Di-lepton production in p+p and Au+Au collisions at 200 GeV from STAR

Bingchu Huang (for STAR collaboration)

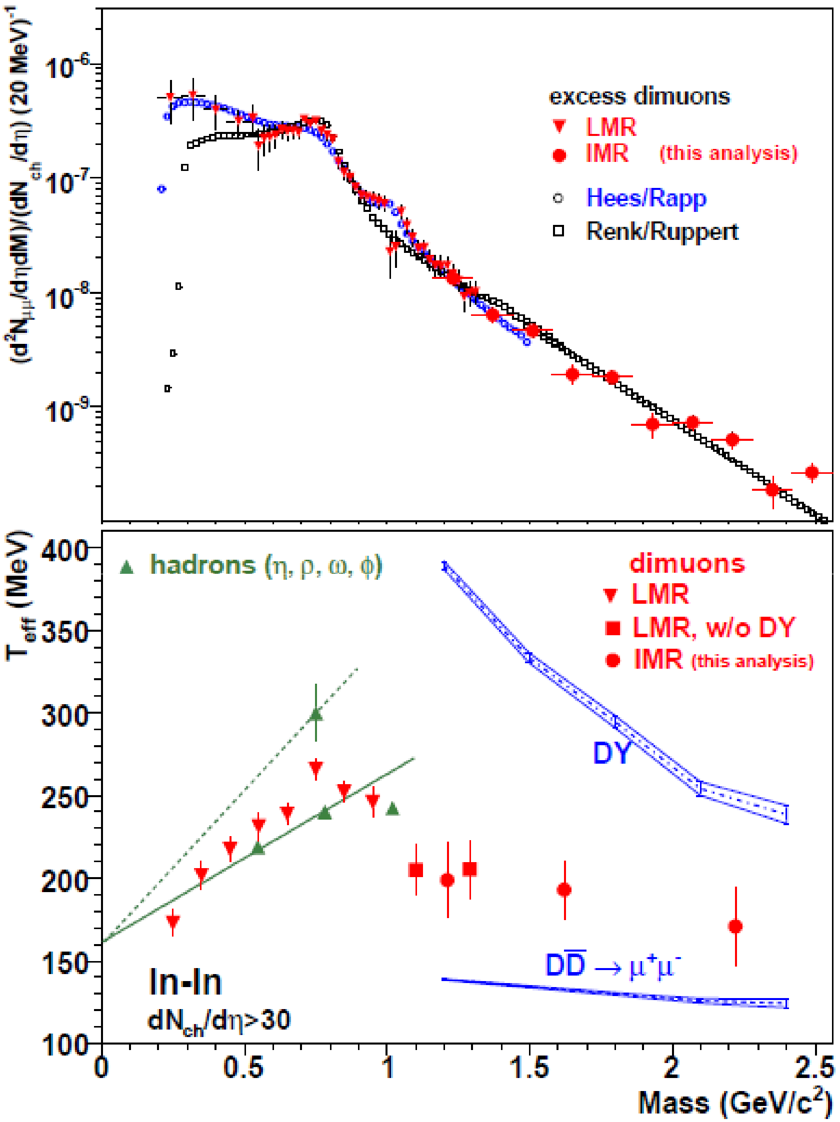
University of Science and Technology of China (USTC)

Brookhaven National Laboratory (BNL)

Outline

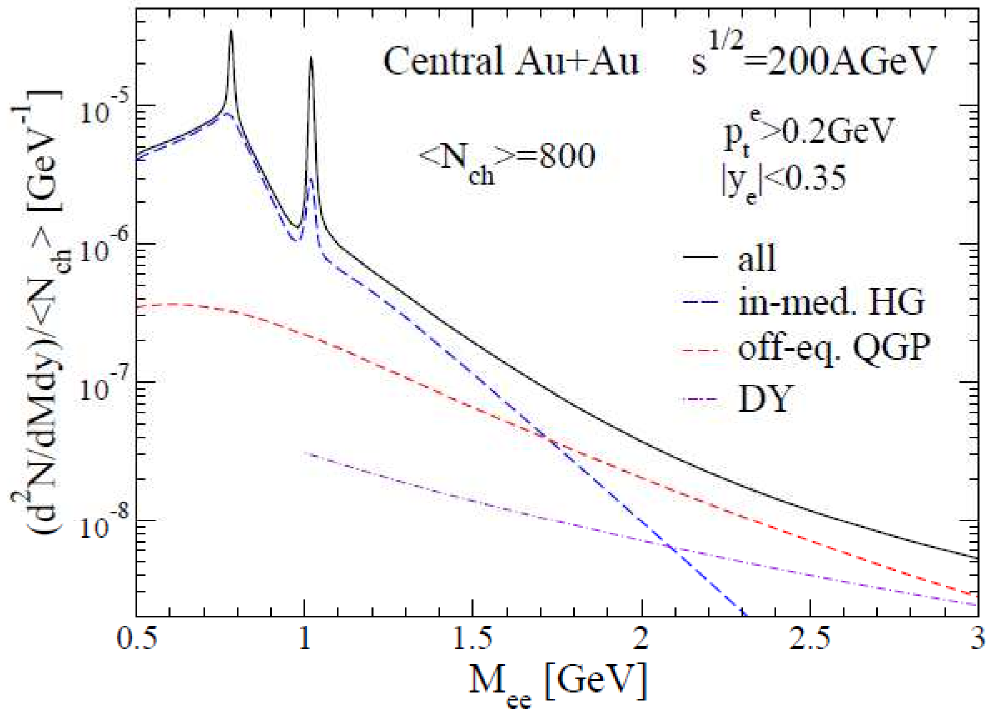
- Introduction
- Di-electron production in p+p and Au+Au collisions at 200 GeV
- Low mass range (LMR) enhancement
- Di-electron elliptic flow v_2
- Summary & outlook

Introduction



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

***R. Rapp**, Phys.Rev. C63 (2001) 054907.*



Low mass range (LMR):

In-medium modifications of vector mesons.

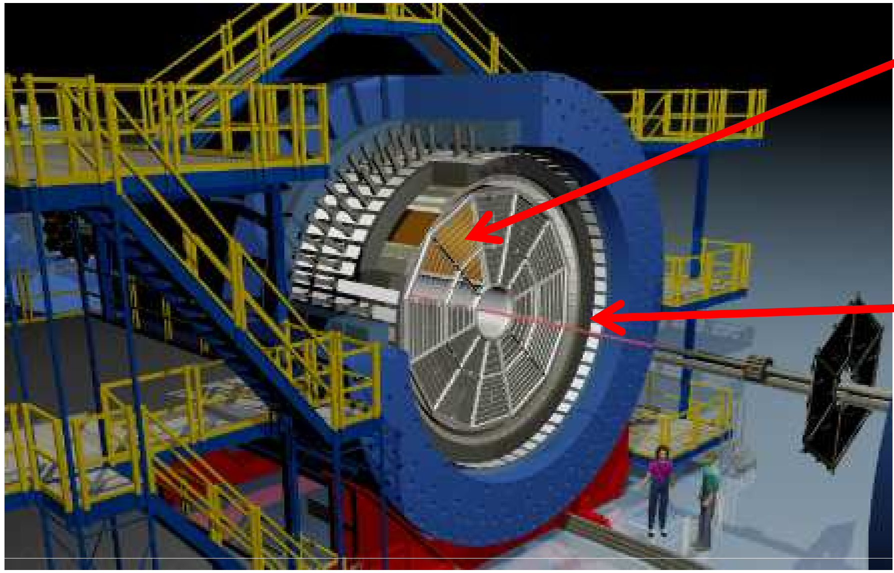
Possible link to chiral symmetry restoration.

Intermediate mass range (IMR):

QGP thermal radiation.

Heavy flavor modification.

