Measurement of angular distribution of the Drell-Yan process in p + Fe at FNAL-SeaQuest

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SeaQuest[1] is a fixed-target experiment conducted at the Fermi National Accelerator Lab (FNAL). It primarily measures the Drell-Yan process[2] using a proton beam with $E = 120$ GeV extracted from the FNAL Main Injector and liquid hydrogen, liquid deuterium, carbon, iron and, tungsten as targets. The use of light-to-heavy targets enables exploring the nuclear effect[3] on the partonic structure of the nucleon.

In the Drell-Yan process, a quark and an anti-quark in two colliding hadrons annihilate into a virtual photon and then decay into a muon pair. The angular distribution of muon pairs from the Drell-Yan process can be expressed in a virtual-photon rest frame, called the Collins-Soper frame,[4] as follows:

$$\frac{d\sigma}{d\Omega} \propto 1 + \lambda \cos^2\theta + \mu \sin 2\theta \cos\phi + \frac{\nu}{2} \sin^2\theta \cos 2\phi,$$

where ϕ and θ are the azimuthal and polar angles and λ, μ and ν represent the magnitude of angular dependence. The angular distribution of the Drell-Yan process has been measured with various types of beams and targets. The NA10[5] and E615[6] experiments use π^- beams to observe sizable $\cos 2\phi$ dependence (*i.e.*, $\nu \neq 0$). An origin of $\cos 2\phi$ dependence is the Boer-Mulders function. It is one of the eight transverse-momentum-dependent parton distribution functions (TMD PDFs) in the proton and represents the correlation between the transverse spin and the transverse momentum of partons. A non-zero Boer-Mulders function results in non-zero $\cos 2\phi$ dependence.

The beam dump[1] at SeaQuest is formed of iron with a thickness of 5 m. The Drell-Yan events that occurred in an upstream part (50 cm) of the beam dump were analyzed to extract the angular distribution. The use of dump events provided higher statistics than the target events, because the thickness of the iron target is 2 cm.

Figure 1 shows the angular parameters extracted from the SeaQuest data as a function of the dimuon transverse momentum (P_T). They are close to the NuSea $p + p$ and $p + d$ results,[7] *i.e.*, $\lambda \sim 1$ and $\nu \lesssim 0.05$. It indicates that the difference in ν between NuSea versus NA10 and E615 arises from the different beam particles. Because this measurement used p + Fe, evaluation of the nuclear effect[3] on the angular parameters is ongoing.

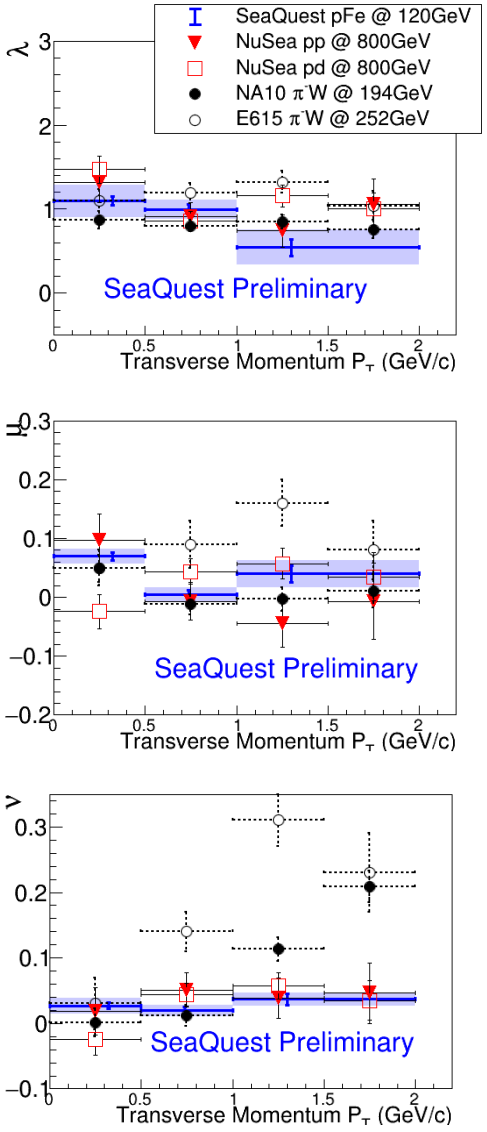

Fig. 1. Angular parameters versus dimuon transverse momentum (P_T) extracted from the SeaQuest data. The blue band on the SeaQuest result represents the total of statistical and systematic errors.

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