Detectors at the Large Hadron Collider

Challenges, Status

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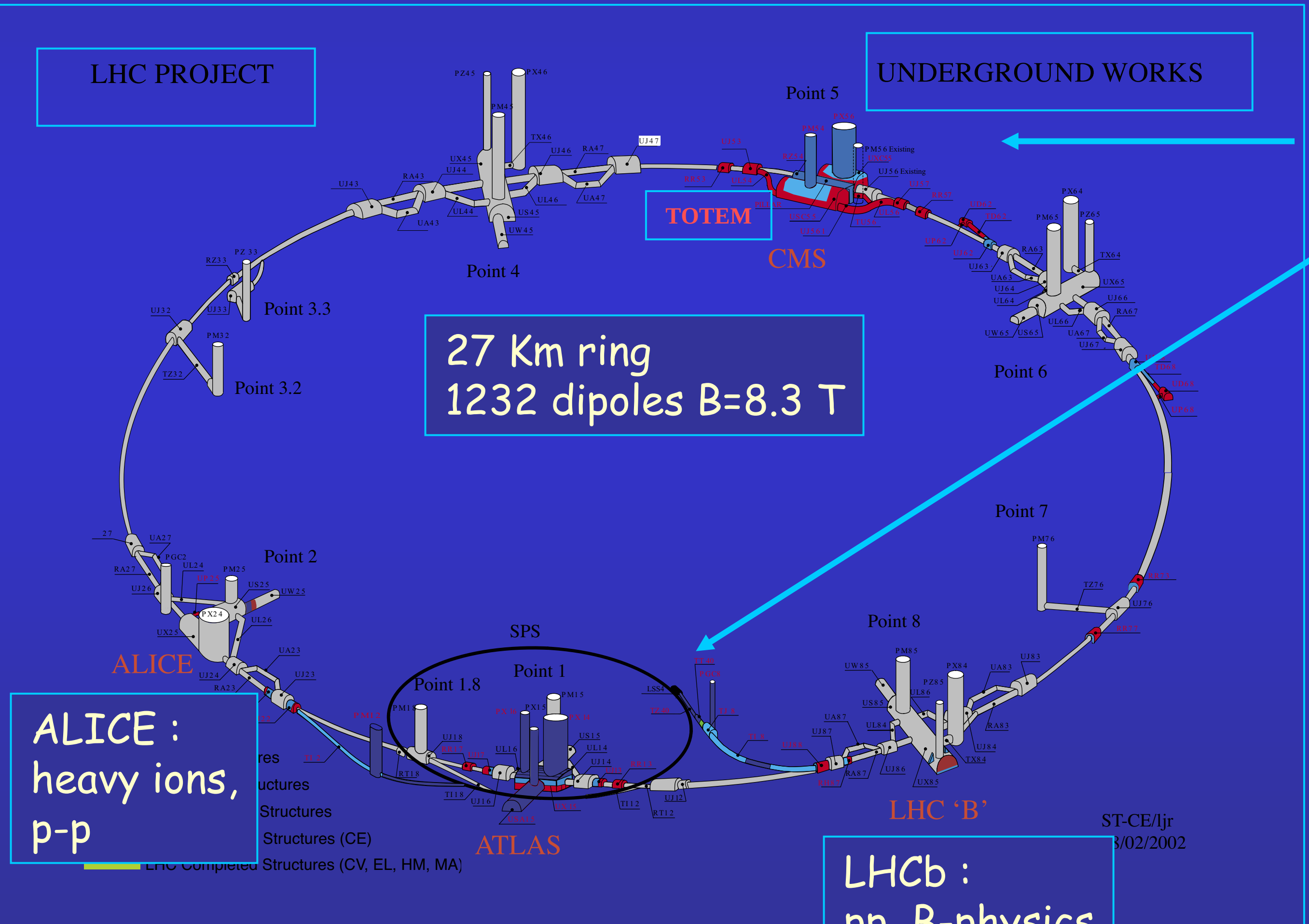
February 15, 2005

- pp $\sqrt{s}$ = 14 TeV (Pb Pb 5.5 TeV/N)
- Start-up : Summer 2007
- Initial/low luminosity L ~ 10^{33} cm^{-2} s^{-1}

  $\leq$ 2 minimum bias/x-ing → "Tevatron-like" environment
- Design/high luminosity L = 10^{34} cm^{-2} s^{-1}

  ~ 20 minimum bias/x-ing → **fast rad hard detectors**

Note : 10 fb^{-1} collected in 10^7 s ≡ 3 months at 10^{33}, i.e. in one year assuming 30% running efficiency



27 Km ring
1232 dipoles B=8.3 T

ATLAS and CMS
pp, general purpose

ALICE :
heavy ions, p-p

LHCb :
pp, B-physics

ATLAS, CMS

Event rate ~20 per bunch crossing (every 25 ns)
--> 10^9 events / s --> >10^{11} 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 spatial 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.

Not unlike earlier detectors: they should allow discovery of the unexpected!

Atlas and CMS took up the challenge to elucidate electro-weak symmetry breaking, find 'the' Higgs boson and more...

LHCb took up the challenge to exploit the prolific production of b-quarks in the forward direction to study CP violation and rare decays

ALICE took up the challenge to explore the evolution of the quark-gluon plasma over a large, new region of the phase diagram

TOTEM took up the challenge to accurately measure the total cross section (and more)

Pixel Detectors

Radiation hardness of sensors has been achieved empirically, there are many parameters that can be varied – crystal cut orientation (<100>, <111>); geometry of implants; pixel dimensions, pitches; temperature; etc., etc. Increasing depletion voltage can (up to limit) compensate for signal loss

Radiation hardness of electronics can be achieved by using special rules and processes (e.g. DMILL), but there was a very pleasant ‘coincidence’: the 0.25 μ technology appears to be intrinsically radiation hard (will be widely used by LHC experiments, not only for pixel detectors)

Electromagnetic Calorimetry

New concepts for electromagnetic calorimetry have been developed:

- LAr 'accordion' (Atlas) – no 'dead space'; very good spatial resolution
- $PbWO_4$ crystals (CMS) – very good energy resolution R&D: from cm^3 to m^3

Energy resolution, spatial resolution, no 'dead' regions

in order to have adequate sensitivity to
'light Higgs' H --> $\gamma\gamma$

Two more (out of many more) remarkable features of the LHC detectors:

CMS will have a SC central solenoid, 6m in diameter, with a 4 T field

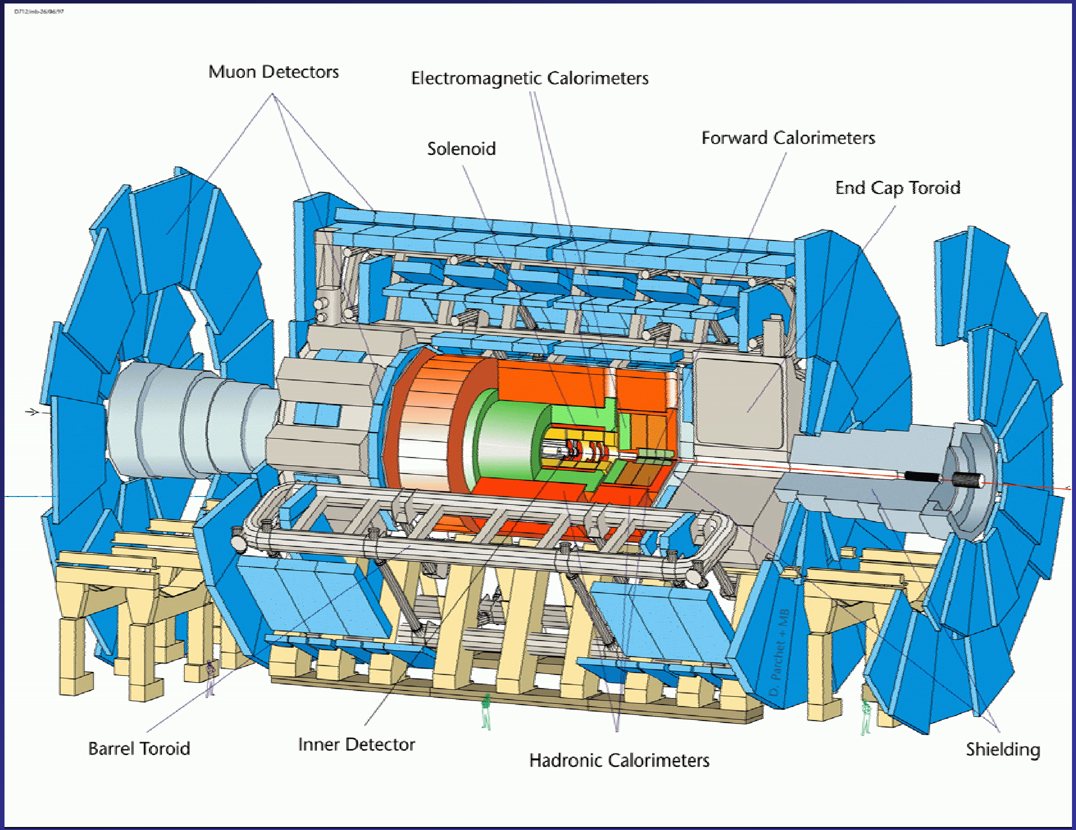
The Atlas muon spectrometer will have 8 large SC toroids and large muon chambers with remarkable mechanical precision

Other issues (and challenges):
Civil Engineering, Assembly, Installation

Civil Engineering of transfer tunnels, large underground caverns, access shafts, surface buildings etc. very well advanced; there were 'surprises'

Assembly, Installation is THE challenge right now

	ATLAS	CMS
MAGNET(S)	Air-core toroids + solenoid in inner cavity Calorimeters outside field 4 magnets	Solenoid Calorimeters inside field 1 magnet
TRACKER	Si pixels+ strips TRT $\rightarrow$ particle identification B=2T $\sigma/p_T \sim 5\text{x}10^{-4}\ p_T \oplus 0.01$	Si pixels + strips No particle identification B=4T $\sigma/p_T \sim 1.5\text{x}10^{-4}\ p_T \oplus 0.005$
EM CALO	Pb-liquid argon $\sigma/E \sim 10\%/\sqrt{E}$ uniform longitudinal segmentation	$PbWO_4$ crystals $\sigma/E \sim 2\text{-}5\%/\sqrt{E}$ no longitudinal segmentation
HAD CALO	Fe-scint. + Cu-liquid argon (10 λ) $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$	Brass-scint. (> 5.8 λ +catcher) $\sigma/E \sim 100\%/\sqrt{E} \oplus 0.05$
MUON	Air $\rightarrow$ σ/p_T < 10 % at 1 TeV standalone; larger acceptance	Fe $\rightarrow$ $\sigma/p_T \sim 5\%$ at 1 TeV combining with tracker



ATLAS
A Toroidal Lhc ApparatuS

Length : ~45 m
Radius : ~12 m
Weight : ~ 7000 tons

- Tracking ($|\eta|<2.5$, B=2T) :
  -- Si pixels and strips
  -- Transition Radiation Tracker (e/π separation)

- Calorimetry ($|\eta|<5$) :
  -- EM : Pb-LAr
  -- HAD: Fe-scintillator (central), Cu/W-LAr (fwd)

- Muon Spectrometer ($|\eta|<2.7$) :
  air-core toroids with muon chambers (standalone capabilities)

Status ATLAS

The ATLAS detector construction is proceeding within the framework of the accepted Completion Plan

Further important milestones have been passed in the construction, pre-assembly, integration and installation of the detector components, and several outstanding technical problems have been overcome recently

Large-scale system tests continue, and in particular the combined test beam runs have been a very major activity in 2004

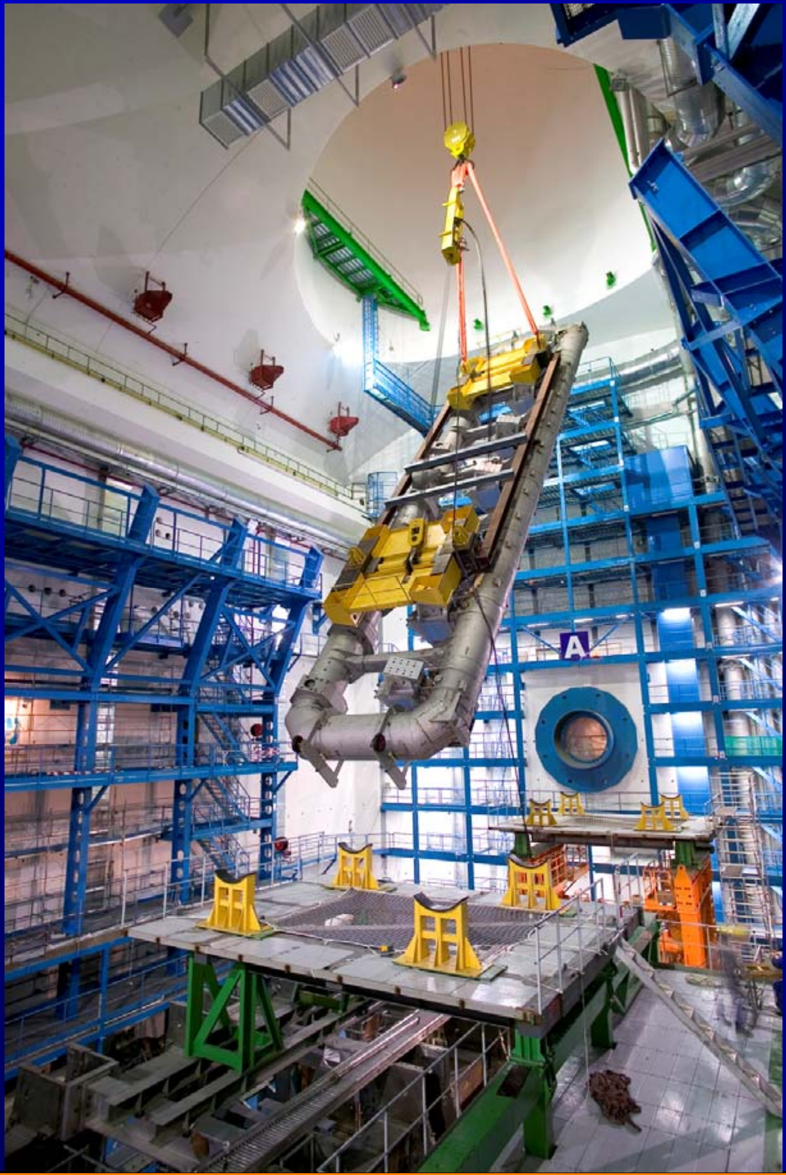
The installation in the cavern was impacted by the most critical component construction delay for ATLAS given by the Barrel Toroid, but good progress can be noted there as well, on which a new schedule can be based

