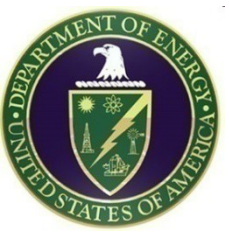


Di-electron spectra in p+p and Au+Au at 200 GeV from STAR

Bingchu Huang *(for the STAR Collaboration)*

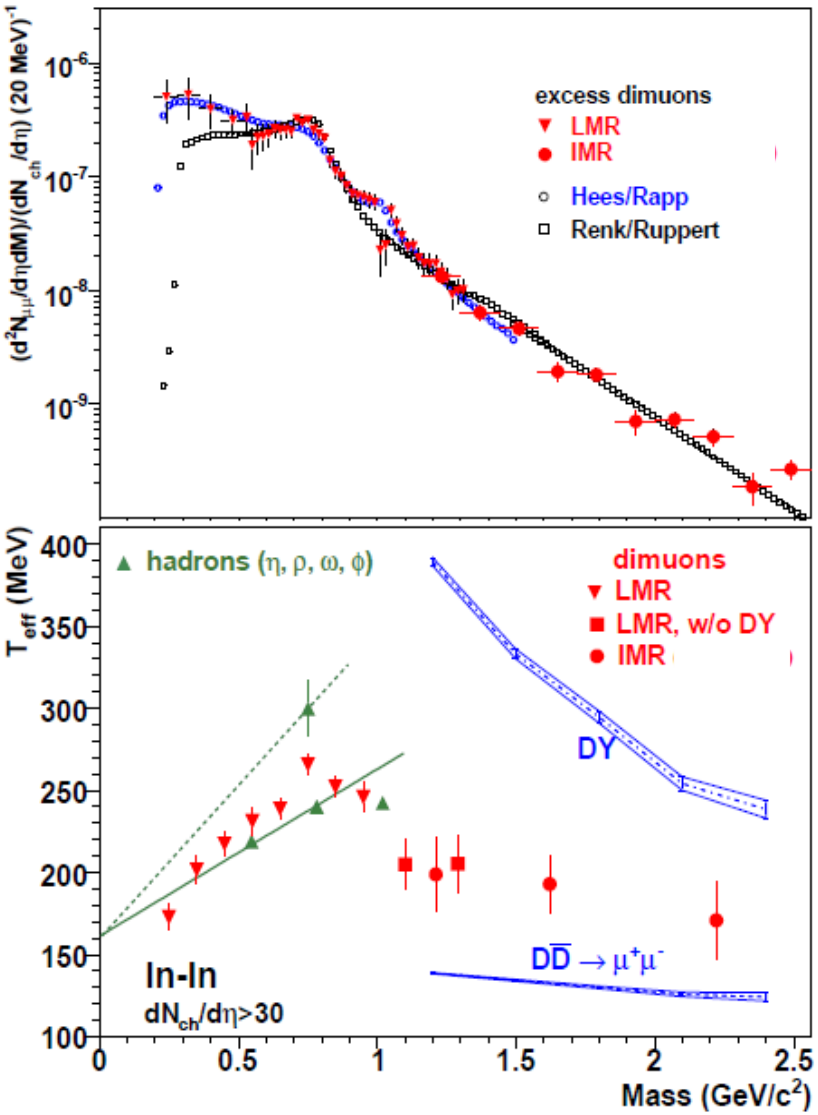
Brookhaven National Laboratory

BROOKHAVEN
NATIONAL LABORATORY

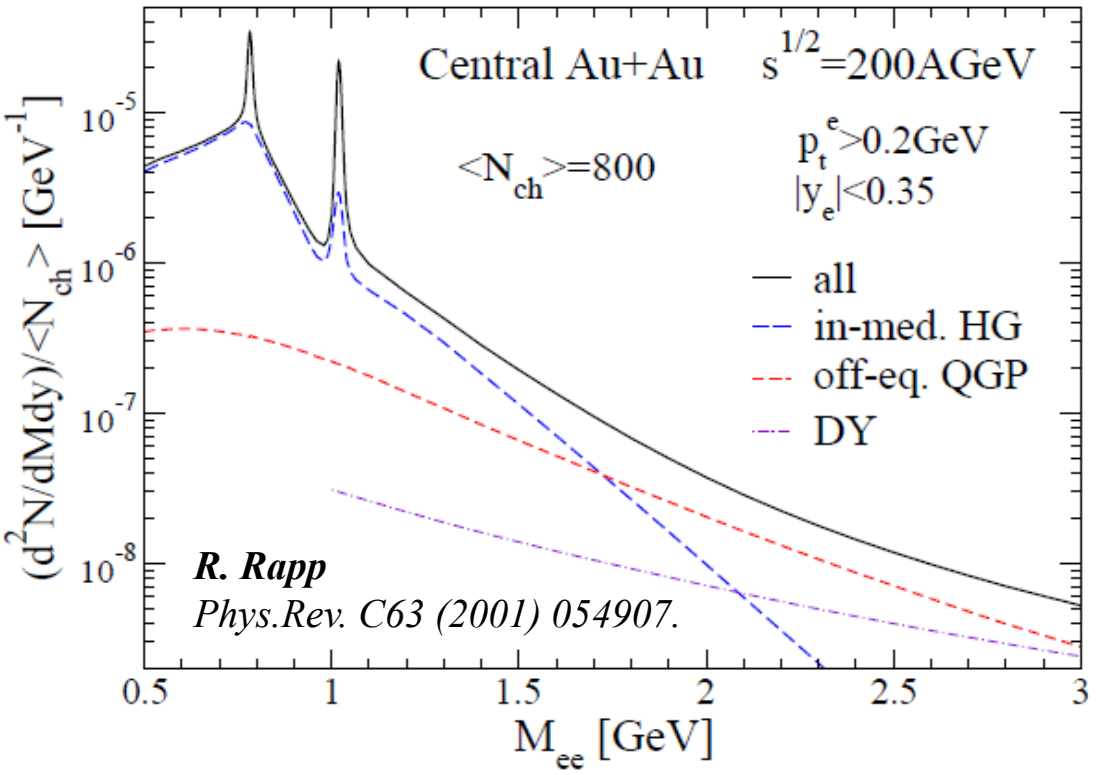
Outline

- Motivation
- Analysis
- Di-electron production in p+p and Au+Au at 200 GeV
- Summary

Motivation



NA60: ***Eur.Phys.J.C59:607-623,2009***



Low mass range (LMR):

In-medium modifications of vector mesons.

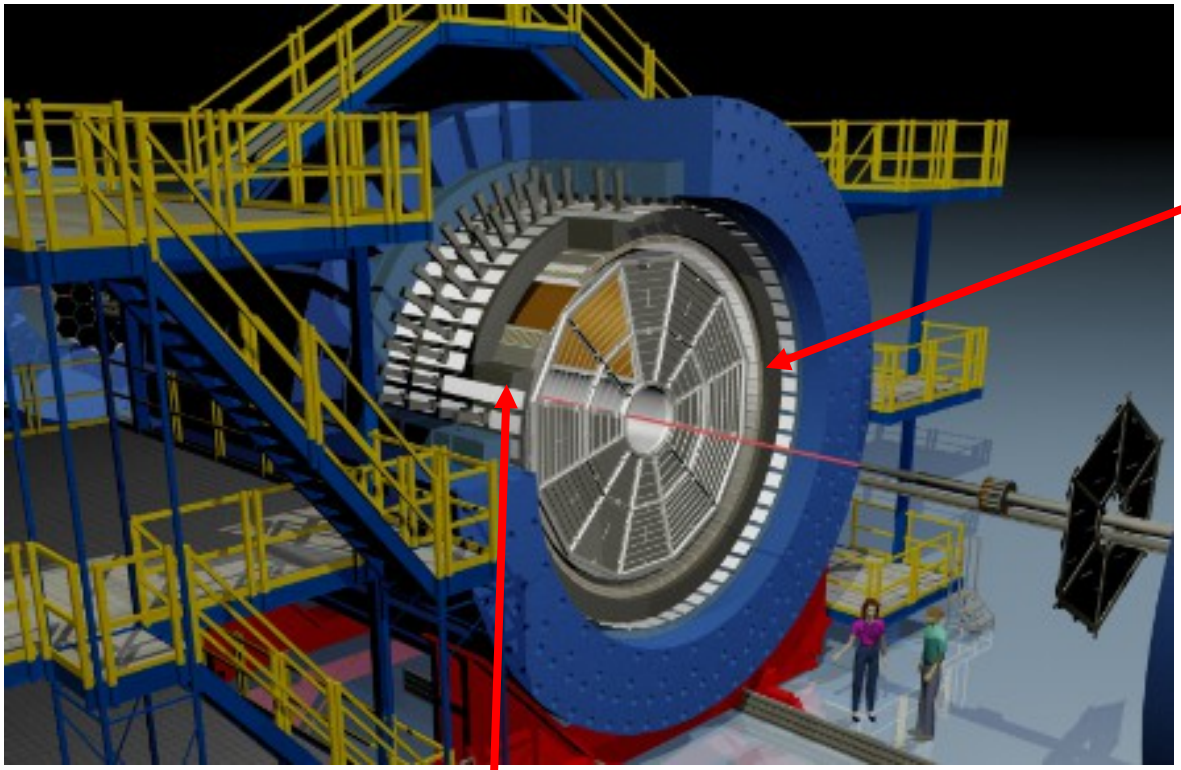
Possible link to chiral symmetry restoration.

Intermediate mass range (IMR):

QGP thermal radiation.

Heavy flavor modification.

Electron identification

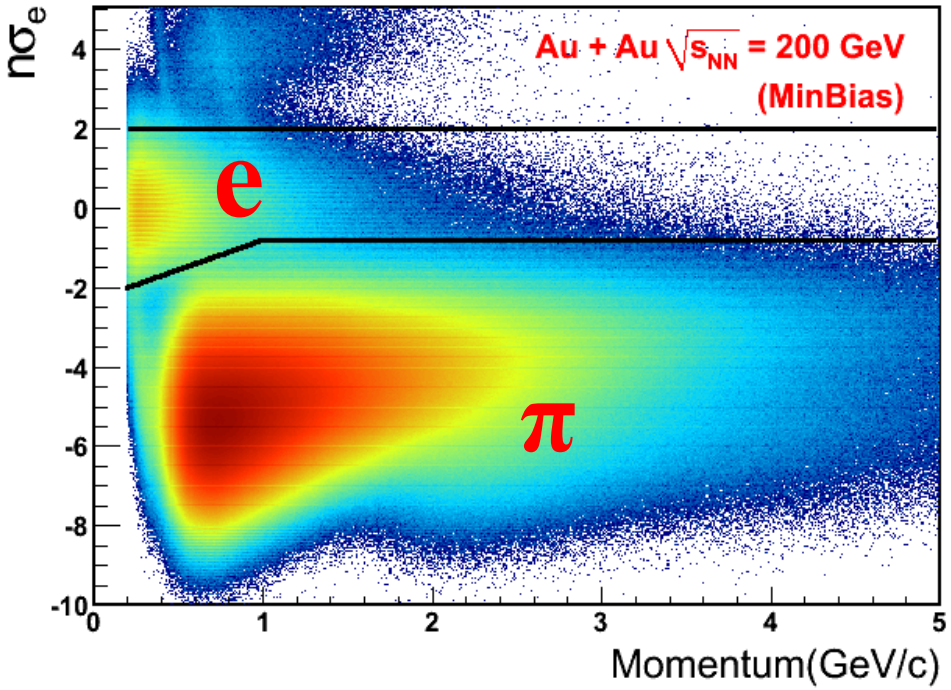


Tracking: TPC

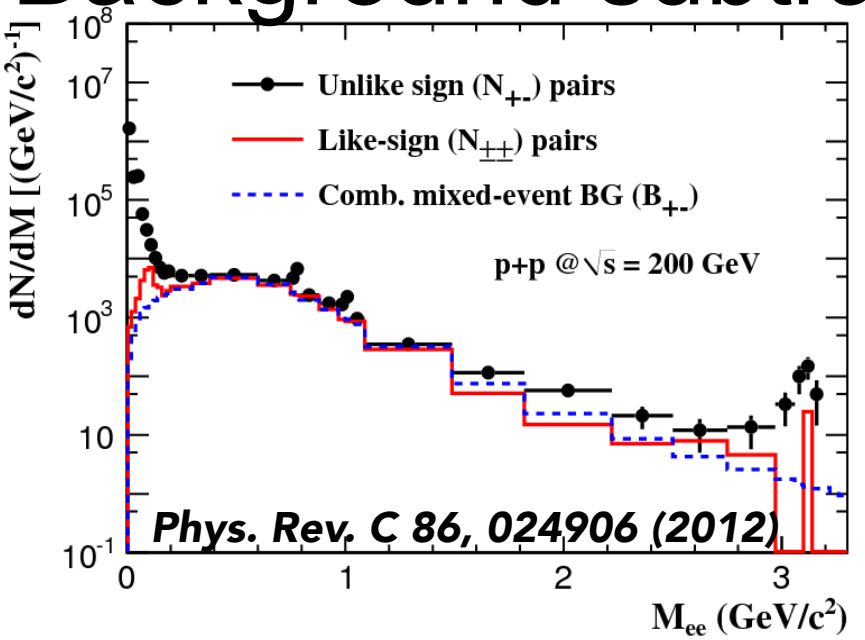
Time Projection Chamber
1. Tracking
2. Ionization energy loss (dE/dx PID)
3. Coverage -1<η<1

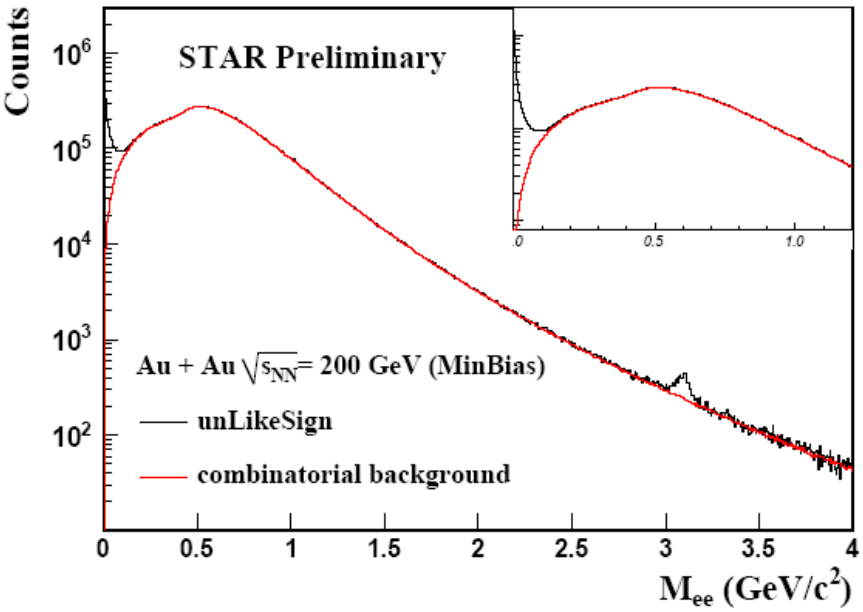
Particle ID: TOF

Time Of Flight ----
1. Timing resolution (<100ps)
2. Coverage: -0.9<η<0.9
3. Completed in 2010 (72% in 2009)



