Commissioning of the ATLAS Pixel Detector

Lidia Dell'Asta
INFN & Università degli Studi di Milano

On behalf of the ATLAS Collaboration

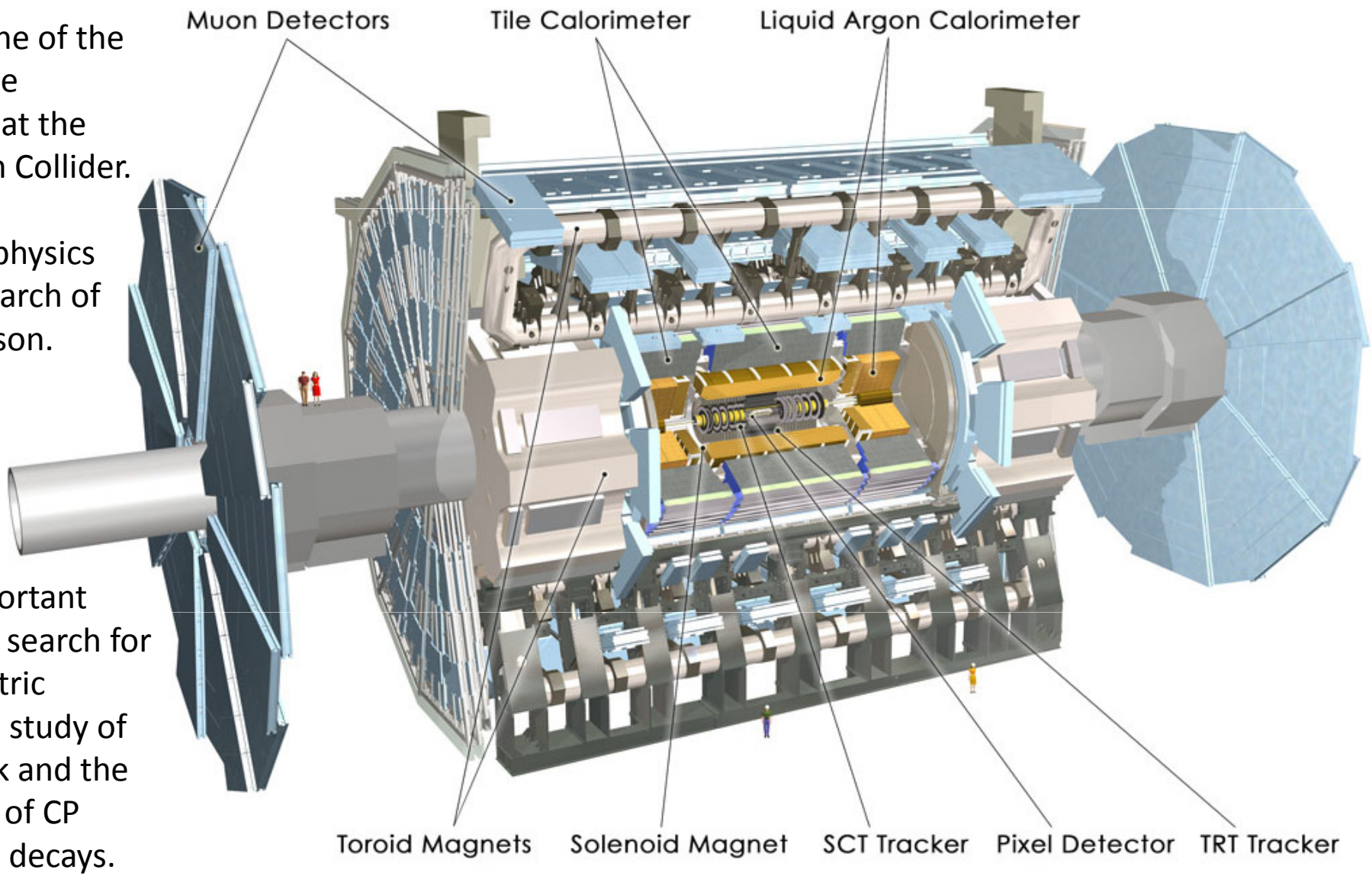
SIF – Bari – 1st October 2009

The ATLAS Experiment

✓ ATLAS is one of the multi-purpose experiments at the Large Hadron Collider.

✓ The main physics goal is the search of the Higgs boson.

✓ Other important goals are the search for supersymmetric particles, the study of the top quark and the investigation of CP violation in B decays.