Very major software and computing activities are underway, with the running of DC2, which turned out to be a harder task than initially foreseen

Planning for the commissioning and the early physics phases is progressing well

ATLAS remains on track for LHC physics in 2007

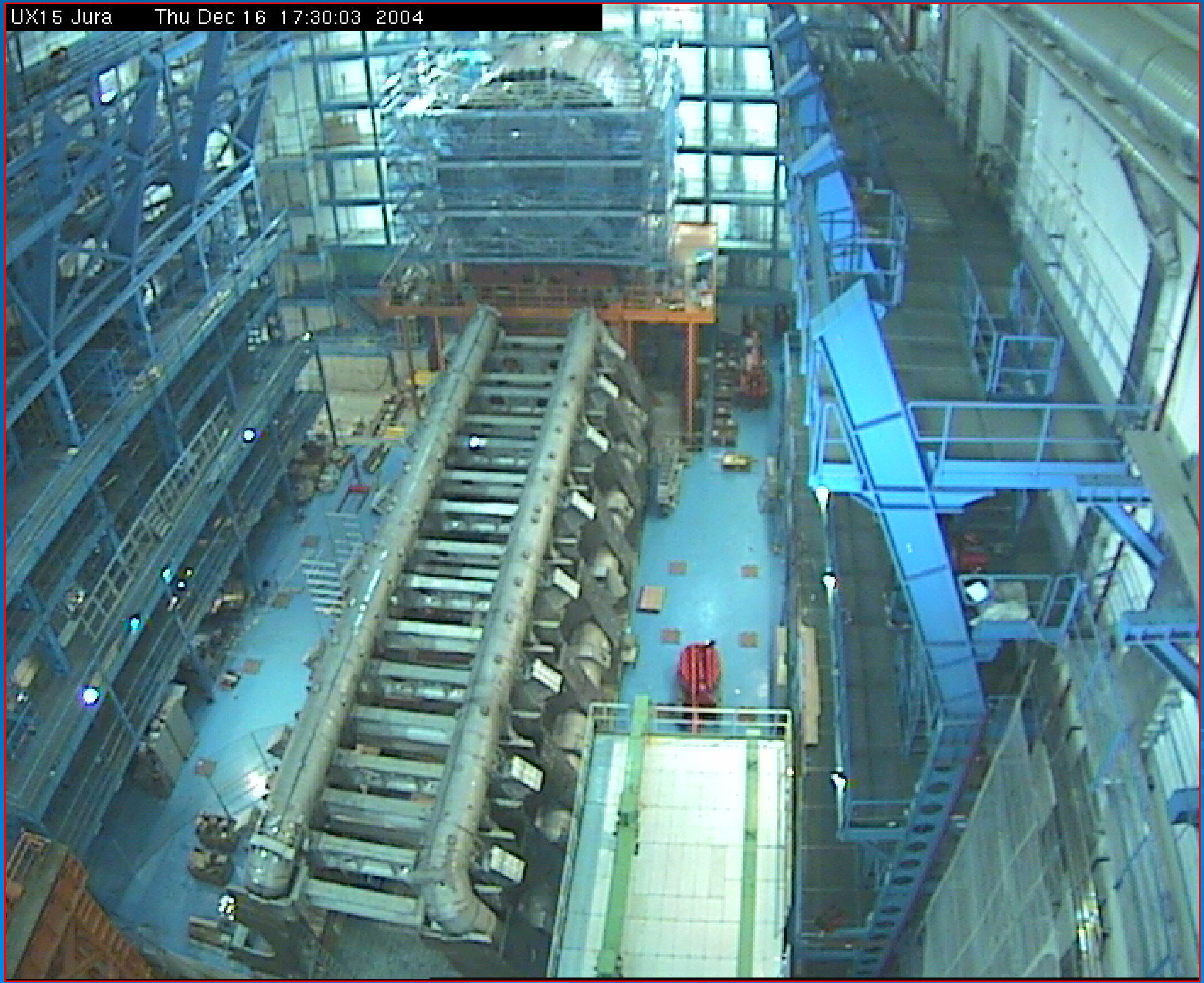
BT-1 installation in the cavern



Installation of the Barrel Cryostat on 28th October 2004 in the pit onto the lower part of the Barrel Tile Calorimeter

The positioning was adjusted to be well within the design specifications

The ATLAS detector: construction in the underground cavern



CALORIMETERS

Scintillating PbWO4 crystals — **ECAL**

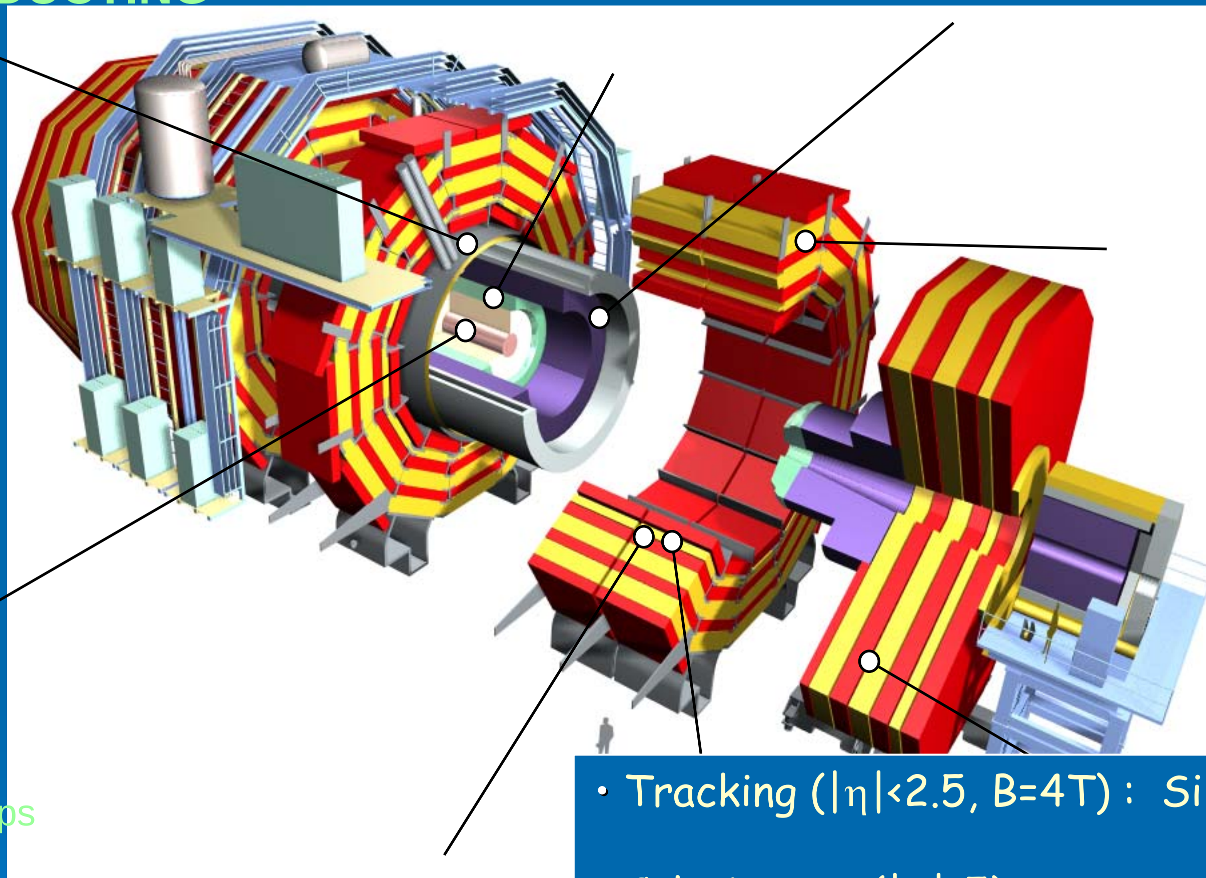
HCAL — Plastic scintillator/brass sandwich

SUPERCONDUCTING COIL

IRON YOKE

TRACKER

Silicon Microstrips
Pixels



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

MUON B

Drift Tube Chambers

- Tracking ($|\eta|$<2.5, B=4T) : Si pixels and strips
- Calorimetry ($|\eta|$<5) :
  -- EM : $PbWO_4$ crystals
  -- HAD: brass-scintillator (central+ end-cap), Fe-Quartz (fwd)
- Muon Spectrometer ($|\eta|$<2.5) : return yoke of solenoid instrumented with muon chambers

Status

Civil Engineering: USC delivered 4 Aug 04 and UXC delivered 1 Feb 05 (~3 month delay).
Magnet: Project nearly complete. All 5 coil modules at CERN. Magnet test starts Oct 2005.
HCAL, Muons : construction on schedule and well advanced.

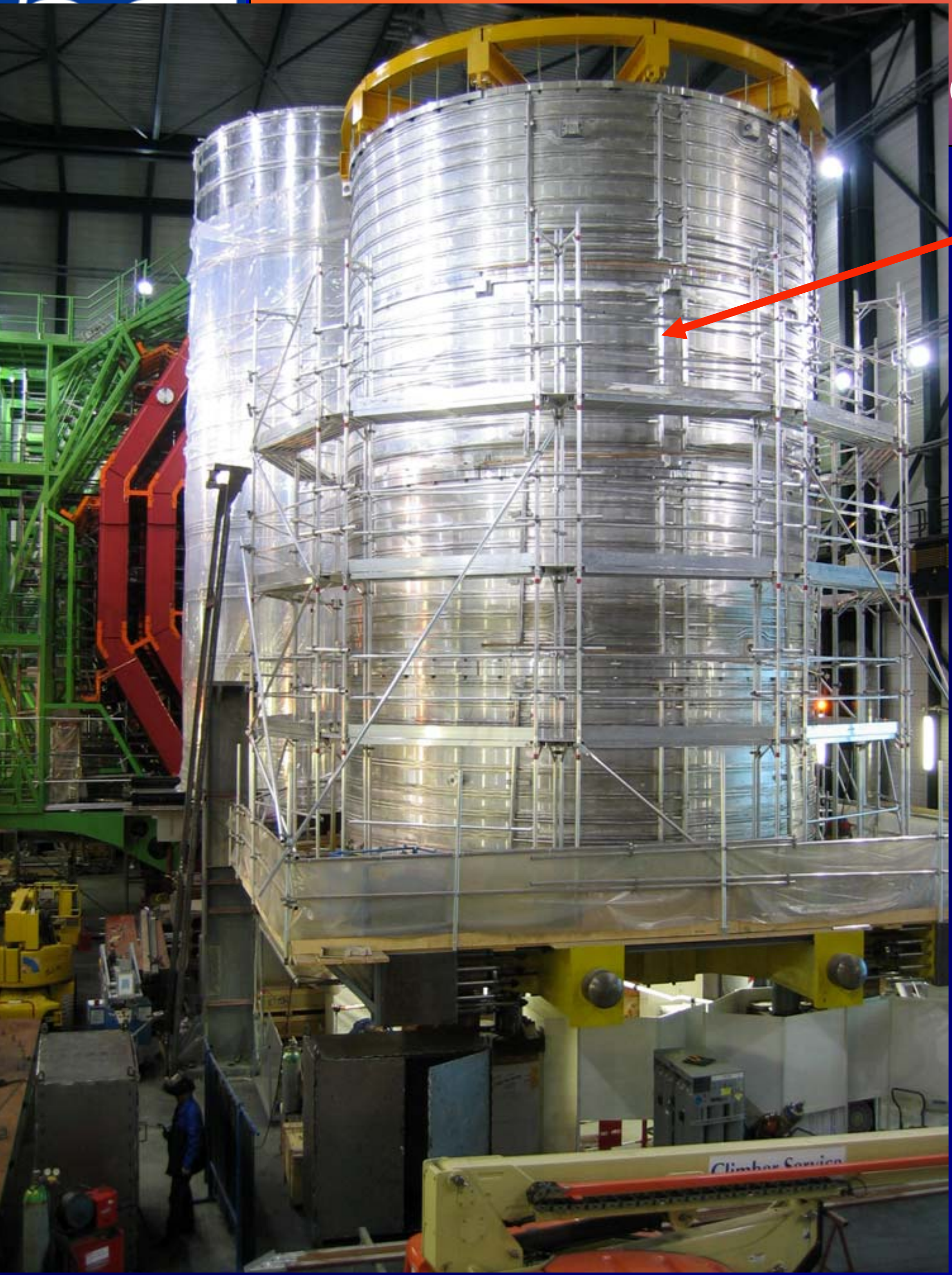
TO WATCH
ECAL: Crystals production, contracts need to be placed with multiple vendors, cost of crystals. No float in 'ready for installation' (rfi) milestone.
TRACKER: Re-start of mass assembly of Si modules. Integration and schedule. No float left in rfi.

CMS now tracking wrt to v34.1 Schedule
Ready to close 1 July 07 (ready to operate in Aug 07).

We will present an updated cost and funding of CMS at the next RRB in April 2005 when the exact size of the increases (in ECAL and Tracker) and additional contributions will be better known.

An initial CMS detector (minus the ECAL endcaps and pixels) will be ready for the pilot run in 2007.

