Report on the JSA Initiatives Fund Program project

**Nuclear Photoproduction with GlueX workshop**

A. Somov (PI) and E. Chudakov (co-PI)

**Introduction**

Photoproduction on nuclear targets (A > 1) at multi-GeV energies is being considered as an interesting future application of the GlueX detector beyond the meson spectroscopy program. The aim of the workshop is to explore the physics potential of nuclear photoproduction with GlueX, including theoretical motivation, experimental methods, equipment needs, and wider context of such measurements. Unique capabilities that GlueX would bring to photoproduction physics are linear photon polarization, excellent energy resolution through tagging, and wide energy coverage from ~5 GeV to 12 GeV. Physics topics include:

- Medium modification of light vector mesons (rho, omega, phi)
- J/psi as a probe of nuclear color fields
- Coherent nuclear processes, including Primakoff production
- Polarization observables in nuclear photoproduction

A Letter of Intent for nuclear photoproduction with GlueX was favorably reviewed by JLab's PAC43 in 2015. The workshop aims to solicit the advice of world experts and stimulate further development, in order to initiate preparation of a full proposal.

The workshop is part of a broader effort by the GlueX collaboration and Jefferson Lab to explore new physics applications of the GlueX detector beyond the meson spectroscopy program. An initial assessment of the physics potential of nuclear photoproduction with GlueX was made at the 2008 Workshop "Photon-hadron physics with the GlueX detector at Jefferson Lab".

**Workshop Organization**

The workshop **Nuclear Photoproduction with GlueX** took place at Jefferson Lab on April 28 – 29, 2016 ([https://www.jlab.org/conferences/photoproduction16](https://www.jlab.org/conferences/photoproduction16)). The organizing committee consisted of:

Curtis Meyer (Carnegie Mellon U.)
Eugene Chudakov (JLab)
Sergey Gevorkyan (JINR Dubna)
Alexander Somov (JLab)
Christian Weiss (JLab)
The workshop was attended by about 30 participants from Jefferson Lab, members of US universities, and world experts from Europe. The remote workshop connection via Blue Jeans was available for those participants who were not able to come to Jefferson Lab. The workshop was organized into several topical sessions with 24 presentations. The scientific program is attached to this document.

**Budget Justification**

Funds from the JSA Initiatives Fund Program were used to partially support travel expenses of three invited speakers:

Mark Strikman, Penn State University ($637)

Stan Brodsky, Stanford University ($695)

Volker Metag, Physikalisches Institute at the University of Giessen, Germany ($858)

The workshop organizers are thankful to Bob McKeown for the Jefferson Lab directorate support of the workshop in the amount of $2500 (and also thankful for some support received from the experimental Hall D).

**Workshop Summary**

The workshop played an important role in the development of a future physics program (after meson spectroscopy) for the GlueX experiment using photoproduction on nuclear targets. The workshop fostered collaboration with theorists and attracted people interested in future GlueX measurements. Some physics topics discussed at the workshop deserve special attention:

- The study of photoproduction of mesons off different nuclei and measurements of mesons absorption in the nuclear matter (V.Metag, M.Woods, S. Gevorgyan, etc.) is one of the topic to be explored. The GlueX detector provides a unique capability to study nuclear photoproduction in the large beam energy range between 6 GeV and 12 GeV for mesons decaying to different final states. Such measurements are essential in understanding some discrepancies of experimental results obtained by other experiments.

The study of absorption of vector mesons and measurements of the spin density matrix elements in the incoherent photoproduction off nuclei allows one to obtain cross sections of transversely and longitudinally polarized vector mesons with nucleons. The meson-nucleon cross sections for longitudinally polarized mesons have never been measured. Recent numerical calculations (presented by S. Gevorgyan) of cross sections were
performed for various meson wave functions predicted by different theoretical models. The results drew attention of theorists and were widely discussed (see presentation of S. Brodsky). These calculations provide additional motivation for the proposed experiment to measure cross sections of longitudinally and transversely polarized omega mesons with nucleons with GlueX. The proposal will be submitted to one of the PAC meetings (the LOI12-15-006 was presented to PAC43).

Simulation of elementary reactions on nuclei is critical in understanding background and for planning of new experiments. The event generator provided by the GiBUU team was presented (by J. Weill) and discussed at the workshop. The ‘collaboration’ between the GiBUU team and GlueX members was established with the goal to use the generator in the GlueX framework.

- Measurements of differential cross-sections for reactions such as $\gamma p \rightarrow \pi^0 p$, $\gamma p \rightarrow \rho^0 p$, $\gamma p \rightarrow K+\Lambda$, … on the free and bound nucleon provide a capability to probe short-range nuclear structure (E. Piasetzky, O. Hen). The letter of intent to measure short-range correlations with the GlueX experiment is currently being prepared and will presumably be submitted to the next PAC meeting.

