Quarkonium production at LHCb

Maddalena Frosini[1], Giulia Manca[2]

[1] CERN, University of Florence and INFN

[2] University of Cagliari and INFN

On behalf of the LHCb collaboration

Introduction

Despite large experimental and theoretical efforts, quarkonium production in hadronic collisions is not yet satisfactorily understood. Due to its forward geometry, LHCb has the unique opportunity to explore the field of quarkonium production at high rapidity, thus exploring a new and unknown territory. We report the measurement of the double differential J/ψ, $\psi(2S)$ and Υ cross section at LHCb with the data sample recorded by the LHCb experiment during the 2010 data taking. The J/ψ and $\psi(2S)$ prompt components are separated from the products of b-hadrons decays using topological information. The results are compared with several theoretical models and other experiments. Preliminary results and prospects for the other quarkonium states will also be given.

Quarkonium production at LHCb

Double differential cross section in transverse momentum and rapidity bin with 2010 data with $\Delta p_T = 1$ GeV/c and $\Delta y = 0.5$. Rapidity range: $2 < y < 4.5$.

- J/ψ, $\Upsilon(1S)$ and $\psi(2S)$ in $\mu^+\mu^-$ decay mode;
- $\psi(2S)$ also measured in $J/\psi\pi^+\pi^-$ decay mode, with J/ψ reconstructed from $J/\psi \to \mu^+\mu^-$.

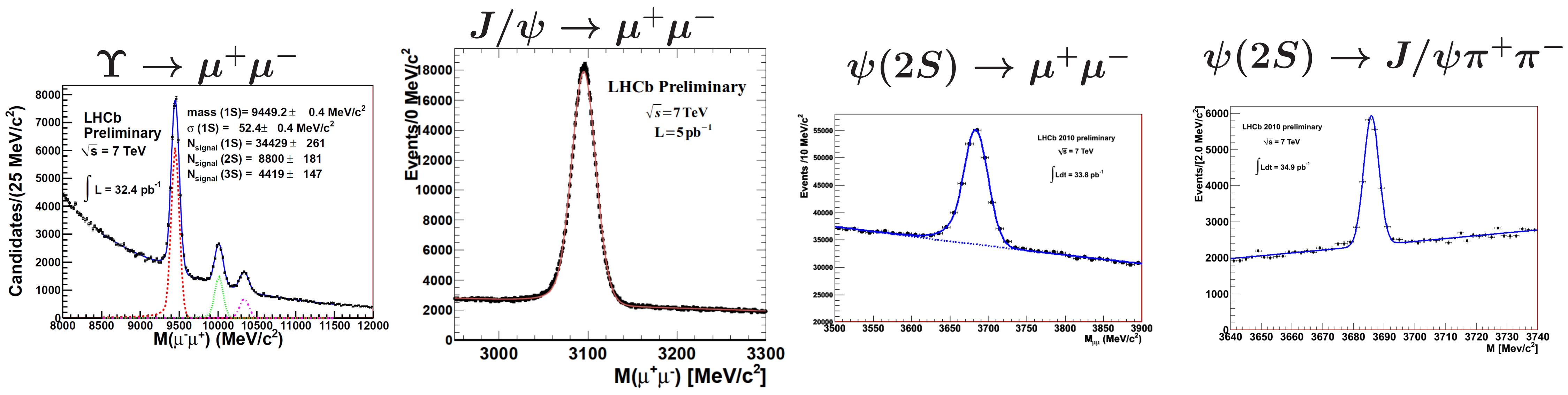
Method

- Require good tracks reconstruction and vertexing.
- Total efficiency ε includes detector acceptance, reconstruction and trigger. Estimated from MC unpolarized sample.
- Polarization affects acceptance and reconstruction: efficiency is simulated for transverse and longitudinal polarization and deviation from zero polarization is taken as systematic uncertainty

Main systematics coming from:

Unknown polarization
Luminosity $\sim 10\%$
Trigger efficiency depending on the bin
Tracking efficiency discrepancy data/MC $\sim 4\%$ per track

