PAC48 PRELIMINARY REPORT

Results of Jeopardy Review to be added

Jefferson Lab

48th PROGRAM ADVISORY COMMITTEE (PAC 48)

August 10-14, 2020

U.S. DEPARTMENT OF ENERGY

JSA

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From the Director

From the Chair

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Hamburg, 14 August 2020

Robert D. McKeown
Deputy Director for Science
Jefferson Lab

Dear Bob,

This letter transmits the findings and recommendations of the 48th Jefferson Lab Program Advisory Committee (PAC48). The Committee met August 10 to 14 and considered 13 new proposals, 3 conditionally approved proposals, 5 proposals for run group additions, and 3 letters of intent. Experiments in Jeopardy will be reviewed separately on September 25, and the results of that review will be added to the present document.

Written reports on the proposals and letters of intent were prepared and reviewed by the Committee before we adjourned. 7 proposals were granted full approval, 2 proposals were approved pending a technical review by the lab (C1), and 5 proposals were approved pending review by a future PAC (C2). Two proposals were deferred. The PAC endorsed all run group additions.

The chair of the Jefferson Lab Users Organization (JLUO) participates in all PAC sessions and is included in all communication between the PAC and the spokespersons of proposals. He represents the user community at all stages of the PAC review. We regard this as highly beneficial for both sides and would like to see this tradition continue.

After a letter of intent to PAC46 (LOI12-18-004), this year's PAC received the first two proposals for measurements with a positron beam at CEBAF. In addition, a White Paper on "An Experimental Program with Positron Beams at Jefferson Lab" appeared on the arXiv just briefly before the PAC meeting in August. The Committee sees great physics potential in a positron program. We encourage a vigorous effort to explore the technical feasibility of providing positron beams, and we are looking forward to receiving further proposals in this area. Clearly, it is difficult at the present stage to predict the characteristics of positron beams that will be achievable. Our recommendations in this report are based on the hypothesis that it will be possible to provide beams with the specifications given in the proposals.

Several of the proposals received by this PAC aim at high precision measurements, reflecting the supreme potential of the upgraded CEBAF beam and detectors. In this context, the impact of

effects beyond statistics on the expected results becomes increasingly important. Therefore, we ask the authors of future proposals to provide sufficient details on how point-to-point systematic uncertainties, overall normalization errors, and theoretical uncertainties have been estimated. More generally, *the PAC urges all proponents of future experiments to carefully read and follow the "Guidelines for Proposals" on the PAC web pages.*

The TAC physics and theory reports provided to the PAC were a most valuable resource for our review, and we thank all those involved in their preparation.

Given the special situation in summer 2020, all open and closed PAC sessions were held online. We are grateful to the Jefferson Lab staff for their efforts in setting up and running the required infrastructure. This was not always easy, and our special thanks go to Susan Brown, Lorelei Carlson, and Pat Stroop, whose tireless efforts kept us afloat during the meeting.

The PAC is at your disposal for any other information or assistance we can give you. Congratulations to you, Jefferson Lab, and the user community on continued success.

With best regards,
Markus

Markus Diehl
PAC48 Chair

Introduction

The Jefferson Lab Program Advisory Committee held its 48th meeting from August 10th through August 14th, 2020. The membership of the committee is given on pages 40-41. In response to the charge (page 42) from the JLab Science Director, Dr. Robert McKeown, the committee reviewed 13 new proposals, 3 conditional proposals, 5 run group additions and 3 Letters of Intent.

Recommendations

PAC 48 SUMMARY OF RECOMMENDATIONS								
Number	**Contact Person**	**Title**	**Hall**	**Days Req'd**	**Days Awarded**	**Scientific Rate**	**PAC Decision**	**Topic**
C12-18-005	M. Boer	Timelike Compton Scattering Off Transversely Polarized Proton	C	50			**C2**	4
C12-19-001	M. Amarian	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	D	200	200	A-	**Approved**	1
C12-19-002	T. Gogami	High accuracy measurement of nuclear masses of Lambda hyperhydrogens	A	13.5			**C2**	5
PR12-20-001	J. Bernauer	Dark Light: Search for New Physics in e+e- Final States Near an Invariant Mass of 17 MeV Using the CEBAF Injector	INJ	55			**Deferred**	6
PR12-20-002	R. Milner	A Program of Spin-Dependent Electron Scattering from a Polarized He-3 Target in CLAS12	B	30	30	A-	**C1**	4
PR12-20-003	L. Tang	Extension request for E12-17-003: Determining the unknown Lambda-n interaction by investigating the Lambda-nn resonance	A	8.5			**C2**	5
PR12-20-004	A. Gasparian	PRad-II: A New Upgraded High Precision Measurement of the Proton Charge Radius	B	40	40	A	**C1**	2
PR12-20-005	H. Szumila-Vance	Precision measurements of A=3 nuclei in Hall B	B	60	60	A-	**Approved**	5
PR12-20-006	A. Gasparian	Precision Deuteron Charge Radius Measurement with Elastic Electron-Deuteron Scattering	B	40			**Deferred**	2
PR12-20-007	W. Li	Backward-angle Exclusive pi0 Production above the Resonance Region	C	29.4	29	B	**Approved**	4
PR12-20-008	A. Puckett	Polarization Transfer in Wide-Angle Charged Pion Photoproduction	A	2	2	B+	**Approved**	4
PR12-20-009	E. Voutier	Beam charge asymmetries for Deeply Virtual Compton Scattering on the proton at CLAS12	B	100			**C2**	4
PR12-20-010	E. Fuchey	Measurement of the Two-Photon Exchange Contribution to the Electron-Neutron Elastic Scattering Cross Section	A	2	2	A-	**Approved**	2
PR12-20-011	A. Deur	Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule	D	29.1	33	A-	**Approved**	3
PR12-20-012	C. Munoz Camacho	Deeply Virtual Compton Scattering using a positron beam in Hall C	C	77			**C2**	4
PR12-20-013	F. Garibaldi	Studying Lambda interactions in nuclear matter with the 208Pb(e,e'K+)208_LambdaTl	A	20	20	B+	**Approved**	5

Topic*

1 The Hadron Spectra as Probes of QCD
2 The Transverse Structure of the Hadrons
3 The Longitudinal Structure of the Hadrons
4 The 3D Structure of the Hadrons
5 Hadrons and Cold Nuclear Matter
6 Low-Energy Tests of the Standard Model and Fundamental Symmetries

C1=Conditionally Approved w/Technical Review
C2=Conditionally Approved w/PAC Review

RUN GROUP ADDITION SUMMARY				
Number	**Contact Person**	**Title**	**Hall**	**Topic**
E12-06-106A	R. Dupre	Nuclear TMDs in CLAS12	B	5
E12-13-008A	E. Smith	Measuring the Neutral Pion Polarizability	D	2
E12-09-007A	C. Dilks	Studies of Dihadron Electroproduction in DIS with Longitudinally PolarizedHydrogen and Deuterium Targets	B	3
E12-11-007A/E12-10-006E	Y. Tian	A Precision Measurement of Inclusive g2n and d2n with SoLID on a Polarized 3HeTarget at 8.8 and 11 GeV	A	3
E12-06-117A	M. Arratia	Dihadron measurements in electron-nucleus scattering with CLAS12	B	5

Proposal Reports

C12-18-005

Scientific Rating: N/A

Recommendation: C2

Title: Timelike Compton Scattering Off Transversely Polarized Proton

Spokespersons: M. Boër (contact), D. Keller, V. Tadevosyan,

Motivation: This proposal aims to measure Timelike Compton Scattering (TCS) off the proton using a transversely polarized NH_3 target in Hall C. By measuring transverse spin asymmetries and the unpolarized cross-section, this process gives access to Compton Form Factors (CFFs), some of which are accessible in approved DVCS and TCS experiments. Assuming the applicability of factorization, CFFs can be parametrized in terms of universal Generalized Parton Distributions (GPDs). This measurement can be used to test the universality of GPDs and to obtain useful information to constrain them, in particular the GPD E, which is of considerable interest due to its relation with partonic angular momentum.

