Measurement of J/Ψ → $\mu^+\mu^-$ and Υ → $\mu^+\mu^-$ production in pp collisions at $\sqrt{7}$ TeV with CMS

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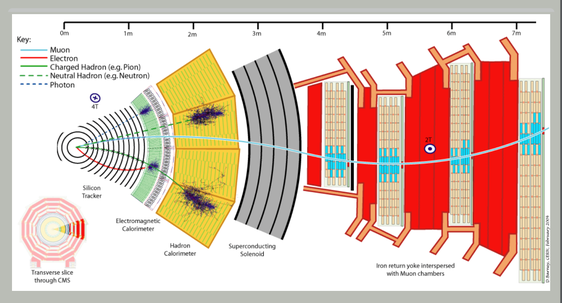
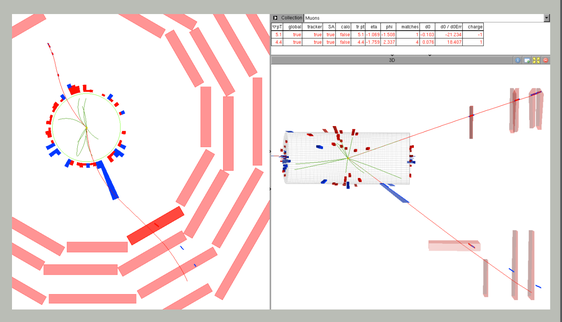
MOTIVATION

- J/Ψ and Υ are standard candles, used for efficiency measurements and detector calibration
- none of existing theories explains differential cross section and the polarization simultaneously (measured at Tevatron)
  - expectation: improvements from data collected at higher energies, extending to larger p_T to help clarifying production mechanism for Υ and J/Ψ in hadronic collisions





CROSS SECTION DEFINITION for $Q\bar{Q}$ = J/Ψ resp. Υ

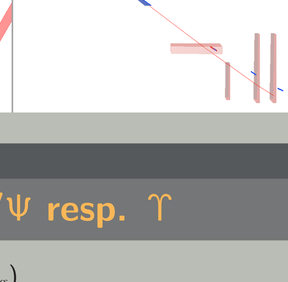
$$\frac{d\sigma\left(pp\to Q\bar{Q}X\right)}{dp_T}\cdot\mathcal{B}\left(Q\bar{Q}\to\mu^+\mu^-\right)=\frac{N^{\mathrm{fit}}_{Q\bar{Q}}(p_T;\mathcal{A},\epsilon_{\mathrm{track}},\epsilon_{\mathrm{id}},\epsilon_{\mathrm{trig}})}{\int Ldt\ \cdot\Delta p_T}$$

- $N^{\mathrm{fit}}_{Q\bar{Q}}=\frac{N^{\mathrm{fit,uncorr}}_{Q\bar{Q}}}{\epsilon\mathcal{A}}$ corrected signal yield in given p_T bin, obtained from a weighted 1-D fit to $M_{\mu^+\mu^-}$ distribution
  - $\mathcal{A}$ = geometrical and kinematical acceptance for J/Ψ,Υ
  - $\epsilon_{\mathrm{trig}}, \epsilon_{\mathrm{id}}, \epsilon_{\mathrm{track}}$ = trigger, muon identification and tracking efficiency
- $\int Ldt$ = integrated luminosity
- Δp_T = Υ, J/Ψ transverse momentum bin size

ACCEPTANCE

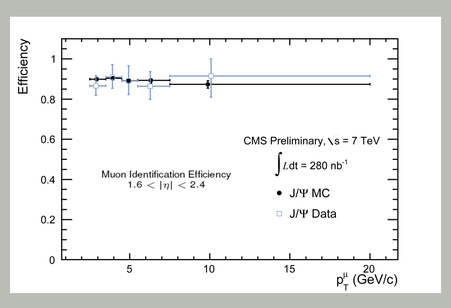
$$\mathcal{A}(p_T,y)=\frac{N_{Det}(p_T,y)}{N_{Gen}(p_T,y)},$$

- p_T, y: transverse momentum and rapidity of Υ, J/Ψ
- acceptance dependent on polarization of Υ, J/Ψ:
  - extreme polarization scenarios were tested: unpolarized, polarized longitudinally and transversely with respect to difference reference frames (Helicity and Collins-Soper frame)
- use unpolarized scenario for results



