Opportunity for a Polarized Target Drell-Yan Experiment @Fermilab

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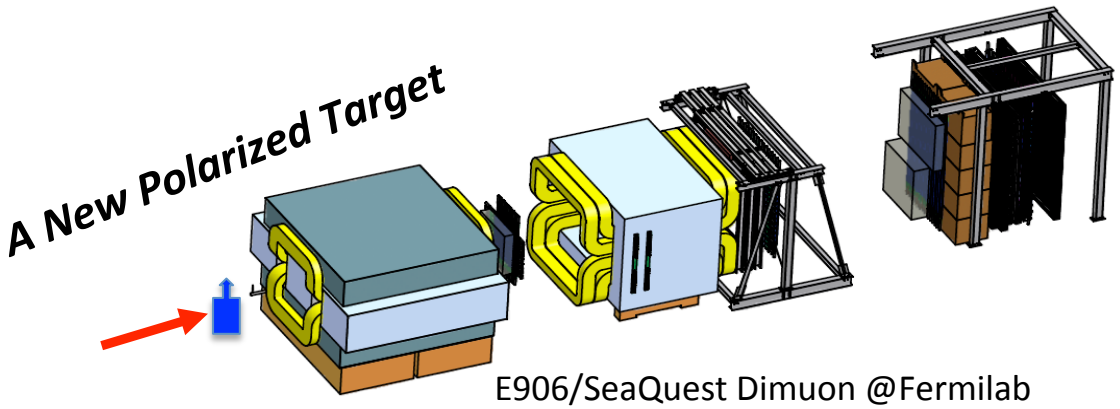
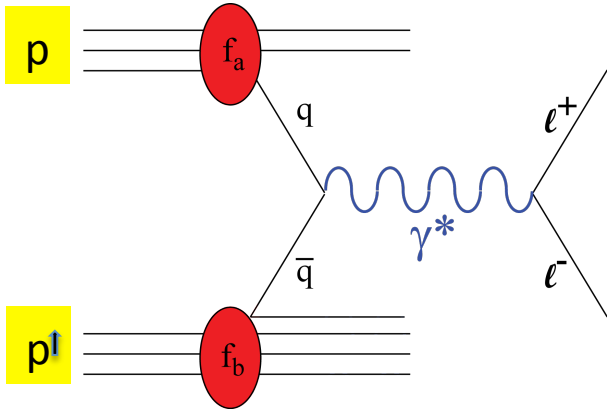
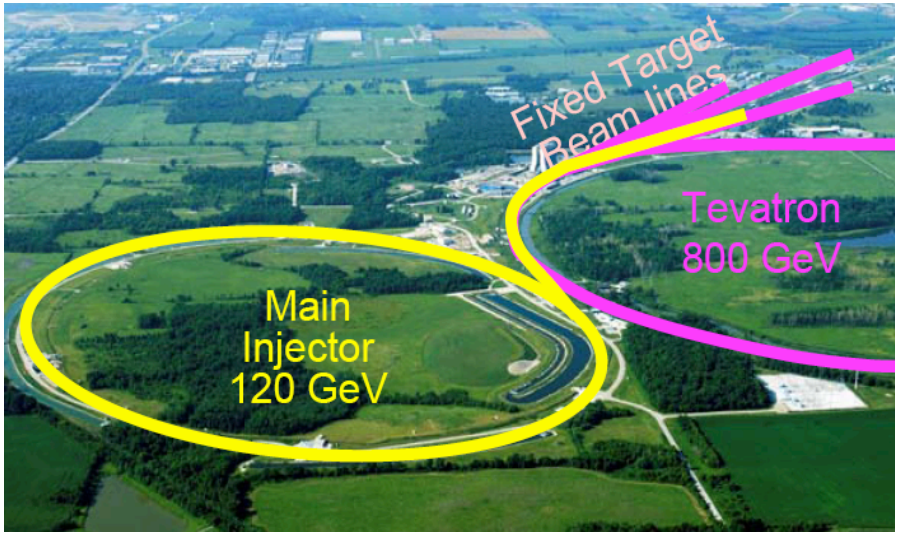


E906/SeaQuest Dimuon @Fermilab



Drell-Yan Transverse Single Spin Asymmetry:

- Polarized 120 GeV proton beam from the Fermilab's Main Injector, E-1027
- Polarized proton (NH_3) target, design & construction at LANL
- Polarized Target Drell-Yan (LOI submitted to PAC 2013)

