Open heavy-flavor production from the high-mass dilepton spectrum in pp collisions at √s = 13 TeV with ALICE

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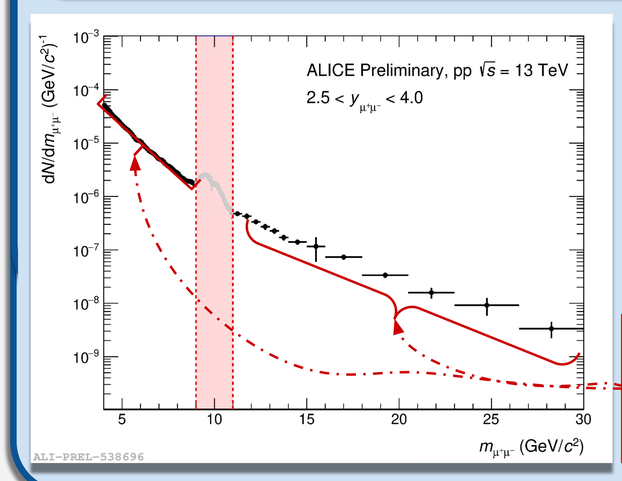
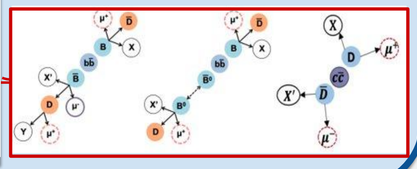
1. Physics motivations and Analysis goal

- **Heavy-quark production represents a stringent test of perturbative QCD ($\alpha_s < 1$ due to their large masses)** [1]
- **The measurement of heavy-flavor (HF) production in pp is a mandatory reference for studies in nuclear collisions where a quark-gluon plasma (QGP) is produced** [2]

Evaluate the $c\bar{c}$ and $b\bar{b}$ cross section in the rapidity region $2.5 < y_{\mu\mu} < 4$, comparing the dimuon invariant mass (m) and p_T distributions with corresponding signal templates



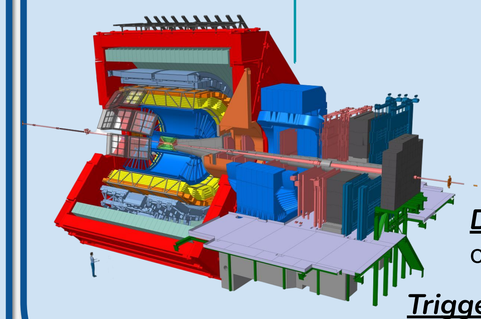
- New approach in ALICE to investigate the heavy-quark production in pp collisions: explore the region $m_{\mu\mu} > 4$ GeV/c^2
- $\mu^+\mu^-$ production in the ***continuum region*** $4 < m_{\mu\mu} < 9$ GeV/c^2 mainly due to semileptonic decays of:
  - ⇨ HF hadrons: from the hadronization of $c\bar{c}$ and $b\bar{b}$ pairs **[3]**
  - ⇨ Light Flavor (LF) mesons (π/K) pairs (combinatorial bkg.)



2. The ALICE detector (*Run 2 configuration*)

The ALICE detector is specifically designed to study heavy-ion collisions

- Central Barrel: enable dielectrons studies at midrapidity -> $|y| < 0.9$
- Muon Spectrometer: reconstruct dimuons at forward rapidity -> $2.5 < y < 4$



Muon Spectrometer

Front Absorber: reduces the particle rate coming from the interaction point, filtering out hadrons

Tracking system: used to reconstruct muon tracks, consists of 10 cathode pad chambers arranged in 5 stations

Dipole magnet: provides a magnetic field integral of 3 Txm

Trigger system: located after an iron wall, consists of 4 Resistive Plate Chambers planes arranged in two stations

3. Data sample & analysis steps

pp collision dataset collected at √s = 13 TeV in 2018 (Run 2)

