



# CMS Status

## CMS and US CMS

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**March 28, 2003**



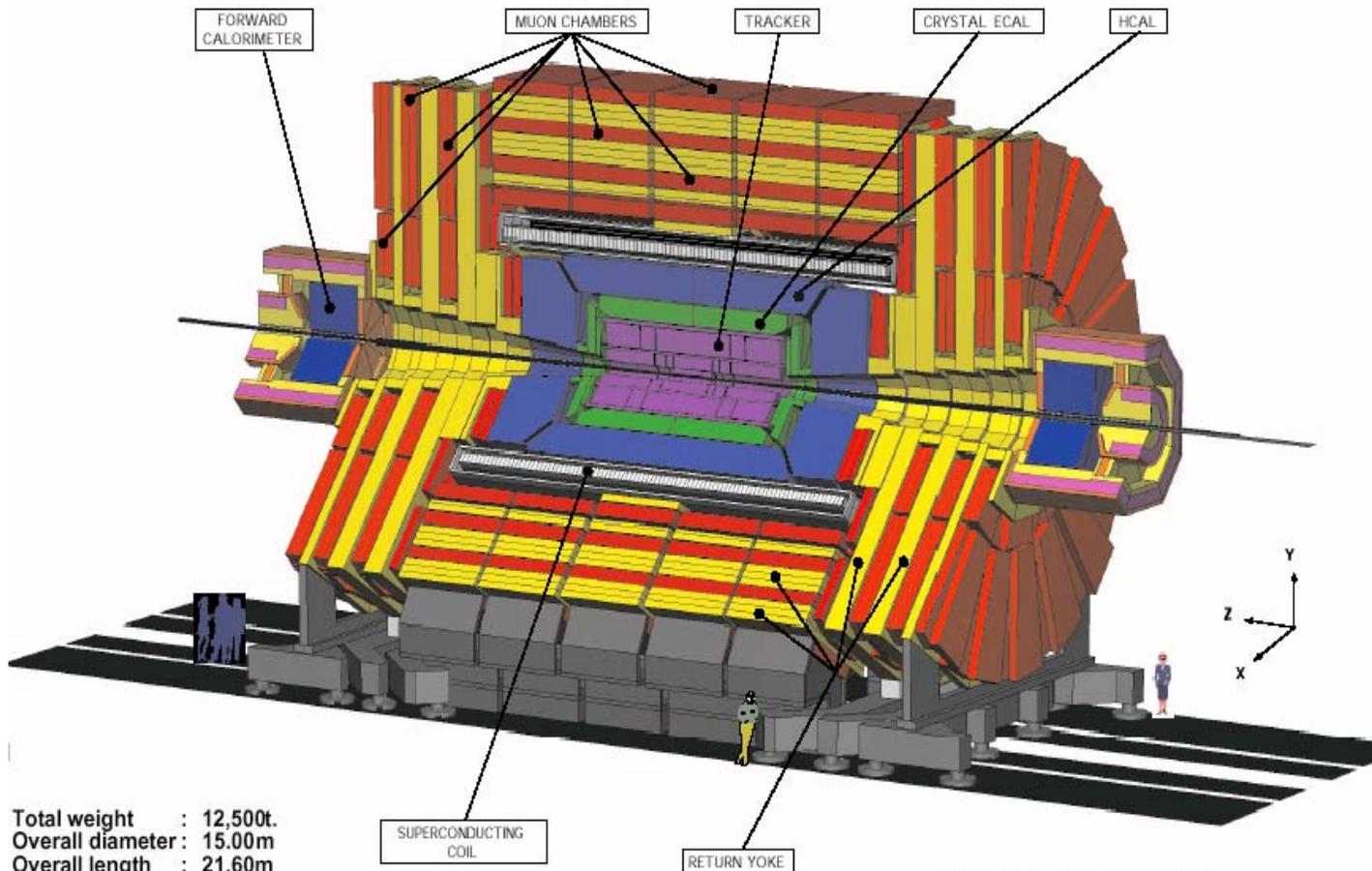
# Outline

- **Progress on Detector Construction**
- **Costs and Schedule**
- **SWC**
- **Physics in CMS and US CMS**



# Compact Muon Solenoid (CMS)

## CMS A Compact Solenoidal Detector for LHC



Total weight : 12,500t.  
Overall diameter : 15.00m  
Overall length : 21.60m  
Magnetic field : 4 Tesla

