LHC: Machine and Experiments
Status and Prospects

CHEP 07
Victoria, Canada
3 September 2007

- Introduction: The Standard Models and LHC
- The Status of the LHC Machine
- The Status of the LHC Experiments
- Physics Prospects from Early Running(primarily ATLAS and CMS)
- Conclusions

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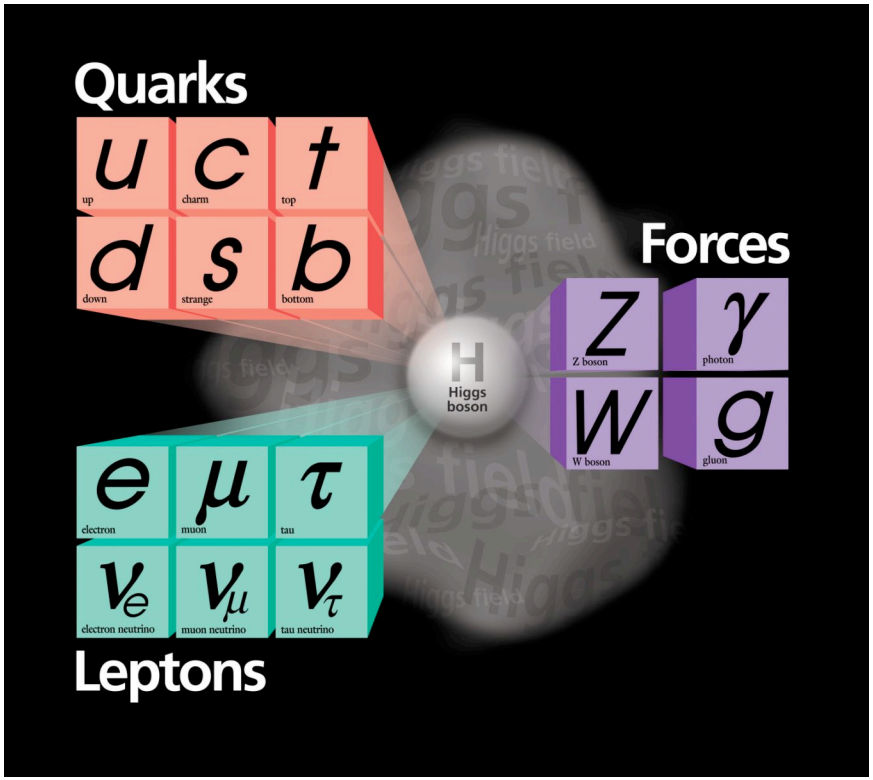
Acknowledgements

Talks by
J. Ellis (EPS07), F. Gianotti (CERN-TH Workshop, Aug07),
L. Evans (TRIUMF Aug07)

Material from LHC Experiment Spokespersons
P. Jenni, T. Nakada, J. Schukraft

The Standard Model of Particle Physics



e.g. LEP and SM

Quantity	Value	Standard Model	Pull
m_t [GeV]	$172.7 \pm 2.9 \pm 0.6$	172.7 ± 2.8	0.0
M_W [GeV]	80.450 ± 0.058	80.376 ± 0.017	1.3
	80.392 ± 0.039		0.4
M_Z [GeV]	91.1876 ± 0.0021	91.1874 ± 0.0021	0.1
Γ_Z [GeV]	2.4952 ± 0.0023	2.4968 ± 0.0011	−0.7
Γ(had) [GeV]	1.7444 ± 0.0020	1.7434 ± 0.0010	—
Γ(inv) [MeV]	499.0 ± 1.5	501.65 ± 0.11	—
$\Gamma(\ell^+\ell^-)$ [MeV]	83.984 ± 0.086	83.996 ± 0.021	—
$\sigma_{\rm had}$ [nb]	41.541 ± 0.037	41.467 ± 0.009	2.0
R_e	20.804 ± 0.050	20.756 ± 0.011	1.0
R_μ	20.785 ± 0.033	20.756 ± 0.011	0.9
R_τ	20.764 ± 0.045	20.801 ± 0.011	−0.8
R_b	0.21629 ± 0.00066	0.21578 ± 0.00010	0.8
R_c	0.1721 ± 0.0030	0.17230 ± 0.00004	−0.1
$A_{FB}^{(0,e)}$	0.0145 ± 0.0025	0.01622 ± 0.00025	−0.7
$A_{FB}^{(0,\mu)}$	0.0169 ± 0.0013		0.5
$A_{FB}^{(0,\tau)}$	0.0188 ± 0.0017		1.5
$A_{FB}^{(0,b)}$	0.0992 ± 0.0016	0.1031 ± 0.0008	−2.4
$A_{FB}^{(0,c)}$	0.0707 ± 0.0035	0.0737 ± 0.0006	−0.8
$A_{FB}^{(0,s)}$	0.0976 ± 0.0114	0.1032 ± 0.0008	−0.5
$\bar{s}_\ell^2(A_{FB}^{(0,q)})$	0.2324 ± 0.0012	0.23152 ± 0.00014	0.7
	0.2238 ± 0.0050		−1.5
A_e	0.15138 ± 0.00216	0.1471 ± 0.0011	2.0
	0.1544 ± 0.0060		1.2
	0.1498 ± 0.0049		0.6
A_μ	0.142 ± 0.015		−0.3
A_τ	0.136 ± 0.015		−0.7
	0.1439 ± 0.0043		−0.7
A_b	0.923 ± 0.020	0.9347 ± 0.0001	−0.6
A_c	0.670 ± 0.027	0.6678 ± 0.0005	0.1
A_s	0.895 ± 0.091	0.9356 ± 0.0001	−0.4
g_L^2	0.30005 ± 0.00137	0.30378 ± 0.00021	−2.7
g_R^2	0.03076 ± 0.00110	0.03006 ± 0.00003	0.6
$g_V^{\nu e}$	-0.040 ± 0.015	-0.0396 ± 0.0003	0.0
$g_A^{\nu e}$	-0.507 ± 0.014	-0.5064 ± 0.0001	0.0
A_{PV}	-1.31 ± 0.17	-1.53 ± 0.02	1.3
Q_W(Cs)	-72.62 ± 0.46	-73.17 ± 0.03	1.2
Q_W(Tl)	-116.6 ± 3.7	-116.78 ± 0.05	0.1
$\frac{\Gamma(b\to s\gamma)}{\Gamma(b\to Xe\nu)}$	$3.35^{+0.50}_{-0.44} \times 10^{-3}$	$(3.22 \pm 0.09) \times 10^{-3}$	0.3
$\frac{1}{2}(g_\mu - 2 - \frac{\alpha}{\pi})$	4511.07 ± 0.82	4509.82 ± 0.10	1.5
τ_τ [fs]	290.89 ± 0.58	291.87 ± 1.76	−0.4

The Standard Model is a beautiful theory and arguably the one most precisely tested

Open Questions for the Standard Model

SM contains too many apparently arbitrary features

SM has an unproven element: the mechanism to generate observed masses of known particles

e.g. why $M_\gamma = 0$, $M_\nu \sim 0$, $M_e \sim 0.5$ MeV
$M_Z \sim 100{,}000$ MeV, $M_t \sim 175{,}000$ MeV!

Higgs mechanism ? + other physics ?

SM gives nonsense at high energies

At centre of mass energies > 1000 GeV the probability of $W_L W_L$ scattering becomes greater than 1 !!

A solution is to introduce a Higgs boson exchange to cancel the bad high energy behaviour

SM is logically incomplete – does not incorporate gravity - need a quantum theory of gravity to build a unified theory

Superstring theory, extra space-time dimensions ?

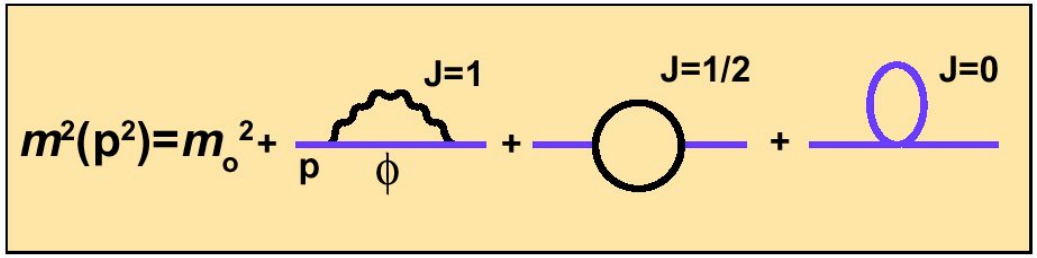
Experimentally ⇨ New particles/new symmetries/new forces?

⇨ Higgs boson(s), Supersymmetry, Extra dimensions etc. ?

Naturalness

What happens if extend validity of SM in presence of Higgs boson to scales $\Lambda >> 1/\sqrt{G_F}$?

Radiative corrections to the Higgs boson mass



$$M_H^2 \rightarrow M_H^2\,(\text{bare}) + c\,\Lambda^2$$

Λ is the scale of the underlying theory (could be $M_{GUT} \sim 10^{15}$ GeV !)

Requires incredibly unnatural fine tuning to keep M_H small !!

What can be done ?

L_{SSB} does not contain an elementary Higgs boson (Alternatives ?)

OR

Cancel quadratic divergences (Supersymmetry ?)

SUSY and Alternatives

Fundamental Higgs unattractive in all but SUSY theories

SUSY predicts a new "zoology" of particles. Every particle has a partner (sparticle). None found as yet - they must be heavy (~ 1TeV ?).

If no fundamental Higgs boson is found then SSB may proceed via a dynamical mechanism

QCD inspired

Identify W_L and Z_L with 'pions' of a new interaction

rescale f_π to $1/\sqrt{G_F}$ leading to strong interaction in TeV range

V_L- V_L scattering is a replica of π - π scattering

Technicolour

Dampening of Higgs-less SM via a techni-ρ

Wealth of new states predicted

Strong breaking of E-W symmetry

No Higgs boson but a triplet of massive bound states - vector bosons V^0, $V^\pm$ (similar to techni-ρ)

Inclusion of Gravity ?

- **Modern physics rests on two foundations:**

- **Einstein's General Theory of Relativity (GR) – theoretical framework for understanding the universe on the largest scales – stars, galaxies etc.**
- **Quantum Mechanics (QM) - theoretical framework for understanding the universe on the smallest scales – molecules, atoms, electrons, quarks etc.**

- **Both experimentally confirmed to tremendous accuracy**

- **BUT as currently formulated GR and QM cannot both be right ??**
- GR and QM simultaneously needed in extreme conditions – inside black holes, first moments of Big Bang – 'tiny yet incredibly massive'

Inclusion of Gravity ?

In 3-D(∞ large dim): Gravity Law

$$F = \frac{GMm}{r^2}$$

e.g. in 2-D (∞ large dim):

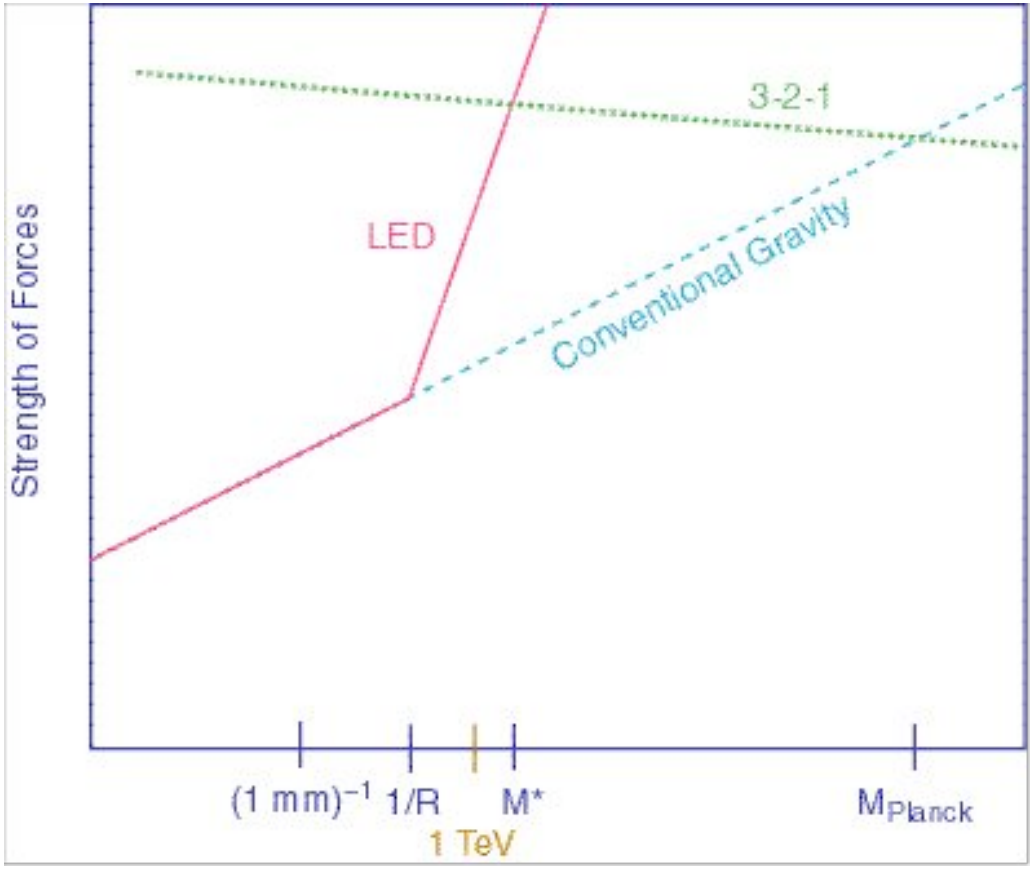
$$F \propto \frac{1}{r}$$

Law of gravity depends on no. of space dimensions ! And the running

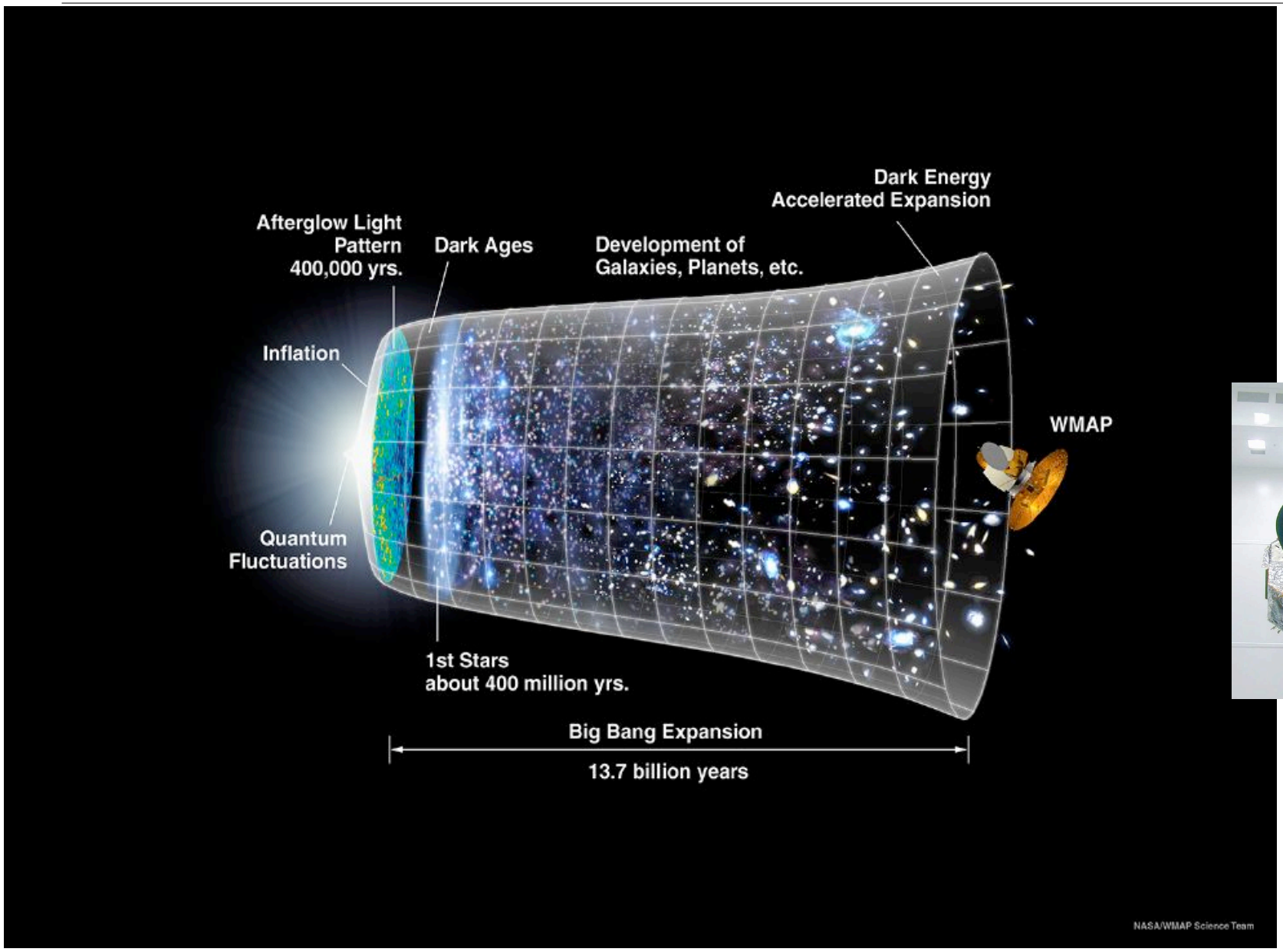
Space-time may have more dimensions than 4 !! EXTRA DIMENSIONS

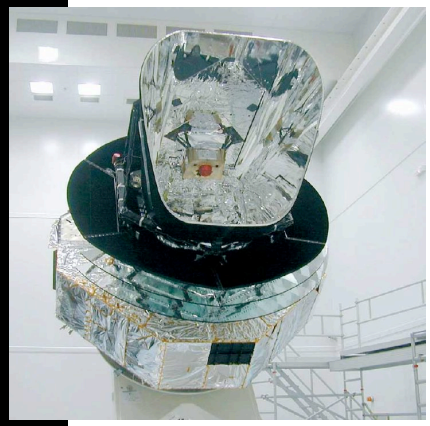
We do not see them because they are curled-up
Many signatures
Detectable in ATLAS and CMS !
Similar to SUSY signatures

If gravity does change at some mass scale 1/R, then the Planck mass could be a "mirage"



The Standard Model of Cosmology





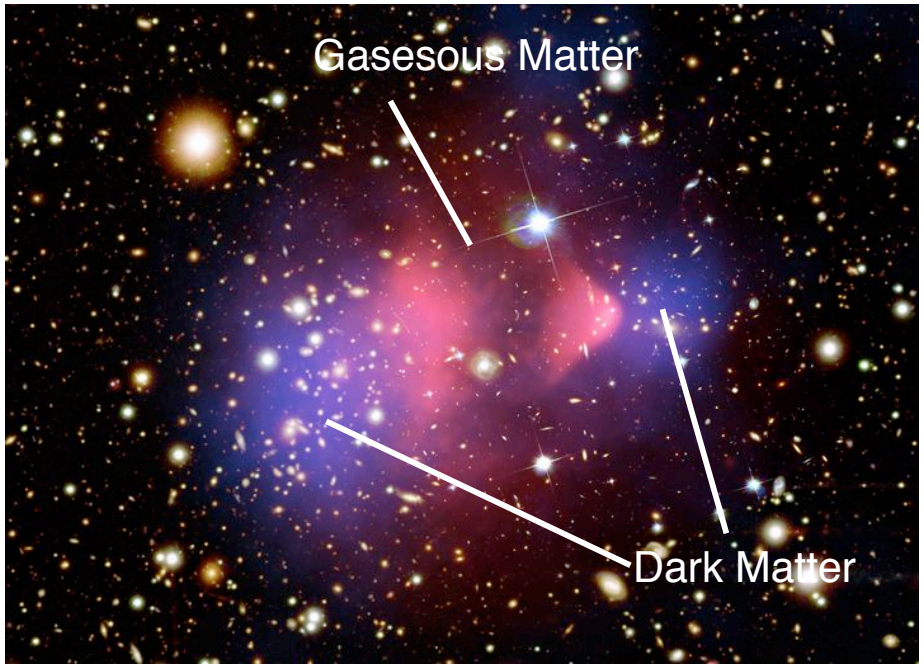
Potential Impact of Planck Satellite

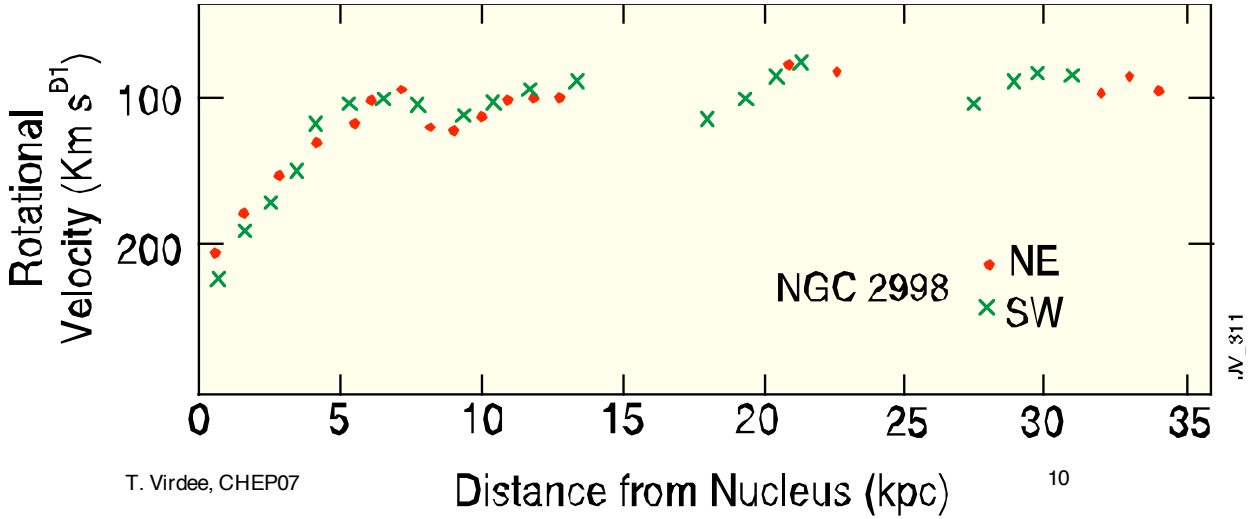
Dark Matter

Collision of two galaxies
"Bullet Cluster"
Clowe et al.

