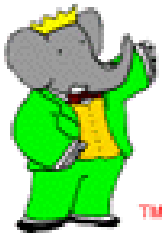

The BaBar Level 1 Drift-Chamber Trigger Upgrade with 3D Tracking

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Representing the BaBar Trigger Upgrade Team

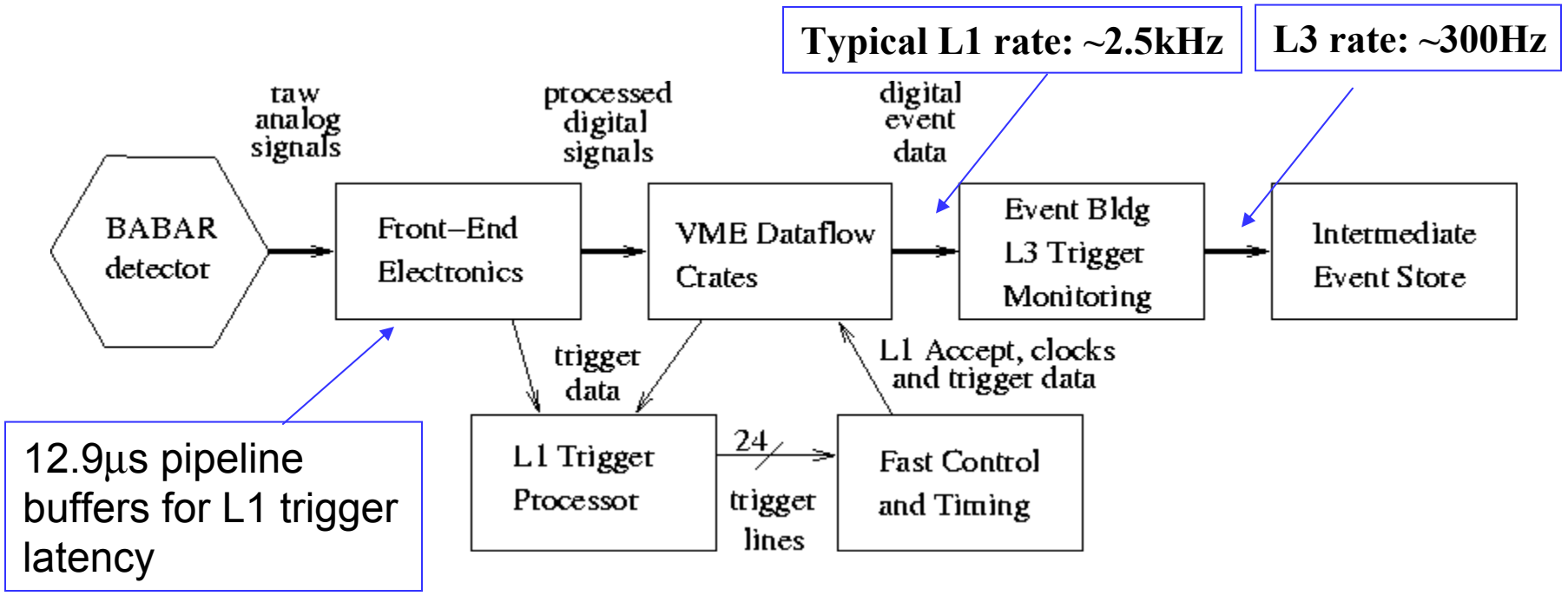
DPF 2004, UC Riverside, August 27th 2004

THE UNIVERSITY OF IOWA

Outline

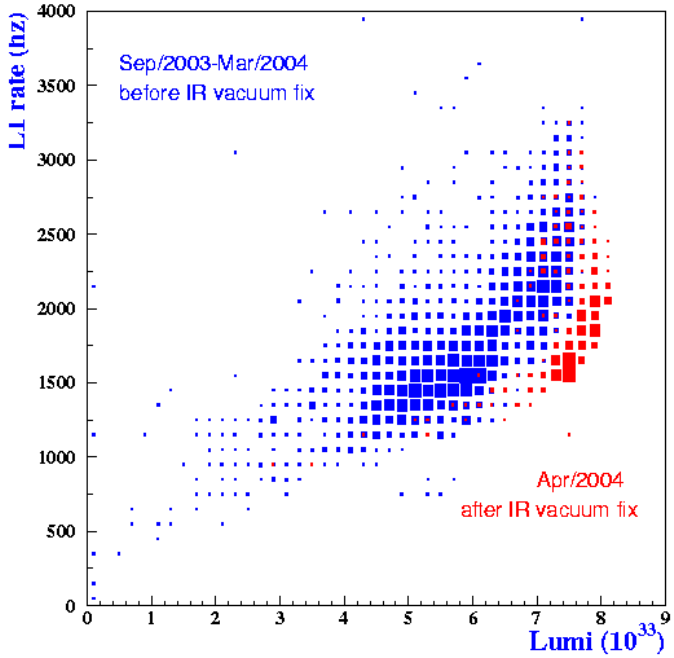
- Overview of BaBar Trigger/DAQ System
- Upgrade motivation
- Design implementation
- System integration and testing strategy
- Initial performance from the full system commissioning in Jul 2004
- Summary

