ϕ meson production in the K^+K^- decay channel and Cronin effect in d+Au collisions

Chitrasen Jena, for the STAR Collaboration

Lawrence Berkeley National Laboratory, Berkeley, USA

Institute of Physics, Bhubaneswar, INDIA

Abstract

The Cronin effect [1], the enhancement of hadron spectra at intermediate p_T in p+A collisions as compared to those in p+p collisions, has received renewed interest at RHIC [2]. It is thought that this effect may reflect on the early parton scatterings in high energy nuclear collisions. In order to further investigate the Cronin effect and shed light on the initial conditions at RHIC, we have analyzed the rapidity dependence of ϕ meson production in d+Au collisions at RHIC. Here we present STAR preliminary results of ϕ meson production in the K^+K^- decay channel from 200 GeV d+Au collisions.

1. Motivation

➢The atomic number dependence of invariant cross section per nucleus is

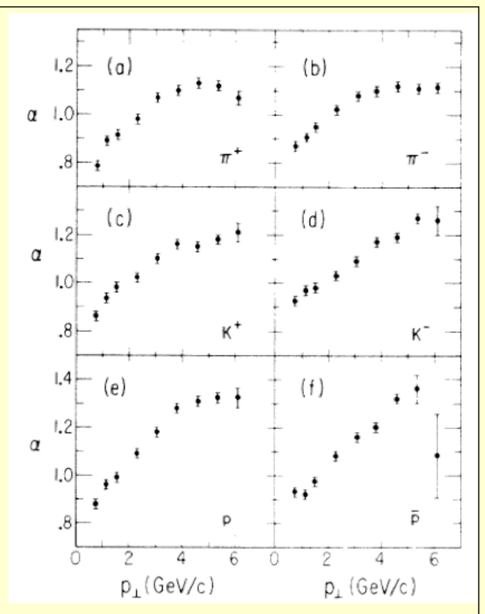
$$I_i(p_T, A) = I_i(p_T, 1)A^{\alpha_i(p_t)}$$

α is significantly larger than unity at high p_T.

➢This effect is larger for protons compared to pions and kaons.

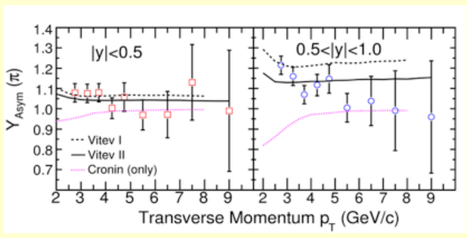
How do we understand this effect?

➢The ϕ meson may help us to understand this effect as it is a meson with mass comparable to proton (baryon).
➢The nuclear modification factor (R_{dAu}) of the ϕ meson is important in differentiating between mass and particle species ordering.
➢The ϕ meson has also a small hadronic cross section, which makes it a very useful particle to study the initial state effects.



J.W. Cronin et al., Phys. Rev. D **11**, 3105(1975)

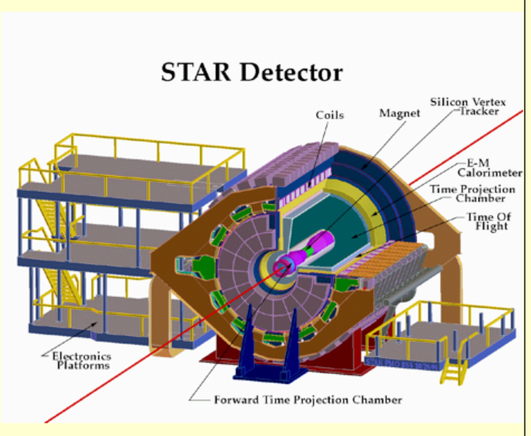
➢The mechanism for particle production in d+Au collisions at RHIC may be different at forward and backward rapidities.
➢ Rapidity asymmetry, the ratio of particle yields at backward rapidity (Au beam direction) to those at forward rapidity (d beam direction), may provide unique information to determine relative contributions of various physical processes to particle production, such as multiple scattering, nuclear shadowing, recombination of partons and parton saturation.
➢ Being a ratio, most systematic effects gets cancelled and only statistical errors dominates.

