



WBS 3.1 - Trigger

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CMS Trigger Project Manager**

**DOE/NSF Review
February 17, 1999**

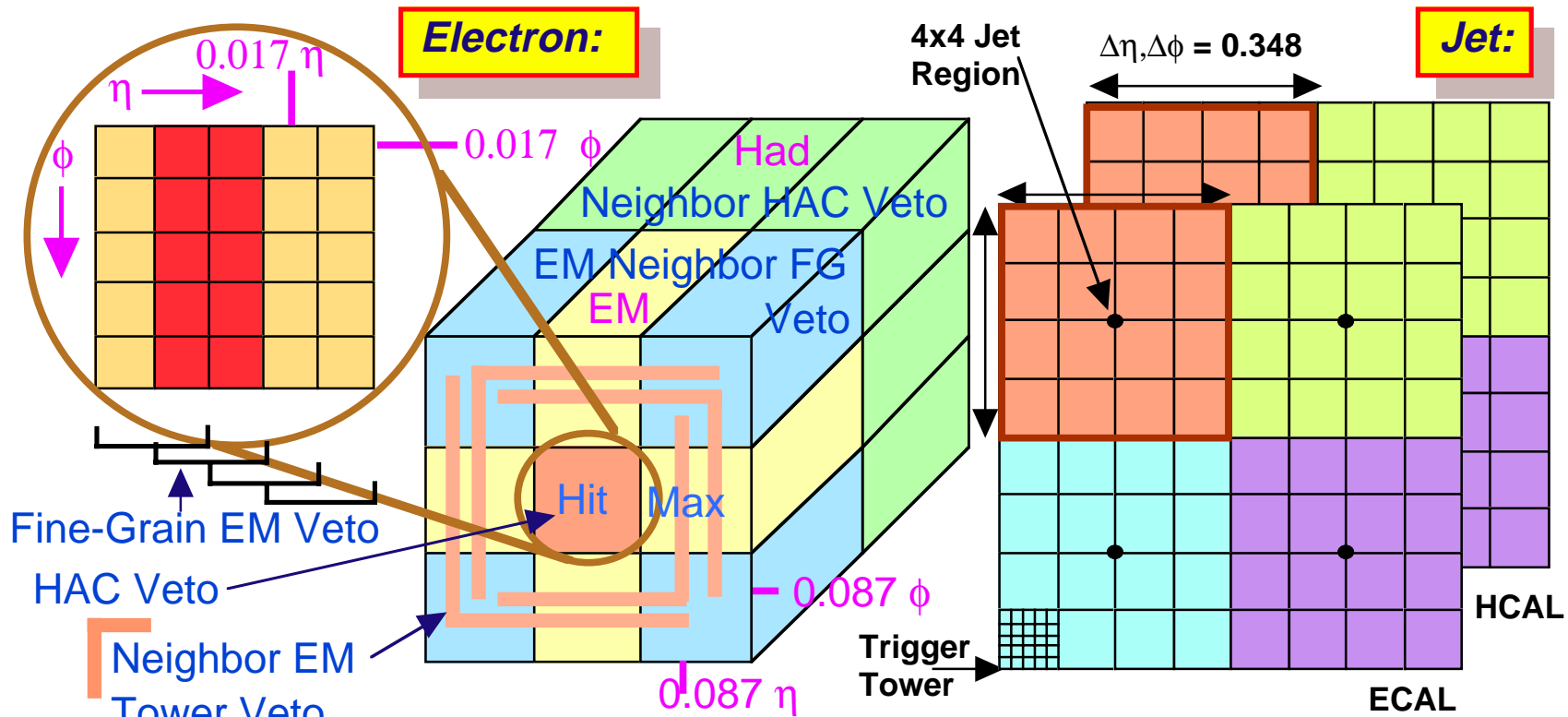


Outline

- **Overview of Calorimeter and Muon Triggers**
- **Cost Drivers**
- **Organization**
- **Status and Technical Progress**
- **Scope and Contingency Since Last Review**
- **Milestones, and Schedule**
- **Commitment and Resource Profiles**
- **Statements of Work - FY99**
- **Committee Concerns and Corrective Actions**
- **Issues**
- **Summary and Conclusions**



Calorimeter Triggers

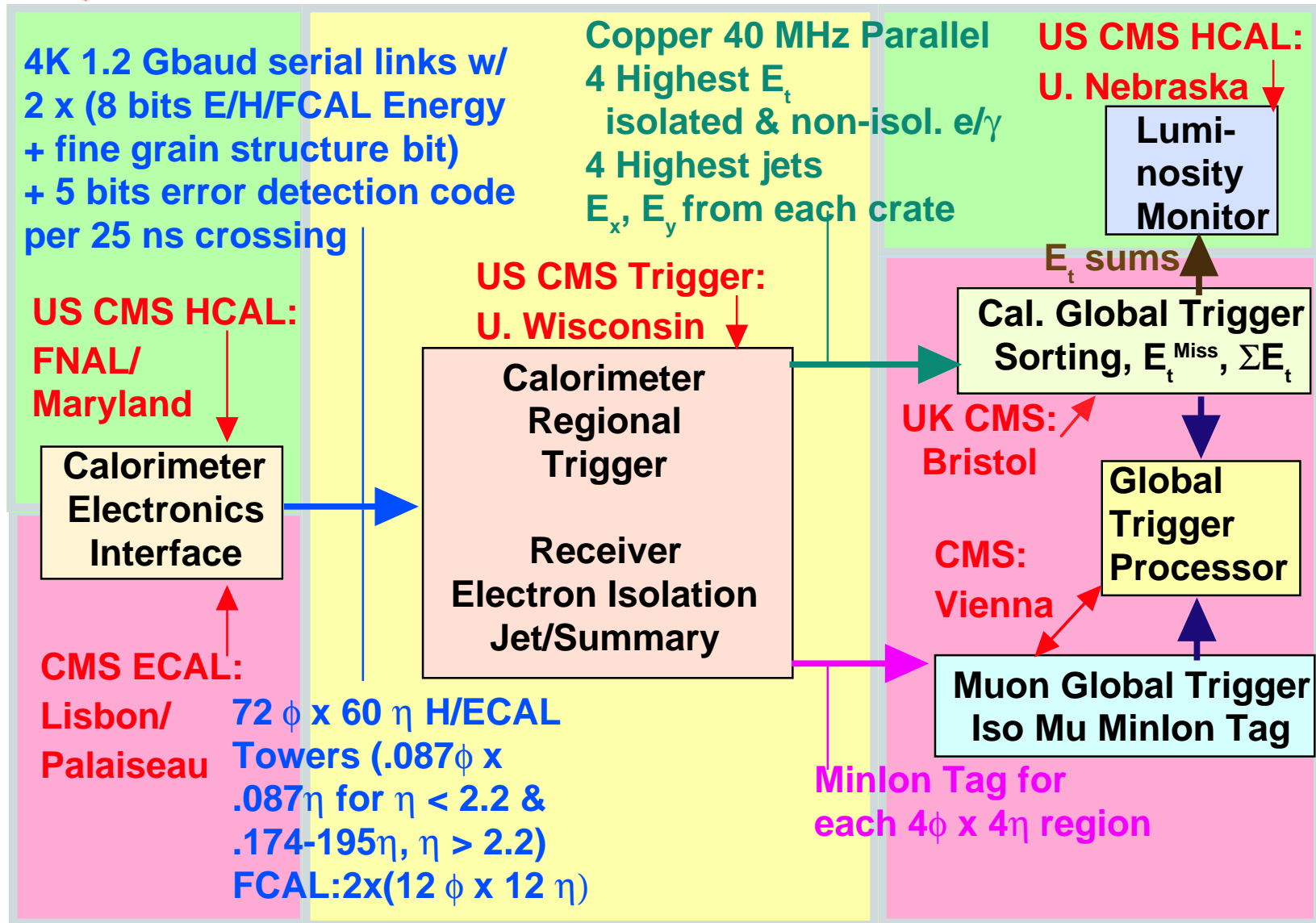


3 x 3 sliding window centered on ECAL/HCAL trigger tower pairs
Tower count =
 $72\phi \times 60\eta \times 2 = 8640$

