Status of ATLAS

LHCC

24th September 2008

ATLAS Collaboration

(Status July 2008)

37 Countries
169 Institutions
2500 Scientific Authors total
(1800 with a PhD, for M&O share)

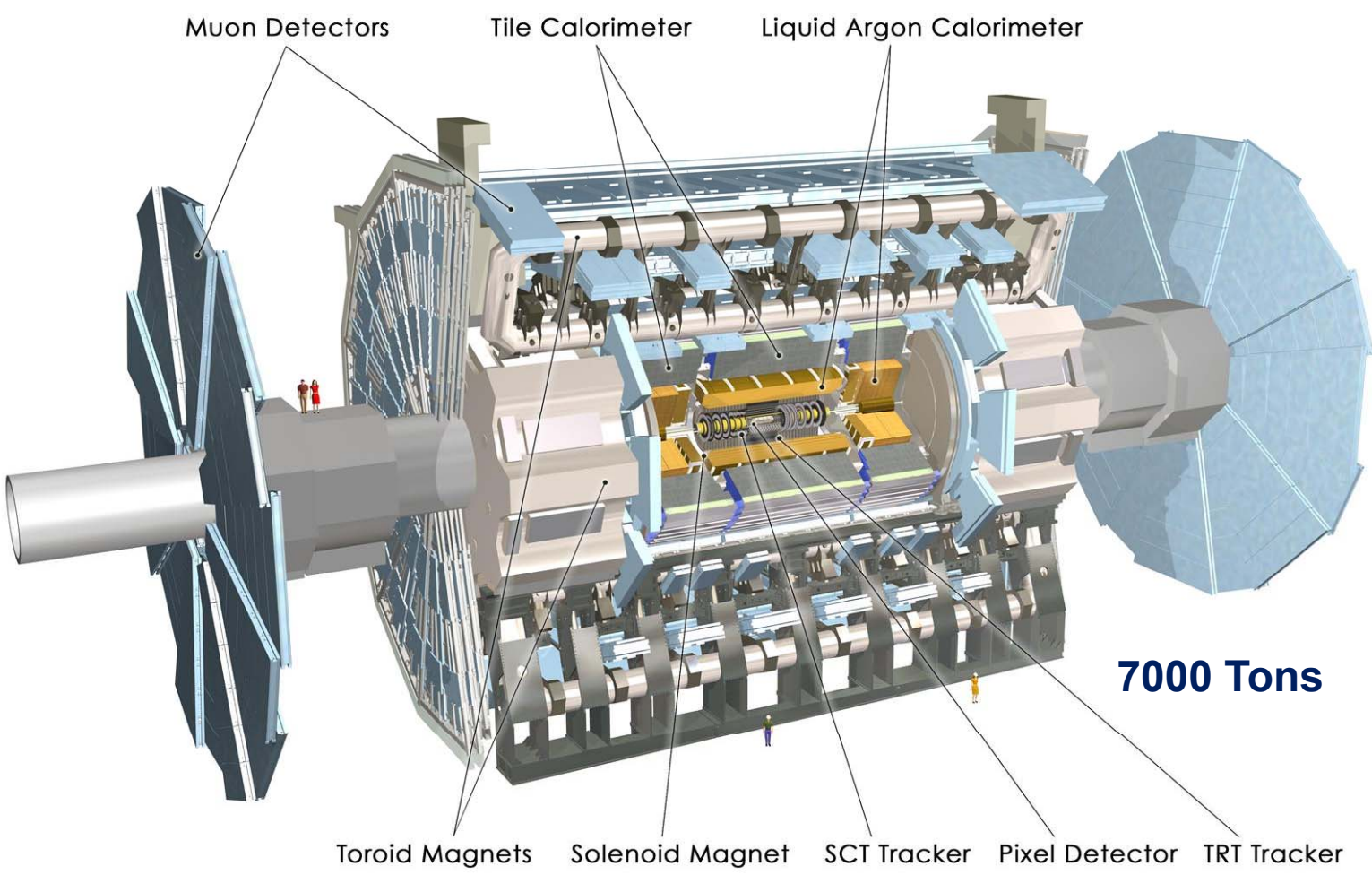
Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, UAN Bogota, Bologna, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, 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, 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, Nagoya, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Ritsumeikan, UFRJ Rio de Janeiro, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, 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/ICTP, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

ATLAS Detector

ATLAS superimposed to
the 5 floors of building 40

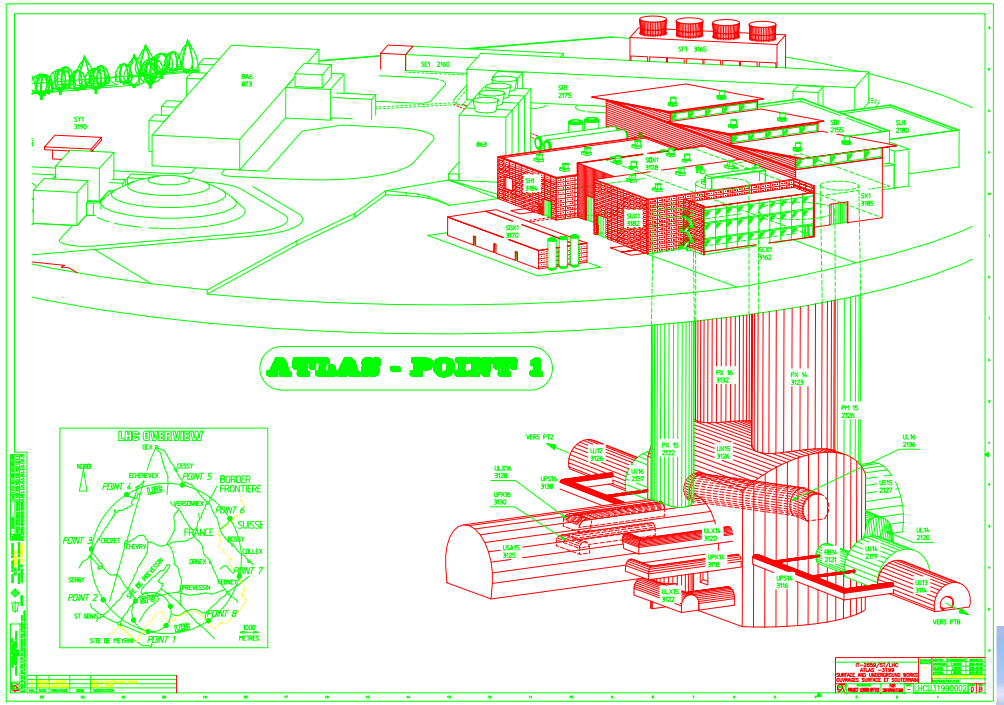
45 m

24 m

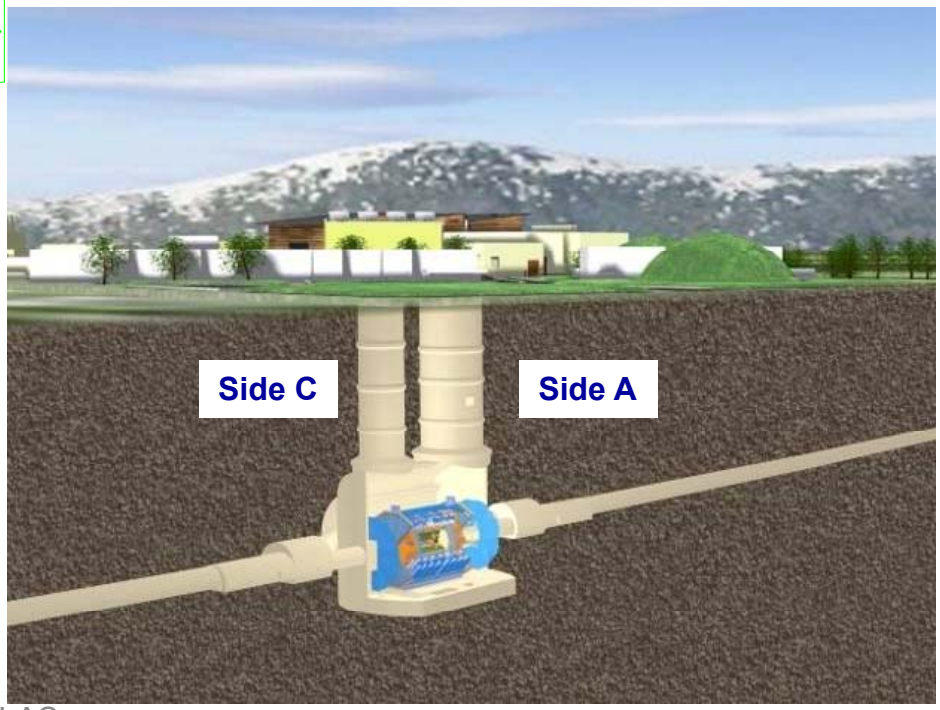


7000 Tons

The Underground Cavern at Point-1 for the ATLAS Detector



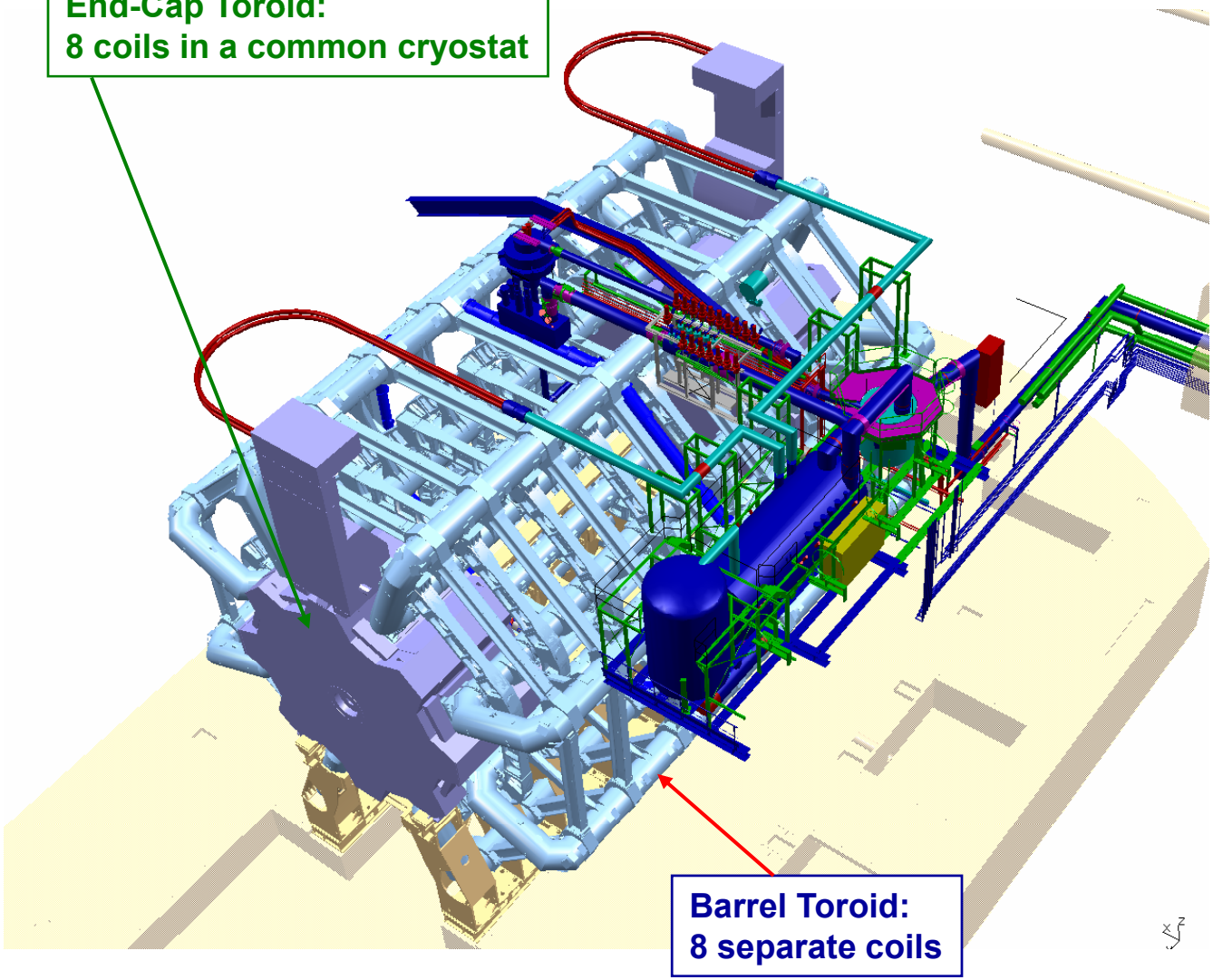
Length = 55 m
Width = 32 m
Height = 35 m



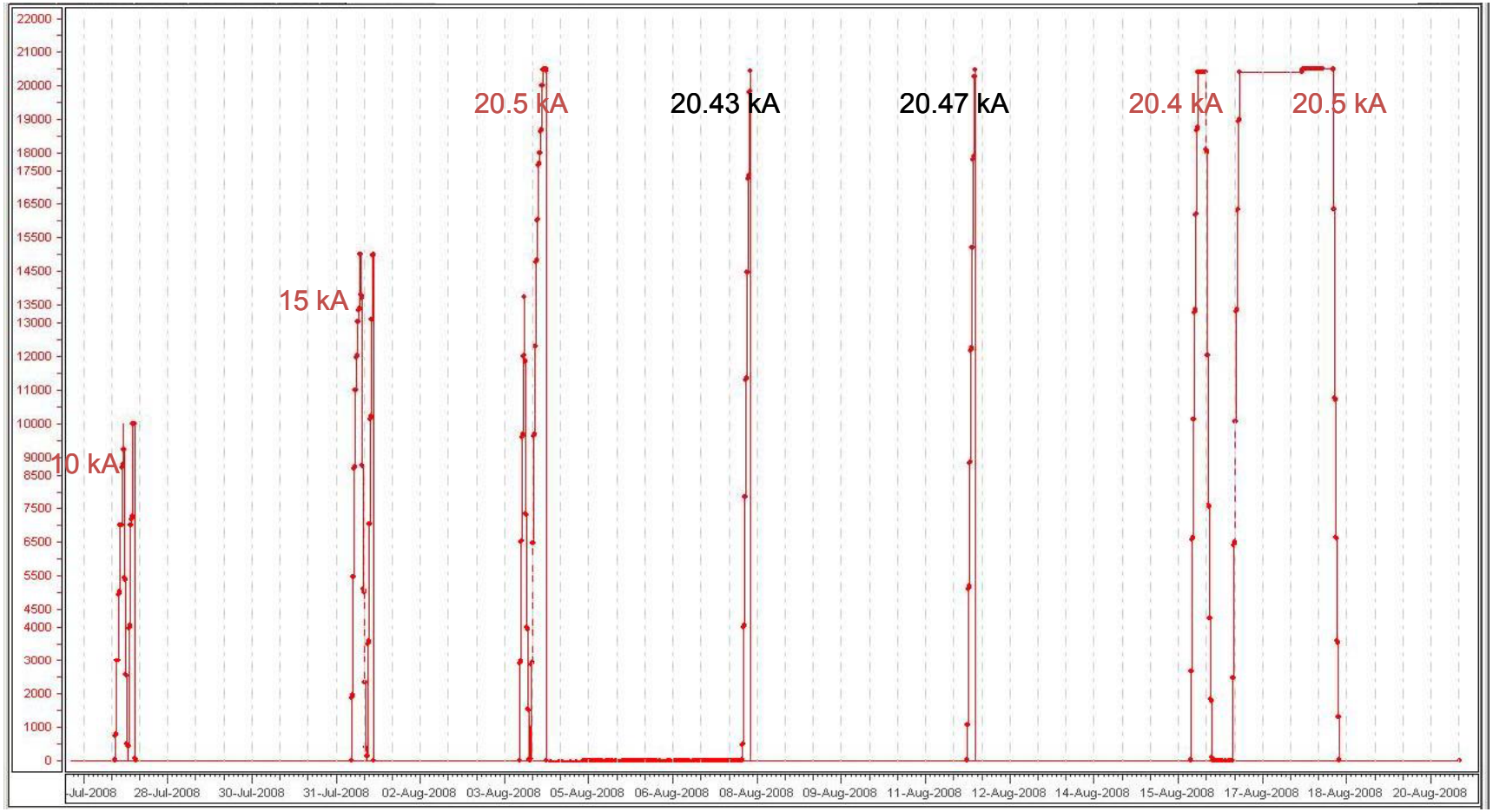
Toroid system

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



ATLAS Toroid Commissioning Runs (27 July to 19 August 2008)

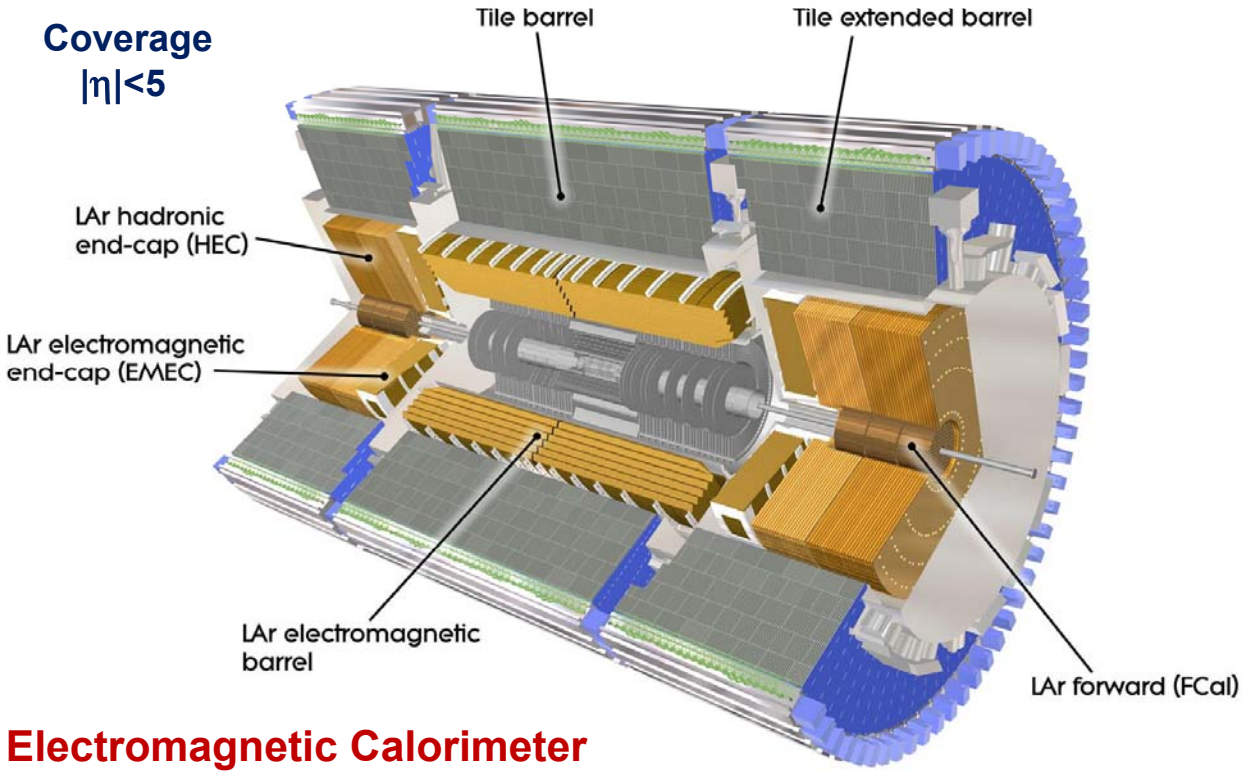


Ramp-up of the current in 3 h10 min, slow dump in 2 h 40 min, fast dump in 2 min
Recovery time after a fast dump (quench) is typically 100 hrs

Since then the full magnet system has been operated for days (including the central solenoid), one more training quench occurred in ECT-A

