Opportunities with Drell-Yan Scattering at Fermilab

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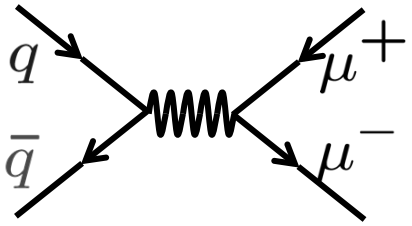
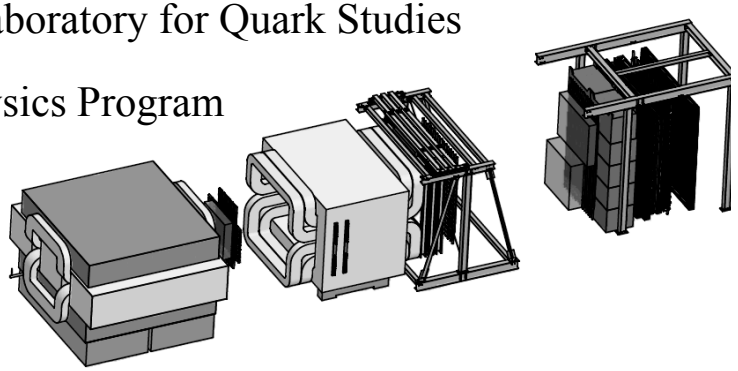
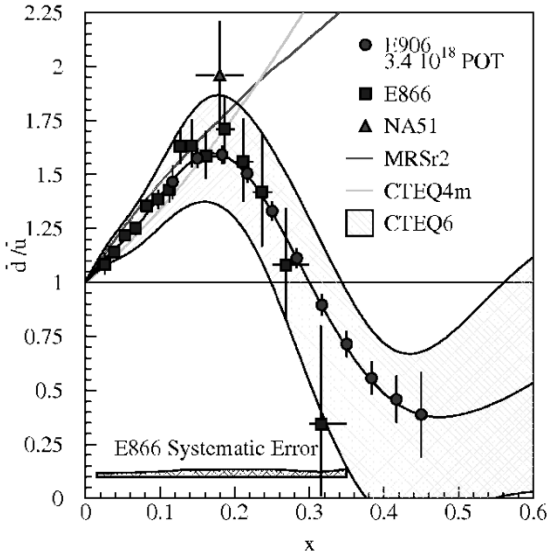


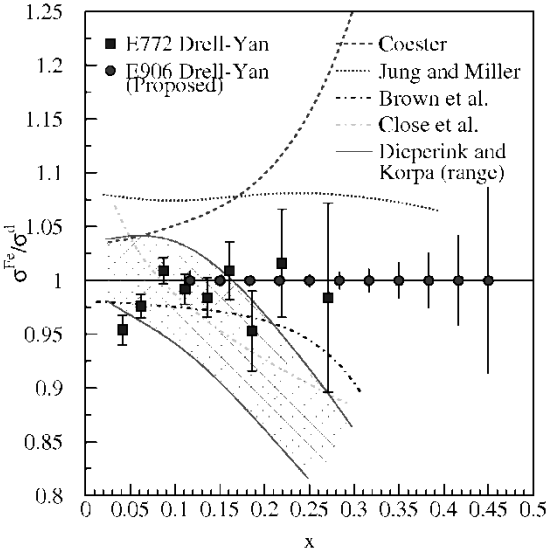
1. The Drell-Yan Process—A Laboratory for Quark Studies
2. Fermilab E-906/SeaQuest Physics Program
   - Sea quark in the proton
   - Sea quarks in the nucleus
   - Angular distributions
3. What can the future hold? Polarized targets or beams?



$$f_{1T}^{\perp}(x, k_T)\big|_{\mathrm{DIS}} = -\, f_{1T}^{\perp}(x, k_T)\big|_{\mathrm{DY}}$$


HERMES
U. Elschenbroich





With help from Chiranjib Dutta,
Wolfgang Lorenzon, U. Michigan
and Yuji Goto, RIKEN

