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

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for the STAR collaboration

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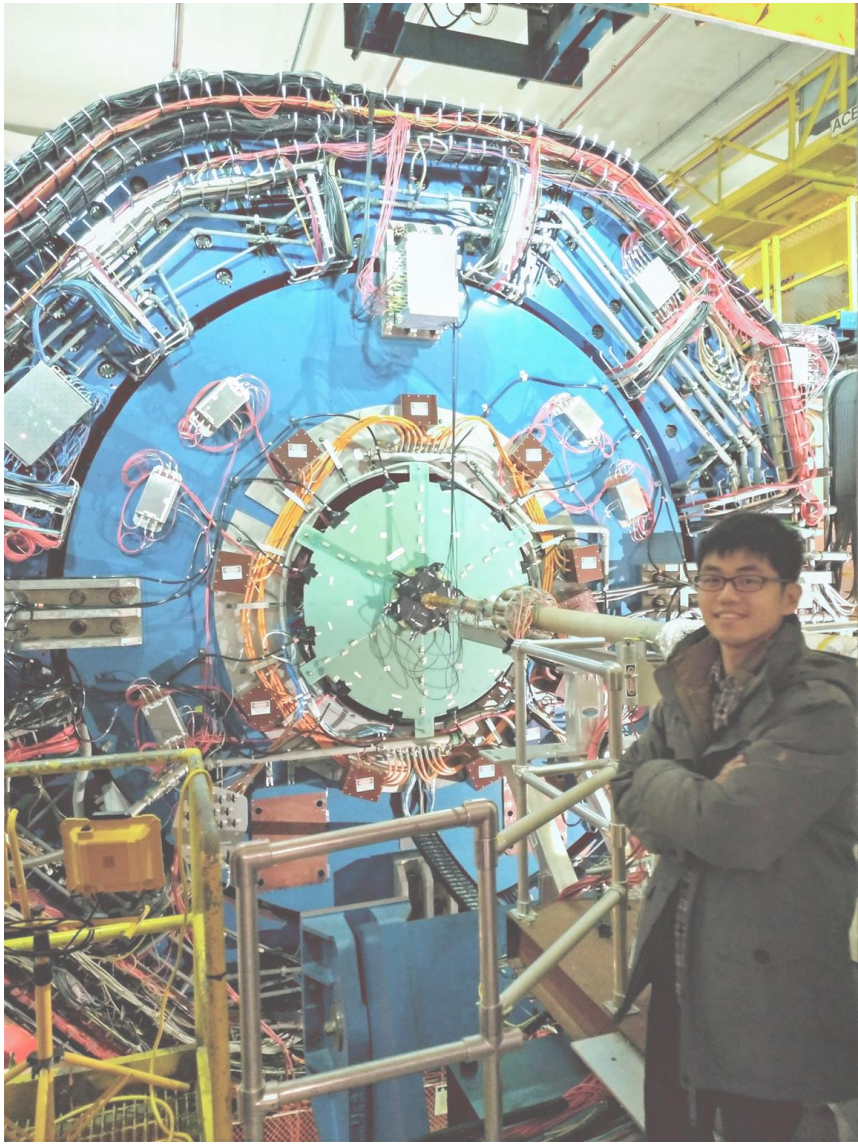
~~Hyatt Regency Hotel, New Orleans, LA~~

APS physics

Outline

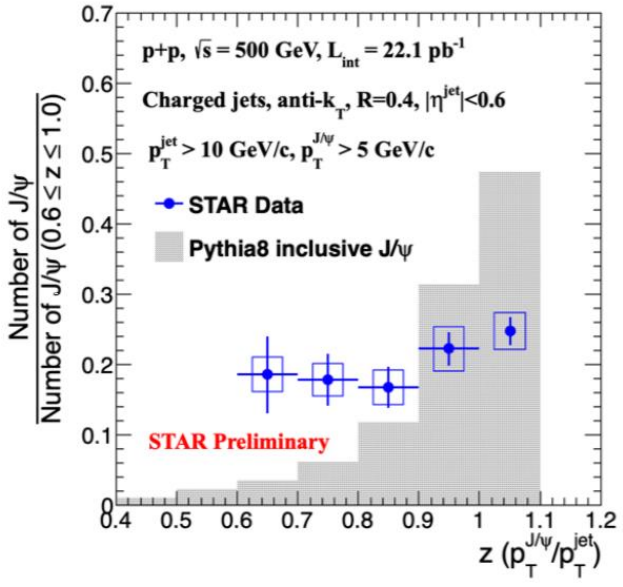
- Motivation
- The STAR detector
- Analysis strategy
- Summary