CMS: 4th Coil Module at Pt 5 since Dec 04

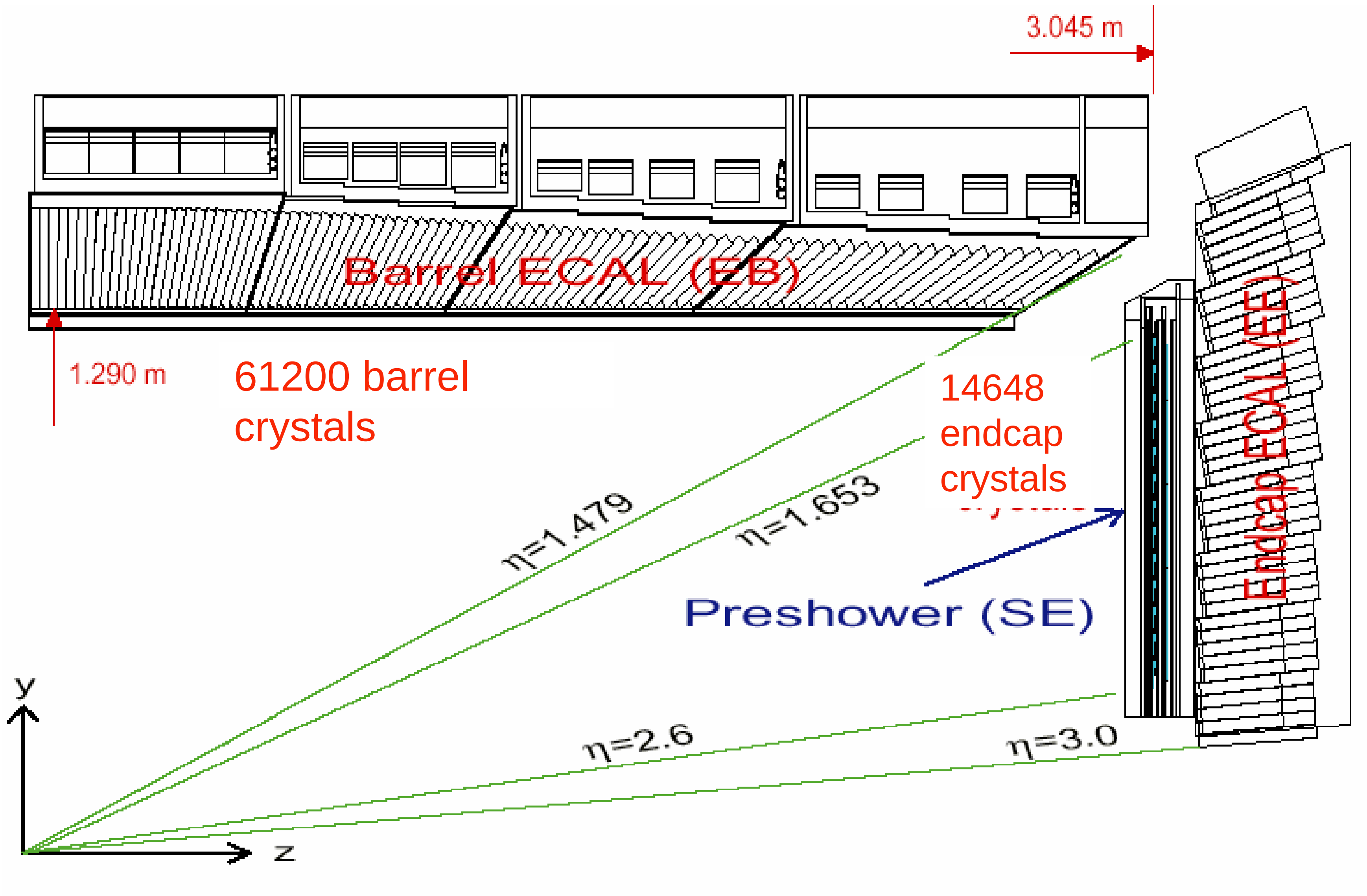


- Pt 5: 4 coil modules connected. Inner vac-tank can be seen behind coils.
- 5th module is being connected
- Cold mass swiveling and insertion by Jun05
- Start cool-down in Sept05.
- Q405 - Magnet Test and ‘Cosmics Challenge’

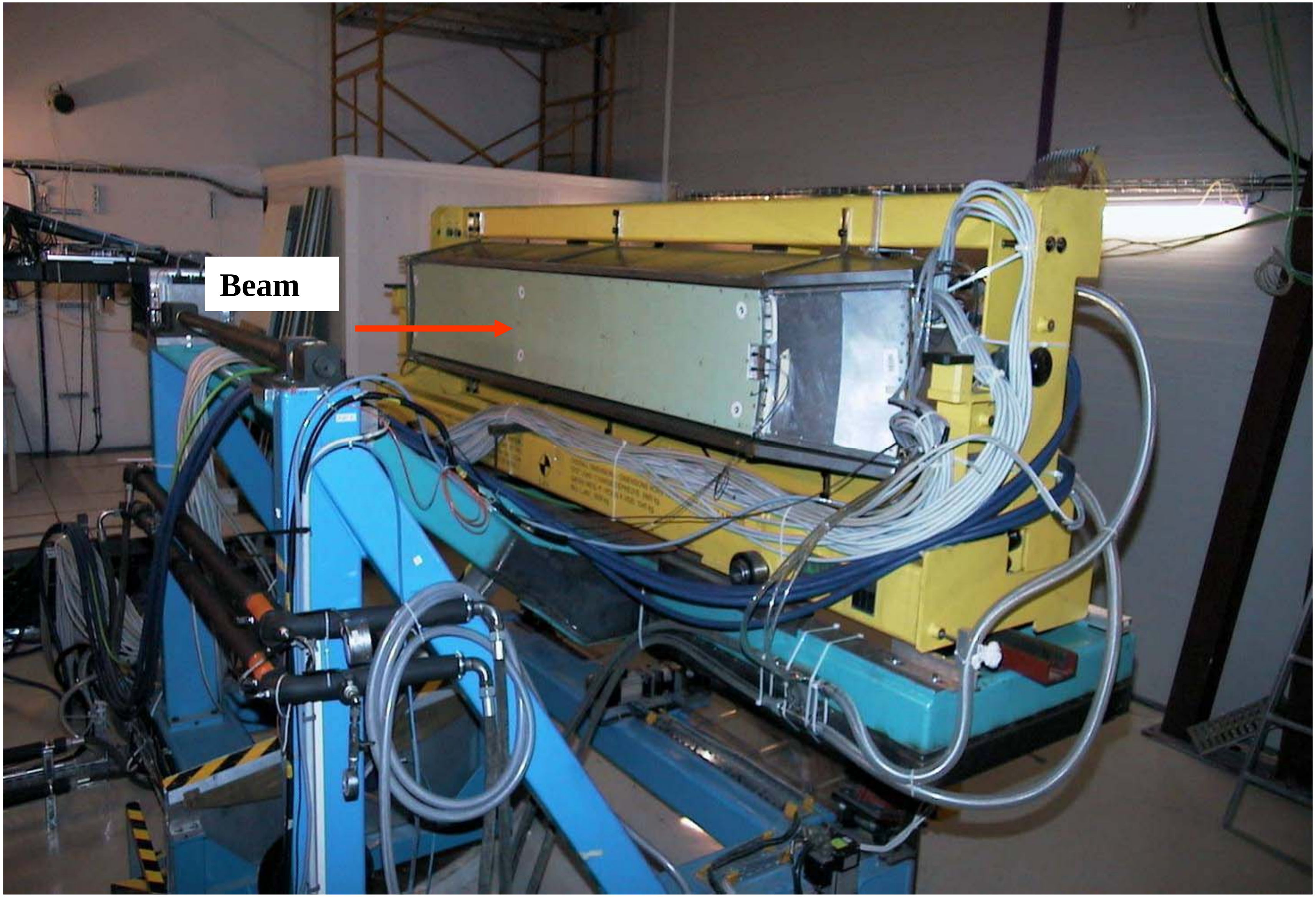
Tracker: Main Issues

- **Sensors**
- Thin Sensors : 95% in hand
- 6,000 Thick sensors in hand (4000 HPK and 2000 ST) out of 20,000 (need+10% Spares)
- Still miss 1400 sensors from ST (pending…. end of the negotiation)
- All remaining sensors have been ordered to HPK with last scheduled delivery in September 05.
- **Hybrids**
- Hybrid production re-launched after modifications, technical and managerial (improved quality control at factory)
- Module production will be launched in February. Expect to end module production in Q1-2006.
- A somewhat revised sequence of operations being worked out to catch up. Some of previous serial sequences put in parallel now. Investigating how to introduce 3 mo. contingency for 'ready for installation' milestone (1 Nov 2006).

ECAL

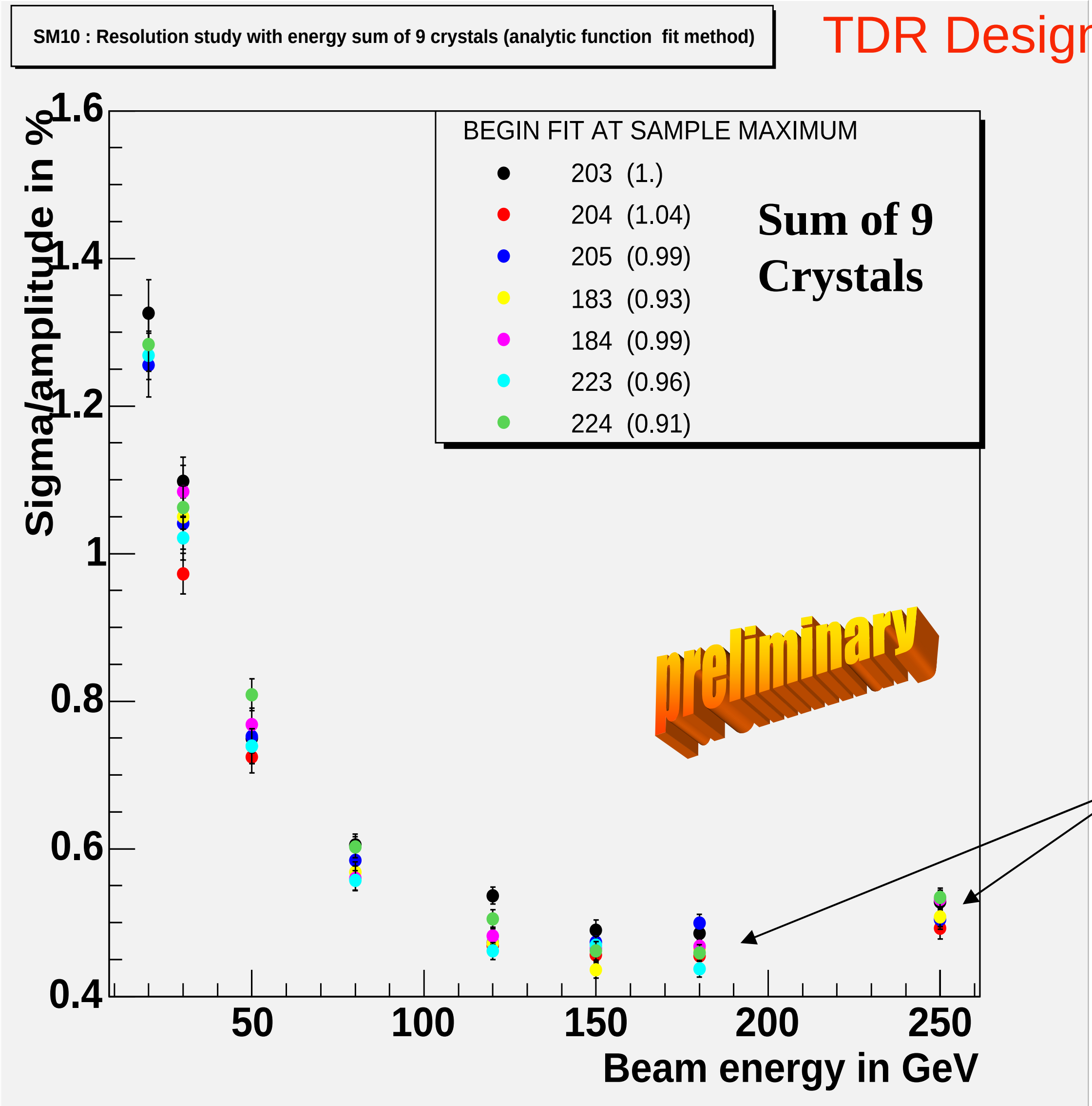

3.045 m
Barrel ECAL (EB)
1.290 m
61200 barrel crystals
14648 endcap crystals
η=1.479
η=1.653
Preshower (SE)
Endcap ECAL (EE)
η=2.6
η=3.0
y
z

ECAL: SM in Beam



ECAL: SM Preliminary Results

TDR Design Performance Achieved



Gain switch region
Requires detailed understanding

ECAL: Main Issue

- First six months program after factory (BTCP) restart has been executed with expected rate
- 31400 EB crystals have been delivered. Milestone of 50% of EB crystals passed. Need 62000 barrel and 15000 endcap crystals. First half-barrel lowered Q1-2005.
- Finish remainder on current contracts (10100 crystals) by Aug 2005 at a rate of 1200 crystals/mo.
- Preparing future contracts, in close collaboration and with help from CERN Management.
- SIC: Contract, based on tender response, in circulation at CERN. 2 SMs worth of EB crystals by June 06, 3250 EE crystals by June 07
- BTCP: place order by end Q1-05 for remainder of the barrel and endcap crystals in cooperation with Russian Ministry of Science and Technology.

Schedule and Initial detector

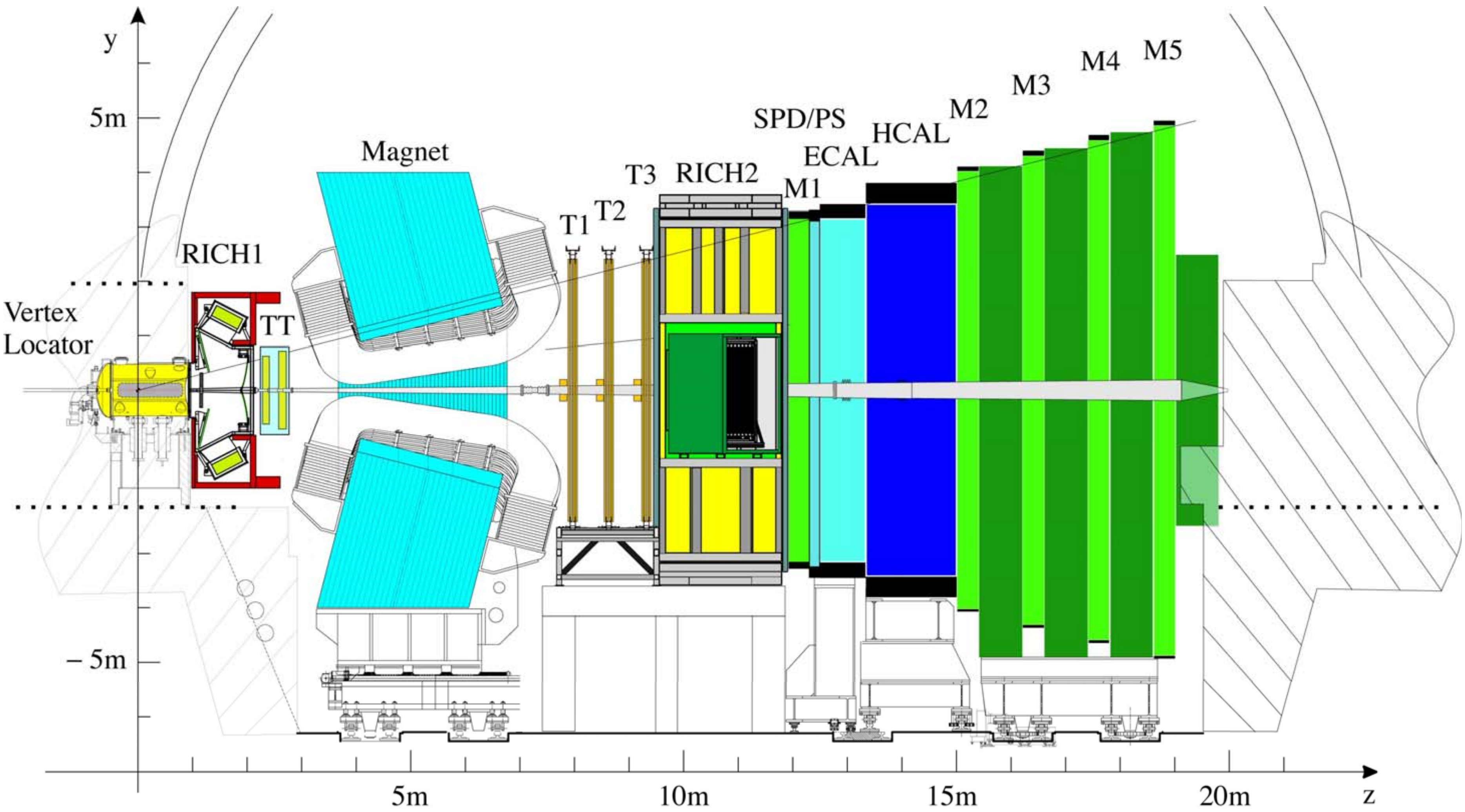
Pilot Run Collisions in Summer 2007
Shutdown Winter of 2007/2008
Physics Run Spring 2008

CMS Initial Detector for Pilot Run in 2007
Without staged items AND without endcap ECAL, pixel detector (though latter will be ready). Only 2 DAQ slices will be deployed.

