PROCEEDINGS OF SCIENCE

QCD physics measurements at LHCb

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The LHCb experiment is a general purpose forward detector which studies a phase space region complementary to ATLAS and CMS. Its excellent vertex and track reconstruction system allows to perform several measurements of perturbative QCD physics in a region unexplored by other experiments. In the following the latest QCD physics analyses performed at LHCb studying pp collisions during Run 1 and Run 2 data are presented.

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1. QCD physics at LHCb

The LHCb experiment [1] is a forward spectrometer originally designed to study b- and c-hadron physics. It covers a phase space region in the pseudorapidity range $2.0 < \eta < 5.0$, complementary to other collider experiments such as ATLAS and CMS. It has an excellent track momentum resolution and very good muon and electron identification efficiencies, with low misidentification rates. Its excellent vertex reconstruction system allows to tag jets produced by b- and c-quarks by reconstructing secondary vertices formed by tracks inside the jet. At LHCb it is possible to test perturbative QCD (pQCD) in a phase space region unexplored by other experiments. In this way it is possible to study parton distribution functions (PDFs) and proton structure at high x values and at low x values and high Q^2, where x is the longitudinal momentum fraction of the proton carried by the parton and Q^2 is the energy scale of the interaction.

2. $b\bar{b}$ and $c\bar{c}$ production

Heavy-flavour di-jet production is an excellent test of pQCD in the forward region. Here 2016 data have been analysed, for a total integrated luminosity of 1.6 fb^{-1}. Differential cross section measurements [2] have been performed with respect to four kinematic variables: leading jet p_T, leading jet η, di-jet invariant mass m_{jj} and difference in jet rapidity $\Delta y^* = 1/2|y_0 - y_1|$. Two multivariate analysis (MVA) methods based on Boosted Decision Trees have been used to get jet flavour composition. Also cross section ratio $R = \sigma_{c\bar{c}}/\sigma_{b\bar{b}}$ with respect to the same kinematical variables have been computed. Results are in agreement with next-to-leading order prediction. This is the first measurement of $c\bar{c}$ di-jet differential cross section at a hadron collider.

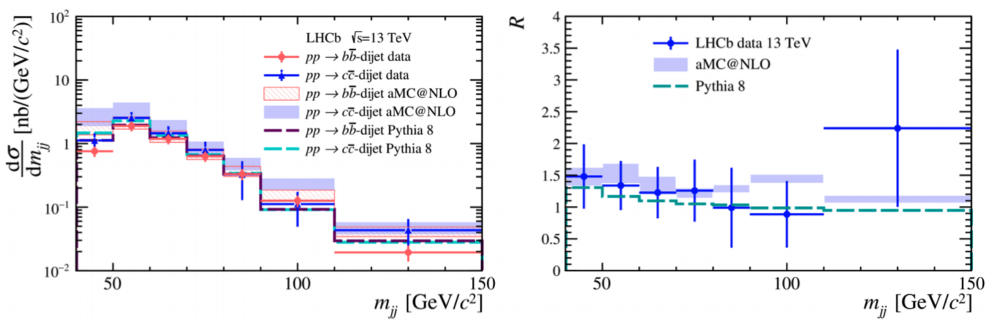

Figure 1: Differential cross section (left) and cross section ratio $R = \sigma_{c\bar{c}}/\sigma_{b\bar{b}}$ (right) with respect to di-jet invariant mass m_{jj}.

3. $Z + c$-jet production: intrinsic charm

The proton could have a charm component which could be extrinsic or intrinsic. The extrinsic component is related to gluon-splitting, while the intrinsic is directly related to valence or sea quarks. Particularly the valence-like component would have a clear signature at $x > 0.1$ as predicted by Light front QCD (LFQCD) calculations. The $Z + c$-jet production in the forward region is sensitive to the intrinsic charm component in the high x and high Q^2 ranges, where LHCb could perform its measurements. Run 2 data have been analysed [3] and heavy-flavour jets have been tagged using a displaced vertex (DV) technique. The DV corrected mass and its number of tracks are fitted to obtain flavour component. Finally the cross section ratio $\sigma(Zc)/\sigma(Zj)$ is computed with respect to the Z pseudorapidity: results show a hint of the intrinsic charm component in the high rapidity interval ($3.5 < y(Z) < 4.5$). The measurement is still dominated by statistical uncertainties and more data are needed to confirm the intrinsic charm component.