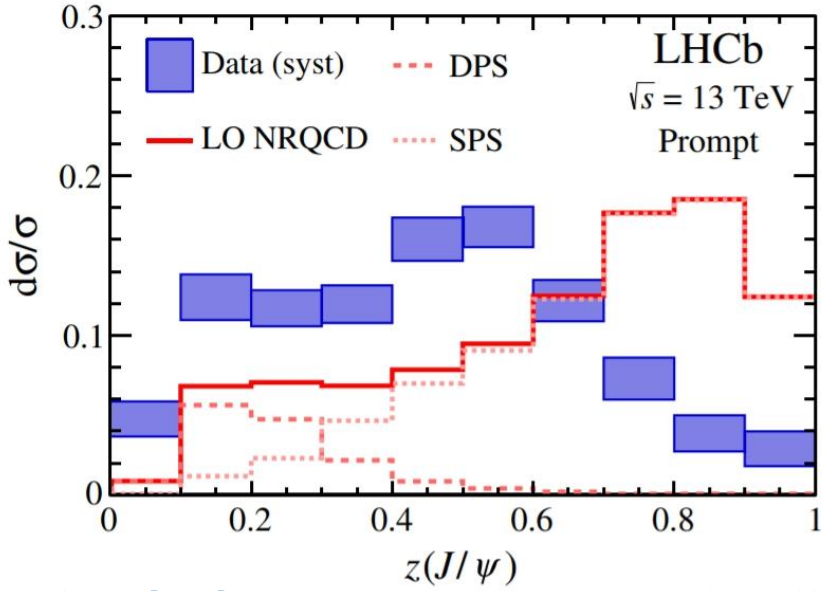
J/ψ Production Associated with Jets

- The J/ψ production mechanism is not fully understood
- Benefits of studying J/ψ production with jets
  - Related to fragmentation process
  - Better understanding of J/ψ production
- J/ψ within a jet studies from RHIC (inclusive) and LHC (prompt):

RHIC



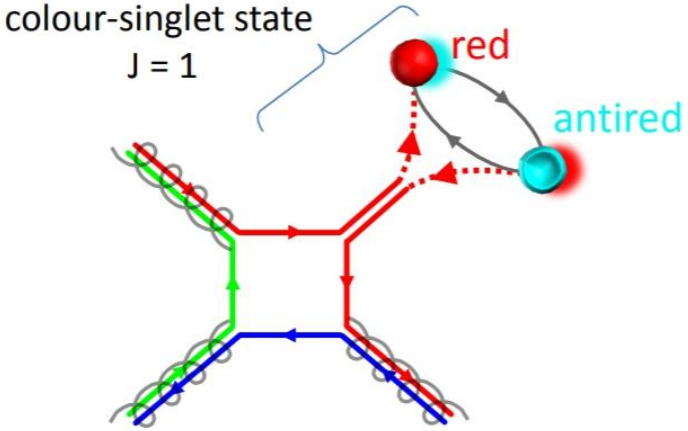
LHC

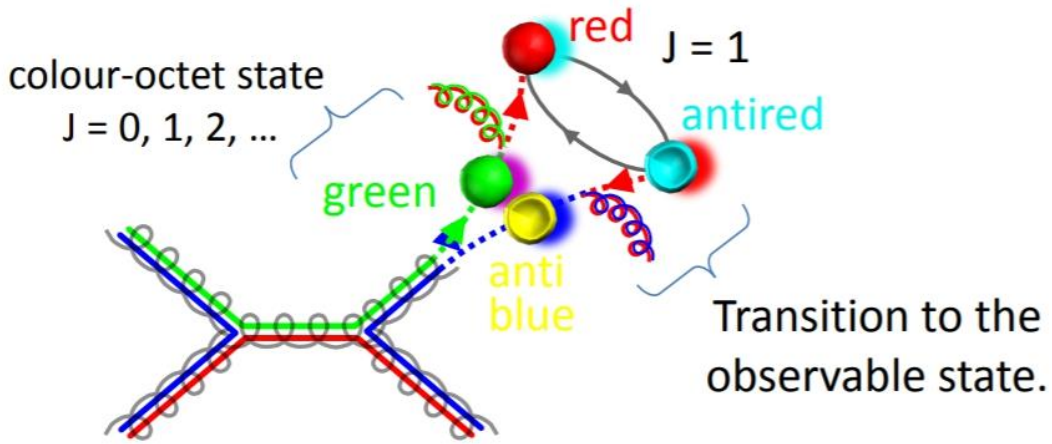


(LHCb, Phys. Rev. Lett. 118, 192001 (2017))

J/ψ Production vs. Jet Activity

- Quarkonium production from color singlet model (CSM) should result in larger jet activity (number of jets per event) than from color octet mechanism (COM) (arXiv:1903.09185 [hep-ph])
- Study of J/ψ production with jet activity is a more straightforward analysis that can be used to distinguish between CSM and COM



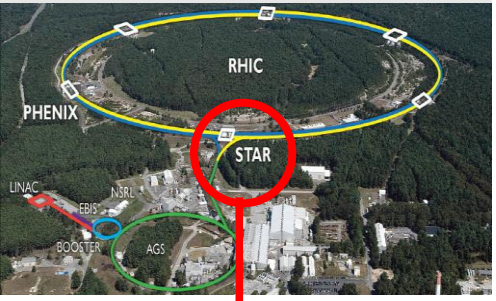


(Pietro Faccioli, Particle polarizations in LHC physics, Course on Physics at the LHC 2014)

