CMS

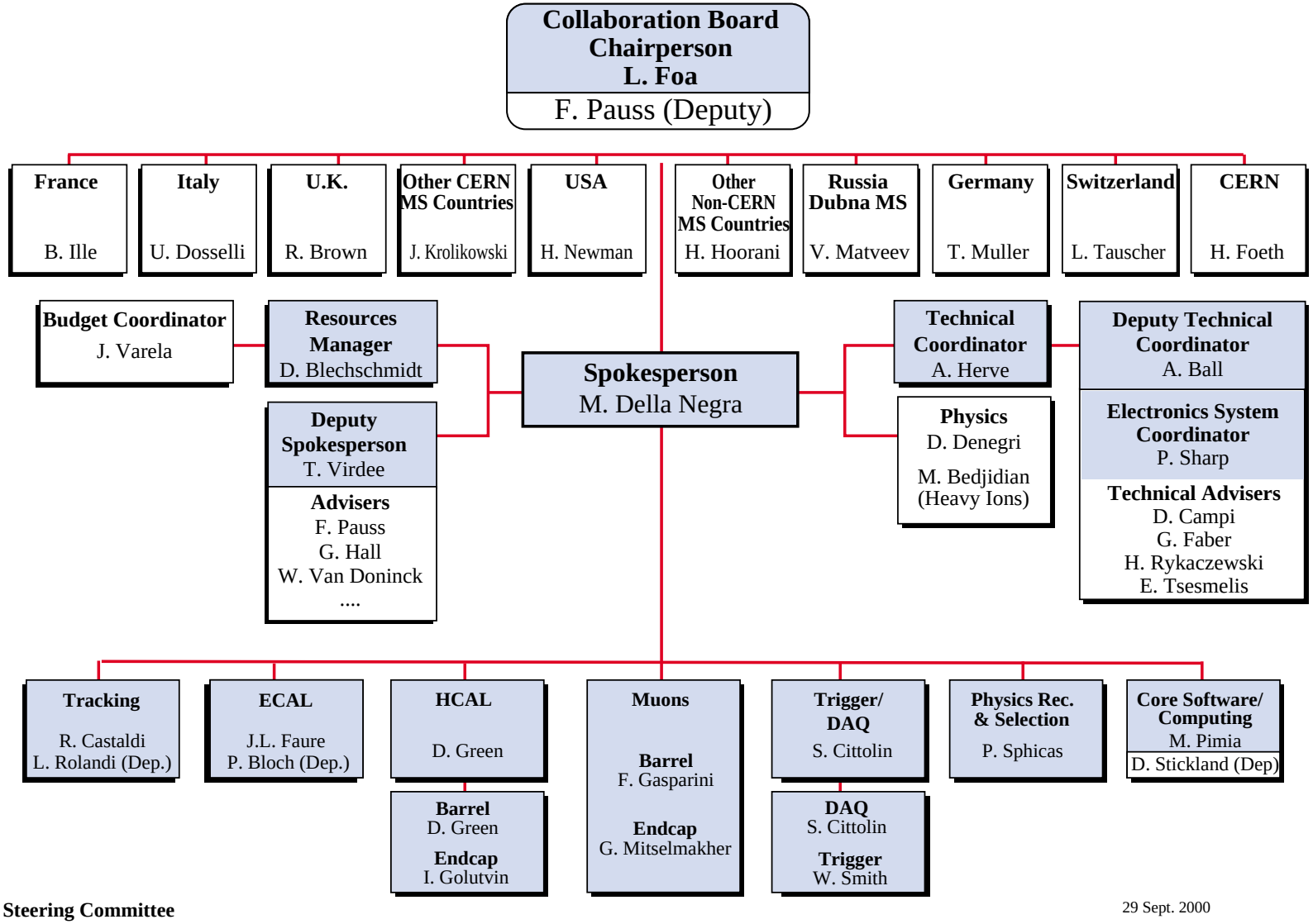
Compact Muon Solenoid

Status Report

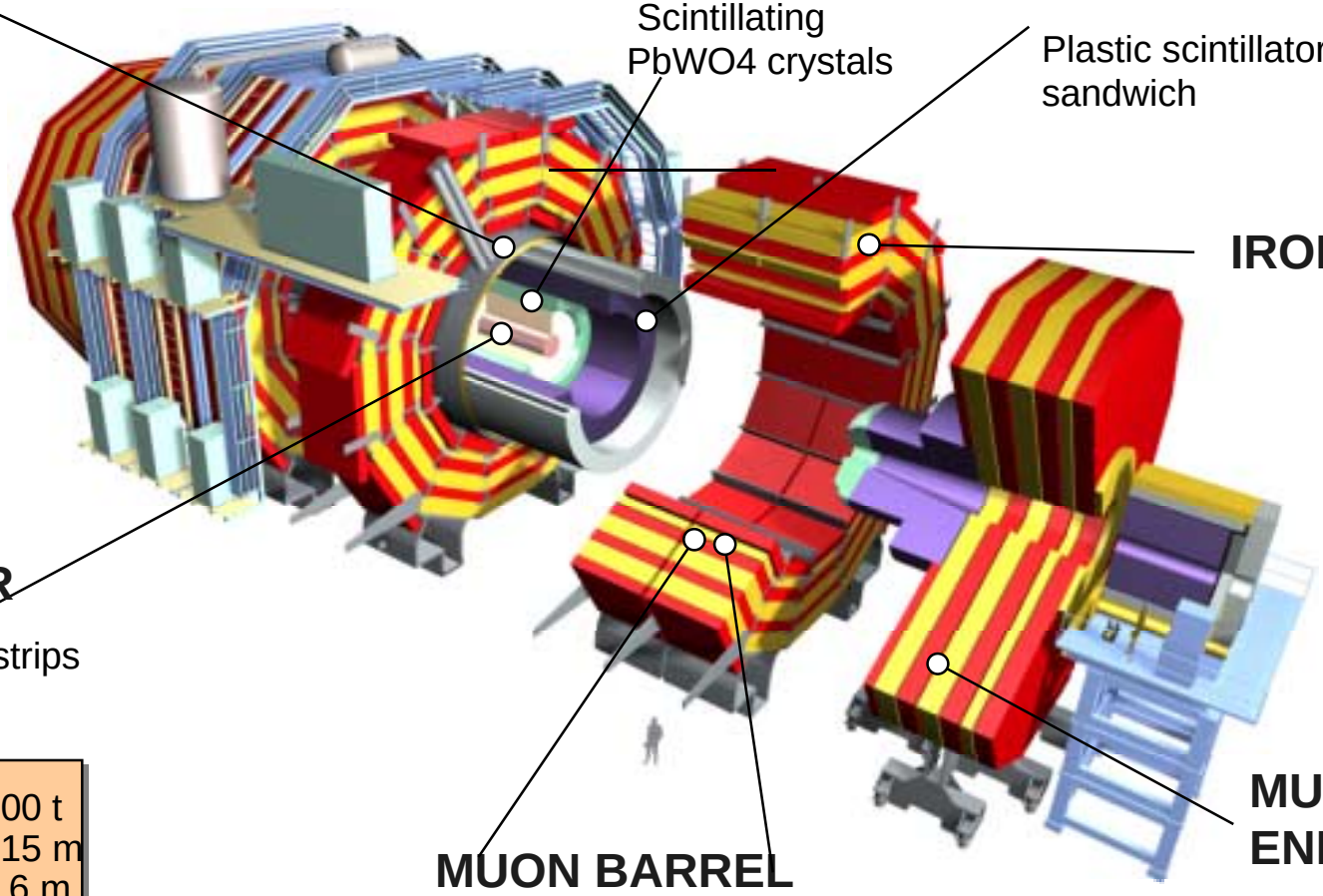
T. S. Virdee
Lehman Review 8 May 2001

General
Civil Engineering and Magnet
Status of Sub-detectors
CPT
Conclusions

CMS Management Board and Steering Committee

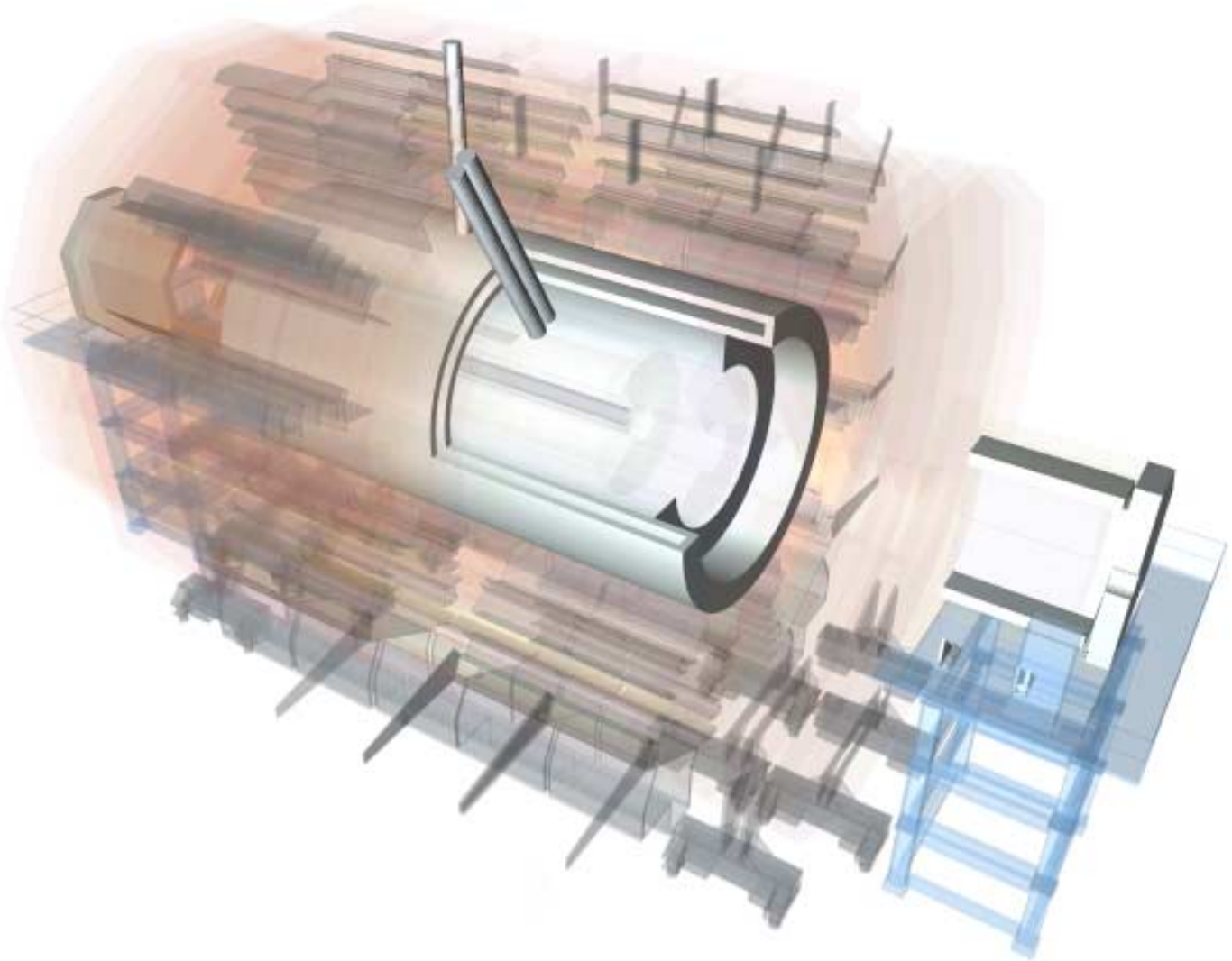


The CMS Detector

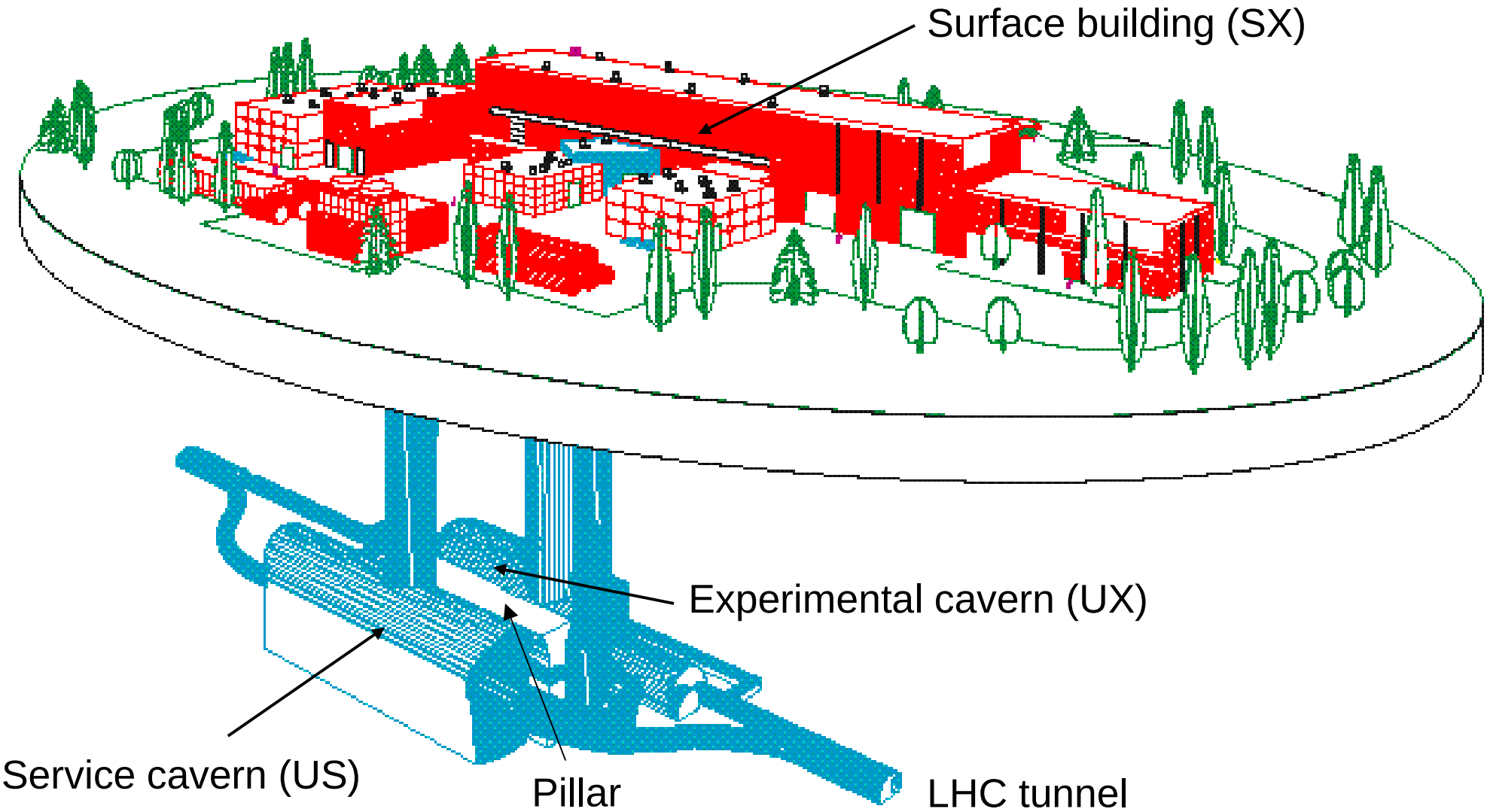


Total weight : 12,500 t
Overall diameter : 15 m
Overall length : 21.6 m
Magnetic field : 4 Tesla

1. Magnet and Civil Engineering



Surface and Underground Installations



Civil Engineering: Overview

The Status

- Surface hall, SX5 - delivered on time
- Underground hall UX5 - an extra 4 mo. delay announced in Jan 01.
  (total delay is now 9 months w.r.t contractual planning)

Underground halls (UX5 & US5) will now be delivered in Apr 04 !

