J/ψ production in Au+Au and Cu+Cu collisions at $\sqrt{s}$ =200 GeV at STAR

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Outline

- Motivation
- Electron identification & J/ψ reconstruction
- Results

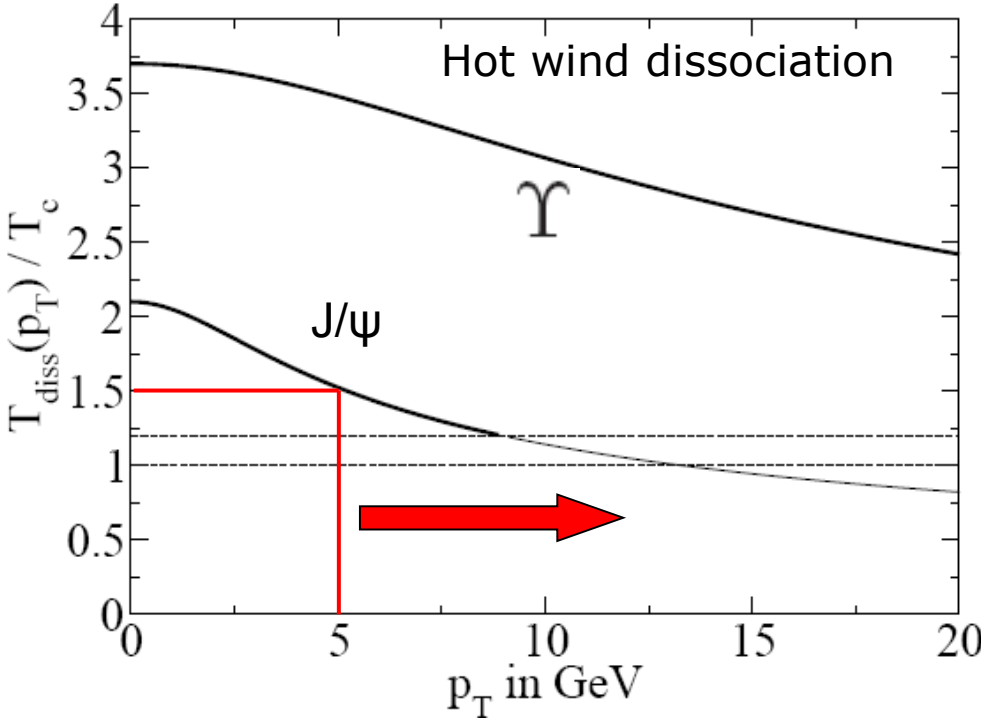
Why J/ψ?

- Charm quarks
  - large mass → produced in the initial hard parton-parton interactions
  - excellent tool to study properties of the hot and dense matter created in A+A 200GeV collisions
- J/ψ suppression – classic QGP signature T. Masui, H. Satz, Phys. Lett. B178, 416 (1986).
- low-p_T J/ψ suppression at RHIC similar to one at SPS
  - suppression vs. regeneration? P. Braun-Munzinger and J. Stachel, Phys. Lett. B490,196 (2000); L. Grandchamp and R. Rapp, Phys. Lett. B523, 60 (2001); M. I. Gorenstein et al., Phys. Lett. B524, 265 (2002); R. L. Thews, M. Schroedter, and J. Rafelski, Phys. Rev. C63, 054905 (2001); Yan, Zhang and Xu, Phys.Rev.Lett.97, 232301 (2006);
  - sequential melting of charmonia states? F. Karsch, D. Kharzeev and H. Satz, PLB 637, 75 (2006); B. Alessandro et al. (NA50), Eur. Phys. J. C 39 (2005) 335; H. Satz, Nucl. Phys. A (783):249-260(2007)
  - …

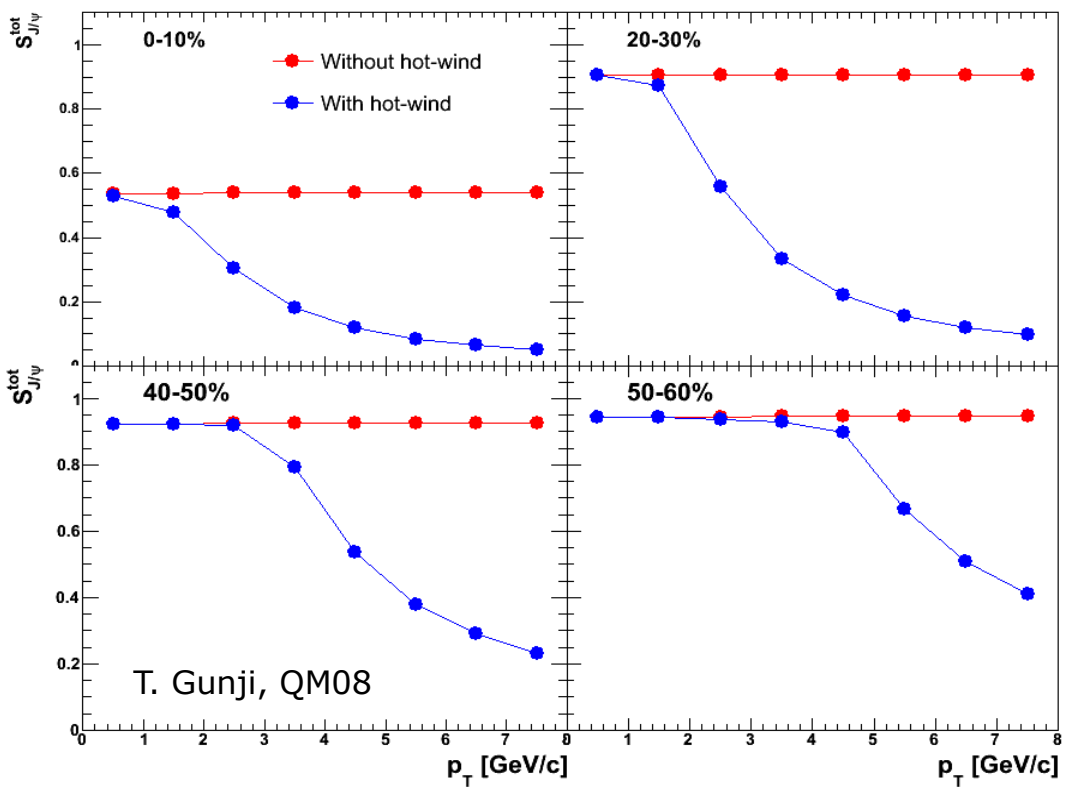
Why J/ψ?

- Hot wind dissociation → high p_T direct J/ψ suppression

(H. Liu, K. Rajagopal and U.A. Wiedemann, PRL 98, 182301(2007) and hep-ph/0607062, M. Chernicoff, J. A. Garcia, A. Guijosa hep-th/0607089)