✓ ***Muon/Dimuon cuts:***

- $2.5 < \eta_\mu < 4$ (on muons) and $2.5 < y_{\mu\mu} < 4$ (on dimuons) corresponding to the spectrometer acceptance
- matching of a track reconstructed in the tracking chambers with a track reconstructed in the trigger system with $p_T > 0.5$ GeV/c (online estimate of the p_T)
- cut on the momentum timex the distance of closest approach to the primary interaction vertex, to reject beam-gas event

✓ ***Analysis steps:***

1. Dedicated MC to simulate different $\mu^+\mu^-$ sources above $m_{\mu\mu} = 4$ GeV/c^2
2. Creation of a cocktail based on the HF $\mu^+\mu^-$ sources as provided by ***PYTHIA8*** **[4]**
3. Simultaneous fit of p_T and m data distributions with the template built as the ***superposition*** of the $\mu^+\mu^-$ <- c,c and $\mu^+\mu^-$<- b,b Probability Density Function (PDF)

4. Template creation

Minimum Bias production

❑ 48M events with *PYTHIA8 Monash tune*

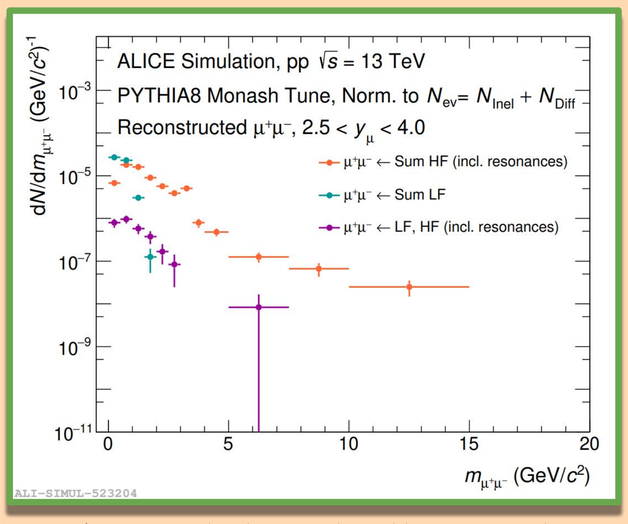
⇝ study the contamination from LF <- $\mu^+\mu^-$ and mixed LF,HF <- $\mu^+\mu^-$

➢ *Dimuon per pp collision:* distributions normalized to the number of simulated events N_{ev}

⇒ $\mu^+\mu^-$<-*HF* : both μ produced by HF decay

⇒ $\mu^+\mu^-$ <-*LF*: both μ produced by LF decay

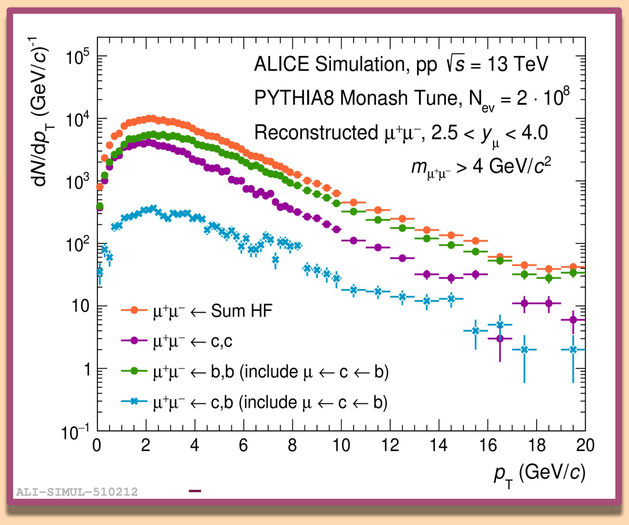
⇒ $\mu^+\mu^-$ <-*LF,HF* : one μ from HF, the other μ from LF



High statistics HF-enriched productions:

❑ 200M events with PYTHIA8

↪ triggered by the production of a pair of HF quarks, with at least a decay μ in the acceptance of the spectrometer



⇒ $\mu^+\mu^-$ <- *c,c* : both μ produced by prompt charm particles decay

⇒ $\mu^+\mu^-$<- *b,b* : both μ produced by beauty particles decay (include non-prompt charm component)

⇒ $\mu^+\mu^-$ <- *c,b* : one μ from prompt charm particle, the other μ from beauty particle (include non-prompt charm component)

