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J/ψ production at high p_T at STAR

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arXiv:0904.0439

Outline

- **Motivation**
- **Spectra in p+p and Cu+Cu**
- **R_{AA} (Cu+Cu/p+p)**
- **J/ψ–hadron correlations**
- **Summary**

J/ψ(1S) PDG values:

Mass m = 3096.916 ± 0.011MeV

Full width Γ = 0.0934 ± 0.0021MeV

J/ψ→e^+e^- branch ratio: (5.94 ± 0.06) %

Rare probe at RHIC
B*dN/dy ~10^{-6} in p+p

High p_T J/ψ in A+A collisions

- **As a probe of the hot dense medium**

  J/ψ dissociation due to color screening → Signature of the QGP formation

  T. Matsui and H. Satz, PLB178, 416 (1986)

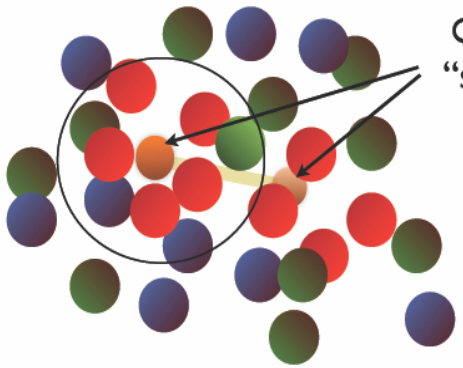
- **Test hot wind dissociation**

  dissociation temperature decrease as p_T

- **Investigate heavy quark energy loss**

  open charm vs. hidden charm

Screening in a deconfined medium: effective charge of Q and $\bar{Q}$ reduced

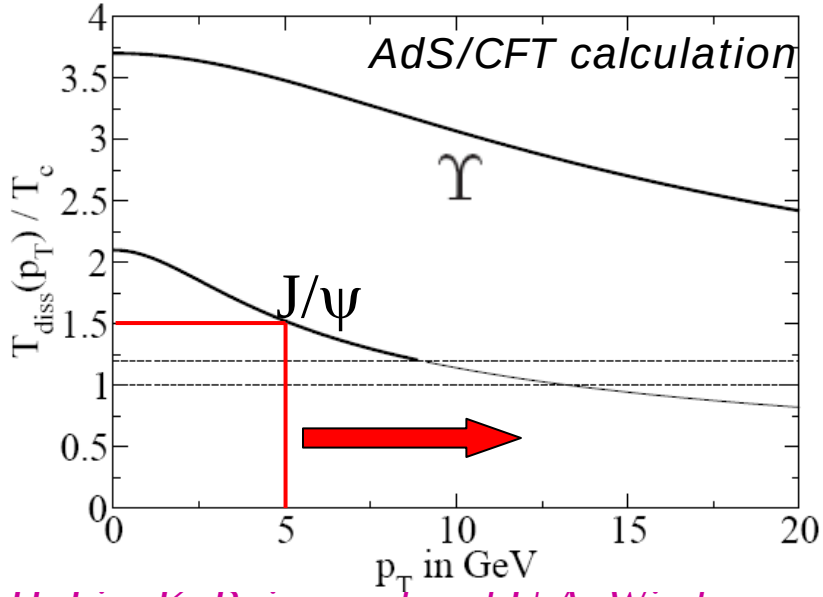


Q and $\bar{Q}$ cannot "see" each other

$r_D < r_{Q\bar{Q}}$

Assume: medium effects described with a T-dependent potential

$$-\frac{\alpha_{eff}}{r} e^{-r/r_D(T)}$$



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

High p_T J/ψ in p+p collisions

- **Baseline for A+A**
- **Production mechanism**

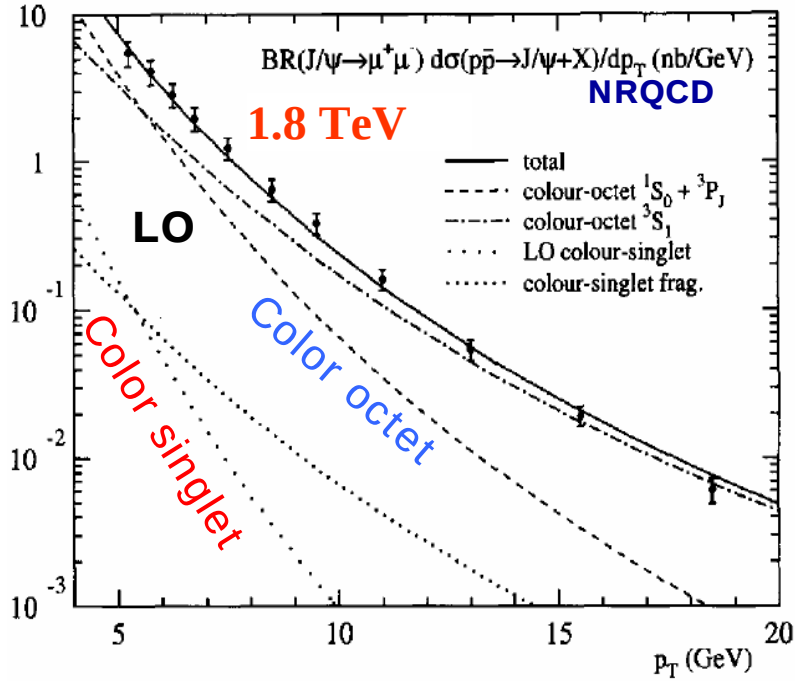
Color singlet model (CSM):

underpredicted CDF data by order of magnitude

Color octet model (COM):

