



# FNAL Users' Meeting

## CMS, Fermilab, and Users

Bob Cousins

UCLA

June 3, 2004



**In a few years, LHC will open up the first big increase in Energy in a long while...**

**Fermilab is deeply involved:**

**In contributions to the machine (which I will not have time to cover in this talk)**

**As Host Laboratory to U.S. CMS (Project Office, management oversight, etc.)**

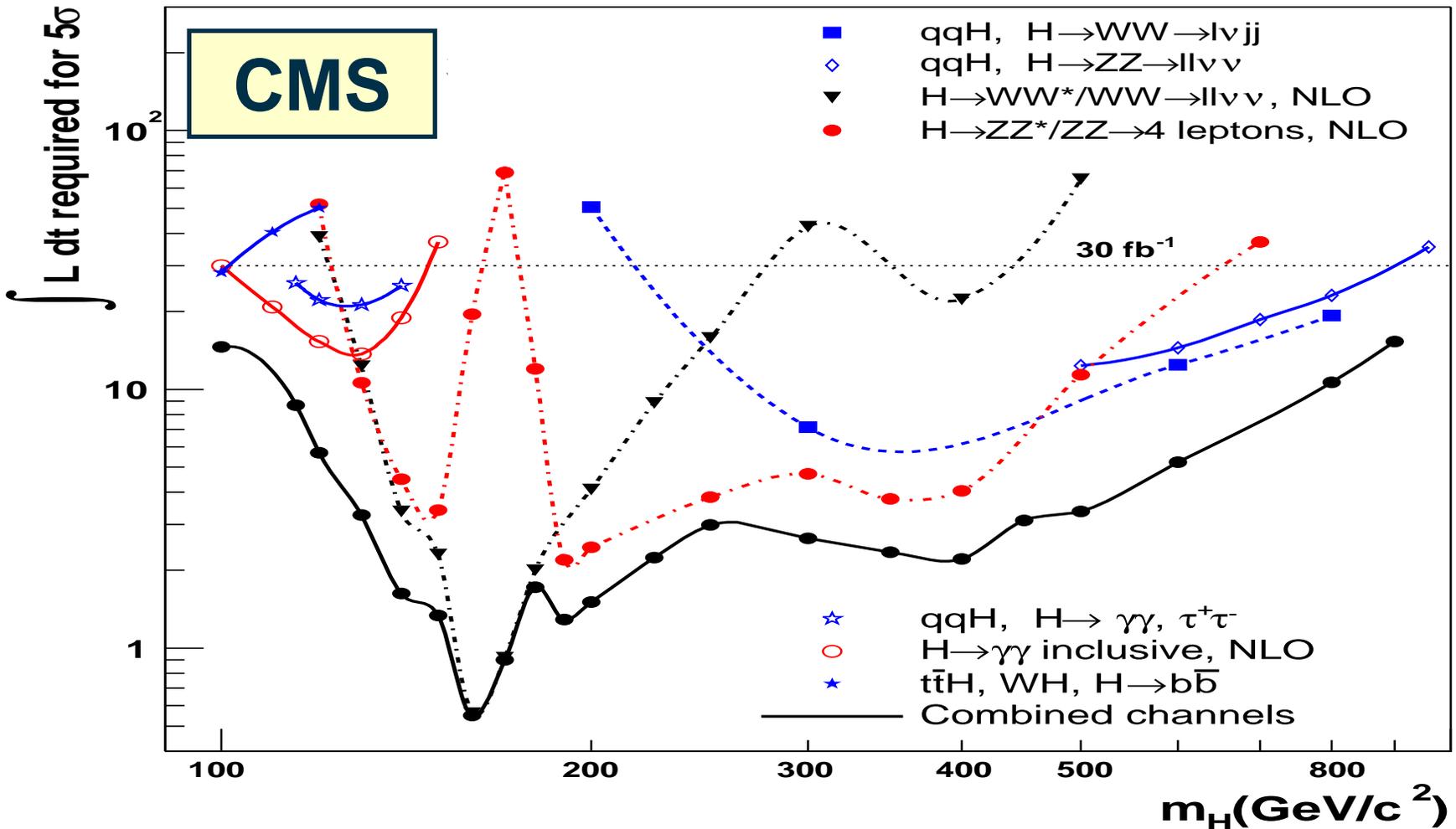
**As collaborator on many aspects of the detector, software, and computing.**

**...Fermilab and its users will be able to work efficiently on CMS and access the physics.**

**Much relevant experience at CDF and D0!**



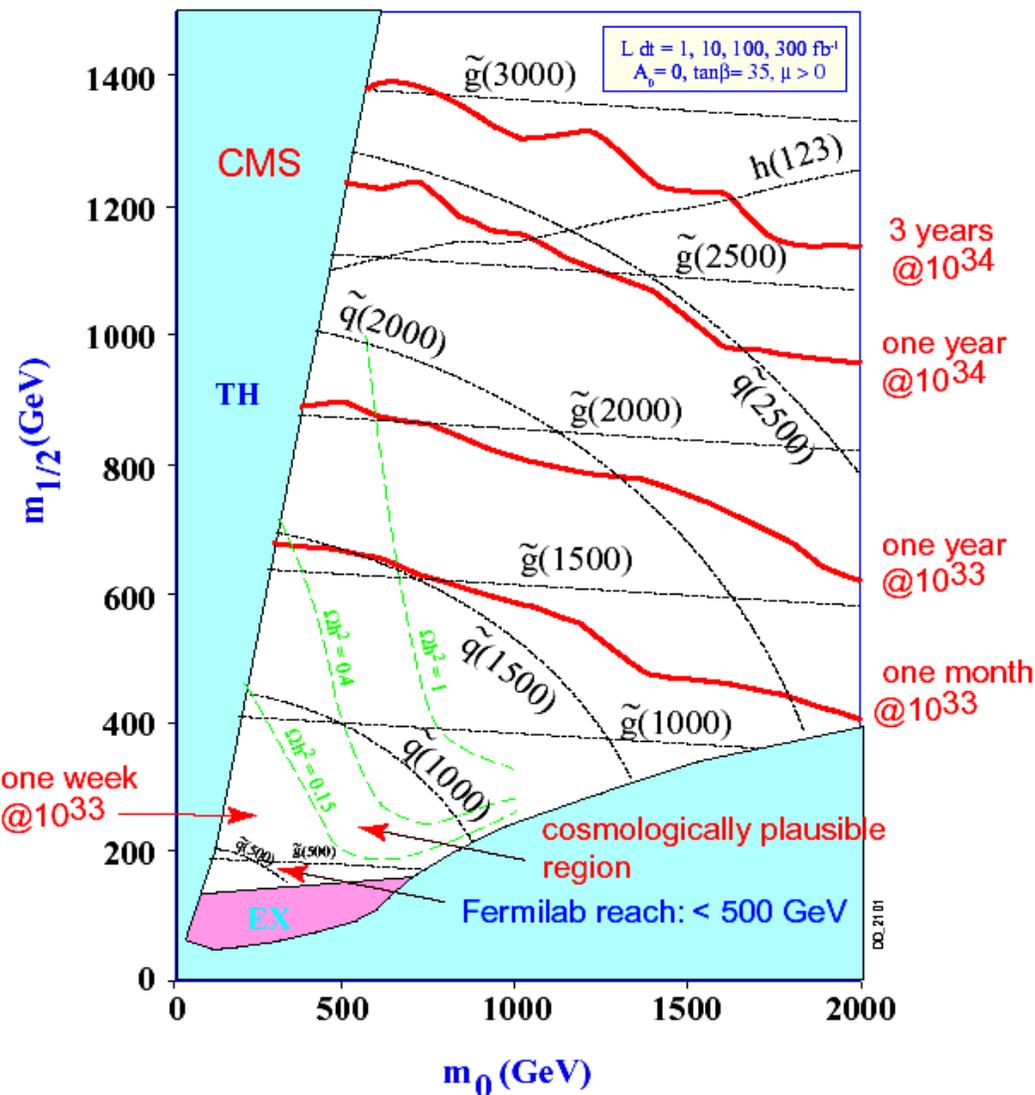
# We Want to be Ready to Discover and Study New Physics on Day 1



The Higgs, or Other New Physics Might Be Discovered **Early**



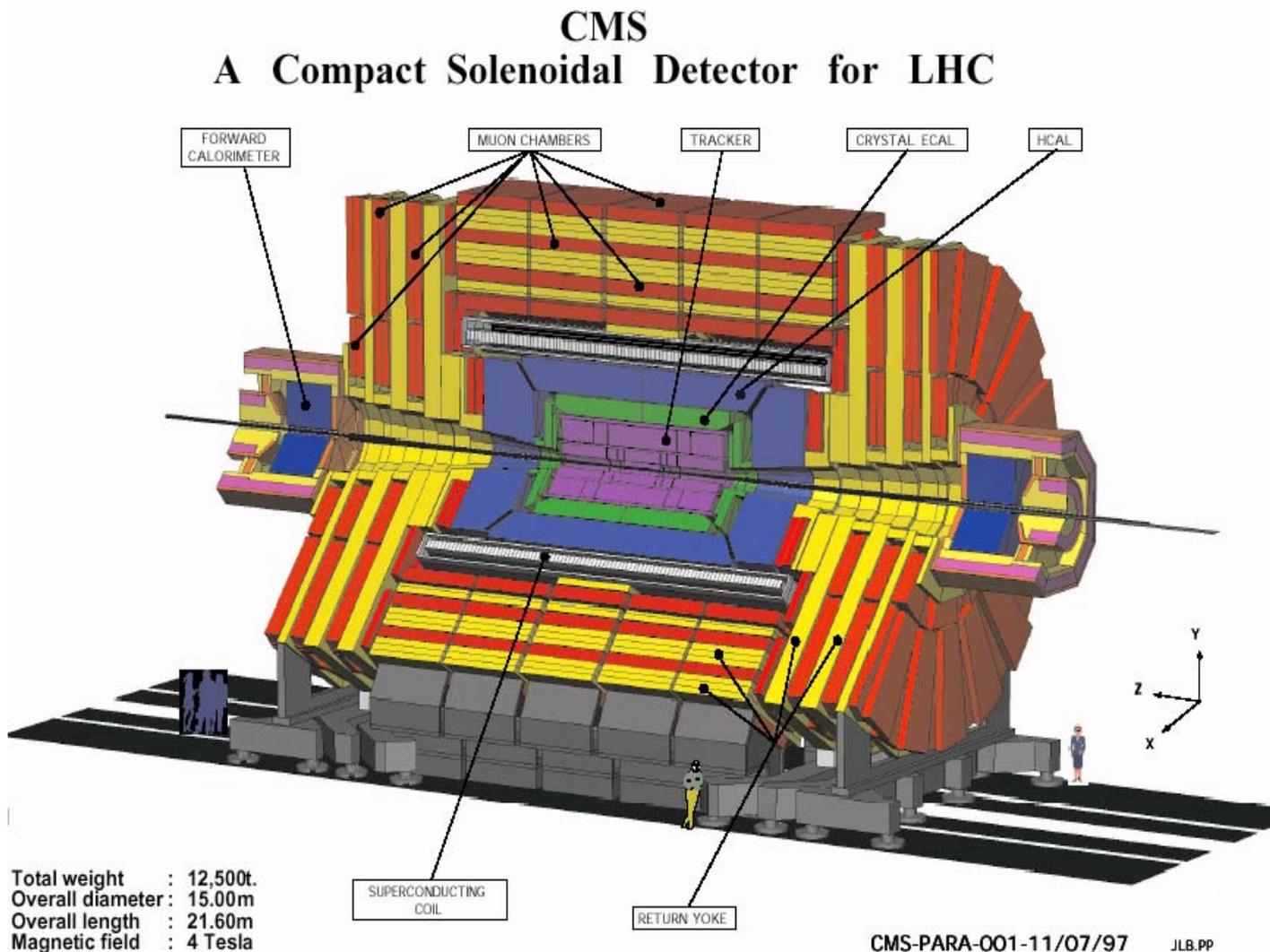
# CMS SUSY Reach



- ◆ The LHC could establish the existence of SUSY; study the masses and decays of SUSY particles
- ◆ The cosmologically interesting region of the mSUGRA search could be covered in the first weeks of LHC running.
- ◆ The 1.5 to 2 TeV mass range for squarks and gluons could be covered within one year at low luminosity. Final mass reach 2.6 – 3 TeV [mSUGRA].

