Inner Detector Commissioning Overview

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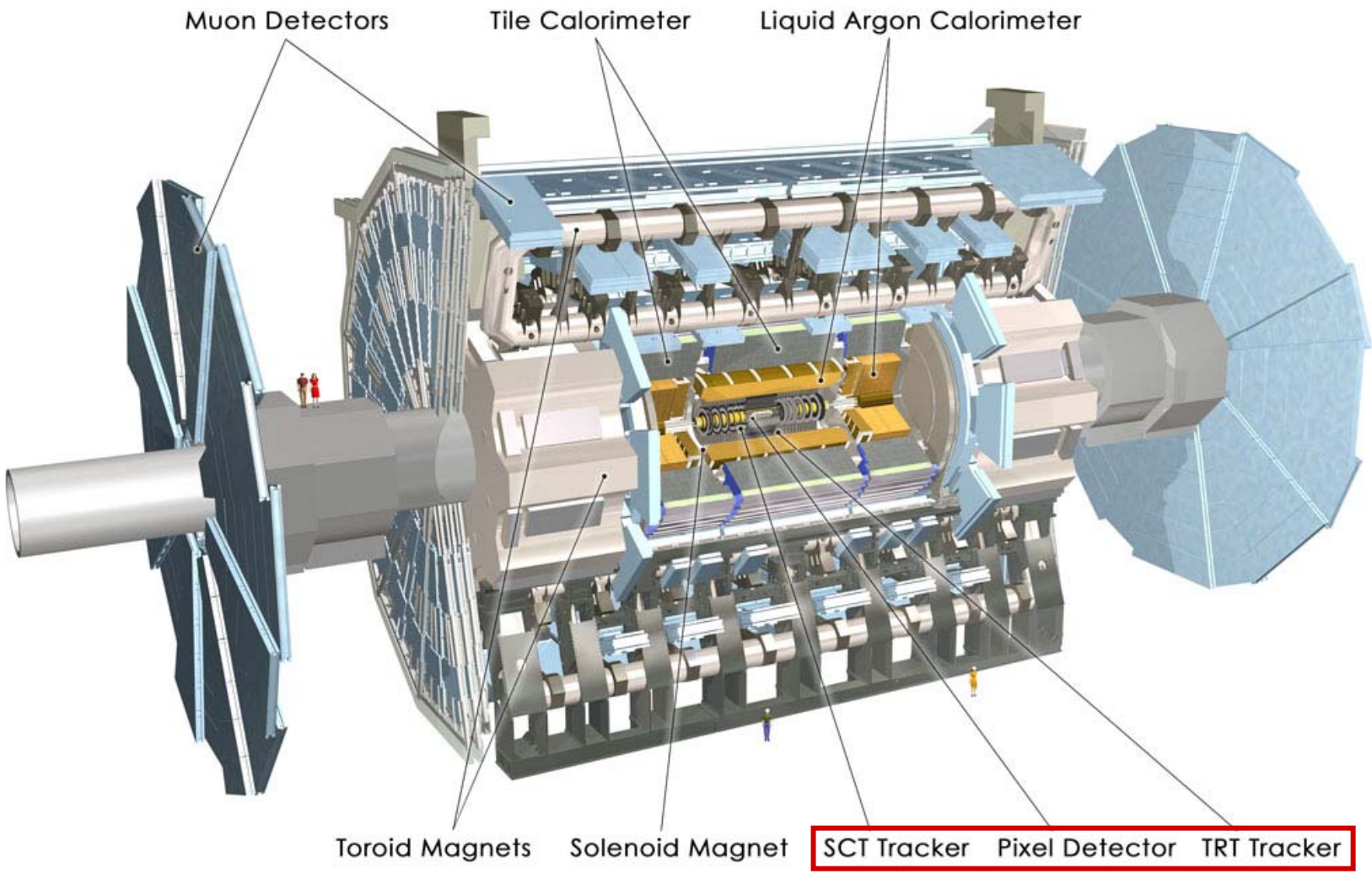
On behalf of the ATLAS Inner Detector Group

April 15, 2009

ATLAS Tau Workshop

The ATLAS Detector

At the very heart of ATLAS; ~90% of all channels are in the ID

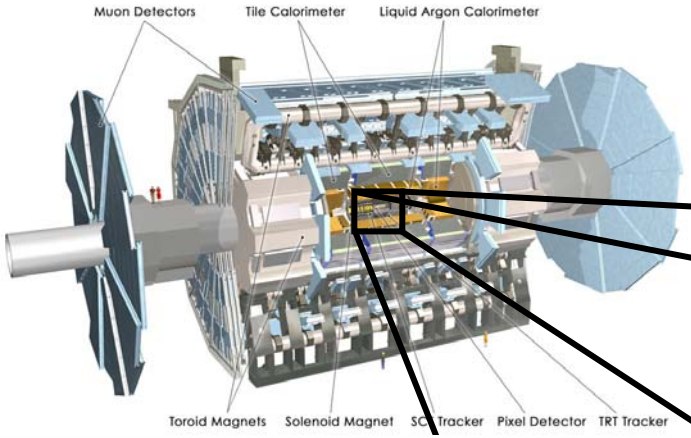


Operated inside 2 Tesla solenoidal field, coverage $\eta < 2.5$ (Transition Radiation Tracker $\eta < 2.0$)

$\sigma/p_T = 0.05\%\ p_T \oplus 1\%$

The ATLAS Inner Detector

Barrels (Pixel, SCT and TRT)

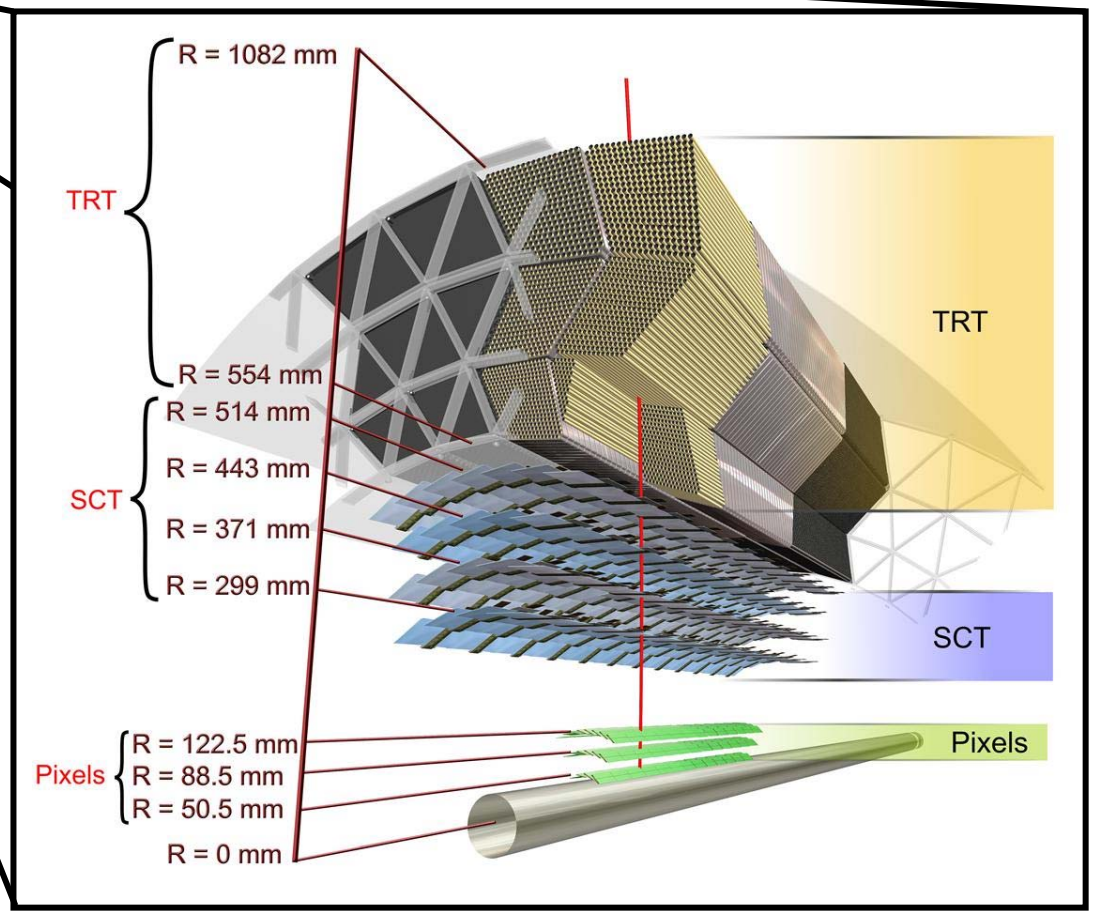


Pixel Detector

- 3 cylindrical layers with 5, 9, 12 cm radius in barrel region
- 2 × 3 disks in forward regions
- 1744 modules, each with 46860 pixel of 50 μm × 400 μm
- 80 M channel
- Resolution: 10 μm × 110 μm