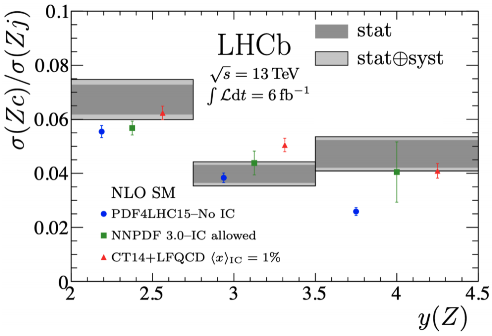

Figure 2: Results for $\sigma(Zc)/\sigma(Zj)$ in several pseudorapitidy bins. Results show a hint of the intrinsic charm component in the high rapidity interval ($3.5 < y(Z) < 4.5$).

4. Charged hadron production in Z+jet

In the forward region studied by LHCb, $Z(\to \mu\mu)$+jet production is dominated by light-quark jets. In this analysis [4] the production of charged hadrons in jets recoiling on a Z boson is measured in pp collisions at $\sqrt{s}$ = 8 TeV. Differential distributions of the longitudinal momentum fraction, momentum transverse to the jet axis and radial profile of charged hadrons are measured with respect to the jet axis. Results are then compared with Pythia8 predictions and show that simulation underestimates the number of high momentum charged hadrons. Comparisons with inclusive jets ATLAS measurements at central rapidity show differences accountable to differences between light-quark and gluon fragmentation. These results are important input for fragmentation functions in the forward region.

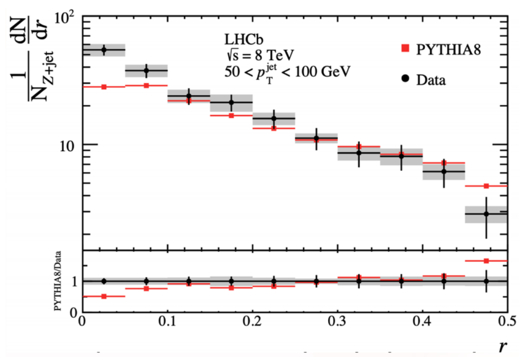

Figure 3: Differential cross section of charged hadrons with respect to radial profile r. Comparison with Pythia8 shows that simulation underestimates results.

5. Prompt charged particles production in pp collision at 13 TeV

In this analysis [5] prompt charged long-lived particles are studied in pp collisions at $\sqrt{s} = 13$ TeV for a total luminosity of 5.4 nb^{-1}. Differential cross-section is measured as a function of transverse momentum p_T and pseudorapidity η of the tracks, in the range $p_T \in [0.08, 10]$ GeV and $\eta \in [2.0, 4.8]$. Main background contributions for this analysis come from fake tracks and secondary particles. Results are compared with simulations: generators tend to overestimate forward particle production, and best agreement is obtained for EPOS-LHC and Pythia8.1 for particle density, and Pythia8.3 for charged ratio. The precision achieved in this measurement is fundamental for improving the simulation of underlying event in collisions at LHC.

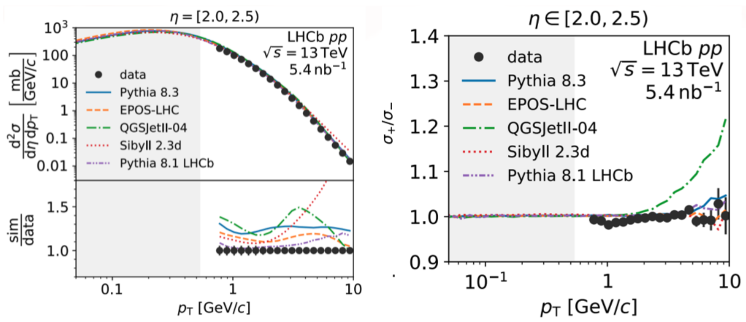

Figure 4: Differential cross section (left) and charge ratio (right) with respect to tracks p_T for data and several generators.

6. Conclusions

The LHCb experiment is by all means a general purpose forward detector. In this proceeding the latest results on QCD physics measurements at LHCb have been presented. Interesting results on pQCD processes have been obtained and theoretical models have been tested, resulting in very interesting input for further studies. In the future runs more data will be collected and more interesting results are expected to come.

References

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