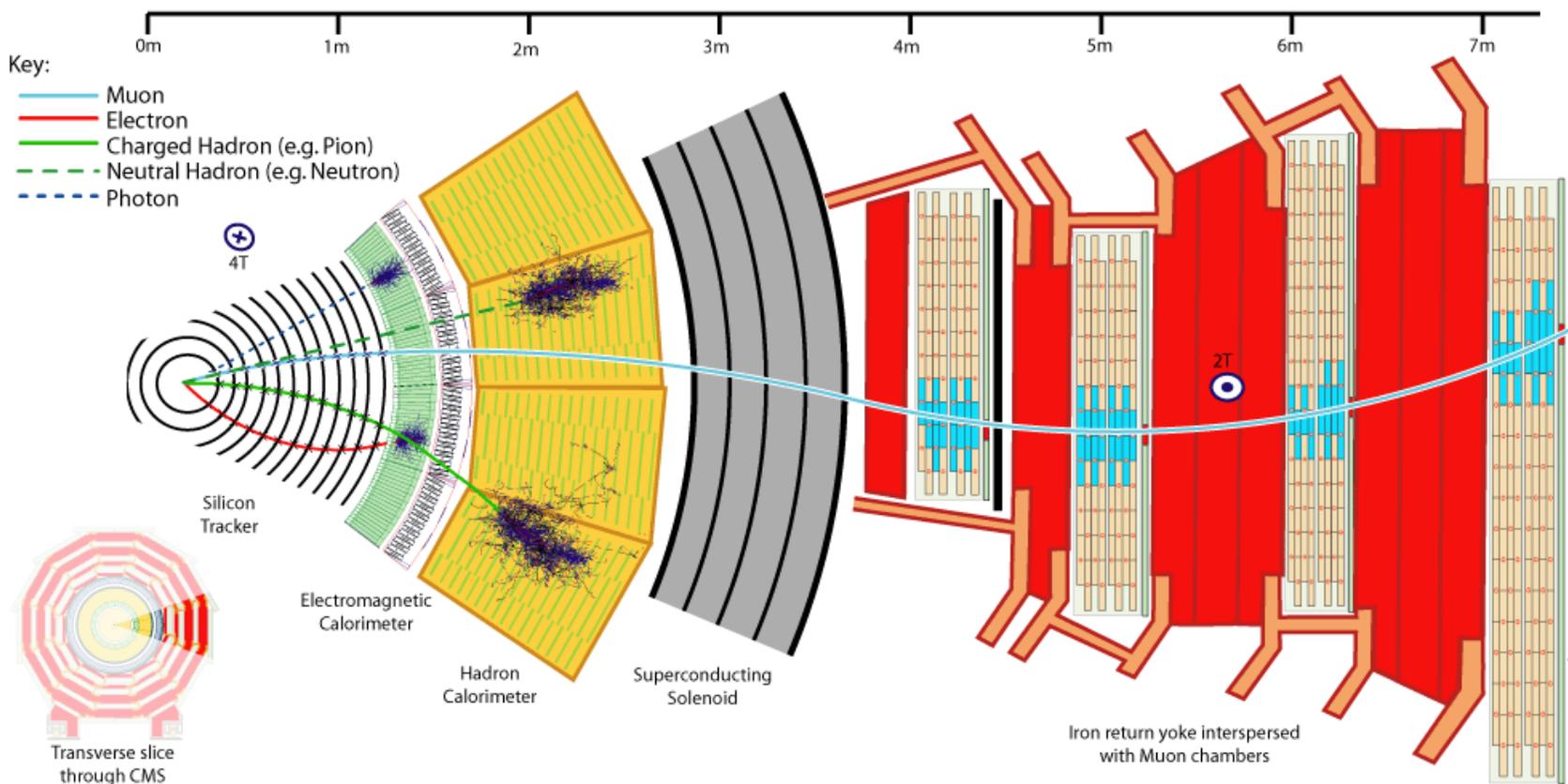


# The CMS Detector



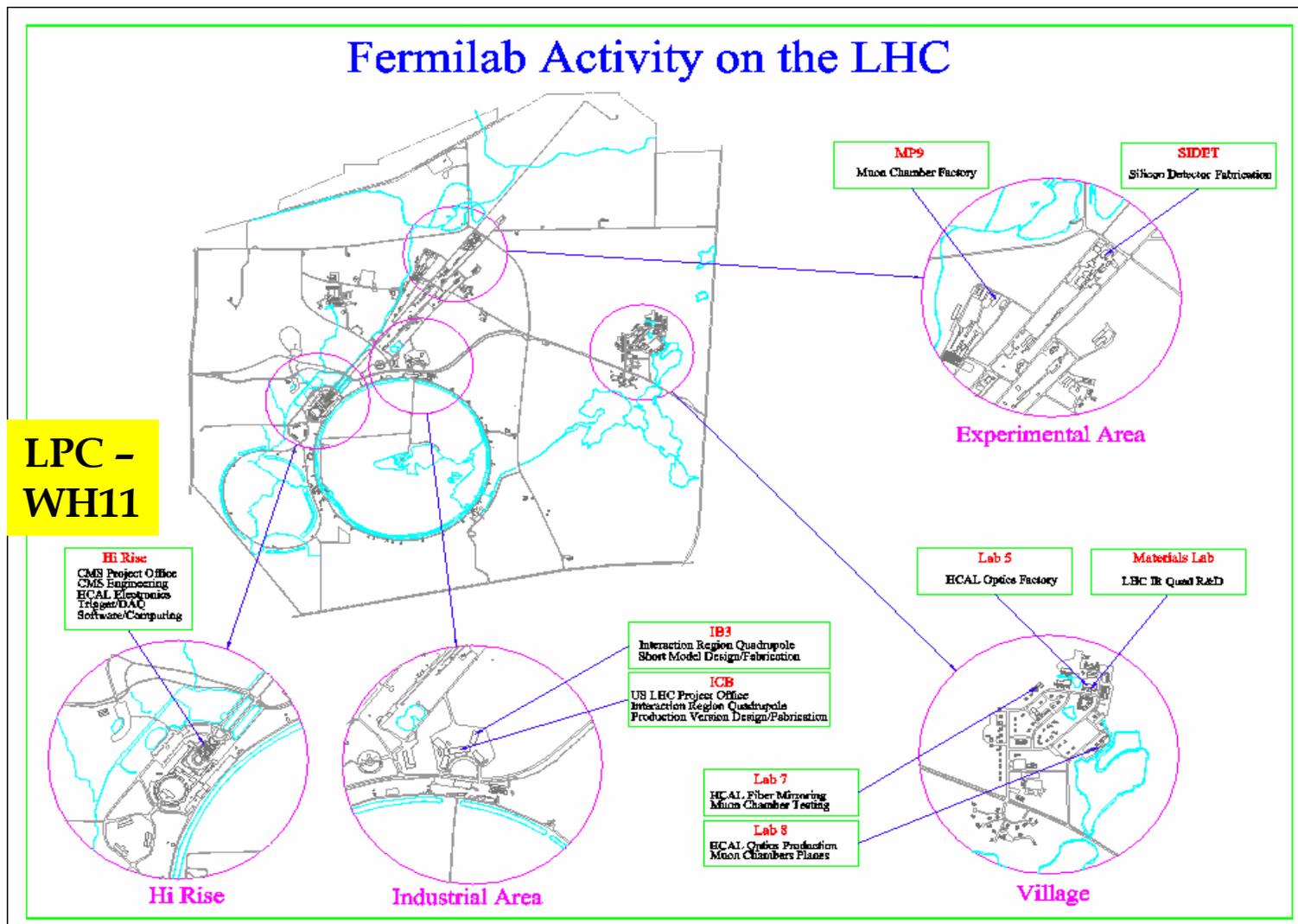


# 4T central B, -2T in return yoke





# Turning Cartoons into Reality: Fermilab and US CMS





# History I: HCAL at Fermilab



- Absorber done in industry to FNAL design
- Scintillator done in Lab5
- Wedge assembled at CERN



# History II: Fermilab CSC factory

## Gluing Station

Anode bars, gap bars are glued to panels



## Winding Station

Wires are wound directly on panels



## Soldering Station

Automated soldering of wires



## Wire Tension/Spacing Station

Tension and spacing of wires are checked

## Ionized Air Knife Station

Dust is removed from wires and panels

## Assembly Station

Panels are stacked to make 6 gap chamber:



# On to CERN (via Florida, Calif., ...)

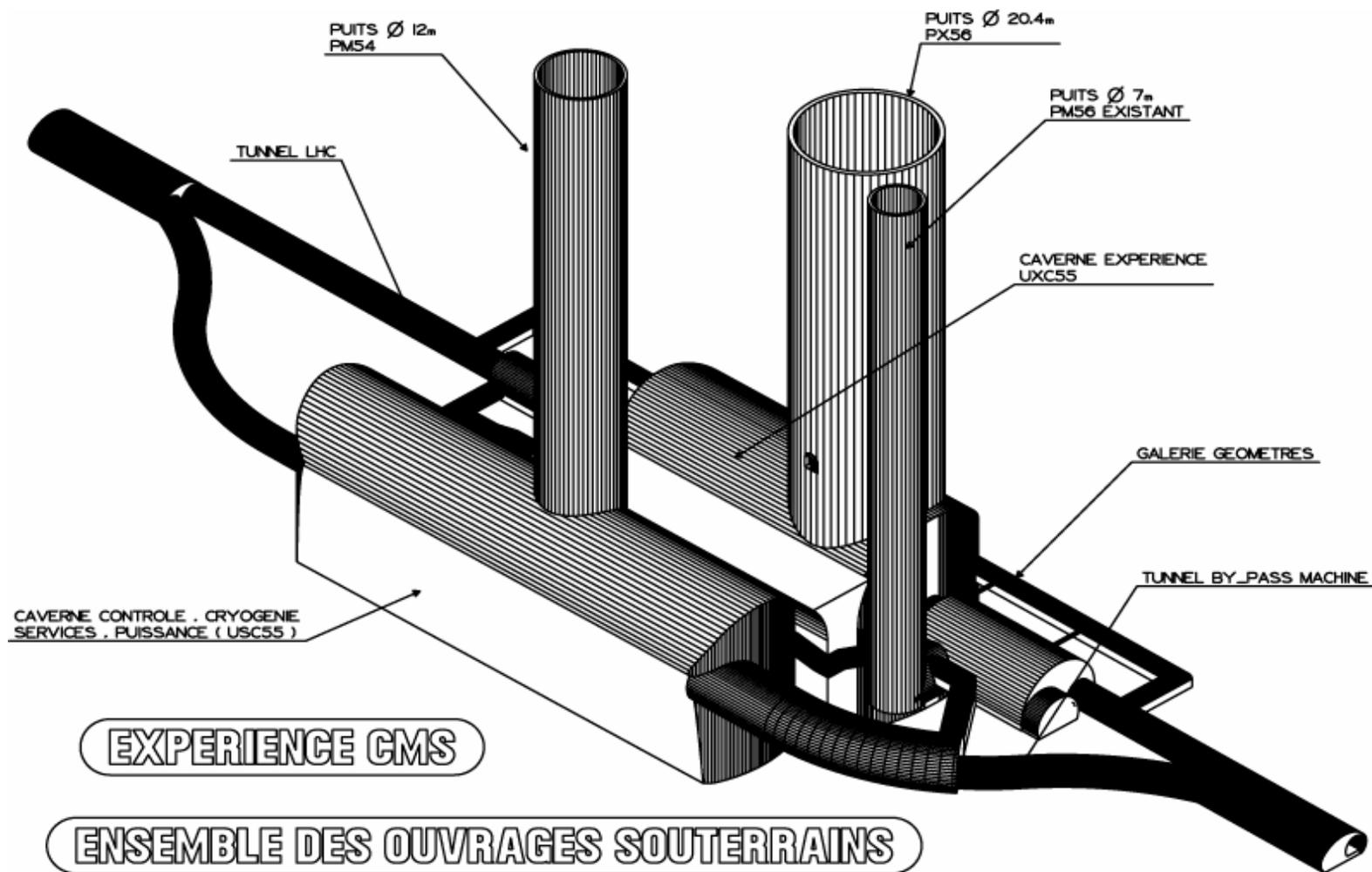
CMS

CMS offices





# CMS Site at Cessy: Cartoon and ...



MOHALD JF LE 24 - OCTOBRE - 2007

CM400088PL



# ...(Already out of date) Reality at Surface...





# ...and descending



Cover (“bouchon”) complete.  
First closing test ~ now.  
Hall delivery Oct 04.  
Heavy lowering Nov. 05.