The BaBar Trigger/DAQ System Layout



Motivation

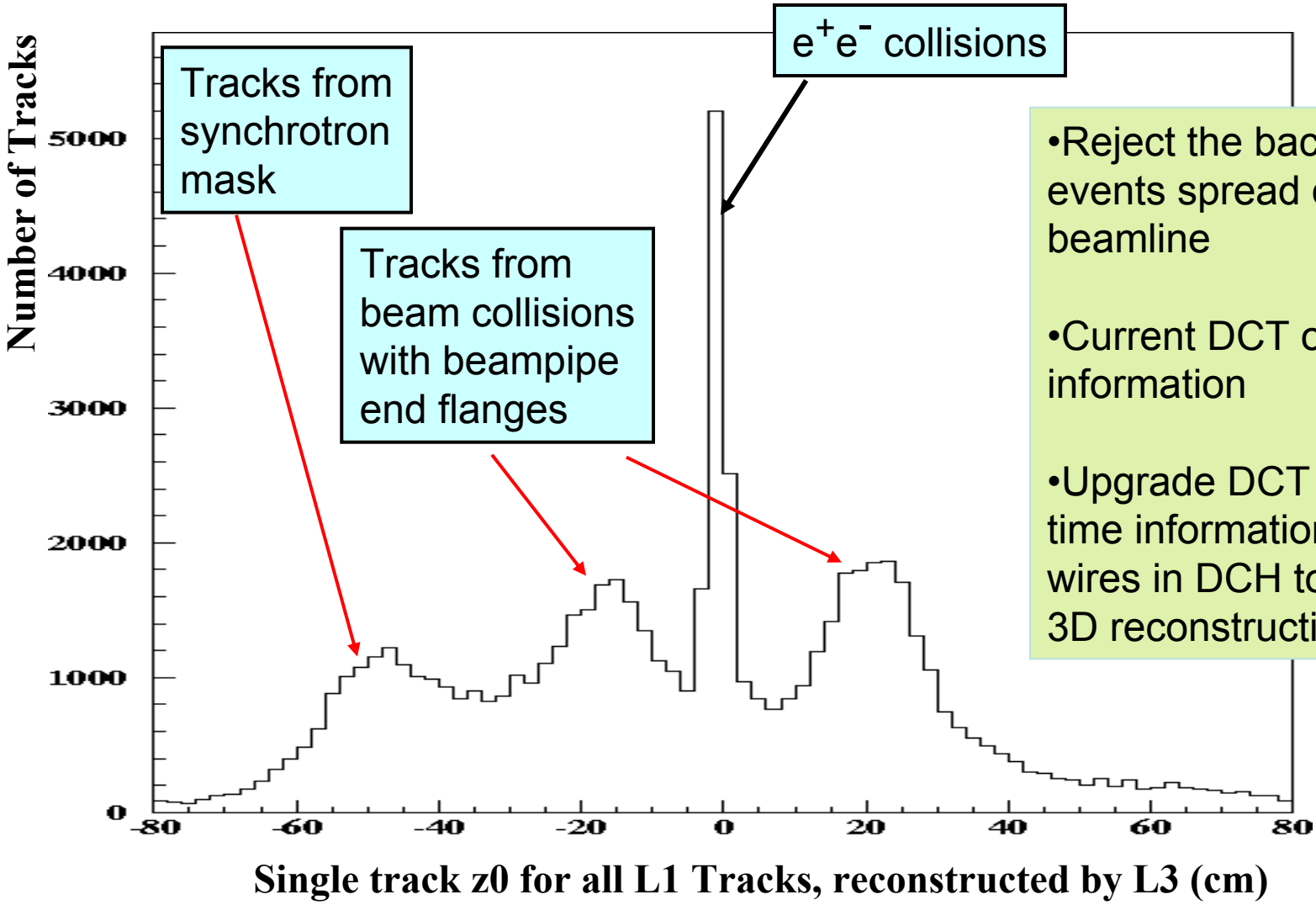
- Excellent performance of PEP-II
  - $L^{design} = 3*10^{33}cm^{-2}s^{-1}$
  - $L^{peak} = 9.2*10^{33}cm^{-2}s^{-1}$
  - $L^{upgrade} >= 2*10^{34}cm^{-2}s^{-1}$



- High Luminosity ->high Background rate, and long dead time
  - L1 rate <3kHz, dead time up to *3%*
  - L1 rate in 3-5 kHz, dead time up to *20%*

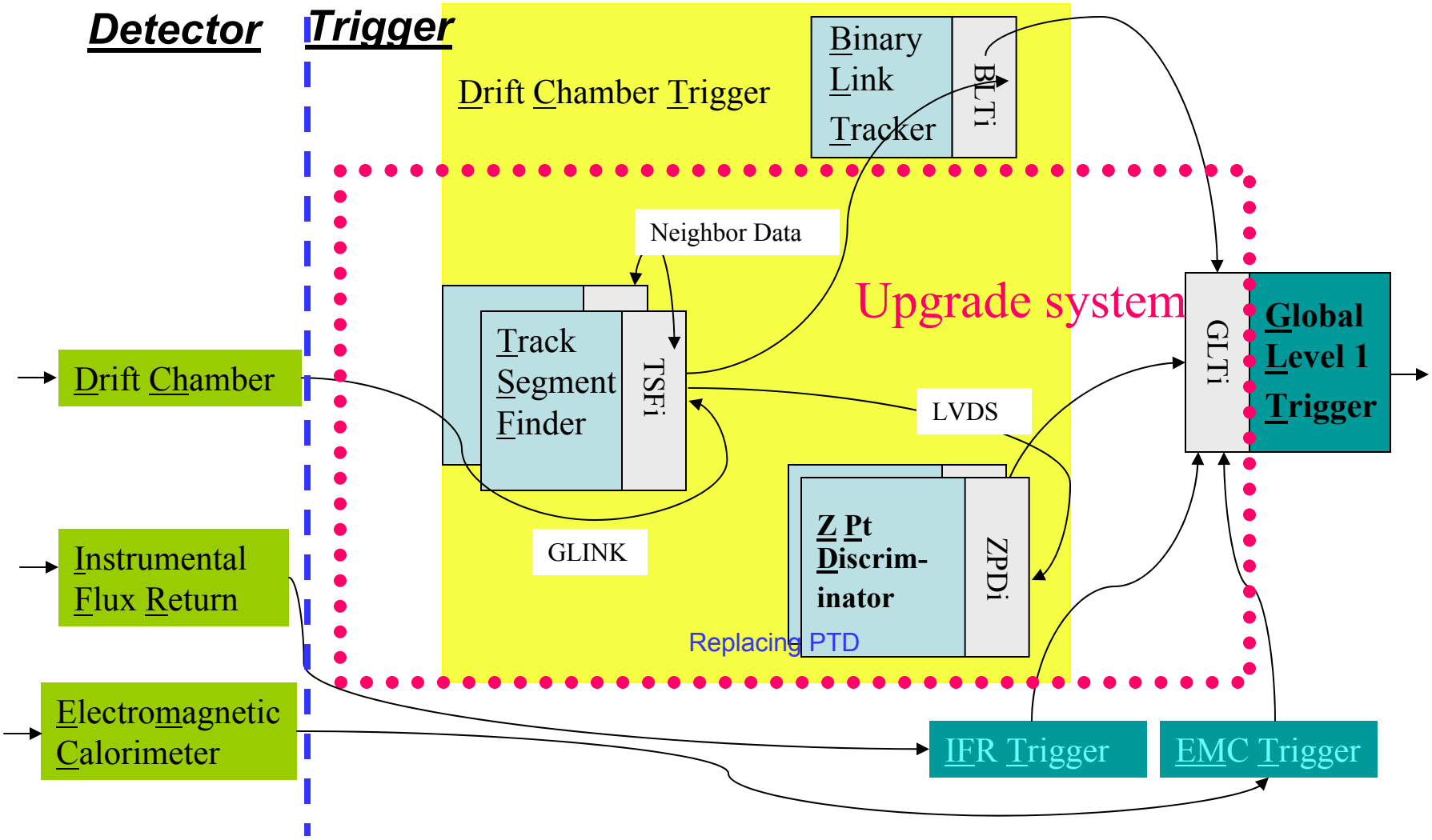
- Goal: L1 rate <4kHz at ~$2*10^{34}cm^{-2}s^{-1}$
  Low dead time

Machine Background



- Reject the background events spread out along the beamline
- Current DCT only uses r-φ information
- Upgrade DCT Use the drift time information and stereo wires in DCH to perform fast 3D reconstruction

L1 Trigger system and upgrade



Track Segment Finding

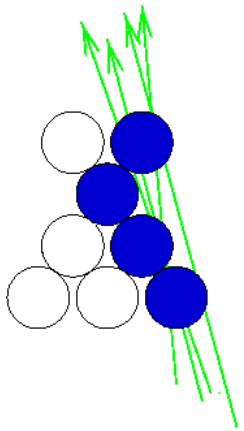
Use drift time information to better determine track postion and event time

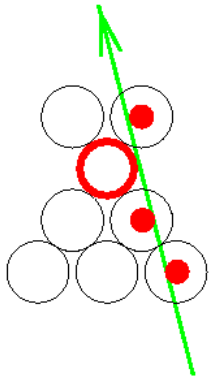
Utilize the 267ns sampling over the max ~1ms drift time

⇒ 0.8mm spatial resolution for a segment

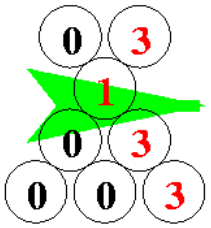
Translates to ~1.5cm δ_Z for stereo layers.

