Track and Vertex Reconstruction in the ATLAS Experiment

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The ATLAS Inner Detector

The ATLAS Inner Detector tracker is composed of three sub-detectors:

- the *Pixel Detector* made of silicon pixels (3 hits/track)
- the *Semi-Conductor Tracker* (SCT) made of silicon micro-strips (8 hits/track)
- the *Transition Radiation Tracker* (TRT) made of proportional drift tubes (~30 hits/track)

	Channels	Element size (X * Y)	Resolution (X * Y) μm
Pixel	80×10^6	$50 \mu\text{m} \times 400 \mu\text{m}$	10×115
SCT	6.3×10^6	$80 \mu\text{m} \times 12 \text{ cm}$	17×580
TRT	3.5×10^5	4 cm (diam.)	130

- All these sub-detectors allow precision measurement of charged particle trajectories in the high-multiplicity LHC environment.
- Each detector consists of barrel and endcap regions in order to minimize the material traversed by particles coming from the interaction vertex.

Track Reconstruction And Performance

Two-stage pattern recognition:

- Inside-out:
 - Starts from 3-point seeds.
 - Adds hits moving away from the interaction point using a combinatorial Kalman filter.
- Outside-in:
 - Tracks are extended into the TRT.
 - Mostly primary charged particles.
- Outside-in:
 - Reconstruct segments in the TRT.
 - Extends them inwards by adding silicon hits (back-tracking).
 - Mostly secondary particles.

Resolution on track parameters is fairly close to expectation for the simulation of a perfectly aligned detector.

Impact of Detector Alignment on Physics Performance

The Inner Detector has been aligned using the Global χ^2 algorithm.

Physics performance with $Z \rightarrow \mu^+ \mu^-$

- Muon tracks tagged with the Muon Spectrometer.
- $M_{\mu\mu}$ computed from Inner Detector tracks only after they have been identified as muons.
- Ideal alignment performance based on Monte Carlo is compared to observed performance of data processed with spring 2011 alignment and data processed with updated alignment constants.

Physics performance with $K_s^0 \rightarrow \pi^+ \pi^-$

- Mean reconstructed mass for K_s^0 candidates minus the world average K_s^0 mass as a function of ϕ in the positive end-cap of the ATLAS Inner Detector.
- A mass bias as a function of ϕ was observed in 2010 data and was explained by a misalignment of the solenoid field.
- Corrected by rotating the magnetic field in the reconstruction software by 0.55 mrad around the x-axis.

Vertex Reconstruction And Performance

Vertex reconstruction is used to identify with high efficiency the hard-scattering process and to measure the amount of pile-up interactions. Both aspects are crucial for many physics analyses.

Iterative Vertex Finder

- Find seeds from maximum in z_0 distribution of the tracks.
- Adaptive vertex fit around seed to determinate the vertex position.
- Repeat until no unassociated tracks are left or no more vertices found.

This algorithm has a high reconstruction efficiency and is robust against additional pile-up.

Vertex resolution is measured from data using the split-vertex method:

- Split the reconstructed vertices in two (half number of tracks each one).
- Use their separation to get an estimate of their combined intrinsic resolution.

Resolutions of the vertices of events with 70 contributing tracks:

- $\sigma_x, \sigma_y \sim 23 \mu\text{m}$
- $\sigma_z \sim 40 \mu\text{m}$

Material effects

The precise knowledge of the material budget within the tracking volume is mandatory for an accurate track reconstruction:

- Photon conversions & hadronic interactions allow the material to be studied.

Photon conversions allow for:

- Very precise estimate of the material
- "calibrate" w.r.t. well known reference object such as beam pipe.
- Understand geometrical data/MC differences
 - supporting structures, cooling pipes, power cables, ...

Reconstructed vertices after K0S, Gamma, Lambda vetoes

Time Dependent Detector Movements

- Alignment corrections at subsystem level were performed in a run-by-run basis starting from a common set of alignment constants.
- Sizable movements of the detector up to 10 μm occurred after hardware incidents.
- In between these periods little (<1 μm) movement is observed indicating that the detector is generally very stable.