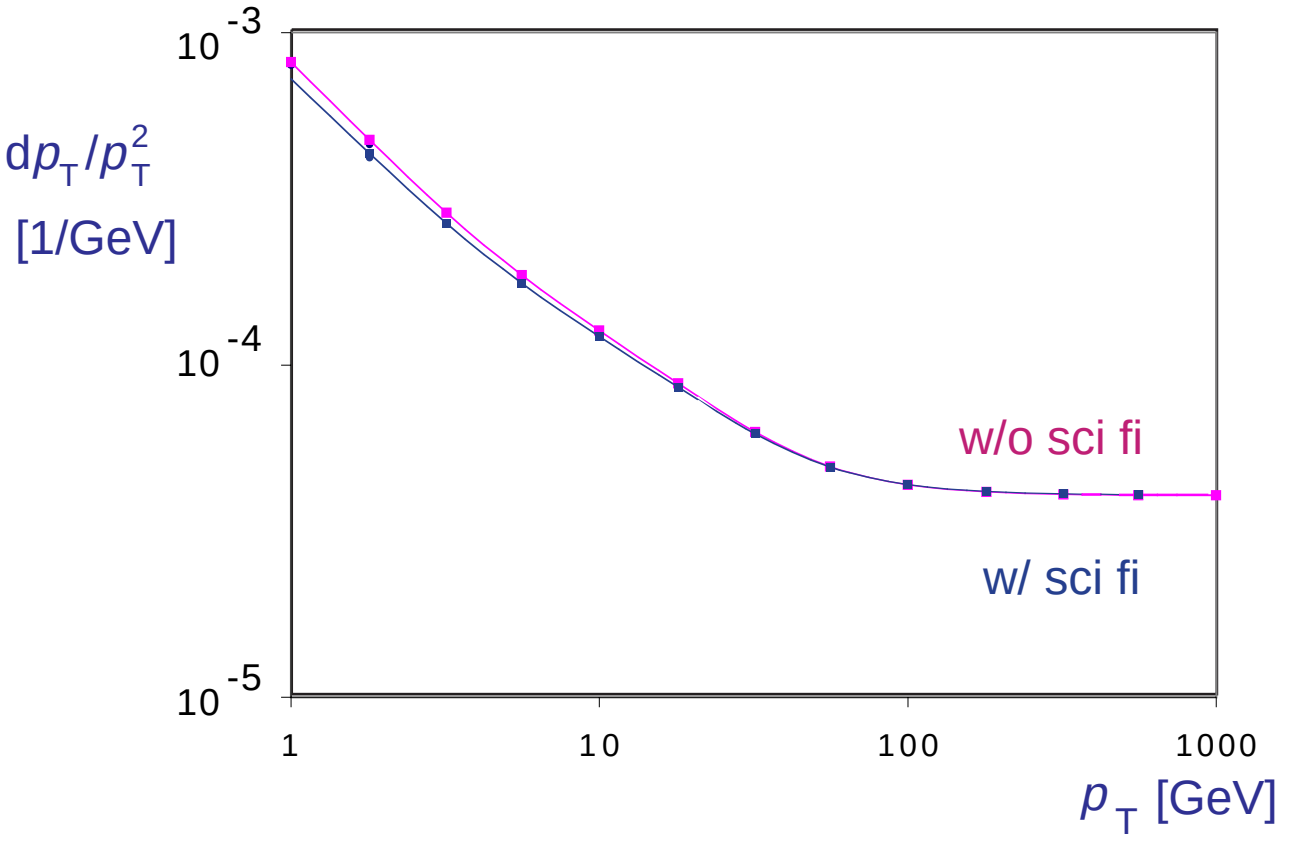
  "Strawman" for L detector:
  Two axial layers, two 3 degree stereo layers
  Half-length of 29.5 cm, average radius of 48 cm
  (mounted on inside of inner layer of TPC)

  ~15,000 channels

- Single-hit resolution of 80–100 μm ,
  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

