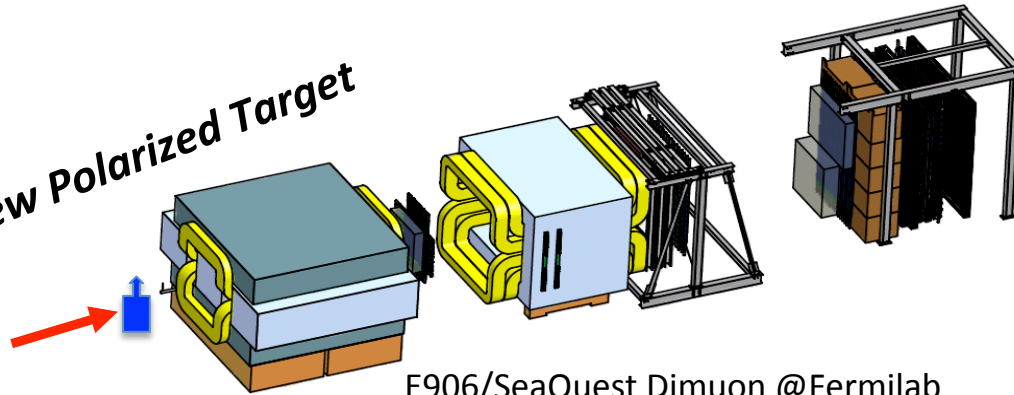


# Opportunity for a Polarized Target Drell-Yan Experiment @Fermilab

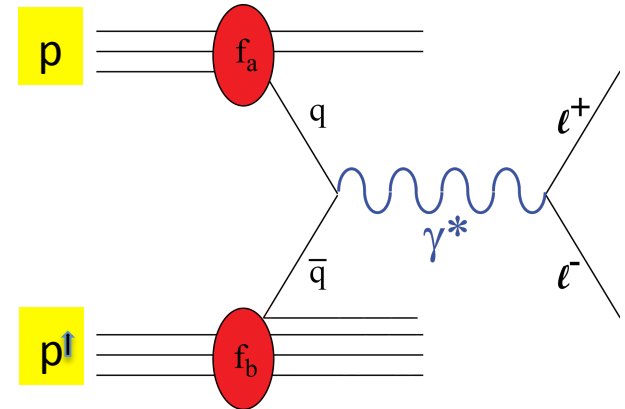
Ming Liu

Los Alamos National Laboratory

A New Polarized Target

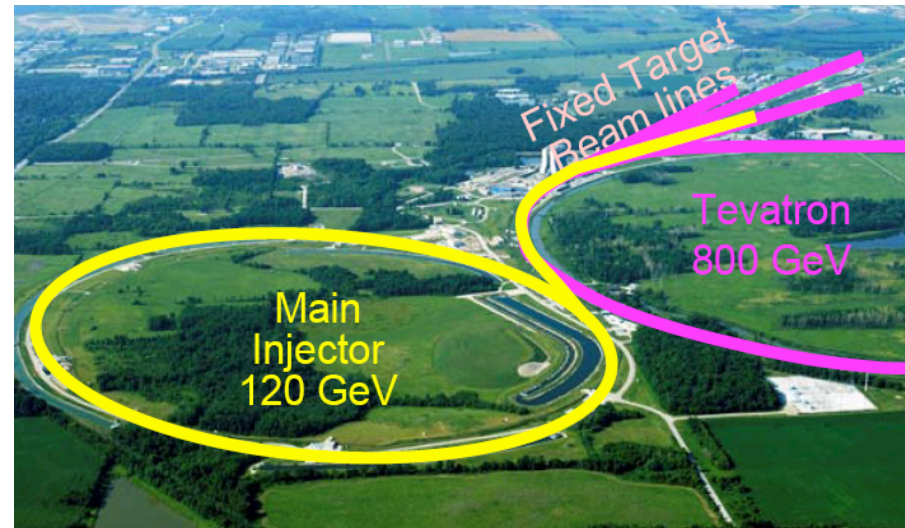


E906/SeaQuest Dimuon @Fermilab



## Drell-Yan Transverse Single Spin Asymmetry:

- Polarized 120 GeV proton beam from the Fermilab's Main Injector, E-1027
- Polarized proton ( $\text{NH}_3$ ) target, design & construction at LANL
- Polarized Target Drell-Yan (LOI submitted to PAC 2013)