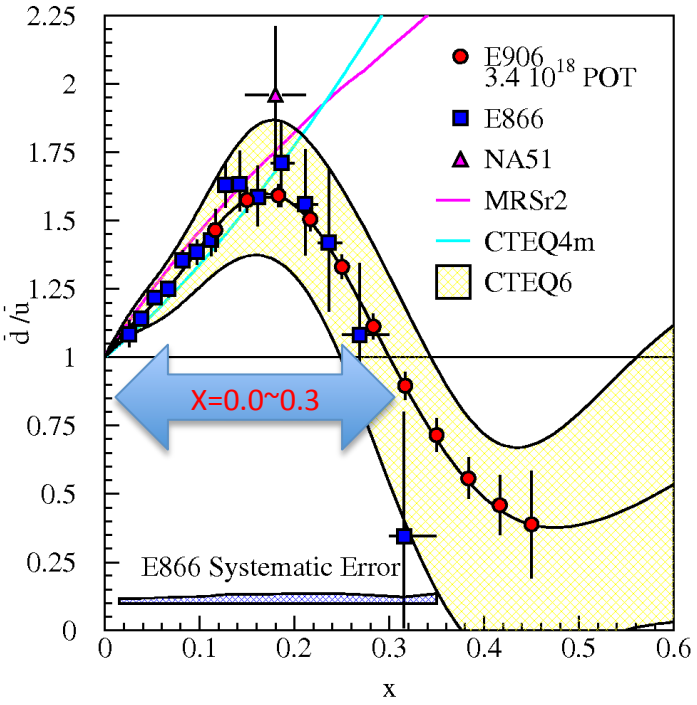


Flavor Asymmetry

$$\frac{\bar{d}(x)}{\bar{u}(x)} \neq 1 \quad x = 0 \sim 0.3$$

Thanks J.C. Peng for the flavors!

E906 dbar/ubar projection

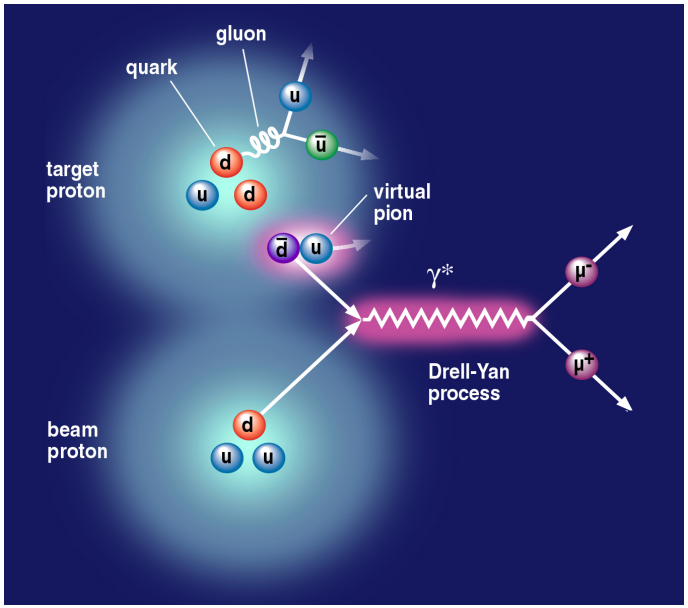


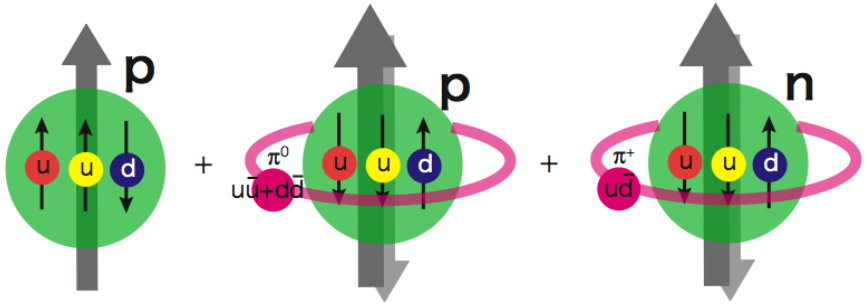
The Physics

all about sea quarks

$$|P\rangle = c_1|p\rangle + c_2|p,\pi^0\rangle + c_3|n,\pi^+\rangle + \ldots$$

- ***Sea-quark*** flavor asymmetry
- ***Sea-quark*** orbital angular motion and Sivers function at x = 0.0 ~ 0.3
- Proton spin puzzle





