LHCC Poster Session - CERN, 23 March 2011

J/ψ cross-section production and B-fraction

Introduction

The inclusive J/ψ production cross-section

$$\frac{d^2\sigma(J/\psi)}{dp_T dy} \cdot Br(J/\psi \to \mu^+\mu^-)$$

and fraction of J/ψ produced in B-hadron decays

$$f_B \equiv \frac{d\sigma(pp \to B + X \to J/\psi X')}{d\sigma(pp \xrightarrow{\text{Inclusive}} J/\psi X'')}$$

are measured in proton-proton collisions at √s=7 TeV with the ATLAS detector at the LHC, as a function of the transverse momentum (p_T) and rapidity (y) of the J/ψ

From the inclusive production cross-section and fraction of J/ψ produced in B-hadron decays, the differential production cross-sections of prompt and non-prompt J/ψ are separately determined and are compared to the theory predictions

Data taking

2.4 pb^{-1} of pp collisions at √s = 7 TeV

Three separate data-taking periods with different trigger p_T thresholds were used (open trigger, 4 GeV and 6 GeV)

Spanning J/ψ $1<p_T<70$ GeV across 78 slices of p_T and y

Selections

- At least 3 tracks from primary vertex
- One pair of opposite-sign reconstructed muons
- One J/ψ muon with both Inner Detector and Muon Spectrometer tracks
- One J/ψ muon triggered the event
- Muons from common vertex with loose quality requirement
- Muon p > 3 GeV, |pseudorapidity (η)| < 2.5

B-fraction study:

- Vertex fit probability > 0.005
- Events with muons from two different primary vertices rejected

Procedure

J/ψ yield was corrected to account for detector efficiency, bin migration and acceptance effects

$$N^{J/\psi}_{corr} = \omega \cdot N^{J/\psi}_{measured}$$

$$w^{-1} = \mathcal{A} \cdot \mathcal{M} \cdot \mathcal{E}^2_{\text{trk}} \cdot \mathcal{E}^+_\mu(p^+_T, \eta^+) \cdot \mathcal{E}^-_\mu(p^-_T, \eta^-) \cdot \mathcal{E}_{\text{trig}}$$

Detector acceptance

Trigger efficiency

Inner Detector tracking efficiency

Muon reconstruction efficiency

Bin migration correction

Yields distributions fitted with a binned χ^2 Gaussian + linear function and scaled by luminosity to get cross-section

The inclusive differential cross-section was calculated as

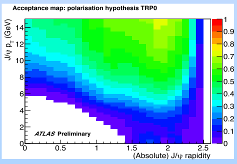
$$\frac{d^2\sigma(J/\psi)}{dp_T dy} \cdot Br(J/\psi \to \mu^+\mu^-) = \frac{N^{J/\psi}_{corr}}{\mathcal{L} \cdot \Delta p_T \Delta y}$$

The prompt production cross-section was derived from the inclusive cross-section and the J/ψ B-fraction measurement

Detector corrections

Detector Acceptance: Probability for J/ψ muons to fall into the fiducial detector volume. Calculated using generator-level MC with muon p_T and η cuts to emulate detector geometry

To model the spin-alignment dependence of the acceptance – calculated maps for 5 extreme spin-alignment scenarios for systematics



Bin migration correction: Migration of the true value of J/ψ p_T to a measured value which may not remain in a given analysis bin. p_T distribution parameterized with and without detector resolution smearing. The ratio of the two in a given analysis bin used as a correction factor

Inner Detector tracking efficiency: 99.0%±0.5% per track

Muon reconstruction efficiency: Data-driven efficiency map using Tag & Probe method. Muons (tags) were paired with Inner Detector tracks (probes). Fitting invariant mass of pairs to acquire number of J/ψ

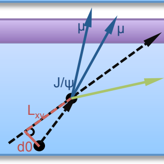
$$\varepsilon_{reco} = \frac{N^{J/\psi}_{\text{matching probe}}}{N^{J/\psi}}$$

Trigger efficiency: Using a hybrid data-driven and MC approach. MC-based efficiency maps used to model fine-structure of trigger features. Data-driven efficiencies used to scale MC-based efficiencies to data in wider regions

