Centrality and p_T Dependence Study of Di-electron Production in $\sqrt{s_{NN}}$= 200 GeV Au+Au Collisions at STAR

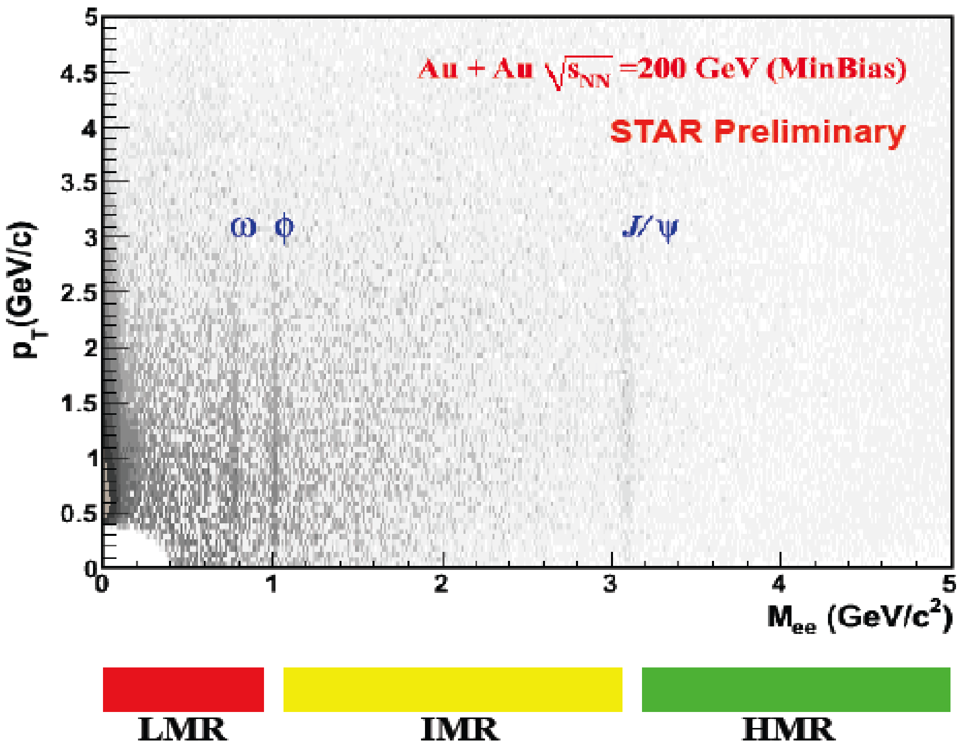
Yi Guo[1,2]
for the STAR Collaboration

1. Brookhaven National Laboratory
2. University of Sci & Tech of China

Outline

- Motivation
- STAR detector and electron identification
- Background reconstruction
- Cocktail simulation
- Centrality & p_T dependence
- Summary and outlook

Motivation



- Di-leptons – *a bulk penetrating probe*

  do not suffer strong interactions

  bring us the direct information of the medium in heavy-ion collisions

Di-lepton source:

- **Low mass region (LMR):**

  in-medium modifications of vector meson.

- **Intermediate mass region (IMR):**

  Contribution from QGP thermal radiation is expected to be significant.

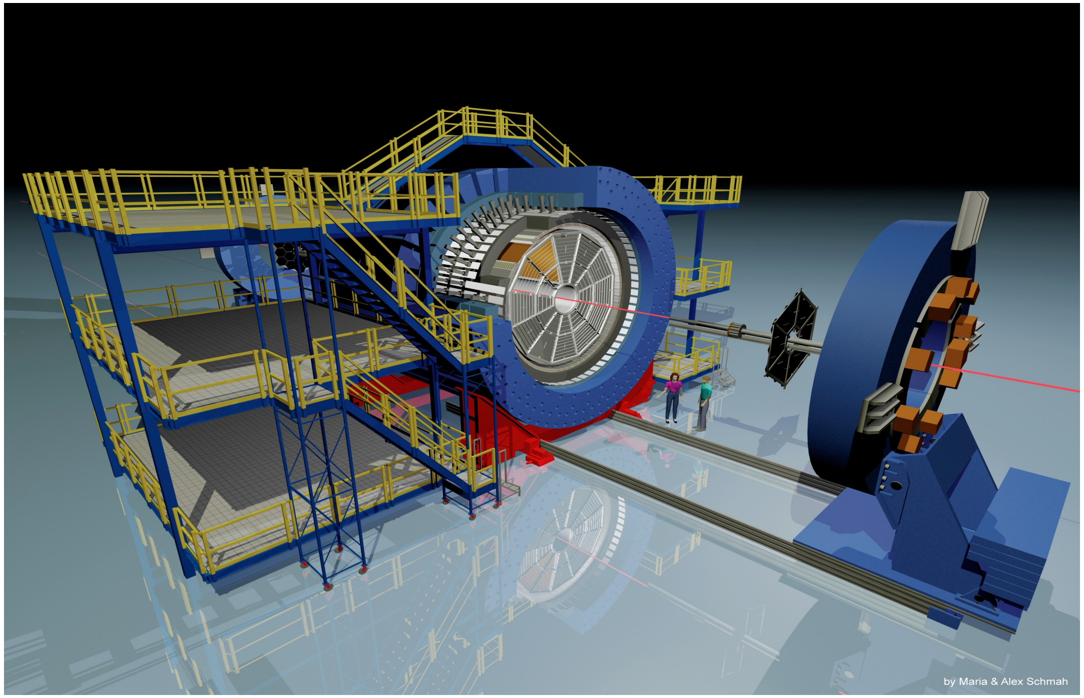
  semi-leptonic decays of charmed mesons dominated in p+p but the contribution is expected to be modified in Au+Au.