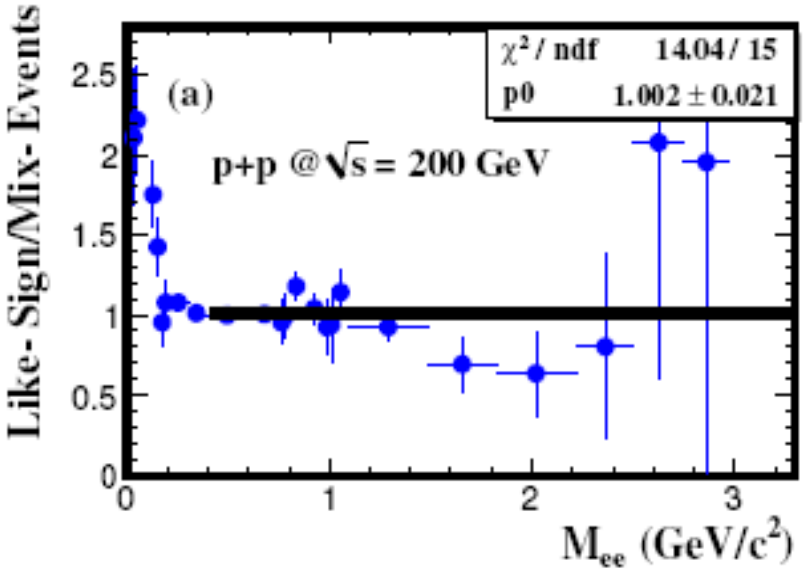
Background subtraction

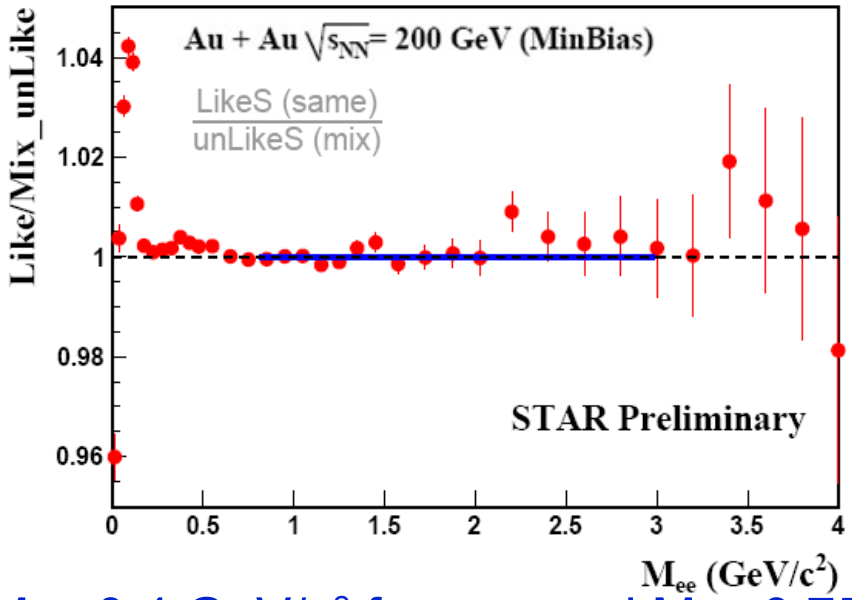




Like-sign background has been corrected by acceptance factor:

$$\frac{B_{+-}^{Mix}}{2\sqrt{B_{++}^{Mix}B_{--}^{Mix}}}$$

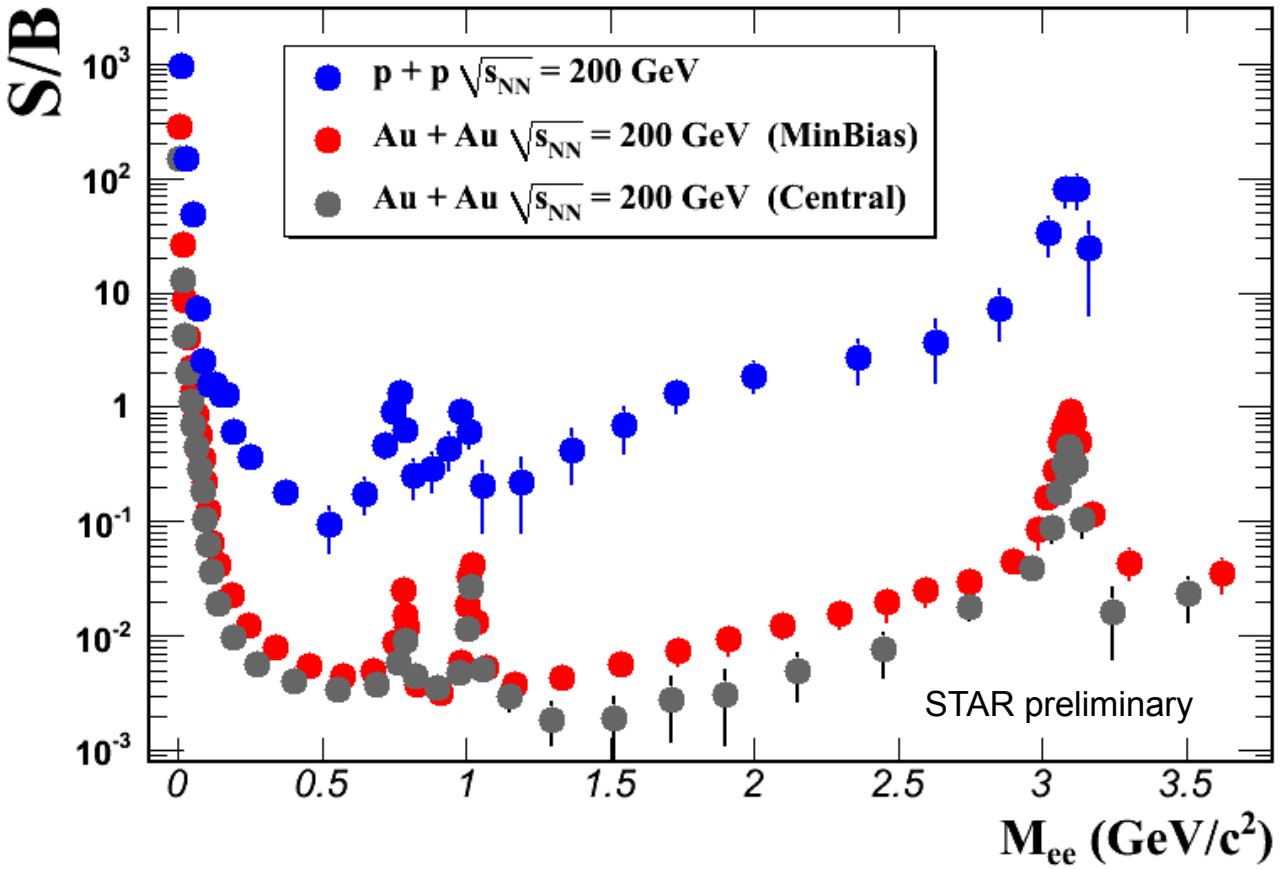




Normalization range of Mee:
p+p :
(0.4,1.5) GeV/c^2
Au+Au:
(0.7,3) GeV/c^2

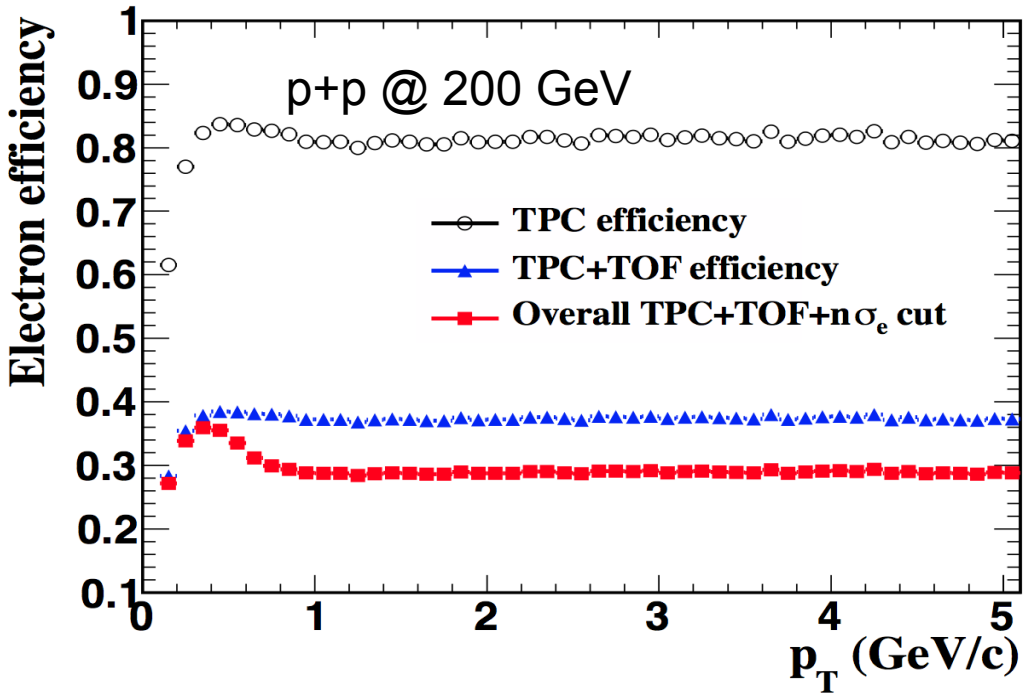
Mixed-event BG subtraction range: M_{ee}>0.4 GeV/c^2 for p+p and M_{ee}>0.75 GeV/c^2 for Au+Au 200 GeV.

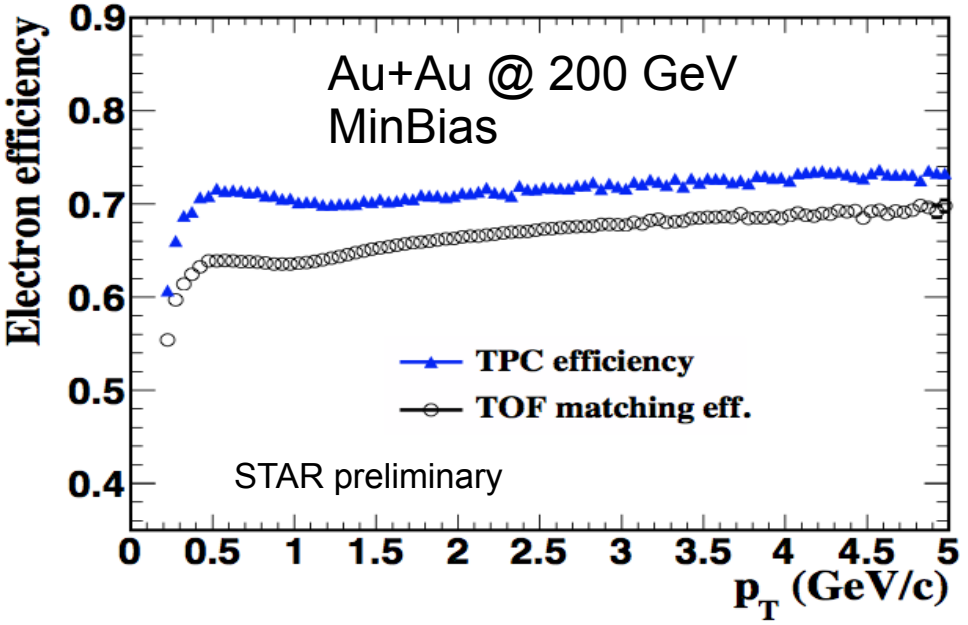
Signal/background

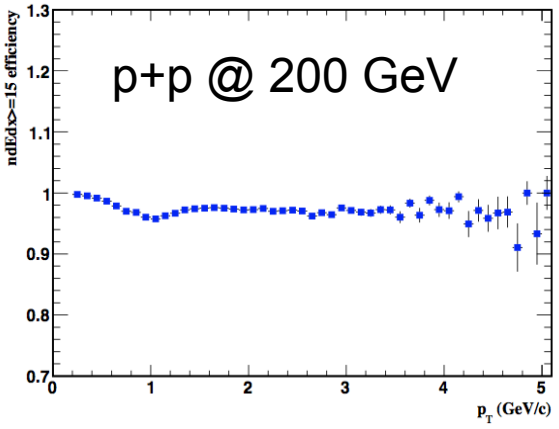


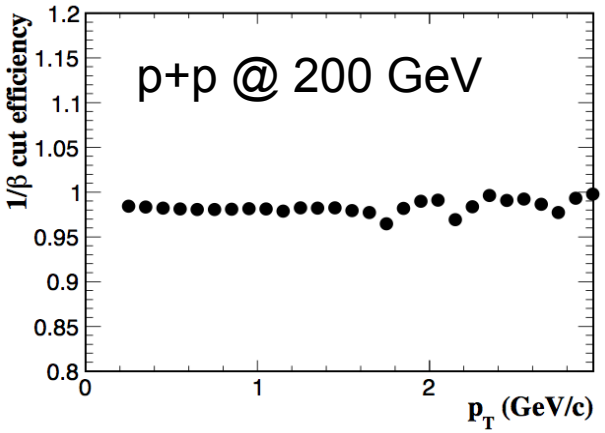
- **Signal/background ratio: M_{ee} ~ 0.5 GeV/c^2**
  - *~ 1:10 for p + p collisions*
  - *~ 1:200 for Au + Au minbias collisions*
  - *~ 1:250 for Au + Au central collisions*

