Heavy ion quarkonia and heavy flavor results from ALICE and LCHb

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For LHCb and ALICE

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Roadmap to Heavy Ion Studies

- **p-p** Baseline (cross sections)

- **p-A** Cold Matter and Initial State Effects

- **A-A** Two tools presented:
  - Nuclear Modification Factor
  - Azimuthal Asymmetries

\[ R_{AA} = \frac{\text{yield in } A+A}{N_{\text{coll}}(\text{yield in } p+p)} \]

\[ \frac{dN}{d\phi} \propto 1 + 2 \sum_{n=1}^{\text{inf}} v_n \cos n(\phi - \Phi_R) \]
Quarkonia
QGP Temperature

![Graph showing binding energy versus quarkonia state](image)
p-Pb Quarkonia “Breaking”

- Relative nuclear modification of $Y_{2S}$, $Y_{3S}$ over $Y_{1S}$
- Data reproduced by comover calculations without QGP
Pb-Pb $J/\psi$ Polarization Studies

- Consistent with zero in all frames
**p-Pb**  \( J/\psi \)  **Elliptic Flow**

- Same model describing \( J/\psi \) \( R_{pA} \) using transport in-medium cannot describe \( v_2 \)
- Coalescence/Hydro in small systems?
- "No flow" result
- Bottomonia should not be produced by coalescence (small number)
Heavy Quarks
**p-Pb Beauty Production @ 8.16 TeV**

- Benchmark data
- At large $Q^2$ agreement with nPDFs (smaller uncertainties)
p-Pb $\Lambda_c$ Production

- Ratio larger larger than those measured previously in different colliding systems
- Ratio at mid-rapidity larger than forward-rapidity
**p-Pb Baryon/Meson Ratio @ 8.16 TeV**

- Baryon/meson ratio same as p+p at forward rapidity
- Large fluctuation at backward rapidity
p-He/p-Ar  $D^0$ Production Fixed Target

- No evidence for strong charm enhancement predicted by intrinsic charm estimation
- More data will allow a better exploration of $x_2$
**Pb-Pb Semi-leptonic Decays of Beauty**

- Electron impact parameter selection
- Hint of smaller suppression of b-quarks?
- Caveat: B-meson $p_T$ vs. electron $p_T$

**ALICE Preliminary**

- $0-10\%$ Pb-Pb, $\sqrt{s_{NN}} = 5.02$ TeV

**Average $D^0, D^+, D^{*+}$ from**

JEHP 1810 (2018) 174
Pb-Pb D-Meson Tagged Jets

- Inclusive and D-meson tagged jets $R_{AA}$ similar
- No radial profile modification for higher D-meson $p_T$
Pb-Pb $\Lambda_c$ Production

- ALICE results consistent with charm coalescence in medium
Pb- Pb $\Lambda_c$ Ratios

- Sensitive to the charm quark hadronisation mechanisms in the medium
- Two standard deviation difference between p-Pb and Pb-Pb – coalescence?
Pb-Pb Event-Shape-Engineering with D Mesons

- Correlation of flow for D-meson and light hadron
- Similar eccentricities

60% smallest $q_2^{TPC}$
$\langle v_2 \rangle_{\text{small-}q_2} < \langle v_2 \rangle_{\text{unb}}$

20% largest $q_2^{TPC}$
$\langle v_2 \rangle_{\text{large-}q_2} > \langle v_2 \rangle_{\text{unb}}$
Pb-Pb Initial Magnetic Fields?

- Charge asymmetry of direct flow $v_1$ is a signature for the initial magnetic field in the collision.
- Effect depends on the quark mass and formation time, charm should be more sensitive than light quarks.
Summary of Highlights

- No intrinsic charm in fixed target mode
- Stronger suppression of excited quarkonia states
- Azimuthal asymmetry for J/ψ in pPb - coalescence unlikely
- Large regeneration of charm hadrons and perhaps in bottom hadrons
- More observations of J/ψ flow attributed to charmonium coalescence
- γ shows no azimuthal asymmetry confirming that bottomonium coalescence is small
- Exciting new measurement of direct flow of D-mesons indicating a sensitive probe for initial magnet fields