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

Yoshiyuki Miyachi, Yamagata University

For the E1039 collaboration

Contents

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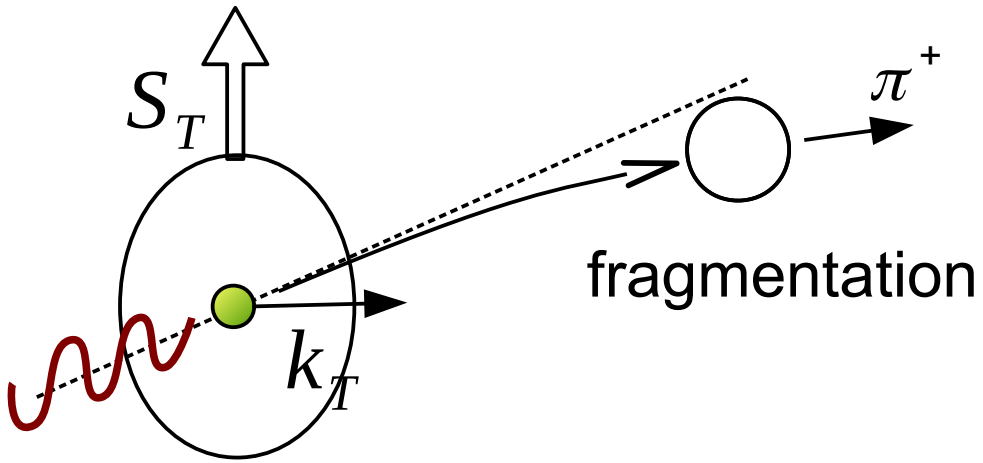
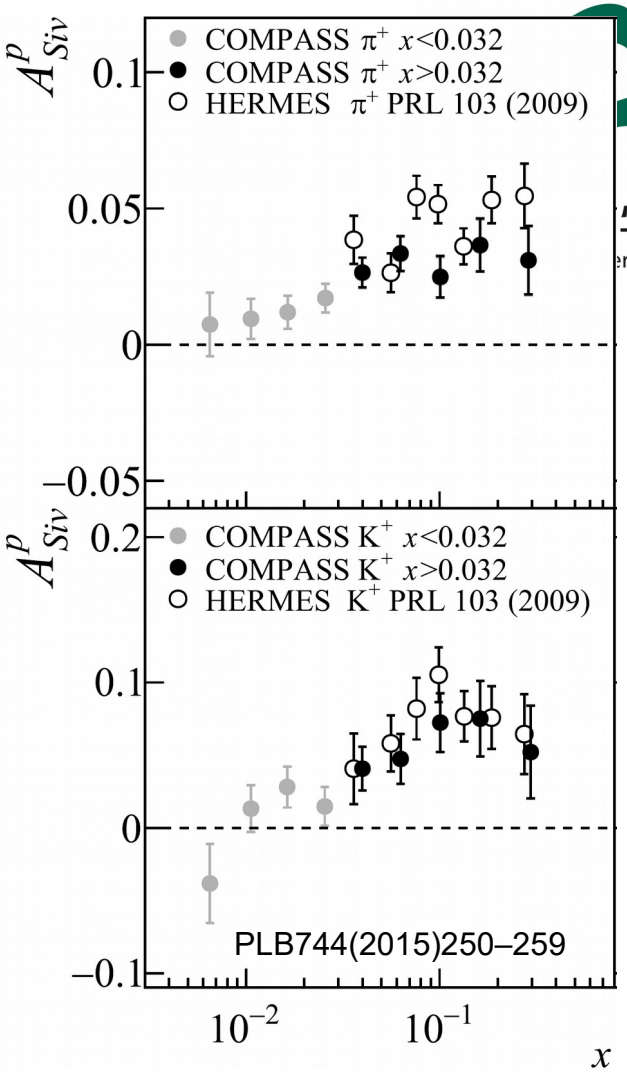
- Sivers asymmetry
- Fermilab-E1039
  - SeaQuest + Polarized target
  - Projection of E1039
  - Recent activity
  - Time-line
- Summary

