**Heavy quarks: physics motivation**

- Heavy quarks are produced in hard scattering processes in the initial stages of the collisions → they are an excellent probe to study the medium created in heavy-ion collisions.
- They interact with the medium and lose energy via: gluon radiation and elastic scatterings in the medium.
- Colour-charge and mass-dependent energy loss → \( \Delta E_h > \Delta E_\text{EL} > \Delta E_\text{GL} \) [4]
- To quantify D-meson production we evaluate the nuclear modification factor:
  \[
  R_{AA} = \frac{dN_{AA}/dpt}{(T_A \lambda_\text{A})d\sigma_{pp}/dpt},
  \]
  where \((T_A \lambda_\text{A})\) is the average nuclear overlap function from the Glauber model.

**D\(^+\) → K\(^-\)π\(^+\)π\(^+\) reconstruction**

- D\(^+\) fully reconstructed via their hadronic decay channel D\(^+\) → K\(^-\)π\(^+\)π\(^+\) (B.R. \( \approx 9.13\% \)) and charge conjugates.
- D\(^+\) displaced by few hundred \( \mu m \) from the primary vertex.

Require excellent capabilities in:
- Vertex reconstruction to separate primary and secondary vertices.
- Tracking for impact parameter and \( p_T \) resolution.
- Particle identification to reduce the huge combinatorial background.

**PID approach:** 3\( \sigma \) compatibility cut between the expected and measured signals of \( dE/dx \) in TPC and TOF time-of-flight for the different particle species.

**Analysis strategy:** selections based on topological options, i.e. distance between primary and secondary vertices.

**Results**

**Raw yield extraction**

Raw yield extracted fitting the invariant mass distributions of the candidates with a Gaussian for the signal and an exponential for the background.

**Corrections**

- **Efficiency:** Correction factor obtained from Monte Carlo simulations to take into account geometrical acceptance of the detector, the tracking efficiency and the selection cuts.
- **B feed-down subtraction:** Contribution of D\(^+\) mesons from B-hadron decays evaluated from FONLL prediction [2].

Hypothetical on non-prompt \( R_{AA} \): 2\( \times \)\( R_{AA} \) prompt. Systematic uncertainty evaluated varying the hypothesis in the range: 1 < \( R_{AA} \) (non-prompt)/\( R_{AA} \) (prompt) < 3 → 7 – 16%.

**D\(^+\)-yield systematic uncertainties**

- **Yield extraction:** variation of fit range, background function (polynomial) and signal extraction technique (bin counting after background subtraction or fit integral), 8 – 12%.
- **Topological selection:** analysis repeated with different selections, 10 – 15%.
- **Tracking efficiency:** different track selection criteria, 15%.
- **PID efficiency:** analysis repeated without PID, 5%.
- **MC \( p_T \) shape:** vary the simulated D\(^+\) \( p_T \) distribution to evaluate the efficiency, 1 – 10%.

**Summary**

- \( R_{AA} \) is compatible for all three D-meson species over the full \( p_T \) range.
- D-meson production suppressed by a factor of about 6 (3) in \( p_T = 10 \) GeV/c in central (semi-peripheral) Pb-Pb collisions.
- Several theoretical models can reproduce D-meson \( R_{AA} \) reasonably well.
- No indication of cold nuclear matter effects in p-Pb collisions.
- D-meson suppression increases from peripheral to central collisions.
- Similar suppression observed for D mesons and charged pions.
- Indication of a difference in the suppression of D mesons and non-prompt J/\( \psi \) from B decays (measured by CMS [5]).

**References**

- [4] B. Chatrchyan et al. [CMS Collaboration], JHEP 05 (2012) 003