Jet E_t from sum of ECAL & HCAL trigger tower E_t in non-overlapping 4x4 regions (also used for $E_x, E_y, E_t, E_t^{Miss}$)
Use multijet triggers
Jet candidates are sorted to find highest energy jets



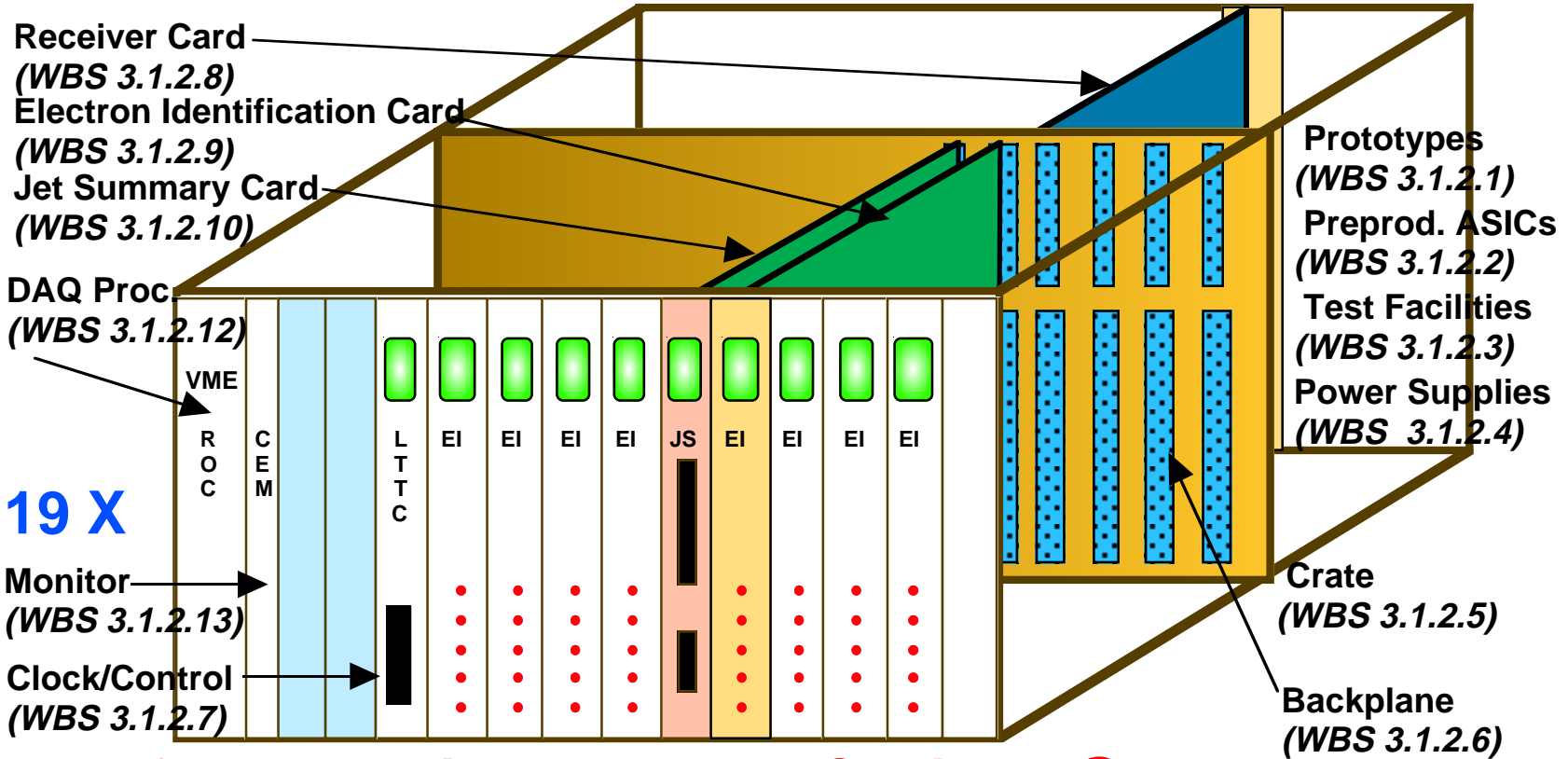
Calorimeter Trigger Overview





Regional Calorimeter Crate

(WBS 3.1.2)



Data from calorimeter FE on Cu links @ 1.2 Gbaud

- Into 152 rear-mounted Receiver Cards (ptyp. built)

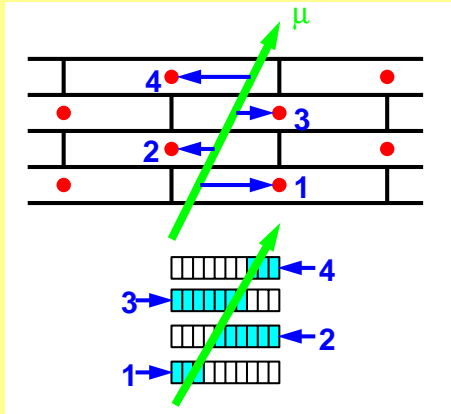
160 MHz point to point backplane (ptyp. built)

- 19 Clock&Control (ptyp. built), 152 Electron ID (ptyp. built)
19 Jet/Summary, Receiver Cards operate @ 160 MHz

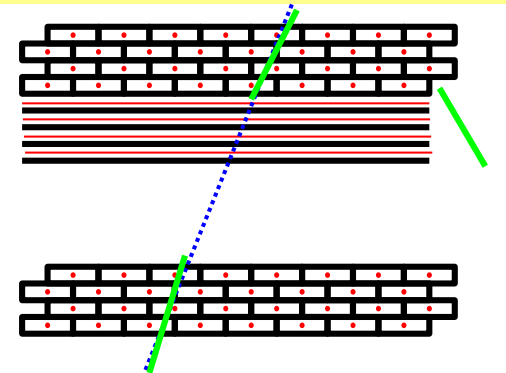


Muon Chamber Trigger

Drift Tubes

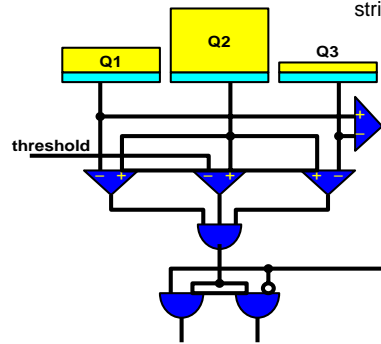
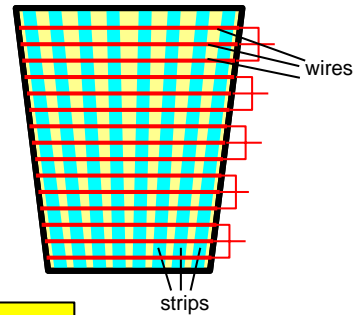


Meantimers recognize tracks and form vector / quartet.

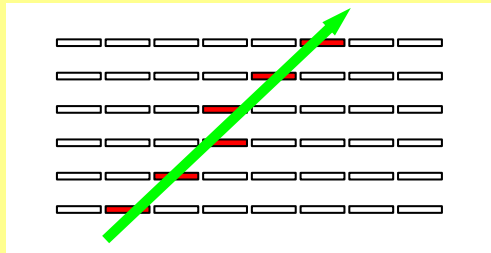


Correlator combines them into one vector / station.

