TRACK AND VERTEX RECONSTRUCTION IN THE ATLAS EXPERIMENT

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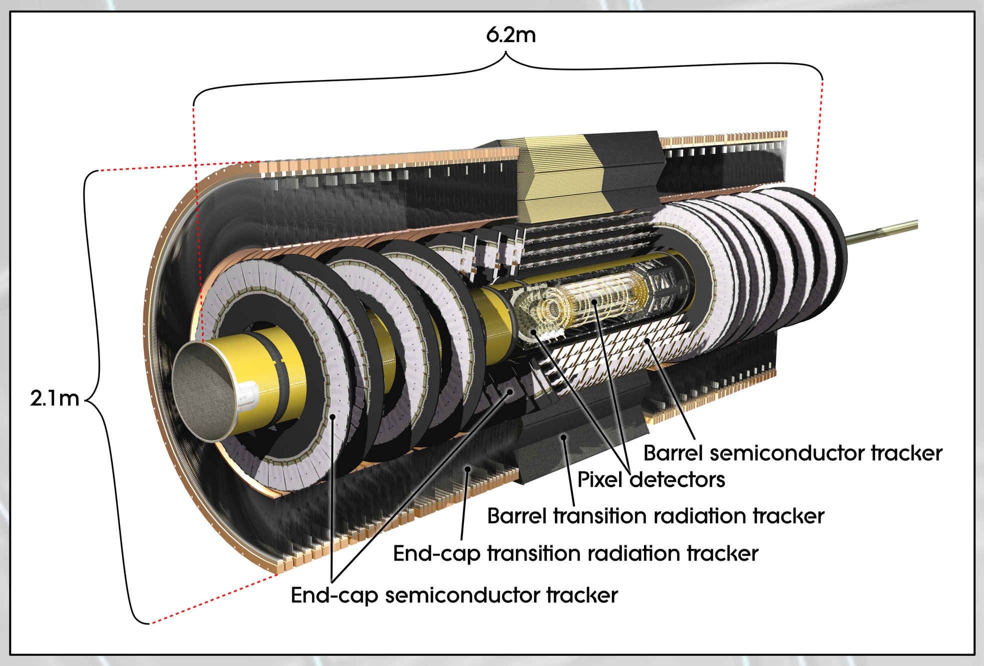
The ATLAS Inner Detector tracker is composed of three sub-detectors:

- 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

	Channel	Resolution (XxY) μm	$\langle hits \rangle$/track
Pixel	80×10^6	10×115	~ 3
SCT	6.3×10^6	17×580	~ 8
TRT	3.5×10^5	130	~ 36



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)

