Dielectron Production in Au+Au Collisions at $\sqrt{s_{NN}}$ = 27 GeV with the STAR Experiment

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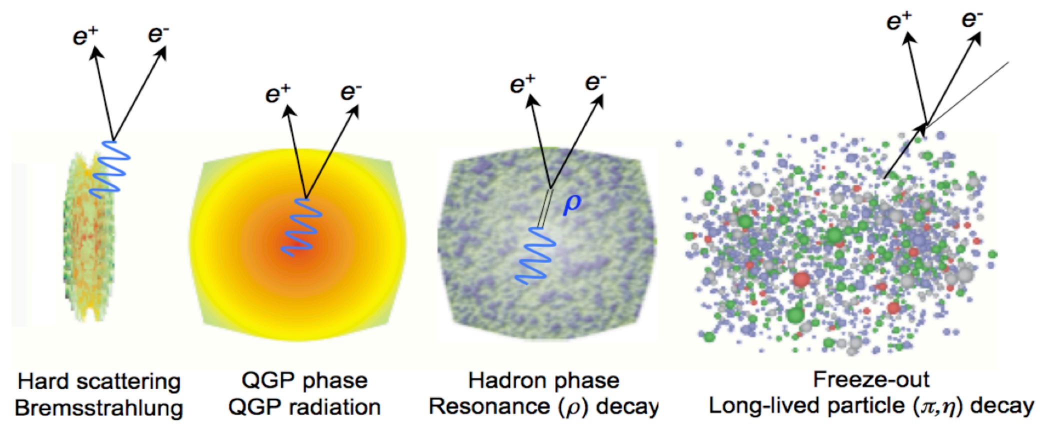
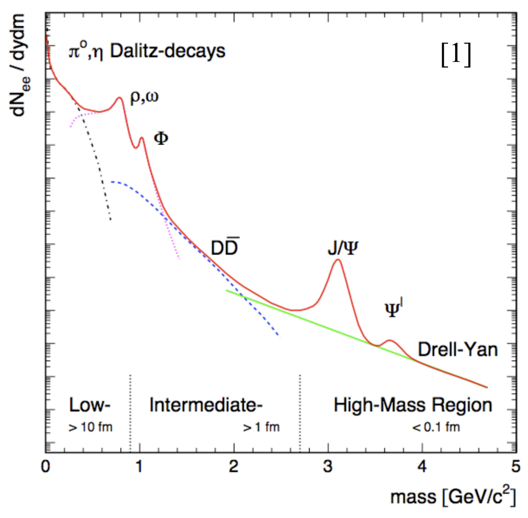
Abstract

Dielectron production is suggested as an excellent probe of the hot, dense and strongly interacting medium (QGP) created in relativistic heavy-ion collisions due to their minimal interactions with the medium and the final state hadrons. Dielectrons can be produced at different evolution stages of the collision system. Different invariant mass ranges are sensitive to different physics processes. In the low mass region ($M_{ee} < M_\phi$), dielectron production is sensitive to the in-medium modifications of vector mesons which could provide an access to the chiral symmetry restoration. In the intermediate mass region ($M_\phi < M_{ee} < M_{J/\psi}$), the dielectron production from the medium thermal radiation is sensitive to the medium temperature, thus can serve as a thermometer of the medium. However, the dominant source in this mass region, semi-leptonic decays of open heavy flavor hadrons, makes the extraction of the thermal radiation contribution very challenging.

In this poster, we present the results from the 1.5 B minimum-bias events taken in 2018 Au+Au collisions at $\sqrt{s_{NN}}$ = 27 GeV. This data sample is about 10 times larger than that from the STAR Beam Energy Scan phase I program and allows a much more precise measurement of the in-medium modification of ρ mesons. The much lower open charm production rate at this energy compared to RHIC top energies greatly reduces their contributions to the dielectron spectrum at the intermediate mass region, providing a better opportunity to extract the medium temperature.