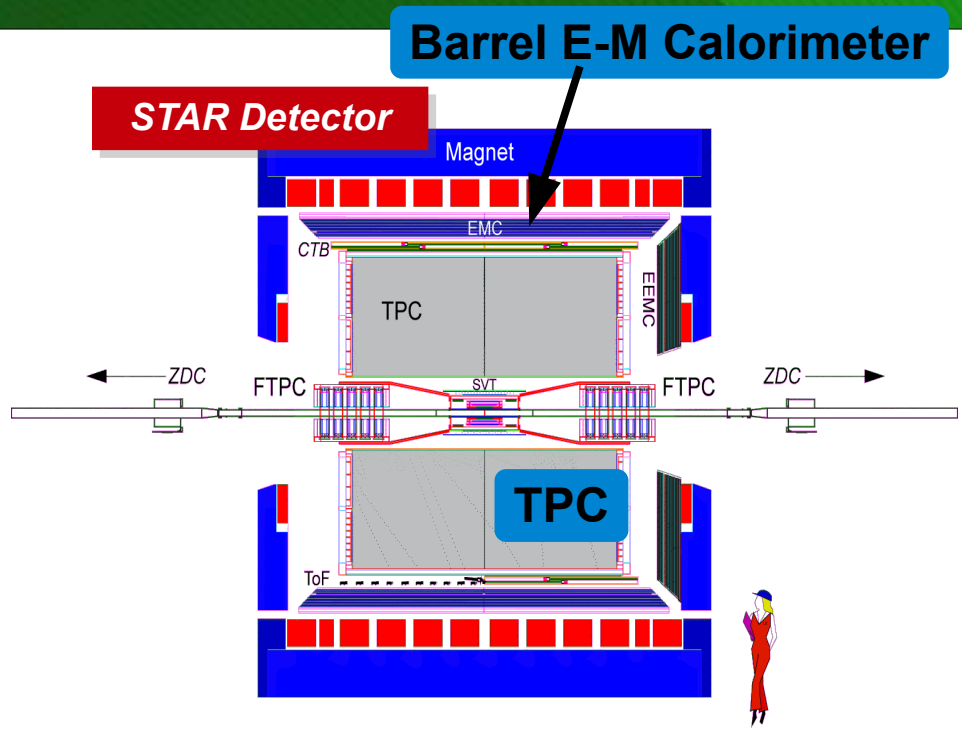


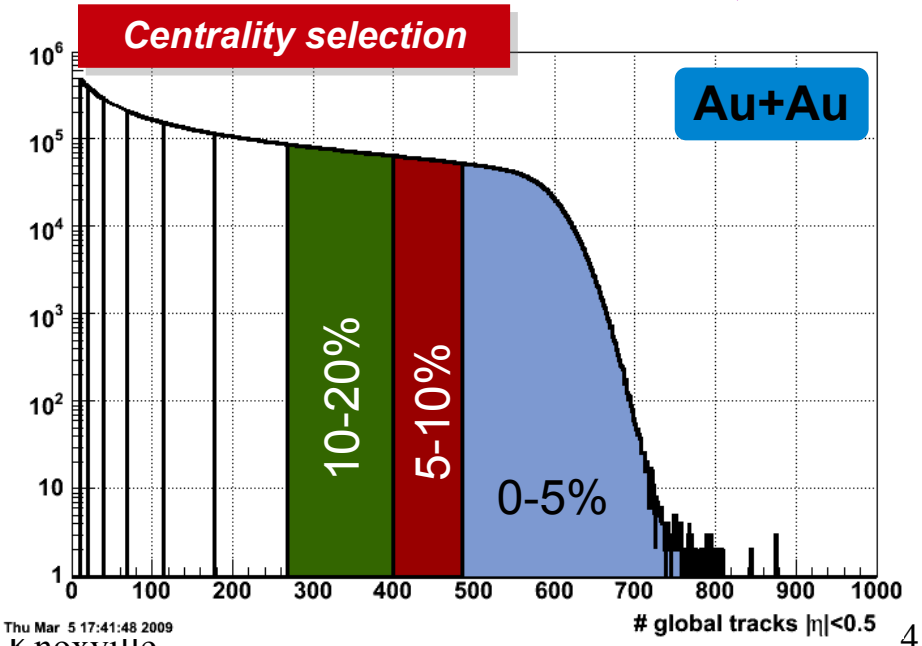
AdS+CFT with hydro



J/ψ measurement – low p_T J/ψ

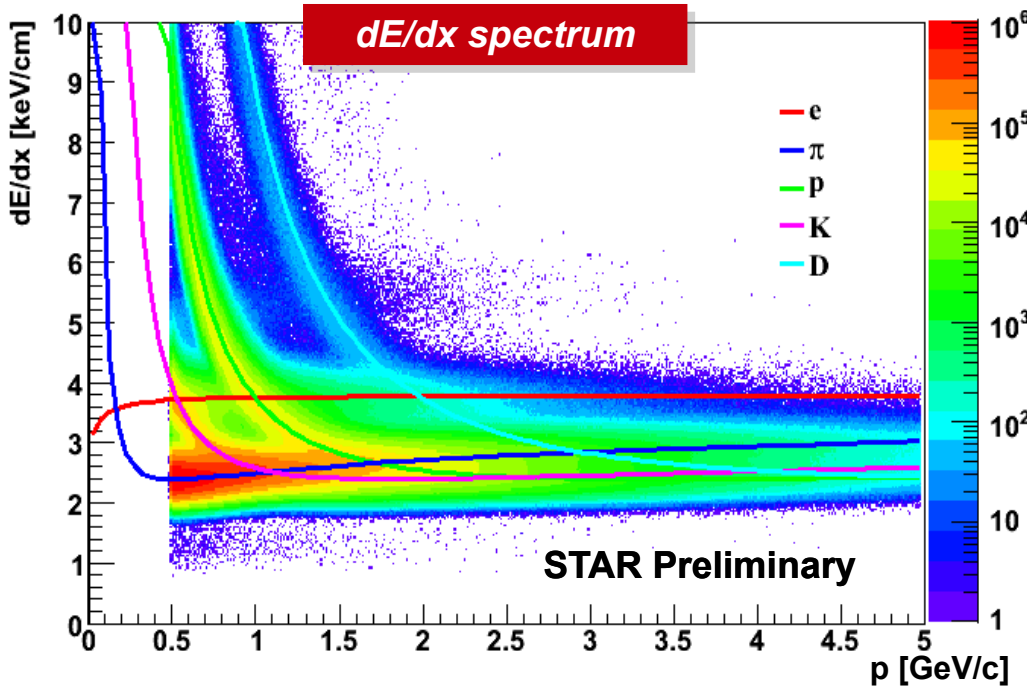
- Dataset:
  - Min-bias Cu+Cu (0-60%), 27M
  - Min-bias Au+Au (0-80%), 64M
  - $\sqrt{s}$=200 GeV
- Di-electron decay channel:
  - ***J/ψ→e⁺e⁻ (6%)***
- J/ψ reconstruction
  - Electron identification:
    - Cu+Cu – dE/dx (TPC)
    - Au+Au – dE/dx (TPC) + p/E (BEMC)
  - Background estimated by event mixing





Electron identification – low p_T J/ψ

- Single electron p_T cut:
  - Au+Au: p_T > 1.2 GeV/c
  - Cu+Cu: p_T > 1.1 GeV/c



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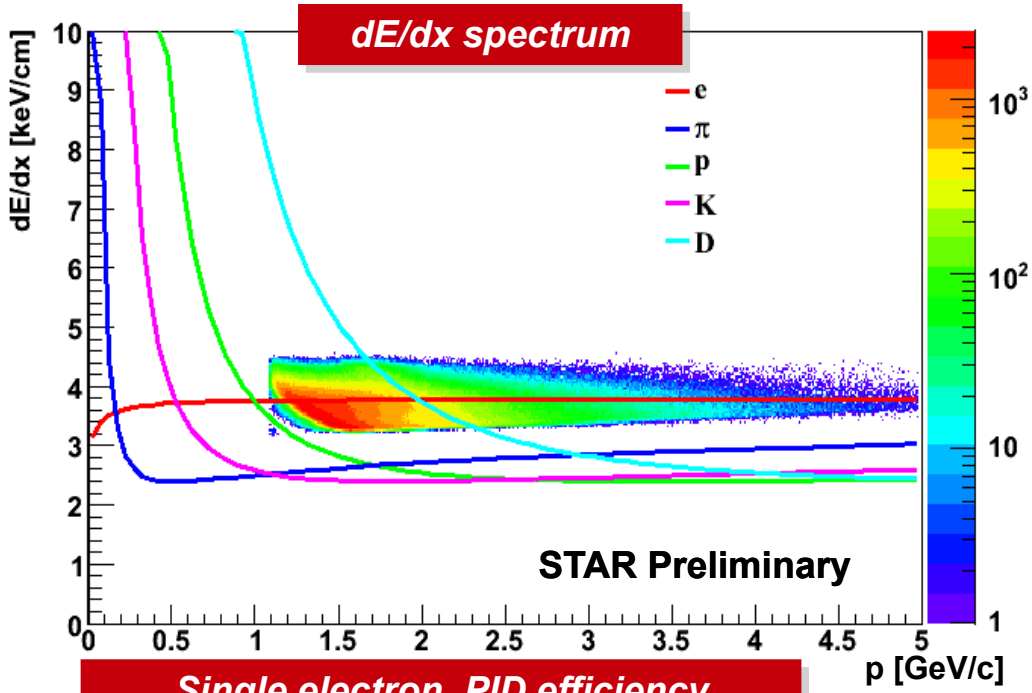
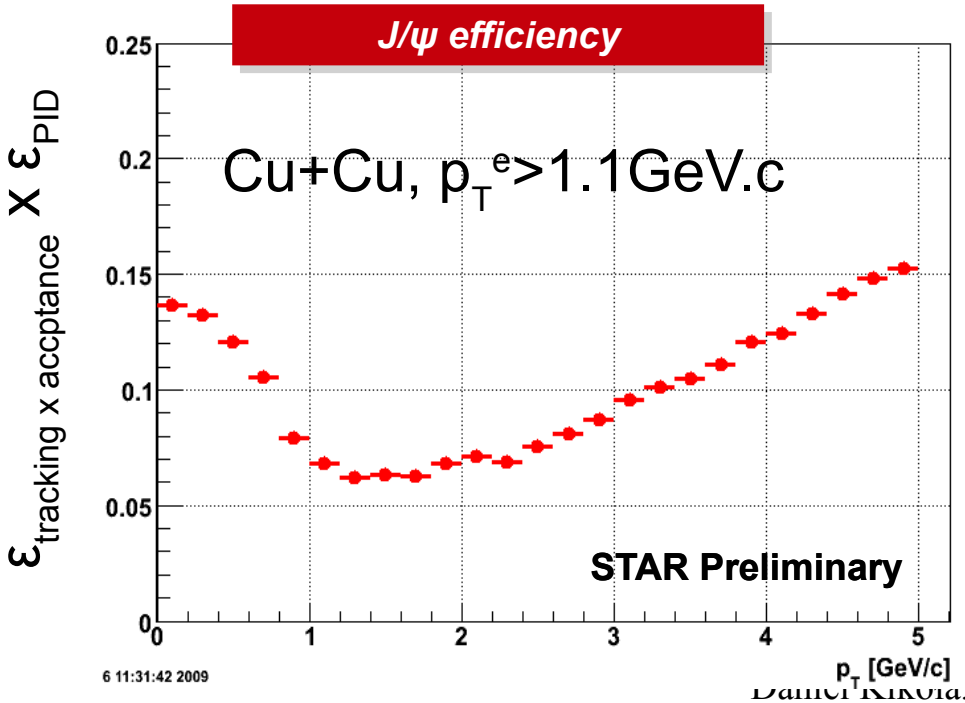
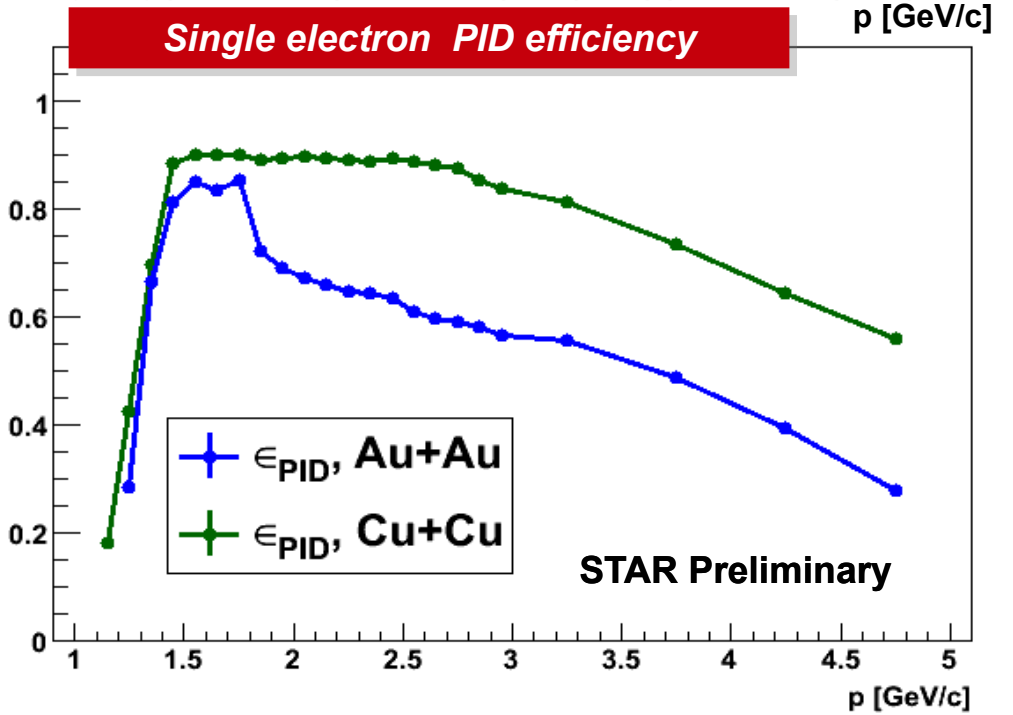
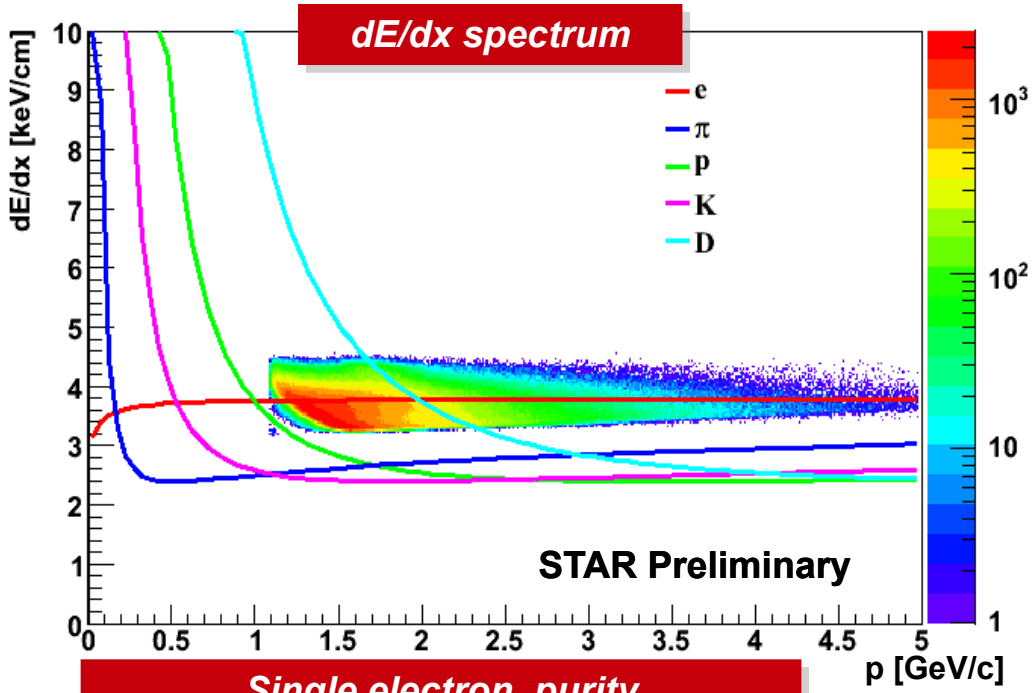


