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The ATLAS Forward Proton Time-of-Flight Detector System

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The Time-of-Flight (ToF) detectors in the ATLAS Forward Proton (AFP) system are designed to determine the primary vertex z-position of the pp -> pXp processes by comparing thearrival times measured in the ToF for the two intact protons in the final state. We present performance studies in terms of efficiencies and timing resolutions using high-statistics, low, and moderate pile-up data collected during the ATLAS Run 2 and Run 3 periods.

In Run 2, low efficiencies of a few percent are observed, and the resolutions of the two ToF detectors measured individually are 21 ps and 28 ps. This results in an expected precision of 5.3 ± 0.6 mm for the vertex reconstruction resolution provided by the ToF. This value aligns with the results from subsequent statistical analysis of the distribution of differences between the vertex z-positions reconstructed by the ATLAS central detector and the ToF. This distribution comprises a background component from combinatorics due to non-negligible pile-up and a significantly narrower signal component (6.0 ± 2.0 mm) from events where protons from the same interaction are detected in the ToF.

For Run 3, the ToF detector underwent major upgrades in electronics, optics, and mechanics, resulting in a substantial improvement in detection efficiency exceeding 80%. There was a slight, but not critical, degradation in its timing capabilities, leading to a vertex reconstruction precision at the level of 10 mm.

Author: CERNY, Karel (Palacky University (CZ))

Presenter: CERNY, Karel (Palacky University (CZ))