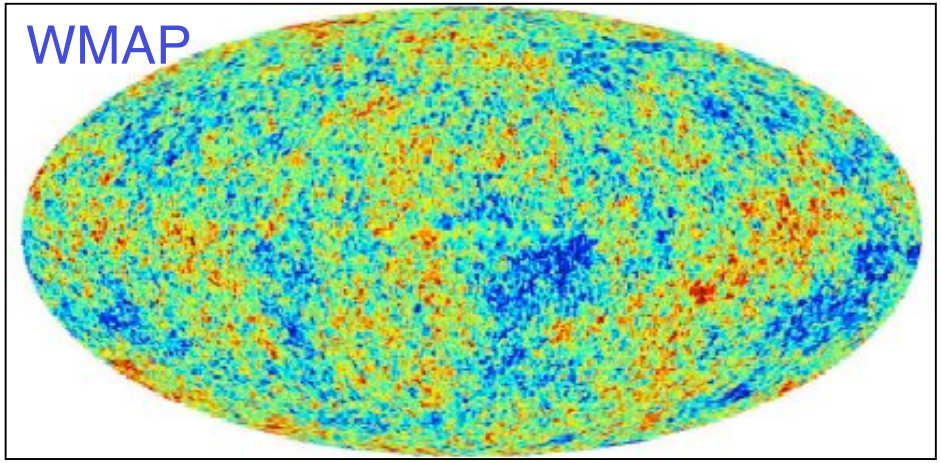
Direct evidence for collisionless Dark Matter

Chandra, Magellan, HST, Gravitational Lensing

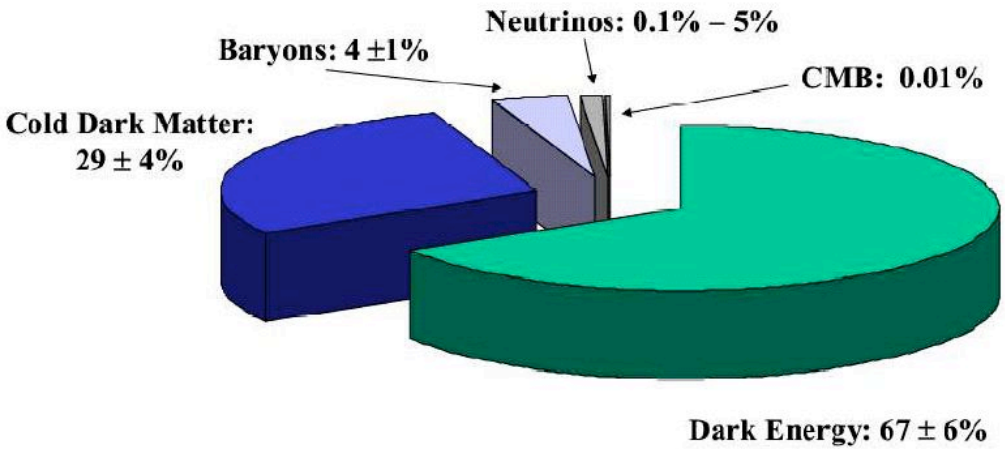


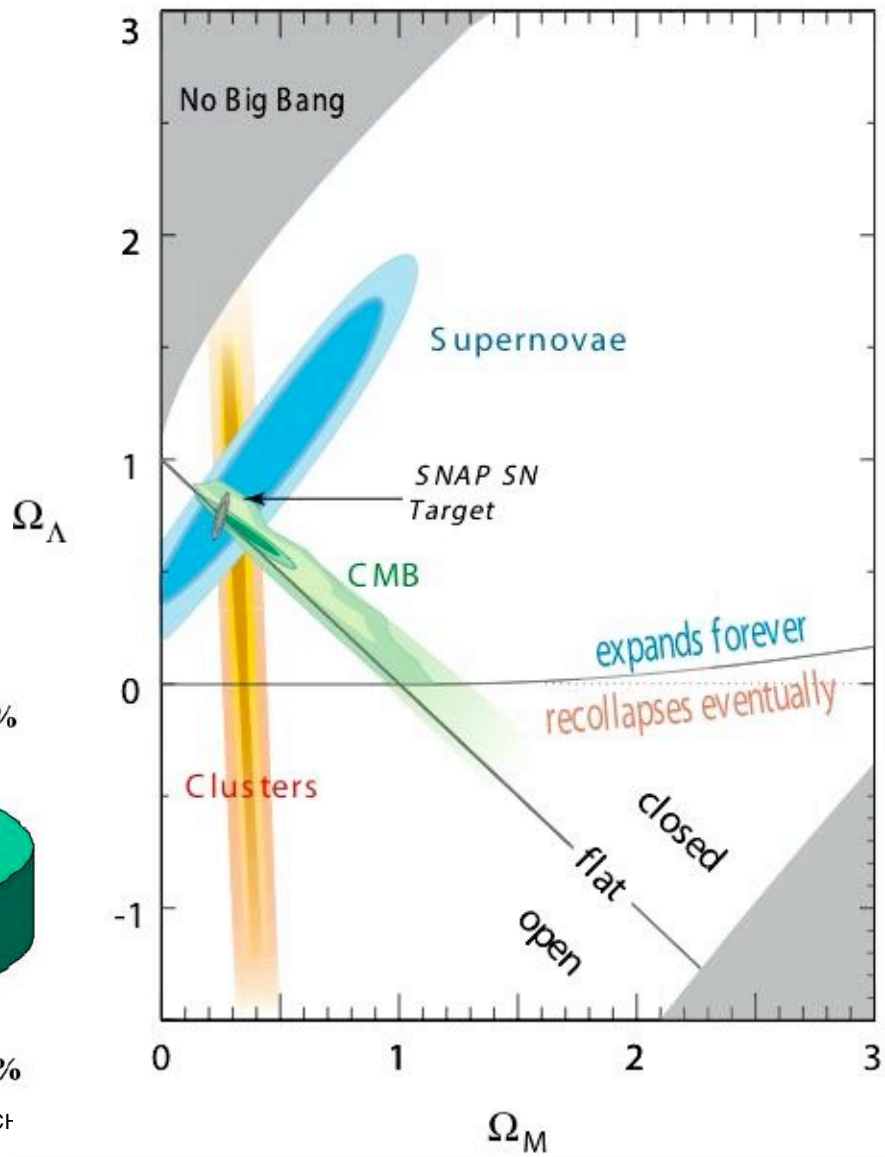


SM of Cosmology: Content of the Universe



Convergence Model





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Q's for SM of Cosmology and Particle Physics

J. Ellis & D. Nanopoulos
astro-ph/0411153

What is the origin of inflation ?
Front-runner: elementary scalar field (inflaton) analagous to the Higgs field of the SM_{PP} !

What is the origin of dark energy?
Remnant of some elementary scalar field analagous to the Higgs field ? May need a quantum theory of gravity to really understand it.

What is the origin of dark matter?
Some sort of WIMP - mass scale for a thermal relic dark matter particle coincides with the mass required to stabilize mass hierarchy with supersymmetry !

What is the origin of matter?
Thought to be linked to the small asymmetry between matter and antimatter which in turn thought to be possible because of the proliferation of particle types !

What is the origin of the Big Bang?
Ultimate challenge for the quantum theory of gravity !

LHC Accelerator

The LHC is now in its final installation and commissioning phase

To reach the required energy in the existing tunnel, the dipoles operate at 1.9 K in superfluid helium.

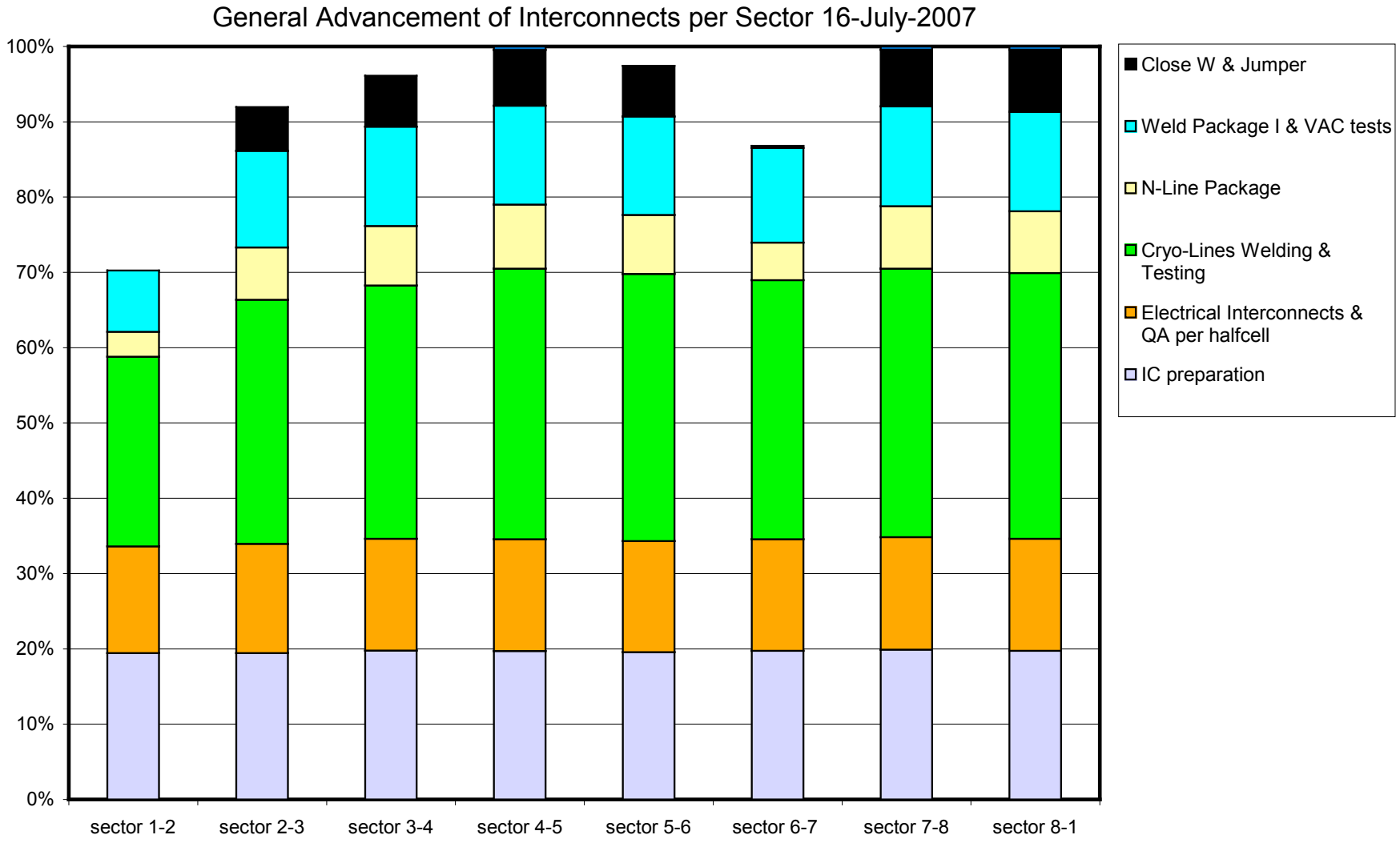
wrt Tevatron

B-field	x 1.5
luminosity	x 20
collimation efficiency	70 -> 96 %
beam stored energy	x 100 (300 MJ)

Installation & Interconnection of Magnets

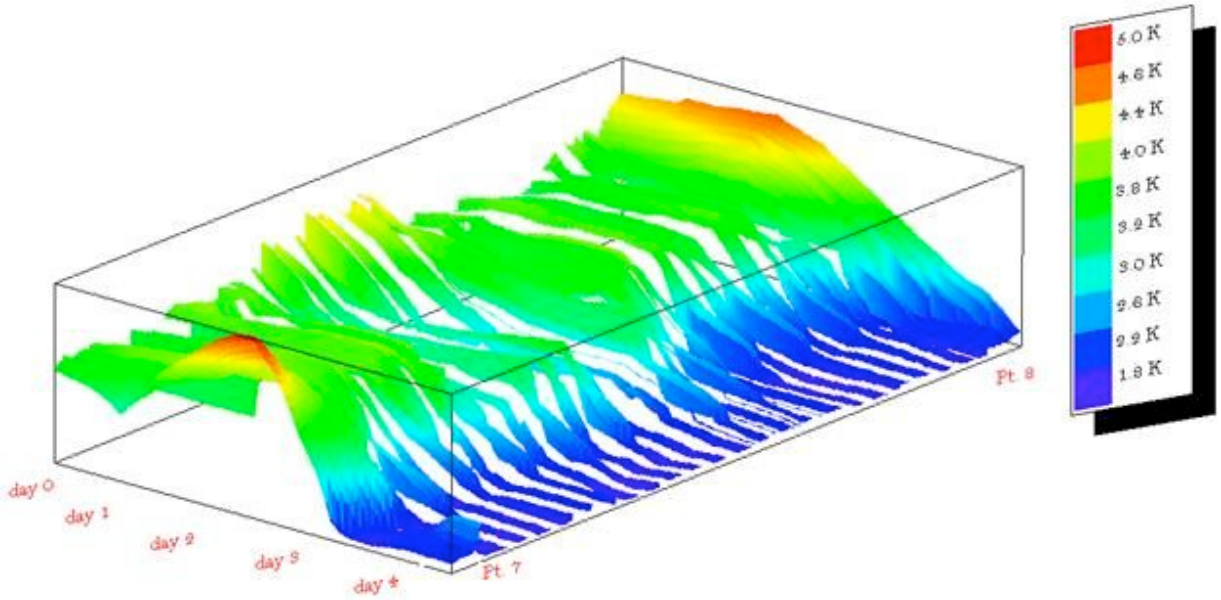
Interconnections

Interconnection of Magnets



First Cooldown of Sector 7-8

Magnet temperature profile along Sector 7-8 during final cool down to He II



- From RT to 80K pre-cooling with LN2. 1200 tons of LN2 (64 trucks of 20 tons). Three weeks for the first sector.
- From 80K to 4.2K. Cooldown with refrigerator. Three weeks for the first sector. 4700 tons of material to be cooled.
- From 4.2K to 1.9K. Cold compressors at 15 mbar. Four days for the first sector.
- First sector cooled down to nominal temperature and operated with superfluid helium; teething problems with cold compressor operation have now been fixed.

Warmup Sector 7-8

The consolidation work with the sector at room temperature is advancing well.

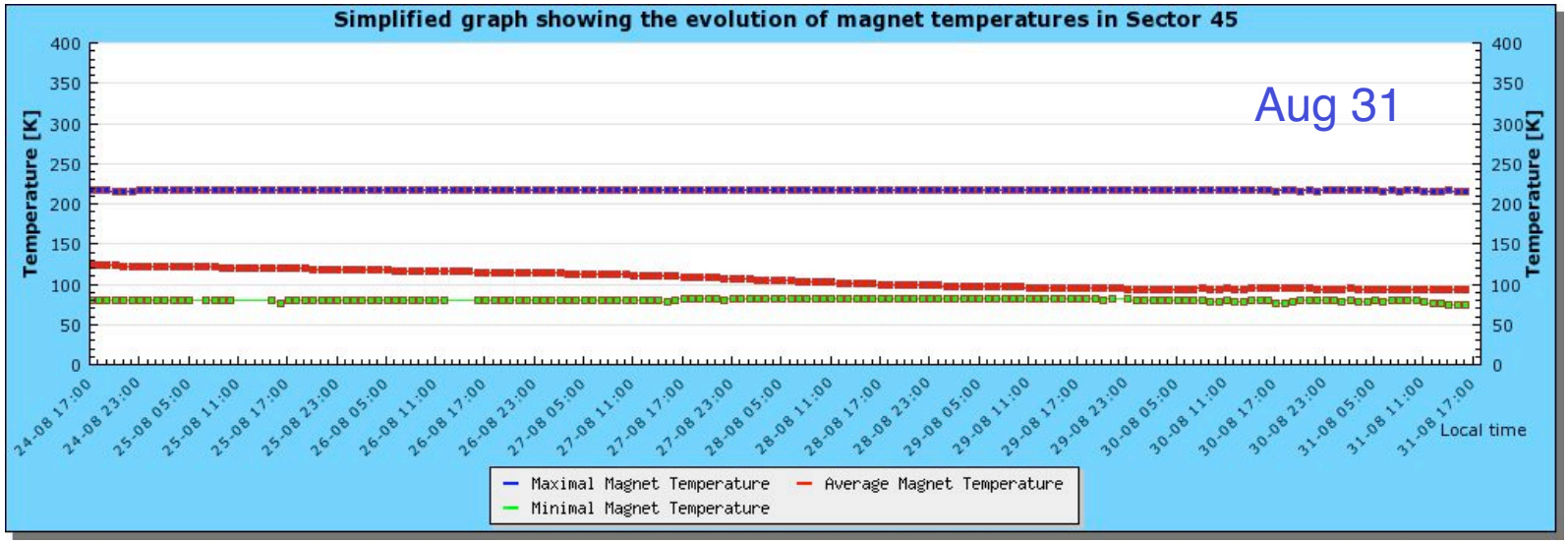
The faulty dipole (1055) has been already replaced;
Different leaks found during the pressure tests are being localized and repaired;

Inner triplet quadruple (Q1L8), which had to be brought to the surface to fix a spider that had been damaged during the pressure tests, is already repaired and installed;

In order to check the state of all the **plug-in** modules on the beam lines, all the cold interconnects of the sector are being X-rayed

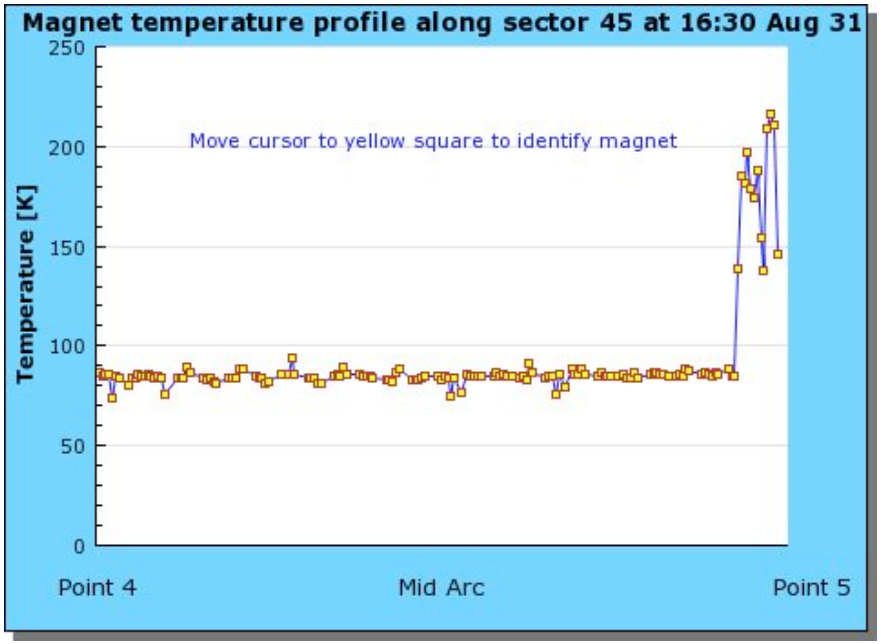
On Friday August 31st, out of the 100 X-rayed interconnects (out of 183) in the arc, one presented plug in modules with buckled RF fingers;

Cooldown of Sector 4-5



Active cool down **restarted** August 7: first, the cells which had been warmed up for the repair, were cooled down to the temperature of the majority of the cells which had been left floating around 180K during the intervention.

All magnets of sector 45 are now at 80K; this excludes the vacuum sector A7L5 where there is a leak. This leak will be repaired after the ElQA campaign which starts on Monday September 3rd.



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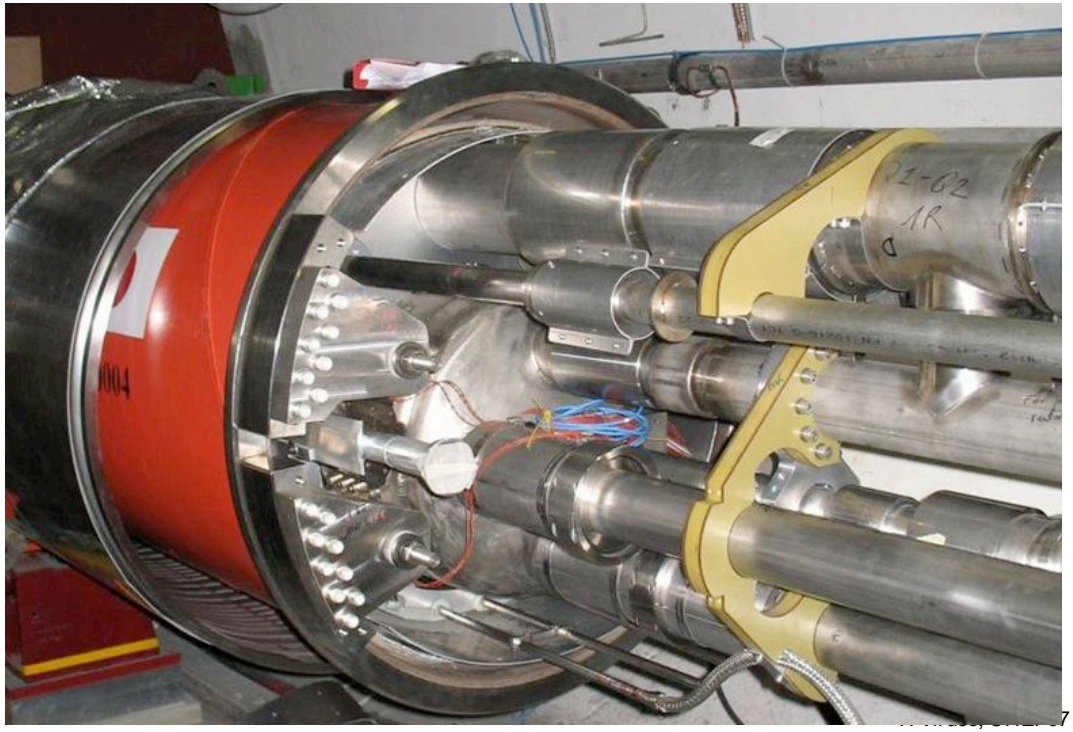
Triplet Repair

An inner triplet assembly of quadrupole magnets at Point 8-Right of the LHC was successfully tested in the accelerator tunnel on Friday, July 13.

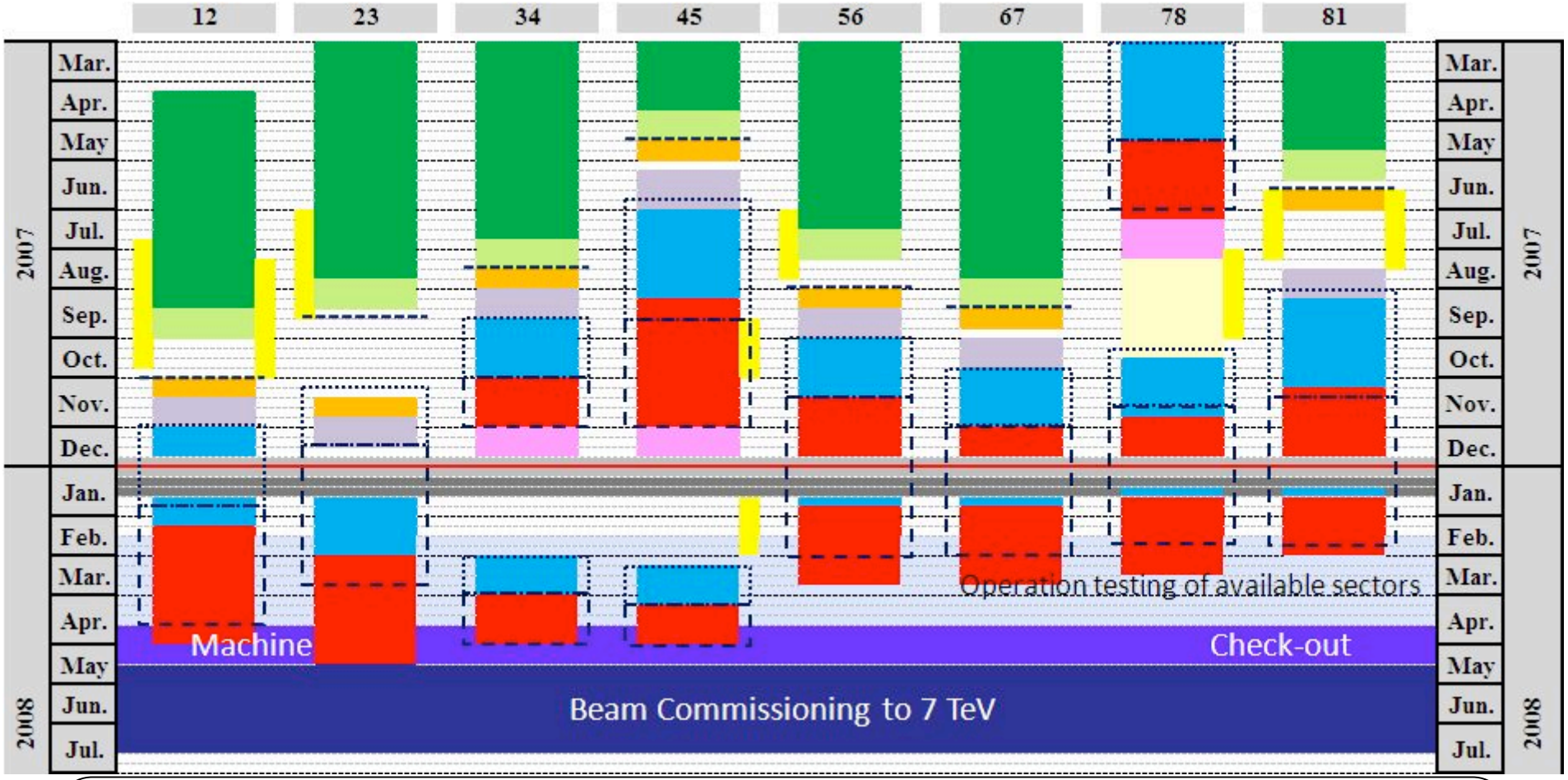
Q1 and Q3 magnets, at either end of the triplet assembly fitted with a set of four metal cartridges of a compound design consisting of an aluminum alloy tube and an Invar rod to allow them to function over a broad range of temperatures.

