



US CMS Trigger

DOE-NSF Review

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Outline:

Overview

Labor & Funding Profiles

Status & Plans

Foreign Contributions & Shared Resources

Upgrades

This talk is available on:

http://hep.wisc.edu/wsmith/cms/Trig_MO_0204.pdf



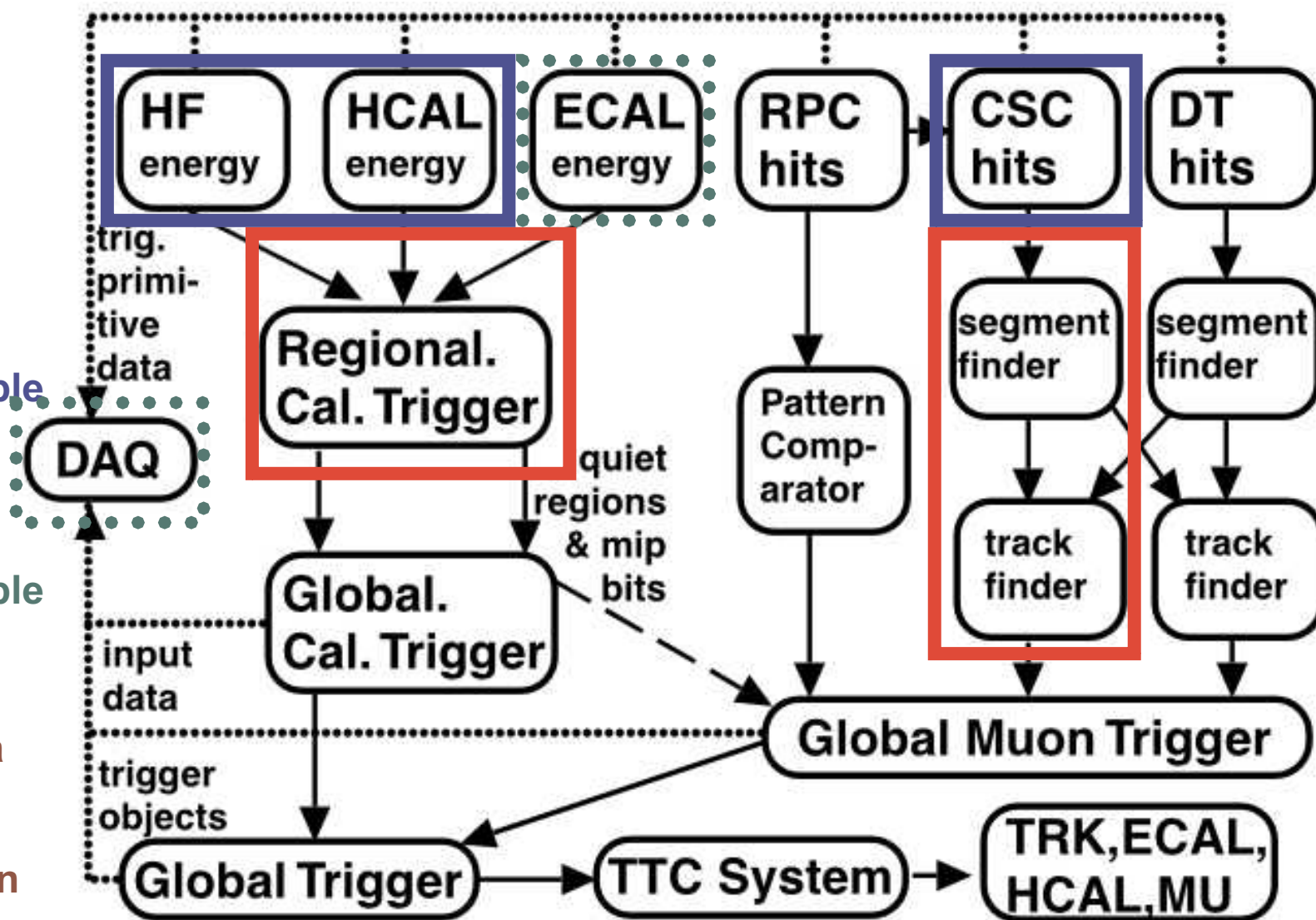
L1 Trigger Hardware Overview

US CMS
Trigger
(this talk)

