Status of the LHC and the future of CERN

a politically incorrect title...

Annual Theory Meeting, Durham

J. Engelen

December 20, 2005

Contents

- Status Large Hadron Collider project
  - Accelerator / Collider
  - Experiments
  - Computing
- Physics prospects
- Beyond LHC
  - CLIC or ILC (exclusive 'or')
  - Thoughts on Proton Accelerators for the Future (PAF) and Physics Opportunities (POFPA)
  - The future of CERN

The Large Hadron Collider

The Large Hadron Collider: 14 TeV pp collisions at 10^{34} $cm^{-2}s^{-1}$

New energy domain (x10), new luminosity domain (x100)

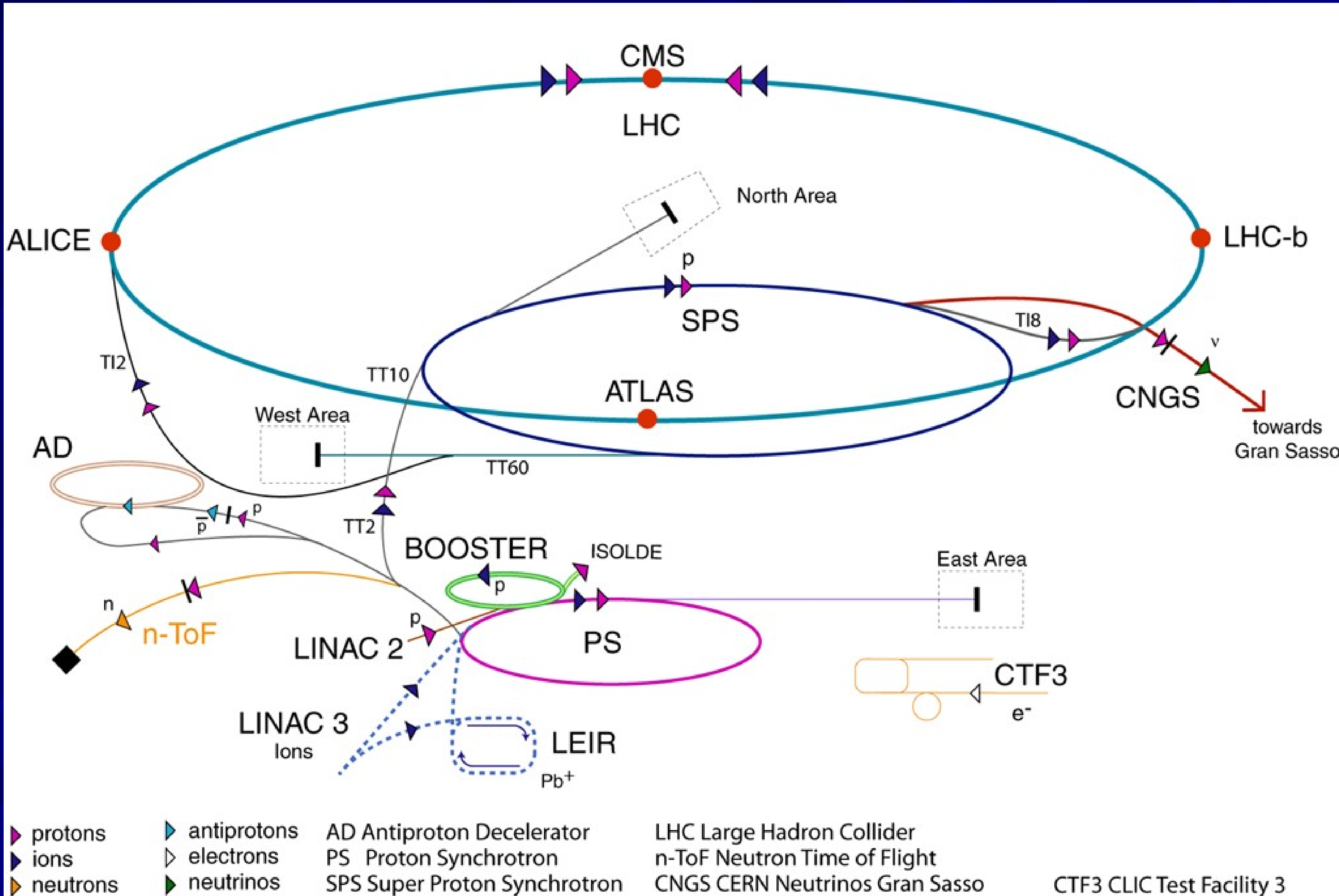
Will have to cross threshold of electroweak symmetry breaking; unitarity of WW scattering requires $M_{Higgs} < 850$ GeV

Many possibilities: Standard Higgs – SUSY (many possibilities...) –Large Extra Dimensions (quantum gravity)

–and many more results on CP violation, Quark Gluon Plasma, QCD, ..., surprises...

The LHC results will determine the future course of High Energy Physics

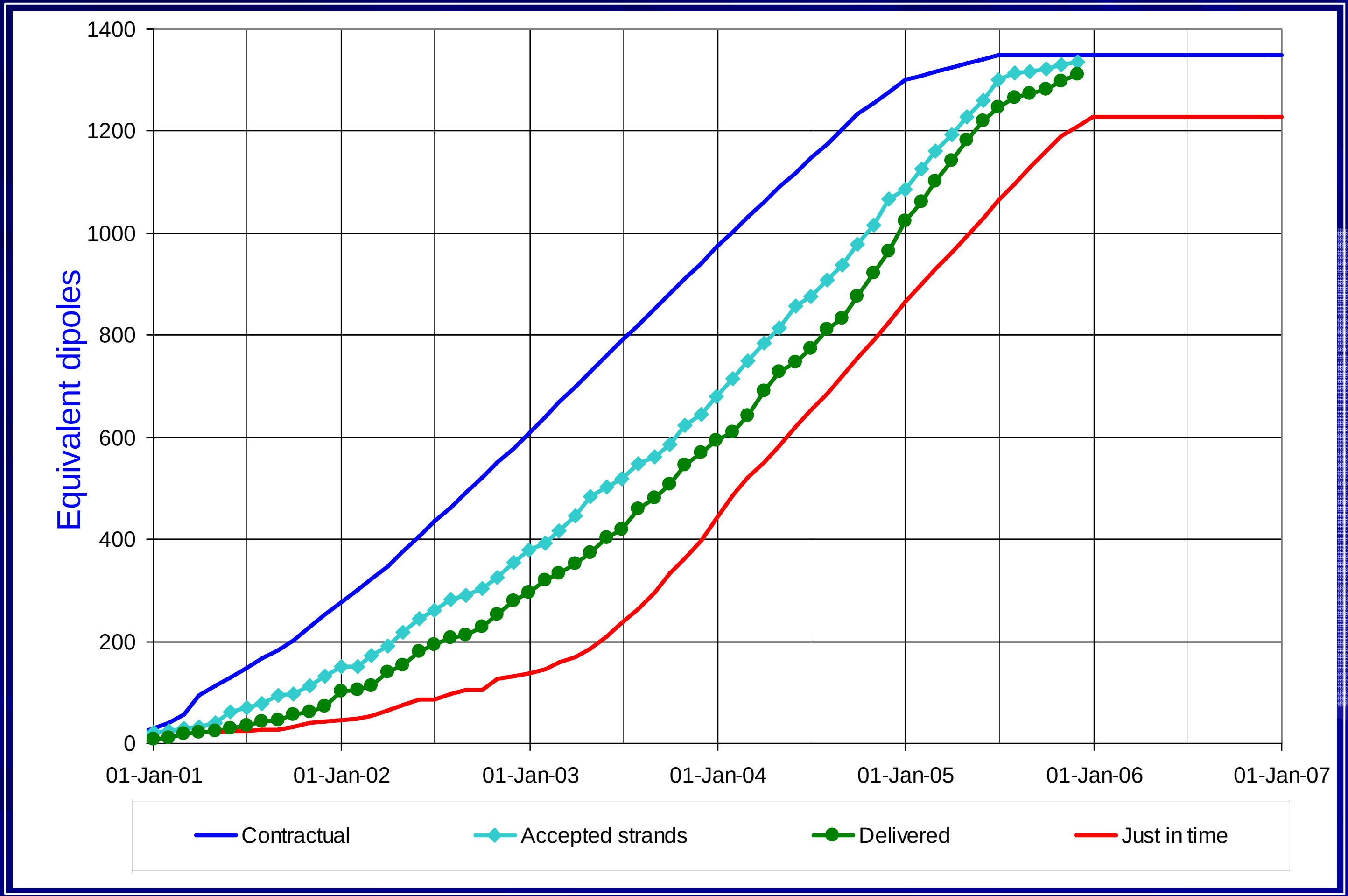
CERN: the World's Most Complete Accelerator Complex
(not to scale)



Project leader: Lyndon Evans

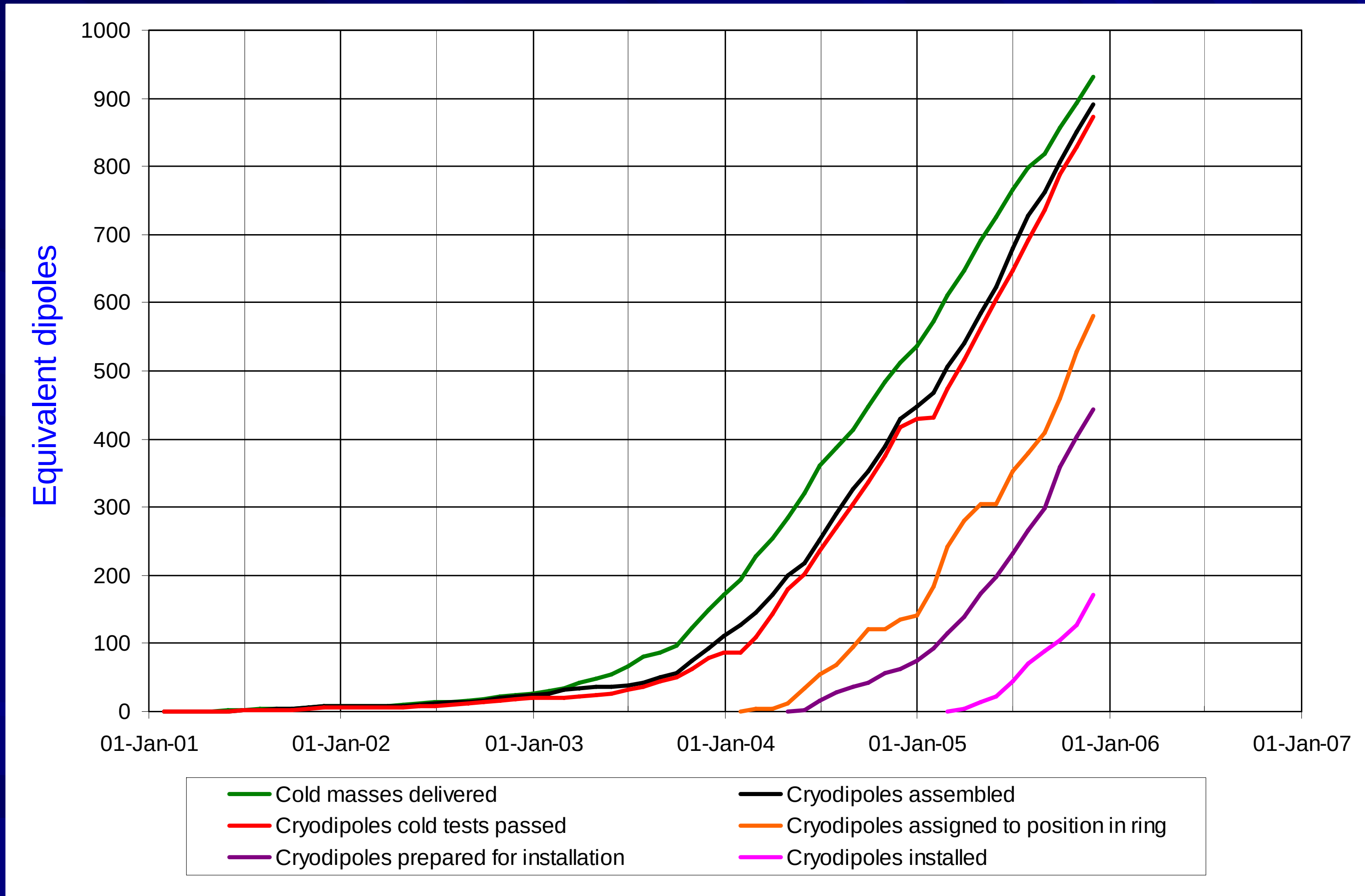
LHC Status

Superconducting cable 1
(dipole inner layer)



416th and last BNN dipole
(November 2005)

Cryodipole overview



Preparation for installation in SMI2

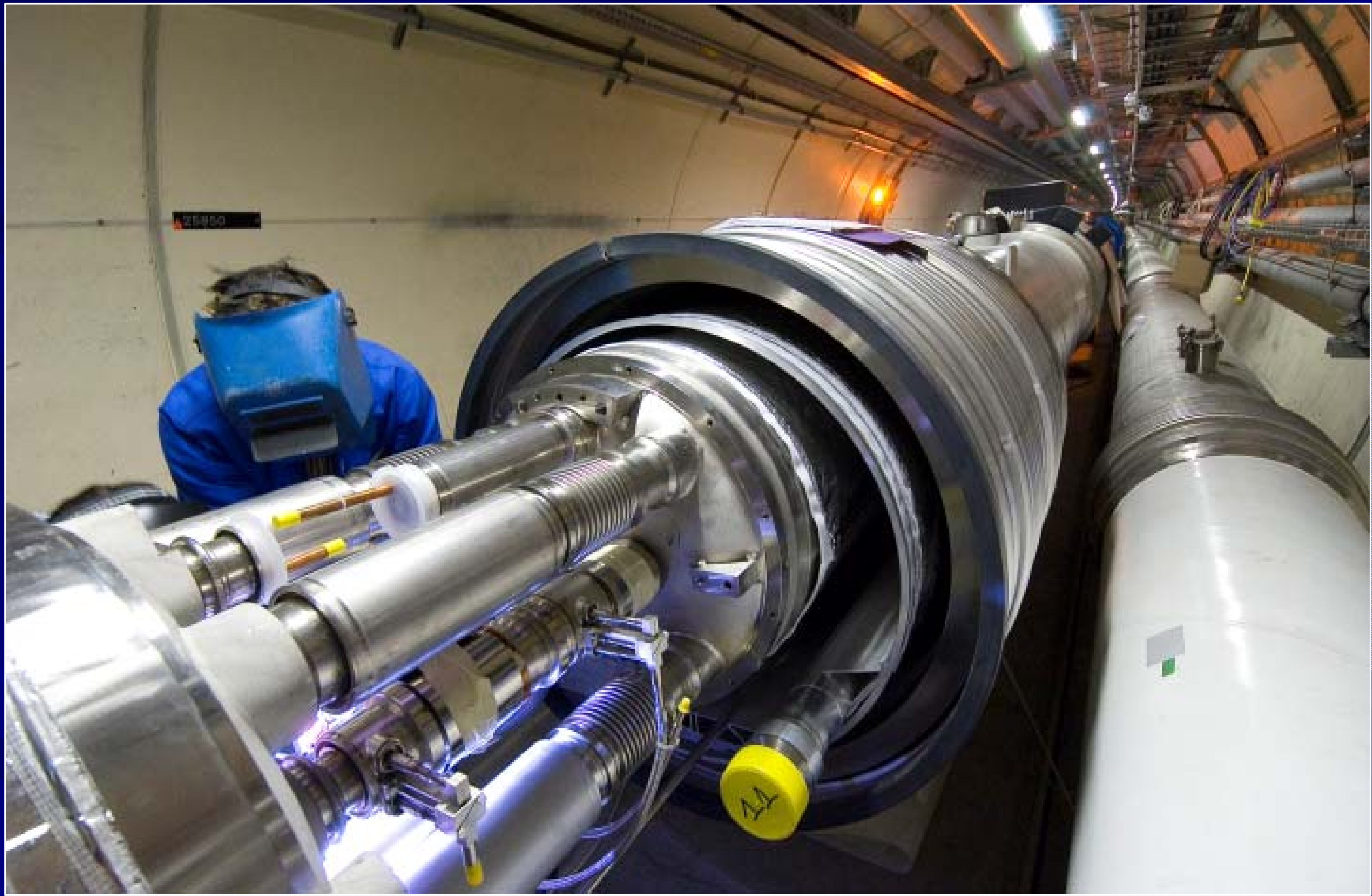
Hall SMI2

First cryodipole lowered on 7 March 2005

Transport in the tunnel is very tight!

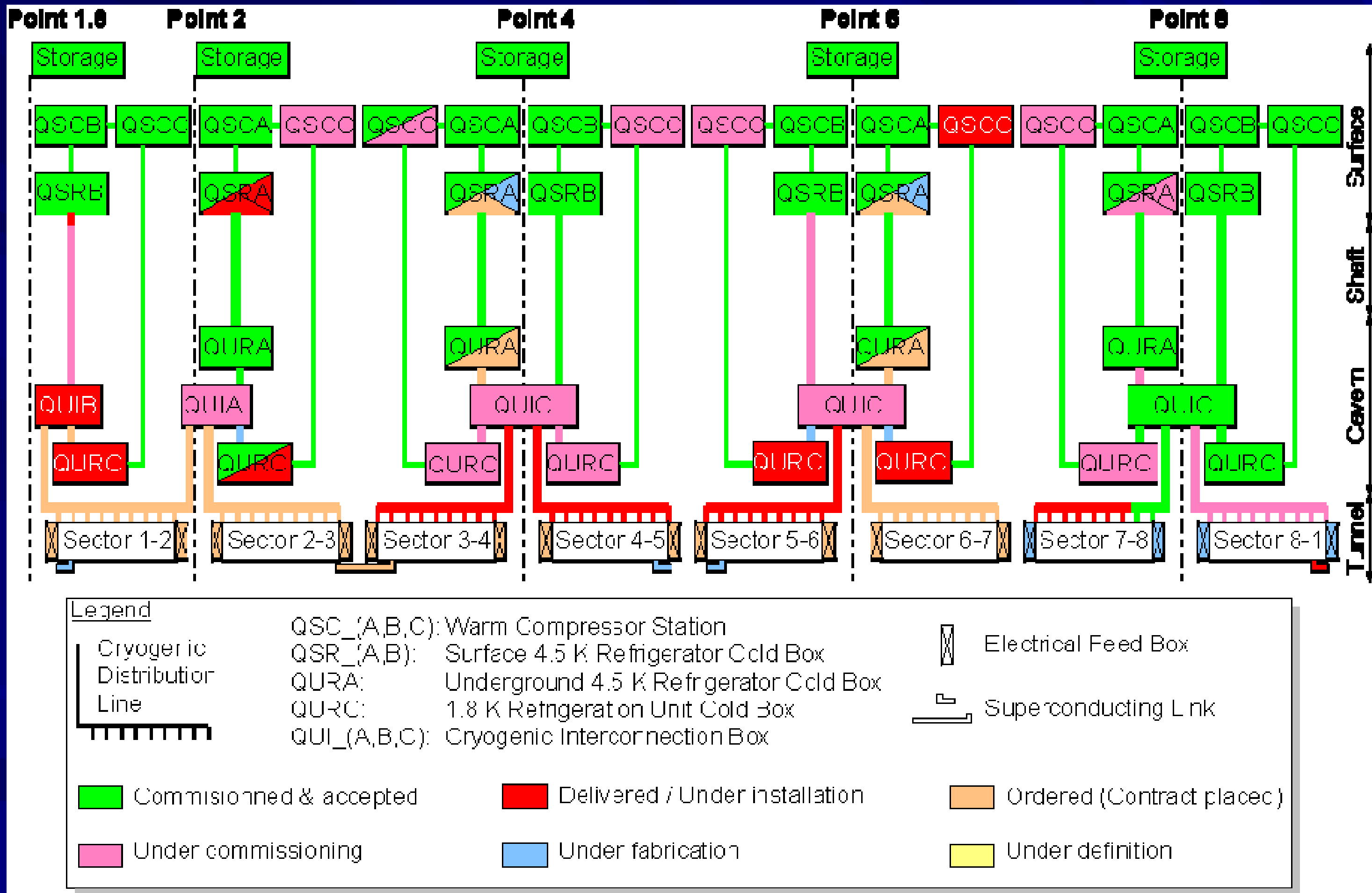
Transfer on jacks

Cryomagnets interconnect in the tunnel

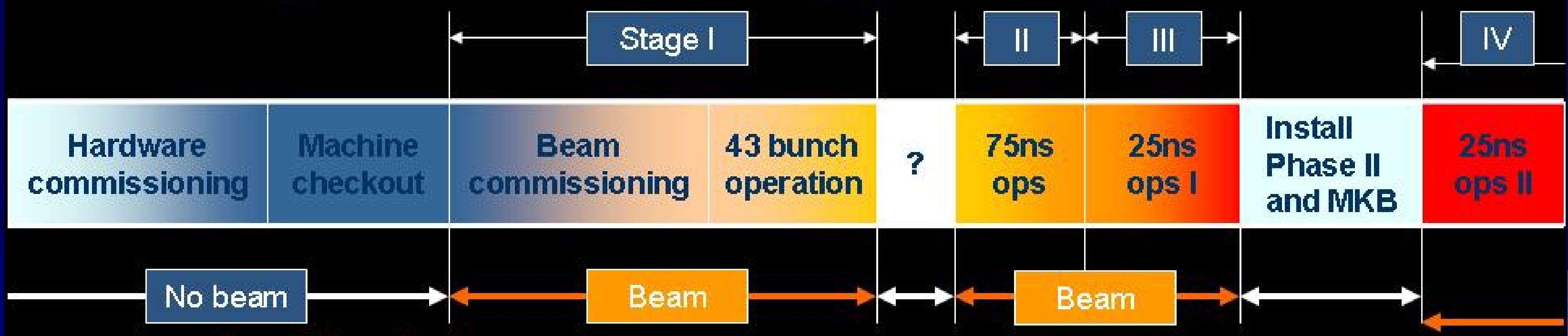


Electrical quality control in the tunnel

Cryogenics overview



Staged commissioning plan for protons



I. Pilot physics run
- First collisions
- 43 bunches, no crossing angle, no squeeze, moderate intensities
- Push performance (156 bunches, partial squeeze in 1 and 5, push intensity)
- Performance limit 10^{32} cm^{-2} s^{-1} (event pileup)

