Firday Upgrade Meeting
August 21th, 1997

COT Stereo Segment Finding with the XFTII

R. Hughes
for the XFTII Group

Basic Facts about XFT

- Input to XFT from TDC mezannine board

  Uses existing Ansley cable plant

  Total of 360 Ansleys needed

- Finder covers 4 adjacent axial COT cells.

  336 total Finders needed.

- Linker covers 1.25 degrees

  288 total Linkers needed

- Finder/Linker implementation in Altera cPLDs

Global Algorithm Description:

- Takes hit data from Tracker TDC
- Hit data is binned.
  For 100 nsec max drift:

  Prompt bin 0-33 nsec window

  Delayed bin 34-100 nsec window
- Finder:

  Operates on hit data

  Identifies track segments ($P_T \geq 1.5$) in all 4 axial superlayers

  Outputs pixel position of track segment
- Linker:

  Operates on Finder output

  Identifies tracks with $P_T \geq 1.5\, GeV/c^2$ (one per 1.25 degrees)

  Outputs track P_T and ϕ
- Track results are sent to XTRP for extrapolation:

  EM clusters $\rightarrow$ L1 electron

  Muon stubs $\rightarrow$ L1 muon

  L1 Track trigger

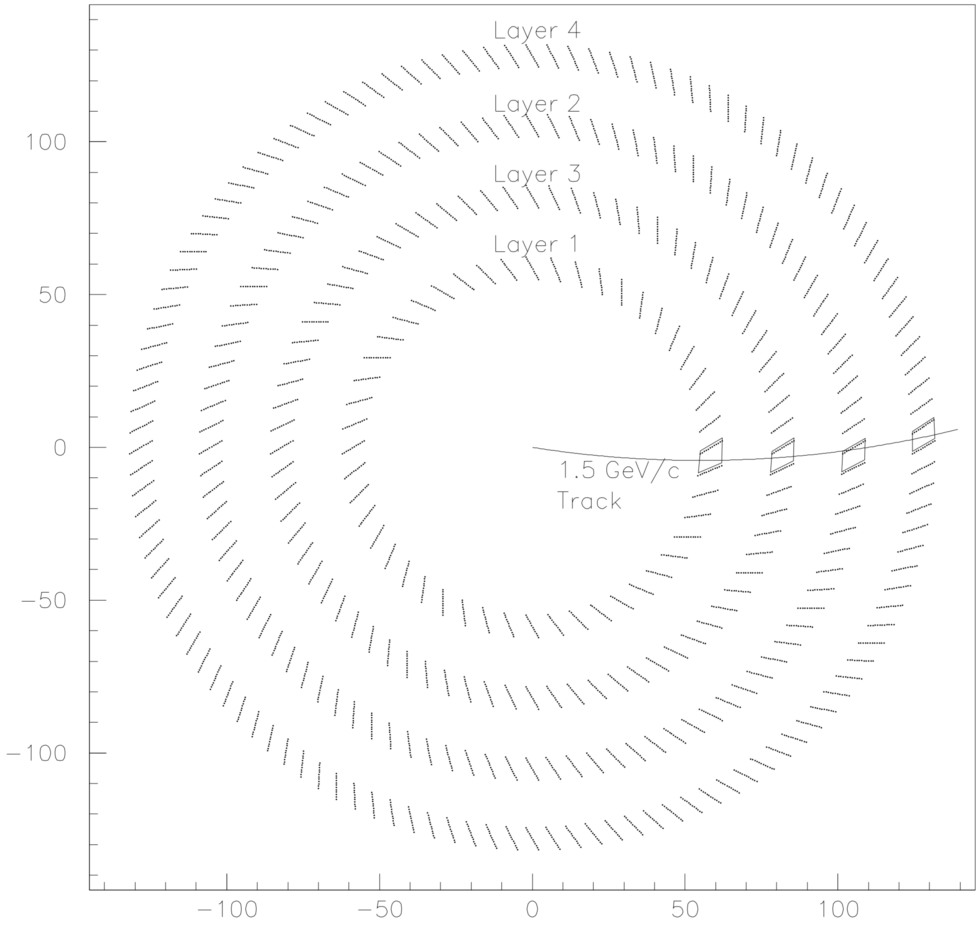
  L2 SVT trigger

Finder Algorithm Description:

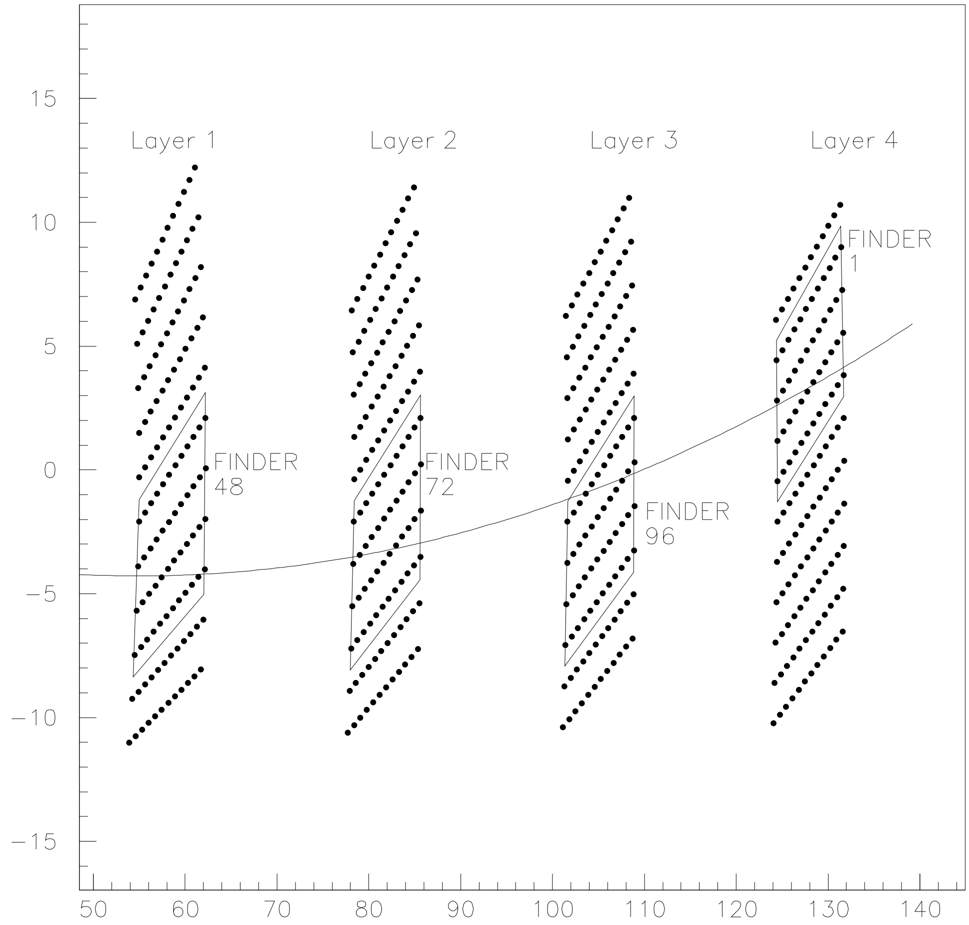
- Each Finder covers 4 adjacent COT cells.
- Total of 68 COT wires needed on input:

  the 4*12 wires for each of the 4 cells

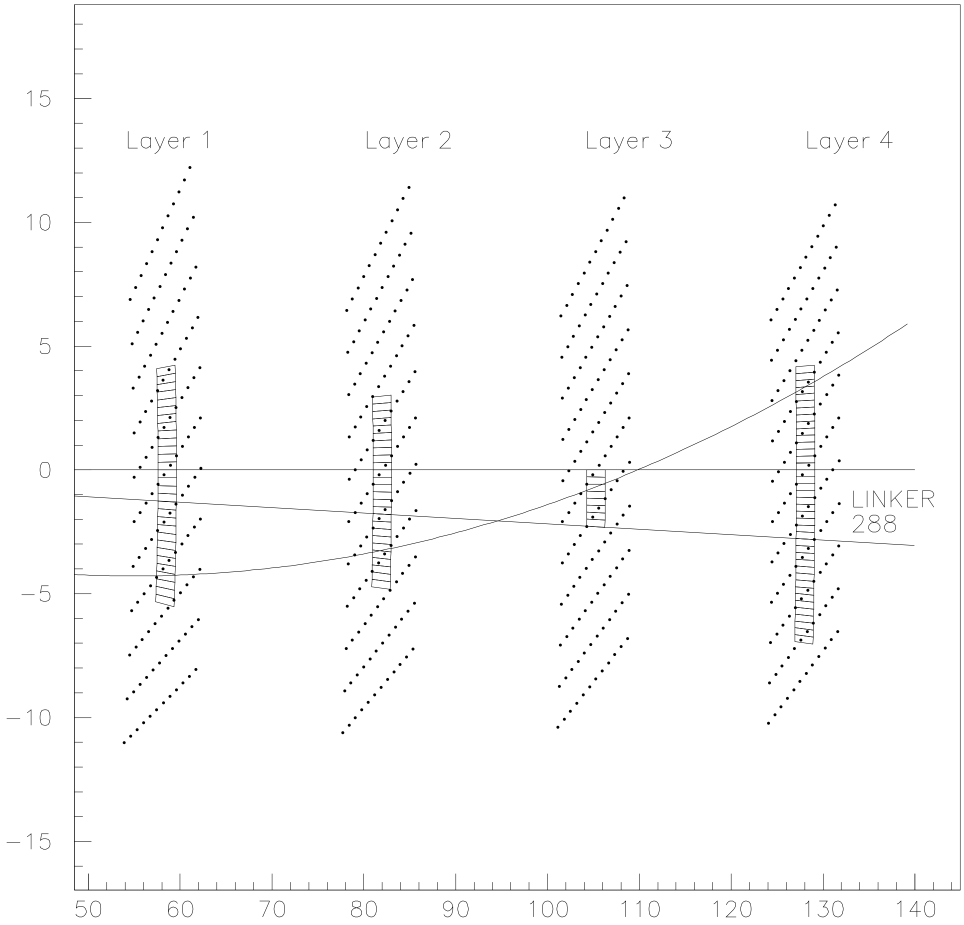
  plus 2*10 neighbor wires.
- Finder stores patterns for only one cell. Remaining 3 cells are multiplexed.
- Store *all* patterns of wires needed to find every segment from tracks with $P_T \geq 1.5\ GeV/c$.
- Allow up to 3 misses (programmable)
- $\sim$ 100% segment finding efficiency
- Each Finder reports pixel position of all segments found (with $P_T \geq 1.5\ GeV/c$).
  24 pixels per Finder.



A schematic drawing of a track with $P_t = 1.5\ GeV/c$ in the COT. The four axial layers are shown, and only every 4th cell is shown in each layer.