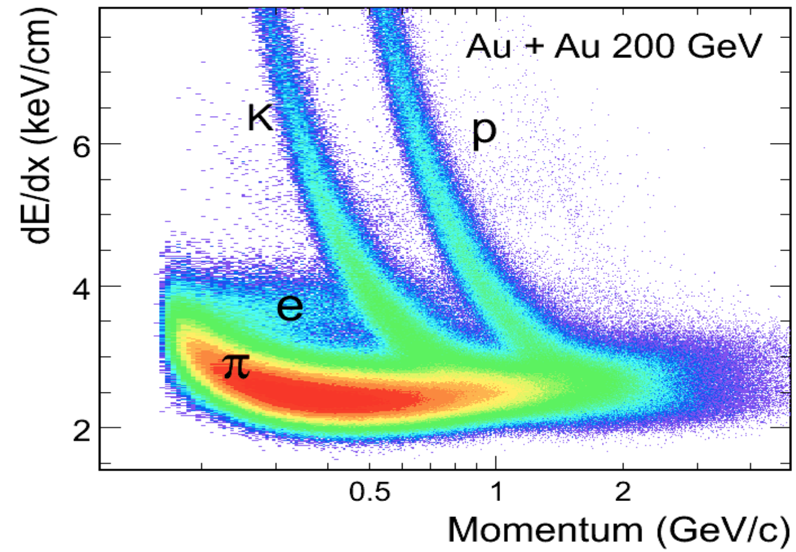
- **High mass region (HMR):**

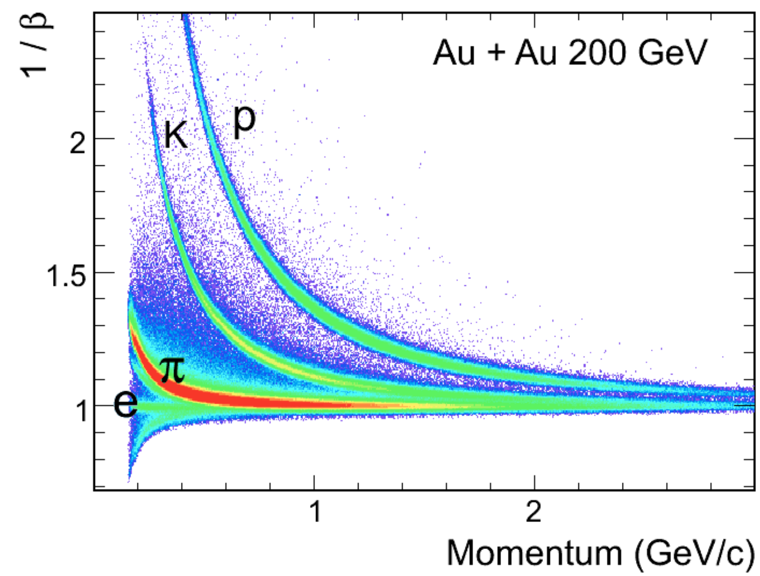
  heavy quarkonia.

  Drell-Yan contribution.

STAR detector







- **T**ime **P**rojection **C**hamber (0<Φ<2π,|η|<1)

  Tracking – momentum

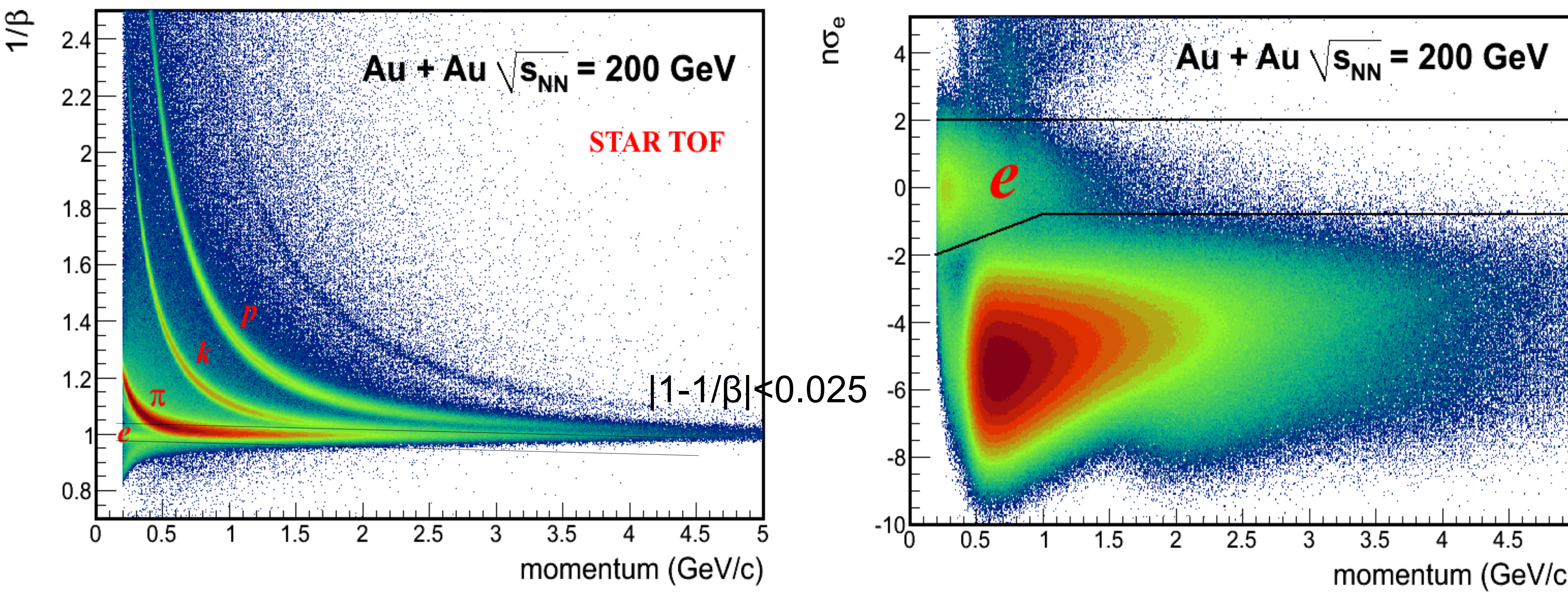
  Ionization energy loss – dE/dx (particle identification)

- **T**ime **O**f **F**light detector (0<Φ<2π,|η|<1)

  Time resolution < 100ps – significant impovement for PID

- **Large data samples** --- *270M M.B. Au+Au 200 GeV events and 150M Central (0~10%) events in year 2010.*

Electron Identification



➢**Clean electron PID in p+p and Au+Au collisions with a combination of TPC dE/dx and TOF velocity**

hadron contamination contribution to the correlated background is small, and has been included in the systematic uncertainties (Au +Au).

