Non-prompt J/ψ production as a function of multiplicity in proton-proton collisions at $\sqrt{s}$ = 13 TeV with ALICE

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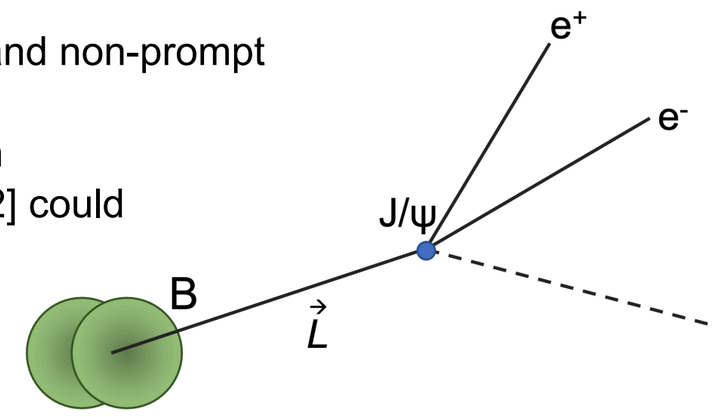
Motivation

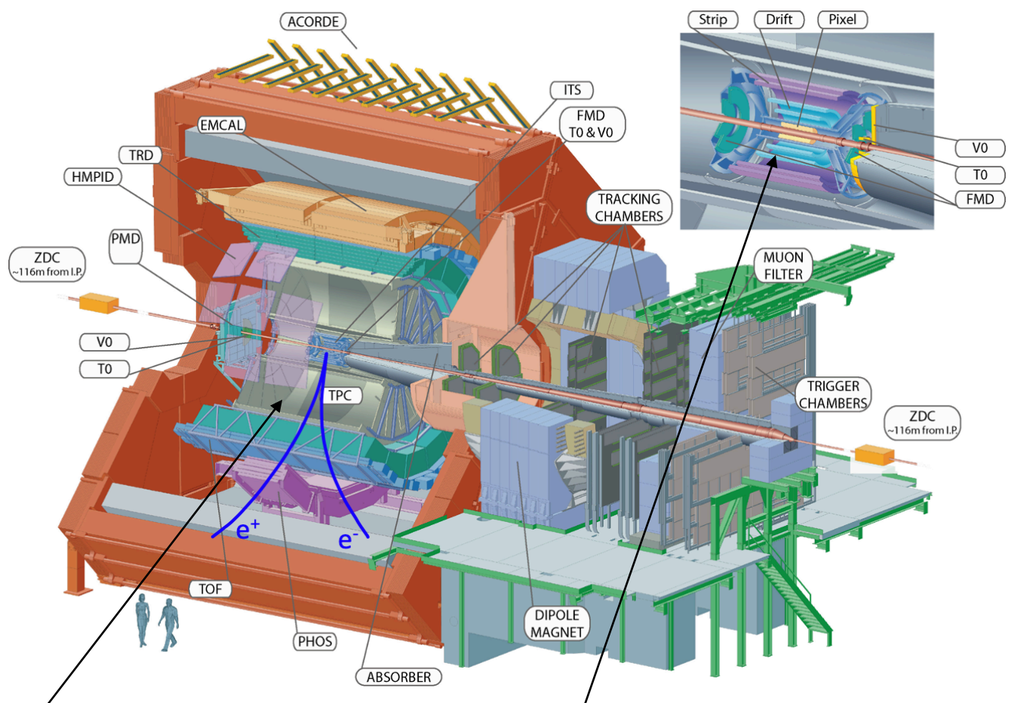
- The inclusive J/ψ yield can be separated between prompt J/ψ (produced at the primary vertex) and non-prompt J/ψ (from B hadron decay) [1].
- Separation allows to measure prompt J/ψ cross section and to access beauty hadron production
- Quarkonium production in proton-proton collisions as a function of charged-particle multiplicity [2] could provide insight into the processes occuring in the collision at the partonic level such as:
  - Multi parton interactions (MPI)
  - Interplay between soft and hard processes
  - Investigation of collective effects in high multiplicity events



Reconstruction of J/ψ

- J/ψ mesons are reconstructed at midrapidity ($|y| < 0.9$) in the dielectron decay channel down to $p_T = 0$. Prompt and non-prompt J/ψ are separated for $p_T > 1$ GeV/c
- Events are classified based on the charged-particle multiplicity at midrapidity ($|\eta| < 1$).