US CMS
fully
responsible

US CMS
partially
responsible

Groups:
U. Florida
Rice
UCLA
Wisconsin





Calorimeter Trigger Crates

(U. Wisconsin)

18 Crates make up the full RCT System covering $|\eta| < 5$ & $0 < \phi < 2\pi$:



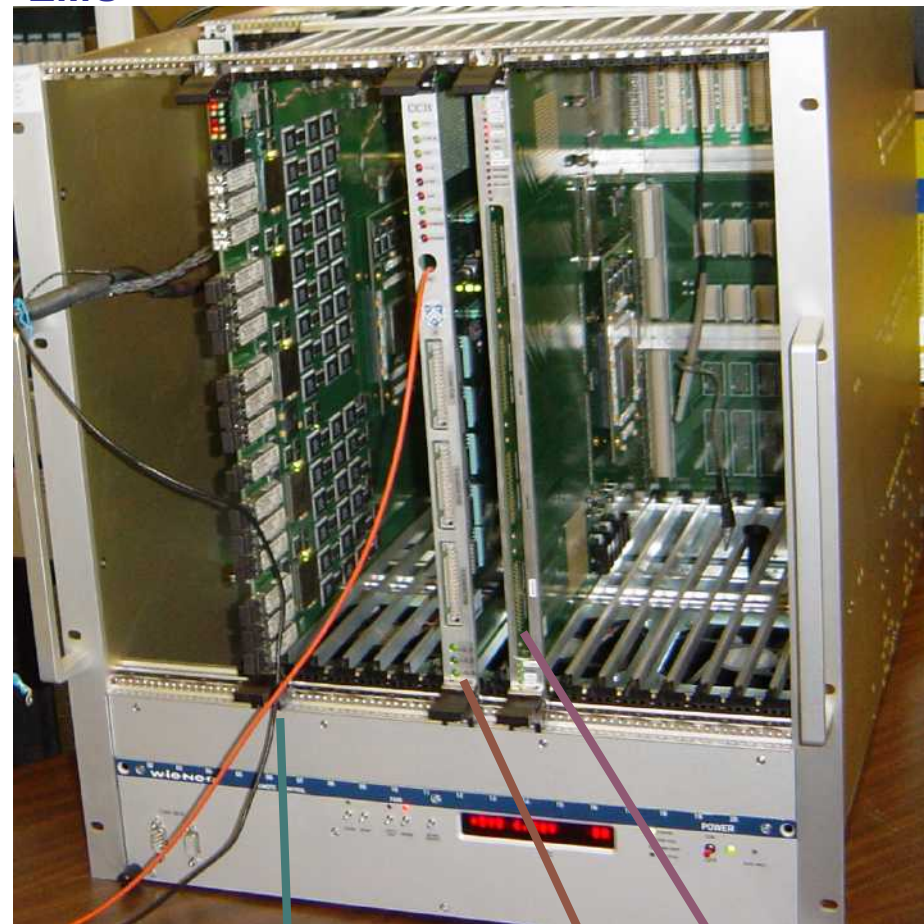
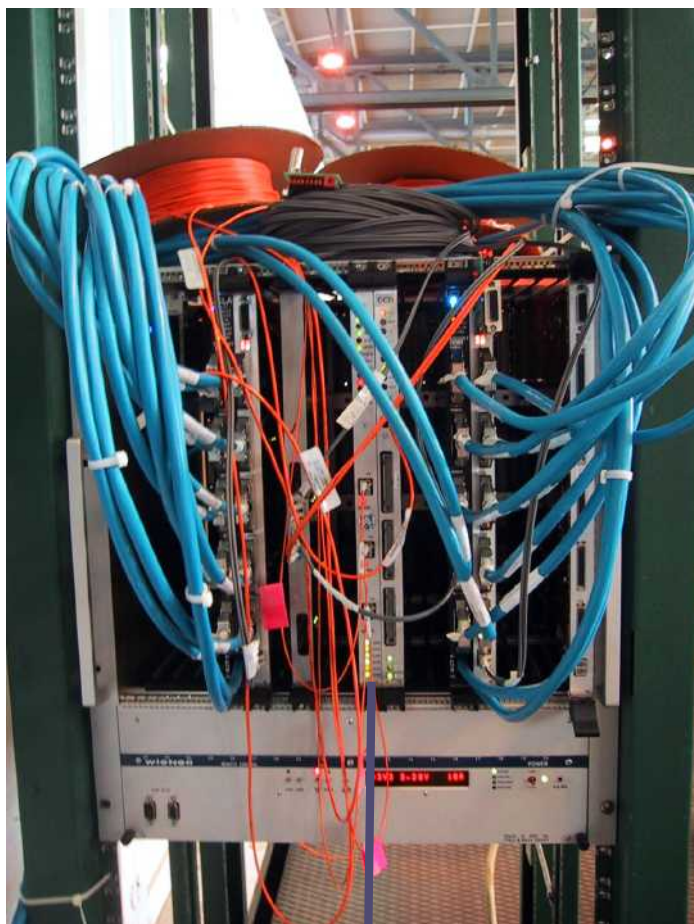
Rear: 7 Receiver Cards w/8 mezz. cards ea. Front: 7 Electron, 1 Jet, 1 Clock Cards



