CMS Status and Plans

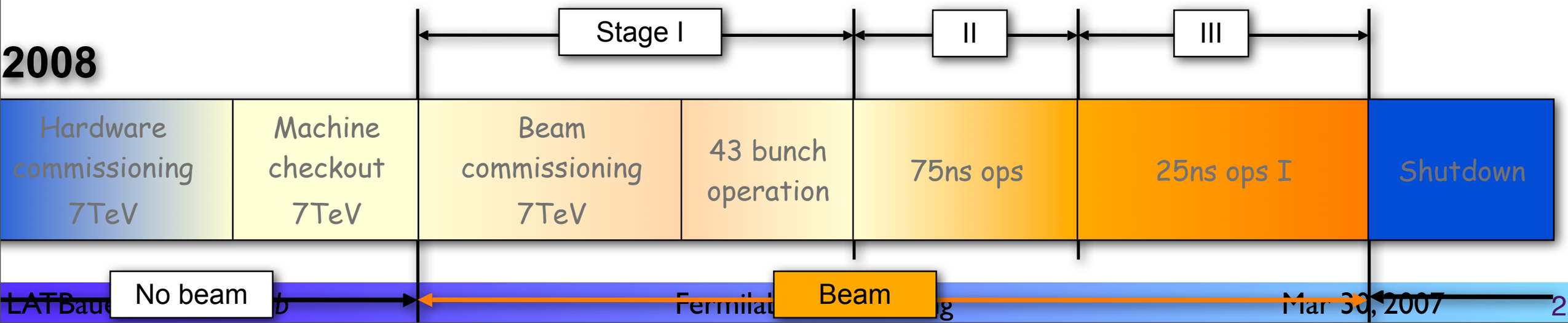
Progress on
CMS Installation and Commissioning,
Offline and Computing,
USCMS Research Program, LPC and CMS Center

LATBauerdick/Fermilab

Fermilab PAC Meeting March 30, 2007

LHC Schedule

- March 2007 — Last LHC Dipole Installed
- Aug 31st, 2007 — Machine and experiments closed
  - ★ CMS preferred schedule v35.3 has BP closed/baked out by Oct 15
- Nov 2007 — Pilot Engineering Run
  - ★ Multiple bunches (43) in each ring, injection optics (β*= 11 m in IR 1 & 5)
  - ★ No squeeze, no crossing angle, experiment magnets off at the start
  - ★ First Collisions, for a few fills
  - ★ Secondary goals: commission ramp to 1TeV, crossing angle, 75ns beams
- April 2008 — Pilot physics Run
  - ★ first collisions at 14 TeV, 75ns commissioning down to 25ns,



CMS Reference Data

- ★ June 2008 Collisions at 14 TeV
- ★ April 2008 Close for 14 TeV physics run
- ★ Nov 2007 Collisions at 900 GeV
- ★ 30 Aug 07 Beam-pipe closed
- ★ 16 Jul 07 Commissioned Tracker Ready for Installation
- ★ 30 Mar 07 >50% of detector lowered, HB+ and HB- installed in YB0

✦ Prospects for Integrated Luminosity

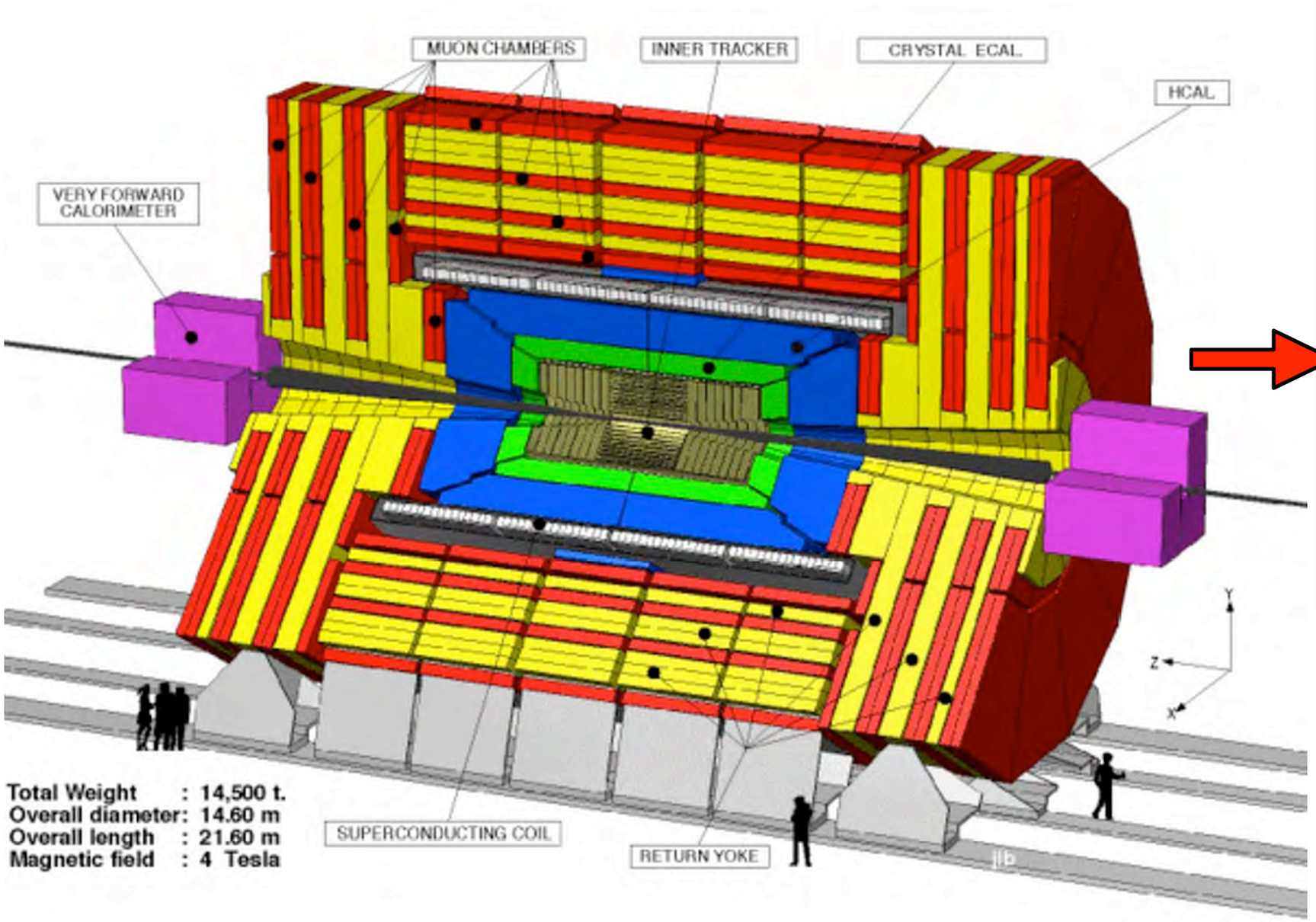
- ★ 2008 1 fb^{-1}
- ★ 2009 5 fb^{-1}

✦ CMS objectives

- ★ 900 GeV Collisions - Nov 2007
  - ✦ initial CMS detector (no ECAL Endcaps, pixels) ready to take data
  - ✦ commission and operate detector, and prepare collab for data taking and analysis
- ★ 14 TeV Collisions - June 2008
  - ✦ low lumi detector commissioned and ready for efficient physics data taking, collaboration trained and ready for analysis of data at 14 TeV

