

# US CMS Trigger

## DOE-NSF Review

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### Outline:

Project Completion

M&O

Upgrades

This talk is available on:

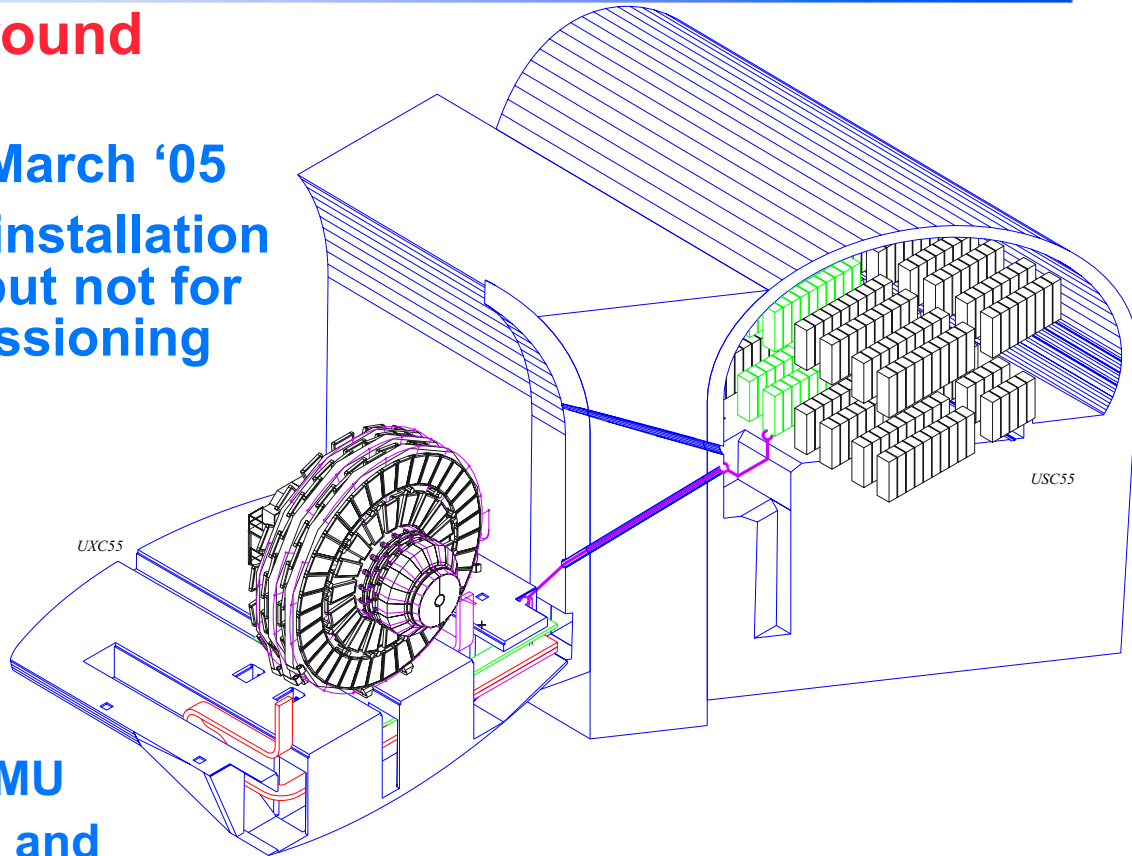
[http://hep.wisc.edu/wsmith/cms/Trig\\_M&O\\_0403.pdf](http://hep.wisc.edu/wsmith/cms/Trig_M&O_0403.pdf)



# Define Project Completion

## Installation in Underground Counting Room

- Expect access by March '05
- Sufficient time for installation and some testing but not for completing commissioning with detectors



## Slice Test (on surface)

With Both HCAL and EMU

Verify trigger functions and interfaces by testing with detectors on surface at CERN.

Suggest as substitute for commissioning completion step.

Will check as much on surface before gaining access to underground facilities.