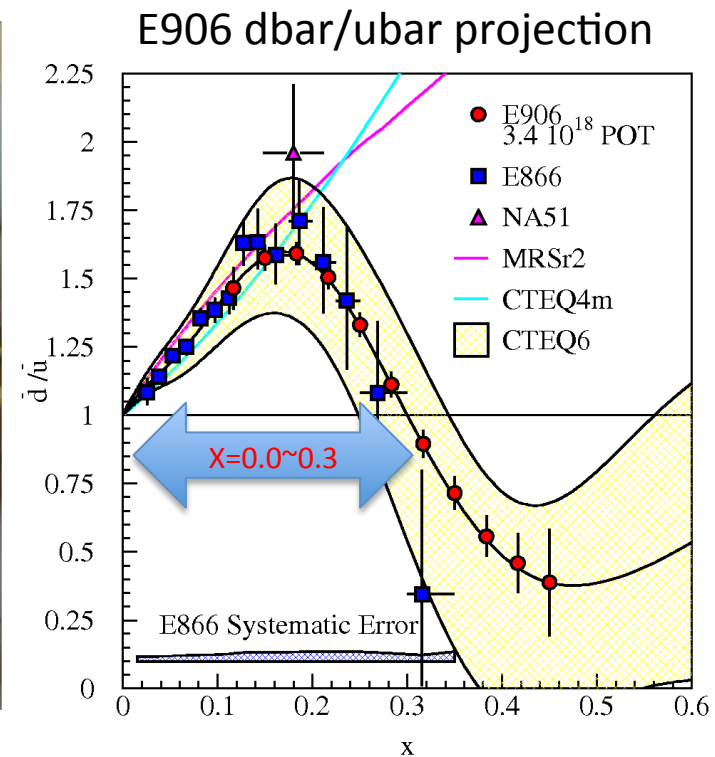


# Flavor Asymmetry

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



Thanks J.C. Peng for the flavors!

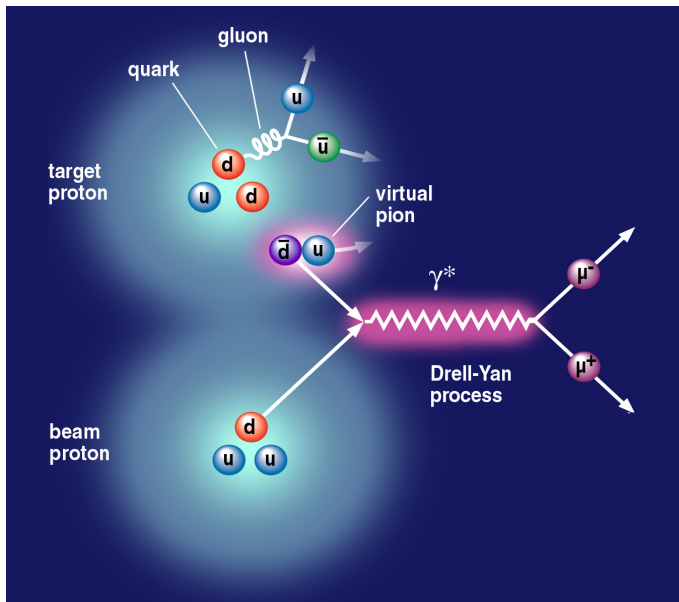
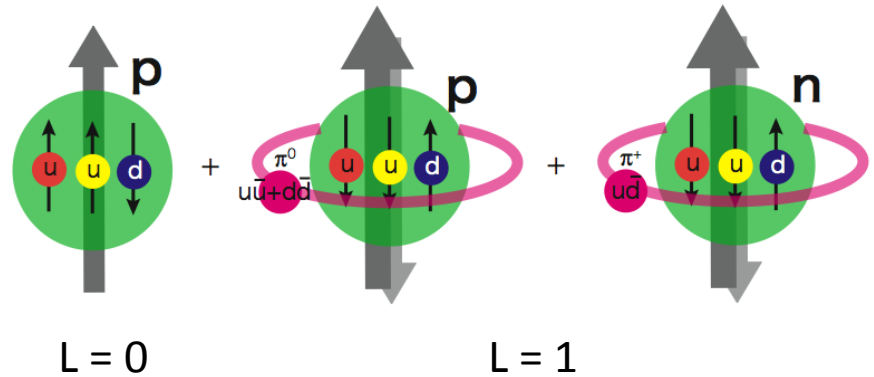


