Spin Alignment of Vector Mesons and Angular Momentum in High Energy Collisions

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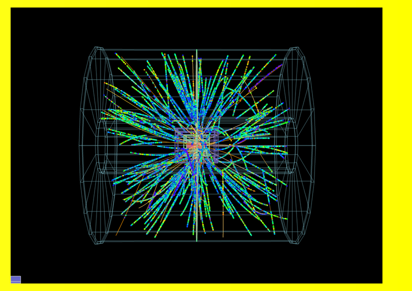

Objectives

→To study distribution of Orbital Angular Momentum as a function of Impact Parameter for non-central heavy ion collisions using Optical and Monte Carlo Glauber Model.
→ To derive the expression for angular distribution of daughter particles produced from Vector Mesons in pp collisions.
→ To calculate spin density matrix element ρ_{00} for K^* & check for spin alignment in pp collisions at 7 TeV from simulated data.

Plots using Glauber Model

The Angular Momentum for Monte Carlo Glauber Model was calculated using position and momenta of participating nucleons in the overlapping region for various values of impact parameter (b).

$$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{P}}$$

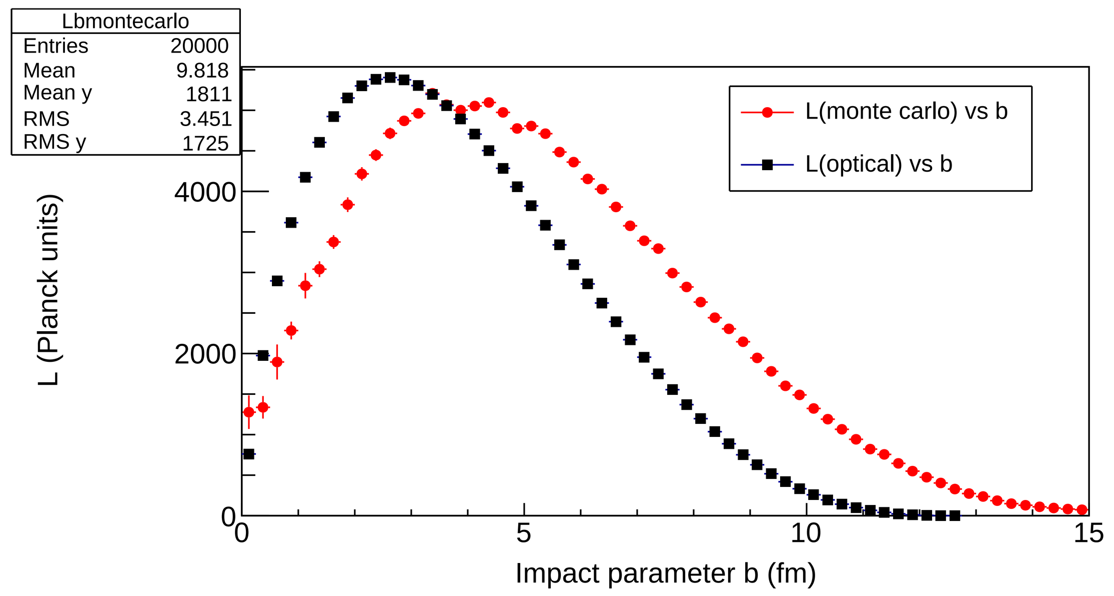

Figure 5: Angular Momentum comparison obtained from Optical Glauber Model (for hard sphere) and Monte Carlo Glauber Model.

Thus we observe that there is large angular momentum of the interaction region.The plots are comparable by both the methods.

Angular Momentum

When heavy ions collide at ultra-relativistic speeds, the overlapping region of the colliding nucleus leads to QGP. A large part of initial angular momentum is carried away by spectator fragments while a fraction of it is left to the interaction region. The angular momentum using **Optical Glauber Model** is given by $\mathbf{J(b)} = \iint \mathbf{dxdy\,x[T(x-b/2,y) - T(x+b/2,y)]}\frac{\sqrt{s_{NN}}}{2}$
Where $\mathbf{T(x,y)}$ is the Thickness function,b is impact parameter and $\sqrt{s_{NN}} = 200$ GeV for Au-Au.