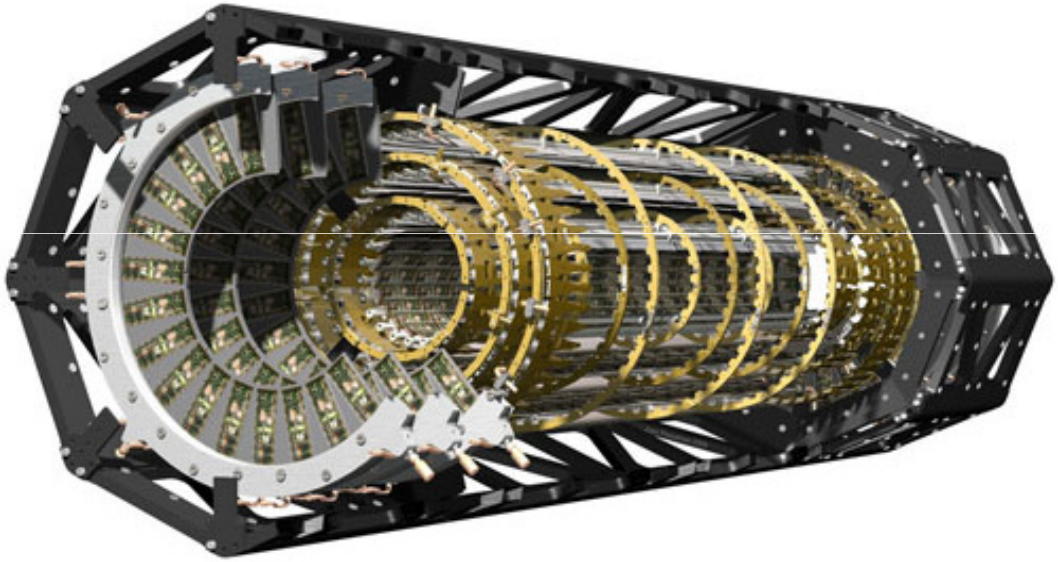


The ATLAS Pixel Detector

✓ The Pixel Detector is the innermost sub-system of the ATLAS experiment.
✓It operates within a magnetic field of 2 Tesla.
✓ It helps to determine the momenta of charged particles and to reconstruct tracks and vertexes. It permits to obtain high precision on the determination of the impact parameter.

$$\sigma(d_0) = 10\mu m \oplus 140\,\mu m/p_T\,[GeV/c]$$

✓It's made by Silicon pixel sensors.
✓ 80 M channels.
✓The first sensor is only 5 cm away from the interaction point.
✓ The system covers up to $|\eta|<2.5$ with three measured points.



