ATLAS Inner Detector commissioning with cosmic rays

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On behalf of the
ATLAS Inner Detector community

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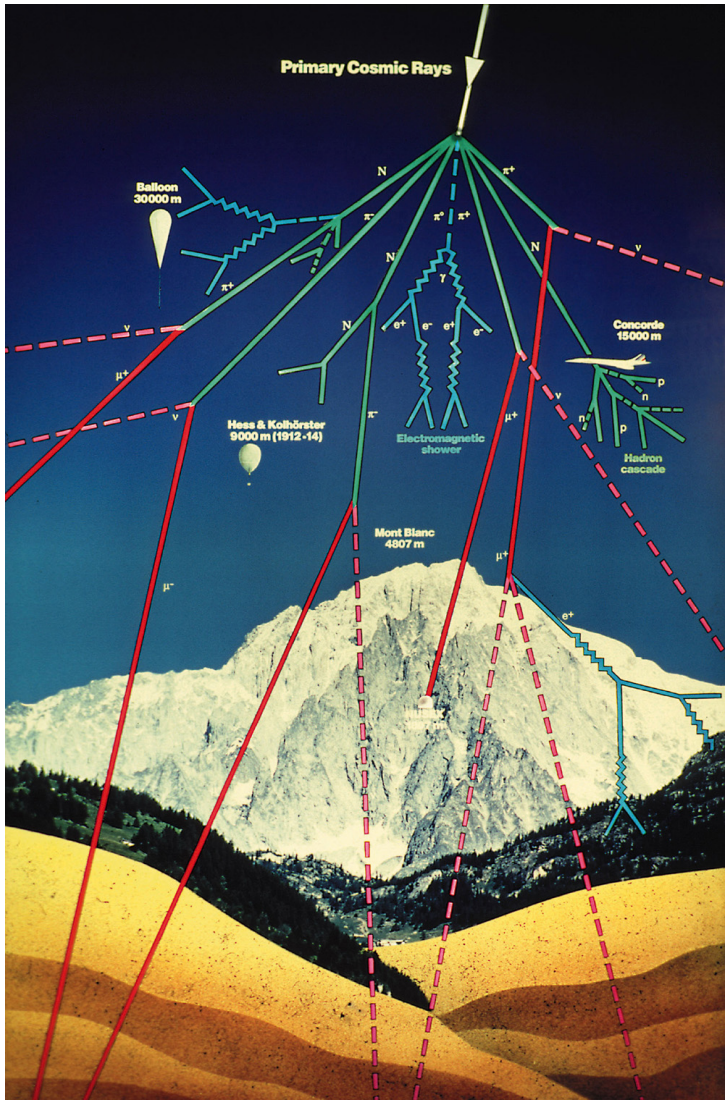
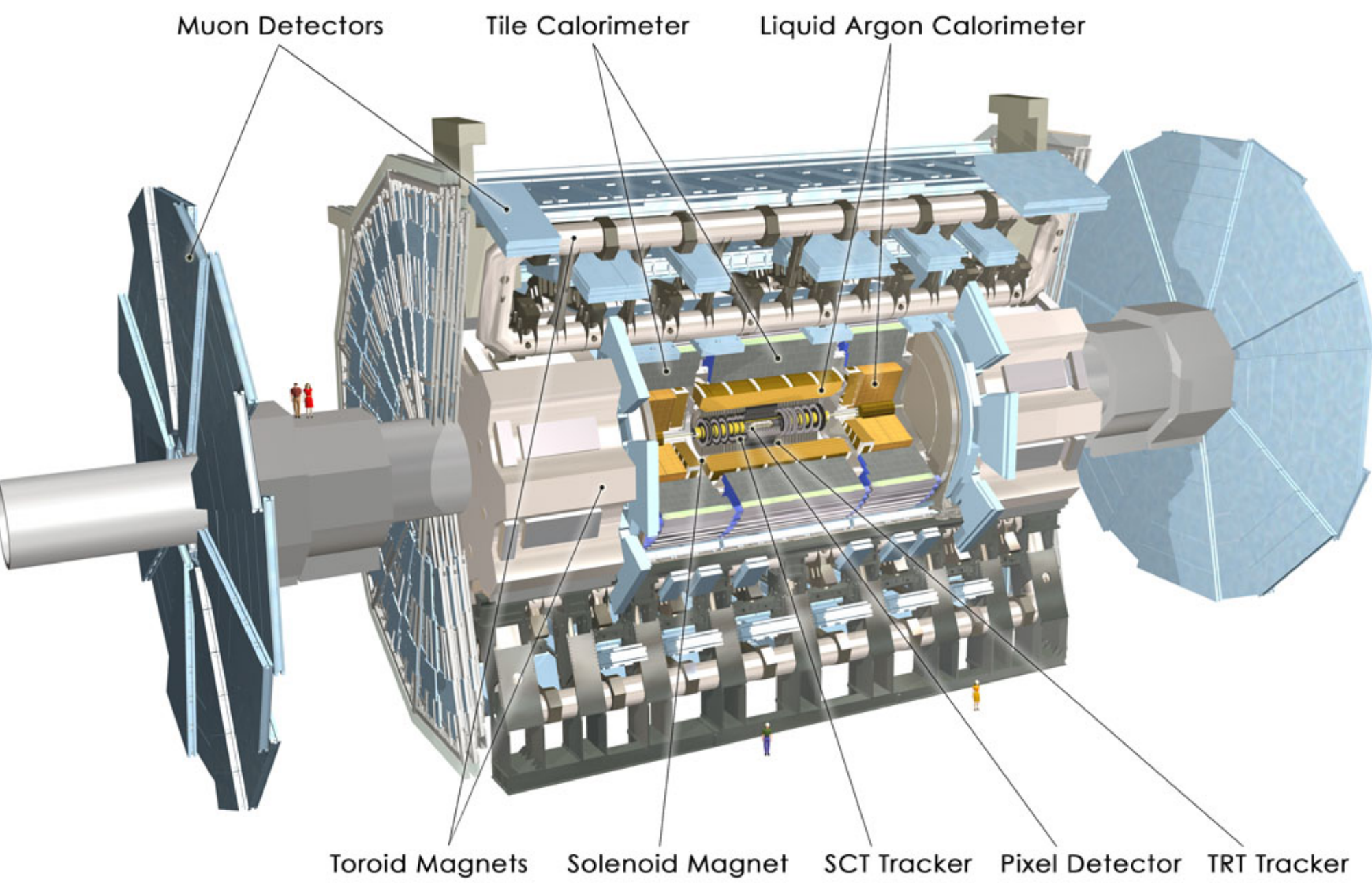
Overview

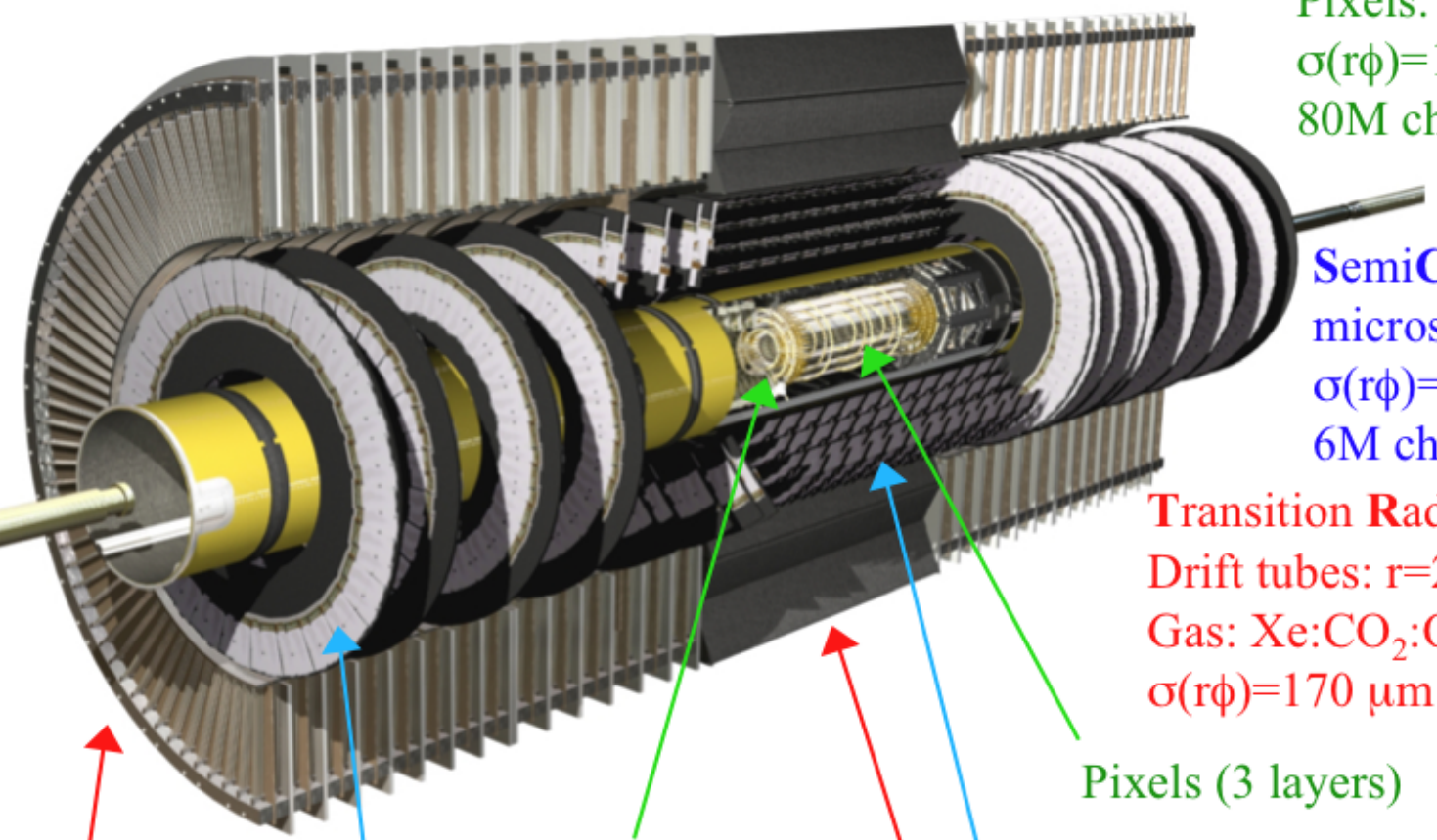
- The ATLAS (inner) detector
- Inner detector commissioning strategy
- Simulation and reconstruction chain
- Online and Offline Monitoring
- Tests at the surface
  - Random Triggers (noise studies)
  - Cosmic Triggers
- Tests in the ATLAS cavern
  - Combined test with all ATLAS detectors
- Summary & Conclusions