# The Physics

## all about sea quarks

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

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



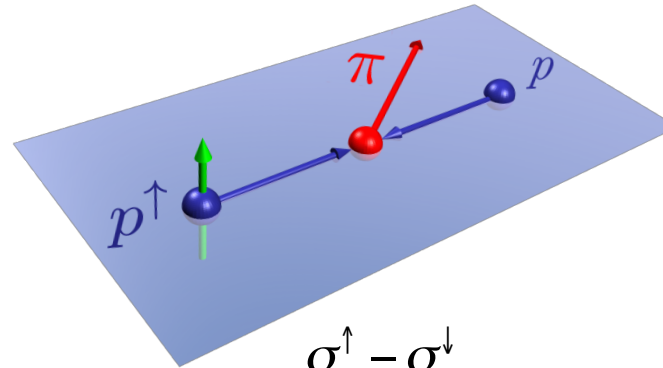
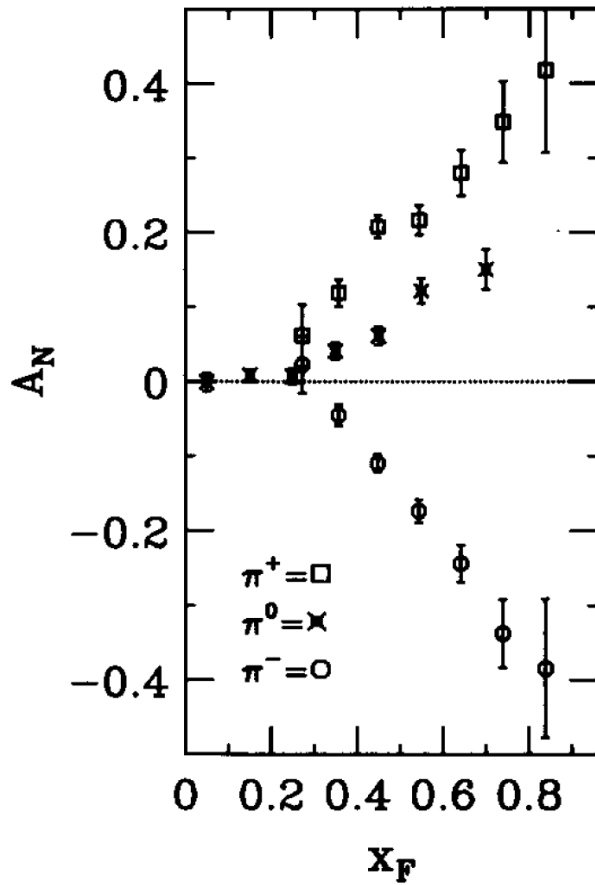
$$\frac{1}{2} = \frac{1}{2} \Delta q + L_q^z + \Delta G + L_g^z$$

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

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

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

# Transverse Single Spin Asymmetry

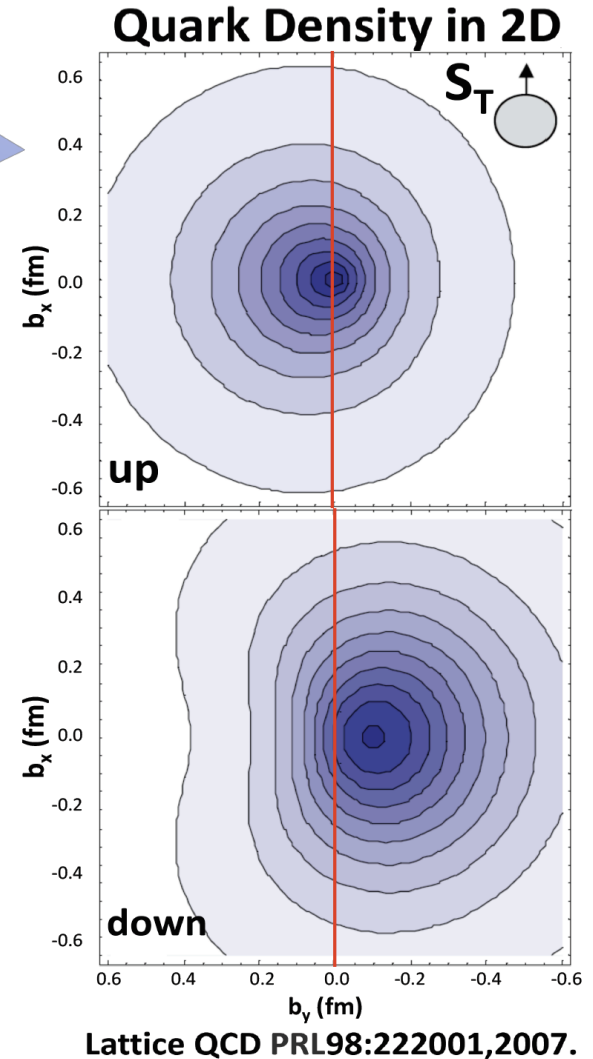


$$A_N = \frac{\sigma^\uparrow - \sigma^\downarrow}{\sigma^\uparrow + \sigma^\downarrow}$$