One - shot *versus* ***Counter - Based***





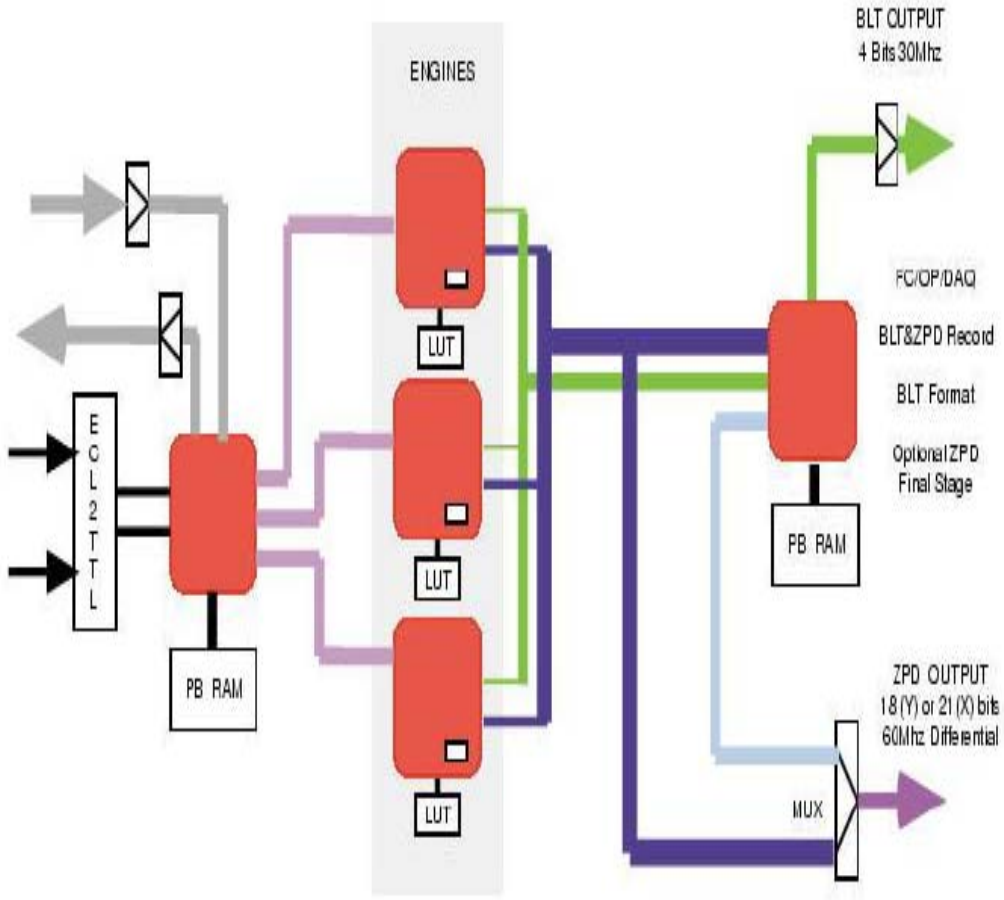
Look-Up-Table address



position & time

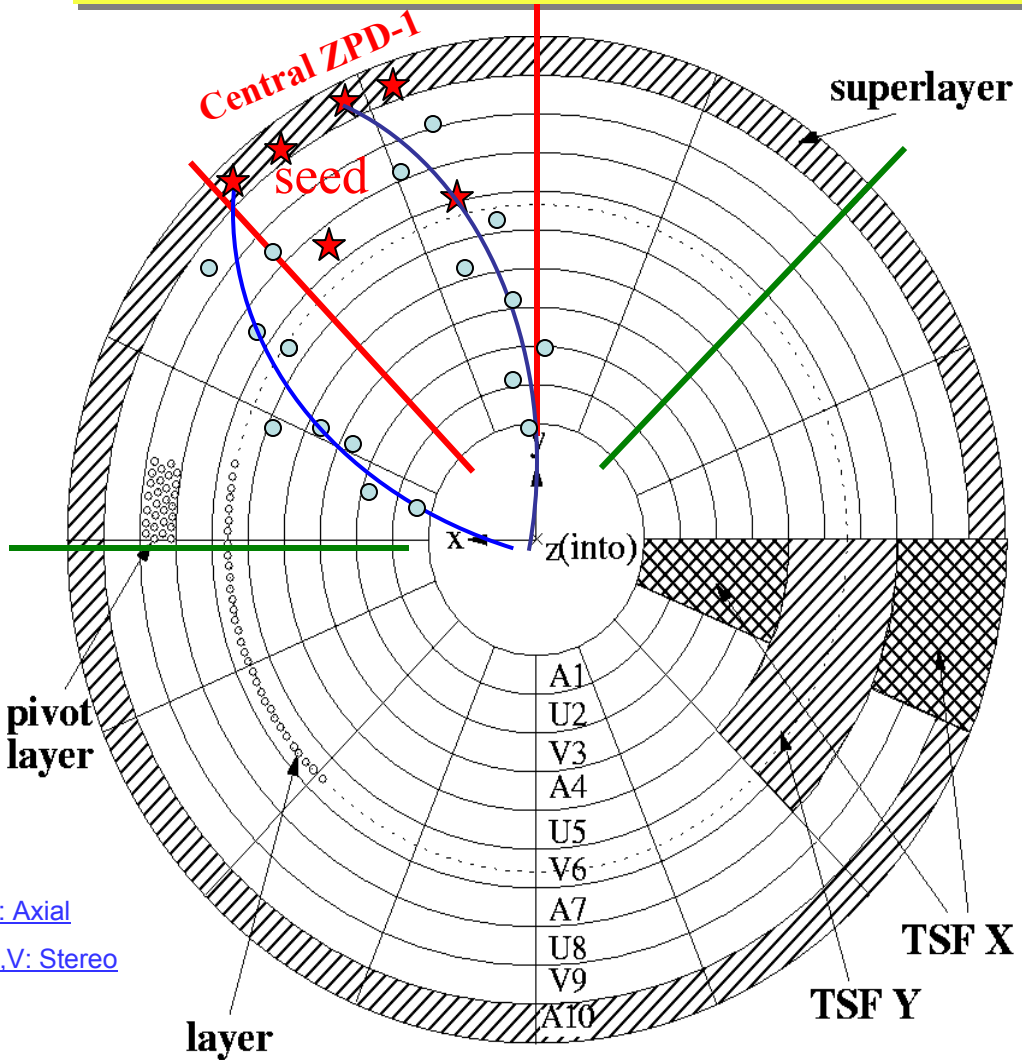
The Main reason we need to rebuild TSF is to ship the stereo layer information to ZPD

TSF Block Diagram



- New replacement TSFs are half 9U Euro cards with 5 XILINX FPGAs (4 XC2V1000 +1XC2V1500).
- ZPD need stereo layer give the additional fine-phi information
- Improve fine-phi information LUT from 5-bit to 6 bits
- Increase number of segment output : 1per supercell ->3 per supercell pair

Drift Chamber Trigger Geometry



BaBar Drift Chamber (DCH):

- 40 wire layer (10 superlayers)
- 4 axial / 6 stereo (44-76mrad)
- 96-256 cells/layer (18mm width)
- 1 bit/cell to TSF every 267ns via Gbit optical fibers.

