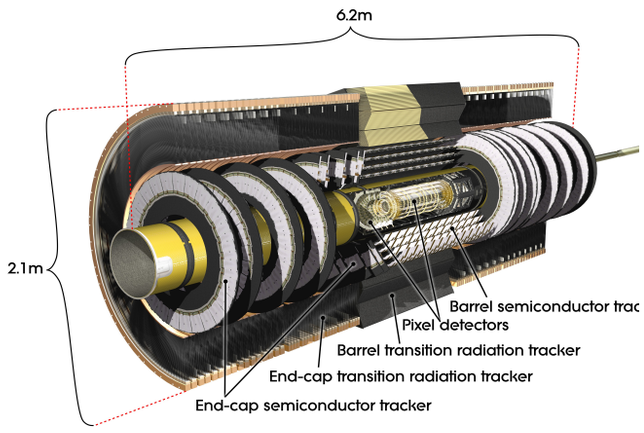
LHCC Poster Session - CERN, 21 March 2012

ATLAS Inner Detector Track Reconstruction in high pile-up

Abstract

With an average number of up to 23 pile-up interactions per bunch crossing (μ) in 2011 data taking the ATLAS Inner Detector (ID) already reached its design specifications. This poster presents studies in data and simulation demonstrating that the ID track reconstruction is well-prepared for the high pile-up expected in 2012.

ATLAS Inner Detector

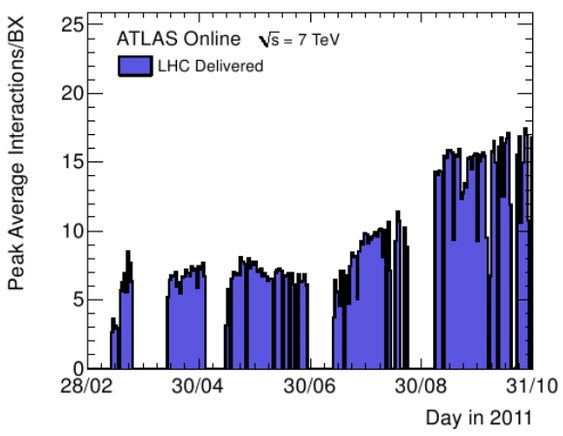


Pixel detector
3 barrel and 2x3 end caps with silicon pixels (size 50 x 400 μm²)

Semiconductor tracker
4 barrel and 2x9 end caps with silicon strips (size 80 μm x 12 cm)

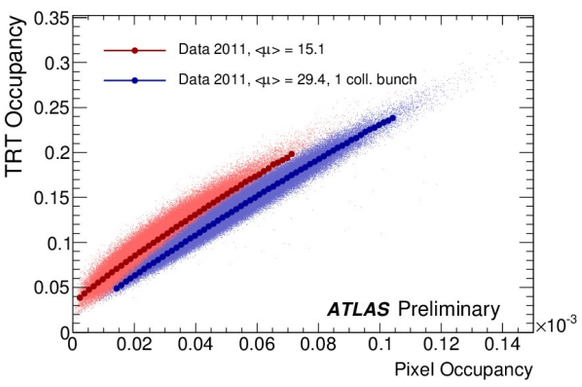
Transition radiation tracker
73 barrel and 160 end-cap planes with drift tubes (size 4 mm)

