Atlas SemiConductor Tracker final integration and commissioning

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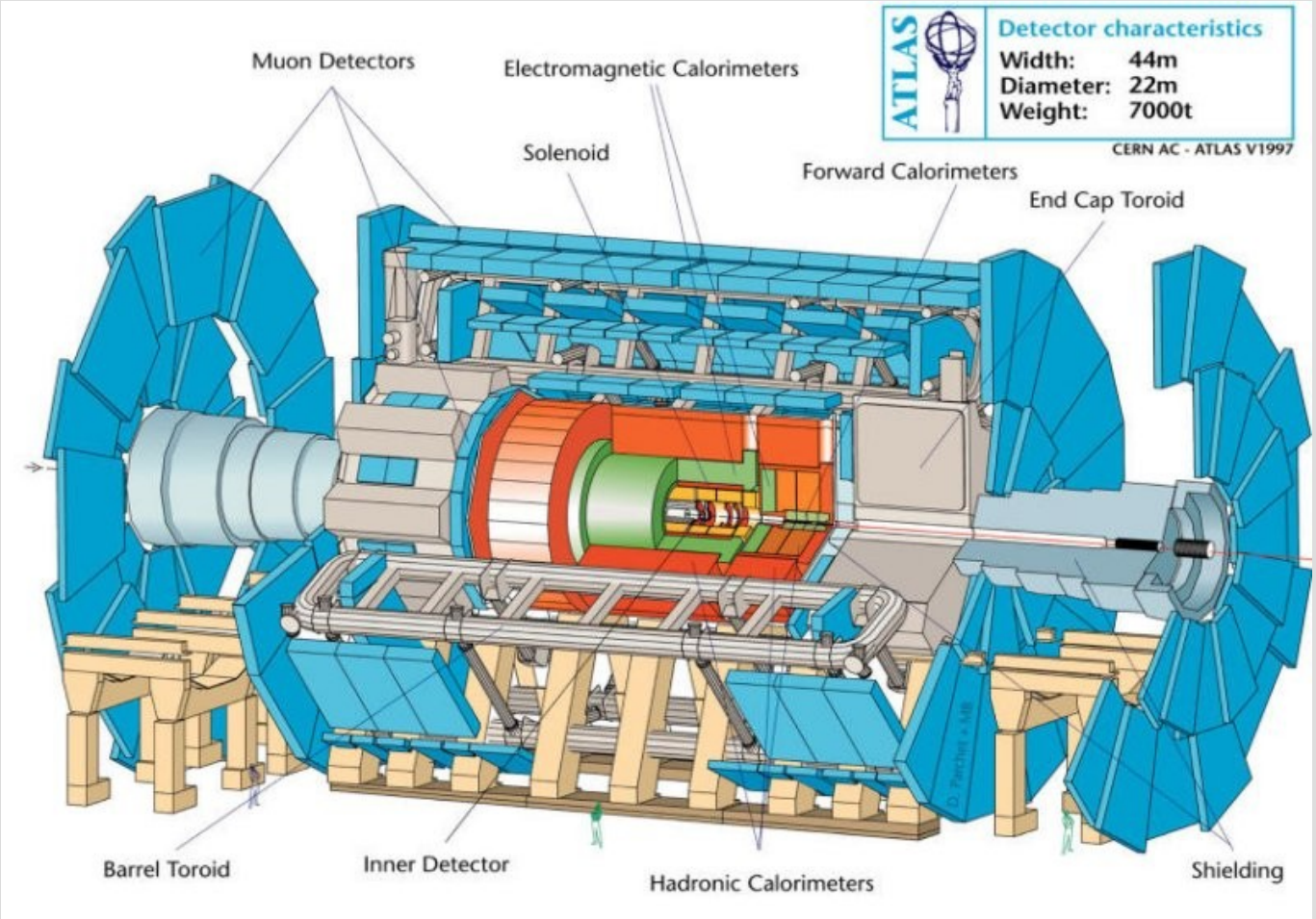
On behalf of the SCT collaboration

Outline

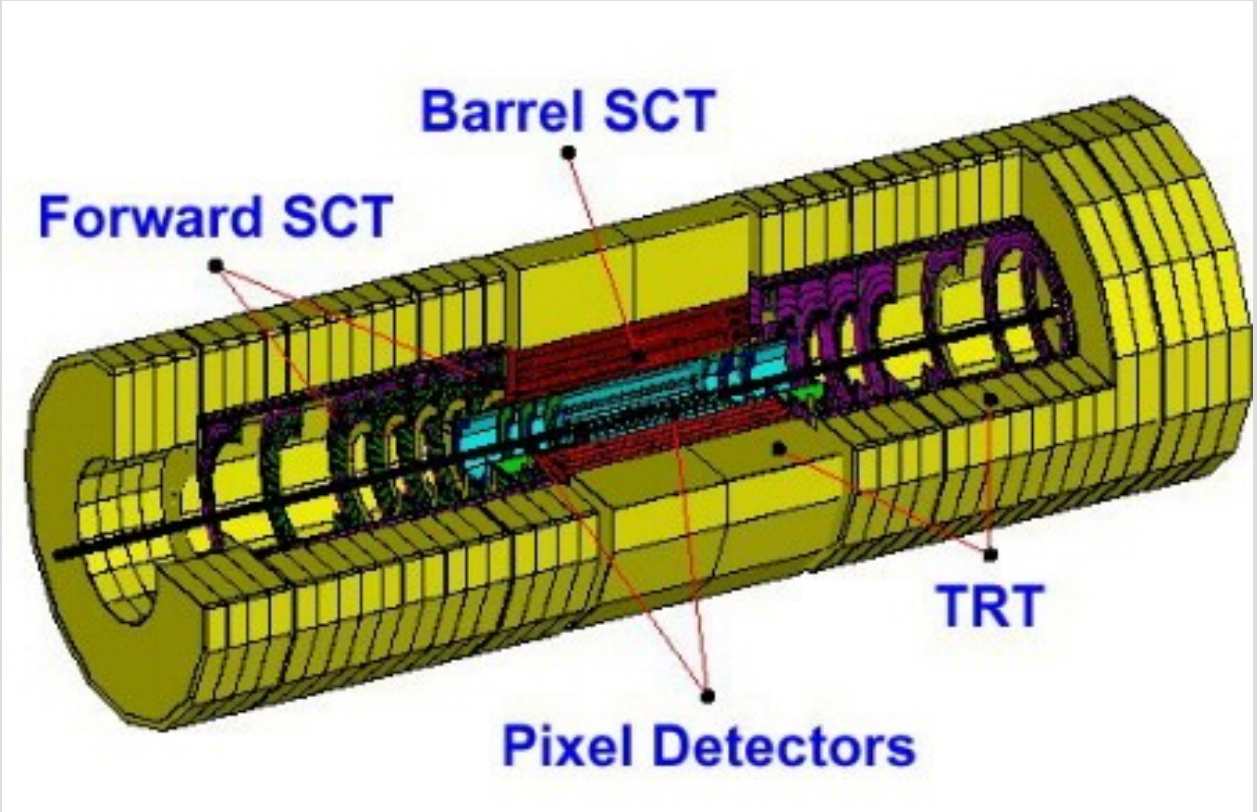
- The Atlas and SCT detectors
- Detector integration and commissioning on surface
  - DCS
  - Noise studies
  - Cosmics data
- Detector commissioning underground
  - Noise studies
- Conclusions and Outlook

A Toroidal Lhc ApparatuS



- The Atlas Detector is divided into several subdetectors
- Out of them, 2 systems are using silicon sensors technologies:
- SCT
- Pixels

The Inner Detector



Tracking in Atlas

TRT: 96 modules + 28 wheels Straw tubes
SCT: 4 layers + 18 disks Si strips
Pixels: 3 layers + 6 disks Si pixels

Covers from R=5 cm up to R=1.2 m and sits inside a 2 T magnetic field provided by a superconducting solenoid.