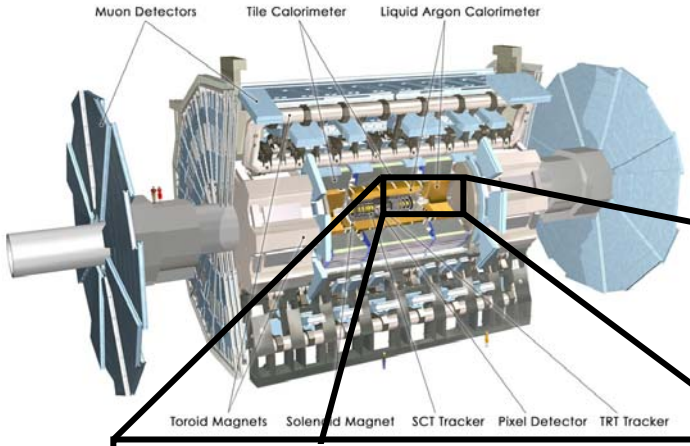
Semiconductor Tracker (SCT)

- 4 cylindrical double layers with radius 30, 37, 44, 51 cm in barrel region
- 2 × 9 disks in forward regions
- 4088 modules with 80 μm strips
- 6 M channel
- Resolution: 17 μm × 580 μm



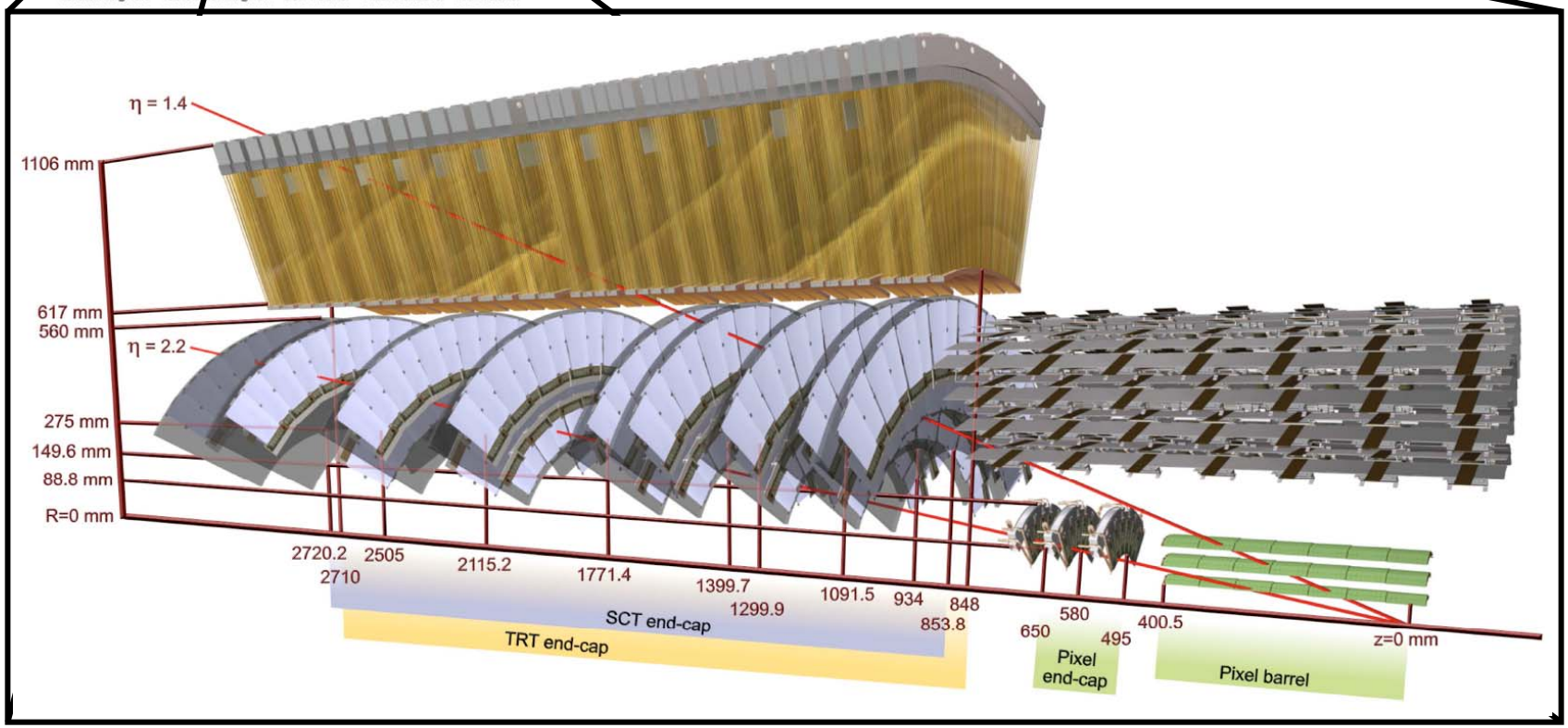
The ATLAS Inner Detector

Endcaps (Pixel, SCT and TRT)



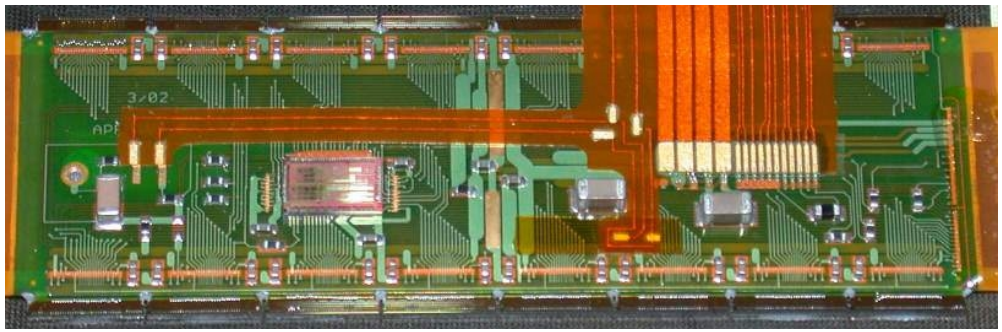
Transition Radiation Tracker (TRT)

- Polypropylen-polyethylene fibers (barrel) polypropylene foils (endcap) as radiator
- 4 mm diameter straw tubes with 35 μm anode wires
- 73 layers in barrel region with axial straws
- 2×160 (20 disks each) with radial straws in forward region
- 351 K channel
- e-π identification: 0.5 GeV $<$ E $<$ 150 GeV