Measurement and Feasibility: The measurement will take place in Hall C which requires the use of a Compact Photon Source and a transversely polarized NH_3 target. The recoil proton and the e^+e^- pair are reconstructed using the GEMs, a set of hodoscopes and the NPS electromagnetic calorimeter. The proposal requests 50 PAC days. This measurement requires the selection of the exclusive final state e^+e^- with an untagged bremsstrahlung photon beam. The various subdetectors are all existing and will be used in other experiments in Hall C. As the photon beam is untagged, to suppress the non-exclusive background a first and second level trigger setup is used. It is based on the energy deposition in the NPS and on timing responses of the NPS and the hodoscope as well as 2 hits out of the 3 GEMs aligning with the hodoscope info.

Issues: Some of the goals of the experiment (e.g., testing universality of GPDs) are overstated as they require many complementary experiments involving DVCS and TCS over a wide range of kinematics. To better understand the impact and complementarity of TCS measurements with respect to DVCS measurements, one should extract the CFFs from DVCS and TCS pseudo-data corresponding to the precision of the planned experiments. The presented impact study is very difficult to interpret, as the uncertainties do not represent the existing and planned data.

The proposal does not give enough details about what the signal to background ratio is, and which cuts are most effective to suppress it. A detailed discussion about the magnitude of the background would also be very helpful to understand the performance of the experiment, most importantly how the Monte Carlo simulation has been validated, so as to be sure that the absolute background level is reasonable. Furthermore, the concerns of the TAC report need to be addressed in more detail, as well as the following points:

1. The radiation load of the calorimeter is quoted to be 100 krad, which is 33 times the radiation hardness of the crystals: it needs to be shown how the radiation damage between recovery periods influences the energy calibration stability for the signal.

2. Good proton identification through the dE/dx measurement can only be achieved up to a momentum of 0.5 GeV: it should be shown how this impacts the measurement.

3. A full GEANT simulation of the electromagnetic calorimeter response for e/π simulation should be provided.

4. A more detailed description of the following critical experimental details is missing: the timing resolutions of all components, the timing requirement to suppress background, and how the GEMs are used in the trigger.

Summary: The PAC thinks that the physics case of the proposal is strong and nicely complements the extensive program of GPD-related measurements at JLab. However, in order for the experiment to be successful, the PAC feels that the issues mentioned above need to be adequately addressed.

C12-19-001

Scientific Rating: A-

Recommendation: Approved

Title: Strange Hadron Spectroscopy with Secondary KL Beam in Hall D

Spokespersons: M. Amaryan (contact), M. Bashkanov, S. Dobbs, J. Ritman, J. Stevens, I. Strakovsky

Motivation: The spectroscopy of strange baryons and mesons, including their fundamental strong interactions, are the focus of this proposal. New and unique data can be obtained with an intense K_L beam aimed at a hydrogen/deuterium target, using the GlueX apparatus to detect final state particles.

Measurement and Feasibility: The proponents have answered to all questions outlined in the PAC47 report. Substantial progress has been made on the issues of simulations: details on backgrounds and background reactions have been demonstrated, a demonstration of partial wave analysis for hyperon production was given. The proponents have demonstrated the measuring technique of missing mass reconstruction, allowing them to extend the measuring range both regarding small four-momentum transfers and isospin decomposition. No show stoppers have been pointed out by the TAC.

Issues: The PAC strongly recommends the collaboration to intensify their cooperation on two issues. (1) Coordinated leadership must be established together with the host laboratory to address the various technical issues connected with the R&D efforts and construction of the K_L beam. (2) Continuous cooperation with JPAC and associated members is recommended on developing tools to master the challenges connected with the clean extraction of $K\pi$ scattering, the identification of the exchange processes at small momentum transfers, and the amplitude analysis for Δ final states.

Summary: The future K_L facility will add a new physics reach to JLab, and the PAC is looking forward to see the idea being materialized, in conjunction with the plans for Hall D as spelled out in the 2019 White Paper. The collaboration should now devote all its energy to turn this challenging project into an experimental facility and in parallel prepare for a successful data analysis.

C12-19-002

Scientific Rating: N/A

Recommendation: C2

Title: High accuracy measurement of nuclear masses of Lambda hyperhydrogens

Spokespersons: T. Gogami (contact), S.N. Nakamura, F. Garibaldi, P. Markowitz, J. Reinhold, L. Tang, G. M. Urciuoli

Motivation: The hyperon-nucleon interaction is of fundamental interest in the non-perturbative regime of QCD and has implications for nuclear physics as well as astrophysical problems in the development of stars. Current theoretical calculations do not correctly predict the neutron star mass limit. This has received renewed attention in the community due to the recent limits set by gravitational wave analysis from neutron star mergers. Existing baryonic force models must be refined, and the inclusion of a three-body repulsive force via hyperon interactions is important. The specific nature of hyperon-nucleon three-body forces is debated in the theory community. Experiments providing high precision information about few-body hyperon systems are needed for theorists to refine hyperon-nucleon forces (2 and 3 body) and to determine charge-symmetry breaking terms in those forces. This not only has consequences for the description of light hyperon systems but will also be influential in constructing the neutron star equation-of-state.

Measurement and Feasibility: This proposal aims to make a precision measurement of the binding energy of $^{3}_{\Lambda}$H and $^{4}_{\Lambda}$H. The measurements require 12 days of 4.5 GeV, 50 μA beam on gaseous targets. The binding energy is determined using the missing-mass technique, reconstructed from the scattered electron and K^{+} detected in the HRS and HKS respectively. The determination of the Λ decay point requires a magnetic optics analysis. The concerns raised by PAC47 regarding a better simulation of the stated precision, the separation of the $3/2^{+}$ and $1/2^{+}$ states, as well as relating the proposed experiment to planned J-PARC experiments were satisfactorily addressed.

Issues: The PAC noted the discrepancy that the high pressure target presented in the proposal is incompatible with the geometry of the available space in the scattering chamber. There are possible solutions, where the target will have to be modified. The required re-design may affect the necessary beam time. The PAC encourages the collaboration to work with the JLab target group on a workable target for the experiment and then adjust the required beam time such that the required precision for the physics results is not compromised.

Summary: The need for new, more precise data on the binding energies of $^{4}_{\Lambda}$H and the $1/2^{+}$ and $3/2^{+}$ states of $^{3}_{\Lambda}$H is well motivated, and such data is eagerly awaited by the theoretical community. The main reason for this proposal to be classified as C2 is that the required beam time may be changed as a consequence of the modified design of the target.