STAR Detector

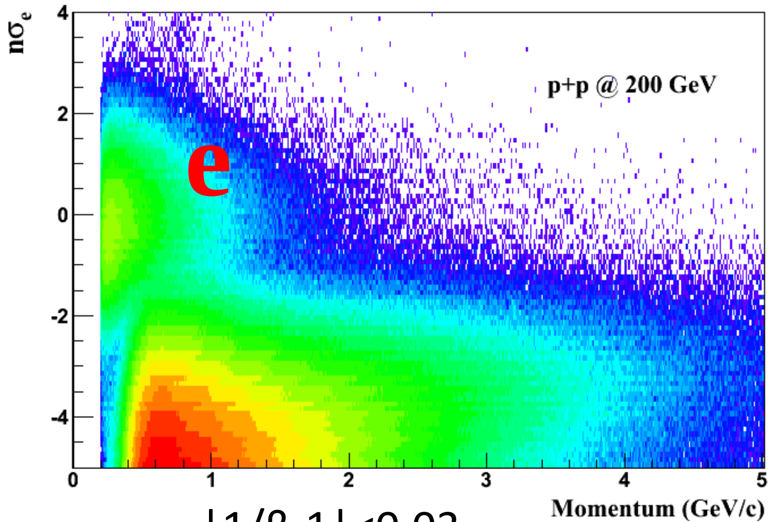


Tracking: TPC

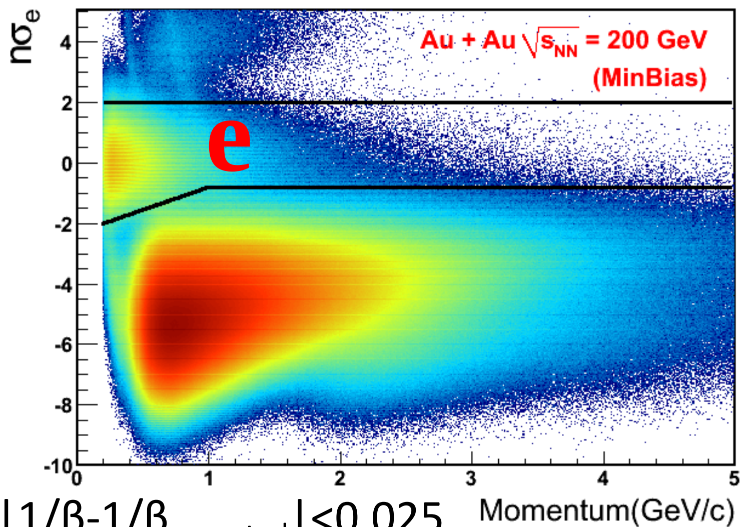
Time Projection Chamber
1. Tracking
2. Ionization energy loss (dE/dx PID):
3. Coverage $-1<\eta<1$

Particle ID: TOF

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



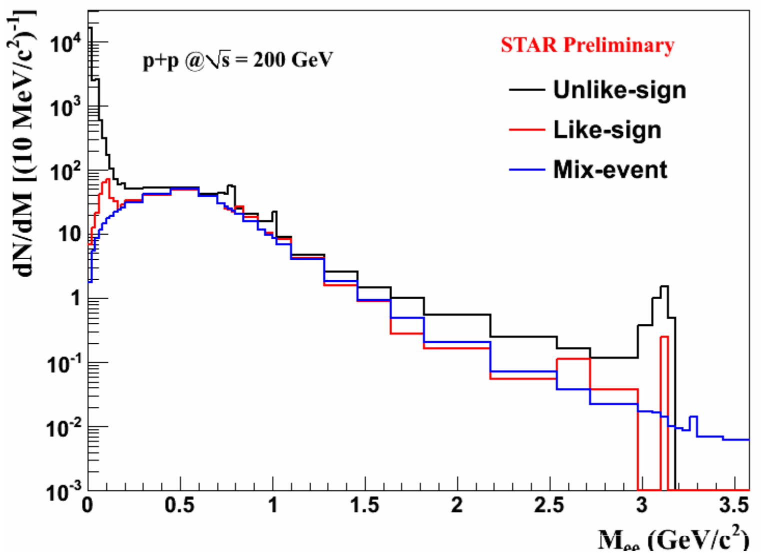
$|1/\beta-1|<0.03$

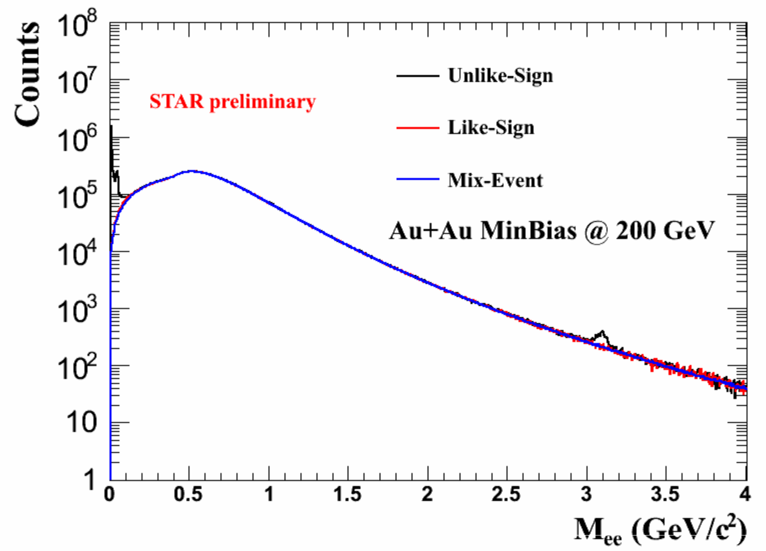


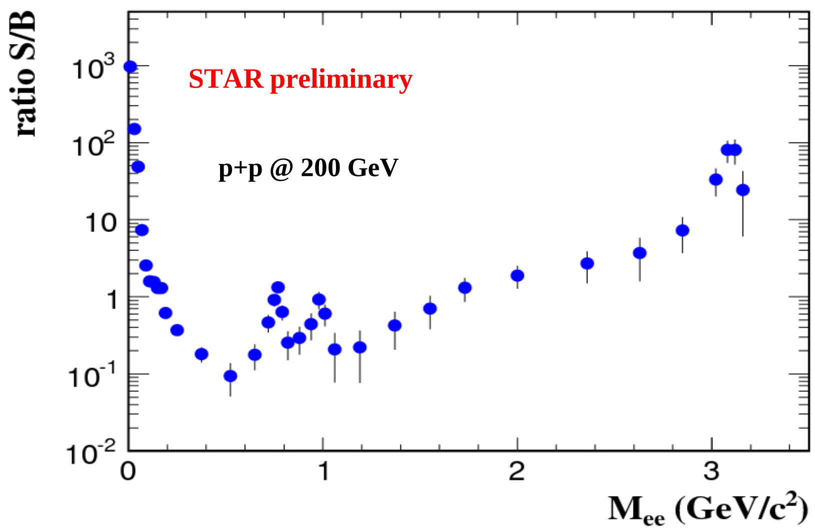
$|1/\beta-1/\beta_{expected}|<0.025$

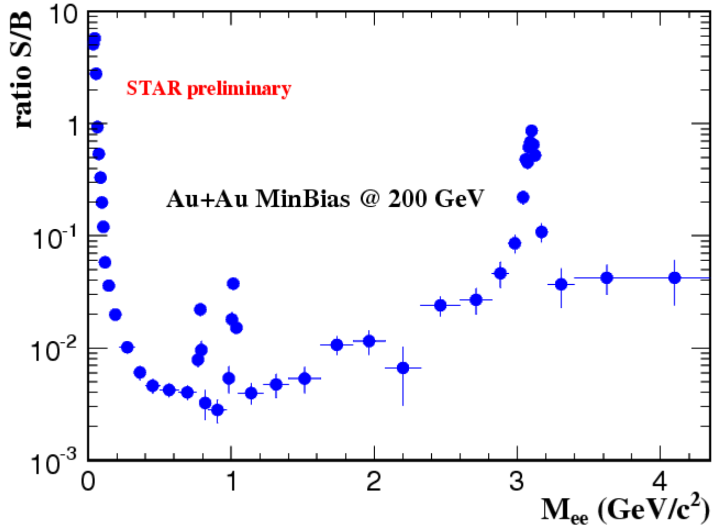
$$n\sigma_e = \frac{\log(\frac{dE/dx}{B_e})}{\sigma_e}$$