Install ECAL endcap + Preshower (EE/ES) and Pixels during the 2007/2008 winter shutdown

CMS Low Luminosity Detector for Physics Run in 2008
Items still staged are:
Muons: ME4/2, RE4, REs at small radius (RE1/1, RE2/1, RE3/1)
Tracker: 3rd forward pixel disks
DAQ (4 DAQ slices 6 DAQ slices?)

LHCb



y
5m
− 5m
Vertex
Locator
RICH1
TT
Magnet
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
z

LHCb is a dedicated experiment at LHC to study CP violation and other rare phenomena in B-meson decays.

Impressive progress by

LEP experiments

$|V_{cb}|$ (b→c+W), $|V_{ub}|$ (b→u+W),

$|V_{td}|$ (Δm_d), $|V_{ts}|$ (b→s penguin)

Experiments at Υ(4S)

$|V_{cb}|$, $|V_{ub}|$,

$|V_{td}|$ (Δm_d), $|V_{ts}|$ (b→s penguin),

arg V_{td} (CP in b→c+W),

arg V_{ts} (CP in b→s penguin)

arg V_{ub} (CP in b→c+W⊗b→u+W via D-$\overline{\text{D}}$ mixing)

arg V_{ub} (CP in b→c+W⊗b→u+W

Tevatron experiments

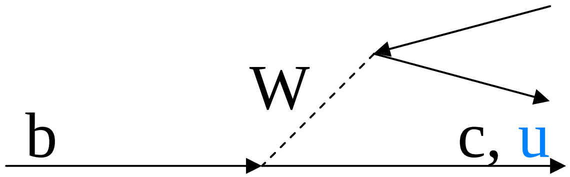
$|V_{td}|$, $|V_{ts}|$, arg V_{td}

Standard Model

Tree

$\Gamma(b \to c)$

$\Gamma(b \to u)$



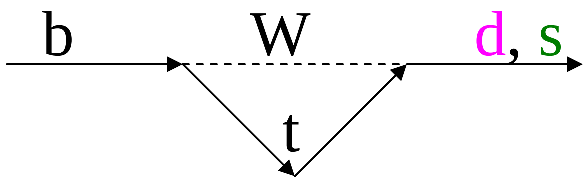
$|V_{cb}|$

$|V_{ub}|$

Penguin

$\Gamma(b \to s)$

$\Gamma(b \to d)$



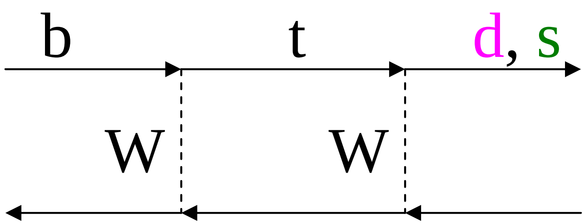
$|V_{td}|$

$|V_{ts}|$

Box

$\omega(B_d\text{-}\bar{B}_d)$

$\omega(B_s\text{-}\bar{B}_s)$



$|V_{td}|$

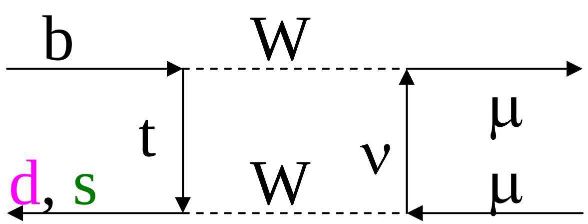
$|V_{ts}|$

$\not{CP}$(Tree⊗Box) $2 \arg V_{td}\,(V_{ts}) + \arg V_{cb}\,(V_{ub})$

$\not{CP}$(Peng⊗Box) $2 \arg V_{td}\,(V_{ts}) + \arg V_{td}$

$2 \arg V_{td}\,(V_{ts}) + \arg V_{ts}$

$\Gamma(B \to \mu\mu)$



$|V_{td}|$

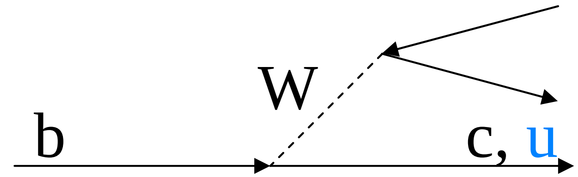
$|V_{ts}|$

Standard Model — New Physics

Tree

$\Gamma(b\to c)$

$\Gamma(b\to u)$



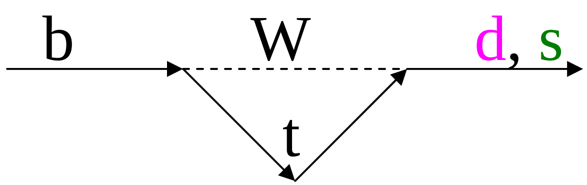
$|V_{cb}|$ unaffected

$|V_{ub}|$

Penguin

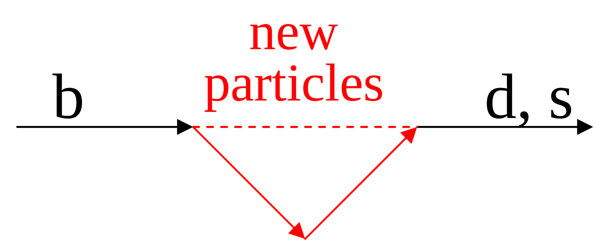
$\Gamma(b\to s)$

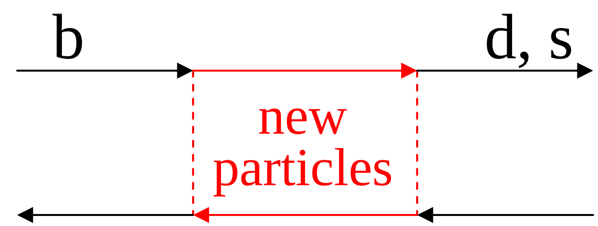
$\Gamma(b\to d)$



$|V_{td}| + \Delta_{peng(d)}$

$|V_{ts}| + \Delta_{peng(s)}$

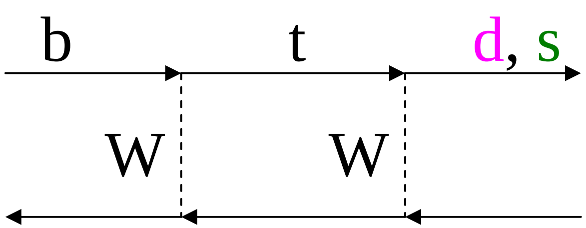




Box

$\omega(B_d\text{-}\overline{B}_d)$

$\omega(B_s\text{-}\overline{B}_s)$



$|V_{td}| + \Delta_{box(d)}$

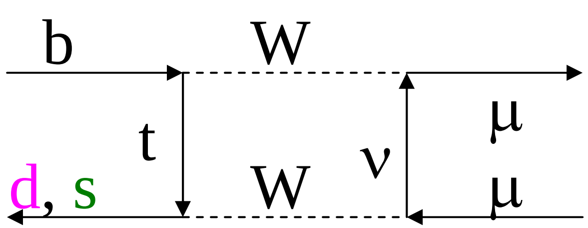
$|V_{ts}| + \Delta_{box(s)}$

~~CP~~(Tree⊗Box) $2\arg V_{td}\ (V_{ts}) + \arg V_{cb}\ (V_{ub}) + \Phi_{box(d)}\ (\Phi_{box(s)})$

~~CP~~(Peng⊗Box) $2\arg V_{td}\ (V_{ts}) + \arg V_{td} + \Phi_{box(d)}\ (\Phi_{box(s)}) + \Phi_{peng(d)}$

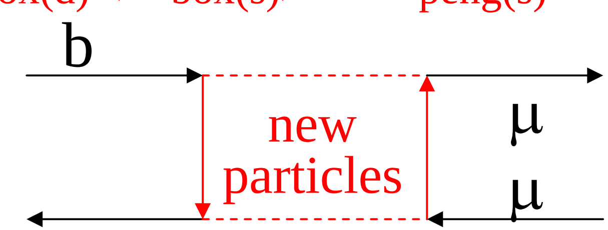
$2\arg V_{td}\ (V_{ts}) + \arg V_{ts} + \Phi_{box(d)}\ (\Phi_{box(s)}) + \Phi_{peng(s)}$

$\Gamma(B\to\mu\mu)$



$|V_{td}| + \Delta_{\mu\mu(d)}$

$|V_{ts}| + \Delta_{\mu\mu(s)}$



The LHCb Experiment will

-determine the CKM parameters in a model independent manner and look for new physics-

e.g.

- extracting B_d and B_s oscillation frequencies and phases: *B. Carron*
  (in the Standard Model V_{td} and V_{ts})
  -$B_d \to J/\psi K_S$, $B_s \to J/\psi\phi$, $B_s \to J/\psi\eta$,

- extracting arg V_{ub} from CP asymmetries in
  -$B_s \to D_s K$(+ B_s oscillation phase): *E. Rodrigues*
  no hadronic uncertainties
  no effect from new physics
  large asymmetries

  -$B_d \to \pi^+\pi^- \oplus B_s \to K^+K^-$(+ B_d and B_s oscillation phase) *L. Fabbri*
  hadronic uncertainties (U-spin)
  affected by new physics in penguin

  -$B_d \to DK^*$ *S.Amato* — affected by new physics in D-$\overline{D}$

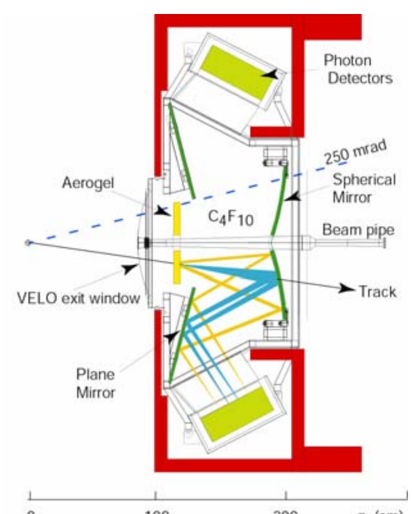
-and look for surprises-

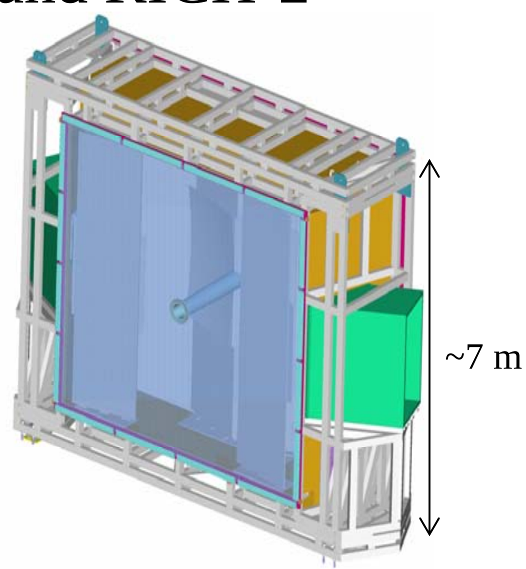
e.g. rare decays *I. Belyaev*

Most important features of the LHCb experiment

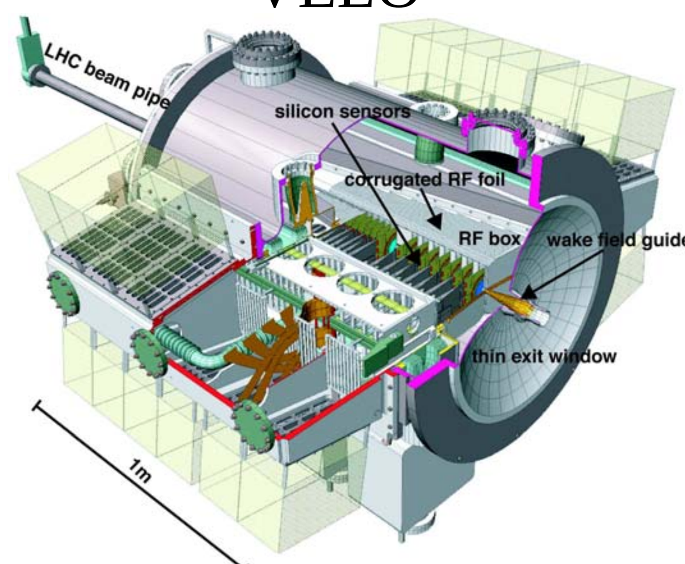
- Hadron (K/π) identification from few GeV/c up to ~100 GeV/c
  Two Ring Imaging Cherenkov counters with three radiators (RICH)
- Excellent B proper time resolution of ~40 fs
  Si micro-strip detector (VELO) very close to the beam
- Trigger also sensitive to the B meson final states with only hadrons
  Level-0 “high” p_T lepton/hadron trigger @ 40MHz → hardware
  Level-1 “high” p_T + impact parameter trigger @ 1 MHz ⎫
  High Level Trigger with all the data @ 40 kHz ⎭ → software

RICH-1 and RICH-2





VELO



Status LHCb

Good progress for the many subsystems:

-Beam pipe, Magnet, RICH2 mechanics, Calorimeter system, and Online system are progressing well.

-Outer Tracker, RICH1 mechanics, HPD and VELO are also making good progress, however with tight planning.