Muon Trigger Crates

60 EMU Detector Peripheral Crates
- EMU

1 Counting Room Track-Finder Crate
- Florida



Muon Port Card (x 1/crate) - Rice

Sector Processor - Florida (x12)

Sorter - Rice (x1)

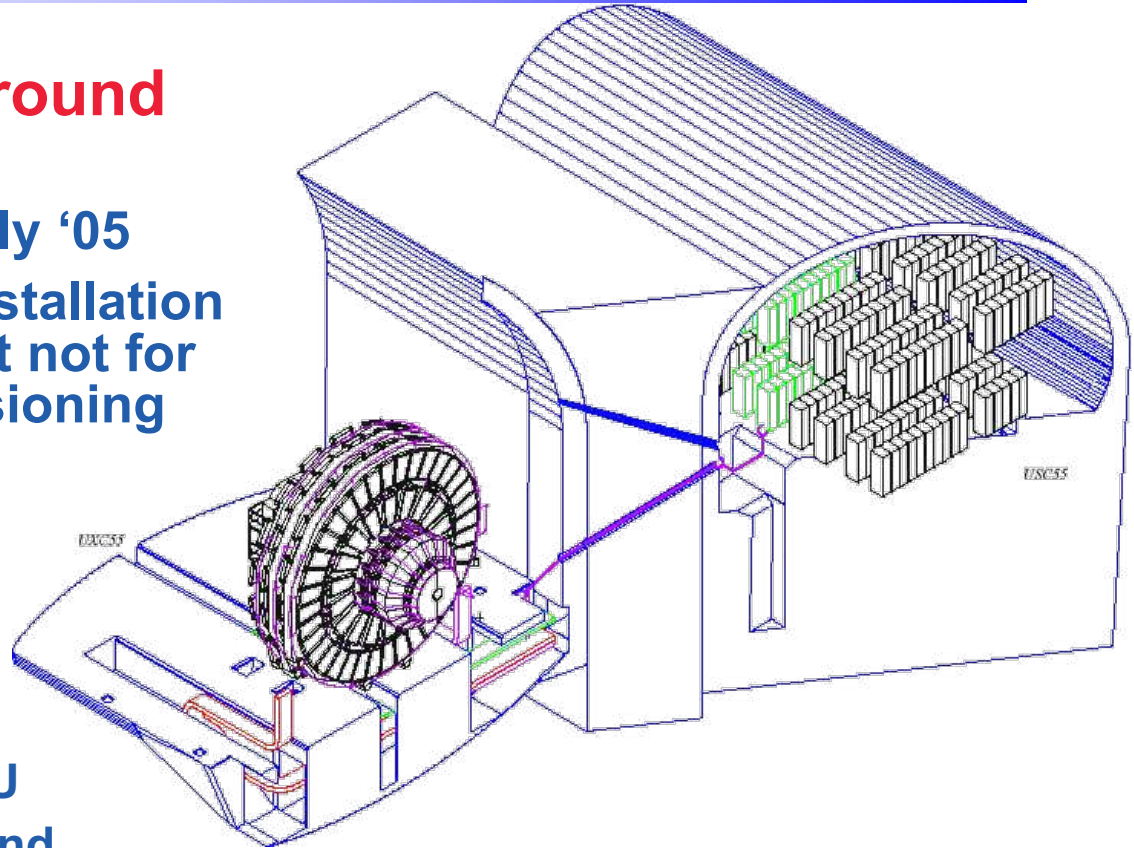
Clock & Control - Rice (x1)