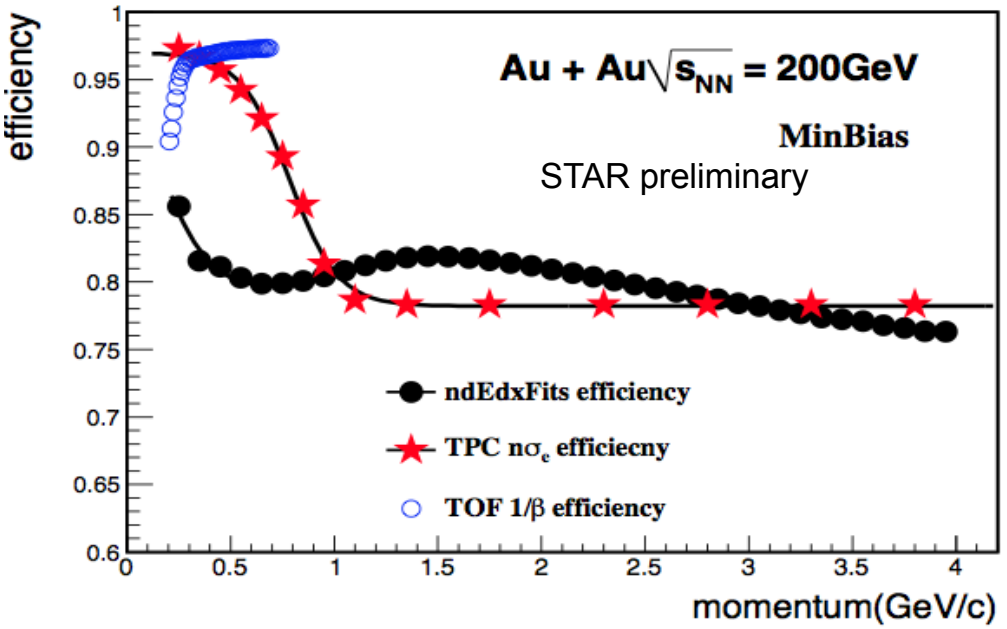
Efficiency of single electron







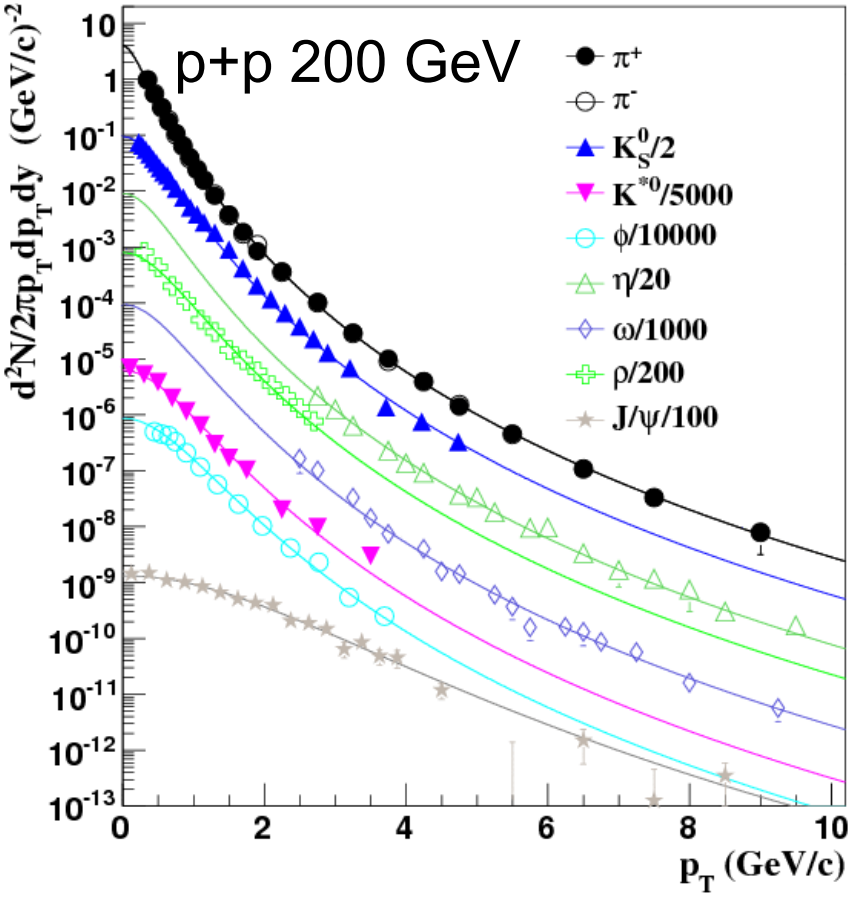


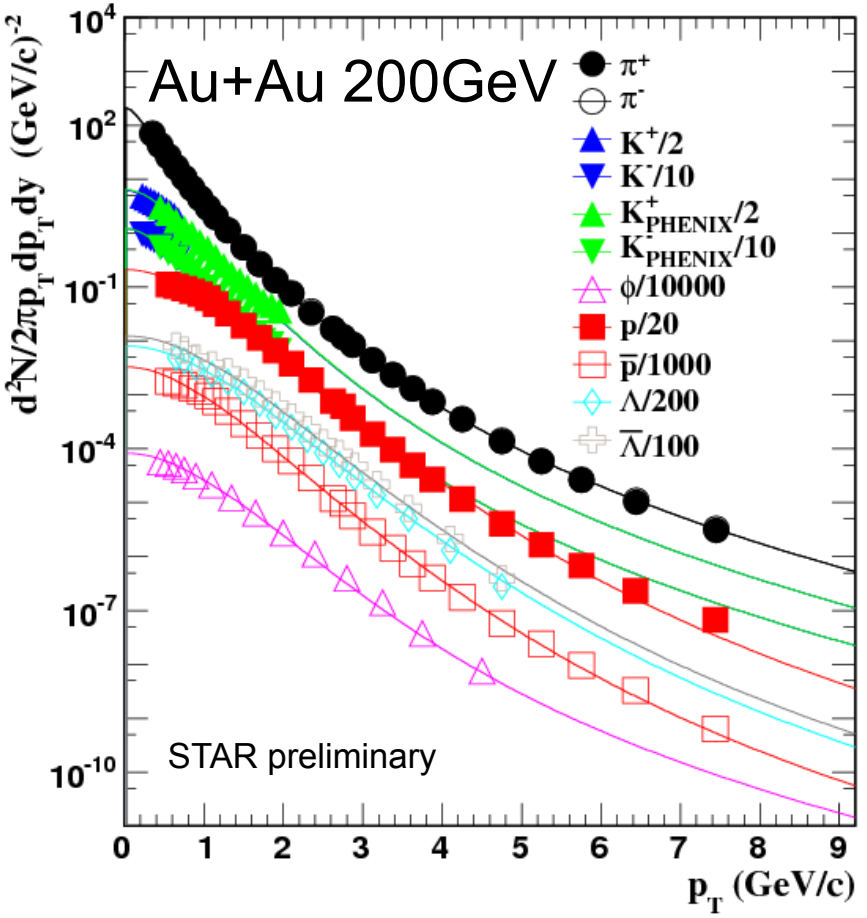


Simulation

Inputs:

- **Kinetics: flat rapidity (-1,1) , flat Φ (0, 2π), p_T Tsallis function fit for all measured particles.**
- **Hadrons decay: using Kroll-Wada formula, form factors are from measurements.**
- **Heavy flavor sources: line shapes from PYTHIA, scaled by STAR measured cross-section.**





η and J/ψ are fitted separately in Au+Au.

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

Meson decay

Kroll-Wada Formula:

$$\frac{dN}{dm_{ee}} \propto \sqrt{1-\frac{4m_e^2}{m_{ee}^2}} \cdot \left(1+\frac{2m_e^2}{m_{ee}^2}\right) \cdot \frac{1}{m_{ee}} \cdot \left(1-\frac{m_{ee}^2}{M_h^2}\right)^3 |F(m_{ee}^2)|^2$$

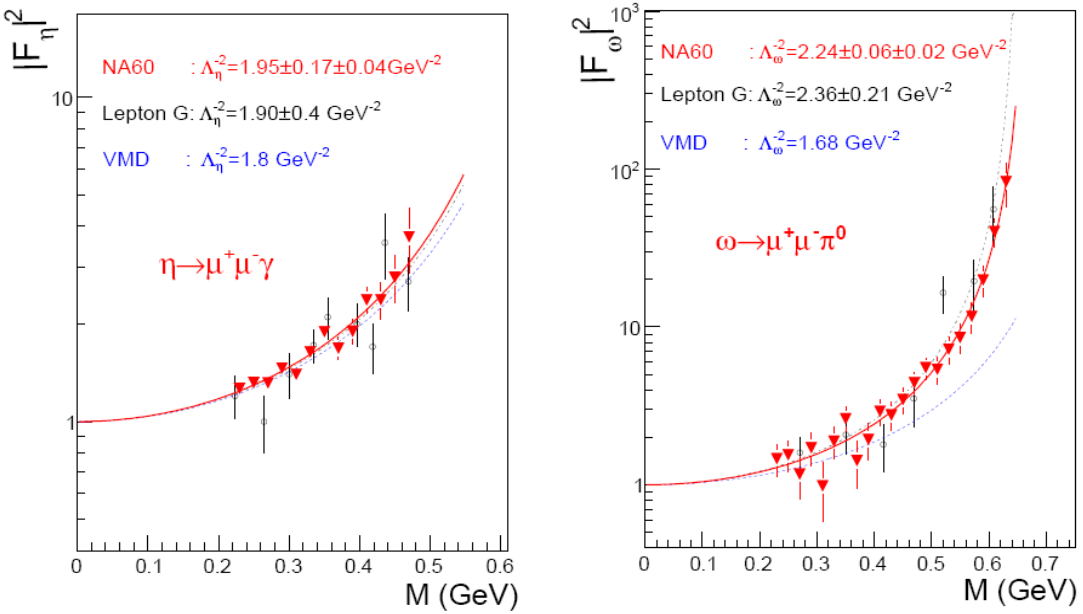
QED | Phase Space | Form Factor

N.M. Kroll, et al., Phys Rev, 98 (1955) 5.

Twobody: Breit-Wigner

Dalitz: Kroll-Wada

FF: parameterized from measurement.



NA60: PLB677 (2009) 260.

$$|F(m_{ee}^2)|^2 = \frac{1}{(1-m_{ee}^2\cdot\Lambda^{-2})^2+\Gamma_0^2\cdot\Lambda^{-2}}$$

Phase Space term for omega, phi:

$$(1-\frac{m_{ee}^2}{m_h^2})^3 \Rightarrow ((1+\frac{m_{ee}^2}{m_\omega^2-m_{\pi^0}^2})^2-\frac{4m_\omega^2 m_{ee}^2}{(m_\omega^2-m_{\pi^0}^2)^2})^{\frac{3}{2}}$$

$$\frac{dN}{dm_{ee}dp_T} \propto \frac{m_{ee}M_\rho\Gamma_{ee}}{(M_\rho^2-m_{ee}^2)^2+M_\rho^2(\Gamma_{\pi\pi}+\Gamma_{ee}\Gamma_2)^2}\times PS,$$

Rho meson:

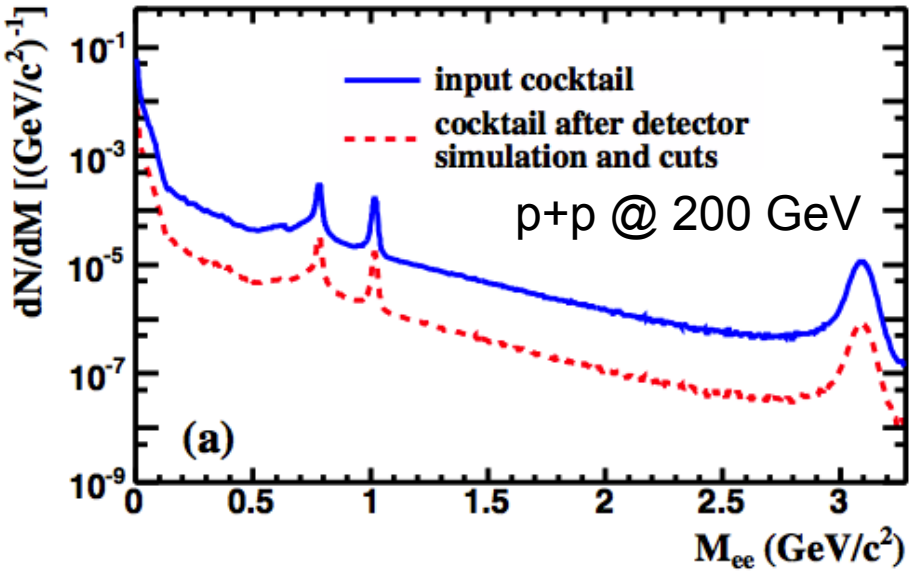
P-wave of ππ channel: $\Gamma_{\pi\pi}=\Gamma_0\frac{M_\rho}{m_{ee}}(\frac{m_{ee}^2-4M_\pi^2}{M_\rho^2-4M_\pi^2})^{3/2}$,

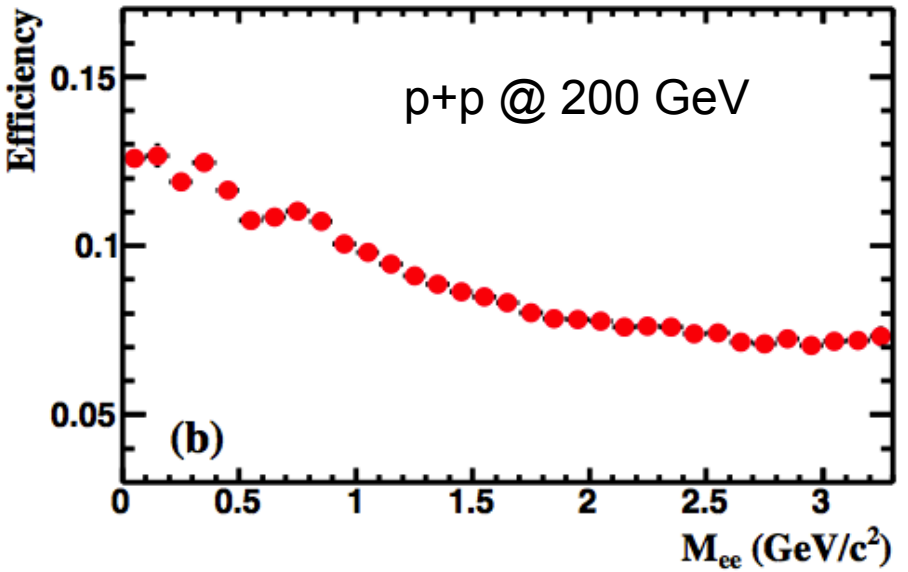
S-wave of ee channel: $\Gamma_{ee}=\Gamma_0\frac{M_\rho}{m_{ee}}(\frac{m_{ee}^2-4m_e^2}{M_\rho^2-4m_e^2})^{1/2}$,

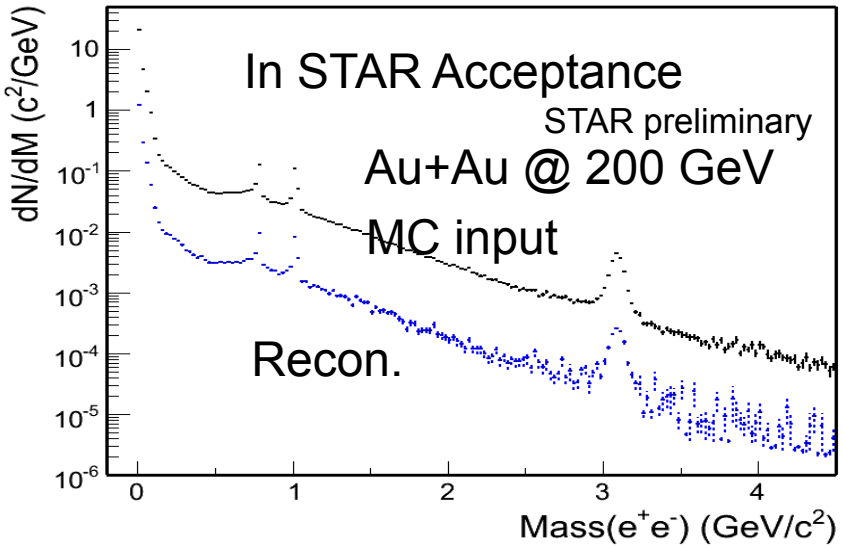
$$PS=\frac{m_{ee}}{\sqrt{m_{ee}^2+p_T^2}}e^{-\frac{\sqrt{m_{ee}^2+p_T^2}}{T}}.$$

