PR-05-001: *Search for Exotic Pentaquark* Θ^+ Θ^{++} *in Hall C at Jefferson Laboratory*

David Richards, Wally Melnitchouk

This experiment has two successive aims. The first is the search for the Θ^{++}; the observation of such a particle, or lack thereof, will facilitate the determination of the isospin of a flavor-exotic state, and in particular whether or not it is isotensor. This will then be followed by a determination of the mass and width of the Θ^+ through the process $\gamma n \longrightarrow \Theta^+ K^-$.

Our knowledge of the cross-sections for Θ^+ production are limited, and the couplings of the Θ^+ are essentially unknown, and completely unknown in the case of a putative Θ^{++}. Thus estimates of the expected number of events, particularly for the Θ^{++}, rely primarily on models. The expected number of events, particularly for the Θ^{++}, listed in Table V using the calculation of Oh, does seem surprisingly large. It would be interesting to know the impact from, and implication for, the current Hall A study of pentaquark partners, E04-012.

PR-05-002: *The* $\gamma n \longrightarrow \pi^- p$ *Process...*

David Richards, Ian Balitsky

This is a jeopardy experiment seeking to explore the onset of perturbative behaviour in exclusive photo-production, and in particular the oscillatory behaviour of the cross section about the scaling prediction due to interference with Landshoff-type multiple-scattering processes. Though such oscillations have been observed in the differential pp elastic cross section, the proposed experiment has a far less severe fall in the cross-section with increasing energy (s^{-7}vs. s^{-10}) due to the smaller number of constituents in the initial and final states. As in the original proposal, the ability to observe such oscillations with the given resolution in $\sqrt{s}$ might be questioned (see in particular Fig. 8), though the effective resolution is improved by combining data with those from E94-104.

The applicability of perturbative QCD, and the derivation of the quark-counting rules, to exclusive scattering has long been debated. The authors have noted that, since the original proposal, further explanations of the oscillatory behavior and derivations of counting rules have been propososed, most notably through the interference with helicity-flip amplitudes.

PR-05-003: *Initial state helicity correlation in Wide Angle Compton Scattering*

Marc Vanderhaeghen, Robert Edwards

This experiment addresses high energy wide angle real Compton scattering (WACS) on the proton. In a previous JLab experiment (E-99-114), the double polarization asymmetry K_{LL} for a circularly polarized photon and measuring the polarization of the recoiling proton (i.e. the process $\vec{\gamma}+p \rightarrow \gamma+\vec{p}$ has been measured. This experiment gave compelling evidence for the handbag mechanism where the Compton scattering takes place on one quark (in contrast to the two-gluon exchange process where there are 3 active quarks).

The present experiment would measure the double polarization asymmetry A_{LL} for a polarized target, i.e. the $\vec{\gamma}+\vec{p} \rightarrow \gamma+p$ reaction at c.m. energy $\sqrt{s} \simeq 3$ GeV and at two scattering angles : $\theta_{\gamma\gamma}^{c.m.} = 70^o$ and 140°. The handbag approach predicts, under neglect of all quark mass effects, that A_{LL} should be equal to K_{LL}. The difference between K_{LL} and A_{LL} arises from finite quark mass or from quark helicity flip effects. A recent calculation for constituent quark degrees of freedom shows that in general $A_{LL} \neq K_{LL}$ when including such effects. While the present proposal is motivated by this particular constituent quark model calculation, its physics interest is much broader. The difference between A_{LL} and K_{LL} would indeed allow to test the onset of the handbag approach in terms of generalized parton distributions, and would shed a light on the nature of quark helicity flip processes. In this context it would be worthwhile to make a measurement at two different beam energies, to really check that the difference between A_{LL} and K_{LL} diminshes with increasing energy.

PR-05-004: $A(Q)$ *at low* Q *in* ed *elastic scattering*

Franz Gross, Jose Goity

One of the best ways to test relativistic theories is to compare accurate calculations (possible at low Q) with precise data. This proposed experiment, now in jeopardy, would measure the A structure function of elastic electron deuteron scattering at low $0.2 < Q < 0.8$ GeV, where disagreement between the two most accurate data sets is as large as 6%. As it turns out, predictions of different relativistic approaches in this Q range also differ by the same 6%, so more accurate data is needed to discriminate between them. The proposed experiment would resolve this issue by measuring A to an absolute accuracy of about 2% and a relative accuracy of less than 1%. These accurate measurements are of great theoretical interest; they will stimulate the further development of relativistic theory.