Putting Together CMS Underground

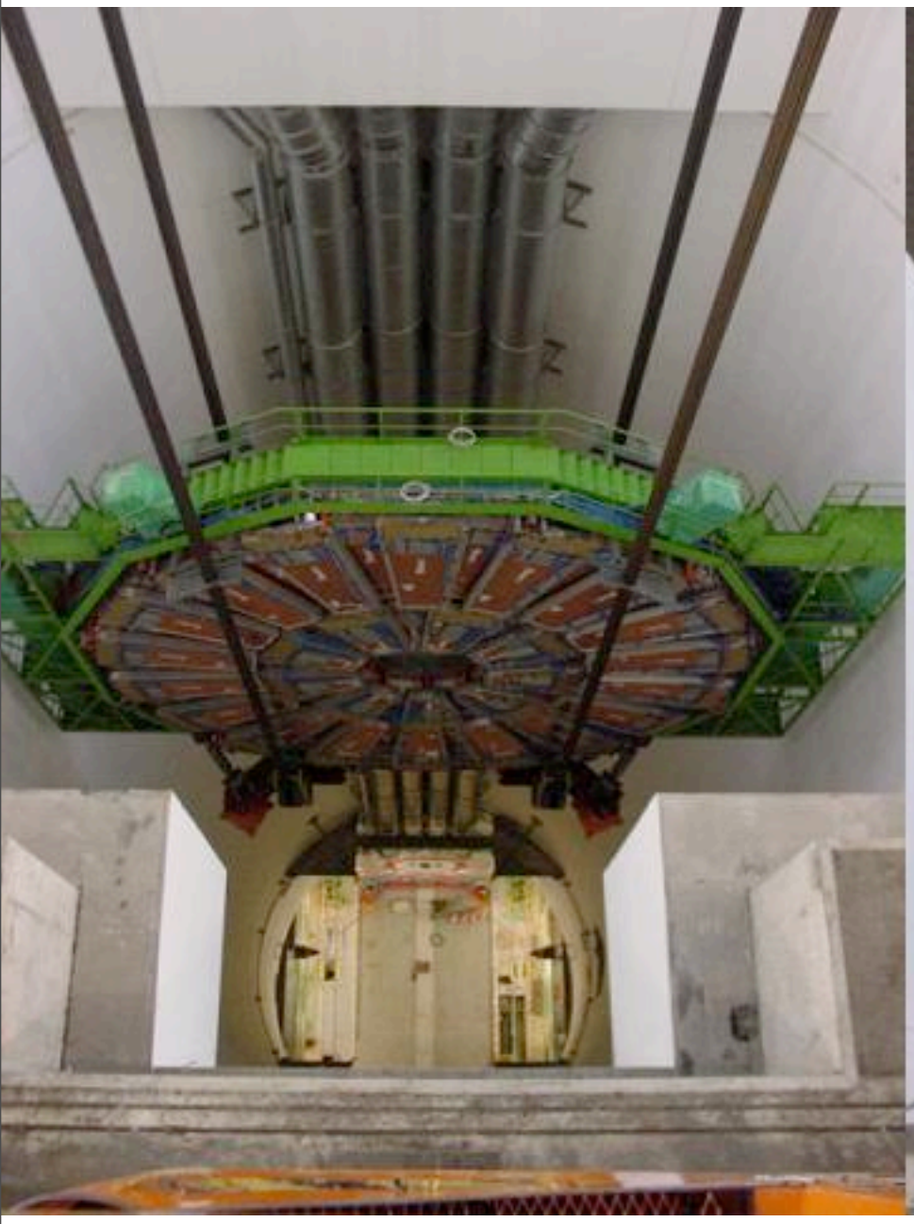
- *Assembling CMS in the underground cavern out of 15 huge pieces*
  - ★ biggest central slice YB0 w/ coil cryostat ~ 2000t



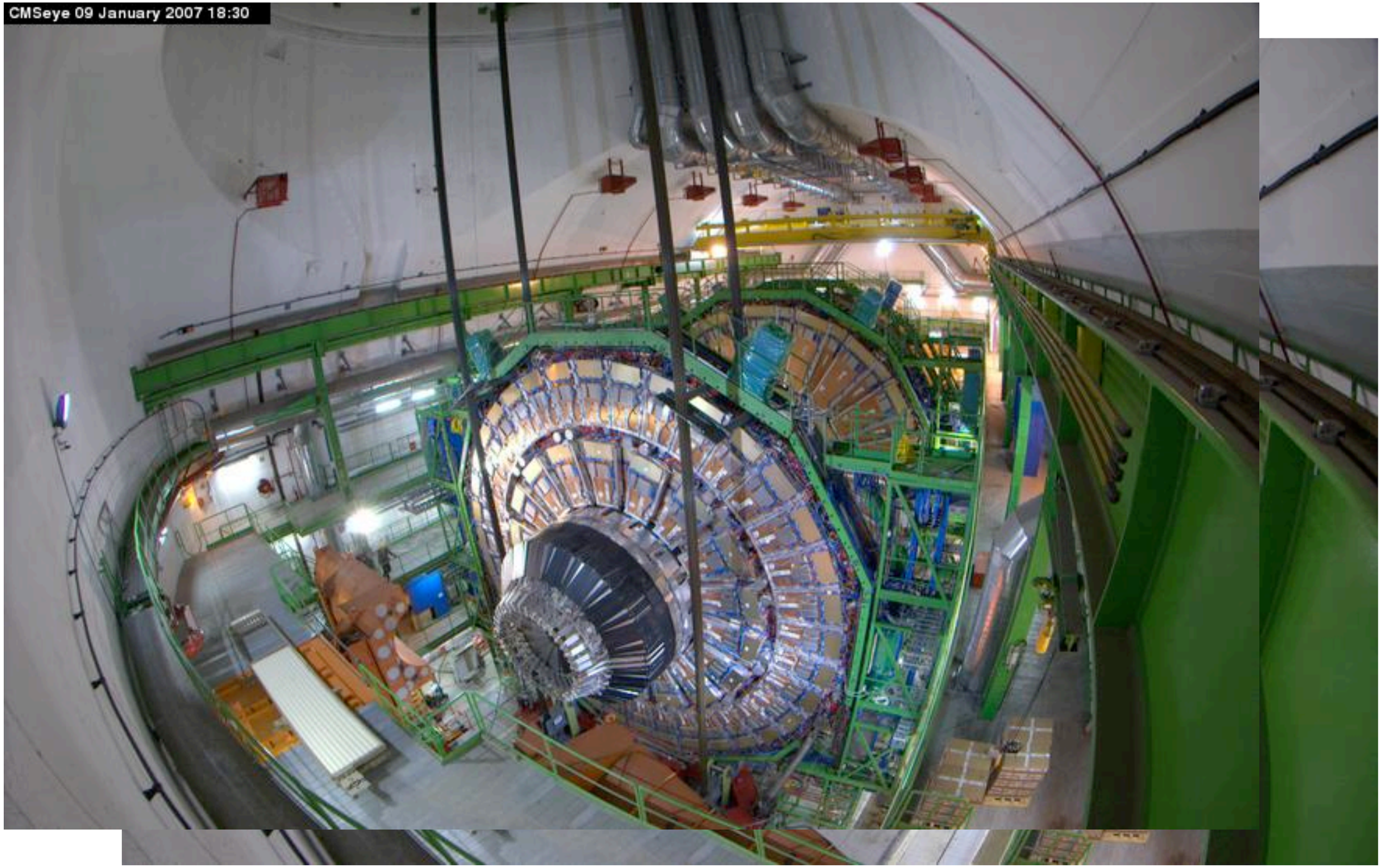
Section	CMS Designation	Weight in tonnes
1	HF+	250
2	YE+3	410
3	YE+2	880
4	YE+1	1310
5	YB+2	1250
6	YB+1	1250
7	HB+	700
8	YB0	1920
9	HB-	700
10	YB-1	1250
11	YB-2	1250
12	YE-1	1310
13	YE-2	880
14	YE-3	410
15	HF-	250

