J/ψ-hadron correlations in high multiplicity proton-proton collisions at $\sqrt{s} = 13$ TeV at mid-rapidity in ALICE

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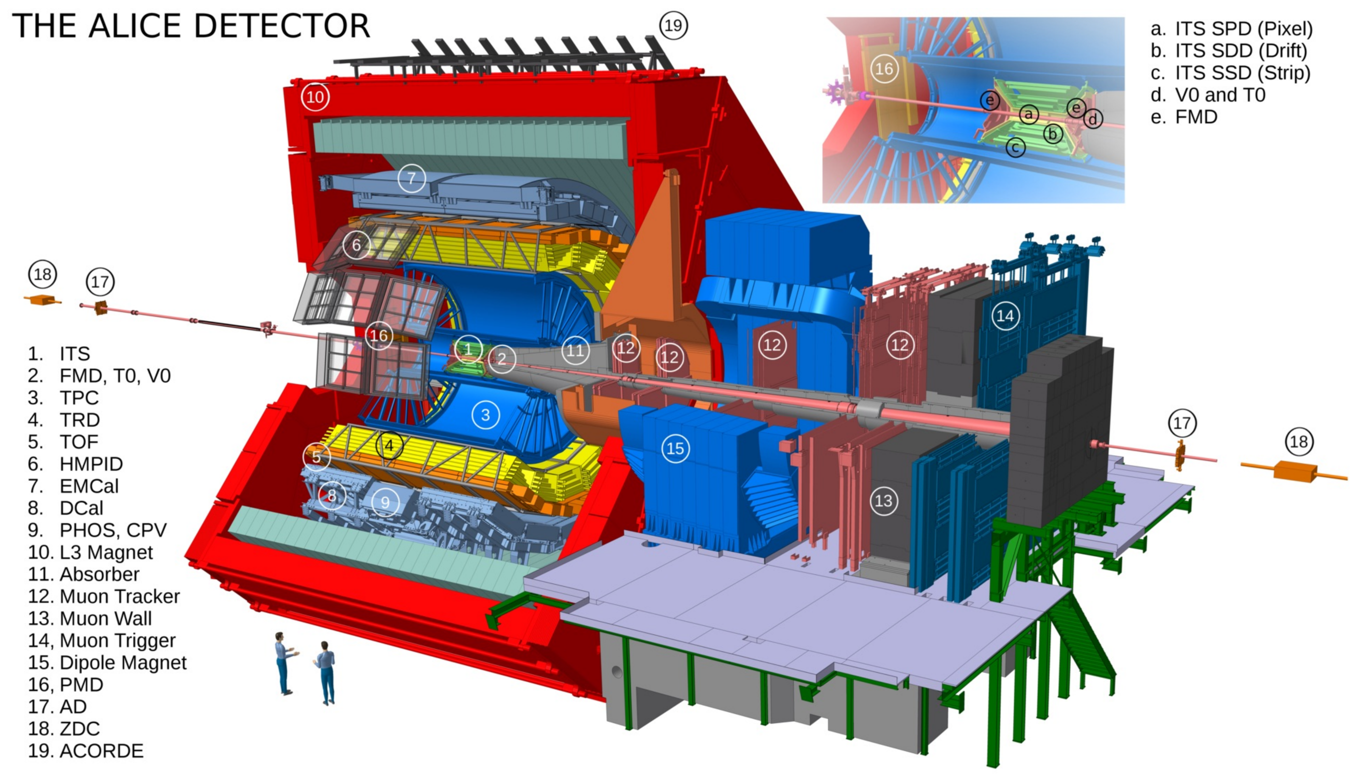
Motivation

- charmonium production involves very different energy scales and is thus an important test bench for QCD
- J/ψ production mechanism not yet understood, correlation measurements can provide constraints (color-singlet vs. color-octet) [1,2]
- collective effects suggested in small systems [3,4,5]

Data sample

- pp collisions at $\sqrt{s} = 13$ TeV, taken by ALICE in 2016
- high-multiplicity triggered events, based on V0 multiplicity
- mean multiplicity ~ 4 times larger than in minimum bias (in $|\eta| < 1$)
- integrated luminosity ~ 0.5 pb^{-1}, corresponding to $\sim 3 \times 10^8$ events

ALICE detector



The presented analysis uses:

Central barrel detectors

- ITS (Inner Tracking System) for tracking and vertex reconstruction
- TPC (Time Projection Camber) for tracking and particle identification

