PROCEEDINGS OF SCIENCE

Soft QCD and diffractive processes in ATLAS

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Recent results on soft QCD and diffractive processes in proton–proton collisions are presented, obtained using the ATLAS detector at the LHC and including measurements with the ALFA forward detector. A report on the AFP forward detector system is also given.

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1. Introduction

This report presents recent results in soft QCD physics, obtained from proton–proton (*pp*) collisions using the ATLAS detector [1] at the LHC. Measurements of diffractive processes with the ALFA detector are included, with an update on the newly installed AFP forward detector system.

2. Single diffractive dissociation using the ATLAS ALFA spectrometer

Diffractive dissociation in *pp* collisions is a process in which a soft colourless object, the so-called Pomeron, is emitted from an interacting proton and in so doing dissociates the proton into a state in which hadrons are emitted. In the case of single diffractive dissociation, just one of the colliding protons is dissociated while the other loses a fraction ξ of its energy and may be registered in a forward detector system. Single diffractive dissociation has been measured with ATLAS at $\sqrt{s}$ = 8 TeV, using the ALFA forward system to identify events with one forward scattered proton [2, 3]. The ALFA system comprises pairs of scintillating-fibre detectors mounted in Roman pots which approach the beam in a vertical direction. They are located on both sides of the main ATLAS detector, at distances of 237 m and 241 m from the interaction point.

Data were taken under special LHC running conditions with parallel-to-point focussing and a low pile-up factor $\mu \leq 0.08$. This type of beam focus brings small-angle scattered protons into the ALFA acceptance. A primary vertex in ATLAS and one identified proton in ALFA were required. PYTHIA8 [4] was used for simulations of the acceptance, using the Donnachie–Landshoff Pomeron model [5]. The scattered proton angle and momentum were determined from the ALFA measurements using the known beam optics, and charged particles with $p_{\mathrm{T}} > 200$ MeV were used to measure the visible rapidity gap $\Delta\eta$ and other event properties. The value of ξ was obtained from the relation $\xi = \Sigma(E \pm p_z)/s$, which reduces the effects of undetected particles. A fiducial region with acceptance above 10% was defined in terms of ξ and the squared momentum transfer t.

Results are illustrated in Figure 1 and show that the differential cross sections with respect to t exhibit the expected exponential dependence. Those with respect to $\Delta\eta$ are accurately represented in shape by several models, none of which accurately gives the absolute values.

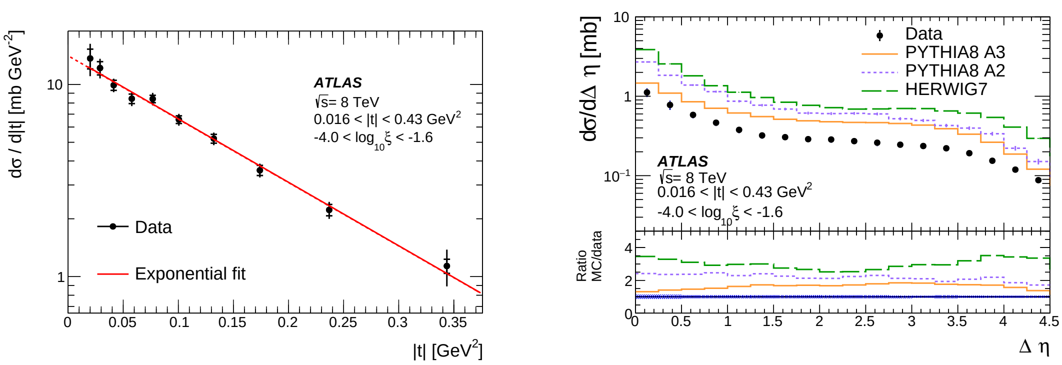

Figure 1: Differential cross sections for single-diffractively produced particles: (left) as a function of squared momentum transfer t, and (right) as a function of pseudorapidity gap $\Delta\eta$ [3].

