ϕ(1020) and ω(782) mesons from di-leptonic decay channels at the STAR experiment

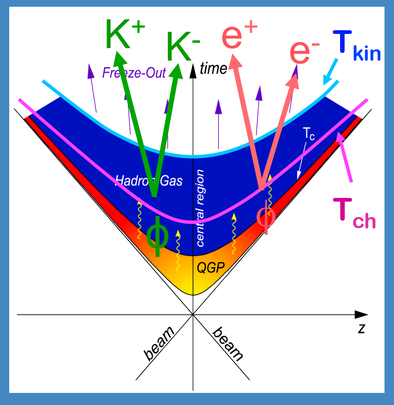
Masayuki Wada, *for the STAR Collaboration (UT Austin)*

Abstract

Hadronic resonances can play a pivotal role in providing experimental evidence for partial chiral symmetry restoration in the deconfined quark-gluon phase produced in high energy nucleus-nucleus collisions. Their lifetimes, which are comparable to that of the fireball, make them a valuable tool to study medium modifications to the resonant state. Mass shifts and/or width broadenings are considered as signatures of chiral phase transition. This can be done via the leptonic decay of resonances with relatively small cross section of leptonic daughter particles with dense and hot matter created in the collision, however hadronic regeneration of resonances feeds into this signature as well.

The measurement of masses, widths, transverse momentum spectra, and yields of ϕ(1020) mesons at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV are presented and compared to the ϕ (1020) result from the hadronic decay channel. The ω(782) meson signals are shown in 4 momentum bins. Particle identification based on the STAR Time-of-Flight upgrade detector in conjunction with energy-loss (dE/dx) from the Time Projection Chamber is used for a clean electron and positron identification.

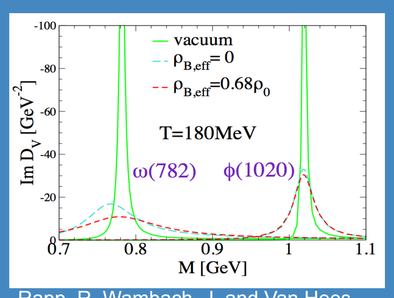
Resonances In Medium



We focus on two kinds of resonance decays, hadronic decay and leptonic decay.

Resonance **hadronic** decay daughters interact with the hadronic medium in heavy ion collision. Due to the extended hadronic phase, the contribution of resonances from an early stage (near the phase transition) is diminished. Because of this effect, however, one can place constraints on the lifetime of the hadronic phase by measuring the resonance yield suppression, and changes in the shape of resonance spectra.

Resonance **leptonic** decay daughters don't strongly interact with the hadronic medium. Medium modifications to the resonances' mass and width due to chiral phase transition may be obtained via this decay channel.



Rapp, R, Wambach, J, and Van Hees, H., arXiv:0901.3289

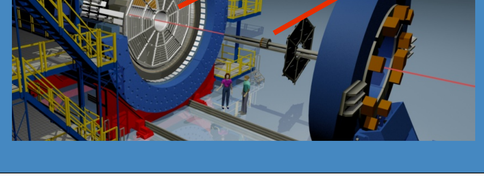
Resonance	Lifetime [fm/c]	decays (BR)
ϕ (1020)	46.3	K^+K^-, e^+e^- (10^{-4})
ω (782)	23.2	$\pi^+\pi^-\pi^0$, e^+e^- (10^{-5})

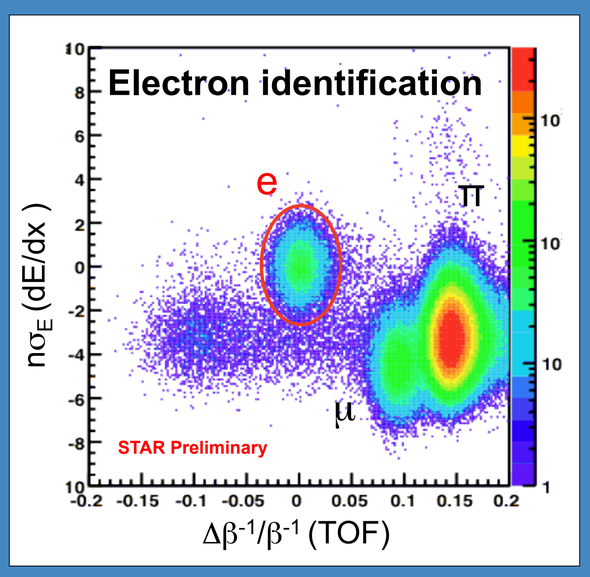
Hadronic Decay
- Interact with hadronic medium
- sensitive to lifetime of hadronic medium