PR12-20-001

Scientific Rating:

Recommendation: Defer

Title: DarkLight: Search for New Physics in e^+e^- Final States Near an Invariant Mass of 17 MeV Using the CEBAF Injector

Spokespersons: J. Bernauer (contact), R. Corliss, P. Fisher, R. Milner

Motivation: To search for a narrow resonance in the e+e– invariant mass region around 17 MeV, motivated by anomalies observed in the decays of excited states of ^{8}Be and ^{4}He, which can also be used to explain the muon g-2 anomaly. This 17 MeV resonance could be a fifth force carrier, with a suppressed proton couplings relative to the neutron.

Measurement and Feasibility: A run of 1000 hours (45 days) at the CEBAF injector (45MeV beam with 150μA current) is requested to search in the e^+e^- invariant mass region around 17 MeV in electron scattering from a tantalum target: e- Ta → e- Ta A' → e- Ta (e^+e^-). This proposal includes additional requests of 3 days for 1497 MHz accelerator commissioning and setup, and of 7 days for the commissioning of the spectrometers. This is a proposal from the existing DarkLight collaboration.

Issues: (1) The recent result on the observed anomaly in ^{4}He with an e+e- invariant mass also around 17 MeV are certainly encouraging. However, given that it is from the same experimental group that reported the ^{8}Be anomaly, it is unclear how much correlation this new result has with the previous 17 MeV anomaly. The interpretation of the anomaly by a fifth force carrier, whilst simultaneously satisfying the existing experimental constraints, requires a certain tuning of the couplings of the dark photon to quarks and leptons. Nevertheless, it is important to confirm or exclude a dark photon explanation of the anomaly in ^{8}Be and ^{4}He decay. (2) The experimental setup, the detector simulation, and the background considerations presented in the proposal have not been fully worked out, despite the recommendations by the previous TAC and PAC reports. (3) Given the running and maintenance schedule of JLab, the likely earliest start time of the proposed experiment would be in 2022, assuming that the funding for the spectrometer can be secured and that the detailed design of the experiments and background studies in GEANT can be worked out. Given the timelines of competing experiments worldwide, the proposed experiment might miss the optimal time window to be relevant.

Summary: Given that the experimental set and background simulations have not been fully developed, and given the JLab scheduling challenge in the near future, the PAC decides to defer this proposal.

PR12-20-002

Scientific Rating: A-

Recommendation: C1

Title: A Program of Spin-Dependent Electron Scattering from a Polarized ^{3}He Target in CLAS12

Spokespersons: H. Avakian, J. Maxwell, R. Milner (contact), D. Nguyen

Motivation: The goals of the experiment are to measure the transverse momentum dependence of the longitudinal spin structure of the neutron and to investigate nuclear effects in SIDIS off ^{3}He targets compared to deuterium targets.

Measurement and Feasibility: The experiment will measure inclusive and semi-inclusive spin asymmetries in electron scattering off a longitudinally polarized ^{3}He target, in a fine binning of (x, z, P_T, Q^2 and φ_h) over a large kinematic range: $0.05 < x < 0.7$, $1 < Q^2 < 9$ GeV^2, $0.2 < z < 0.9$, $0 < P_T < 1.3$ GeV. The experiment will use the CLAS12 detector, including PID for $\pi^\pm$, $K^\pm$ and pion pairs. The experiment requests 30 PAC days. Similar measurements have already been approved for proton and deuterium targets in CLAS12. Feasibility, statistical resolution and systematic uncertainties have been studied, based on simulations using the full CLAS12 Monte Carlo chain. It was found that the CLAS12 spectrometer is adequate for the measurement. A new ^{3}He polarized target using metastability exchange optical pumping (MEOP) is being developed. Significant R&D for this target has to be carried out. It needs to be demonstrated that it can reach simultaneously high polarization, high target densities and sufficiently long spin relaxation times.

Issues: The proposal submitted to the PAC assumed a beam current of 2.5 μA, necessitating a new beam dump and possibly significant updates on radioprotection. In response to the TAC and the PAC, the proponents demonstrated that a beam current of 0.5 μA can still provide sufficiently high statistical precision.

A careful R&D program with realistic target densities, magnetic fields and beam load currents is needed to establish that the high target densities and polarizations required for the measurement can be achieved. A polarimeter scheme should be devised that will monitor for possible radial or longitudinal polarization dependencies (using, e.g., measurements of the inclusive double spin asymmetry A_{LL}).

To provide as much information as possible to check the applicability of a partonic interpretation of the data, it is important to provide multidimensionally binned data and polarization-averaged multiplicities where possible.

Summary: The successful development of MEOP ^{3}He targets will make it possible to pursue a highly interesting program for studying TMD quark structure of the neutron. Comparison with future results from proton and deuterium targets will provide valuable input for improving the knowledge of quark distribution and fragmentation functions, in particular their flavor dependence, and for quantifying nuclear effects. Exciting additional opportunities may arise in the future, as

upgrades may make it possible to operate with transverse target polarization. The PAC recommends to continue the ongoing polarized target R&D vigorously.

PR12-20-003

Scientific Rating: N/A

Recommendation: C2

Title: Extension request for E12-17-003: Determining the unknown Λ-n interaction by investigating the Λnn resonance

Spokespersons: L. Tang (contact), F. Garibaldi, T. Gogami, P.E.C. Markowitz, S.N. Nakamura, J. Reinhold, G.M. Urciuoli

Motivation: Theoretical studies suggest the possibility of a Λnn resonance, and that the knowledge of its excitation energy and width can provide crucial information for a better determination of the Λn interaction. Precision mass spectroscopy using the ^{3}He(e,e',K^{+})(Λnn) reaction can give information on this resonance. The experiment E12-17-003 was approved for 10 days of data collection on Λnn events plus 2 days of calibration with the H target, from which free Λ and Σ^0 were produced. However, the statistics in E12-17-003 was such that the number of events was too small for a meaningful extraction. Therefore, it is proposed to repeat the experiment with the optimized HKS-HRS system to possibly find the Λnn resonance and the bound Σ^0nn state. If the latter exists, it will provide for the first time crucial information for determining the strength of the ΛN-ΣN interaction, which plays an essential role in bound A=3 hypernuclei.

Measurement and Feasibility: The optimized E12-17-003 experiment proposes to use the same HRS-HKS system that is designed for the E12-15-008 hypernuclear experiment, without a change of equipment or configuration. Only the target would be changed to a tritium target. The latter is the critical issue in this experiment.

Issues: (1) According to the technical review, the main concern is related to the target design and installation. The implementation of a tritium gas target with the HKS detector and magnet systems is likely to require a significantly new design and construction effort. Therefore, a resubmission of the proposal needs to include a discussion on target specifics. The PAC recommends to work with the target group on concrete plans on how the tritium target could be safely implemented in the experimental setup. (2) In addition, a sense of the uncertainties in the data analysis of the spectrum should be given, together with a state-of-the-art statistical analysis. In particular the statistical significance of the previous observation needs to be quantified (including the look-elsewhere-effect), as well as its impact on the proposed experiment.

Summary: Determining the properties of a possible Λnn resonance and a Σ^0nn bound state is an important step for determining the properties of the ΛN interaction, specifically the strength of the ΛN-ΣN transition, which may otherwise not be accessible directly. Before resubmission, the above issues must be addressed.

