Appendix G

Summary of PAC15 Workshop on Nucleon and Meson Form Factors and Sum Rules (Sanderling Inn, January 30, 1999)

INTRODUCTION:

This was the second workshop focusing on one of the five scientific topics that characterize the Jefferson Lab physics program. It should be noted that the motivation for these workshops is to review the approved physics program at JLab in the context of recent scientific developments and to match the existing program with recent key questions in the sub-field in order to identify opportunities for future experimental work.

The workshop began with a summary of key theoretical questions and recent developments, presented by A. Radyushkin, followed by a summary of recent experimental developments both at Jefferson Lab and elsewhere by S. Kuhn. An overview of the approved program in each Hall covering the topic of nucleon and meson form factors and sum rules was then presented by the Hall leaders. This was followed by an extensive discussion where key scientific questions were formulated and then matched to the approved program in order to identify possible future experimental opportunities for the Lab. These discussions are summarized below.

SCIENTIFIC QUESTIONS

Hadronic form factors are fundamental functions describing the internal structure of hadrons. It is difficult to identify broad themes associated with this sub-field that go beyond this basic statement. Of course, there are a variety of issues that pervade this topic. Some questions that were discussed at the workshop include:

- What is the role of perturbative QCD in understanding nucleon form factors at high Q^2?
- Can we understand form factors as manifestations of parton correlations?
- Can we understand the nucleon as a strongly interacting few-body system?
- Can form factor ratios be calculated in believable QCD-motivated models?
- Can non-forward distributions provide a link between form factors and structure functions?

The key element that emerged in the discussion on form factors was that JLab will likely play an important role in elucidating the link between perturbative (PQCD) and non-perturbative QCD (NPQCD). For nucleon form factors, PQCD is not expected to make dominant contributions

until at least $Q^2 = 10$ GeV^2. Thus, JLab at 6 GeV and later at 12 GeV will provide precision data from the purely NPQCD region of $Q^2 < 3$ - 5 GeV^2, to, hopefully, the edge of the PQCD regime.

Other scientific aspects of form factor studies include the important role they play in understanding nuclear structure. When nuclei are probed at length scales < 1 fm, the structure of the nucleon must be accurately included to interpret the data.

There is always some ambiguity in how certain experiments are identified with certain sub-fields. A flavor decomposition of the nucleon form factors will require information on the proton and neutron from both virtual photon exchange and Z^0 exchange (via parity violation). An interesting complement to elastic form factors are non-forward distributions. It remains uncertain if Jlab's energies will be sufficient to allow comprehensive study of these distributions.

Discussion of sum rules focussed on the Gerasimov-Drell-Hearn (GDH) sum rule for photon-nucleon scattering. This sum rule follows from general principles (eg. causality, unitarity, ...) and assumes the applicability of certain dispersion relations within QCD and Regge phenomenology. A clear distinction was made between this sum rule and the Bjorken (BJ) sum rule in deep-inelastic polarized lepton scattering. What occurs between the $Q^2 = 0$ GDH sum rule prediction and the high Q^2 BJ prediction is not a testable sum rule. Rather it is an interesting regime where the Q^2 dependence of the helicity response of the nucleon resonances must dominate. Approved measurements at JLab will provide direct information on the level of saturation of the GDH sum rule and explore the Q^2 dependence of the resonance contributions to virtual photon scattering.

EXPERIMENTAL OPPORTUNITIES FOR THE FUTURE

The approved JLab program has identified many of the important scientific questions that exist in this sub-field. PAC members were asked in an "around-the-table" format to discuss potentially important measurements that are presently part of the approved program. The following ideas were discussed:

- Nucleon $G_A(Q^2)$ and $G_{PS}(Q^2)$ determined from near threshold pion electroproduction .
- G_E^n to $Q^2 > 2$ GeV^2: It was generally felt that a significant effort in this regard should wait until the first precision data are available from the approved experiments at lower Q^2.
- Precision measurement of $G_M^p(Q^2)$: this form factor does not appear to be explicitly part of the approved program.
- Precision measurement of $G_E^p(Q^2)$ using polarized beam and polarized target to complement recoil polarization measurements.
- Performing a global reanalysis of nucleon form factor data including JLab data: perhaps a form factor sub-group would be useful for coordinating such global re-analyses.

CONCLUSIONS

The approved program for this sub-field includes many highly rated proposals. JLab is poised to make important contributions to our understanding of nucleon and meson structure through form factor measurements. Many of these measurements (including those at higher beam energies) will explore this structure at scales corresponding to the transition between non-perturbative and perturbative QCD.