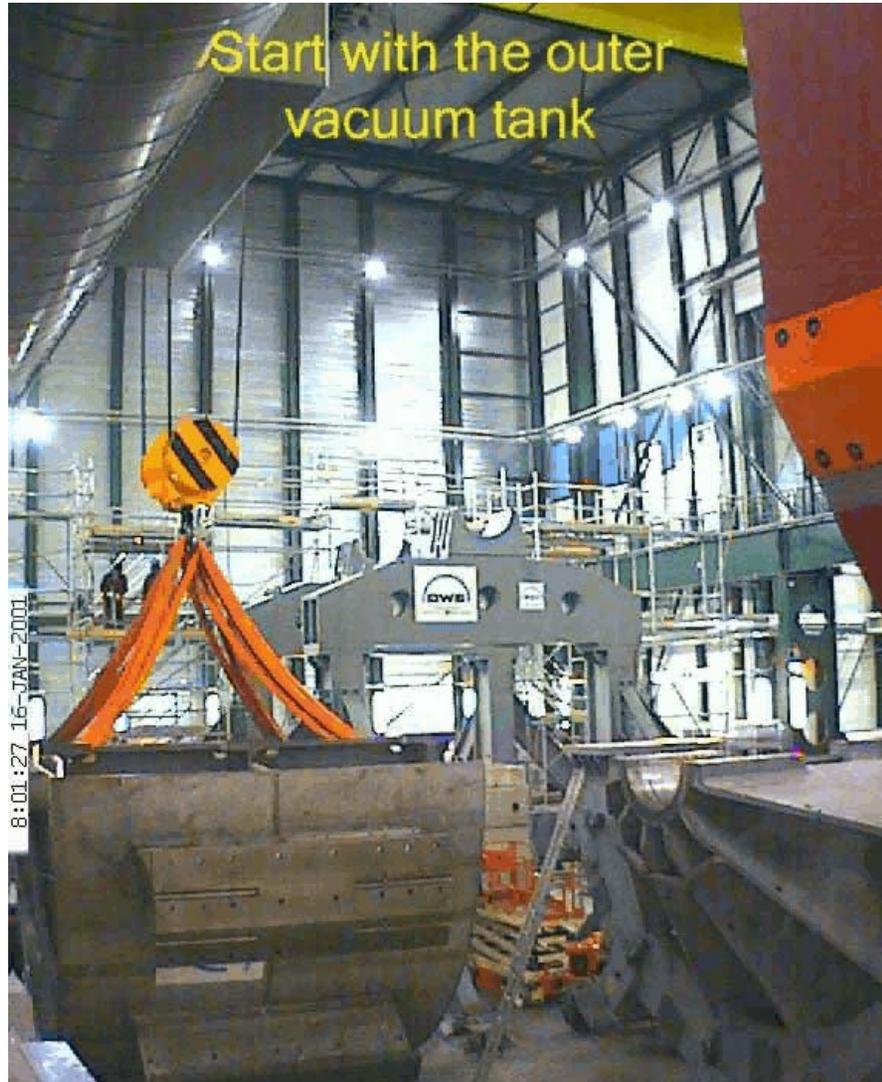
SUPERCONDUCTING COIL

RETURN YOKE

CMS-PARA-001-11/07/97 JLB,PP

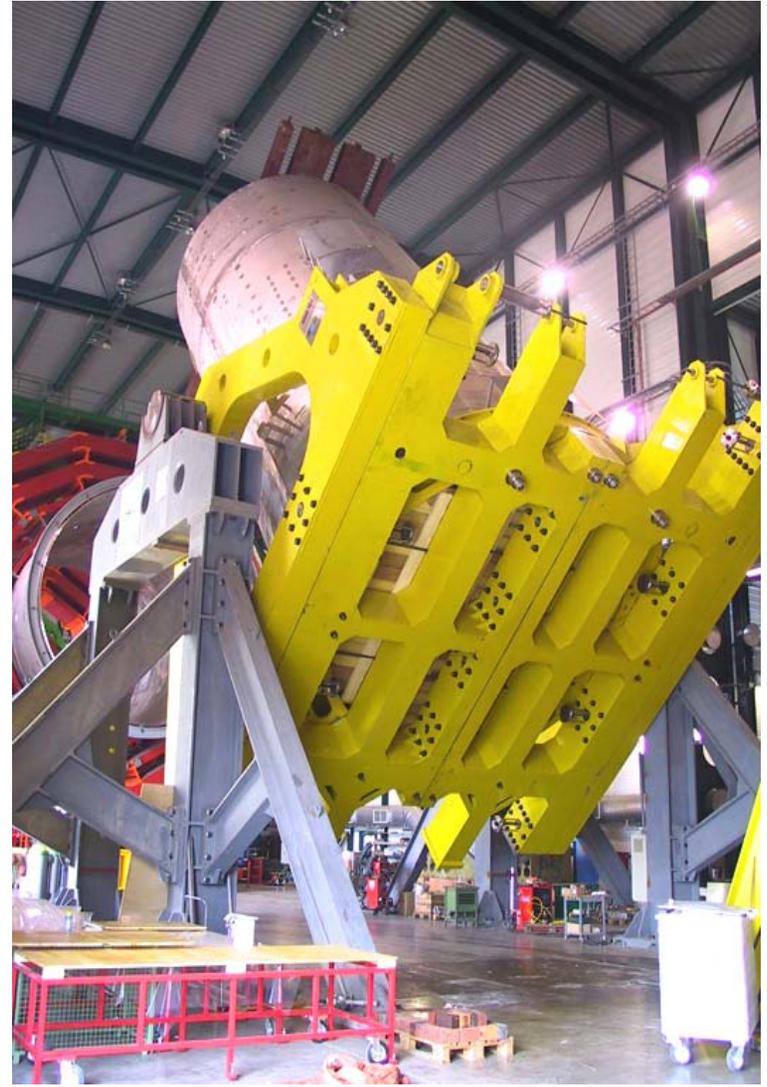


# Progress in SX5 - Webcam





# Test Coil Swiveling





# Coil Winding - Ansaldo



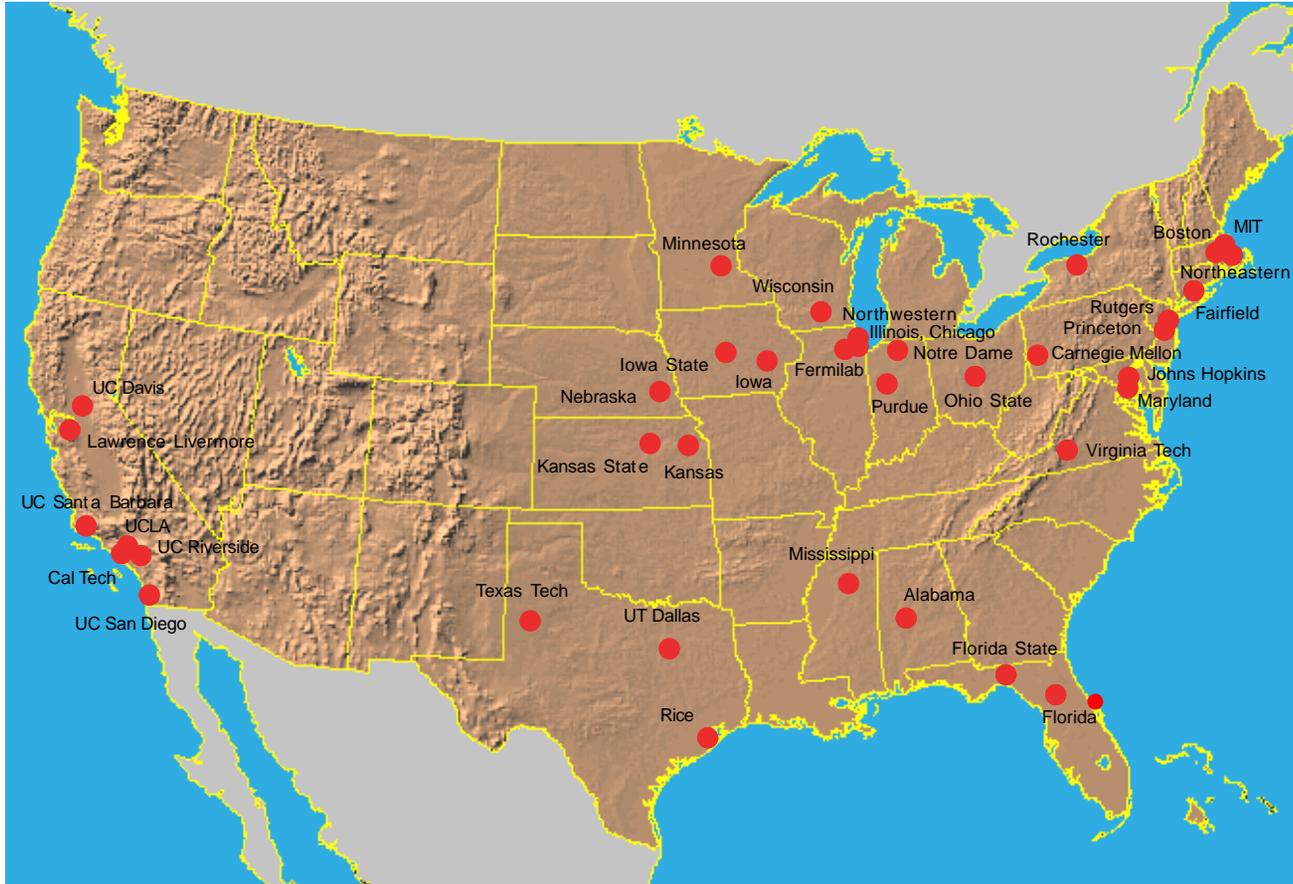
CB-2 winding is finished  
(photo taken during last layer winding)





# US CMS

## 387 Members from 38 Institutions



November 10, 2000

**New groups from FIT, FIU, and Yale.**

**Expect that FTE will double by 2007.**



# pp collisions at 14 TeV

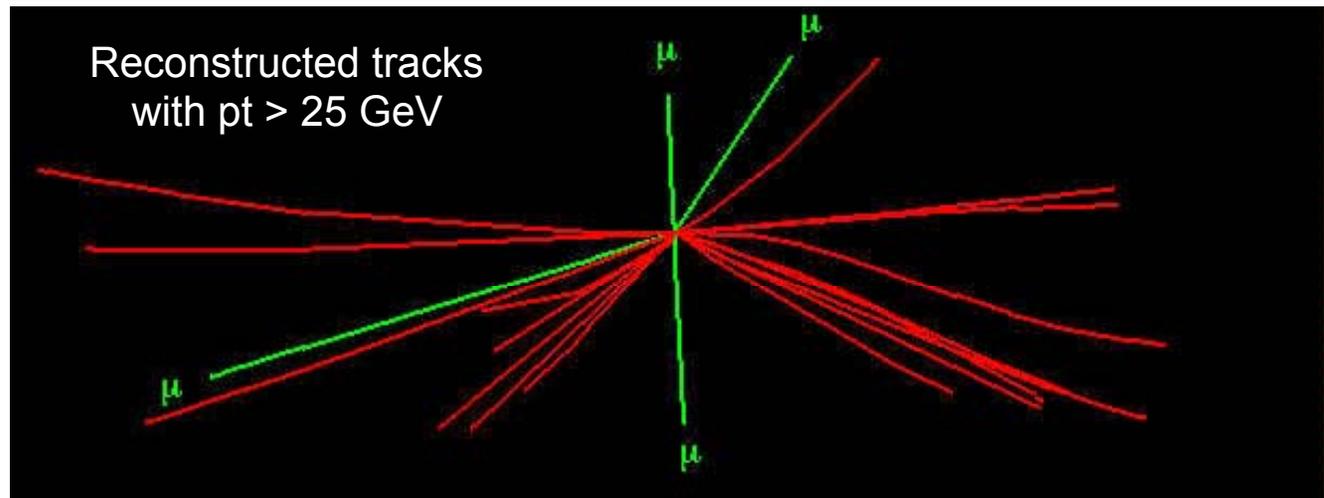
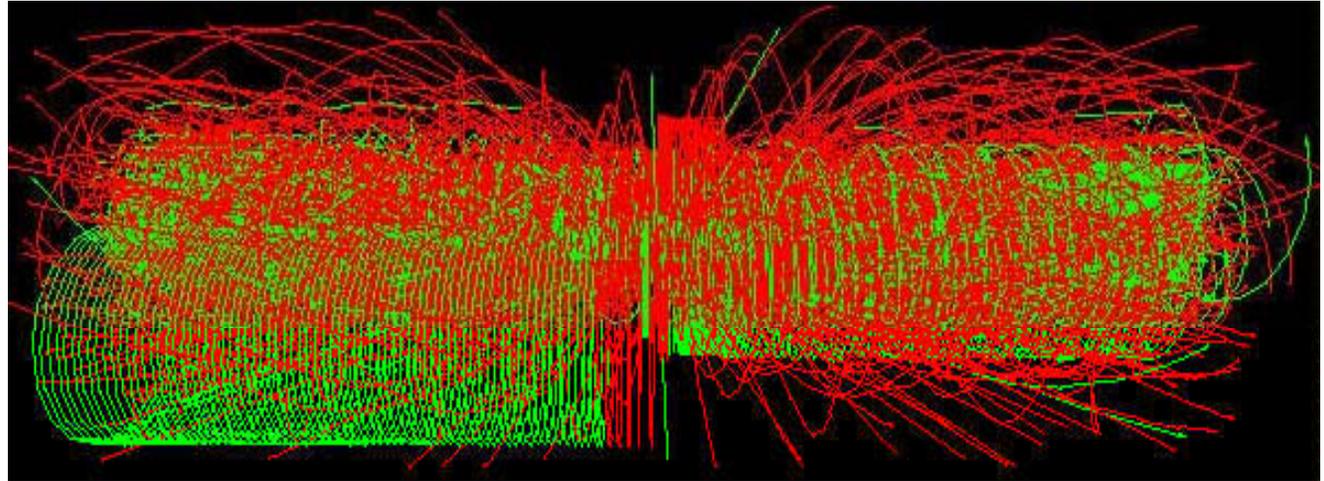
20 min  
bias  
events  
overlap