Di-electron signals in p+p and Au+Au



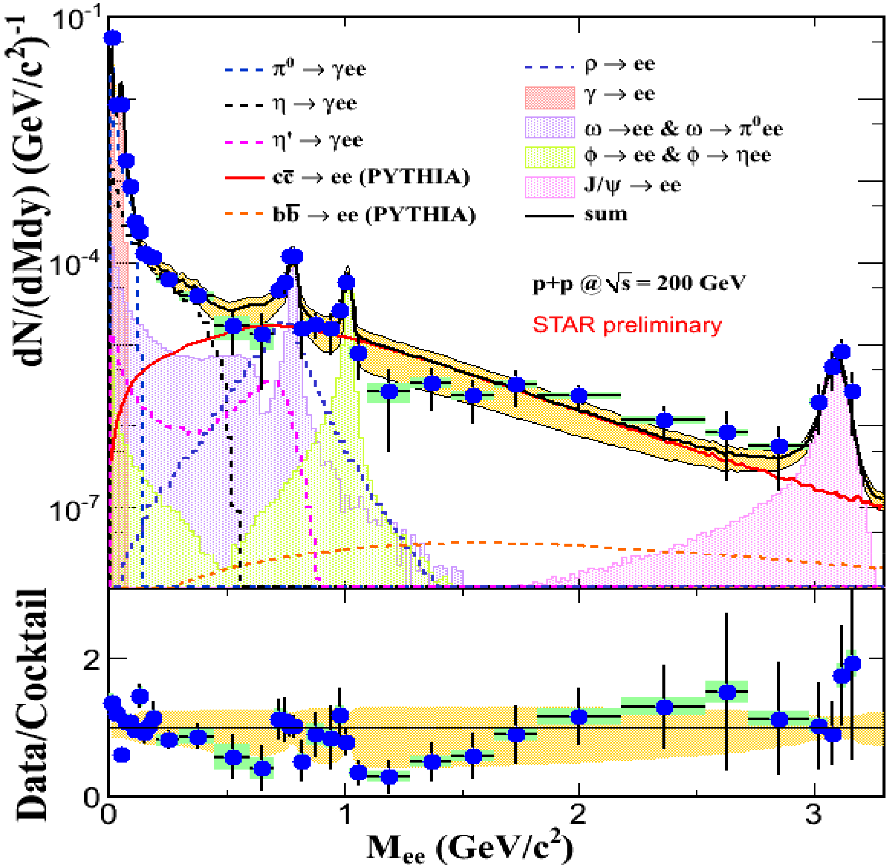


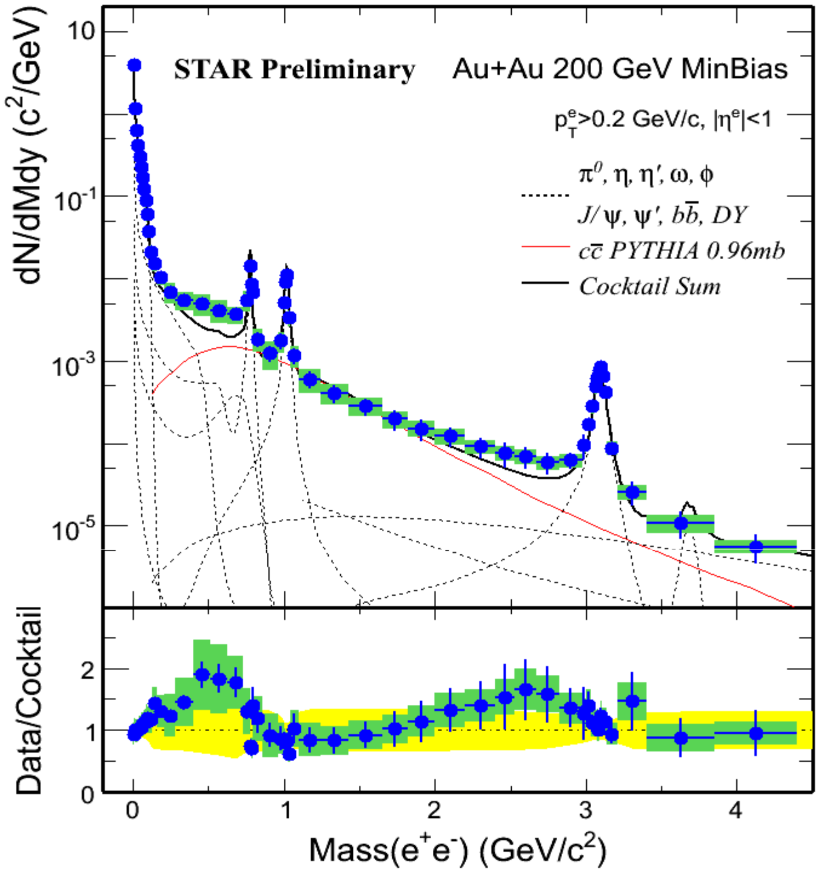




Stat. err only

Di-electron production in p+p and Au+Au



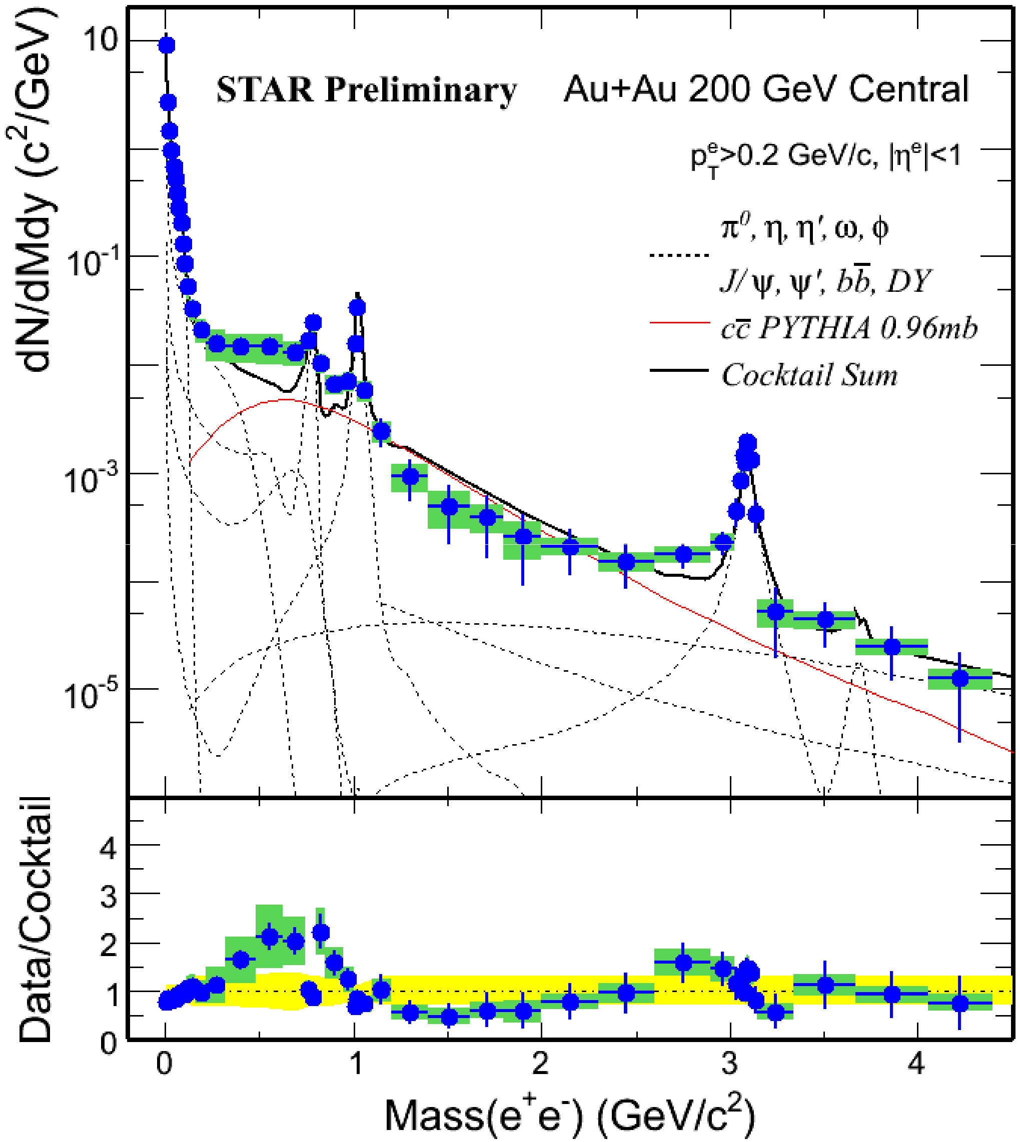


p+p: cocktail simulation consistent with data. cc→ee scaled with charm cross section measured from STAR[1].

[1]. *STAR Collaboration, PRL94(2005)062301*

Au+Au: a hint of enhancement at LMR compare to cocktail without ρ.

Au+Au central



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

- **Clearer LMR enhancement in central collisions compared to minimum bias collisions.**

