Performance of the ATLAS Transition Radiation Tracker

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Abstract

The ATLAS Transition Radiation Tracker (TRT) is an integral subsystem for precision tracking at ATLAS. In addition, transition radiation signatures allow for particle identification capabilities. Monitoring the performance of the TRT helps establish the necessary foundation for understanding higher level tracking reconstruction and particle identification. We present our current studies on how the TRT is performing, in particular as the number of interactions per bunch crossing increases.

The ATLAS Inner Detector

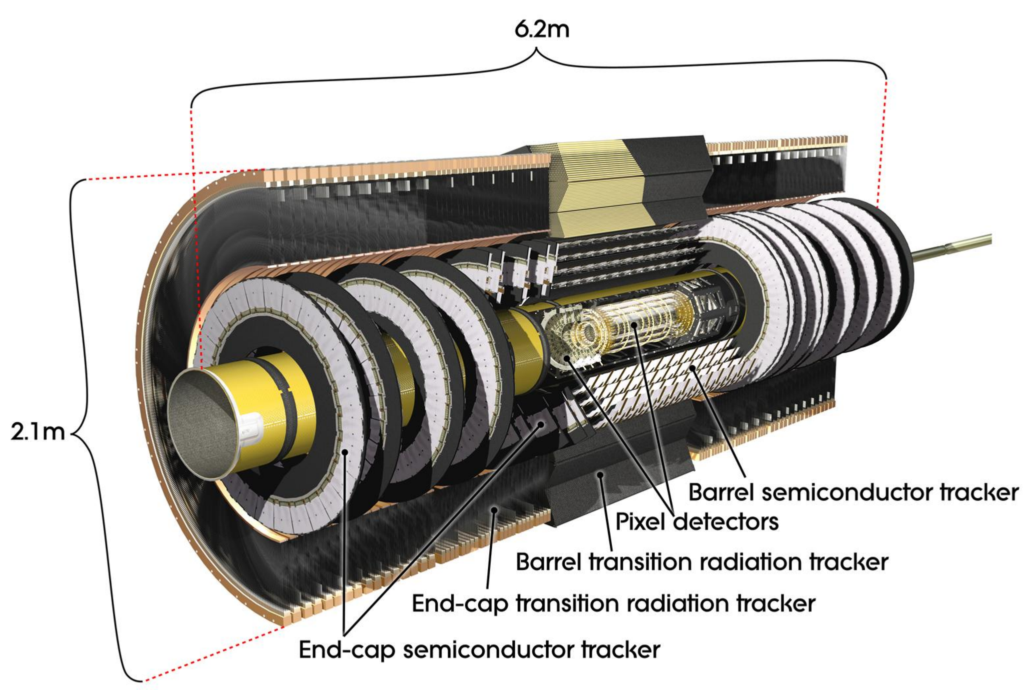

Figure 1: The ATLAS inner detector

The inner detector consists of the silicon pixel, silicon strip, and transition radiation tracker subdetectors. The TRT's role in tracking is to provide a large lever-arm to complement the semiconductor trackers closer to the beamline. The TRT also provides a vital component in particle identification through the application of transition radiation.

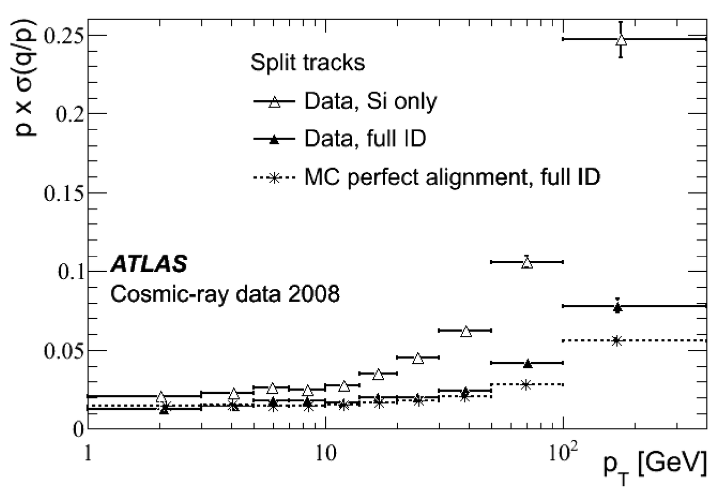

Figure 2: p_T resolution of the inner detector, illustrating the importance of the TRT at high momentum.