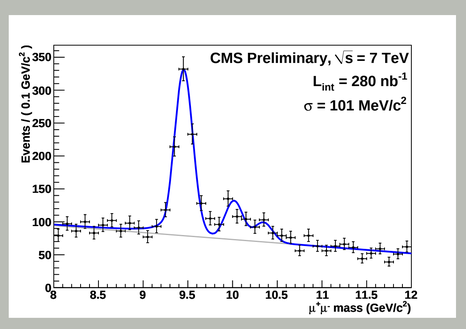
EFFICIENCIES

$$\epsilon_\mu = \epsilon_{trig}\cdot\epsilon_{id}\cdot\epsilon_{track}$$



- ϵ_{track} = probability, that accepted tracker track of muon within selection criteria is found
- ϵ_{id} = probability, that reconstructed tracker track of muon is identified as muon within selection cuts
- $\epsilon_{trigger}$ = probability, that identified muon fires the trigger
- obtained via data driven tag and probe method; only for J/Ψs due to low statistics

DATA AND EVENT SELECTION FOR Υ



Υ(1S) mean free parameter,
$\Delta m(\Upsilon(2,3S)-\Upsilon(1S))$ fixed to PDG
N(Υ(1S))=678 ± 37

$$L = 280 \pm 31\ \mathrm{nb}^{-1}$$

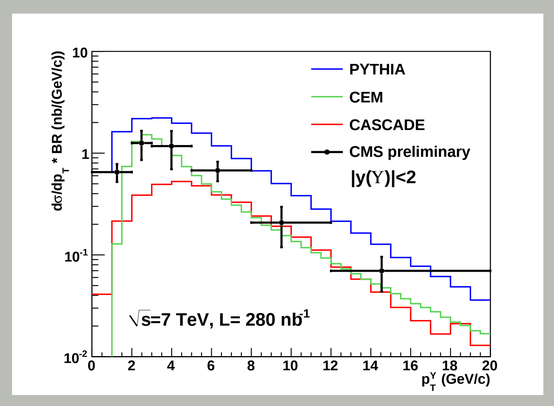
- Trigger: two muons required
- high quality track associated to muon segments
- Track Quality Cuts: $|d0|$,$|dxy|$,χ^2/ndf, Nhits, NPixelhits,
- $|y_\Upsilon| < 2.0$, $\eta^\mu < 2.4$, $p_T^\mu > 2.5$ GeV/c
- Yield extraction: Unbinned ML fit to dimuon masses: 3 Crystal Ball for signal + linear for background

CROSS SECTION Υ

$$\sigma\left(pp\to\Upsilon(1S)X\right)\cdot\mathcal{B}\left(\Upsilon(1S)\to\mu^+\mu^-\right)=\left(8.3\pm0.5_{stat}\pm0.9_{lumi}\pm1.0_{sys}\right)nb$$
$|y|<2.0$

extreme polarization scenarios lead to additional changes in cross section by about 20 % for J/Ψ and Υ results

$$R=\frac{\sigma(\Upsilon(2S)+\Upsilon(3S))}{\sigma(\Upsilon(1S))}$$
$$=0.44\pm0.06_{stat}\pm0.07_{sys}$$

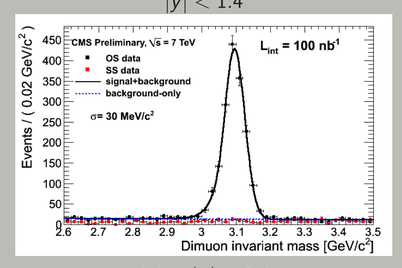


DATA AND EVENT SELECTION FOR J/Ψ

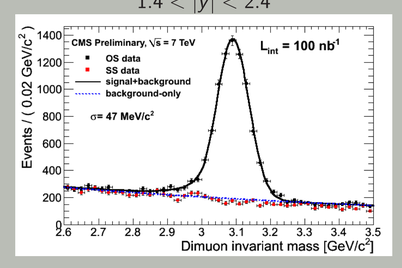
$$L = 100.44 \pm 11.05\ \mathrm{nb}^{-1}$$

- Trigger: 2 Muons required and one Muon with $p_T > 3$ GeV/c
- $|y_{J/\Psi}| < 2.4$, $\eta^\mu < 2.4$, $p_T^\mu > 0.8$ GeV/c
- Yield extraction: Unbinned ML fit to dimuon mass: Crystal Ball for signal + exponential for background

