Forward production of $\Upsilon$ mesons in pp collisions at $\sqrt{s} = 7$ and 8 TeV

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1. Introduction

Studies of heavy quarkonium systems, such as the $\Upsilon$(1S), $\Upsilon$(2S) and $\Upsilon$(3S), probe the dynamics of the colliding partons providing insight into the non-perturbative regime of quantum chromodynamics (QCD). Despite many models that have been proposed, a complete description of heavy quarkonium production is still not available. The study of production of heavy quarkonia could help to shed light on this long-standing question.

In this paper we report on the measurement of the inclusive production cross-sections of the $\Upsilon$ states at $\sqrt{s} = 7$ and 8 TeV and of their ratios. The existing LHCb measurements of these quantities were performed at $\sqrt{s} = 7$ TeV with a data sample collected in 2010 corresponding to 25 pb$^{-1}$ [1], and at $\sqrt{s} = 8$ TeV for early 2012 data using about 50 pb$^{-1}$ [2]. Both measurements were differential in $p_T$ and $y$ of the $\Upsilon$ mesons in the ranges 2.0 $< y <$ 4.5 and $p_T <$ 15 GeV/c. Based on these data, an increase of the production cross-section in excess of 30% between $\sqrt{s} = 7$ TeV and 8 TeV was observed, which is larger than the increase observed for other quarkonium states such as the $J/$ψ [2,3] and larger than the expectations from NR QCD [4].

2. Dataset and selection

- Run-I dataset with $\sqrt{s} = 7$ TeV (2011) & 8 TeV (2012)
- Reconstructed using $\Upsilon(nS) \rightarrow \mu^+\mu^-$ decay mode, selected in 2.0 $< y <$ 4.5 and $p_T <$ 30 GeV/c
- Measurement performed in bins of $p_T$ and $y$

$\Upsilon(nS)$ signal extraction performed by unbinned extended maximum likelihood weighted fit (baseline method), crosschecked by the method used in [5] based on the $\nu$Pilot technique.

3.1 Differential cross-sections

Figure: Double differential cross-sections for $\sqrt{s} = 7$ TeV (left) and $\sqrt{s} = 8$ TeV (right) data

Rapidity ranges: 2.0 $< y <$ 2.5, 2.5 $< y <$ 3.5

4. Production ratios

Figure: The production ratios $R_{3,1}$ and $R_{2,1}$ for $\sqrt{s}$ = 7 TeV (left) and $\sqrt{s}$ = 8 TeV (right) data. The fitted lines show the fit results with the colour-octet model predictions in 2.5 $< y <$ 4.0 and dashed lines show extrapolation to the full range $\sqrt{s}$ = 7 TeV.

5. Ratios of cross-sections

Figure: Ratios of differential cross-sections (left) and (right) at $\sqrt{s}$ = 7 TeV for $\Upsilon$(1S), $\Upsilon$(2S) and $\Upsilon$(3S). The left plot, the results of the fits with a linear function are shown. In the same plot, the NR QCD (QCD model predictions) are shown as a thick line. On the right plot, the results of the fits with the colour-octet model predictions are shown for $\Upsilon$(1S) and $\Upsilon$(3S).

6. References

[8] LHCb collaboration, R. Aaij et al. (2011) 118206