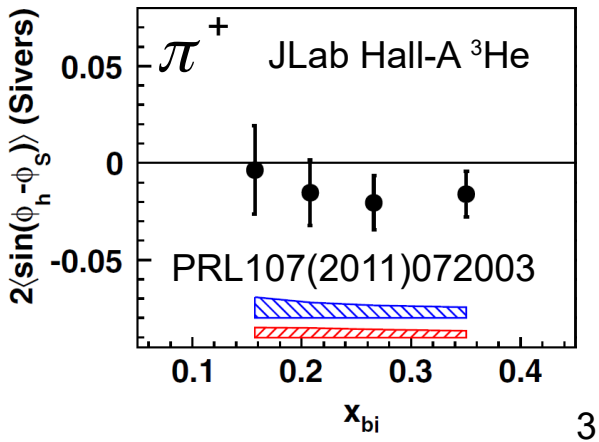
Sivers asymmetry



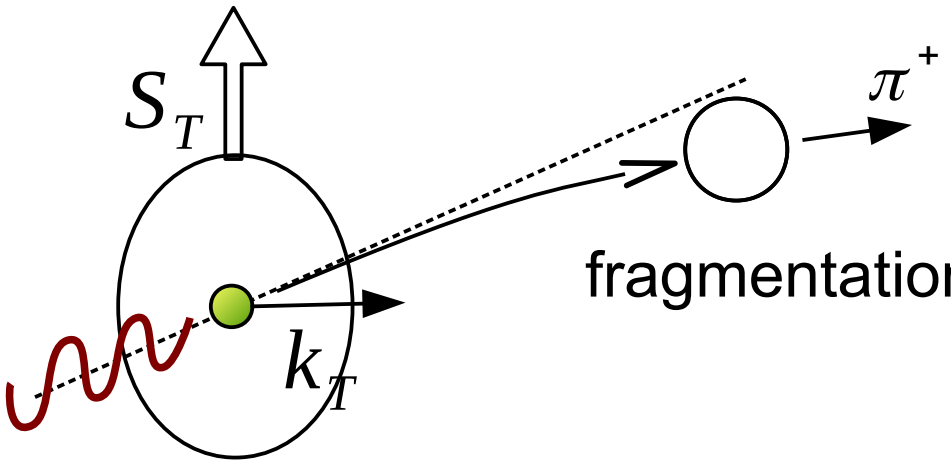
Azimuthal asymmetry of the hadrons
from **the unpolarized quark**
inside **the transversely polarized nucleon**
with respect to **the nucleon spin**

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





Sivers TMD distribution



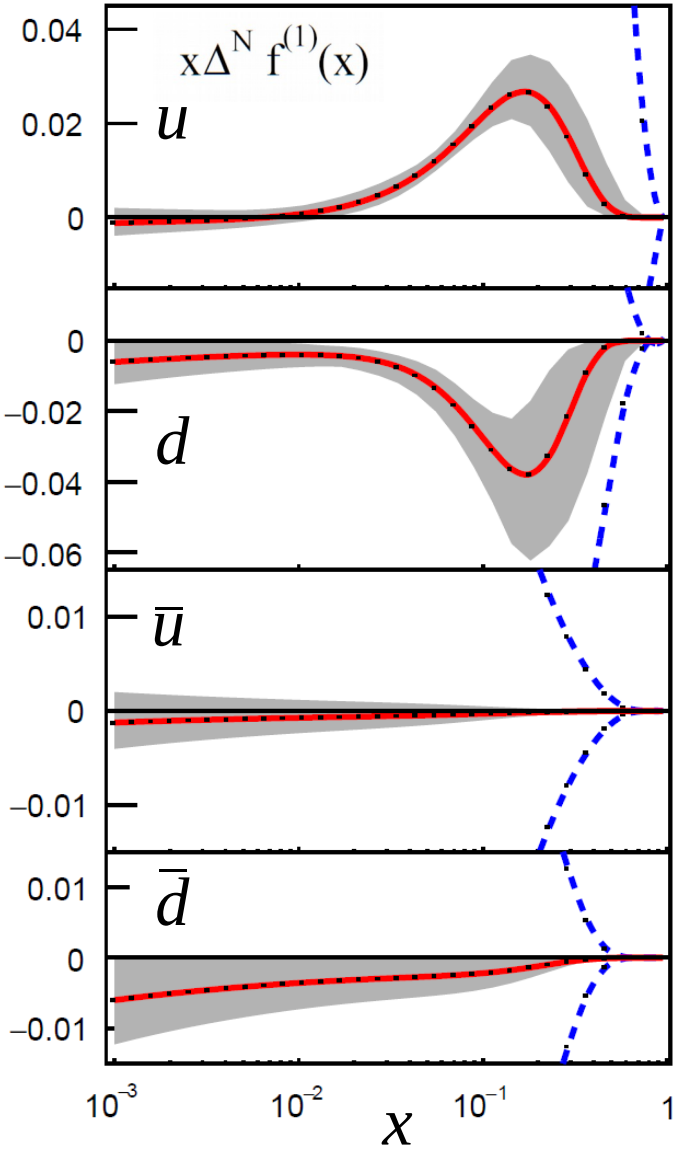
Global analysis of the measured symmetries

⇒ 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

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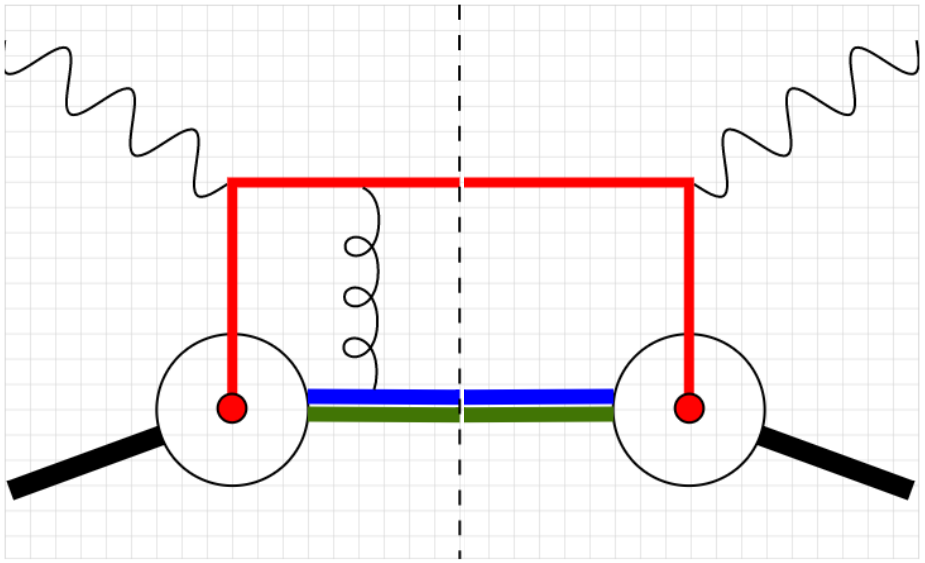
DIS $\gamma^* + q \rightarrow q'$