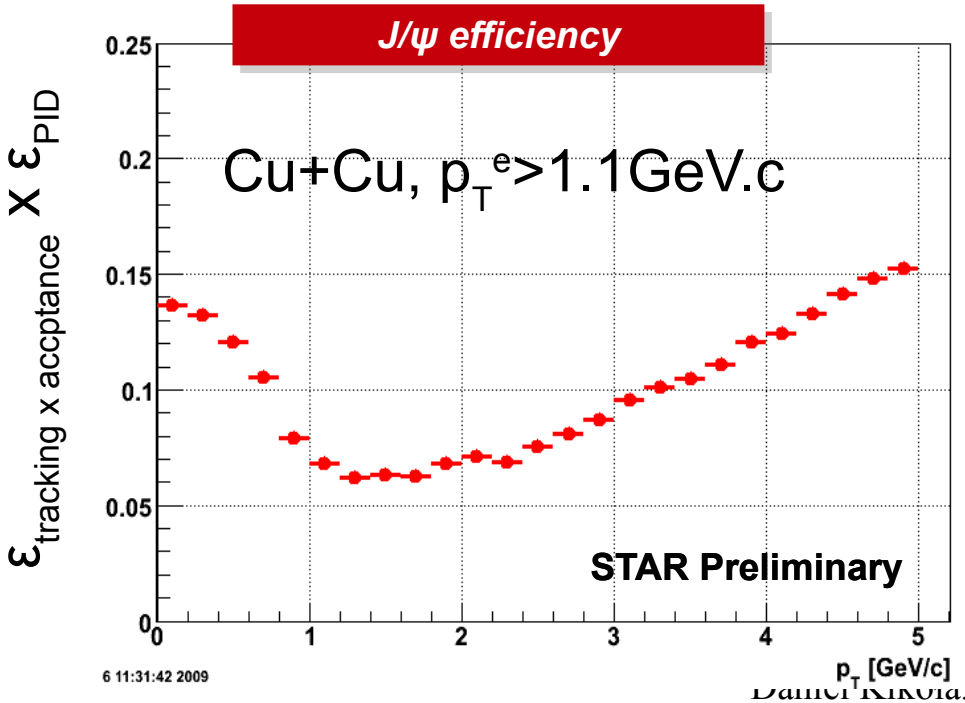


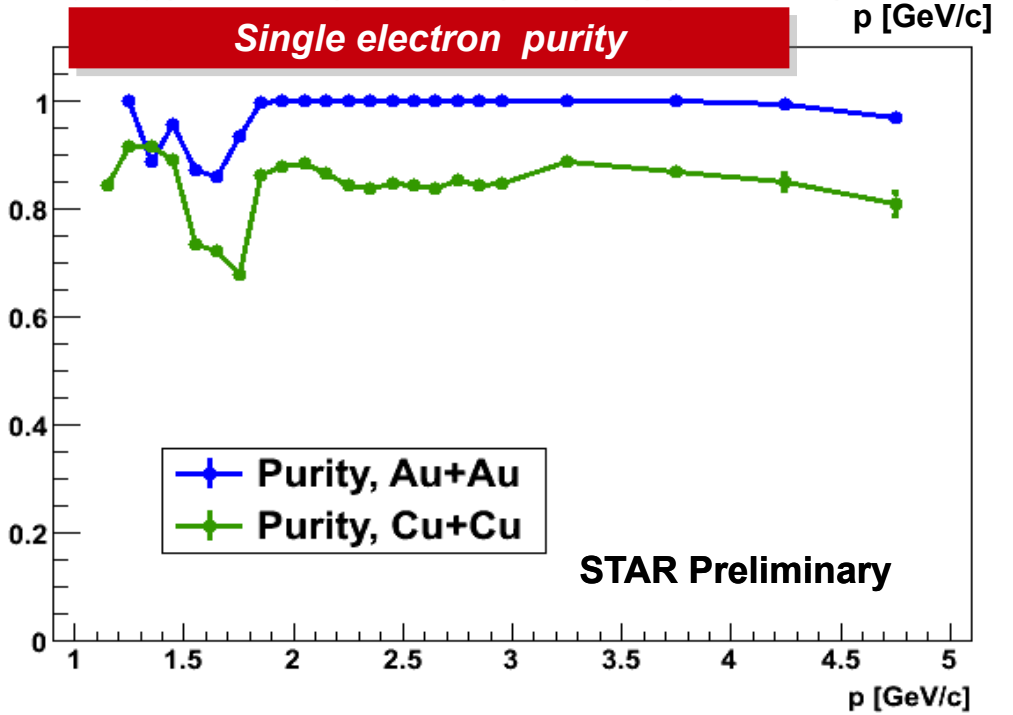


Electron identification – low p_T J/ψ

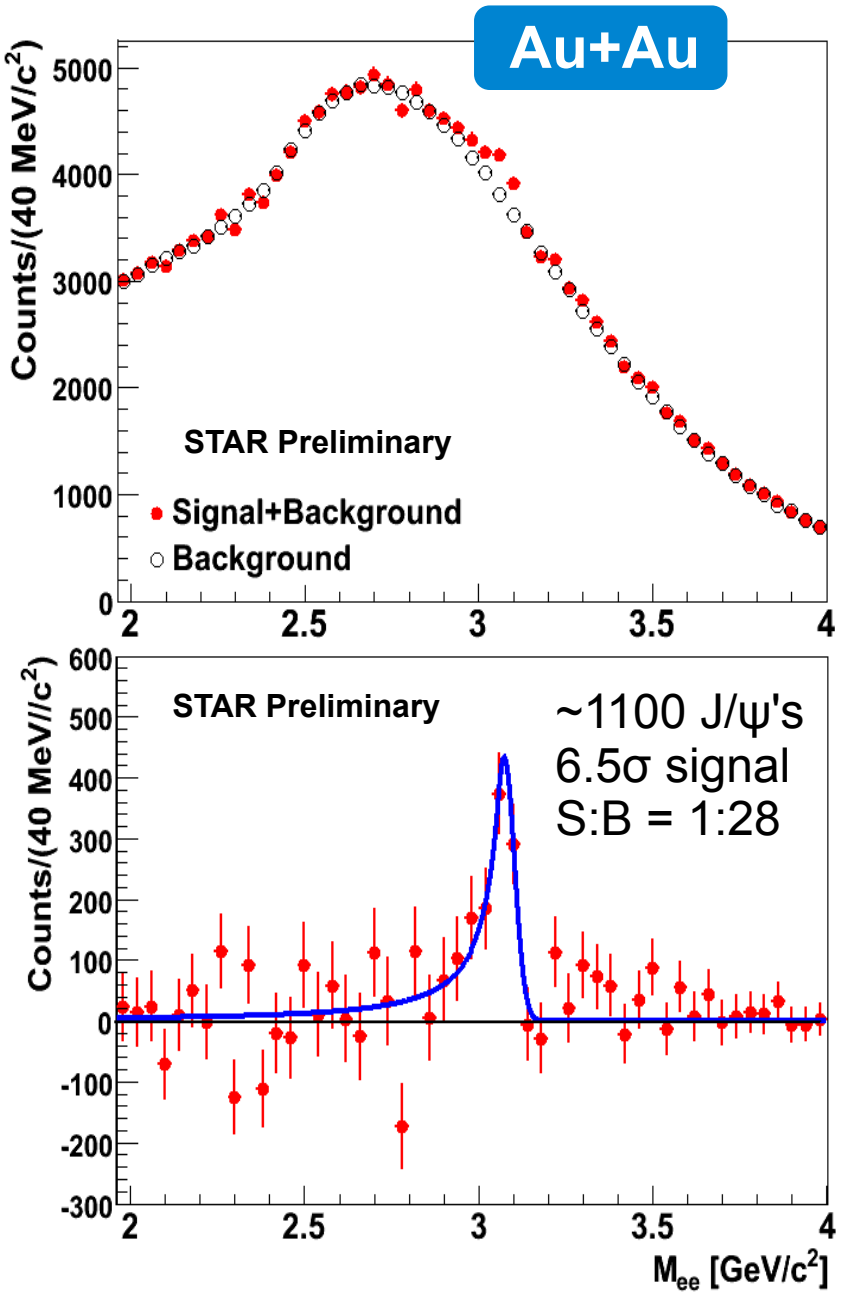
- Single electron p_T cut:
  - Au+Au: p_T > 1.2 GeV/c
  - Cu+Cu: p_T > 1.1 GeV/c
- Au+Au – clean sample
  - Purity ~ 100% for p>2GeV/c