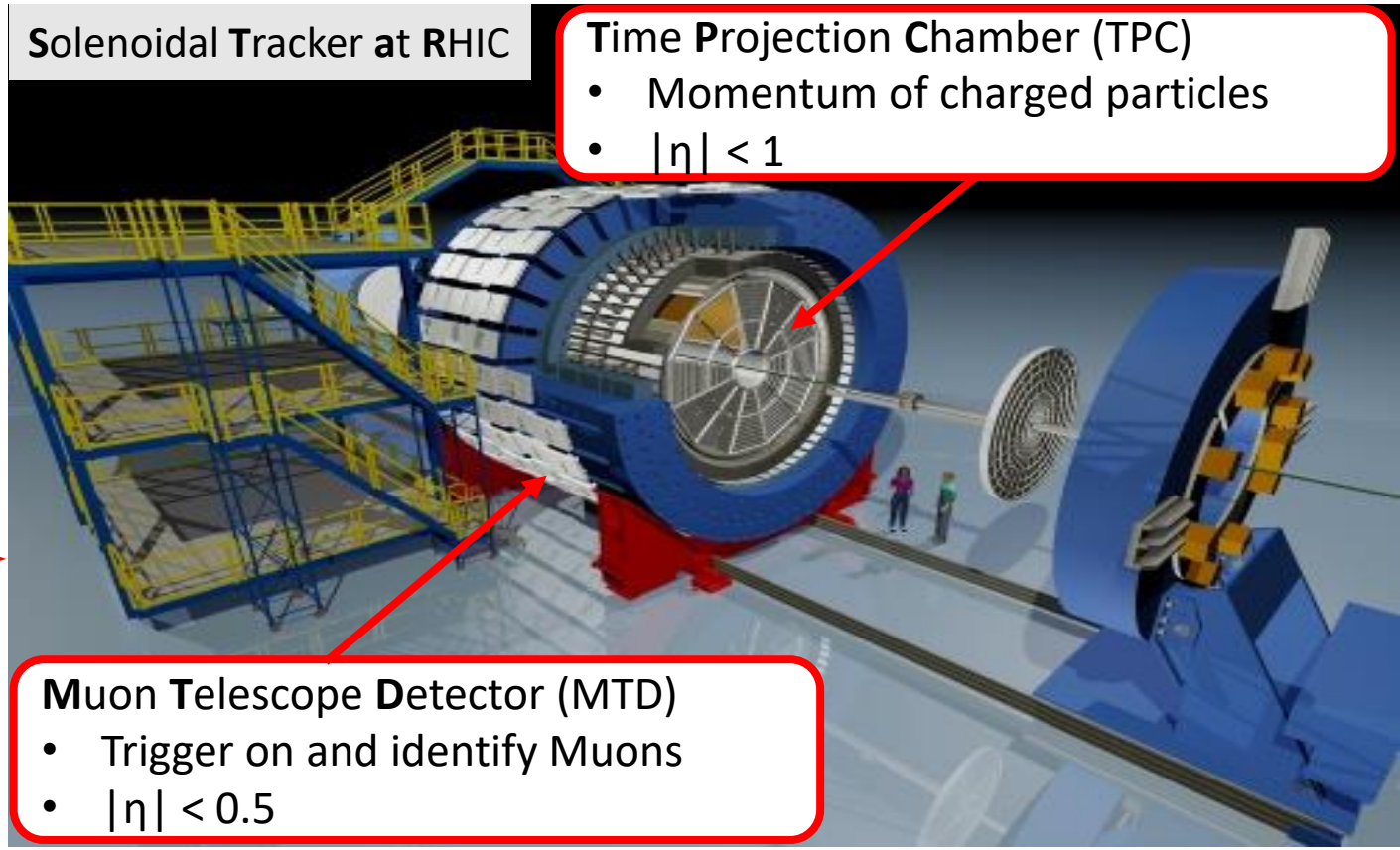
The STAR Detector

- Located at Brookhaven National Laboratory on Long Island, New York
- Covers full azimuthal angle and mid-rapidity ($|\eta| < 1$)

Relativistic **H**eavy **I**on **C**ollider



Solenoidal **T**racker **a**t **RHIC**

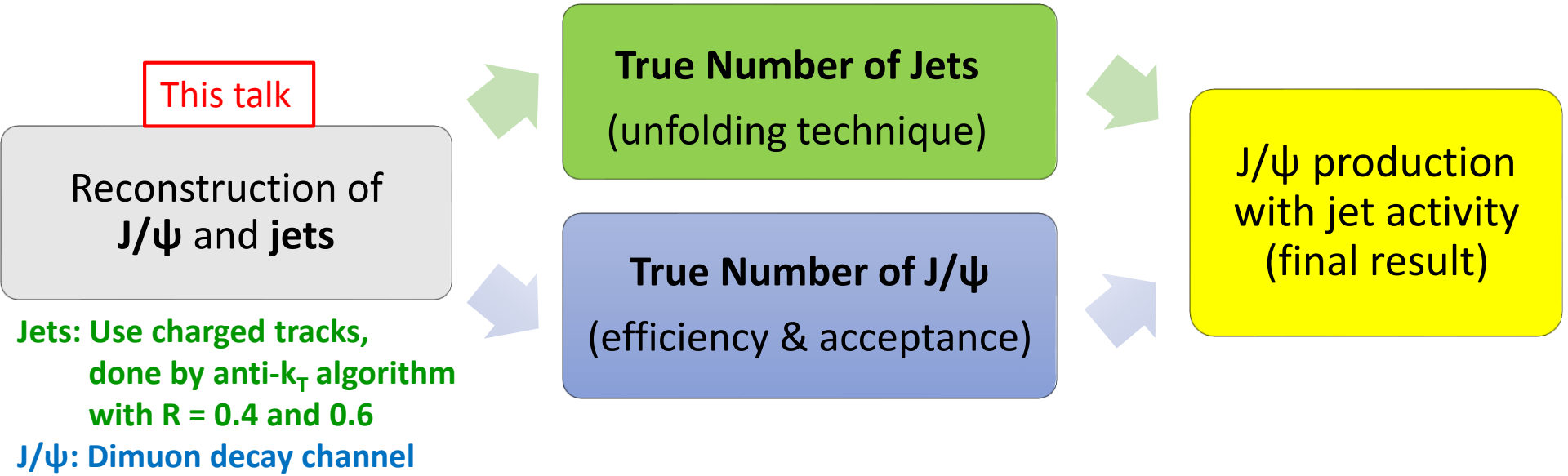


Time **P**rojection **C**hamber (TPC)
- Momentum of charged particles
- $|\eta| < 1$