CSC

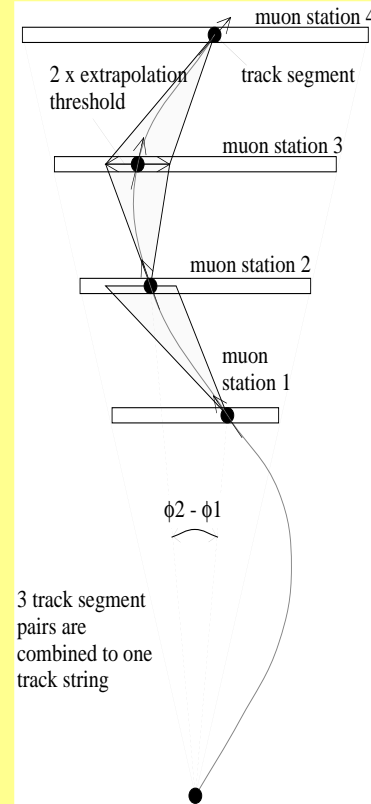


Comparators give 1/2-strip resol.



Hit strips of 6 layers form a vector.

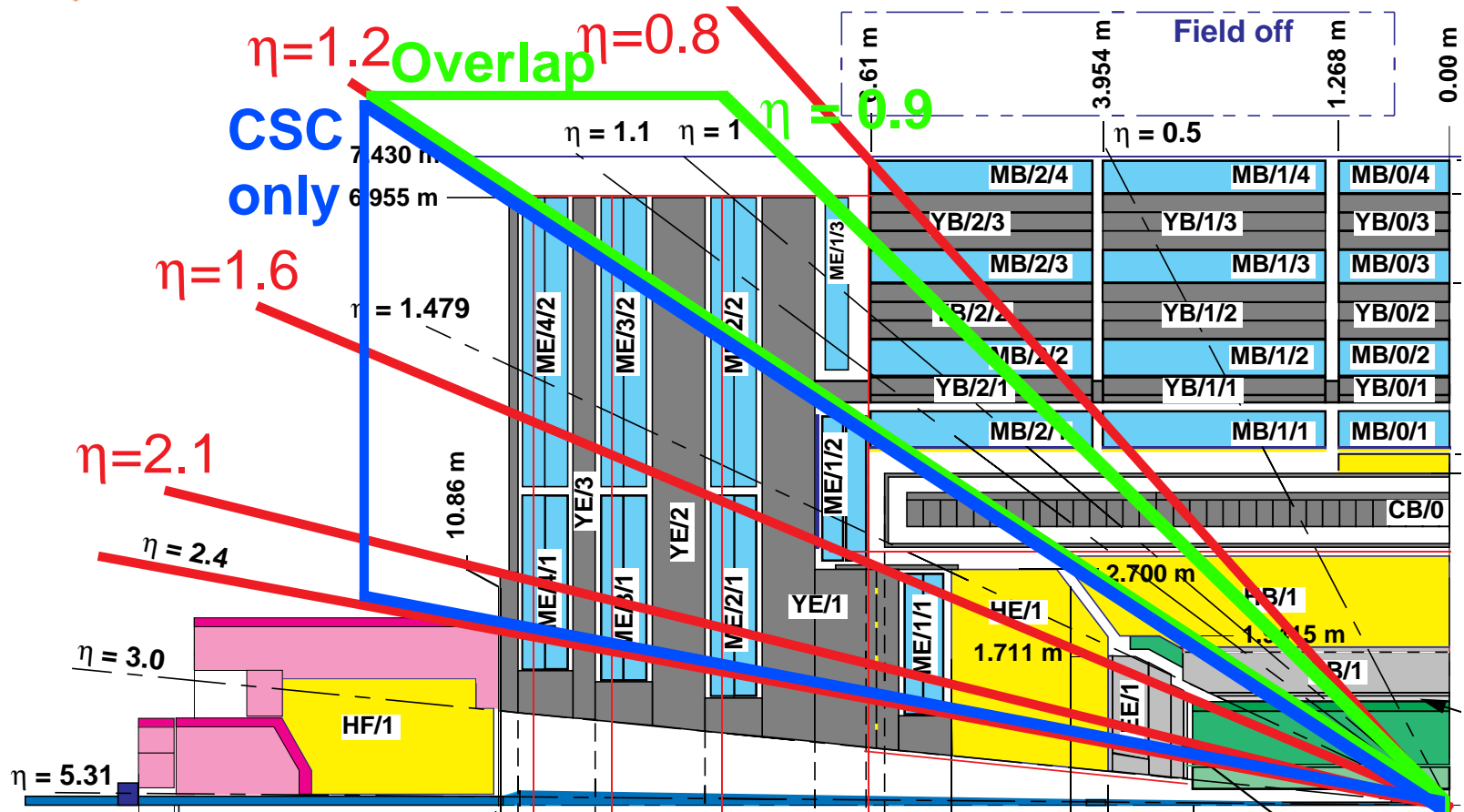
Track Finder



- combines vectors,
- forms a track,
- assigns p_t value.



CSC Muon Trigger Geometry



CSC Track-finding:

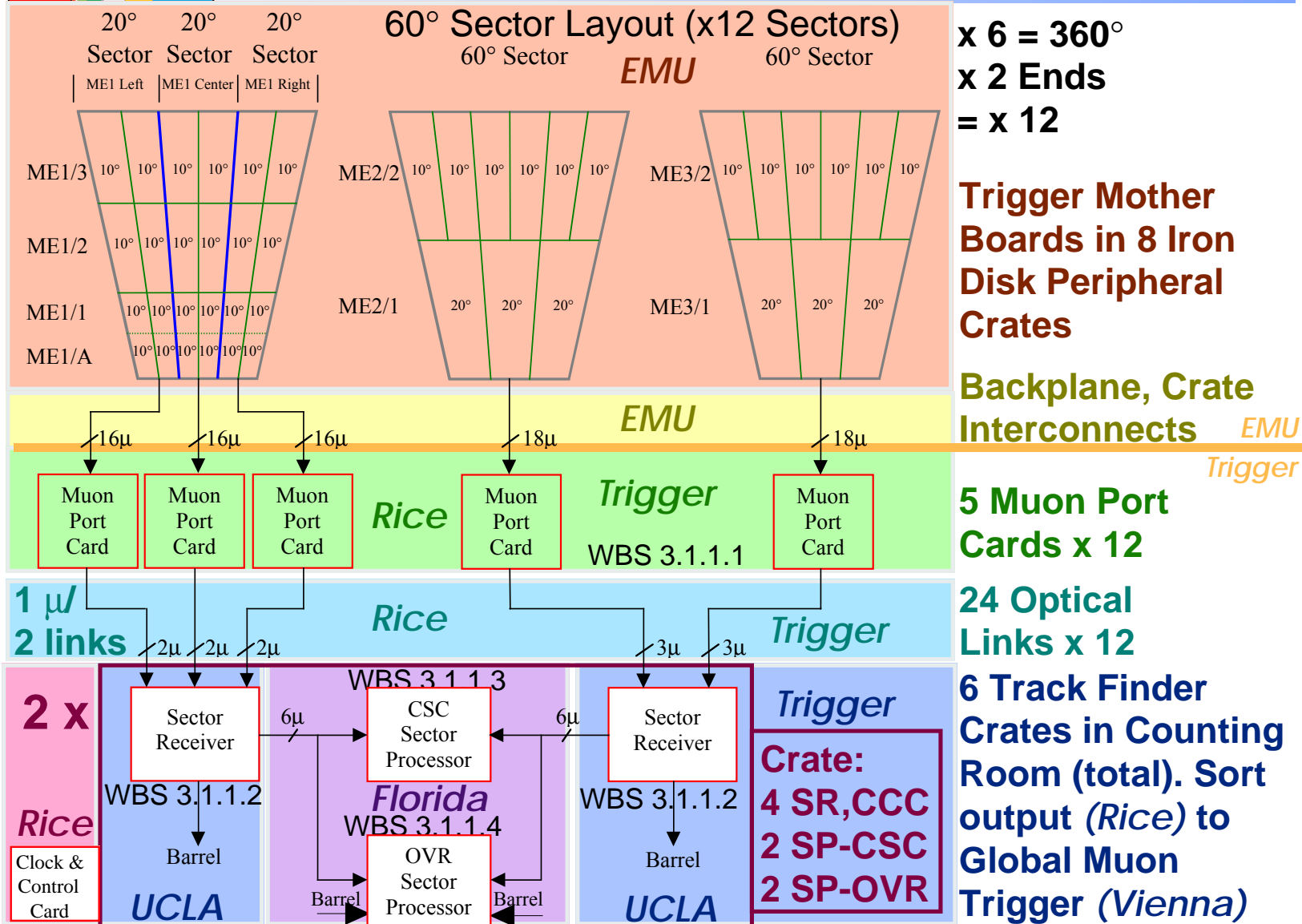
- Two Types of 60° Sector Processors:

- 12 SP-Overlap: $0.9 > |\eta| > 1.2$:CSC's & Barrel DT's
- 12 SP-CSC: $1.2 > |\eta| > 2.4$:CSC's only



CSC Trigger Layout

(WBS 3.1.1)



x 6 = 360°
x 2 Ends
= x 12

Trigger Mother Boards in 8 Iron Disk Peripheral Crates

Backplane, Crate Interconnects *EMU Trigger*

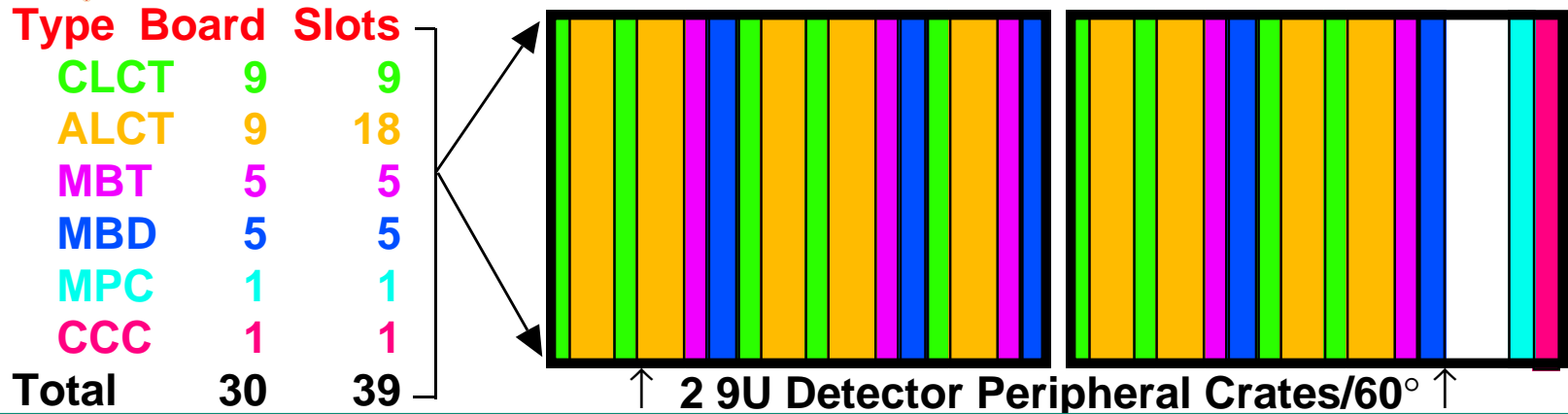
5 Muon Port Cards x 12

24 Optical Links x 12

6 Track Finder Crates in Counting Room (total). Sort output (*Rice*) to Global Muon Trigger (*Vienna*)

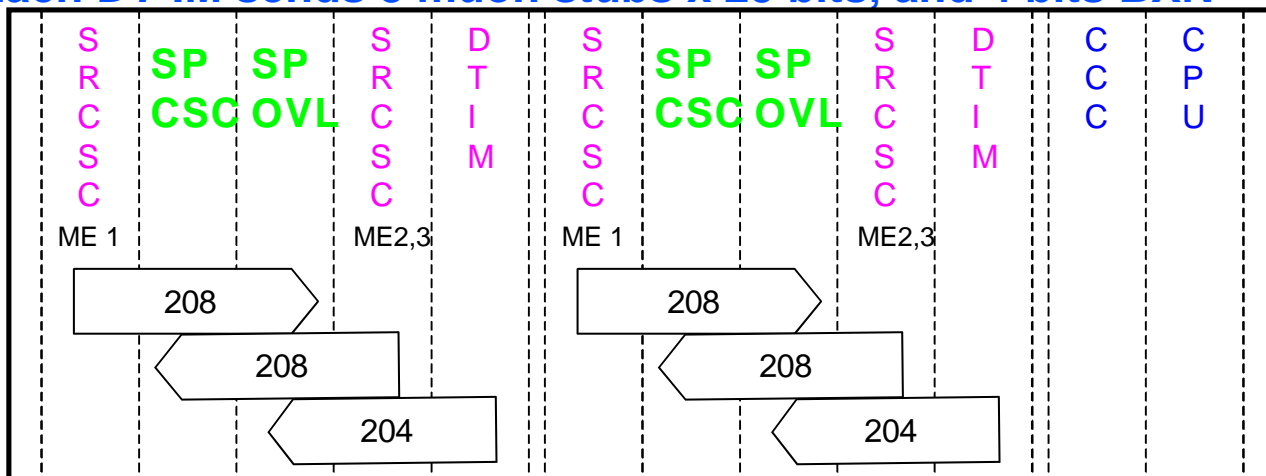


Endcap Muon Crates (Detector & Counting Room)



6 Counting Room 9U VME Track Finder Crates with custom backplanes:

- Each SR-CSC sends 6 muon stubs x 34 bits, and 4 bits BXN = 208 bits
- Each SP sends to the CSC sorter 3 best muons x 22 bits = 66 bits
- Each DT-IM sends 8 muon stubs x 25 bits, and 4 bits BXN = 204 bits





Cal.Trig. - 3.1.2 Milestones

	WBS	Task Name	1997		1998		1999		2000		2001		2002		2003		2004								
			Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr							
218	3.1.2.0.1	Start Prototype Boards			◆	1 Oct																			
219	3.1.2.0.2	Begin ASIC Development			◆	1 Oct																			
263	3.1.2.0.3	Internal Design Review 1					◆	11 Nov																	
264	3.1.2.0.4	Prototype Design Finished						◆	24 Jun																
265	3.1.2.0.5	Internal Design Review 2							◆	7 Oct															
266	3.1.2.0.6	Proto. Boards & Tests Finished								◆	11 Nov														
267	3.1.2.0.7	Begin ASIC Preproduction									◆	25 May													
289	3.1.2.0.8	Begin Backplane & Crate Production										◆	23 Mar												
290	3.1.2.0.9	ASIC Development Complete											◆	4 May											
291	3.1.2.0.10	Finish ASIC Preproduction												◆	24 Aug										
318	3.1.2.0.11	Begin Trigger Board Production													◆	28 Jan									
328	3.1.2.0.12	Begin ASIC Production														◆	28 May								
329	3.1.2.0.13	Crate & Backplane Complete															◆	22 Jul							
330	3.1.2.0.14	Begin Production Board Tests																◆	4 Nov						
358	3.1.2.0.15	Designs Finished																	◆	1 Mar					
359	3.1.2.0.16	Finish ASIC Production																		◆	13 Sep				
360	3.1.2.0.17	Finish Trigger Board Production																			◆	6 Dec			
361	3.1.2.0.18	Finish Production Board Tests																				◆	8 Apr		
373	3.1.2.0.19	Begin Trigger Installation																					◆	9 Apr	
374	3.1.2.0.20	Trigger Installation Finished																						◆	10 Oct