L = 0 L = 1

$$\frac{1}{2} = \frac{1}{2}\Delta q + L_q^z + \Delta G + L_g^z$$

$$\Delta q \sim 30\% \quad (pol.\ SIDIS)$$

$$\Delta G \sim \frac{1}{2} \times 30\%\,(?) \quad (RHIC - spin)$$

$$L \sim 30\%? \qquad (FNAL?)$$

Transverse Single Spin Asymmetry

$$p\,p^{\uparrow} \rightarrow \pi X$$

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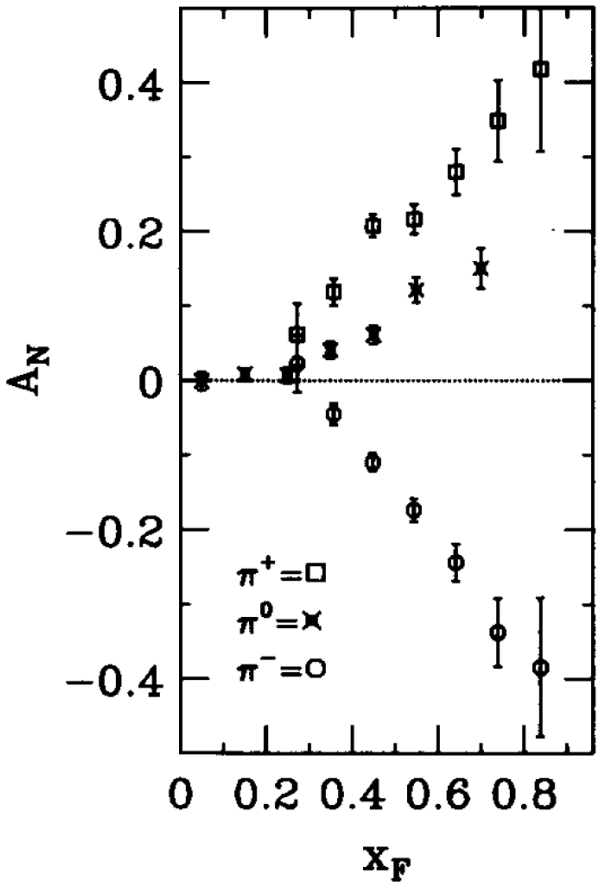
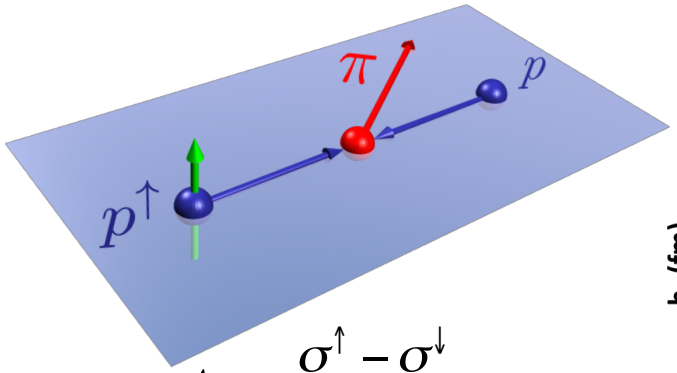


Fig. 4. A_N versus x_F for π^+, π^- and π^0 data.