# Detectors: HCAL at Surface, Point 5



Barrel



Forward



Endcap

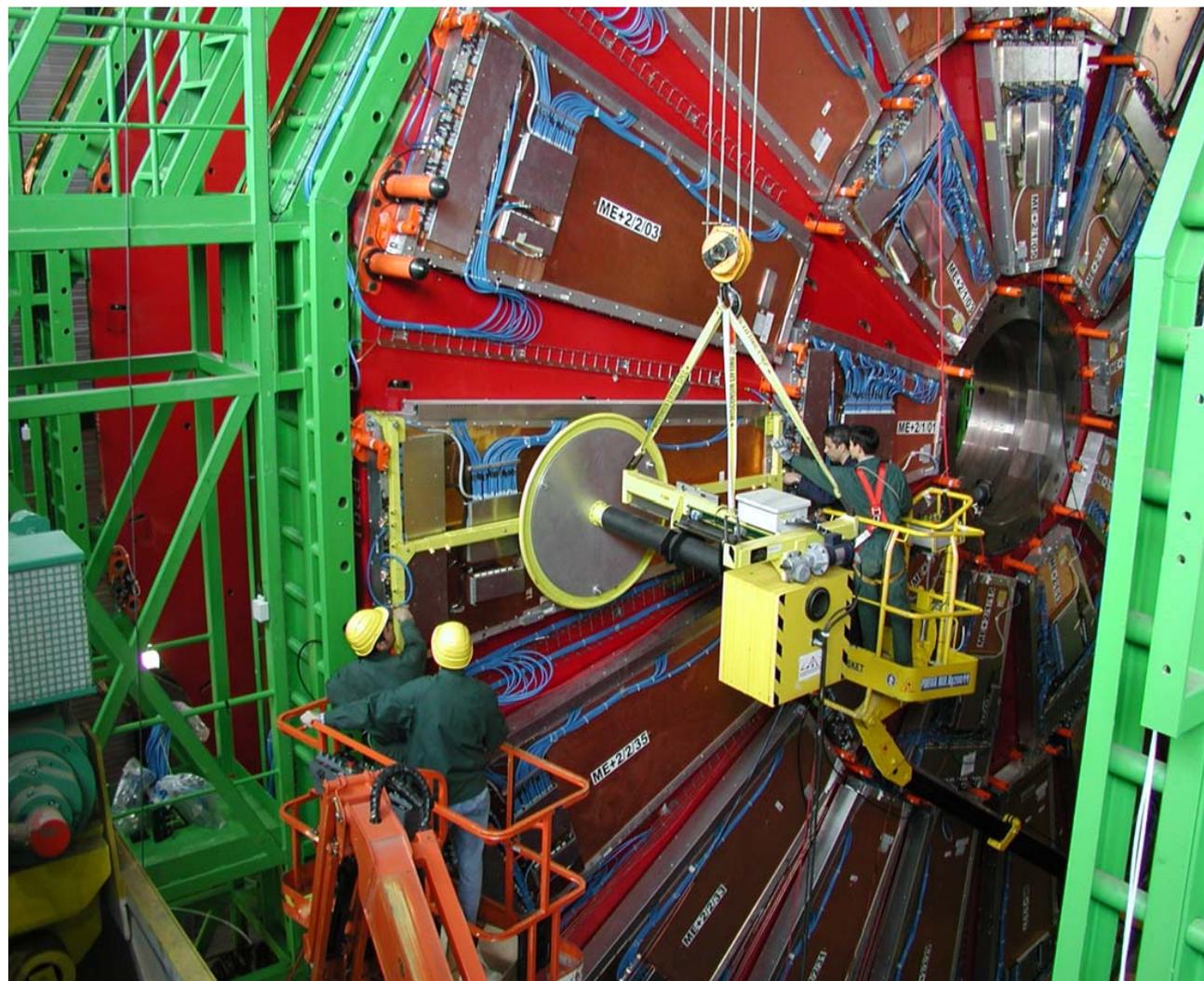
**Much of US CMS detector effort in HCAL and Endcap Muon is complete. Activity now shifts to commissioning, operations and preparation for data taking.**



# Installing muon chambers at Point 5

CSC production complete (total 482 CSCs including spares)