$H \rightarrow ZZ$

$Z \rightarrow \mu\mu$

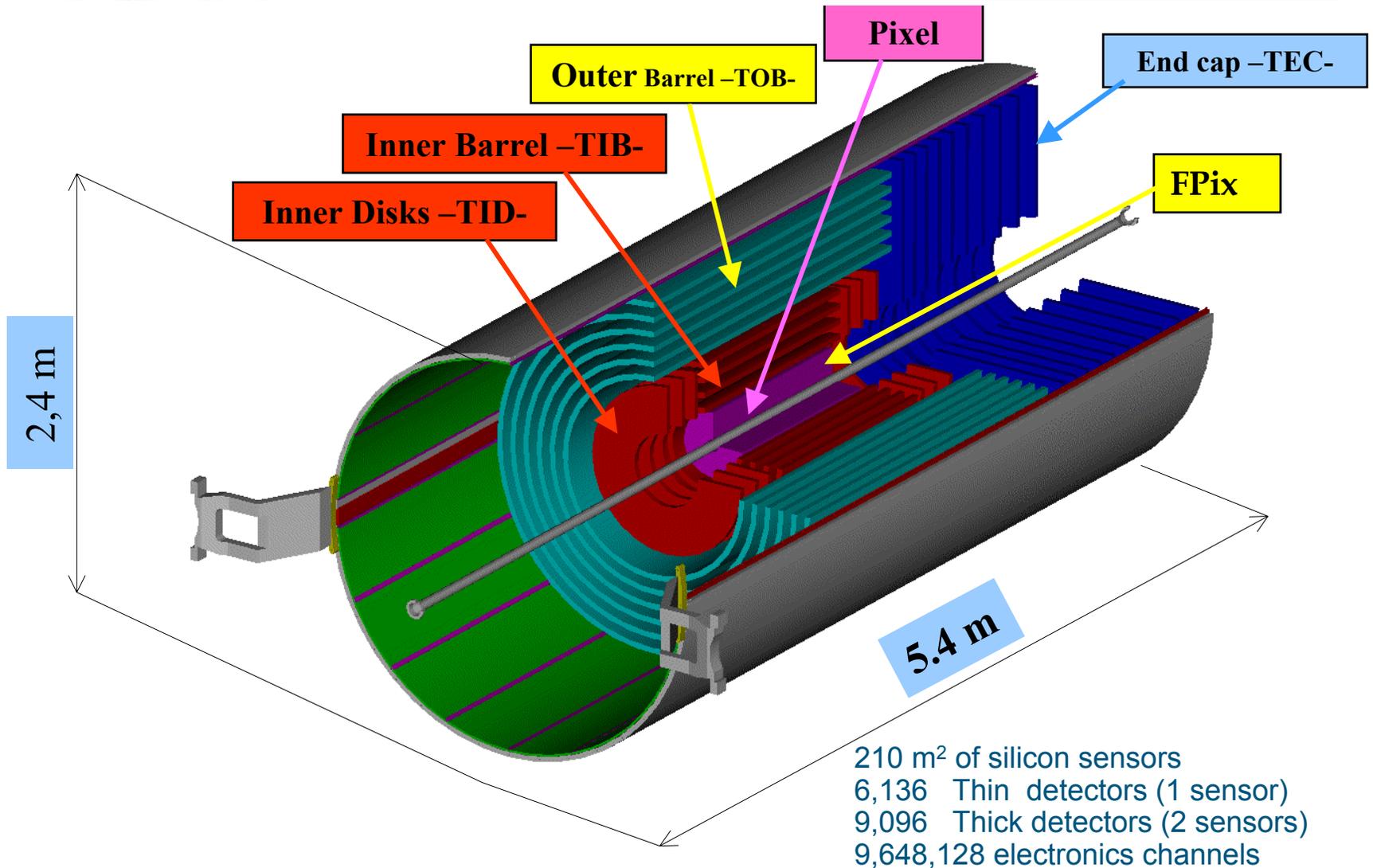
$H \rightarrow 4$   
muons

cleanest  
signature



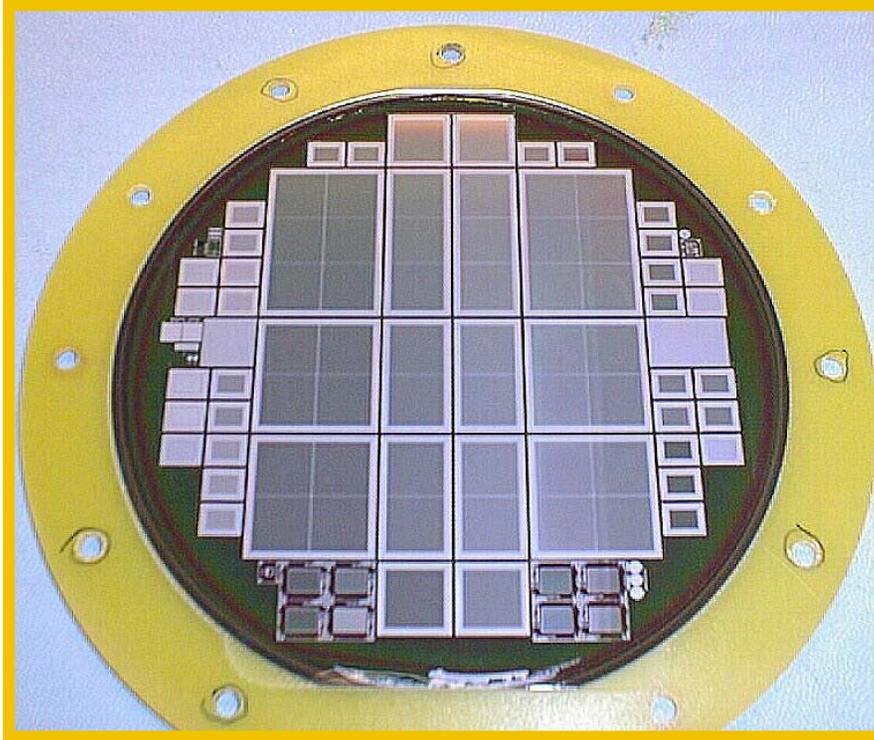


# CMS Inner Tracker





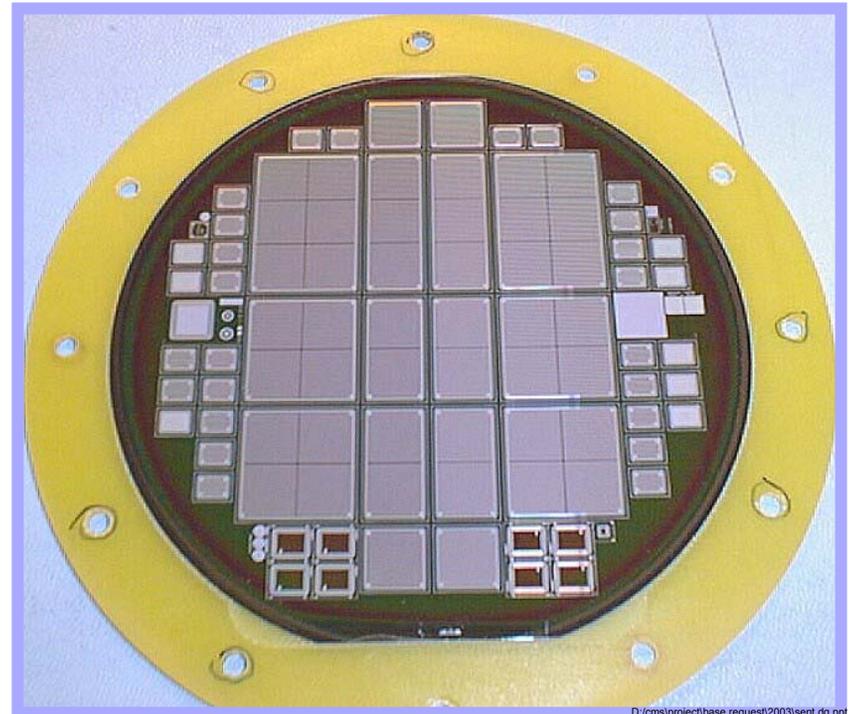
# Pixel Wafer Sensors



Wafer n-side

Second Submission  
SINTEF. Purdue

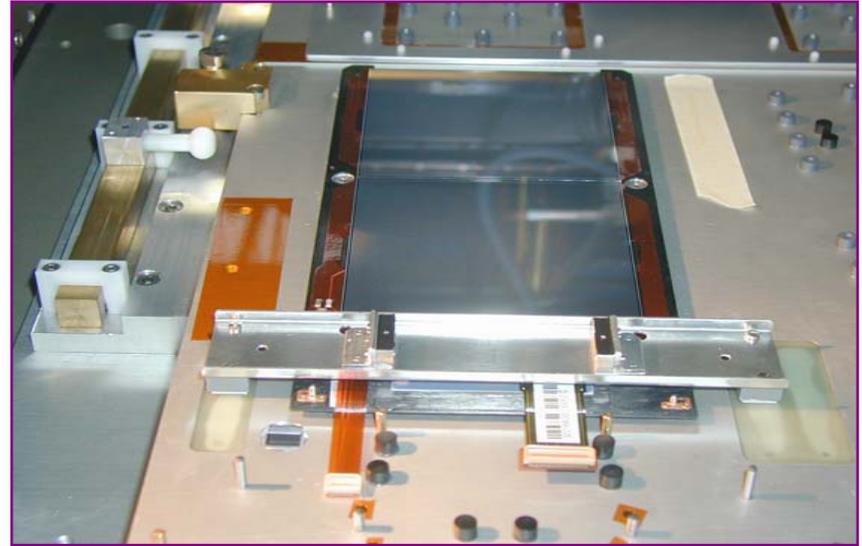
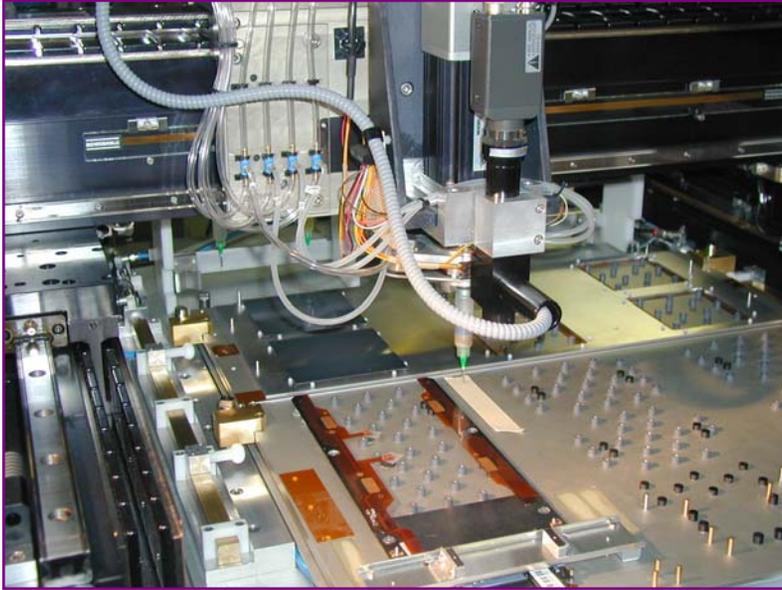
Wafer p-side



- 15 wafers delivered 06-12-02
- Tested at Purdue
- Irradiated at  $\Phi=10^{15}n_{eq}/cm^2$
- Testing of irradi. sensors has started



# Robotic Assembly at FNAL & UCSB



## FNAL pick and place gantry

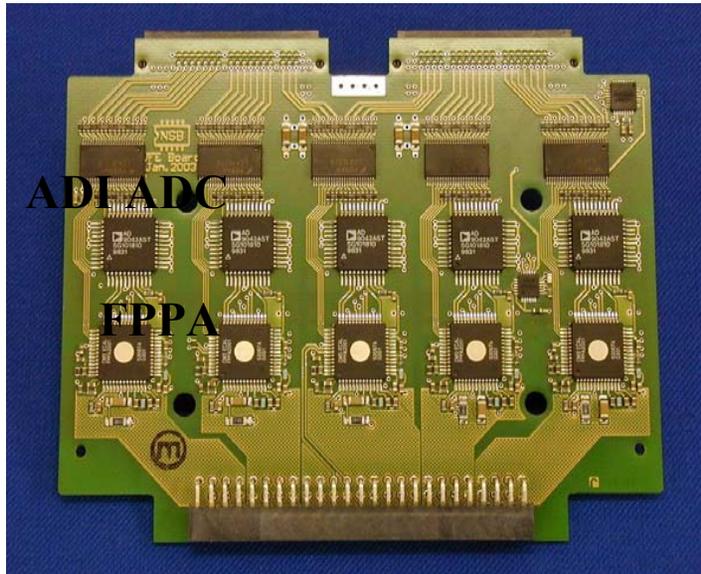
- Fully qualified for production
- Starting first modules now at FNAL.



# ECAL - Electronics Status

## VFE Electronics Baseline:

- FPPA returned from Fabrication and meets Specification