December 2006: HF+
First piece of CMS landing in Cavern

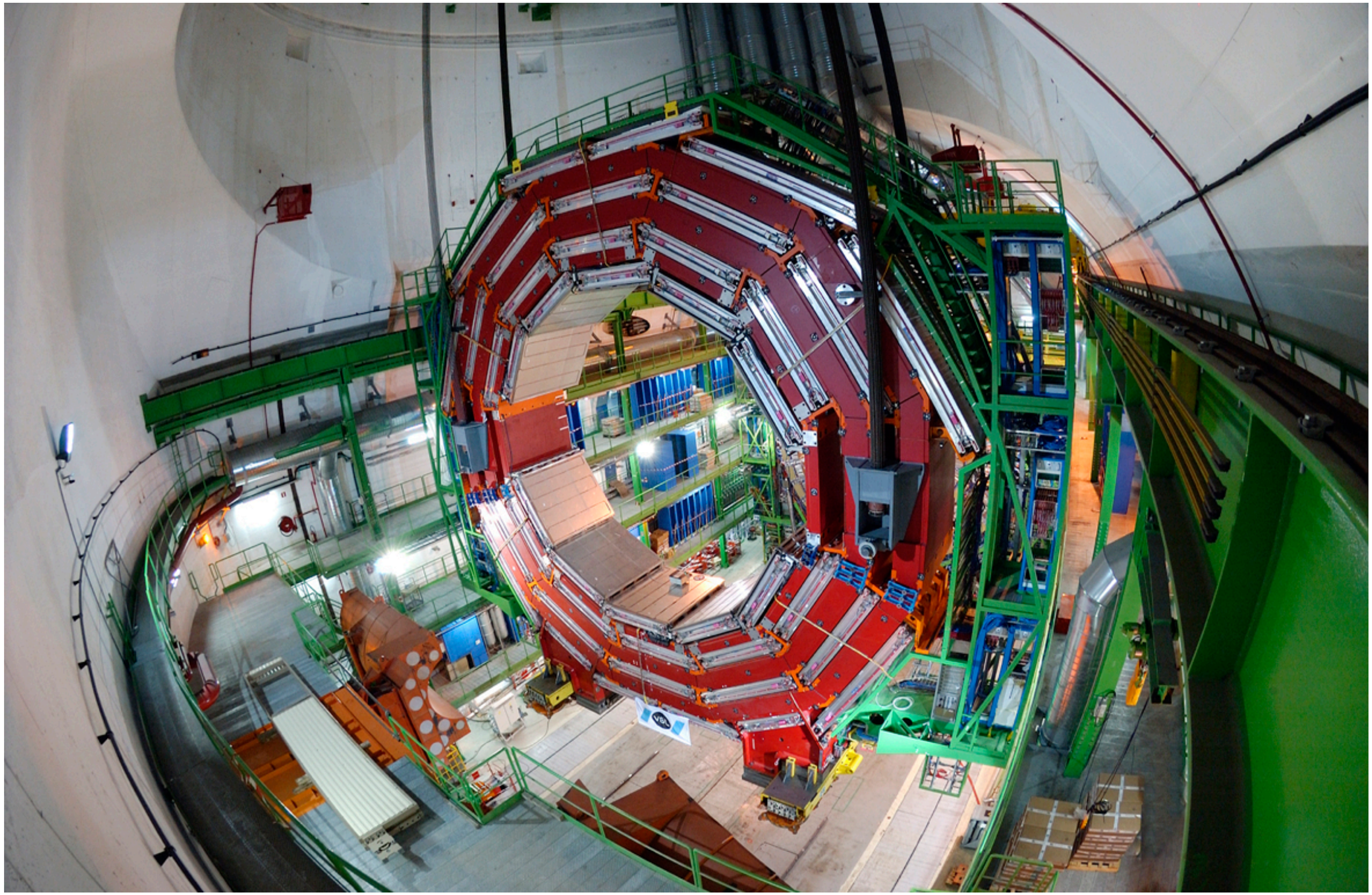
Since then choreography unfolded...