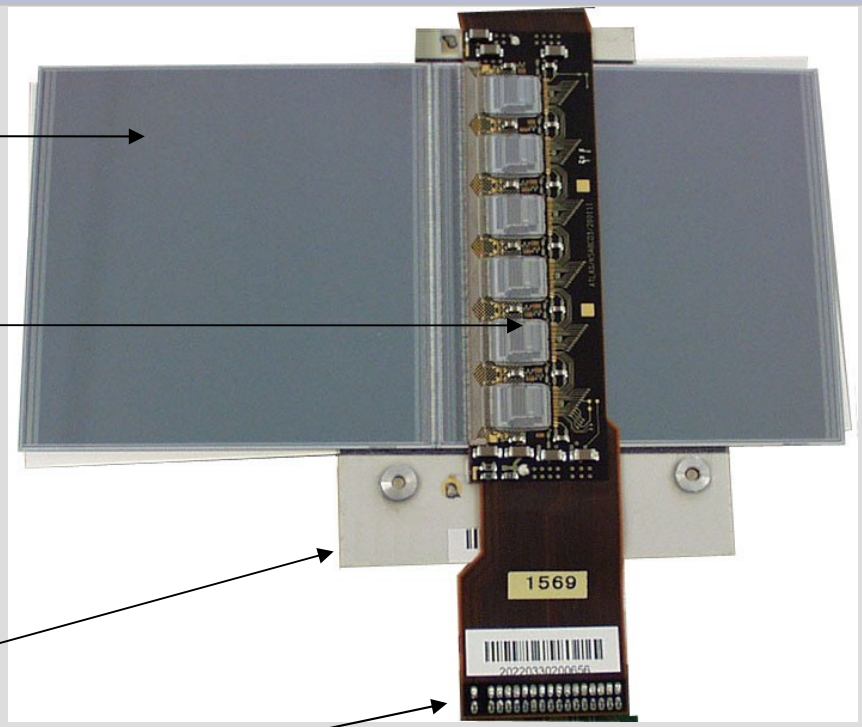
The SemiConductor Tracker

A factual tour...

- 61 m^2 of Si resulting in 6.2 million readout channels
- Barrel : 2112 modules (1 type), coverage $|\eta|<1.1-1.4$
- End-Cap : 1976 modules (4 types), coverage $1.1-1.4<|\eta|<2.5$
- Operation temperature : -7 °C (on the Si sensor)
- Radiation hardness : $2x10^{14}$ 1-MeV neutron equivalent $\cdot cm^{-2}$ (10 years LHC)
- Low material budget
- Modules : double-sided, with optical communication (CLK/COM + data)
- Power consumption : 5.6 W/module (10 W after 10 years of LHC)

The Barrel module

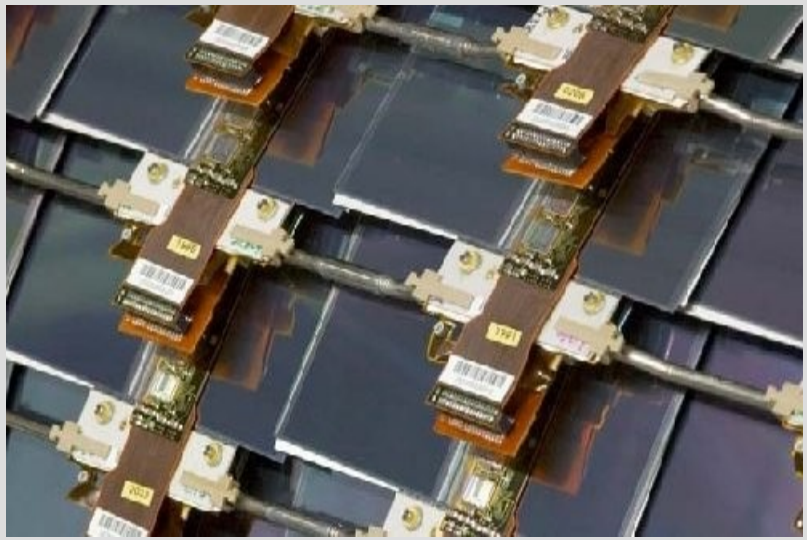
- 4 p-on-n sensors (285 μm thick) from Hamamatsu, strip length = 12 cm pitch = 80 μm
- Maximum bias voltage = 500 V
- 12 binary ABCD readout chips (6 on each side, radiation hard DMILL technology) on Cu/Polyimide flexible circuit hybrid
- Stereo angle = 40 mrad
- BeO Facings and Central TPG (thermal pyrolithic graphite) baseboard for sensor cooling and mechanical base
- Connector for power and data



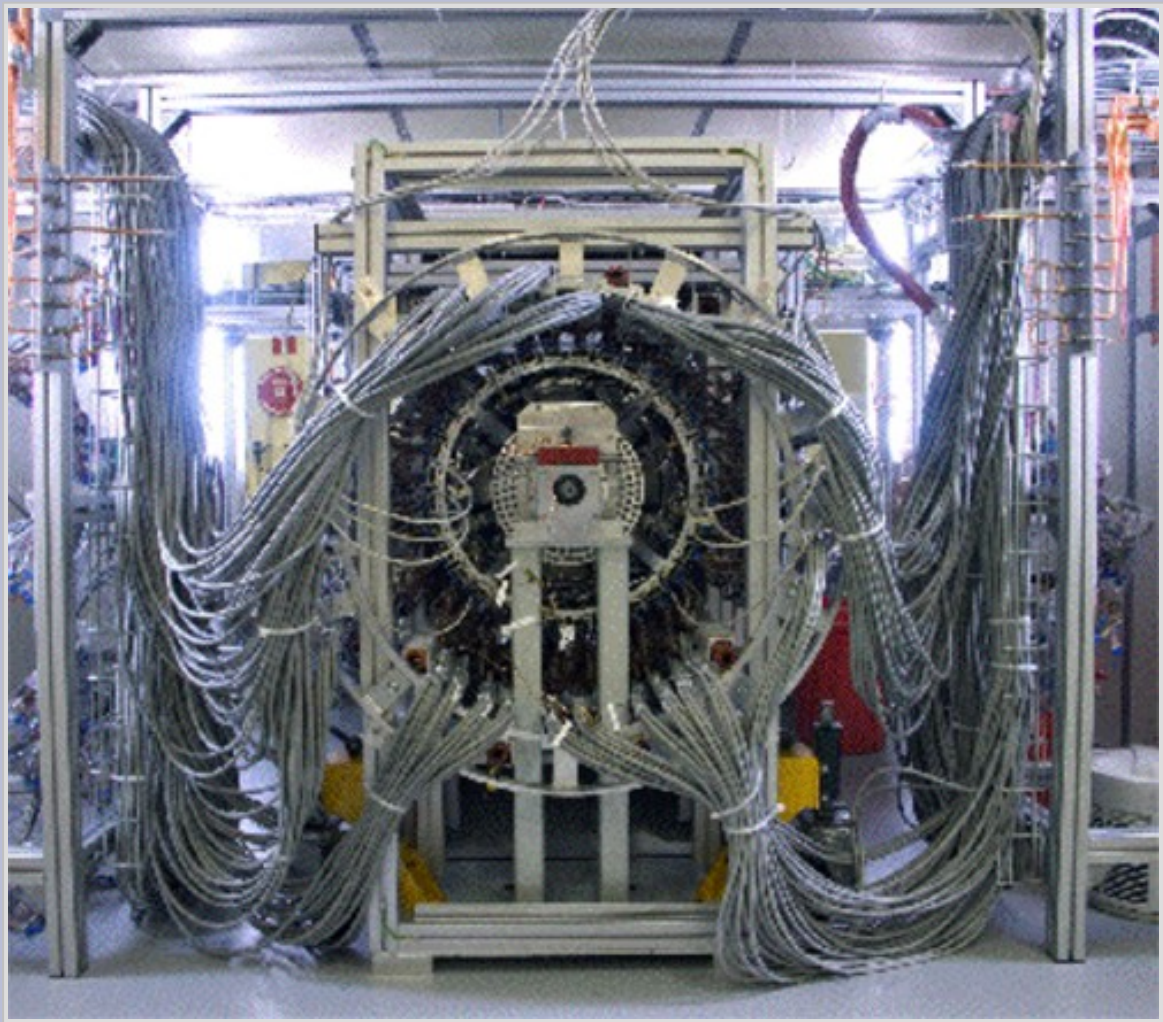
The End-Cap modules are similar except for geometry (4 types of wedge-shaped modules depending on position)

