Coherent Vector Meson Production with Nuclear Excitation in Ultra-Peripheral Heavy Ion Collisions

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Vector mesons are copiously produced by photon-Pomeron and photon-meson interactions in ultra-peripheral heavy ion collisions[1]. These collisions occur at moderate impact parameters b where hadronic interactions cannot occur. However, additional electromagnetic interactions are possible. The two nuclei may exchange additional photons[2], exciting one or both nuclei; we consider mutual excitation here.

This mutual excitation 'tags' reactions as occuring at smaller average b than for exclusive vector meson production alone. The cross section for vector meson production with mutual excitation is about 7% of that for exclusive vector meson production. For very low backgrounds, a specific tag requiring single neutron emission from each nucleus is interesting. This is usually caused by Giant Dipole Resonance (GDR) excitation.

Tagging is important because the vector meson rapidity distribution, $d\sigma/dy$ and transverse momentum p_T both depend on b. The photon spectrum of the electrmagnetic fields has a maximum energy $\gamma\hbar/b$; as b rises, the photon spectrum becomes softer. Larger photon energies correspond to more central production, so $d\sigma/dy$ is more central for events with nuclear excitation.

The p_T spectrum for vector meson production from a single nucleus depends only weakly on b. However, the interference between the two production sites is very sensitive to the impact parameter; at $y = 0$[3]

$$\sigma \approx 1 - \cos(\vec{p} \cdot \vec{b}). \qquad (1)$$

As the median b decreases, this interference becomes important at larger p_T.

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References

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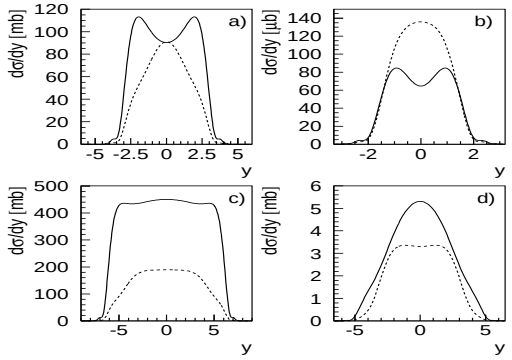

Figure 1: (a) $d\sigma/dy$ with and without nuclear breakup, for the (a) ρ and (b) J/ψ with gold at RHIC and the (c) ρ and (d) J/ψ with lead at the LHC.

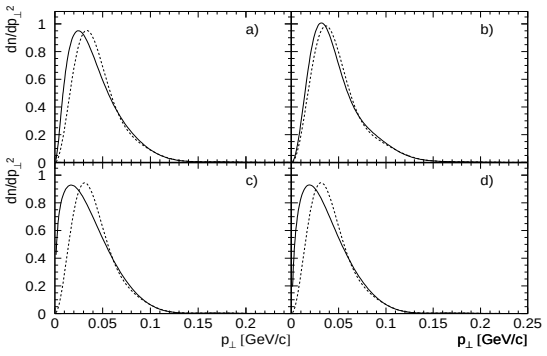

Figure 2: (a) The dn/dp_T^2 with (dashed line) and without (solid line) nuclear breakup for the (a) ρ and (b) J/ψ with gold at RHIC and the (c) ρ and (d) J/ψ with lead at the LHC.