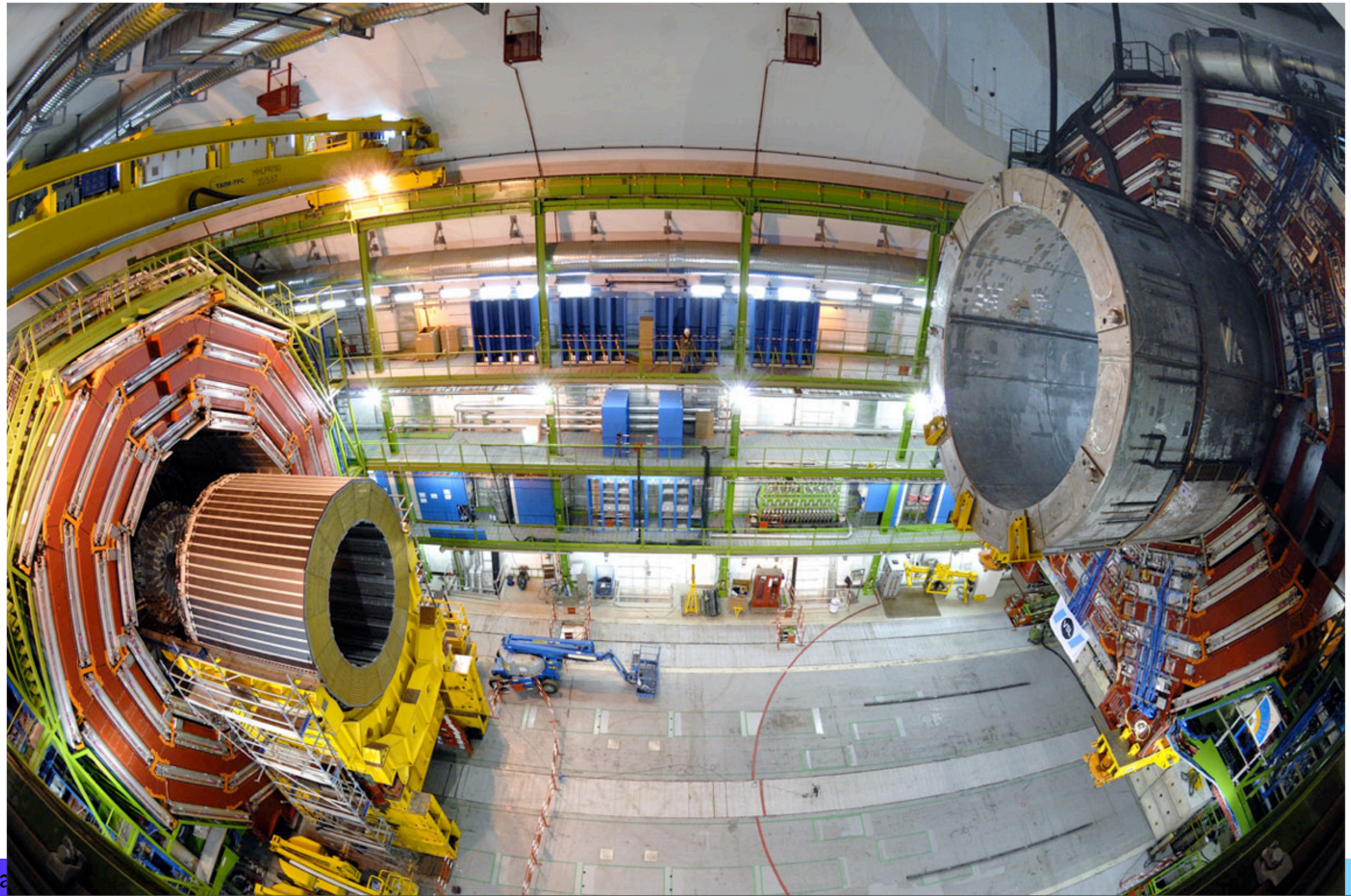
YE+1



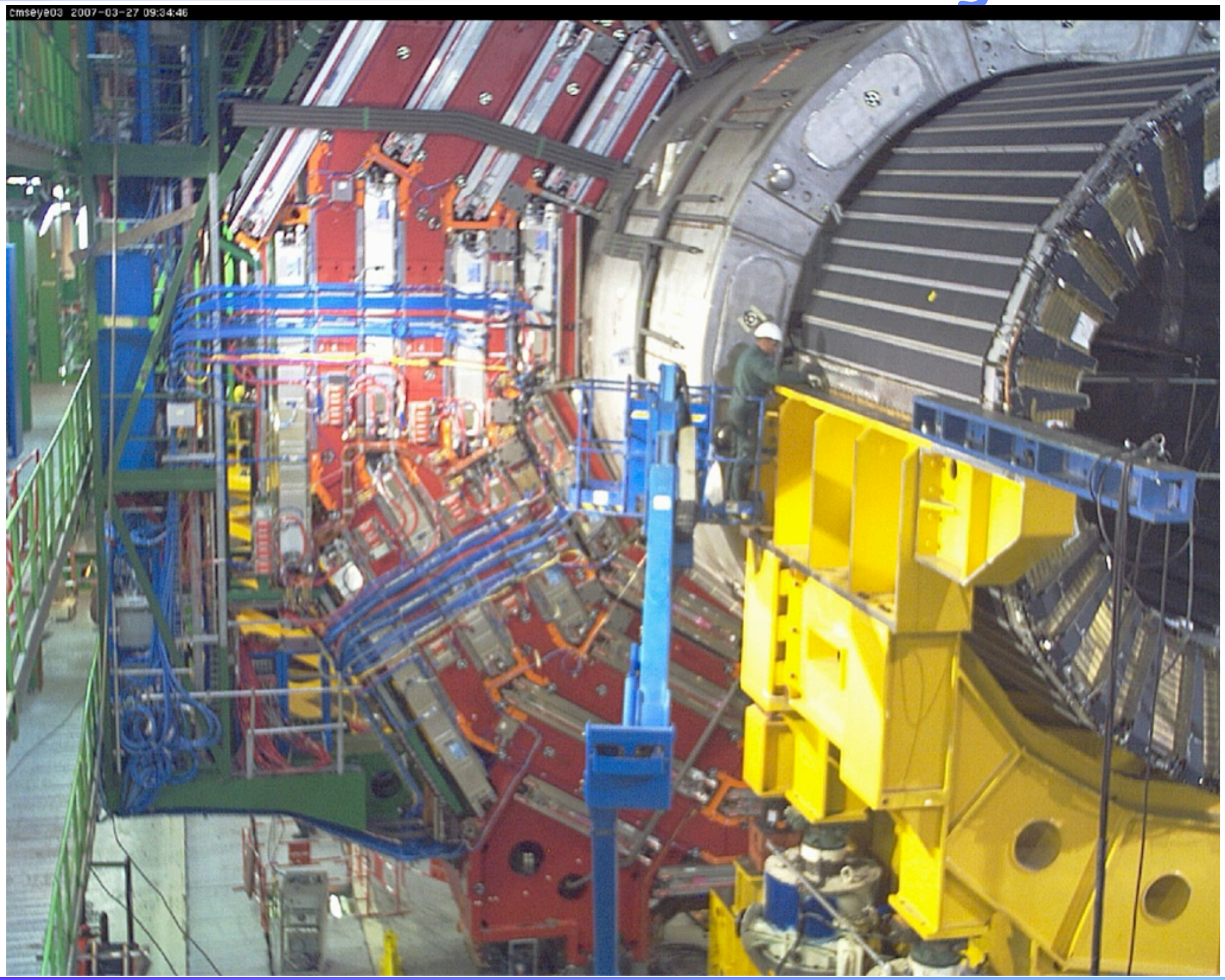
YB+2



Feb 28: YB0 lowered — big event



YB0 now centered and positioned and HB moved in and aligned



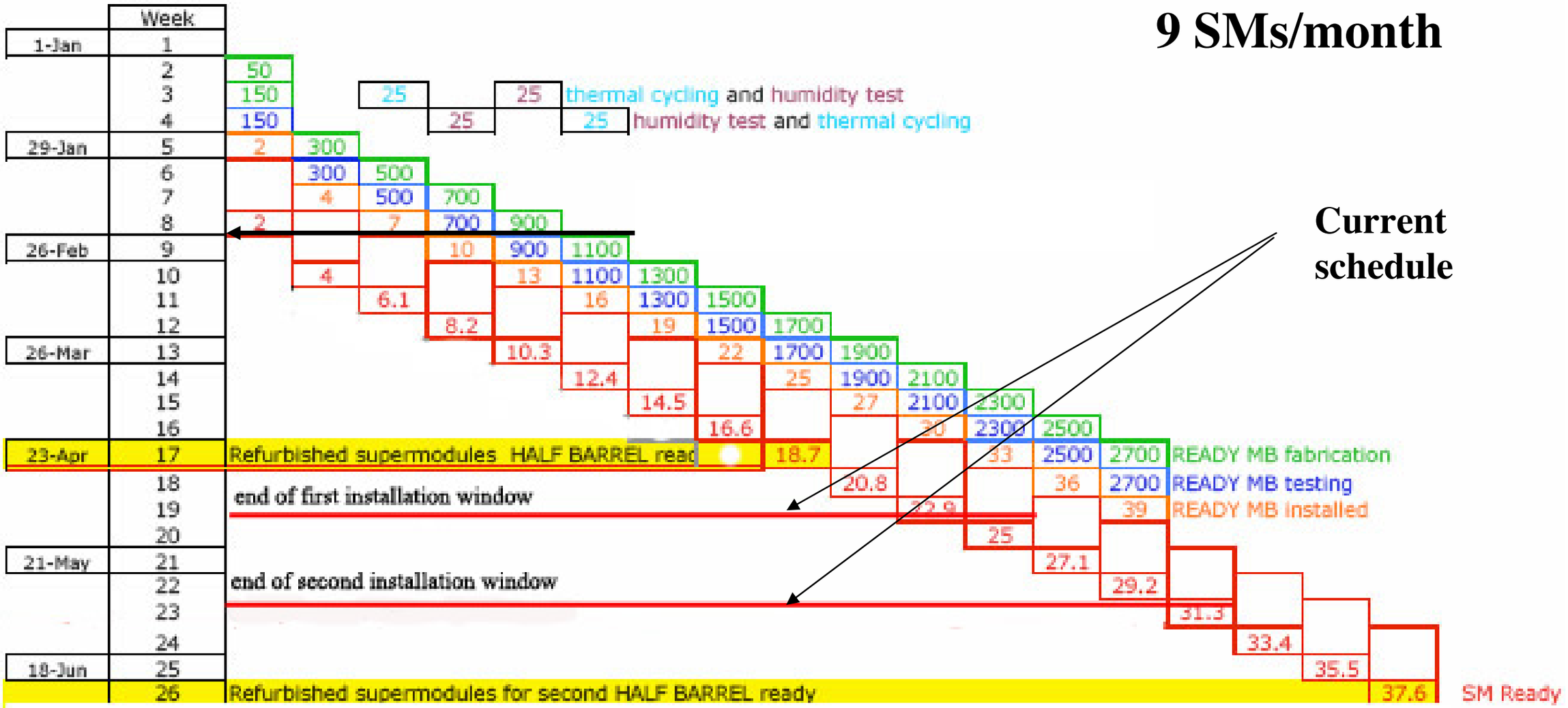
CMS Schedule

- CMS showed v35.3 schedule in December
  - ★ Beam-pipe closed and baked out by 15 Oct. instead of 31 Aug.
    - Incorporates delay in YB0 lowering, advanced work on beam-pipe installation, allowed time for EB refit (off the critical path).
  - ★ v35.3 has complete initial detector for the November run
    - schedule with beam-pipe closure on 31 Aug leads to reduced functionality detector in Nov (EB, HB, Tracker almost fully cabled but not closed).
  - ★ Will meet with the DG/DDG in March/April to decide final pathway
- YB0 services project
  - ★ Set-up a Specific Project to Manage the Installation of Services onto YB0 to ensure the Tracker is installed on Schedule.
  - ★ A critical activity for securing the CMS schedule. Despite progress this activity needed to be pulled out and made very focused
  - ★ Will include HCAL, ECAL and Tracker services and cabling.
- Following CMS request, Fermilab is making a special effort to provide additional help so we can meet the schedule

ECAL SuperModule Schedule

Number of MB fabricated — Green
Number of MB tested — Blue
Number of SM installed — Orange