- Serious implications for CMS installation and commissioning.

- UX5: move some UX activities to SX (surface) – will need extra resources
- USC: delay will be much harder to recover – activities cannot be moved to SX.

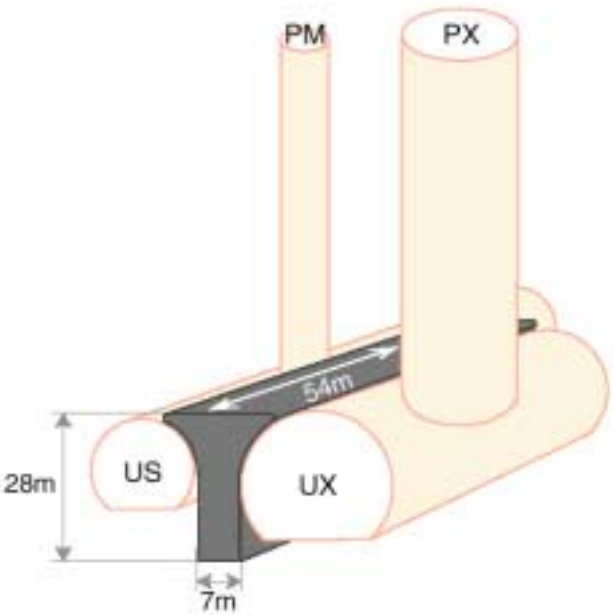
Move to V31 General Schedule (detailed consequences still being worked out)
Final L1, L2, L3 milestones will be given to LHCC in June.

Concerns

Further delays

Underground Civil Engineering

Excavation of the Pillar



Magnet: Overview

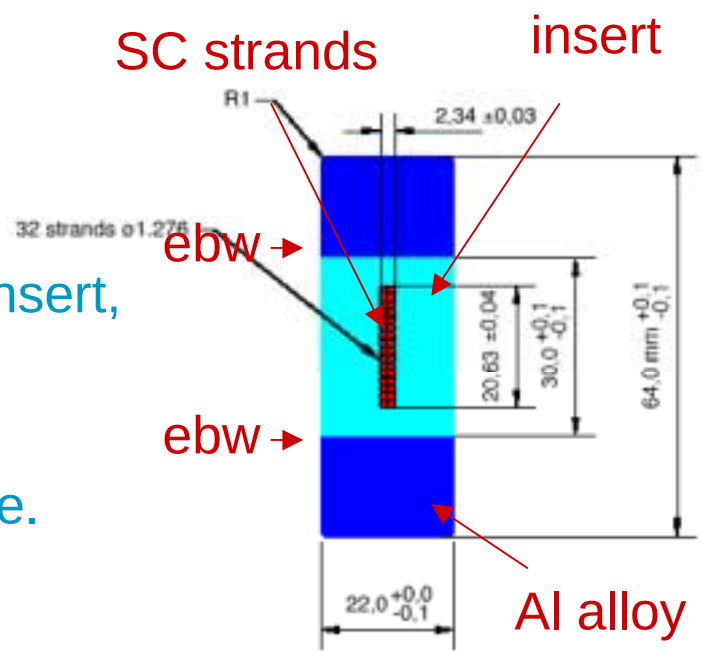
- Most of the major contracts have been placed (86% of budget committed, 104 MCHF). Estimated total cost of the magnet (122.9 MCHF) unchanged

YOKE Status

- 3 of the 5 barrel yoke rings assembled at Point 5
- Assembly of 1st endcap disk started in April (2nd endcap @ CERN in 9/01)

COIL Status

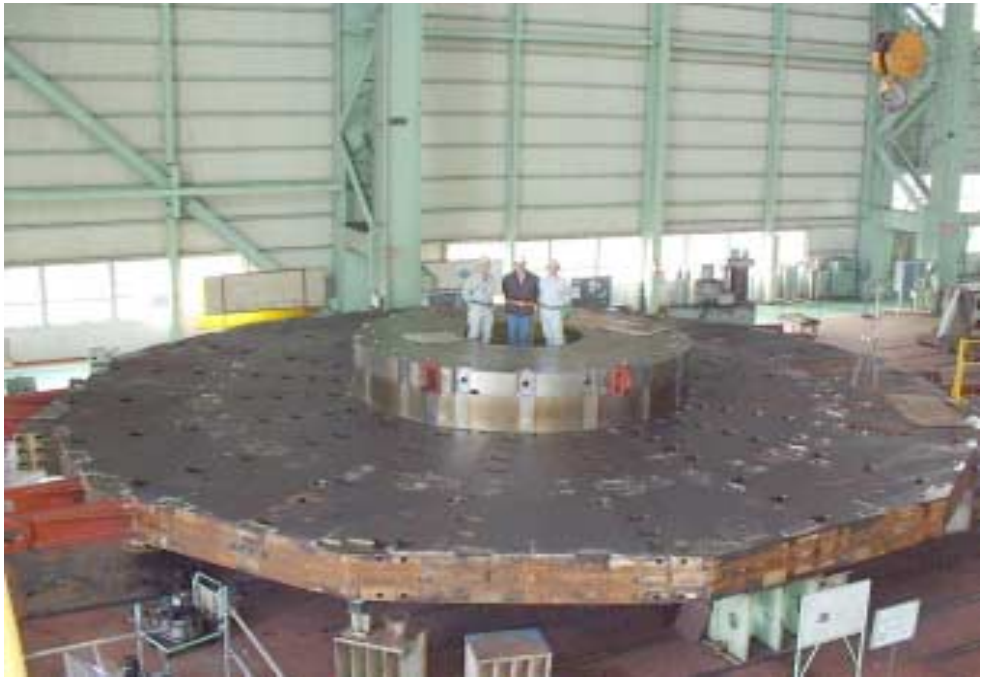
- SC cable: Need 21 lengths of 2.65km (coil has 5 sections, 4 lengths/section + 1 spare)
- Produced: 8 cables worth of s.c. strands, 5x2.65km of Rutherford cable, 4x2.65km of real insert, 20 out of 40 lengths of Al alloy.
- EBW reinforcement tested with dummy insert.
- First full length of final conductor expected in June.
- Tests of winding machine started



Finish Magnet Test on the surface by July 2004

Magnet Yoke

YE-1 & nose trial assembly Nov '00
In Kawasaki (Japan)



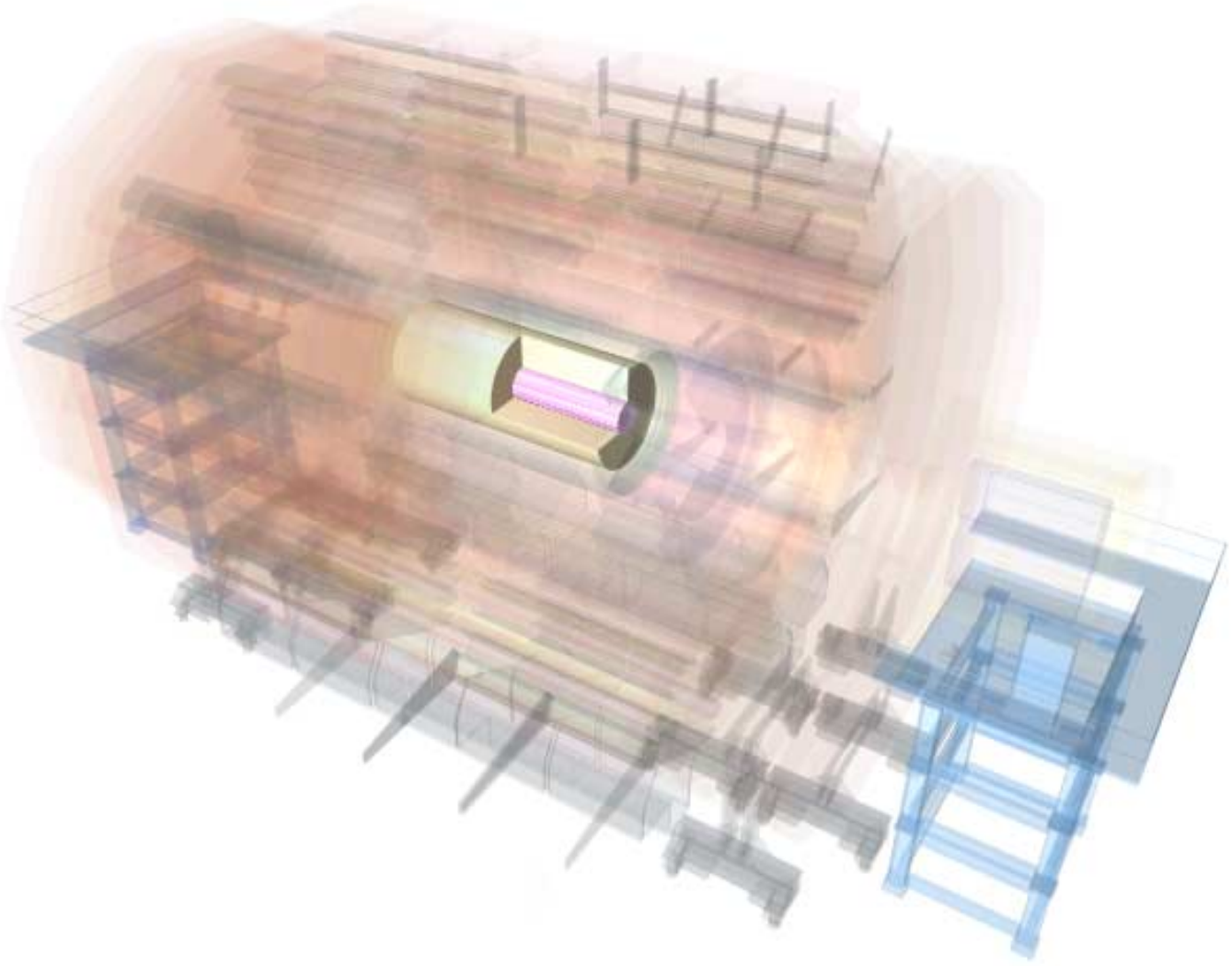
YB-2, YB-1, YB0 ready, YB1 started.

