Forward Tracking Hodoscope for SANE and g_1^d / F_1^d

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Goals and Requirements of the Tracker

Goals:

- **Provide redundant and efficient electron detection with limited tracking resolution ($\sim$5 mm) to suppress background.**

- **Reject non-target related backgrounds.**

- **Determination of particle charge sign – discriminate low momentum positrons from electrons.**

- **Measure positron asymmetry for transverse field configuration.**

- **Partially reduce positron contamination of electron sample.**

Requirements:

- **Locate detector as close to target as possible to reduce contributions from knock-ons to gas Čerenkov background.**

- **Detector as thin as possible.**

- **Operate in high magnetic field ($\sim$4 kG) region.**

- **To determine particle charge sign, need position resolution of $\sigma_y \sim$1–2 mm for p=1 GeV/c particle.**

Tracking Hodoscope Design
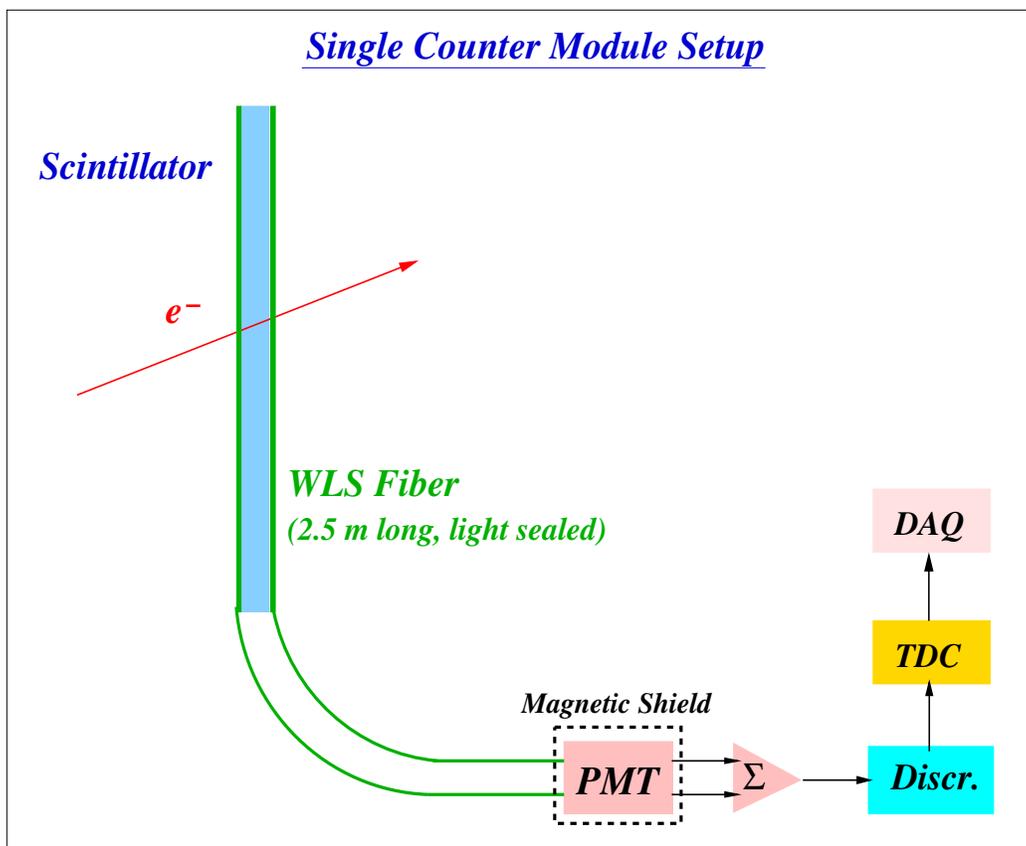
Location and Size:

- *Located 50 cm downstream of target directly in front of gas Čerenkov.*

- *Active area: 38 cm (vertical) $\times$ 21 cm (horizontal).*

- *128 bars along vertical and 64 along horizontal.*

- *Two Y planes, offset by 1.5 mm for redundancy, and one X plane.*

- *Vertical position resolution (1/2 bar width): $\sigma_y \sim 1.5$ mm.*

Material:

- *Bicron BC-408 Plastic Scintillator (3 mm $\times$ 3 mm square).*

- *Bicron BCF-92MC multi-clad blue-green WLS Fiber (1.2 mm $\varnothing$, 2.5 m long).*

- *Two fibers glued on to front and back of scintillator surfaces along length of bar.*

- *Scintillator/Fiber unit wrapped with Teflon for reflectivity.*

Tracker Readout System

- *Single-ended readout with 64-channel multianode PMT (Hamamatsu 8804).*

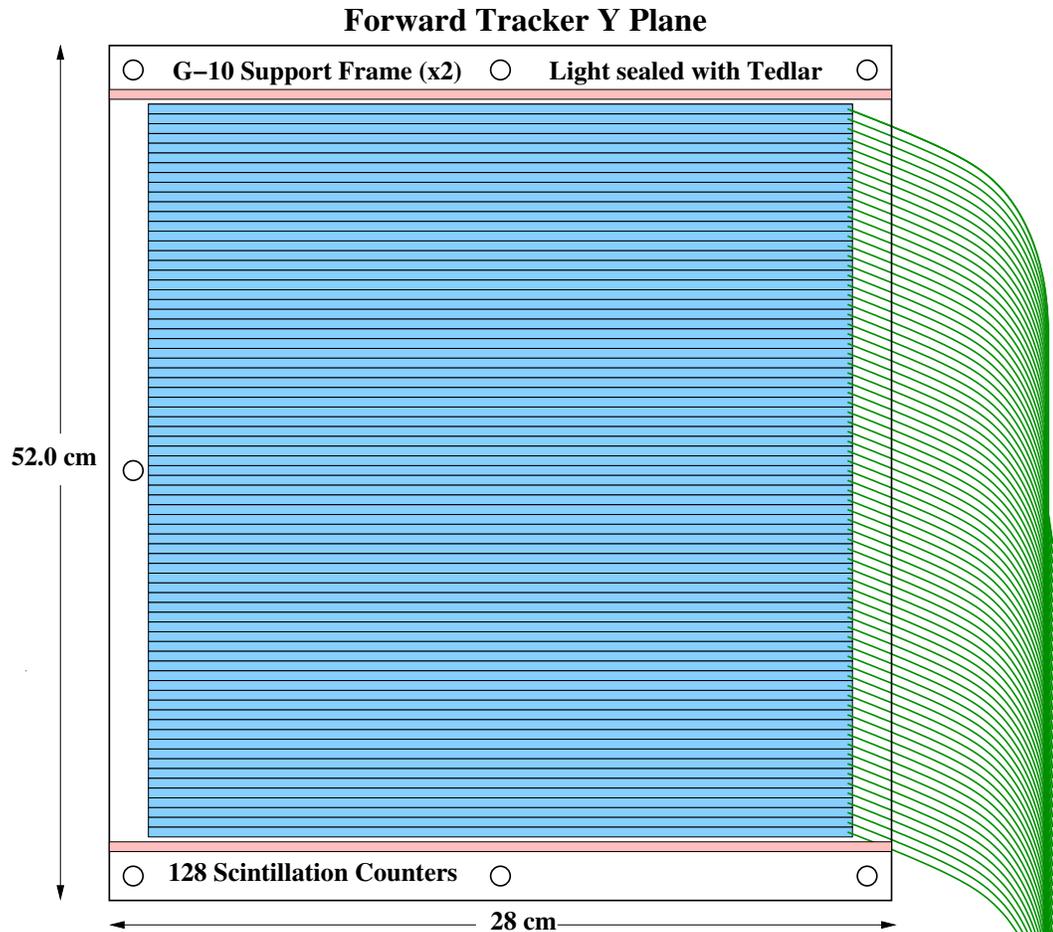- *Discriminator (LeCroy 4413) plus TDC (LeCroy 1877) per channel.*

Single Counter Module Setup

Scintillator

e^-

WLS Fiber
(2.5 m long, light sealed)