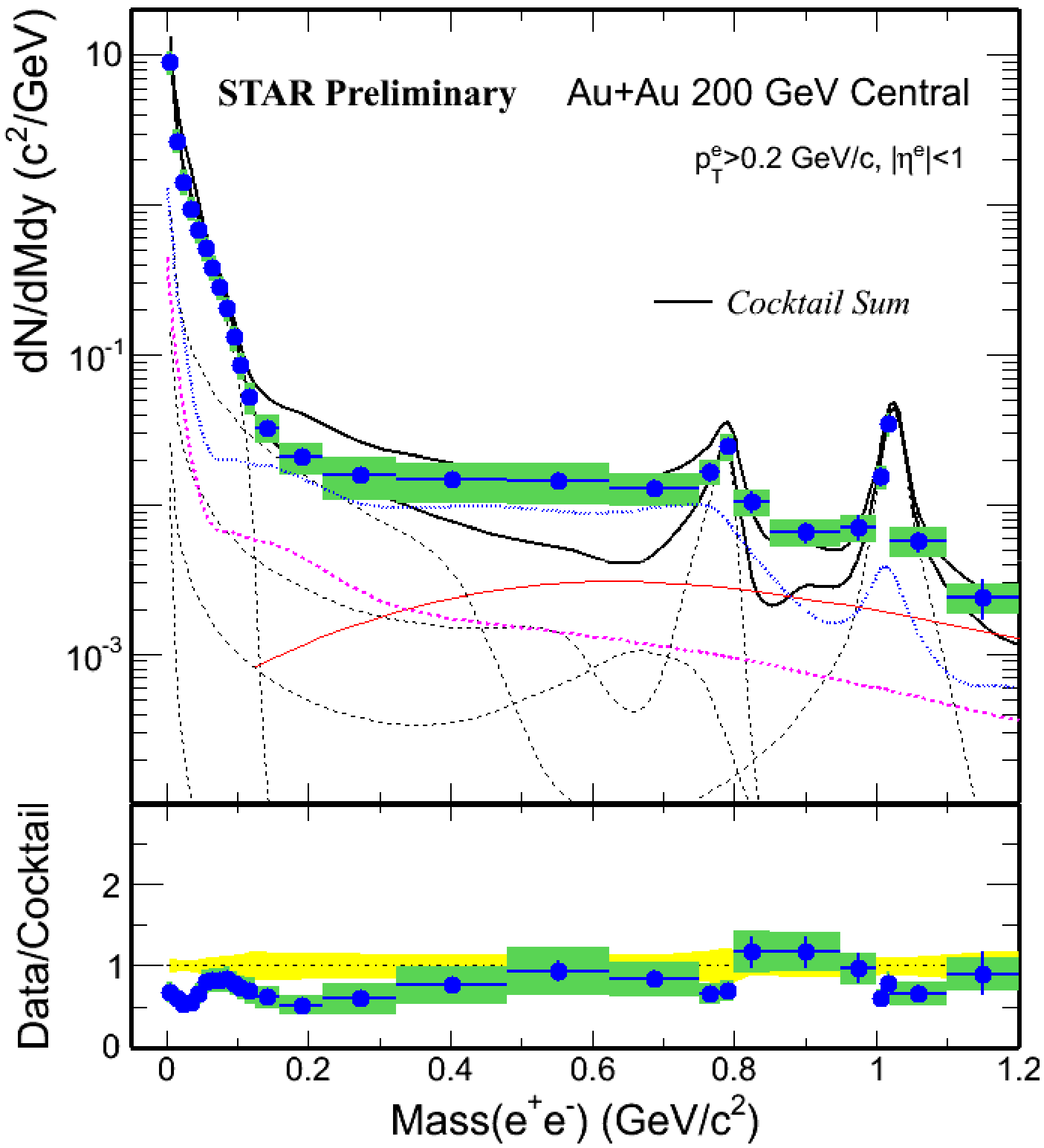
  - *ρ contribution not included in the cocktail*

  - *charm = PYTHIA*N_{bin} (0.96mb) indicating possible charm modifications in central Au +Au collisions*

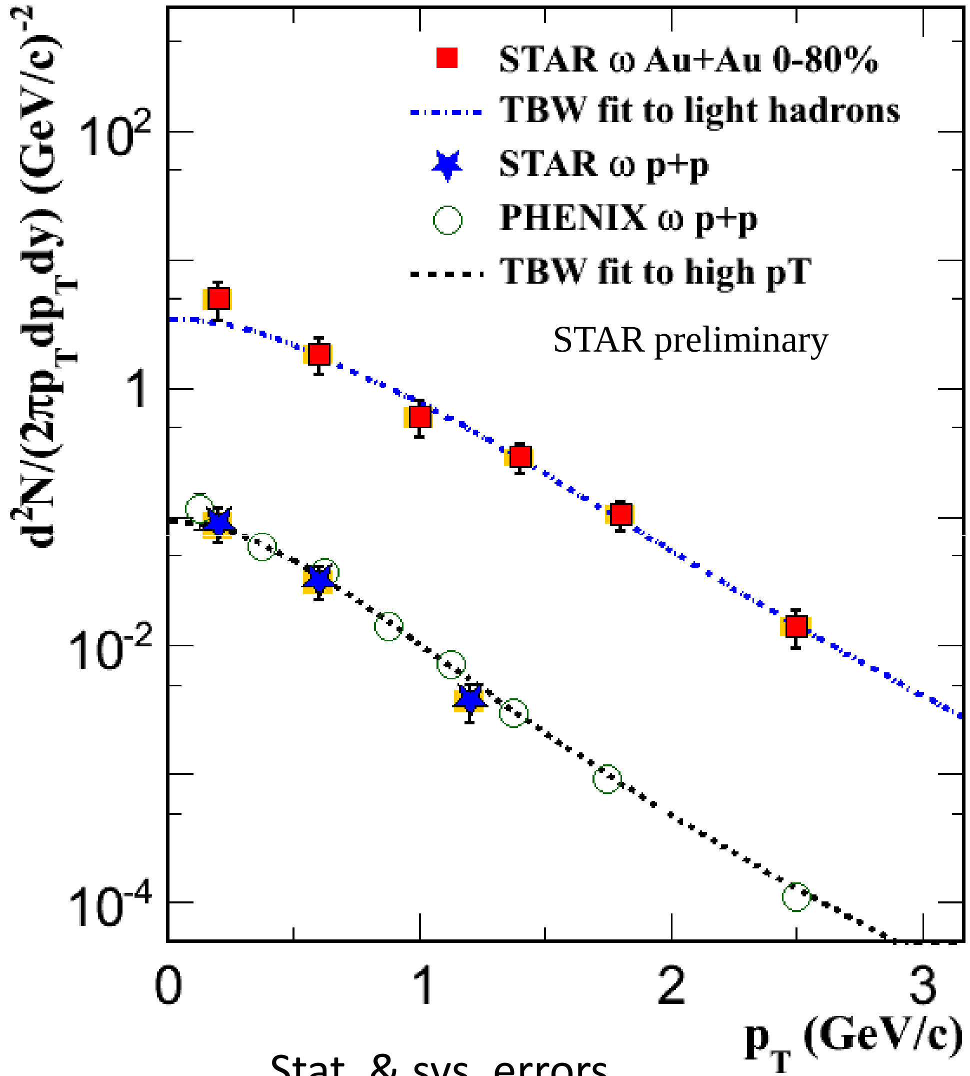
Comparison to theoretical calculation

Theoretical calculation:
Blue dotted: Hadron gas contribution in medium(HG).
Pink dotted: QGP.
From *R. Rapp*(private communication).
R. Rapp and J.Wambach, Adv. Nucl. Phys. 25, 1 (2000).

Solid lines:
upper: cocktail + HG+QGP
lower : cocktail



ω spectra



Stat. & sys. errors

> ***ω from ee channel has a same flow velocity <β>=0.47 as light hadrons in Au+Au MB with the Tsallis blast-wave model fit.***

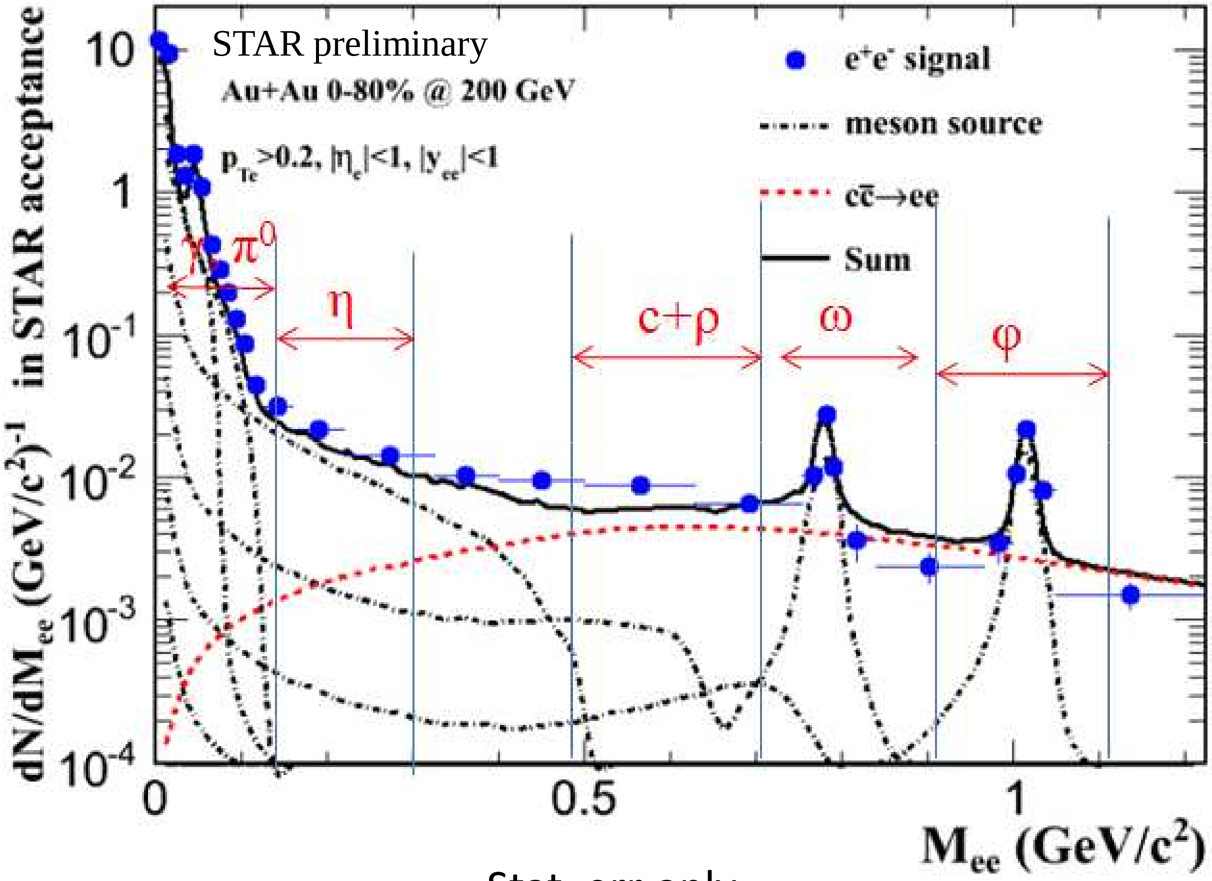
Tsallis Blast-wave fit:

In p+p: T=96.4 MeV, q = 1.0926 for mesons.

