Quarkonium production at LHCb

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1 J/ψ, $\psi(2S)$ and $\Upsilon(1S)$ production cross section

Despite large experimental and theoretical efforts, quarkonium production in hadronic collisions is not yet fully understood. Due to its forward geometry, LHCb (described in [1]) has the opportunity to investigate the quarkonium production at high rapidity. LHCb has excellent trigger and tracks reconstruction, good particle identification, with a muon identification efficiency of 97%. The J/ψ mass resolution observed in the data is around 14.6 MeV, close the expectation from simulation. Measurements of the double differential cross-sections for the production of J/ψ, $\psi(2S)$ and $\Upsilon(1S)$ have been made using around 35 pb^{-1} of pp collision data collected during the 2010 LHC run. The cross sections are measured in the $\mu^+\mu^-$ decay channel. In addition for the $\psi(2S)$ case the $J/\psi\pi^+\pi^-$ mode has also been studied. The selections require good particle reconstruction and vertexing. The total efficiency, including the acceptance, reconstruction and trigger, is measured with an unpolarized simulated data sample. The effect due to the polarization is estimated as the difference between the fully transverse and fully longitudinal polarization and the zero polarization scenarios. Fig. 1 show the results of the J/ψ cross section for prompt and delayed component, separated using the J/ψ pseudo proper time [2]. The total cross sections are

$$\sigma^{(2.0<y<4.5, p_T<15\mathrm{GeV}/c)}_{\mathrm{prompt}\ J/\psi} = \left[10.52 \pm 0.04(\mathrm{stat}) \pm 1.40(\mathrm{sys})^{+1.64}_{-2.20}(\mathrm{pol})\right] \mu\mathrm{b}$$

$$\sigma^{(2.0<y<4.5, p_T<15\mathrm{GeV}/c)}_{J/\psi\ \mathrm{from}\ b} = [1.14 \pm 0.01(\mathrm{stat}) \pm 0.16(\mathrm{sys})]\, \mu\mathrm{b}$$

where the first uncertainty is statistical, the second systematic and the third one due to the polarization, for prompt and J/ψ coming from b decays. From the latter the $b\bar{b}$ cross section has been been estimated, using Pythia to extrapolate to the full solid angle $\sigma(pp \to b\bar{b}X) = [288 \pm 4(\mathrm{stat}) \pm 48(\mathrm{sys})]\, \mu\mathrm{b}$. Fig. 2 shows the results for the $\Upsilon(1S)$ and $\psi(2S)$ production in the $\mu^+\mu^-$ and $J/\psi\pi^+\pi^-$ decay mode [3], [4]. The integrated cross sections are

$$\sigma^{(2.0<y<4.5, p_T<15\mathrm{GeV}/c)}_{\mathrm{incl}\ \Upsilon(1S)} = \left[108.3 \pm 0.7(\mathrm{stat})\, ^{+30.9}_{-25.8}(\mathrm{sys})\right] \mathrm{nb}$$

$$\sigma^{(2.0<y<4.5, p_T<12\mathrm{GeV}/c)}_{\psi(2S)\to\mu^+\mu^-} = \left[1.88 \pm 0.02(\mathrm{stat}) \pm 0.31(\mathrm{sys})^{+0.25}_{-0.48}(\mathrm{pol})\right] \mu\mathrm{b}$$

$$\sigma^{(2.0<y<4.5, p_T\in[3;16]\mathrm{GeV}/c)}_{\psi(2S)\to J/\psi\pi^+\pi^-} = \left[0.62 \pm 0.04(\mathrm{stat}) \pm 0.12(\mathrm{sys})^{+0.07}_{-0.14}(\mathrm{pol})\right] \mu\mathrm{b}$$

The main systematics for the three analyses come from the unknown polarization, the luminosity determination ($\sim 10\%$), the trigger and track reconstruction efficiencies.

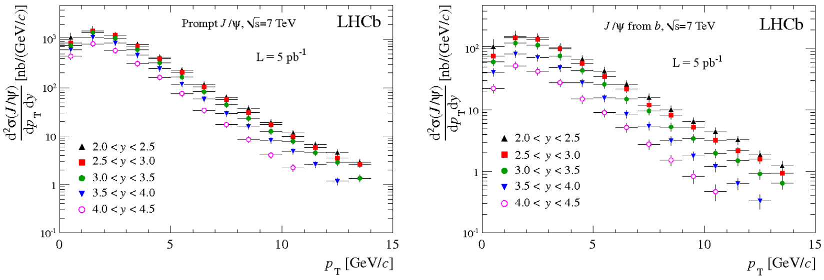

Figure 1: J/ψ cross section for prompt (left) and delayed (right) component.

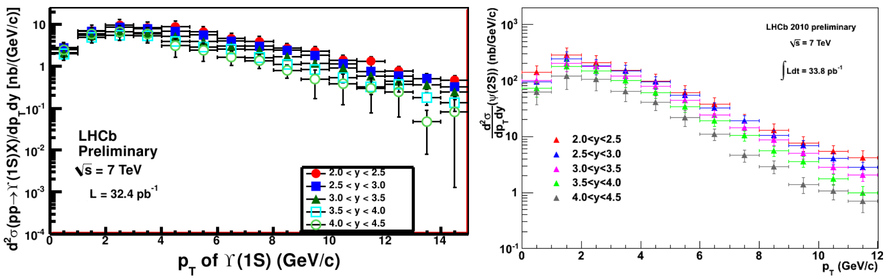

Figure 2: $\Upsilon(1S)$ (left) and $\psi(2S)$ (right) cross section in the dimuon mode.

2 Conclusion

The production cross sections of J/ψ, $\Upsilon(1S)$ and $\psi(2S)$ have been measured in bins of rapidity and transverse momentum. The results have been compared with several theoretical models and they show a very good agreement in particular with the NRQCD expectations [2, 3, 4].

References

[1] LHCb Collaboration, JINST **3** (2008) S08005.

[2] LHCb Collaboration, Eur. Phys. J. C **71**, 1645 (2011).

[3] LHCb Collaboration, LHCb-CONF-2011-016.

[4] LHCb Collaboration, LHCb-CONF-2011-026.