Barrel
- ✓ 3 layers
- ✓ 1456 modules

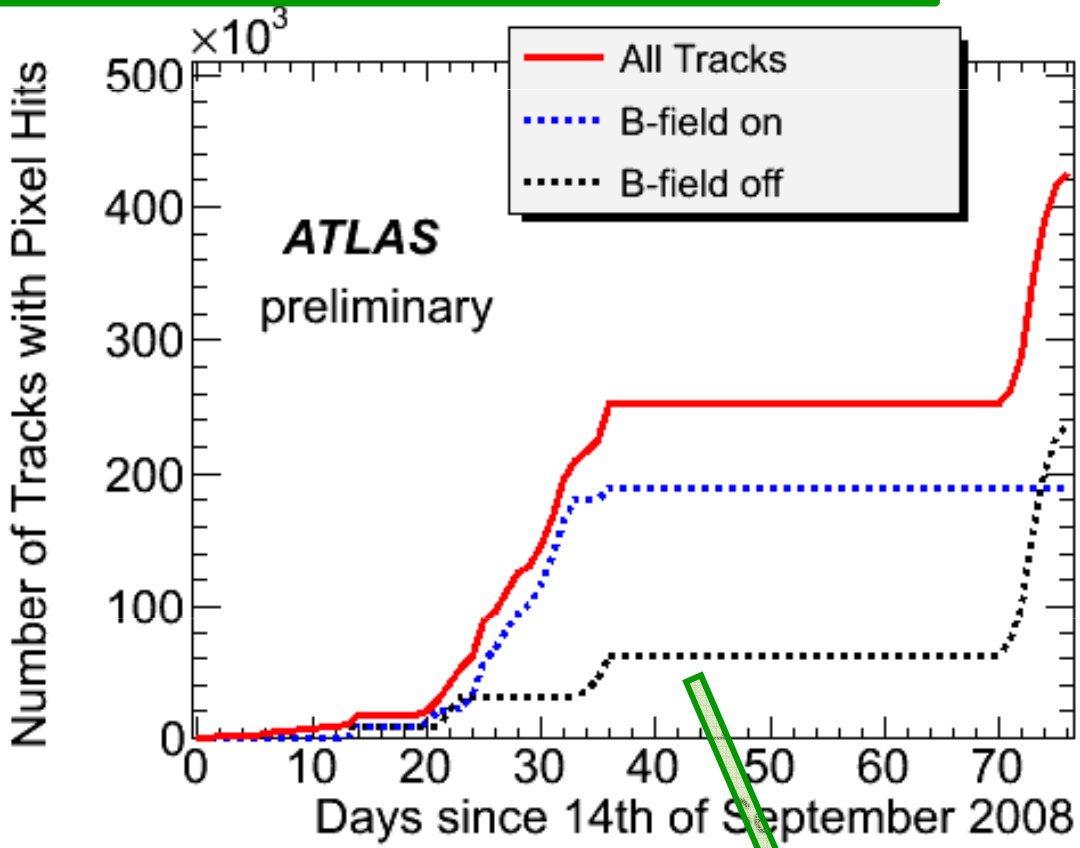
Disks
- ✓ 3 disks
- ✓ 288 modules

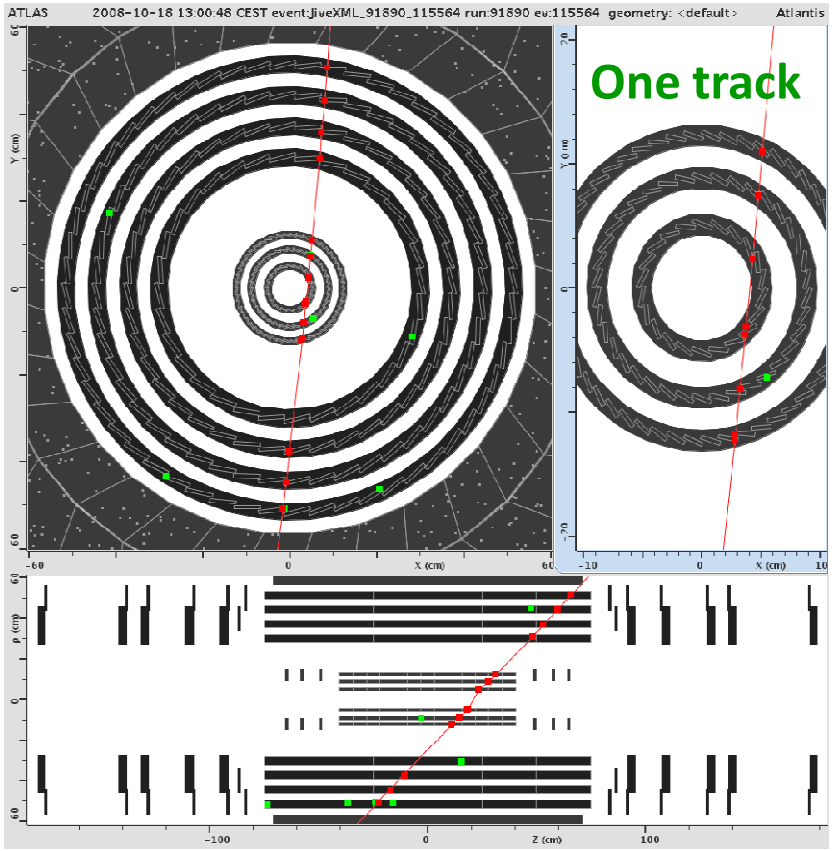
Module
- ✓ sensor of (60.8mm X 16.4mm X 250µm)
- ✓ segmentation of pixels: 400µm X 50µm
- ✓ 16 front-end chips
- ✓ bump-bonding between sensor and FE

✓ Installed in the pit in June 2007.
✓Fully connected and evaporative cooling commissioned in August 2008.
✓ First cosmic track seen by the Pixel detector on the 14th September 2008.

The cosmic rays data taking – 2008/2009

2008 data taking - Total number of tracks:
- ✓ 240,000 with magnetic field ON
- ✓ 190,000 with magnetic field OFF





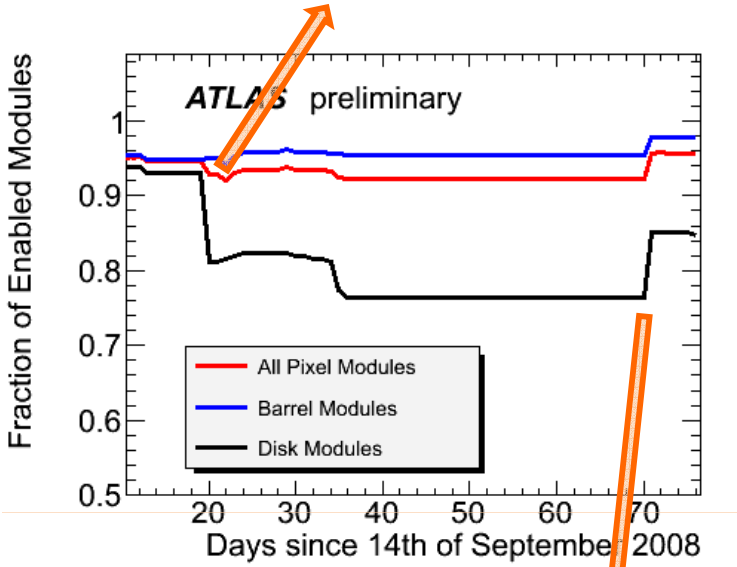
New cosmic data taking in 2009.

