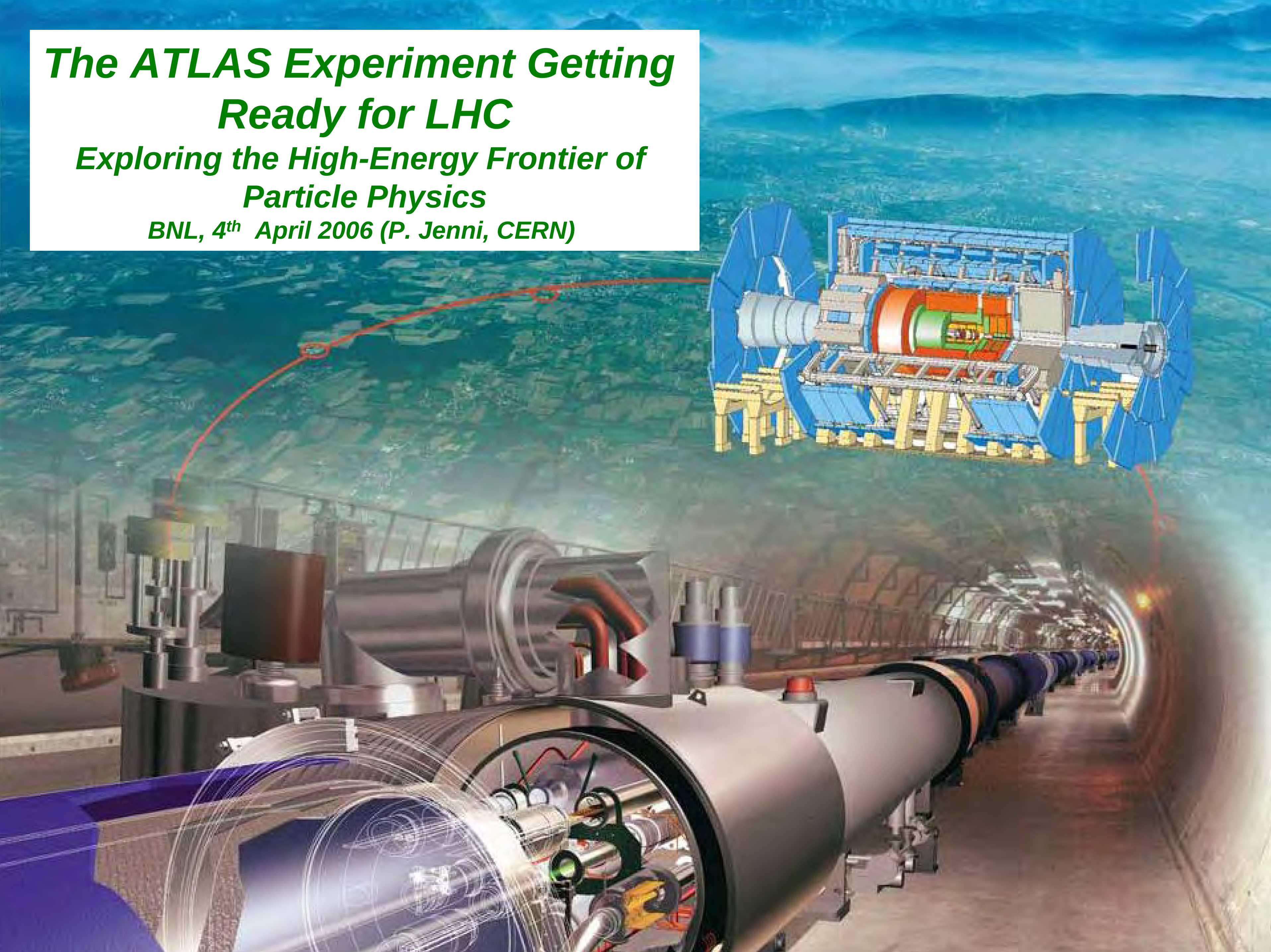
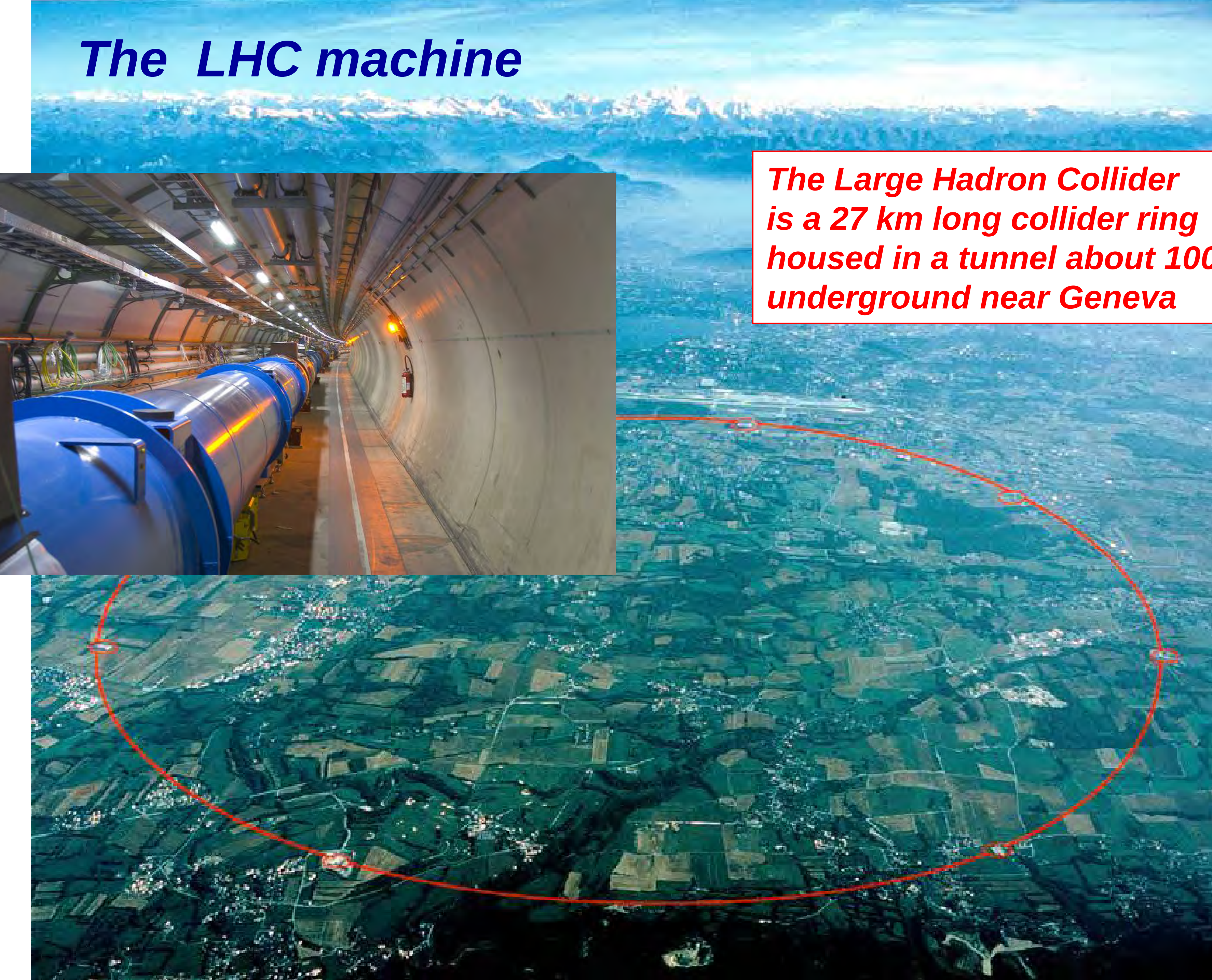
The ATLAS Experiment Getting Ready for LHC

Exploring the High-Energy Frontier of Particle Physics

BNL, 4th April 2006 (P. Jenni, CERN)



The LHC machine



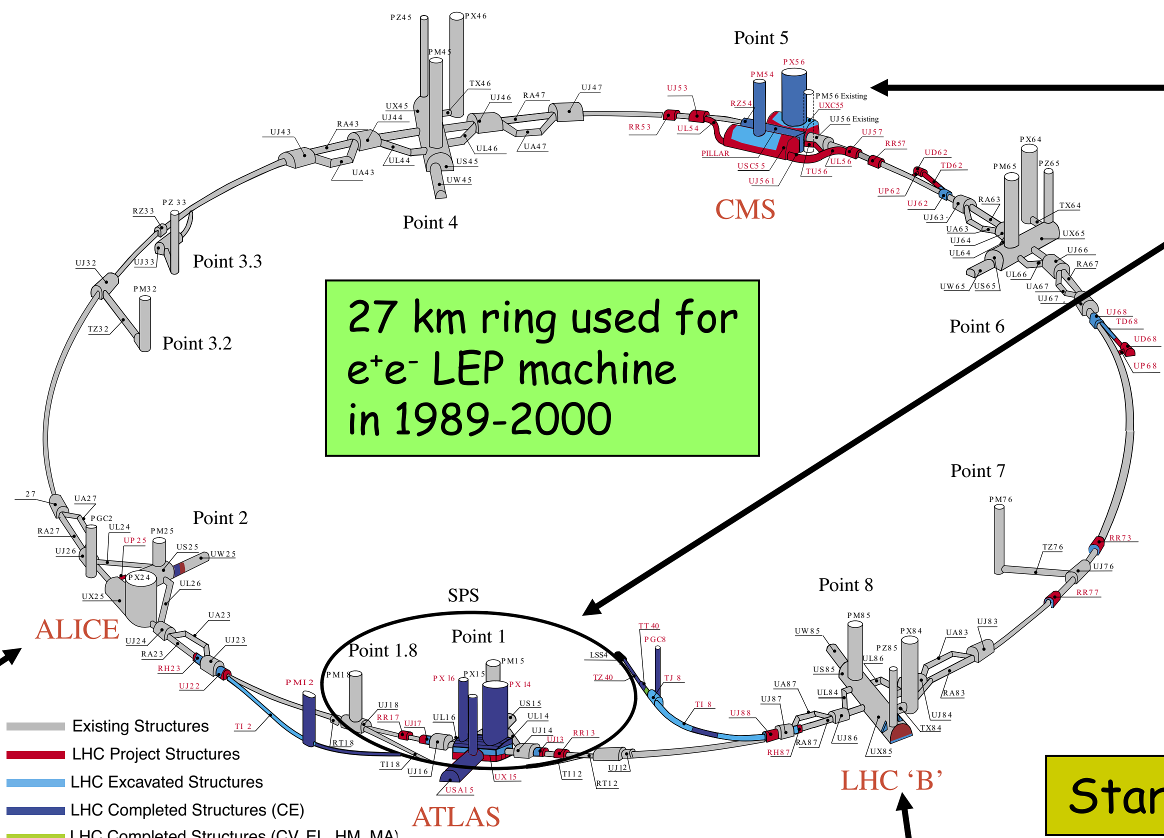
The Large Hadron Collider is a 27 km long collider ring housed in a tunnel about 100 m underground near Geneva

LHC

pp

- $\sqrt{s}$ = 14 TeV (7 times higher than Tevatron/Fermilab)
  → search for new massive particles up to m ~ 5 TeV

- $L_{design} = 10^{34}\ cm^{-2}\ s^{-1}$ (>10^2 higher than Tevatron/Fermilab)
  → search for rare processes with small σ ($N = L\sigma$)



27 km ring used for e^+e^- LEP machine in 1989-2000

ATLAS and CMS : pp, general purpose

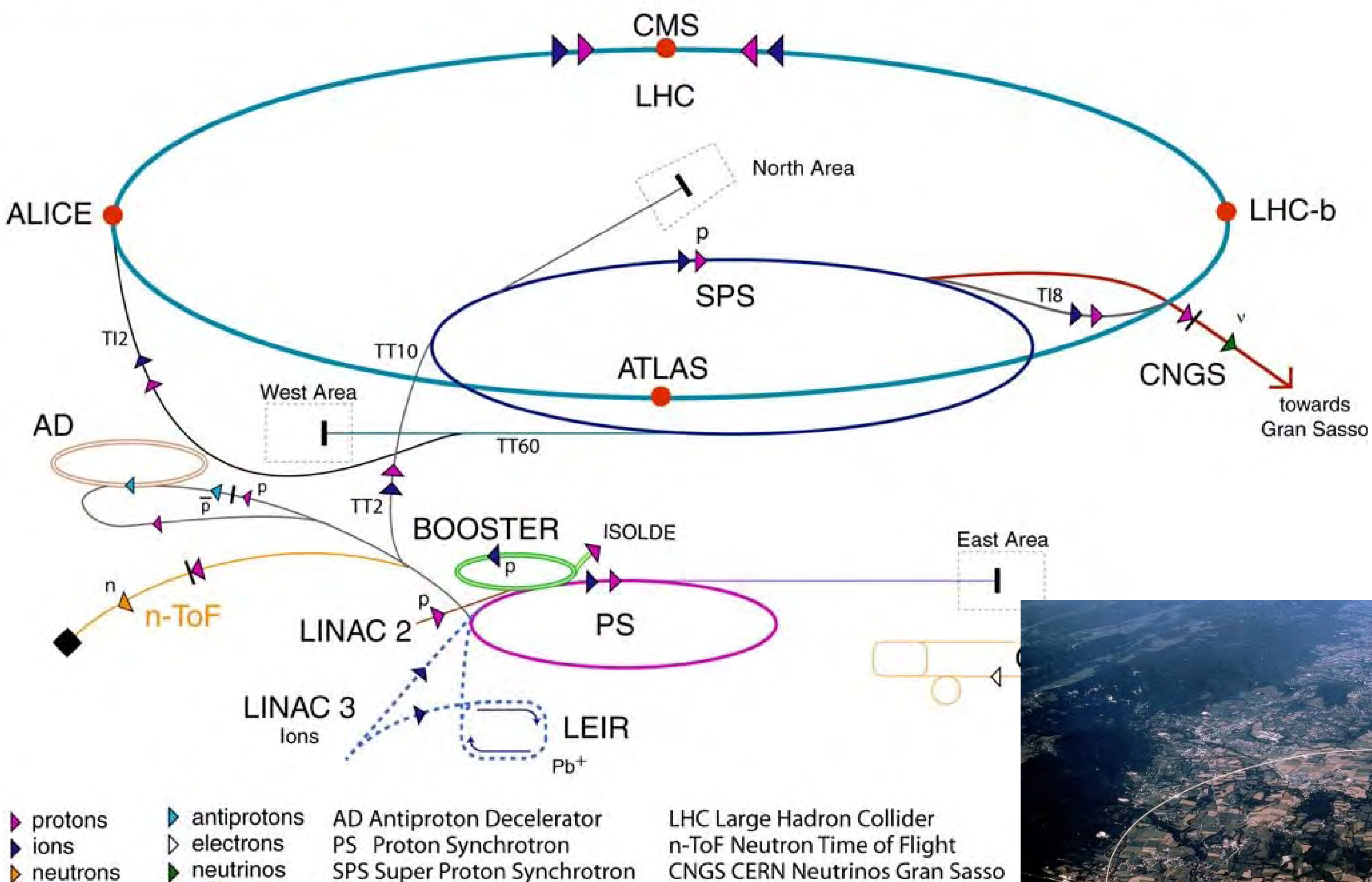
ALICE : heavy ions

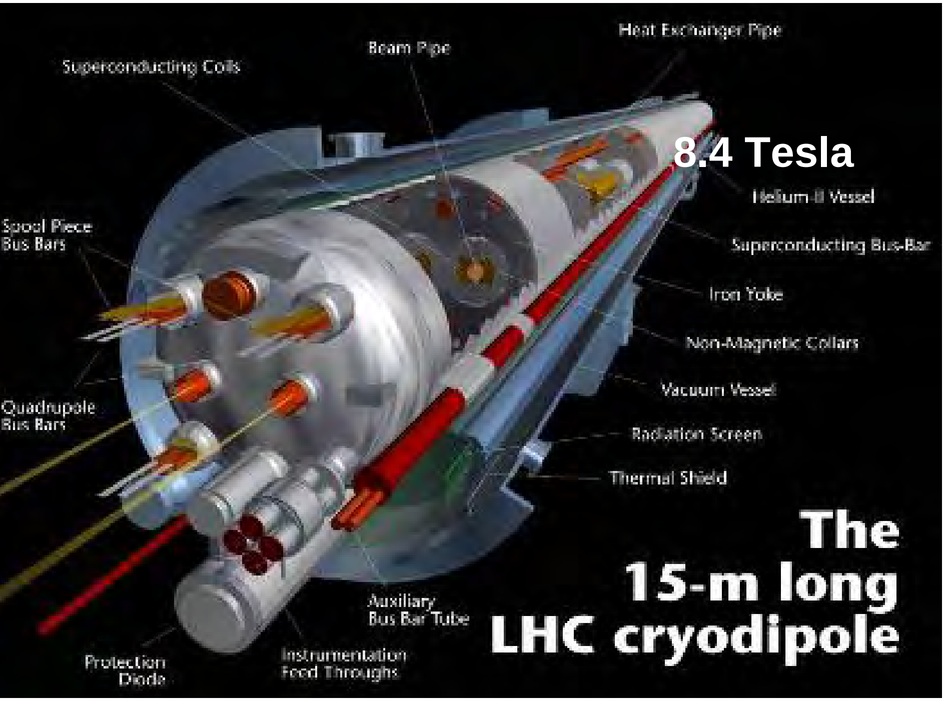
LHCb : pp, B-physics

Start : Summer 2007

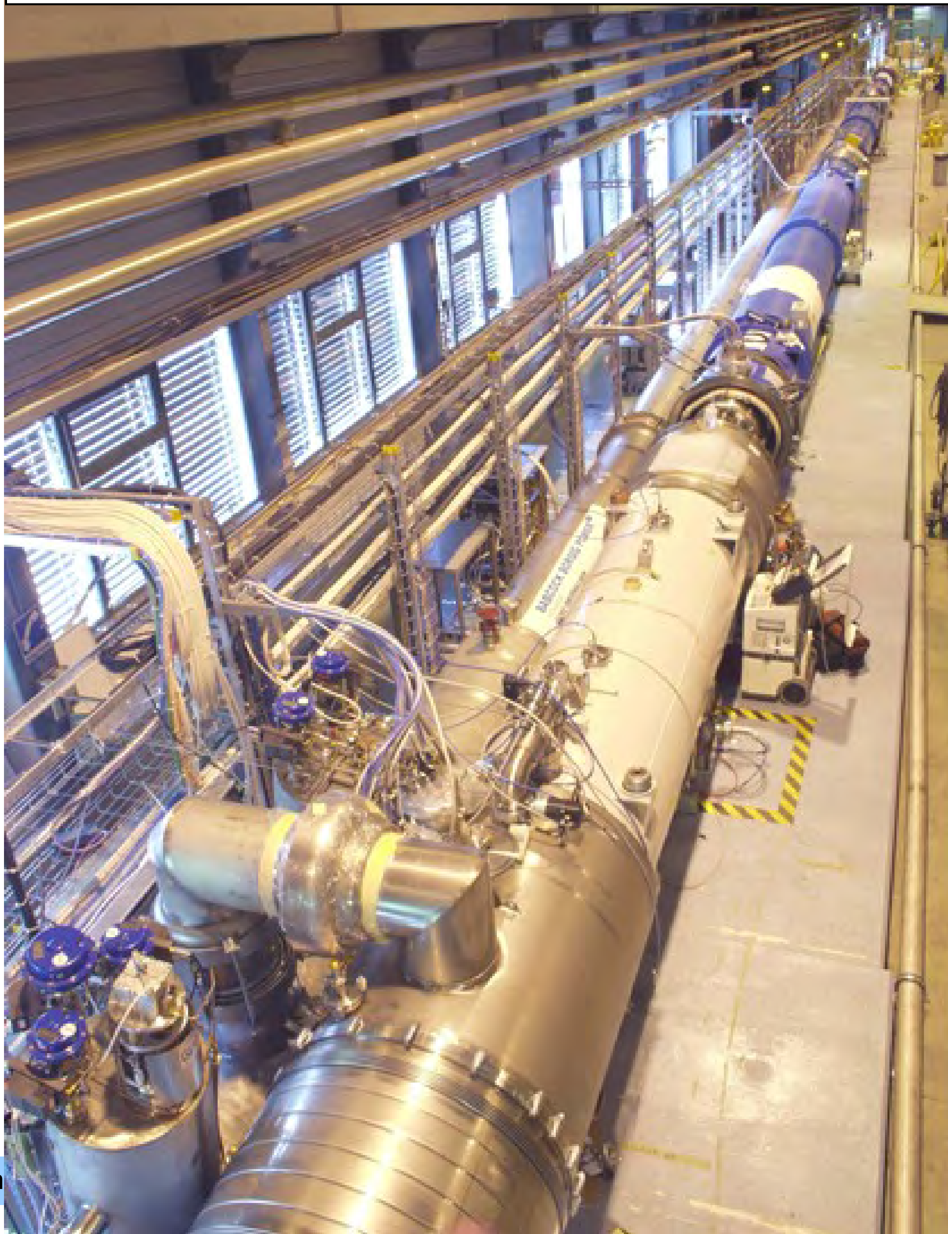
Accelerator complex at CERN

(Not to scale)





First full LHC cell (~ 120 m long) :
6 dipoles + 4 quadrupoles;
successful tests at nominal current (12 kA)



LHC Machine Parameters

Energy	E	[TeV]	7.0
Dipole field	B	[T]	8.4
Luminosity	L	$[cm^{-2} s^{-1}]$	10^{34}
Beam–beam parameter	ξ		0.0034
Total beam–beam tune spread			0.01
Injection energy	E_i	[GeV]	450
Circulating current/beam	I_{beam}	[A]	0.53
Number of bunches	k_b		2835
Harmonic number	h_{RF}		35640
Bunch spacing	τ_b	[ns]	24.95
Particles per bunch	n_b		$1.05\ 10^{11}$
Stored beam energy	E_s	[MJ]	334
Normalized transverse emittance $(\beta\gamma)\sigma^2/\beta$	ε_n	[μm.rad]	3.75
Collisions			
β-value at I.P.	β^*	[m]	0.5
r.m.s. beam radius at I.P.	σ^*	[μm]	16
r.m.s. divergence at I.P.	σ'^*	[μrad]	32
Luminosity per bunch collision	L_b	$[cm^{-2}]$	$3.14\ 10^{26}$
Crossing angle	ϕ	[μrad]	200
Number of events per crossing	n_c		19
Beam lifetime	τ_{beam}	[h]	22
Luminosity lifetime	τ_L	[h]	10

Limiting factor for √s: Bending power needed to keep beams in 27 km LHC ring

p(TeV) = 0.3 B(T) R(km)

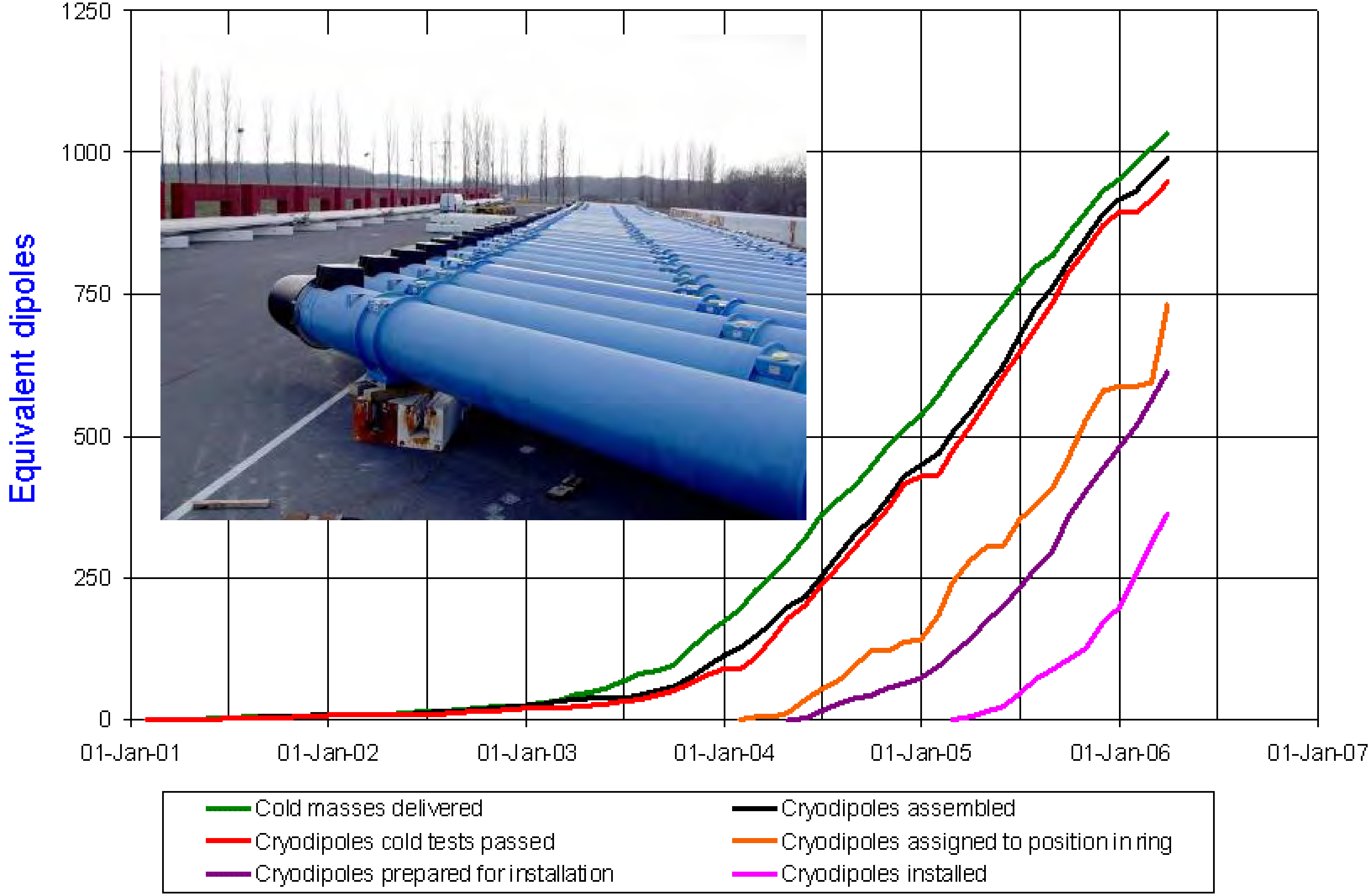
With the typical magnet packing factor of ~ 70%, the 1232 dipoles with B = 8.4 T give 7 TeV beams

LHC Progress Dashboard

More than 1000 of 1232 dipoles are now assembled at CERN

Accelerator Technology Department

Cryodipole overview



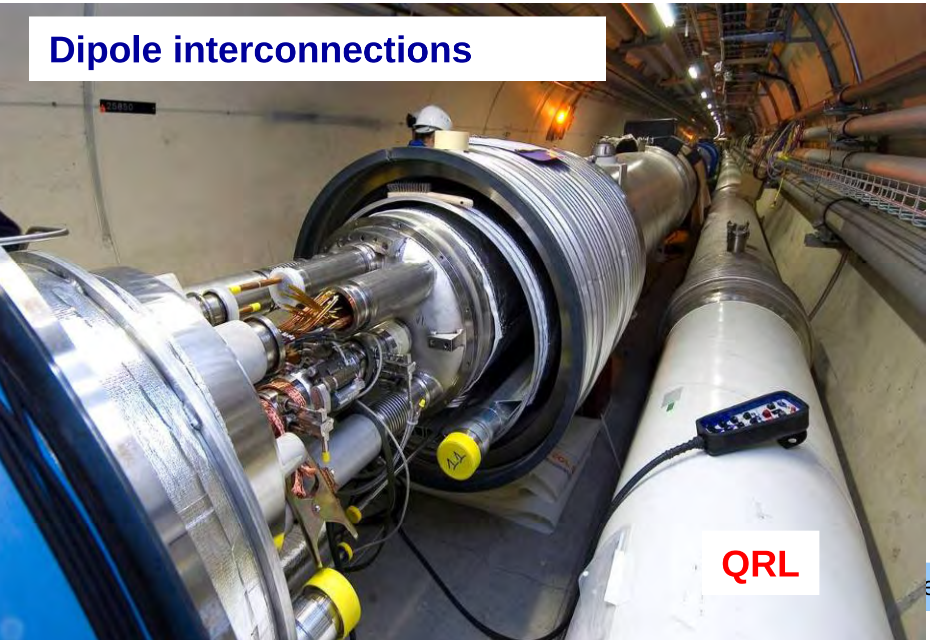
Updated 31 Mar 2006

Data provided by D. Tommasini AT-MAS, L. Bottura AT-MTM

More than 350 dipoles of the 1232 already installed in the underground tunnel

Installation rate:
20 dipoles/week reached for several weeks
(goal during 2006 is 20-25/week constantly)

First 600 m of cryoline (QRL) successfully cooled down on September 14, followed by cool-down of full cryoline sector 8-1 end of November 2005



Not only dipoles ….