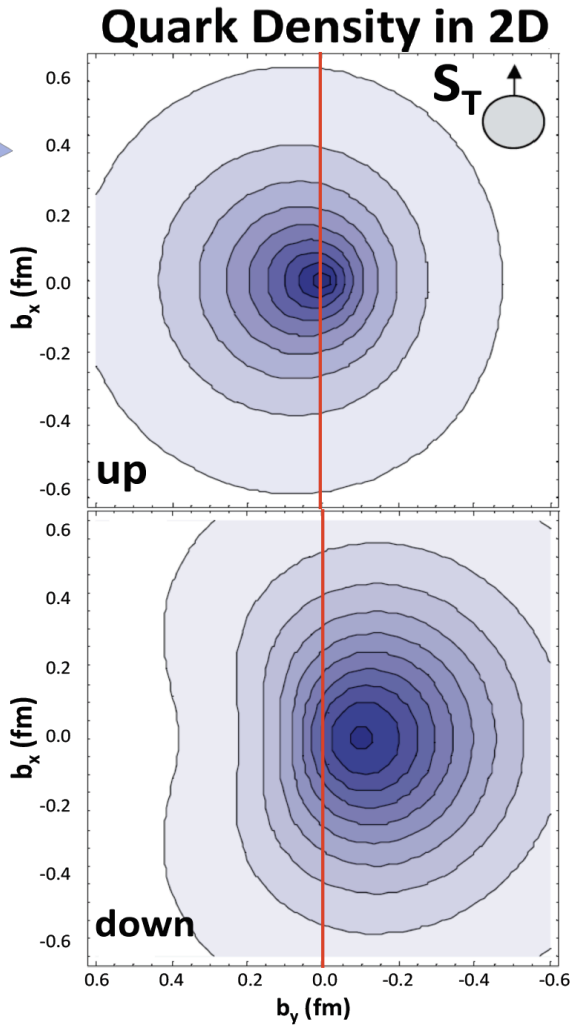


$$A_N = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}}$$

$\pi^+ (u\bar{d})$ favors left

$\pi^- (d\bar{u})$ favors right

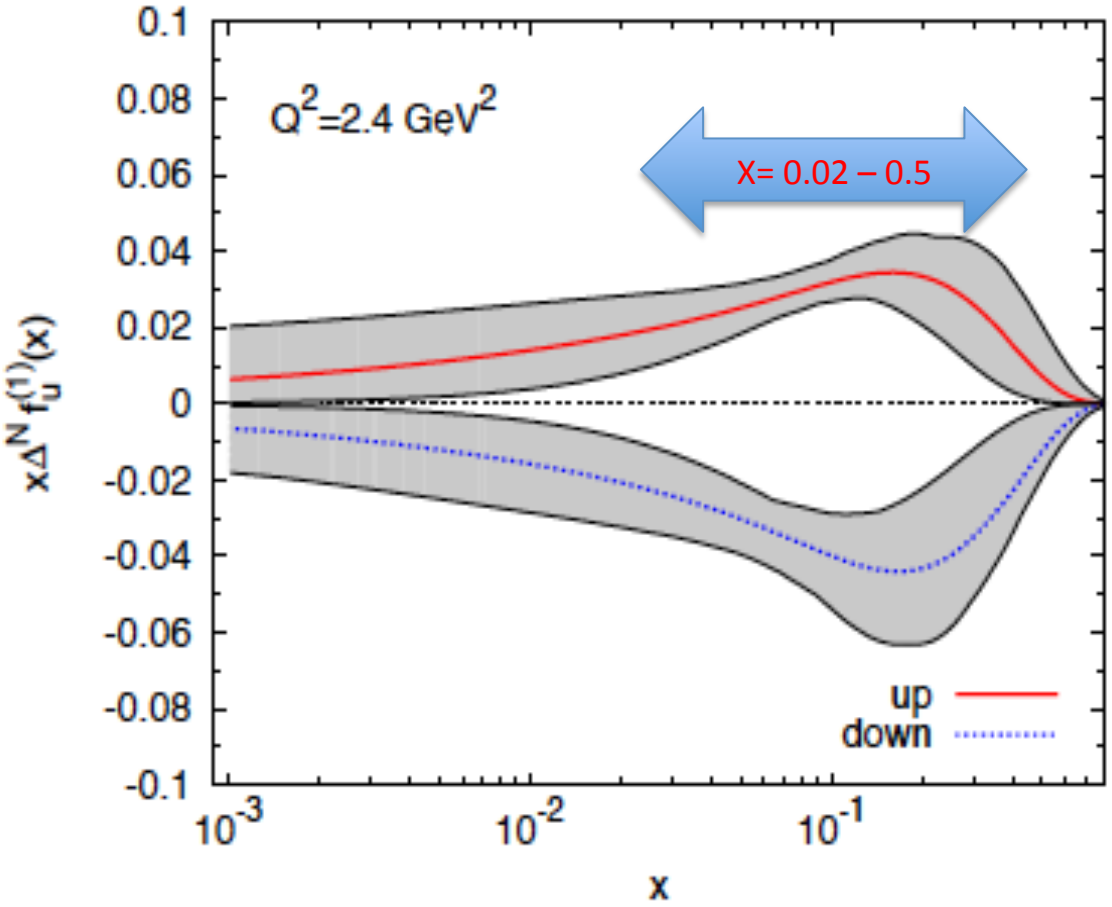
One possible explanation (Sivers effect): quark transvers motion generates a left-right bias.

