

CMS

Status Report

T. S. Virdee

FNAL 27th July 00

Collaboration Matters

Magnet and Infrastructure

Tracker

ECAL

HCAL

Muon

Trigger & DAQ

Physics Reconstruction and Selection

Software/Computing

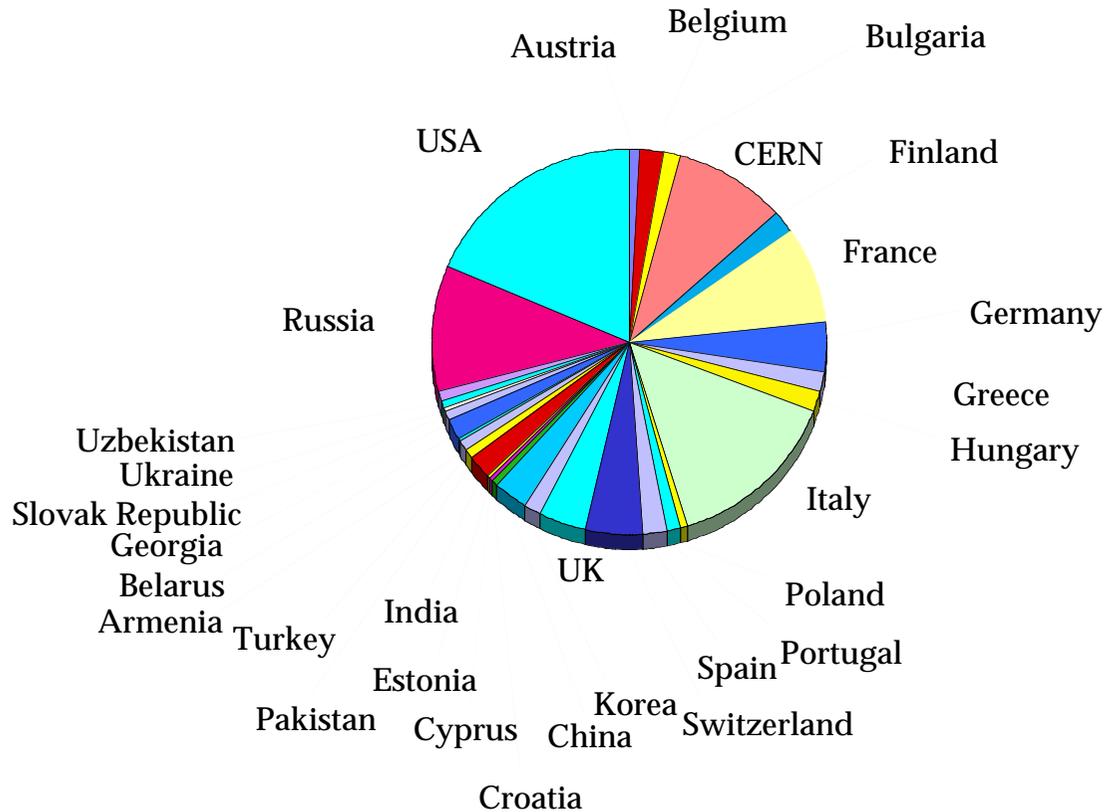
Cost, Funding and Schedule

Compact Muon Solenoid



The CMS Collaboration

1792 Physicists & Engineers
31 Countries
141 Institutions



All MoU's signed
(last ones Hungary, Korea, Bulgaria)

New Members
Taiwan (ECAL)

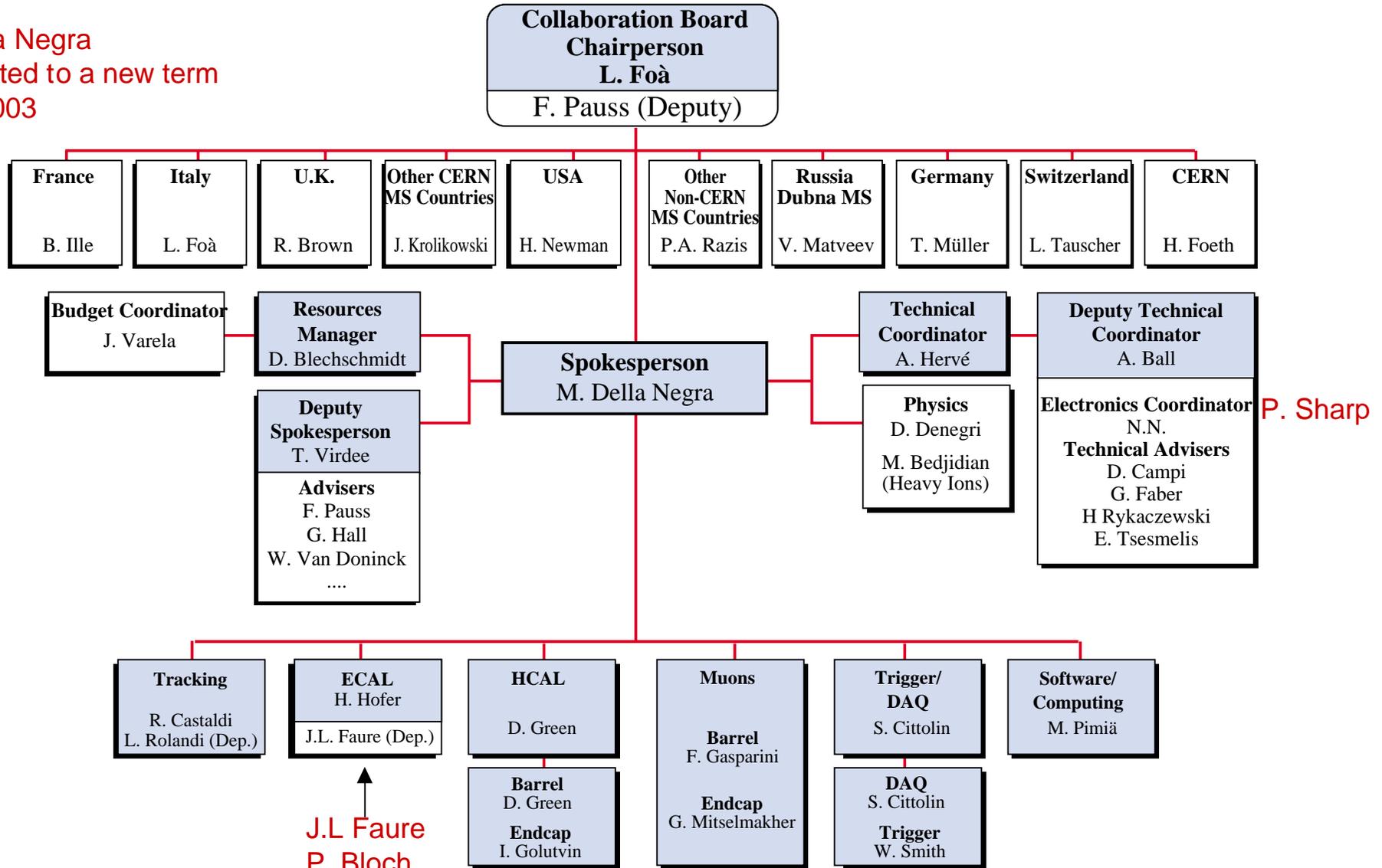
In discussions with
Brazil
Ireland

February, 21st, 2000/av
<http://cmsdoc.cern.ch/pictures/cmsorg/overview.html>



CMS Management Board and Steering Committee

M. Della Negra
 Re-elected to a new term
 2001-2003

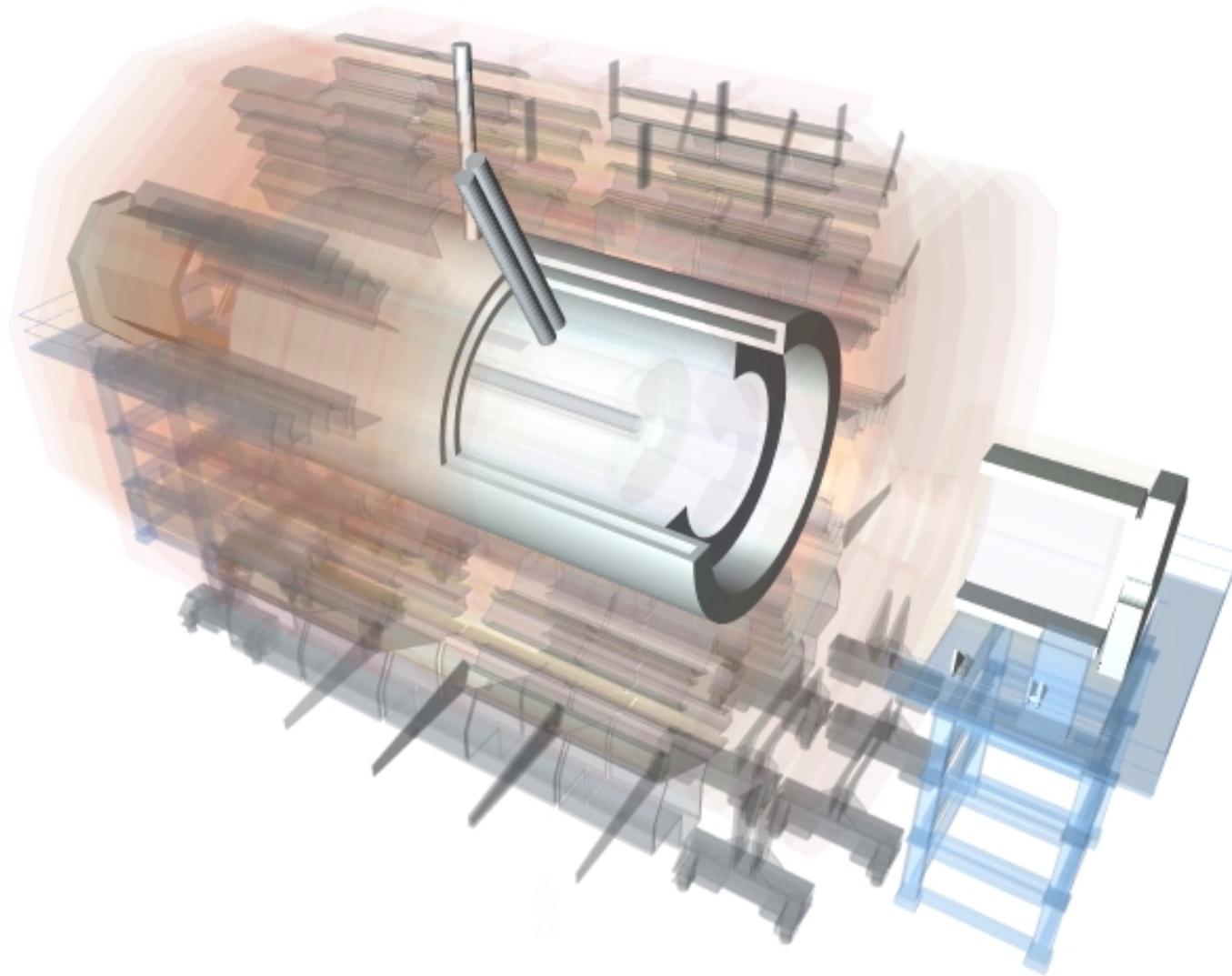


Steering Committee

CMS Status/ Jun00

06 March 2000

1. Magnet and Infrastructure





Civil Engineering: Overview

- **The Status**

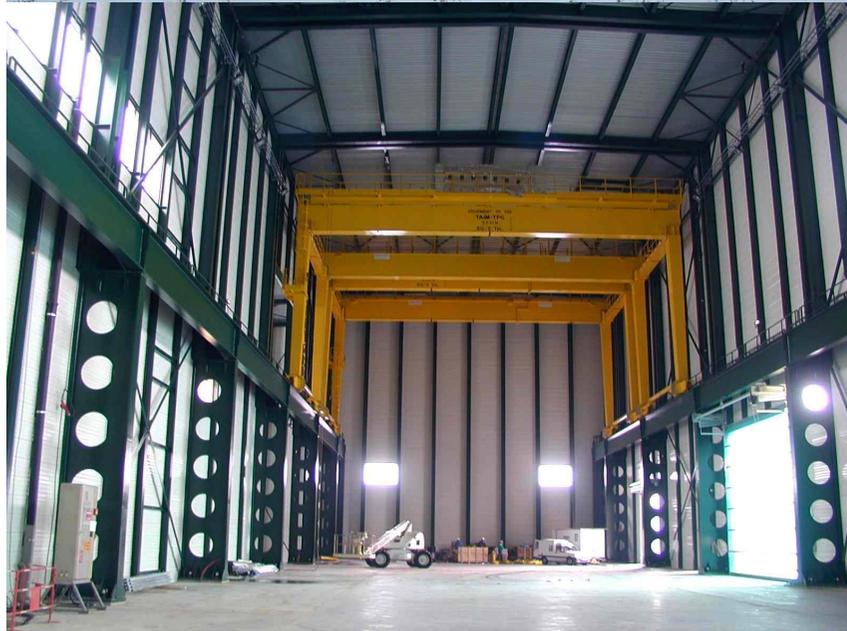
- The surface hall, SX5, has been delivered on time
- The civil engineering of the underground cavern, UX5, is delayed by 5 months compared with the contractual planning

- **Plans and milestones for 2000**

- Underground assembly schedule will be adjusted to allow completion of a working CMS detector for first LHC beams in 2005
 - Surface hall, SX5, will be fitted-out by Jul 00 to allow magnet yoke assembly to start
-
- **Underground Area ready in mid-03**



Civil Engineering at Point 5



Jun 00: $\phi=12\text{m}$ shaft at -70m
 $\phi=20.4\text{m}$ shaft at -40m



The two 80-tonne cranes in SX5 are operational



Magnet: Overview

- **The Status**

- All major contracts have been placed (84 MCHF ($\approx 70\%$) worth are under contract)
- The cost estimate of the magnet (121.9 MCHF) is maintained
- Magnet yoke construction is on schedule
- The SC Coil schedule, based now on contractual dates, exhibits a 5 month delay (sits in the shadow of the delay in civil engineering).