Dipoles	1232
Quadrupoles	400
Sextupoles	2464
Octupoles/decapoles	1568
Orbit correctors	642
Others	376
Total	~ 6700

All coming along well …

Assembly of Short Straight Sections

Inner triplet quads assembly hall 181

One of the special insertion magnets from Brookhaven being installed at point 8

Conclusions from Lyn Evans' recent presentation at the CERN LHC Committee (LHCC) on 22nd March 2006

(Available via the official LHC Web: http://lhc.web.cern.ch/lhc/)

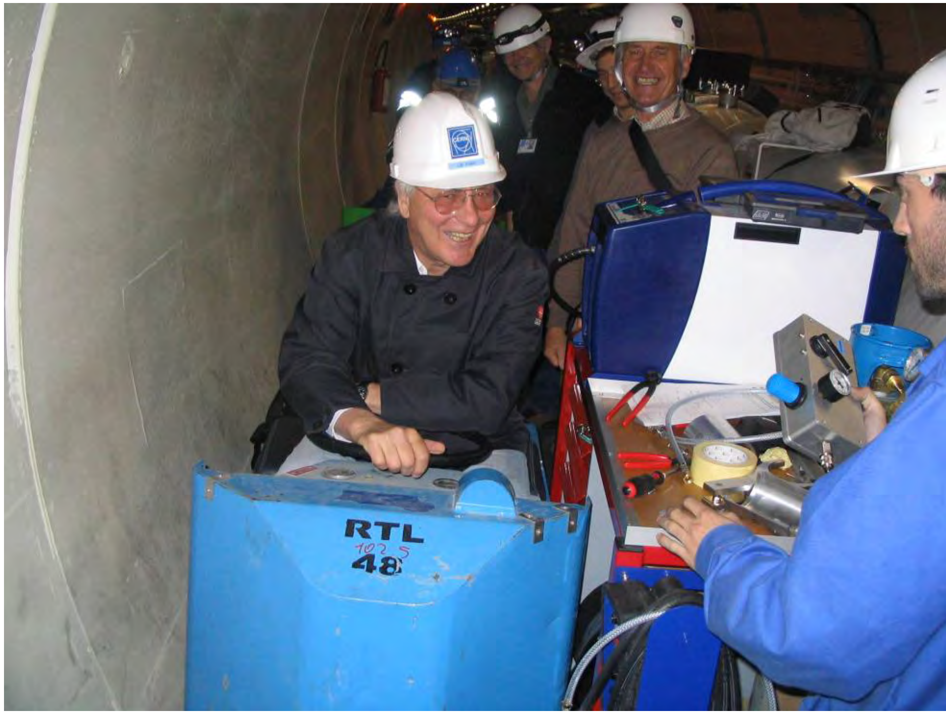
All key objectives have been reached for the end of 2005

- **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 two full octants of power converters**

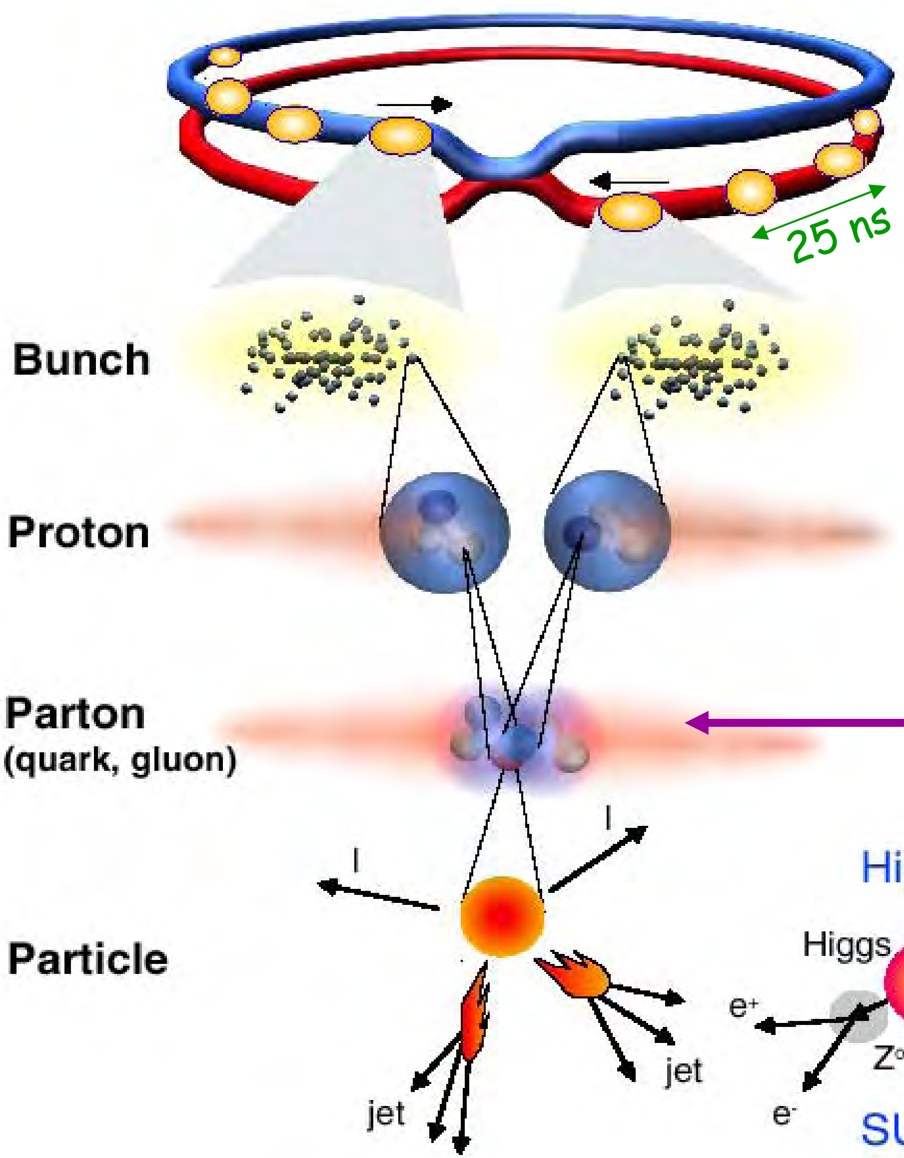
Magnet installation rate is now at 20 per week with more than 450 installed (25%)

In the next month, we will ramp up to 25/week

Installation will finish end February 2007



Collisions at LHC



Proton-Proton

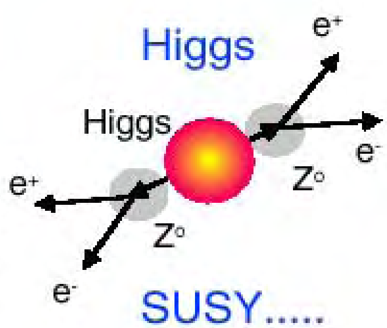
Protons/bunch	10^{11}
Beam energy	7 TeV (7×10^{12} eV)
Luminosity	10^{34} cm^{-2} s^{-1}

Event rate in ATLAS :

$N = L \times \sigma$ (pp) ≈ 10^9 interactions/s

Mostly soft (low p_T) events

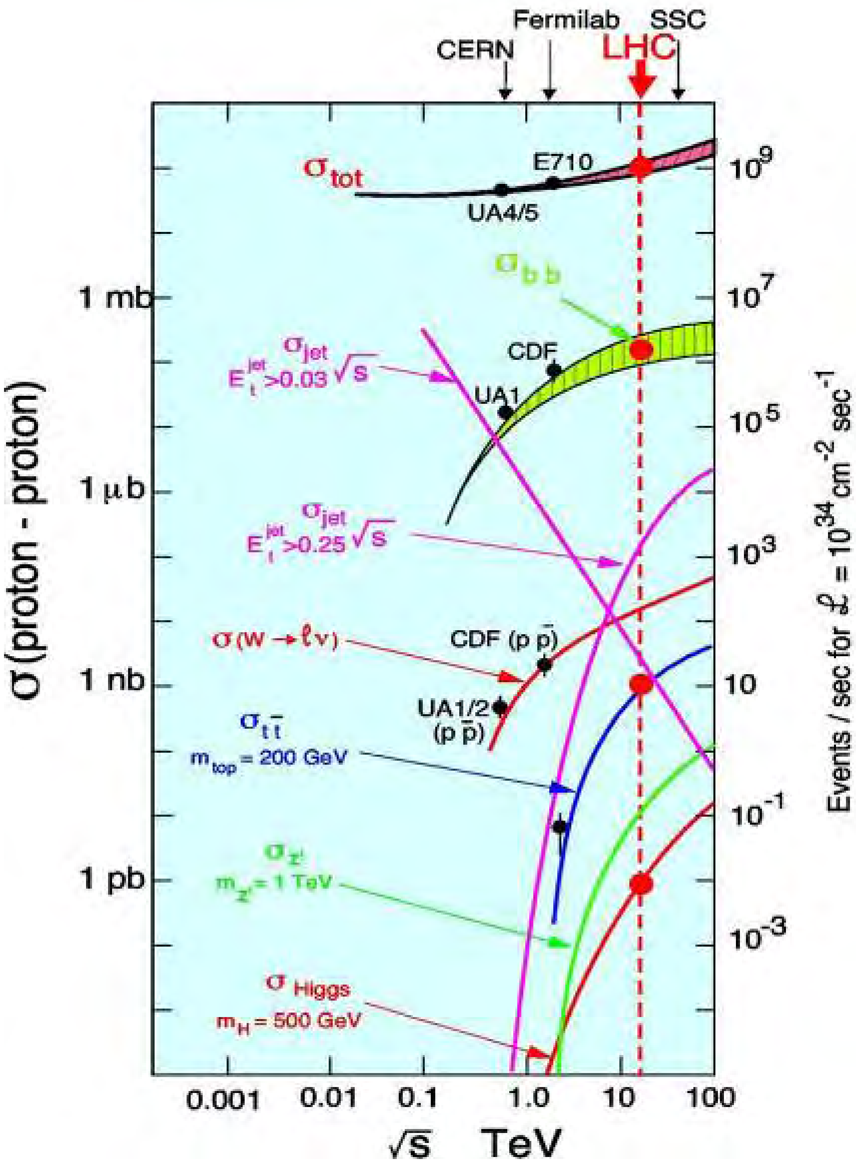
Interesting hard (high-p_T) events are rare



Selection of 1 in 10,000,000,000,000

→ very powerful detectors needed

Cross Sections and Production Rates



Rates for L = 10^{34} cm^{-2} s^{-1}: (LHC)

• **Inelastic proton-proton reactions:**	**10^9 / s**
• bb pairs	5 10^6 / s
• tt pairs	8 / s
• W → e ν	150 / s
• Z → e e	15 / s
• Higgs (150 GeV)	0.2 / s
• Gluino, Squarks (1 TeV)	0.03 / s

LHC is a factory for:
top-quarks, b-quarks, W, Z, ……. Higgs, ……

(The challenge: you have to detect them !)

Which physics the first year(s) ?

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

Process	Events/s	Events for 10 fb^{-1}	Total statistics collected at previous machines by '07
$W \to e\nu$	15	10^8	10^4 LEP / 10^7 Tevatron
$Z \to ee$	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**

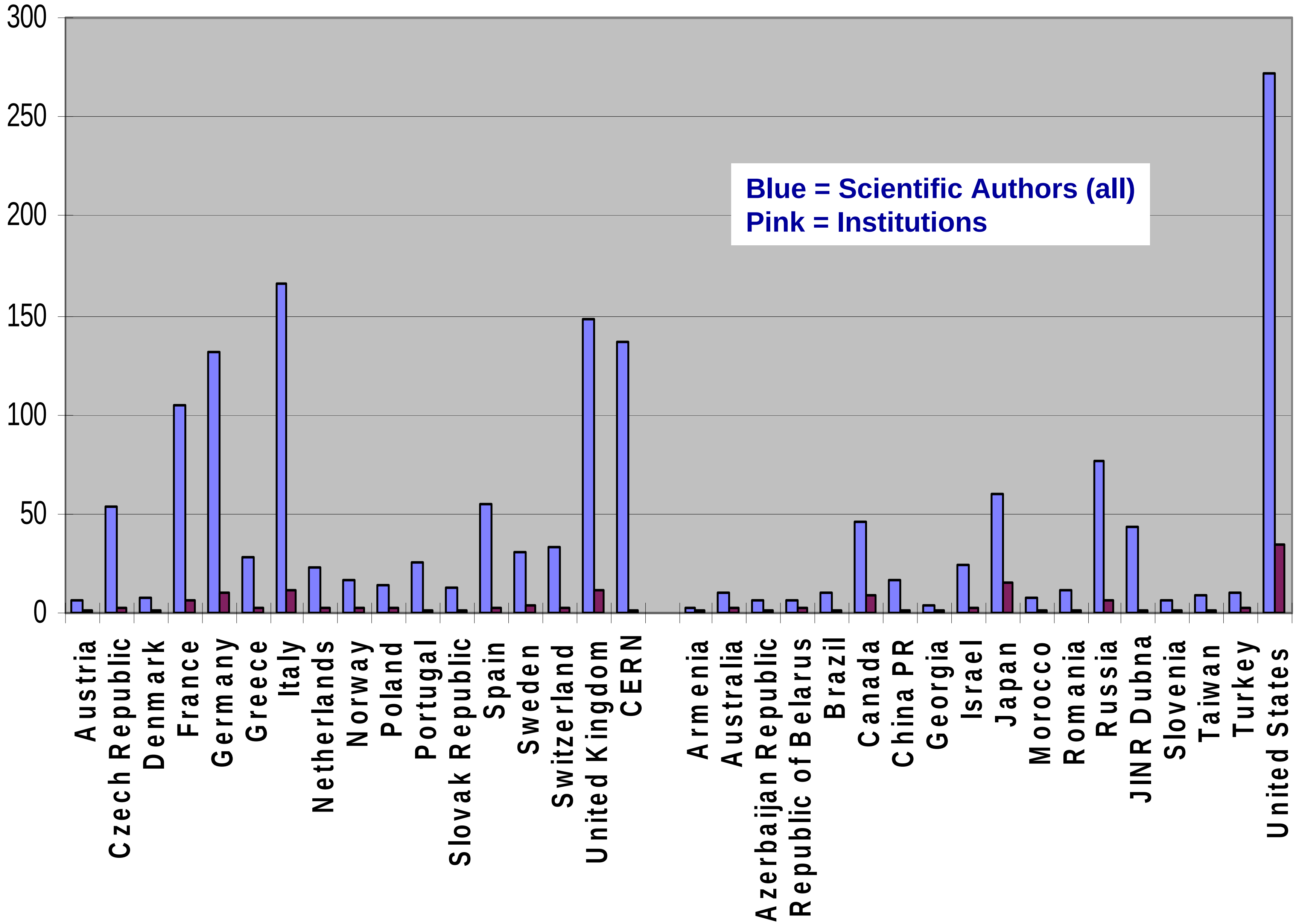
ATLAS Collaboration

(As of the March 2006)

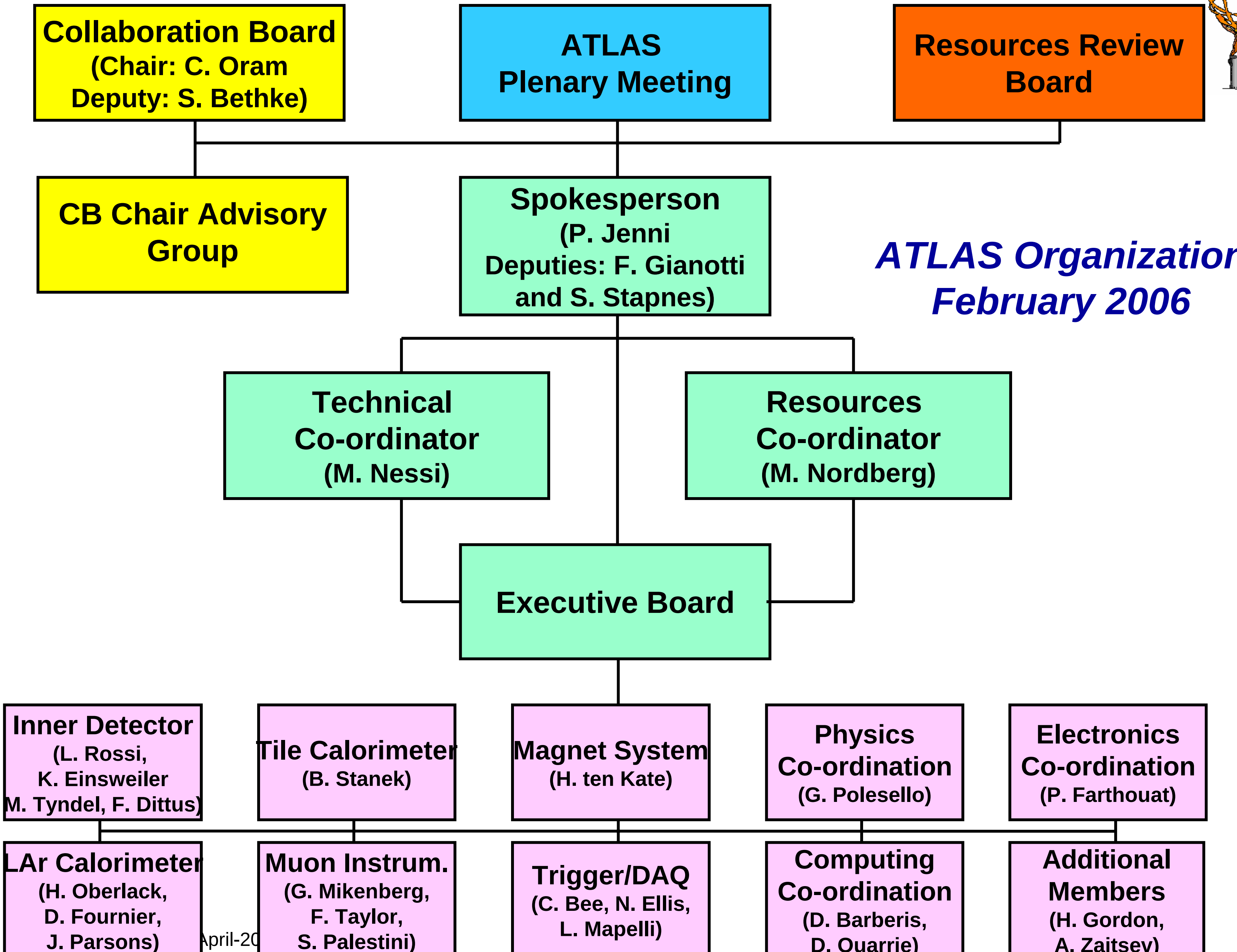
35 Countries
158 Institutions
1650 Scientific Authors total
(1300 with a PhD, for M&O share)

New application for CB decision in July
DESY, Humboldt U Berlin (Germany)
SLAC, New York U (US)

Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, Bern, Birmingham, Bologna, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, INP Cracow, FPNT Cracow, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, Mannheim, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Naples, Naruto UE, New Mexico, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Ritsumeikan, UFRJ Rio de Janeiro, Rochester, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, Wisconsin, Wuppertal, Yale, Yerevan

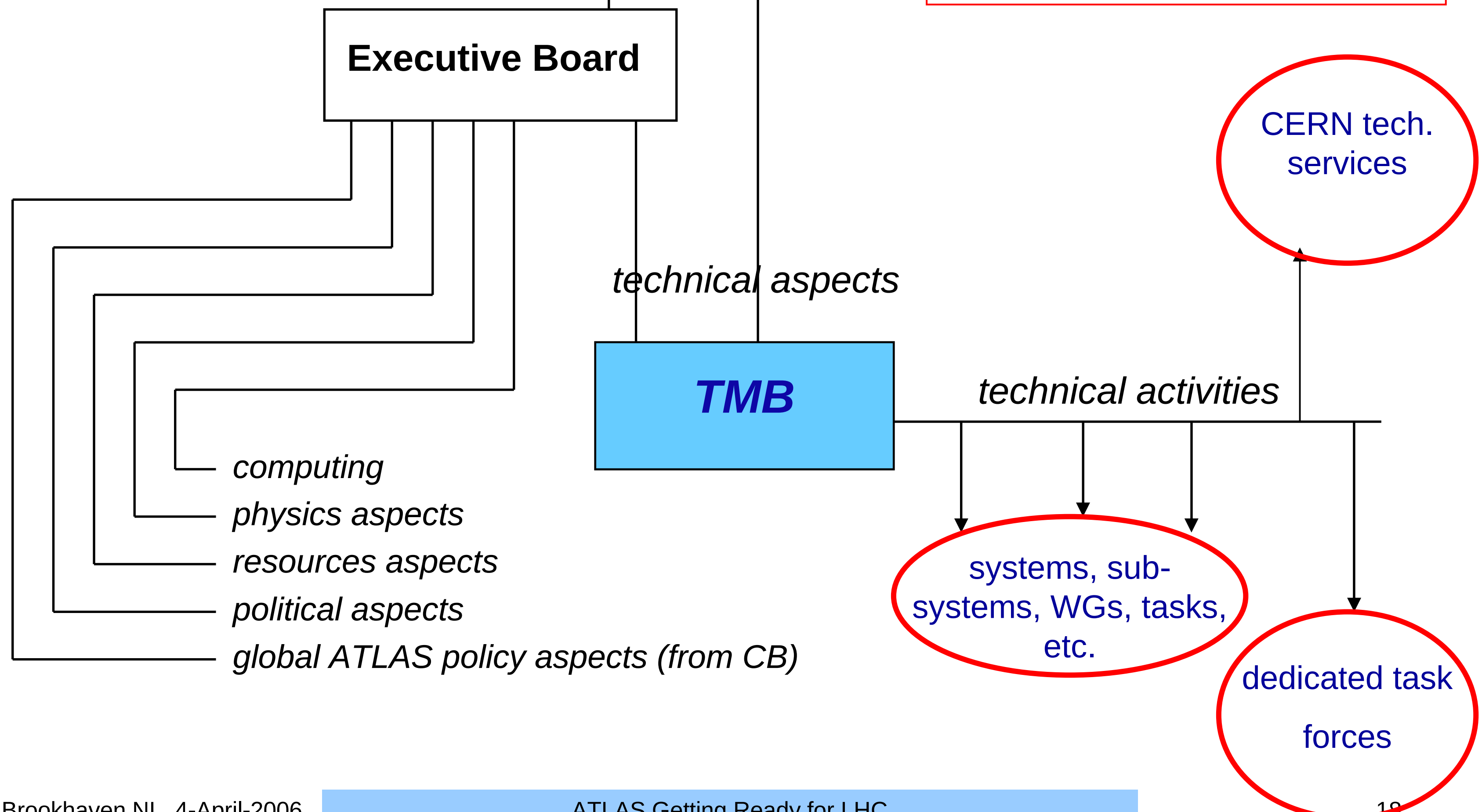


(Status October 2005)


ATLAS Organization
February 2006
Collaboration Board
(Chair: C. Oram
Deputy: S. Bethke)
ATLAS
Plenary Meeting
Resources Review
Board
CB Chair Advisory
Group
Spokesperson
(P. Jenni
Deputies: F. Gianotti
and S. Stapnes)
Technical
Co-ordinator
(M. Nessi)
Resources
Co-ordinator
(M. Nordberg)
Executive Board
Inner Detector
(L. Rossi,
K. Einsweiler
M. Tyndel, F. Dittus)
Tile Calorimeter
(B. Stanek)
Magnet System
(H. ten Kate)
Physics
Co-ordination
(G. Polesello)
Electronics
Co-ordination
(P. Farthouat)
LAr Calorimeter
(H. Oberlack,
D. Fournier,
J. Parsons)
Muon Instrum.
(G. Mikenberg,
F. Taylor,
S. Palestini)
Trigger/DAQ
(C. Bee, N. Ellis,
L. Mapelli)
Computing
Co-ordination
(D. Barberis,
D. Quarrie)
Additional
Members
(H. Gordon,
A. Zaitsev)

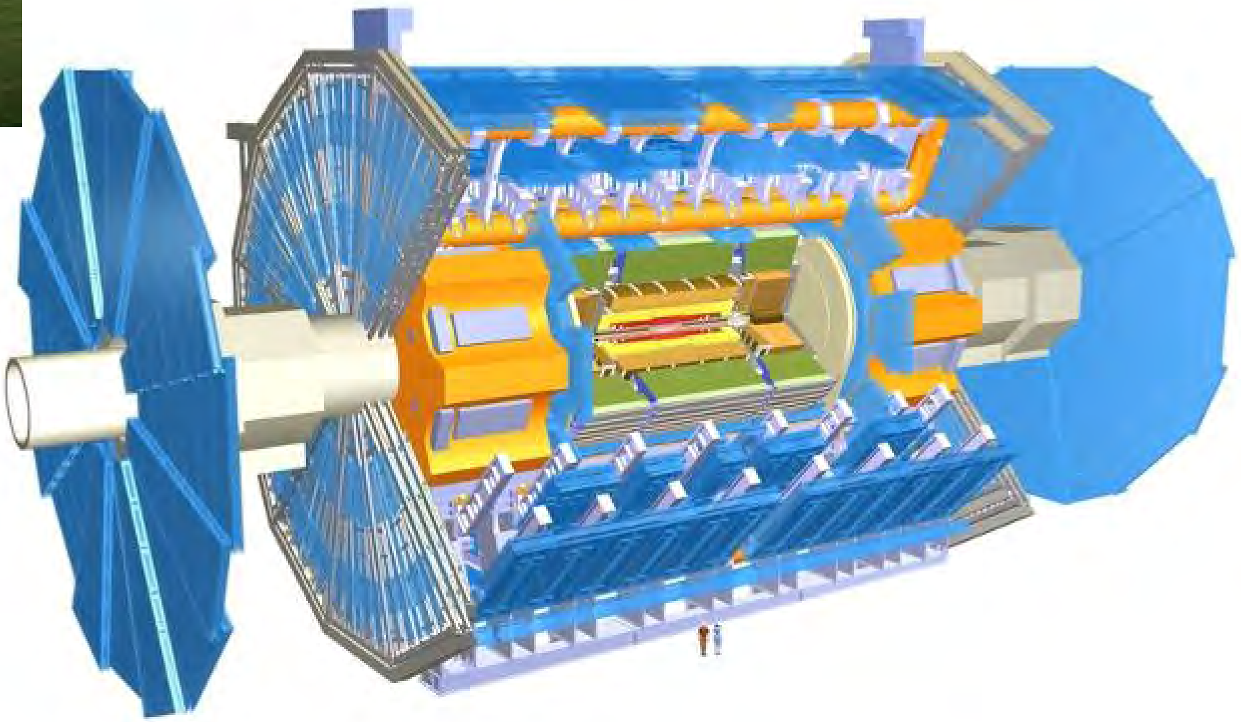
Technical Management Board - TMB
(Chaired by the Technical Coordinator)

US ATLAS plays a strong and very beneficial role in the Technical Coordination (lead by D Lissauer)

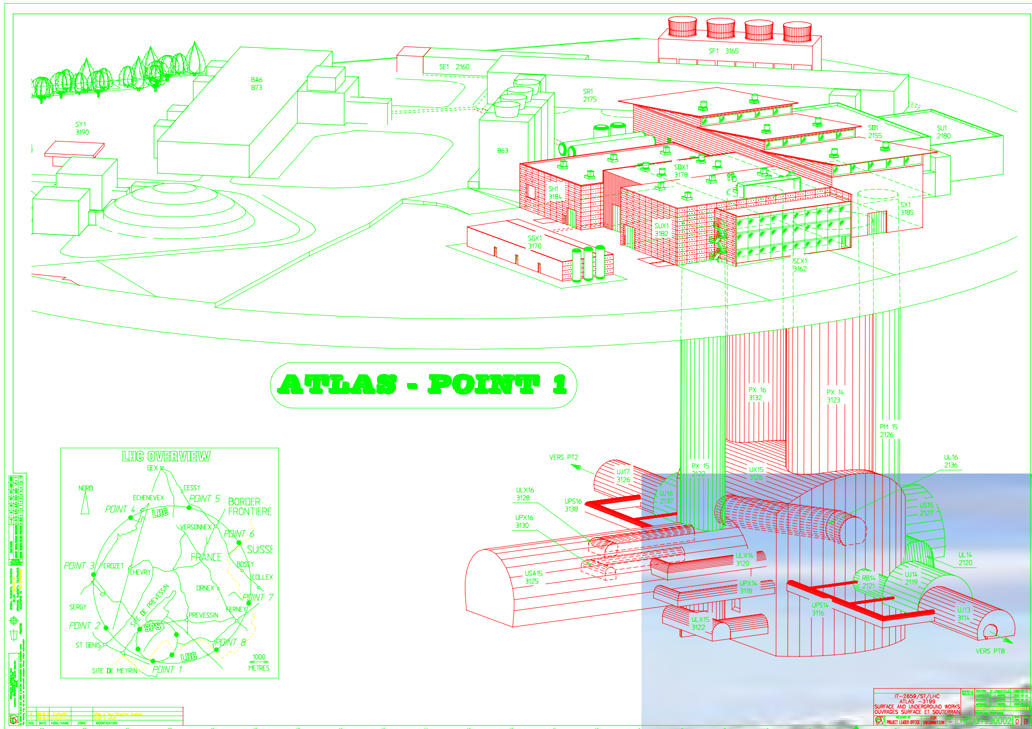


ATLAS superimposed to
the 5 floors of building 40

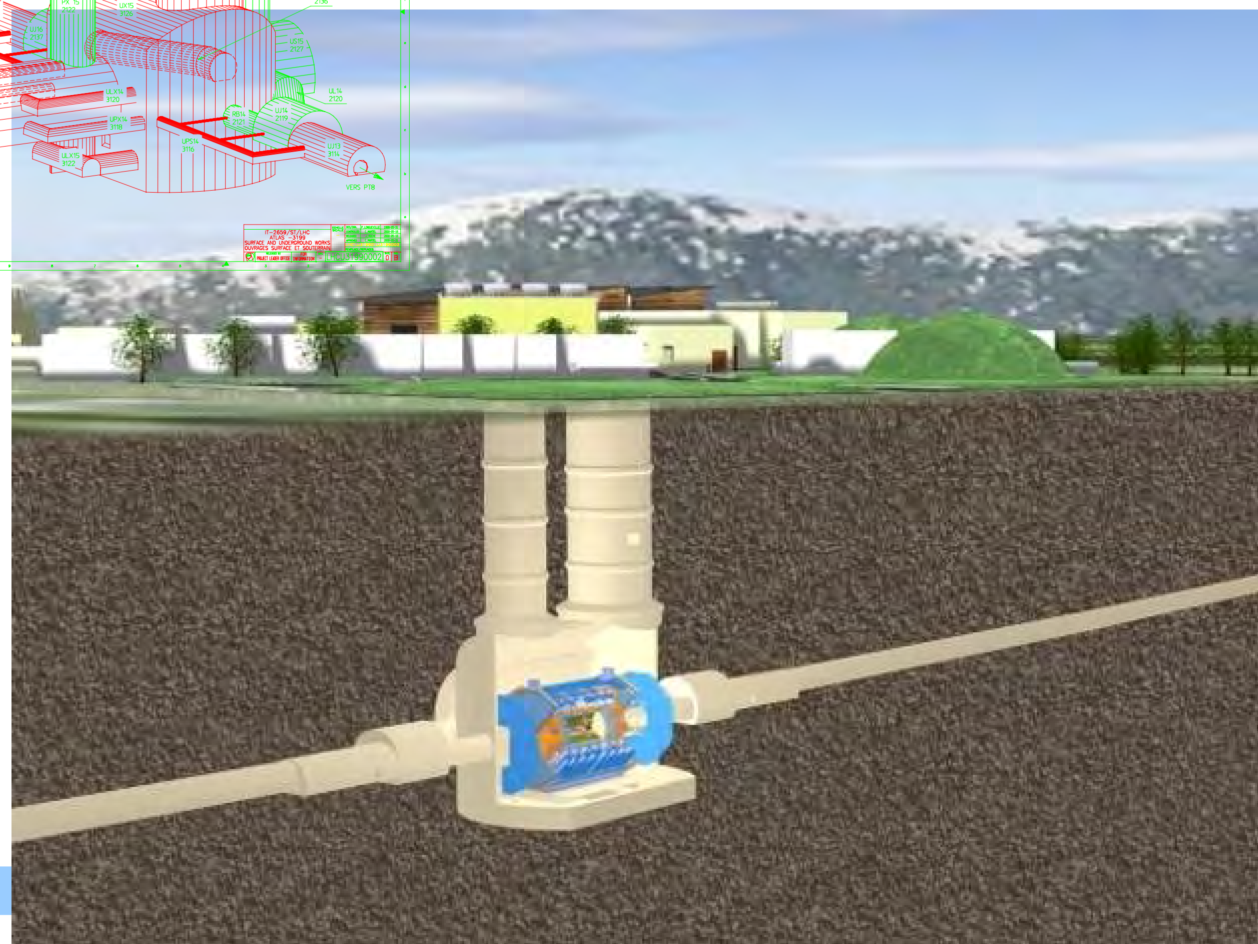
Construction, integration and installation progress of the ATLAS detector



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



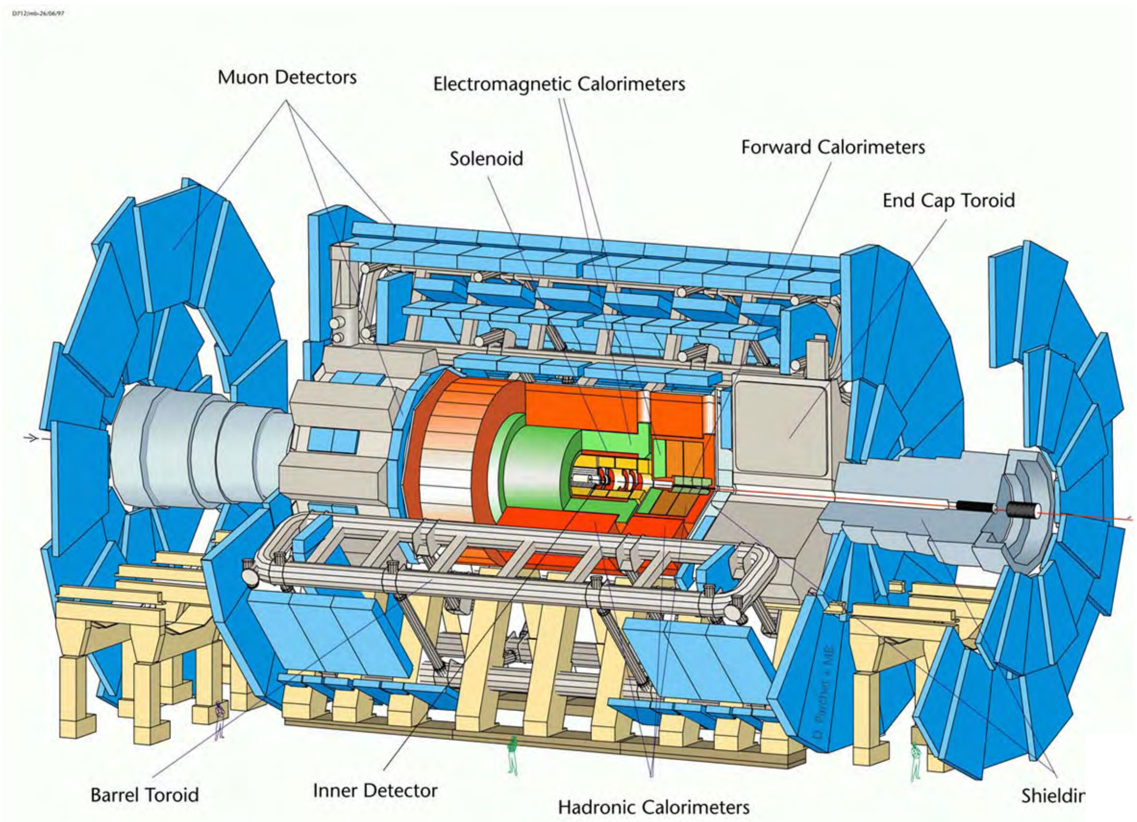
The Underground Cavern at Pit-1 for the ATLAS Detector