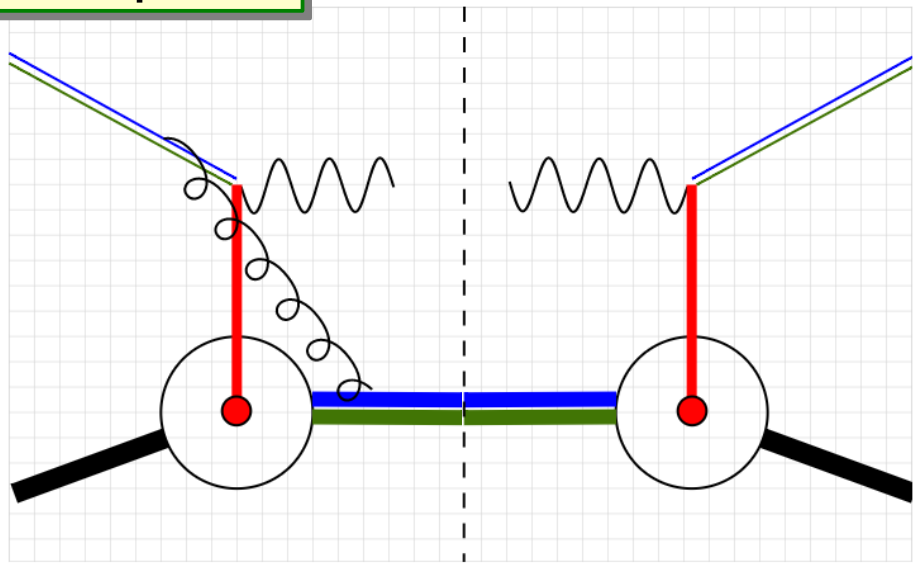


Sivers: Final state interaction

→ attractive

Drell-Yan $q + \bar{q} \rightarrow \gamma^*$

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



Sivers: Initial state interaction

→ repulsive

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

“Non”-universality of Sivers distribution

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

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- Results from W-prod. @RHIC and Drell-Yan @COMPASS indicate

