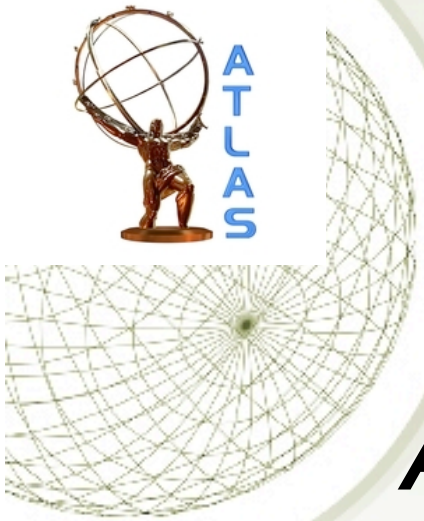


ATLAS Inner Detector Commissioning with Cosmic Rays

Helen Hayward,

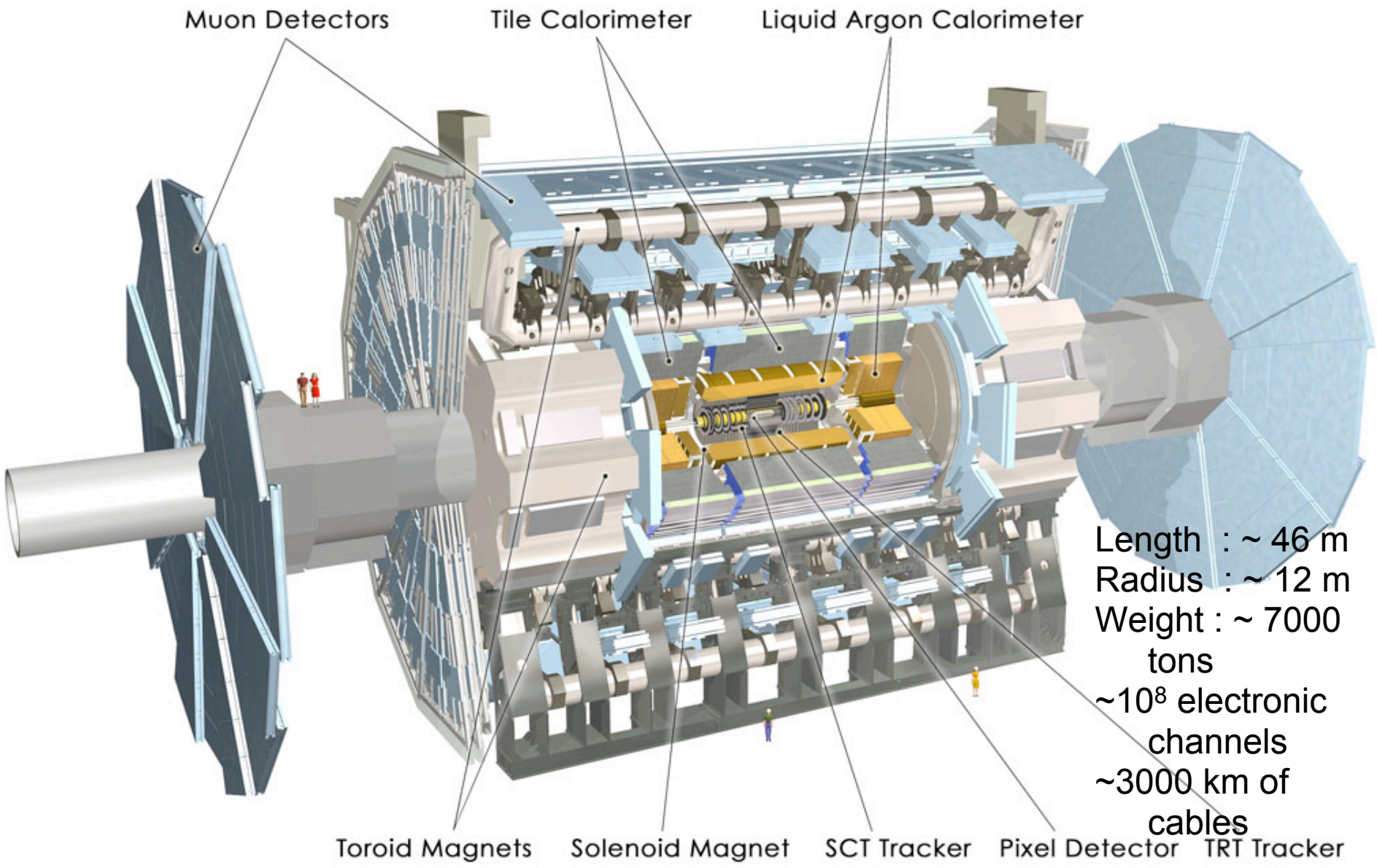
University of Liverpool

On behalf of the ATLAS Inner Detector Commissioning Group

Outline

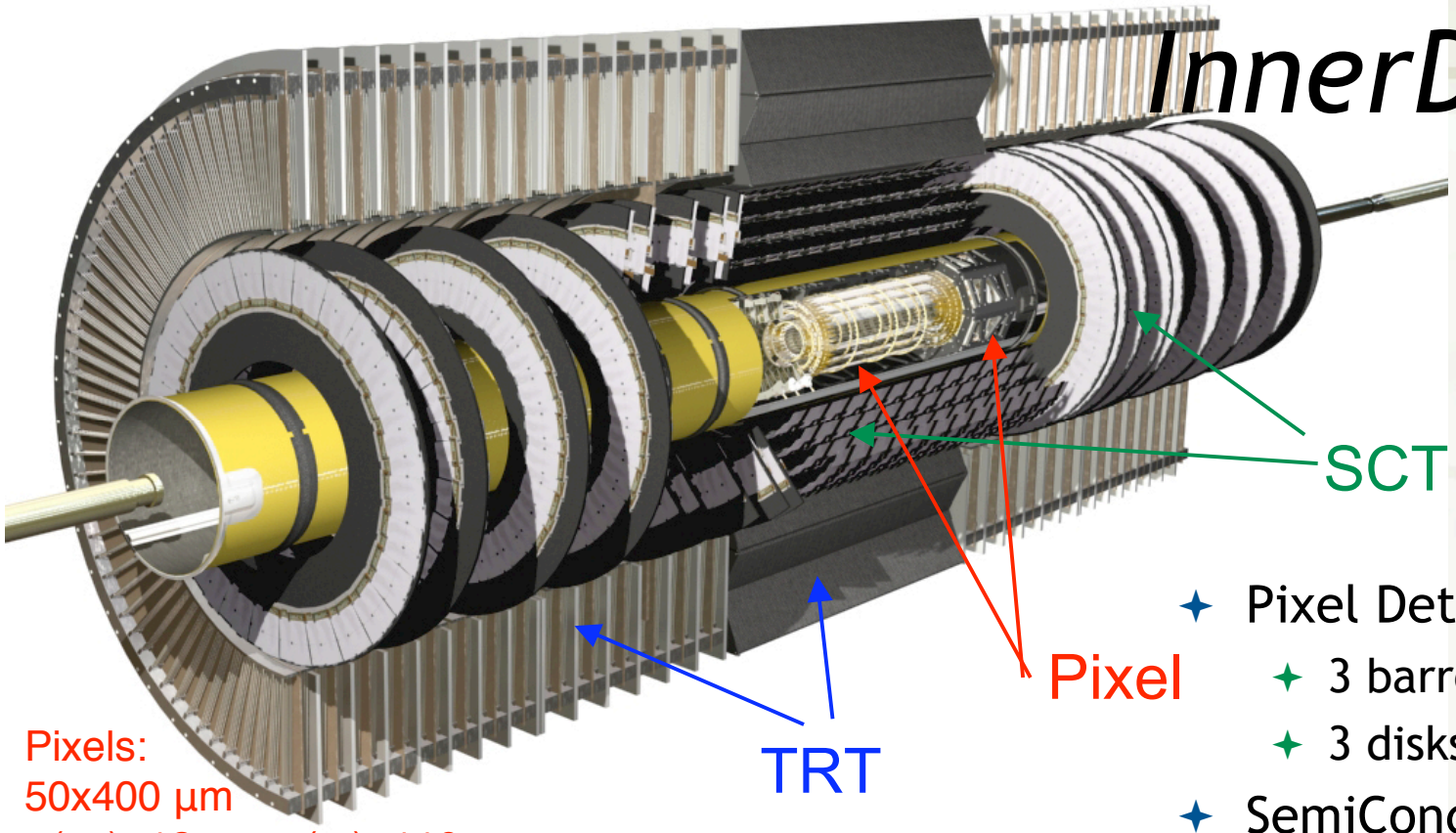
- The ATLAS inner detector
- Inner detector commissioning strategy
  - At the surface
  - In the cavern
- Event reconstruction and Monte Carlo Simulation Chains
- Monitoring of Data
- Tests at the surface
  - Noise
  - Efficiencies
  - Residuals
- Tests in the ATLAS cavern
  - Combined test with all ATLAS detectors
- Summary & Conclusions