II. 75ns operation
- Establish multi-bunch operation, moderate intensities
- Relaxed machine parameters (squeeze and crossing angle)
- Push squeeze and crossing angle
- Performance limit 10^{33} cm^{-2} s^{-1} (event pileup)

III. 25ns operation I
- Nominal crossing angle
- Push squeeze
- Increase intensity to 50% nominal
- Performance limit 2 10^{33} cm^{-2} s^{-1}

IV. 25ns operation II
- Push towards nominal performance

Stage I physics run

$$L = \frac{N^2 k_b f \gamma}{4\pi \varepsilon_n \beta^*} F$$

$$Eventrate\ /\ Cross = \frac{L\sigma_{TOT}}{k_b f}$$

- Start as simple as possible
- Change 1 parameter (k_b N $\beta^*_{1,5}$) at a time
- All values for
  - nominal emittance
  - 7TeV
  - 10m β* in point 2 (luminosity looks fine)

Protons/beam ≲ 10^{13}
(LEP beam currents)

Stored energy/beam ≲ 10MJ
(SPS fixed target beam)

Parameters			Beam levels		Rates in 1 and 5		Rates in 2	
k_b	N	β* 1,5 (m)	I_{beam} proton	E_{beam} (MJ)	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing
1	10^{10}	18	$1\ 10^{10}$	10^{-2}	10^{27}	<< 1	$1.8\ 10^{27}$	<< 1
43	10^{10}	18	$4.3\ 10^{11}$	0.5	$4.2\ 10^{28}$	<< 1	$7.7\ 10^{27}$	<< 1
43	$4\ 10^{10}$	18	$1.7\ 10^{12}$	2	$6.8\ 10^{29}$	<< 1	$1.2\ 10^{30}$	0.15
43	$4\ 10^{10}$	2	$1.7\ 10^{12}$	2	$6.1\ 10^{30}$	0.76	$1.2\ 10^{30}$	0.15
156	$4\ 10^{10}$	2	$6.2\ 10^{12}$	7	$2.2\ 10^{31}$	0.76	$4.4\ 10^{30}$	0.15
156	$9\ 10^{10}$	2	$1.4\ 10^{13}$	16	$1.1\ 10^{32}$	3.9	$2.2\ 10^{31}$	0.77

Stage II physics run

$$L = \frac{N^2 k_b f \gamma}{4\pi\varepsilon_n \beta^*} F$$

$$F = 1/\sqrt{1+\left(\frac{\theta_c \sigma_z}{2\sigma^*}\right)^2}$$

$$Eventrate\ /\ Cross = \frac{L\sigma_{TOT}}{k_b f}$$

- Relaxed crossing angle (250 μrad)
- Start un-squeezed
- Then go to where we were in stage I
- All values for
  - nominal emittance
  - 7TeV
  - 10m β* in points 2 and 8

Protons/beam ≈ few 10^{13}

Stored energy/beam ≲ 100MJ

Parameters			Beam levels		Rates in 1 and 5		Rates in 2 and 8	
k_b	N	β* 1,5 (m)	I_{beam} proton	E_{beam} (MJ)	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing
936	$4\ 10^{10}$	18	$3.7\ 10^{13}$	42	$1.5\ 10^{31}$	<< 1	$2.6\ 10^{31}$	0.15
936	$4\ 10^{10}$	2	$3.7\ 10^{13}$	42	$1.3\ 10^{32}$	0.73	$2.6\ 10^{31}$	0.15
936	$4\ 10^{10}$	1	$3.7\ 10^{13}$	42	$2.5\ 10^{32}$	1.4	$2.6\ 10^{31}$	0.15
936	$9\ 10^{10}$	1	$8.4\ 10^{13}$	94	$1.2\ 10^{33}$	7	$1.3\ 10^{32}$	0.76

Stage III physics run

$$L = \frac{N^2 k_b f \gamma}{4\pi\varepsilon_n \beta^*} F$$

$$F = 1 / \sqrt{1 + \left(\frac{\theta_c \sigma_z}{2\sigma^*}\right)^2}$$

$$Eventrate / Cross = \frac{L\sigma_{TOT}}{k_b f}$$

- Nominal crossing angle (285 μrad)
- Start un-squeezed
- Then go to where we were in stage II
- All values for
  - nominal emittance
  - 7TeV
  - 10m β* in points 2 and 8

Protons/beam ≈ 10^{14}

Stored energy/beam ≈ 100MJ

Parameters			Beam levels		Rates in 1 and 5		Rates in 2 and 8	
k_b	N	β* 1,5 (m)	I_{beam} proton	E_{beam} (MJ)	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing	Luminosity ($cm^{-2}s^{-1}$)	Events/ crossing
2808	$4\ 10^{10}$	18	$1.1\ 10^{14}$	126	$4.4\ 10^{31}$	<< 1	$7.9\ 10^{31}$	0.15
2808	$4\ 10^{10}$	2	$1.1\ 10^{14}$	126	$3.8\ 10^{32}$	0.72	$7.9\ 10^{31}$	0.15
2808	$5\ 10^{10}$	2	$1.4\ 10^{14}$	157	$5.9\ 10^{32}$	1.1	$1.2\ 10^{32}$	0.24
2808	$5\ 10^{10}$	1	$1.4\ 10^{14}$	157	$1.1\ 10^{33}$	2.1	$1.2\ 10^{32}$	0.24
2808	$5\ 10^{10}$	0.55	$1.4\ 10^{14}$	157	$1.9\ 10^{33}$	3.6	$1.2\ 10^{32}$	0.24
Nominal			$3.2\ 10^{14}$	362	10^{34}	19	$6.5\ 10^{32}$	1.2

Conclusions Status LHC

- All key objectives have been reached for the end of 2005.
  - End of repair of QRL, reinstallation of sector 7-8 and cold test of sub-sectors A and B.
  - Cool-down of full sector 8-1.
  - Pressure test of sector 4-5.
  - Endurance test of full octant of power converters.
- Magnet installation rate is now close to 20/week, with more than 200 installed. This, together with interconnect work, will remain the main bottleneck until the end of installation.

The Detectors

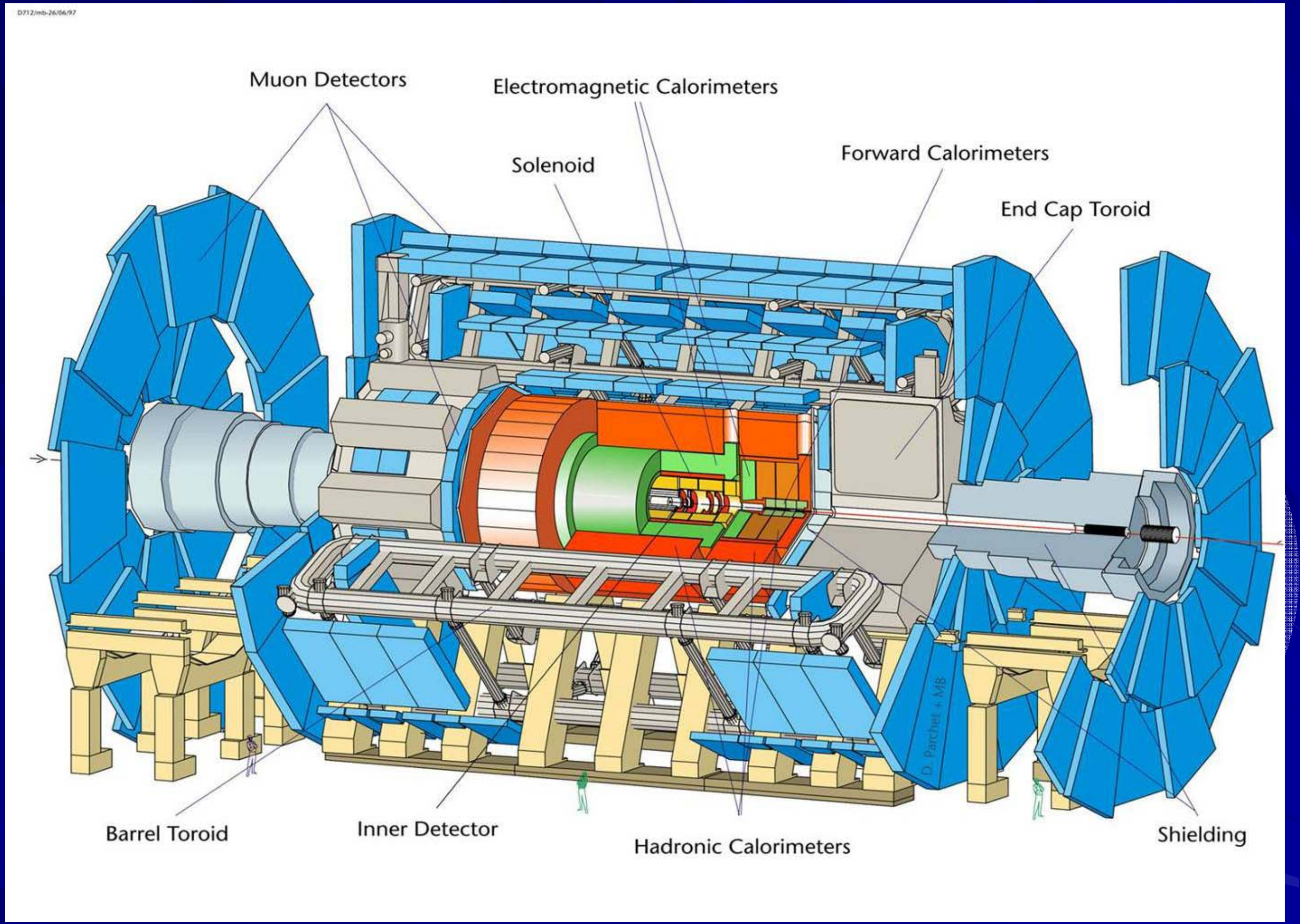
Event rate 20 – 25 per bunch crossing (every 25 ns)
--> 10^9 events / s --> 10^{11} – 10^{12} tracks /s

Very remarkable: experiments will, in this environment:

- reconstruct secondary vertices from B mesons, only mm's away from the primary vertex.
- reconstruct individual photons with sufficient energy and angular resolution for (light) Higgs detection

in addition to many more capabilities: they are 'general purpose – 4π' detectors, featuring tracking, magnetic momentum analysis, calorimetry, muon spectrometry, in an almost **hermetic** setup

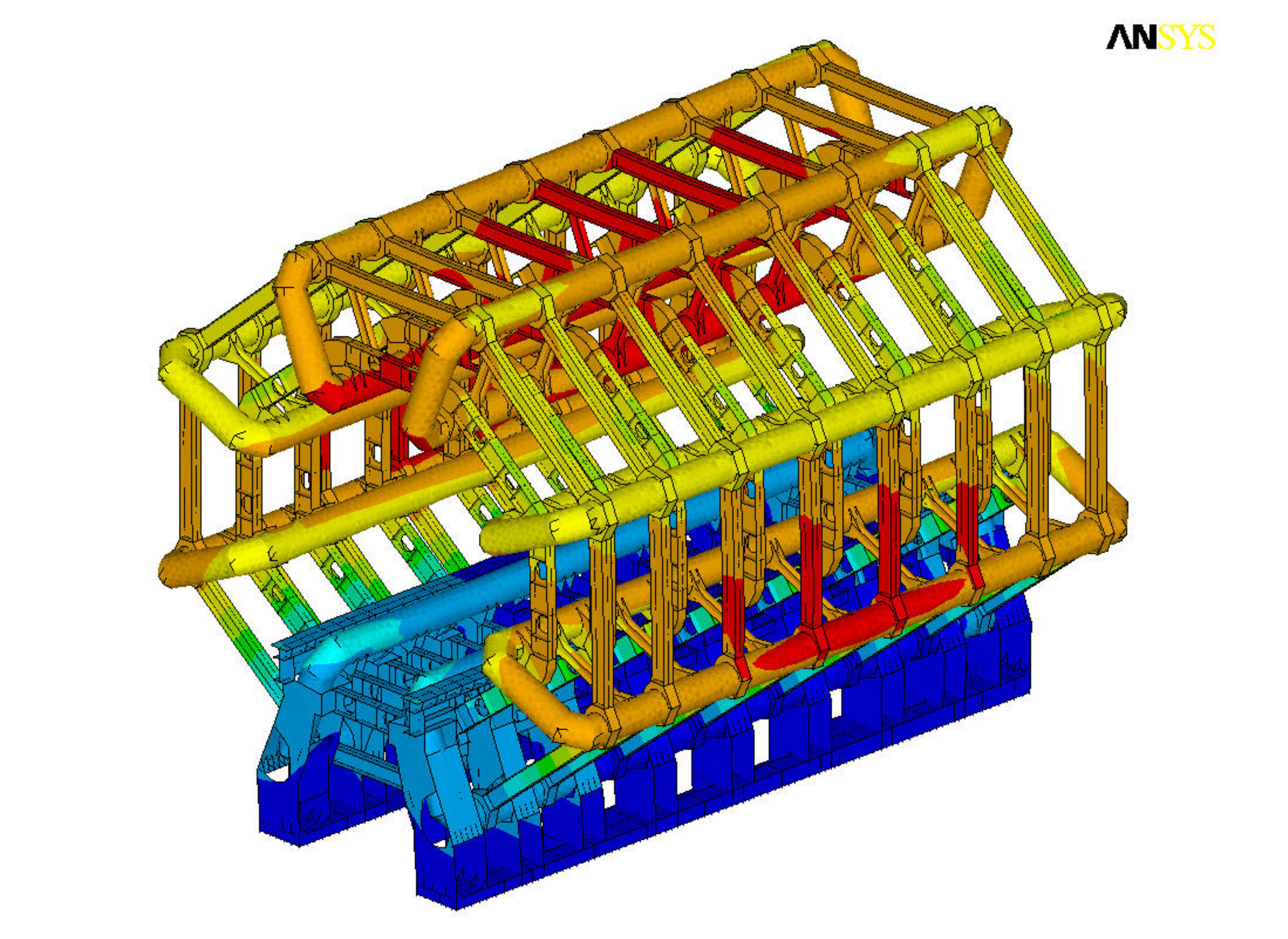
ATLAS (spokesperson Peter Jenni)



ATLAS superimposed to
the 5 floors of building 40

Diameter	*25 m*
Barrel toroid length	*26 m*
End-cap end-wall chamber span	*46 m*
Overall weight	*7000 Tons*

The Barrel Toroid



8 coils interconnected with an aluminum warm structure

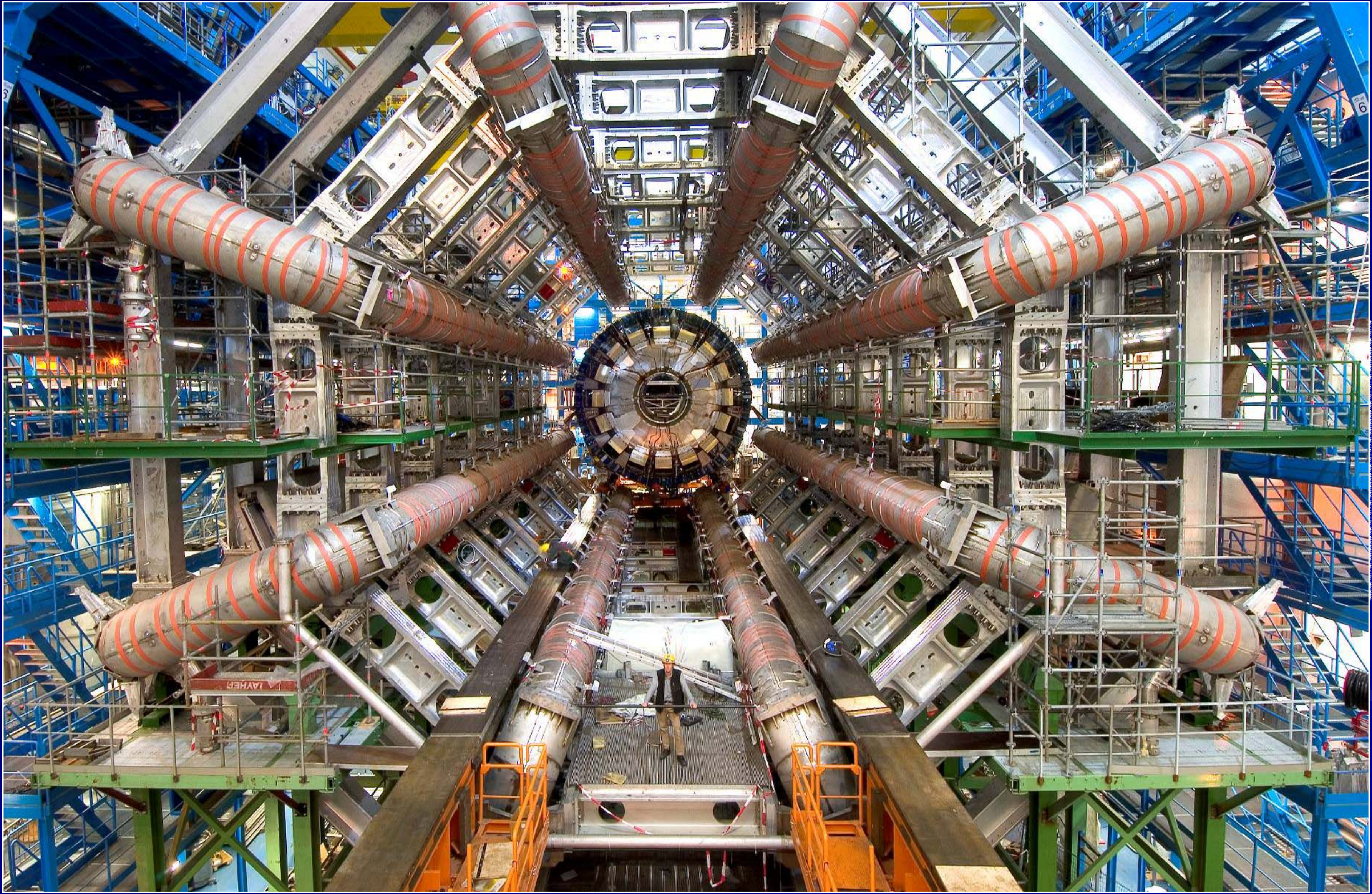
- ***20 m diam. x 25 m length***
- ***8200 m^3 volume***
- ***170 t superconductor***
- ***700 t cold mass***
- ***1320 t total weight***
- ***90 km superconductor***
- ***20.5 kA at 4.1 T***
- ***1.55 GJ stored Energy***

BT Mechanical Assembly

- Difficult but safe manipulations
- Use of 2 lifting frames
- Hydraulic winch with load capacity 190T (subcontracted)

Barrel Toroid installation status

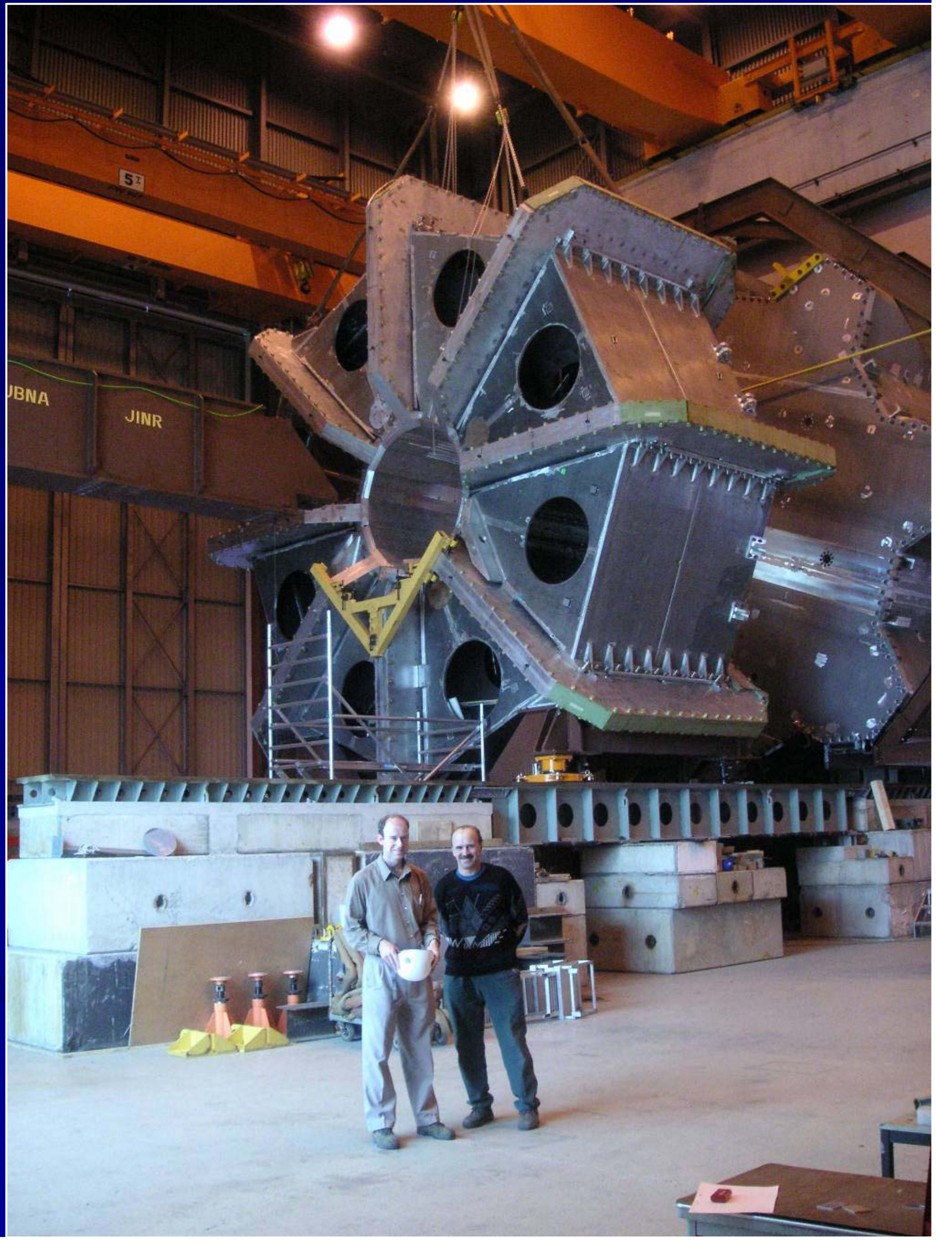
The mechanical installation is complete, electrical and cryogenic connections are being made now, for a first in-situ cool-down and excitation test in spring 2006



End-Cap Toroids

The picture shows a successful trial assembly of the full cold mass in front of the vacuum vessel for the first ECT (side A)