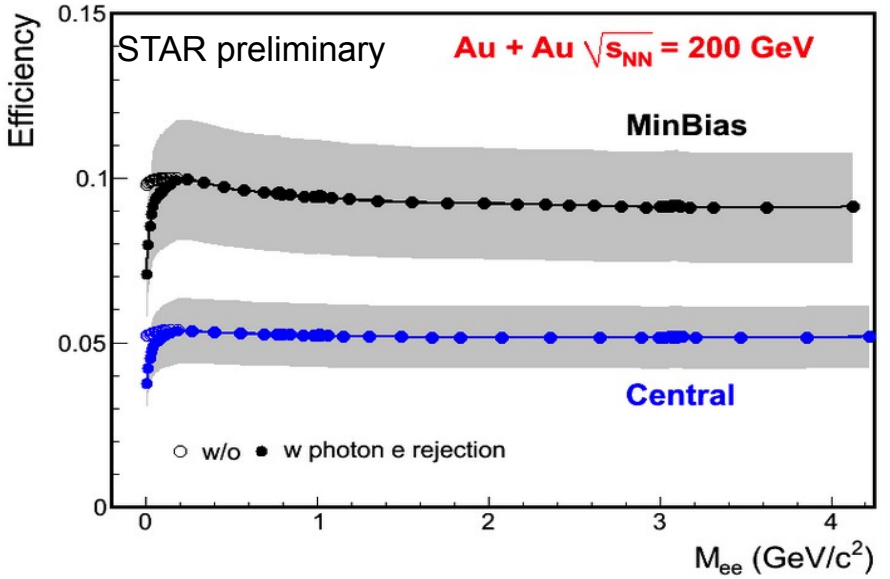
PRC 78, 044906 (2008)

Pair efficiency



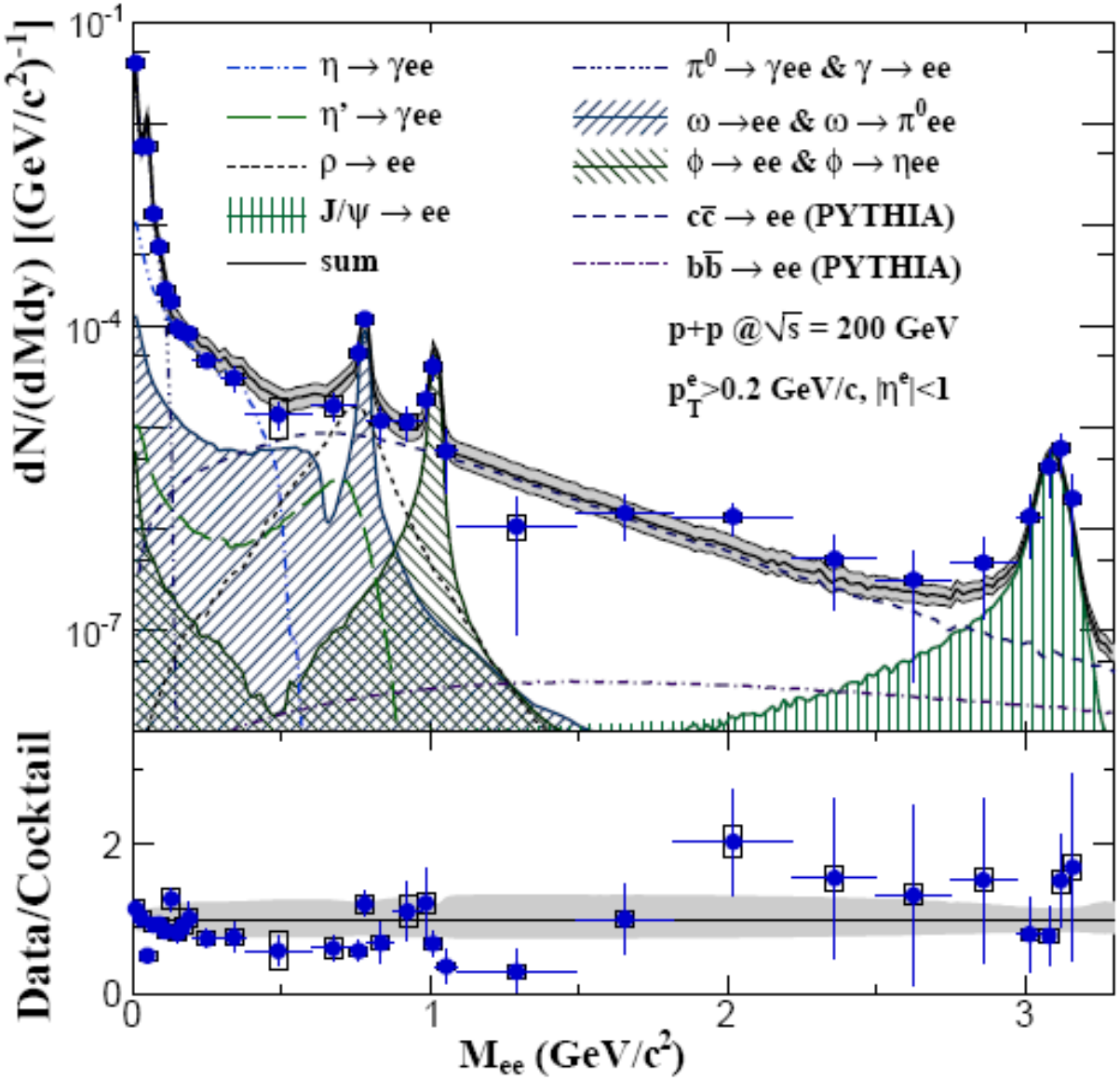






$$pair\ eff. = \frac{(cocktail\ sampled\ single\ electron\ eff.)}{(input\ cocktail)}$$

Di-electron results in p+p 200 GeV

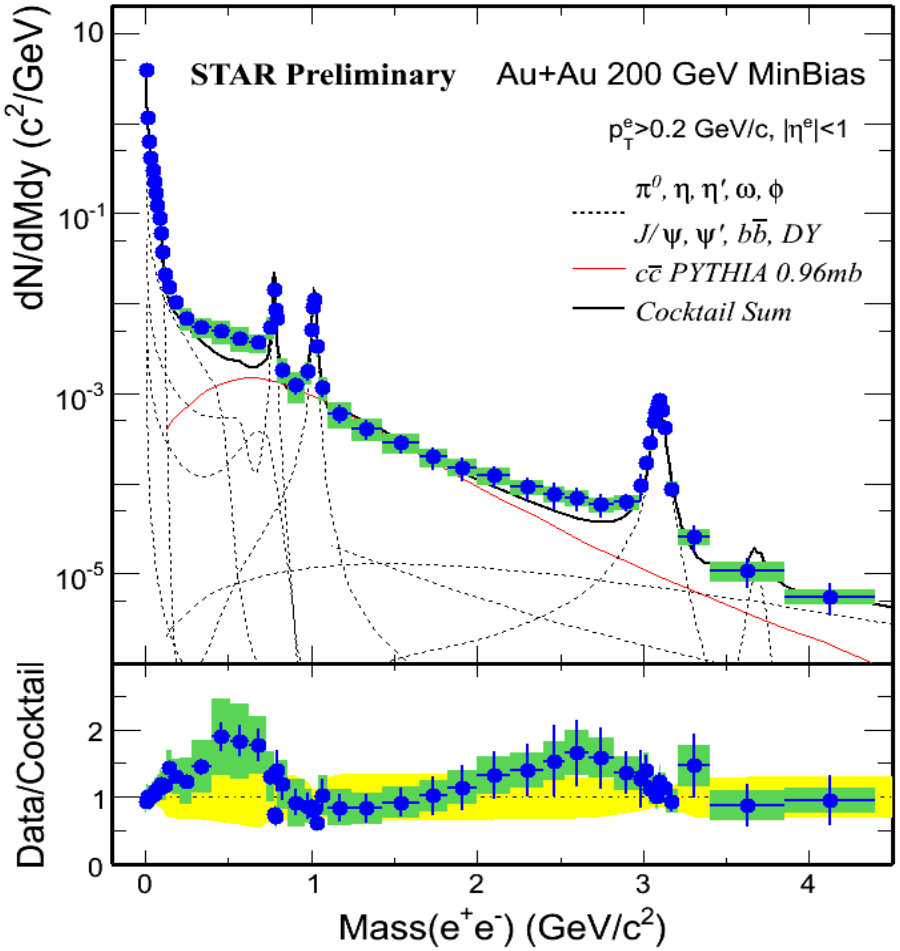


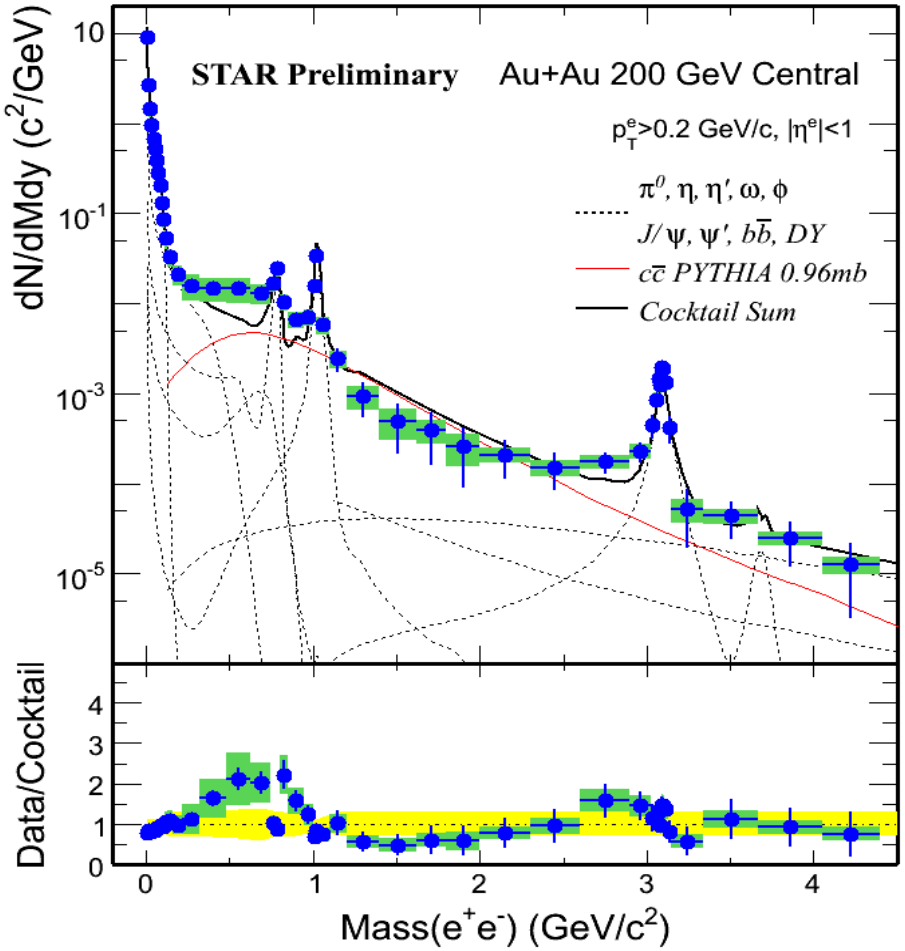
Phys. Rev. C 86, 024906 (2012)

- Cocktail simulation is consistent with di-electron spectrum within quoted uncertainties.
- Intermediate mass region is dominated by charm correlation contribution.

Di-electron results in Au+Au 200 GeV

STAR QM2011:J. Phys. G:38 124134





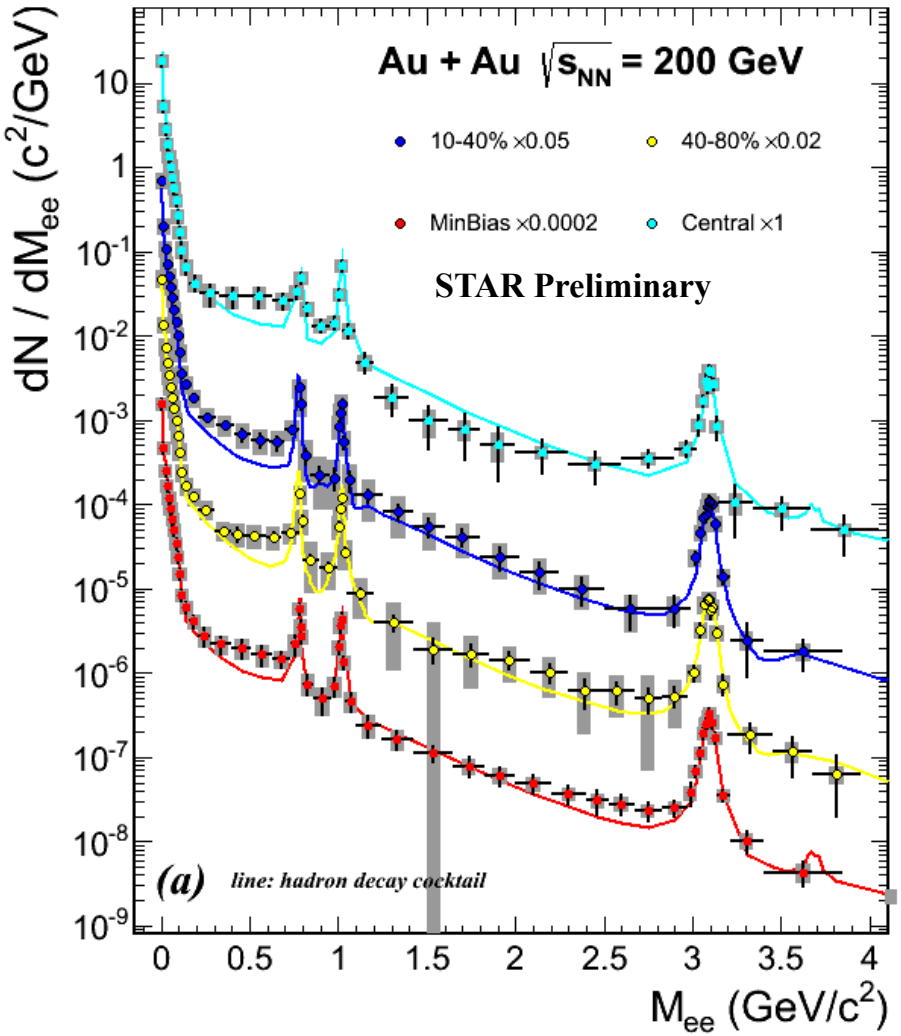
Enhancement factor in 0.15<Mee<0.75 Gev/c2