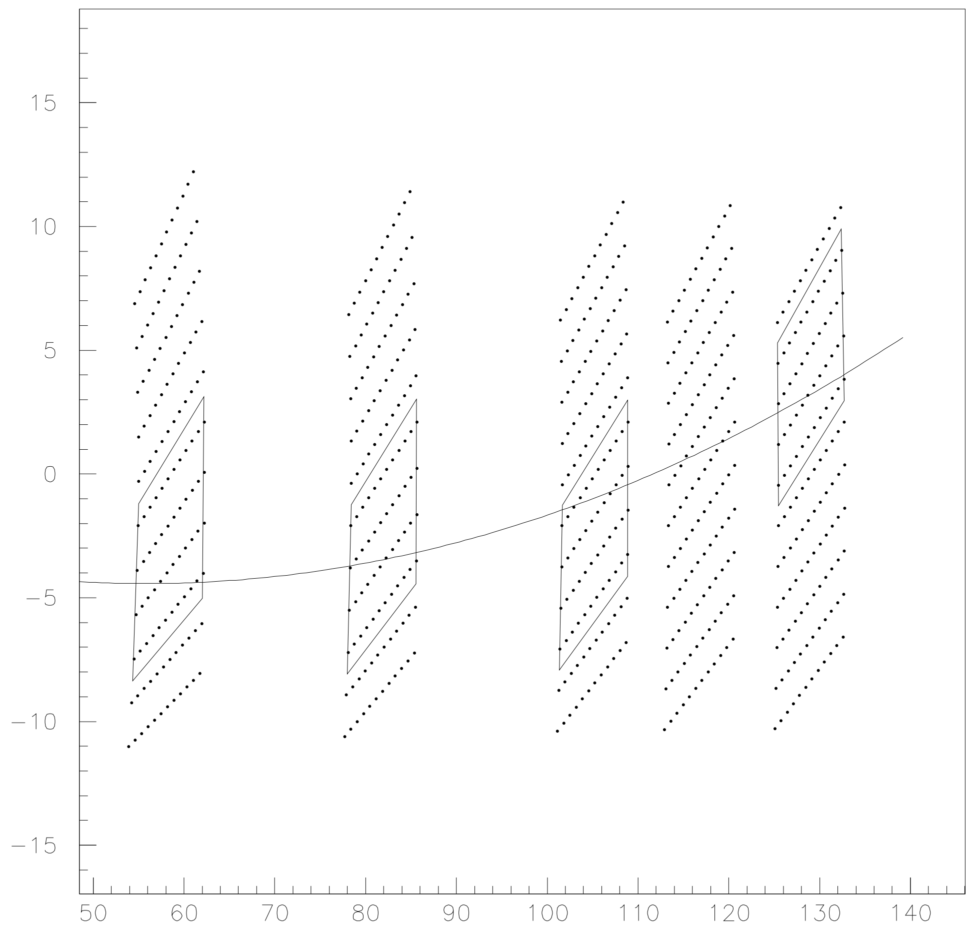


A close up of the previous figure of a track in the COT. All cells in all four axial layers are shown. The relevant Finder in each layer is highlighted.



Same as the previous figure, but now showing the Linker the track should be found in. Also shown are all of the pixels needed by this Linker.

25/06/97 14.13



Stereo Segment Finding with the XFT

- *Same* method used for the stereo as for the axial layers
- Total number of masks needed: ~ 300
- Masks are generated assuming no stereo angle
- Each mask corresponds to a track (with $P_T \geq 1.5$ GeV/c) traversing a cell at a given pixel, at Z=0.
- Each cell is divided into 6 pixels.
- Each pixel is characterized by 2 bits. The definition of the bits is:
  - 00 = no mask found
  - 01 = negative low Pt track segment
  - 10 = positive low Pt track segment
  - 11 = high Pt track segment (nominal $P_T \geq 8$ GeV/c)

Some COT and XFT information vs COT superlayer.

Layer	Radius	Number of Cells	Finders	Finder masks
1	46	168	xx	xx
2	58	192	48	170
3	70	240	xx	xx
4	82	288	72	230
5	94	336	xx	xx
6	106	384	96	272
7	119	432	108	300
8	131	480	120	310

Determining Z position for XFT tracks

- XFT track must be found (using axial layers only).
- Using XFT P_T and ϕ (reported at 3rd axial layer), determine expected track position in the outermost stereo layer. Assuming that the track comes from the beam spot, and assuming zero stereo angle, the extrapolated position is SL7 is given by:

$$\phi_{SL7} = \phi_{SL6} + sin^{-1} K \cdot \frac{R_7 - R_6}{P_T}$$

  where

  - ϕ_{SLx} and is the ϕ position in radians corresponding to the XFT pixel position in superlayer x.
  - R_x is the radius in centimeters of superlayer x
  - K is a constant $(= 0.5 \cdot c \cdot B = 0.00014989 \cdot 14.116)$.

- This uses the same information available to the trigger. The position in the outermost stereo layer is that expected in the absence of a stereo tilt.

Determining Z position for XFT tracks(continued)

- Look for found XFT segments in the stereo layer in a valid region around the expected position. For a +/- 3 cell stereo offset this is +/- 18 pixels.
- The difference between the expected ϕ_{exp} position (from the XFT track) and the found stereo ϕ_{fnd} position gives the Z position of the track in the stereo layer.

$$Z = \tan\left(\phi_{exp} - \phi_{fnd}\right) \cdot \frac{1}{Slbr}$$

where $Slbr$ is a constant dependent on the "stereo angle".
The uncertainty on the Z position coes from two sources:

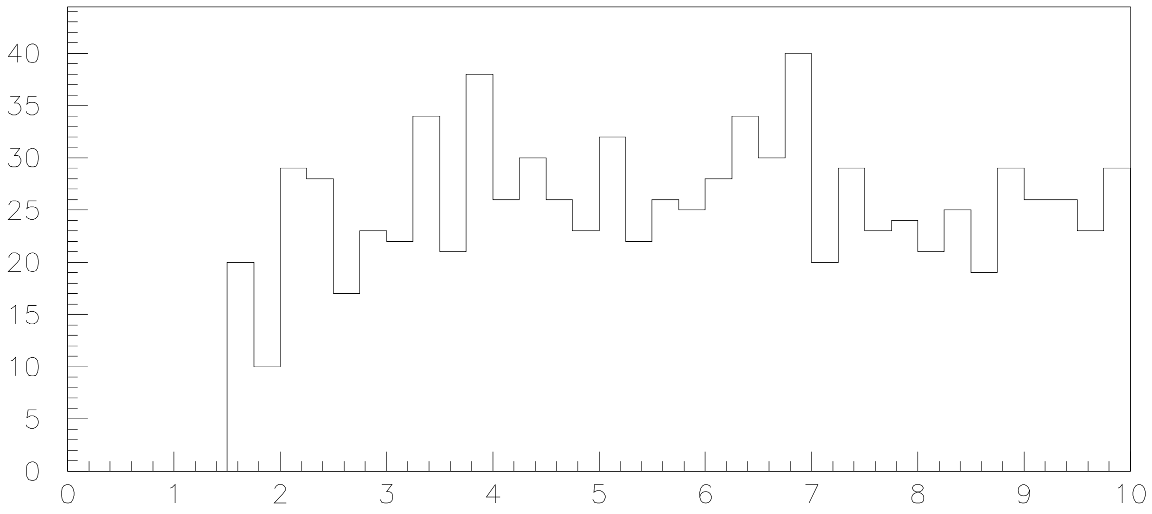
- The uncertainty on ϕ_{fnd}.
- The uncertainty on ϕ_{exp} (dominates).

XFTII Simulation:

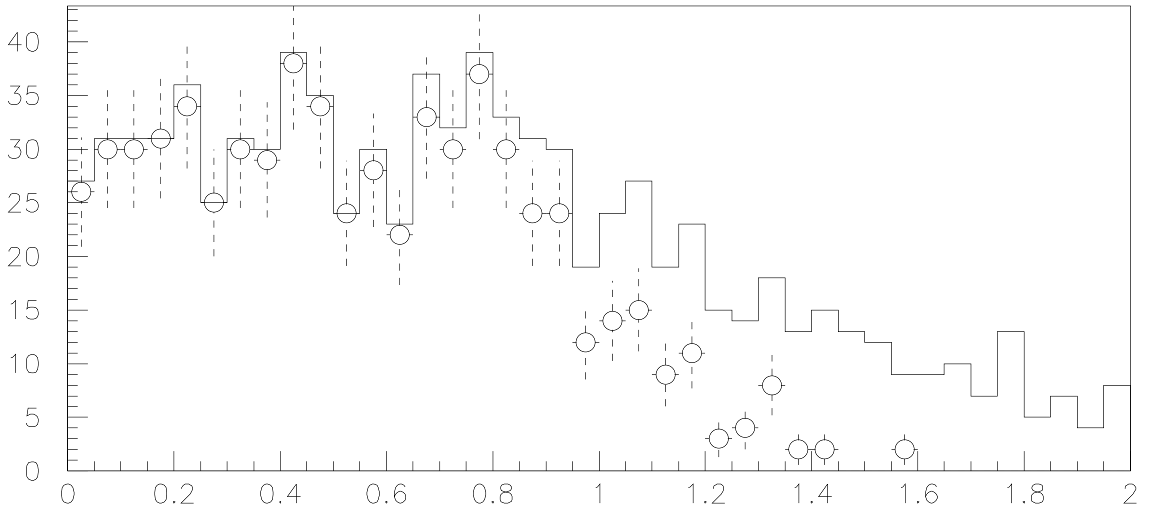
- Standalone simulation used for COT.
- Geometry is implemented
- The pulse with incorporates the same pulse width modeling used by the standard COT simulation, including the aspect angle variation.
- Stereo implementation uses standard (COT/CTC) code.

Events used for simulation studies:

- Used single track Monte Carlo, flat P_T from 1.5 to 10 GeV/c.
- Overlayed on top of this hit data from minimum bias events from Monte Carlo.
- For Luminosity of 2E32, use mean number of interactions/crossing of 2
- For Luminosity of 1E33, use mean number of interactions/crossing of 10
- COT wire efficiency is set to 0.99.
- Number of allowed misses in the Finder is 1 (for both axial and stereo Finders).