The ATLAS Detector



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

InnerDetector



Radius = 115 cm
Length = 7 m
B = 2 T

- Pixel Detector
  - 3 barrel layers
  - 3 disks in each endcap
- SemiConductor Tracker
  - 4 barrel layers
  - 9 disks in each endcap
- Transition Radiation Tracker
  - 73 straw layers in barrel
  - 160 straws in each endcap

Pixels:
50x400 μm
σ(rφ)=12 μm σ(rz)=110 μm
80M channels

SCT: microstrips
Pitch: ~57-90μm
σ(rφ)=16 μm σ(rz)=580 μm
6M channels

TRT:
Drift tubes: d=4mm
Gas: Xe:CO2:O2
(Ar comm)
σ(rφ)=170 μm
372K tubes

Commissioning Strategy

- Over the last 18 months the larger structures of the ATLAS inner detector have been put together in the SR1 assembly hall at CERN.
  - SCT + TRT barrel
  - SCT + TRT endcap
  - Pixel detector
- Before lowering into the ATLAS Cavern these substructures were tested to check their performance.
- Inner Detector status today:
  - All components of the innerdetector is installed in Cavern
- Currently being integrated into the combined DAQ to collect cosmic data with the other subdetectors (calorimeters, muon detectors)
- These tests are as much a commissioning of the software as the detector itself !!
- With the exception of some minor changes required to deal with the peculiarities of cosmic data, the software used is the software that will be used with collision data!

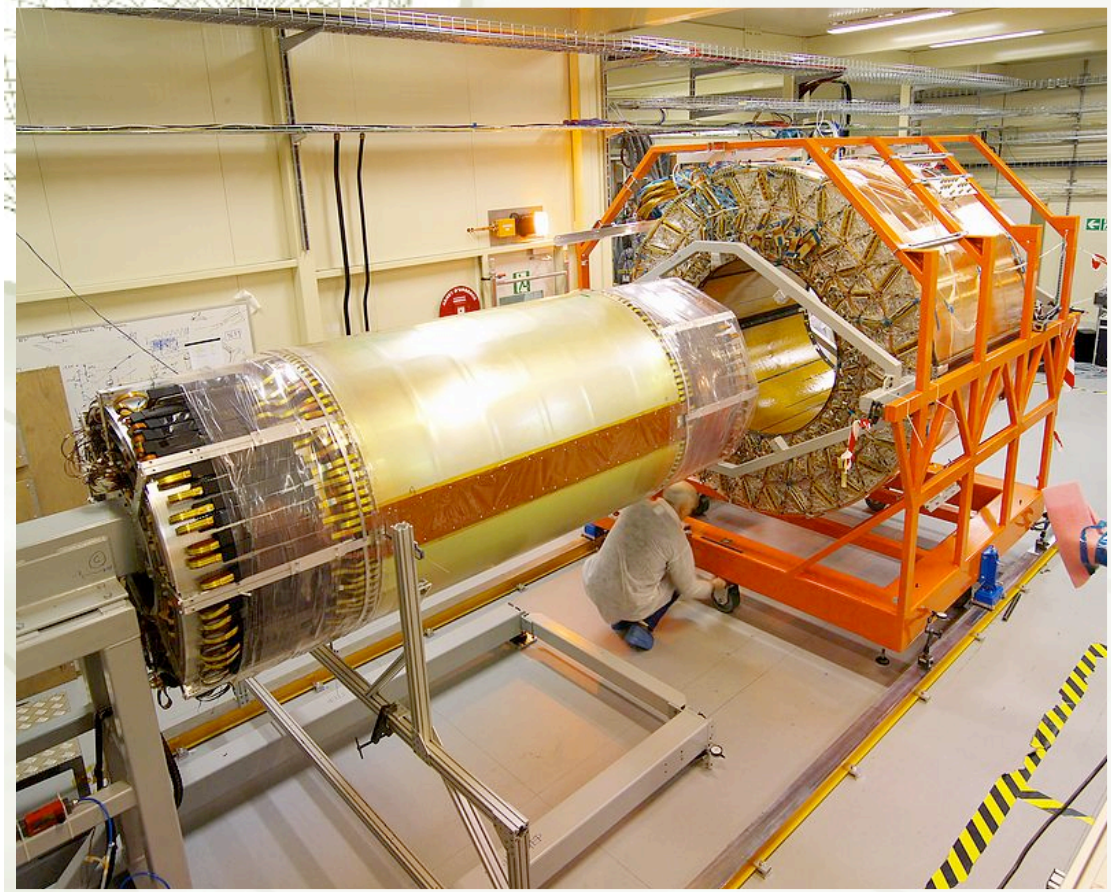
Commissioning TimeLine

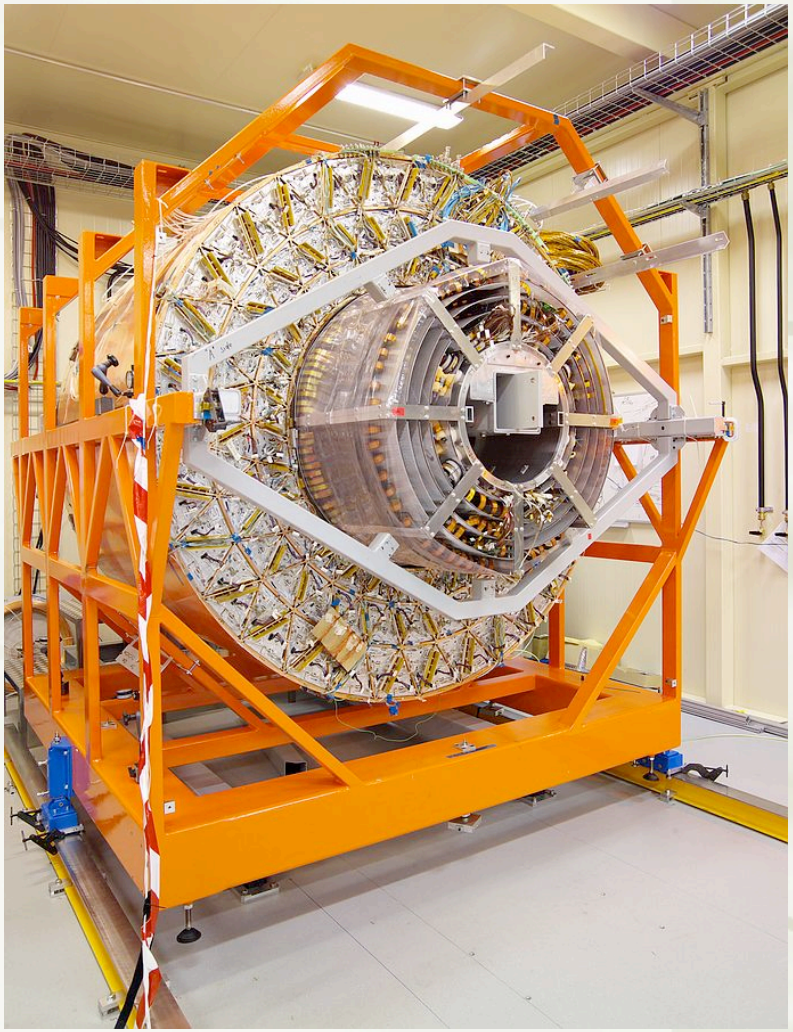
- SCT barrel into TRT barrel (Feb 2006)
  - SCT+TRT barrel (June 2006)
- barrel SCT/TRT installed in cavern (August 2006)
- SCT Endcap into TRT endcap (Nov 2006)
  - SCT+TRT endcap (Autumn 2006)
  - Pixel Endcap (Autumn 2006)
- SCT/TRT endcaps into cavern (May - June 2007)
- pixel installation in cavern (June 2007)
  - First run with TRT Barrel in cavern (June 2007)
  - SCT integrated into DAQ (June 2007)
  - Pixel integrated into DAQ (October 2007)