Magnetic Shield

DAQ

TDC

PMT | Σ | **Discr.**

- *Tracker not included in event trigger.*

- *Coincidence (in software) of offset Y planes for reliability.*

Tracker Mount Support Frame

- *Groups of 8-single-counter modules stacked next to each other in each plane.*

- *Tedlar separator between counters to prevent light crosstalk.*

- *Counters held in place between two G-10 frames per plane.*

- *WLS fibers coupled to PMT with Delrin block adapter and optical grease.*

- *All three planes mounted on self-support frame.*

- *Shielded box with PMTs on SOS platform >2 m away from target magnetic field.*
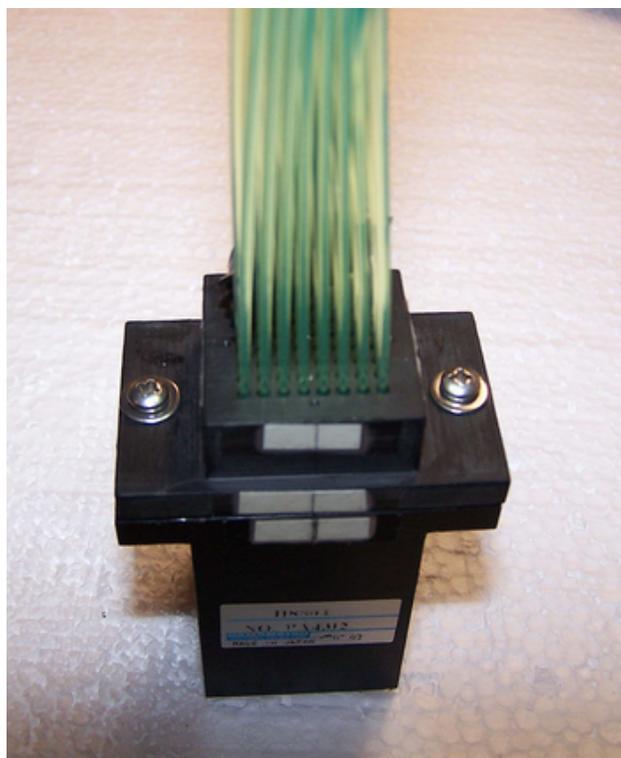
Tracker Mount Support Frame

Forward Tracker Y Plane

○ **G−10 Support Frame (x2)** ○ **Light sealed with Tedlar** ○

52.0 cm

○

○ **128 Scintillation Counters** ○

28 cm

Wavelength Shifting Fibers To Hamamatsu H8804 PMT
2.5 m long (light sealed)   64 Channel Multianode