good agreement with CDF cross section

disagreement with CDF polarization

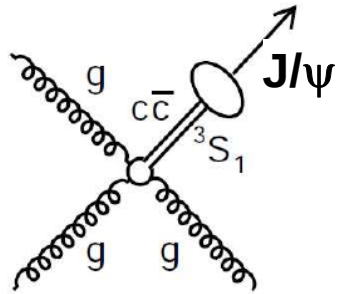


Both have improvements by including NLO and/or NNLO*

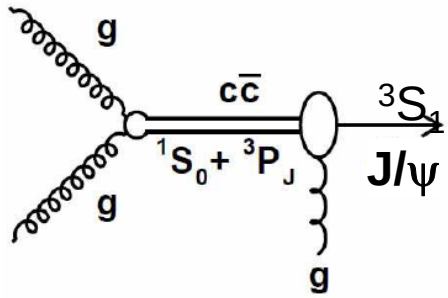
But only applicable at intermediate/high p_T (p_T>3-7 GeV/c)

- **Feeddown**

B→J/ψ through J/ψ-hadron correlation



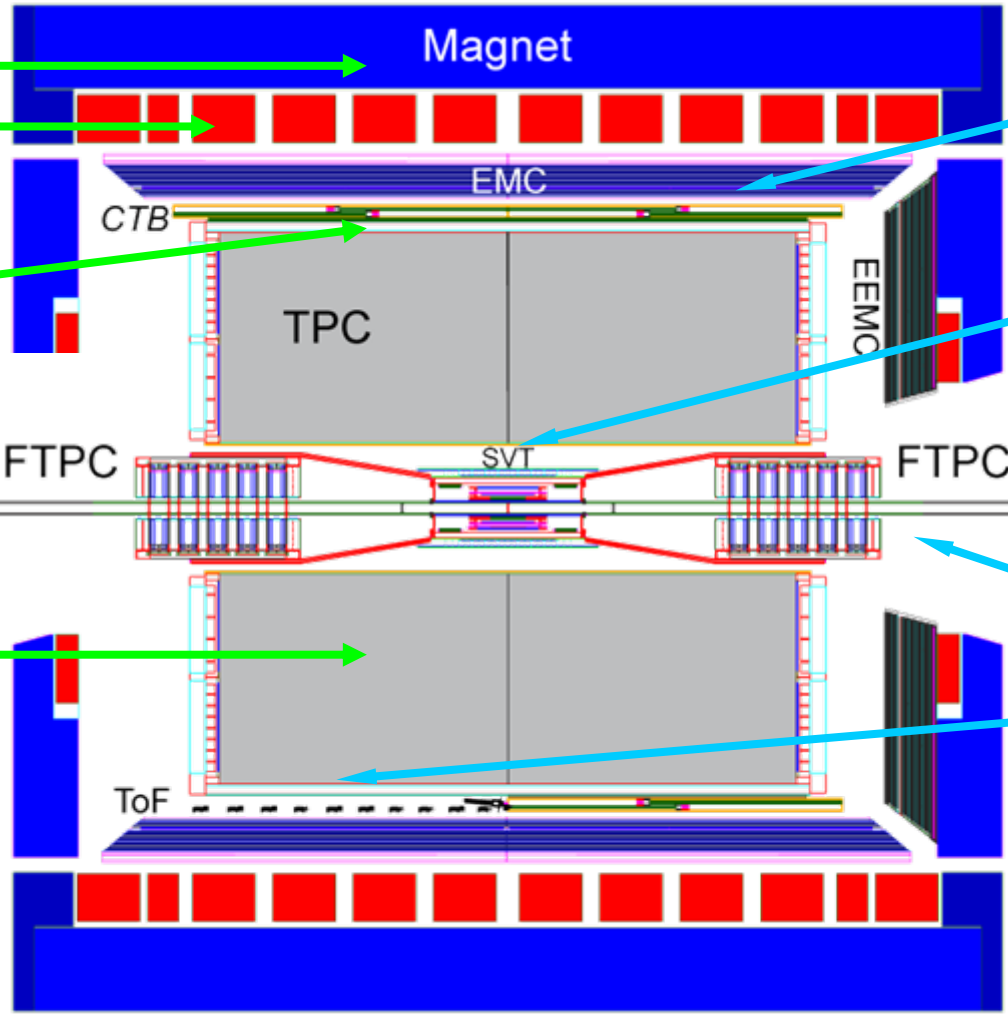
LO CSM



LO COM

STAR Detector

Large acceptance: 2π coverage at mid-rapidity



Magnet

Coils

Central Trigger Barrel (CTB)

ZCal

Time Projection Chamber (TPC)

Year 2000

Barrel EM Cal (BEMC)

Silicon Vertex Tracker (SVT)
Silicon Strip Detector (SSD)