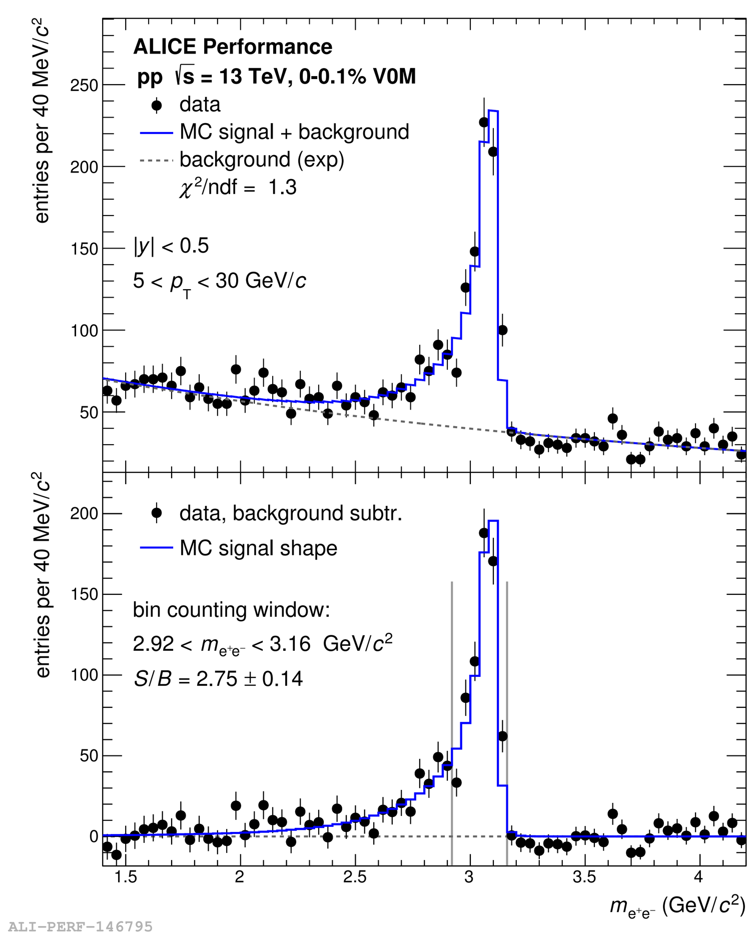
Event trigger

- V0 counters at forward and backward rapidity provide event trigger

A detailed detector description can be found in [6]

Analysis method

e^+e^- *invariant mass distribution:*



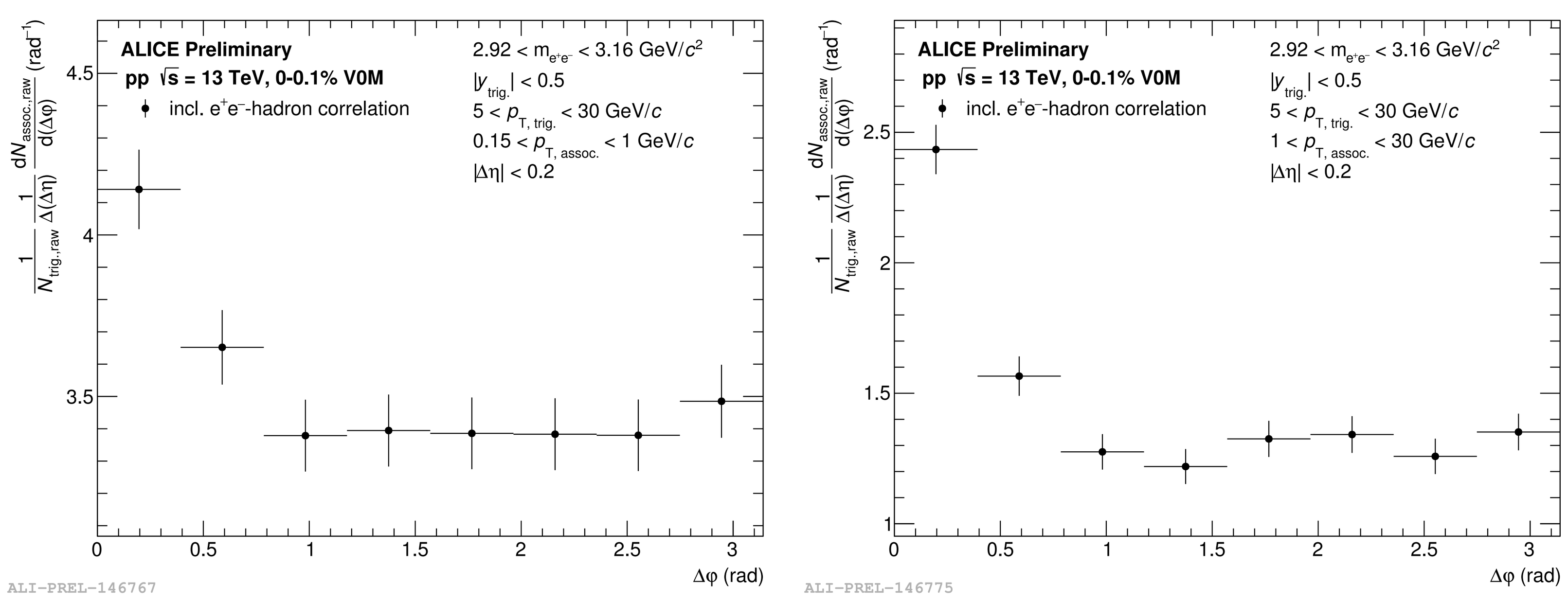
Signal extraction:

- J/ψ reconstructed from di-electron decays at mid-rapidity
- electrons tracks are
  - reconstructed in ITS+TPC ($|\eta| < 0.9$)
  - identified using $\mathrm{d}E/\mathrm{d}x$ in the TPC
- background under peak determined with fit: scaled MC signal + exponential
- signal from bin counting after background subtraction in $2.92 < m_{e^+e^-} < 3.16$ GeV/c^2

Determination of the J/ψ-hadron correlation function ($\mathrm{CF}_{J/\psi}$)

- statistical analysis of J/ψ-hadron correlation, di-electrons correlated with unidentified, charged hadrons measured at mid-rapidity in ITS+TPC
- starting point: inclusive e^+e^--hadron correlation function ($\mathrm{CF}_{e^+e^-}$) in J/ψ signal region
  - associated yield per trigger (i.e. e^+e^- pair) as function of distance in azimuth
  - corrected for limited acceptance and inhomogeneity of detector with event mixing

inclusive e^+e^-*-hadron correlation function in* J/ψ *signal mass region:*



- J/ψ-hadron correlation function obtained from inclusive e^+e^--hadron correlation and identified background correlation ($\mathrm{CF}_{\mathrm{bkg.}}$) via superposition principle:

$$\mathrm{CF}_{J/\psi}(\Delta\varphi) = \frac{1}{f} \times \mathrm{CF}_{e^+e^-}(\Delta\varphi) - \frac{1-f}{f} \times \mathrm{CF}_{\mathrm{bkg.}}(\Delta\varphi) \quad \text{with} \quad f = \frac{S}{S+B}$$