The ATLAS detector



The ATLAS inner detector



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

Semi**C**onductor **T**racker (SCT):
microstrip pitch: ~57-90 μm
σ(rϕ)=16 μm σ(rz)=580 μm
6M channels

Transition **R**adiation **T**racker (TRT):
Drift tubes: r=2 mm
Gas: Xe:CO_2:O_2(Ar for commissioning)
σ(rϕ)=170 μm 298k straw tubes

Pixels (3 layers)

SCT (4 layers)

TRT (73 straw layers)

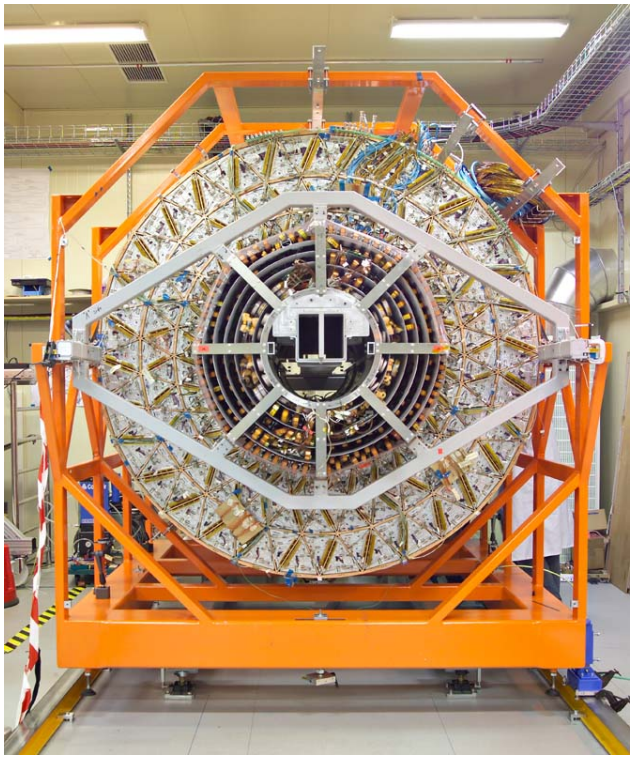
Pixels (3 disks)

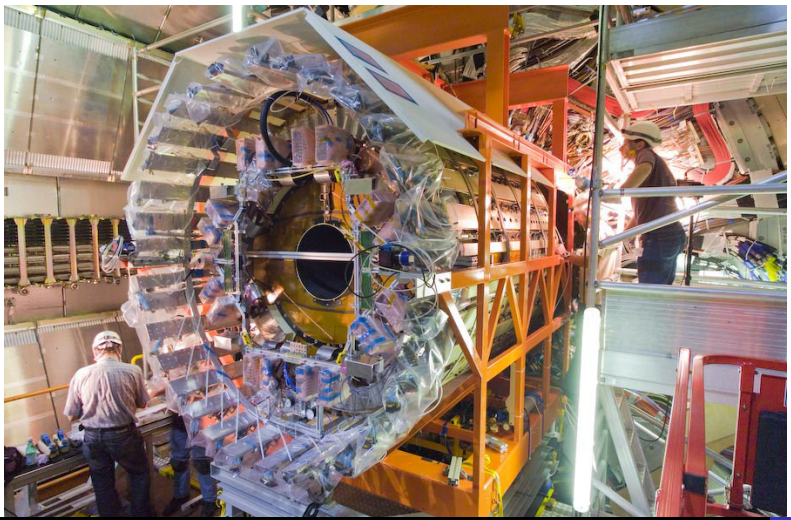
SCT (9 disks)

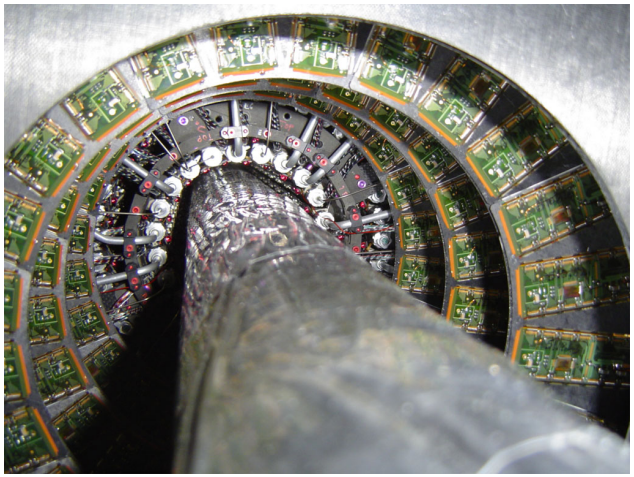
TRT (160 straw layers)

Inner detector commissioning strategy

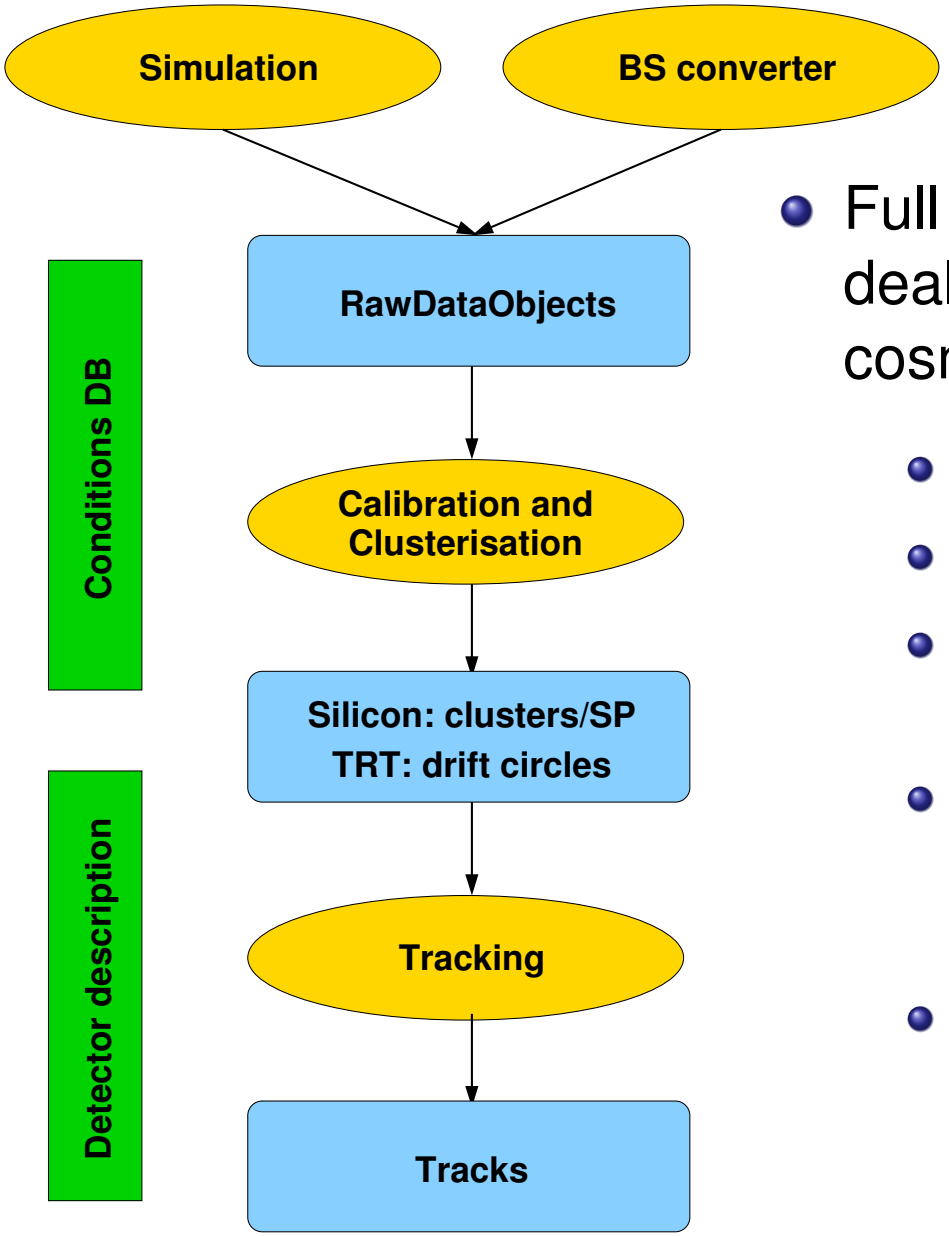
- At the surface after integration of the different subsystems
  - SCT+TRT Barrel (Spring 2006)
  - SCT+TRT Endcap (Autumn 2006)
  - Pixel Endcap (Autumn 2006)
- In the ATLAS cavern after installation and integration into the combined DAQ
  - First run with TRT Barrel (June 2007)
  - SCT integrated into DAQ (June 2007)
  - Pixel will be integrated in October 2007