➢***Electron purity: (0.2-2.0GeV/c²)***

MinBias: 0.946 +/- 0.024   Central: 0.921 +/- 0.025

$$n\sigma_e = \frac{\log\left(\frac{dE/dx_e}{dE/dx_e^{expect}}\right)}{\sigma_e}$$

Background Reconstruction

- **Background**

  a. Low mass region

  Like Sign – acceptance corrected

  ✓ *can reproduce both the combinatorial and correlated background.*

  ✗ *but lack of statistics and need correct acceptance factor*

$$B_{LikeSign} = 2\sqrt{N_{++}\cdot N_{--}}\cdot\frac{B^{Mix}_{+-}}{2\cdot\sqrt{B^{Mix}_{++}\cdot B^{Mix}_{--}}}$$

Acceptance factor

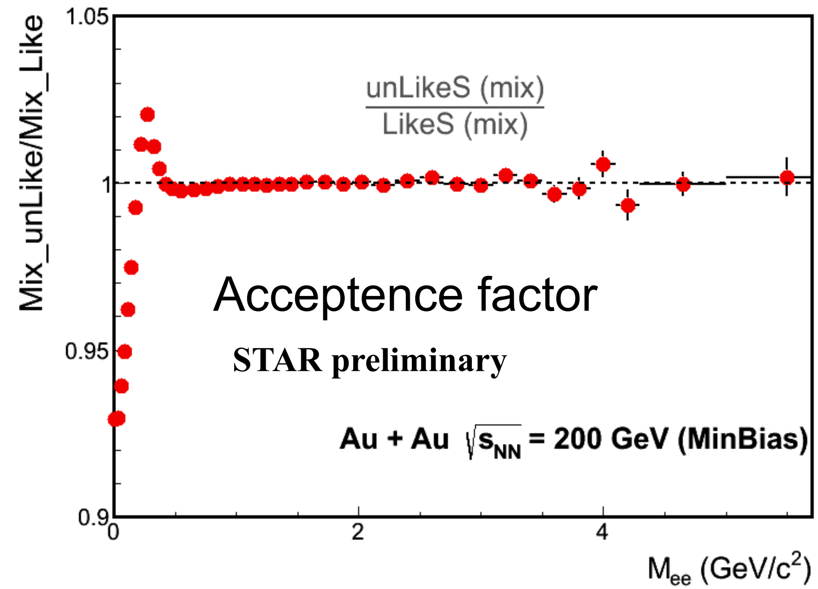
N : same Event , B^{mix} : mixed Event