TRT Overview

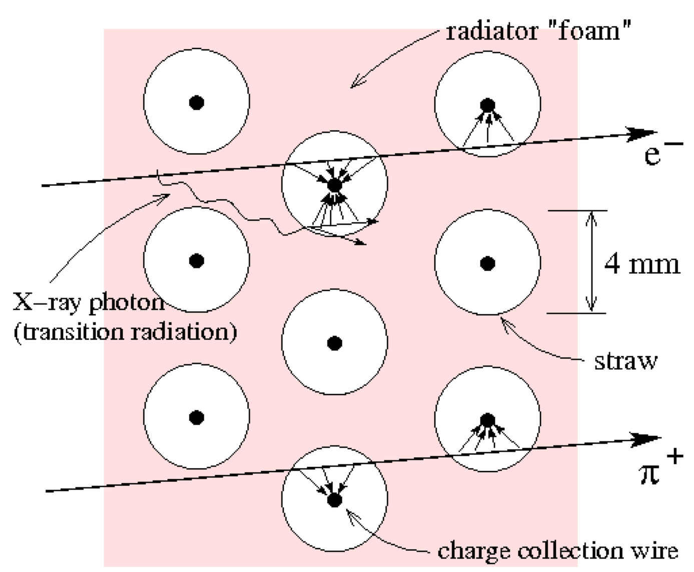

Figure 3: Depiction of gas ionization and transition radiation by electron and pion tracks in a view transverse to beam direction.

The TRT is the outermost component of the inner detector, consisting of a barrel and two end-cap partitions. Immersed in a 2T magnetic field, it provides tracking and particle identification coverage out to $|\eta| < 2.0$.

- 4mm-diameter Kapton straws filled with $Xe/CO_2/O_2$ gas provide tracking coverage. As charged particles pass through the straws, they ionize the gas and electrons collect on the wires at the straw center.
- The space between straws is filled with radiator material, the surfaces of which provide interfaces of different indices of refraction which can lead to the emission of transition radiation as a particle traverses these interfaces. This in turn is used for particle identification (see below).

Performance at High Pileup

Recent run conditions provide increased challenges for tracking in the inner detector. As instantaneous luminosity increases, the number of interactions per bunch-crossing ($\langle\mu\rangle$) will also increase, leading to increased detector occupancy. $\langle\mu\rangle$ is a measure of both in-time and out-of-time pileup, and depends proportionally on the instantaneous luminosity. For example, in 2011 data, $\langle\mu\rangle = 22$ corresponds to $L \approx 6 \times 10^{33}$ cm^{-2}s^{-1}.