The final assembly is planned to be completed in the coming weeks



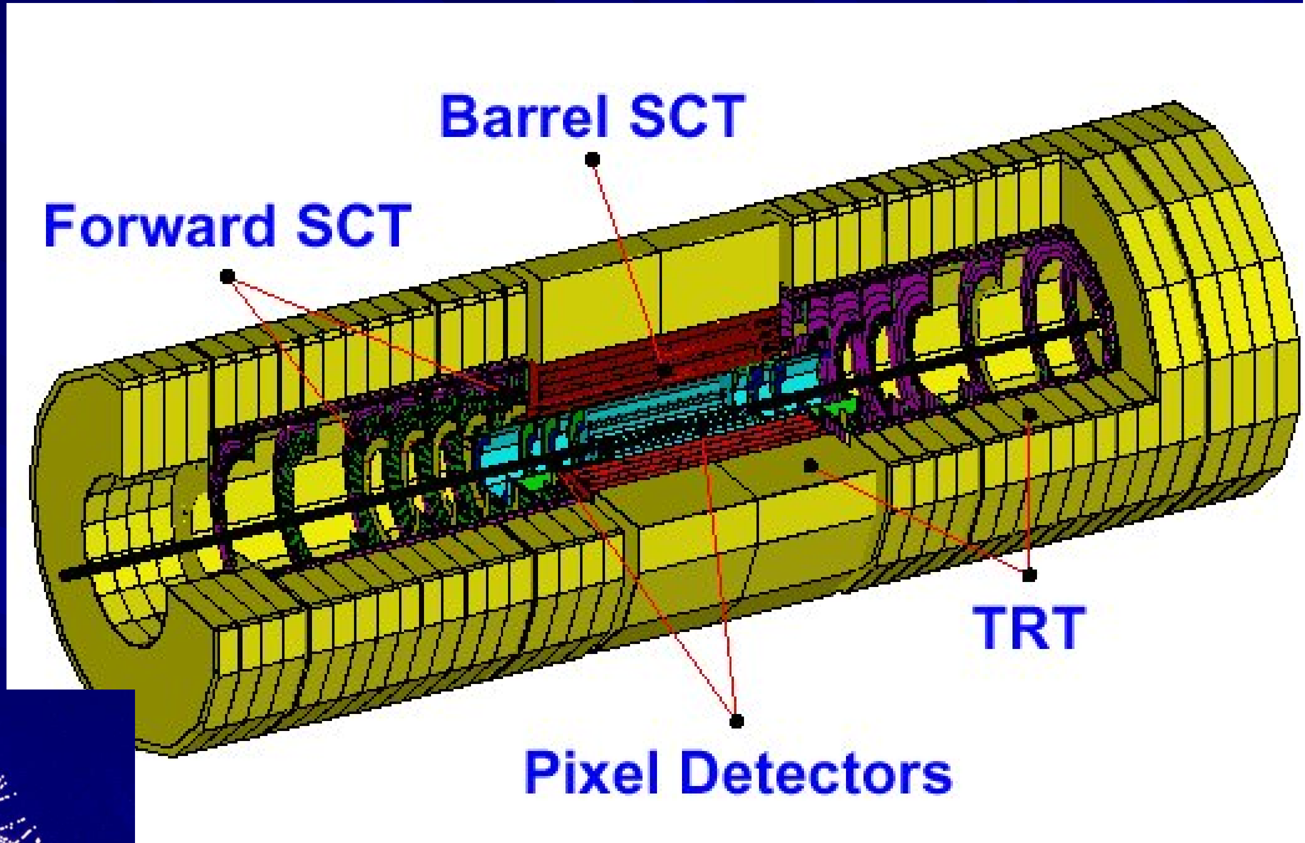
Inner Detector (ID)

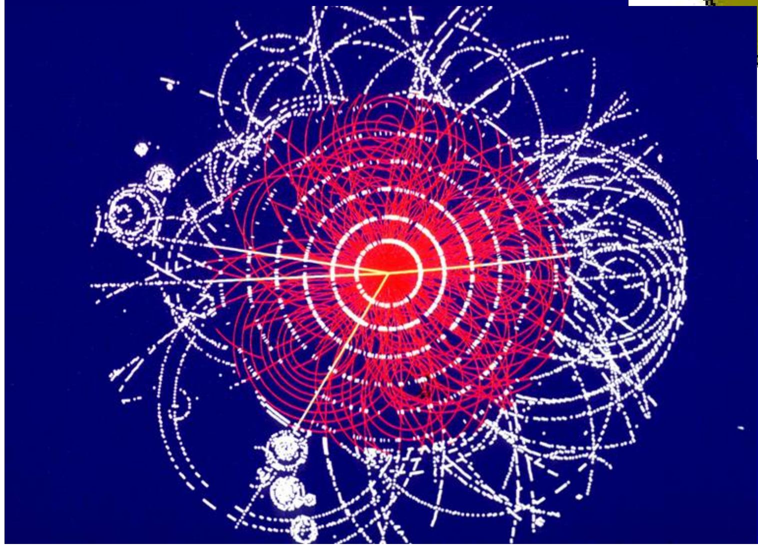
The Inner Detector (ID) is organized into four sub-systems:

Pixels (0.8 10^8 channels)

Silicon Tracker (SCT) (6 10^6 channels)

Transition Radiation Tracker (TRT) (4 10^5 channels)





Pixels

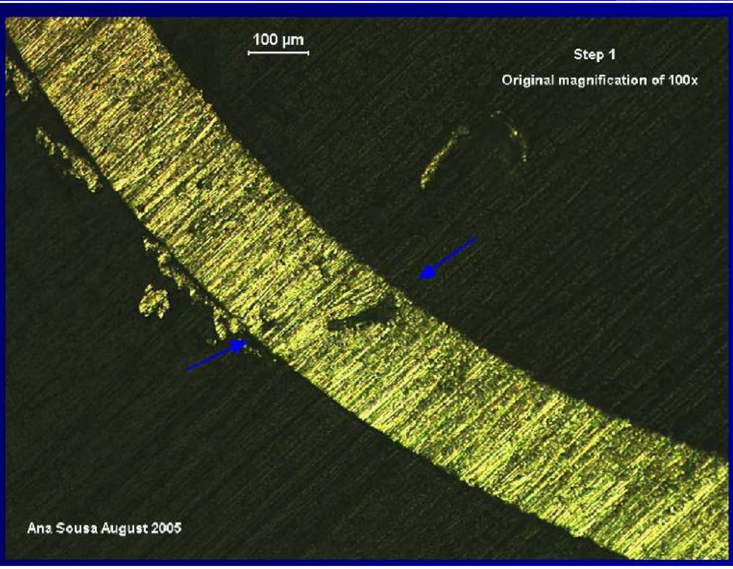
Recent technical problem

- Corrosion leaks in the barrel cooling tubes (highest priority is given to implement an optimum strategy for repair and rebuilding of staves)

This means that there is a schedule risk for the installation of a 3-layer system in time for the start-up, even though the recovery progress is good

The installation schedule has been adapted to accommodate a late availability

(Note that the Pixel sub-system can be installed independently from the rest of the Inner Detector)

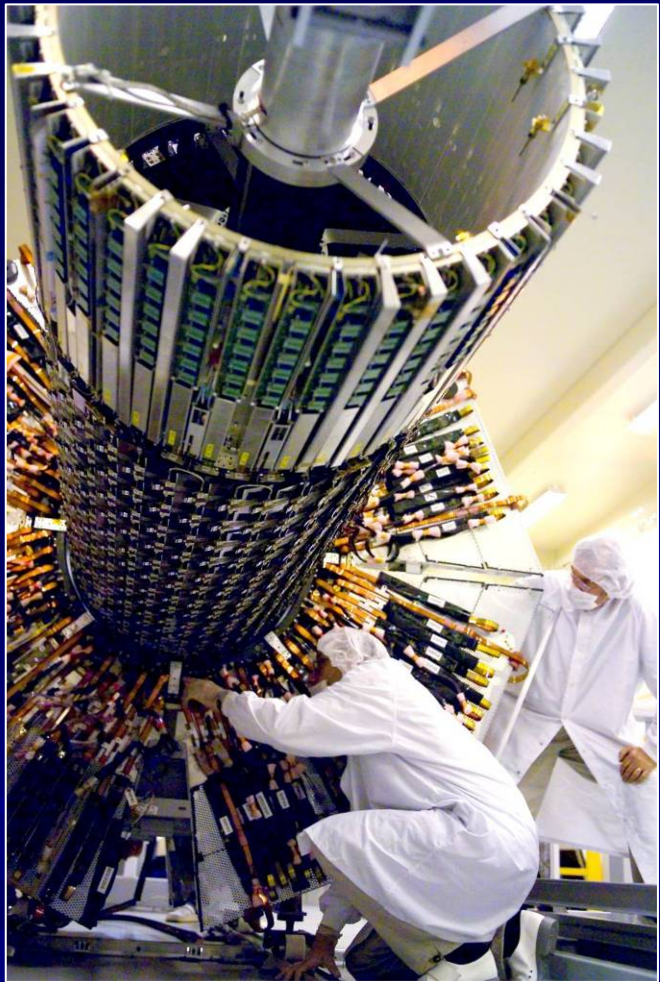


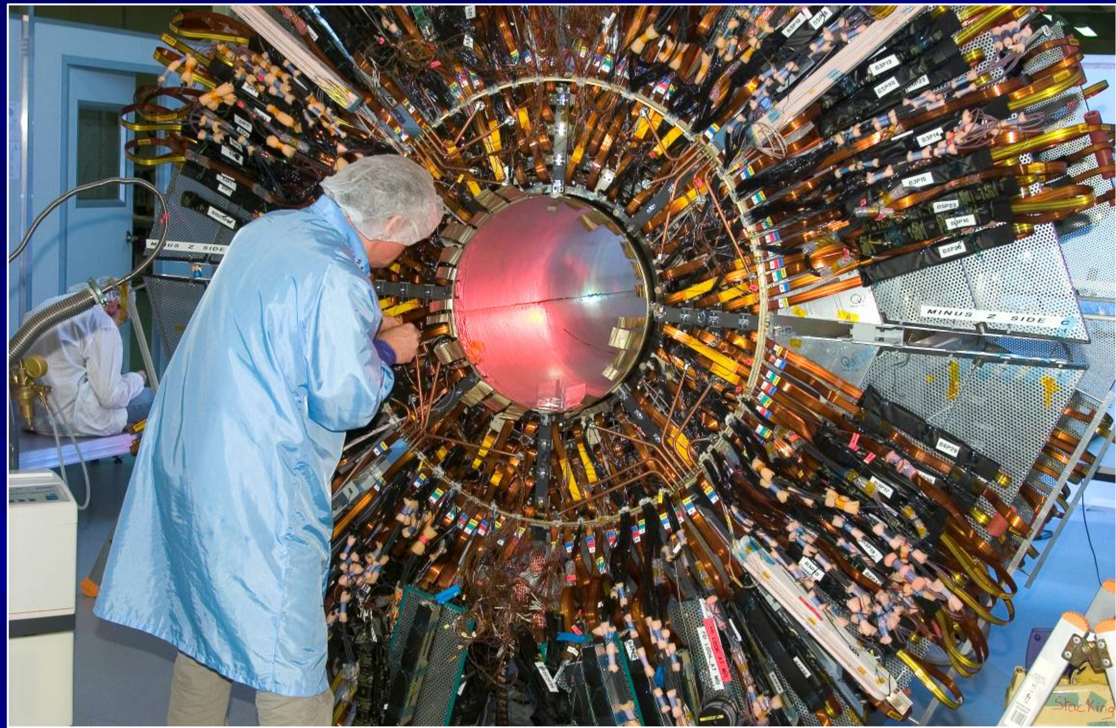
Example of a galvanic corrosion hole that is opening

Completed barrel stave

Silicon Tracker (SCT)

All four barrel cylinders are complete and at CERN





Assembly of the four barrel cylinders is complete (left), and the SCT barrel is now being prepared for insertion into the TRT barrel

Transition Radiation Tracker (TRT)

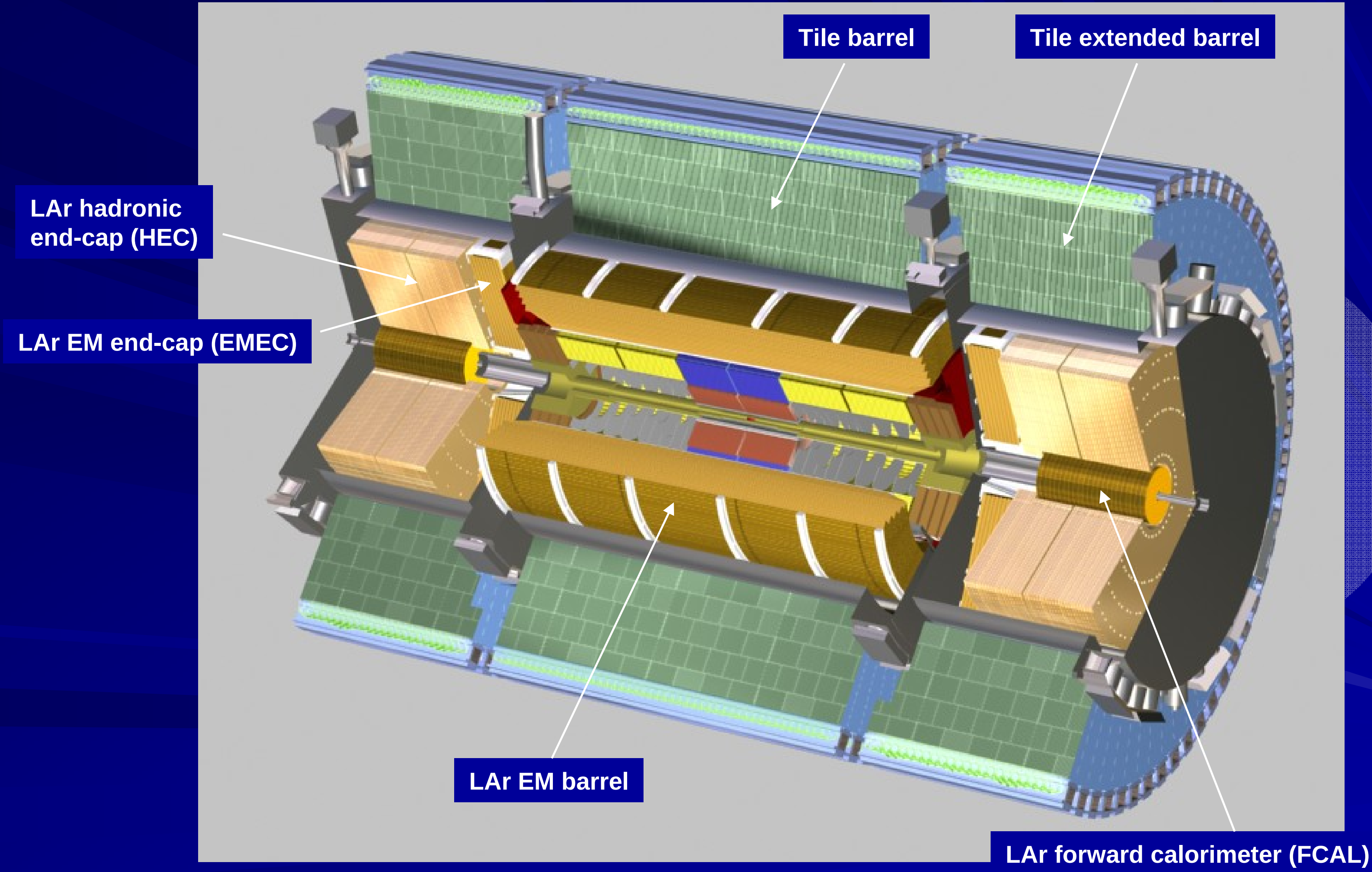
The module construction for the end-cap TRT will also be complete by the end of the year, and the first end-cap side (A and B wheels) has been assembled and integrated, whereas the barrel has been ready since several months

A previously reported excessive failure rate of HV fuses has been overcome

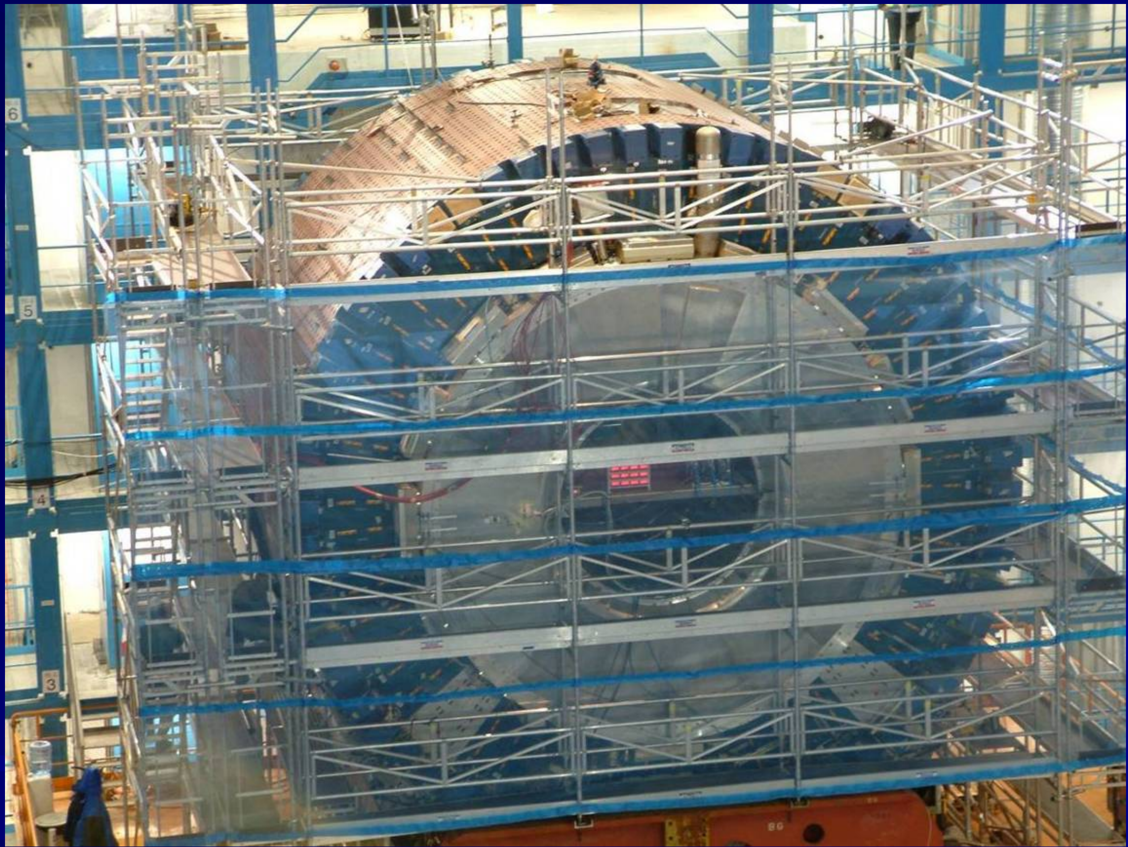
A new technical issue concerns leaks in the barrel cooling line manifolds, due to bad brazing → a redesign was adopted in a recent review and will be implemented in the coming months

The first of the two end-cap TRTs (A and B type wheels) fully assembled

LAr and Tile Calorimeters

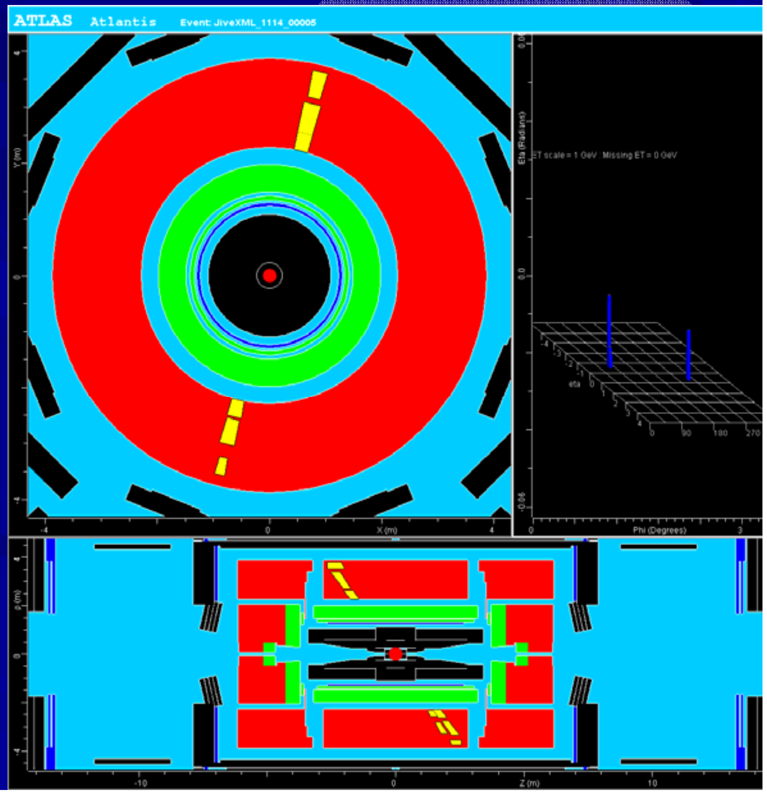


Barrel LAr and Tile Calorimeters



The barrel LAr and Tile calorimeters have been since some time in the cavern in their ‘garage position’ to be moved into their final position at the end of this month

A cosmics muon registered in the barrel Tile calorimeter



The delicate transport of the first LAr End-Cap to point-1 (22nd Sep)

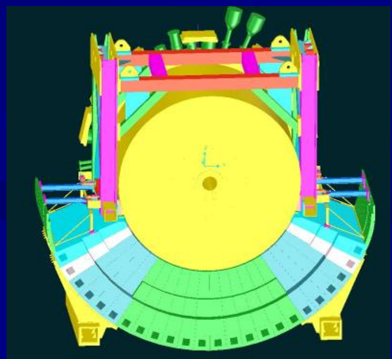
The lower part of the Extended Barrel Tile Calorimeter and the LAr End-Cap are ready for the lowering into the cavern (side C)