Central wheel YB0, supporting the vacuum tank

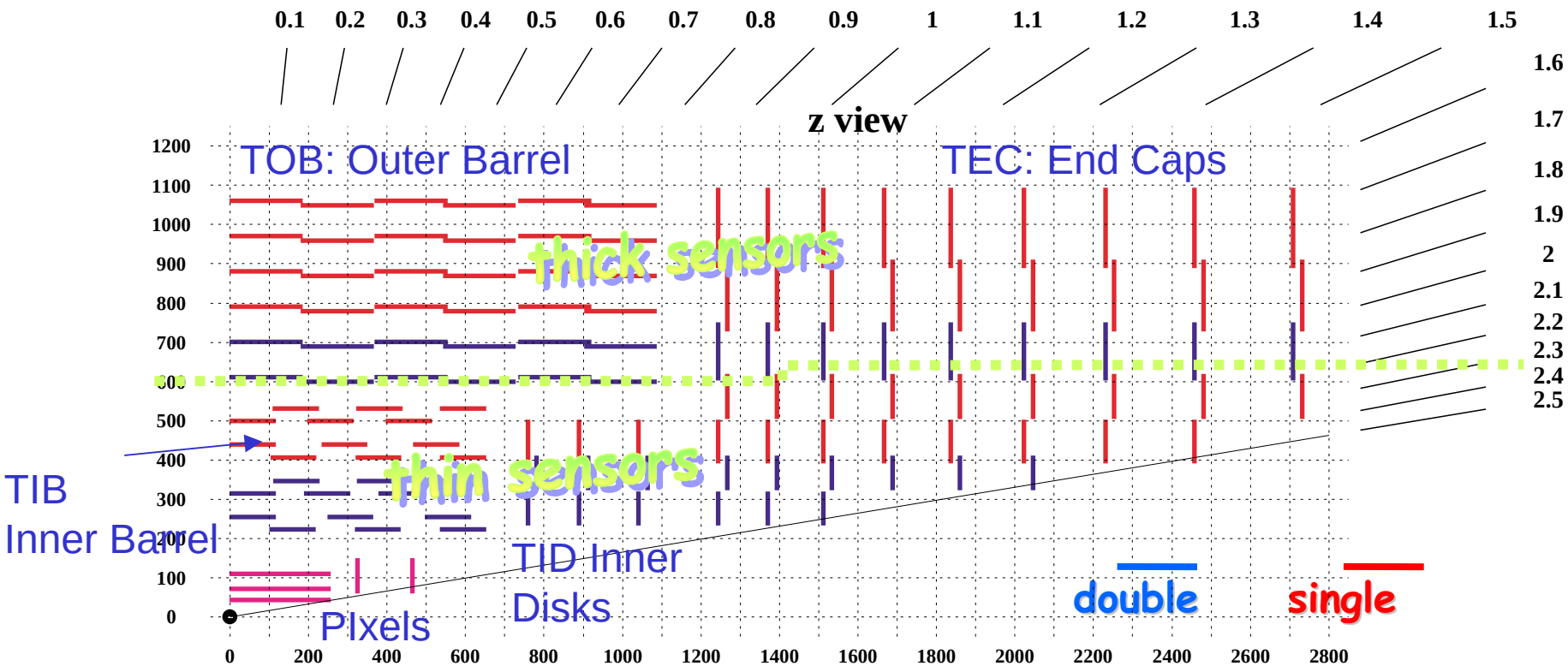
Magnet: Coil

Electron Beam Welding at Techmeta

2. Tracker



Tracker Layout



Some Numbers

6,136 Thin sensors - **3112 + 1512** Thin **modules** (ss +ds)

19,632 Thick sensors - **4776 + 2520** Thick **modules** (ss +ds)

223 m^2 of silicon sensors

26 M Bonds - **10.0 M strips** ≡ electronics channels - 78,256 APV chips

Tracker Overview

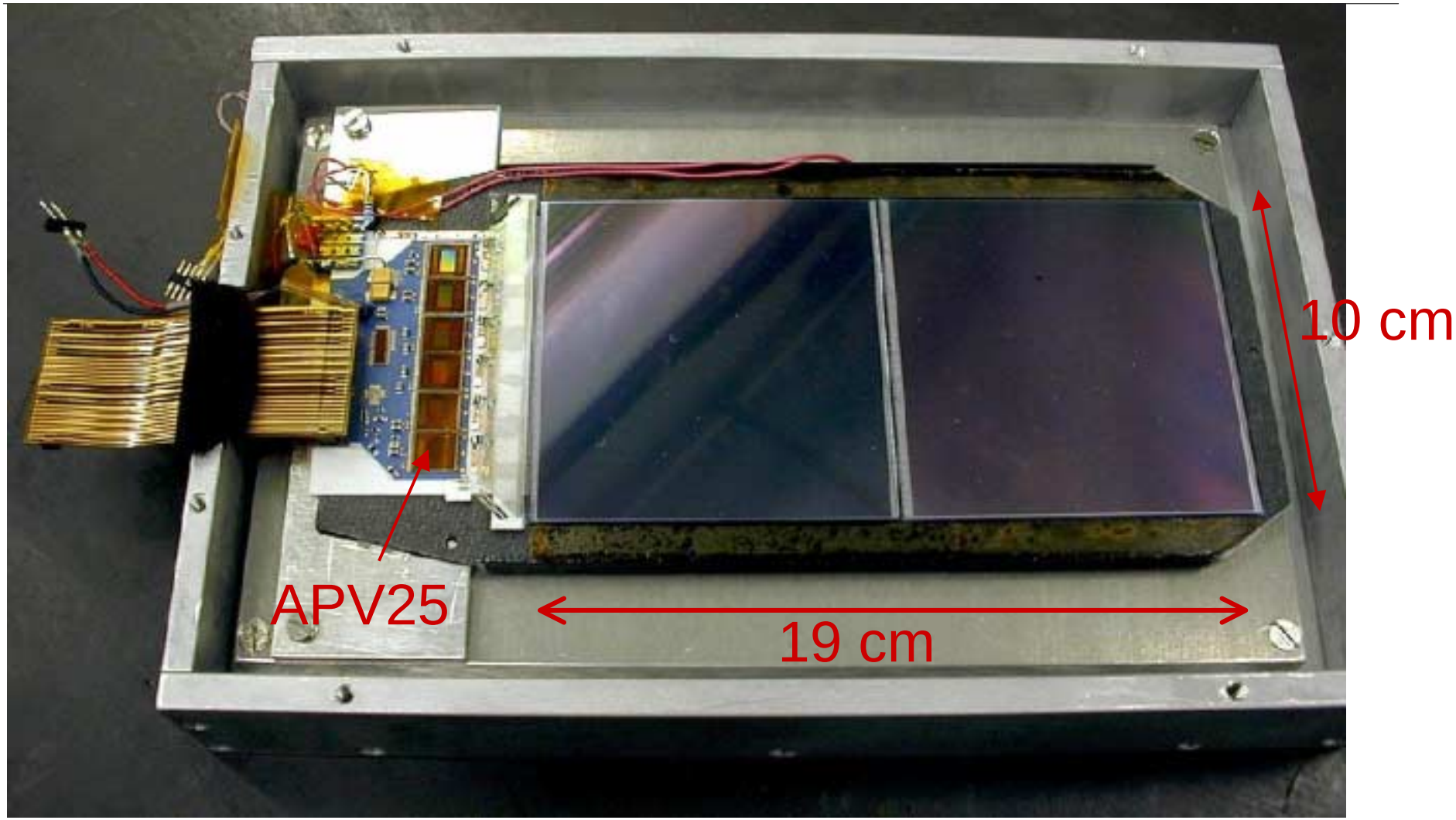
The Status

- EDR passed in Nov 00
- P*re-production of 200 detectors to exercise automated assembly procedure*
- Sensors tender opened recently – order will be placed soon

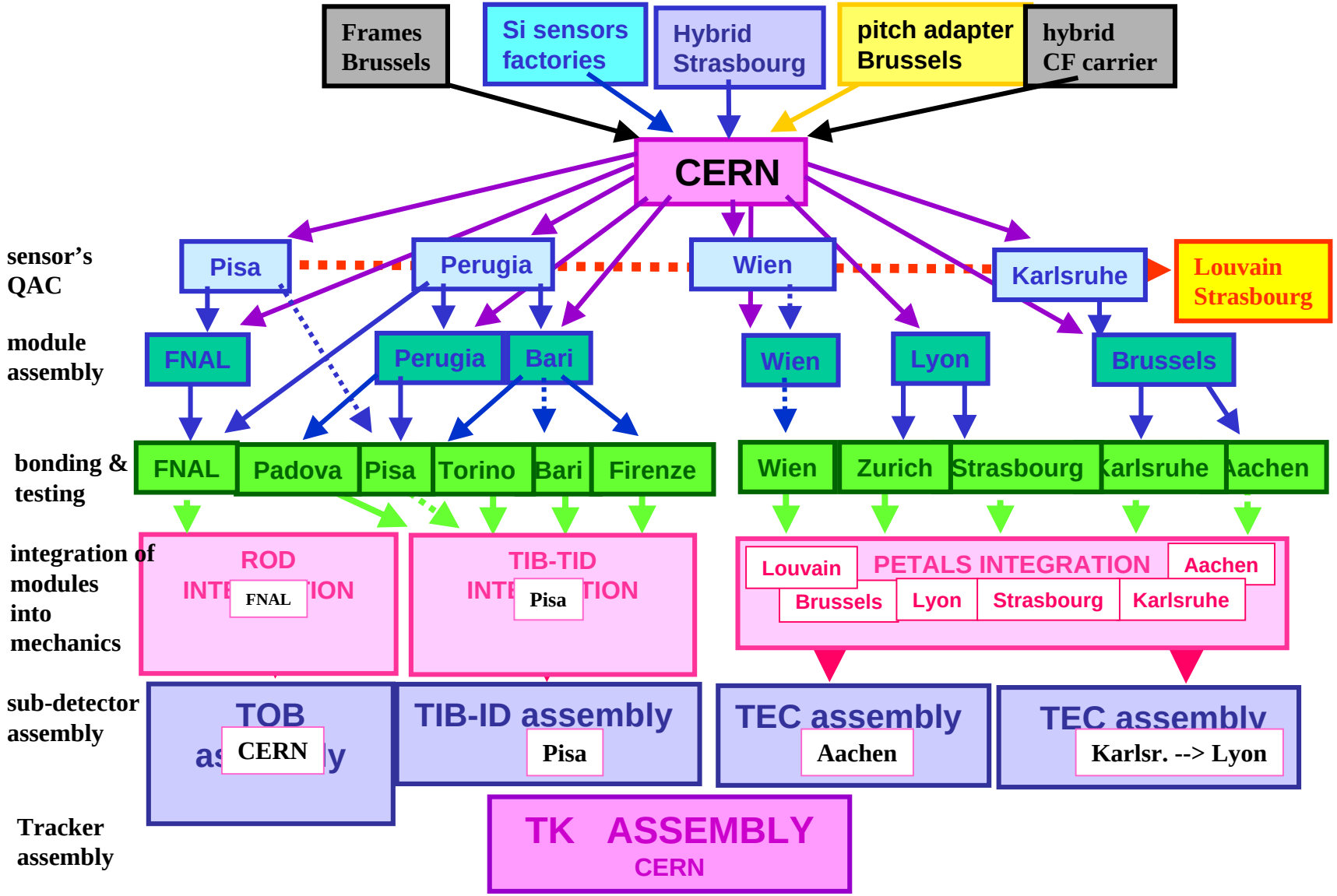
- Major Milestones in 2001
  System test of final electronics chain followed by ESR in October
  Start production of final modules