Almost all of the quadrupole magnets have been repaired



A Q1 magnet assembly with cartridges held in place by the four earlike brackets bolted to the outer flange

Schematic of the LHC General Schdeule (5July)



General schedule Baseline rev. 4.0

- Global pressure test &Consolidation
- Cool-down
- Powering Tests

- Interconnection of the continuous cryostat
- Leak tests of the last sub-sectors
- Inner Triplets repairs & interconnections
- Global pressure test &Consolidation

- Flushing
- Cool-down
- Warm up
- Powering Tests

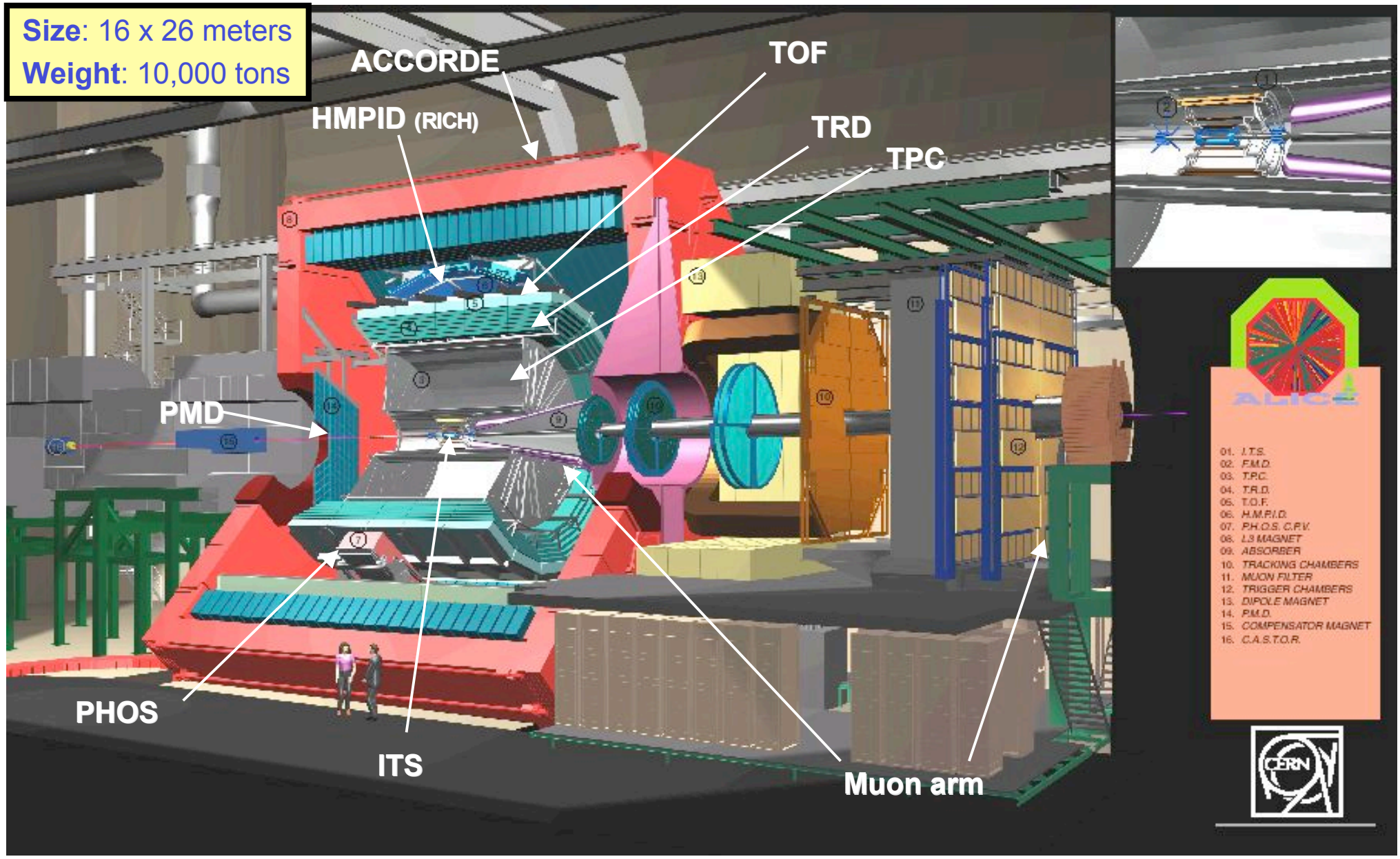
General LHC schedule

L. Evans

- Engineering run originally foreseen at end 2007 now precluded by delays in installation and equipment commissioning.
- 450 GeV operation now part of normal setting up procedure for beam commissioning to high-energy
- General schedule has been revised, accounting for inner triplet repairs and their impact on sector commissioning
  - All technical systems commissioned to 7 TeV operation, and machine closed April 2008
  - Beam commissioning starts May 2008
  - First collisions at 14 TeV c.m. July 2008
  - Luminosity evolution will be dominated by our confidence in the machine protection system and by the ability of the detectors to absorb the rates.
- No provision in success-oriented schedule for major mishaps, e.g. additional warm-up/cooldown of sector

LHC Experiments

ALICE


Size: 16 x 26 meters
Weight: 10,000 tons
ACCORDE
HMPID (RICH)
TOF
TRD
TPC
PMD
PHOS
ITS
Muon arm
01. I.T.S.
02. F.M.D.
03. T.P.C.
04. T.R.D.
05. T.O.F.
06. H.M.P.I.D.
07. P.H.O.S. C.P.V.
08. L3 MAGNET
09. ABSORBER
10. TRACKING CHAMBERS
11. MUON FILTER
12. TRIGGER CHAMBERS
13. DIPOLE MAGNET
14. P.M.D.
15. COMPENSATOR MAGNET
16. C.A.S.T.O.R.

ALICE Status

Establish and study quark-gluon plasma

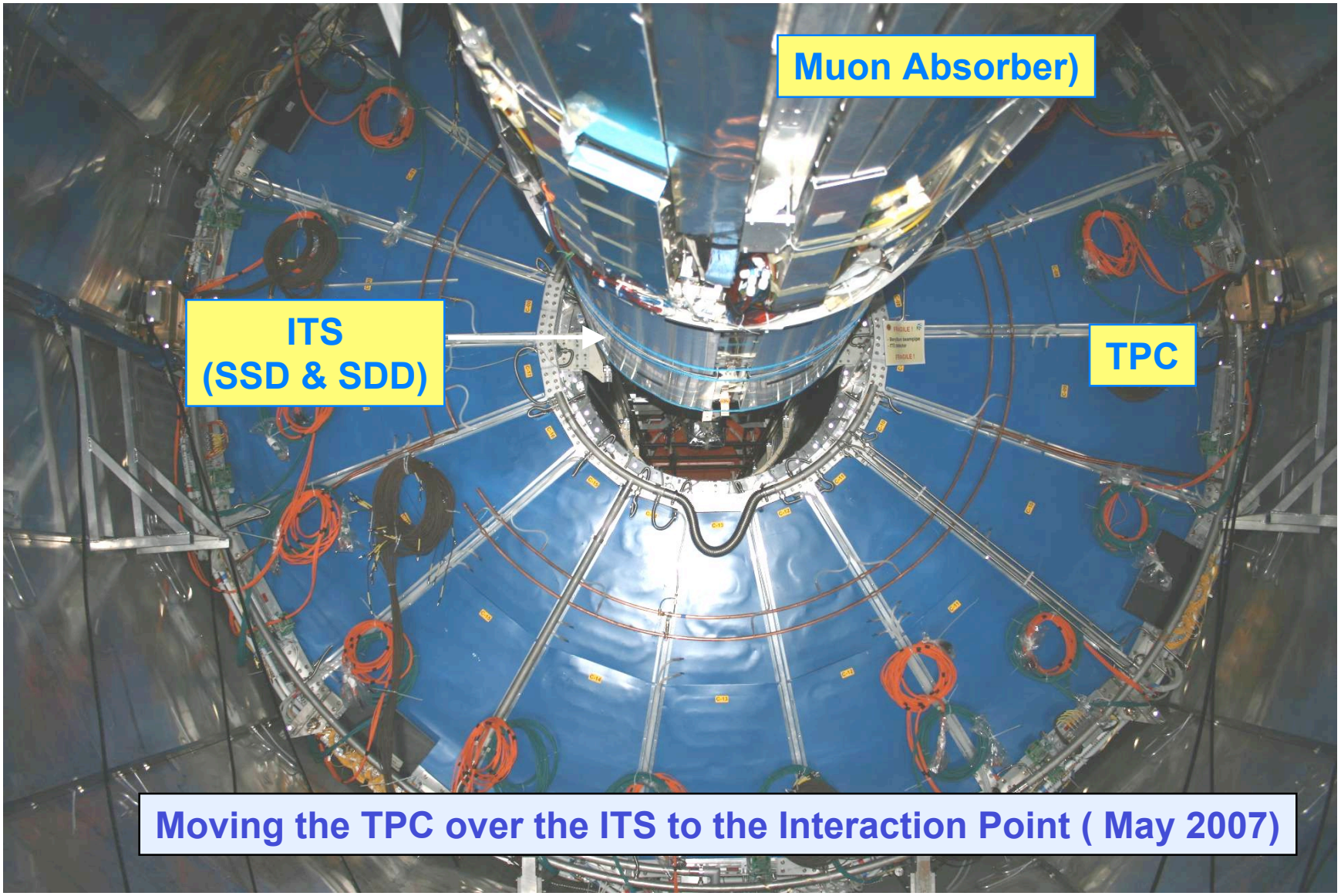
Installed: TPC, ITS (pixel/drift/strips), trigger detectors, DAQ, HLT
Installation progressing: HMPID, TOF modules, TRD module, muon stations,
Commissioning: Being done - of the cosmic trigger (ACORDE) and the Central Trigger processors (CTP)and the installed TRD & TOF & FMD modules.
First cosmics triggers in the pit. TRD had first cosmic run.

Planning: installation continues until mid October, followed by cosmics run (magnet on).
January 2008 to mid-February: Installation of further TOF/TRD/Phosmodules.
Starting mid/end February: Cosmics until beam arrives

Expected start-up configuration for 2008
Complete: ITS, TPC, HMPID, muon arm, PMD, trigger dets (V0, T0, ZDC,ACCORDE),..
Partially complete: PHOS(3/5), TOF(~15/18), TRD (~5/18), DAQ (20%)

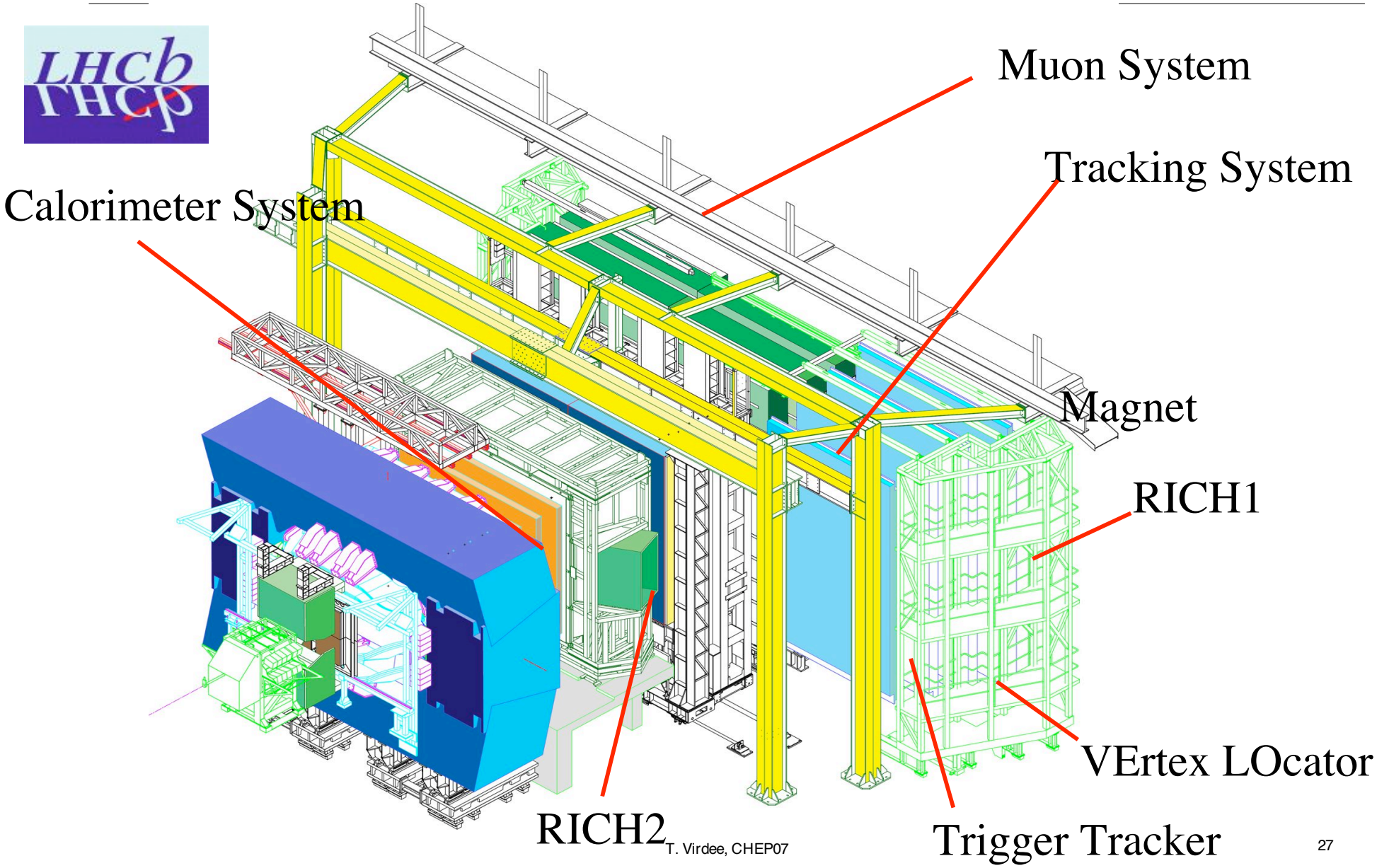
Beyond mid 2008
Complete DAQ capacity (2008/9) complete modular detectors.

ALICE

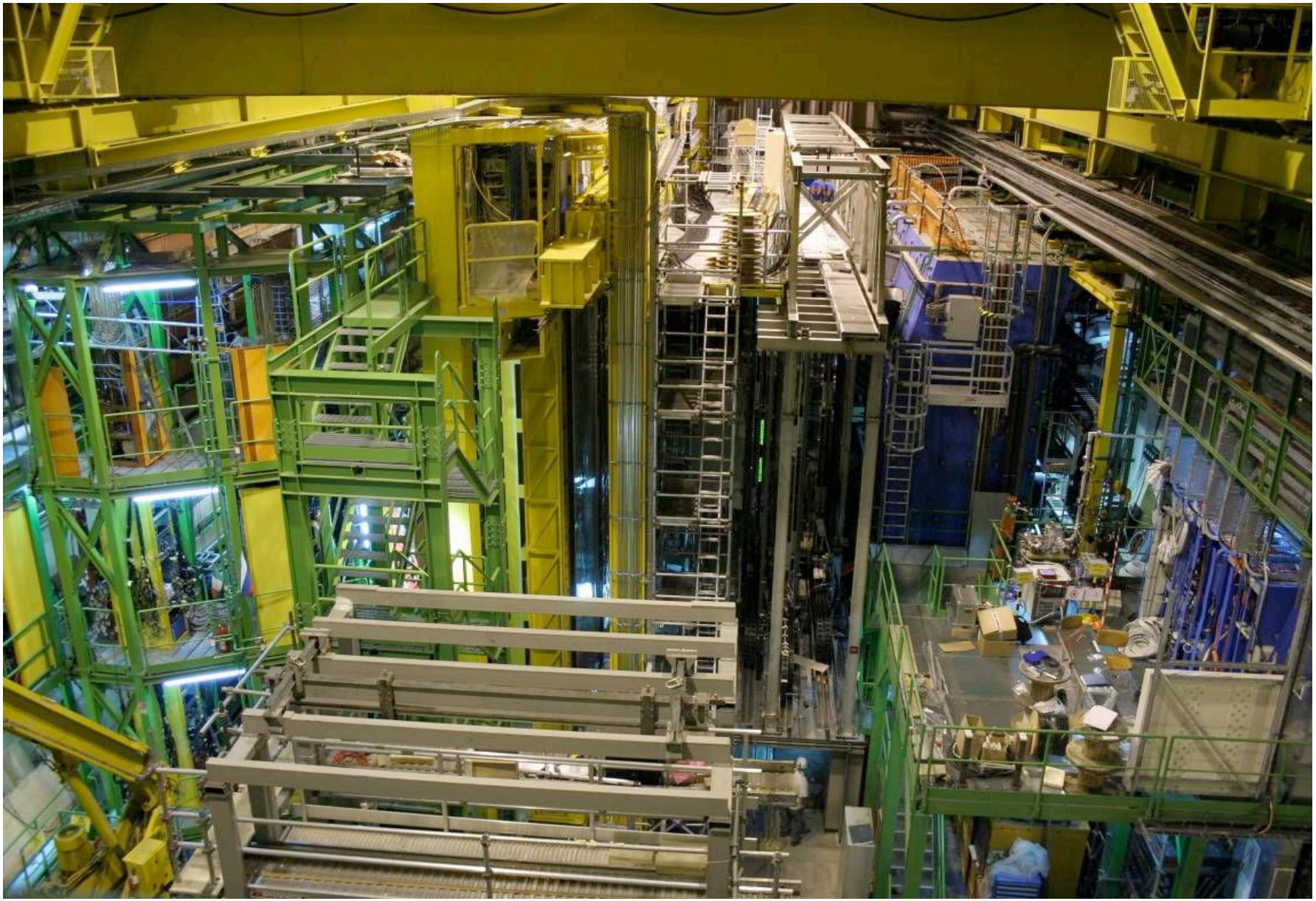


Moving the TPC over the ITS to the Interaction Point (May 2007)

LHCb


Muon System
Tracking System
Calorimeter System
Magnet
RICH1
VErtex LOcator
RICH2
Trigger Tracker

LHCb



LHCb: Status

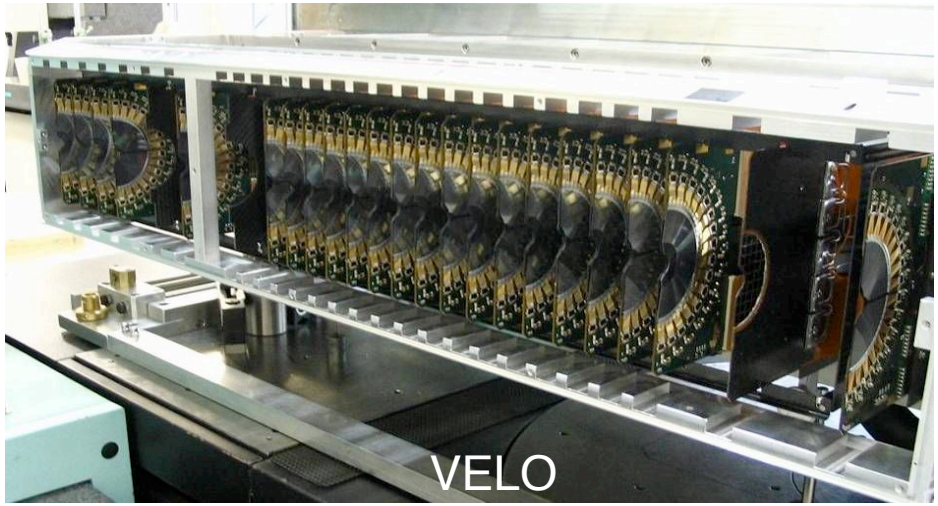
Study CP-violation

Beam pipe: Installed, baked & vacuum tested, now filled with Ne

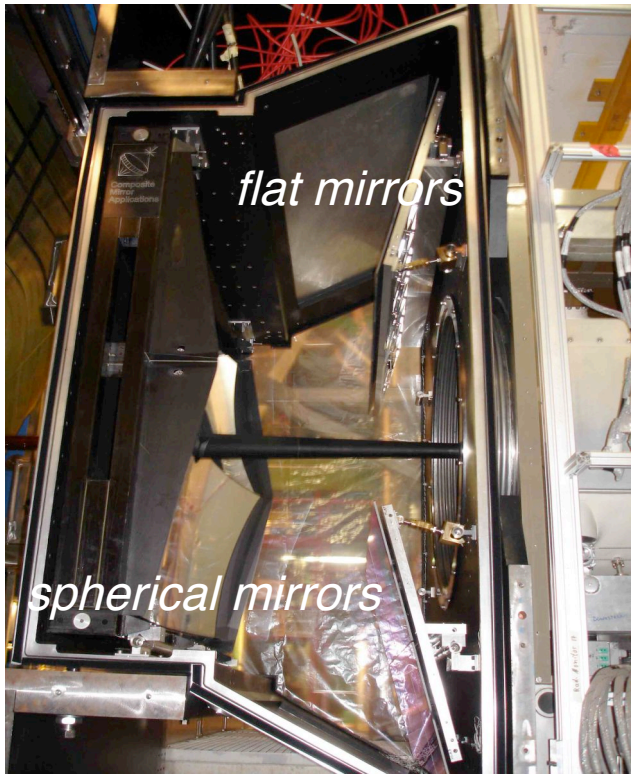
Installed and being commissioned: Outer Tracker, HCAL and ECAL, RICH2, Muon - M2 to M5 chambers

Being Completed/Installed: VELO, RICH1, online system, Lvl-0 Trigger

HLT and software: Baseline framework is in place; continue testing and improving; alignment and calibration ongoing work

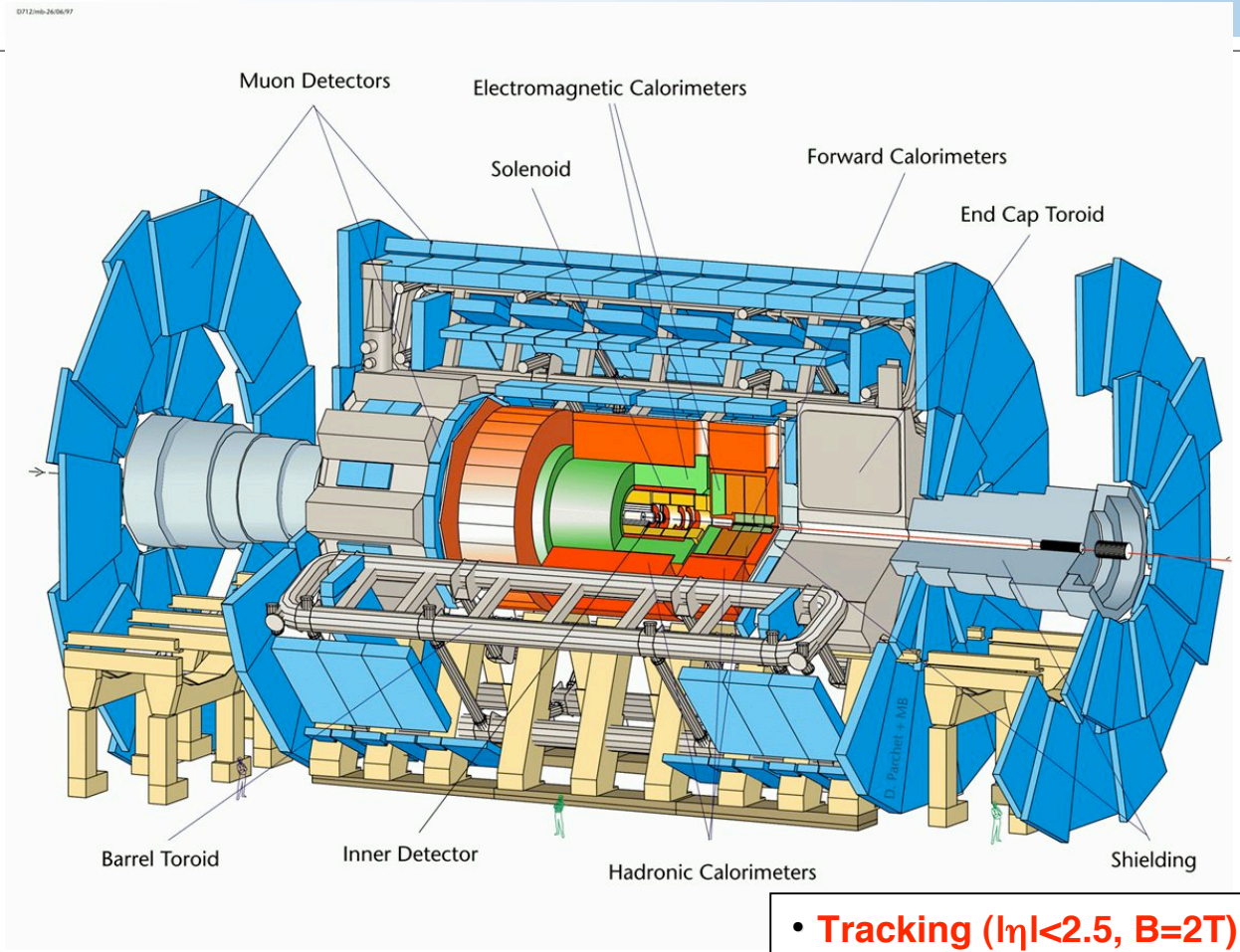


Si sensors installed -metrology, electrical and mechanical tests being done before installing in the vacuum tank