PR12-20-004

Scientific Rating: A

Recommendation: C1

Title: PRad-II: A New Upgraded High Precision Measurement of the Proton Charge Radius

Spokespersons: A. Gasparian (contact), H. Gao, D. Dutta, D. W. Higinbotham, E. Pasyuk, N. Liyanage, C. Peng

Motivation: Precision information on the size of hadrons can be obtained both from electron scattering and from atomic spectroscopy. It came as a big surprise that the extraction of the proton charge radius from muonic hydrogen Lamb shift measurements is in strong contradiction with the values obtained from electron-proton scattering. This 'proton radius puzzle' has triggered a large activity worldwide.

In this context, the PRad Experiment has pioneered a new technique to extract the proton radius in elastic electron scattering. Instead of using the traditional experimental technique based on magnetic spectrometry, the experiment has adopted a new calorimetric method for low Q^2 elastic scattering, using a windowless target and simultaneously recording Møller scattering for normalization of the measured cross-sections. In principle, this avoids individual point to point normalization uncertainties, which would impact the measured Q^2 spectrum.

The results obtained by this pioneering experiment (recently published in Nature) are in apparent conflict with all previous modern electron scattering experiments, especially at high values of Q^2. A new experiment with a much improved control of radiative corrections (which at the moment account for the largest part of the systematic uncertainty), with larger data sets, and which makes use of a blind analysis, is imperative to clarify the current status and to reach for the ultimate precision in *ep* scattering.

The proposed experiment aims at reducing the total uncertainty down to 0.54%, which is 3.8 times smaller than what PRad achieved, by upgrading the experimental setup.

Measurement and Feasibility: The experiment relies on the PRad setup undergoing a variety of upgrades, in particular:

1. improving the overall tracking capabilities of the setup by adding a second plane to the tracking detector,

2. adding new rectangular cross-shaped scintillator detectors to separate Møller events in the angular range 0.5^o to 0.8^o,

3. upgrading the HyCal by replacing the lead glass blocks by $PbWO_4$ and converting its readout to FADC based one,

4. improving radiative correction calculations by going to NNLO.

Three beam energies are requested, namely 0.7, 1.4 and 2.1 GeV. The lowest and highest beam energies will allow to cover the Q^2 range from 4×10^{-5} to 0.06 GeV^2. The 1.4 GeV run will serve as an important cross-check for possibly unaccounted systematics.

Issues:

- The μRWell technology (point 1 above) has never been used in a running experiment, and its reliability and radiation hardness have not been fully demonstrated. Since the main reduction on the total uncertainty arises from the addition of a second tracking station, the PAC recommends considering a second GEM station instead, further relying on the present GEM technology to reduce the risks of jeopardizing the final physics goal.
- The upgrade of HyCal (point 3 above) implies 1500 additional $PbWO_4$ crystals and a new electronic readout. The cost estimate is about $5M. While it is clear that the new readout based on FADC will strongly increase the rate of data taking (and thus reduce the statistical uncertainty), the PAC could not be convinced on the necessity of the costly replacement of the crystals for reaching the final uncertainty on the proton radius.
- The PAC strongly suggests the planning of a blind analysis to convincingly reduce possible bias stemming from the normalization and the Q^2-dependence of the form factor. In particular, all radiative correction calculations and their implementation in the Monte Carlo simulation should be fixed before the fit for the proton radius.

Summary: Given the compelling physics case and the current tension between the form factor data of PRad and all previous *ep* scattering experiments, the PAC strongly supports the request for 40 days of beam time, pending a thorough technical investigation of the actual benefits or necessity of the HyCal upgrade and the adoption of the μRWell technology.

PR12-20-005

Scientific Rating: A-

Recommendation: Approved

Title: Precision measurements of A=3 nuclei in Hall B

Spokespersons: H. Szumila-Vance (contact)**,** O. Hen, D. Meekins, D. Nguyen, E. Piasetzky, A. Schmidt, L.B. Weinstein

Motivation: Few-body systems are a unique laboratory for investigating and understanding the dynamics in nuclei, since they are sufficiently simple to allow for an exact theoretical and computational description, yet complicated enough to contain essential ingredients of a many-body system. The proposed measurements plan to constrain the theory of fundamental few-nucleon physics by measuring cross sections with high statistics over a large kinematic range on both ^{3}He and ^{3}H. Physics goals include benchmarking of few-nucleon models, constraints of the NN interaction and resulting nuclear wave functions at high momenta, scale separation of short-range correlation pairs and their formation, and the measurement of G_M^n at low and moderate Q^2.

In addition, deuterium data will be taken to complement the A=3 data. Those are also critical to the evaluation of non-quasi-elastic contributions in the measured cross sections and observables.

Measurement and Feasibility: The large acceptance and open trigger of the CLAS12 detector is used to measure inclusive and semi-inclusive hard scattering from ^{3}H, ^{3}He, and ^{2}H targets.

The target design and construction is discussed extensively in the proposal and does not seem to have any issues. The requested beam time is justified for obtaining reasonable statistics at the highest p_{miss}.

Issues: The question about systematic errors in measuring absolute cross sections in CLAS12 was adequately answered in correspondence between the proponents and the PAC.

Summary: At present, there is no experiment that probes both ^{3}He and ^{3}H across the full quasi-elastic kinematical regime. The fundamental understanding of the lightest nuclear systems and their underlying interaction needs the study of both targets with equal accuracy and a more thorough evaluation of the non-quasi-elastic reaction mechanism.

PR12-20-006

Scientific Rating: N/A

Recommendation: Deferred

Title: Precision Deuteron Charge Radius Measurement with Elastic Electron-Deuteron Scattering

Spokespersons: A. Gasparian (contact), H. Gao, D. Dutta, D. W. Higinbotham, E. Pasyuk, N. Liyanage

Motivation: Precision elastic scattering can provide information on nucleon form factors. Measurements at low values of Q^2 mostly probe the electric form factor. With the shape of the form factor close to $Q^2 = 0$ revealing the charge radius square, one obtains complementary information to the one from atomic Lamb shift measurements. The latter currently dominate the measurements for deuterium, but reveal inconsistencies between electronic and muonic deuterium on the level of 3σ. The aim of the proposed measurement is to provide new and far more precise measurements of elastic *ed* scattering and to help solving the discrepancy between different $\langle r_d^2 \rangle$ determinations in atomic physics.

Measurement and Feasibility: The experiment plans to use the upgraded PRAD detector set-up, complemented by a new target chamber instrumented with a double-layer position-sensitive silicon recoil detector.

Issues: For *ed* scattering, radiative corrections are not known precisely and are even more difficult to calculate than for *ep* scattering. In addition, the PAC finds that the physics case outlined in the proposal is not compelling enough to anticipate the resolution of these issues. Nevertheless, valuable electron scattering data at low values of Q^2 would complement the presently scarce data set on the deuteron.

The PAC suggests to carefully address the issues on radiative corrections (where the proponents currently rely on external support, which is presently focused on new calculations for the *ep* case) and to readdress the issue of deuteron breakup reactions, using more sophisticated model descriptions.

Summary: The PAC welcomes the proposed precision measurement of elastic *ed* scattering down to very small values of Q^2 and the extraction of the deuteron charge radius complementary to atomic spectroscopy measurements. It also appreciates the further use of the innovative PRad II setup. However, the potential for interpretation for the measurement cannot be evaluated at this time, as this depends on radiative correction calculations that are not expected in the near future. Moreover, the projected precision is not high enough to have an impact on the present inconsistencies of the radius extraction using electronic and muonic deuterium. Therefore, the proposal is deferred.