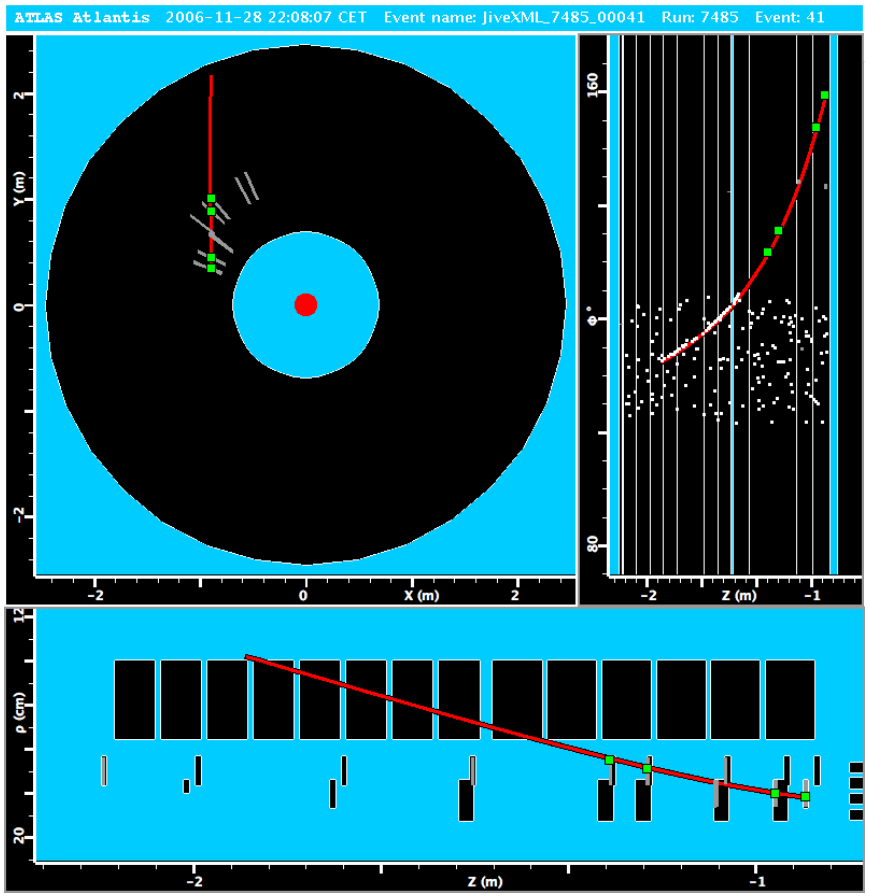
Simulation and reconstruction chain

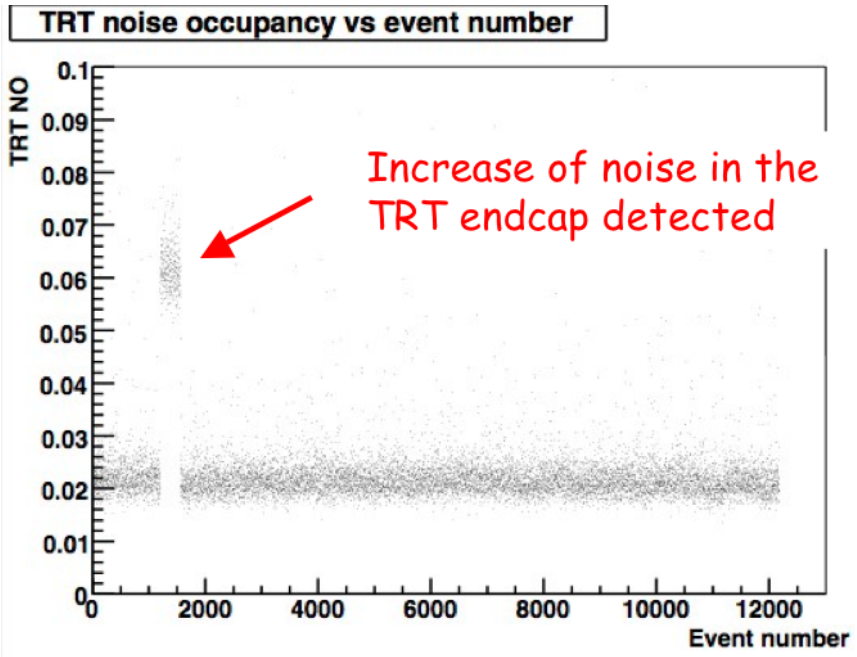


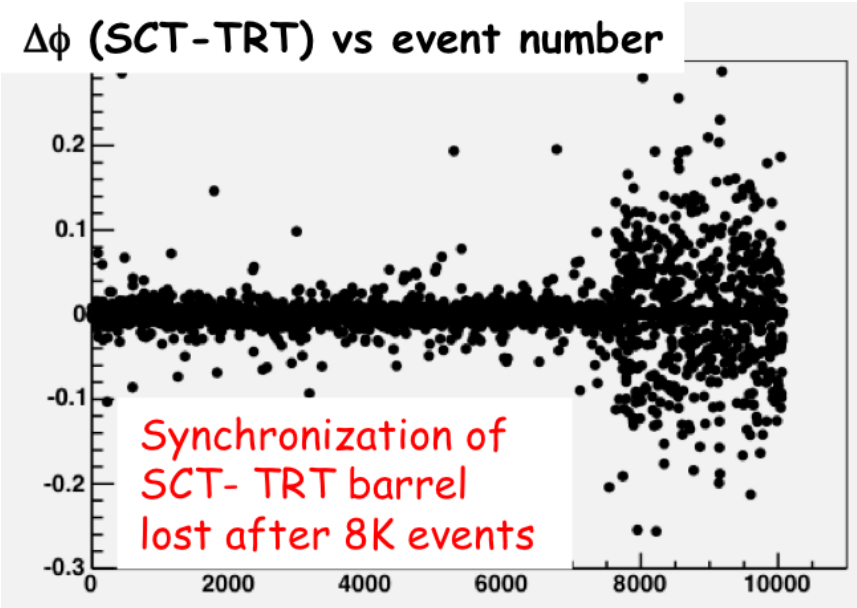
- Full reconstruction chain in place to deal with simulated as well as real cosmic data
  - Detector description for each setup
  - Data decoders in place
  - Random cosmic arrival time taken into account
  - Standard tracking as well as dedicated cosmic tracking (no vertex constraints)
  - Use of information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

Online/Offline Monitoring & Event display

- Check Data quality and detector performance
  - Offline/Online (Event Filter) Monitoring
  - Event display

