WESLEY SMITH, U. WISCONSIN
CMS Trigger Project Manager

FNAL Review
April 11, 2001
Trigger System Installation

UXC55

USC55
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<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Start Date</th>
<th>Finish Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical path from SX assembly</td>
<td>M15/Mar/04</td>
<td>T15/Jul/04</td>
</tr>
<tr>
<td>Magnet test</td>
<td>M15/Mar/04</td>
<td>T15/Jul/04</td>
</tr>
<tr>
<td>Install EB +</td>
<td>T15/Jul/04</td>
<td>W15/Sept/04</td>
</tr>
<tr>
<td>Assemble HF</td>
<td>M15/Mar/04</td>
<td>S1/Aug/04</td>
</tr>
<tr>
<td>YB-, YE- mu install (SX)</td>
<td>S15/Aug/04</td>
<td>W15/Dec/04</td>
</tr>
<tr>
<td>UX Installation</td>
<td>T1/Apr/04</td>
<td></td>
</tr>
<tr>
<td>UX Civil Engineering finish</td>
<td>T1/Apr/04</td>
<td>W1/Sept/04</td>
</tr>
<tr>
<td>Prepare UX area</td>
<td>M1/Dec/03</td>
<td>T1/Jan/04</td>
</tr>
<tr>
<td>Install floor plates &amp; CMS shielding</td>
<td>M15/Dec/03</td>
<td>T1/Jul/04</td>
</tr>
<tr>
<td>Prepare US area (infra/racks/cooling)</td>
<td>T1/Jul/04</td>
<td>M1/Nov/04</td>
</tr>
<tr>
<td>Equip US with crates, DCS</td>
<td>T15/Nov/04</td>
<td>T15/Feb/05</td>
</tr>
<tr>
<td>SCX ready for control room inst</td>
<td>T1/Nov/04</td>
<td>S31/Jan/05</td>
</tr>
<tr>
<td>Commission detectors/ DAQ</td>
<td>T15/Nov/04</td>
<td>M31/Oct/05</td>
</tr>
<tr>
<td>Cabling (heavy + fibre optics)</td>
<td>T1/Nov/04</td>
<td>S31/Jan/05</td>
</tr>
<tr>
<td>Lower major elements</td>
<td>S1/Nov/04</td>
<td>M31/Jul/05</td>
</tr>
<tr>
<td>Install HB. Commission HB/HE/HF</td>
<td>S15/Jan/05</td>
<td>M15/May/05</td>
</tr>
<tr>
<td>EB supermod. assembly/calibration</td>
<td>S15/Jan/05</td>
<td>S31/Jul/05</td>
</tr>
<tr>
<td>EB- install. Commission EB+ &amp; EB-</td>
<td>S15/Jan/05</td>
<td>S31/Jul/05</td>
</tr>
<tr>
<td>SE/SE+ install &amp; commission</td>
<td>S31/Jul/05</td>
<td>F30/Sept/05</td>
</tr>
<tr>
<td>Install beam pipe</td>
<td>F30/Sept/05</td>
<td>S31/Dec/05</td>
</tr>
<tr>
<td>Close exp (yoke/HF/shielding)</td>
<td>S31/Dec/05</td>
<td>T31/Jan/06</td>
</tr>
<tr>
<td>Online/Offline Computing preparation</td>
<td>W1/Sept/04</td>
<td>W1/Feb/06</td>
</tr>
<tr>
<td>LHC 1-beam commissioning</td>
<td>T31/Jan/06</td>
<td>S1/Apr/06</td>
</tr>
<tr>
<td>CMS ready for colliding beam</td>
<td>S1/Apr/06</td>
<td></td>
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<tr>
<td>LHC pilot run</td>
<td>S1/Apr/06</td>
<td></td>
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<tr>
<td>Open detector</td>
<td>S1/Apr/06</td>
<td></td>
</tr>
<tr>
<td>Install EE-, pixels, T1 +maintain</td>
<td>S6/Jul/06</td>
<td>F21/Jul/06</td>
</tr>
<tr>
<td>Close detector</td>
<td>S21/Jul/06</td>
<td>M31/Jul/06</td>
</tr>
<tr>
<td>Complete CMS ready</td>
<td>M31/Jul/06</td>
<td>F3/Dec/04</td>
</tr>
</tbody>
</table>

