# The ALICE High Level Trigger

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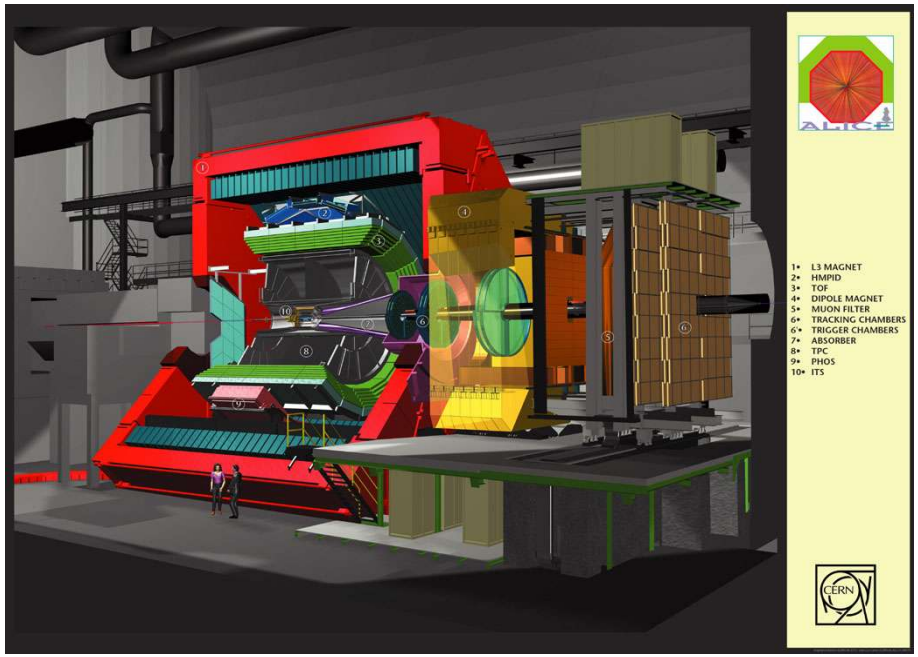
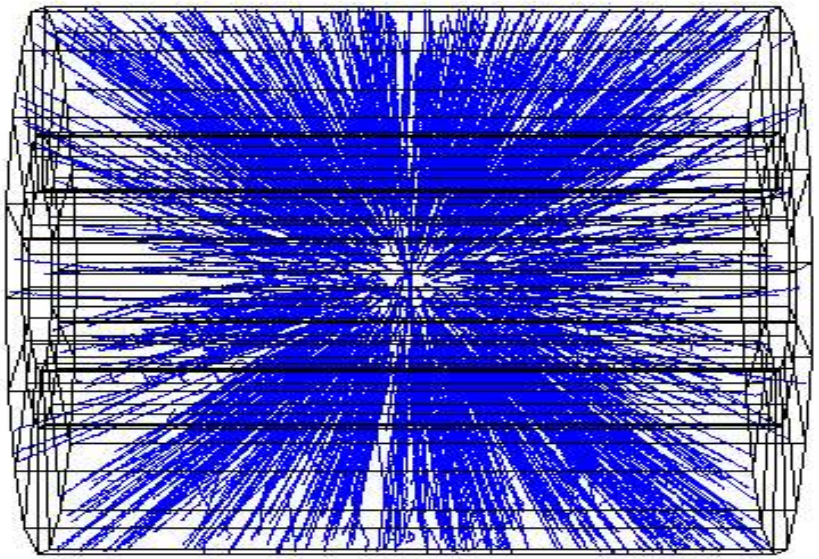
# Data rates

## ALICE data rates (TPC only)

- Event rates
  - Central Pb-Pb: < 200 Hz (past/future protected)
  - Min. bias pp: < 1000 Hz (roughly 25 piles)
- Event sizes (after zero suppression)
  - Pb Pb: ~75 Mbyte
  - pp: ~2.5 Mbyte
- Data rates
  - Pb Pb: < **15 Gbyte/sec**
  - pp: ~2.5 Gbyte/sec



