Contribution ID: **19** Type: **Performance and Tools**

Luminosity determination for the measurement of the total proton-proton cross section and the rho-parameter with the ATLAS experiment at the LHC

ATLAS has measured the total cross section during the LHC Run-1 at sqrt(s) = 7 and 8 TeV and in Run-2 at sqrt(s)=13 TeV using a luminosity dependent approach which exploits the relation ensured by the Optical Theorem between sigma_tot and the imaginary part of the scattering amplitude in the forward direction. To reach values of the Mandelstam variable -t down to 2.5 x 10ˆ-4 GeVˆ2 needed to probe the Coulomb-Nuclear interference region of the elastic cross section, a small LHC-beam divergence is needed, which is obtained with special high-beta*optics. During Run-2 beta*=90 m and 2.5 Km were used, resulting in very different beam-spot sizes and in an instantaneous luminosity up to 7 orders of magnitude lower than in standard data taking conditions and 3 orders of magnitude lower than the van der Meer runs used for the absolute calibration of the luminosity detectors. These conditions represent a challenge for the luminosity measurement, and the systematic uncertainty in the luminosity determination represents one of the dominant components of the overall uncertainty on sigma_tot and the rho-parameter, defined as the ratio of the real to the imaginary part of the elastic-scattering amplitude in the limit of the Mandelstam variable t−>0. Thanks to the excellent performance and sensitivity of the main ATLAS luminometer, LUCID, and of the ancillary measurement based on track-counting algorithms used to estimate the systematic uncertainty, a precision on the luminosity determination of 1.0% (2.15%) was obtained in the measurement at beta*=90 m (2.5 Km) acquired in 2018 (2016) at sqrt(s) = 13 TeV.

In this poster, a detailed description of the luminosity measurement in the Run-2 data takings at high-beta* aimed to measure sigma_tot and rho is given, with emphasis on the ATLAS approach, based on the redundancy of the luminosity information provided by different detectors and methods with different sensitivity to the LHC optic conditions, backgrounds and systematic effects.

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Session Classification: Poster session

Track Classification: Performance and Tools