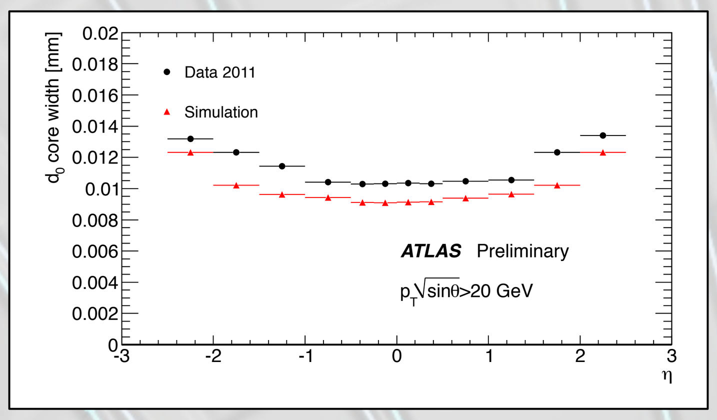
- Create seeds of three spacepoints

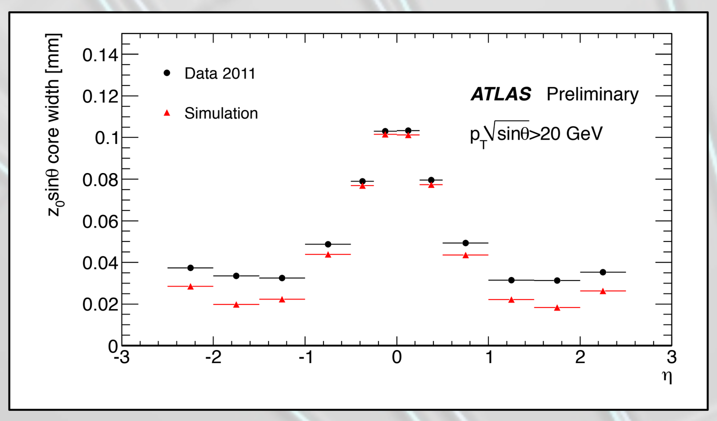
Two-stage pattern recognition

- Inside-out: pixel seeding + outward extension
- Outside-in: TRT track segment seed + inward extension

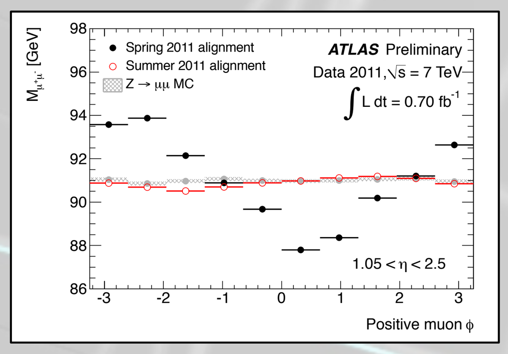
After extrapolating to next layer, the trajectory is refitted (Combinatorial Kalman Filter)

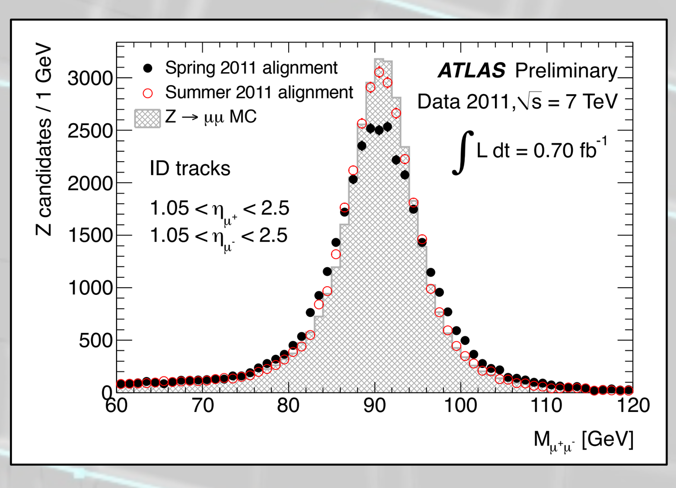
- Ambiguity solver scores track candidate to obtain final tracks





Track Selection		
p_T	$\lvert d_0 \rvert$	$\lvert z_0 \rvert$
400 MeV	10 mm	320 mm



