Study of multiplicity-dependent charmonia production in p+p collisions at PHENIX

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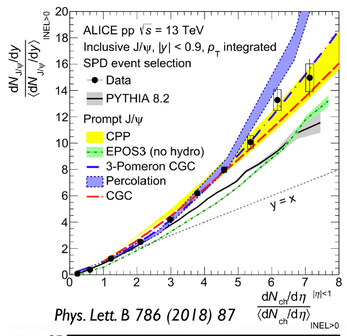
Motivation

- Inclusive J/ψ yield increases with particle multiplicity in p+p collisions at 13 TeV and 200 GeV
  ➔Similar multiplicity dependence at two energies
  ➔Multiparton interaction is important for J/ψ production in both energies

  J/ψ and charged particle multiplicity at mid-rapidity
  ➔Charged tracks of the decay product are included in the charged particle multiplicity
  ➔Multiplicity dependence is possibly affected depending on $dN_{\rm ch}/d\eta$ values

- In PHENIX, multiplicity can be measured in various regions
  ➔Detailed correlation between J/ψ production and underlying events can be investigated

Phys. Lett. B 810 (2020) 135758



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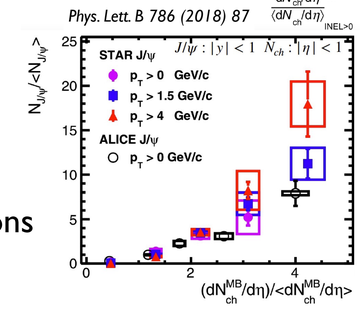
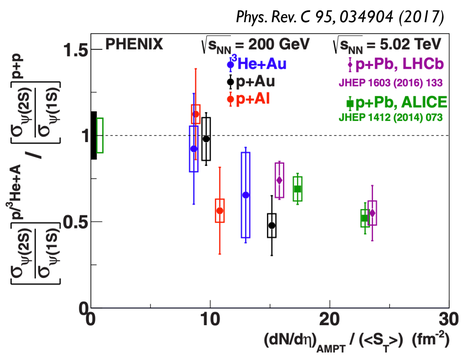


Phys. Rev. C 95, 034904 (2017)



- Relative suppression of $\psi(2S)$ than J/ψ becomes stronger as the multiplicity density increases in p/^{3}He+A collisions
  ➔Final-state effects

- The study can be extended even in p+p collisions
  ➔The system size is small but almost independent of the multiplicity

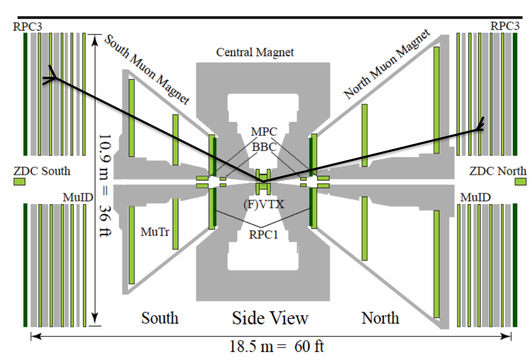
PHENIX muon spectroscopy

PHENIX muon arms are composed of Forward Silicon Vertex Tracker, Muon Tracker, and Muon Identifiers to measure hadron/muon tracks at forward rapidity region

Forward Silicon Vertex Tracker
- 4 stations of silicon strip detector
- precise measurement of the radial direction of track trajectory at forward rapidity
- charged particle multiplicity

Muon Tracker
- 3 stations of cathode strip chamber
- momentum measurements of charged tracks

Muon Identifier
- 5 layers of 2 planes of Iraocci tube chambers and steel absorber
- hadron/muon separation



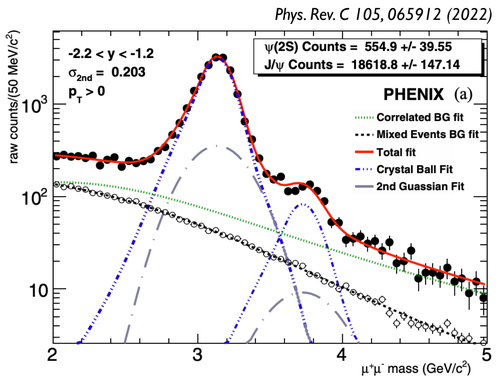
South arm $-2.2 < \eta < -1.2$ **North arm** $1.2 < \eta < 2.4$

Charmonia measurement

- At least one MuTr-FVTX matching is required to separate J/ψ and $\psi(2S)$
- Signal shape:
  Crystal ball function and 2nd Gaussian function
- Combinatorial background:
  Mixed events normalized with like-sign
- Correlated background:
  Modified Hagedorn function based on the measurements of correlated dimuons

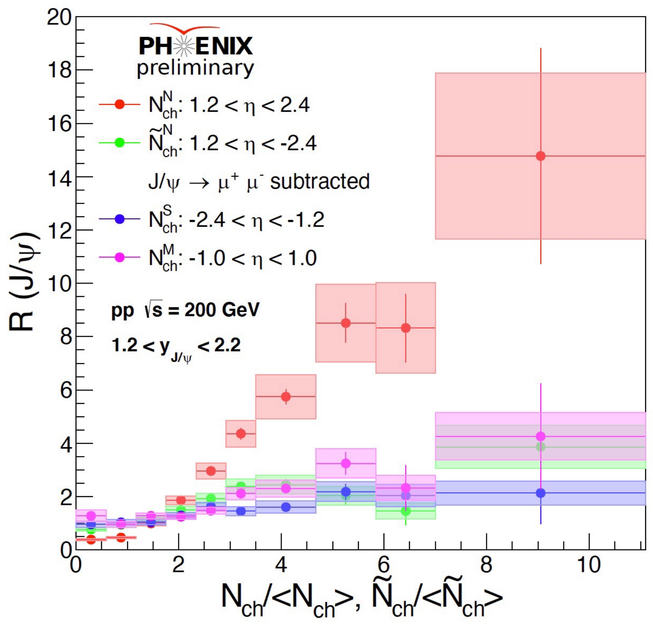
Phys. Rev. D 99, 072003 (2019)

