Highlights from QCD measurements in the ATLAS experiment

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This report was originally prepared for the proceedings of LISHEP 2013 conference. Here we concentrate on a few highlights only referring to [1] for a complete report of the results presented at the conference.

High energy proton–proton collisions at the Large Hadron Collider (LHC) offer a natural ground for studying the strong interactions by testing its perturbative description provided by the Quantum–Chromo–Dynamic (QCD) sector of the Standard Model (SM) as well as by validating the modeling of the non–perturbative phenomena in current Monte Carlo (MC) event generators. Two particularly important areas of study are the production of jets and of vector gauge bosons; these processes lead to backgrounds to Higgs boson analyses and to Beyond Standard Model (BSM) searches.

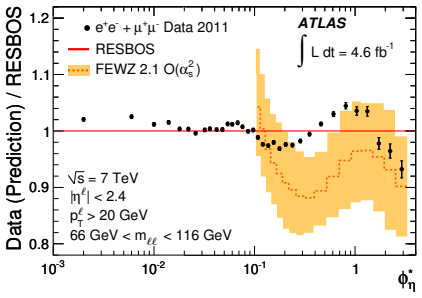

Figure 1. The ratio of the measured normalized differential cross section [2] to RESBOS predictions as a function of ϕ^*_η. The measurement is also compared to an NNLO QCD calculation, represented by a dashed line.

The identification of $W^{\pm}/Z$ production using their leptonic decay modes [1] benefits from clean experimental signatures and small systematic uncertainties. Moreover, the theory calculation of the $W^{\pm}/Z$ cross section is available up to NNLO in QCD and NLO in EW, therefore these processes offer a solid benchmark for testing the predictions for the QCD corrections.

[1]Here the decay channel $W \to \tau\nu$ and $Z \to \tau\tau$ are not considered.

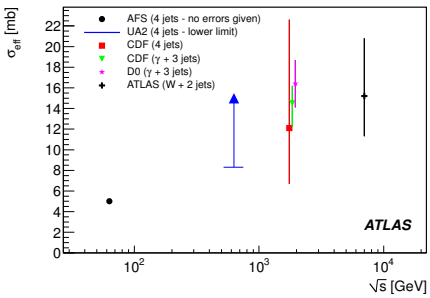

Figure 3. The center-of-mass energy $\sqrt{s}$ dependence of σ_{eff} [4] extracted in different processes and experiments.

Inclusive production of Z/γ^* allows resolution of initial state QCD radiation up to very soft scales. The ϕ^*_η observable [2] has been measured; it is known to be fully correlated to the Z transverse momentum, but it has a better resolution at low transverse momentum with typical purity of $\gtrsim 85\%$. The measurement of the differential ϕ^*_η spectrum has been presented in [2]; in Fig. 1 it is displayed normalized to the RESBOS prediction and it is reported in Fig. 1. The ratio of the data to RESBOS are compared to two different predictions shown by a dashed line, namely, a NLO+NLL QCD calculation and a NNLO QCD prediction. The data are generally well described by the theory predictions and exhibit very high accuracy compared to the current theoretical precision.

Jet production in association with a Z boson has been extensively studied in Ref. [3]. The measured cross section for $Z(\to \ell\ell)$+jets is shown in Fig. 2 as a function of the inclusive jet multiplicity (N_{jet}), the invariant mass of the two leading jets (m^{jj}), and the azimuthal angle separa-