Length = 55 m
Width = 32 m
Height = 35 m

An Aerial View of Point-1

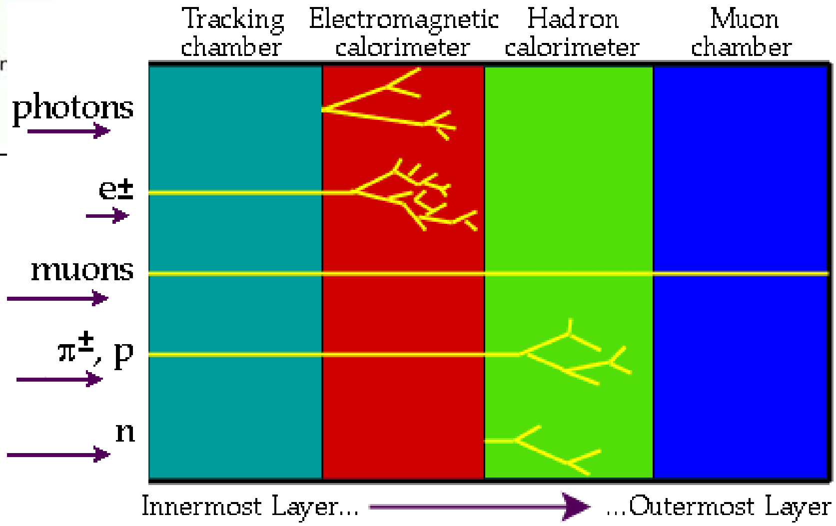
(Across the street from the CERN main entrance)



ATLAS

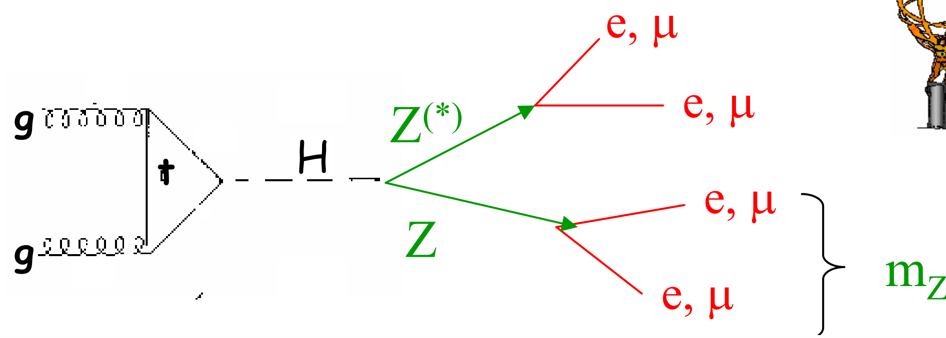
Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~ 10^8 electronic channels
~ 3000 km of cables

- **Tracking (|η|<2.5, B=2T) :**
  - **-- Si pixels and strips**
  - **-- Transition Radiation Detector (e/π separation)**
- **Calorimetry (|η|<5) :**
  - **-- EM : Pb-LAr**
  - **-- HAD: Fe/scintillator (central), Cu/W-LAr (fwd)**
- **Muon Spectrometer (|η|<2.7) :**
  air-core toroids with muon chambers

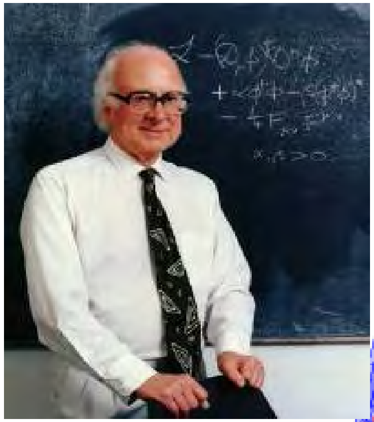


Physics example

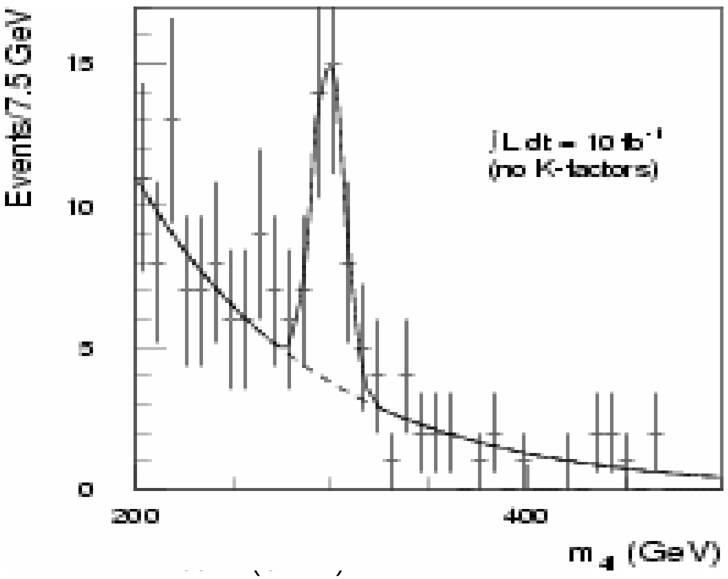
$H \to ZZ \to 4\,\ell$

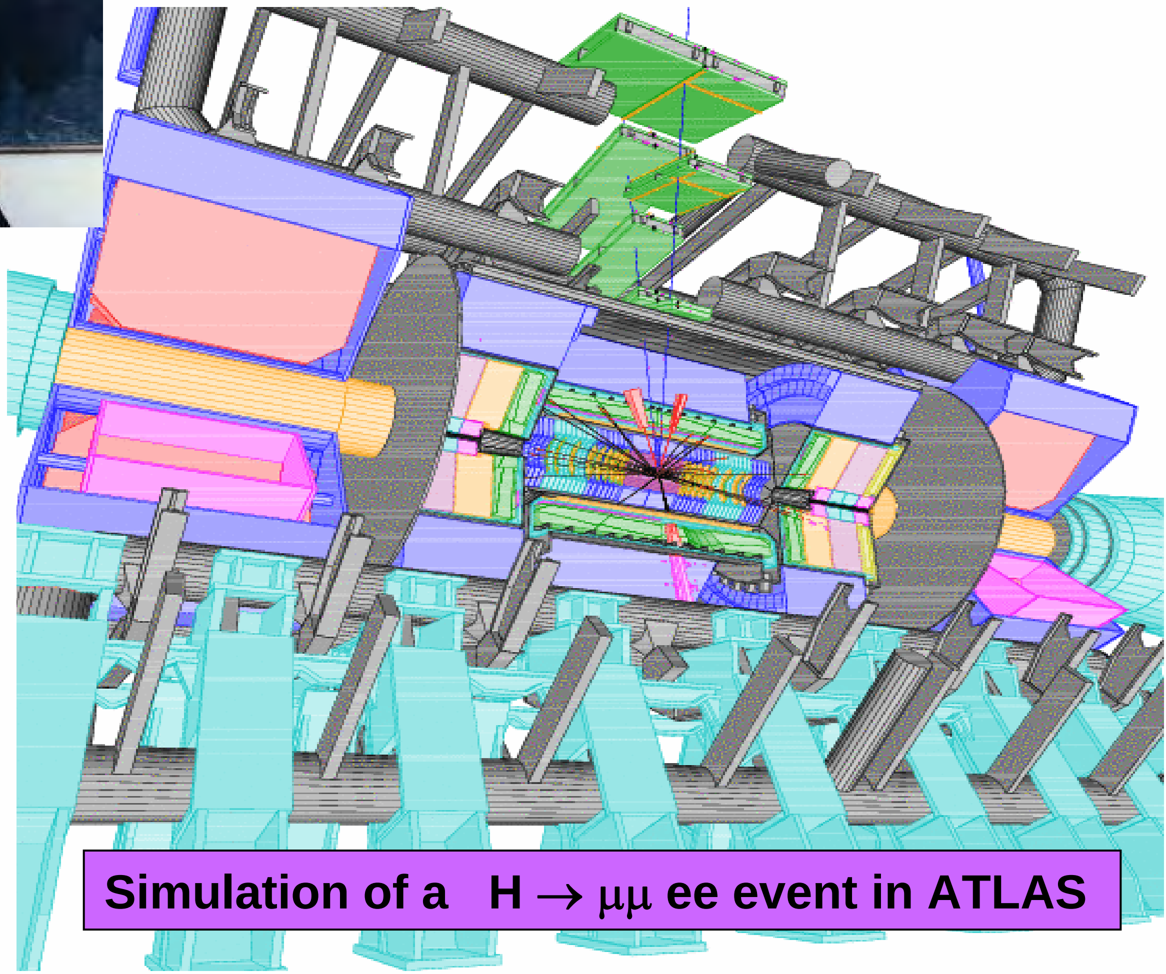


"Gold-plated" channel for Higgs discovery at LHC



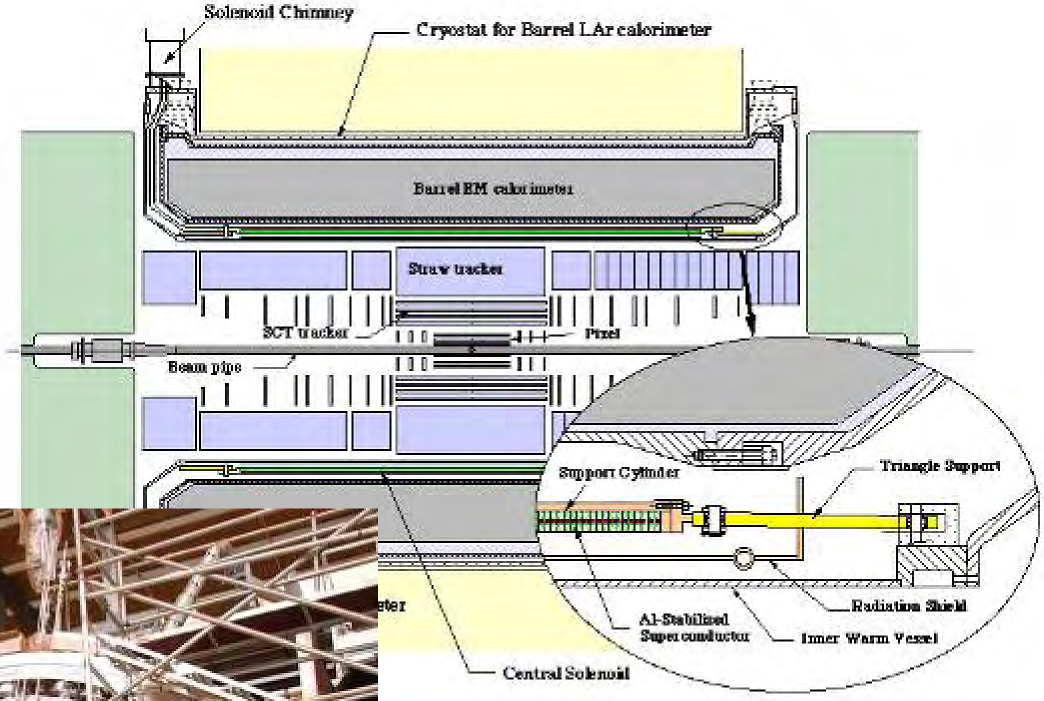
Signal expected in ATLAS after 1 year of LHC operation





Simulation of a $H \to \mu\mu\, ee$ event in ATLAS

Magnet System



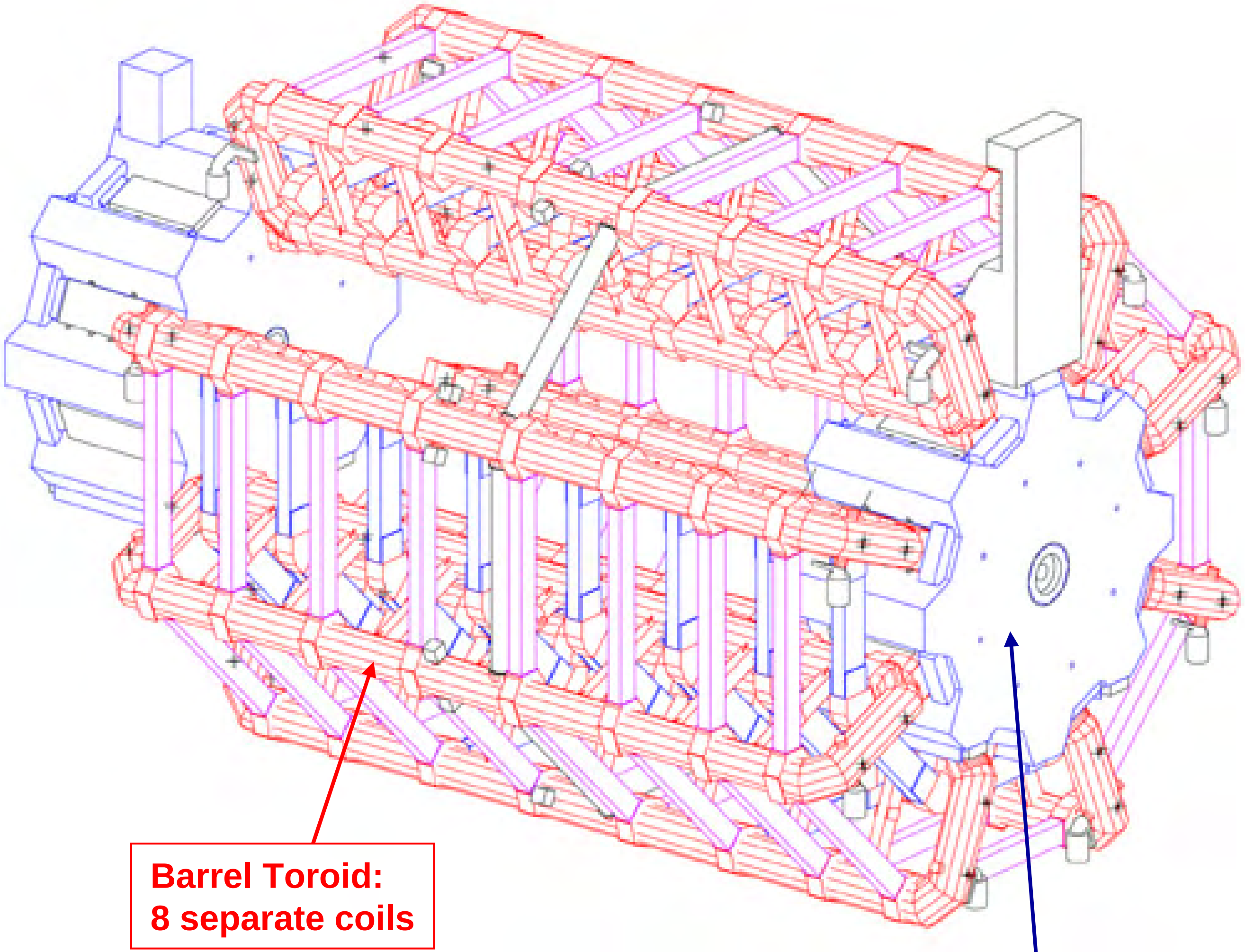
Central Solenoid

2T field with a stored energy of 38 MJ

Integrated design within the barrel LAr cryostat

The solenoid has been inserted into the LAr cryostat at the end of February 2004, and it was tested at full current (8 kA) during July 2004

Toroid system



Barrel Toroid parameters

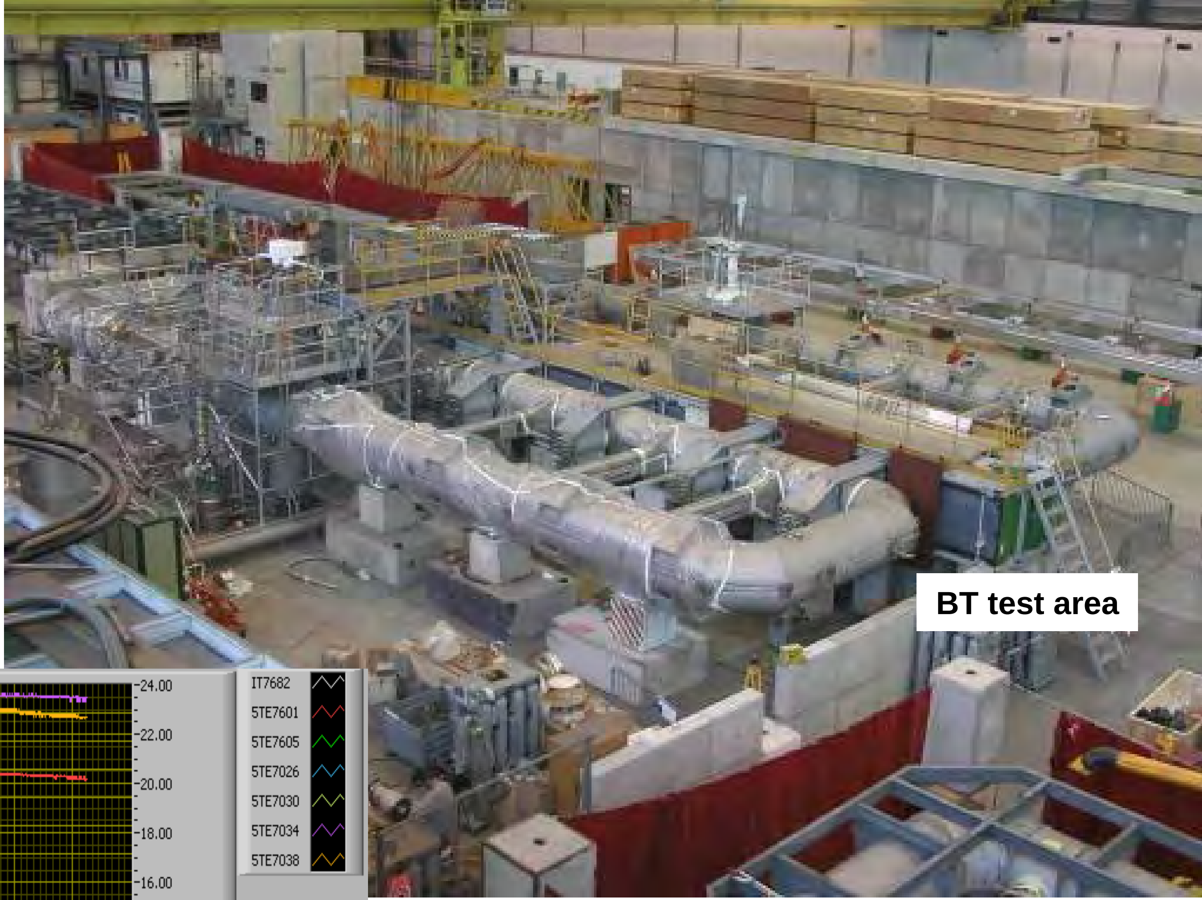
25.3 m length
20.1 m outer diameter
8 coils
1.08 GJ stored energy
370 tons cold mass
830 tons weight
4 T on superconductor
56 km Al/NbTi/Cu conductor
20.5 kA nominal current
4.7 K working point

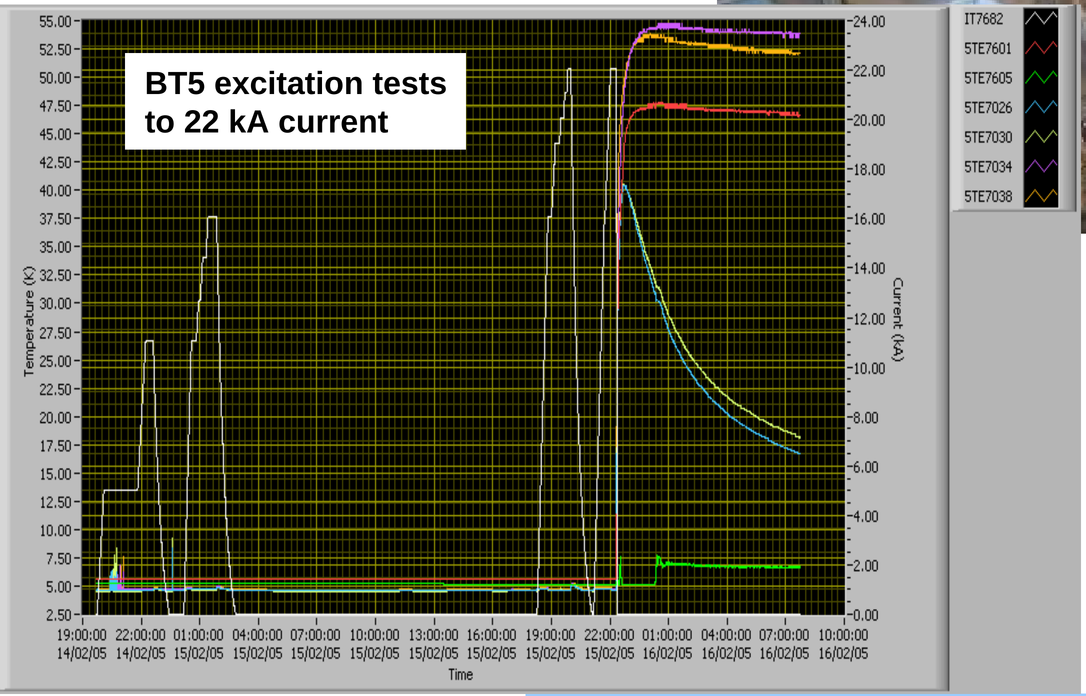
End-Cap Toroid parameters

5.0 m axial length
10.7 m outer diameter
2x8 coils
2x0.25 GJ stored energy
2x160 tons cold mass
2x240 tons weight
4 T on superconductor
2x13 km Al/NbTi/Cu conductor
20.5 kA nominal current
4.7 K working point

Barrel Toroid construction

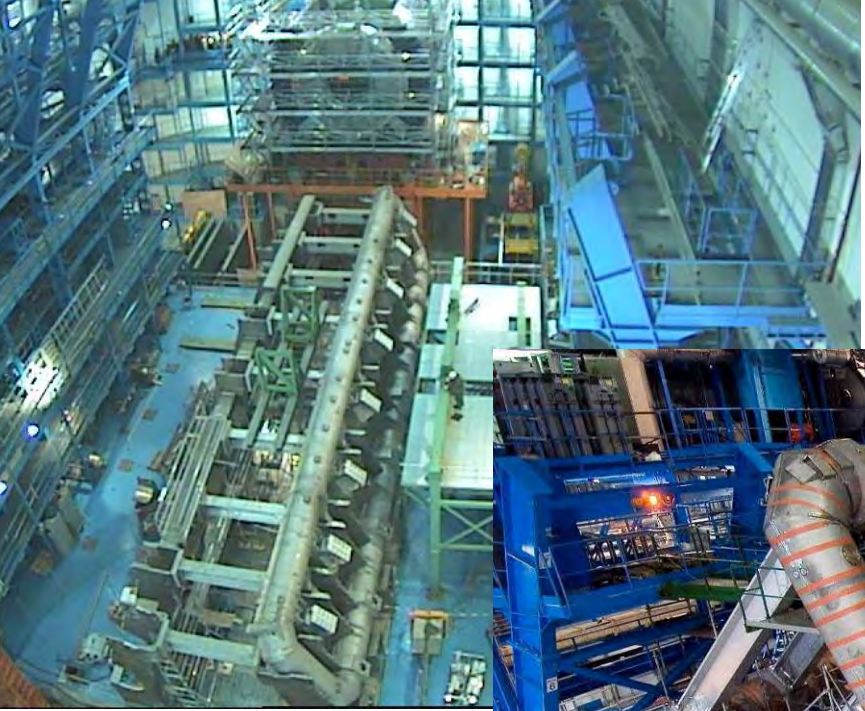
Series integration and tests of the 8 coils at the surface were finished in June 2005





Barrel Toroid coil transport and lowering into the underground cavern

The first coil was installed in October 2004



The last coil was moved into position on 25th August 2005

In-situ cool down will start in April, and first full current excitation end of May 2006

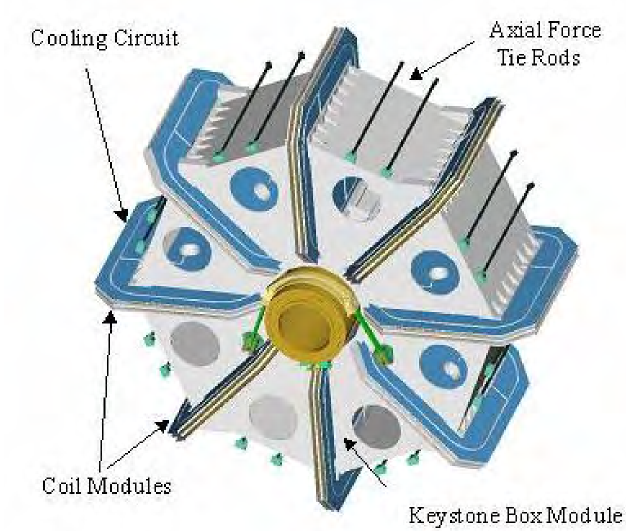
(latest news: no major leaks, the system is being pumped down)

End-Cap Toroids

All components are fabricated, and the assembly is now ongoing at CERN

The ECTs will be tested at 80 K on the surface, before installation and excitation tests in the cavern

The first ECT will move to the pit in August 2006, the second one in November 2006



The first of the two ECT cold masses ready for insertion into the large vacuum vessel

Inner Detector (ID)

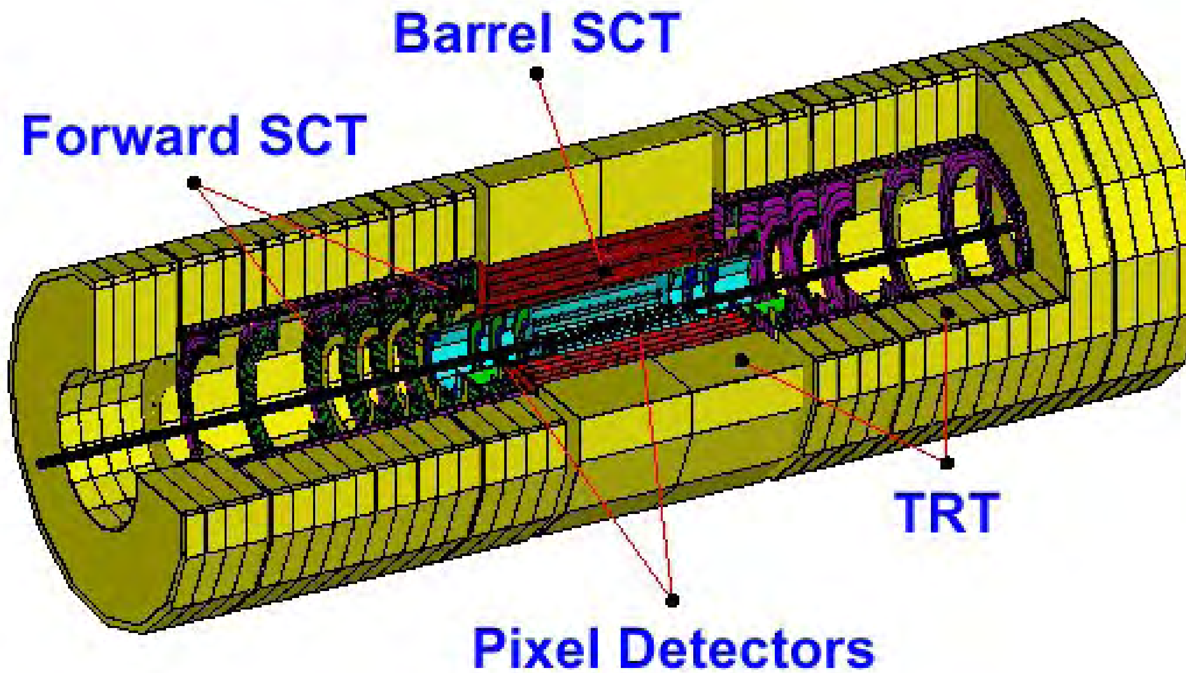
The Inner Detector (ID) is organized into four sub-systems:

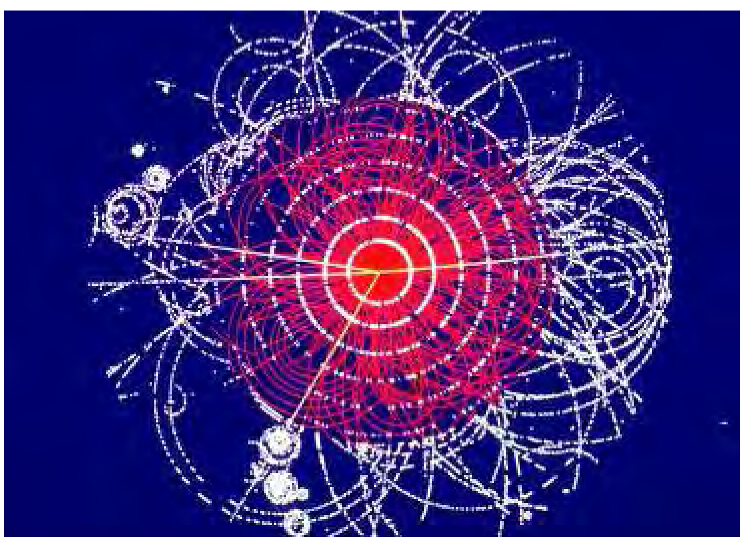
Pixels
(0.8 10^8 channels)

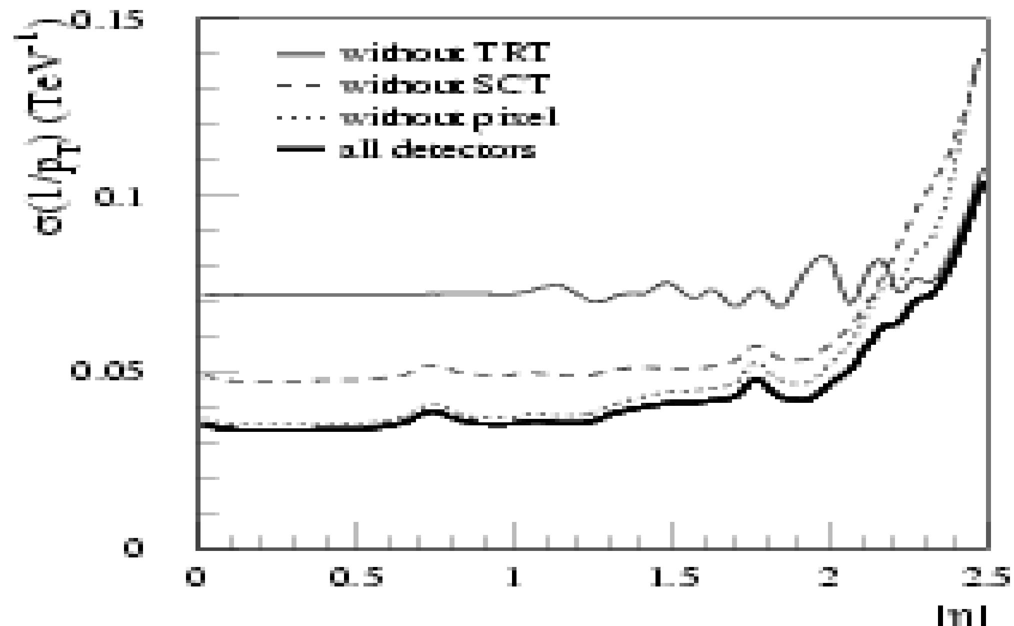
Silicon Tracker (SCT)
(6 10^6 channels)

