Study of J/ψ production with jet activity in the STAR experiment

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Abstract

Quarkonium production from Color Singlet Model (CSM) and Color Octet Mechanism (COM) is expected to result in different jet activity (the number of jets per event) [1] due to different number of emitted hard partons, and therefore studying quarkonium production associated with jet can potentially be used to differentiate different production mechanisms. In this poster, we present the first results from RHIC of the production cross section of J/ψ as a function of jet activity via the dimuon decay channel using the data from p+p collisions at $\sqrt{s}$ = 200 GeV collected by the STAR experiment in 2015 and compare them with the PYTHIA predictions.

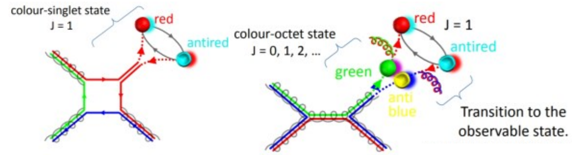
Introduction and motivation

➢**J/ψ meson**

- Produced via intermediate color-singlet or color-octet state.
- Different models on the market to describe the production of J/ψ, such as Color Singlet Model (CSM), non-relativistic QCD (NRQCD), Improved Color Evaporation Model (ICEM) [1].
- New observables can help to discriminate between different models.

➢**J/ψ production associated with jet activity**

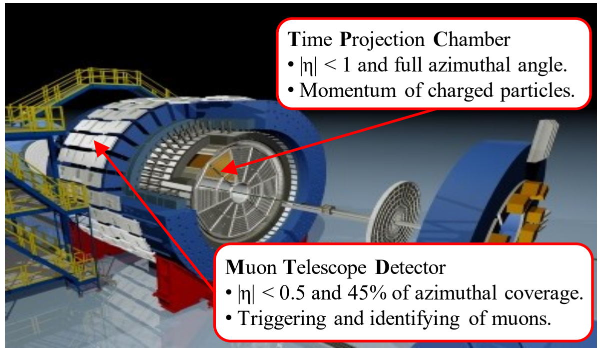
- Quarkonium production from the Color Singlet Model (CSM) should result in a larger jet activity (number of jets per event) than that from the Color Octet Mechanism (COM) [1].



- Color Singlet Model (CSM) and Color Octet Mechanism (COM) [2].

The STAR detector

➢At Brookhaven National Laboratory on Long Island, New York.
➢Full azimuthal angle and large rapidity (|η| < 1) coverage.



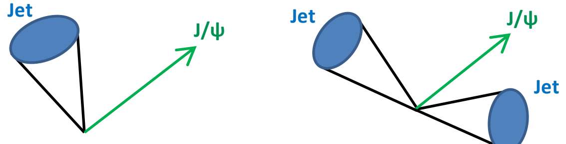
Analysis

➢**Observable**

- J/ψ production cross section as a function of jet activity.

➢**Extract raw J/ψ signal in different jet activity events**

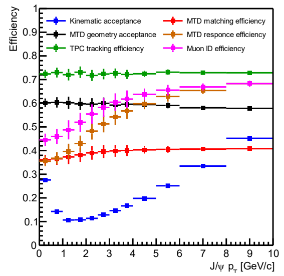
- p+p collisions at $\sqrt{s}$ = 200 GeV with dimuon trigger.
- J/ψ are reconstructed via dimuon decay channel.
- Charged jets are reconstructed with anti-k_T algorithm [3].
- Consider two jet radii, R = 0.4 and R = 0.6.



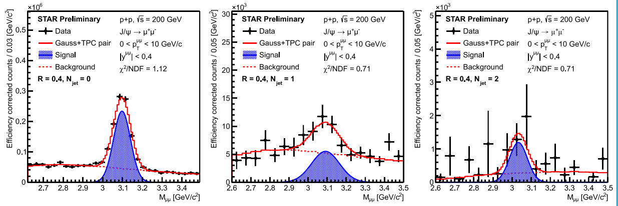
• J/ψ with one jet. • J/ψ with two jets.

