Measurement of heavy-flavor production in the high-mass dimuon spectrum in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

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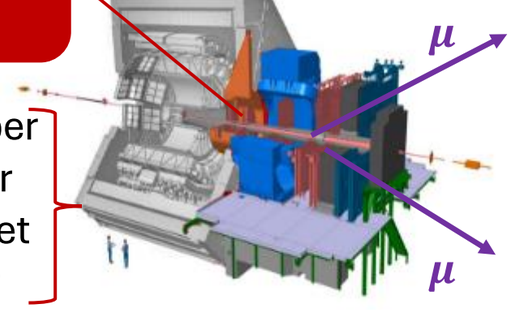
Main purpose of analysis: investigate the heavy-quark production in pp collisions by exploring the dimuon invariant mass spectrum in the continuum region beyond $m_{\mu^+\mu^-} > 4.0$ GeV/c^2

The ALICE Detector

Muon Spectrometer *2.5 < y < 4.0*

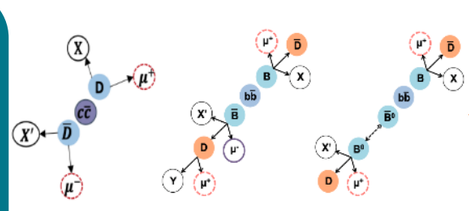
- Front Absorber
- Muon Tracker
- Dipole Magnet
- Muon Trigger

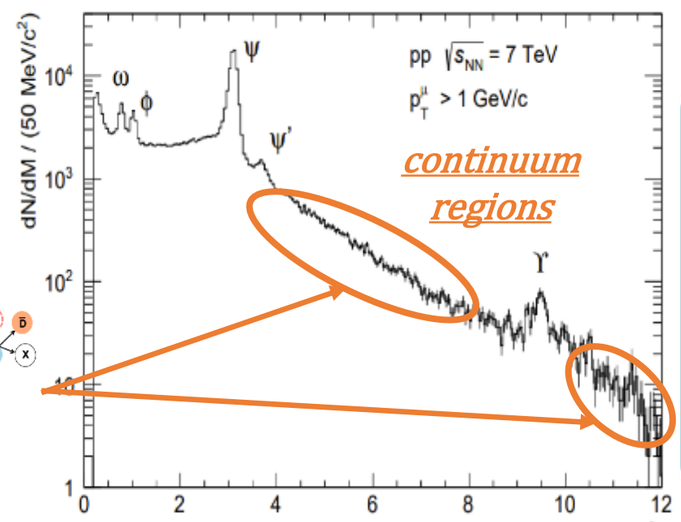


Physics Motivation

- Heavy quark production represents a stringent test of perturbative QCD ($\alpha_s \ll 1$, due to their large mass) **[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]**

Dimuon production in these **continuum regions** mainly due to semileptonic decay of HF hadrons from the hadronization of $c\bar{c}$ and $b\bar{b}$ pairs **[3]**





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Analysis Outline

- ***Evaluation of the various components of the μμ yield with dedicated Monte Carlo simulations***
- ***Creation of templates needed to fit the ALICE RUN2 data***
  - ✓ ***Extraction of the charm and beauty probability density functions (PDF)***
  - ✓ ***Closure test with a toy MC***

Simulation of the various components of the $\mu^+\mu^-$ yield

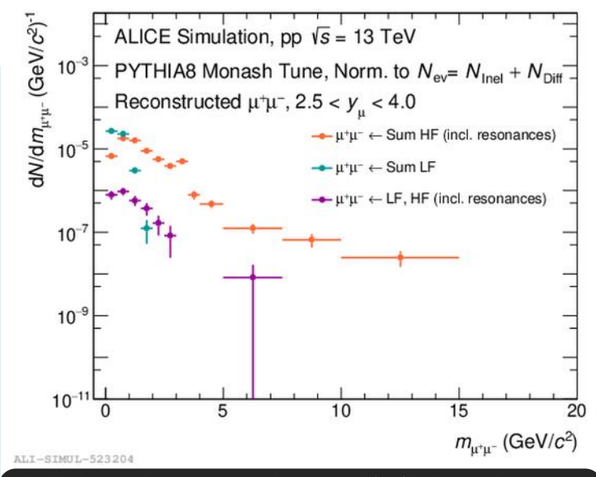
MC samples were generated by using the ALICE computing GRID