Surface Cosmic Tests

Cavern Cosmic Tests

Commissioning at the Surface

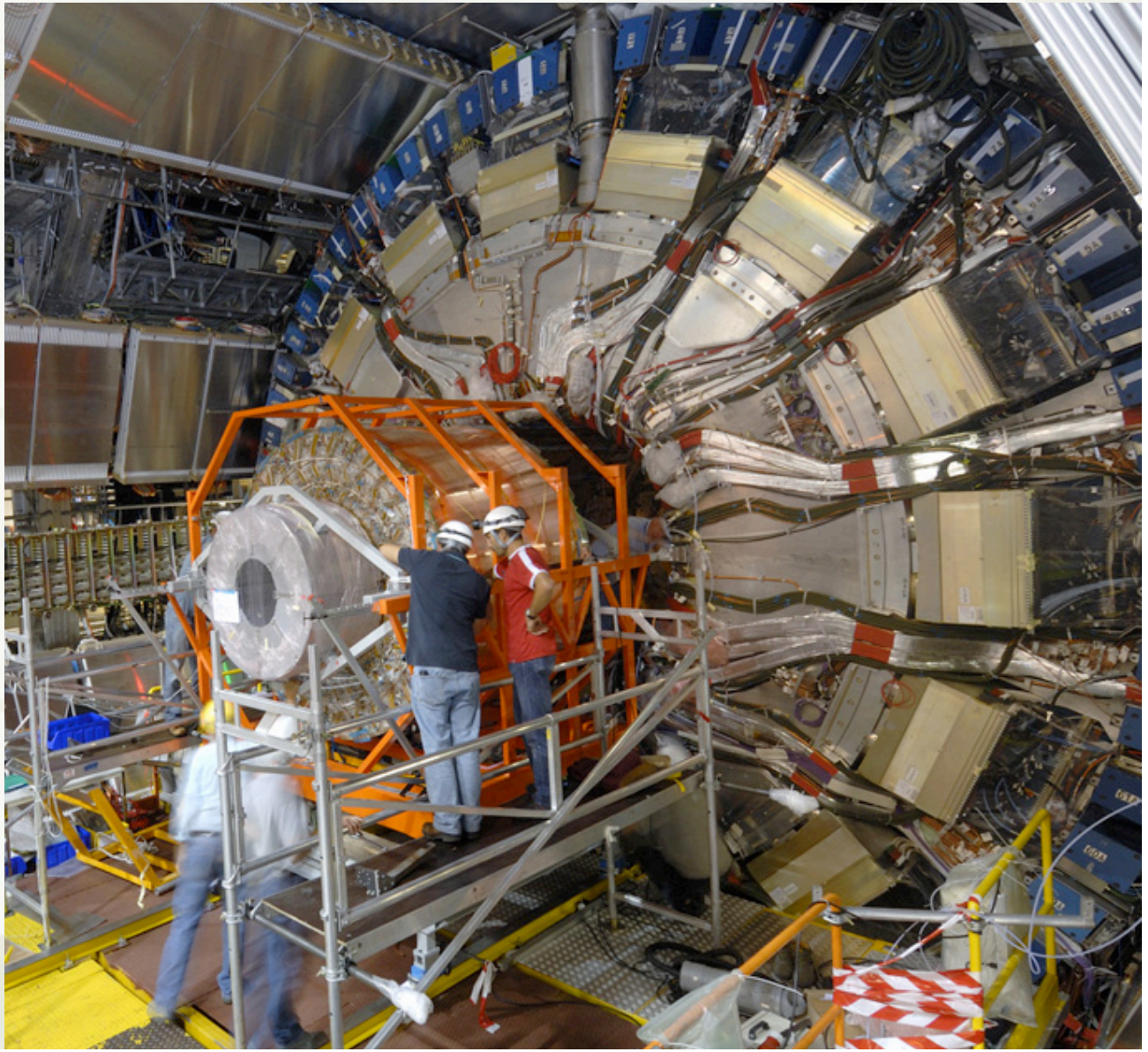




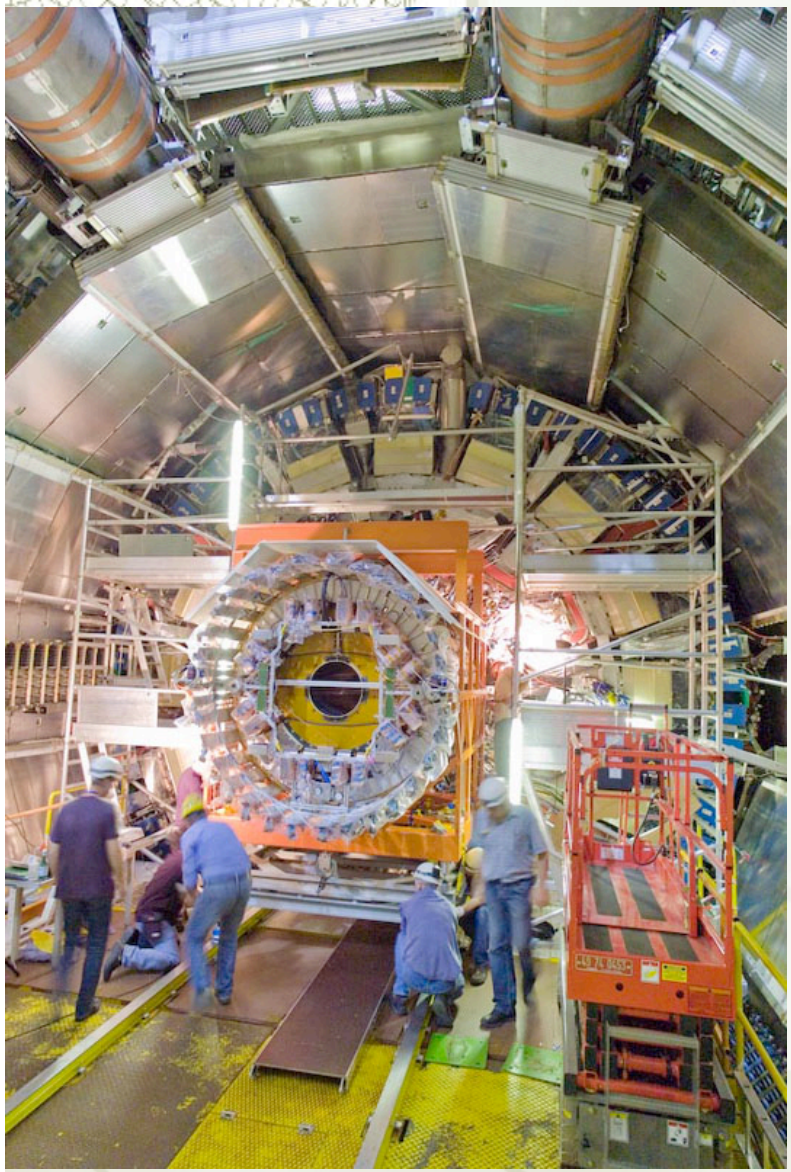
Barrel SCT and TRT: February 17,2006

Installation in Cavern (I)