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

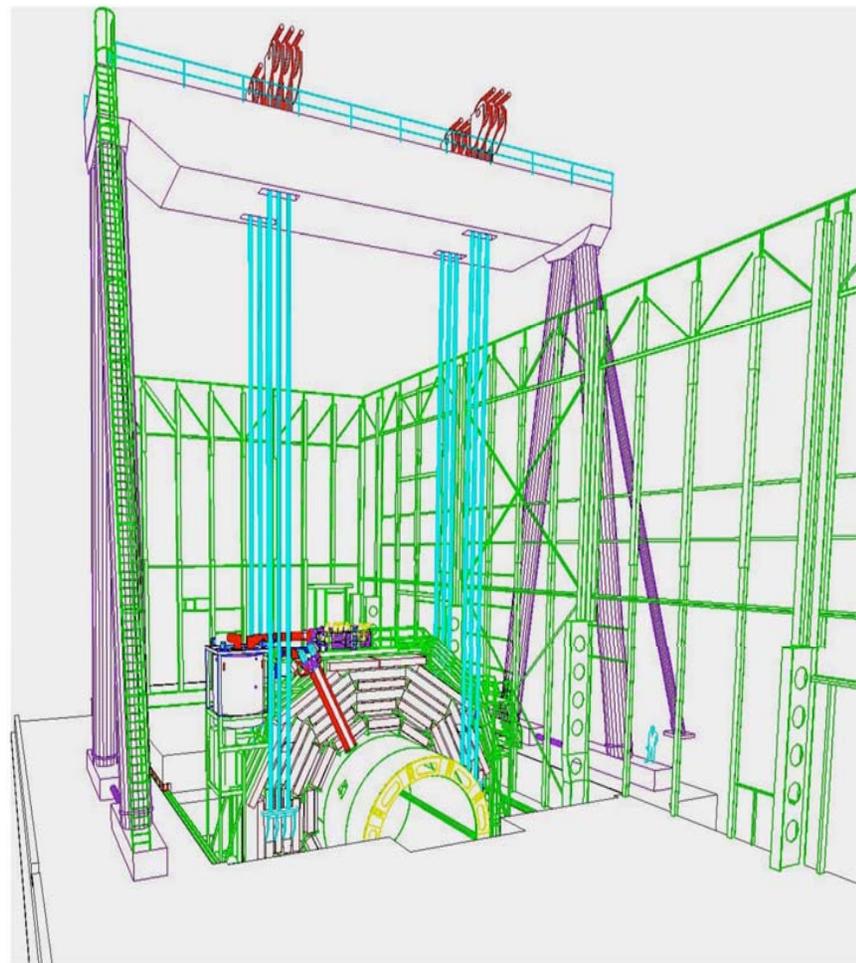




# Central barrel ring



**Above ground today.**



**To be lowered end of 2005**



# As we speak: System tests with LHC-like beam structure



**HCAL at other CERN test beam.  
Plan to combine with muon test.**

**Muon CSC "Slice Test" of 4 chambers  
(from Dubna, IHEP, U.S.) and  
multiple trigger/DAQ crates.**

**CSC-RPC integration planned as well.**





# Only a subset can be at CERN ⇒ Virtual Control Room at FNAL

11<sup>th</sup> Floor WH



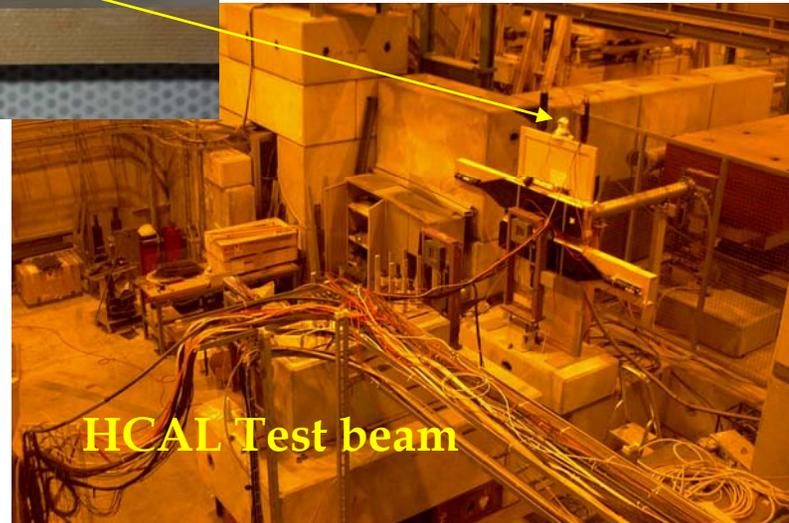
Virtually there,  
24/7



CERN Analysis Room



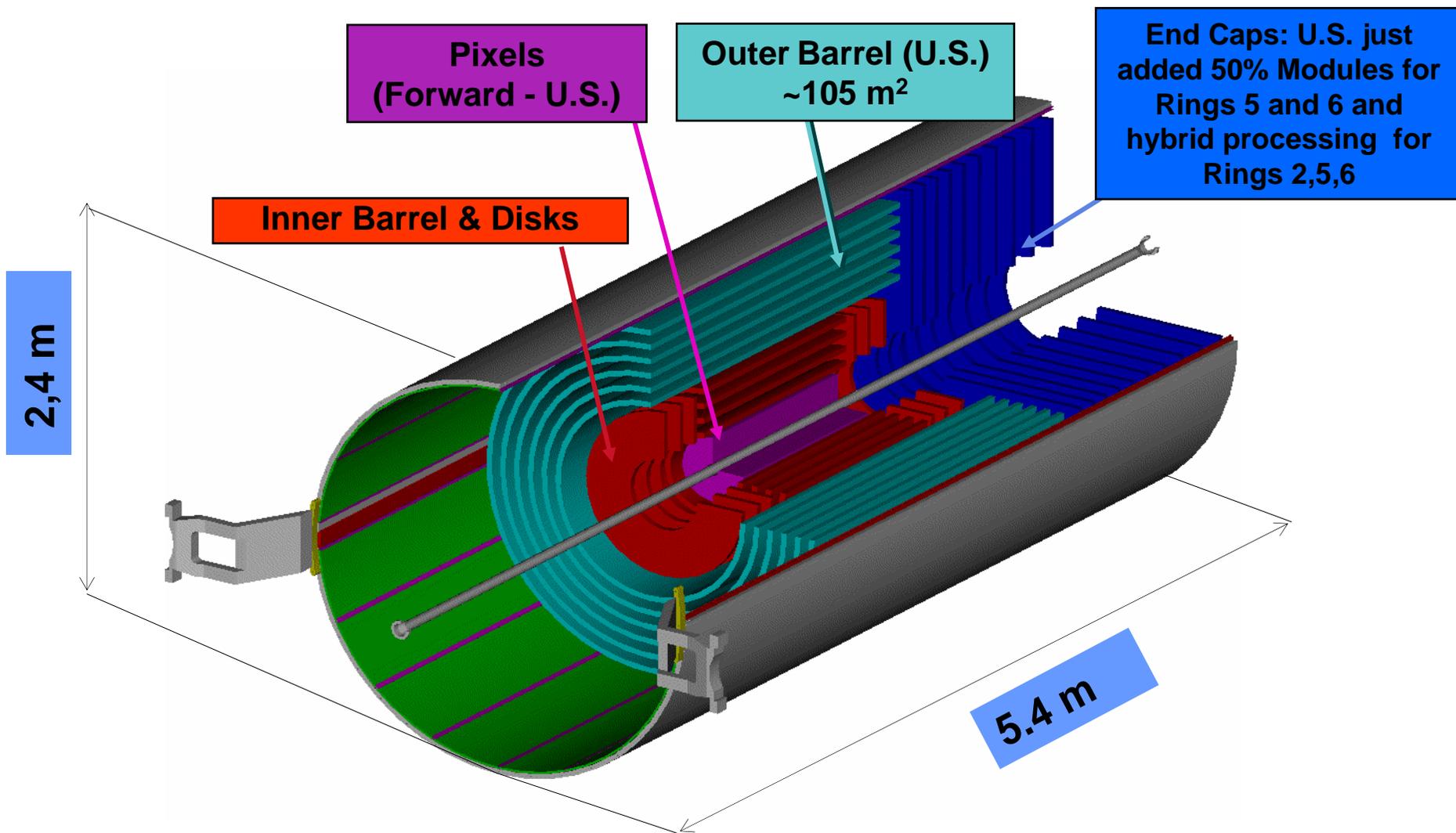
CERN HCAL  
Control Room



HCAL Test beam



# CMS All-Silicon Tracker: Cartoon...



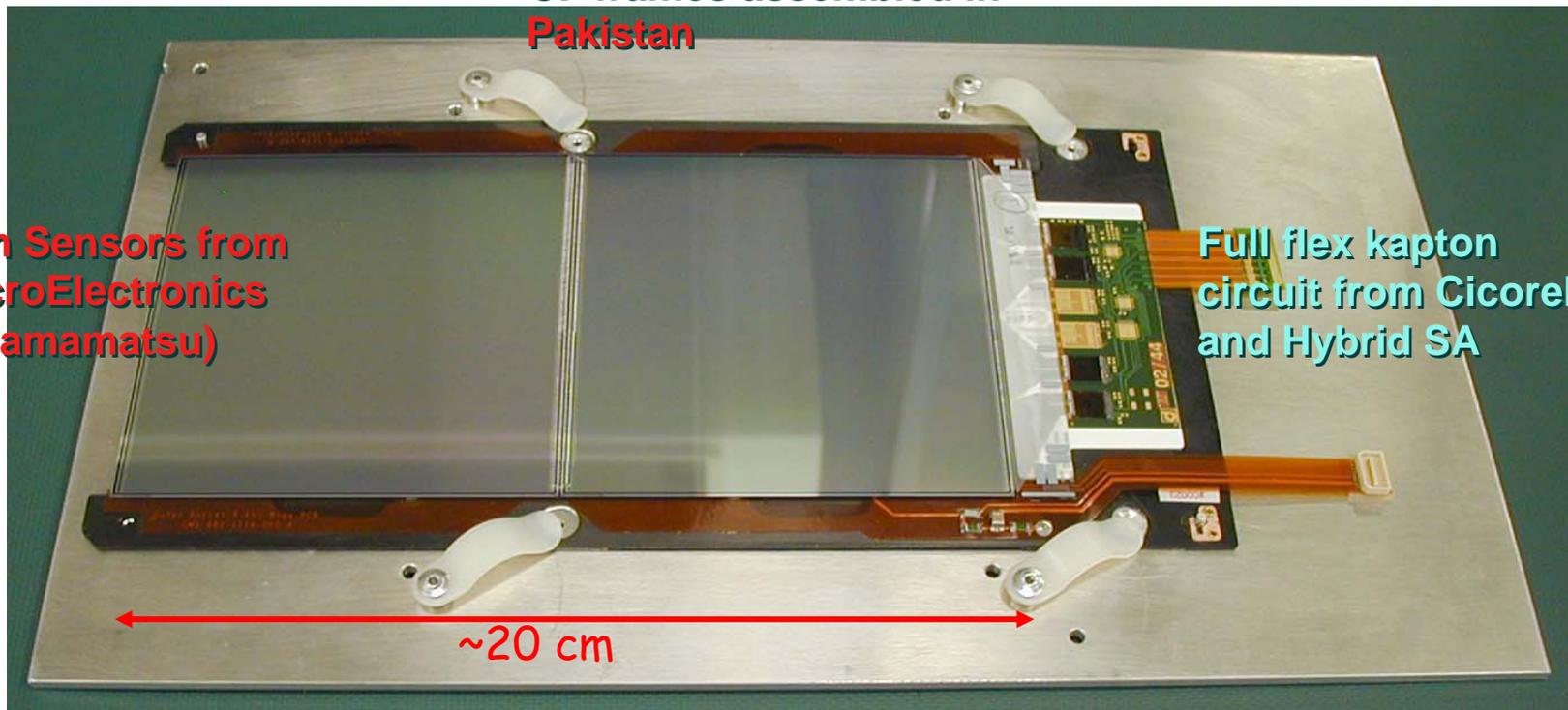


# ...Reality: First Outer Barrel Modules

CF frames assembled in  
Pakistan

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

Full flex kapton  
circuit from Cicorel  
and Hybrid SA

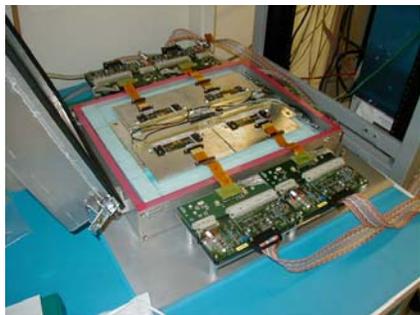


~5,600 Tracker Outer Barrel (TOB) modules to be assembled  
and tested at FNAL & UCSB

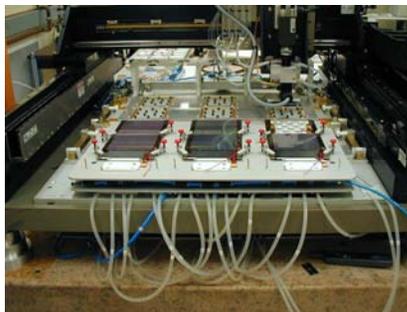
- Delayed by parts flow issues – Sensors (fixed)
- U.S. to help also with hybrid bonding (scope increase)



# Outer Barrel Testing & QA



Thermal/quick test hybrid



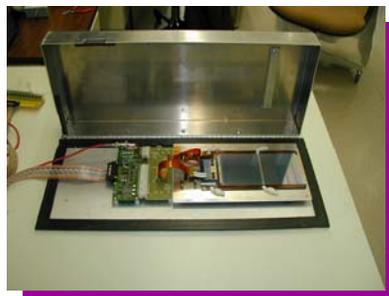
Gantry makes modules



Quick test unbonded module



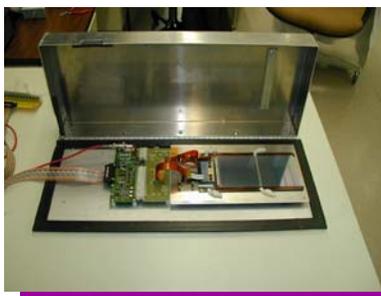
Thermal cycle module



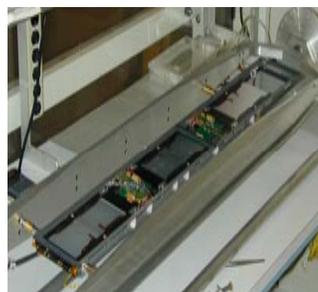
Bonded module test



Wirebond



Final pinhole test



Assemble/test rods



Rod burn-in



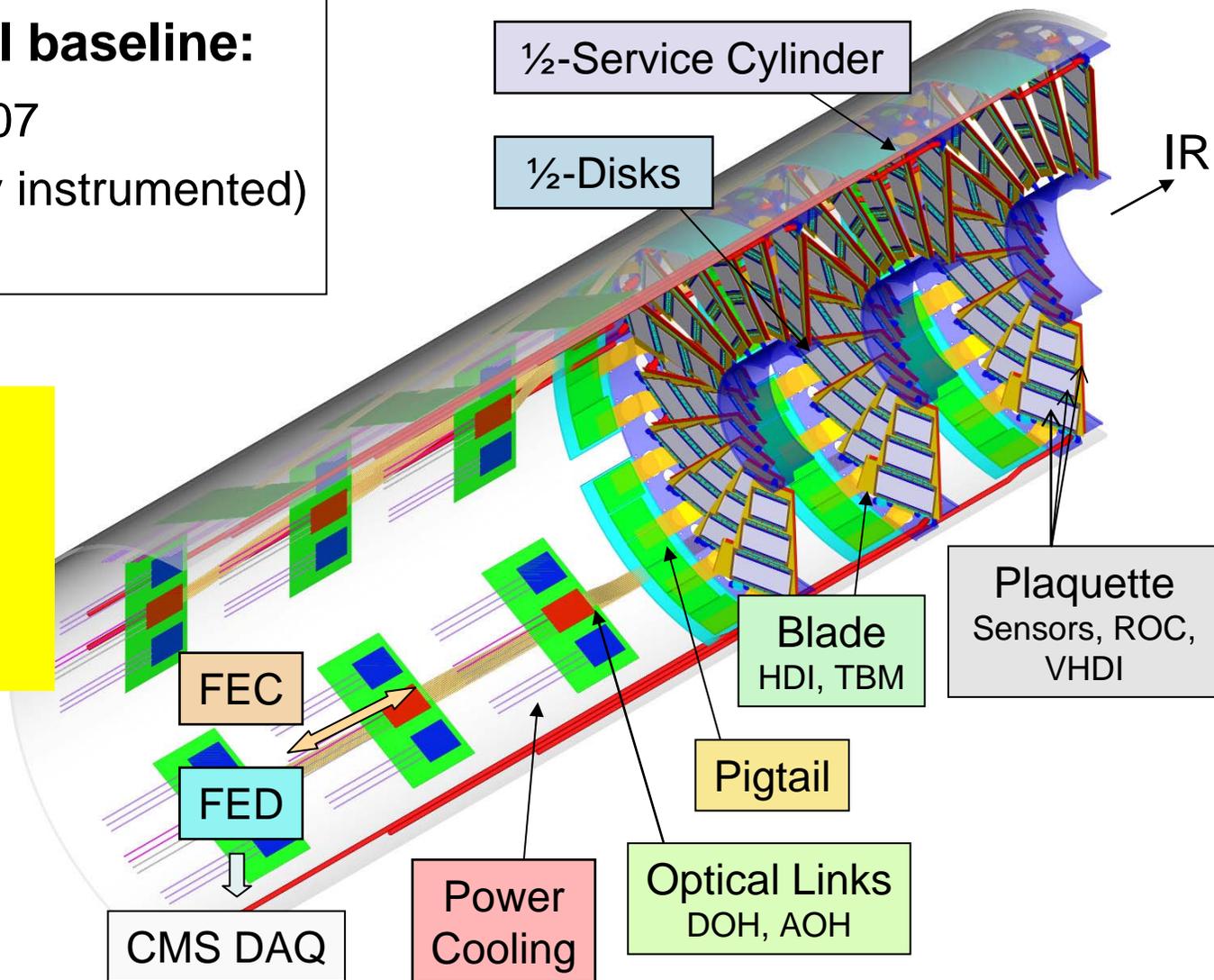
# U.S. CMS Forward Pixel Project

## Forward Pixel baseline:

US delivers in '07

- 4 Disks (fully instrumented)
- Electronics

Exciting project,  
much interesting  
work to do:  
**NEW GROUPS  
WELCOME**





# ICs and Circuit Boards of All Sorts

Front End, Trigger, DAQ...

ASICs, FPGAs, Optical links...