In Au+Au 0-80%: T=117 MeV, q = 1.0416, <β>=0.47 in 0-80% AuAu.

Z.Tang et al., arXiv:1101.1912

Dominant particle contribution in different mass range



Stat. err only

M_{ee}(0-0.14) : π^0+others

M_{ee}(0.14,0.3): η+others

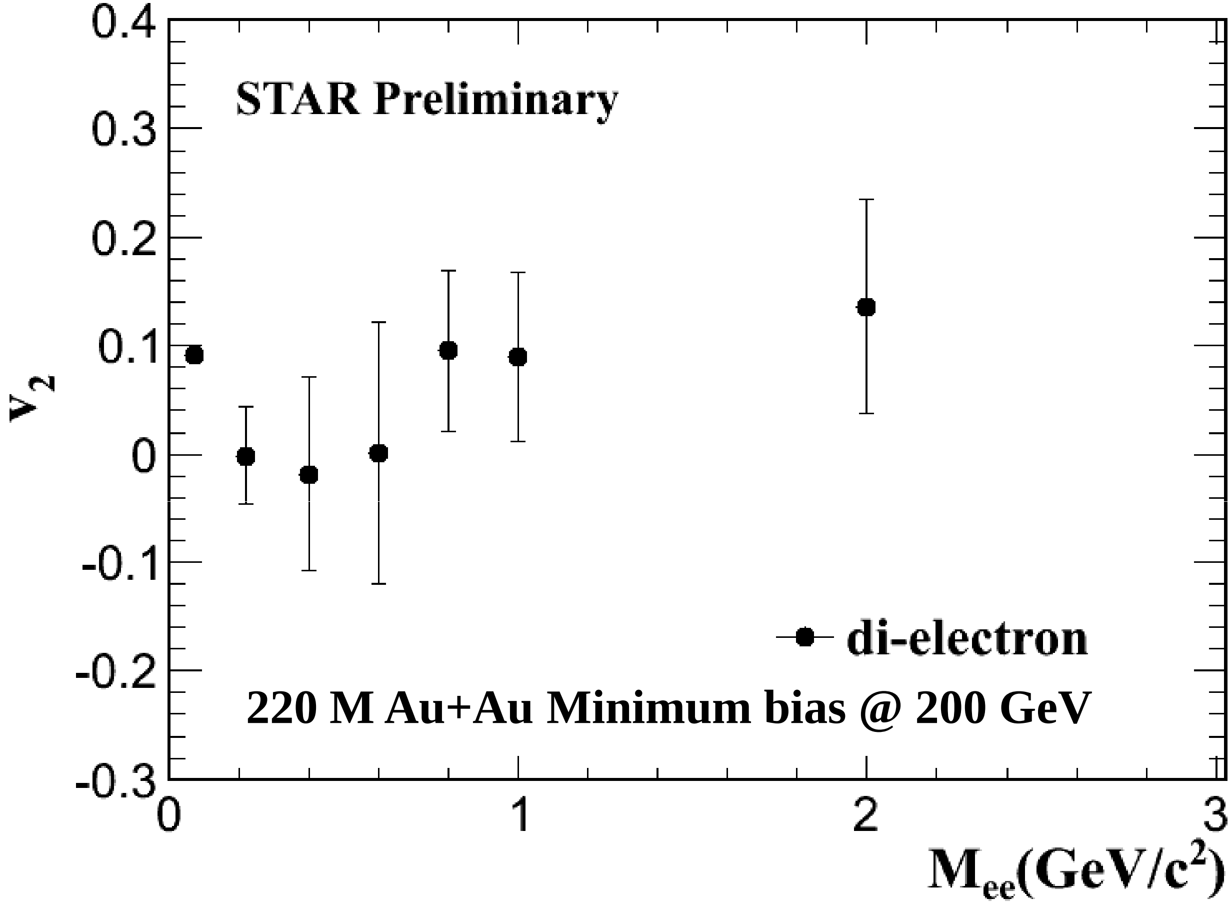
M_{ee}(0.5,0.7) : charm+ρ+ others

M_{ee}(0.7,0.9): ω+others

M_{ee}(0.9,1.1): φ+others

M_{ee}(1.1,2.9): charm+others

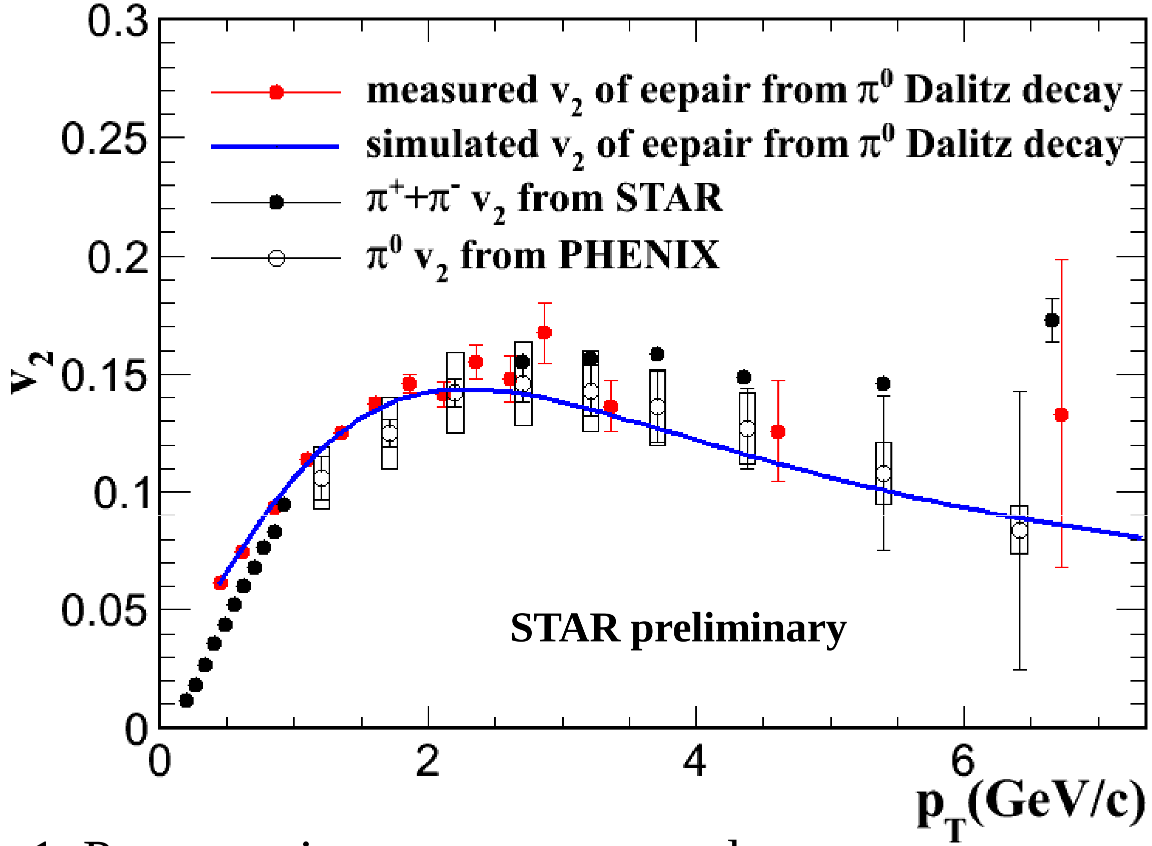
v_2 versus M_{ee} at 200 GeV Au+Au MB



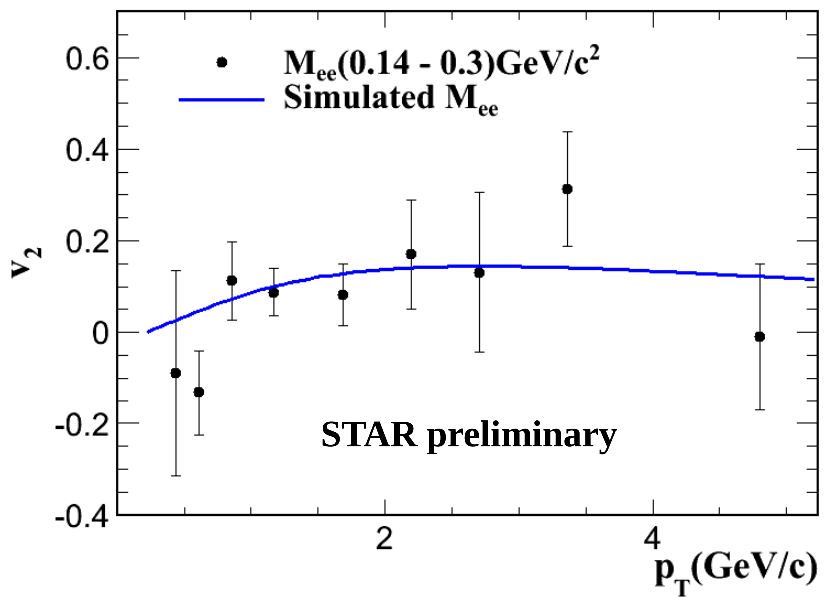
Stat. error only

- First di-electron elliptic flow v_2 measured at STAR.

v_2 of di-leptons in different mass bin



1. Parameterize π meson v_2 results
2. Do the Dalitz decay simulation and obtain expected v_2 of di-electron pairs from π^0 dalitz decay.
3. This is consistent with our di-electron v_2 results.