Barrel Assembly

- Modules assembled into Barrel in Oxford
- Mounted by a Robot on 4 carbon fiber lightweight barrels
- Cu/Ni cooling pipe running along the modules (70 μm wall thickness) using C_3F_8 as coolant
- Modules serviced by Kapton/Al low-mass tapes (LMT) for power and hybrid temperature readings (used for PS firmware interlock)



Reception testing

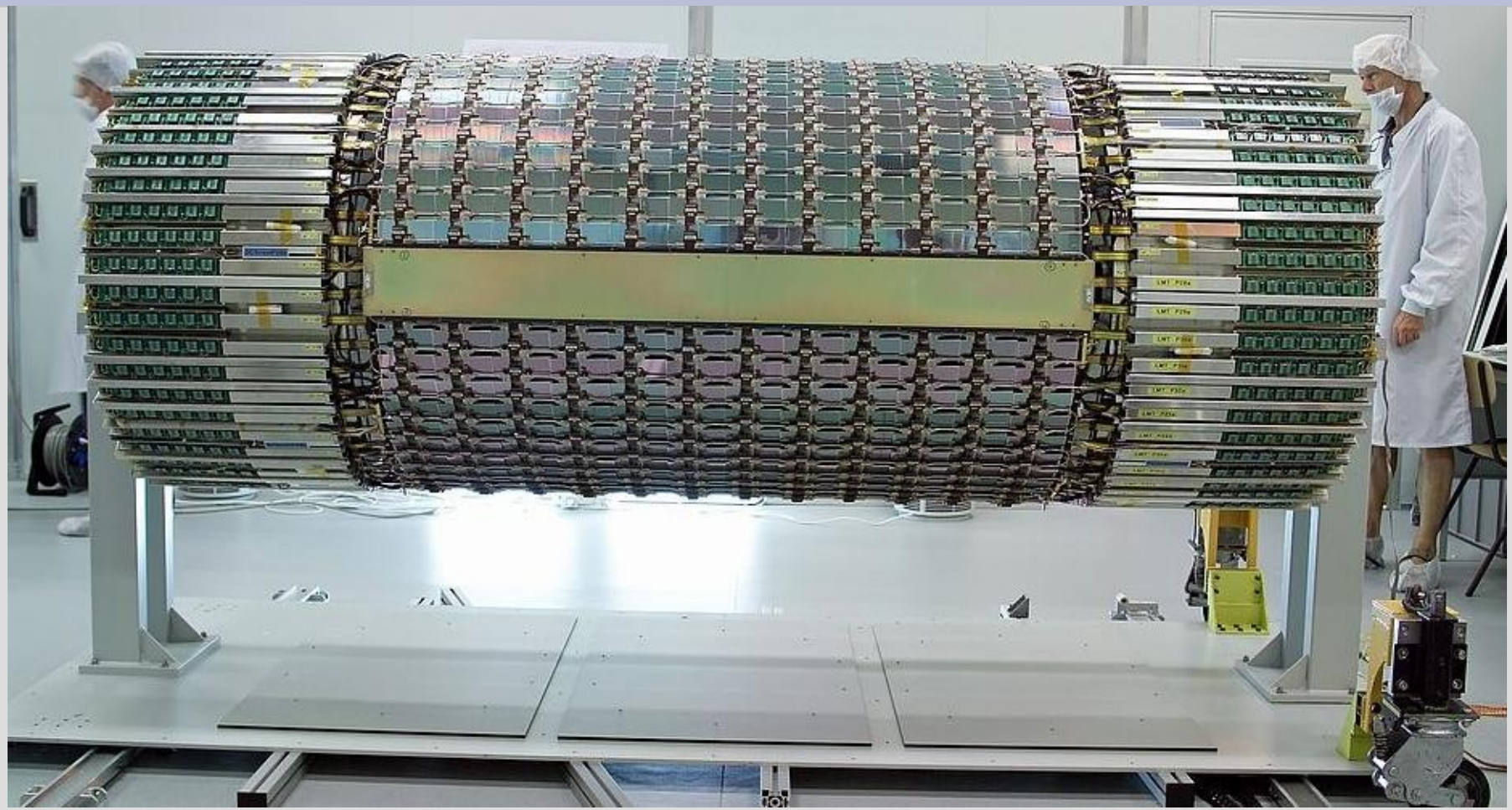


Single barrel tests after reception at CERN
Dec 2004–July 2005

Were tested:
- Cooling uniformity+stability
- DAQ & DCS operations
- Noise performance
- Signal response