LAr and Tile Calorimeter End-Caps

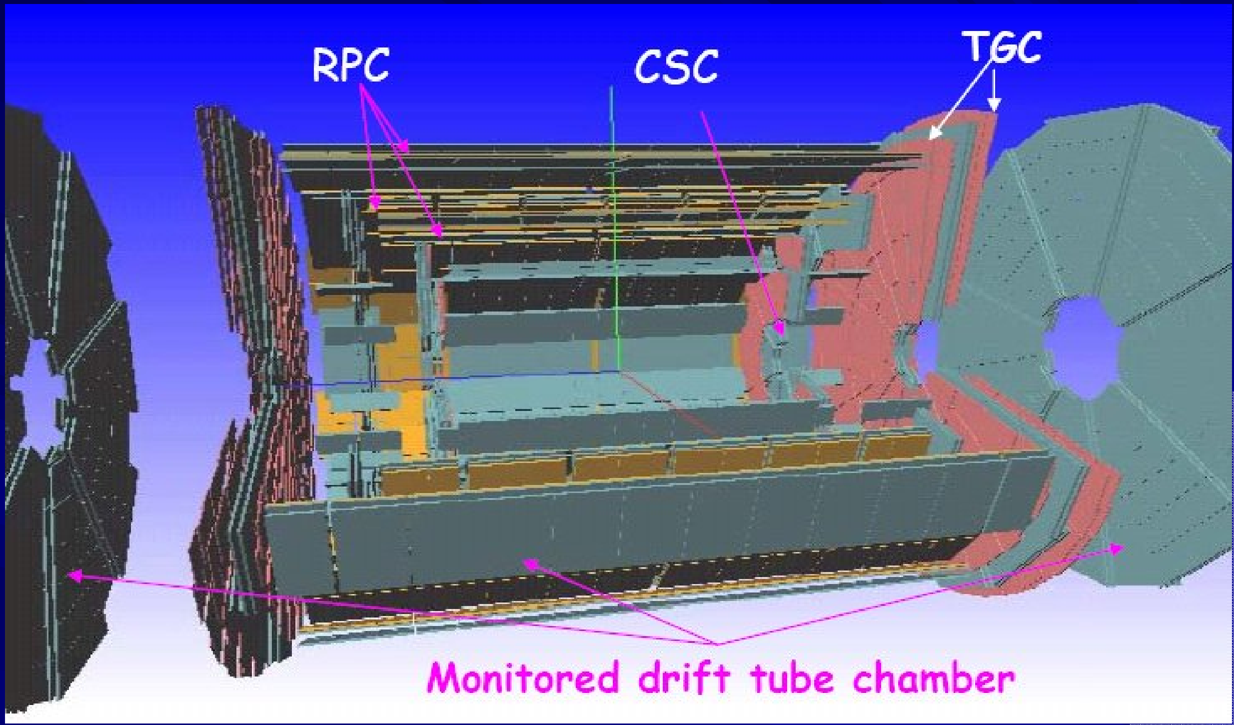
Next major activities:

End-Cap C installation from Nov 05 → Jan 06

End-Cap A installation from Jan 06 → Mar 06



Muon Spectrometer Instrumentation



The Muon Spectrometer is instrumented with precision chambers and fast trigger chambers

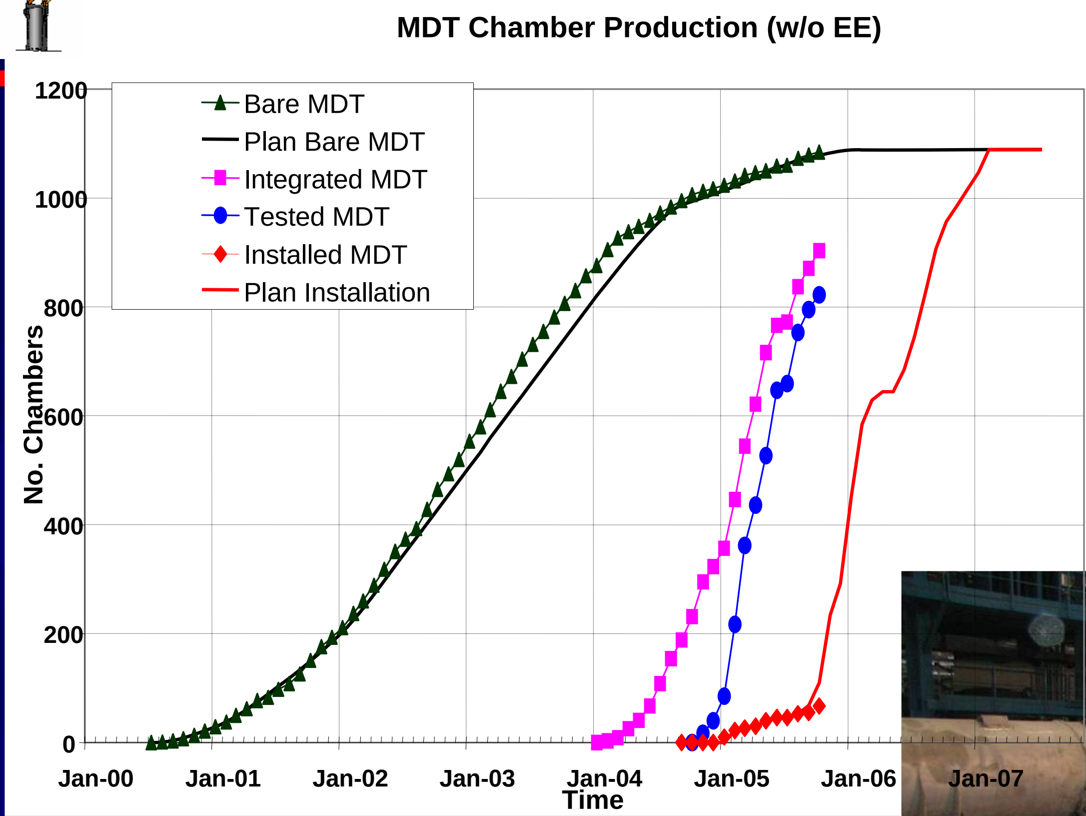
A crucial component to reach the required accuracy is the sophisticated alignment measurement and monitoring system

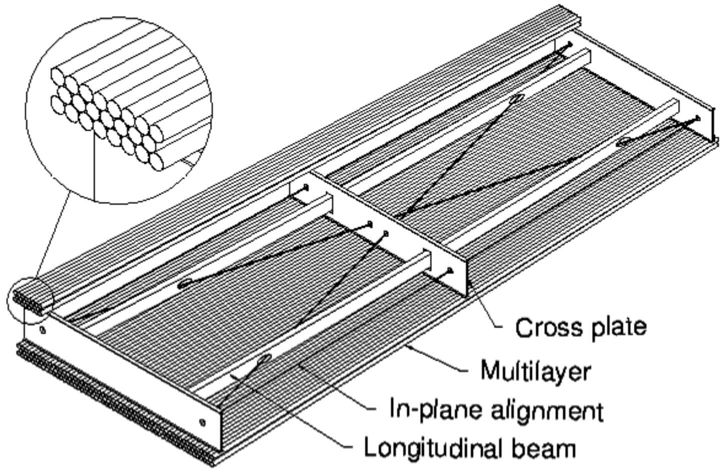
Precision chambers:
- MDTs in the barrel and end-caps
- CSCs at large rapidity for the innermost end-cap stations

Trigger chambers:
- RPCs in the barrel
- TGCs in the end-caps

At the end of this year the huge and long effort of series chamber production in many sites will be completed for all chamber types

Barrel Muon MDTs



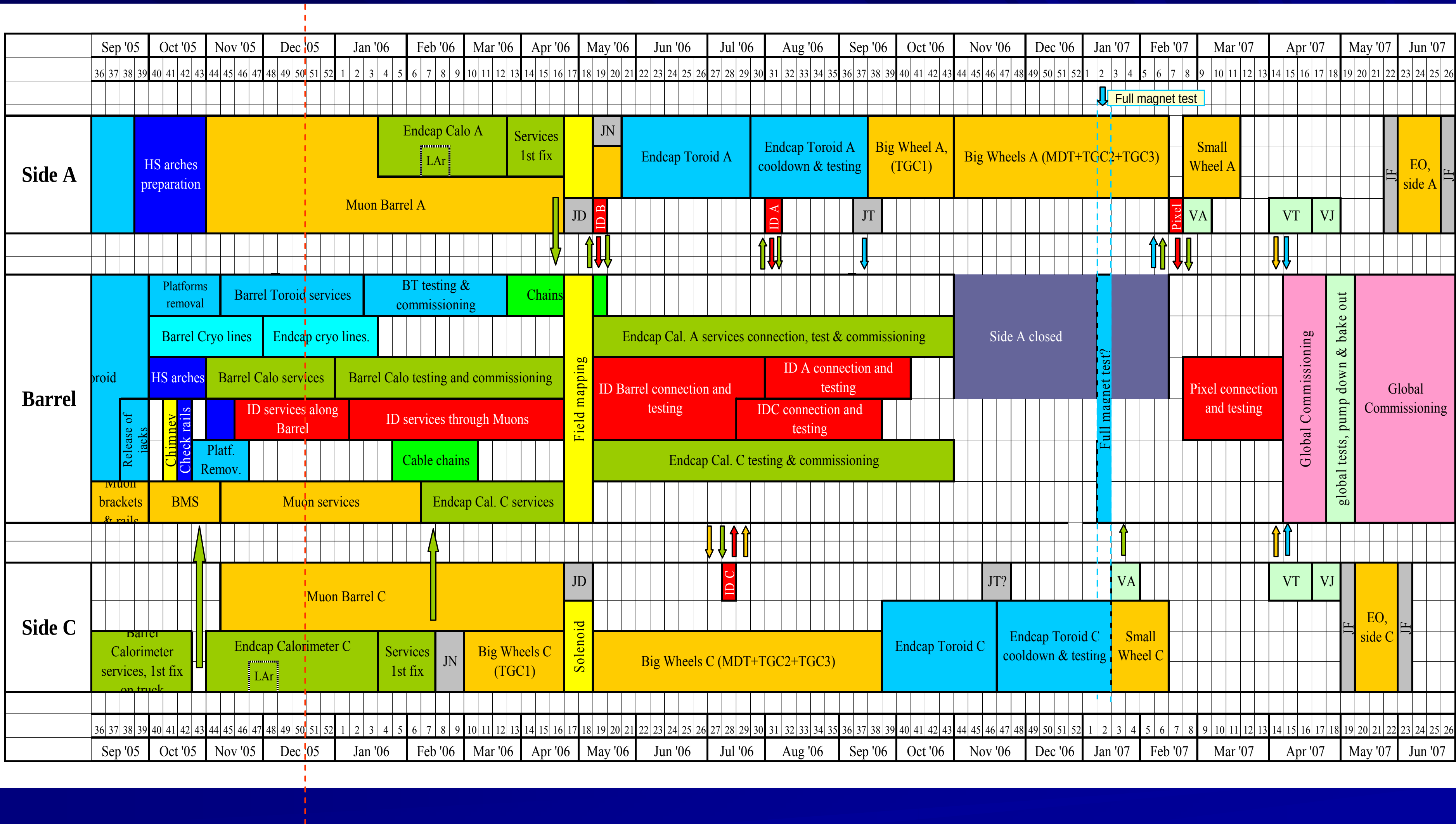


A major effort is spent in the preparation and testing of the barrel muon stations (MDTs and RPCs for the middle and outer stations) before their installation in-situ

The electronics and alignment system fabrications for all MDTs are on schedule

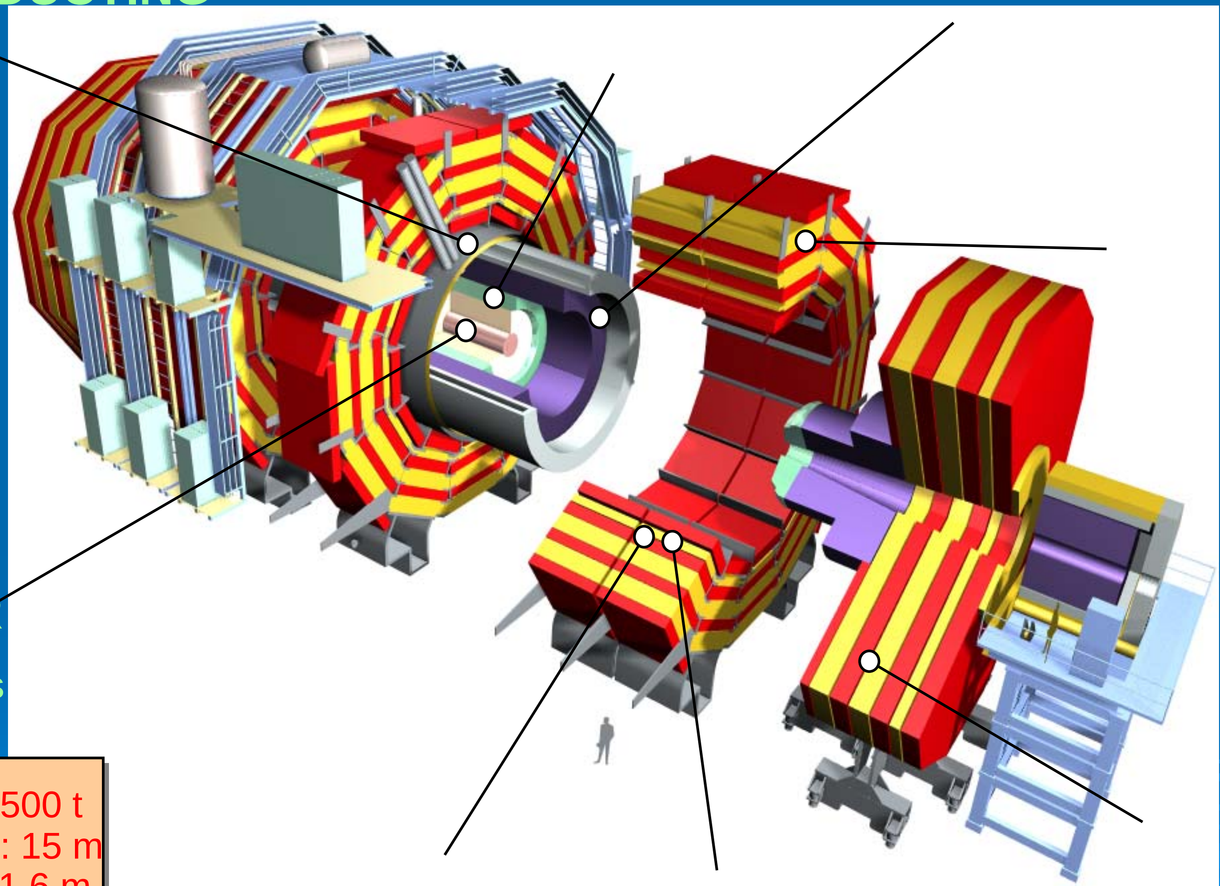
Installation of barrel muon station

Summary representation of the installation activities in the experimental cavern at Point-1 (Installation Schedule Version 7.09)



The CMS Detector

Spokesperson: M. Della Negra



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

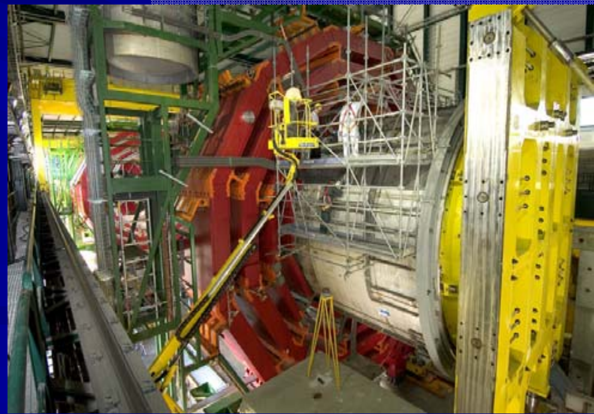
Coil Swiveling and Insertion

Swiveling of coil carried out on 25 Aug.



Coil inserted 14 Sep.

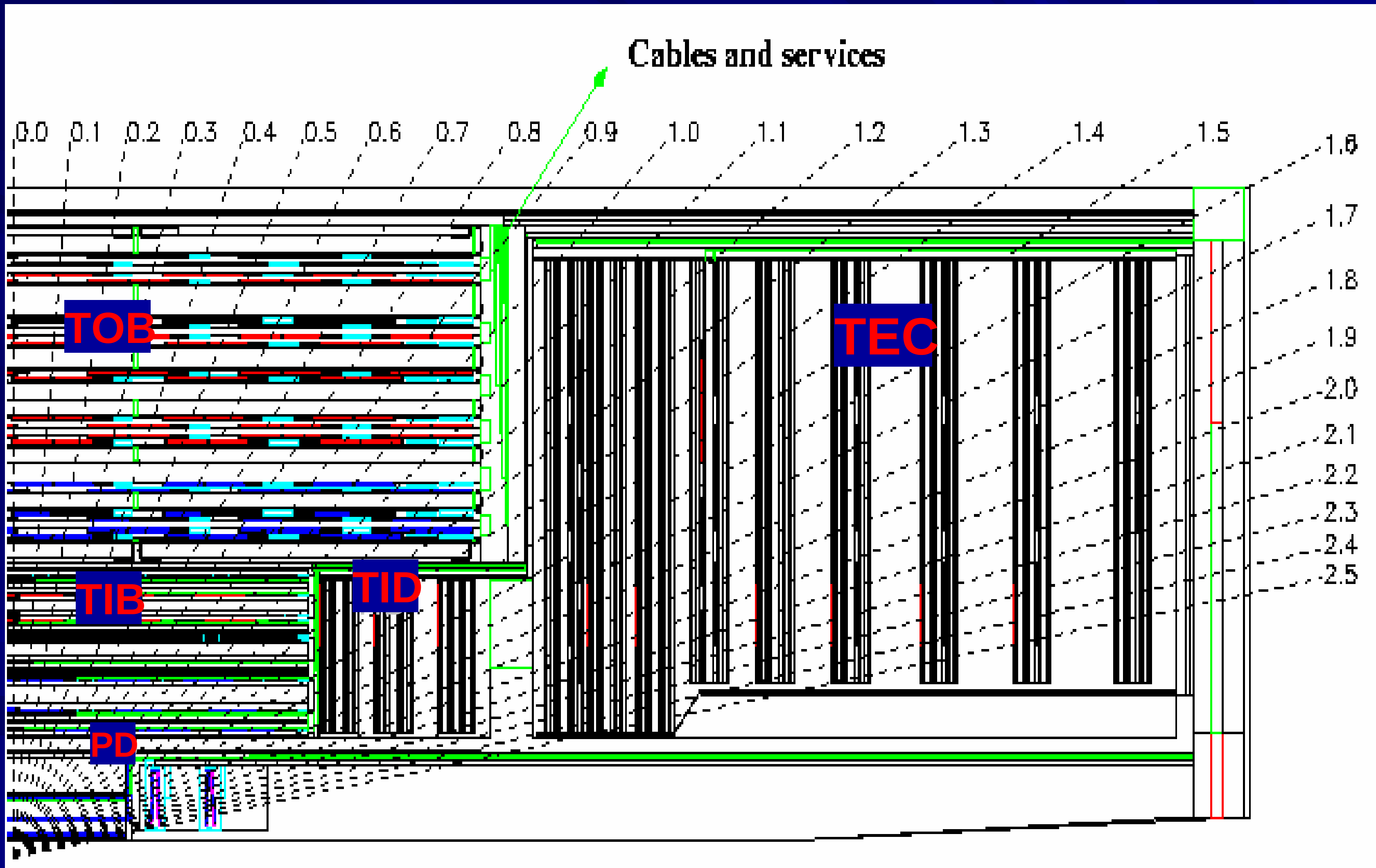




Platform disconnected from Coil (28 Sep)

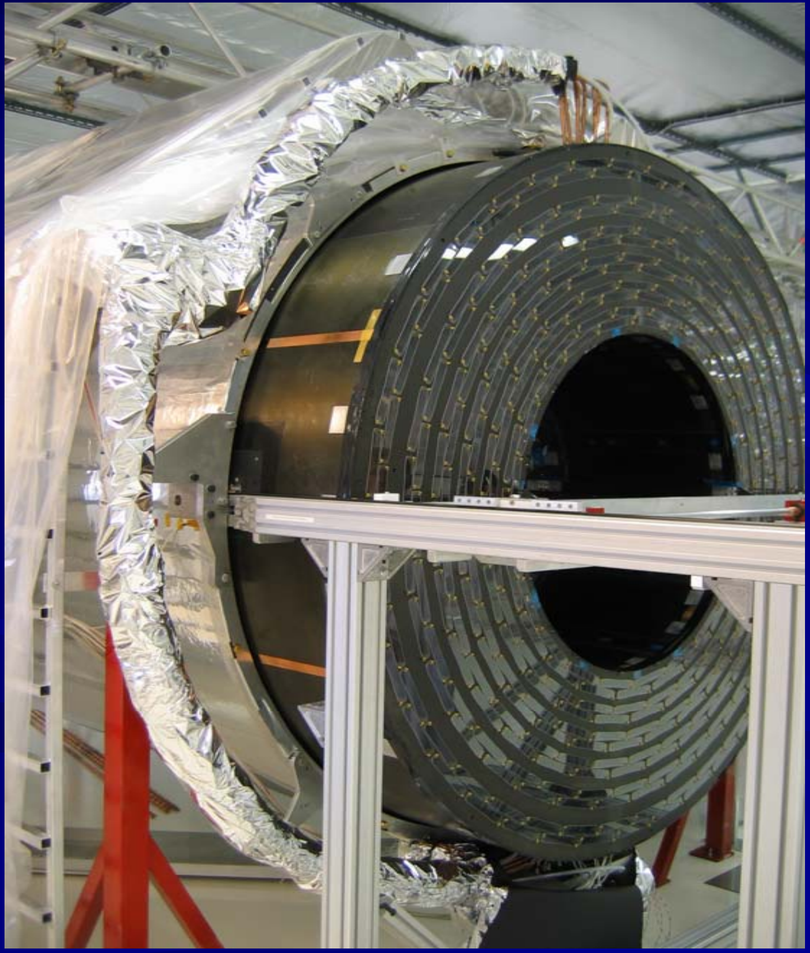
Swivelling of inner vac tank: ~ 20 Oct
Coil cool-down and start of electrical tests : Jan 06