Number of SM READY — Red
Number of OLD SM — Gray

Periode of Integration (2 weeks for installation and testing, 1 week for commission)



9 SMs/month

Current schedule

★ last crystals for EB delivered, EE crystal production has started

★ April: End EB- (first half of barrel ECAL) underground installation

Progress in EndcapMUons: Installation of last of 468 CSC

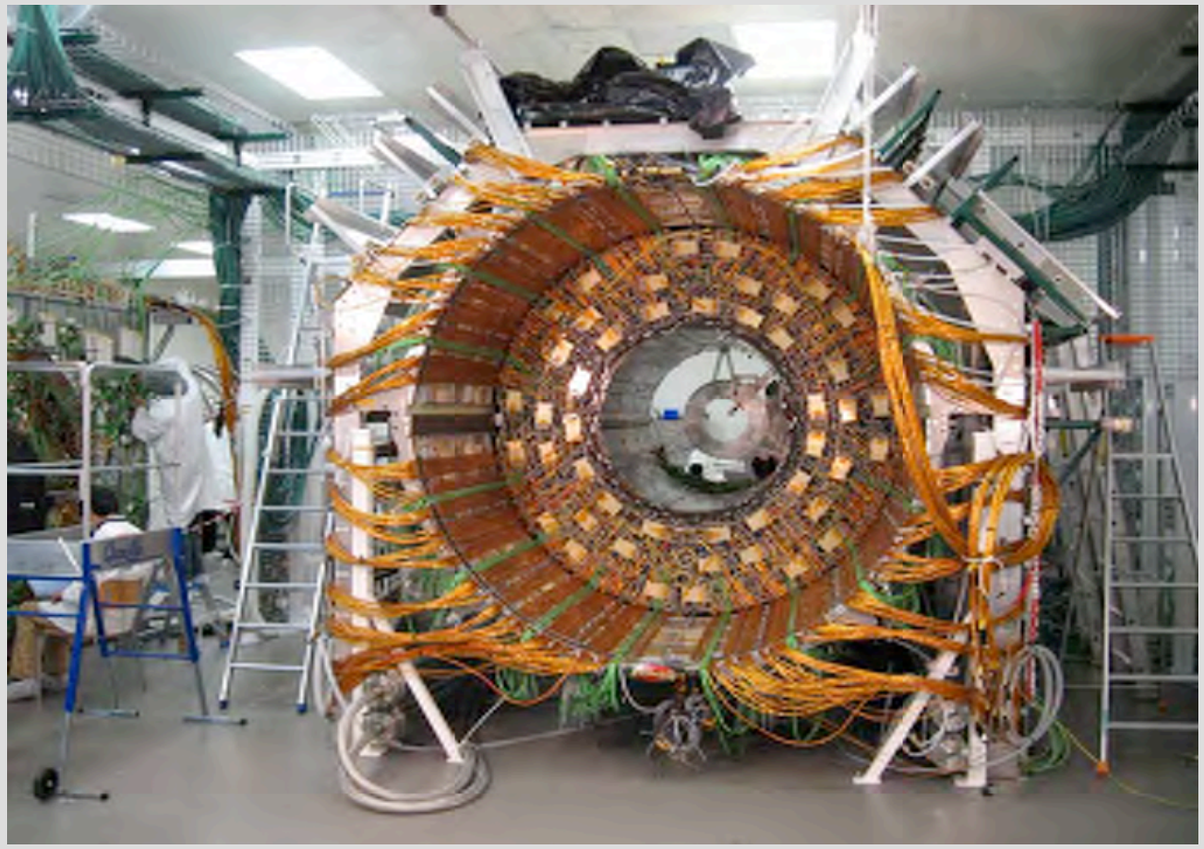
Progress in HCAL

- Detector ready and installed
- Good progress with installation in UndergroundServiceCavern
- Global Readout tests with HF being successful
- Problem with Noise in HPDs
  - ★ During the MTCC operations (re)discovered that the HPDs produced notable noise pulses in the self trigger mode.
    - Noise has a B-field dependence, worst at 1T if not aligned with HPD axis
  - ★ Impact
    - HB/HE little effect: B field aligned with HPD, effect small at 4T.
    - HO is different: local B-field < 1 Tesla, non-aligned with HPD axes
    - Checks being performed with simulation on impact on Jets and MET, and tuning Lvl-1 trigger

Tracking System

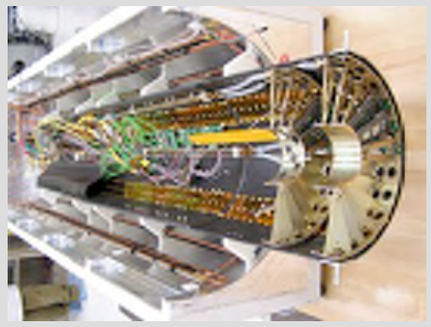
TIB/TID+

TEC+



TOB inside thermal screen

All strip modules at Tracker Integration Facility since last year. Slice tests now underway. Will need to stop ~May in preparation for move to Point 5.
Over 70 million channels in final Tracking system!



