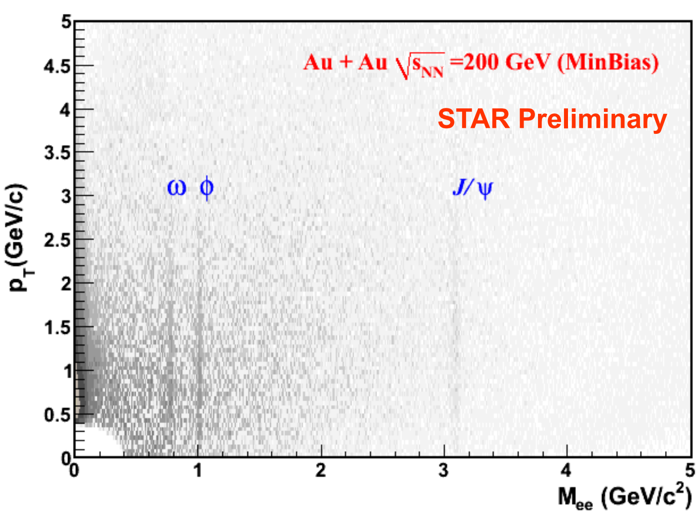
Di-electron Continuum Production from $\sqrt{s_{NN}}$=200GeV p+p and Au+Au Collisions at STAR



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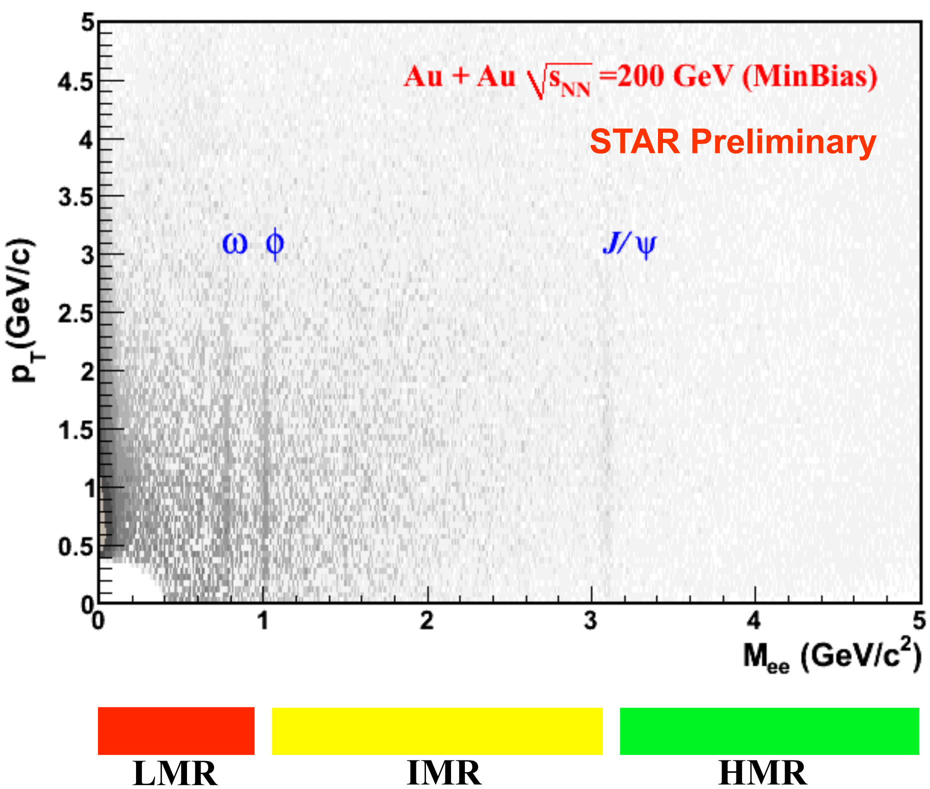
Outline

- Motivation
- STAR detector and electron identification
- Background subtraction
- Di-electron production in p+p and Au+Au collisions
- Transverse mass spectra at IMR
- Summary and outlook

Motivation(1)

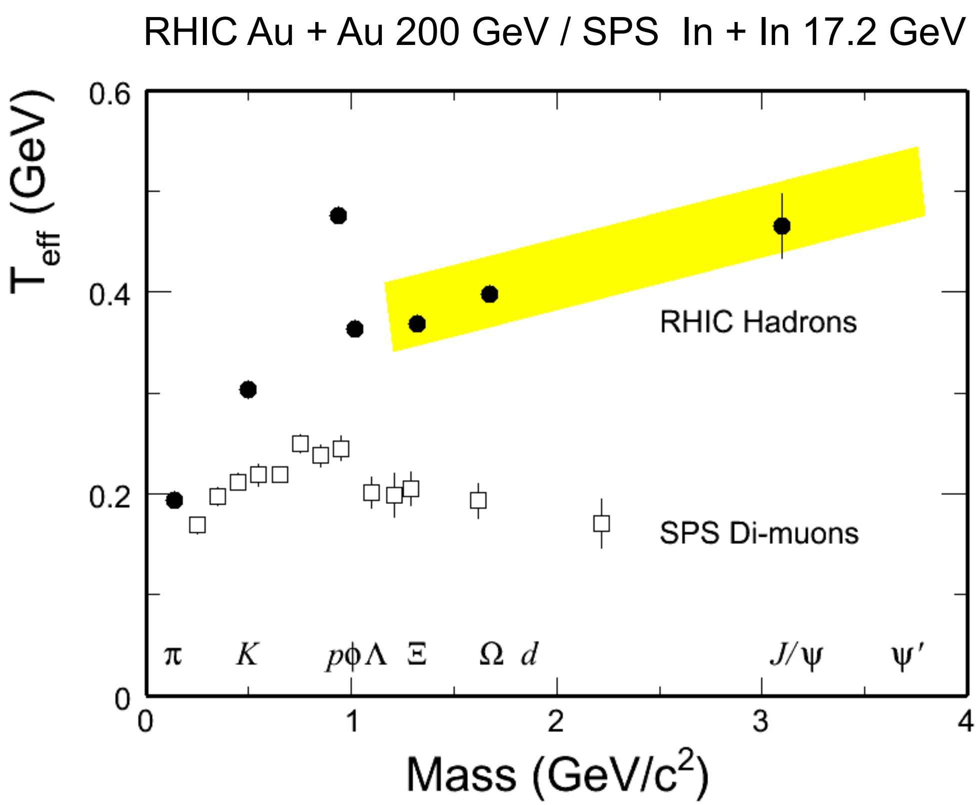


Dileptons: Clean probe

✓ *no strong interaction - direct information of the medium in heavy ion collisions*

- **Low mass region (LMR):**
  - ✓*in-medium modifications of vector mesons*
  - ✓*chiral symmetry restoration*
- **Intermediate mass region (IMR):**
  - ✓*thermal radiation expected to have significant contribution*
  - ✓*dominated by charm in p+p, but the contribution is expected to be modified in Au+Au*
- **High mass region (HMR):**
  - ✓*heavy quarkonia*
  - ✓*Drell-Yan contribution*

Motivation(2)



NA60, PRL 100, 022302 (2008)
STAR, NPA 757,102 (2005)
PHENIX, PRL 98, 232301 (2007)

Different slope in m_T spectra in low and intermediate mass at SPS energy

➢ *hint of partonic thermal dileptons*

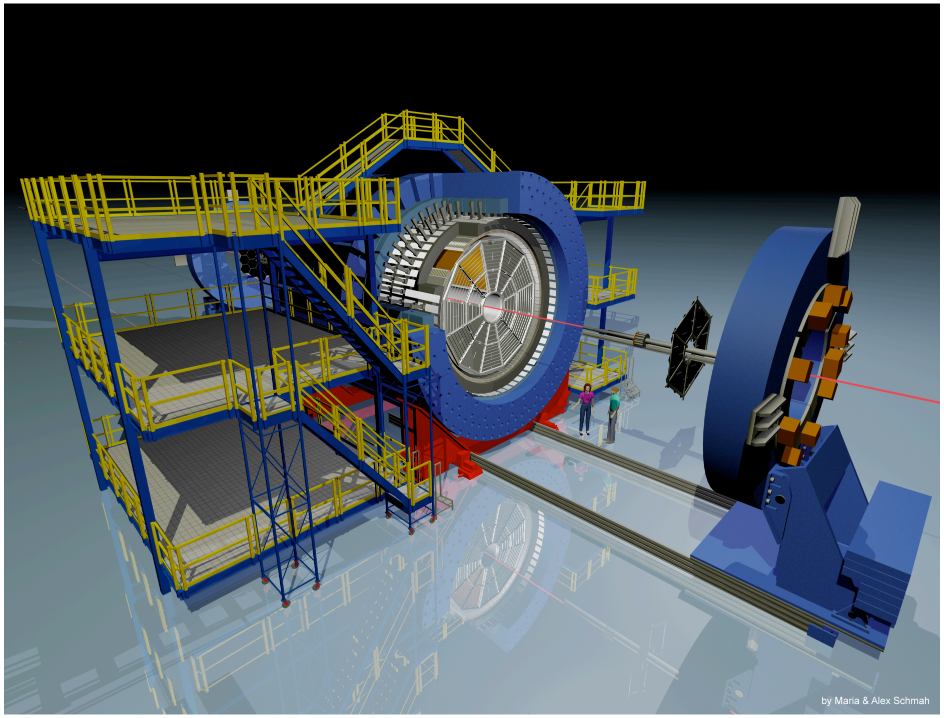
$$q\bar{q} \rightarrow l\bar{l}$$

What about at RHIC energy?

