



# DOE Annual Program Review

## The Fermilab Role in US CMS

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US CMS Research PM

March 24, 2004



# Outline – FNAL Roles

- **Host Lab for the Detector Construction Project**
- **Host Lab for the Research Program**
  - **SWC**
  - **M&O**
- **Collaborating institution and site of US p-p collider Physics at the Tevatron**



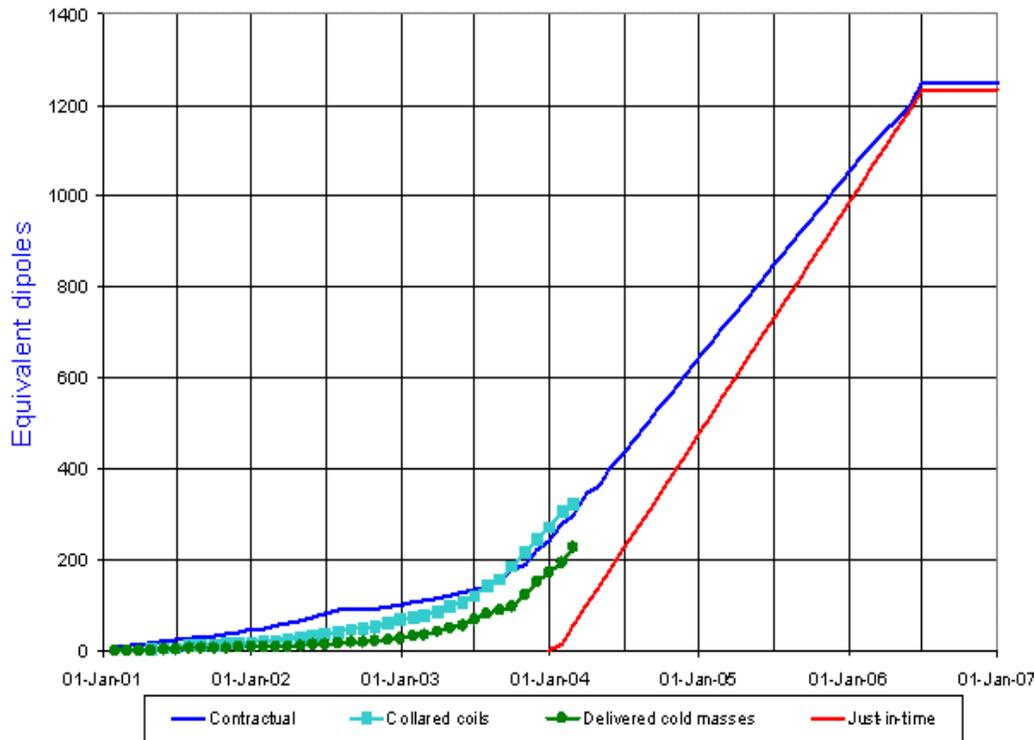
# LHC Status



LHC Progress  
Dashboard



Dipole cold masses



Updated 29 Feb 2004

Data provided by P. Lienard AT-MAS

The LHC appears to be ~ on schedule.

The new CERN management appears to be strongly committed to the schedule for both accelerator and the experiments.

The implication is that a shift of US physicists to LHC will begin ~ now (and must be anticipated and planned for).



# CMS Schedule

The civil engineering delays (3 mo) alone force the use of contingency of omitting both the EE/SE endcaps from the April 2007 configuration → **v34**

- surface magnet test is now foreseen to start in August 2005,
- start lowering CMS in December 2005,
- EB+ installation in December 2005, last EB- installation & cabling in Nov. 2006,
- tracker installation and cabling in August 2006.
- CMS ready to close for beam in April 2007

The time available for Detector/Trigger/DAQ Integration and Commissioning stretches from October 2006 to May 2007 (2 months less than in v33.3).

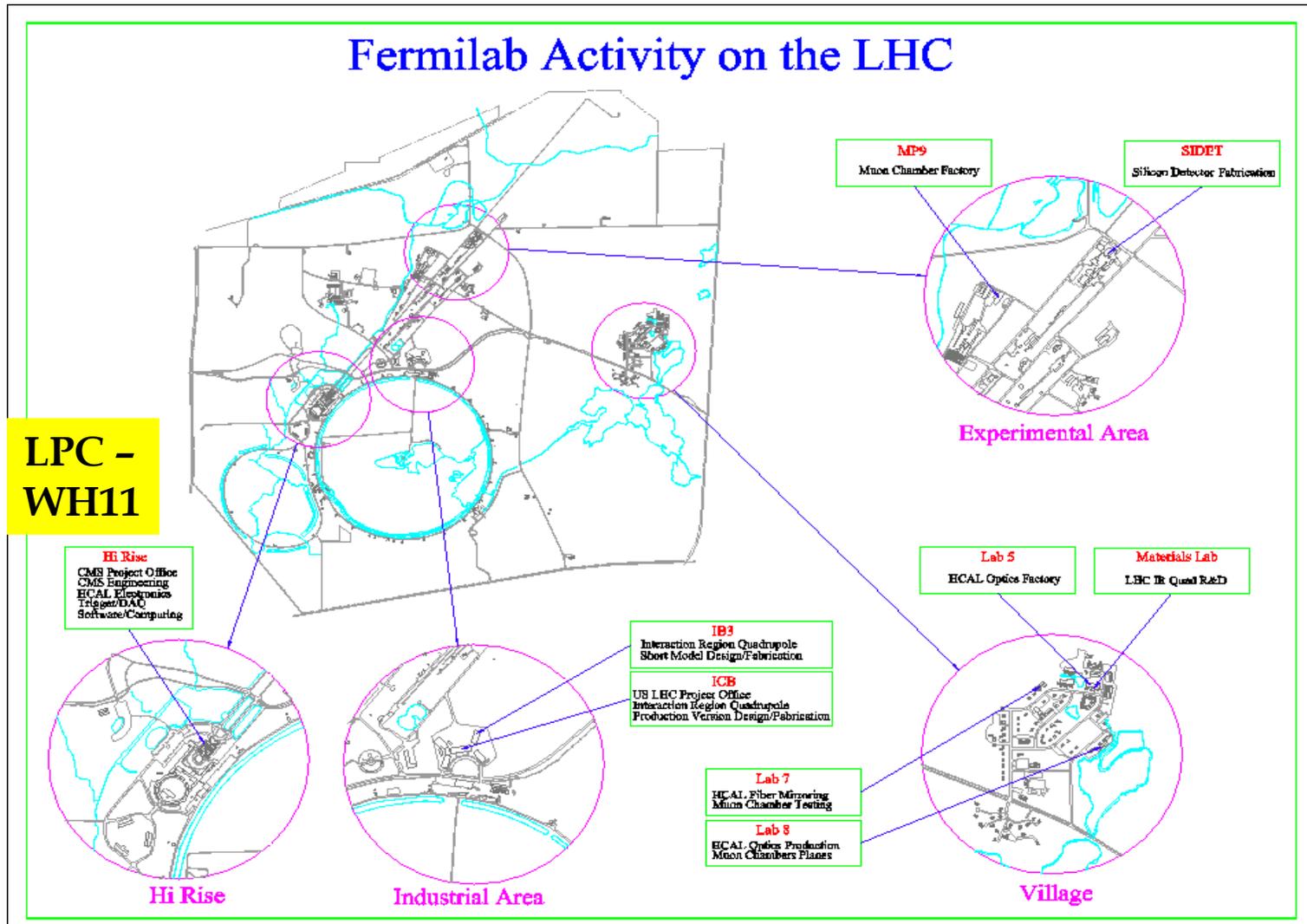
**Objective: CMS Ready to close for beam in April 2007  
Initial Low Luminosity CMS Detector but now without ECAL\_Endcaps**