Two forward pixel half disks, recently delivered for the engineering run.

cosmics test (warm and cold)

US Teams at CERN and in the US

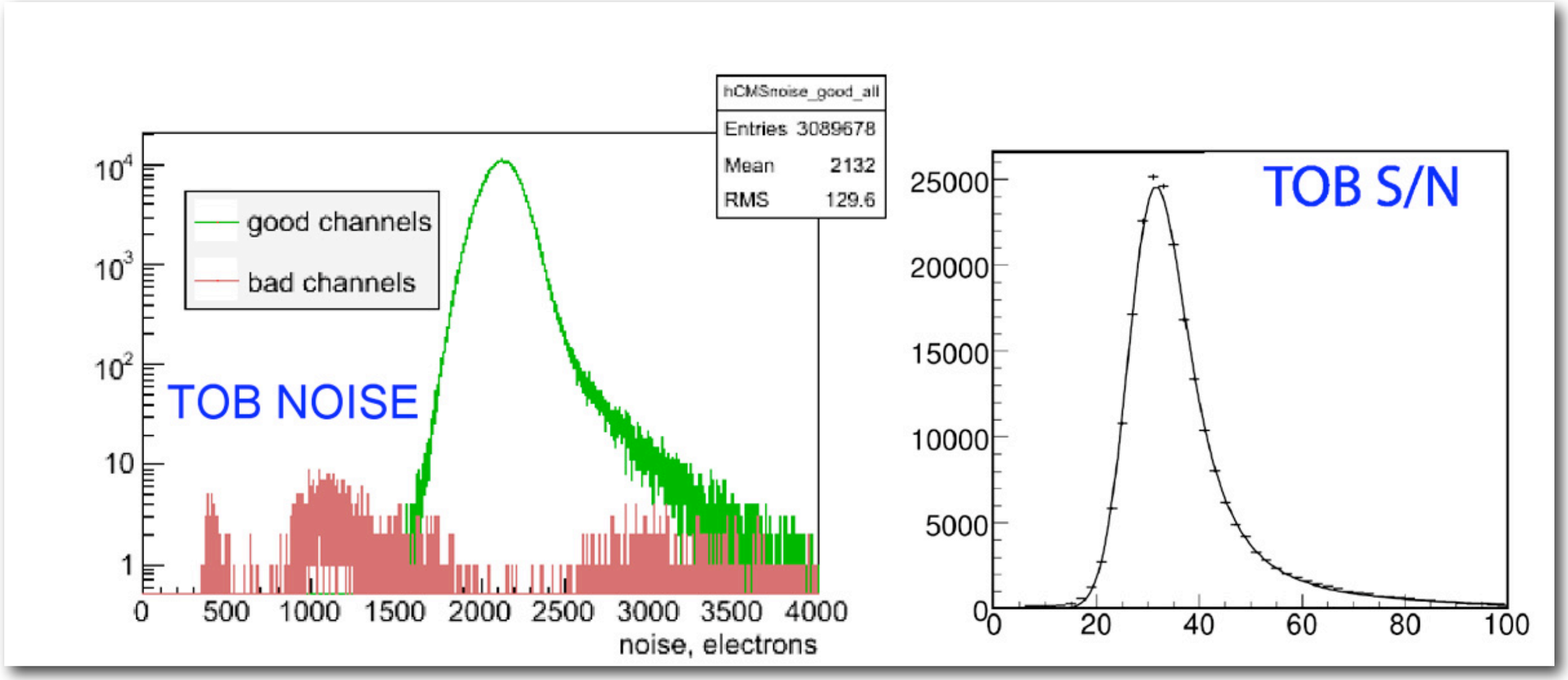
- Example of US Tracker Group
  - ★ more than 15 physicists, engineers and technicians at CERN
    - Jeff Spalding (FNAL) involved in Tracker Integration.
    - Slawek Tkaczyk (FNAL) coordinator for Electronic Systems and Online Software.
    - Stefano Moccia (FNAL) lead engineer for Point 5 installation preparation.
    - Steve Nahn (MIT) Operations co-Coordinator for TIF with Michael Eppard(CERN).
    - BrownU, UCSB, Riverside (UCR),

and MIT scientists spent the last year testing the TOB during assembly and in the current slice test. They also initiated high rate tests that will advance the commissioning of the Tracker. These activities are supported by US-based physicists and engineers from UCSB, FNAL and Wisconsin.

US Teams at CERN and in the US

- ★ Inside the US many physicists are involved in monitoring and offline tasks
  - ✦ Lenny Spiegel (FNAL) and Lisa Shabalina U. of Illinois Chicago (UIC) lead a large, productive monitoring group, working out of Remote Operations Center (ROC)
  - ✦ Yuri Gotra (Rochester) co-leading data validation group with P.Azzi (Padova).
  - ✦ Scientists from Kansas and UCSB are working on the slow controls and error diagnostics for the tracker.
  - ✦ Kevin Burkett (FNAL) and Steve Wagner (Colorado) convene the LPC offline tracking group.
  - ✦ Scientists from FNAL, UCSB, and UCR are working on tracking code for such things as the HLT and identification of converted photons. They have recently been looking at Cosmics in the TOB and TIB.
  - ✦ Cecilia Gerber (UIC) and Meenakshi Narrain (Brown) convene the LPC b-tag group.

Example for Tracker Performance



- Noise for all of the 3,089,678 channels of the TOB: The performance is exceptional with only 2290 (0.07%) bad channels shown in Red. The signal to noise ratio (S/N), seen at right, is typically over 30, as measured in the recent cosmics data taken with a slice of the TOB at the TIF by Pushpa Bhat (FNAL) and Yuri Gotra (Rochester).