PR-05-005 - *Parity Violating Electron Scattering in the Resonance Region*

Wally van Orden, Franz Gross

This proposal requests time to measure the parity-violating asymmetry for the proton and deuteron for invariant masses in the resonance region with Q^2 of 0.4 to 1 GeV^2. The primary goal is to learn about the onset of Bloom-Gilman duality in this region. This would help to fill in an important gap in the data for weak interactions and will provide valuable information about the onset of scaling. There are no significant theory issues with this proposal.

PR-05-006: *Measurements of Charge Symmetry Violating Quark Distributions*

Christian Weiss, David Richards

The aim of this experiment is the study of charge symmetry violation in the nucleon's valence quark distributions [*i.e.*, a non-zero difference between $u^p(x)$ and $d^n(x)$] through semi-inclusive deep–inelastic scattering. Charge symmetry has been assumed in practically all parametrizations of deep–inelastic scattering data so far, and there is little evidence for its violation from hadronic physics. The issue of a possible violation has come up because it was noted that a substantial violation may exlpain the anomalous value of the Weinberg angle obtained in the NuTeV neutrino DIS experiment ("NuTeV anomaly").

The observable measured in the experiment is the ratio of the yields for π^+ and π^- production in semi-inclusive DIS off the deuteron, at $x > 0.35$ and large z (> 0.5). Assuming the validity of leading–twist QCD factorization, a certain expression in this ratio can be decomposed into contributions sensitive to charge violating terms in the valence quark distribution and fragmentation functions, and a sea and strange quark contribution. The authors plan to separate the terms proportional to charge symmetry violation in the quark distribution and fragmentation functions by measuring separately the x– and z–dependence of the yield ratio. The charge symmetry violating term in the valence quark distributions can then be extracted if one neglects contributions from sea quarks $(\bar{u}, \bar{d})$, as well as from strange valence and sea quark $(s, \bar{s})$.

While the envisaged extraction procedure is correct in principle, it remains unclear if the multiple assumptions made along the way are justified in the kinematical region covered by JLAB. The necessary separation of x– and z–dependent terms can be obscured by deviations from leading–twist factorization, in particular, at large z. Such deviations could be caused, for example, by exclusive $\rho^\pm$ meson production, with subsequent decays into $\pi^\pm$ and π^0. Furthermore, with only two bins in x envisaged, the separation involves considerable model dependence. Also, the neglection of the strange valence and sea quark distributions at the quoted x–values (> 0.35) is questionable. In view of the smallness of the expected charge symmetry violation, these effects need to be quantified and treated as a contribution to the overall error.

PR-05-007 - *Polarized e-2H parity violating deep inelastic scattering at CEBAF 6 GeV*

Ian Balitsky, Jose Goity

This proposal to measure parity-violating deep inelastic scattering from the deuteron is devoted to the most important topic in modern physics - the search for the new particles beyond the Standard Model (SM). The role of low-energy facilities, such as JLab, in this search is to find violations of the SM by precise measurements of the amplitudes of selected processes which are sensitive to possible contributions of virtual heavy new particles. One such experiment is a measurement of Q_{weak}; this experiment may be regarded as complementary since it addresses a product of weak and electromagnetic coupling constants not accessible in the Q_{weak} experiment. With the proposed accuracy, the estimates of masses of relevant new particles (such as new gauge bosons or leptoquarks) are around 1-2 TeV which is well within the range of the new physics predicted by some models such as sypersymmetric extensions of the SM. If violations of the SM are not detected, it will place a new, stricter bound on the set of parameters of the possible models.

My only concern is that at low energies the QCD higher-twist effects may be very important. This question is addressed by the proposal, but the fact remains that at present there are no reliable estimates of the higher-twist effects besides the common belief (based on various models) that they should be around 1%for the asymmetries that are ratios of the amplitudes.