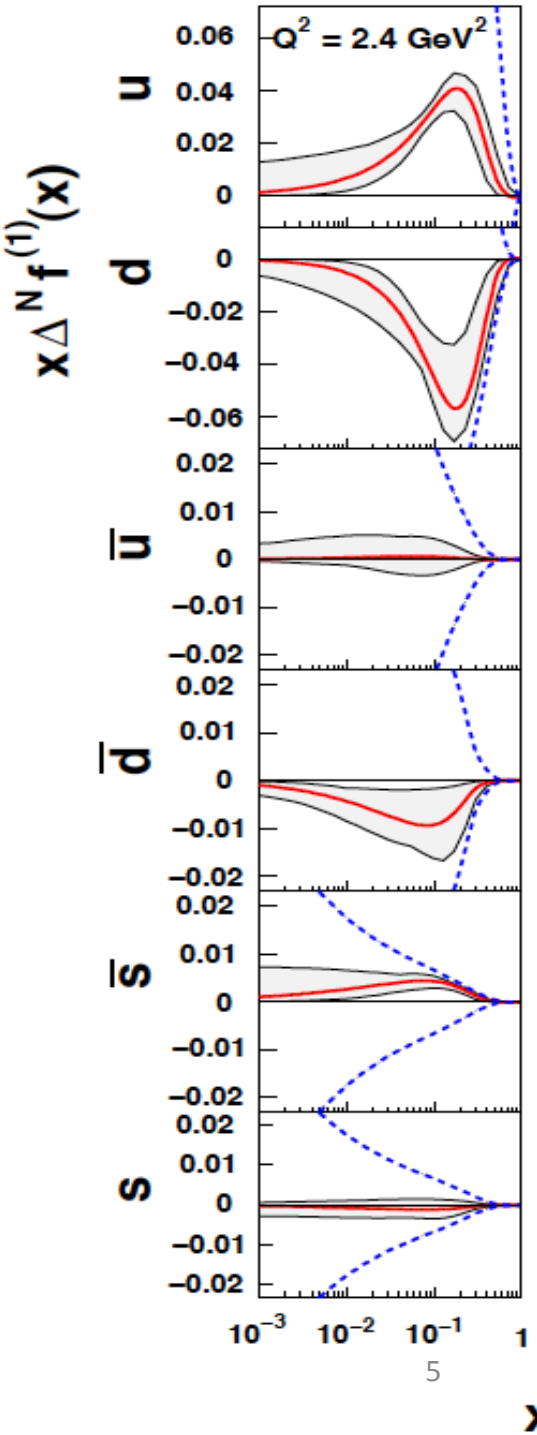


Lattice QCD PRL98:222001,2007.

Anselmino et al PRD 79 54010(2009)

Sea quark Sivers: not much constraint by SIDIS data





Drell-Yan Transverse Single Spin Asymmetry @Fermilab

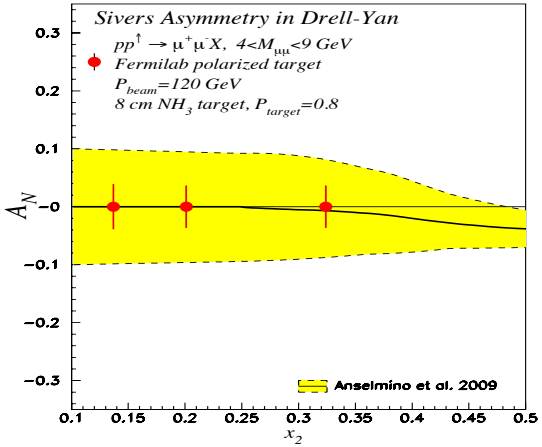
SeaQuark Sivers Effects

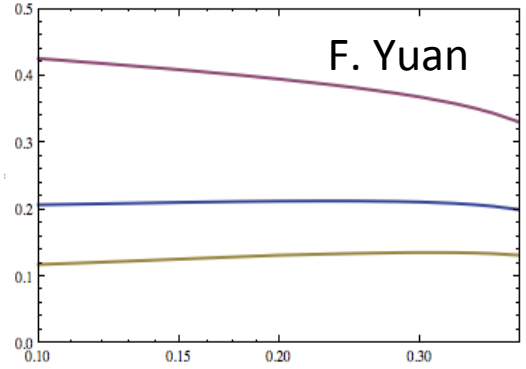
- The first precise measurements of seaquark Sivers distributions
- @ large x = 0.1~0.4 where significant Sivers Asymmetry observed in pol. SIDIS
- Sea-quark's Sivers Funcs poorly known

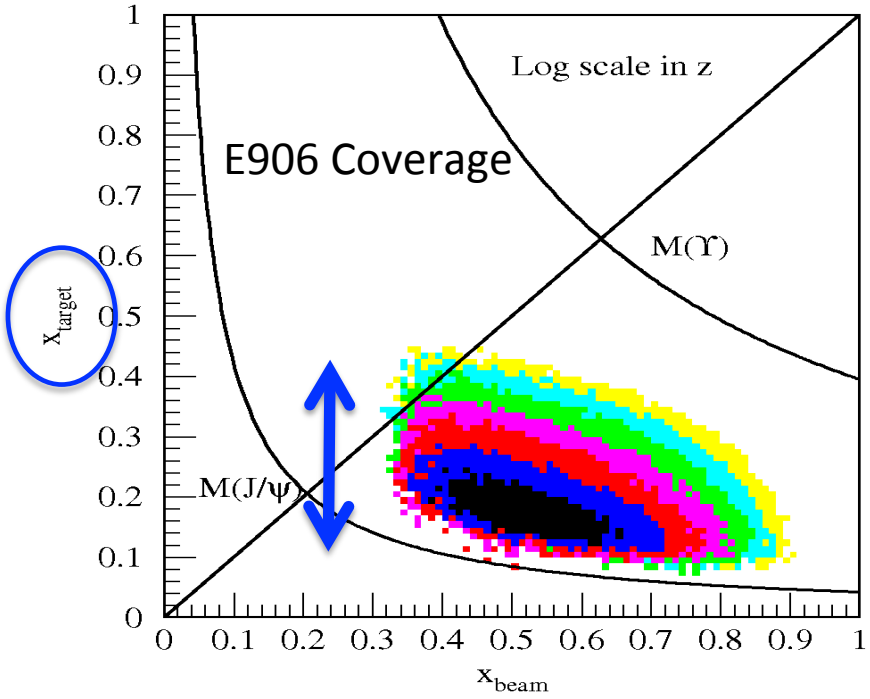
$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_1x_2s}\sum e^2[q_b(x_b)\bar{q}_t(x_t) + \bar{q}_b(x_b)q(x_t)]$$