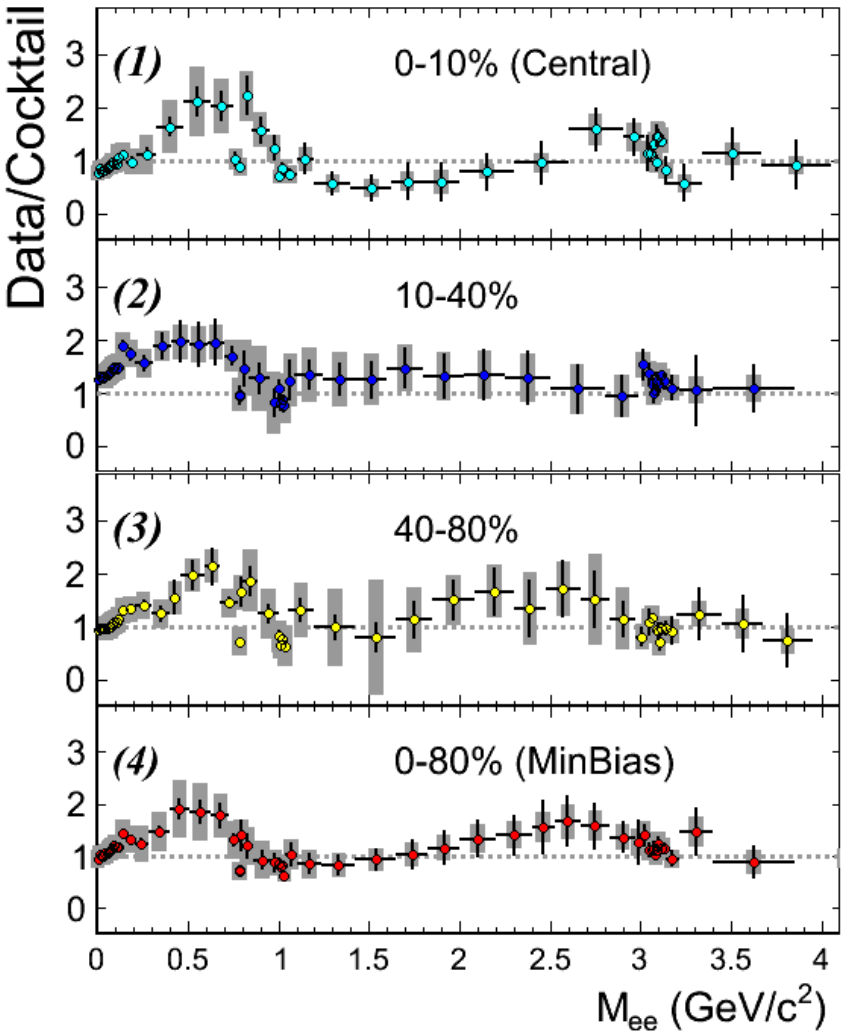
	Minbias (value ± stat ± sys)	Central (value ± stat ± sys)
STAR	1.53 ± 0.07 ± 0.41 (w/o ρ) 1.40 ± 0.06 ± 0.38 (w/ ρ)	1.72 ± 0.10 ± 0.50 (w/o ρ) 1.54 ± 0.09 ± 0.45 (w/ ρ)
PHENIX	4.7 ± 0.4 ± 1.5	7.6 ± 0.5 ± 1.3
Difference	2.0 σ	4.2 σ

PHENIX *Phys.Rev. C81 (2010) 034911*

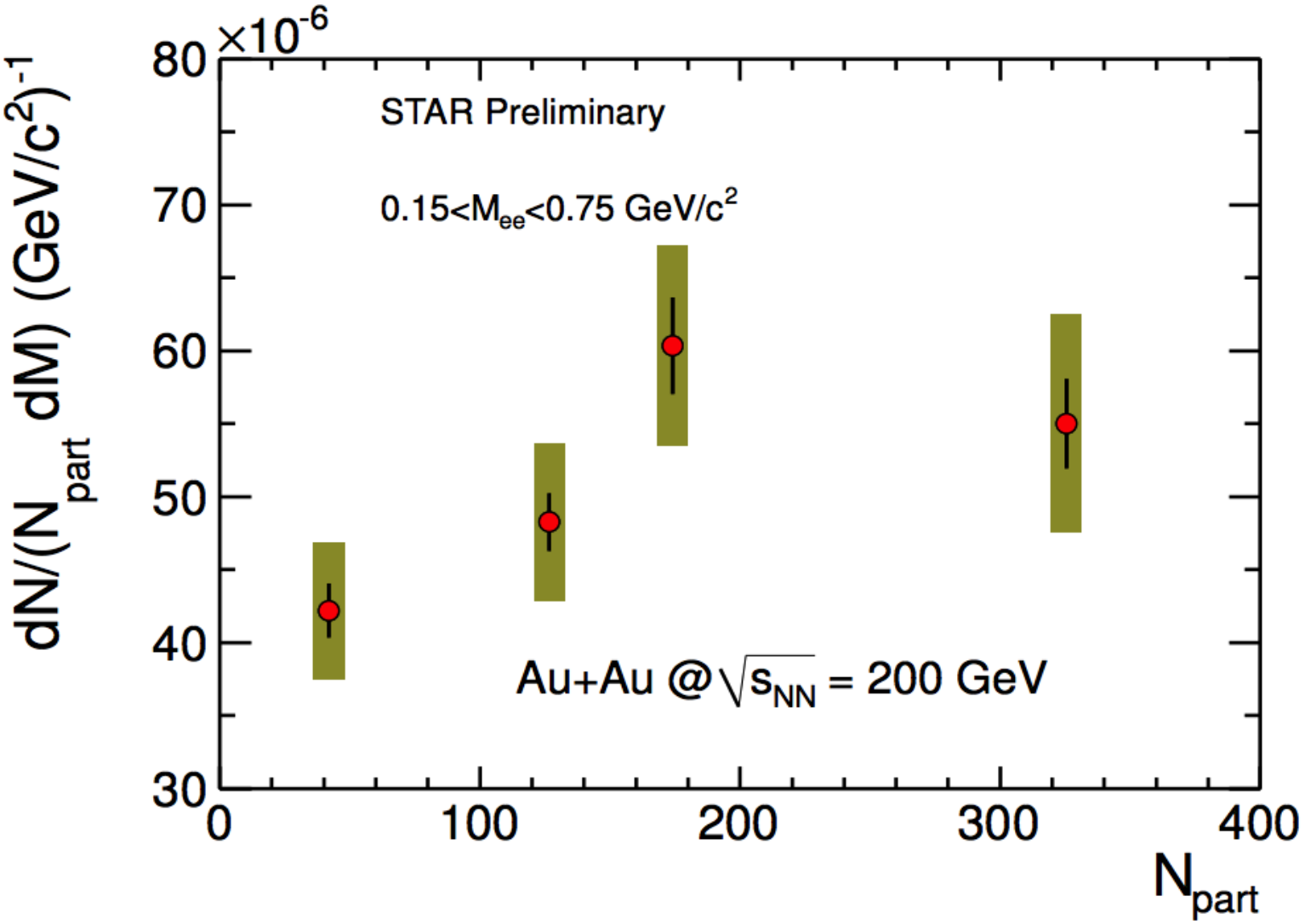
Centrality dependence in Au+Au 200 GeV

By Jie Zhao





LMR yields in Au+Au

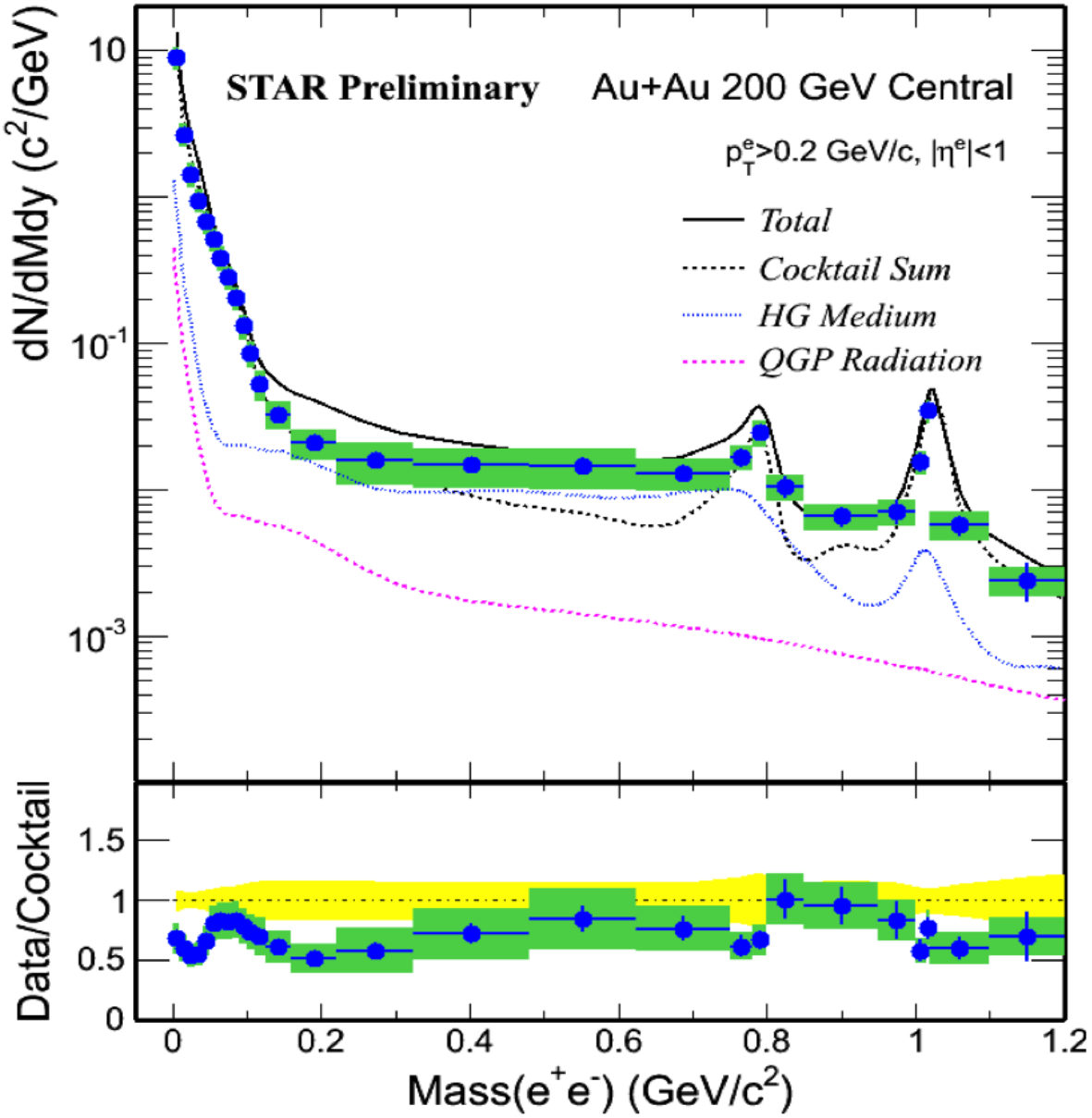


LMR enhancement scaled by Npart vs. centrality.

Comparison to theoretical calculation

Theoretical calculation:
Blue: Hadron gas contribution in medium(HG) with a broadened ρ spectral function.
Pink: QGP.
R. Rapp(private communication).
R. Rapp, Phys.Rev. C 63 (2001) 054907
R. Rapp & J. Wambach, EPJ A 6 (1999) 415

Solid lines: *cocktail + HG+QGP*
Black : cocktail

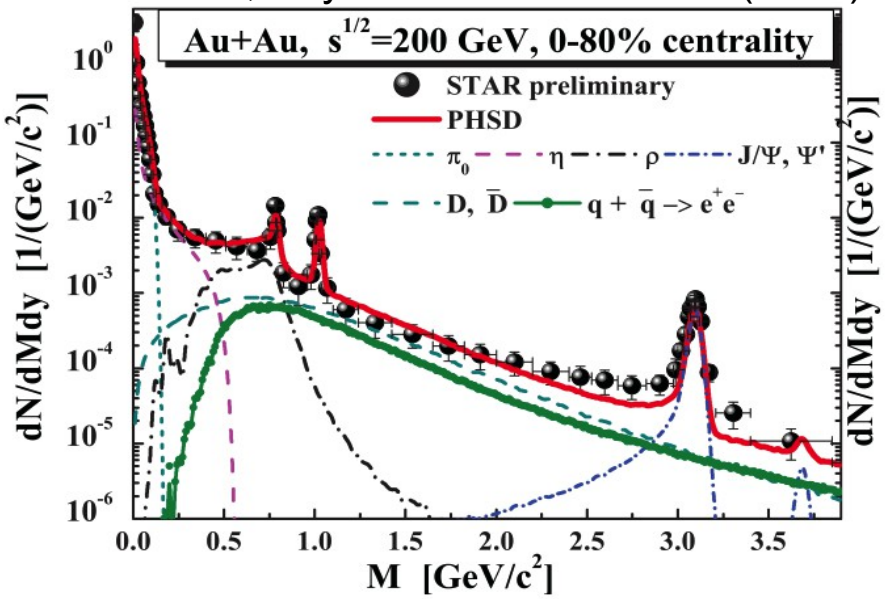


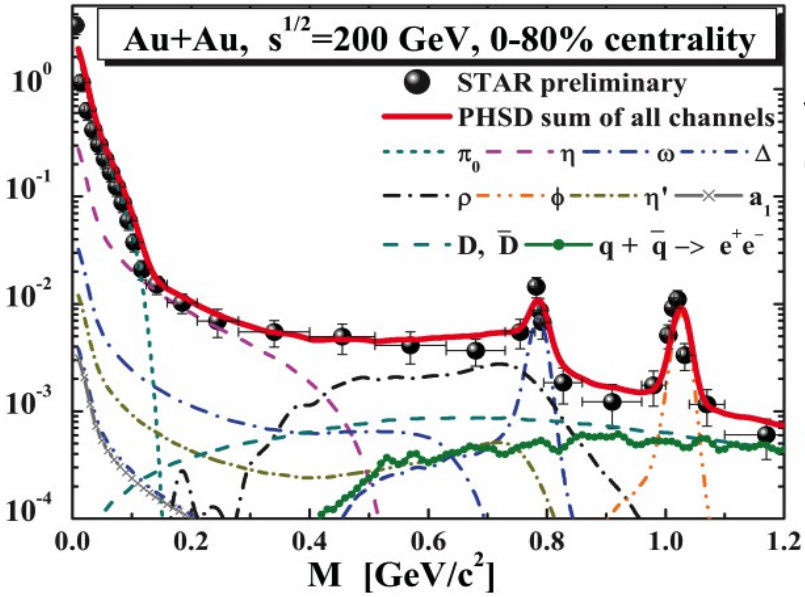
A sum of cocktail+HG+QGP agree with data within uncertainty. It satisfies with a broadened rho spectral function. Indicates the rho emission rate is dominated by hadron gas phase.