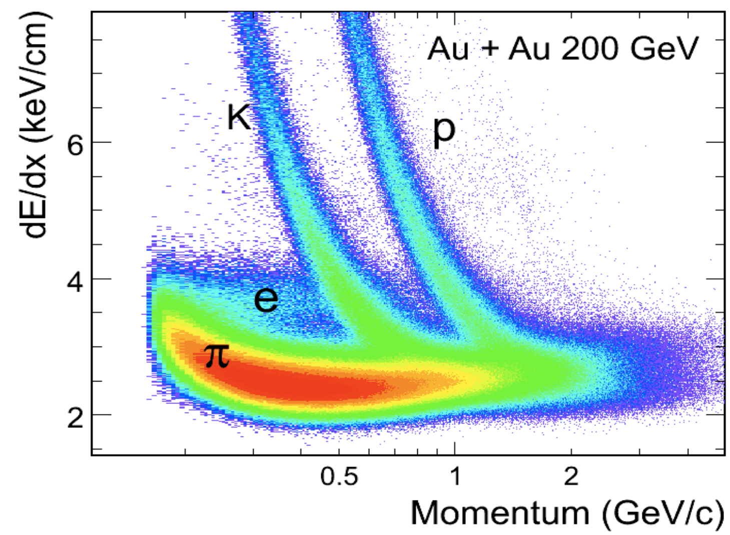
➢ **Experimental observables**

- *production cross section vs (mass, p_T)*
- *elliptic flow* - *in the future*

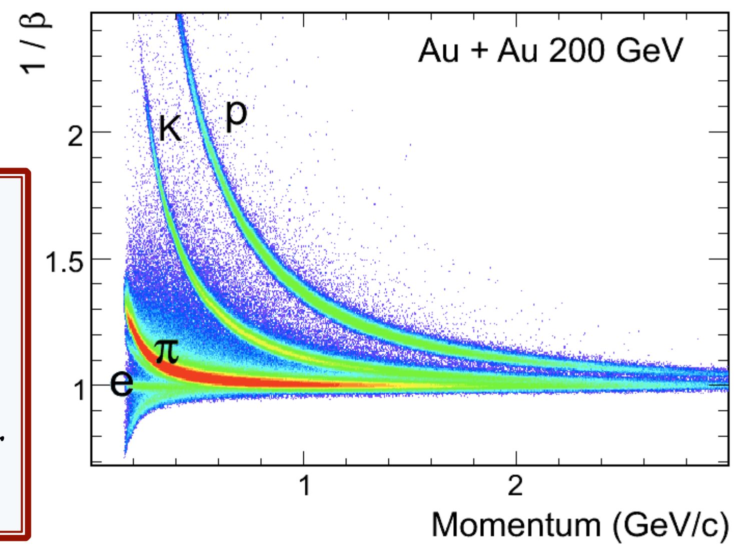
STAR detector



STAR TPC



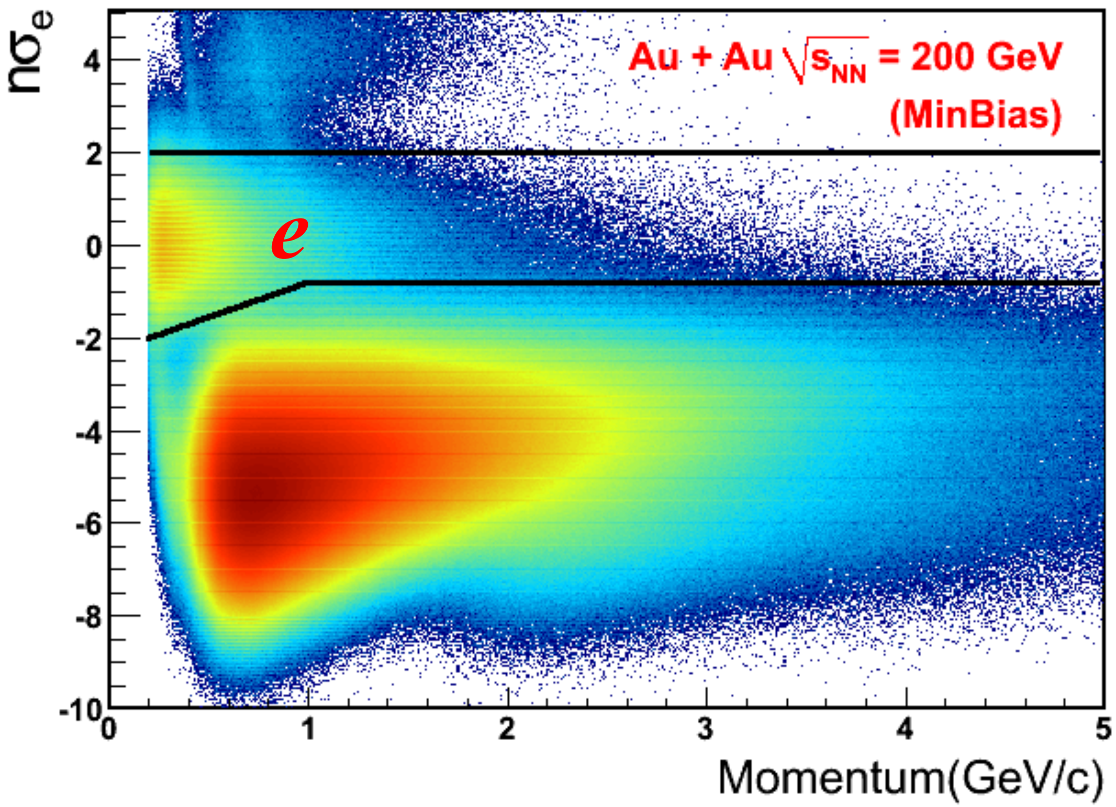
STAR TOF



- **Time Projection Chamber** $(0<\phi<2\pi, |\eta|<1)$
  Tracking – momentum
  Ionization energy loss – dE/dx (particle identification)
- **Time Of Flight detector** $(0<\phi<2\pi, |\eta|<0.9)$
  Timing resolution <100ps - significant improvement for PID

Electron Identification

TOF velocity cut to remove slow hadrons



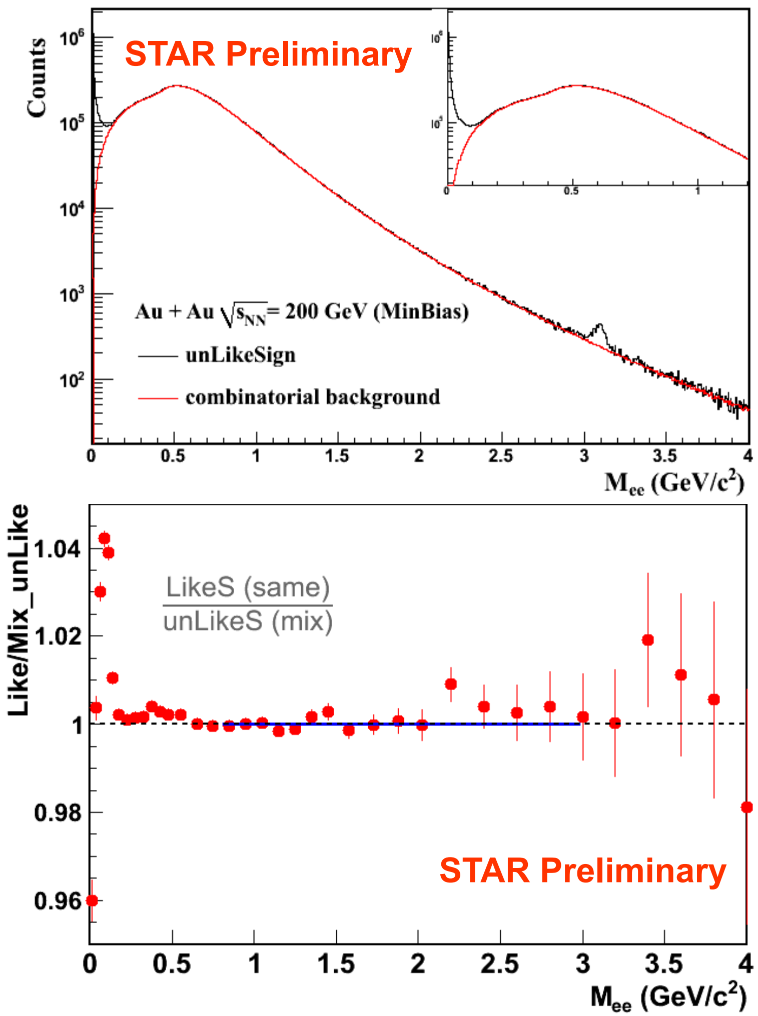
$$n\sigma_e = \frac{\log(\frac{dE/dx}{B_e})}{\sigma_e}$$