Results:
Module condition unchanged compared to module production

4-barrel Assembly



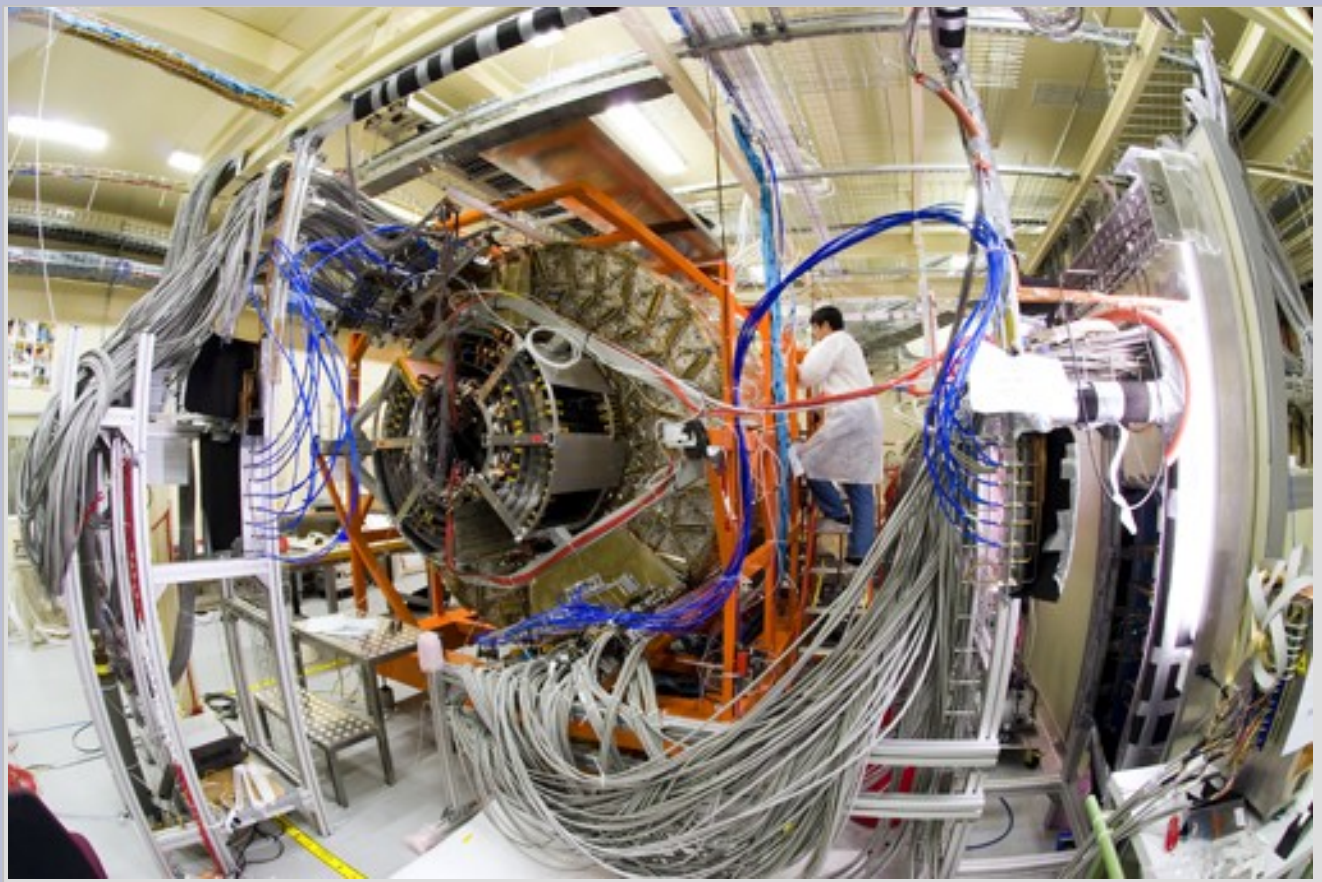
Individual barrels received at CERN and assembled into one SCT Barrel

ID barrel integration

February 12, 2006

CERN

ID combined tests



¼ of the SCT Barrel and 1/8 of the TRT Barrel cabled up for these tests.

Goals:

- Retest after integration
- Exercise the detector and the DAQ for cosmics data taking

Detector Control System

In parallel to the detector assembly, the DCS was developed to provide safe operation of the SCT.

It includes the control and monitoring of:

- Power supplies
- Environmental conditions (Temp, Humi)
- Cooling

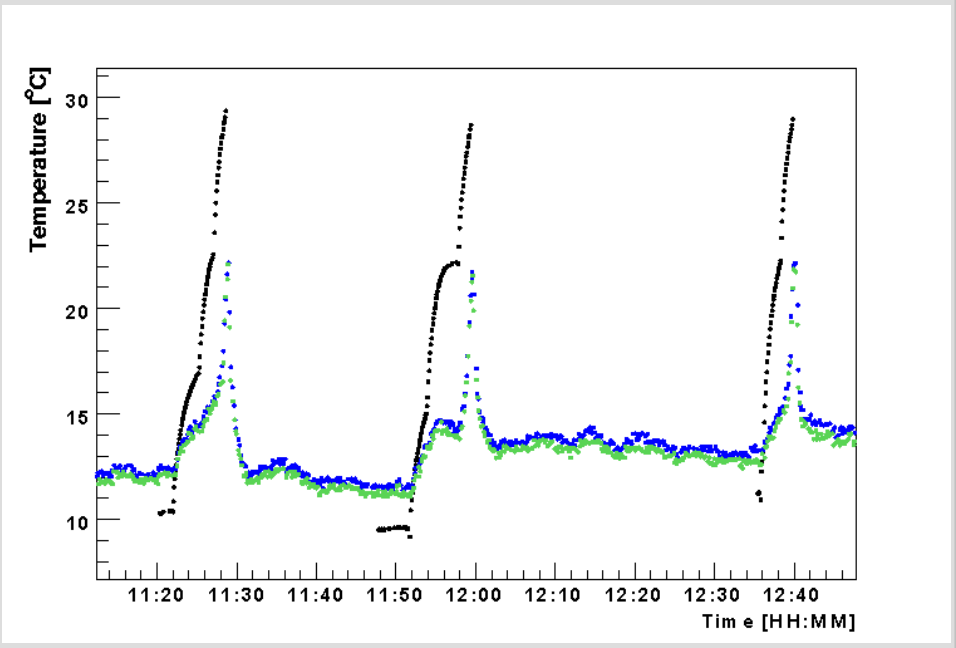
A hardware interlock on cooling temperature adds an extra protection to the software controls.

The ID combined test were a good opportunity to test these systems and get experience for the final installation.

DCS experience

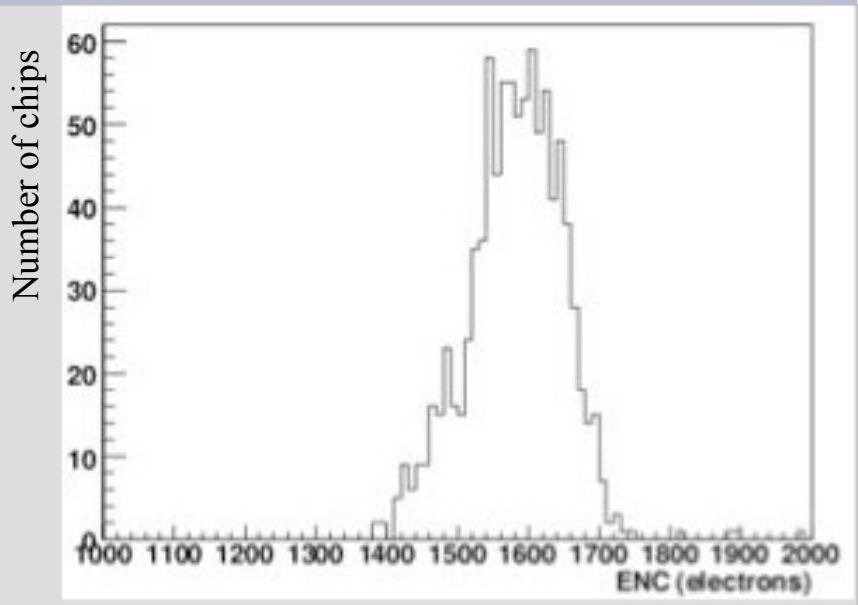
- Worked really well during all tests on surface
- Allowed for communication with the DAQ
- Final (or close to) hardware used
- Software went through great development

