Measurements of spin asymmetries for semi-exclusive hadron production in HERMES can provide useful information on the flavor dependence of quark helicity distributions in the nucleon. Such data may be useful in sorting out the contributions of the valence and the sea contributions to the quark polarization. It could be obtained by the addition of a relatively modest system of particle identification to the HERMES detector configuration. The simplest case conceptually is the production of strange leading hadrons. The production of $K^-$, an all sea object (su), should be sensitive to polarization of the sea quarks. For large $z=Q^2/E_T$ the kaon will contain the struck quark in most events. Therefore, a leading $K^-$ provides a tag for scattering by sea quarks, and a measurement of the spin asymmetry for the leading strange hadron events can provide a measurement of the helicity distributions for sea quarks.

The possibilities of polarized semi-exclusive lepton production of hadrons has been discussed in some detail by Close and Milner and Frankfurt et al. Close and Milner use empirical fragmentation functions and measured unpolarized quark distributions in calculations of the virtual photon asymmetries for pion and kaon production as a function of $x$, $z$, and charge. They observe that when both $x$ and $z$ are small, the pion asymmetries are very sensitive to the sea polarization, and a comparison of asymmetries for the two charges can provide information on the $u$ and $d$ polarizations. They note that a comparison of $K^+$ and $K^-$ asymmetries is sensitive to the relative polarization of the strange and non-strange sea. Frankfurt and coworkers consider only pion production and focus on the total pion charge, i.e., $N(x^+)-N(x^-)$, as a function of net helicity of electron and target nucleon. They use empirical data on
quark structure and fragmentation functions to determine the virtual photon asymmetries in the net pion charge yield as a function of $x$, and demonstrate that the results of measurements of these asymmetries for the proton and neutron can give estimates of the net polarization of the $u$ and $d$ valence components in the nucleon. They also demonstrate that the multiplicities of charged pions measured as a function of parallel/antiparallel beam target polarization can be directly used to extract the strange sea polarization in the nucleon.

The virtual photon asymmetries calculated by these two groups can be large if specific constituent quark components are highly polarized. Figure 1 shows the $K^-$ asymmetry for the proton as a function of $x$. The dotted (dashed) line corresponds to maximum positive (negative) sea polarization. Figures 2 and 3 present the total pion charge asymmetries expected for polarized protons and deuterons calculated by Frankfurt et al. They estimate the feasibility of measuring these asymmetries in the SMC experiment, and conclude that because of large dilution factors the CERN experiment is marginal at best. Because of the absence of dilution of the HERMES targets, asymmetries should be 5-8 times larger in the HERA experiment.

Estimates of the hadron yields made with the LERD code indicate that in a typical 400 hour run on the proton, asymmetries for leading hadrons with kinematic cuts as severe as $z>0.6$ can be made with 12 precision, provided hadrons can be identified with high efficiency. A tabulation of particle yields is presented in Table 1. Particle Identification can be accomplished in the HERMES experimental configuration with a minimum perturbation by the addition of a pair of threshold gas Čerenkov detectors placed between the back drift chamber planes, BC1 and BC2. Threshold counters have the advantage of a minimum of radiator material intercepting the spectrometer acceptance and simplicity of operation. A possible particle identification scheme is
Estimate of particle yields in HERMES for a 500 hour run with a hydrogen target, using a LUND Monte Carlo simulation. Minimum cuts were \( p_T > 0.1 \text{ GeV} \) and \( \phi > 51 \text{ GeV} \) resulting in a total of \( 2.7 \times 10^6 \) events. The number statistics have been divided by \( 10^3 \).

<table>
<thead>
<tr>
<th>( z )</th>
<th>( \eta )</th>
<th>( x^+ )</th>
<th>( x^- )</th>
<th>( K^+ )</th>
<th>( K^- )</th>
<th>( n )</th>
<th>( p )</th>
<th>( \phi )</th>
</tr>
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<td>34</td>
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<td>40</td>
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<tr>
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<td>27</td>
<td>18</td>
<td>4.1</td>
<td>3.9</td>
<td>2</td>
<td></td>
</tr>
<tr>
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<td>-</td>
<td>3.5</td>
<td>6.3</td>
<td>7.3</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

presented in Fig. 4. It would consist of a forward counter, C0, containing perfluoropentane, \( \text{C}_5\text{F}_{12} \), at atmospheric pressure as a radiator, and a second counter, C1, with a radiator of a mixture of freon 112 and nitrogen. The additional thickness of material intercepted along particle trajectories in units of radiation lengths would be about 0.05 \( x_0 \). This combination will provide identification of pions from 2.4 to 13.3 \text{ GeV}, and separation of kaons and protons between 6.4 and 15.3 \text{ GeV}. Above 15.3 pions would not be separated from kaons. This configuration is well matched to the spectrum of leading hadrons as estimated in the LUND simulation of HERMES. Should it prove to be important to extend complete separation of pions, kaons and protons to higher energies, consideration could be given to converting C1 to a ring imaging system, albeit at a much higher complexity of design and operation as well as higher cost.
The dimensions of the Heeney counters would be chosen to provide identification over the full acceptance of the FERMSS apparatus. This would imply cross-sectional dimensions of approximately 2.2 m X 4.2 m for units above and below the median plane. A radiator thickness of 0.5 m would yield about 40 photoelectrons for a f1 particle in G1, based on the performance of current designs.3) Similarly, a radiator thickness of 1.5 m in G2 would yield about 10 photoelectrons. In total about 3.0 m of drift space between drift chambers BC1 and BC2 would be required to accommodate G1 and G2. This means that the target to component distance of the FERMSS detector system beyond BC1 would be increased by 2.0 m. In such a configuration, the angular acceptance of the T20 and the calorimeters will be approximately 1.0 times those of the current design.

REFERENCES

Figure 1. The virtual photon asymmetry for $K^-$ production on the proton for $x=0.02$ as a function of $z$. The dotted (dashed) line corresponds to maximum positive (negative) sea polarization. The solid line is the prediction for zero sea polarization.
Figure 2  The proton semi-inclusive asymmetry (eq. 7) calculated in two different models for quark distributions in the nucleon. The relativistic light-cone quark model [3] (solid line) predicts the valence-quark spin contributions to the nucleon spin to be equal to constituent quark contributions. The model of Ref. [4] (dashed line) assumes no sea polarization but appropriate spin "libration factors" applied to the valence quark distributions.
Figure 3: The deuteron semi-inclusive asymmetry (eq. 8) calculated in two different models for quark distributions in the nucleon. The relativistic light-cone quark model [3] (solid line) predicts the valence quark spin contributions to the nucleon spin to be equal to constituent quark contributions. The model of Ref. [4] (dashed line) assumes no sea polarization but appropriate spin "dilution factors" applied to the valence quark distributions.
POSSIBLE PID SCHEME

C0 \( \text{rad}=\text{CSF12} \)
\( n=1.0017 \)
\( \gamma \thp = 17 \)
\( \gamma \ 3 \ 1 \ \thp = \)

C1 \( \text{rad}=\text{FR112/N2} \)
\( n=1.00052 \)
\( \gamma \thp = 43 \)
\( \gamma \ 4 \ 3 \ \thp = \)

\( \pi \)
\( \pi \ k \)
\( k \)
\( k \ p \)
\( p \)

fig. 4