- Dec 2004 Tracker ready for installation

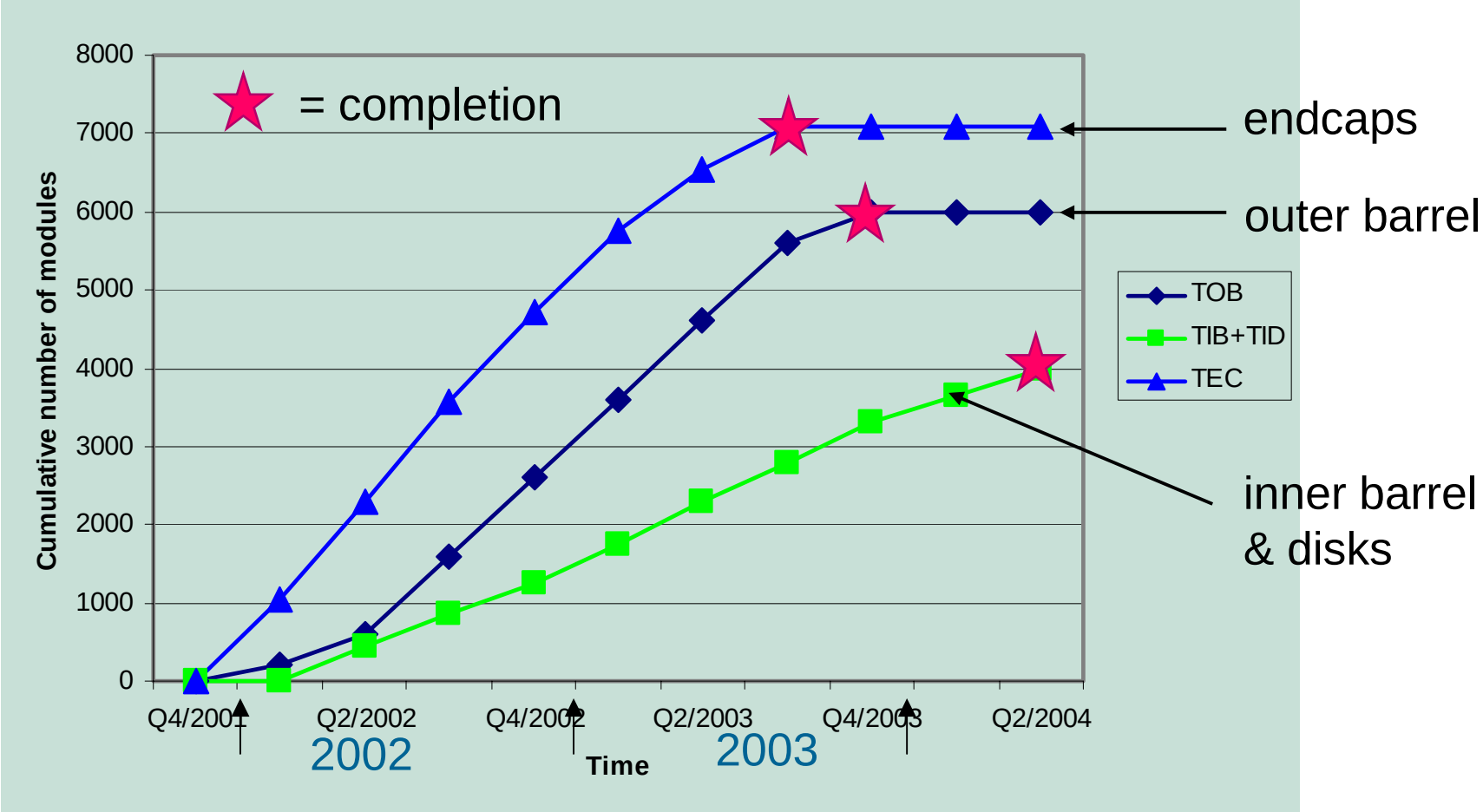
TOB Module with final hybrid



Tracker Logistics

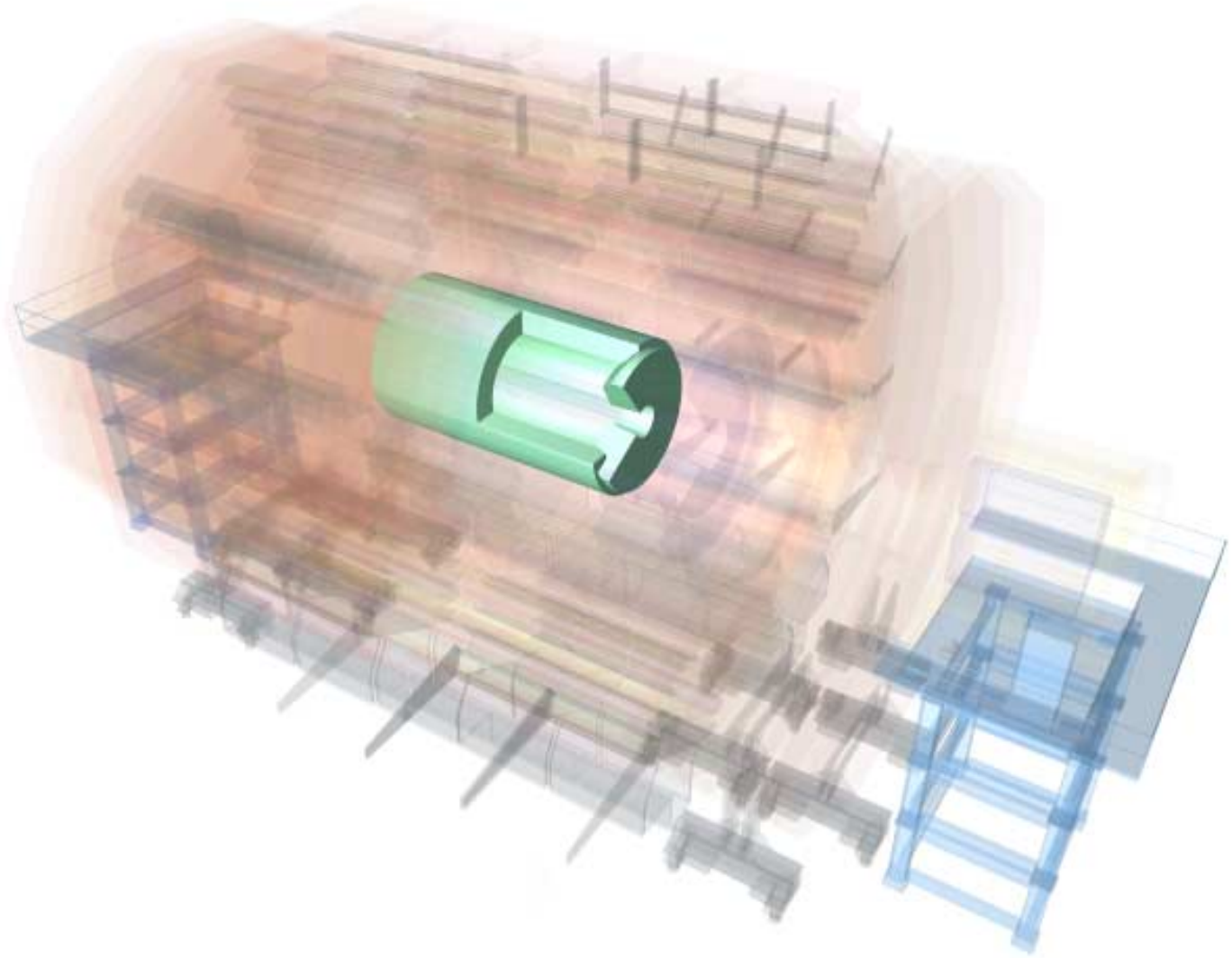


Tracker: Si Module Production

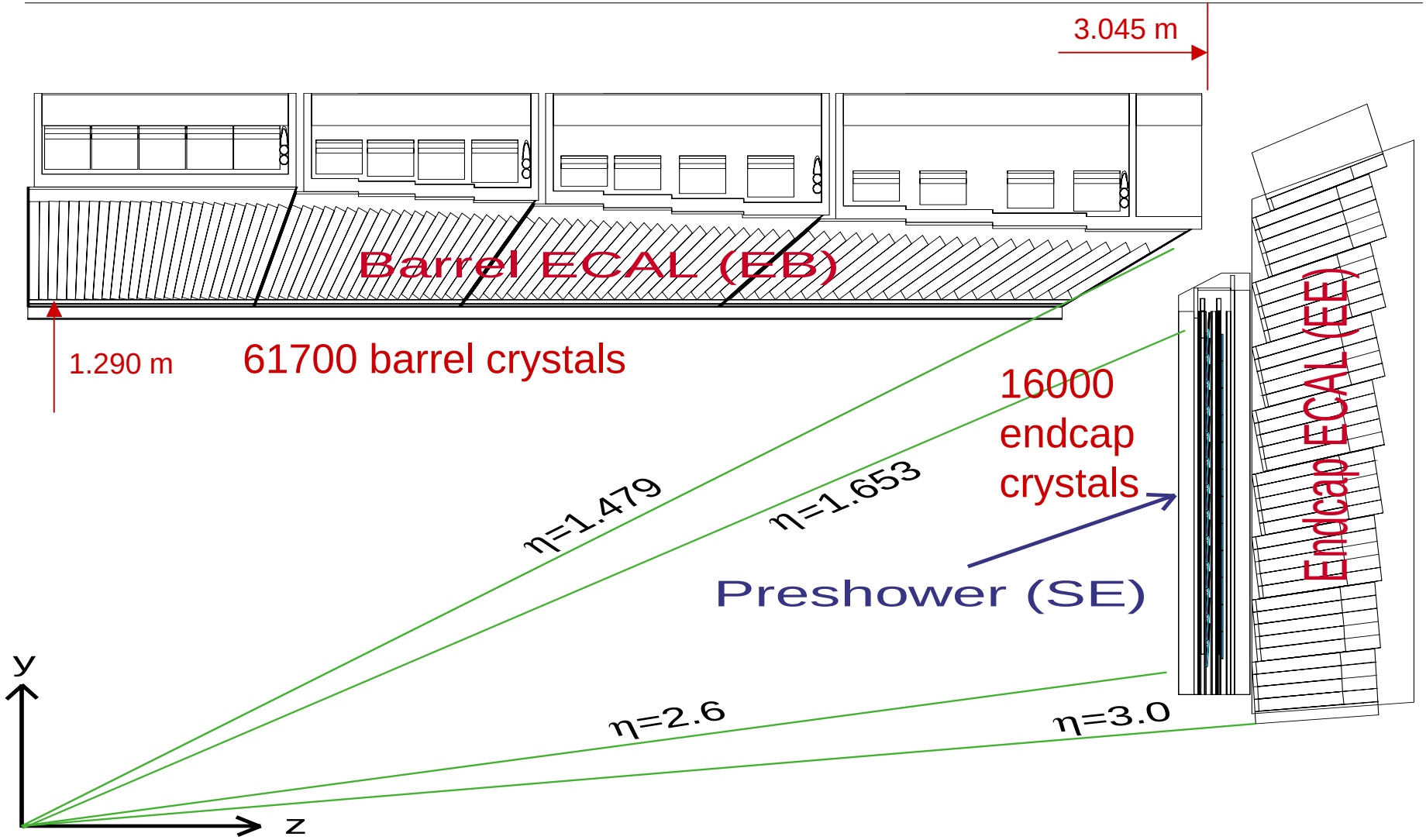


To be updated based on 2001 pre-production experience
Several months time contingency in present manufacturing plan.

3. ECAL



ECAL


3.045 m
Barrel ECAL (EB)
1.290 m
61700 barrel crystals
16000
endcap
crystals
Endcap ECAL (EE)
Preshower (SE)
η=1.479
η=1.653
η=2.6
η=3.0
y
z

ECAL Overview

The Status

- 7500 Russian crystals delivered.
- Contract signed with BTCP (Russia) for manufacture of 30k barrel crystals.
- A breakthrough in crystal growing in Russia: Large diameter ingots can be grown allowing two crystals to be cut from one ingot => Yield of crystals per oven is increased considerably. BUT larger crucibles needed.
- 0.25 μm serialiser (CERN) has been chosen.
- Issues of barrel mechanics and APDs resolved (cross-check on delivery of 1000 APDs)
- Tender for the remaining 40000 crystals opened on April 5

Milestone for 2001

- Module M0' (400 crystals) + electronics chain for autumn 01.

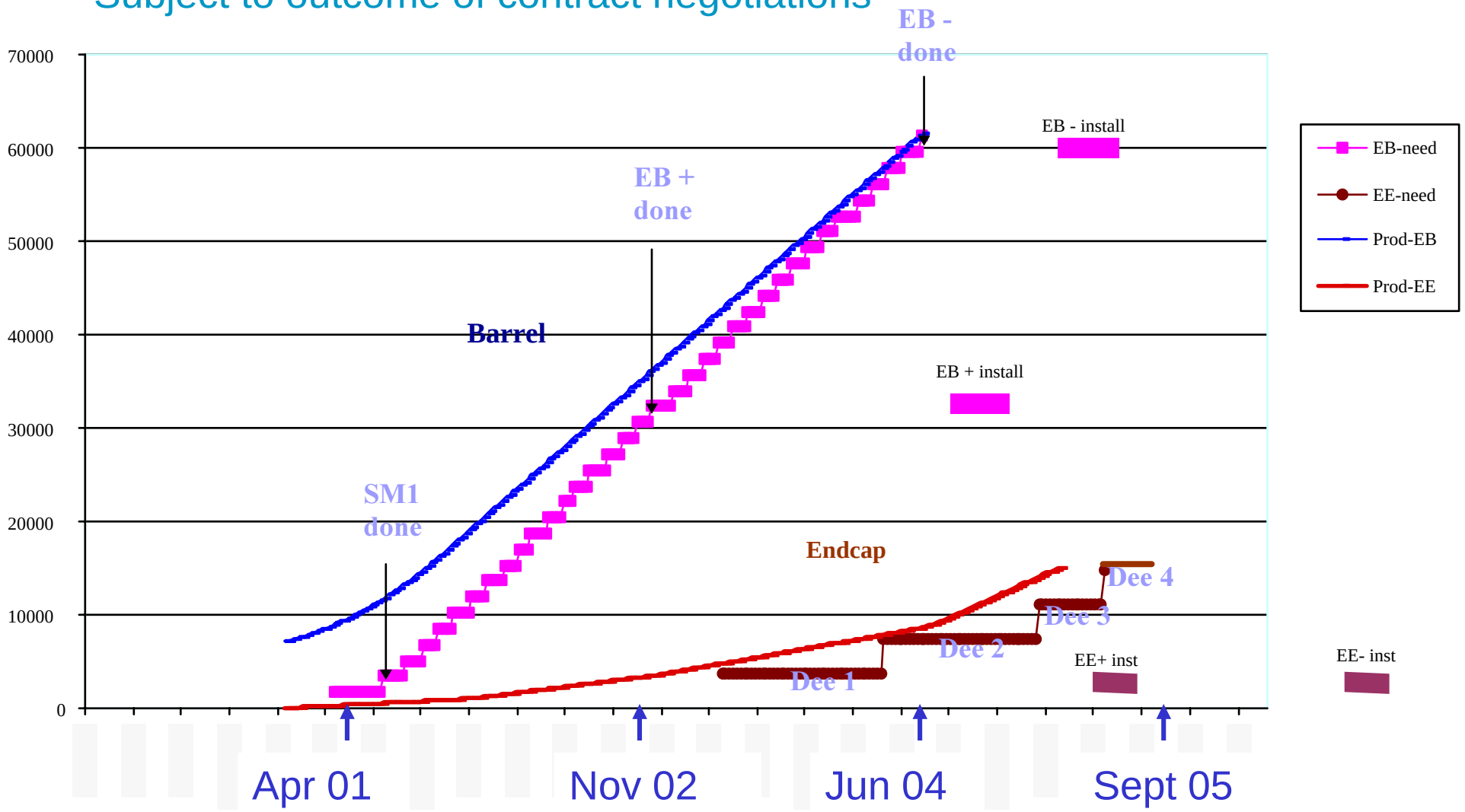
Concerns

- Total cost of crystals likely to be higher - more investment needed (than foreseen) in order to hold to the schedule
- Crystals are priced in $/cc. Prevailing $/SFr higher than in Cost Book V9 (MoU).
- Electronics components – FPPA, serialiser

Large Diameter Ingots in Russia

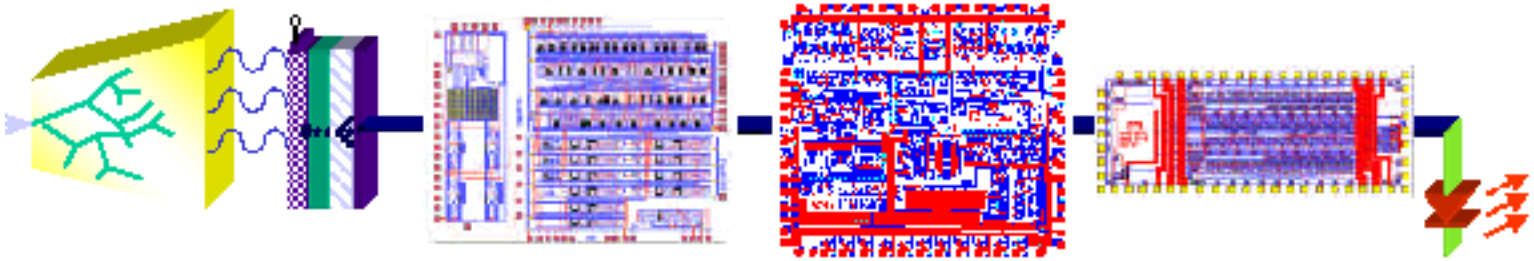
ECAL: Crystal Production

Subject to outcome of contract negotiations



ECAL Electronics Chain

LIGHT to LIGHT



APD → Hamamatsu Delay in start of production - Breakdown under irradiation

FPPA → Harris rad-hard technology - noise in latest iteration?