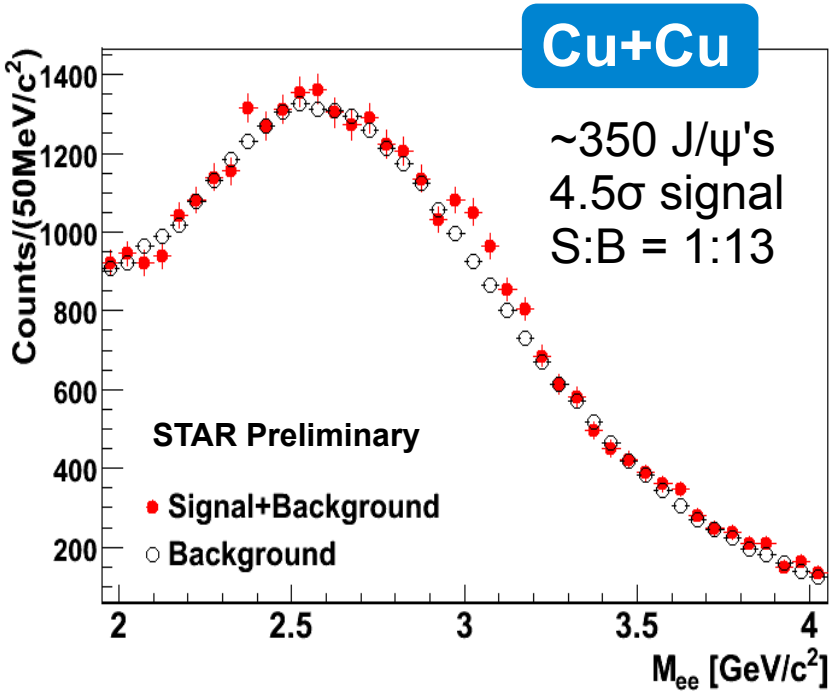






low p_T J/ψ





Crystal Ball function

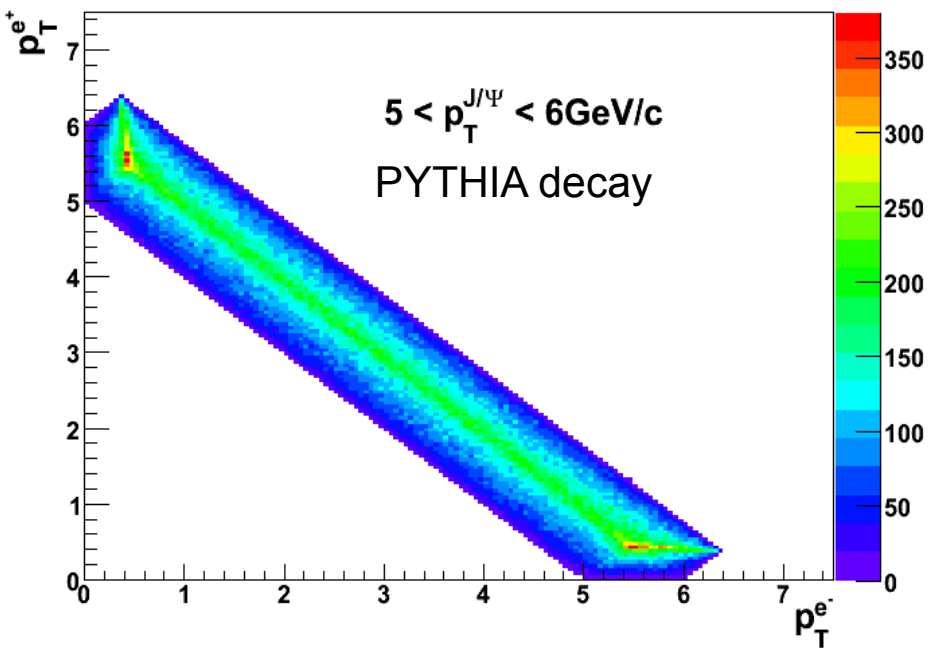
- Gaussian core and a power-law low-end tail
- α, n - describe energy loss

$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant -\alpha \end{cases}$$

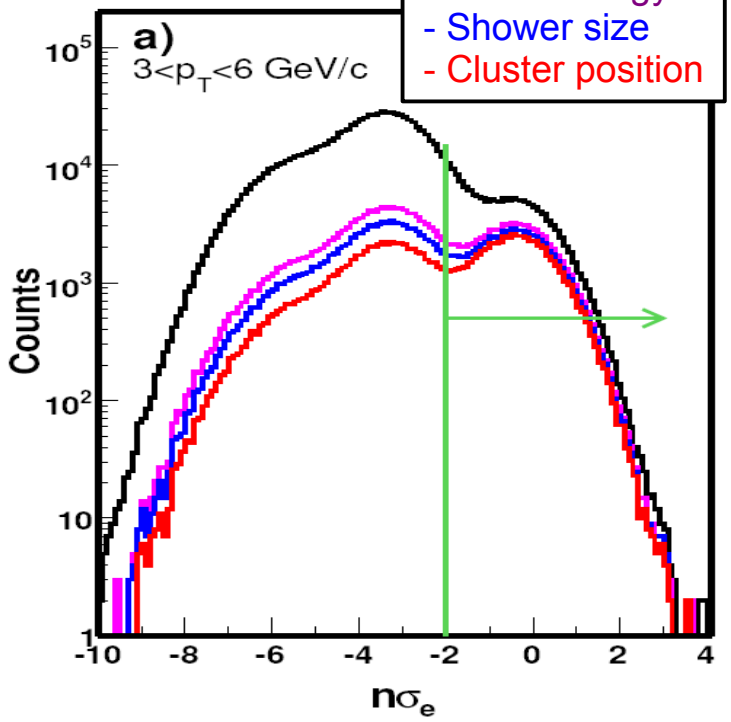
$$A = \left(\frac{n}{|\alpha|}\right)^n \cdot \exp\left(-\frac{|\alpha|^2}{2}\right) \qquad B = \frac{n}{|\alpha|} - |\alpha|$$

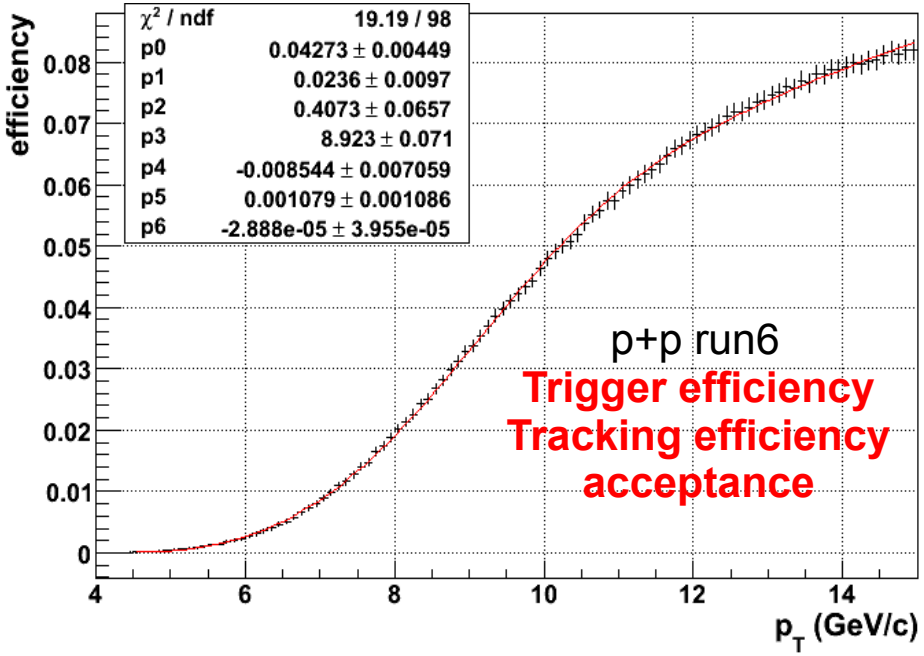
J. E. Gaiser, SLAC-R-255 (1982)