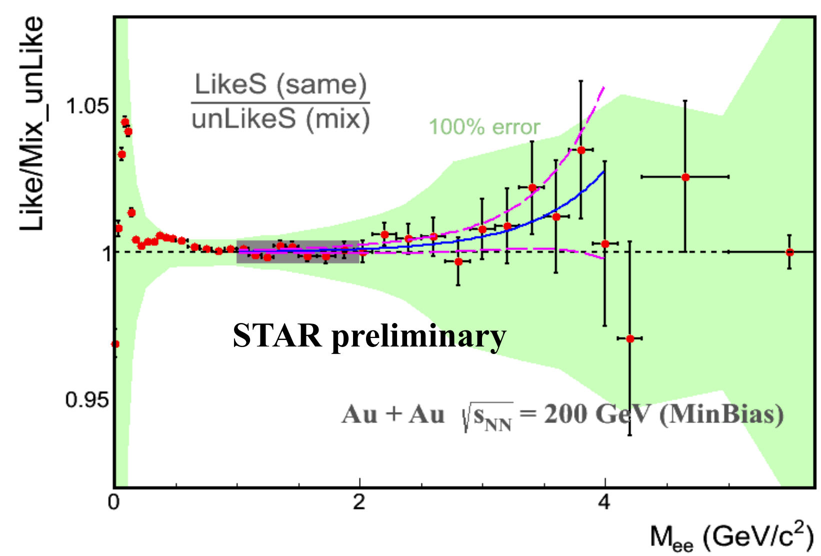
  b. Mass>0.75GeV/c^2

  Mixed Event – normalized to Like Sign in mass region [1,2] GeV/c^2

  ✓ *large statistics and no need to correct acceptance.*

  ✗ *but can't reproduce correlated background*

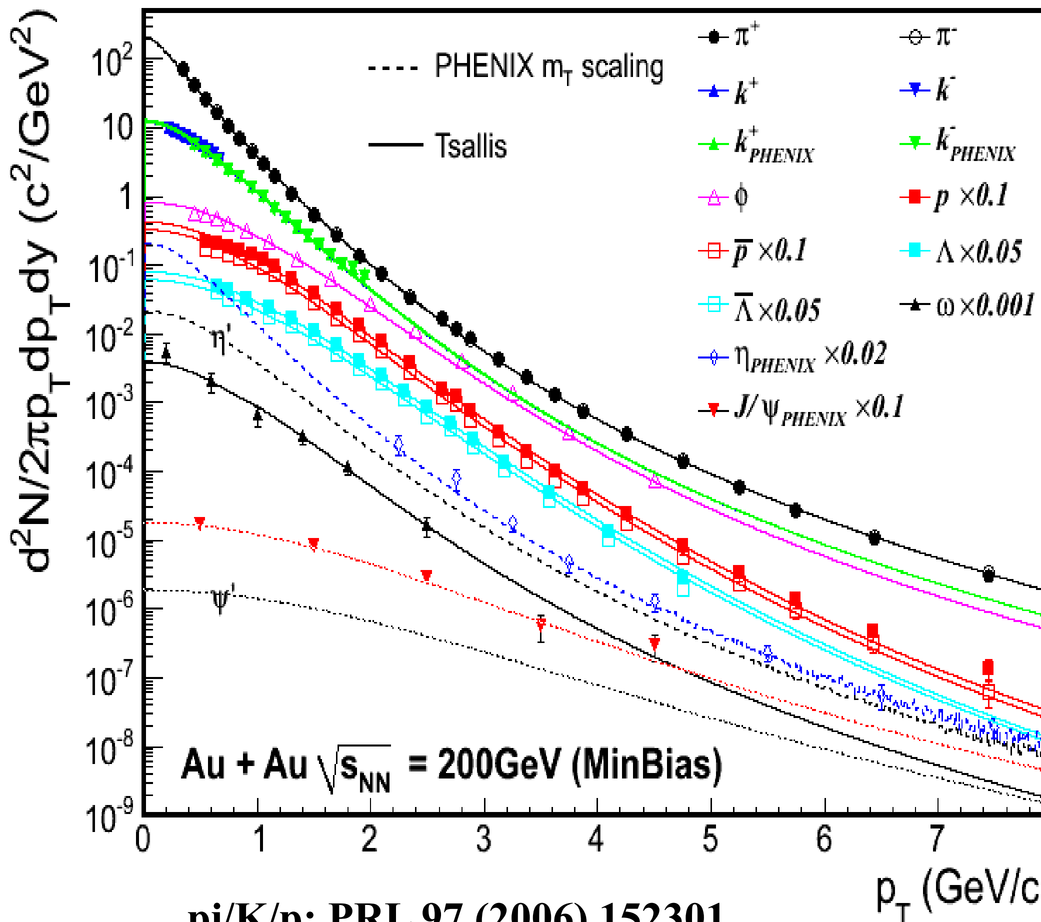




Cocktail simulation

➢ Inputs:

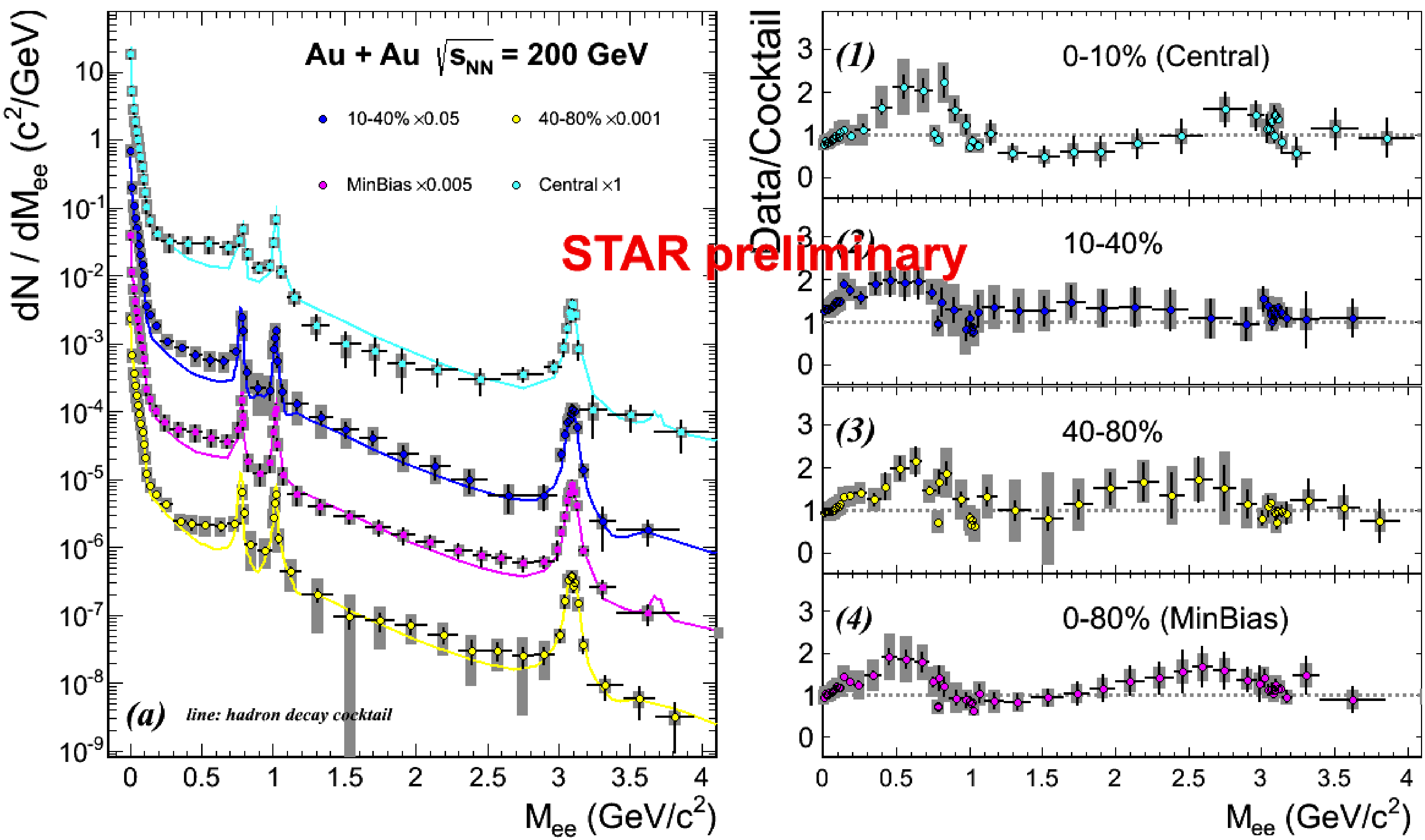
- flat rapidity (-1,1),
- flat Φ (0, 2π),
- p_T: for measured π^0,*J/ψ* use Tsallis function fit, and use m_T-scaling for η, ω, φ, η'.
- ρ is not included.
- Charm contribution is taken from number of binary scaled PYTHIA simulation.