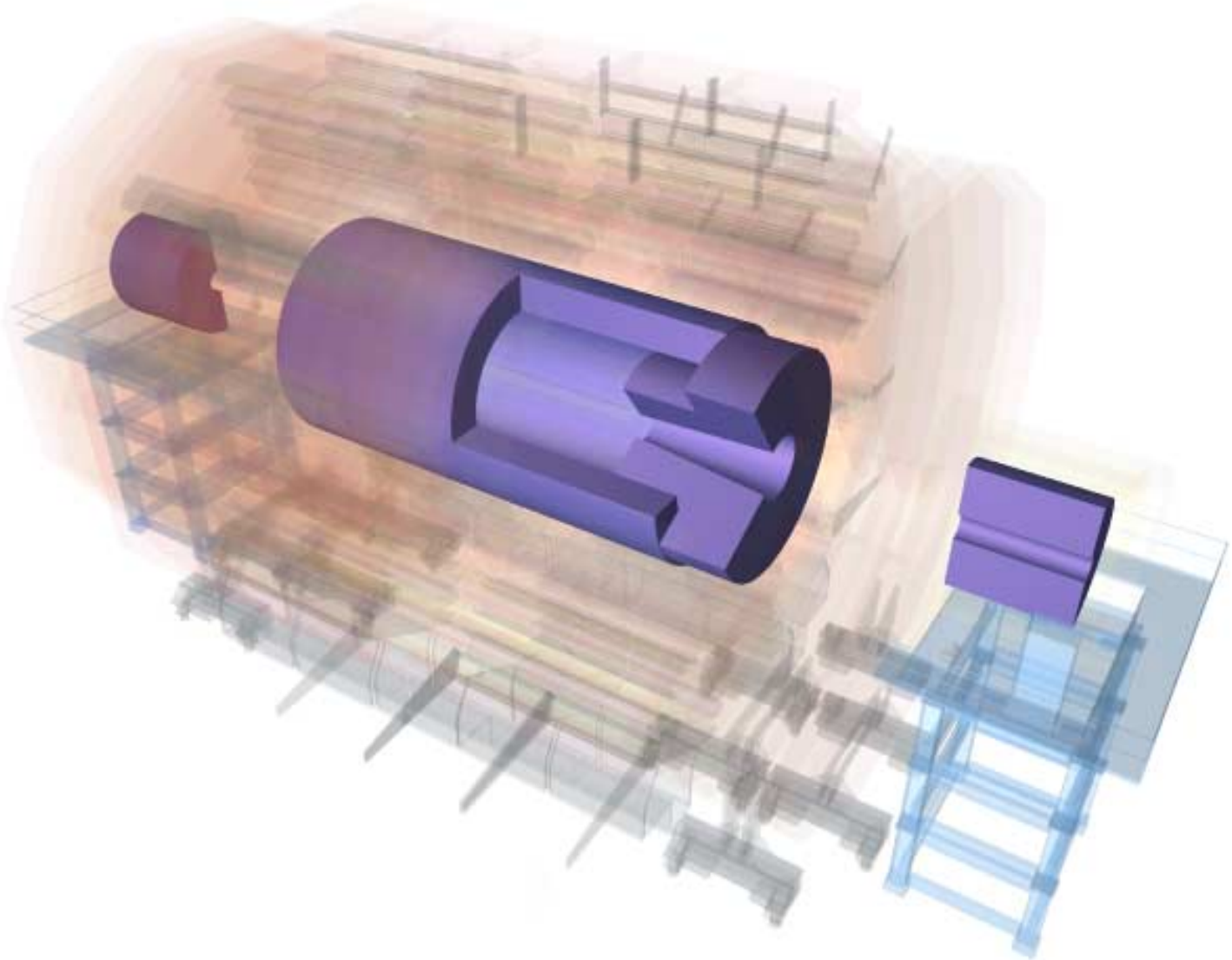
ADC → Analog Devices Place conrtact soon

Serialiser → Move to 0.25µm serialiser - expect CMS version end-01

VCSEL

Test M0' (400 channels) and chain starting autumn '01

4. HCAL



HCAL Overview

The Status

- Barrel (HB) absorber and optics manufacture is on schedule
- 1 Endcap (HE) absorber manufactured & assembled at MZOR.
- Forward (HF) design simplified – PPP wedge by summer 01.
- QIE electronics chain progressing

Concerns

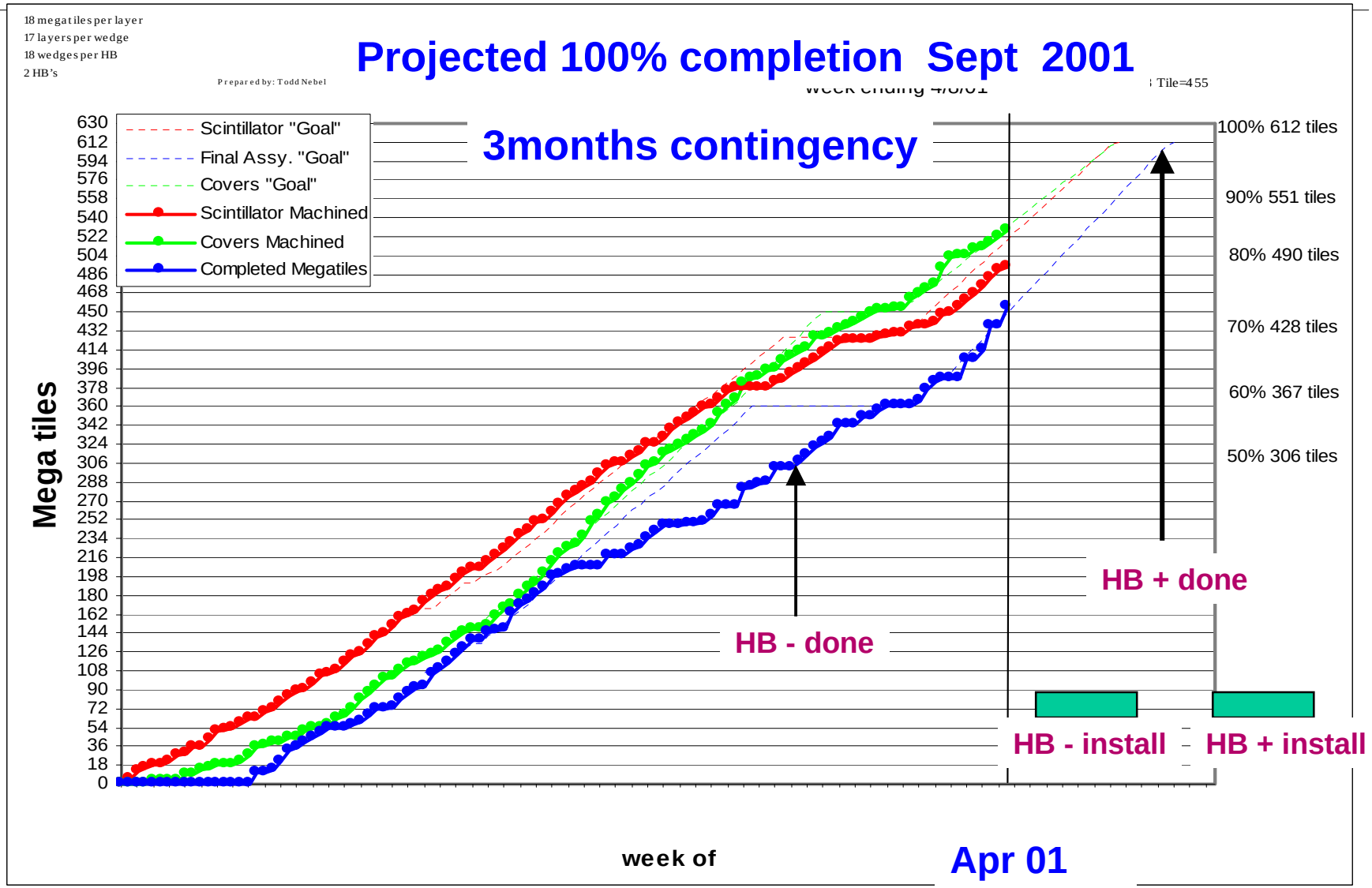
- Timely resolution of HPD cross-talk (optical ?)
- HF schedule tight – finish assembly by end 2003

HB-1 Complete

27 October 2000

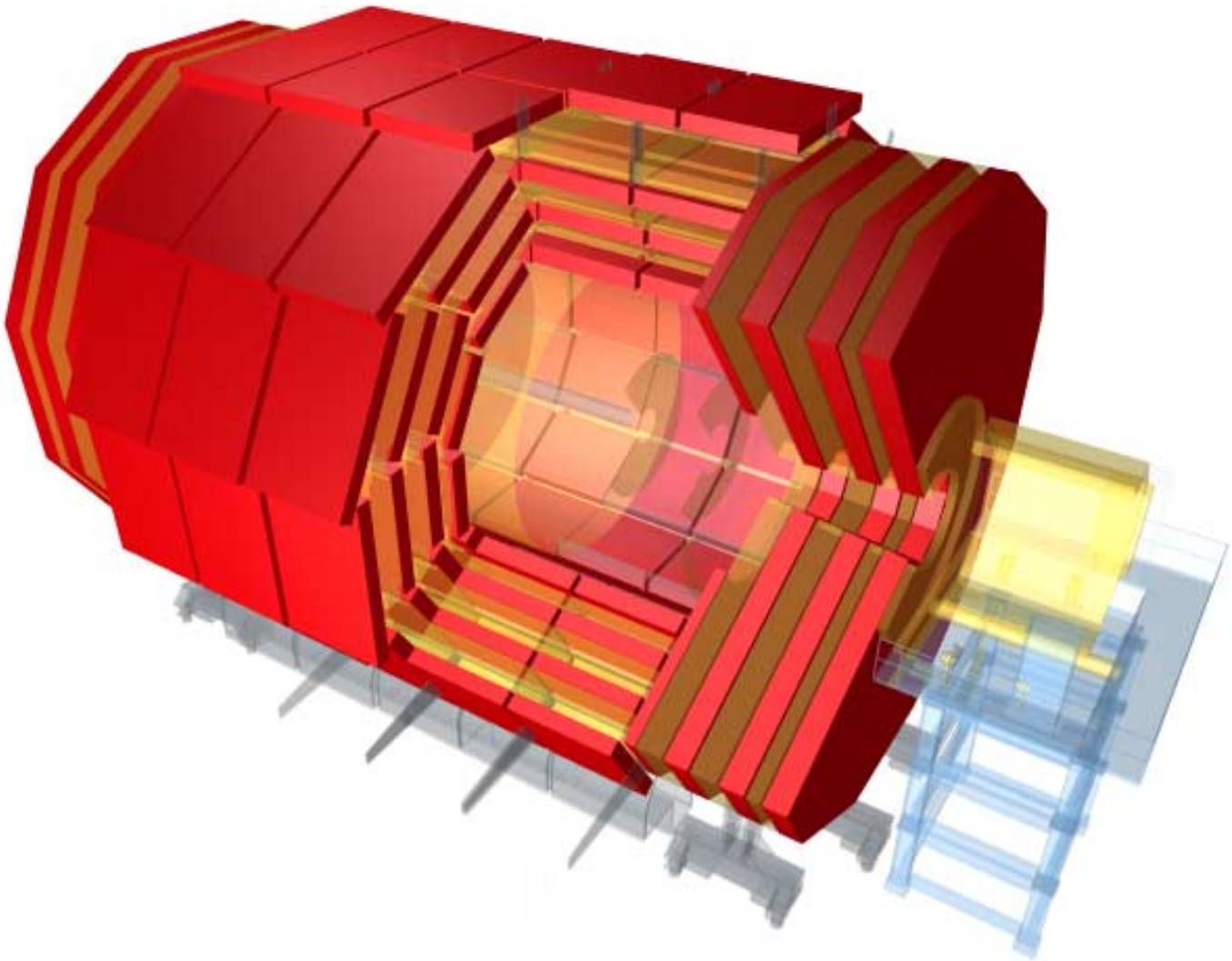
Reception of HB-1 at Felguera, Oviedo (Spain)

HCAL: HB Optics Production



HE-1, 22 Feb 01, MZOR, Minsk

5. Muon System



Muons Overview

The Status

- **Barrel DTs**: Two MB2 chambers assembled in CIEMAT using final assembly tools and procedures.
- Assemble at least one DT in Aachen and Legnaro (Padova) by May 01
- Assemble around 20 DTs by end-01