- 1 Wafer tested at LBL, 6 Wafers sent for Packaging – now in Lyon
- **Tests show that FPPA Meets Specification**
  - Noise 25% too high (traced back to low  $\beta$  of BiCMOS process)
  - Yield ? Needs more statistics
- **New VFE Board (FPPA) ready for tests**



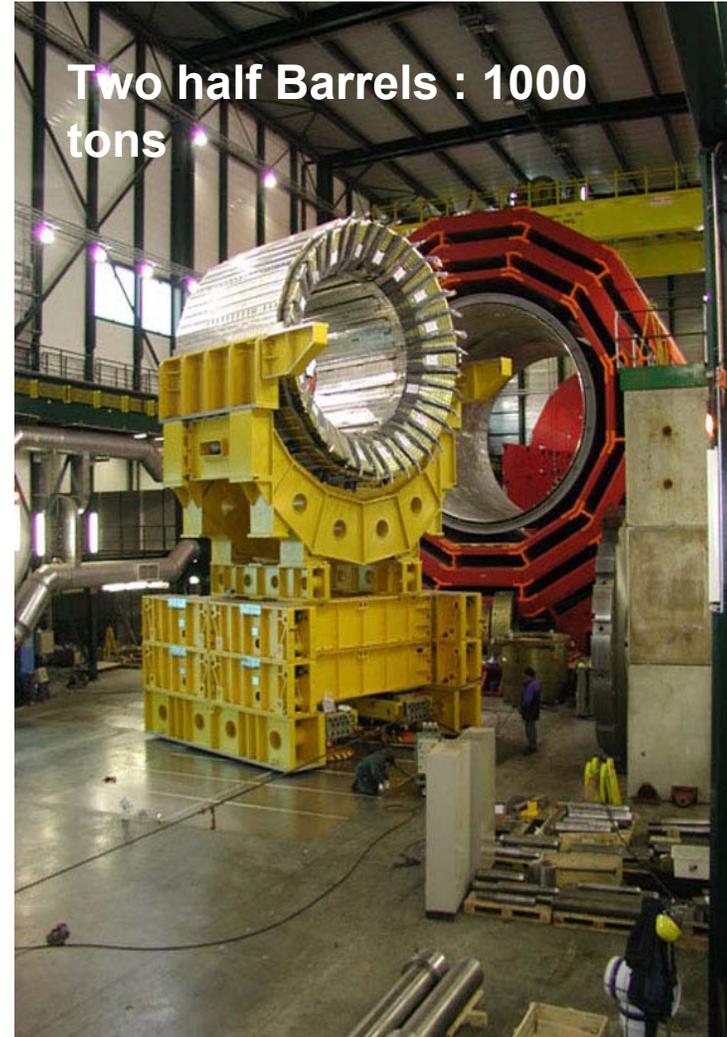
US CMS does laser monitoring, APD, optical links (tracker) and FE testing (FNAL, Yarema).



# HCAL – US CMS Does Electronics, HB



Each EndCap 300  
tons



Two half Barrels : 1000  
tons



# US CMS Does Endcap CSC



US CMS is scheduled to deliver chambers in 2003. They will need to be operated and tested. This situation leads to the plan for “slice tests”. They consist of data readout of the detector operated with a portable Trigger and DAQ in SX5.

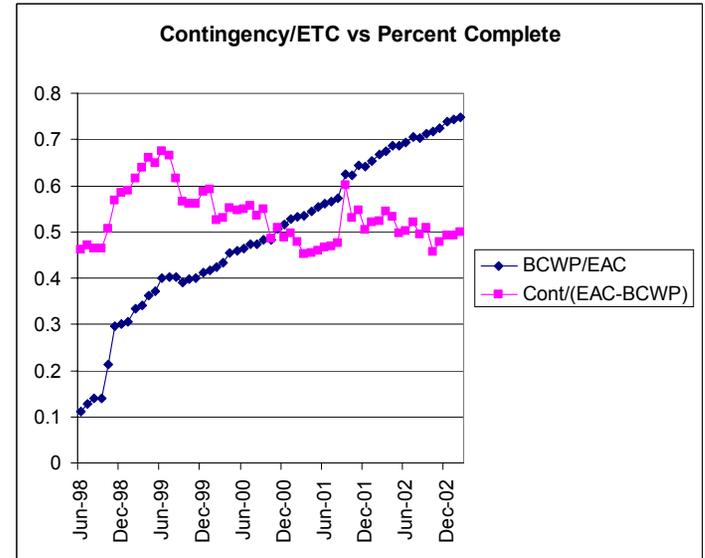
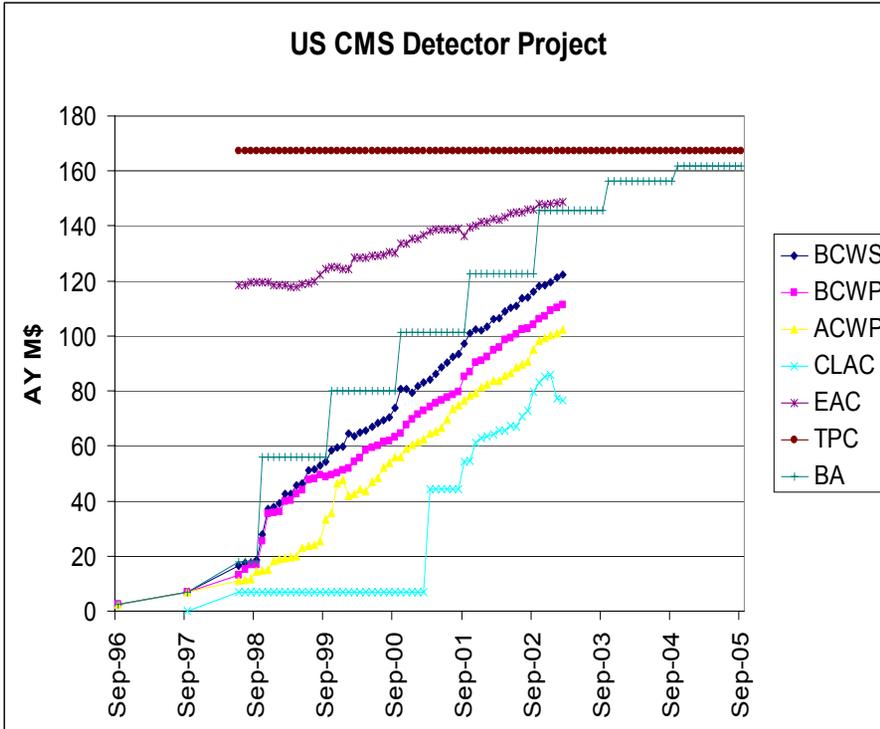