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

✓ *electron purity ~99% in p +p collision, ~97% in Au + Au MinBias collision.*

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

Background Reconstruction

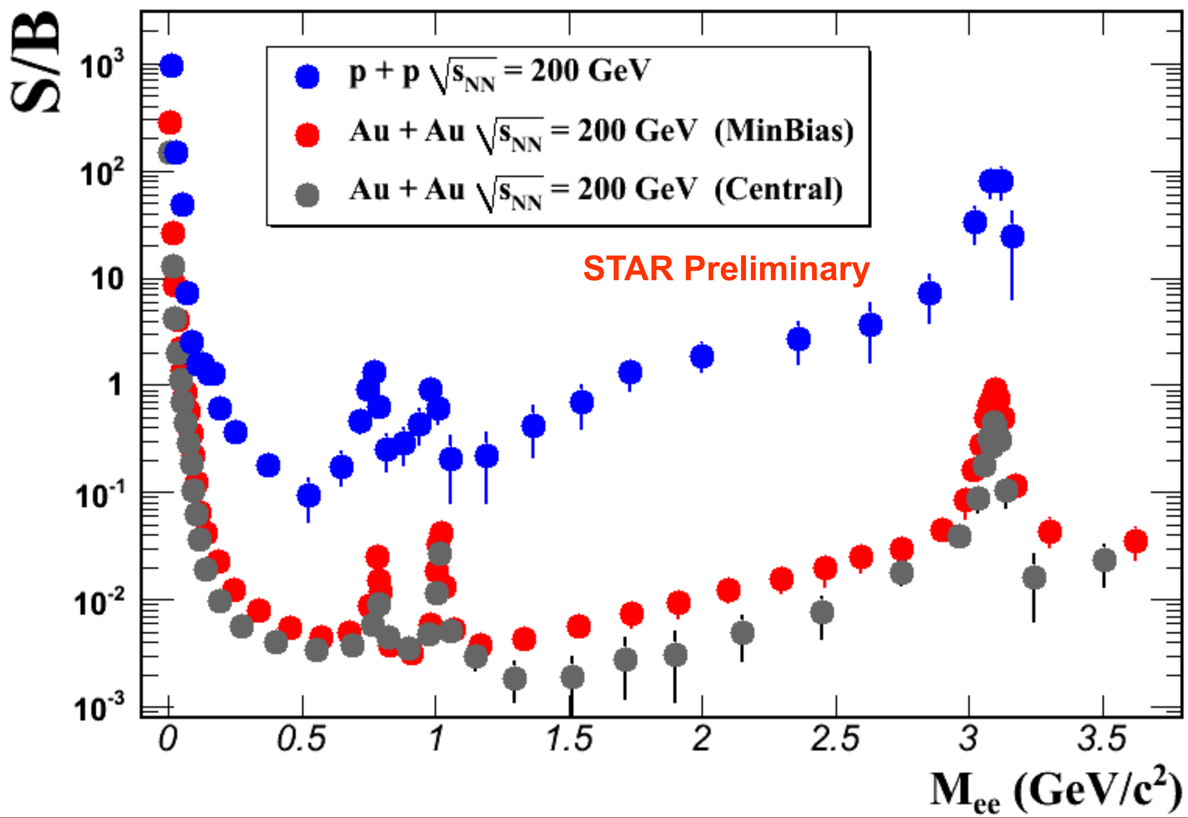


- **Conversion electrons removed from pair reconstruction**
- **Background**
  - **a. Low mass region**
    - *Like Sign – acceptance corrected*
    - *Cross pair and Jet contribution*
  - **b. Mass>0.75GeV/c^2**
    - *- Mixed Event*
    - *- Like Sign*
- **Systematic errors**
  - *- acceptance uncertainty < 0.1 %*
  - *- normalization uncertainty < 0.1%*

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

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

Signal/Background



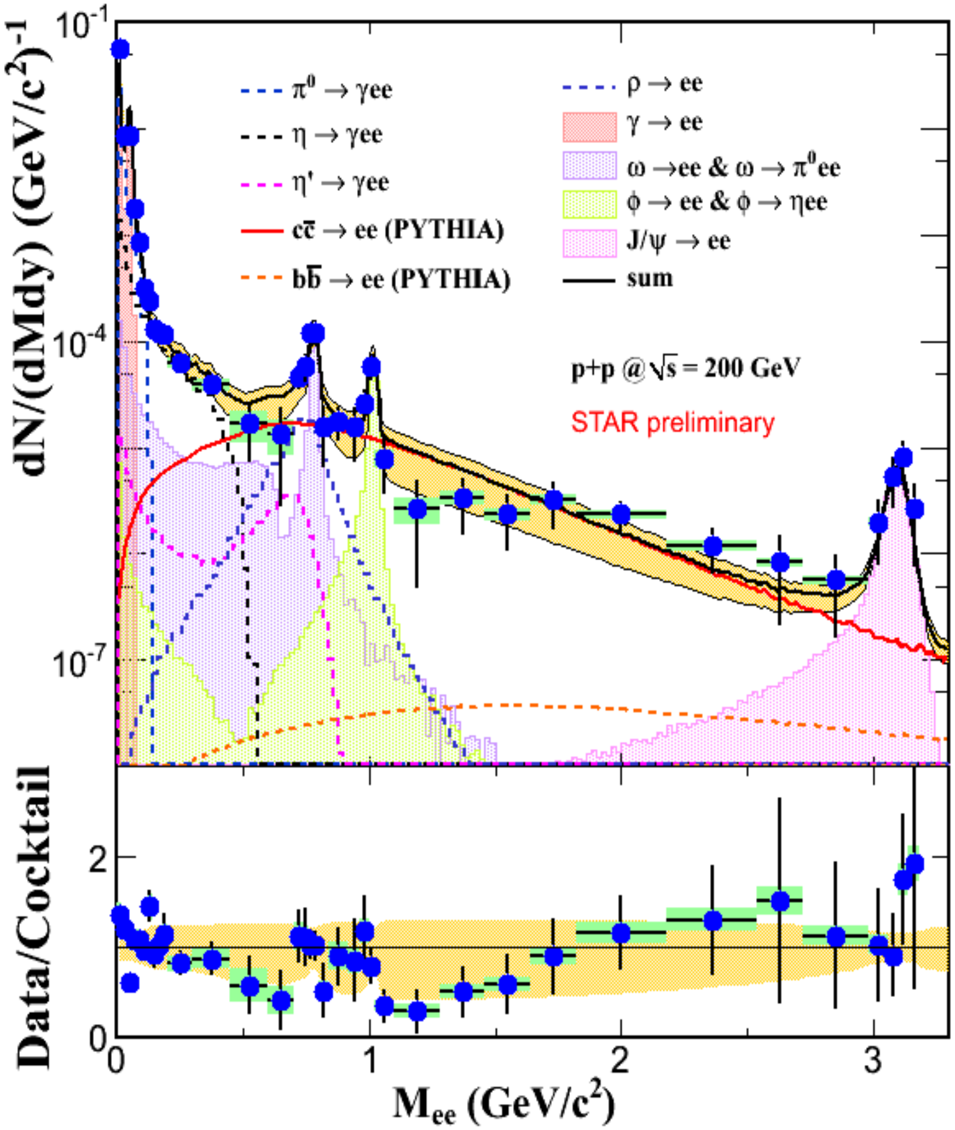
- **Signal/background ratio: mass(ee) ~ 0.5 GeV/c^2**

  ~ 1:10 for p + p collisions

  ~ 1:200 for Au + Au minbias collisions

  ~ 1:250 for Au + Au central collisions

Di-electron production in p + p collisions



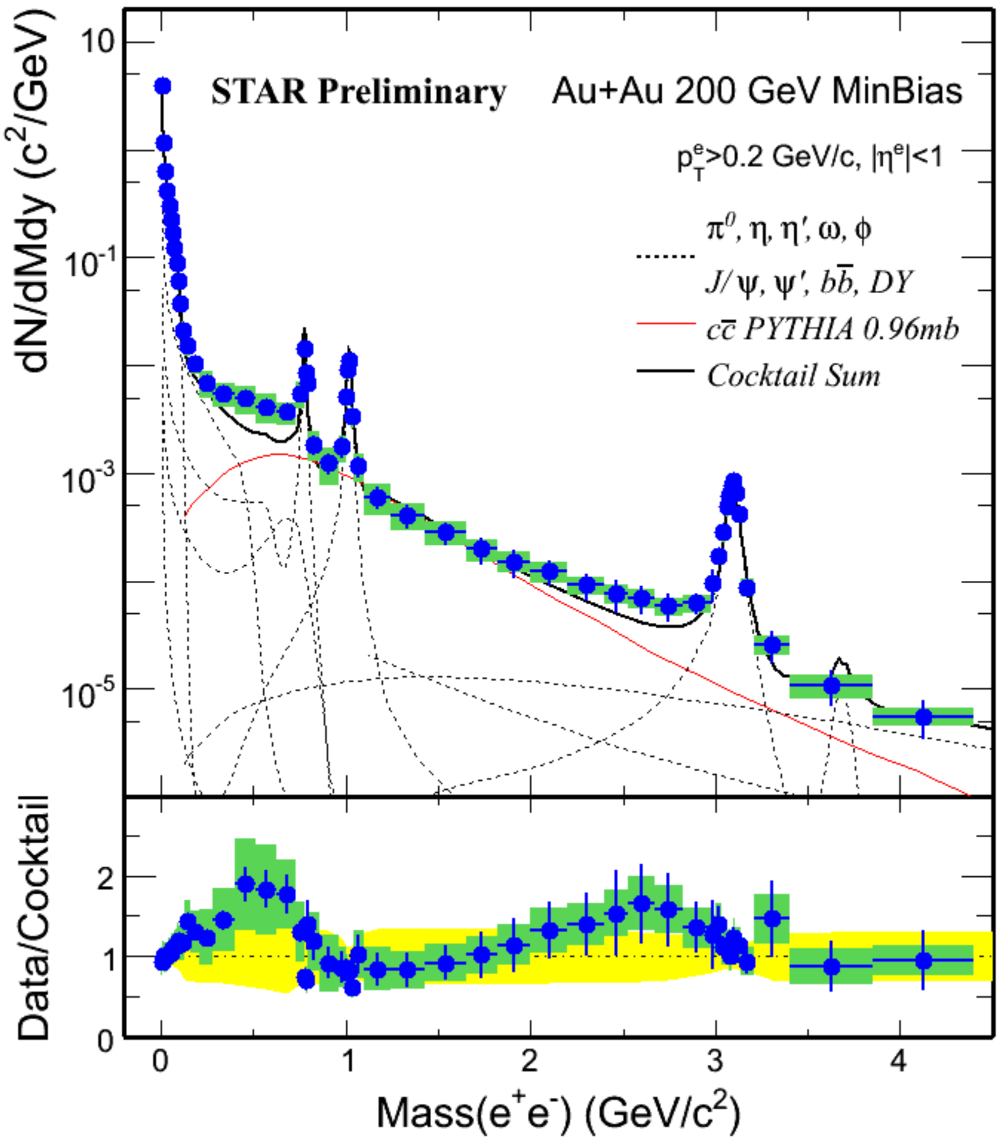
~ 107M events!