- **Plans and milestones for 2000**

- Assembly of barrel yoke in surface hall, SX5, will start in July 00
- A 1 km demonstration length of conductor will be fabricated by Oct 00
- The winding line should be completed by Oct 00

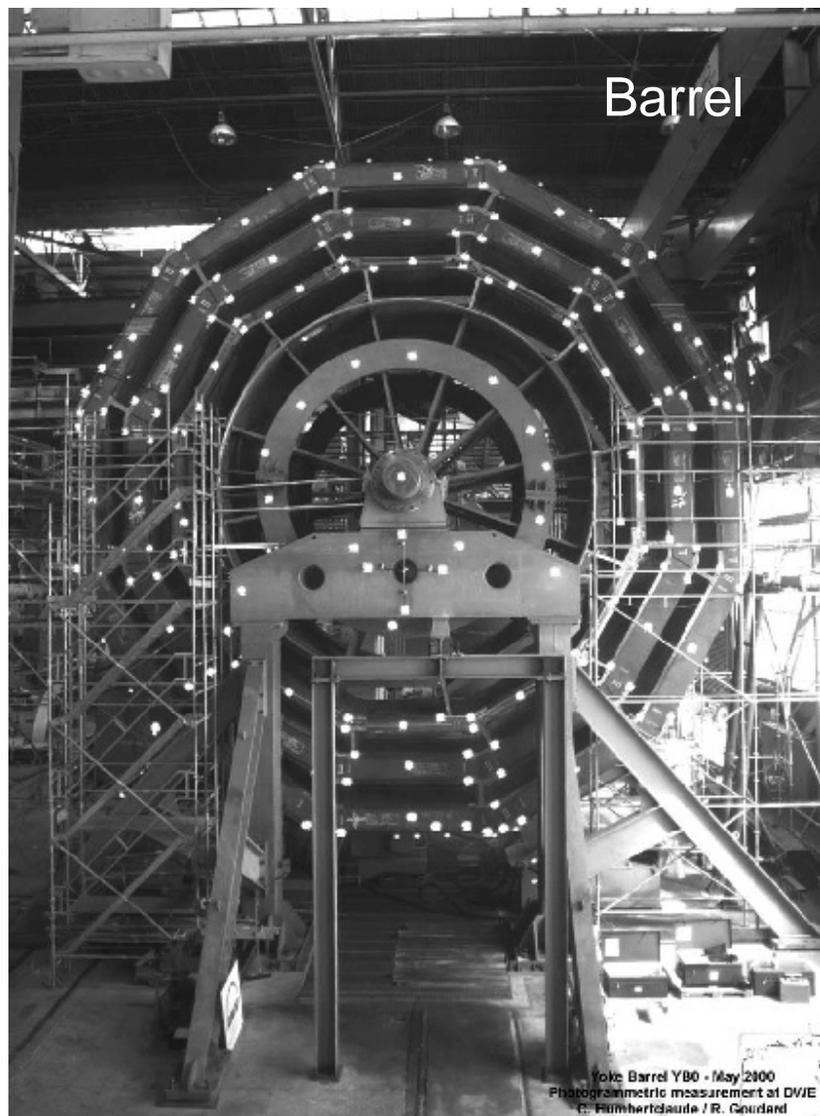
- **Concerns**

- No major concerns

- **Magnet Test on surface Spring 04**



Magnet: Yoke



Photogrammetry measurements





Magnet: Coil



Model of Winding Machine

Major Contracts for Coil

Superconducting Strands

IGC-US, Outokumpu-Finland

Rutherford cable

Brugg Cabelmetal-CH

Pure Al Insert

Sumitomo HI, Japan

Insert Extrusion

Alcatel Suisse at Cortaillod, CH

Electron Beam Welding

Techmeta, France

Winding

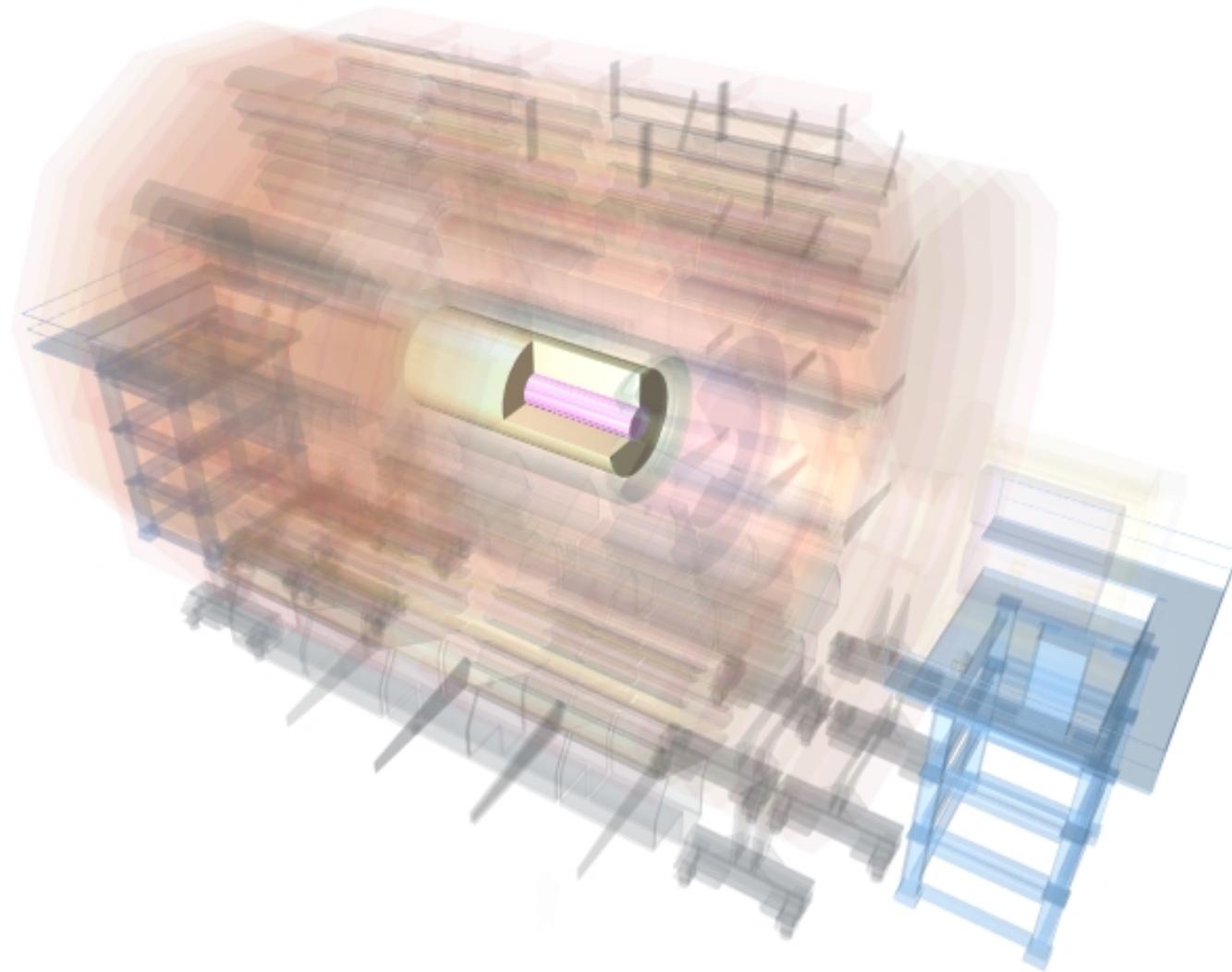
Ansaldo, Italy

External Cryogenics

Air Liquide, France



2. Tracker



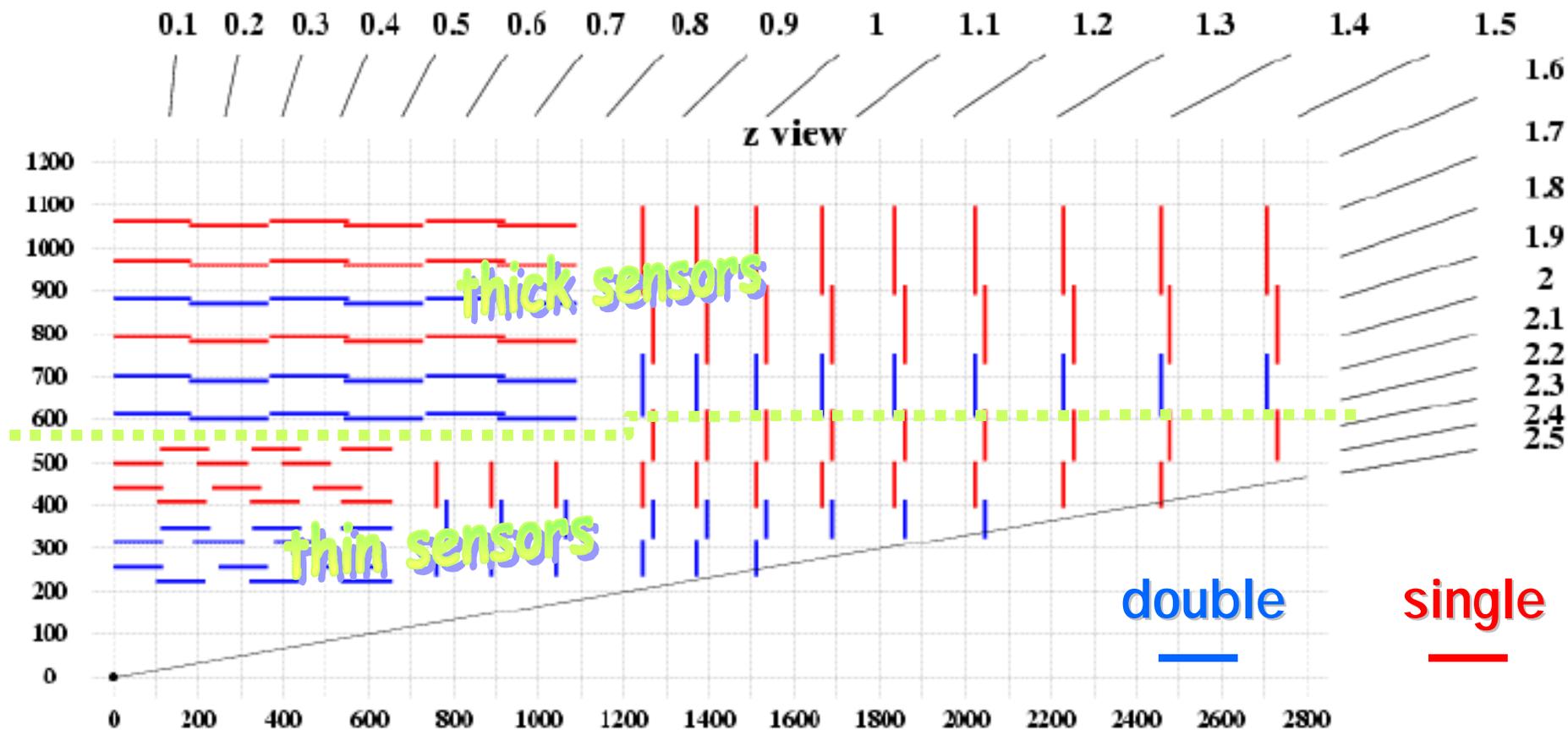


Tracker: Overview

- **The Status - Change to all-Si tracker**
 - continuing decrease in cost of Silicon sensors
 - emergence of fabrication of larger area sensors on 6" wafers
 - possibility of streamlining module assembly through automation
 - availability of 0.25 μ m electronics with reduced cost and better performance
- Good progress with pixel detectors and electronics
- **Plans and milestones for 2000**
 - Optimize layout - done
 - Procurement Readiness Review in June (pre-production sensors) - done
 - Establish schedule - done
 - Systems tests in 25 ns beam - done
 - Study integration and maintenance scenarios - EDR in Nov 00
 - Prototypes of final size pixel sensors
- **Concerns**
 - Funding shortfall - Draft Tracker MoU for Oct RRB - Italy and US ?



