Dielectron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV at STAR

Zhen Wang *for the STAR Collaboration*

Institute of Frontier and interdisciplinary science, Shandong University, Qingdao, Shandong

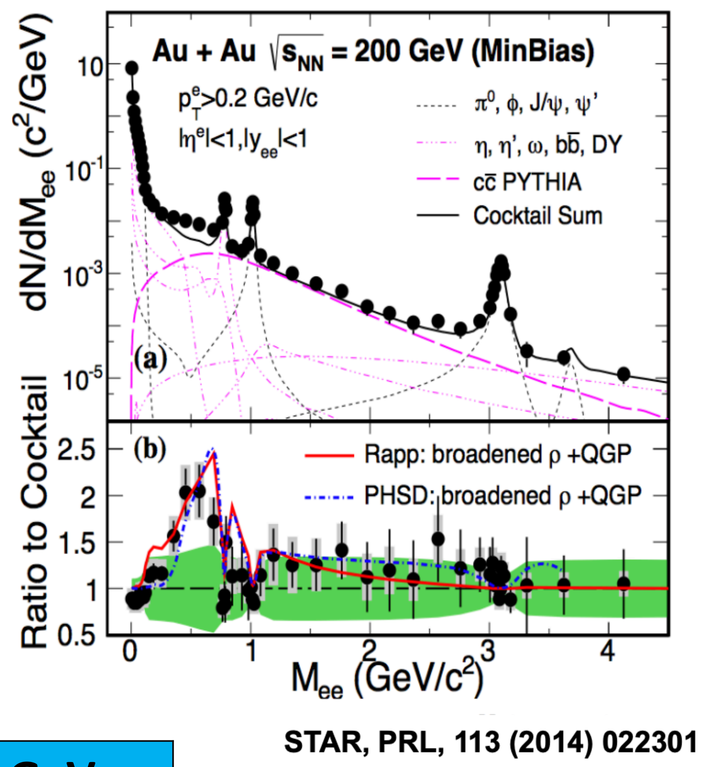
Abstract

Dielectrons are excellent probes of the Quark-Gluon Plasma (QGP) created in high-energy heavy-ion collisions. Because they can be produced at all stages of the collision system evolution and do not interact with the medium strongly, dielectrons carry the information from the initial stage to the final stage. In the low mass region (LMR, $M_{ee} < M_{\phi}$), the mass spectra of vector mesons will be modified by the hot and dense medium which is related to the chiral symmetry restoration in the medium. In the intermediate mass region (IMR, $M_{\phi} < M_{ee} < M_{J/\psi}$), QGP thermal radiation can be used as a QGP thermometer. However, it is hard to measure the QGP thermal radiation because of the heavy flavor semi-leptonic decay contributions.

In this poster, we present the dielectron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV at STAR. With a 10 times larger data sample than that at 62 GeV from the first phase of the STAR Beam Energy Scan (BES-I) program, in-medium ρ modification can be studied with better precision and compared to different theoretical predictions.

Motivation

- Dielectrons are produced at all stages of the system evolution and escape with minimum interaction with the medium.
- They can carry the information form the initial stage to the final stage.
- Mass spectrum in LMR is related to chiral symmetry restoration.
- In IMR, QGP thermal radiation can be used as a QGP thermometer.
- STAR collected 875M minimum-bias(MB) events in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV. With a data sample that is 10 times larger that for the BES-I program, a more precise measurement is possible.



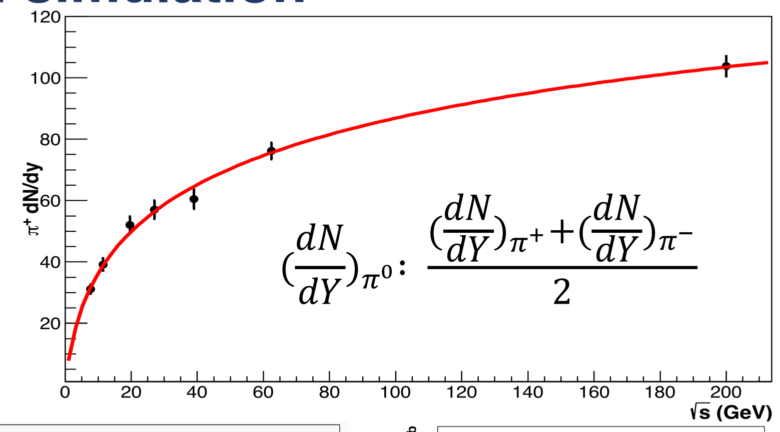
STAR, PRL, 113 (2014) 022301

Data samples of 54 GeV and BES-I program

Energy	27 GeV	39 GeV	54.4 GeV	62 GeV
Used MB events	68M	132M	875M	62M

Hadronic cocktail simulation

- The contribution of the dielectron pairs from hadronic decays is called hadronic cocktail. The input meson yield and cross section are extrapolated from worldwide data.[3][4]