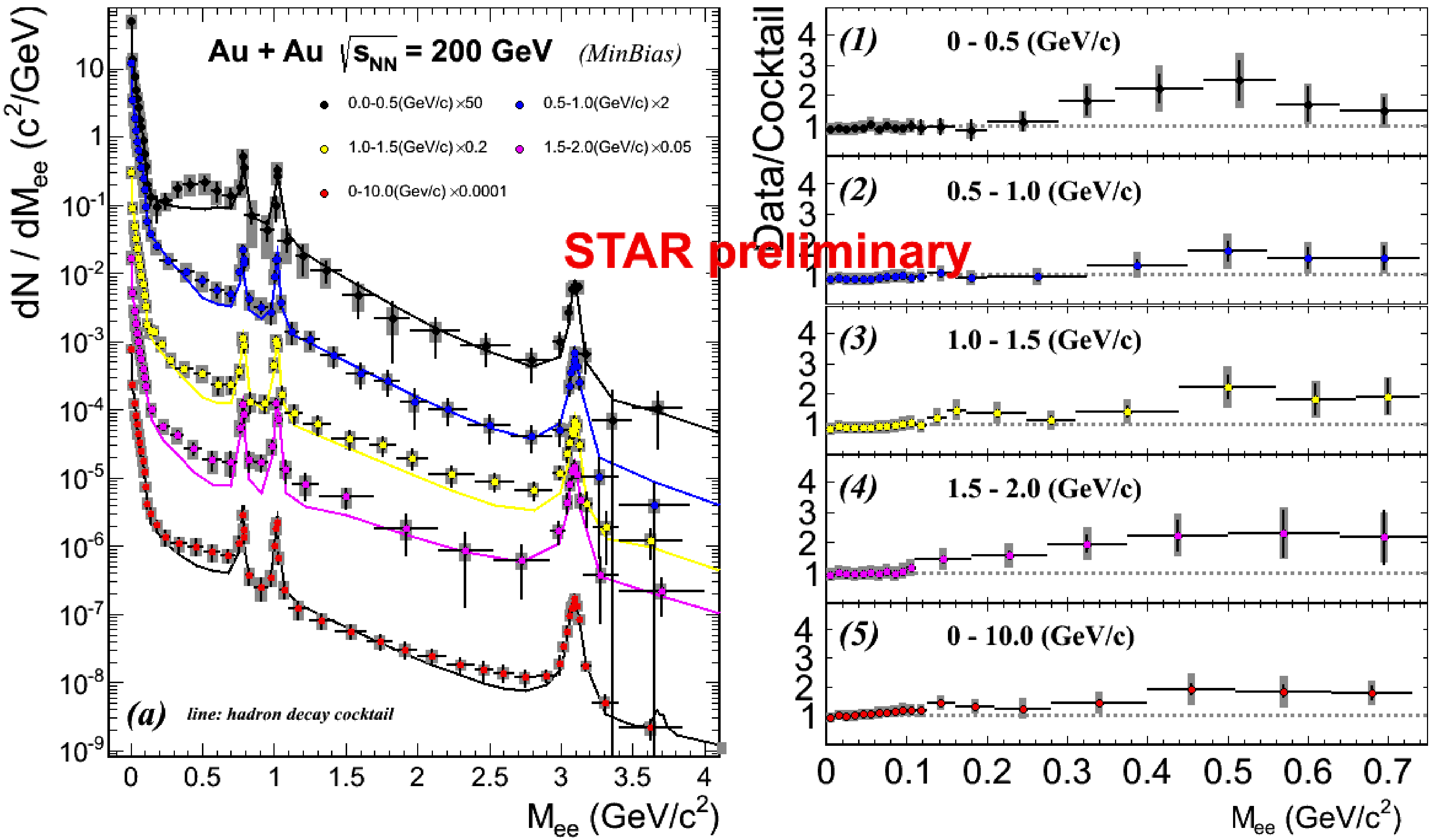
pi/K/p: PRL 97 (2006) 152301
phi: PLB 612 (2005) 181
strangeness: PRL 98 (2006) 062301

TBW fit: Zebo Tang et al, PRC 79, 051901(R) (2009)
m_T-scaling : PHENIX PRC 81,034911 (2010)