Define Project Completion

Installation in Underground Counting Room

- Expect access by July '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.

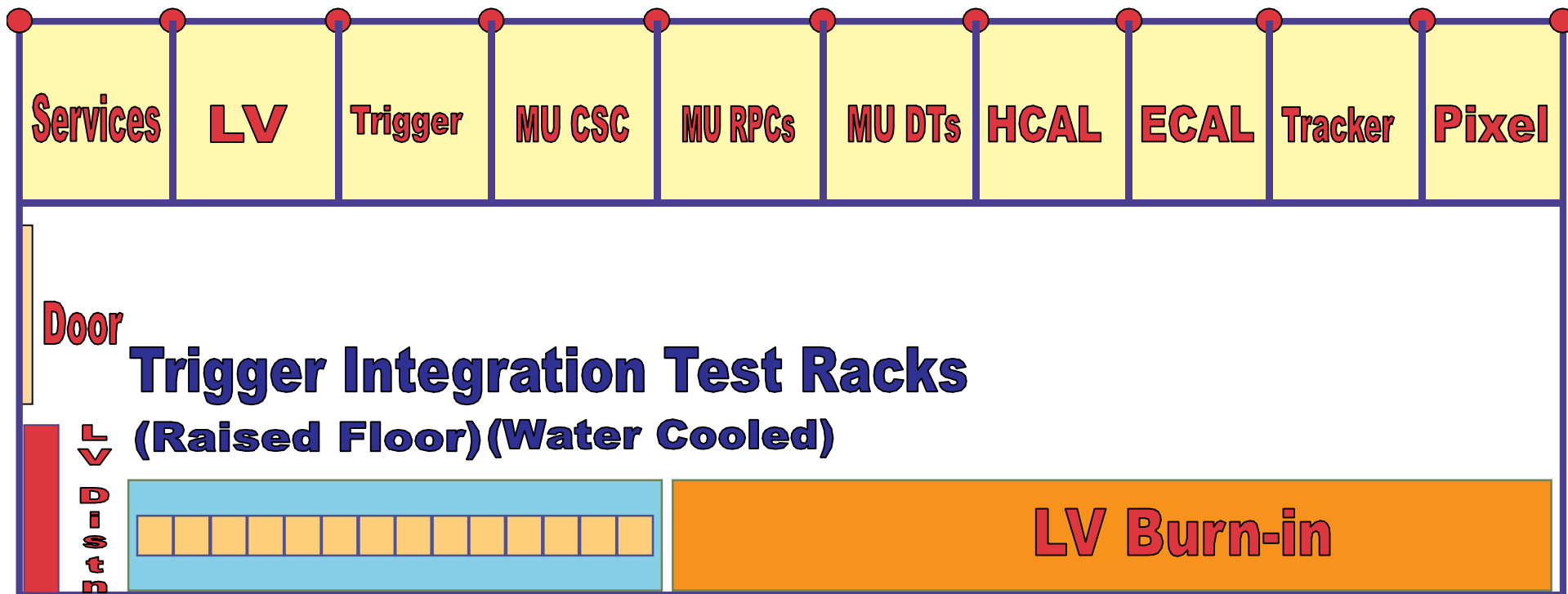
Will check as much on surface before gaining access to underground facilities.