**CMS continues to progress and to prepare for first beam. The detector will not be the full high luminosity device, but that can come adiabatically as L ramps up.**





# Fermilab and US CMS





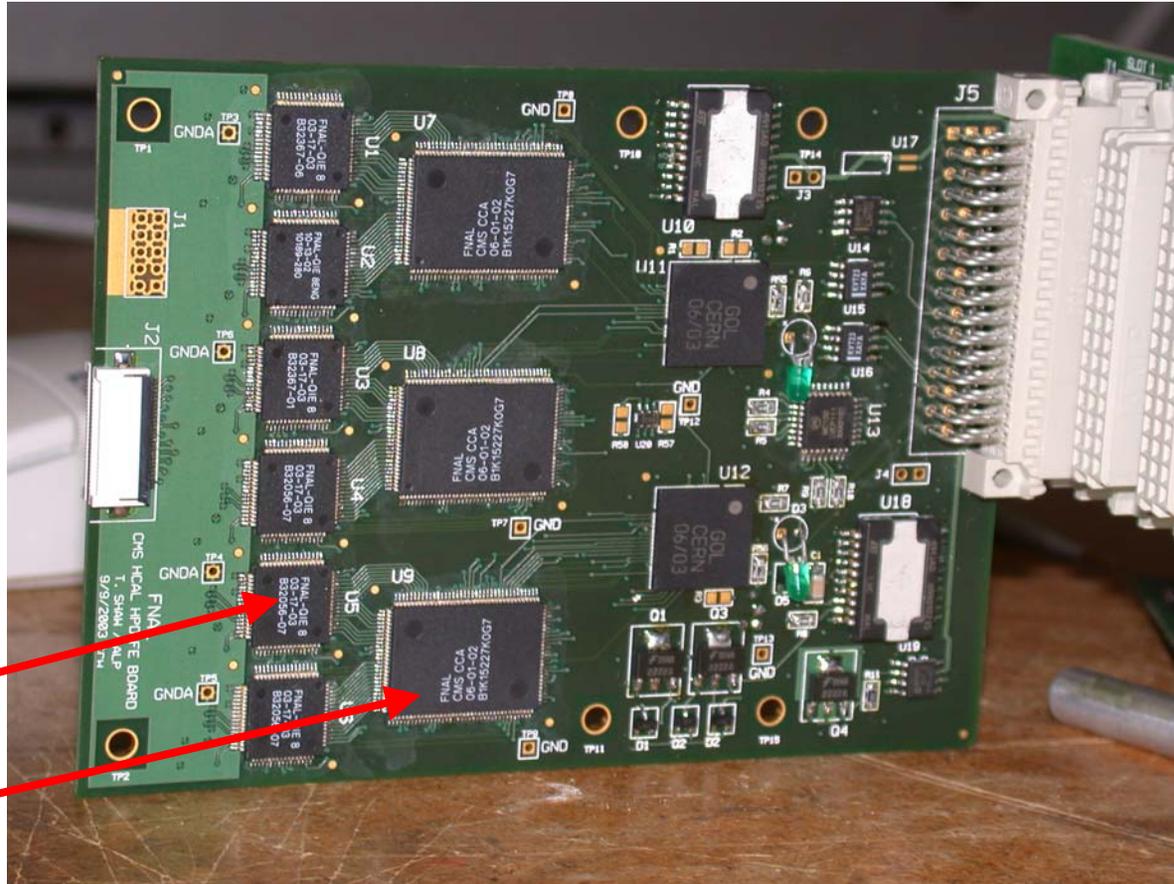
# HCAL - HE and HB at LHC Point 5



**Much of US CMS detector effort is complete.  
Activity now shifts to commissioning, operations  
and preparation for data taking.**



# Production HCAL FE Card



QIE

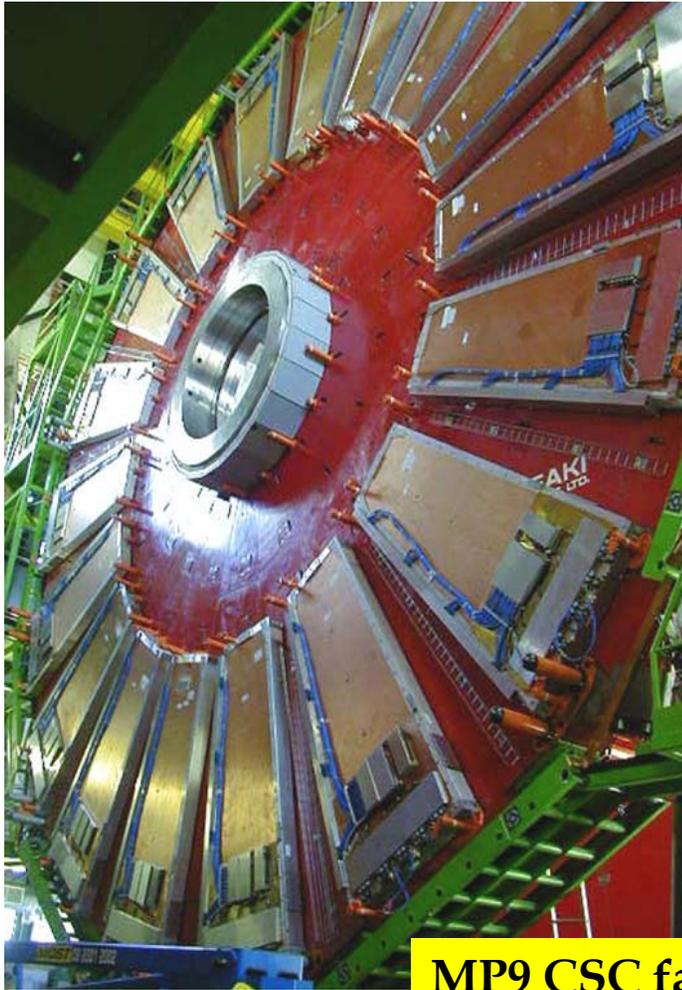
CCA

Card design, ASICs (QIE, CCA), optical cables/drivers done at Fermilab. See the poster session on FE electronics.