No data taking.
Full new calibration of the pixel detector performed.

Performance

After 2009 data taking – 98% of the Pixel detector is operational.

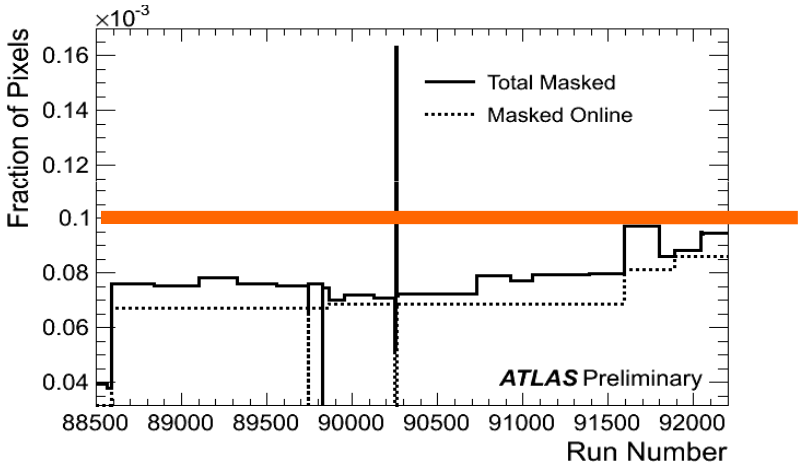
Three disk cooling loops turned off – 36 modules off.



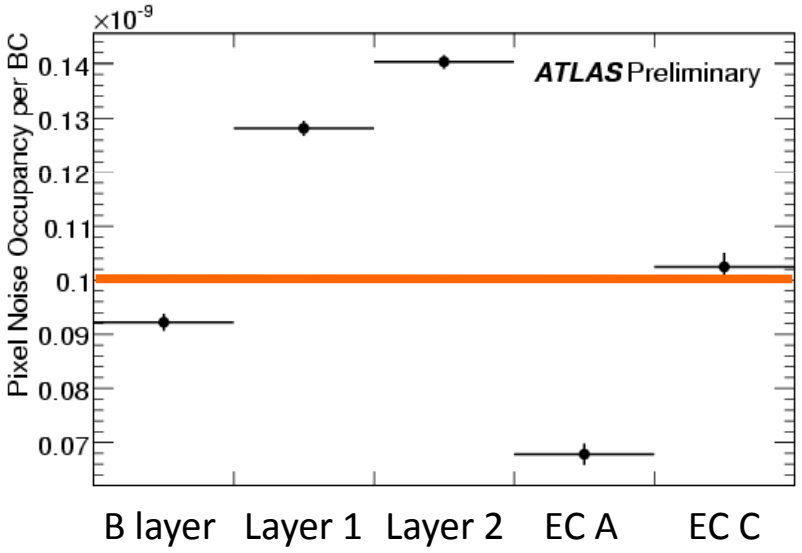
New tuning of the optical links performed and some new TX plugins installed

Intrinsic detector efficiency: 99.8%.

Number of pixel masked (online and offline) due to high noise. The fraction of problematic pixels is well below 0.01%.



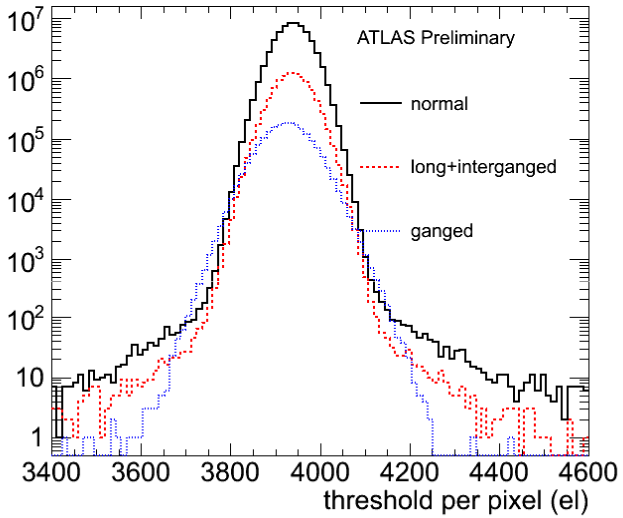
10^{-4}



The noise occupancy is about 10^{-10}.