Poster 102, B. Huang

- Consistent with hadron cocktails
- Charm cross section from STAR p + p measurement[1]
- Provide baseline for Au + Au collisions

[1] Yifei Zhang, Friday 16:00.

Di-electron production in Au + Au collisions



~ 270M Au+Au MinBias events

- **Data show a hint of enhancement at LMR compared to the hadron cocktails w/o ρ.**

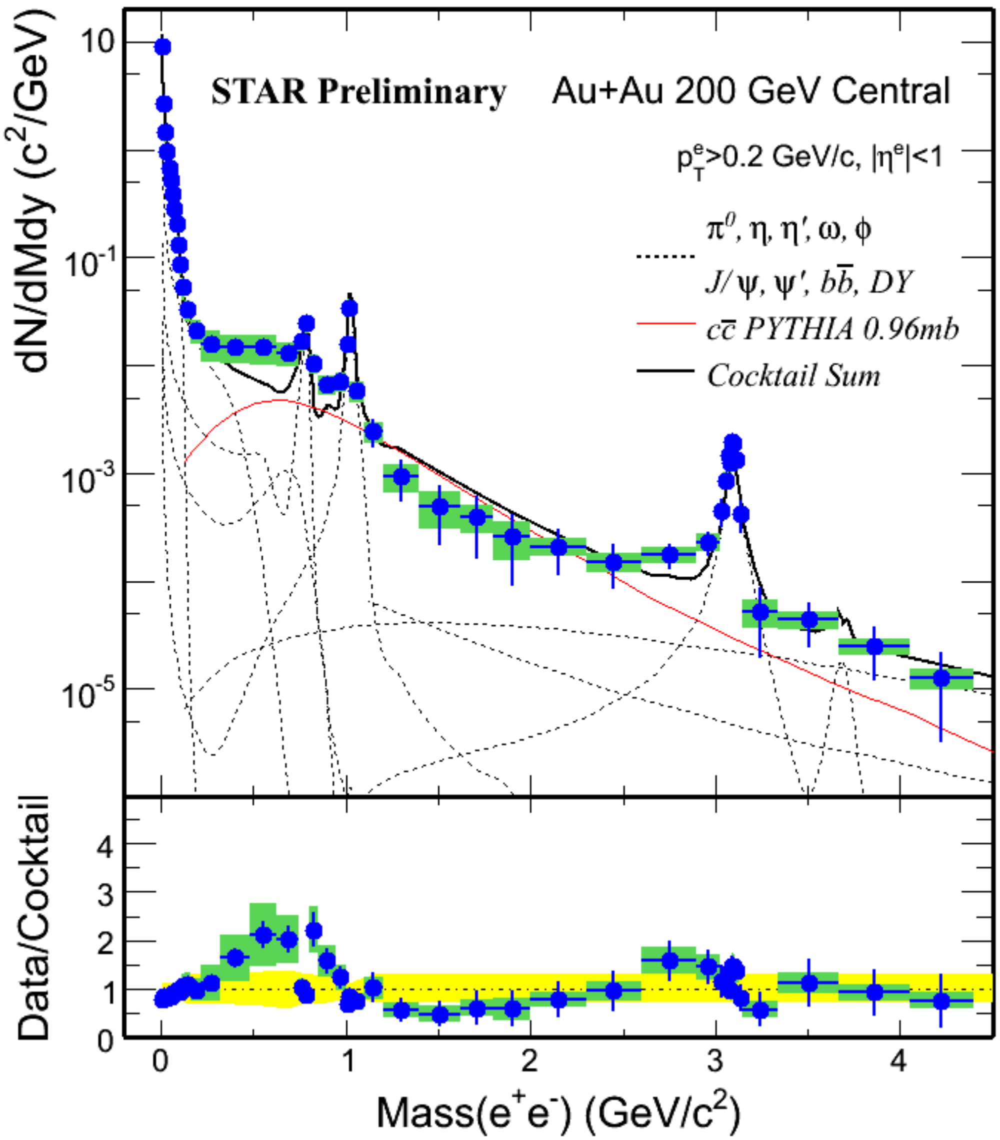
  - *ρ contribution not included in the cocktail*

  - *charm = PYTHIA*N_{bin} (0.96 mb) real contribution in Au+Au is an open question*

  - *$\pi^0(\pi^\pm)$, ϕ from STAR*
  - *η, ω J/ψ from PHENIX*

- *Green box: syst. errors on data*
- *Yellow band: syst. errors on cocktail*

Di-electron production in Au + Au collisions



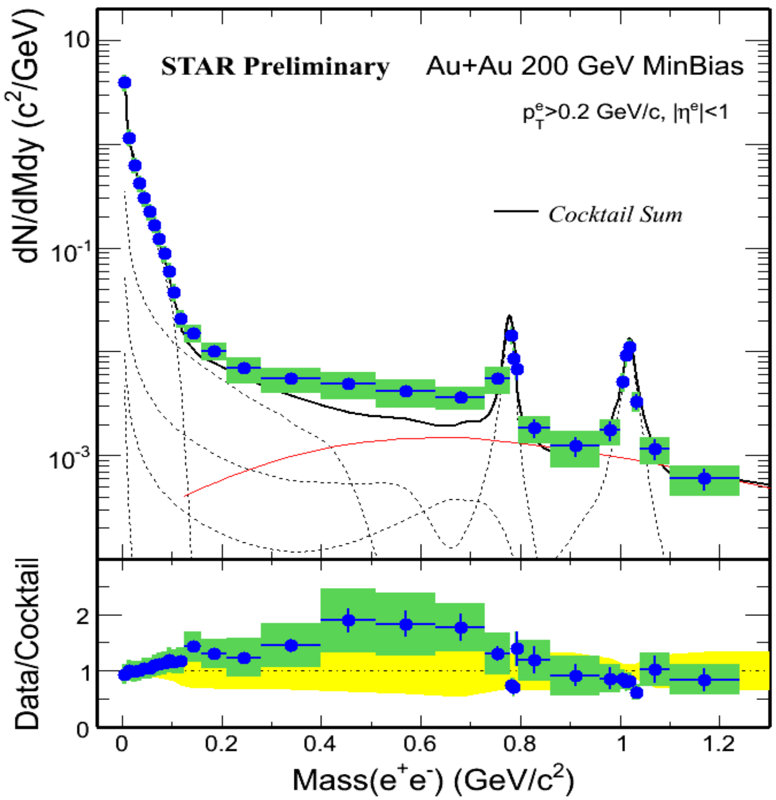
~ 150M Au+Au Central (0-10%)

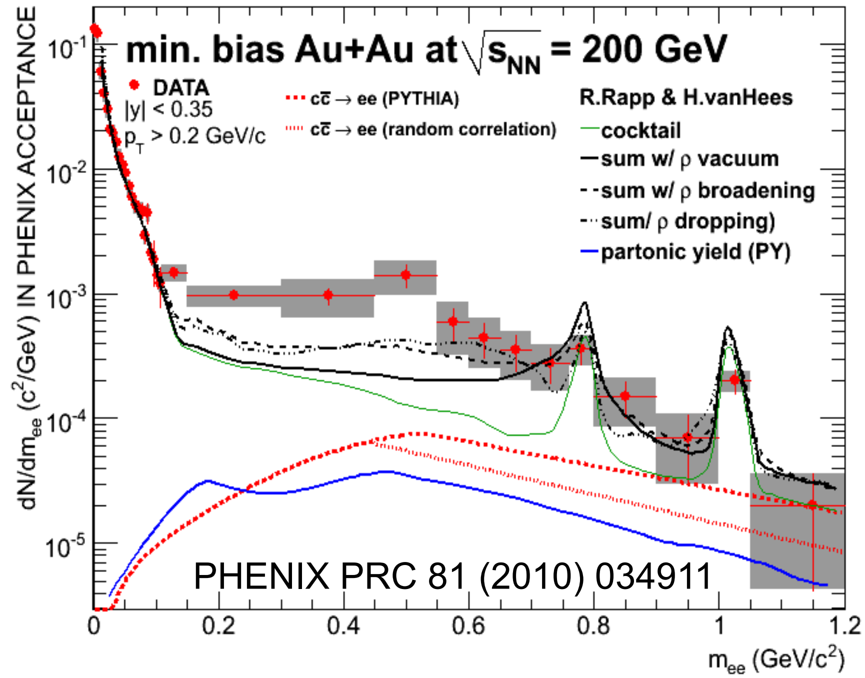
- **Clearer LMR enhancement in central collisions compared to minbias collisions**

