WBS 3.1.1 Muon Trigger Overview

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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

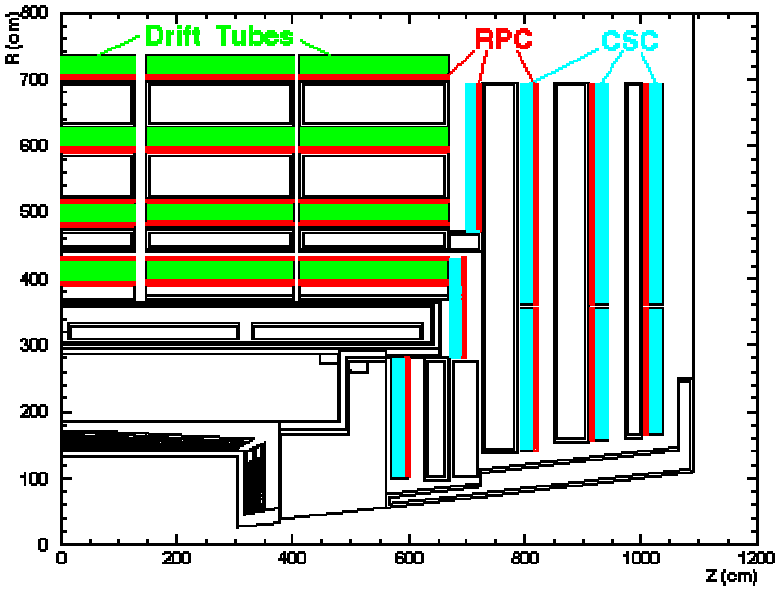
- Test beam '98 results
- Design and documentation