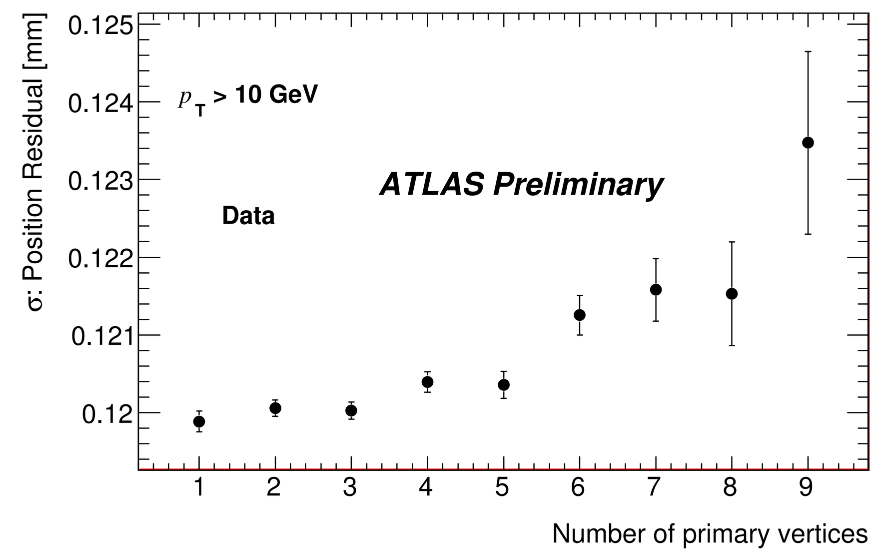

Figure 4: Position residuals of TRT tracks as a function of the number of primary vertices.

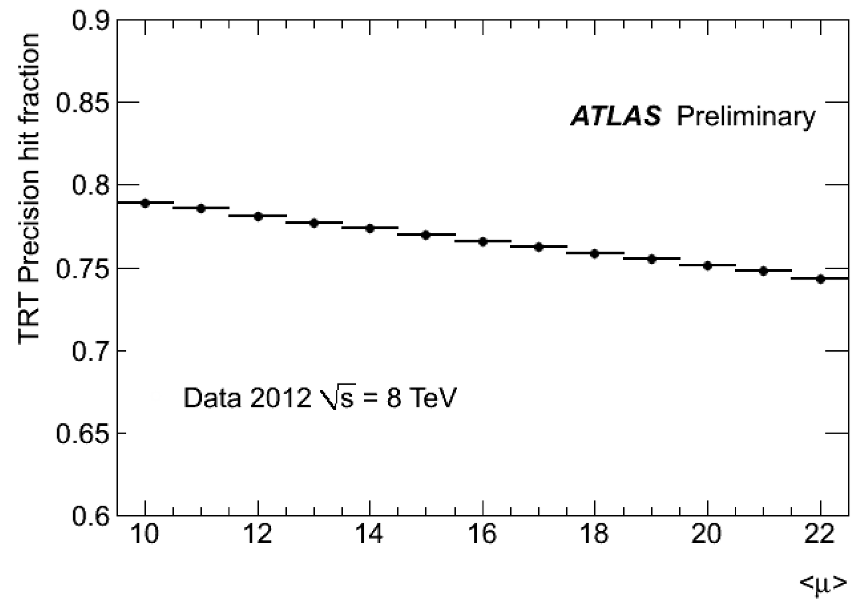

Figure 5: The fraction of TRT track hits that are precision hits versus $\langle\mu\rangle$. Non-precision hits are due to overlapping tracks, poorly measured drift times, and out-of-time pileup.

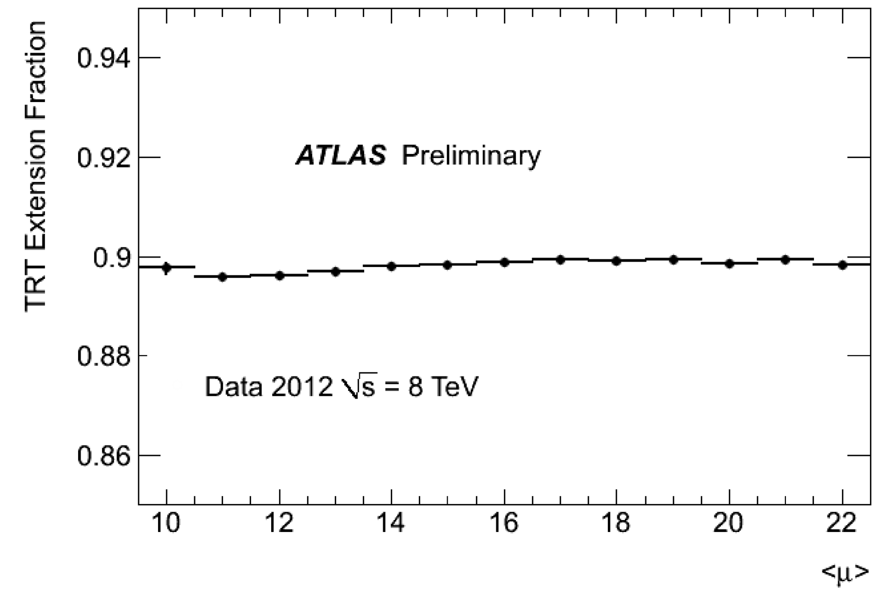

Figure 6: The fraction of tracks found in the silicon that have extensions found in the TRT as a function of $\langle\mu\rangle$.