RICH1

ATLAS



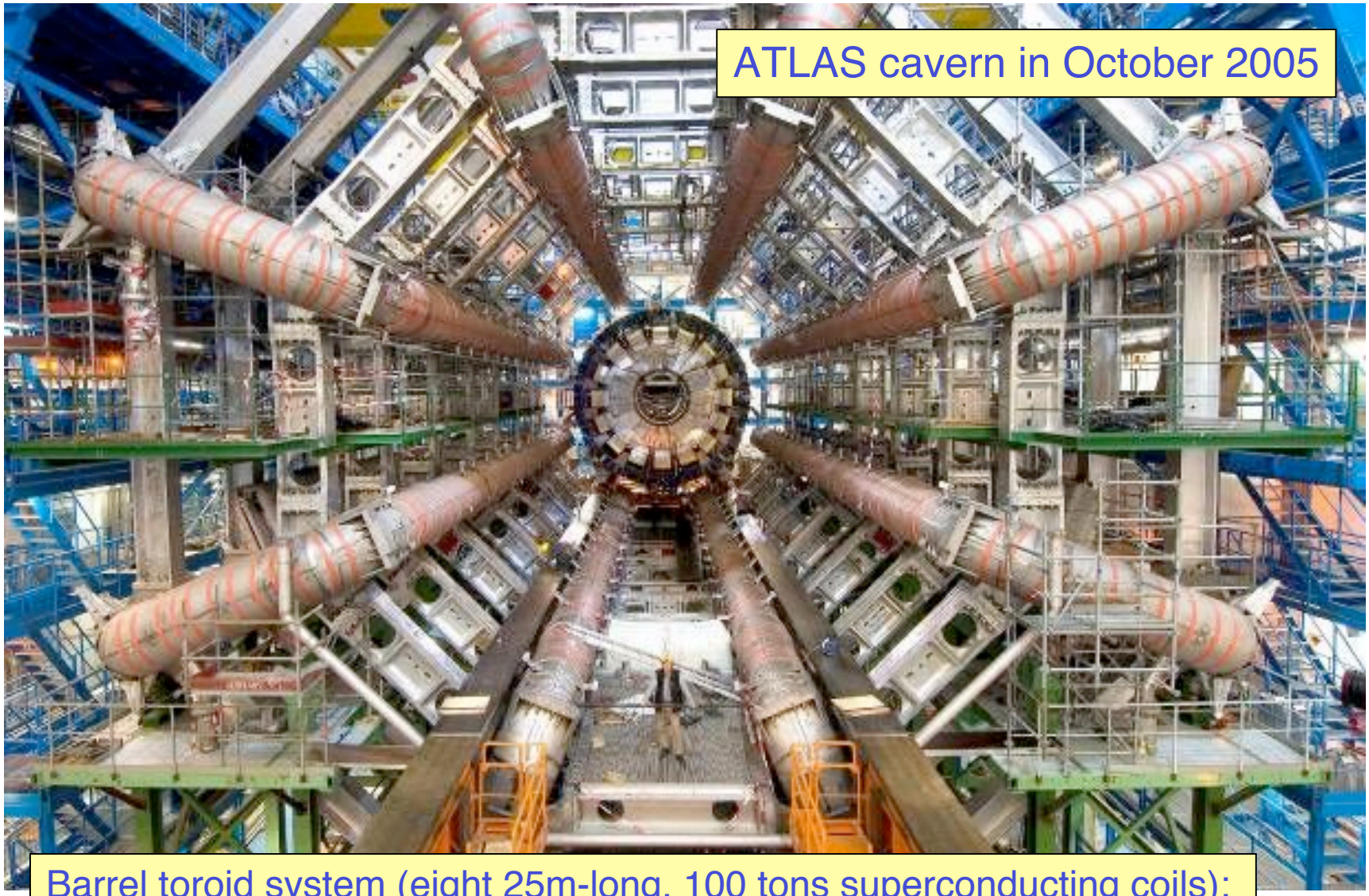
Diameter	*25 m*
Barrel toroid length	*26 m*
End-cap end-wall chamber span	*46 m*
Overall weight	*7000 Tons*

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

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

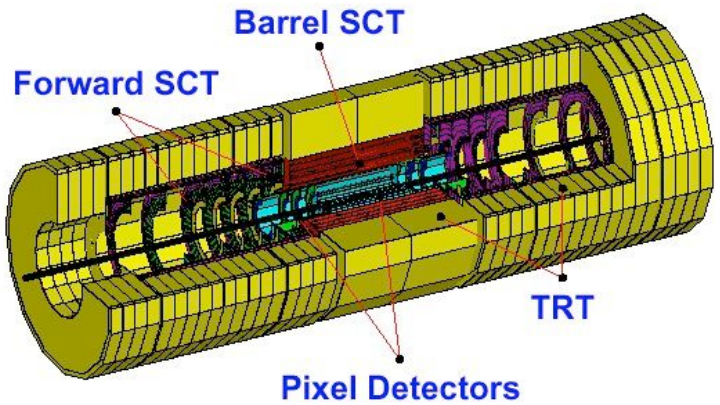
- **Muon Spectrometer ($|\eta|<2.7$)**
  air-core toroids with muon chambers

ATLAS: Central Systems

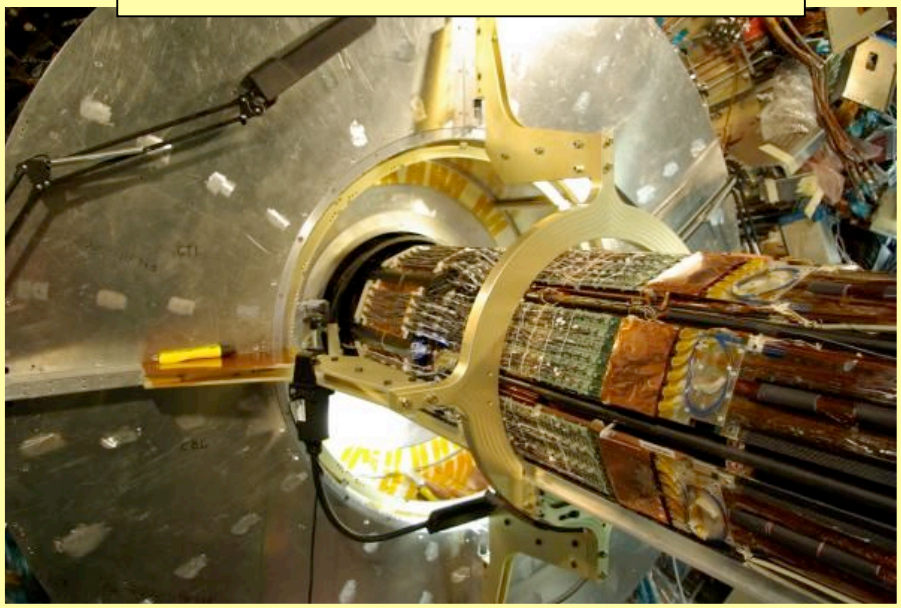


Barrel toroid system (eight 25m-long, 100 tons superconducting coils): tested at full field (20 kA current) in November 2006.

ATLAS: Inner Tracker

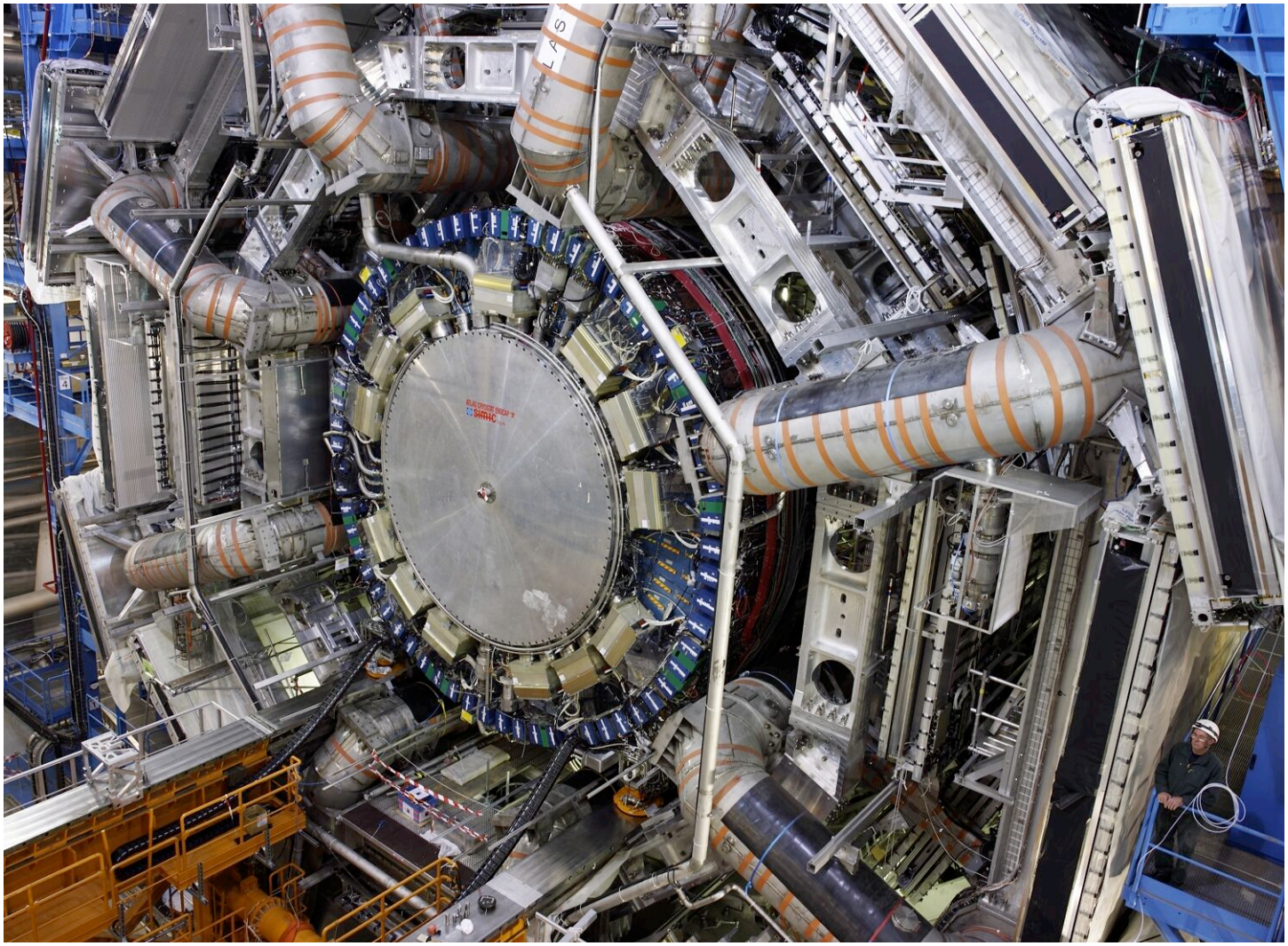


Pixels (+ beam pipe) insertion
June 2007



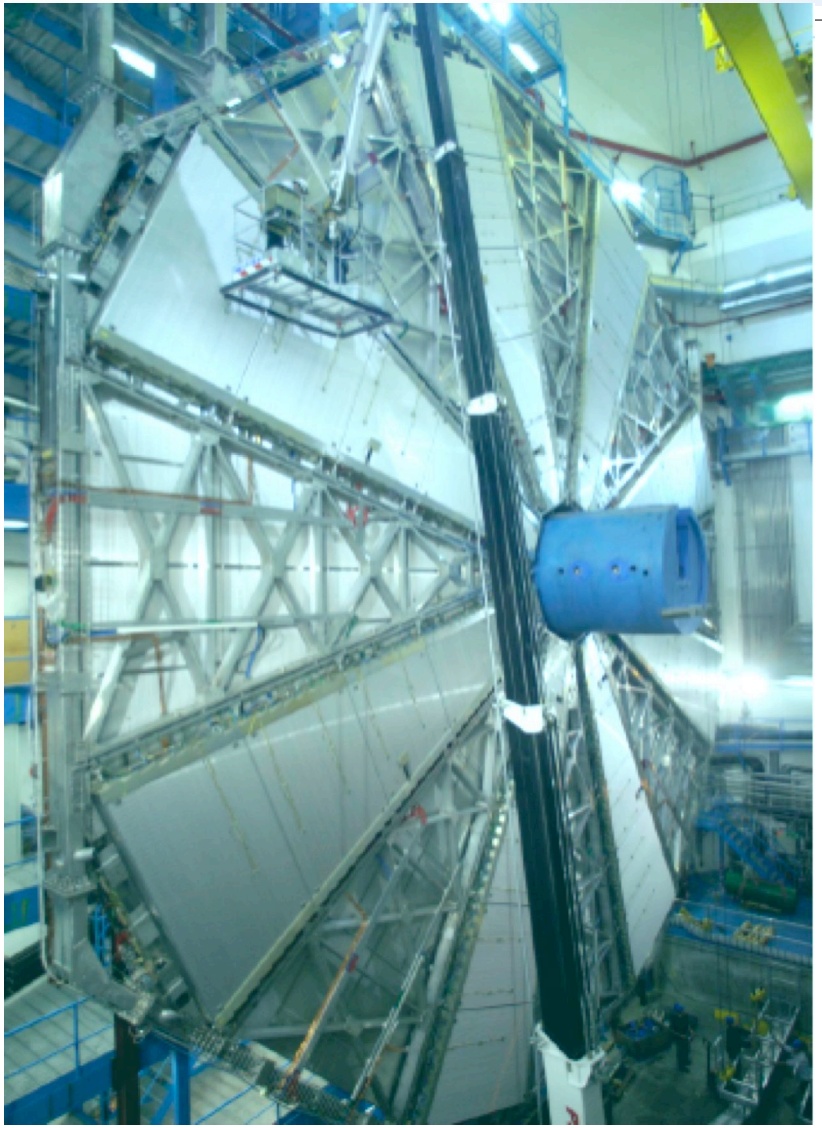
Inner Detector installation
in underground cavern completed

ATLAS: Calorimeters



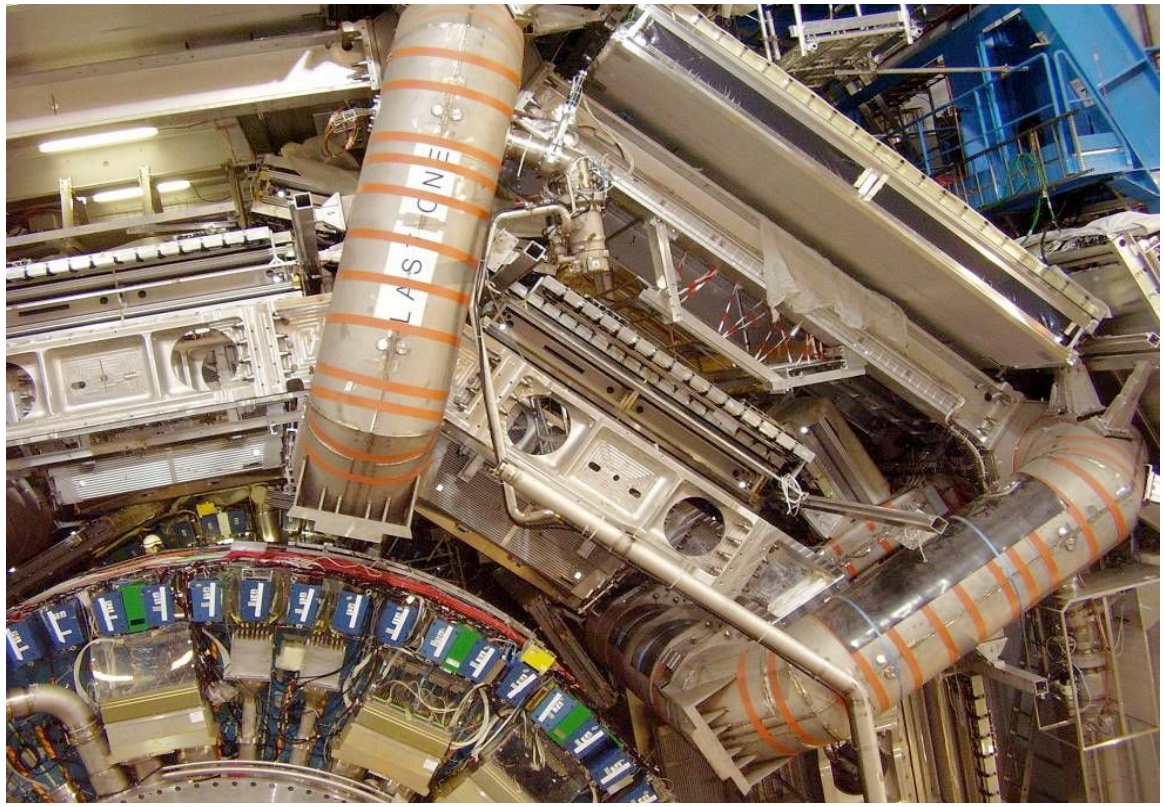
The calorimeter end-cap partially inserted, the LAr end-cap is filled with LAr

ATLAS: Muon System



First complete MDT Big Wheel

Barrel chamber installation is ~ completed
End-cap muon installation has progressed in parallel on both sides (6 of 8 Big Wheels done)

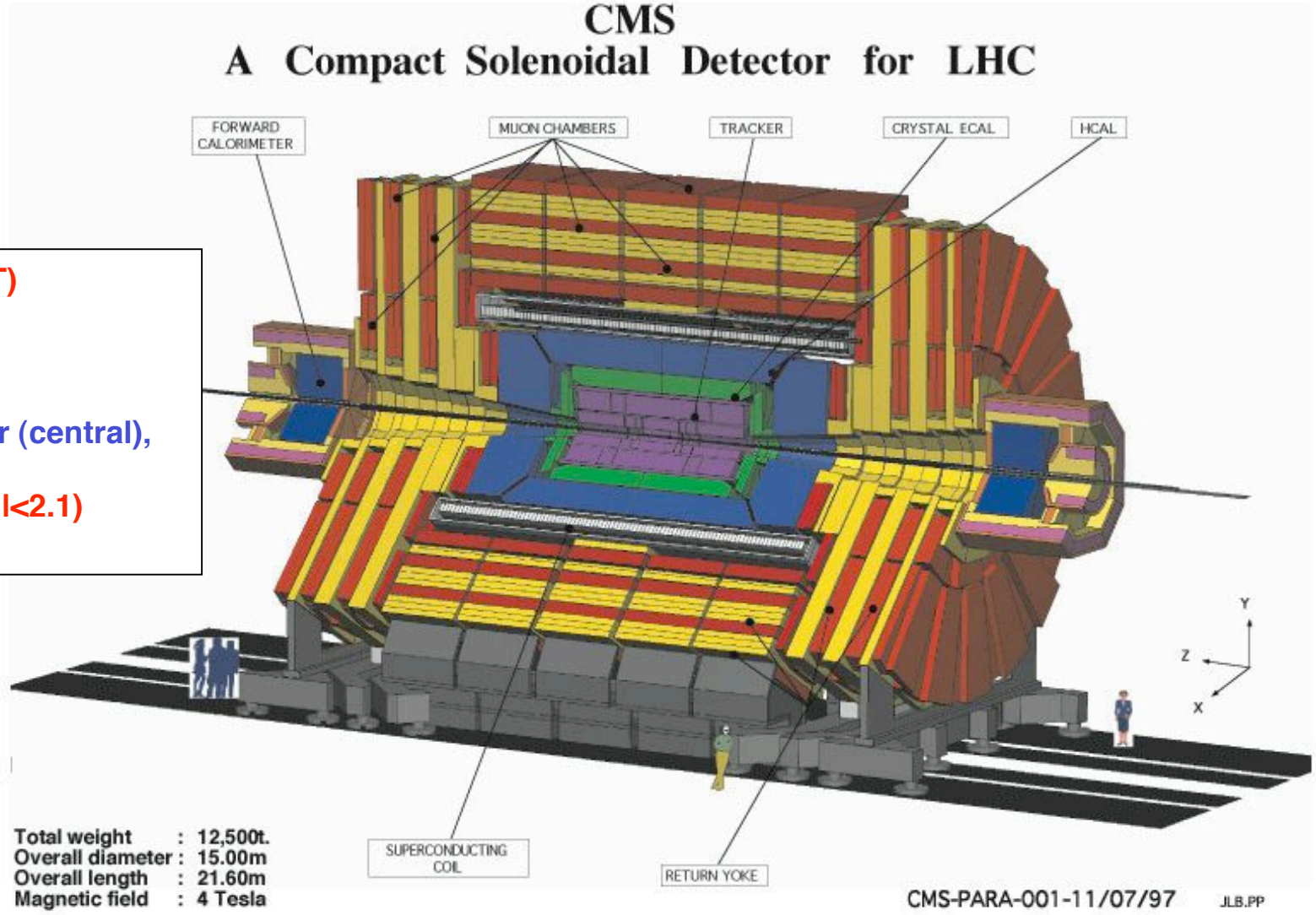


Barrel muon stations

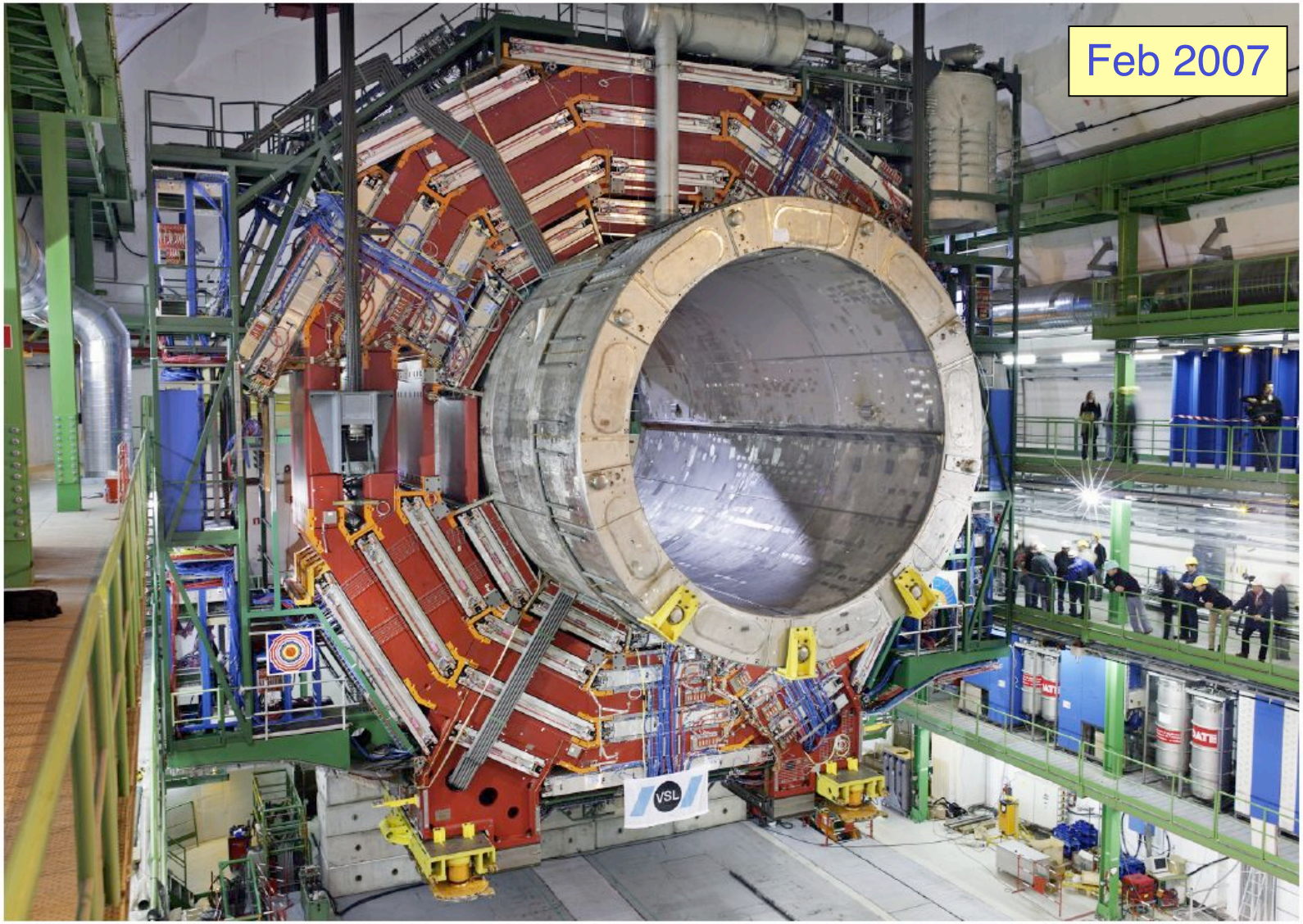
CMS

- Tracking ($|\eta|<2.5$, B=4T)
  - Si pixels and strips

Calorimetry ($|\eta|<5$)
  - EM : PbWO4 crystals
  - HAD: Brass/scintillator (central), Fe/Qfibres (fwd)
- Muon Spectrometer ($|\eta|<2.1$)
  DTs, CSCs, RPCs