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

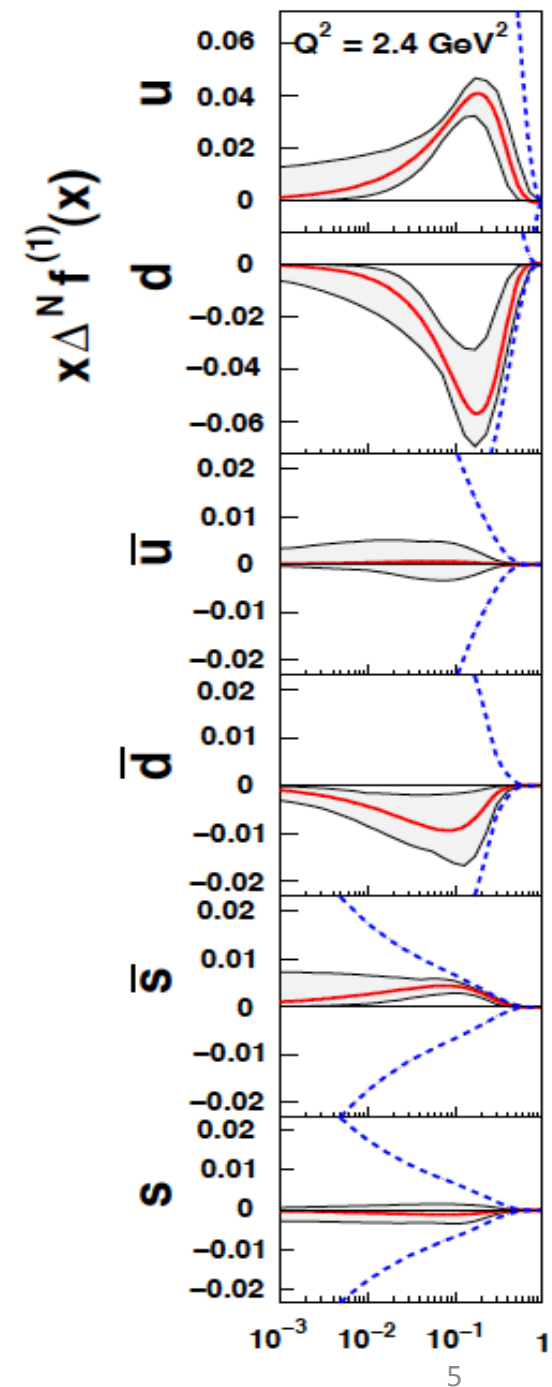
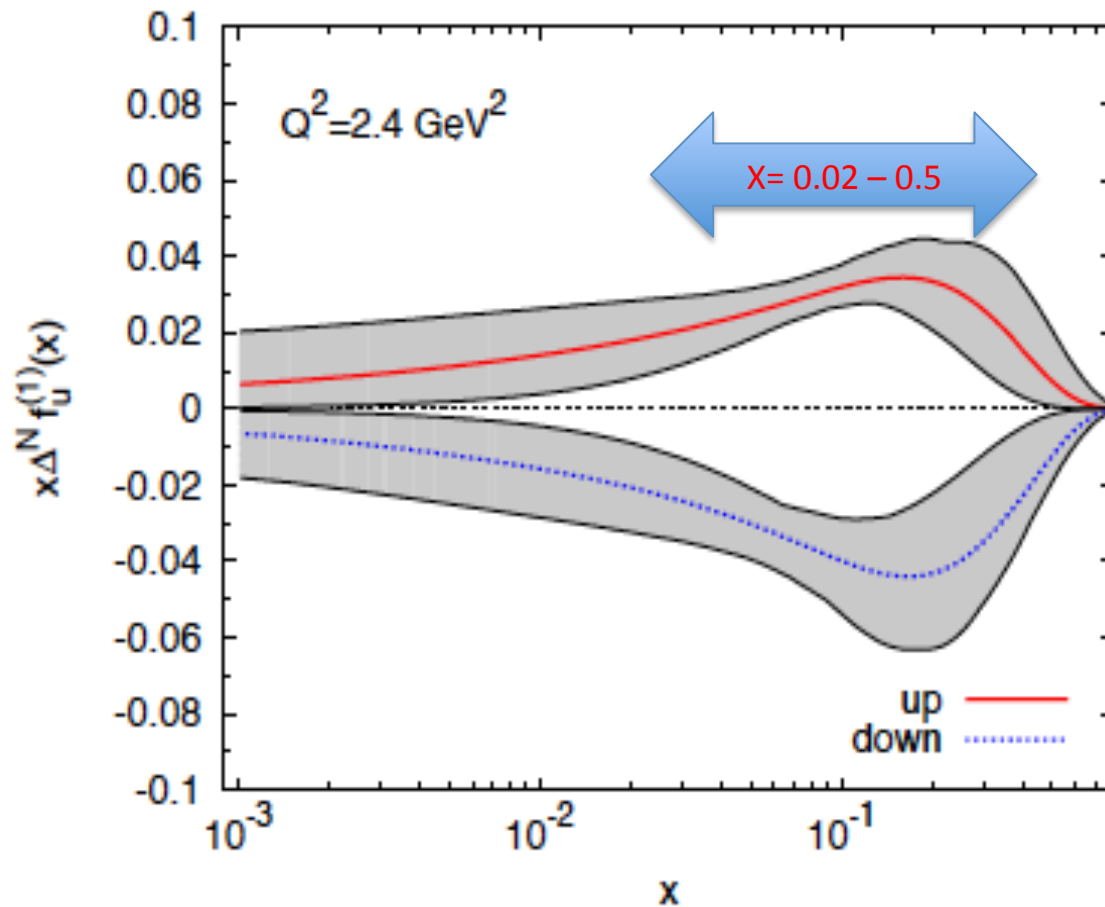
One possible explanation (Sivers effect): quark transversal motion

