J/ψ production at high p_T in p+p and A+A collisions at STAR

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Outline

- **Motivation**
- **Data Analysis:**
  - **J/ψ→e^+e^-**
  - **$|\eta|<1$**
  - **p_T>5GeV/c (EMC trigger)**
- **Results**
  - **Spectra in p+p collisions**
  - **Spectra in Cu+Cu collisions**
  - **R_{AA} (Cu+Cu/p+p)**
  - **J/ψ–hadron correlations**
- **Summary**
- **Outlook**

***J/ψ(1S)* PDG values:**

Mass $m = 3096.916 \pm 0.011$MeV

Full width $\Gamma = 0.0934 \pm 0.0021$MeV

J/ψ→e^+e^- branch ratio:

$(5.94 \pm 0.06) \times 10^{-2}$

p+p data sample:

1. EMC triggered events in year 2005
   E_T>3.5 GeV
   Integrated luminosity: 2.83 $(pb)^{-1}$
2. EMC triggered events in year 2006
   E_T>5.4 GeV
   Integrated luminosity: 11.35 $(pb)^{-1}$

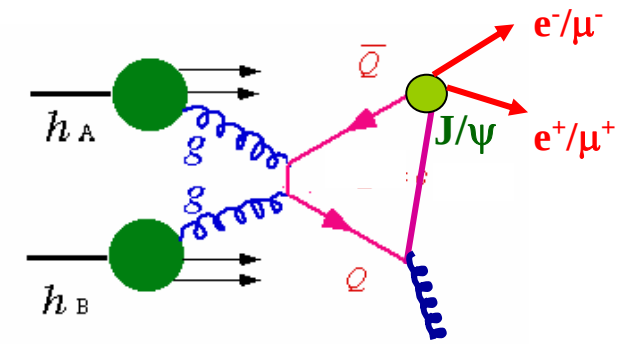
Cu+Cu data sample:

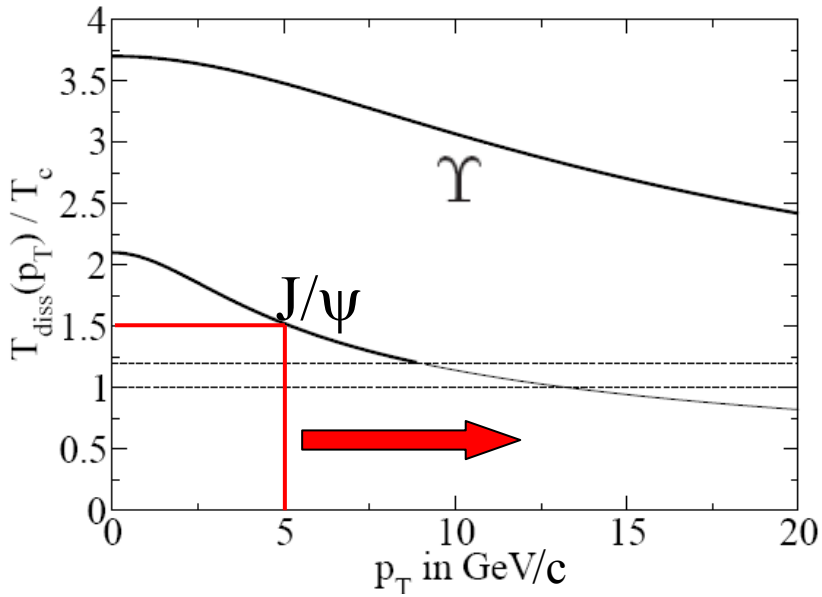
1. EMC triggered events in year 2005
   E_T>3.75 GeV
   Integrated luminosity: 0.860 $(nb)^{-1}$
   pp-equivalent: 3.4 $(pb)^{-1}$

Motivation(1)

Investigate heavy quarkonium production mechanism and hadronization

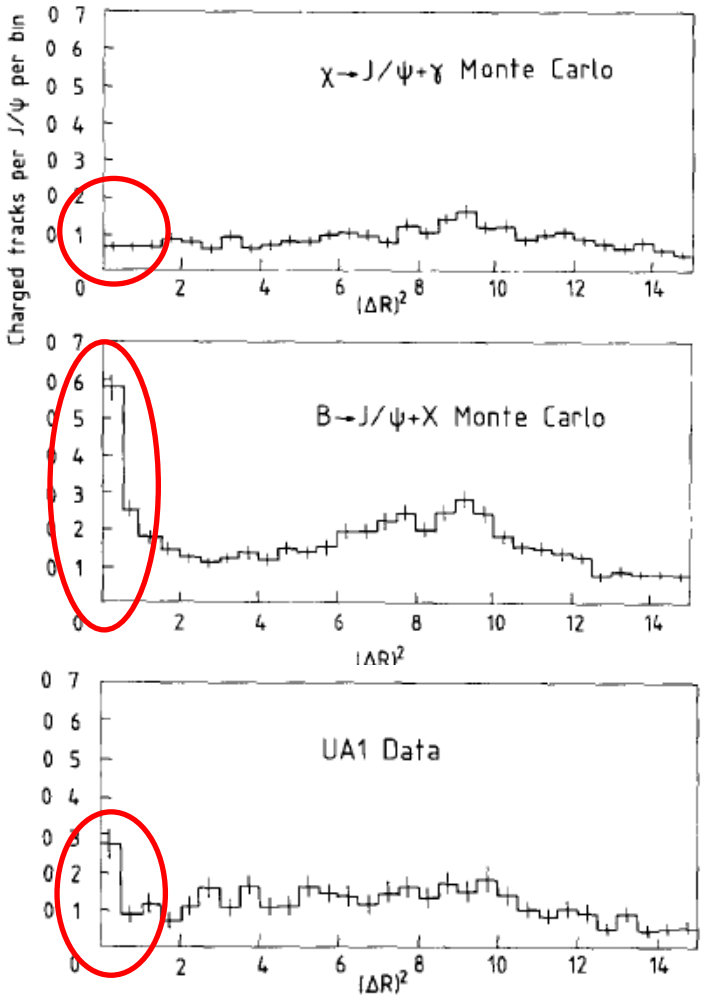
- **In p+p collision**
  - **Gluon fusion**
  - **Charm fragmentation**
  - **Feed down**
- **In heavy ion collision**
  - **Gluon energy loss**
  - **Heavy quark energy loss**
  - **Hot-wind dissociation in QGP**





H. Liu, K. Rajagopal and U.A. Wiedemann
PRL 98, 182301(2007) and hep-ph/0607062

Motivation(2)



$$(\Delta R)^2 = (\Delta\eta)^2 + (\Delta\phi)^2$$

J/ψ–hadron correlation:

$\Leftrightarrow$ **1)** $g + g \rightarrow \chi + g$

$\rightarrow J/\psi + \gamma$

no near side correlation

$\Leftrightarrow$ **2)** $g + g \rightarrow b + \bar{b}$

$\rightarrow B_{hadron} + X$

$\rightarrow J/\psi + X$

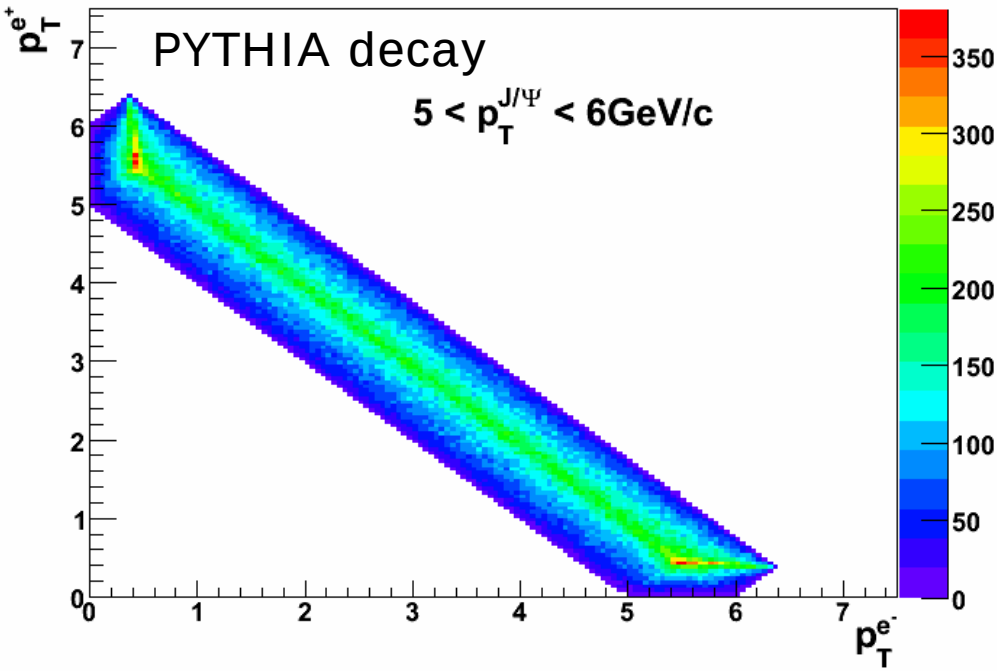
strong near side correlation

J/ψ–hadron correlation can shed light on different source contribution to J/ψ production

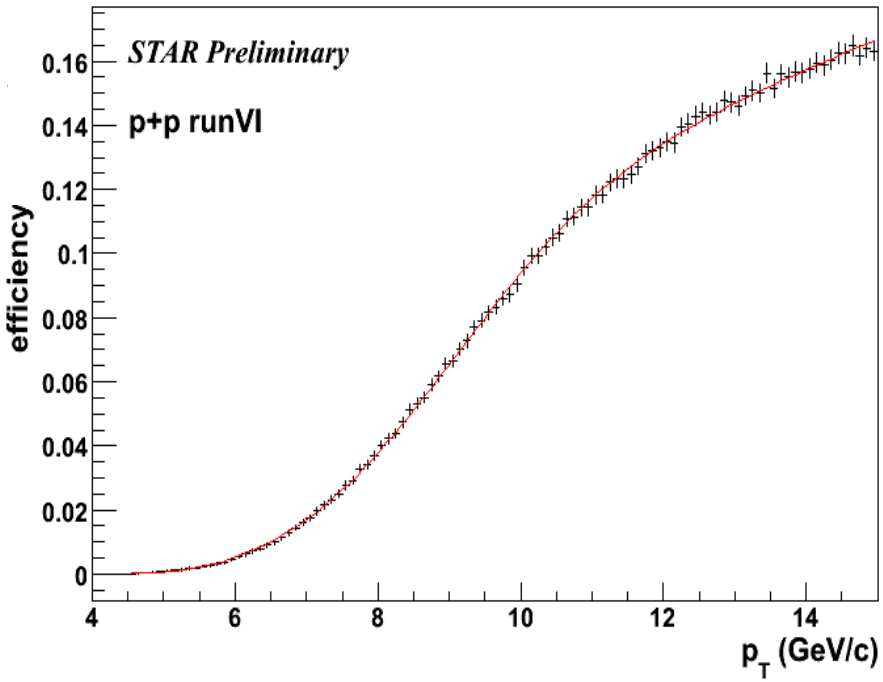
PLB 200, 380(1988) and PLB 256,112(1991)

J/ψ reconstruction

Daughters' p_T correlation



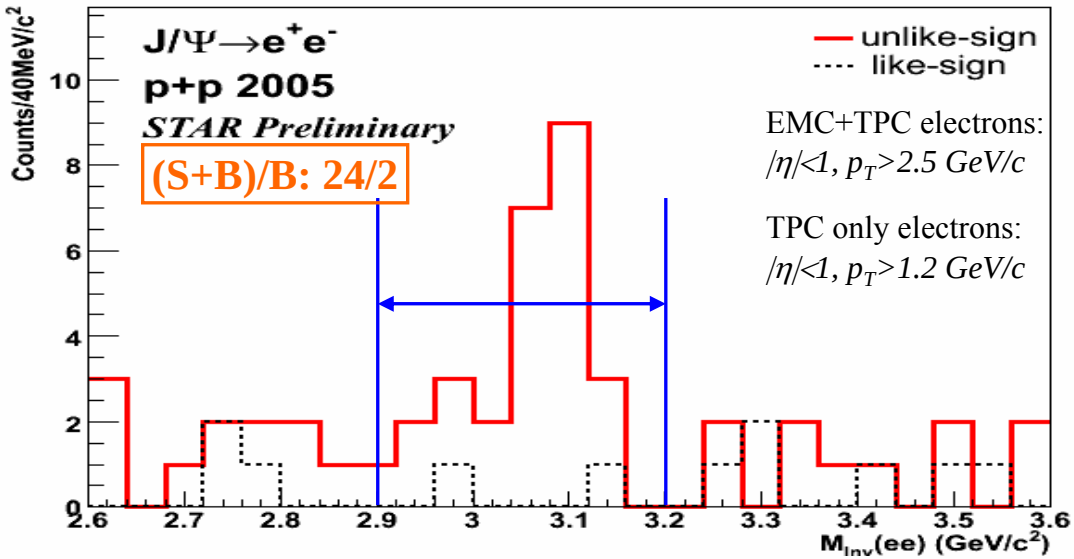
J/ψ efficiency

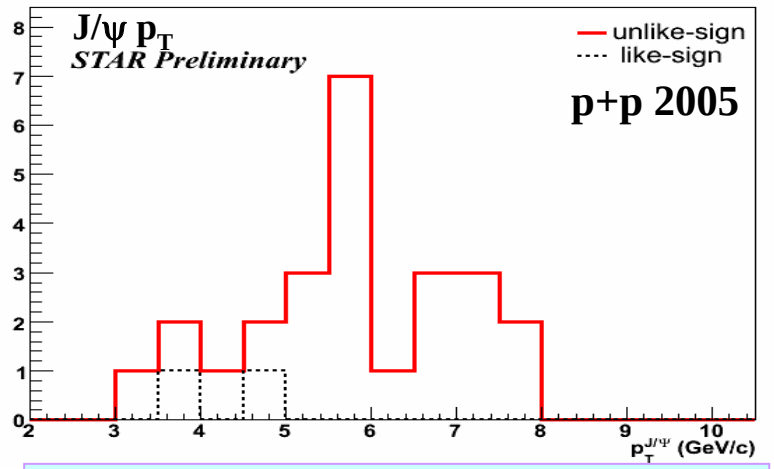


J/ψ is reconstructed with:

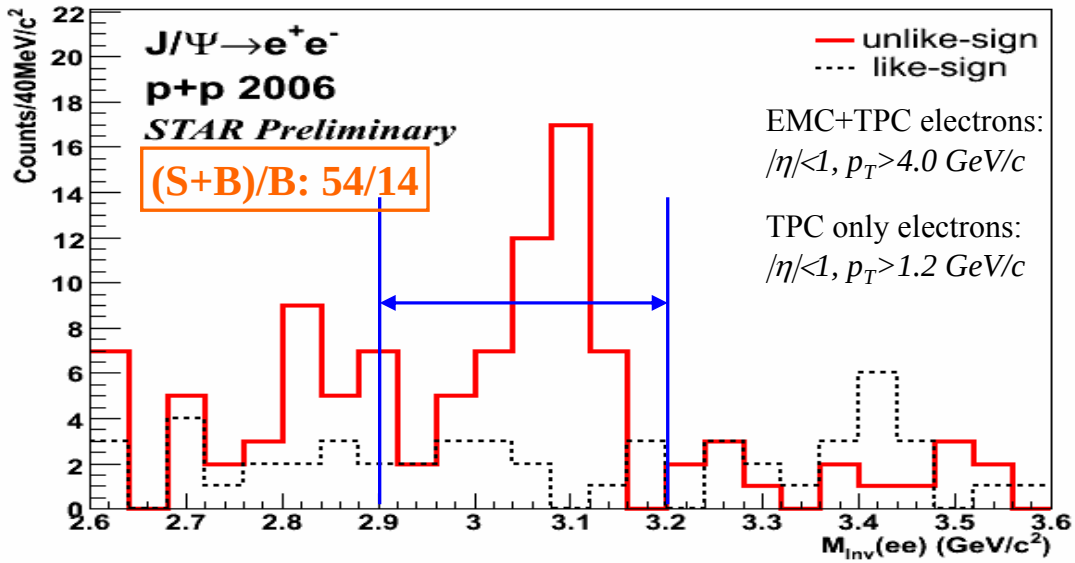
- A high p_T electron *(p_T>2.5GeV/c)* identified by combination of TPC and EMC, triggered by EMC
- A lower p_T electron *(p_T>1.2GeV/c)* identified cleanly by TPC only

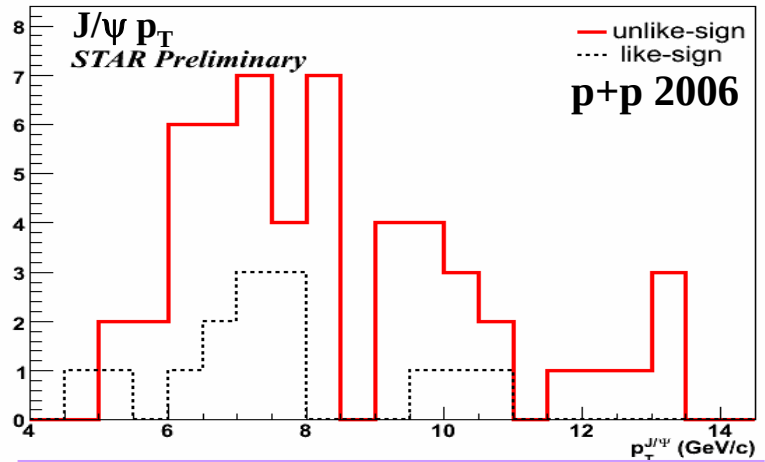
J/ψ invariant mass distribution





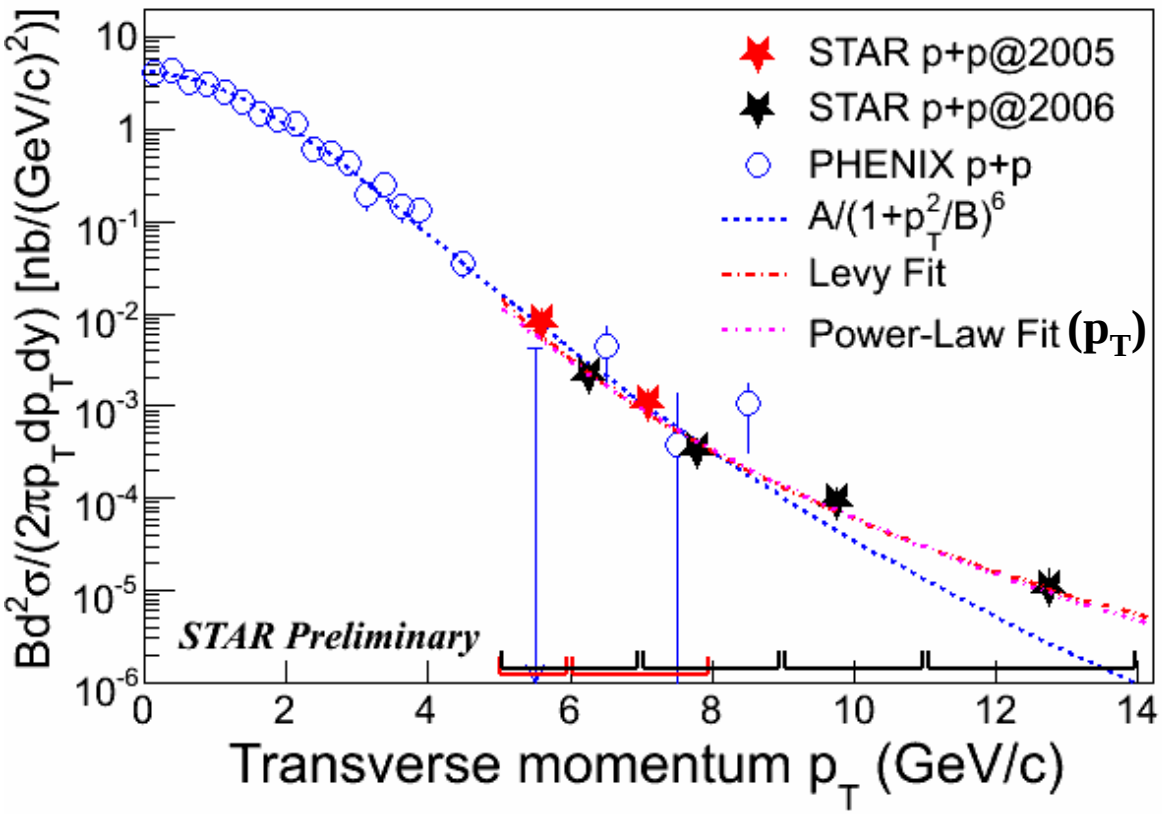
No background at p_T>5GeV/c





Reach higher p_T (~14GeV/c)