ALICE detector (Run 2)



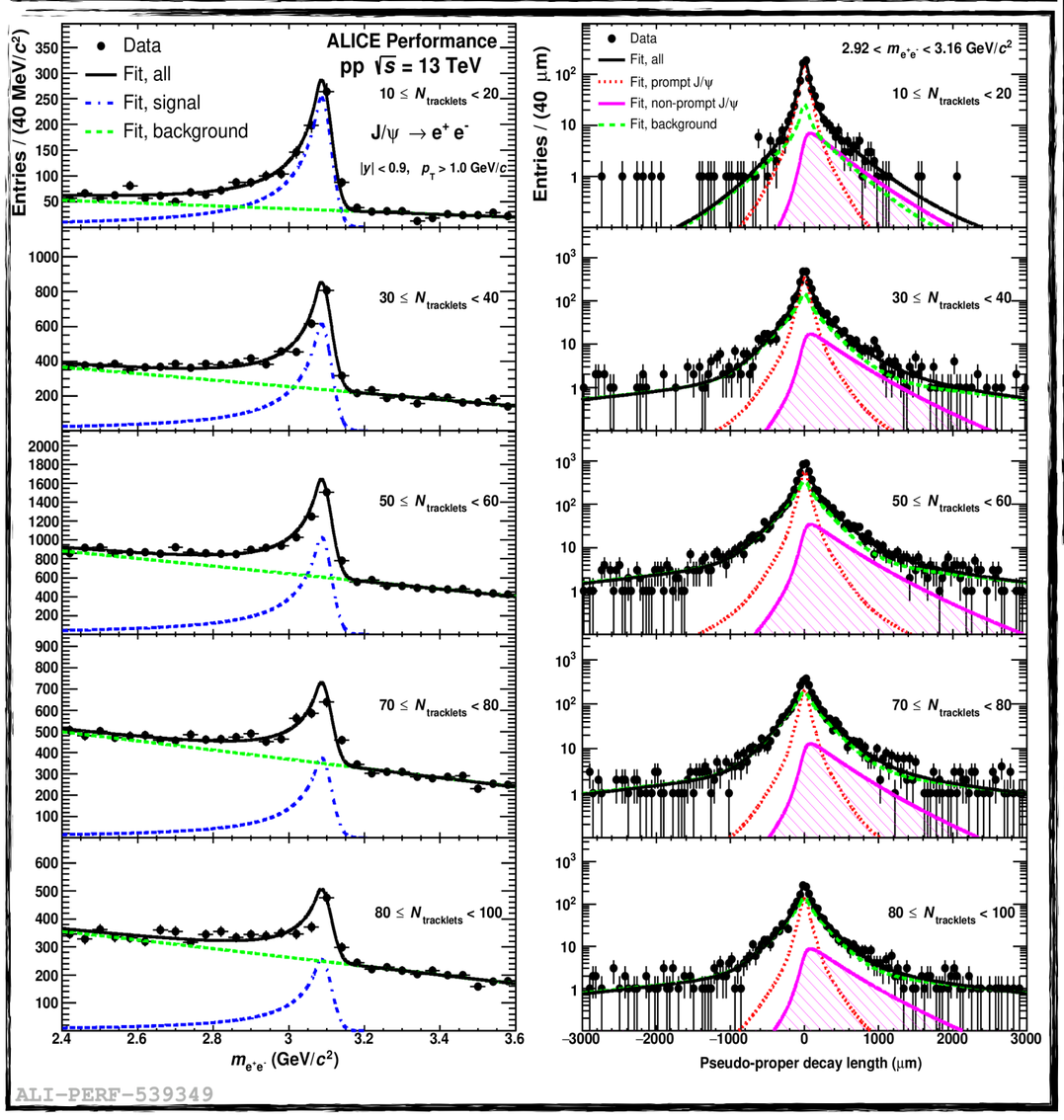
TPC:
tracking
electron identification

ITS:
vertex reconstruction
tracking
event selection

VZERO:
triggering
minimum bias
high-multiplicity events)
Background rejection

Central Barrel ($|y| < 0.9$)