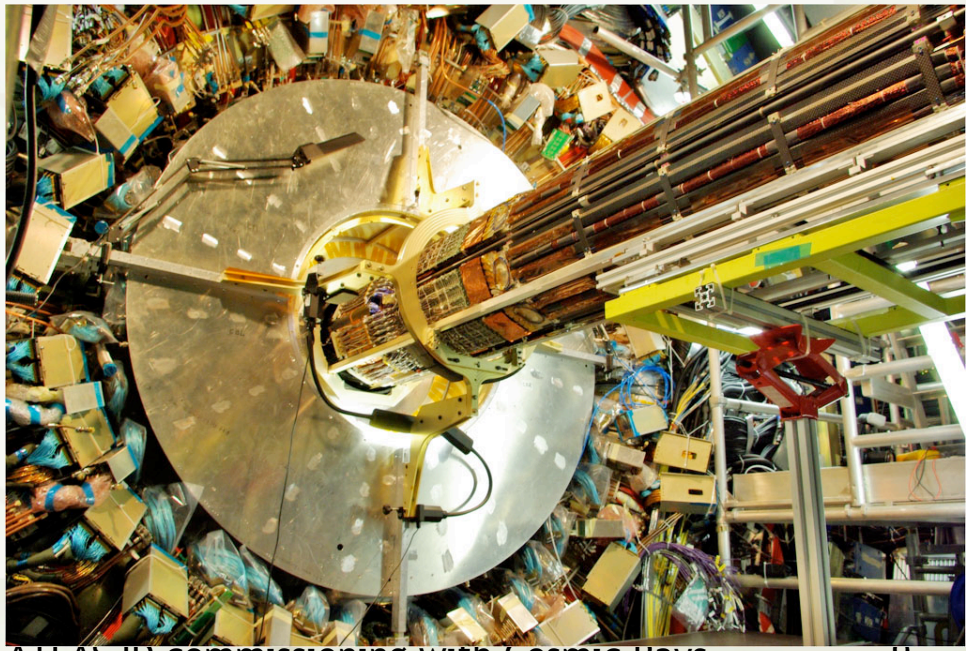
- Inner Detector Installed into cavern in August 2006



Installation in Cavern (II)

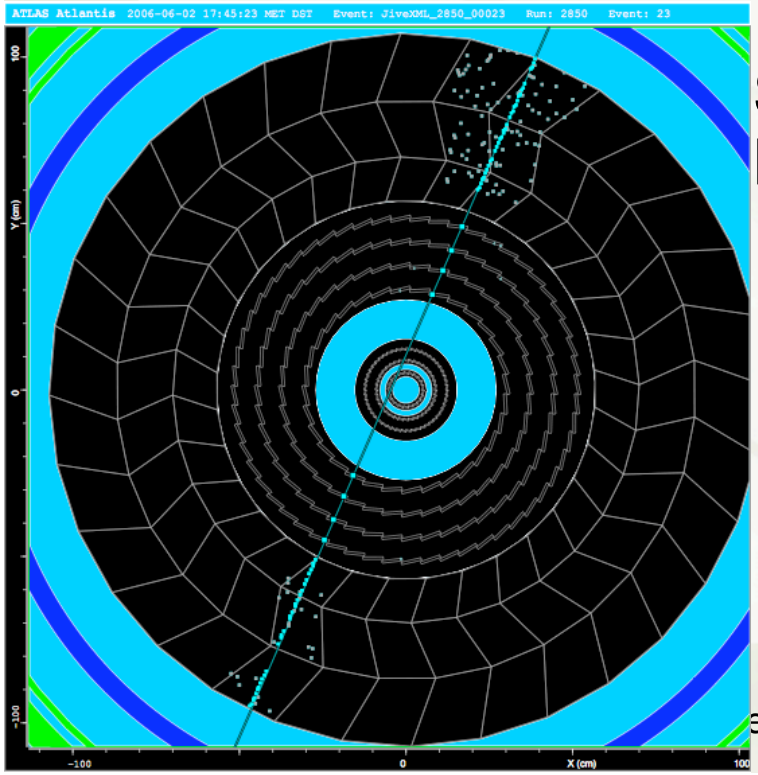


- Installation of 1st endcap (may 2007)
- Installation of pixel detector (June 2007)



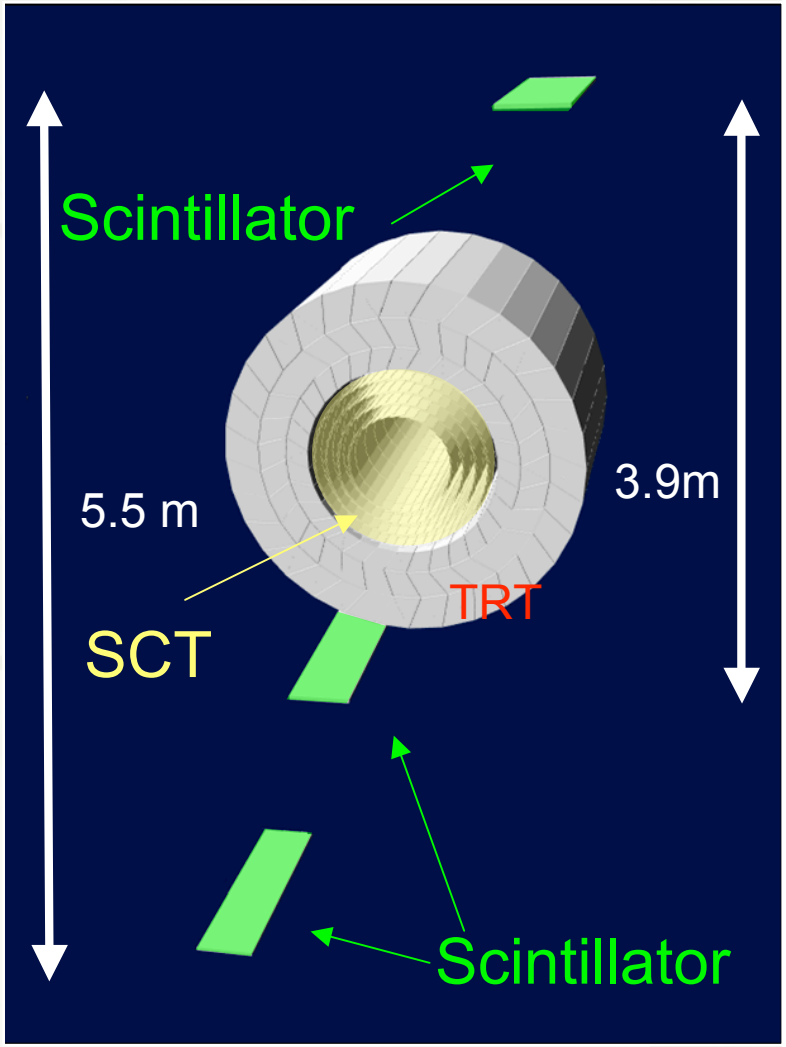
Commissioning at the Surface(II)

- 3 tests/setups on Surface:
  - SCT+TRT Barrel (June 2006)
  - SCT+TRT endcap (Autumn 2006)
  - Pixels endcap (Autumn 2006)
- Calibration and physics runs with both random and cosmic triggers