PR-05-008: *The Q_{weak} Experiment: A search for physics at the TeV scale via a measurement of the proton's weak charge.*

Jose Goity, Ian Balitsky

Measurement of parity violating beam spin asymmetry on the proton at low Q^2 can provide a determination of the proton's weak charge. The important point here is that such a determination can at the same time give a rather precise value for $\sin^2\theta_W$ at the low Q^2 scale, actually precise enough to test the running of this quantity from $M^2_{Z^0}$ down to that scale. It turns out that the running is determined theoretically within the Standard Model with good precision (a 10σ effect!), and therefore a deviation would be a sign of new physics above the electro-weak scale. This experiment aims at a precision measurement of the asymmetry that will translate into a sensitivity to new physics at the TeV scale. The extraction of Q_{weak} from the asymmetry requires knowledge of electromagnetic and weak form factors of the proton. For this there is input from other parity violation experiments that serve to reduce the uncertainties. A 4% determination of Q_{weak} facilitates this sensitivity to TeV scale physics.

It is important to note that only an Cs atomic parity violation experiment and a measurement of the electron's weak charge via Moeller scattering provide information on $\sin^2\theta_W$ at low Q^2. These are however incompatible at the 2σ level. Another result below the Z^0 mass obtained from neutrino DIS by the NuTeV experiment shows a discrepancy with the Standard Model at the 3σ level (here there are corrections that when more realisticall taken into account may bring agreement). The determination from this experiment aims at reducing the error bar by a factor 1/3 with respect to the other low Q^2 experiments, giving the best determination of $\sin^2\theta_W$ at low Q^2.

This experiment had been approved with an A rating in 2002. It is clear that this is an important experiment that will provide a measurement of a fundamental quantity and at the same time explore the possibility of new physics beyond the electro-weak scale.

PR-05-009: *High-resolution study of the resonance in the nK^+ system*

Winston Roberts, David Richards

The authors of this proposal are interested in searching for and measuring the parameters of the putative pentaquark state, using the reaction $Be(e, nK^+K^-)X$. They expect an accurcay of 0.7 MeV for a resonance that is 3 MeV wide. They will use the High Resolution Spectrometer, the BigBite spectrometer and a large neutron detector, and they expect to be able to detect resonances with widths up to 1 MeV unambiguously.

The motivation of this experiment is the pentaquark: does it, or does it not exist, and what are its properties? As such, this measurement is very well motivated. One of the attractive aspects of this experiment is that it should be able to detect the pentaquark, with relatively narrow width, even with very small production cross sections (according to their simulations). This is very important for resolving questions about this state, which continues to generate much interest in the hadron physics community. The number of conflicting experimental results requires some kind of definitive measurement, and this experiment claims to be able to do what may be required.

PR-05-010: *Structure of the Roper resonance from measurement of the double-polarization* $p(e, e'p)\pi 0$ *reaction*

Robert Edwards, Winston Roberts

The authors of this proposal want to study the reaction $p(e, e'p)\pi 0$ in Hall A, with W ranging from 1380 MeV to 1500 MeV, and $Q2$ between 0.13 and 0.93 GeV^2. The motivation is the investigation of the structure of the Roper resonance, and the authors provide a short summary of some of the interpretations of the Roper resonance. In particular, they mention its interpretation as the radial excitation of the ground-state nucleon, or as a hybrid baryon. They also point to the different model calculations of the properties of this state, and suggest that this experiment will help clarify the structure of the state. In addition, they note that many of the models have difficulty acommodating the 'data' on this state.

An experiment such as this is one of the experiments that must be performed in order for us to understand the dynamics of QCD confinement. In this sense, the experiment could be well motivated. However, as stated, the motivation is lacking for a number of reasons. First, it is surprising that with pentaquarks being uppermost in so many people's minds, they neglected to mention the possibility that the Roper resonance could be a partner to the Θ^+. This arises in Jaffe's 'tightly-bound-diquark' scenario for the pentaquark, for instance (which also implies the existence of a nearby spin-orbit partner). Furthermore, in either the pentaquark or hybrid scenario, one still has to account for the quark-model state that would be expected to be nearby (mixing will occur between the hybrid and three-quark states, or between the pentaquark and three quark states, but there should still be two (three?) states in relatively close proximity to each other): where is it? An experiment like this could help to clarify this question in the sense that if no evidence for nearby partner states are found, then it would suggest that the three-quark interpretation is correct.