Pt of single tracks



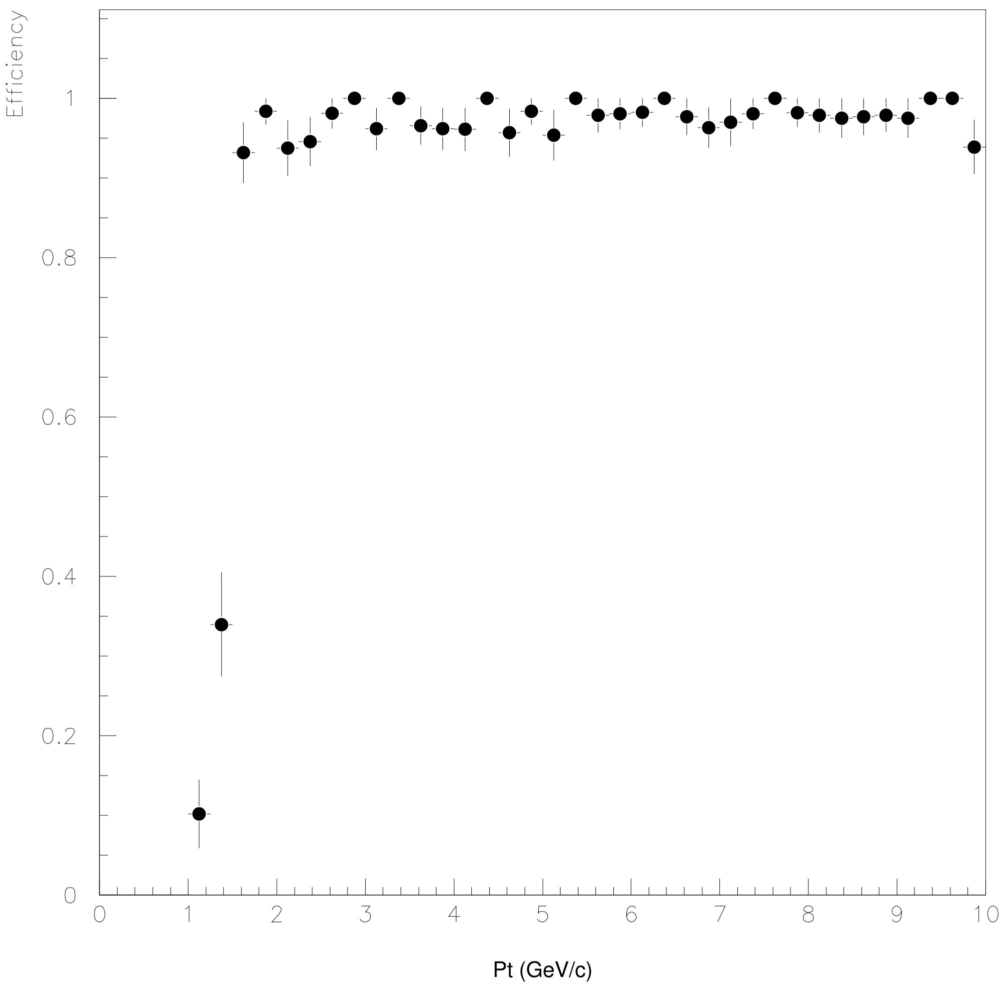
Cot(Theta) of single tracks

Single Track Monte Carlo

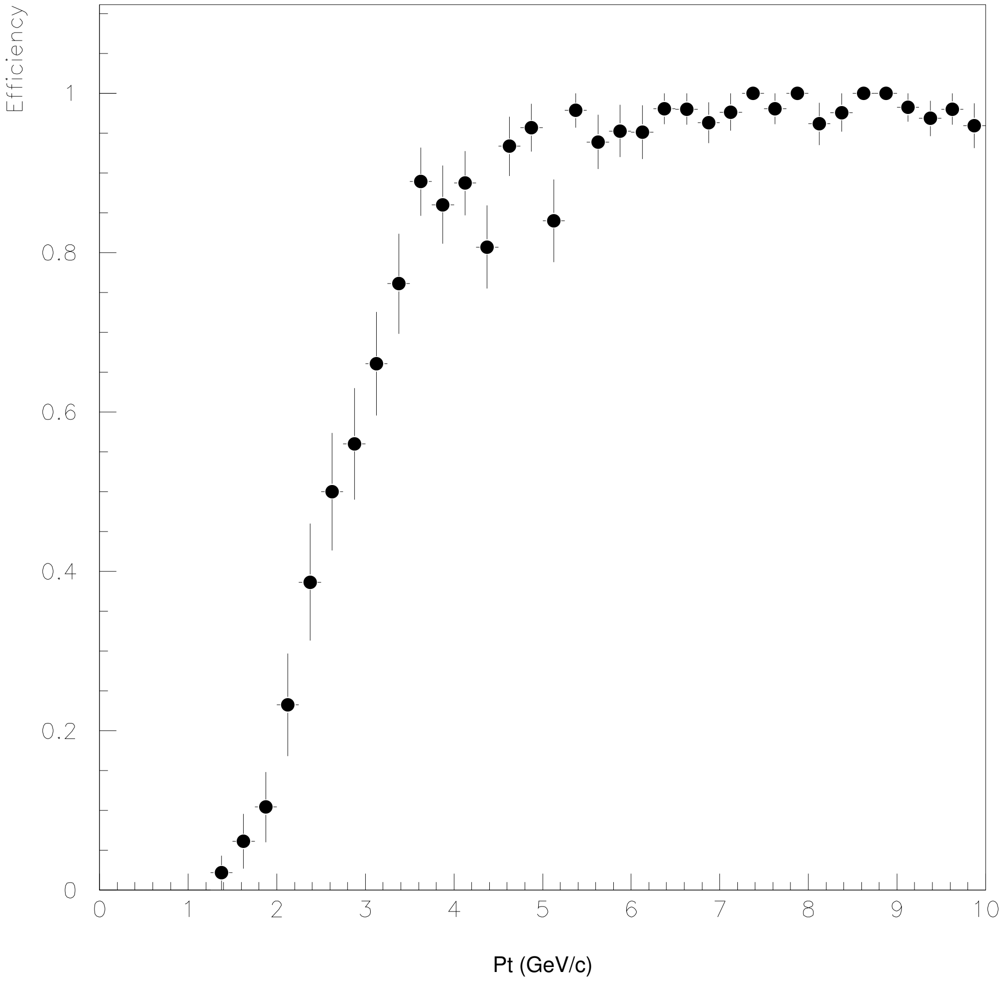
- Top plot: P_T Distribution of embedded tracks.
- Bottom plot: Cot(Theta) Distribution of embedded tracks.