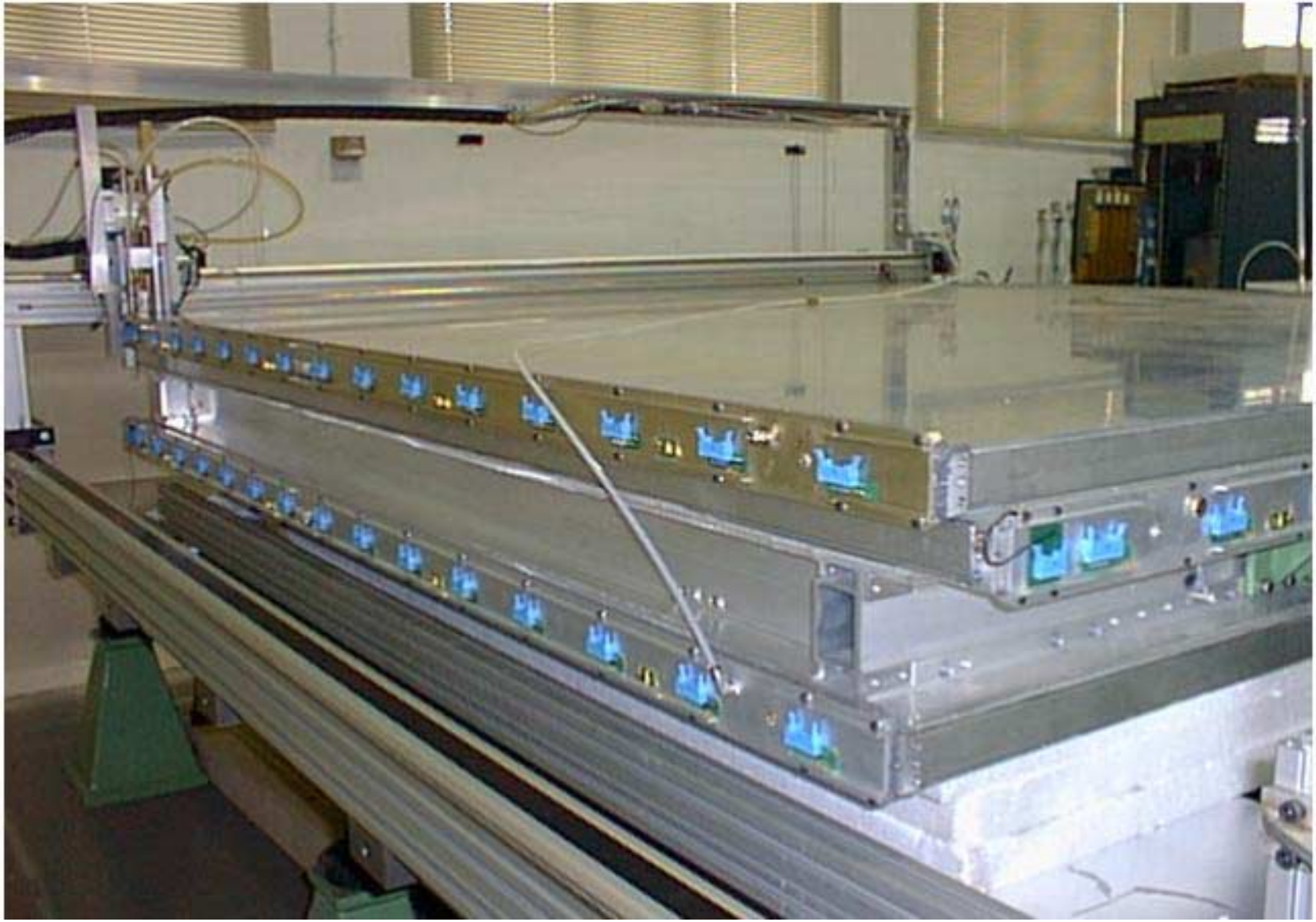
- **Endcap CSCs**: 30 chambers manufactured in FNAL.
- Parts and tools for IHEP and PNPI sites procured and shipped.
- Manufacture 1/5th of CSCs by end-01
- ME1/1: Panel production progressing in Dubna

- **RPCs**: Assemble 10 barrel RPCs by Jun 01. Determine target values of critical parameters using production chambers.

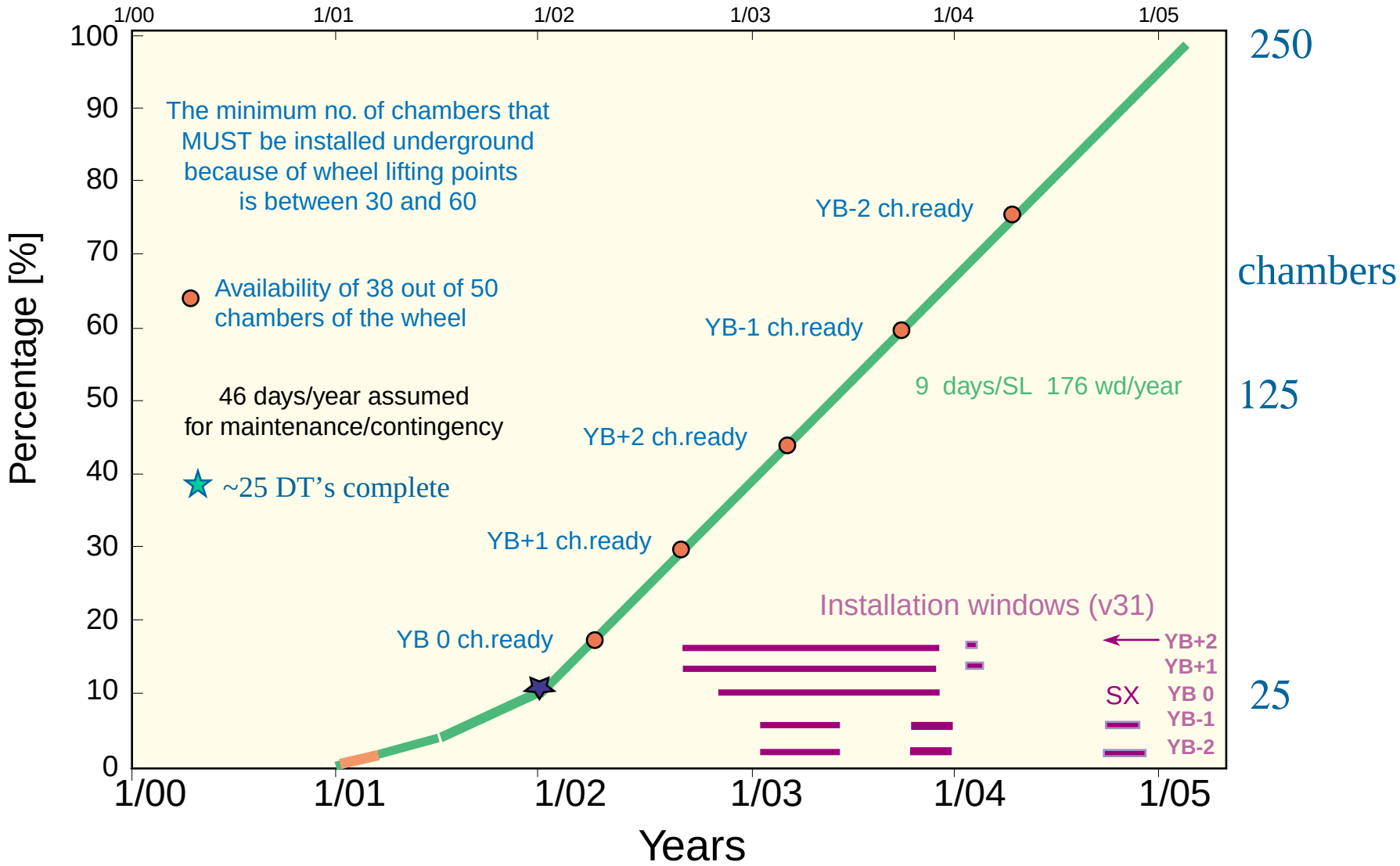
Concerns

- Logistics for DT chamber production – must assure on-time parts deliveries
- RPC chamber/trigger rate – decide to oil or not to oil – summer 01.

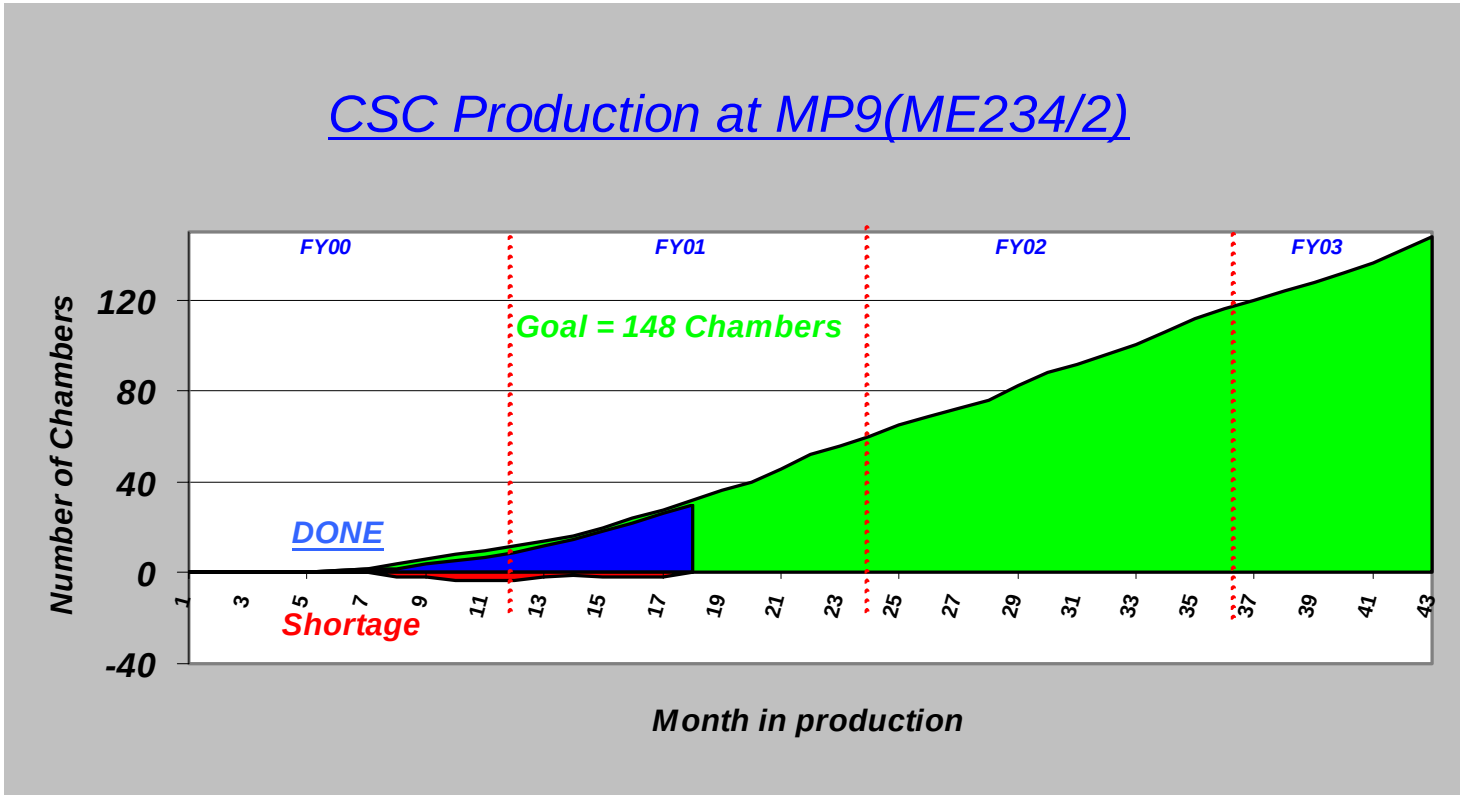
First MB2 Chamber Assembled at CIEMAT



MB: DT Chamber Production



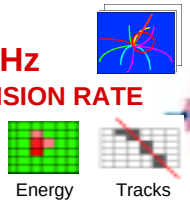
ME: CSC Chamber Production



			Expect end 2001
FNAL	144+4	ME23/2	60 (30 done)
PNPI	144+4	ME23/1	10
IHEP	72+4	ME1/23	1
Dubna	72+4	ME1/1	10

6. Trigger/DAQ

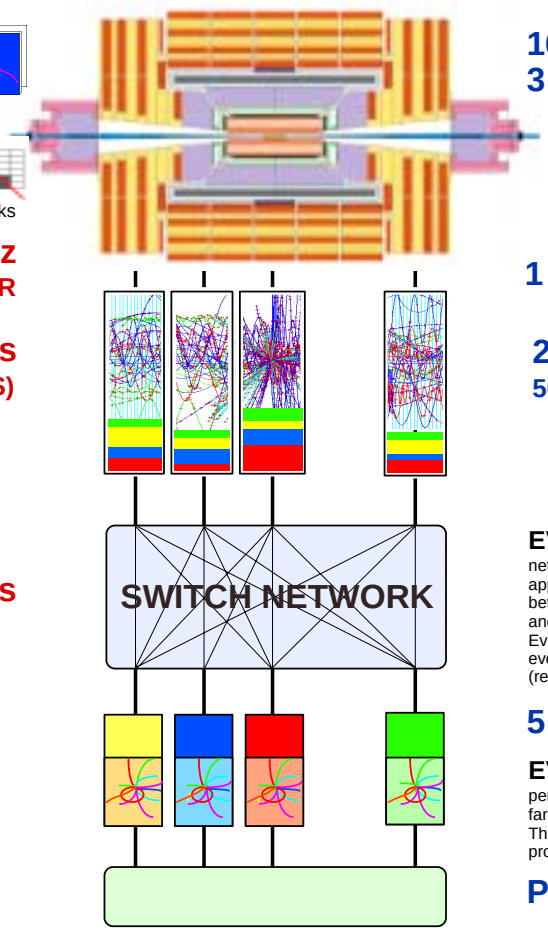
40 MHz
COLLISION RATE



100 kHz
LEVEL-1 TRIGGER

1 Terabit/s
(50000 DATA CHANNELS)

500 Gigabit/s



16 Million channels
3 Gigacell buffers

1 Megabyte EVENT DATA

200 Gigabyte BUFFERS
500 Readout memories

EVENT BUILDER. A large switching network (512+512 ports) with a total throughput of approximately 500 Gbit/s forms the interconnection between the sources (Readout Dual Port Memory) and the destinations (switch to Farm Interface). The Event Manager collects the status and request of event filters and distributes event building commands (read/clear) to RDPMs

5 TeraIPS

EVENT FILTER. It consists of a set of high performance commercial processors organized into many farms convenient for on-line and off-line applications. The farm architecture is such that a single CPU processes one event

Petabyte ARCHIVE

TriDAS Overview

The Status

- Level-1 Trigger TDR submitted end 2000. General approval recommended by LHCC in March.
- DAQ TDR submission postponed from Nov. 2001 to Nov. 2002 in line with new planning for first data in 2006.

