Measurement of proton induced Drell-Yan with the polarized nucleon targets at Fermilab-E1039

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For the E1039 collaboration

- Sivers asymmetry
- Fermilab-E1039
 - SeaQuest + Polarized target
 - Projection of E1039
 - Recent activity
 - Time-line
- Summary

Sivers asymmetry

Azimuthal asymmetry of the hadrons from the unpolarized quark inside the transversely polarized nucleon with respected to the nucleon spin

Measured in the DIS experiments
HERMES, COMPASS, Jlab
w/ polarized p, d, and ^3He

Sivers TMD distribution

Global analysis of the measured symmetries

⇒ Sivers TMD distribution

M. Anselmino et al.,
JHEP04 (2017) 046

M. G. Echevarria et al.,
PRD89 (2014) 074013

TMD2P. Sun, F. Yuan,
PRD88 (2013) 114012

“Non”-universality of Sivers TMD

DIS

$$\gamma^* + q \rightarrow q'$$

Sivers: Final state interaction

→ attractive

Drell-Yan

$$q + \bar{q} \rightarrow \gamma^*$$

W/Z prod.

$$q + \bar{q} \rightarrow W/Z$$

Sivers: Initial state interaction

→ repulsive

$$f_{1T}^\perp|_{\text{DIS}} = - f_{1T}^\perp|_{\text{DY, W/Z}}$$

“Non”-universality of Sivers distribution

$$f_{1T}^{\perp}|_{\text{DIS}} = -f_{1T}^{\perp}|_{\text{DY, W/Z}}$$

- Results from W-prod. @RHIC and Drell-Yan @COMPASS indicate
the possible sign-change
 - It requires
more statistic
to understand Q^2 evolution
 - TMD framework seems to be OK
- The next is “anti-quarks”!

PRL116(2016)132301

PRL119(2017)112002

Role of anti-Quarks in the proton spin puzzle

Fermilab-E1039: SeaQuest w/ pol. targets

- **Quark from the beam** and **anti-quark from the target**

Polarized NH_3 ,

$\rightarrow \bar{u}$

and ND_3 targets

$\rightarrow \bar{d}$

- Sivers asymmetry from anti-quarks

Projection of Sivers asymmetry measurement

- Proton Beam
 - Energy: 120 GeV ($\sqrt{s}=15$ GeV)
 - Instant luminosity: $4 \cdot 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$
 - Integrated luminosity: $1.1 \cdot 10^{43} \text{ cm}^{-2} \text{ year}^{-1}$
 - Beam time: 2 years
- Mass range $4 < M < 8 \text{ GeV}/c^2$
- Polarized targets
 - Upstream by ~ 2 m by E906
 - Lower x_2 acceptance
 - Better target and dump separation

E1039 polarized target

- NH_3 and ND_3 targets
- Dynamic Nuclear Polarization
 - 1 K (^4He refrigerator)
 - 5 T magnetic field
 - 140 GHz microwave irradiation
 - Polarization
 - ~ 90% for proton
 - ~ 50% for deuteron
- Challenge with the high intense proton beam

E1039 polarized target

- New 90 degree beam monitor in the target area
New fiber scintillators are added in the station 1 and 2
- Chamber and hodoscope maintenance and repair
fix the known problems from SeaQuest
- DAQ upgrade, Trigger upgrade,

- 2018
 - **Fermilab 2nd-stage approval (2018.05)**
 - E906 decommissioning
 - E1039 commissioning
 - New shielding and target platform
 - Detector maintenance and repair
 - Spectrometer tuning starts at the end of the year
- 2019
 - Polarized target installation
 - Beam time (~2 years)

- Fermilab-E1039
 - SeaQuest (anti-quark) + Polarized target (spin)
 - Measure Sivers asymmetry in polarized Drell-Yan
 - Proving orbiting u -bar, or d -bar ant-quarks inside the polarized nucleon
- **Green light** on E1039 in 2018
 - 2nd stage approval
 - from E906 to E1039
 - E1039 commissioning is on-going
- 2019
 - Beam time!