The ATLAS Inner Detector tracker is composed of three sub-detectors:
- the Pixel Detector
- made of silicon pixels
- the Semi-Conductor Tracker (SCT)
- made of silicon micro-strips
- the Transition Radiation Tracker (TRT)
- made of proportional drift tubes

<table>
<thead>
<tr>
<th>Pixel</th>
<th>SCT</th>
<th>TRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$60 \times 10^3$</td>
<td>$6.3 \times 10^4$</td>
<td>$3.5 \times 10^5$</td>
</tr>
</tbody>
</table>

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

Form spacepoints from clusters of neighboring silicon measurements (hits)
- Create seeds of three spacepoints
- Two-stage pattern recognition
- Inside-out: pixel seeding + outward extension
- Outside-in: TRT track segment seed + inward extension

After extrapolating to next layer, the trajectory is refitted (Combinatorial Kalman Filter)
- Ambiguity solver scores track candidate to obtain final tracks

<table>
<thead>
<tr>
<th>$p_T$</th>
<th>400 MeV</th>
<th>10 mm</th>
<th>320 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_{\text{track}}$</td>
<td>$\sigma$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Resolution on track parameters is very near to expectation for the simulation of a perfectly aligned detector
- Mostly concerned with weak modes: second order corrections checked with physics processes
- Affects track curvature

### 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 maxima in $z_0$
- Adaptive vertex fit around seed
- Select primary vertex with highest $\Sigma p^2$

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

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

$$\sigma_{\text{vert}} = K \cdot \sigma_{\text{vert,Pl}}$$

- Measured resolution correspond to expectation from the vertex fit at better than 10%
- Resolutions @ 70 tracks
  - $\sigma_t \sim 23 \mu m$
  - $\sigma_\rho \sim 40 \mu m$

### VERTEX RECONSTRUCTION IN HIGH PILE-UP

The presence of additional interactions affects also vertex reconstruction.
- **Excellent efficiencies** up to high $\mu$
- **Robust track selection** keeps fakes to a negligible level
- The reconstruction algorithm is robust against split and masked vertices

### TRACKING IN HIGH PILE UP

The LHC has delivered a steadily increasing instantaneous luminosity and $\mu$, the number of interactions at each bunch crossing.
- The LHC design value for bunch intensity reached and exceeded.

The increased detector occupancy makes track reconstruction more challenging:
- the TRT operates well even at more than 50% occupancy in the innermost layers

<table>
<thead>
<tr>
<th>Track Selection</th>
<th>Default</th>
<th>Robust</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{\text{track}}$</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

- A robust track selection has been devised against pile-up effects
  - Reduces significantly the amount of fake tracks
  - Stability of track quality and track efficiency against pile-up has been checked in both data and simulation

### TRACKING WITH ELECTRON BREMSSTRAHLUNG RECOVERY

The behavior of high-energy electrons is dominated by radiative energy losses.
- deviations from original particle’s path
- significant inefficiencies during the electron trajectory reconstruction

The Gaussian Sum Filter (GSF) algorithm improves the estimated electron track parameters.
- The GSF consists of a number of Kalman filters running in parallel, each one representing a different contribution to the full Bethe-Heitler spectrum.
- In its current ATLAS implementation, the GSF is used to account for the radiative loss effects of electrons as they traverse the silicon trackers.

### REFERENCES

[1] 2008 JINST 3 S08003