PROCEEDINGS OF SCIENCE

Measurement of the $b\bar{b}$ dijet cross section in pp collisions at $\sqrt{s} = 7$ TeV with the 2011 dataset collected by the ATLAS detector

Monica Verducci[*†]
Università e INFN Roma Tre
E-mail: monica.verducci@cern.ch

The dijet production cross section for jets containing a b-hadron (b-jets) has been measured in proton–proton collisions with a centre-of-mass energy of $\sqrt{s}$ = 7 TeV, using the ATLAS detector at the LHC. The data used correspond to an integrated luminosity of 4.2 fb^{-1}. The cross section is measured for events with two identified b-jets with a transverse momentum $p_{\mathrm{T}} > 20$ GeV and a minimum separation in the η–ϕ plane of ΔR = 0.4. At least one of the jets in the event is required to have $p_{\mathrm{T}} > 270$ GeV. The cross section is measured differentially as a function of dijet invariant mass, dijet transverse momentum, boost of the dijet system, and the rapidity difference, azimuthal angle and angular distance between the b-jets. The results are compared to different predictions of leading order and next-to-leading order perturbative quantum chromodynamics matrix elements supplemented with models for parton-showers and hadronization.

The European Physical Society Conference on High Energy Physics
5-12 July, 2017
Venice

[*] Speaker.
[†] on behalf of the ATLAS collaboration

PoS(EPS-HEP2017)747

1. Introduction

The measurement of jets containing a b-hadron (b-jets) produced in proton–proton (pp) collisions at the Large Hadron Collider provides an important test of perturbative quantum chromodynamics (pQCD). Calculations of the b-quark production cross section have been performed at next-to-leading order (NLO) of α_s in pQCD. The measurement of the $b\bar{b}$-dijet differential cross section, here presented, is performed with the ATLAS detector [1], using pp collisions at a centre-of-mass energy of $\sqrt{s}$ = 7 TeV. The data were recorded in 2011 and correspond to an integrated luminosity of 4.2 fb^{-1} [2].

2. Analysis Strategy

The lowest-order Feynman diagrams for $b\bar{b}$ production, shown in Figure 1, define the three different production mechanisms of the $b\bar{b}$ system. In *flavour creation* (FCR) both b-jets originate from the hard scatter: these jets tend to be the hardest in the event and are predicted to have an approximate back-to-back configuration in the transverse plane. The *gluon splitting* (GSP) production mechanism creates a pair of b-jets that are expected to have a small angular separation. The topology of *flavour excitation* (FEX) is less distinctive, but it tends to contain an additional parton, which reduces the angular separation between the b-jets.

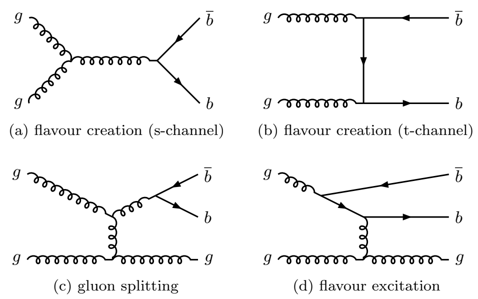

Figure 1: Lowest-order Feynman diagrams for $b\bar{b}$ production.

The differential cross section is defined as:

$$\frac{\mathrm{d}\sigma\left(pp\to b\bar{b}+X\right)}{\mathrm{d}\mathscr{O}} = \frac{N_{\mathrm{tag}} f_{bb}\,\mathscr{U}}{\varepsilon\mathscr{L}\Delta\mathscr{O}}, \tag{2.1}$$

with $\mathscr{O}$ the dijet observable under investigation, N_{tag} the number of b-tagged jet pairs, f_{bb} the purity of the selected sample, ε the selection efficiency, $\mathscr{L}$ the integrated luminosity and $\mathscr{U}$ the correction of the measured distribution for detector effects, such as the jet energy resolution. The $\mathscr{O}$ represents: the invariant mass of the dijet system m_{bb}, the transverse momentum of the dijet system $p_{\mathrm{T,bb}}$, the boost y_B of the dijet system ($y_B = \frac{1}{2}|y_{b_1}+y_{b_2}|$), the azimuthal angle between the two b-jets $\Delta\phi$, the angular separation between the two b-jets ΔR and the rapidity y^* difference between the two b-jets ($y^* = \frac{1}{2}|y_{b_1}-y_{b_2}|$).

3. Event Selection

Events are selected using two calorimeter-based single-jet triggers with a p_{T}-thresholds of 180 and 240 GeV and $|\eta| < 3.2$. Quality requirements are applied to ensure that the selected events are well measured. The leading jet is not required to be identified as a b-jet, but the selected events must have at least two b-tagged jets with $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.5$, and the two highest p_{T} b-tagged jets within the $|\eta|$ requirement are taken as the dijet pair. To avoid selecting jets with significant overlap, the two b-tagged jets in the pair are also required to be separated by $\Delta R > 0.4$.

3.1 Purity

The fraction of true b-jet pairs in the sample of b-tagged jet pairs, referred to as the purity f_{bb} of the sample, is determined by performing a template fit to the combined IP3D and JetFitter probability distributions [3]. These distributions use the reconstructed decay vertex of the b-hadron to identify b-jets. To obtain optimal separation between b- and c-jets, the fit variable is constructed as $\sum \log_{10}(p_b/p_c)$, where the sum is taken over both of the b-tagged jets. The probabilities p_b and p_c correspond to the probability of the jet being a b-jet or a c-jet respectively. The fit uses a maximum-likelihood method to determine the relative contributions of four templates that best describe the flavour content of the $b\bar{b}$ pair in data.