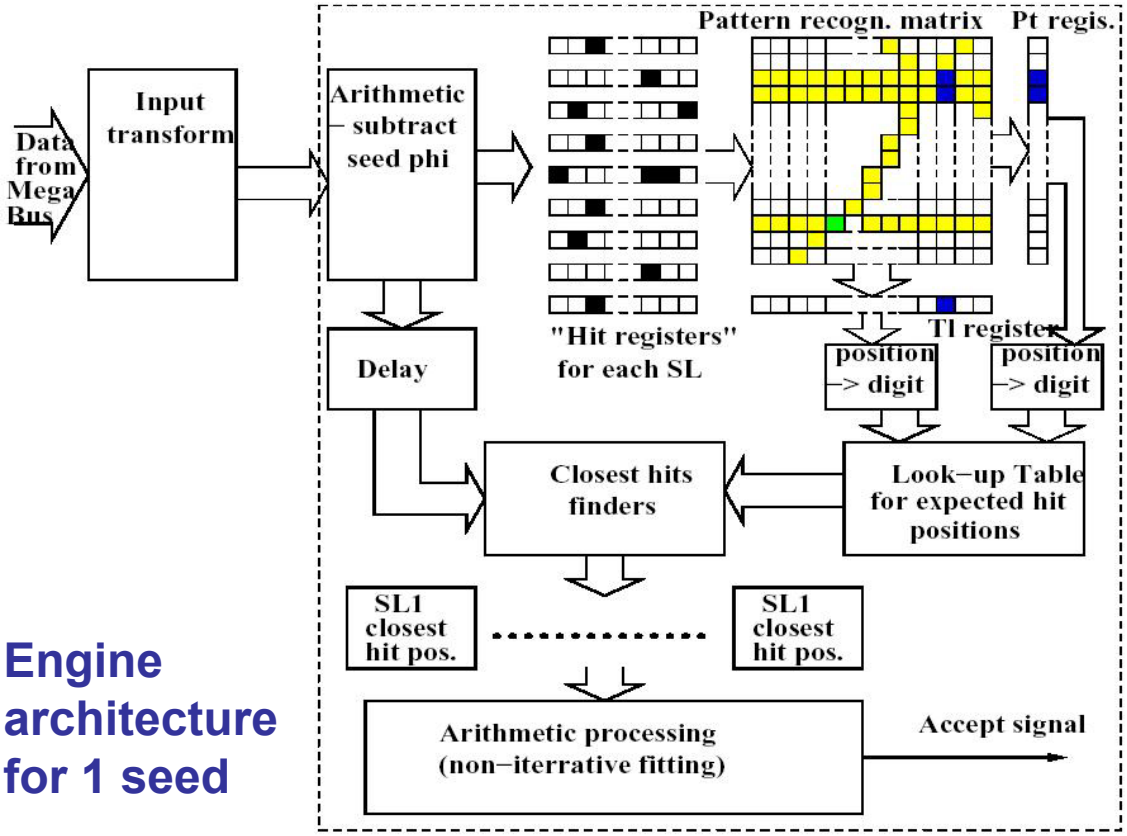
Track Segment Finders (TSF):

- 16 TSFX + 8 TSFY
- Up to 3 segments per 1/16 ϕ selected for ZPDs via LVDS channel links.

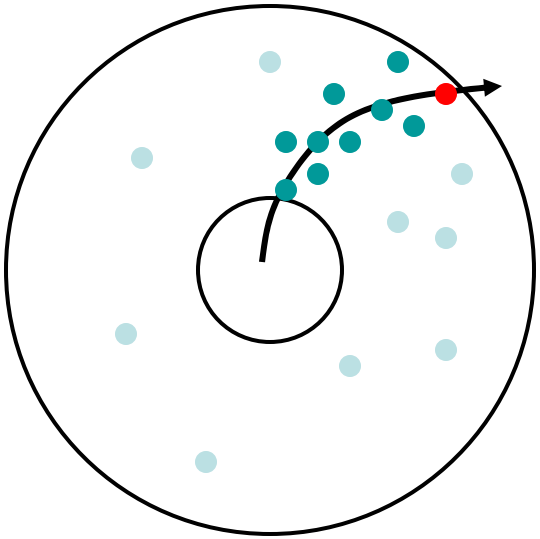
Z-P_t Discriminator (ZPD):

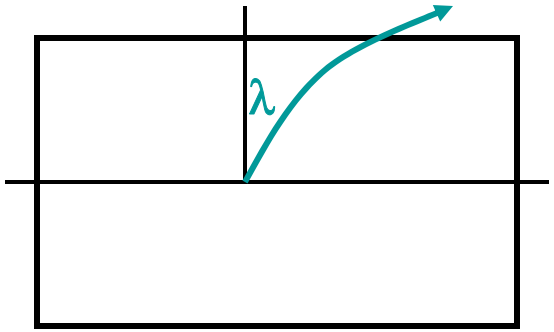
- Each ZPD works on A10,A7 seeds from 1/8 ϕ central region, but using data from 3/8 ϕ from 6 TSFX + 3 TSFY, aiming for Pt reach down to 250MeV.
- Issue 2 types of track triggers in 1/16 ϕ bins for GLT every 134ns.

ZPD Seed Track Finder Algorithm



Engine architecture for 1 seed



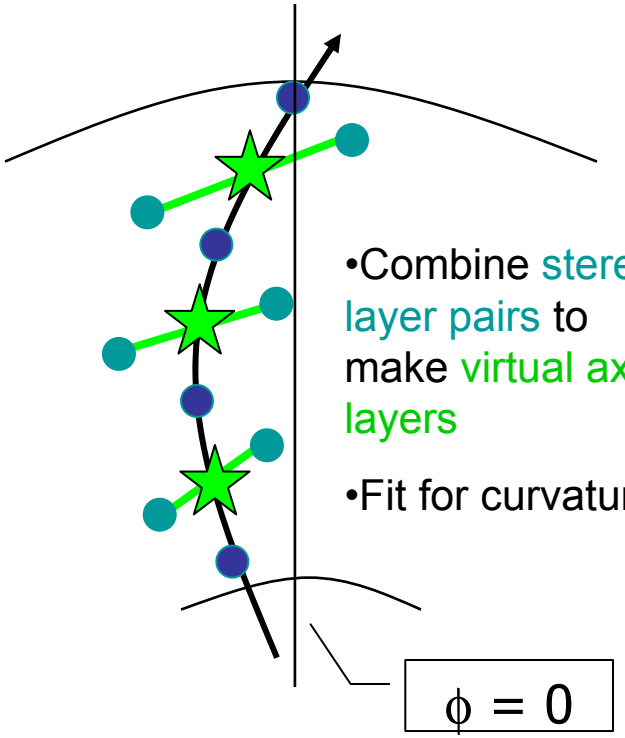


Pattern recognition: by *Hough transform*

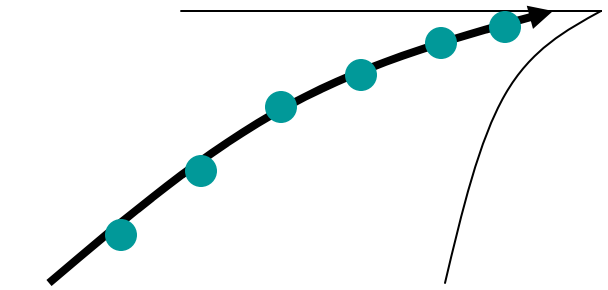
Seed segment and IP pin track arc.Other segments on track can be represented as a line in (tanλ, Pt) space.