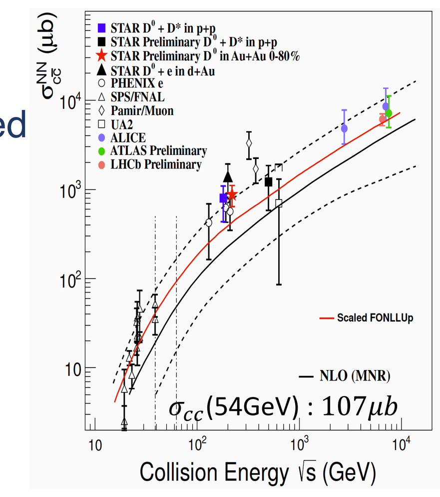


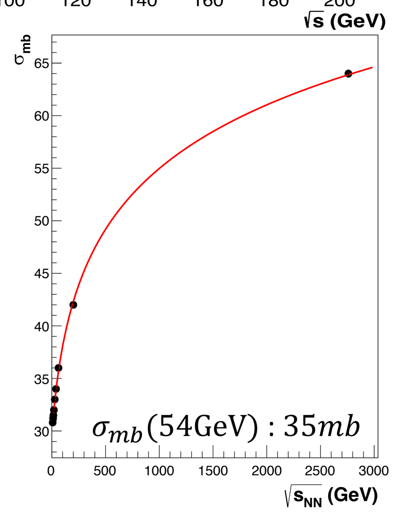
- Meson decay contributions are scaled by:

$$\frac{dN}{dM} = \frac{1}{nEvt}\left(\frac{dN}{dY}\right)_{\pi^0} dY \frac{\sigma_{had}}{\sigma_{\pi^0}} BR_{hadron \to (X) e^+ e^-} \frac{1}{dM}$$

- Charm semi-leptonic decay contribution is scaled by:

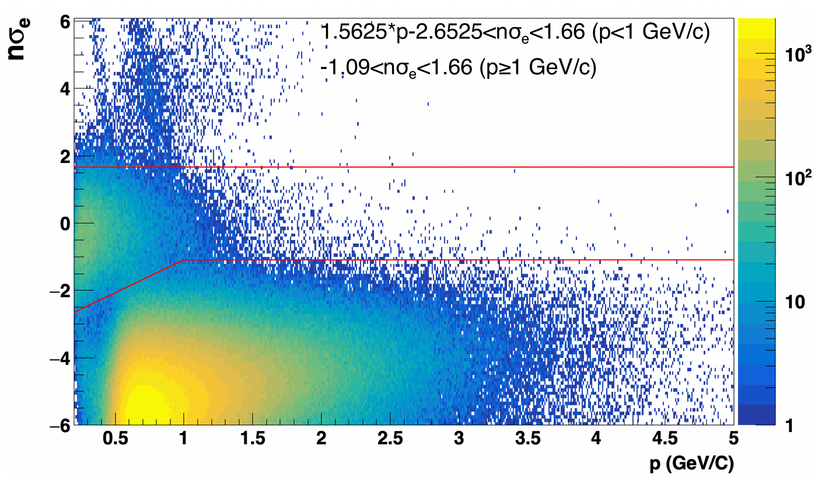
$$\frac{dN}{dM} = \frac{1}{nCharm}\left(\frac{dN}{dM}\right)_{pp} \frac{\sigma_{c\bar{c}}}{\sigma_{mb}} N_{bin} BR_{(c \to e^+)} BR_{(c \to e^-)}$$