Motivation



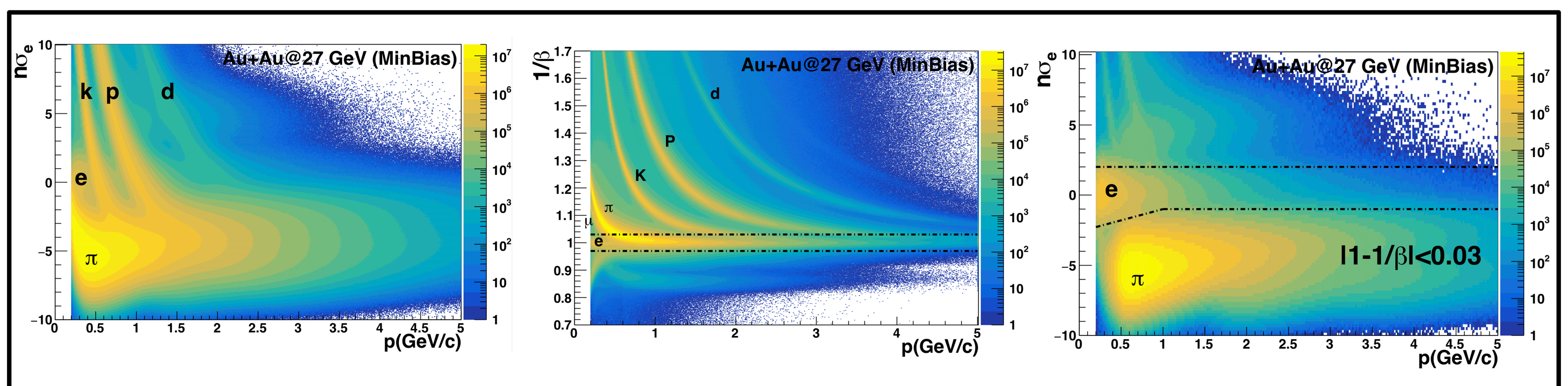


- ❖ **Produced at entire evolution stages of the collision system**
- ❖ **Not suffer from strong interactions, direct probe of the medium in heavy-ion collisions**
- ❖ **Low mass region ($M_{ee} < M_\phi$):**
  - sensitive to the in-medium modifications of vector mesons
  - provide an access to the chiral symmetry restoration.
- ❖ **Intermediate mass region ($M_\phi < M_{ee} < M_{J/\psi}$):**
  - di-electron from the medium thermal radiation is sensitive to the medium temperature, serve as a thermometer of the medium
  - semi-leptonic decays of open charm mesons dominant the production

Raw Signal Reconstruction

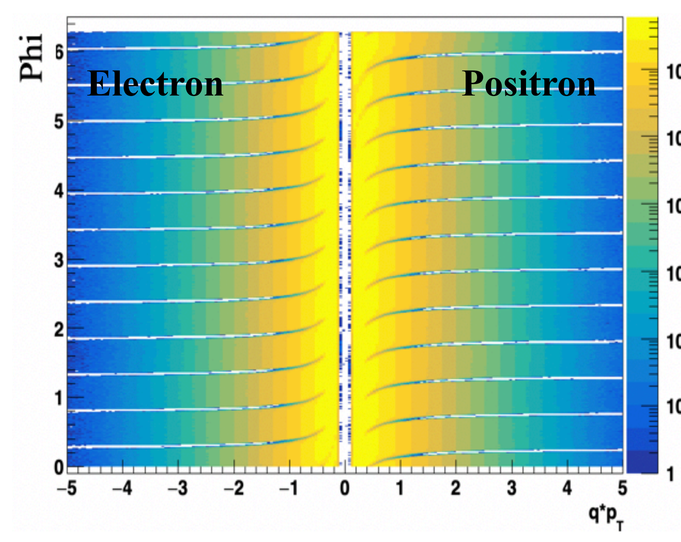
❖ **Electron identification via Time Projection Chamber (TPC) and Time of Flight (TOF) detectors**

- TPC: tracking, momentum, Ionization energy loss (dE/dx) → Excellent particle identification (PID)
- TOF: time of flight (→ measure the velocity β) → Improve electron identification