  the possible sign-change

- It requires

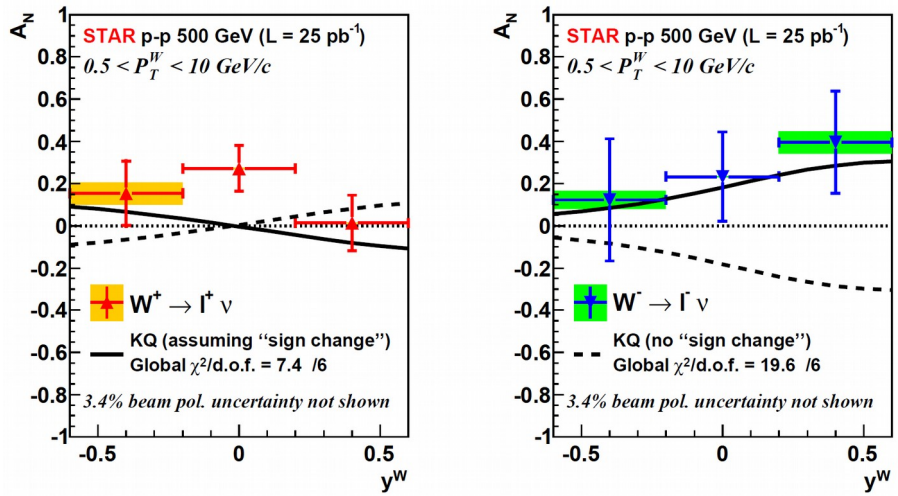
  more statistic

  to understand Q^2 evolution

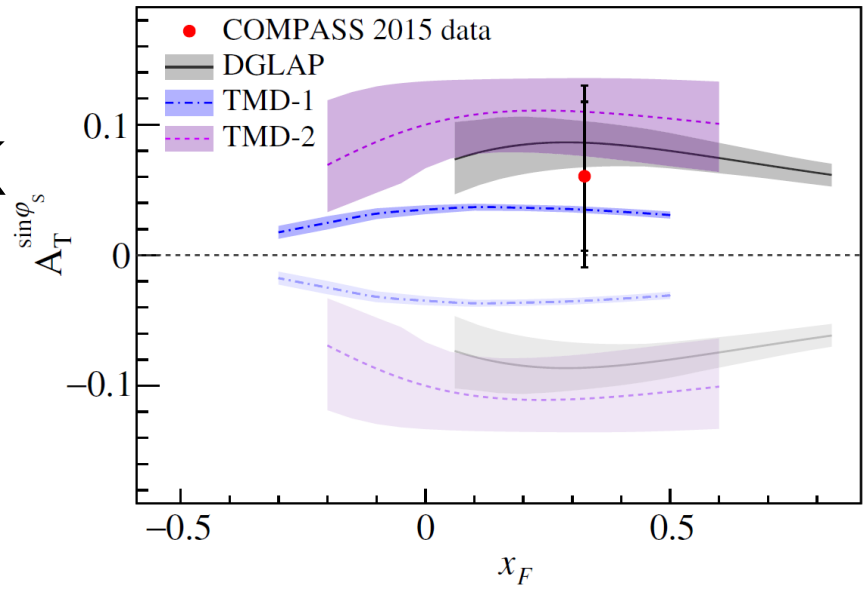
- TMD framework seems to be OK

  The next is “anti-quarks”!

