



A z-Vertex trigger based on drift chamber signals

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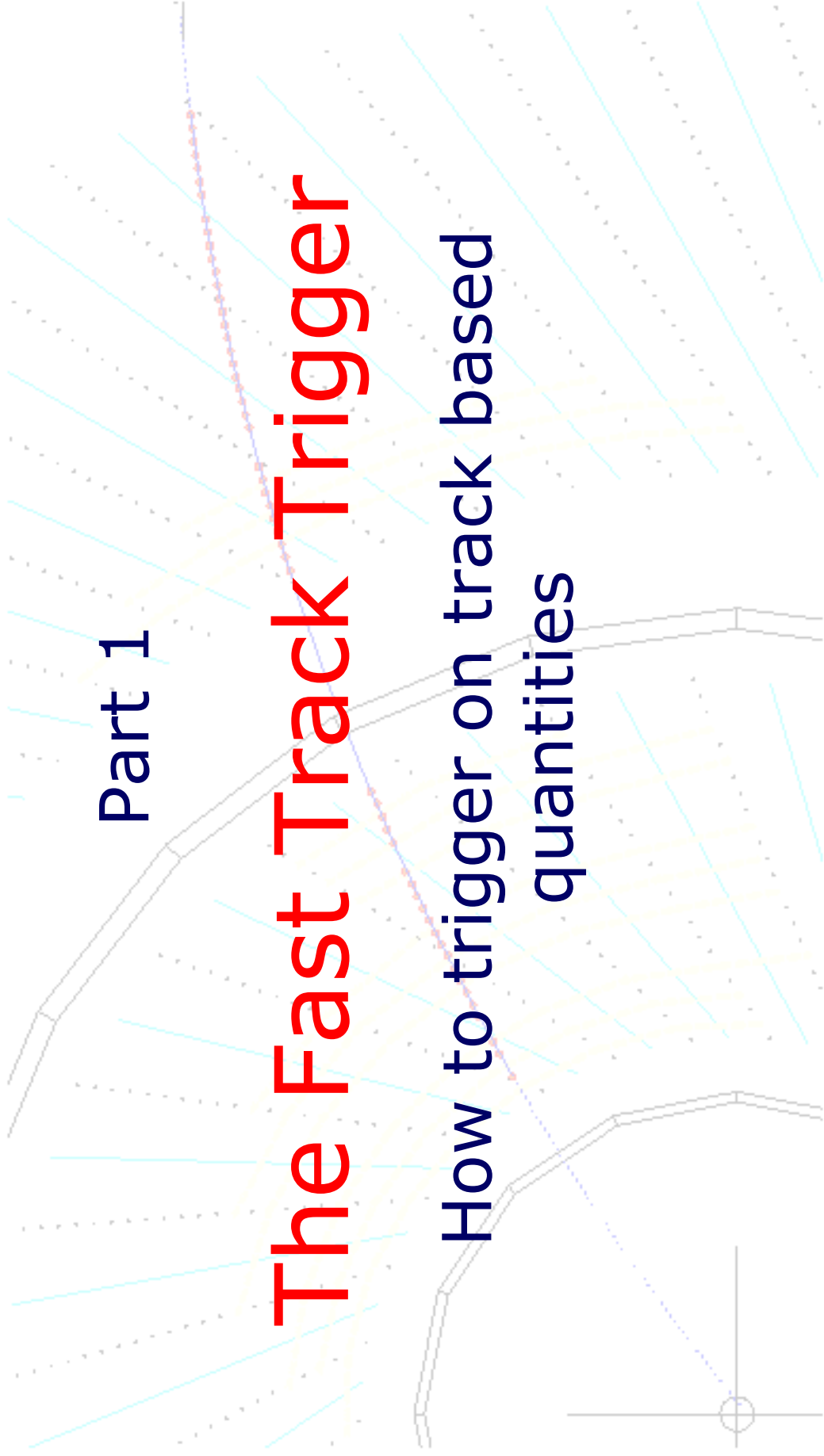
Overview

- Introduction
 - Triggering at H1
 - The H1 **F**ast **T**rack **T**rigger
- A Level 1 z-Vertex trigger using the **FTT**
- A precise vertex determination on Level 2
- Summary