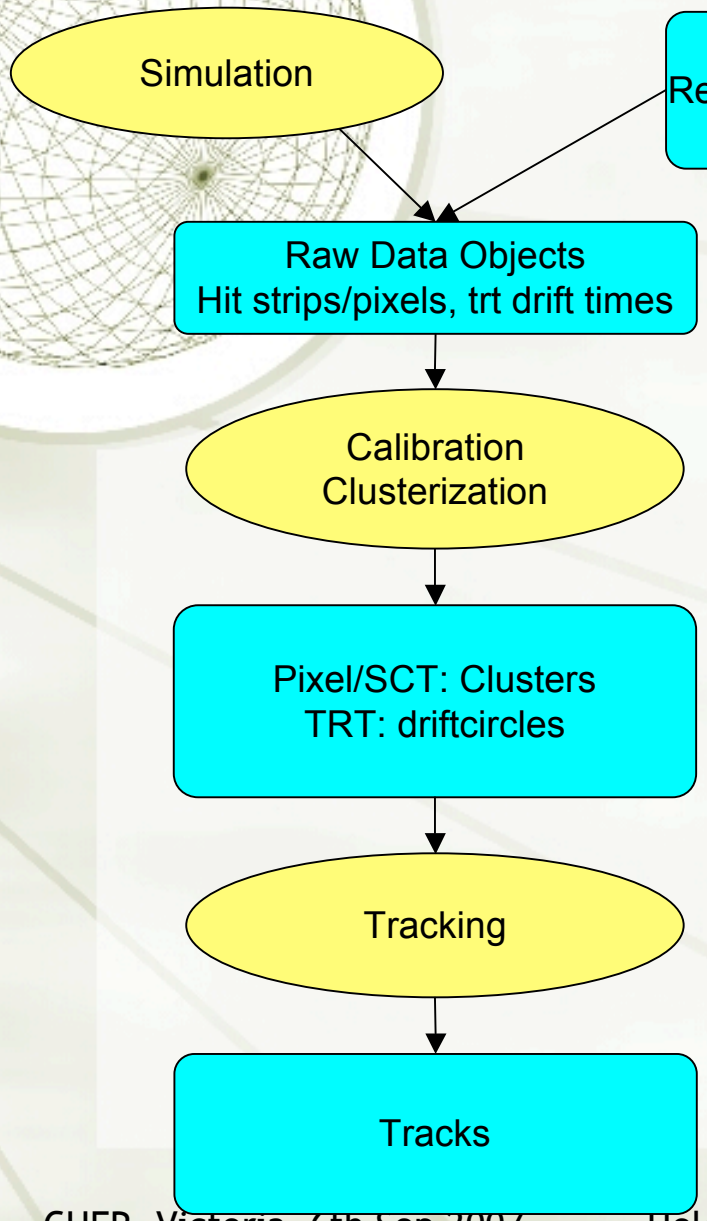


SCT + TRT Barrel setup:

- Scintillator Trigger
- B field off
- Detector partially cabled



Reconstruction data flow



- Full reconstruction chain in place to deal with cosmic data
  - Detector description for each commissioning setup
  - Use information from conditions database (cabling, calibration, alignment, DAQ, slow control data)
- Specific for cosmic test
  - Random cosmic arrival time taken into account
  - Standard tracking as well as dedicated cosmic tracking (no vertex constraints)

Cosmics generation and simulation

Single Muon generated at a given Surface

Filtering events: require muon initially points to a given distance from the detectors centre

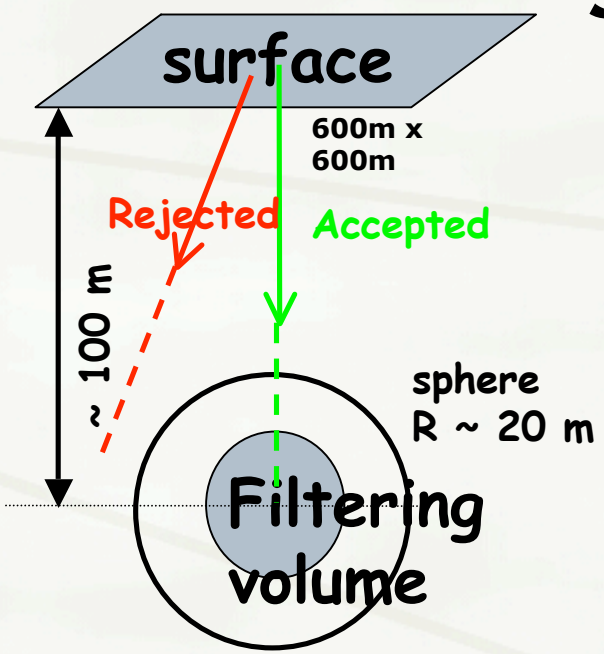
Geant4 Simulation

Hits

Filtering looking at hits in a given volume

Digitization & Trigger emulator

RawDataObjects & Trigger Information

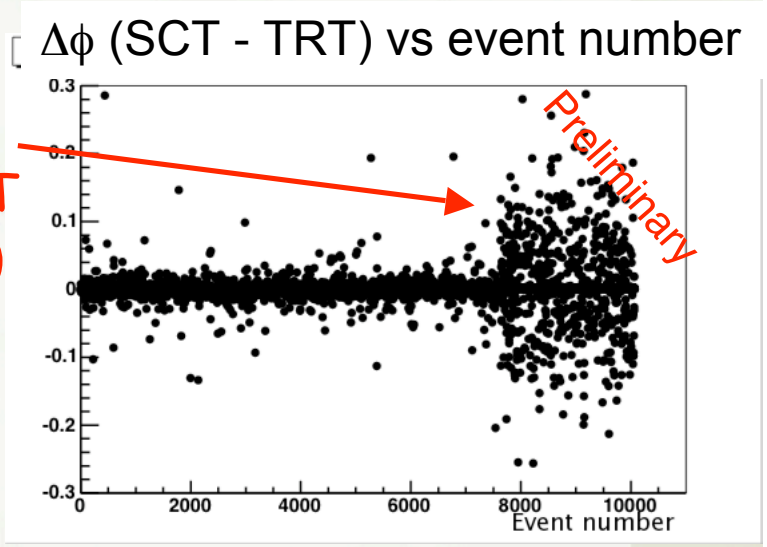


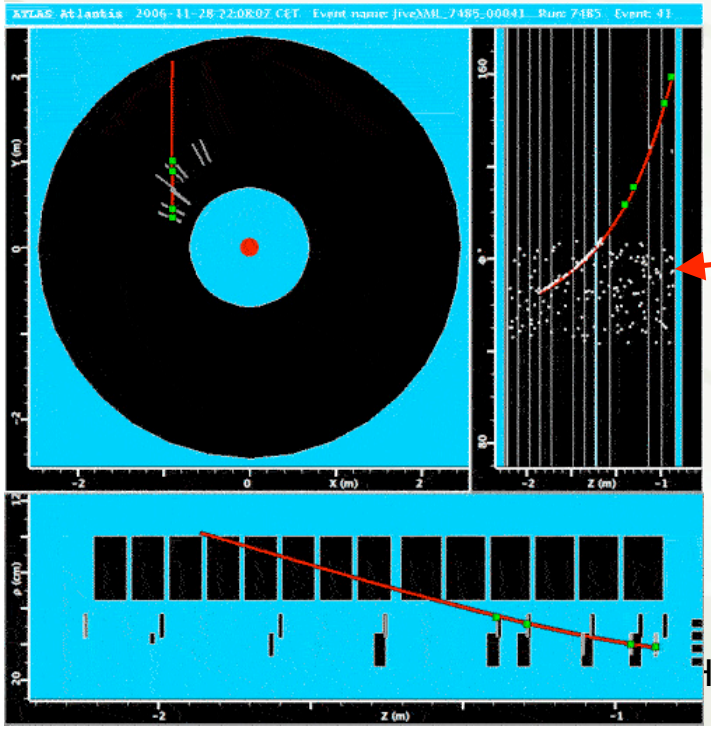
- Digitization
  - Depends on conditions data (e.g.) :
    - Modules which are being readout
    - Electronic settings (voltages, thresholds)
- Trigger
  - Scintillators, muon chambers or calorimeters
- Additional complication for cosmic rays:
  - Muons simulated far from the detector
  - Origin of the muon not constant

