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Nuclear Research with the Electromagnetic Probe

A Progress Report for the renewal of
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Stanford University

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I. Introduction

The main goal of this project is to provide new electron scattering and photo-absorption data on light and heavy nuclei in order to answer some of the forefront questions raised by the recent results in high energy nuclear physics. The properties of free protons have been extensively studied and are used as basic input to describe many of the electric and magnetic properties of nuclei. However electron scattering measurements in the quasielastic region at low momentum transfer (0.5 to $.3 \text{ (GeV/c)}^2$) and in the deep inelastic region at very high momentum transfers (5 to 10 (GeV/c)^2) seem to indicate that the properties of free protons are modified substantially in the nuclear medium. In our attempt to study the short range nucleon-nucleon correlation in nuclei it is of first importance to understand how the free properties of nucleons are modified (It was suggested that nucleons are swollen in nuclei). At the same time we are testing the extremes of the traditional description of nuclear systems.

We are collaborating on two experiments at SLAC using the Nuclear Physics Injector. One is to perform the separation of the transverse and longitudinal response functions of ^3He , ^4He , ^{27}Al and ^{56}Fe to electron scattering at $Q^2 = 1 \text{ (GeV/c)}^2$. The other is to measure the photodisintegration of deuterium at large photon energies (.8 to 1.6 GeV), looking at deviation from the standard calculations including nucleons, mesons exchange currents and resonance components. The sensitivity of the reaction mechanism to quark degrees of freedom is tested at the same time. We are also collaborating on two experiments at the Saclay linear Accelerator center. On one hand the study of the momentum distribution of $^4\text{He}(e, e')$ is to be extracted from both the transverse and longitudinal exclusive response functions in the quasielastic region. A comparison of these two response functions as a function of Q^2 will provide some information on the density effect of the modification of the free nucleon properties in nuclear medium. On the other hand transverse and longitudinal separation of the exclusive response functions in the region of the three-body break up of ^3He is performed aiming to study the proton-proton correlation in a direct way through $^3\text{He}(e, e'p)pn$ reaction. A serious progress has been achieved in performing "complete" theoretical calculations on ^3He that would allow to understand the proton-proton correlation in ^3He .

II. Progress Report

II.1. Slac Program:

II.1.a *Transverse and Longitudinal Response Functions in Inclusive Scattering.*

This experiment known as NE-9 at the Nuclear Physic Program at SLAC did run for a period of one month at the end of 1987. We have taken successfully data using the 8 GeV spectrometer after a preparation of almost a year. The analysis is in progress at two institutions, Stanford University and the University of Virginia. At Stanford the newly purchased Vax station 3200 with a 6250 bpi tape drive is used extensively for analyzing the data. The analysis is performed by myself acting as a spokesman for this experiment, a graduate student from Stanford and with some help from undergraduate students in the physics department. The amount of data to be analyzed is very large since the experiment was performed on three different nuclei. We are typically working on the first pass of the analysis where we have modified and significantly improved the software for the analysis and started to analyze raw data. Figure 1. shows some of the preliminary results on hydrogen. It represent a spectrum of inclusive cross section of hydrogen at forward angle from the NE-9 experiment. Part of the ^{56}Fe data have been presented at the American Physical Society meeting in Santa Fe, October 13, 1988. by the student from Virginia

We are planning to publish more than two papers on these data within the next year. We have also asked the associate Director at SLAC to consider our request for a week of beam time within the next year for covering a wider region of kinematics in the (Q^2, ω) plane for the separated response functions in nuclei. This extension is approved in "principle".

II.1.b *Two body Photodisintegration of deuterium between .6 and 1.8 GeV*

This experiment known as NE-8 at SLAC has also been performed in a one month period. This experiment has used the 1.6 GeV spectrometer of end station A at SLAC. The data collection was also successful and a first analysis of the data have been completed. The results of the analysis show no agreement with the traditional calculation using exchange currents and Isobar contributions (more theoretical work is needed in this area now that data at high energy from the NE-8 experiment are available). The paper describing the important results in this

experiment is published in Phys. Rev. Lett. 61 (1988)2531

II.2 Saclay program:

II.2.a *Transverse and Longitudinal Exclusive Response Functions in ^4He*

Our collaboration at Saclay in the study of ^4He and ^3He using coincidence experiments have started in the summer 1987. The electrodisintegration of ^4He experiment has been performed in the beginning of 1988. The experiment took place in a period of three weeks and the first results are very interesting and will impact on the approval of what has been proposed as the NE-16 experiment at SLAC. The analysis programs for the coincidence experiments are already in a production phase at Saclay allowing a fast analysis of the experiment leading to a paper that has been submitted and approved for publication in Physics Letters.