  - ρ contribution not included in the cocktail

  - charm = PYTHIAN_{bin} (0.96mb) overpredicts the data at IMR indicating charm modifications in central Au +Au collisions*

LMR Enhancement



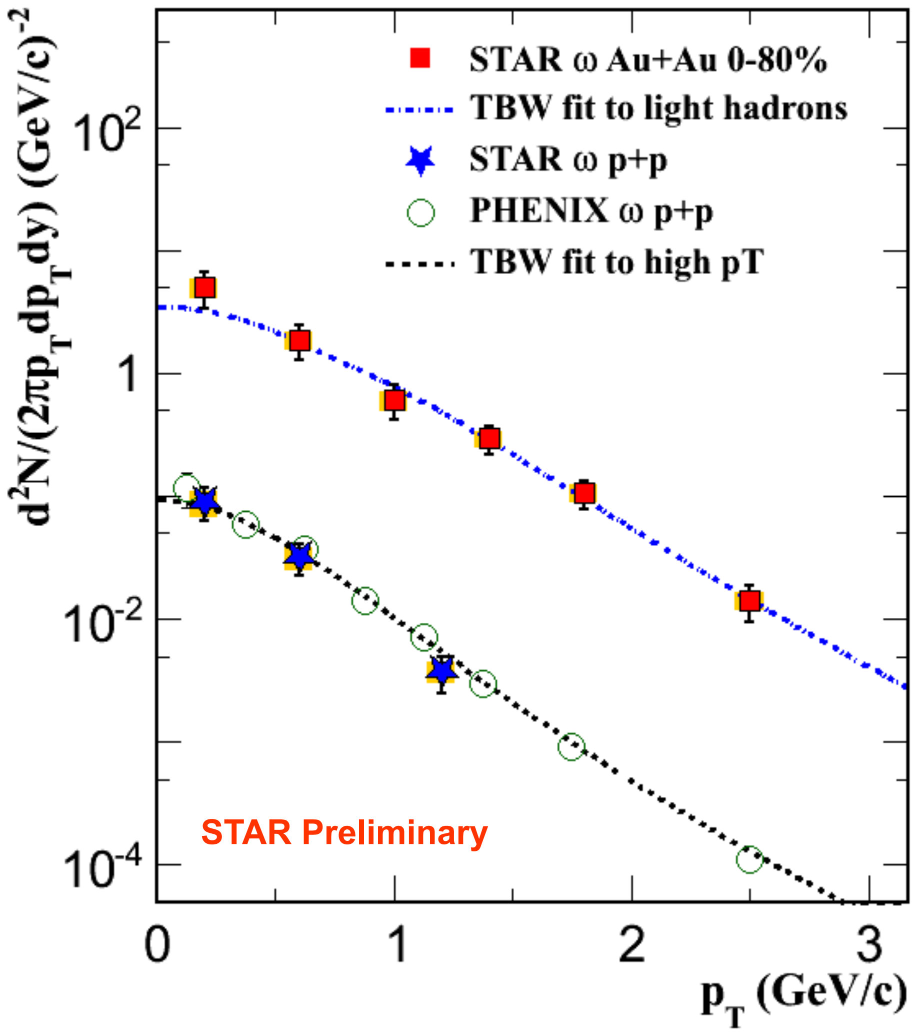


Enhancement factor in $0.15<M_{ee}<0.75$ Gev/c^2

	Minbias (value ± stat ± sys)	Central (value ± stat ± sys)
STAR	1.53 ± 0.07 ± 0.41 (w/o ρ) 1.40 ± 0.06 ± 0.38 (w/ ρ)	1.72 ± 0.10 ± 0.50 (w/o ρ) 1.54 ± 0.09 ± 0.45 (w/ ρ)
PHENIX	4.7 ± 0.4 ± 1.5	7.6 ± 0.5 ± 1.3
Difference	2.0 σ	4.2 σ

Note: Acceptance difference etc.

Low mass vector mesons



Poster 102, B. Huang (ω)
Poster 103, C. Markert (ϕ)

- ω measurements via di-lepton channel in p+p and Au+Au at STAR
- ϕ is in progress

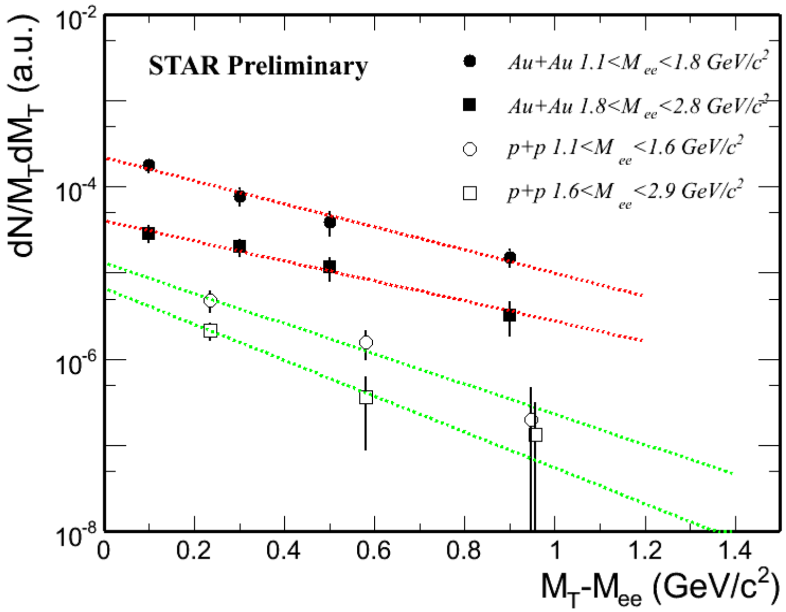
Tsallis Blast-wave(TBW) fit:

<β>=0 in p+p,

<β>=0.47 in 0-80% AuAu.

Z.Tang et al., arXiv:1101.1912

Transverse mass spectra

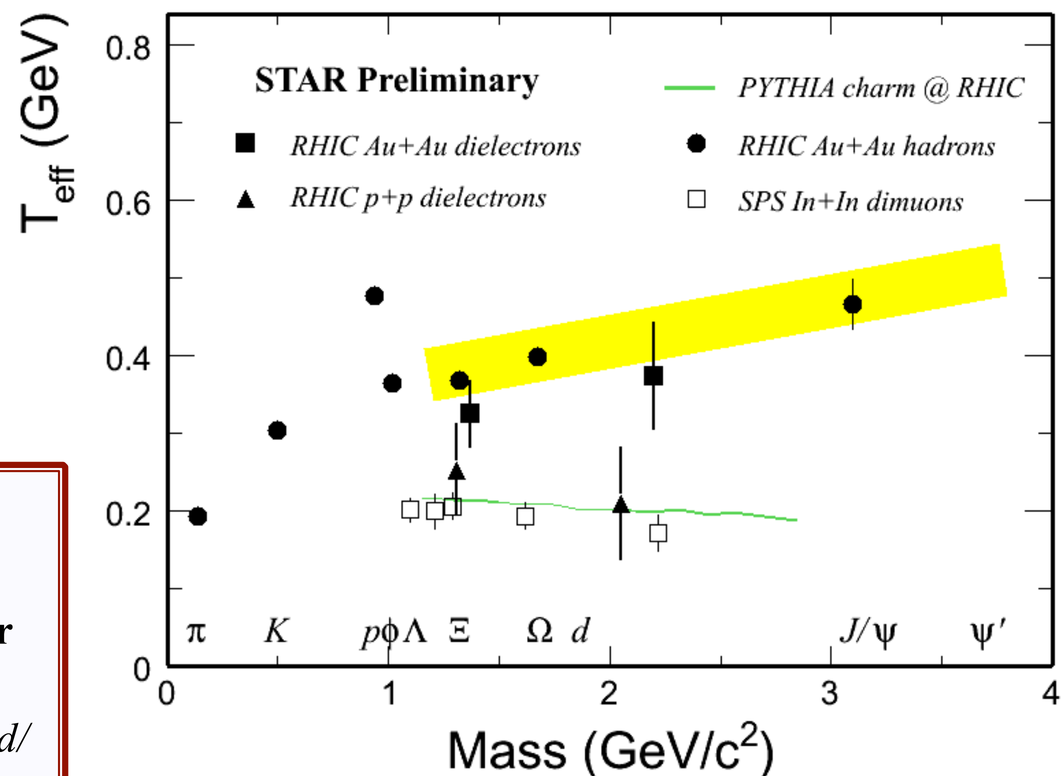


- p + p result consistent with PYTHIA charm
- m_T slope parameter in Au+Au is higher than that in p + p

  hint of thermal di-lepton production and/ or charm modification
- Inclusive di-lepton slope in Au+Au at RHIC is also higher than that (charm/DY subtracted) from SPS

A + A: Minbias collisions

RHIC Au + Au 200 GeV / SPS In + In 17.2 GeV



SPS data: charm/DY subtracted - PRL 100, 022302 (2008)
STAR data: inclusive di-electron, statistical error only

Summary and Outlook

- **First di-electron measurement from 200GeV p + p and Au + Au collisions at STAR**

- **Low mass region:**

  - Enhancement in Au + Au central collisions compared to the cocktail

  ρ *in-medium modifications*? – call for theory calculations in STAR acceptance

- **Intermediate mass region:**

  - Inclusive di-electron m_T slope parameter is higher in Au + Au compared to p + p

  modification of charm and/or thermal radiation contribution ?