Coincidence of hits from many layers with same tan λ,Pt identifies Track.

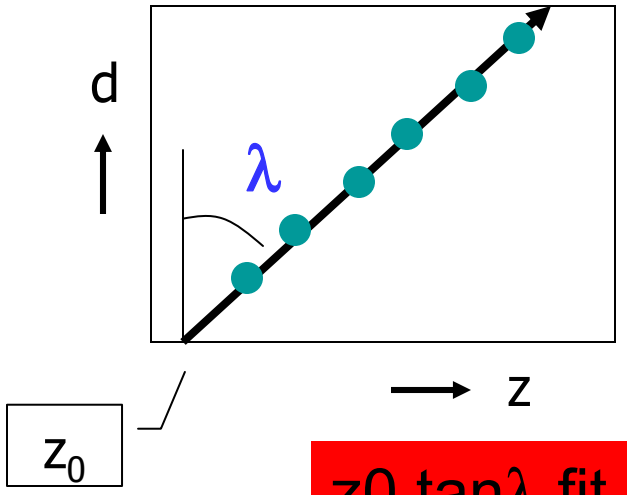
ZPD Track Fitter Algorithm



r-φ fit

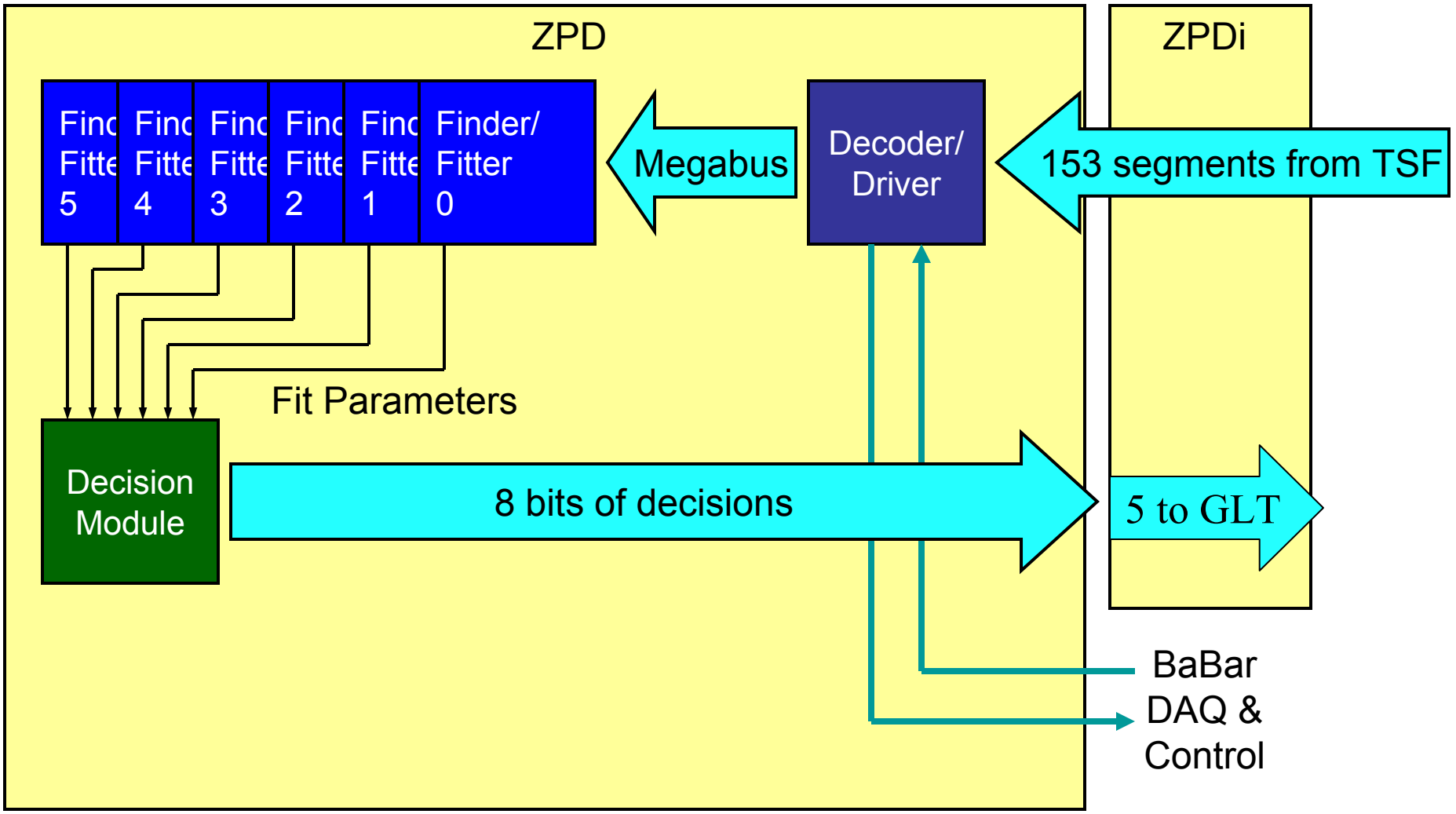


6 z_i make a straight line in d-z plane

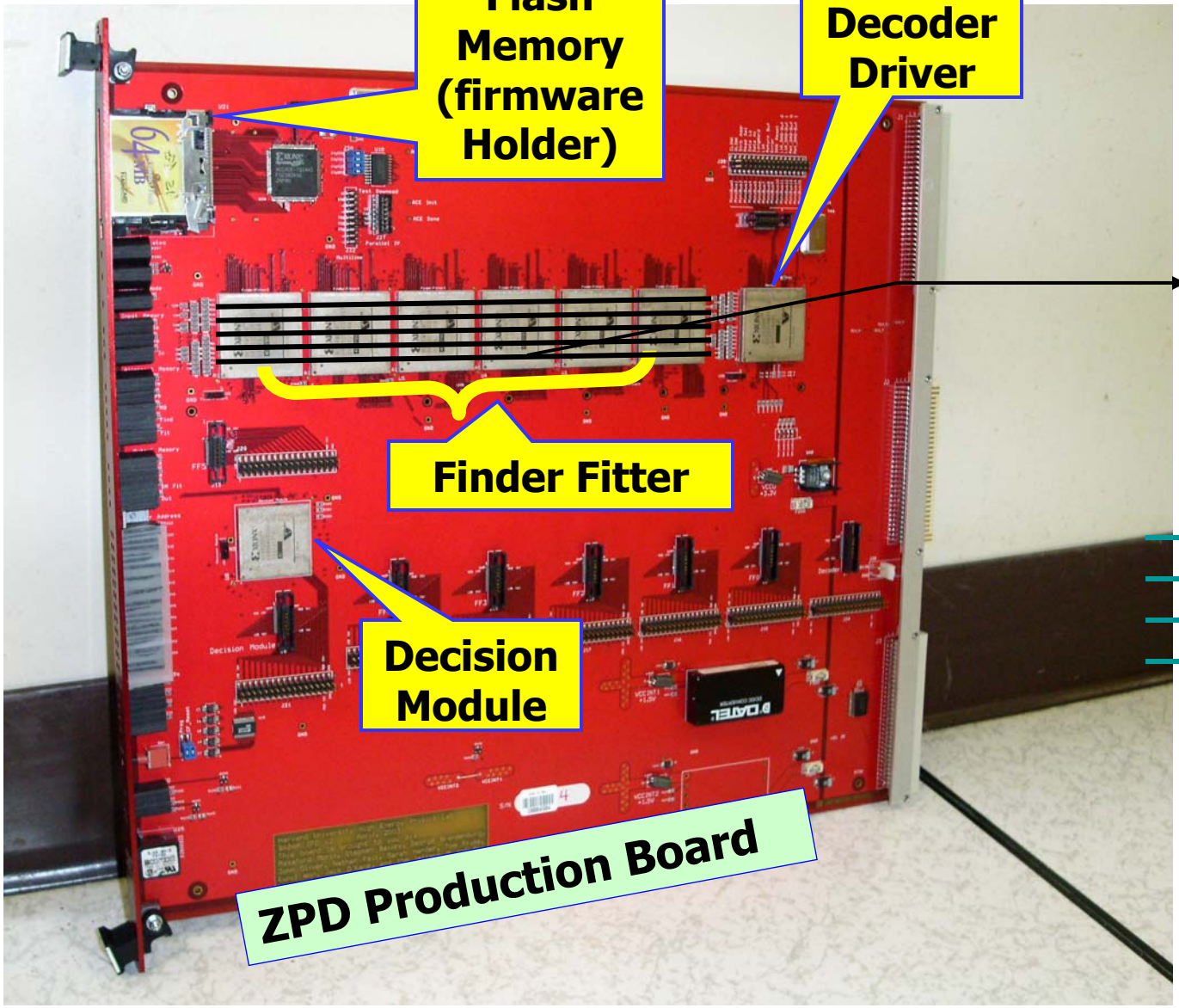


z0 tanλ fit