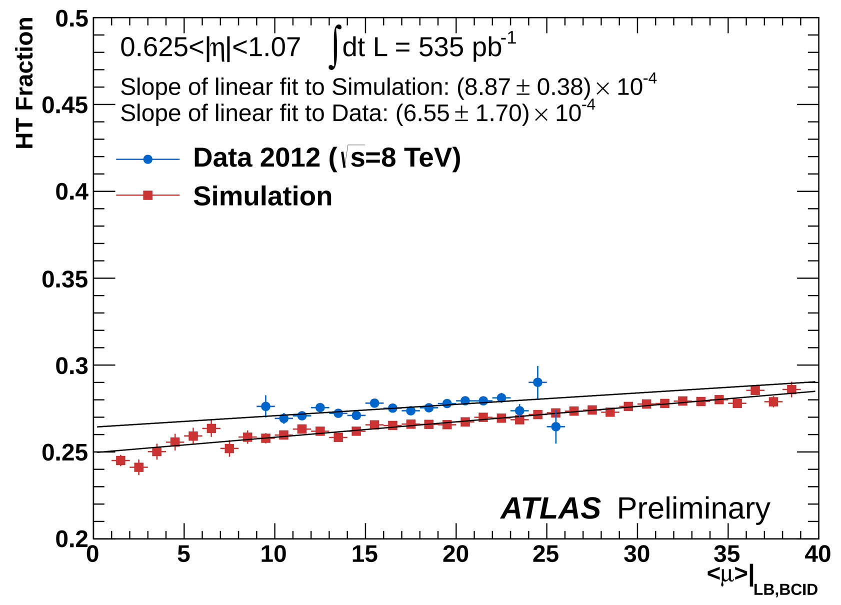

Figure 7: HT fraction for electron candidates passing through the TRT barrel and end-cap wheel A as a function of $\langle\mu\rangle$

Studies in high pileup conditions indicate that tracking becomes inherently more difficult when detector occupancy reaches high levels; position residuals increase and the number of precision hits decreases with increasing $\langle\mu\rangle$. Despite high pileup conditions, the TRT is continuing to perform well in tracking and electron identification, indicated by the extension fraction and high threshold fraction remaining relatively flat.

Signal Digitization

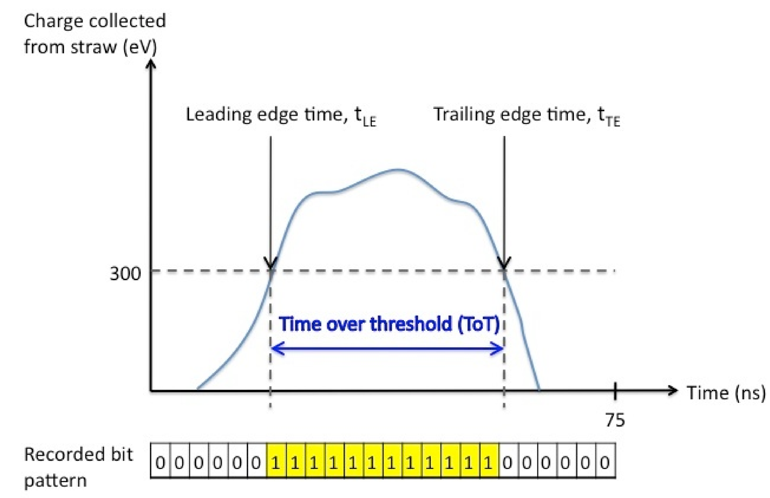

Figure 8: Diagram depicting the digitization of a TRT low threshold signal from a single straw.

