Measurements of the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ cross sections at 7 TeV

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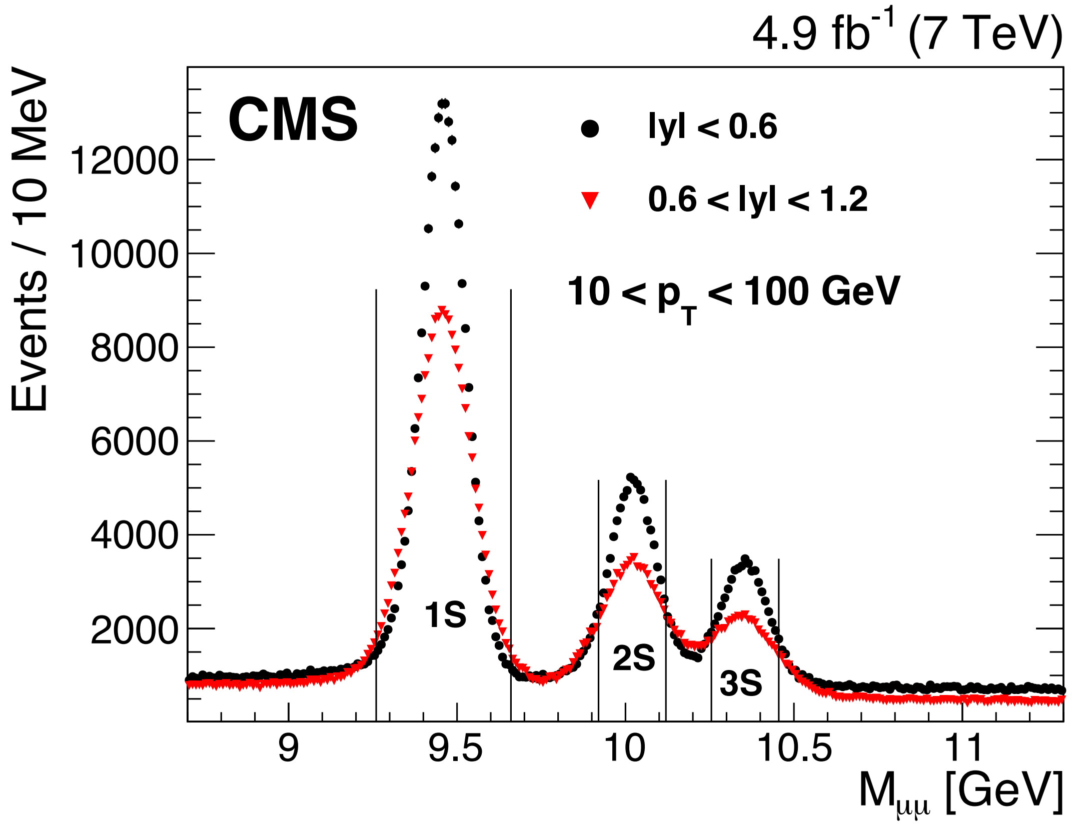
Motivation

- Measurements of bb mesons (e.g. Υ) are important probes of QCD
- There are several models that predict different high p_T cross section shapes
    - color singlet model, k_T-factorization, NRQCD
- Measurements of the differential cross section over a range of p_T can clarify the theoretical picture

Procedure

$$\left.\frac{d\sigma\left(pp\to\Upsilon(\mathrm{nS})\right)}{dp_T}\right|_{\Delta|y|}\times\mathcal{B}\left(\Upsilon(\mathrm{nS})\to\mu^+\mu^-\right)=\frac{N^{\mathrm{fit}}_{\Upsilon(\mathrm{nS})}}{L_{int}\cdot\Delta p_T\cdot\mathcal{A}\cdot\varepsilon}[p_T,y]$$

- Computed for two rapidity $|y|$ bins
  - $|y| < 0.6$, $0.6 < |y| < 1.2$
- L_{int}: integrated luminosity, 4.9fb^{-1}
- Δp_T: bin width
- N^{fit}: number of Υ events determined from fit for each state
- ε: trigger and efficiency
- $\mathcal{A}$: acceptance



Unique features of this analysis

- Utilizes 4.9 fb^{-1} of 7 TeV for highest p_T reach yet reported
- Using measured polarization to compute the acceptance and reduces the systematic uncertainty
- Introduced a new way to compute the signal shapes from data
  - Especially useful for bins with poor mass resolution (high p_T, rapidity)
  - Allows separation of $\Upsilon(2S)$ and $\Upsilon(3S)$ states