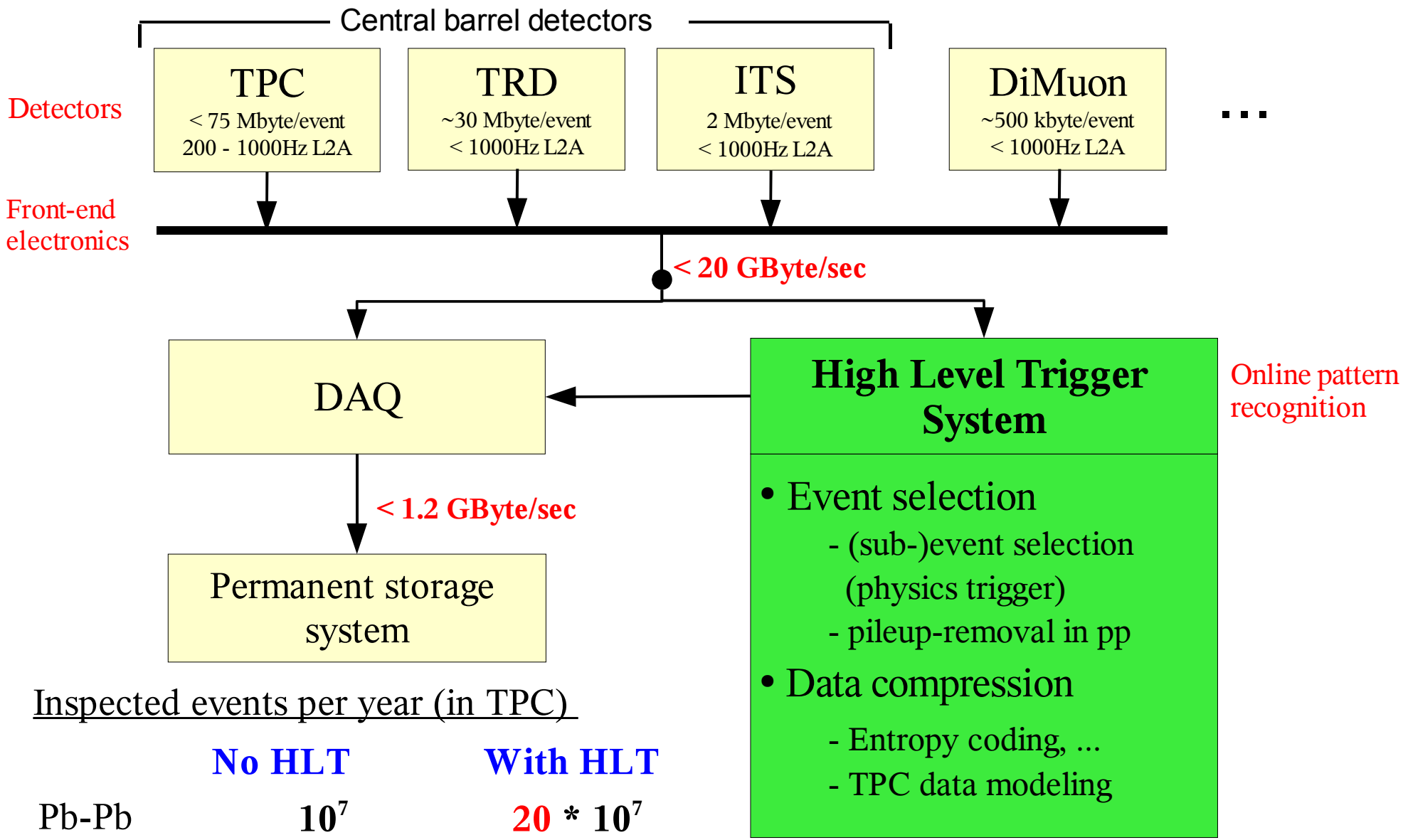

TPC is the largest data source with 570132 channels, 512 timebins and 10 bit ADC value.



Data rate exceeds by far the foreseen total DAQ bandwidth of **~1.2 Gbyte/sec**

*A. Vestbø, The ALICE High Level Trigger, Quark Matter 2004, Oakland*

# Introducing the HLT system




Inspected events per year (in TPC)

| | No HLT | With HLT |
|---|---|---|
| Pb-Pb | $10^7$ | $20 * 10^7$ |
| p-p | $10^9$ | $10 * 10^9$ |

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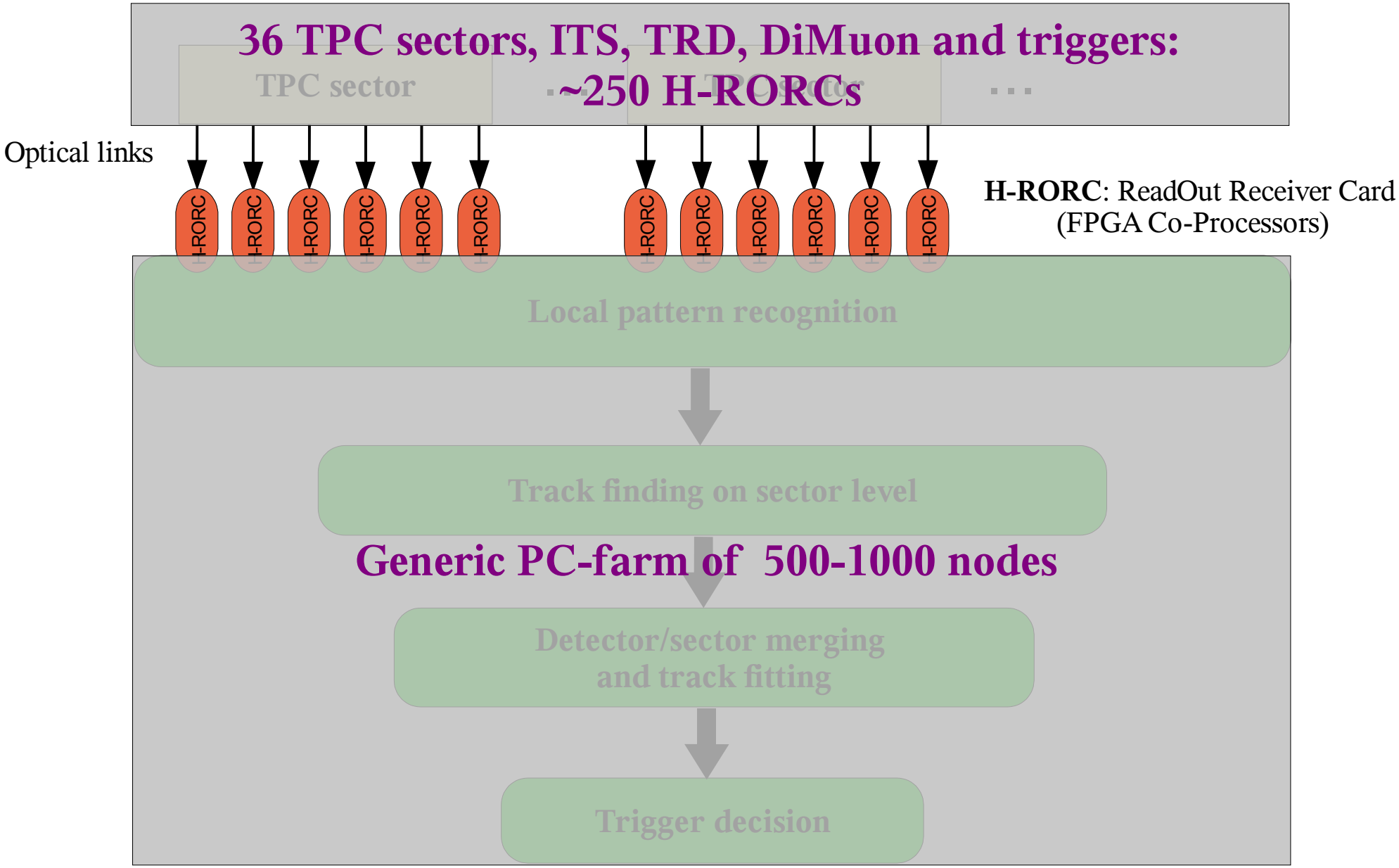
# HLT data flow architecture