❖ **Dielectron Raw Signal Reconstruction**

- Unlike-Sign electron pairs = signal + background
- Background = combinatorial + correlated + photon conversion
- Combinatorial and correlated BG can be estimated from Like-Sign electron pairs
- Detector acceptance for negative and positive tracks are different, thus the acceptance of Unlike-Sign and Like-Sign pairs are different
- Difference in the acceptance between Unlike-Sign and Like-Sign pairs can be estimated via a mixing event technique
- Mixing event: combine electrons from different events with similar properties (Z vertex, centrality, event plane angle)
- Photon conversion background can be removed via ϕ_V angle cut method



$$N^{corr}_{++\&--} = 2\sqrt{N_{++}(M,p_T)\cdot N_{--}(M,p_T)} \times \underbrace{\frac{B_{+-}(M,p_T)}{2\sqrt{B_{++}(M,p_T)\cdot B_{--}(M,p_T)}}}_{\text{Acc. corr. factor}}$$

- "N" is the number of electron pairs from the same event
- "B" is the number of electron pairs from different events

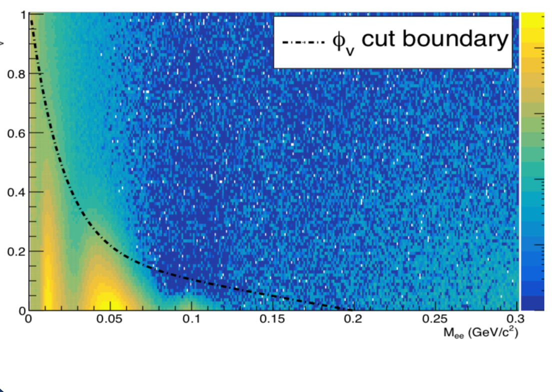
Definition of via ϕ_V angle [2]

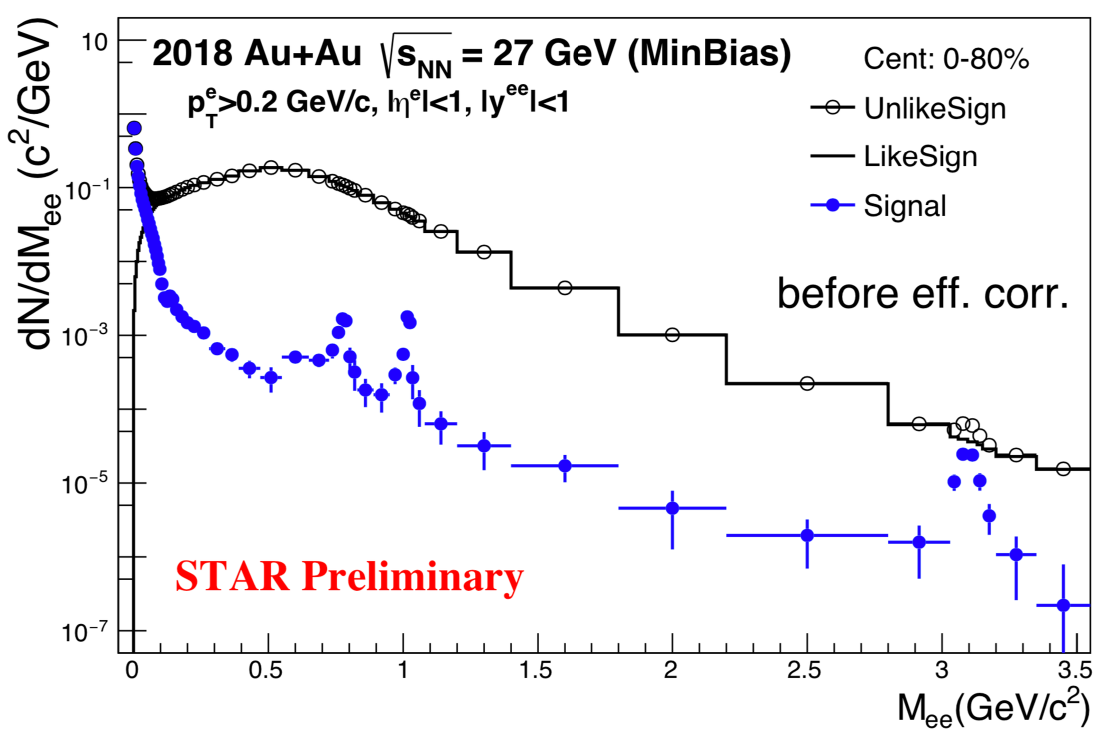
$$\hat{u} = \frac{\vec{p}_+ + \vec{p}_-}{|\vec{p}_+ + \vec{p}_-|}, \hat{v} = \vec{p}_+ \times \vec{p}_-$$

