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Total Cross Section Measurement with TOTEM at the LHC

The TOTal Elastic and diffractive cross section Measurement (TOTEM) experiment [1] at the Large Hadron Collider (LHC) is an experiment specialized in forward physics. The main goals include a precise measurement of the total proton-proton cross section as well as cross sections for elastic and different inelastic processes (single, double and central diffractive). In addition to the cross section, the topologies (e.g. charged multiplicity and invariant mass distributions) of single, double and central diffraction are studied. These measurements will lead to a better understanding of the nature of the proton structure.

A first measurement of the elastic and total p-p cross sections has been done [2] by TOTEM. This is a luminosity dependent measurement using the measurement supplied by the Compact Muon Solenoid (CMS) experiment [3]. The cross section is obtained from the elastic cross section extrapolated to zero momentum transfer. The first measured cross section of (98.3 ± 0.2stat ± 2.8syst) mb at the center of mass energy of 7 TeV is in good agreement with the extrapolation from the overall fit of previously measured proton-proton and proton-antiproton cross sections at much lower energies.

A next measurement of the total and partial cross sections, with data taken on special optics conditions that are essentially free from pileup and allow detection of all protons with momentum transfer $t \geq 0.01$ GeV^2, is foreseen. The inelastic rate will be measured using the T1 and T2 detectors as event counters. Due to the limited acceptance of the detectors (geometrical acceptance in pseudorapidity η is for T1 $3.0 < \eta < 4.6$ and for T2 $5.3 < \eta < 6.5$), the inelastic rate needs to be corrected for geometrical acceptance and this is done by extrapolating the diffractive mass distribution to low mass. The measured inelastic rate together with the elastic rate and the extrapolation of the differential elastic rate to zero momentum transfer allows for a cross section measurement, based on the optical theorem, which is luminosity independent.

The inelastic rate is estimated from the number of collected inelastic events correcting for trigger, reconstruction and acceptance inefficiencies. The beam gas background is evaluated from events collected with non-colliding bunches. The reconstructed diffractive mass distribution is extrapolated to zero to estimate the rate of events with all final state particles beyond the η-acceptance of T2. Event classification is used to minimize the background of non-diffractive events for the diffractive mass reconstruction.

The goal for the luminosity independent total p-p cross section measurement is a precision of 1-2 %.

[1] http://totem.web.cern.ch/Totem/
[2] G. Antchev et al.: "First measurement of the total proton-proton cross-section at the LHC energy of $\sqrt{s}$ = 7 TeV"EPL, 96 (2011) 21002.
[3] http://cmsinfo.web.cern.ch/cmsinfo/

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