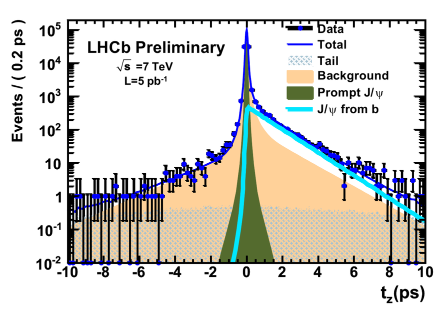
Signal events yield



Number of signal events from fit to invariant mass distribution. Model signal peak with:

- combination of Crystal Ball functions: $J/\psi \to \mu^+\mu^-$, $\Upsilon \to \mu^+\mu^-$, $\psi(2S) \to \mu^+\mu^-$
- Gaussian function: $\psi(2S) \to J/\psi\pi^+\pi^-$

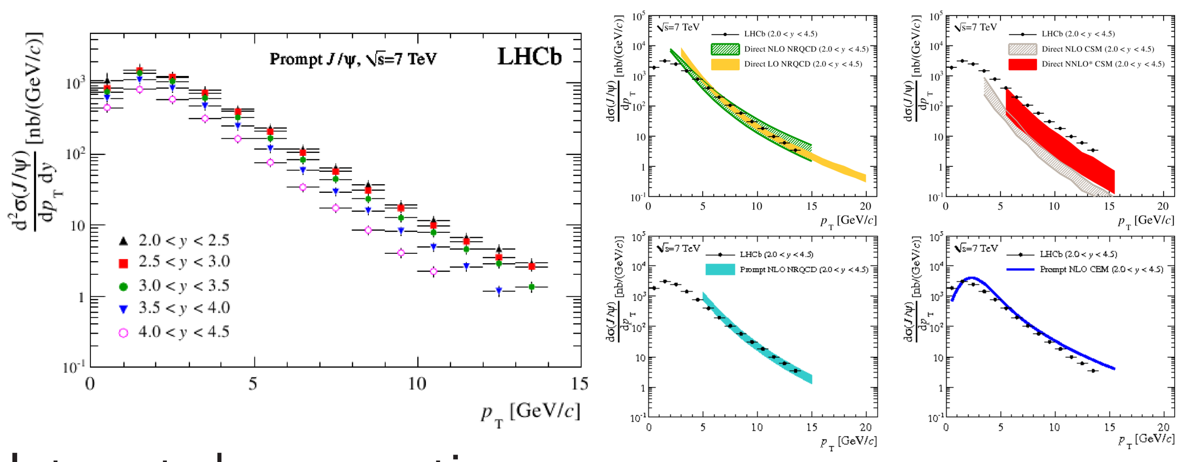
Separating prompt and delayed J/ψ



- Use J/ψ pseudo proper time to disentangle prompt J/ψ and J/ψ from b decays.

$$t_z = \frac{(z_{J/\psi} - z_{PV})m_{J/\psi}}{p_z}$$

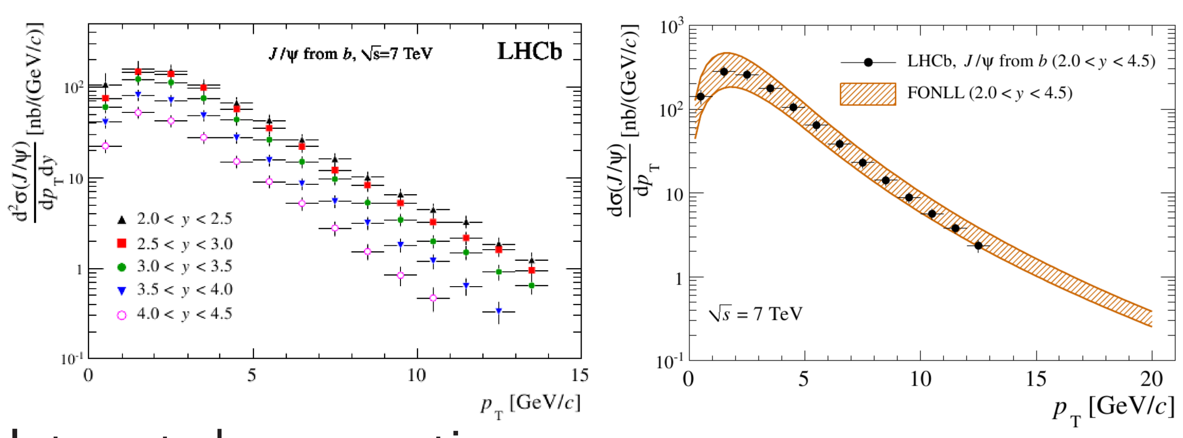
Prompt J/ψ cross section



Integrated cross section:

$$\sigma_{\text{prompt } J/\psi} = [10.52 \pm 0.04(\text{stat}) \pm 1.40(\text{sys})^{+1.64}_{-2.20}(\text{pol})]\ \mu\text{b}$$

J/ψ from b cross section



Integrated cross section:

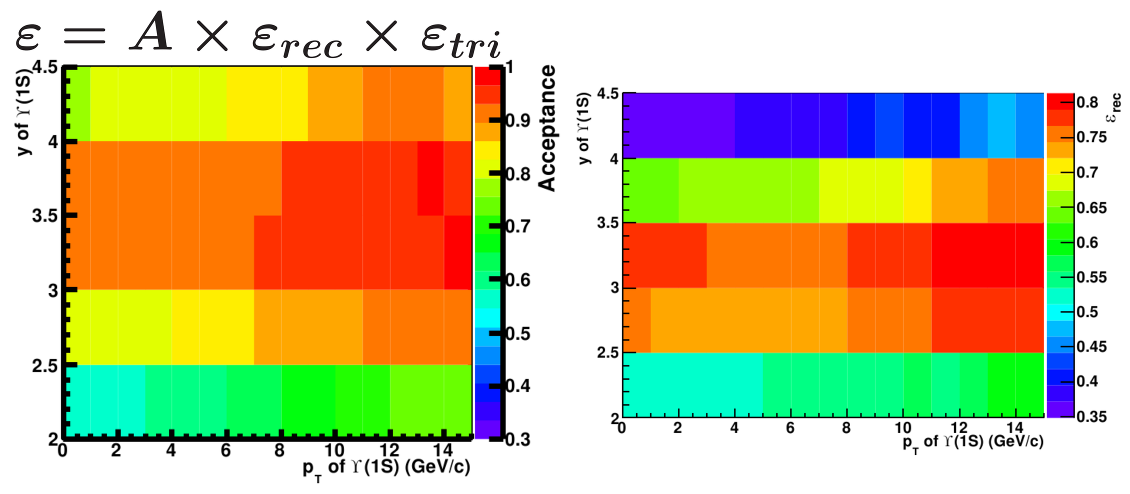
$$\sigma_{J/\psi \text{ from } b} = [1.14 \pm 0.01(\text{stat}) \pm 0.16(\text{sys})]\ \mu\text{b}$$

Extrapolated $b\bar{b}$ cross section (4π angle):

$$\sigma(pp \to b\bar{b}X) = [288 \pm 4(\text{stat}) \pm 48(\text{sys})]\ \mu\text{b}$$