Monitoring Tools

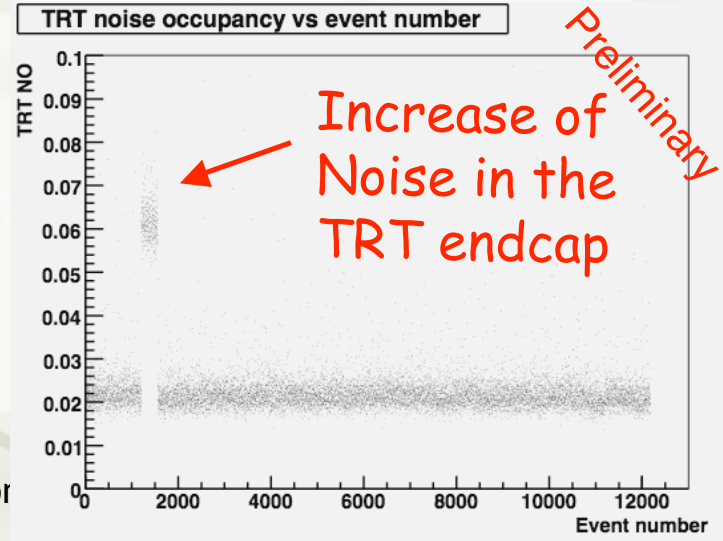
- ATLAS Monitoring Tools have been developed and tested in real data taking environment
  - online at various levels.
  - ATLANTIS Event displays
  - Offline analysis
- Used to verify detector performance

Synchronization between the SCT and TRT (barrel) lost after 8000 events





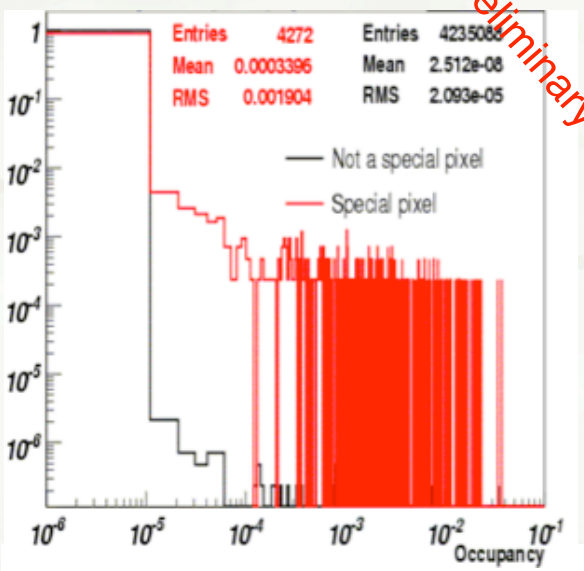
Cosmic from SCT-TRT Endcap Test



Increase of Noise in the TRT endcap

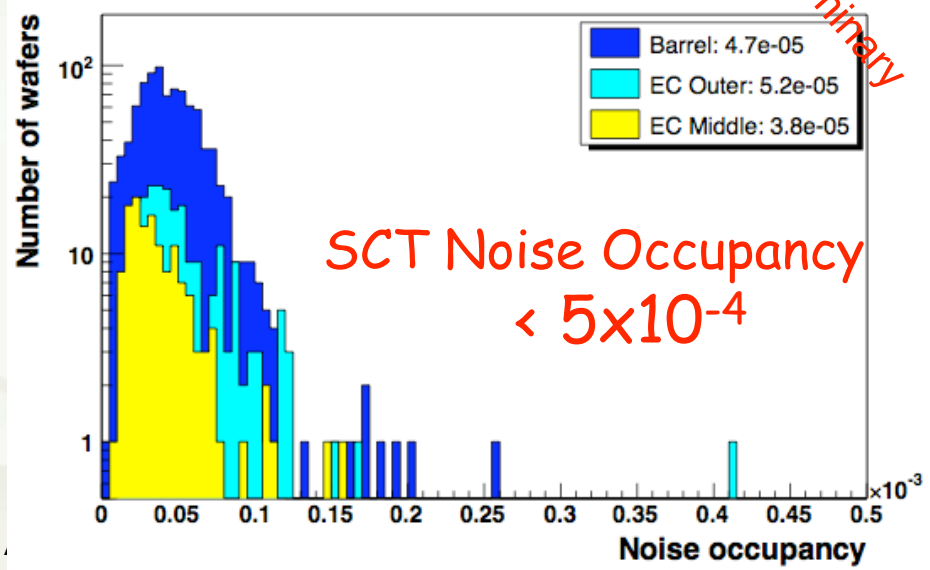
Noise Studies

- Random (time) Triggers used to study the noise in many different configurations
  - Noise well within specifications and in agreement with production tests
  - No increase of noise observed in any tested configuration (e.g. pickup noise from another subdetector, heaters on/off)



Pixel Noise Occupancy

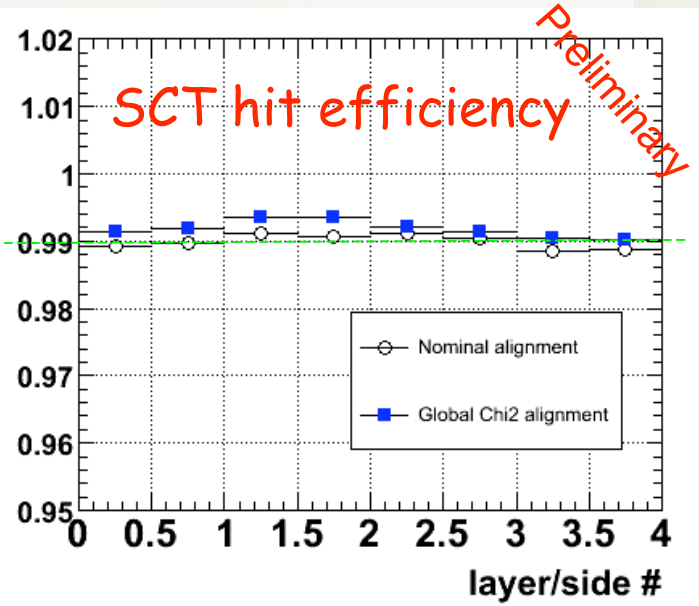
(special pixels detected during production tests)

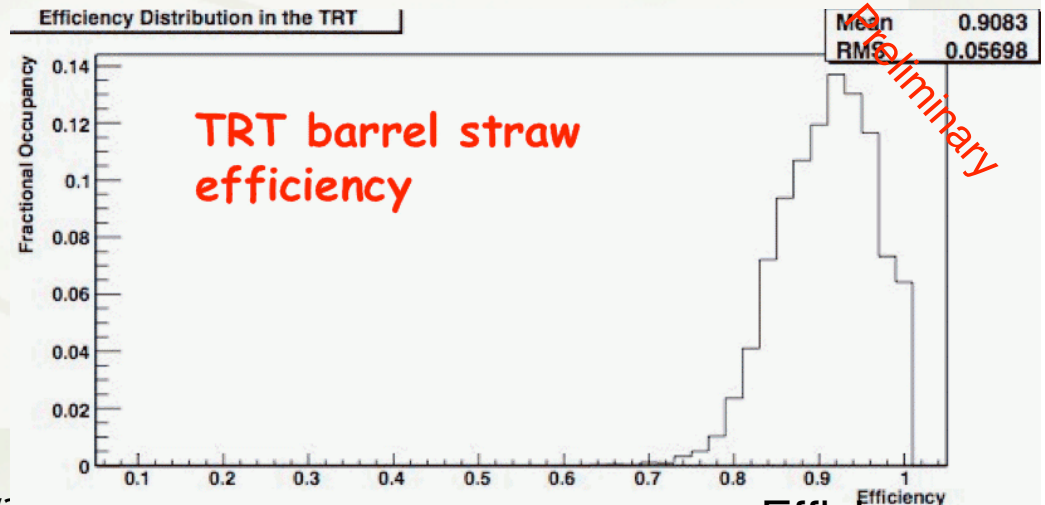


SCT Noise Occupancy
< 5x10^{-4}

Measuring Efficiencies

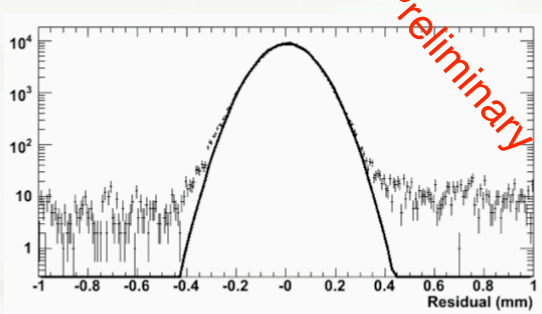
- SCT+TRT barrel test
- Using Cosmic Trigger
- Reconstructed tracks have been used to calculate hit efficiencies in each sub-detector
- Efficiencies are well within specifications:
  - SCT: hit efficiency after alignment > 99%
  - TRT: (Argon instead of nominal Xenon): eff. ~ 90%