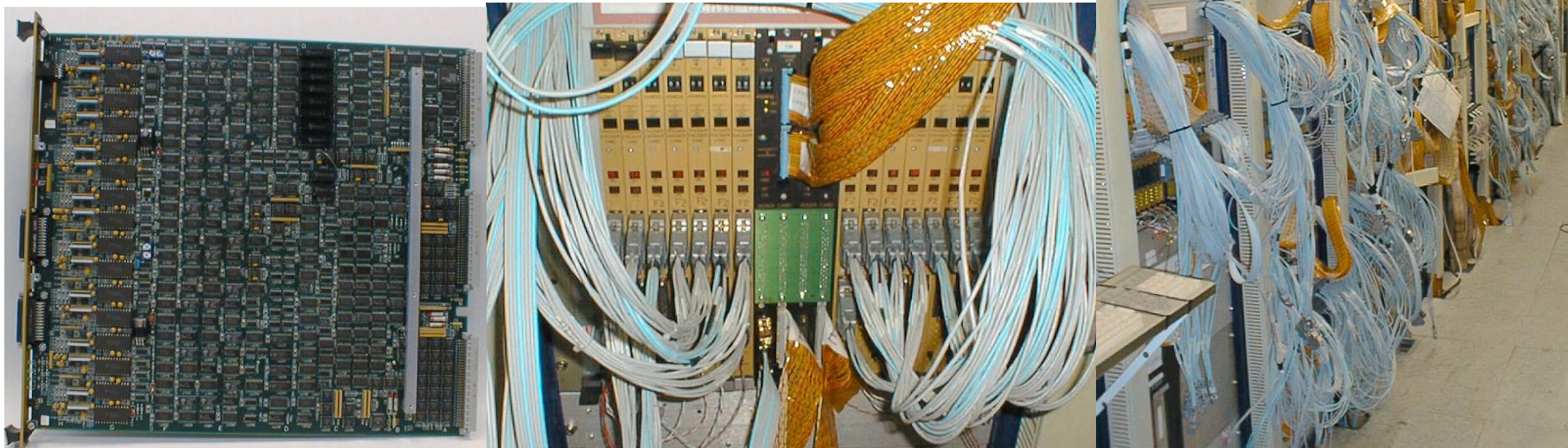
Milestone (HG1018) planned for completion November '04



# M&O Basis of Estimate

## Zeus Level-1 Calorimeter Trigger

- 16 80 MHz Crates operating on 96 ns collision frequency
  - CMS: 18 160 MHz crates at 25 ns collision frequency
- 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,  $E_T$ ,  $E_{Tmiss}$
- Successful operation: 1992 - 2002





# Tasks: Trigger Evolution

## Responsibilities of Physicists

- 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



# Tasks: Trigger Operations

## Responsibility of Physicists & Technicians

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

## Electronics Operations

- Write, test & maintain electronics test programs
- Maintain & update bad channel list
- Diagnose & repair electronics
- Daily checking programs
- Maintain & operate Repair 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 maintenance



# Trigger Calibration/Validation

## Responsibility of Physicists

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

## Trigger Calibration

- Frequent calibration is performed with test systems to set the time & energy/position
- Calibration of a single trigger cell 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



# Physicists on M&O

## Based on Zeus Cal. Trigger M&O 1992-2002

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

## Ph.D. Physicists (2)

- Responsible for daily operations
- Work with students on trigger duties
- Trigger Coordination

## Students (6)

- **Beginning (2)**
  - Learning, trigger shifts (on call 24x7)
- **Intermediate (2)**
  - Responsible for trigger shifts, begin physics analysis
- **Senior (2)**
  - Released for thesis work, available for consultation, assistance, shifts



# Technical Personnel on M&O

## Based on Zeus Cal. Trigger M&O 1992-2002

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

### Technician

- Operates, repairs, maintains test facility
- Repairs boards & infrastructure under physicist & visiting engineer guidance
- Total required = 0.5 FTE resident + 0.25 FTE visiting

### Expert Engineer

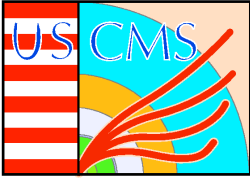
- ~ 5 trips/year for 2-3 weeks to make difficult repairs

### 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

### Ramp up: First year at 50% of this





# CMS Specific M&O Support

**Goal: Maintain the critical technical team**

## **Muon Trigger**

- **Need expertise from 3 institutes**
  - Rice - Muon Port Card, Clock/Control, Sorter
    - Mike Matveev -- share support w/EMU
  - Florida - Sector Receiver/Processor
    - Alex Madorsky -- share support w/EMU
  - PNPI - Collaborated on engineering on above
    - Need their help at beginning of operations
- **Build in engineering support to cover this**

## **Calorimeter Trigger**

- **Need expertise of lead Wisconsin Engineer**
  - Joe Lackey → Tom Gorski
- **Need institutional technical support**
  - Experience is vital