Invariant cross section



*PRL **98,** 232002 (2007)*

PHENIX data only

STAR data only

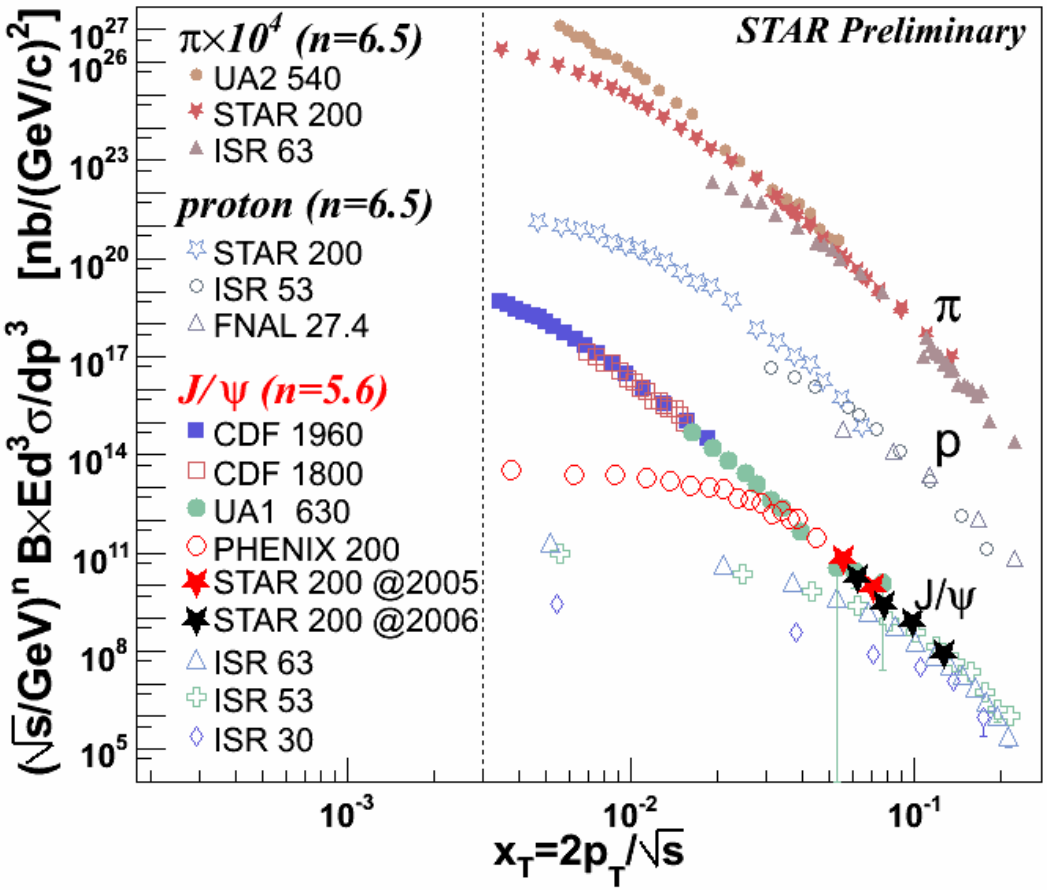
For low p_T results from STAR see:

T. Hallman, Plenary-I

M. R. Cosentino, poster 109

- Significantly extend p_T range of previous J/ψ measurement in p+p at RHIC to 14 GeV/c
- Consistent with PHENIX at overlap p_T
- Provide a good reference for measurements in A+A collisions

x_T scaling



n is related to the number of point-like constituents taking an active role in the interaction

n=8: diquark scattering

n=4: QED-like scattering

Depends on:

1) Running coupling constant α_s
2) Evolution of structure
3) Evolution of fragmentation function
4) Initial state k_T

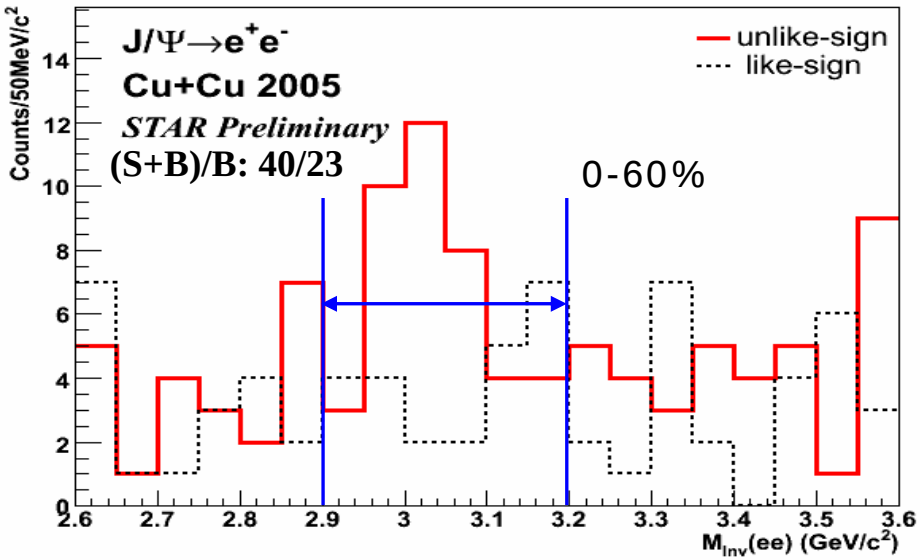
R. Blankenbecler, S. J. Brodsky and J. F. Gunion, ***PLB 42,461(1972)***

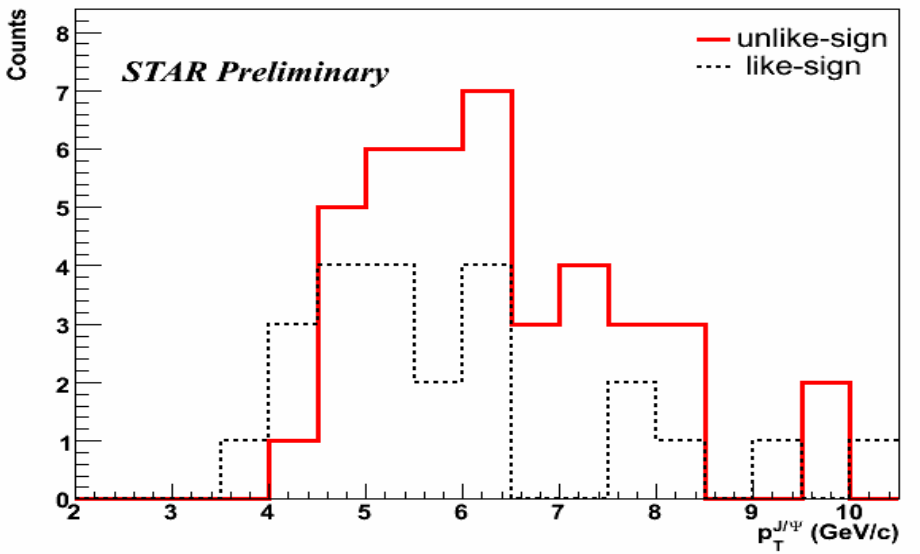
R. F. Cahalan, K. A. Geer, J. Kogut and L. Susskind, ***PRD 11, 1199(1975)***