Muon **T**elescope **D**etector (MTD)
- Trigger on and identify Muons
- $|\eta| < 0.5$

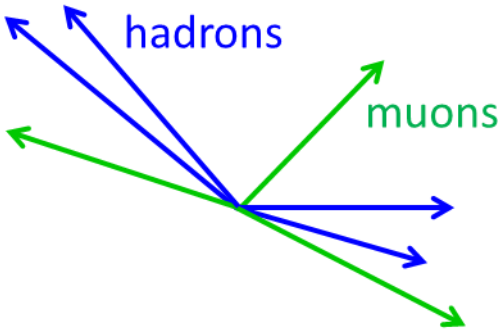
Analysis Strategy

- Aim: J/ψ cross section as a function of jet activity (number of jets)
- Data set: p+p collisions at $\sqrt{s}$ = 200 GeV in 2015



Jet Finding Associated with J/ψ Production

0. Particles in an event



1. Reconstruct a μμ pair

2. Reconstruct a set of jets

3. Repeat step 1. and 2. with another μμ pair, obtain another $M_{\mu\mu}$, N_{jet} , Jet p_T , η , ϕ...

4. Generate $M_{\mu\mu}$ distributions and fit to obtain the number of J/ψ

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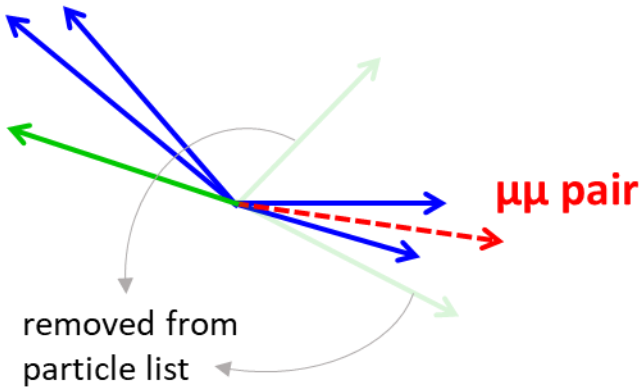

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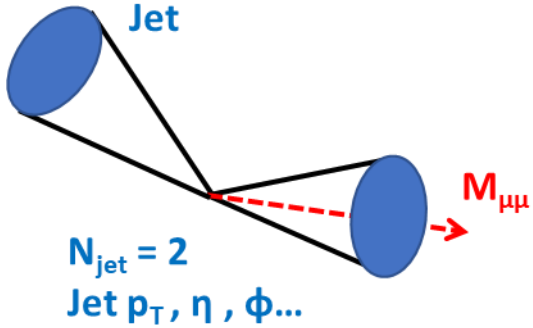

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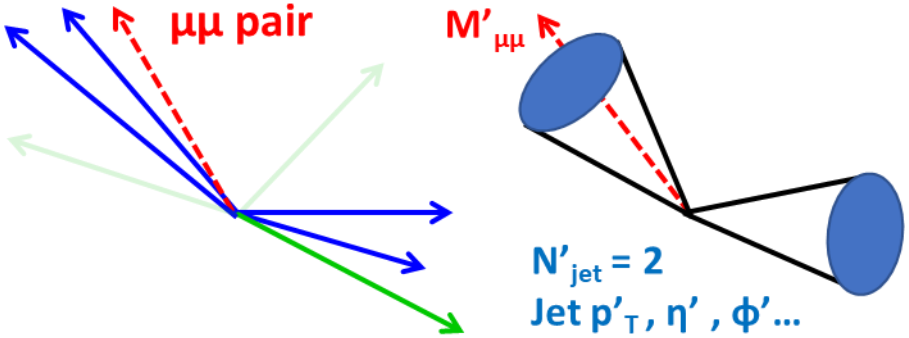

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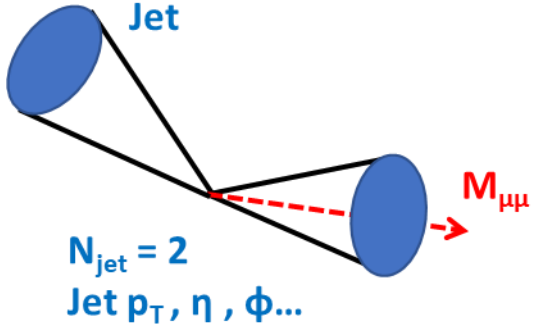

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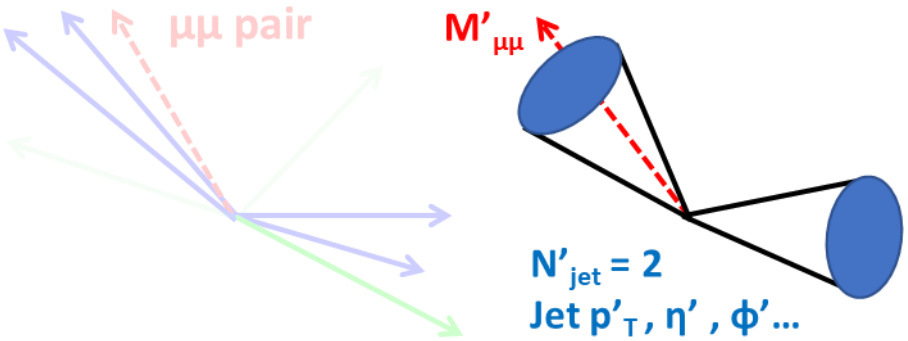