# CSCs Mounted on YE disks

CSC production complete (total 482 CSCs including spares)

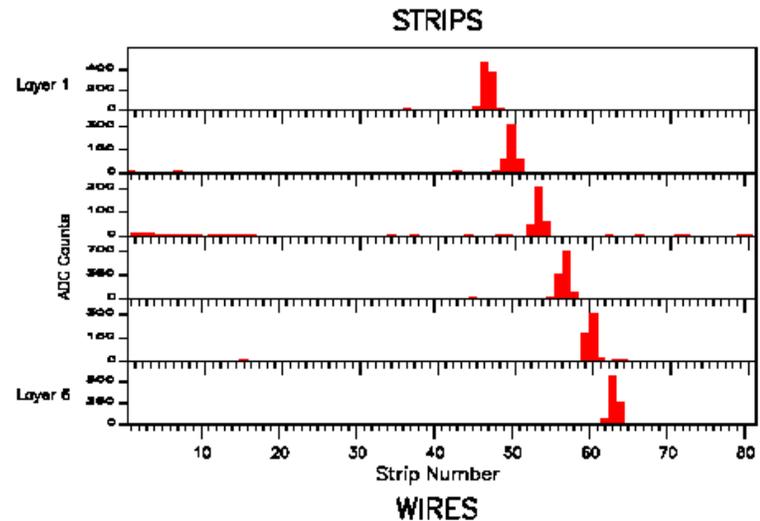


**MP9 CSC factory closed - Chambers installed at SX5**

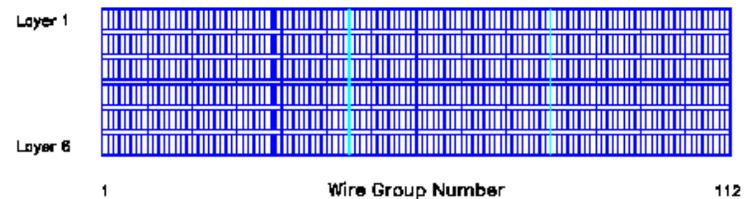


# First Muons in CMS

1. 90 chambers have been installed on disks.
2. On 60 chambers skew clear cables had been installed.
3. Recently the cables have been installed on 30 more chambers.
4. Two weeks ago the working gas was provided for 9 ME+2/1 chambers.



1. 63 chambers have been tested without HV.
2. The first muon was detected by a chamber installed on a disk.
3. 9 chambers have been tested with HV.



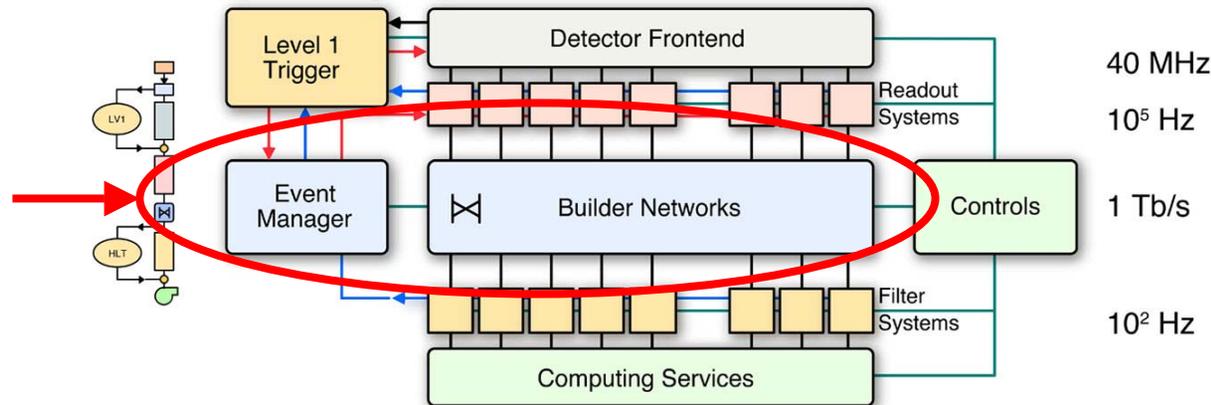
Commissioning plan is for "slice tests" - stand alone, then multiple systems (e.g. HE + ME1) data and trigger primitives



# CMS DAQ at FNAL

## Basic principle:

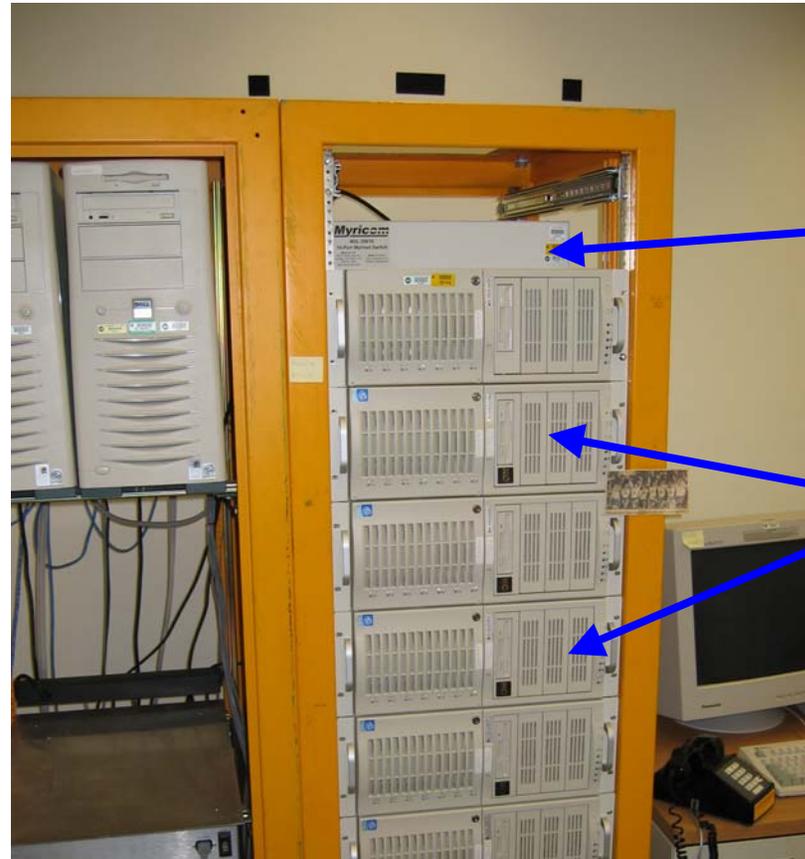
FNAL task  
Switch and  
Switch  
Manager



- Full DAQ is a sum of functionally identical, parallel, smaller DAQ systems.
- One system for the detector readout and the transport of data to the surface.
- Multiple identical systems for event building