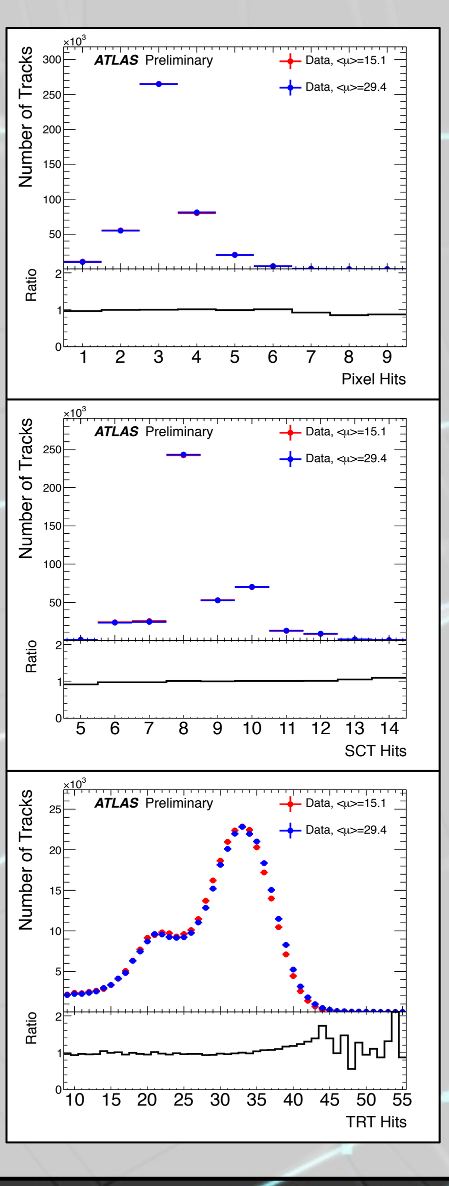


- Resolution on track parameters is very near to expectation for the simulation of a perfectly aligned detector

Alignment is itself a key feature for track resolution

- Mostly concerned with *weak modes:* second order corrections checked with physics processes
- Affects track curvature

TRACKING IN HIGH PILE UP



The LHC has delivered a steadily increasing instantaneous luminosity and μ, the number of interactions at each bunch crossing.

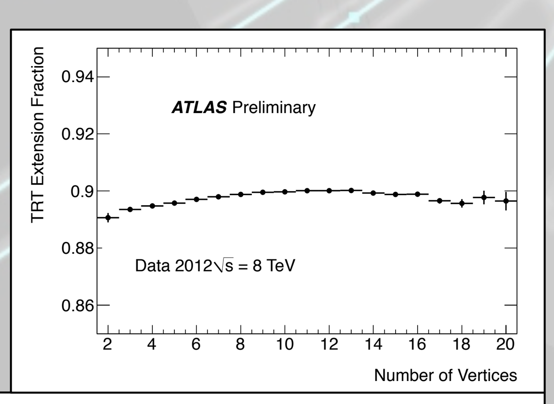
- The LHC design value for bunch intensity reached and exceeded.

$$\mu = \frac{L \cdot \sigma_{inel}}{n_{bunch} \cdot f_r}$$

- *Early 2011 <μ>=5*
- *Late 2011 <μ>=15*
- *Early 2012 <μ>=22*

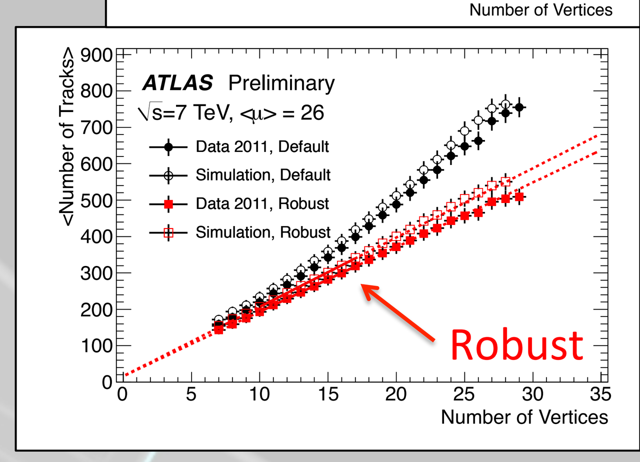
The increased detector occupancy makes track reconstruction more challenging:

- the TRT operates well even at more than 50% occupancy in the innermost layers



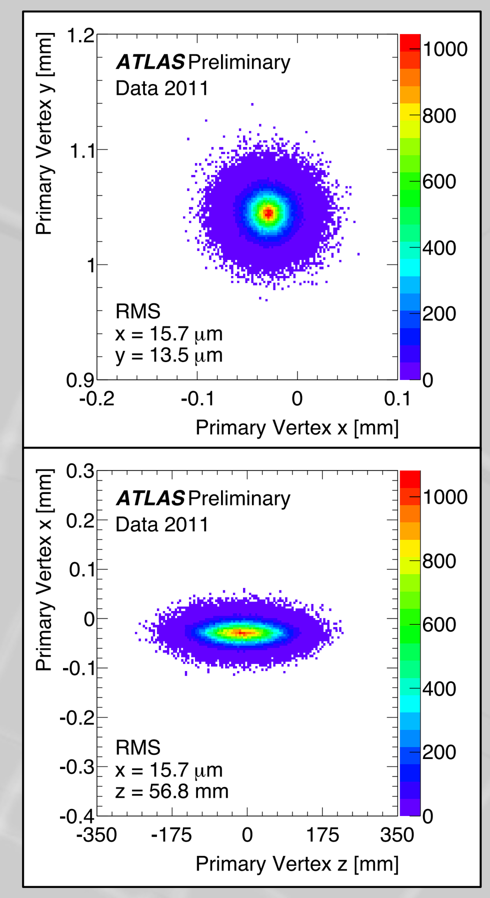
	Min. Si Hits	Max. Pixel Holes
Default	7	2
Robust	9	0