ZPD Block Diagram

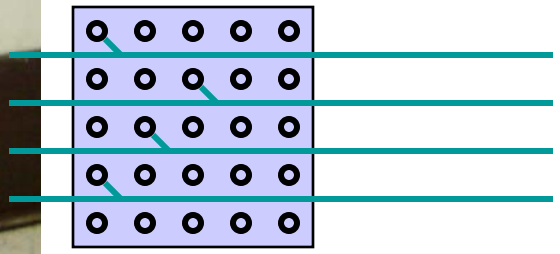


ZPD Hardware Implementation



- 9U Eurocard
- 6 Xilinx XC2V4000
- 1 Xilinx XC2V3000
- 1 Xilinx XC2V2000

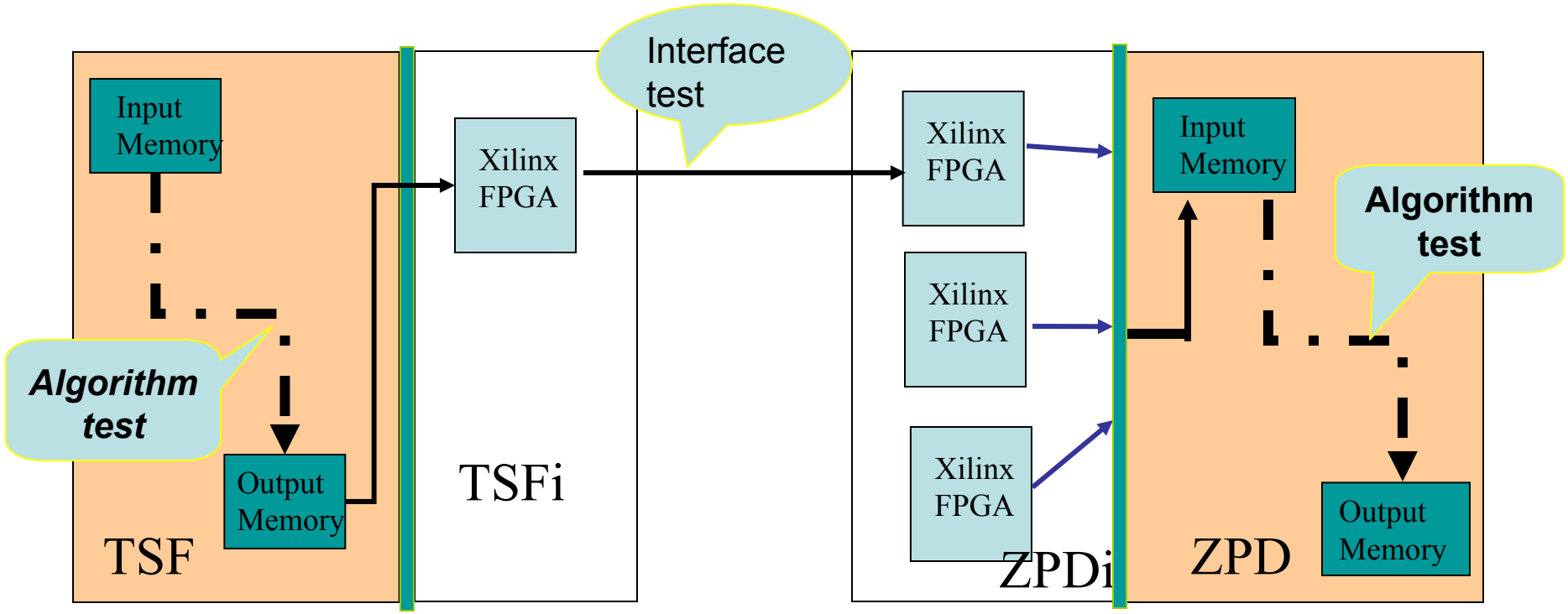
Megabus:
75 LVDS pairs@120MHz transports segment info to 6 Finder/Fitters,