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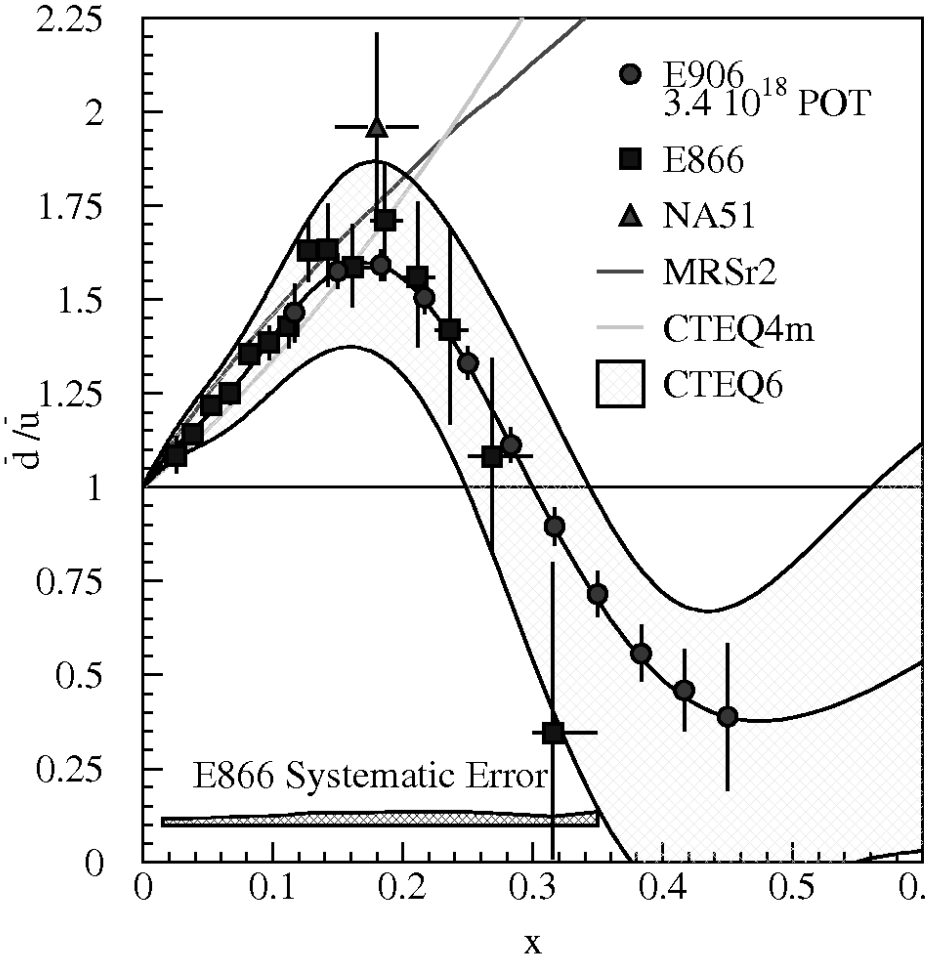
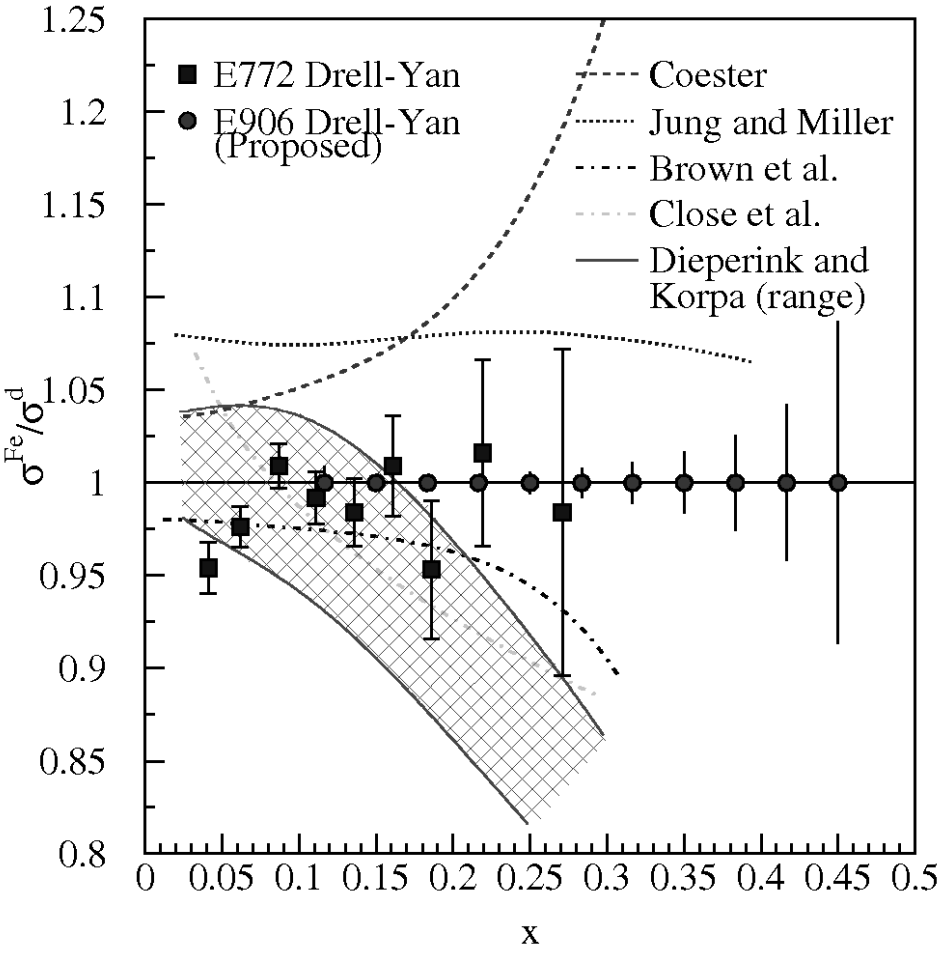
U.S. DEPARTMENT OF ENERGY