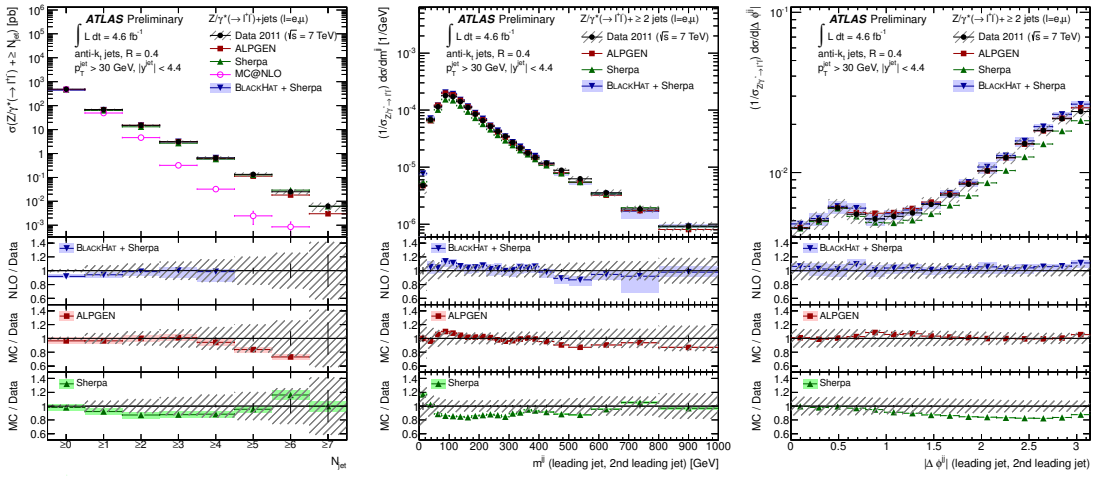

Figure 2. Measured cross section for Z($\to \ell\ell$)+jets as a function of the inclusive jet multiplicity (left), invariant mass of the two leading jets (center) and $\Delta\phi$ between the two leading jets (right) [3]. The data are compared to NLO multileg QCD predictions BLACKHAT+SHERPA and the ALPGEN, SHERPA and MC@NLO event generators.

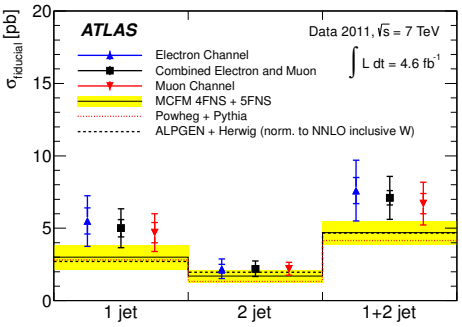

Figure 4. Measured fiducial cross sections in the electron, muon, and combined electron and muon channels [5]. The measurements are compared with NLO QCD predictions calculated with MCFM, a NLO prediction from POWHEG interfaced to PYTHIA and the calculation from ALPGEN interfaced to HERWIG and JIMMY.

tion between the two leading jets ($\Delta\phi^{jj}$). The data are compared to NLO multileg QCD predictions of BLACKHAT+SHERPA, and the ALPGEN, SHERPA and MC@NLO event generators. The MC@NLO generator is unable to describe the data for high jet multiplicity as it is based on a NLO QCD calculation of the $2 \to 2$ matrix element; ALPGEN and SHERPA, corrected for NNLO k-factor for inclusive Z cross section, provide a good description of the data; the NLO calculation of BLACKHAT+SHERPA, shown without k-factor correction, describe well both the total cross section and the distributions profiles observed in the data.

The copious production of W+2jets allows a test of the models of multiple parton interactions. The double-parton-interactions, DPI, in W+2jets events have been measured in [4] reporting the detector level fraction of DPI ($f_{DPI}^{(D)}$) and the effective parameter area (σ_{eff}). In Fig. 3 the unfolded value of σ_{eff} is compared to previous measurements preformed at different center of mass energy.

Beyond the inclusive analysis of jet production in association with gauge boson, measurements involving heavy flavors drew attention recently since they are interesting channels to constrain the parton distribution functions and because it are background to $H \to b\bar{b}$ observation in associated production with W/Z bosons. The cross section for b-jets produced with a W boson has been recently measured using the 2011 dataset [5]. The cross section in jet multiplicity bins is reported in Fig. 4. The data are compared to NLO QCD (MCFM as well as LO multileg predictions (ALPGEN.

Some of the most significative QCD measurements performed with the ATLAS detector have been summarized.

The production of jets as well as gauge bosons at the LHC were investigated in ATLAS with several measurements. The data are compared at particle level with the most advanced avail-

able theoretical predictions; a broad agreement between data and the predictions based on the Standard Model is found for wide spectrum of observables in various kinematical configurations. For several measurements the data were shown to be sensitive to NLO and NNLO QCD effects. In particular, electroweak boson cross section data tend to favor NNLO and NLO, or LO multileg matrix element based predictions.

REFERENCES

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