Assume η v_2 same as K_S, do the same Dalitz decay procedure.

Results of other mass bins and systematical uncertainties are in progress.

Summary & Outlook

- **Di-electron cocktail simulation consistent with data in p+p.**

- **Comparison between di-electron cocktail simulation and data in Au+Au collisions shows:**
  - *possible enhancement at low mass range.*
  - *possible charm modification at intermediate mass range.*

- **Di-electron v_2 has been measured in Au+Au MB events at $\sqrt{s_{NN}}$ = 200 GeV.**
  - *v_2 of di-electrons from π^0 dalitz decays is consistent with expectations from the measured v_2 of PHENIX π^0 and STAR $\pi^+ + \pi^-$.*

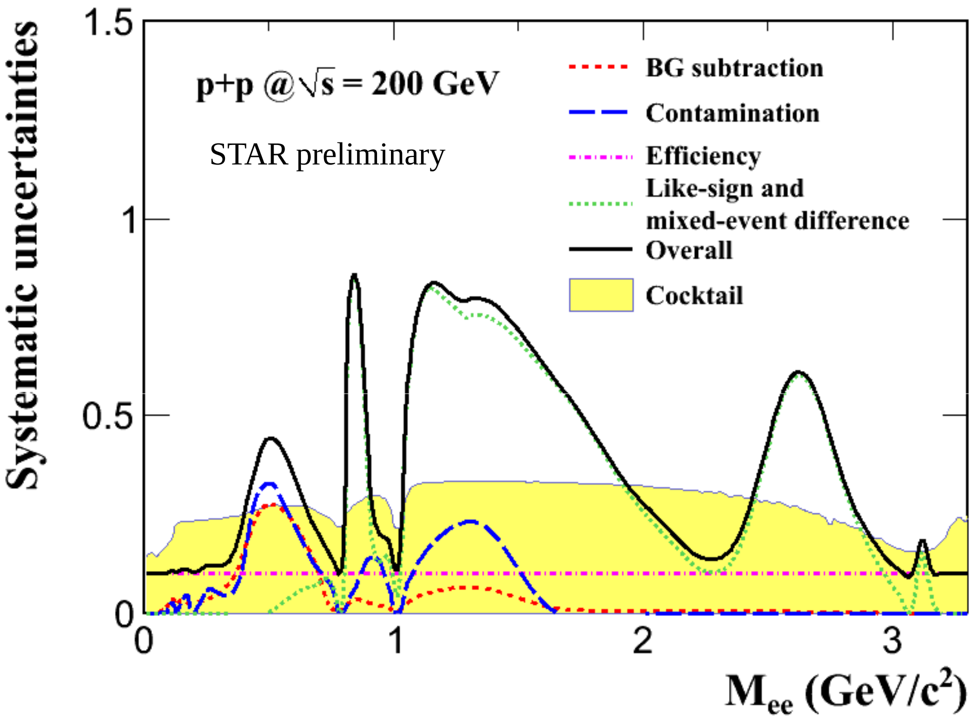
Outlook:

- **A factor of two more Au+Au data from 2011 will be analyzed.**
- **Muon Telescope Detector will help us to understand the charm contribution in the future.**
- **Heavy Flavor Tracker will greatly improve the charm measurements.**

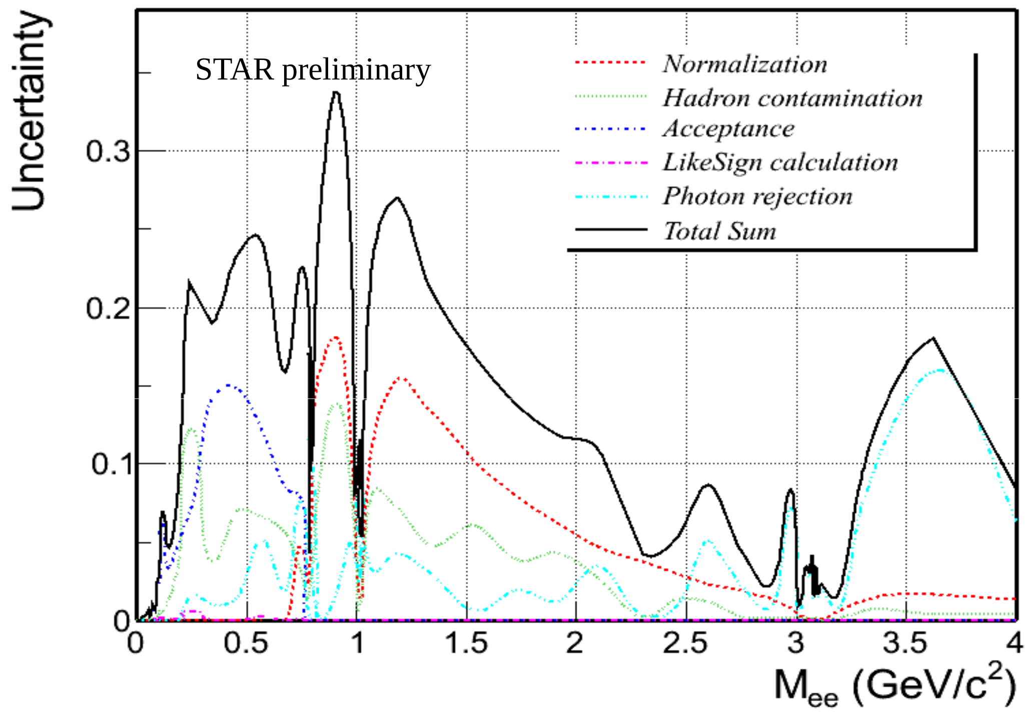
Backup

Systematic uncertainties

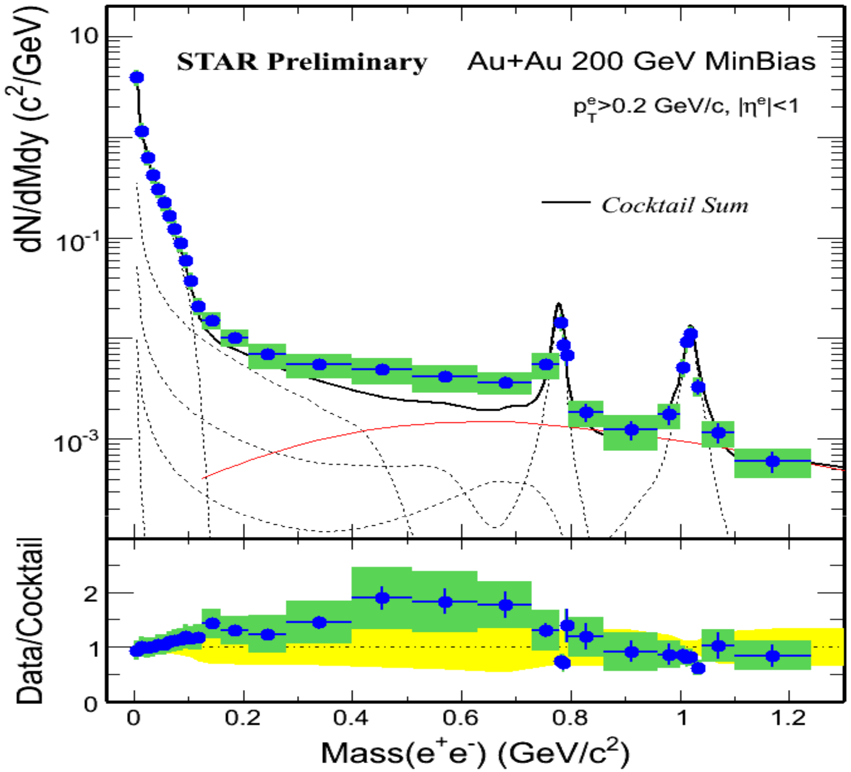
p+p:

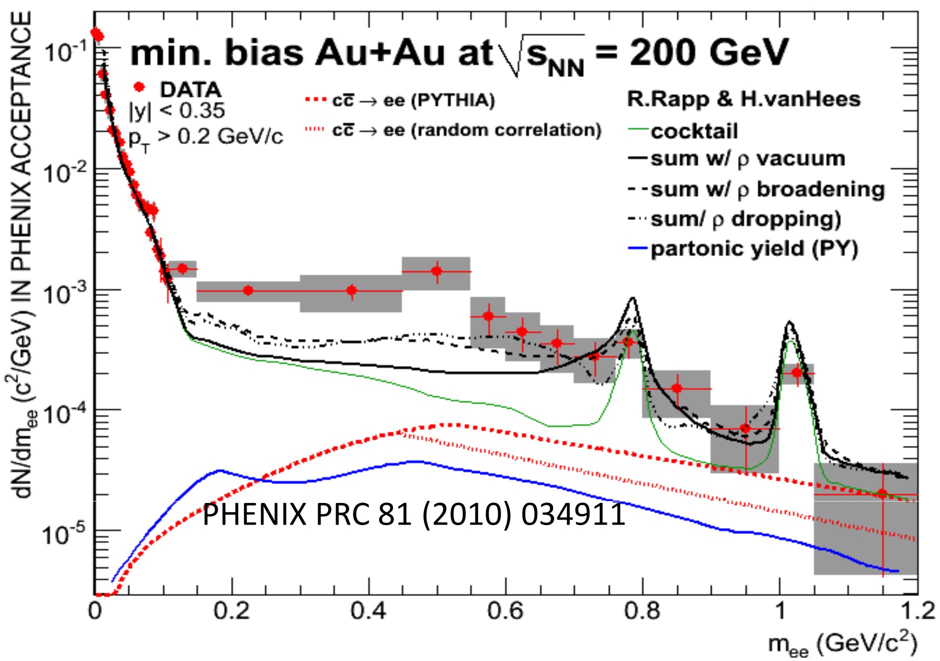


Au+Au:



Low mass enhancement



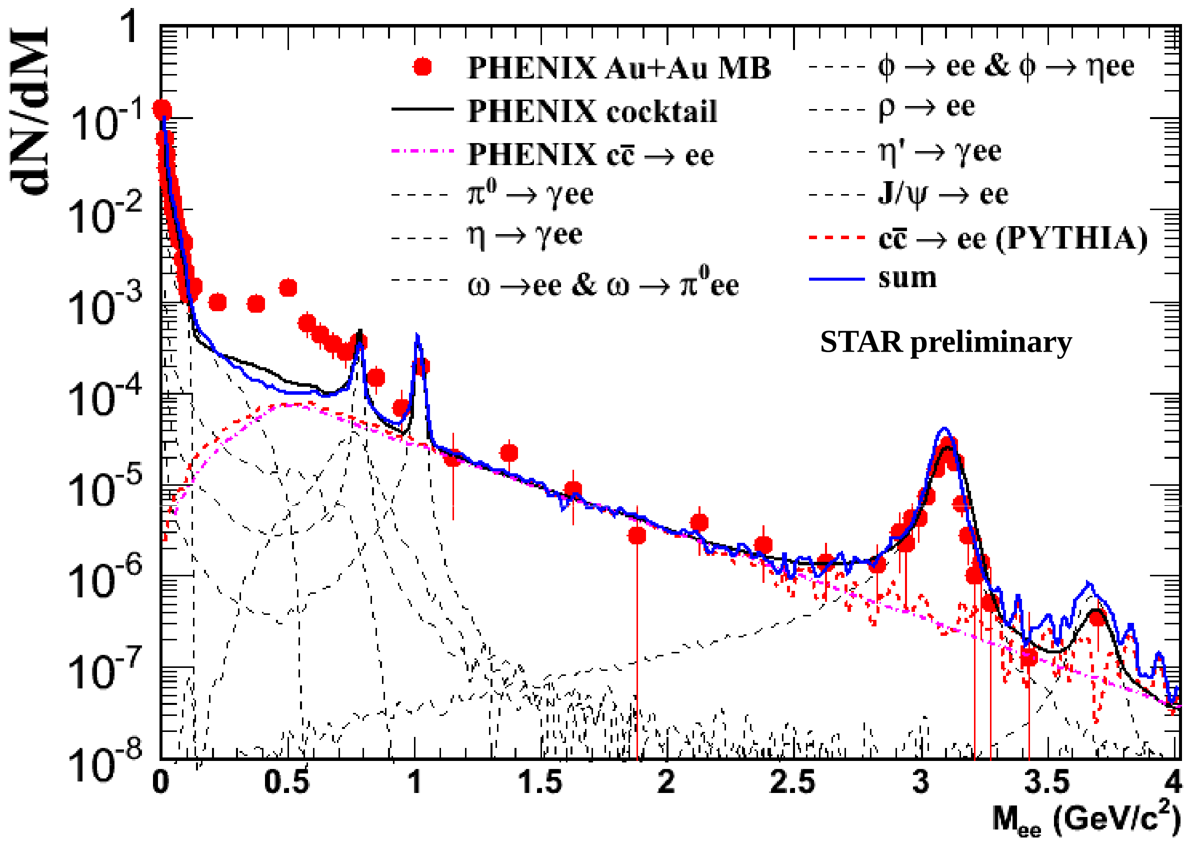


Enhancement factor in $0.15<M_{ee}<0.75$ Gev/c2

	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**

Note: Acceptance difference etc.

Reproduce PHENIX cocktail



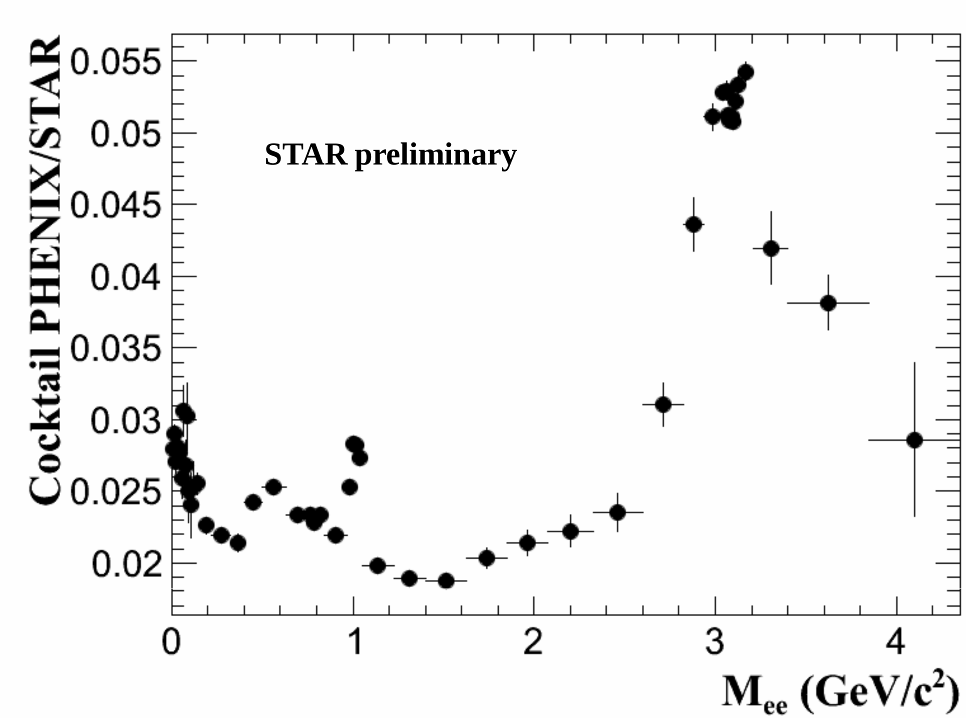
Reproduce the cocktail within PHENIX acceptance by our method.

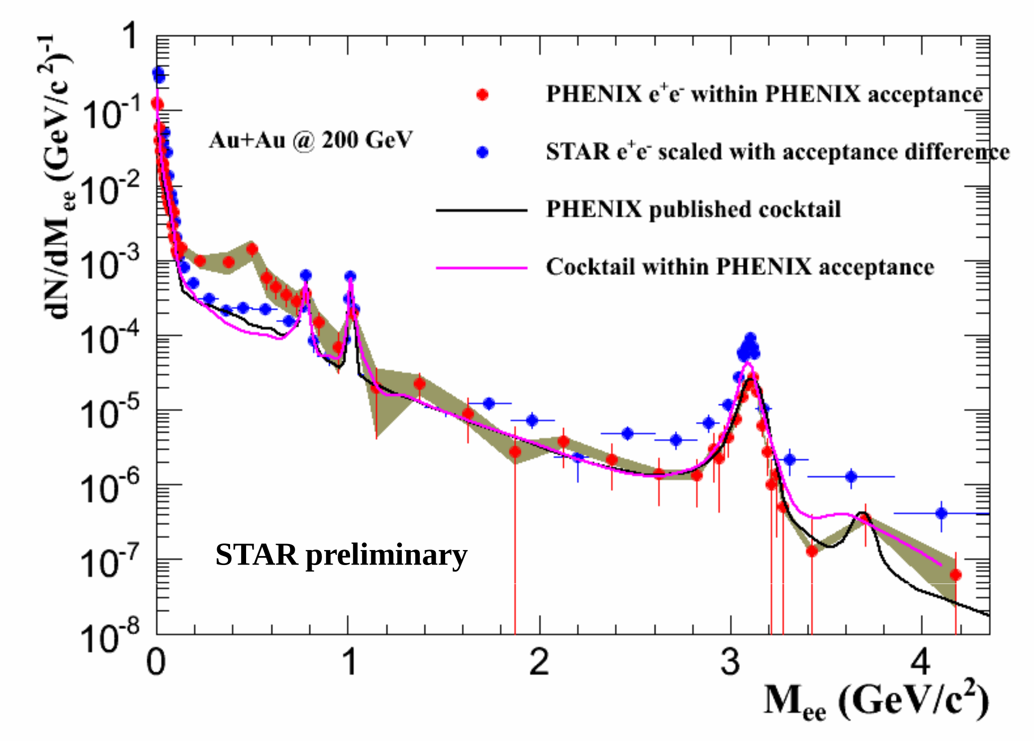
The momentum resolution are still from STAR.

