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Luminosity and Beamspot Determination Using the ATLAS Detector

We present the algorithms and results of the reconstruction of the luminous region (also known as beam spot) and measurement of the luminosity in the ATLAS experiment during the first LHC run at energies between $\sqrt{s}$ = 900 GeV (in 2009) and $\sqrt{s}$ = 7 TeV (in 2010).
The LHC luminosity is determined in real time approximately once per second using a number of detectors and algorithms, each having different acceptances, systematic uncertainties and sensitivity to background. These results are displayed in the ATLAS control room and archived every two minutes; a single "preferred" measurement is reported to the LHC. During offline analysis, additional luminosity algorithms are studied and are compared to online results to further constrain systematic uncertainties on the measurement. Relative luminosities between detectors and methods agree to within a few per cent. Determination of the absolute luminosity using Monte Carlo calibrations is limited by a ˜20% systematic uncertainty from the modeling of diffractive components of the cross section. Smaller systematic uncertainties are obtained using an absolute calibration of the luminosity via beam separation scans.
The spatial distribution of pp interactions is first reconstructed in real time by a dedicated algorithm in the high-level trigger and later more precisely by an offline reconstruction algorithm. The latter takes full advantage of the high tracking efficiency and resolution of the Inner Detector through an unbinned maximum-likelihood fit to reconstructed vertices of candidate primary interactions. This fit determines all relevant parameters of the LHC luminous region at the ATLAS interaction point, including the resolution-corrected size of the beam spot. Using beam separation scans, the length scales of the beam-position monitors are calibrated against the displacement of the luminous centroid measured during these scans. This significantly improves the absolute accuracy of the luminosity calibration obtained via beam scans. The rate of reconstructed primary vertex candidates provides a relative measurement of the luminosity.

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