Milestone (HG1018) planned for completion November '04



Trigger Installation Preparation

Individual Testing Labs & Integration Test Area



Assemble one each of critical racks in central trigger core in underground counting room

Contingency in case of further delays in occupancy



Physicist M&O Tasks

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

- Monte Carlo studies of new conditions, validate with present data

Respond to changing apparatus

- Changes in material, configuration, etc. \Rightarrow changes in simulation

Operations - 24x7 support during running

- Write, test & maintain electronics test programs
- Maintain & update bad channel list & run daily checking programs
- Run Control maintenance
- Trigger data validation and calibration
 - Online & Offline analysis of rates & efficiencies
- Monte Carlo & data trigger simulation maintenance
 - Continuous validation of trigger using simulation & readout data



Physicists on M&O

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



Engineers & Technicians

Tasks: 24x7 support during running :

- Diagnose & repair electronics -
- Daily checking procedures
- Maintain & operate Repair Facility
- Maintain inventory, order supplies, ship items for vendor repair

Personnel:

- **Technician**
 - Operates, repairs, maintains test facility
 - Repairs boards & infrastructure under physicist & 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



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**
 - Tom Gorski
- **Need institutional technical support**
 - Experience is vital

Muon & Cal can share resident technician services



New M&O Task

TTC M&O Engineering

- Maintenance and Operations of the Trigger Timing and Control System being used in the Slice Test, Detector Commissioning and Operations.
- Includes interfaces to CMS electronics front end, readout, trigger and data acquisition. Tasks include diagnostics, monitoring, and testing.
- 1 FTE EE cost shared with CERN, US M&O cost is \$38K/year from FY04 - FY07.



Summary: M&O Personnel

(does not include upgrade R&D)

From Project Support:

- **1 / 2 / 2.25 / 2 FTE Engineers in FY04 / 5 / 6 / 7+**
 - 0.5 FTE ea. for cal. & mu trigger + PNPI 0.25 for mu
 - **0 / 50% / 100% of this in FY04 / 5 / 6, PNPI in FY05,6 only**
 - 1 FTE (cost shared w/CERN) on TTC M&O FY04 - FY07
- **0 / 0.6 / 1.25 FTE Technicians in FY04 / 5 / 6+**
 - 0.5 FTE ea. resident for cal & mu + 0.25 visiting for cal
 - **0 / 0.3 FTE ea. resident for cal & mu in FY04/ 5**

From Base Program Support:

- **2.6 / 4 FTE Ph.D. Physicists in FY05 / 6+ (ramp up in FY05)**
 - 2 FTE ea. for cal & mu trigger
 - 50% of time on M&O
- **12 FTE Graduate Students by FY07 (ramp up starting in FY05)**
 - 6 FTE ea. for cal & mu trigger
 - 25% (e.g. training, physics, thesis) of total tenure on trigger
 - Fewer students → more postdocs