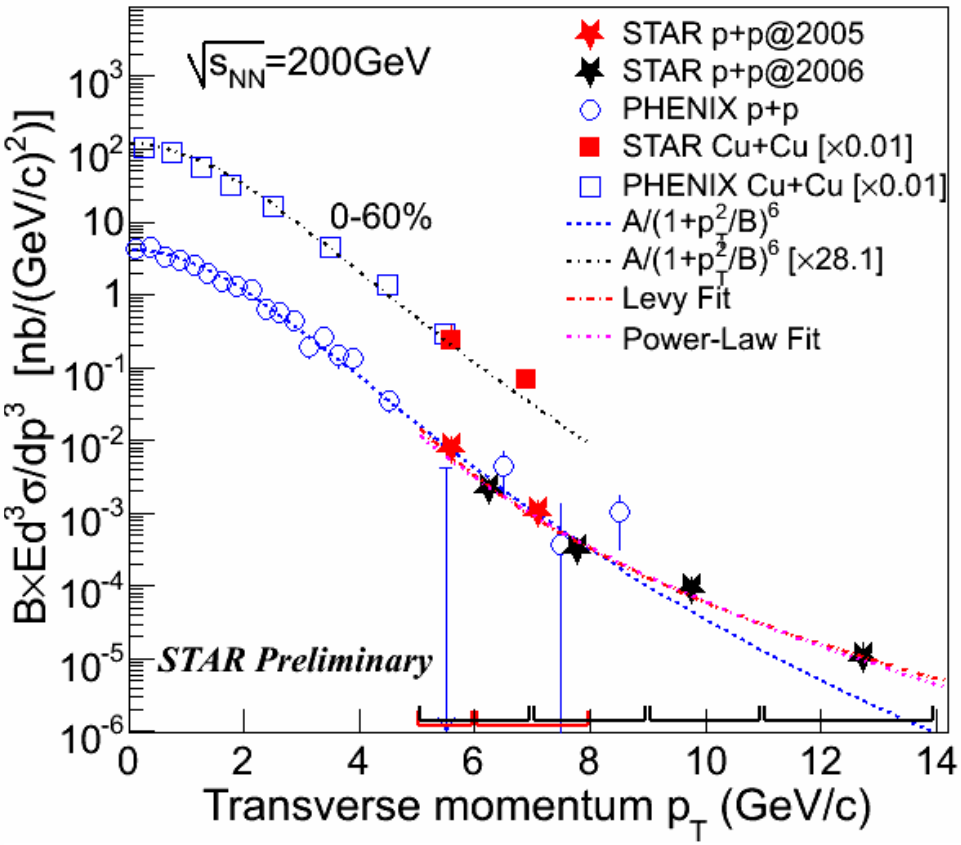
x_T scaling:

- ✓ **π and proton: n=6.5±0.8** *PLB 637, 161(2006)*
- ✓ **J/ψ: n=5.6±0.2**
- ✓ **J/ψ production: closer to 2→2 scattering**

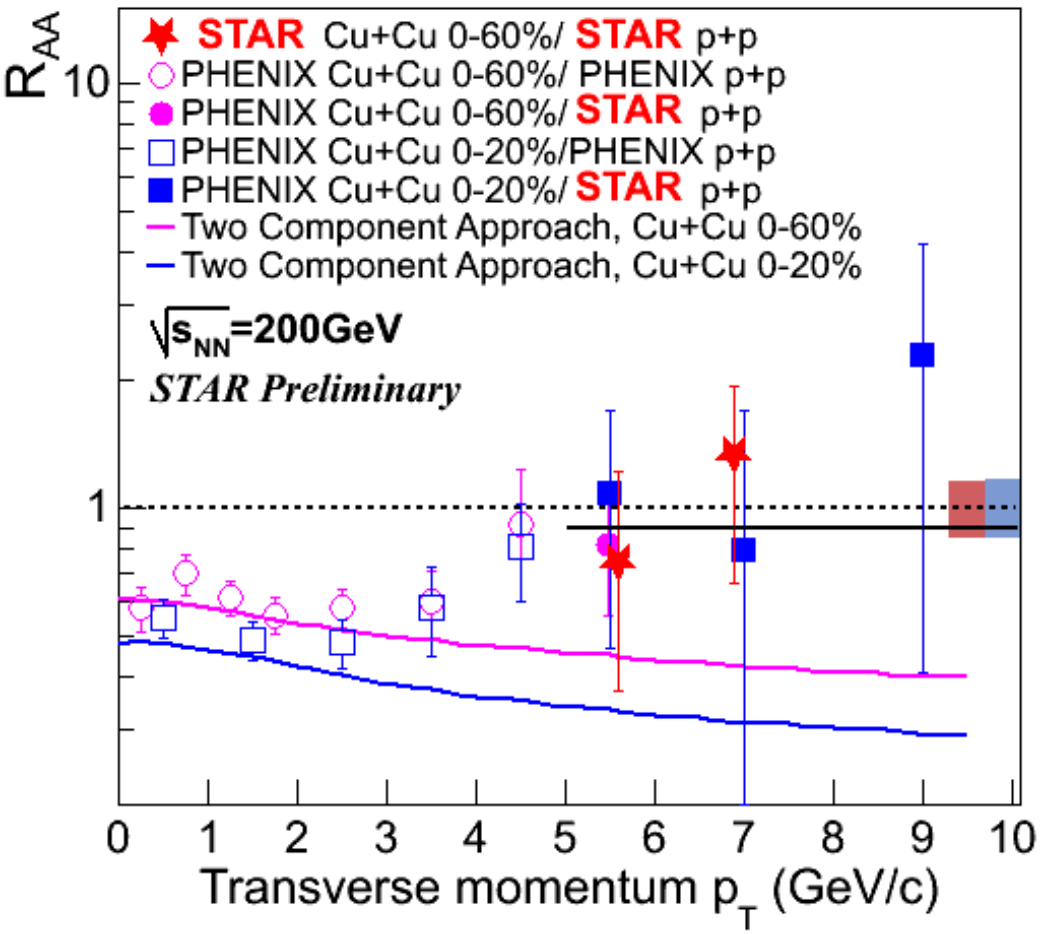
J/ψ in Cu+Cu collisions







Nuclear modification factor R_{AA}



- Double the p_T range to 10GeV/c
- Consistent with no suppression at high p_T:
  $R_{AA}(p_T>5\ \text{GeV/c}) = 0.9 \pm 0.2$
- Indicates R_{AA} increase from low p_T to high p_T
- Most models expect a decrease R_{AA} at high p_T:
  AdS/CFT:
  H. Liu, K. Rajagopal and U.A. Wiedemann, PRL 98, 182301(2007) and hep-ph/0607062
  Two Component Approach:
  X. Zhao and R. Rapp, hep-ph/07122407
  Private communication
- Color singlet model predicated a increase R_{AA} at high p_T:
  K. Farsch and R. Petronzio, PLB 193(1987), 105
  J.P. Blaizot and J.Y. Ollitrault, PLB 199(1987),499

Understanding J/ψ production mechanism

Investigate heavy quarkonium production mechanism and hadronization

- **In p+p collision**
  - **Gluon fusion**
  - **Charm fragmentation**
  - **Decay Feeddown**
- **In heavy ion collision**
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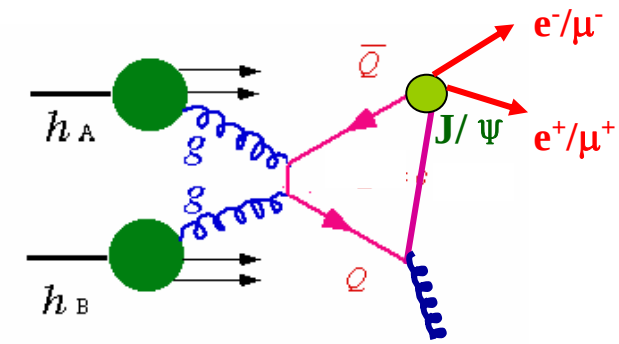