Calorimetry

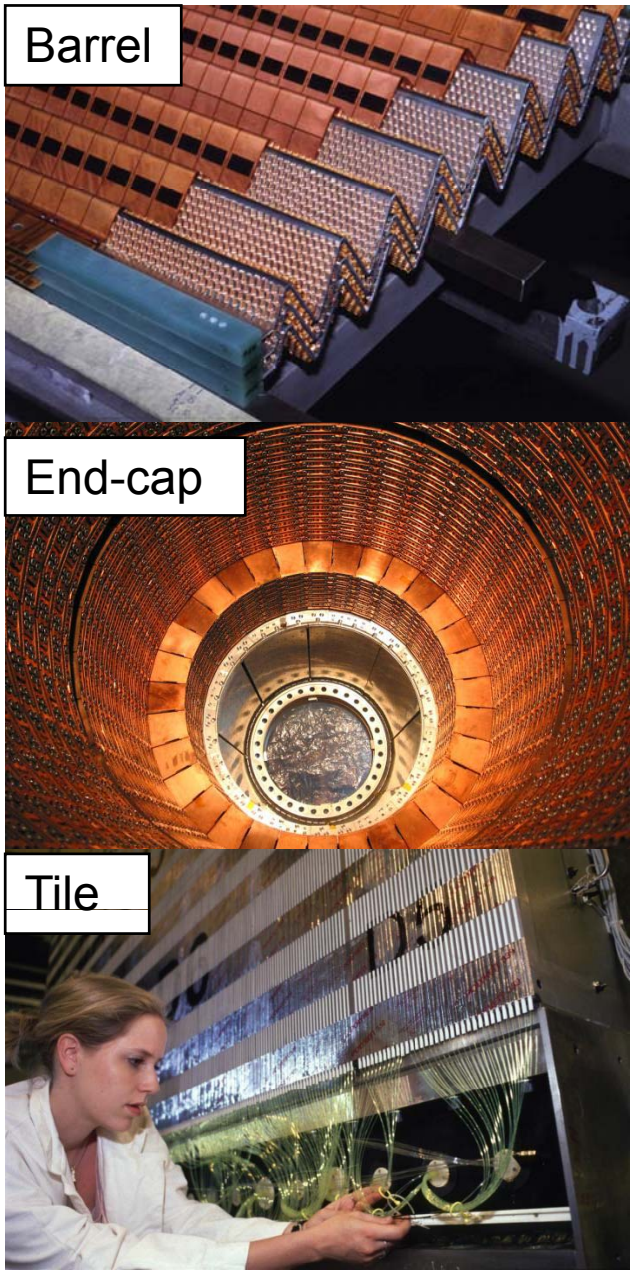
Coverage
|η|<5



Electromagnetic Calorimeter
barrel, end-cap: Pb-LAr
~10%/√E energy resolution e/γ
180'000 channels: longitudinal segmentation

Hadron Calorimeter
barrel Iron-Tile, EC/Fwd Cu/W-LAr (~20000 channels)
σ/E ~ 50%/√E ⊕ 0.03 pion (10 λ)

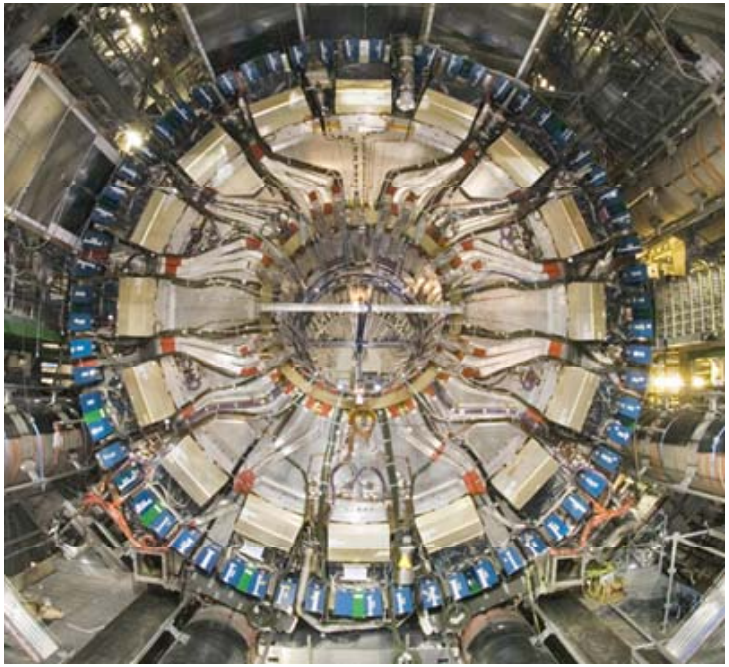
Trigger for e/γ , jets, missing E_T ,etc



Hardware Readiness: Liquid Argon Calorimeters

Installation in the cavern
Barrel in October 2004,
End-caps by 2006

Electronics equipment completed
Back-End May 2007
Front-End April 2008
(some refurbishment was needed)



Since May 2008

full calorimeter up, integrated in DAQ, slow control

in steady running mode

all channels read-out

~0.02 % dead (isolated) channels, plus 0.8% dead readout, including

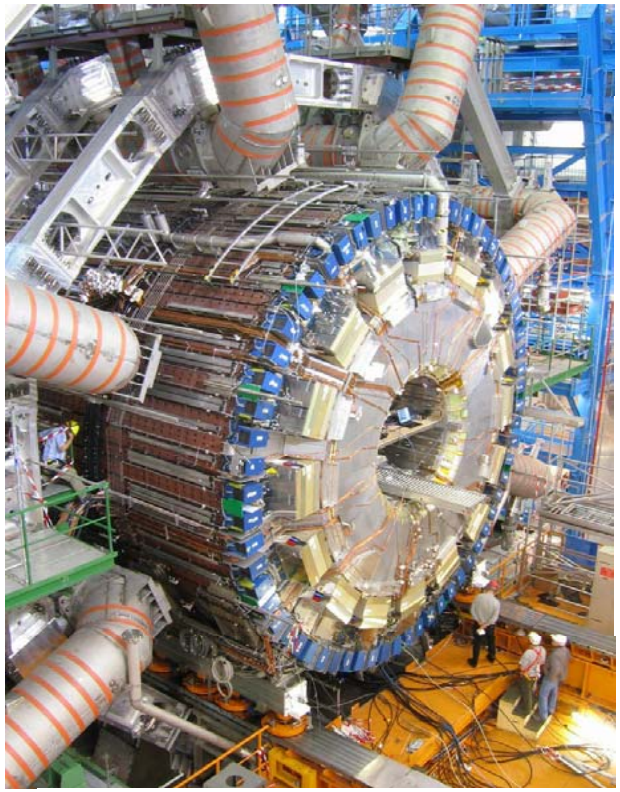
1 of 8 HEC low voltage power supply off (need access for repair)

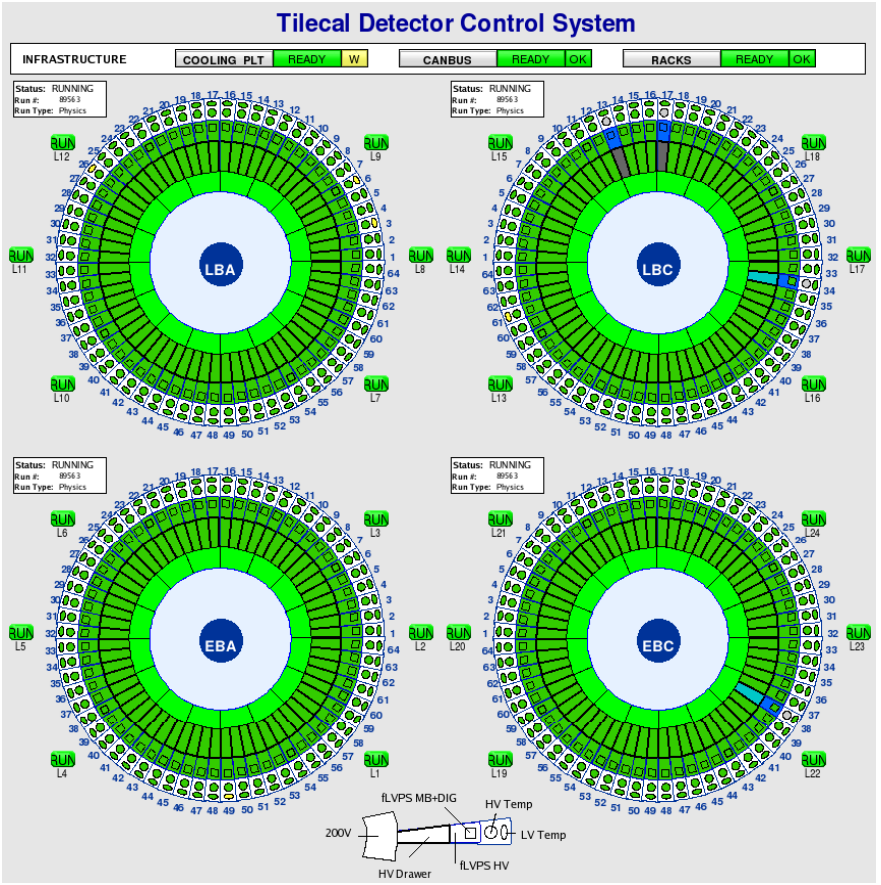
Commissioning on-going (cosmics and beam backgrounds)

Hardware Readiness: Tile Calorimeter

Installation in the cavern

Ext. Barrel C December 2004
Barrel October 2005
Ext. Barrel A May 2006





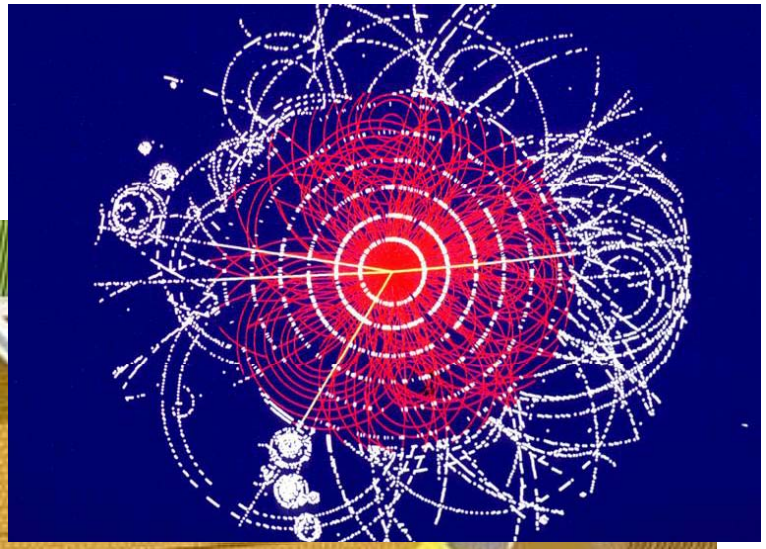
Electronics equipment completed May 2008
(some refurbishment was needed)

full calorimeter up and running, integrated in DAQ
~10000 PMTs → 5000 cells

~0.2% dead (isolated) cells, and 2 of 256 sectors off – power supply problem
will be repaired during shutdown with access

ATLAS Tracking Detectors

2 Tesla solenoid $\sigma/p_T \sim 5\times10^{-4}\, p_T \oplus 0.01$



Transition Radiation Tracker (TRT)
(4 10^5 channels) with e/π separation

Pixels
(0.8 10^8 channels)

Si Strips Tracker (SCT)
(6 10^6 channels)

Inner Detector hardware status

The critical path issue was the evaporative cooling system repair and cleaning of the plant, after a failure on 1st May 2008, which ended late July

Priority then given to Pixel operation

- **First to safely bake-out the beam pipe (early August)**
- **Then to operate the full detector (for the first time)**

By now we have gained considerable experience with the evaporative system and, more in general, with the environmental control

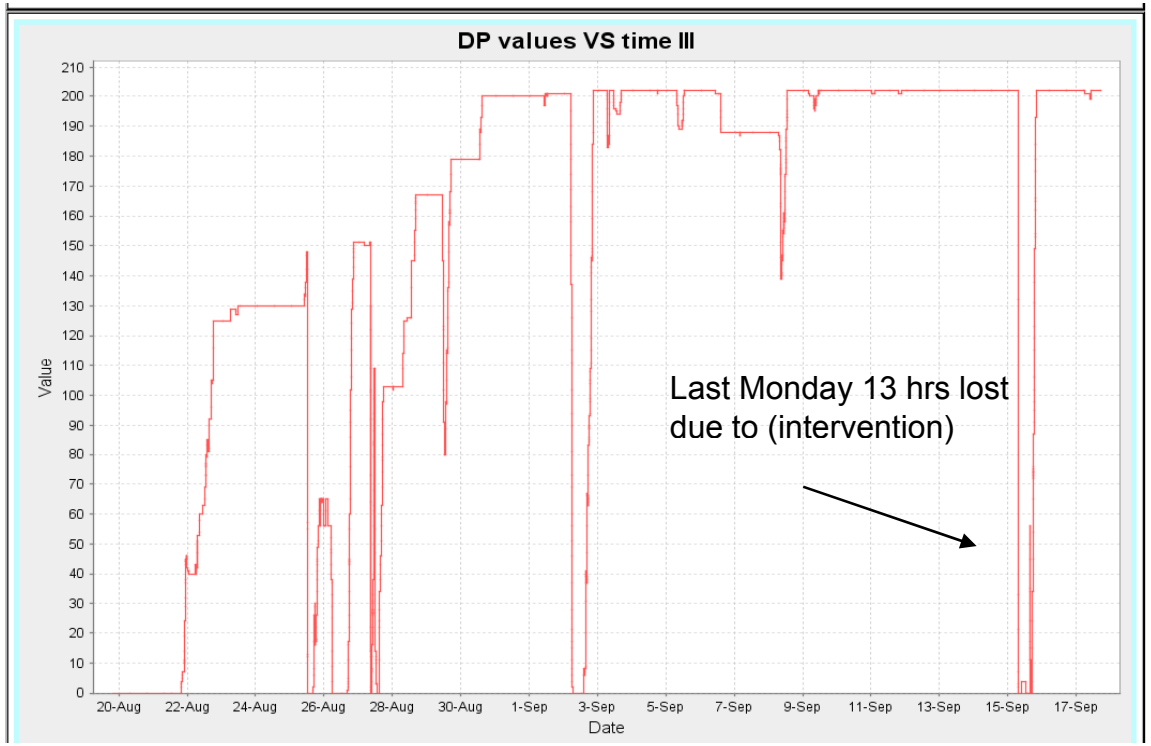
- **Many more heater hours during last month than in the plant lifetime**
- **Operation is stable**

All ID sub-detectors integrated in the ATLAS DAQ and took significant data

An issue remain TX plug-ins (opto-transmitter) which are dying at a significant rate

- **Off-detector: they affect both SCT and Pixel**
- **A new production is now planned.**

The evaporative cooling system has been an issue for ~ 2 years, now 202/204 loop on (we planned to leave 5 off for 2008: 3 in the Pixels (2.1% modules lost) and 2 in the SCT (0.9% modules lost))

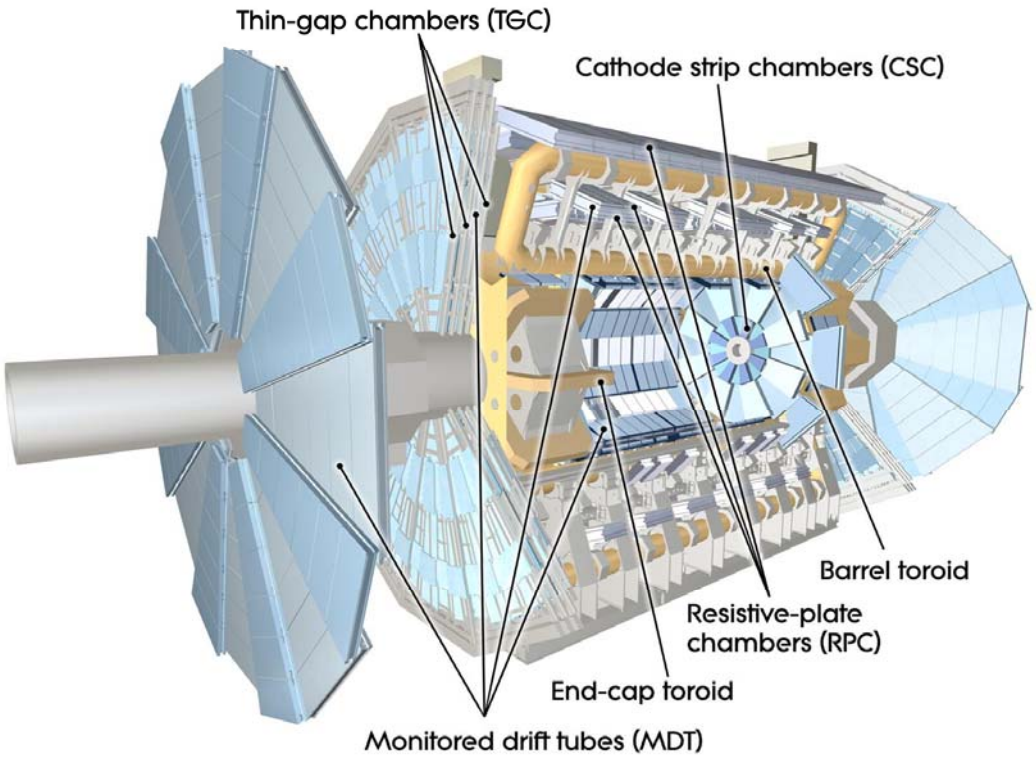


Overall: Pixels 95% of the modules run stable (and improving every day as commissioning proceeds)

SCT 99.8% barrel and 97.6% end-cap modules in operation

TRT 98% read out (2% dead channels from assembly and installation)

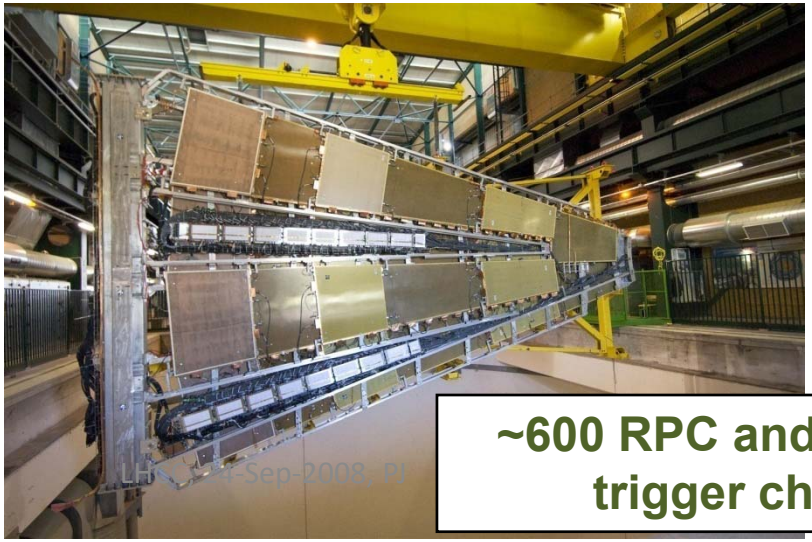
Muon System



Stand-alone momentum resolution
ΔpT/pT < 10% up to 1 TeV

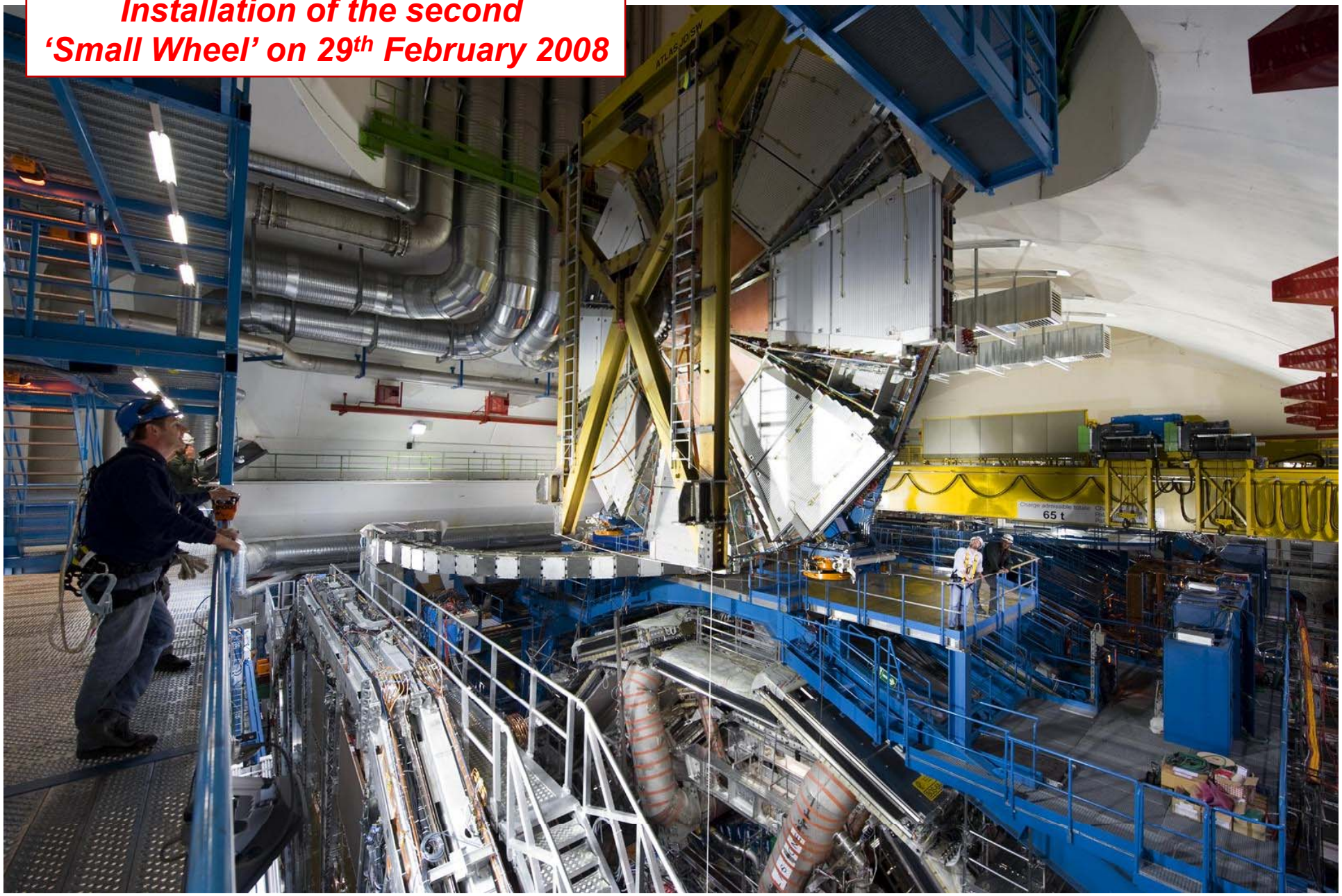
2-6 Tm |η|<1.3 4-8 Tm 1.6<|η|<2.7

~1200 MDT precision chambers for track



~600 RPC and ~3600 TGC trigger chambers

Installation of the second 'Small Wheel' on 29th February 2008



Muon spectrometer hardware status

MDT

Problematic chambers: < 1%
(HV, read-out, gas)