Evaluating the performance of Stereo segment finding:

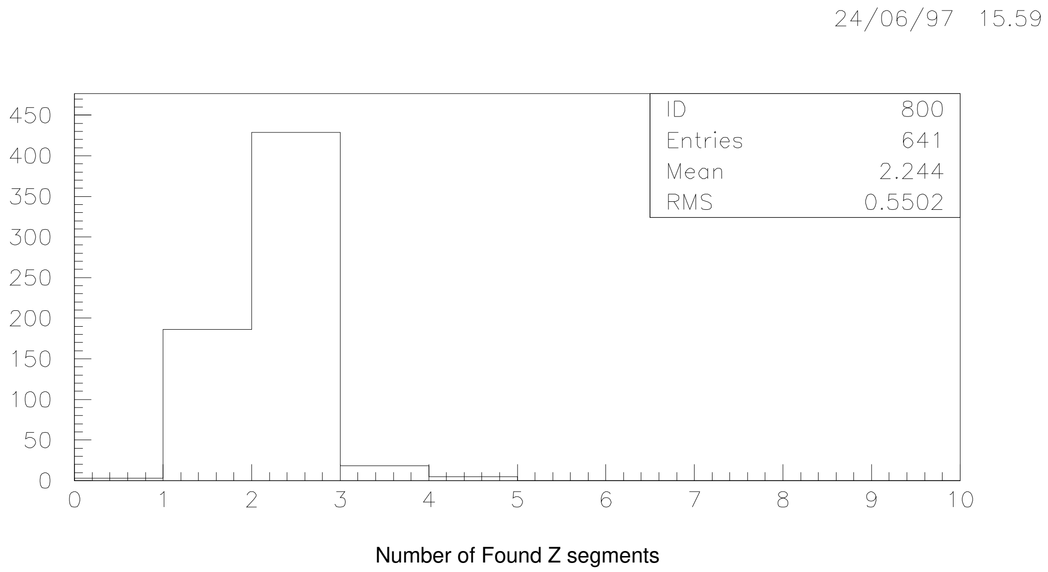
- Efficiency: How often do we find (or miss) a stereo segment, for a found XFT track?
- Background: How often is there an additional XFT stereo segment within a valid region around an XFT track?
- Resolution: How well do we measure the Z position of a track at the outer stereo layer?
- Also examine these issues as a function of number of overlaid minimum bias.

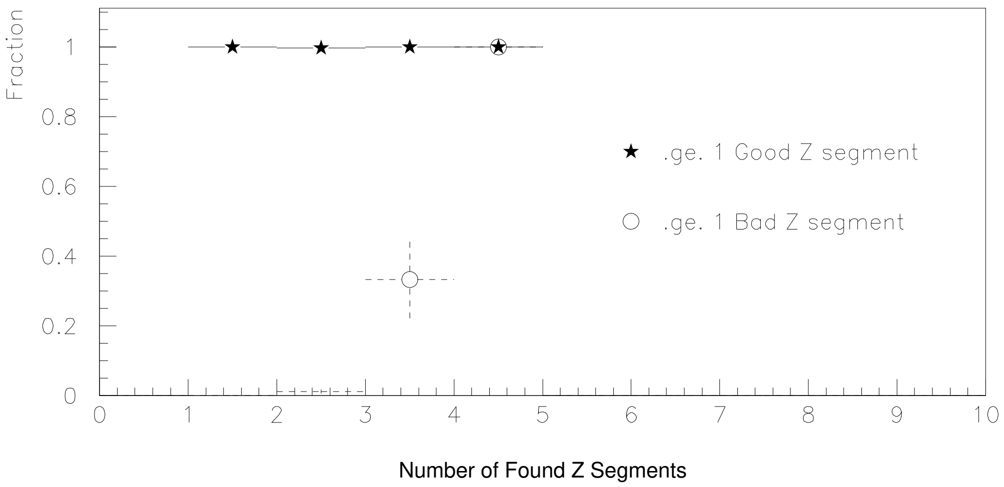


Plot of segment finding efficiency vs track P_T, for masks with nominal $P_T \geq 1.5$ GeV/c.



Plot of segment finding efficiency vs track P_T, for masks with nominal $P_T \geq 8.0$ GeV/c.

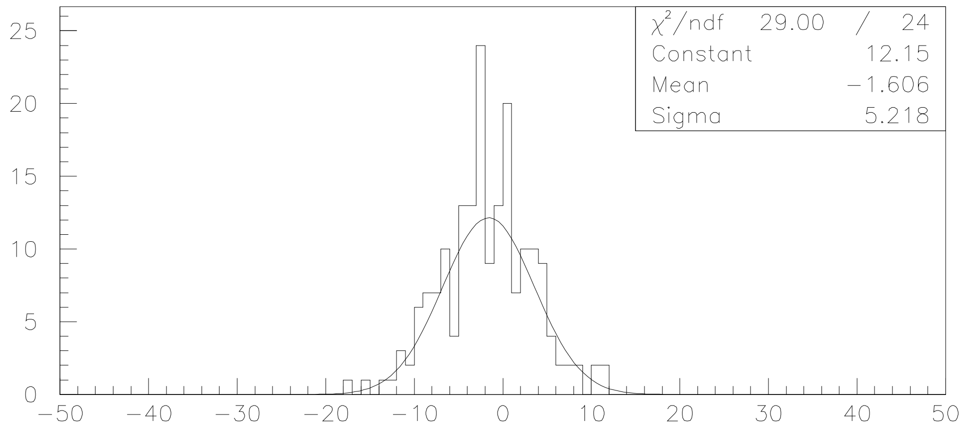




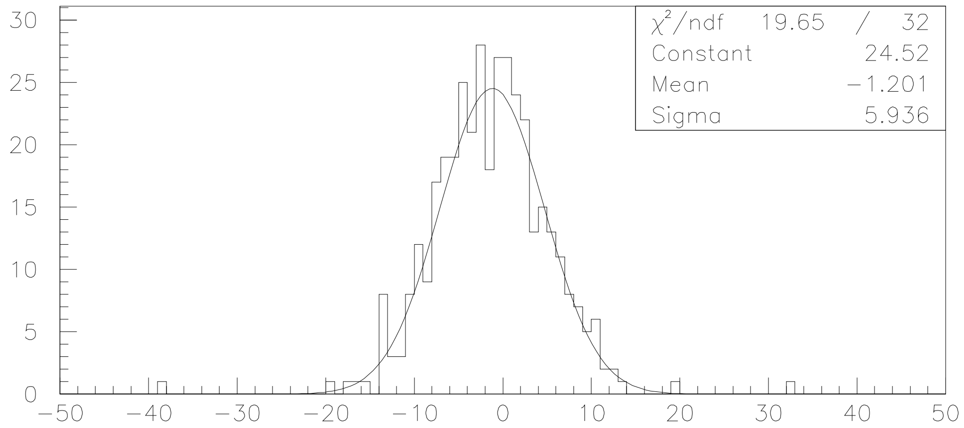
+/-3 cell offset for Stereo Layers

- Average number of overlaid min-bias=2.
- Top plot: Number of valid stereo segments per found XFT track.
- Bottom plot: Fraction of above tracks with at least one good (or bad) stereo segment.