Changes Since Last Review

Responses to 5/98 Committee Concerns

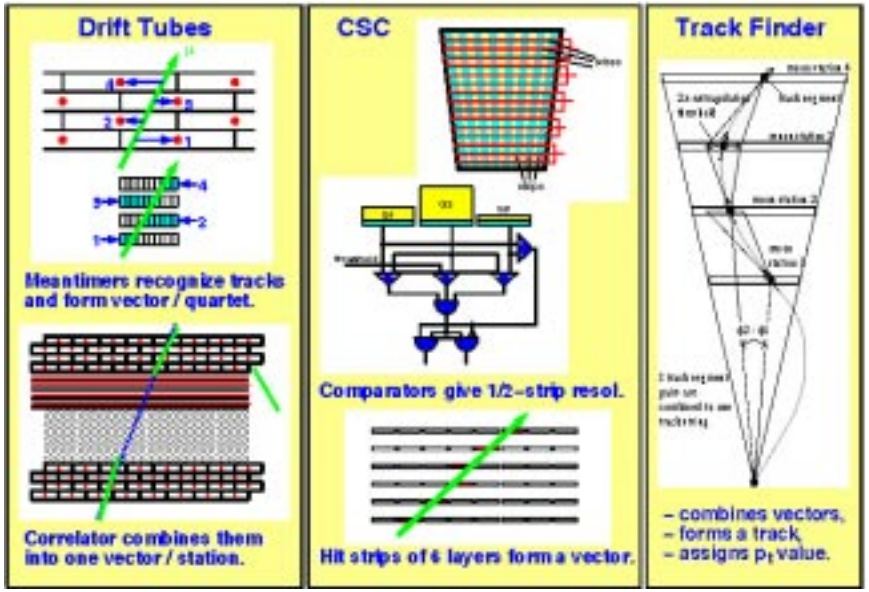
Conclusions

Muon Detectors, Trigger Logic

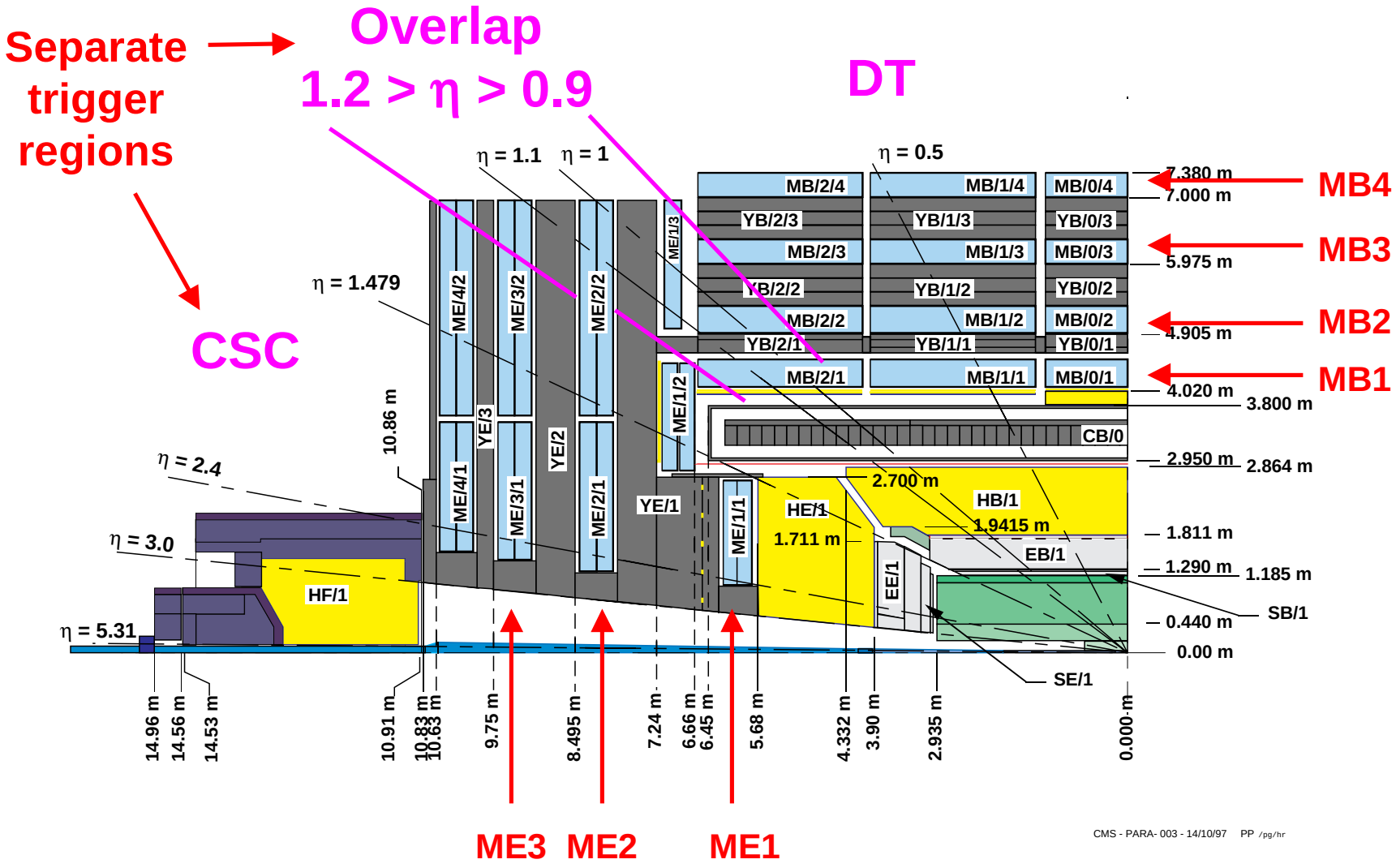


Muon Detectors

Trigger Logic



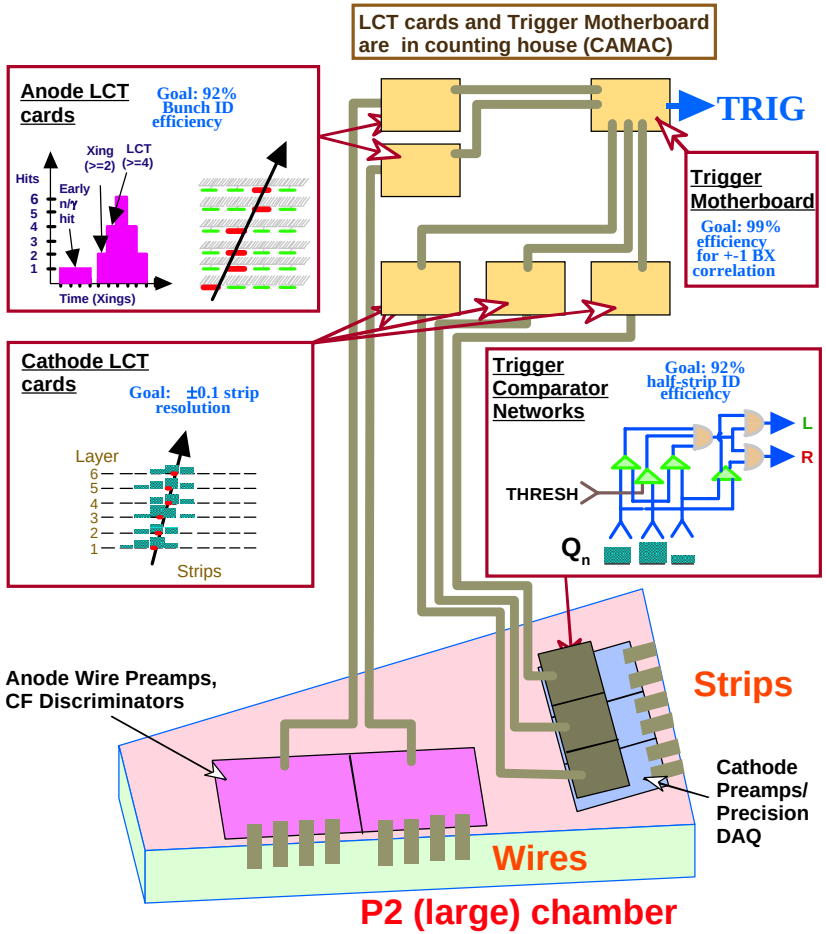
Trigger Regions in η



CSC Trigger Primitives

Focus of '98 prototypes:

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

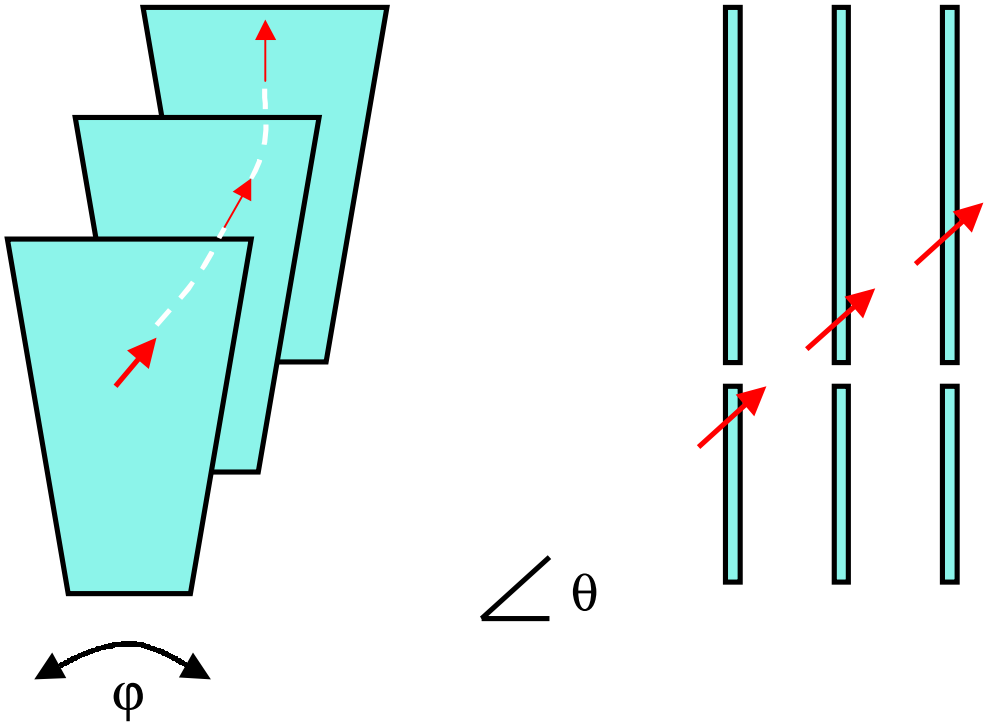


Muon Track-Finding

Link trigger primitives into tracks

Assign P_T, φ, and η

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:

- $\sigma_{Pt} / P_t \leq 30\%$ (*Requires η information*)

Selection:

- ≤ 3 muons per 60° sector

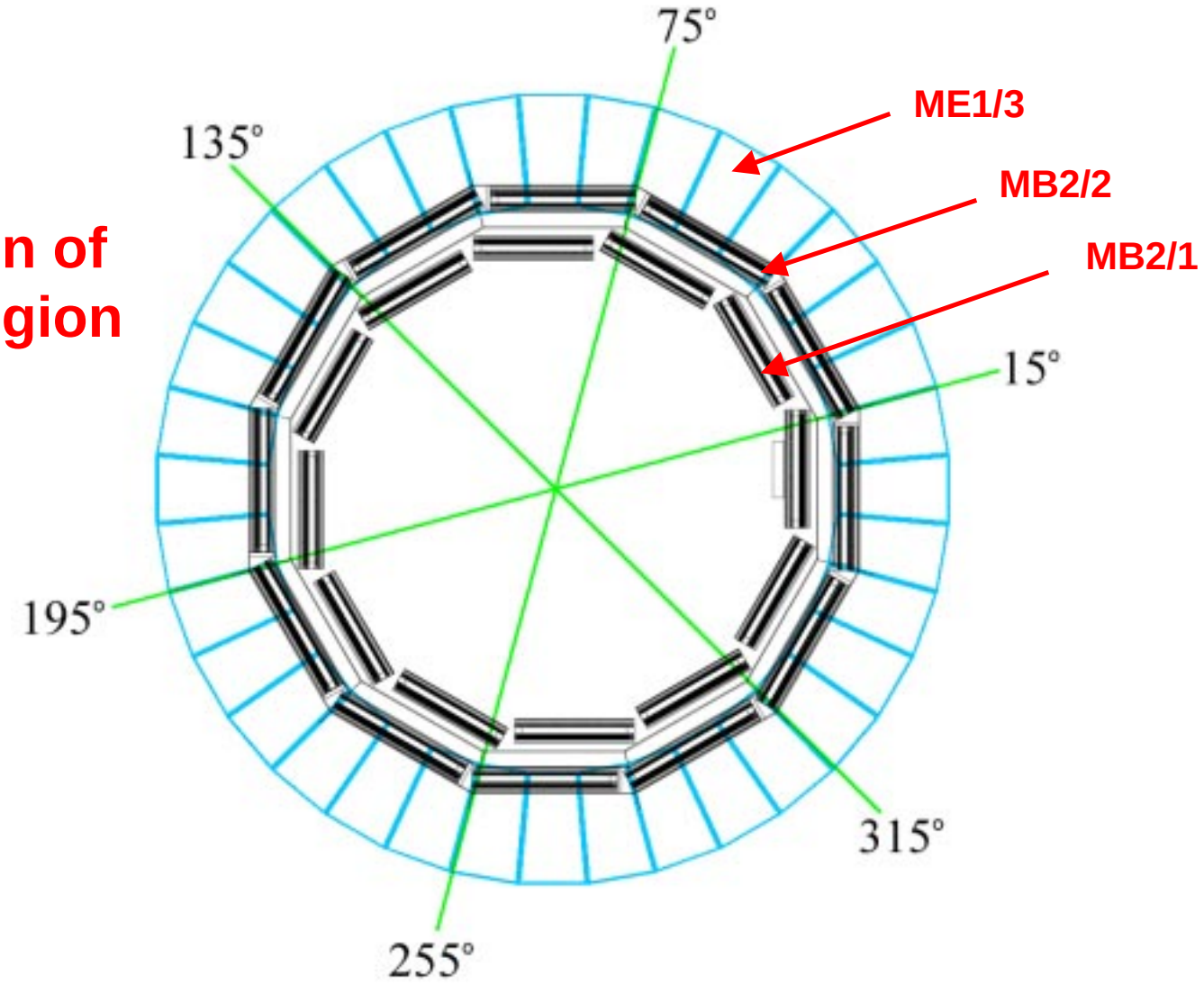
Redundancy

- Require only 2 stations out of 3 (or 4)

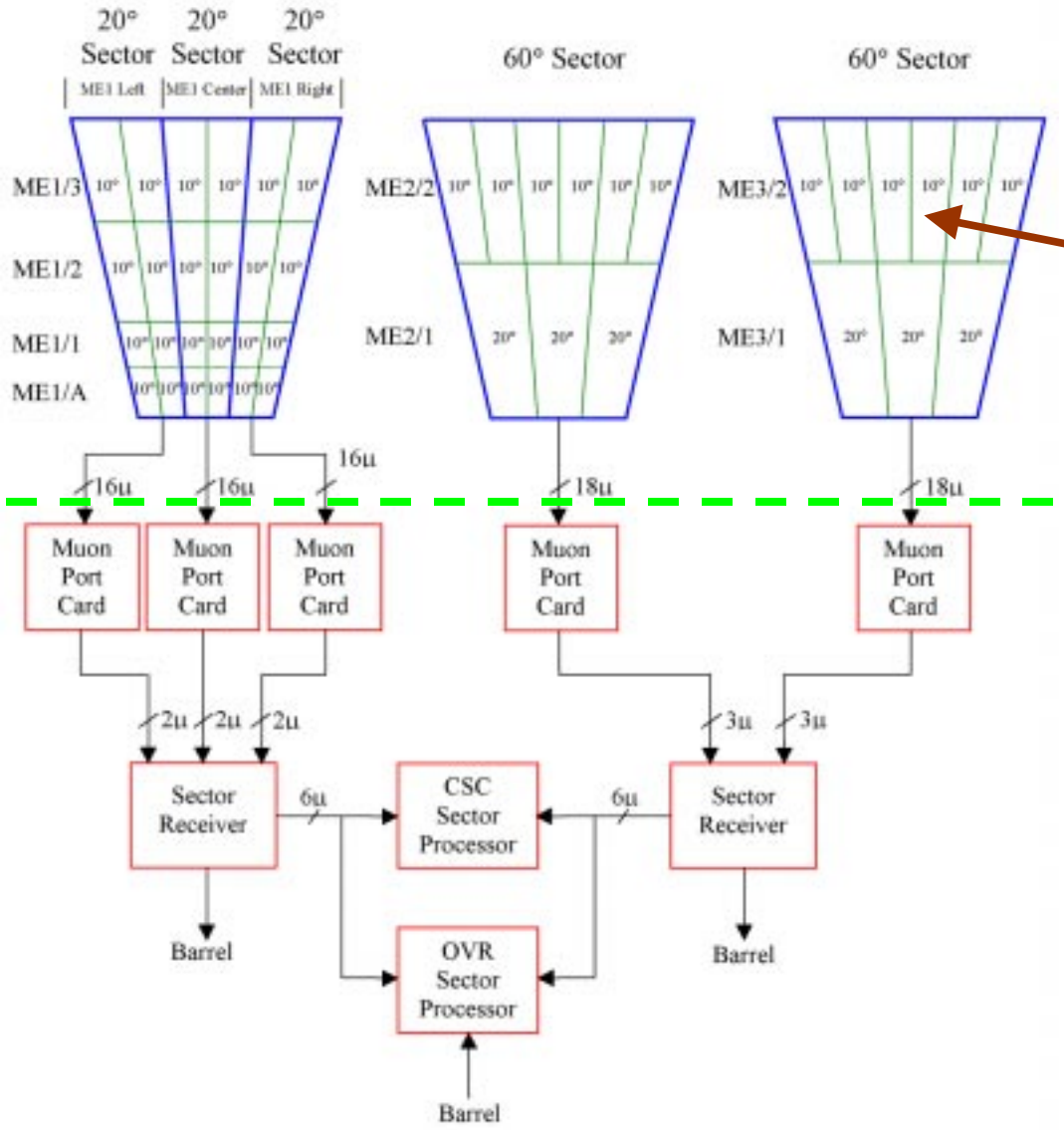
Minimal latency, pipelined, programmable