# Prototype DAQ System at FNAL



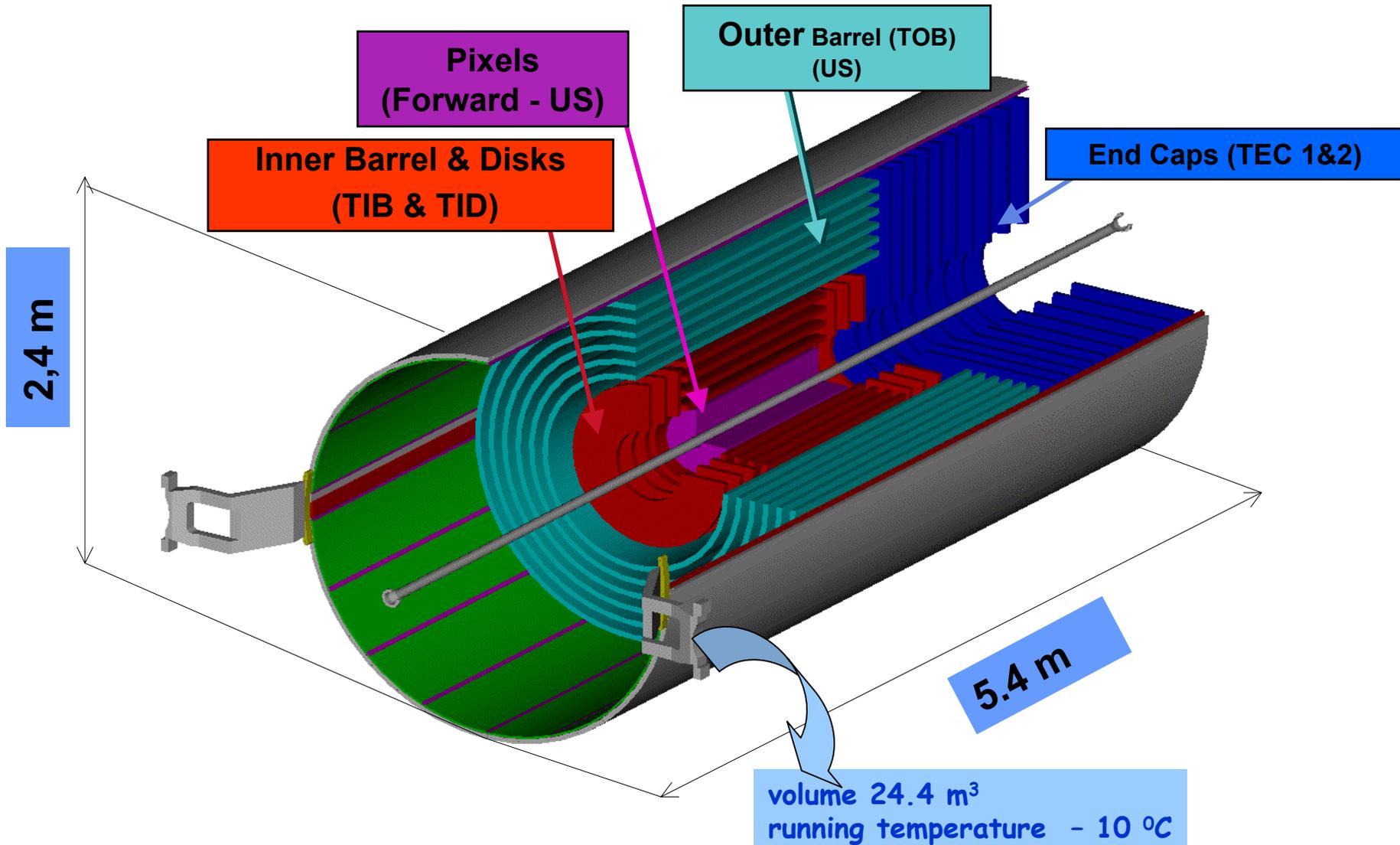
Myrinet  
Switch

Computer  
nodes

US CMS plan is to exploit the rapid completion and installation of US detectors to prepare for LHC beam in "slice tests" - in the CMS assembly area, SX5 - HCAL + ME + Trig + DAQ. Use the fact of "vertical integration" in choice of US deliverables.



# CMS Si Tracker



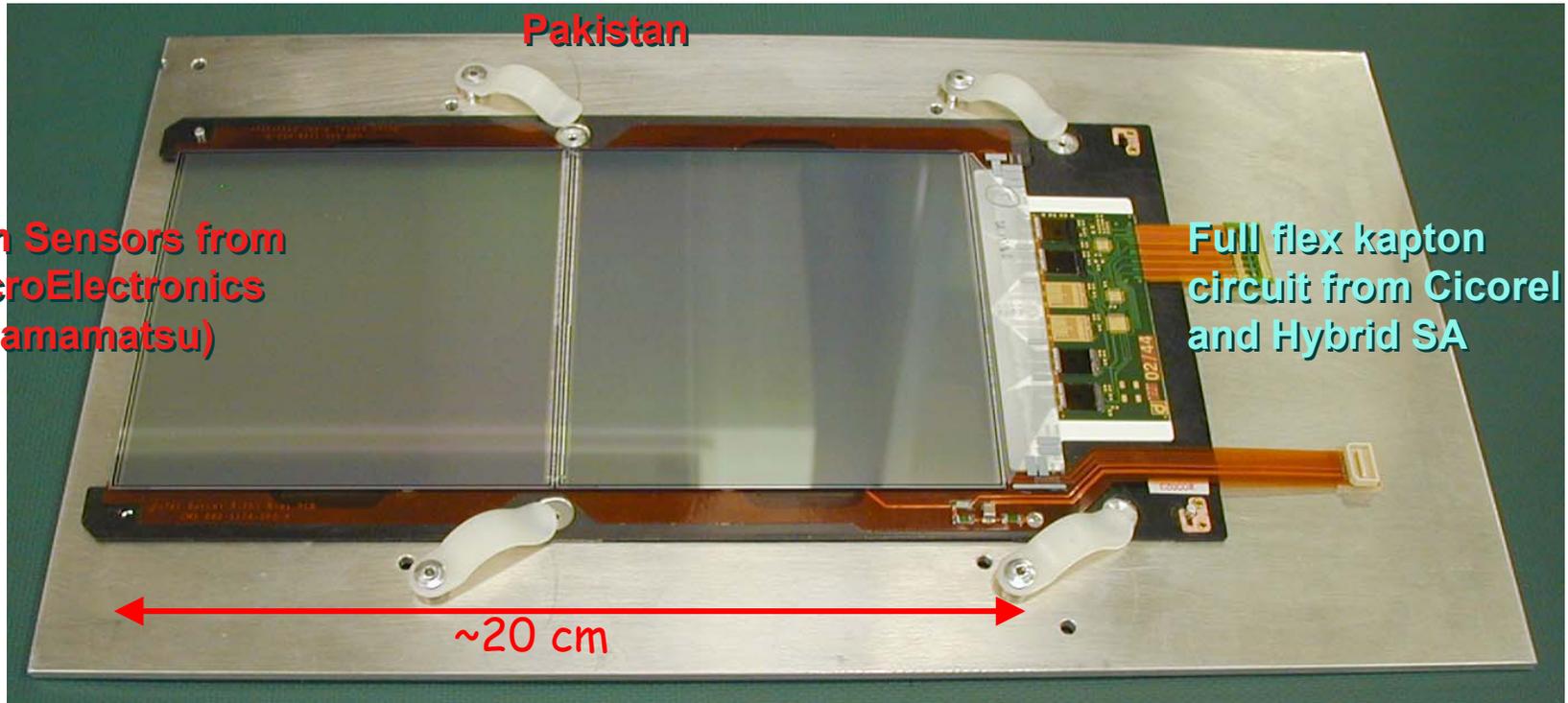


# TOB Modules

CF frames assembled in  
Pakistan

500  $\mu\text{m}$  Sensors from  
ST MicroElectronics  
(and Hamamatsu)

Full flex kapton  
circuit from Cicorel  
and Hybrid SA



~5,600 Tracker Outer Barrel (TOB) modules

- To be assembled and tested at FNAL (SiDet) & UCSB
- Delayed by parts flow issues – Sensors (fixed)
- Help also with TEC hybrid bonding (scope increase)



# The TOB Electronic Testing Cycle



Quick test hybrids on ARC

Wire bond

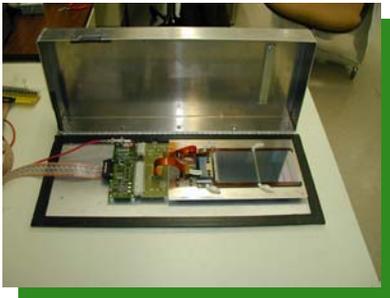


Thermal cycle hybrids



Gantry makes modules.