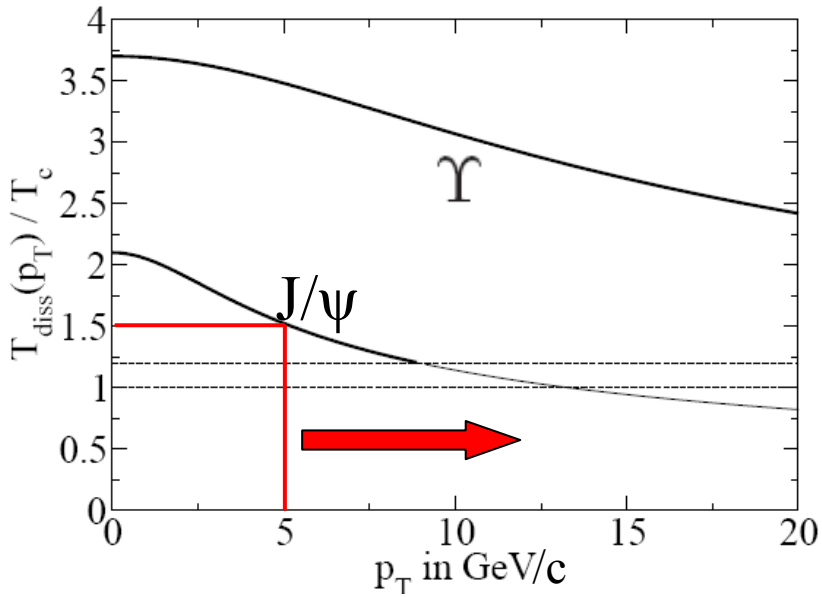

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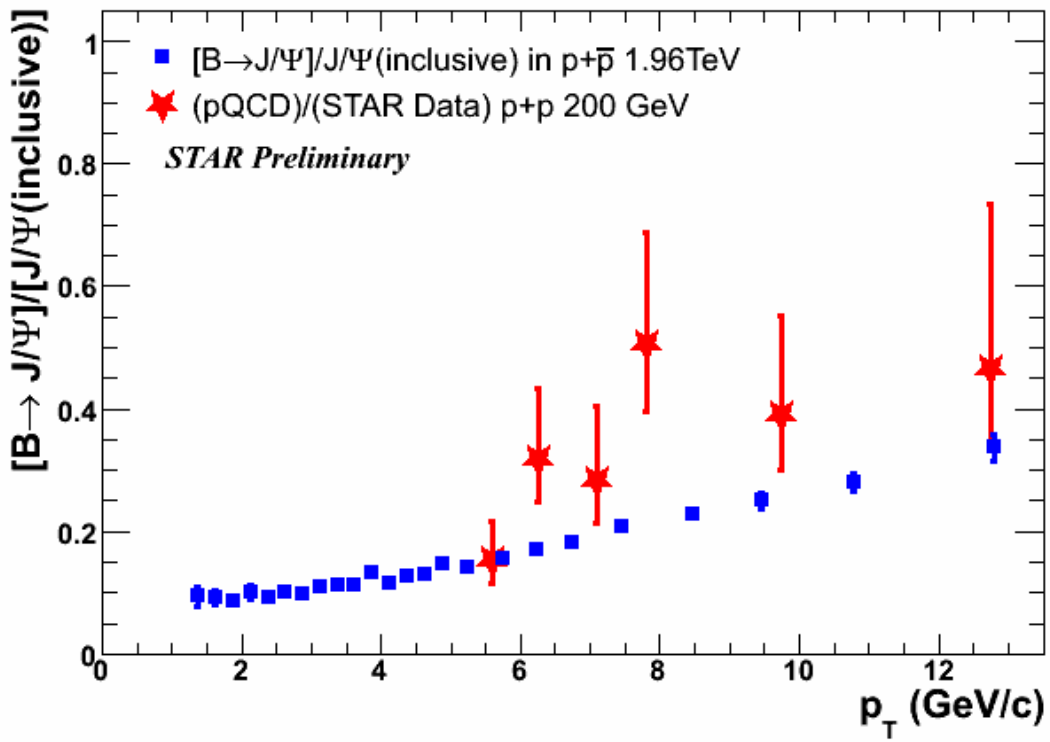
PRL 98, 182301(2007) and hep-ph/0607062

(B→ J/ ψ)/(inclusive J/ ψ)



1) Generated B spectrum is from pQCD

M. Cacciari, P. Nason and R. Vogt

PRL 95(2005),122001

2) Decay B→J/ψ, kinematics and branch ratio are from CLEO measurements

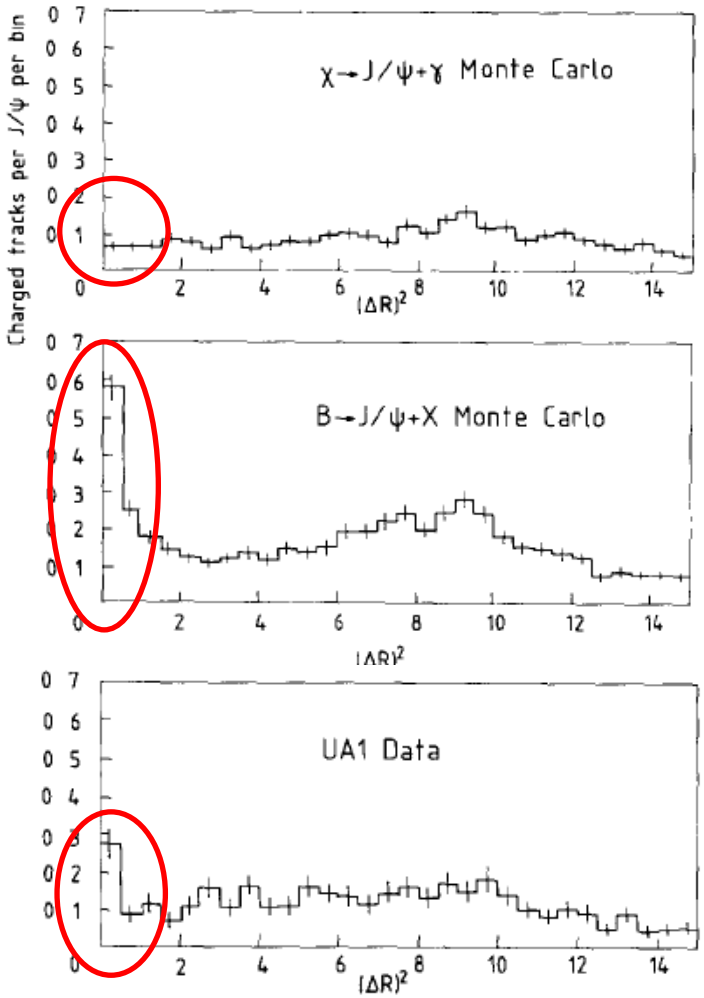
CLEO collaboration

PRL 89(2002),282001

- Can be used to constrain B production
- B→J/ψ contributes significantly to the inclusive J/ψ yields at high p_T (>5 GeV/c)

  Assuming B production from pQCD
  (no experimental B spectra at RHIC yet)

Disentangle contributions via Correlations



$$(\Delta R)^2 = (\Delta\eta)^2 + (\Delta\phi)^2$$

J/ψ–hadron correlation:

$\Leftrightarrow$ **1)** $g + g \rightarrow \chi + g$

$\rightarrow J/\psi + \gamma$

no near side correlation

$\Leftrightarrow$ **2)** $g + g \rightarrow b + \bar{b}$

$\rightarrow B_{hadron} + X$

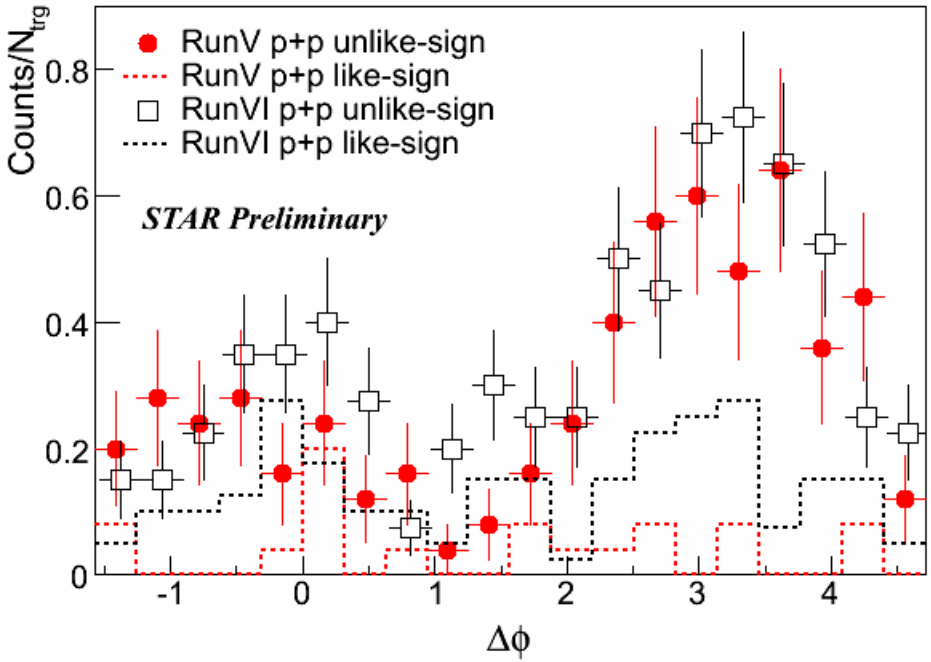
$\rightarrow J/\psi + X$

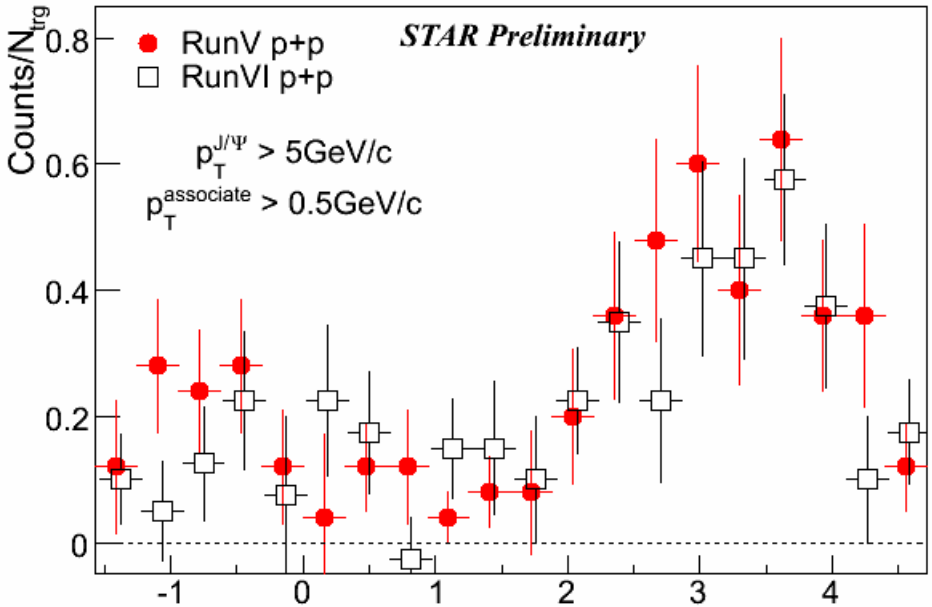
strong near side correlation

J/ψ–hadron correlation can shed light on different source contribution to J/ψ production

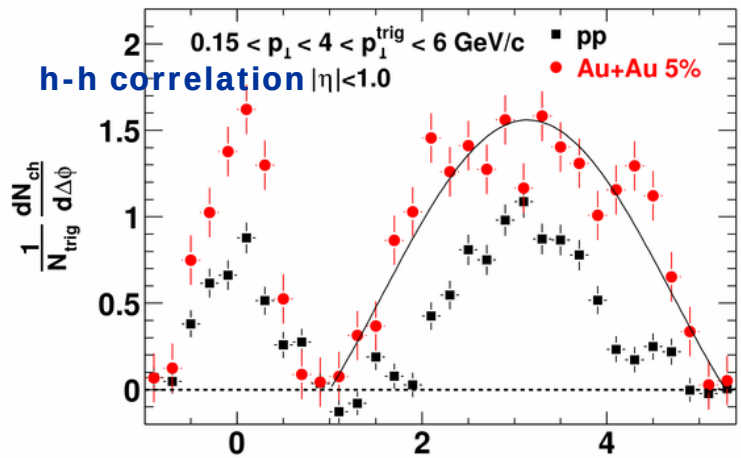
PLB 200, 380(1988) and PLB 256,112(1991)

J/ψ–hadron correlation in p+p



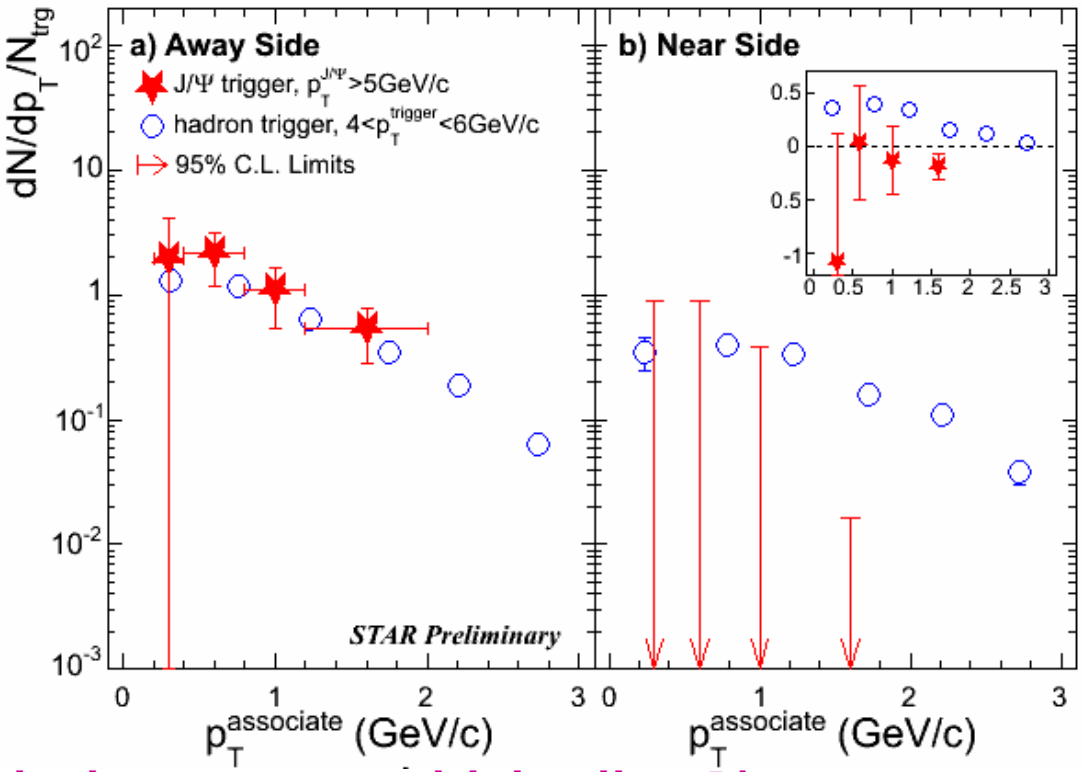


- Charged hadrons from TPC: $|\eta|<1$, $p_T>0.5$ GeV/c
- No significant near side J/ψ–hadron azimuthal angle correlation
- Constrain B meson's contribution to J/ψ yield



