Annual Report for Period: 09/2010 - 08/2011
Submitted on: 09/01/2011
Principal Investigator: Forest, Tony .
Award ID: 0855661
Organization: Idaho State University
Submitted By:
Forest, Tony - Principal Investigator
Title:
A Program to Study Hadronic Matter using Electromagnetic Probes at Jefferson Lab

Project Participants

Senior Personnel

Name: Forest, Tony
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Dale, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Cole, Philip
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Didberidze, Tamar
Worked for more than 160 Hours: Yes
Contribution to Project:
The NSF sponsored this graduate students work on the Qweak experiment and her SIDIS data analysis of EG1 data for her thesis

Name: Parsons, Warren
Worked for more than 160 Hours: Yes
Contribution to Project:
The NSF sponsored part of this students thesis on the Qweak readout system. The student graduated in the summer of 2010.

Name: Martinez, Danny
Worked for more than 160 Hours: Yes
Contribution to Project:
This NSF sponsored graduate student is working on a thesis based on the data collected by the g8 run group from JLab's Hall B. His analysis is on the photoproduction of omega mesons with linearly polarized photons off the proton.

Name: Taylor, Charles
Worked for more than 160 Hours: Yes
Contribution to Project:
The NSF sponsored this students thesis work on the g13 experiment and his start counter calibration for the Frost experiment during their run this year in JLab's Hall B. His PhD thesis project is on extraction of polarization observables in the photoproduction of the K/Lambda channel using both circularly- and linearly-polarized photons off neutrons off unpolarized deuterons.

Name: Salamanca, Julian
Worked for more than 160 Hours: Yes

Contribution to Project:
Julian was an NSF student who finished his thesis on the g8 dataset from JLab's Hall B in December of 2010. His analysis was on the photoproduction of phi mesons with linearly polarized photons off protons.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:
As part of their graduate studies, students working with the group gain skills and experiences in the area of detector development and error analysis. Students working with PI Forest have been trained in the use of electronics for nuclear physics. One student wrote the library for a readout system and designed electronics boards. Another student instrumented detectors for performance tests including building their own NIM module. Students working with PI Cole have been calibrating the CLAS detector and using those results together with their analysis programs to analyze photo nuclear reactions.

Outreach Activities:
The physics department also holds a mentoring program for high school teachers and their students during the first month of summer. In the summer of 2010, the group instructed about 14 teachers and students on the operating principles of drift chambers and scintillators. The students were part of an REU program at Idaho State University and were tasked with designing and constructing PMT bases for use in experiments at the Idaho Accelerator Center. The program is a fortuitous example of how research and education can combine efforts and improve the public's understanding of science and technology.

Journal Publications

S.Anefalos Pereira et al., "Differential cross section of gamma n to K+ Sigma- on bound neutrons with incident photons from 1.1 to 3.6 GeV.", Phys. Lett., p. 289-293, vol. B688, (2010). Published,

H. Avakian et al., "Measurement of Single and Double Spin Asymmetries in Deep Inelastic Pion Electroproduction with a Longitudinally Polarized Target", arXiv:1003.4549, p. , vol. , (2010). Submitted,

I.G. Aznauryan et al., "Electroexcitation of nucleon resonances from CLAS data on single pion electroproduction.", Phys.Rev., p. 055203, vol. C80, (2009). Published,

T.E. Rodrigues, et. al., "Nuclear incoherent photoproduction of pi0 and eta from 4 to 12 GeV", Phys.Rev., p. 024608, vol. C82, (2010). Published,

Osipenko, M; Ricco, G; Simula, S; Ripani, M; Taiuti, M; Adhikari, KP; Amaryan, MJ; Anghinolfi, M; Avakian, H; Baghdasaryan, H; Battaglieri, M; Batourine, V; Bedlinskiy, I; Biselli, AS; Branford, D; Briscoe, WJ; Brooks, WK; Burkert, VD; Careccia, SL; Carma, "Measurement of the nucleon structure function F-2 in the nuclear medium and evaluation of its moments", NUCLEAR PHYSICS A, p. 1, vol. 845, (2010). Published, 10.1016/j.nuclphysa.2010.05.05

Pereira, SA; Mirazita, M; Rossi, P; De Sanctis, E; Niculescu, G; Niculescu, I; Stepanyan, S; Adhikari, KP; Aghasyan, M; Anghinolfi, M; Baghdasaryan, H; Ball, J; Battaglieri, M; Berman, BL; Biselli, AS; Bookwalter, C; Branford, D; Briscoe, WJ; Brooks, WK;, "Differential cross section of gamma n -> K+Sigma(-) on bound neutrons with incident photons from 1.1 to 3.6 GeV", PHYSICS LETTERS B, p. 289, vol. 688, (2010). Published, 10.1016/j.physletb.2010.04.02