As mentioned above, the authors also pointed out that many models failed to agree with the 'data' regarding this state. The authors need to be reminded that the numbers in PDG are not data, but the result of a number of analyses: the variation over the years in the parameters extracted for this state is a testament to the reliability of the analyses that have been carried out. Are the analysis methods that will be applied to these data more

reliable? Furthermore, given that models have difficulty with existing data, how will the results of the experiment be used to determine the structure of the Roper (which the authors claim will be possible with this experiment)?

The use of recoil polarization in Hall A makes the experiment particularly interesting and is complementary to the Hall B efforts.

In summary, this experiment is one that needs to be done, but the motivation should be restated in order to strengthen the case. Given the complex mechanisms that can contribute to a process such as this, it is not clear, to us at least, that the stated goals of the proposal can be achieved.

PR-05-011: *Coherent Vector Meson Production off the Deuteron*

Christian Weiss, Anatoly Radyushkin

This experiment measures exclusive electroproduction of vector mesons (ρ^0, ω, ϕ) off the deuteron. The main aim is the study of color transparency (CT) effects. QCD predicts that small–size color singlet configurations (such as $q\bar{q}$ pairs) interact with the nuclear medium only weakly. If a vector meson is produced in such a small–size configuration (electroproduction at large Q^2), and remains sufficently small while it traverses the nucleus, its interactions with the nuclear medium should be different compared to that of a fully formed, hadronic–size vector meson. This manifests itself in a suppression of coherent (single–scattering) relative to incoherent (double–scattering) production. Specifically, the ratio of differential cross sections $d\sigma/dt$ at two different t–values, corresponding to coherent ($|t_1| \sim 0.4\,\mathrm{GeV}^2$) and incoherent production ($|t_2| \sim 0.8\,\mathrm{GeV}^2$), is expected to decrease as a function of Q^2 due to this effect.

Preliminary results have been obtained for the t–dependence of $d\sigma/dt$ for ρ^0, ω and ϕ meson photoproduction ($Q^2 = 0$) in 2004 (g10 run period). The data clearly show the existence of two regimes in the t–dependence, corresponding to coherent and incoherent production. Very preliminary results have been obtained for the Q^2–dependence of the ratio of electroproduction cross sections at t_1 and t_2, from the CLAS e6a data.

The authors propose to detect CT effects by comparing the measured ratio of differential cross sections at t_1 and t_2 with model calculations incorporating CT effects or not. The theoretical studies [6,20] quoted in the proposal demonstrate that finite interaction length effects and expansion phenomena, which tend to obscure CT effects at intermediate energies, can be suppressed in the coherent electroproduction off light nuclei at large t. Nevertheless, it is not completely clear whether the 20% discrepancy in the cross section ratio discussed here could not alternatively be explained by traditional nuclear many–body effects, with no reference to CT. Furthermore, given the fact that the whole calculation is strongly based on a particular model of CT effects, more theoretical studies are needed to clarify the situation.

We stress that the study of coherent electroproduction of vector mesons off light nuclei is interesting in itself, independently from its connection to CT. The near–threshold region corresponds to an extreme kinematical situation, where the standard description of large–Q^2 electroproduction in terms

of generalized parton distributions (GPD's) needs to be modified (large $|t_{\min}|$ and "skewness" effects). Accurate measurements in this region will help to understand the limits of the applicability of the GPD description. This information will be important for future attempts to extract the GPD's from vector meson production data at 12 GeV.

PR-05-012: *Measurement of polarization observables in eta-photoproduction with CLAS*

Wally Melnitchouk, Winston Roberts

The authors of this proposal are interested in measuring a number of single and double polarization observables that arise in the photoproduction of η mesons from nucleons. They propose to measure all seven of the observables that are accessible with polarized beams and targets, utilizing both linearly polarized and circularly polarized photons. As physics motivation, they discuss the 'missing baryon' problem, pointing out that many of the resonances that are well known from πN scattering and pion photoproduction, are not well known in η photoproduction. They also point out that the existing database of measurements - any measurements - of η photoproduction, is small, with all observables totalling fewer than 1500 data points. Many of the measurements that they propose to make will be first measurements.