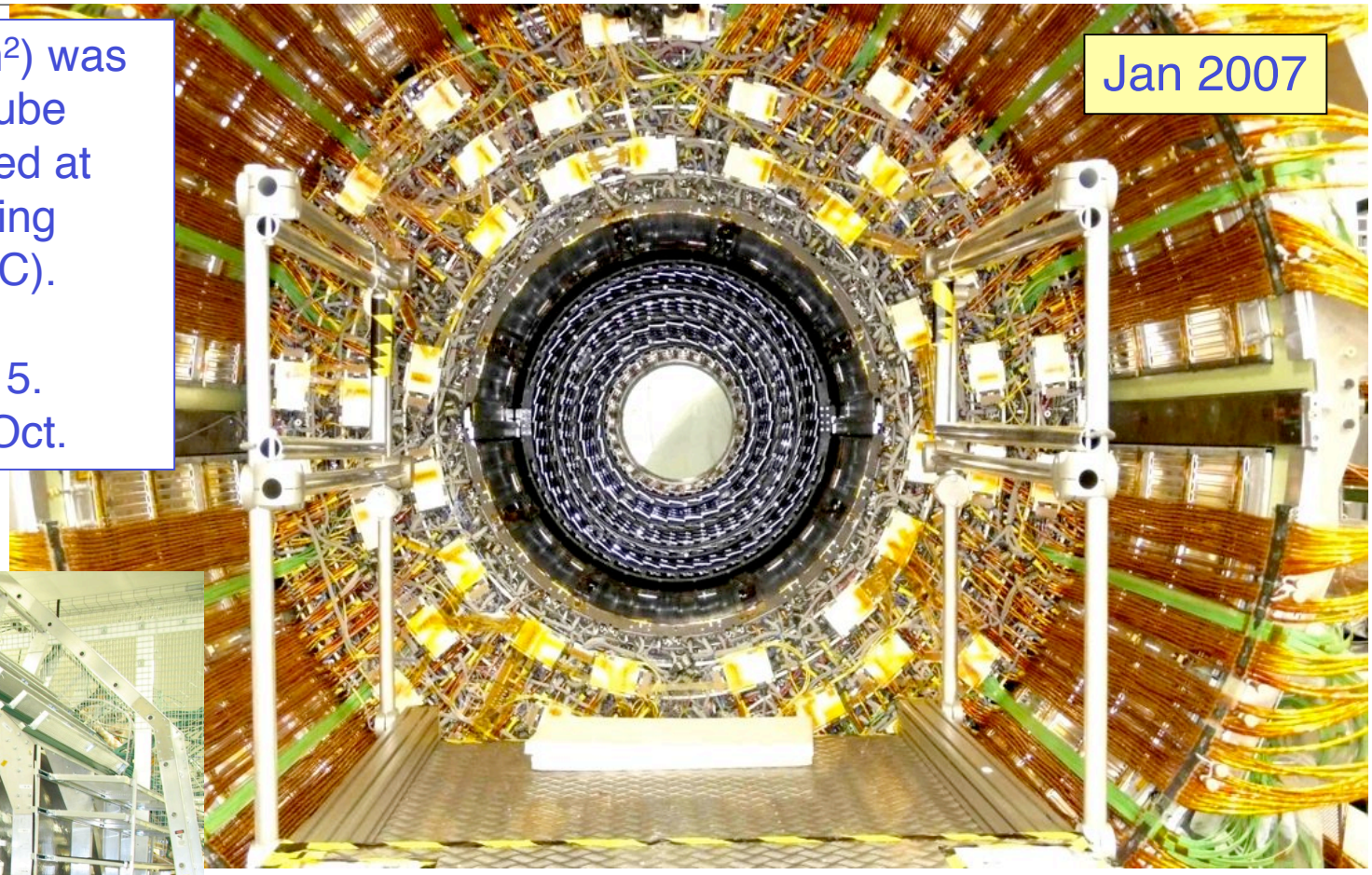
CMS Heavy Lowering: YB0

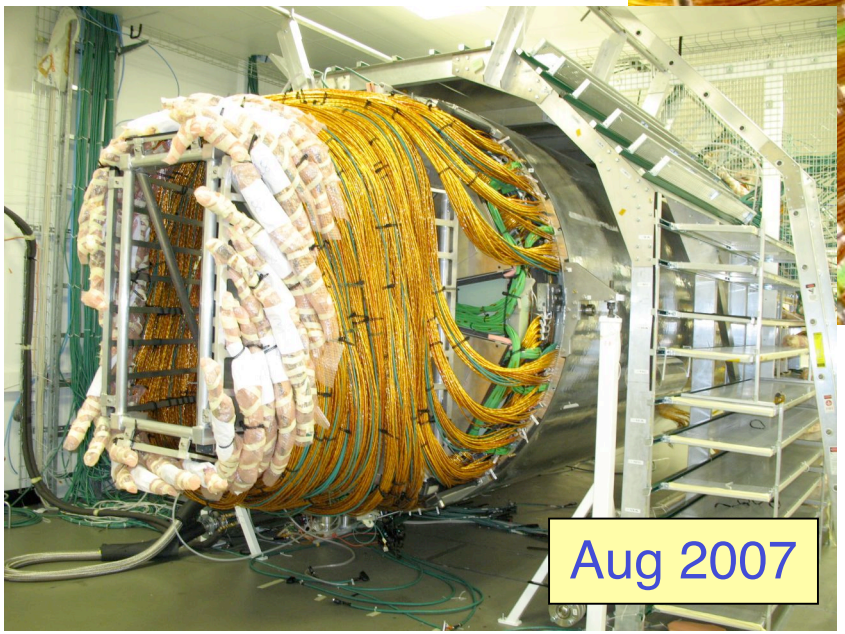


YB0 landing in the CMS experiment hall

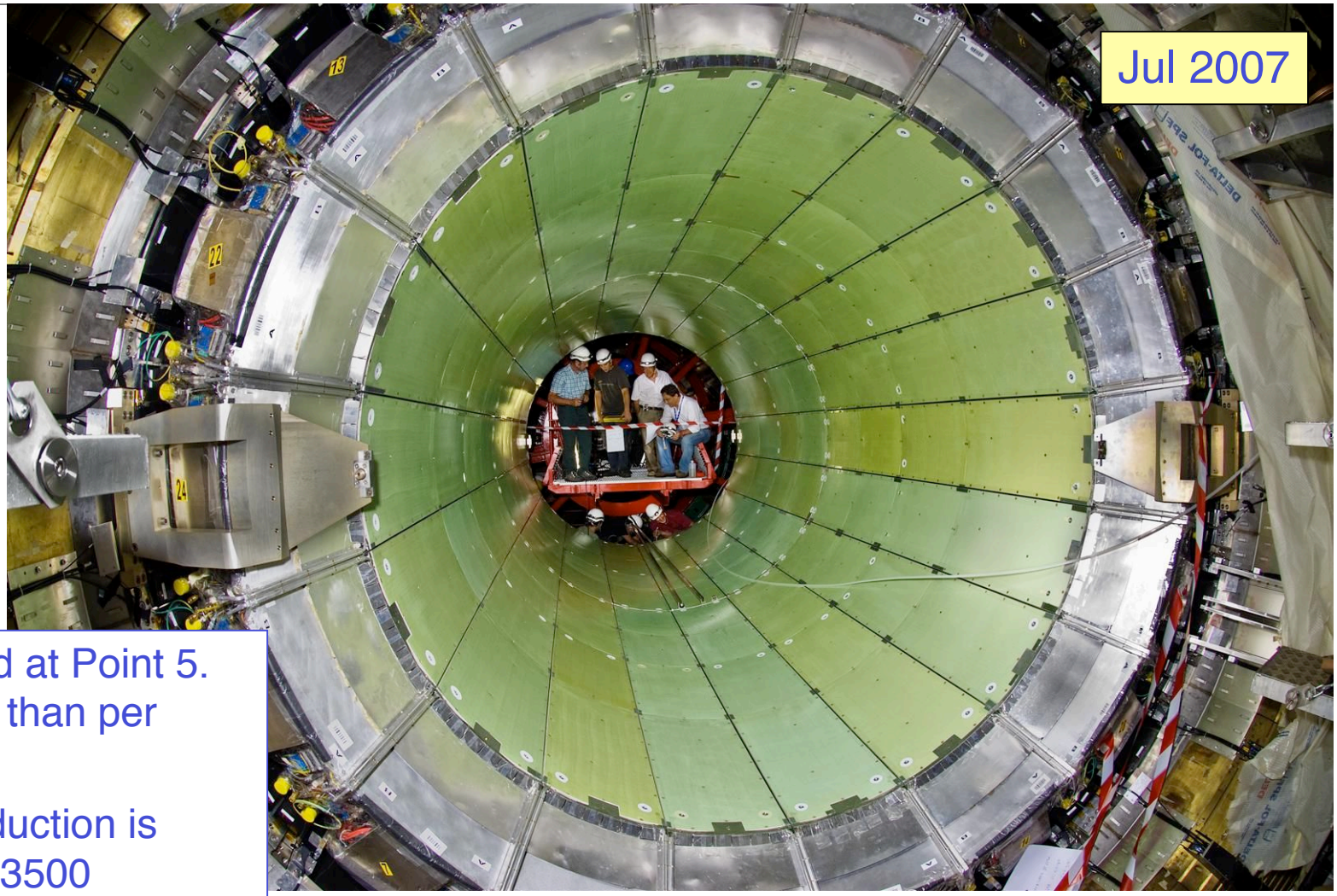
CMS Tracker (Jan07)

- The Silicon tracker (200m^2) was integrated into the support tube end-Mar. Been commissioned at several temperatures including operating temperature (-15°C).
- ~ 5 M cosmics recorded,
- Ready for transport to Pt. 5.
- Will be installed in UX in Oct.





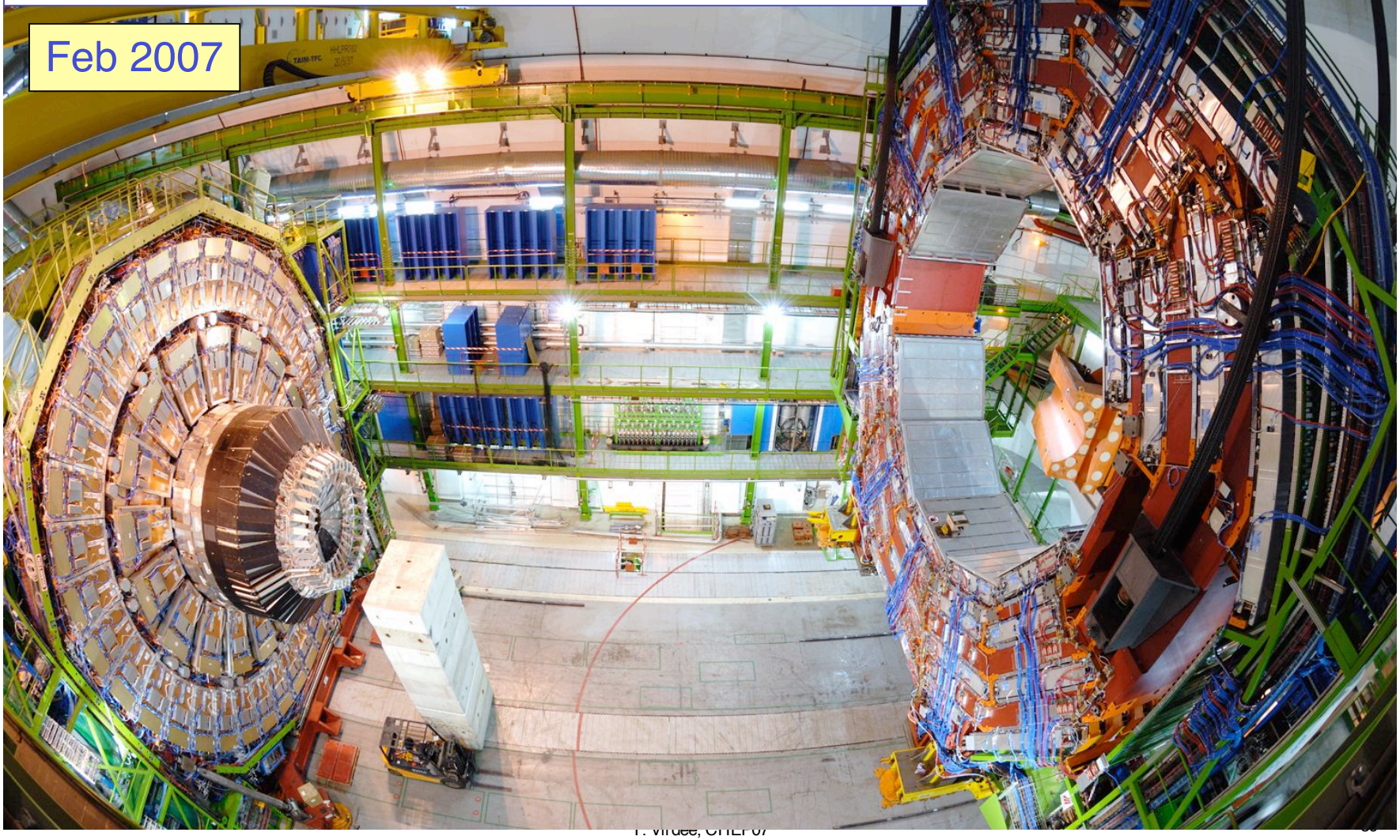
CMS: Barrel ECAL



- Barrel ECAL installed at Point 5. Excellent quality (less than per mille).
- Endcap crystals production is proceeding well: over 3500 crystals now delivered (out of 14750 needed). Last EE crystal will be delivered end-Mar'08.

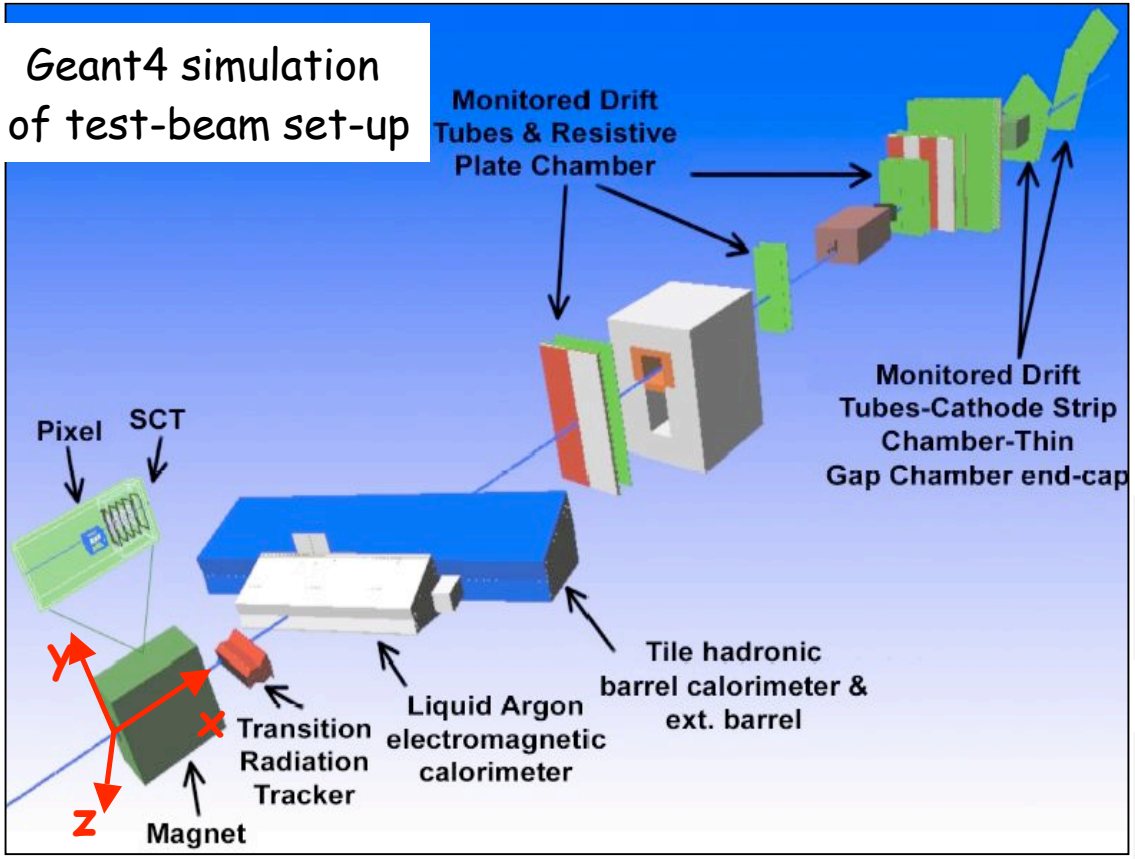
CMS: Muon Chambers

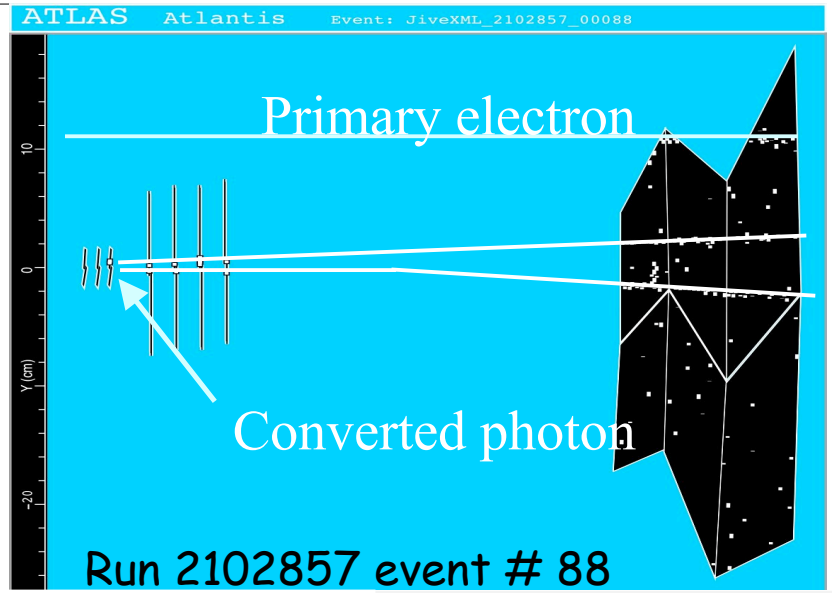
All precision muons chambers installed and tested.
RPC chamber installation will finish in September.

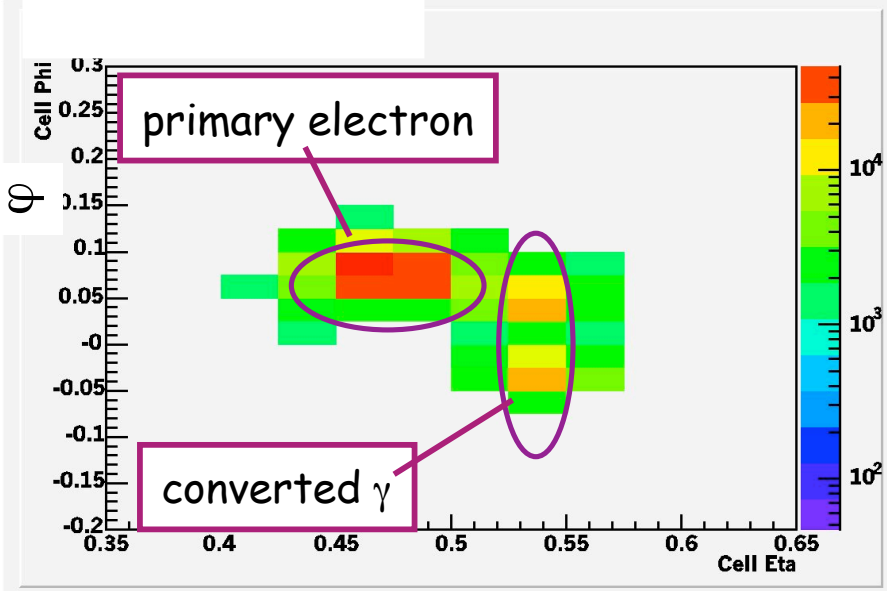


LHC Experiments Commissioning

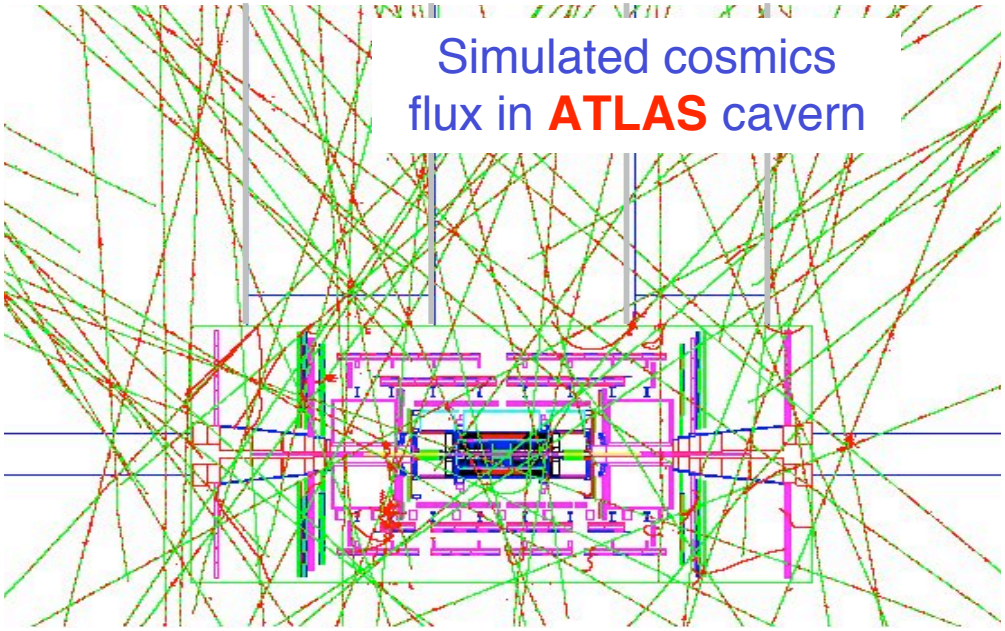
ATLAS: "Vertical Slice" test in CERN H8 beam in 2004

