Inclusive Particle Production

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The LHCb detector has a unique pseudorapidity coverage and low transverse momentum theshold. These properties allow for measurements providing unique insight into particle production in the forward region at the LHC. The latest LHCb soft-QCD results, the measurements of charged particle multiplicity at 7 TeV and the measurement of the $\bar{p}/p$, K^-/K^+, π^-/π^+, $(\bar{p}+p)/(\pi^- + \pi^+)$, $(K^- + K^+)/(\pi^- + \pi^+)$ production ratios at 0.9 TeV and 7 TeV are presented. These results offer an important input to the understanding of baryon transport and of the hadronization process in a kinematical range where QCD models have large uncertainties.

1 Introduction

The LHCb detector [1] at the LHC at CERN covers a unique kinematic range for tracks of $2 < \eta < 5$ and down to $p_{\mathrm{T}} \approx 0$. It is a forward spectrometer optimized for b- and c-physics, has an excellent vertex resolution due to its vertex detector (VELO) and good $\pi/K/p$ separation due to its two RICH detectors. The trigger used in the analyses presented in this contribution is a trigger with minimal bias, requiring just one track in the VELO.

The measurement of inclusive particle production delivers important input to models of pp interactions. Measurements provide essential input for the tuning of event generators and the modeling of the underlying event. They can also be used to test predictions of particle production and hadronization models. Finally they can probe baryon number transport mechanisms. The forward region is of special interest as it is much less covered by other experiments and QCD models have large uncertainties.

In the remainder of this contribution the measurements of charged particle multiplicities and densities will be discussed in Section 2. This will be followed by the description of the measurements of the hadron ratios in Section 3. Note that measurements of strange particle production [2, 3, 4] are not included in this summary.

2 Charged particle multiplicity

LHCb has measured the multiplicity of primary charged particles [5], i.e., those directly produced in pp-collisions, or from short lived decays. In this measurement only information from the VELO, the silicon vertex detector which has a low material budget, was used (except for defining hard events, see below). The measurement is performed in a uniform acceptance and high efficiency range of $2 < \eta < 4.5$ ("forward"), $-2.5 < \eta < -2$ ("backward"). There is no magnetic field in the VELO, thus tracks are straight lines and we apply no explicit momentum cut. We used $1.5 \cdot 10^6$ pp events of each magnet polarity at $\sqrt{s} = 7$ TeV from the low luminosity running phase in 2010 with a low pile up of 3.7 %. To select primary particles from pp-collisions we cut on the minimal track distance to the beam line and select only particles from the "luminous region" in beam line direction. In addition to suppress fake tracks we apply track quality cuts. There are two background sources that have to be corrected for. We carry out per event corrections for remaining fake tracks [5] and for remaining non-prompt particles, i.e., gamma conversions and V^0s. Using unfolding we correct for migrations due to reconstruction efficiency. Finally we do a correction for the small pile up to get the result for single interactions.

Figure 1 shows the multiplicity distribution in the forward range with comparison to different MC tunes. Only events with at least one track in the forward range are accepted. All generators underestimate the charged particle multiplicity. Agreement is improved if diffractive processes are excluded in Pythia.