A blocked pipe could be detected through the DCS.
Blue and Green lines are temperature sensors on this pipe and black line the hybrid temperature.
Good reaction time of the interlock



Barrel Input Noise Results

- Modules tested at ~30 °C
- <ENC>~ 1600 e^-
- Input noise corresponds to module production (after temperature correction)
- Reduces at final operation temperature by ~ 5e^-/C * 30 °C



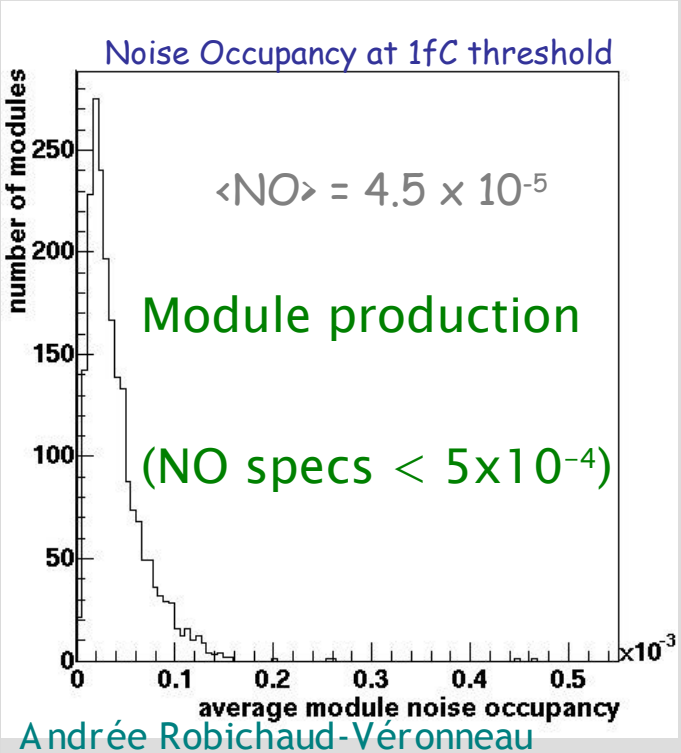
99.8% of the SCT channels after integration were functional

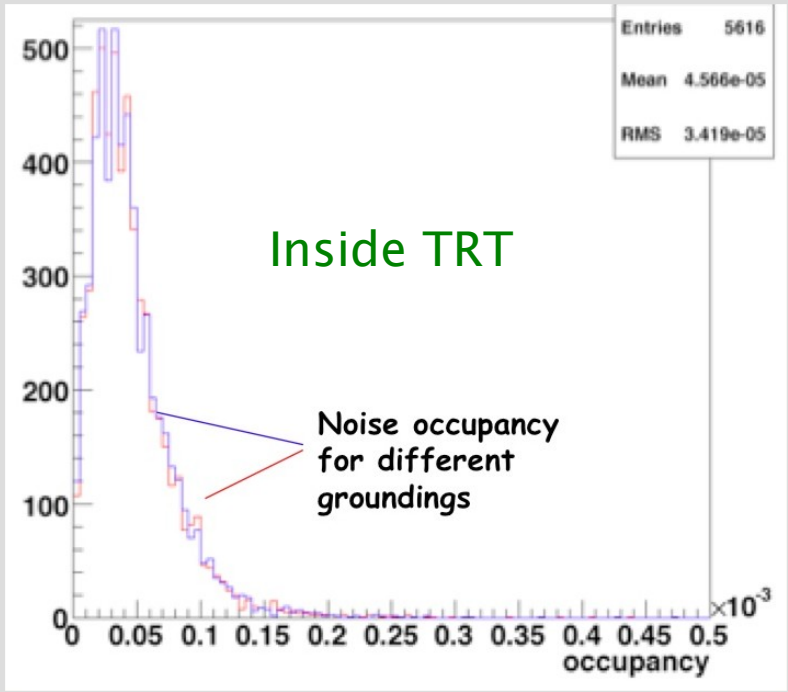
0.03% of channels lost since single barrel tests

Barrel Noise Occupancy

Found no evidence of significant change of NO found during

- Synchronous operation of 4 Barrels
- With different trg rate (5Hz–50kHz)
- With TRT on / off
- With heaters on – off – switching
- With different grounding scheme
- SCT FE noise during TRT readout cycle





Barrel Cosmics

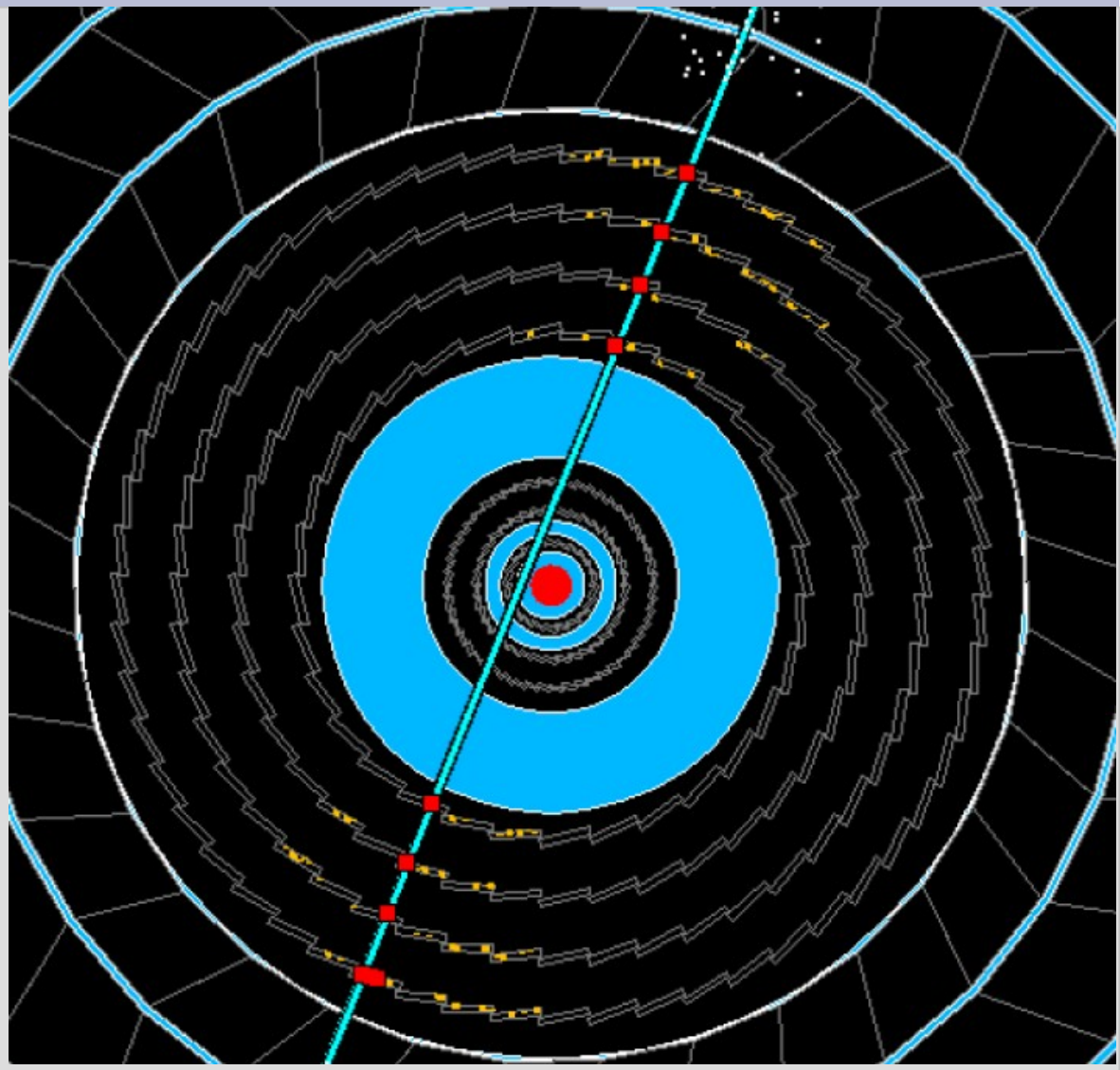
450 k events taken from March to June 2006