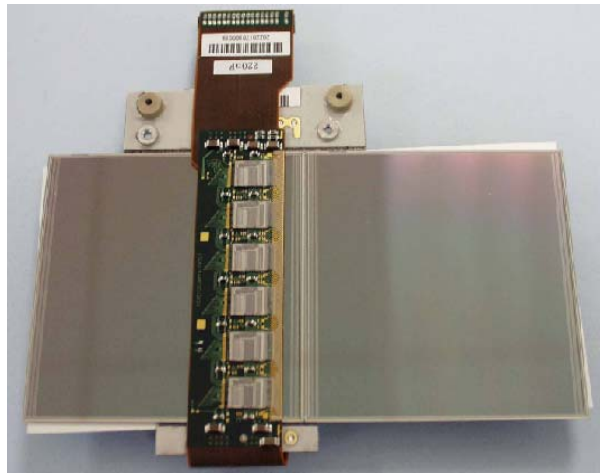


Critical for the ATLAS Physics Program

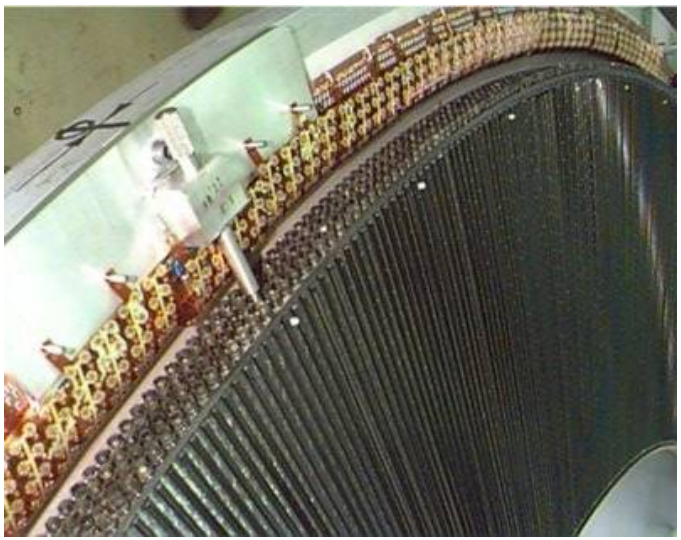
Pixel Module



SCT Barrel Module



TRT Straws



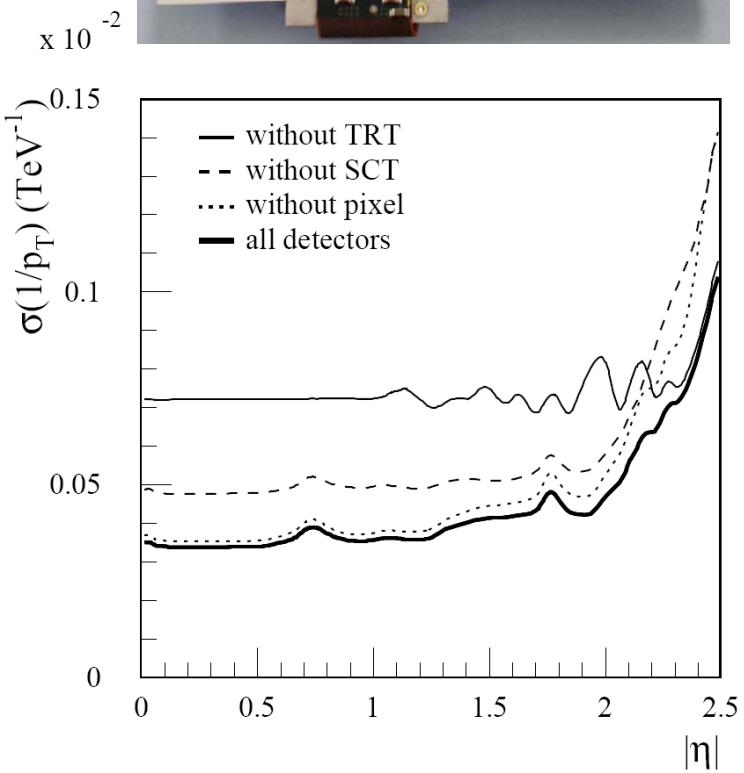
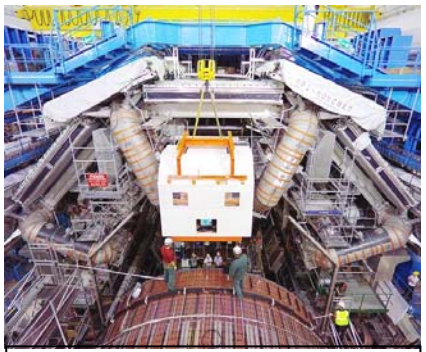


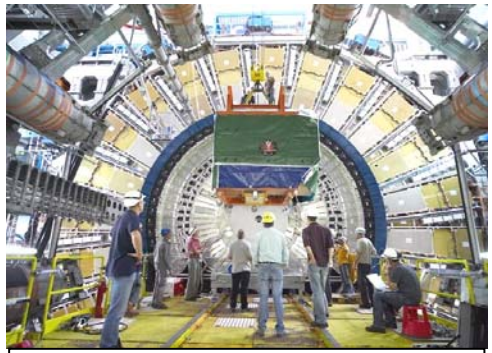
Figure: ATLAS Inner Detector TDR

Inner Detector Installation Timeline



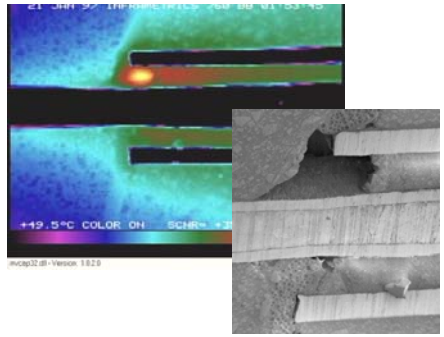
ID Barrel Installed

Aug. 25, 2006



ID endcaps installed

May 29, 2007



Ev. heater saga

Jun. 19, 2007

ID sealed

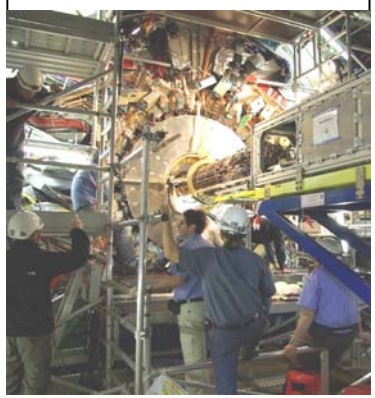
Apr. 24, 2008

2006 **2007** **2008**

Jun. 28, 2007

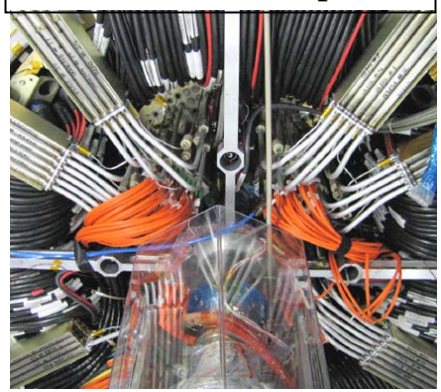
Preparatory work

Pixel installed



Apr. 18, 2008

Connection complete



May 1, 2008

Cooling failure

Inner Detector Status (2008)

Pixel Detector

- 98.4% of all modules are operational
- Noise occupancy of 5×10^{-9}
- Hit efficiency 99.8%
- 4 leaking cooling loops in the endcaps (3 on the C-Side, 1 on the A-Side)
- High mortality rate of off-detector optical link transmitters (being replaced)

SCT

- >99% of barrel and >97% of endcap modules are operational
- Noise occupancy of 4.4×10^{-5} (barrel) and 5×10^{-5} (endcap)
- Hit efficiency >99%
- 2 cooling loops in the endcaps were not operated during the 2008 cosmics running; one of these was repaired during the recent shutdown
- High mortality rate of off-detector optical link transmitters (being replaced)

TRT

- 98% of all channels are operational (~2% dead from assembly and installation)
- All RODs have arrived at CERN and have been functioning well since Oct. 2008

Status for 2009 is expected to be even better for all sub-systems

TX Plug-in Deaths

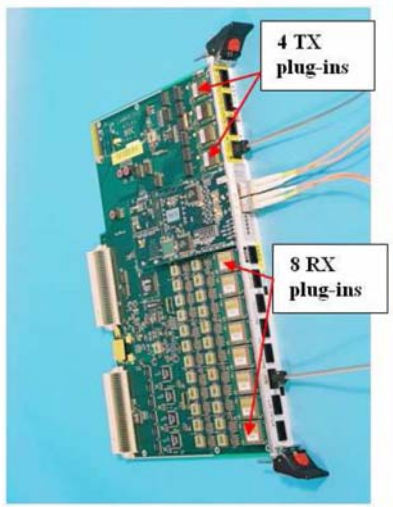
TX VCSEL array sends optical clock and control signals to the modules

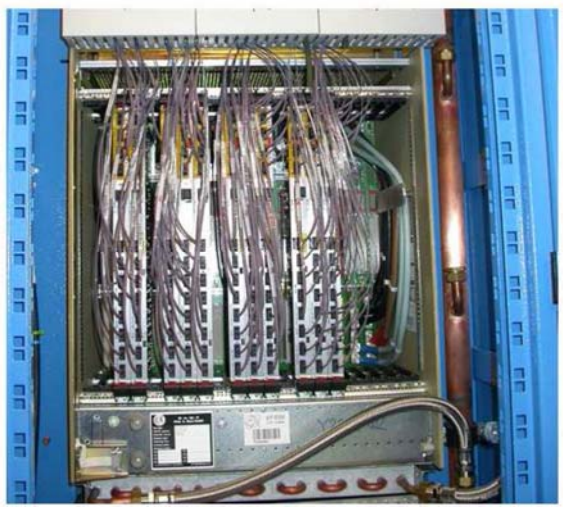
Problem common between Pixel and SCT

- Plug-in failure; VCSEL channels stopping spontaneously
- Failure rate of ~1 - 2 channels per day
- Suspected ESD damage during production (23 / 24 dead devices have shown a shift in the diode IV curve characteristic of ESD)
- We have been able to simulate these delayed deaths using an ESD gun
- It is well known that ESD is the primary cause of early field deaths of VCSELs; so we have very strong reasons for suspecting ESD.