- J/ψ → e+e-
- The SPD (the two innermost layers of the ITS) provides good spatial resolution to separate on a statistical basis the prompt and non-prompt J/ψ components
- Multiplicity classes are determined by SPD tracklets in $|\eta| < 1$



Likelihood fit technique

The measurement of the fraction of J/ψ mesons originating from beauty-hadron decays is carried out through an unbinned two dimensional likelihood fit procedure [3], i.e. a simultaneous fit of the dielectron pair invariant mass (m_{ee}) and pseudoproper decay length (x) distribution [4].

- pseudoproper decay length is defined as $x = c \cdot \vec{L} \cdot \vec{p}_T \cdot M_{J/\psi} / |\vec{p}_T|$
  - $\vec{L}$ is the vector pointing from the primary vertex to the J/ψ decay vertex
  - $M_{J/\psi}$ is the J/ψ mass provided by the Particle Data Group (PDG) [5]
  - p_T is the transverse momentum of J/ψ
- The fit procedure maximises the logarithm of a likelihood function:

$$\ln\{L\} = \sum_{i=1}^{N} \ln\{F(x^i, m^i_{e^+e^-})\}$$

where

$$F(x, m_{e^+e^-}) = f_{Sig} \times \underbrace{F_{Sig}(x) \times M_{Sig}(m_{e^+e^-})}_{\text{Signal}} + (1 - f_{Sig}) \times \underbrace{F_{Bkg}(x) \times M_{Bkg}(m_{e^+e^-})}_{\text{Background}}$$

$$F_{Sig}(x) = \underbrace{f'_B \times T(x)}_{\text{Non-prompt}} + \underbrace{(1 - f'_B) \times R(x)}_{\text{Prompt}}$$

- N: number of candidates
- $F_{Sig}(x)$, $F_{Bkg}(x)$: probability density function (PDF) for the x distribution of signal and background
- $M_{Sig}(x)$, $M_{Bkg}(x)$: PDF for the invariant mass distribution of signal and background
- $T(x)$: PDF for the x distribution of non-prompt J/ψ
- $R(x)$: PDF for the x distribution of prompt J/ψ
- f_{Sig}: fraction of J/ψ signal candidates w.r.t. the total
- f_B': the raw fraction of non-prompt J/ψ, which is extracted from the likelihood fit
  - needs to be corrected by acceptance times efficiency according to:

$$f_B = \left(1 + \frac{1 - f'_B}{f'_B} \cdot \frac{\langle A \times \epsilon \rangle_B}{\langle A \times \epsilon \rangle_{Prompt}}\right)^{-1}$$

Results and outlook

- The measurement of non-prompt J/ψ fraction vs multiplicity is ongoing in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE, via 2D maximum likelihood fit method.
- A significantly higher multiplicity region is reached compared to $\sqrt{s}$ = 7 TeV thanks to high-multiplicity triggered events, reaching 7 times the average multiplicity (4 times at $\sqrt{s}$ = 7 TeV).
- The prompt and non-prompt J/ψ yields vs multiplicity will be evaluated by combining with existing inclusive J/ψ measurements [6].

Reference

[1] ALICE Collaboration, JHEP 11 (2012) 065
[2] ALICE Collaboration, JHEP 09 (2015) 148
[6] ALICE Collaboration, PLB 810 (2020) 135758
[3] CDF Collaboration, Phys. Rev. D 71 (2005) 032001
[4] ALICE Collaboration, JHEP 03 (2022) 190
[5] Particle Data collaboration, Review of Particle Physics, Phys. Rev. D 98 (2018) 030001
[6] ALICE Collaboration, PLB 810 (2020) 135758