Start installation Nov '04  Start integration w/DAQ & FE Mar '05

Start M&O Oct '05
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Trigger L2 Tasks

Tasks | start | finish:
--- | --- | ---
• Produce TDR | 8/00 | 12/00 ✔
• Design Final Prototypes | 11/00 | 12/01
• Construct Final Prototypes | 6/01 | 6/02
• Test/Integrate Final Prototypes | 12/01 | 12/02
• Pre-Production Design & Test | 6/02 | 6/03
• Production | 12/02 | 6/04
• Production Test | 6/03 | 11/04
• Trigger System Tests | 5/04 | 5/05
• Trigger Installation | 11/04 | 11/05
• Integration & Test w/DAQ & FE | 3/05 | 9/05
• Maintenance & Operations | 10/05 | ------

Impact of delayed access to USC55 & UXC55:
• US EDIA cost increased by $200K -- CMS cost unchanged
  • 100K each for CSC & Regional Cal Trigger
Zeus Level-1 Calorimeter Trigger

• 16 80 MHz Crates operating on 96 ns xing freq
  • CMS: 18 160 MHZ crates at 25 ns xing freq
• 300 370 mm x 400 mm boards w/ 1100 components (75% of board area), 8700 vias
  • CMS: 300 370 mm x 400 mm boards with somewhat greater complexity
• Finds isolated $e$, $\mu$, jets, $E_T$, $E_{T\text{miss}}$
• Successful operation: 1992 - 2001
Supervisory Personnel


• Needed each for US CMS Cal. & Muon Trigger Efforts

Ph.D. Physicists (2)

• Assistant Scientist
  • Primarily on Physics Analysis
    • Works with students on thesis topics
  • Local Group Leader
  • Expert on Trigger
    • Available for assistance, consultation, coverage

• Postdoc
  • Primary duties on trigger
    • Responsible for daily operations
    • Works with students on trigger duties

• Trigger Coordinator
  • Provides technical coordination
  • Works with other detector leaders
Students

• **Beginning (2)**
  - Learning
  - Trigger shifts (on call 24x7)

• **Intermediate (2)**
  - Responsible for Cal Trig shifts
  - Begin physics analysis

• **Senior (2)**
  - Released for Thesis analysis
  - Consultation, assistance, shifts

Based on Zeus
Students
Technical Personnel


• Needed each for US CMS Cal. & Muon Trigger Efforts

Technician

• Operates, repairs, maintains test facility
• Repairs boards & infrastructure under physicist guidance
• Total required = 0.5 FTE

Expert Engineer

• ~ 5 trips/year for 2-3 weeks to make difficult repairs

Designer - available for consultation

• ~ 2 trips/year for 2-3 weeks for review & design issues
  • Complicated/Subtle problems
  • Modifications to trigger electronics
• Total Engineering (Expert + Designer) required = 0.5 FTE
Operation of Test Facility

Based on Zeus Cal Trig:
Trigger electronics test with full cal. or \( \mu \) detector infrastructure and DAQ

Resp. of Technician
Complete test crate & interface to other components full-scale check of USC electronics
Responsibilities of Physicists & Students

• Based on Zeus Cal. Trigger M&O 1992-2001
  • Needed each for US CMS Cal. & Muon Trigger Efforts

Change trigger as beam conditions change
Study new trigger configurations

• Test runs, Monte Carlo studies, data studies

Trigger Physics Analysis

• Understand detailed impact of trigger on physics

Preparation for luminosity increases

• Perform Monte Carlo studies of new conditions
• Validate with present data

Respond to changing apparatus

• Changes in material, configuration, etc.
• Must result in changes in simulation
Responsibilities of Physicists & Students

  - Needed each for US CMS Cal. & Muon Trigger Efforts

Detector & Electronics House

- Write, test & maintain electronics test programs
- Maintain & update bad channel list
- Diagnose & repair electronics
- Daily checking programs
- Maintain & operate Jade Hall Test Facility
- 24 hour/day support during running