# US CMS L2 Subsystems

- **The L1 Calorimeter and ME – CSC trigger.**
- **The first of 8 independent DAQ sectors. Use in early testing – tie in to slice tests.**
- **The complete Forward pixel system.**



# FNAL – Host Lab, PO

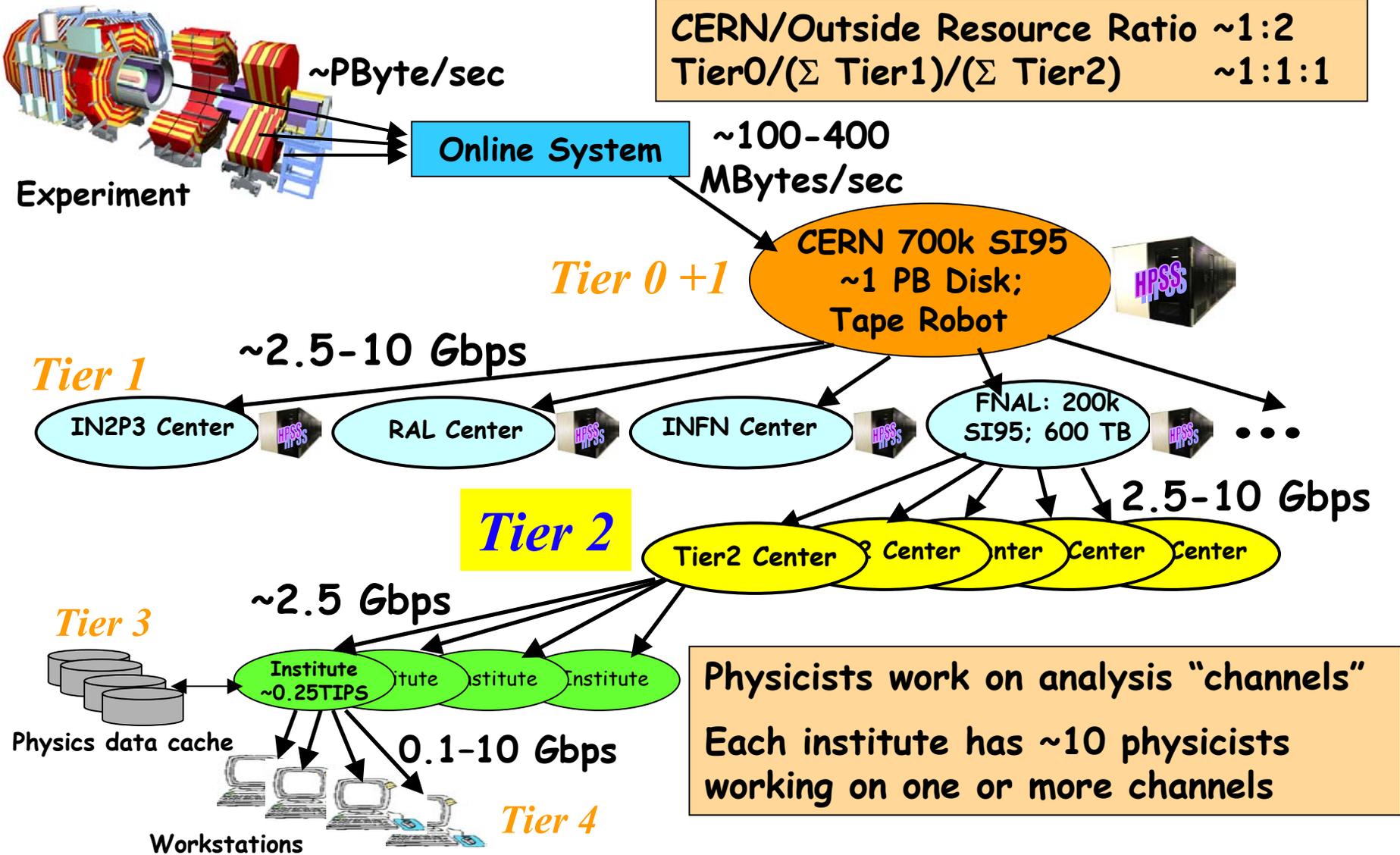


**We will complete ~ 97 % of US CMS by end of FY05.  
Struggle to retain ~ 50% contingency.**





# US CMS – Tier 1 at FNAL



CERN/Outside Resource Ratio  $\sim$ 1:2  
 Tier0/( $\Sigma$  Tier1)/( $\Sigma$  Tier2)  $\sim$ 1:1:1

Physicists work on analysis "channels"  
 Each institute has  $\sim$ 10 physicists working on one or more channels



# Higgs @ LHC Startup

## Example Discovery Reach ( $5\sigma$ ): ATLAS +CMS

At  $L_0=10^{33} \text{ cm}^{-2}\text{s}^{-1}$ :

1 day  $\sim 25 \text{ pb}^{-1}$

1 month  $\sim 0.7 \text{ fb}^{-1}$

At  $L_0= 3 \cdot 10^{33} \text{ cm}^{-2}\text{s}^{-1}$ :

