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

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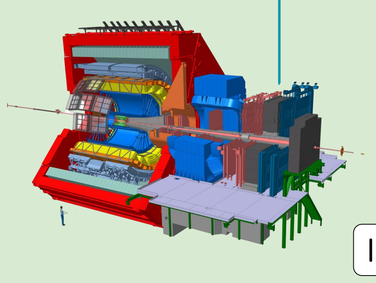
The ALICE detector (*Run 2 configuration*)

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

- Central Barrel: reconstruct dileptons at mid-rapidity -> |*y*| < 0.9
- Muon Spectrometer: reconstruct dileptons at forward rapidity -> 2.5< *y* < 4



Muon Spectrometer

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

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

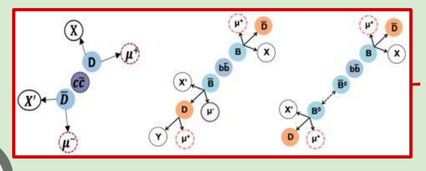
III ***Dipole magnet:*** provides a magnetic field integral of 3 Txm

IV ***Trigger system:*** located after an iron wall, consists of 4 RPC planes arranged in two stations

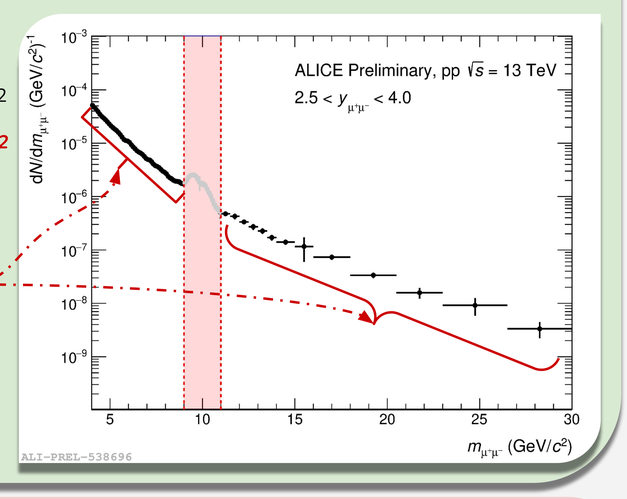
Physics Motivation

- ❑ **Heavy-quark production represents a stringent test of perturbative QCD (α_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]

- ❑ 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 mesons (π/K) pairs (combinatorial background)



Analysis approach

Main goal:
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

1. *Data sample & analysis steps*

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

✓ ***Muon/Dimuon cuts:***
- ↳ $2.5 < \eta_\mu < 4$ 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
- ↳ cut on the distance of closest approach to the primary interaction vertex
- ↳ $2.5 < y_{\mu\mu} < 4$ to match the spectrometer acceptance

✓ ***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,$\bar{c}$ and $\mu^+\mu^-$<- b,$\bar{b}$ PDF