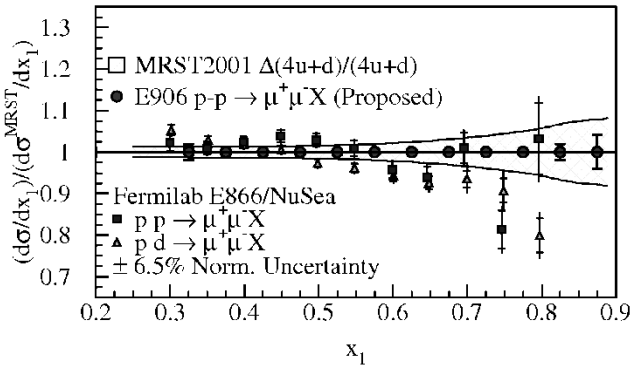
Extracting d-bar/-ubar From Drell-Yan Scattering

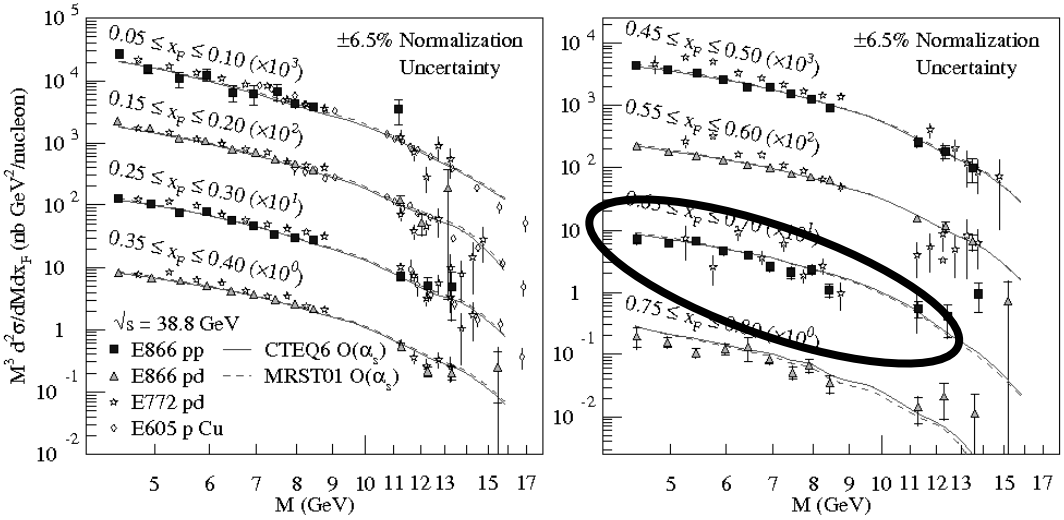




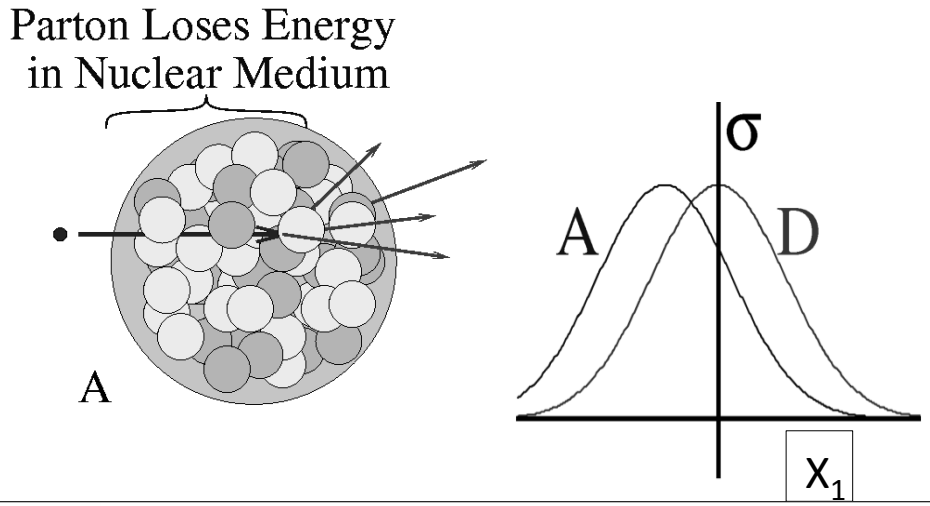
Other Physics from E-906/SeaQuest

