Ratio of J/Ψ to ρ Photoproduction Cross Sections at the Relativistic Heavy Ion Collider with STAR

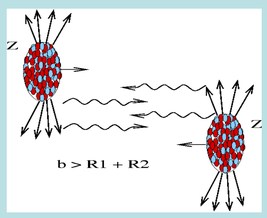
Janet Seger (Creighton University), *for the STAR Collaboration*

Abstract

The intense electromagnetic fields associated with relativistic heavy ions make a heavy-ion collider a unique tool to study two-photon and photonuclear interactions. In this poster, we present a new measurement of J/Ψ photoproduction in 200 GeV AuAu collisions at RHIC. The p_T distribution of the J/Ψ mesons peaks at very low p_T, consistent with expectations for coherent photoproduction. Both the photoproduction cross section and the J/Ψ rapidity distribution are expected to show the effects of gluon shadowing. We present a measurement of the ratio of J/Ψ to ρ^0 meson cross sections in 200 GeV AuAu collisions, as well as a distribution of rapidity within $|y| < 1$ for the J/Ψ mesons. The measured results are compared to theoretical models.

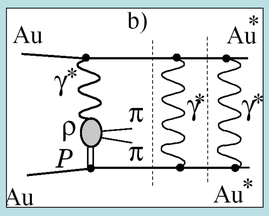
Ultraperipheral Collisions

- Nuclei miss each other and interact via long range electromagnetic fields
  - Weizsacker-Williams: field of almost-real photons
    - Virtuality $Q^2 < (h/R_A)^2$
- Max photon energy ~ $\gamma h/R_A$ ~ 3 GeV with gold at RHIC
- Photon flux ~ Z^2
  - Higher flux with heavy ions → greater probability of multi-photon interactions



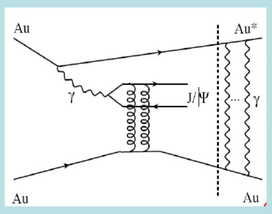
Vector meson production

- Photons fluctuate into quark-antiquark pairs
  - These scatter elastically from the other nucleus and emerge as real vector mesons
- Cross sections are large
  - Coherent production → low momentum transfer, ~ $\hbar/R_A$



Interest in heavy vector mesons

- J/ψ, ψ', Υ
  - Probe short distance scales
  - Scattering may be described via 2-gluon exchange
  - Sensitive to gluon distribution at
    $x = M_V/2\gamma m_p \exp(\pm y)$ → $x \approx 10^{-2}$ and $Q^2 \approx M_V^2$
  - Directly probe 'new phases of matter' like color glass condensate
  - Understand initial state for central collisions



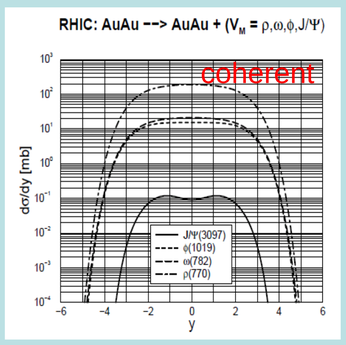
Phys.Lett.B679:321-329,2009

$$\sigma_{\gamma A\to VA}(s_{\gamma N}) = \left.\frac{d\sigma_{\gamma N\to VN}(s_{\gamma N})}{dt}\right|_{t=t_{\min}} \left[\frac{G_A(x_1,x_2,t=0,Q^2_{\rm eff})}{AG_N(x_1,x_2,t=0,Q^2_{\rm eff})}\right]^2 \times \int_{-\infty}^{t_{\min}} dt \left|\int d^2b dz e^{i\vec{q}_T\cdot\vec{b}} e^{-iq_l z}\rho_A(\vec{b},z)\right|^2 .$$

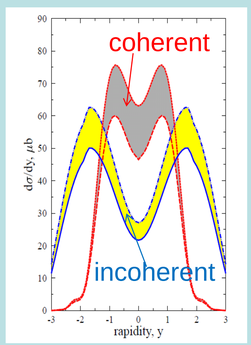
Frankfurt, et al., arXiv:hep-ph/0702212v1

Differing theoretical predictions for rapidity distribution

Color dipole approach with saturation effects



Goncalves and Machado, Eur.Phys.J. C40 (2005) 519-529



Strikman, Tverskoy and Zhalov, Phys.Lett. B626 (2005) 72-79

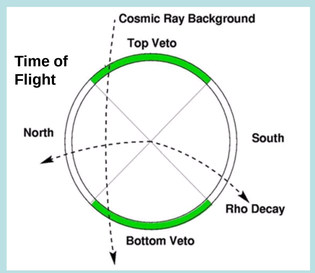
Top lines: impulse approx.
Bottom lines: color dipole with Gribov-Glauber shadowing

Trigger and Event Selection

Two triggers for 2009-10 dataset:

- Minimum Bias (37 M events)
  - At least 1 neutron in each zero degree calorimeter
    - Selects events with mutual Coulomb dissociation
  - Low multiplicity

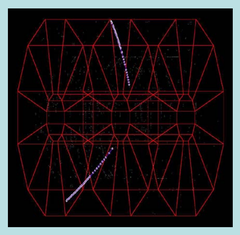
- Topology Trigger (1.5 M events)
  - uses time of flight detector surrounding the STAR TPC
  - requires hits on opposite (horizontal) sides of the interaction region
  - top and bottom are vetoes, to reject cosmic rays.