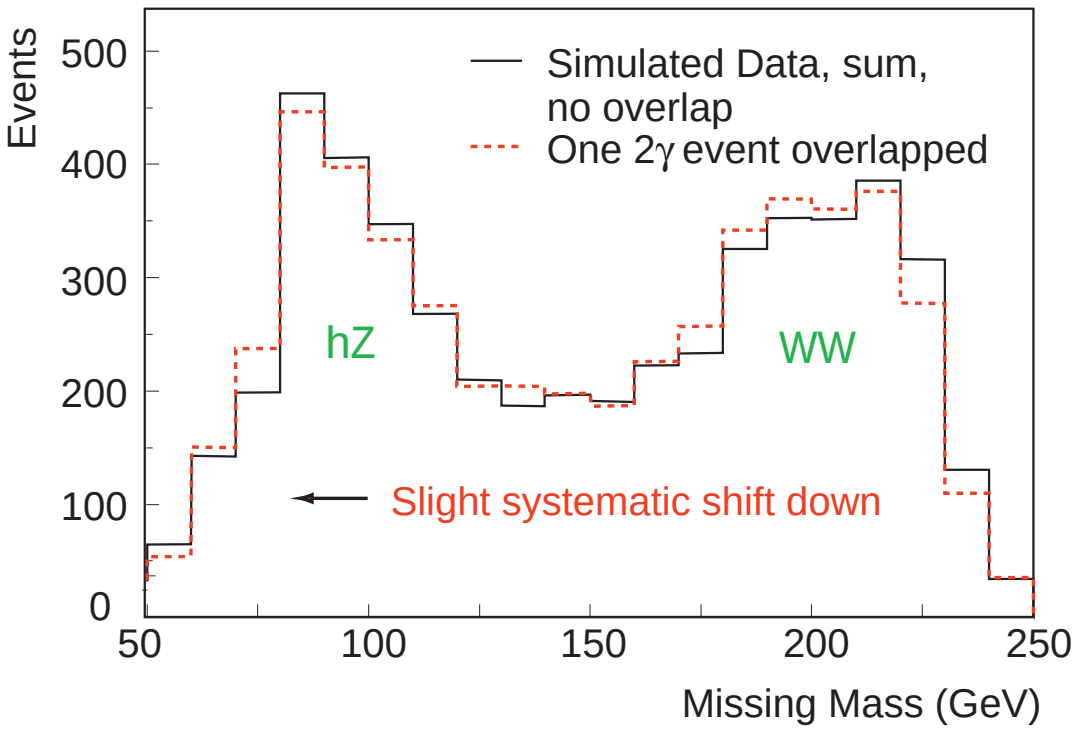
- detector simulations, adding 0.7% X_0 at this radius; extra material, but more measurement points

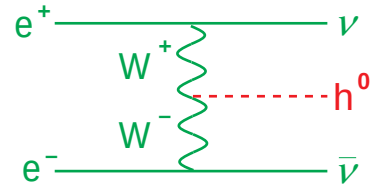


- almost a "wash"; at least no degradation (same is true for impact parameter resolution)

- 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: $\sigma(\nu\nu h)$:





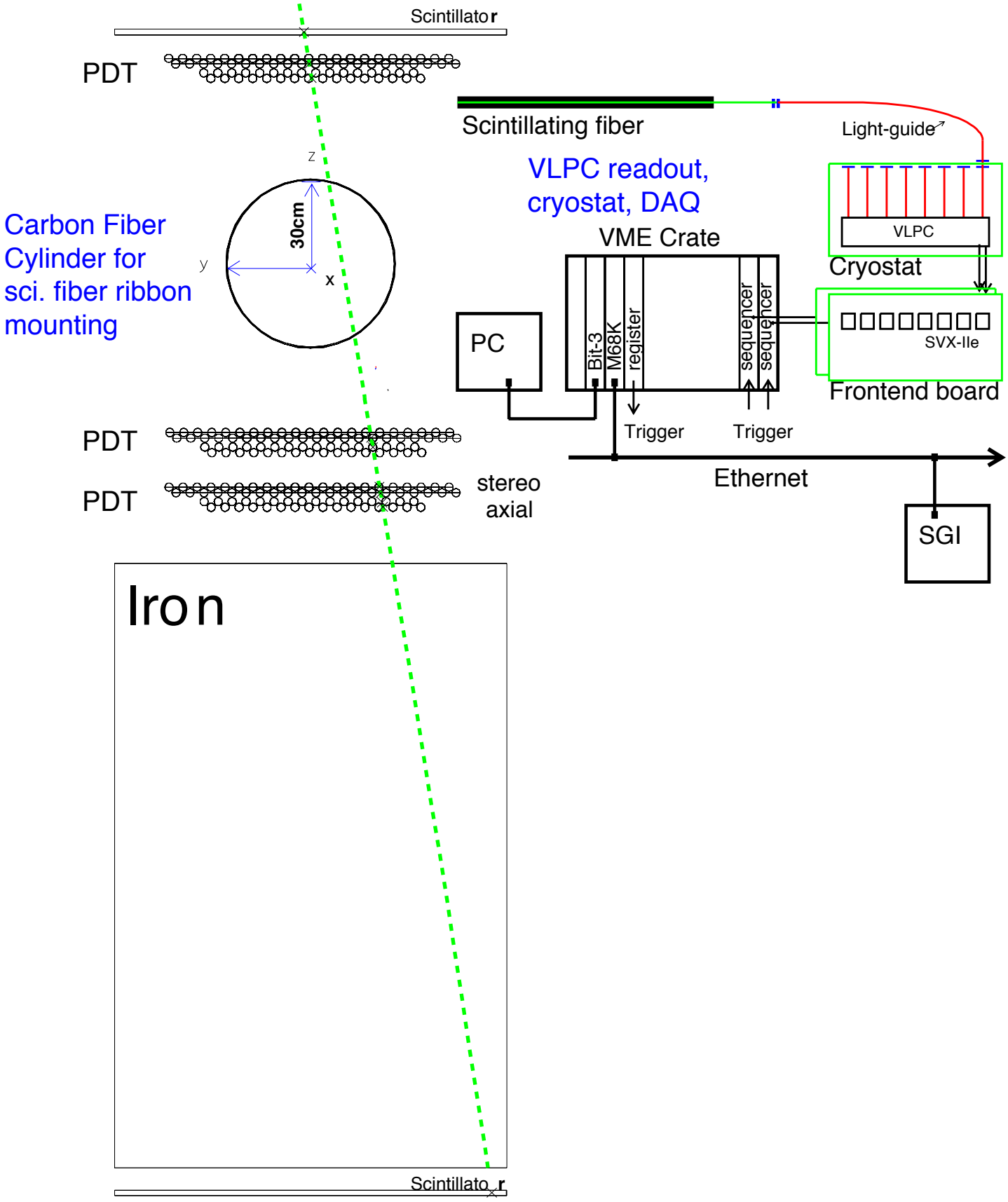
- Potentially large relative systematic effect (use same templates, 2.0% effect) if background level not known well,