Residuals

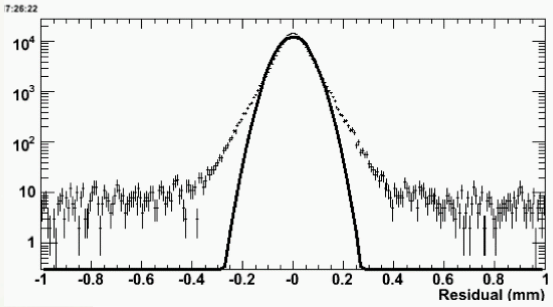
- No B-field in Cosmic test (no pt information)
  - multiple scattering not taken into account
  - Track Uncertainties not well estimated
- Alignment algorithms have been applied
  - (see yesterdays talk [129] by Sergio GONZALEZ-SEVILLA)
- The residual width contains contributions from:
  - Detector resolution
  - Track uncertainty
- extract detector resolution by measuring the width of the residual distribution as a function of the unbiased hit $\chi^2 \rightarrow 0$



SCT barrel Residuals

σ = 96 μm

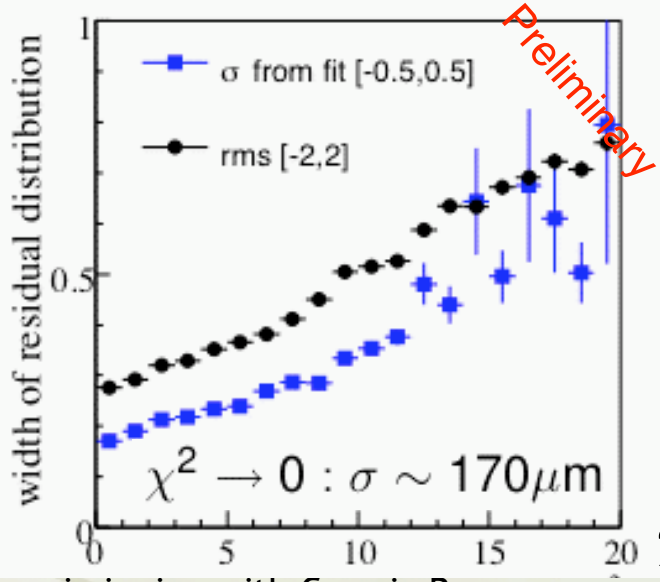
Alignment



σ = 59 μm

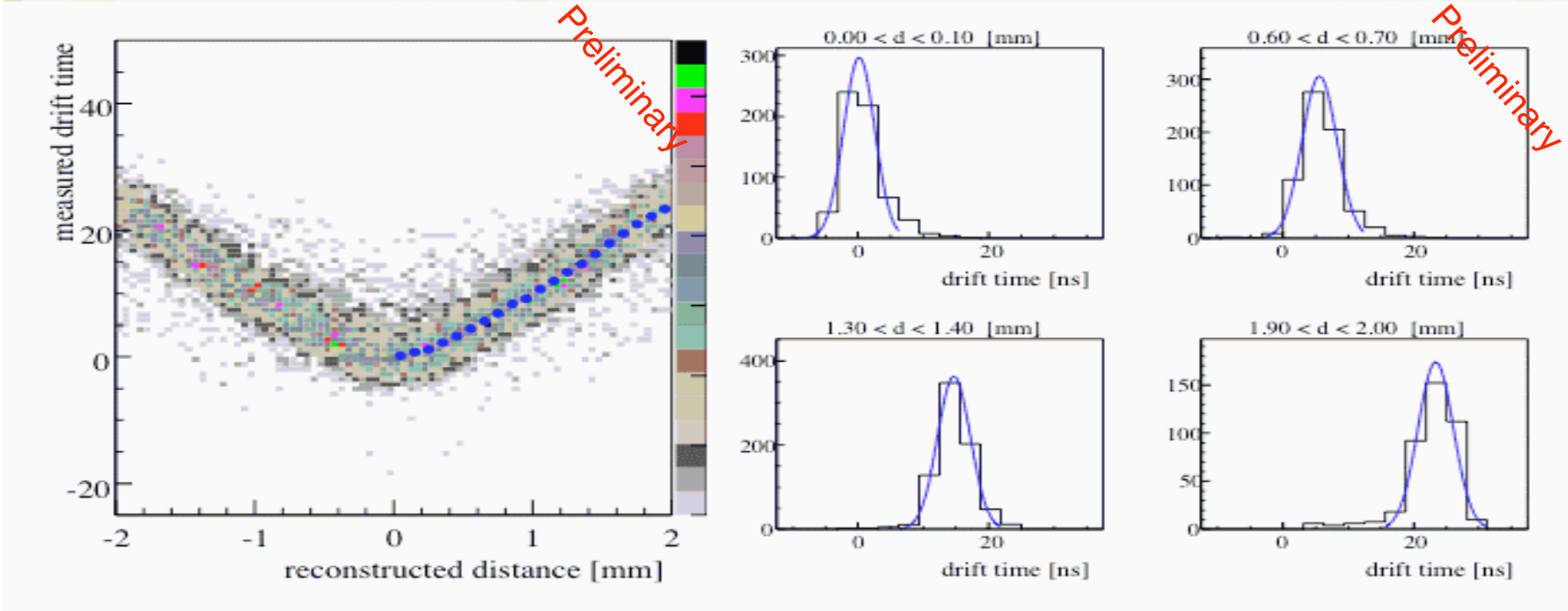
mm

TRT barrel Residuals



TRT Calibration

- Successful test of TRT calibration algorithm
- TRT measures uncorrected drift time t_{raw} but tracking needs drift radius

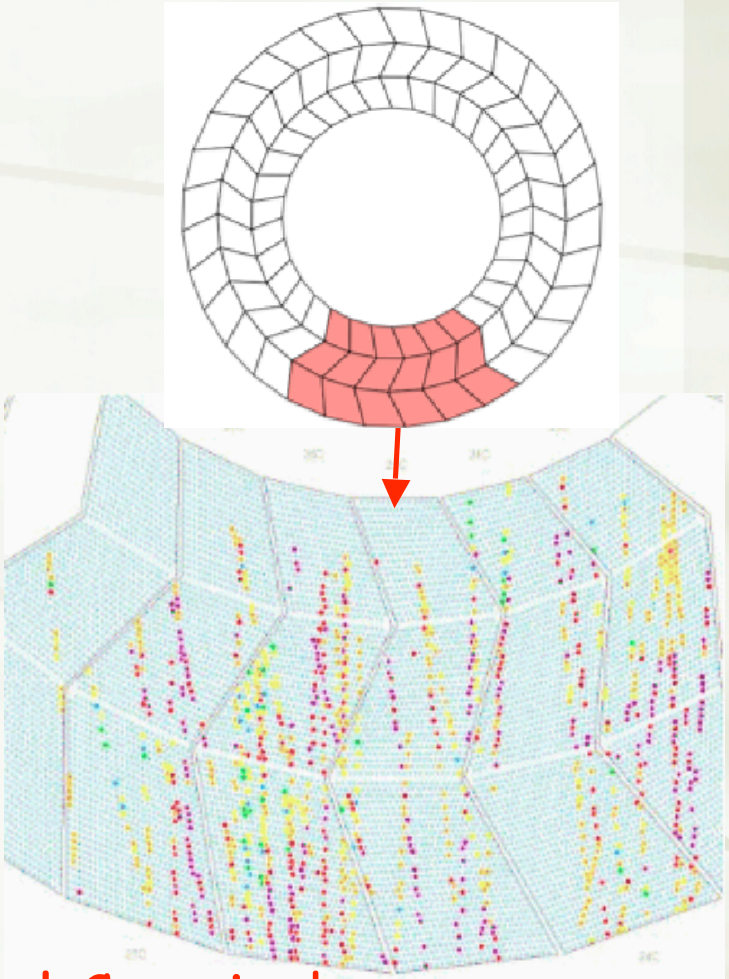


Commissioning plan in the cavern

- InnerDetector Commissioning in the ATLAS cavern after installation and integration into the combined DAQ
  - First run with TRT Barrel (June 2007)
    - (SCT barrel : standalone tests in cavern)
  - Full cosmic test of atlas with all sub-detectors contributing
  - First single beam testing next year…
  - PHYSICS!