$$\hat{w} = \hat{u} \times \hat{v}, \hat{w}_c = \hat{u} \times \hat{z}$$

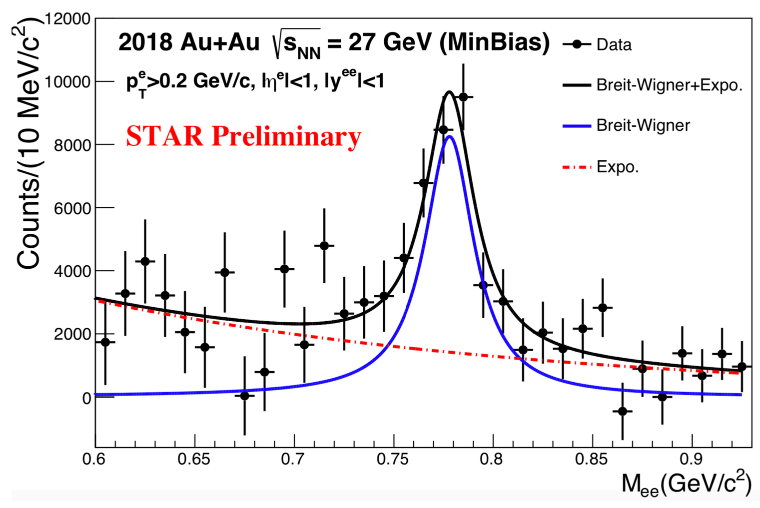
$$\cos\phi_V = \hat{w} \cdot \hat{w}_c$$

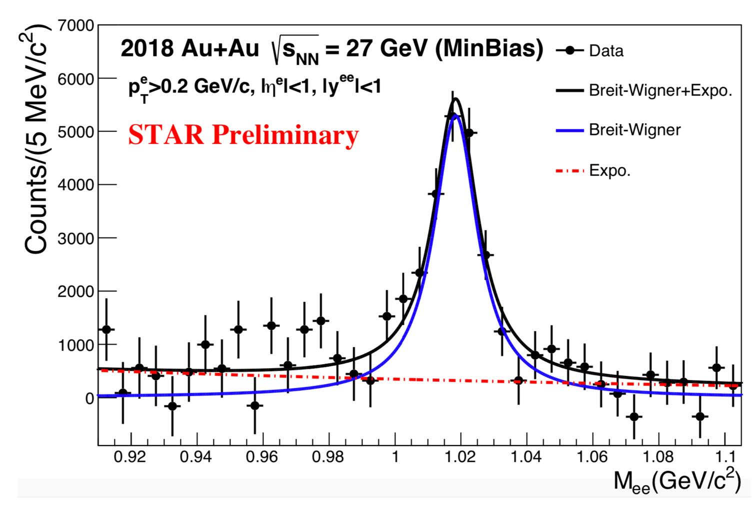
$\vec{p}^{\pm}$ are momentum vectors of $e^{\pm}$