TPC+EMC for this analysis

FTPC
Endcap EM Cal
FPD

TOFp, TOFr

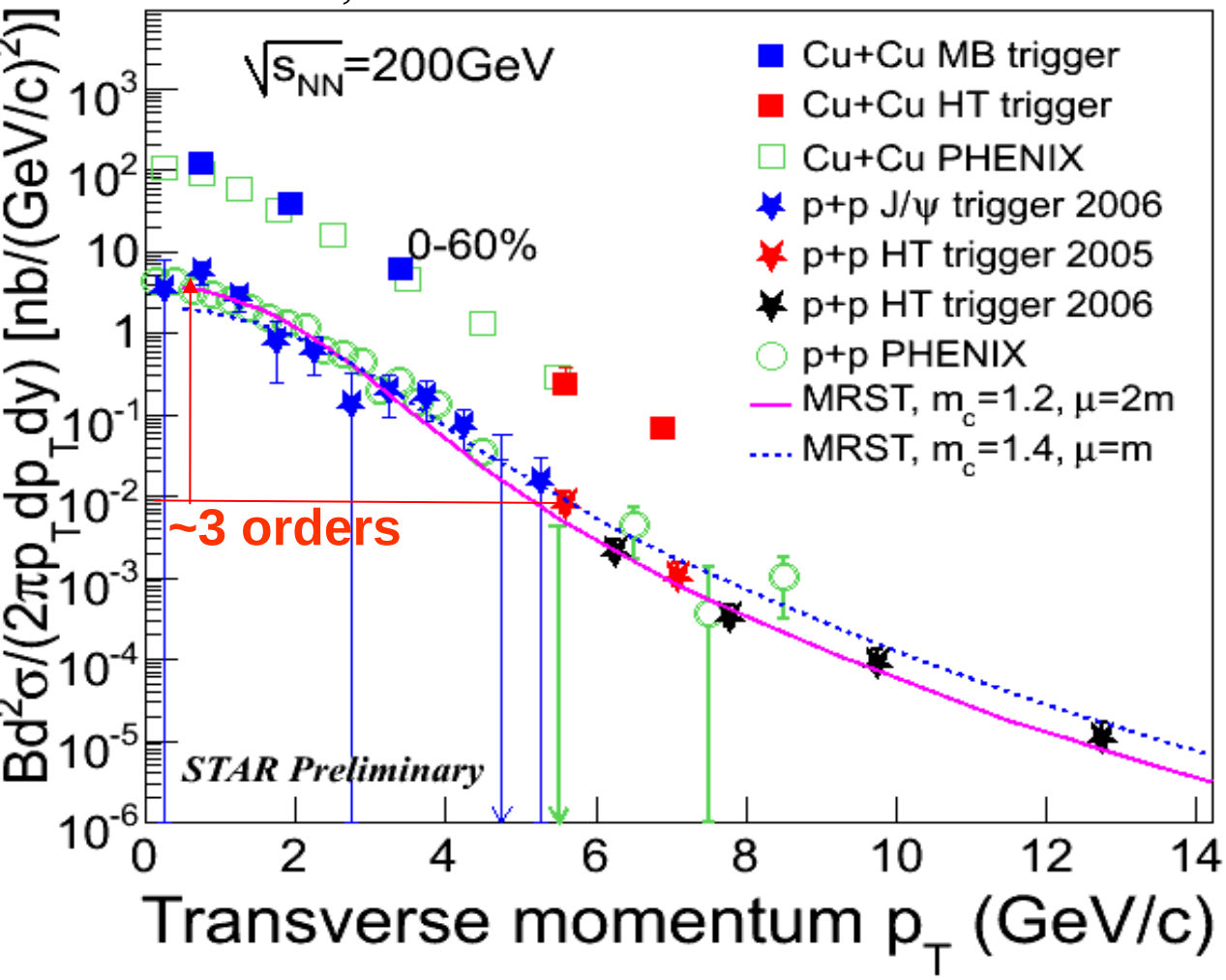
PMD

Year 2001+

Future upgrade: Time of Flight, DAQ1000, Heavy Flavor Tracker, Muon Telescope Detector