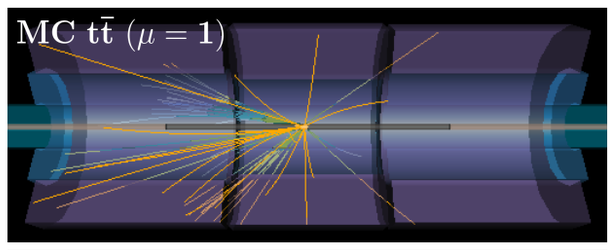
Pile-up

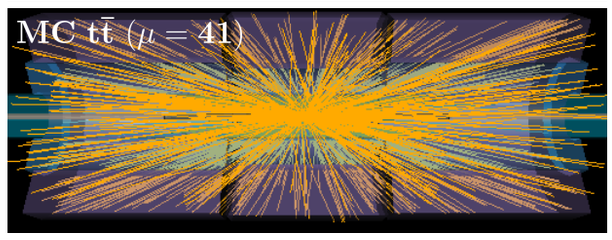


$$\mu = \frac{L\sigma_{\text{inel}}}{n_{\text{bunch}} f_r}$$

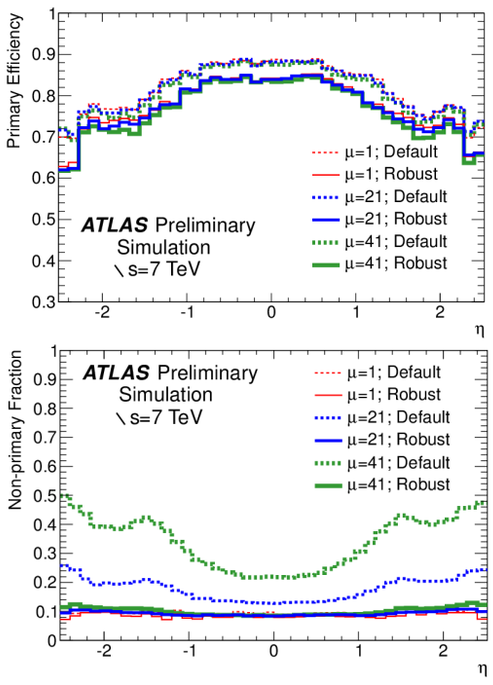
LHC fill with μ=15 (50 ns bunch spacing, 5.8 pb^{-1}) and a special μ=29 fill (one bunch per beam, 60 nb^{-1}). Occupancy reached 0.01% in pixel and 30% in TRT. **No significant saturation** yet, but reconstruction challenging with respect to CPU time, disk space and fake tracks.







Simulation



Track reconstruction efficiency
Fraction of primary particles within ID acceptance matched to reconstructed track. **Stable with increasing pile-up**. Robust selection decrease efficiency by 5%.

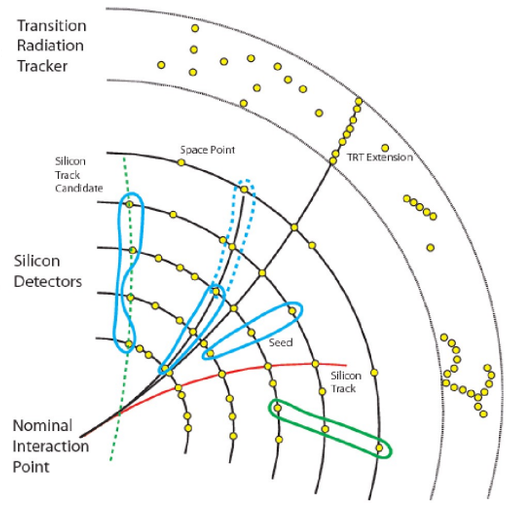
	min Si hits	max pixel holes*
Default	7	2
Robust	9	0

* Hole: no hit found for track fit traversing sensitive detector layer

Non-primary fraction
Sum of secondary and fake tracks. Significant increase with pile-up. Can be kept **stable with robust selection**.

Track and Vertex Reconstruction

Tracking
- Form spacepoints from clusters of neighbouring silicon measurements (hits)
- Create seeds of three spacepoints
- Successively extrapolate to next layer and refit trajectory (Combinatorical Kalman Filter)
- Ambiguity solver scores track candidate to obtain final tracks
- Extend track into TRT



Back-tracking
To better reconstruct secondaries start from TRT and extend seed into silicon detectors.