Analysis and Results

Event Selection:

- Fewer than 10 total tracks in an event
- Exactly two tracks emerging from central vertex
- Pair $p_T < 0.150$ GeV → coherent production
- Vector meson rapidity: $0.05 < |y| < 1$
  - Lower limit reduces cosmic rays
  - Upper limit from STAR acceptance



A typical ρ^0 event

Analysis:

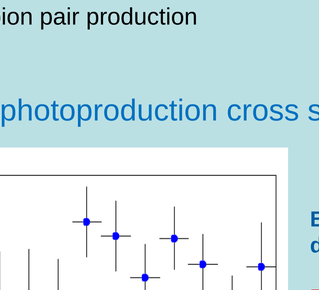
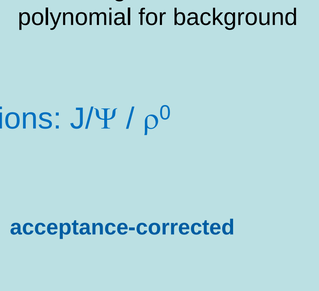
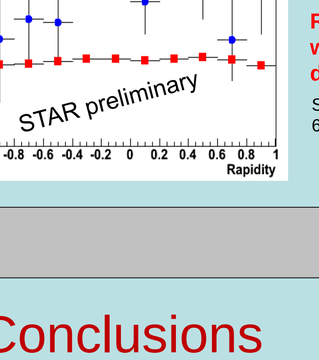
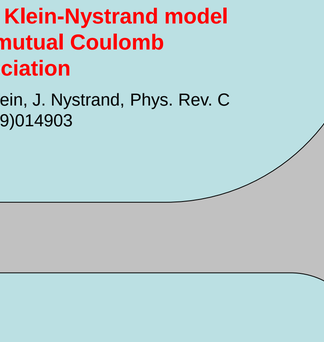
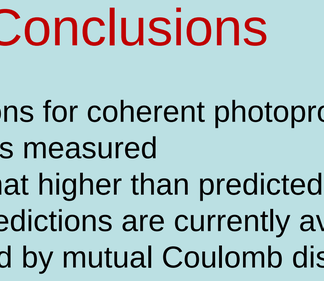
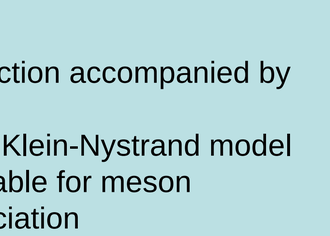
- No particle ID has been applied
- Data is corrected for STAR acceptance using Starlight Monte Carlo
- Background modeled with like-sign pairs, scaled to match data for $p_T > 0.2$ GeV
- All error bars are statistical only

Pair p_T:
Blue: data
Red: background estimated with like-sign pairs

For analysis, only events with $p_T < 0.15$ GeV are used

Pair rapidity:
After preliminary acceptance corrections; time-dependence of TPC acceptance has not been accounted for
Dip at y = 0 is from cut to remove cosmic rays

Pair Invariant mass:
~ 650,000 ρ^0 and
~ 125 J/Ψ

ρ^0 candidates (opposite-sign pairs with $0.4 < m_{INV} < 1.1$)	J/Ψ candidates (opposite-sign pairs with $2.5 < m_{INV} < 3.5$)
	
	
	
Rho mass is fit with a cocktail that includes a Söding term for interference with direct pion pair production	J/Ψ is fit with exponential for e^+e^- continuum, Gaussian for J/Ψ signal and polynomial for background

Ratio of coherent photoproduction cross sections: J/Ψ / ρ^0

Blue: acceptance-corrected data

Red: Klein-Nystrand model with mutual Coulomb dissociation

S.R. Klein, J. Nystrand, Phys. Rev. C 60(1999)014903

Conclusions

- Ratio of J/Ψ to ρ cross sections for coherent photoproduction accompanied by mutual Coulomb dissociation is measured
  - Measured ratio is somewhat higher than predicted by Klein-Nystrand model
    - No other theoretical predictions are currently available for meson production accompanied by mutual Coulomb dissociation
  - No significant rapidity dependence in the cross-section ratio is observed