Unfolding the transverse momentum distribution for very forward neutron production in pAu collisions at $\sqrt{s_{NN}} = 200$ GeV

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The PHENIX collaboration measured that when a transversely polarized proton with spin up collides with unpolarized proton at $\sqrt{s} = 200$ GeV, they generate neutrons predominantly to the right.[1] In 2011, theorists explained this result in terms of the interference of pion and a_1 reggeon exchanges.[2] But in 2015 using run 15 pAu data, we observed that when a polarized proton collides with a gold nucleus at $\sqrt{s_{NN}}$ = 200 GeV, they generate more neutrons to the left[3] contrary to theoretical predictions.[2] This nuclear dependence of the asymmetry (A_N) has, therefore, attracted a massive interest in nuclear physics.

We are now studying A_N as a function of the transverse momentum (Pt). We begin with an understanding that our measurements are limited by known effects such as the detector resolution and detection efficiency among others. Our technique is, therefore, to employ a method known as unfolding to remove these known effects and recover the distribution.

We proceed by parametrizing measurement effects using the response matrix in Fig. 1 from Monte Carlo.[4] What this matrix does is to map the binned true spectrum in the magenta line onto the smeared spectrum in the green line of Fig. 2. For the smeared and true distribution bins R_i and T_j, respectively, the smearing matrix element S_{ij} gives the fraction of entries from bin T_j that end up being reconstructed in bin R_i.

The unfolding has been performed using the singular value decomposition method[5] contained in CERN's ROOT toolkit. Since our smearing matrix is not perfectly diagonal, we unfolded with a parameter, alias Kreg,[5] which determines the regularization of the unfolding. The unfolded spectrum is the distribution corresponding to an optimum regularization parameter, Kreg = 6 as depicted in Fig. 2.

We are now optimizing and extending the ideas of the one dimensional unfolding to two dimensional unfolding of transverse momentum (Pt) in azimuthal angle (Φ). The transverse single spin asymmetry (A_N) for very forward neutron production will then be calculated as a function of the unfolded Pt distribution.

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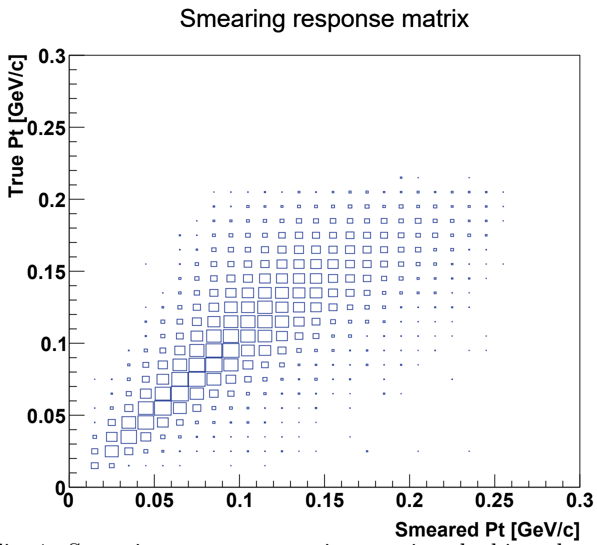

Fig. 1. Smearing response matrix mapping the binned true Pt spectrum to the smeared Pt spectrum.

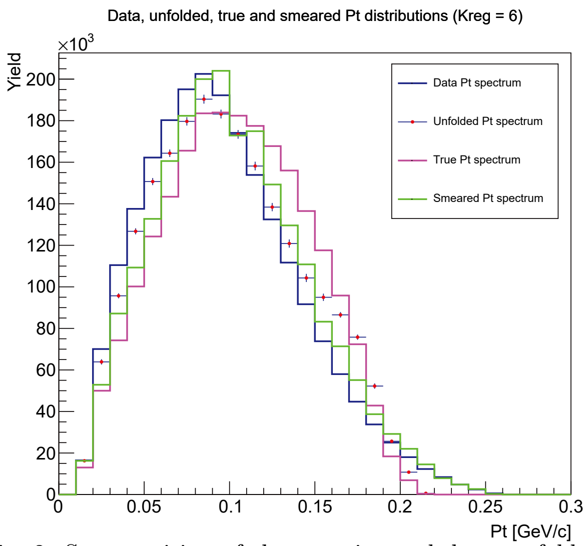

Fig. 2. Superposition of the experimental data, unfolded, true and smeared Pt distributions. The Pt distribution in the green line is smeared from Monte Carlo while that in the dark blue line is the experimental data. The Pt distribution in the magenta line is generated using Monte Carlo event generator.[4]

References
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