The measurements that the authors wish to make do not constitute a 'complete' experiment, as recoil polarization measurements will be needed for this. However, the proposers intend to turn this to their advantage, and plan to use the two relations that must be satisfied by the observables they measure, to check their systematics. In addition, the proposed experiment is one of the crucial experiments that must be performed in order for us to make any headway in understanding the baryon spectrum.

One negative point on this proposal is the suggestion that, with the data they will collect, it will be possible to carry out 'model independent analyses'. This may be correct only as far as the extraction of multipoles goes, but any interpretation in terms of resonances will necessarily require a model. More accurately, it will require a systematic analysis effort of the kind that the proposed Excited Baryon Analysis Center will perform.

PR-05-013: *A Search for bound Θ^+ nuclei in Hall A*

Christian Weiss, Franz Gross

The aim of this experiment is the study of nuclear bound states of a possible $S = +1$ exotic baryon ("pentaquark", $uudd\bar{s}$). A state with these quantum numbers has recently been observed in various photon–, electron– and hadron–induced reactions. Its width is reported to be surprisingly small, $< 15\,\mathrm{MeV}$ from direct observations, possibly much smaller, $\sim 1\,\mathrm{MeV}$. The search for nuclear bound states of this exotic baryon, drawing from the experience with Λ hypernuclei, is clearly an interesting goal.

The proposed production mechanism is the reaction ${}^{12}C(e, e'K^-)^{12}_{\Theta}C$, in which the outgoing electron and K^- are measured directly, and the energy of the produced for the $S = +1$ nuclear system is reconstructed using the missing mass technique. Nuclear bound states of a narrow $S = +1$ baryon would manifest themselves in the form of an enhancement of the cross section for certain energies. This is a simple setup, which is well suited for the high–resolution spectrometer in Hall A.

While the proposed experiment has a potential for new discoveries, it is clear that its chances for success would be increased if some of the properties of the $S = +1$ exotic baryon were more convincingly established from production of free (unbound) states. In particular, this concerns the parity and the width of this state. Also, better knowledge of the hadronic couplings of the exotic baryon would reduce the uncertainty in the theoretical estimates of the nuclear binding energy, and allow for a more effective high–resolution search in missing mass. In short, it seems that the proposed experiment belongs to a "next generation" of exotic baryon studies, which should be undertaken after the situation surrounding the present production experiments has settled.

PR-05-014: *Neutron Tagged bound proton structure to probe the origin of the EMC effect*

Marc Vanderhaeghen, Anatoly Radyushkin

The goal of the proposed experiment is a direct measurement of the EMC effect for the bound proton. This will be achieved through inclusive electron-deuteron scattering with a simultaneous detection of the scattered electron and the recoil spectator neutron. The selection of the spectator configuration for the neutron is arranged via choosing an extreme backward kinematics and a low transverse momentum for the detected neutron. According to existing theoretical estimates, this kinematics minimizes the final-state interaction.

An important feature of the method is that the recoil neutron momentum serves as a measure of the nuclear binding strength for the bound proton. As a result, the proposed experiment allows to study the dependence of the EMC effect on the strength of the nuclear binding. It should be also emphasized that the structure functions of the bound proton are compared in this approach with the structure functions of the free proton which are known from hydrogen measurements. This is in contrast to the neutron case, where the free neutron structure functions can be obtained only in a model-dependent way. Moreover, the accessible range of the recoil neutron momentum from 50 to 400 MeV allows to study the evolution of the EMC effect from a barely bound to a strongly bound proton.

The measurement of the bound proton structure function is also very important for extraction of the neutron structure functions from nuclear targets. In particular, this is absolutely vital for an unambiguous extraction of the F_2^n/F_2^p and u/d ratios, which are among the major goals of the CEBAF 12 GeV upgrade. On a more theoretical side, the accurate measurement of the EMC effect for the proton would strongly contribute to understanding the origins of the EMC effect and distinguish between different classes of models trying to explain the EMC effect.

PR-05-015: *Measurement of the target single–spin asymmetry in quasi–elstic* $^3\mathrm{He}^{\uparrow}(\mathrm{e},\mathrm{e}')$

Christian Weiss, Wally van Orden

The aim of this experiment is to measure the two–photon exchange contribution to the elastic eN scattering amplitude. The target transverse single–spin asymmetry in elastic eN scattering, A_y, is proportional to the interference term between the one–photon and two–photon exchange amplitudes, and thus represents a clean observable sensitive to two–photon exchange effects.