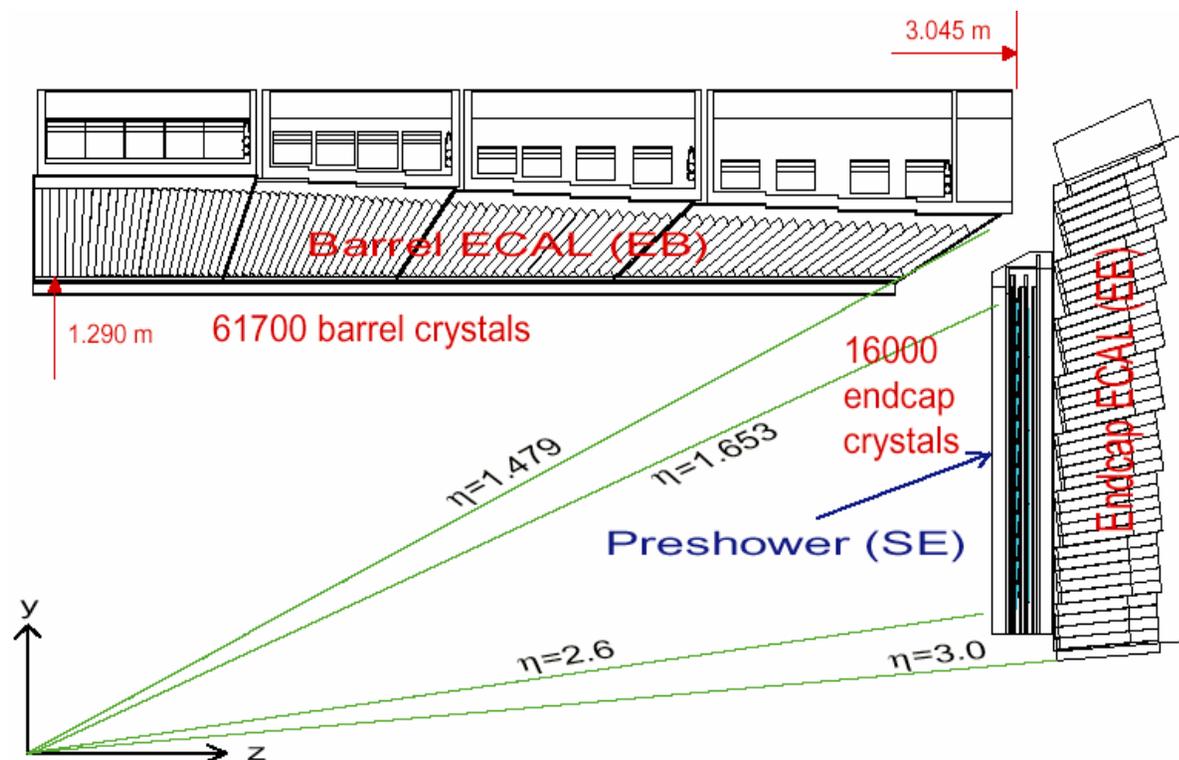
(See any talk by Wesley Smith, CMS L1 Trigger PM)



# Major Cost/Schedule Problems with ECAL

Problems with Russian suppliers, production halted for two months awaiting resolution.

Back in production now, but still seeking financial and schedule solutions.



**At present, CMS aims to have ECAL barrel for 2007 pilot run, add endcaps prior to 2008 physics run.**



# Software and Computing: Vast, Multi-faceted-- Overlapping All Aspects of CMS

## Formally part of S&C:

- Core Application Software (Simulation, Display, etc.)
- User Facilities: Tier 1 (FNAL), Tier 2 (Univs.)
- GRID(s)

## Formally part of M&O:

- Data Acquisition (V. O'Dell)
- Detector databases
- Physics analysis centers

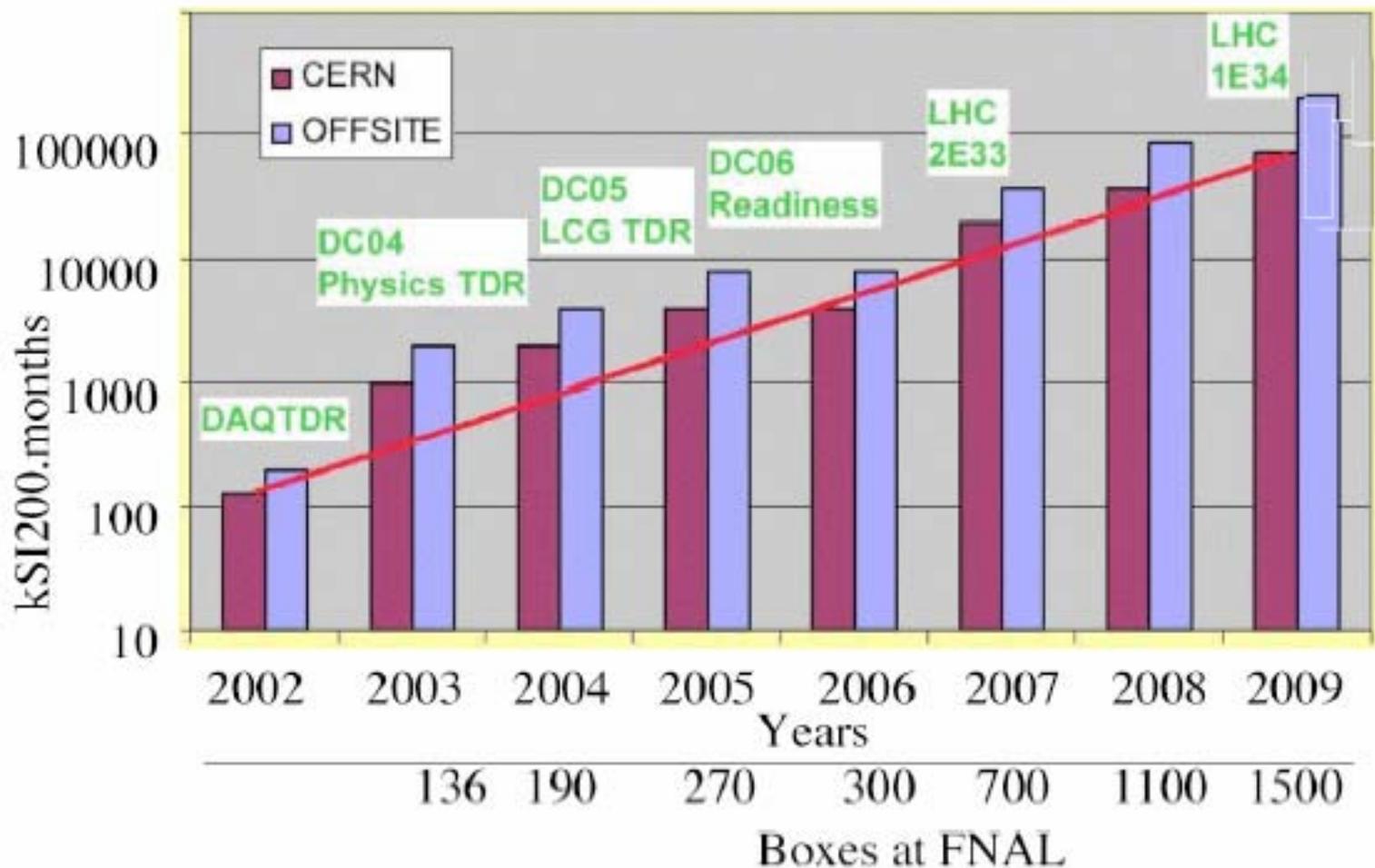
## As well as...

- High-level triggers, physics analyses, etc.

## Can only mention a few in this talk...



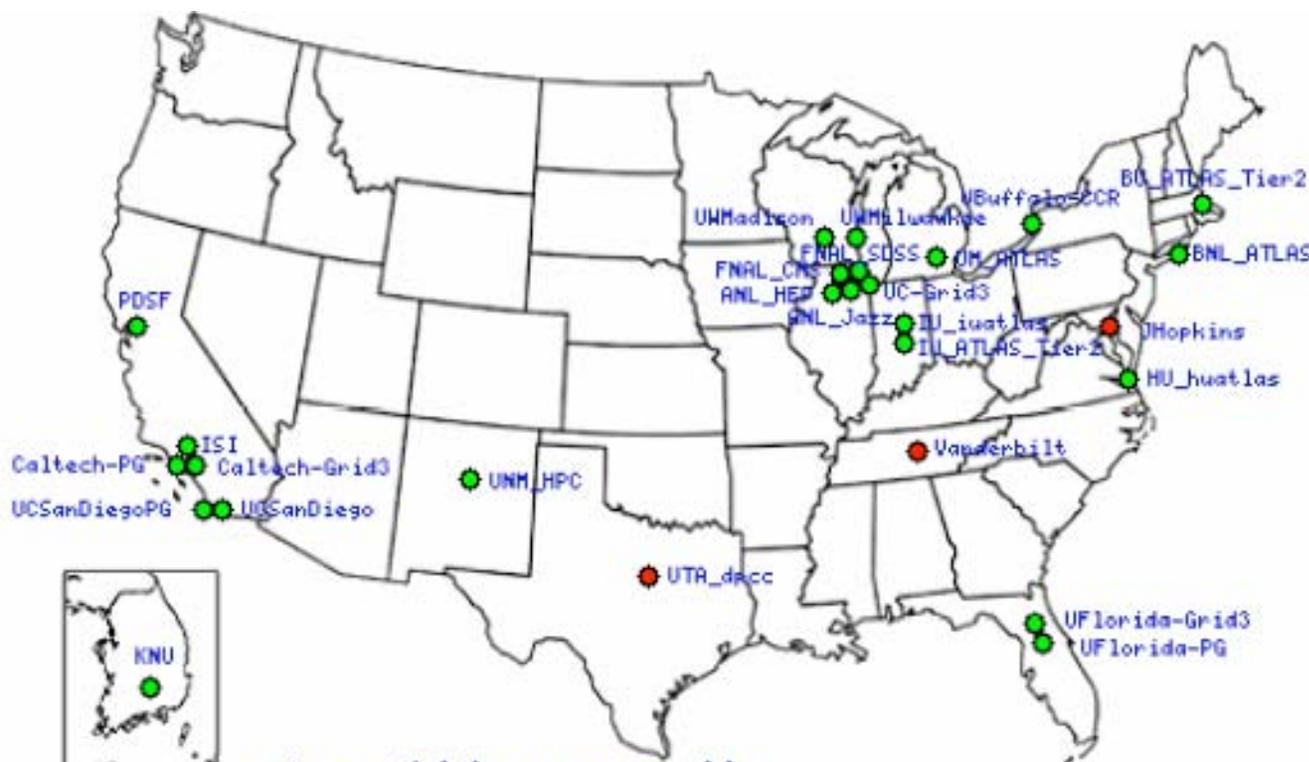
# Ramping up the Computing Power





# Putting Real Grids to Do Real Work for CMS

**Grid-2003: 26 Sites including ATLAS and CMS;  
2500 CPUs; Used for massive CMS event simulation**



(site availability generated by heartbeat scripts) Wed Nov 26 15:47:09 EST 2003

**2004: Work to combine with other Grids in world.**

**Computing MOUs among CERN, U.S., others.**

**Progress on technical and political issues.**

**Meanwhile Caltech and CERN setting data transfer records – see CERN Courier earlier this year.**



# Earlier this year: CMS Data Challenge 2004

## Major milestone for CMS software and computing

- Validate software; 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
- Data sample available for analysis at Tier-1 and Tier-2 centers
- 5% (design luminosity) throughput test