Alignment

99.7% of the barrel, 99% of the end-cap alignment lines are working

RPC

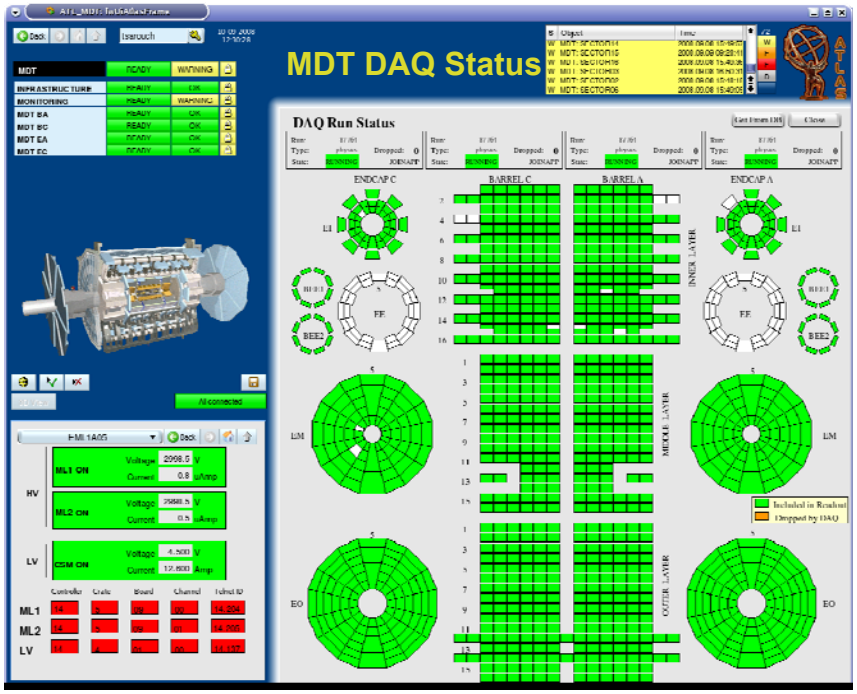
16 sectors fully commissioned
- 3 sectors under final timing adjustments
- 2 sectors affected by missing CAEN HV
- 1 not ready (noise on clock propagation)

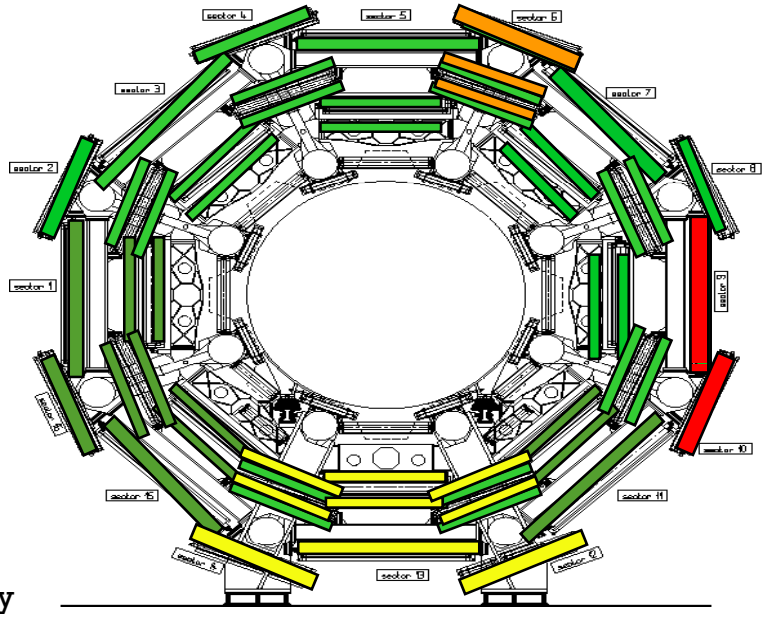
TGC

All wheels on both sides ready for operation (need some HV for TGC on Small Wheel due to HV failure and shortage of spares)

CSC

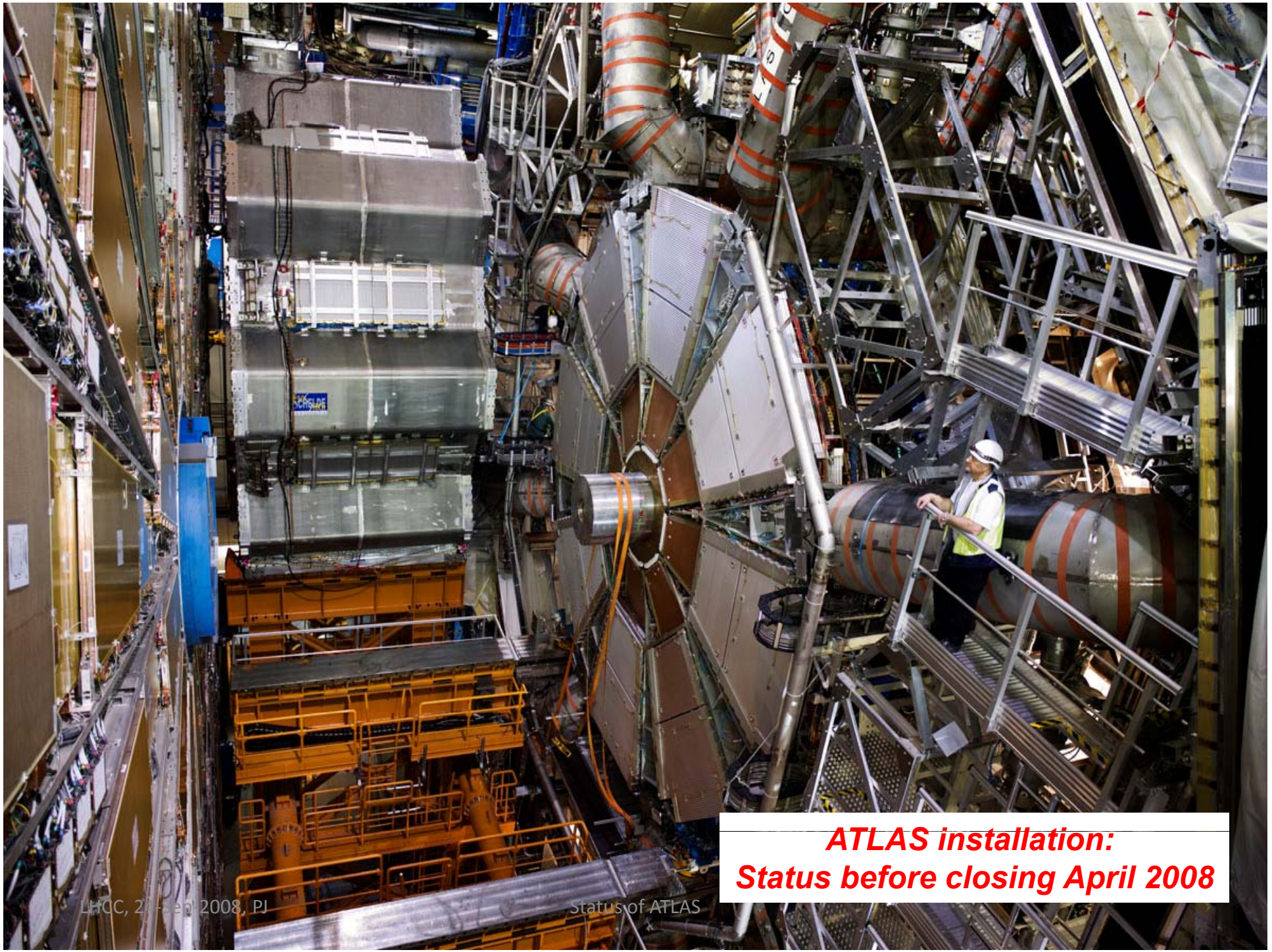
Chambers work, but read-out limitation being worked on



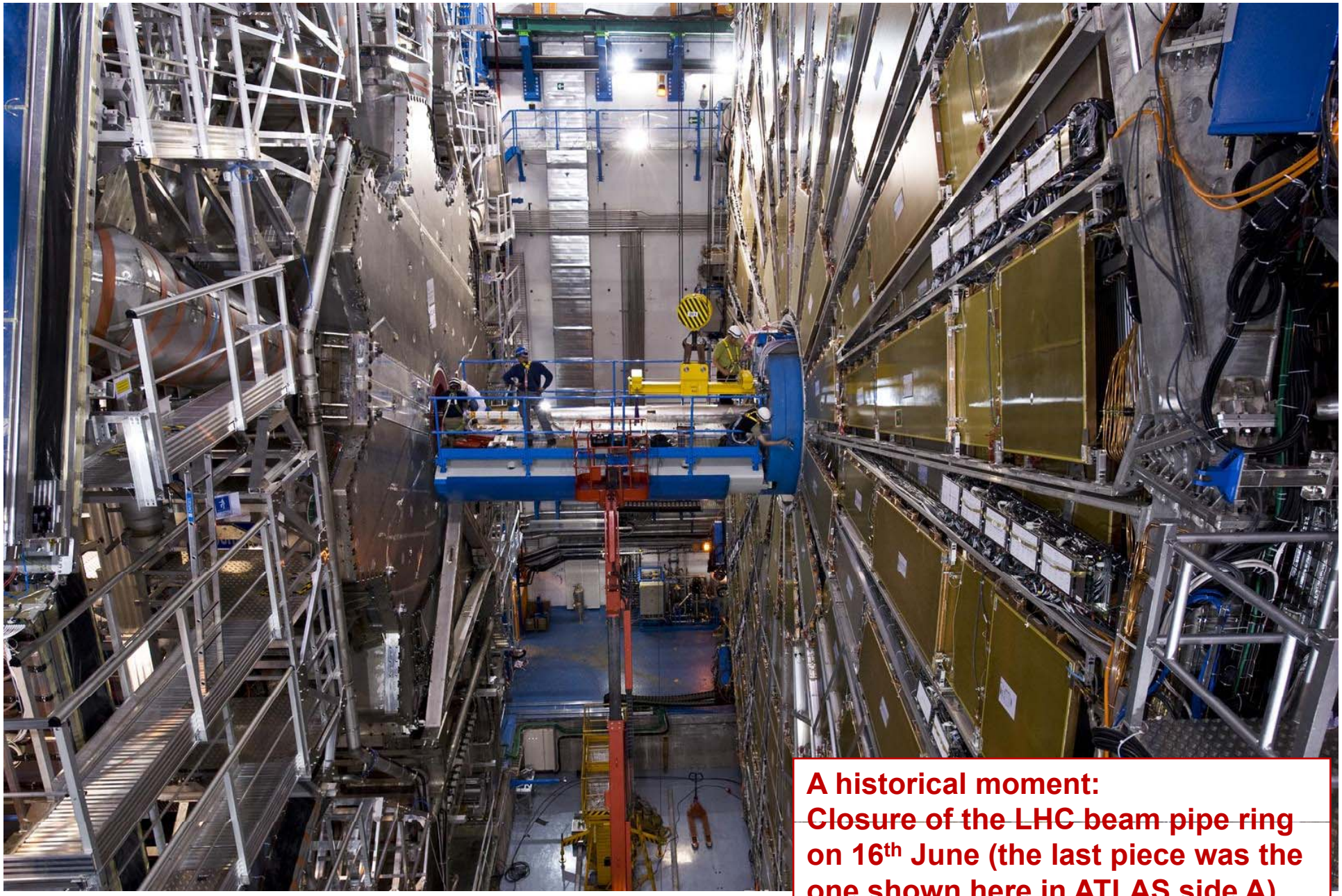


Ready
Missing timing adjustment
Noise on clock propagation
Missing CAEN boards

RPC

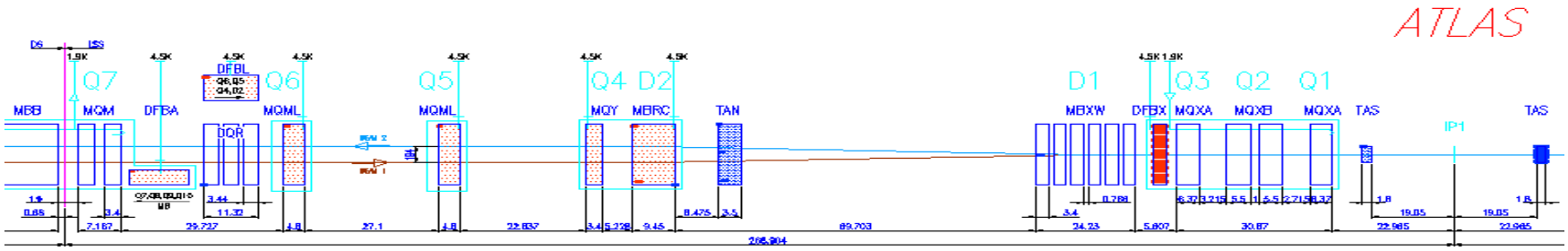


ATLAS installation:
Status before closing April 2008

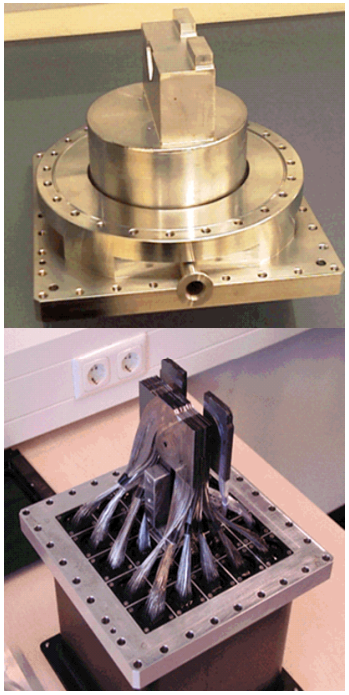


A historical moment:
Closure of the LHC beam pipe ring on 16th June (the last piece was the one shown here in ATLAS side A)

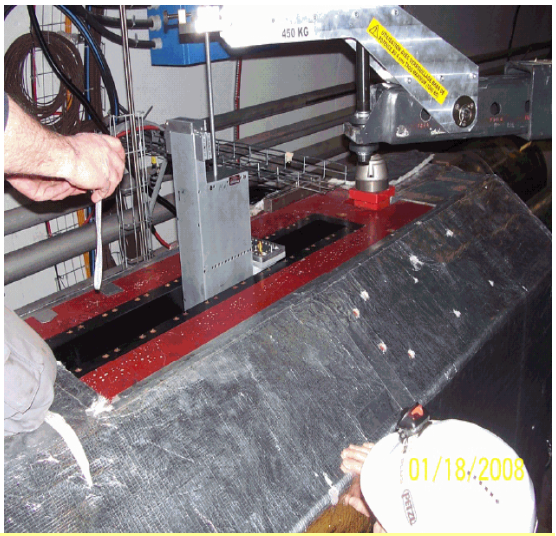
Forward Detectors



ALFA at 240 m

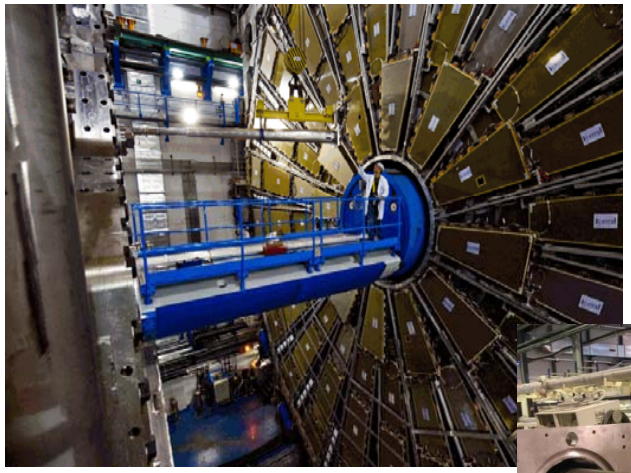


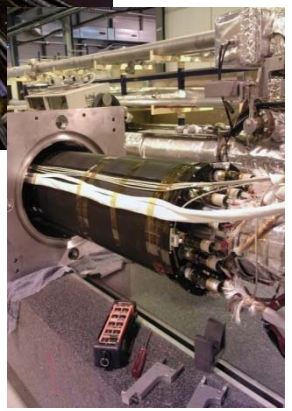
ZDC at 140 m



Zero Degree Calorimeter

LUCID at 17 m





Luminosity Cerenkov Integrating Detector

(Phase I detector is operational)

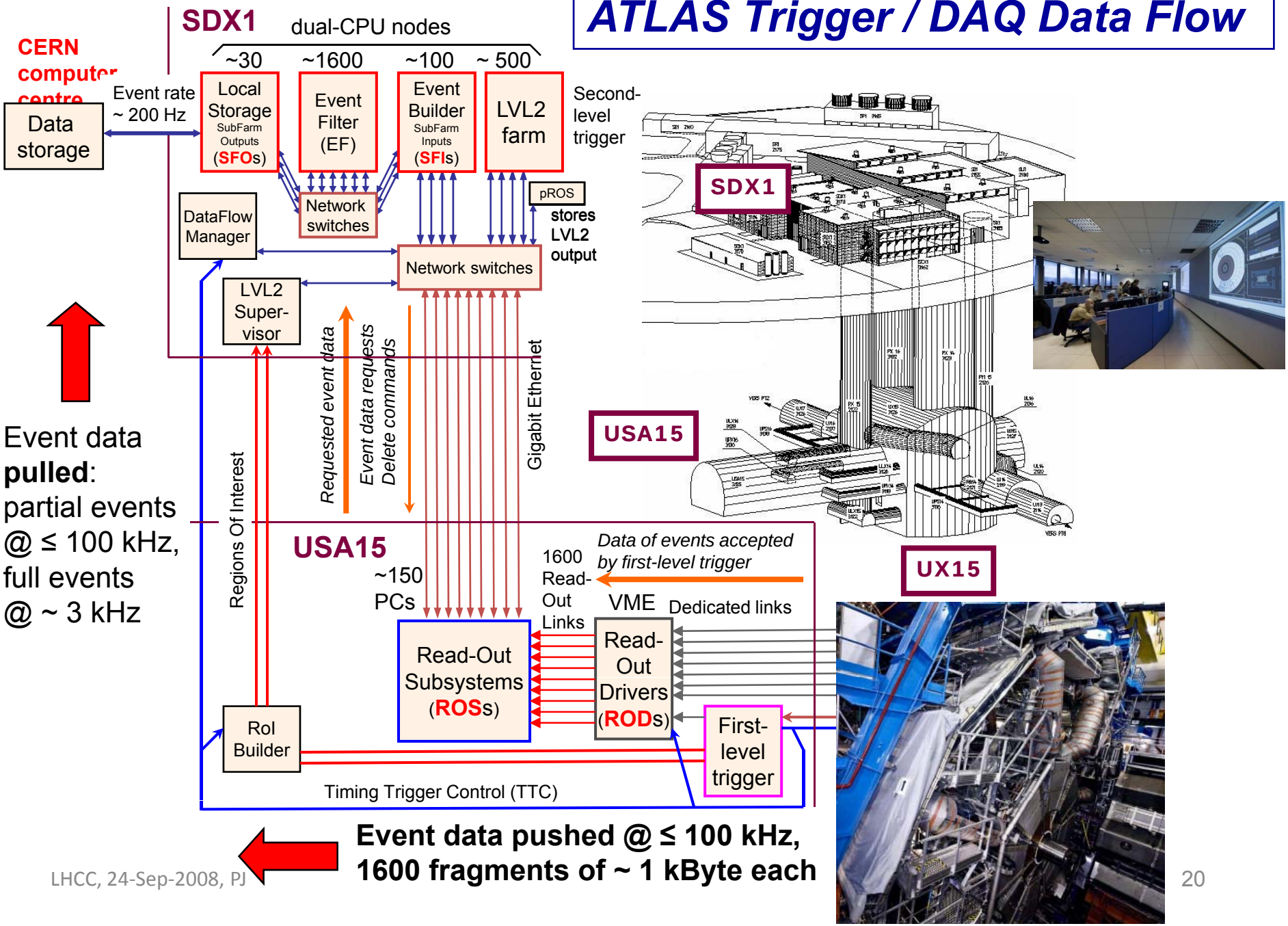
Absolute Luminosity for ATLAS

(Plus an internal LoI for future Forward Proton detectors at 220 and 420 m)