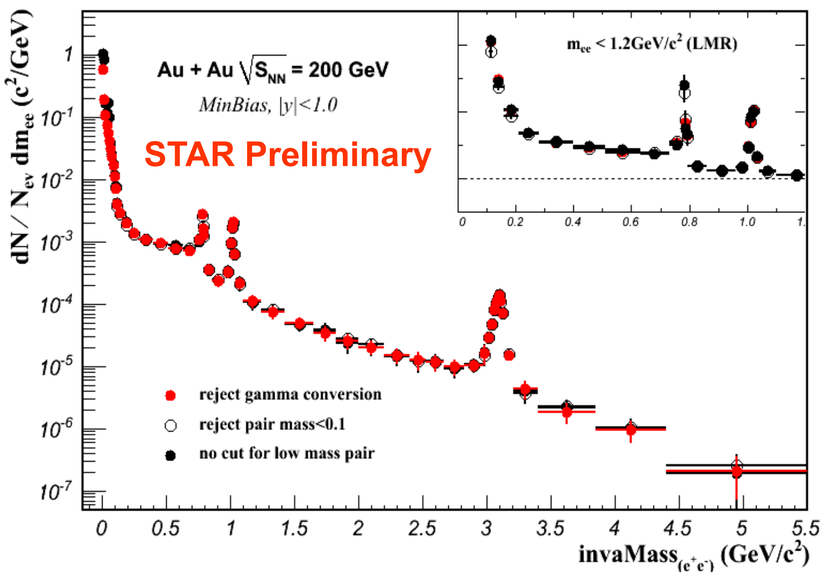
  - Need more precise measurement to constrain charm and QGP thermal radiation contributions

Outlook: STAR Heavy Flavor Tracker and Muon Telescope Detector - charm contribution!