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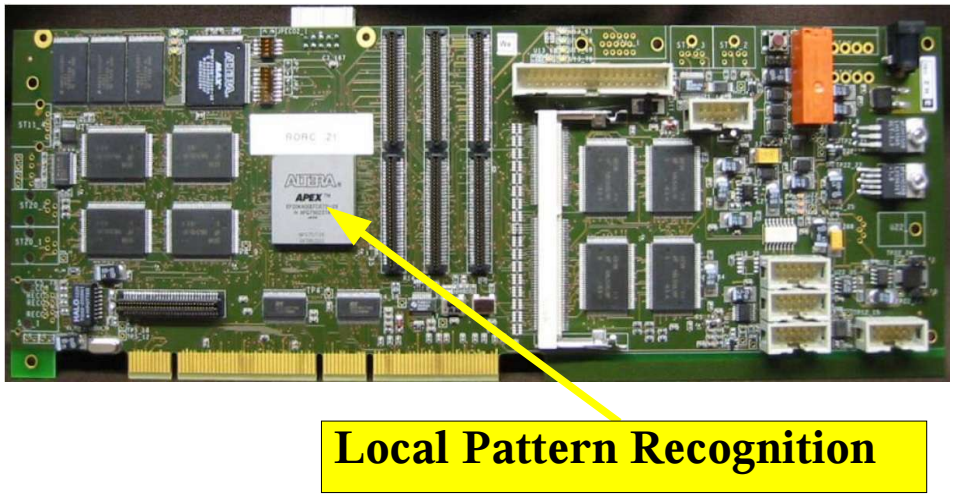
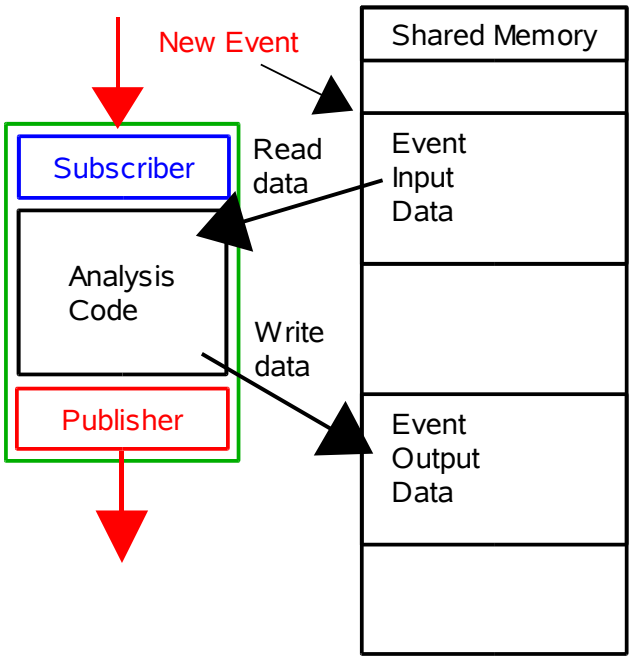
# Components

- Commercial off-the-shelf PCs
  - ~300 PCs equipped with **FPGA Co-processor** cards
  - ~300-500 compute nodes
- Light-weight Communication
  - NIC (GE, Infini-Band,...)
  - Network protocol (TCP, STP, ...)
- Fault-tolerant cluster management
- Publisher-Subscriber Interface
  - Common interface for communication between processes across underlying network
  - Generic modular framework allowing arbitrary connectivity metric; one-to-many, many-to-one ...

**Readout Receiver Card**



# Physics case I : HLT Jet Trigger

Estimated jet production within

TPC acceptance (200 Hz central Pb-Pb):

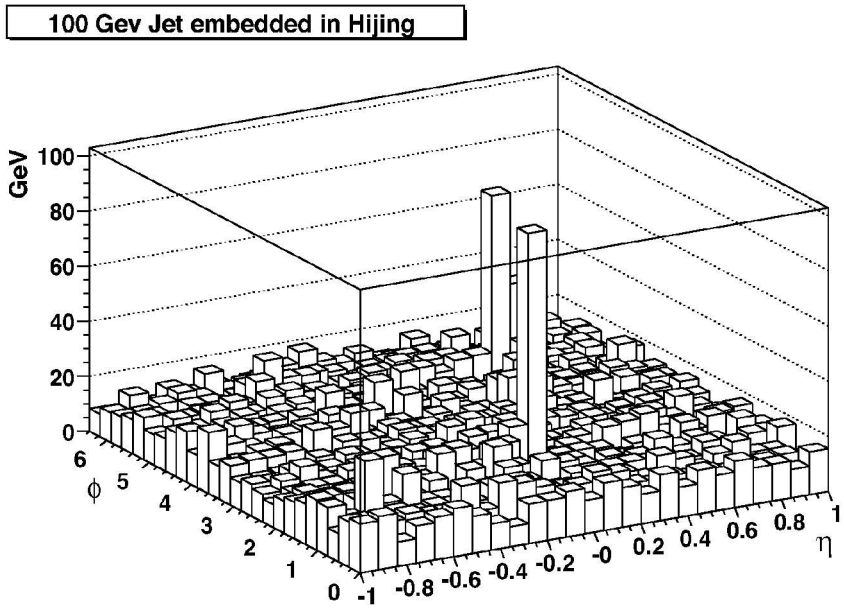
$E_T$>100: **0.1/sec** (1 in every 2000 event)

$E_T$>200: **0.004/sec** (1 in every $5x10^4$ event)