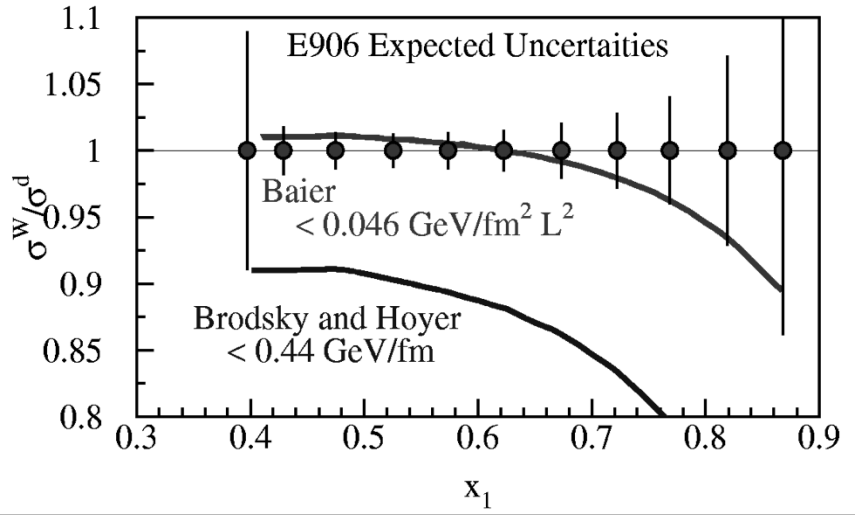
- Absolute High-x_{Bj} Parton Distributions





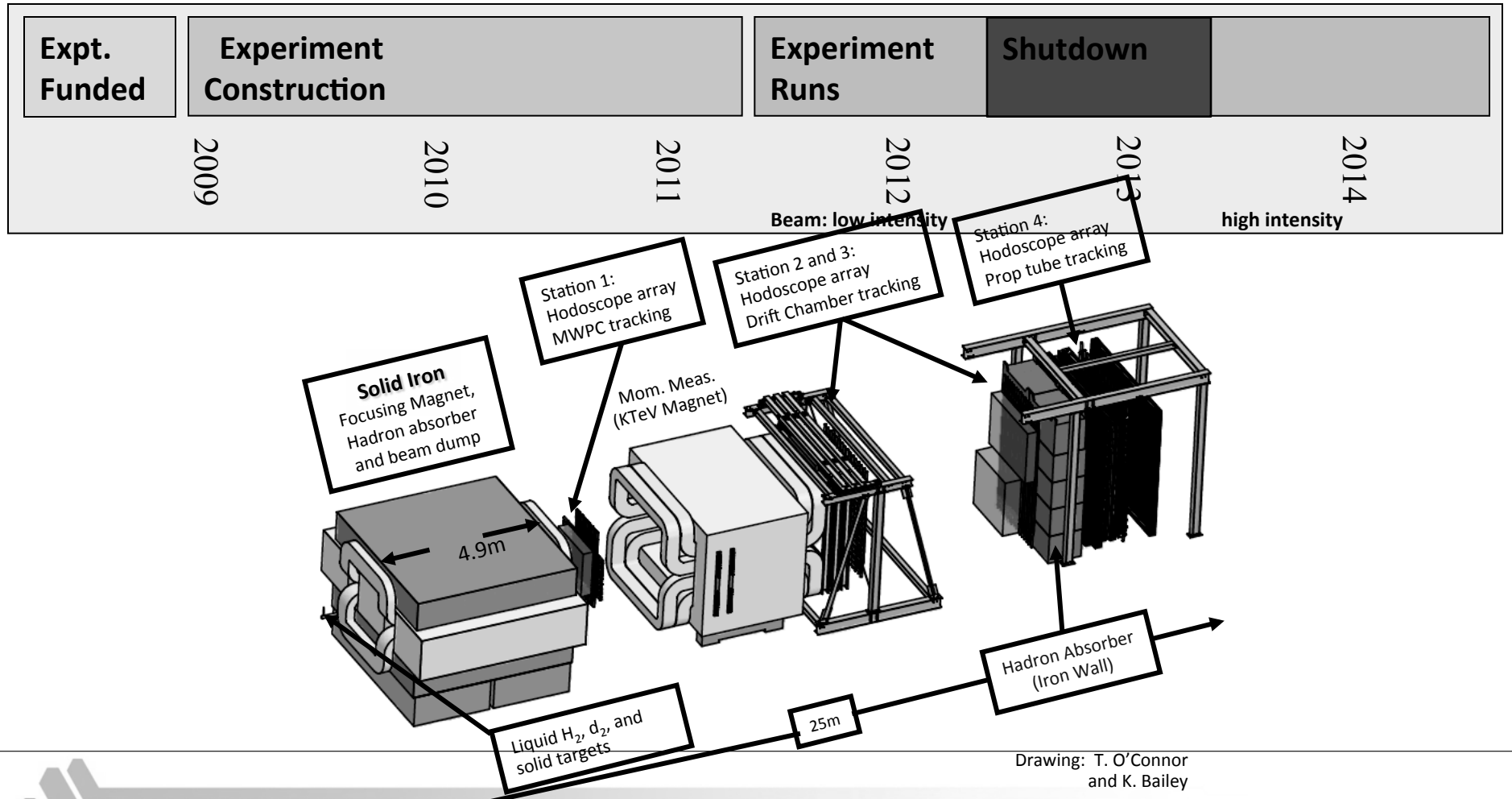
- Partonic Energy Loss in Cold Nuclear Matter