1 day  $\sim 75 \text{ pb}^{-1}$

1 month  $\sim 2 \text{ fb}^{-1}$

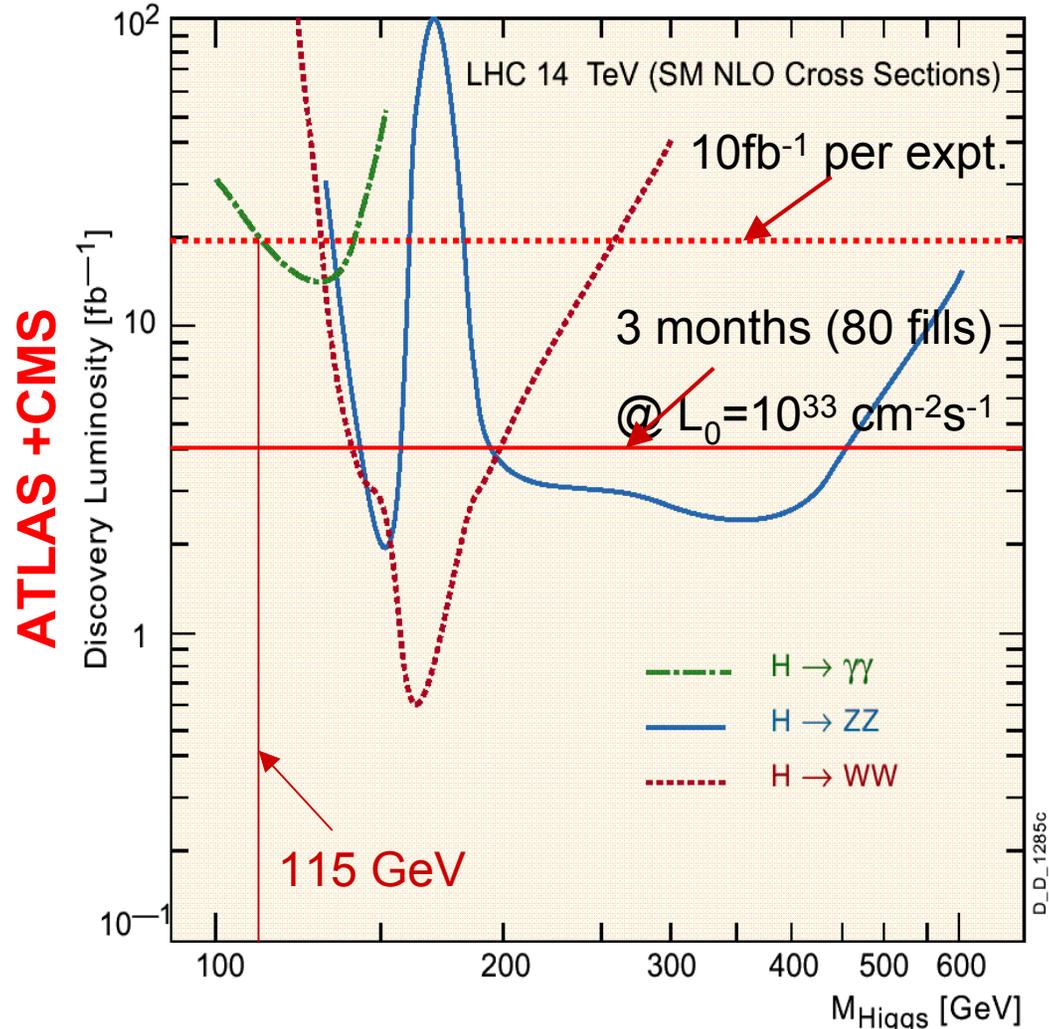
### Assumptions

14hr run and 10hr to refill

i.e. 1 fill/day

$\tau_L \sim 20 \text{ hr}$

Efficiency of 2/3

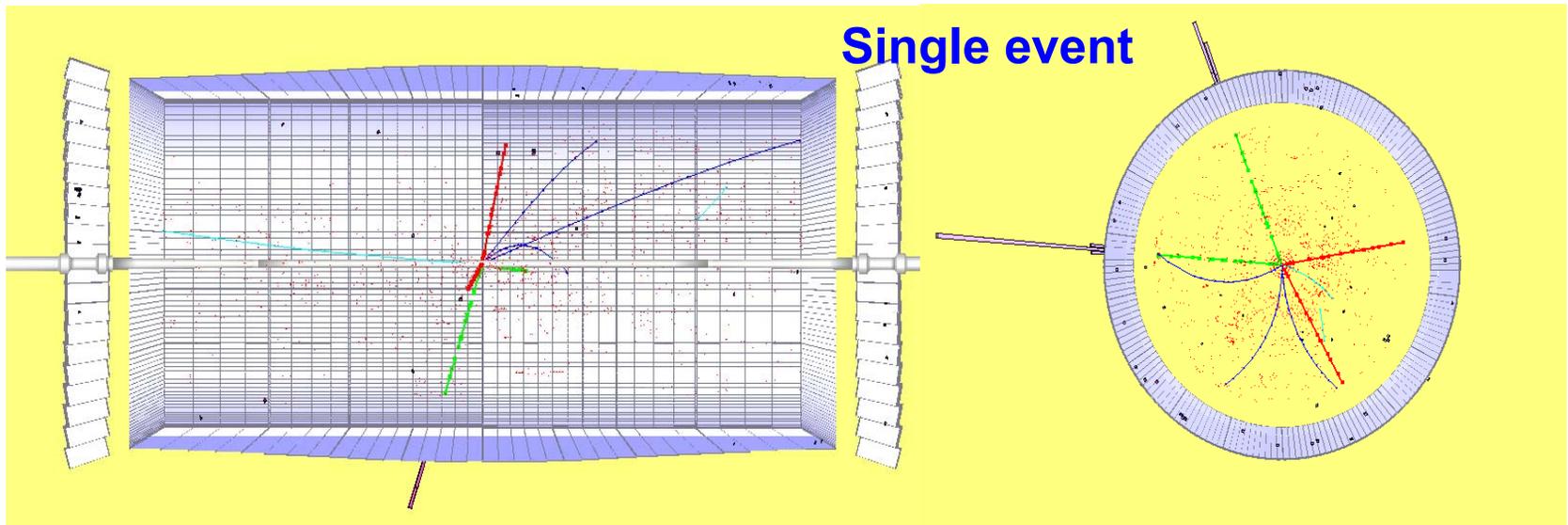




# CMS: $H \rightarrow ZZ \rightarrow 2e 2\mu$

At nominal proton intensity/bunch ( $1.1 \times 10^{11}$  p) and nominal  $\beta^*$  we get  
~ 20 pileup events/crossing superposed on the one of interest

For initial physics data taking ATLAS and CMS wish to operate in  
conditions with  $< 2$  pileup events/crossing

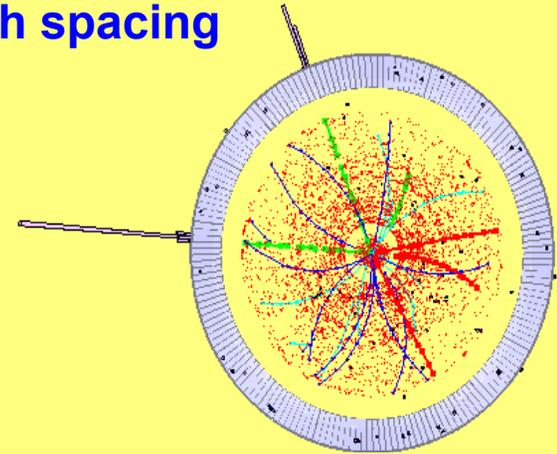
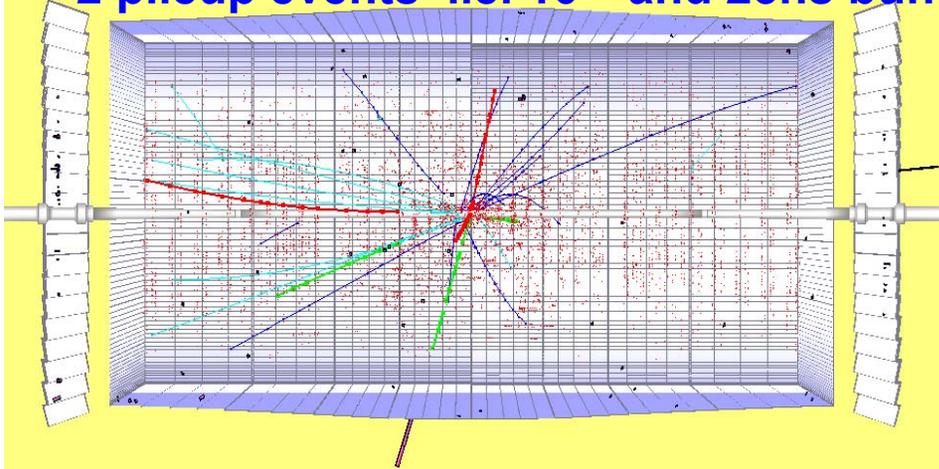


Only tracks with  $p_T > 2$  GeV are shown

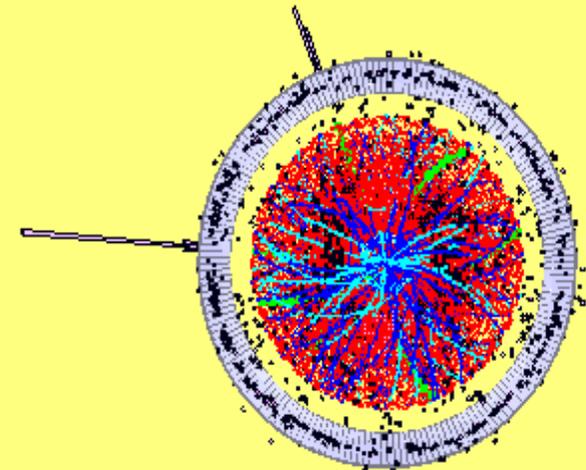
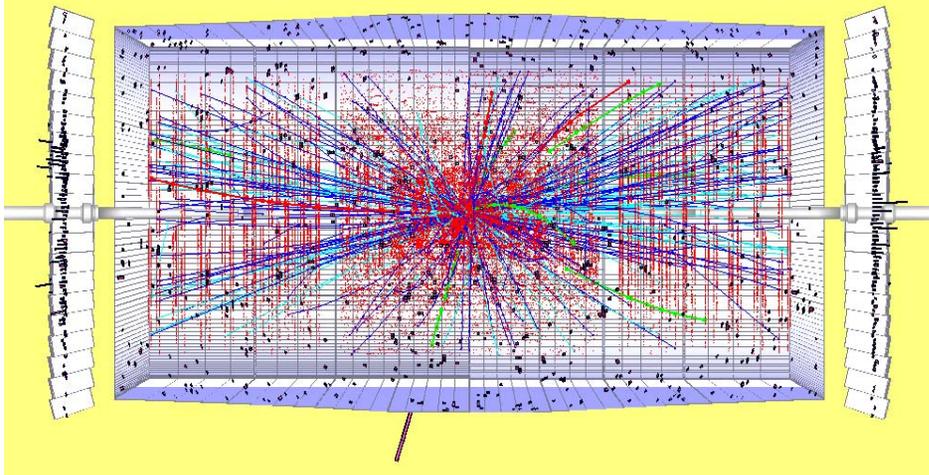