The installation of the inner part of the forward shielding completed the configuration for the 2008 run

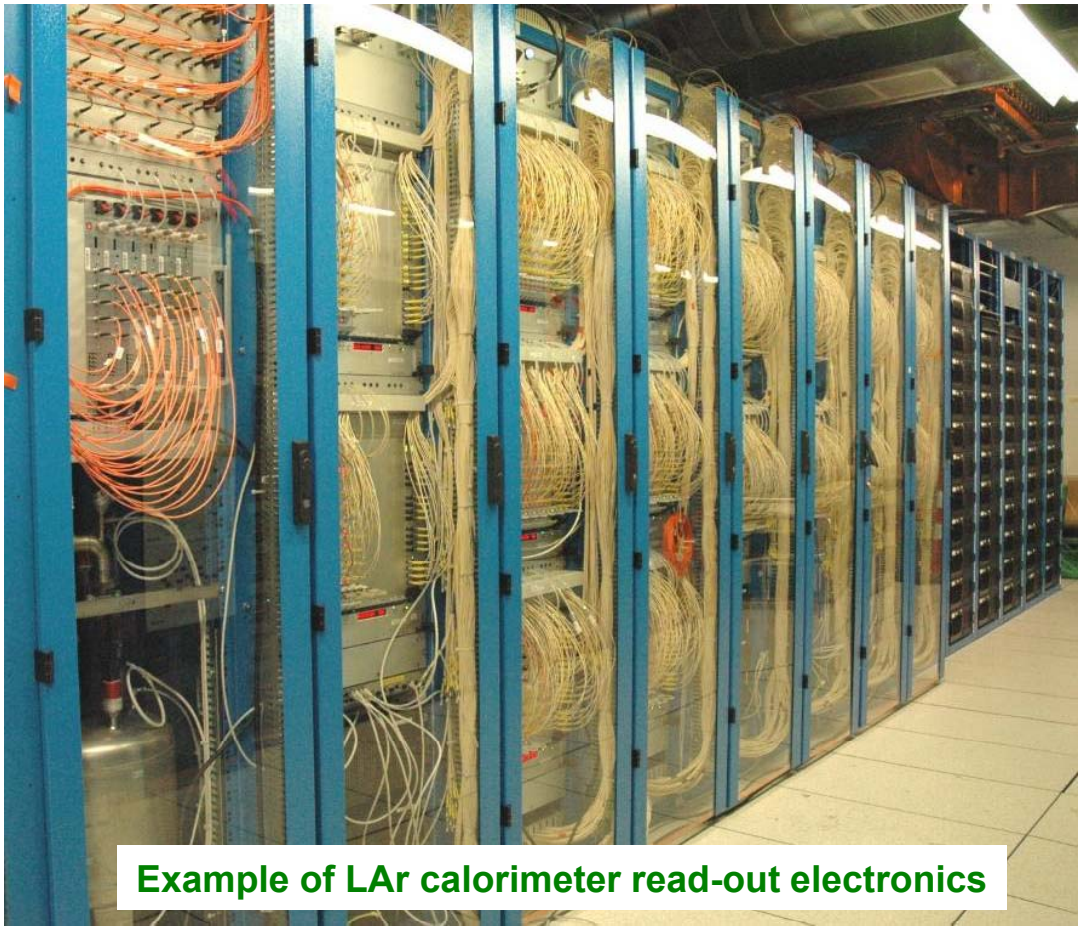
Note also the TGC 'Big Wheel' and MDT 'End Wall' chamber planes

ATLAS Trigger / DAQ Data Flow



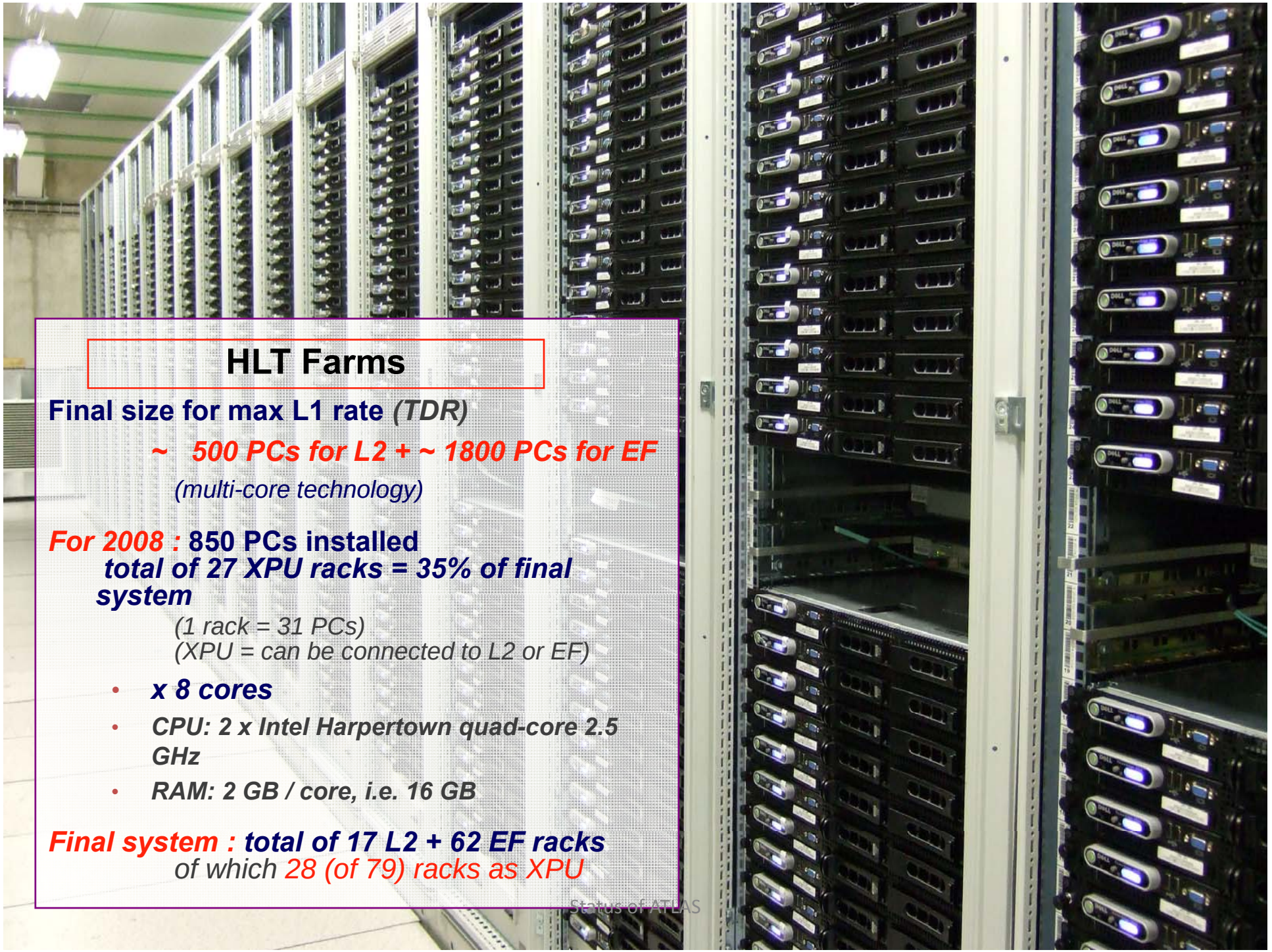
Example of Level-1 Trigger electronics

The read-out electronics, trigger, DAQ and detector control systems have been brought into operation gradually over the past years, along with the detector commissioning with cosmics



Example of LAr calorimeter read-out electronics

In total about 300 racks with electronics in the underground counting rooms



HLT Farms

Final size for max L1 rate *(TDR)*

~ 500 PCs for L2 + ~ 1800 PCs for EF

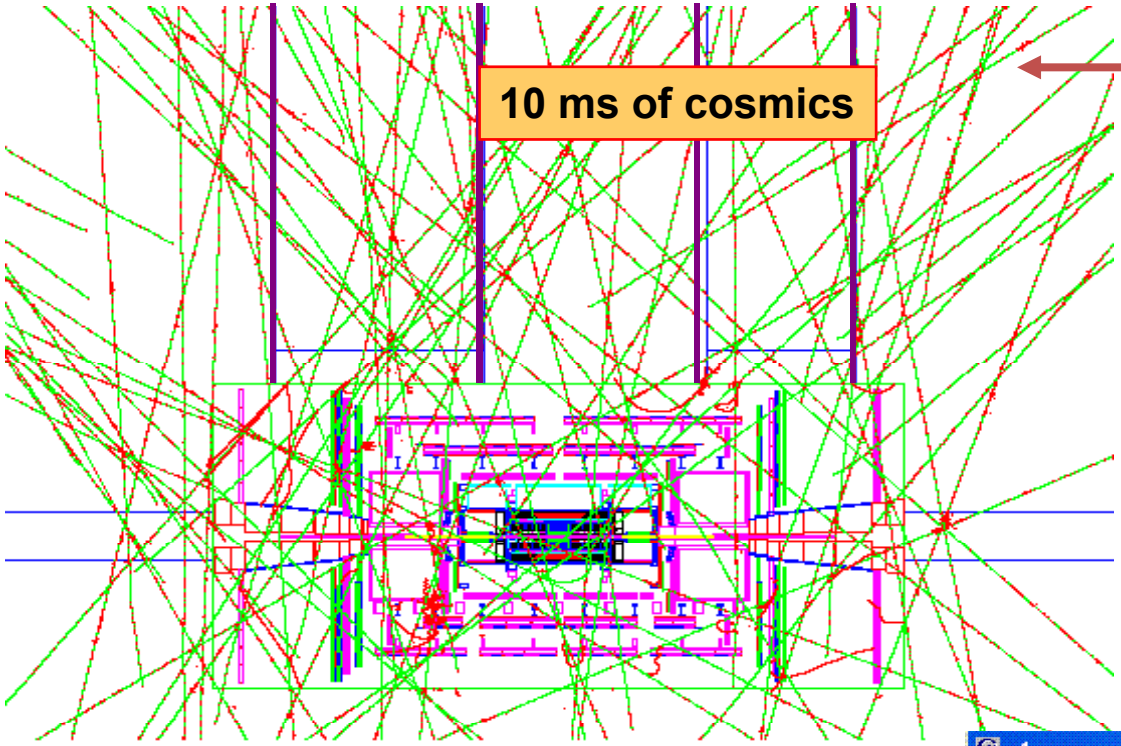
(multi-core technology)

***For 2008 :* 850 PCs installed**
total of 27 XPU racks = 35% of final system

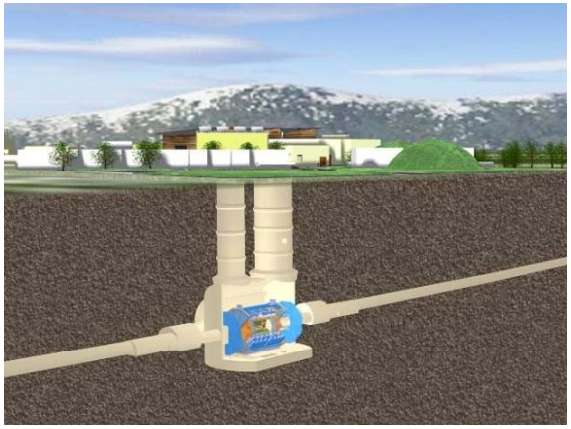
(1 rack = 31 PCs)
(XPU = can be connected to L2 or EF)

- ***x 8 cores***
- ***CPU: 2 x Intel Harpertown quad-core 2.5 GHz***
- ***RAM: 2 GB / core, i.e. 16 GB***

Final system : total of 17 L2 + 62 EF racks
of which 28 (of 79) racks as XPU



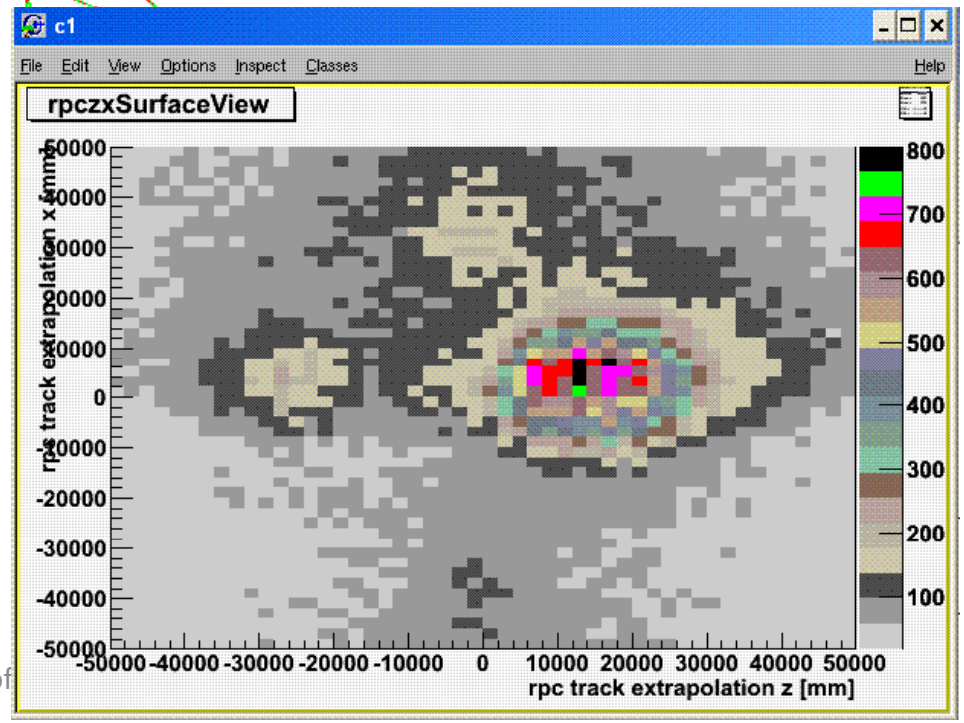
Simulated cosmics flux in the ATLAS cavern



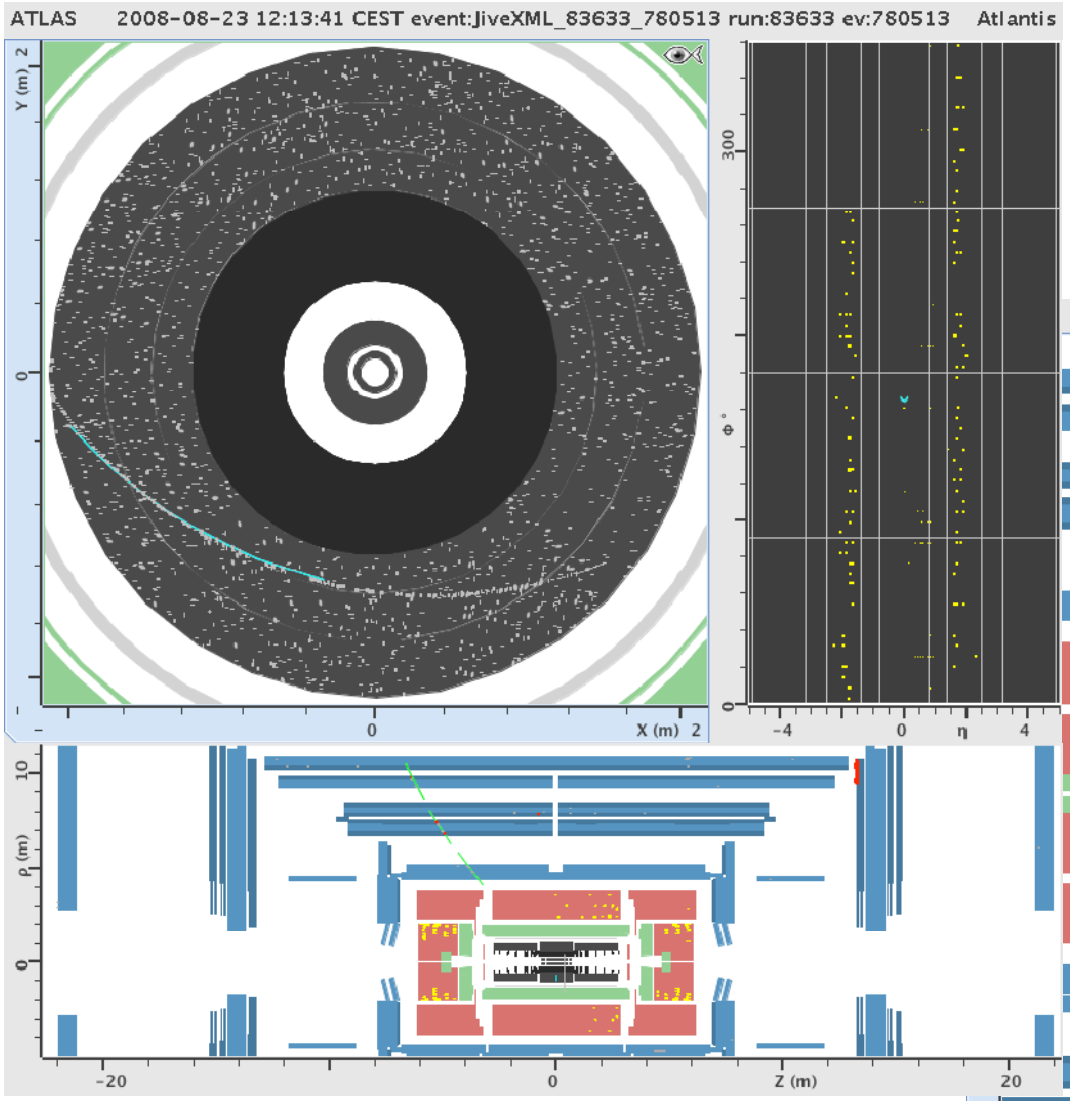
Cosmics data:

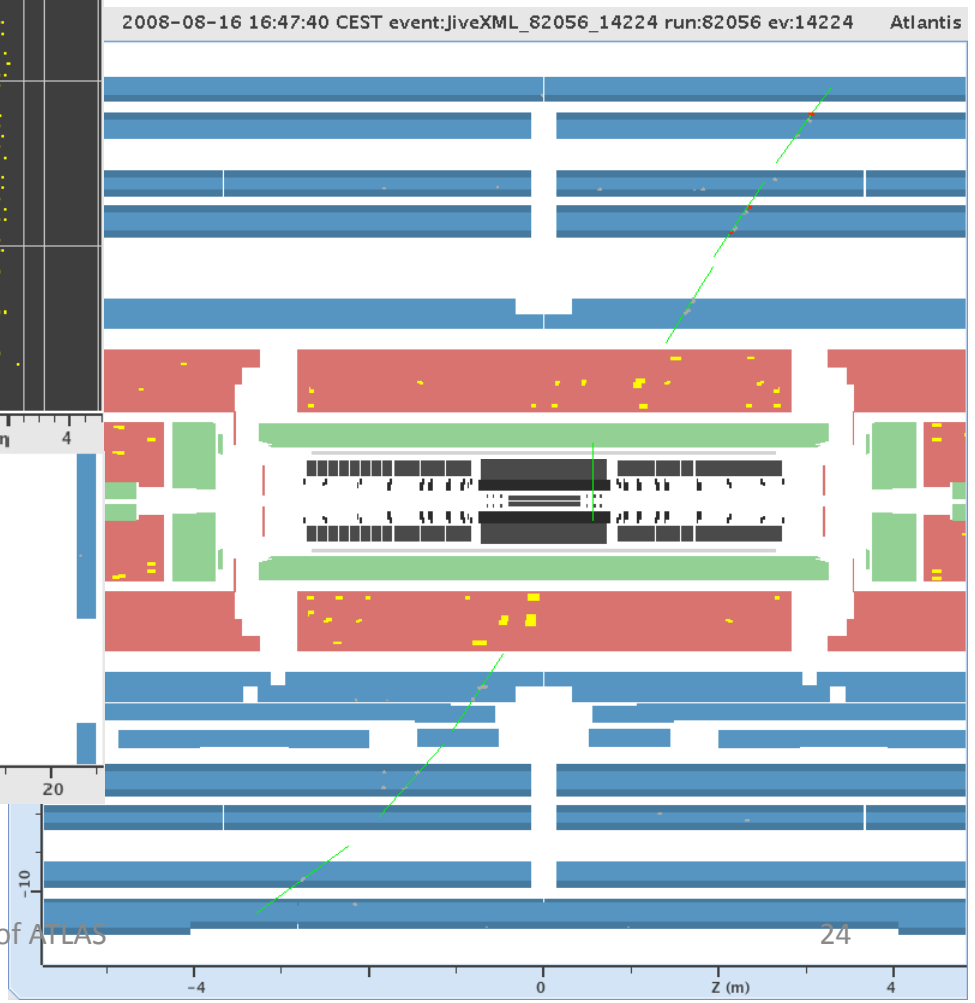
Muon impact points extrapolated to surface as measured by Muon Trigger chambers (RPC)

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



Example cosmic events with magnets on

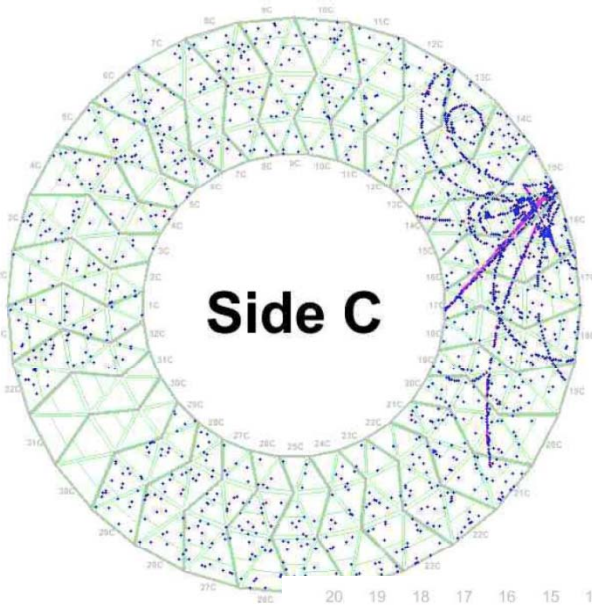


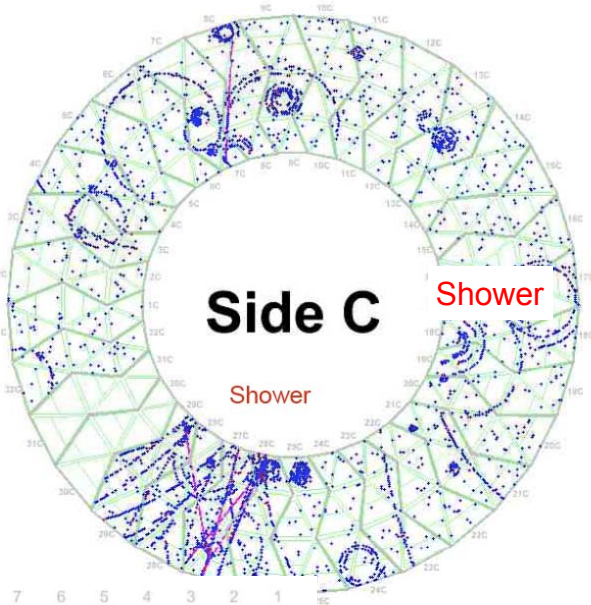


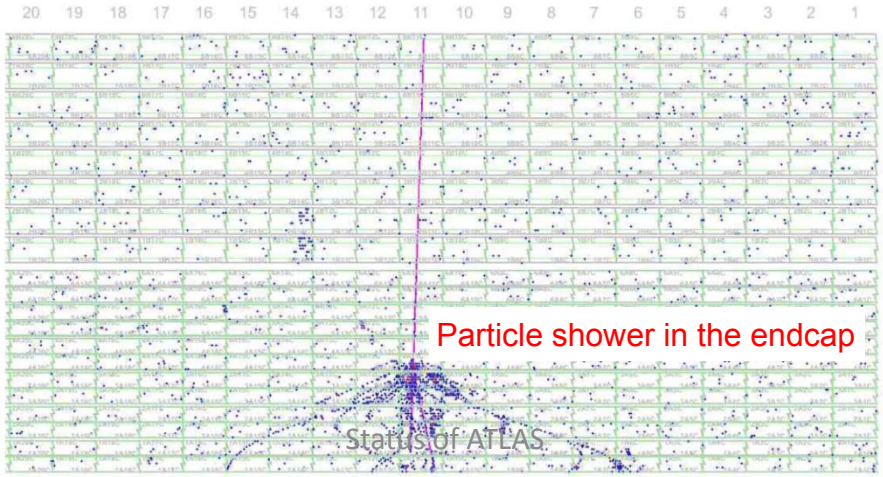
Cosmics showers/interactions in the TRT with solenoid on

Fully commissioned and inside ATLAS partition since long

(Xe is in since few days → results shown are with $Ar/CO_2/O_2$; 70/27/3%)

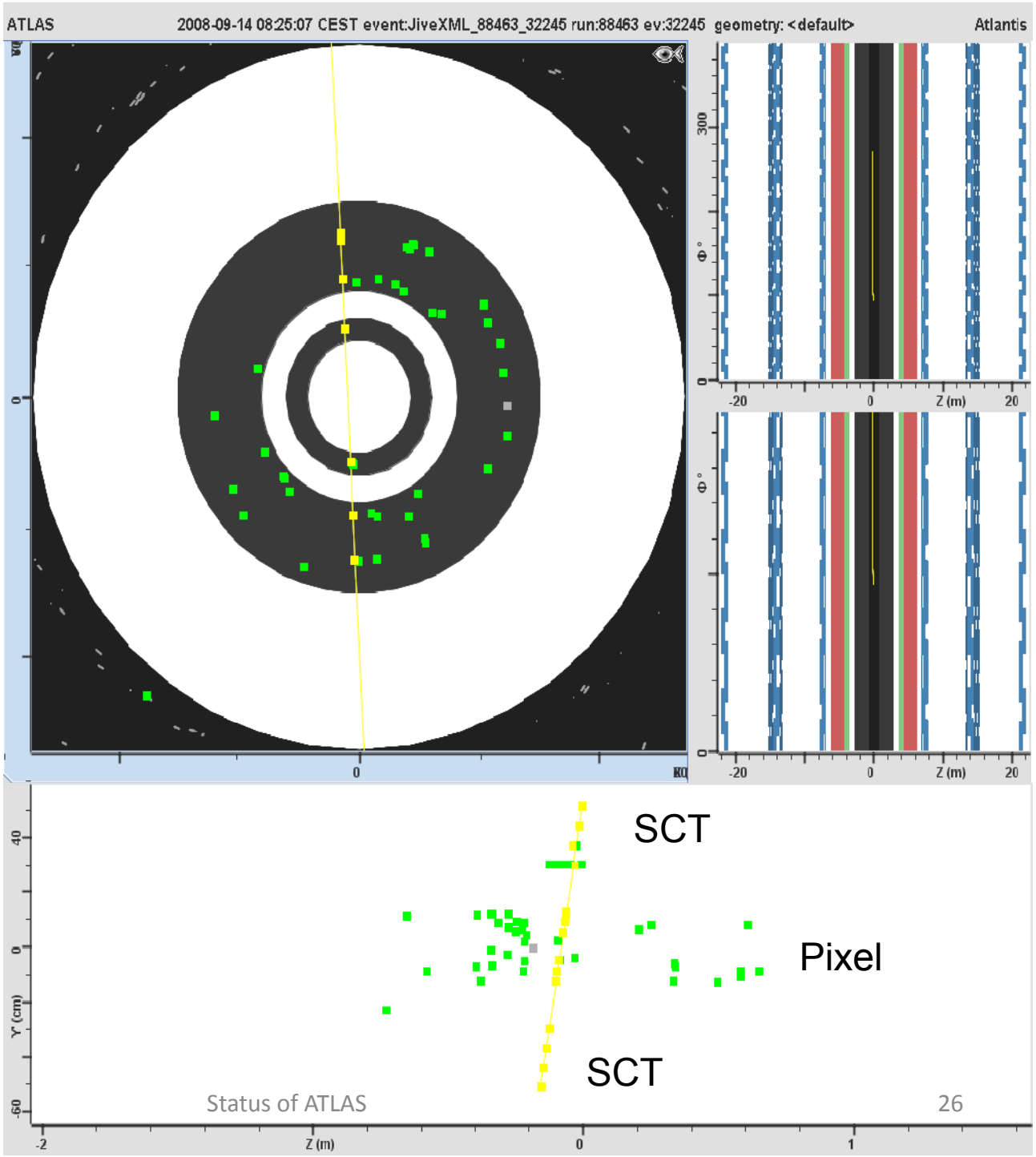






Cosmics in Pixel and SCT

Event with 7 Pixel hits (overlapping L2 modules) and 16 SCT hits



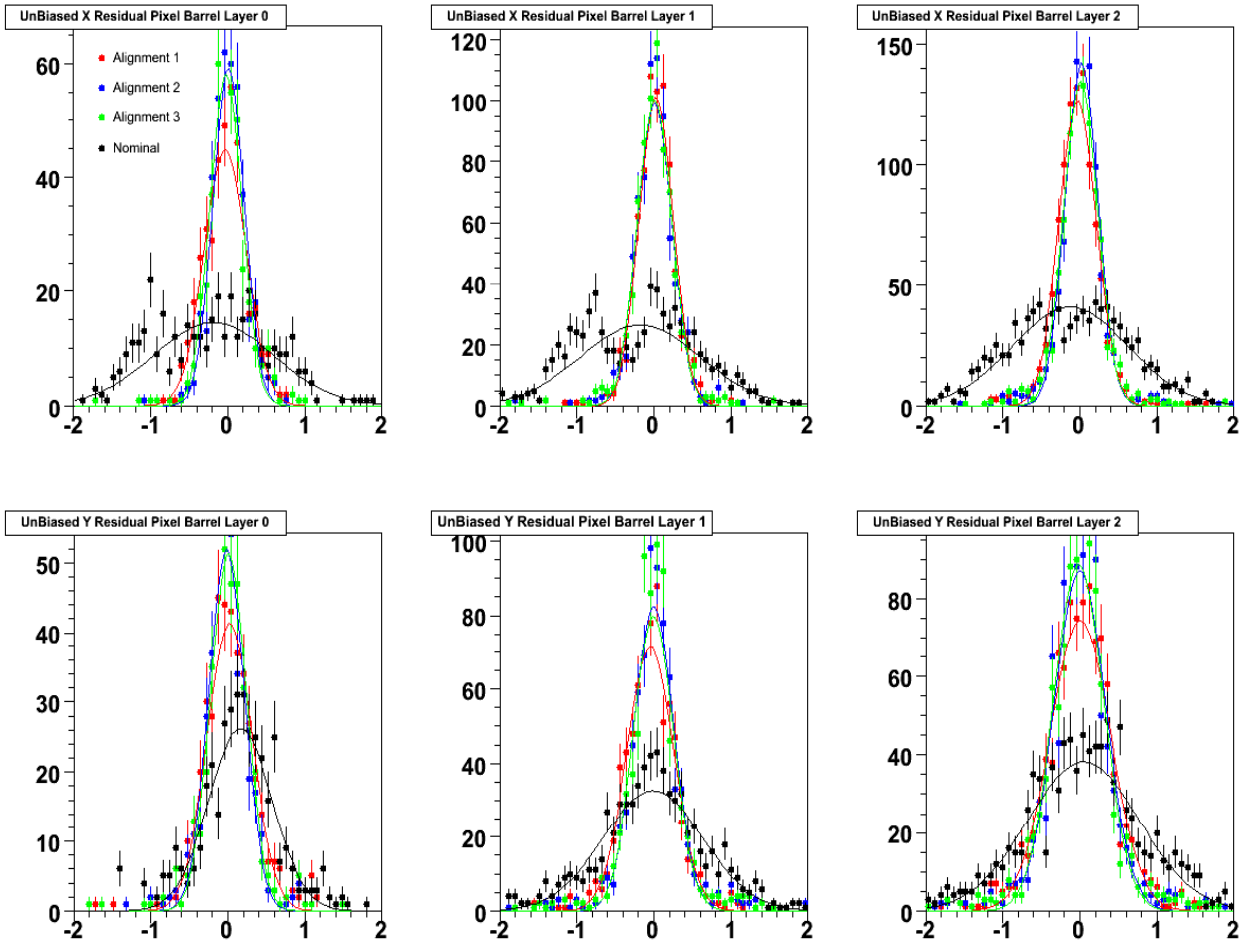
Pixel-SCT alignment with cosmics

Cosmics have been taken with SCT and Pixel

- **Pixel Tracks : 261 (at least 4 hits)**
- **SCT Tracks: 4710**

and alignment done (at the level of the layers not yet of the modules)

Pixel residuals, still wide (scale is mm), but large improvement vs nominal (black curve)



(x and y residuals for the 3 Pixel layers)

Full Dress Rehearsal (FDR)

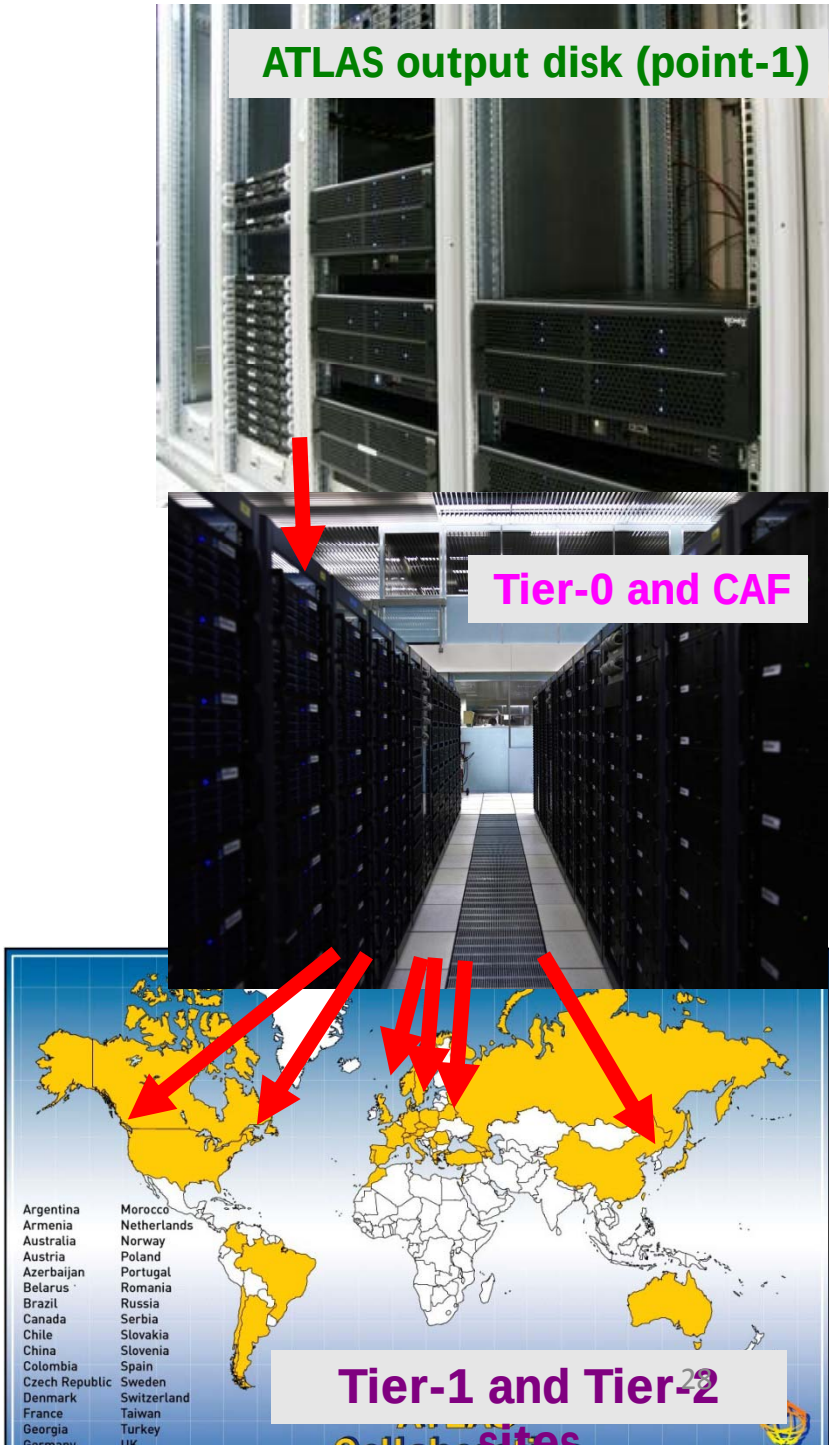
Played data through the computing system just as for real data from the LHC

- started at point 1, as though real data
- processed data at CERN Tier-0, *various calibration & data quality steps*
- shipped out to the Tier-1s and Tier-2s for physics analysis

Complementary to “milestone runs” which test the real detector, but only with cosmic rays

Two “FDR runs”
(February and June-July)