Optimized Tracker Layout



Pixels not shown

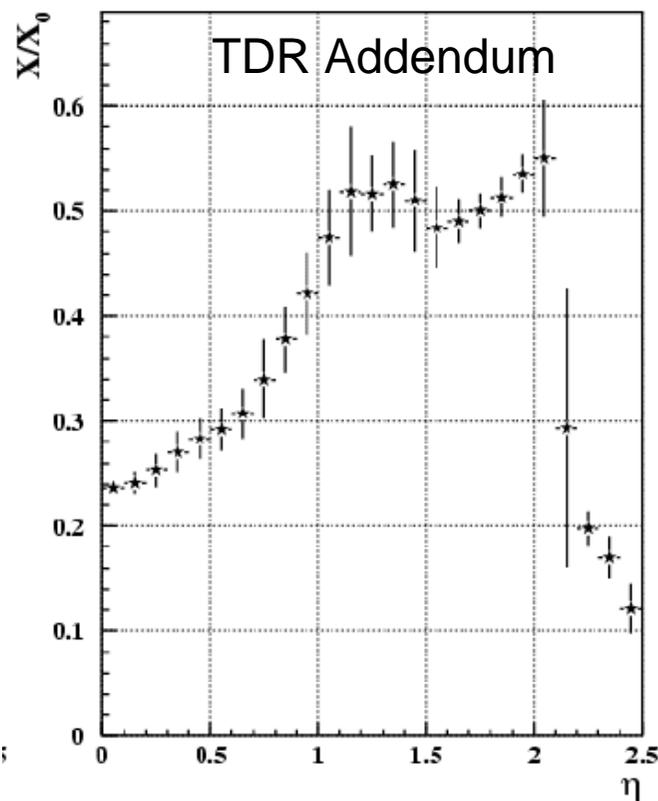
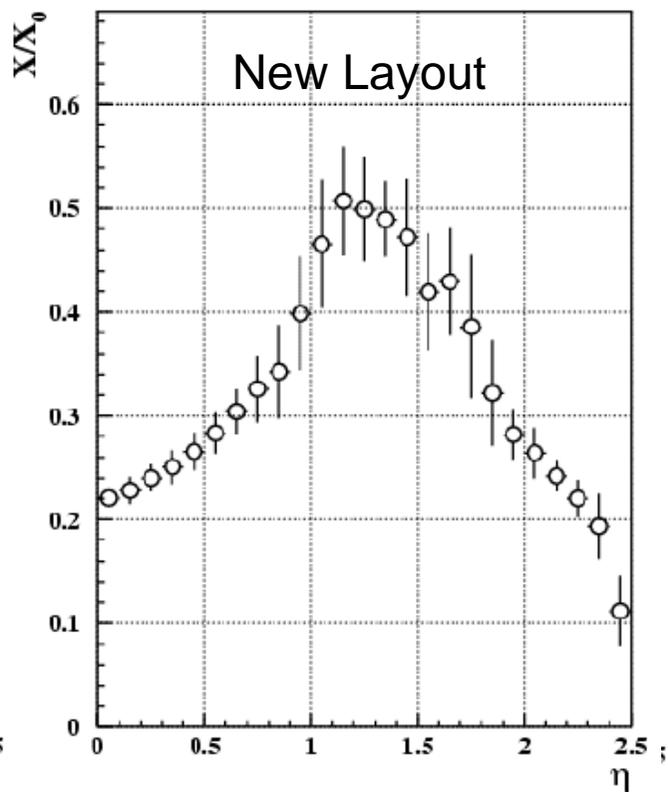
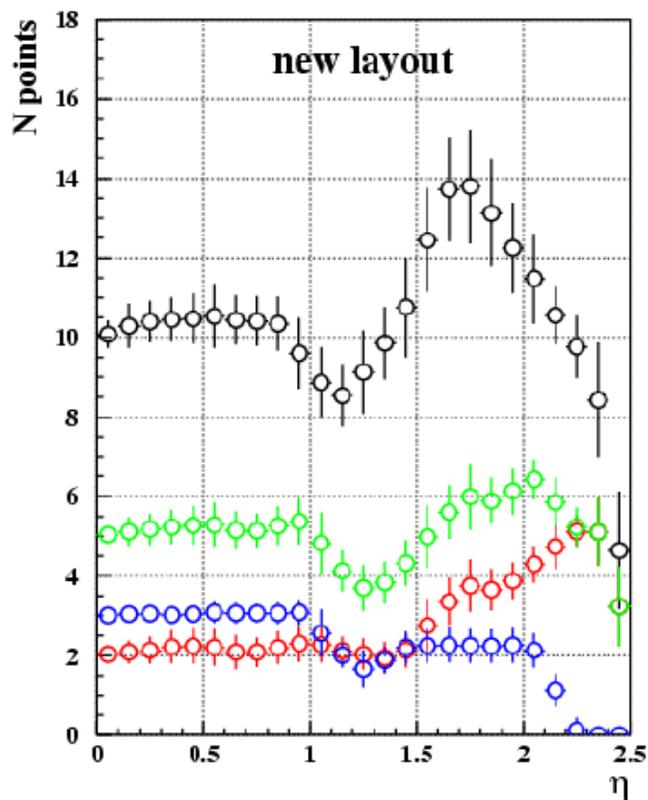
w.r.t. TDR addendum

~10M ch (-5%), 17,500 SS modules (-4%), more points, better pitch, less material



Material Budget

pixels excluded

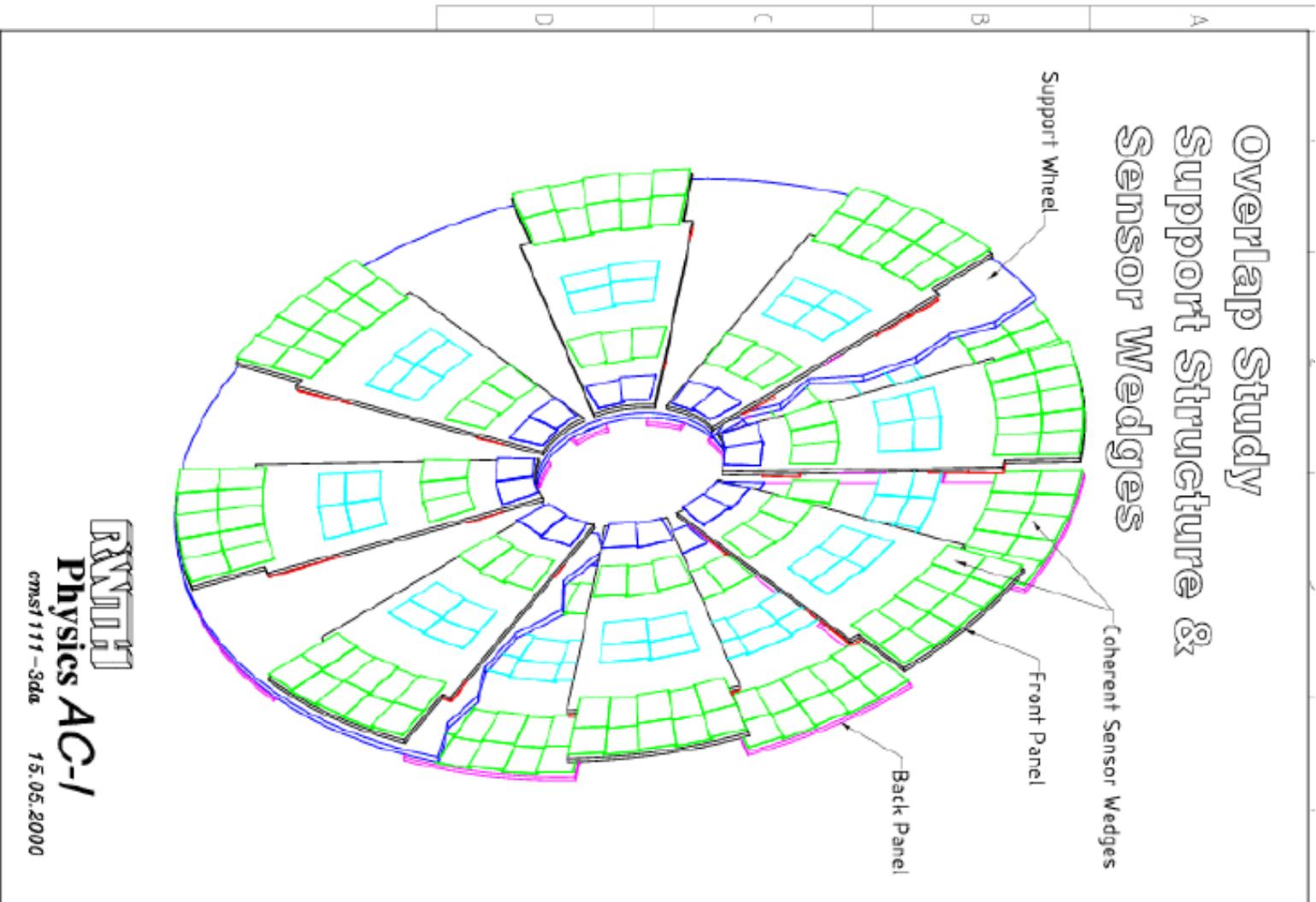


| Total

| Total DS



Forward Discs





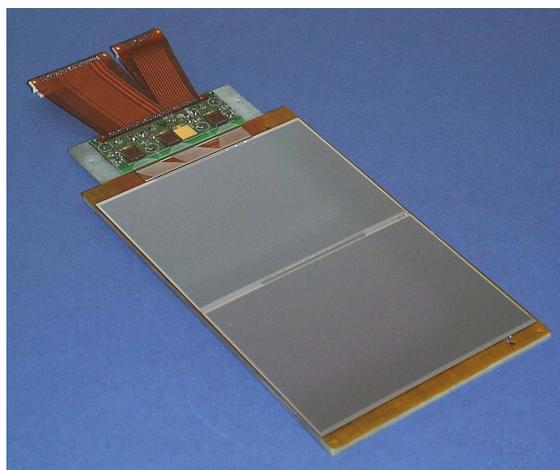
Tracker: Logistics

223 m² of silicon sensors

6,136 Thin detectors (1 sensor)
9,816 Thick detectors (2 sensors)
26 M Bonds

10.0 M strips \equiv electronics channels
78,256 APV chips

All sensors, modules and electronics
can be produced in 2.5 yrs



Automatic Module production





Schedule - Sharing of Responsibilities

Version 26 General Planning

PRR	15/6/00
Tender for sensors	3/7/00
EDR	20/11/00
Signature of sensor contract	15/2/01
Test of system aspects with pre-production modules	15/3/01
Tender mechanical structures	15/1/01
First production module ready	30/9/01
First rod ready	21/1/02
First petal ready	15/4/02
Mechanical structures ready	16/9/02
Delivery of TIB to CERN for Final test	2/2/04
Delivery of End-Cap to CERN	27/2/04
Delivery of TOB to the Tracker	15/4/04