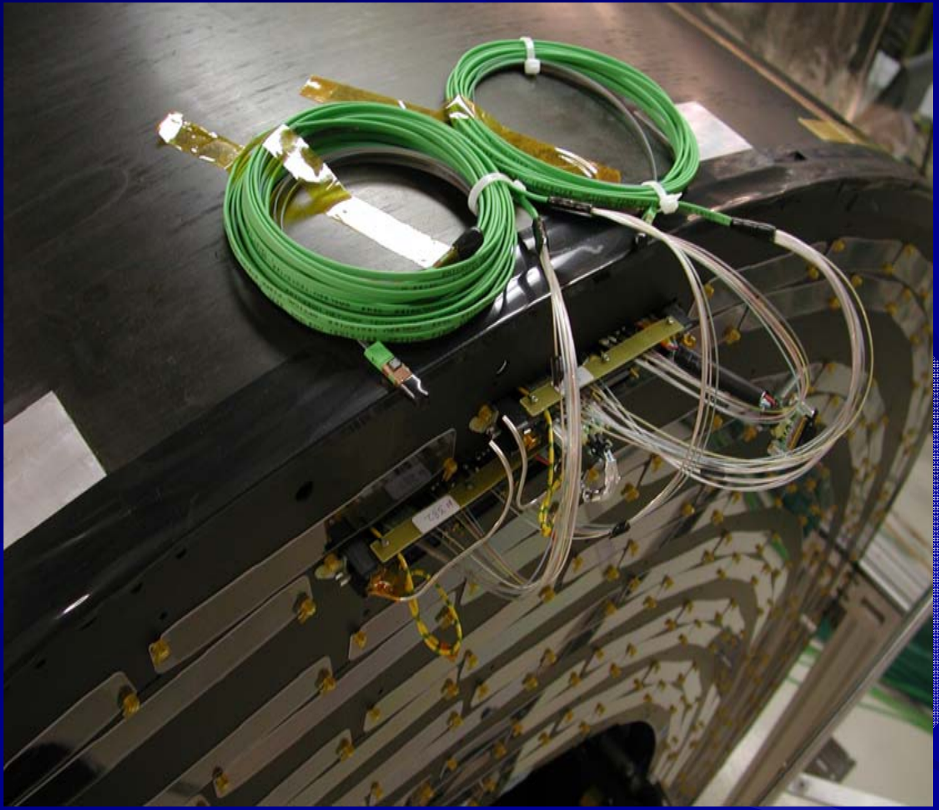
Inner Tracker



Tracker Outer Barrel

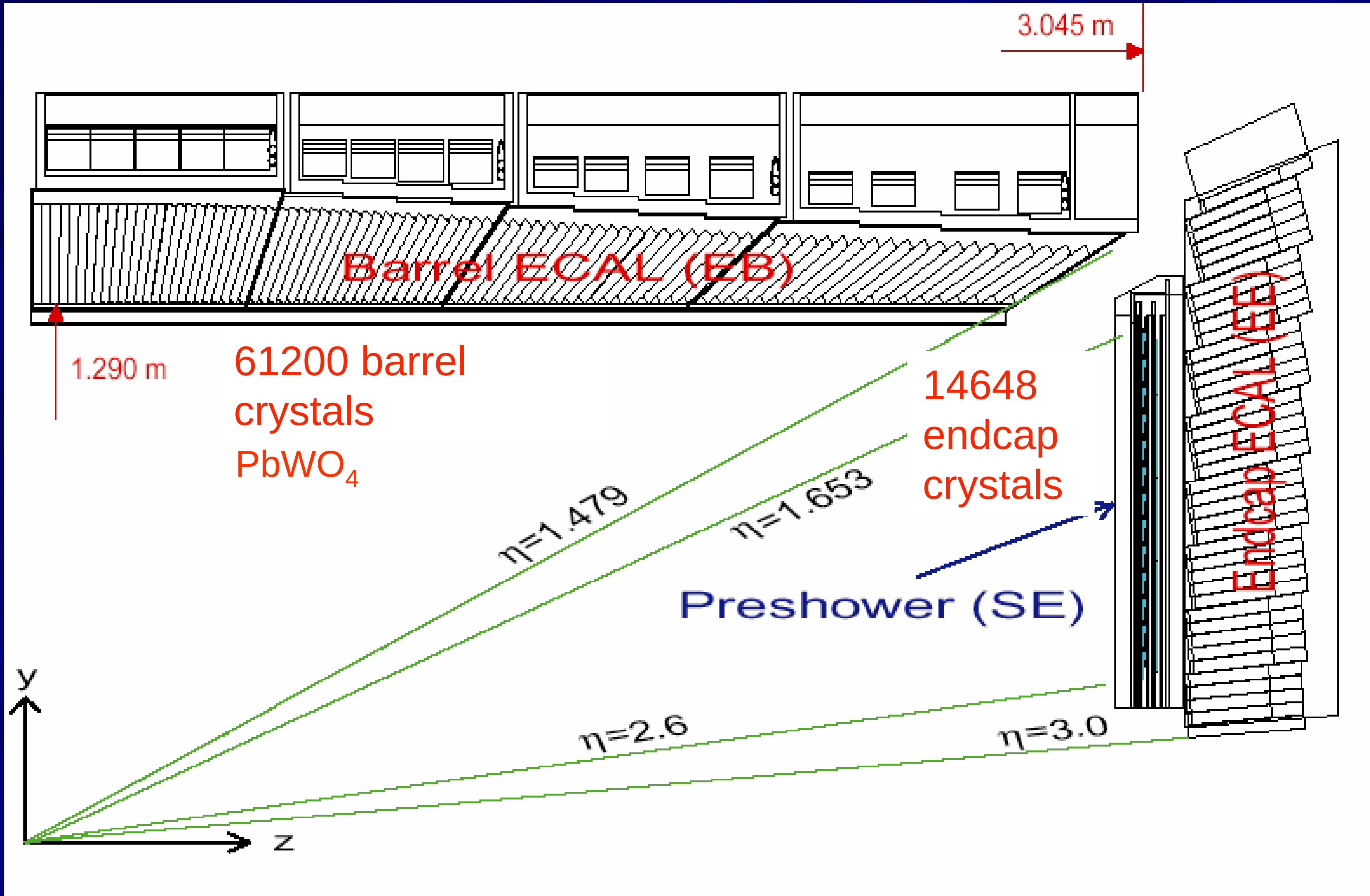
The TOB Support Structure partially inserted into the Tracker Support Tube



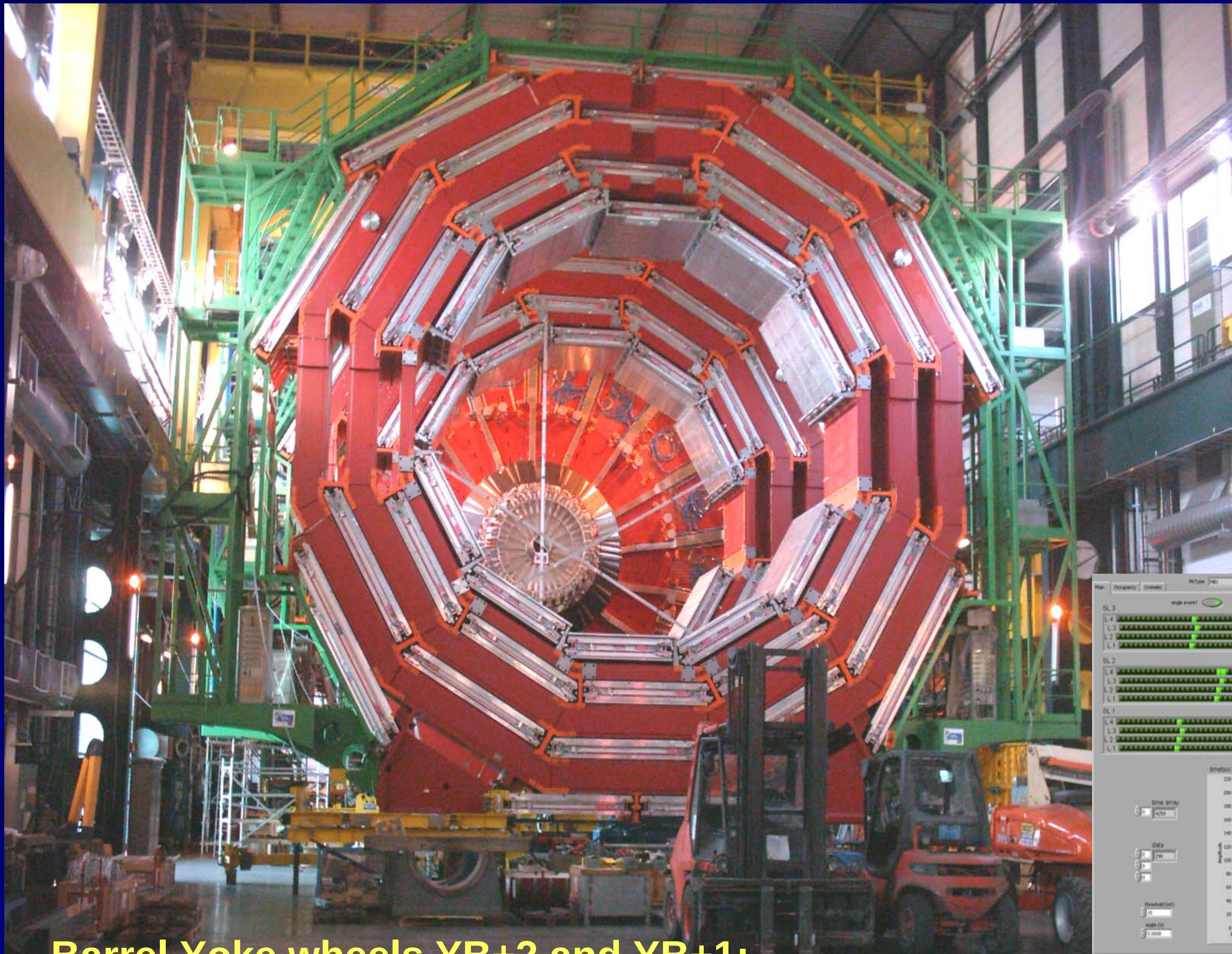


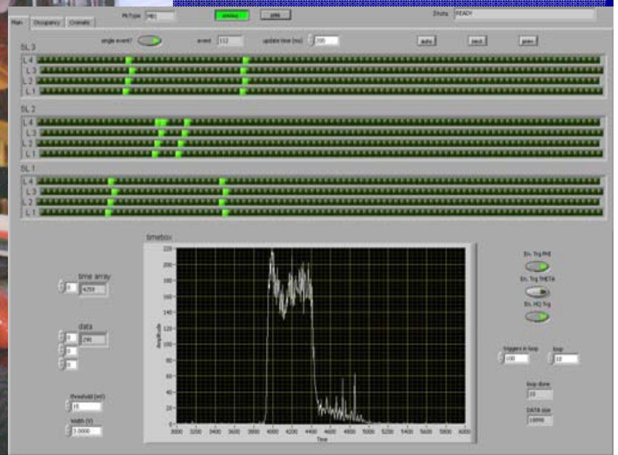
The Trial Insertion of Two RODs into the TOB Structure

Electromagnetic CALorimeter

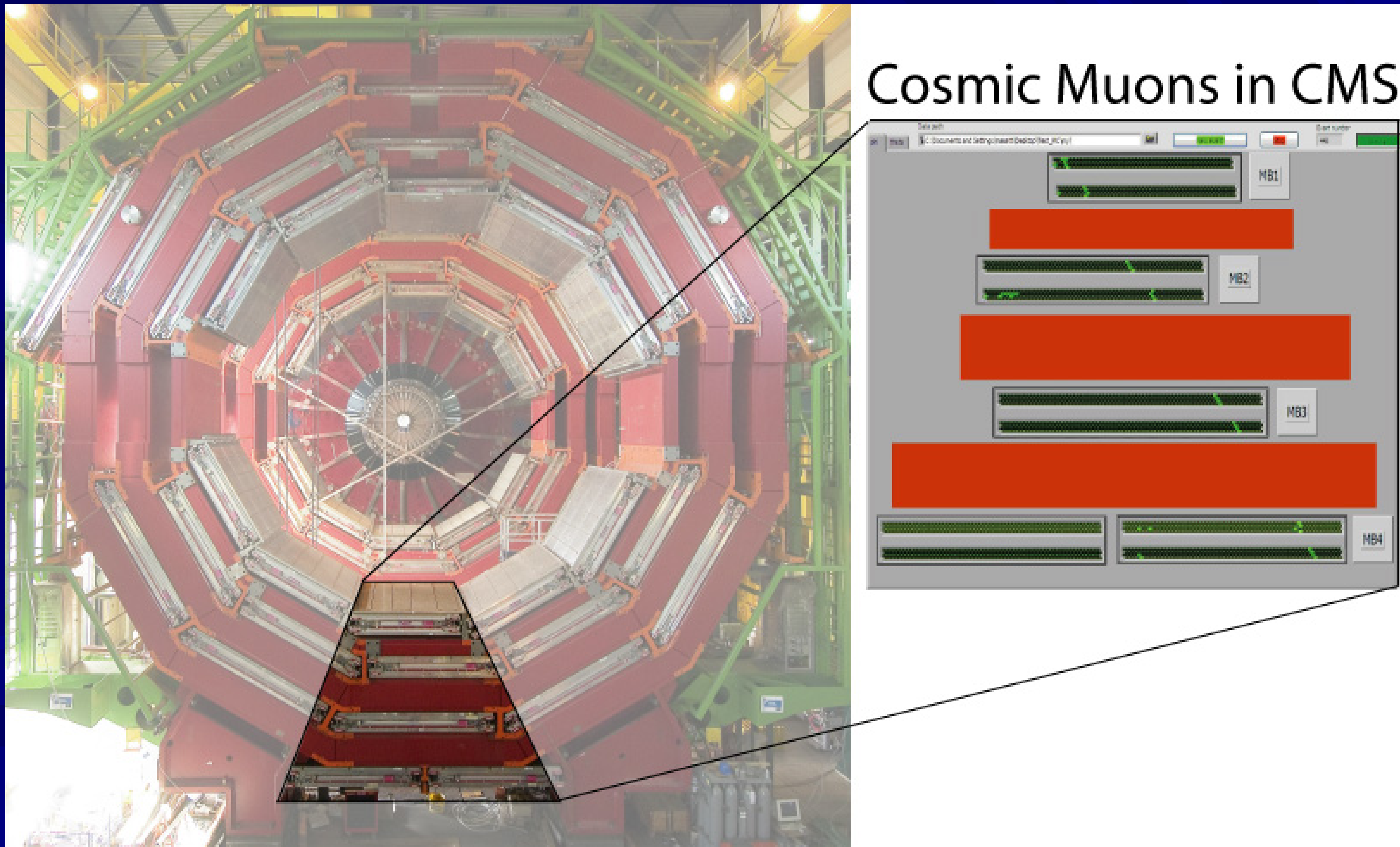


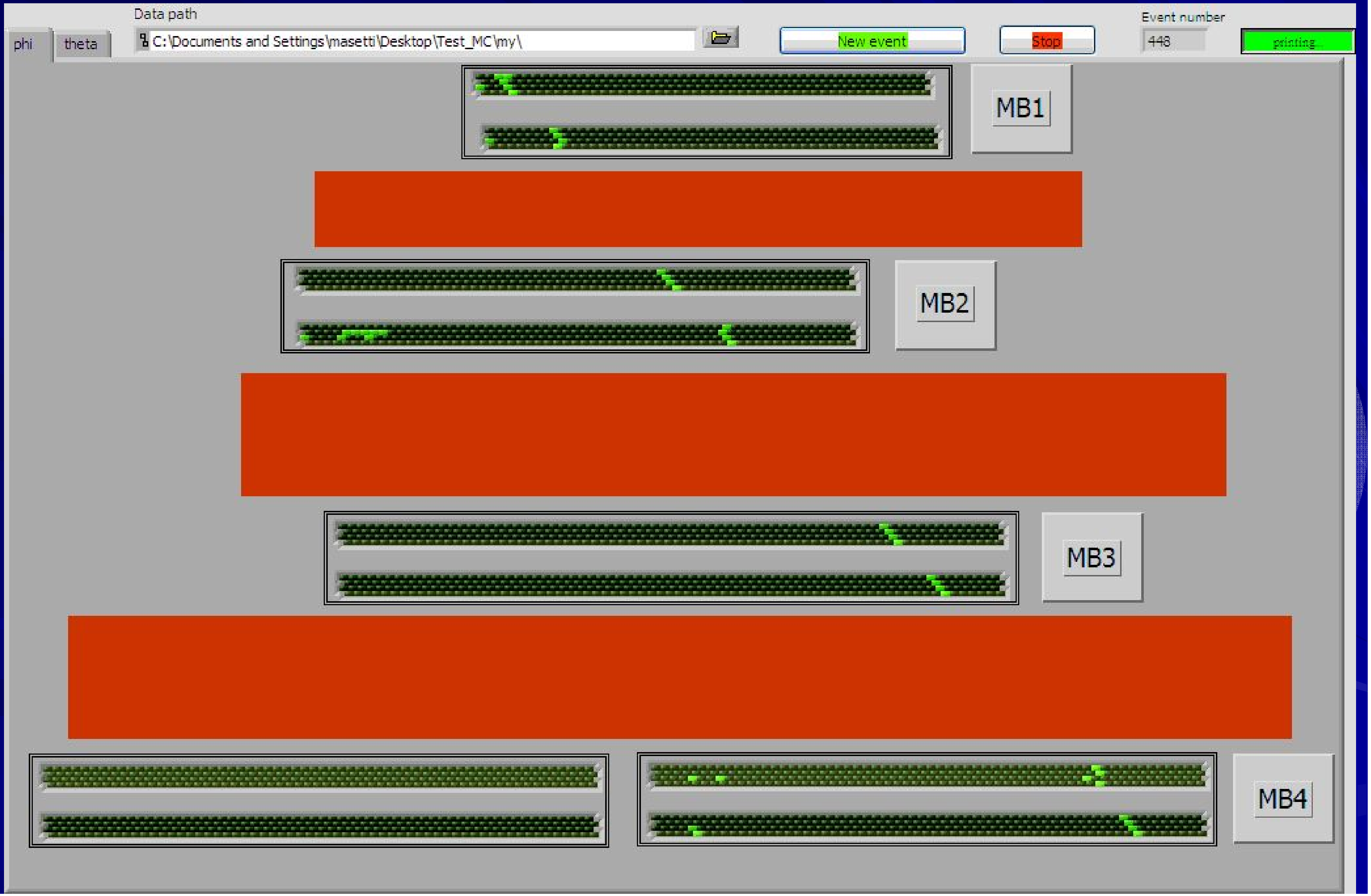
Barrel Muons: DriftTubes Assembly and Installation



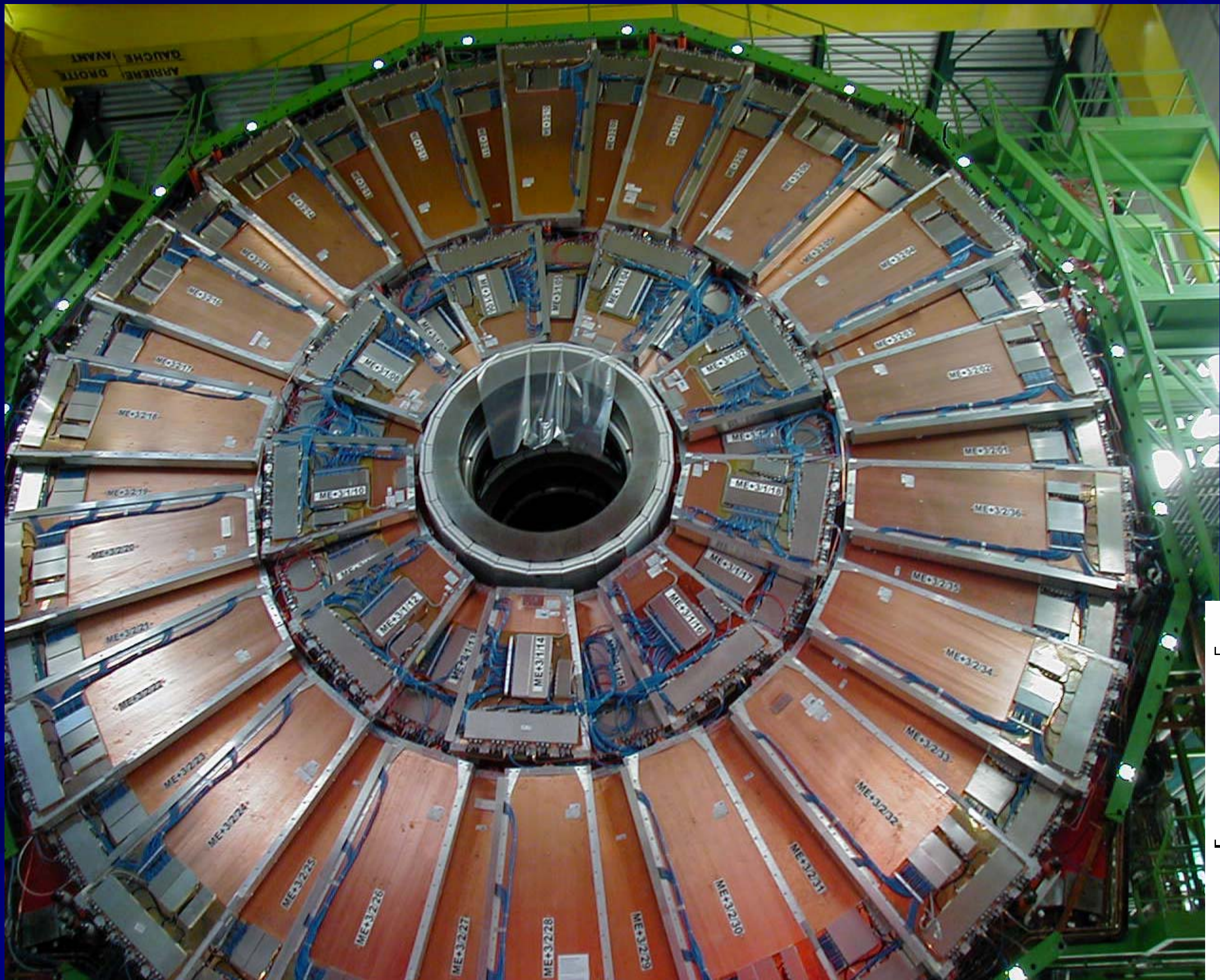


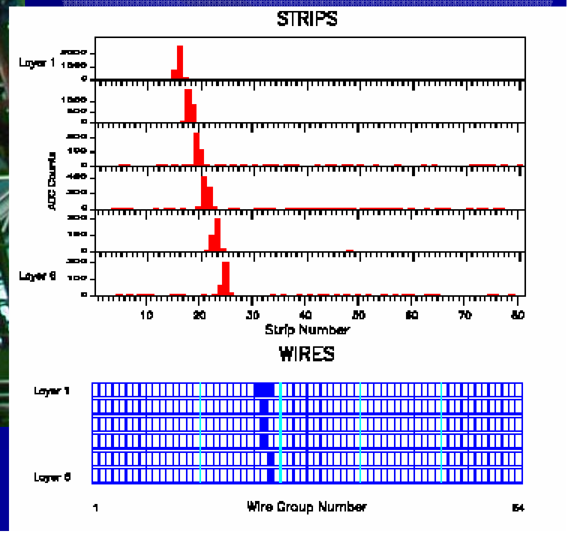
Barrel Yoke wheels YB+2 and YB+1:
80 (out of 210) DT/RPC Ch. Installed; 40 Ch. commissioned


Cosmic Muons in CMS
MB1
MB2
MB3
MB4


phi
theta
Data path
C:\Documents and Settings\masetti\Desktop\Test_MC\my\
New event
Stop
Event number
448
printing...
MB1
MB2
MB3
MB4

Endcap Muons: ME2, ME3 and ME4 stations





CMS Schedule

Currently see a delay of an average of 6 weeks wrt v34.2. Will try to regain time during repetitive operations after lowering in second half of 2006.