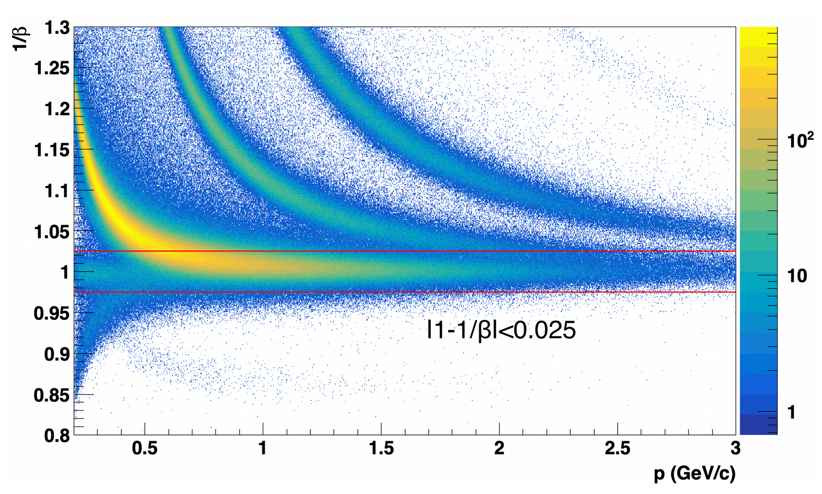




Electron identification

- Electrons candidates are selected by Time Projection Chamber (TPC) and Time of Flight (TOF) information.
- TPC : ionization energy loss(dE/dx)
- TOF : velocity





- $n\sigma_e$ (left plot)and $1/\beta$ (right plot) cuts as a function of momentum. [1]
- $R_{dE/dx}$ is the dE/dx resolution of TPC

$$\sigma_e = \log\left(\frac{dE/dx_{Mea.}}{dE/dx_{The.}}\right) * \frac{1}{R_{dE/dx}}$$

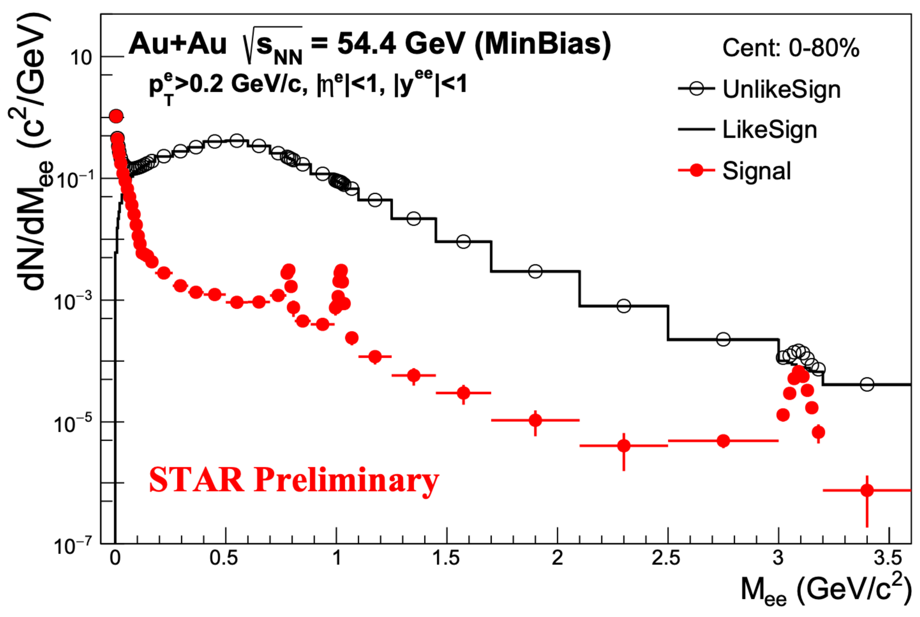
Pair reconstruction and background subtraction

- Raw signal is obtained via subtracting the background from unlike-sign spectrum.

$$\text{Raw signal} = N_{+-} - N^{corr}_{++\&--}$$

- Like-sign same event method is used to estimate the combinatorial background.
- Pair acceptance factor obtained from a mixed event method.

$$N^{corr}_{++\&--} = 2\sqrt{N_{++} * N_{--}} * \frac{B_{+-}}{2\sqrt{B_{++} * B_{--}}}$$