Trigger Regions in φ

Illustration of overlap region



60° Sector Block Diagram



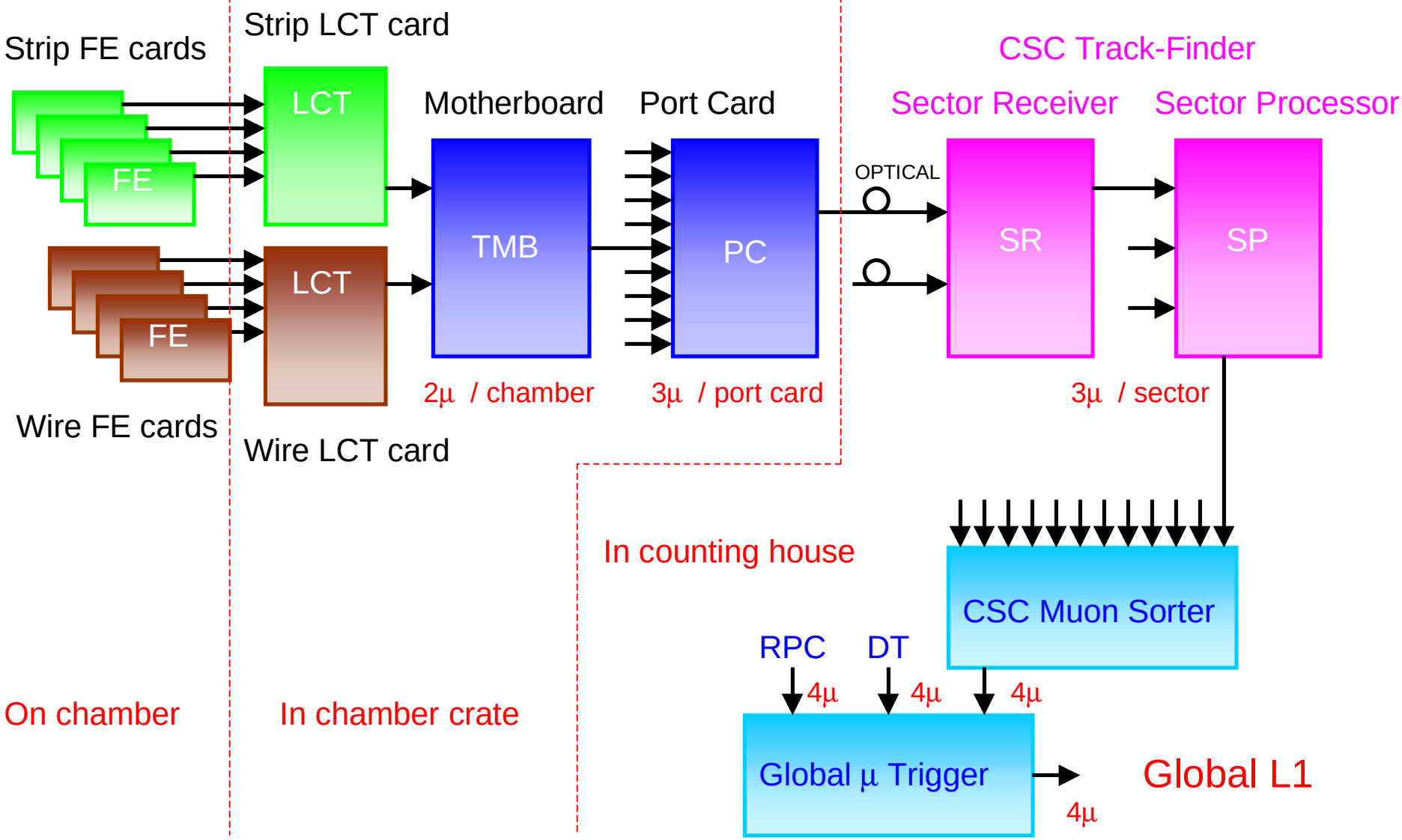
12 Sectors
(2 Endcaps)

Individual CSC Chambers

Endcap Muon

TRIDAS

CSC Muon Trigger Scheme



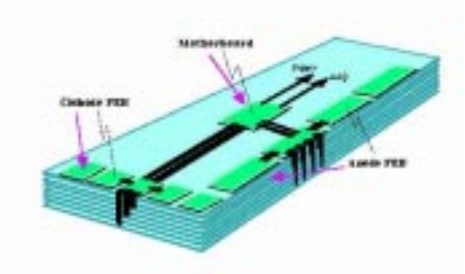
Physical Layout of CSC Trigger Electronics