- 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



VERTEX RECONSTRUCTION AND PERFORMANCE

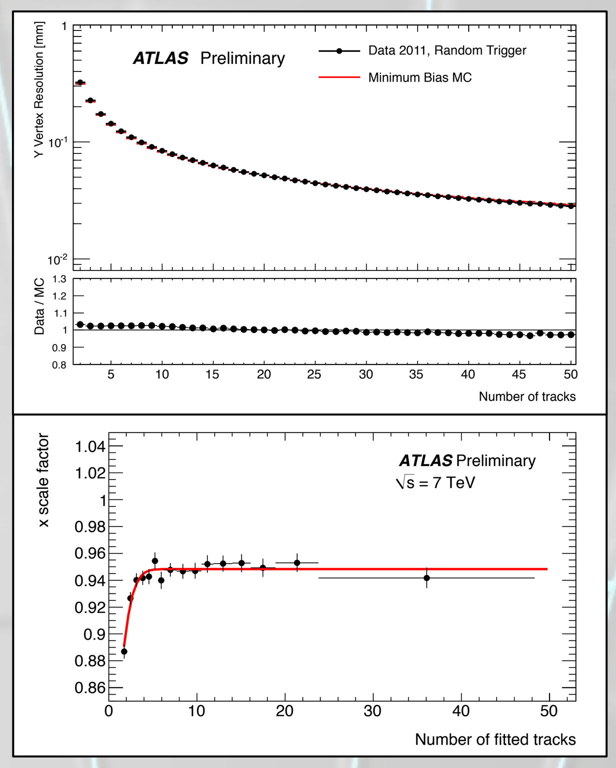
Vertex reconstruction is used to identify with high efficiency the hard scattering process and to measure the amount of pile-up interactions. Both aspects are crucial for many physics analyses.

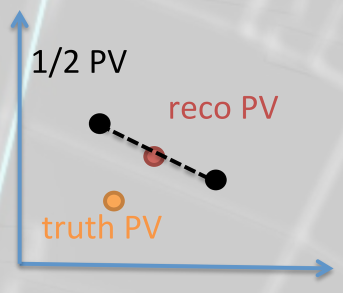


Iterative Vertex Finder

- Find seeds from maxima in z_0
- Adaptive vertex fit around seed
- Select primary vertex with highest Σp^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.