PR12-20-007

Scientific Rating: B

Recommendation: Approved

Title: Backward-angle Exclusive π^0 Production above the Resonance Region

Spokespersons: W. Li (contact), J. Stevens, G. Huber

Motivation: This proposal aims at measuring backward-angle exclusive π^0 production above the resonance region with a proton target. Theoretical models to describe this process include a soft mechanism (Regge exchange) and a hard QCD mechanism in terms of so-called transition distribution amplitudes (TDAs). Since the applicability of the TDA formalism is not guaranteed, the proposal aims at checking two specific predictions: the dominance of the σ_T cross section over σ_L and the $1/Q^8$ behavior of the cross section. The idea of a *u*-channel exchange is an interesting concept that is worth exploring.

Measurement and Feasibility: The proposed measurement will take place in Hall C. Detection of backward pion production requires the use of the HMS and SHMS spectrometers for the electron and proton, respectively, whilst the pion is reconstructed with the missing-mass method. The proponents will undertake a L/T/LT/TT separation at 4 different values of Q^2, with a few additional model calibration settings. The requested time is 29.4 PAC days, with 4 different beam energies.

Issues: Spectrometers need to be at more forward angles than previously used; this group will use the settings of the Fpi-12 experiment running prior to them. Since this is an unexplored kinematic region, cross sections must be estimated in order to gauge the beam time required. We note that the Theory TAC recommendations from 2018 and 2020 are somewhat in opposition regarding the assessment of the two theory descriptions mentioned above. Because of significant theoretical uncertainties in both cases, the impact of the measurement may not be very strong.

Summary: The exploration of backward pion electroproduction is feasible, and JLab is an ideal venue at which to perform it. However, the PAC has concerns about the ultimate relevance of the proposed measurement.

PR12-20-008

Scientific Rating: B+

Recommendation: Approved

Title: Polarization Transfer in Wide-Angle Charged Pion Photoproduction

Spokespersons: J. Arrington, A.J.R. Puckett (contact), A.S. Tadepalli, B. Wojtsekhowski

Motivation: This experiment plans to measure the helicity correlation parameters K_{LL} and K_{LS} for π^- photoproduction in the wide-angle regime. The nature of the interaction mechanism for this relatively simple process is not yet well understood. Theoretical studies based on GPDs suggest the dominance of twist-3 contributions and predict a sizeable and positive K_{LL} and a small K_{LS}.

Measurement and Feasibility: The measurement will take place at Hall A, using the apparatus of the GEn-RP experiment (E12-17-004), scheduled to run in 2021, with minor modifications. The proposal requests 2 PAC days. The result is expected to be measurements of the polarization observables K_{LL} and K_{LS} at well-motivated kinematic points.

Issues: Twist-3 dominance predicts K_{LL} to be roughly equal and opposite to the initial nucleon helicity correlation parameter A_{LL}, but the uncertainty on the size of K_{LL} is presently unknown. Therefore, the significance of the proposed measurement by itself is limited, but could be enhanced by a future measurement of A_{LL}.

Summary: The PAC believes that it is important to understand the basic mechanism of wide-angle pion photoproduction. This measurement by itself can give a partial contribution to this effort. It could become more relevant if combined with other measurements and if the uncertainties affecting theoretical predictions are better understood.

PR12-20-009

Scientific Rating: N/A

Recommendation: C2

Title: Beam charge asymmetries for Deeply Virtual Compton Scattering on the proton at CLAS12

Spokespersons: V. Burkert, L. Elouadrhiri, F.-X. Girod, S. Niccolai, E. Voutier (contact)

Motivation: The goal is to measure the unpolarized and polarized Beam Charge Asymmetries (BCAs) of the $e^{+/-}\, p \rightarrow e^{+/-}\, p\, \gamma$ process on unpolarized hydrogen with CLAS12, using polarized positron and electron beams at 10.6 GeV. The DVCS cross section can be expressed in terms of Compton Form Factors (CFFs), which in turn may be written in terms of Generalized Parton Distributions (GPDs) using factorization. Accurate determination of both real and imaginary parts of the CFFs is essential for the analysis of hard exclusive processes and the determination of GPDs. To this end, it is proposed to measure

- the unpolarized beam charge asymmetry A^C_{UU}, which is sensitive to the real part of CFFs,
- the polarized beam charge asymmetry A^C_{LU}, which is sensitive to the imaginary part of CFFs,
- the beam-charge averaged beam spin asymmetry A^0_{LU}, which is in particular sensitive to higher twist effects.

The combination of measurements with oppositely charged incident beams is theoretically the cleanest way to access the CFFs described above. It hence provides a highly attractive way to constrain the GPDs. The kinematic range accessible with an 10.6 GeV beam on an proton target will allow one to investigate the Q^2 dependence at fixed x.

Measurement and Feasibility: The measurements are planned with the CLAS12 spectrometer in the out-bending mode, using the regular detector arrangement with a luminosity of 0.6×10^{35} $cm^{-2}\, s^{-1}$. The requested beamtime is 2400 hours. As a secondary e^+ beam has a much larger momentum dispersion and emittance than the primary e^- beam currently existing, one has the same $\delta p/p$ with a spot size 2-3 times larger at the target. Therefore, a target cell with 50% larger (15 mm diameter) entrance and exit windows is needed to avoid any interaction with the target structure frames. This difference in the beam parameters leads the collaboration to require equal statistics of electron and positron data using secondary e^+ *and* e^- beams.

Issues: The iTAC report concludes that "while a positron beam upgrade is a major upgrade, which will require substantial accelerator physics development, a detailed cost and implementation plan, and expensive changes to the CEBAF accelerator, a multi-Hall positron beam capability could have great potential for a future JLAB 12-GeV science program." The PAC fully agrees with this statement.

To clearly show what science would be left unaddressed without having a polarized positron beam available at JLab, the physics impact of positron beam experiments should be demonstrated more rigorously. This should include an impact study with positron beam pseudo-data and all other existing and anticipated future data with an electron beam. One would also like to see which amount of electron data alone would be needed to obtain comparable constrains on the CFFs. Furthermore, to guide the technological development of a positron source, it is important that the experiment determines clear performance requirements for the positron beam.

The PAC notes that proposal PR12-20-012 requires no electron data set with equal beam conditions for an extraction and separation of CFFs with high accuracy. It would be interesting if both groups could come to a common understanding on this issue.

Summary: The PAC recognizes the strong science case of positron beams for the GPD program at JLab. However, it feels that more rigorous simulations are needed to highlight the unique potential of the proposed experiment for constraining Compton Form Factors and eventually GPDs. Moreover, the amount of required beam time with secondary electron beams needs to be justified in a more quantitative way.

PR12-20-010

Scientific Rating: A-

Recommendation: Approved

Title: Measurement of the Two-Photon Exchange Contribution to the Electron-Neutron Elastic Scattering Cross Section

Spokespersons: E. Fuchey (contact), S. Alsalmi, B. Wojtsekhowski

Motivation: This proposal aims to provide a first measurement of the two-photon exchange contribution to elastic electron-neutron scattering

Measurement and Feasibility: This is is a two-day extension to the GMn experiment E12-09-019 in Hall A, which is presently scheduled for 2021. It uses the approved beam time at 4.4 GeV of the GMn experiment together with new beam time at 6.6 GeV. A method originally used at Mainz takes ratios of d(e,e'n)p and d(e,e'p)n cross sections. With the large acceptance of the hadronic calorimeter, neutrons from *en* and protons from *ep* scattering can be detected simultaneously. The main goal is to measure the Rosenbluth slope for *en* elastic scattering at $Q^2 = 4.5\ GeV^2$. The two-photon exchange contribution will be determined by comparing this to results on G_E^n/G_M^n obtained with the polarization transfer method.