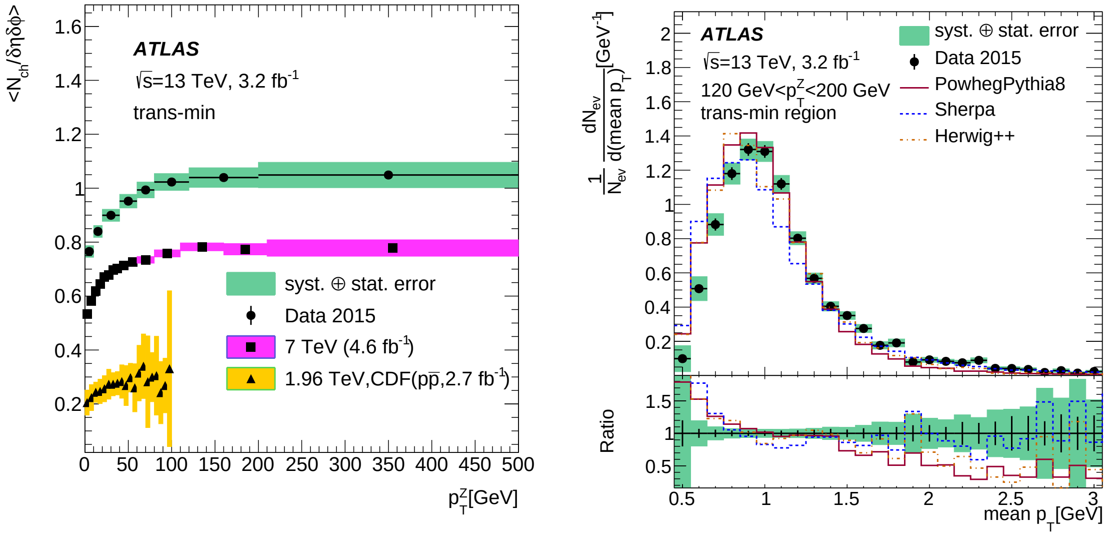

Figure 2: Charged-particle distributions in the transverse azimuth region with lower summed p_{T}. Left: present results compared with earlier results. Right: illustration of results, in comparison with theoretical models [6].

3. Distributions sensitive to the underlying event in inclusive Z production

Measurements of charged-particle distributions sensitive to the properties of the underlying event have been performed in events that contain a Z boson with $p_{\mathrm{T}} > 10$ GeV decaying into a muon pair, recorded at a centre-of-mass energy of 13 TeV [6]. Distributions of the charged-particle multiplicity and the charged-particle transverse momentum were measured in a set of azimuth regions defined relative to the Z boson direction: regions directed towards and away from the Z boson and "transverse" regions at 60°–120° relative to the Z boson.

The measured distributions are compared with the predictions of various Monte Carlo generators which implement different underlying-event models. In the "towards" and "away" azimuthal regions, the experimental distributions are found to be in broad agreement with the Monte Carlo models. In the intermediate "transverse" regions, the distributions are dominated by the effects of the underlying event and are illustrated in Figure 2. Some significant discrepancies are observed.

4. Inclusive K^0_S and Λ^0 production

Measurements of K^0_S and Λ^0 production in $t\bar{t}$ final states have been performed at a pp centre-of-mass energy of 7 TeV [7]. The K^0_S mesons are separated into three classes, depending on whether they are contained in a jet that does or does not have a b-tag, or else not associated with a selected jet. The data are compared with several Monte Carlo simulations that use different choices of hadronisation and fragmentation schemes, colour reconnection models, and tuned sets of parameters for the underlying event. Typical results are illustrated in Figure 3. The K^0_S and Λ^0 production in $t\bar{t}$ dileptonic events are found to be well described by the Monte Carlo models for both types of neutral strange particle, with respect to most of the kinematical features of the events.

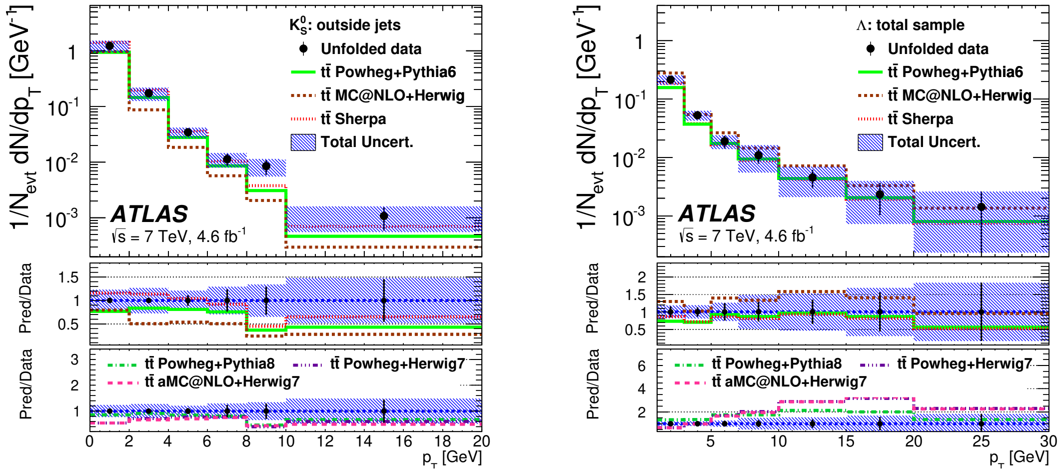

Figure 3: Illustrative distributions of K^0 outside jets (left) and of Λ^0 inside and outside jets (right), compared with various theoretical models [7].

5. AFP

The AFP forward proton detector system consists of sets of silicon pixel detectors mounted in Roman pots and inserted horizontally close to the beam at distances of approximately 205 m and 217 m on either side of the interaction point. Forward scattered protons can be detected if they have lost an energy fraction ξ in the range 0.02–0.085, and the AFP system can take data as part of the normal running operations of ATLAS.

The detectors were operated during data-taking runs in the years 2017–2018, and are now well calibrated. Physics analyses are in progress towards publication. Time-of-flight detectors are located behind the more distant of the two AFP installations on each side, and will enable diffractive and photon-photon events to be identified in running conditions with high pile-up. Tests of these detectors and their high-performance photomultipliers have been encouraging.

References

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