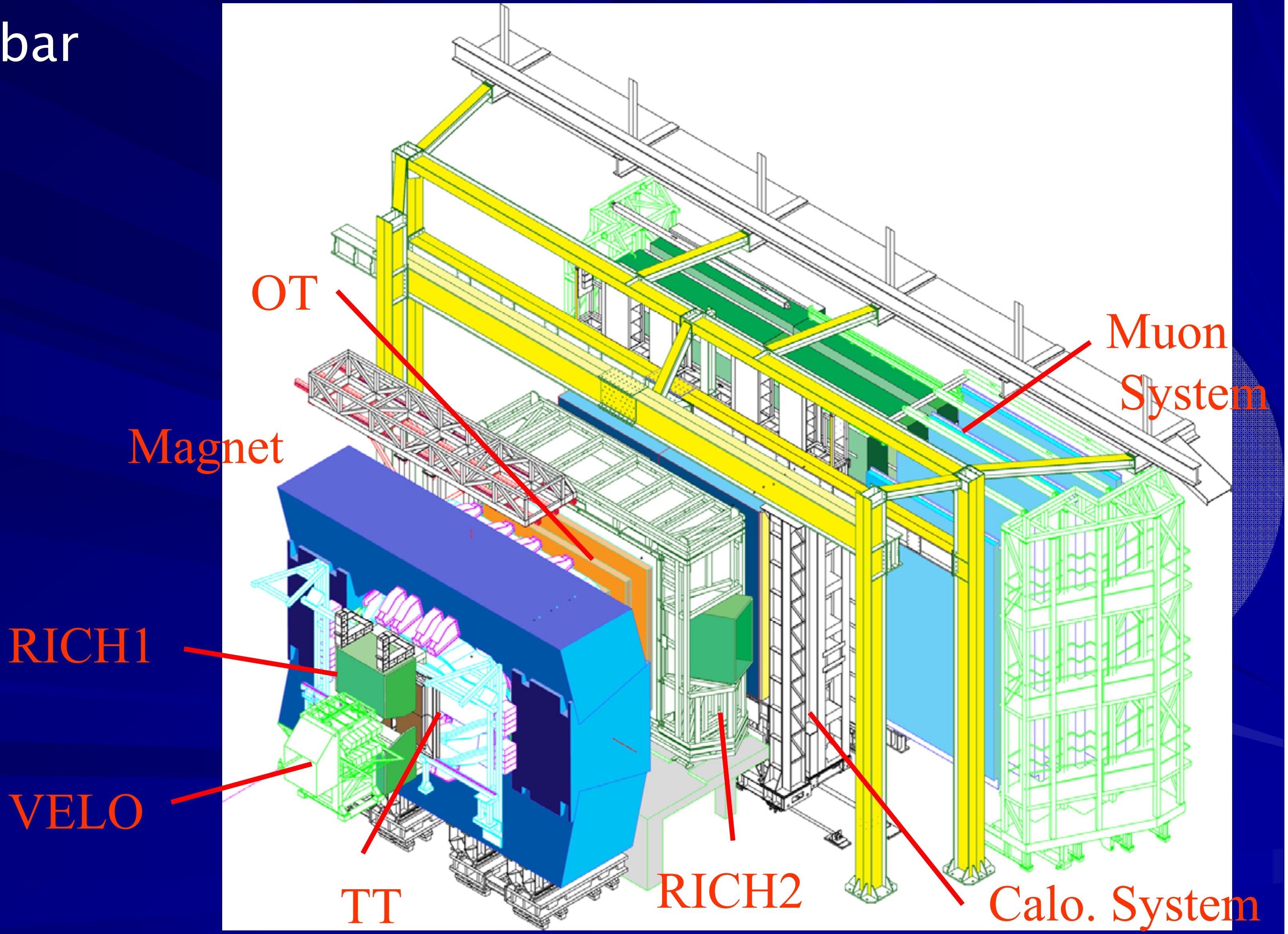
	v34.2	**Estimate**
• Magnet test on surface start	Nov 05	Feb 06
• Start Lowering CMS (HF first)	Feb 06	Apr 06
• ECAL barrel EB+ installation	Mar 06	May 06
• ECAL: EB- installation & cabling	Oct 06	Oct 06
• Tracker installation + cabling start	Nov 06	Nov 06
• Beampipe Installation	Mar-Apr 07	Mar-Apr 07
• CMS "ready to close" for beam	15 Jun 07	15 Jun 07
• CMS "ready for beam"	30 Jun 07	30 Jun 07

During first shutdown after pilot physics run:

• Pixel Tracker installation	Dec 07	Dec 07
• EE/ES installation	Dec07/Feb 08	Dec07/Feb 08

LHCb Spectrometer (spokesman Tatsuya Nakada)

gg→b bbar



Beam Pipe

- –25 mrad Be section completed
- –10 mrad Be
  1st section being tested at IHEP, Protvino
- –10 mrad Be
  2nd section under construction by Kompozit, Moscow

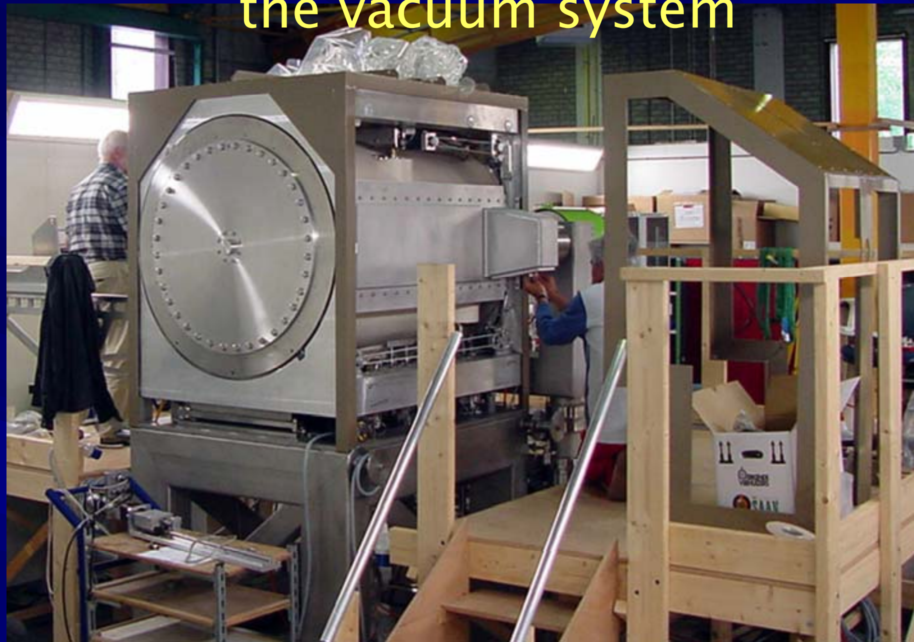
- All the other components are also under construction

VErtex LOcator

VELO tank installed in the support frame and connected to the vacuum system

CO_2 cooling capillaries

feedthrough flanges



All the parts are now being produced

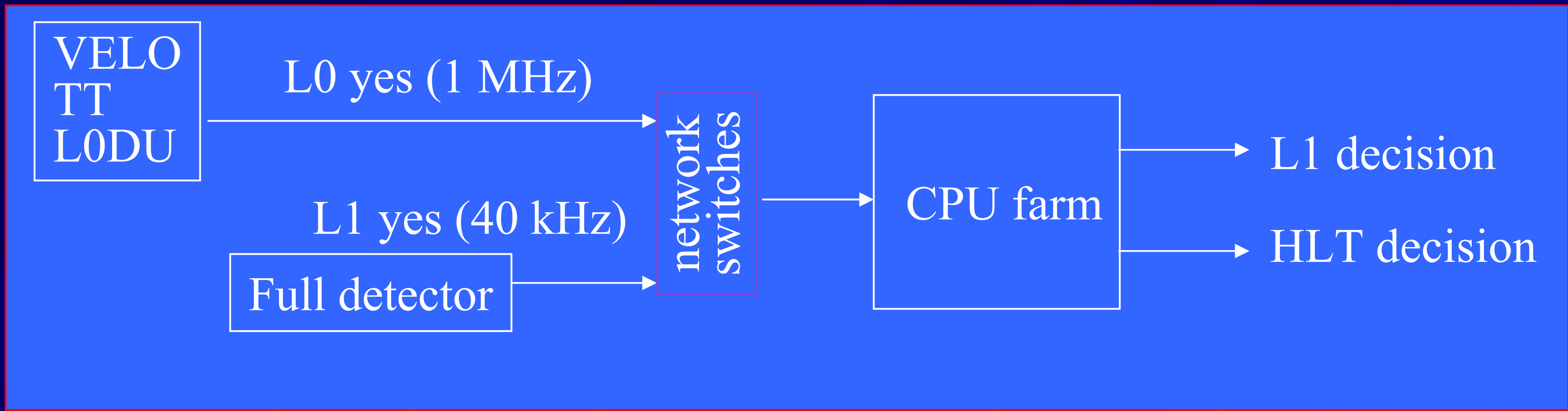
r-sensor

hybrid and module support

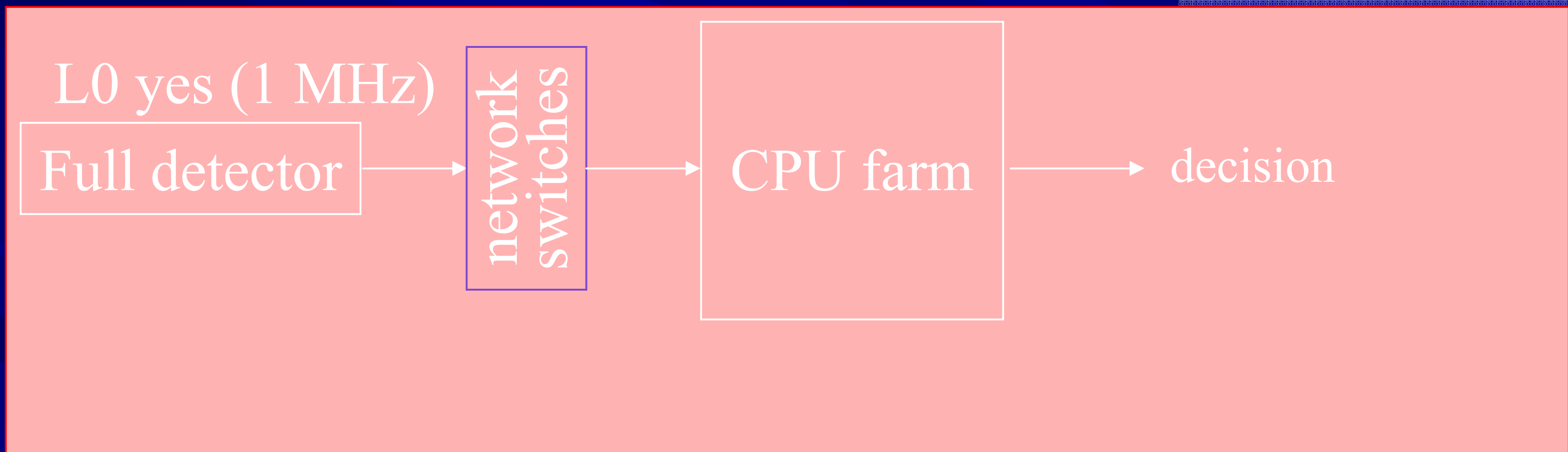
RICH-2 transport to IP8

L-1 and HLT hardware now completely unified

Old scheme



Newly adopted 1 MHz readout scheme



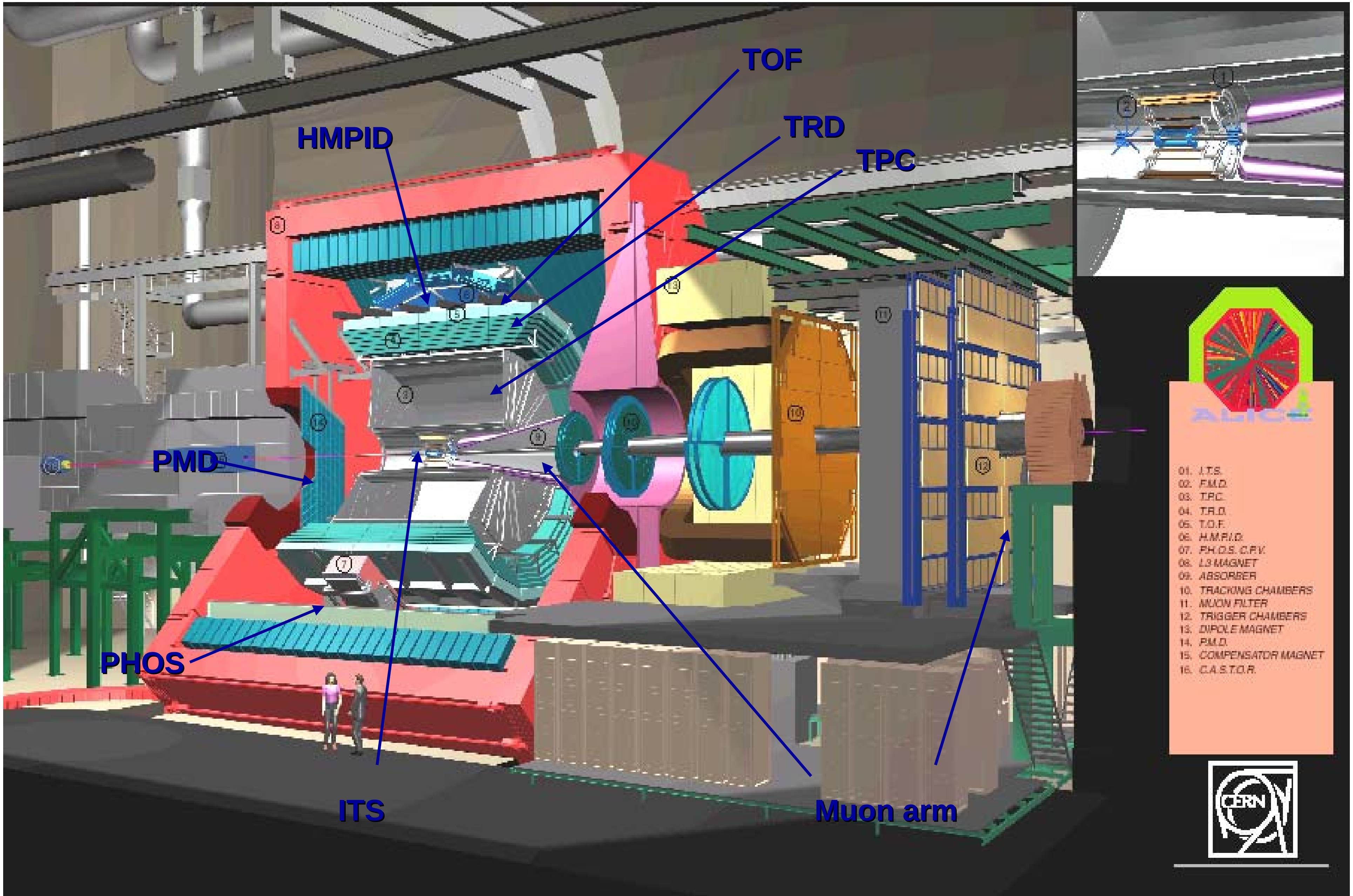
This was foreseen as an upgrade, but the cost of the network switches has dropped faster than anticipated.

LHCb

Production, installation and commissioning of all the subsystems are progressing well

No problem with the TT and ST sensor delivery any more

Still tight schedule for VELO sensors, RICH1 mechanics, HPD's and Muon chambers

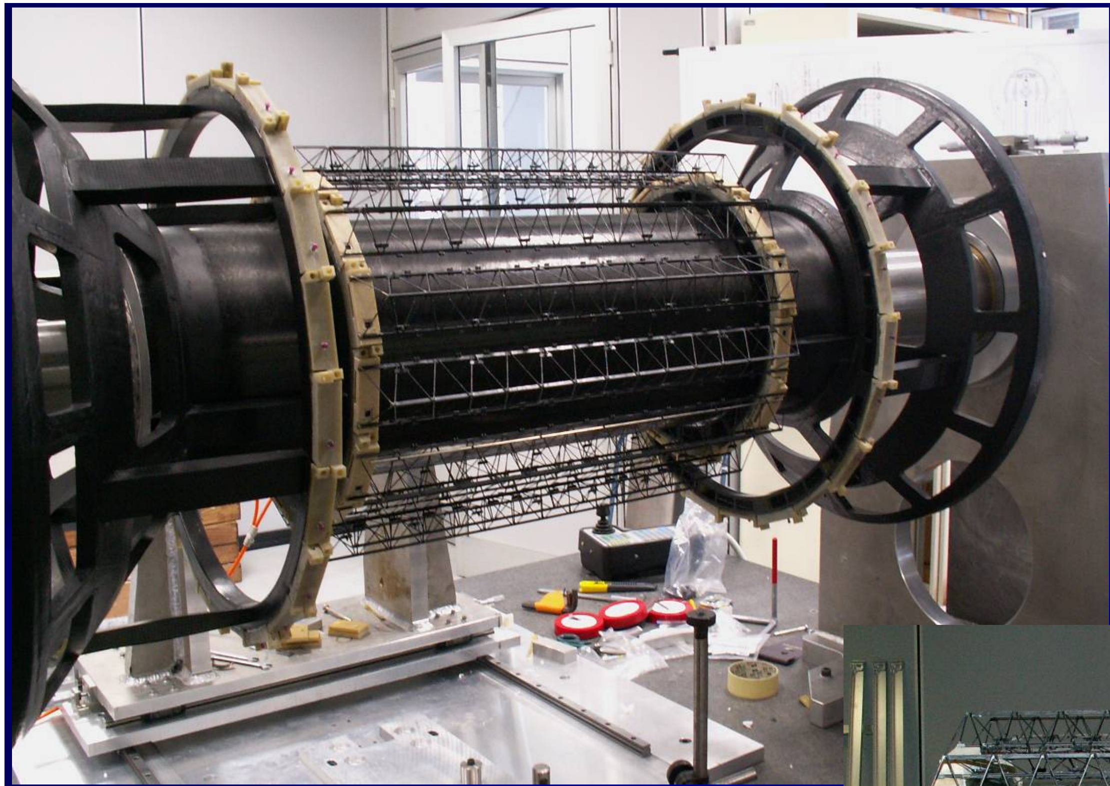


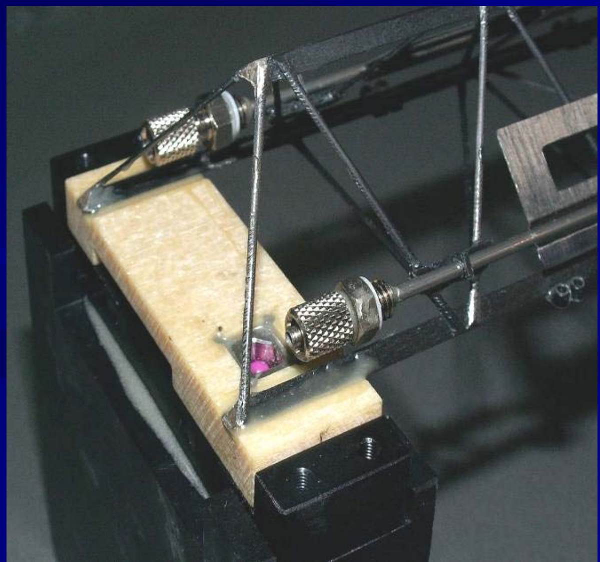
ALICE Detector

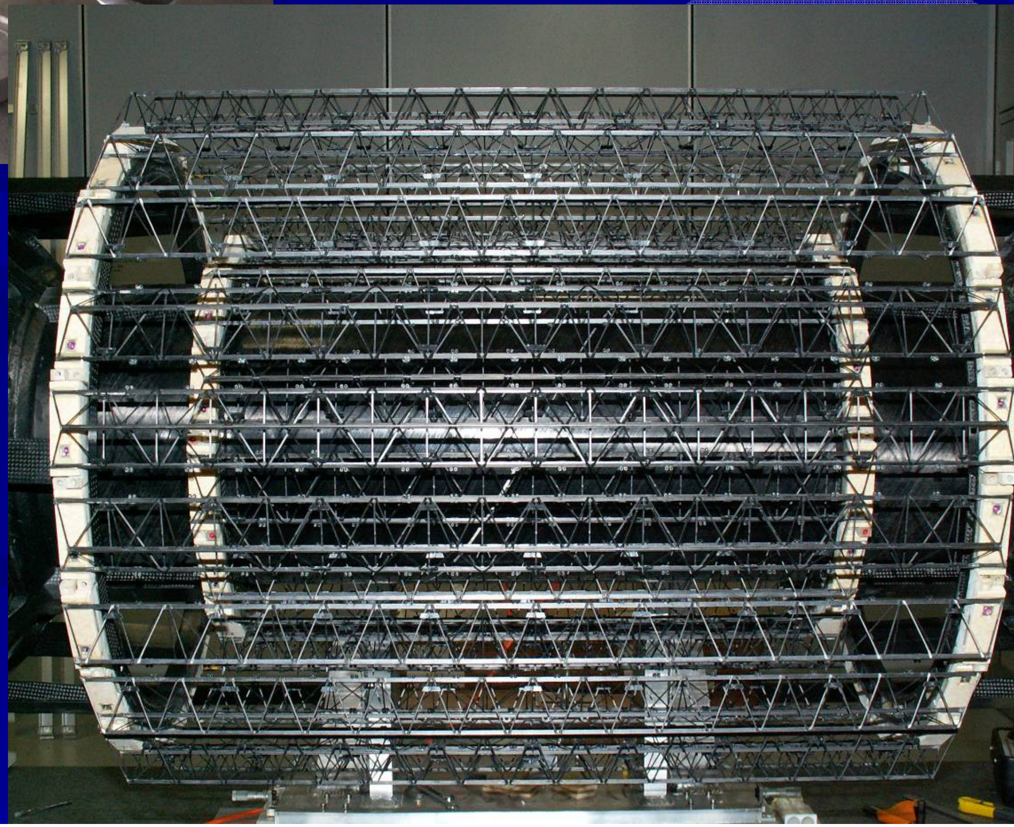
(spokesman Juergen Schukraft)