Trigger M&O M&S

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

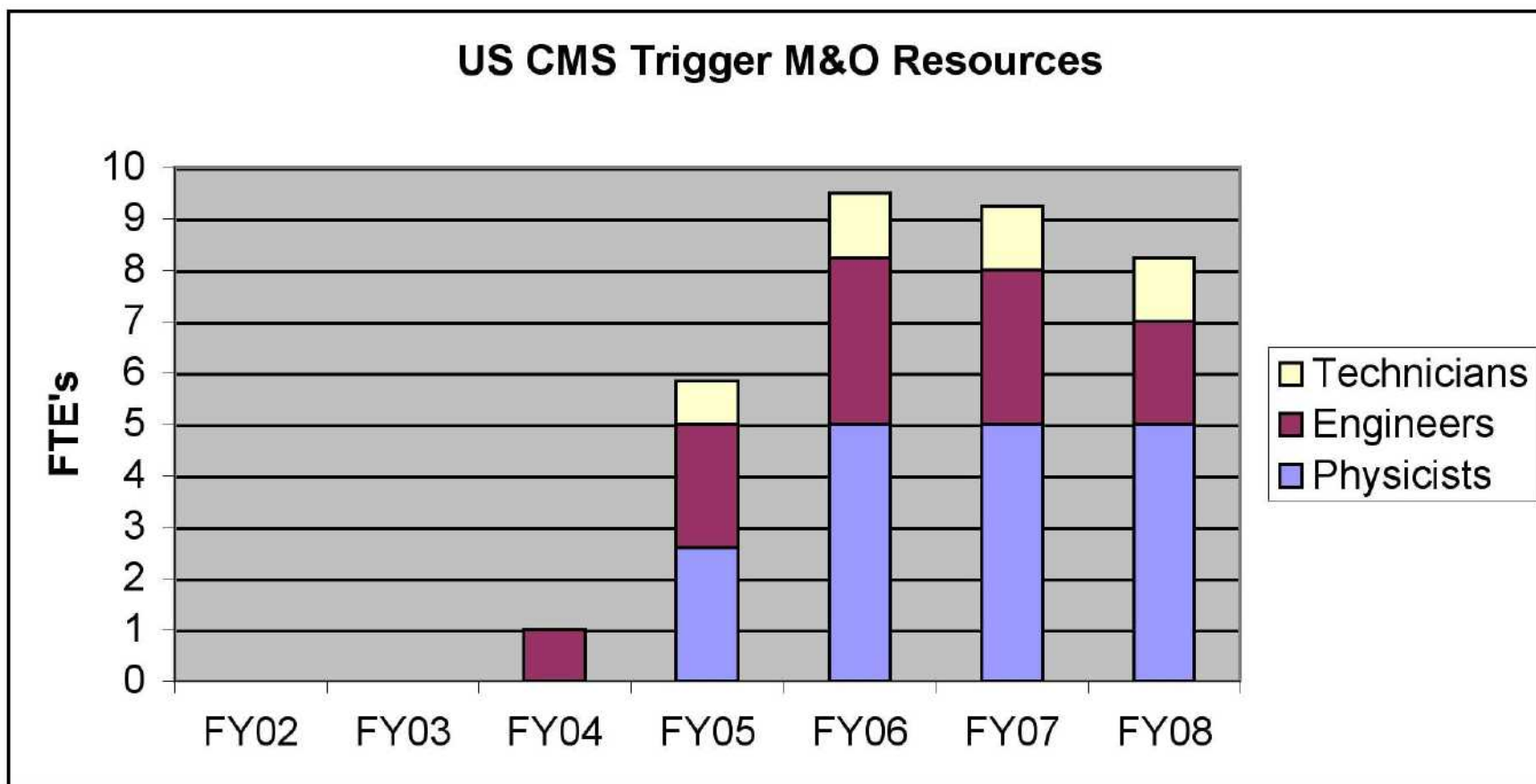
- Sending items back to US for major work
 - Either to FNAL, University, or manufacturer