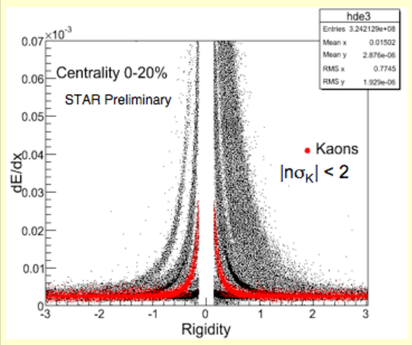


STAR Collaboration, Phys. Rev. C 76, 054903(2007)

2. Experiment

➢ The Solenoidal Tracker at RHIC (STAR) is one of the two large detector systems at RHIC consisting of several sub-detectors.
➢STAR's Time Projection Chamber (TPC) is the main tracking device for charged particles, covering a pseudorapidity range $|\eta| \leq 1.8$ and providing complete azimuthal coverage.





➢Particle identification was achieved by correlating the ionization energy loss (dE/dx) of charged particles in the TPC gas with their measured momentum.

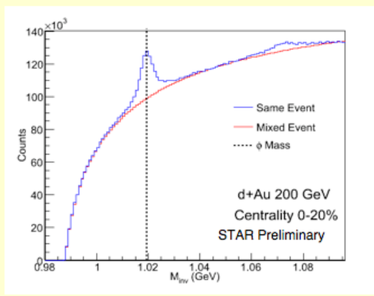
Data set: d+Au 200 GeV
Year: 2008 (Significantly reduced material run)
Number of minimum bias events: ~32M

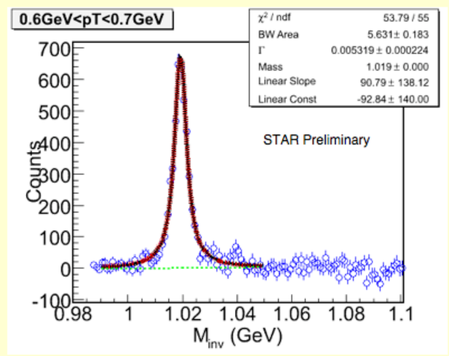
3. ϕ Reconstruction

$\phi \rightarrow K^+K^-$, Branching ratio: ~ 49.2%

➢The ϕ meson signal was reconstructed by pairing all K^+K^- tracks from the same event that passed the selection criteria and by then calculating the invariant mass for all possible permutations.

➢The combinatorial background was estimated using the mixed event technique, where the invariant mass was calculated by pairing two kaons from two different events.





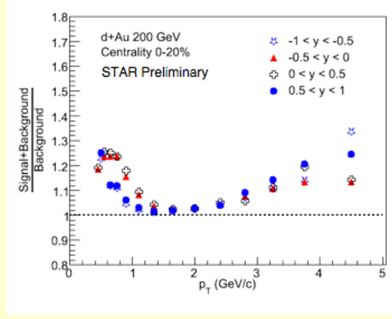
Breit-Wigner function:

$$BW(M_{inv}) = \frac{1}{2\pi} \times \frac{A\Gamma}{\left(M_{inv} - m_\phi\right)^2 + \left(\Gamma/2\right)^2}$$

A = Area under the mass peak
Γ= FWHM for the distribution
m_ϕ = Mass of the ϕ meson

➢The ϕ meson yield in each p_T bin was extracted from the invariant mass distributions of K^+K^- candidates after the subtraction of combinatorial background. The resultant distribution is well described by a Breit-Wigner function (red line) and a linear background function (green line).

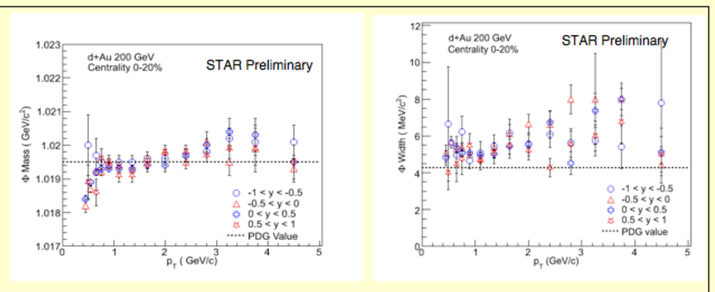
➢Signal to background ratio is very good for p_T < 5 GeV/c.