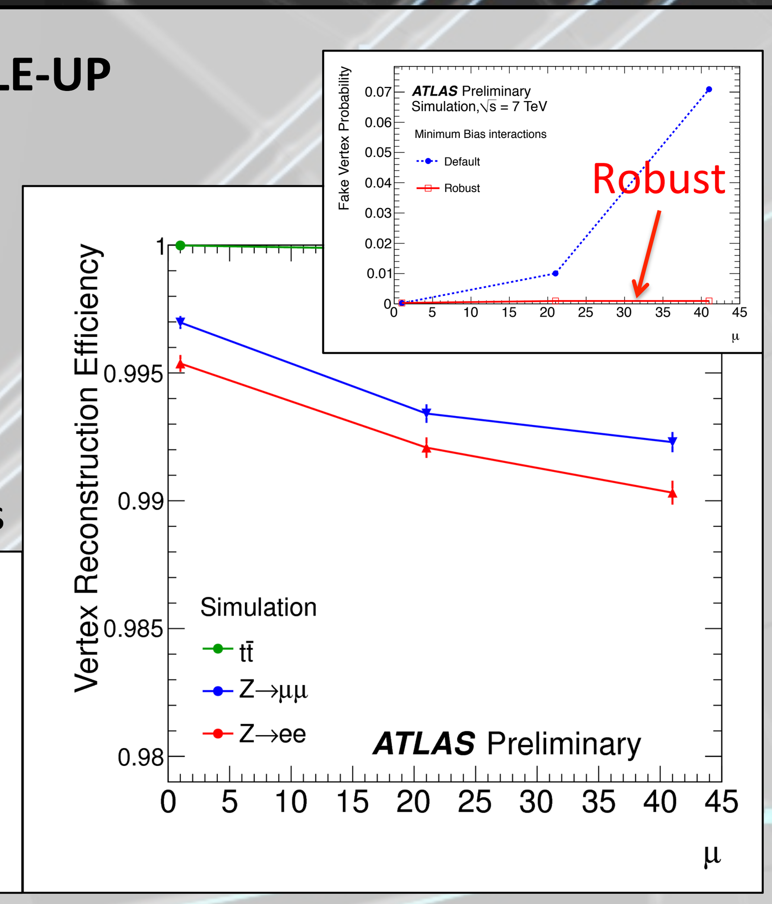
$$\sigma_{xPV,true} = K_x \sigma_{xPV,fit}$$

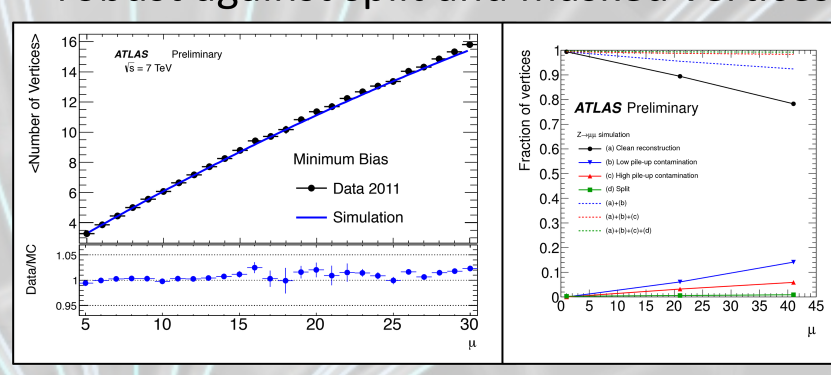
- Measured resolution correspond to expectation from the vertex fit at better than 10%
- Resolutions @ 70 tracks $\sigma_x \sim 23 \mu m$ $\sigma_z \sim 40 \mu m$

VERTEX RECONSTRUCTION IN HIGH PILE-UP

The presence of additional interactions affects also vertex reconstruction.

- Excellent efficiencies up to high μ
- Robust track selection keeps fakes to a negligible level
- The reconstruction algorithm is robust against split and masked vertices



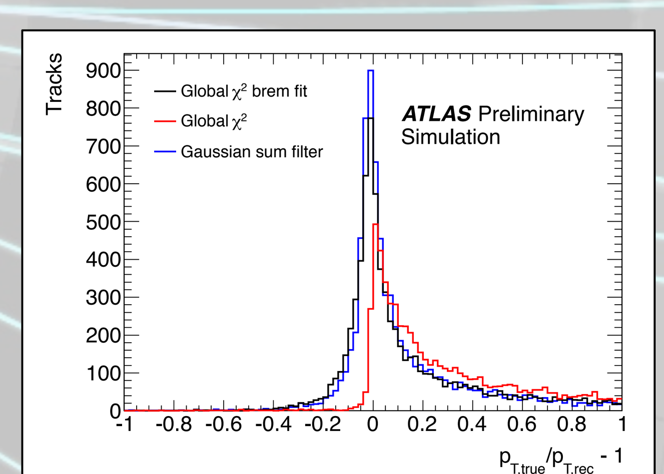


TRACKING WITH ELECTRON BREMSSTRAHLUNG RECOVERY

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*
[2] *ATLAS-CONF-2012-042*
[3] *https://twiki.cern.ch/twiki/bin/view/AtlasPublic/InDetTracking PerformanceApprovedPlots*