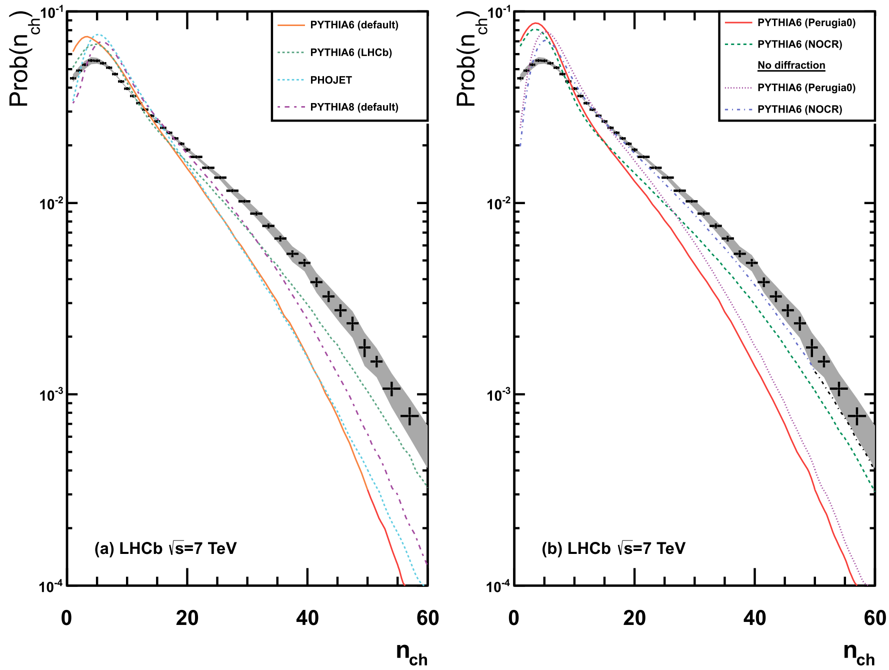

Figure 1: Charged particle multiplicity in the forward region in comparison to MC tunes.

The multiplicity distribution in the forward range for hard events, i.e., events with at least one track with $p_{\mathrm{T}} > 1$ GeV, are better described by MC, where the best agreement is achieved with PYTHIA in LHCb [6] and NOCR [7] tuning. Figure 2 shows the particle densities where only events with at least one track in the forward direction were accepted in data as well as in MC. The charged particle density is larger than in the standard MC prediction. The models without diffractive processes provide a better quantitative description but fail to describe the shape. The details of this analysis are given in [5].

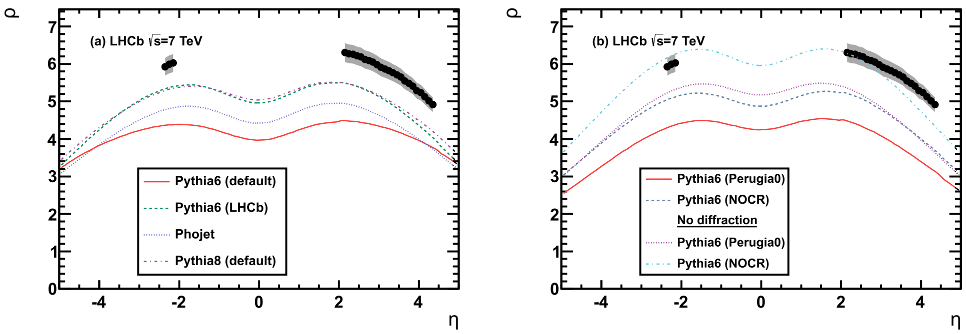

Figure 2: Charged particle densities with at least one track in the forward region.

3 Hadron production ratios

LHCb has measured the production ratios of $\frac{\overline{p}}{p}$, $\frac{K^-}{K^+}$, $\frac{\pi^-}{\pi^+}$, $\frac{\overline{p}+p}{K^-+K^+}$, $\frac{\overline{p}+p}{\pi^-+\pi^+}$ and $\frac{K^-+K^+}{\pi^-+\pi^+}$. The measurements are performed at $\sqrt{s} = 900$ GeV (0.3 nb^{-1}) and $\sqrt{s} = 7$ TeV (1.8 nb^{-1}). Prompt particles with $p > 5$ GeV are selected with particle identification (PID) requirements. The efficiency and purity of the PID are evaluated on data using a tag and probe method on $\phi \to K^+K^-$, $K^0_s \to \pi^+\pi^-$ and $\Lambda \to \pi p$. The measurements are done in bins of p_T and η. The cross contamination effect due to PID misidentification is taken from the calibration samples. The correction of particle losses due to interaction with material is extracted from MC.

Figures 3 and 4 show a sample of the results in comparison to different MC tunes. There are some disagreements while the NOCR [7] and LHCb [6] tunes describe the data best. The complete plots can be found in the slides of the talk [8]. Using the rapidity loss $\Delta y = y_{\text{beam}} - y$ used to compare data from different $\sqrt{s}$, was used to compare our results with those from other experiments. The LHCb data is consistent with previous experiments but significantly more precise. The full details of the analysis and the results will be give in a paper [9].