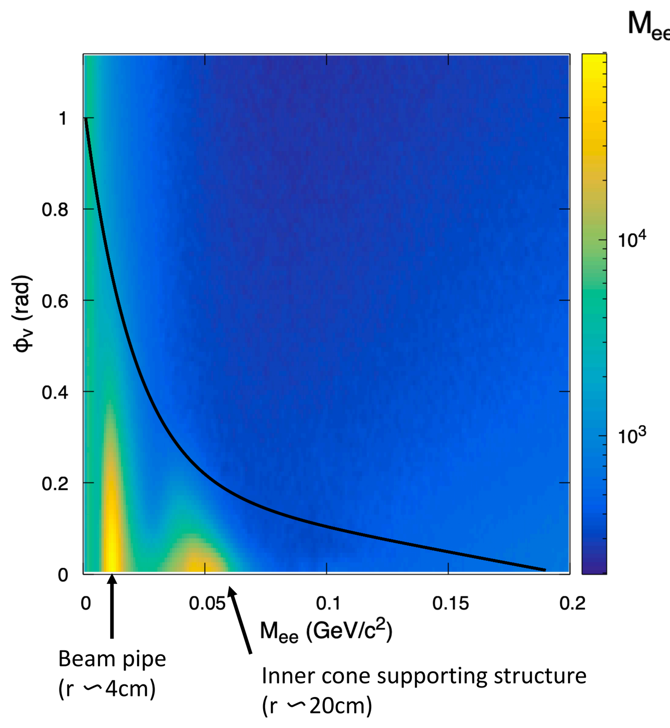


- The electron pairs from photon conversion can not be reconstructed by like-sign same event method or mixed event method.
- Such photon conversion electron pairs are removed by ϕ_v cut.
- ϕ_v is defined as the following [2] :

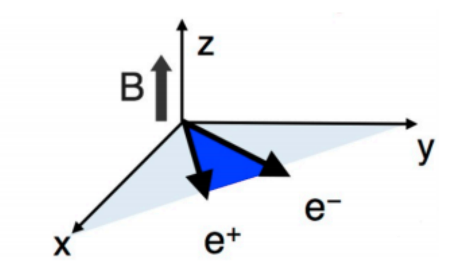
$$\hat{u} = \frac{\vec{p}_+ + \vec{p}_-}{|\vec{p}_+ - \vec{p}_-|}, \hat{v} = \frac{\vec{p}_+ \times \vec{p}_-}{|\vec{p}_+ \times \vec{p}_-|}$$

$$\hat{\omega} = \hat{u} \times \hat{v}, \hat{\omega_z} = \hat{u} \times \hat{z}$$

$$\cos\phi_v = \hat{\omega} \cdot \hat{\omega_z}$$



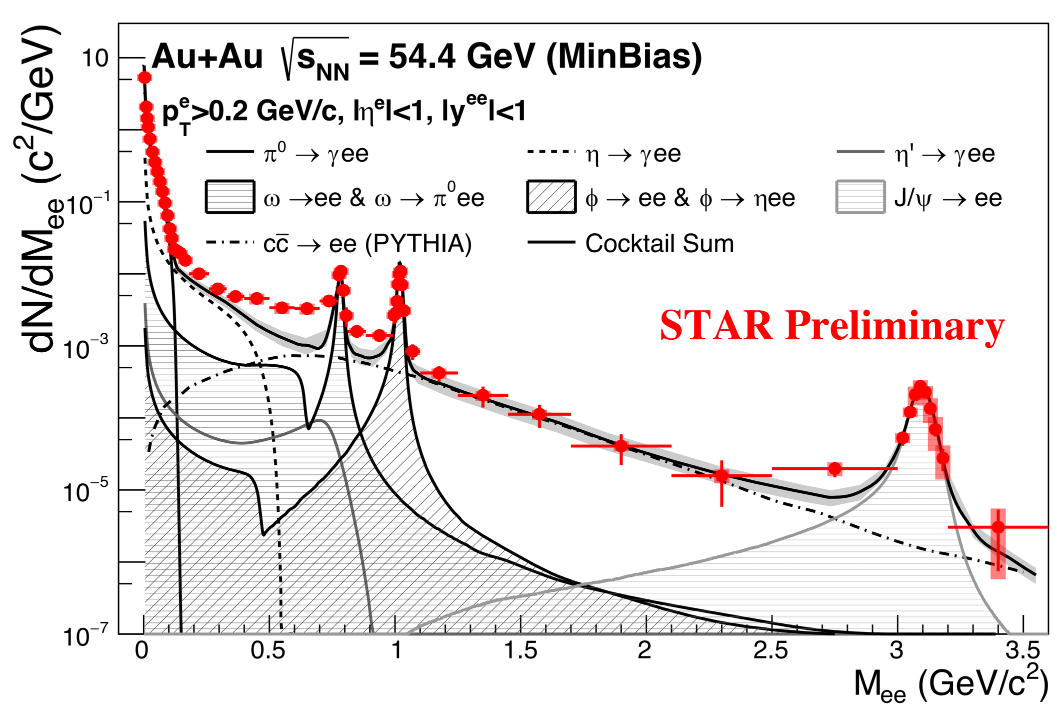
- The opening angle of conversion electron pairs should be very close to 0.
- ϕ_v cut can remove most electron pairs from photon conversion.