Leptonic Decay
- Less interaction with hadronic medium
- Small branching ratio~10^{-4}

Data Set

- Au+Au collisions at $\sqrt{s_{NN}}$=200GeV
- ~250M (after event selection) minimum bias data



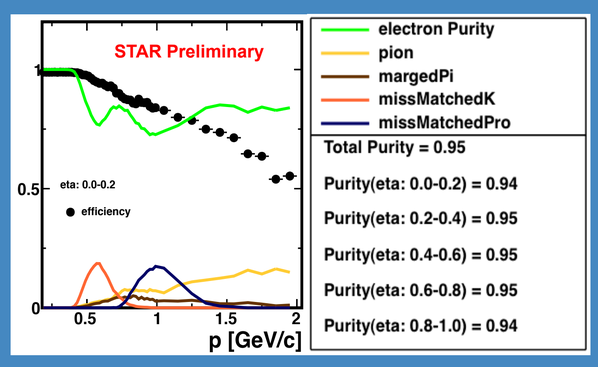


Event Selection

- 0-80% most central events (#VPD≥1)
- |Vz| < 30 cm
- |Vr| < 2 cm
- |Vz- VPDVz| < 13 cm

Track Selection

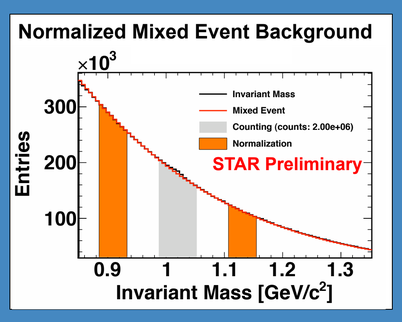
- Quality Cut
  - DCA(Distance of closest approach to primary vertex) < 1.5 cm
  - Number of fit points > 15 points
  - Number of fit points / possible points in the TPC > 0.52
  - $p_T \geq 0.2$ GeV/c
  - opening angle > 0.3 rad (pair cut)
- EID(Electron Identification) Cut
  - Momentum : 0.2 to 2.0 GeV/c
  - dE/dx TOF combined probability cut

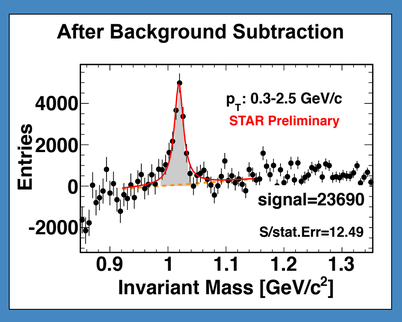


Analysis

Background Subtraction

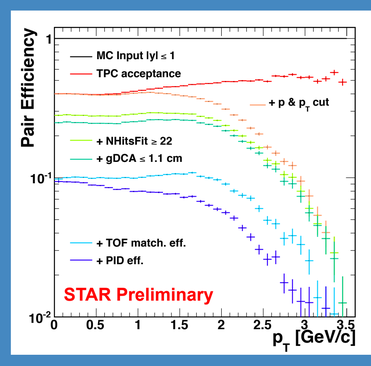
The mixed event technique is used to subtract combinatorial background. The events are mixed with other events in the same event classes (event multiplicity & z-vertex position).