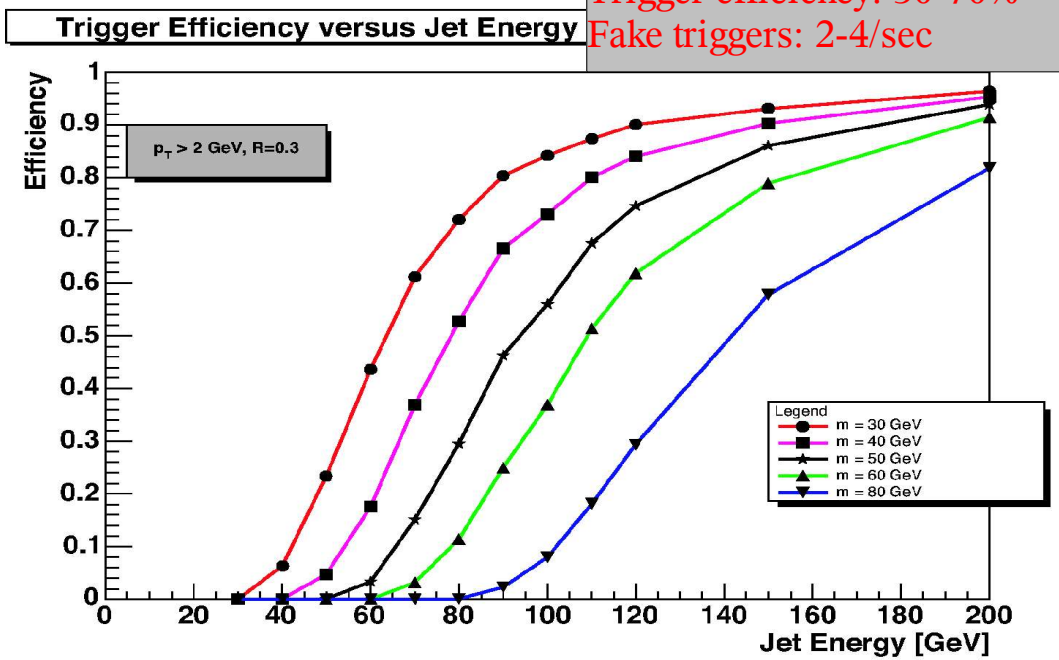
HLT trigger:

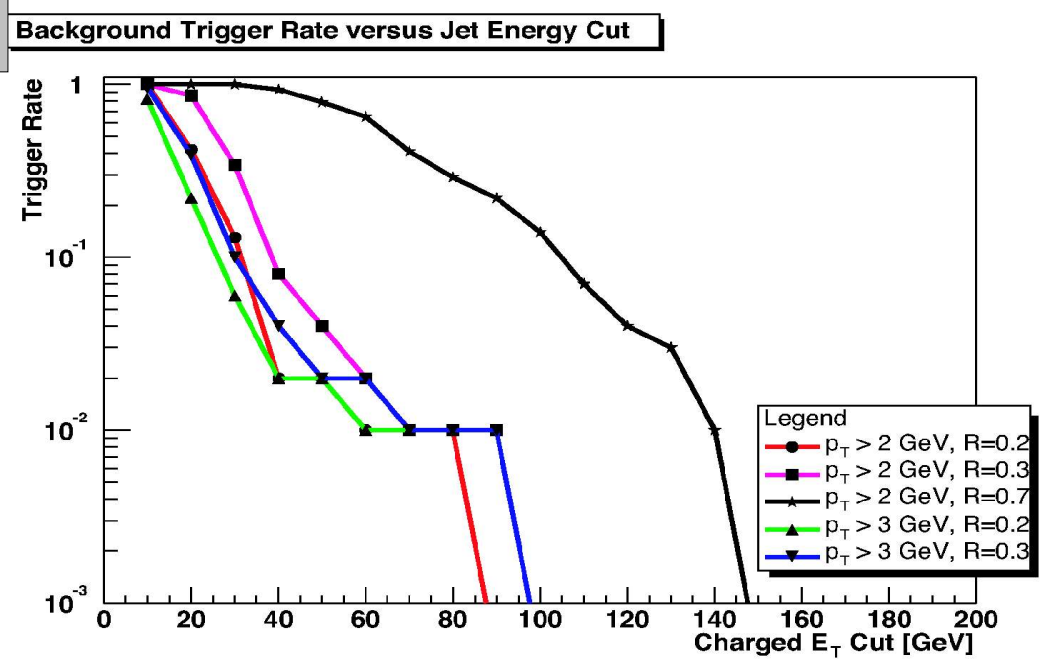
Online reconstruct all tracks in TPC

Apply **cone jet finder** to identify the leading jets




Trigger efficiency: 50-70%
Fake triggers: 2-4/sec

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# Physics case II : HLT $e^+e^-$ trigger

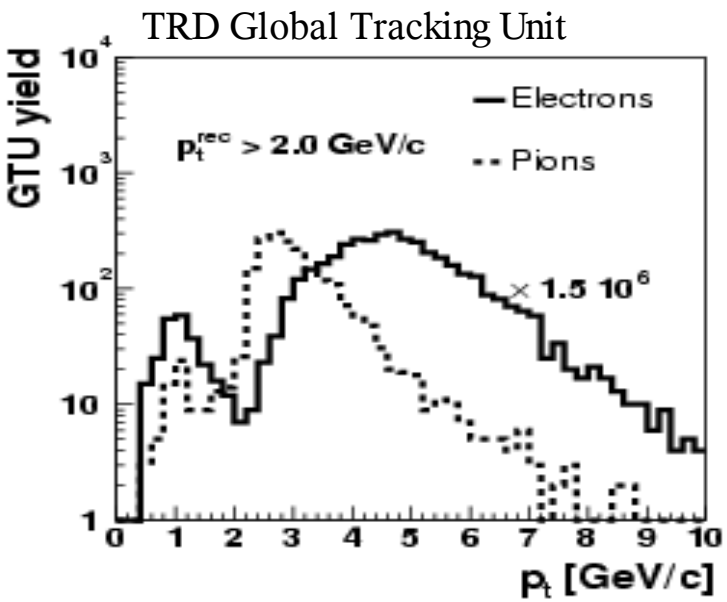
Enhance the yield of J/ψ and Υ

TRD triggers on high pt electron tracks:

Signal (Υ): **$10^{-2}$ Hz**

Background: **300-700 Hz** ($dN_{ch}/d\eta$=8000)

- Secondary electrons from conversions
- Misidentified pions

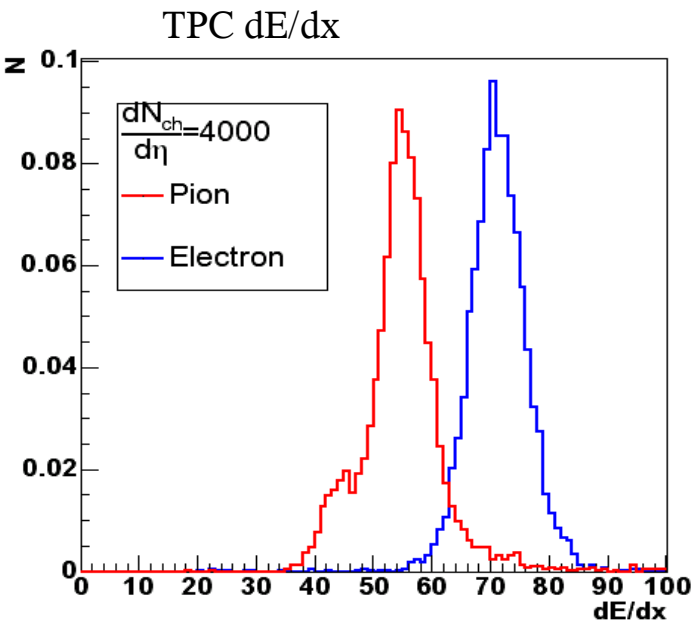



HLT trigger:

Online reconstruct tracks in TPC/ITS

Combine TRD tracklets with TPC/ITS tracks

Reject fake triggers by adding PID from TPC dE/dx




**Reduce background by a factor 10!**

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# TPC data compression

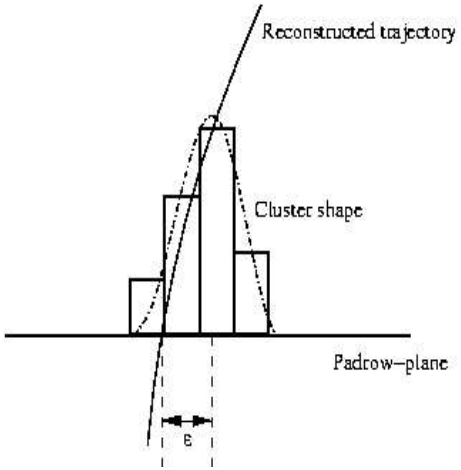
## Apply compression algorithms to further minimize the event size written to tape

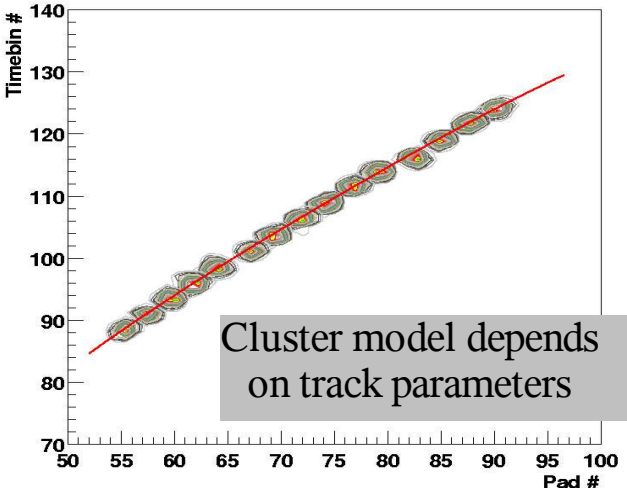
Standard loss(less) algorithms; entropy encoders, vector quantization ...

- achieve **compression factor ~ 2**

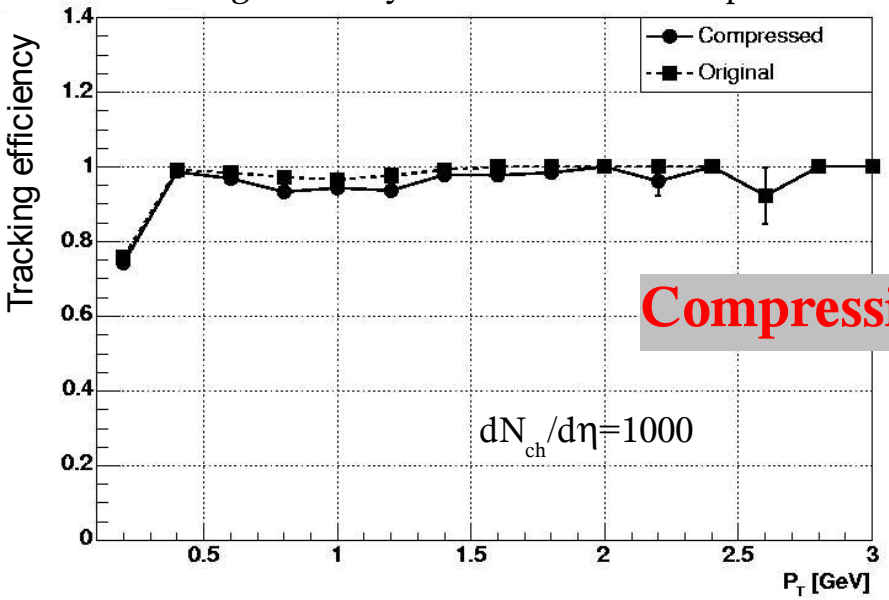
Data model adapted to TPC tracking

Store (small) deviations from a model:

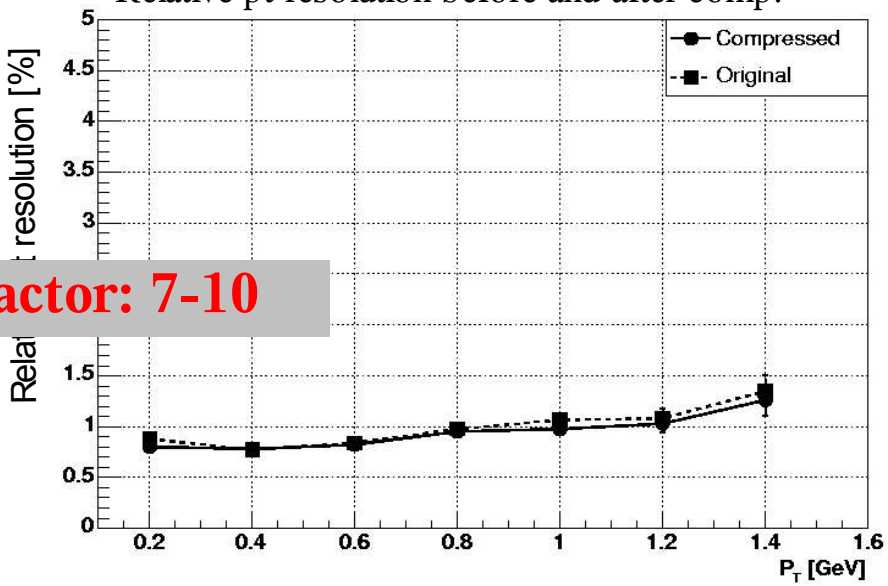



Tracking efficiency before and after comp.




Relative pt-resolution before and after comp.




**Compression factor: 7-10**

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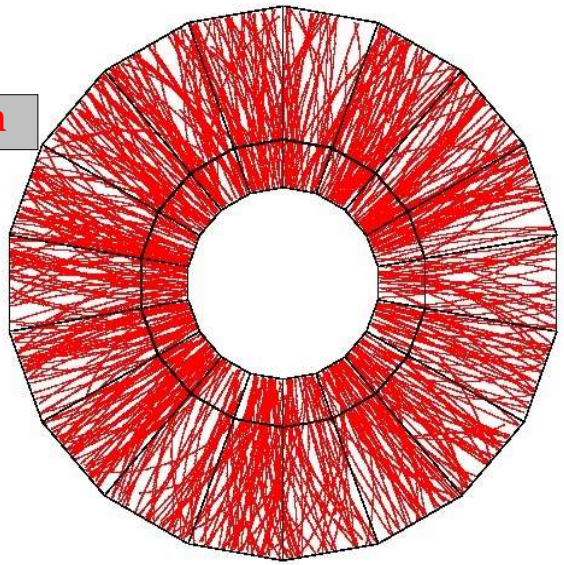
# HLT task: Online pattern recognition



1% of all tracks shown

## What should we expect?

Extreme-case:

$dN_{ch}/d\eta$=8000 : **20000** tracks in the TPC

Extrapolating from RHIC:

$dN_{ch}/d\eta$ ~ 2000-4000

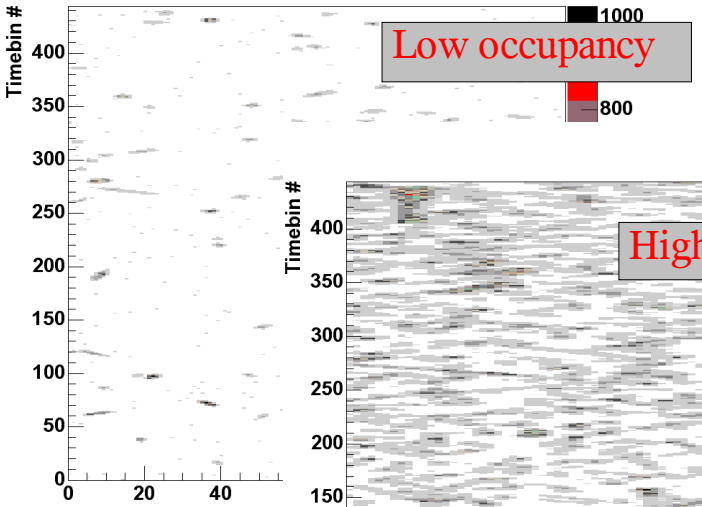
- Cluster finder + Track follower (like STAR L3)

Step 1: Cluster finding

Step 2: Track follower

- Conformal mapping
- Follow-your-nose (P. Yepes NIM A380 (1996) 582)

Synthesized on a FPGA (Altera APEX 20K-1x)