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

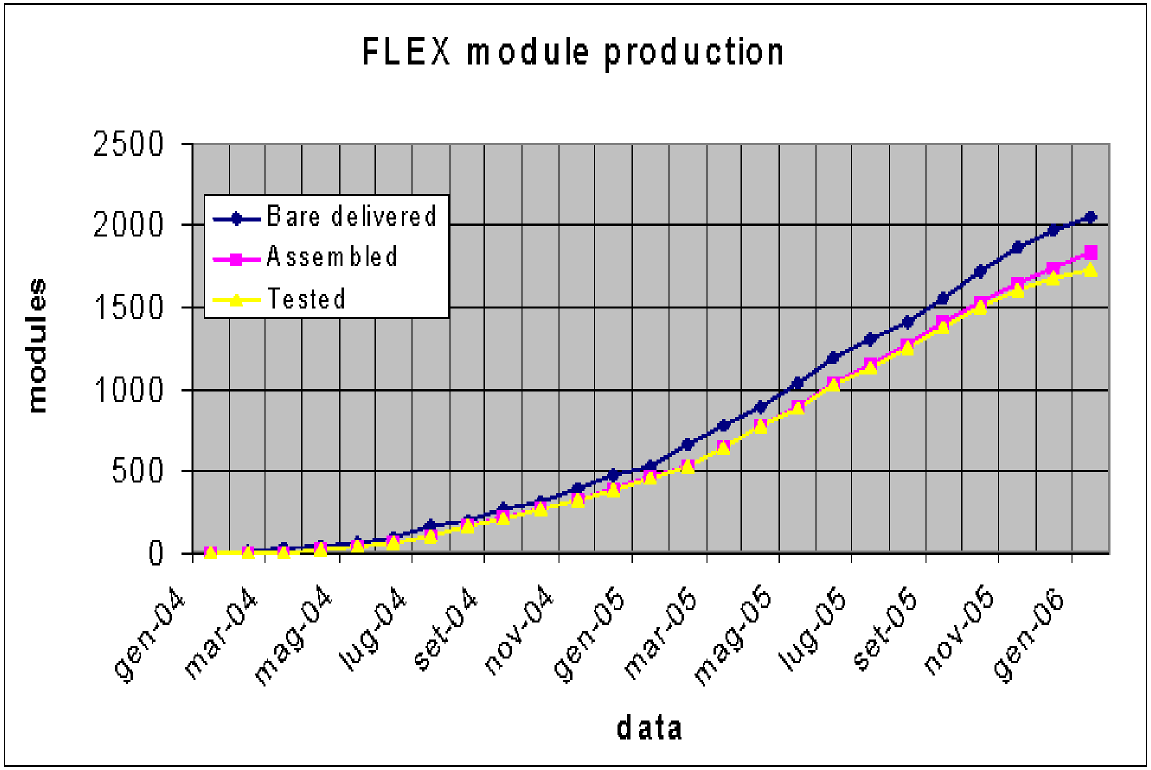
Common ID items



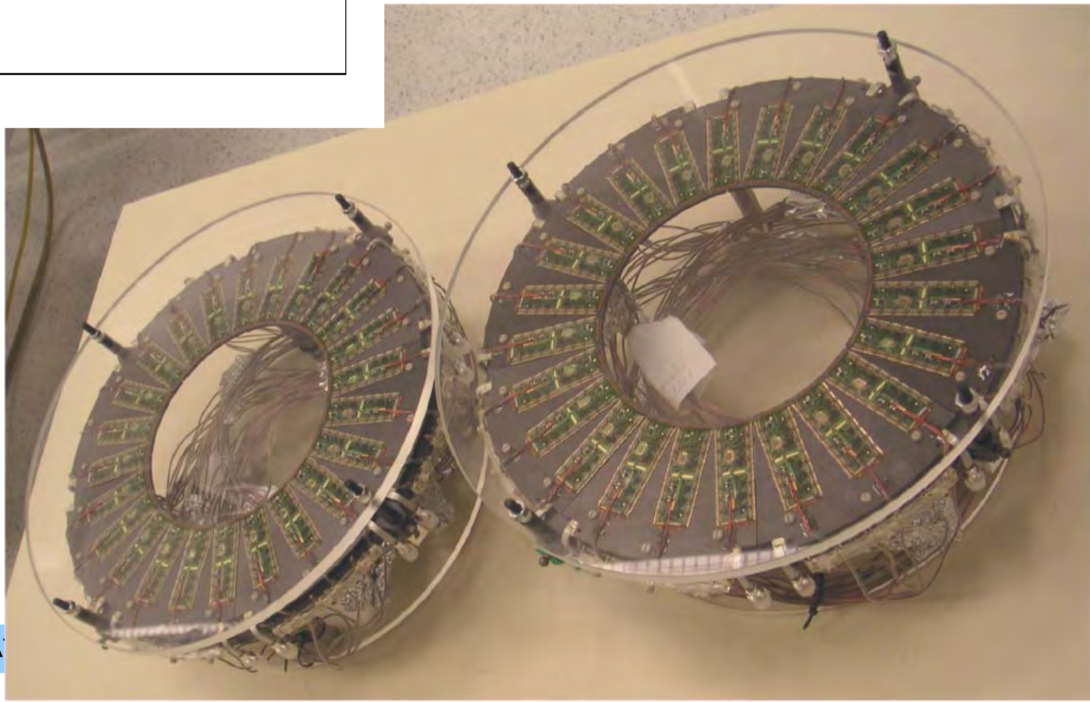




Pixels



The rate for assembled and fully qualified modules meets the needs for a 3-hit system in time (1766 modules needed)



Two completed Pixel disks, each with 2.2 M channels

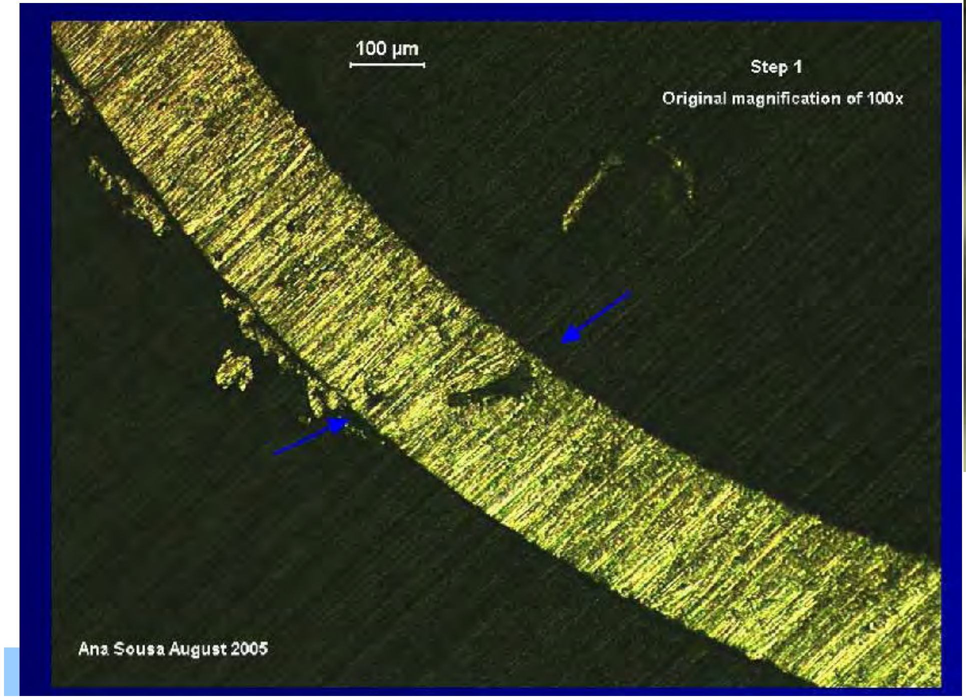
Pixels

After excellent progress on the Pixel project a technical problem has affected the schedule

Corrosion leaks in the barrel cooling tubes (highest priority is given to implement an optimum strategy for repair and rebuilding of staves, and the work is well on track until now)

The installation schedule has been adapted as to accommodate a late availability

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

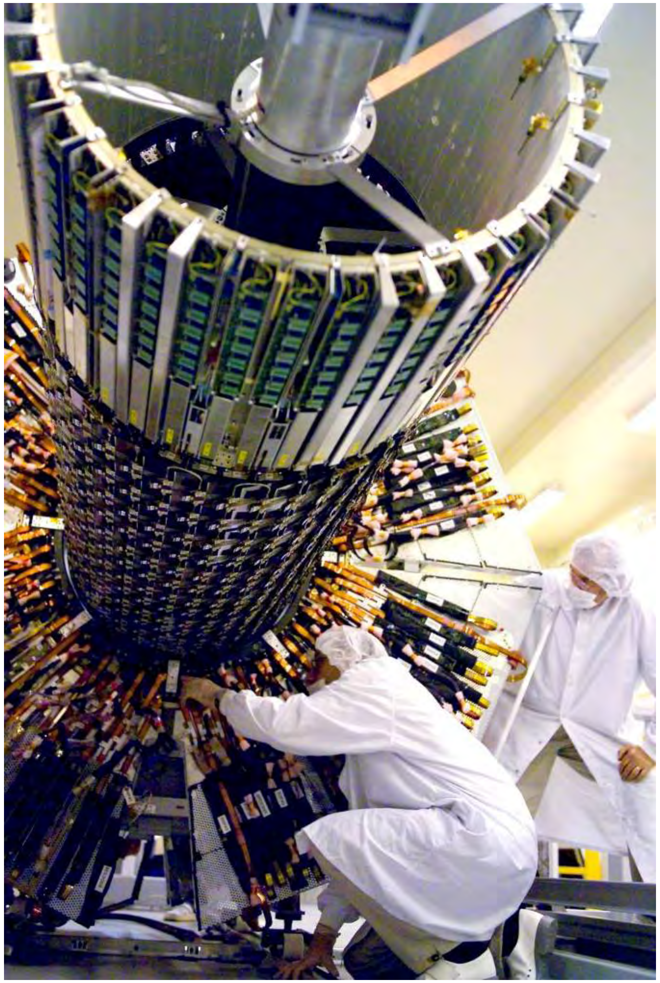


Example of a galvanic corrosion hole that is opening

Completed barrel stave

Silicon Tracker (SCT)

All four barrel cylinders are complete and at CERN

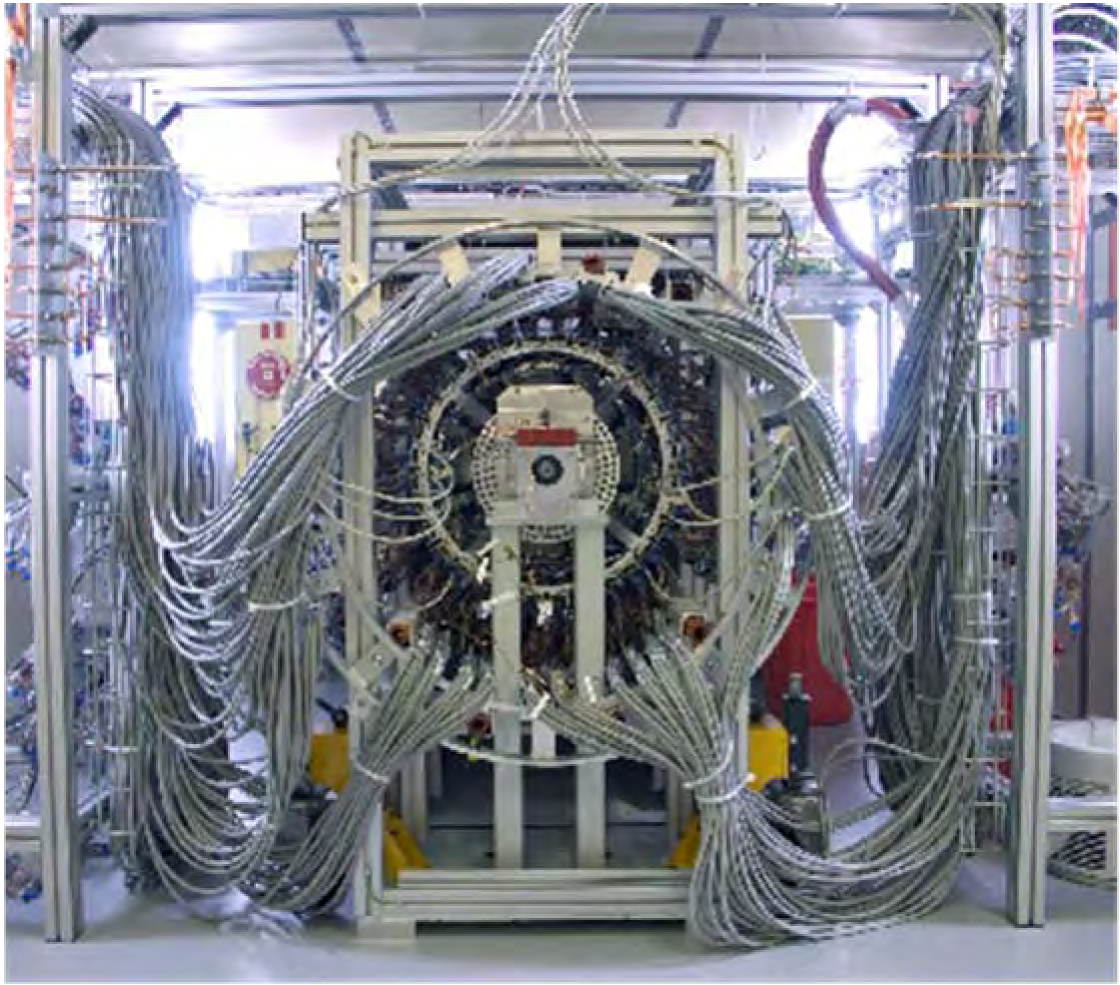


ID integration and commissioning at the surface

SCT acceptance tests
(each barrel was fully tested)

Barrel	Total Channels	Total Defects
3	589824	1483
4	737280	841
5	884736	1818
6	1032192	5720
Total	**3244032**	**9862**

Total of 99.7% of all channels fully functional



SCT barrel during acceptance test

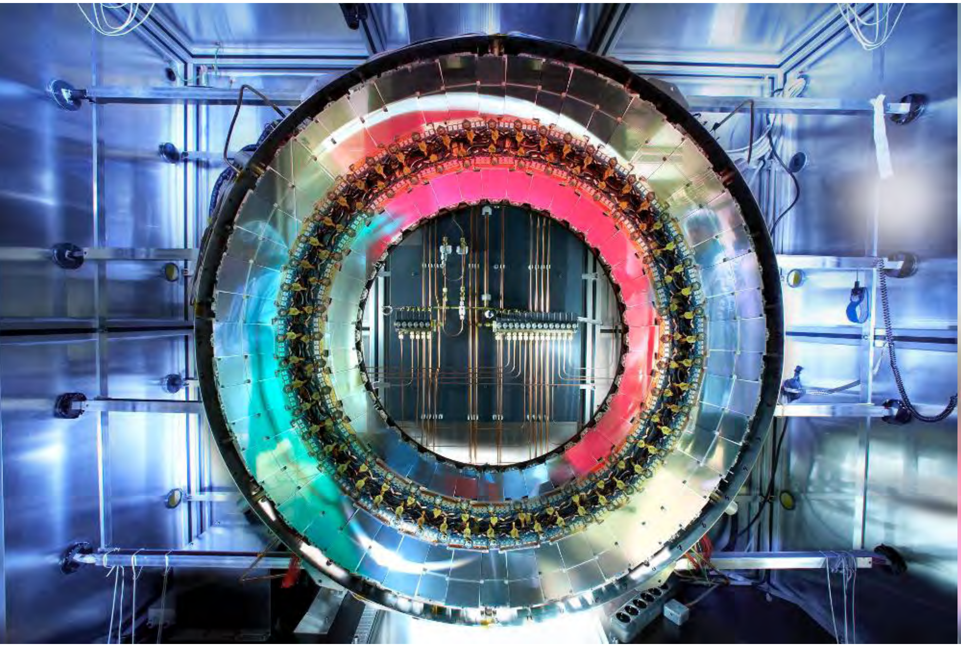
End-cap SCT

All disks for the end-caps are finished as well

The first end-cap arrived end of February 2006 at CERN, the second is expected in May 2006

A completed end-cap SCT disk

Support cylinder to receive SCT end-cap disks

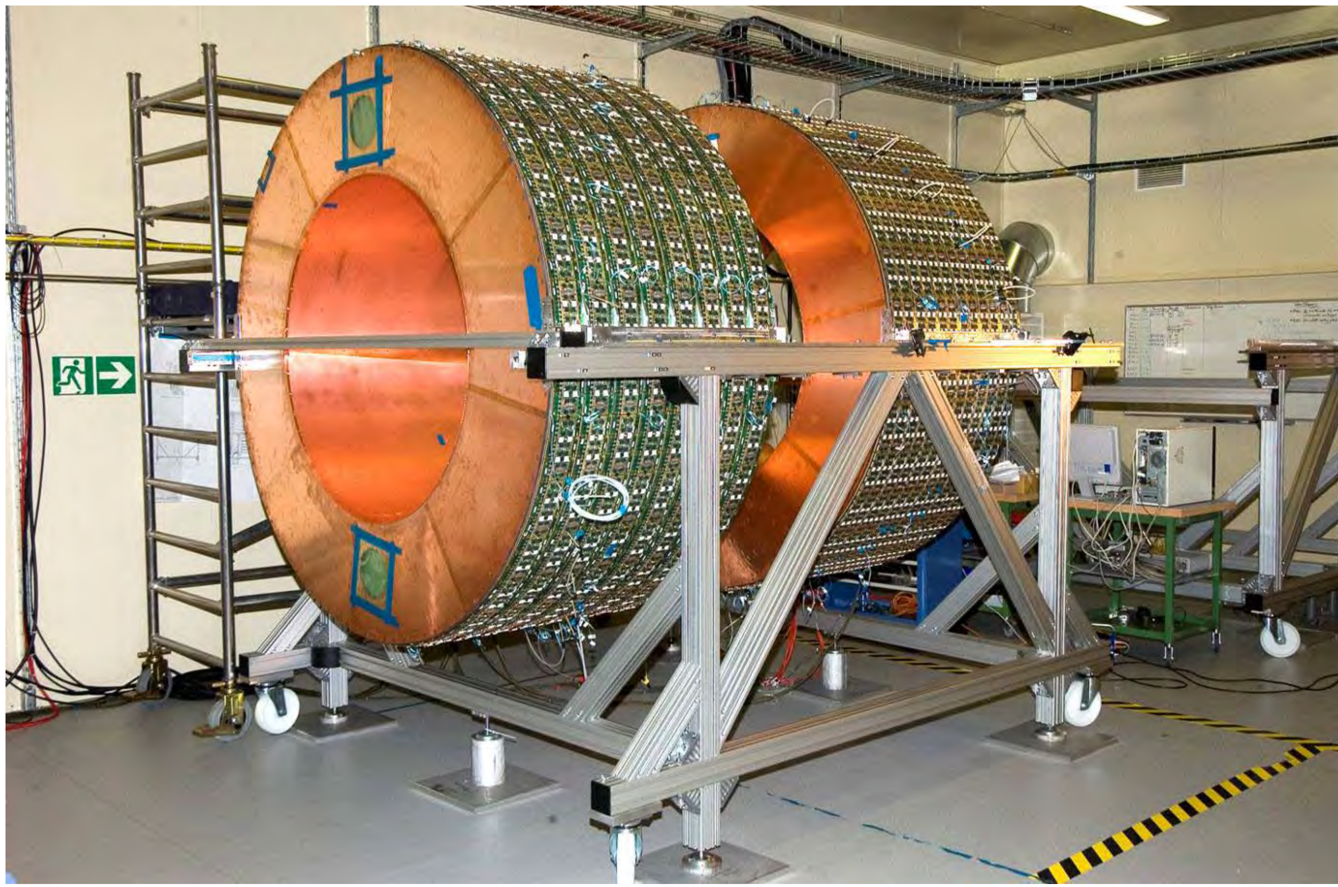


(Pictures taken by a famous photographer, P. Ginter, as art-work…)

Transition Radiation Tracker (TRT)

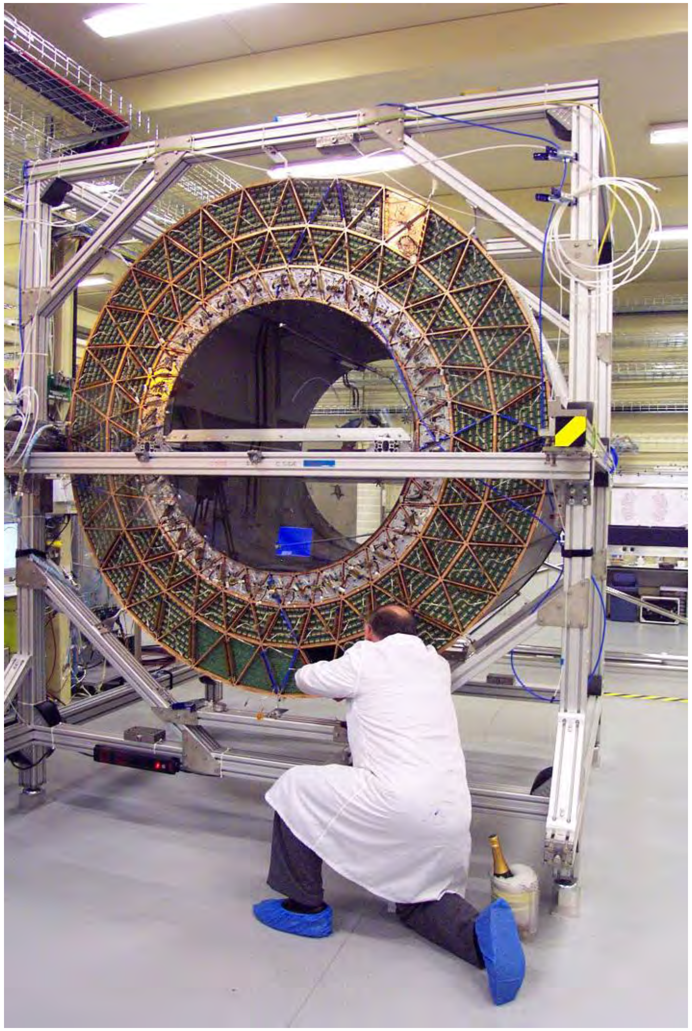
This detector will not only contribute to tracking, but also to electron identification by detecting transition radiation X-rays in a gas mixture containing ~ 70% Xe

The module construction for the TRT is complete



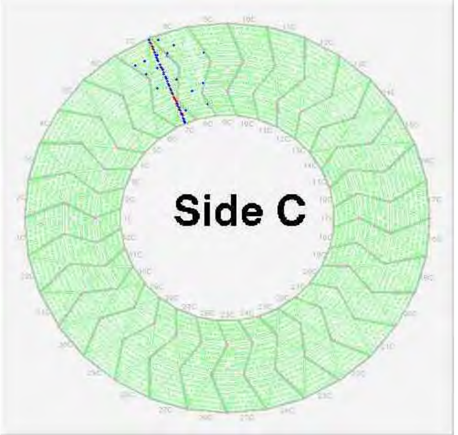
The first of the two end-cap TRTs fully assembled

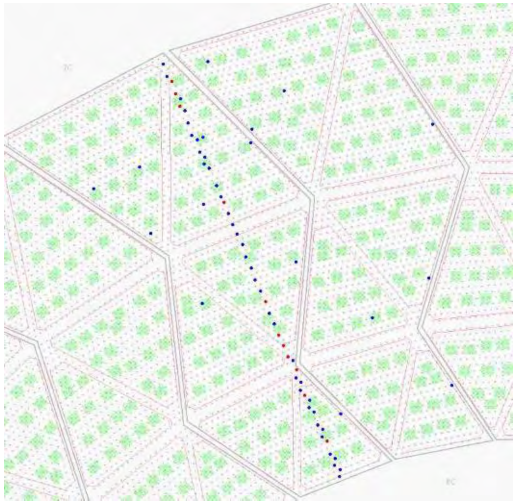
Two examples of cosmic rays registered in the barrel TRT in the Inner Detector surface clean room facility SR1



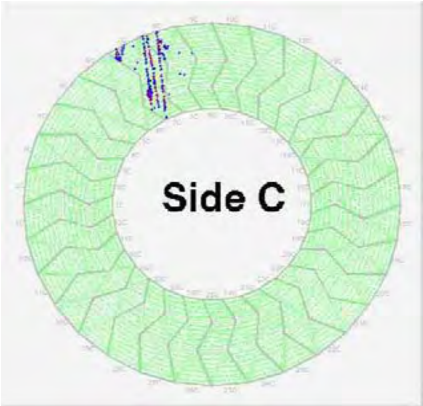
Barrel TRT during insertion of the last modules (February 2005)

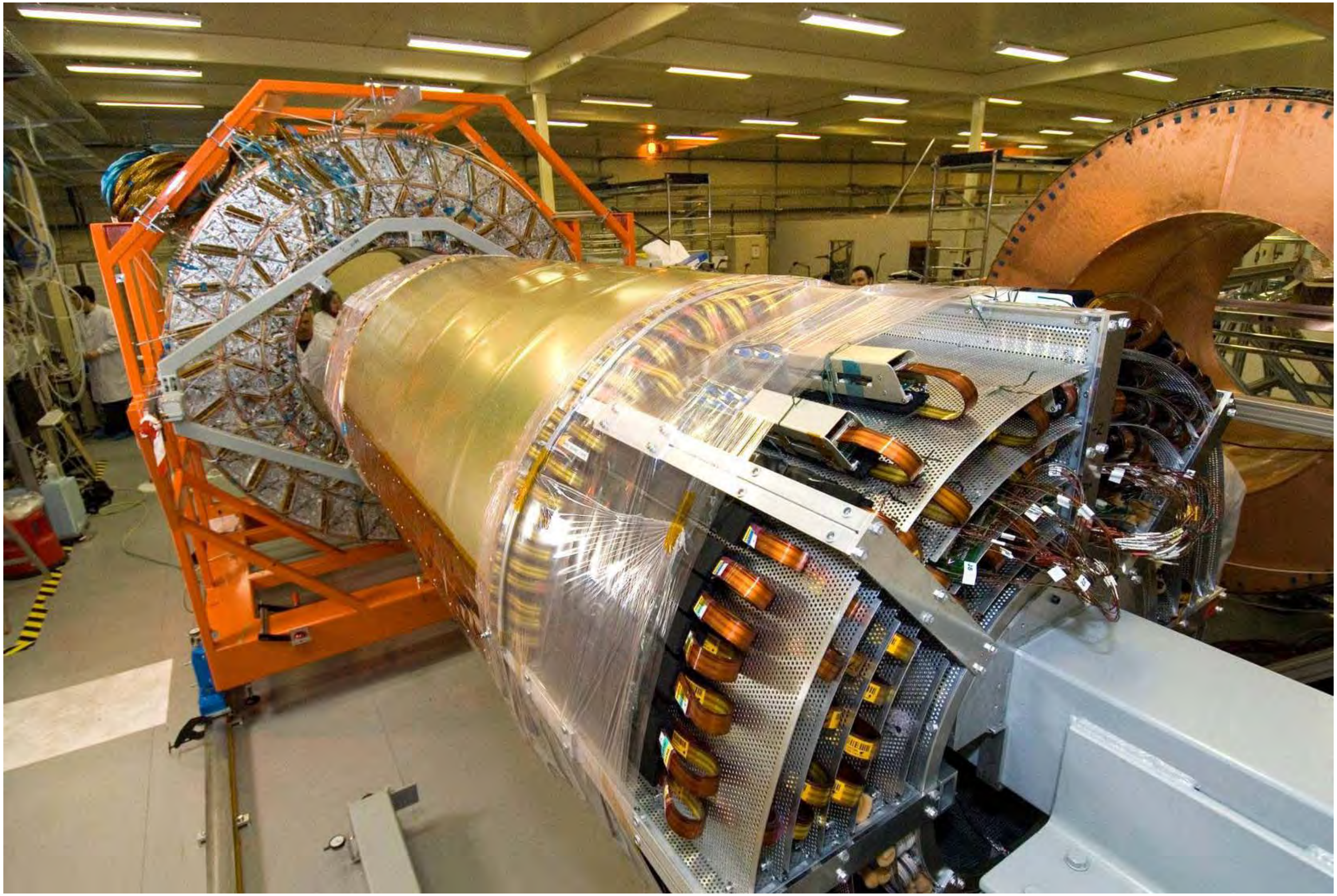
Example 1





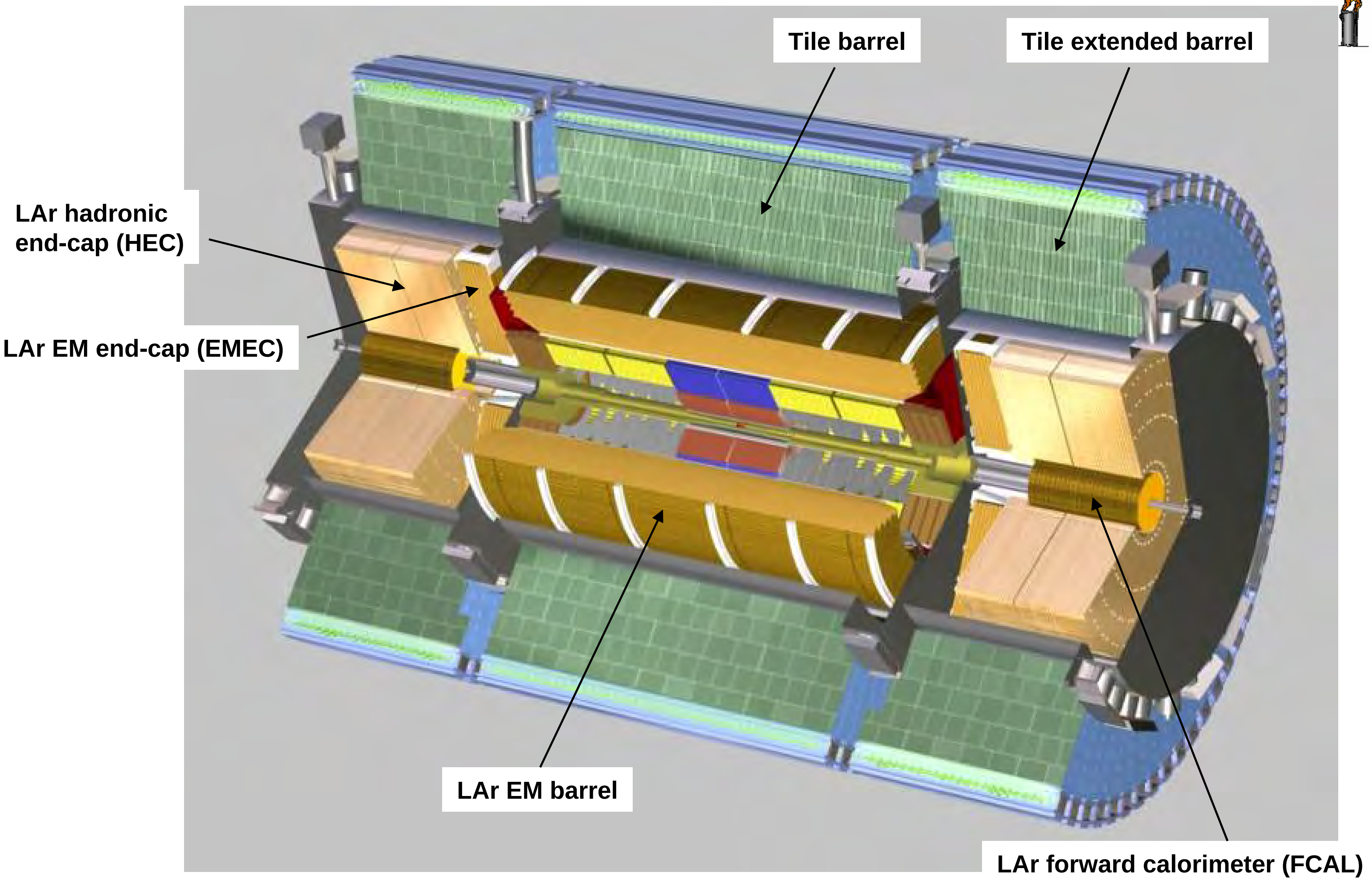
Example 2





End of February 2006 the barrel SCT was inserted into the barrel TRT, and this Inner Detector system will be ready for the final installation in ATLAS in June 2006

LAr and Tile Calorimeters



LAr EM Barrel Calorimeter Commissioning at the Surface

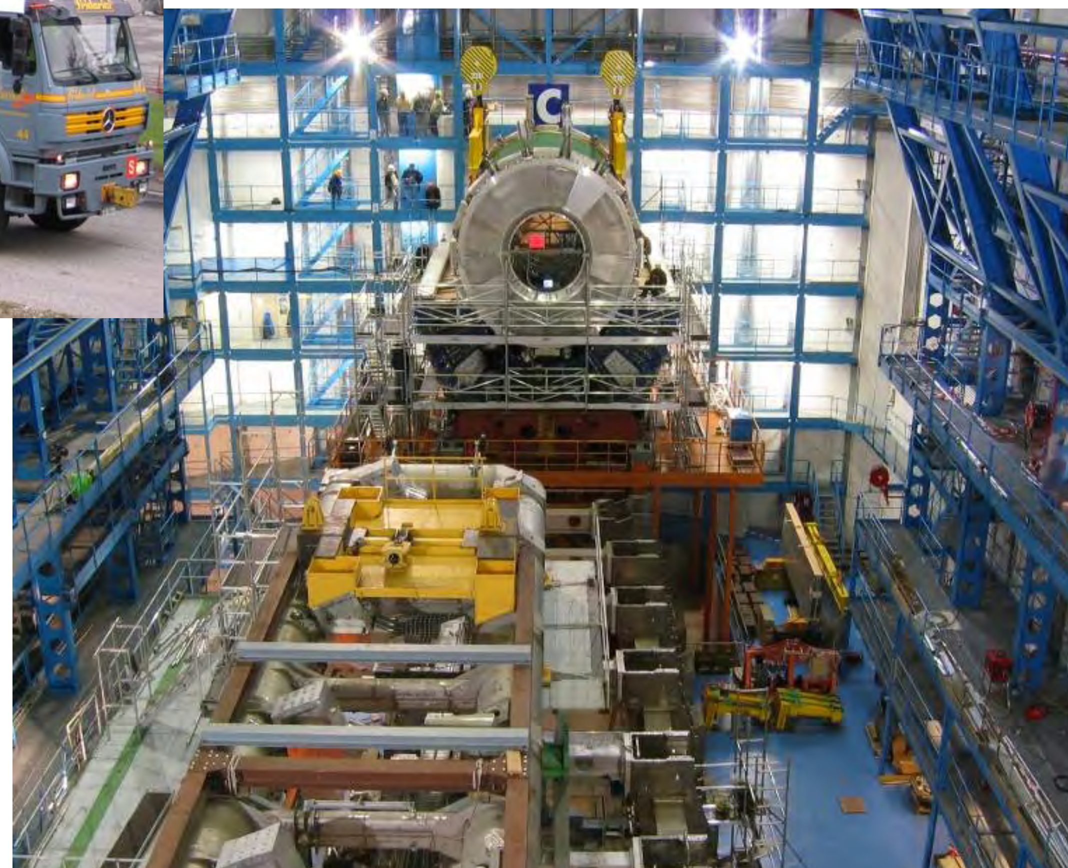
After many years of module constructions, the barrel EM calorimeter was installed in the cryostat, and after insertion of the solenoid, the cold vessel was closed and welded early 2004