Part 1

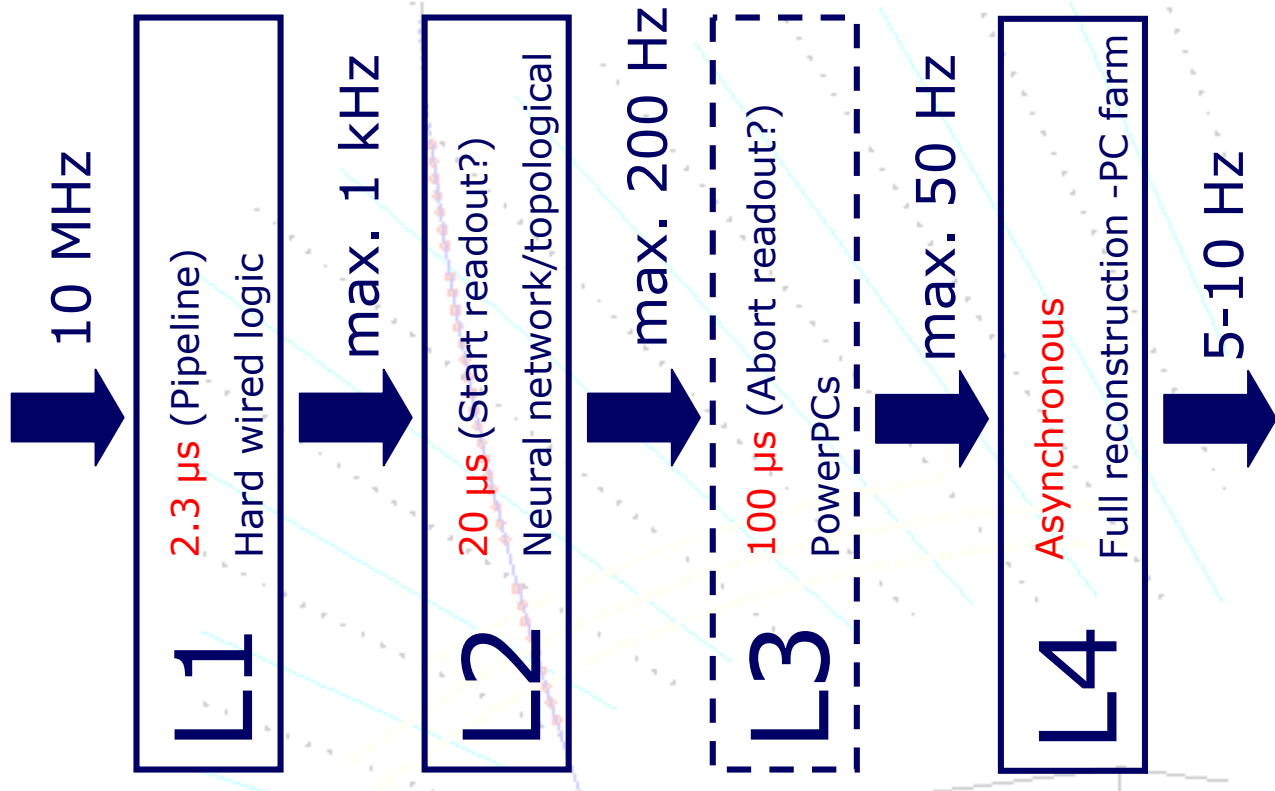
The Fast Track Trigger

How to trigger on track based quantities



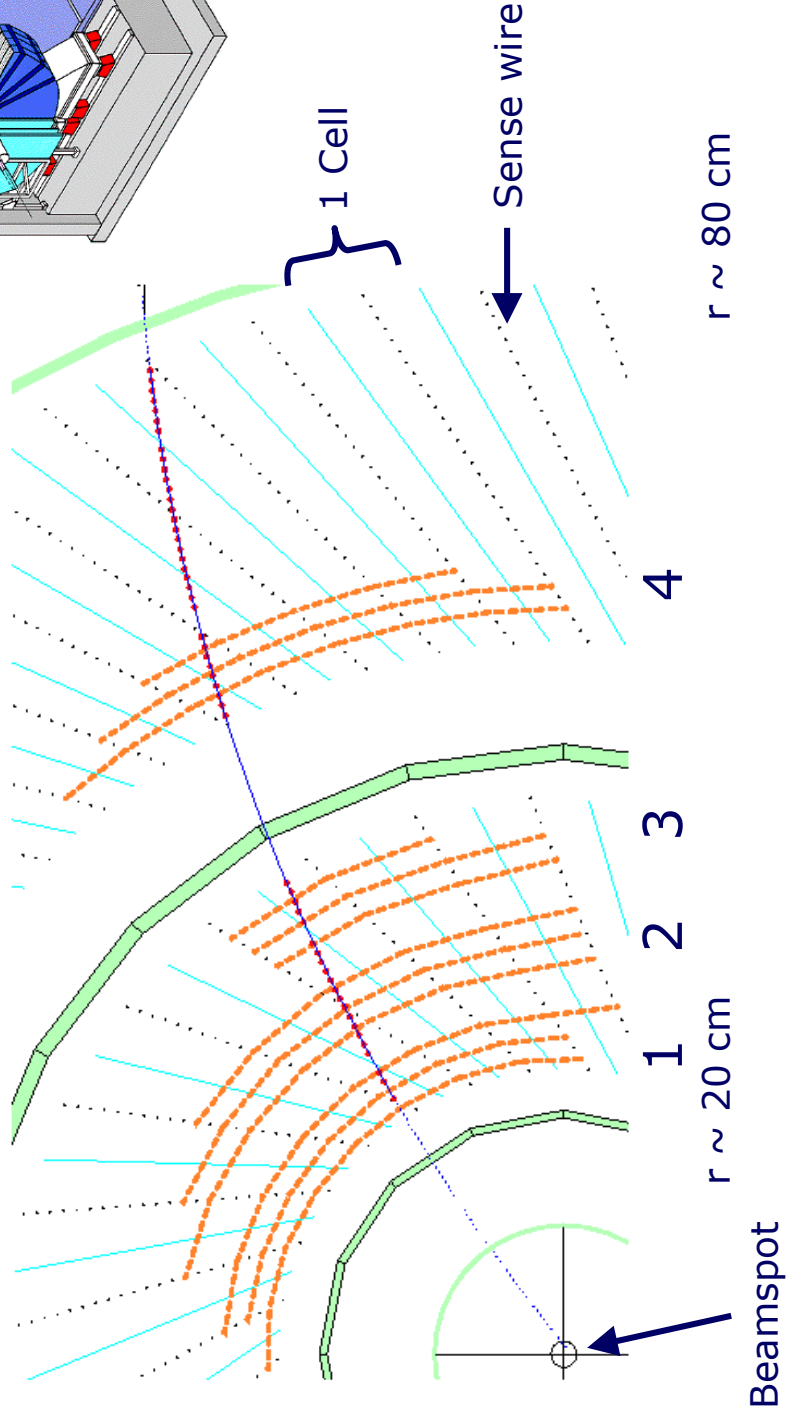
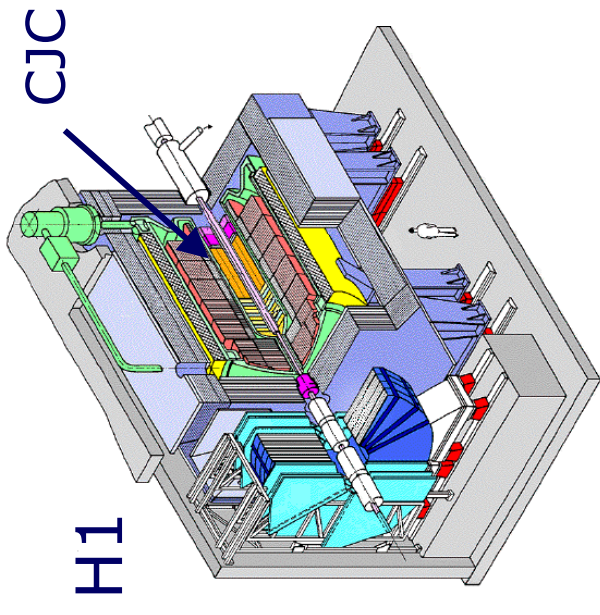
Triggering at H1

- 10 MHz bunch crossing rate
- ~ 5 Hz written to tape
- 4 Trigger levels
- L3 was not used in the HERA I phase
- HERA II: Lumi (and backgrounds) **x 5**
- New Track Triggers:
 - Proportional Chamber: CIP2000 (Max)
 - **Drift Chamber: Fast Track Trigger**



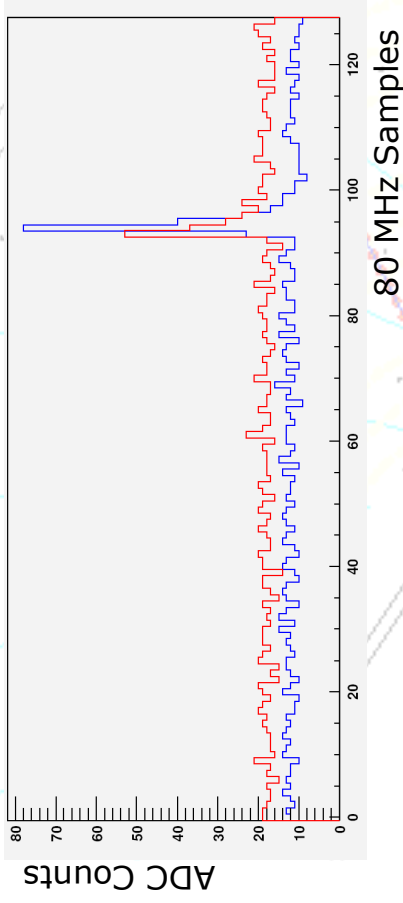
The Fast Track Trigger

- Use signals from the Central Jet Chamber (CJC)
- Use four groups of three wires per cell to identify track segments

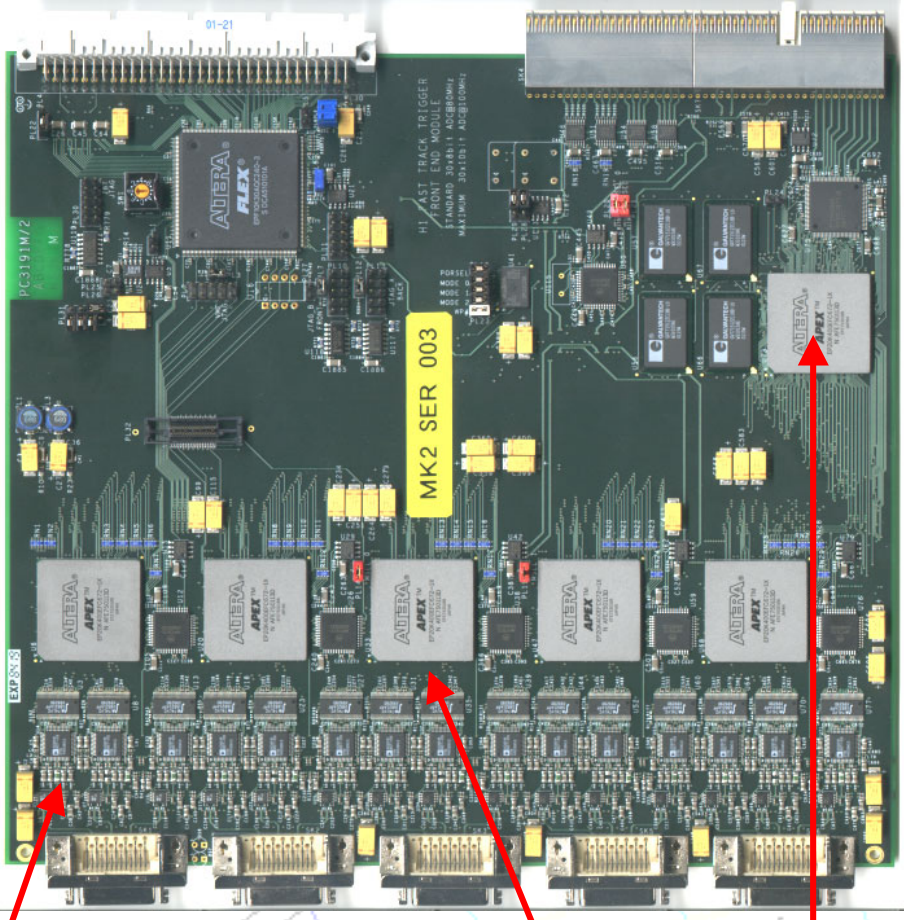


FTT - Level 1

- Digitize drift chamber signals (80 MHz 10 bit ADCs)