1 2 3 4 5 6 7 8

3 cm

57 58 59 60 61 62 63 64

Fiber−PMT Mount
Delrin Block

2 cm
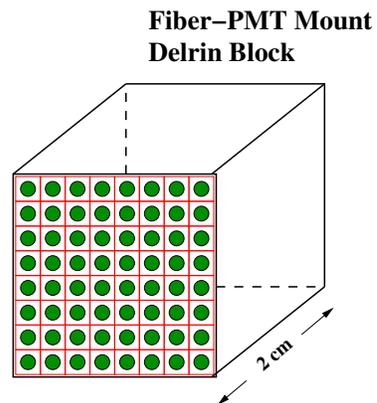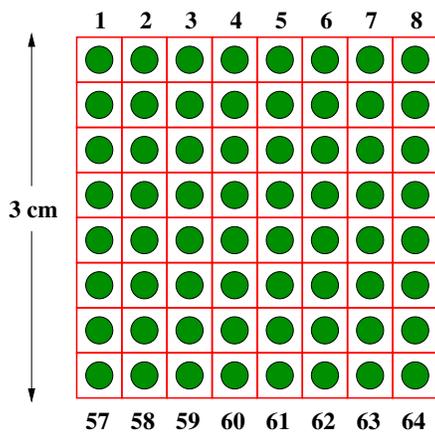
Tracker Mount Support Frame
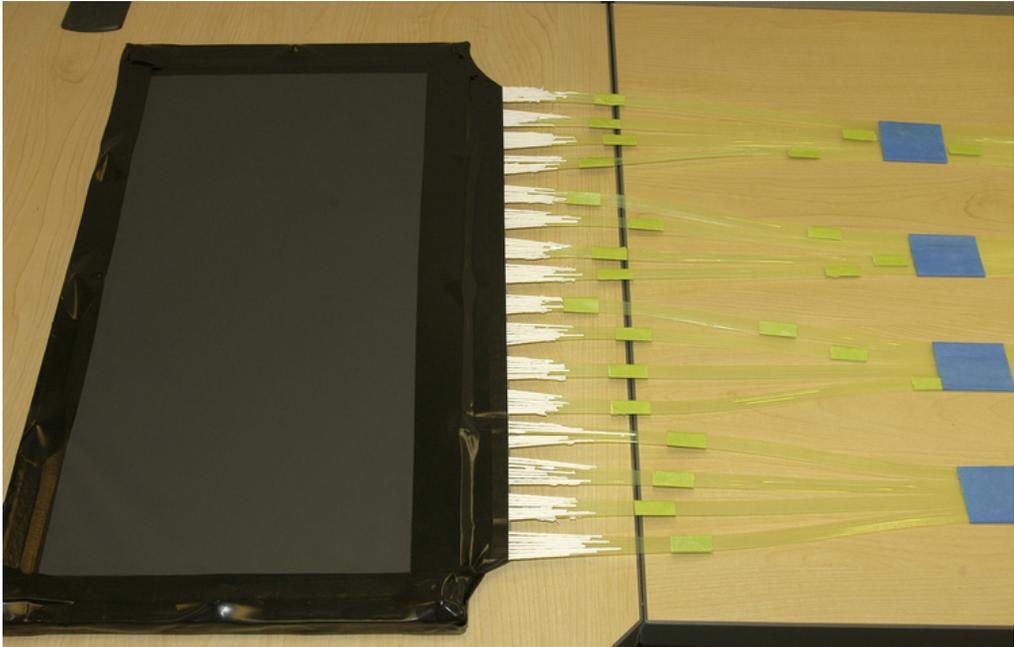
Fiber-PMT Mount Block

Tracker Beam Tests

- *Prototype Y plane (May-June, 2007)*

  - *12 scintillator-fiber units and 4 only WLS fibers units.*

  - *Tracker mounted on Minerνa test frame in SOS hut.*

  - *z-distance 83 cm from SOS focal plane.*

  - *SOS at θ=147°, p=300–480 MeV/c for negative particles.*

- *One complete Y-plane of 128 counters (November, 2007)*

  - *Located ~65 cm from target at ~60 deg.*

  - *BigCal at 600 cm from target.*

  - *Target: 4 cm LH2 and BeO.*

  - *E_e=2.536 GeV.*

  - *I_e=0.5 and 0.1 μA.*

- *All three planes: Y1, Y2, and X (April, 2008)*

  - *Y1, Y2 counters with single fibers.*

  - *X counters with double fibers.*

  - *Target: 4 cm LH2 and Thin C.*

  - *E_e=5.71 and 3.46 GeV.*

  - *I_e=0.20 to 0.35 μA.*

Prototype in SOS Test Results

- *Very clean timing response observed with $\sigma \sim 5$ ns.*

- *Measured vertical separation between counters $\Delta y \sim 3.2$ mm.*

- *Observed vertical position resolution $\sigma_y \sim 3$ mm.*

- *Crosstalk between adjacent PMT channels due to misalignment in same row or in consecutive rows ~ 10–15%.*