A successful complete cold test (with LAr) was made during summer 2004 in hall 180 at CERN (dead channels much below 1%)

LAr barrel EM calorimeter module at one of the assembly labs

LAr barrel EM calorimeter after insertion into the cryostat

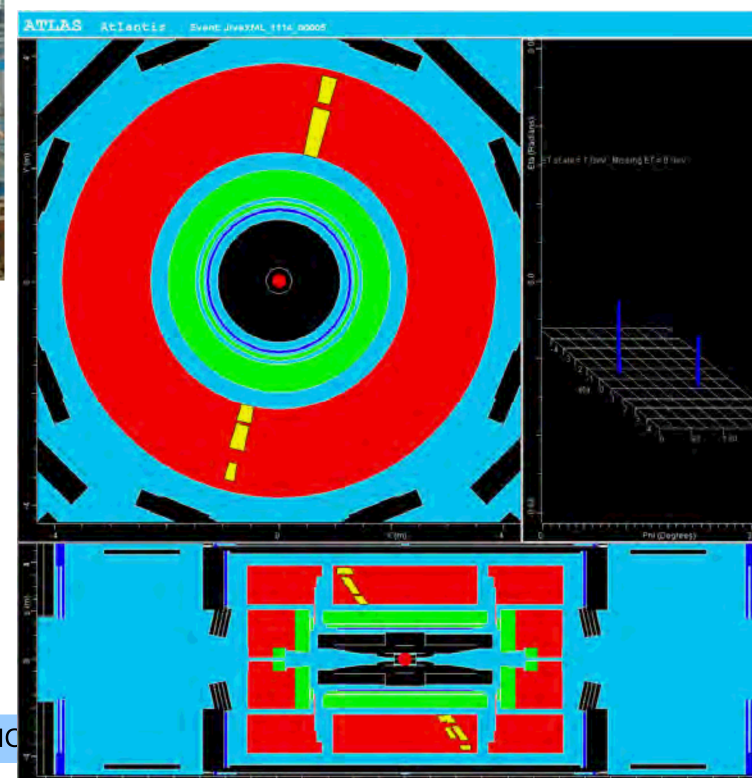
End of October 2004 the cryostat was transported to the pit, and lowered into the cavern



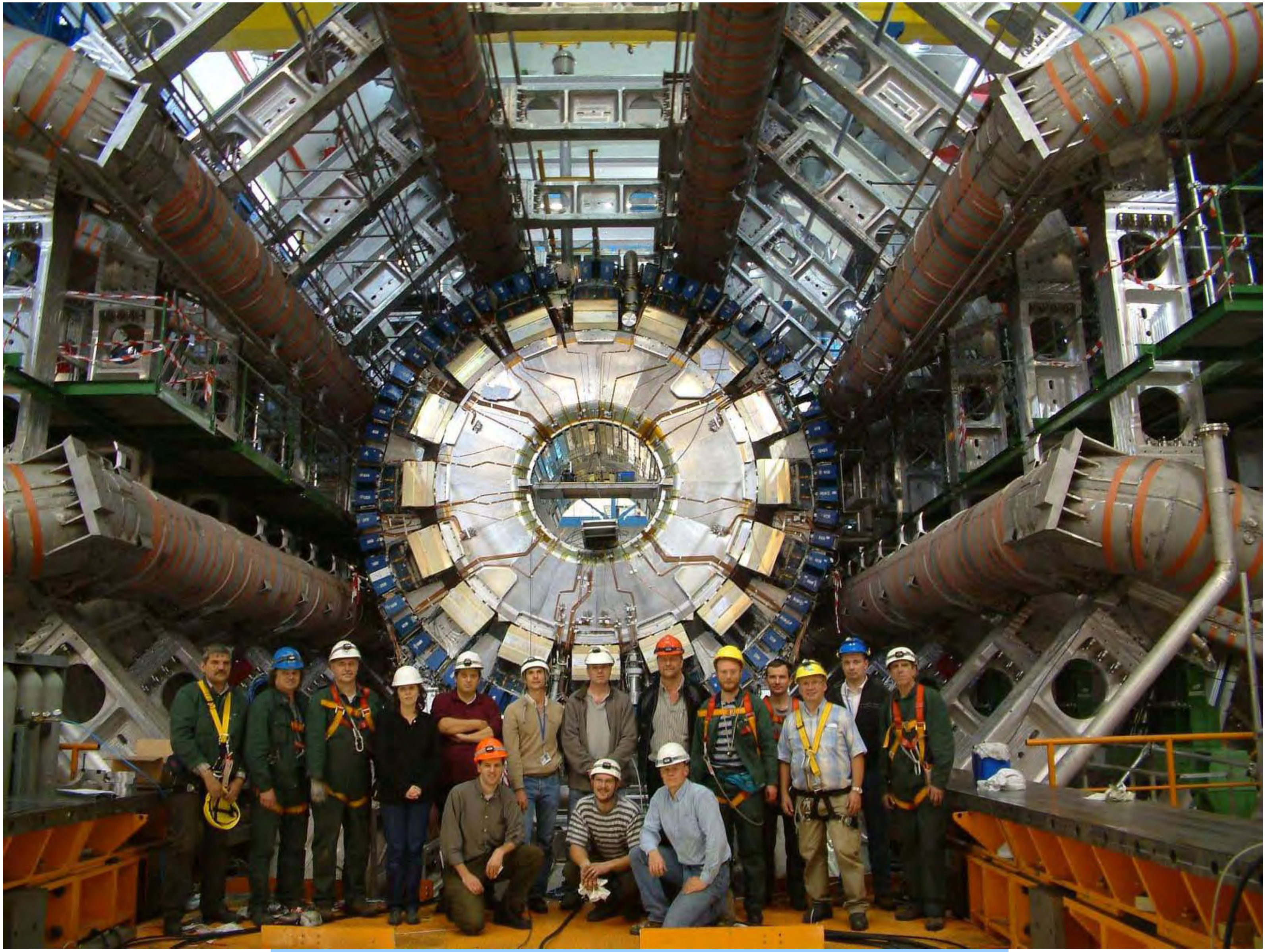
Barrel LAr and Tile Calorimeters

The barrel LAr and scintillator tile calorimeters have been since January 2005 in the cavern in their 'garage position' (on one side, below the installation shaft)

A cosmic ray muon registered in the barrel Tile Calorimeter

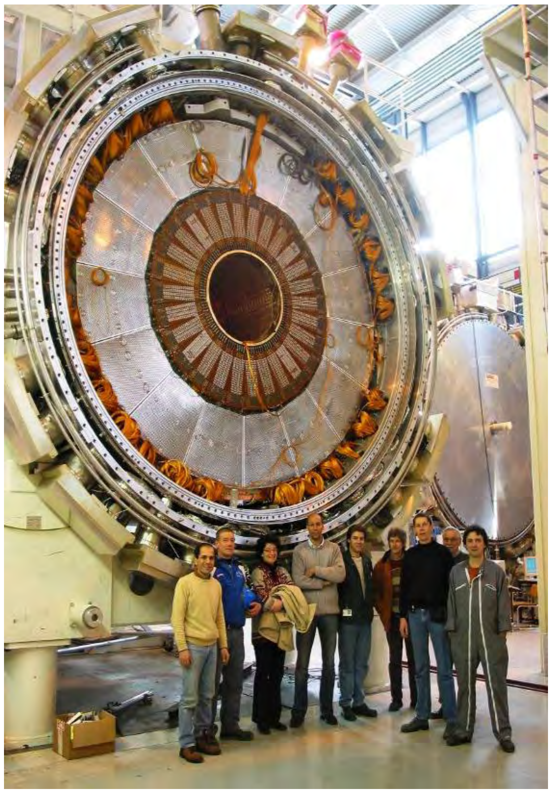


November 4th 2005: *Calorimeter barrel after its move into the center of the ATLAS detector*

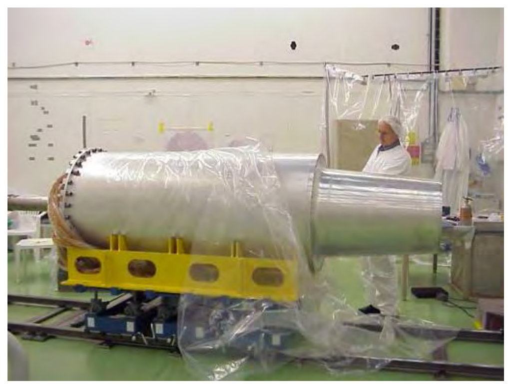


LAr End-Caps

The surface cold tests with LAr are finished, with very good results (dead channels well below 1%)



End-Cap cryostat A before the insertion of the FCAL and closure

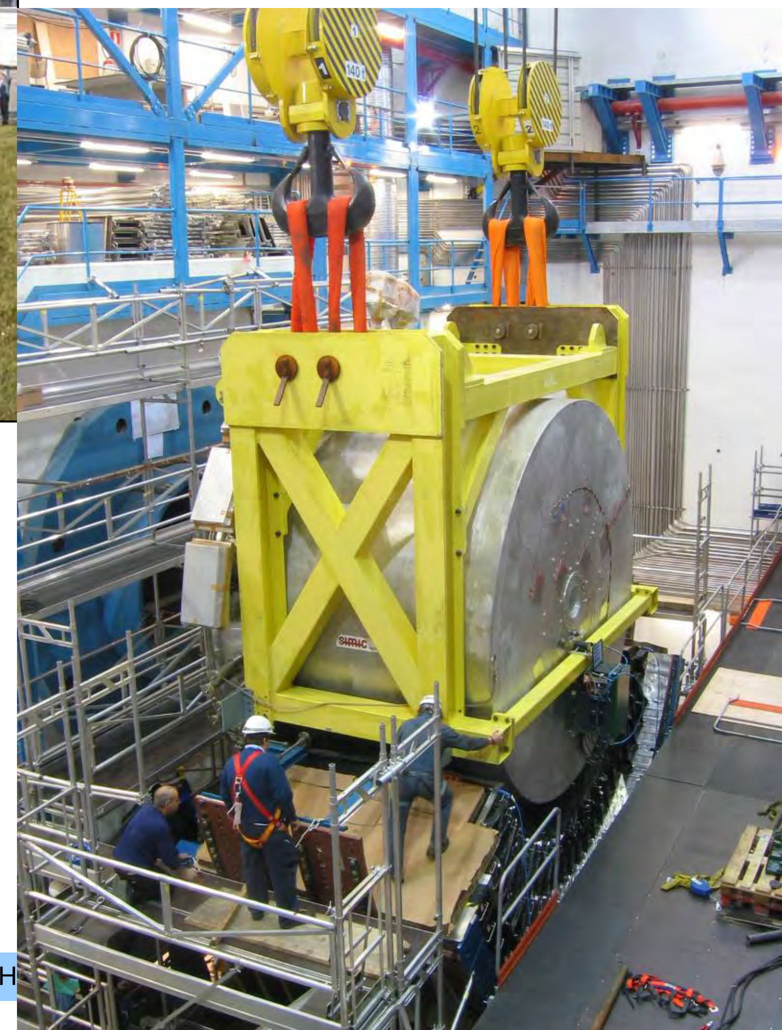


FCAL A before insertion

End-Cap A during the surface cold tests

The delicate transport of the first LAr End-Cap to point-1

The first LAr End-Cap arriving safely on the Tile Calorimeter in the cavern through the shaft on the C-side

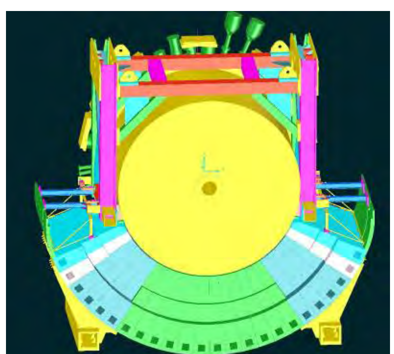


LAr and Tile Calorimeter End-Caps

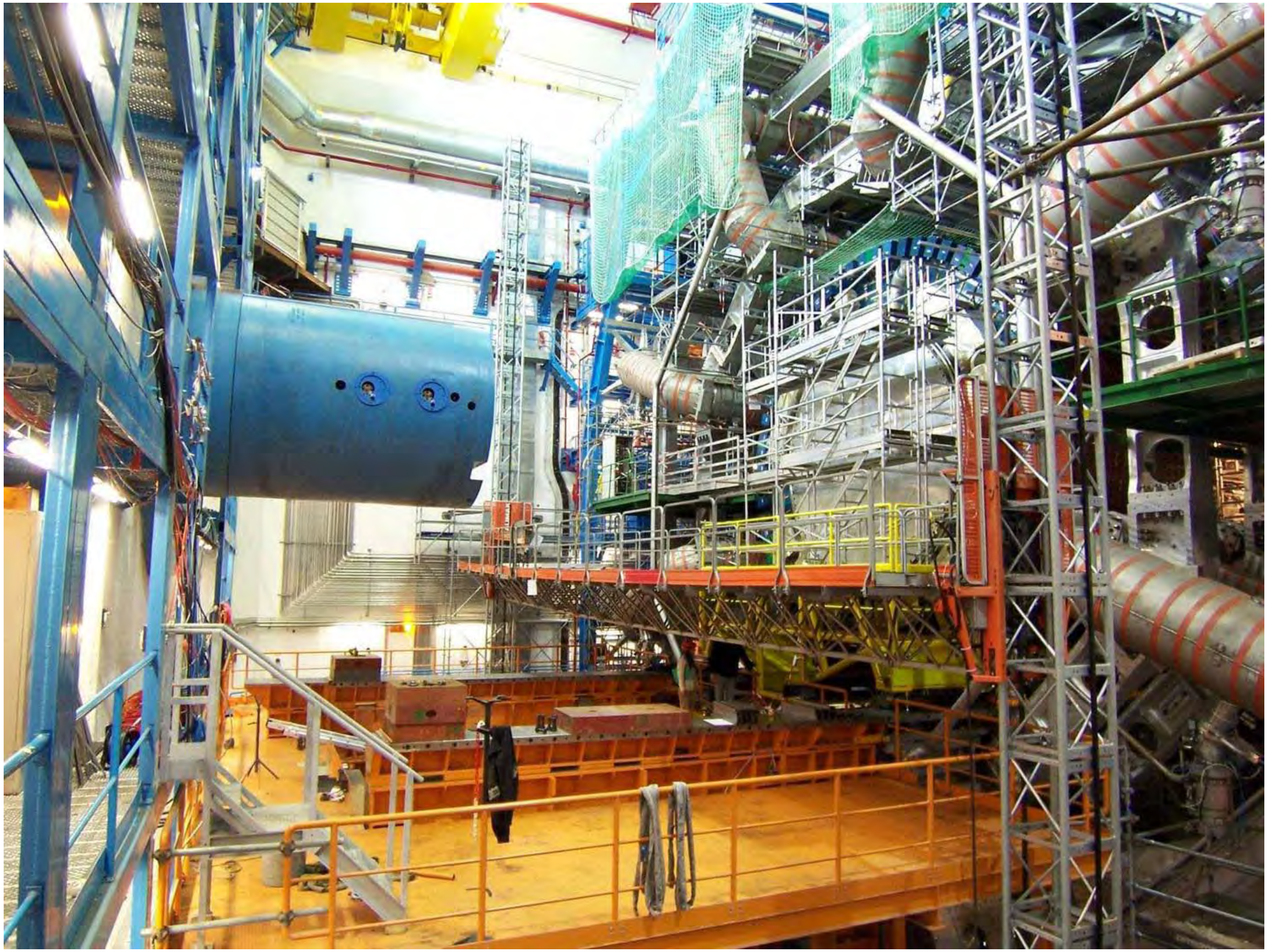
Next major activities:

End-Cap C installation from Nov 05 → Feb 06

End-Cap A installation from Feb 06 → Apr 06



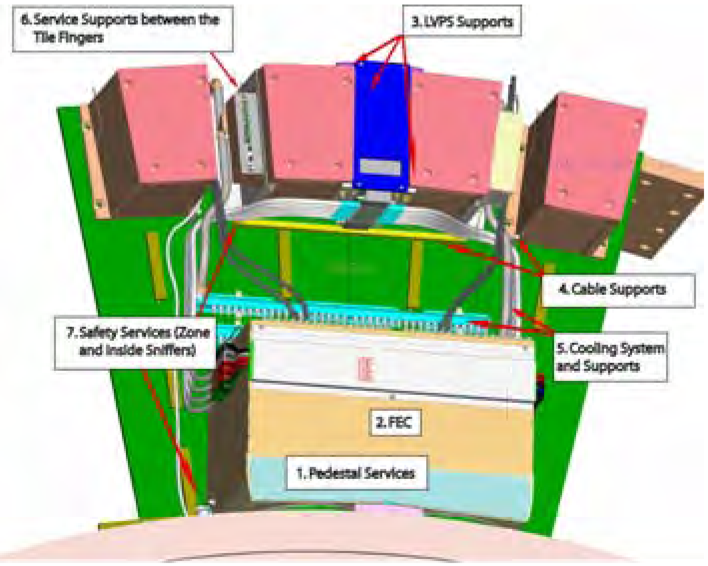
First completed end-cap calorimeter inserted (partially) into the detector



(Latest news: pumping and cool down in situ of the barrel LAr are imminent)

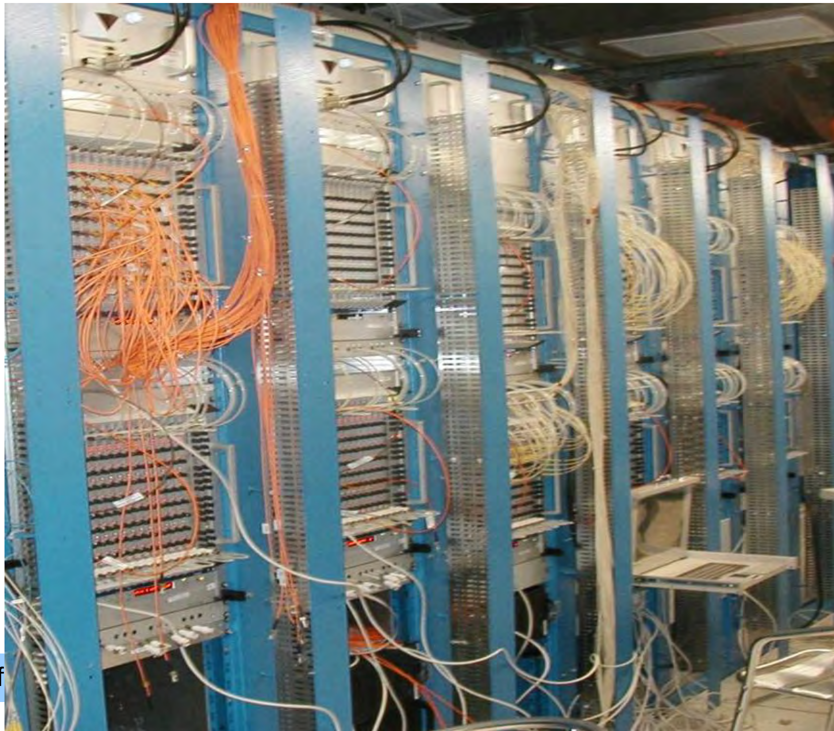
LAr electronics

This is a very major aspect of the LAr calorimeter (and involves in a leading way the Columbia and BNL teams)

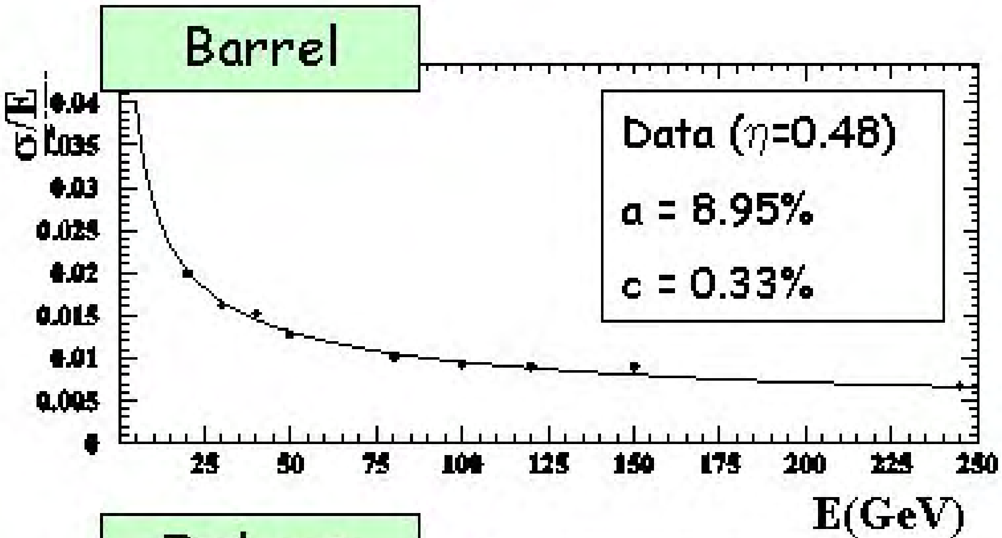


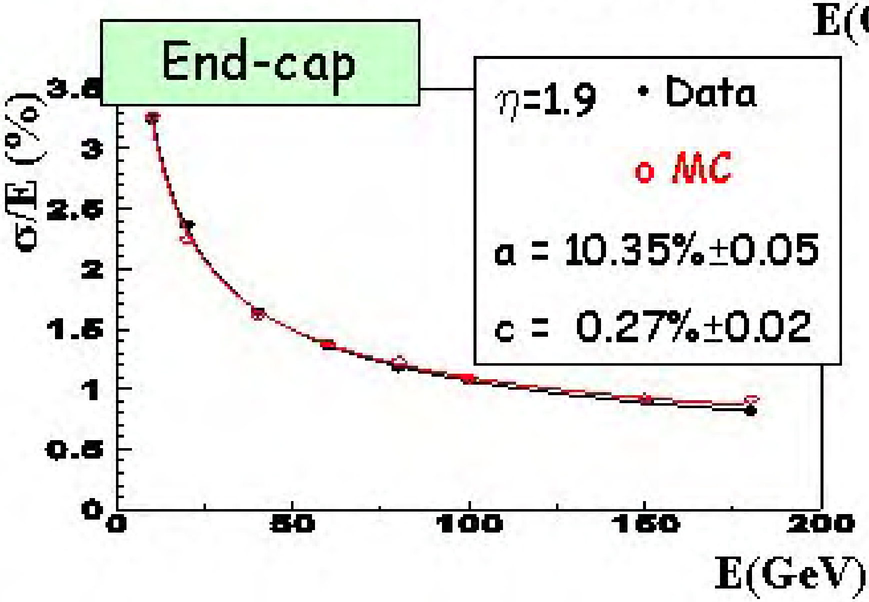
Front End (FE) electronics installed on the detector, Back End (BE) read-out electronics in the underground control room

A particular challenge are currently the low and high voltage power supplies, where a large effort is made with the vendors to improve reliability



EM beam test results: Energy resolution





$$\sigma_E/E = a/\sqrt{E} \oplus c \oplus n/E$$

For every tested points:

Barrel	End-cap
a < 10%	a < 12.5%
c < 0.4%	c < 0.5%

- Within specifications
- Good agreement with MC

Impact on Higgs mass resolution

Simulations, m_H=130 GeV

✓ $H \rightarrow \gamma\gamma$

Resolution: 1% (low lum)

1.2% (high lum)

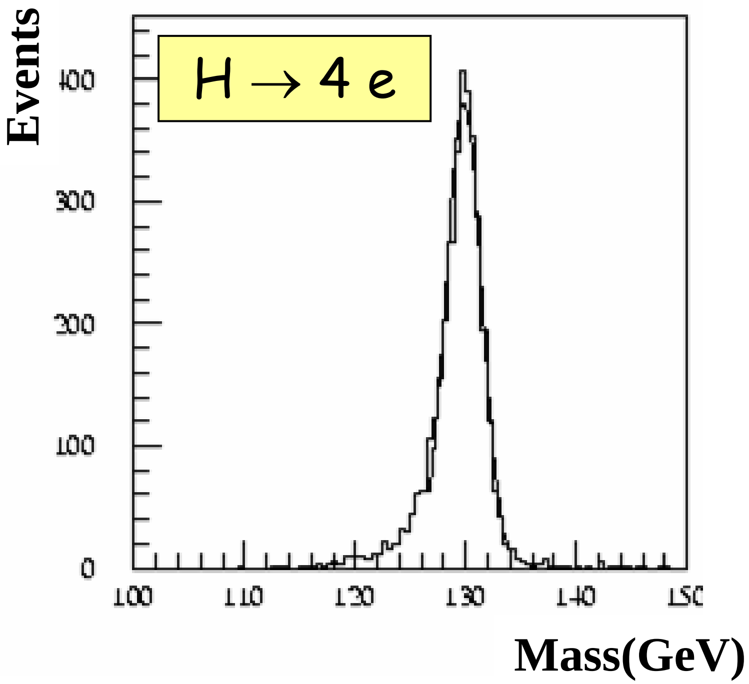
Acceptance: 80% within $\pm$1.4 σ

✓ $H \rightarrow 4e$

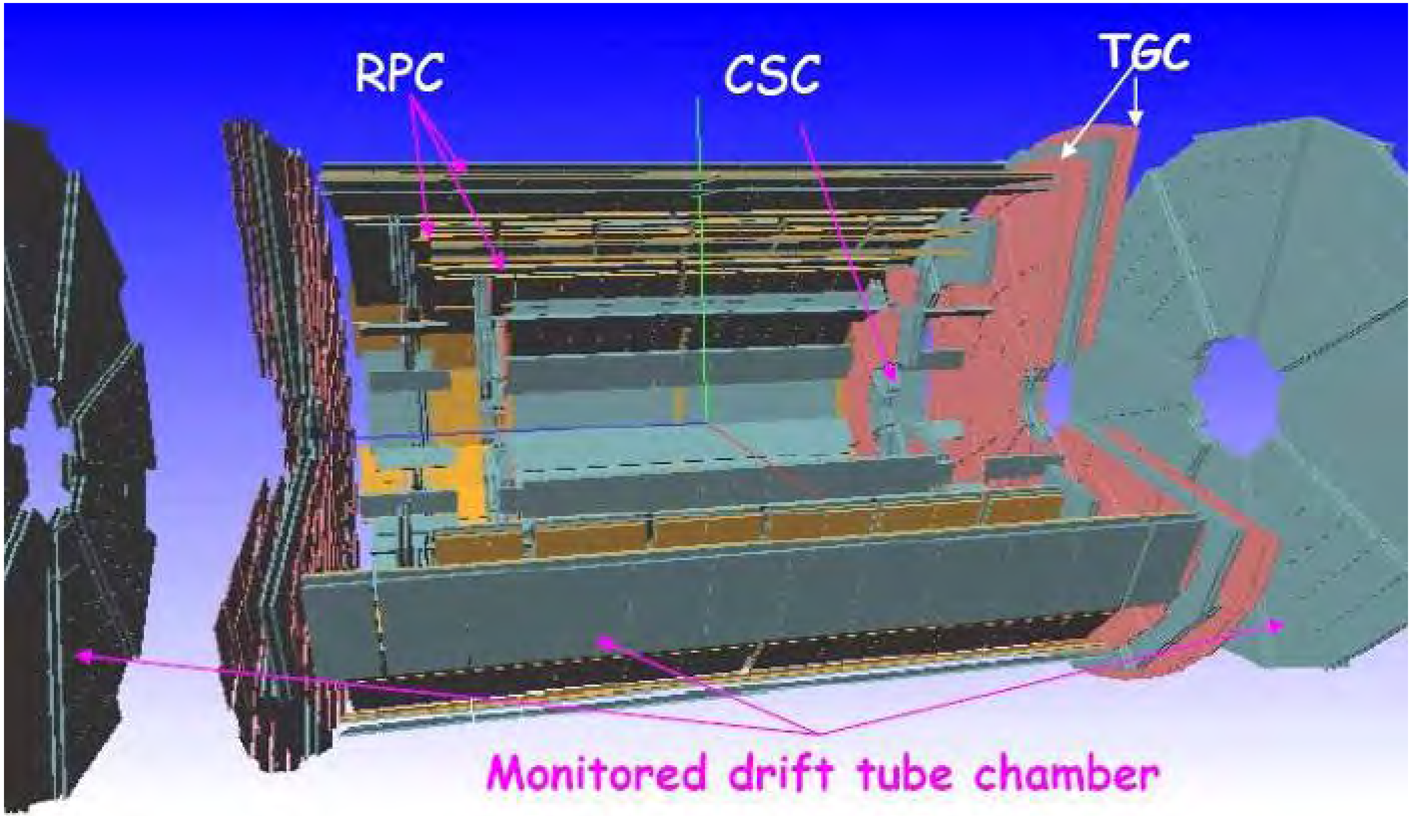
Resolution: 1.2% (low lum)

1.4% (high lum)

Acceptance: 84% within $\pm$2 σ



Muon Spectrometer Instrumentation



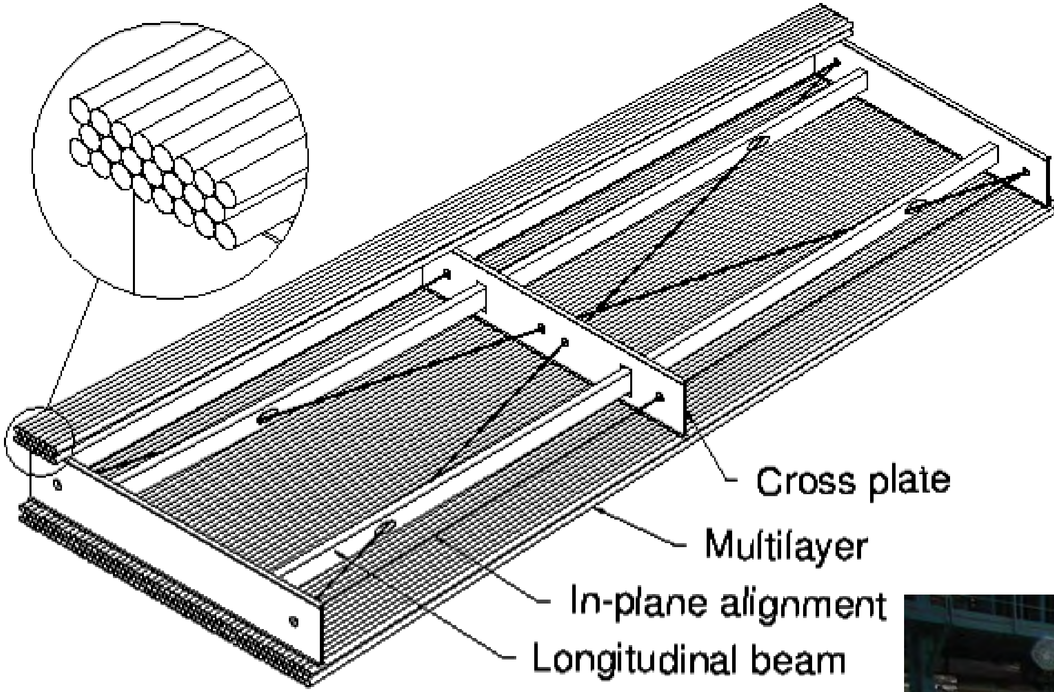
The Muon Spectrometer is instrumented with precision chambers and fast trigger chambers

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

Barrel MDTs



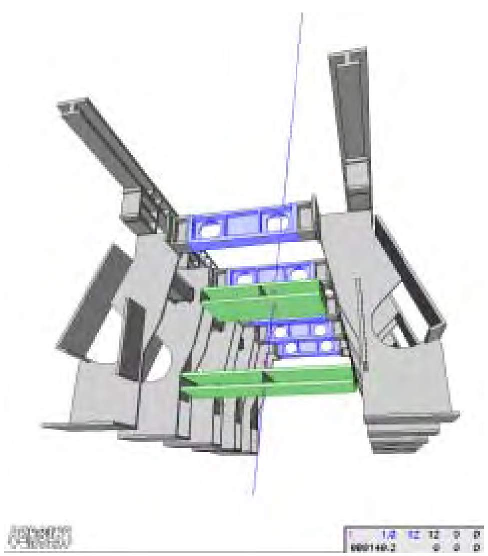
A major effort is spent in the preparation and testing of the barrel muon stations (MDTs and RPCs for the middle and outer stations) before their installation in-situ