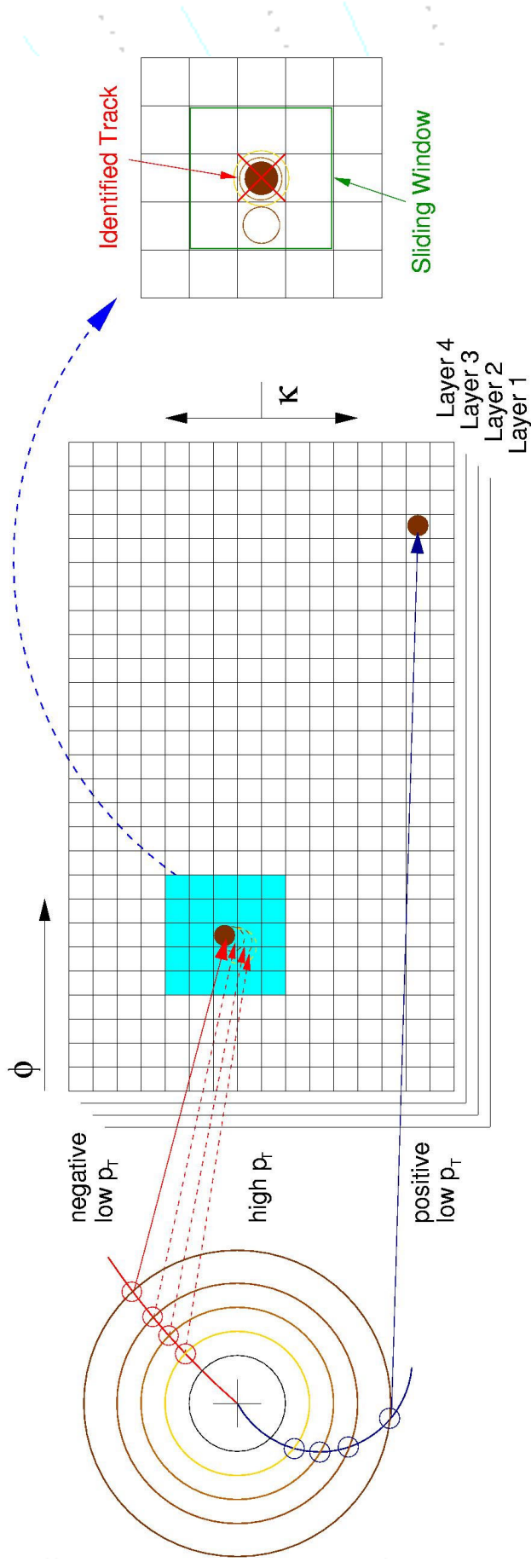
30 Front End Modules (FEMs)



- Search hits, then track segments (5 Altera FPGAs)
- Forward data to the L1 trigger card (another FPGA)

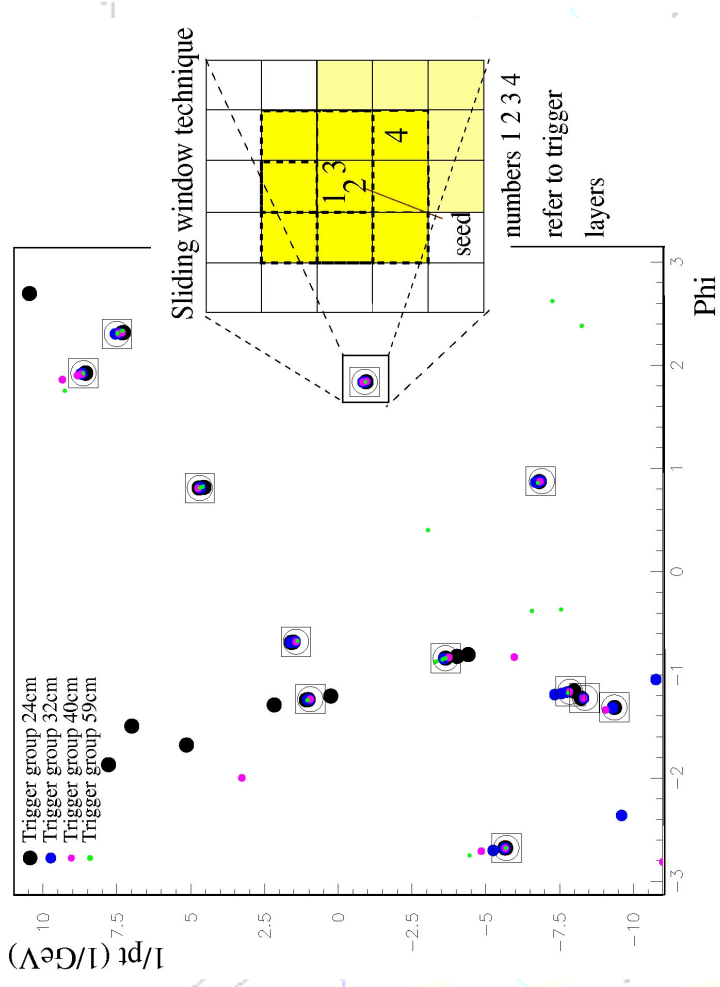
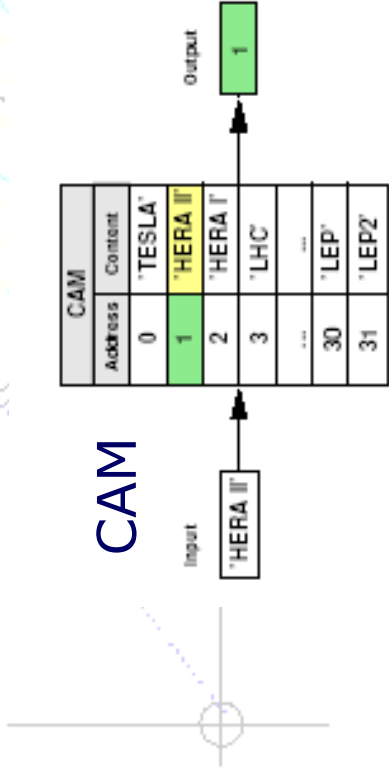
FTT - Level 1

- Collect information from all cells and layers (30 5 Gbit/s LVDS Links)
- Search for coincidences of at least 2 out of 4 layers in the $\kappa - \phi$ (track curvature - azimuthal angle) plane
- Count track multiplicities, apply p_T thresholds etc.
- Generate L1 Trigger signals



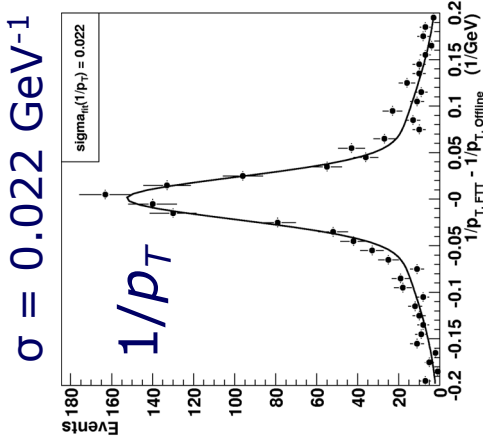
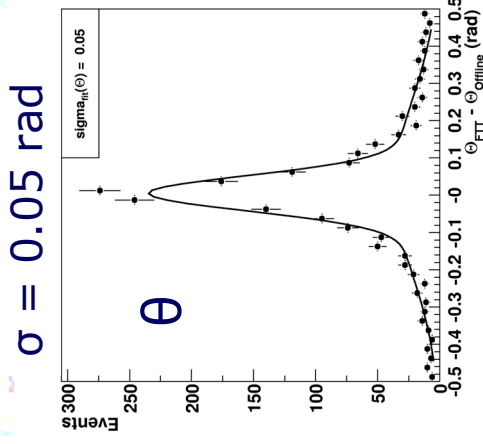
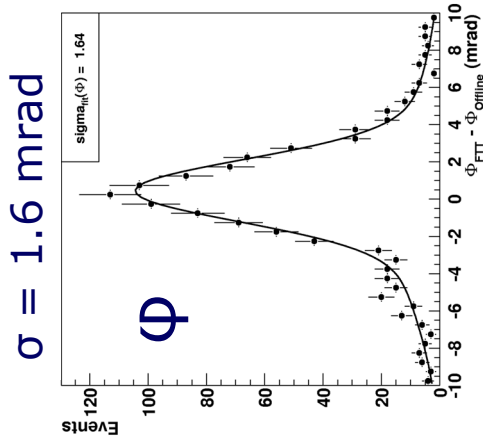
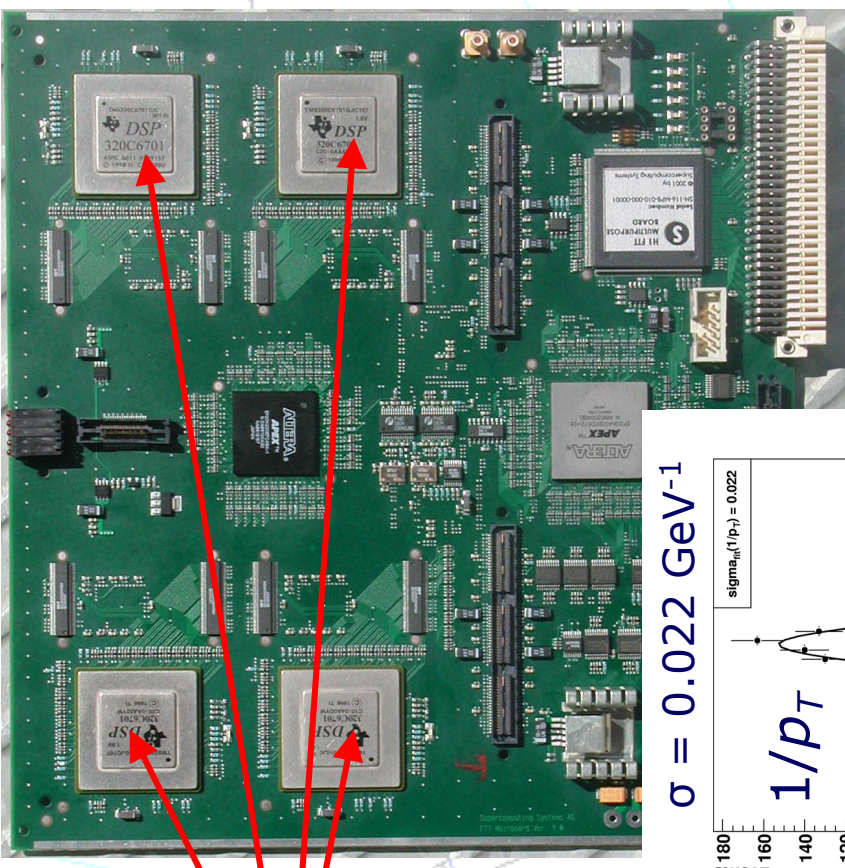
FTT - Level 2 - Linker