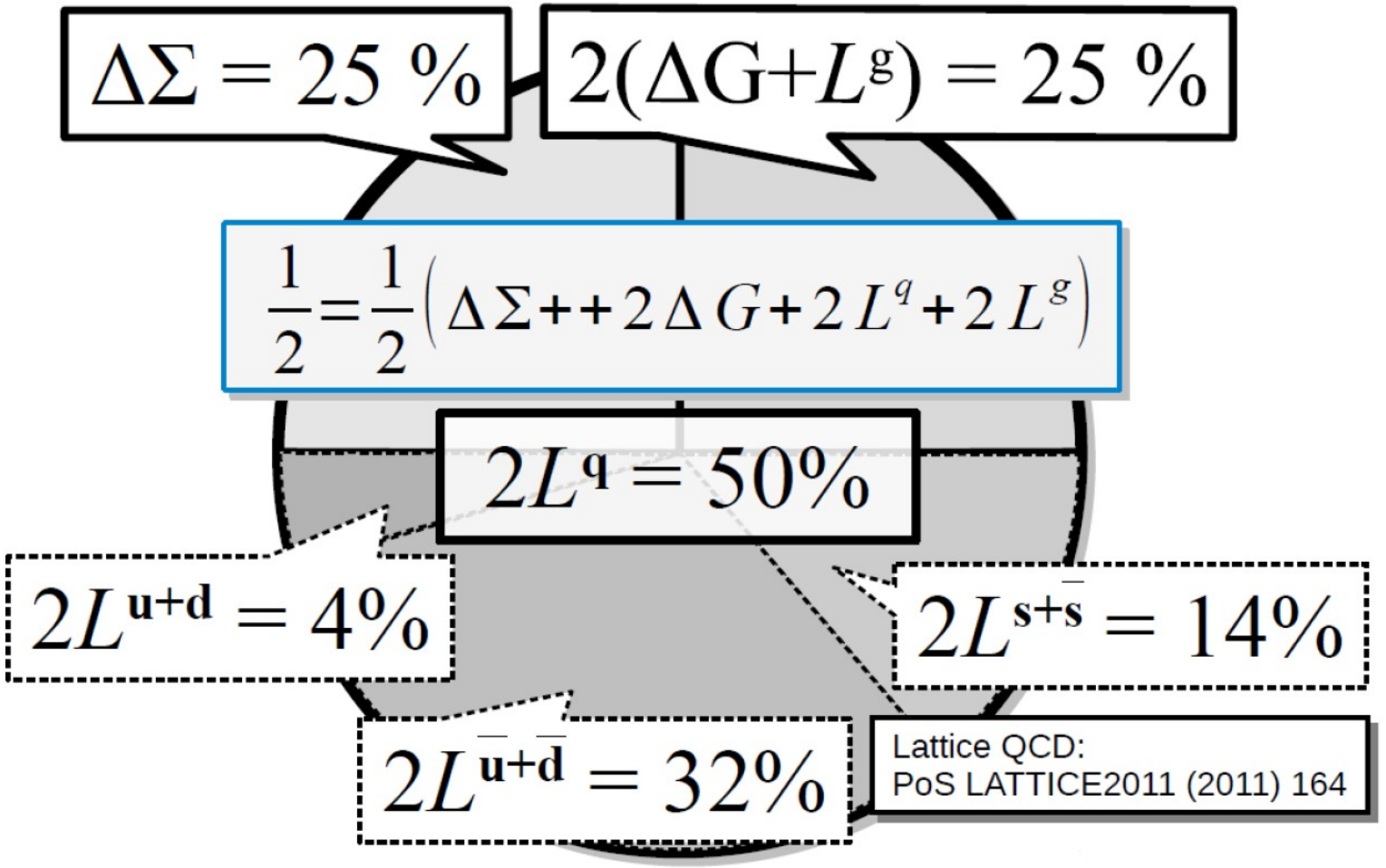
PRL116(2016)132301



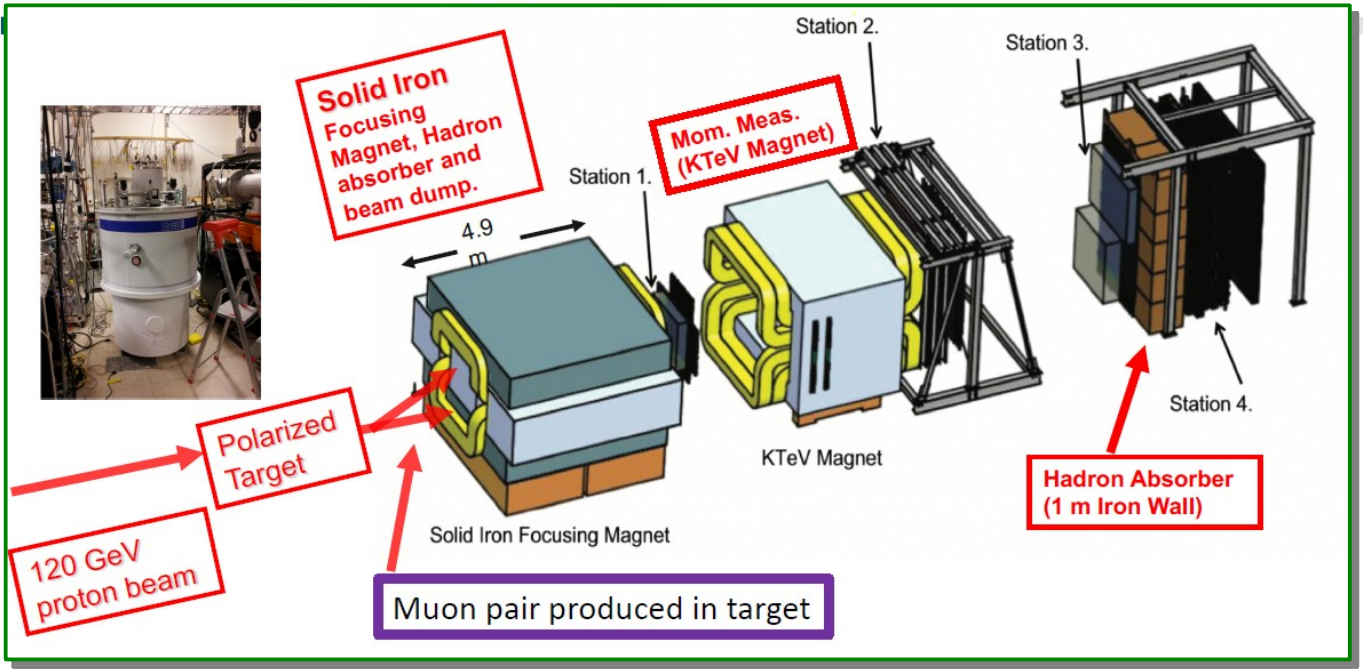
PRL119(2017)112002

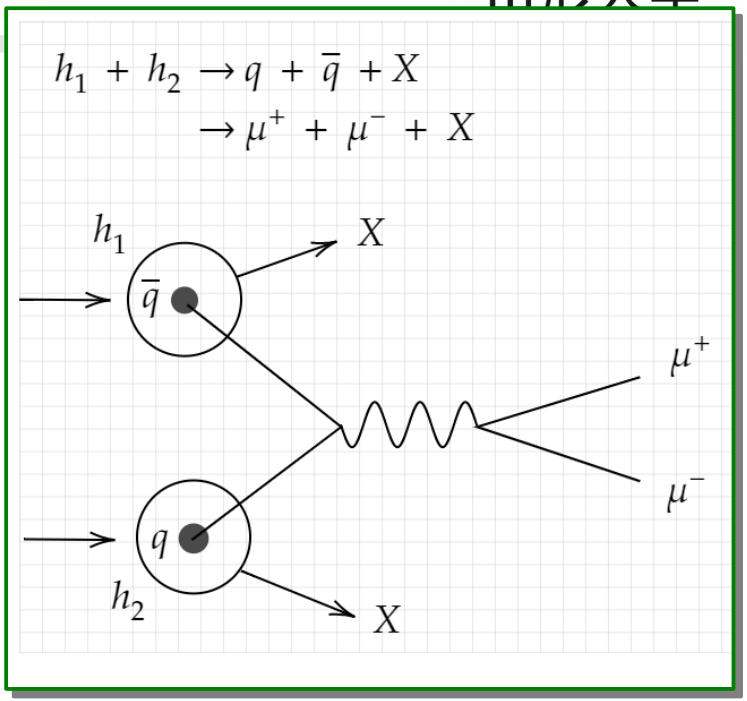


Role of anti-Quarks in the proton spin puzzle



Fermilab-E1039: SeaQuest w/ pol. targets