Angular Distribution K^*

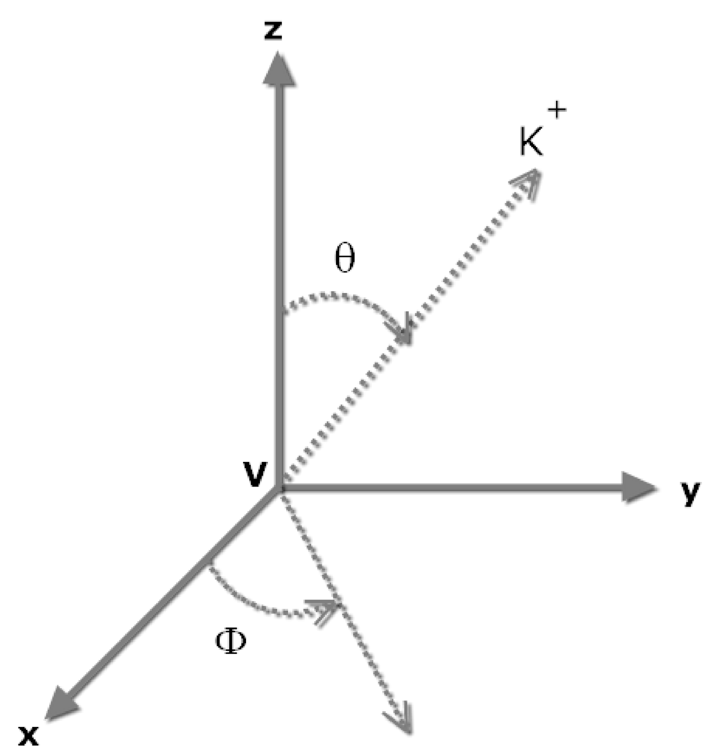

Figure 6: Decay Distribution angles made by daughter particle in the rest frame of the mother Vector Meson.

For the reaction:

$$\mathbf{K^* \rightarrow K^+ + \pi^-}$$

The angular distribution formula is given by:

$$\frac{\mathbf{dN}}{\mathbf{dcos}\theta} = \frac{\mathbf{3}}{\mathbf{4}}\left[(\mathbf{1}-\rho_{\mathbf{00}}) + (\mathbf{3}\rho_{\mathbf{00}}-\mathbf{1})\mathbf{cos^2}\,\theta\right]$$

Signal Extraction and Resonance

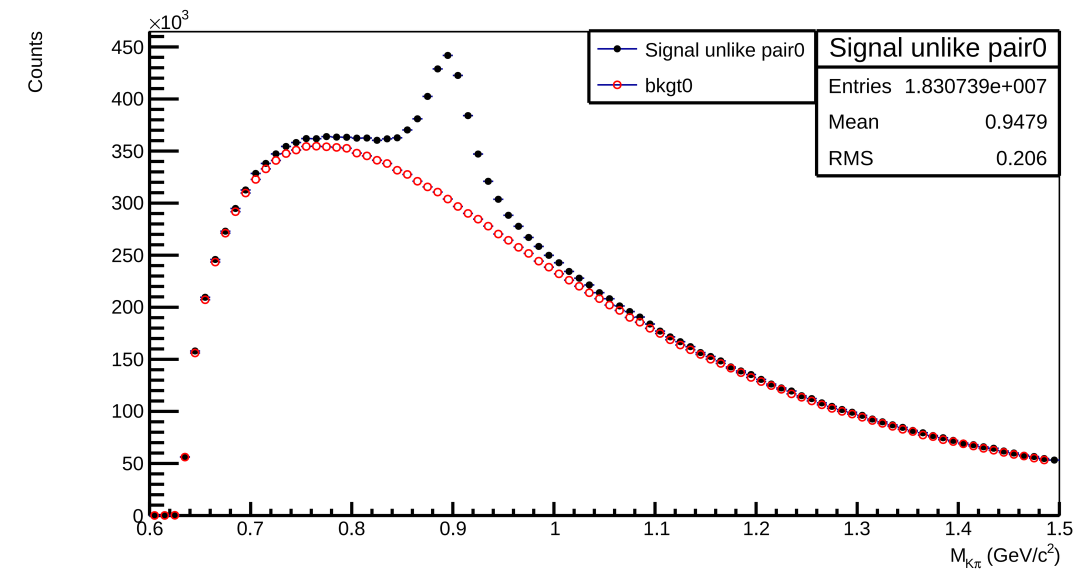

Figure 1: Signal Extracted from the first $cos\theta$ bin.The figure shows the number of counts of the unlike pair combinations(black): $K^+\pi^-$ & $K^-\pi^+$ along with total background signal(red). The peak can clearly be seen around K^* invariant mass of $0.896\ GeV/c^2$. The total background is obtained using the like-sign technique.