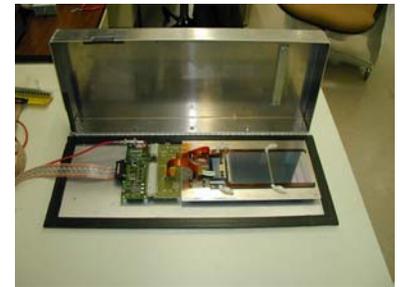
Wire bond



Final pinhole test on ARC



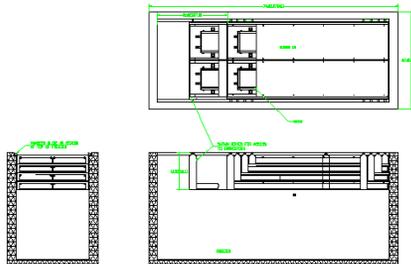
Thermal cycled module



Modules test on ARC



Assemble rods from modules



Rod burn-in



Rods shipped to CERN



# CMS Issues with SiTrkr

## ST Sensors

With agreement of ST, at least 7000 out of 18000 sensor are in process of being ordered from HPK. Start deliveries in May 2004.

**Module Production:** Problems with hybrids solved. Tracker Inner Barrel module production proceeding Tracker Outer Barrel and EndCap started (latter two with ST sensors). Checkout complex nested logistics – works!.

**Electronics** (on detector and off detector) and **Mechanics** proceeding well except TEC Kapton HV Bias circuits: Some 1% of circuits have open connections. Remove unreliable circuits by tests. Test protocol defined. I2C : clock and data go out of synchronization – Solution found.

**Schedule:** delay of 6 months, incorporated in v34.

**First time US CMS TOB effort could project a reasonable schedule based on proven parts flow of tested components and tested production line and test stations.**