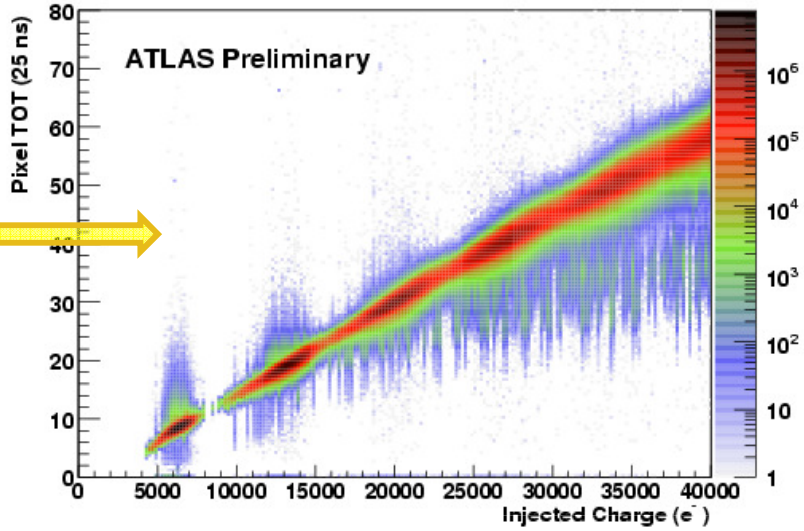
10^{-10} hits/pixel /event/BC

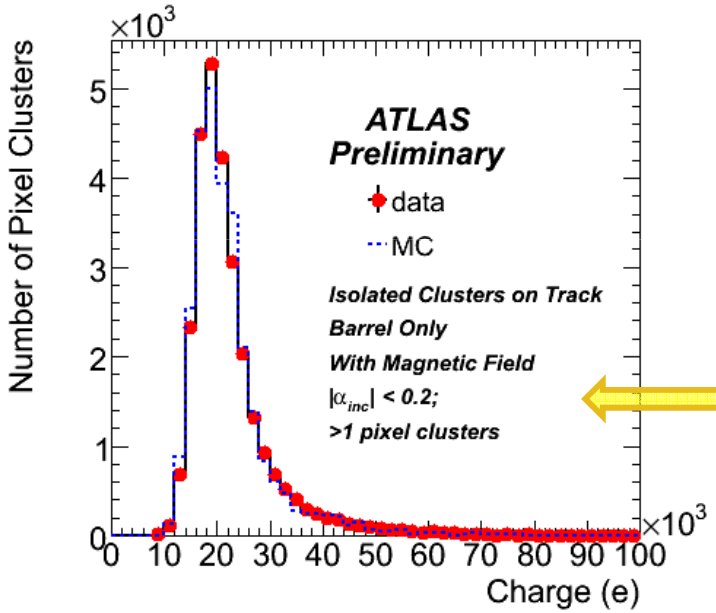
Pixel detector calibration



✓ The Pixel detector has been fully calibrated.
✓ The thresholds have been tuned for the different types of pixels.
✓4000 e threshold with 40 e dispersion.

✓ The Time over Threshold (ToT) as a function of the injected charge has been measured. The relationship is almost linear.
✓ 30 ToT per m.i.p. (20 ke) with 2% dispersion

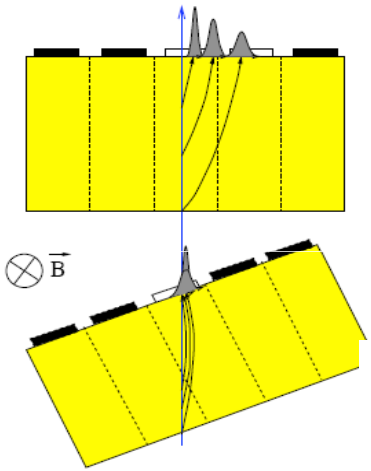




✓ Pixel cluster charge distributions in data is in good agreement with expectations.

The Lorentz angle

Due to the presence of the magnetic field, the charge drift along the Lorentz angle direction.