Pseudo-proper time

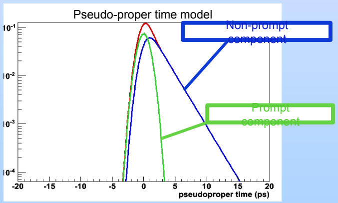
Lxy - the B flight distance from the primary vertex (PV) projected on the xy plane was used to calculate pseudo-proper time τ

$$\tau = \frac{L_{xy} m^{J/\psi}}{p_T^{J/\psi}}$$



B-fraction fitting model

Mass and pseudo-proper time are simultaneously fitted with a Maximum-Likelihood fit



$$L = \prod_{i=1}^{N} \left[f_{\text{sig}} P_{\text{sig}}(\tau, \delta_\tau) F_{\text{sig}}(m_{\mu\mu}, \delta_m) + (1 - f_{\text{sig}}) P_{\text{bkg}}(\tau, \delta_\tau) F_{\text{bkg}}(m_{\mu\mu}) \right]$$

B-fraction of signal

Pseudo-proper time PDF

Mass PDF

Signal: Gaussian

Background: polynomial

Pseudo-proper time PDF:

Signal: δ function + exponential convoluted with Gaussian

Background: δ function + a symmetric double exponential (positive and negative) + a positive exponential all convolved with a Gaussian

Systematics

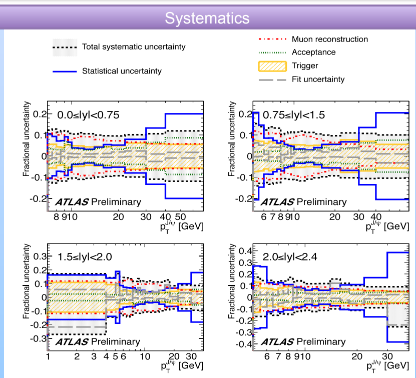


Figure 1. Systematic uncertainty contributions for differential J/ψ cross-section as a function of J/ψ p_T in four J/ψ rapidity slices

Inclusive J/ψ cross-section

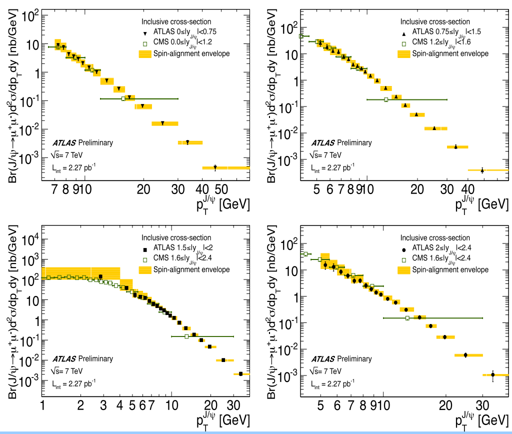


Figure 2. Inclusive J/ψ production cross-section as a function of J/ψ p_T in four rapidity slices. Yellow regions represent uncertainty due to different spin-alignment scenarios

B fraction

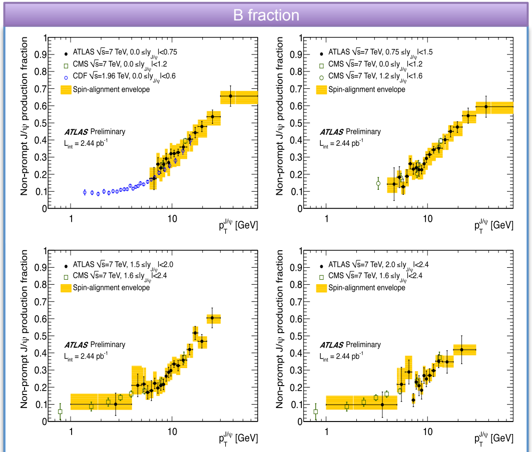


Figure 3. B-fraction of non-prompt to inclusive J/ψ as a function of J/ψ p_T in four rapidity slices. Yellow regions represent uncertainty due to different spin-alignment scenarios

Prompt J/ψ cross-section

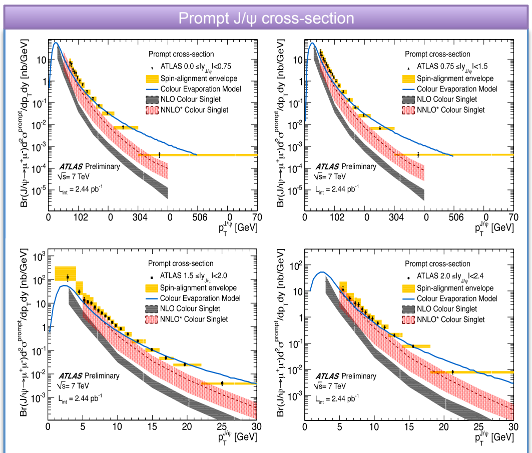


Figure 4. Production cross-section for prompt J/ψ as a function of J/ψ p_T in four rapidity slices. Yellow regions represent uncertainty due to different spin-alignment scenarios. NLO, NNLO and phenomenological Color Evaporation predictions overlaid

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ATLAS EXPERIMENT