- ~70 % good tracks

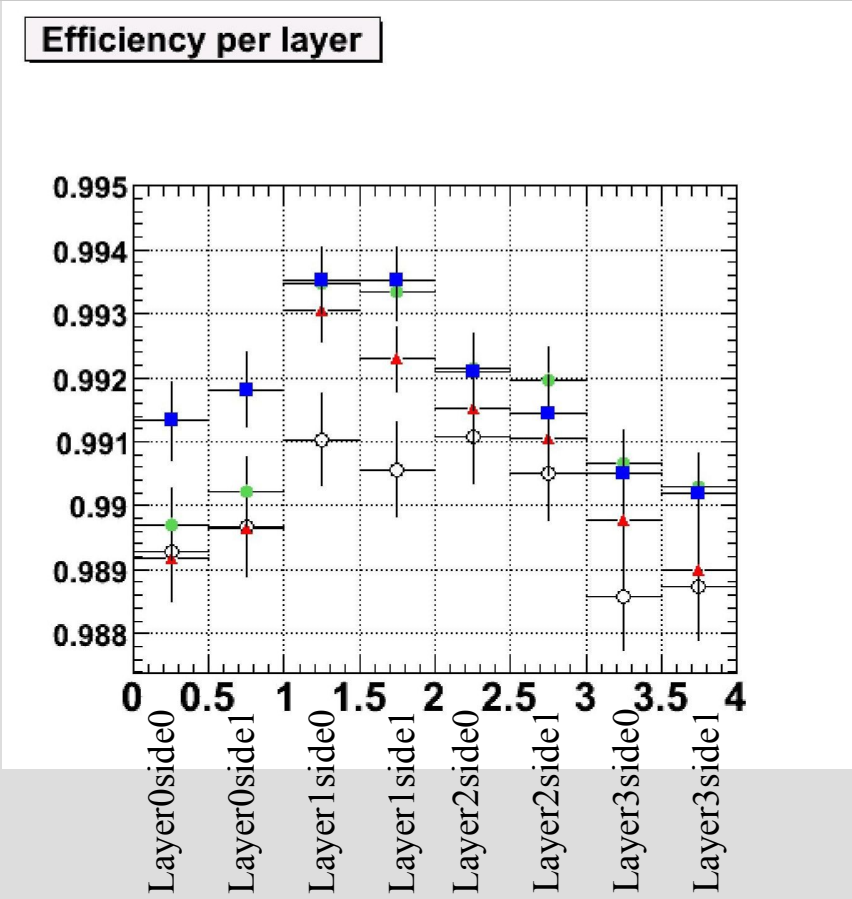
Run at nominal threshold (1 fC)

Allowed for testing of:

- Online monitoring
- Event Display
- Offline reconstruction
- Alignment



Barrel Hit Efficiency



Efficiency = #Observed Hits / #Expected Hits

- Nominal geometry (open circles)
- Global χ^2 (squares)
- Local χ^2 (filled circles)
- Robust (triangles)

Efficiency per layer > 98.8 %

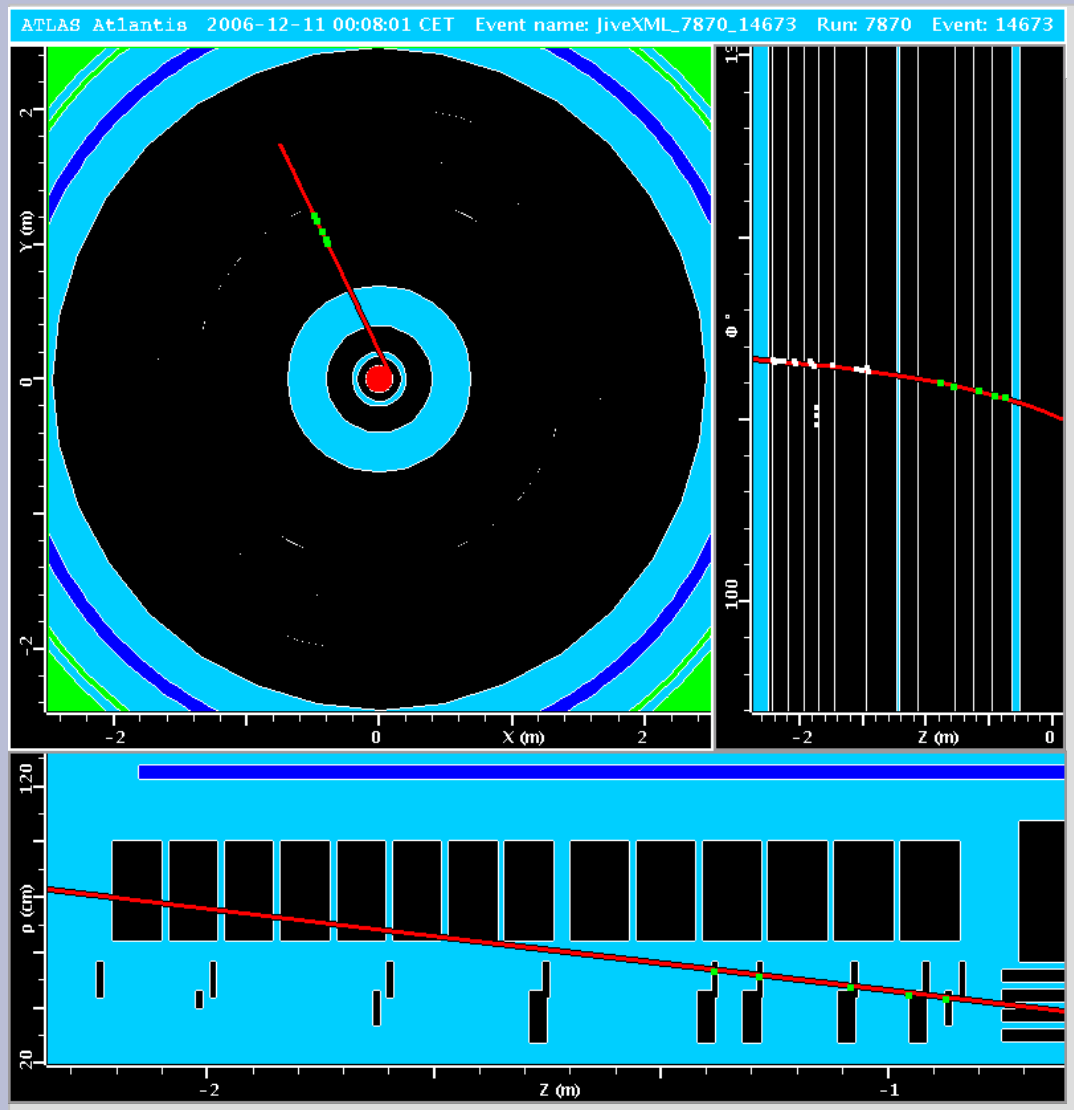
Global χ^2 gives the best results

End-Cap Integration

- 2 identical ECs assembled using mechanical module mounting jig in NIKHEF and Liverpool
- ECs received at CERN in 2006
- Went through similar testing phases as barrel
- Only one EC underwent combined testing with TRT