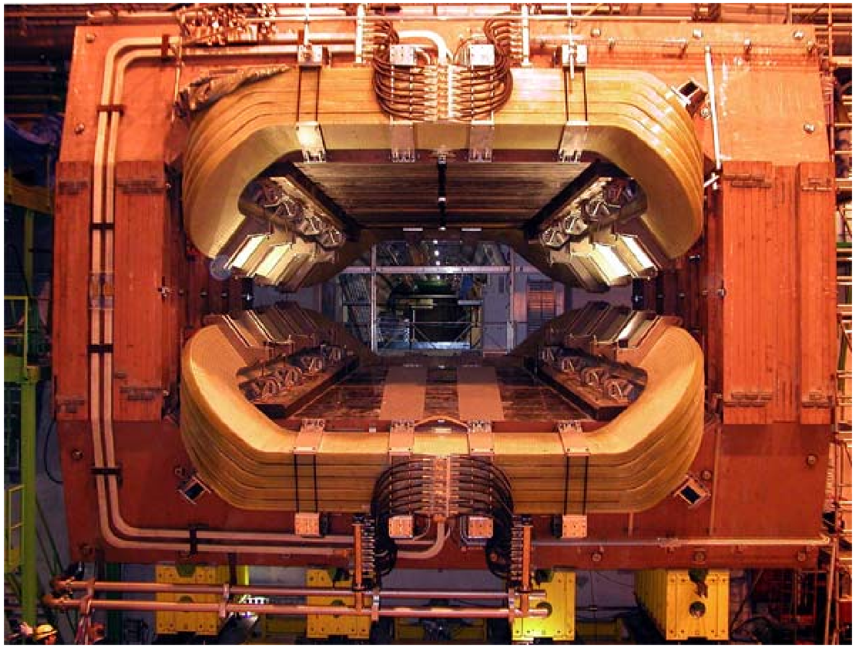
-We are looking forward to seeing the production of the Trigger Tracker and Inner Tracker start as planned. A major concern is how to solve the conflict with CMS on the delivery schedule for the TT sensors.

-Production of the Muon chambers is facing a substantial delay. Necessary action will be decided in March 2005 when we expect to have all the information needed.

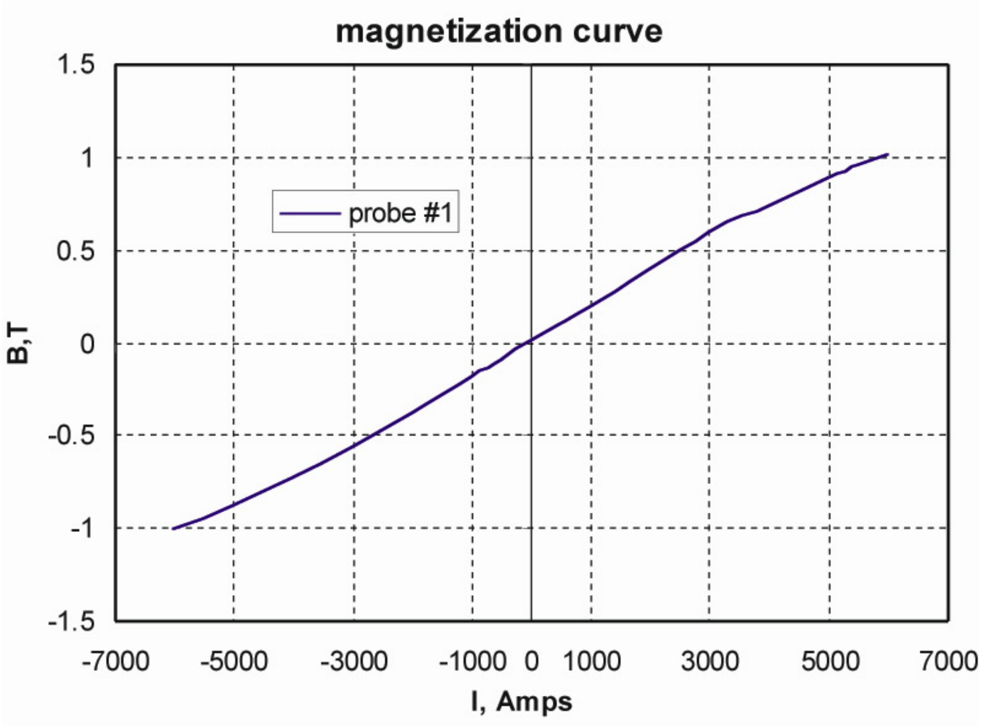
-Need of computing resources is evolving and its effect on computing model is being investigated.

Magnet

Completed and successfully switched on



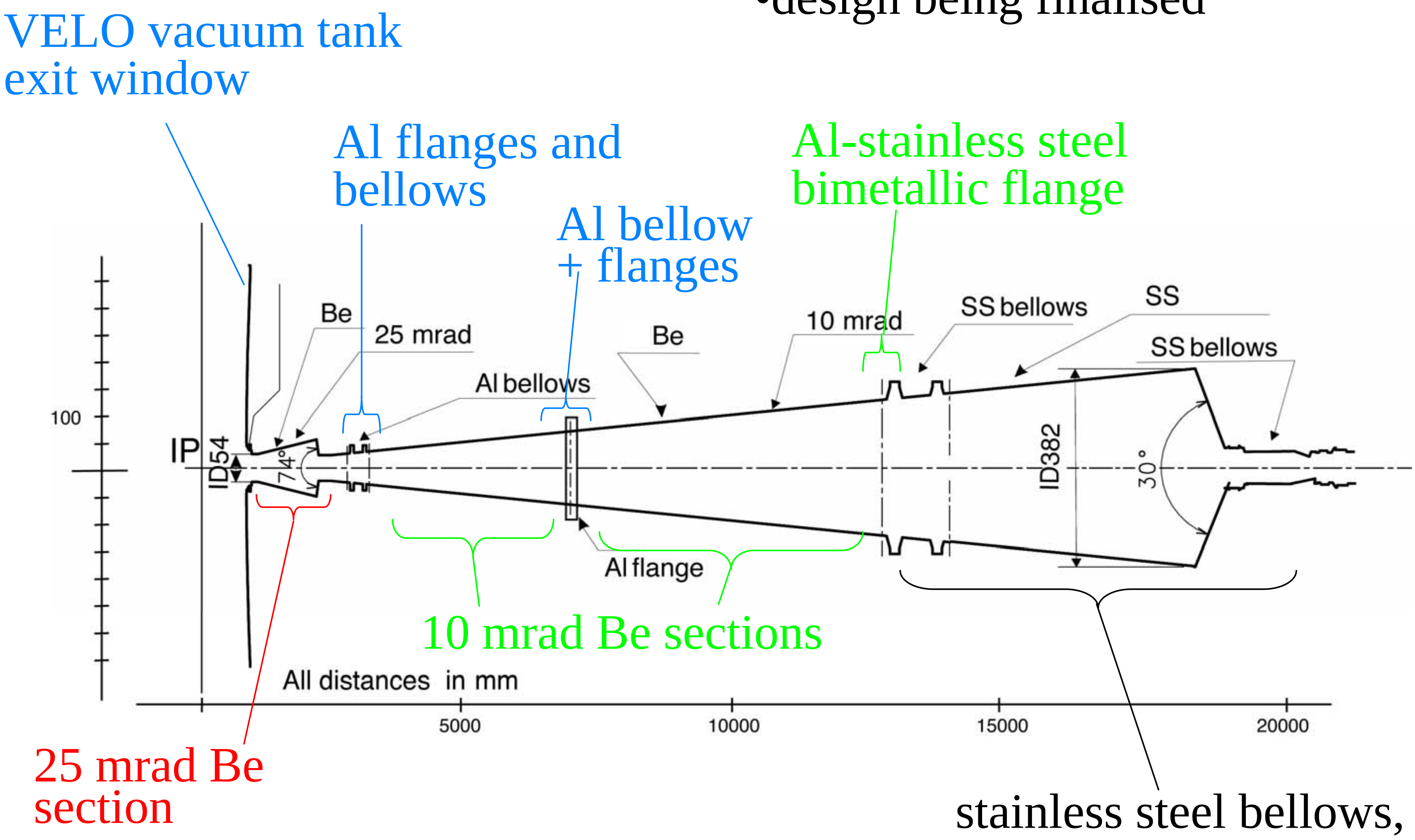
Fe Yoke 1.45 kt
Al normal conductive coil 2   25 t



Power 4.2MW at 1 T field

Beam pipe

- completed by industry
- ready for fabrication at CERN
- being fabricated by industry
- design being finalised