- *Detected number of photoelectrons $\langle N \rangle_{p.e.} \sim 3$–$4$.*

Prototype X-Position Resolution
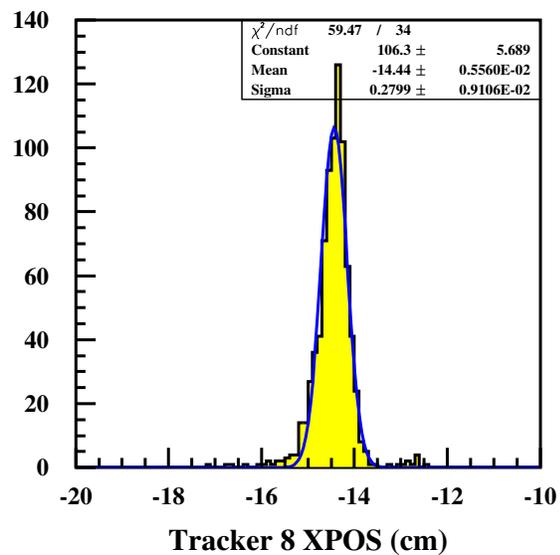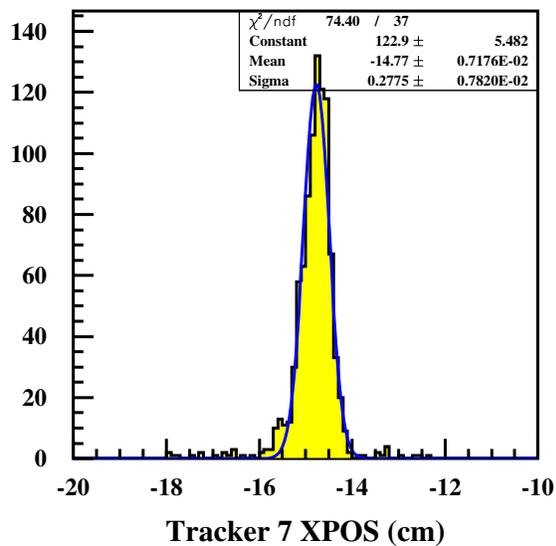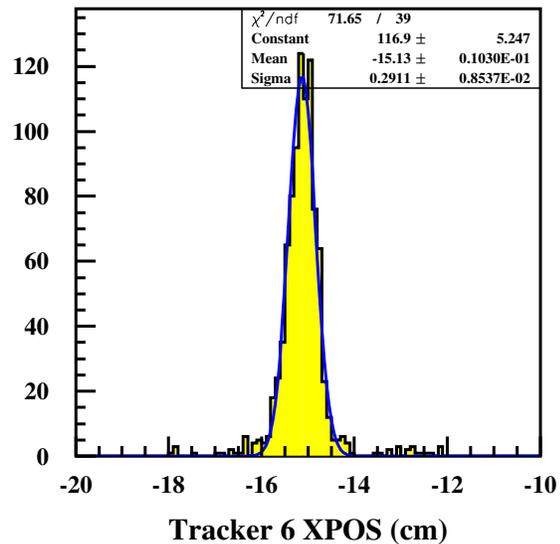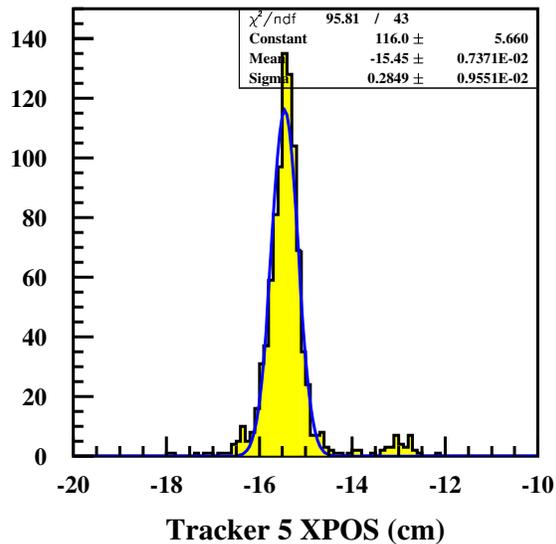
- **Δx between counter centroids ~ 3.2 mm.**