Software Operations

- Run Control maintenance
- Trigger data validation
  - Online & Offline analysis of rates & efficiencies
- Monte Carlo & data trigger simulation maint.
More Physicist/Student Tasks

Trigger Calibration/Maint.
• Frequent calibration is performed with charge injectors to set the time & energy/position
  • Calibration of a single trigger tower trigger vs. full resolution readout data

Online Diagnostic Simulation
• Trigger bits vs. simulation of trigger using reconstructed data as input.
• Each trigger efficiency curve is monitored & checked online.

Real-Time study of Trigger Function
• Need sophisticated online display
• Difference between simulated & data trigger bits set
More Physicist/Student Tasks

Automatic Data Quality Monitor

- **Input:**
  - Online & Offline Trigger Histograms

- **Functions:**
  - Analysis of threshold curves, efficiencies, subtrig. rates

- **Purpose:**
  - Find trigger problems online automatically & rapidly

- **Output:**
  - Error messages, Logs of performance
  - Email/cell-phone call to online calorimeter trigger crew

- **Goal:**
  - Problems found by Automatic DQM before Shift Crew
Web-based Information Server

Up-to-date performance information

Run by run online & offline analysis

Up-to-date status

Full system documentation

Operation of diagnostics
1 FTE Engineer
  • 0.5 FTE ea. for cal. & mu trigger

1 FTE Technician
  • 0.5 FTE ea. for cal & mu trigger

4 FTE Ph.D. Physicists
  • 2 FTE ea. for cal & mu trigger
  • 50% of time on M&O

12 FTE Graduate Students
  • 6 FTE ea. for cal & mu trigger
  • 25% (effectively) of total tenure on trigger
  • Fewer students → more postdocs

All From Base Program Support
Diagnostic equipment
- Scopes & probes, logic analyzers, computers, interfaces, etc.
- Construction of additional specialized test boards

Repair equipment & supplies
- Soldering stations (BGA repair), misc. supplies
- Tools, Voltmeters
- Module repair/replacement costs
  - Power supplies, regulators, breakers, thermal sensors, crate CPUs, etc.
- Replacement of broken cables, fiber optics, etc.
- Vehicle lease for hauling back & forth?

Shipping Costs
- Sending items back to US for major work
  - Either to FNAL, University, or manufacturer
Trigger M&O M&S Estimate

Estimated Yearly Cost of 80K$

- 40K$ each for US CMS Cal. & Muon Trigger Efforts

Total for FY06-FY08: 240K$
Trigger Upgrades

R&D effort to study upgrades to level-1 trigger to handle luminosity beyond $10^{34}$

- May need more sophisticated logic to distinguish physics signals from increased backgrounds
- Upgraded logic will have to operate in same amount of time as present logic
  - Increase in speed to provide more sophisticated algorithms

R&D effort to study upgrades to level-1 trigger to handle changes in bunch crossing time

- Possibility of increase from 25 ns to 12.5 ns
  - Detector response times are slower than 25 ns crossing time
  - In some cases (e.g. HCAL & ECAL), timing information is sufficiently precise to identify 12.5 ns crossings.
  - Upgrade to trigger logic to allow analysis of 12.5 ns crossings
Trigger Upgrade R&D Program

Based on experience with CMS Level-1 trigger R&D & prototype program

Personnel requirements

- 1 FTE Engineer from Project
  - Engineering Design
  - 0.5 FTE ea. for cal. & mu trigger
  - Could be other "half" of engineer on M&O
- 1 FTE Ph.D. Physicist from base program
  - Simulation & Design Studies
  - 0.5 FTE ea. for cal & mu trigger

M&S Requirements

- $40K/year for Prototypes
  - $20K ea. for cal. & mu trigger
  - ~ 2 prototype boards ($10K ea.) per year for cal. & mu
Trigger Upgrade Estimate

Estimated Yearly Cost of 120K$

- M&S of 40K$ for prototyping
- EDIA of 80K$ for engineering

Total for FY06-FY08: 360K$