Issues: Results should be presented as cross section ratios in addition to the two-photon interpretation. In this way, theorists will be able to use the data for their own interpretation.

Summary: We judge this to be a quality measurement and an efficient use of beam time.

PR12-20-011

Scientific Rating: A-

Recommendation: Approved

Title: Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule

Spokespersons: M. M. Dalton, A. Deur (contact), S. Sirca, J. Stevens

Motivation: The Gerasimov-Drell-Hearn sum rule relates the integral over the doubly-polarized spin-dependent photo-production cross section off a hadron to the anomalous magnetic moment of the hadron. It may be derived in dispersion theory, where it rests on fundamental concepts such as causality, unitarity, Lorentz and gauge invariance, as well as on a "no-subtraction'' hypothesis. Whilst the integral runs all the way to infinitely large photon energy, experimental studies at LEGS, MAMI, and ELSA have so far been limited to 2.9 GeV. The proposal extends the exploration of the high-energy regime to 12 GeV. The measurement would provide valuable information on Regge phenomenology in the polarization domain in this energy range. This is well motivated and uniquely possible at JLab. An experiment planned for the 6 GeV program did not run.

This experiment will enrich the physics program of Hall D, in particular by using a polarized target. As such, the proposal is strongly endorsed by the GlueX collaboration.

Measurement and Feasibility: The experiment is to run in Hall D with a circularly polarized photon beam generated by polarized electrons impinging on a radiator. It will run in two configurations, which require two different CEBAF beam energies with 21 PAC days at the nominal CEBAF energy and 12 PAC days at an energy 1/3 to 1/2 of the nominal one. It is planned to measure photo-production off protons as well as off deuterons, so that also the neutron GDH integral could be tested. The proponents have decided to use the FROST target design, due to its easier operation and higher neutron polarization. A new version of the target will need to be built. The Hall D detection system is well suited for this measurement, thanks to its large solid angle.

Issues: The TAC report notes that the experiment is quite demanding, but that no real show-stopper has been identified. The PAC agrees with this statement. In addition, the polarized target infrastructure may be re-used in other physics programs at JLab.

Summary: The PAC recognizes the strong science case for this proposal, and recommends running with the full beam time requested in the proposal.

PR12-20-012

Scientific Rating: N/A

Recommendation: C2

Title: Deeply Virtual Compton Scattering using a positron beam in Hall C

Spokespersons: J. Grames, C. Munoz Camacho (contact), M. Mazouz

Motivation: The goal of the proposed experiment is to cleanly separate the squared Compton amplitude, $DVCS^2$, from the DVCS-BH (Bethe-Heitler) interference term in the process $e\,p \rightarrow e\,p\,\gamma$ at large Q^2. This separation allows one to disentangle the real and imaginary parts of the Compton Form Factors (CFFs), which can be expressed in terms of Generalized Parton Distributions (GPDs) using factorization. An accurate determination of both real and imaginary parts of the CFFs is essential for the analysis of hard exclusive processes and the determination of GPDs.

The combination of measurements with oppositely charged incident beams is the theoretically cleanest way to disentangle the contribution of the $DVCS^2$ term and its interference with the BH amplitude. It hence provides a highly attractive way to constrain the GPDs.

Measurement and Feasibility: To achieve high precision, the experiment will use the High Momentum Spectrometer (HMS) of Hall C together with the Neutral Particle Spectrometer (NPS), which is a high-resolution $PbWO_4$ electromagnetic calorimeter. It is proposed to measure the cross section of the DVCS reaction with positrons on unpolarized protons in a wide range of kinematics, using beam energies of 6.6, 8.8 and 11 GeV. This will allow for several values of Q^2 at given values of x.

To exploit the beam charge dependence of the cross section and separate the $DVCS^2$ from the DVCS-BH terms, these measurements will be combined with DVCS cross section measurements that use the existing CEBAF electron beam.

The proponents request 77 days of unpolarized positron beam with a current $I > 5\mu A$. At the moment when the experiment could run, the experimental setup will have been used in several other experiments and will therefore very well understood. Therefore, there are no concerns about the experimental setup, and the committee is confident that the described measurements can be performed.

Issues: The iTAC report concludes that "while a positron beam upgrade is a major upgrade, which will require substantial accelerator physics development, a detailed cost and implementation plan, and expensive changes to the CEBAF accelerator, a multi-Hall positron beam capability could have great potential for a future JLAB 12-GeV science program." The PAC fully agrees with this statement.

To clearly show what science would be left unaddressed without having a polarized positron beam available at JLab, the physics impact of positron beam experiments should be demonstrated more rigorously. This should include an impact study with positron beam pseudo-data and all other existing and anticipated future data with an electron beam. One would also like to see which amount of electron data alone would be needed to obtain comparable constrains on the CFFs. Furthermore, to guide the technological development of a positron source, it is important that the experiment determines clear performance requirements for the positron beam.

The PAC notes that proposal PR12-20-009 requires an equal-statistics electron data set for an extraction and separation of CFFs with high accuracy. It would be interesting if both groups could come to a common understanding on this issue.

Summary: The PAC recognizes the strong science case of positron beams for the GPD program at JLab. However, it feels that more rigorous simulations are needed to highlight the unique potential of the proposed experiment for constraining Compton Form Factors and eventually GPDs.

PR12-20-013

Scientific Rating: B+

Recommendation: Approved

Title: Studying Λ interactions in nuclear matter with the ^{208}Pb (e,e' K^+) $^{208}{}_{\Lambda}$Tl reaction

Spokespersons: O. Benhar, F. Garibaldi (contact), P.E.C. Markowitz, S.N. Nakamura, J. Reinhold, L. Tang, G.M. Urciuoli, T. Gogami

Motivation: The proposal focuses on measuring the excitation spectrum of $^{208}{}_{\Lambda}$Tl obtained from the ^{208}Pb (e,e' K+) $^{208}{}_{\Lambda}$Tl reaction, in order to aid the resolution of problems associated with the role of hyper-nuclear matter in determining the maximum mass of neutron stars. A similar experiment using ^{40}Ca and ^{48}Ca targets, proposed by this group, has been approved to investigate the isospin dependence of hyperon dynamics (E12-15-008).

Using the heavier target with large neutron access provides an as good as possible proxy of matter in the interior of a neutron star. State-of-the art calculations of neutron matter with modern two- and three-body hyperon-nucleon forces indicate that the three-body forces become repulsive at high density, a feature that cannot be constrained considering only lighter systems.

Measurement and Feasibility: The measurement is proposed to take place in Hall A, using the same experimental apparatus as for experiment E12-15-008 but a cryogenic cooled Pb target. The proposal gives less specific information on the feasibility of the proposed measurement, such as details and simulations of the statistical resolution and backgrounds, as well as on the extraction of the Λ binding energy from the measurement and on the improvement with respect to the already approved E12-15-008 experiment. More information was provided in correspondence between the proponents and the PAC.

Issues: The PAC recommends the proponents to perform a state-of-the-art analysis of the results they expect to extract from the measurements, taking into account statistical and systematic errors as well as background. This should help optimizing the experiment. Also, the PAC recommends to work with the JLab target group to make a concrete plan of the target.