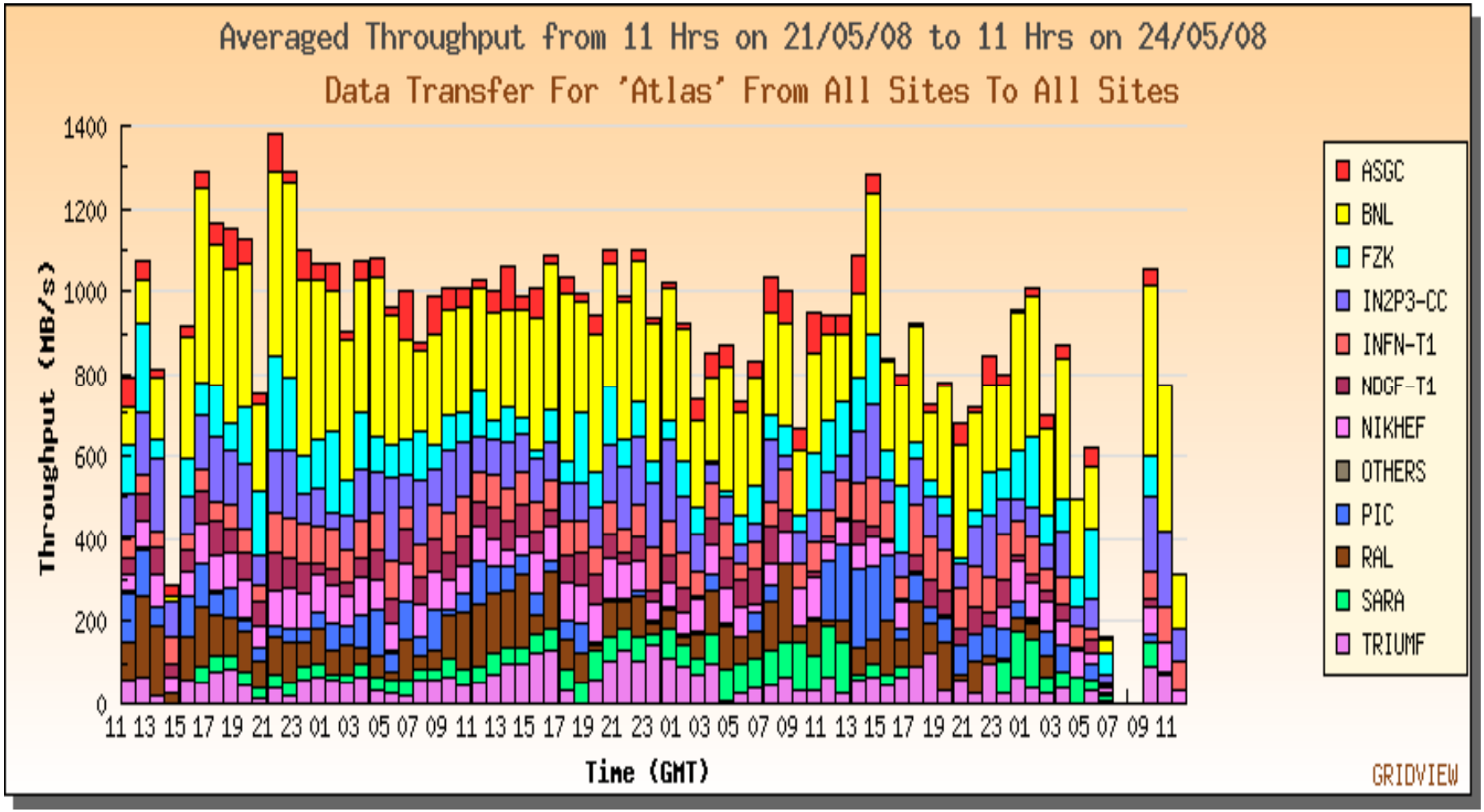
Were a vital preparation for processing and analysing the first LHC data



wLCG Grid: Tier-0 and the 10 ATLAS Tier-1s

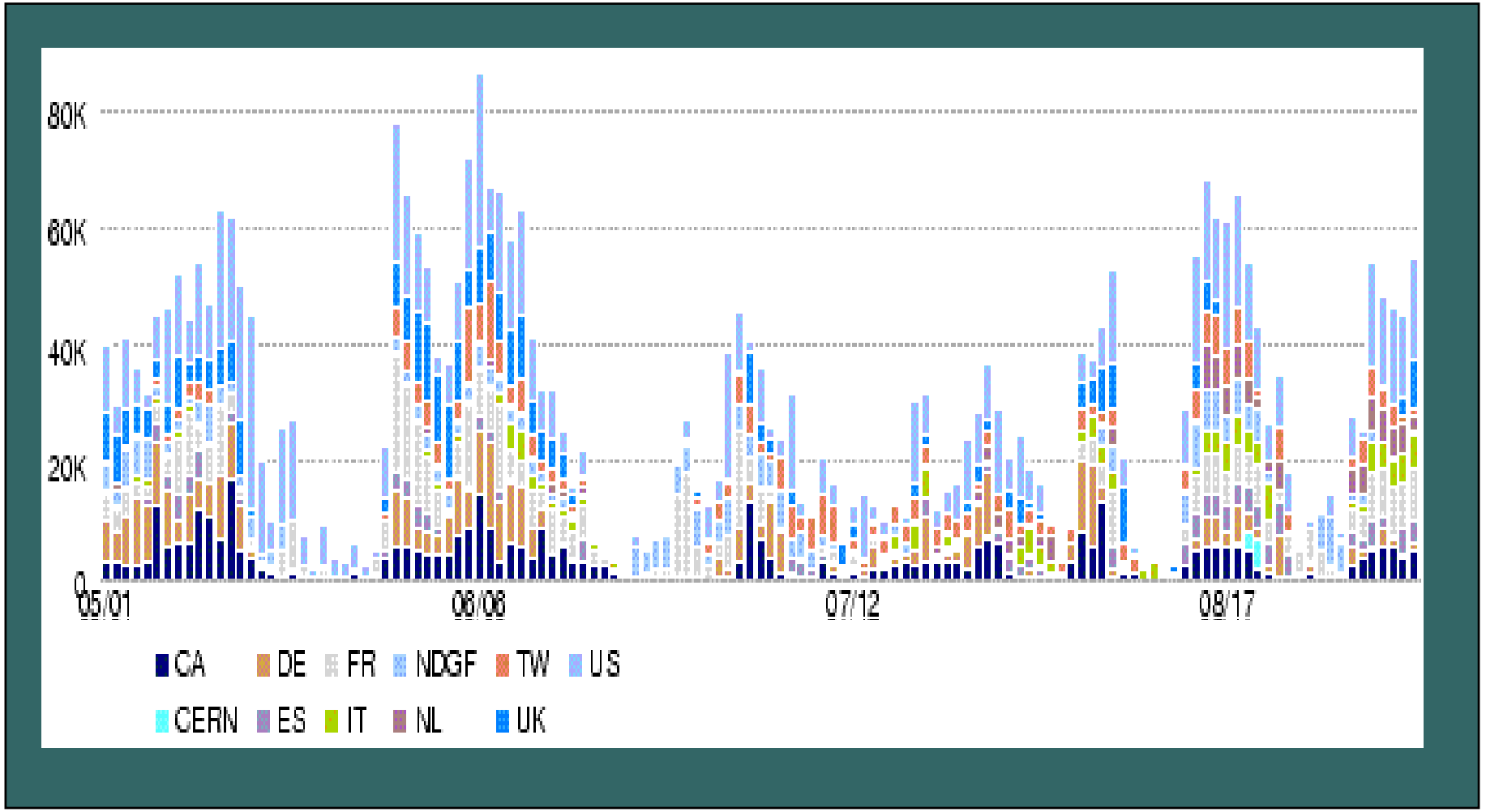
ATLAS during the Common Computing Readiness Challenge CCRC Phase 2

Data transfer Tier0--> Tiers-1



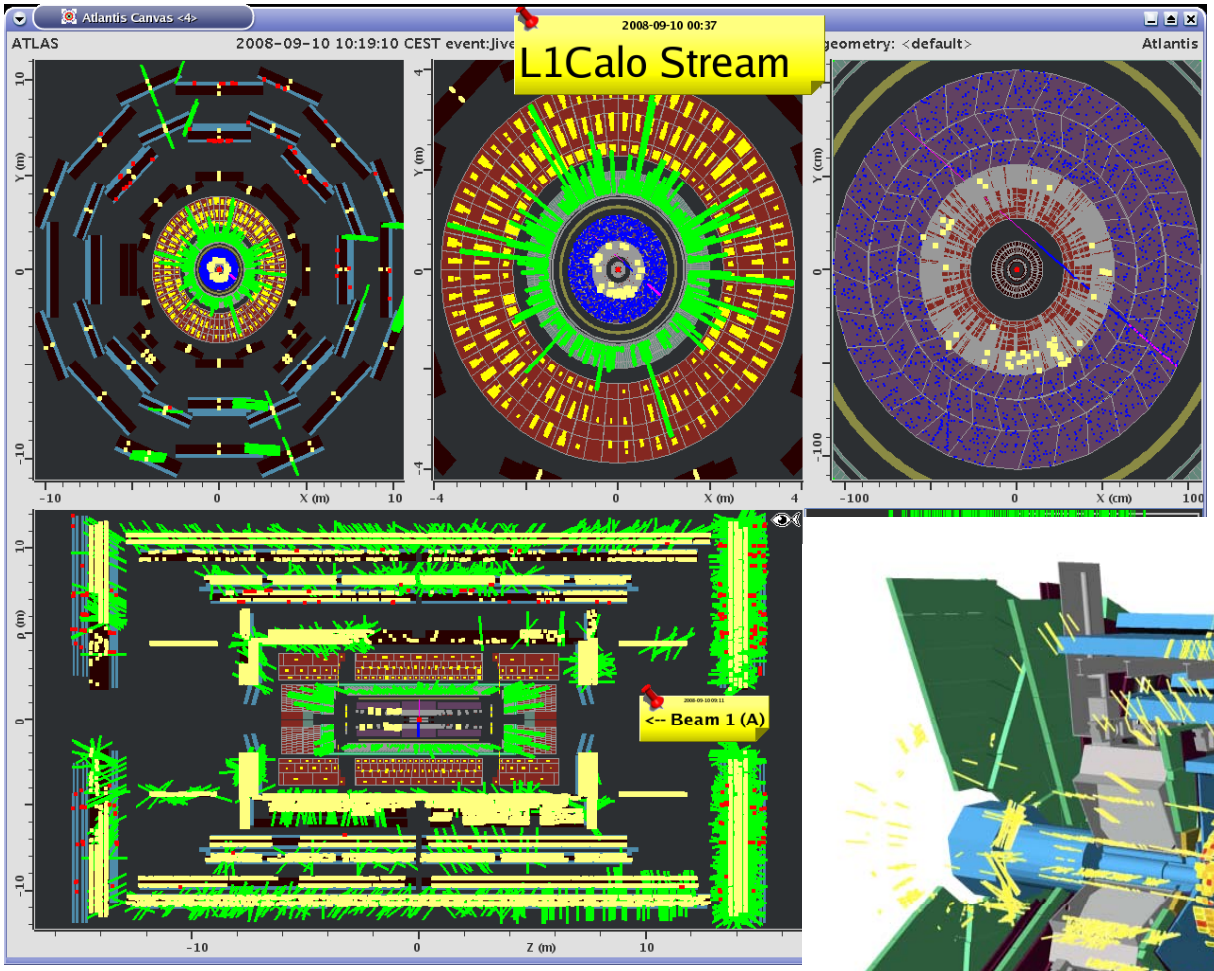
Nominal peak level (~1 GB/s) sustained over 3 days

Number of world-wide ATLAS production jobs per day from 1 May to 5 September 2008



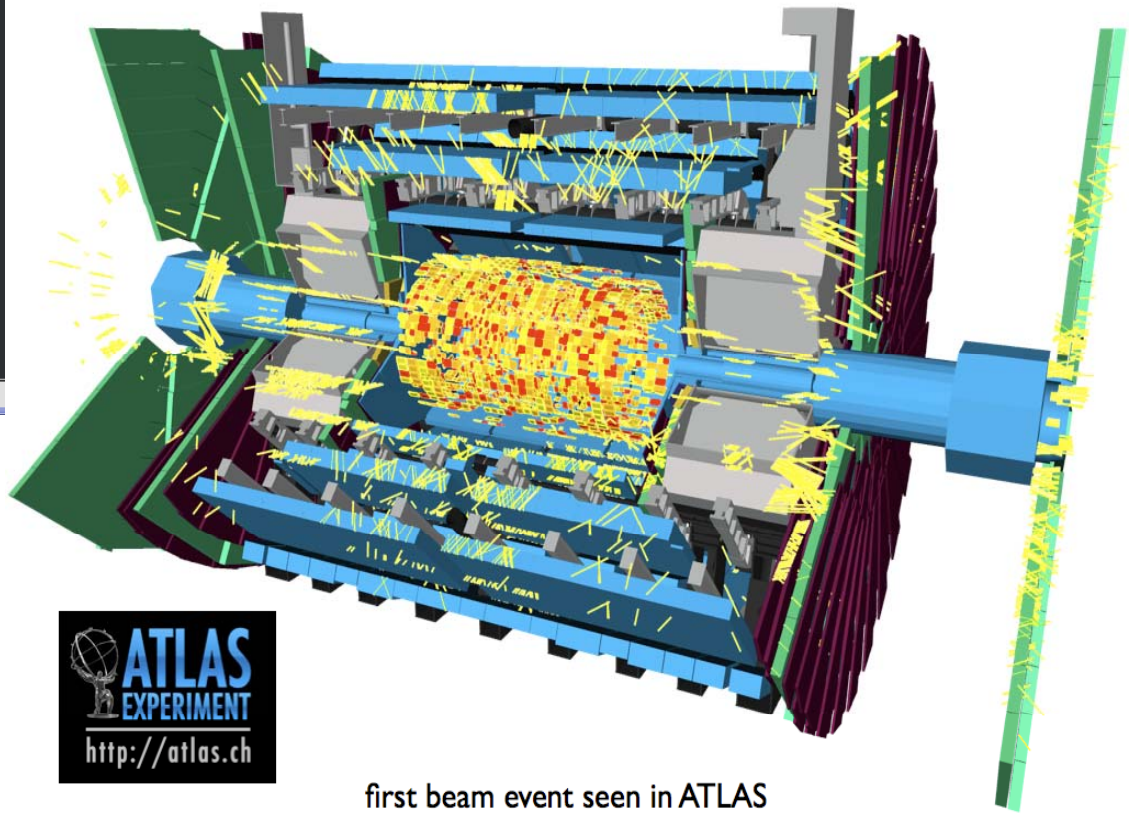
Excitement in the ATLAS Detector Control Room: The first LHC event on 10th September 2008

… as well as in the ATLAS Tier-0 and Data Quality Control Rooms: Reconstruction follow-up and analysis of the first LHC events



Online display

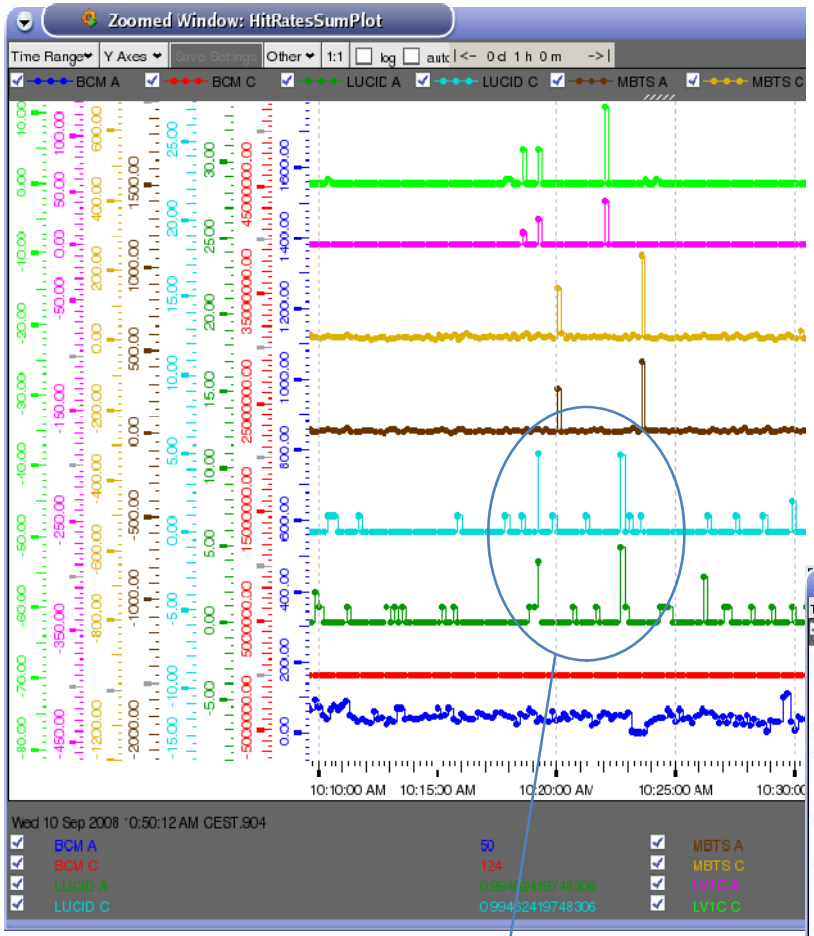
The very first beam-splash event from the LHC in ATLAS on 10:19, 10th September 2008



first beam event seen in ATLAS

Offline display

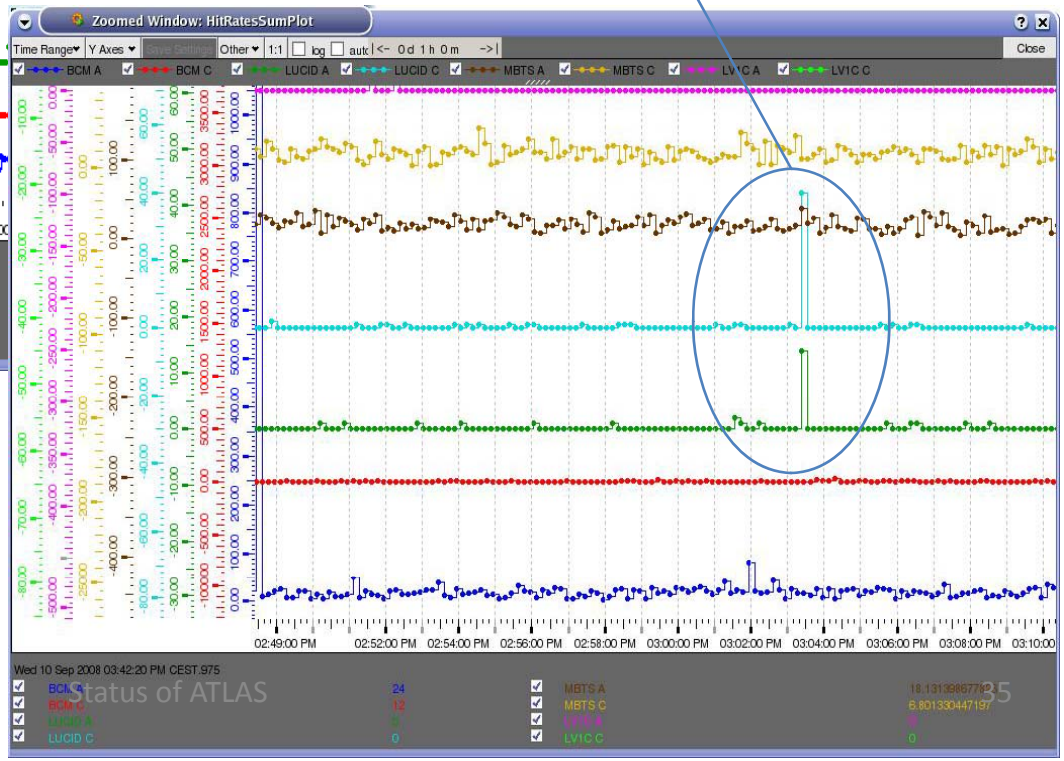
First hits in the LUCID detectors on Sep. 10th !