$\Upsilon(1S)$ efficiency determination

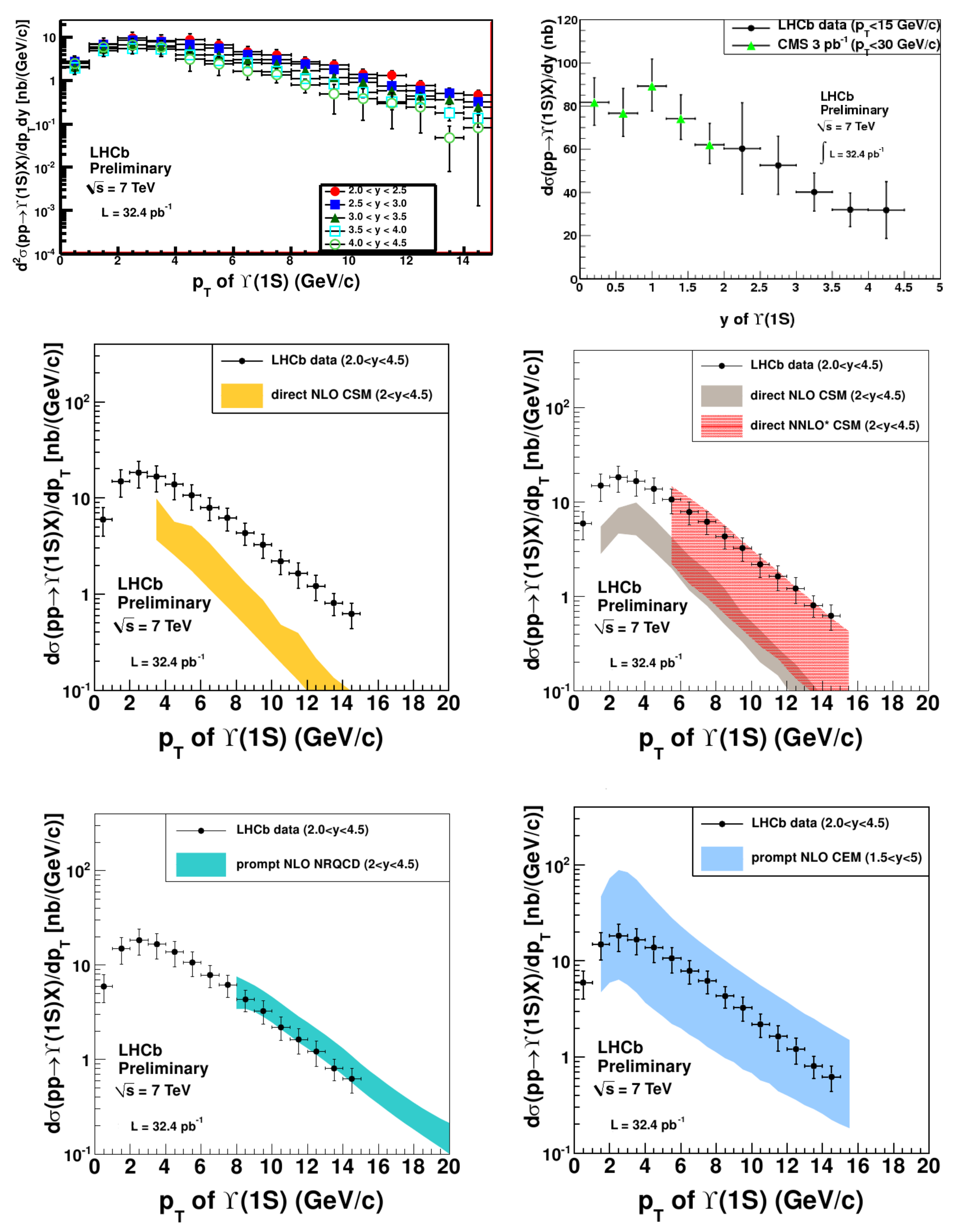
$$\varepsilon = A \times \varepsilon_{rec} \times \varepsilon_{tri}$$



$\Upsilon(1S)$ differential cross section

$\Upsilon(1S)$ integrated cross section:

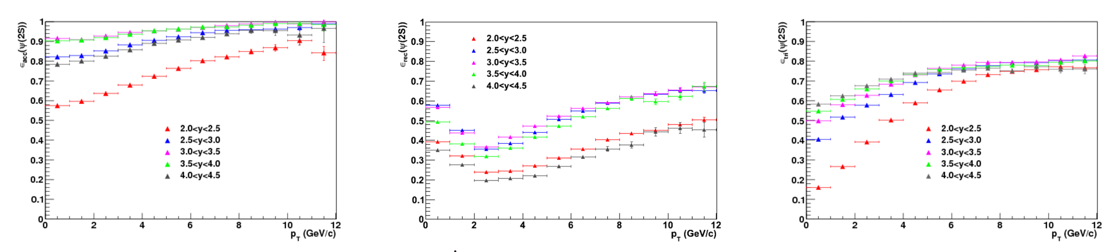
$$\sigma_{\text{incl } \Upsilon(1S)} = [108.3 \pm 0.7(\text{stat})^{+30.9}_{-25.8}(\text{sys})]\ \text{nb}$$