Two DAQ demonstrators available for studies:

1) Event Builder 32x32:

64 Intel-PCs interconnected by two networks based on the most advanced technologies:

64 port Gbit Ethernet switch (Foundry, USA)

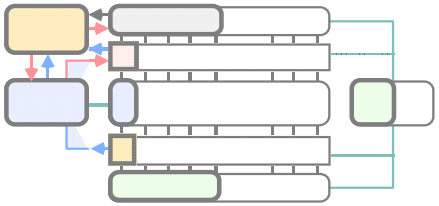
128 port Myrinet switch (Myricom, USA)

2) DAQ column:

Develop/integrate hardware or software prototypes of column components:

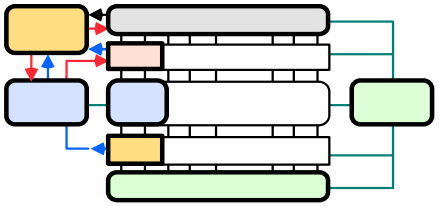
FED, RU, BU, FU

DAQ Commissioning Phases



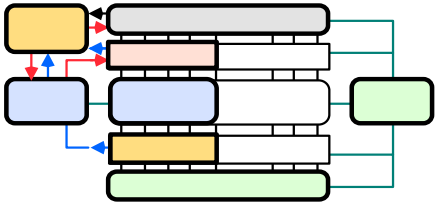
2004. Pre-series (lab demonstrators and test beams)

FED Links	RU	BU	EVB	FilterSubfarm	DCS&Services
256	64	32	128	4 (128 CPU)	**50%**



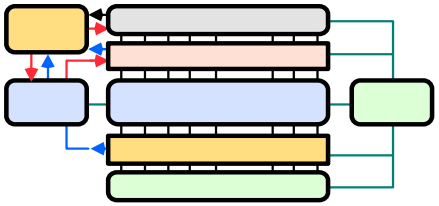
2005. DAQ-0 (final installation)

FED Links	RU	BU	EVB	FilterSubfarm	DCS&Services
512	128	128	256	16 (256 new)	
100%	**25%**	**25%**	**25%**	**25%**	**100%**



2006/7. DAQ-1

FED Links	RU	BU	EVB	FilterSubfarm	DCS&Services
512	256	256	512	32 (256+160new))	
100%	**50%**	**50%**	**50%**	**50%**	**100%**

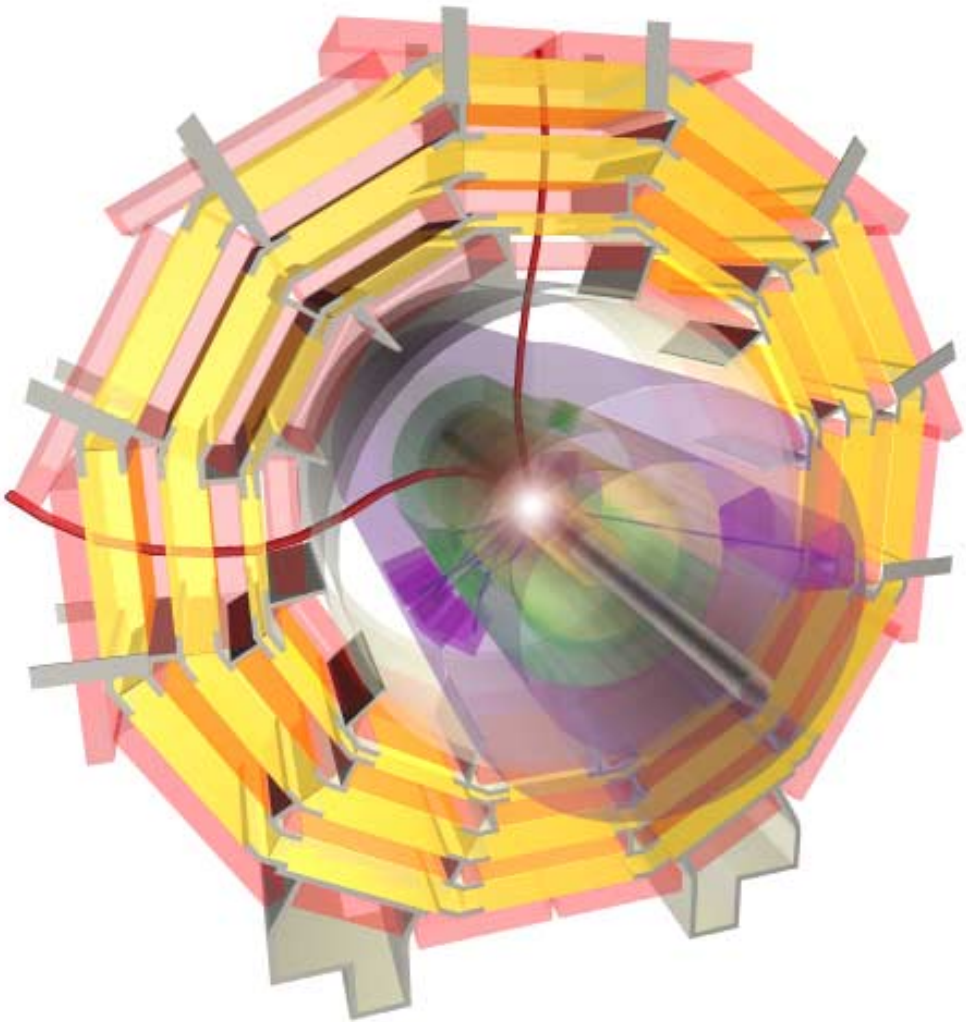


2007/8. DAQ-2

FED Links	RU	BU	EVB	FilterSubfarm	DCS&Services
512	512	512	1024	64 (160+256new)	
100%	**100%**	**100%**	**100%**	**100%**	**100%**

FED-Link-RUIO	: FED-Slink. Concentrator (5 GBit/s channels). 250 m Fiber. Receiver_ PC interface
RU	: PC. RUI-RUM board, Output interfaces (multiple of 1GBit/s)
Event Builder	: Switch N+N with 2 Gbit/s ports. Input/Output PC interface boards
BU	: PC. BUI-RUM. Input Interfaces and BU-FU interconnect
Filter Subfarm	: 100 GFlop. 16BU-FU interconnect. 10 Gb/s I/O bandwidth. 1 TeraByte storage

7. PRS/Software/Computing



Software and Computing Overview

The Status

• Organised as a coherent project called **CPT**: Computing and Core Software (**C**CS), Physics Reconstruction and Selection (**P**RS) and software and computing aspects of **T**riDAS.

• Functional prototypes released in October 2000 (OO and C++): Framework CARF, Recontruction Program (ORCA), basic prototype of simulation program based on GEANT4 (OSCAR).

• Millions of events reconstructed in ORCA and stored in Objy for PRS studies.

Plans for 2001/2002:

• >10 Millions of events to be simulated, reconstructed and stored in ODBMS (Objy) at various computing centers for use by PRS: Online High Level Triggers to be demonstrated for DAQ TDR (Nov. 2002).

• Ramping up of hardware facilities (Tier0, Tier1 and Tier2 prototypes centres): Test of distributed production, focus for R&D on GRID computing.

• Choice of ODBMS moved from Dec 2001 to Dec 2002

Concerns:

Lack of of professional Software engineers.

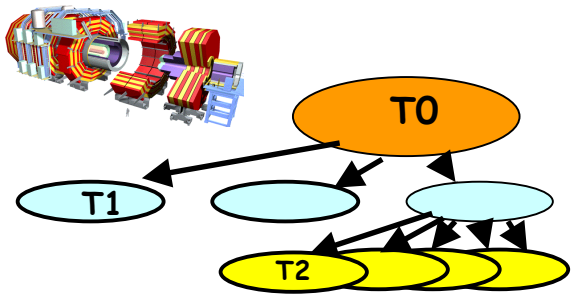
Computing iMoU/MoU

IMoU required in 2001 for

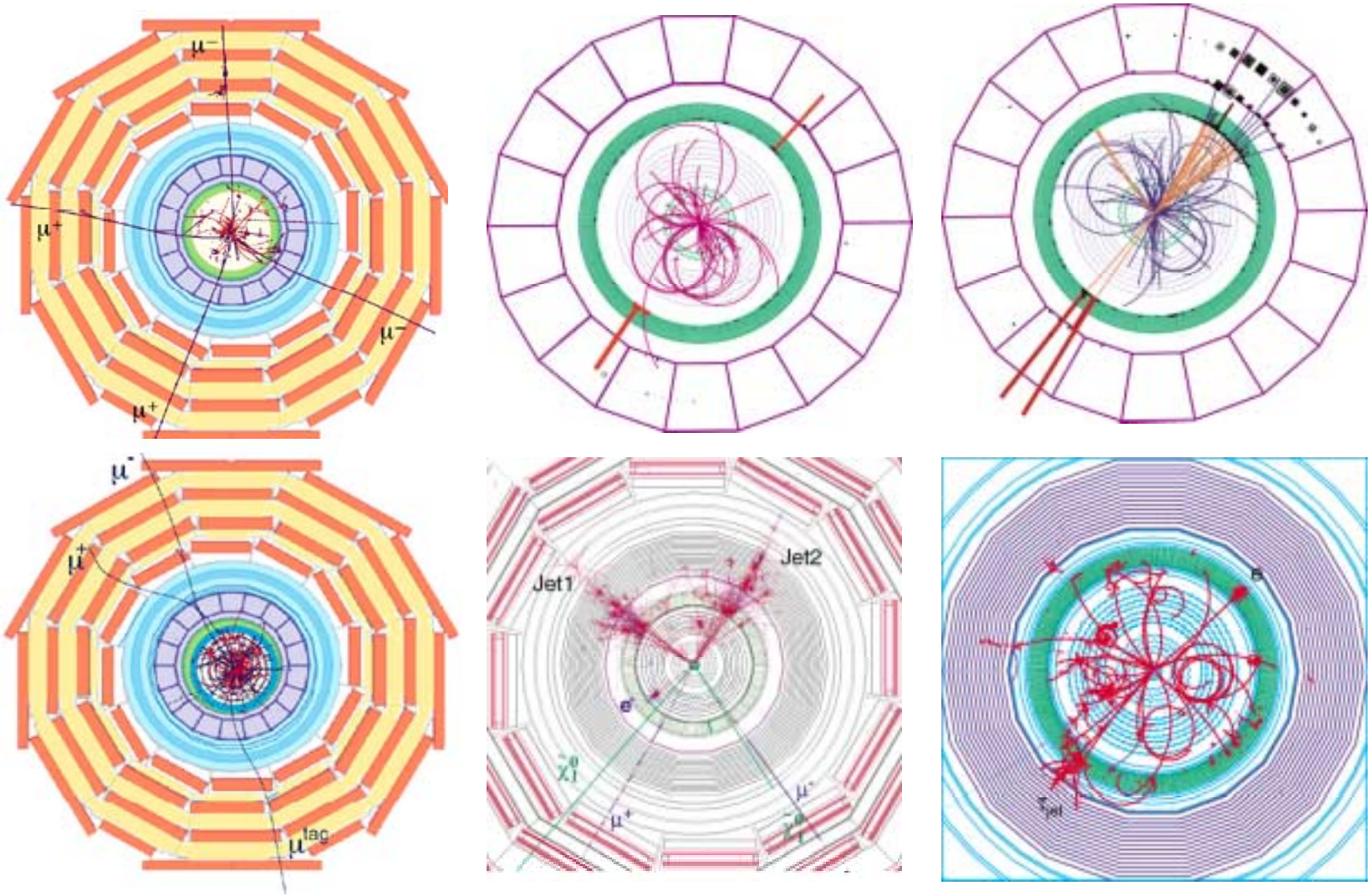
- **Software Manpower**
  - •Engineering is required now.
  - •We urgently need a special effort from agencies
- **Computing Prototypes**
  - •Complexity is hard to simulate. It must be tested
  - •Massive productions needed 2001-2004
  - •Much still to learn about Distributed Computing
  - •Encourage agencies that are ready to contribute
    - –Account for their contributions

Leading to a Full MoU in ~2004

- **Continued Software Manpower**
- **LHC Production Computing Systems**
  - •Two orders of magnitude in CPU/Disk/Tape
  - •Build in 2005-2007
  - •Financial and Infrastructure preparations required