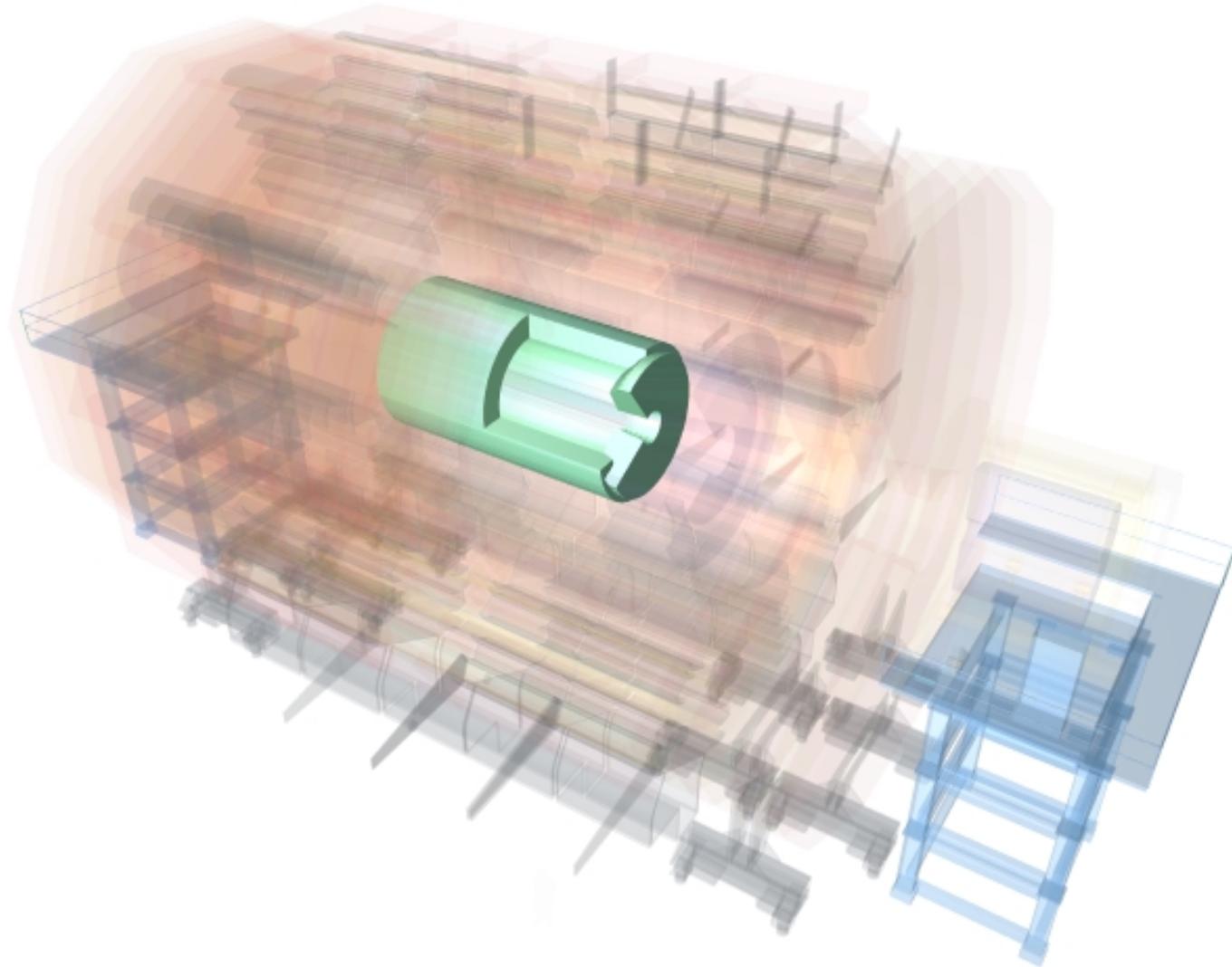
TRACKER DETECTOR INSTALLED 9/5/05

US: Propose to expand role in Tracker: 1/3rd of modules
 FNAL, Kansas State, Northwestern, Purdue, Kansas U, Illinois U, Rochester

Draft MoU for Oct RRB

Detector Production		37% USA, 38% C.E., 25% INFN		
Frames		Brussels		
Sensor test		Louvaine, Karlsruhe, Perugia, Pisa, Strasbourg, Vienna		
Pitch adapters		Brussels		
FE Hybrid		Strasbourg		
Bonding P.A.		Cern		
Detector Mounting		Bari/Catania, Brussels, Fermilab, Lyon, Perugia, Vienna		
Detector Bonding		Aachen, Bari, Fermilab, Florence, Karlsruhe, Padova, Pisa, Strasbourg, Torino, Vienna, Zurich		
Detector Burn in		All above institutions		
Electronics				
FE Analog electronics	UK			
FE Control	Cern			
Opto-electronics	Cern			
Optohybrid	Perugia			
Power Supplies	Firenze, Torino			
FED	UK			
FEC	CERN, Vienna			
Mechanical Structures				
Inner Barrel	Pisa			
Inner Endcap	Pisa			
Outer Barrel	Finland/Cern			
Outer Barrel rods	Finland/Cern			
Endcaps	Aachen			
Endcaps petals	Aachen			
Support tube	Cern			
Thermal screen	Cern			
General cooling	Cern			
Cabling	Cern			
Integration	Cern			
Integration of Detectors				
Inner Barrel	INFN/Fermilab			
Inner Endcap	INFN			
Outer barrel rods	USA + Cern			
Outer barrel	Cern			
Endcap petals	C.E.			
Endcaps	Aachen, Karlsruhe, Lyon			
Position Monitoring System	Aachen, Cern			

3. ECAL





ECAL: Overview

- **The Status**

- Russian crystals continue to be delivered on schedule. Reject $\leq 2\%$ (within target)
- Agreement reached in Russia for manufacture of 1/2 of barrel crystals (1.6 \$/cc)
- Delay of 9 months in crystal manufacturing in China. Price agreed (1.6 \$/cc)
- Two milestones missed (delay of ≈ 9 months) - through errors in manufacturing
 - Module-0 - grid and basket out of tolerance
 - 500 electronics channel - very low yield (but ones received performed well)

- **Plans and milestones for 2000**

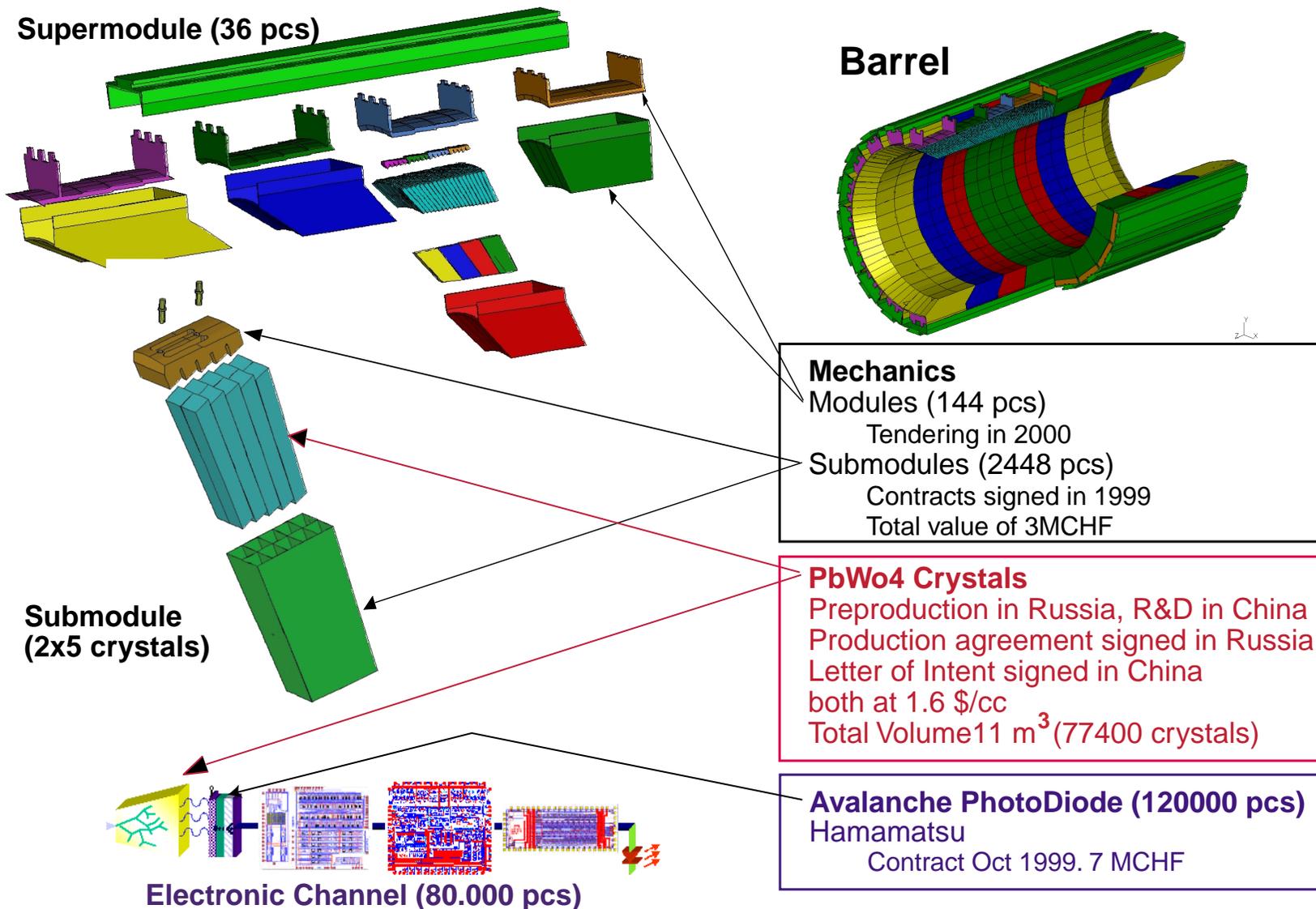
- Delayed milestones will be completed
- Start pre-production of crystals in China before end-00
- Engineering Design Review of Endcap and Pre-shower system
- Electronic and Electrical System Review (Sept '00)

- **Concerns**

- The critical path item is crystals production, invest in extra crystal-growing capacity
- ETH funding profile
- Crystals are priced in \$/cc. Prevailing \$/SFr higher than in Cost Book V9 (MoU).



ECAL. EB Exploded View

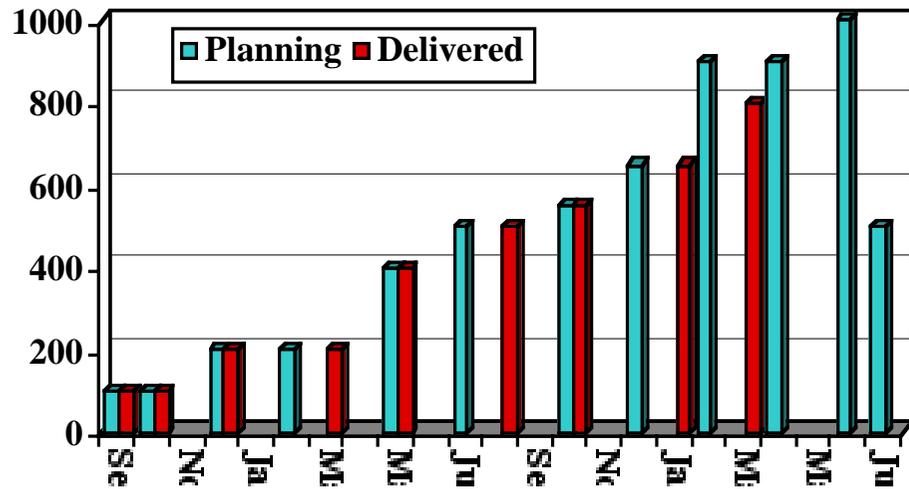




ECAL. Status of crystal delivery (Russia)

3500 crystals have been delivered (Mar 00)

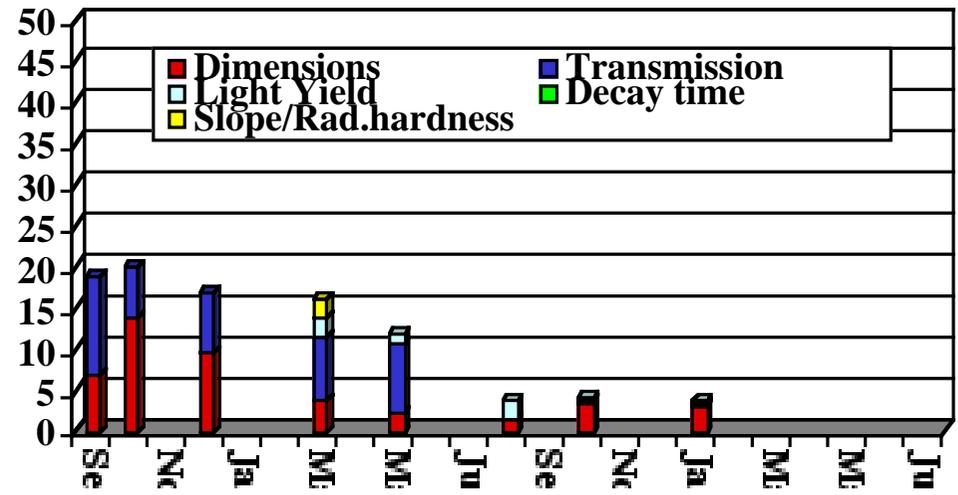
Delivered crystals-Preproduction contract ISTC # 354b



99

00

Rejected crystals (in%)



