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DOE/NSF Review

February 18, 1999
Outline (20’)

Overview of Muon Trigger Design
  • Relation between CSCs and trigger electronics
  • Front-end electronics (Endcap Muon)
  • Data collection and Track Finder (TRIDAS)

Overview of Technical Progress since 5/98
  • Test beam ‘98 results
  • Design and documentation

Changes Since Last Review

Responses to 5/98 Committee Concerns

Conclusions
Muon Detectors, Trigger Logic

Muon Detectors

Trigger Logic
Focus of ‘98 prototypes:

- Single BX timing from anode wires
- Phi (bend) position to 1mm from cathode strips
Muon Track-Finding

Link trigger primitives into tracks
Assign $P_T$, $\varphi$, and $\eta$
Send highest $P_T$ candidates to Global L1 trigger
CSC Track-Finder

Requirements

High efficiency

Trigger Rate:
  • Single muon rate < few kHz at $L = 10^{34}\text{cm}^{-2}\text{s}^{-1}$

Resolution:
  • $\frac{\sigma_{P_t}}{P_t} \leq 30\%$  \(\text{(Requires } \eta \text{ information)}\)

Selection:
  • $\leq 3$ muons per 60° sector

Redundancy
  • Require only 2 stations out of 3 (or 4)

Minimal latency, pipelined, programmable
Trigger Regions in $\phi$

Illustration of overlap region

ME1/3
MB2/2
MB2/1
60° Sector Block Diagram

12 Sectors
(2 Endcaps)

Individual CSC Chambers

Endcap Muon

TRIDAS
CSC Muon Trigger Scheme

Strip FE cards
Strip LCT card
LCT
Motherboard
Port Card
TMB
PC
CSC Track-Finder
Sector Receiver
Sector Processor
SR
SP

OPTICAL

2μ / chamber
3μ / port card

3μ / sector

On chamber
In counting house
In chamber crate

Wire FE cards
Wire LCT card

CSC Muon Sorter

Global μ Trigger

Global L1

RPC
DT

4μ
4μ
4μ
Physical Layout of CSC
Trigger Electronics

Front-end A/D for Trigger:
- Cathode cards have comparator ASICs
- Anode cards have discriminators and BX latch

Muon Stubs:
- Raw bits go to 9U crates on iron disk periphery
- 6-layer muon stubs measured by LCT cards
- Anode/cathode matching, RPC coincidence at Trigger Motherboards
- Collection of data & optical links from Port Cards

Muon Track Measurement:
- Stubs go to 9U crates in counting house
- Stubs received, formatted, aligned in Sector Receivers
- Tracks found in Sector Processors
- Tracks selected by CSC Muon Sorter
CSC Trigger Primitives

Focus of ‘98 prototypes:

- Single BX timing from anode wires
- Phi (bend) position to 1mm from cathode strips
98 Prototype Beam Test

CSC Chamber

Comparators

Anode/ Cathode LCT

Trigger Motherboard
CSC Trigger Results from CERN '98 Test Beam

Prototype electronics worked well (reliable, no pickup noise, etc.)

Cathodes for position:
- half-strip eff. 90% per layer
- 0.1 strip/chamber position resolution

Anodes for timing:
- bunch crossing efficiency 99%
- works at 7x max LHC rate

Cathode-anode timing:
- +/-1 bunch xing 98% efficient

Prototypes meet the CMS design criteria in all aspects
<table>
<thead>
<tr>
<th>Object</th>
<th>No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Anode Front-End</td>
<td>1476</td>
<td>Custom ASICs, custom size cards</td>
</tr>
<tr>
<td>Cathode Front-End</td>
<td>1728</td>
<td>Custom ASICs, custom size cards</td>
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<tr>
<td>Anode LCT</td>
<td>360</td>
<td>9U cards: gate arrays</td>
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<tr>
<td>Cathode LCT</td>
<td>360</td>
<td>9U cards: gate arrays</td>
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<tr>
<td>Trigger Motherboards</td>
<td>192</td>
<td>9U cards: gate arrays</td>
</tr>
<tr>
<td>SCSI cables to FE</td>
<td>3204</td>
<td>Indiv. Shielded twisted-pair</td>
</tr>
<tr>
<td>Flat cables to FE</td>
<td>1476</td>
<td>34-conductor</td>
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<tr>
<td>Crates</td>
<td>96</td>
<td>9U VIPA standard</td>
</tr>
<tr>
<td>Power Supplies</td>
<td>96</td>
<td>High-power 5v and 3.3v</td>
</tr>
<tr>
<td>Flat cables between 9U modules</td>
<td></td>
<td>34-conductor</td>
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## TriDAS Component Count