Space Frame LOAD TEST

ITS mechanics being assembled







TPC ROC Installation

More experiments at LHC

Totem: elastic and total cross section;
hard diffraction (together with CMS)

Moedal: magnetic monopoles

LHCf: very forward production of π^0's, γ's (cf. energy calibration of very high energy cosmic rays)

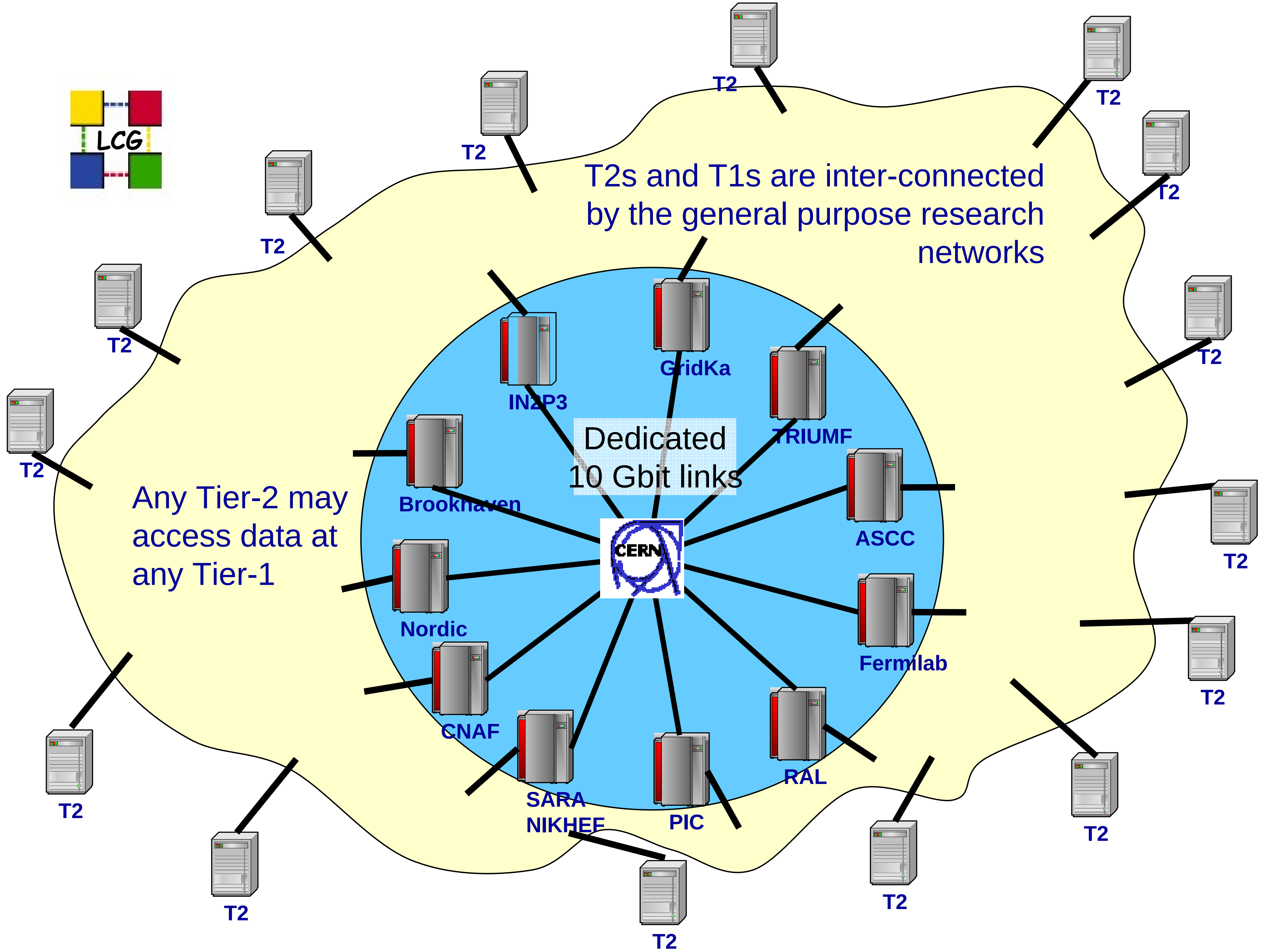
Computing

The LHC Computing Grid: LCG
(Project leader Les Robertson)

is about storing 15 PB (imagine!) of new data per year; processing them and making the information available to thousands of physicists all around the world!

Model: ‘Tiered’ architecture; 100,000 processors; multi-PB disk, tape capacity

Leading ‘computing centers’ involved


LCG
T2s and T1s are inter-connected
by the general purpose research
networks
Any Tier-2 may
access data at
any Tier-1
Dedicated
10 Gbit links
CERN
IN2P3
GridKa
TRIUMF
Brookhaven
ASCC
Nordic
Fermilab
CNAF
SARA
NIKHEF
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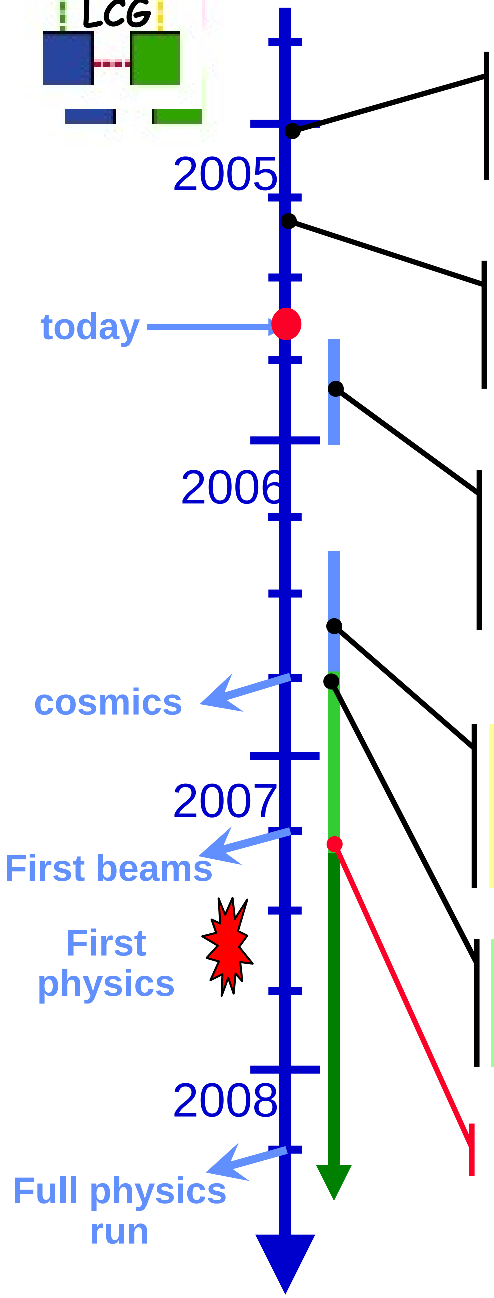
Building the Service



SC1 - *Nov04-Jan05* - data transfer between CERN and three Tier-1s (FNAL, NIKHEF, FZK)

SC2 – *Apr05* - data distribution from CERN to 7 Tier-1s – 600 MB/sec sustained for 10 days (one third of final nominal rate)

SC3 – *Sep-Dec05* - demonstrate reliable basic service – most Tier-1s, some Tier-2s; push up Tier-1 data rates to 150 MB/sec (60 MB/sec to tape)

SC4 – *May-Aug06* - demonstrate full service – all Tier-1s, major Tier-2s; full set of baseline services; data distribution ***and*** recording at nominal LHC rate (1.6 GB/sec)

LHC Service in operation – ***Sep06*** – over following six months ramp up to full operational capacity & performance

LHC service commissioned – ***Apr07***

LCG

- The "Baseline Services" for the LCG services at startup have been agreed. These are the basic services that must be provided at CERN, Tier-1 and Tier-2 centres, and have to be in operation for Service Challenge 4 in April 2006.

- A detailed plan for Service Challenge 3 has been agreed with Tier-1 sites and the experiments. Service Challenge 3 is being prepared now and is scheduled to open as a stable service including 9 Tier-1 centres and several Tier-2s in September 2005.

- The deployment plan for the new CASTOR mass storage management system at CERN has been agreed with the experiments, with the aim of completing the migration of LHC to this system by the end of February 2006.

- The TDR for the initial LHC computing services is complete.

The LCG project is taking an active part in the preparation of the proposal for the second phase of the EGEE project (April 2006-March 2008). This will be an evolution of the current project, with the major emphasis remaining grid operations.

Physics

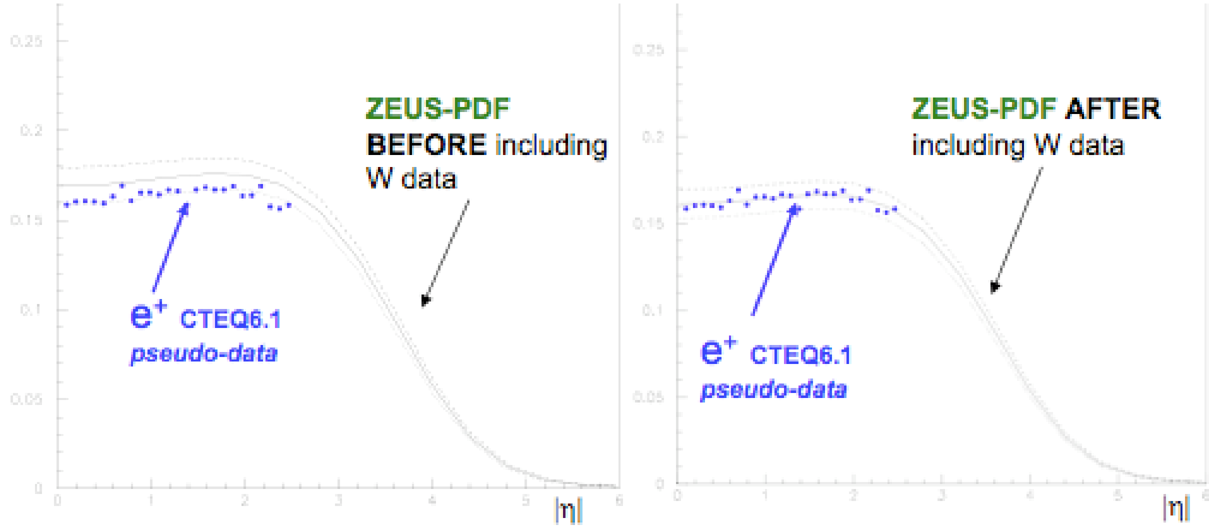
EXAMPLE of initial physics study

Studies of W and Z production

Constraints on Parton Distribution Functions (PDF) from W and Z rapidity distributions

Simulation of realistic experimental conditions for $W \to e\nu$:

- Backgrounds • Systematics on charge misidentification (Rome data)



PDF constraining potential of ATLAS: Include 1M ATLAS pseudo-data (ATLFAST) in ZEUS PDF fit

Impose a 4% uncertinty on data points

Observe 35% error reduction on low-x gluon shape parameter λ $(xg(x) \sim x^{-\lambda})$

EXAMPLE, TOP STUDIES

no b-tagging required, straightfwd analysis

Missing	E_T > 20 GeV
1 lepton	P_T > 20 GeV
4 jets(R=0.4)	P_T > 40 GeV

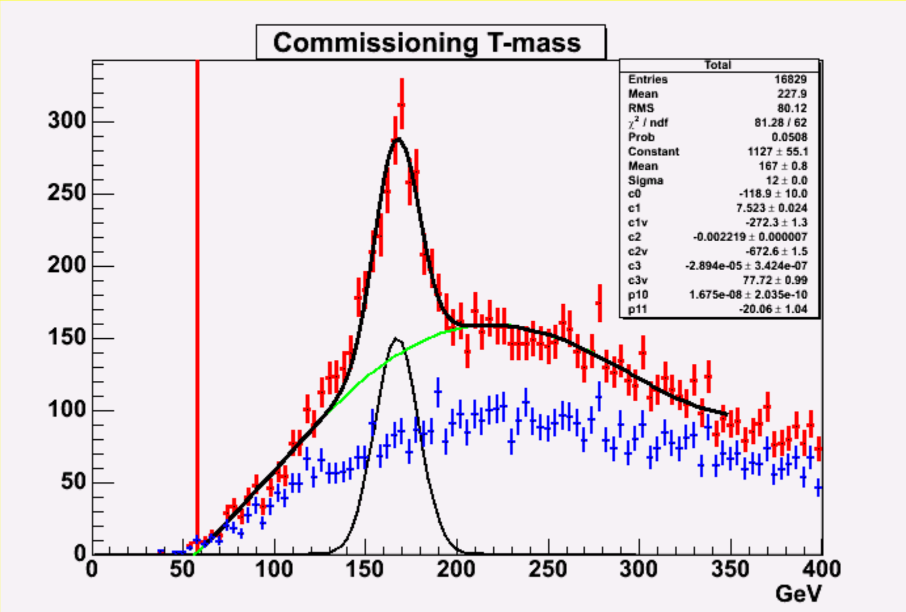
Assign jets to W, top decays

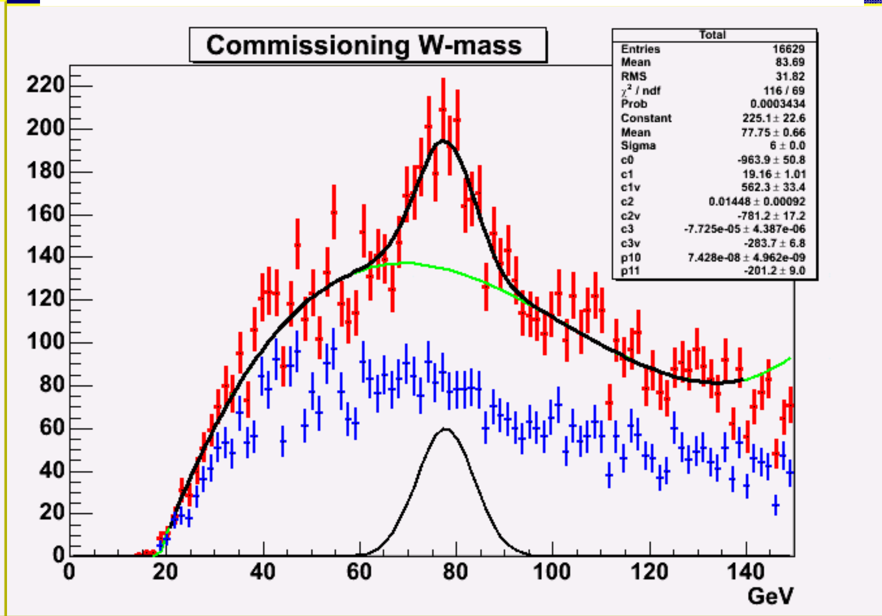
1 Hadronic top:

Three jets with highest vector-sum pT as the decay products of the top

2 W boson:

Two jets in hadronic top with highest momentum in reconstructed jjj C.M. frame.



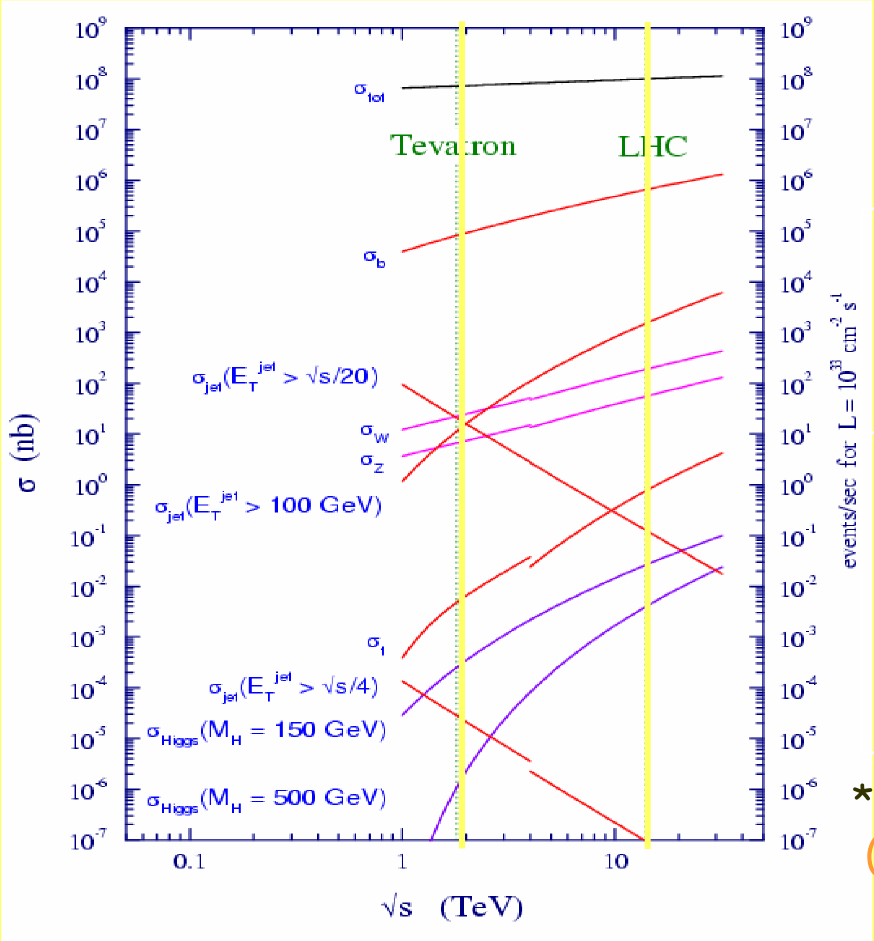


Which physics the first year(s) ?

Expected event rates at production in ATLAS or CMS at $L = 10^{33}$ cm^{-2} s^{-1}

Process	Events/s	Events for 10 fb^{-1}	Total statistics collected at previous machines by 2007
$W \to e\nu$	15	10^{8}	10^{4} LEP / 10^{7} Tevatron
$Z \to ee$	1.5	10^{7}	10^{7} LEP
t tbar	1	10^{7}	10^{4} Tevatron
b bbar	10^{6}	10^{12} - 10^{13}	10^{9} Belle/BaBar
H m=130 GeV	0.02	10^{5}	?
gluino gluino m= 1 TeV	0.001	10^{4}	---
Black holes m > 3 TeV (M_D=3 TeV, n=4)	0.0001	10^{3}	---

Already in first year, large statistics expected from:
-- known SM processes $\to$ understand detector and physics at $\sqrt{s}$ = 14 TeV
-- several New Physics scenarios



Implications for light Higgs
(assuming the same luminosity/detector/analysis)

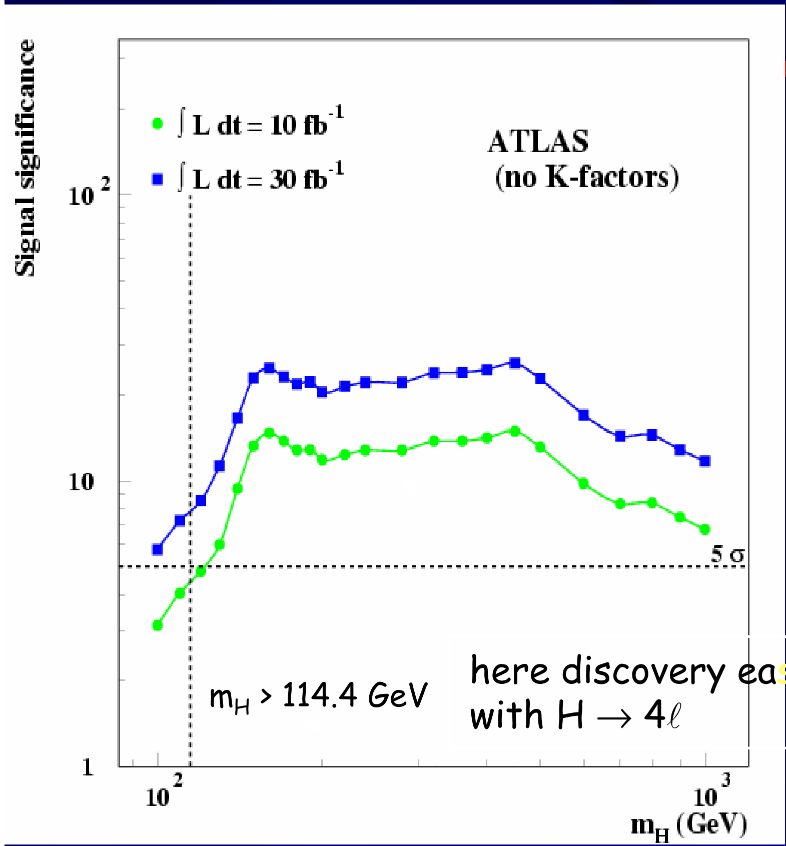
	$qq \to WH \to \ell\nu\, bb$ $qq \to ZH \to \ell\ell\, bb$ m_H=120 GeV	$gg \to H \to WW \to \ell\nu\, \ell\nu$ m_H=160 GeV
S(14)/S(2)	≈ 5*	≈ 30
B(14)/B(2)	≈ 25	≈ 6
S/B(14)/S/B(2)	≈ 0.2	≈ 3
S/√B(14)/ S/√B(2)	≈ 1	≈ 7

*Acceptance ~ 2 times larger at Tevatron (physics is more central, less initial-state g radiation)

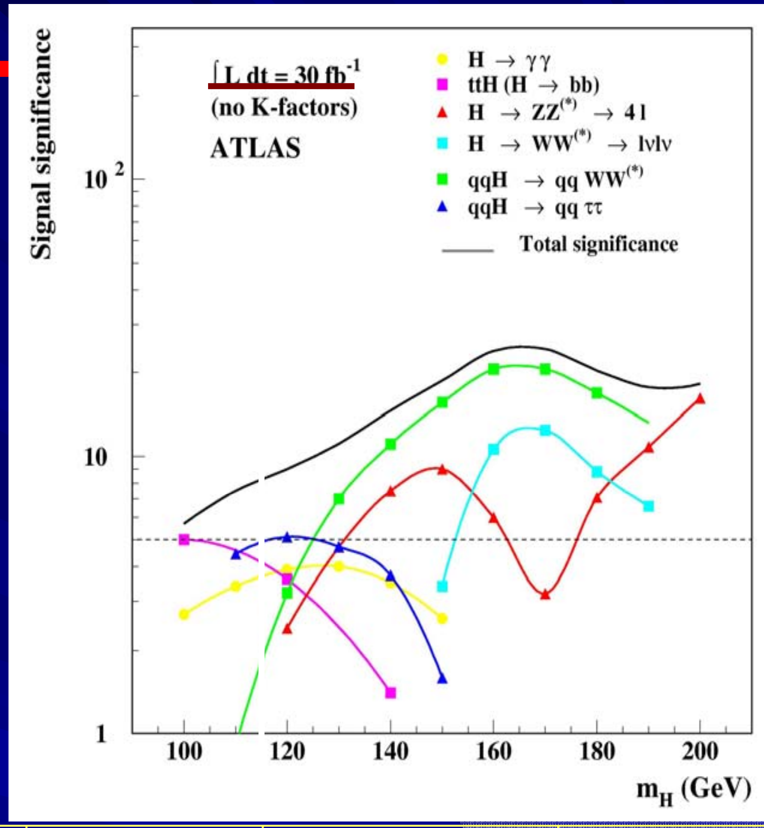
EW cross-sections (e.g. qq→ W, Z, WH) :
LHC/Tevatron ~ 10
QCD cross-sections (e.g. tt, gg→ H) :
LHC/Tevatron ≥ 100 (because of gluon PDF) → cf HERA results

e/jet ~ 10^{-3} √s = 2 TeV
e/jet ~ 10^{-5} √s = 14 TeV
} p_T > 20 GeV

Standard Model Higgs



here discovery easier with $H \to 4\ell$



$m_H \sim 115$ GeV 10 fb^{-1}

total $S/\sqrt{B} \approx 4^{+2.2}_{-1.3}$

ATLAS	$H \to \gamma\gamma$	$ttH \to ttbb$	$qqH \to qq\tau\tau$ ($\ell\ell$ + ℓ-had)
S B	130 4300	15 45	~ 10 ~ 10
$S/\sqrt{B}$	2.0	2.2	~ 2.7

$K-\text{factor} \equiv \frac{\sigma_{NLO}}{\sigma_{LO}} \approx 2$ not included

Full GEANT simulation, simple cut-based analyses

Conclusions

The LHC project (machine; detectors; LCG) is well underway for physics in 2007

Detector construction is generally proceeding well, although not without concerns in some cases; an enormous integration/installation effort is ongoing – schedules are tight but are also taken very seriously.