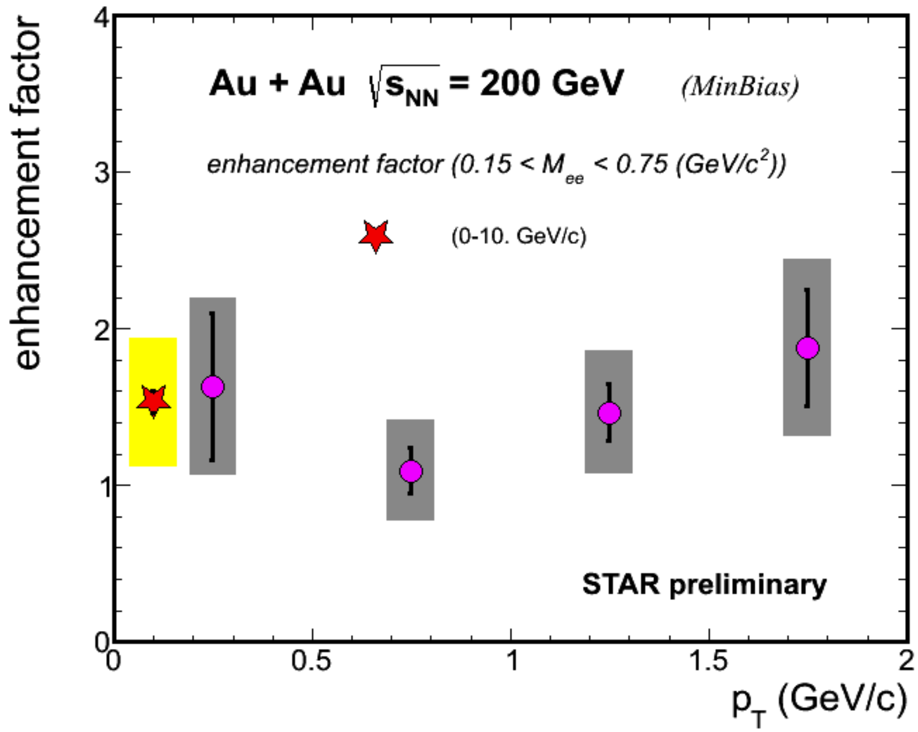
Centrality dependence



p_T dependence



Enhancement factor at LMR



p_T (GeV/c^2)	LMR Enhancement
0-0.5	1.63 ± 0.47 ± 0.57
0.5-1	1.09 ± 0.15 ± 0.32
1-1.5	1.46 ± 0.18 ± 0.39
1.5-2	1.88 ± 0.37 ± 0.56

- Need more statistics to clarify the trend of p_T dependence
- Charm contribution: in Au+Au is still an open question
  More detail study on charm contribution is needed.

Summary and Outlook

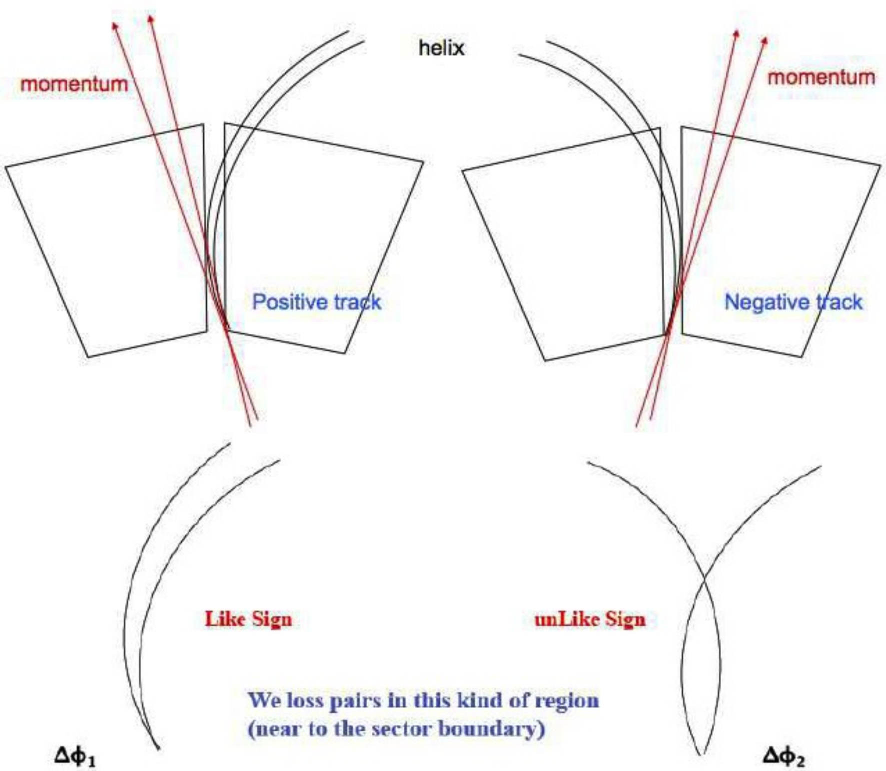
- 1) Report p_T and centrality dependence of dielectron mass spectra.
- 2) Data is compared with cocktail simulation in different centrality and p_T regions.
- Need more statistics to study p_T dependence.
- Further study and measure on charm contribution is needed.

Outlook:

STAR Run11 Au+Au $\sqrt{s_{NN}}$=200GeV data is being analyzed. The dataset's statistics of Run11 is about a factor of two compared to that collected in Run10. It will significantly increase the overall statistics.