Summary: The proposal was presented at PAC46 and deferred. In this resubmission, issues previously raised are adequately addressed as far as the technical description is concerned. In addition, the group reached out to the relevant theory community investigating the hyperon puzzle in neutron stars with state-of-the-art approaches. For this community, the outcome of the measurements will be of interest in its own. Therefore, the remark in the PAC46 report that "it will highly valuable to see the results of the approved ^{40}Ca and ^{48}Ca measurements and their impact on ΛN and ΛNN forces" is not an issue any more, and PAC48 recommends approval.

Run Group Additions

E12-06-106A

Title: Nuclear TMDs in CLAS12

Spokespersons: Z.-E. Meziani, H. Szumila-Vance, R. Dupré (contact)

Motivation: There is a large program of measuring transverse momentum dependent parton distribution functions (TMDs) on nucleons. This proposal wants to extend this program to nuclei so as to explore an essential aspect of QCD studies, the effect of the nuclear medium on the dynamics and motion of quarks and gluons. These measurements are a natural extension of the program of measuring collinear nuclear parton densities and fragmentation functions. Like in the nucleon case, the tool to be used is semi-inclusive deep inelastic scattering (SIDIS).

Measurement and Feasibility: This proposal complements the already approved physics program of CLAS12. In order to perform these studies, it is planned to use the targets and beam time already approved for Run Group D, with the only addition being the use of beam polarization. In this way, the beam time is optimized.

Summary: There is no question that the proposed measurements are interesting if one can really interpret them in the TMD framework. There are a couple experimental hurdles that need to be well controlled, namely acceptance and radiative corrections. It is especially important that the acceptance corrections and radiative corrections be applied in a combined Monte Carlo method, because they do not factorize. In parallel to the experimental program, it would be good to see a theoretical development to interpret the data and to provide an understanding whether factorization holds in the kinematic regime and how much of the data is really in the current fragmentation region.

E12-13-008A

Title: Measuring the Neutral Pion Polarizability

Spokespersons: E. Smith (contact), M. Ito, B. Zihlmann, R. Miskimen, I. Larin

Motivation: This proposal aims to provide a first measurement of the π^0 electric polarizability

Measurement and Feasibility: The experiment will use 20 days existing beam time and the same apparatus as the charged pion polarizability experiment in Hall D. This uses the GlueX detector with an additional radiator and additional shower counters. The experiment uses the Primakoff method to measure the $\gamma\gamma \rightarrow \pi^0 \pi^0$ cross section. Getting an accurate normalization of the cross section must be a priority.

Summary: This is a well-justified measurement with existing apparatus.

E12-09-007A

Title: Studies of Dihadron Electroproduction in DIS with Longitudinally Polarized Hydrogen and Deuterium Targets

Spokespersons: H. Avakian, C. Dilks (contact), O. Soto

Motivation: The goal of this proposal is to measure dihadron correlations in SIDIS off longitudinally polarized hydrogen and deuterium targets. This measurement can provide useful information to constrain twist-three parton distribution functions, dihadron fragmentation functions, and fracture functions.

Measurement and Feasibility: The proposal is an addition to Run Group C in Hall B and is fully endorsed by the CLAS collaboration. The measurement *per se* is feasible, but the interpretation in terms of partonic distributions needs to be carefully assessed.

Summary: The PAC considers the proposal a valuable addition to Run Group C, especially because it can be useful to study higher-twist contributions, the limits of applicability of twist-three factorization (both collinear and TMD), and the separation of current and target fragmentation. The PAC recommends to provide results for all observables suitable to confront those issues (for instance, multidimensional binning of data and polarization-averaged multiplicities).

E12-11-007A/E12-10-006E

Title: A Precision Measurement of Inclusive g2n and d2n with SoLID on a Polarized ^{3}HeTarget at 8.8 and 11 GeV

Spokespersons: Chao Peng and Ye Tian (contact)

Motivation: Precision study is proposed of the fundamental spin structure function $g^n_2(x,Q^2)$ for the neutron. This would quantify higher twist contributions to $g^n_2(x,Q^2)$ by determining the 3rd moment, dn^2 (Q^2), of a properly chosen linear combination of $g^n_1(x,Q^2)$ and $g^n_2(x,Q^2)$. The measurement would provide a test of the Burkhardt-Cottingham sum rule.

Measurement and Feasibility: The proposal aims at the measurement of longitudinal spin asymmetries in inclusive DIS from a polarized ^{3}He target using the SOLID detector. The feasibility of this measurement has been established through careful Monte Carlo simulation studies of inclusive DIS and SIDIS with different targets and the SOLID detector. There are no concerns with regard to the experimental feasibility.

Summary: The cross section in inclusive DIS is described by four fundamental structure functions, $g_1(x,Q^2)$, $g_2(x,Q^2)$, $F_1(x, Q^2)$ and $F_2(x,Q^2)$. It is highly important to characterize these four structure functions over a large kinematic area with high precision for protons and neutrons, using targets of polarized protons, deuterium, and ^{3}He. Measuring g_2 and d_2 offers the exciting opportunity to determine the size of the higher twist contribution to g_2.

E12-06-117A

Recommendation:

Title: Dihadron measurements in electron-nucleus scattering with CLAS12

Spokespersons: M. Arratia (contact), A. El Alaoui, K. Joo

Motivation: The proposed addition to the CLAS12 Run Group E physics program is to study di-hadron angular correlations in nuclear DIS. Evidence of angular correlations has been seen in CLAS6, in particular the suppression of back-to-back pion pairs. The increase in beam energy and luminosity, as well as the improved instrumentation of the CLAS12 detector will allow one to confirm and further elucidate the nature of this effect. The proposed measurements will be complementary to those at the future EIC, as they explore a different kinematic range. This is crucial for a full understanding of QCD effects in nuclei.

Measurement and Feasibility: The experiment is planning to measure azimuthal correlations of di-hadron production in deep-inelastic scattering off nuclei (deuterium, C, Fe and Pb). Key observables to be determined are the multiplicity ratio R_h and the conditional modification factor R_{2h}, as defined in the proposal.

Preliminary results from CLAS6 have been compared with the GiBUU transport code, and qualitative agreement was observed. The proposed measurements would also allow one to improve the description of hadron production in this transport code.

This proposal does not require additional beam time, nor any modification of the detector or trigger. The already approved experimental setup of Run Group E is well suited for this proposal.

Issues: It is mentioned in the proposal that the results can provide valuable input to neutrino oscillation programs such as DUNE, for which multi-pion production in DIS off argon dominates the total cross section. The PAC encourages the collaboration to present the results of the measurements also in the form of pion kinematic distributions, so that it is useful for neutrino oscillation experiments.

Summary: The PAC recommends Run Group E to integrate this proposal into their running plan.

Letters of Intent

LOI 12-20-001

Title: Measurement of the Neutral Pion Transition Form Factor and Search for the Dark Omega Vector Boson

Spokespersons: A. Gasparian

Motivation: Two experiments are proposed. The first is to measure the neutral pion transition form factor (TFF) in the Q^2 range from 0.001 to 0.1 GeV^2. This will help to narrow down the uncertainties of the hadronic light-by-light (HLbL) contribution to the muon anomalous magnetic moment, g-2. The second proposed experiment is the search for a hidden sector vector boson (dark omega), coupled to matter via the baryonic current, in the 140 – 620 MeV mass range.