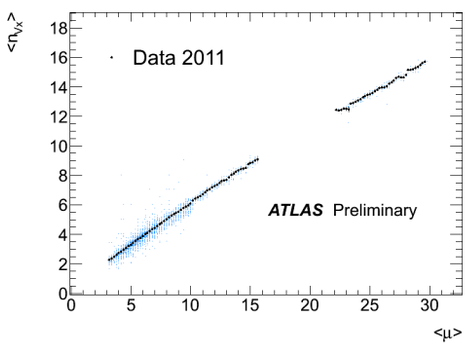
Vertexing
- Iteratively find seeds from maxima in z_0
- Adaptive vertex fit around seed
- Select primary vertex with highest Σp_T^2

Track Selection

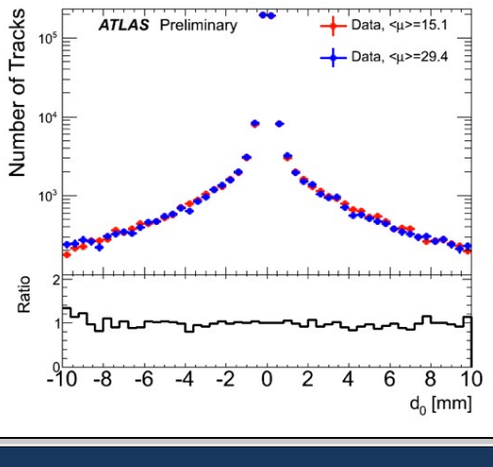
p_T	$\lvert z_0 \rvert$	$\lvert d_0 \rvert$
400 MeV	320 mm	10 mm

Performance in data

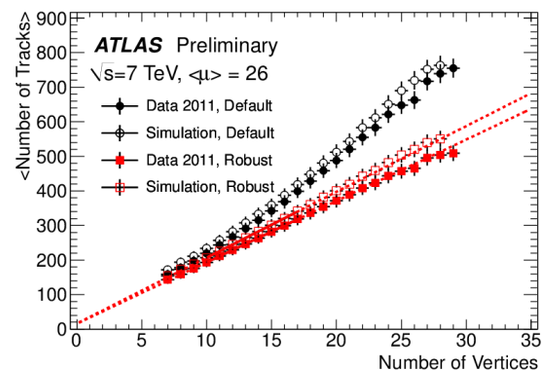
Vertex reconstruction
Small deviation from linear increase of number of vertices with μ indicates that vertex reconstruction algorithm is fairly **robust against additional pile-up**.



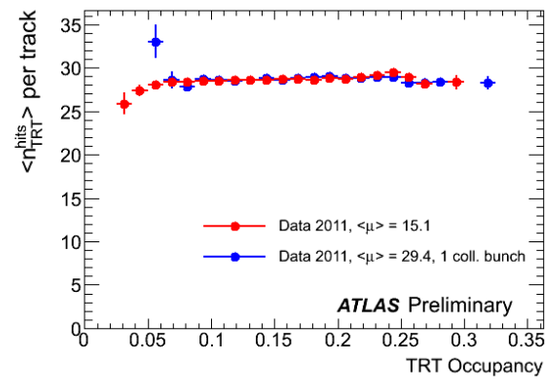
Transverse impact parameter
Tails at d_0 > 2mm are sensitive to secondary tracks. Unchanged size demonstrates **no significant change to secondary efficiency** with pile-up, which corresponds to findings from simulation.



Fake rate
Average number of particles per interaction is independent of pile-up. For μ=29 large increase in default tracks compared to robust tracks with number of vertices demonstrates the increase in combinatorial fakes. **Robust cuts eliminate this fake contribution**. Stability of robust tracks is seen in both, data and dedicated simulation which matches the pile-up profile of the data.



Track quality
The number of hits on tracks is important for track quality. In the inner detectors (shown here for TRT) it remains **unaffected by increasing μ**.



Conclusion

A good performance of the Inner Detector track reconstruction has been found even in data containing significant amounts of pile up. Although there is no impact on the track reconstruction efficiency, an increase in the fake rate has been observed. Therefore robust tracking cuts have been developed to effectively control the fake rate. With these cuts the impact parameter resolution and track quality in high pile-up is on par with current values.
In summary the ATLAS Inner Detector track reconstruction is well prepared for 2012 data taking.

References

[1] *2008 JINST 3 S08003*

[2] *ATLAS-CONF-2012-042*

[3] *https://twiki.cern.ch/twiki/bin/view/AtlasPublic/InDetTrackingPerformanceApprovedPlots*

Christoph Wasicki, for the ATLAS Collaboration