- Level 2 Linker (David Meer)
- Search for coincidences of layers in a 40 x 640 bin histogram in the $\kappa - \phi$ plane
- Implemented on a Altera FPGA, makes extensive use of CAMs (Content Addressable Memories)



FTT - Level 2 - Fitter

- Perform a helix fit to the linked track segments
- Uses Texas Instruments DSPs on a Multi Purpose Board (MPB)
- Resolution comparable to full offline reconstruction
- L2 Trigger decision based on track information

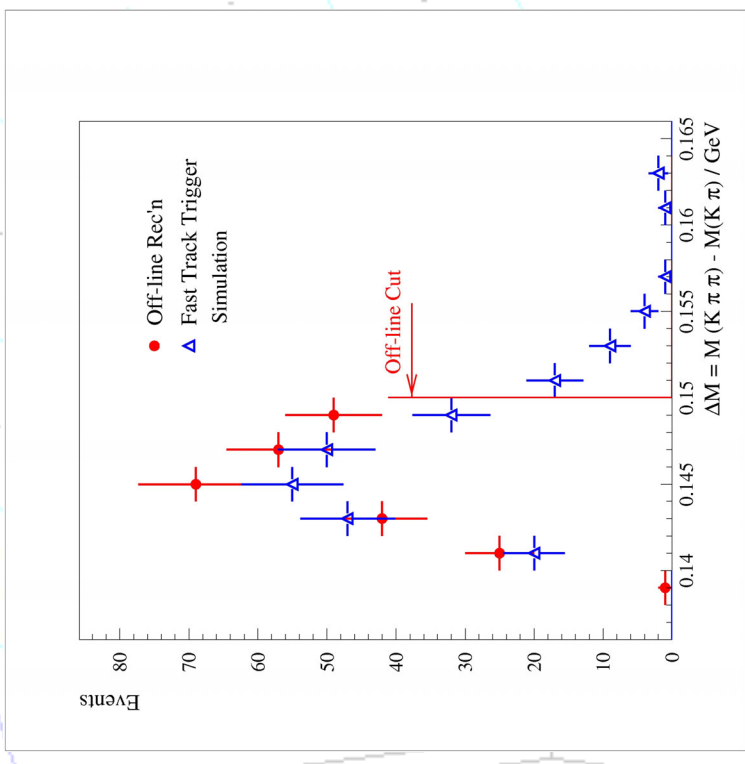
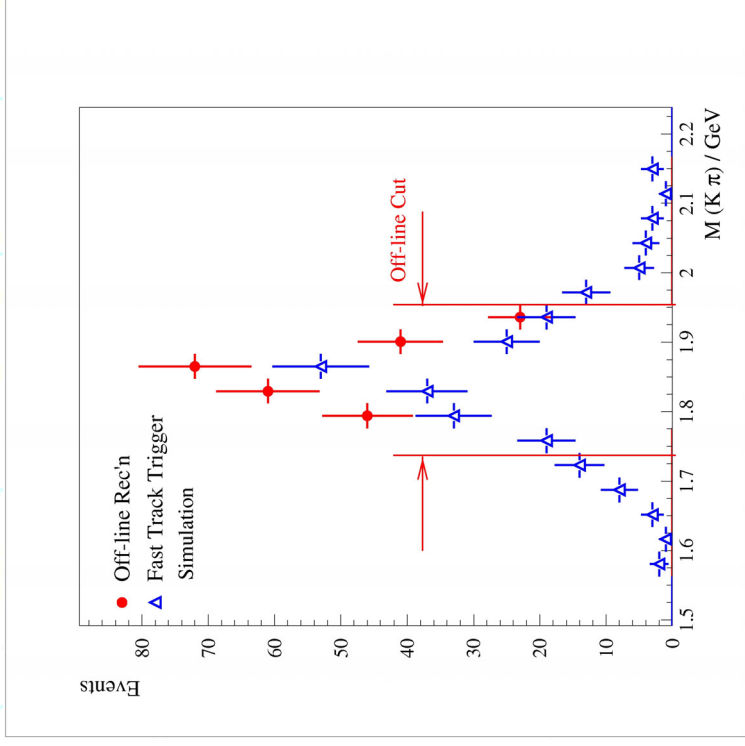
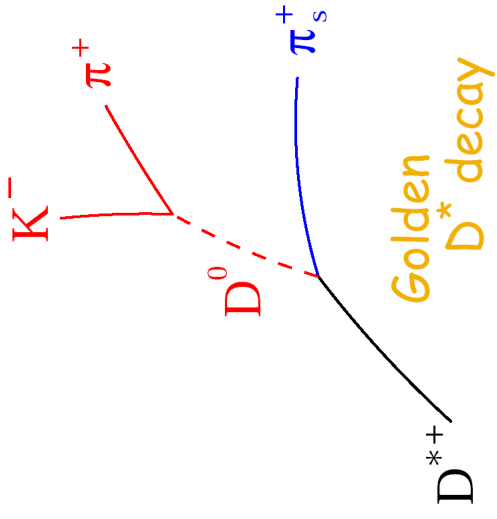