Books or Other One-time Publications

Ricardo Alarcon, Phil Cole, Andres J. Kreiner, Hugo F. Arellano,, "VIII Latin American Symposium on Nuclear Physics and Applications -- Santiago,
Chile 15-19 December 2009", (2010). Book, Published
Editor(s): Ricardo Alarcon, Hugo F. Arellano, Philip L. Cole, Andres J. Kreiner
Collection: VIII Latin American Symposium on Nuclear Physics and Applications -- Santiago,
Chile 15-19 December 2009
Bibliography: AIP Conference Proceedings -- 1265

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners
Any Web/Internet Site
Any Product
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference

Major Research and Education Activities

NSF award #0855661, A Program to Study Hadronic Matter using Electromagnetic Probes at Jefferson Lab, has supported Idaho State University's nuclear physics group. The group is actively engaged in constructing five drift chambers for the CLAS12 upgrade and three experiments at Jefferson Lab; Primex, Qweak, and g8/g13. PI Dale, has published the results from the Primex I experiment and has completed collecting data for the Primex II experiment in Jefferson Lab's Hall B. PI Forest and graduate student T. Diberidze have worked on maintaining the R1 tracking detector and investigating a readout electronics option for Qweak. PI Cole and graduate students D. Martinez and C. Taylor have been working with CLAS's g8 and g13 run groups in JLab's Hall B. The progress of these endeavors is described below.

A. CLAS12 R1 drift chamber construction

The construction of the R1 drift chambers for Jefferson Lab's Hall B is about to begin at Idaho State University (ISU). Jefferson Lab awarded subcontract JSA-11-C1841 to ISU on April 11, 2011 for the construction of 5 R1 drift chambers. PI Forest and ISU's latest faculty hire, Dr. Dustin McNulty, spent the summer installing and preparing a CLAS 10,000 clean room for the project. The clean room is shown below in Figure 1. The committee concluded "that the ISU team is ready to proceed with stringing chambers and doing related work on this project immediately." A Detector Fabrication Manager, Larry Lim, has been hired, using funds from the subcontract, to manage the daily stringing operations and train up to 4 people hired to string the chambers. PI Forest and Dr. Dustin McNulty will manage the project. A successful readiness review was held at ISU on August 18, 2011 by Jefferson Lab's Mac Mestayer, Bob Miller, and Bruce Lenzer. We anticipate beginning to string the first chamber in late September.

Figure 1. The ISU cleanroom. A R1 drift chamber is shown mounted on the stringing platform. Particle counter measurements show the room is withing a class 10,000 rating.

B. Primex

Significant progress has been made in the program to measure the neutral pion lifetime. First, the results of the first run (PrimEx I) were accepted for publication in Physical Review Letters (Phys. Rev. Lett. 106 (2011) 162303) where a radiative width of 7.83 +- 0.14 (stat) +- 0.17 (sys) eV was reported. This number is a factor of 2.5 times more precise than the current Particle Data Group average and is consistent with theoretical predictions.

Second, data were collected for PrimEx II in the Fall of 2010. Dan Dale is a spokesperson for this experiment and served as a run coordinator. The primary goal of the run was to increase the statistical precision of the measurement. Improvements on the apparatus used for PrimEx I included (1) modifications to the photon beam line to minimize the effect of collimator scraping, (2) individual TDC's were implemented in the central portion of the HYCAL pion detector, and (3), data on both a carbon and a silicon target were obtained to further investigate the model dependence of the analysis.

Third, substantial progress was made in the area of documenting the techniques utilized in PrimEx I to limit the uncertainty in the luminosity to about 1%. A draft of a paper has been written by Dan Dale based on the work of his student, Aram Teymurazyan, and has been circulated to a small group of PrimEx members. Based on feedback on this, a draft will be prepared and circulated to the Collaboration for ultimate submission to Nuclear Instruments and Methods.