Phys. Rev. C 105, 065912 (2022)



Results

Multiplicity-dependent J/ψ production

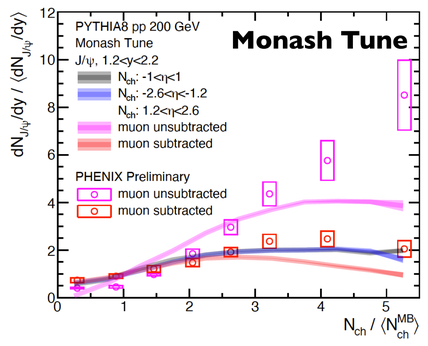


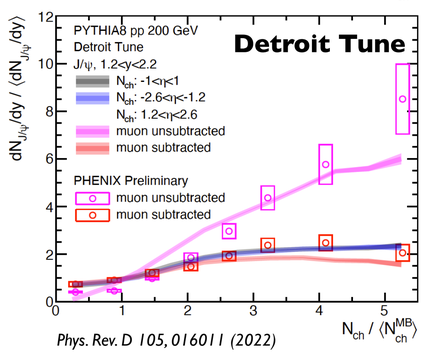
- J/ψ at forward rapidity and multiplicity at mid-rapidity
  ➔Increasing yield as charged particle multiplicity becomes larger

- J/ψ at forward rapidity and multiplicity at backward rapidity
  ➔A similar trend in the results with the multiplicity at mid-rapidity

- J/ψ and multiplicity at the same rapidity (forward rapidity)
  Multiplicity without subtraction of muons from J/ψ
  ➔More steeply increasing than other results
  Multiplicity with subtraction of muons from J/ψ
  ➔Weaker multiplicity-dependence and similar trend with other results

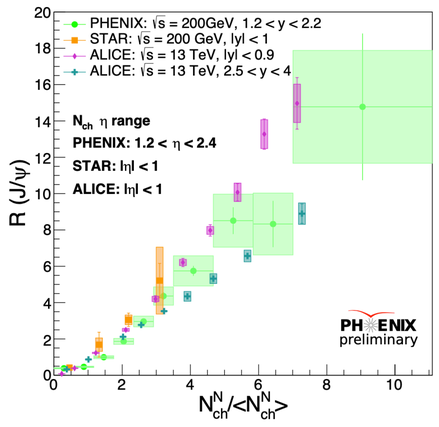
- Comparison with PYTHIA8
  A better agreement with the Detroit tune for RHIC energies than the Monash tune

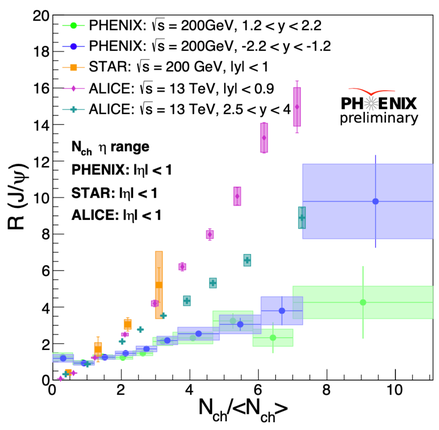




Phys. Rev. D 105, 016011 (2022)

Comparison with other results





- J/ψ and multiplicity at mid-rapidity
  ➔A similar multiplicity dependence is observed in 200 GeV and 13 TeV

  Tracks from J/ψ are included in both results, but more significant impact in 200 GeV due to smaller multiplicity ($dN_{\rm ch}/d\eta$ in 13 TeV is about x3 larger than 200 GeV)

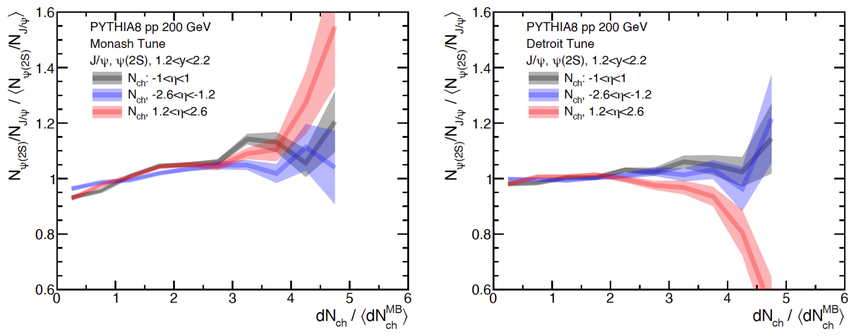
- PHENIX results without subtraction of muons from J/ψ
  ➔A similar multiplicity dependence with the LHC results

- After the subtraction of muons from J/ψ
  ➔Significantly lower multiplicity dependence than STAR results (same collision energy without subtraction) ALICE results (higher collision energy without subtraction)

- At 200 GeV where $dN_{\rm ch}/d\eta$ is comparable with 2 (tracks from J/ψ), considering the muon contribution is very important to interpret the multiplicity dependence

- Multiparton interaction is important for J/ψ production for both energies

Outlook



- Multiplicity-dependent J/ψ and $\psi(2S)$ ratio is ongoing to study final-state effects in p+p collisions

- Two PYTHIA tunes show different multiplicity dependence in the J/ψ and $\psi(2S)$ ratio
  ➔Another check of the underlying event description