New TX plug-ins

- New production is on-going in Taiwan (with much stricter ESD protection during fabrication); all will be installed prior to physics running later this year
- Will have several installation sessions prior to August





Operations

DAQ, DCS, DQ and Offline

Pixel Detector

- Improved stability and performance of the ROD DSP Code
- Software development / improvements for DAQ, DCS, DQ and Offline

SCT

- Stable and improving throughout the DAQ, DCS, DQ and Offline
- Improvements to operation and performance along the way
- ROD firmware fix resolves problem of decreasing efficiency

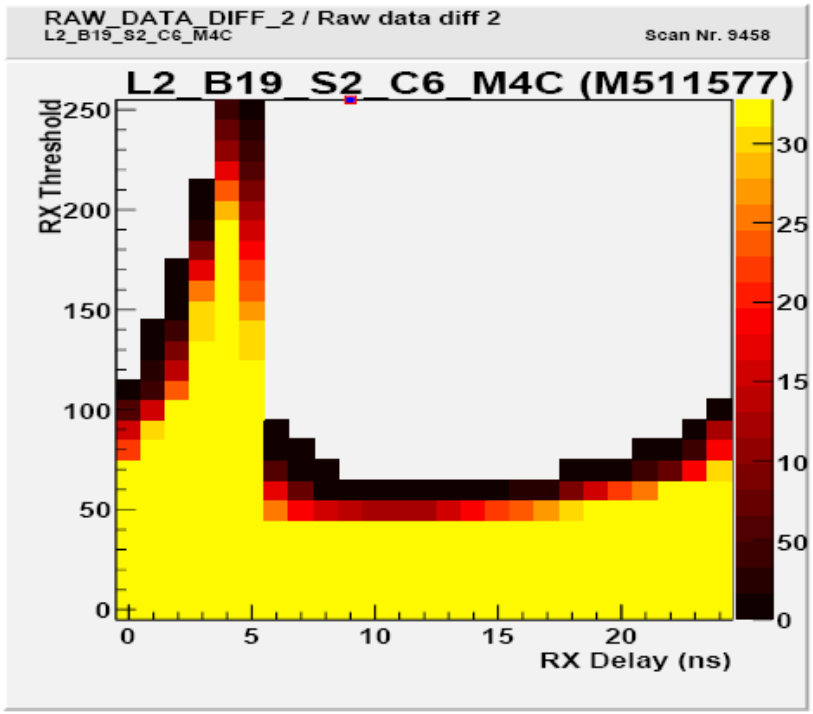
TRT

- Offline software effort directed at code clean-up; preparations for Release 15
- TRT DAQ code improved for better stability in Run State transitions
- Online monitoring working in the latest ATHENA releases at Point 1

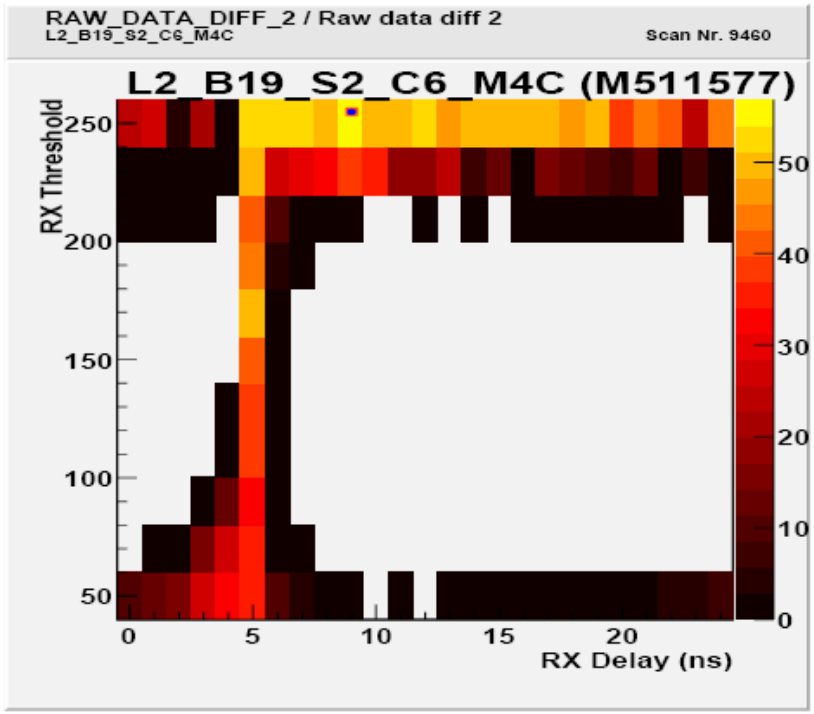
Calibrations (Pixel)

As one example: Optical tuning

- Cannot operate a module without good optical tuning
- Adjust: on-detector laser power, PIN current threshold of the off-detector PIN diode, the off-detector sampling clock delay



Error Rate with a 20 MHz Clock Pattern

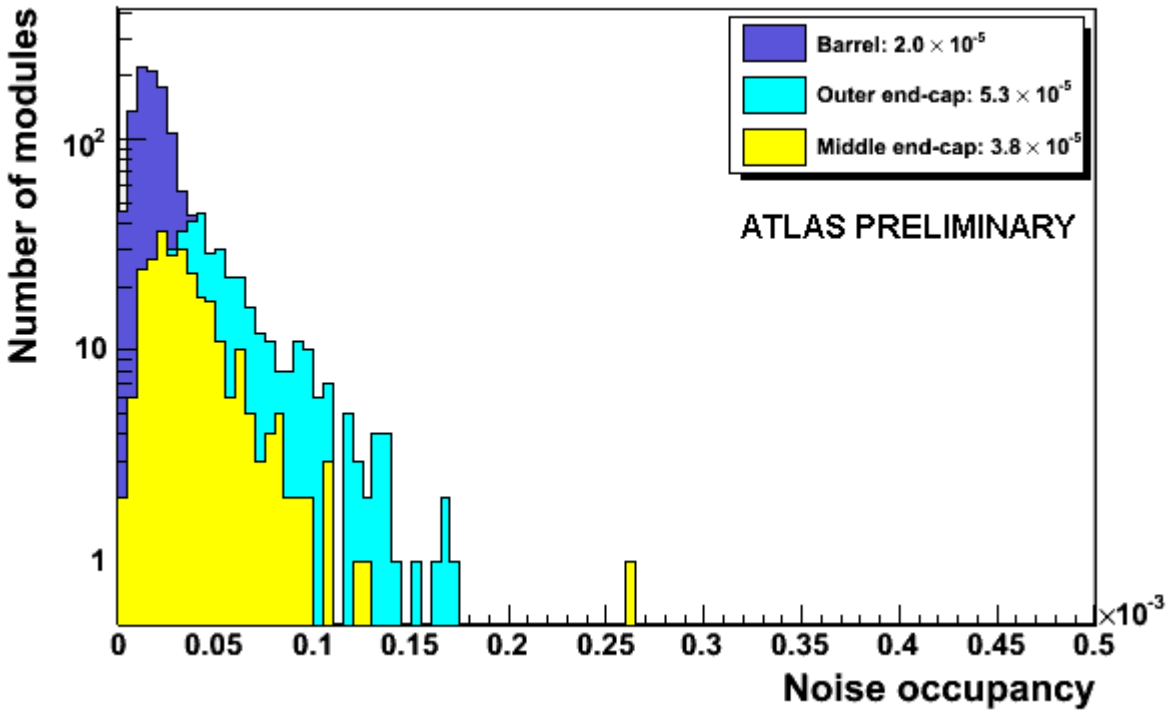


Error Rate with Pseudo-Random Data

Calibrations (SCT)

As one example: Noise occupancy

- Low noise occupancy means that if you have a hit on a strip, it is most likely from a real particle