C. Qweak

The Qweak experiment completed taking data estimated to correspond to a 25% measurement of the weak mixing angle ($\sin^2(\theta)$) on May 13, 2011. The inelastic parity-violating asymmetry was measured during this time as well. The measurements, in addition to determining one of the asymmetry backgrounds for Qweak, may also be used to extract a low energy constant d_Δ. The low energy constant d_Δ characterizes the parity violating electric dipole matrix element for the $\gamma N\Delta$ transition accessible by inelastic parity violation measurements on the proton. The application of Siegert's theorem at the photon point, ($Q^2=0$), results in the Q^2 independence of the transition amplitudes leading term and a non-zero value for the asymmetry at the photon point if d_Δ is non-zero. The statistical precision of a 1 week measurement, predicted using the current data set, is shown in figure. In addition to measuring a fundamental low energy constant, the results may also have implications to hyperon decay physics as d_Δ impacts the asymmetry parameter in radiative hyperon decay physics such as the $\Sigma\gamma^+ \rightarrow p\,\gamma$ decay.

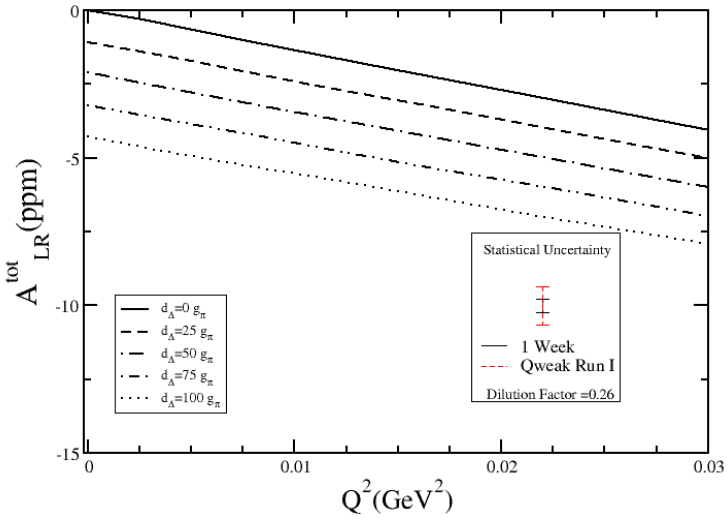

Figure 2. Statistical precision of an inelastic asymmetry measurement using the Qweak apparatus. The lines show the expected asymmetry for several values of d_Δ as a function of Q^2. The precision of a one weak measurement using the Qweak apparatus is shown in the insert. The estimate is based on the statistical prcision observed from the first Qweak measurement of the inelastic asymmetry.

The testing and installation of the Region 1 tracking system for the Qweak experiment at Jefferson Lab has been a research activity supported by this grant. The Qweak Region 1 tracking system is one of three tracking systems designed to measure the Q^2 profile of elastically scattered electrons as well as background contributions to the parity violating signal. The Region 1 tracking system is located behind the first collimator at a distance of about 550 cm from the main torus magnet (200 cm from the target). The collimator divides the ϕ acceptance into 8 regions, octants, and reduces the azimuthal acceptance by almost 30 percent.

Two Region 1 detectors were built at ISU and delivered to JLab after observing signals which indicated that the detectors were sensitive to ionizing radiation. Figure 1a in the last annual report illustrated a detector mounted in position for a commissioning test. Although ionization signals were observed in the JLab test facility prior to installation, signals were not observed from the detector during the commissioning run. It was found that the detector was damaged by a spark discharge at some point during the commissioning tests. The detector was removed from the experimental Hall and repaired by graduate student T. Didberidze in the JLab test facility using GEM foils from the second R1 detector.

The R1 detector was put through several additional tests before installing it back into the Hall. Figure 2 shows the measured cosmic rate as a function of high voltage.

The detector appeared to plateau at the expected cosmic rate of about 2 Hz. Additionally, a Co-60 radiation source was used to demonstrate to the collaboration that the detector's counting rate increased when the source was placed in the detector's acceptance. The success of these tests was used to justify placing the detector in the experimental Hall. The detector was placed far from the target and not inside the R1 enclosure in order to make it easier to repair if there was another failure. On November 22, 2010 a beam test was conducted in Hall C. As shown in Figure 2, the detector rate was observed to depend on the beam current. The R1 detector appeared to be working.