# CMS: $H \rightarrow ZZ \rightarrow 2e 2\mu$

+ 2 pileup events i.e.  $10^{33}$  and 25ns bunch spacing

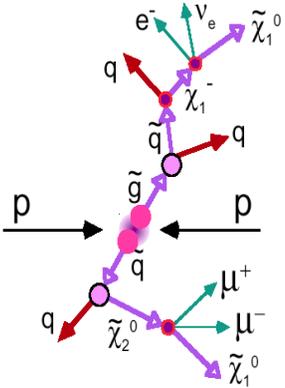


+ 20 pileup events i.e.  $10^{34}$  and 25ns bunch spacing



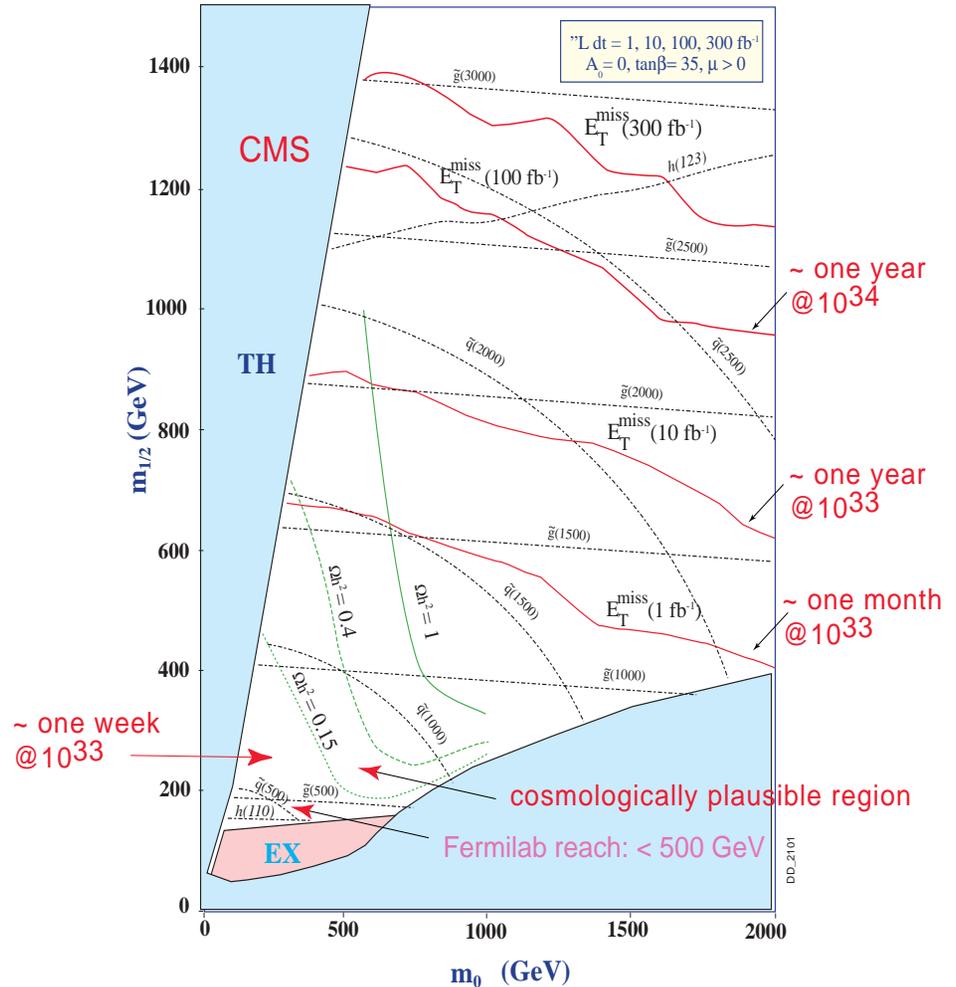
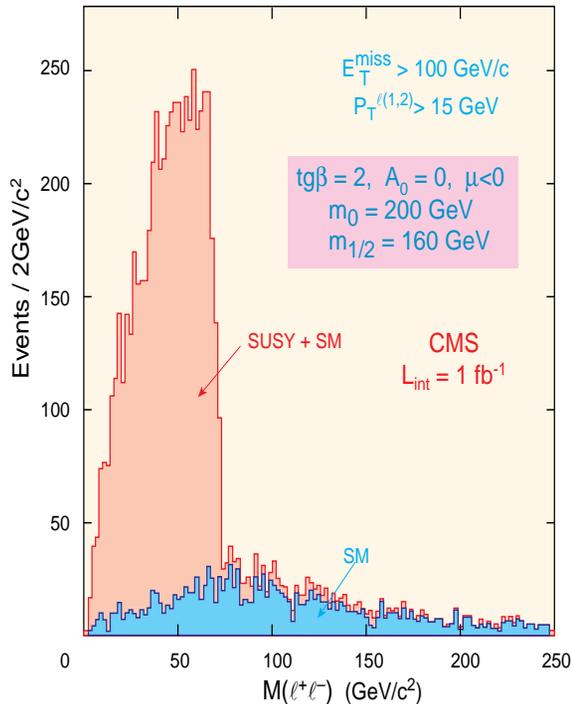


# Discovering SUSY @ LHC Startup



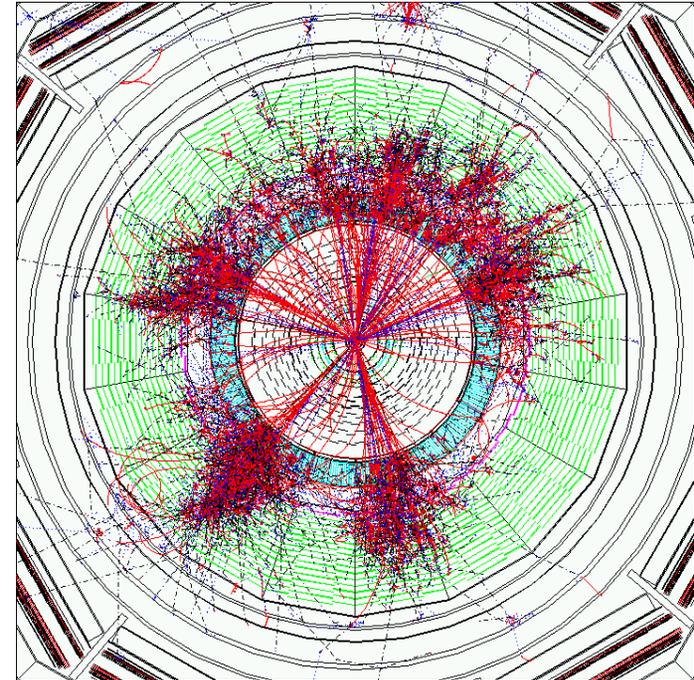
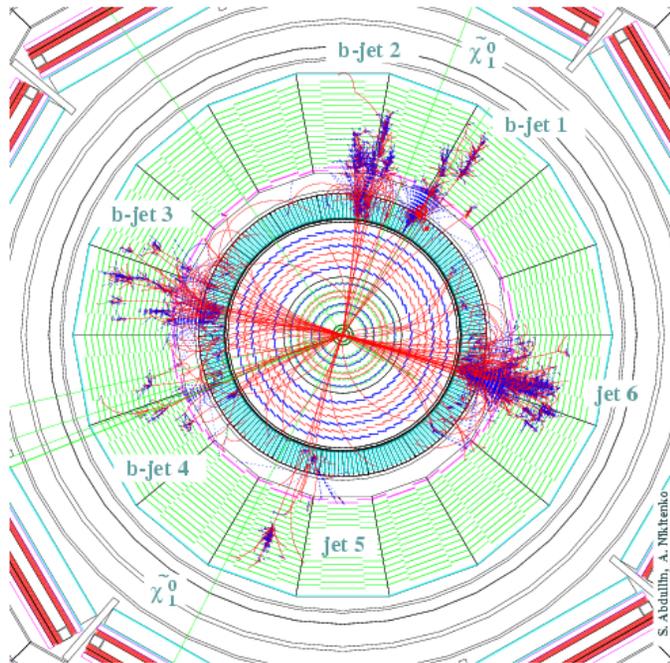
Will find  
SUSY quickly  
if it is there

CMS  $\tilde{q}, \tilde{g}$  mass reach in  $E_T^{\text{miss}} + \text{jets}$  inclusive channel for various integrated luminosities