LV1C

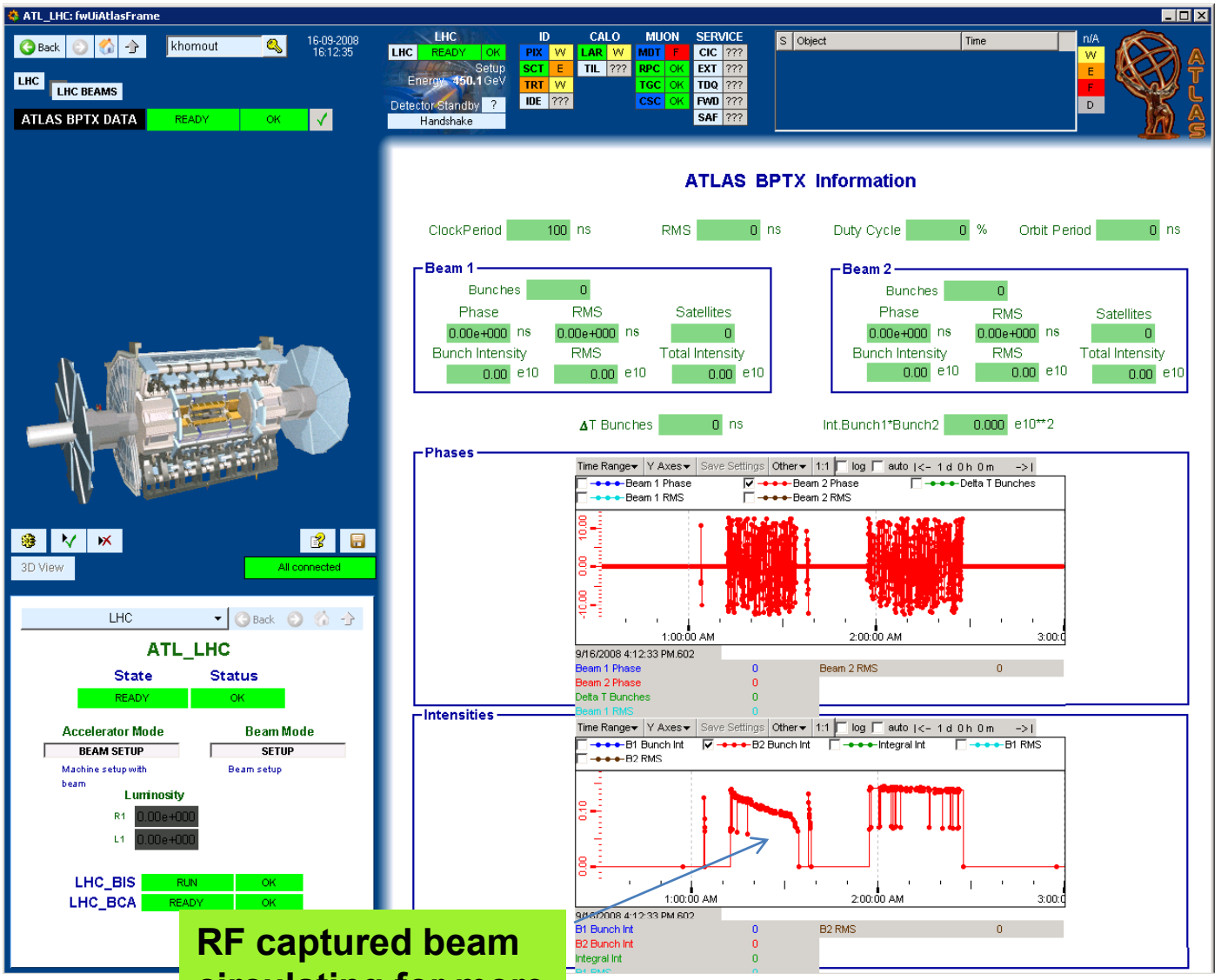
MBTS

LUCID with beam 2



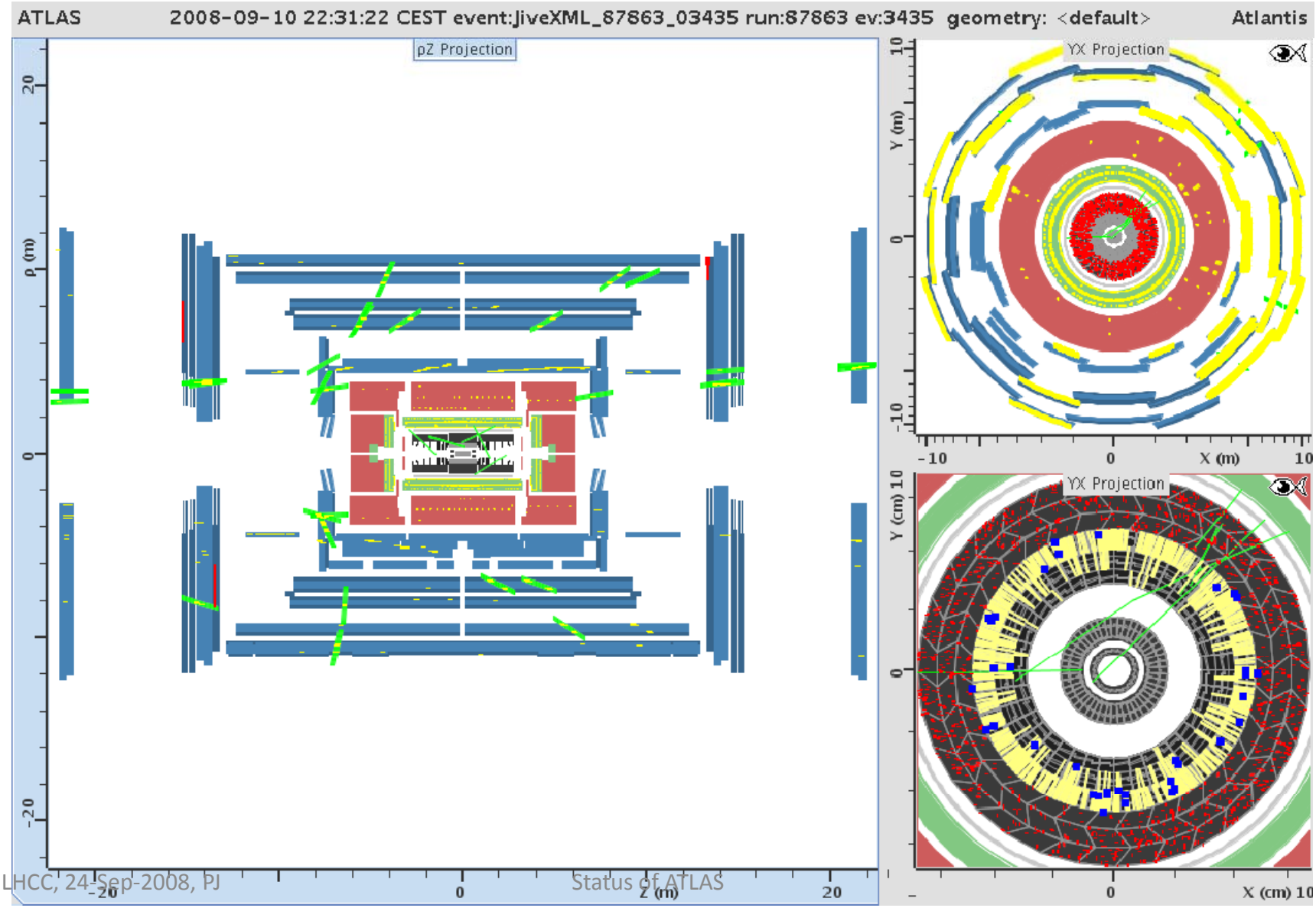
Lucid with beam 1

Example: Beam Condition Information from ATLAS

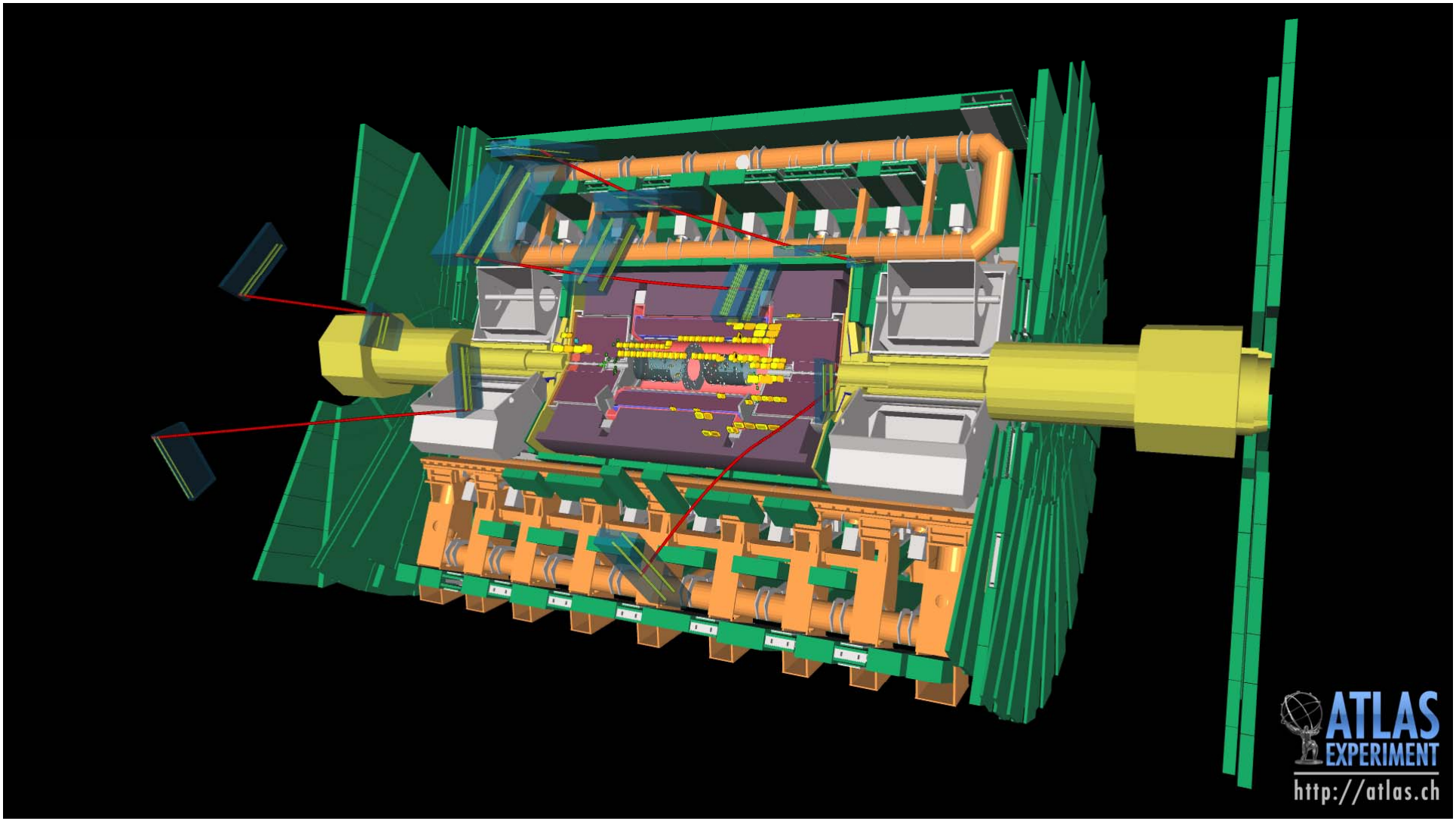


RF captured beam circulating for more than 20 min.

A busy beam-halo event with tracks bent in the Toroids from the start-up day (offline)

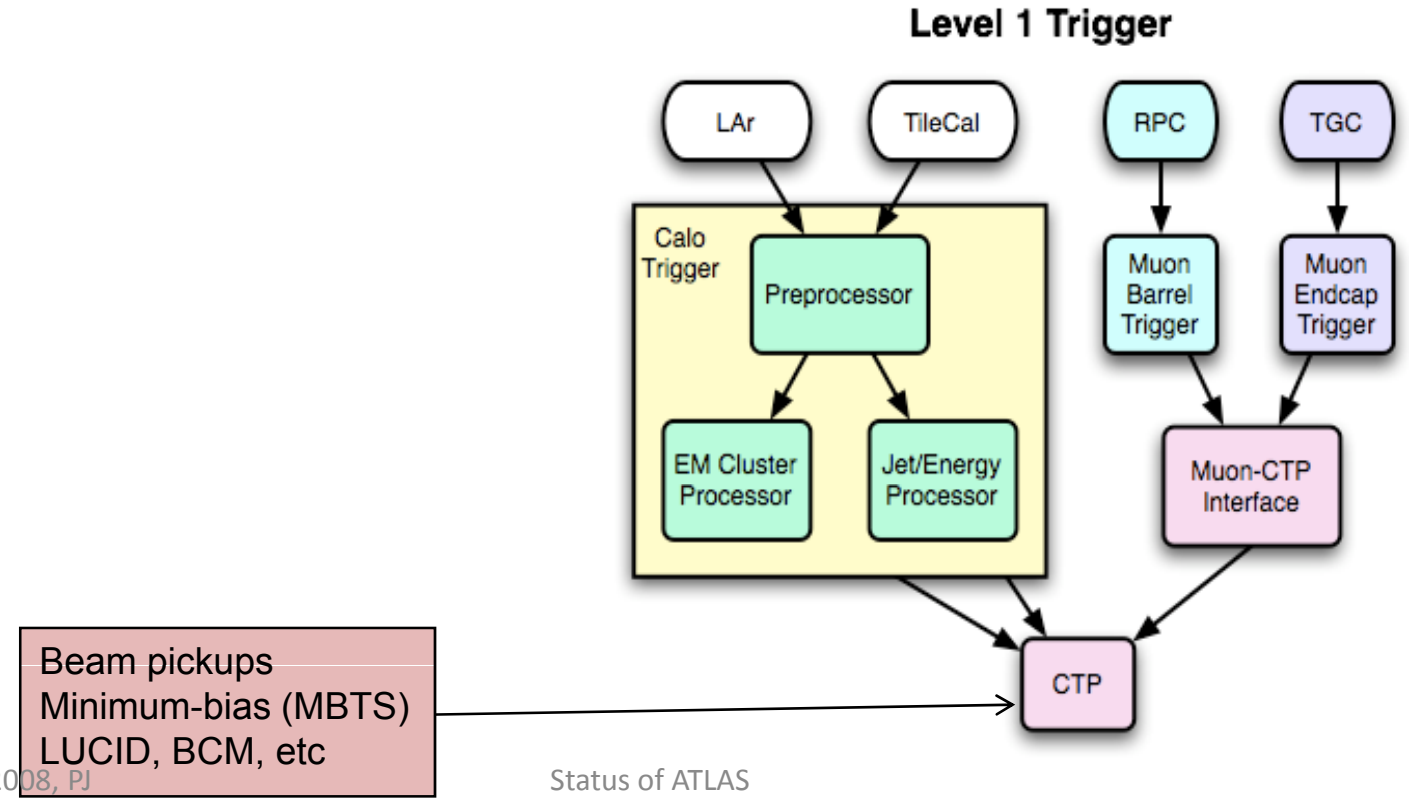


Another beam-halo event



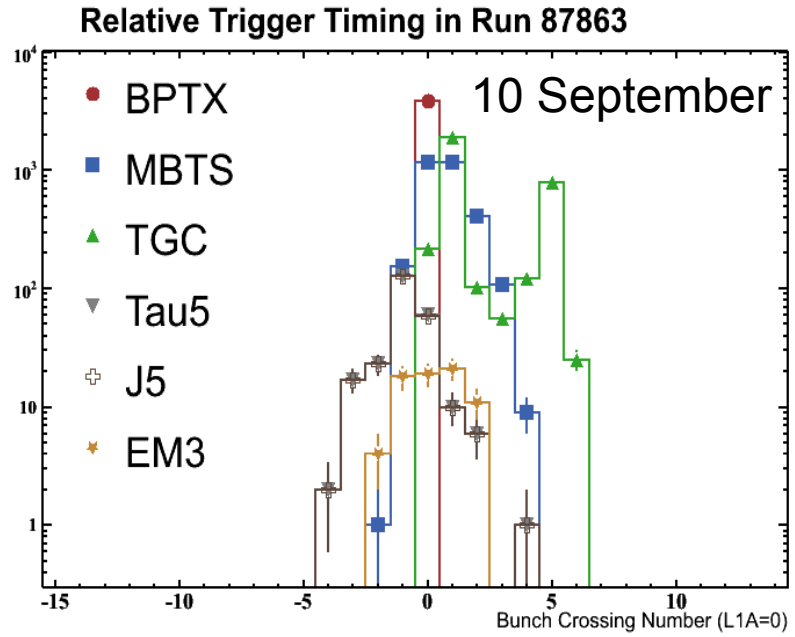
LVL1 System

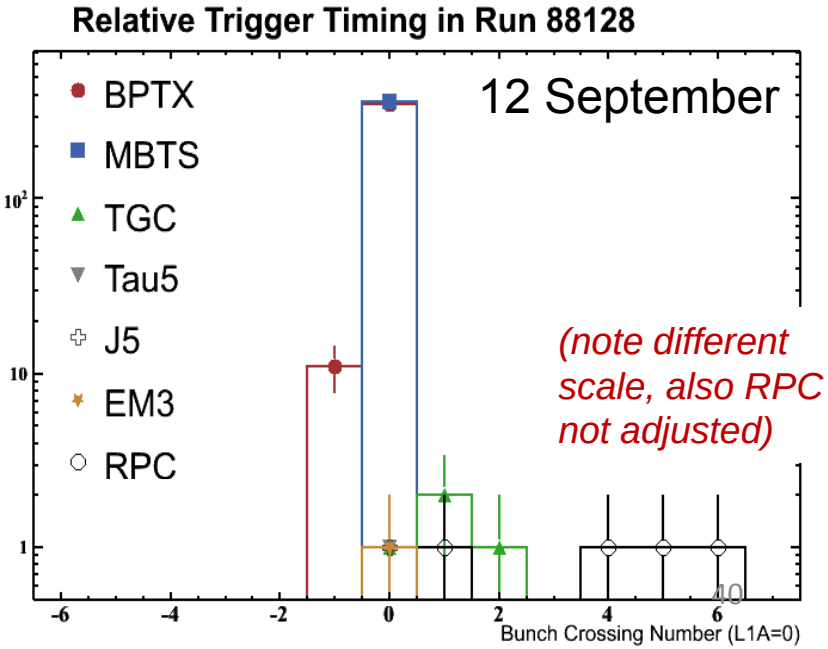
- **System is fully installed**
  - **Still large programme of work to be done to commission it with beam**
    - **Much work done with cosmic rays, test pulses, etc**
    - **Already made good start with single beam, starting on 10th September**
    - **Some aspects of commissioning can only be done with collision data**
      - **E.g. detailed time alignment of barrel muon trigger**



Timing-in the trigger

- **Experiment timing currently based on beam-pickup ("BPTX") reference**
  - **First task of LVL1 central trigger team on 10th September was to commission the beam pickups**
- **Times of arrival of other triggers are being adjusted to match**
  - **Plots show evolution from 10 to 12 September**
  - **Timing-in for down-stream side for single beam to have similar timing to collisions**
- **Each LVL1 sub-system also needs to be timed in internally**
  - **L1-calo, L1-RPC, L1-TGC, MBTS, etc**





High-Level Trigger

- **LVL2 and Event Filter processor system installed**
  - **Full processing power will be added later**

- **HLT has been used routinely online**
  - **Cosmic-ray selection to enhance purity of data samples for detector studies**
    - **E.g. data with TRT tracks**
  - **"Dummy" algorithms performed data streaming from 10th September**
    - **Based on HLT examination of LVL1 trigger type**

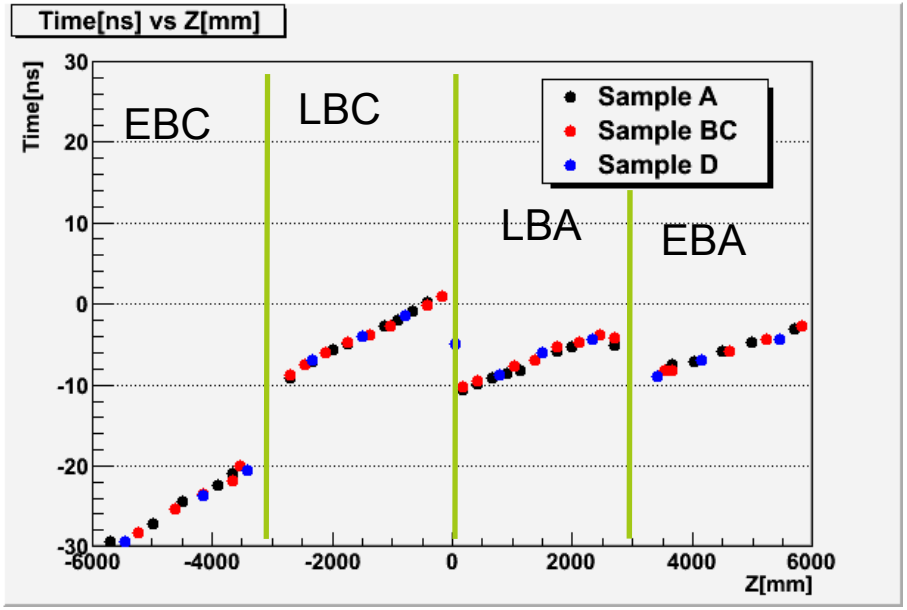
- **Full set of algorithms available for collision running**
  - **Muon, electron, photon, tau, jet, MET, B-physics, etc**
    - **Very extensive studies performed on simulated raw-data events**
    - **Rate, efficiency and timing performance consistent with computing resources for initial running**

- **Also have HLT menu for commissioning LVL2 and EF in single-beam and 900 GeV collisions operations**
  - **Raw data collected in the morning of 10th September were passed, offline, through some algorithms during the same day**
    - **Studies, tuning, etc. continue since then**

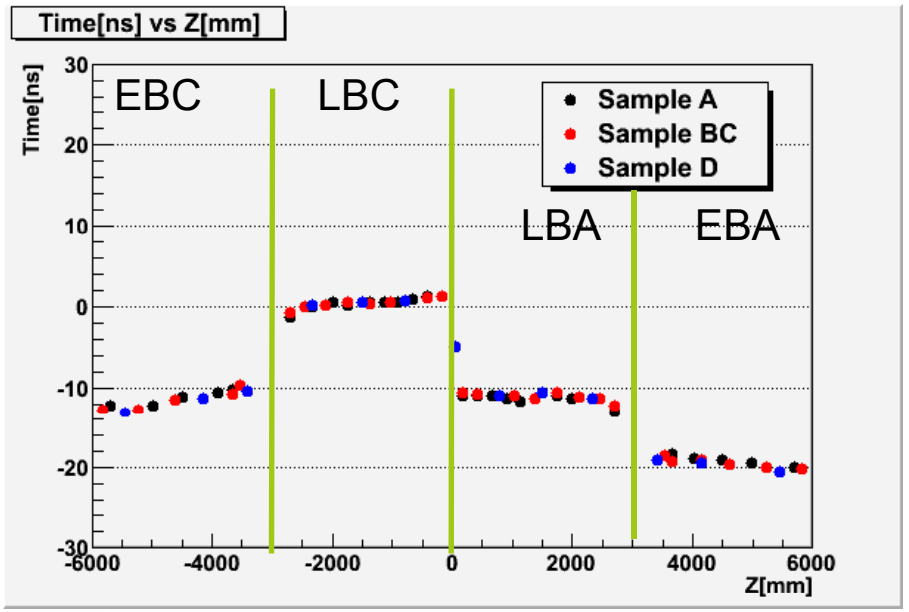
Some example plots from the beam splash and single beam (halo) runs