No change in Noise Occupancy after integration with TRT for both End-Caps

EC C Cosmics



~167 k events taken in December 2006

Scintillators placed to catch horizontal tracks

No dependence on trigger rate in physics mode detected

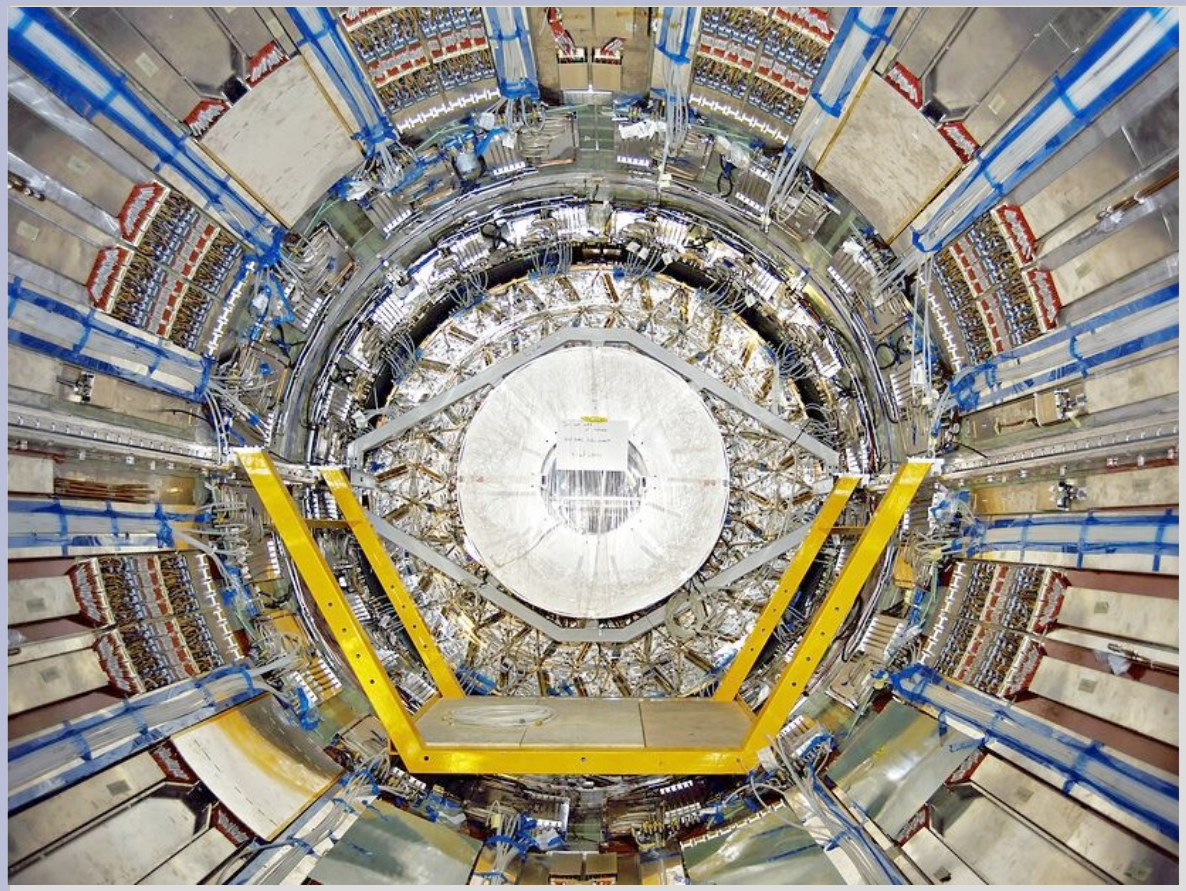
No influence from TRT activities

Surface tests Summary

- All three detector parts (barrel, end-cap A, end-cap C) have been tested successfully
- No significant influence of TRT on SCT activities
- Noise Occupancy is within expected limits
- Offline software was tested with real data
- Experience gained with several monitoring tools (DCS, Online monitoring, Event display)
- Experience gained also for the DAQ in physics mode (with cosmics data)

=> All the experience acquired will now be used in Atlas commissioning

ID integration in ATLAS



- ID Barrel lowered in the Atlas pit in Aug. '06
- Cabling and testing was completed Feb. '07
- EC A was lowered May 25th
- EC C was lowered June 18th
- The SCT Barrel is now integrated with Atlas central DAQ & DCS

SCT ECs will be cabled and tested this summer to participate in Atlas commissioning this fall

Barrel Pit Sign-off

- March '07, all SCT Barrel modules were re-tested with evaporative cooling on (see next slide for details)
- Final versions of the DAQ and DCS software were also commissioned

Runs were taken for the following configurations:

- 7971: TRT on
- 7974: TRT on but with ground shorted
- 7977: with TRT off

For these runs, only ¾ of the barrel was readout.

Noise occupancy and TRT pick up were studied.

Evaporative Cooling

Overall good performance of the cooling system during barrel sign-off (from the detector point of view)

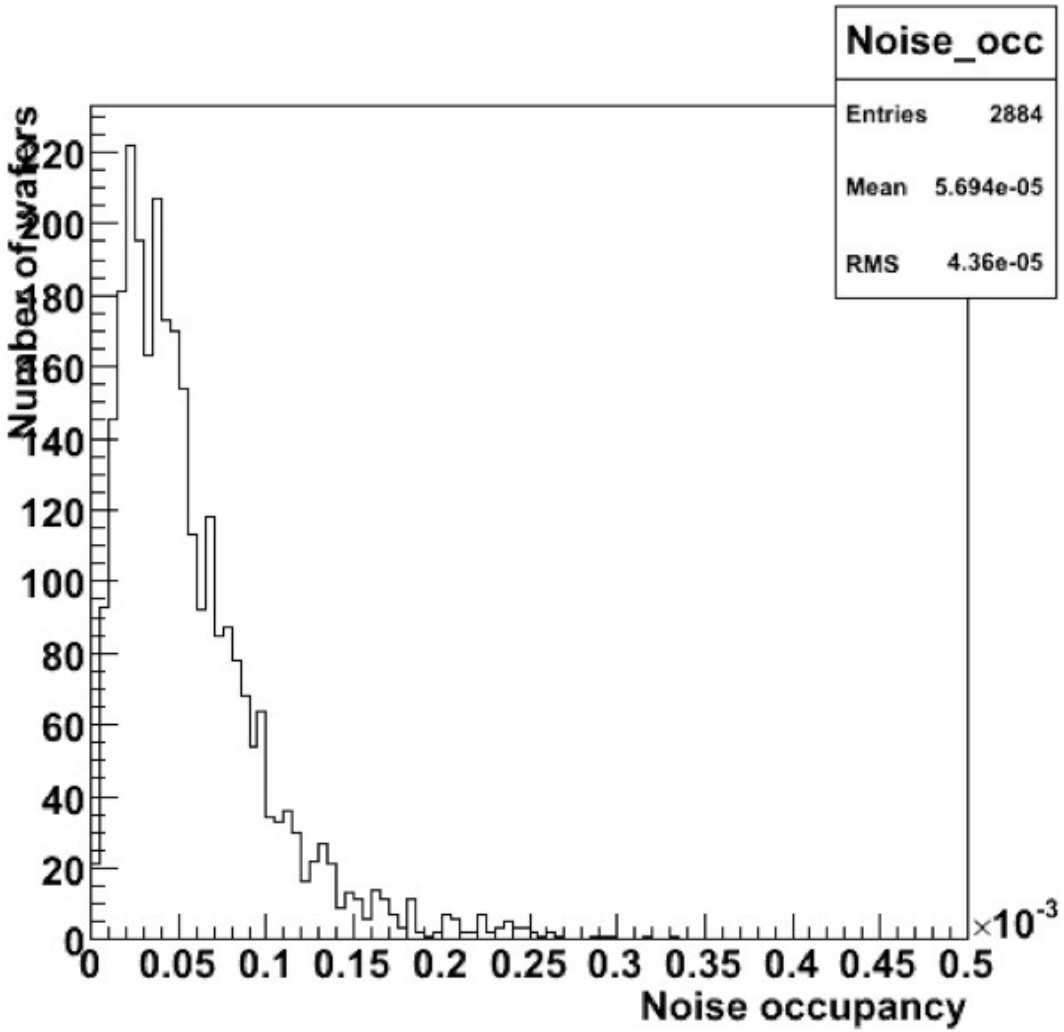
Problematic components: heaters-> used to boil off remaining liquid at the exhaust of the detector
-> suffered from problems in power connectors