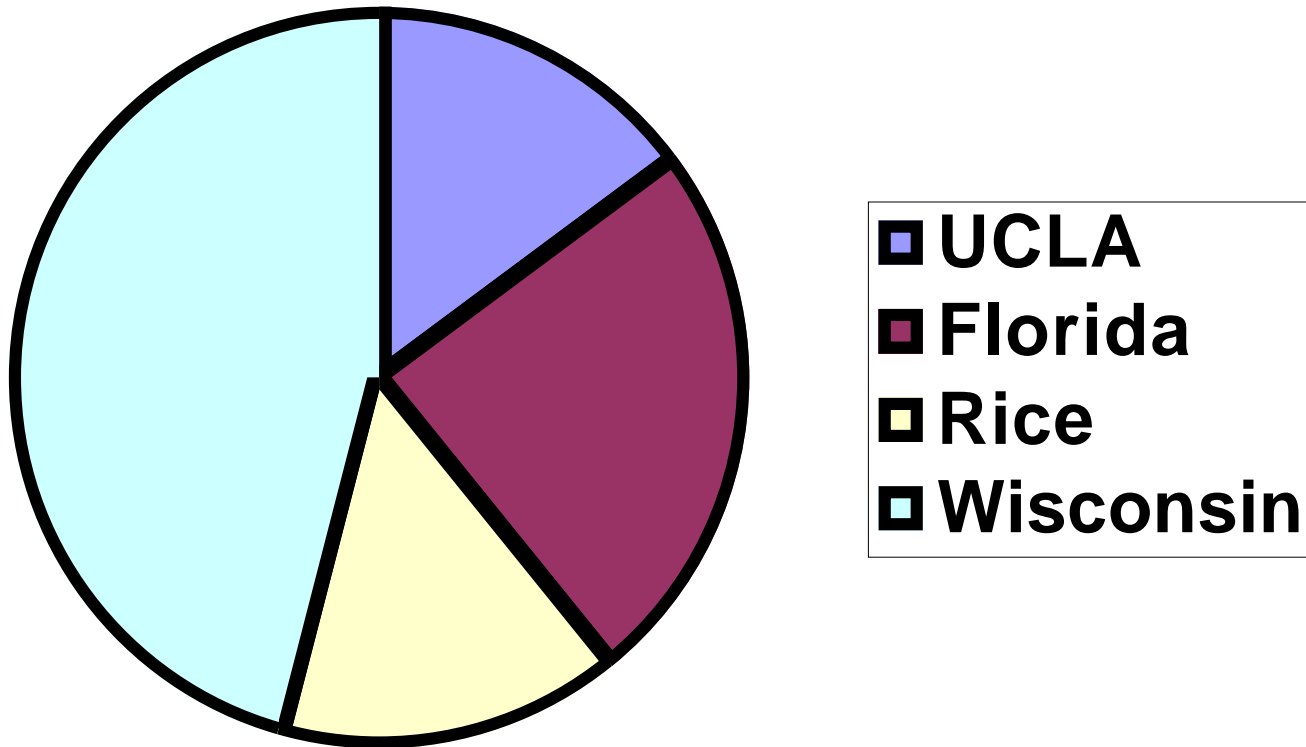
Muon Trig. - 3.1.1 Milestones

	WBS	Task Name	1997		1998		1999		2000		2001		2002		2003		2004		2005	
			Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr
153	3.1.1.0.1	⊕ Begin Initial System Design			◇ 1 Oct															
157	3.1.1.0.2	⊕ Finish Initial System Design	4 Feb	◇◇	13 May															
161	3.1.1.0.3	⊕ Begin Prototype Design	4 Feb	◇◇	13 May															
165	3.1.1.0.4	⊕ Finish Prototype Design			1 Apr	◇◇	22 Jul													
169	3.1.1.0.5	⊕ Begin Prototype Construction			1 Apr	◇◇	13 May													
173	3.1.1.0.6	⊕ Finish Prototype Construction			19 Aug	◇◇	9 Dec													
177	3.1.1.0.7	⊕ Begin Prototype Test			19 Aug	◇◇	30 Sep													
181	3.1.1.0.8	⊕ Finish Prototype Test			21 Apr	◇◇	23 Jun													
185	3.1.1.0.9	⊕ Begin Final Design			14 Apr	◇◇	9 Jun													
189	3.1.1.0.10	⊕ Finish Final Design							7 Sep	◇◇◇	15 Apr									
193	3.1.1.0.11	⊕ Begin Production							7 Sep	◇◇◇	15 Apr									
197	3.1.1.0.12	⊕ Finish Production										20 May	◇◇	19 Aug						
201	3.1.1.0.13	⊕ Begin Installation										20 May	◇◇	19 Aug						
205	3.1.1.0.14	⊕ Finish Installation												7 Oct	◇◇◇	1 Apr				
209	3.1.1.0.15	⊕ Begin Trigger System Tests															◇ 2 Apr			
213	3.1.1.0.16	⊕ Finish Trigger System Tests																		◇ 30 Sep