J/ψ measurement – high p_T J/ψ



- Track quality
- Tower energy
- Shower size
- Cluster position

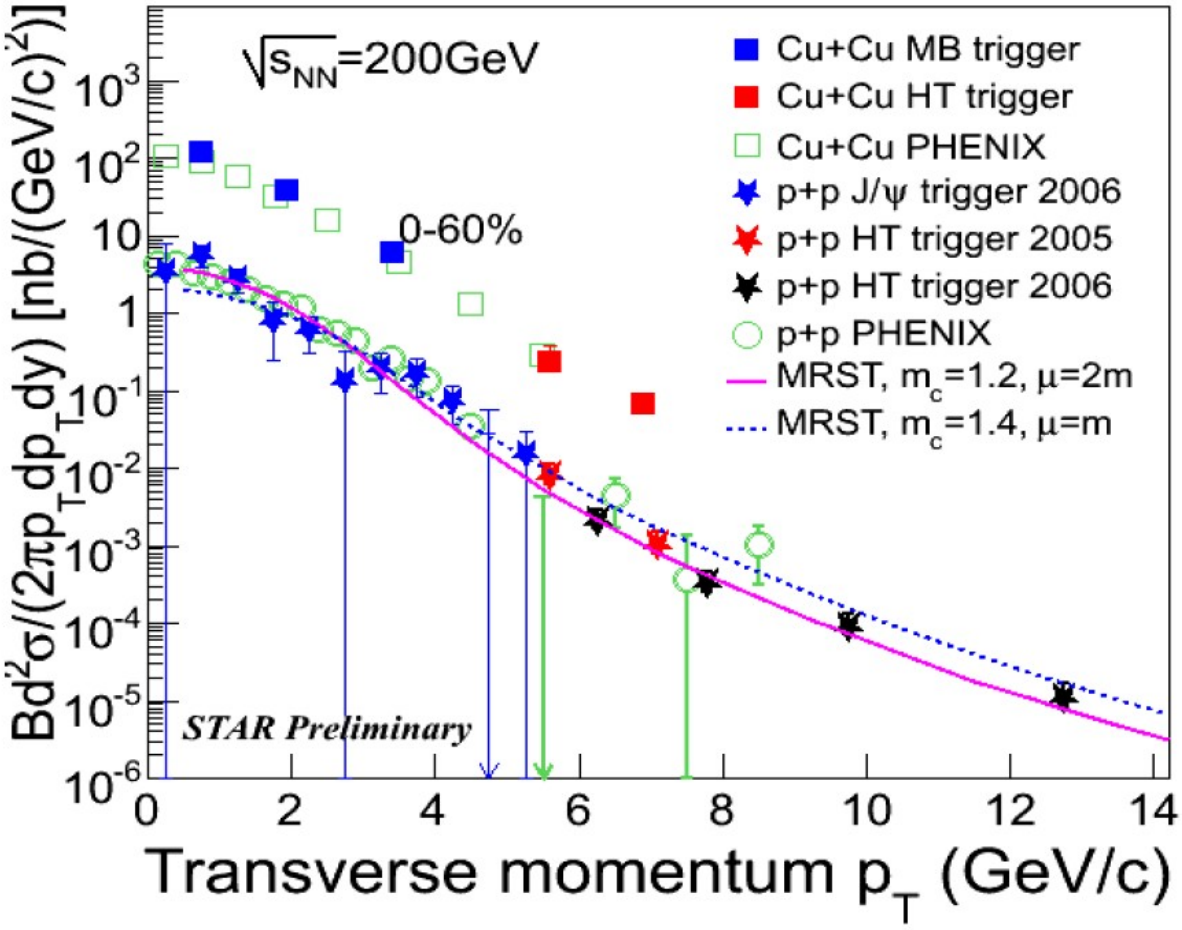




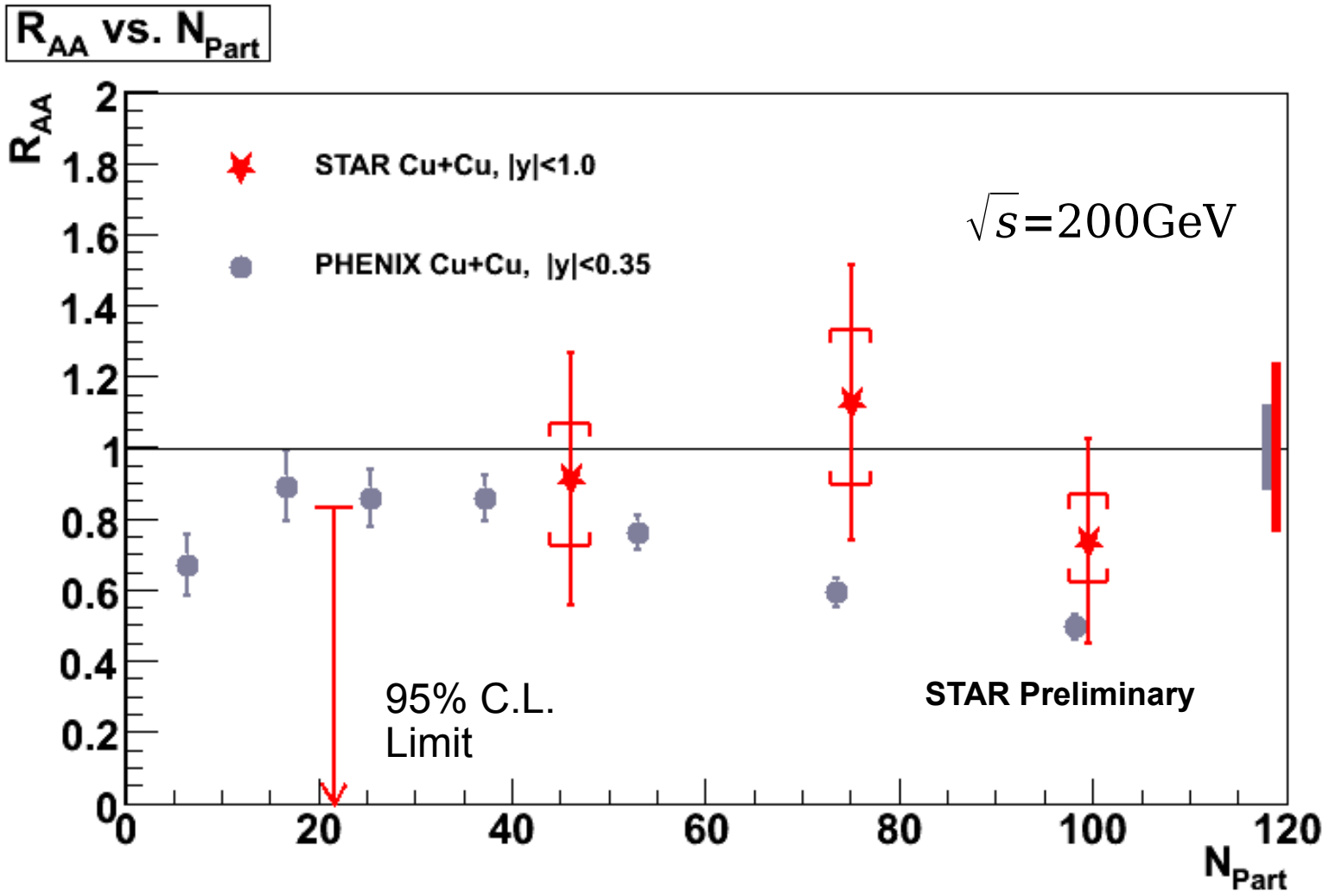
	$p+p$ (2005)	$p+p$ (2006)	Cu+Cu
MB trigger	BBC	BBC	ZDC
E_T (GeV)	> 3.5	> 5.4	> 3.75
Sampled int. lumi	2.8 pb^{-1}	11.3 pb^{-1}	860 μb^{-1}
p_{T1} (GeV/c)	> 2.5	> 4.0	> 3.5
p_{T2} (GeV/c)	> 1.2	> 1.2	> 1.5
J/ψ p_T (GeV/c)	5-8	5-14	5-8
J/ψ counts	32 ± 6	51 ± 10	23 ± 10
S/B	9:1	2:1	1:4

J/ψ p_T spectrum STAR

- STAR - ability to measure J/ψ from low- to high-p_T
- Consistent with Color Evaporation calculations (R. Vogt, Private communication)

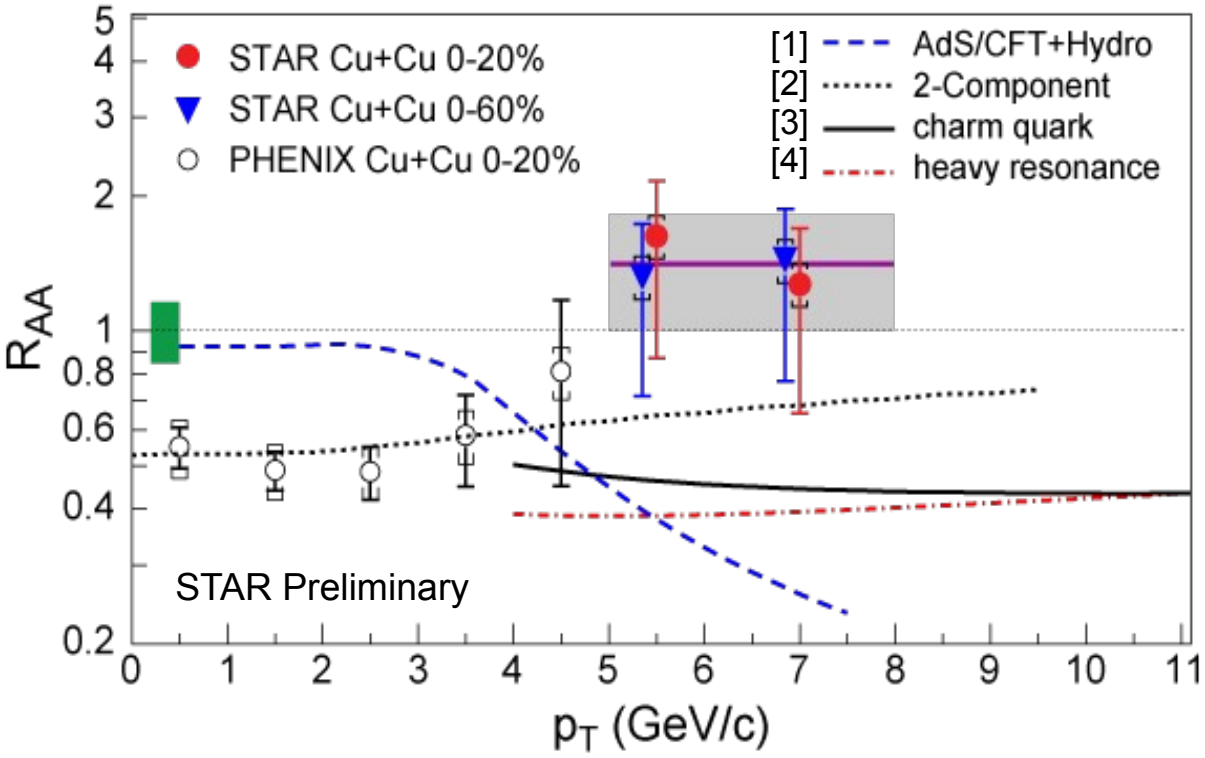


Cu+Cu - R_{AA} vs. centrality



Low p_T J/ψ: limited statistics → limited discrimination power

Nuclear modification factor R_{AA} vs. p_T



Consistent with no suppression at high p_T:

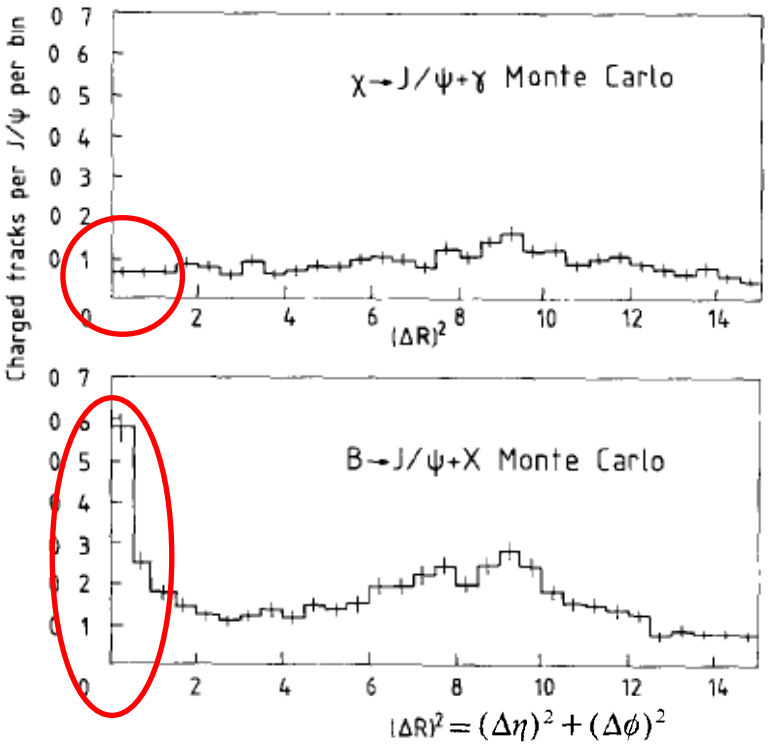
$R_{AA}(p_T>5$ GeV/c) = 1.4± 0.4±0.2

Indicates R_{AA} increases from low to high p_T

- Contrast to AdS/CFT+ Hydro prediction [1] T. Gunji, J. Phys.G: Nucl. Part. Phys. 35, 104137 (2008)
- Jet quenching: strong open charm suppression. [4] A. Adil and I. Vitev, Phys. Lett. B649, 139 (2007), and I. Vitev private communication; [3] S. Wicks et al., Nucl. Phys. A784, 426 (2007), and W. A. Horowitz private communication.

- Formed out of medium? Affected by heavy quark/gluon energy loss
- Decay from other particles? [2] R. Rapp, X. Zhao, nucl-th/0806.1239

Disentangle contributions via Correlations



UA1:PLB 200, 380(1988) and PLB 256,112(1991)

1) $g + g \longrightarrow \chi + g$

$\hookrightarrow J/\psi + \gamma$

No near side correlation

2) $g + g \longrightarrow b + \bar{b}$

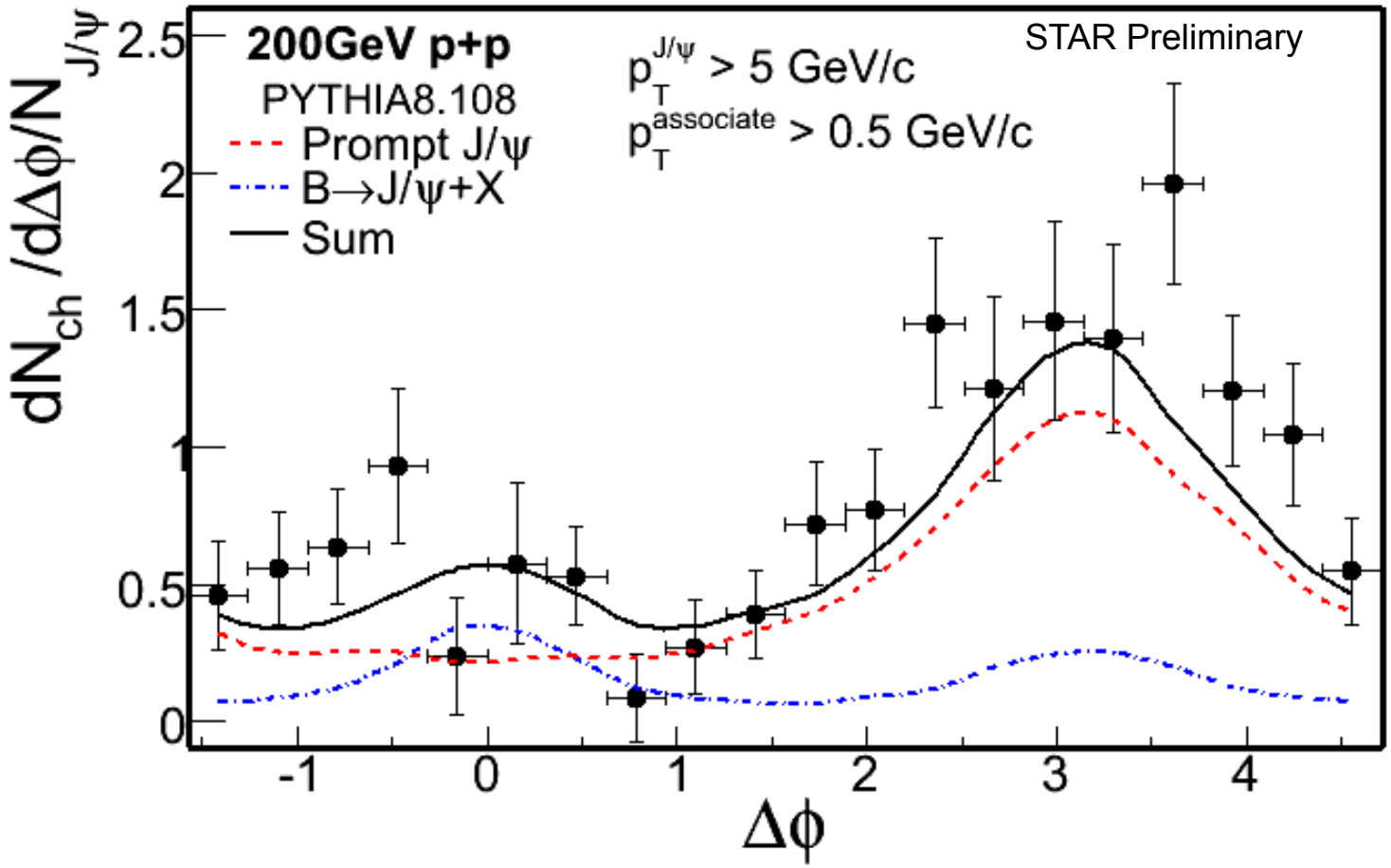
$\hookrightarrow B_{hadron} + X$

$\hookrightarrow J/\psi + X$

Strong near side correlation

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

J/ψ - hadron correlations - constrain bottom yields



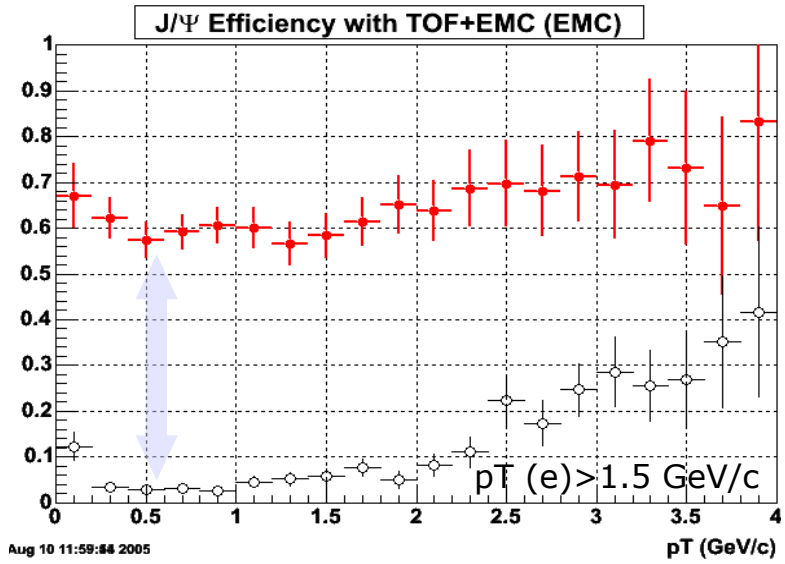
- No significant near side J/ψ-hadron azimuthal angle correlation
- Constrain B meson's contribution to J/ψ yield
- Correlations show low B contribution (13 ± 5)%
- Can be used to further constrain B yields

Summary and outlook

- No J/ψ suppression in high-p_T region in Cu+Cu 200GeV
- Prominent J/ψ signal in Au+Au and Cu+Cu