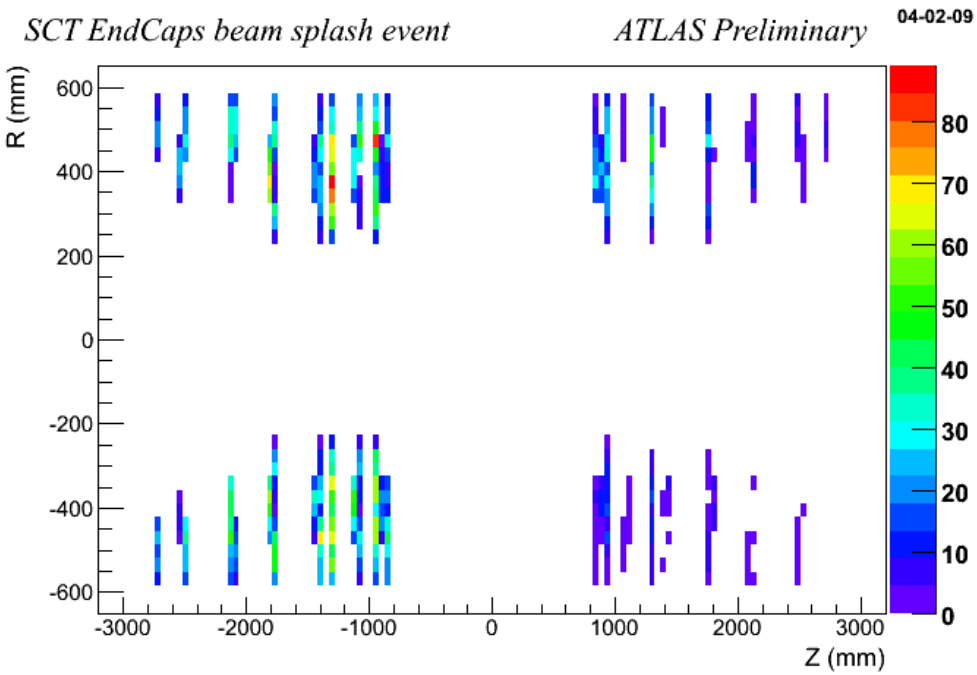
September 10, 2008

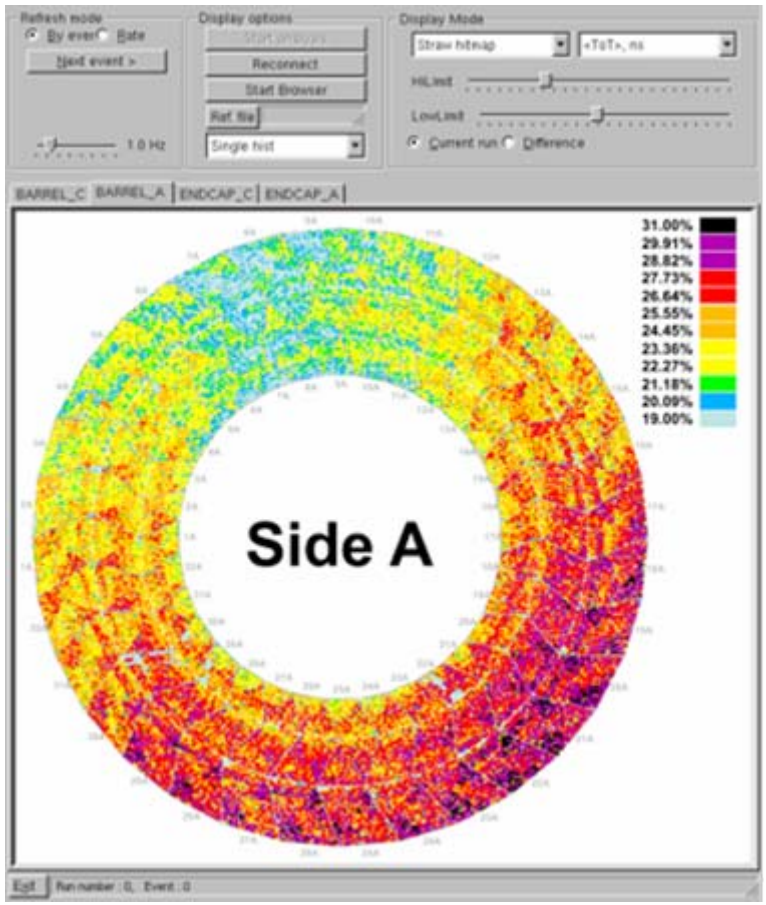
First Beam

- Pixels OFF, SCT Barrel OFF, SCT Endcaps at reduced voltage, TRT ON
- Despite the reduced SCT Endcap voltage, can see a large number of hits in beam splash event

SCT able to check endcap timing at the level of ~25ns with beam splash

TRT barrel timed in to the level of ~1ns; endcap to the level of ~few ns





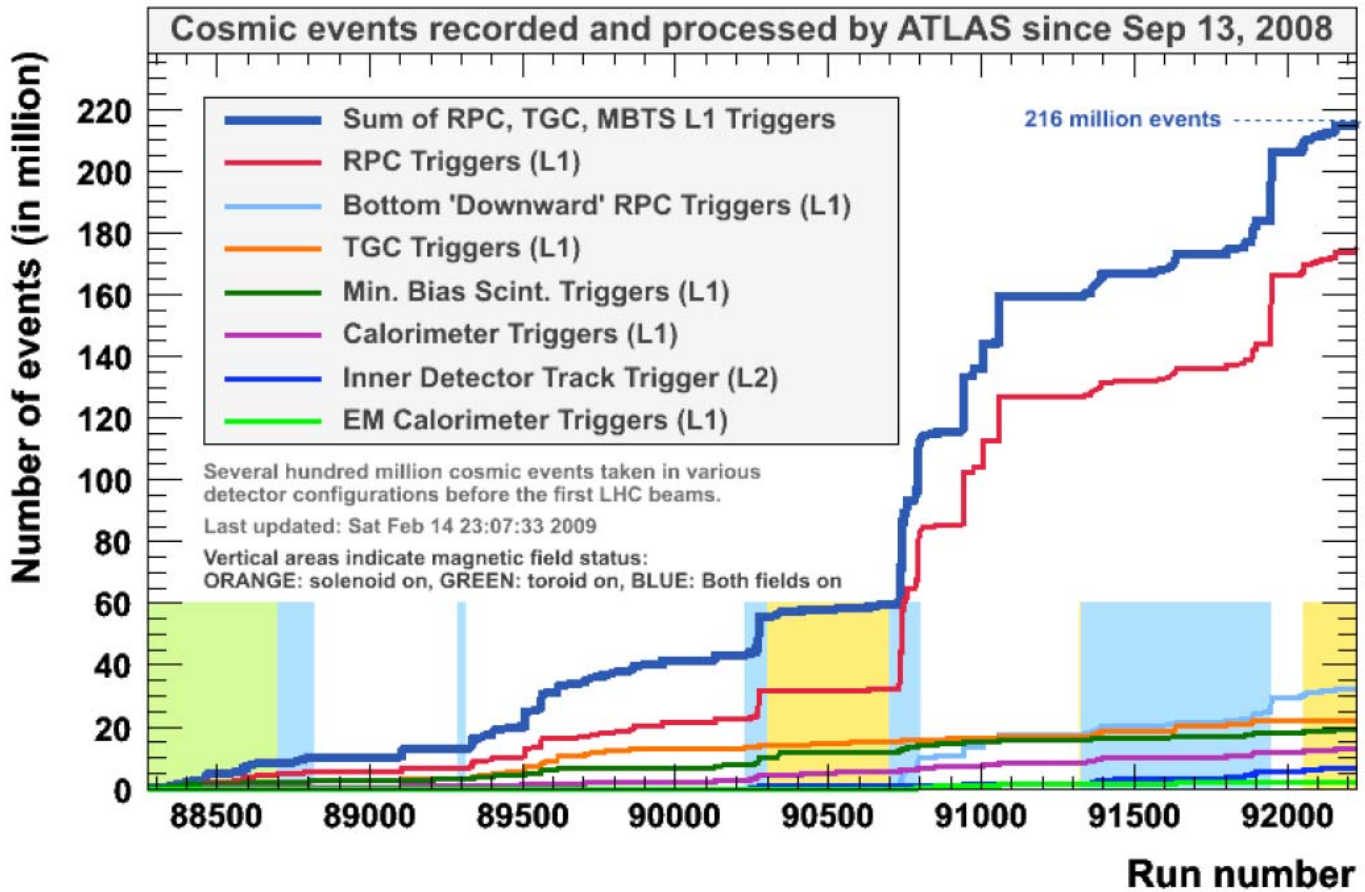
Cosmics Data-Taking

First Pixel cosmics on Sept. 14, 2008

- ATLAS Combined Run Sept. 14 – Oct. 22; B-field ON and OFF
- Main triggers: RPC and TGC at L1; TRT or Silicon at L2

ID Combined Run Nov. 26 – Dec. 1, 2008

- 150 k B-Field OFF cosmics events
- Main triggers: TRT FastOR at L1; TRT or Silicon at L2



Data-taking Overview

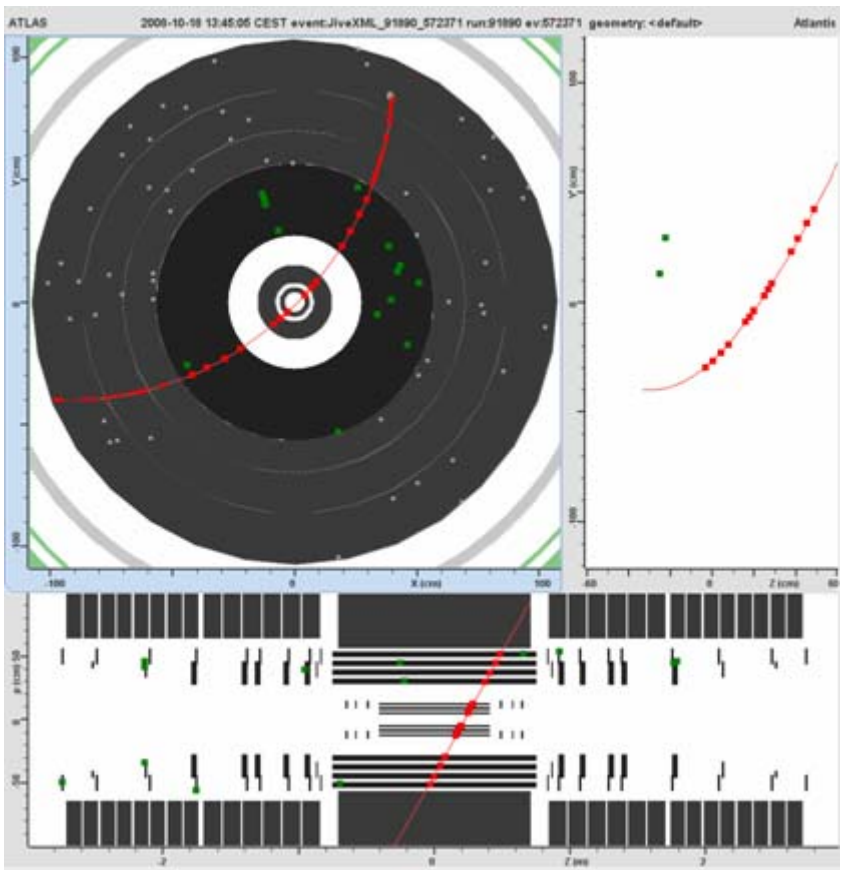
Cosmic events recorded with B-field ON:

- 2.6 M ID tracks; 880 k with SCT hits; 190 k with Pixel hits

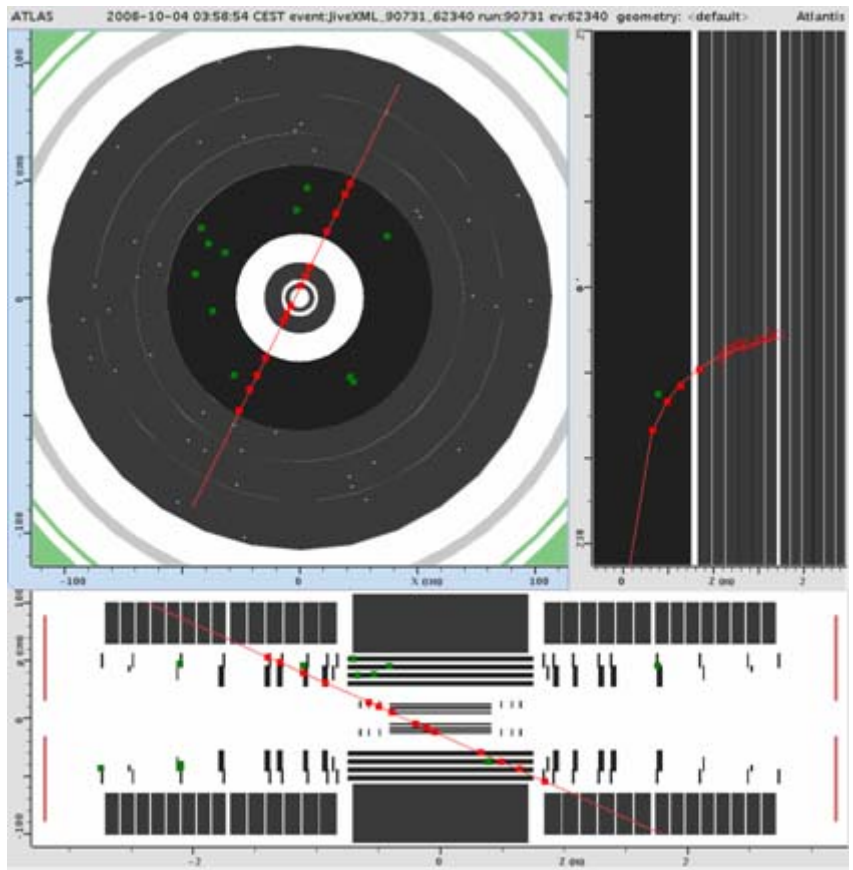
Cosmic events recorded with B-field OFF:

- 5 M ID tracks; 2 M with SCT hits; 230 k with Pixel hits

Extremely useful for alignment studies (See Oleg Brandt's talk)



B-field ON

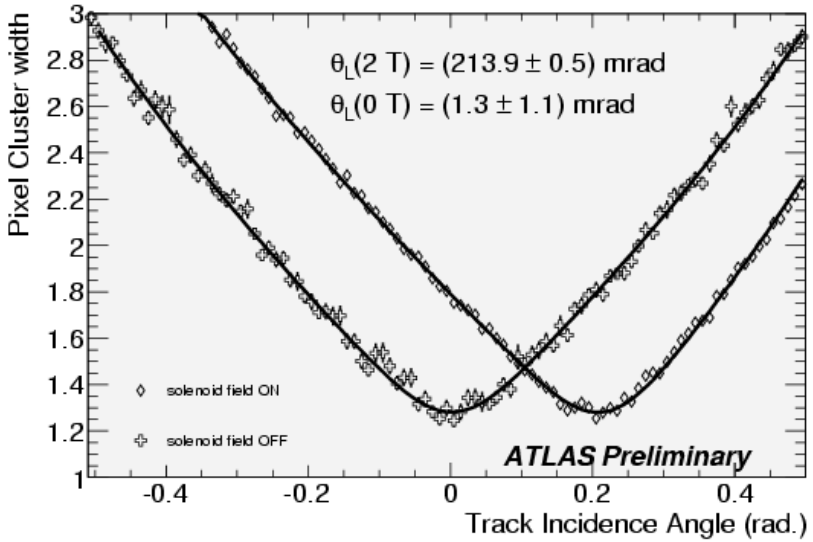


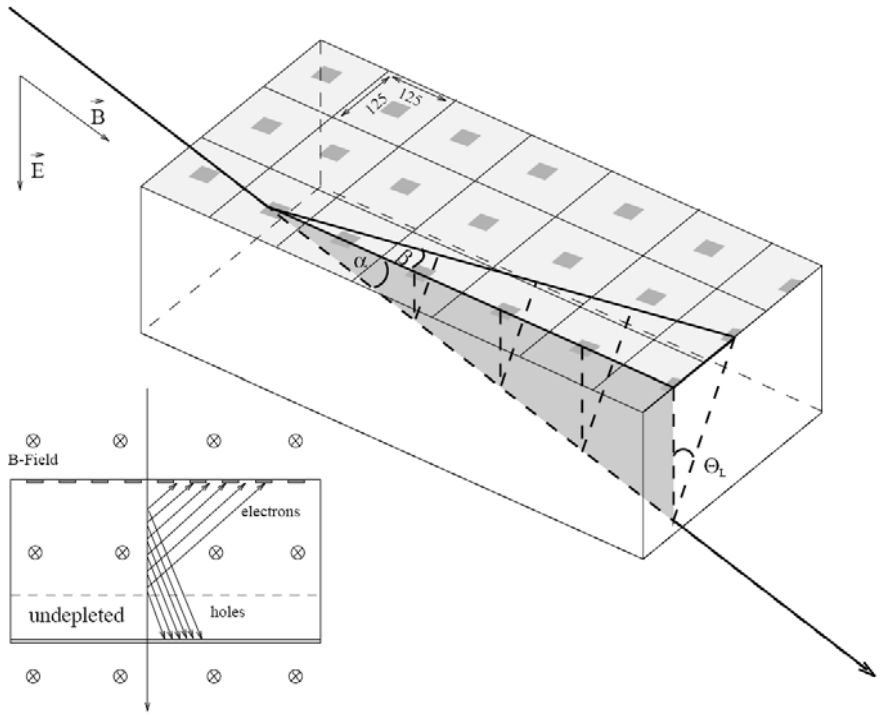
B-field OFF

Commissioning Results (Pixel)

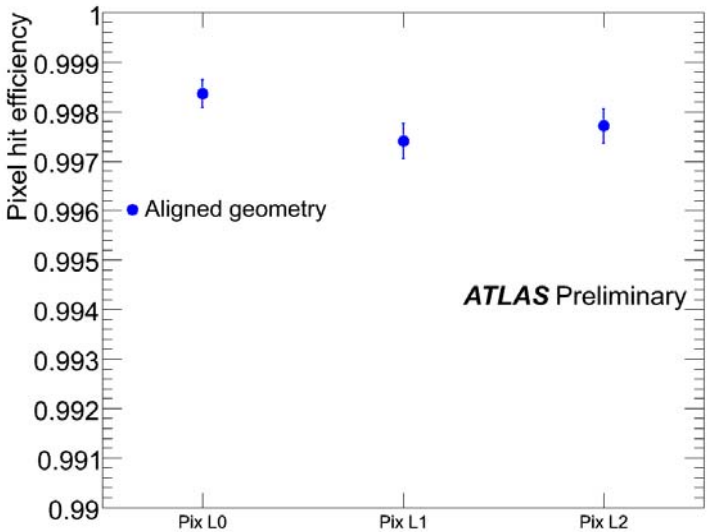
Lorentz Angle measurement (understanding is crucial for alignment)