TRT tracking information is read out in 24 time bins of 3.12 ns using a low threshold (LT) of 300 eV. In addition, electron identification information is read out in 3 time bins of 25 ns using a high threshold (HT) of 6 keV.

Electron Identification

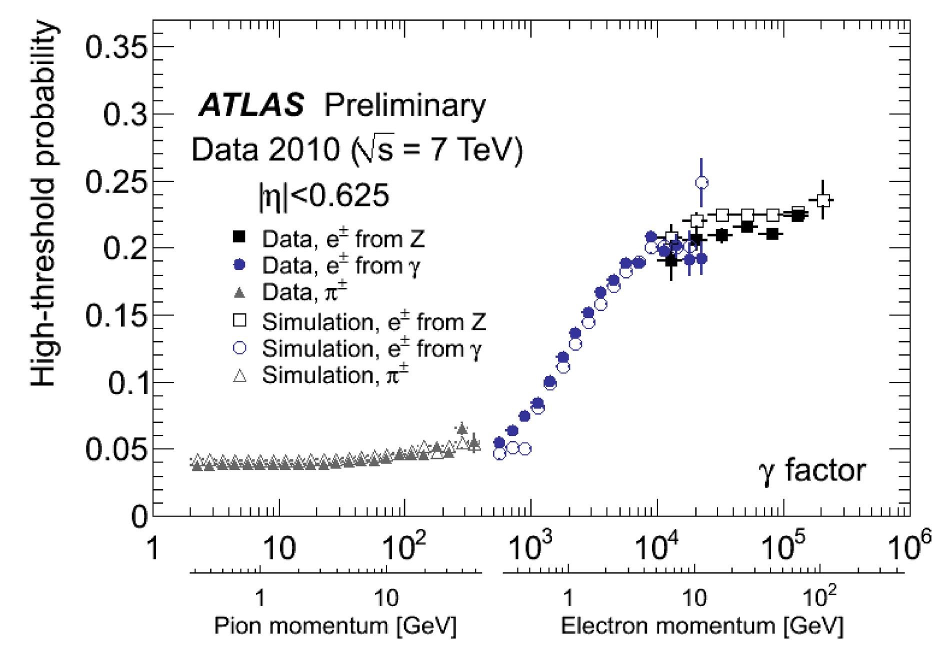

Figure 9: HT turn-on curve for the TRT barrel region.

The probability of emitting transition radiation depends on a particle's relativistic gamma factor. We use the fraction of hits with a HT bit to discriminate between high γ and low γ particles, providing an effective means of distinguishing electrons from heavier particles like pions.

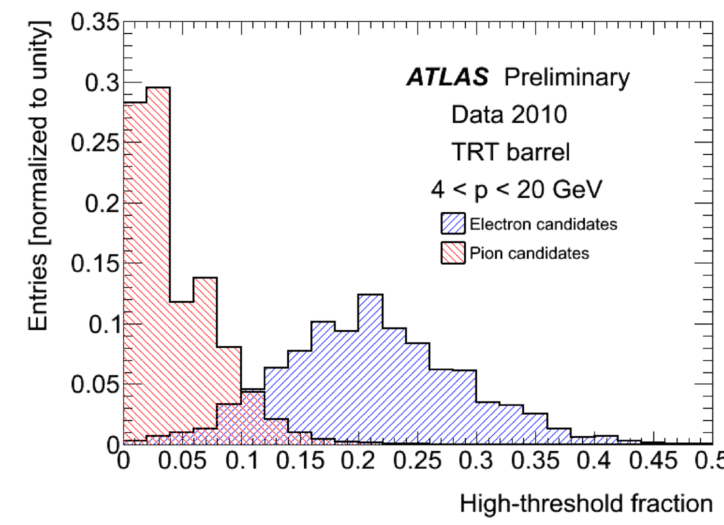

Figure 10: Fraction of HT hits on track for electron and pion candidates in the TRT barrel region.