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

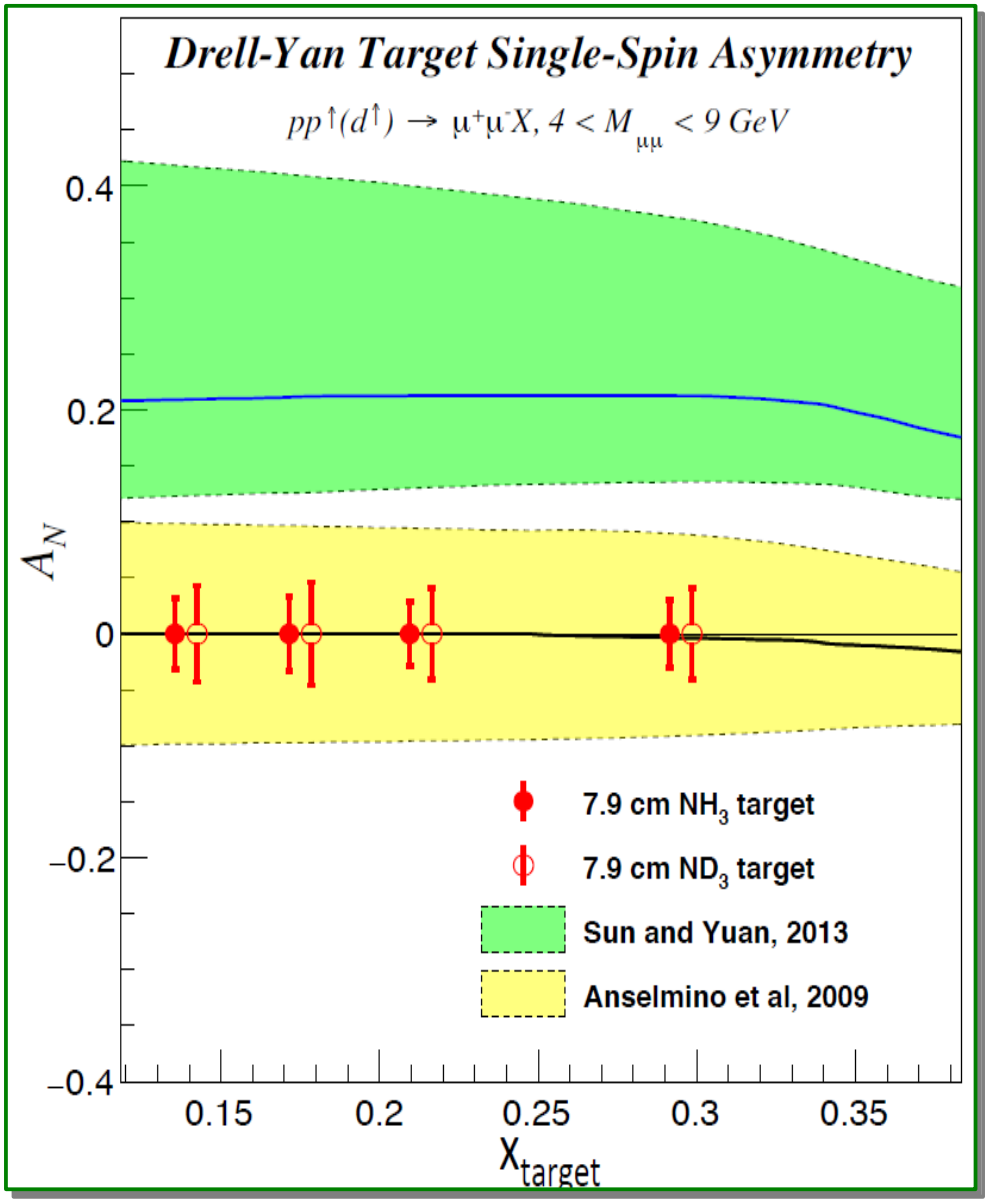
  Polalized NH_3, and ND_3 targets

  $\to \bar{u}$ $\to \bar{d}$

- Sivers asymmetry from anti-quarks

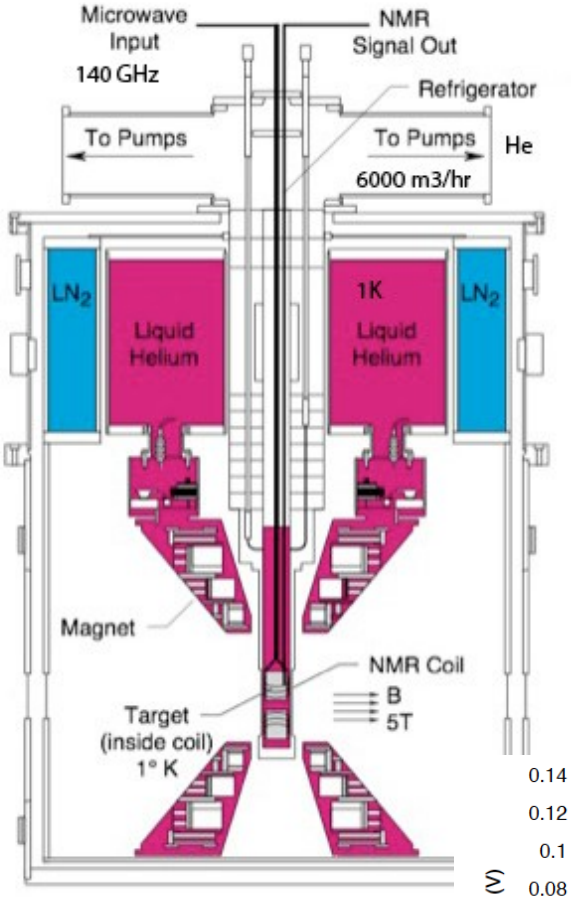
Projection of Sivers asymmetry measurment

