The SPIN@FERMI collaboration has updated its 1991-95 Report [1] on the acceleration of polarized protons in Fermilab’s Main Injector, which was commissioned by Fermilab. The Updated Report [2] summarizes some updated Physics Goals for a 120-150 GeV/c polarized proton beam. It also contains an updated discussion of the Modifications and Hardware needed for a polarized beam in the Main Injector, along with an updated Schedule and Budget. Some highlights of the Update are:

- Two superconducting Siberian snakes in the Main Injector, one superconducting 60° rotator in the 120-150 GeV/c extraction line, a 4% partial warm solenoidal Siberian snake in the 8.9 GeV/c Booster (oscillating with the Booster frequency) and some other minor hardware should allow about 75% polarization to be maintained and manipulated in the RFQ, Linac, Booster, Recycler Ring and Main Injector, and then extracted to the experiments.

- Polarized ion sources now have intensities of 1.0 - 1.5 mA. With either the former IUCF Atomic Beam (ABS) type polarized ion source (which is now at Dubna), or the reconstructed and improved ZGS/AGS ABS, we expect to obtain an intensity of about 1 mA. With 10% of the beam-time polarized, SeaQuest’s 50 cm long \( H_2 \) target would have a time-averaged luminosity of about \( 2 \cdot 10^{35} \, \text{cm}^{-2} \, \text{s}^{-1} \).

- The estimated total cost of the project is about $4 Million (2012 dollars). The construction time could be about 2 years after approval and funding.

### I. EXPERIMENTAL OVERVIEW

**Introduction.** The interest in spin phenomena has significantly increased in recent years. It is now clear that spin effects in high energy interactions provide essential information about the elementary particles’ properties and structure. Recently, there has been significant progress in understanding the nucleon’s longitudinal and transverse spin structure due to many polarization experiments done at SLC, HERA, CERN and RHIC. The Main Injector polarized proton beam would allow unique studies of spin phenomena such as the 1-spin asymmetry in all inclusive processes, including Drell-Yan and hadron and hyperon production. It would also allow both 1-spin and 2-spin asymmetry measurements of exclusive processes such as proton-proton elastic scattering at large \( P_T^2 \). Thus, the Main Injector’s very high intensity could test the validity of strong interaction theories at the far larger \( P_T^2 \) values possible at 120-150 GeV/c.

**Polarized Drell-Yan Experiments.** The E-866 [3] and E-906 (SeaQuest) collaborations have had a long-term interest in studying Drell-Yan processes with a 120-150 GeV/c polarized beam. Polarized Drell-Yan scattering has become a major milestone in the hadronic physics community, motivated by a fundamental prediction of QCD that postulates a sign change in the Sivers function [4] measured in Drell-Yan scattering as compared to semi-inclusive deep inelastic scattering (SIDIS) [5, 6]. Each quark and antiquark flavor has its own Sivers function described by a transverse-momentum dependent distribution function that captures non-perturbative spin-orbit effects inside a polarized proton. The experimental verification of the sign change goes to the heart of the gauge formulation of QCD and would fundamentally test the factorization approach to the description of processes sensitive to transverse parton momenta. It would be crucial to confirm the validity of our present conceptual framework for analyzing hard hadronic reactions.

**Polarized large \( P_T^2 \) elastic and inclusive scattering.** Transverse spin effects appear experimentally to increase at large-\( P_T \). A high intensity polarized beam could determine if these unexpected spin effects persist at the larger \( P_T \) possible at the 120-150 GeV/c Main Injector. The SPIN@FERMI Collaboration hopes to continue studying the proton’s transverse spin structure by scattering a 120-150 GeV/c extracted polarized proton beam from a solid polarized proton target and a liquid hydrogen target. A large left-right asymmetry \( A_L \) was found in polarized proton-proton elastic scattering at large \( P_T^2 \) [7], see Fig 1. Currently, the nucleon’s transverse spin structure is unexplored experimentally above about \( P_T^2 = 7 \, (\text{GeV}/c)^2 \). Similar large asymmetries were found in large-\( X_F \) inclusive pion production [8] from \( P_{lab} = 12 \, \text{GeV}/c \) to \( s = 3900 \, (\text{GeV}/c)^2 \), as shown in Fig. 3.
There are 2 independent 1-spin $A_N$ asymmetries in large $P_2^2$ elastic scattering (polarized beam and polarized target), $p_1 + p \rightarrow p + p$. For identical particles, such as 2 protons, the 2 independent $A_N$ asymmetries must be equal. These would be measured simultaneously with the 2-spin $A_{NN}$ asymmetry, $p_1^+ + p_1^- \rightarrow p^+ + p^-.$

A large and unexpected 2-spin asymmetry was found at large $P_2^2$ near 12 GeV/c [9], see Fig. 2. One could determine if the large and still unexplained $A_{NN}$ disappears or persists at the large $P_2^2$ available at the high-intensity 120-150 GeV/c Main Injector. Moreover, with the high intensity Main Injector, one could simultaneously measure the unpolarized proton-proton elastic cross section at large $P_2^2$ with much better precision than now exists [10].

FIG. 3: Inclusive 1-spin $\pi^+$ and $\pi^-$ $A_N$ (left-right asymmetry) plotted against $X_F$ [8].

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