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

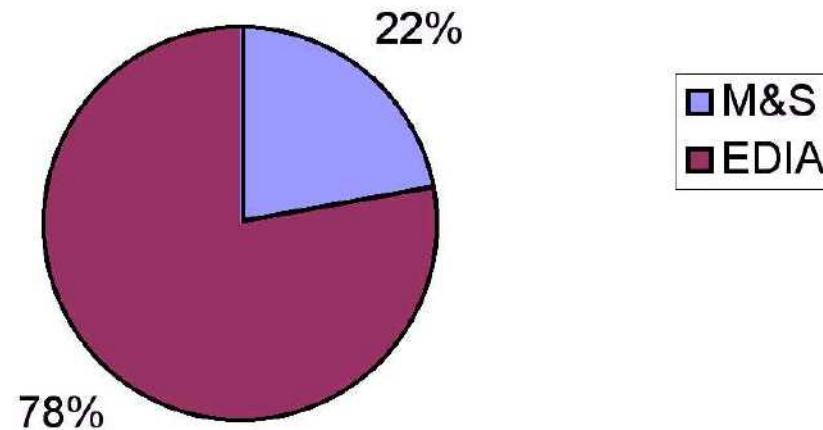


Peak due to operation of slice test, commissioning of test facilities and operations startup. Level from FY08 onwards is constant.



Trigger M&O FY02-08

Trigger M&O FY02-FY08
\$2,223,404 AY\$



Costs dominated by support of engineers and technicians



Foreign Contributions & Shared Resources

Trigger Guidelines:

- Each institute maintains the hardware it built
 - Includes Labor & M&S
 - No exceptions
- Spare Parts are purchased before commissioning

Shared Resources:

- Test facilities in Preveessin 904
- CERN Electronics Pool

CERN Contributions:

- Rack, Cable & Power/Cooling infrastructure
- Local engineering assistance (CMS Electronics group)



Response to April '03 Review

MEG Comment:

- “The M&O costs for the Trigger subsystem are reasonable and consistent with the comparison to the ZEUS experience, although the risks are difficult to estimate. The Trigger management is to be commended for the shared use of manpower between the calorimeter trigger and the muon trigger. The only concern was that perhaps the need for computer professionals is not accounted for – this should be re-evaluated. Also, the MEG was unsure about an apparent discrepancy between the 1.25 EE FTE shown in the presentation by the subsystem manager and the 2 EE FTE shown in the MS Project manpower tables – this apparent discrepancy should be understood.”

Response:

- The discrepancy was due to whether R&D Manpower was included in the FTE totals along with the M&O Manpower. The EE breakdown is as follows in both categories:

	FY05	FY06	FY07+
R&D	0.4	1	1
M&O	1	1.25	1
TOTAL	1.4	2.25	2

- The need for computer professionals has been re-evaluated. The tasks can be handled with occasional consultation from computer professionals working on other aspects of the CMS project.



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

USCMS and CMS SLHC Effort Launching now

- USCMS Workshop on Feb 13, CMS Workshop Feb 26,27



Trigger Upgrade R&D Program

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

Personnel requirements

- **0.4 / 1 FTE Engineer from Project in FY05 / 6+**
 - Engineering Design: 0.5 FTE ea. cal. & mu (ramp up in FY05)
 - Could be other "half" of engineer on M&O
- **0.4 / 1 FTE Ph.D. Physicist from base program in FY05 / 6+**
 - Simulation & Design Studies
 - 0.5 FTE ea. cal & mu trigger (ramp up in FY05)

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



Trigger M&O Conclusions

Realistic M&O Plan:

- Ramp up in FY05, start with Slice Test
- Based on > decade of (ongoing) ZEUS experience and recent CMS testing experience
- Provision for testing, commissioning facilities
- Flexible planning

Resources:

- Sufficient for task requirements
- All other collaborators equally participating

Upgrade:

- Planning beginning now
- Ramp up in FY05