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FTT Level 3

- Farm of Power PCs
- Calculate invariant masses and identify resonances



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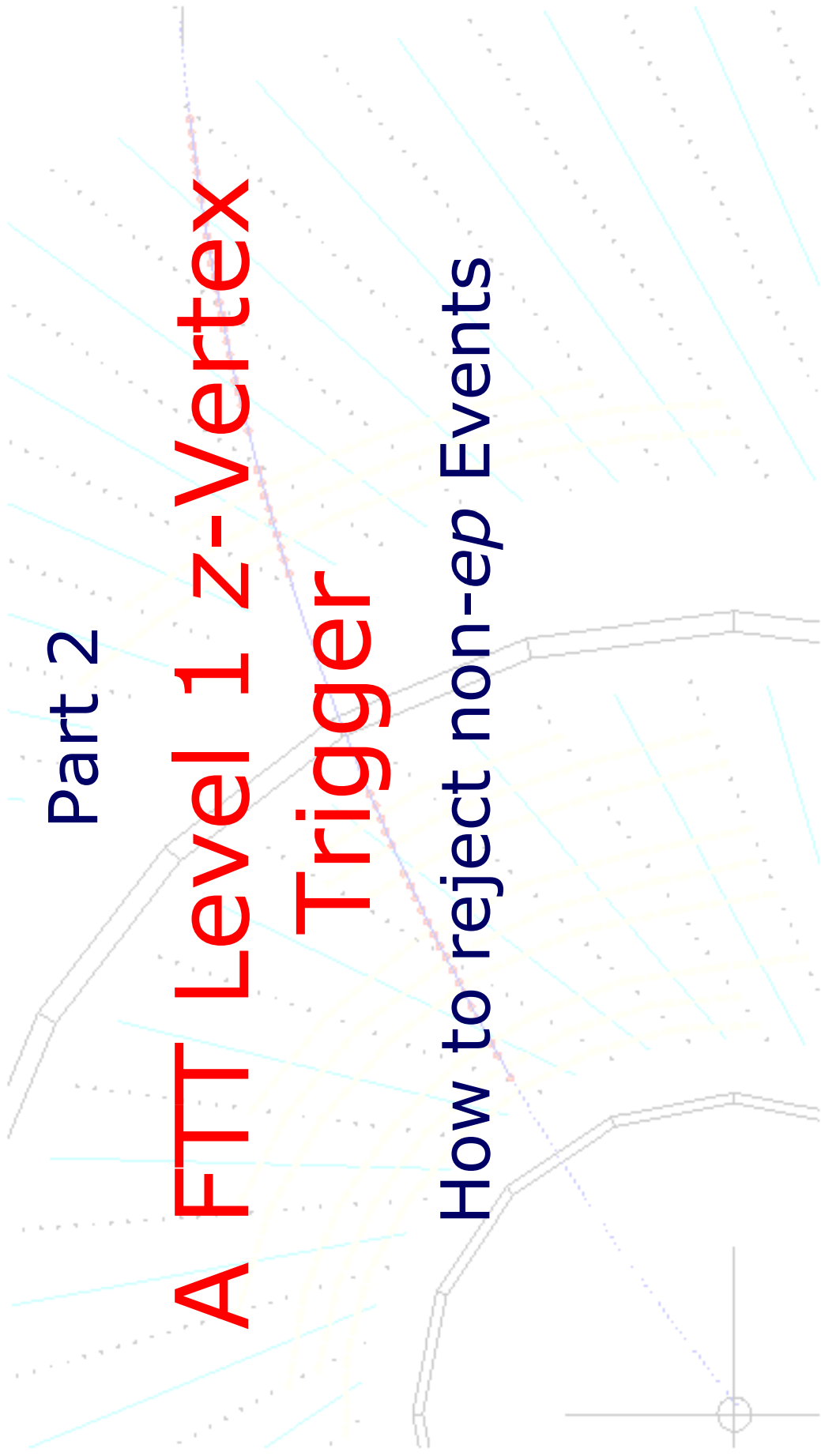
FTT - Current Status

- All hardware ready and working
- Analogue part commissioned and working
- Firmware is being finalised and tested
- Some more software (e.g. readout, calibration) needs to be written
- FTT on track for first trigger signals this year

Part 2

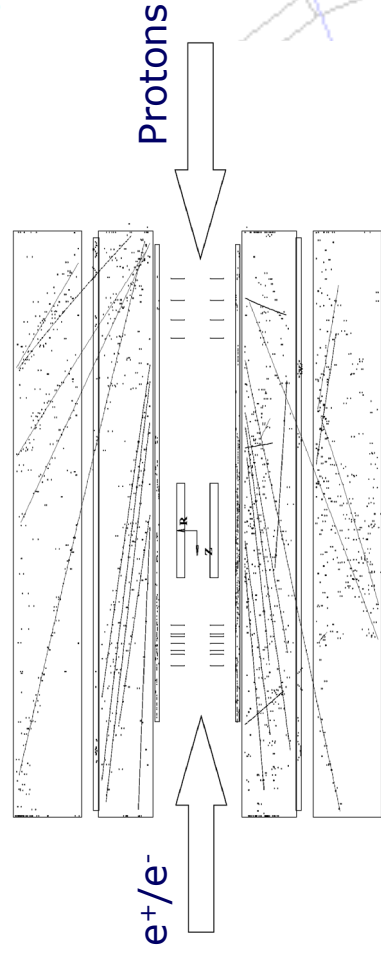
A FTT Level 1 z-Vertex Trigger

How to reject non-ep Events

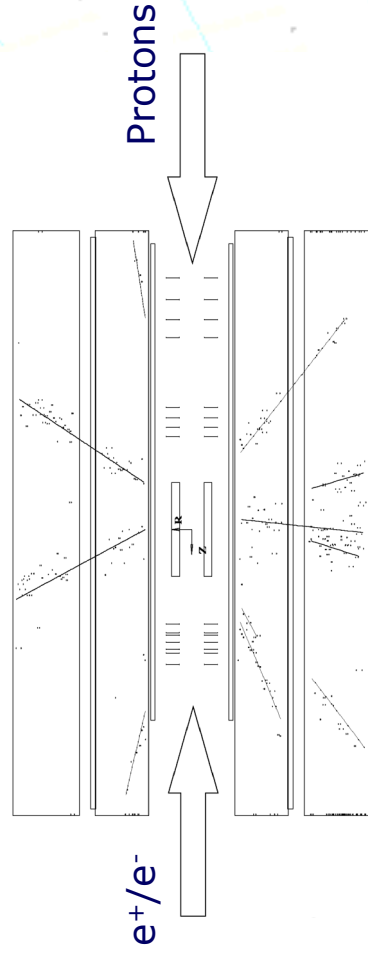


HERA II: Background

Problems

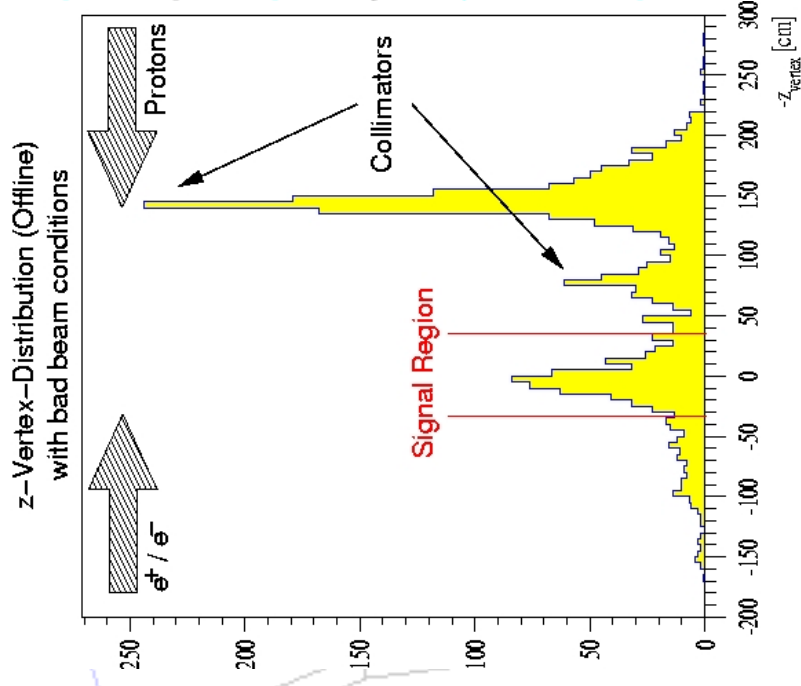


Proton - Wall



Proton - Positron

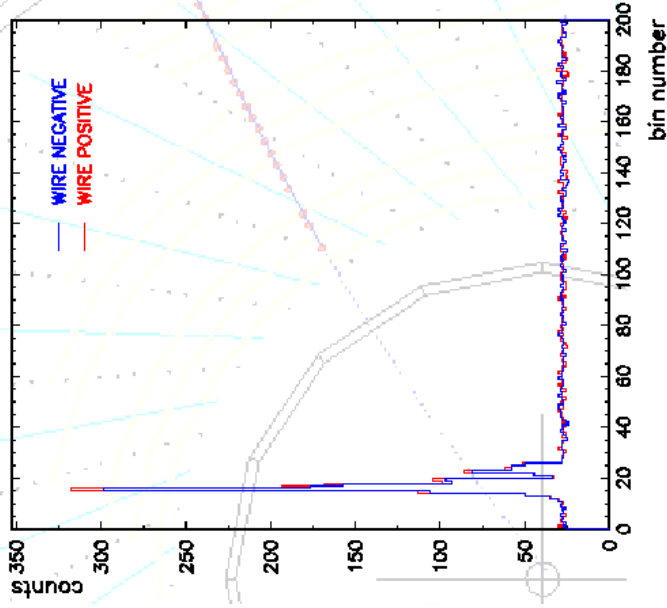
- Hera II: A lot of background from beam-gas and beam-wall interactions



Solution: A z-Vertex trigger

- Identify the common origin of tracks along beamline to distinguish ep and background
- The CIP2000 trigger does just that (-> Max)
- The Fast Track Trigger can also use z-Information on Level 1
- Allows for crosschecks and redundancy
- **2nd part of this talk:** Present algorithm for a FTT z-Vertex trigger