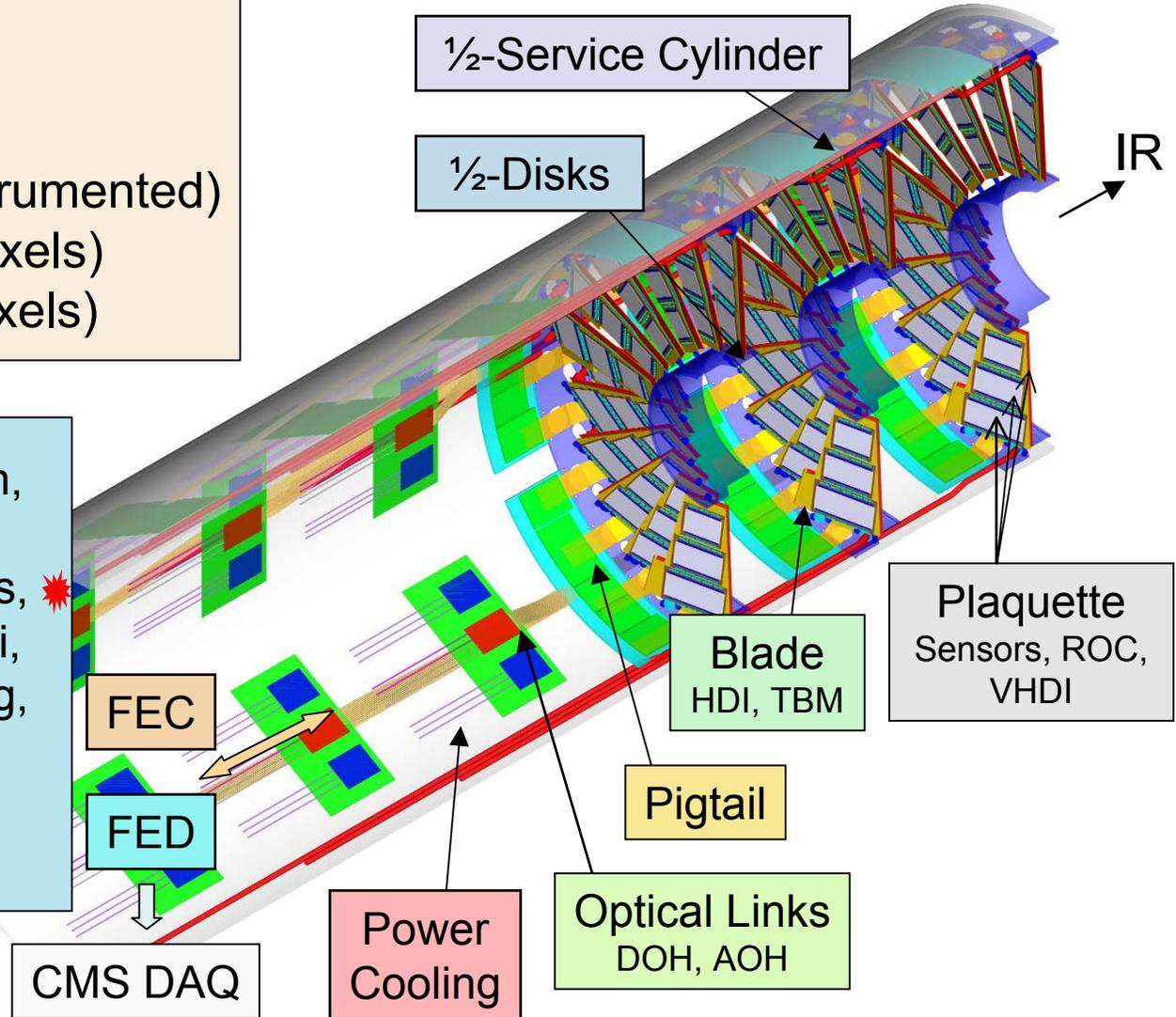
# US-CMS Pixel Project

## FPix baseline:

US delivers in '07

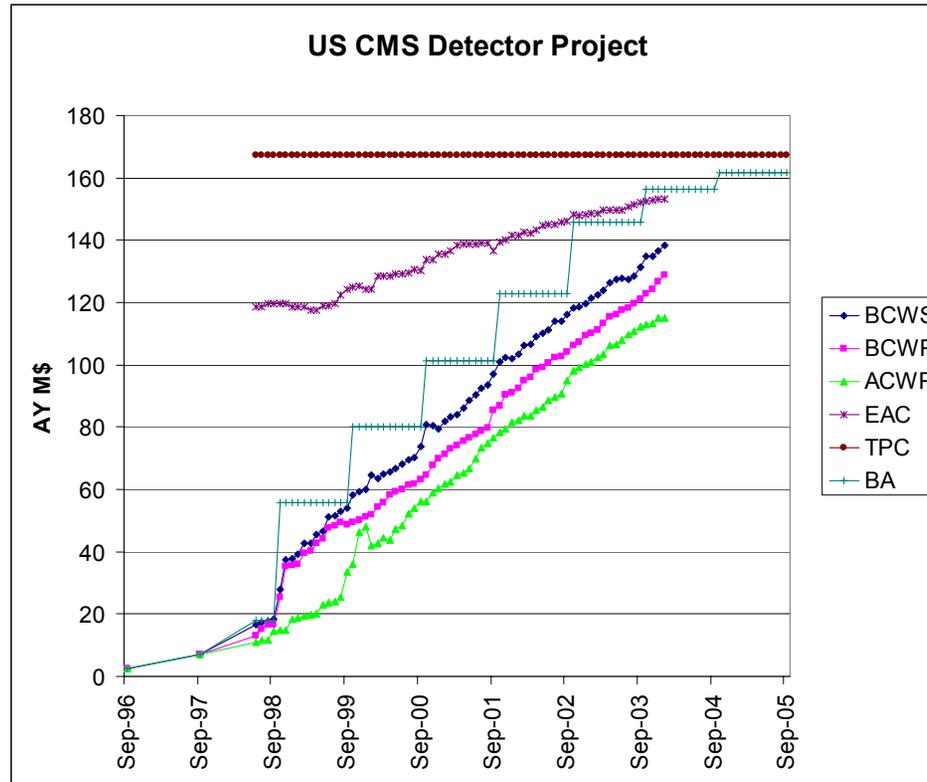
- 4 Disks (fully instrumented)
- TBM (for CMS Pixels)
- FEC (for CMS Pixels)

**Fnal:** M. Atac, B. Baldin, I. Churin, C. Gingu, U. Joshi, S. Kwan, S. Los, M. Matulik, A. Nomerotski, V. Polubutko, E. Ramberg, C. Selcuk, G. Sellberg, Jae Chul, (J.C.) Yun, W. Wester





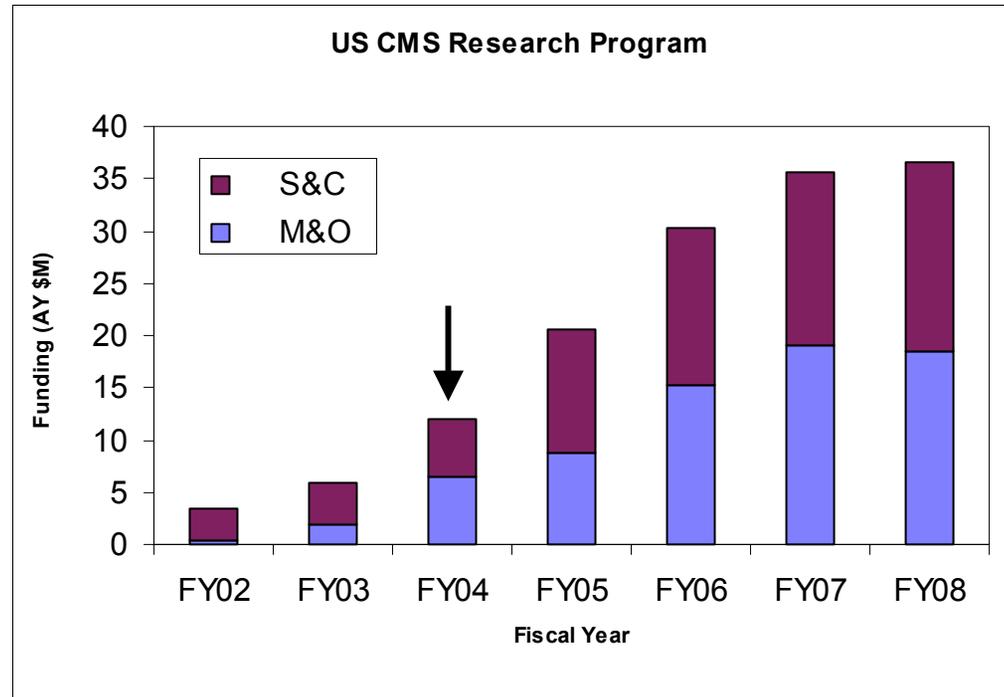
# Construction Project



**FNAL hosts the Project Office and US CMS management. The Construction Project is scheduled to ~ finish (CD4-A) in FY05. FNAL role will then shift to the Research Program.**



# The Research Program



**Fermilab is also the host of the management and Program Office of the Research Program. New expanded structure with DRPM from a US CMS university and responsible for NSF funding management. Response to revised fiscal guidance has exercised the new management - RPM and RPDM working with M&O PM and SWC PM to prioritize the RP and adjust the FY04 and FY05 planning. FNAL PMG serves as the body for Change Control**



# US Software Contributions

U.S. share to CMS software: key contributions related to event I/O, geometry databases, production systems, visualization, Geant-4, etc

**OSCAR**  
Detector Simulation

**ORCA**  
Detector Reconstruction  
HLT  
Physics Analysis

**FAMOS**  
Fast Simulation

## U.S. CMS Contributions

**Iguana**  
Core Visualization  
GUI and Scripting Services

**COBRA**  
Core Framework(s)  
Core Services

**Production**  
(McRunjob)

**Mantis**  
G4 Simulation  
Framework

**DDD**  
Detector Description  
Framework

**Profound**  
PRS  
Foundation

Generator  
Interface

G3 OO  
Interface

**CARF**  
Reconstruction  
Framework

**Event Store**  
Persistency  
Layer

Application  
Infrastructure



# CMS Data Challenge 2004

## Major milestone for CMS software and computing

- Validate software and get input for computing model
- Reconstruction at Tier-0, data streams with DSTs
- Streaming data to Tier-1s (FNAL for US CMS) using Grid tools
- making data sample available for analysis at Tier-1 and Tier-2 centers
- 5% (design luminosity) throughput test