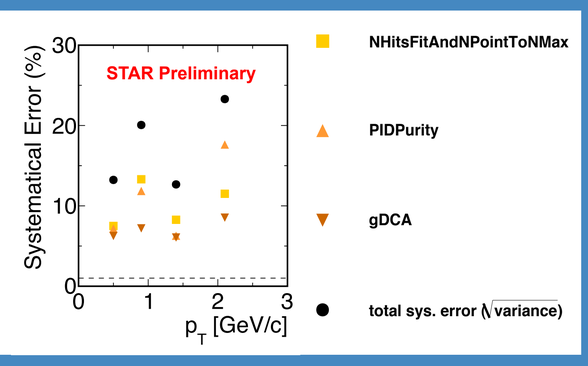




Efficiency Correction & Systematic Uncertainty

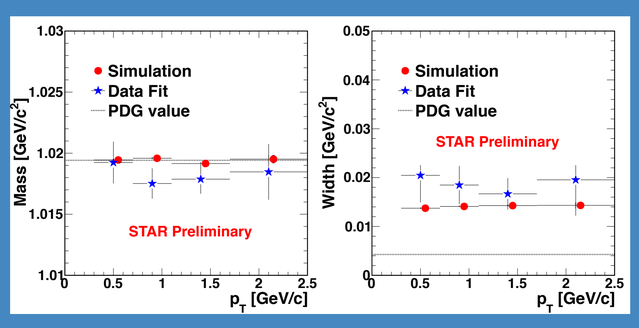
Efficiencies are calculated from embedding data sample.
Systematic uncertainties are calculated by changing track selections and fit conditions.





Result

ϕ meson



Mass

Masses from fits are consistent with the PDG value and simulation results within ~ 1.5σ .

Width

Widths from fits show significant increase but consistent with simulation results, in which the PDG value is used as an input width and detector resolutions is included.

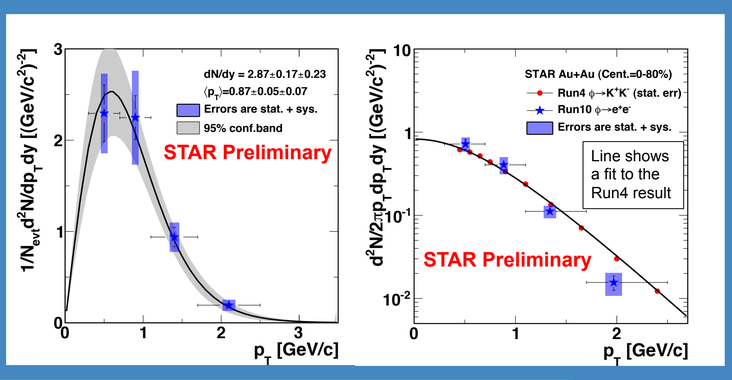
dN/dy

2.87±0.17(stat.)±0.23(sys.)

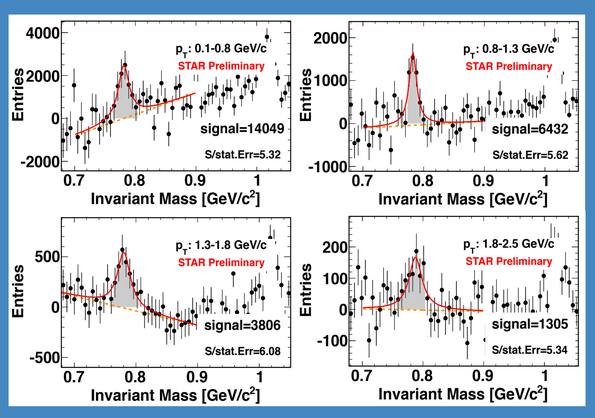
$\langle p_T \rangle$

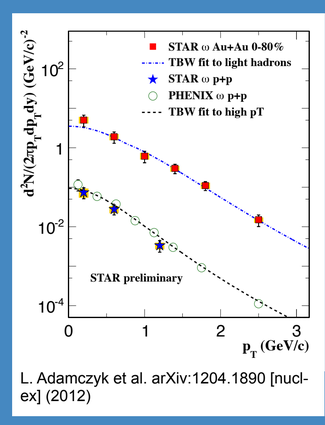
0.87±0.05(stat.)±0.07(sys.) [GeV/c].

They are consistent with the results from hadronic channel with in errors.



ω meson





L. Adamczyk et al. arXiv:1204.1890 [nucl-ex] (2012)

Conclusion

- The clear $\phi \rightarrow e^+e^-$ signal (significance ~12.5) at rapidity |y| < 1 for the 0-80% centrality events from Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV is measured.
- We obtain dN/dy = 2.87 ± 0.17(stat.) ± 0.23(sys.) and $\langle p_T \rangle$ = 0.87 ± 0.05(stat.) ± 0.07(sys.) [GeV/c].
- The $\phi \rightarrow e^+e^-$ result is consistent with the previous $\phi \rightarrow K^+K^-$ result.
- No mass shift or width broadening beyond the known detector effects are observed for ϕ mesons.
- The clear ω signals in di-electron channel are measured.
- Measurement of ω mass and width are under study.

Office of Science U.S. DEPARTMENT OF ENERGY

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

THE UNIVERSITY OF TEXAS AT AUSTIN