Endcap Muon System

TriDAS System

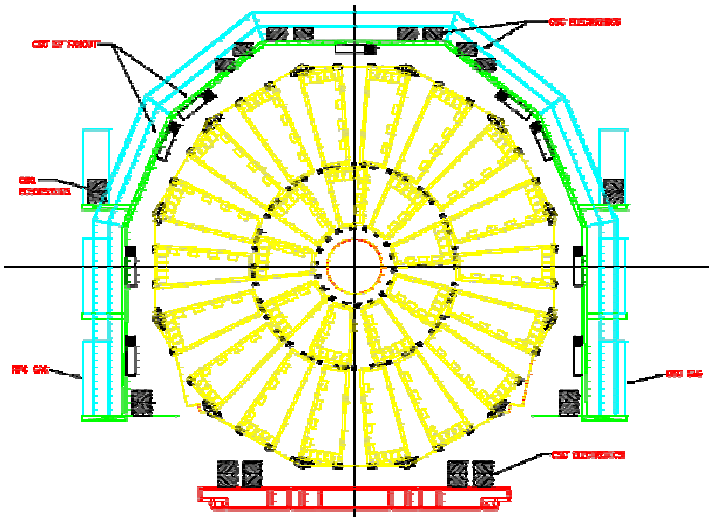
Front-end A/D for Trigger:

- *Cathode cards* have comparator ASICs
- *Anode cards* have discriminators and BX latch



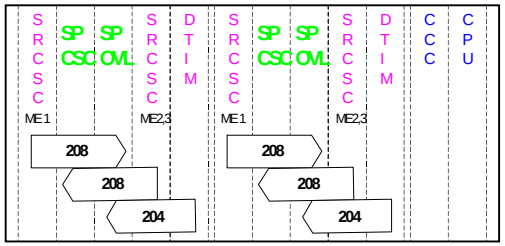
Muon Stubs:

- 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*



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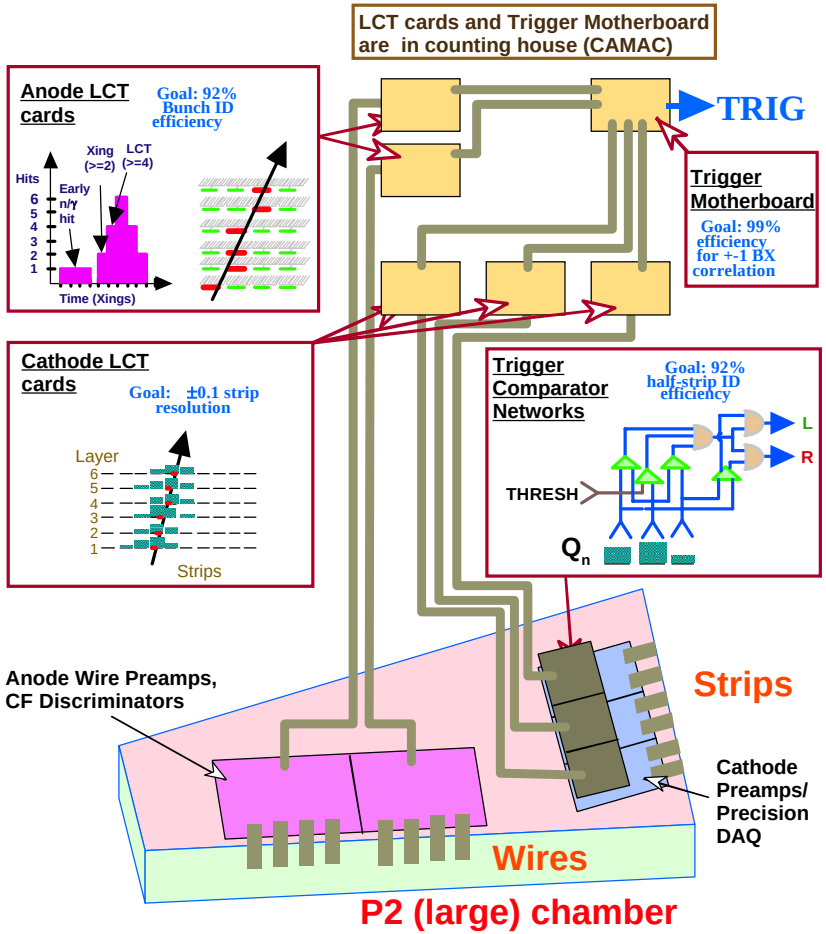
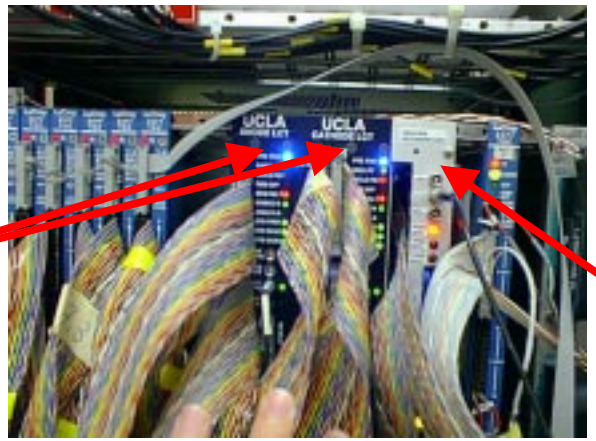