Tile Timing (700 single beam events)

Measured time, Beam from C side

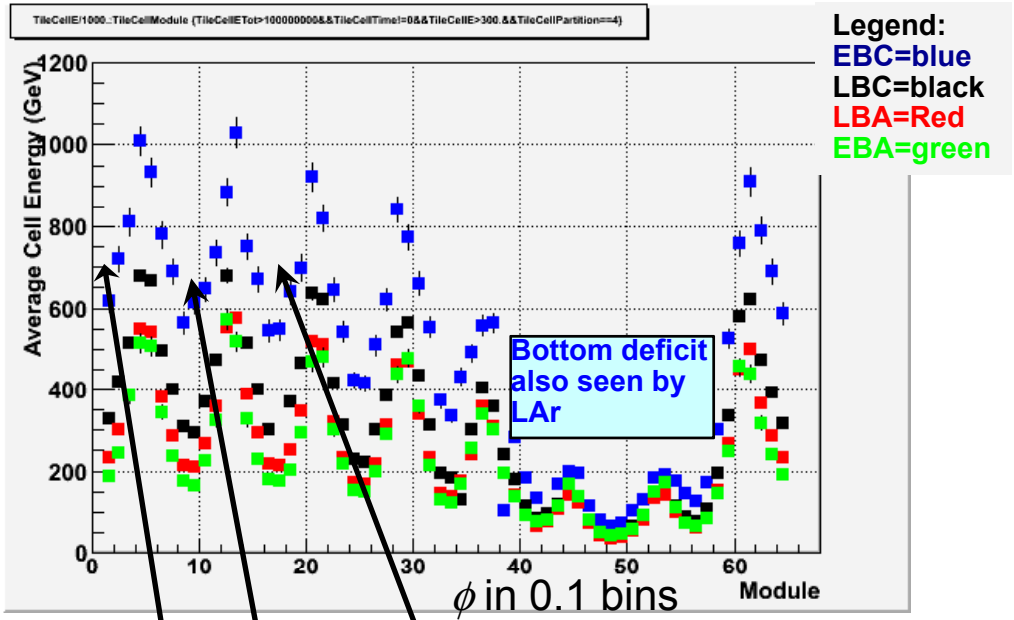


Expected Time, Particles from IP

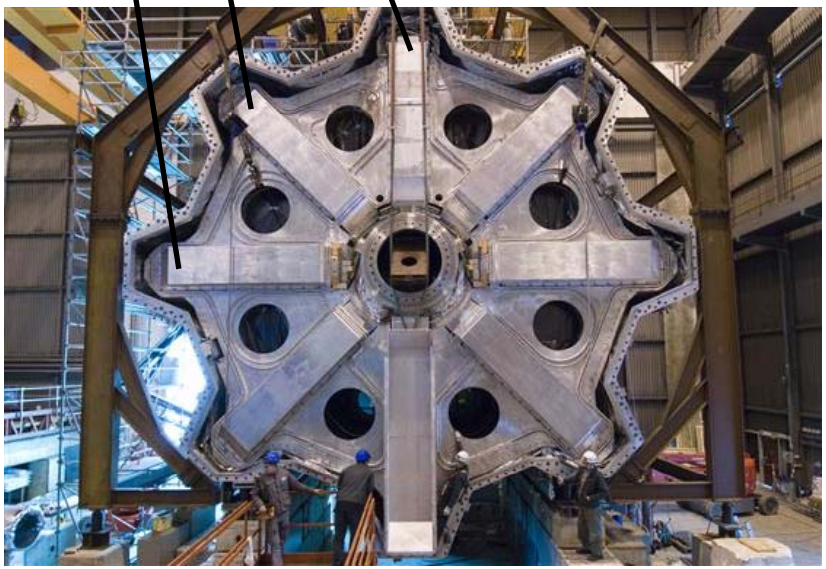


IP correction applied

8-fold Structure with Beam Splash



26 events that triggered both L1Calo and MBTS_BCM_LUCID

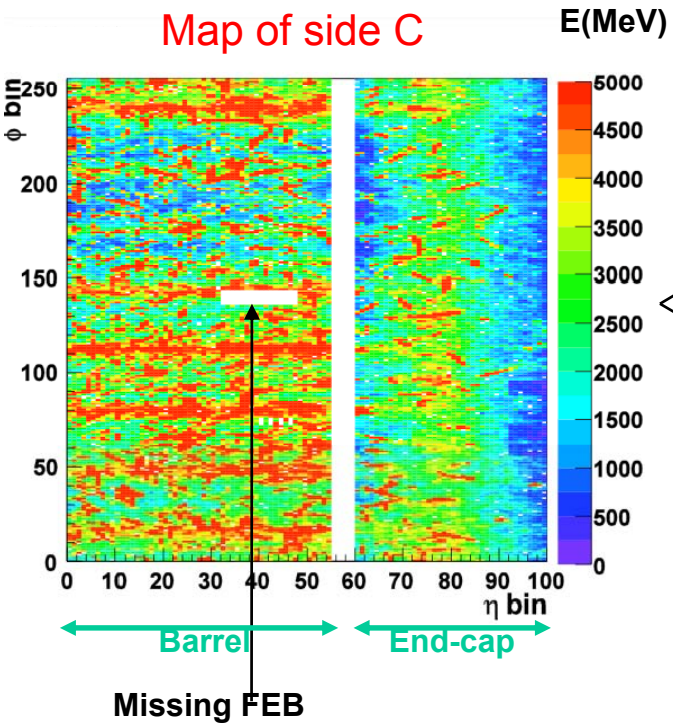


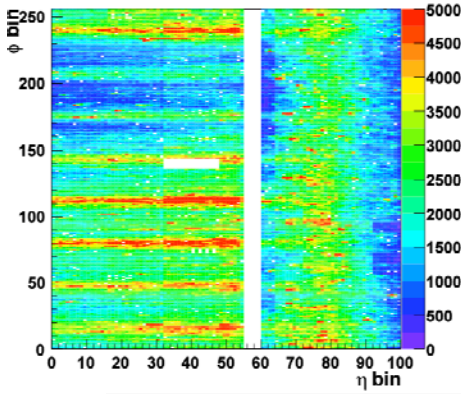
Clear π's and μ's in the splash beam. π's attenuated in the beamline magnet supports (Bottom deficit) as well as by the ECT support (valleys).

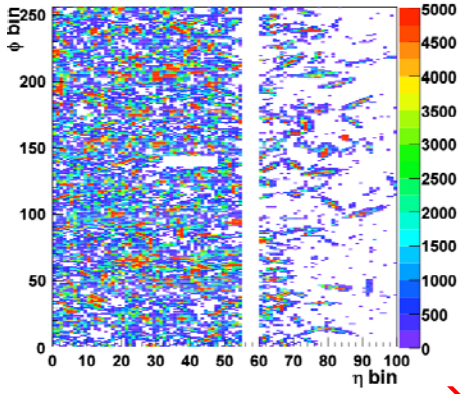
π signature clearly seen from ratio C-energy/A-energy.

Accumulated energy in S2 cells

- Run 87764: **first LHC beam in ATLAS**, L1 Calo stream → **EM3, J5, TAU5**
- Data: **RAW** or **ESD** (36035 events up to 2pm)







26 events that triggered also MBTS_BCM_LUCID

→ **beam activity**

(muons from beam impact on IR1 collimators)

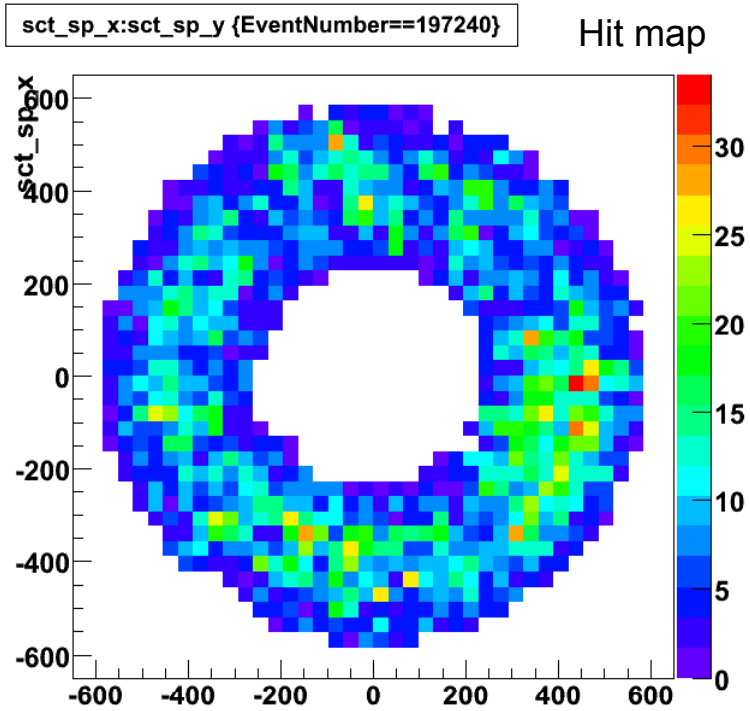
All other (36009) events

→ **cosmics**

→ Similar results for side A

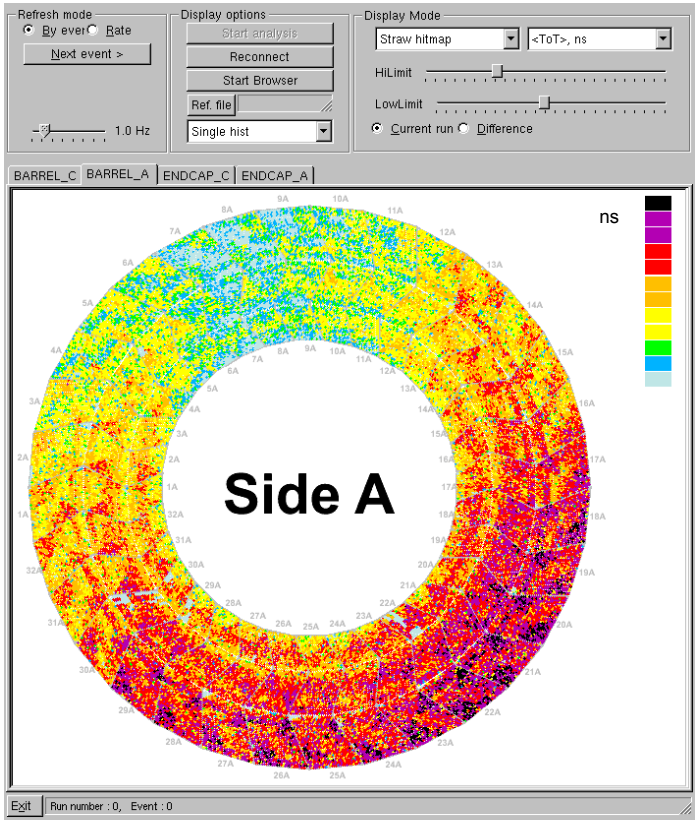
➔ See **beam** + **cosmic** activity

Beam splash event in the Inner detector



SCT at reduced bias voltage: 1000 space points in end-cap C during beam 2 dump, useful for timing

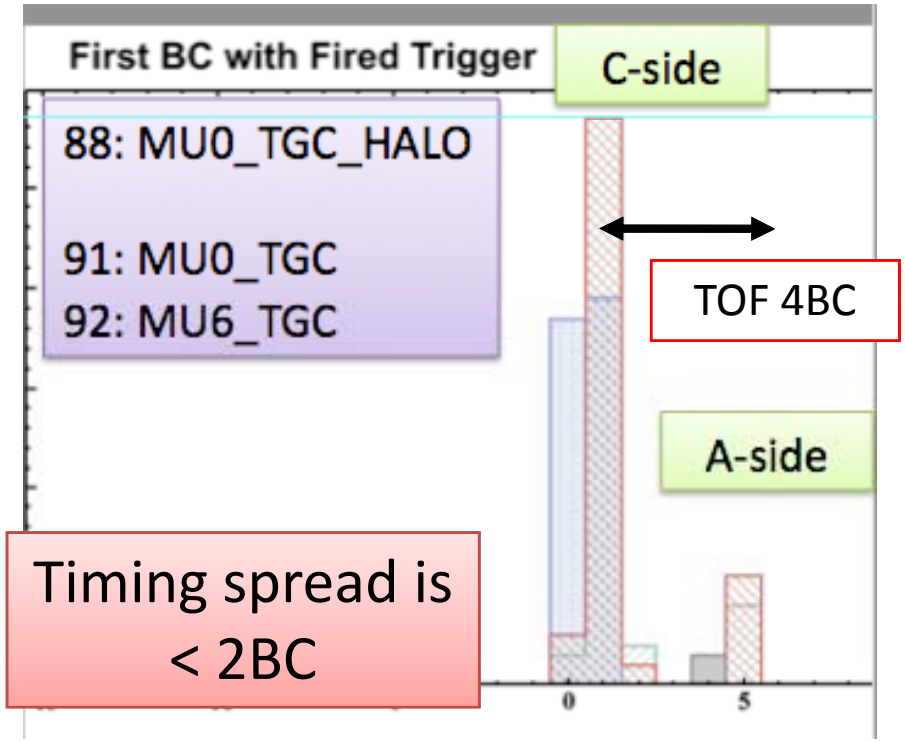
(Pixels requires stable beam flag to switch on the HV)

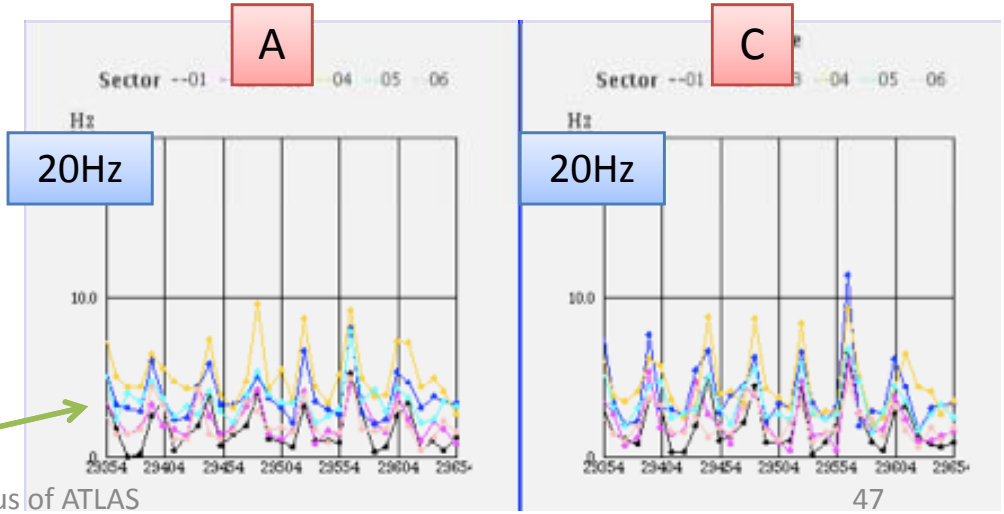


TRT: the splash events fill all straws and were vey useful for timing (1 ns accuracy)

Figure shows timing differences for one splash event. The TRT was timed in with cosmics, which accounts for 6 out of the 8 ns spread

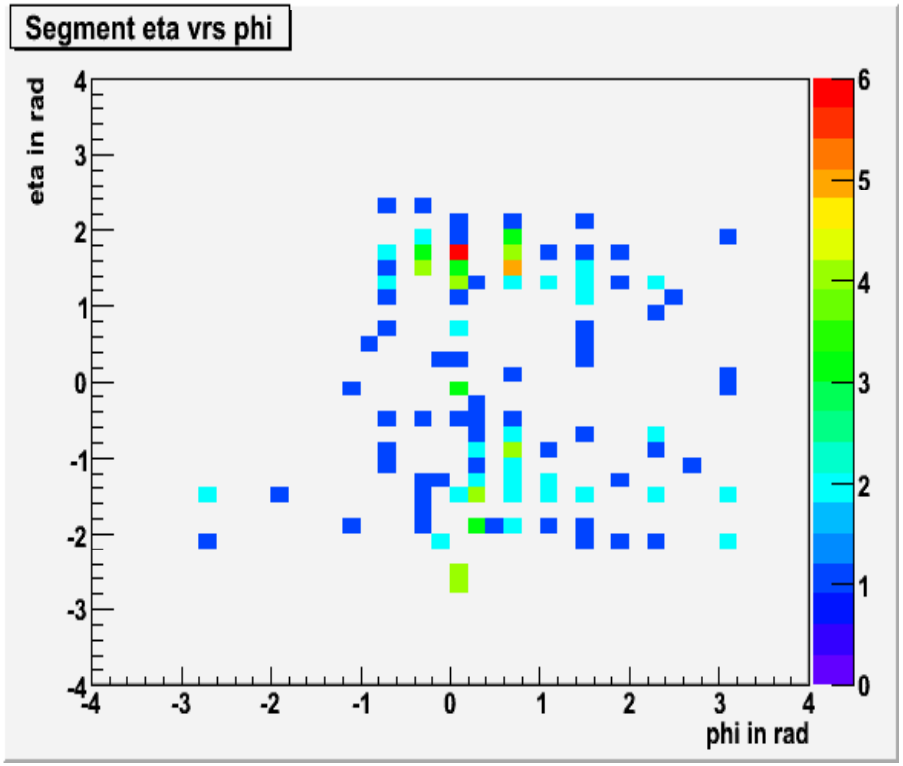
TGC trigger rates



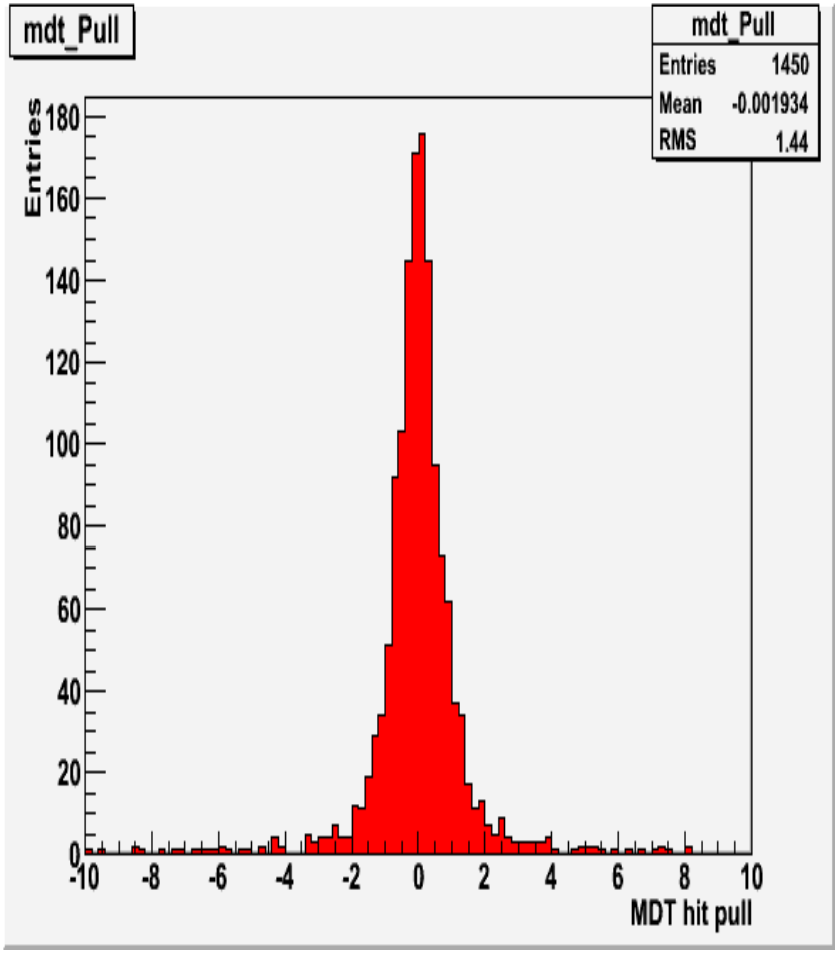


Every 40sec trigger
TGC trigger rate rise up

Beam-halo events in MDTs



Location of reconstructed track segments per chamber



Pull (residuals/errors) in the hits of these track segments

The ATLAS experiment as a whole has made over the past months great progress and is ready for operation