Recent QCD Results from ATLAS

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The ATLAS collaboration has performed studies of a wide range of QCD phenomena, from soft particle to hard photon and jet production. Recent soft-QCD measurements include studies of underlying event, vector meson production and quark confinement effects. Differential measurements of inclusive and multi-jet production provide stringent tests of high-order QCD predictions and provide input for determination of parton density functions. Measurements of isolated inclusive and di-photons cross sections for high p_{T} photons test various theoretical predictions and constrain parton density functions. In addition the total pp cross section at 7 TeV, together with the elastic and inelastic contributions, is measured and compared to various models. An overview of these results is given.

1 Introduction

The measurements described in this overview cover wide range of quantum chromodynamics (QCD) processes. The soft part of these processes characterized by low momentum transfer, comprehend processes with underlying events and is important at the total pp cross section determination. These processes cannot be calculated by the perturbative approach within the Standard Model (SM) however the obtained results test and constrain phenomenological models. The hard processes like jets, isolated prompt photon, photon and jet production provide a stringent tests for high-order theoretical QCD calculations.

The results were obtained using data produced in pp collisions at $\sqrt{s} = 7$ and 8 TeV collected by the ATLAS detector in years 2010, 2011 and 2012.

2 The ATLAS detector

The ATLAS detector is described in detail elsewhere [1]. The beam-line is surrounded by a tracking detector that uses silicon pixel, silicon strip and straw tube technologies and is embedded in a 2 T magnetic field. The tracking system covers the pseudorapidity range $|\eta| < 2.5$. It is surrounded by electromagnetic and hadronic calorimeters covering $|\eta| < 3.2$ which are complemented by a forward calorimeter covering $3.1 < |\eta| < 4.9$.

The Minimum Bias Trigger Scintillator (MBTS) detectors, the detectors used in the soft QCD measurements, are mounted in front of the endcap calorimeters on both sides of the interaction point at $z = \pm 3.56$ m and cover the range $2.09 < |\eta| < 3.84$.

The Absolute Luminosity for ATLAS (ALFA) sub-detector is located at 240 m from the interaction point in Roman Pots, its purpose is the measurement of elastic pp-scattering and small angles in the Coulomb-Nuclear Interference region.

3 Results of the ATLAS measurements

Underlying events (UE) comprise soft processes accompanying hard parton-parton interaction in pp collisions. There is no way to unambiguously distinguish between signals from the hard processes and from the UE.

The η, φ plane[1] can be divided into regions around the leading object (the highest p_{T} track or cluster in the event). Three regions are defined. The *toward* one ($\Delta\phi < 60°$) containing the leading object, the *away* one ($\Delta\phi > 120°$) containing the second leading jet in the di-jet events and the *transverse* one. The transverse region is the region most sensitive to the UE. One can distinguish the transverse region according to the leading object in this region with the maximum value of an observable into the *trans-min* and the *trans-max* sides on the event-by-event basis. Each observable has its definition of the sides.

ATLAS measured distributions sensitive to the underlying event in QCD jet events [2] using data collected at $\sqrt{s} = 7\,\mathrm{TeV}$ separately for inclusive jets and exclusive di-jet events. A sample of results is shown in Fig. 1. Comparisons to the predictions of different Monte-Carlo (MC) models show a need for further model tuning, but in general the standard approach is found to reproduce the features of the underlying event in both types of event selection.