Fig. 4.  $A_N$  versus  $x_F$  for  $\pi^+$ ,  $\pi^-$  and  $\pi^0$  data generates a left-right bias.



# Anselmino et al PRD 79 54010(2009)

Sea quark Sivers: not much constraint by SIDIS data





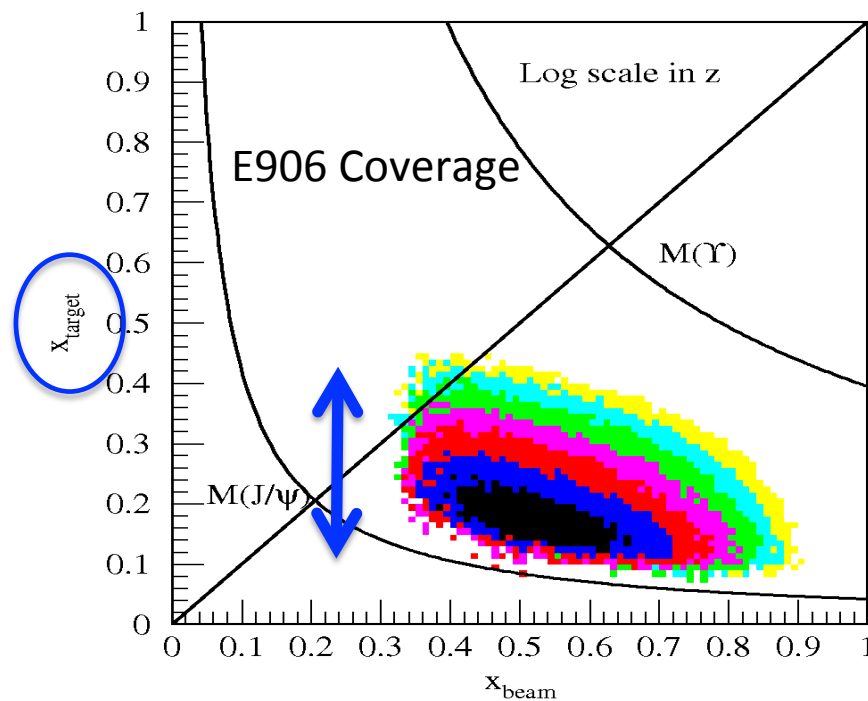
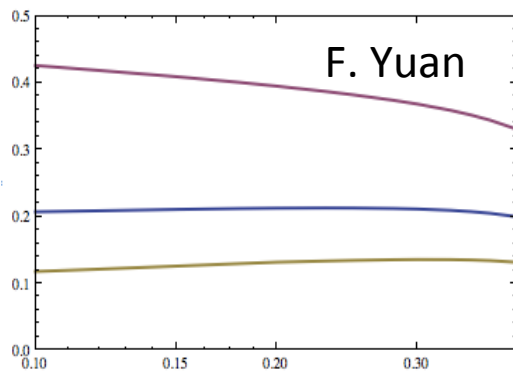
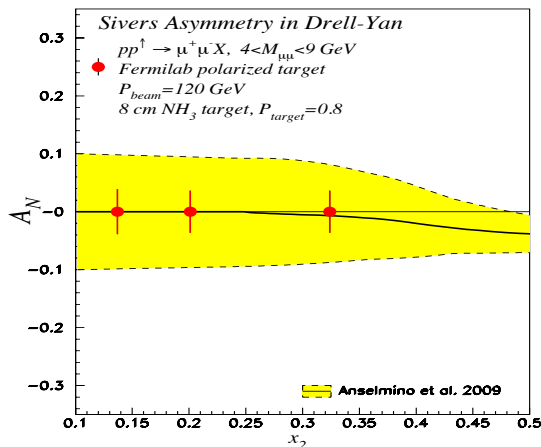
# Drell-Yan Transverse Single Spin Asymmetry @Fermilab