Measuring z: Charge Division

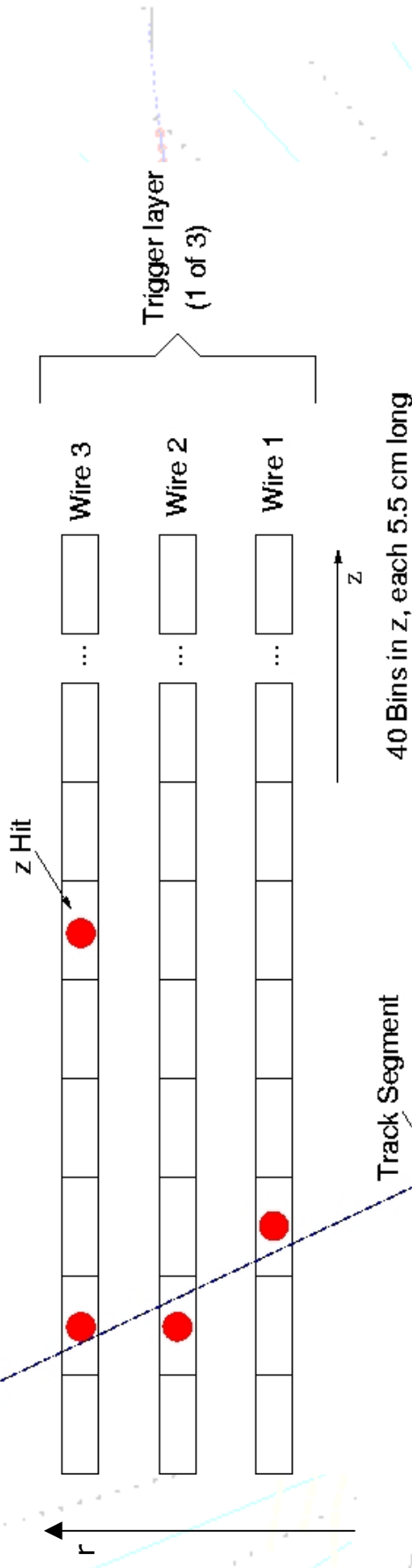


- Hit Position along wire is determined from the ratio of the charges collected at the two ends

$$\frac{Q_L}{Q_R} = \frac{z}{L - z}$$

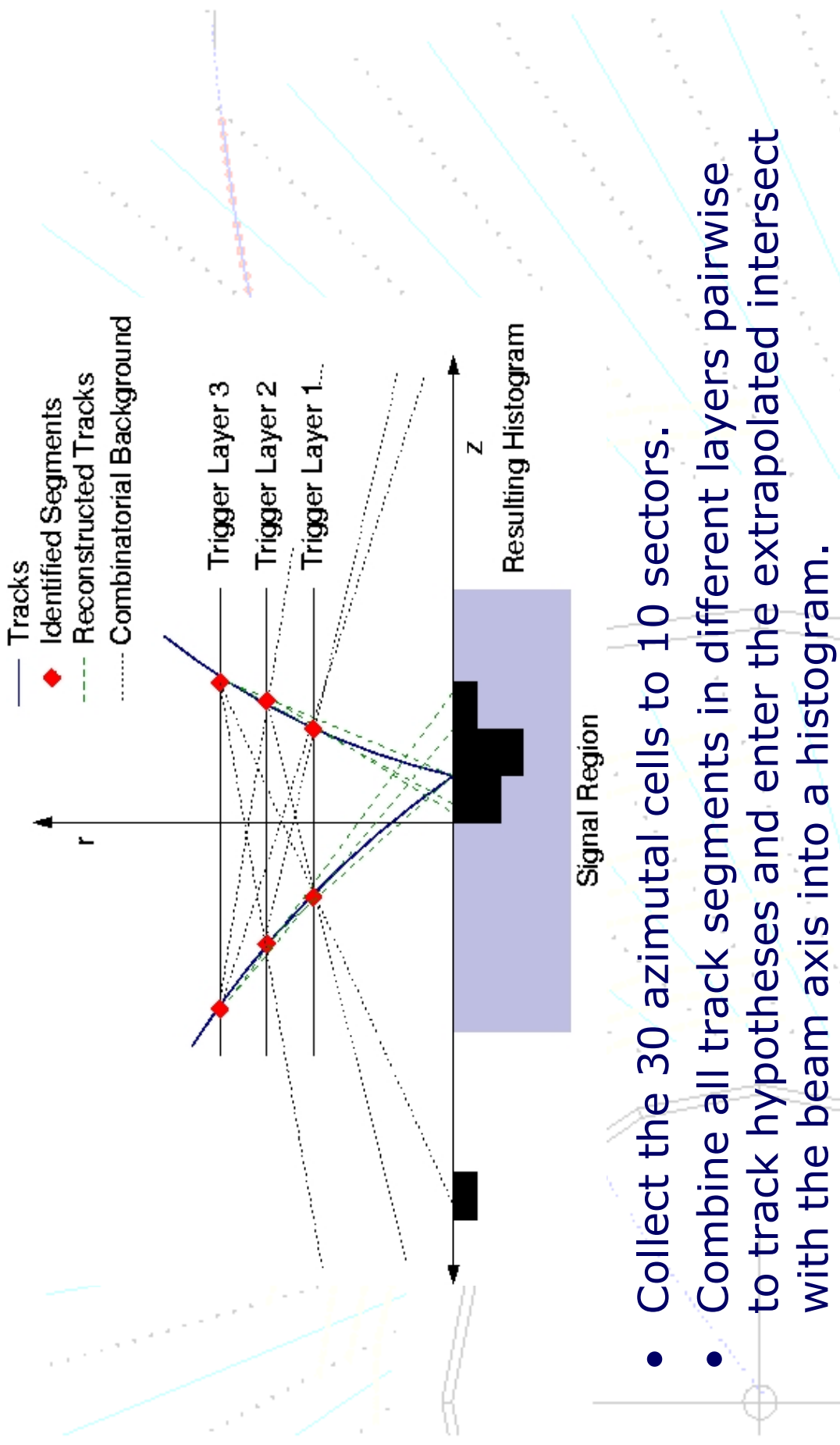


Identifying track segments



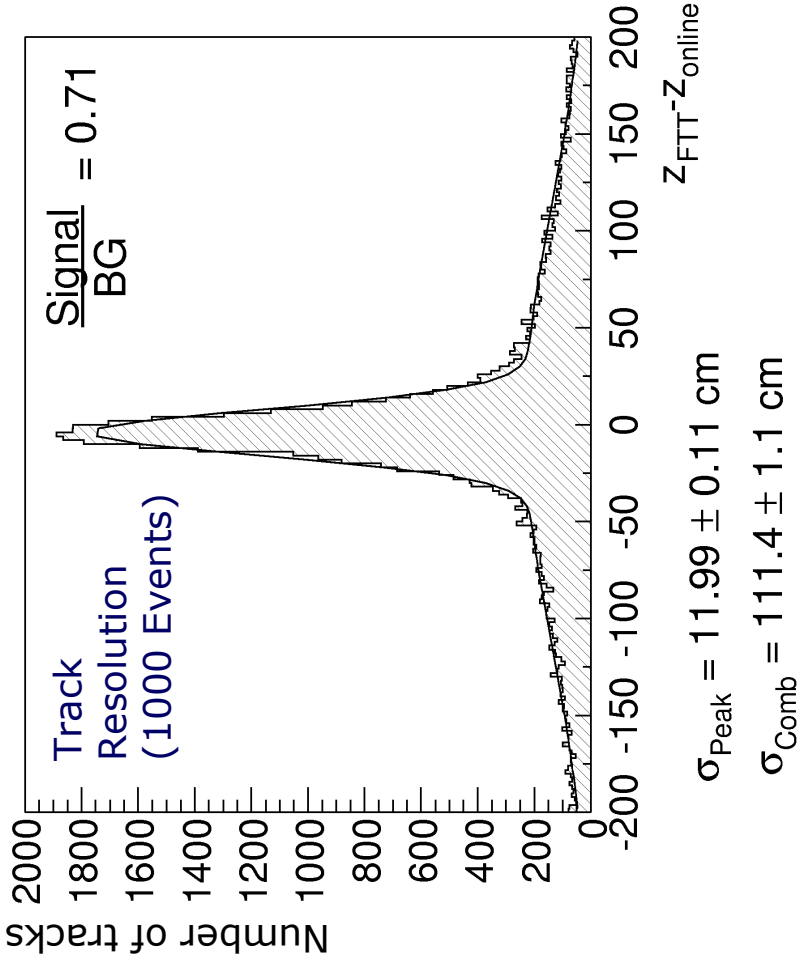
- In each trigger layer, valid **hit combinations** are combined to track segments
- CAM's (Content Addressable Memories) allow pattern recognition in a single computing cycle
- The existing FFT allows a p_T cut

Combining track segments



- Collect the 30 azimuthal cells to 10 sectors.
- Combine all track segments in different layers pairwise to track hypotheses and enter the extrapolated intersect with the beam axis into a histogram.