Scaled by all the yields from PHENIX paper[1], we can reproduce the PHENIX cocktail.

[1]. Phys. Rev. C 81, 034911 (2010).

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.

v_2 standard event-plane method

$$v_2^{Total}(M) = v_2^B(M) * \frac{N_B}{N_{(S+B)}}(M) + v_2^s * \frac{N_S}{N_{(S+B)}}(M)$$

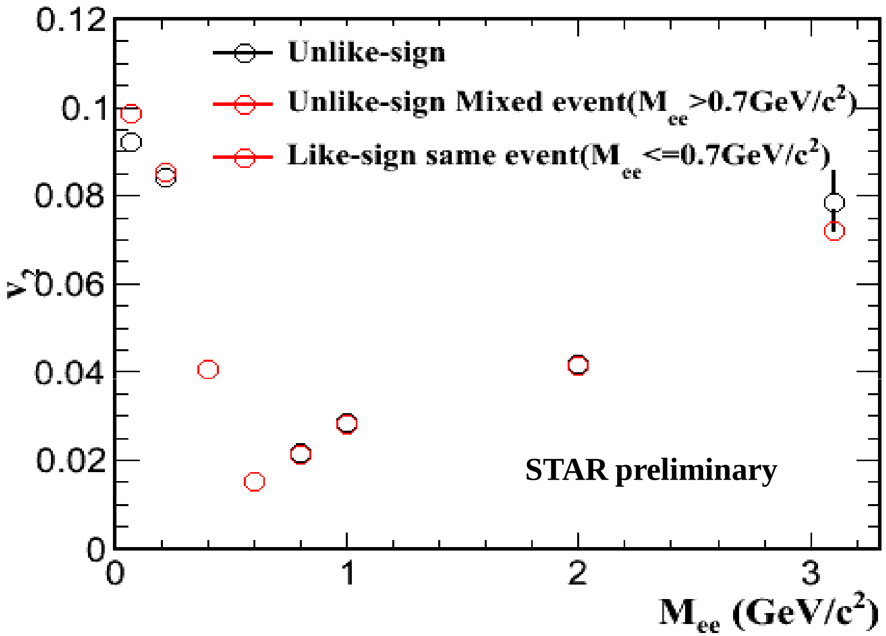
$$v_2^{Total}(M) - v_2^B(M) * \frac{N_B}{N_{(S+B)}}(M) = v_2^s * \frac{N_S}{N_{(S+B)}}(M)$$

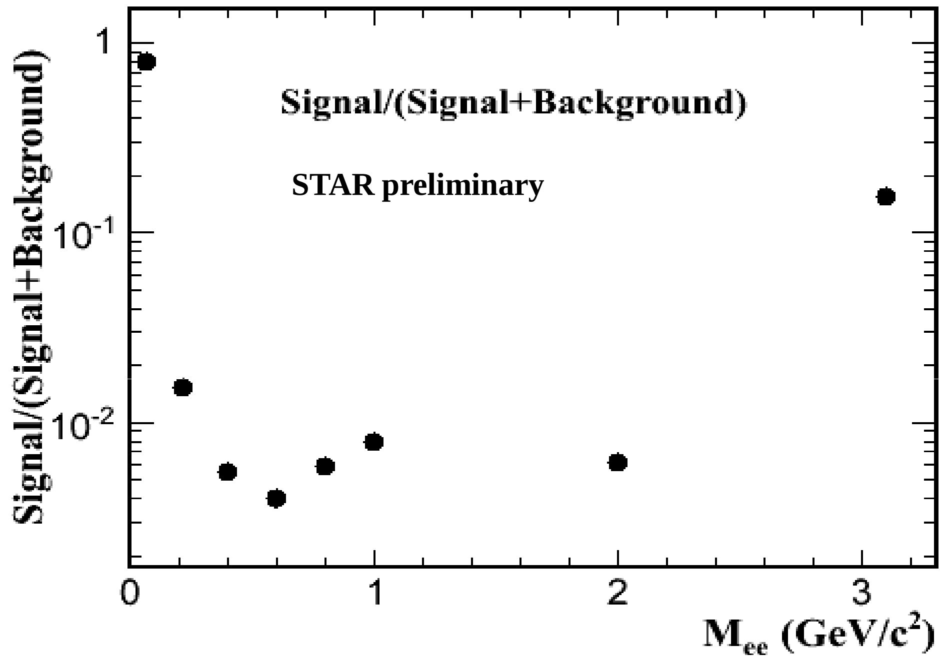
$$v_2^{Total} =< \cos(2(\phi_i - \psi_r)) / r_j >$$

$$v_2^B =< \cos(2(\phi_i - \psi_r)) / r_j >$$

v_2 ^{Total} is flow of unlike-sign pairs.
$v_2^B(M)$ is flow of background calculated using the like-sign or mixed events pairs.
v_2^S is flow of signal.
N_S is the signal number, N_B is the background (like-sign) number.
$N_{(S+B)}$ is unlike-sign number.

Unlike-sign and background v_2





$$v_2^{Total}(M) - v_2^{B}(M) * \left(1 - \frac{Ns}{N_{(S+B)}}(M)\right) = v_2^{s} * \frac{N_S}{N_{(S+B)}}(M)$$

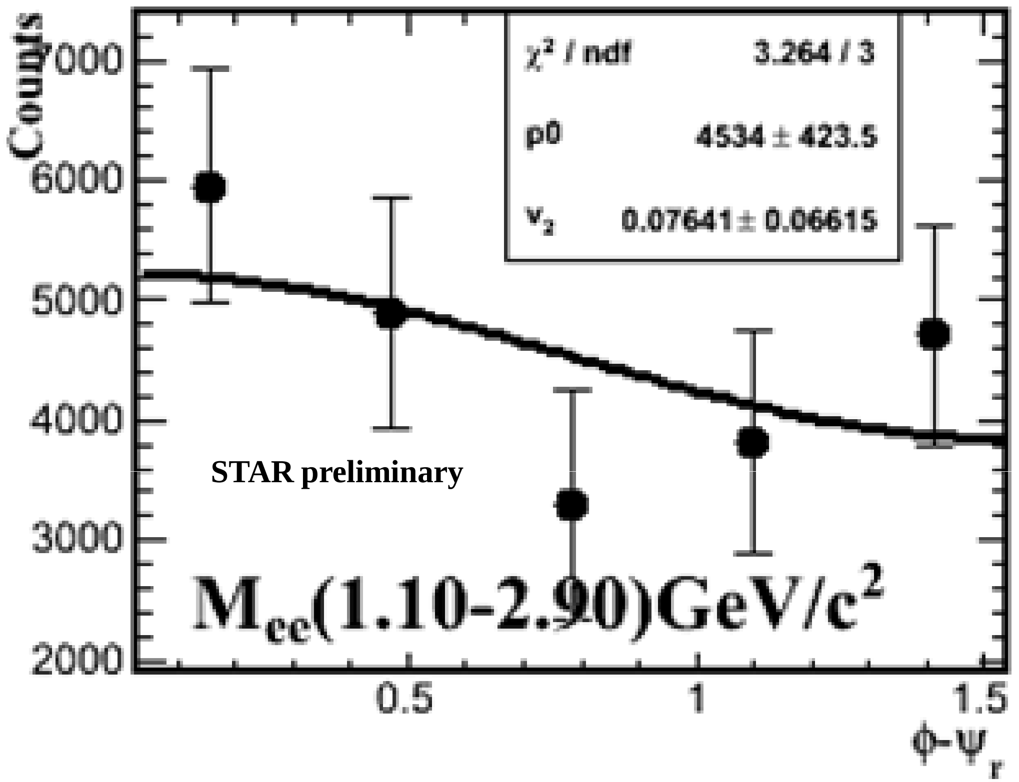
Unlike-sign v_2

Background v_2

Signal/(Signal+Background)

Signal flow

Standard Event-plane method II



$$\frac{dN}{d(\Phi-\Psi_2)} = N(1+2v_2^{obs}\cos(2(\Phi-\Psi_2)))$$

Count the counts of signal in different (ϕ- ψ_2), and use the above formula to fit it