PRL 95,152301(2005)

Yields in near/away side



Associated hadron spectra with leading J/ψ:

- Away side: consistent with leading charged hadron correlation measurement (h-h)
  ➔away-side from gluon or light quark fragmentation
- Near side: consistent with no associated hadron production
  B➔J/ψ not a dominant contributor to inclusive J/ψ

Summary

- **J/ψ signal in 200 GeV p+p collisions at STAR/RHIC**
  - ✓Cover p_T range from 5GeV/c to ~14 GeV/c
  - ✓High p_T J/ψ follows x_T scaling with n=5.6
  - ✓Can be used to constrain B production
    If assume B spectra from pQCD
    => B→J/ψ contributes 20%-40% to inclusive J/ψ

- **J/ψ signal in 200 GeV Cu+Cu collisions at STAR/RHIC**
  - ✓Extend R_{AA} from p_T = 5 GeV/c to 10 GeV/c
  - ✓Indication of R_{AA} increasing at high p_T

- **J/ψ–hadron azimuthal correlation in p+p**
  - ✓no significant near side correlation
    ←Expect strong near-side correlation from B→J/ψ+X
    ←Need further quantify contributions
    by modeling J/ψ-h correlation
  - ✓Away-side spectra consistent with h-h correlation
    →indicates gluon or light quark fragmentation

Outlook

- **Coming soon**

  RunVII 200GeV Au+Au data is under production

- **In the near future**
  - DAQ1000 and high luminosity→ enhance statistics
  - Time Of Flight → electron ID at low-pt
  - Heavy Flavor Tracker → reject γ conversion background

    J. Kapitan, poster 156

    → topologically reconstruct J/ψ from B decay
  - Muon Telescope Detector → muon ID

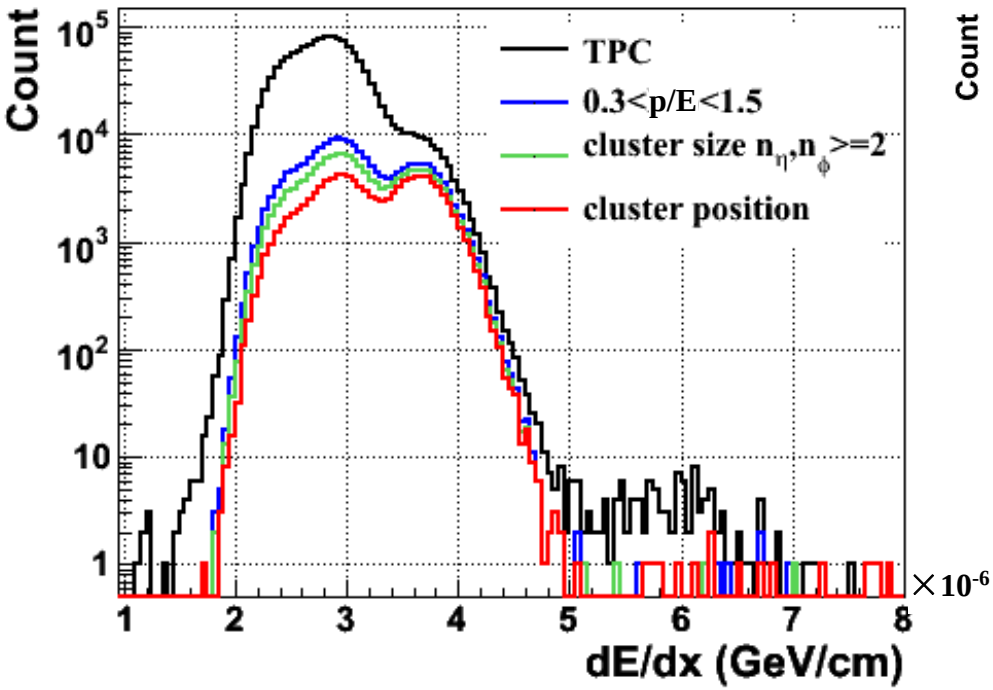
    L. Ruan, poster 181

Thanks!

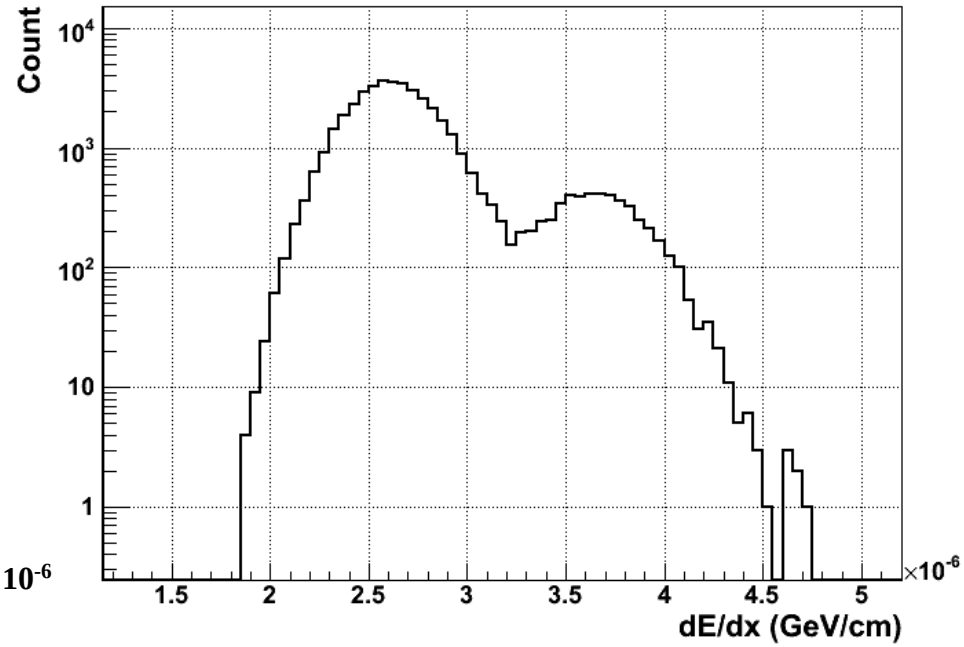
Back up slides

Electron ID

TPC+EMC, p_T>2 GeV/c



TPC only, 1.2<p_T<2 GeV/c



- EMC can trigger and identify high p_T electrons
- TPC dE/dx can reduce background for lower p_T electrons