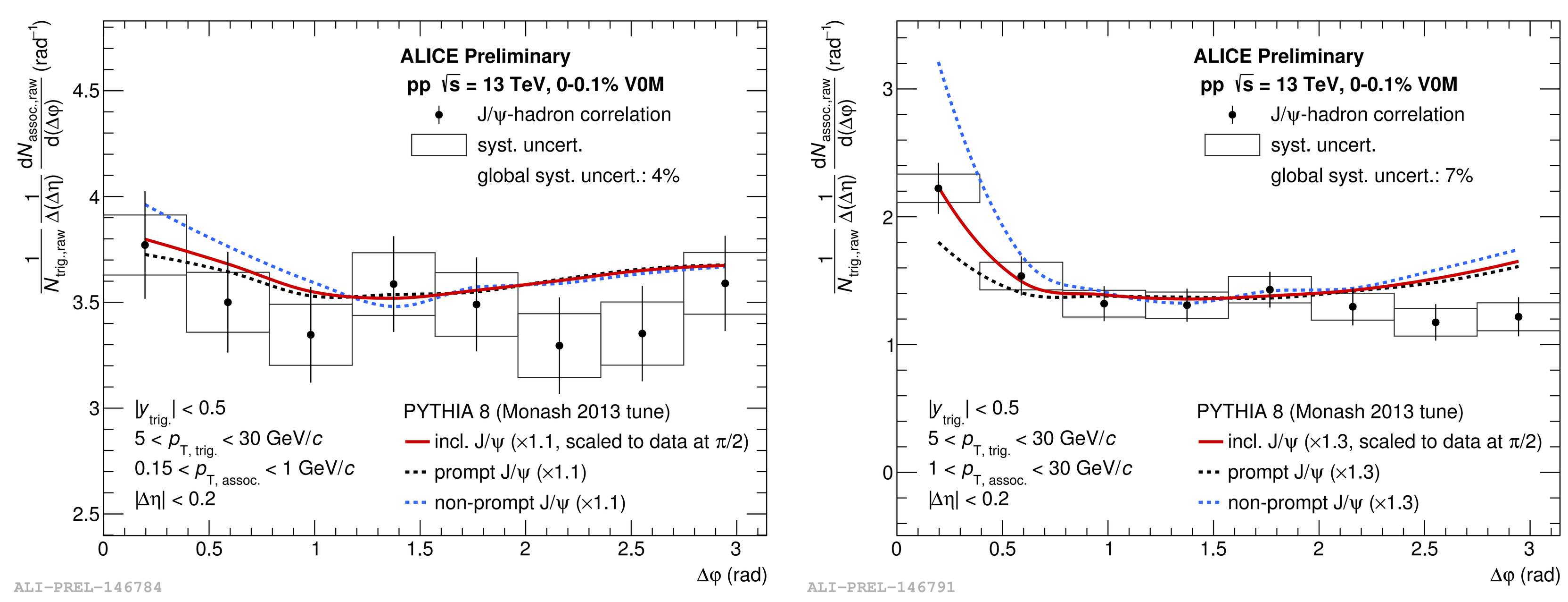
- background correlation can be determined with different methods:
  - side-band (w/o J/ψ signal): $\mathrm{CF}_{\mathrm{bkg.}} \sim \mathrm{CF}^{\text{side-band}}_{e^+e^-}$
  - like-sign pairs: $\mathrm{CF}_{\mathrm{bkg.}} \sim \langle \mathrm{CF}^{J/\psi \text{ mass range}}_{e^+e^+\,(e^-e^-)} \rangle$
  - or by directly exploiting the superposition principle
- superposition expressed in two (adjacent) invariant mass bins, i and j, provides system of equations which can be solved directly for J/ψ-hadron correlation
  - assuming no variation of background correlation within these bins, i.e. $\mathrm{CF}^i_{\mathrm{bkg.}} = \mathrm{CF}^j_{\mathrm{bkg.}}$

$$\mathrm{CF}_{J/\psi}(\Delta\varphi) = \frac{1}{f_i - f_j}\left[(1-f_j) \times \mathrm{CF}^i_{e^+e^-}(\Delta\varphi) - (1-f_i) \times \mathrm{CF}^j_{e^+e^-}(\Delta\varphi)\right]$$

Results

- J/ψ-hadron correlation not corrected for associated hadron acceptance and efficiency
- correlations shown for high-p_T J/ψ ($p_\mathrm{T} > 5.0$ GeV/c) in two kinematic regimes
  - $0.15 < p_{\mathrm{T,\,assoc.}} < 1$ GeV/c
  - $1 < p_{\mathrm{T,\,assoc.}} < 30$ GeV/c
- correlations compared to PYTHIA 8 (Monash 2013 tune) [7]
  - shown for inclusive, prompt and non-prompt (b-hadron feed-down) J/ψ
- relative contributions to p_T integrated, inclusive J/ψ cross section [8,9]
  - direct production: $\sim 50\%$ } prompt
  - charmonium feed-down: $\sim 30\%$ } prompt
  - non-prompt: $\sim 20\%$ (can reach $\sim 30\%$ for J/ψ with $p_\mathrm{T} > 5$ GeV/c)

J/ψ-hadron correlation function:



Summary

- clear near-side correlation observed for high-p_T J/ψ and hadrons with $p_\mathrm{T} > 1$ GeV/c
- away-side diluted due to $|\Delta\eta| < 0.2$ cut (spreads over large range in η)
- PYTHIA 8 qualitatively agrees with data on near-side

Outlook

- inclusion of TRD and EMCal trigger into analysis
- with full Run-2 dataset gain of factor ~ 100 in statistics for J/ψ at $p_\mathrm{T} > 5$ GeV/c
- finer kinematic scan for both trigger J/ψ and associated hadrons ongoing
- determination of correlation separately for prompt and non-prompt J/ψ

References

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