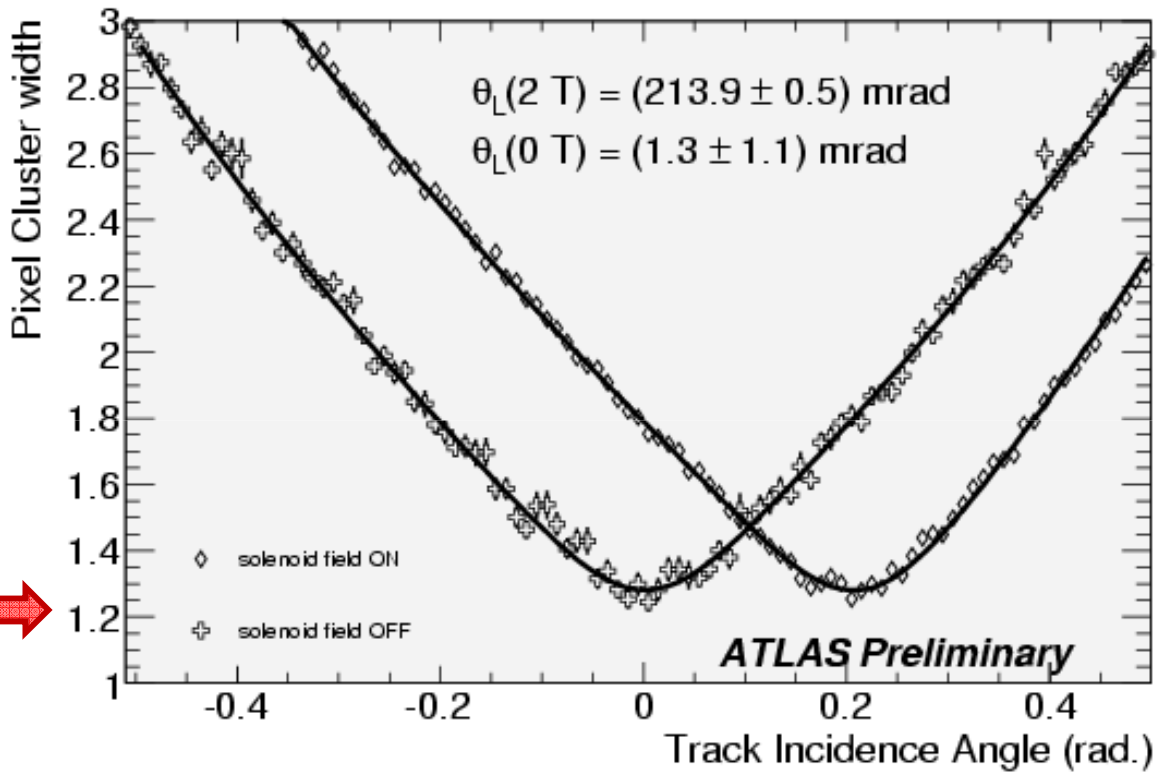


$$\tan \alpha_L = \mu_H B$$

The point displacement due to the Lorentz angle is ≈ 30 μm, bigger than the intrinsic detector resolution.

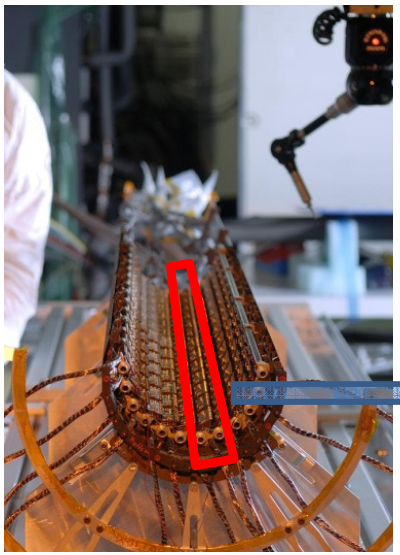
Width of the cluster (i.e. group of adiacent pixels) as a function of the track incidence angle.
The minimum of the distribution determines the Lorentz angle.

B field ON
Expected – 225 mrad
Measured – 213.9 ± 0.5 mrad
B field OFF
Measured value consistent with 0

