LHCb measurements of $J/\psi$ and open charm cross-sections at $\sqrt{s} = 13$ TeV

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1. Motivation

Measurements of production cross-sections of prompt $J/\psi$, $J/\psi$-from-$b$ hadrons [1], and prompt $D^0$, $D^+$, $D^*$ and $D^{**}$ [2] in early Run 2 data gave:

- New precise tests of QCD calculations in yet unobserved energy regions.
- Test cases for detector and a novel data processing.

The master relation

$$\frac{d^2\sigma(X)}{dp_T dy} = \frac{1}{\Delta p_T \Delta y} N(X \rightarrow f) \cdot \epsilon(X \rightarrow f) \cdot B(X \rightarrow f) \cdot L$$

2. The LHCb trigger system in Run 2

- TurboStream
  - Candidates out of trigger with offline-quality reconstruction.
  - Detector alignment and calibration in real time.
  - Analysis-ready candidates stored to disk with no need for additional offline reconstruction.
  - Faster and smaller event size on disk.
  - Candidate to become default procedure in Run 3.

- Data are fitted to extract the signal yield in each $p_T < y$ bin.

- Fit distributions in $m_c^2$ or $t_{2}$ to separate prompt and secondary mesons.

Efficiencies estimated partly from data-driven techniques, partly from simulation.

3. Analysis strategy

- Measured differential and integrated production cross-sections and their ratios at different, $\sqrt{s}$ and between different mesons.
- Compared with three sets of NLO predictions.
- Uncertainty dominated by systematic sources: tracking, luminosity, particle identification.
- Ratios between different mesons agree with results at $e^+e^-$ colliders.

4. 13 TeV to 7(8) TeV cross-section ratios

- Correlated systematic uncertainties cancel for both measurements and theoretical predictions.
- Sensitive to choice of PDF in QCD predictions [3].

Theoretical uncertainties in charm NLO predictions of $e^+$-production

- Measured $\sigma_{J/\psi}$ for prompt $J/\psi$ and $J/\psi$-from-$b$ and their ratio.
- Measured integrated production cross-section: $\sigma_{J/\psi}$ (prompt) = $15.30 \pm 0.03$(stat) $\pm 0.86$(syst)$\mu$b
- $\sigma_{J/\psi}$ (from-$b$) = $2.34 \pm 0.01$(stat) $\pm 0.13$(syst)$\mu$b
- Uncertainty is dominated by systematic sources: luminosity, trigger efficiency, muon identification and others.
- Measured ratio of 13 TeV to 8 TeV results.

5. Results for $D^0 \rightarrow K^-\pi^+$ [2]

Double differential cross-section for $D^0$

6. Results for $J/\psi \rightarrow \mu^+\mu^-$ [1]

Cross-section for prompt $J/\psi$

Fractions of $J/\psi$-from-$b$

Integrated cross-section in fiducial region

13 TeV to 8 TeV ratio compared with theory

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