- Quantifies the electron drift in the sensor due to the magnetic field





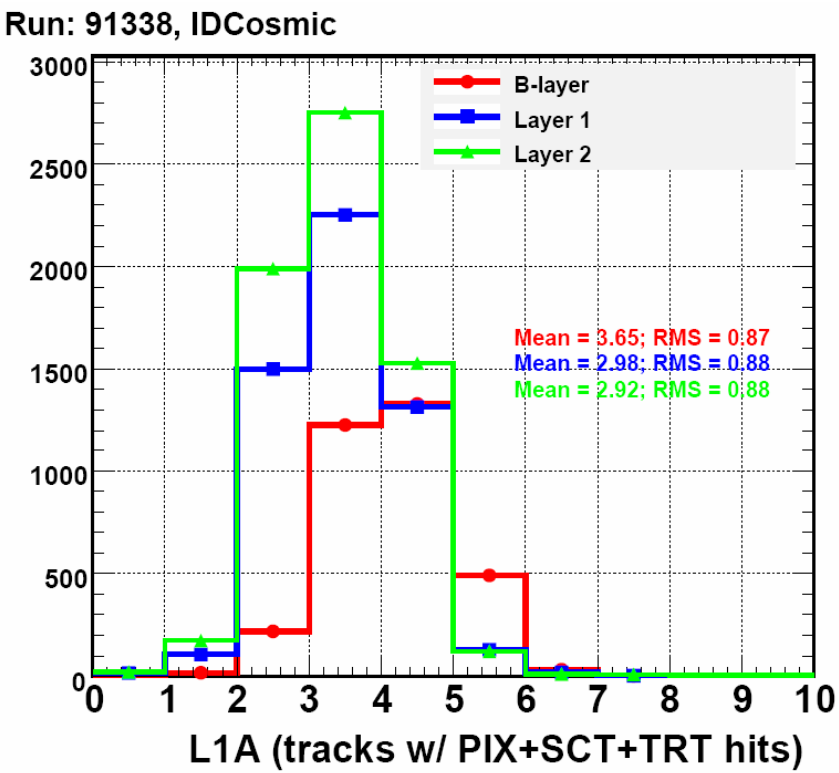
Hit efficiency



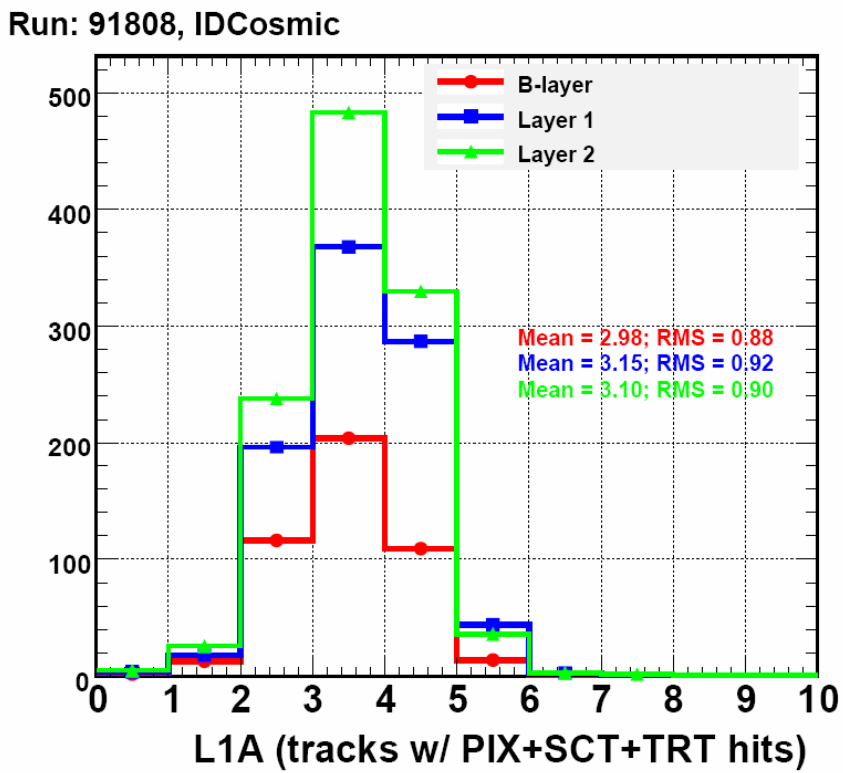
Commissioning Results (Pixel)

Pixel Timing Studies

- Proper calibration → Proper ToT measurement
- Leads to higher precision in clustering and better vertexing



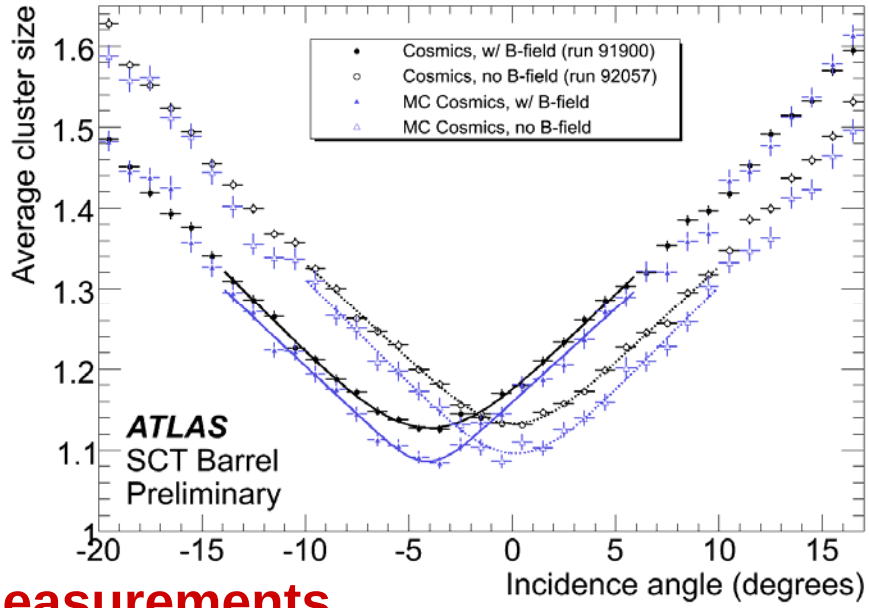
Before adjustment: Run 91338



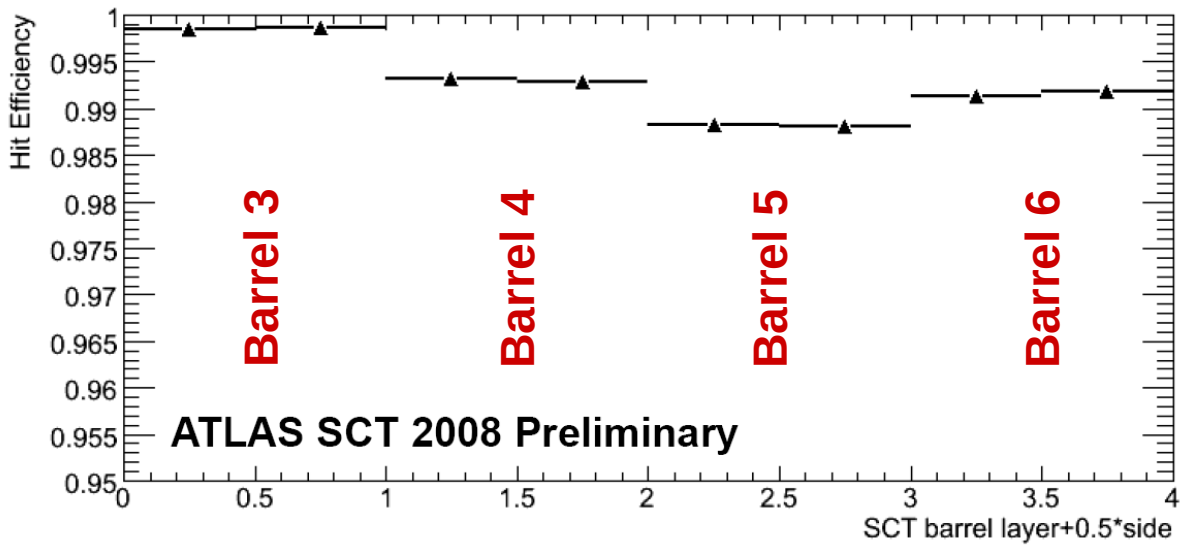
After adjustment: Run 91808

Commissioning Results (SCT)