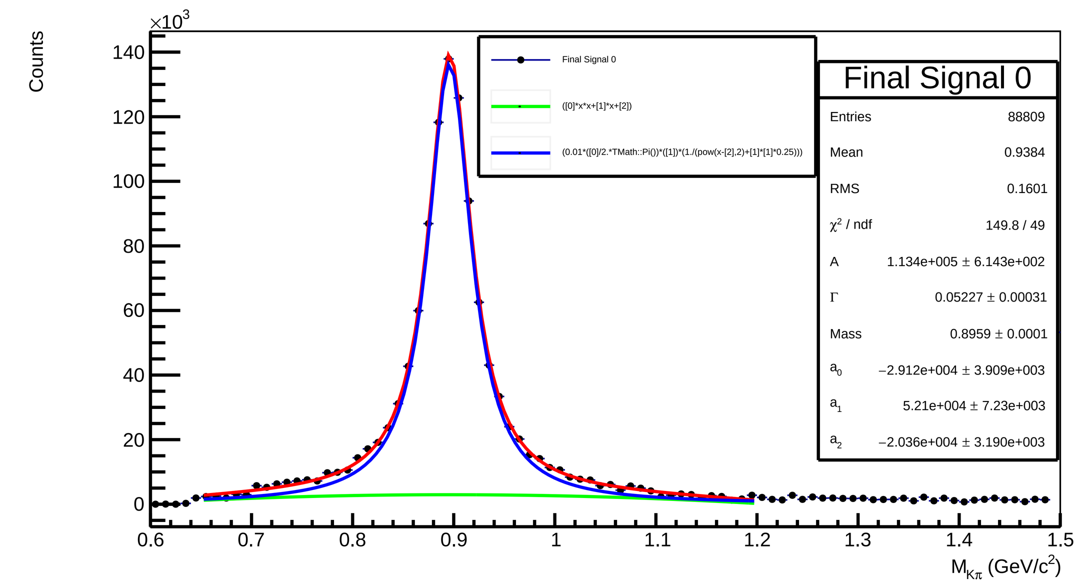

Figure 2: Final signal obtained after background substraction for the first $cos\theta$ bin.The final signal is fitted with a non-relativistic Briet Wigner function plus a polynomial of degree 2. The yield is obtained from the fit parameters.Black represents the final signal. Blue curve represents the Breit Wigner Fuction and Green curve represents the degree 2 polynomial background.