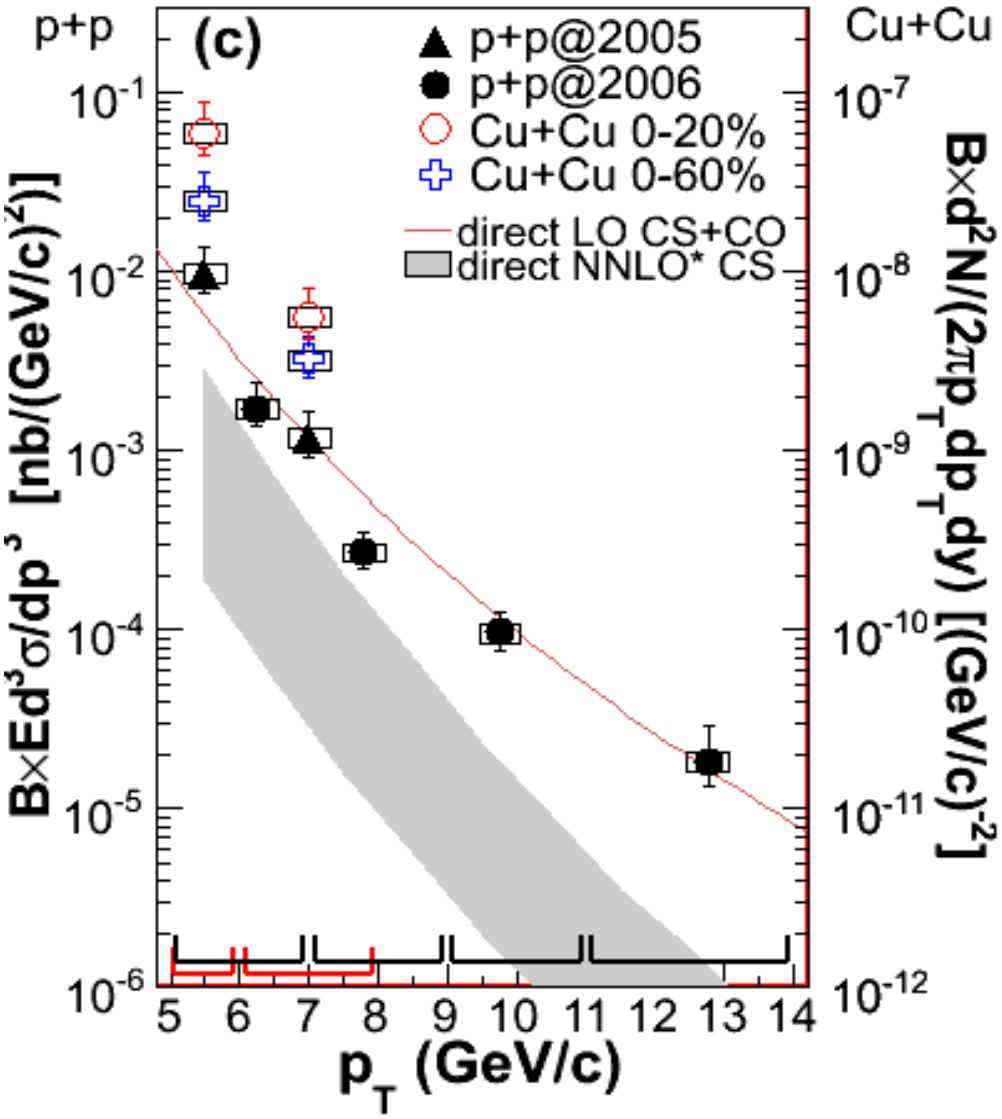
J/ψ spectra in p+p and Cu+Cu

ZBT, WWND2009



- **Used EMC triggered events to take advantage of the high luminosity**
- **Significantly extend p_T range of previous measurements in p+p at RHIC to 14 GeV/c**

J/ψ p_T spectra



Model comparisons:

Color singlet model: direct NNLO* still miss the high p_T part. P. Artoisenet et al., Phys. Rev. Lett. 101, 152001 (2008), and J.P. Lansberg private communication.

LO CS+CO: better agreement with the measurements, leave little room for higher charmonium states and B feeddown contribution. G. C. Nayak, M. X. Liu, and F. Cooper, Phys. Rev. D68, 034003 (2003), and private communication.

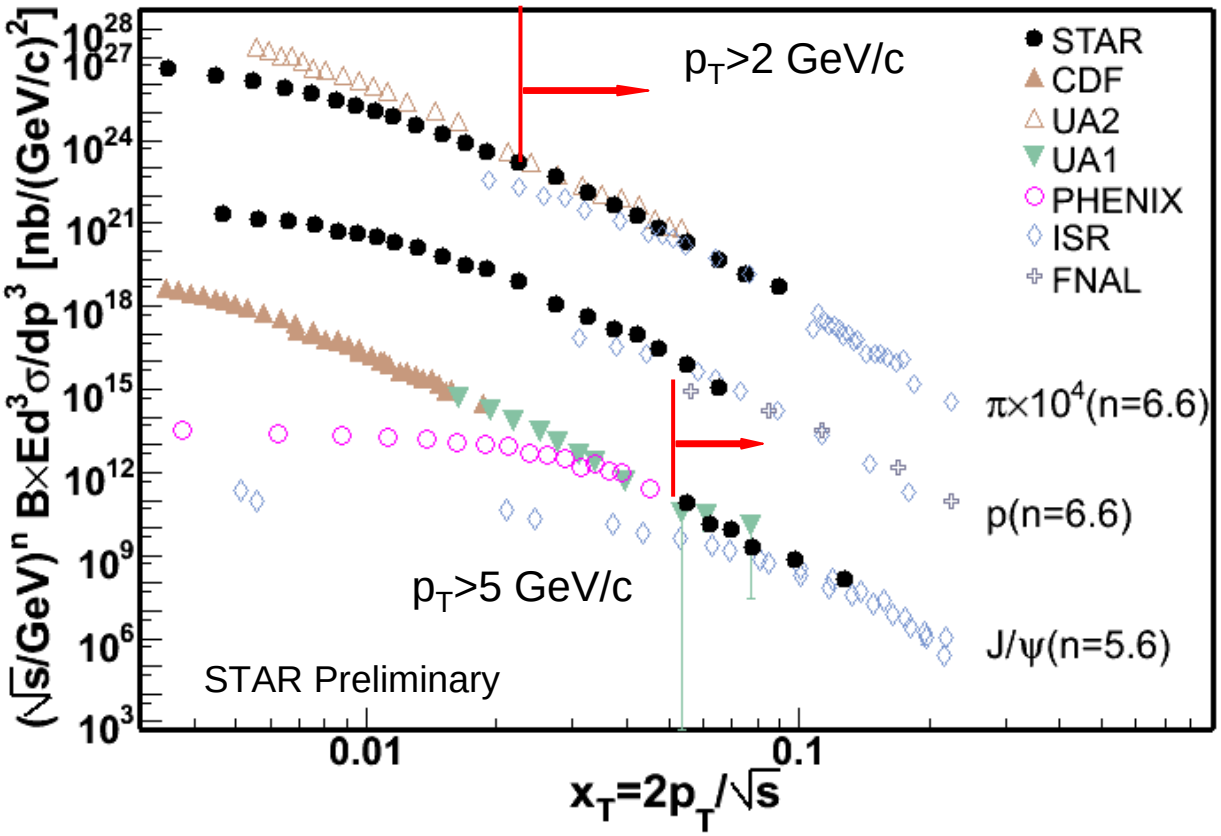
CS and LO CS+CO have different power parameters → different diagram contribution?