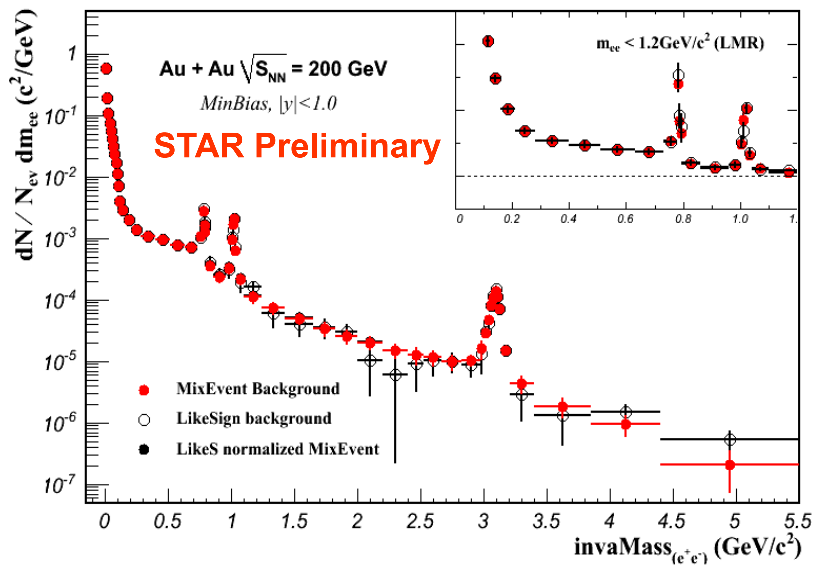
MTD: Poster 129, L. Ruan

BACKUP

Systematic check



Different photonic rejection

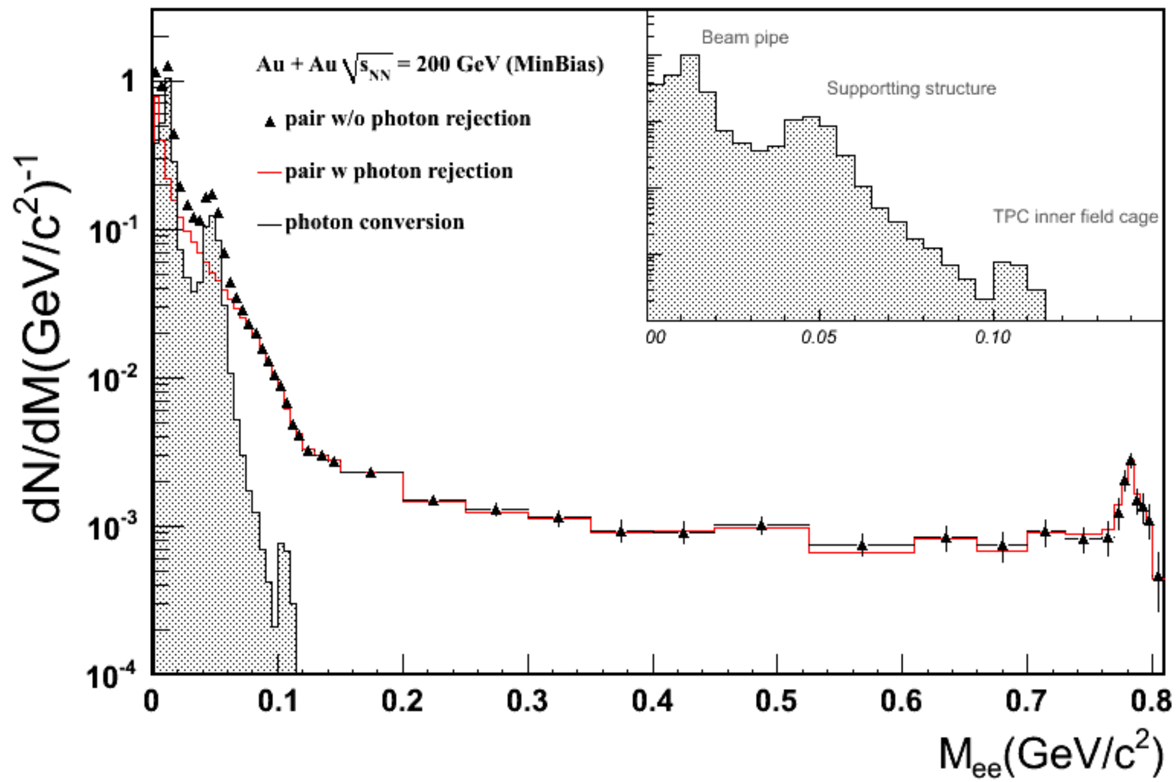


Different background subtraction

Included in systematic uncertainties

Photon conversion removal

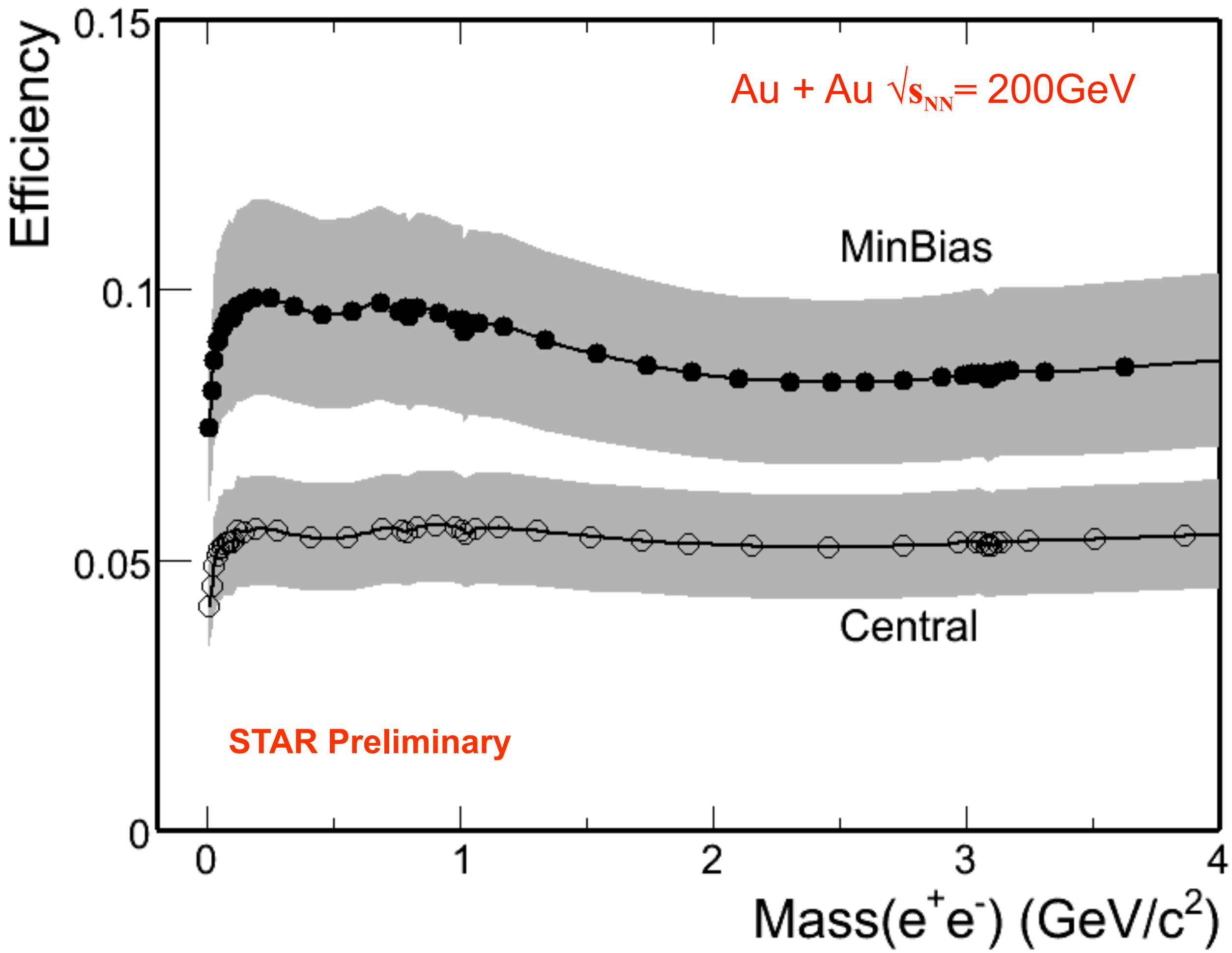
Low material budget in run9 and run10



- Conversion electrons are removed from signal pair reconstruction.

- Difference between w/ and w/o photon conversion rejection to the final signal is less 10% at $M>0.2GeV/c^2$ (included in the systematic errors)

Efficiency



Efficiency
0.15
0.1
0.05
0
0
1
2
3
4
Mass(e^+e^-) (GeV/c^2)
Au + Au $\sqrt{s_{NN}}$= 200GeV
MinBias
Central
STAR Preliminary

Background Reconstruction

Like Sign:

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

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

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

MixEvent:

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

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

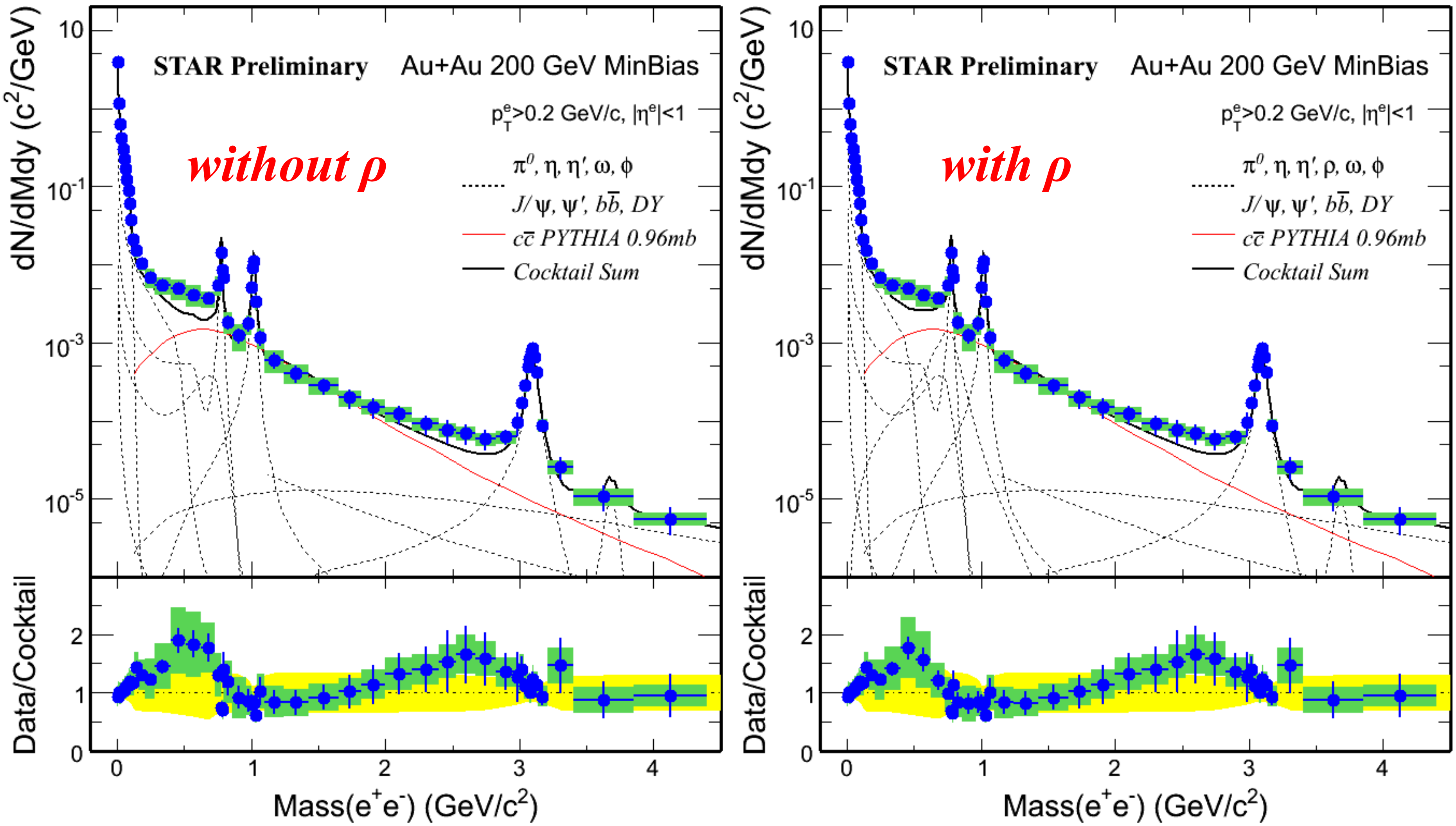
$$B_{++}^{mix} = \int_0^\infty A_+ B_{++}^{mix} dmdpT \quad , \quad B_{--}^{mix} = \int_0^\infty A_- B_{--}^{mix} dmdpT,$$

- normalize mixed unlikeSign (combinatorial background)

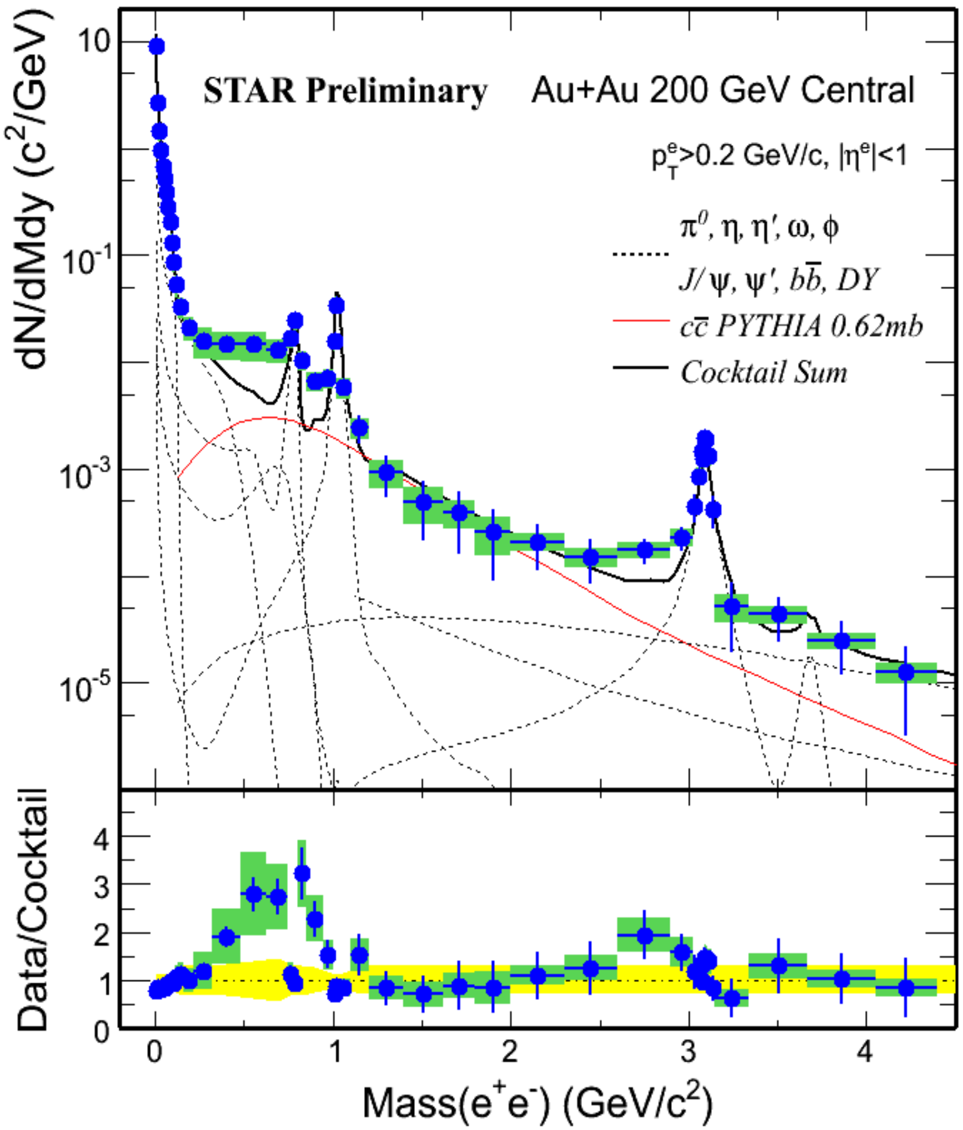
$$B_{+-}^{combinatorial} = \frac{2\sqrt{B_{++}^{mix} \cdot B_{--}^{mix}}}{\int_0^\infty B_{+-}^{mix} dmdpT} B_{+-}^{mix}$$