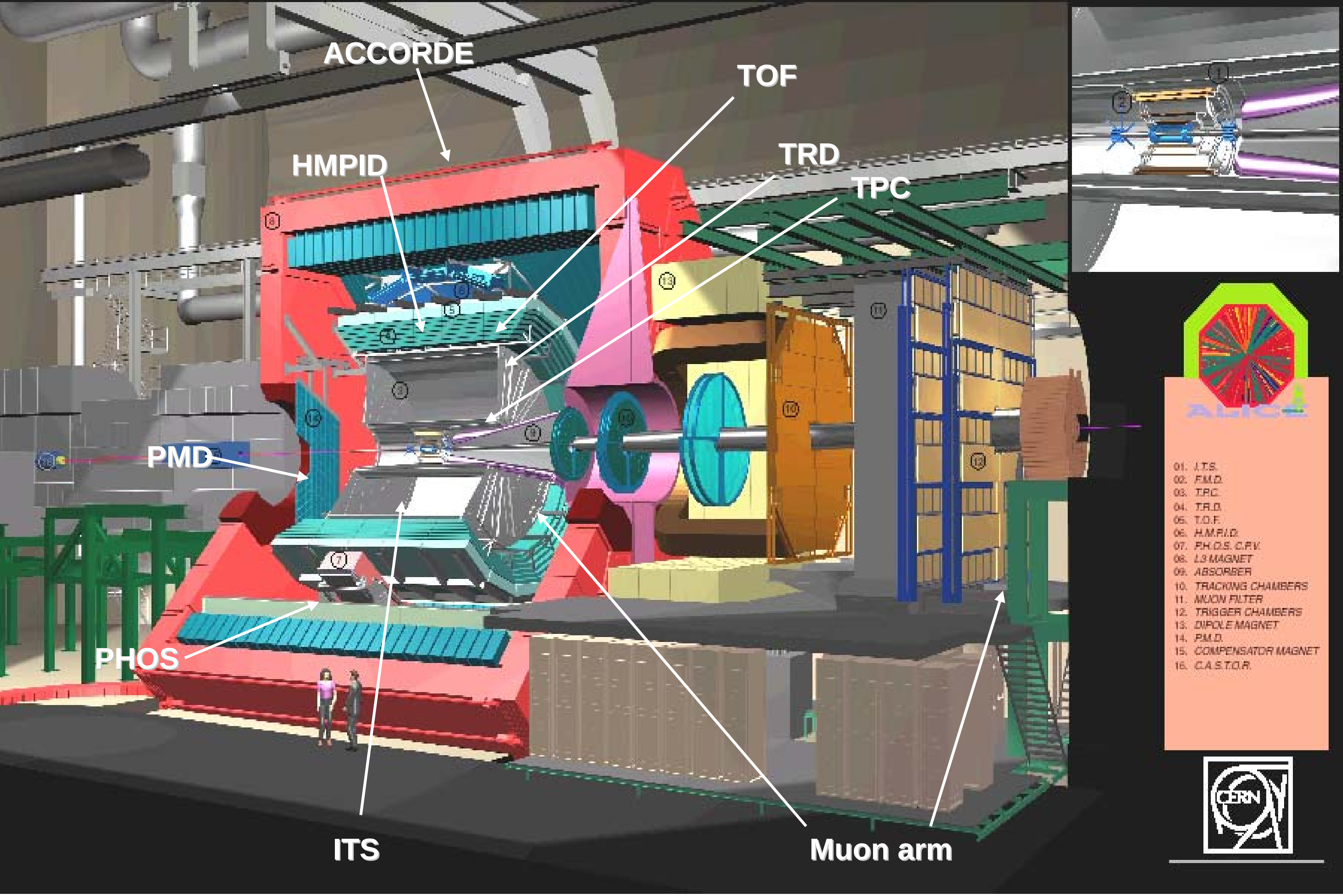


VELO window

Al bellows and flanges

25 mrad Be pipe

Al bellow and flange



ALICE Detector

ALICE R&D

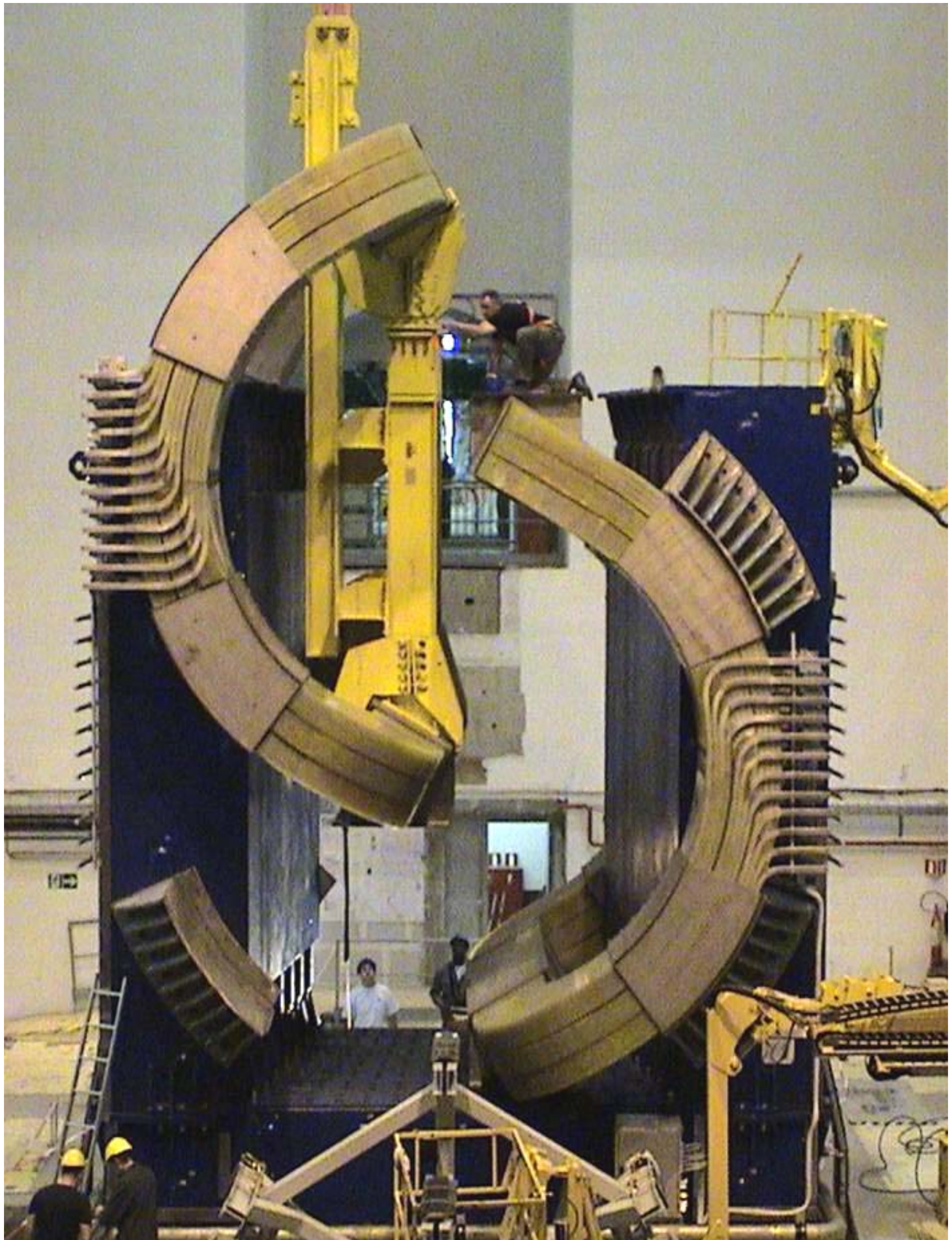
From 1990:strong R&D activity

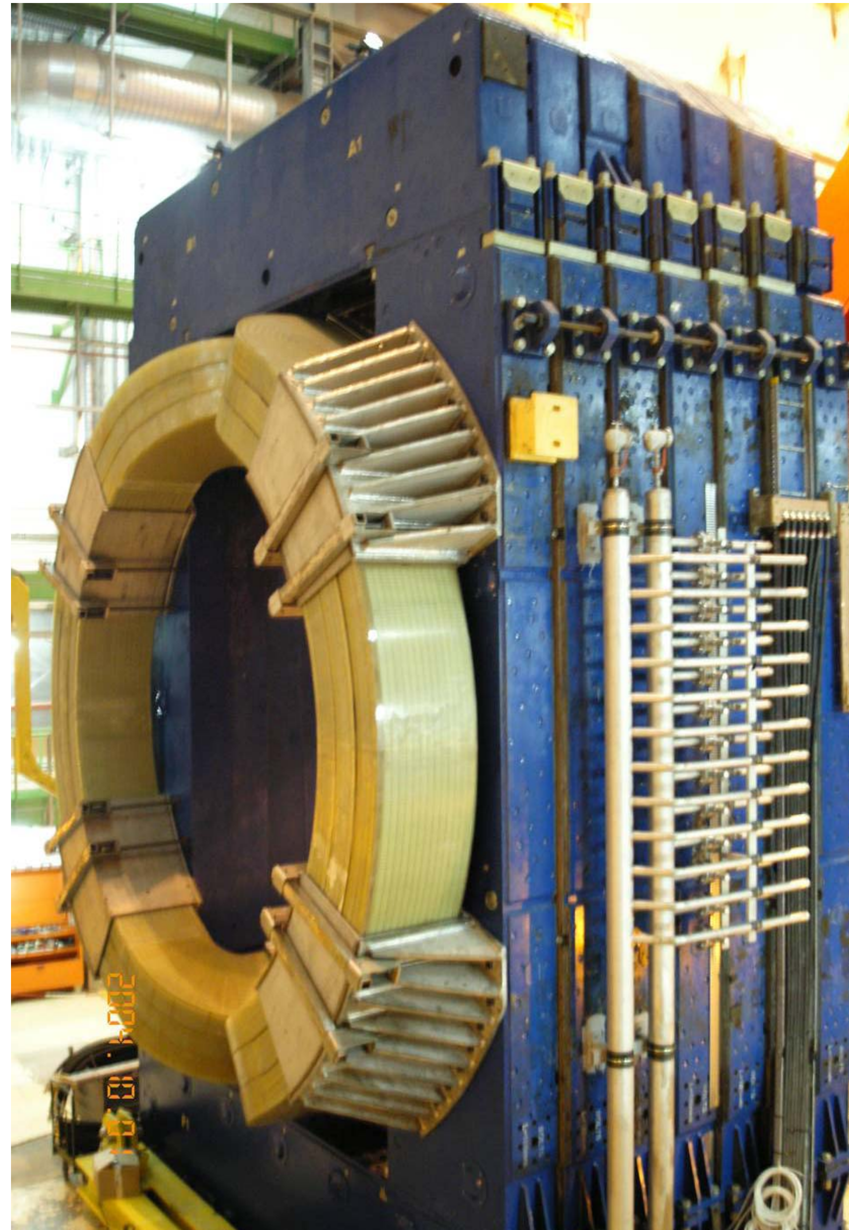
- **Inner Tracking System (ITS)**
  - ⇨ Silicon Pixels (RD19)
  - ⇨ Silicon Drift (INFN/SDI)
  - ⇨ Silicon Strips (double sided)
  - ⇨ low mass, high density interconnects
  - ⇨ low mass support/cooling
- **TPC**
  - ⇨ gas mixtures (RD32)
  - ⇨ new r/o plane structures
  - ⇨ advanced digital electronics
  - ⇨ low mass field cage
- **em calorimeter**
  - ⇨ new scint. crystals (RD18)
- **PID**
  - ⇨ Pestov Spark counters
  - ⇨ Parallel Plate Chambers
  - ⇨ Multigap RPC's (LAA)
  - ⇨ low cost PM's
  - ⇨ solid photocathode RICH (RD26)
- **DAQ & Computing**
  - ⇨ scalable architectures with COTS ?
  - ⇨ high perf. storage media ?
  - ⇨ GRID computing ?
- **misc**
  - ⇨ micro-channel plates
  - ⇨ rad hard quartz fiber calo.
  - ⇨ VLSI electronics

Installation, Large Structures

- Main installation crane was out of service for 3 months
  - ⇨ major **disruption** to installation activities
  - ⇨ **impact minimized** using mobile cranes and re-scheduling of activities
- Space frame load tests and installation tests proceeding
  - ⇨ dummy T**RD and TOF modules inserted** successfully
  - ⇨ first l**oad tests & deformation measurements** done
- Muon arm foundation finished
- Muon Magnet: Coils were inserted
  - ⇨ proved to be much more **difficult and time consuming** than foreseen
  - ⇨ installation in **final position:** delayed to early 2005 (still not on critical path)
  - ⇨ **power test:** done end October
- Muon absorber assembly under way
  - ⇨ one section finished, remaining two in progress

Muon Magnet





Project Summary

- Infrastructure (structures, services, magnets,..) & Integration
  - ⇨ more complex & time consuming than foreseen => delays
    - ✪ reasons: both **technical** & **organizational** (safety, planning, work sharing with TS)
  - ⇨ **will be ready in time**, but <u>needs increased resources </u>(shift work, quality assurance)

- Read-out & Controls (DAQ, Trigger, DCS, ECS..)
  - ⇨ good progress, on schedule, **no concerns**

- Forward Detectors
  - ⇨ **ZDC**: **on schedule** **T0/V0/FMD**: late start, now starting construction, **will be ready**

- TPC
  - ⇨ **production finished** (FC, ROC, FEE) or soon finished (RCU)
  - ⇨ even with a very **conservative schedule** for ROC & FEE installation **ready well in time**
    - ✪ including thorough **pre-commissioning** on surface

Project Summary

- HMPID : well advanced, no concerns
- Muon arm
  - ⇨ **chamber** production: **ok** major activity of **electronics testing & assembly still ahead**
- TOF
  - ⇨ despite delays in the assembly tender, most **(>>20%)** if not all TOF modules **will be ready**
- TRD
  - ⇨ **radiator** production finished, **chamber** production getting on speed
  - ⇨ some **revisions** to **FEE** (TRAP chip, R/O board) and **mechanics** necessary
  - ⇨ some super-modules **will be ready**
- PHOS
  - ⇨ **1 module ready end 2005**, 2nd module by end 2006 may even be feasible
- ITS

Initial working detector well on track for collisions in summer 2007

We aim for more

(~completion of 'funded' detector for 2007)

TOTEM Physics: Total p-p Cross-Section

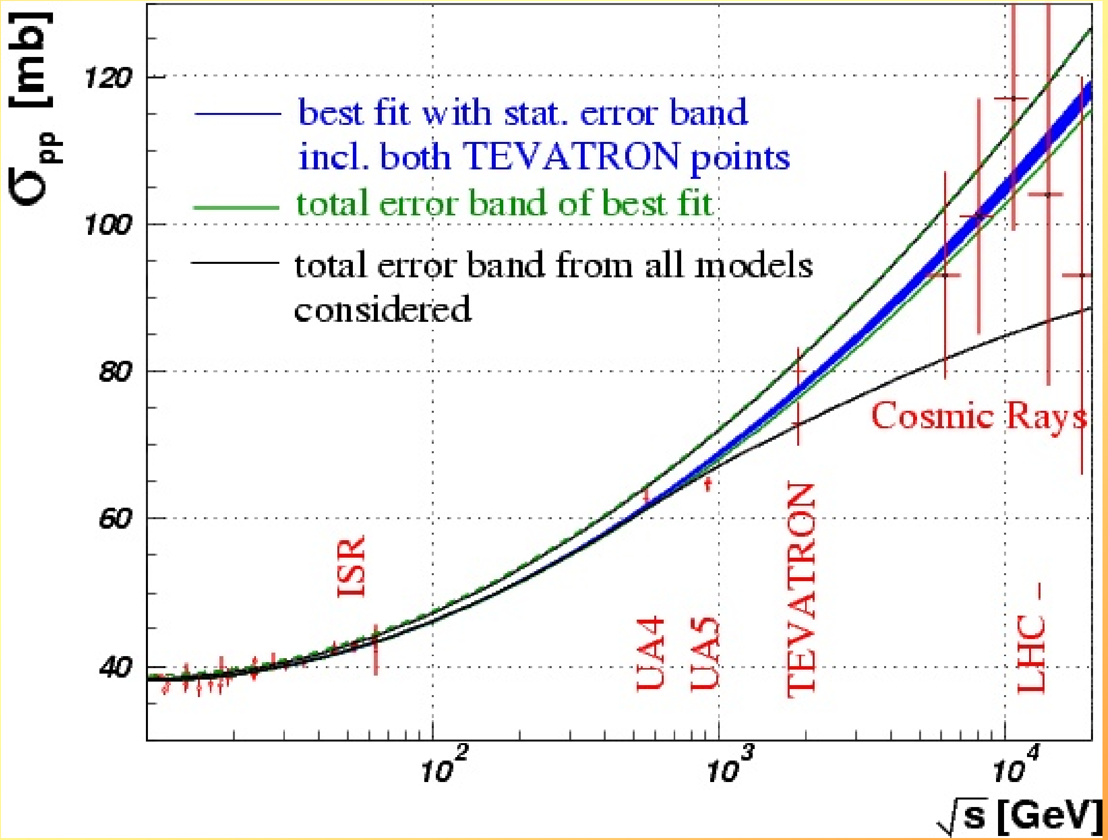
- Current models predict for 14 TeV: 90 – 130 mb
- Aim of TOTEM: ~ **1%** accuracy
- **Luminosity independent method**:

Optical Theorem
$$\mathcal{L}\,\sigma_{tot}^2 = \frac{16\pi}{1+\rho^2} \times \left.\frac{dN}{dt}\right|_{t=0}$$

$$\mathcal{L}\,\sigma_{tot} = N_{elastic} + N_{inelastic}$$

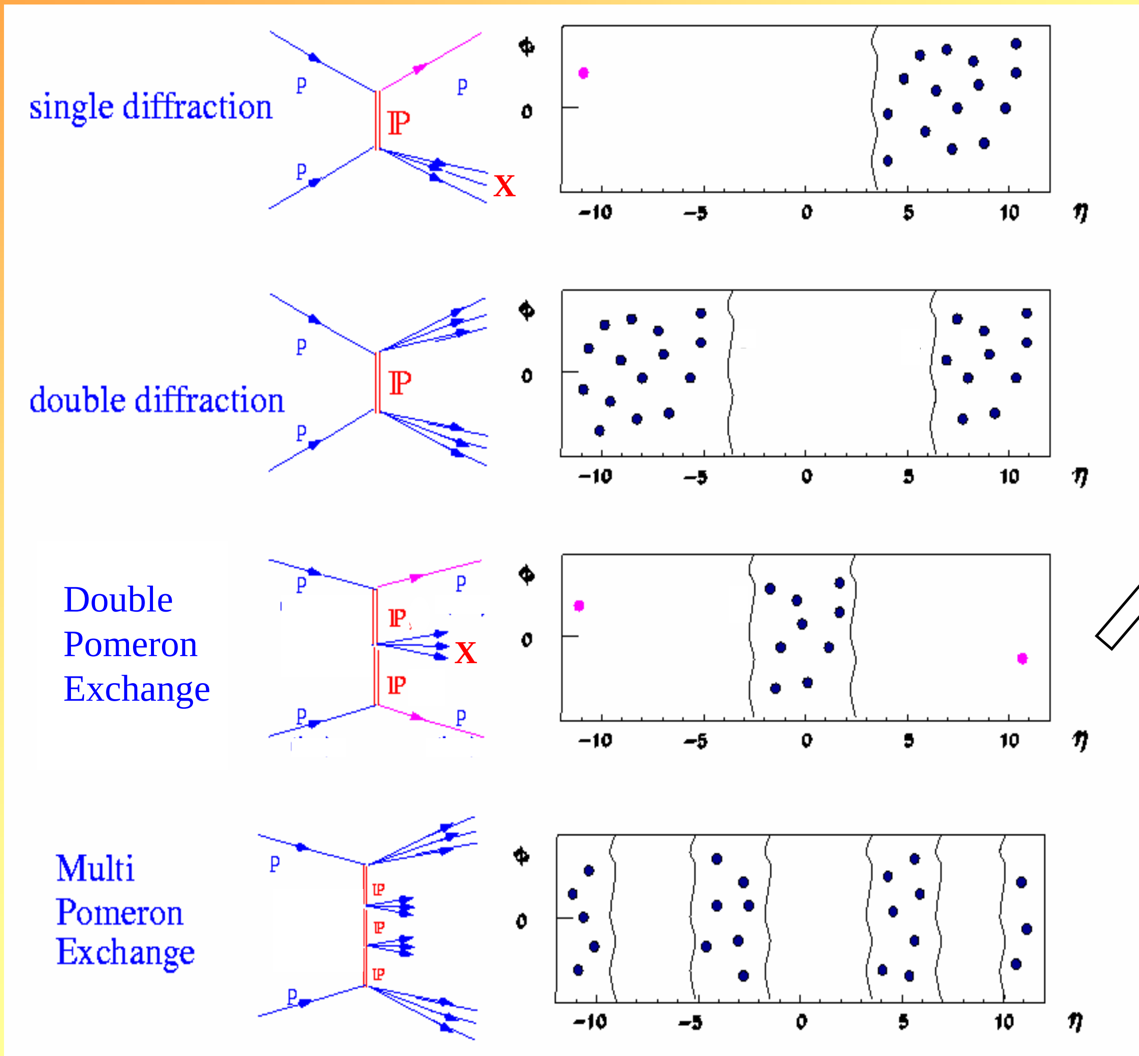
$$\sigma_{tot} = \frac{16\pi}{1+\rho^2} \times \frac{(dN/dt)|_{t=0}}{N_{el} + N_{inel}}$$