power parameter:

n=8 for NNLO CS

n=6 for LO CS+CO

x_T scaling in p+p collisions



$$E\frac{d^3\sigma}{dp^3}=\frac{g(x_T)}{s^{n/2}}$$

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

n=8: diquark scattering

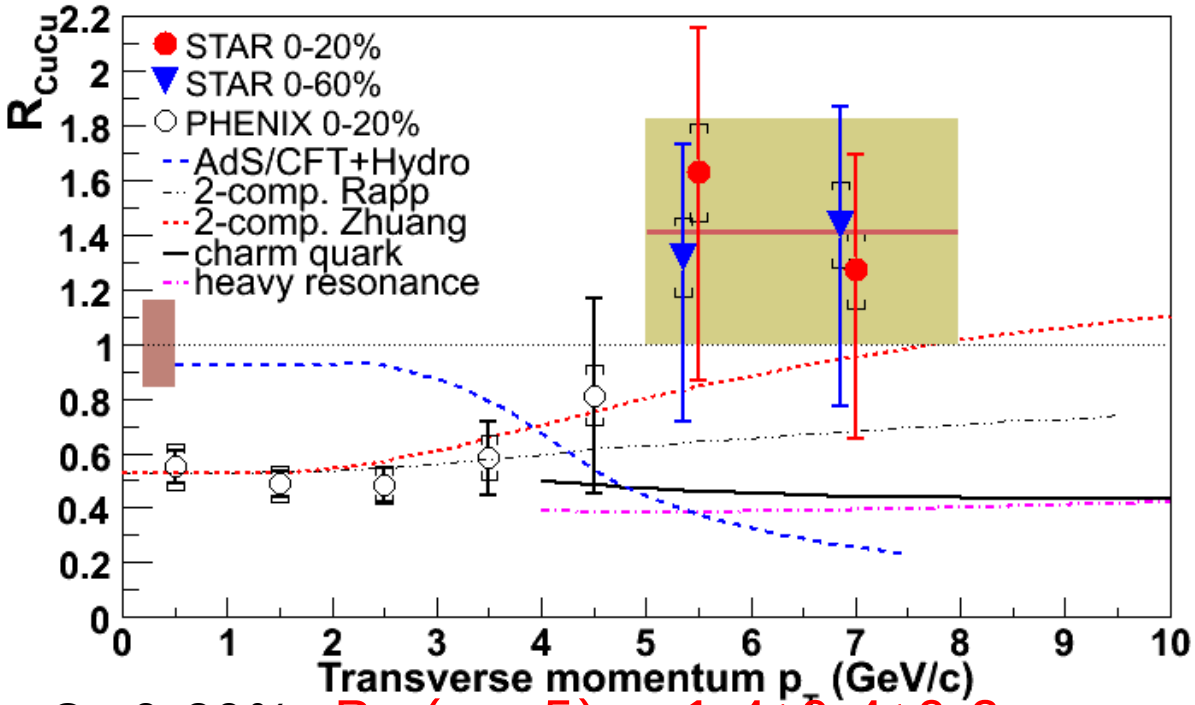
n=4: QED-like scattering

π and proton at p_T>2 GeV/c: n=6.6±0.1 (PLB 637, 161(2006))

J/ψ at high p_T: n=5.6±0.2 (close to CS+CO prediction)

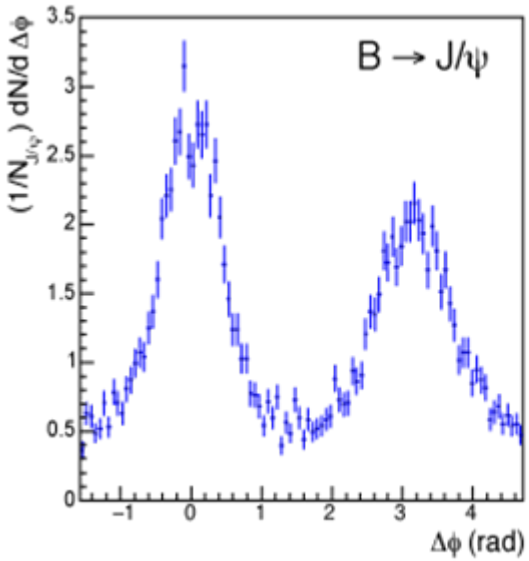
Soft processes affect low p_T J/ψ production

