Measurement of Sivers Asymmetry for Di-jets in 200 GeV pp Collisions at STAR

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Sivers functions [1] describe possible correlations between the transverse spin ($\vec{S}_T$) direction of a polarized proton and transverse momentum ($\vec{k}^{\perp}$) directional preferences of unpolarized partons carrying longitudinal momentum fraction *x* of the proton:

$$\frac{1}{2}\Delta^N f(x,k^{\perp})\frac{\vec{S}_T\cdot\left(\vec{P}\times\vec{k}^{\perp}\right)}{\left|\vec{S}_T\right|\cdot\left|\vec{P}\right|\cdot\left|\vec{k}^{\perp}\right|}\,, \qquad (1)$$

where $\vec{P}$ is the momentum vector of the polarized proton. Because parton orbital angular momentum is a prerequisite for a non-zero Sivers function [2], there is considerable interest in measuring the effect and isolating it from other possible contributions to transverse spin asymmetries.

Boer and Vogelsang suggested [3] that the Sivers effect would be manifested as a spin-dependent azimuthal side preference for almost back-to-back di-jets produced in proton-proton collisions involving a transversely polarized beam. The di-jet measurement is a leading-twist probe of the Sivers function [3], with possible sensitivity to gluon transverse motion preferences, to which semi-inclusive deep inelastic scattering [4] is insensitive. The di-jets are insensitive to Collins [5] asymmetries in polarized quark fragmentation functions.

The large acceptance of the STAR detector at RHIC makes it well suited for jet and di-jet measurements. It can trigger on jets using its fully instrumented Electromagnetic Calorimeter (EMC) covering the pseudorapidity (η) range [-1,+2] and measure the charged components of jets with its Time Projection Chamber (TPC) over the η range [-1.5,1.5]. We will report first results from the just completed 2006 RHIC polarized proton collision run, during which STAR devoted 3 weeks to measurements with both beams vertically polarized (with typical polarizations of 60%), yielding a sample of several million reconstructable di-jet events.

The 3 million event sample to be presented here was acquired with a trigger especially designed to select relatively low p_T di-jets with sizable calorimeter energy components. Figures 1(a) and (b) show the azimuthal angle distribution of jets determined from the EMC information available at trigger level, averaged over all beam spin states. Frame (b) shows the spectrum of (signed) azimuthal opening angle ζ between di-jets, where ζ is chosen above or below 180° depending on whether the bisector of the two jet thrust axes (related to the $\vec{k}^{\perp}$ direction) has a positive or negative projection vs. the cross product of beam spin and momentum.

A non-zero Sivers function would be manifested, at leading order, by a small spin-dependent shift in the centroid of the ζ-distribution. We will show that there can also be a two-spin Sivers asymmetry in the width of the distribution.

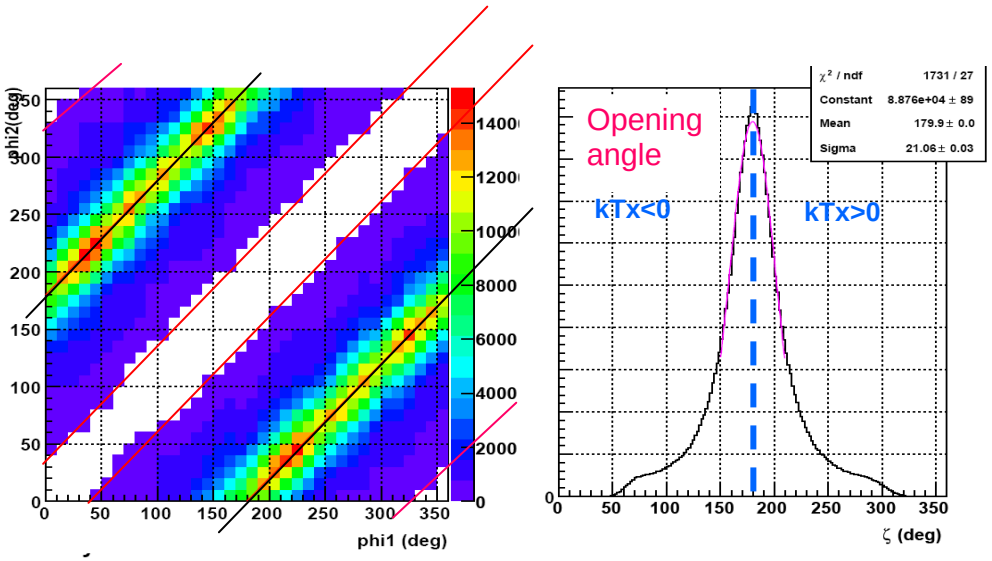

Fig 1. Di-jets reconstructed on-line from EMC energy information during 2006 p+p data taking. a) Azimuthal angle correlation between the two jets. Black lines mark the loci of the most probable back-to-back di-jet events. Red lines mark azimuthal opening angles of 60°, below which the trigger did not accept events. b) The same events vs. di-jet opening angle ζ.

Although the full off-line analysis including TPC will take some time, we will present preliminary di-jet Sivers asymmetries based on the trigger-level EMC data. From a sample of jet events fully reconstructed off-line, we infer a jet ϕ resolution deteriorates by ~3° using EMC information only. By selecting subsets of events within particular phase space regions – e.g., di-jets boosted into the endcap region by a collision of partons with significantly different Bjorken *x*-values – we can emphasize quark- or gluon-dominated Sivers functions. In addition to experimental results, we will present toy model simulations that demonstrate the correlations among various measures of the Sivers asymmetries, and their sensitivity to the shape of the underlying $\vec{k}^{\perp}$ distribution.

References

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