More beam time has been approved during the PAC meeting at Saclay this january to extend the study of the ^4He nucleus by inclusive electron scattering in order check the consistency between the inclusive and exclusive observation of the quenching of the longitudinal response function A long paper will be devoted to describe and present both the exclusive and inclusive experiments performed on ^4He

III. Plan for research in 89-90

Our plans are to first finish the analysis of the NE-9 experiment and publish the results on ^{56}Fe . On a second stage we will study the density and A dependence of the quenching of the Coulomb sumrule by performing the analysis on ^3He and ^4He . This should lead to a second publication. We are also considering to be prepared for a possible one or two weeks of beam time at SLAC to perform the extension of NE-9 as we proposed to the associate director of SLAC, C. Prescott.

The next project is to perform the $^3\text{He}(e,e'p)^3\text{H}$ experiment at Saclay. Beam time will be available during the summer and fall of 1989. The transverse and longitudinal separation of the exclusive response functions in the three body break up region will be performed. The longitudinal response will be directly sensitive to the proton-proton correlation.

Until now our participation at CEBAF was mainly to write two letters of intent and to participate in defining the physics program in Hall A. This year we will propose to take the responsibility in the design of the electron beam polarimeter for the polarization experiments in Hall A. With the agreement of the CEBAF management we will put a proposal to the Department of Energy to build such a polarimeter.

We will be participating in the design of the beam polarimeter at HERA in Germany. The measurement of the spin structure functions planned at HERA are part of our project for the next four years. The collaboration will be meeting next April to set the final version of the proposal to the HERA management. Stanford contribution will be the measurement of the longitudinal polarization of the beam after the spin rotators in west Hall at HERA.

We are also involved in the PEGASYS collaboration where our contribution will be the design and construction of the flux exclusion plates. We will also perform all necessary magnetic field calculations.

We would like to have the possibility for a visit of one month of Dr. J. M. Laget from Saclay this summer 1989. This is collaboration on a theoretical calculation for the photodisintegration of deuterium in the GeV region photon energy. This work is directly related to the experiment NE-8 performed at SLAC. I took the responsibility in the collaboration to improve the already existing model of photodisintegration of Laget. Higher resonances contributions beside the delta and final

state interaction at high energies have to be included before conclusions about the break down of traditional calculations compared to perturbative QCD calculations.

VI. Capital equipment description

DEC Memory Cartridge	\$ 503
Lecroy 2735B 16channel MWPC discriminator card (4 units)	\$1,400
Lecroy 2738 PCOS III system controller	\$3,275
Lecroy 2323A Dual gate and delay generator	\$1,815
Lecroy 2301 qvt Camac	\$ 990
DEC VT220 terminal	\$ 609
DEC RD54 Disk Drive	<u>\$4,125</u>
Total	\$12,717

IV. Budget 89-90

The proposed budget for this year is covering two months summer salary of the principal investigator, a year salary of a graduate student and 25% contribution to the salary of a secretary. We are also asking funds to cover part of the expenses of the collaboration visit of Dr. J. M. Laget from Saclay for one month this next summer.

The foreign travel budget include two trips to Saclay to perform the continuation of $^4\text{He}(e, e')$ experiment and the new coincidence experiment on ^3He and one trip to HERA in Germany for a collaboration meeting to measure the spin structure functions of the proton.

The travel budget in the U. S. will cover the analysis collaboration meetings in Virginia and also our contribution to the CEBAF program. That corresponds to four trips to Virginia during this coming year.

The capital equipment part of the budget is described in a separate sheet (page 10) showing the detail of our remaining equipment needs. It consists mainly on elements that will allow us to complete the data acquisition system for the test of a proportional wire chamber and its efficiency online using cosmic rays. We are considering constructing wire chambers on site for a future experiment at Bates. This will allow to have an active test laboratory for a detection package to be used at different electron accelerator sites in the U.S.