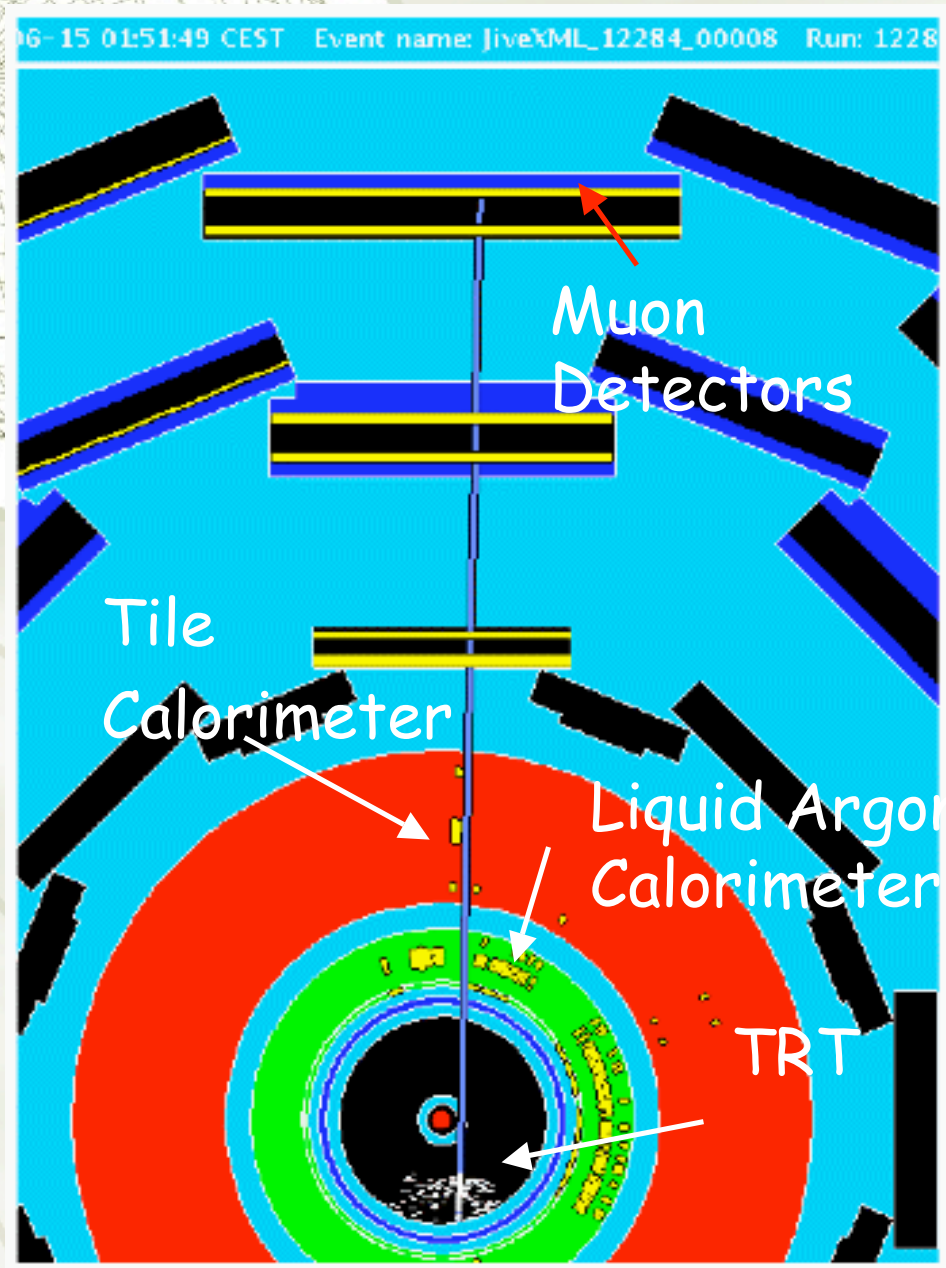
Cosmic Tests with InnerDetector installed in ATLAS Cavern

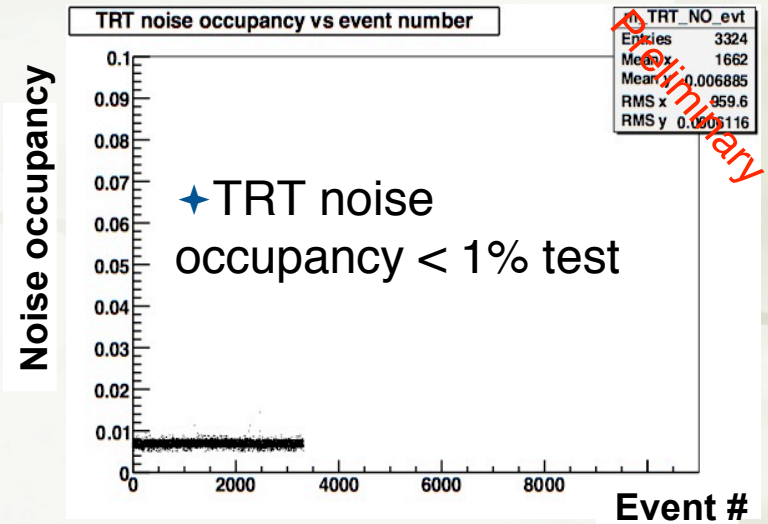
- First combined data taking of Inner Detector (TRT barrel) with other ATLAS subdetectors in June 2007
- Reconstruction software, monitoring and event display successfully tested
- Trigger provided by Muon spectrometer and Tile calorimeter
- 1/6 of TRT Barrel in readout
- (To date 1/3 of barrel TRT is in readout)

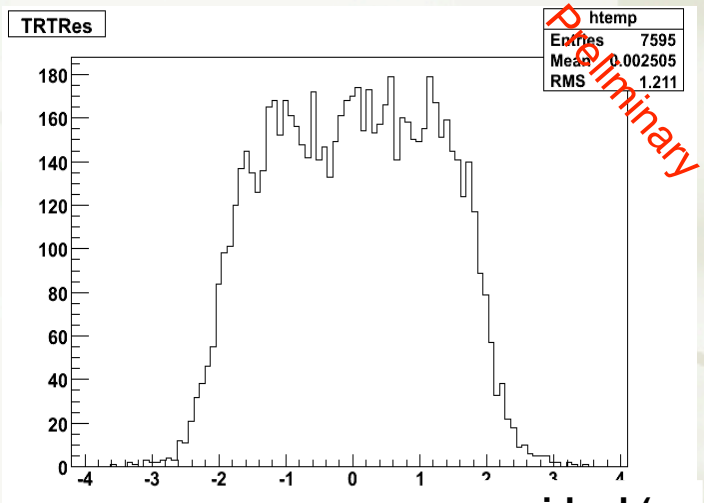


Real Cosmics! (integrated few seconds)

TRT analysis







No drift time information used

Summary & Conclusions

- Extensive program of commissioning The ATLAS inner-detector using cosmic rays:
  - first at the surface
  - in the ATLAS cavern with the rest of the ATLAS detectors
- The detector is performing well:
  - noise, efficiency and spatial resolution
- The full software chain has been successfully tested with real data:
- Monitoring tools are already providing prompt feedback on the detector performance
- In addition extensive analysis of detector performance:
  - reconstruction, alignment, calibration
  - A simulation of the different setups has also been provided to allow for a MC tuning and to prepare the full chain before dealing with real data.
- Over the next months the commissioning with cosmic rays continues with more and more coverage of the individual subsystems of the ID
- Commissioning with beam and collision data next year !!