**Muon & Cal can share resident technician services**



# Summary: M&O Personnel

## From Project Support:

- **1.25 FTE Engineer**
  - 0.5 FTE ea. for cal. & mu trigger + PNPI 0.25 for mu
- **1.25 FTE Technician**
  - 0.5 FTE ea. resident for cal & mu + 0.25 visiting for cal

## From Base Program Support:

- **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



# Trigger M&O M&S

## Scaled from Zeus Cal. Trigger M&O 1992-2002

### Diagnostic equipment

- Scopes & probes, logic analyzers, computers, interfaces, etc.
- Construction of additional specialized test boards

### Repair equipment & supplies

- Soldering stations (BGA repair), Tools, Voltmeters, misc. supplies
- 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 and/or contract repair Costs

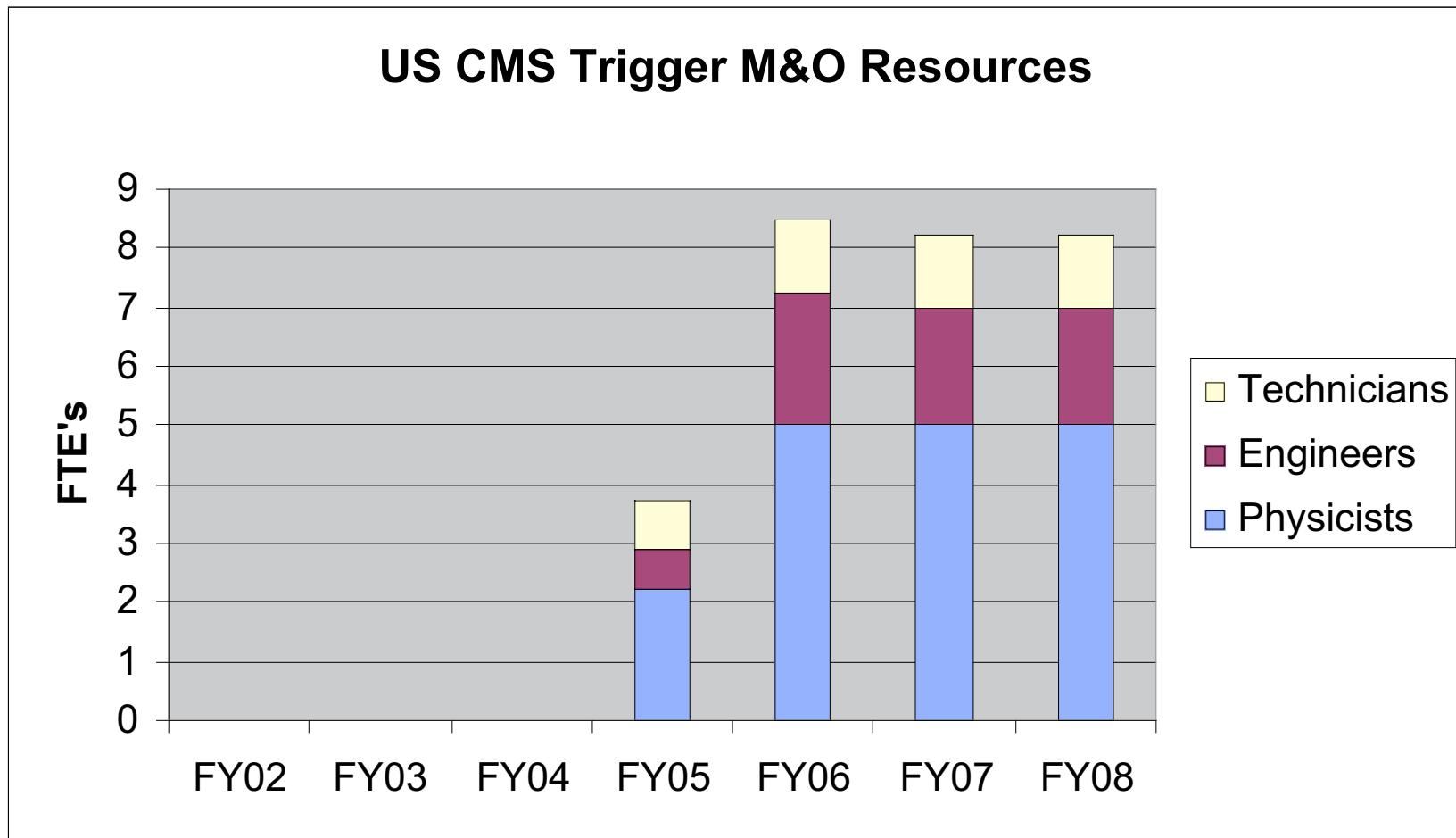
- Sending items back to US for major work
  - Either to FNAL, University, or manufacturer