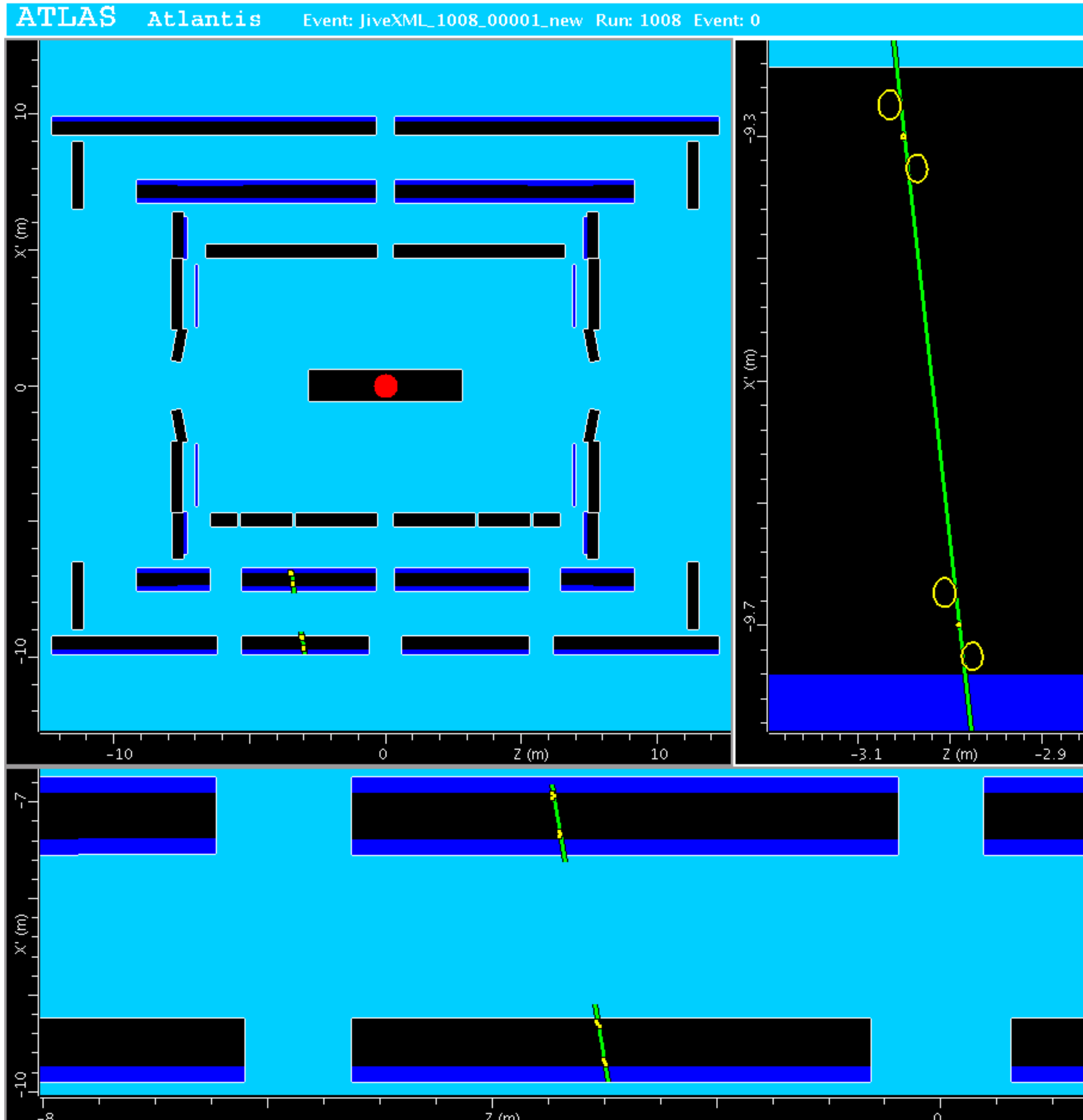
The electronics and alignment system fabrications for all MDTs are on schedule

Installation of barrel muon station

Just before Christmas:

First cosmics muons registered in the stations installed in the bottom sector of the spectrometer





End-cap muon chamber sector preparations

'Big Wheel' end-cap muon MDT sector assembled in Hall 180

'Big Wheel' end-cap muon TGC sector assembled in Hall 180

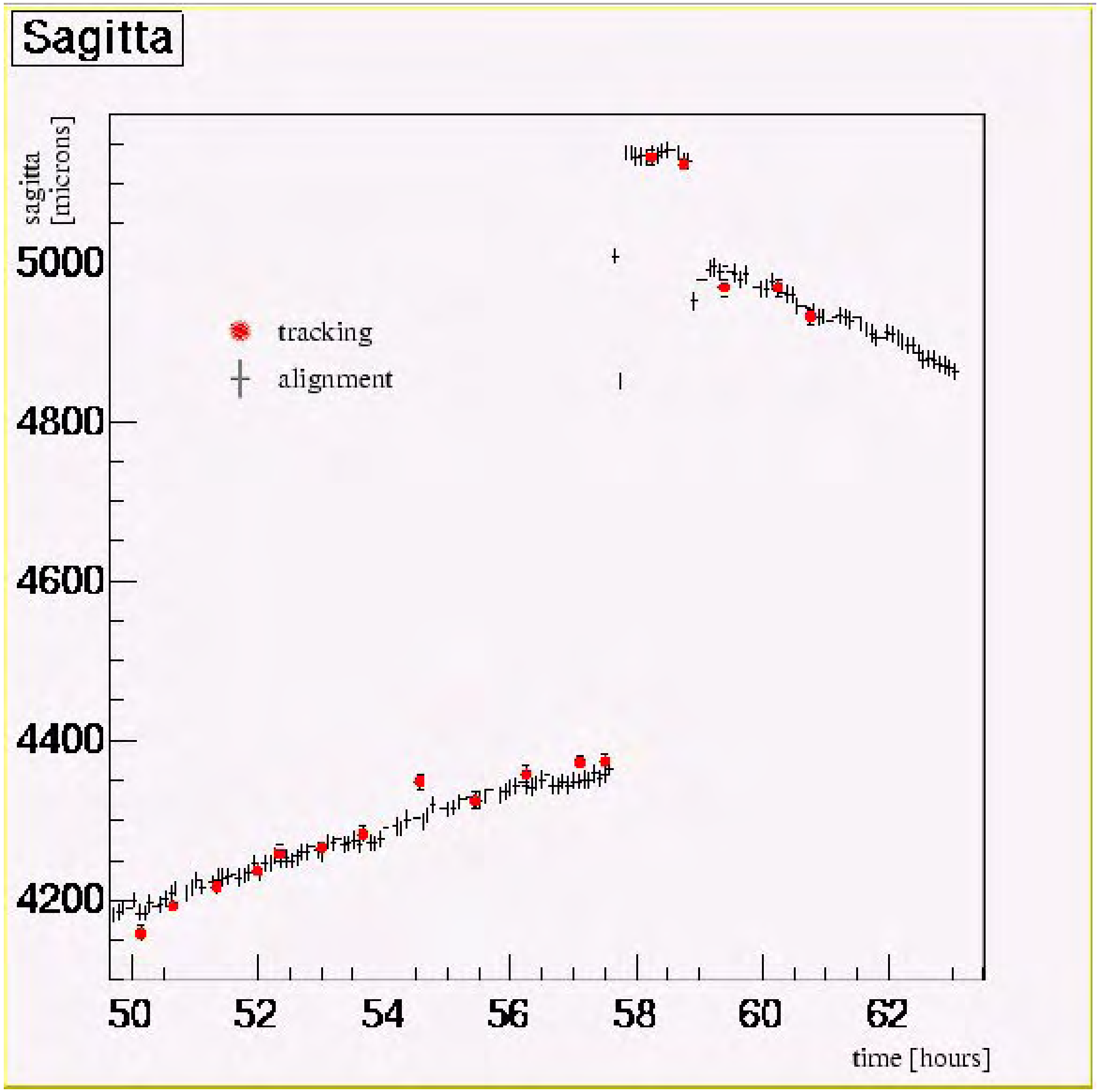
72 TGC and 32 MDT 'Big-Wheel' sectors have to be assembled

This work is now in full swing in the hall where previously the Barrel Toroid and the LAr integration and tests were done

The large-scale system test facility for alignment, mechanical, and many other system aspects, with sample series chamber station in the SPS H8 beam

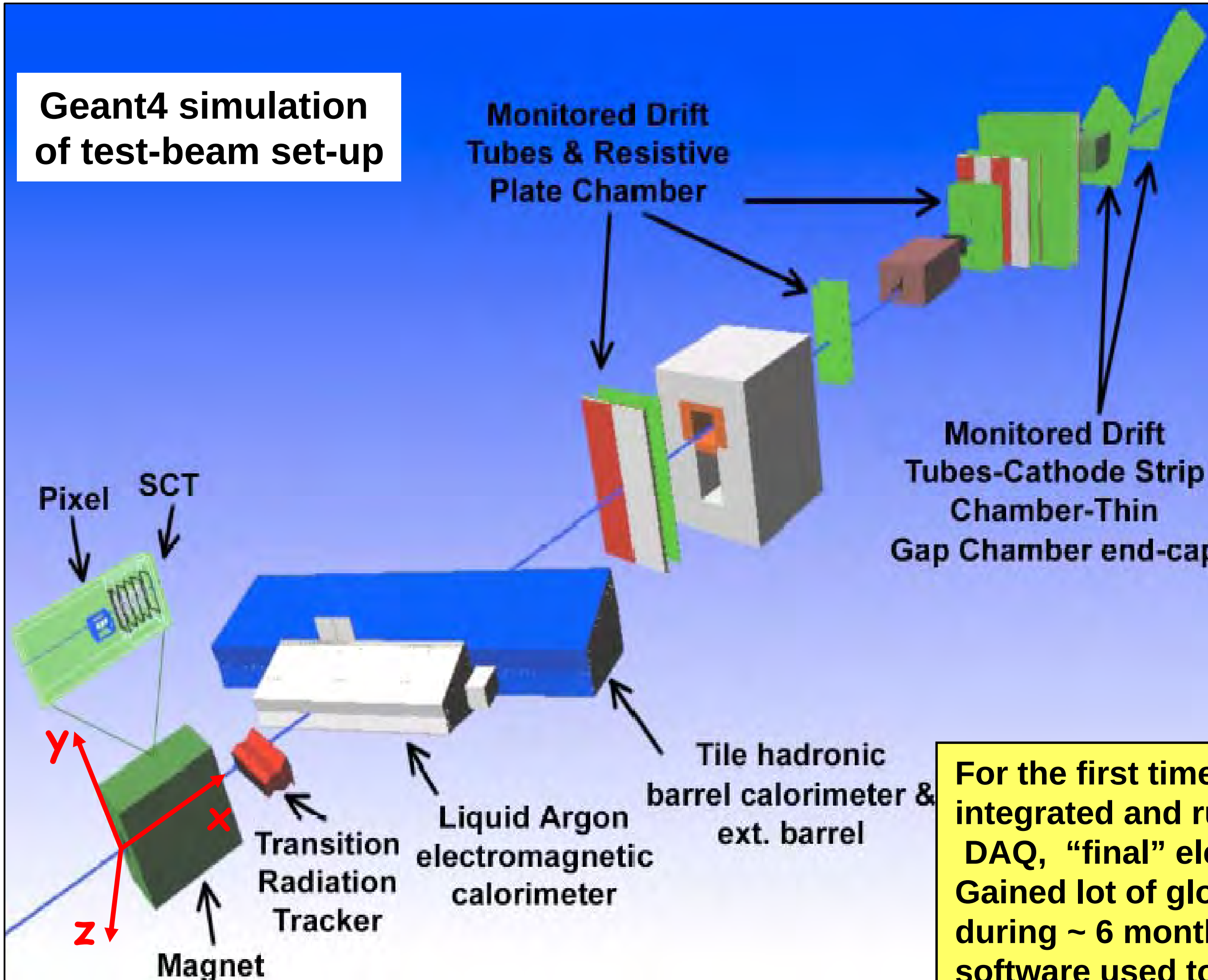
Shown in this picture is the end-cap set-up, it is preceded in the beam line by a barrel sector

Example of tracking the sagitta measurements, following the day-night variation due to thermal variations of chamber and structures, and two forced displacements of the middle chamber

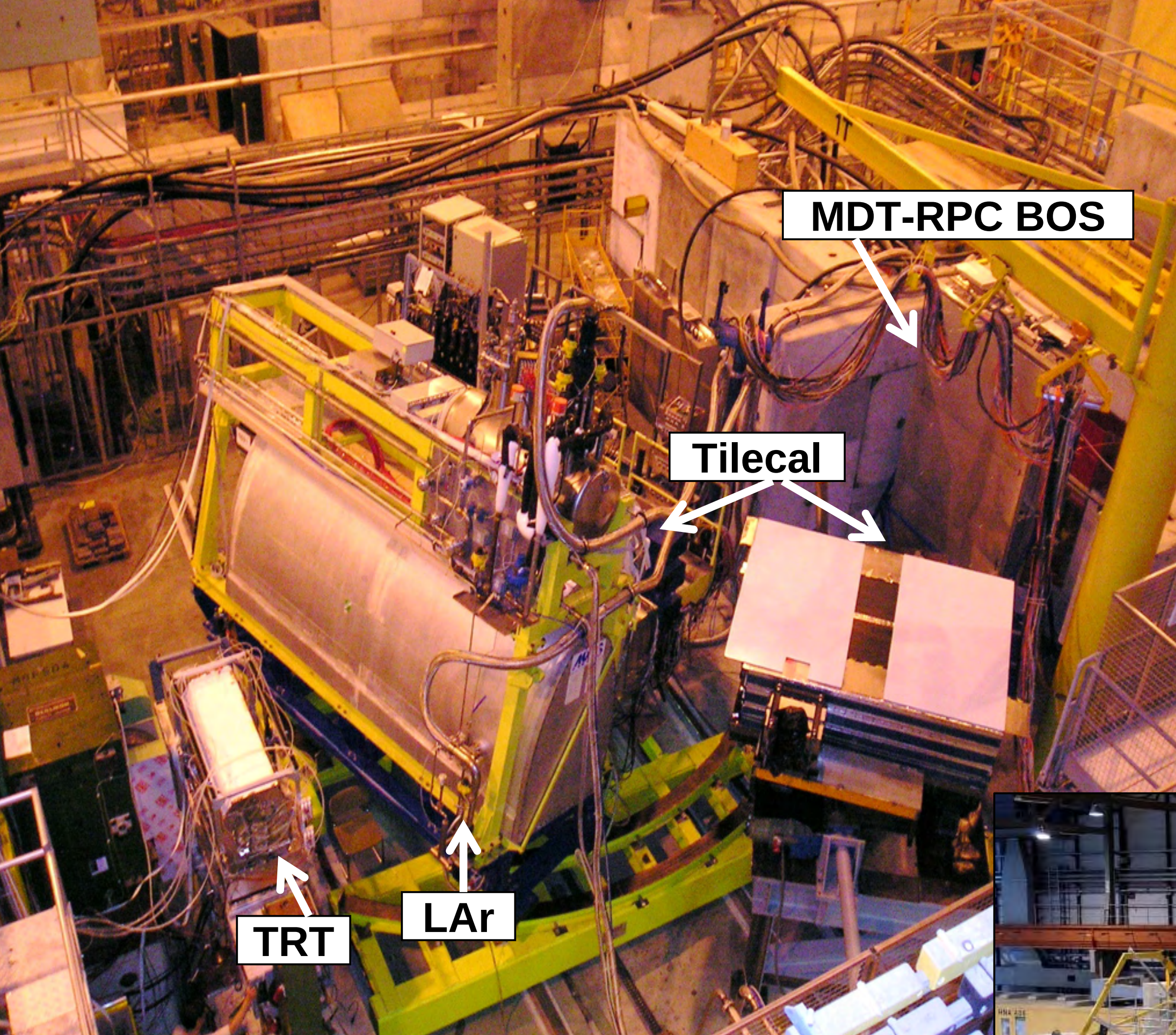


Towards the complete experiment: ATLAS combined test beam in 2004

Full "vertical slice" of ATLAS tested on CERN H8 beam line May-November 2004



For the first time, all ATLAS sub-detectors integrated and run together with common DAQ, "final" electronics, slow-control, etc. Gained lot of global operation experience during ~ 6 month run. Common ATLAS software used to analyze the data



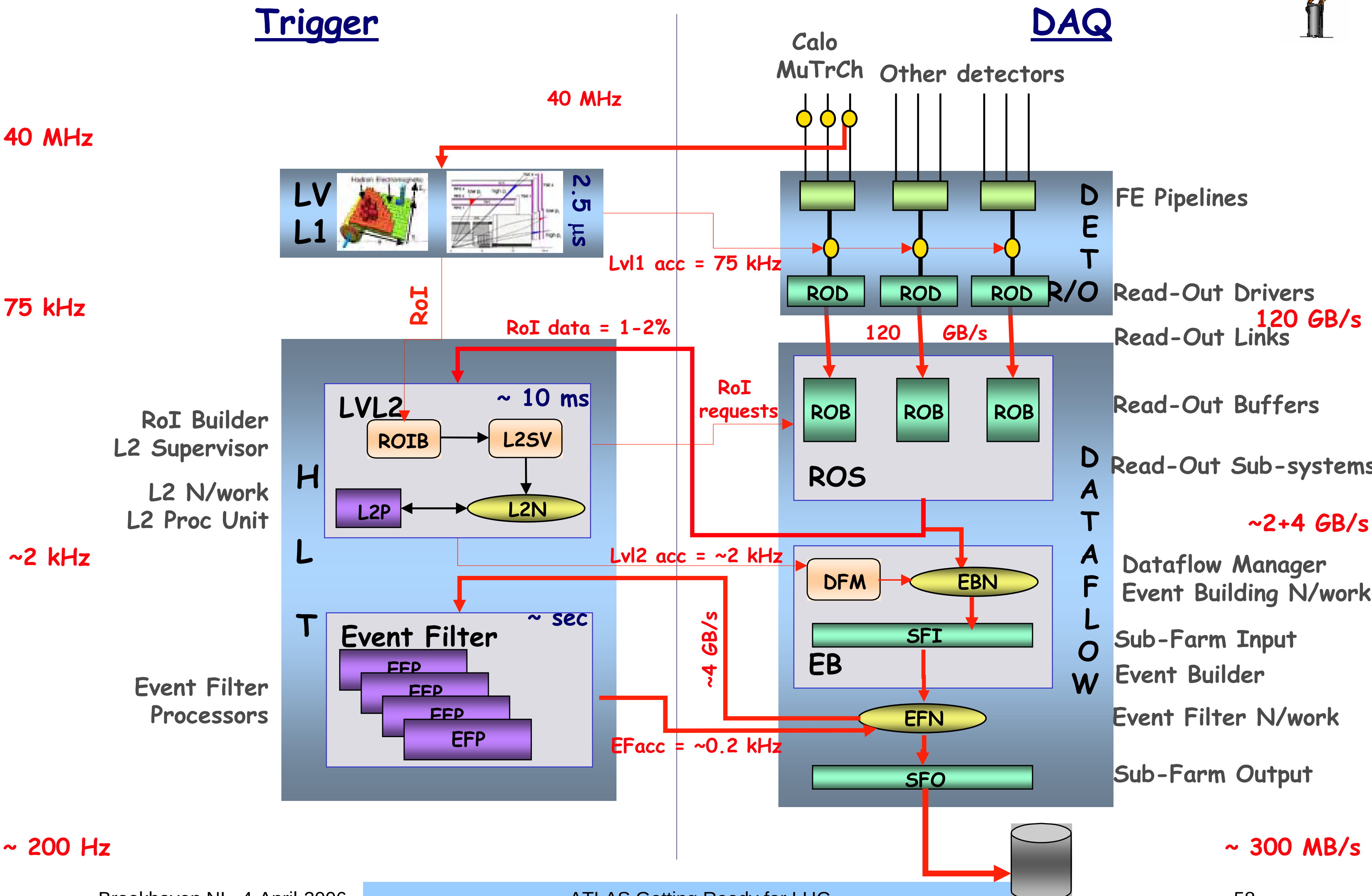
~ 90 million events collected
~ 4.5 TB of data:

$e^{\pm}$, $\pi^{\pm}$	1 $\rightarrow$ 250 GeV
$\mu^{\pm}$, $\pi^{\pm}$, p	up to 350 GeV
γ	~ 30 GeV

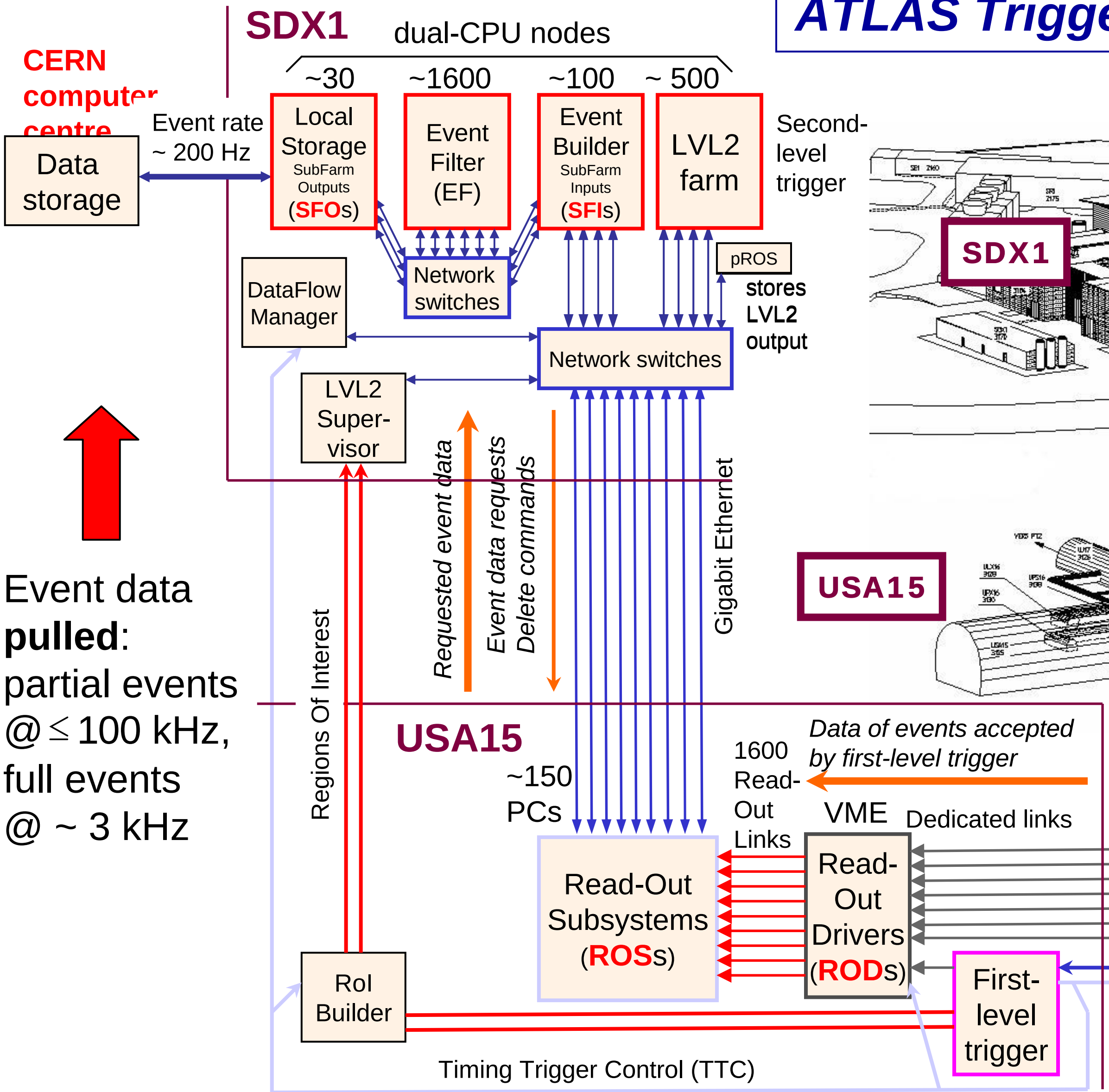
B-field = 0 $\rightarrow$ 1.4 T

End-cap muon chambers

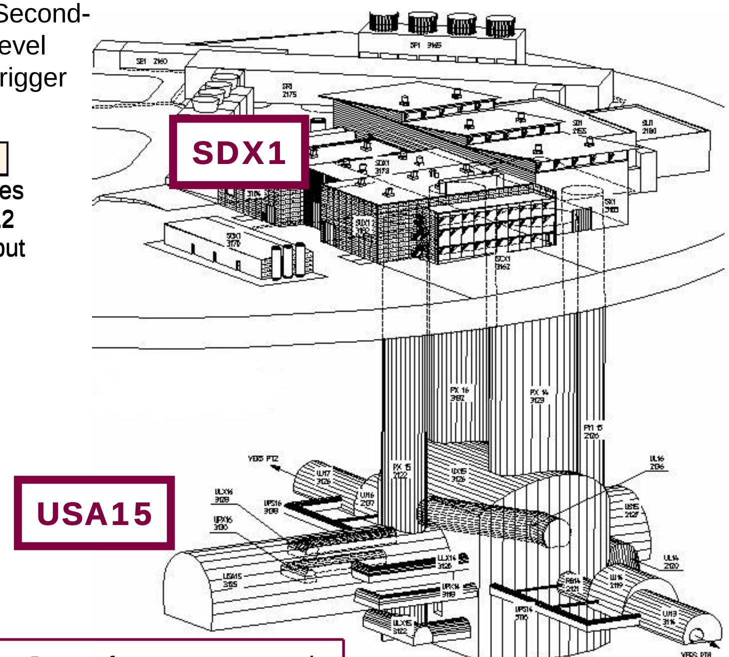
Trigger, DAQ and Detector Control



ATLAS Trigger / DAQ Data Flow



Event data **pulled**: partial events @ ≤ 100 kHz, full events @ ~ 3 kHz



Event data **pushed** @ ≤ 100 kHz, 1600 fragments of ~ 1 kByte each

Level-1

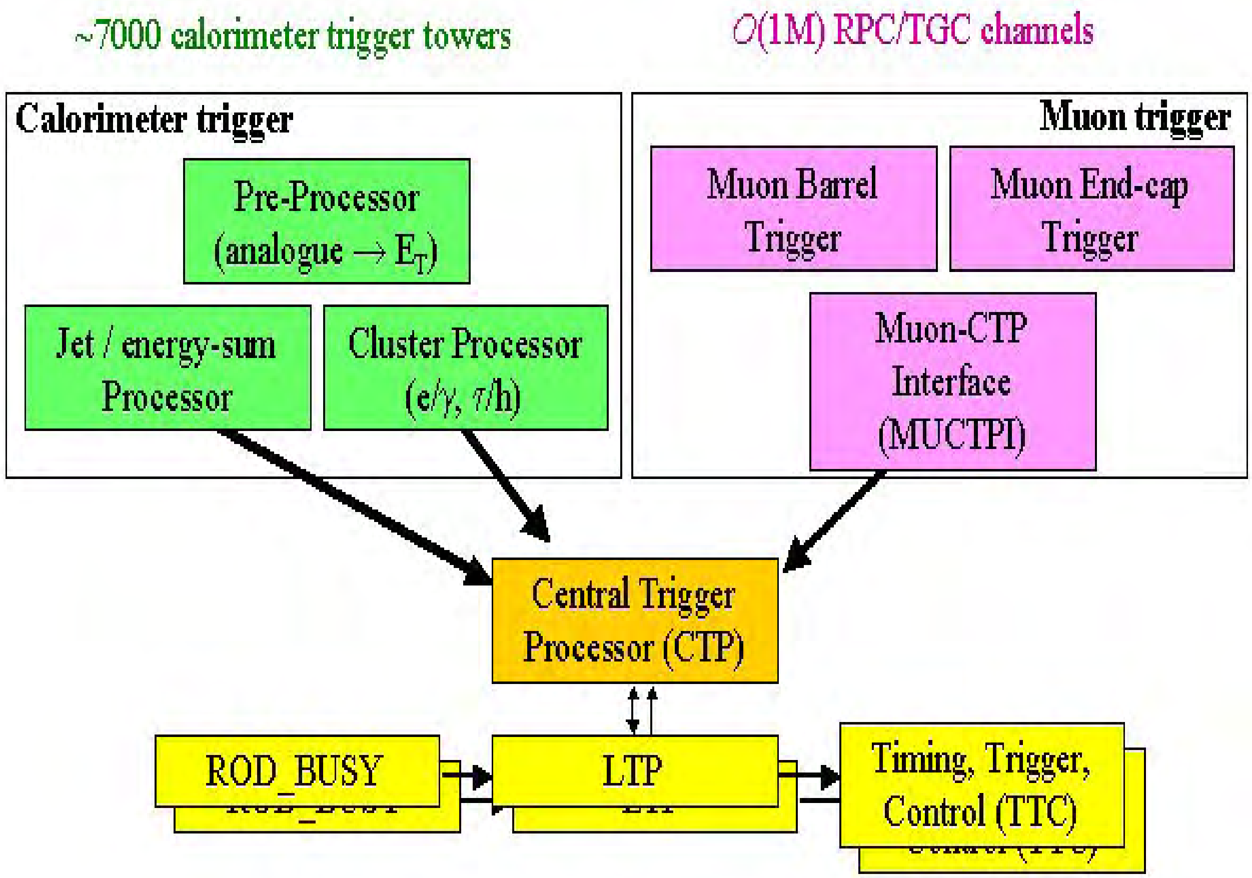
The level-1 system (calorimeter, muon and central trigger logics) completed the final ASICs developments and testing of full-functionality prototype modules; series production has started

The calorimeter level-1 trigger worked successfully at the combined test beam in 2004

The series production of the various modules is now starting

The muon level-1 trigger has been tested with 25 ns bunched test beams, final improvements were implemented in a last iteration

The Central Trigger Processor progresses on schedule



HLT/DAQ/DCS

The pre-series of final system with 8 racks at Point-1 (10% of final dataflow) is now in operation

USA15 | **SDX1**

One ROS rack
-
TC rack + horiz. Cooling
-
12 ROS
48 ROBINs

RoIB rack
-
TC rack + horiz. cooling
-
50% of RoIB

One Full L2 rack
-
TDAQ rack
-
30 HLT PCs

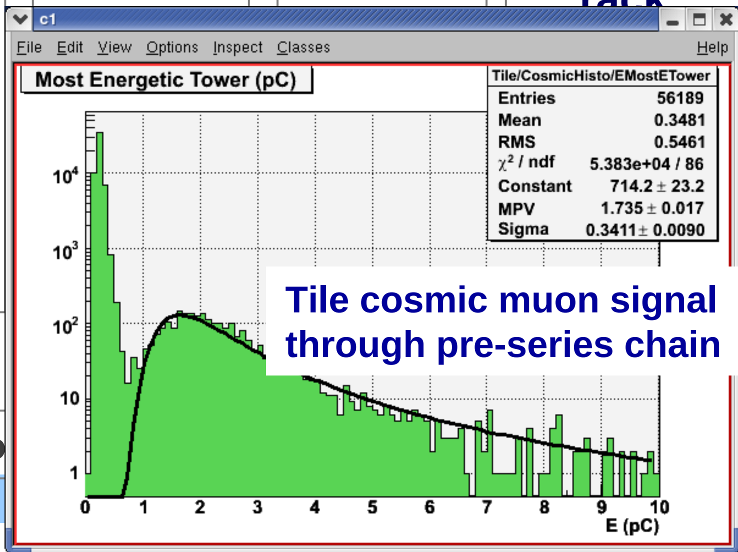
Partial Superv'r rack
-
TDAQ rack
-
3 HE PCs

One Switch rack
-
TDAQ rack
-
128-port GEth for L2+EB

Partial EFIO

Partial EF rack

Partial ONLINE rack



Tile cosmic muon signal through pre-series chain

ROS, L2, EFIO and EF racks: one Local File Server, one o

DAQ/HLT Large-scale Tests

Large scale tests in previous years:

- Pure infrastructure tests at LXBATCH successful
Individual sub-systems had limited success
- DAQ/EF on the Westgrid cluster (Canada)
with 300 nodes and 1 day with 800 nodes

LXBATCH testbed at CERN
5 weeks, June/July 2005
100 – 700 dual nodes
farm size increasing in steps

Large Scale Tests July 2005

Integrated DAQ/HLT software system
- With real algorithms and geometry and conditions DBs
- Obtained useful feedback on performance

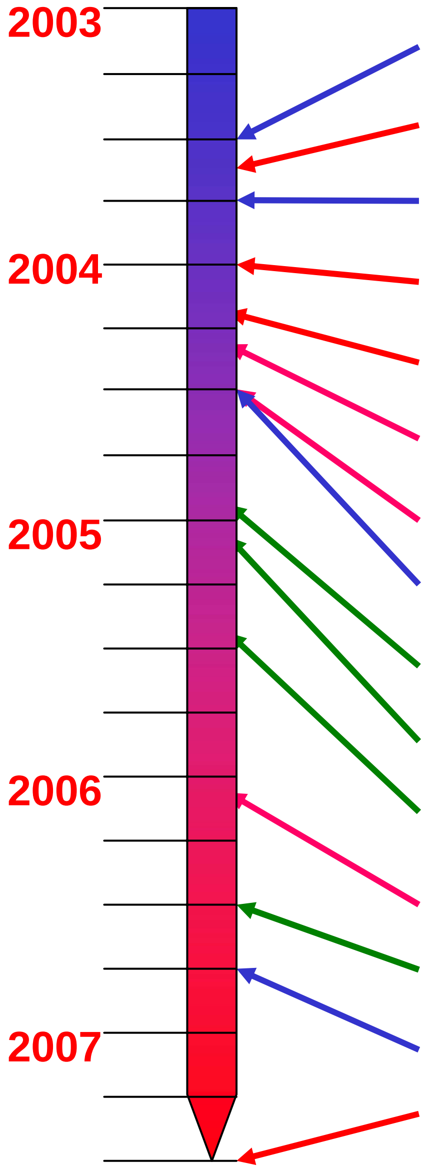
HLT Software image built and efficiently distributed on 660 nodes