$$\approx \frac{4\pi\alpha^2}{9x_1x_2s}\sum e^2[q_b(x_b)\bar{q}_t(x_t)]$$

Pol. Target



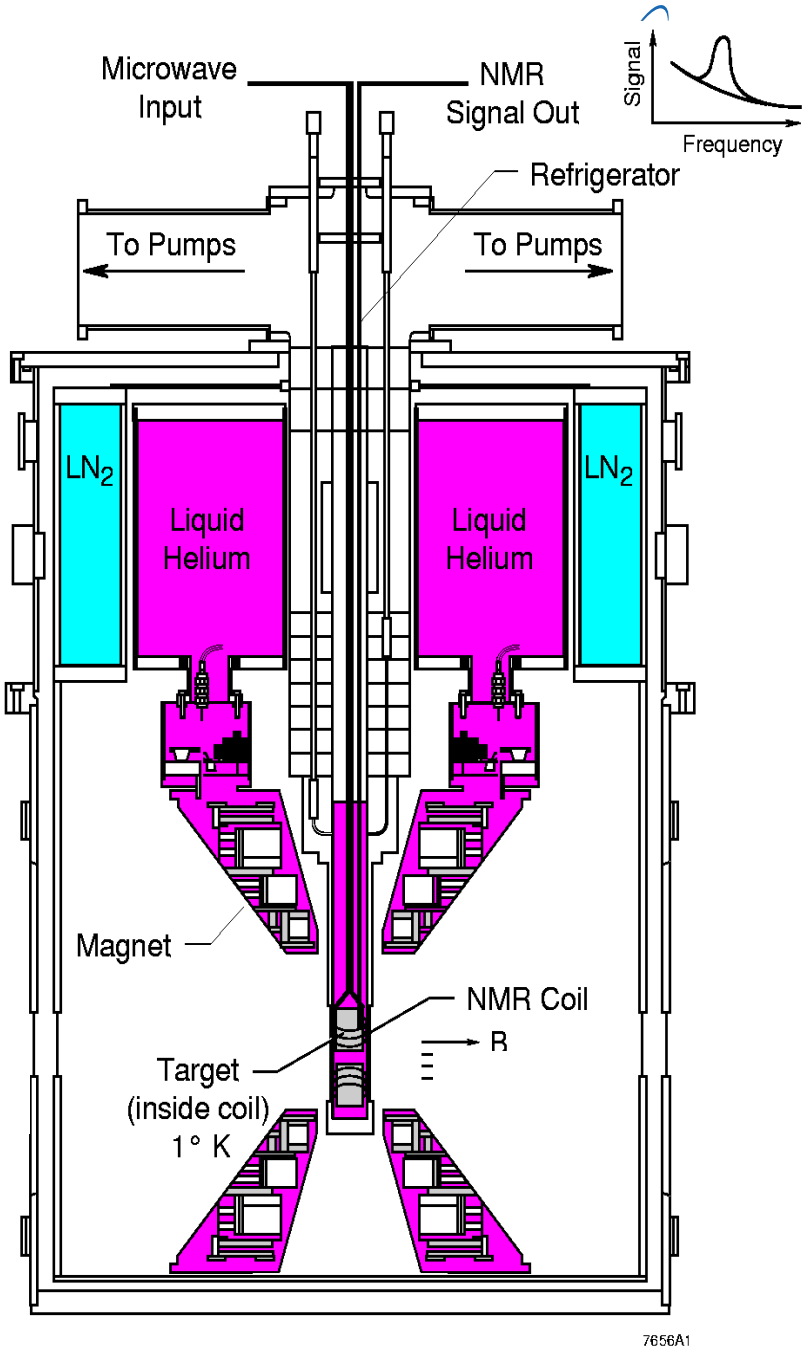




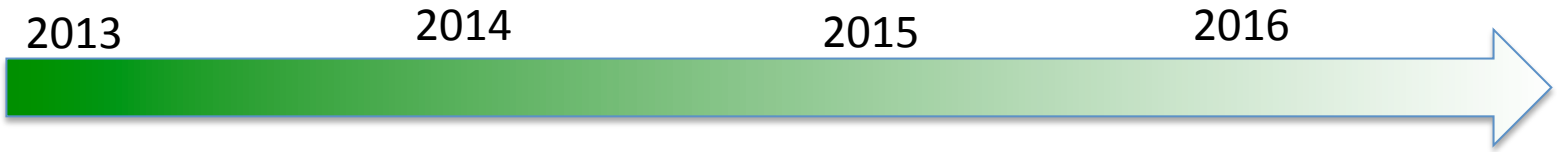
LANL High Density Polarized Proton (Neutron) Target

- Superconducting dipole magnet
  - Temperature ~ 1 K
  - Magnetic Field: 5 Tesla
  - 10cm long NH_3 target
- Proved capable of handling high luminosity
  - up to ~ 10^{35} (Hall C)
    ~ 10^{34} (Hall B)