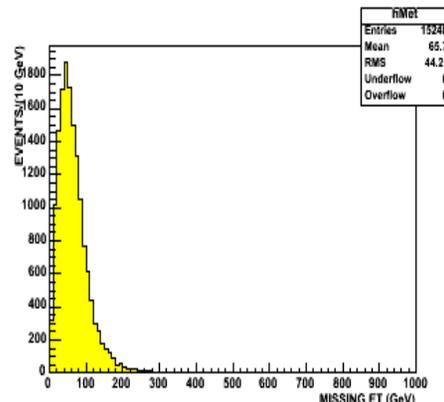
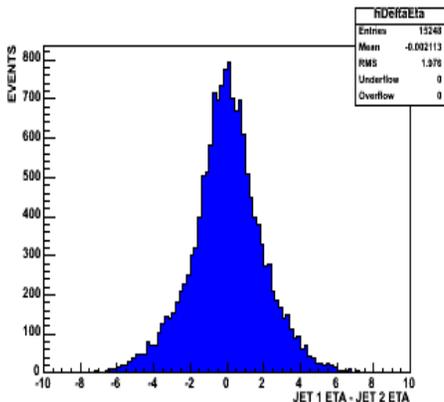
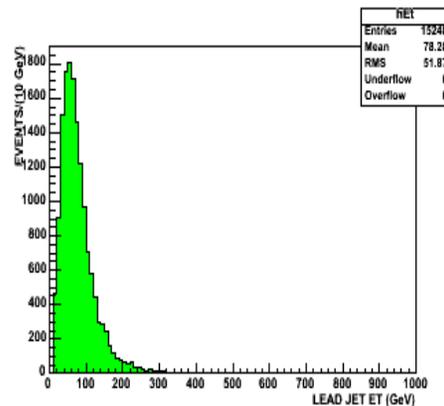
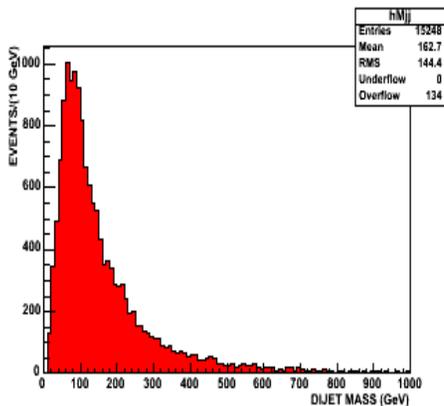
Many aspects achieved, bottlenecks in sustained rates studied...



# Jet/Missing $E_T$ Analysis of DC04 Data At FNAL

Presented by R. Harris (FNAL) , with thanks to many, at May U.S. CMS collaboration meeting...

$t t \rightarrow W b W b \rightarrow \mu \nu b \mu \nu b$



His conclusions (see collab meeting talk for details):

- We are able to analyze the DC04 data
- We have learned some valuable lessons
- DC04 data is now available for CMS users



# Physics TDR – End of 2005

**Work such as the above is underway.**

**Time to revisit generator-level studies of the proposal with:**

**Full Geant3→4 Simulation**

**Reconstruction: High Level Trigger version already exists and benchmarked in TDR**

**Analysis of systematic errors in its infancy – much interesting work to do with alignment, calibration, PDF's...**



# The CMS Collaboration: CERN Counting



## Number of Laboratories

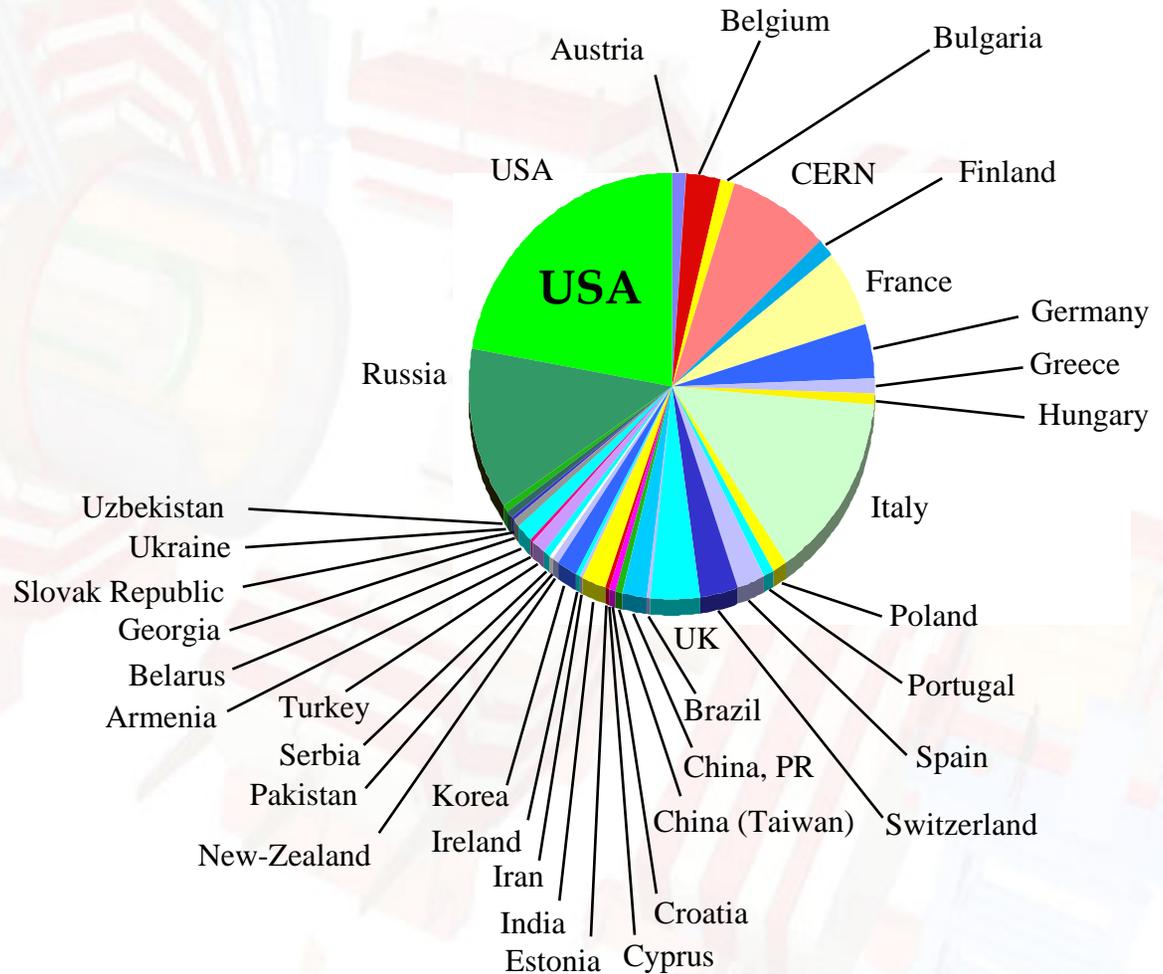
Member States	59
Non-Member States	56
USA	38
<b>Total</b>	<b>153</b>

## Number of Scientists

Member States	1005
Non-Member States	528
USA	443
<b>Total</b>	<b>1976</b>

## Associated Institutes

Number of Scientists	73
Number of Laboratories	10



**1976 Physicists and Engineers**  
**36 Countries**  
**153 Institutions**

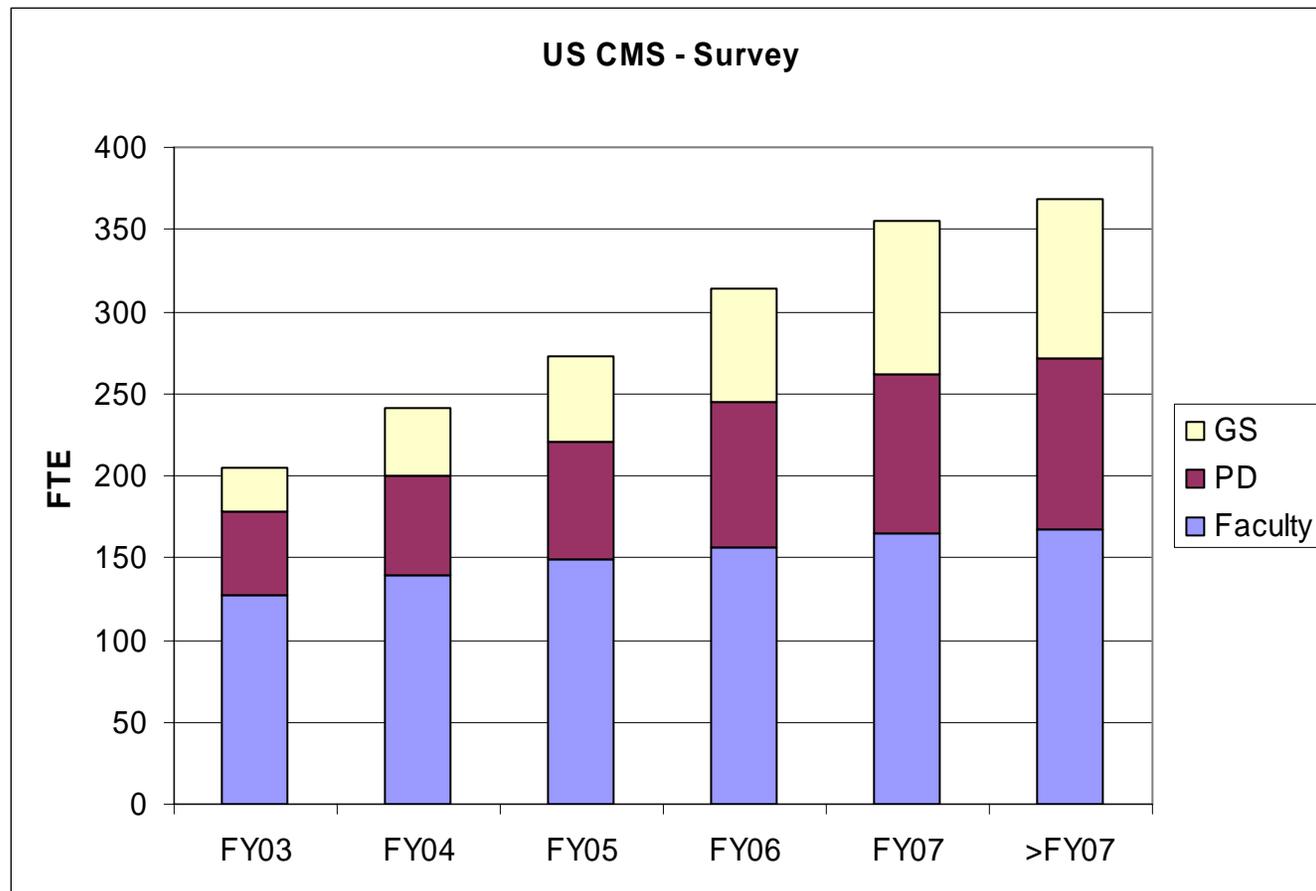
April, 05 2004/gm  
<http://cmsdoc.cern.ch/pictures/cmsorg/overview.html>

**N.B. "Scientist" = Physicist + Engineer**





# U.S. CMS – Survey of Intent, FTE

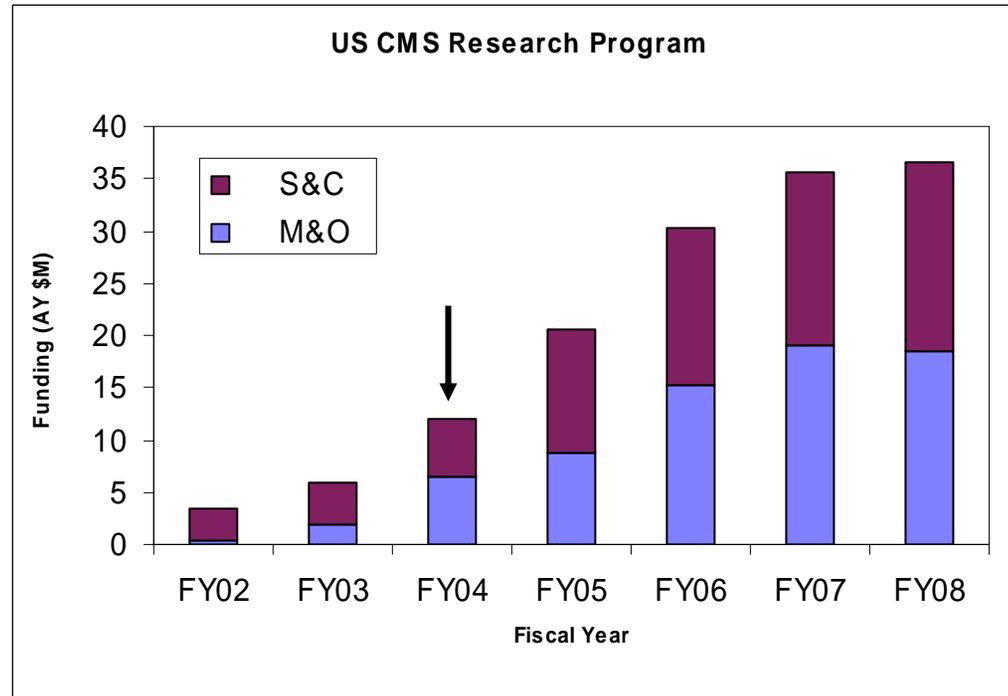


**N.B. FY03  
faculty +  
PD bodies  
> 300**

**US CMS made a survey of intent in regards to redirection of effort.  
Results are scaled to the fraction of physicists covered by the responses.**