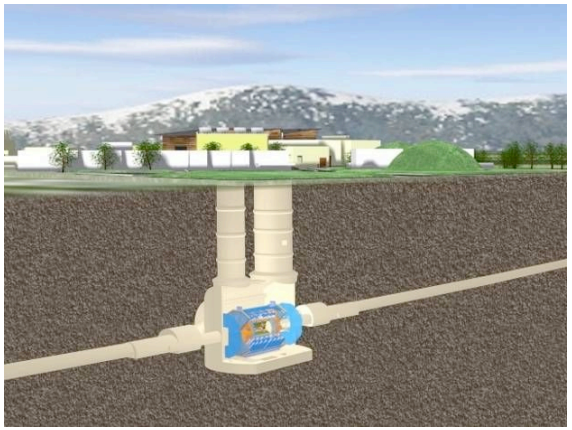






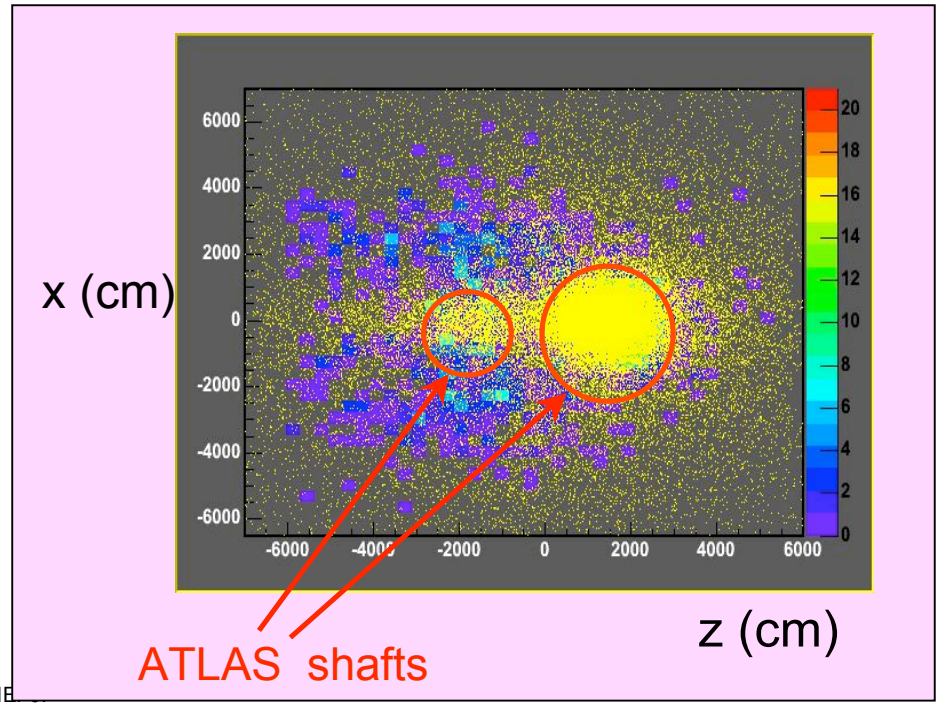
Commissioning *in situ* with Cosmics



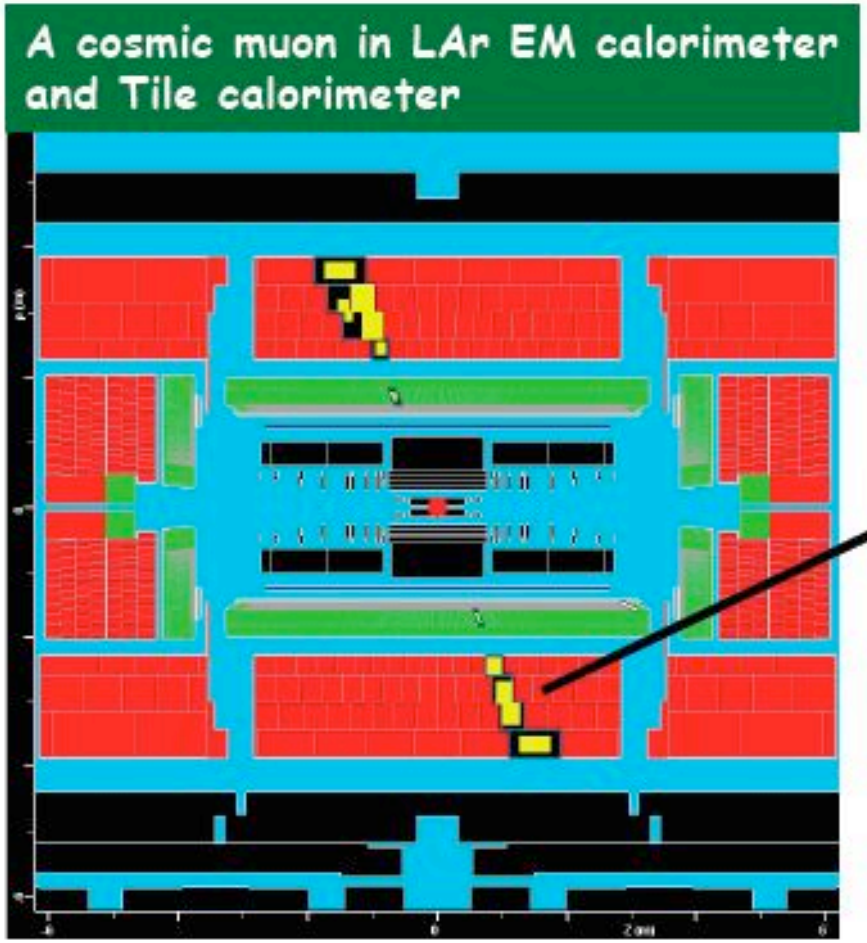


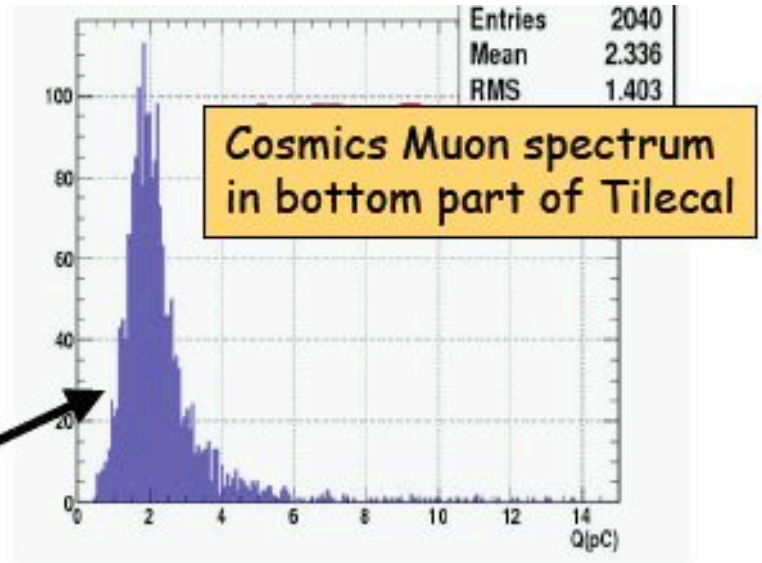
Cosmics data:
muon impact points extrapolated
to surface as measured by
Muon Trigger chambers (RPC)

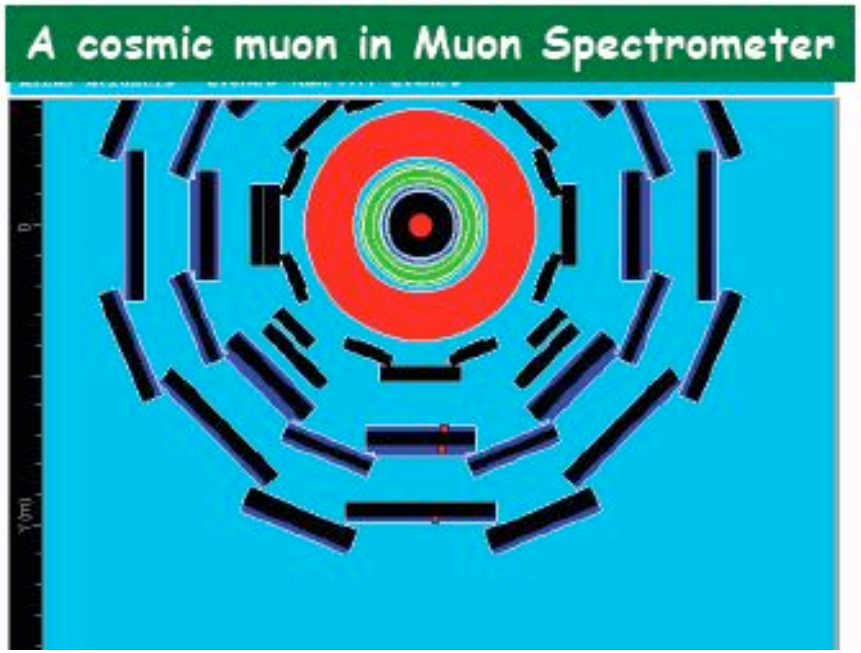
Rate ~100 m below ground: ~ O(10 Hz)



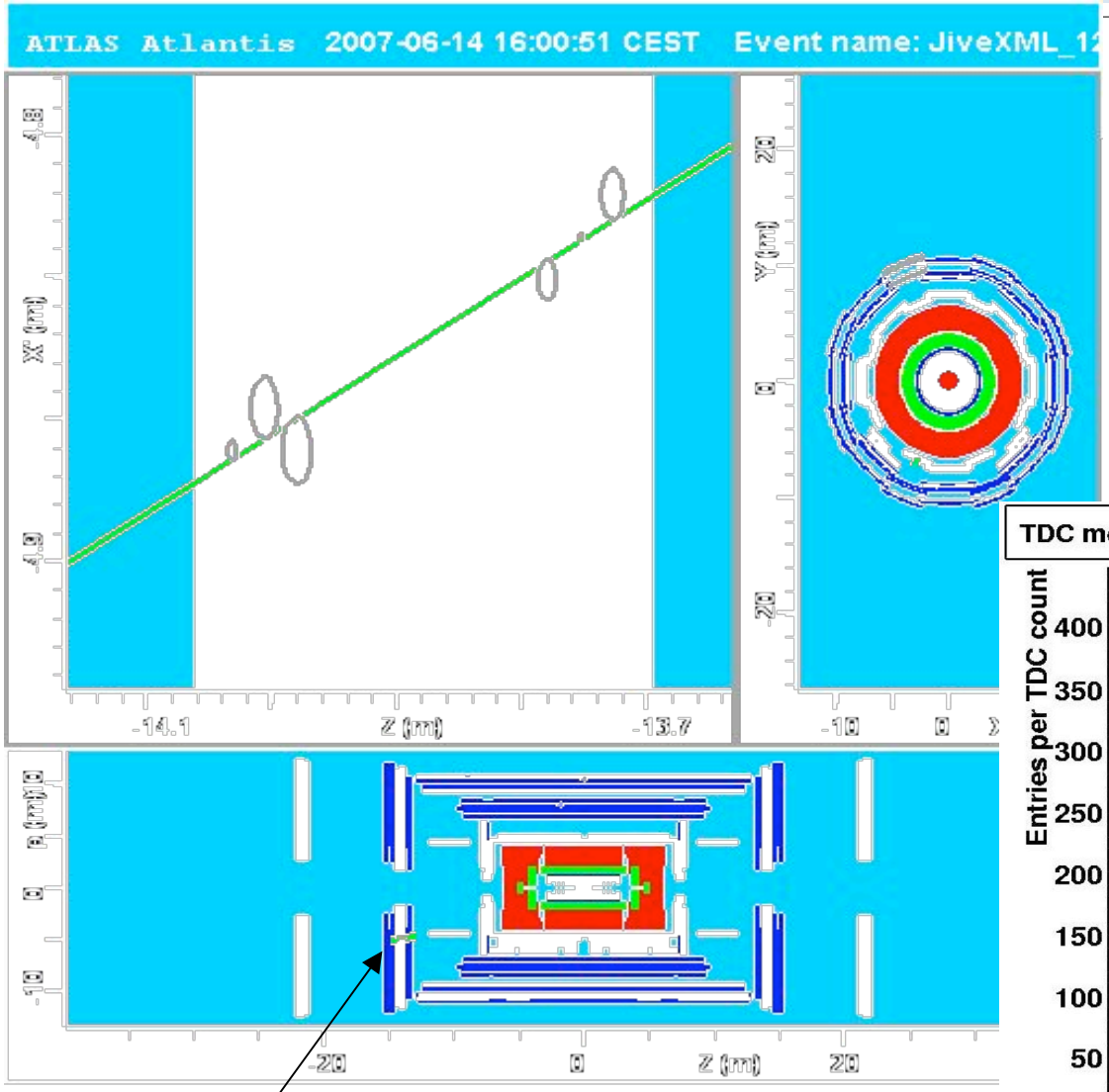
Commissioning: ATLAS





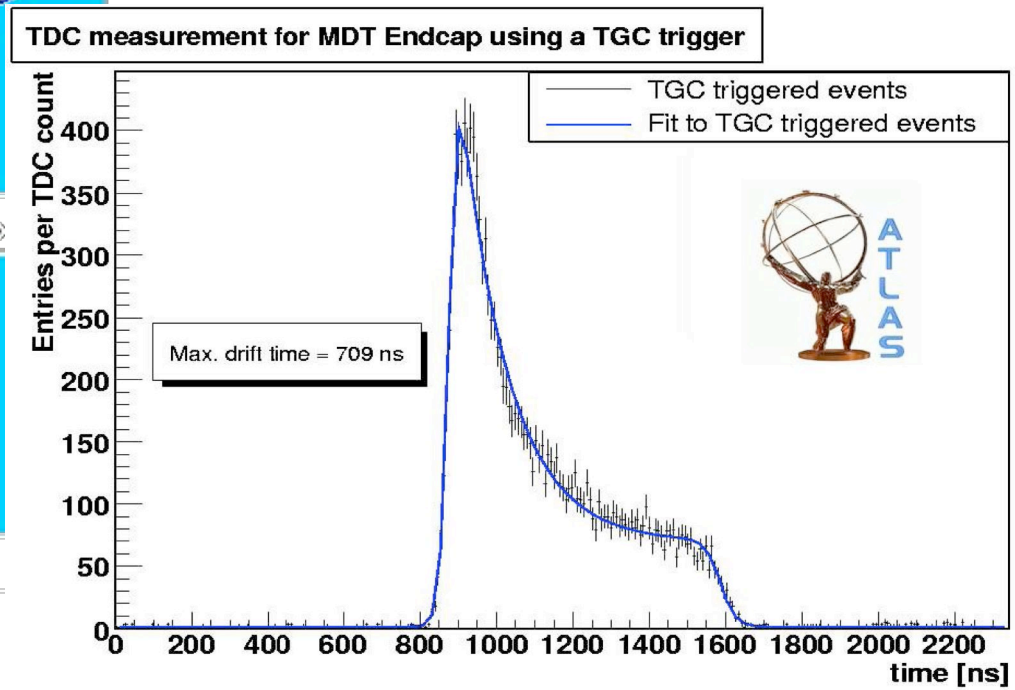


Commissioning ATLAS - Muon Chambers

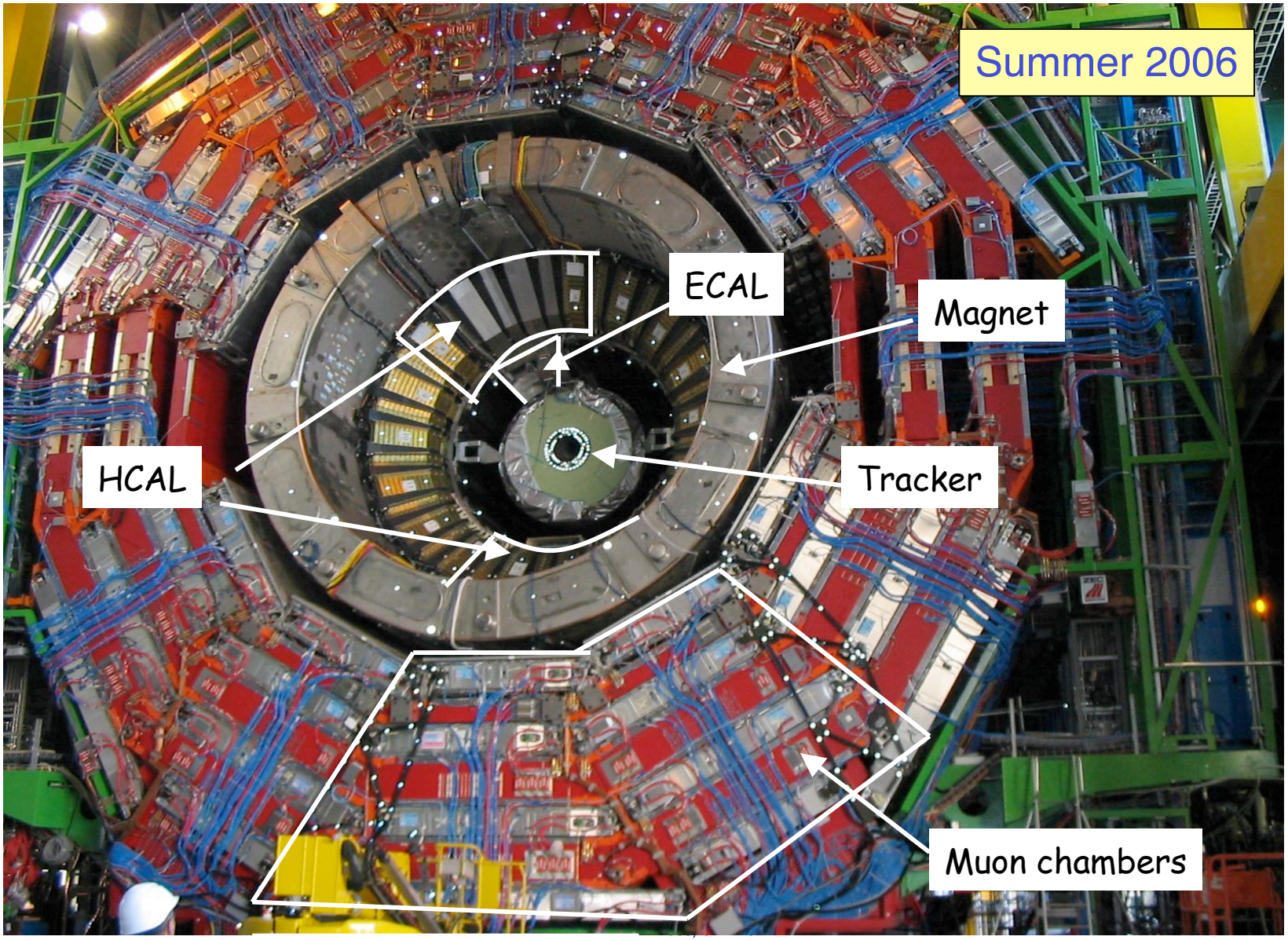


End-cap muon track segment

First cosmics in a segment of the ATLAS end-cap Big Wheels MDT and TGC muon chambers (15th June 2007)