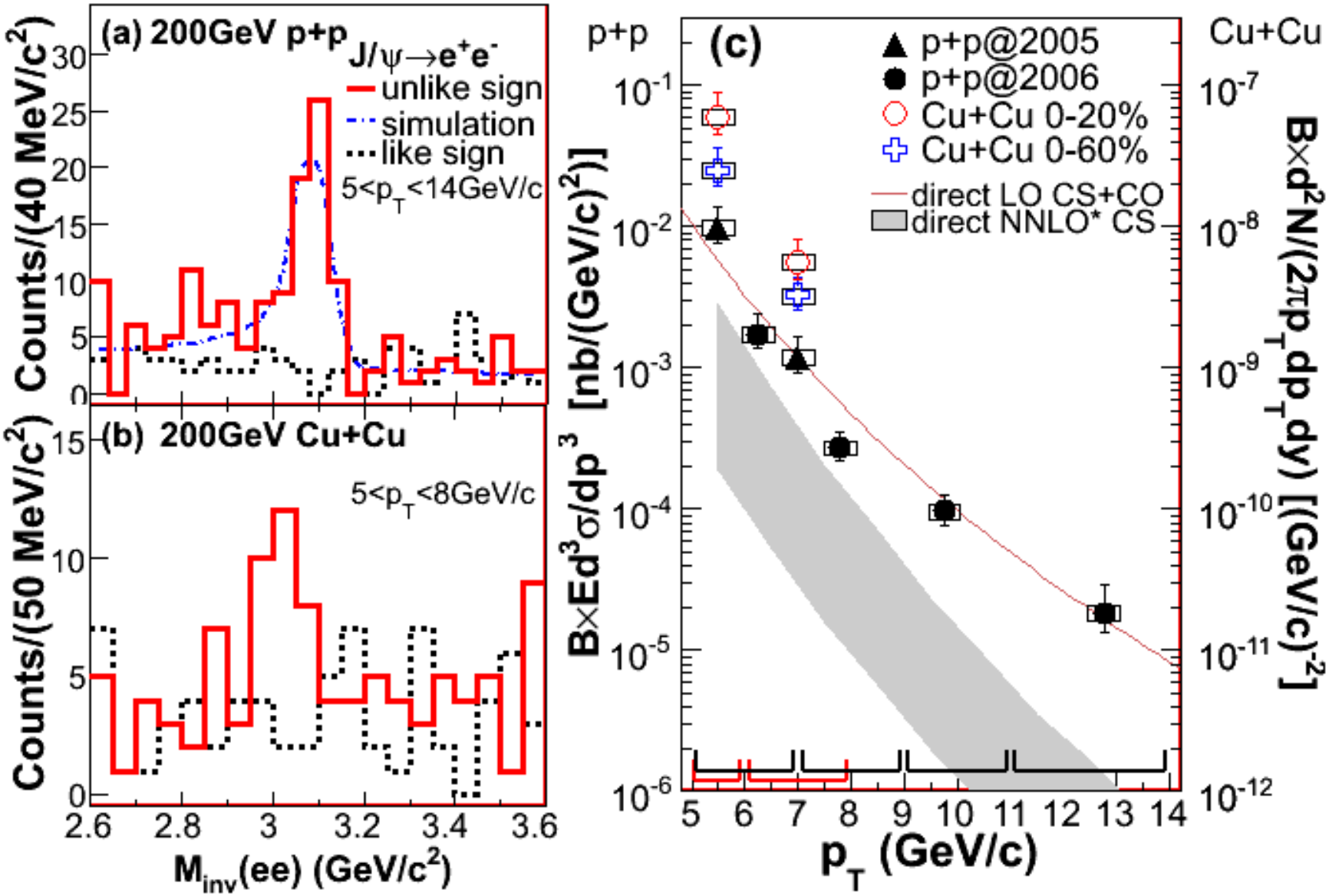
- Outlook
  - New STAR J/ψ measurements in d+Au 200GeV: posters by Zebo Tang (high-p_T J/ψ) and Chris Powell (low-p_T J/ψ)
  - TOF + DAQ1000 + EMC = dramatic improvement of low-p_T J/ψ

    → precise J/ψ v_2 measurement

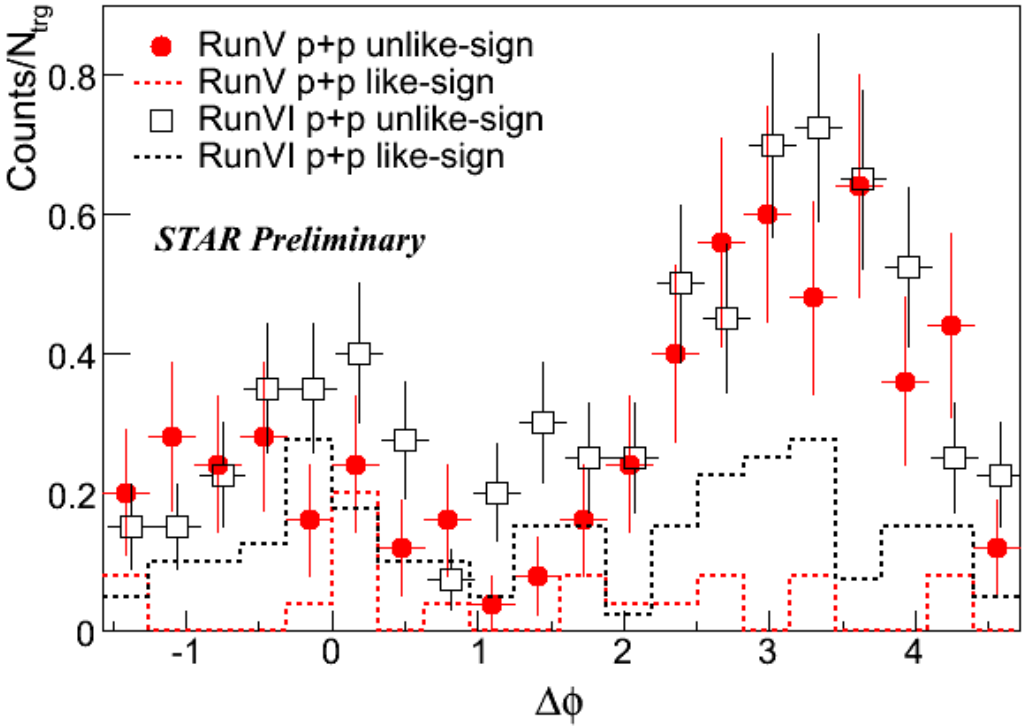


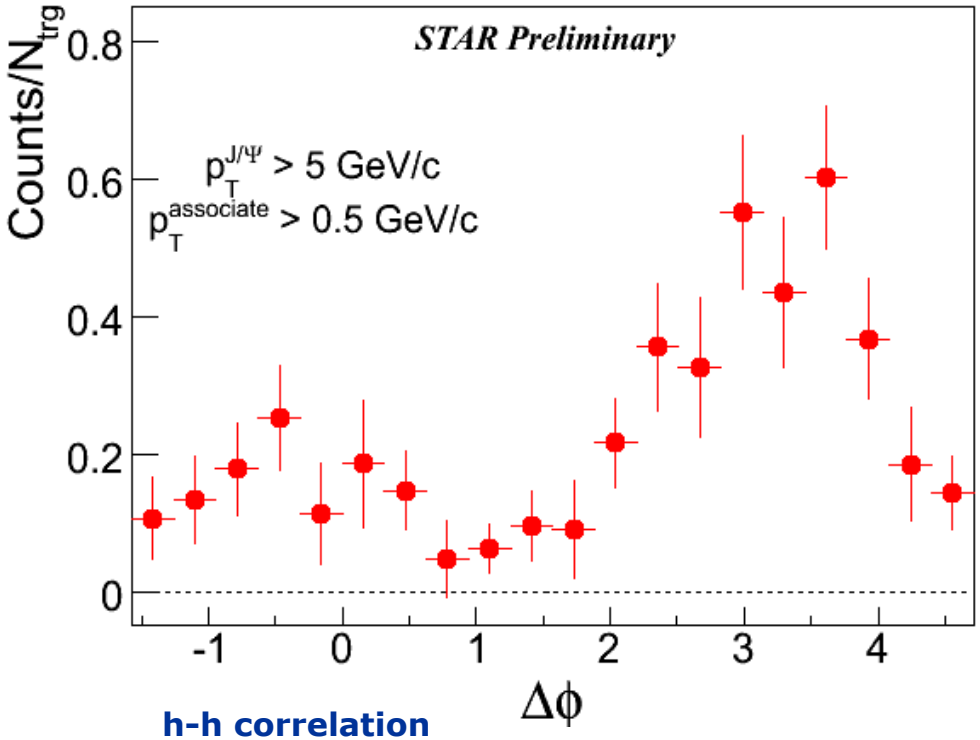
Backup

high p_T J/ψ


(a) 200GeV p+p
J/ψ→e+e-
unlike sign
simulation
like sign
5<pT<14GeV/c
Counts/(40 MeV/c2)
(b) 200GeV Cu+Cu
5<pT<8GeV/c
Counts/(50 MeV/c2)
Minv(ee) (GeV/c2)
p+p
(c)
p+p@2005
p+p@2006
Cu+Cu 0-20%
Cu+Cu 0-60%
direct LO CS+CO
direct NNLO* CS
Cu+Cu
B×Ed3σ/dp3 [nb/(GeV/c)2)]
B×d2N/(2πpTdpTdy) [(GeV/c)-2]
pT (GeV/c)