Pol ~ 70%
I ~100nA



Proposed Timeline



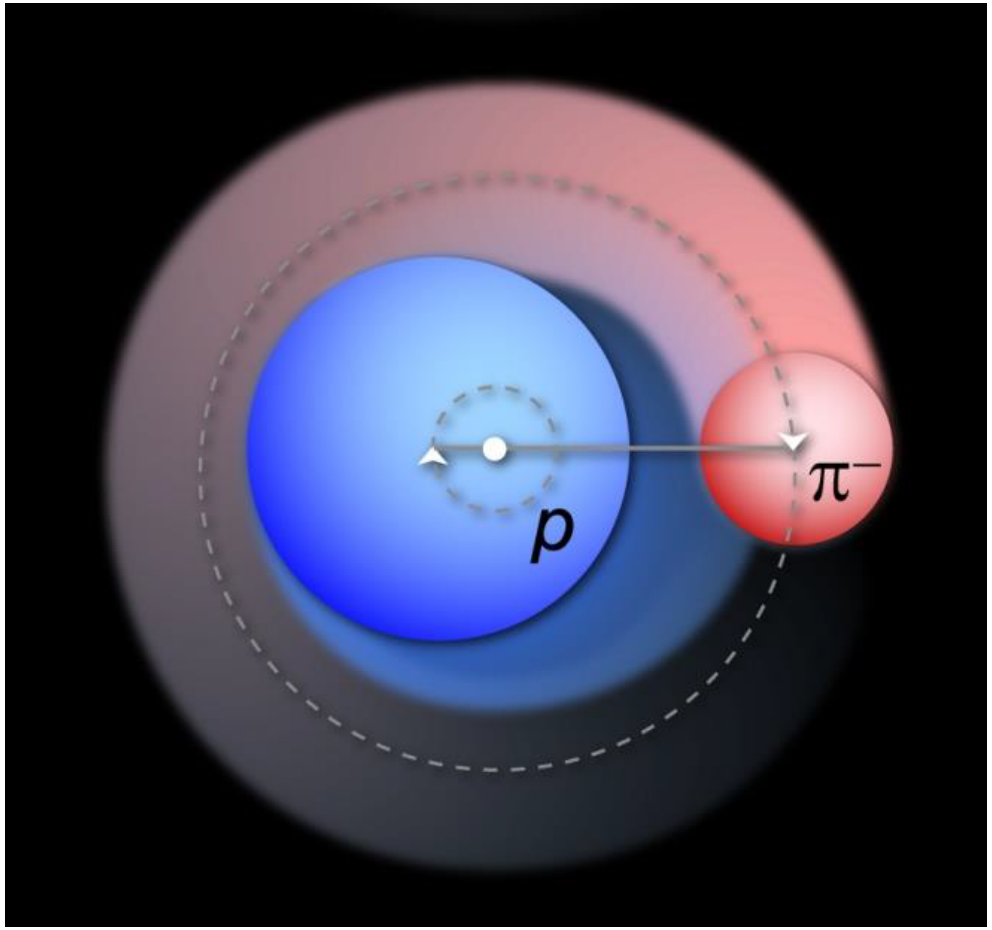
LOI & Approval

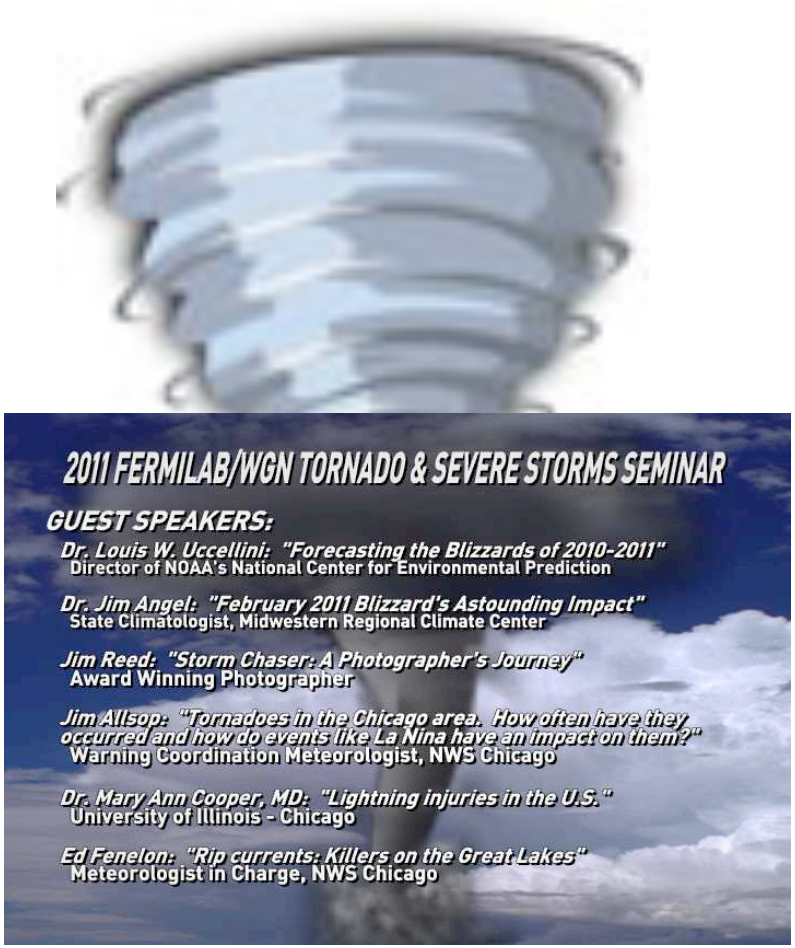
Build Pol. Target

Installation @E906
and take data

Preliminary results of 1st
antiquark Sivers asymmetry

Pion Cloud or Tornado ?





Proposed Future Polarized DY Exp's

Y. Goto 4/2010 CERN DY

experiment	particles	energy	x1 or x2	luminosity
COMPASS	$\pi\pm + p\uparrow$	160 GeV $\sqrt{s}$ = 17.4 GeV	x2 = 0.2 – 0.3	2×10^{33} cm^{-2}s^{-1}
COMPASS (low mass)	$\pi\pm + p\uparrow$	160 GeV $\sqrt{s}$ = 17.4 GeV	x2 ~ 0.05	2×10^{33} cm^{-2}s^{-1}
PAX	$p\uparrow$ + pbar	collider $\sqrt{s}$ = 14 GeV	x1 = 0.1 – 0.9	2×10^{30} cm^{-2}s^{-1}
PANDA (low mass)	pbar + $p\uparrow$	15 GeV $\sqrt{s}$ = 5.5 GeV	x2 = 0.2 – 0.4	2×10^{32} cm^{-2}s^{-1}
J-PARC	$p\uparrow$ + p	50 GeV $\sqrt{s}$ = 10 GeV	x1 = 0.5 – 0.9	10^{35} cm^{-2}s^{-1}