4. Mass & Width

Mass: 1019.46 ± 0.019 MeV
Full width: 4.26 ± 0.05 MeV

➢The mass peak position and width of the reconstructed ϕ meson matches well with the PDG value and the differences are understood within the scope of detector resolution effect.

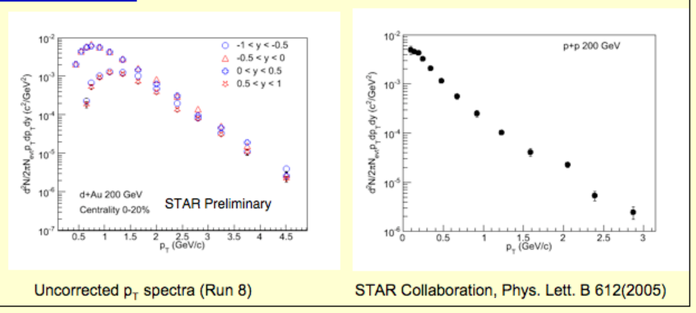


5. Nuclear Modification Factor

$$R_{dAu}(p_T) = \frac{d^2N/(2\pi p_T dp_T dy)}{T_{dAu} d^2\sigma_{inel}^{pp}/(2\pi p_T dp_T dy)}$$

$$T_{dAu} = \langle N_{bin} \rangle / \sigma_{inel}^{pp}$$

➢The R_{dAu} of ϕ mesons will be compared to the R_{dAu} of protons to understand the Cronin effect in d+Au collisions.
➢Efficiency is under study.



Uncorrected p_T spectra (Run 8)

STAR Collaboration, Phys. Lett. B 612(2005)

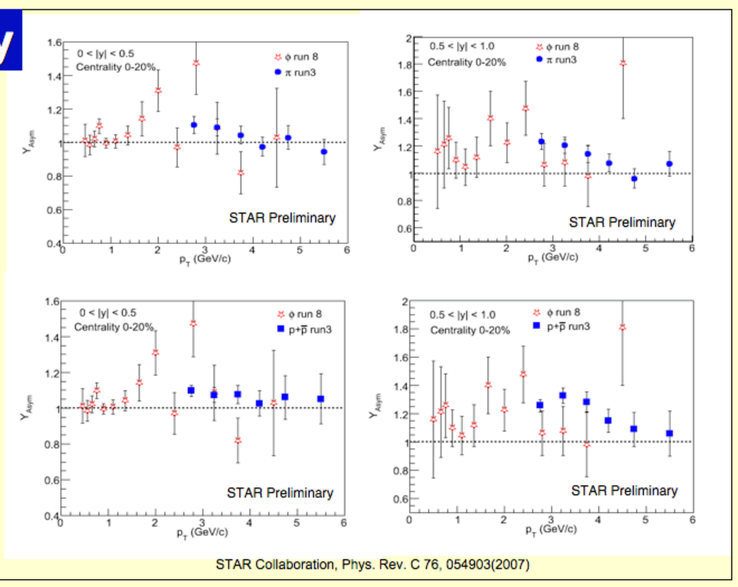
6. Rapidity Asymmetry

$$Y_{Asym}(p_T) = \frac{Y_B(p_T)}{Y_F(p_T)}$$

Y_F = ϕ yields in forward rapidity
Y_B = ϕ yields in backward rapidity

➢No strong particle type dependence is observed for Y_{Asym} for 2.5 < p_T < 5 GeV/c.
➢Efficiency is under study.

➢Error bars shown for Y_{Asym} for ϕ mesons are statistical only.



STAR Collaboration, Phys. Rev. C 76, 054903(2007)

7. Summary and Outlook

➢We presented STAR preliminary results on ϕ meson production from d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

➢Y_{Asym} for ϕ mesons has been studied.

➢No strong particle type dependence is observed for Y_{Asym} for 2.5 < p_T < 5 GeV/c.

➢The R_{dAu} of ϕ mesons will be compared to the R_{dAu} of protons to understand the Cronin effect in d+Au collisions.

References

[1] J.W. Cronin et al., Phys. Rev. D 11, (1975) 3105.

[2] J. Adams et al., Phys. Lett. B 616, (2005) 8.

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

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