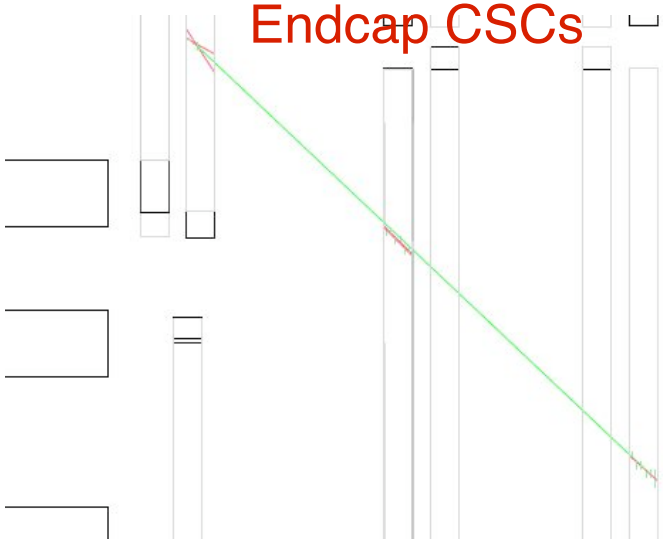


CMS "Slice Test"
Magnet Test & Cosmic Challenge

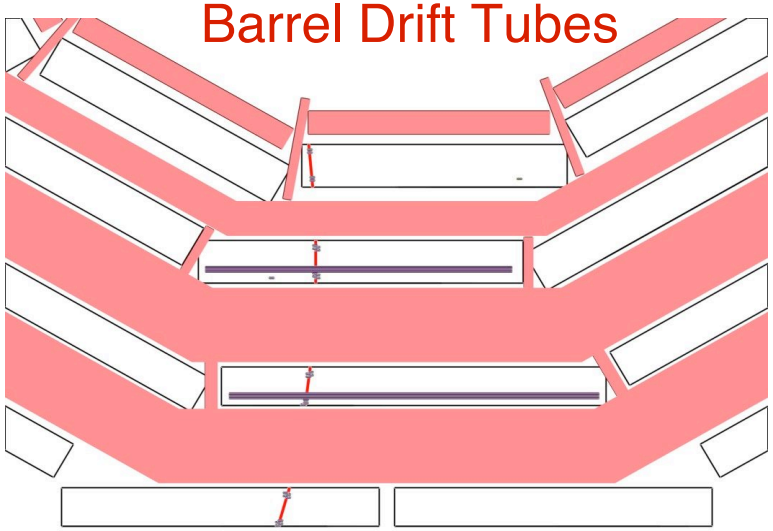


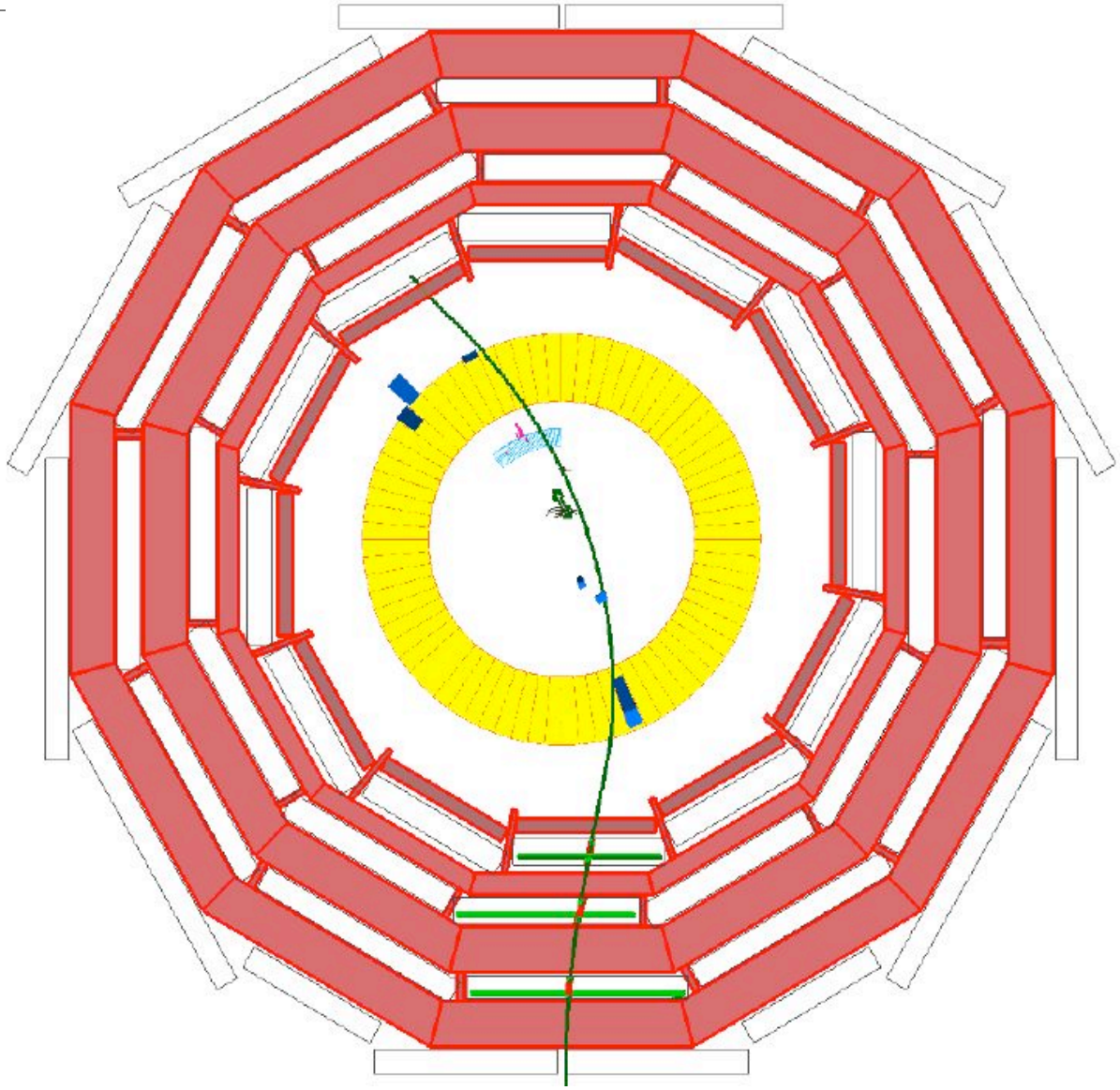
Commissioning: CMS - Cosmics Event

Endcap CSCs

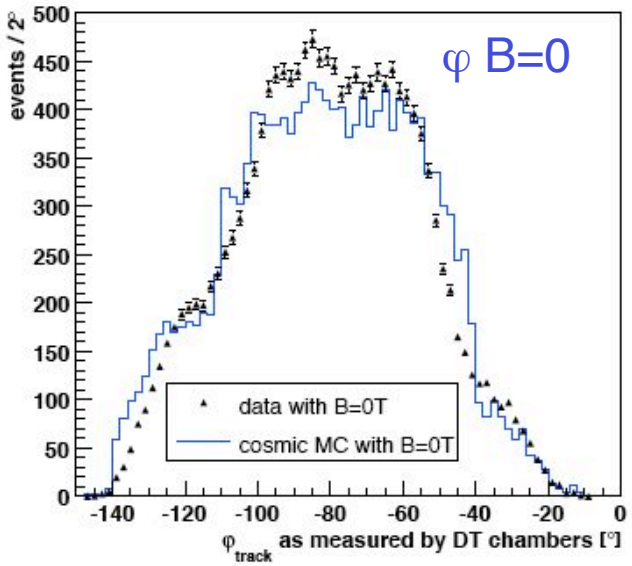


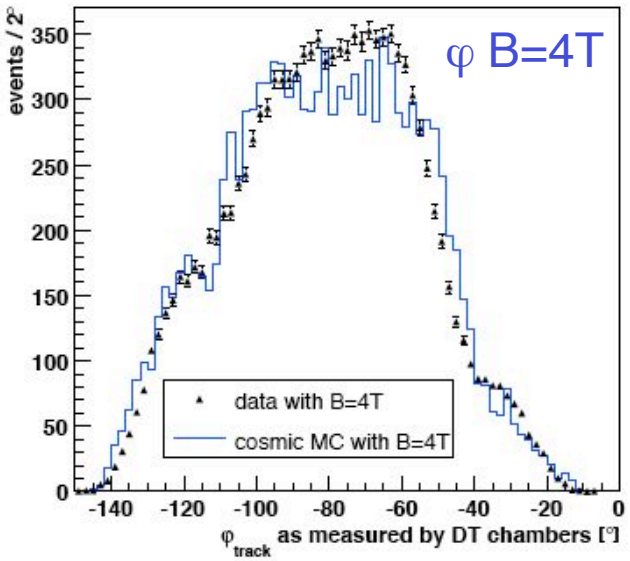
Barrel Drift Tubes



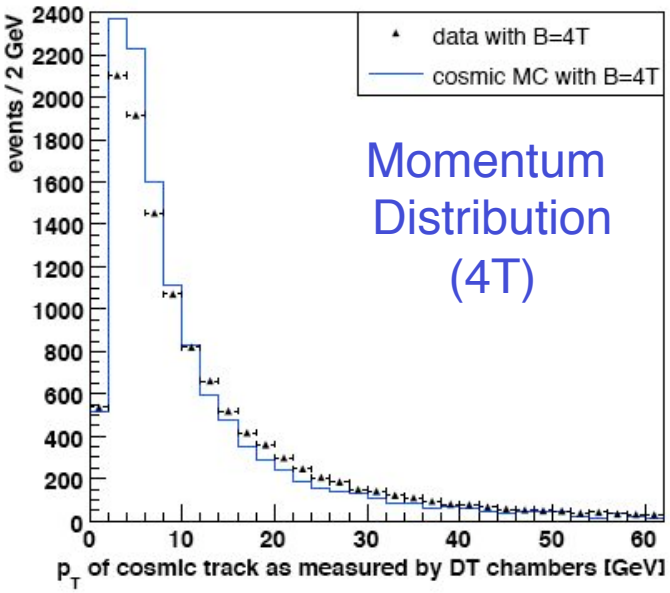


Commissioning: CMS MTCC Data (2006)





Azimuthal distribution measured by DTs.



Cosmic muons data normalised to Monte Carlo simulation

Reasonable agreement between data and simulation.

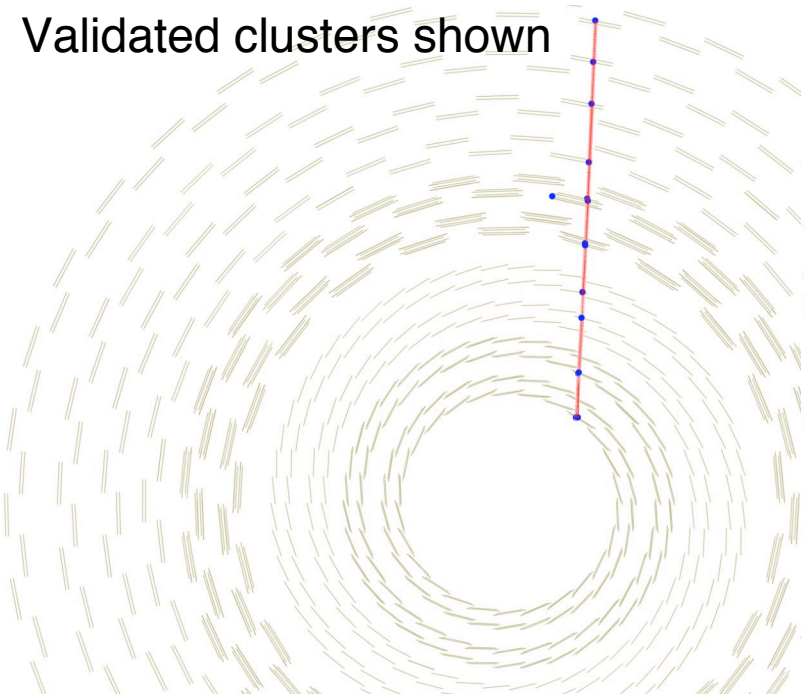
Almost every aspect of final CMS from detector to CMSSW had to work to produce these plots.

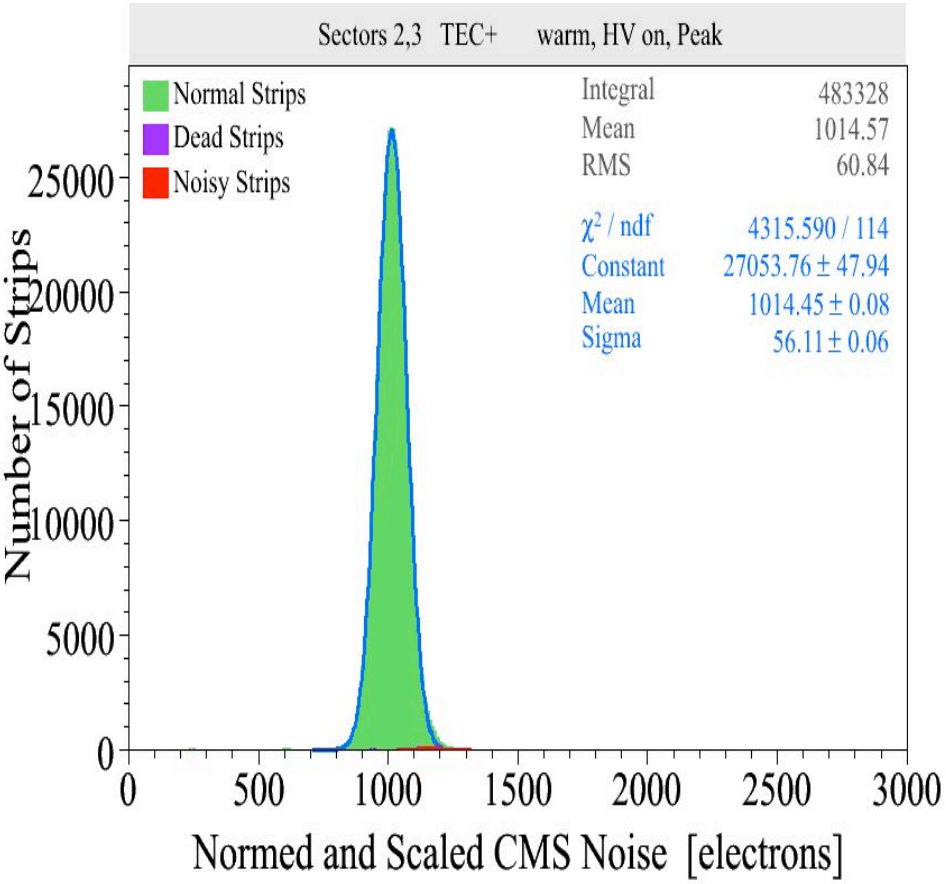
Commissioning: CMS Tracker

Example of Performance

A cosmic at -15°C

Validated clusters shown





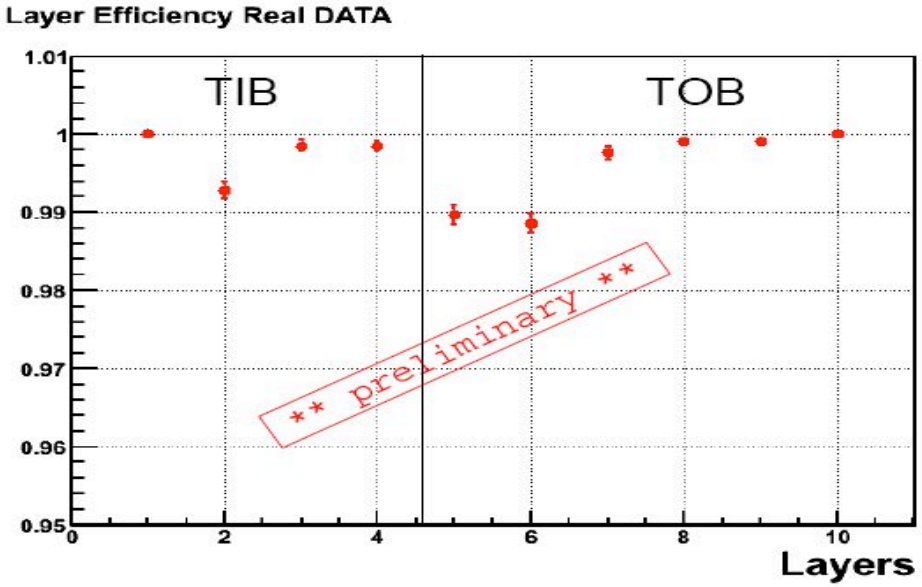
•The Quality of the CMS Tracker is Excellent:

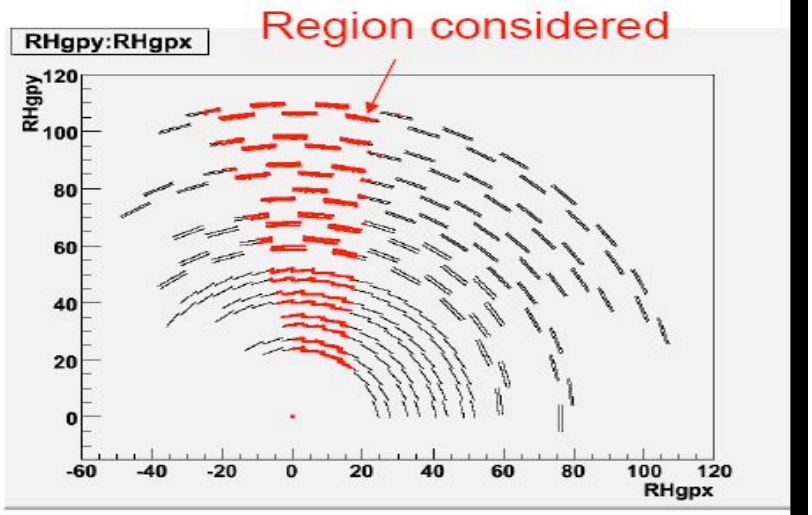
- Dead or Noisy Strips < 3 / 1000
- Signal:Noise > 25:1 in Peak Readout Mode
- Enormous experience gained in operating the Tracker at TIF

Measurement of Efficiency in the CMS Tracker

Real Data: Layer efficiency Summary

The alignment position error (APE) is set to 2 mm

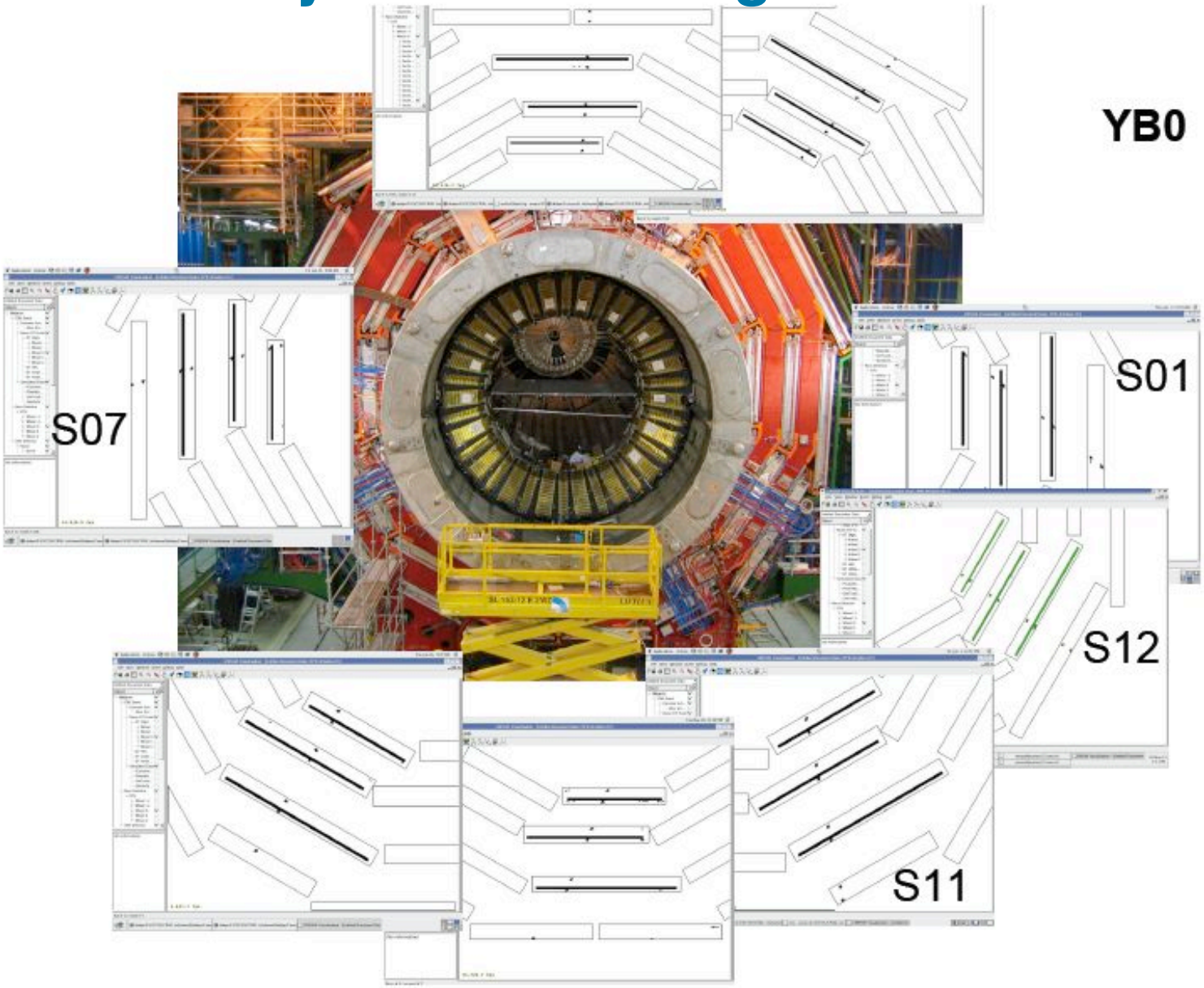




The layer efficiency in the region considered is more than 99.7% for single side layers and more than 99% for double side layers.
Further cross check need for double side layers.

02 May 2007 Daniele Benedetti - Università&INFN Perugia 14

Commissioning: CMS
Muon System in Underground Cavern



Commissioning of Software, Computing and Physics Analysis

This "Hidden Sector" is equally important to get right as the preceding "Visible Sector".
Need to synchronize commissioning of the two sectors to get ready in good time for data taking and analysis.
Much effort is going into this.

Commissioning: ATLAS Software, Computing & Physics

The 'Full Dress Rehearsal'

A complete test of the final chain of data handling, distribution and analysis from last stage of TDAQ to the user's laptop

- **Simulate 1 complete LHC fill (~10 hours of data taking) → ~7 x 10^6 events**
- **Mix and filter events at MC generator level to get correct physics mixture as expected at HLT output**
- **Pass events through G4 simulation ("as installed" detector geometry)**
- **Produce byte streams → emulate raw data format**
- **Send "raw data" to Point 1, inject at Sub-Farm Output (SFO), write out events to separate streams, closing files at boundary of luminosity blocks**
- **Send events from Point 1 to Tier-0; imitate final file structure and movement**
- **Perform calibration and alignment at Tier-0/Tier-1s/Tier-2s**
- **Run reconstruction at Tier-0/Tier-1s → produce ESD, AOD, TAGs**
- **Distribute ESD, AOD, TAGs to Tier-1s and Tier-2s**
- **Perform distributed analysis**

Commissioning CMS Computing, Software and Analysis

Mimic in detail @ 50% of what is needed in 2008

CSA07
Sep/Oct

100Mevt miscalibrated/misaligned (for 10-100pb^{-1})

Making (at the T0) and distributing (to all T1 centers) the AOD data.

- The placement of data in the various Tier-1 centers will be decided by the computing project.

Running of skims at Tier-1 centers.

Re-reconstruction at the T1 centers

Re-making of the full AOD samples after a re-reconstruction step.

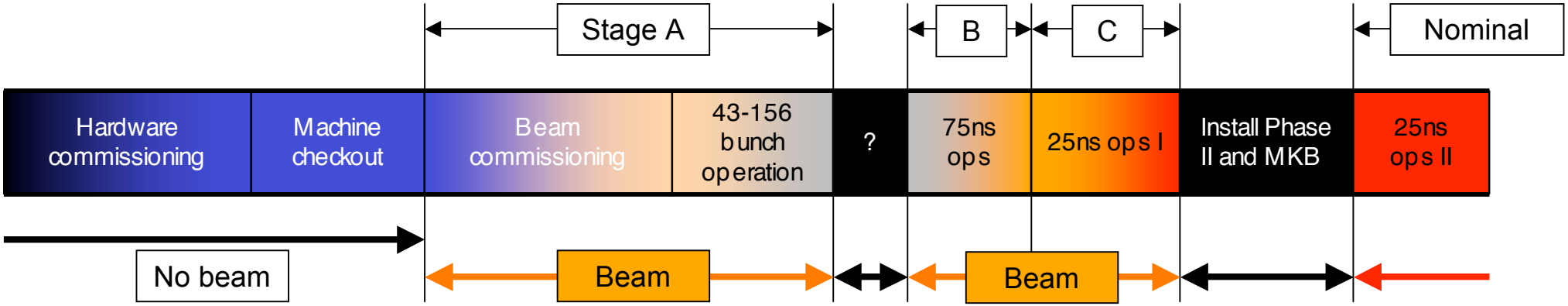
Copying of the skimmed datasets to Tier-2 centers and execution of analysis exercises at these centers.

- Migrate the bulk of analysis activities to Tier-2 centers and encourage the adoption of workflow tools to facilitate the use of remote computing centers.

Parallel (with the processing of the CSA07 data at the Tier-0) Monte Carlo production of signal events at the Tier-2 centers

Physics Prospects
Early Running

Expectations of Luminosity Buildup



Parameter	Phase A	Phase B	Phase C	Nominal
k / no. bunches	43-156	936	2808	2808
Bunch spacing (ns)	2021-566	75	25	25
N (10^{11} protons)	0.4-0.9	0.4-0.9	0.5	1.15
Crossing angle (μrad)	0	250	280	280
$\sqrt{(\beta^*/\beta^*_{nom})}$	2	$\sqrt{2}$	1	1
σ^* (μm, IR1&5)	32	22	16	16
L ($cm^{-2}s^{-1}$)	6×10^{30}-10^{32}	10^{32}-10^{33}	$(1-2)\times10^{33}$	10^{34}

J. Wenninger

Phase A: Luminosities

Approx 30 days of beam time to establish first collisions

1 to N to 43 to 156 bunches per beam

N bunches displaced in one beam for LHCb

Pushing gradually one or all of:

- Bunches per beam
- Squeeze
- Bunch intensity

IP 1 & 5

Bunches	β^*	I_b	Luminosity	Event rate
1 x 1	18	10^{10}	10^{27}	Low
43 x 43	18	3×10^{10}	3.8×10^{29}	0.05
43 x 43	4	3×10^{10}	1.7×10^{30}	0.21
43 x 43	2	4×10^{10}	6.1×10^{30}	0.76
156 x 156	4	4×10^{10}	1.1×10^{31}	0.38
156 x 156	4	9×10^{10}	5.6×10^{31}	1.9
156 x 156	2	9×10^{10}	1.1×10^{32}	3.9