NICA	$p\uparrow$ + p	collider $\sqrt{s}$ = 20 GeV	x1 = 0.1 – 0.8	10^{30} cm^{-2}s^{-1}
SPASCHARM (low mass)	p + $p\uparrow$	60 GeV $\sqrt{s}$ = 11 GeV	x2 = 0.05 – 0.2	
SPASCHARM (low mass)	$\pi\pm + p\uparrow$	34 GeV $\sqrt{s}$ = 8 GeV	x2 = 0.1 – 0.3	
RHIC PHENIX Muon	$p\uparrow$ + p	collider $\sqrt{s}$ = 500 GeV	x1 = 0.05 – 0.1	2×10^{32} cm^{-2}s^{-1}
RHIC Internal Target phase-1	$p\uparrow$ + p	250 GeV $\sqrt{s}$ = 22 GeV	x1 = 0.25 – 0.4	2×10^{33} cm^{-2}s^{-1}
RHIC Internal Target phase-2	$p\uparrow$ + p	250 GeV $\sqrt{s}$ = 22 GeV	x1 = 0.25 – 0.4	6×10^{34} cm^{-2}s^{-1}

- **Polarized DY Dimuon Exp. at Fermilab Main Injector: 120GeV**

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$$\approx \frac{4\pi\alpha^2}{9x_1x_2s}\sum e^2[q_b(x_b)\bar{q}_t(x_t)]$$

Pol. Target