

Recent Quarkonia Highlights from LHCb

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2nd workshop on advancing the understanding of non-perturbative QCD using energy flow

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Quarkonia in a hadronic medium





Color screening

- Quarkonia states have long served as probes of the hadronic medium formed in nuclear collisions
- Comparison of different states allows
- Study of various states in small systems can place limits on the temperature of medium→sensitive to QGP formation



Co-mover breakup



Sinding energy (GeV)

The LHCb detector



JINST 3 (2008) S08005 Int. J. Mod. Phys. A 30, 1530022 (2015)

RICH detectors Muon system μ identification $\epsilon(\mu \rightarrow \mu) \sim 97 \%$ $K/\pi/p$ separation mis-ID $\varepsilon(\pi \rightarrow \mu) \approx 1-3 \%$ ε(K→K) ~ 95 %, mis-ID $\epsilon(\pi \rightarrow K) \sim 5 \%$ Vertex Detector reconstruct vertices **Dipole Magnet** decay time resolution: 45 fs bending power: 4 Tm IP resolution: 20 µm Tracking system: TT and OT momentum resolution **Calorimeters (ECAL, HCAL)** Acceptance: $\Delta p/p = 0.5\% - 1.0\%$ energy measurement 10 mrad $< \theta < 300$ mrad (5 GeV/c - 100 GeV/c) e/γ identification 2 < y < 5 $\Delta E/E = 1 \% \oplus 10 \%/VE (GeV)$ Los Alamos Matt Durham – Quarkonia at LHCb

J/ψ in *p*Pb collisions







- J/ψ in *p*Pb at LHCb is generally well described by nPDF calculations
- No strong final-state suppression observed for J/ψ
 - Potential color screening and/or breakup do not have large effect



- ψ (2S) is a different story: double ratio shows suppression beyond J/ψ
- Room for significant final-state effects





- ψ (2S) is a different story: double ratio shows suppression beyond J/ψ
- Room for significant final-state effects
 - Prompt component consistent with comover dissociation
- No effect seen in nonprompt \rightarrow suppression due to activity at primary vertex Los Alamos Matt Durham – Quarkonia at LHCb

New results: $\chi_c \rightarrow J/\psi\gamma$



 $F_{\chi_c \to J/\psi} \equiv rac{\sigma_{\chi_c \to J/\psi\gamma}}{\sigma_{J/\psi}}$

- *p*Pb data at TeV
- J/ψ reconstructed through dimuon decays
- Add EMCal photon to J/ψ to construct sum of $\chi_{c1} + \chi_{c2}$
- Subtract dimuon mass to remove contribution from dimuon resolution



Fraction of J/ψ from χ_c decays





- First measurement at the LHC!
- Initial state effects on charm production ~cancel in ratio
- Forward rapidity consistent with pp
- Backward rapidity largely consistent with pp, slightly higher at low p_T (2.4 σ)
 - Compatible with the suppression of the $\psi(2S)$ contribution to prompt J/ψ

No significant final-state suppression observed for χ_c in *p*Pb



Survey of quarkonia suppression



Energy available in *p*Pb collisions does not affect charmonia with $E_h > 200 MeV$

Double ratios ~cancel initial state effects

- Tightly bound states show no variation between *p*Pb and *pp* collisions.
- The $\psi(2S)$, with binding energy significantly below freeze-out temperature, shows significant suppression.
 - Potential effect on $\Upsilon(3S)$
 - Significantly larger than χ_c
 - Lower velocity in medium



Summary



- LHCb is uniquely well suited for measurements of a wide range of charmonia states.
 - Also exotic multiquark states! Seminar this afternoon!
- The fraction of J/ψ from χ_c decays is basically unchanged from pp to pPb
 - Any medium formed in the small *p*Pb collision system has little effect on χ_c
- This places new limits on the available energy for QGP formation in the small pPb system.





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Backup