LCG (like machine and detectors at a technological level that defines the new 'state of the art') needs to fully develop the functionality required; new 'paradigm'.

Large potential for exciting physics.

The Compact Linear Collider

CLIC aim:

develop technology for e^-/e^+ collider with

E_{CMS}= 1 - 5 TeV

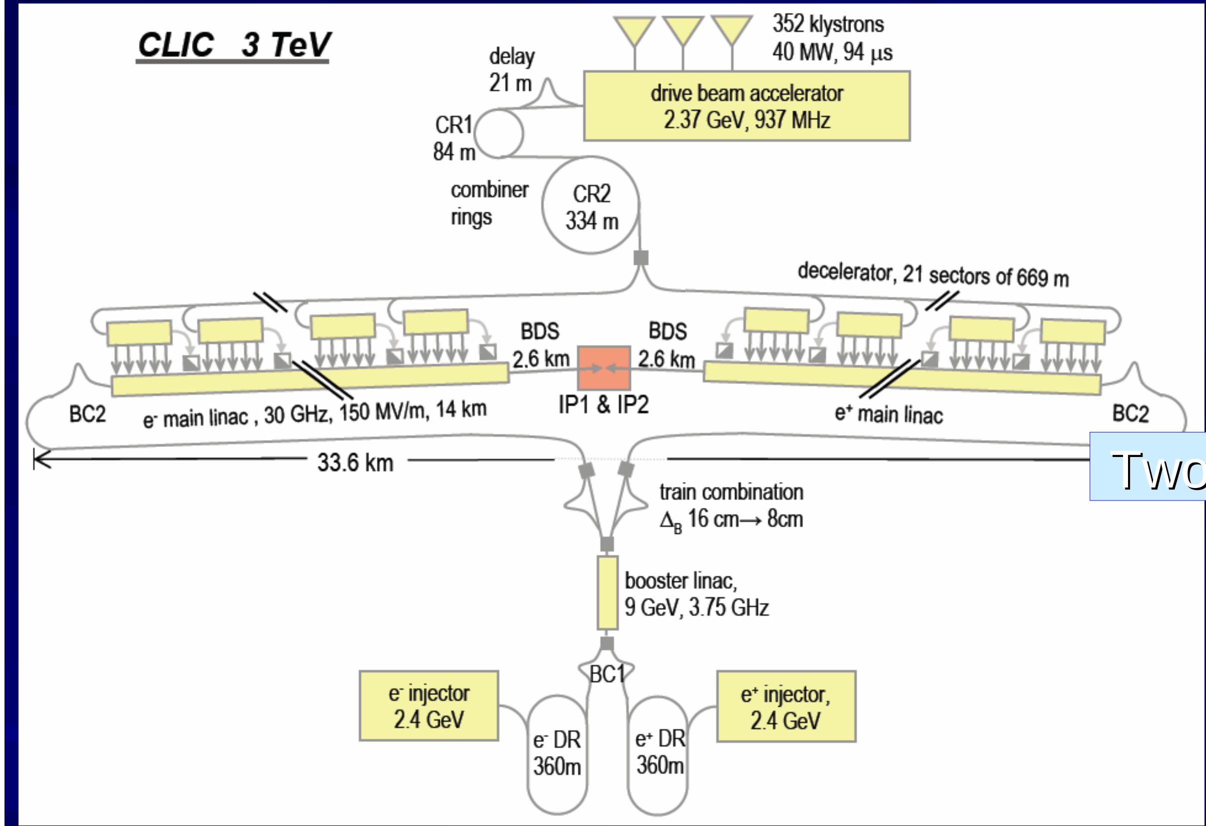
Physics motivation:

"Physics at the CLIC Multi-TeV Linear Collider :
report of the CLIC Physics Working Group,"
CERN report 2004-5

Present mandate:

Demonstrate all key feasibility issues by 2010

BASIC FEATURES OF CLIC



Overall layout of CLIC for E_{CMS} = 3 TeV

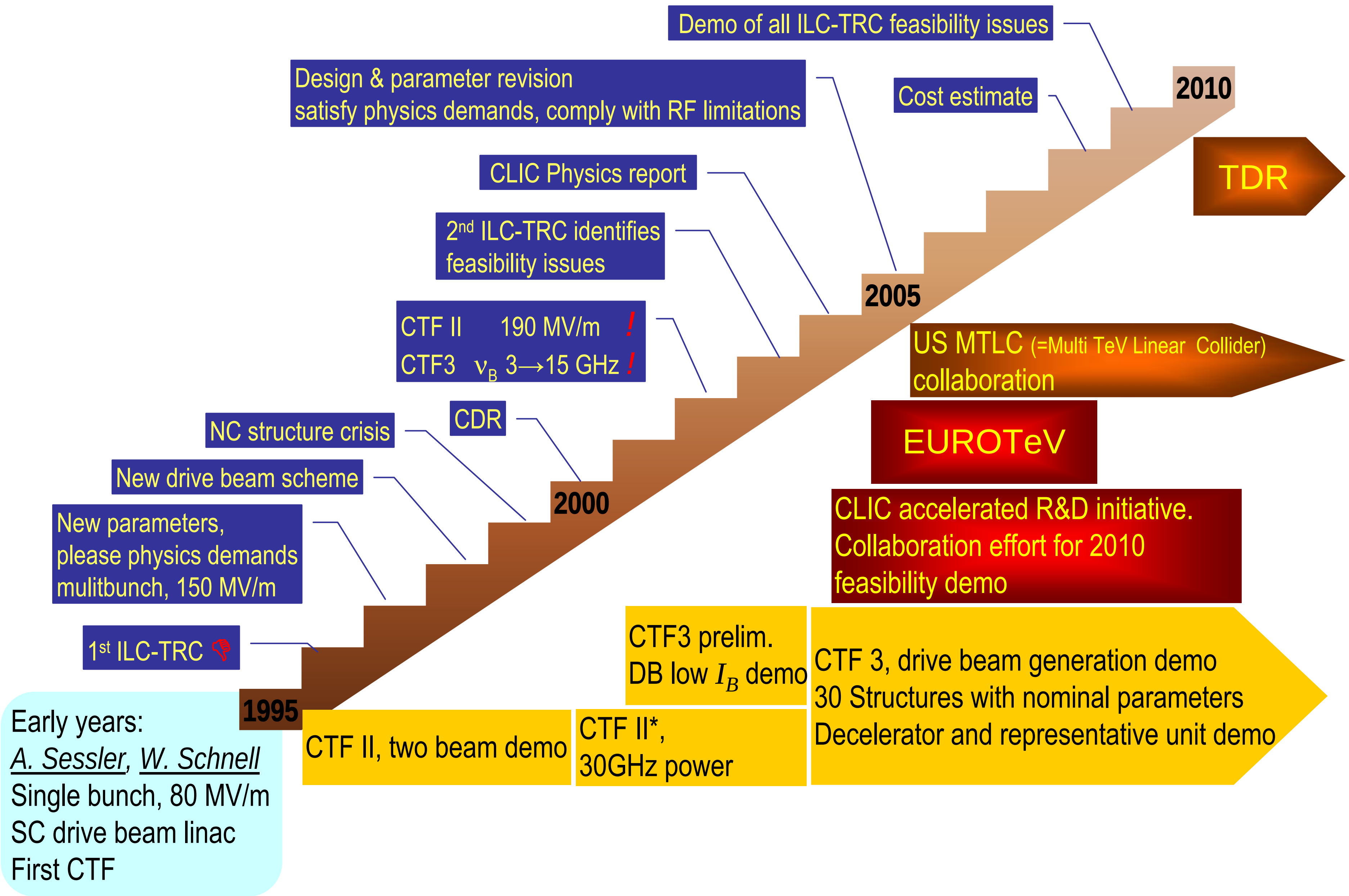
High gradient 150 MV/m

- "Compact" collider - overall length < 34 km
- Normal conducting accelerating structures
- High acceleration frequency (30 GHz)

Two-Beam Acceleration Scheme

- Capable to reach high frequency
- Cost-effective & efficient (~ 10% overall)
- Simple tunnel, no active elements
- "Modular" design, can be built in stages

A short history of CLIC



The CLIC Technology related key issues as identified by 2nd ILC-TRC, 2003

Covered by CTF3

R1: Feasibility

- R1.1: Test of damped accelerating structure at design gradient and pulse length
- R1.2: Validation of drive beam generation scheme with fully loaded linac operation
- R1.3: Design and test of damped ON/OFF power extraction structure

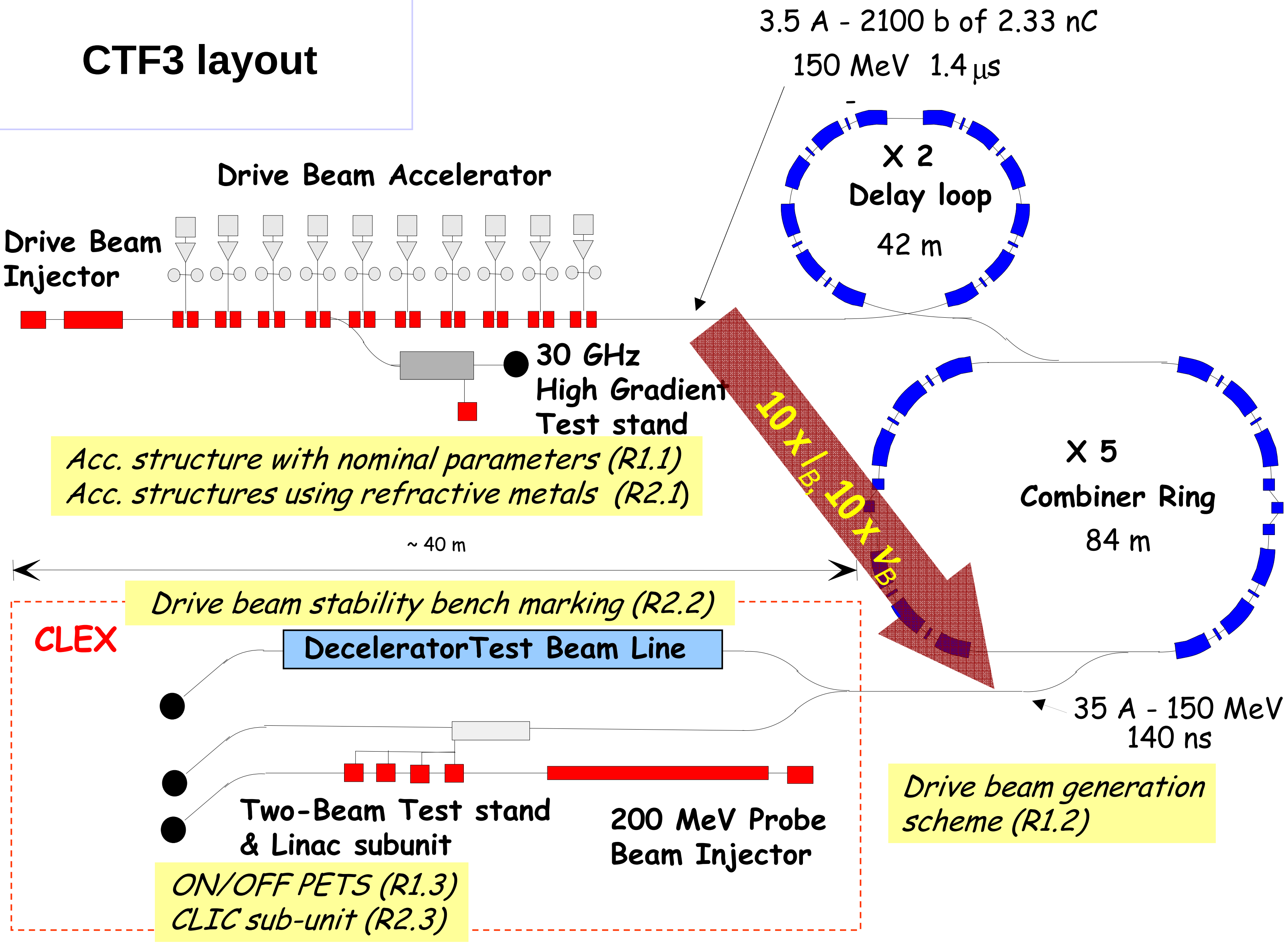
R2: Design finalization

- R2.1: Developments of structures with hard-breaking materials (W, Mo…)
- R2.2: Validation of stability and losses of DB decelerator; Design of machine protection system
- R2.3: Test of relevant linac sub-unit with beam
- R2.4: Validation of drive beam 40 MW, 937 MHz Multi-Beam Klystron with long RF pulse *
- R2.5: Effects of coherent synchrotron radiation in bunch compressors
- R2.6: Design of an extraction line for 3 TeV c.m.

Covered by EUROTeV

** Feasibility study done – need development by industry.*
N.B.: Drive beam acc. structure parameters can be adapted to other klystron power levels

CTF3 layout



3.5 A - 2100 b of 2.33 nC
150 MeV 1.4 μs
X 2
Delay loop
42 m
Drive Beam Accelerator
Drive Beam Injector
30 GHz High Gradient Test stand
Acc. structure with nominal parameters (R1.1)
Acc. structures using refractive metals (R2.1)
10 x I_B, 10 x ν_B
X 5
Combiner Ring
84 m
~ 40 m
Drive beam stability bench marking (R2.2)
CLEX
DeceleratorTest Beam Line
35 A - 150 MeV
140 ns
Drive beam generation scheme (R1.2)
Two-Beam Test stand & Linac subunit
200 MeV Probe Beam Injector
ON/OFF PETS (R1.3)
CLIC sub-unit (R2.3)

CTF3 schedule

	2004	2005	2006	2007	2008	2009
Drive Beam Accelerator						
30 GHz power test stand in Drive Beam accelerator						
30 GHz power testing (4 months per year)						
R1.1 feasibility test of CLIC structure						
Delay Loop						
Combiner Ring						
R1.2 feasibility test of Drive beam generation						
CLIC Experimental Area (CLEX)						
R1.3 feasibility test PETS						
Probe Beam						
R2.3 feasibility test representativeCLIC linac section						
Test beam line						
R2.2 Beam stability bench mark tests						

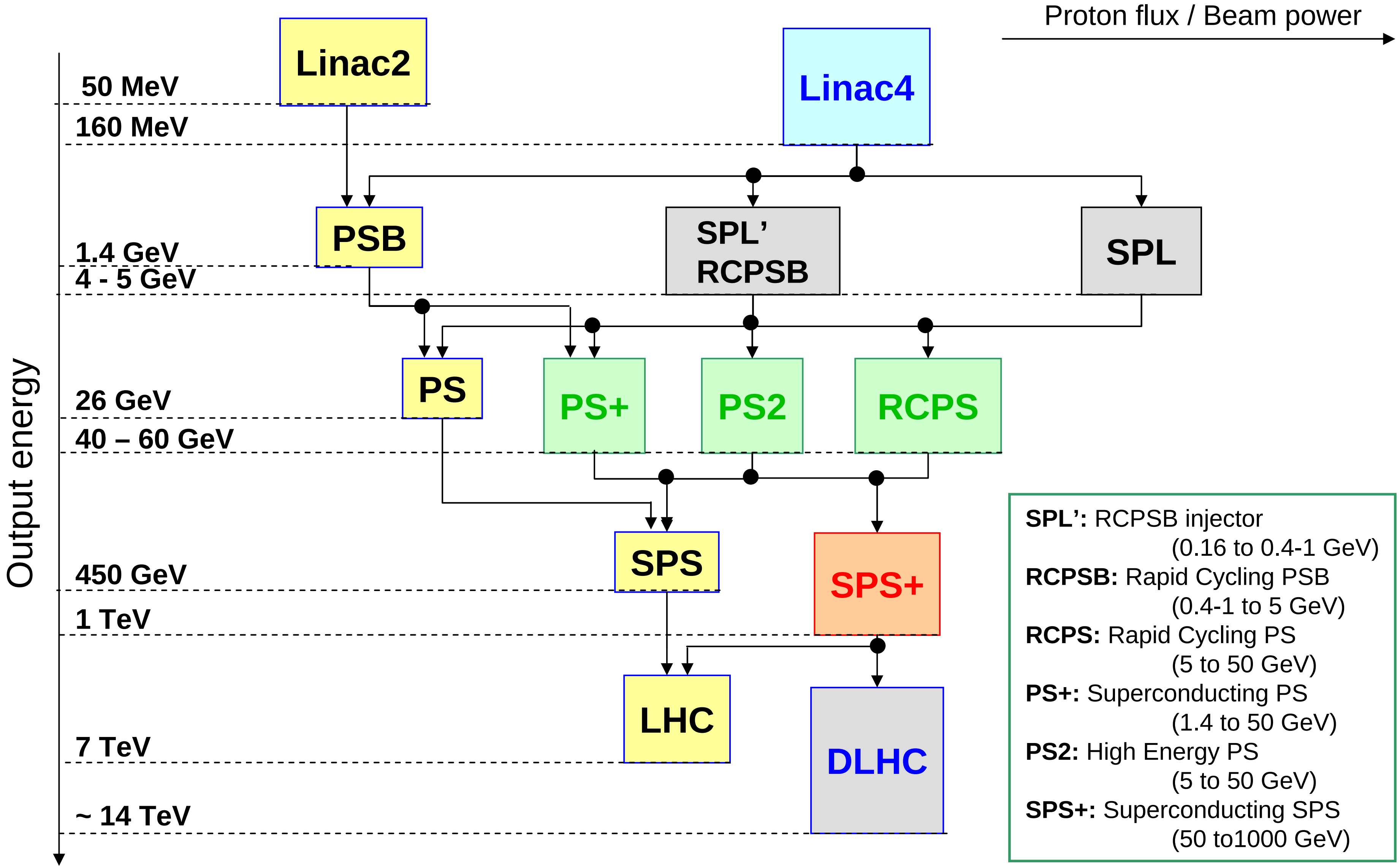
The future

CERN: prepare for important decisions in 2010.
Most important input: first LHC results
Also available: result of CLIC feasibility study; CTF3
And (?): strategy for neutrino oscillation studies
Etc. (smaller but important projects, e.g. $K \rightarrow \pi\nu\nu$)

In CERN's present Medium Term Plan (2005 + 5 years) there is only room for LHC (priority number 1, of course) and 'paying the debt' (reaching a maximum of 1 GSF...). The debt should be paid for by 2011 – but additional funding is required to prepare the decisions to be taken in 2010

- accelerator consolidation, construction and R&D (in addition to CLIC)
  – LINAC4 and beyond;
  SPL; beta beams; neutrino factory design study (following scoping study)
- Detector R&D (LHC luminosity upgrade; ILC, CLIC; neutrino detectors)

Scenarios for proton injectors (1/4):
- possible combinations



Scenarios for proton injectors (2/4):

- PS+ based (superconducting synchrotron 1.4 → ~ 50 GeV / 0.3 Hz)

		PS+ based		
	Linac4 PSB PS SPS	*Linac4* PSB *PS+* SPS	*Linac4* *SPL* *PS+* SPS	*Linac4* *SPL* *PS+* *SPS+*
L1, L2	Ultimate beam from PS	PS replaced Ultimate beam from SPS	PSB & PS replaced Ultimate beam from SPS	PSB, PS & SPS replaced
SLHC	+	++	++	+++
DLHC	+	++	++	+++
β beam	-	-	++ (γ >100)	++ (γ >200)
ν Factory	-	-	+++ (~5 GeV prod. beam)	+++ (~5 GeV prod. beam)
K, μ	-	x00 kW beam at 50 GeV	x00 kW beam at 50 GeV	x00 kW beam at 50 GeV
Nuclear Physics	-	-	+++	+++

- CERN Council Strategy Group
- Special Council meeting in Lisbon, July 2006

- Later in 2006: Medium Term Plan that is not just an extrapolation of the previous one