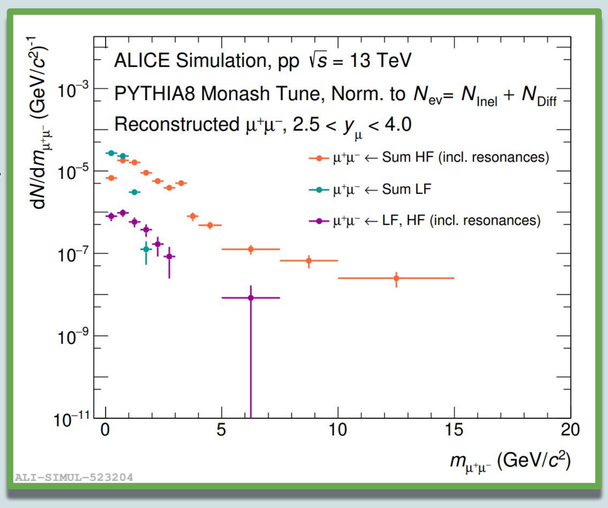
2. *Template creation*

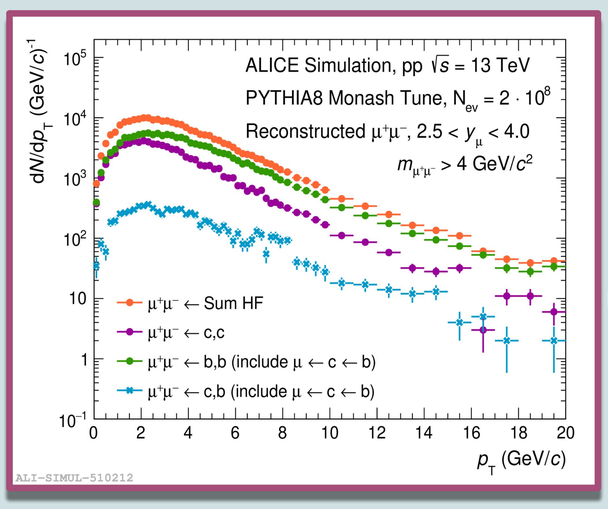
Minimum Bias production

- ❑ 48M events with *PYTHIA8 with Monash tune*
  - ↳ study the contamination from LF-> $\mu^+\mu^-$ and mixed LF,HF -> $\mu^+\mu^-$

➢ *Dimuon per p-p 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





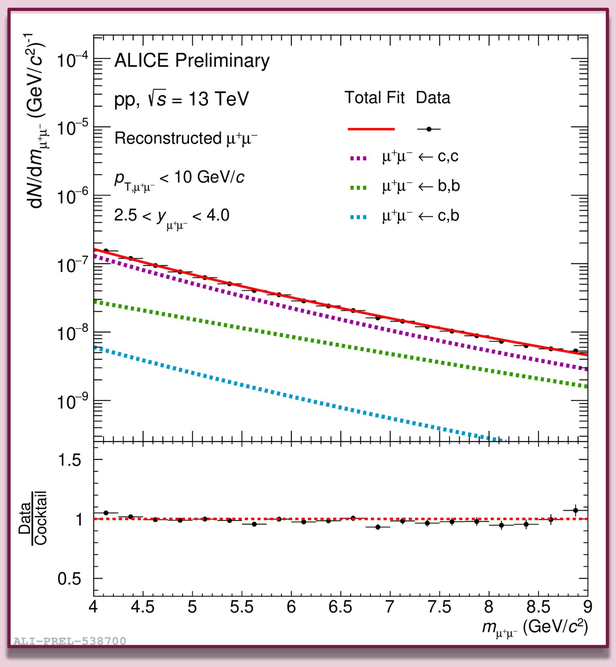
➢ *PYTHIA8 predictions above* $m_{\mu\mu} = 4$ GeV/c^2 :
- Negligible contribution from the mixed LF-HF and LF components
- $\mu^+\mu^-$ mainly produced by b decays
- HF-mixed contribution is small

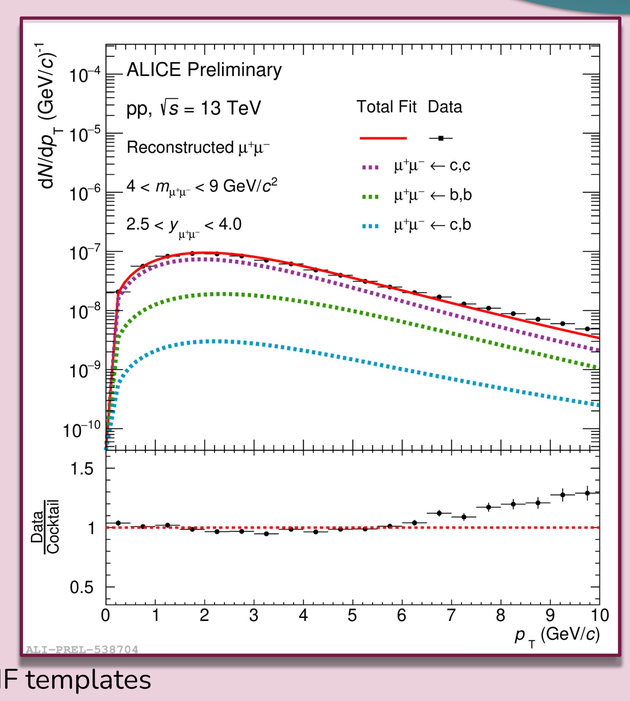
High statistics HF-enriched productions:

- ❑ 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,$\bar{c}$: both μ produced by prompt charm particles decay
⇒ $\mu^+\mu^-$<- b,$\bar{b}$: 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)

3. *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

Good agreement between the fit and the data in the m and p_T region studied (slight underestimation at high-p_T)

4. *Results*

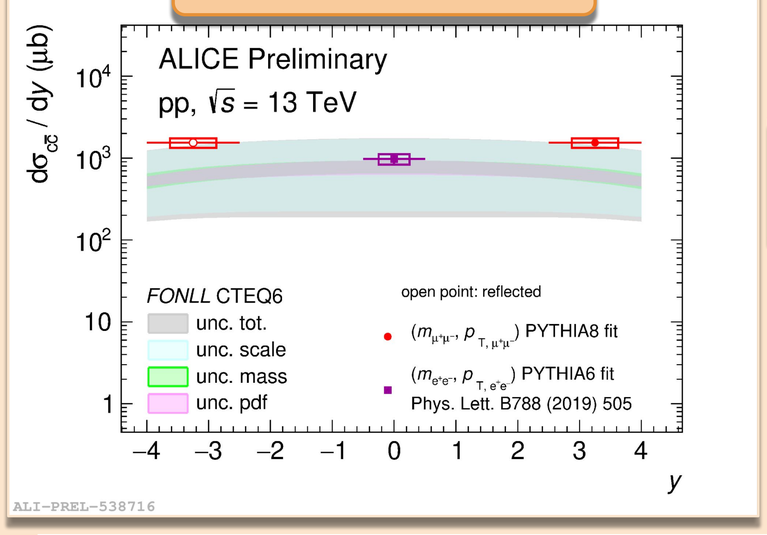
❖ The charm and beauty differential cross sections have been evaluated from:

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

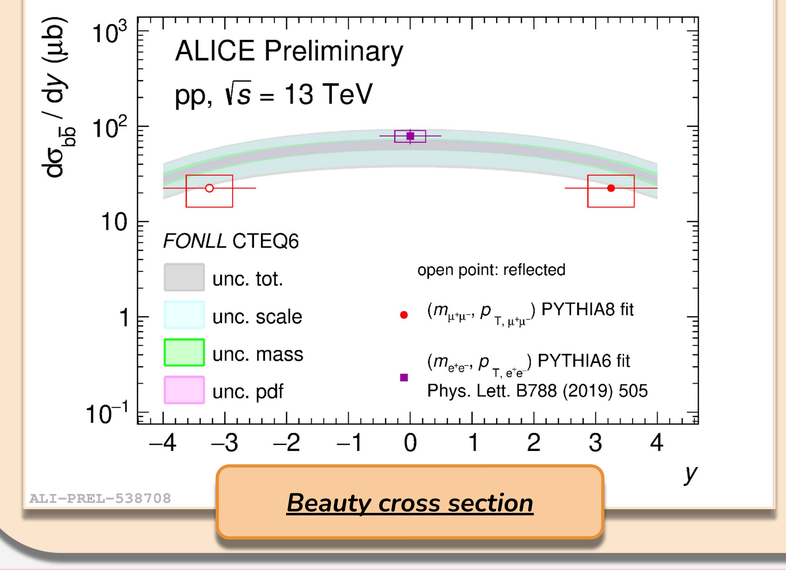
❖ The results are compared with *dielectron measurements @13 TeV** **[5]** and with *FONLL calculations* **[6]**

* Update of c,$\bar{c}$ -> e^+e^- will be released soon, with an updated BR

❖ Good agreement with ***FONLL***



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 in good agreement with theoretical calculations (***FONLL***), providing a complementary measurement w.r.t other ALICE results at mid-*y*

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***

[1] M.L. Mangano, arXiv:hep-ph/9711337
[2] N. Armesto, J. Phys. G, vol. 32, pp. R367–R394, 2006
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[4] Sjöstrand et *al*, arXiv:1410.3012 [hep-ph]
[5] Acharya et *al*, Phys. Lett. B, vol. 788, pp. 505–518, 2019
[6] M. Cacciari et *al.* , arXiv:1205.6344 800 [hep-ph]
[7] C. Oleari, Nucl. Phys. B Proc. Suppl., vol. 205-206, pp. 36–41, 2010

References