LVDS pairs run directly under BGAs, very short taps to pins

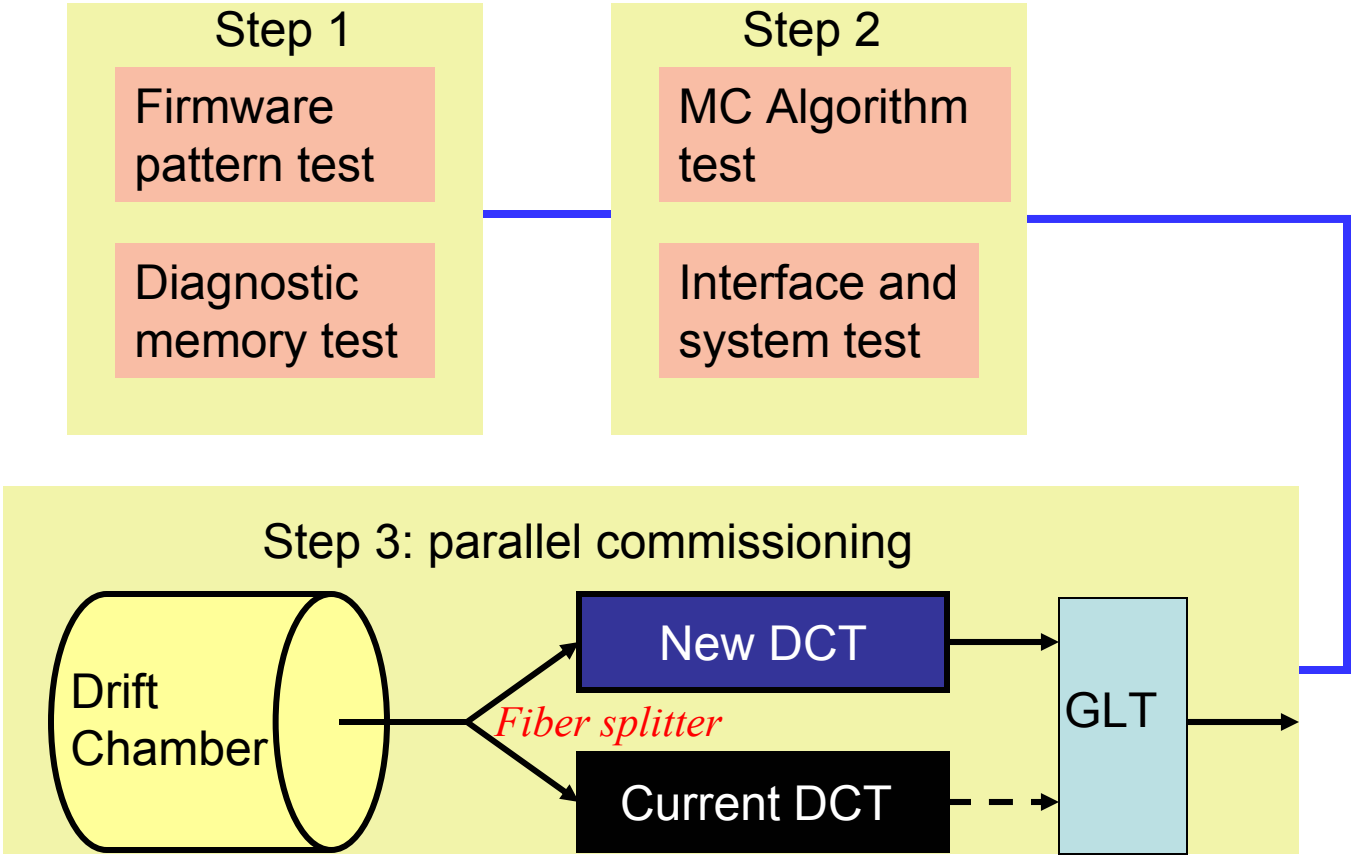
X. Chai, DPF2004

Test Strategy



- All trigger boards have diagnostic memory.
- Monte Carlo events played from input to output to do bitwise validation of implementation.
- These memories are also used to do interface tests between boards.

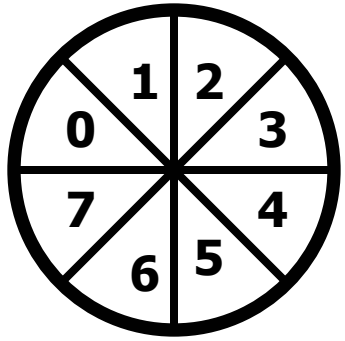
Test Strategy



- ***Parallel commissioning allow comparisons between the old and new trigger***
- ***No interfering with the ongoing BABAR data taking operations***