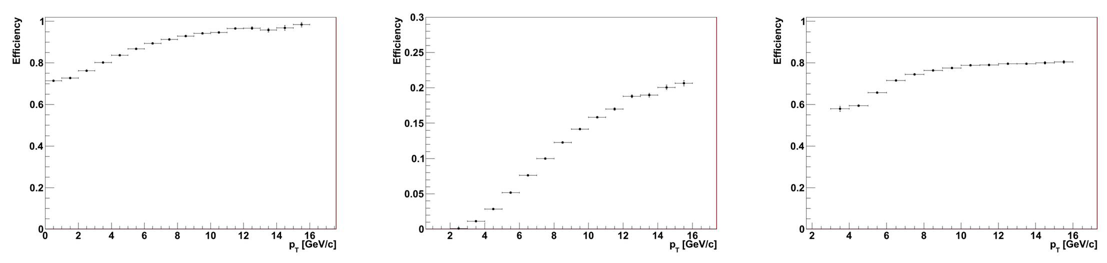
$\psi(2S)$ efficiency determination

Acceptance, reconstruction, trigger efficiency:

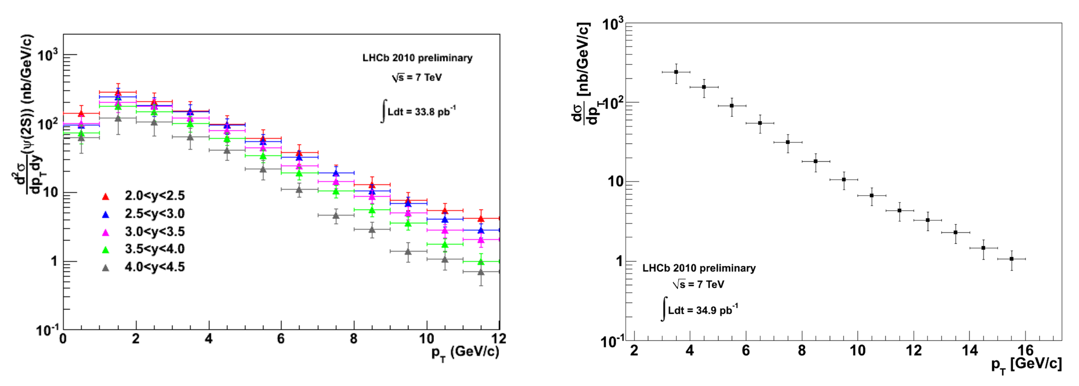
- $\psi(2S) \to \mu^+\mu^-$ channel

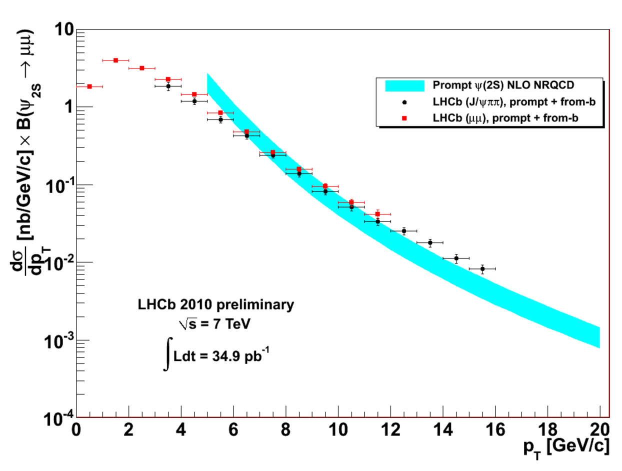


- $\psi(2S) \to J/\psi\pi^+\pi^-$ channel



$\psi(2S)$ differential cross section





Integrated cross section:

- Range $p_T \in [0; 12]$ GeV/c, $2 < y < 4.5$:

$$\sigma_{\psi(2S)\to\mu^+\mu^-} = [1.88 \pm 0.02(\text{stat}) \pm 0.31(\text{sys})^{+0.25}_{-0.48}(\text{pol})]\ \mu\text{b}$$

- Range $p_T \in [3; 16]$ GeV/ c, $2 < y < 4.5$:

$$\sigma_{\psi(2S)\to J/\psi\pi^+\pi^-} = [0.62 \pm 0.04(\text{stat}) \pm 0.12(\text{sys})^{+0.07}_{-0.14}(\text{pol})]\ \mu\text{b}$$