Single „Track“ resolution



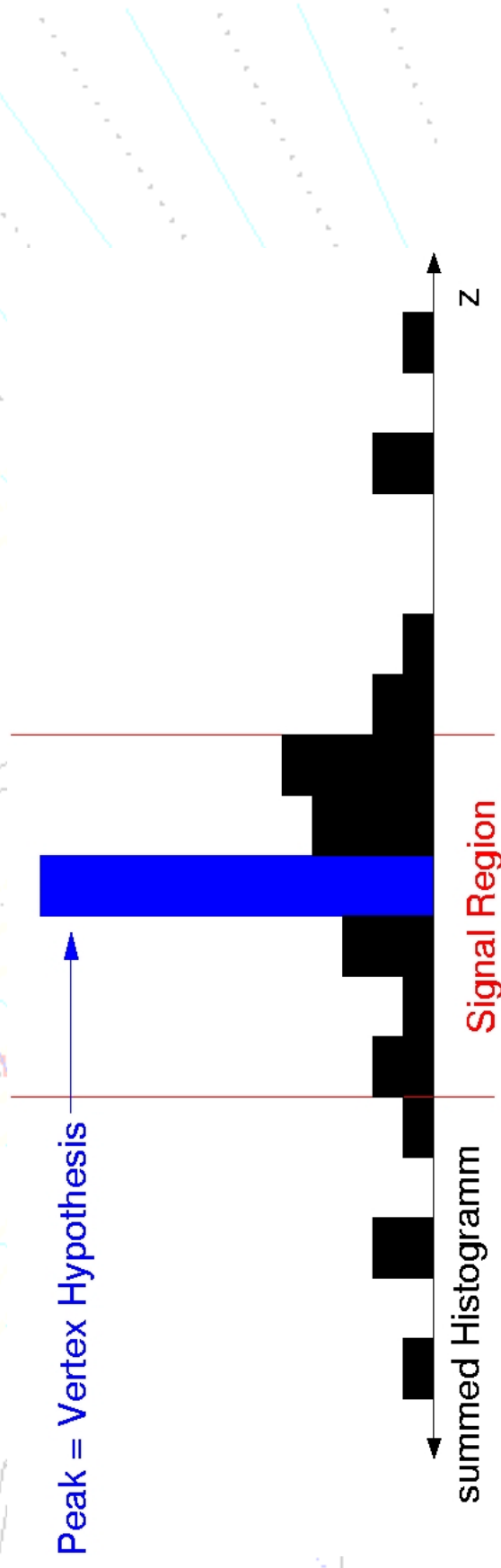
- Resolution of track candidates:

$$\sigma \approx 12 \text{ cm}$$

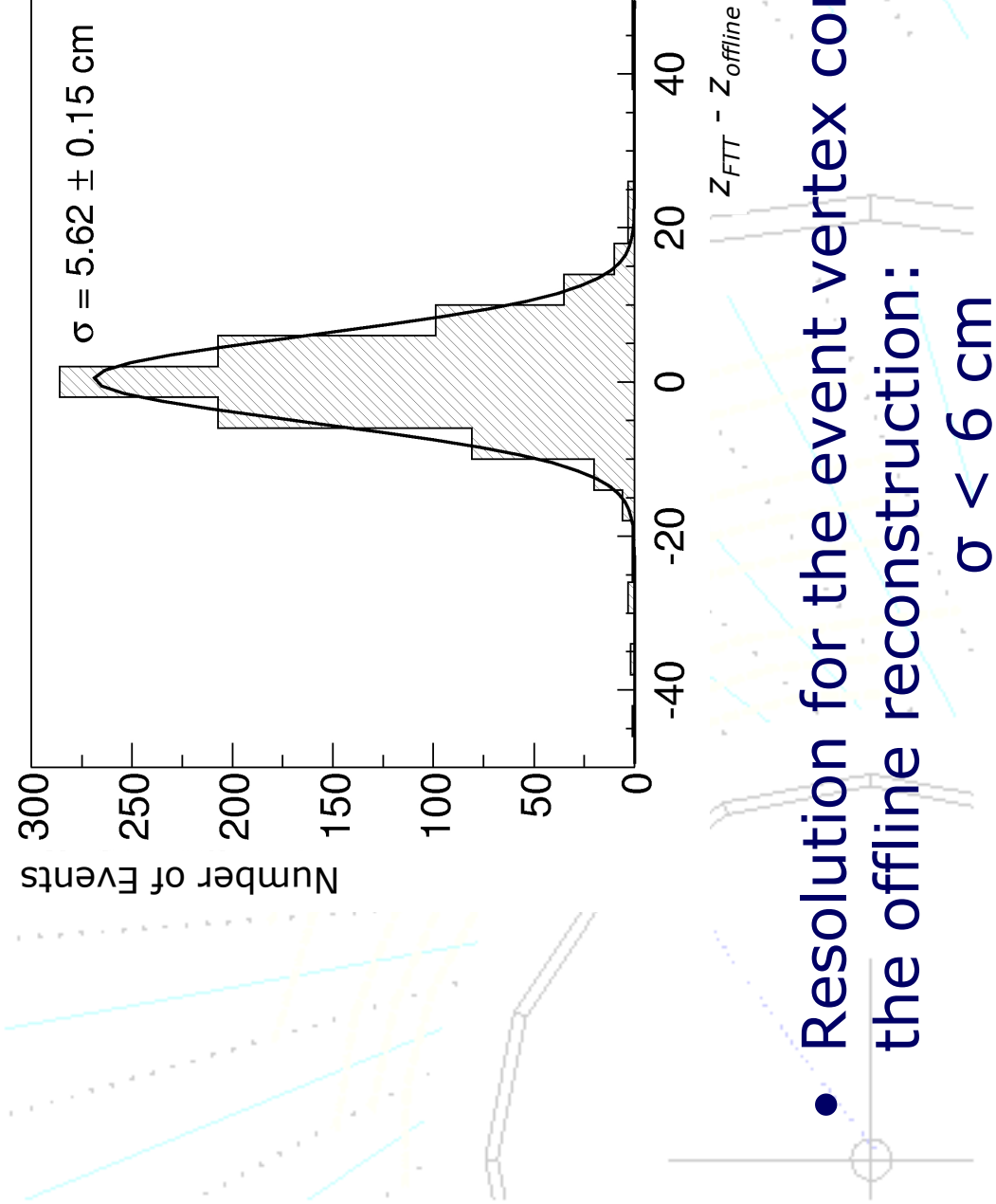
- Combinatorial background is under control

Trigger decision

- Sum histograms of all φ sectors
- Search a peak
- If the peak is within the signal region, the event is triggered
- More trigger elements, based on the peak height, the number of histogram entries etc. are planned
- The whole algorithm runs within the Level 1 latency of $2.2 \mu\text{s}$ (of which $1 \mu\text{s}$ drift time in the chamber)