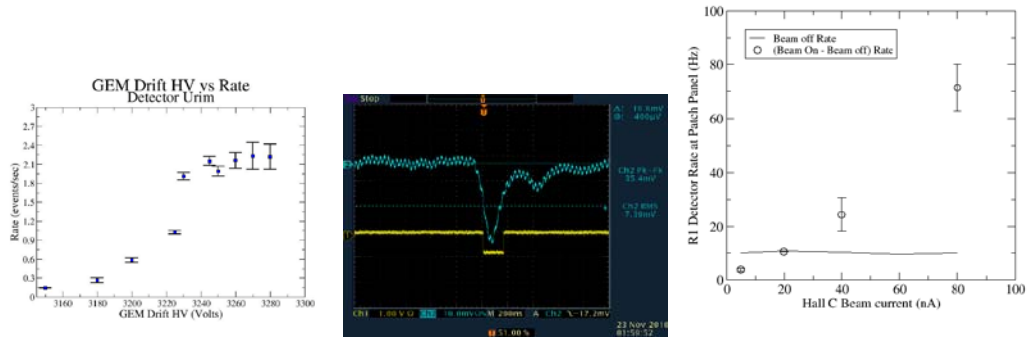

Figure 3. Qweak GEM detector signals. The left most figure shows how the Cosmic rate in the detector approaches the expected 2 Hz rate as a function of GEM Drift/amplifier voltage. The middle picture is the output captured by an oscilloscope. The right most figure illustrates how the detector rate increased with the Hall C beam current.

On January 10, 2011, the R1 detector was moved to a region just outside the acceptance of the main detector. A test stand was built that placed two large scintillators upstream and downstream of the R1 detector. During a low current tracking run the detector was moved to a location that would intercept elastically scattered electrons. Collaborators measured an efficiency of 4%. It is believed that the detector was under voltage during these measurements. The plan was to increase the voltage during the next tracking run and repeat the measurement.

Unfortunately, collaborator Kathleen Johnston decided to remove the detector from the Hall before the next test. It has been reported that, after removal from the Hall, the detector can no longer reach the operating high voltage used previously. As written in Louisiana Tech's NSF proposal, "For the Qweak experiment the Louisiana Tech group is responsible for the Region 1 GEM based tracking system ...". Louisiana Tech was also responsible for the detector readout electronics and rotation system for R1 even though ISU was working on a candidate system.

D. CLAS g8 and g13

The g8b dataset'" will measure the beam asymmetry (and other polarization observables) using polarized photons interacting with protons and deuterons which result in the final states ηp, KY (Y=Λ,Σ0, Σ+), ρ0p, (ρ+n), ωp, and φp from Eγ=1.1 GeV to 2.1 GeV. This is to be compared to higher energy measured asymmetries at GRAAL (Eγ < 1.5GeV) which observed the final states ηp, K+Λ . For φp ,g8b will afford an extension of the measured asymmetry at SPring8 (Eγ >1.7GeV) to lower energy and higher "t". Julian Salamanca has completed his Ph.D. thesis titled: THE PHOTOPRODUCTION OF φ-MESONS OFF PROTONS BY USING A BEAM OF LINEARLY POLARIZED PHOTONS AT THRESHOLD ENERGIES on October, 2009 (see http://www.jlab.org/~salamanc/phd_thesis_new-5-ds-v3.pdf). Danny Martinez is currently working on his thesis titled: THE PHOTOPRODUCTION OF ω-MESONS OFF PROTONS BY USING A BEAM OF LINEARLY POLARIZED PHOTONS AT THRESHOLD ENERGIES.

Similarly, '"the g13a/b datasets'" will yield the measurement of beam asymmetry (and other polarizeation observables) in ηp, ηn, KY (Y=Λ,Σ0, Σ+,Σ-), ρ0p, ρ0n,(ρ+n & ρ-p), ωp, and φp from Eγ=1.1 GeV to 2.3 GeV. Charles Taylor is currently working on his thesis title: THE PHOTOPRODUCTION OF THE KΛ OFF NEUTRONS BY USING A BEAM OF LINEARLY AND CIRCULARLY POLARIZED PHOTONS.

II. Physics Analysis

Graduate students T. Didberidze, D. Martinez, and C. Taylor are analyzing Jefferson Lab data sets taken in Hall B. T. Didberidze is currently analyzing data from Hall B's EG1 run group which will test independent fragmentation for SIDIS. D. Martinez completed calibrating the time-of-flight system for the g13 experiment but has since discovered some errors which he is correcting. Mr. Martinez has observed asymmetries at all energy settings between 1.3 and 2.1 GeV, binned in 0.2 GeV intervals, for the polarization observables from polarized photon interactions using a proton target. C. Taylor used his calibration work on g13 to calibrate the start counter for the FROST experiment at Jlab as a collaborative service task. Mr. Taylor is now processing the data to reconstruct particles in the g13a data set, a process called "cooking", and he is continuing to analyze data for his Ph.D.

Findings

The finding below was published in PRL **106**, 162303 (2011) and is available electronically at http://arxiv.org/abs/1009.1681. The figure illustrates the latest measurement of the pion lifetime from the PRIMEX collaboration in comparison to other experiments reported by the Particle Data Group.