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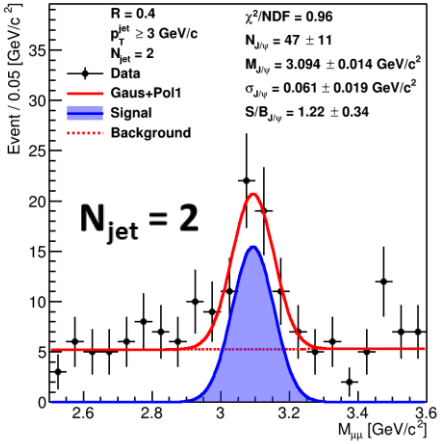
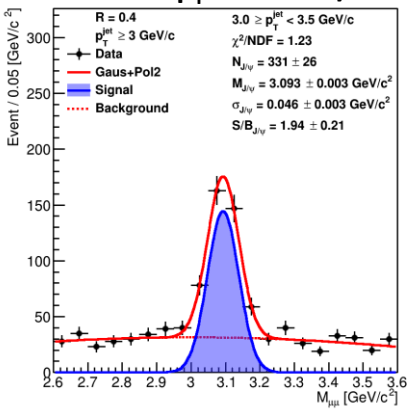


Obtain Jet Information

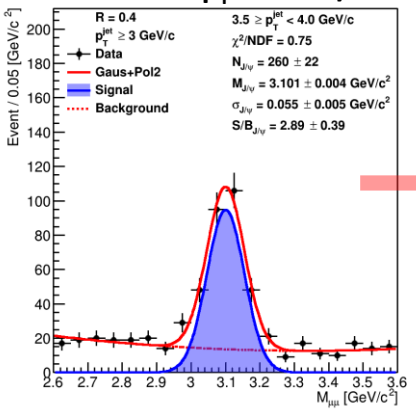
➢ $p_T^{jet} \geq 3$ GeV/c to suppress the combinatorial jets

Fit $M_{\mu\mu}$ in different **jet p_T** ranges (R = 0.4)

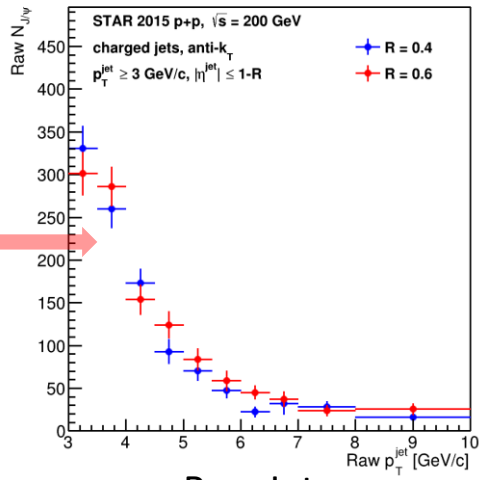
3 ≤ Jet p_T < 3.5 GeV/c



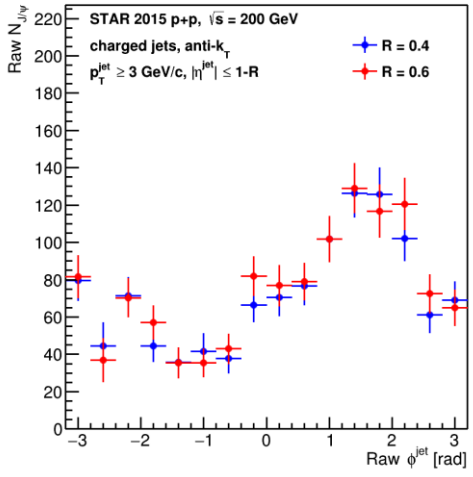
3.5 ≤ Jet p_T < 4 GeV/c



Raw Jet p_T

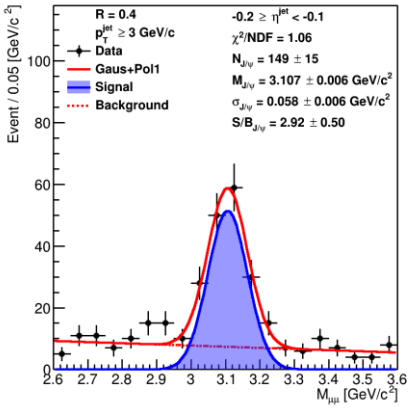


Raw Jet ϕ

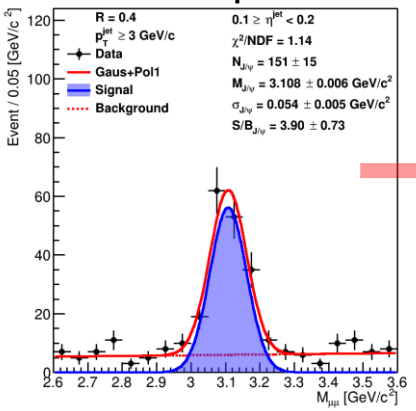


Fit $M_{\mu\mu}$ in different **jet η** ranges (R = 0.4)