- ***Resolution ($\sigma \sim 3$ mm) mostly accounted for by multiple scattering in S1Y counters of SOS.***
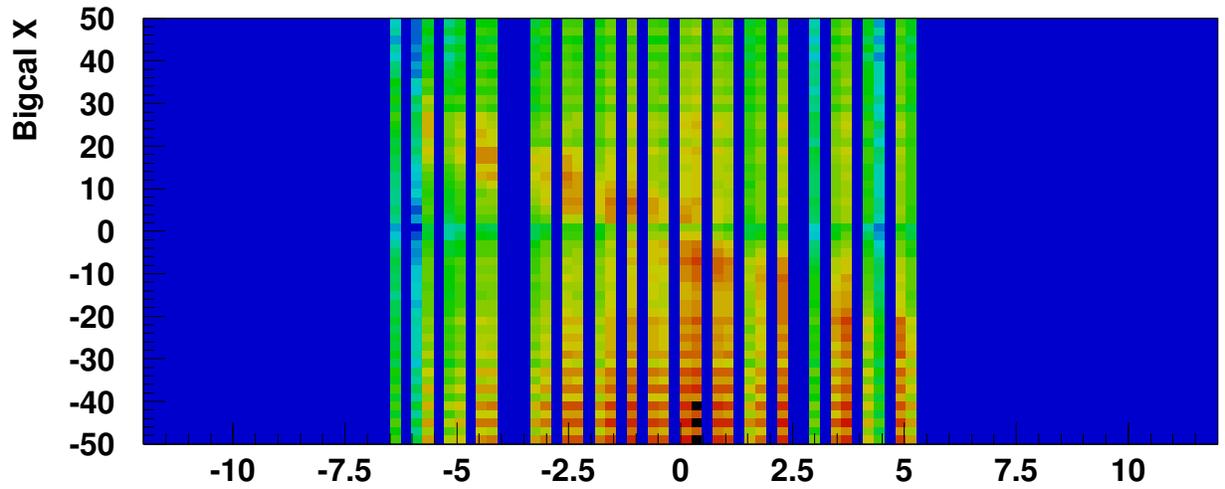
Tracker Setup during GEP-III

Single Counter Pulse Heights and Rates
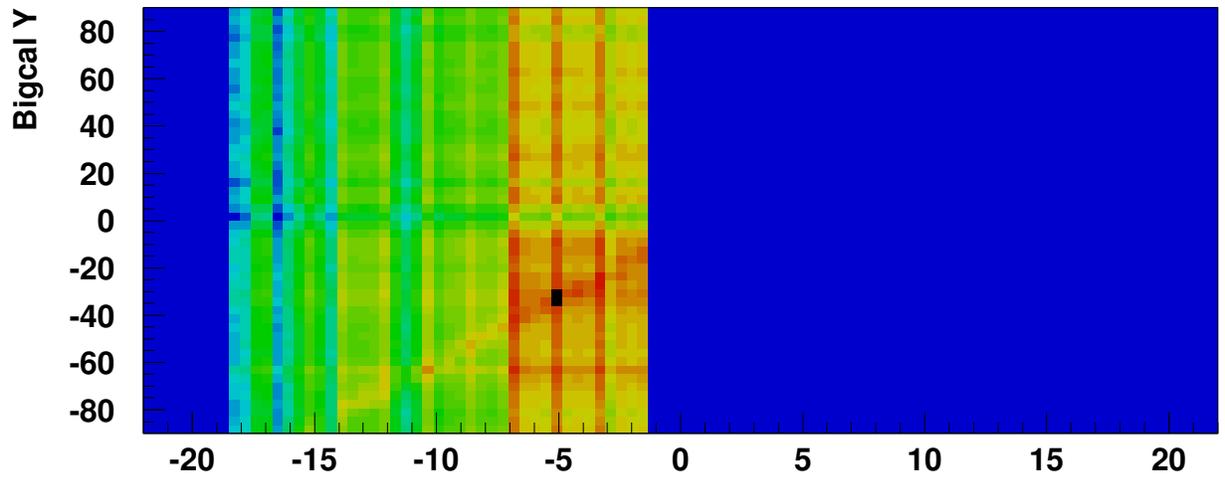
- $I_e \sim 0.35 \mu A$, LH2, Discr. @25 mV

- Pulse heights $\sim$ 50-60 mV for all three planes.

- Y1 PMT sagged above $I_e \sim 0.25 \mu A$.