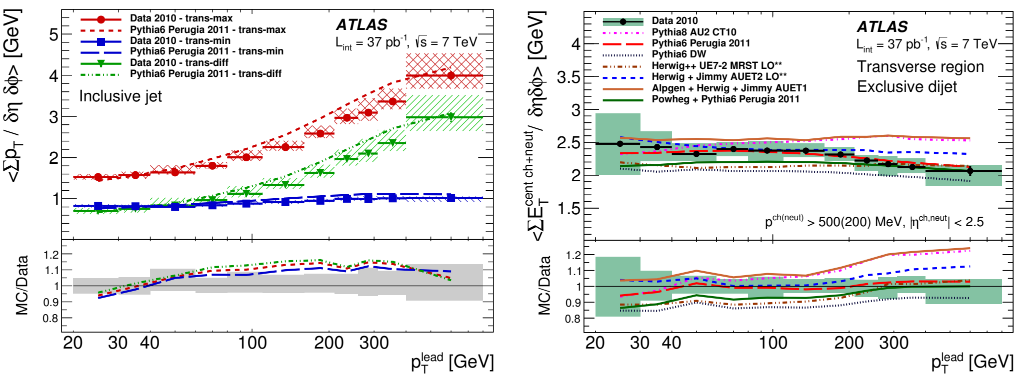

Figure 1: Comparison of profiles of charged-particle $\sum p_{\mathrm{T}}$ left (neutral and charged $\sum E_{\mathrm{T}}$ right) as a function of $p_{\mathrm{T}}^{\mathrm{lead}}$ in transverse regions for ATLAS measurements and MC predictions.

A measurement of charged-particle distributions sensitive to the properties of the underlying event for an inclusive sample of events containing a Z-boson decaying to an electron or muon pair [3] was performed using the ATLAS detector. The measured distributions are compared to the similar ones measured in jet events and to the predictions of various MC generators implementing different underlying event models.

ATLAS measured the inealistic pp cross section using the MBTS detector [4] for an acceptance region $\xi = M_{\mathrm{X}}^2/s > 5\times10^{-6}$ (M_{X} is a mass of the dissociation system) and the differential cross section for the rapidity gap size $\Delta\eta$ (central part of detector without activity) for $\Delta\eta < 8$ and $|\eta| < 4.9$ [5]. Fig. 2 left shows the ATLAS measurements with the TOTEM measurements and model predictions. The ATLAS results are consistent.

The total pp cross section measurement [6] was performed using the ALFA subdetector of

[1]ATLAS uses cylindrical coordinates (η, φ) in the transverse plane. η is the pseudorapidity, φ the azimuthal angle around the beam pipe.

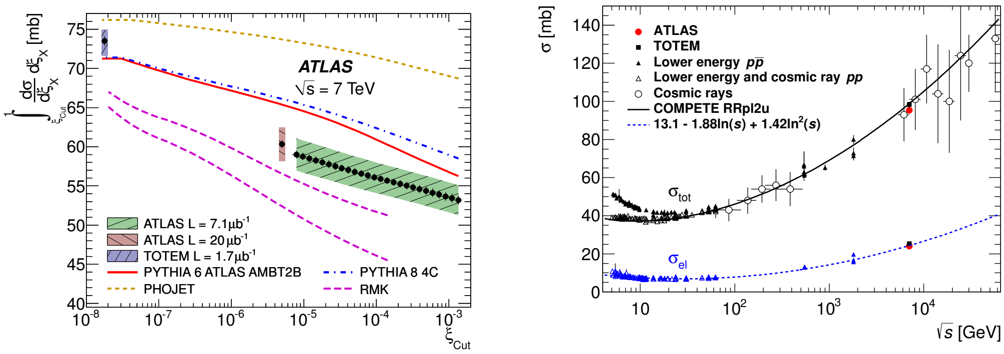

Figure 2: The differential inelastic (left) and total/elastic (right) pp cross section.

ATLAS. The total cross section is extracted using the optical theorem and its value is $\sigma_{\mathrm{tt}}(pp \to X) = 95.35 \pm 0.38(\mathrm{stat.}) \pm 1.25(\mathrm{exp.}) \pm 0.37(\mathrm{extr.})\,\mathrm{mb}$. Fig. 2 right shows this measurement compared with other published measurements.

The measurement of the $\varphi(1020)$ [7] probes strangeness production at a soft scale $Q = 1\,\mathrm{GeV}$. It is sensitive to s-quark and low-x gluon densities. It is also sensitive to the fragmentation details. The $\varphi(1020)$ measurements can constrain phenomenological hadroproduction models.

Additional jet activity in di-jet events was measured using pp collisions at ATLAS [8]. The measurement tests the perturbative QCD theoretical predictions in extreme regions of phase space. In cases of large rapidity separation of jets or when a veto of additional jet activity is applied, higher order corrections become increasingly important. No theoretical prediction provides good agreement with the data in all observables over the whole phase space.