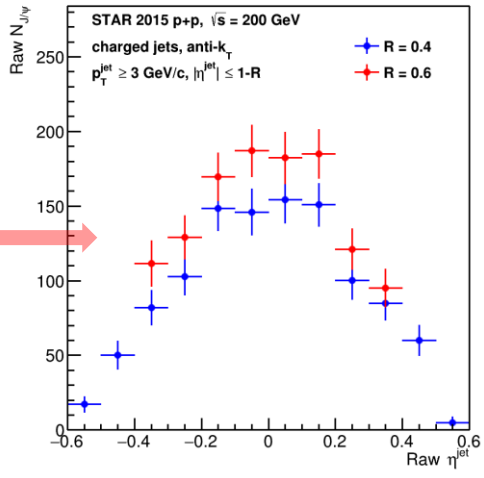
-0.2 ≤ Jet η < -0.1



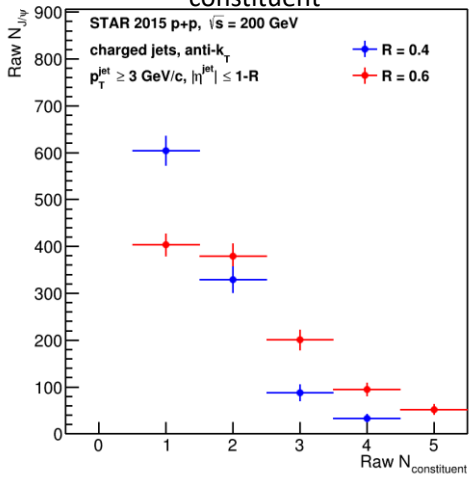
0.1 ≤ Jet η < 0.2



Raw Jet η



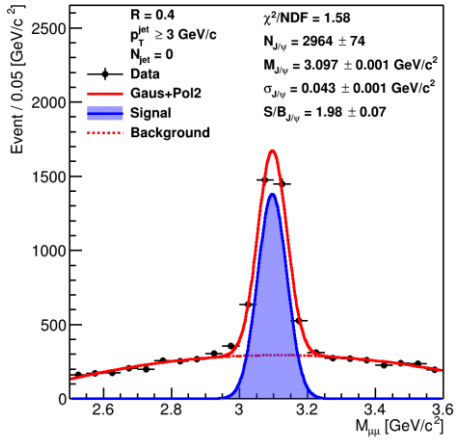
Raw $N_{constituent}$ in Jets



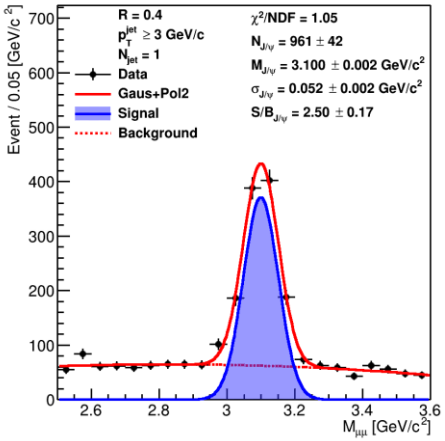
Raw $N_{J/\psi}$ vs. Raw Jet activity

- $p_T^{jet} \geq 3$ GeV/c to suppress the combinatorial jets

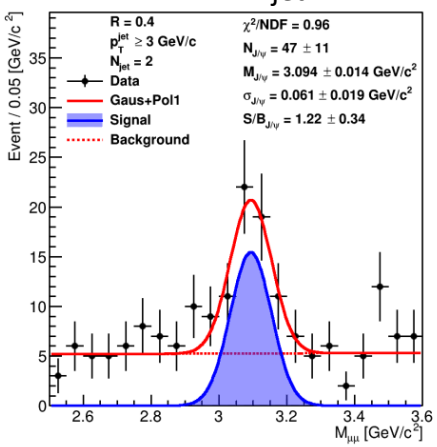
R = 0.4, N_{jet} = 0



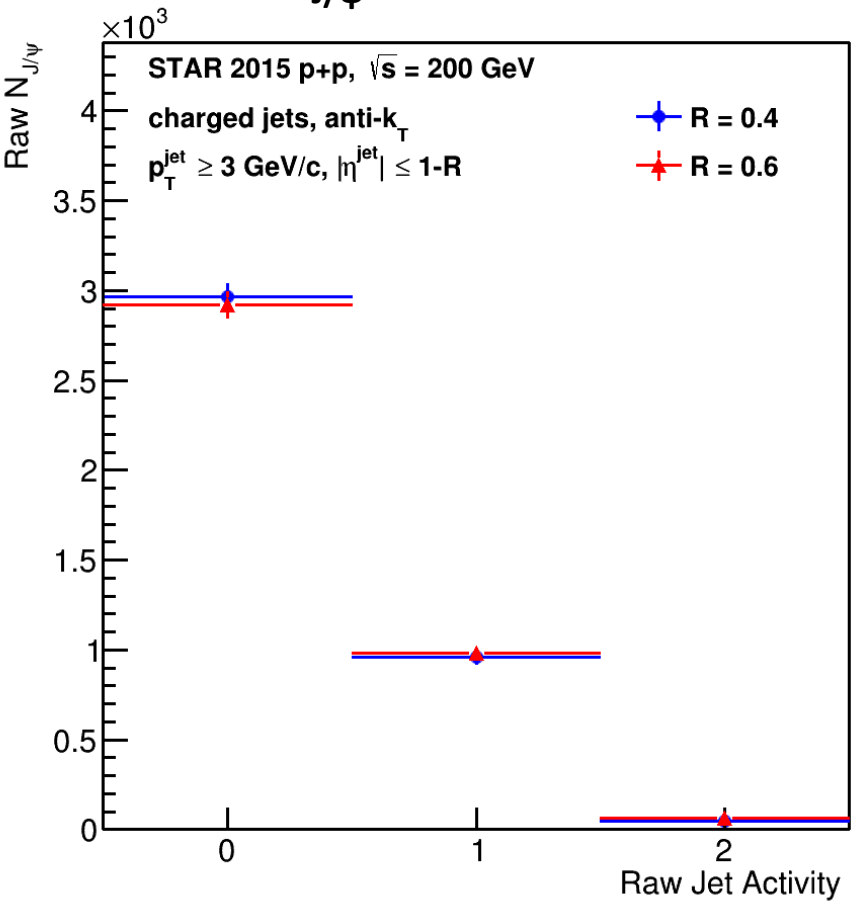
R = 0.4, N_{jet} = 1



R = 0.4, N_{jet} = 2



Raw $N_{J/\psi}$ vs. Raw Jet activity



Summary

- Study J/ψ production with jet activity can help to distinguish between CSM and COM J/ψ production mechanisms
- Following analysis steps were presented:
  - Reconstruction of charged jets associated with J/ψ production
  - J/ψ reconstruction via dimuon decay channel
  - Extraction of raw jet p_T, η, φ information and raw $N_{J/\psi}$ vs. raw jet activity