Original location: inside the calorimeter cryostat bore (impossible to access when EC are inserted)

Heaters will be repositioned outside the cryostat to allow continuous installation and connection of SCT End-Caps and Pixel

Work is ongoing to solve the heaters reliability problem

Preliminary NO results

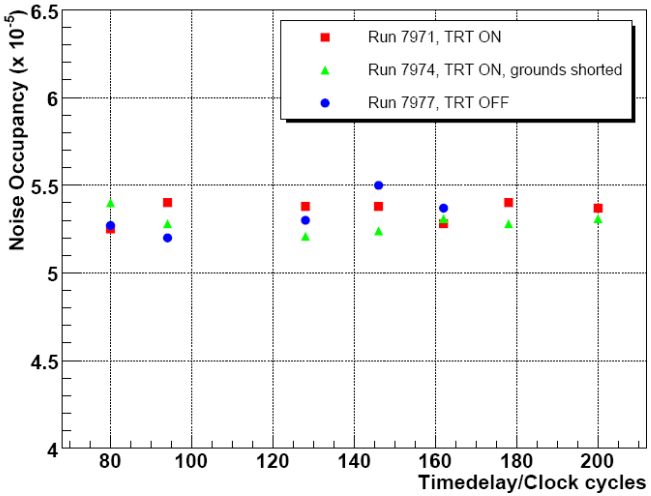


Results from run in physics mode (2 entries/module)

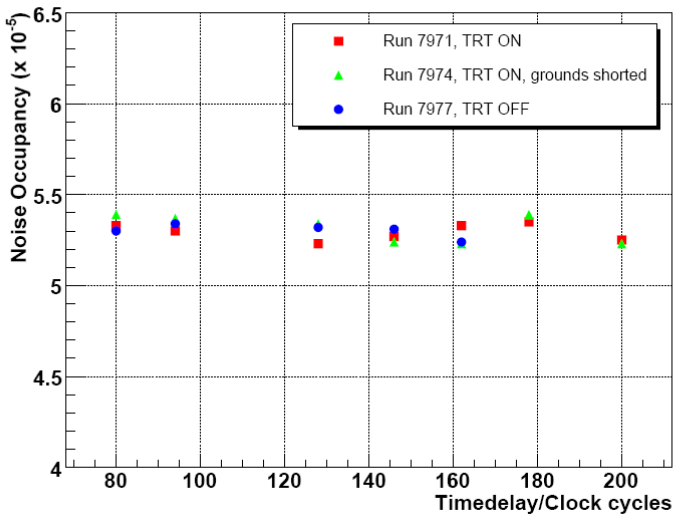
Shows NO = 5.7×10^{-5} after ~5 days with detector powered

TRT Pickup Noise

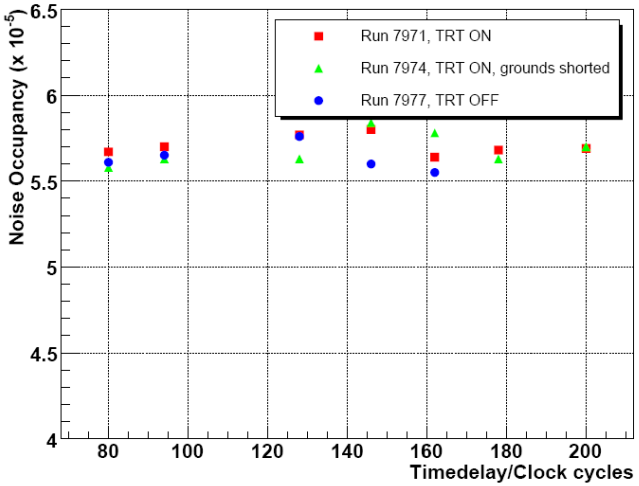
Noise Occupancy Layer 0 both sides



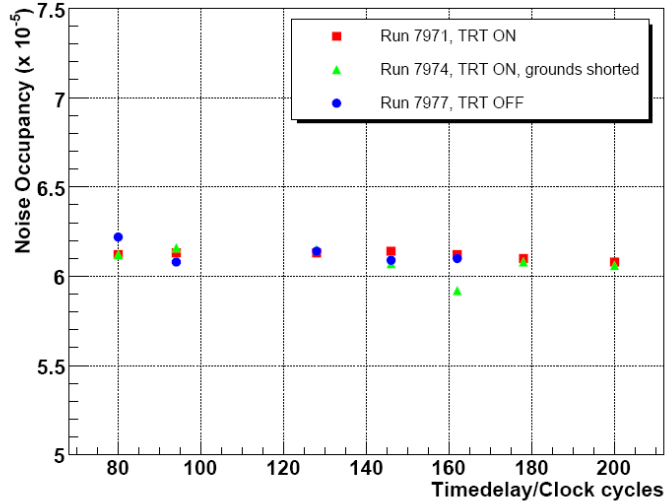
Noise Occupancy Layer 1 both sides



Noise Occupancy Layer 2 both sides



Noise Occupancy Layer 3 both sides



No evidence for TRT influence on noise occupancy

Conclusion and Outlook

- The SCT is integrated in Atlas
  - Barrel has already been tested for noise occupancy
  - Full scale commissioning in 3-4 months
- The integration tests were a great success in many aspects
  - ~99.7 % of barrel channels functional (1 module lost - HV)
  - Cosmics data taken
- Still a lot of work to be done!
  - Continue development of Barrel DAQ & DCS for the fall
  - Connect and Test both End-Caps
  - Integrate the End-Caps with Central Atlas
  - Work ongoing on the evaporative cooling heaters

=> Looking forward for the first LHC data!