24/06/97 16.01



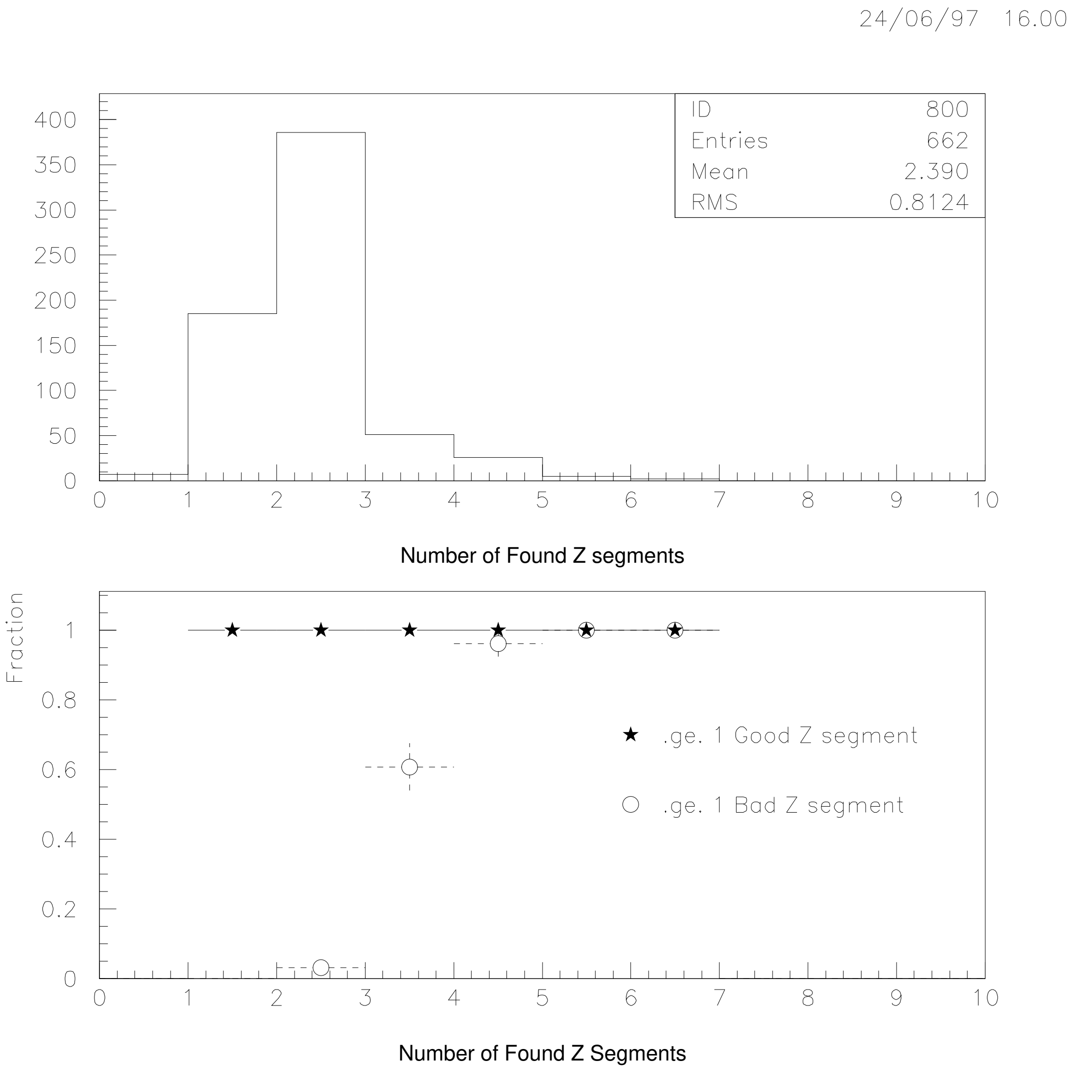
Delta Z (Real-XFT), NFZ=1



Delta Z (Real-XFTavg), NFZ=2

+/-3 cell offset for Stereo Layers

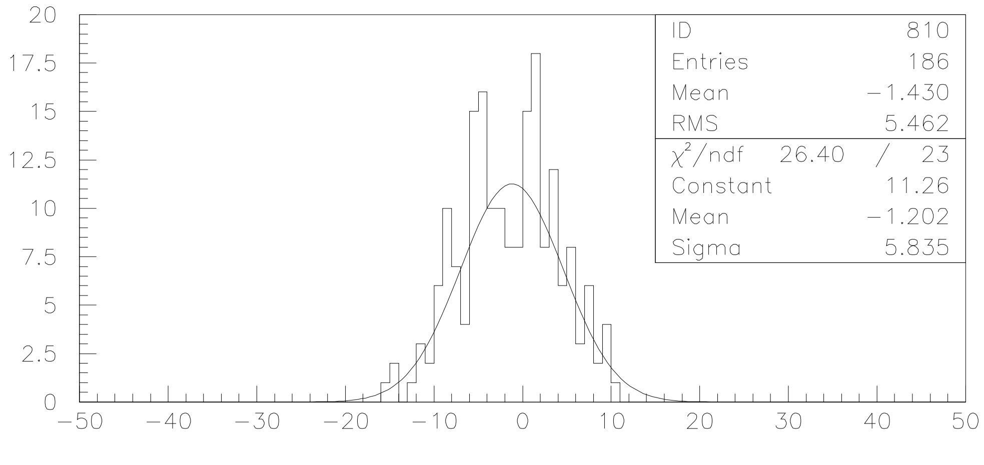
- Average number of overlaid min-bias=2.
- Top plot: True Z position - XFT Z Position, at outer stereo layer. Only 1 valid stereo segment near XFT track.
- Top plot: True Z position - XFT Z Position, at outer stereo layer. 2 valid stereo segments near XFT track.