99

00



ECAL: Crystals Procurement

	1999	2000	2001	2002	2003	2004	2005
Barrel							
Russia	2700	5900	7900	8600	8600	4000	
China		500	3500	4000	3500	3000	
Extra(in R)*			1900	3400	3400	1000	
Endcap							
Russia		200					
China			500	2000	4500	4500	4000
No. Of Barrel crystals		61900					Barrel Ready in mid-05
No. Of Endcap crystals		15700					Endcap Ready in mid-06

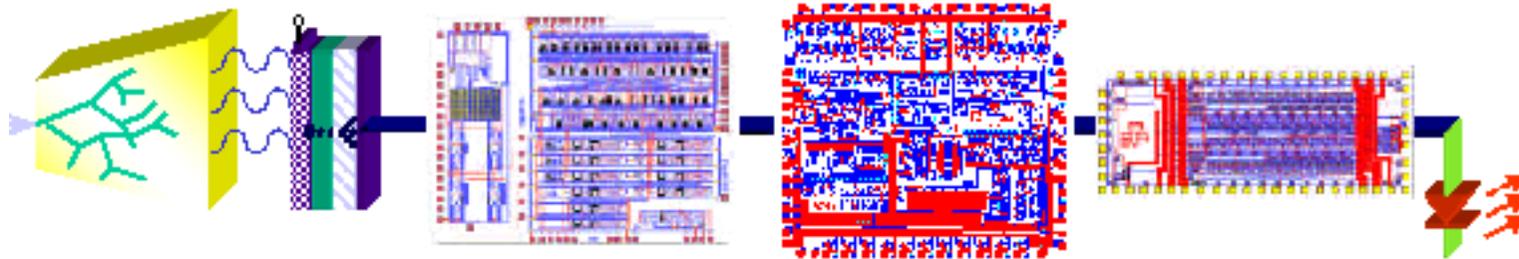
*Invest 1.5M\$ now to increase capacity in Russia by 10k crystals



ECAL. Front-End chain

Princeton,+

LIGHT to LIGHT



APD

FPPA

ADC

Serialiser

VCSEL

Hamamatsu
Contract placed
Start production
120k pieces

Minnesota,PSI

In Harris rad-hard
technology - processing
problems - low yield but
perform well

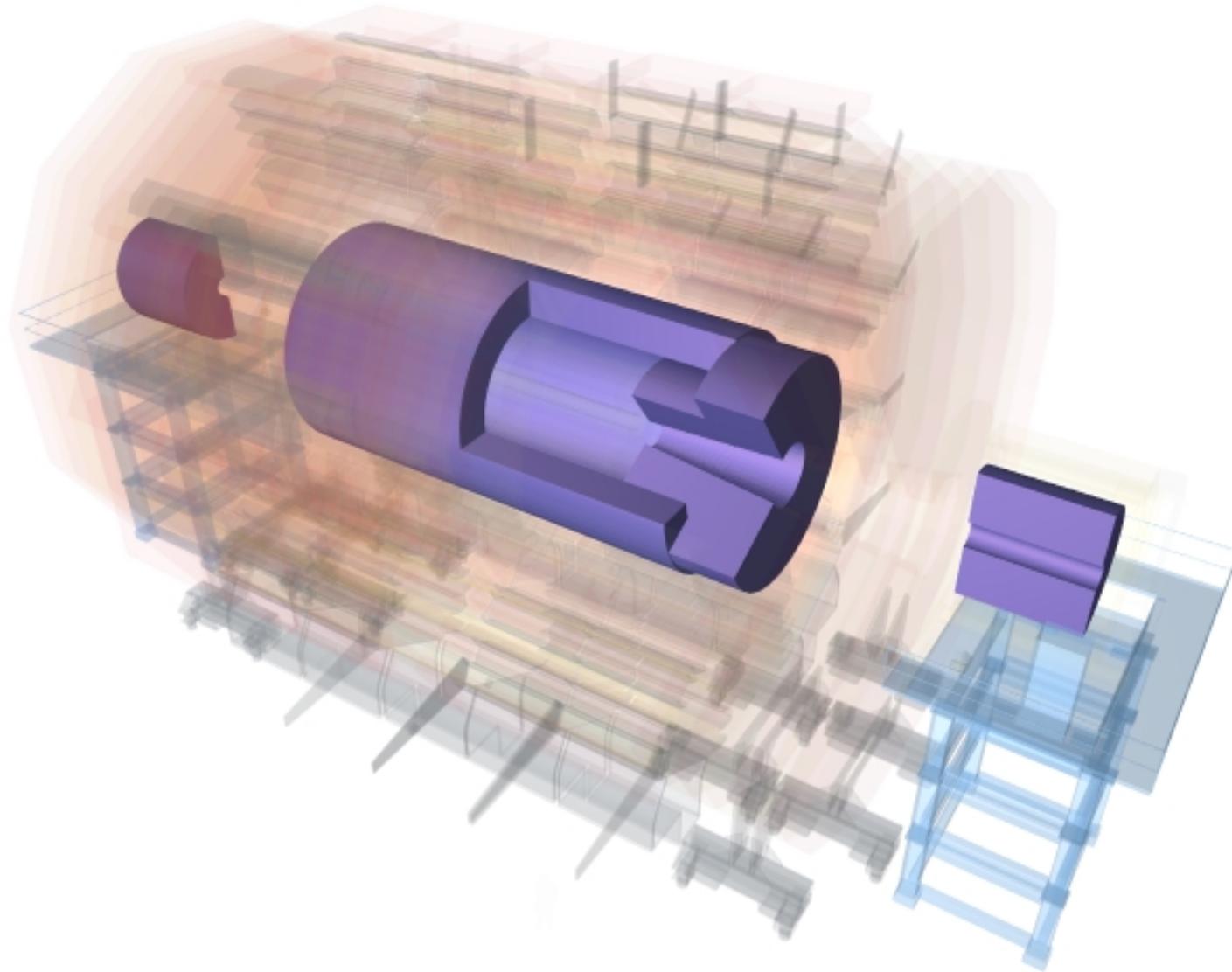
Analog Devices
OK

Problem of yield in
pilot production
In-spec samples work
Delay in pre-production

Discussing
packaging

Foresee few hundred channels test of whole chain in beam in '00

4. HCAL





HCAL: Overview

US management responsibility

• The Status

- Barrel (HB) absorber and optics manufacture is on schedule
- Endcap (HE) absorber is all under contract and manufacture has begun at MZOR
- **HB/HE electronics design is significantly delayed (> 1 year)**
- A prototype HF 'brick' module was built (diffusion welding) and tested.
- HF engineering design transferred to FNAL - 'brick' -> 'sector' geometry.

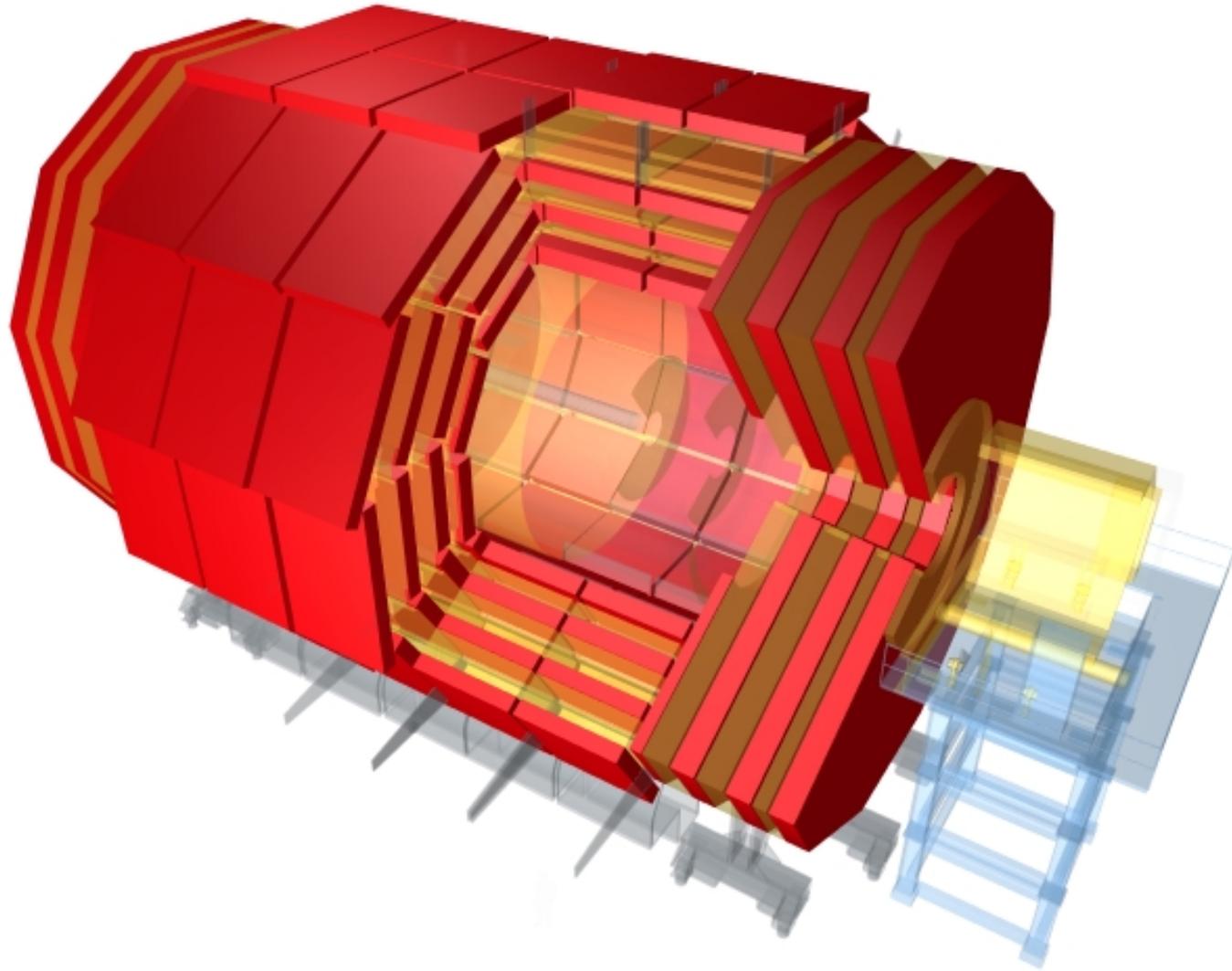
• Plans and milestones for 2000

- Absorber and scintillator 'optics' package manufacture will continue
- An alternative method of manufacture of HF under study

• Concerns

- HB/HE electronics design must be kept off critical path. ECAL chain being considered as an alternative - decide in Sept '00.

5. Muon systems





Muon System: Overview

- **The Status**

- CSC manufacture underway in FNAL. Sites in Beijing and St Petersburg are in preparation (**CSCs - US management responsibility**)
- Commissioning of MB drift tube assembly lines at Padua and Aachen taking longer
- MB site at Madrid building pre-production prototype MB2 without difficulty
- Assembly of barrel RPC gaps in industry will start soon. Bakelite manufacture started in February
- Results of a test of a minimal configuration of barrel alignment being analysed