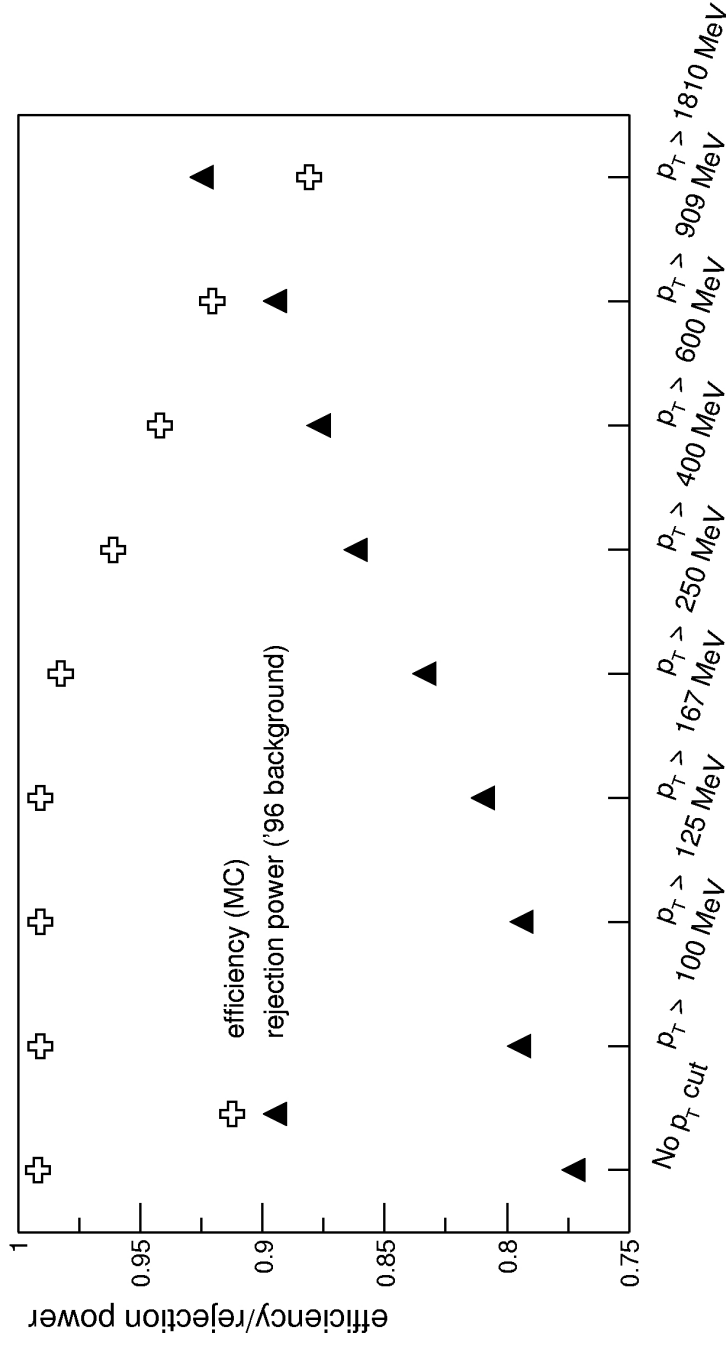


Vertex resolution



- Resolution for the event vertex compared to the offline reconstruction:

Trigger efficiency



- High efficiencies (98.5%) with good background suppression (factor 5) possible

Part 3

Precise z-Vertex determination

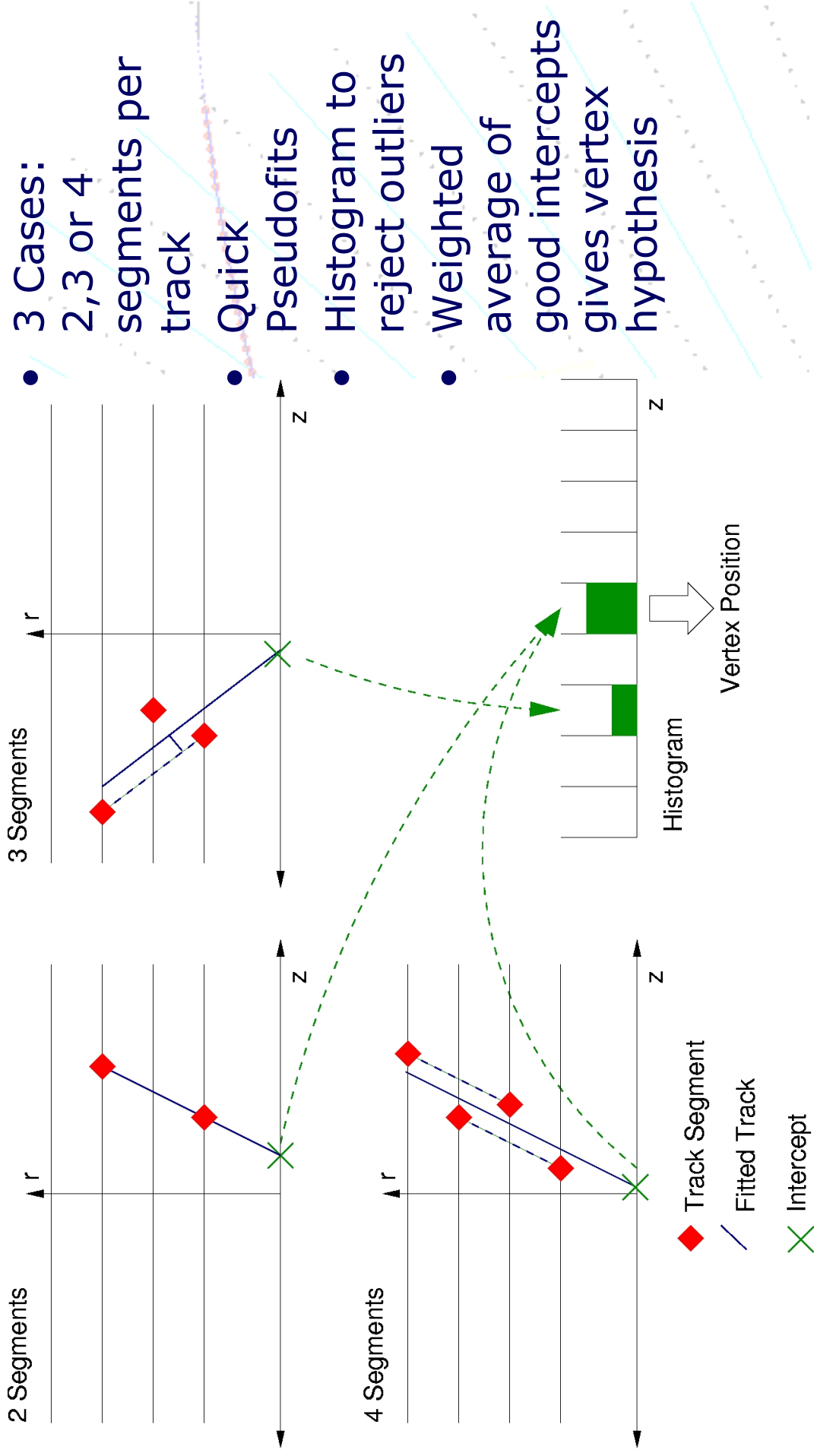
How to get a good input for
track fits



More of the same: L2 z-vertex finding

- z-Vertex position is used to as an input parameter to the track fit performed on the DSPs.
- Perform a quick pseudofit to the L2 linked segments
 - No combinatorial background
 - Up to four segments per track
- Pipelined algorithm taking 30 clock cycles (300 ns)

Algorithm



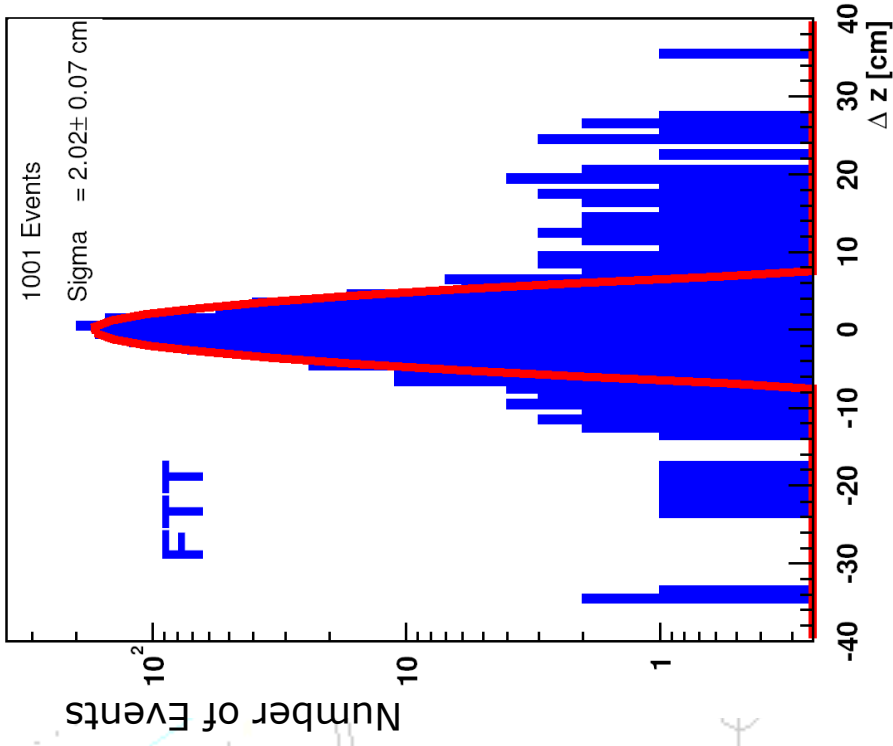
- 3 Cases: 2, 3 or 4 segments per track

• Quick Pseudofits

• Histogram to reject outliers

• Weighted average of good intercepts gives vertex hypothesis

L2 z-Vertex: Performance



- Resolution:

$$\sigma = 2 \text{ cm}$$

(compared to full
offline reconstruction)

- Firmware is written
and tested