## Preparations for DC04

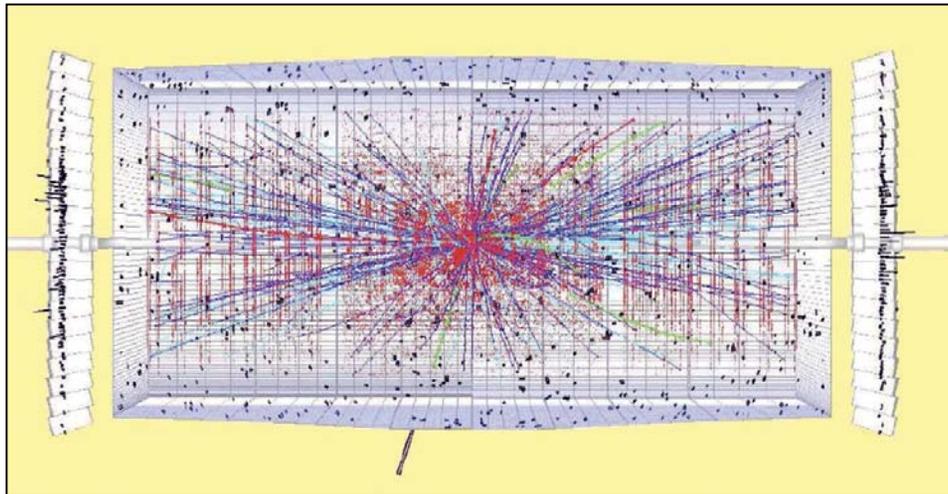
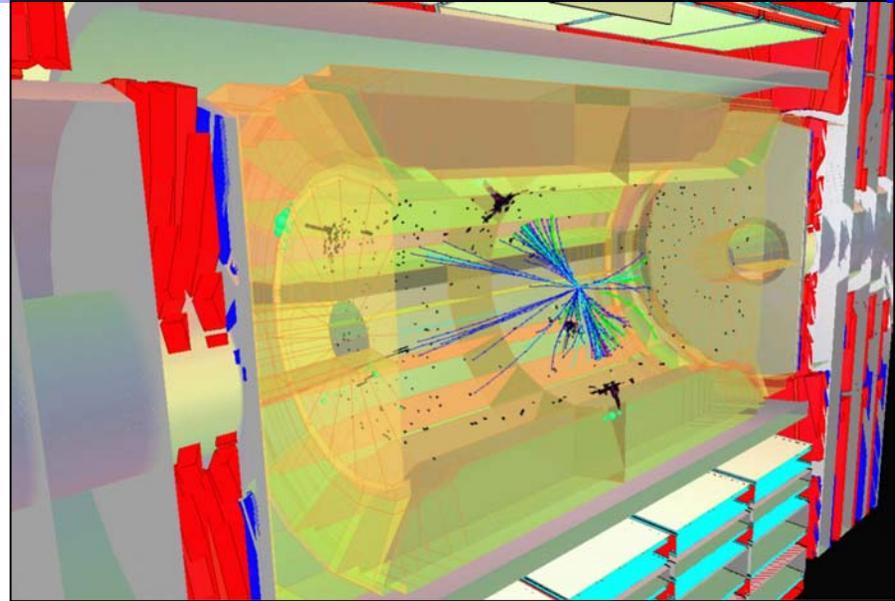
- 69M events being simulated, including pile-up and shipped to CERN Tier-0 center
- Massive CPU, storage and data transfer needs:
  - worldwide production
  - U.S. share done on U.S. CMS Grid and Grid3
- Geant-3 to Geant-4 transition complete
- DC04 data samples to be used for physics studies in preparation of physics TDR in 2005



# CMS Fully Constructed Events

## Detailed Geometry

- Detector Description Database
- Geant-4 Simulation
- Iguana Event Display



## Pile-up simulation:

- Important for realistic physics, trigger, detector studies
- Computationally demanding...



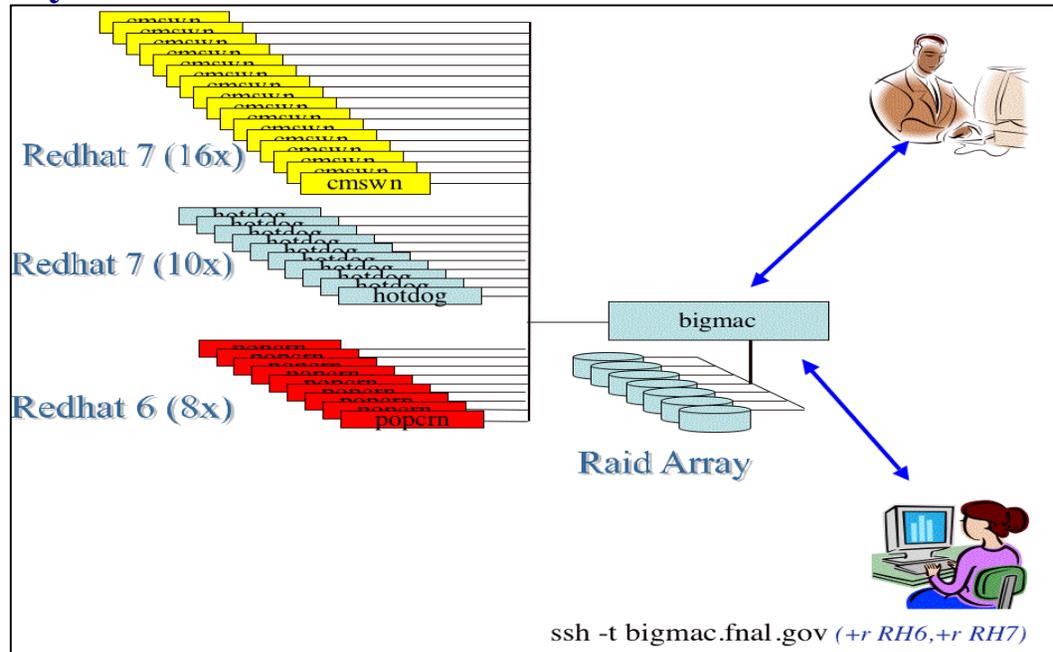


# User Analysis Facility – SWC and CD

Commissioned a facility for analyzing CMS physics data

- Large simulated data samples to be analyzed for physics TDR
- Emerging user base at Fermilab – LHC Physics Center (LPC). Massive Data Serving + Analysis Disk Space for Users
- R&D work on system architectures and software components
- Developing the CMS analysis environment end-to-end

Provide production team, physics groups and individual physicists seamless and high-throughput access to CMS data





# Remote Participation and Virtual Control Room – M&O



A screenshot of a web-based logbook interface. The interface includes a search bar with 'From' and 'To' date fields (05.22.2003 12:11 to 05.22.2003 20:11), a 'Number of' field (8) and a 'Hours' dropdown. There are buttons for 'Search From-To', 'To Present Time', 'Previous', and 'Next'. A 'Filters' section on the right allows selecting keywords like 'INCLUDE ALL', 'Shifts', 'Runs', 'Conf. Change', 'Summary', and 'Notes'. Below the search fields, there is a section for 'Annotate This Entry' with fields for 'Date Created', 'Date Saved', 'Category - Topic - sequence number', 'Operator(s)', and 'Keyword(s)'. The main content area displays a log entry for a scheduling meeting on Thursday, 2003.05.21 at 11h, followed by a report on PS and SPS start-up, and notes about structured beam injection trials and CERN closure on Thursday, 2003.05.29.

**CERN testbeam is a proving ground for the ideas in the VCR. We have 24-7 VRVS virtual meeting, daily coordination meetings, video cameras and mikes, e-logs. Has proved the ability to debug and monitor remotely. Each year, upgrade based on past experiences. Remotely stationed people can read logbook comments, create/annotate, insert analyses, ... Ultimately run CMS shifts remotely → save travel funds.**



# LHC Physics Center (LPC) at FNAL – M&O and PPD

- Goal of US CMS Collaboration is to make major physics contributions to CMS (not just build detectors.)
- The US CMS Collaboration has requested that Fermilab create a center for CMS physics analysis.
- Create an intellectual center of US CMS physics analysis. A core of experts that understand the detectors, calibrations, alignments, software, simulations, test beam data and databases.
- Computing Resources available in the RP (computing, training in ROOT, C++, ... CD)
- Meetings have begun between the FNAL Directorate, PPD, CD, and US CMS RP management.
- A L2 manager for the LPC has been appointed (K. Maeshima). Space on WH11 has been identified and assigned.
- US CMS LPC leaders are beginning to organize (S. Eno + A. Yagil) – new LPC “LPC Steering Committee” - Feb 12 meeting. Monthly meetings to follow.