Comparison to theoretical calculation

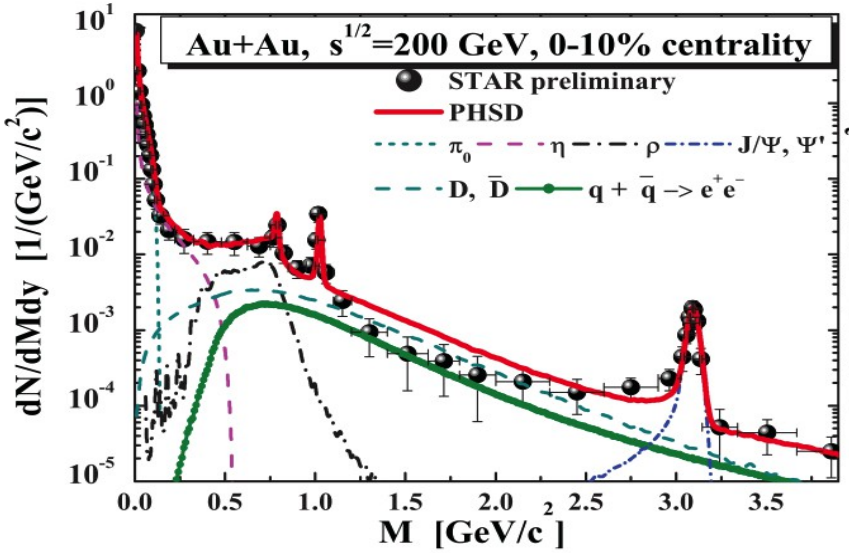
O. Linnyk et al., Phys. Rev. C 85 024910 (2012)
H. Xu et al., Phys. Rev. C 85 024906 (2012)

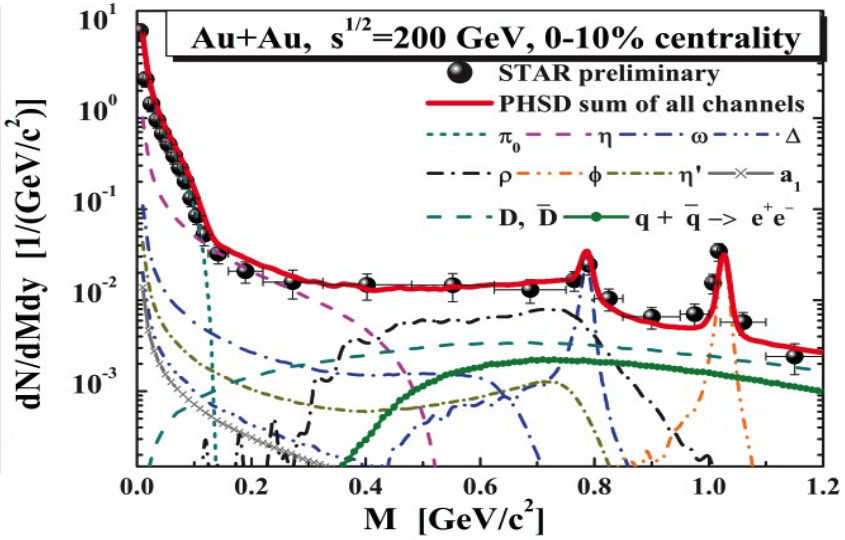
Parton-Hadron-String Dynamics (PHSD)





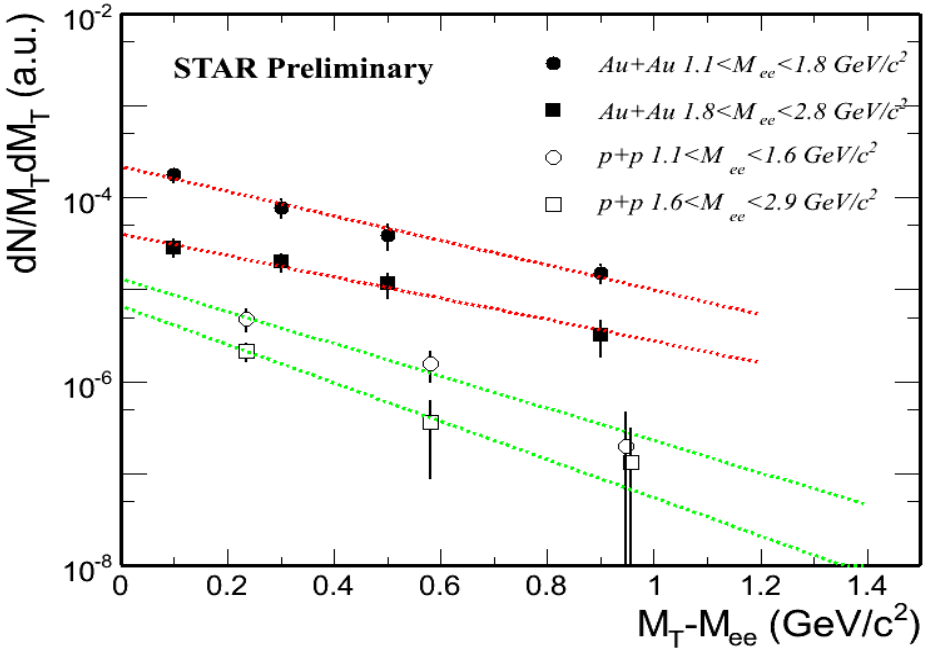
Consists of broadened vector mesons and QGP thermal radiation.





Agreements show in enhancement region (0.3-0.7 GeV/c^2) in minbias and central.

Transverse mass spectra

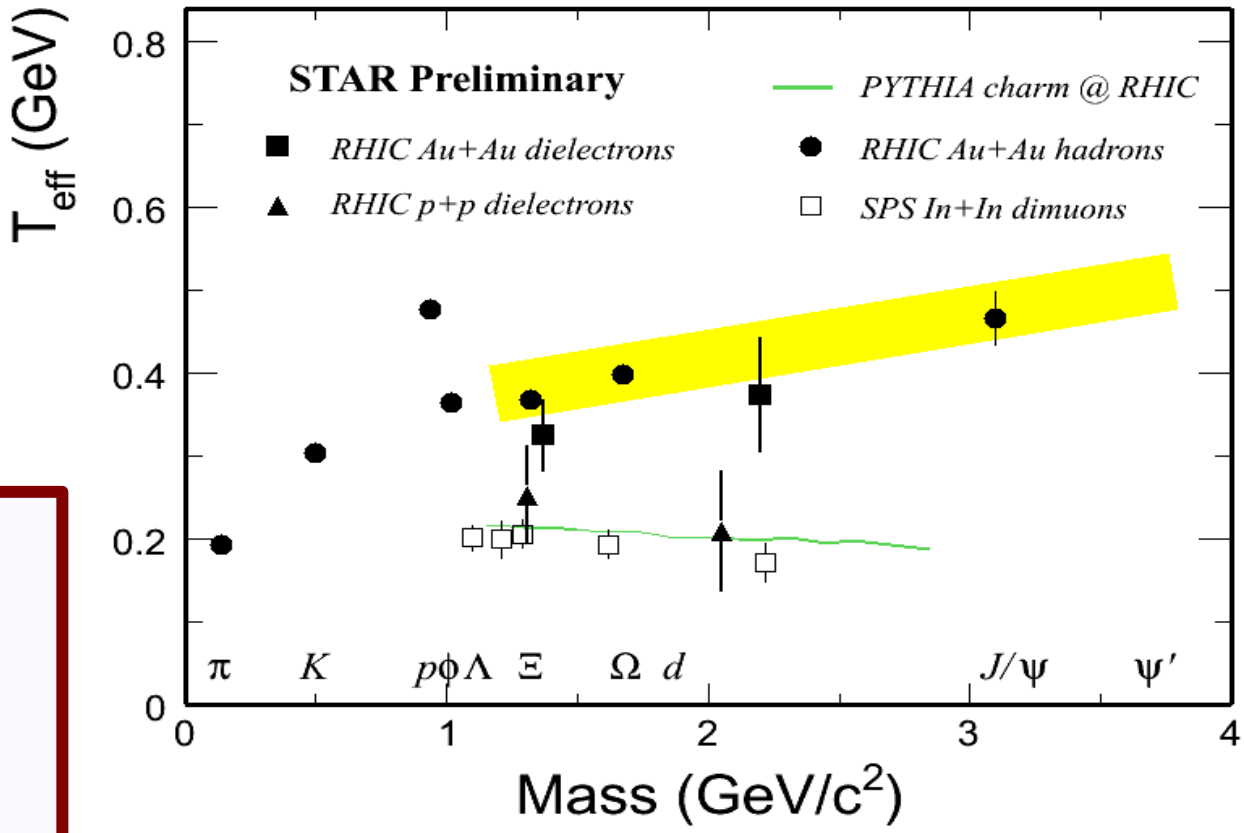


- **p + p result consistent with PYTHIA charm**
- **m_T slope parameter in Au+Au is higher than that in p + p**

  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
Yellow band indicates the sys. uncertanties at STAR.

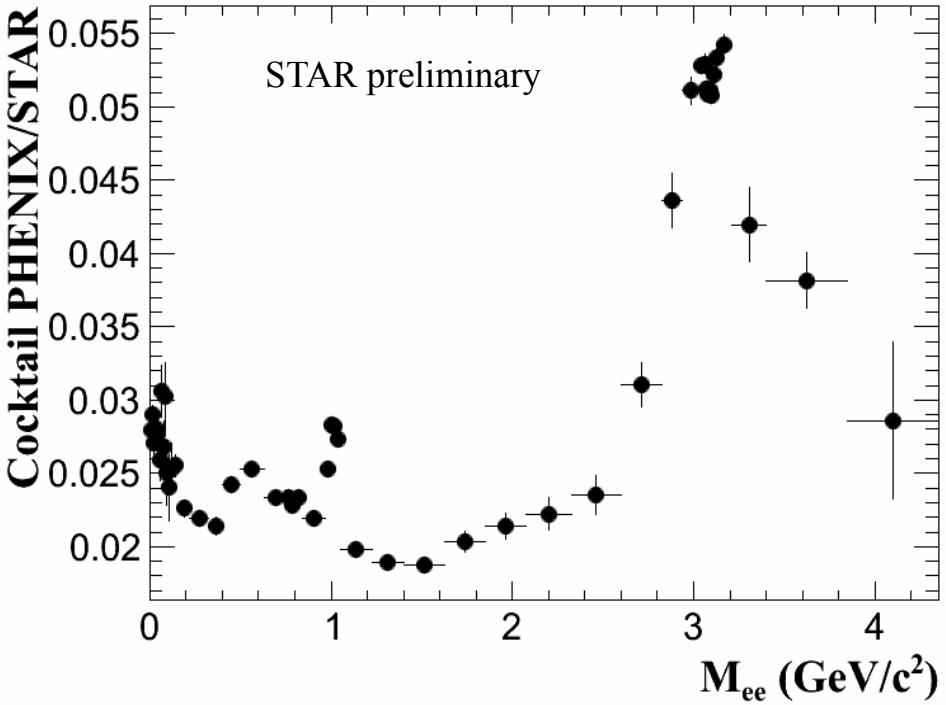
Summary

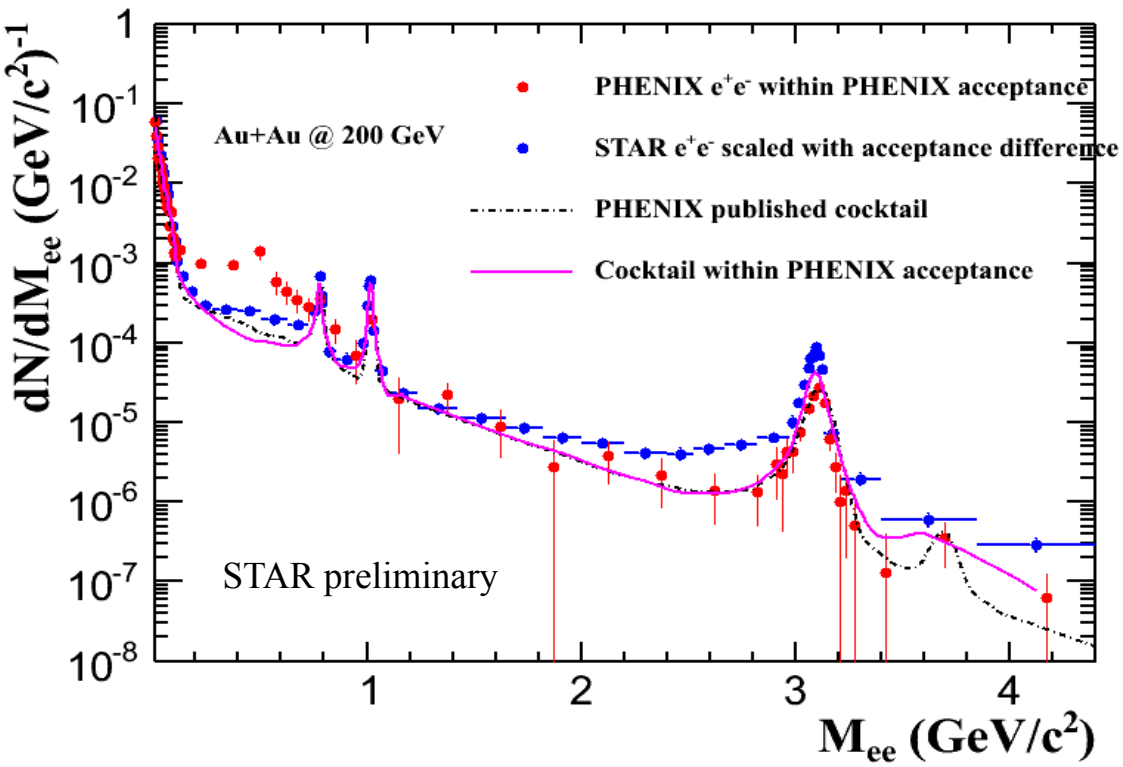
- Di-electron productions have been measured in p+p and Au+Au at 200 GeV.
  - Di-electron measurement in p+p is consistent with the expected yields within uncertainties.
  - Observed an enhancement at low mass region in Au+Au at 200 GeV.
  - Slope parameter in Au+Au is higher than that in p+p.
- A broadened ρ spectral function scenario can describe the low mass enhancement observed in Au+Au central collisions at 200 GeV.

Thank you !

