Inelastic proton cross-section at $\sqrt{s} = 13$ TeV

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Abstract
Poster presents the recent measurement of the inelastic cross-section at 13 TeV with the ATLAS detector, extracted with independent measurements of the rate of inelastic collisions and the LHC luminosity. The result of $79.3 \pm 2.9$ mb has been obtained after extrapolation to the full phase space and is compared with a range of theoretical predictions. In addition, the fraction of diffractive events is measured using two event selections. The low-luminosity data of total integrated luminosity of 60.1 $\mu$b$^{-1}$ recorded in 2015 was used.

Motivation
- Probes phenomenological models of non-perturbative QCD regime
- Complementary measurement to elastic cross-section connected through optical theorem
- Extends our understanding of the rise of total pp cross-section with $\sqrt{s}$
- Used to estimate pile-up at the LHC
- Important for cosmic ray shower models

Minimum Bias Trigger Scintillators (MBTS)
- Thin polystyrene scintillation counters, the total of 24 counter segments
- Located at ≤3.6 meters between inner tracking detector and calorimeter
- Pseudo-rapidity acceptance: 2.07 < $|\eta|$ < 3.86
- Sensitive in the kinematical region $\xi > 10^{-6}$ (efficiency above 50% for at least 2 hits)

Event selection
- At least 2 MBTS counters with a charge above 0.15 pC (N_{MBTS} > 2)
- Fiducial region: $\xi > 10^{-6}$ ($\leftrightarrow M_X > 13$ GeV)
- Proton energy loss: $\xi = \frac{M^2}{s}, \Delta \eta \approx -\ln \xi$
- Elastic limit: $\xi > 6.10^3$

Results for $\sigma_{\text{inel}}$

- Measurement in the fiducial region
  $$\sigma_{\text{inel}}(\xi > 10^{-6}) = \frac{N_{\text{signal}} - N_{\text{bg}}}{\varepsilon_{\text{trig}} \cdot L} \cdot C_{\text{MC}}$$
  where:
  - $N_{\text{signal}} = 4,159,074$ events, $N_{\text{bg}} = 51,187$ events
  - $L = 60.1 \mu$b$^{-1}$
  - $\varepsilon_{\text{trig}} = 99.7$ % = MBTS trigger efficiency
  - $C_{\text{MC}} = 99.3$ % = correction for event selection efficiency and migration of events from $\xi < 10^{-6}$ (estimated using Monte Carlo simulations)
  - $\sigma_{\text{inel}}(\xi > 10^{-6}) = 68.1 \pm 0.6$ (exp.) $\pm 1.3$ (lum.) mb

Diffractive events

- $\sigma_{\text{inel}} = \sigma_{\text{non-diffractive}} + \sigma_{\text{diffractive}}$

  - Fraction of diffractive events $f_D$

    - Variety of MC generators is compared (fitted) to data
      $$R_{SS} = \frac{N_{\text{signal}}(\text{one side})}{N_{\text{signal}}} = \frac{442,192}{4,159,074} = (10.4 \pm 0.4)\%$$
      MC models vary: 21% < $f_D$ < 31%.
      Best fit: Pythia 8 DL ($\varepsilon = 0.085$) ~ 25.5%

    - $N_{\text{signal}}(\text{one side})$ = events with MBTS hits only on one side (no hits on the other side)
    - Pythia 8 with pomeron flux: (SS) = (Schuler & Sjöstrand) DL = (Donnachie & Landshoff with tunable parameter $\varepsilon$) or Minimum-Bias Rockeferell (MBR)
    - EPOS LHC and QGQJET-II ($f_D$ fixed)

Summary
- No pile-up run
- Background only 1.2%
- Low exp. uncertainty
- Result is consistent with some selected models within current uncertainties
- 13 vs 7 TeV: increased fiducial phase space, triple larger statistics, smaller uncertainties
- References:
  - ATLAS 7 TeV: Nature Commun. 2 (2011) 463