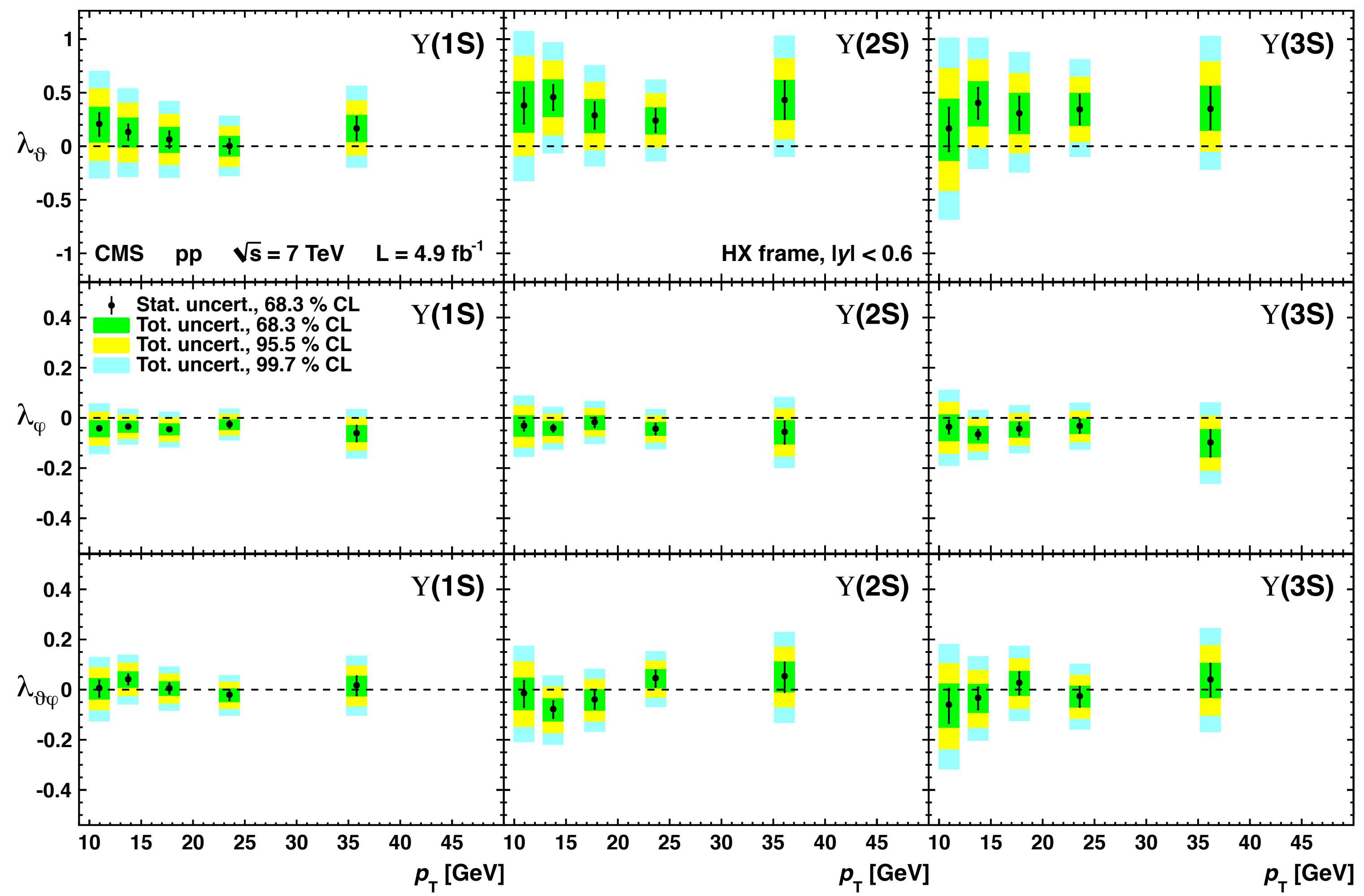
Physics
Carnegie Mellon University

Acceptance: improved with polarization measurement

arXiv: 1209.2922

- $\mathcal{A}$ is the fraction of events where both muons satisfy the muon requirements:

$$
\begin{aligned}
p_T(\mu) &> 3\,\text{GeV} && \text{for } 1.4 < |\eta(\mu)| < 1.6, \\
p_T(\mu) &> 3.5\,\text{GeV} && \text{for } 1.2 < |\eta(\mu)| < 1.4, \\
p_T(\mu) &> 4.5\,\text{GeV} && \text{for } |\eta(\mu)| < 1.2.
\end{aligned}
$$



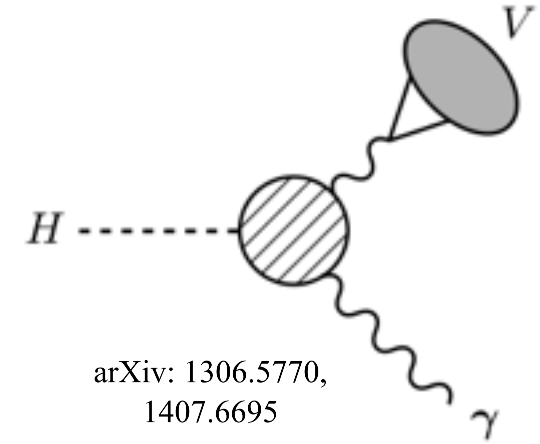
- $\mathcal{A}$ is weighted by the angular correlation factor w, where λ_θ, λ_ϕ, $\lambda_{\theta\phi}$ are the measured of the polarization

$$w = \frac{3}{4\pi}\left(\frac{1}{3+\lambda_\theta}\right)(1 + \lambda_\theta \cos^2\theta + \lambda_\phi \sin^2\theta \cos 2\phi + \lambda_{\theta\phi} \sin 2\theta \cos\phi)$$

Physics Carnegie Mellon University

Long term (HL-LHC) motivation

- Measurement of H→J/$\psi\gamma$ is the only known way to measure the Higgs coupling to c quarks
  - H→J/$\psi\gamma$($\Upsilon\gamma$) is a potential window to new physics
  - Branching fractions are very small, so measurement requires HL-LHC
- Need maintain capability for J/ψ (Υ) measurements
  - e.g. high-pt triggers for J/ψ and Υ



arXiv: 1306.5770, 1407.6695

arXiv:1501.03276