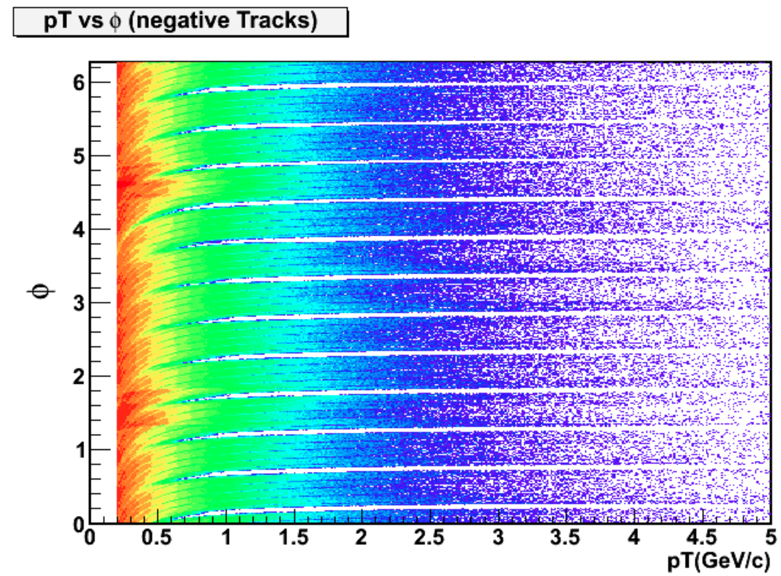
Backup

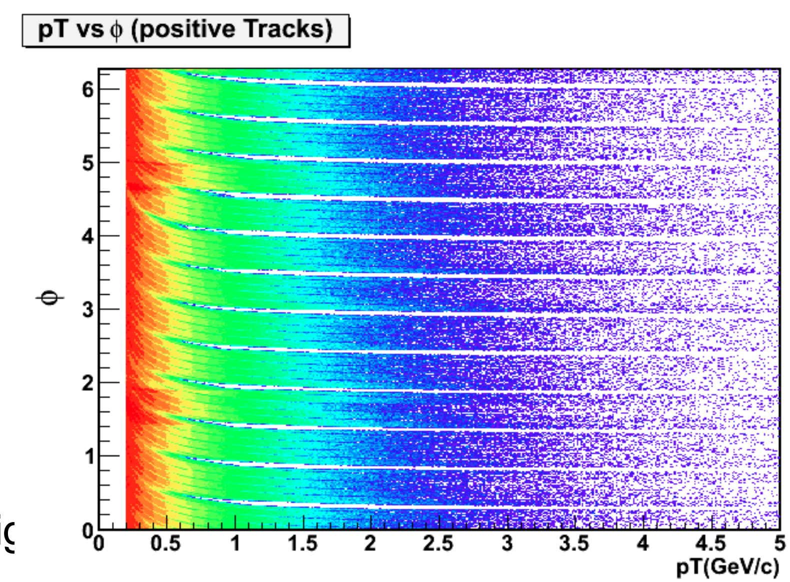
Acceptance correction



$$mass = \sqrt{(mass_1^2 + mass_2^2 + 2E_1E_2 - 2p_1p_2\cos(\Delta\phi))}$$

$\Delta\phi_1 < \Delta\phi_2$ → Loss like Sign pair in low mass ($\Delta\phi_1$) 0.2GeV
Loss unlike Sign pair in high mass ($\Delta\phi_2$) 0.2-0.5GeV





positive and negative tracks: - TPC sector boundary
lost in different phi region, especially in low pT region.
loss Like Sign pair in mass(<0.2 GeV/c2), loss unLike Sig
GeV/c2).

Background

Like Sign:

$$1: B_{LikeSign} = 2\sqrt{N_{++}\cdot N_{--}}\cdot \frac{B^{Mix}_{+-}}{2\cdot\sqrt{B^{Mix}_{++}\cdot B^{Mix}_{--}}}$$

Acceptance correction factor

$$2: B_{LikeSign} = a(N_{++}+N_{--})\cdot \frac{B^{Mix}_{+-}}{(B^{Mix}_{++}+B^{Mix}_{--})b}$$

$$a = \frac{\int_0^{\infty} 2\cdot\sqrt{N_{++}\cdot N_{--}}\,dmdpT}{\int_0^{\infty}(N_{++}+N_{--})\,dmdpT}\quad , \qquad b = \frac{\int_0^{\infty} 2\cdot\sqrt{B^{mix}_{++}\cdot B^{mix}_{--}}\,dmdpT}{\int_0^{\infty}(B^{mix}_{++}+B^{mix}_{--})\,dmdpT}$$

MixEvent:

- normalize mixed likeSign ++ and -- to same event ++ and --

$$A_{+} = \int_{N.R.}\frac{N_{++}}{B^{Mix}_{++}}dmdpT \quad , \qquad A_{-} = \int_{N.R.}\frac{N_{--}}{B^{Mix}_{--}}dmdpT$$

$$B^{mix}_{++} = \int_0^{\infty} A_{+}B^{mix}_{++}\,dmdpT \quad , \qquad B^{mix}_{--} = \int_0^{\infty} A_{-}B^{mix}_{--}\,dmdpT,$$

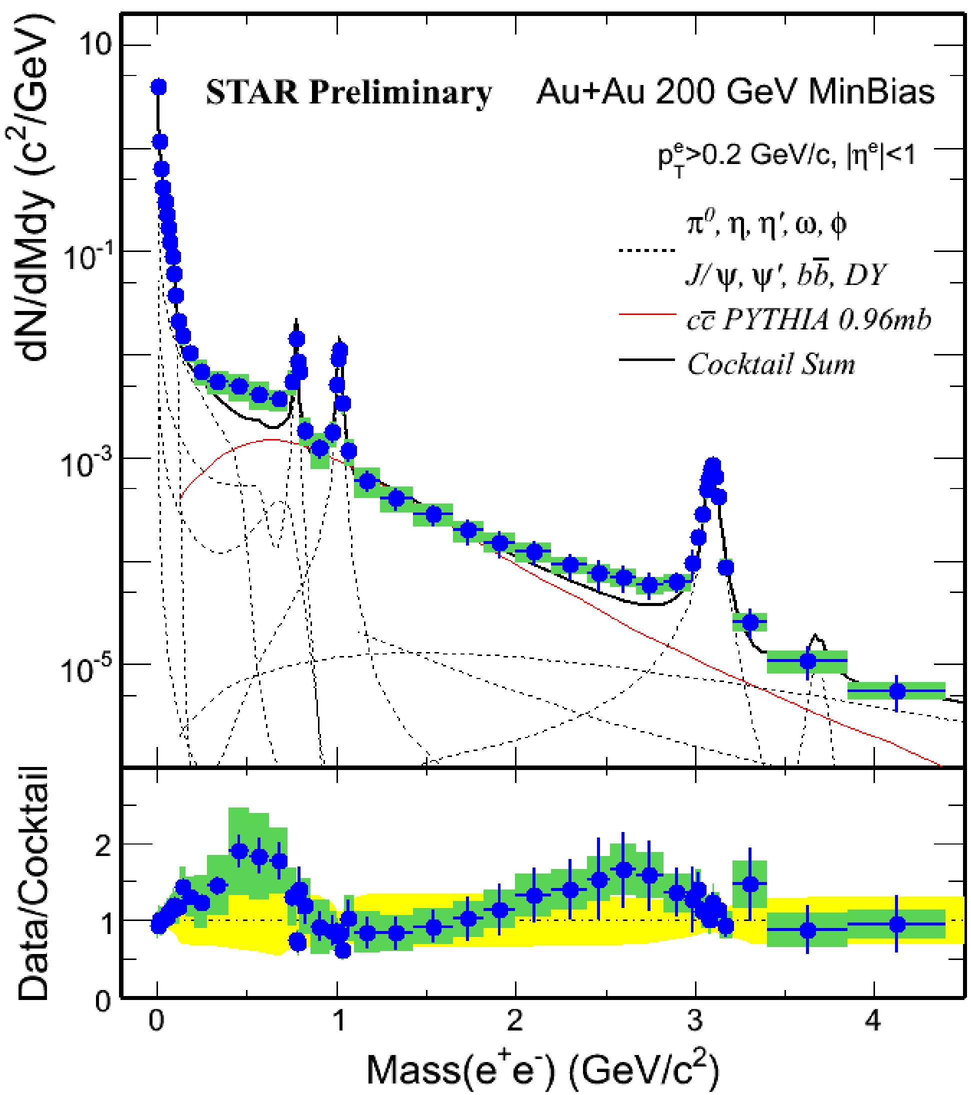
- normalize mixed unlikeSign (combinatorial background)