# As Construction Project Ends, the “Research Program” Ramps Up



**Fermilab is host of management and Program Office of the RP.**

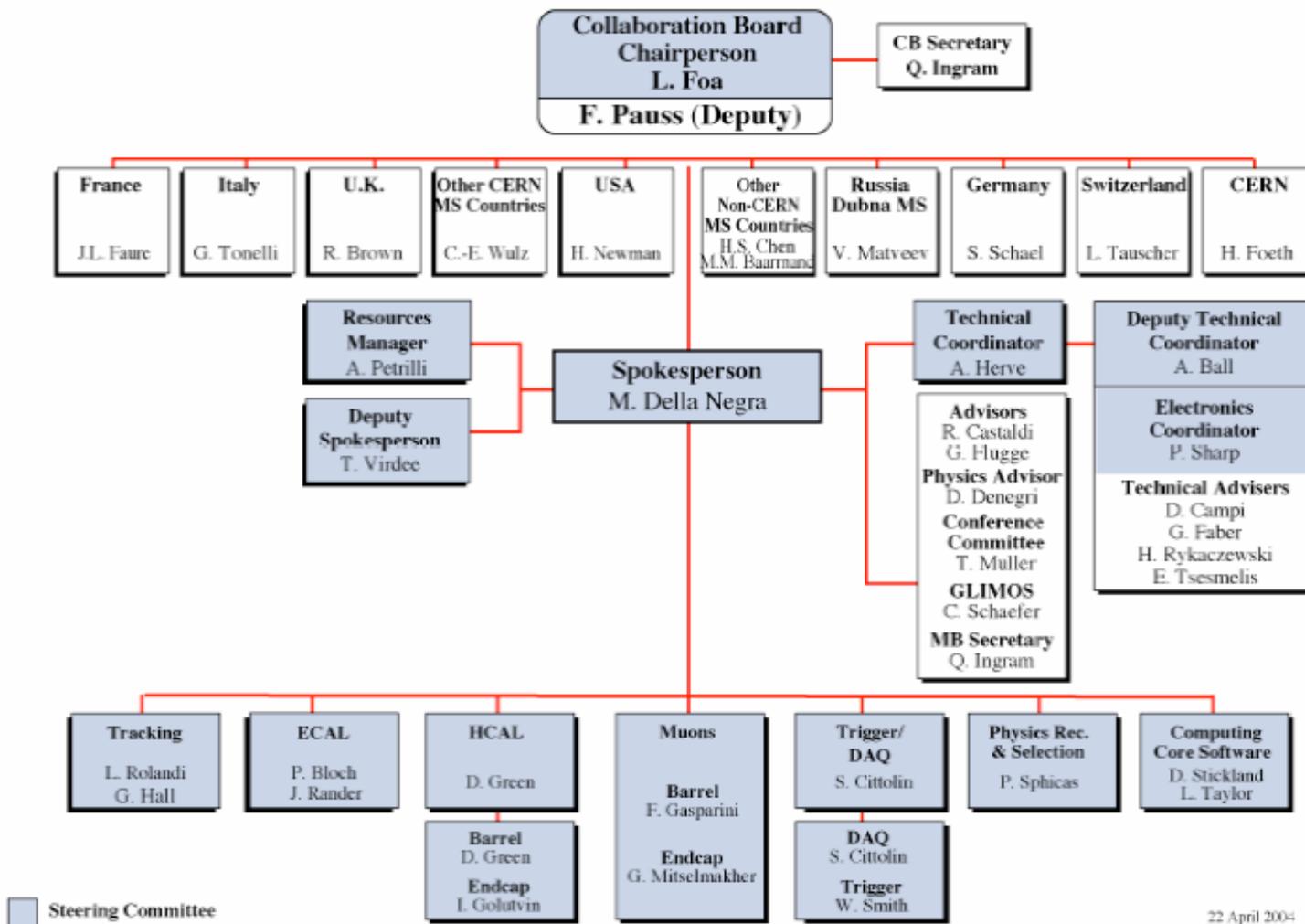
**Funding profile shown was guidance until earlier this year -- is being revisited by agencies.**

**Agencies' Base Programs are separate.**



# How are we organized?

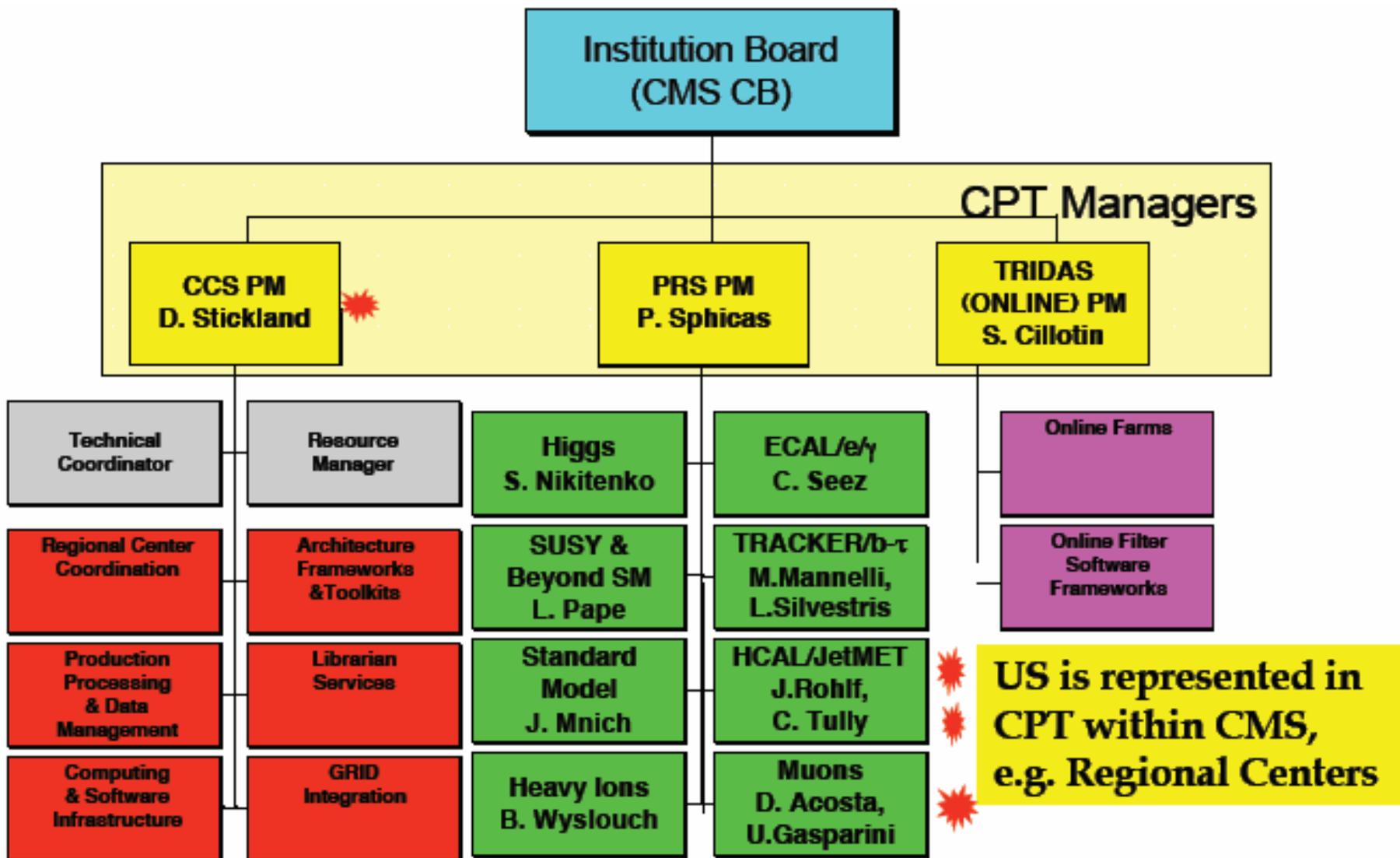
## CMS Management Board and Steering Committee



22 April 2004



# CMS Computing, Physics, Trigger/DAQ





# U.S. CMS Elective Offices

**Collaboration Board, Advisory Board Chair and Deputy:**  
H. Newman, V. Hagopian

**Advisory Board members:** D. Acosta, J. Branson, L. Cremaldi, S. Dasu, T. Ferguson, R. Ruchti, C. Tully, R. Zhu;  
Ex officio: L. Bauerdick, D. Green

**Advisory S&C Board:** S. Dasu (Chair), P. Avery, T. Cox, S. Kunori, R. Wilkinson, J. Rohlf;  
Ex officio: L. Bauerdick, J. Branson, R. Clare, I. Fisk, D. Green, H. Newman, D. Stickland, V. White

**Physics Coordinator:** J. Branson

**Education and Outreach Coordinator:** R. Ruchti

**Election Committee:** M. Baarmand, J. Hanlon

<http://uscms.fnal.gov/uscms/organization/organization.html>



# (Appointed) Research Program Management

## Final pieces in place ~ April 2004

- **RP Manager**

- Deputy

- **Software and Computing**

- User Facilities
- Core Application Software

- **M&O**

- L2 Managers: G. Appollinari (FNAL), B. Gobbi (Northwestern), J. Incandela (UCSB), V. O'Dell (FNAL), R. Rusack (Minnesota), A. Skuja (Maryland), W. Smith (Wisconsin)
- Education and Outreach: R. Ruchti (Notre Dame)