- **Plans and milestones for 2000**

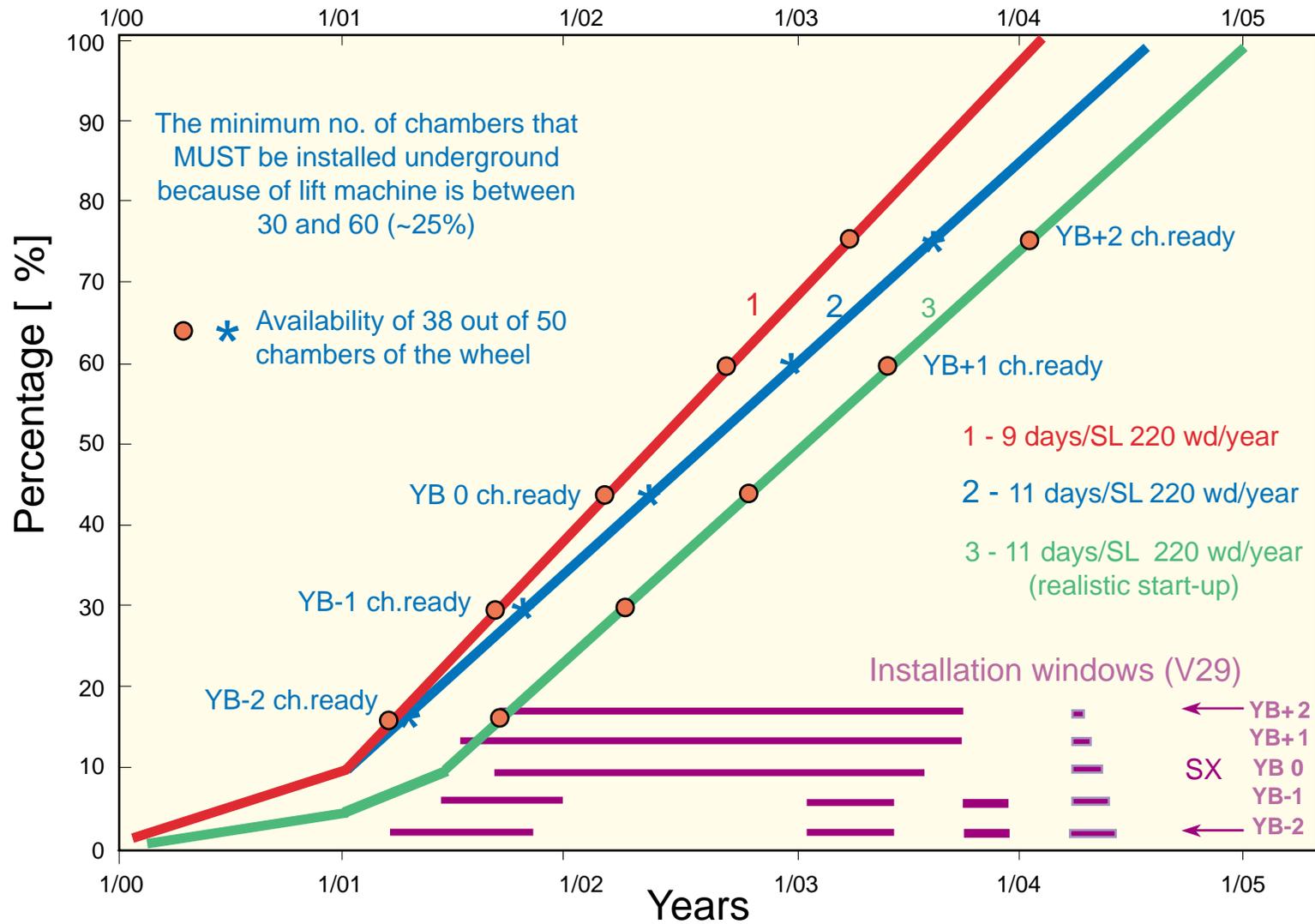
- Start-up of MB assembly lines in Padua and Aachen
- Transfer manufacture of electrode plates and I-beams to Dubna and Protvino resp
- ESRs for electronics mounted on DTs, and on-chamber electronics of CSCs
- Design of endcap RPCs (RE) will be completed
- EDR for alignment system

- **Concerns**

- Rate of muon chambers manufacturing must be reviewed at the end of 2000 to check consistency with installation schedule



MB. DT Chamber production





ME. CSC production status

- **Fermilab Site:**
 - Panel Production began in May '99
(360 CSCs: ME1/2, 1/3, 2/1, 2/2, 3/1, 3/2)
 - Assembly: chambers production start Jul '00
(144 large CSCs: ME2/2 and ME3/2)
- **Florida (UF) and California (UCLA) Sites:**
 - Final Assembly (with electronics) and System Tests - start Dec '00
(72+72 CSCs: ME2/2, 3/2)
- **St.Petersburg, Russia (PNPI) and Beijing, China (IHEP) Sites:**
 - Final Assembly (with electronics) and System Tests - start Jan '01
(144+72 CSCs: ME1/2, 1/3, 2/1, 3/1)
- **Dubna Site**
 - Final Assembly (with electronics) and System Tests - start Jul '01
panel production began in Jan 2000
(72 CSCs: ME1/1)



Muon. RPC overview

Barrel

- Single gaps from industry
- RB1 assembled in China
- RB2 assembled in Italy
- RB3 assembled in Bulgaria
- RB4 assembled in Italy

Problems

Bulgarian funds almost established

Forward

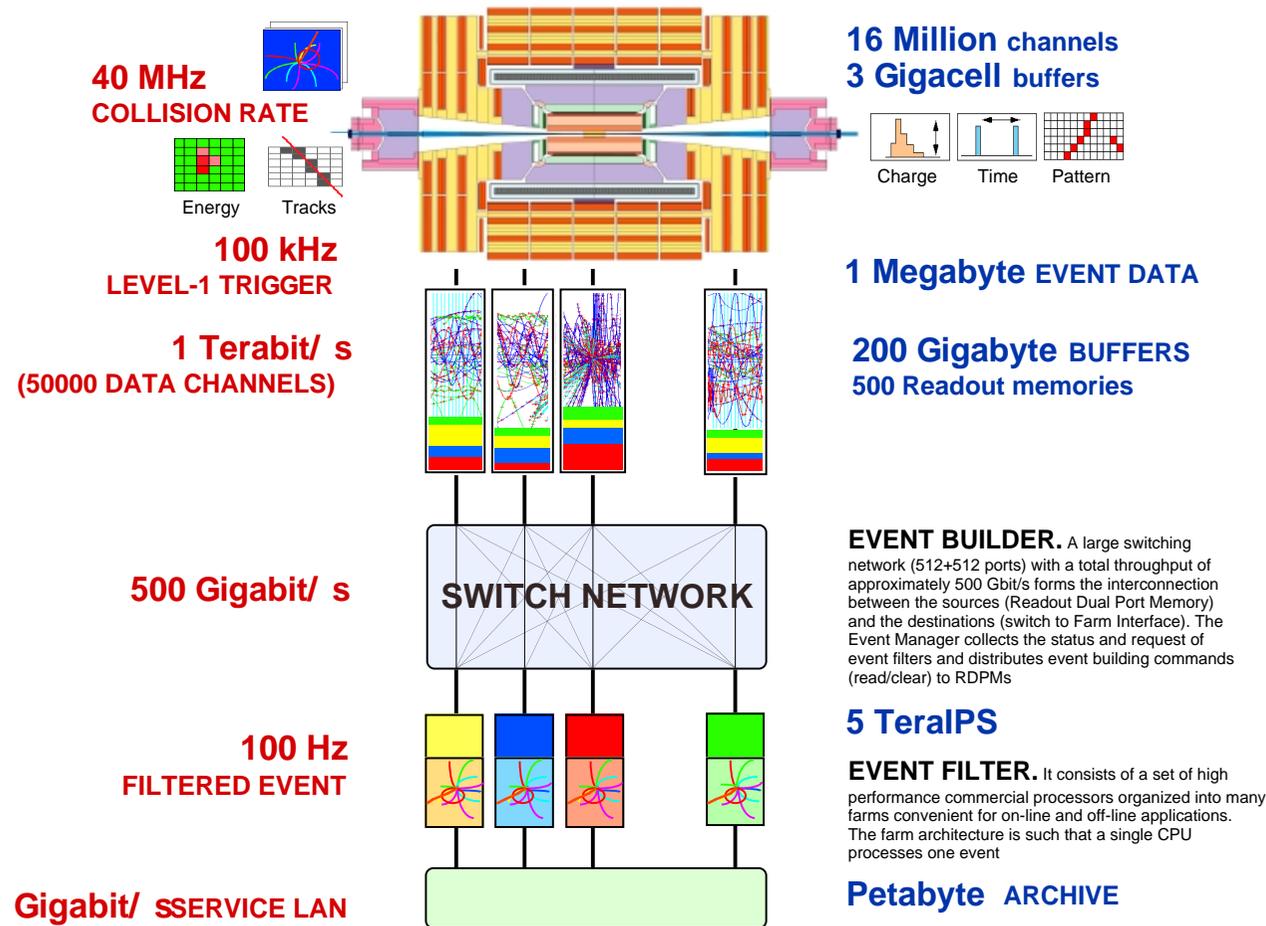
- Single gaps from Korea
- RE1 assembled in China
- RE n/1 assembled in Korea
- RB n/2 assembled in Pakistan
- RB n/3 assembled in Pakistan

Pakistan has increased its contribution to **1.8 MCHF**.

Problems

Finalise design
Not all needed funding established

6. Trigger and data acquisition





Level 1 Trigger Update

Level 1 Trigger TDR for November 2000 - (Draft already in circulation)

Recent improvements in Calorimeter trigger:

Jet algorithm & Tau-Trigger

New design of jet algorithm with sharper efficiency turn-on and tau-jet bit for narrow jets based on 4x4 regions sums into 12x12 region jets with sliding windows logic.

Rates being cross-checked using more detailed code (ORCA4)



Higher Level Trigger

Basic Job: 100 kHz to 100 Hz (keeping physics)

After hardware Level-1 assume two steps:

Level-2 only uses calorimeter & muon data

Level-3 uses tracker data as well

New CMS Project: Physics Reconstruction & Selection (PRS):

4 groups: b/τ (vertex), Electron/Photon, Jet/Missing E_T , Muons

HLT milestone delayed to July '00



e- γ : L2 Preliminary Results

- **Level 1**

- Single electron L1 threshold @29.5 (95% at 35 GeV)
- Double electron L1 threshold @12.5 (95% efficient at 17.5 GeV)

- **Level 2**

- Single electron cuts for 85% efficiency at threshold Pt (35 GeV)
- Double electron cuts for 85% overall (event) efficiency at 17.5 GeV

- **Rate out of Level1: 10.6 \pm 0.2 kHz**

- **Rate out of Level2: 1.63 \pm 0.05 kHz**

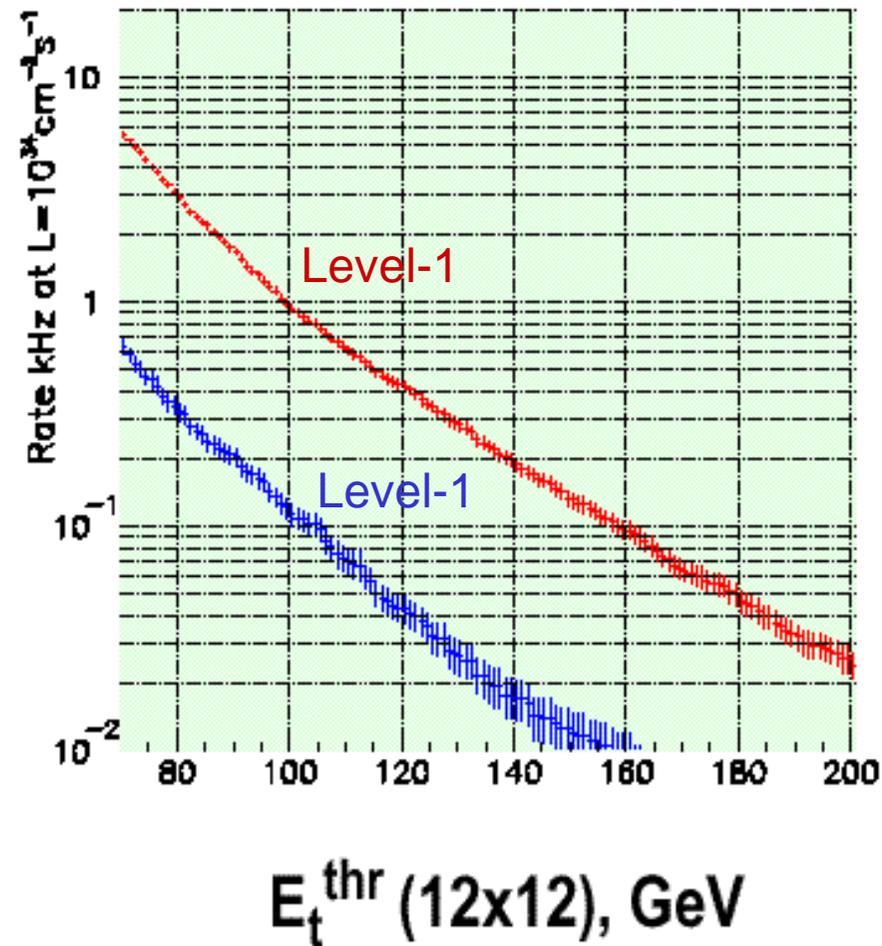
- Contributed by single: 1.48 kHz
- Contributed by double: 0.15 kHz