## SeaQuark Sivvers Effects

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

$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_1 x_2 s} \sum e^2 [q_b(x_b) \bar{q}_t(x_t) + \bar{q}_b(x_b) q_t(x_t)]$$

$$\approx \frac{4\pi\alpha^2}{9x_1 x_2 s} \sum e^2 [q_b(x_b) \bar{q}_t(x_t)] \quad \text{Pol. Target}$$

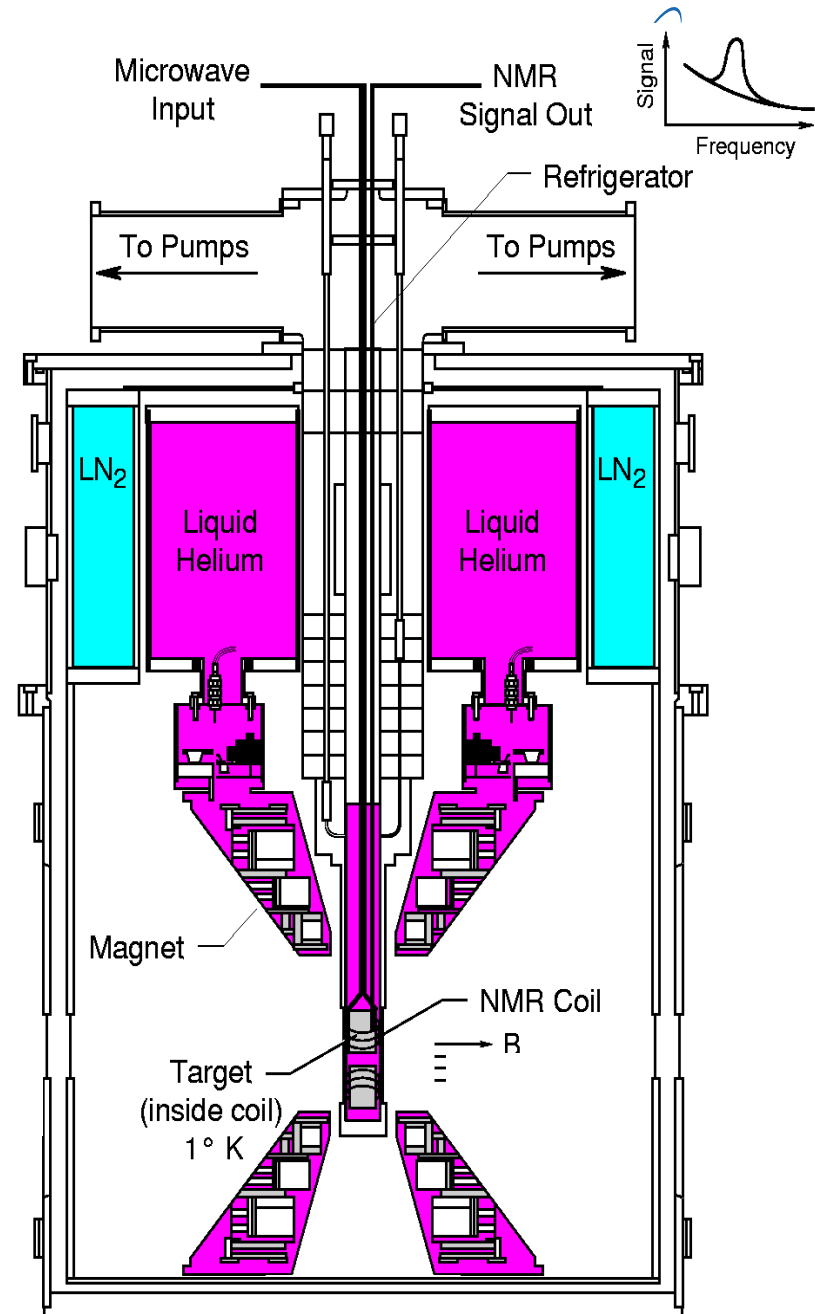


# LANL High Density Polarized Proton (Neutron) Target

- Superconducting dipole magnet
  - Temperature  $\sim 1$  K
  - Magnetic Field: 5 Tesla
  - 10cm long  $\text{NH}_3$  target
- Proved capable of handling high luminosity
  - up to  $\sim 10^{35}$  (Hall C)
  - $\sim 10^{34}$  (Hall B)