Minimum bias production

- PYTHIA8 with Monash Tune [4]
- 48M events
- Comparison of LF and HF spectra

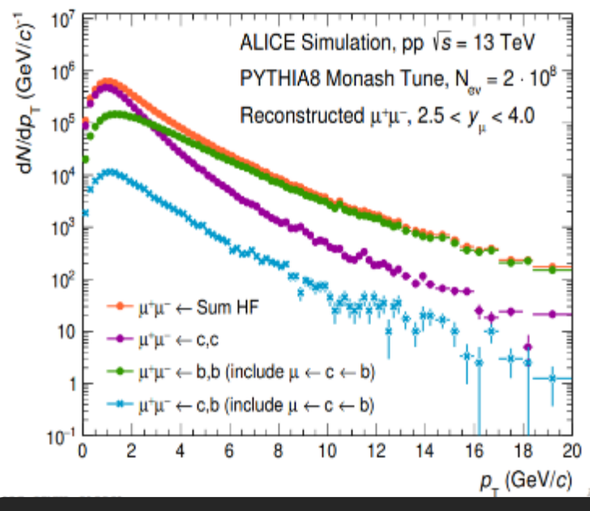
High statistics HF production

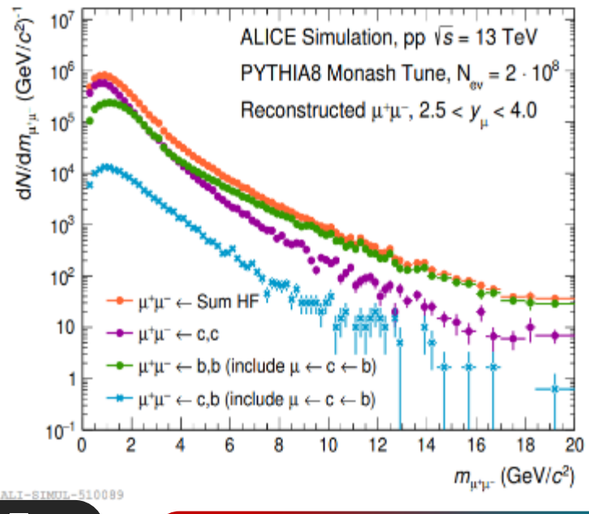
- 200M events triggered by the production of a pair of HF quarks, with at least a decay μ in the acceptance of the spectrometer (2.5< y<4)



LF background negligible above $m_{\mu^+\mu^-} > 4$ GeV/c^2!!!

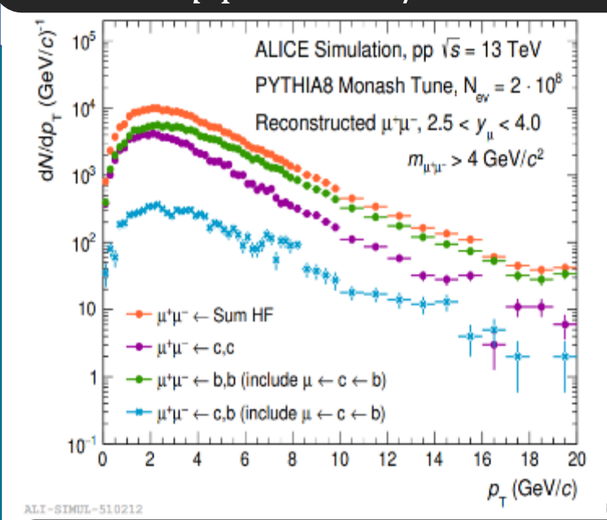
HF dimuon sources: $c\bar{c}$, $b\bar{b}$ and c,b pairs

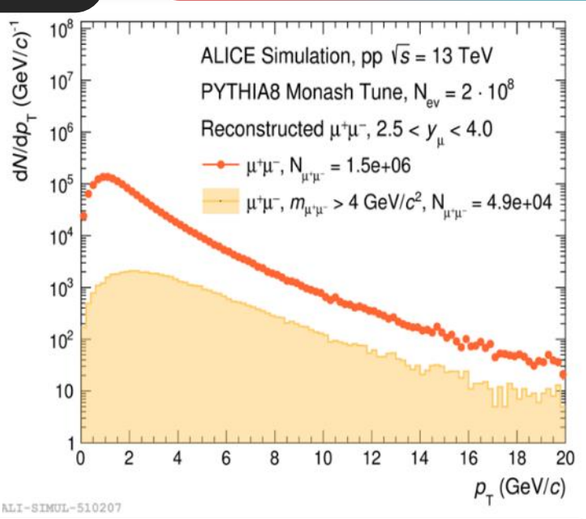




Spectra are dominated by the $b\bar{b}$ component for $m_{\mu^+\mu^-} > 4$ GeV/c^2 or $p_T > 3$ GeV/c^2 !!!