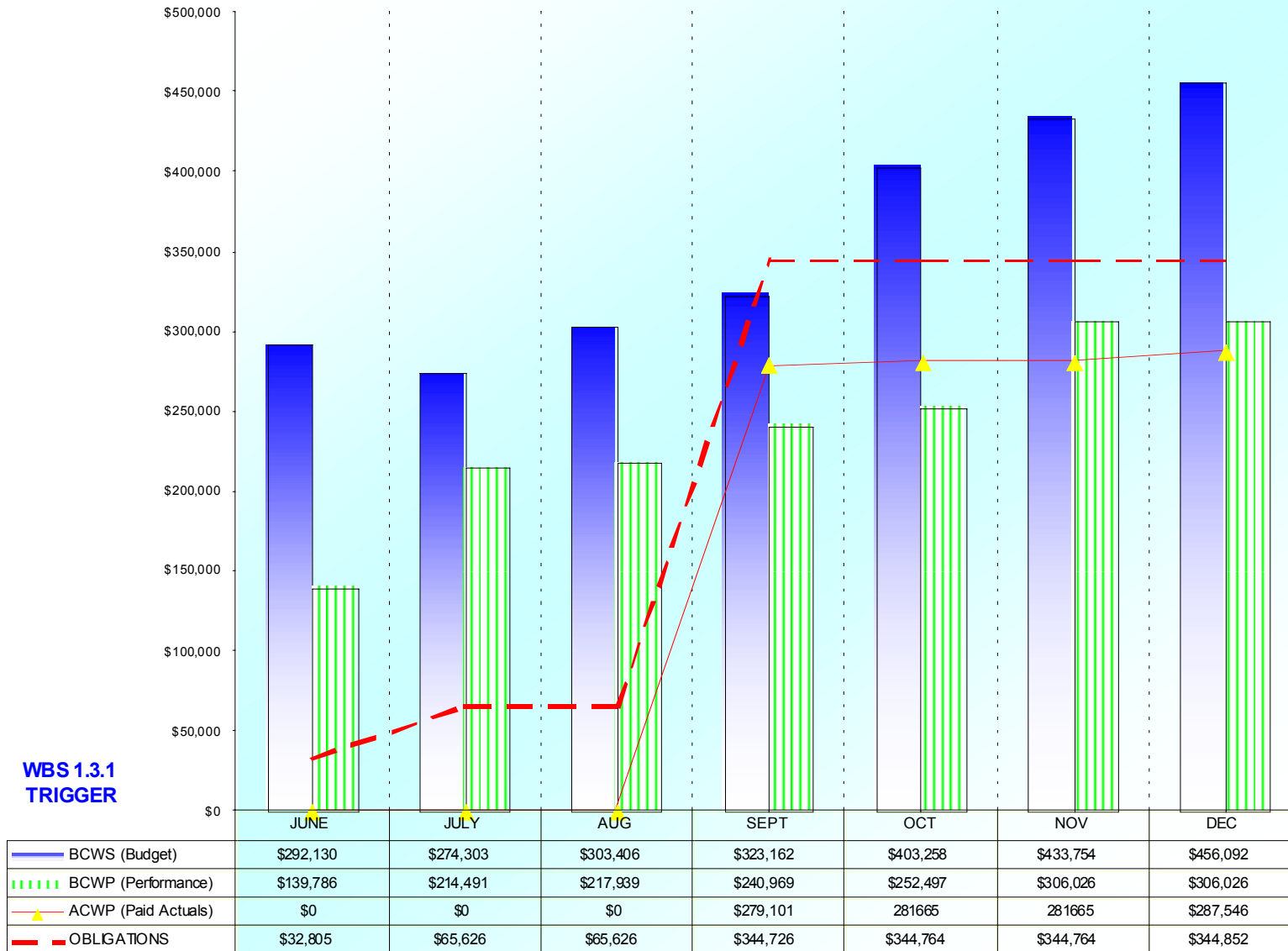
Statements of Work - FY99

**TRIGGER - SOW99
TOTAL = 496K**



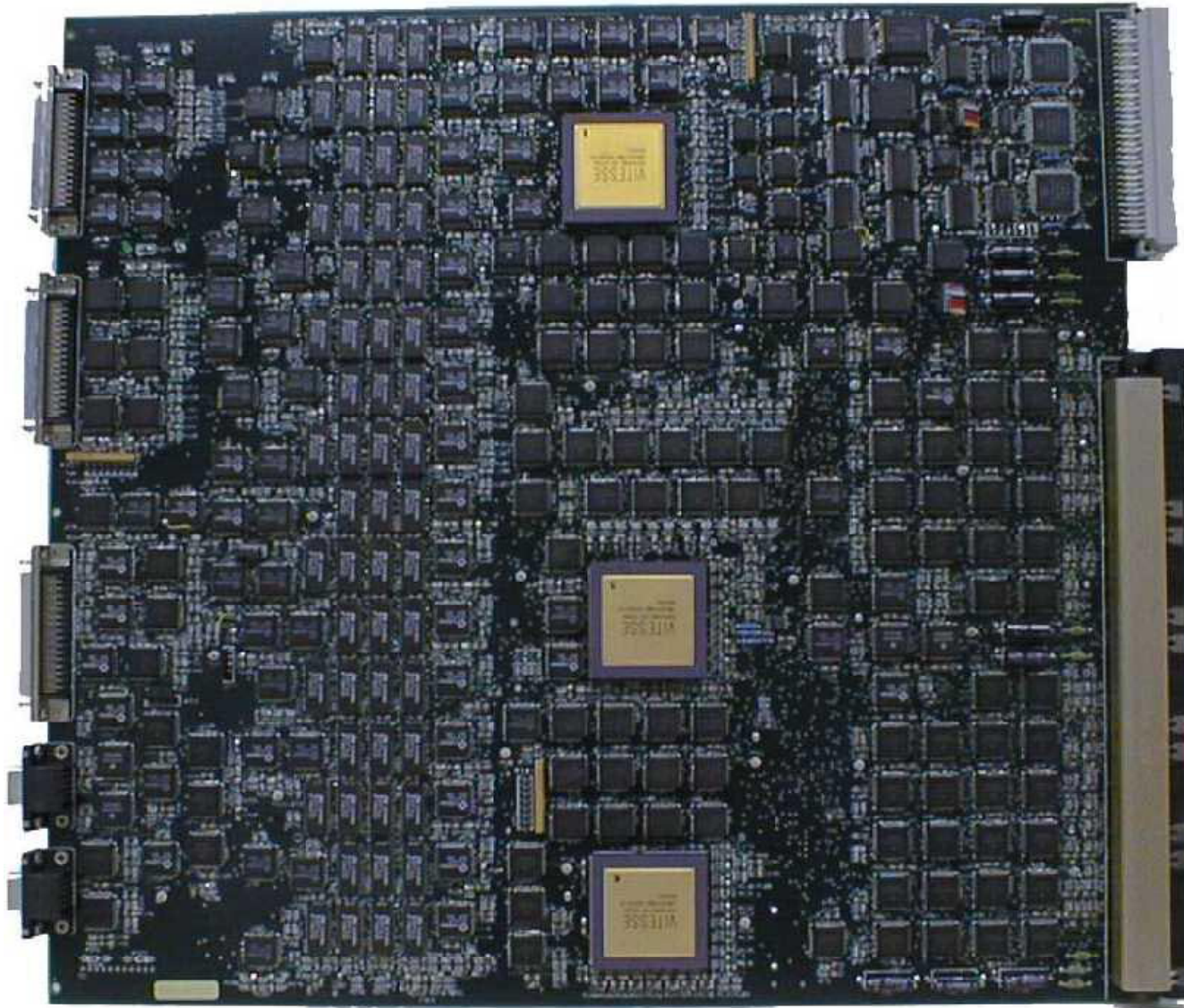


CPR - WBS 1.3.1, Trigger





Calorimeter Trigger Progress



160 MHz Prototype Receiver Card Under Test:

- VME Interface working
- Adder ASIC's functioning
- Detailed timing under study



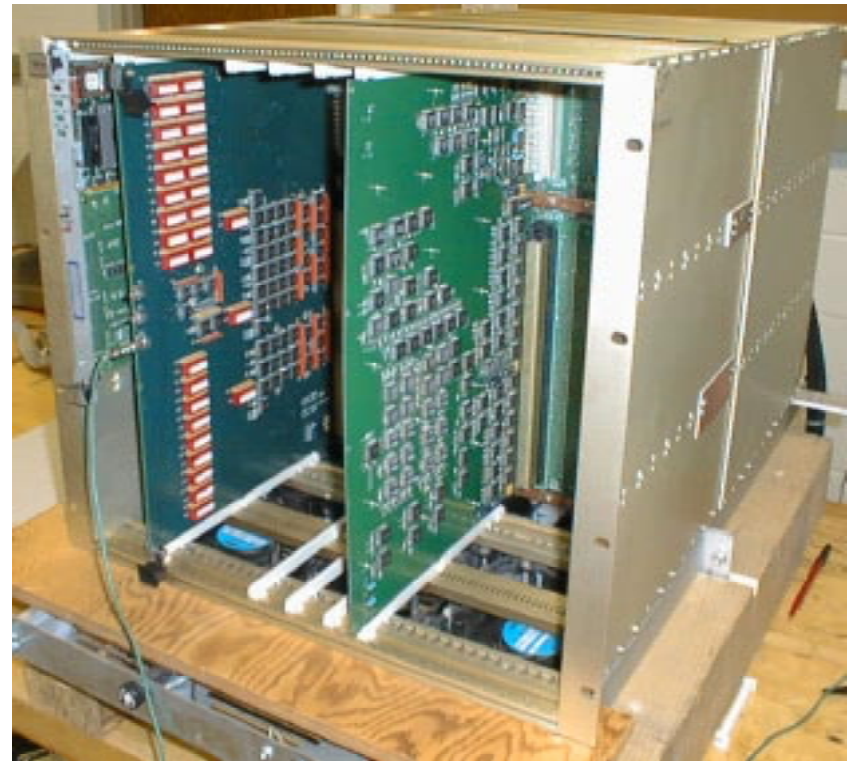
Cal. Trigger Dataflow Test



REAR

Prototype Crate with

- 160 MHz Backplane
- Proto. Receiver Card (rear)
- Proto. Clock Card (front)
- Proto. Electron ID Card (front)