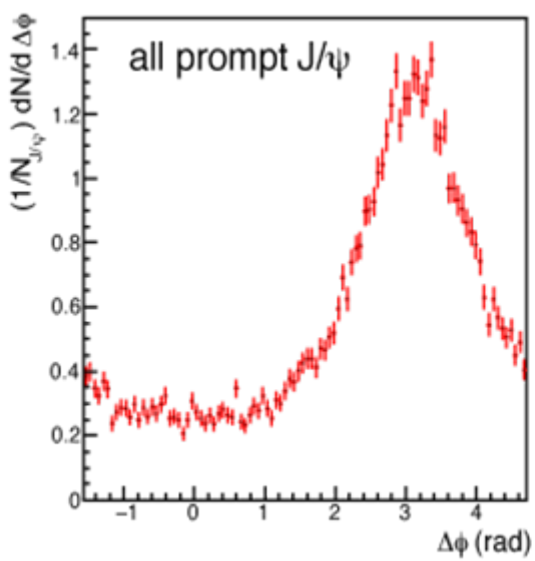
Nuclear Modification Factor R_{AA}

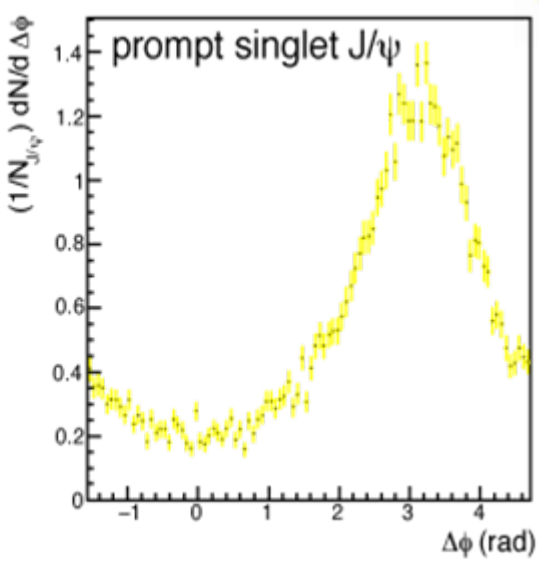


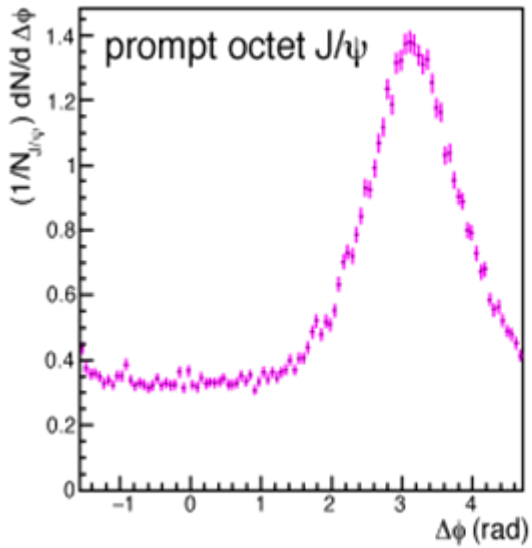
- STAR Cu+Cu 0-20%: $R_{AA}(p_T>5) = 1.4\pm0.4\pm0.2$
  - **The only hadron no suppression at high p_T in RHIC Heavy-ion collisions**
  - **Contrast to open charm, CS vs. CO? CNM effect? Formation Time?**
- R_{AA}>AdS/CFT+Hydro, 99% C.L.
  Contrast to AdS/CFT+Hydro prediction
- **2-component model describes the overall trend**