- **D. Green (FNAL)**

R. Cousins (UCLA)

- **L. Bauerdick (FNAL)**

I. Fisk (FNAL)

R. Clare (UC Riverside)

- **J. Freeman (FNAL)**



# CMS Education and Outreach Activities (R. Ruchti, Coordinator)

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

**REU/RET at CERN  
(Northeastern/Michigan)**

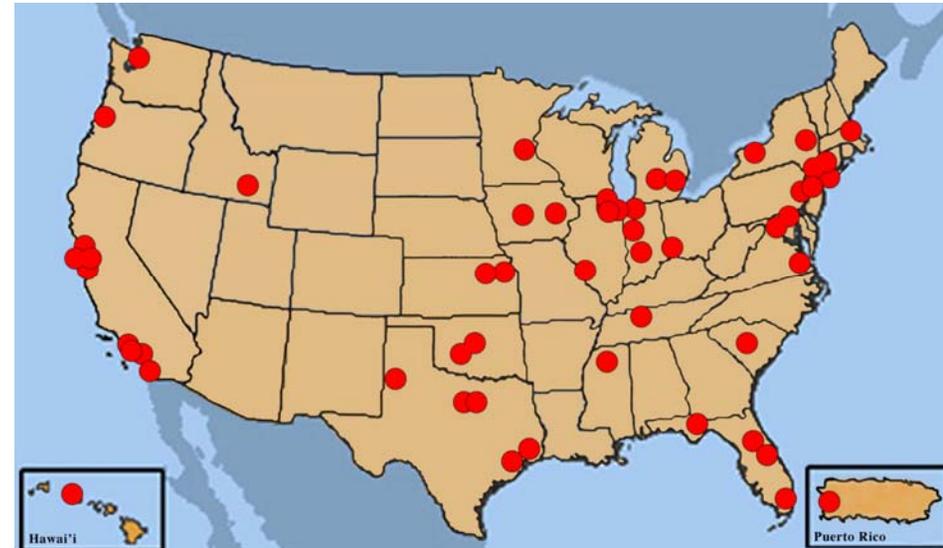
**U.S. CMS Fellows**

**Education and the GRID**

**CMS Outreach at CERN**

**Portable/handheld Particle  
Detectors**

**In Planning: Exhibit for CMS  
Remote Control Room at  
Fermilab**

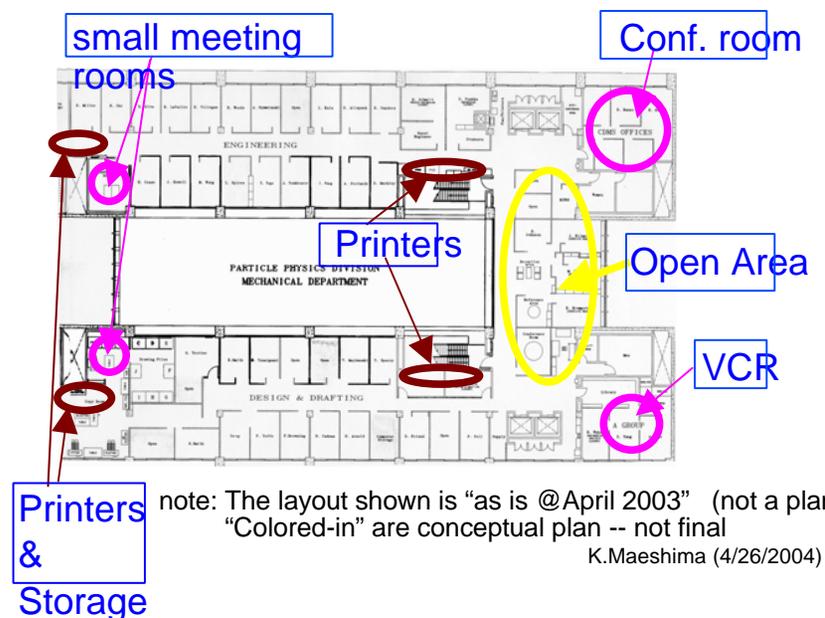


QuarkNet Centers ~2004



# LHC Physics Center at FNAL

- **Critical mass** (clustering) of young people who are actively working on software (reconstruction, particle identification, physics analysis)
- One stop shopping for your analysis questions
- Analysis tools such as large meeting rooms, video conferencing, large scale computing, “water cooler”
- Virtual control room



**Kaori Maeshima: infrastructure, Virtual CR**

**Sarah Eno, Avi Yagil: local analysis groups**

**Heidi Schellman: workshops, users org**



# LPC: The Stars Are Aligning!

**Has core of leaders who will make it work.**

**Potential users have put on two well-attended workshops. A number of university groups are committed to being a presence.**

**Lab management has started to commit real resources (space, bodies).**

**Tier 1 location: much expertise. Tutorials written for workshop users.**

**CDF/D0 leadership understand why it's a good thing.**

**It's agreed that LPC work will be well-integrated into CMS PRS organization.**



# Summary

- **CMS construction project headed toward completion; U.S. part of CMS will be >95% built by end of 2005.**
- **Fermilab deeply committed to CMS both as Host Laboratory for U.S. CMS and as collaborator on numerous subprojects.**
- **Virtual Control Room already useful for test beams, will grow.**
- **Fermilab employees, users, and CERN users are seeing confluence of interests in an LHC physics analysis center at Fermilab.**



# Acknowledgments

**Thanks to the many people from whom I  
“borrowed” slides or portions thereof...**

**D. Green, J. Freeman, D. Acosta, M. Della  
Negra, S. Eno, K. Maeshima, S. Kunori,  
I. Fisk, H. Newman, W. Smith, T. Virdee,  
R. Harris, R. Pordes...**

**and of course to all those whose work I  
describe.**



# Backup slides



# LHC Status



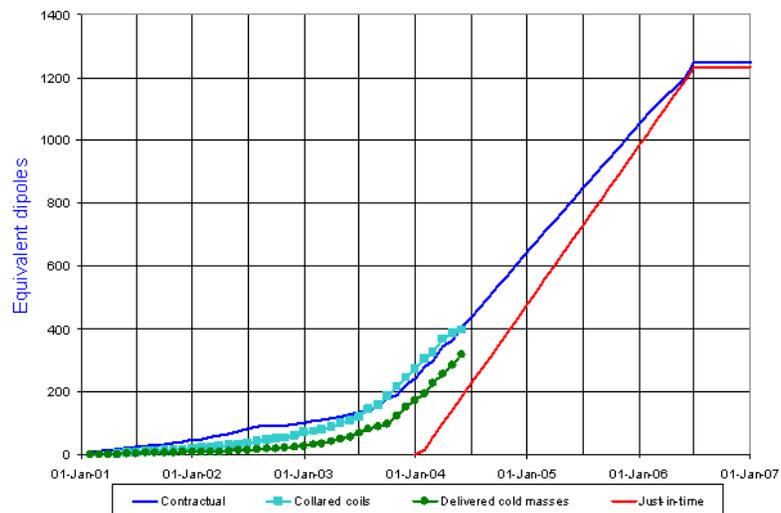
LHC Progress  
Dashboard



LHC Progress  
Dashboard



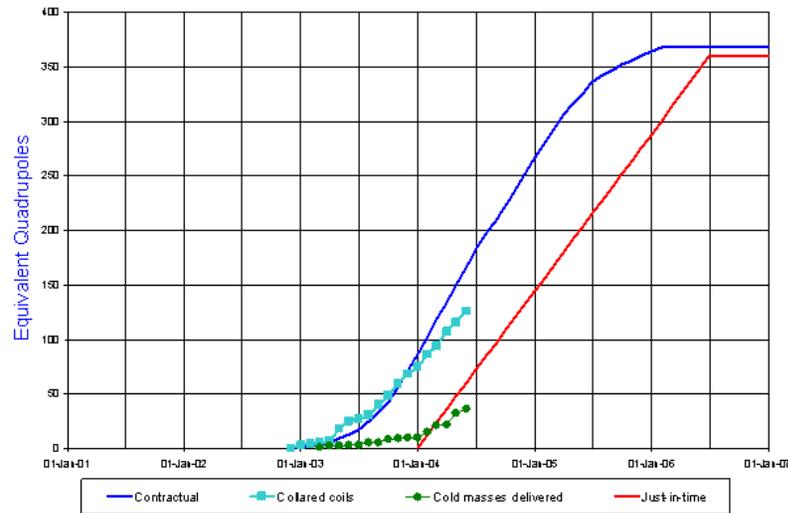
Dipole cold masses



Updated 31 May 2004

Data provided by P. Lienard AT-MAS

Quadrupole cold masses



Updated 31 May 2004

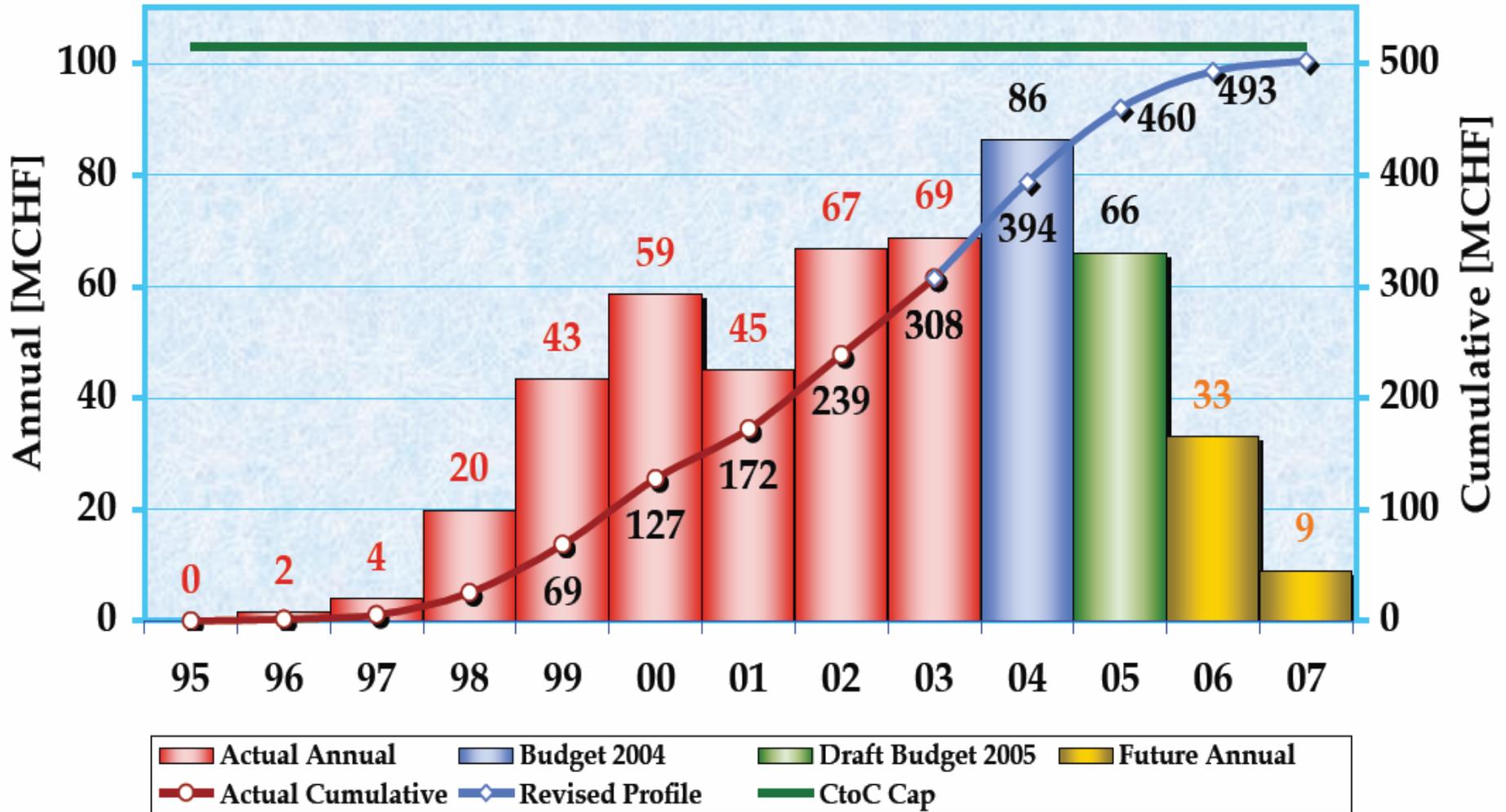
Data provided by T. Tortschanoff AT-MAS

**Recently revised LHC schedule with known delays still has first beams in 2007.**

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



# Payment Profile (MCHF)





# Schedule: re-baseline to v34.0

- **Magnet test ends:** 31 Oct 2005
  - **Start of heavy lifting in UXC:** 15 Nov 2005
  - **Ready for crates in USC:** 15 Jul 2005  
Above milestones consistent with CE delays
  - **Tracker ready for Installation:** 22 May 2006  
Consistent with sensor delivery schedule discussed with HPK and STM.
  - **Start tracker installation:** 1 Aug 2006
  - **Last EB- SuperModule installed:** 30 Nov 2006  
Install 3-4 SMs with tracker in place.  
Consistent with last EB crystal 30 Jun 2006
  - **CMS ( without ECAL endcaps) “ready to close”:** 1 Apr 2007
  - **Pilot Run (1st collisions) starts:** 1 Aug 2007
  - **2nd endcap EE- ready for installation on YE-:** 20 Feb 2008  
Consistent with last EE crystal delivery 30 Jun 2007.  
Work on improving delivery rate to exploit parallel assembly of last 2(3) Dees
  - **CMS with full ECAL ready for 1st physics run:** 1 Apr 2008
- ~5 months delay wrt V33.2 (Oct 03)