E-906/SeaQuest timeline and plans

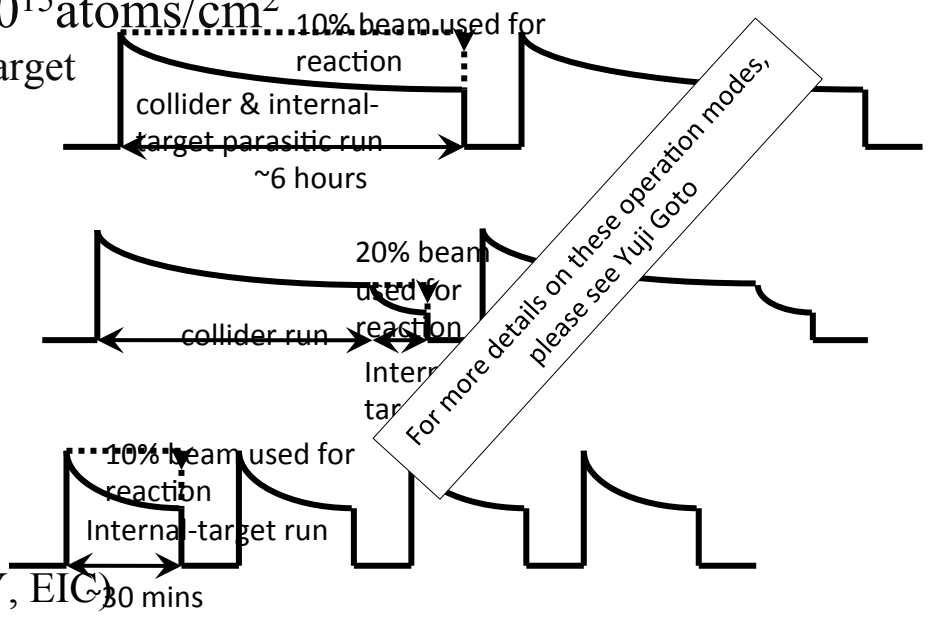
- Fermilab PAC approved the experiment in 2001—but experiment was not scheduled due to concerns about "proton economics"
- Fermilab Stage-II Approval granted on 24 December 2008
- Expected first beam in late June 2011



Drawing: T. O'Connor and K. Bailey

At RHIC?

- Internal Cluster-jet or pellet target 10^{15}atoms/cm^2
  - 50 times thinner than RHIC CNI carbon target
- Operational modes
  - Parasitic
  - End-of-fill (HERMES)
  - Dedicated (in-and-out strike)
- Other questions/obstacles
  - Competition for interaction region (AnDY, EIC)
  - Beam compensation for double dipole spectrometer
  - Beam pipe through spectrometer?