Commissioning Task

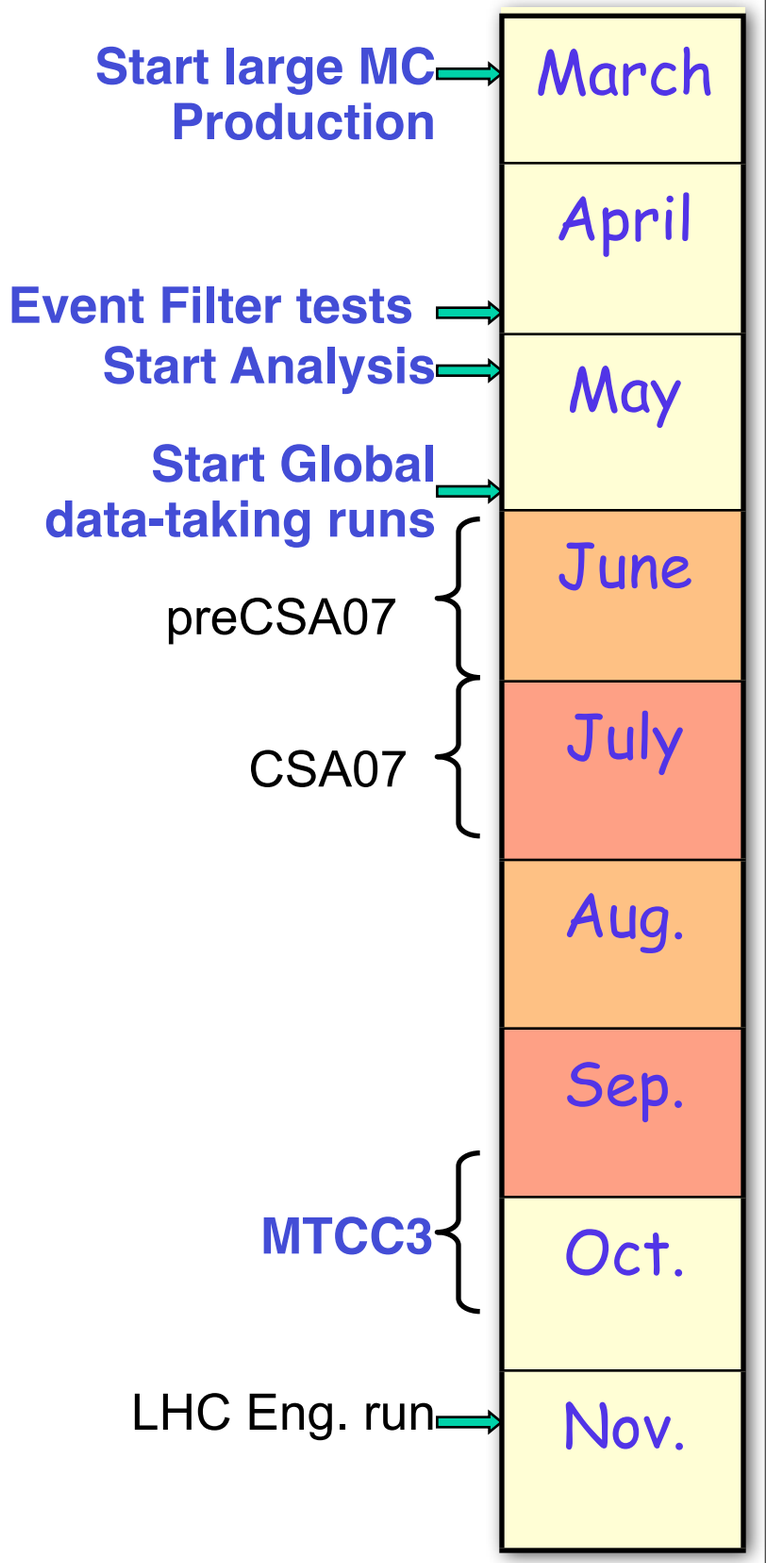
- new organization with T. Camporesi and D.Acosta
  - ★ hardware and online commissioning: central DAQ, global trigger, slice tests with some detectors — few days of global running every 4 weeks
  - ★ thinking through Run organization and needs -- collab participation
  - ★ overseeing and getting effort from Detector Performance Groups
  - ★ Alignment and calibration group
  - ★ monitoring and DQM to allow global views, event and non-even DQM
  - ★ Luminosity, delivery of lumi information
  - ★ preparations for LHC engineering run data taking
- Commissioning effort has been ramping up steadily
  - ★ from single detector commissioning focus on global activities in USC and single detector slice tests (e.g. HF full chain readout)
  - ★ DPG become operational — global rendez-vous through global runs
    - hardware – offline – computing
  - ★ engineering run is their main target: use it to verify that we have all it takes to exploit successfully the physics run of 2008

Computing, Software, Analysis Systems Test Successful (Nov 2006)

- CMS Software, Computing, Analysis Systems at 25% of 2008
  - ★ Tier-0 prompt reconstruction of RECO, AOD, AlCaReco, and with Calibration/Alignment dbase access @100% efficiency for 207M evts
  - ★ Export to Tier-1 @ 150 MB/s and higher
  - ★ Skim production at T1s demonstrated, analysis data transferred to Tier-2s
  - ★ Re-reconstruction demonstrated at 6 Tier-1 centers
  - ★ Job load exceeded 50K/day - scaling of grid production and analysis jobs
  - ★ Alignment/Calibration/Physics analyses widely demonstrated
- CSA06 was a huge enterprise
  - ★ Commissioned the CMS data-handling workflow @ 25% scale
  - ★ Everything worked down to the final analysis plots
  - ★ Many lessons being drawn for the future as we prepare for data-handling operations, and more things to commission
    - DAQ Storage Manager —> Tier-0
    - Support of global data-taking during detector commissioning

Plans for 2007: Computing, Software, Physics

- March — CMSSW validation completed
  - ★ Physics-TDR Volume I recovered
- June — HLT exercise complete
  - ★ Full trigger table, algorithms, CPU
- October — First physics papers prepared
  - ★ Full analysis breakdown; details of how and what for each physics analysis; writeup
- Software Releases and Computing Systems
  - ★ getting systems ready for global data taking
    - including Tier-0, HLT, Storage Manager etc
    - software release plan being worked out
    - computing integration and CSA07
  - ★ Continuing data taking plans until accelerator turn-on
    - before Apr 2007: data taking with individual detectors (now running cosmics with SiTracker)



Fermilab Tier-1 and LPC-CAF

- "2008 facility": Tier-1 + LPC-CAF
  - plan for 2008: 7.3 MSI2k, 2.5PB disk, 4.7PB tape (no change)
  - today:
    - facility is now at roughly 2 MSI2k, roughly 1800 batch slots
    - Have now 700TB of dCache space
    - Tier-1 has access to a 10G/s WAN link and 30GB/s of campus networking
- with slow LHC startup, push last phase procurements to FY08
  - facility still ready for 2007 running and start of physics data spring 2008
  - LPC-CAF (previously known as UAF) ramp-up this year
- delays of procurement help with slow technology developments
  - costs don't drop as fast, but delay compensates total costs to ~$200k
    - reasons are thresholds of 1TB disk, 4-core CPU later than anticipated
  - Crossing of FY boundary helps
- with new plan, facility budget is balanced

Beyond Tier-1 and Tier-2s....