PYTHIA8 predictions above $m_{\mu\mu} = 4$ GeV/c^2 :

- Negligible contribution from the mixed LF-HF and LF components
- $\mu^+\mu^-$ mainly produced by b decays
- HF-mixed contribution is around 4%

6. Results

❖ The charm and beauty differential cross sections have been evaluated from:

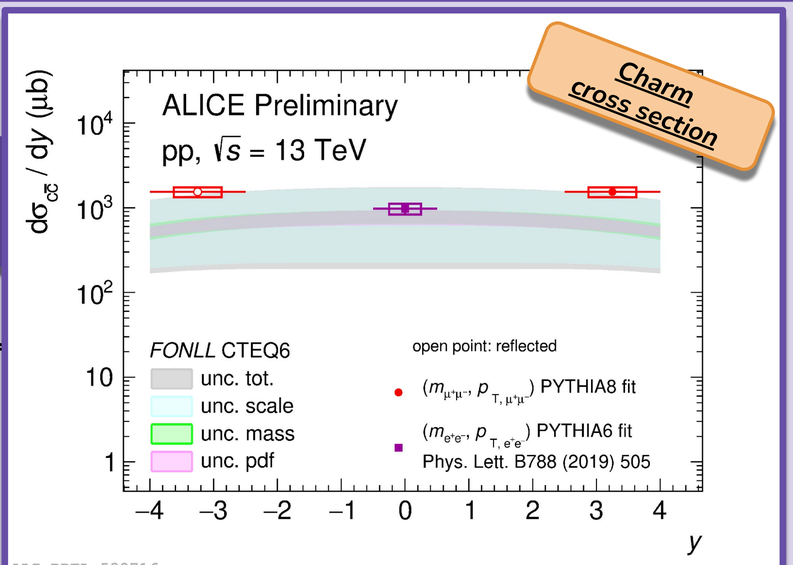
$$d\sigma^{meas}_{c\bar{c}/b\bar{b}}/dy\,{}_{2.5<y<4} = \frac{N^{c\bar{c}/b\bar{b}\,fit}_{\mu\mu\,,\,MB\,data}}{N^{c\bar{c}/b\bar{b}\,PYTHIA}_{\mu\mu\,,\,MB\,PYTHIA}} \times d\sigma^{PYTHIA}_{c\bar{c}/b\bar{b}}/dy\,{}_{2.5<y<4}$$

❖ **The results are compared with *dielectron measurements* at √s = 13 TeV* [5] and with *FONLL calculations* [6]**

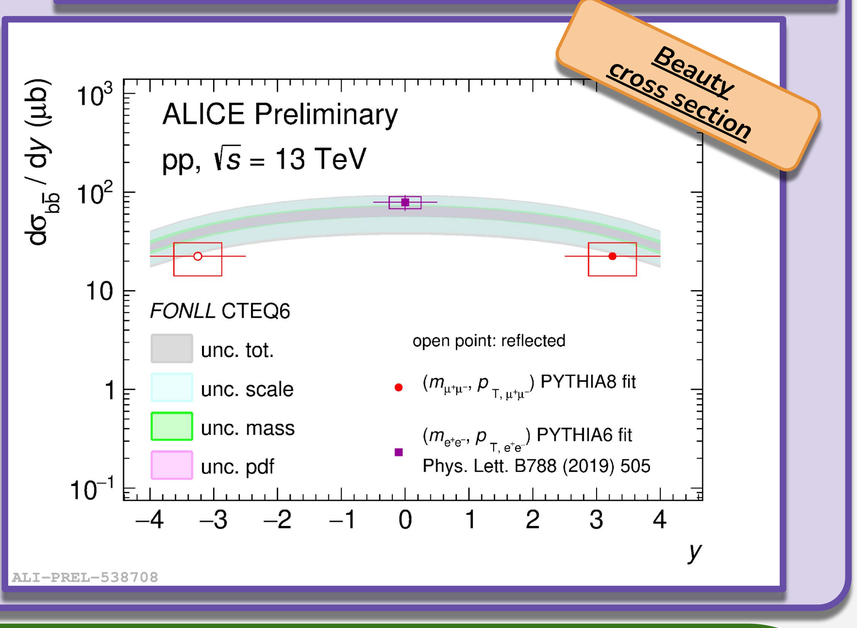
* Update of c,c -> e^+e^- will be released soon, with an updated BR