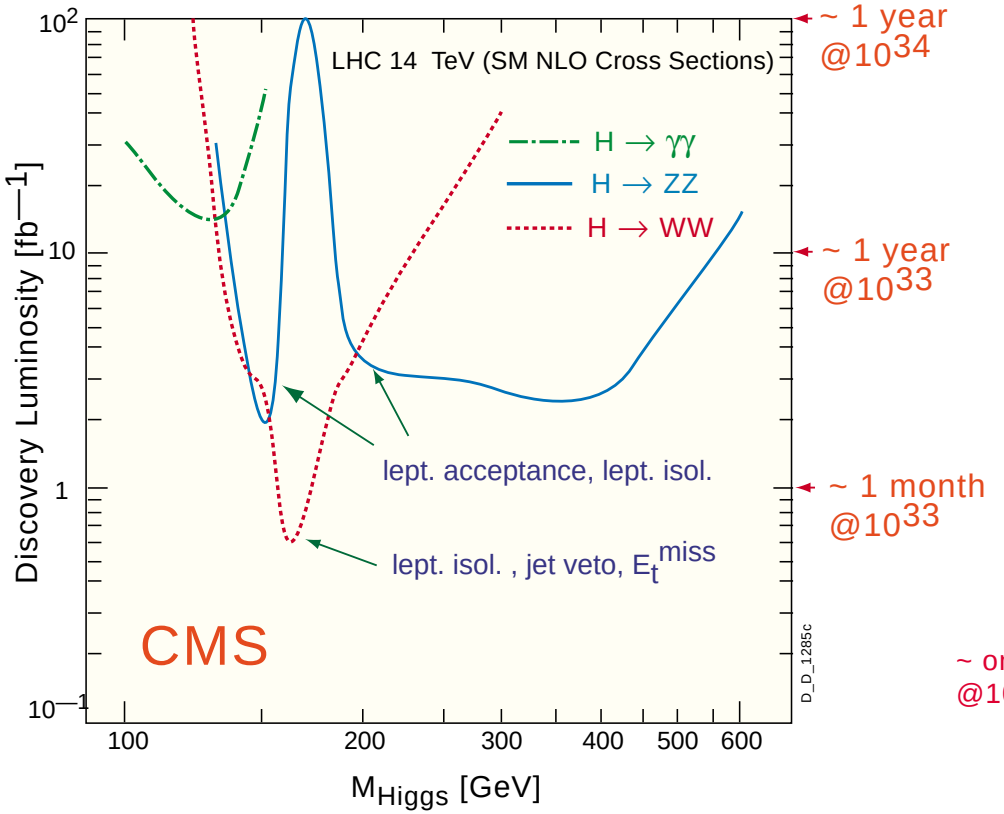


8. Physics

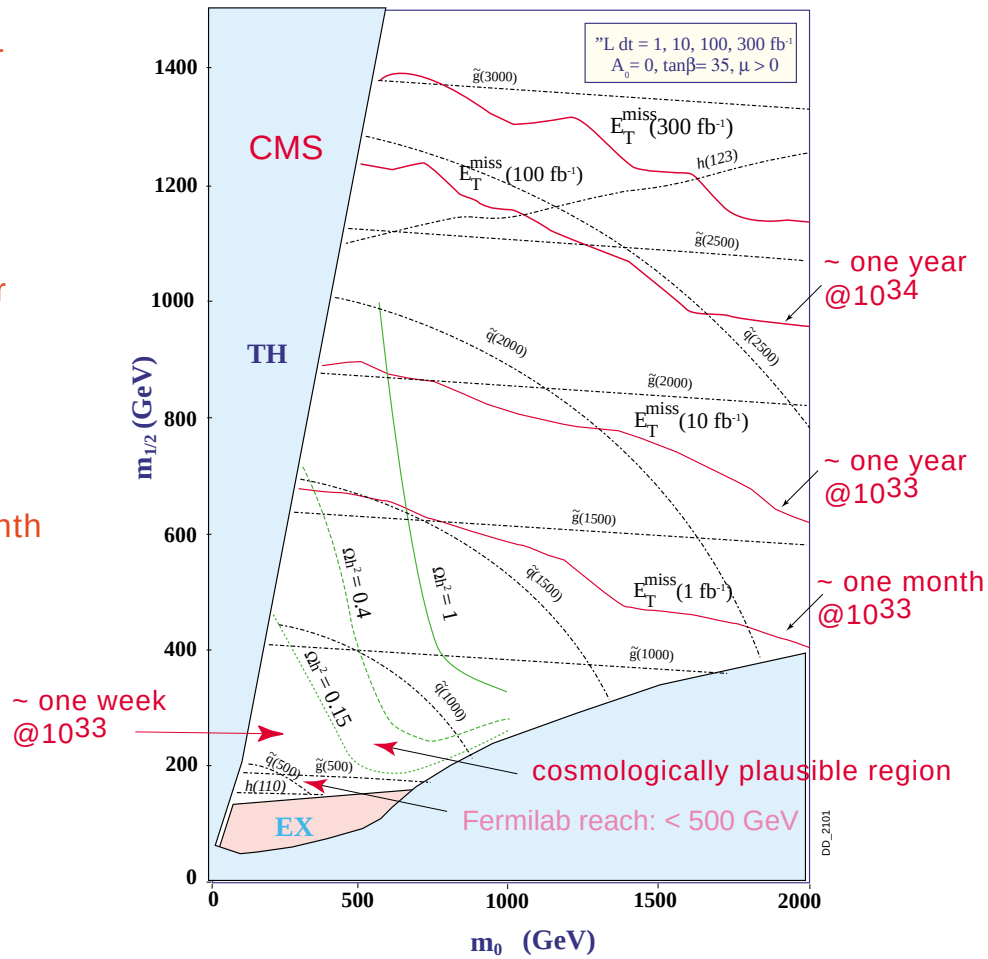


Physics Timeline ?

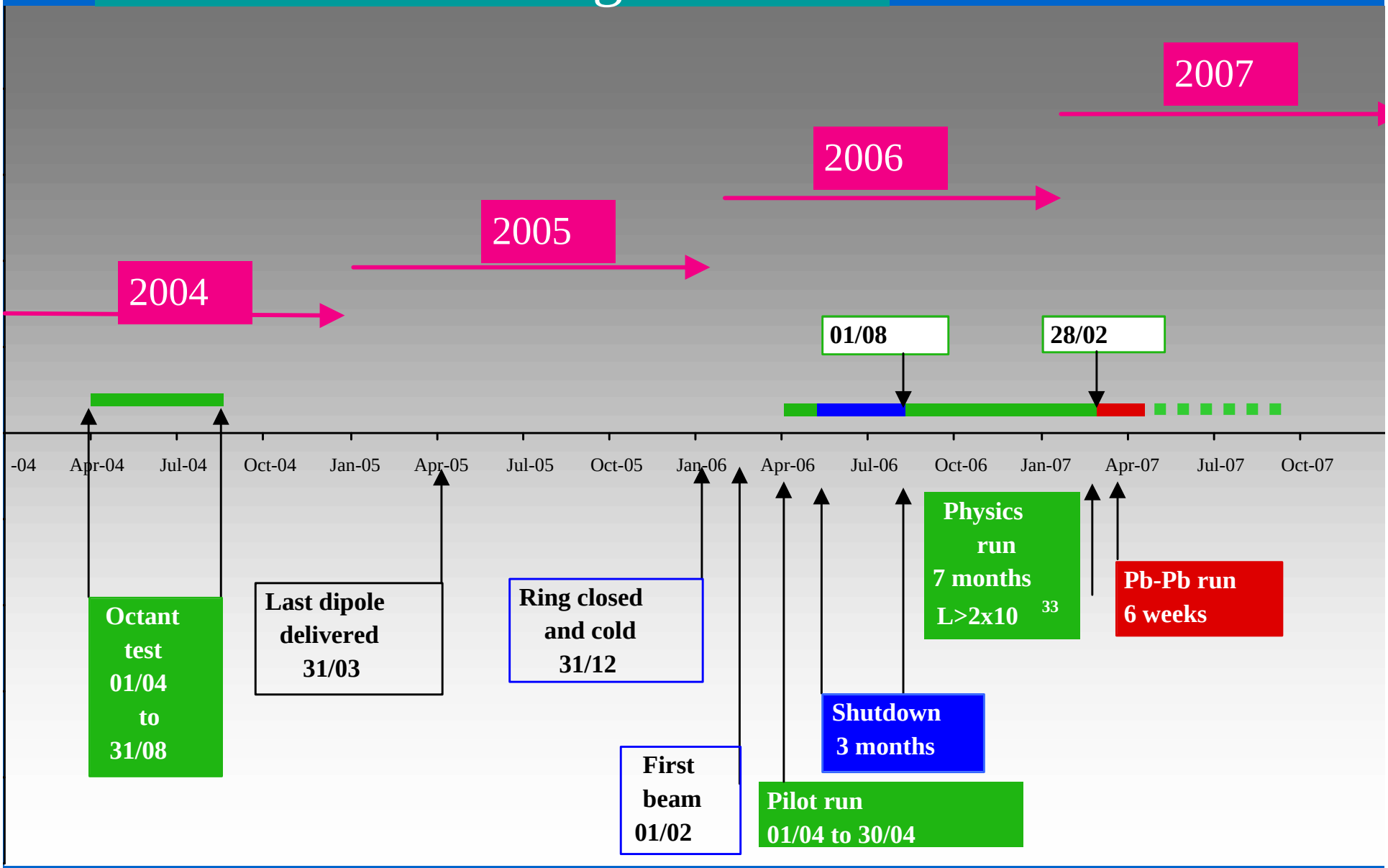
5σ Higgs Signals (statistical errors only)



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



LHC commissioning schedule



LHC Schedule

01/04/04 to 30/09/04	Octant test	
31/03/05	Last dipole delivered	
31/12/05	Ring closed and cold	Full access to experimental caverns
01/01/06 to 31/01/06	Full machine commissioning Beam pipes in place	Full access to experimental caverns
01/02/06 to 31/03/06	1 beam (2 months)	Restricted access to experimental caverns
01/04/06 to 30/04/06	First Collisions 1 month Pilot run	Luminosity: $5x10^{32}$ to $2x10^{33}$
01/05/06 to 31/07/06	Shutdown	Full access to experimental caverns
01/08/06 to 28/02/07	Physics run: 7 months	Luminosity: $\geq 2x10^{33}$ (≥ 10 fb^{-1})
01/03/07 to 12/04/07	Lead ion run, 6 weeks	

V30 -> V31 General CMS Schedule

Key dates:	v30	v31
UX, US delivery	1 Dec 2003	1 Apr 2004
UX installation start	1 May 2004	1 Sep 2004
CMS closed for single circulating beam	1 Feb 2006	1 Feb 2006
CMS closed for pilot run	15 Apr 2006	1 Apr 2006
Start of 3-month shutdown	15 May 2006	1 May 2006
CMS closed for 10fb^{-1} physics run	15 Aug 2006	1 Aug 2006
pp physics run ends		28 Feb2007

Key critical path windows:		
UX equipping	5 mo	5 mo
CMS underground installation	21 mo	17 mo
US equipping	5 mo	3 mo
readout/trig/DAQ install commission	20 mo	17mo

Modifications Required to get to V31

Move activities from UX to SX, will need more resources

SX: Magnet test delayed 2 mo. (coil)

Pre-cabling, pre-testing, try to move some CMS infrastructure activities into civil engineering (e.g. shielding concreting, floor plates)

HF assembly, MU+ installation lengthened 2 mo

MU- installation shifted 4 mo later

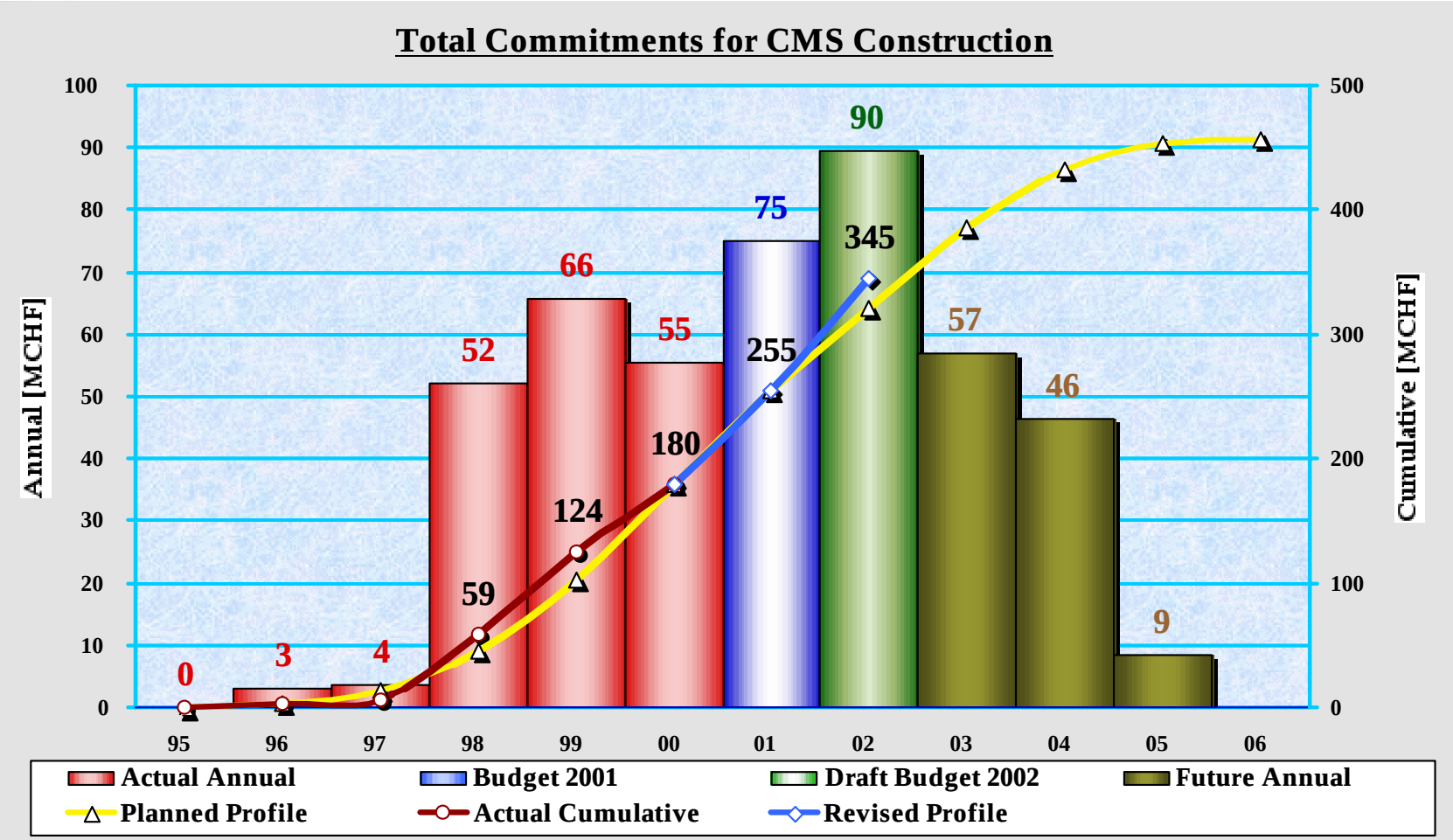
EB+ installed on surface 1 mo earlier (gain 1.5 mo)

UX: EE- installed after pilot run (gain 1.5 mo)

SE- installed parasitically with TK

Overlap b.p. installation & TK commissioning (gain 1mo)

Expenditure: Reported to CMS RRB Apr01



Conclusions

Magnet Project progressing well – (>85% committed)

In mass production: ME (forward CSCs), HB, HE (bareel&endcap HCAL)
Ramping up production in 2001 – MB (barrel DTs), RB (barrel RPCs)
Starting production in 2001 – EB(barrel ECAL SM), Tracker (Si modules)

Slopes of rate of production will be better known doe almost all sub-detectors by next Spring

Concerns – ECAL (Crystals, electronics), DTs (rate of production)

CMS has made plans for a complete detector (except for the 4th endcap muon station, which is staged) ready for the physics run starting Aug 2006.

The additional 4 month delay in the delivery of the underground caverns has serious implications for CMS installation and commissioning.

Discussions have started in the Resources Review Board on what is necessary to:
- complete the CMS detector (by Aug 2006)
- maintenance and operations
- computing