Measure not only the sign of the Sivers but also ***the shape*** of the function

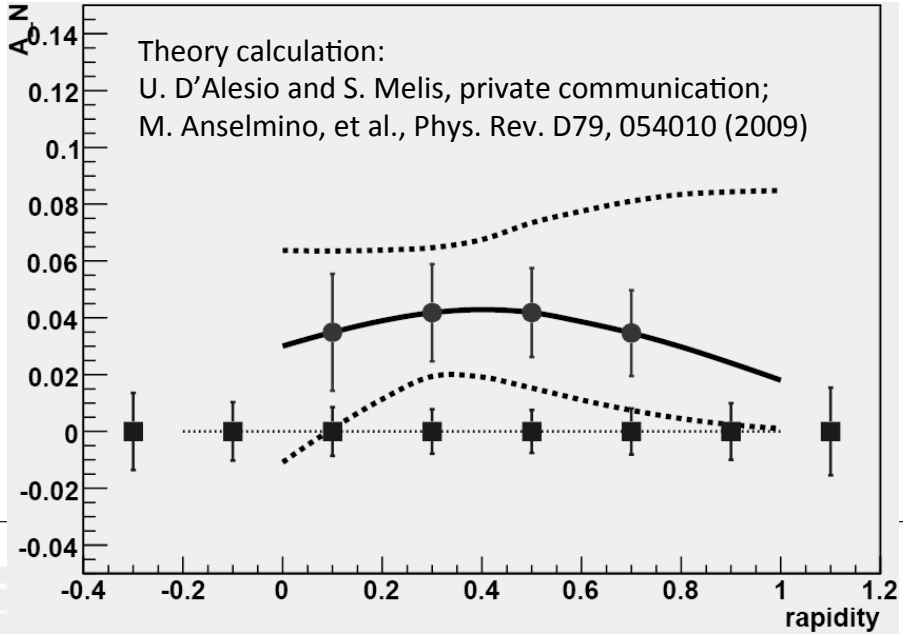
What if

$$\left|f_{1T}^{\perp}\right|_{\mathrm{DIS}} \times \left|f_{1T}^{\perp}\right|_{\mathrm{DY}} < 0$$

but

$$\left|f_{1T}^{\perp}\right|_{\mathrm{DIS}} \neq \left|f_{1T}^{\perp}\right|_{\mathrm{DY}}$$

?