❖ **Charm and beauty cross sections are on the upper and lower edge of FONLL predictions, respectively.**

Charm cross section



Beauty cross section



Conclusion:

❖ First measurement of charm and beauty cross sections at forward rapidity with ALICE from the dimuon continuum region

❖ Results are in agreement within uncertainty with the FONLL calculations, providing a complementary measurement w.r.t to ALICE midrapidty results

Future prospects:

❖ Obtain HF templates with NLO MC generator (*POWHEG* **[7]**)

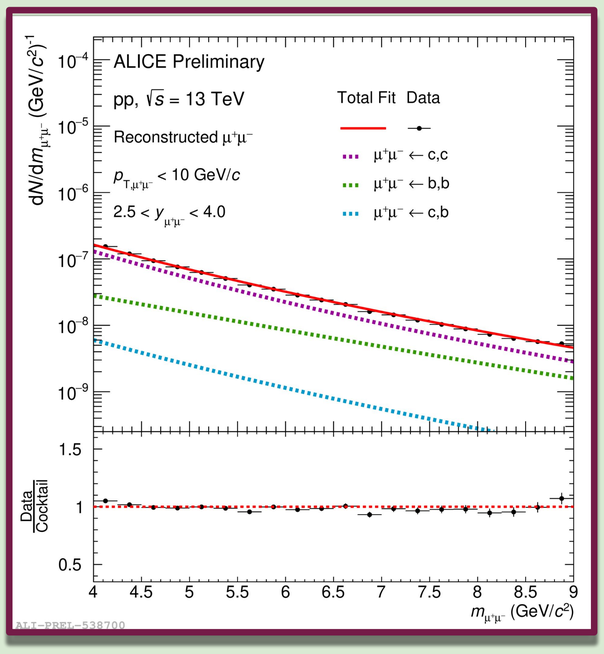
❖ Study possible contributions in the very high m and p_T regions from ***Drell-Yan process***

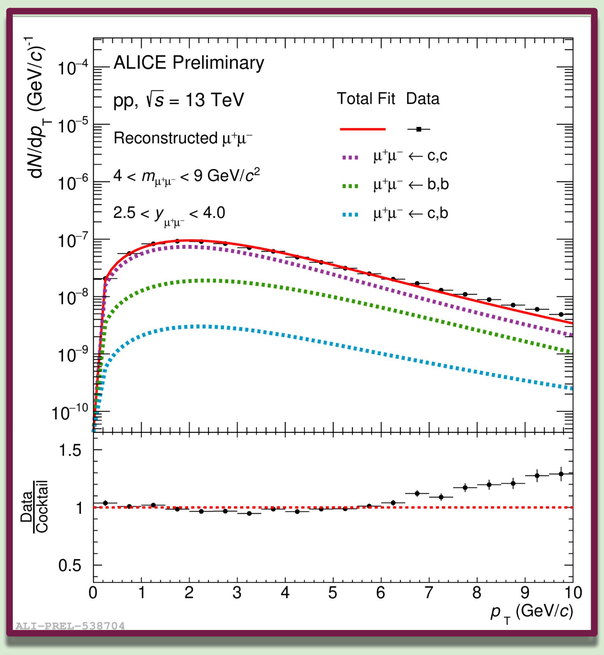
5. Data Analysis

❖ Estimation of the charm and beauty yields by performing a ***simultaneous unbinned fit*** to the m and p_T dimuon data distributions using the HF templates

➢ Kinematic region of the fit: $4 < m_{\mu\mu} < 9$ GeV/c^2 and $p_T < 10$ GeV/c

➢ HF-mixed contribution fixed to the 4% of total number of dimuons as per PYTHIA8 simulation predictions





Agreement between the fit and the data in the m and p_T region studied with slight underestimation at high-p_T

References

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