Measurement and Feasibility: The two proposed experiments will run concurrently and use the PRad-II setup in Hall B. The measurement of the neutral pion TFF is via the Primakoff reaction with virtual incident photons. The virtual Primakoff scattering cross section can be distinguished from the nuclear coherent and incoherent reactions, which was shown to work in the PrimEx-II data. The second experiment is to search for dark omega in the direct electroproduction on a silicon target in the forward direction of 10.5 GeV electron beam. The dark omega decays into a neutral pion and a photon, leading to a bump in the three-photon invariant mass distribution. An initial design of the experiments, as well as preliminary estimates of their acceptance, resolution, uncertainties, backgrounds, and sensitivity have been worked out. The results of this exercise are encouraging.

Issues: (1) For the neutral pion TFF measurement: given the recent progress in lattice QCD calculations, the authors are encouraged to put their anticipated results for the neutral pion TFF more closely into the context of the efforts to control the uncertainty on the HLbL contribution to the muon g-2. Ideally, this should include an estimate of how much the measurement would decrease that uncertainty. (2) For the search of the dark omega: while it is useful to search for such gauge boson in the three-photon final state, the motivation for the specific model considered in the proposal is relatively weak. (3) On the experimental side: the detailed experimental layout and detector design need to be carefully worked out, along with a full Monte Carlo simulation of backgrounds.

Summary: Both proposed experiments will provide insight in the search for new physics beyond the Standard Model. The authors are encouraged to sharpen their theoretical motivation, to develop a detailed design of the experiments, and to perform comprehensive background studies. Given the status of the physics motivation for each proposed experiment, the PAC recommends to prioritize the neutral pion TFF measurement when detector setup and optimization are considered.

LOI 12-20-002

Title: Measurement of the neutron charge radius

Spokespersons: N. Sparveris (contact), M. Paolone, Z.-E. Meziani, M. Jones, A. Camsonne

Motivation: Present evaluations of the charge radius square $<r_n^2>$ of the neutron use low energy neutron scattering on diamagnetic materials (inverse kinematics). The various experiments agree rather well with each other, apart from a few outliers that follow statistical fluctuations. However, as charge radius square measurements are often affected by unknown systematics, the proponents of this LoI intend to use standard kinematic electron-nucleon scattering and to derive $<r_n^2>$ from the slope of the electric form factor $G_E^n(Q^2)$ at $Q^2=0$. Although the expected accuracy for this measurement will not really impact the present knowledge of $<r_n^2>$, it would constitute a systematic check of all previous measurements.

Measurement and Feasibility: The experiment aims at determining the electric form factor $G_E^n(Q^2)$ at very small Q^2 from electric and Coulomb quadrupole transitions of the proton to the Δ. The reaction $e\ p \rightarrow e\ \Delta^+ \rightarrow e\ p\ \pi^0$ is reconstructed, using the double arm spectrometer in Hall C running at a beam momentum of 1.3 GeV/c and reconstructing the π^0 through missing mass. The measurement technique builds on many similar measurements that were performed in the past at larger values of Q^2. Normalisation is a key issue, as different Q^2 values require different settings of the magnetic spectrometers. Using asymmetries in the proton polar angle with respect to the virtual photon, the electric and quadrupole $p \rightarrow \Delta$ transition form factors can be extracted. From these, the electric form factor G_E^n is obtained using relations derived for the large-N_c limit of QCD, where N_c is the number of colors.

Issues: (1) The theory TAC report points out that the large-N_c relations just mentioned are valid only at tree level. In the language of chiral perturbation theory, they receive corrections from pion (and kaon) loops. The one-loop contributions have been computed for G_E^n [Phys. Rev. D 101 (2020) 054026], but no corresponding analysis for the $p \rightarrow \Delta$ transition is currently available. These loop contributions could substantially modify the large-N_c relations in the region of very low Q^2, which is crucial to determine the slope of G_E^n at $Q^2=0$ but outside the region in which the proposal has corroborated the validity of the relations using existing data. A reliable estimate of theoretical uncertainties of the proposed method to determine $<r_n^2>$ thus requires further studies. (2) The physics TAC report points out technical issues related to the operation of the HMC spectrometer for low-momentum protons. These need to be addressed and resolved by the proponents.

Summary: The PAC regards the proposed measurements at very small Q^2 as very interesting, However, the committee suggests that the proponents seek close cooperation with theory on the issue of pion loop corrections laid out above. They should re-evaluate the uncertainties with respect to the $<r_n^2>$ extraction and - if necessary - consider putting the main emphasis of this measurement on the $p \rightarrow \Delta$ transition form factors.

LOI 12-20-003

Title: Sub- and Near-threshold Production of J/Ψ Mesons from a Deuterium Target at SoLID

Spokespersons: H. Gao

Motivation: The LOI proposes measurements of sub-threshold and near-threshold real photoproduction and quasi-real photoproduction (low Q^2 electroproduction) of a J/Ψ meson from a 15-cm liquid deuterium target, using SOLID with the same experimental configuration as the approved experiment E12-12-006. By comparing the J/Ψ N → J/Ψ N scattering amplitude - accessed by photo-producing the J/Ψ off one nucleon and then having it rescattered off the other nucleon - with modern LQCD calculations, the experiment may allow for an extraction of the J/Ψ N potential. In addition, based on the prediction by Hatta and collaborators (PLB 803 (2020) 135321), the experiment aims at probing short-range correlations (SRC) in deuterium by sampling the large relative momentum part of the deuteron wavefunction, accessed by producing the J/Ψ below the J/Ψ N kinematic threshold.

Measurement and Feasibility: The proposed measurements will use an identical experimental configuration as the already approved experiment E12-12-006, except for the deuterium target. Both quasi-real photoproduction (low Q^2 electroproduction) and real photoproduction will be used, so as to maximize event counts. The experiment as briefly outlined in the LOI seems feasible.

Issues: The extraction of the J/Ψ N potential necessarily contains model dependence. Additional calculations could allow one to study this dependence.

The theory TAC report suggests further detailed model studies as a prerequisite for a reliable estimate of the theoretical uncertainty of the proposed method, because coupled multiple subprocesses will lead to the same final state.

The results should be presented in a model independent way (J/Ψ and nucleon kinematic distributions) so that any other researcher can interpret the data. Any further analysis by the proposers can have significant model dependence. Extensive simulations to determine explicit uncertainty estimates for backgrounds, as well as a realistic precision estimate of the proposed measurement must be given in a full proposal.

Summary: The proposed experiment provides a timely and interesting science case that nicely extends the JLab 12 GeV program of measurements of charm production near threshold. The authors are advised to follow the suggestions of both the TAC physics and theory reports, to perform detailed simulation studies and to examine more carefully the theoretical uncertainties.

Program Status

12 GeV Approved Experiments by Physics Topics

12 GeV Approved Experiments by PAC Days

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Charge to PAC 48

Review new proposals, previously conditionally approved proposals, and letters of intent for experiments that will utilize the 12 GeV upgrade of CEBAF and provide advice on their scientific merit, technical feasibility and resource requirements.

Identify proposals with high-quality physics that, represent high quality physics within the range of scientific importance represented by the previously approved 12 GeV proposals and recommend for approval.

Also provide a recommendation on scientific rating and beam time allocation for proposals newly recommended for approval.

Identify other proposals with physics that have the potential for falling into this category pending clarification of scientific and/or technical issues and recommend for conditional approval. Provide comments on technical and scientific issues that should be addressed by the proponents prior to review at a future PAC.