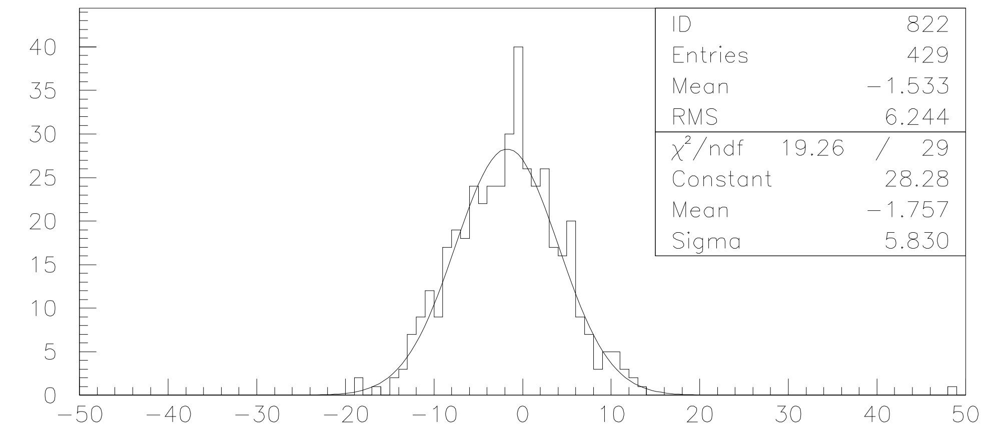
+/-3 cell offset for Stereo Layers

- Average number of overlaid min-bias=10.
- Top plot: Number of valid stereo segments per found XFT track.
- Bottom plot: Fraction of above tracks with at least one good (or bad) stereo segment.

24/06/97 15.38



Delta Z (Real-XFT), NFZ=1



Delta Z (Real-XFTavg), NFZ=2

+/-3 cell offset for Stereo Layers

- Average number of overlaid min-bias=10.
- Top plot: True Z position - XFT Z Position, at outer stereo layer. Only 1 valid stereo segment near XFT track.
- Top plot: True Z position - XFT Z Position, at outer stereo layer. 2 valid stereo segments near XFT track.

Results of Simulation, +/-3 cell offset:

Performance	MB2	MB10
Efficiency	99.5%	98.9%
Z Resolution	5.8cm	5.9cm
Comb. Backg	3.5%	12.7%

Hardware implementation - Stereo Segment Primitives

Current Finder board design:

- Two flavors of Finder board

  SL4/2 board 8 Finders

  SL3/1 board 6 Finders (but split L1)

- Each board receives information via transition card
- 8 Ansley cables input to transition card
- Finder (as is Linker) board is pipelined. New pixel information is sent to the linker every 132 nsec.
- Each Finder processes 4 neighboring COT cells.
- Inner 2 axial layers output 12 pixels/cell, outer 2 axial layers output 6 pixels $\times$ 2 slopes/pixel.
- Pixel information from each Finder is sent via National channel link, 12 bits every 33nsec.

Possible implementation

- Stereo segments are found in exactly the same way as axial.
- Output of stereo segment board is different - need to send information to L2 interface board (D. Saltzberg/UCLA is working on this).
- Need a second board to do the association of Linker tracks to Stereo segments.
- Note that the association is very simple - a look-up table.

What would be needed for Stereo Finder boards:

Parameter	Value
TDC Mezzanine Cards	54
COT Transition Modules	54
Ansley Cables	110
XFT VME Crates	1
XFT Finder Backplane	1
XFT Transition Modules	18
XFT Finder Chips	108
XFT Finder Cards	18

Which parts of the XFT Finder design need modification to implement Stereo segment Finding?

- TDC mezzanine card, TDC transition module:
  - No changes.
- Finder transition module: The transition module is the board that plugs into the back of the VME crate behind each Finder board. It has the connectors and LVDS receivers for the Ansley cables. The current design has connectors for up to 8 Ansley cables and should be fine for the stereo Finder design.
  - No changes
- Ansley cables: A total of 110 ansley cables would be required (not including spares).

Which parts of the XFT Finder design need modification to implement Stereo segment Finding? (continued)

- Finder Backplane: The Finder backplane is responsible for routing neighbor wires from slot to slot, and so this will be new.
  - New, simple.
- Finder Board:
  - Input section: no changes
  - Finder chip section: no changes (neighbor wires from chip to chip the same as SL8)
  - Output section: Needs changes. No longer driving to Linker (can't use). Need to drive to Level 2 board.
- Finder chip: This will be the same.
  - benefit of using reprogrammable chips
  - already includes l1/l2 buffers (for diagnostics)
  - code for segment finding generated automatically
  - No changes

Conclusions:

- Stereo segment finding can be done in the outer layer of the COT.
- The method used is exactly the same as is already planned for the axial layers.
- The segment finding efficiency is very high, and the Z position resolution is $\sim 6cm$ at $R = 118cm$.
- The implementation of the segment finding appears straightforward.
- The association of stereo segments with tracks is not thought out in detail yet, but does not appear difficult.