Future Work

- Correct N_{jet} and obtain an unfolded result
- J/ψ production cross section vs. corrected N_{jet}
- Work on systematic uncertainties
- Compare to theoretical calculations

BACKUP SLIDES

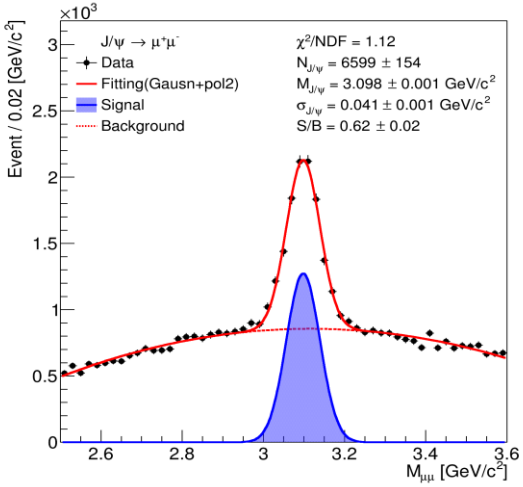
Data Set and Event Selection

- Run15 pp collision@200 GeV
- Trigger Selection
  - Dimuon trigger
- Vertex Selection
  - |TPC Vz| ≤ 100 cm
  - |TPC Vz – VPD Vz| ≤ 6 cm
- Track Quality Selection
  - Primary Tracks
  - NHitsFit ≥ 15
  - NHitsdEdx ≥ 10
  - NHitsFit/NHitsMax ≥ 0.52
  - DCA < 1.5 cm
- Track Kinematic Selection
  - $p_T \geq 0.2$ GeV/c
  - $|\eta| \leq 1$

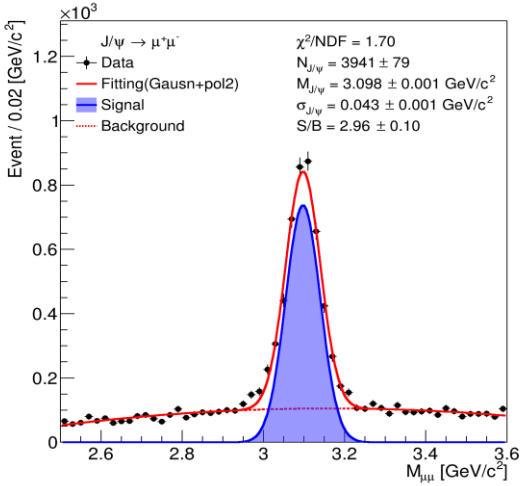
J/ψ Reconstruction

- Dimuon Decay Channel
- Muon Candidate
  - $p_T \geq 1.3$ GeV/c
  - $|\eta| < 0.5$
  - Matched to MTD hits
- Muon Identification
  - Likelihood Ratio Method
  - Variables:
    $\Delta y \times q/\sigma_{\Delta y \times q}$, $\Delta z/\sigma_{\Delta z}$, ΔToF, $n\sigma_\pi$ and DCA
- J/ψ Reconstruction
  - Opposite sign pair of muon candidates