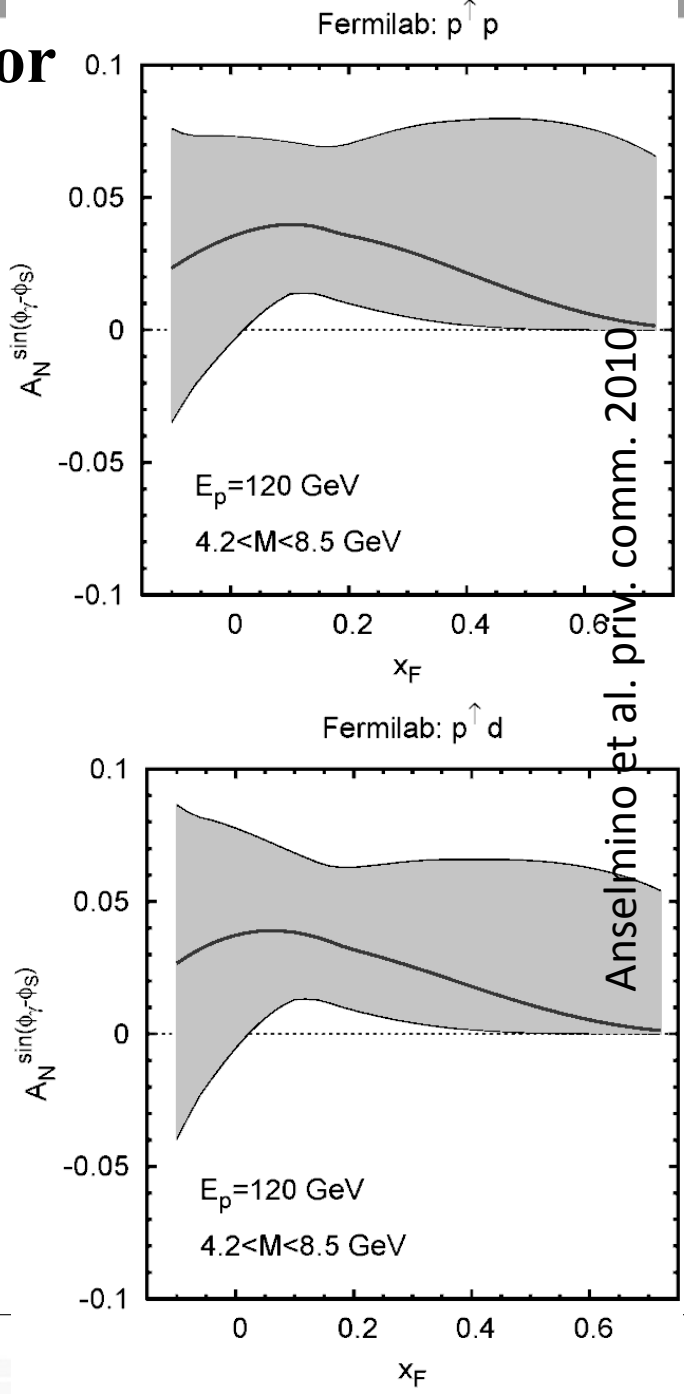


Polarized beam at Fermilab Main Injector

- 1 mA at polarized source delivers 8.1 x 10^{11} p/s (=130 nA)
  - A. Krisch: Spin@Fermi study in 1995
  - Fermilab Main Injector can be polarized (not Tevatron)
  - Revisit study to re-evaluate cost (done in early fall 2011)
  - Feasibility depends on cost (both in $$ and down time of MI)
- Scenarios:
  - SeaQuest liquid H_2 target can take ~5 x 10^{11} p/s (=80 nA)
  - **$\mathcal{L}$ = 1 x 10^{36} /cm^2/s** (60% of beam delivered to experiment)
  - **$\mathcal{L}$ = 2 x 10^{35} /cm^2/s** (10% of beam delivered to experiment)
- *x*-range:

  x_1 0.3 – 0.9 (valence quarks)

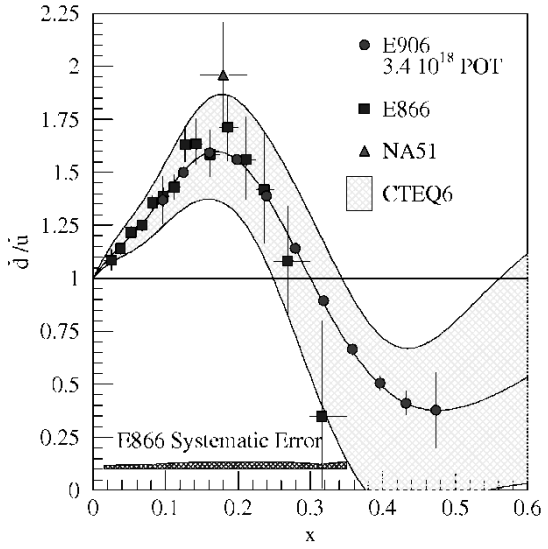
  x_2 0.1 – 0.5 (sea quarks)
- Unpolarized SeaQuest
  - luminosity: $\mathcal{L}$ = 3.4 x 10^{35} /cm^2/s
  - I_{av} = 1.6 x 10^{11} p/s (=26 nA)
  - N_p = 2.1 x 10^{24} /cm^2
  - 2-3 years of running: 3.4 x 10^{18} pot