# Points of Contact

**Heidi Schellman (NW) - LHC “Users Org”,  
Workshops on 1/4 basis? Jets →  
Muons → Phenomenology, ....**

**K. Maeshima - WH11 layout and funding,  
US CMS RP management**

**L. Bauerdick, I. Fisk - Tier 1 and SWC  
interfaces - the UAF at FNAL**

**S. Eno (U Maryland) + A. Yagil - Think  
through initial tasks and assemble the  
core group which will reside on WH11.**



# LPS SC – Letter of 2/13 to M.W.

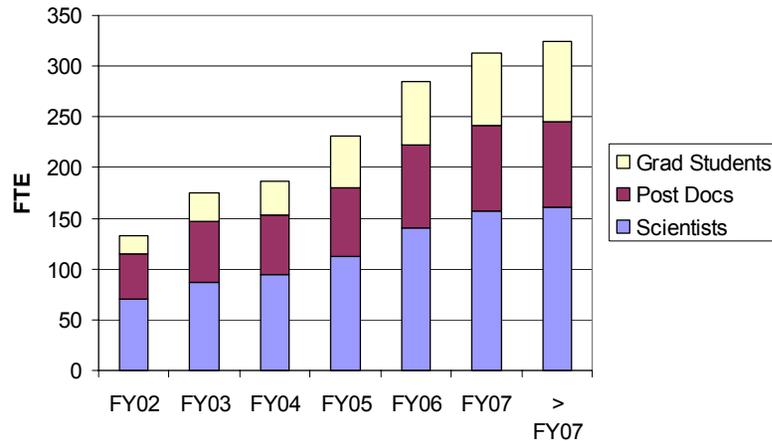
- In the next 6 months: establish a physical place at FNAL in the Hirise with first class computing and video conferencing for a core team of about six researchers working full time on CMS who will collectively develop expertise in all areas of the CMS reconstruction code and prepare to support and help the postdocs who will join them, working part-time on CMS.
- Within the next year: have an additional 10 University postdocs and some number of students working part-time on CMS and part time on a running experiment join the core team. These part-time postdocs and students would need desks in the same physical location as the 6 core researchers.
- In the following years: increase the number of University postdocs shared between CMS and a running experiment to 20 by the end of 2005 and 35 by the end of 2006, and start to have students who will do an LHC thesis working at the center.
- We need to establish milestones to judge our progress, especially over the timescale of the next year, when the success or failure of this project will become clear.
- Over the coming year, meet monthly to make sure we are making the required progress towards our goals that is needed to make the LPC a success.

**LPC SC has made a poll of the 24 university groups that are on both CDF/D0 and US CMS. The response has been quite positive in terms of a commitment of postdocs that will work on both CDF and D0. One can hope that FNAL will make an appropriately scaled commitment.**



# US CMS and the RP

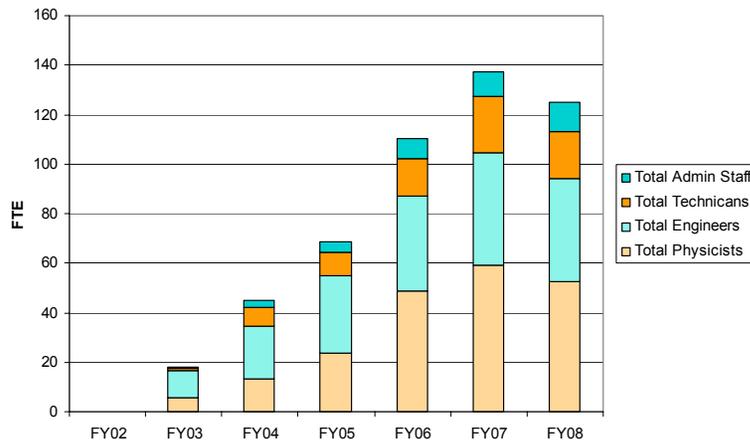
Scientific Effort on US CMS



The US CMS survey of redirection – if realized – will accommodate the US CMS needs for PD+GS in M&O tasks.

Note the ~ 150 FTE GS+PD in US CMS and the ~ 50 FTE base program for M&O. Therefore, the center of gravity of US CMS can, perhaps, remain in the US .

US CMS Resource Loading





# Tevatron -> LHC Transition

- There is concern (e.g. next HEPAP meeting) at how to manage the transition gracefully.
- Given the schedules, CDF/D0 physicists may start to move to LHC in 2005 in order to establish bona fides prior to first data.
- The LPC is a planned attempt to allow for a smoother, US based, and cost effective multiplexing of physicists so that they can work simultaneously on CDF/D0 and LHC.



## Transition - II

- **The LPC should also be open to US ATLAS physicists working on CDF/D0.**
- **It is critical that the LPC be supported and be a success if the commitments of the university physicists to both the Tevatron experiments and the LHC experiments be carried out successfully.**
- **US CMS has initiated the LPC and has a rapidly growing “customer” base.**
- **Fermilab support of the LPC is vitally important.**



# Summary

- **Fermilab has played a major role in the construction of HCAL and ME.**
- **Assembly of the Silicon Strip Tracker and FPixels will start soon.**
- **US CMS is making the transition from construction to a Research Program that will run for decades (SLHC – Upgrade R&D). That program must be a success.**
- **Fermilab has a large responsibility in computing (Tier1) and software development (UAF).**
- **Fermilab is the host of the LPC - an intellectual center for CMS physics based in the US and a means by which the Tevatron -> LHC transition can be accomplished.**



# US CMS Si-Tracker Group

- Fermilab (FNAL)
  - M. Demarteau, M. Hrycyk, A. Ronzhin, K. Sogut, L. Spiegel, S. Tkaczyk + 5 tech.
- *Kansas State University (KSU) → Pixels (but W. Kahl will still pitch in)*
- University of California, Riverside (UCR)
  - Gail Hanson, Gabriella Pasztor, Patrick Gartung
- University of California, Santa Barbara (UCSB)
  - A. Affolder, S. Burke, C. Campagnari, D. Hale, (C. Hill), J. Incandela, S. Kyre, J. Lamb, S. Stromberg, (D. Stuart), R. Taylor, D. White + 7 tech.
- University of Illinois, Chicago (UIC)
  - E. Chabalina, C. Gerber, T. Timour
- University of Kansas (KU)
  - P. Baringer, A. Bean, L. Christofek, X. Zhao
- University of Rochester (UR)
  - R. Demina, R. Eusebi, E. Halkiadakis, A. Hocker, S. Korjenevski, P. Tipton
- Mexico: 3 institutes led by Cinvestav Ciudad de Mexico
- 1-2 more groups are in the process of joining us



# Forward Pixels

**Deliver 2 disks/end in service cylinders**

**125X150  $\mu\text{m}$ , 16M pixels**

**Johns Hopkins – calculations**

**Purdue – sensors**

**Rutgers – token bit manager chips**

**UC-Davis – bump bonding**

**Fermilab, Northwestern, Kansas State –  
all mechanics, assembly and test**



# **CMS Education and Outreach Activities**

**QuarkNet Project, now in its 6<sup>th</sup> year**

**REU/RET at CERN**

**(Northeastern/Michigan)**

**USCMS Fellows**

**Education and the GRID**

**CMS Outreach at CERN**

**Portable/handheld Particle Detectors**

**In Planning: For CMS Remote Control Room at Fermilab**