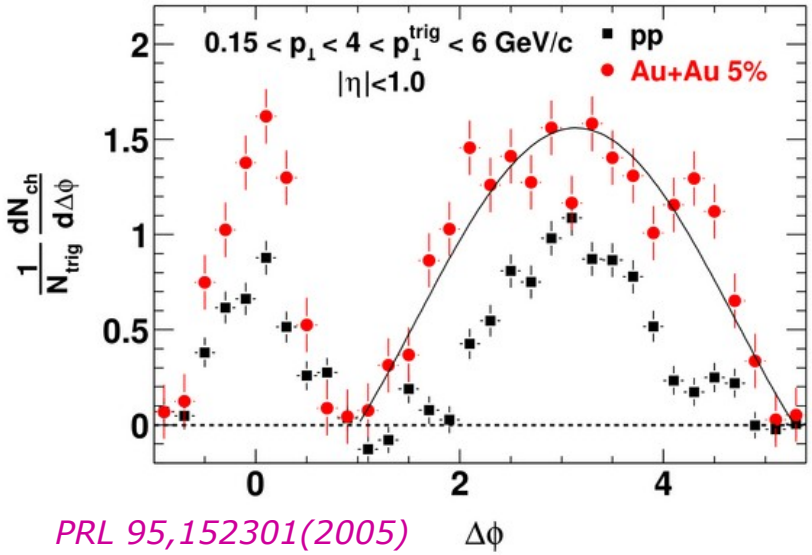
J/ψ - hadron correlation in p+p





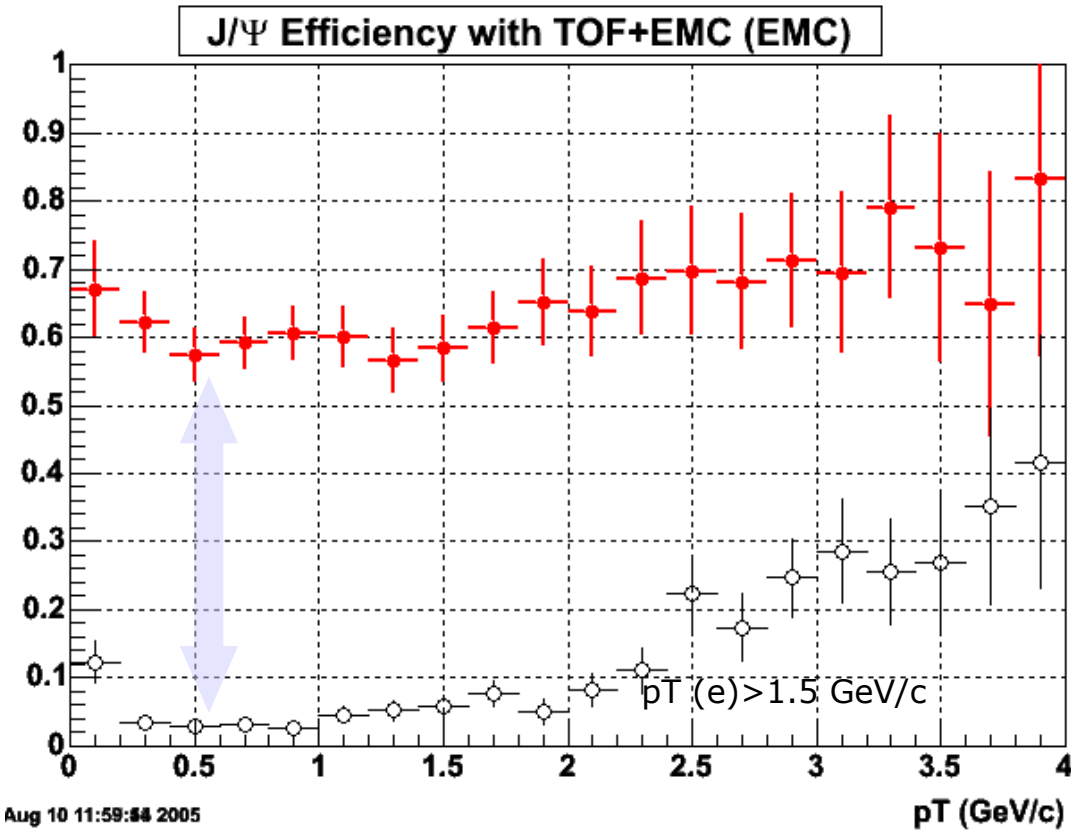
h-h correlation

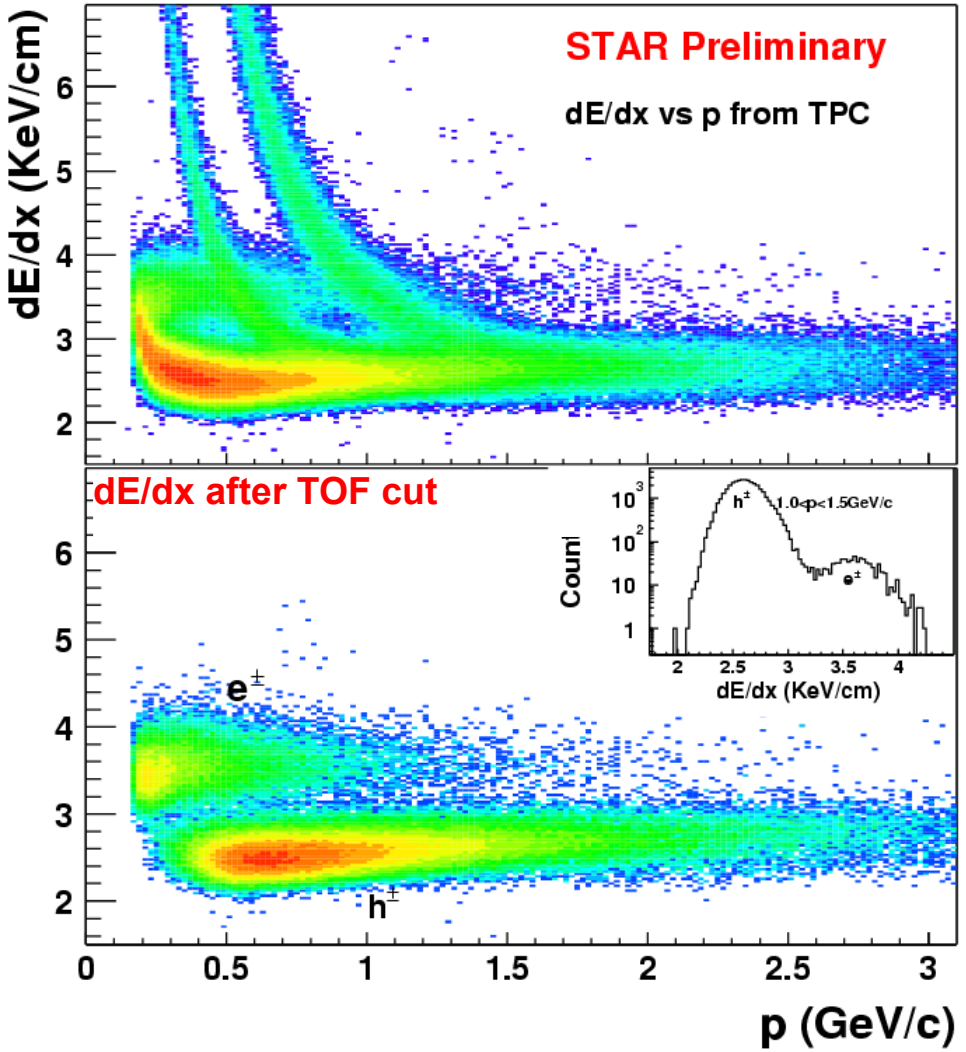
- No significant near side J/ψ-hadron azimuthal angle correlation
- Constrain B meson's contribution to J/ψ yield



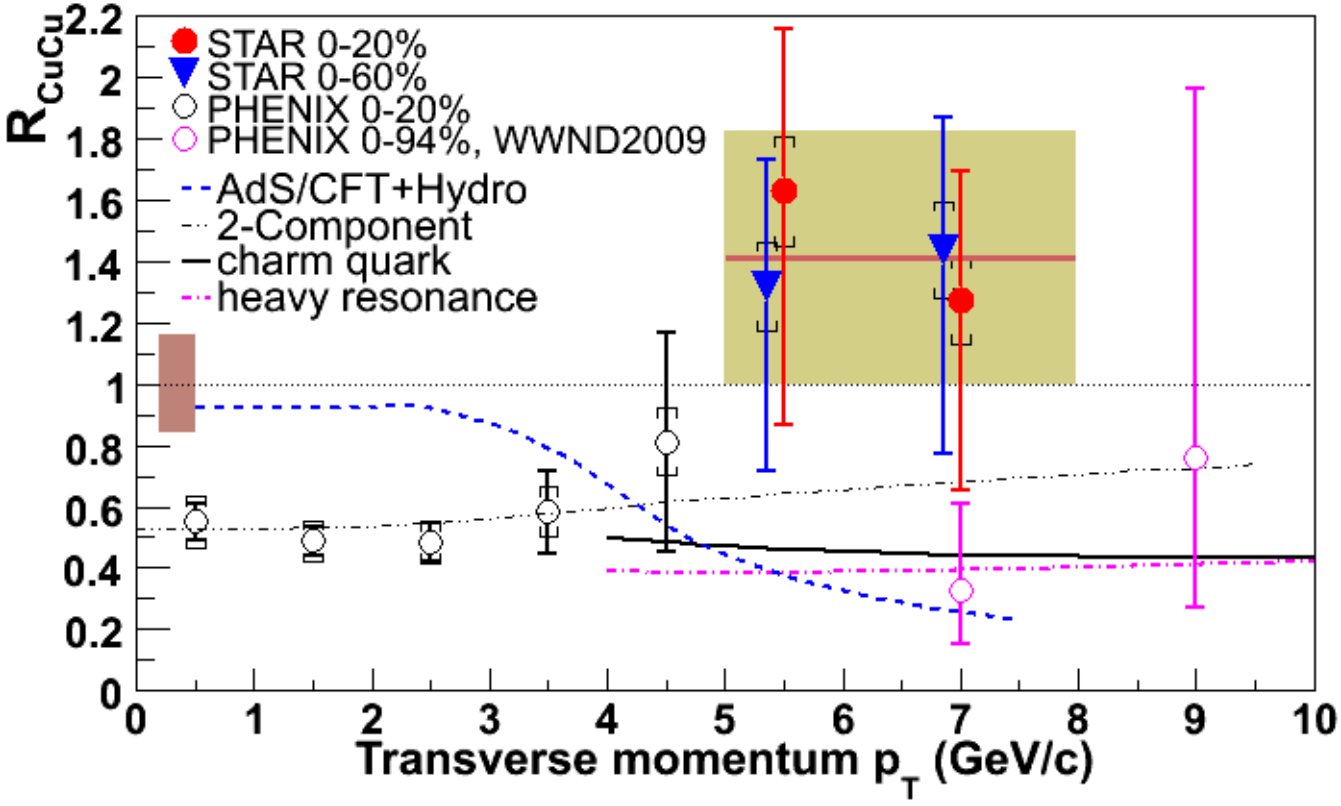
PRL 95,152301(2005)

TOF + BEMC + DAQ1000





R_{AA} vs p_T


R_{CuCu}
STAR 0-20%
STAR 0-60%
PHENIX 0-20%
PHENIX 0-94%, WWND2009
AdS/CFT+Hydro
2-Component
charm quark
heavy resonance
Transverse momentum p_T (GeV/c)