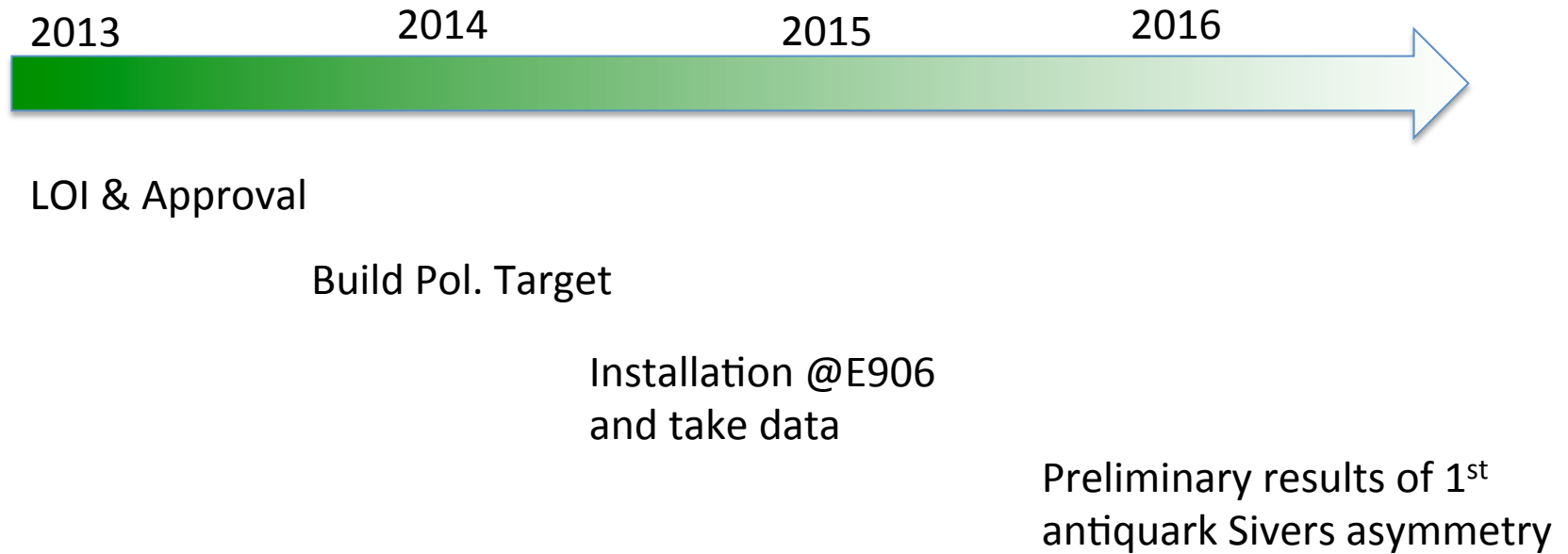
Pol  $\sim 70\%$   
I  $\sim 100\text{nA}$