Plane	Avg. Rate (MHz)
Y1	3-4
Y2	1-2
X	<1

X-Y Coordinate vs BCal X-Y
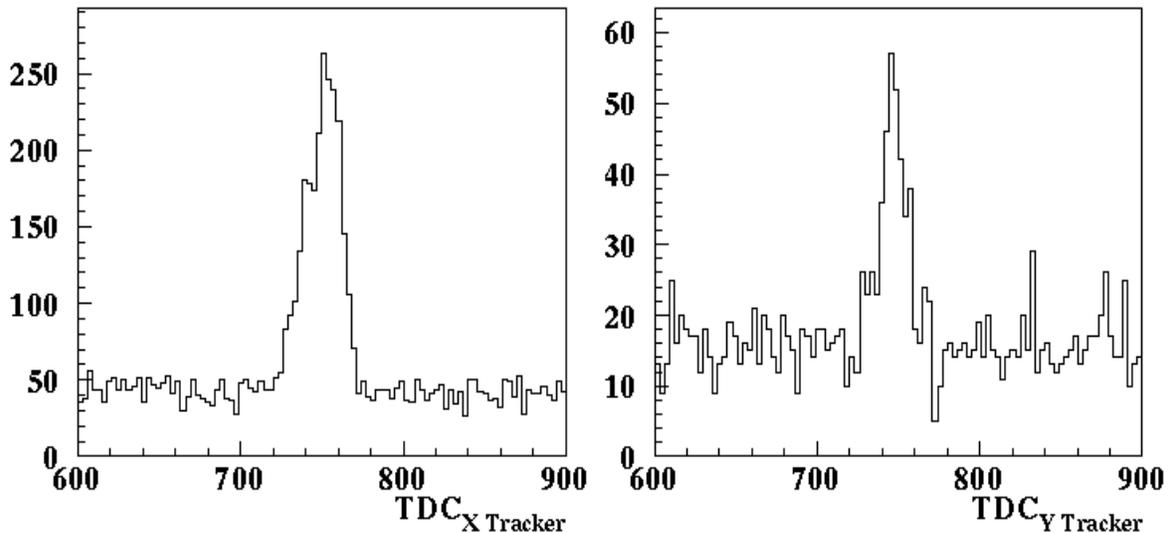
Single- vs Double-Fiber Configuration

- **Double-fiber configuration gives better signal-to-noise ratio.**

- **Modify Y-counters to double-fiber configuration.**

- **Large background from Moller e^- and other low energy ($<$ 1 MeV) particles.**

- **Target field (longitudinal) will help sweep away Mollers.**

- **Software coincidence of two offset Y-planes will further reduce background.**