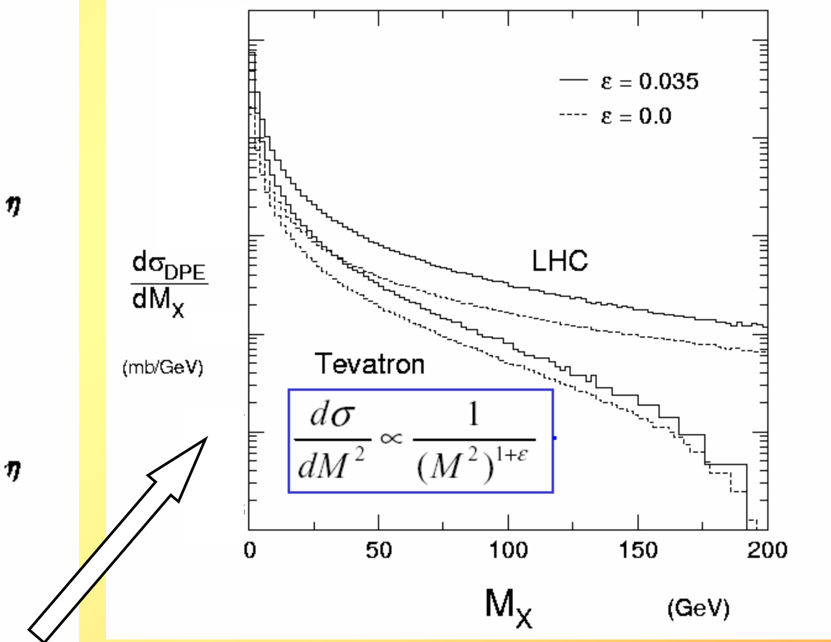
COMPETE Collaboration:



TOTEM+CMS Physics: Diffractive Events

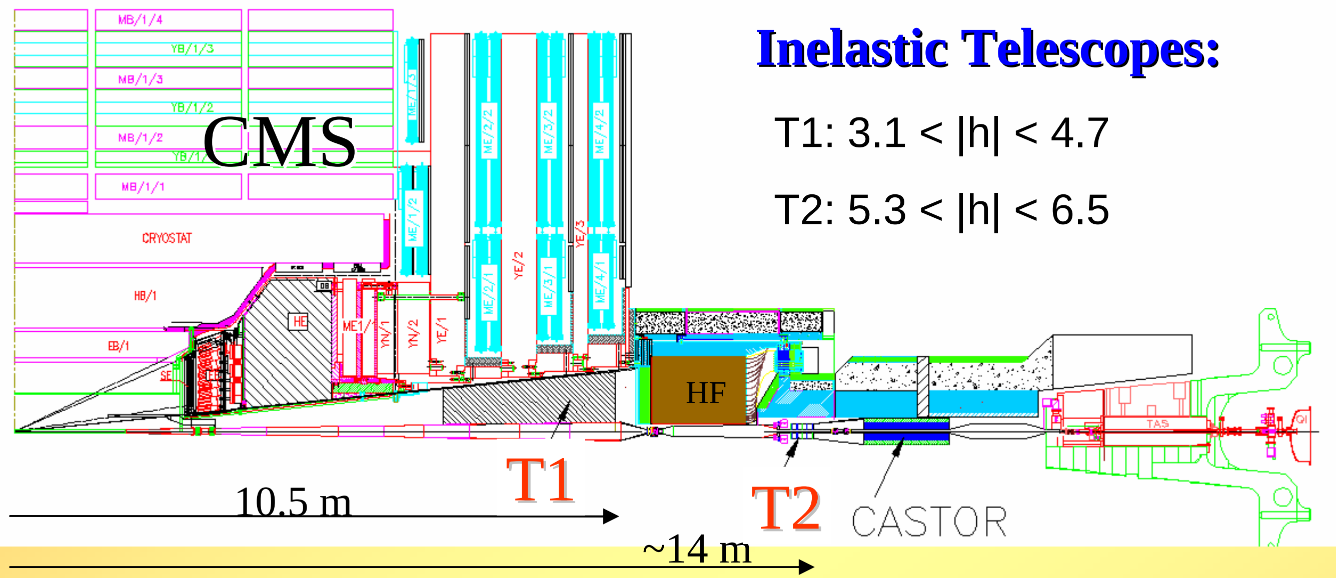
Measure > 90% of leading protons with RPs and diffractive system X with T1, T2 and CMS.





Central production of 0^{++} states X:
X = c_c, c_b, Higgs, dijets,
SUSY particles, ...

TOTEM Detectors

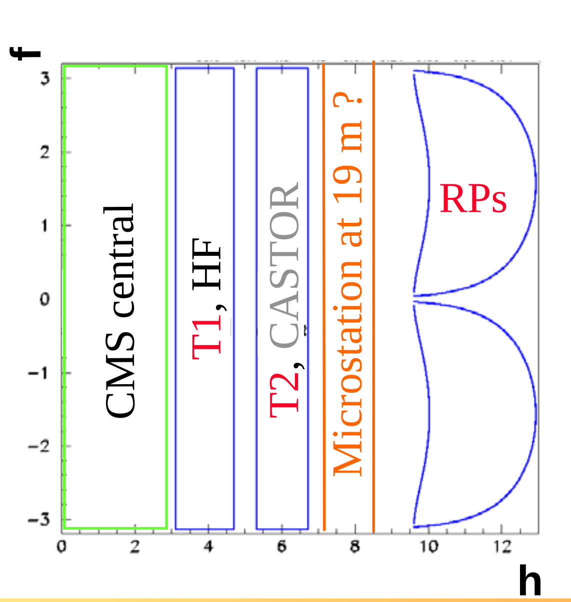


Inelastic Telescopes:

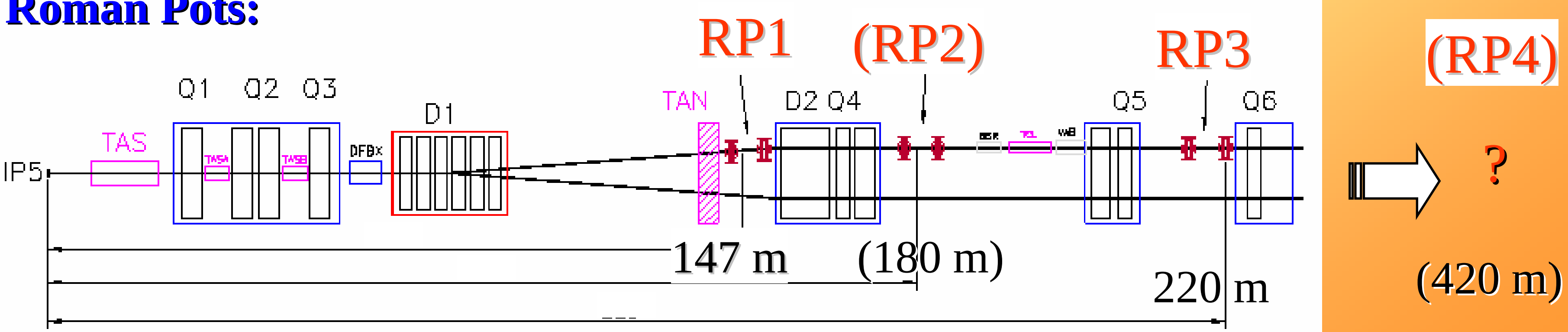
T1: $3.1 < |\eta| < 4.7$

T2: $5.3 < |\eta| < 6.5$

Acceptance:



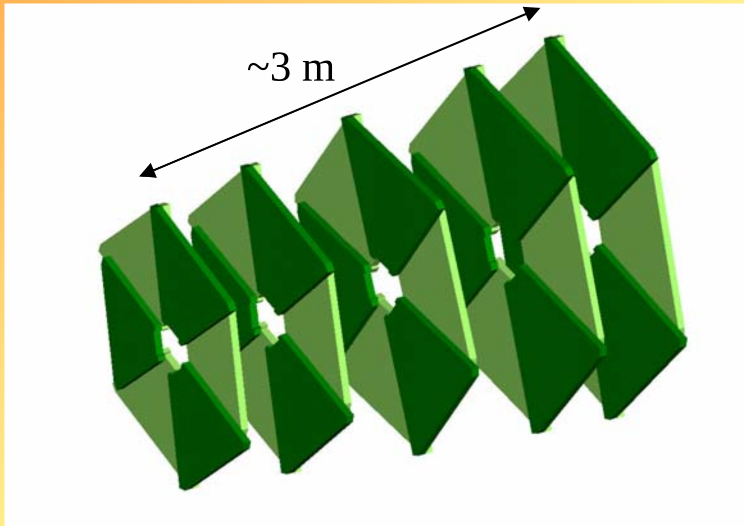
Roman Pots:

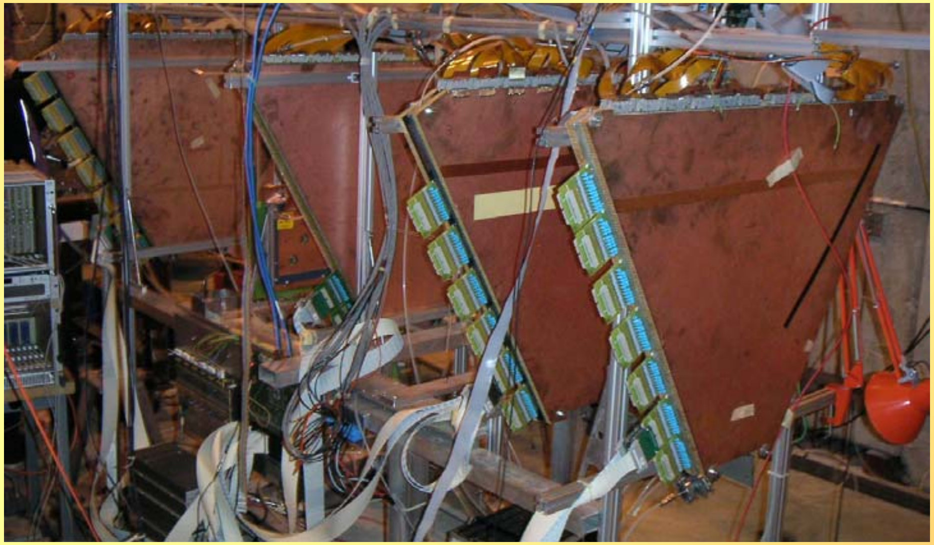


T1 and T2 Telescopes

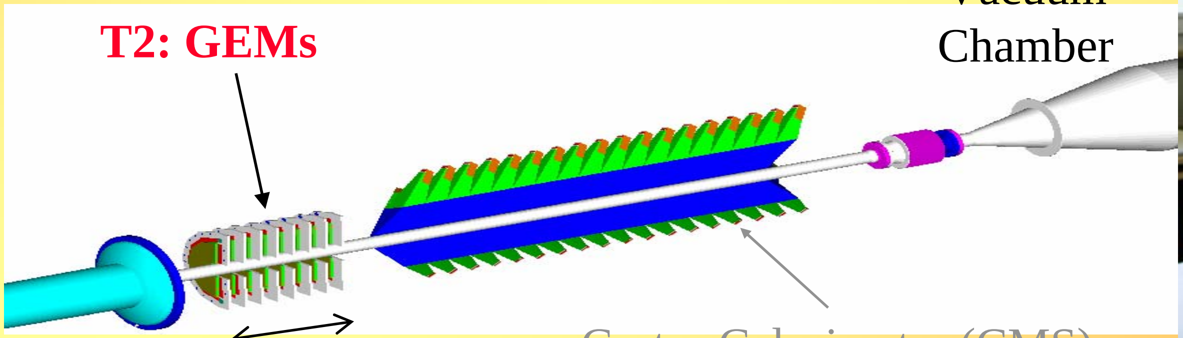
2004 Test Beam in X5

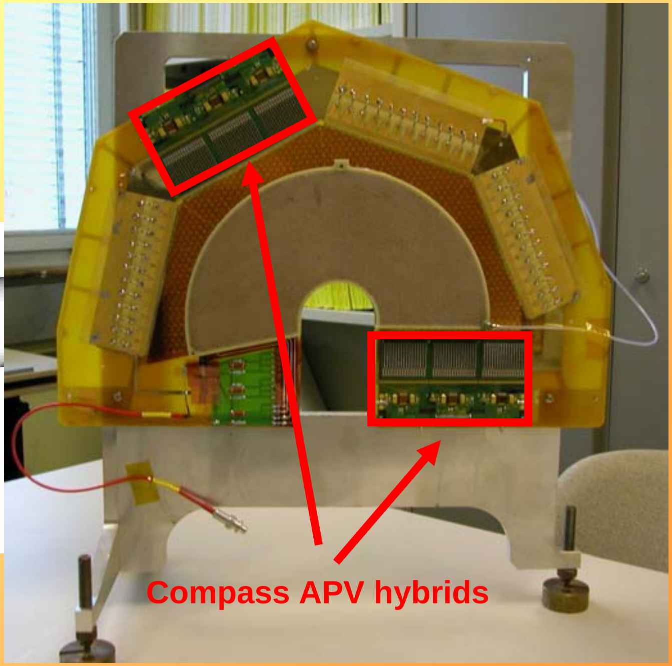
T1: Cathode Strip Chambers





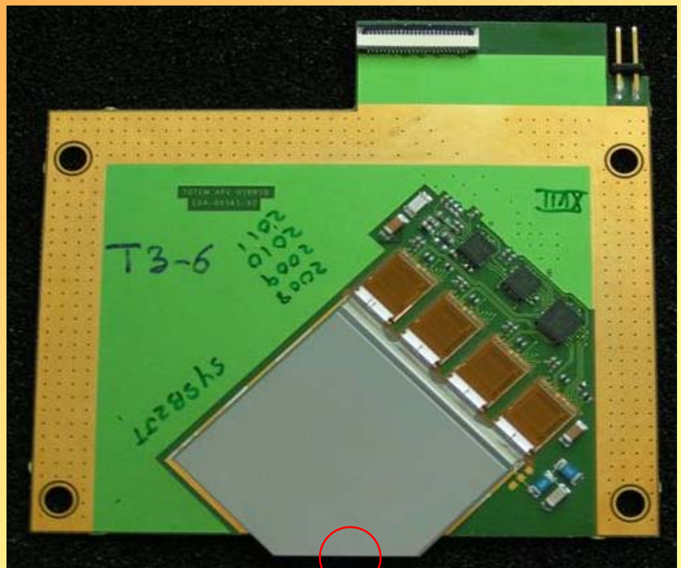
T2: GEMs



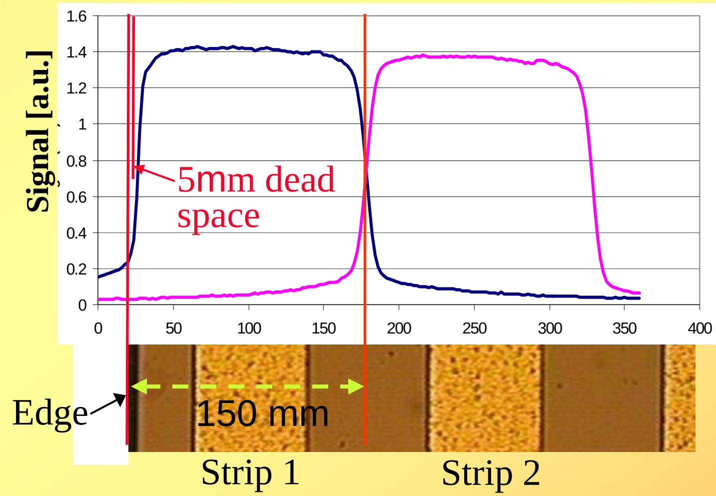


Edgeless Silicon Detectors for the RPs

Measurement of very small proton scattering angles (few mrad):
active area of detectors must approach beam to ~1.5 mm.