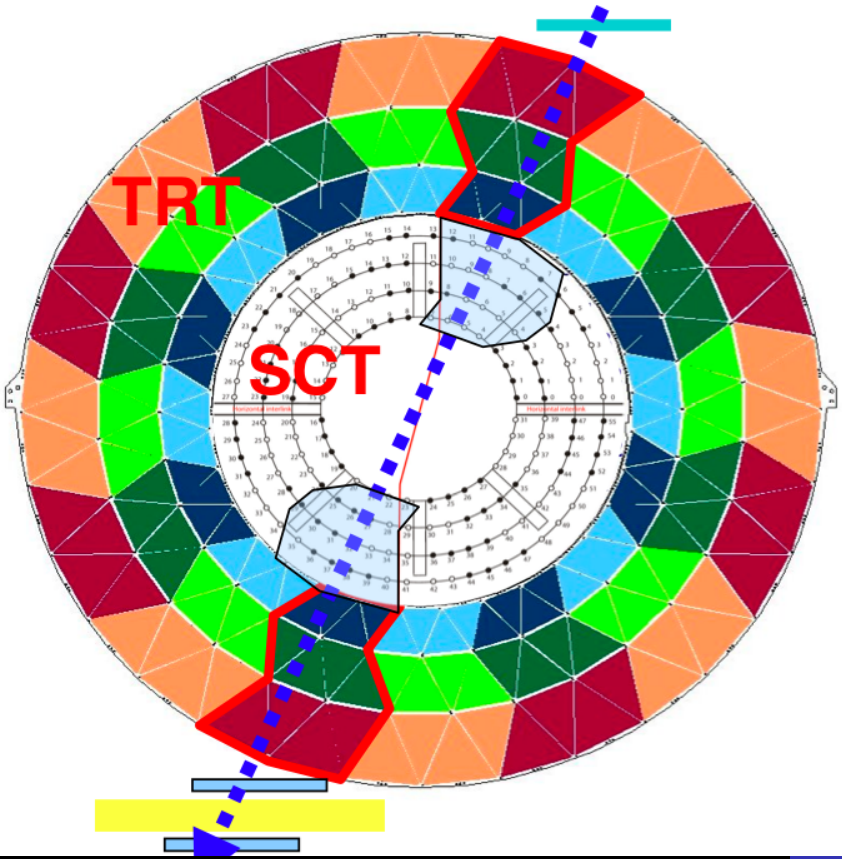


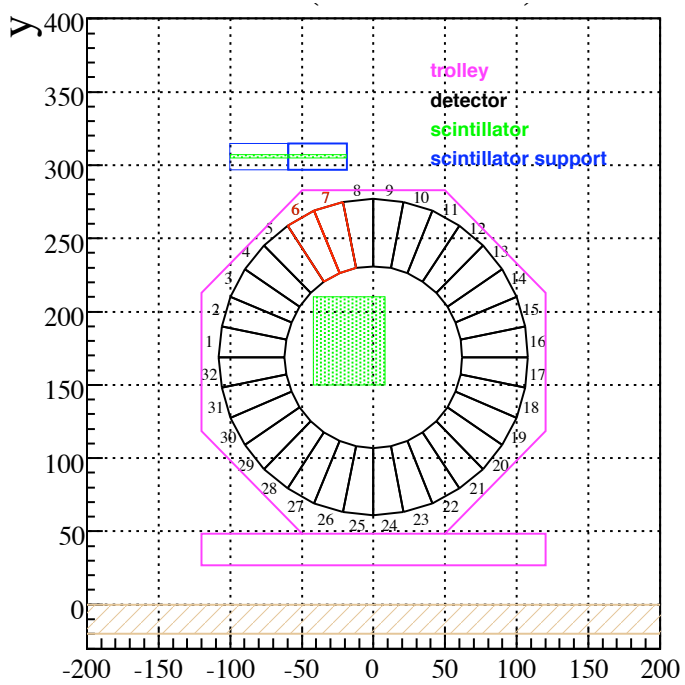


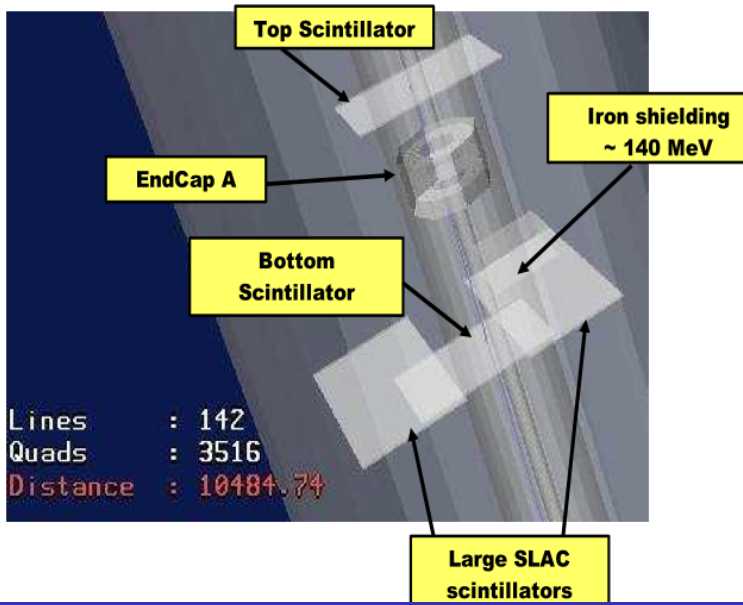


Tests at the Surface

- Calibration tests and physics runs with random and cosmic triggers
  (No B field, part of detector cabled)
  - SCT+TRT Barrel
  - SCT+TRT Endcap
  - Pixel endcap

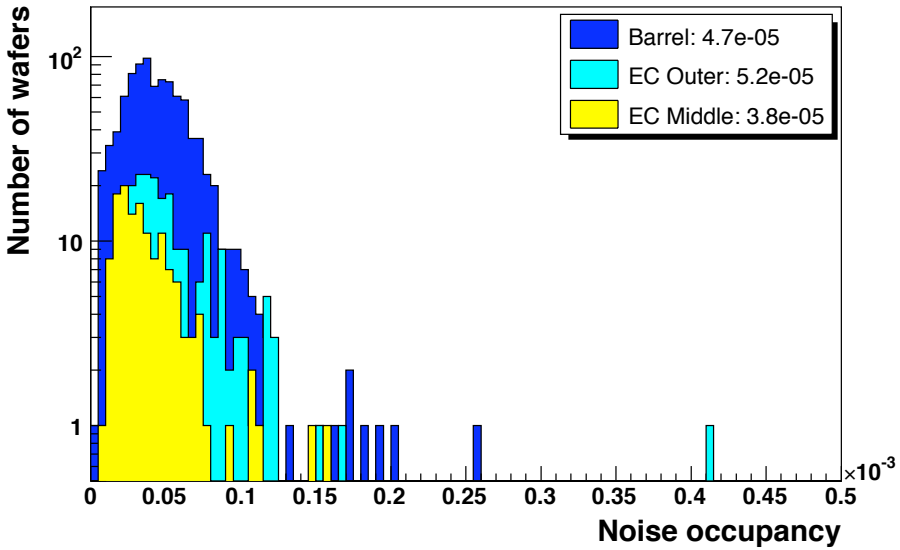




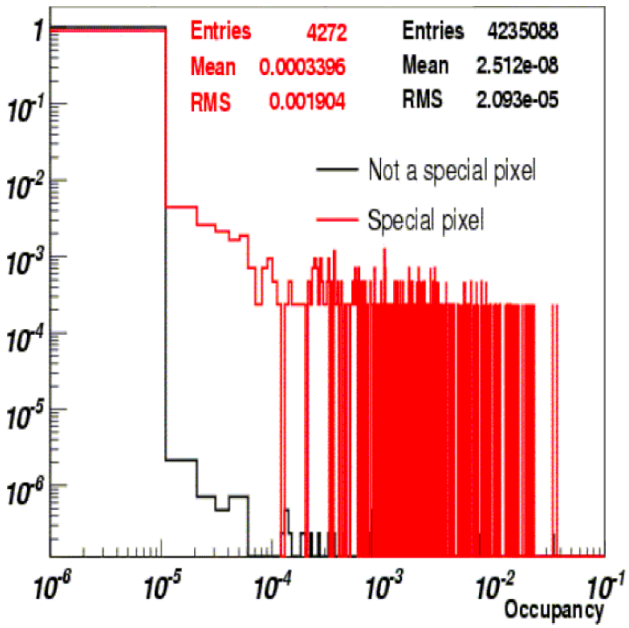


Random Triggers (Noise)

- Random 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)