Disentangle contributions via Correlations





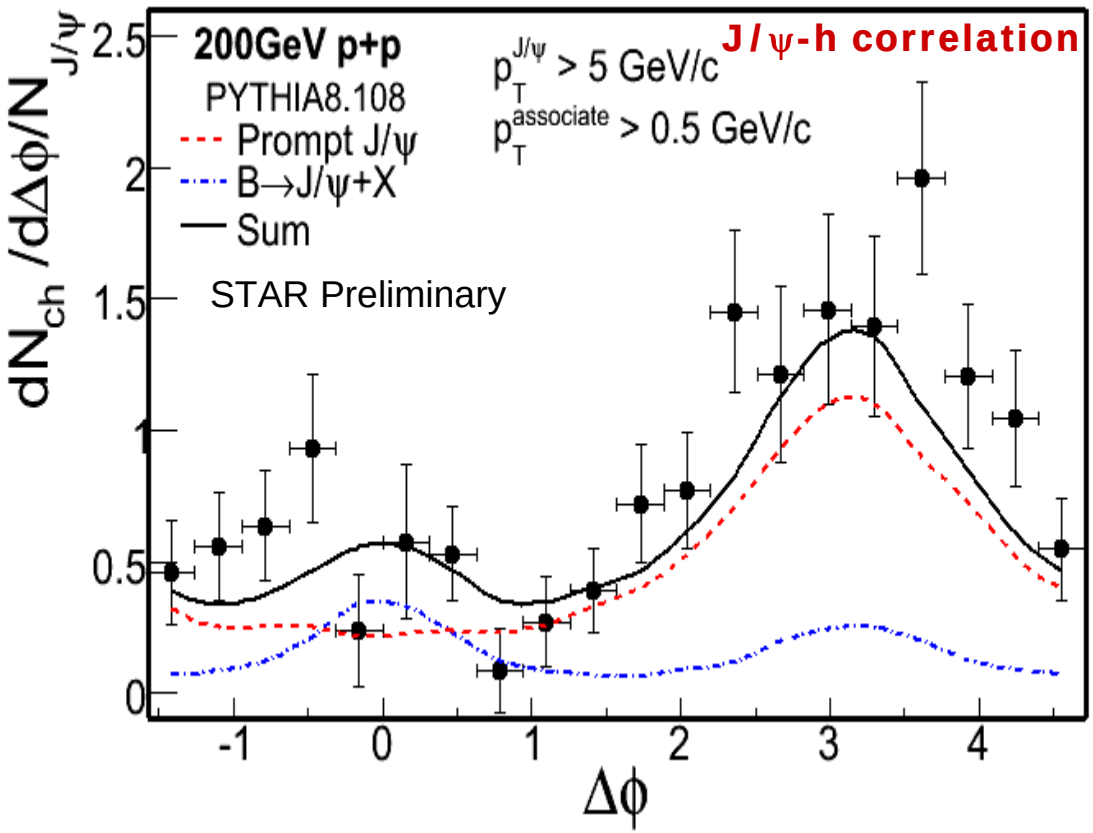


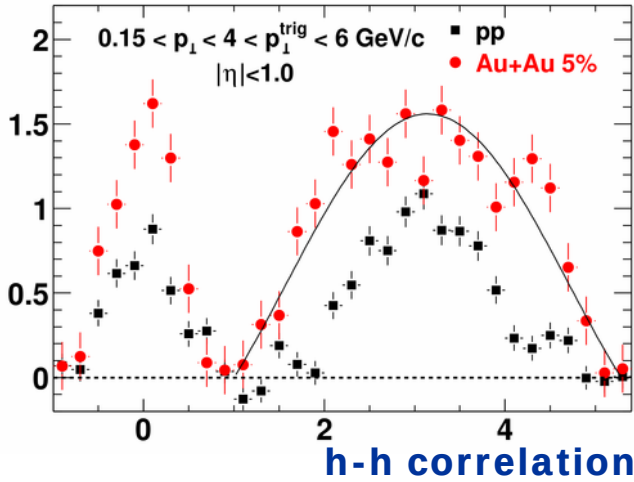


- B→J/ψ, strong near side correlation
- prompt J/ψ, no near side correlation

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

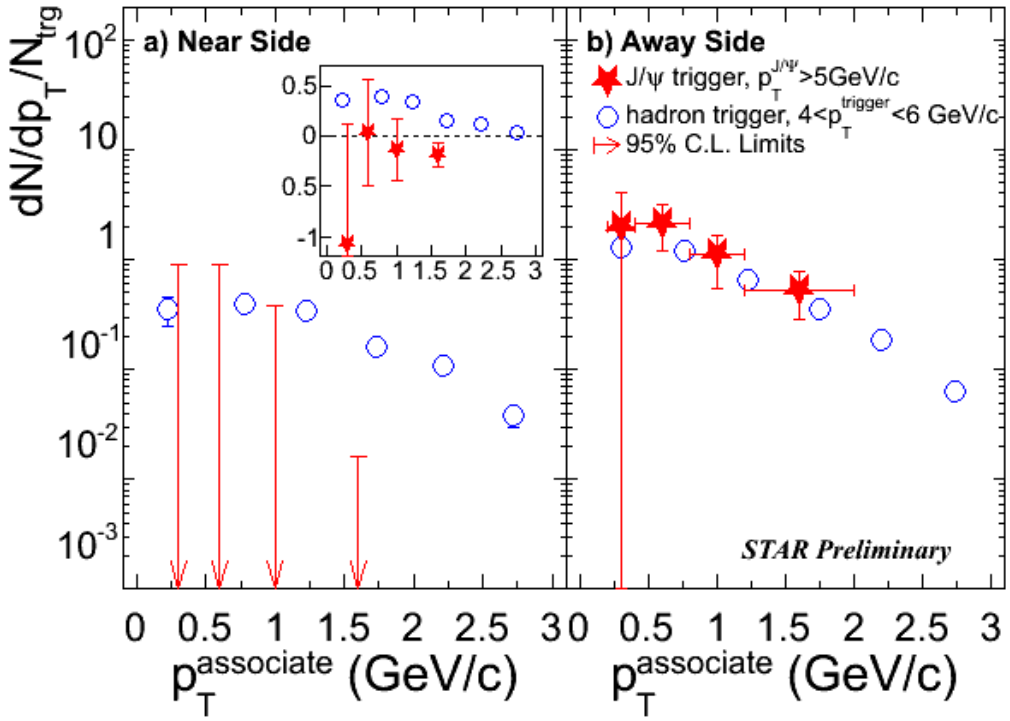
Constrain bottom contribution





- **No significant near side J/ψ-hadron azimuthal angle correlation**
- **Correlations shows low B contribution (13 ± 5) %**
- **Can used to further constrain B yields**

Yields in near/away side



Associated hadron spectra with leading J/ψ:

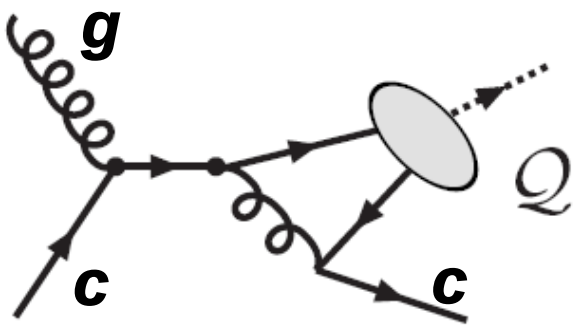
Near side: Consistent with no associated hadron production

Away side: **Consistent with h-h correlation**

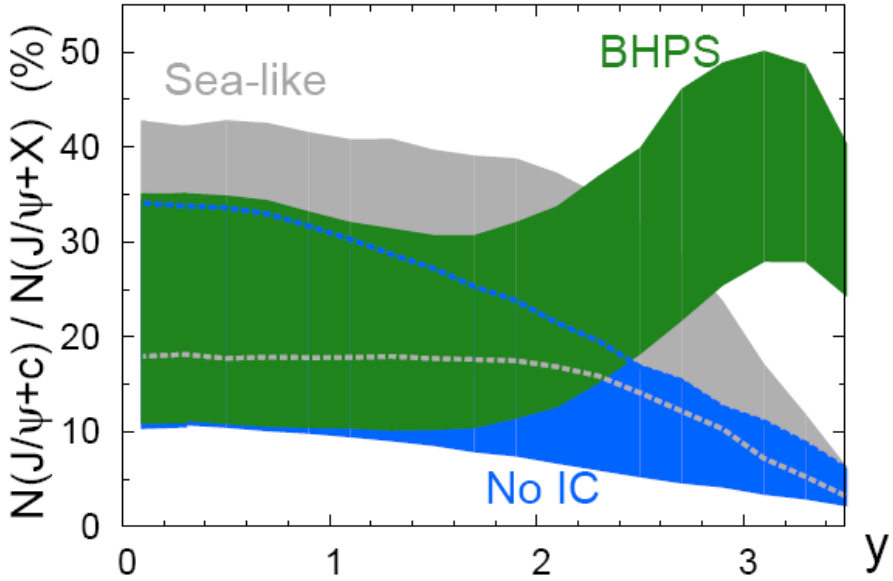
➔**away-side from gluon or light quark fragmentation?**