Backup

Check with acceptance difference





Acceptance difference:

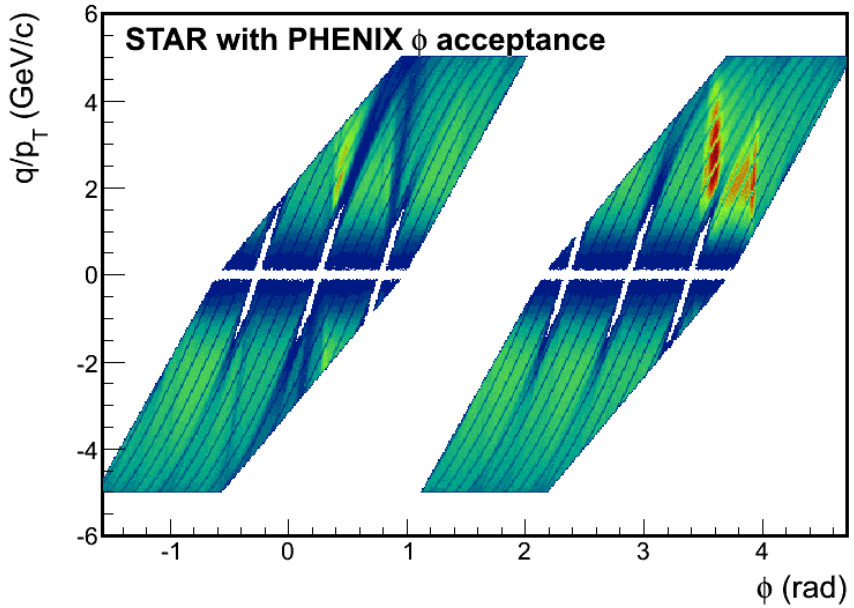
$$\frac{\text{Cocktail in PHENIX acceptance}}{\text{Cocktail in STAR acceptance}}$$

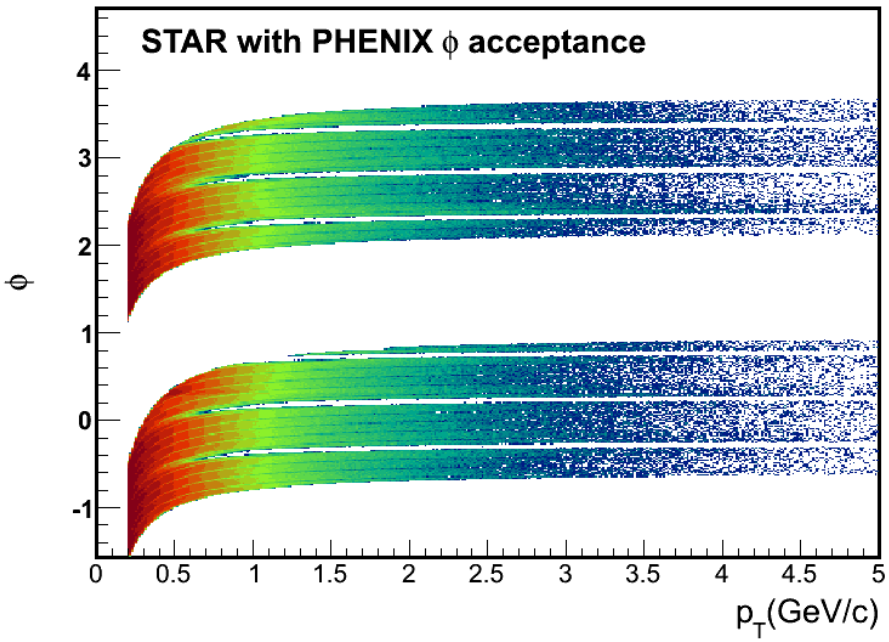
Scaled by same meson and charm yields.

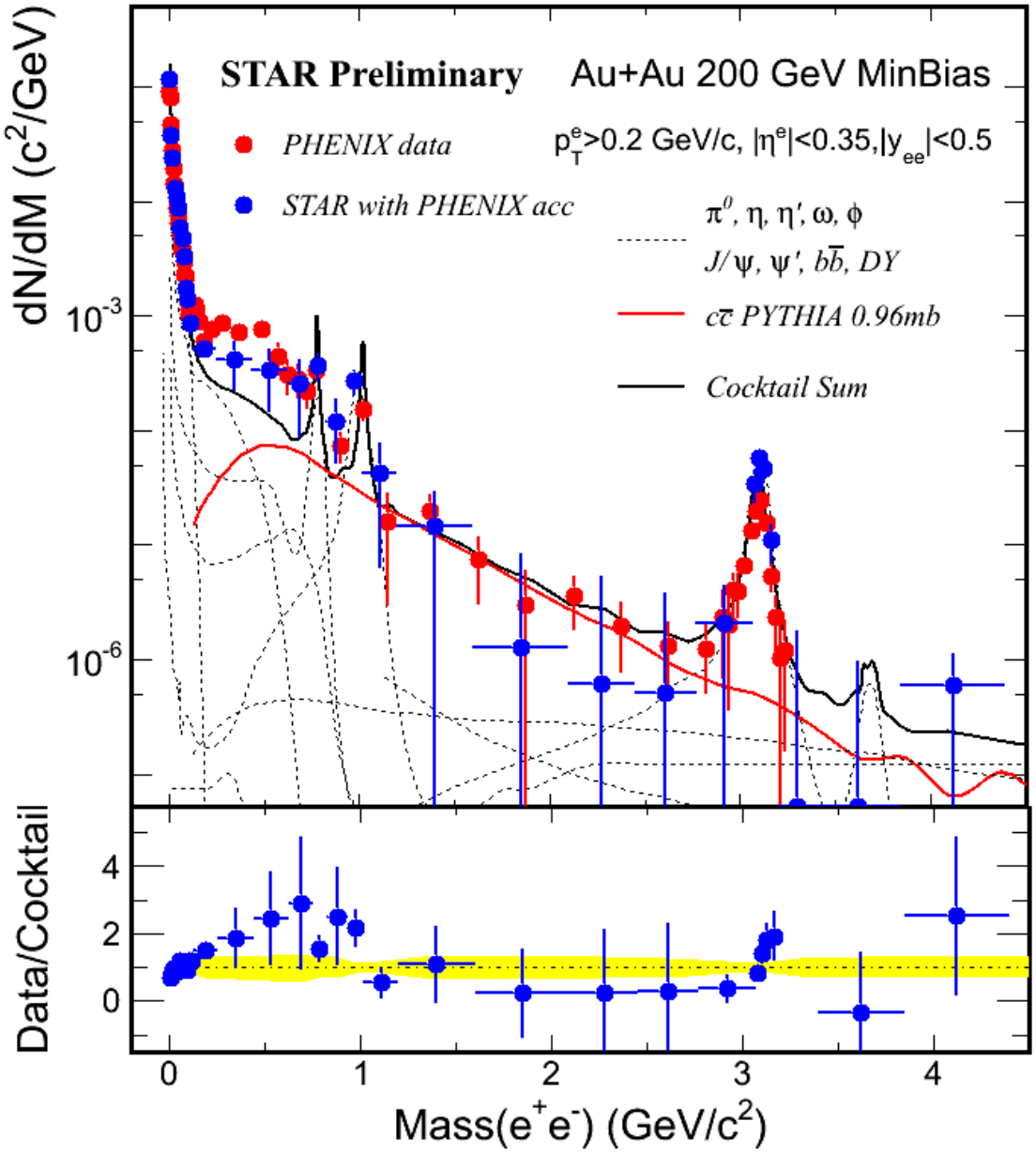
Scaled by the acceptance difference

Difference at low mass is not from the simulation but from the measurements.