- **Overall rejection: 6.65; Rejection on double electron: 28**



JetMet: Preliminary L2 Results

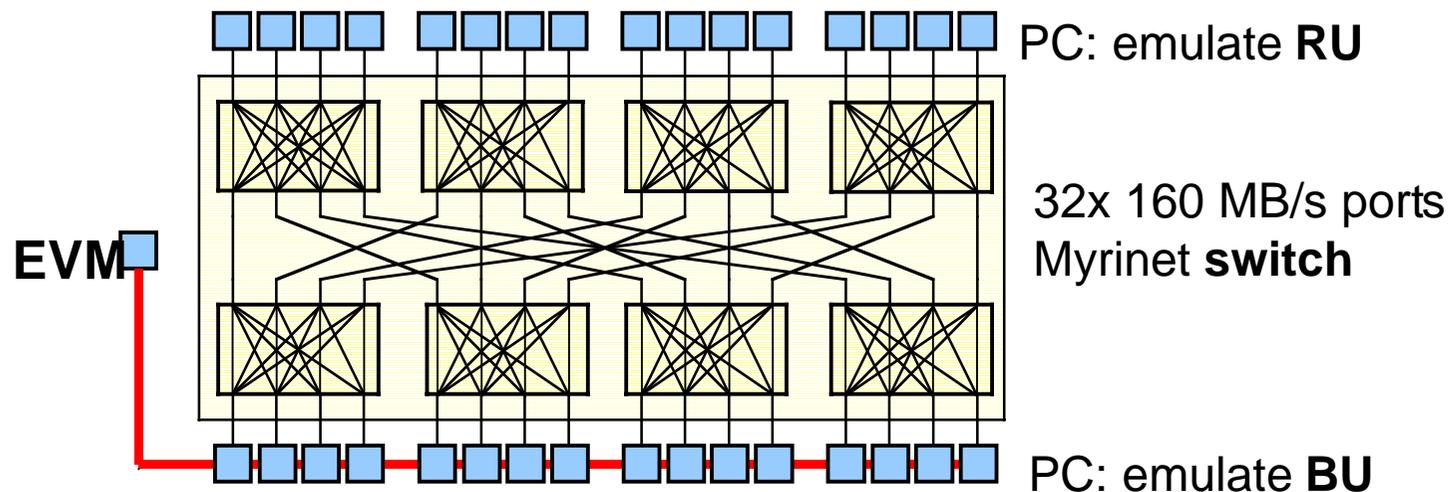
Tau - trigger



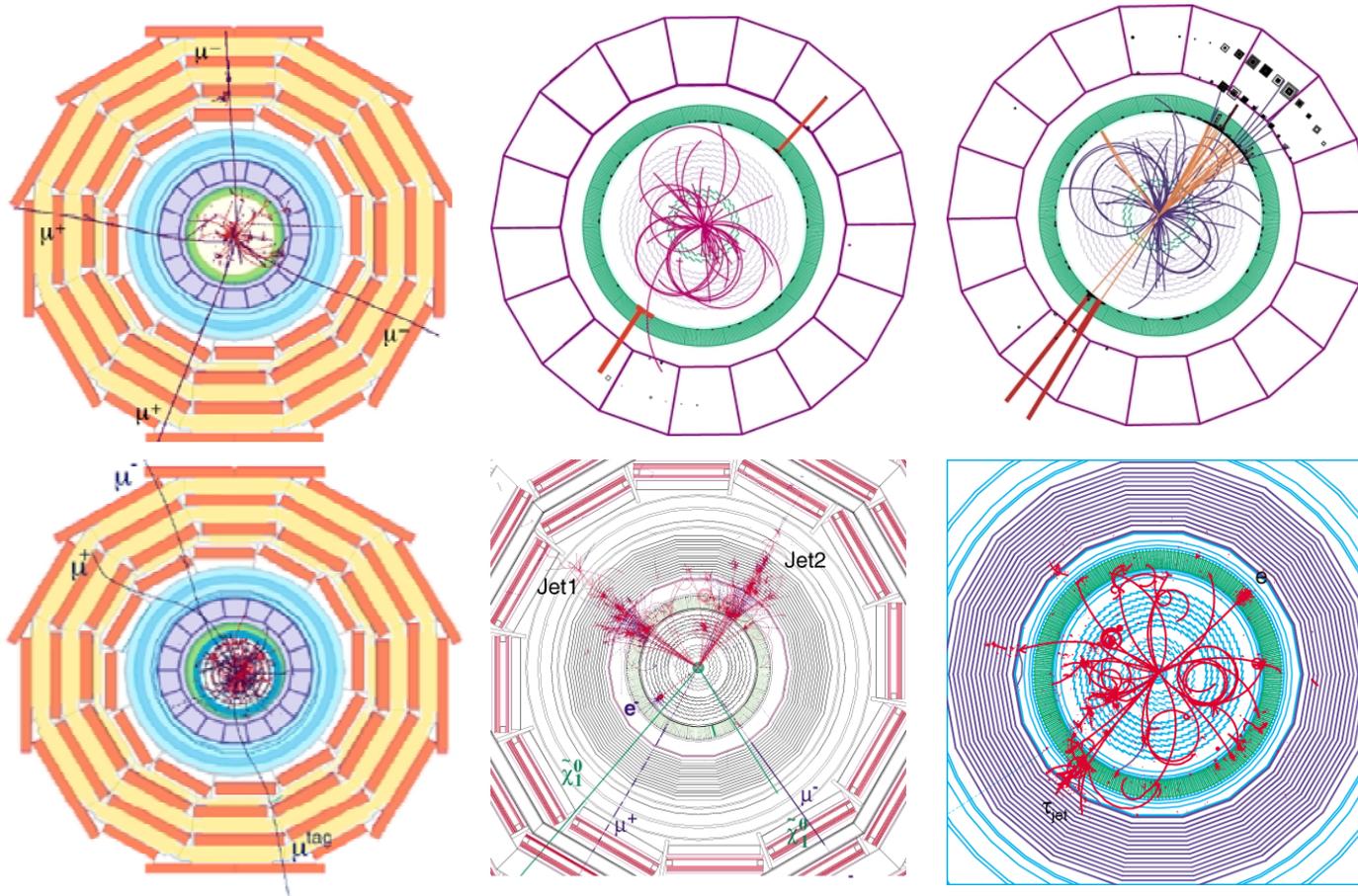


DAQ. Myrinet evaluation 1999

- Event builder demonstrator 16x16 based on Myrinet multistage switch and Linux PCs established.
- Measured event building performance: Achieve about 60 kHz trigger rate or 120 Mbyte/s per node (almost 2 Gbyte/s aggregate) for nominal event fragment sizes with average and RMS of 2 kbyte.
- That is, **today, only a factor two off** from CMS needs.
- Measurements provide parameters for simulation of large scale (512x512) systems. **DAQ TDR in November 2001**



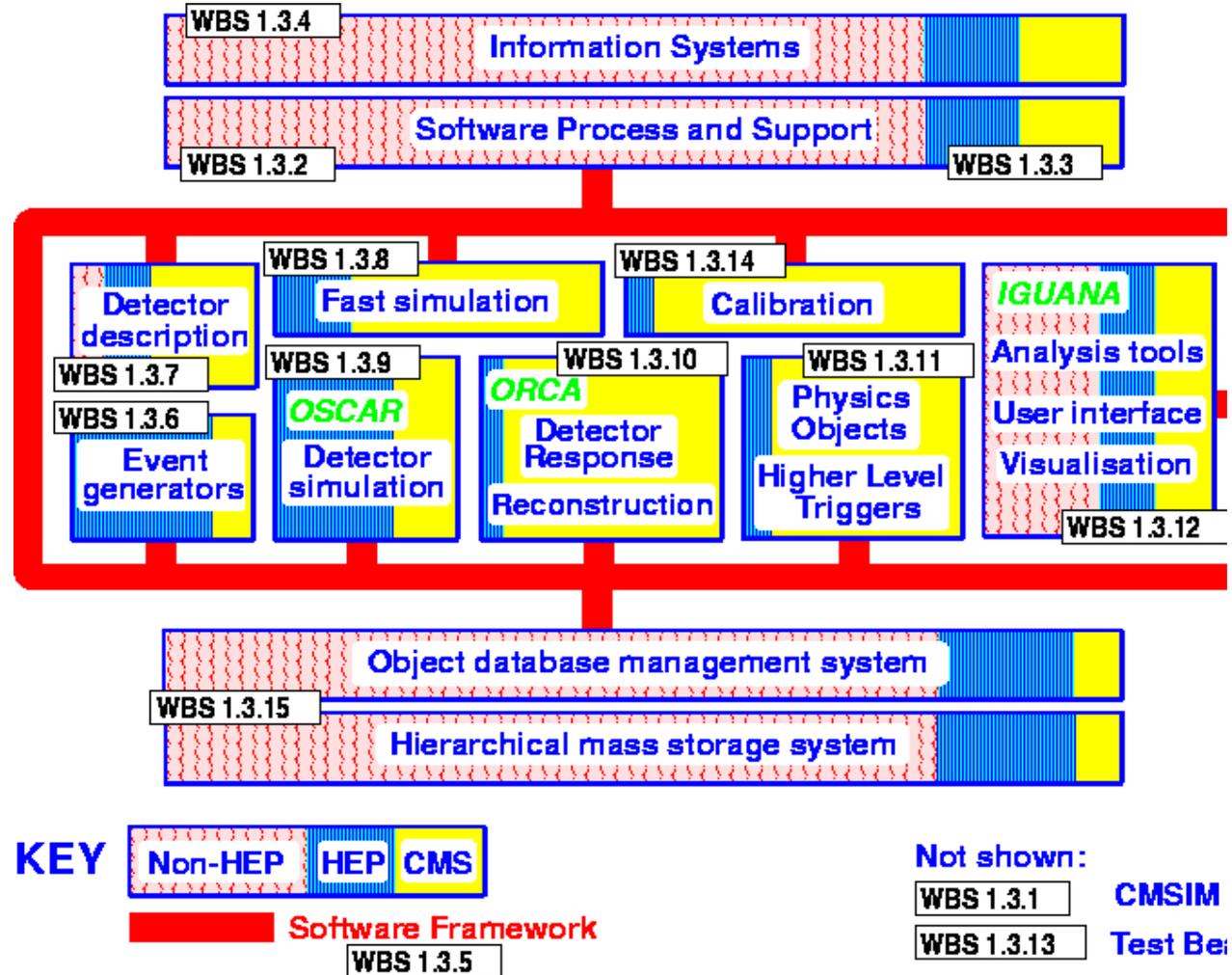
7. Software/ Computing





Software tasks

- 1.1 Project Management
- 1.2 Computing
- 1.3 Software
 - 1.3.1 CMSIM
 - 1.3.2 Software Process
 - 1.3.3 Software Support
 - 1.3.4 Info. Systems
 - 1.3.5 CARF
 - 1.3.6 Event Generators
 - 1.3.7 Det. Description
 - 1.3.8 Fast Simulation
 - 1.3.9 OSCAR
 - 1.3.10 ORCA
 - 1.3.11 **OBSOLETE**
(was POR / HLT)
 - 1.3.12 User Analysis Environment
 - 1.3.13 Test Beam
 - 1.3.14 Calibration
 - 1.3.15 ODBMS





HLT and Software/ Computing Plans

Tie ORCA project to concrete experimental requirement, **the HLT verification**, provides a powerful focus;

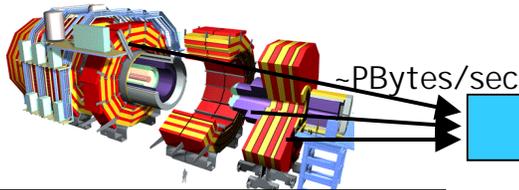
CMS Computing and Software model is designed to meet LHC requirements; use **ORCA and HLT** to study this model in depth

This HLT study is the first in a series of increasingly complex **“mock-data challenges”**

HLT L2 (calo+muon) reduction	July	2000
HLT L3 (tracker) reduction	Fall	2000
Trigger TDR	End	2000
DAQ TDR	End	2001
Software/Computing TDR		2002
(5% data challenge, Use Tier 0, 1, 2 centres)		
Physics TDR		2003
20% Mock-Data Challenge		2004