SCT Noise occupancy $< 5 \times 10^{-4}$

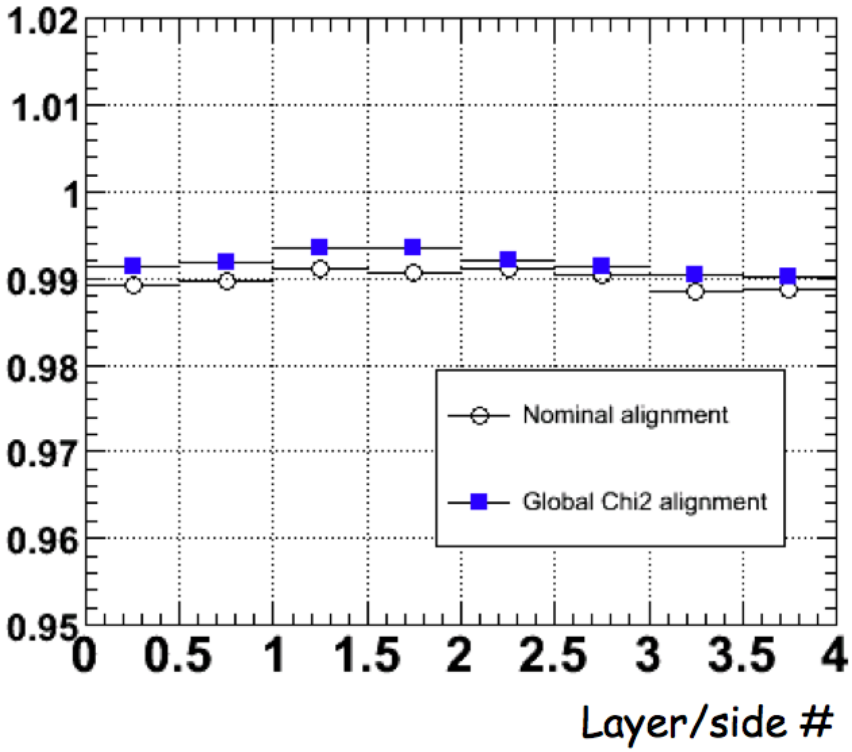


Special pixels: detected during production tests

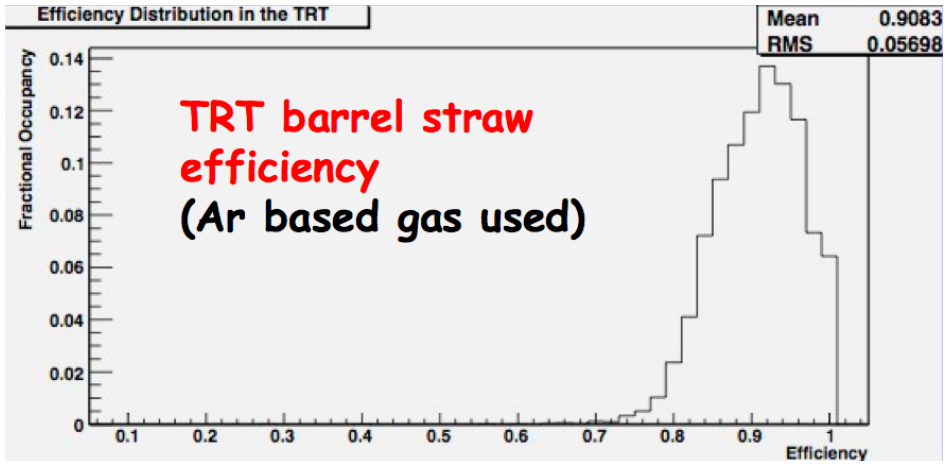
Cosmic Triggers (I)

- Reconstructed tracks have been used to calculate hit efficiencies in each subdetector
- Efficiencies are well within specifications:
  - SCT: hit efficiency after alignment $> 99\%$
  - TRT (Argon instead of nominal Xenon): eff. $\sim 90\%$

SCT Barrel efficiencies



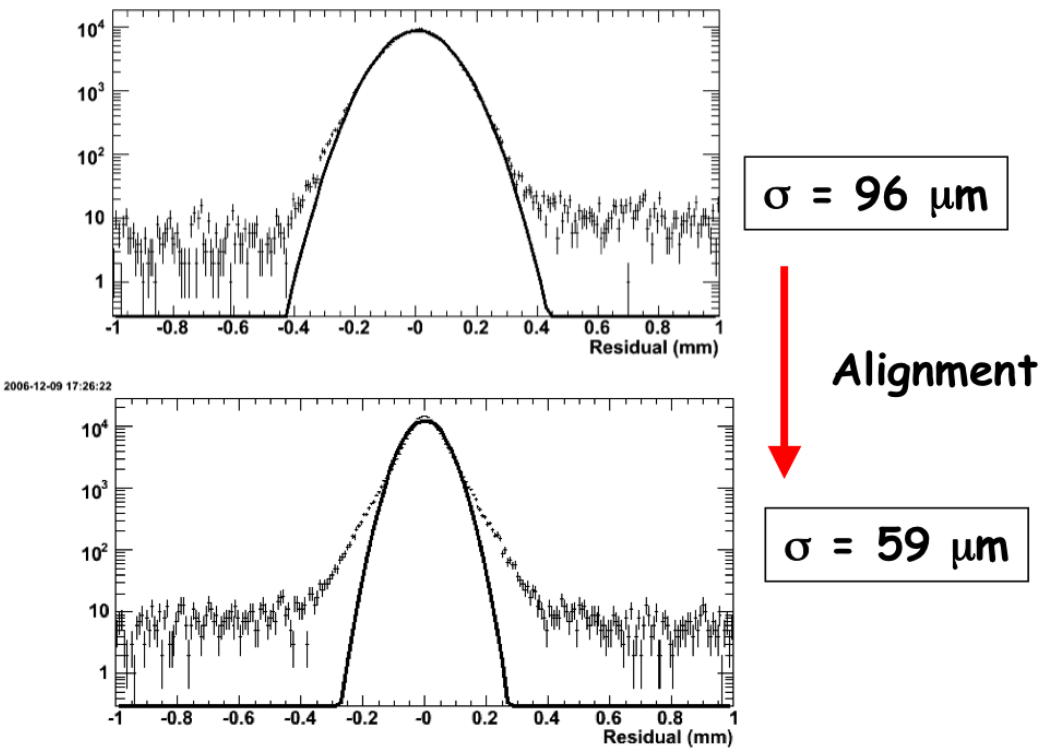
TRT Barrel efficiencies



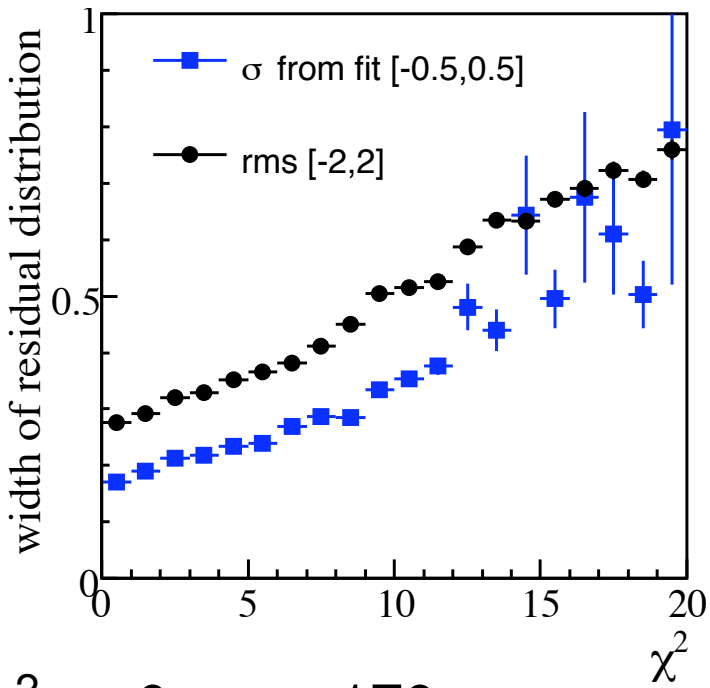
Cosmic Triggers (II)

- No B field in cosmic test $\rightarrow$ multiple scattering not treated properly
- Alignment algorithms have been applied (see talk by T. Göttfert)
- Estimation of TRT resolution by extrapolation of track $\chi^2 \rightarrow 0$