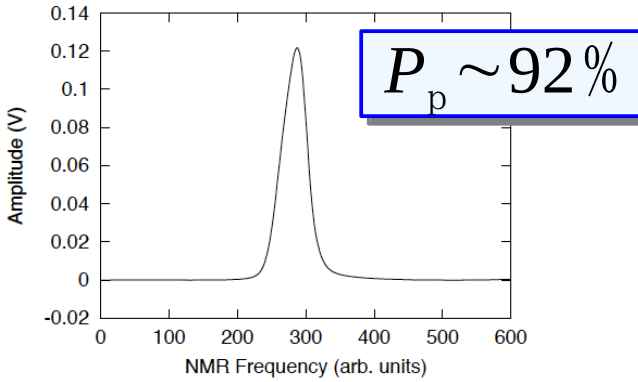
- Proton Beam
  - Energy: 120 GeV ($\sqrt{s}$=15 GeV)
  - Instant luminosity: $4*10^{35}$ cm^{-2} s^{-1}
  - Integrated luminosity: $1.1*10^{43}$ cm^{-2} $year^{-1}$
  - Beam time: 2 years
- Mass range 4 < M < 8 GeV/c^2
- Polarized targets
  - Upstream by ~ 2 m by E906
    - Lower x_2 acceptance
   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