Specifically, the authors plan to compare the measured asymmetry with that obtained in a theoretical calculation of the two-photon exchange contribution based on generalized parton distributions (GPD's). This calculation applies to the scattering off a free nucleon, in which the one–photon exchange contribution to the amplitude is purely real, and the interference term producing the target spin asymmetry involves *only the imaginary part* of the two–photon exchange amplitude. In the quasi–elastic scattering off a bound nucleon, however, the one–photon exchange amplitude is generally complex, due to the inelasticity of the electron–nucleus collision. The interference term should thus involve *also the real part* of the two-photon exchange amplitude. The comparison with GPD models is thus likely to be considerably more complicated than envisaged in the proposal. This aspect needs further theoretical studies (*e.g.* modeling the inelasticity of the one–photon exchange amplitude). Still, even with these complications, the target spin asymmetry in quasi-elastic scattering off nuclear targets is a clean probe of two–photon exchange effects, and thus an interesting quantity to measure.

PR-05-016: *Measurement of the F_2^n/F_2^p and d/u ratios in deep inelastic electron scattering off the tritium and helium mirror nuclei*

Wally Melnitchouk, Wally Van Orden

The main goal of this experiment is to extract the free neutron to proton structure function ratio from a measurement of ^{3}He and ^{3}H structure functions. The main theoretical uncertainty in this extraction is the calculation of the relative sizes of the nuclear EMC effects in ^{3}He vs. ^{3}H; most other effects cancel in the ratio. The theoretical uncertainties have been studied by several groups in some detail, and are at the 1% level or less for the kinematics of this experiment. In addition, this experiment promises to provide data on the absolute EMC ratios in ^{3}He and ^{3}H, which will be essential in determining the systematics A-dependence of the EMC effect. The motivation for the experiment and interpretation of the expected data appear to be clear.

PR-05-017: *A measurement of two-photon exchange in unpolarized elastic electron-proton scattering*

Anatoly Radyushkin, Marc Vanderhaeghen

The goal of the proposed experiment is the investigation of two-photon-exchange effects in elastic electron-proton scattering. These effects are thought of being responsible for the discrepancy between the Rosenbluth and polarization transfer measurements of the proton electromagnetic form factors. It should be emphasized that, from the theoretical side, taking into account the two-photon exchange contribution should not be treated as adding a purely quantum-electrodynamic correction. Strong interactions also come into play, and the results are rather model-dependent. The accurate measurement of the difference between the two extractions of the nucleon EM form factors would provide important experimental information about the two-photon-exchange effects which can be used to test existing (and future) models of the physics of the two-photon exchange. The experiment is proposed to be carried out in a rather wide range $0.9 < Q^2 < 6.6$ GeV^2 of the invariant momentum transfer Q^2, that covers the region already accessed in the polarization transfer measurements, which would allow a more precise extraction of the form factors. At large Q^2, where the electric form factor is rather small, the measurrement of the ϵ dependence of the elastic cross section provides a direct measurement of two-photon-exchange contribution.

LOI-05-001 - *Measurement of meson cloud in the nucleon*

Wally Melnitchouk

This letter of intent discusses a proposed measurement of DIS from hydrogen & deuterium in coincidence with one & two low momentum recoiling protons, respectively. The stated aims are to measure the pion structure function via the Sullivan process, and to provide a check on backgrounds for the BONUS experiment. The motivation for the former aim appears stronger than that for the latter: the pion cloud contribution is restricted to small x ($\sim 0.1 - 0.2$), while BONUS focuses more on large x. The physics which would be addressed in this experiment certainly has intrinsic merit, and a full proposal is encouraged.

In doing so, there are several theoretical issues which need to be addressed by the authors. The pion flux: Drell-Yan experiments only give an upper limit, as there could be other sources of flavor asymmetry in that case. Non-pion exchange backgrounds, such as from quark fragmentation to protons, need to be estimated. The fact that the neutron which emits a pion is bound in a deuteron should be taken into account. For the hydrogen target, there will be larger backgrounds to consider for the charge-0 exchange, such as from Pomeron exchange. Finally, although not addressed in the proposal, measurement of the pion structure function in the pion resonance region would also be of interest, for instance in studies of duality for the pion.