The purchase of the a Winchester disk drive for the microvax is necessary to handle all the data analysis of NE-9 and also this enhancement will be valuable for installing a Monte Carlo program that we are developing for the focal plane polarimeter in Hall A at CEBAF jointly with TRANSPORT and EGS4 and have these programs ready to run.

Electroproduction of Δ in ^2H

$E_0 = 3.8 \text{ GeV}$ $\theta = 15^\circ$
 $q^2 = 0.65 - 0.82 \text{ (GeV/c)}^2$

IV. Publications

J. Napolitano, S. J. Freedman, D.F. Geesaman, R. Gilman, M.C. Green, R. Holt, H. J. Jackson, R. Kowalczyk, C. Marchand, J. Nelson, B. Zeidman, (ANL, Argonne) T. -Y. Tung, R. E. Segel, (Northwestern U.) G. Boyd, D. Beck, D. Collins, B. Fillipone, R. D. McKeown, R. Milner, D. Potterveld, R. Walker, C. Woodward (CaltheC), P. Bosted (American U.), E. R. Kinney (MIT), Z. E. Meziani (Stanford), R. Minehart (U. Virginia). Measurement of the Differential Cross Section for the Reaction $^2H(\gamma, p)n$ at High Photon Energy and $\Theta_{cm} = 90^\circ$, Phys. Rev. Lett. 61(1988)2530

R. M. Sealock, K. L. Giovanetti, S. T. Thornton, Z. E. Meziani, O. A. Rondon-Aramayo, S. Auffret, J-P. Chen, D. G. Christian, D. B. Day, J. S. McCarthy, R. C. Minehart, L. C. Dennis, K. W. Kemper B. A. Mecking and J. Morgenstern. Electroexcitation of the $\Delta(1232)$ in Nuclei, submitted to Phys. Rev. Lett. (1988).

A. Magnon, M. Bernheim, M. Brussel, G. P. Capitani, E. De Sanctis, S. Frullani, F. Garibaldi, A. Gerard, H. Jackson, J. M. Legoff, C. Marchand, Z.E. Meziani, J. Morgenstern, J. Picard, D. Reffay, S. Turck-Chieze, P. Vernin, A. Zghiche, "A Study of the Electrodissintegration Reaction $^4He(e, e'p)^3H$ with Transverse-Longitudinal Separation" submitted to Phys. Lett (1988)

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Abstract Submitted

for the Baltimore, MD Meeting of the

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Dates

Physics and Astronomy
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Number 12.38.Qk

Suggested title of session into
which paper should be placed
Photonuclear Reactions

Measurement of the Differential Cross Section for the
 $^2\text{H}(\gamma, p)n$ Reaction in the GeV Region*. J. NAPOLITANO, S.
FREEDMAN, D. GEESAMAN, R. GILMAN, M. GREEN, R. HOLT,
H. JACKSON, C. MARCHAND, B. ZEIDMAN, Argonne National
Laboratory, R. SEGEL, T. Y. TUNG, Northwestern U., P.
BOSTED, American U., D. BECK, B. FILIPPONE, J. JOURDAN,
R. McKEOWN, R. MILNER, K. WOODWARD, R. WALKER, Cal
Tech, Z.-E. MEZIANI, Stanford U., R. MINEHART, U.
Virginia, E. KINNEY, MIT—As a test of the meson-exchange
vs. QCD models for the deuteron,¹ we have measured the
differential cross section for the reaction $^2\text{H}(\gamma, p)n$ at
several angles and for photon energies between 0.8 and
1.8 GeV. Electrons from the NPI facility at SLAC pass
through a radiator producing bremsstrahlung photons
which impinge on a liquid deuterium target. Protons
from the reaction $^2\text{H}(\gamma, p)n$ are detected in the 1.6-GeV/c
spectrometer with a detector stack capable of π, p, d
particle identification. Results will be presented and
compared to predictions.

*Supported by the U.S. Department of Energy, Nuclear
Physics Division, under contract W-31-109-ENG-38.

¹S. Brodsky and J. Hiller, Phys. Rev. C 28, 475 (1983).

Special instructions (if any):

- ☐ Prefer Poster Session
☒ Prefer Standard Session
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Submitted by:

Signature of APS Member

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