Implemented Cuts

- *BigCal cluster $Y \pm 5$ cm.*

- *BigCal cluster $X \pm 7$ cm.*

- *Čerenkov TDC ± 25 ns.*

- *Lucite TDC.*

Single Counter w/ BCal + Čer + Luc Cuts
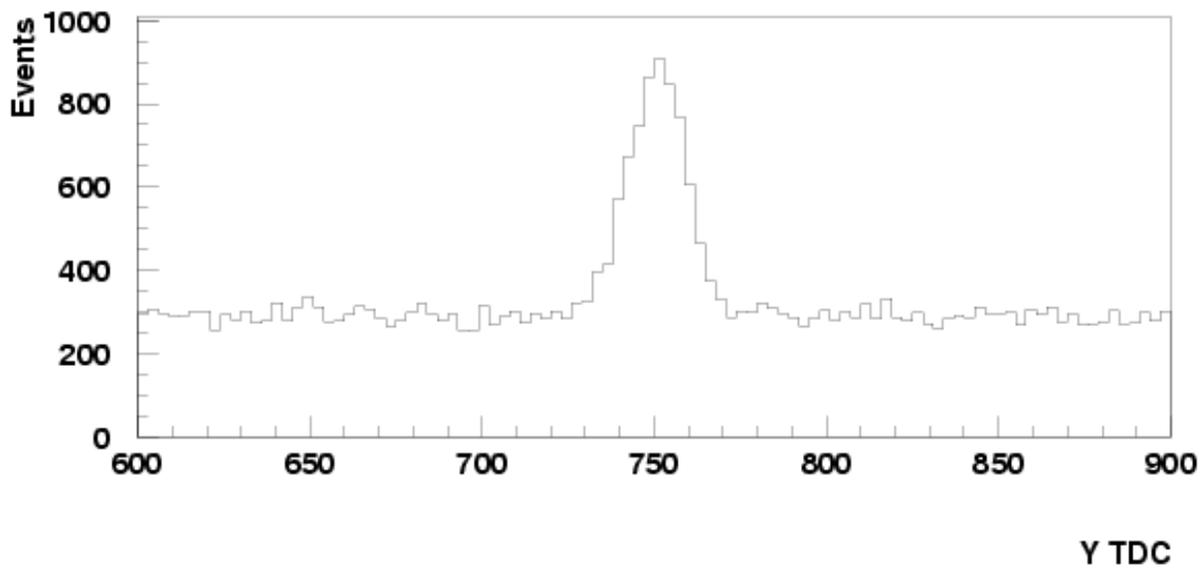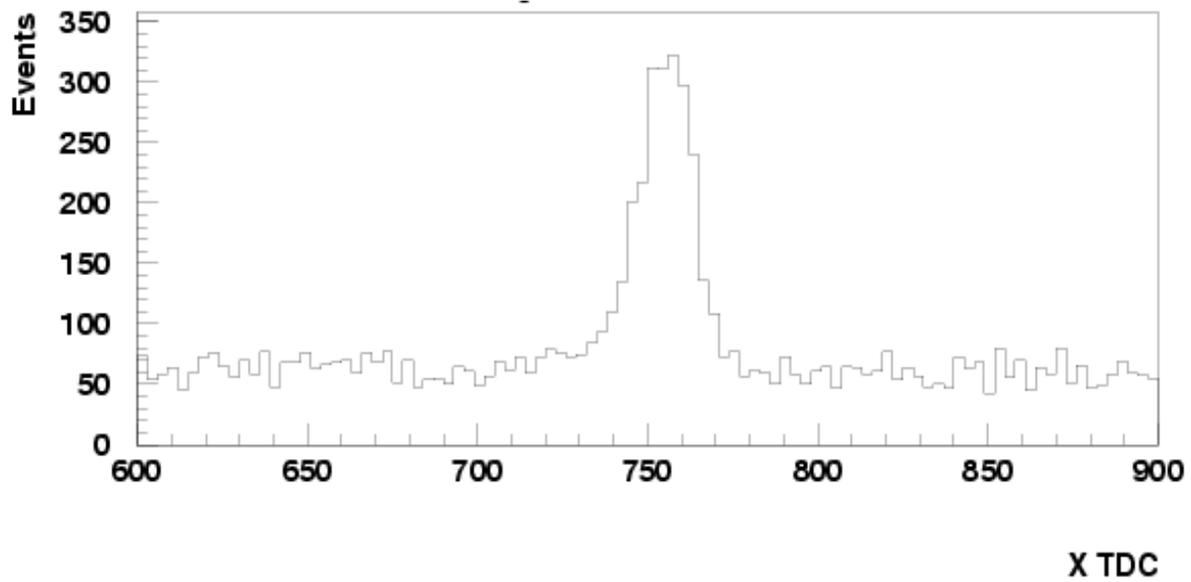
Summary of Beam Tests

- **Nice correlation between X-Y and BigCal coordinates.**

- **Čerenkov + Lucite TDC conditions enhance Tracker TDC considerably.**

- **Signal : Background $\sim$ 7:1**

- **Single counter timing reolution $\sim$ 3.5 ns.**

- **High rate of low energy background problem for Y1.**

Current Status

- *Major portion of hardware for complete detector on-hand.*

- *Additional items on order to be delivered by end of June.*

- *All electronic modules and crates on-hand.*

- *Modify existing two Y planes into one with double fibers.*

- *Construct one new Y plane with double fibers.*

- *Complete X plane with double fibers.*

- *Construct tracker mount frame and PMT shield box.*

- *Adequate manpower available this summer.*

- *Complete detector package to be ready by mid August.*

- *Install tracker in BETA system in September.*