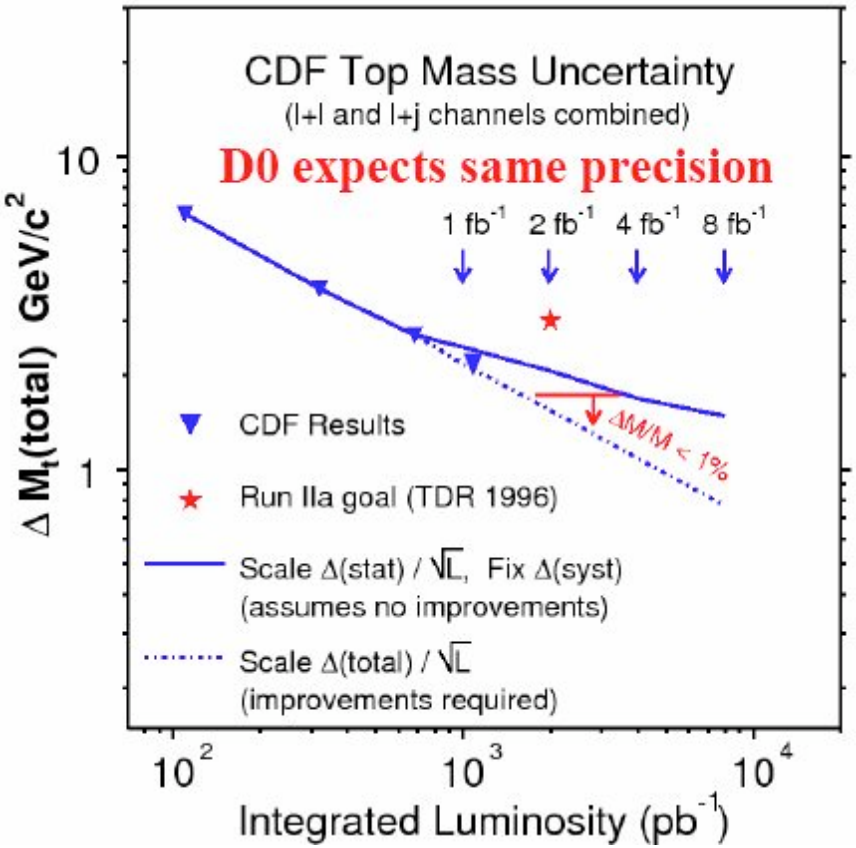
Physics Outlook

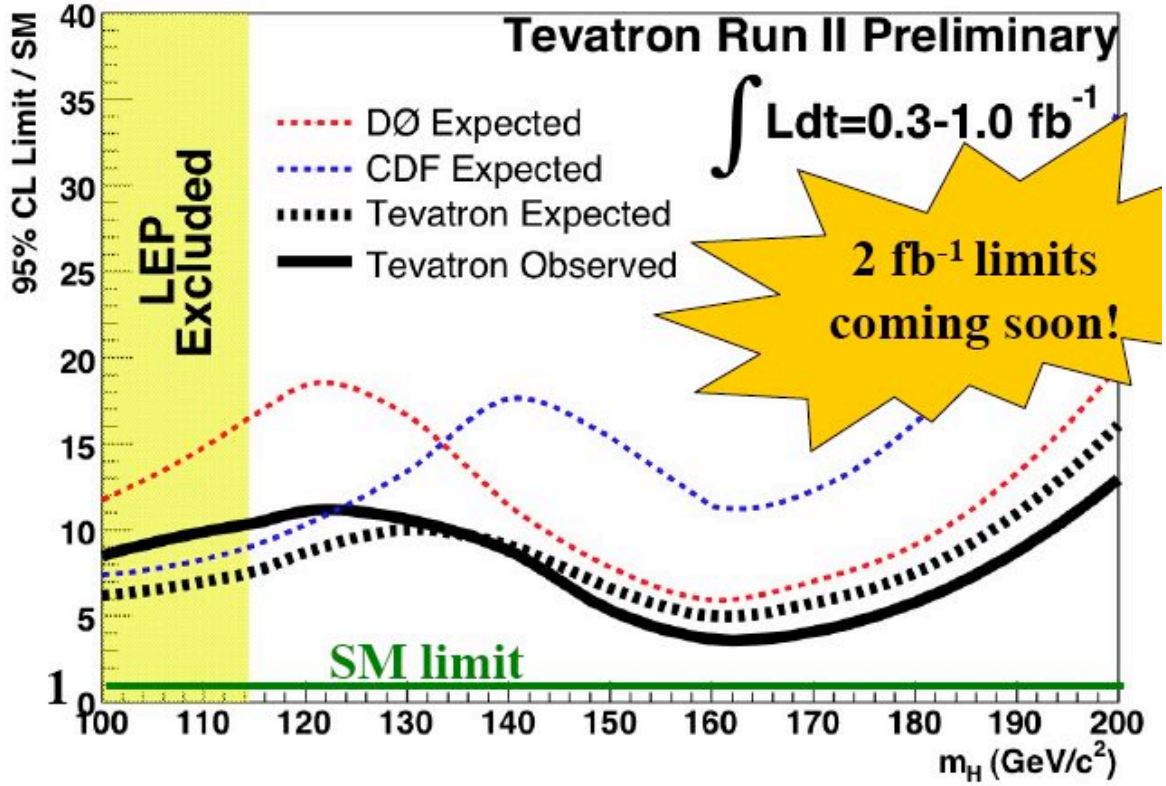
- LEP, SLC and the Tevatron: established that we really understand the physics at energies up to $\sqrt{s}$ ~ 100 GeV
  - And any new particles have masses above 200-300 GeV – and in some cases TeV
- The Higgs itself can have a mass up to ~700-800 GeV;
  - if it's not there, something must be added by ~1.2 TeV, or WW scattering exceeds unitarity
- Even if the Higgs exists, all is not 100% well with the Standard Model alone: next question is "why is the (Higgs) mass so low"?
  - The same mechanism that gives all masses would drive the Higgs mass to the Planck scale. If SUSY is the answer, it must show up at O(TeV)
  - Recent: extra dimensions. Again, something must happen in the O(1-10) TeV scale if the above issues are to be addressed
- We need to study the TeV region

Tevatron: Physics Reach

Current statistics > 2 fb^{-1}. Expect 6-7 fb^{-1} by Oct 09

K. Tollefson LP07





Current Measurement
M_t = 170.9 ± 1.8 GeV

Current Measurements
114 (LEP) < M_H < 182 GeV

LHC: Preparation for Physics

Example CMS

Geared towards discovery physics – which goes through the Standard Model

- The high-P_T SM physics (e.g. QCD, EWK, Top) has to be "understood"
  - e.g. initial aim is not to measure M(W) to a 15 MeV precision
    - Instead, it is to measure the Standard Model – to help establish that there is something new

Current focus: physics with $10pb^{-1}$, $100pb^{-1}$, up to $1fb^{-1}$

Rates of Events

LHC is a factory for b, W,Z, top

1 fb^{-1} (100 pb^{-1}) ≡ 6 months (few weeks) at L= 10^{32} $cm^{-2}s^{-1}$ with 50% data-taking efficiency

Channels (examples …)	Events to tape for 100 pb^{-1} (per expt: ATLAS, CMS)	Total statistics from previous Colliders
$W \to \mu\,\nu$	~ 10^6	~ 10^4 LEP, ~ 10^6 Tevatron
$Z \to \mu\,\mu$	10^5	~ 10^6 LEP, ~ 10^5 Tevatron
$tt \to W\,b\,W\,b \to \mu\,\nu + X$	~ 10^4	~ 10^4 Tevatron
QCD jets $p_T > 1$ TeV	> 10^3	---
$\tilde{g}\tilde{g}$ m = 1 TeV	~ 50	---

With initial data (< 100pb^{-1}):

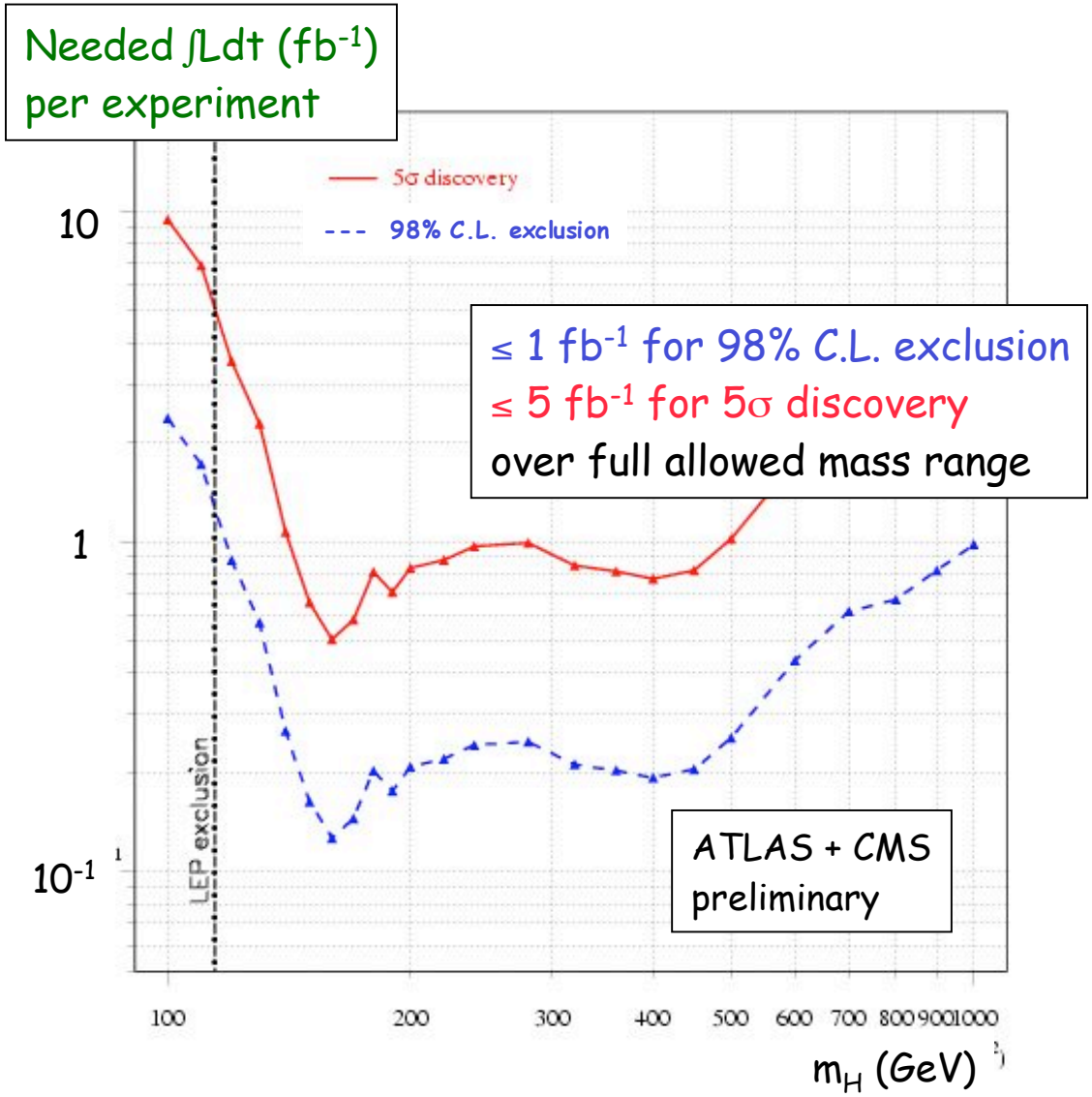
- **Understand and calibrate** detectors *in situ* using well-known physics samples
  e.g. - $Z \to ee, \mu\mu$ tracker, ECAL, Muon chambers calibration and alignment, etc.
  - $tt \to bl\nu\ bjj$ jet scale from $W \to jj$, b-tag performance, etc.

- **Rediscover & Measure SM physics** at $\sqrt{s}$ = 14 TeV : W, Z, tt, QCD jets …
  (also because omnipresent backgrounds to New Physics)

F. Gianotti

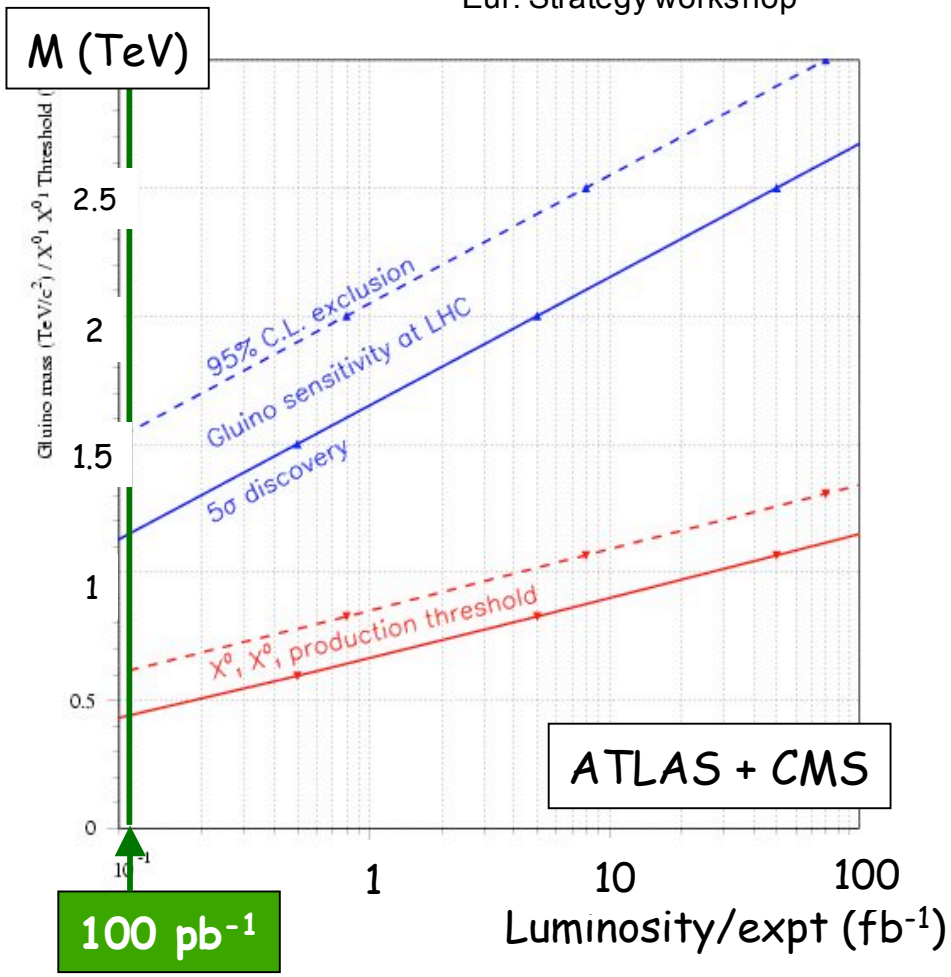
SM Higgs in ATLAS and CMS

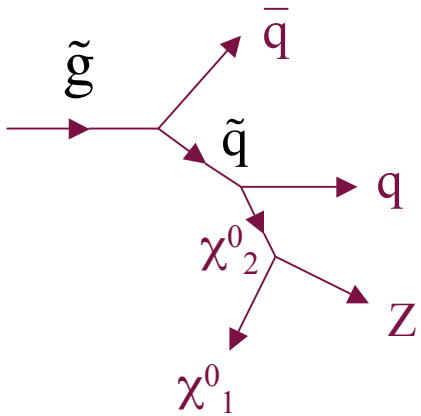
J.J. Blaising et al, input to Eur. Strategy workshop



Example of "Early Discovery": Supersymmetry ?

J.J. Blaising et al, input to
Eur. Strategy workshop



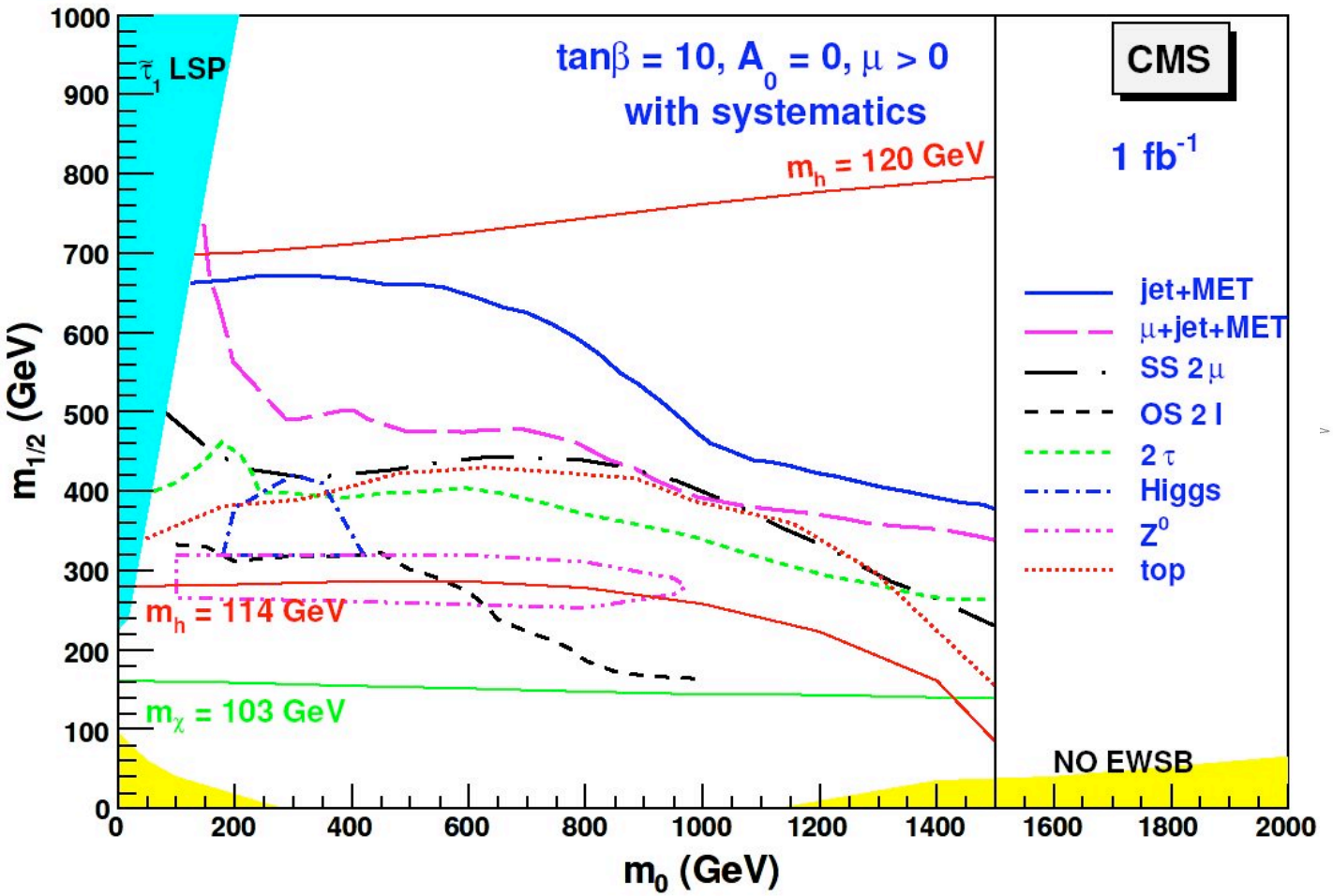


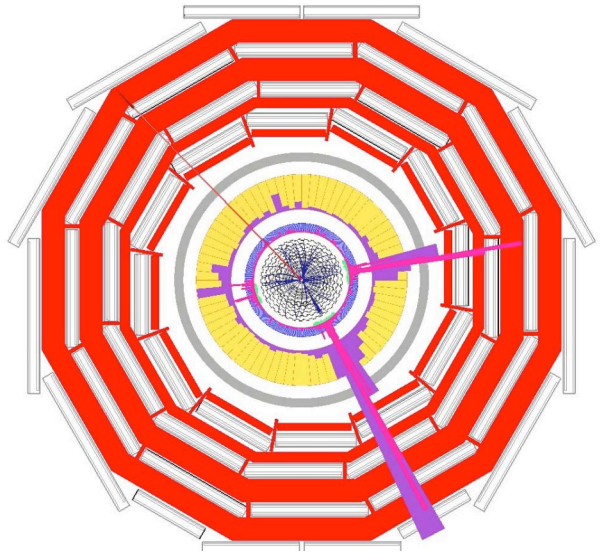
Low mass SUSY(m_{gluino}~500 GeV) shows excess in many channels for O(100) pb^{-1}

Time for discovery determined by:

- Time to understand the detector performance, E_T^{miss} tails, jet scale,lepton identification
- Time collect SM control samples such as W+jets, Z+jets, top..

Discovery Physics (SUSY)





Jets + ME_T

Example of Signature Based Searches Beyond the Standard Model

http://cms.cern.ch/iCMS/

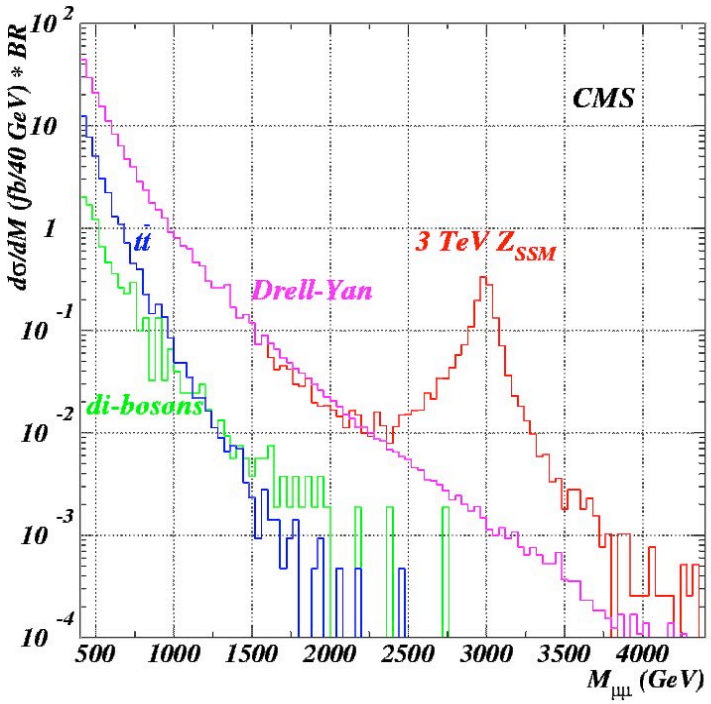
Documents→ TDR → Physics 8.2

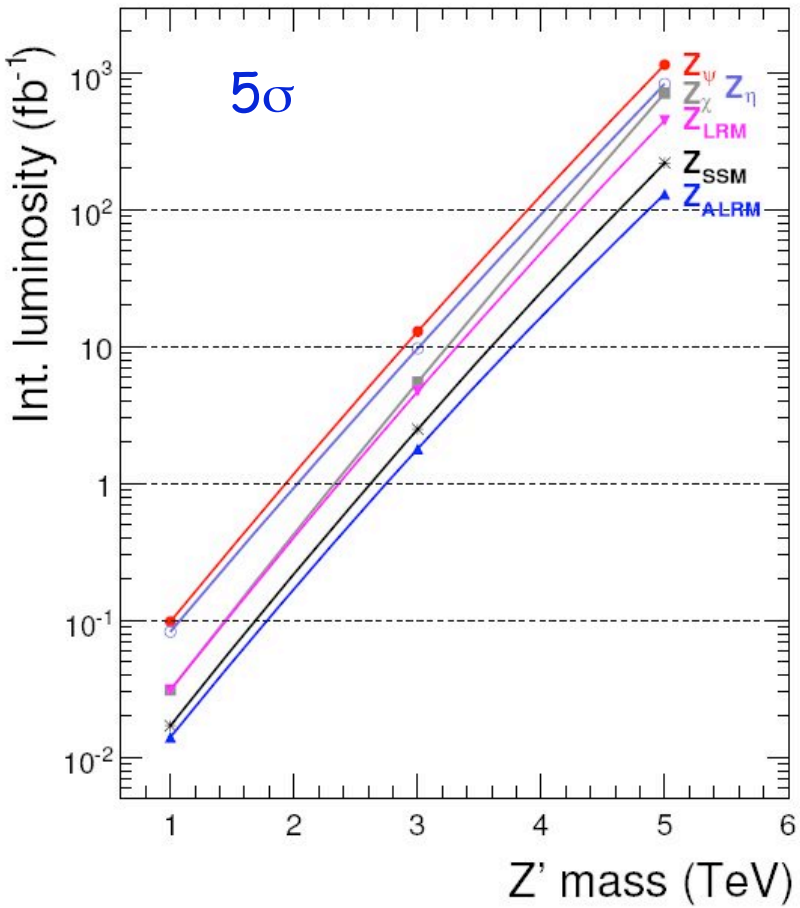
- Di-lepton, di-jet, di-photon resonances
  - using ee, $\mu\mu$, $\gamma\gamma$, diets
  - searching for Z' (leptons,jets), RS Extra Dimensions (leptons,photons,jets), Z_{KK} in TeV $^{-1}$ (electrons) (can also be interpreted in the context of Little Higgs models)
- Di-lepton, di-jet continuum modification
  - using $\mu\mu$, diets
  - searching for ADD graviton exchange (di-muons), contact interactions (di-muons, diets)
- Dilepton+dijets
  - using ee, $\mu\mu$+diets
  - searching for heavy neutrino from right-handed W (can also be interpreted in the context of leptoquark searches)
- Single photon+missing E_T
  - using γ + missing E_T
  - searching for ADD direct graviton emission (can also be interpreted in the context of GMSB gravitino-type searches)

etc.

Discovery Physics (Z')

Z′→μμ production





Low lumi 0.1 fb^{-1} : discovery of 1-1.6 TeV possible
High lumi 100 fb^{-1}: extend range to 3.5-4.5 TeV

Summary: LHC Experiments

- Construction essentially completed
- Installation is very advanced - beam pipes closed end March08.
- Test beam and commissioning work already carried out gives confidence that detectors will behave as expected.
- Commissioning using cosmics with more and more complete setups (complexity and functionality)
  - Using final readout, trigger and DAQ, software and computing systems
- Computing, Software & Analysis 24/7 Challenges, Dress Rehearsals @ 50% of 2008 expectation by end of 2007.
  - LHCC requests an exercise where all 4 experiments run in parallel
- Preparations for the rapid extraction of physics being made

- By spring 2008 experiments will be in 2008 configurations, fields ON, taking cosmics

Conclusions

- Pivotal phase in our science coming up - Experiments turn to speak !
- The LHC at CERN will open window on the “magic” energy scale of 1 TeV.

- Despite challenges impressive progress being made by the LHC and the experiments.
- Collisions expected in mid-summer 2008 when physics data-taking will start.
- If indeed new physics is at the TeV-scale, experiments should find it.

- We are poised to tackle some of the most profound questions in physics.
- The data collected by the LHC detectors could change our perception of how nature operates at the fundamental level.
- The coming years will certainly be very exciting.