# Squark Cascade



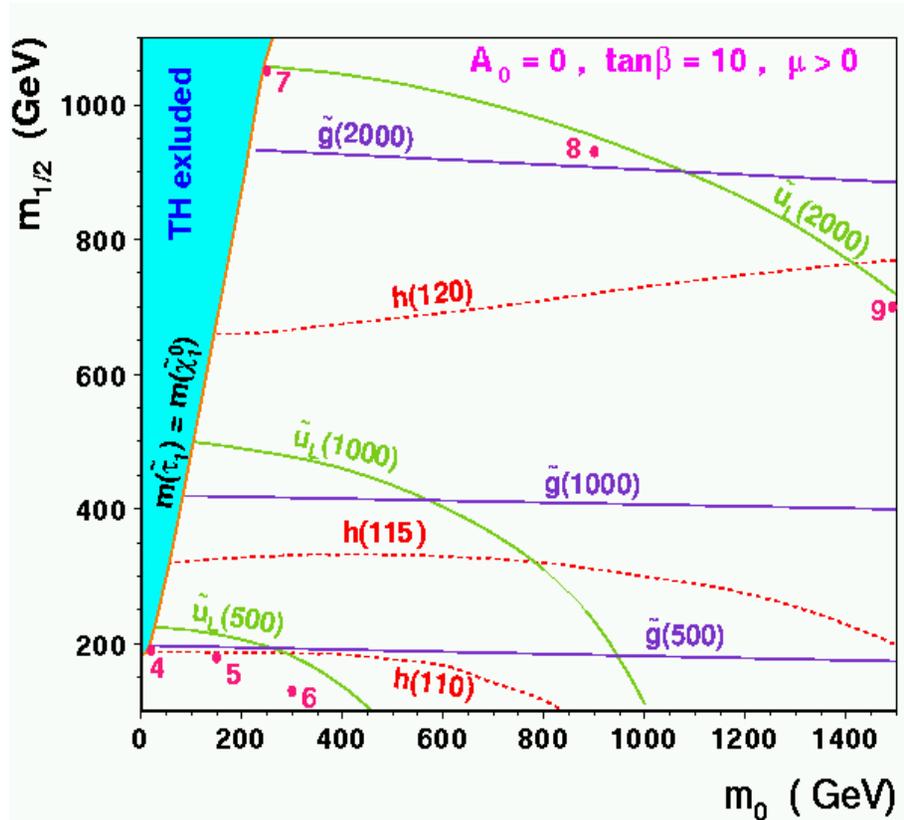
**Work by US led group – the jet and missing energy group. R parity?**

**Work now shifts from HLT (DAQ TDR) to DC04 and Physics TDR.**



# SUSY – HLT at Low L

MSUGRA with  $A_0=0$ ,  $\tan(\beta)=10$ , and  $\mu>0$



**Low lum: points near Tevatron reach used for low lum optimization (trigger tables)**

**High lum: points near LHC reach used for high lum optimization**

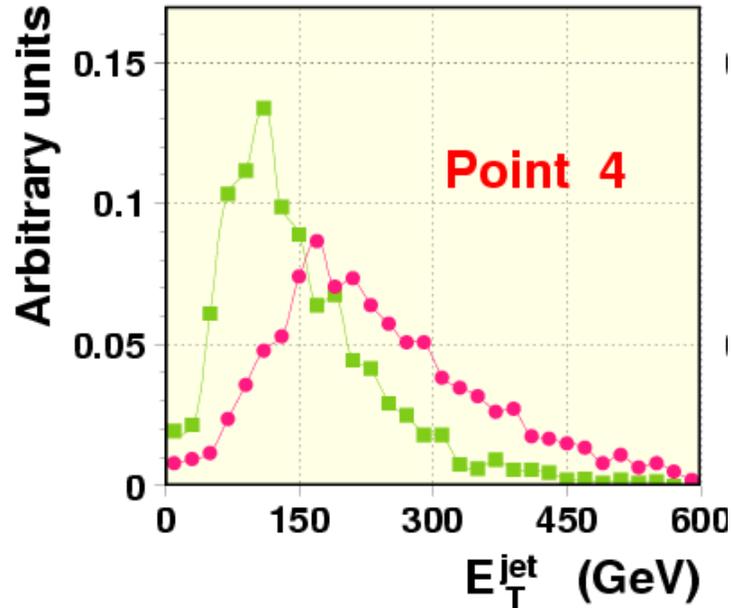


# SUSY: Low L Level 1

With just two triggers

1 jet  $> 130$  GeV

3 jets  $> 60$  GeV



We can have efficiencies of **0.89, 0.90, 0.81, 0.94, 0.95, 0.88** for points 4,5,6,4R,4R,6R (total efficiency, not with respect to offline cuts) and a rate to tape of **2 kHz**.

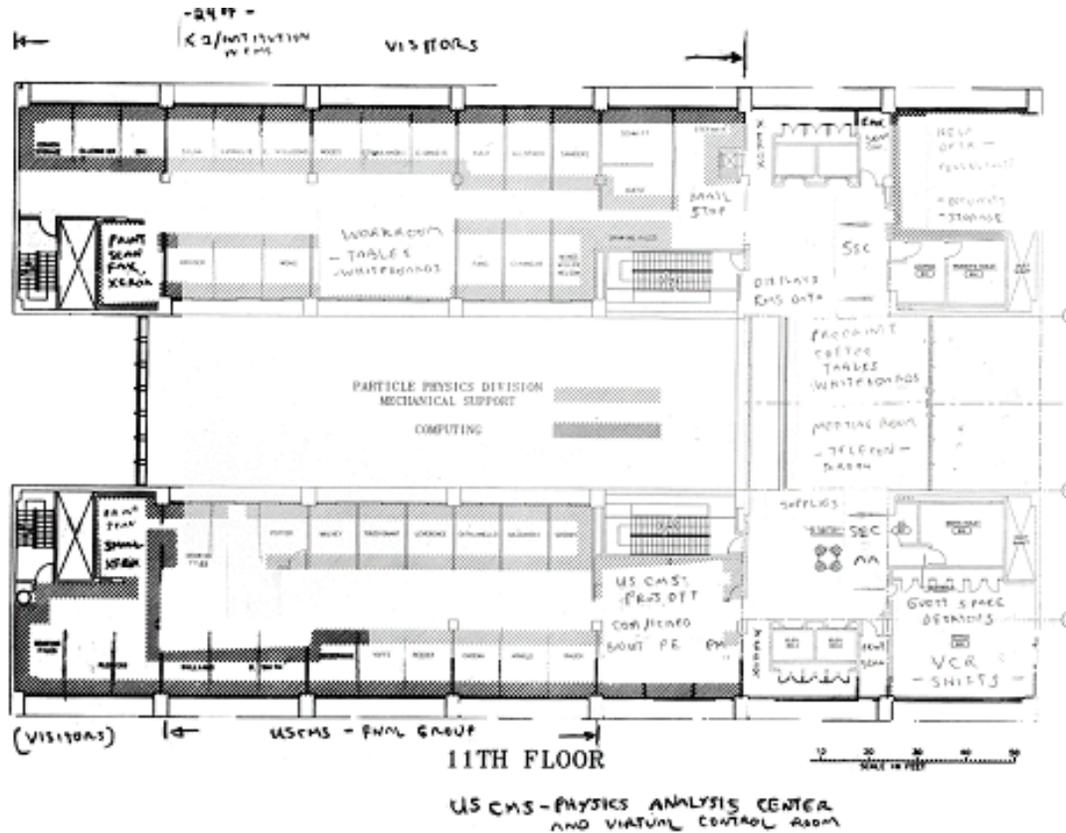


# US CMS Physics

- We have DC starting in 2004. Now setting up to generate 50 M events.
- We plan for first Physics in 2007 – only 4 years to get ready
- There is US leadership in muon reco and Jets/MissEt groups.
- We plan a Physics Analysis Center at FNAL and at a few other locations (Tier 2 ?).



# The VCR and PAC on WH11



Fermilab proposes to use GPP funds to set up US CMS in WH11. The US CMS groups strongly support this initiative because it saves them travel time and money and creates a critical mass of physicists who will be doing analysis - but we must start.

Need space, access to Computing Division, theorists, seminars, other experimenters, PO, VCR



# Summary

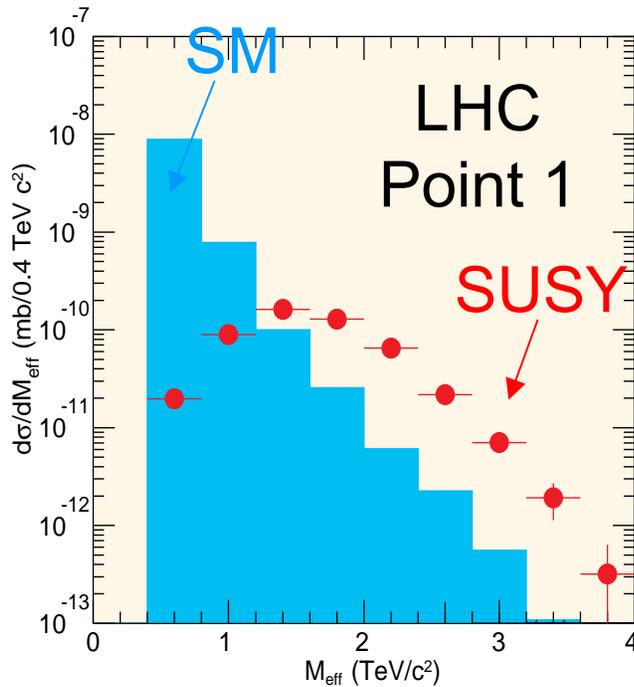
- **Detector Construction is on budget and on schedule to ~ complete in 2005.**
- **We will commission in SX5 in slice tests so as to minimize the time to get to the Physics.**
- **The core software is being deployed for a series of Data Challenges.**
- **In synch with the DC, US groups are planning a ramp up of PACs in the US. We must be ready from the start of LHC beam.**



# SUSY mass scale

Events with  $\geq 4\text{jets} + E_T^{\text{miss}}$   $M_{\text{eff}} = \sum_{j=1}^4 P_{T,j} + E_T^{\text{miss}}$

- Clean: S/B~10 at high  $M_{\text{eff}}$
- Establish SUSY scale ( $\sigma \approx 20\%$ )



Effective mass “tracks”  
SUSY scale well