98 Prototype Beam Test

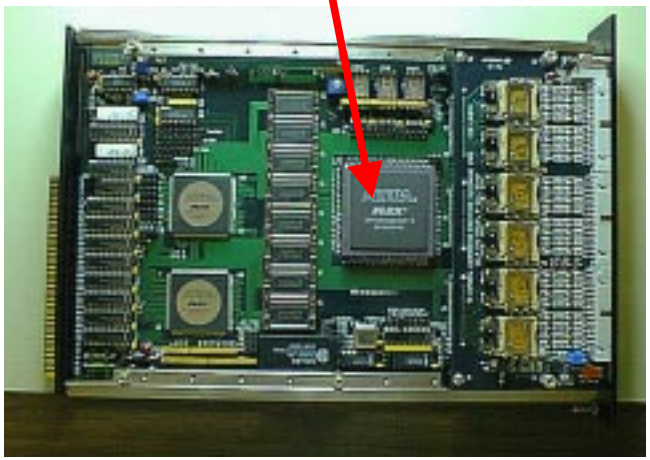
CSC Chamber

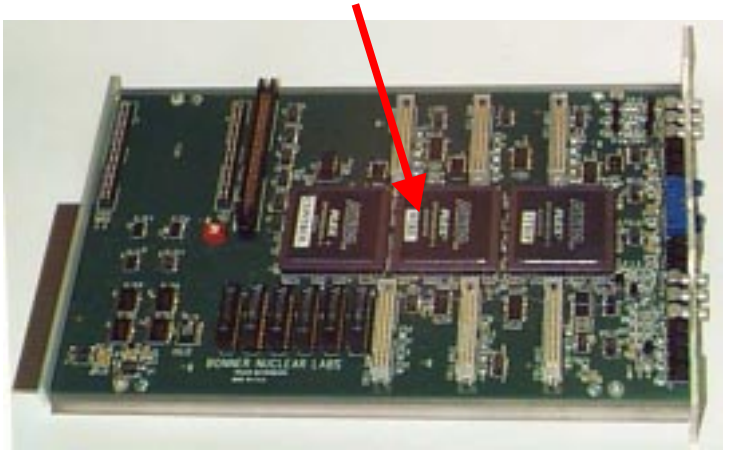
Comparators



Anode/
Cathode LCT

Trigger
Motherboard



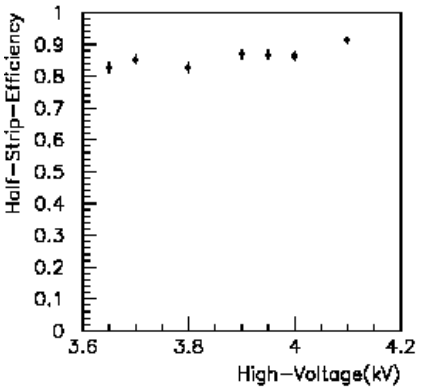


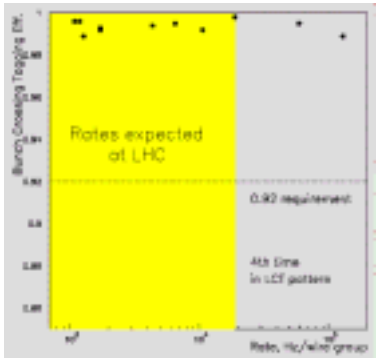
CSC Trigger Results from CERN '98 Test Beam

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

Cathodes for position:

- **half-strip eff. 90% per layer**
- **0.1 strip/chamber position resolution**



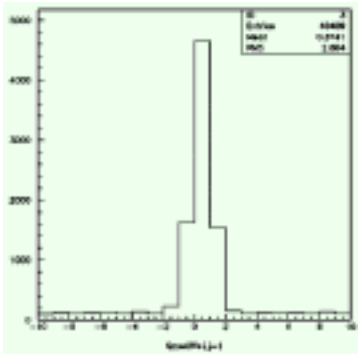


Anodes for timing:

- **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

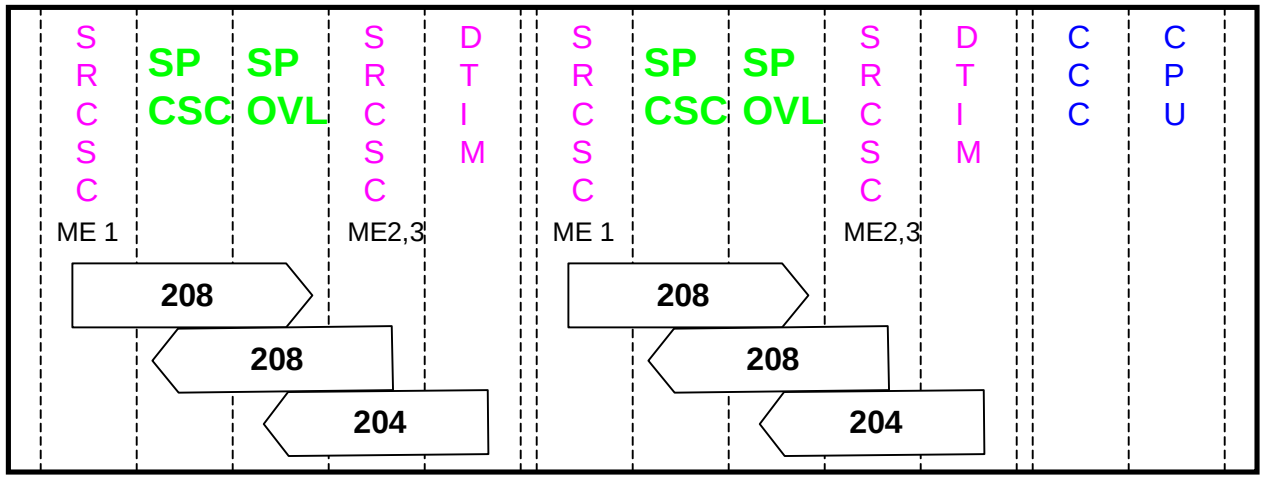
Endcap Muon Subsystem Trigger Component Count

Object	No.	Description
Anode Front-End	1476	Custom ASICs, custom size cards
Cathode Front-End	1728	Custom ASICs, custom size cards
Anode LCT	360	9U cards: gate arrays
Cathode LCT	360	9U cards: gate arrays
Trigger Motherboards	192	9U cards: gate arrays
SCSI cables to FE	3204	Indiv. Shielded twisted-pair
Flat cables to FE	1476	34-conductor
Crates	96	9U VIPA standard
Power Supplies	96	High-power 5v and 3.3v
Flat cables between 9U modules		34-conductor

TriDAS Component Count

Object	No.	Description
Muon Port Card	60	9U cards: clock rcvr., clock distribution, gate arrays, optical xmitters
Optical fibers	360	E.g. Glink type
Sector Receivers	24	9U cards: optical rcvrs., gate arrays
Sector Processors	24	9U card: gate arrays, memories
Clock&Control Cards	6	9U card: clock distribution, DAQ interface
Muon Sorter Card	1	9U card: gate arrays
Crates	6	9U VIPA standard
Power Supplies	6	High-power switchers
Copper cables		Twisted-flat

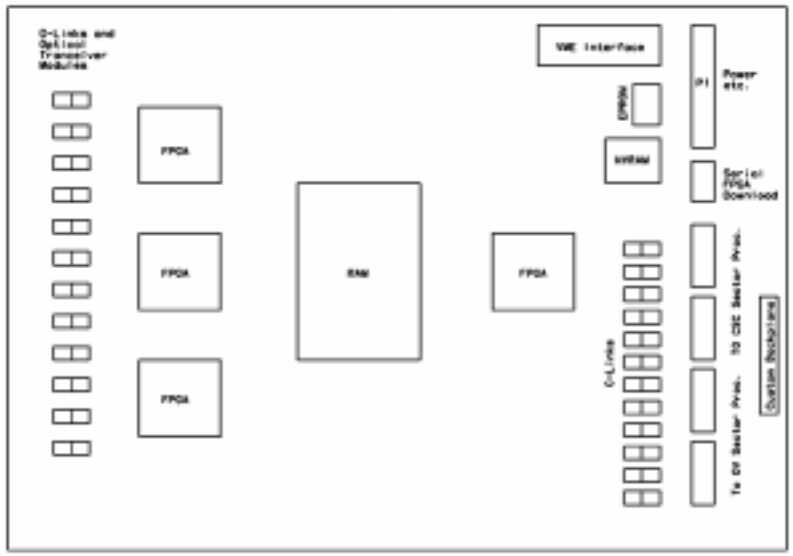
New Layout for CSC Track-Finder Crate



- 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 $\rightarrow \eta, \varphi, \Psi$
- 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



Sector Processor Functionality

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 φ and η

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

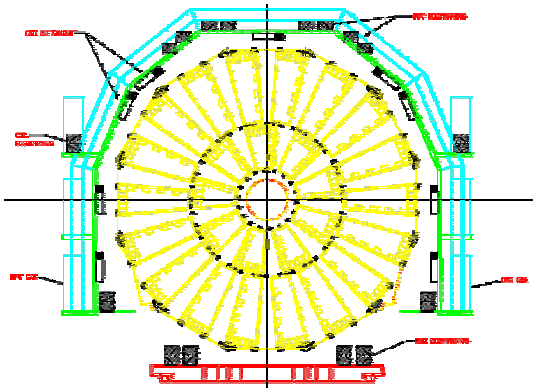
5. Calculate P_T, φ, η and send to CSC muon sorter

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**

Documentation

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