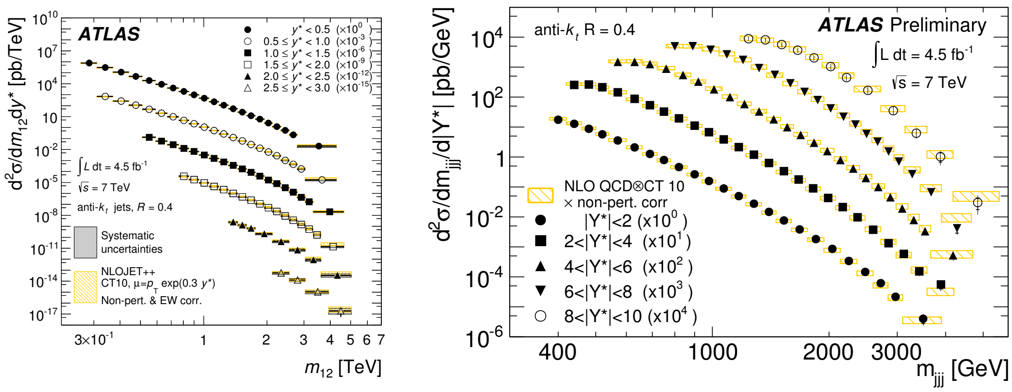

Figure 3: The differential di-jet (left) and three-jet (right) production cross section measured by the ATLAS detector compared to the NLOJet++ calculations.

ATLAS measured the inclusive-jet (not yet published) di-jet [9] and three-jet [10] production cross sections in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$. The measurements are in good agreement with the the NLOJet++ theoretical predictions when using the CT10, NNPDF2.1 and MSTW 2008 PDF sets as shown in Fig. 3.

An ATLAS measurement of the cross section for the production of isolated prompt photons in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ [11] is compared to the LO parton-shower MC models and to the NLO perturbative QCD calculations. The prompt photon production is sensitive to the gluon content of the proton ($qg \to q\gamma$) and can be used to constrain gluon PDFs. The NLO QCD calculations agree with the ATLAS measurements.

The dynamics of isolated-photon plus jet production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ has been studied with the ATLAS detector at the LHC [12]. The production of prompt photons in association with a jet in pp collisions, $pp \to \gamma + \mathrm{jet} + X$ provides a testing ground for perturbative QCD in a cleaner environment than in jet production, since the photon originates directly from the hard interaction. The next-to-leading-order QCD calculations are compared to the measurements and provide a good description of the data, except for the case of the azimuthal opening angle.

4 Conclusion

Various measurements sensitive to the soft and perturbative SM processes have been considered. Their characteristics like total pp cross section, characteristics of the underlying events, jets, isolated prompt photon, photon and jet production cross sections were measured by the ATLAS detector and compared to the theoretical expectations and Monte-Carlo calculations. The results of the measurements are used or have a potential to test and tune PDFs and phenomenological model parameters.

Acknowledgments

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References

[1] ATLAS Collaboration, JINST 3 (2008) S08003

[2] ATLAS Collaboration, Eur.Phys.J. C74 (2014) 2965

[3] ATLAS Collaboration, submitted to EPJC, arXiv:1409.3433

[4] ATLAS Collaboration, Nature Commun. 2 (2011) 463

[5] ATLAS Collaboration, Eur. Phys. J. C72 (2012) 1926

[6] ATLAS Collaboration, submitted to Nuclear Physics B, arXiv:1408.5778

[7] ATLAS Collaboration, Eur. Phys. J. C (2014) 74:2895

[8] ATLAS Collaboration, submitted to EPJC, arXiv:1407.5756

[9] ATLAS Collaboration, JHEP05(2014)059

[10] ATLAS Collaboration, ATLAS-CONF-2014-045

[11] ATLAS Collaboration, Phys. Rev. D 89, 052004 (2014)

[12] ATLAS Collaboration, Nucl. Phys, B 875 (2013) 483–535