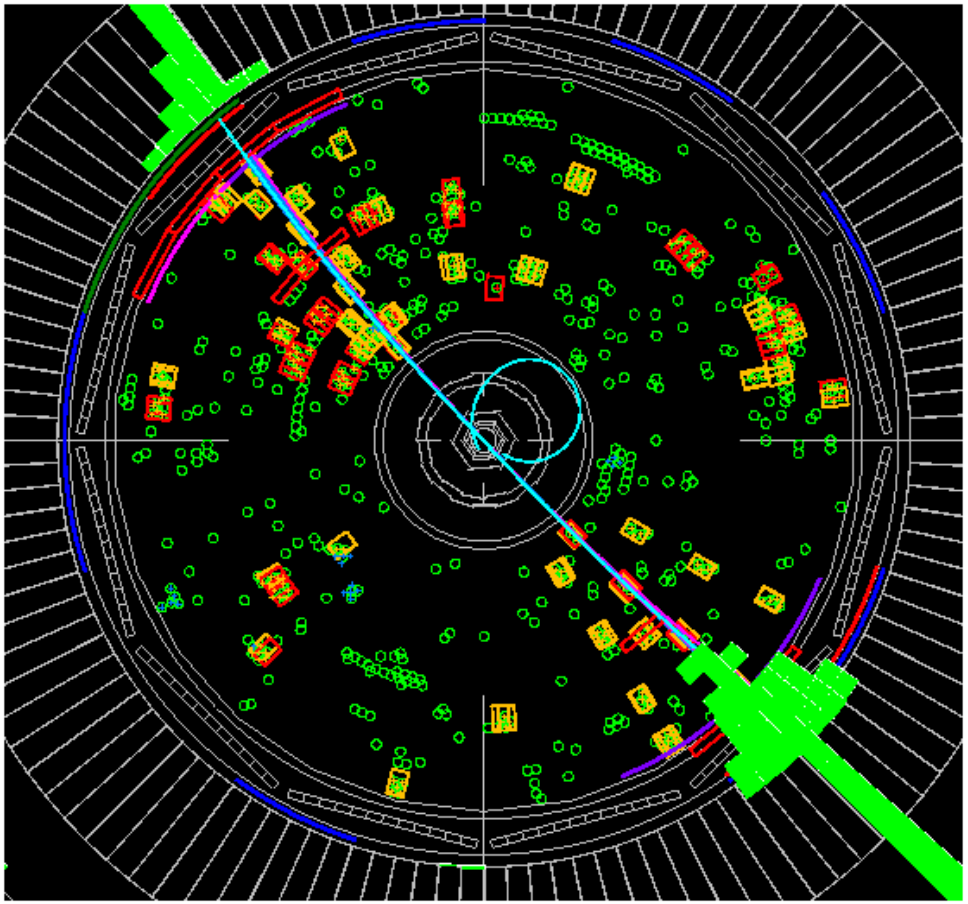
July Commissioning - ZPD

→ z-trigger driving BaBar



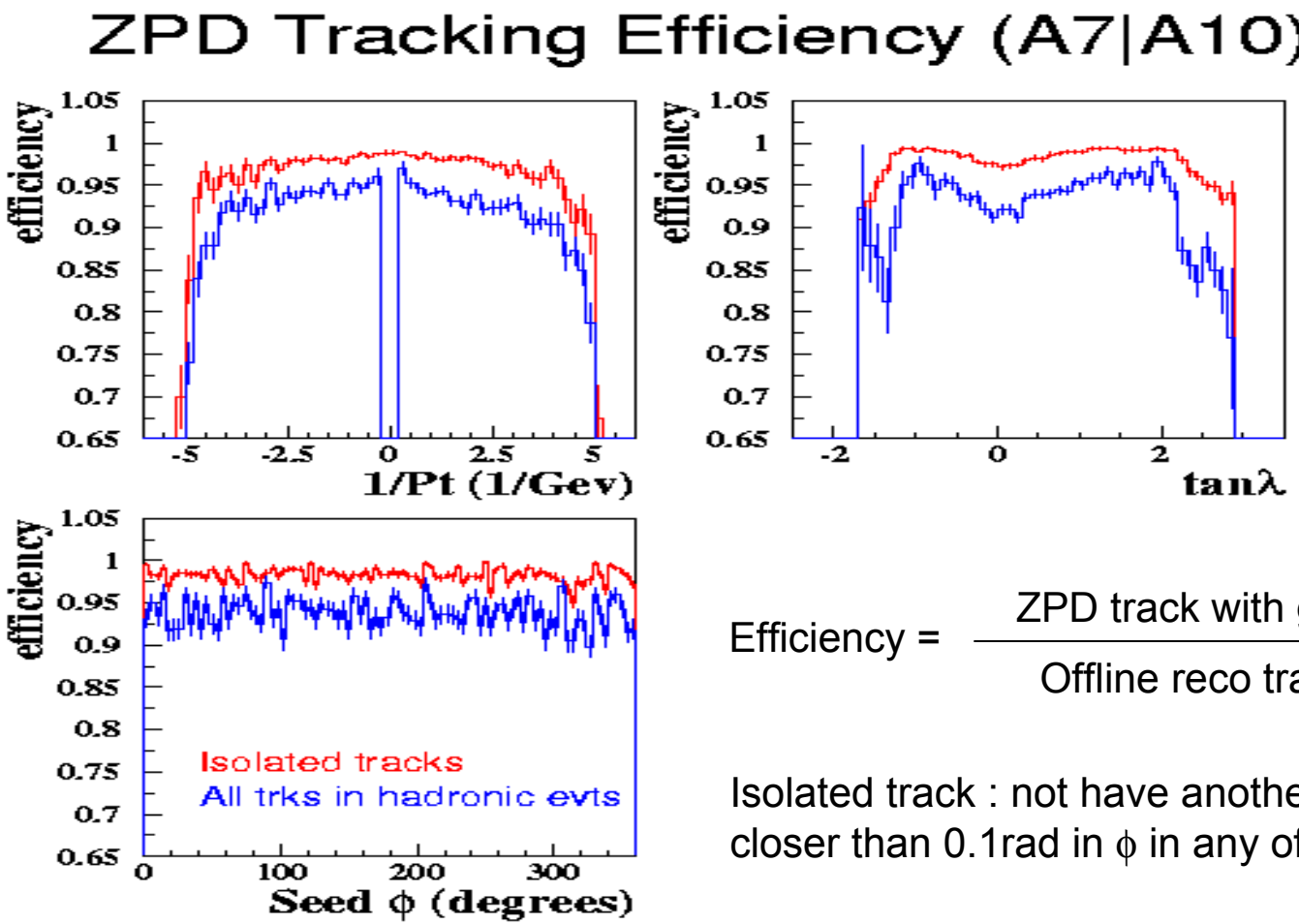
8 boards for a full system

Initial performance on July/04



- Data from physics run
  - DCH hit: Green circle
  - TSF hit (old and new) : Yellow cross
  - reco track: light blue curve
  - ZPD track: purple curve

Initial performance - Efficiency

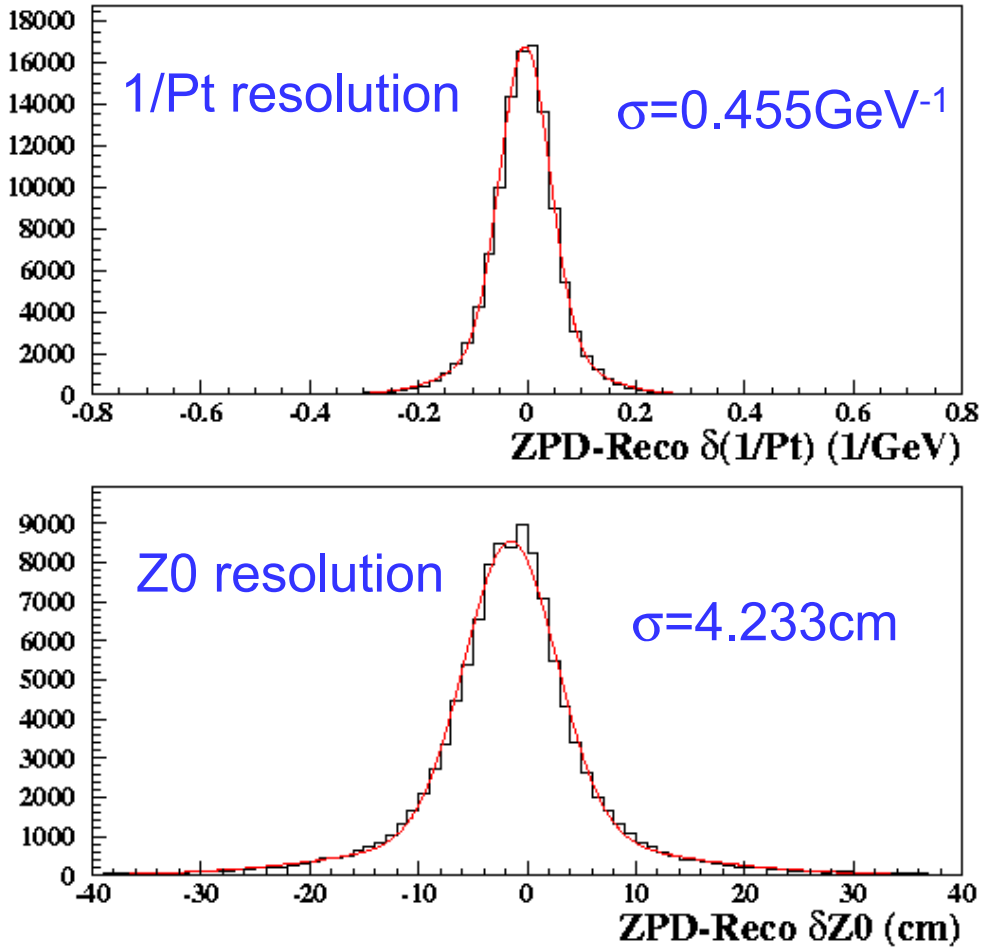


$$\text{Efficiency} = \frac{\text{ZPD track with good Z0,tan}\lambda\text{ fit}}{\text{Offline reco track from IP}}$$

Isolated track : not have another reco track closer than 0.1rad in ϕ in any of superlayer

Efficiency >90%; wide range of Pt over full 360° ϕ;

Initial performance - Resolution



- *Resolution = ZPD track – offline reco*
- *Z0 and 1/Pt resolution agree with expected*
- *Z0 is good enough to make Z cut*

Summary

- The full new trigger system (3D tracking) has already been used for triggering physics data for BaBar in late July
- Its tracking performance is close to design expectation
- Z-trigger configuration optimization in progress , expected to cut the track trigger background in half
- Will be the default BaBar trigger when BaBar starting again in October/04