Signals of ω and ϕ Mesons



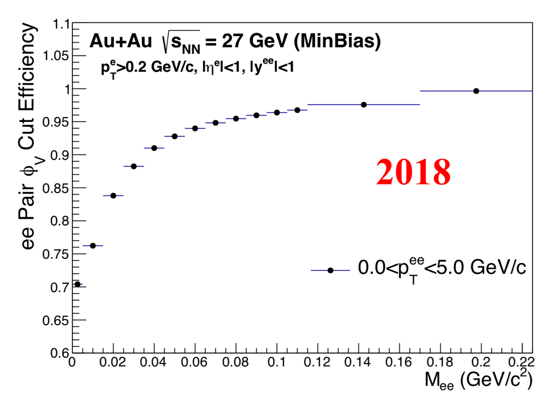


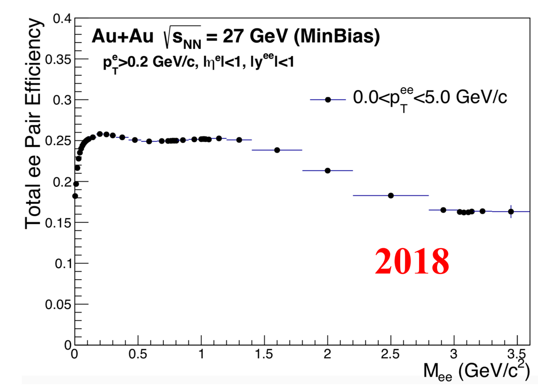
Dielectron Pair Reconstruction Efficiency

Contributions of pair efficiency:

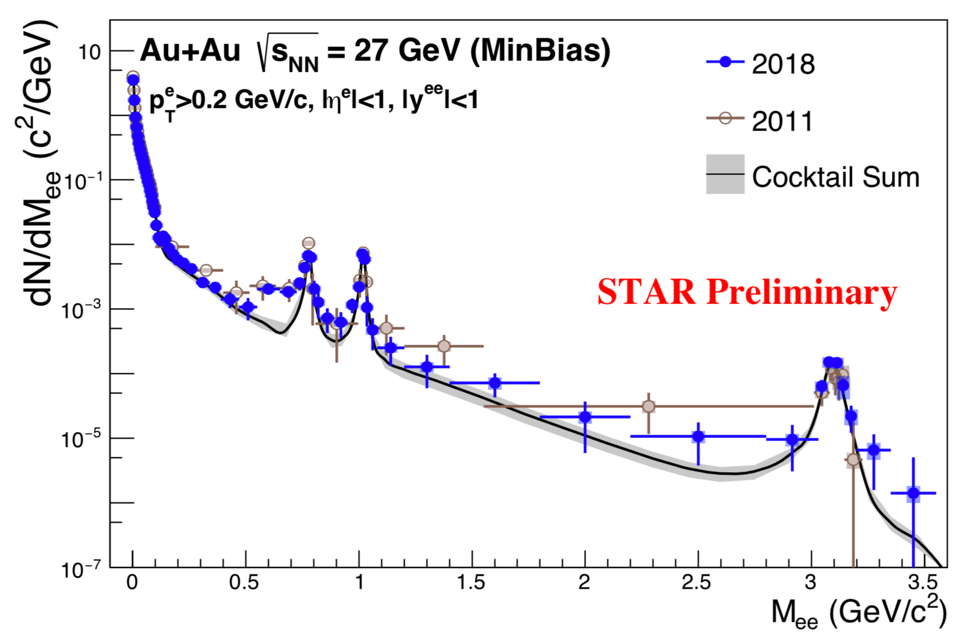
Single electron efficiency, momentum resolution, ϕ_V cut efficiency

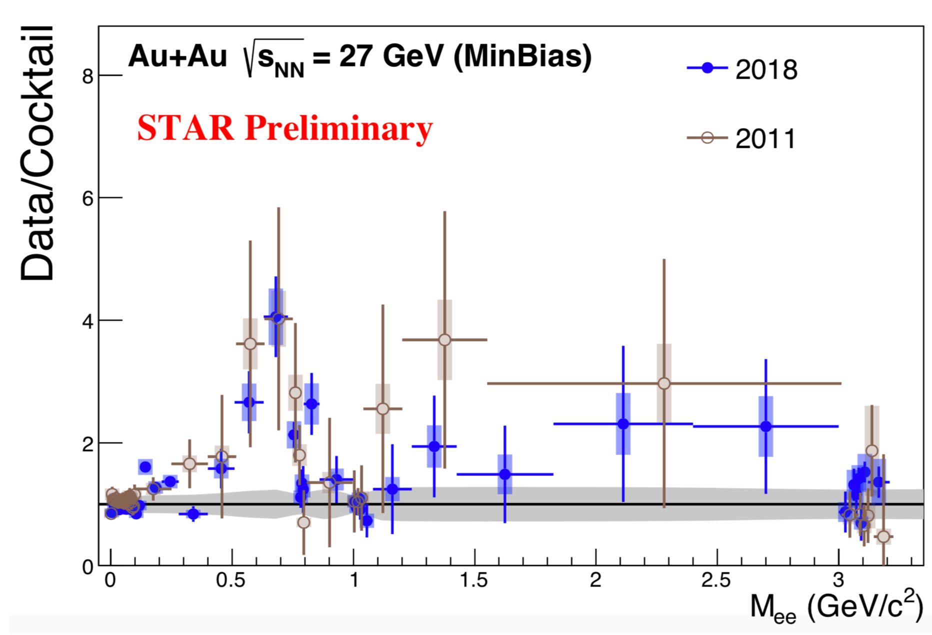
- ❖ **Single electron efficiencies**
  - Tracking efficiency is studied via embedding simulation
  - The energy loss ($n\sigma_e$) cut efficiency is studied with photonic electron samples
  - TOF matching efficiency is studied with pure electron and pion samples
  - $1/\beta$ cut efficiency is studied with photonic electron samples
- ❖ **Momentum resolution is studied via a data driven simulation to match the MC J/ψ signals to real data**
- ❖ **ϕ_V cut efficiency is studied vis virtual photon decays**