- Open Science Grid ready to help university computing to get onto the Grid and become part of the CMS system
  - ★ OSG milestone targeting getting ready for LHC start
- USCMS had a Tier-3 workshop in UC San Diego
  - ★ part of the OSG consortium meeting and USCMS Tier-2 meeting
  - ★ large interest and participation from US CMS universities
  - ★ tutorials on how to use the systems, CMS services (data transfers, storage systems, stuff) and software installations
- put together documentation to help sites getting started
  - ★ appointed a Tier-3 liaison person
- CMS software & computing systems becoming useable for physics at CERN, Fermilab, US Tier-2s and soon also at Tier-3s

US CMS Research Program

- New Leadership in place
  - ★ Joel Butler/Fermilab RPM, Dan Marlow/Princeton DRPM
- Institutional Advisory Group and Technical Advisory Board
  - ★ "advisory boards" to coordinate the Research Program efforts to get the most out of our limited resources, for M&O, S&C and SLHC upgrade
  - ★ make sure that needs and actions of the Research Program are clearly articulated, explained and justified to the US university community
- Successful reviews for S&C and M&O in Jan/Feb
- RPM: monitor the M&O Cat-A costs (per capita cost)
  - ★ help cover the Cost-to-Complete deficit for '08-'10, US share is 7 MCHF
    - shortfall 2008 Detector: Crystals, Common Fund, C&I ~ 17.5MCHF
    - Restore the full DAQ (4 Slices), DAQ Infrastructure ~ 8.4 MCHF
- RPM: will carefully evaluate S&C and M&O budgets in '08
  - ★ look closely at M&O budget, projected data rates and computing needs based on better understanding of schedule, projected luminosity
  - ★ will examine schedule of upgrades and needs for upgrade R&D

Memoranda of Agreement for Maintenance and Operations of CMS

- ★ CMS is asking institutions or consortia to prepare MOA
  - ✦ To cover Operations, Maintenance and some Other tasks like test beams etc
  - ✦ Will be organized by subsystem, including computing operations, magnet and i/s
  - ✦ Software above the DPG line is not considered service work, ditto analysis
  - ✦ coupled to Authorship requirement: 25% FTE Service Task contribution/author
- ★ We need to understand what's required and what's available
  - ✦ personnel and M&S, skill sets, knowledge, and experience
  - ✦ What is available in funding (from RP, Core, FNAL, univs, other)
  - ✦ need to understand this in the context of whole subsystem
- ★ USCMS organizes response of US groups so to make sure that it respects the boundary conditions funding in both RP and Core Program.
  - ✦ aiming for one roll-up for all US groups
  - ✦ It will be by subsystem so it can be attached to CMS-wide subsystem roll-ups
- ★ USCMS has already started this process for subdetectors and computing
  - ✦ There are still issues that we have to clarify with CMS
  - ✦ CMS wants this done by the spring, which is ambitious, but beam is approaching!

CMS Upgrades for SLHC

- The SLHC schedule is not yet known.
  - ★ We assume intermediate Pixel Detector 2011, and for full SLHC upgrade, complete the detector in 2014-2015 for installation during shutdown for machine upgrade in 2015-2016.
- Submitted an EOI for the CMS upgrade for SLHC to the LHCC
- USCMS has written a strawman plan for DOE, requests $145M funding starting in 2010 (corresponding to US share)
  - ★ Expect heavy US involvement in new pixel, new tracker, track trigger, trigger upgrades.
  - ★ USCMS RP starts to provide R&D funds to prepare for the upgrade
- Recent series of "upgrade workshops"
  - ★ a Tracker Upgrade workshop in early Feb.
  - ★ a common CMS-Atlas upgrade workshop on electronics for SLHC
  - ★ a CMS + Atlas sensor meeting
  - ★ a CMS tracker readout meeting, and
  - ★ a CMS upgrade simulation meeting

LPC organizing for physics operations

- CMS new management and physics organization
  - ★ define role and organization of LPC for CMS physics operations
- Program to bring visitors from CERN to the LPC
  - ★ CMS spokesman (Jim Virdee) and deputy (Bob Cousins) came in Nov.
  - ★ Physics coordinator (Paris Sphicas) and deputy (Joe Incandela) in Jan
  - ★ Leaders of the QCD, EWK, Top groups will come in April 2007 for a week.
  - ★ Will have a SUSY/BSM "event" in summer with SUSY/BSM conveners
  - ★ Organize CMS b-tagging workshop in July
  - ★ Trigger workshop in July
- Also, work with "CMS Centre" activity at CERN
  - ★ equivalent of LHC@FNAL/ROC at CERN Meyrin site, high profile in CMS
  - ★ to be put in place before start of engineering run in old PS controlroom
  - ★ to be used for operating DQM, Calibrations, Express Analysis
  - ★ home of Offline and Computing Data Operations
  - ★ meeting areas, offices etc
  - ★ US helping CMS with this effort

CMS Physics Coordinator, P.Sphicas, visiting the LPC:

Summary

- **From the "physics" side of things, we have high hopes that the LPC will contribute in very significant ways to the program of work of CMS.**
  - **And even beyond "physics", the LPC can take responsibility for major tasks in what can be called the "physics operation" of the experiment. Because it has three major ingredients:**
    - **the (human) critical mass,**
    - **the software expertise as well as**
    - **the computing resources**

- **Making CMS to work will be a real challenge, and will need all the experience, wisdom and ability in the collaboration.**
  - **And the LPC is a big fraction of the total EWA of CMS.**

LPC Governance

- Committee to advise Fermilab on LPC structure and leadership
  - ★ representation from USCMS, CMS, LPC, AB, CB,
- Principal Recommendations
  - ★ LPC to be led by two LPC Coordinators with staggered two-year terms.
  - ★ LPC Coordinator Selection Committee, identify short ranked list
    - candidates nominated by the U.S. CMS Collaboration
    - Fermilab Director to appoint the LPC Coordinators from the short list
  - ★ LPC Management Board
    - chaired by the LPC Coordinators, to direct the LPC program of work, to draw up policies and to provide the forum for close coordination with activities in CMS, in U.S. CMS, and in the CMS Center.
  - ★ LPC Advisory Board LPC-AB
    - provide advice to the LPC Coordinators, give regular feedback on LPC performance to the LPC-MB and report to the U.S. CMS Collaboration and Fermilab
- LPC Coordinator selection starting

CMS Center

- CMS Center started in Dec 2006
  - hosting and managing a number of organizations and services
    - the LHC Physics Center LPC
    - the Remote Operations Center ROC
    - the Computing Facilities: Tier-1, Analysis Facility LPC-CAF
    - the Research Program Management and Program Office
  - some 50 CMS physicists at Fermilab
    - including 3 Wilson Fellows and 7 postdocs
  - CMS Center Management Board active
    - CCD, CD, PPD, RPM, LPC, S&C, M&O
    - meeting ~weekly
- Initial budget request and initial budget allocation
  - to strongly participate in CMS commissioning and physics preparation
    - support our work at CMS: travel, COLA and other support for people at CERN
    - guests and visitors for LPC, ROC and other CMS activities

Summary

- CMS is coming together
  - ★ in terms of components in the underground cavern, and as a whole experiment collaboration
  - ★ schedule very tight, but CMS is holding to the plan for the moment

- CMS plan emerges for commissioning and operating detector, and to prepare collaboration for data taking and analysis
  - ★ US and Fermilab to contribute as strongly and efficiently as we can
  - ★ presence **at CERN** and facilities **at home** are key
    - assets are ROC, LPC, detector&software expertise, computing systems
    - good planning and tight communication is important
  - ★ strong US and Fermilab involvement in MTCC, CSA06, commissioning babysteps toward learning how to operate CMS for physics

- US and Fermilab strong contributor to the program to get CMS ready for physics