HLT image
LVL2 with algorithm
EF with algorithm
integrated:
EB
LVL2
EF

DC
LVL2
EF
EF
Infrastructure

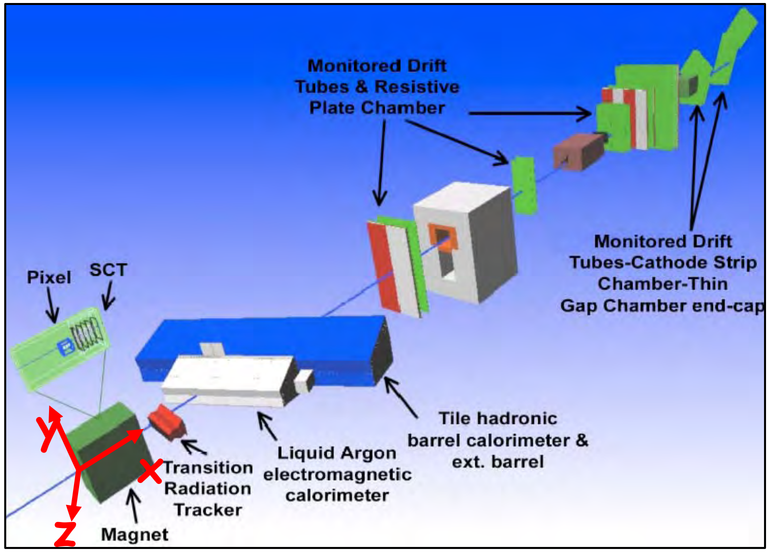
Farm size (nodes):	100	220	220	230	300/800	700
Year:	2001	2002	2003	2004	4/2005	7/2005

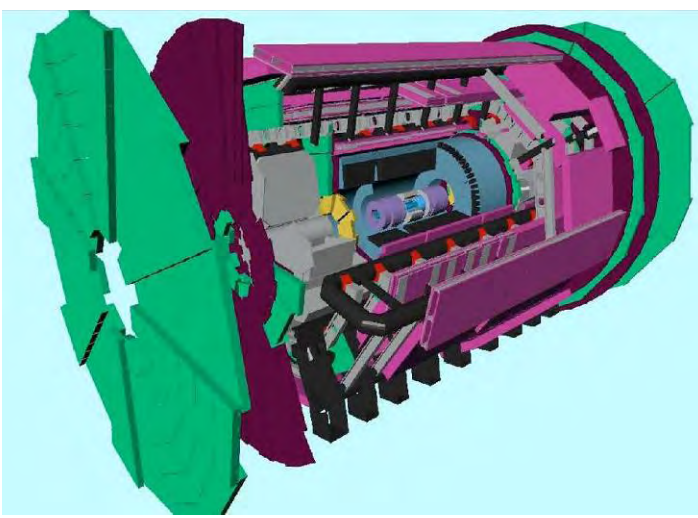
ATLAS Computing Timeline

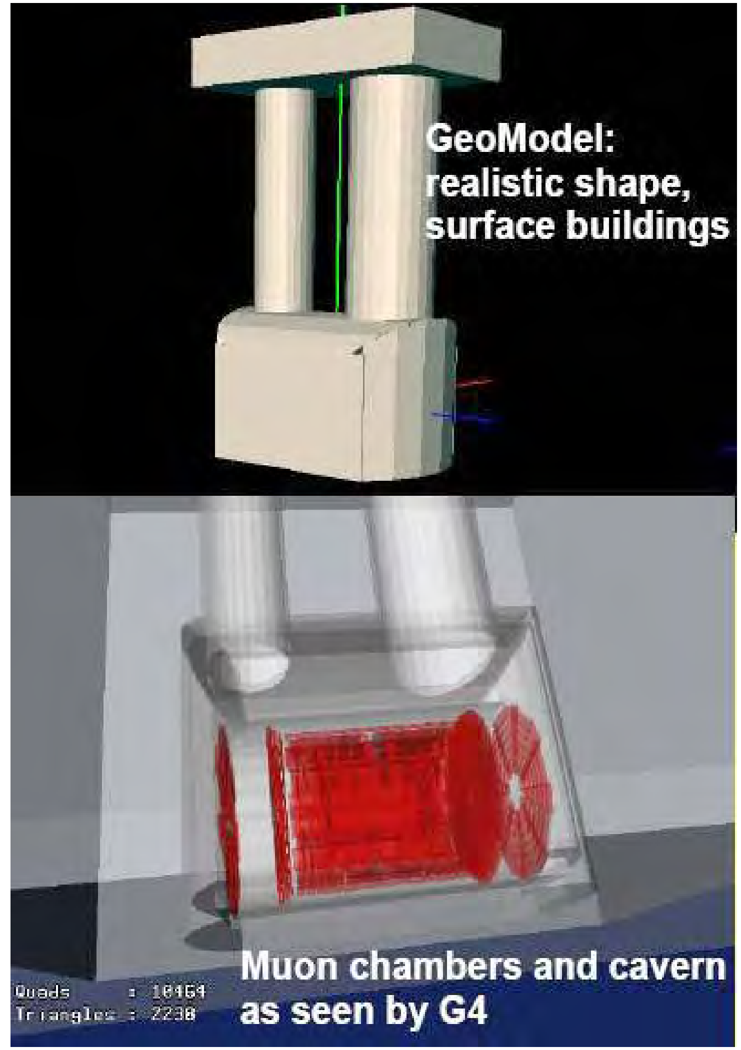


- POOL/SEAL release (done)
- ATLAS release 7 (with POOL persistency) (done)
- LCG-1 deployment (done)
- ATLAS complete Geant4 validation (done)
- ATLAS release 8 (done)
- DC2 Phase 1: simulation production (done)
- DC2 Phase 2: intensive reconstruction (re-scheduled)
- Combined test beams (barrel wedge) (done)
- Computing Model paper (done)
- Computing Memorandum of Understanding (in progress)
- ATLAS Computing TDR and LCG TDR (done)
- Start of Computing System Commissioning
- Physics Readiness Reports
- Start cosmic ray run
- GO!

G4 Simulation: from combined test-beam to cosmic runs to pp collisions







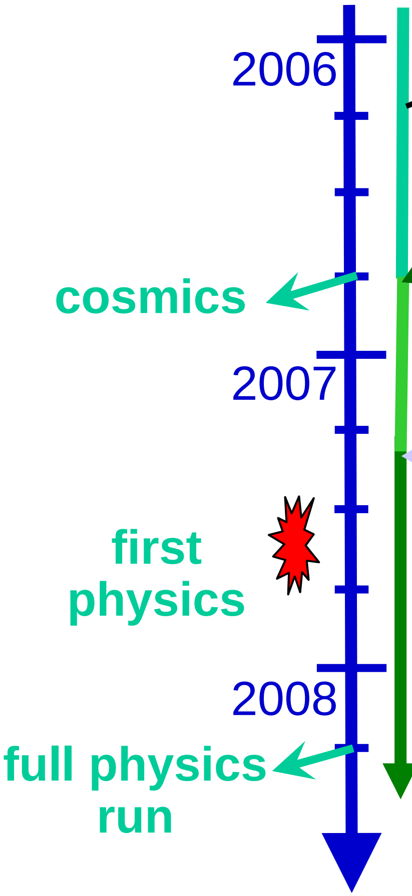
Worldwide LHC Computing Grid (WLCG)

Common infrastructure for the computing resources for the four LHC experiments

A map of the worldwide LCG infrastructure operated by EGEE and OSG.

Service Challenges – ramp up to LHC start-up service

LCG Service Deadlines



Service Challenge 4

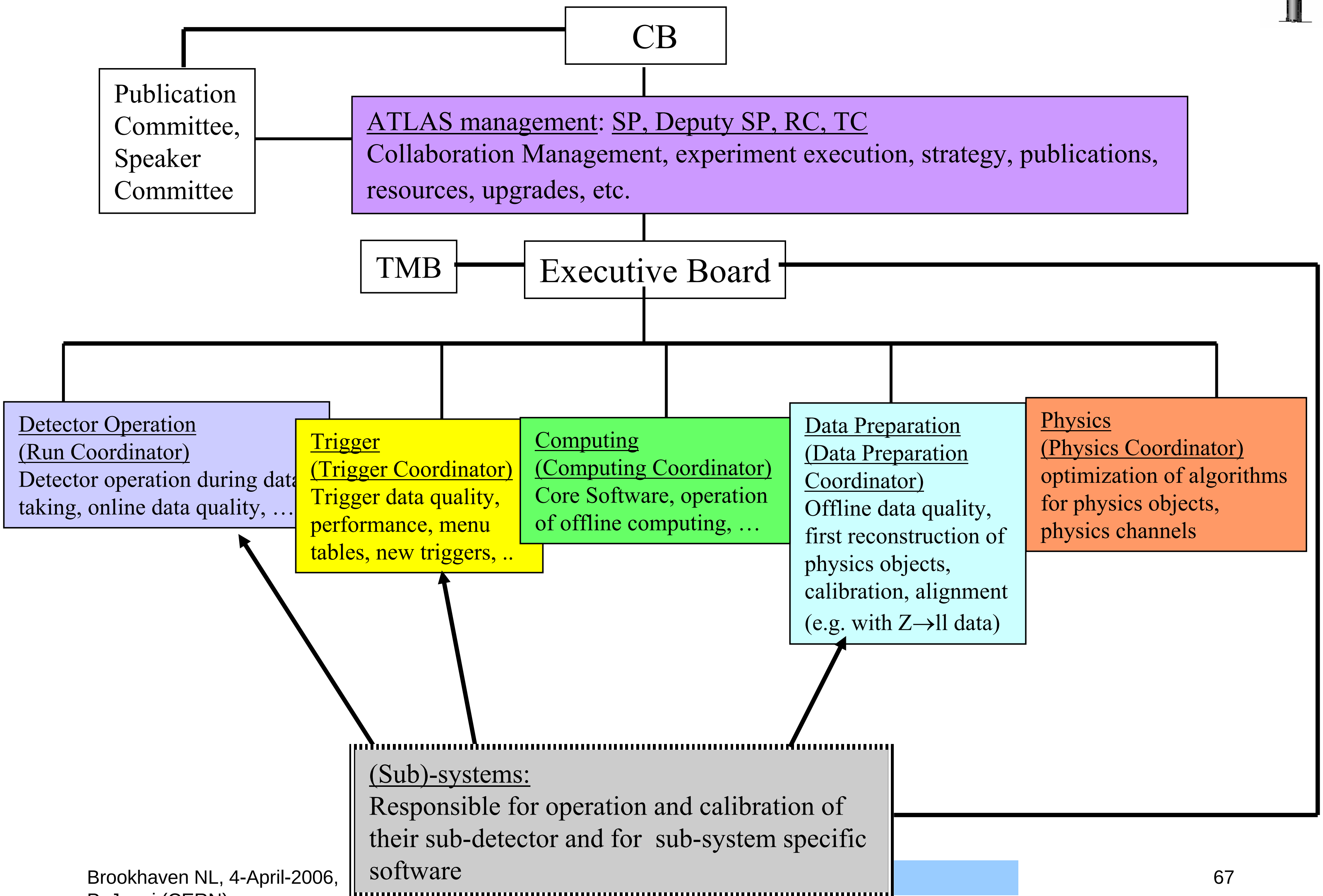
Pilot Services –
stable service from 1 June 06

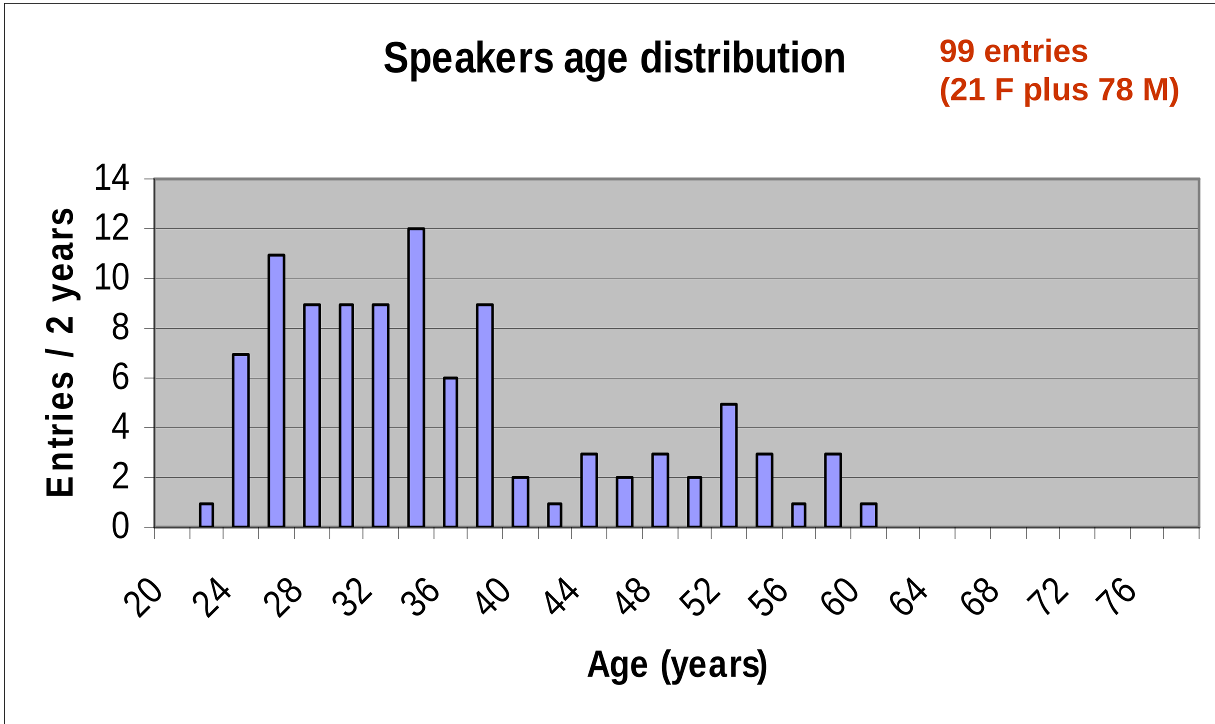
LHC Service in operation – *1 Oct 06*
over following six months ramp up to full operational capacity & performance

LHC service commissioned – *1 Apr 07*

Operation Model (Organization for LHC Exploitation)

(Details can be found at http://uimon.cern.ch/twiki//bin/view/Main/OperationModel)



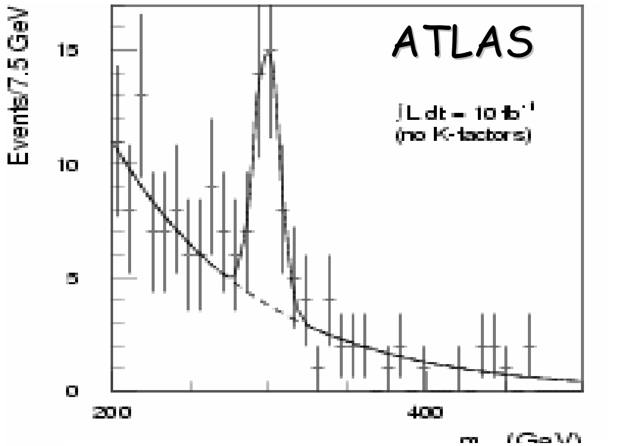


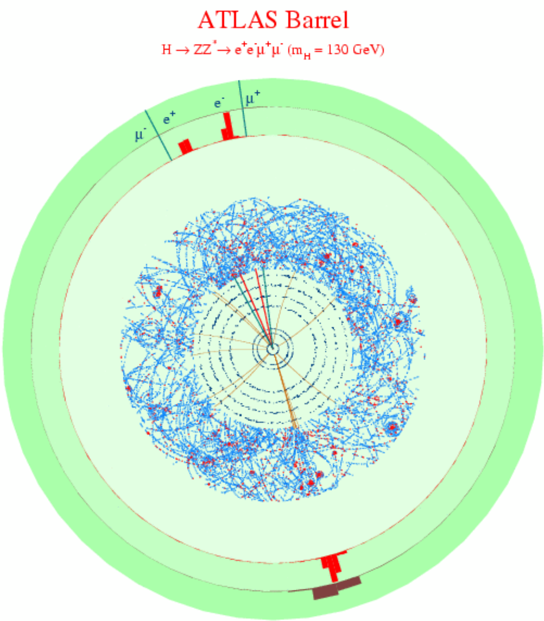
5th ATLAS Physics WS
Rome 6-11 June 2005

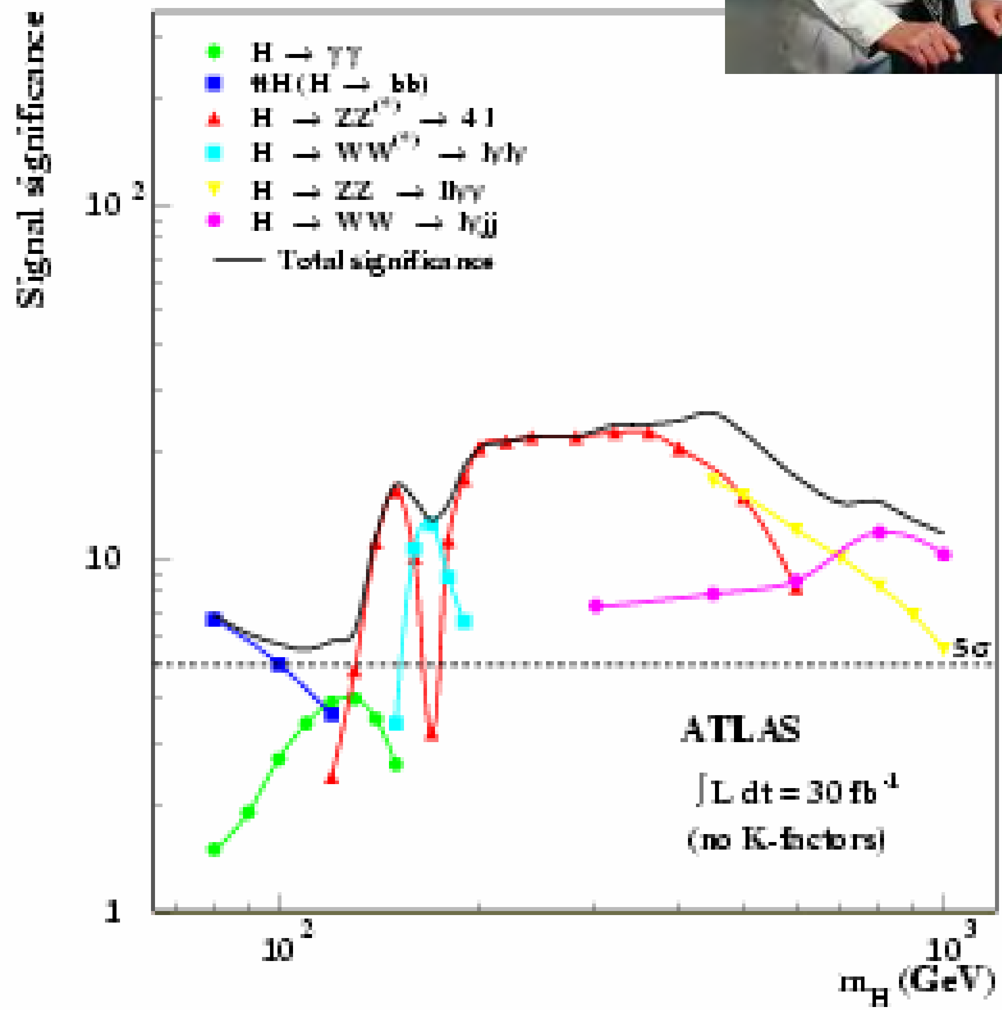
441 registered participants

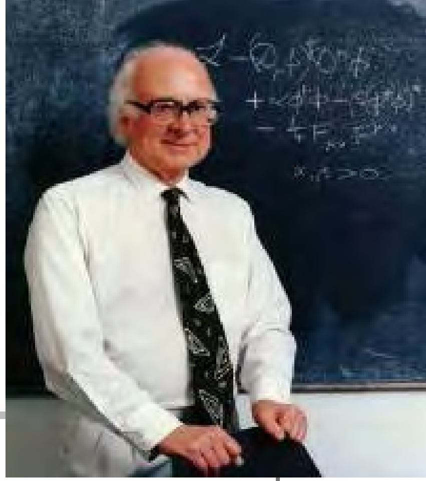
Search for the Higgs boson

$H \rightarrow ZZ^{(*)} \rightarrow 4\ell$

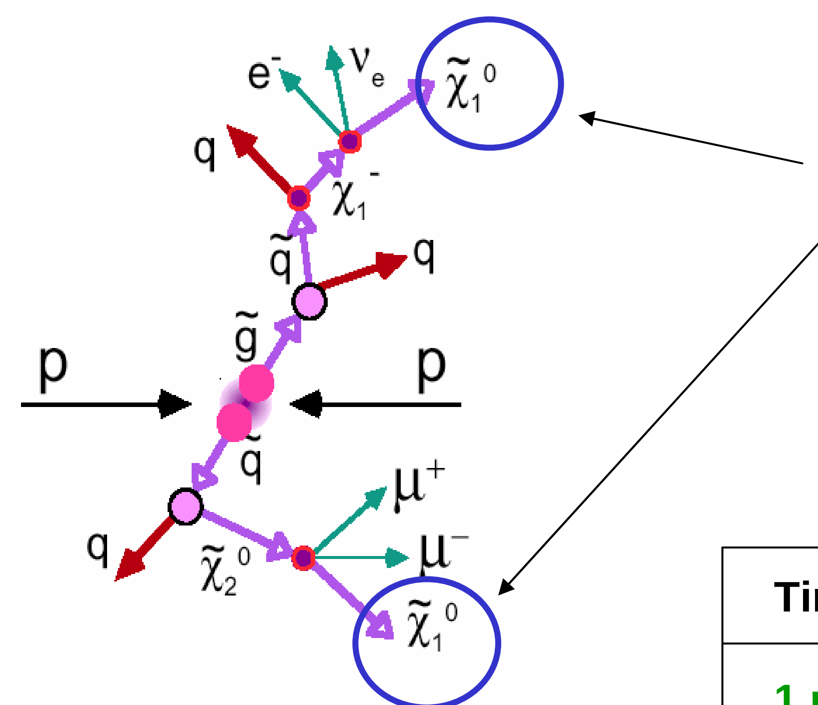








Supersymmetric particles and dark matter



This particle (neutralino) is a good candidate for the universe dark matter

ATLAS discovery reach

Time	reach in squark/gluino mass
1 month	~ 1.3 TeV
1 year	~ 1.8 TeV
3 years	~ 2.5 TeV
ultimate	up to ~ 3 TeV

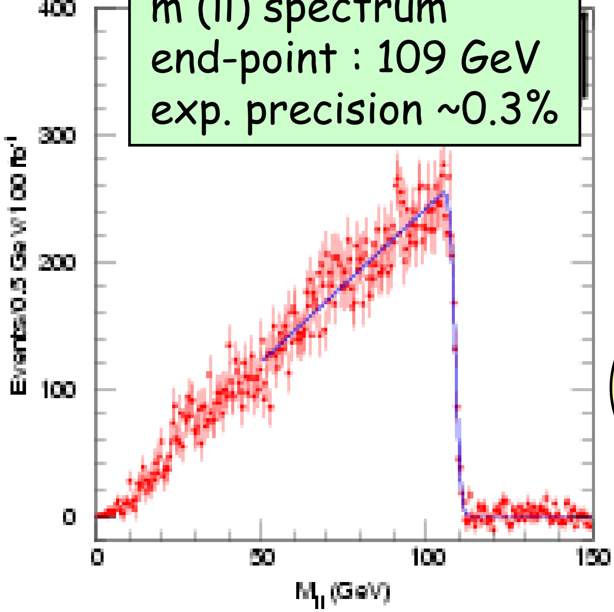
Neutralino mass can be measured to 10% → SUSY discovery and neutralino mass measurement at LHC can solve problem of universe cold dark matter

Example of
a typical chain:

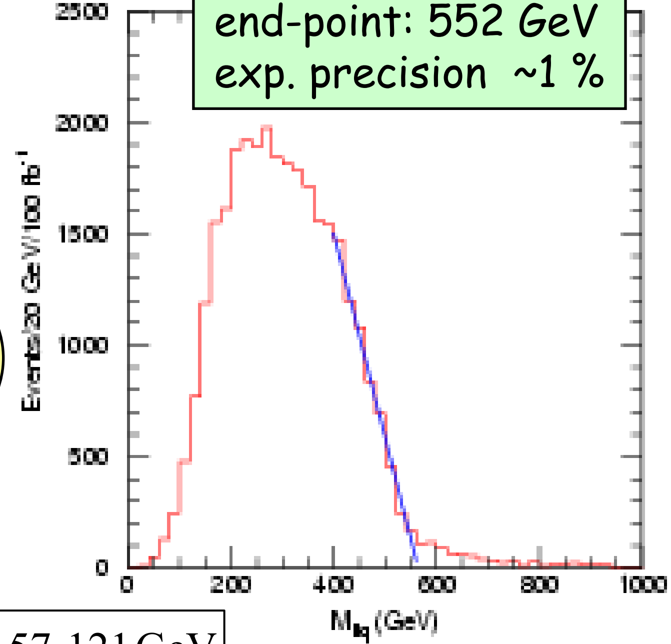
$\tilde{q}_L \rightarrow q\,\chi^0_2$
$\quad\hookrightarrow \tilde{\ell}\; l$
$\qquad\hookrightarrow l\,\chi^0_1$

$m(\tilde{q}_L\ \ \chi^0_2\ \ \tilde{\ell}_R\ \ \chi^0_1) = 690, 232, 157, 121\,\mathrm{GeV}$

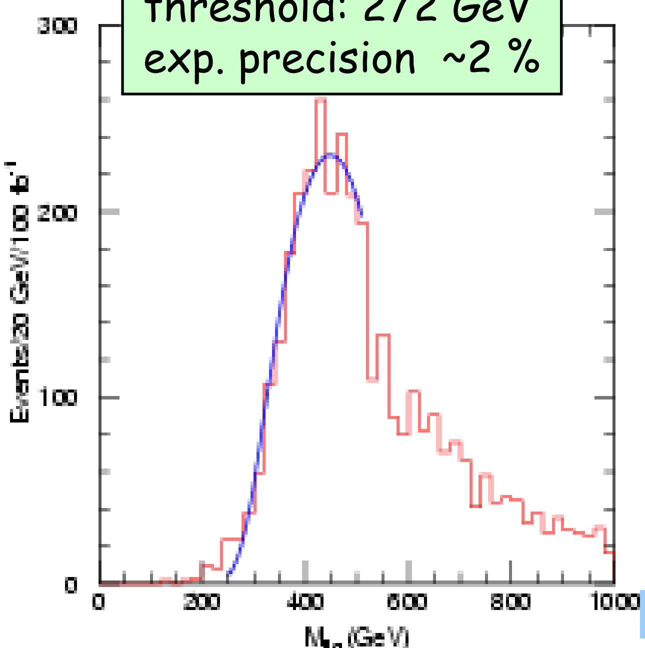
m (ll) spectrum
end-point : 109 GeV
exp. precision ~0.3%



m (llj)^{min} spectrum
end-point: 552 GeV
exp. precision ~1 %

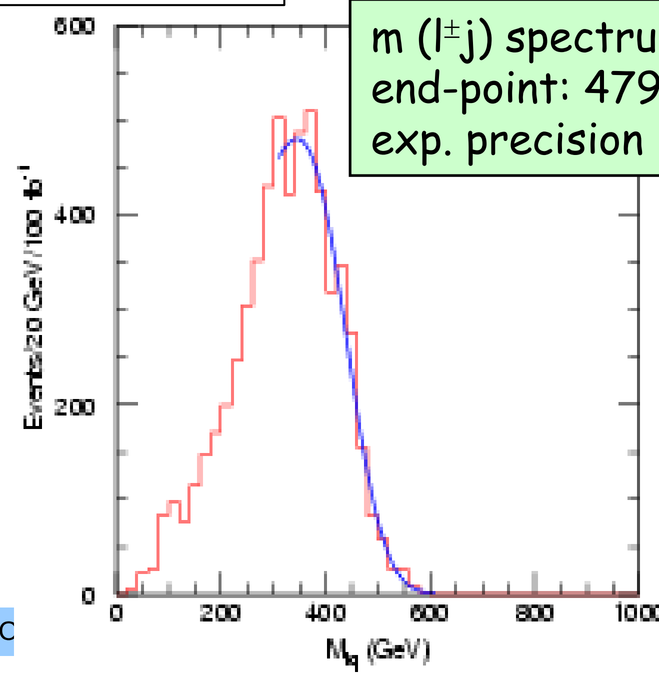


m (llj)^{max} spectrum
threshold: 272 GeV
exp. precision ~2 %

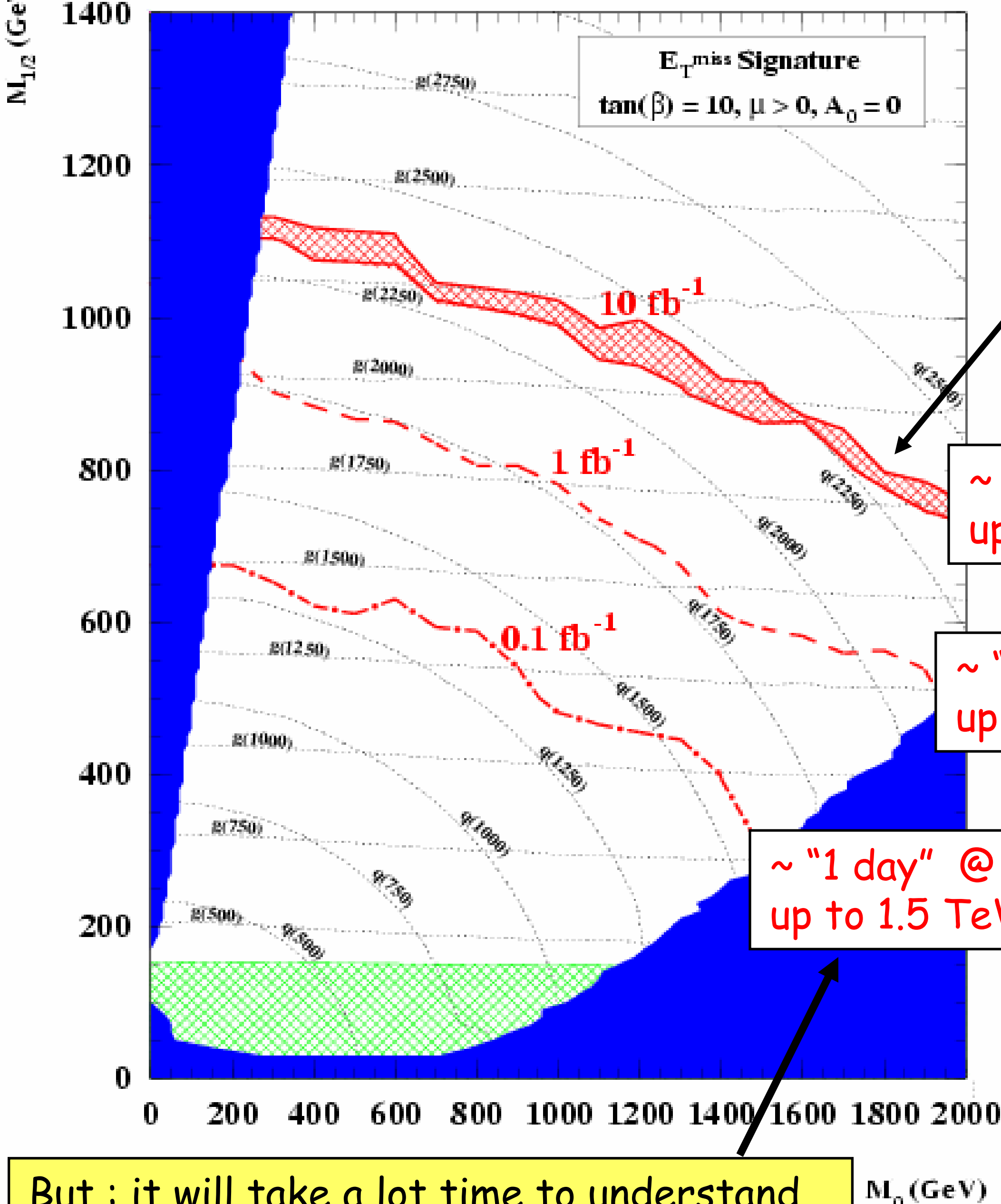


ATLAS
100 fb^{-1}
LHC Point 5

m (l$^{\pm}$j) spectrum
end-point: 479 GeV
exp. precision ~1 %



Discovery reach vs time with jets + E_T^{miss} signature (most model-independent)