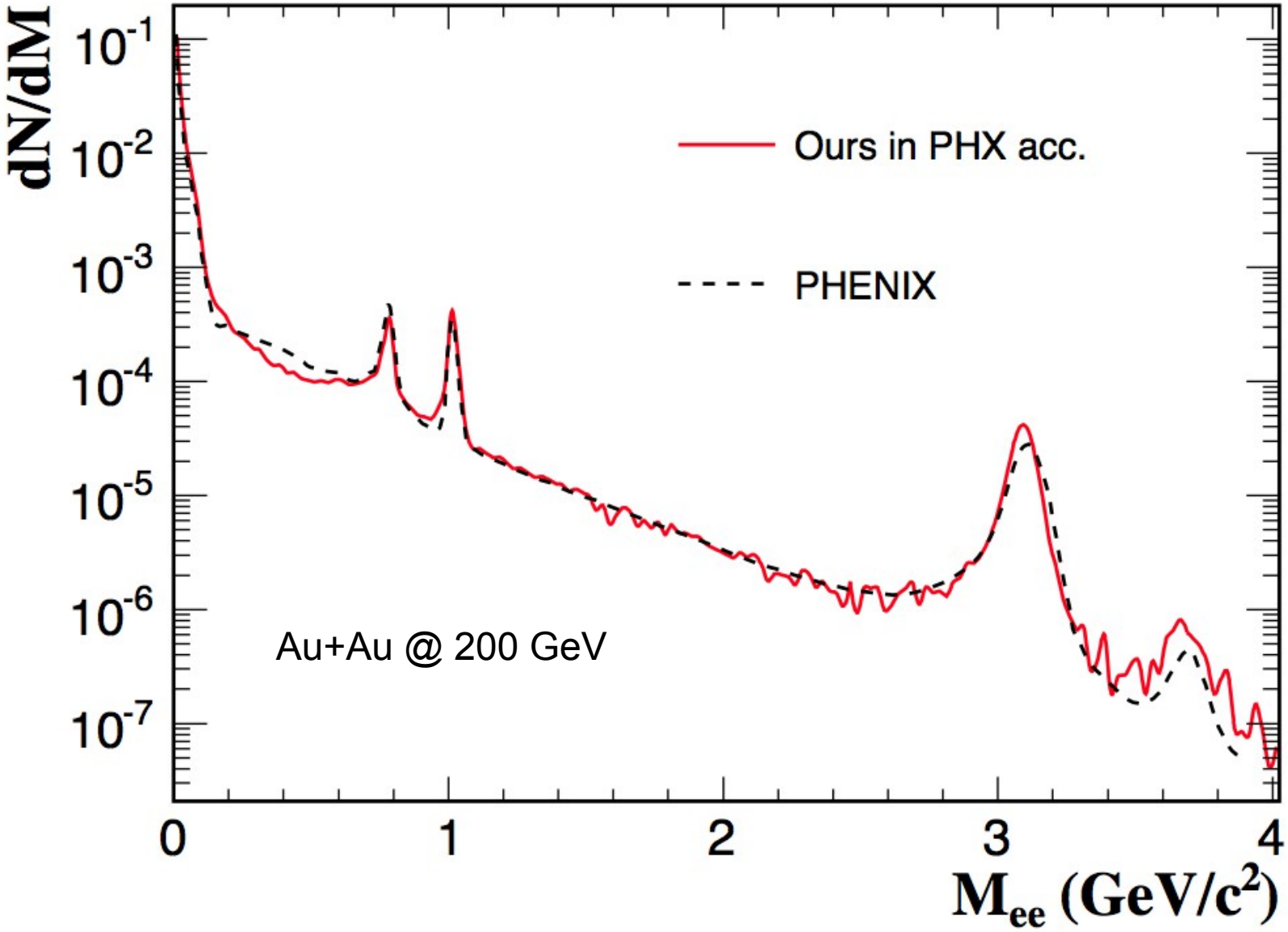
STAR with PHENIX Φ acceptance



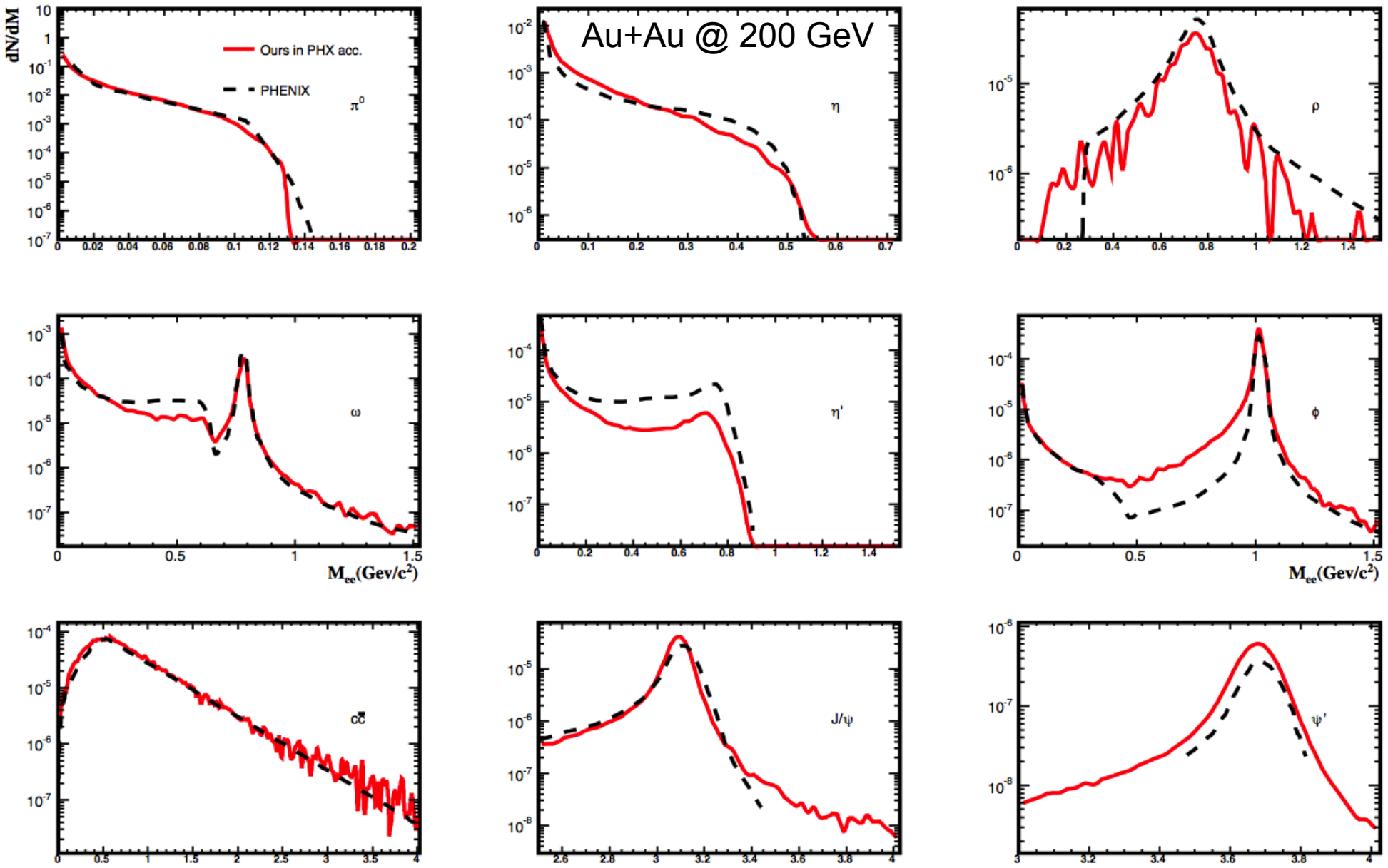




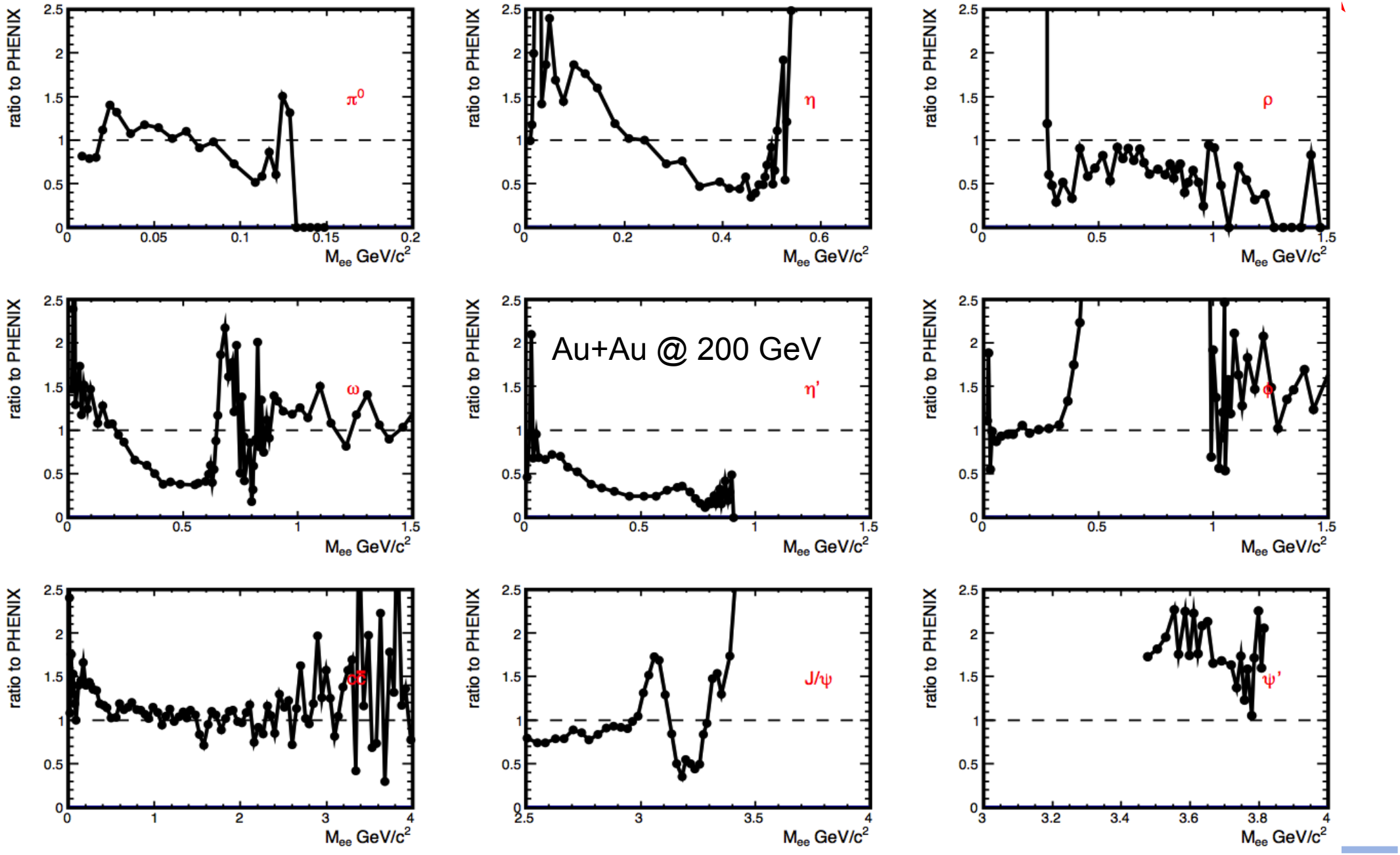
Simulation in PHENIX acceptance



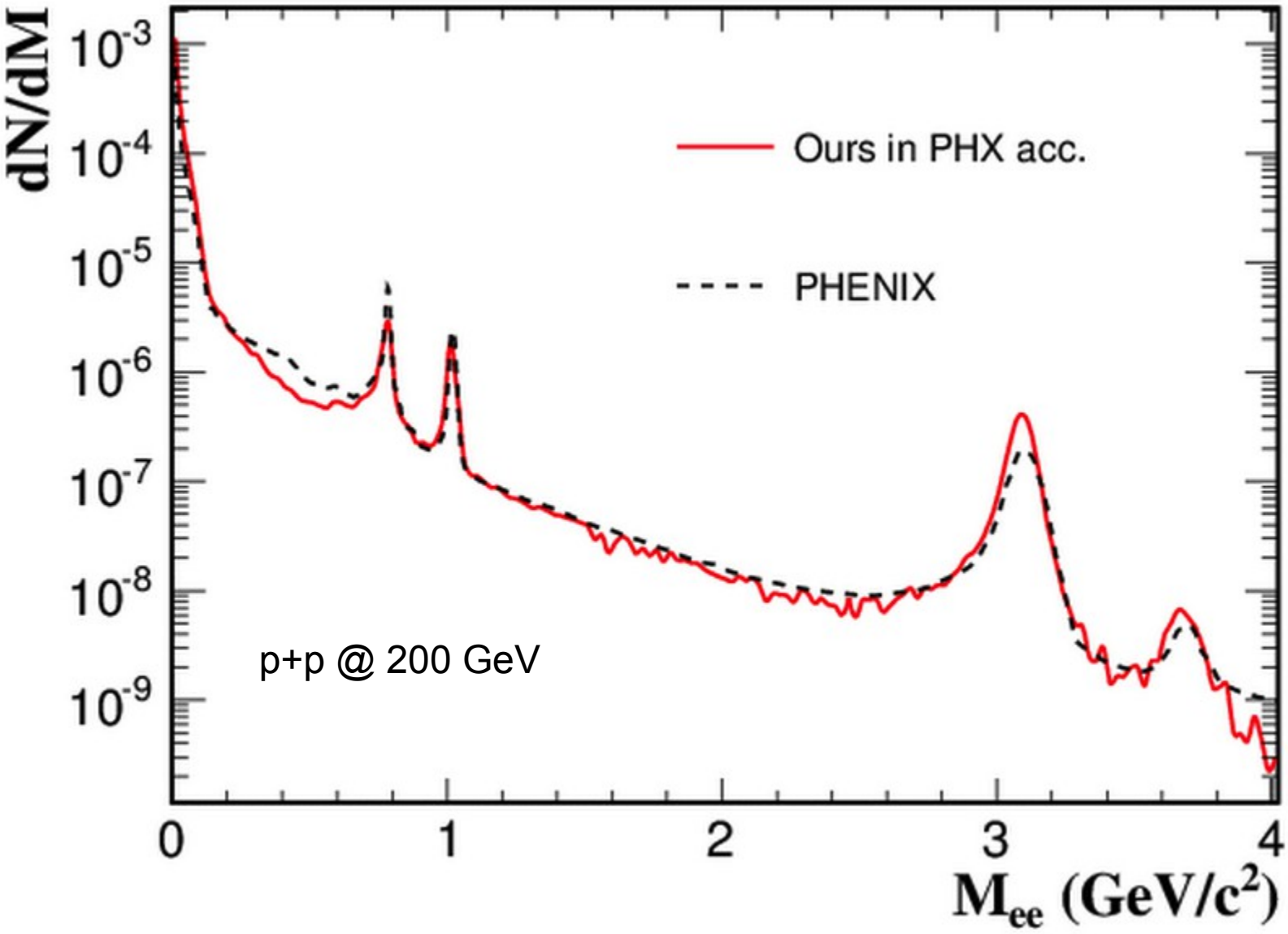
Red line: STAR simulation method applied to PHENIX acceptance. All components scaled by the yields and B.R.s PHENIX used.

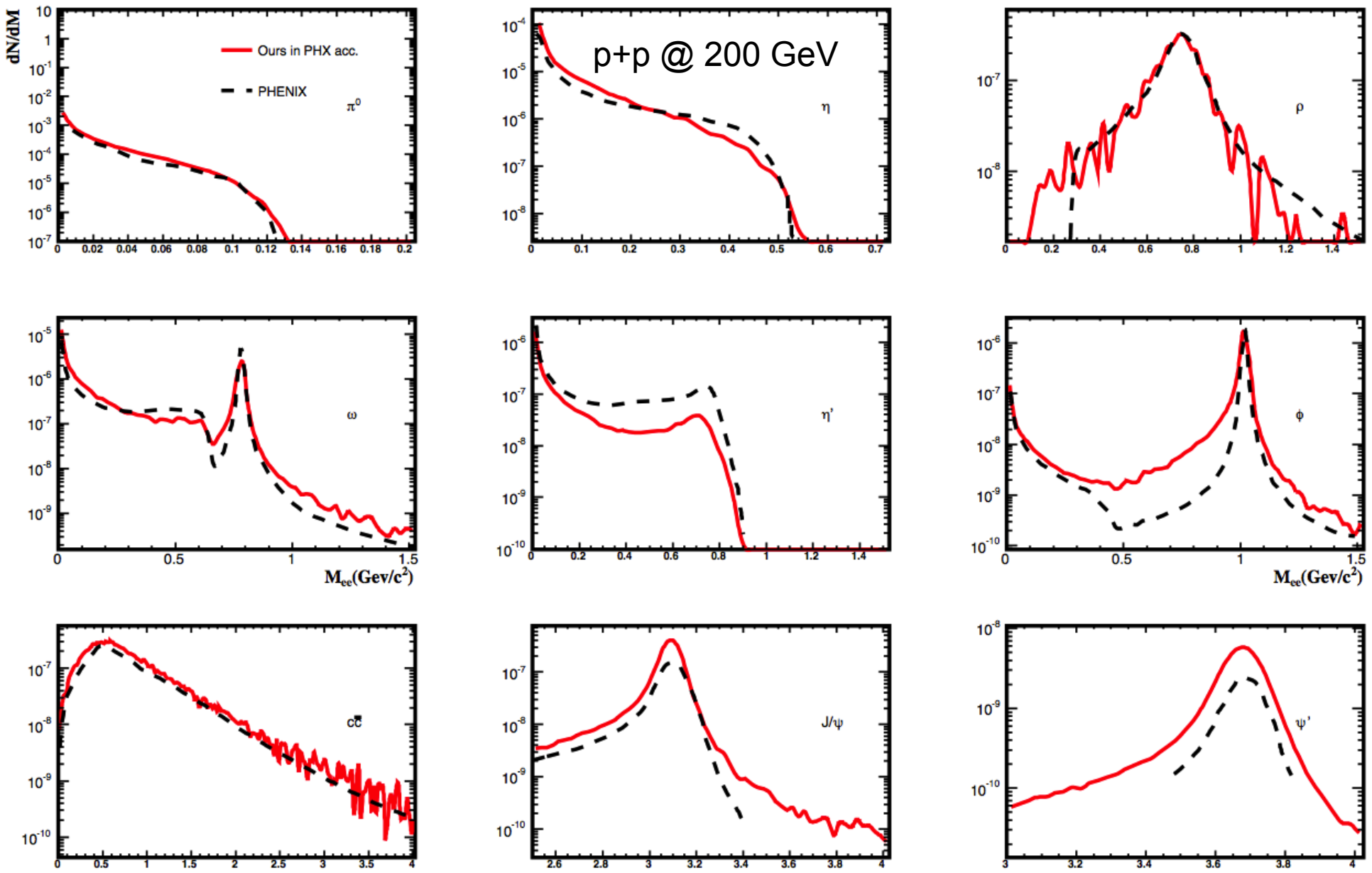

Au+Au @ 200 GeV
dN/dM
Ours in PHX acc.
PHENIX
π0
η
ρ
ω
η'
φ
cc̄
J/ψ
ψ'
Mee(Gev/c2)
Mee(Gev/c2)

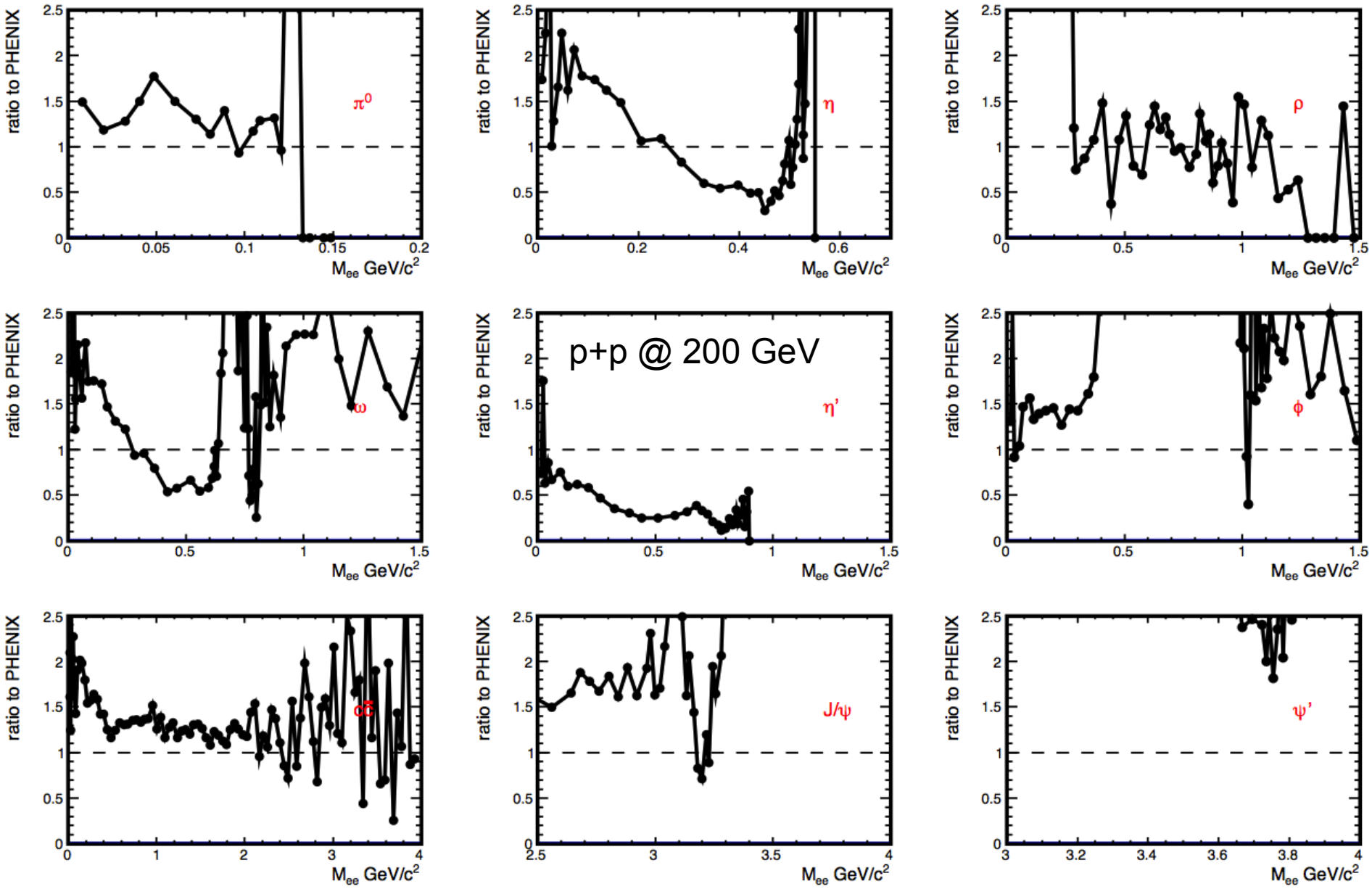
Ratio to PHENIX



Simulation in PHENIX acceptance




p+p @ 200 GeV
dN/dM
Ours in PHX acc.
PHENIX
π^0
η
ρ
ω
η'
φ
M_{ee}(Gev/c^2)
cc̄
J/ψ
ψ'


ratio to PHENIX
M_{ee} GeV/c^2
π^0
η
ρ
ω
p+p @ 200 GeV
η'
ϕ
$c\bar{c}$
J/ψ
ψ'