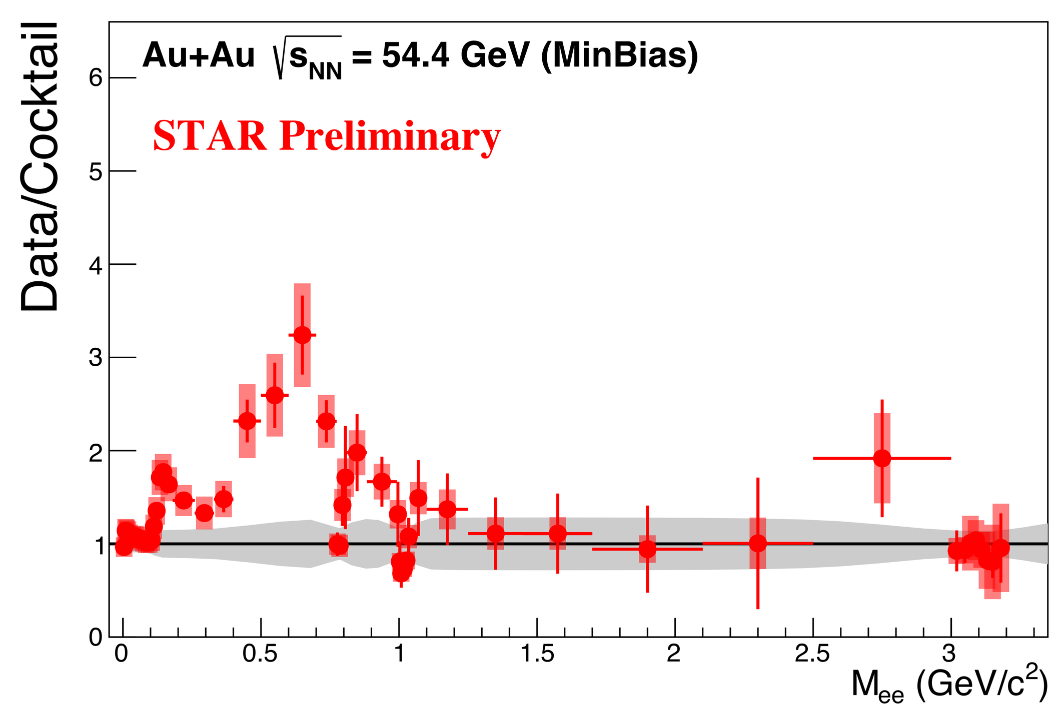
e$^+$e$^-$ from photon conversion

Result & Summary

- Dielectron invariant mass spectrum from Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV is obtained.
- Significant excess over cocktail in the low mass region.



- A significant enhancement of dielectron yields is observed with respect to the hadronic cocktail simulation without ρ contribution in the low mass region.
- An enhancement at intermediate mass region is not observed.



Outlook

- STAR acceptance-corrected dielectron spectrum and excess yields will be studied
- Coherent photonuclear process at very low p_T region in Au+Au collisions at 54.4 GeV will be studied

References

[1] M. Shao, O. Y. Barannikova, X. Dong, Y. Fisyak, L. Ruan, P. Sorensen and Z. Xu, Nucl. Instrum. Meth. A 558 , 419 (2006)
[2] A. Adare et al. (PHENIX Collaboration),Phys. Rev. C 81, 034911 (2010).
[3] Adamczyk, L et al. (STAR Collaboration), Phys.Rev. C 96, 044904 (2017)
[4] G. A. Alves et al. (Fermilab E769 Collaboration), Phys. Rev. Lett. 77, 2388 (1996).
S. P. K. Tavernier, Rep. Prog. Phys. 50, 1439 (1987).
L. Adamczyk et al. (STAR Collaboration), Phys. Rev. D 86, 072013 (2012).
A. Adare et al. (PHENIX Collaboration), Phys. Rev. Lett. 97, 252002 (2006).

In part supported by U.S. DEPARTMENT OF ENERGY Office of Science

The STAR Collaboration
drupal.star.bnl.gov/STAR/presentations