ATLAS
5σ discovery curves

band indicates factor ± 2 variation in background estimate

~ 100 days : up to 2.3 TeV

~ "10 days" : up to 2 TeV

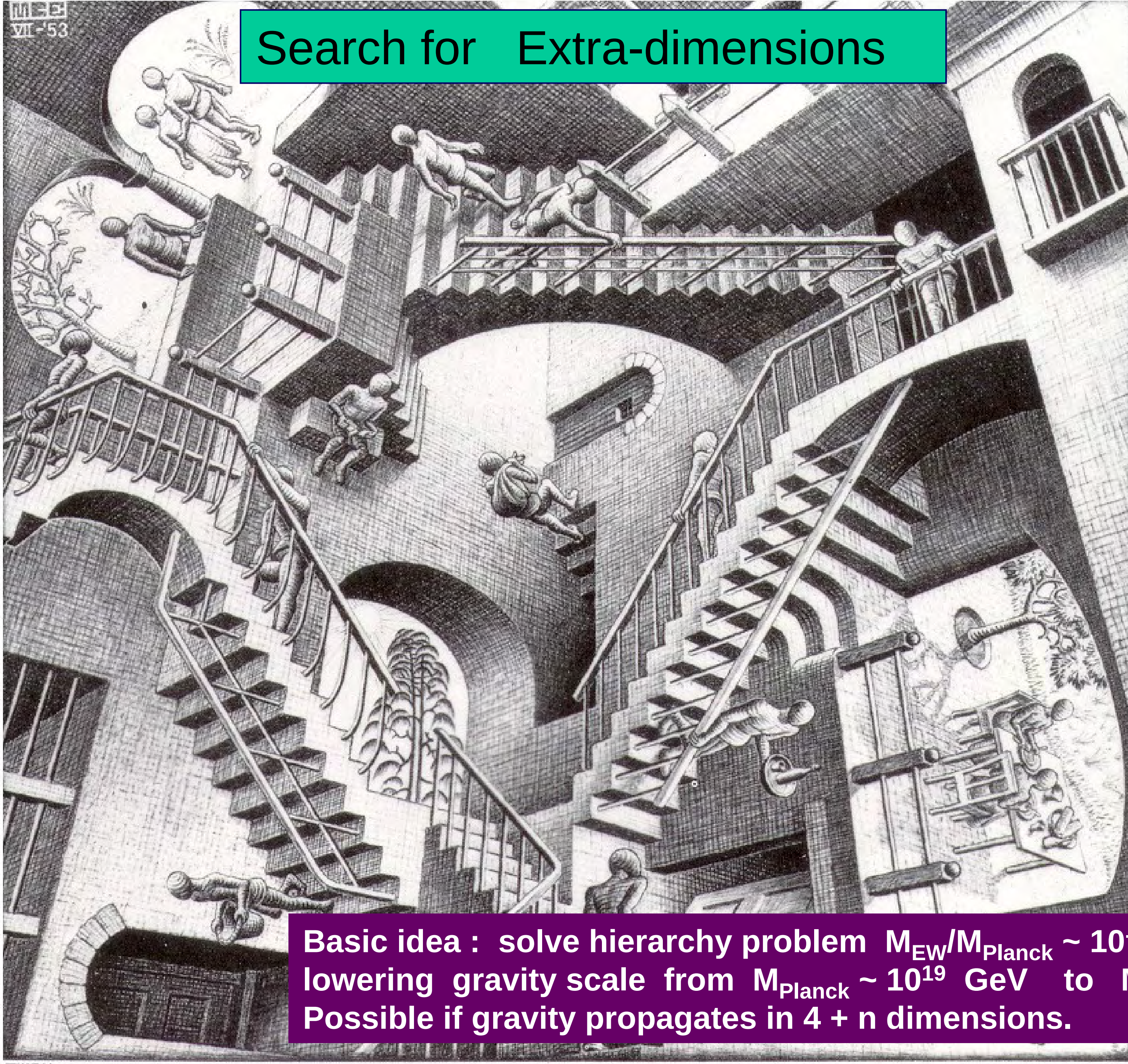
~ "1 day" @ 10^{33}: up to 1.5 TeV

Discovery reach for squarks/gluinos

Time	mass reach
1 month at 10^{33}	~ 1.3 TeV
1 year at 10^{33}	~ 1.8 TeV
1 year at 10^{34}	~ 2.5 TeV
ultimate (300 fb^{-1})	~ 2.5-3 TeV

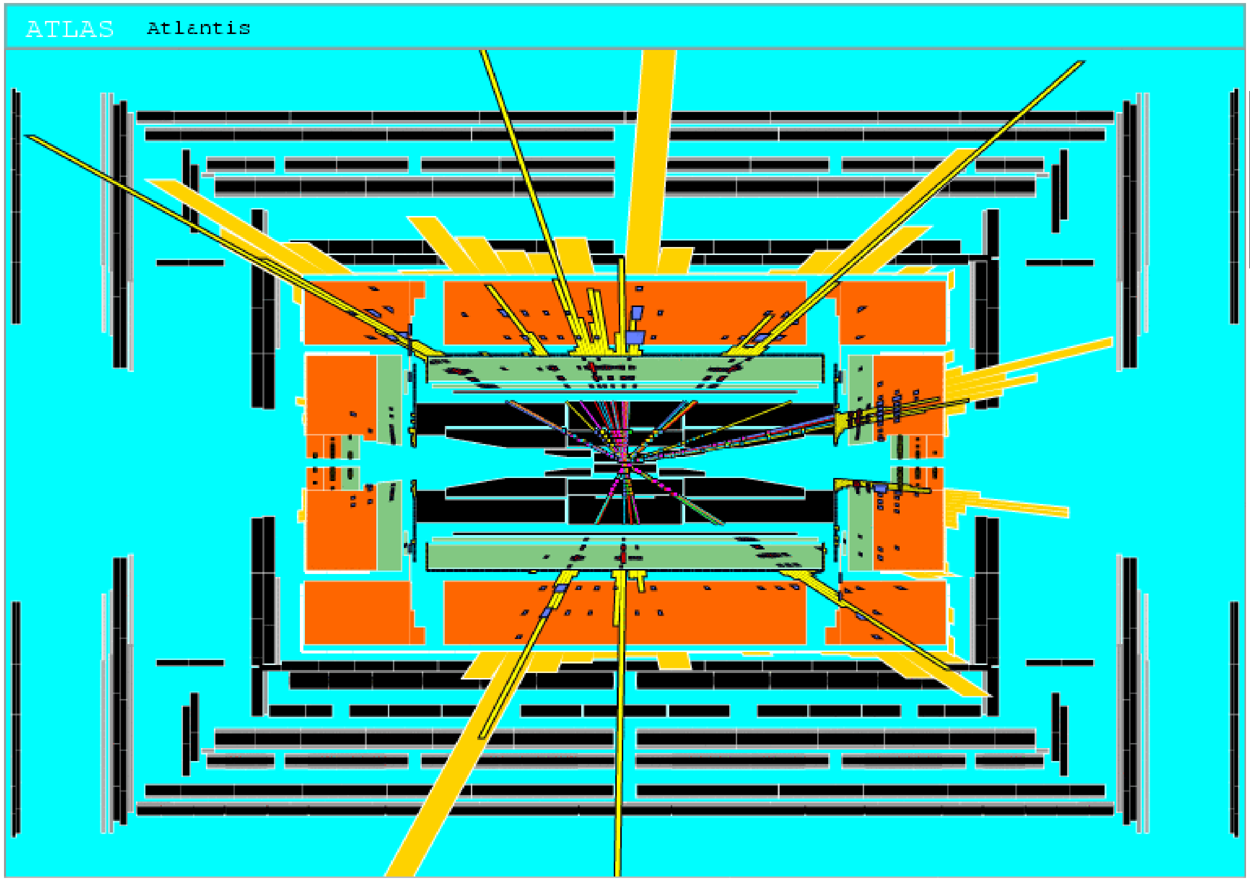
But : it will take a lot time to understand the detectors and the backgrounds …

Search for Extra-dimensions



Basic idea : solve hierarchy problem $M_{EW}/M_{Planck} \sim 10^{-17}$ by lowering gravity scale from $M_{Planck} \sim 10^{19}$ GeV to $M_D \sim 1$ TeV
Possible if gravity propagates in 4 + n dimensions.

If theories with Extra-dimensions are true, mini black holes could be abundantly produced and observed at the LHC.

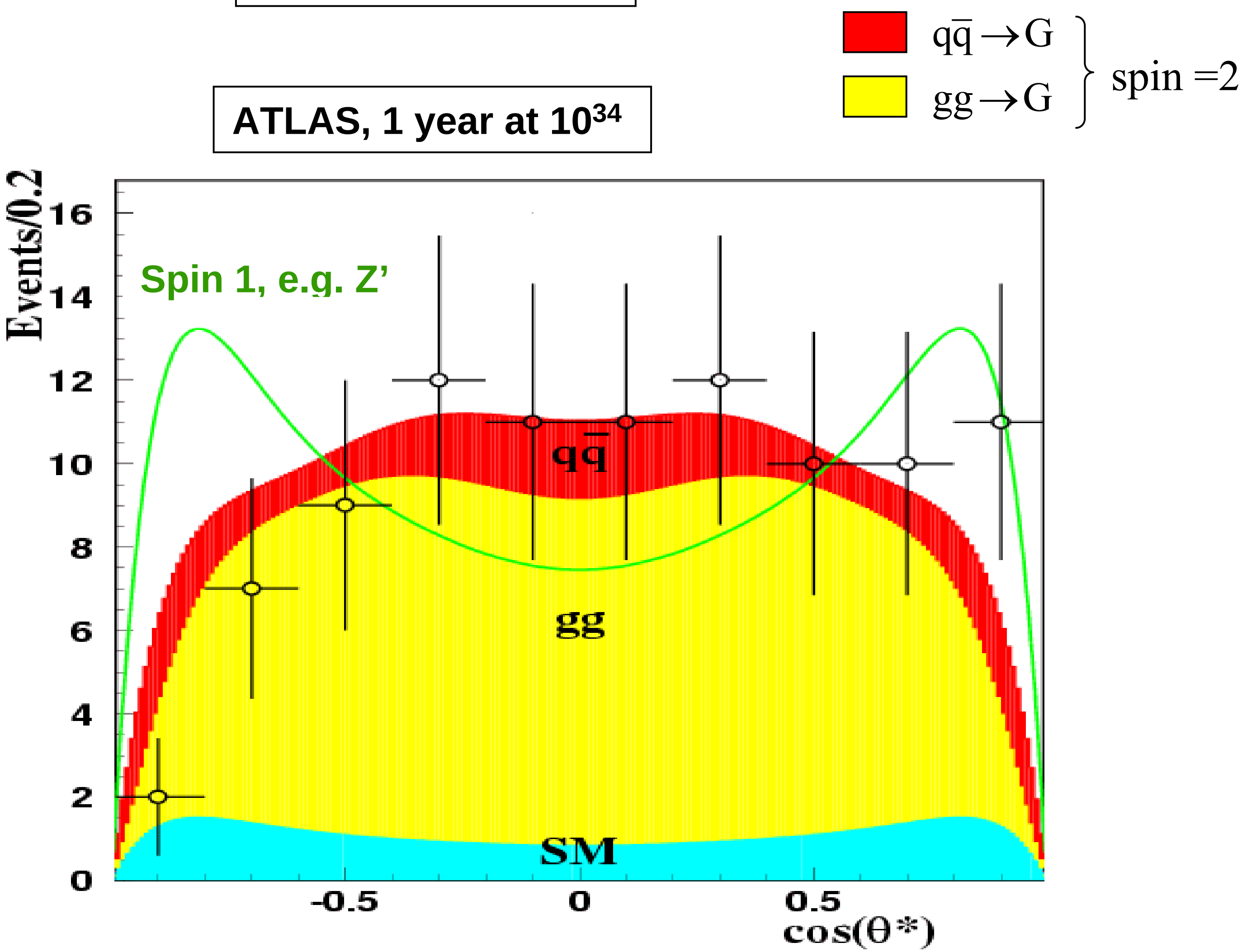


Simulation of a black hole event with M_{BH} ~ 8 TeV in ATLAS

They decay immediately → harmless ….

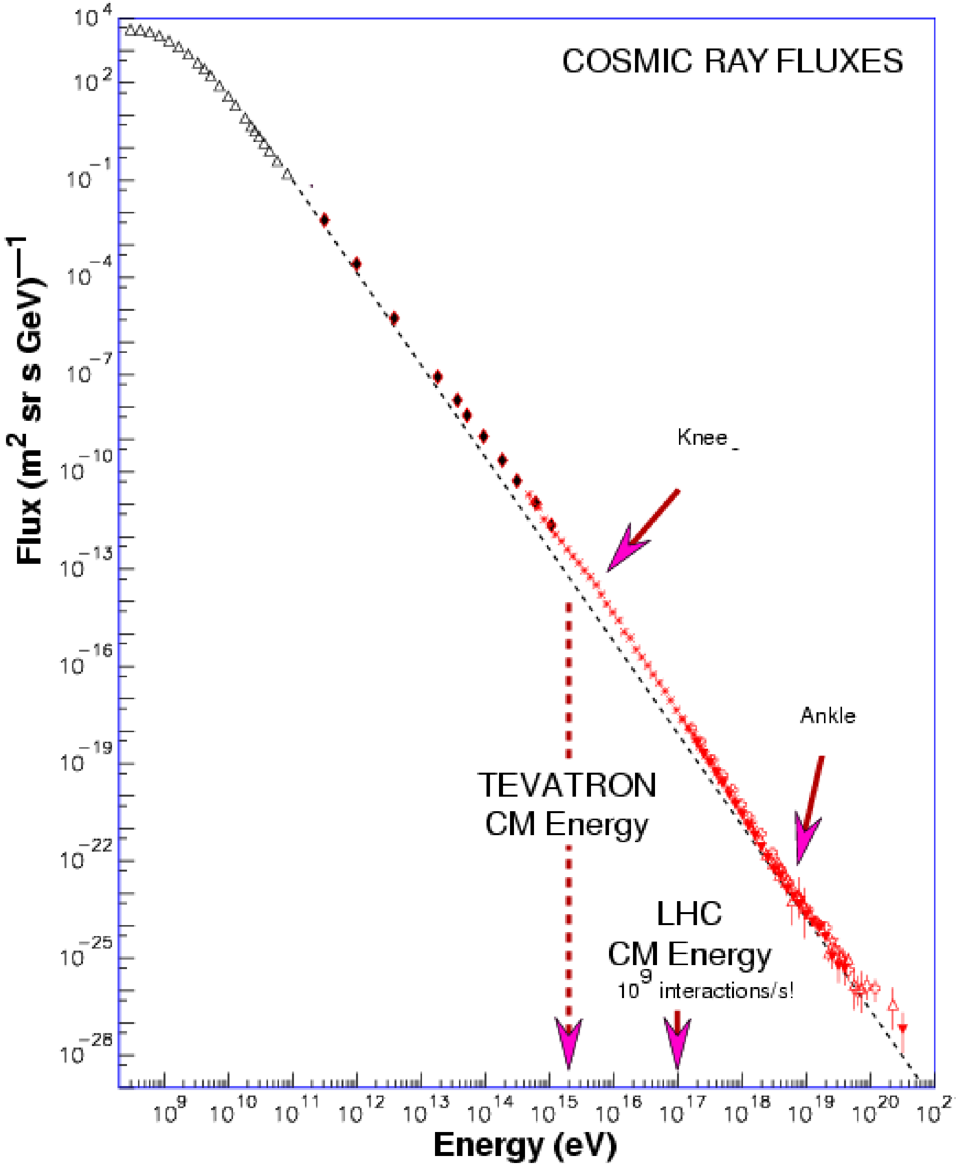
Warped Extra-dimensions (Randall-Sundrum models): production of narrow Graviton resonances

Best discovery channel : $qq, gg \to G \to e^+e^-$



Are there links with astrophysics and cosmology ? Yes, many ….

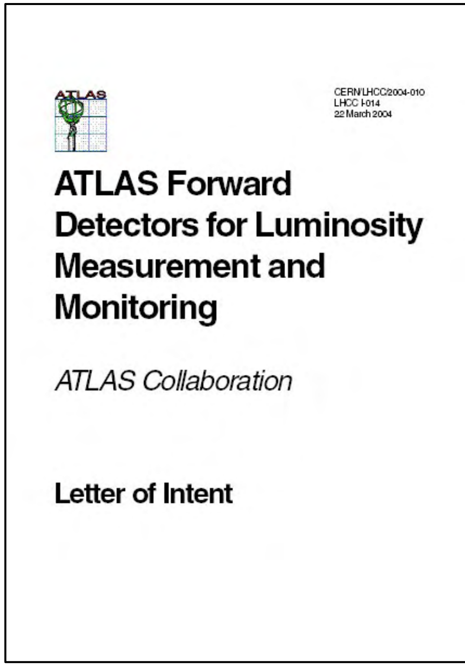
√s = 14 TeV → **corresponds to E ~ 100 PeV fixed target proton beam**



The LHC will be the first machine able to explore the high-E part of the cosmic ray spectrum

ATLAS has an active community preparing for a phased forward physics programme;

1) *Roman pots to measure the total cross-section*
2) *Intend to measure energy flow at zero degree (ZDC)*
3) *Recently we have associated also with LHCf, an experiment driven by groups from the cosmic ray community with the aim to gauge VHE EM showers codes at zero degrees*


CERN/LHCC/2004-010
LHCC I-014
22 March 2004

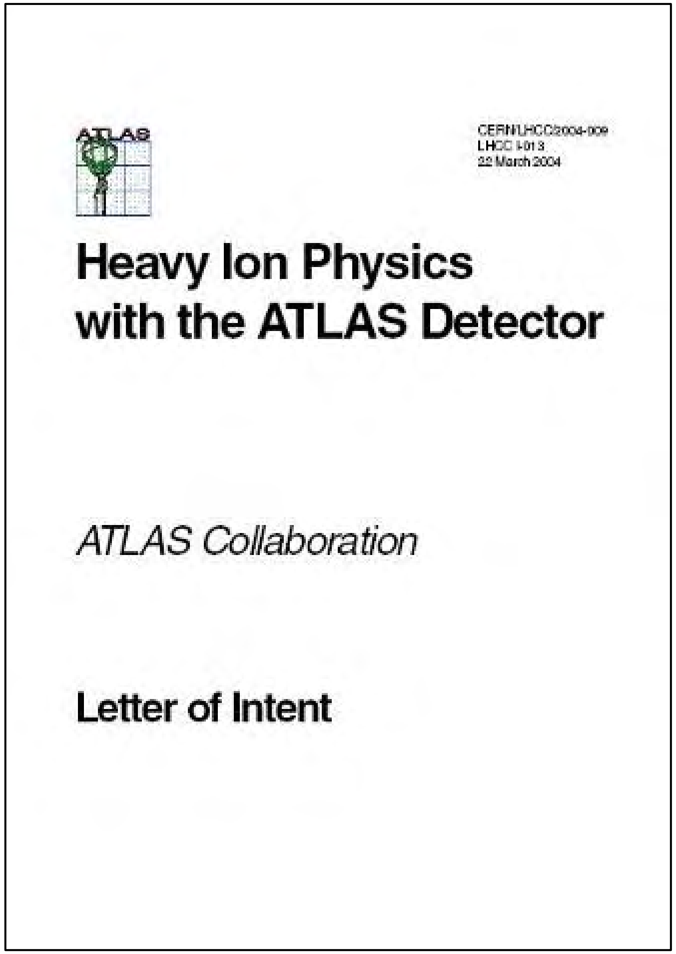
ATLAS Forward Detectors for Luminosity Measurement and Monitoring

ATLAS Collaboration

Letter of Intent

ATLAS potential for heavy ions

Specific strengths of the detector can be exploited for HI
- Best jet calorimetry at LHC → detailed jet quenching
- Tracking and muon spectrometer → production/suppression of heavy quark states

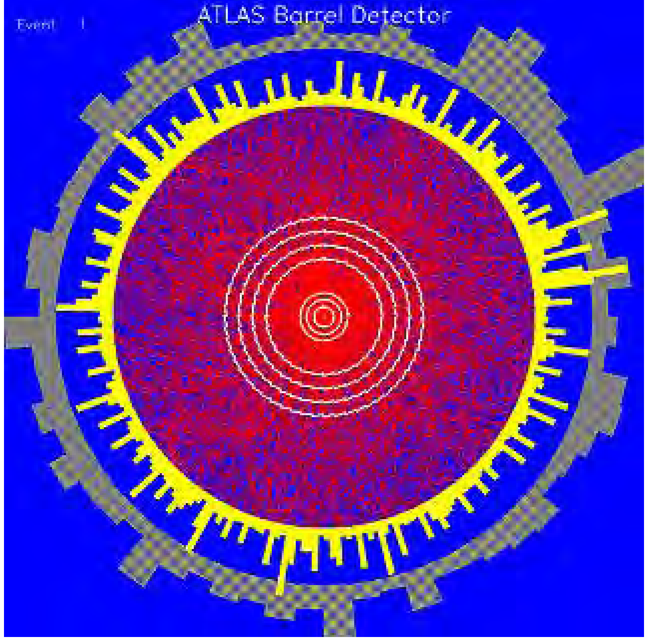

ATLAS

CERN/LHCC/2004-009
LHCC I-013
22 March 2004

Heavy Ion Physics
with the ATLAS Detector

ATLAS Collaboration

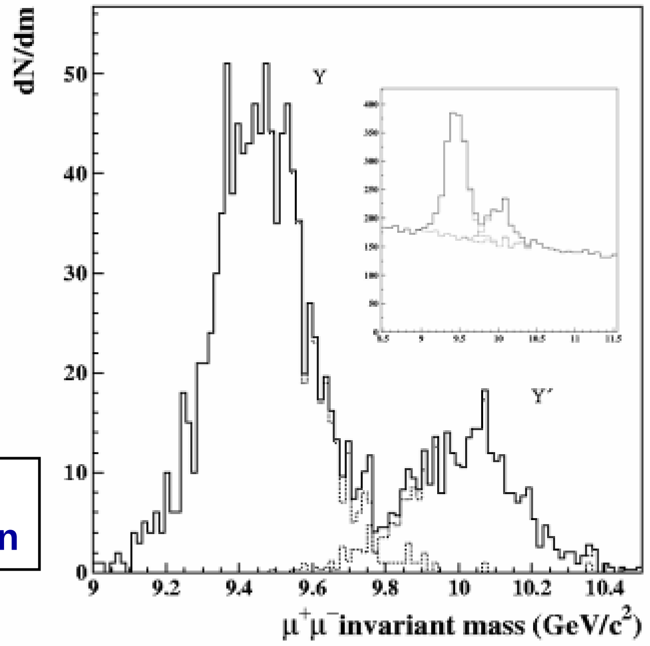
Letter of Intent



Pb-Pb collision
b = 0, dy = 0.5
5.5 TeV/coll. nucl.
10^{27} cm^{-2} s^{-1}

BNL/Columbia interest in a ZDC would enhance the ATLAS HI potential

Pb-Pb collision
Upsilon production

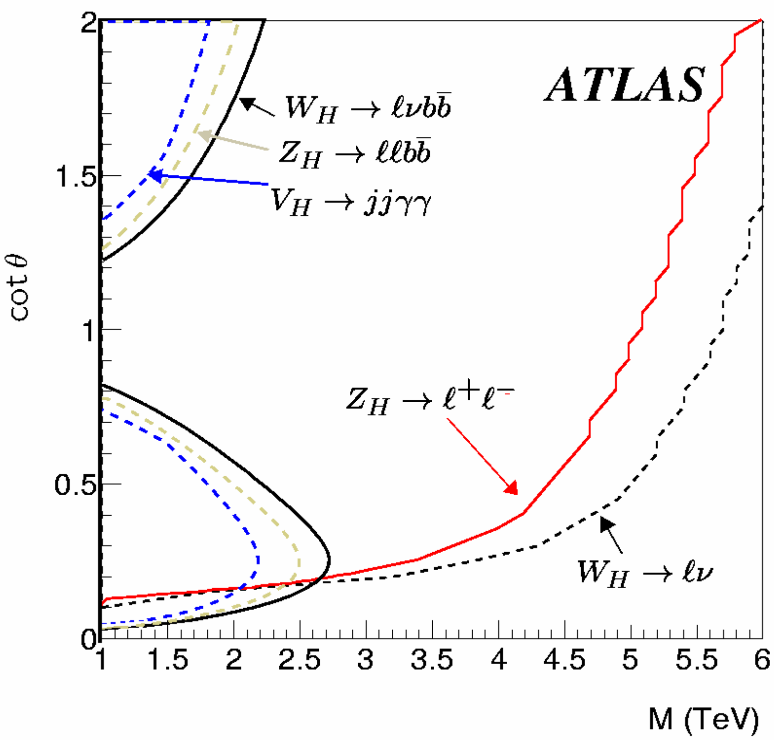


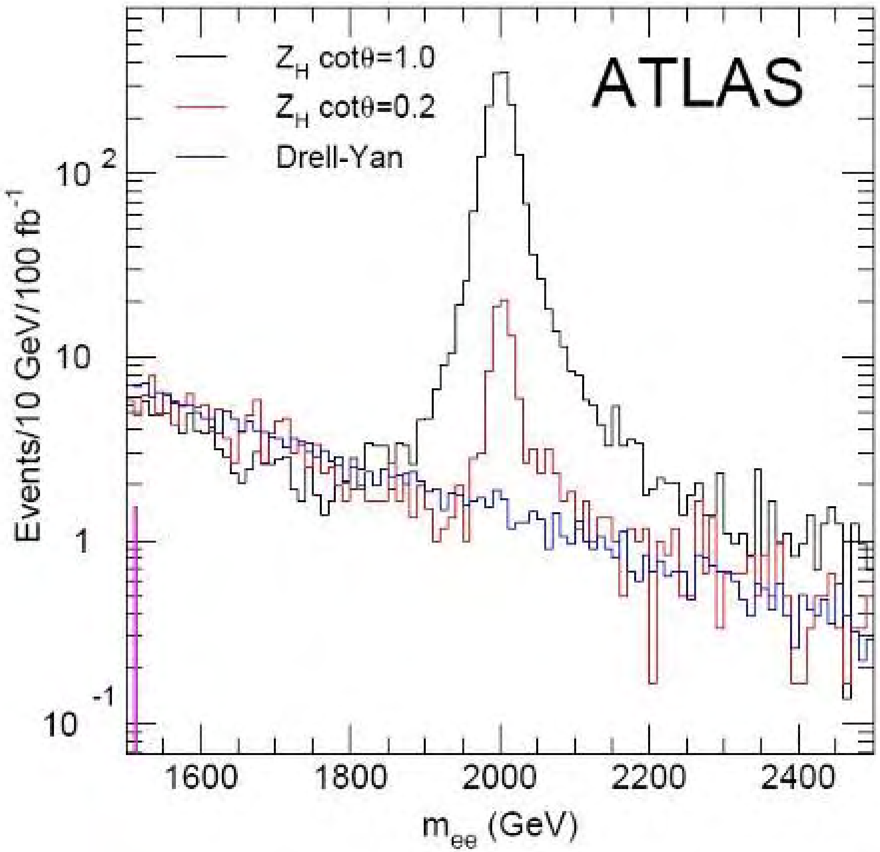
Example of discovery physics: ATLAS potential for 'Little Higgs Models'

LHM New approach to the hierarchy problem, predicting a rich phenomenology with many new particles (heavy top T, new Gauge Bosons W_H, Z_H, A_H and Higgs triplet Φ^0, Φ^+, Φ^{++}),

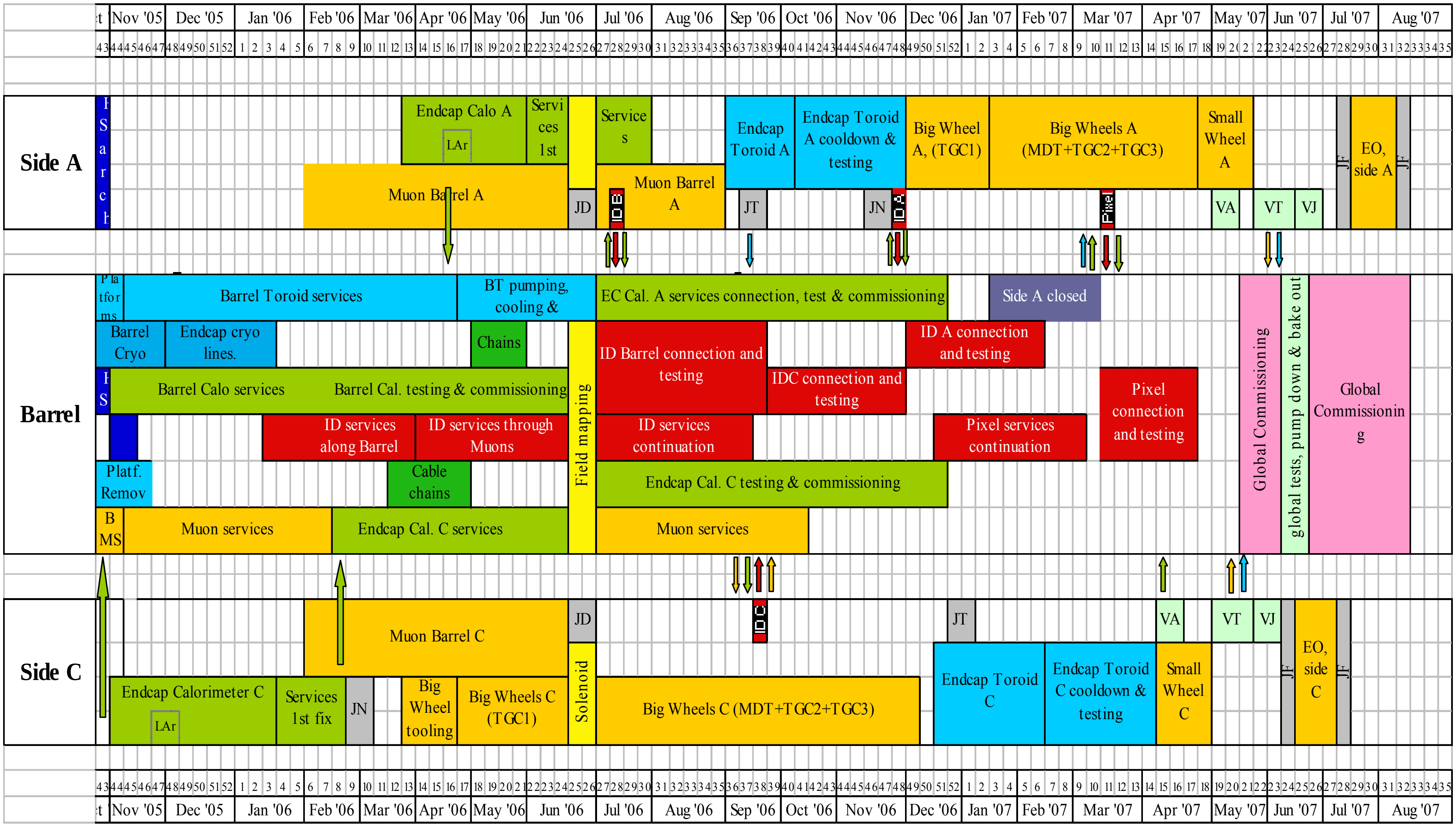
W_H and Z_H search shown is defined by boson mass (M) and mixing angle (θ) parameters

(reach plot is for 300 fb^{-1})





Summary representation of the installation activities and schedule in the experimental cavern at Point-1



Conclusions

The CERN Management and the LHC machine project team are most strongly committed to deliver first collisions in Summer 2007, thereby opening a new chapter in particle physics to be exploited in a truly world-wide collaborative effort

Many important milestones have been passed in the construction, pre-assembly, integration and installation of the ATLAS detector components

Very major software and computing activities are underway as well, using the Worldwide LHC Computing Grid (WLCG) for distributed computing resources

Commissioning and planning for the early physics phases has started

→ The ATLAS Collaboration is highly motivated, and on track, for LHC physics in 2007

(The LHC is expected to remain at the energy frontier of HEP for the next 10 – 15 years, and the ATLAS Collaboration has already set in place a coherent organization to evaluate and plan for future upgrades)

(Informal news on ATLAS is available in the ATLAS eNews letter at http://aenews.cern.ch/)