E1039 polarized target

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





E1039 polarized target

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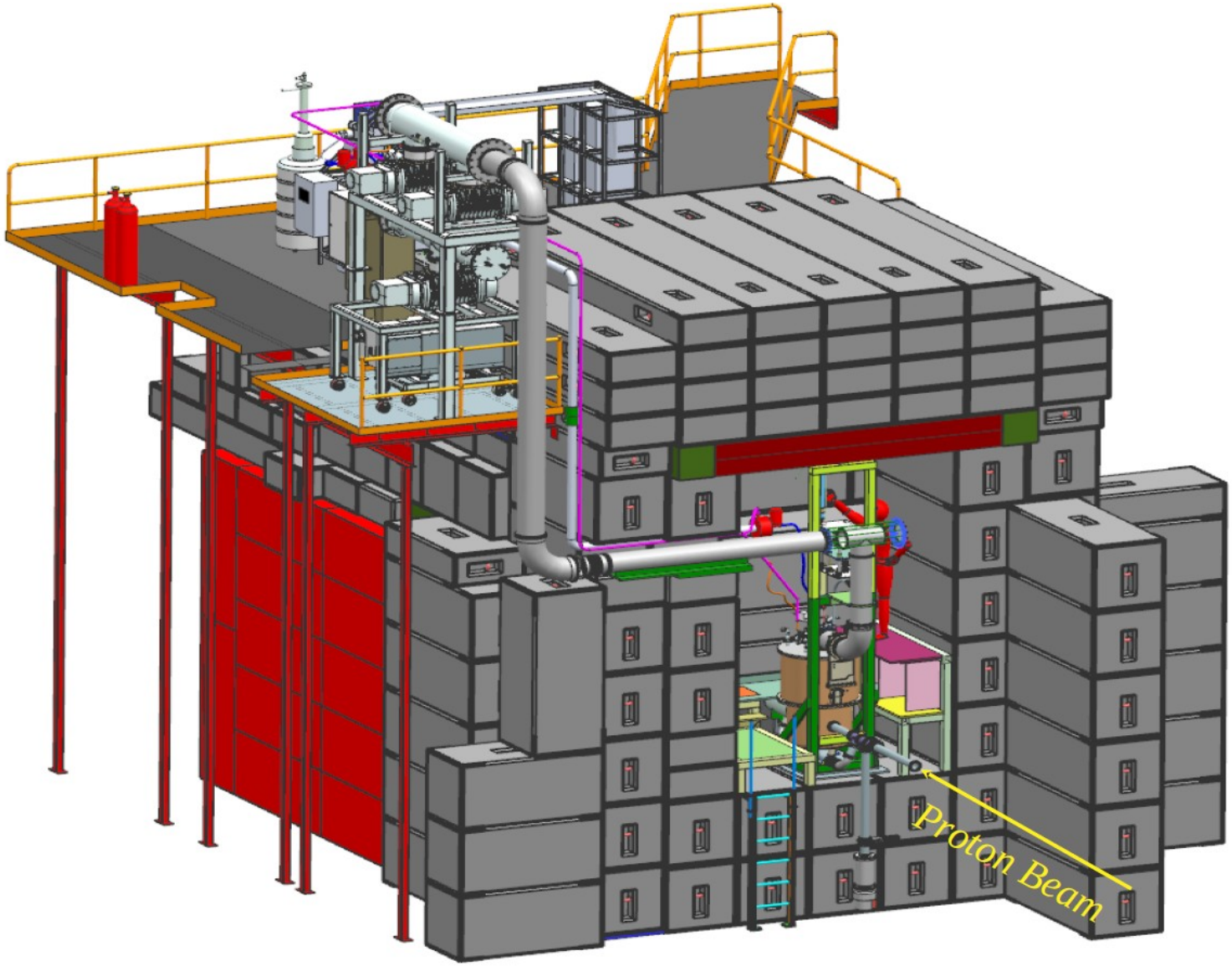
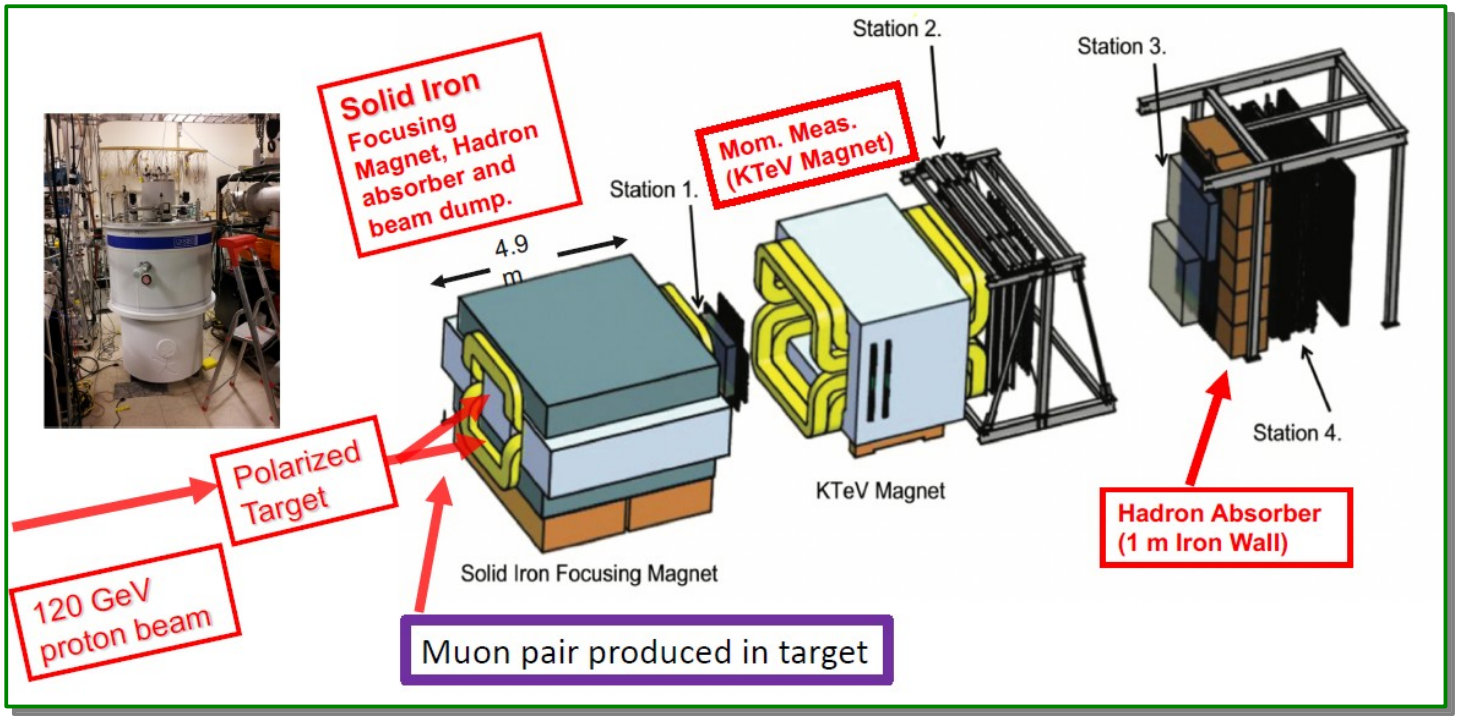


Spectrometer



- 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
  the known problems from SeaQuest
- DAQ upgrade, Trigger upgrade, …..

E1039 Timeline

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- 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)

Summary

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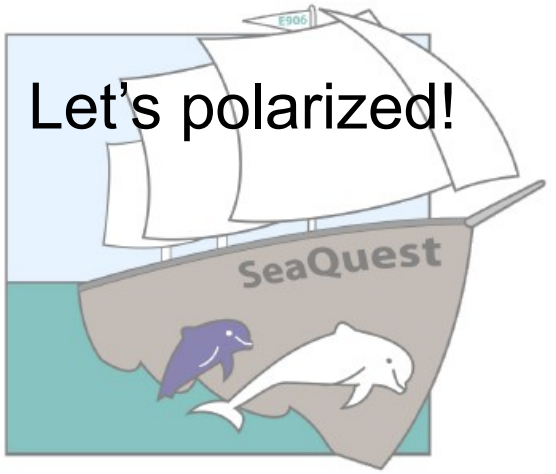
- Fermilab-E1039
  - SeaQuest (anti-quark) + Polarized target (spin)
  - Measure Sivers asymmetry in polarized Drell-Yan
  - Proving orbiting u-bar, or d-bar anti-quarks inside the polarized nucleon
- **Green light** on E1039 in 2018
  - 2nd stage approval
  - from E906 to E1039
  - E1039 commissioning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



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