SCT Barrel residuals



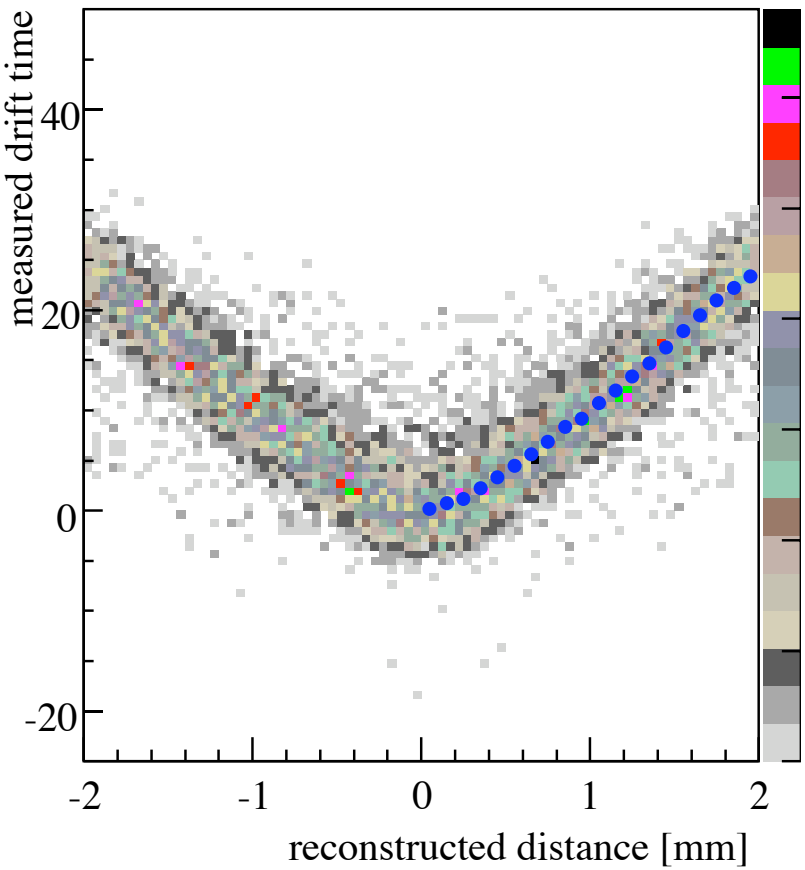
TRT Barrel residuals

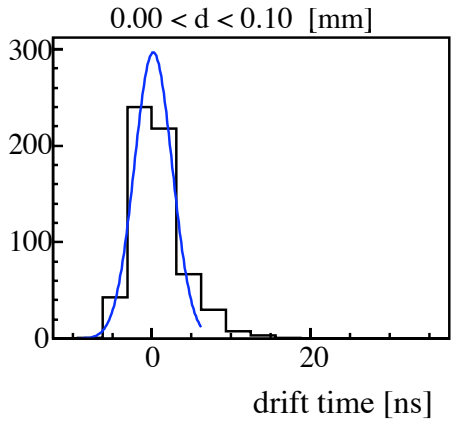


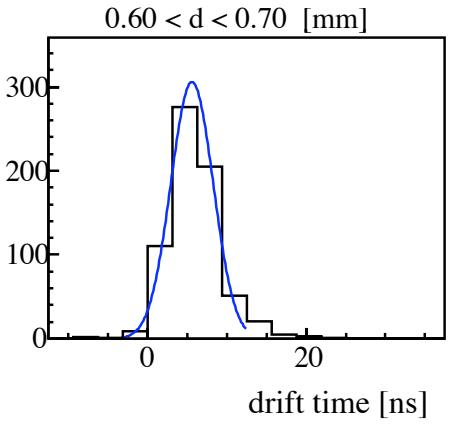
$\chi^2 \rightarrow 0 : \sigma \sim 170 \mu m$

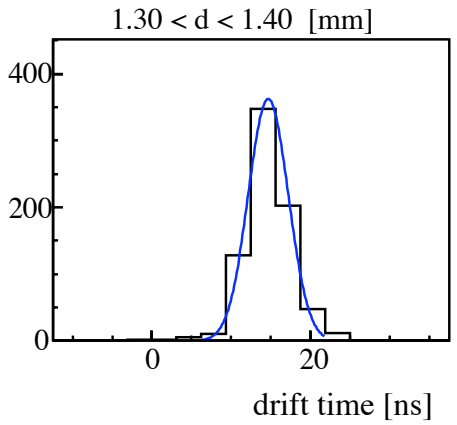
TRT calibration

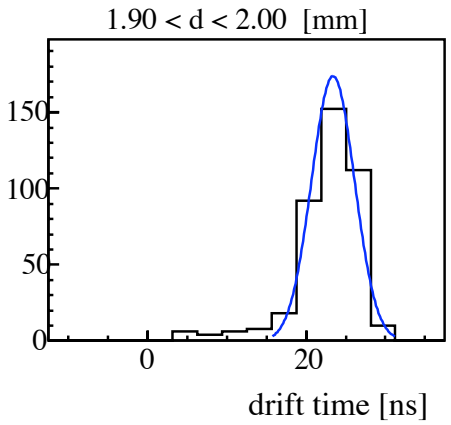
- Successful test of TRT calibration algorithm
- TRT measures uncorrected drifttime t_{raw} but tracking needs driftradius $r = R_t(t_{\mathrm{raw}} - t_0 - t_{\mathrm{phase}})$





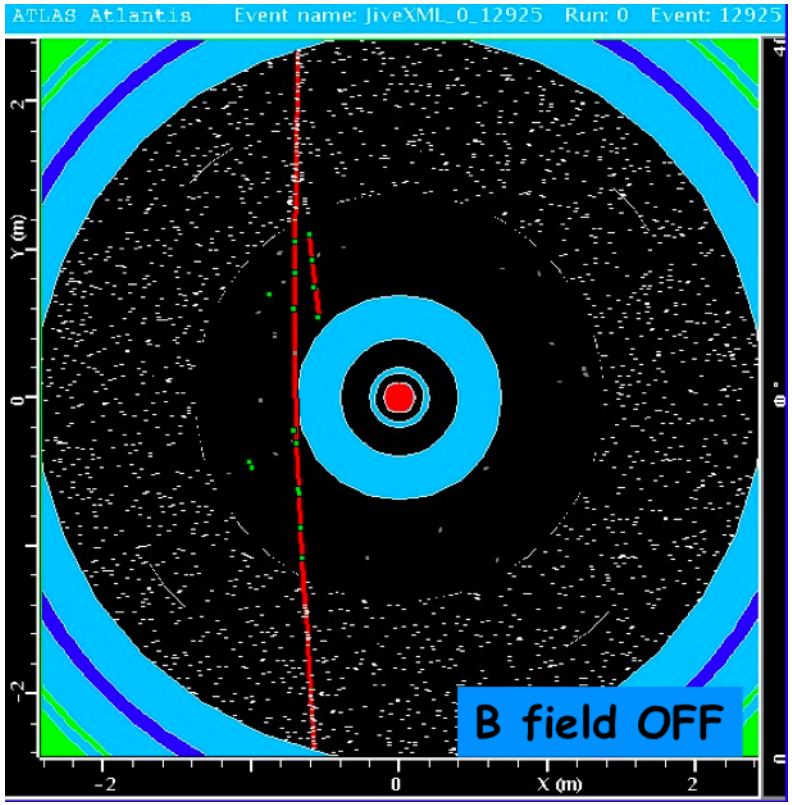


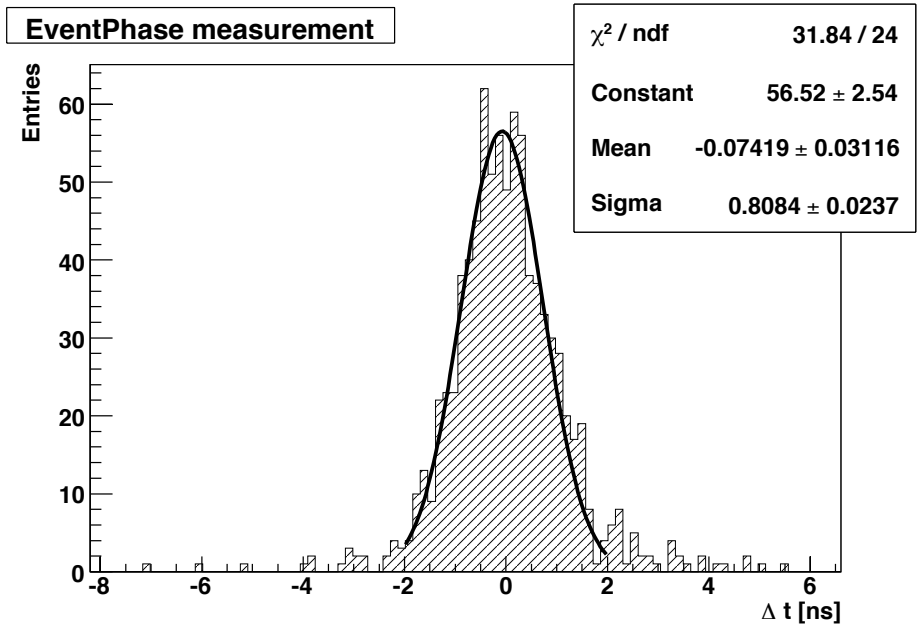




Preparation for cosmic runs in the ATLAS cavern

- Offline preparations for cosmic runs of the ID in the ATLAS cavern started half a year ago
  - Combined simulation of cosmic rays going through the ATLAS detector is now in place (see talk by T. Cornelissen)
  - Full reconstruction chain has been adapted to the Pit setup
  - Treatment of random arrival time of cosmic muon important for drifttime measurement in the TRT