Effect of the $m_{\mu^+\mu^-} > 4$ GeV/c^2 cut



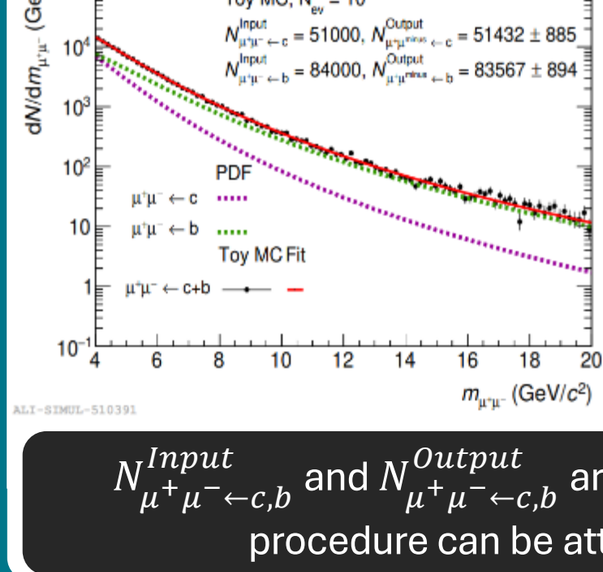


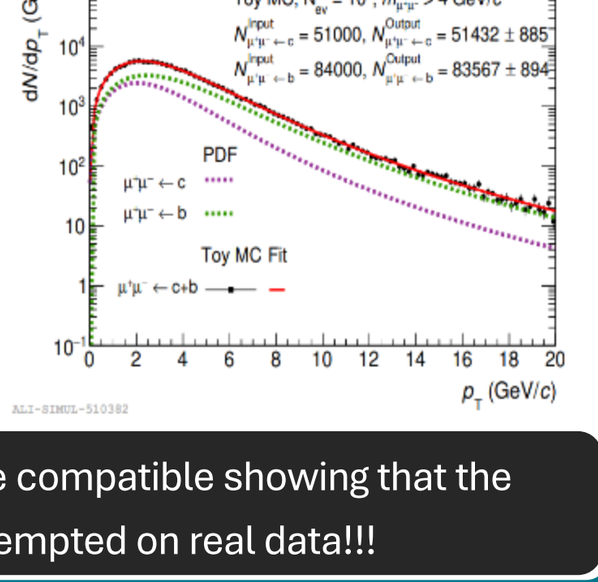
Applying the mass cut, the 97% of the reconstructed μμ pairs is removed and the p_T spectrum becomes harder

Template Creation

1) Extraction of the p_T and mass shapes ($\mu^+\mu^-$ from charm and beauty) is performed by fitting the MC reconstructed distributions
2) Generation of a toy data sample with given yields ($N^{Input}_{\mu^+\mu^-\leftarrow c}$, $N^{Input}_{\mu^+\mu^-\leftarrow b}$)

Extraction of $\mu^+\mu^- \leftarrow c$ $\mu^+\mu^- \leftarrow b$ PDF





The shapes of dimuon spectra from $c\bar{c}$, $b\bar{b}$ are rather different above $m_{\mu^+\mu^-} > 4$ GeV/c^2!

Closure Test with a Toy MC

3) Template fit (m and p_T simultaneously) keeping free the normalization of the distributions
4) Extraction of raw yields ($N^{Output}_{\mu^+\mu^-\leftarrow c}$, $N^{Output}_{\mu^+\mu^-\leftarrow b}$)

$N^{Input}_{\mu^+\mu^-\leftarrow c,b}$ and $N^{Output}_{\mu^+\mu^-\leftarrow c,b}$ are compatible showing that the procedure can be attempted on real data!!!

Summary and Conclusions

- **The selection $m_{\mu^+\mu^-} > 4$ GeV/c^2 removes 97% of the reconstructed μμ pairs, but is expected to be extremely effective in getting a sample free from light flavour background where the $c\bar{c}$ and $b\bar{b}$ are the main dimuon sources**
- **Closure test of the procedure with a Toy MC shows the goodness of the analysis technique.**
- **The procedure will then be applied to the real data collected by ALICE in RUN 2 ($L_{int} \sim 25\ pb^{-1}$) .**

References:
[1] M.L. Mangano, arXiv:hep-ph/9711337
[2] N. Armesto, J. Phys. G, vol. 32, pp. R367–R394, 2006
[3] Aidala et *al*, Phys. Rev. D 99, 072003 (2019)
[4] Sjöstrand et *al*, arXiv:1410.3012 [hep-ph]