4. Results and Conclusions

The results, shown in Figure 2, are compared with NLO QCD predictions and LO predictions. The dominant systematic uncertainties in this measurement result from the b-tagging and the jet energy scale calibrations (order of 20%). The use of single-jet triggers with high p_{T} threshold significantly changes the relative weight of the different production processes because it enhances the gluon-splitting mechanism but suppresses the low-$p_{\mathrm{T,bb}}$ region where the flavour-creation process dominates. The analysis confirms that the current Monte Carlo generators have difficulties in describing regions of phase space which are not dominated by two hard b-jets.

References

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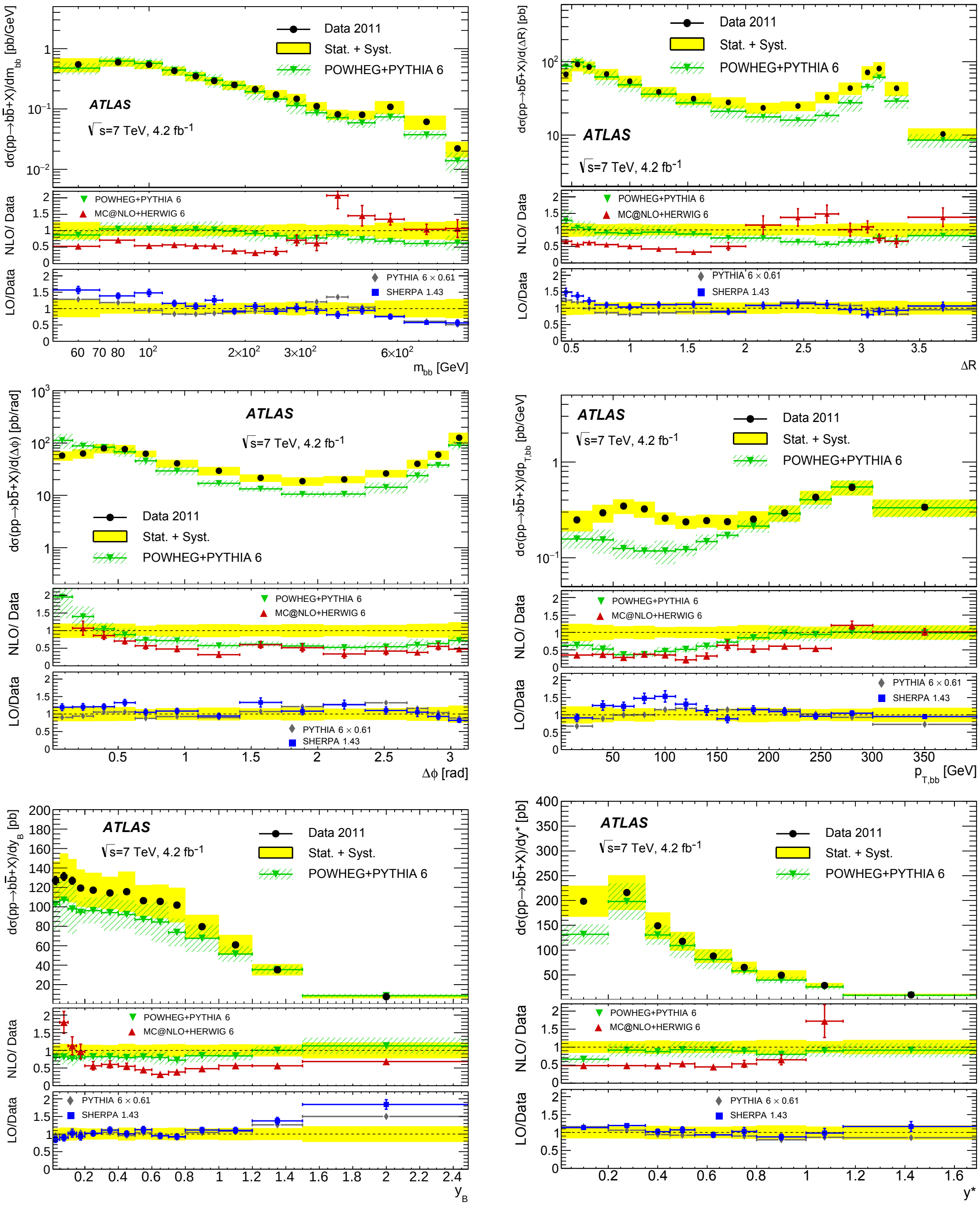

Figure 2: The plots show the differential cross section as a function of the six observables [2]. The legend for each figure is the same. Top panel: the differential cross section for $b\bar{b}$ production as a function of one of six observables is shown and compared to the theoretical predictions obtained using POWHEG [4]. Theoretical uncertainties obtained by using POWHEG are also shown. Middle panel: ratio of the NLO predictions to the measured cross section. Bottom panel: ratio of the LO predictions to the measured cross section. For the predictions from MC@NLO [5], SHERPA [6] and PYTHIA 6.4 [7] only the statistical uncertainties are shown. For both Middle and Bottom panels: the yellow band represents the combined statistical and systematic experimental errors for the data. Theoretical uncertainties on the POWHEG prediction are also shown.