Lorentz angle measurement



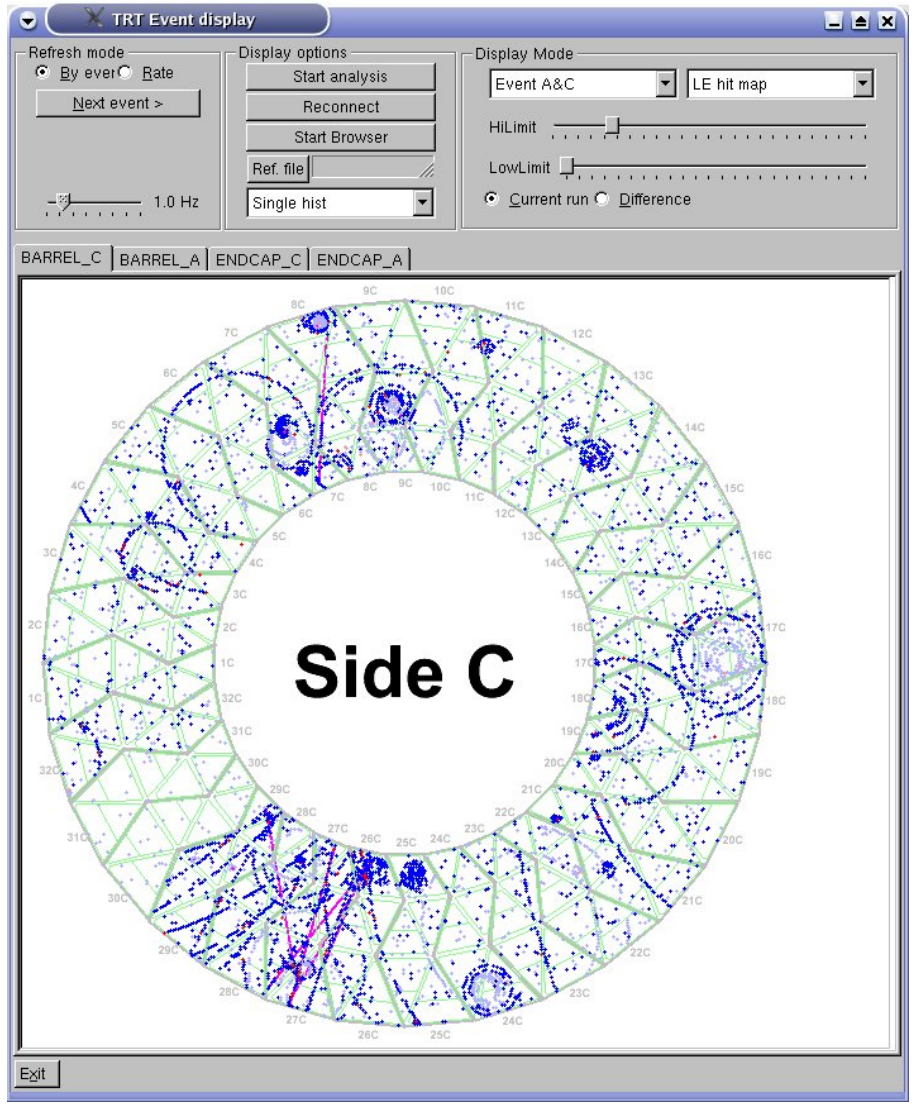
Barrel efficiency measurements



Commissioning Results (TRT)

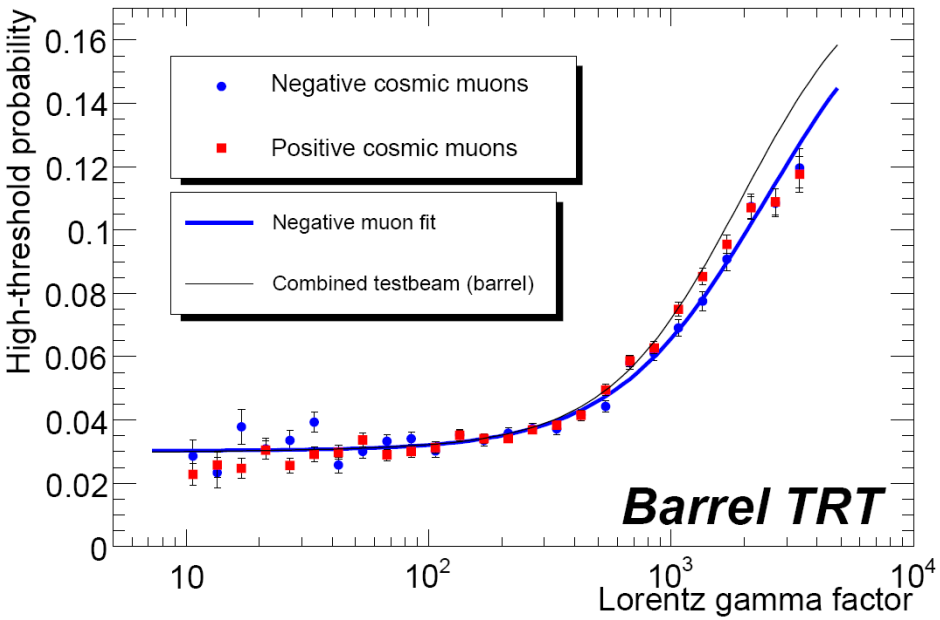
Cosmics data-taking with B-field on

- Produced bubble-chamber like event displays as low-momentum particles curl within the detector volume



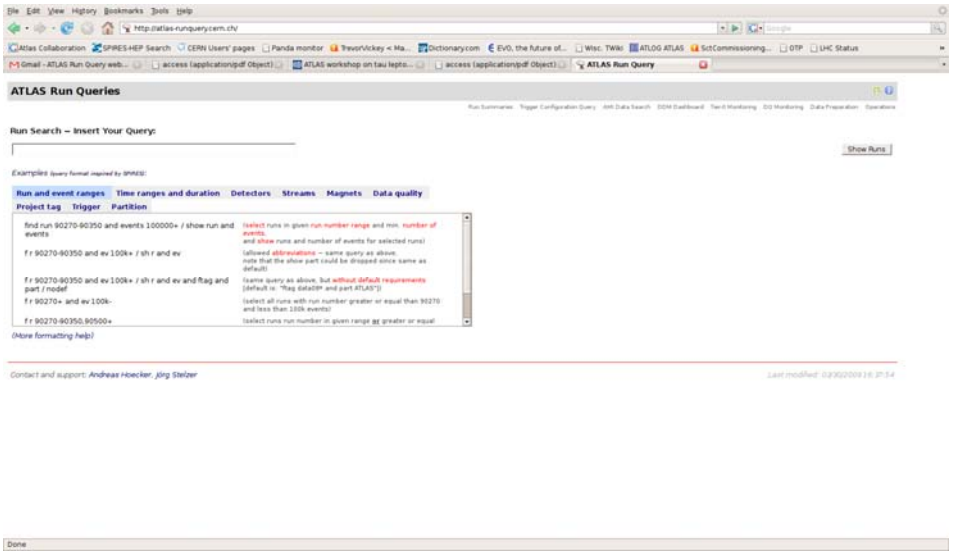
Turn-on of transition radiation

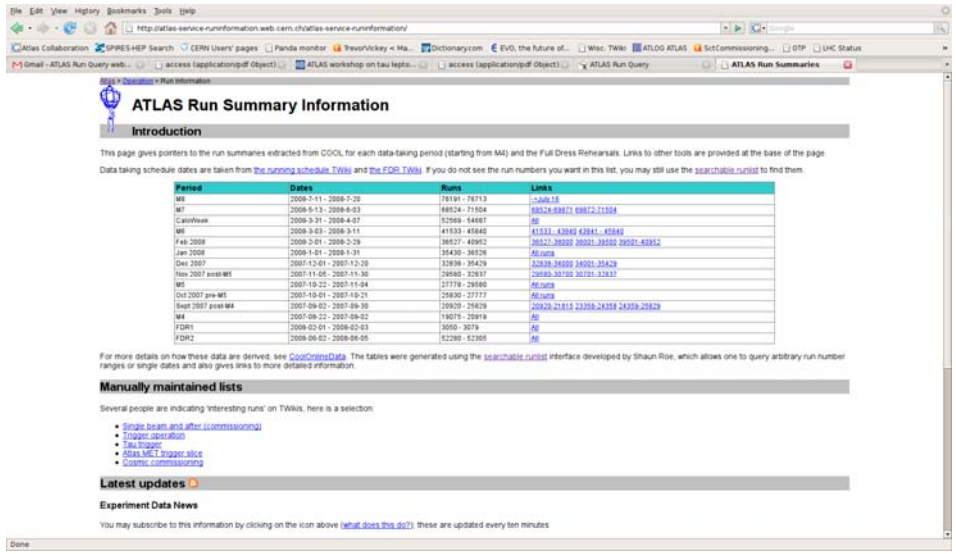
- Measured using cosmic muons



If You're Interested in Real Data…

There are a few ways to find the exact runs that you need





ATLAS Run Summary Information webpage

- Contains links to DQ plots, Trigger Table, B-Field status, etc.
- http://atlas-service-runinformation.web.cern.ch/atlas-service-runinformation

ATLAS Run Queries webpage

- Search for runs with specific numbers of events
- http://atlas-runquery.cern.ch

Conclusions

Extremely successful commissioning with first beam and cosmics

- Many performance notes for each sub-system are now being drafted
- Commissioning will continue into the collision era (e.g., endcap alignment)

Pixels

- Improvements on-going for many software aspects
- Should have all replacement TX plug-ins installed prior to 2009 physics running
- Will operate the 4 affected cooling loops in May – June and evaluate them

SCT

- Continue DAQ, DCS and Firmware developments, improvements and upgrades
- For 2009, 115 / 116 cooling loops will be operated
- Should have all replacement TX plug-ins installed prior to 2009 physics running

TRT

- Plan to improve Active Gas by fixing small leaks and studying the system
- Continue to refine DAQ, DCS and Offline software

Outlook for 2009 / 2010

- All sub-systems are in good shape and looking forward to first collisions!
- Streamline the 24 h calibration loop using express stream data, running on the CAF (CERN Analysis Facility)

Backup Slides