## Est. Yearly Cost of 80K\$, Total for FY05-FY08: 280K\$

- 40K\$ each for US CMS Cal. & Muon Trigger Efforts
  - Half that for FY05 as ramp up

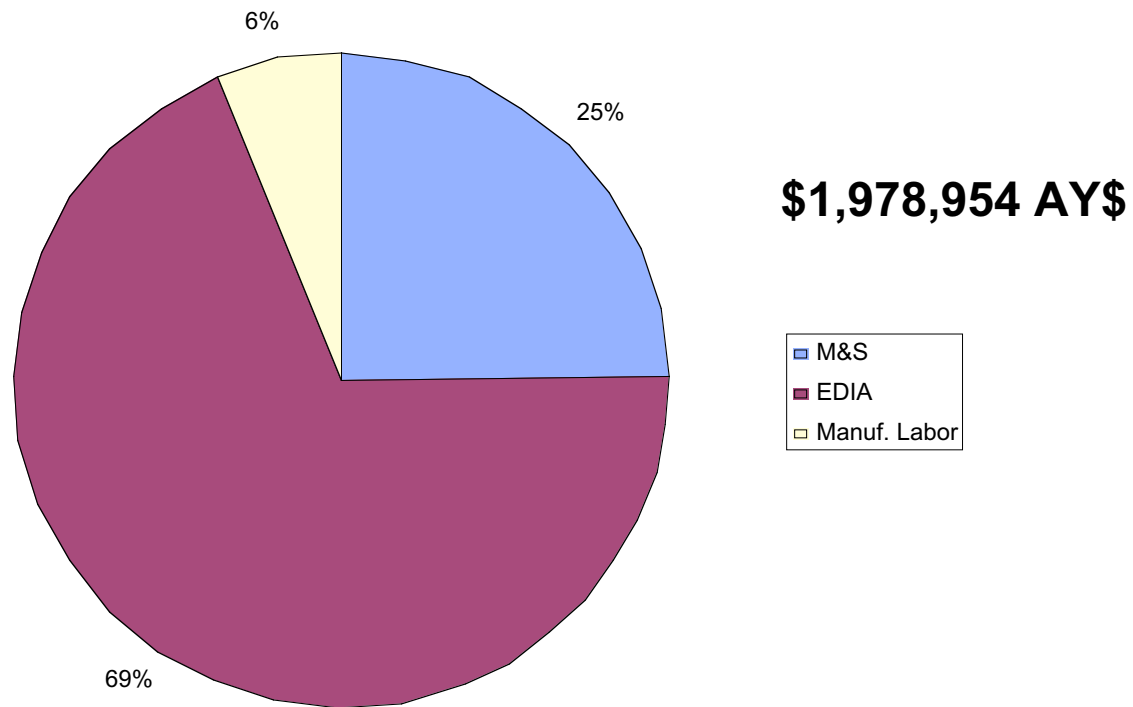


# US CMS Trigger M&O Resources





# Trigger M&O FY02-08





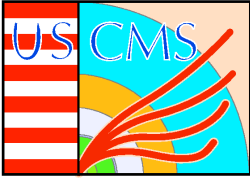
# Trigger Upgrades

## R&D effort to study upgrades to level-1 trigger to handle luminosity beyond $10^{34}$ ( $10^{35}$ )

- Will need more sophisticated logic to distinguish physics signals from increased backgrounds
- Upgraded logic operates in same time as present logic
  - Increase in speed for 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 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 trigger logic to allow analysis of 12.5 ns crossings



# Trigger Upgrade R&D Program

**Based on CMS Level-1 trigger R&D & Prototypes.  
Personnel requirements**

- **1 FTE Engineer from Project**
  - Engineering Design: 0.5 FTE ea. for cal. & muon 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. & muon

**Trigger Upgrade Estimate Total for FY06-FY08: 360K\$**

- **Estimated Yearly Cost of 120K\$**
  - M&S of 40K\$ for prototyping & EDIA of 80K\$ for engineering