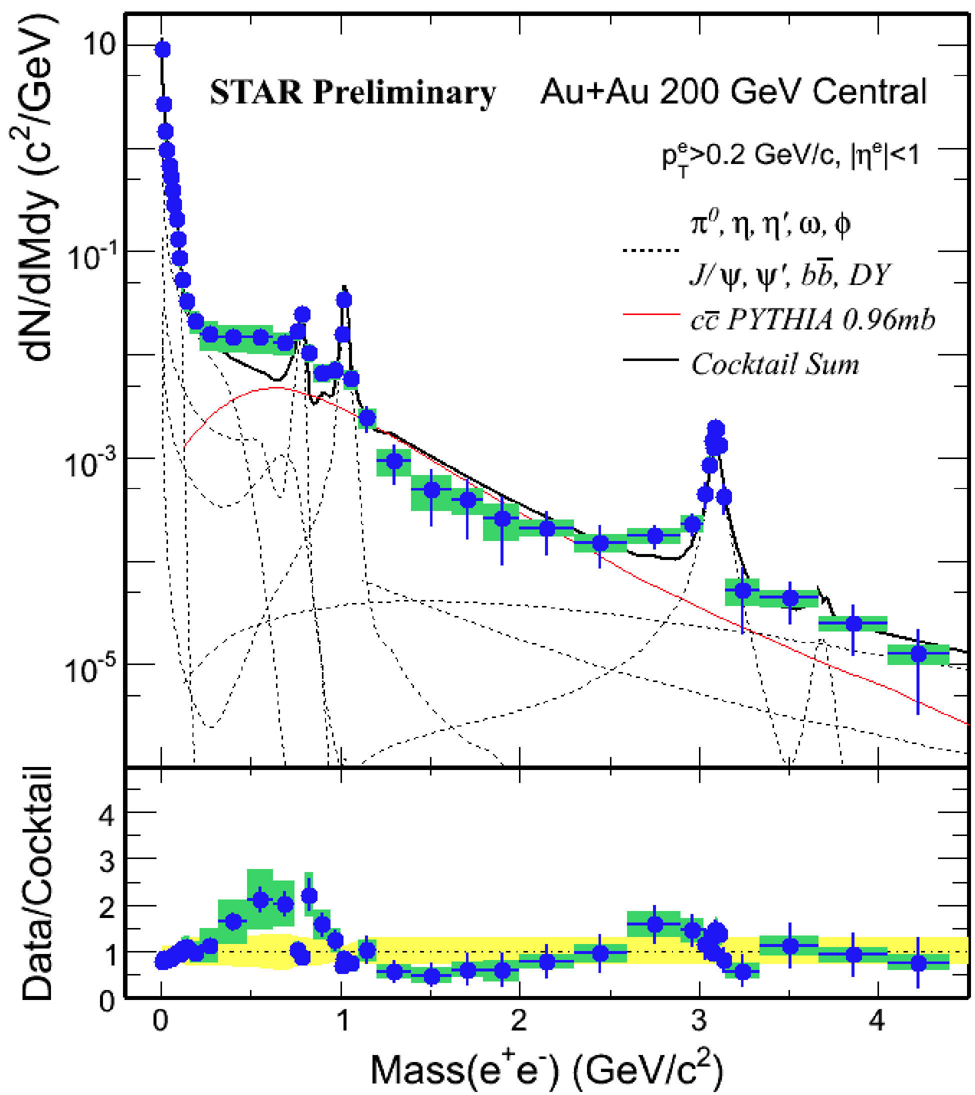
$$B^{combinatorial}_{+-} = a\cdot\frac{2\sqrt{B^{mix}_{++}\cdot B^{mix}_{--}}}{\int_0^{\infty} B^{mix}_{+-}\,dmdpT}B^{mix}_{+-} \qquad (a = sum_{+-}/2\sqrt{sum_{++}\cdot sum_{--}}\text{,w/o normalization})$$

Compare to like-sign: enough statistics, no **acceptance** correction,
but can't reproduce **correlation** background, e.g. cross pair etal.

PHENIX PRC 81, 034911 (2010)

Di-electron production in Au+Au collisions





Run11 analysis status

- Doubled statistics: 270M(Run10) – 580M (Run11)
- Much smaller acceptance correction factor.
  Less acceptance hole.