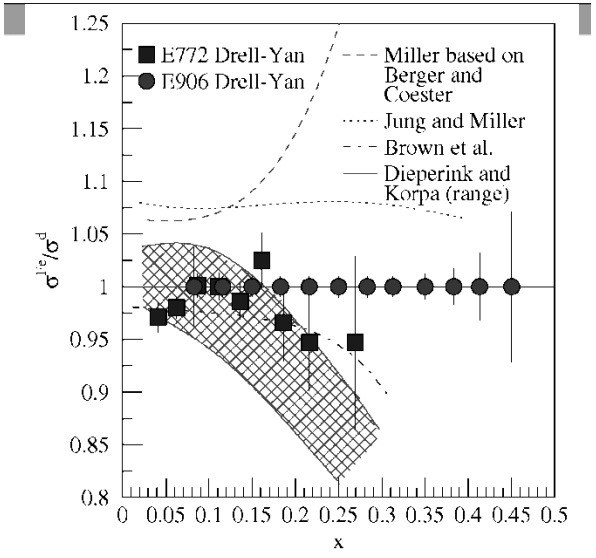


experiment	particles	energy	x_1 or x_2	luminosity	timeline
COMPASS (CERN)	$\pi^{\pm}$ + $p^{\uparrow}$	160 GeV $\sqrt{s}$ = 17.4 GeV	x_2 = 0.2 – 0.3 x_2 ~ 0.05 (low mass)	2 x 10^{33} cm^{-2} s^{-1}	>2012
PAX (GSI)	$p^{\uparrow}$ + p_{par}	collider $\sqrt{s}$ = 14 GeV	x_1 = 0.1 – 0.9	2 x 10^{30} cm^{-2} s^{-1}	>2017
PANDA (GSI)	p_{par} + $p^{\uparrow}$	15 GeV $\sqrt{s}$ = 5.5 GeV	x_2 = 0.2 – 0.4	2 x 10^{32} cm^{-2} s^{-1}	>2016
J-PARC	$p^{\uparrow}$ + p	50 GeV $\sqrt{s}$ = 10 GeV	x_1 = 0.5 – 0.9	1 x 10^{35} cm^{-2} s^{-1}	>2015 ??
NICA (JINR)	$p^{\uparrow}$ + p	collider $\sqrt{s}$ = 20 GeV	x_1 = 0.1 – 0.8	1 x 10^{30} cm^{-2} s^{-1}	>2014
PHENIX (RHIC)	$p^{\uparrow}$ + p	collider $\sqrt{s}$ = 500 GeV	x_1 = 0.05 – 0.1	2 x 10^{32} cm^{-2} s^{-1}	>2018
RHIC internal target phase-1	$p^{\uparrow}$ + p	250 GeV $\sqrt{s}$ = 22 GeV	x_1 = 0.25 – 0.4	2 x 10^{33} cm^{-2} s^{-1}	>2018
RHIC internal target phase-1	$p^{\uparrow}$ + p	250 GeV $\sqrt{s}$ = 22 GeV	x_1 = 0.25 – 0.4	6 x 10^{34} cm^{-2} s^{-1}	>2018
A_nDY RHIC (IP-2)	$p^{\uparrow}$ + p	500 GeV $\sqrt{s}$ = 32 GeV	x_1 = ??	?? cm^{-2} s^{-1}	>2015
SeaQuest (unpol.) (FNAL)	p + p	120 GeV $\sqrt{s}$ = 15 GeV	x_1 = 0.3 – 0.9	3.4 x 10^{35} cm^{-2} s^{-1}	>2010
pol. SeaQuest (FNAL)	**$p^{\uparrow}$ + p**	**120 GeV $\sqrt{s}$ = 15 GeV**	**x_1 = 0.3 – 0.9**	**1 x 10^{36} cm^{-2} s^{-1}**	**>??**

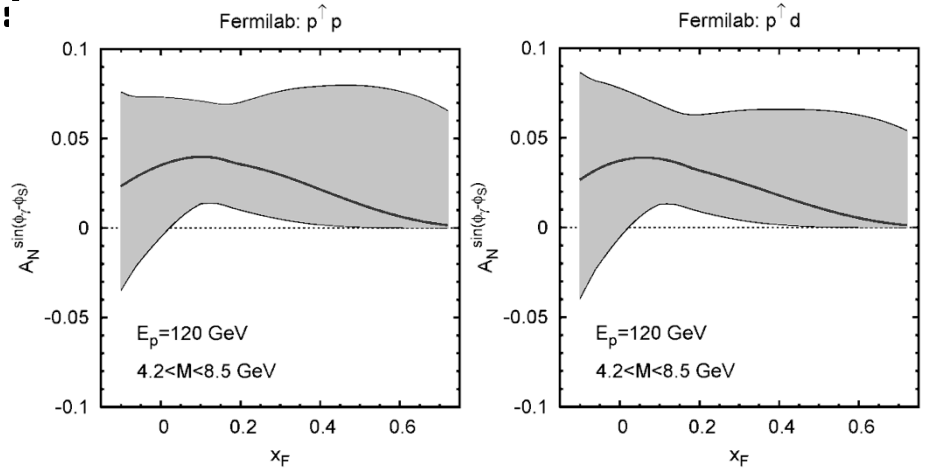
Drell-Yan at Fermilab

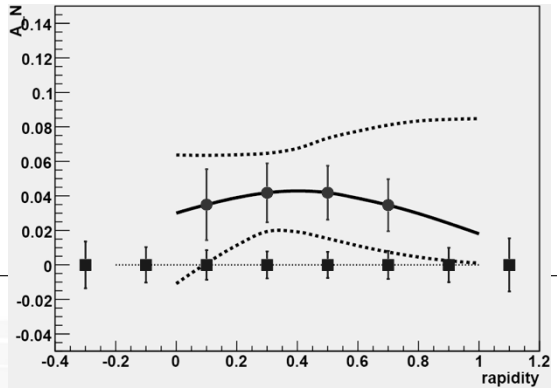
- **What is the structure of the nucleon?**
  - What is d-bar/u-bar?
  - What are the origins of the sea quarks?
  - What is the high-x structure of the proton?





- **What is the structure of nucleonic matter?**
  - Where are the nuclear pions?
  - Is anti-shadowing a valence effect?
- **What is the transverse Structure of the proton?**
  - Polarized beam at Fermilab Main Injector
  - Move apparatus to RHIC or J_PARC





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