$|y| < 1.4$

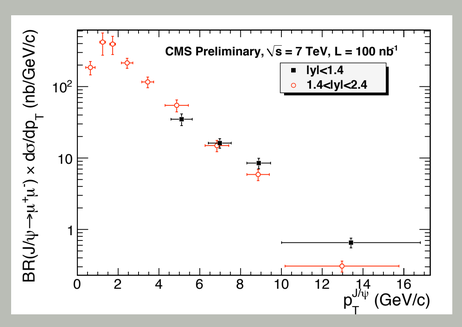


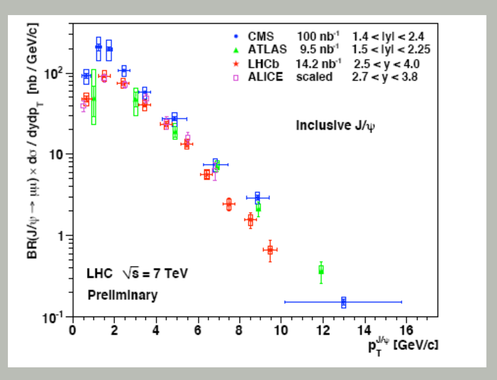
$1.4 < |y| < 2.4$



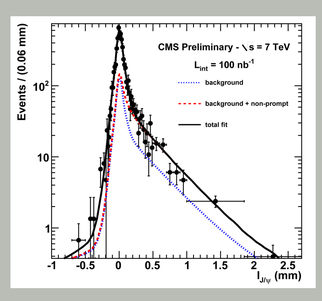
CROSS SECTION J/Ψ

$$\sigma\left(pp\to J/\Psi X\right)\cdot\mathcal{B}\left(J/\Psi\to\mu^+\mu^-\right)=\left(289.1\pm16.7_{stat}\pm60.1_{sys}\right)nb$$
$4< p_T <30$ GeV/c, $|y|<2.4$





PROMPT J/Ψ AND b ⟶ J/ΨX

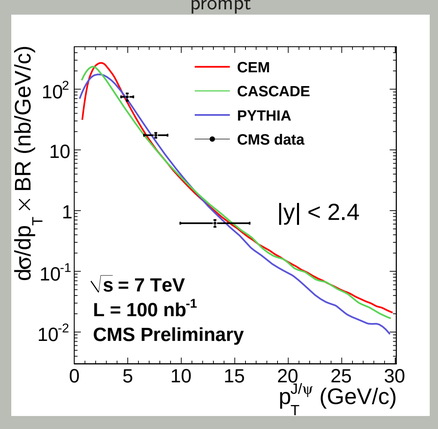


Separation of prompt and non-prompt contributions with a 2D unbinned ML fit to invariant mass and pseudo proper decay length: $l_{J/\psi} = L_{xy}\cdot m_{J/\psi}/p_T$

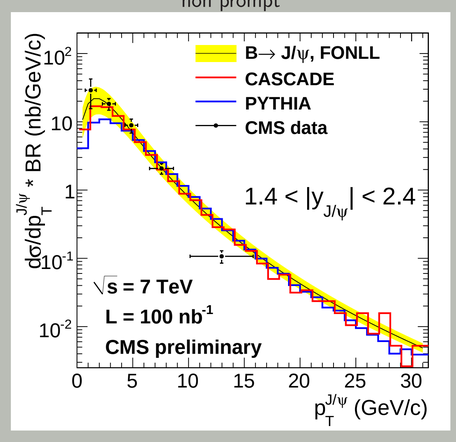
- Prompt contribution: pure resolution function (3-Gaussian)
- Non-prompt contribution: exponential convolved with resolution function

$$\sigma\left(pp\to bX\to J/\Psi X'\right)\cdot\mathcal{B}\left(J/\Psi\to\mu^+\mu^-\right)=\left(56.1\pm5.5_{stat}\pm7.2_{sys}\right)nb$$
$p_T >4$ GeV/c, $|y|<2.4$

prompt



non prompt



REFERENCES

BPH-10-002 J/Ψ prompt and non-prompt cross sections in pp collisions at $\sqrt{s}=7$ TeV
BPH-10-003 Upsilon production cross section in pp collisions at $\sqrt{s}=7$ TeV

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