QCD physics measurements at LHCb

Davide Zuliani\textsuperscript{1,2} on behalf of the LHCb Collaboration

\textit{LHCC Poster Session (Online), 18 November 2021}

\section*{LHCb detector\textsuperscript{[1]}}

- LHCb, originally designed for $b$- and $c$-hadron physics, is now considered a general purpose forward detector
- Track momentum resolution: 0.4\% at 5 GeV and 0.6\% at 100 GeV
- Muon ID efficiency: 97\% with 1-3\% $\mu^{-} \rightarrow e$ misidentification
- Electron ID efficiency: 90\% with 5\% $e^{-} \rightarrow \mu^{-}$ misidentification
- Electron reconstruction: beam-halo recovery and well-measured direction
- Excellent vertex reconstruction system via tagging of $b$- and $c$-jets with reconstruction of secondary vertices formed by tracks inside the jet cone

\section*{QCD physics at LHCb}

- At LHCb, perturbative QCD (pQCD) predictions are tested in a phase space region complementary to ATLAS and CMS
- Parton distribution functions (PDFs) and proton structure can be studied in regions not accessible by other LHC experiments:
  - At high $p_T$ values
  - At low $p_T$ values and high $\tau$: unpolarized by other experiments
- It is possible to study jet fragmentation functions in the forward region
- Results are then compared with the ones obtained by other experiments

Here results are shown for $pp$ collisions, but also $pPb$, $PbPb$ and fixed target studies are performed at LHCb

\section*{bb and c$\bar{c}$ di-jet production\textsuperscript{[2]}}

- Heavy flavour di-jet production is an excellent test of pQCD in the forward region
- 2016 dataset ($1.8 \text{ fb}^{-1}$) is used to perform differential measurements
- Cross section measured as a function of 4 observables:
  - Transverse momentum $p_T$ (from 20 GeV) with respect to ATLAS and CMS
  - Radial distribution $R(y;Z)$
  - Longitudinal distribution $L(y;Z)$
  - Invariant mass $M_{bb}$

- Fit to combination of two MVA discriminators to get flavour composition

\section*{Z + c-jet production: intrinsic charm\textsuperscript{[3]}}

- In proton content charm can be extrinsic or intrinsic
- Intrinsic charm PDF can be valence-like or sea-quark-like, clear signature at $z > 0.1$
- The $Z + c$-jet production in the forward region is sensitive to the high $x$ and high $Q^2$ intrinsic charm component
- Heavy flavour jets are tagged with a Displaced Vertex (DV) technique
- The corrected D0-mass and the number of tracks in the DV are fitted to obtain the flavour components
- Hint of the intrinsic charm component in the high rapidity interval ($3.5 < |y(Z)| < 4.5$)

\section*{Prompt charged particle production in pp collisions at 13 TeV\textsuperscript{[6]}}

- In the forward region, $Z \rightarrow \mu^{+}\mu^{-}$ di-jet production is dominated by jets produced by light-quarks
- At LHCb it is possible to access jets with lower $p_T$ (from 20 GeV) with respect to ATLAS and CMS
- Cross section measured w.r.t. kinematic distributions for charged hadrons:
  - Longitudinal distribution $L_{\eta}$
  - Transverse momentum $p_T$ of jet
  - Radial distribution $R_{\eta}$

- Results are then compared with ATLAS measurements on inclusive jets
- Main differences are due to different fragmentation of quarks and gluons

\section*{Conclusions}

- LHCb is now considered a general purpose forward detector
- QCD physics measurements are performed at LHCb studying a phase space region complementary to ATLAS and CMS
- Interesting results have been obtained and models for QCD and pQCD have been tested
- New data and more interesting results are coming with next Runs!

\section*{References}

[3] LHCb-PAPER-2021-029
[5] LHCb-PAPER-2021-019

\section*{Charged hadron production in Z+jet\textsuperscript{[6]}}

- sdk and c$\bar{c}$ di-jet production is an excellent test of pQCD in the forward region
- 2016 dataset ($1.8 \text{ fb}^{-1}$) is used to perform differential measurements
- Cross section measured as a function of 4 observables:
  - Transverse momentum $p_T$ (from 20 GeV) with respect to ATLAS and CMS
  - Radial distribution $R(y;Z)$
  - Longitudinal distribution $L(y;Z)$
  - Invariant mass $M_{bb}$

- Fit to combination of two MVA discriminators to get flavour composition

\section*{Prompt charged particle production in pp collisions at 13 TeV\textsuperscript{[6]}}

- Prompt charged particles: long-lived particles produced in primary interaction or without long-lived ancestors
- Tracks considered: $2 < y < 4.3$ and $0.08 < p_T < 10$ GeV to loose selection with high efficiency
- Background contributions: fake tracks and secondary particles

- Measurement controlled by systematic uncertainties
- Generators tend to overestimate forward particle production
- Best agreement with:
  - EPOS-LHC and Pythia 8.1 (LHCb tuned) for particle density
  - Pythia 8.3 for charged ratio