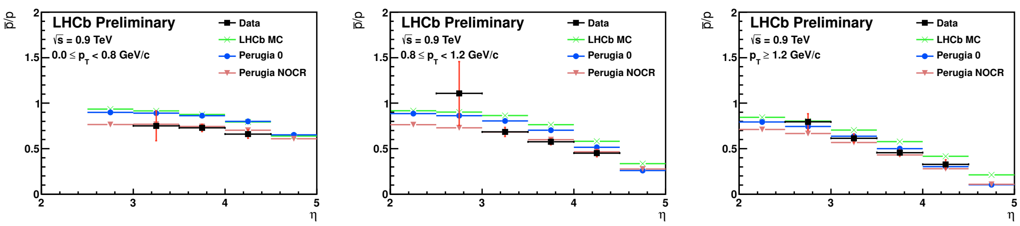

Figure 3: $\frac{\overline{p}}{p}$, $\sqrt{s} = 900$ GeV Left to right: $0 < p_T < 0.8$ GeV, $0.8 < p_T < 1.2$ GeVand $p_T > 1.2$ GeV. Black is data where the black error bars are the statistical errors (mostly invisible) and the red (grey) error bars are systematic errors.

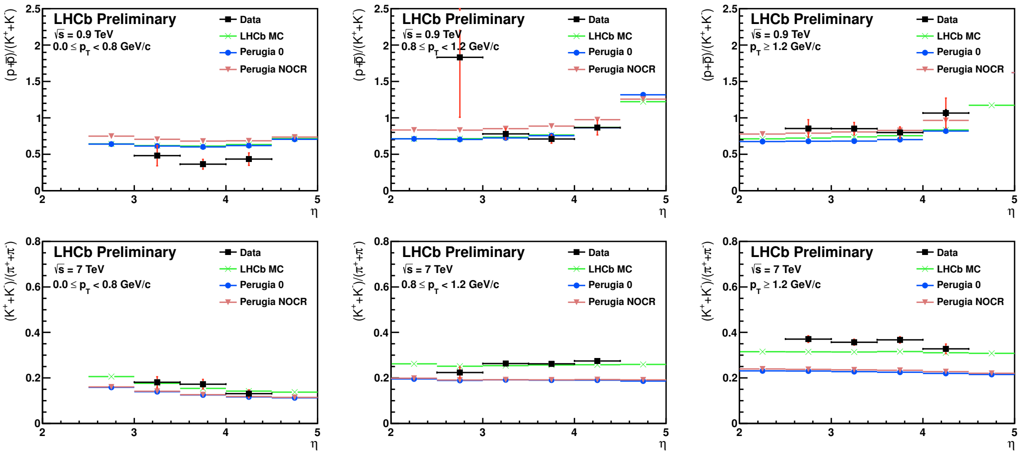

Figure 4: $\frac{\overline{p}+p}{K^-+K^+}$ $\sqrt{s} = 900$ GeV, and $\frac{K^-+K^+}{\pi^-+\pi^+}$ $\sqrt{s} = 7$ TeV. Left to right: $0 < p_{\mathrm{T}} < 0.8$ GeV, $0.8 < p_{\mathrm{T}} < 1.2$ GeVand $p_{\mathrm{T}} > 1.2$ GeV. Black is data where the black error bars are the statistical errors (mostly invisible) and the red (grey) error bars are systematic errors.

4 Summary

LHCb is an excellent environment for particle production measurements in the forward region. The charged particle multiplicities are underestimated by MC generators, which better describe hard events especially the NOCR and LHCb tunes. The light flavor hadron ratios need MC-tuning and are again best described by the NOCR and LHCb tunes. Future analysis will include the $\sqrt{s} = 2.76$ TeV data already taken and the $\sqrt{s} = 8$ TeV data that is about to be taken.

References

[1] A. A. Alves *et al.* JINST **3** (2008) S08005.

[2] R. Aaij *et al.* Phys. Lett. **B693** (2010) 69–80, `arXiv:1008.3105 [hep-ex]`.

[3] R. Aaij *et al.* J. High Energy Phys. **08** (2011) 034.

[4] R. Aaij *et al.* Phys. Lett. B **703** (2011) 267–273.

[5] R. Aaij *et al.* Eur. Phys. J. C **72** (2012) 1947.

[6] M. Clemencic *et al.* Journal of Physics: Conference Series **331** (2011) 3.

[7] P. Skands. Phys. Rev. D **82** (2010) 074018.

[8] M. Britsch, "`https://indico.cern.ch/contributionDisplay.py?contribId=142&sessionId=11&confId=153252`".

[9] R. Aaij *et al.*, "Lhcb-paper-2011-037 (in preparation)", 2012.