- Cluster fitting/deconvolution based on track parameters

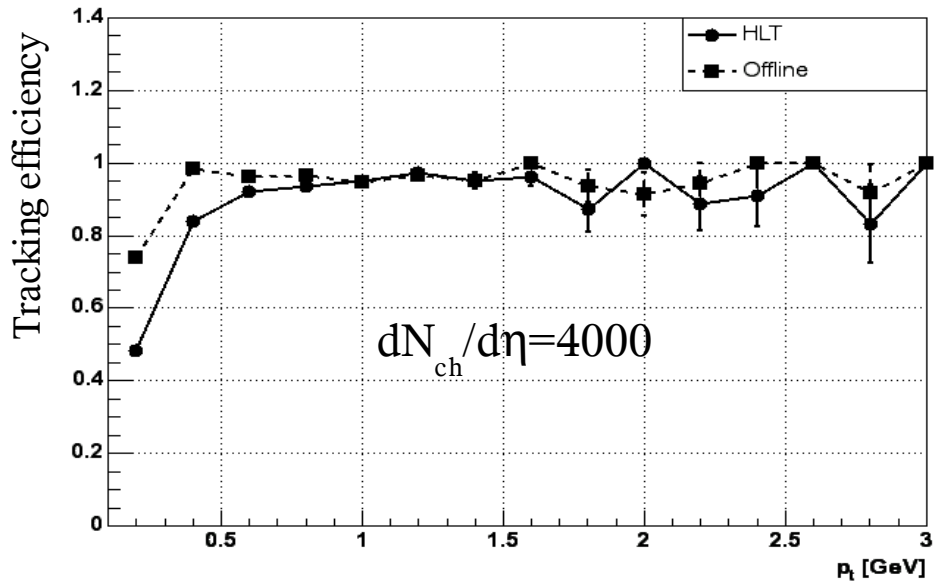
Step 1: Hough Transform on raw TPC data

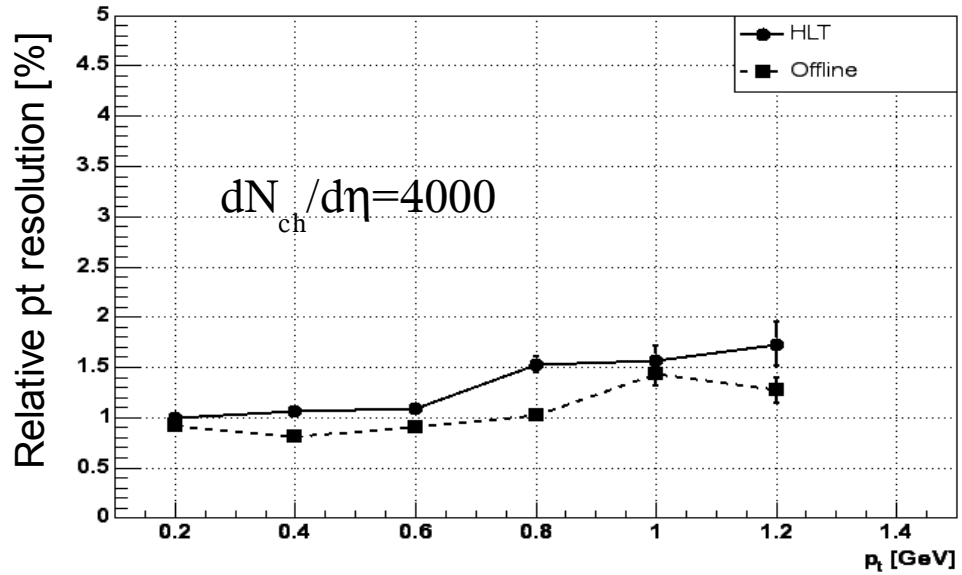
Step 2: Cluster fitting / deconvolution

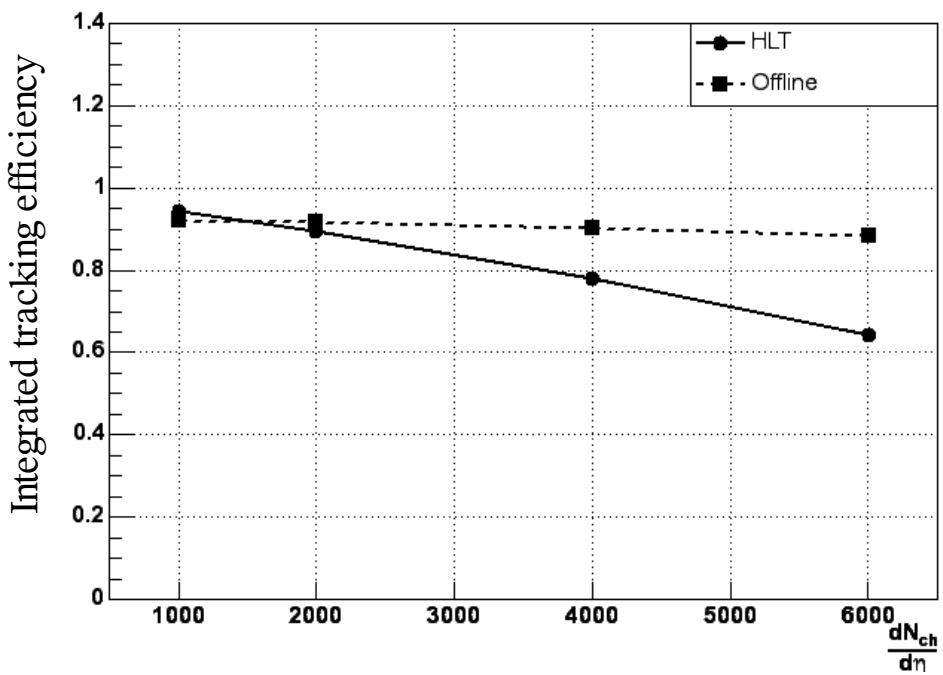
Step 3: Track fit

To be implemented on FPGA

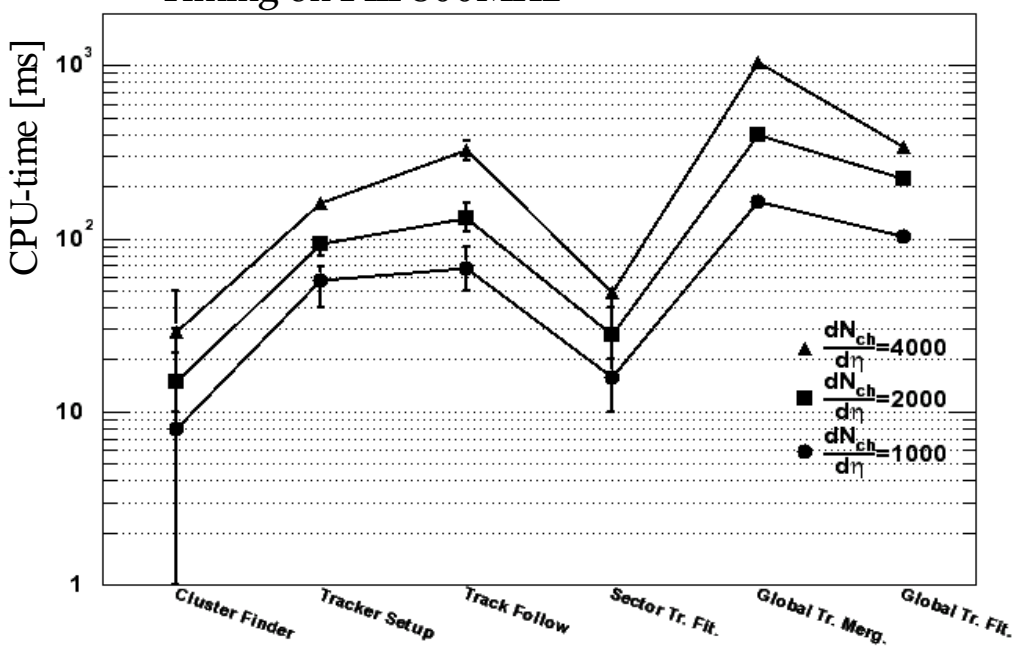
# Tracking performance: Cluster Finder + Track Finder




Timing on PIII 800MHz



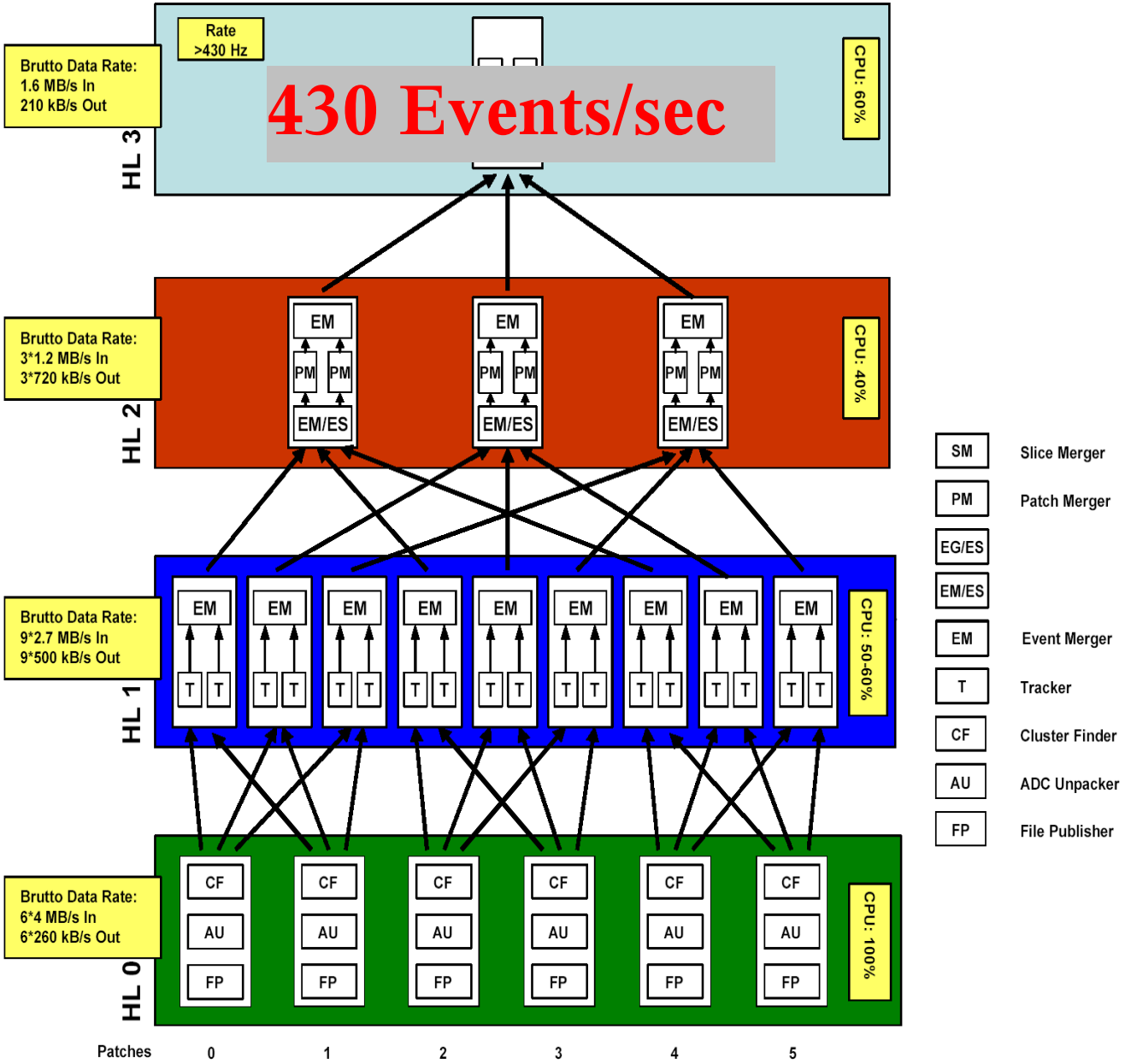
# Small scale prototype (1 TPC sector)

- Simulated 'realistic' pp events -
- 25 piles (~400 particles in TPC)

- Full track reconstruction
  - Cluster finder + Track finder

- 19 Nodes, P3 800 MHz, Fast Ethernet

Heidelberg HLT cluster

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# Summary

- The HLT will enhance the yield of rare cross-section signals in ALICE by online event reconstruction and/or data compression
- The system will consist of 500-1000 PCs, partially equipped with FPGA Co-processors
- Current online tracking performance is sufficient for $dN_{ch}/d\eta < 4000$
- Data modeling indicate compression factors of about 10 with acceptable efficiency loss
- HLT prototype performance on p-p for pileup-removal already very satisfactory