4-94

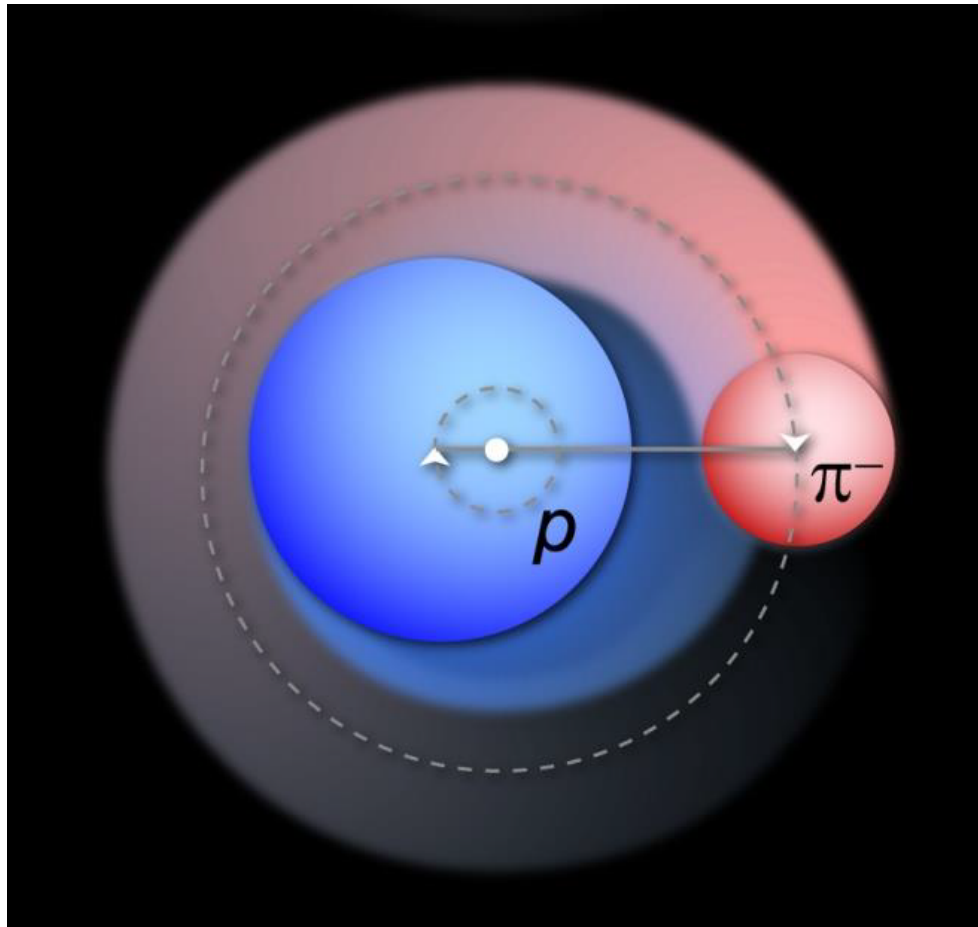
7656A1

# Proposed Timeline





# Pion Cloud or Tornado ?



## 2011 FERMILAB/WGN TORNADO & SEVERE STORMS SEMINAR

### GUEST SPEAKERS:

*Dr. Louis W. Uccellini: "Forecasting the Blizzards of 2010-2011"*  
Director of NOAA's National Center for Environmental Prediction

*Dr. Jim Angel: "February 2011 Blizzard's Astounding Impact"*  
State Climatologist, Midwestern Regional Climate Center

*Jim Reed: "Storm Chaser: A Photographer's Journey"*  
Award Winning Photographer

*Jim Allsop: "Tornadoes in the Chicago area. How often have they occurred and how do events like La Nina have an impact on them?"*  
Warning Coordination Meteorologist, NWS Chicago

*Dr. Mary Ann Cooper, MD: "Lightning injuries in the U.S."*  
University of Illinois - Chicago

*Ed Fenelon: "Rip currents: Killers on the Great Lakes"*  
Meteorologist in Charge, NWS Chicago

# 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	$x_2 = 0.2 - 0.3$	$2 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$
COMPASS (low mass)	$\pi^\pm + p^\uparrow$	160 GeV $\sqrt{s} = 17.4$ GeV	$x_2 \sim 0.05$	$2 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$
PAX	$p^\uparrow + p\text{bar}$	collider $\sqrt{s} = 14$ GeV	$x_1 = 0.1 - 0.9$	$2 \times 10^{30} \text{ cm}^{-2}\text{s}^{-1}$
PANDA (low mass)	$p\text{bar} + p^\uparrow$	15 GeV $\sqrt{s} = 5.5$ GeV	$x_2 = 0.2 - 0.4$	$2 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
J-PARC	$p^\uparrow + p$	50 GeV $\sqrt{s} = 10$ GeV	$x_1 = 0.5 - 0.9$	$10^{35} \text{ cm}^{-2}\text{s}^{-1}$
NICA	$p^\uparrow + p$	collider $\sqrt{s} = 20$ GeV	$x_1 = 0.1 - 0.8$	$10^{30} \text{ cm}^{-2}\text{s}^{-1}$
SPASCHARM (low mass)	$p + p^\uparrow$	60 GeV $\sqrt{s} = 11$ GeV	$x_2 = 0.05 - 0.2$	
SPASCHARM (low mass)	$\pi^\pm + p^\uparrow$	34 GeV $\sqrt{s} = 8$ GeV	$x_2 = 0.1 - 0.3$	
RHIC PHENIX Muon	$p^\uparrow + p$	collider $\sqrt{s} = 500$ GeV	$x_1 = 0.05 - 0.1$	$2 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$
RHIC Internal Target phase-1	$p^\uparrow + p$	250 GeV $\sqrt{s} = 22$ GeV	$x_1 = 0.25 - 0.4$	$2 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$
RHIC Internal Target phase-2	$p^\uparrow + p$	250 GeV $\sqrt{s} = 22$ GeV	$x_1 = 0.25 - 0.4$	$6 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

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

# Drell-Yan Transverse Single Spin Asymmetry @Fermilab

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$$\approx \frac{4\pi\alpha^2}{9x_1 x_2 s} \sum e^2 [q_b(x_b) \bar{q}_t(x_t)]$$

Pol. Target

