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A Long Polarized Target for the Fermilab Muon Beam?§

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The purpose of this short talk is to initiate a discussion on the question of whether a long polarized target should be constructed for the Fermilab muon beam.

Results on $g_1^p(x)$ for deep inelastic scattering by longitudinally polarized electrons or muons on longitudinally polarized protons from SLAC[1,2] and EMC[3] experiments have been presented earlier in the symposium. These results suggest the surprising conclusion that most of the net proton spin is carried by gluons and/or orbital angular momentum. It is essential to confirm these data, especially at small x. Small raw asymmetries need to be measured. Thus, it would be desirable to have an experiment with different (and hopefully improved) systematic errors associated with acceptance, rate effects, chamber efficiencies, etc.

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Small x data at the highest Q^2 are most important to evaluate the fraction of spin carried by quarks. The EMC collaboration has shown[3] that the asymmetry A_1^p is roughly independent of Q^2. However as emphasized by F. Close at the symposium,

$$g_1^p(x) \simeq A_1^p \frac{F_2(x,Q^2)}{2x[1 + R(x)]} .$$

So a Q^2 dependence to $g_1^p(x)$ could arise from the structure function F_2. Therefore, the highest energy polarized muon or electron beams are desirable. This would permit measurements at the largest Q^2 for a given x, or alternately at the smallest x for a fixed Q^2. The Fermilab muon beam fits this requirement.

A number of different experiments have been suggested at the symposium. In addition to a repeat of the EMC measurements for $g_1^p(x)$ with a longitudinally polarized proton target, the corresponding neutron spin structure function $g_1^n(x)$ would be quite interesting as a check of the Bjorken sum rule. A different target material is needed (deuterated butanol or EABA, ND_3, ^6LiD, a gas or gas jet ^3He or D target, etc.), but otherwise the experimental setup is unchanged. With a transversely (S-type) polarized target, the other spin structure functions $g_2^p(x)$ and $g_2^n(x)$ could also be measured.

Polarized gas or gas jet targets have been discussed at the symposium. Their low density is compensated by multiple passes of the beam through the target. Radiation damage effects would not occur. The high purity of these targets is also an advantage, eliminating background nuclei that dilute the measured asymmetry. Gas targets are capable of rapid spin reversal, which may be essential depending on the types of systematic errors that might occur in

these targets. Such errors are better understood for conventional targets, which are not capable of such rapid spin reversal. Thus experiments with conventional targets may be more sensitive to changes in beam or detector conditions. Also, gas targets are considerably cheaper, but they may interfere with the accelerator operation by disruption of the high vacuum. One of the largest problems at present is that gas target experiments would run at lower energies than the EMC measurement.

A new conventional polarized target for the Fermilab muon beam would not be very cheap. Estimates by D. Hill of Argonne, based on the MP beam polarized target and other considerations, for a 5 x 2 cm^2 area target give the following approximate requirements for a 1m and a 3m length target (all elements included).

	1m Length	3m Length
Hardware	~ $2M	~ $4M
Manpower (Physicists, Engineers Technicians)	$\gtrsim$ 20 man years	$\gtrsim$ 40 man years
Time	3 - 5 years	

It should be noted that conventional polarized target expertise exists at various universities and national laboratories.

A number of experiments have already been proposed (but not approved) for other accelerators to pursue this same physics. One letter of intent was submitted to reassemble the polarized target apparatus[4] in the CERN muon beam to measure $g_1^n(x)$ with deuterated target material. Two letters of intent to

do a similar measurement at HERA with polarized electrons on a polarized ^3He gas target have also been submitted, and a polarized gas target for LEP is being considered. Some of these experiments would probably run before a new conventional polarized target could be built for the Fermilab muon beam.

Given the factors above, should a long polarized target be constructed for the Fermilab polarized muon beam?

References

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