➢**Correction for the number of J/ψ**

- $N_{J/\psi}^{corrected} = \sum_1^{N_{J/\psi}} w_i$, where $w_i = (\varepsilon_{reco} \times A)^{-1}$.
- ε_{reco} and A are the total reconstruction efficiency and acceptance (kinematic and MTD geometry), respectively.



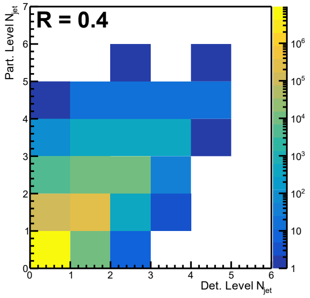
• Efficiencies and acceptances as a function of J/ψ p_T.



• Efficiency corrected J/ψ signal in different jet activity bins.

➢**Correction for the jet activity**

- Unfolding technique with RooUnfold package [4].
- Implemented with RooUnfoldBayes algorithm [5].
- Response matrices are built using PYTHIA8 [6] events with detector effects included.



• Response matrix.

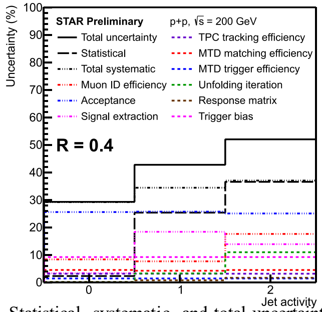
➢**Calculation of J/ψ production cross section**

$$Br(J/\psi \to \mu^+\mu^-) \times \frac{d\sigma}{dN_{jet}} = \frac{1}{\Delta N_{jet}} \times \frac{N^{corrected}_{J/\psi \to \mu^+\mu^-}}{luminosity}$$

- ΔN_{jet} is the bin width of each N_{jet} bin, which equals to 1.

➢**Systematic uncertainties**

- Signal extraction
- Efficiencies
- Acceptance
- Unfolding procedure
- Response matrix



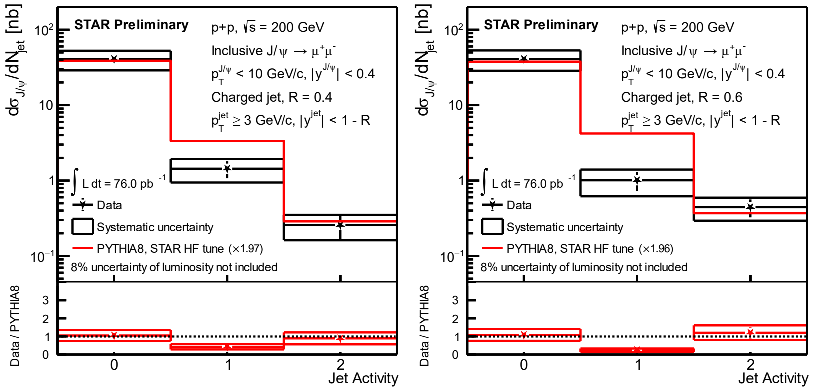
• Statistical, systematic, and total uncertainties.

Results and conclusions

➢First result of J/ψ production cross section as a function of jet activity in p+p collisions at $\sqrt{s}$ = 200 GeV.
➢J/ψ p_T < 10 GeV/c.
➢Charged jet $p_T \geq$ 3 GeV/c.
➢Comparison with PYTHIA8 predictions:

- The result for R = 0.4 jet has a small discrepancy in shape (p-value = 0.18).
- The result for R = 0.6 jet shows an inconsistency in shape (p-value = 0.01).

➢In PYTHIA with the chosen kinematics, a larger fraction of J/ψ are produced associated with jet than in data.



• J/ψ cross section as a function of jet activity with jet radius R = 0.4 (left) and 0.6 (right).

References

[1] Jean-Philippe Lansberg, Physics Reports, 889, 1 (2020).
[2] Pietro Faccioli, Course on Physics at the LHC (2013).
[3] M. Cacciari et al, JHEP, 2008, 63 (2008).
[4] Tim Adye, arXiv 1105.1160 (2011).
[5] G. D'Agostini, NIMA, 362, 487 (1995).
[6] T. Sjostrand et al, Comput. Phys. Comm., 178, 852 (2008).