Systematic Study of Potential False Azimuthal Asymmetries in SpinQuest

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Sea-quark Sivvers Asymmetry from Polarized Drell-Yan

The Drell-Yan Cross Section in Terms of Sivvers Asymmetry:

$$\sigma_{DY}^{\uparrow\downarrow} = \frac{d\sigma^{LO}}{d^4q\,d\phi_S} \propto 1 \pm |S_T| \sin\phi_S A_T^{\sin\phi_S}$$

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$$A_n(\phi_S) = \frac{1}{|S_T|} \frac{\sigma_{DY}^{\uparrow} - \sigma_{DY}^{\downarrow}}{\sigma_{DY}^{\uparrow} + \sigma_{DY}^{\downarrow}} = \sin\phi_S A_T^{\sin\phi_S}$$

xyz is the detector rest frame

$\vec{S}_T$ = Target spin vector.

$\vec{q}_T$ = Dimuon's transverse momentum.

ϕ_{q_T} = Azimuthal angle of the $\vec{q}_T$ vector.

1. $\sigma_{DY}^{\uparrow\downarrow}$ is the Drell-Yan cross section and $A_T^{\sin\phi_S}$ is the Sivvers asymmetry .
2. Azimuthal angle ϕ_S and ϕ_{q_T} can be written as $\phi_S^{\uparrow\downarrow} = \left(\pm\frac{\pi}{2} - \phi_{q_T}\right)$.

Study I: Motivation for the Spectrometer-Induced Asymmetry Systematic Check

$$A_n(\phi_{q_T}) = \frac{N_{DY}^{\uparrow}(\phi_{q_T}) - N_{DY}^{\downarrow}(\phi_{q_T})}{N_{DY}^{\uparrow}(\phi_{q_T}) + N_{DY}^{\downarrow}(\phi_{q_T})}$$

$N_{DY}^{\uparrow\downarrow}$ = The Drell Yan normalized event counts with the target polarization up (down).

The Azimuthal asymmetry can be extracted from the above formula that measures the changes dimuon yields in different spin states. The arrow $\uparrow$ ($\downarrow$) represents the polarization up (down). We consider two possible causes for the spectrometer induced azimuthal asymmetry:

1. The efficiency of the detectors could be changing over time (e.g. the phototubes might suffer a decrease in gain).
2. The numbers of protons hitting the polarized target will not be the same in each spill, and the detector performance could change due to luminosity fluctuations.

→ In either case, it is possible for one target spin state to collect a higher yield than the other, producing a false asymmetry. We will check the size of such effects, by using the SeaQuest experiment dataset.

Extracting the Spectrometer-Induced Azimuthal Asymmetry

1. We have assigned a spin-state to each SeaQuest LH_2 run and arranged to flip the spin with a definite period.
2. The fitting function ($par0 + par1 * \cos \phi_{qT}$) is used with least-squares method.
3. From the results we do not see any false spectrometer generated asymmetry. We also have found that the flipping spin every 50 hour or longer than hourly spin-flipping is more reasonable in SpinQuest.

Study II: Motivation for the Beam-offset Study

1. Since the single spin asymmetries are extracted from different trigonometric fitting functions in the azimuthal modulations, reconstructing the dimuon momentum q_T correctly is very important to get correct reconstructed azimuthal distributions.
 2. If there was any offset in the beam and target interaction point, and if we did not know the offset information, then the dimuon phi distributions could be changed or distorted.
- We will be investigating the effect of the offset to the dimuon distributions and evaluate if they can produce any asymmetry.

Introduction to the Beam-Offset: An Illustration

$$R(\phi_{q_T}) = \frac{N(\phi_{q_T})^{[offset]}}{N(\phi_{q_T})^{[no\ offset]}}$$

In this study we have set the offset in the Y direction

Figure not drawn to scale

Introduction to the Beam-Offset : Accepted True Dimuons

Azimuthal Distributions in Different Beam-Offsets: Hodoscope Accepted True Dimuons ϕ_{qT}

$$\text{Fit} \rightarrow p_0 * (p_1 * \cos(2\phi_{qT}) + 1)$$

Azimuthal Distributions in Different Beam-Offsets: Reconstructed ϕ_{q_T} When Offset is Unknown

Beam-offset affect phi distributions if we did not know the offset information.

Azimuthal Distributions in Different Beam-Offsets: Reconstructed ϕ_{q_T} Ratio When Offset is Known

Beam-offset doesn't affect much if we knew the offset amount.

Summary and Conclusions

1. We have done a systematic study of measuring the fake azimuthal asymmetries that could be introduced due to the spectrometer.
2. We have found that the detector did not generate a false azimuthal asymmetry that could imitate the physics Sivers asymmetry.
3. From the beam-offset study we have found that the azimuthal distributions of dimuon ϕ will be distorted if the beam-offset was unknown, and the shape can be restored if we know the exact offset amount.
4. In SeaQuest the beam position measurement accuracy was about 1 mm and was stable during the data taking. We should not be sensitive to the beam-offset.
5. Beam angle and x offset studies are going on.