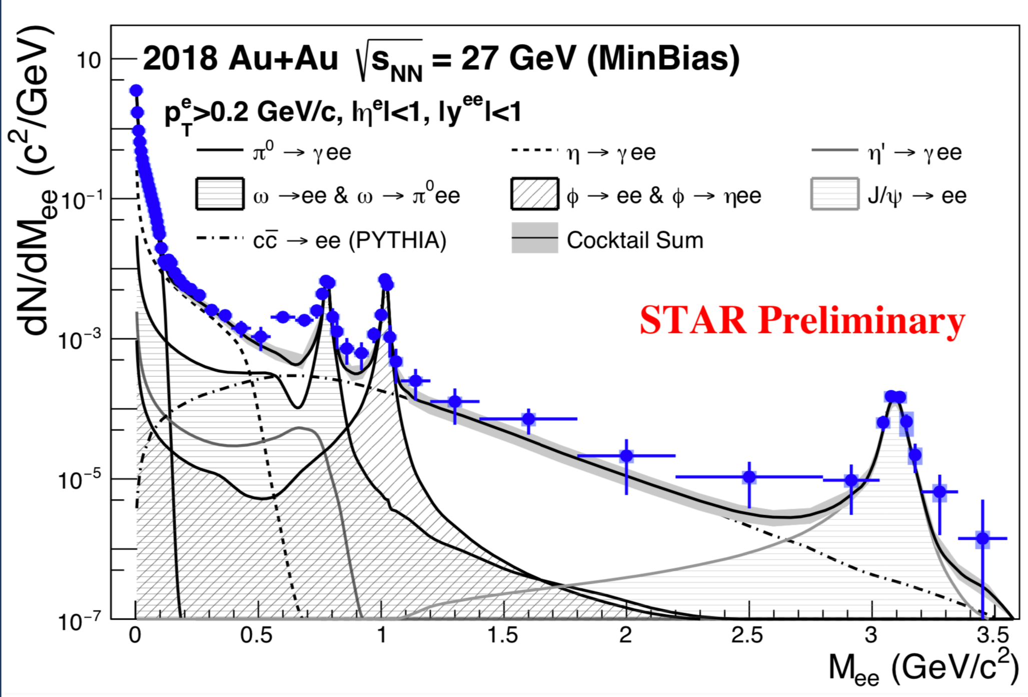




Physics Results and Outlook







Conclusion

- **Consistent to previous BES-I 27 GeV data [3] but with a much better precision**
- **In low mass region: clear excess has been observed in the ρ meson region**
- **In intermediate mass region: a hint of enhancement is observed, which may originate from the thermal radiation**

Outlook

- **ω and ϕ mesons can be measured via dielectron decay channel**
- **The p_T and centrality dependence of dielectron production will be studied**

References

[1] R. Rapp, Phys. Rev. C 63, 054907 (2001)
[2] PHENIX Collaboration, Phys. Rev. C 81, 034911 (2010)
[3] STAR Collaboration, arXiv:1810.10159 [nucl-ex]

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