FRONT



Calorimeter Trigger Plans

Prototype Dataflow Tests - Jun '99

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card →

Serial Data Tests - Oct '99

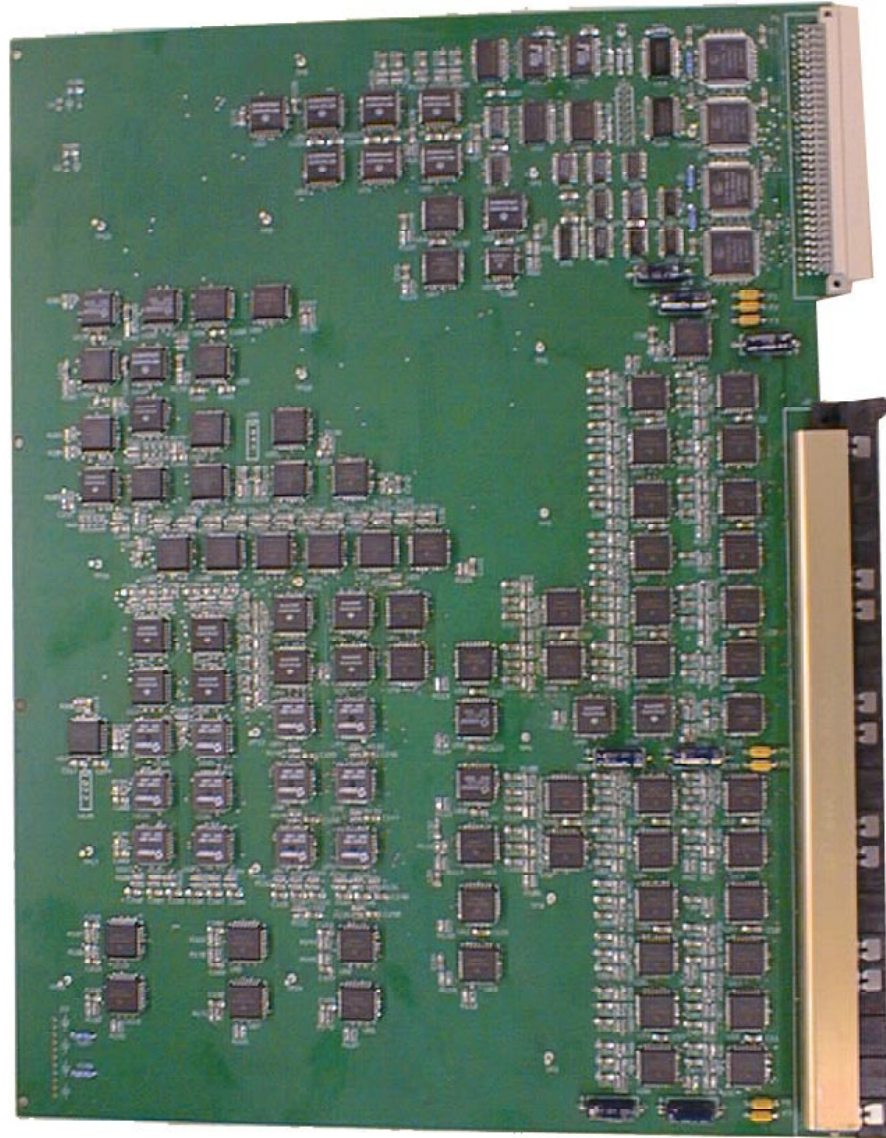
- Serial Link Test Card

ASIC Design & Prototypes - Mar '00

- Electron ID ASIC
- Phase ASIC
- Boundary Scan ASIC
- Sort ASIC

Crate Test - Jun '00

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card
- Proto. Jet Summary Card

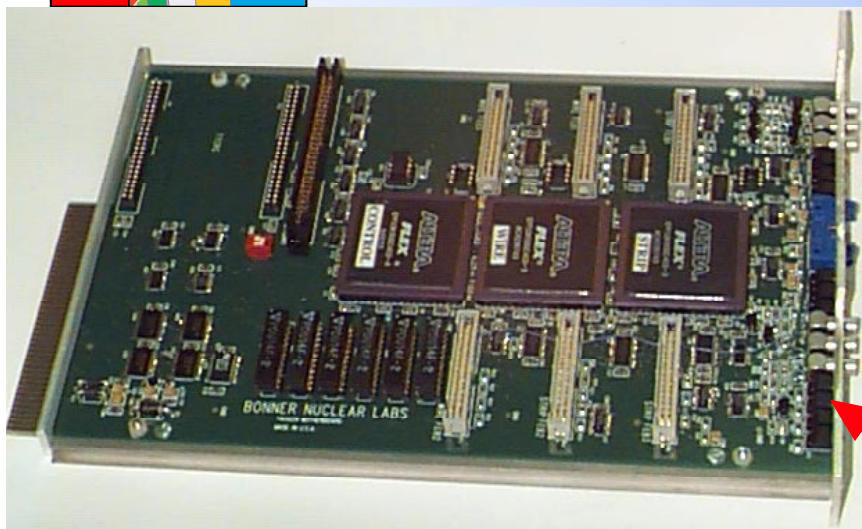




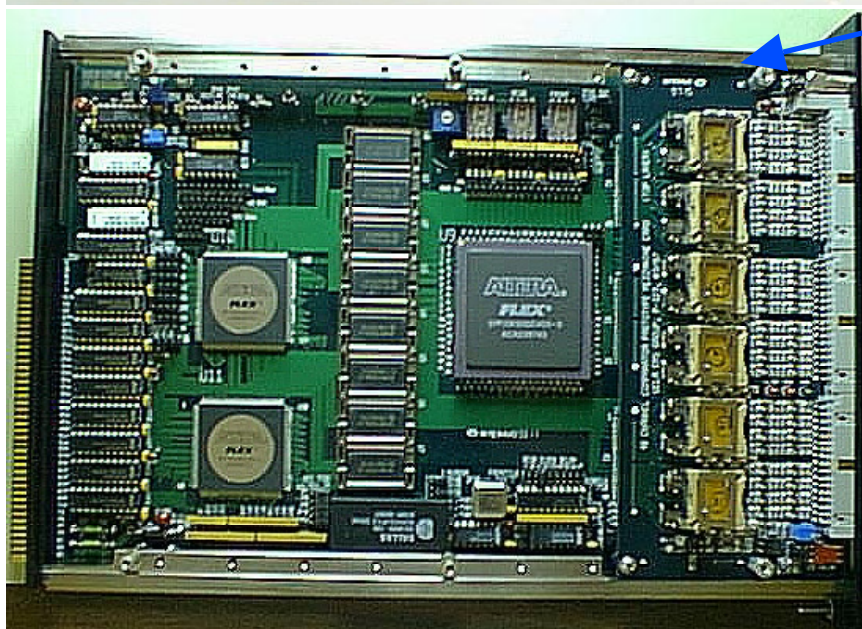
Muon Trigger Progress

Summer '98 test Beam

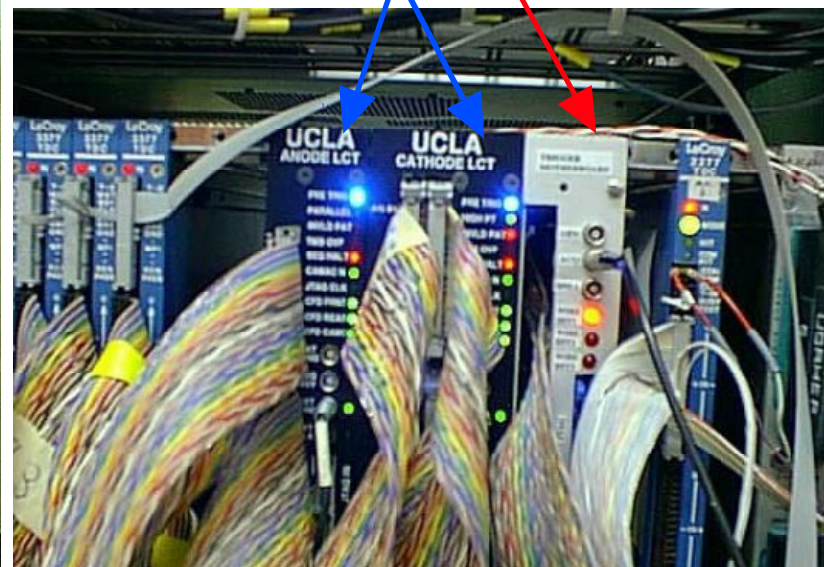
- Proto. UCLA 48-ch LCT Card
 - Software configurable as anode (wire) or cathode (strip) LCT
- Proto. Rice Trigger MotherBoard
 - Combines Wire & Strip LCTs



Rice TMB Proto.