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

  Changes depending on forward tracking and forward calorimetry,
  ⇒ 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

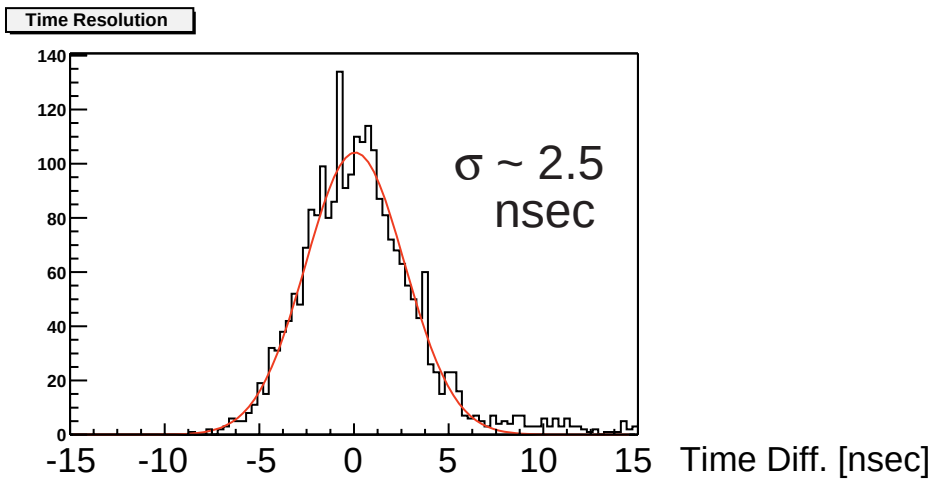


First Year Activities

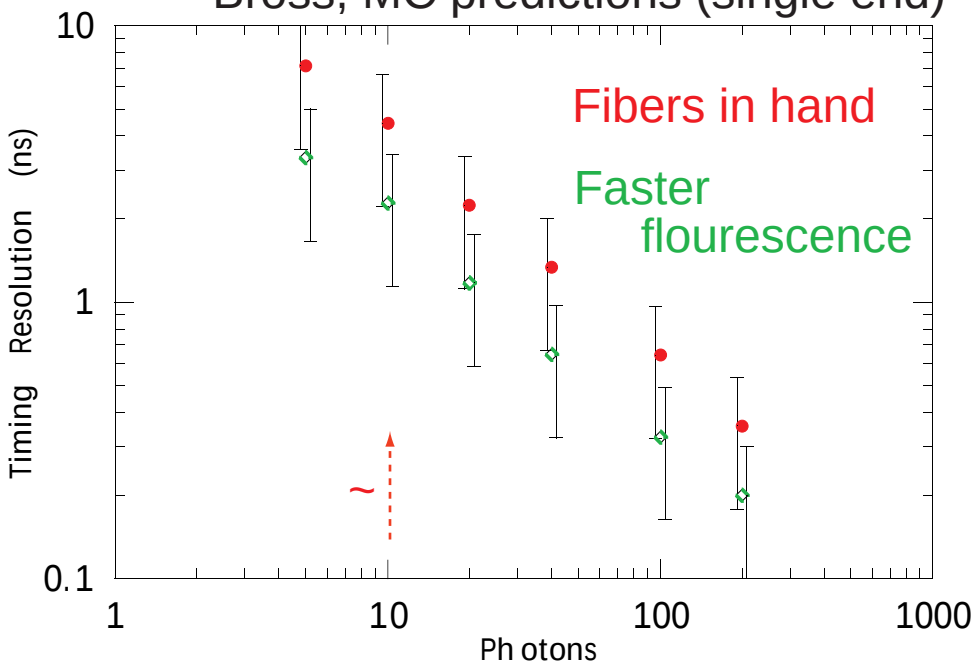
- Modify DAQ for fast timing

- 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 wih light path/response MC verifying time resolutions



Bross, MC predictions (single end)



- 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