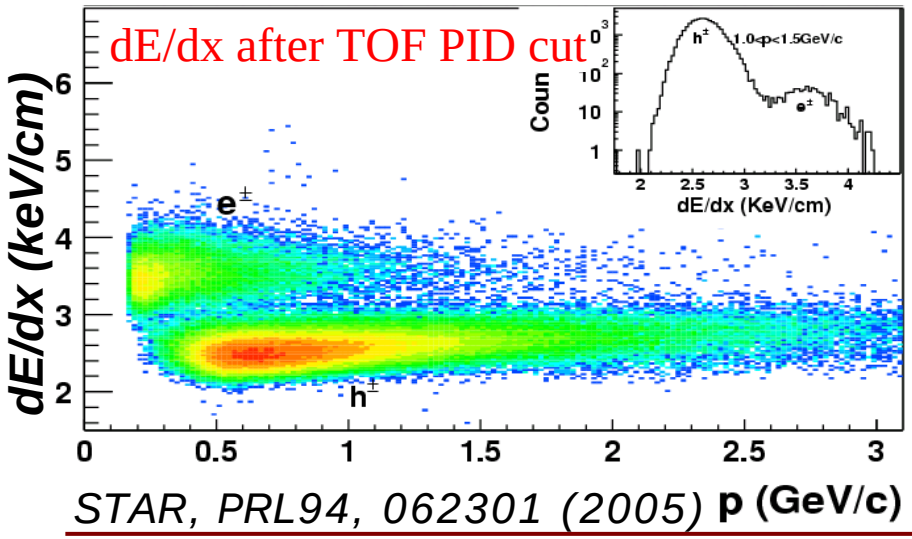
More statistics and/or alternative probe on the experiment side

Further constrain on cg fusion



arXiv: 0908.0754





STAR, PRL94, 062301 (2005)

J/ψ associate with a single charm jet on the away side

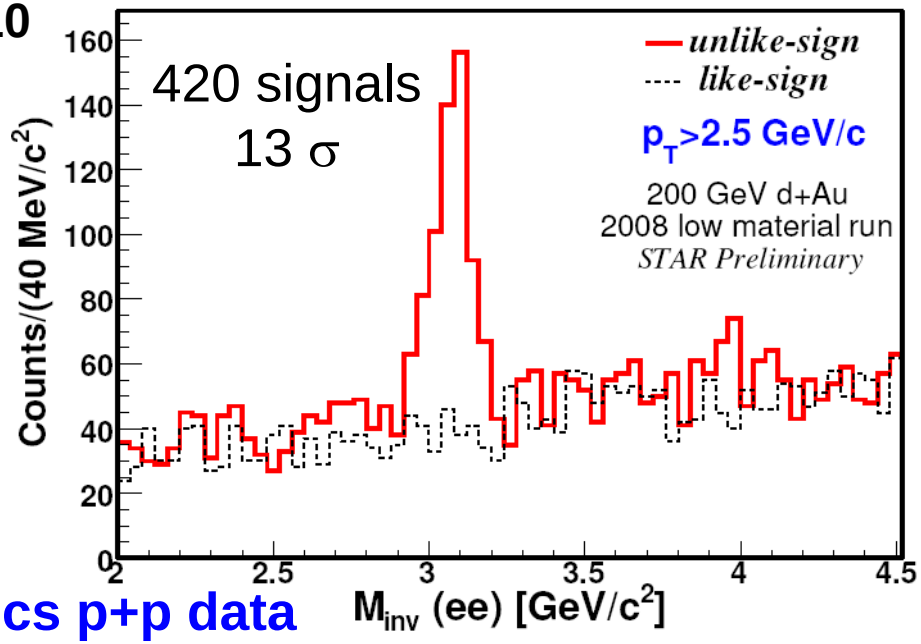
J/ψ-electron correlation (TOF)
J/ψ-muon correlation (MTD)

at STAR will shed light on the importance of this process

Current/Future High-p_T J/ψ at STAR

Removed inter tracks in 2008
Reduced material budget by a factor of ~10
DAQ1000 installed in 2009
TOF had 75% in 2009, 100% in 2010

ZBT, QM2009



On-going analyses:

1. High-pT J/ψ using 2008 d+Au data

13 σ signals observed (4x previous p+p)

Important for Cold Nuclear Matter (**CNM**) effects (gluon showing, cronin effect, nuclear absorption, co-mover etc.)

2. High-pT J/ψ using 2009 high statistics p+p data

~15 σ signal with **S/B~10** using **~1/5** of full statistics

precise measurement on spectra (>1000 counts at p_T>2 GeV/c)

trigger p_T and associated tracks p_T dependent J/ψ-h correlations

J/ψ-charm correlation

500 GeV p+p data
Au+Au 200 GeV and low energy scan
TOF (completed), MTD and HFT

- J/ψ spectra
- ψ(2S)
- χ_c
- J/ψ-hadron correlation
- Isolated J/ψ
- J/ψ in Jet

Summary

- **J/ψ spectra in 200 GeV p+p collisions at STAR**
  - **Significantly extend previous measurement from 5 GeV/c to ~14 GeV/c, provide powerful tool to constrain model calculations**
  - High p_T J/ψ follows x_T scaling with n=5.6, consistent with COM slope
  - Low p_T J/ψ deviates from x_T scaling suggests soft process can affect low p_T J/ψ production.
- **J/ψ spectra in 200 GeV Cu+Cu collisions**
  - **First observation of no suppression for hadron at high p_T at STAR**
  - Indication of R_{AA} increasing from low p_T to high p_T
  - Contrast to AdS/CFT prediction
- **J/ψ–hadron azimuthal correlation in p+p**
  - **First quarknonium-hadron correlation measurement at RHIC**
  - No significant near side correlation
  - B→J/ψ contribution = 13±5% (p_T>5 GeV/c)

Thank you!