Density Matrix Element and Invariant Mass Calculation

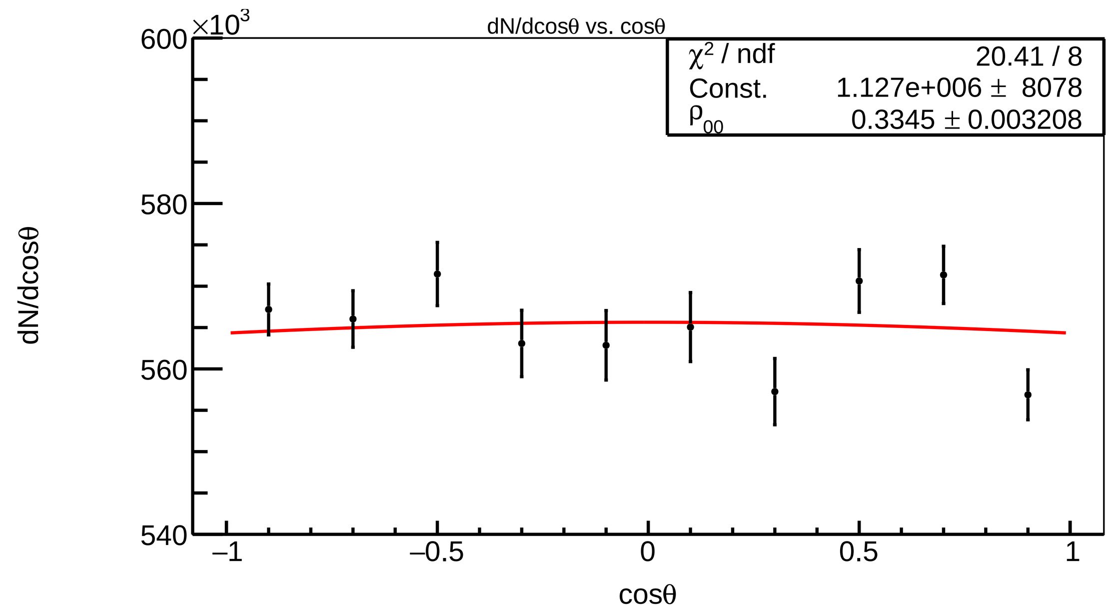

Figure 3: The yield obtained from all the signals is plotted against the respective $cos\theta$. The angular distribution function is fitted to it and ρ_{00} matrix element is calculated. $\rho_{00} \approx \frac{1}{3}$

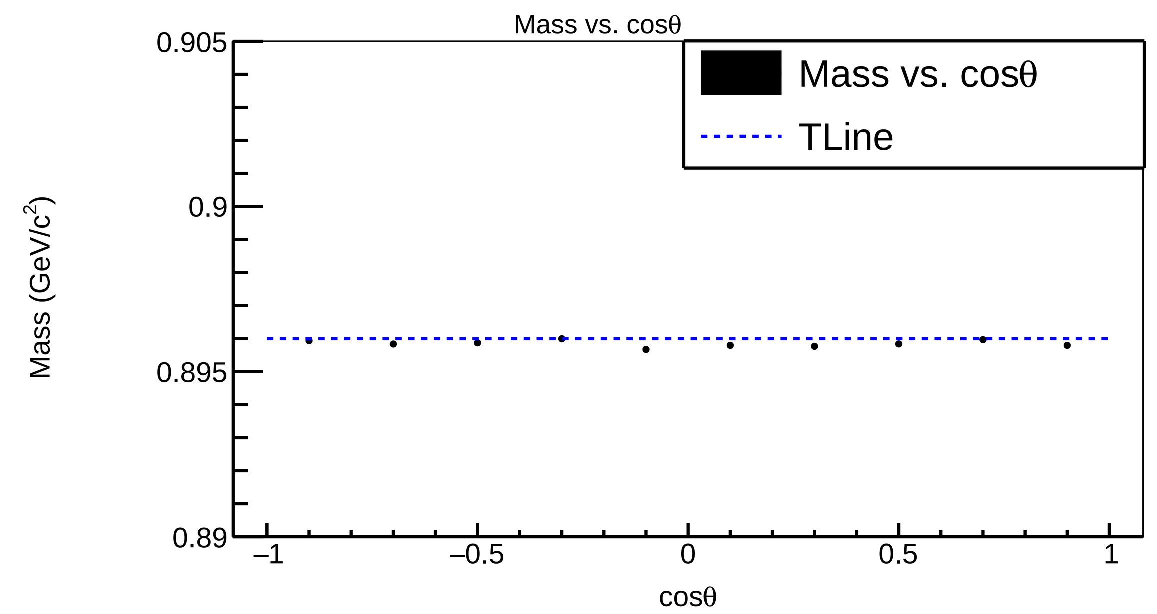

Figure 4: The yield obtained from all the signals is plotted against the respective $cos\theta$. The invariant mass of mother vector meson (K^*) is $0.896\ GeV/c^2$

References

[1] Rizzo Becattini, Piccinini. Angular momentum ... energy. *Physical Review C*, 77(2):024906, 2008.

[2] K Schilling, P Seyboth, and G Wolf. On the analysis of vector-meson production by polarized photons. *Nuclear Physics B*, 15(2):397–412, 1970.

Conclusion

The angular momentum for ultra-relativistic collisions was calculated using Glauber Model. The plots given by Optical and Monte Carlo Glauber Model are comparable.

$\rho_{00} \approx 1/3$ which is in agreement with the no spin alignment value as pp collision does not have any angular momentum.

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