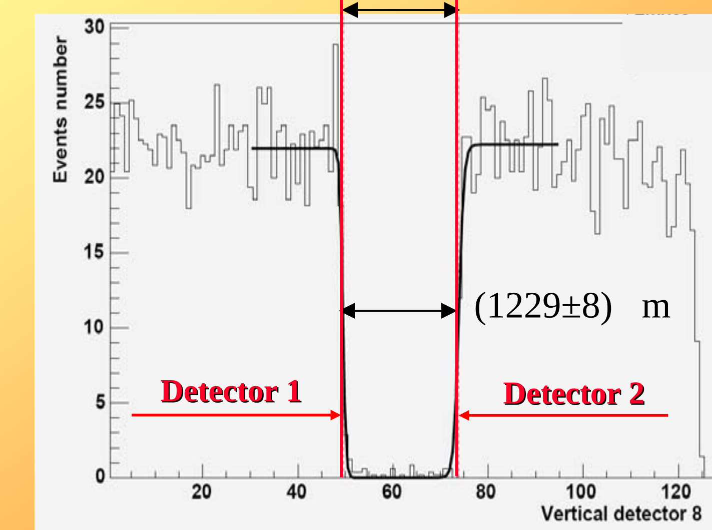


Active edges: X-ray measurement

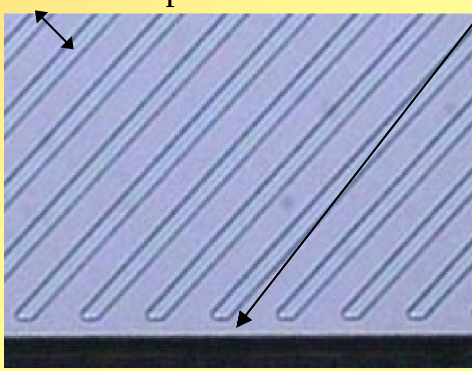


Planar technology: Testbeam

Metrology: (1209±10) m

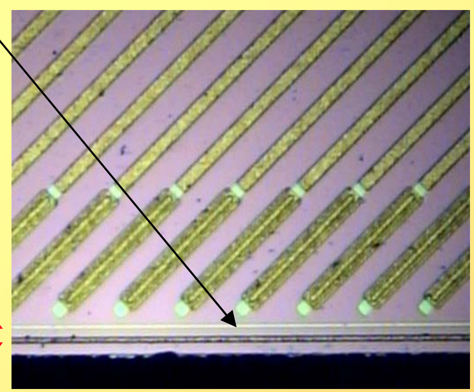


66 mm pitch



5–10 mm dead space

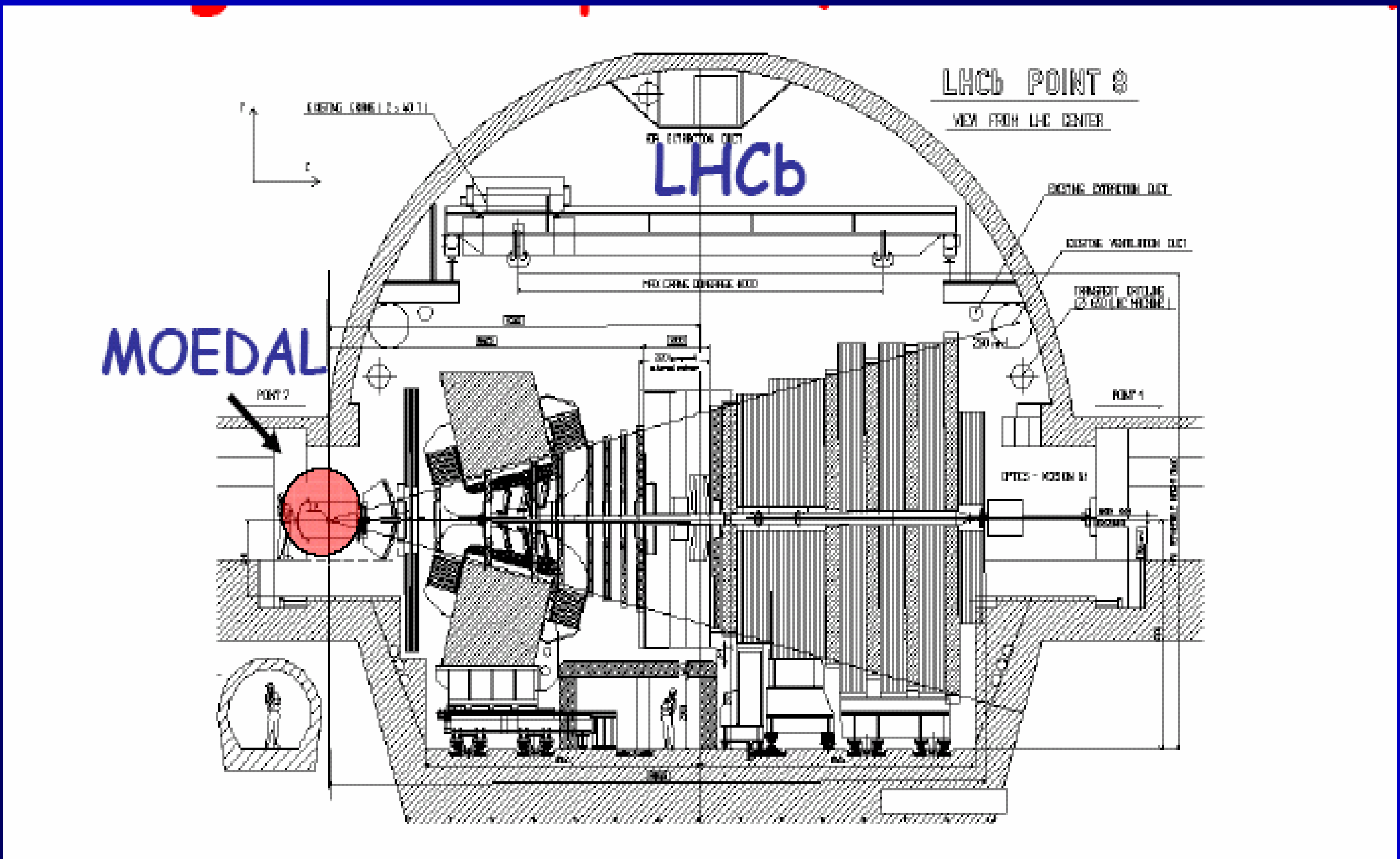
20–50 mm dead space



Active edges ("planar/3D")

Planar technology with minimal guard rings

MOEDAL: Magnetic Monopole Search



4 May 2004
Letter of Intent to CERN LHCC [LHCC 2003-057/I-012 rev. 2]

Measurement of Photons and Neutral Pions in the Very Forward Region of LHC

O. Adriani(1), A. Faus(2), M. Haguenauer(3), K. Kasahara(4), K. Masuda(5), Y. Matsubara(5), Y. Muraki(5), T. Sako(5), T. Tamura(6), S. Torii(6), W.C. Turner(7), J. Velasco(2)

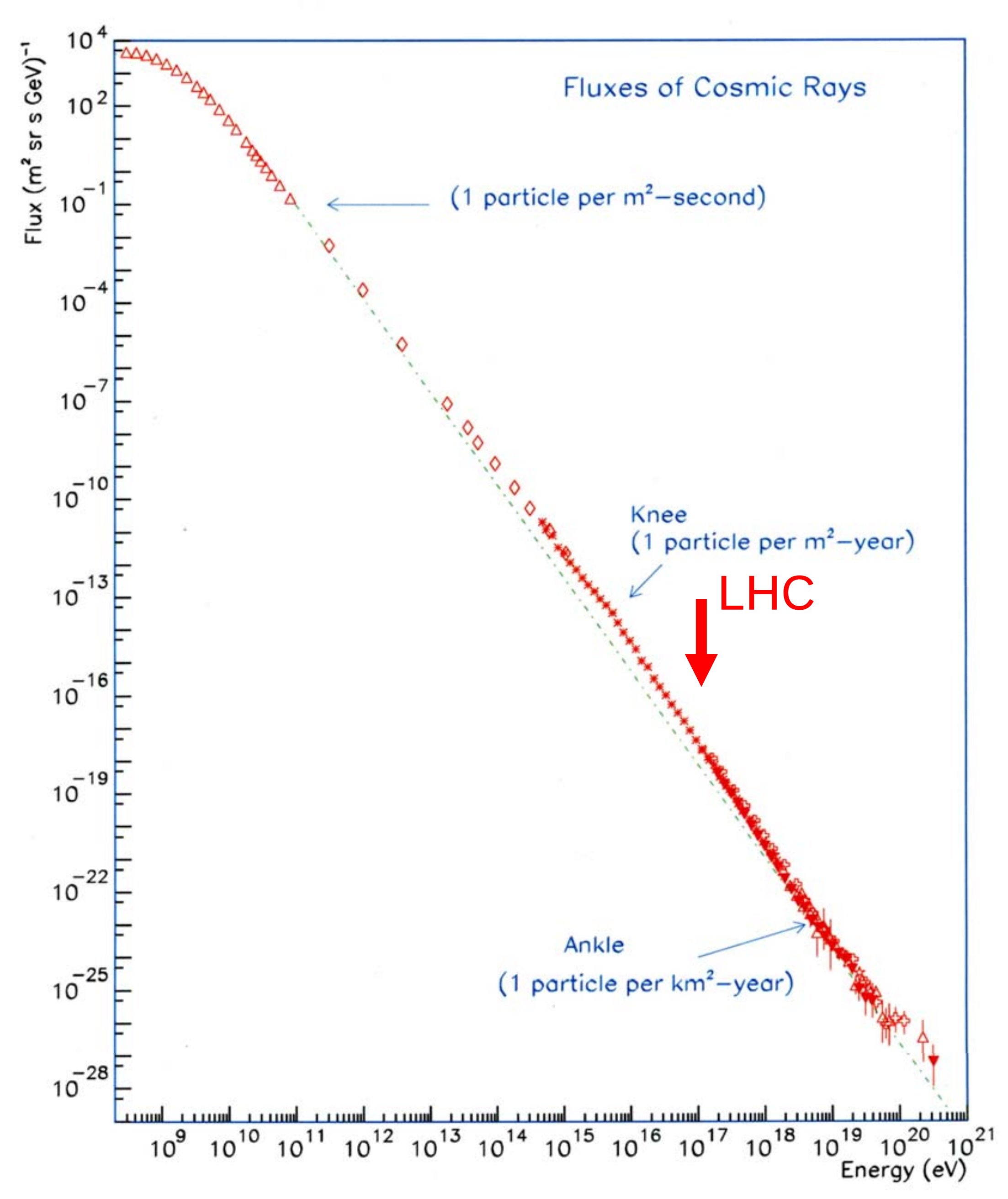
The **LHCf collaboration** (tentative)

(1) INFN, Univ. di Firenze, Firenze, Italy
(2) IFIC,Centro Mixto CSIC-UVEG, Valencia, Spain
(3) Ecole-Polytechnique, Paris, France
(4) Shibaura Institute of Technology, Saitama, Japan
(5) STE laboratory, Nagoya University, Nagoya, Japan
(6) Kanagawa University, Yokohama, Japan
(7) LBNL, Berkeley, California, USA

Abstract

An energy calibration experiment is proposed for ultra high energy cosmic ray experiments in the energy range between 10^{17}eV and 10^{20}eV. Small calorimeters will be located between the two beam pipes in the “Y vacuum chamber” 140m away from the interaction point of the Large Hadron Collider. Within an exposure time of a few hours at luminosity $\approx 10^{29}$ cm^{-2}s^{-1}, very important results will be obtained that will resolve long standing quests by the highest energy cosmic ray physics experiments.

The Cosmic Ray Spectrum



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
$W \rightarrow e\nu$	15	10^8	10^4 LEP / 10^7 Tevatron
$Z \rightarrow ee$	1.5	10^7	10^7 LEP
$t\bar{t}$	1	10^7	10^4 Tevatron
$b\bar{b}$	10^6	10^{12} – 10^{13}	10^9 Belle/BaBar ?
H m=130 GeV	0.02	10^5	?
$\tilde{g}\tilde{g}$ 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 → understand detector and physics at $\sqrt{s}$ = 14 TeV
-- several New Physics scenarios

Computing – LCG Project

Computing Models defined

GRID essential (10^5 PC’s; 10 PB/y)

Middleware evolving (EGEE)

Computing MoU’s – Tier1’s

Conclusions

The LHC collaborations still have a big job in front of them, but it is their top priority and realistic goal to have initial detectors ready to record 14 TeV pp collisions in the summer of 2007 and to have the necessary analysis infrastructure in place