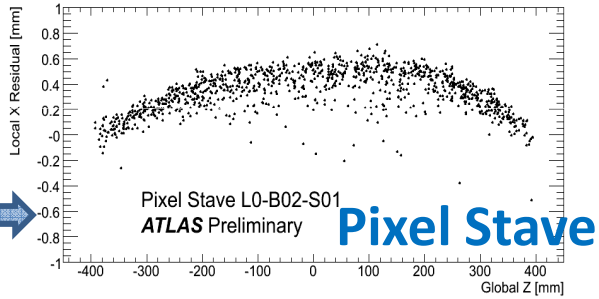


Alignment & Resolution

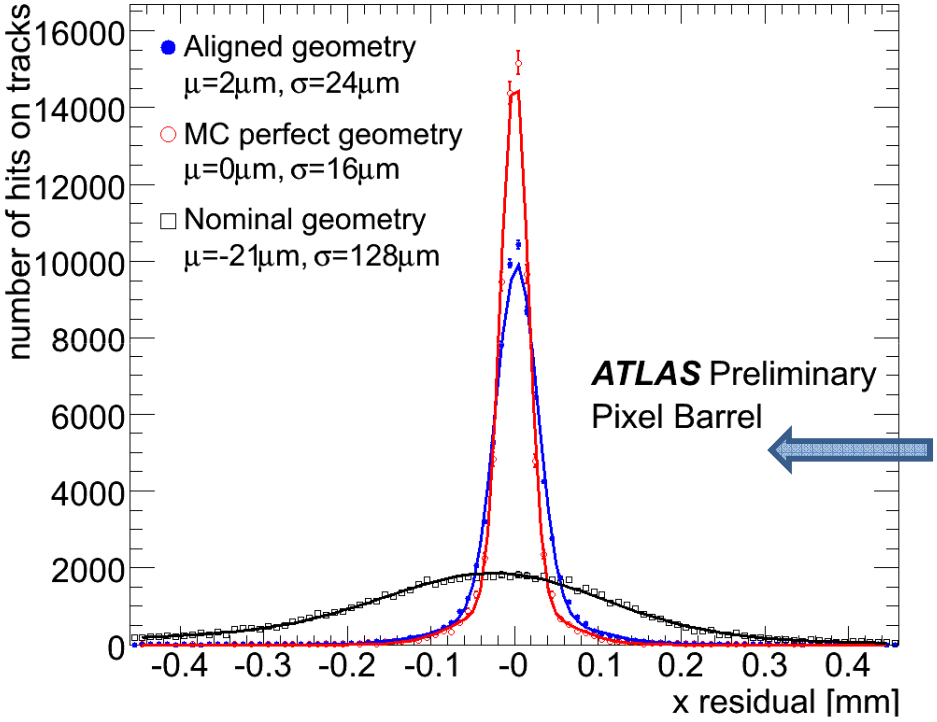
✓ Using cosmic ray data it was possible to align the detector for the first time.
✓ Alignment is an iterative process and is obtained in many steps. Bigger structures (shells and staves) are aligned first and then all the substructures, down to the module level.