<table>
<thead>
<tr>
<th>Object</th>
<th>No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Muon Port Card</td>
<td>60</td>
<td>9U cards: clock rcvr., clock distribution, gate arrays, optical xmitters</td>
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<tr>
<td>Optical fibers</td>
<td>360</td>
<td>E.g. Glink type</td>
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<td>Sector Receivers</td>
<td>24</td>
<td>9U cards: optical rcvrs., gate arrays</td>
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<tr>
<td>Sector Processors</td>
<td>24</td>
<td>9U card: gate arrays, memories</td>
</tr>
<tr>
<td>Clock &amp; Control Cards</td>
<td>6</td>
<td>9U card: clock distribution, DAQ interface</td>
</tr>
<tr>
<td>Muon Sorter Card</td>
<td>1</td>
<td>9U card: gate arrays</td>
</tr>
<tr>
<td>Crates</td>
<td>6</td>
<td>9U VIPA standard</td>
</tr>
<tr>
<td>Power Supplies</td>
<td>6</td>
<td>High-power switchers</td>
</tr>
<tr>
<td>Copper cables</td>
<td></td>
<td>Twisted-flat</td>
</tr>
</tbody>
</table>
New Layout for CSC Track-Finder Crate

- Two 60° sectors housed in one 9U VME crate with custom backplane
- Each SR-CSC sends 6 CSC muon stubs × 34 bits and 4 bits BXN = 208 bits
- Each DT-IM sends 8 DT muon stubs × 25 bits and 4 bits BXN = 204 bits
Sector Receiver Functionality

- Receives 6 stubs via 12 optical links from 2 Port Cards (3 in ME1)
- Synchronizes the data
- Reformats the data
  - LCT bit pattern → η, φ, Ψ
- Communicates to Sector Processor via custom point-to-point backplane
- Fans out signals to CSC overlap processors and sends ME1/3 signals to DT Sector Processor
Identify and measure muons from ~600 bits every 25ns (3 GB/s)

1. Perform all possible station-to-station extrapolations in parallel

   Simultaneously search for roads in $\phi$ and $\eta$

2. Assemble 2-, 3-, 4-station tracks from 2-station extrapolations

3. Cancel redundant short tracks if track is 3 or 4 stations in length

4. Select the three best candidates

5. Calculate $P_T$, $\phi$, $\eta$ and send to CSC muon sorter
Muon Sorter Functionality

- New processor added since last review
- The 3 highest rank muons from each Sector Processor are sent to the **CSC muon sorter**, which selects the 4 highest rank
- Total muon count:
  - 3 muons $\times$ 6 sectors $\times$ 2 endcaps $\times$ 2 regions = 72 muons for CSC and OVL regions
- Sent to Global L1 Muon Trigger for association with RPC and DT triggers
Muon Trigger Changes Since 5/98

- Cathode front-end
  - 4:1 data compression in cathode comparator ASIC (submitted to foundry)
  - Comparator ASICs integrated with cathode front-end board (board layout)

- Anode front-end
  - BX latching integrated with anode front-end board (board layout)

- New CSC/RPC coincidence option

- Trigger logic moved off of chambers
  - VME 9U crates on iron disk periphery
  - Advantages: power, cooling, DAQ readout, access, seamless trigger

- Track Finder refinements
  - Fully documented design, including Endcap/Barrel interface
Highlight TRIDAS Changes:

- Agreement on Barrel/Endcap boundary
  - Barrel and Endcap Track Finders are fundamentally different (2D versus 3D)
  - Information will be sent both ways
  - The actual boundary (0.9-1.2) will be “hard” but programmable

- Data distribution in Track Finder crates
  - CSC and Overlap processors in same crate
  - Saves 2 crates, 24 Sector Receivers, many cables, etc.

- Addition of ME1/1 split strips
  - Costs 12 additional Port Cards, more optical links

- Addition of CSC muon sorter
  - One additional card

- Addition of VME test stands - contingency used
Available Resources

Muon Port Card and Sorter Card (Rice):

- P. Padley – physicists
- M. Matveev, N. Adams – engineers / technicians

Sector Processor (Florida and PNPI):

- D. Acosta, S.M. Wang – physicists
- Florida electronics shop – engineers / technicians
- A. Atamanchuk, V. Golovtsov, B. Razmyslovich – PNPI engineers
- B. Scurlock, M. Watkins – students

Sector Receiver (UCLA):

- J. Hauser, C. Shankar – physicists
- J.K., Y. Shi – engineers
USCMS TriDAS project management
  • http://hep.physics.wisc.edu/wsmith/cms/trig_pm.html

Technical info
  • CMS muon trigger home page
    • http://cmsdoc.cern.ch/ftp/afscms/TRIDAS/mutrig/html/
  • USCMS Endcap muon home page
    • http://uscms.fnal.gov/uscms/subsystems/muon/muon.html
  • CSC muon trigger home page
    • http://www-collider.physics.ucla.edu/cms/trigger/
  • CSC trigger complete bit list
    • ftp://hepsun0.physics.ucla.edu/pub/cms/trigger/triggerbits.ps
  • Motherboard/Port Card home page
    • http://bonner-ntserver.rice.edu/motherboard/
  • Sector Processor home page
    • http://www.phys.ufl.edu/~acosta/cms/trigger.html