PHENIX PRC 81, 034911 (2010)

Cocktail with ρ



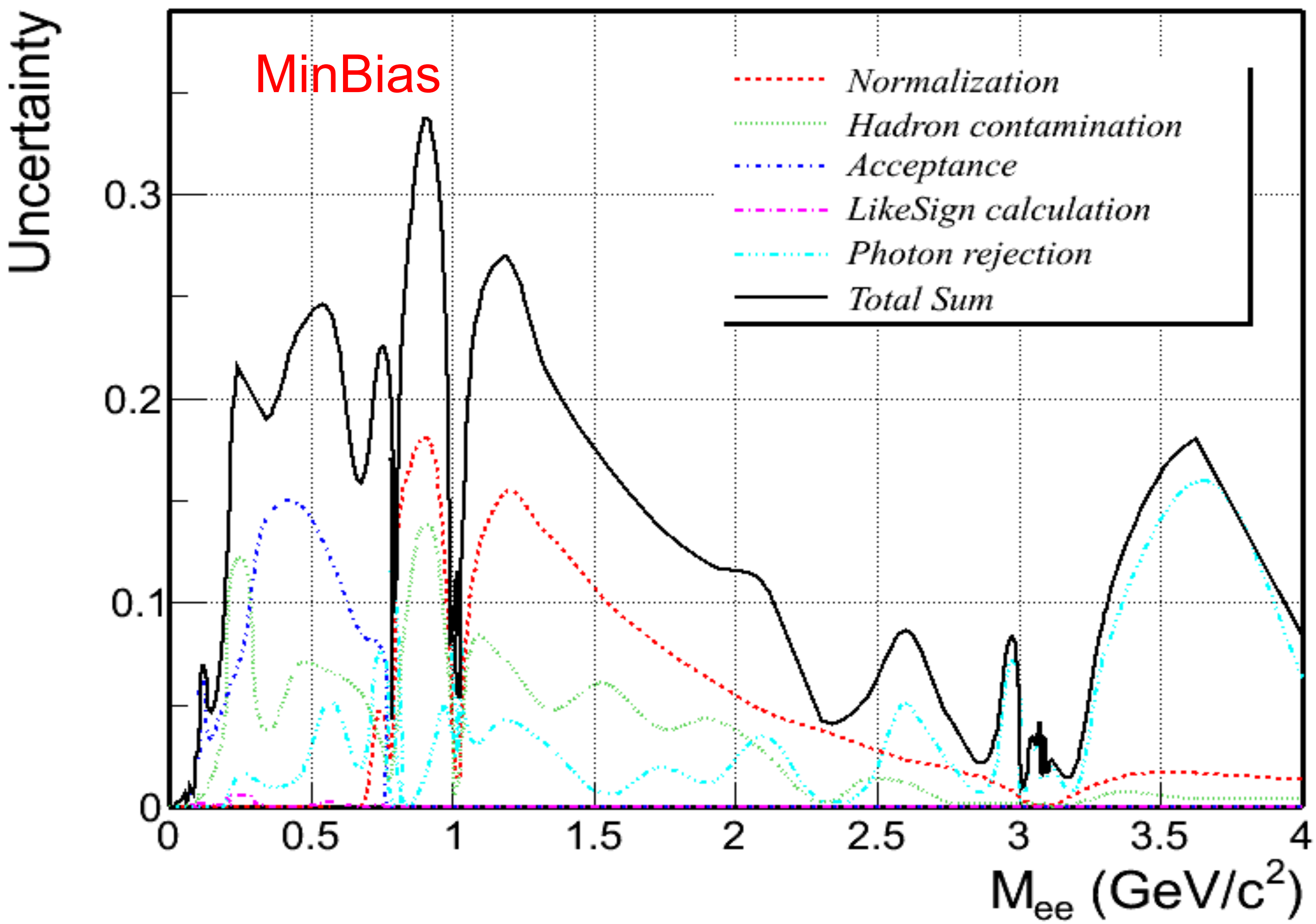
Enhancement in Central collisions



The fit of charm cocktail to the data gives:
0.62 ± 0.14 mb

PYTHIA setting for charm:
V6.416
MSEL=1,
PARP(91)=1.0 (kt),
PARP(67)=1 (parton shower level)

Systematic error

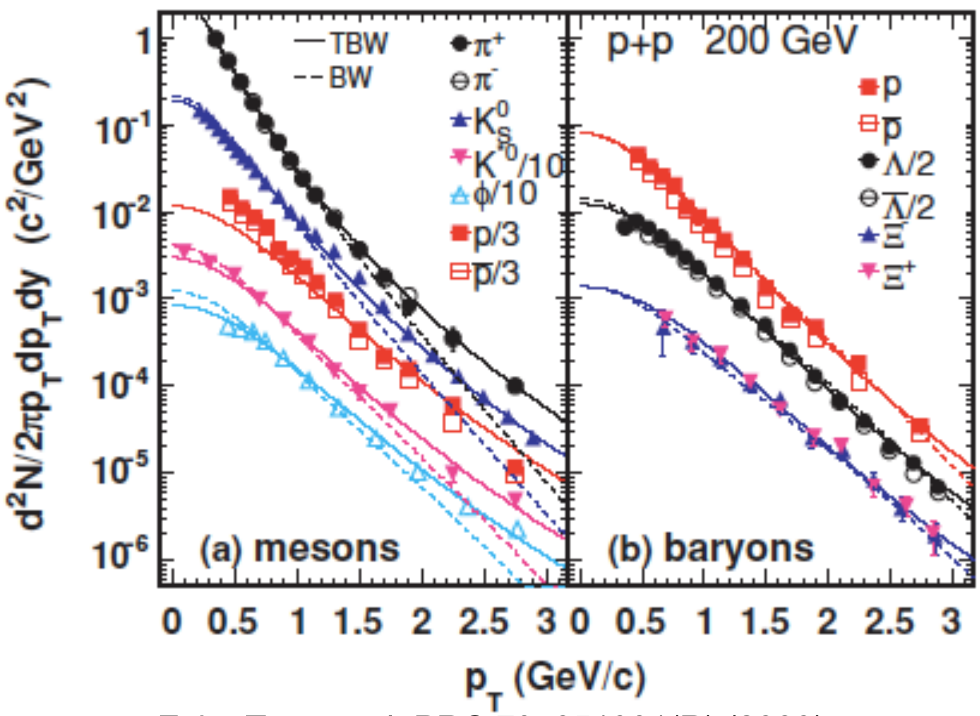


Cocktail

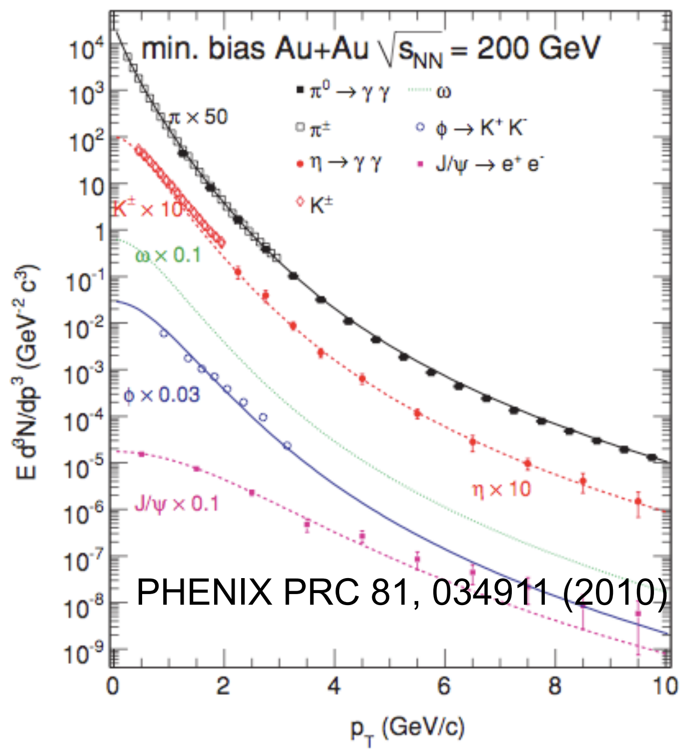
➢ **Inputs:**

flat rapidity (-1,1) flat Φ (0, 2π)

p_T: in p+p, use Tsallis function fit for all measured particles
in Au+Au for measured π^0,J/ψ use Tsallis function fit, and use m_T-scaling for η, ω, φ, η`



Zebo Tang et al, PRC 79, 051901(R) (2009)



PHENIX PRC 81, 034911 (2010)

Considered minbias centrality definition difference between PHENIX (0-93%) and STAR (0-80%)