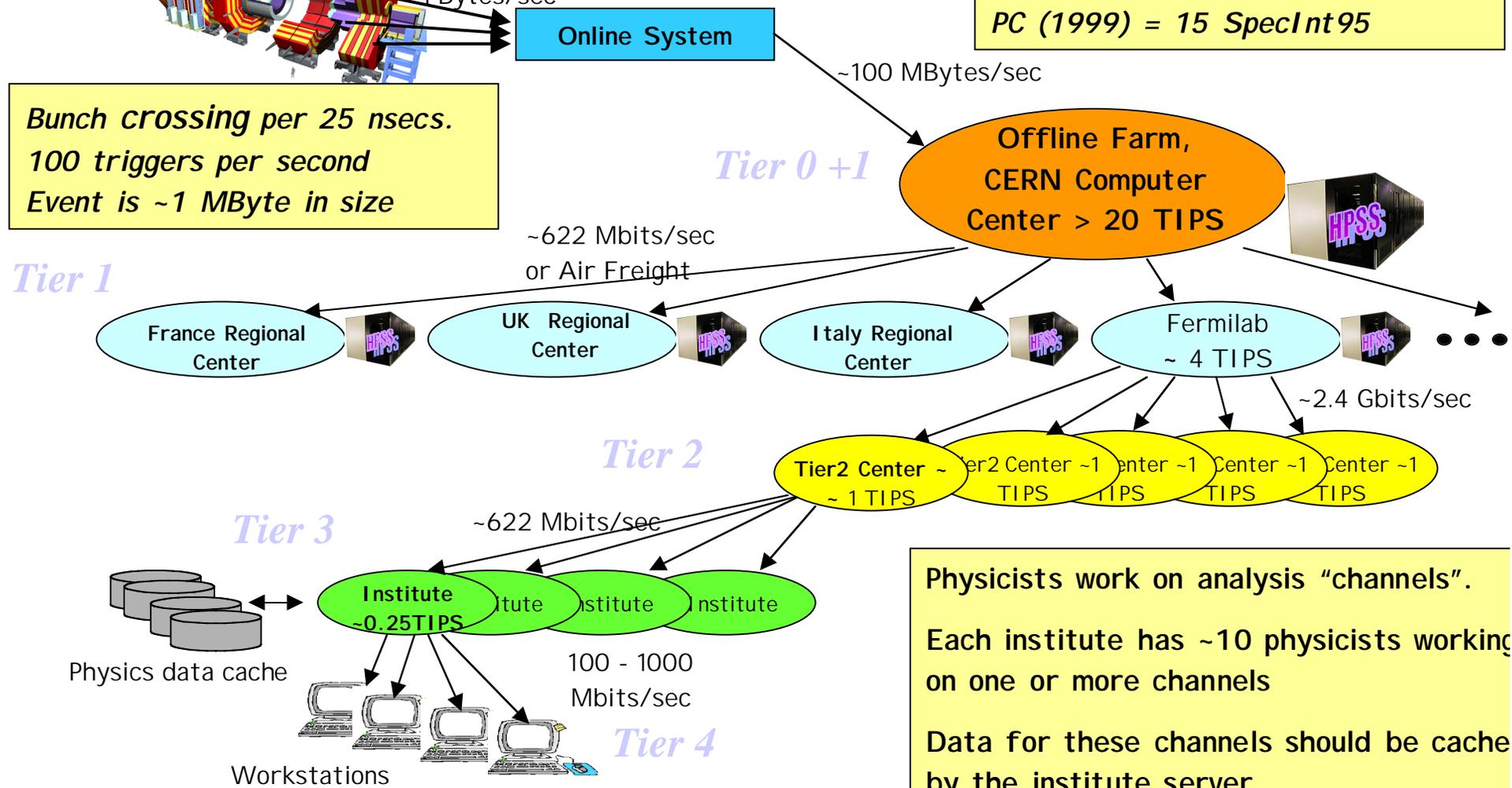


Worldwide Computing Plan



Bunch crossing per 25 nsecs.
100 triggers per second
Event is ~1 MByte in size

1 TIPS = 25,000 SpecInt95
PC (1999) = 15 SpecInt95



Physicists work on analysis "channels".
Each institute has ~10 physicists working on one or more channels
Data for these channels should be cache by the institute server



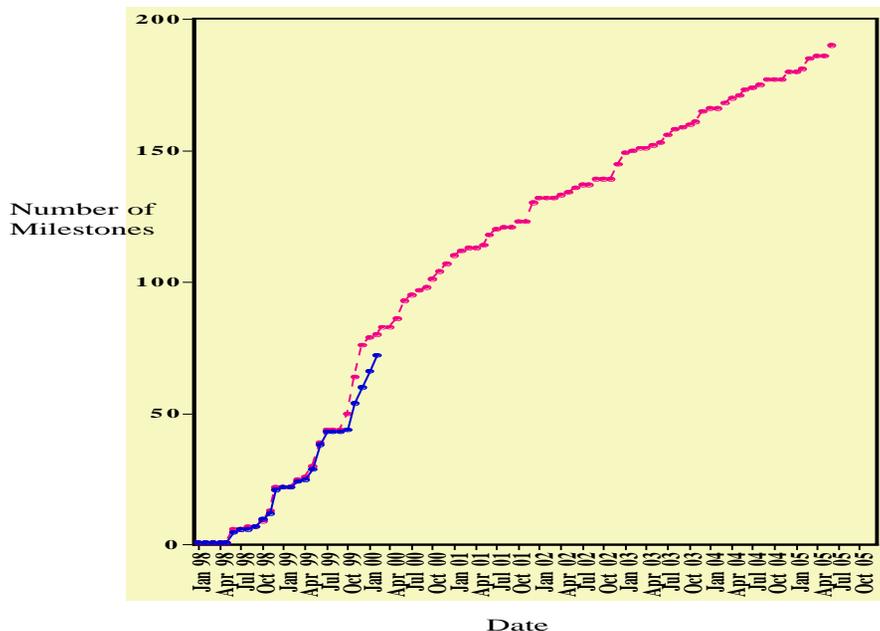
8. Schedule, Funding, Conclusion



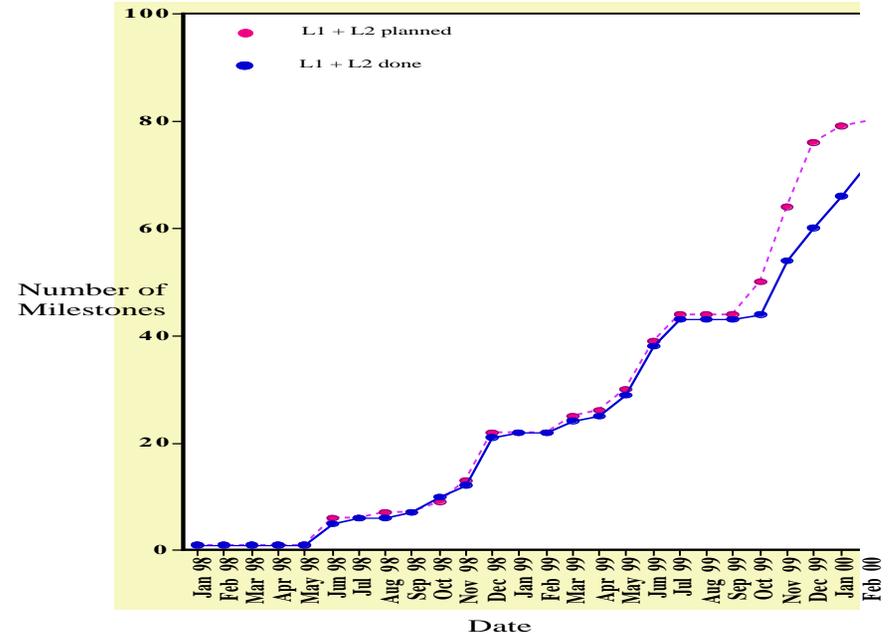
Milestones Completion

- Good progress towards completion of the surface assembly phase.
- Cumulative milestone completion charts are consistent with this.
(and, simplistically, with an overall delay of a few months.)

CMS Milestone Monitoring: update March 2000



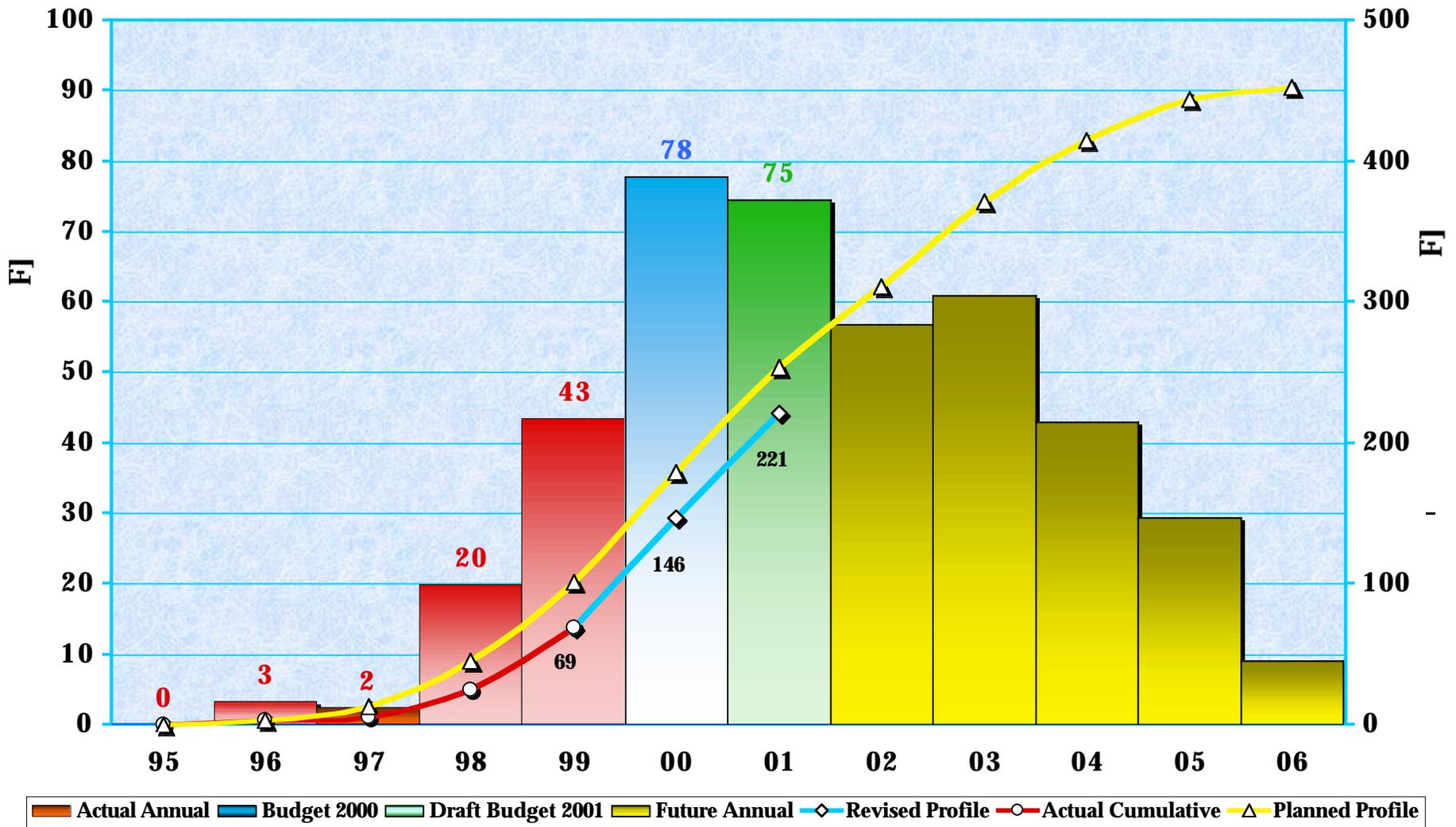
CMS Milestone Monitoring: update March 2000



- Known critical delays from CMS sub-systems are shadowed by the 5 month Civil Engineering delay.



Cumulative Payment Profile





LHCC Comprehensive Review

2-3 October

Areas to be covered

General

- Management and coordination,
- Detector integration
- Milestones and schedules
- Costs

Physics studies

Sub-systems

- Tracking and vertexing
- Calorimetry
- Muon detection and particle identification
- Computing

For each subsystem:

- Technical co-ordination and progress
- Electronics systems
- Status of milestones
- Installation schedule
- Items on critical path
- Availability of resources (budget and manpower)
- Sub-system integration
- Areas of concern



Working Detector

The new Master Schedule (V30) is driven by the requirement that the whole CMS detector be ready by April 06.

CMS is making plans for a 'working detector' ready for first beam in 2005 with minimal shifts from V30.

With minimal adjustments V30 foresees for September 2005:

HB, HE, HF complete and tested,
MB, ME complete (except ME4/2) and tested,
RB and RE1, complete and tested,
EB complete and tested,
Tracker installed but not fully commissioned, pixels not installed,
Trigger/DAQ commissioned with a partial fraction of the online farm

Still to be established: the fractions of EE, RE ready/installed for first beam in '05?
(**Note:** The schedule could be accelerated by ~ 2 months by employing more than 1 shift/day requiring extra resources)

The detector should be completed during the winter shutdown 2005-2006.



Conclusions

The Magnet schedule and cost are now well established.

Construction of HCAL is well underway, on schedule and within cost estimate (to watch - the electronics).

Pre-construction of Muon chambers in 2000 (to watch - rate of chamber production).

ECAL crystal production is under way in Russia. Cost of crystals (negotiated in \$) and photo-sensors within cost estimate (to watch - crystals production - install extra capacity in Russia, mechanics, consequence of exchange rate).

Tracker - change to all-Si sensors, new optimised layout, new schedule worked out, impressive results using 0.25 μm technology.

Trigger, DAQ and Software/Computing proceeding well. Trigger TDR end-00.

CMS is making plans for a 'working' CMS detector to be ready for first LHC beams in 2005, taking into account technical and financial constraints.