Without Muon ID Selection

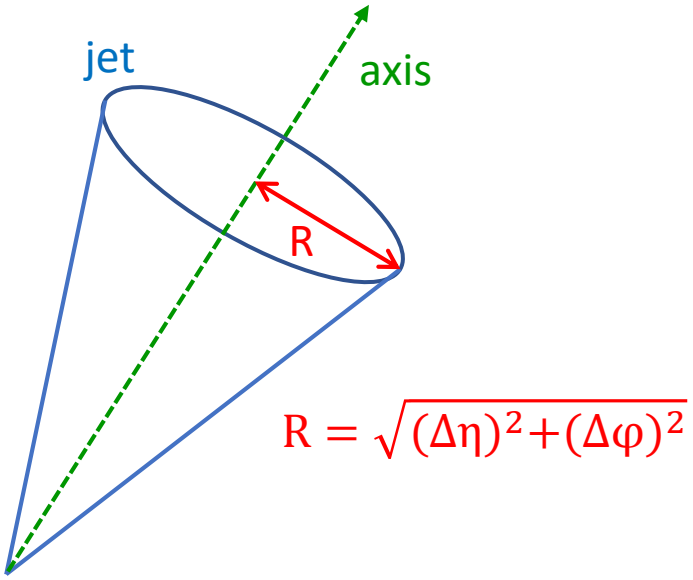


With Muon ID Selection



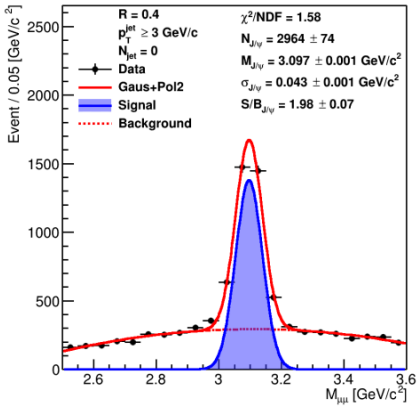
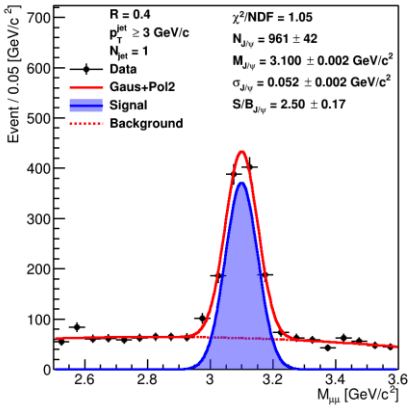
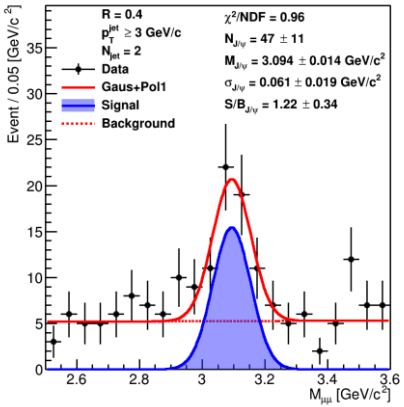
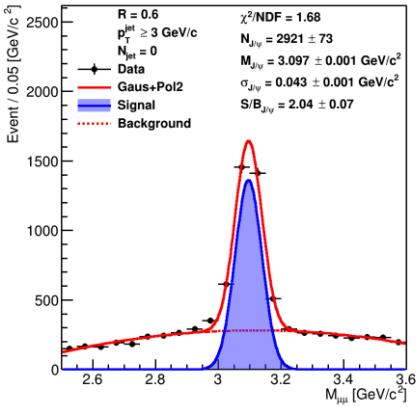
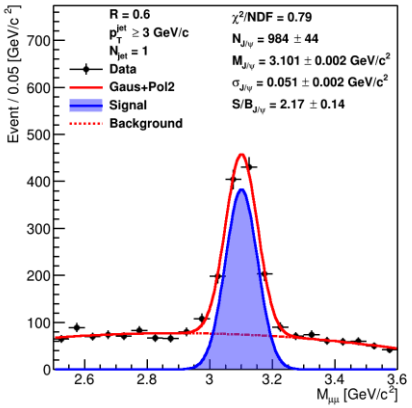
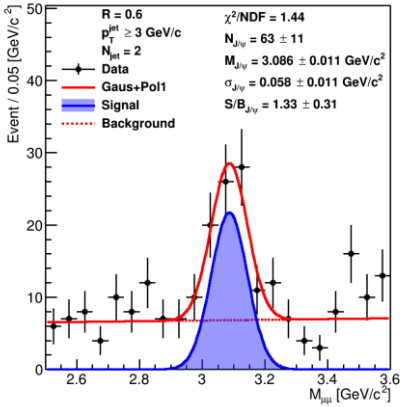
Jet Reconstruction

- FastJet Library
- Anti-k_T algorithm, R = 0.4 and R = 0.6
- Input particles for Jet Finding
  - A dimuon pair
  - Charged tracks from TPC
    - $p_T \geq 0.2$ GeV/c
    - $|\eta| \leq 1$
    - without muons from each μμ pair
  - Set all $M_{TPC\ track}$ as M_π
- Jet Selection
  - $p_T^{jet} \geq 3$ GeV/c
  - $|\eta_{jet}| \leq 1\text{-R}$



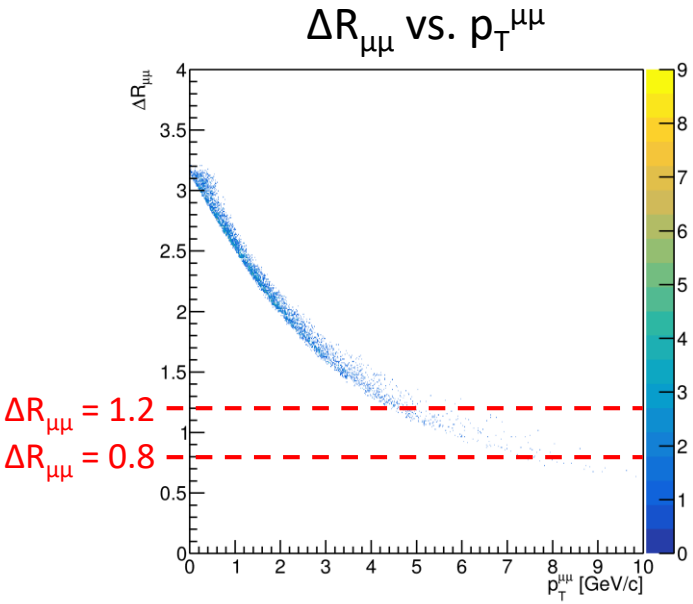
J/ψ in Different N_{jet} Events

- With both of different R, J/ψ are concentrated in events with $N_{jet} \leq 2$

	Raw N_{jet} = 0	Raw N_{jet} = 1	Raw N_{jet} = 2
R = 0.4			
R = 0.6			

Put Dimuon Pairs into Jet Reconstruction

- Most of the two muons from J/ψ candidates ($|M_{\mu\mu} - M_{J/\psi}| \leq 3\sigma_{J/\psi}$) have a $\Delta R_{\mu\mu}$ larger than the diameter of jets
- As a result, these muons cause further contributions to N_{jet}
- Need to reject this effect of muons on my N_{jet}



$$\Delta R_{\mu\mu} = \sqrt{(\Delta\eta_{\mu\mu})^2 + (\Delta\varphi_{\mu\mu})^2}$$