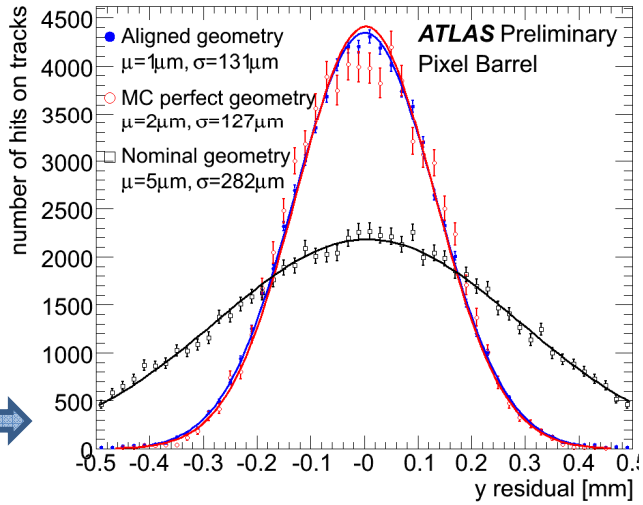
Before the alignment



Pixel Stave

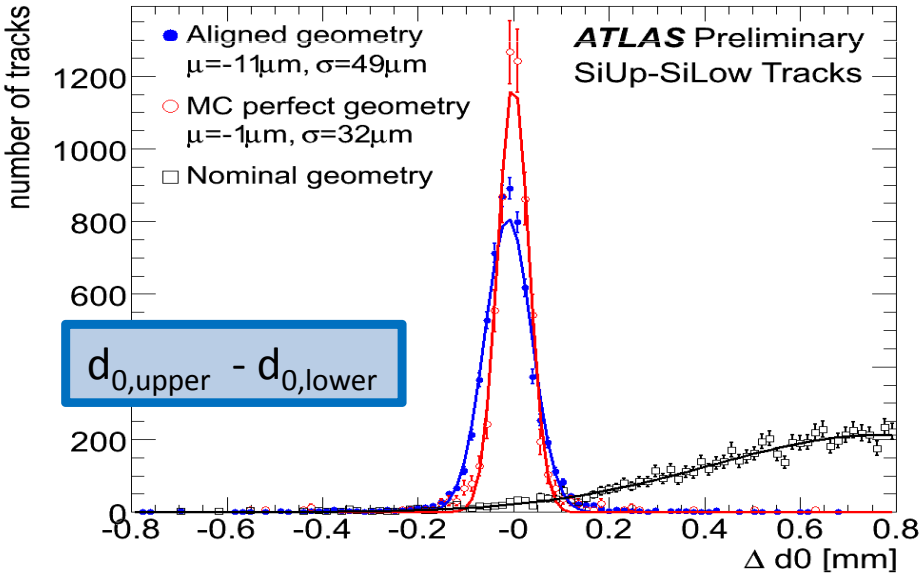


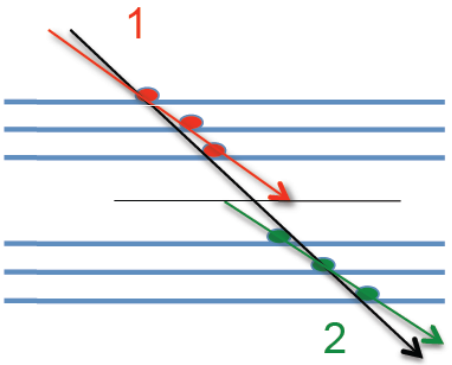
✓ After the alignment procedure, the distribution of the residuals improved up to 24 μm in the short and more precise direction and up to 131 μm in the longer direction.



Alignment & Resolution

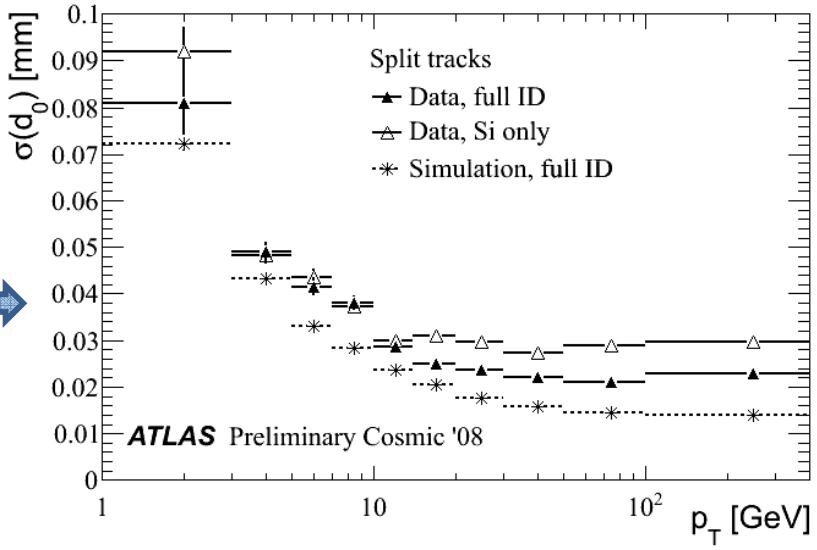
✓ Cosmic tracks crossing the entire Inner Detector leave hits in both the upper and lower halves of the ID. These tracks can be split near the interaction point and fit separately, resulting in two collision-like tracks that can then be compared.





✓ The pixel detector has achieved already a resolution of 22 μm on the impact parameter of muon tracks.

✓ cτ for B hadrons is 450 μm: b-tagging will be possible on early data.

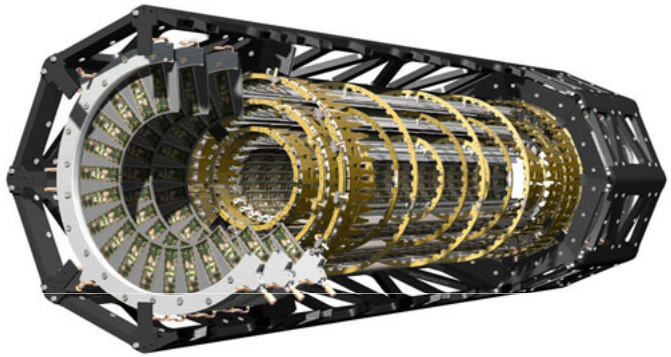


Pixel Detector Commissioning

✓ The ATLAS Pixel Detector has been fully commissioned thanks to the high statistic of cosmic tracks collected in 2008 and 2009.

✓ The 98% of the detector is operational and the intrinsic efficiency of the detector is 99.8%.

✓ The number of noisy pixels is less than 0.01% and the noise occupancy is of the order of 10^{-10} hits/pixel/event/BC.



✓ The detector has been fully calibrated.

✓ The whole Inner Detector has been aligned.

✓ Using splitted tracks it has been possible to determine the impact parameter resolution. It amounts to 22 μm for high momentum tracks and it s already sufficient for initial physics measurements.

✓The ATLAS Pixel Detector is ready for LHC beams this year.