UCLA LCT Proto.

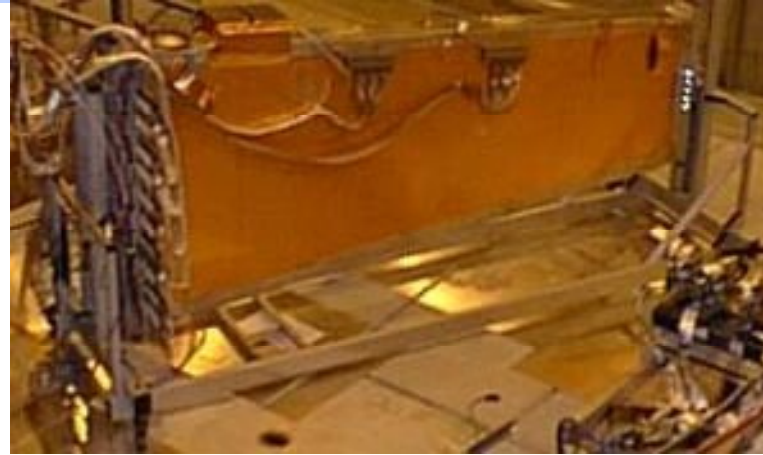




Muon Trigger Results

Summer Test Beam

- **Cathode Strip LCT's**
 - Exact 1/2 strip ID 90% eff.
 - \pm 1/2 strip 98% efficient
- **Anode Wire LCT's**
 - Bunch xing identification 99% efficient
- **Meets requirements for space, time resolution**



Design Progress

- **Full bit-level dataflow from front end to global trigger**
 - Interfaces with EMU FE, Drift Tube Trackfinding, Global Muon Trigger
- **Design of Sector Processor Track-Finder**
 - Converts Sector Receiver stubs into muons w/Pt, Quality
 - Incl.: Extrapolate, Quality, Assemble, Select, Assign units



Muon Trigger Plans

Muon Port Card - Rice

- Construct Prototype - Sep '99
- Test with Sector Receiver - Dec '99
- Test with Trigger Motherboard - Mar '00

Sector Receiver - UCLA

- Prototype Design Review - Mar '99
- Construct Prototype - Oct '99
- Test with Muon Port Card - Dec '99

Sector Processor - Florida

- Prototype Design Review - Mar '99
- Construct CSC Prototype - Oct '99
- Construct OVR Prototype - Dec '99

Crate Test - Jun '00

- Sector Receiver Prototype - UCLA
- Sector Process. CSC & OVR Proto - Florida
- Backplane - UCLA
- Clock & Control Card - Rice





Issues - Calorimeter Trigger

1.2 Gb Serial Cu Link from H/ECAL to Regional Trigger

- Originally fibers from detector direct to trigger
- New CMS R&D effort to switch from fiber to wire to adjacent crates
 - Major improvement in access, environment, power, support
- Engineering load on Receiver Card project
- Moved Link to Mezzanine Card on Receiver Card
- Added 1 FTE EE from U.Wisc. PSL to work on this
 - New WBS for this task at cost < \$100K
 - This engineer also serves as reserve after Link done

Vendor Support

- Vitesse shifting to external ASIC engineering support
 - Experienced customers can still find internal support (small load)
- No Impact on ASIC production runs
- As per Lehman '98: contacting other vendors (AMCC, TriQuint, Fujitsu)

Final Algorithms & Tower Geometry

- Required for final designs of Boards, Backplane & ASICs
- Agreement on trigger tower geometry for HCAL & ECAL
- Agreement on final electron & jet algorithms
- Documents written & being circulated



Issues - Muon Trigger

Peripheral Crates

- Originally LCT circuitry on chambers connected to separate Port Cards
- Now all Strip & Wire LCT Boards, Mother Boards, Muon Port Cards moved to crates on the periphery of the iron disks
- Major improvement in access, environment, power, support
- Required full system redesign -- now complete
 - System redesign also handles ME1/1A split strips using added Muon Port Cards (48→60)

Overlap Region

- Both CSC & Drift Tube segments must be used for $0.9 < |\eta| < 1.2$
- Agreement reached with Barrel Muon groups (Vienna & Bologna):
 - 2 separate Track Finders with programmable sharp η boundary
 - Data sharing between Track Finders
- Requirement of separate sorter for CSC & DT muon tracks
 - Cost estimate $< 100K$
- New Conceptual design documents are being circulated
 - Design eliminates extra signal distribution & reduces crates (8→6) and sector receivers (48→24)



Trigger Project Management

CMS Annual Reviews

- **April: TriDAS Status**
 - Progress, draft R&D plans & expenses for next year
- **November: TriDAS Internal Review**
 - R&D Plans/Progress, Cost & Schedule, Milestones
 - Finalize R&D plans & expenses for next year
 - Internal CMS Review w/CMS and non-CMS referees (M. Campbell)
- **Internal Electronics Reviews by LHC Electronics Board CMS Reps.**
 - G. Hall (Imperial), G. Stefanini (CERN), J. Elias (FNAL) for W. Smith
 - Reports to CMS Management Board (last review in Fall '98)

US Reviews/Reporting

- **Monthly Video Conferences:**
 - Florida, Rice, UCLA, Wisconsin, Davis (sim)
 - Review Progress, milestones, simulation activities
- **Integration Meetings:**
 - Calorimeter Trigger: FNAL, Maryland, Wisconsin
 - Muon Trigger: Ohio, Florida, Rice, UCLA, Wisconsin, others.
- **Annual Site Visits:** Florida, Rice, UCLA



Committee Concerns & Corrective Actions

From May 98 Lehman Review:

- **Add Cal. Trig. & CSC Trig. Crate Tests**
 - C&S for Cal & CSC Trig Crate tests added to CMS Project Planning
 - Done before CMS Trigger TDR planned for end of 2000
- **Continue work on limited loss of Muon Trigger efficiency in the overlap region.**
 - Considerable effort had been put into simulation and design efforts in this area. Documentation of this effort is found on the web at:
 - http://www.phys.ufl.edu/~acosta/cms/wang_sim_12_98.pdf
 - http://www.phys.ufl.edu/~acosta/cms/acosta_tf_cern_12_98.pdf
- **Watch ASIC availability issues, as early procurement may become necessary.**
 - Working on plans to procure an entire ASIC run after performance verification
 - Alternative vendors sought for each ASIC to avoid single vendor dependence.
- **Continue to monitor closely the Level 1 trigger latency.**
 - Full day workshop (“Synchronization Workshop”) held at CERN on Nov. 11. Major Topic was Latency -- thoroughly reviewed -- transparencies on web:
 - <http://cmsdoc.cern.ch/~wsmith/Agenda1198.html>

These concerns have been addressed



Conclusions - Trigger

Good Progress Since May 98 Lehman Review

- Full conceptual design with considerable engineering
- Important revisions result in an improved system
 - Muon trigger move to peripheral crates
 - Trackfinder integration w/ Drift Tubes & Global Muon Trig.
 - Calorimeter trigger serial links to adjacent E/HCAL crates
- Extensive prototyping & test program
 - "Proof of principle" of critical items
 - Number of successes already
 - Muon trigger test beam
 - Calorimeter trigger Receiver Card
- Project Management
 - Extensive system of reviews and monitoring in place
 - Detailed documentation on WWW:
 - <http://cmsdoc.cern.ch/ftp/afscms/TRIDAS/html/level1.html>