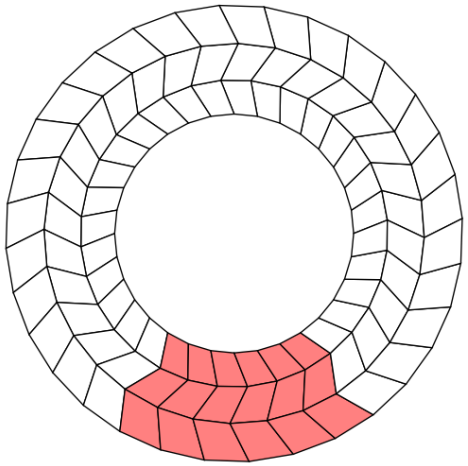




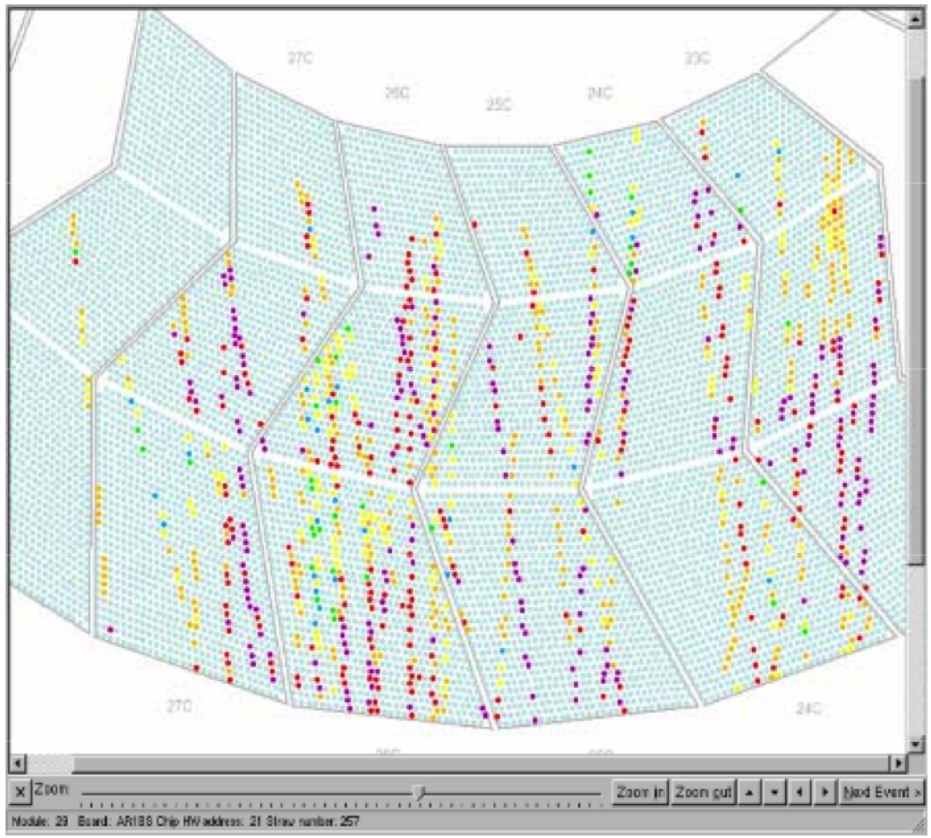
Event phase (t_{phase}) can be estimated from tracks with $\sigma \sim 0.8$ ns

First results with real data (June 2007)

- First combined data taking of Inner Detector (TRT barrel) with other ATLAS subdetectors in June 2007
- Data decoders, reconstruction software, monitoring and event display successfully tested
- Trigger provided by Muon spectrometer and Tile calorimeter

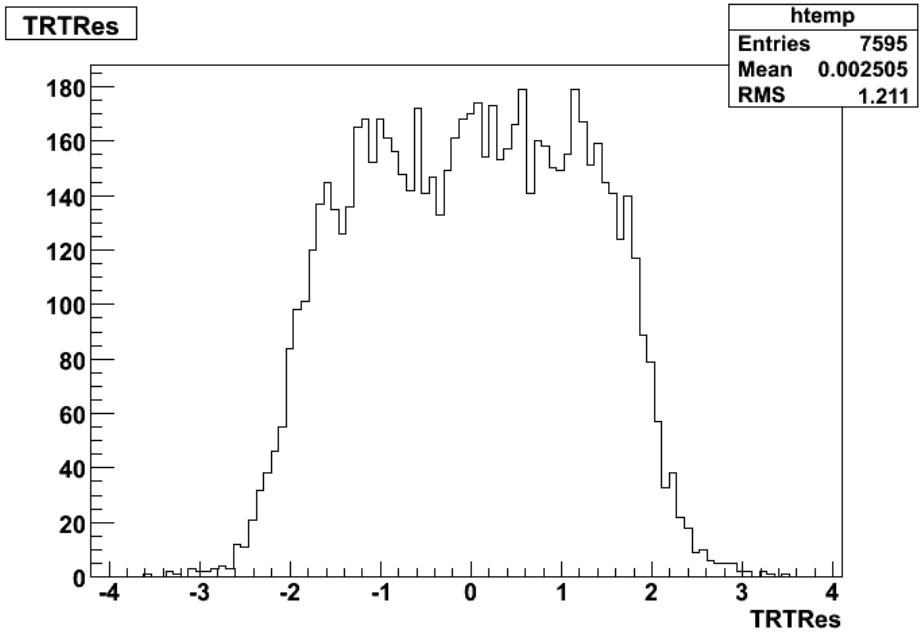


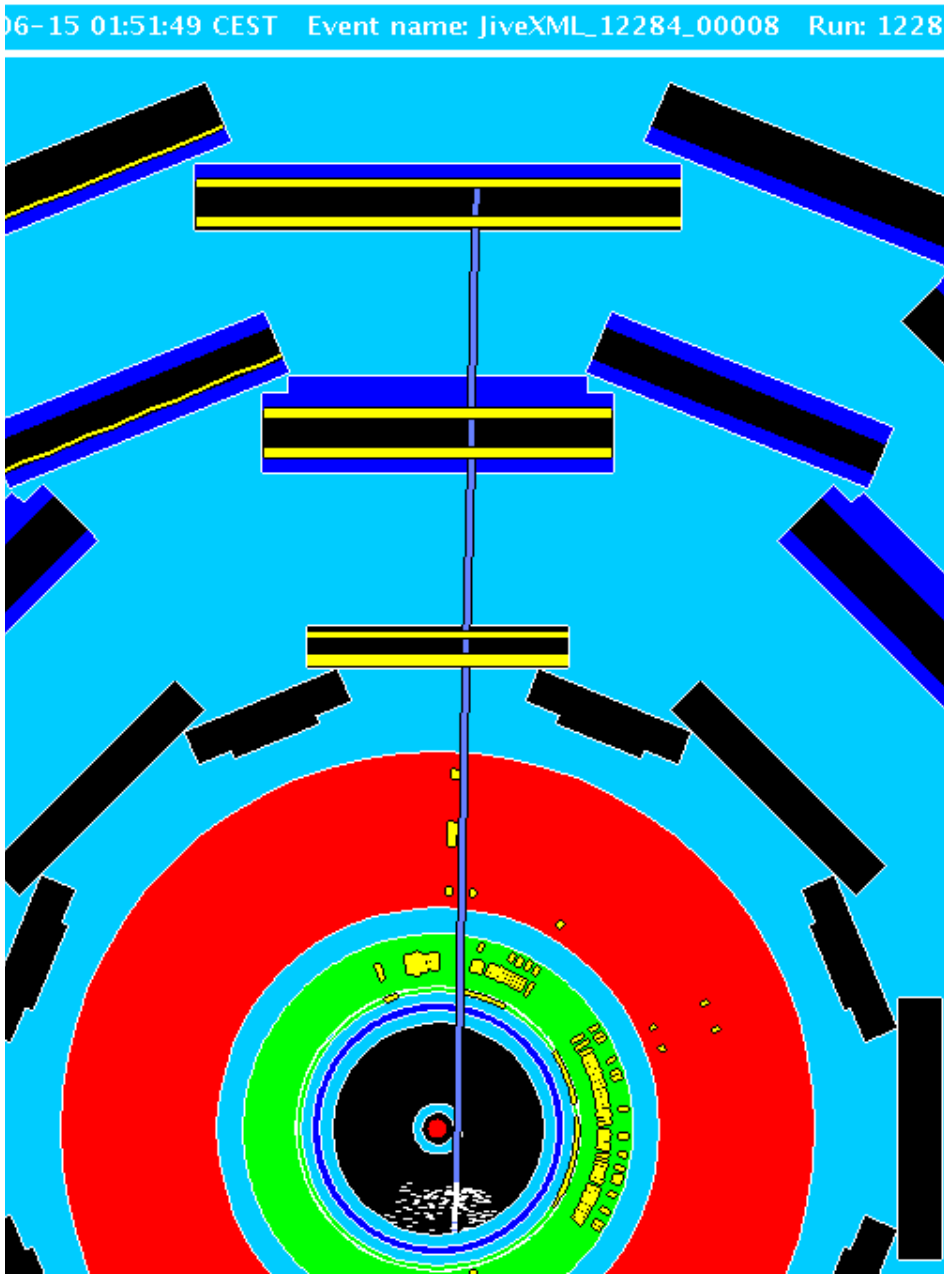
1/6 of TRT Barrel in readout



First results with real data (II) — TRT Barrel

- TRT noise occupancy $< 1\%$ in this test
- No R_t calibration available yet (needs more statistics) $\rightarrow$ no drifttime used in reconstruction





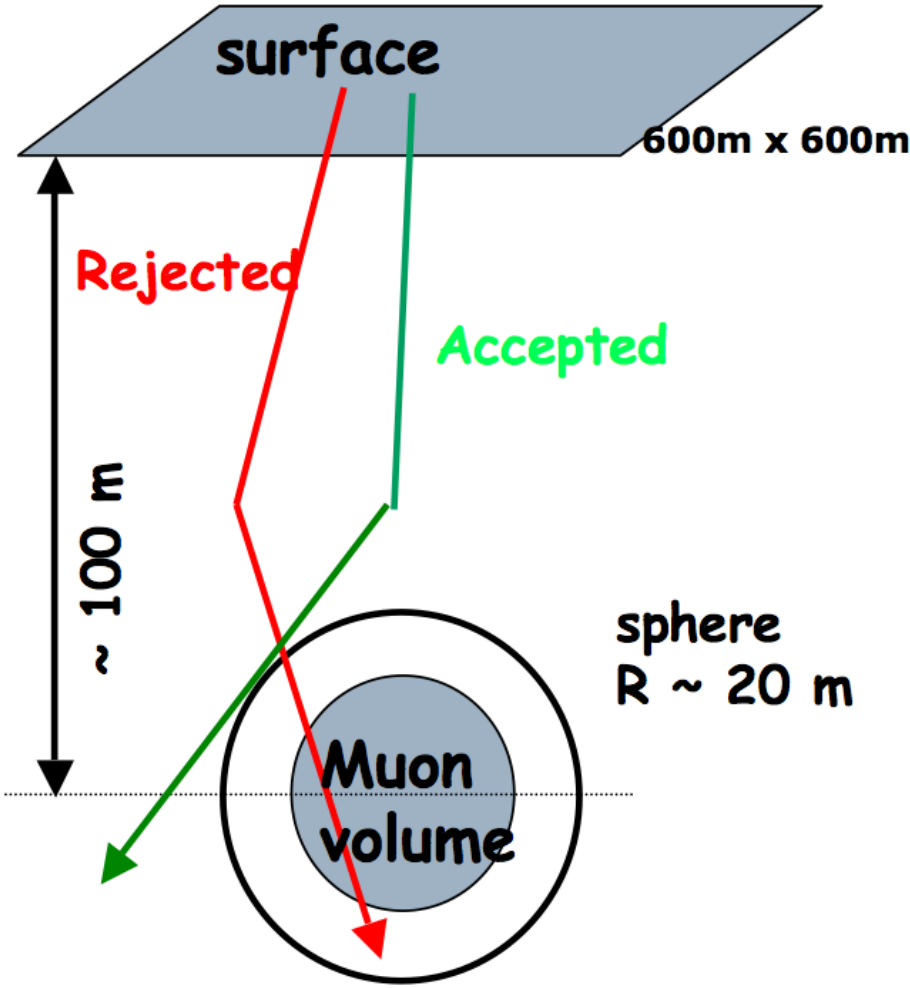
Summary & Conclusions

- The ATLAS inner detector is being commissioned using cosmic rays:
  - Last year at the surface and now in the ATLAS cavern together with all the other subdetectors
- The full offline software chain has been put in place to deal with simulation as well as real data and give prompt feedback on the detector performance
  - Data decoders, track reconstruction, calibration, alignment, monitoring and event display
- All results show that the detector is well within specifications
  - noise, efficiency and spatial resolution
- Over the next months the commissioning with cosmic rays continues with more and more coverage of the individual subsystems of the ID
  - Expect to have the full ATLAS inner detector taking cosmics data by the end of this year

backup slides

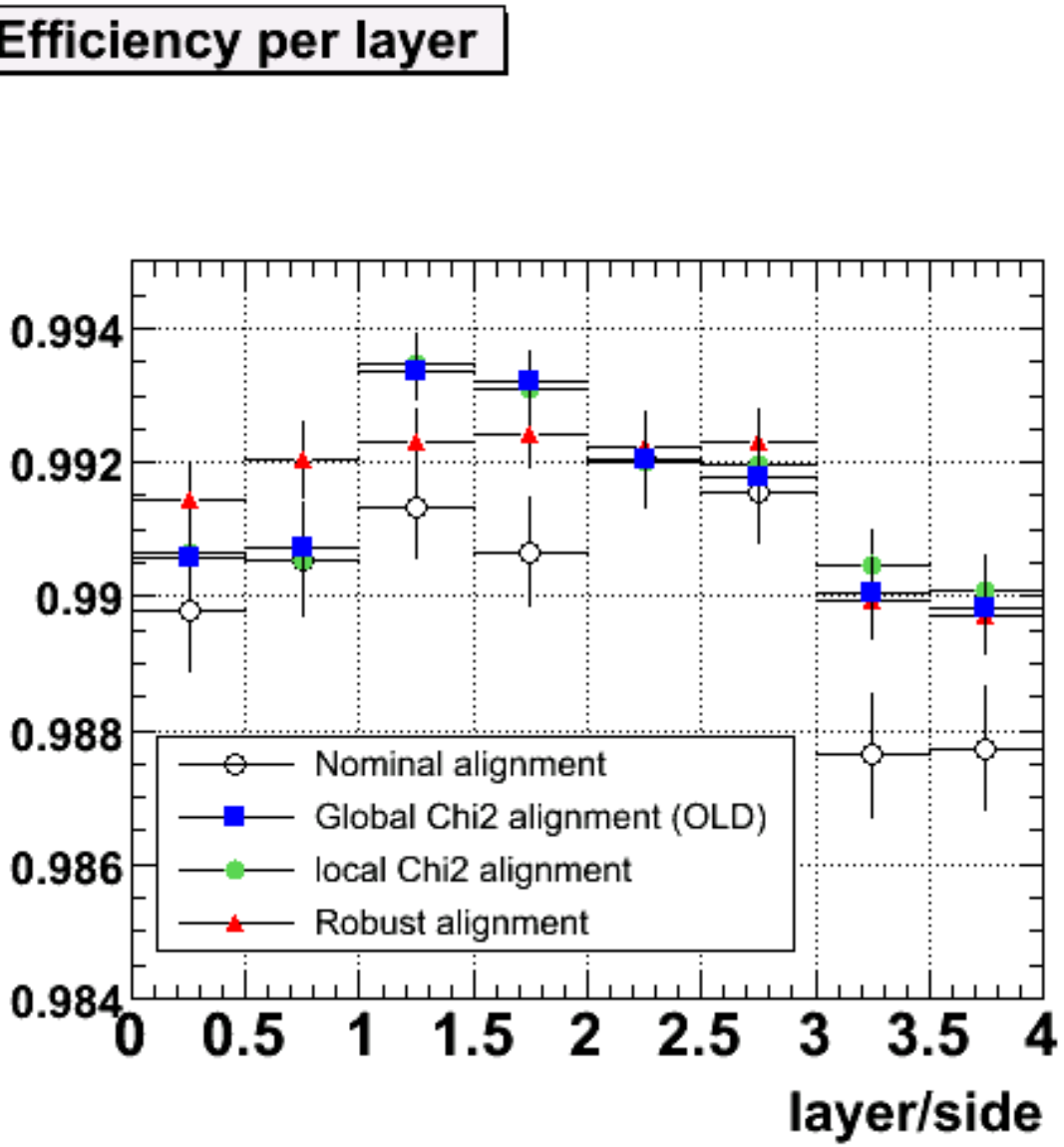
Simulation setup

- Cosmics muons generated across large area on surface
  - Energy range: 10 GeV - 5 TeV
  - Production vertex within $\pm$300 m
- Muons extrapolated through rock (GEANT)
- Apply filter to increase efficiency
  - Keep only generated tracks that point into sphere around detector
  - Keep only events that have a simulated hit in a selected detector volume (e.g. Muon volume)
- Samples with and without magnetic field (solenoid/toroid)



Cut at generator level

SCT Hit efficiencies from different alignment algorithms



- Hit efficiency obviously depends on several factors:
  - Road width (here: 2mm)
  - Multiple scattering
  - Alignment algorithm applied
  - ...