- The effect of the color transparency in photoproduction was overviewed in several presentations (K. Hafidi, M. Strikman, etc.). Photoproduction of light ($\pi$, $\rho$) mesons at large momenta transfer provides good sensitivity to measure color transparency effects. Initial theoretical calculations of the transparency for the $^{12}C(\gamma, \pi^- p)$, $^{197}Au(\gamma, \pi^- p)$ processes were performed for GlueX beam energies (I. Larionov and M. Strikman). Preliminary Monte-Carlo simulation with the GlueX detector demonstrated the feasibility to perform measurements of the color transparency using the $\pi^- p$ final state. The feasibility to measure the color transparency will be further investigated and included as one of the possible topics to the proposal of a new experiment.

- An overview of the Primakoff photoproduction experiments was performed by A. Gasparyan. The feasibility to study Primakoff production of $\eta'$ mesons using light nuclear targets is currently being investigated (I. Larin). Based on the MC simulation, the GlueX detector provides a good reconstruction capability of $\eta'$ mesons in the charged and neutral final states. Large data samples acquired for runs with different nuclear targets will be well suited to study Primakoff production of $\eta'$ mesons.

- The photoproduction of heavy mesons ($J/\psi$ and open charm) at GlueX beam energies was overviewed in several presentations (C. Weiss et. al.). Despite the small $J/\psi$ (open charm) production cross section near thresholds the feasibility to measure the nuclear absorption of mesons has to be investigated.
Thursday, April 28, 2016
Room: CEBAF Center F224/225

8:30am Registration and Coffee

INTRODUCTION
9:00am Welcome and Plan of Meeting Weiss, Christian
9:10am Status and Future of GlueX Chudakov, Eugene
9:30am GlueX Capabilities for Nuclear Photoproduction Somov, Alexander

HADRONS IN NUCLEAR MEDIUM I
9:50am In-medium Properties of Mesons -- Experimental Results and Perspectives Metag, Volker
10:30am Coffee Break
10:50am Vector Mesons in Medium Wood, Michael
11:20am Hadronic Transport with the GiBUU Model Weil, Janus
11:50am Medium Modification of Mesons Discussion
12:20pm Lunch

NUCLEAR TRANSPARENCY IN PHOTOPRODUCTION
1:30pm Color Transparency Experiments Overview Hafidi, Kawtar
2:00pm Color Transparency in Nuclear Photoproduction Strikman, Mark

SHORT-RANGE NUCLEAR STRUCTURE WITH PHOTOPRODUCTION
2:40pm Short-range Nuclear Structure with Photoproduction I Piasetzky, Eli
3:10pm Coffee Break
3:30pm Short-range Nuclear Structure with Photoproduction II Hen, Or
4:00pm Deuteron Photodisintegration with CLAS Ilieva, Yordanka
4:30pm Hard Deuteron Photodisintegration and Polarization Effects Sargsian, Misak
5:00pm High-pT Meson Production on the Proton Boeglin, Werner
5:20pm Nuclear Photoproduction with GlueX Discussion
6:30pm Dinner (off-site)

Friday, April 29, 2016
Room: CEBAF Center F224/225

8:30am Coffee

HADRONS IN NUCLEAR MEDIUM II
9:00am Modifications of the D33(1700) Resonance in the Nuclear Medium Sokhoyan, Vahe
9:30am Omega Meson Photoproduction of Nuclei -- A Challenge for GlueX Gevorkyan, Sergey

MESON PHOTOPRODUCTION AND POLARIZATION EFFECTS
10:00am Photoproduction at CBELSA/TAPS Crede, Volker
10:30am Coffee Break
10:50am Meson Photoproduction with CLAS Pasyuk, Eugene
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<th>Time</th>
<th>Session</th>
<th>Speaker(s)</th>
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<td>11:20</td>
<td>Primakoff Production Overview</td>
<td>Gasparian, Ashot</td>
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<td>11:50</td>
<td>Primakoff Production of eta'</td>
<td>Larin, Ilya</td>
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<td>12:20</td>
<td><strong>Lunch</strong></td>
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<td>1:30</td>
<td>QCD in Nuclear Photoproduction</td>
<td>Brodsky, Stanley</td>
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<td>2:10</td>
<td>J/psi Near-threshold Photoproduction Overview</td>
<td>Weiss, Christian</td>
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<td><strong>Coffee Break</strong></td>
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<td>3:10</td>
<td>J/psi Photoproduction with CLAS12</td>
<td>Nadel-Turonski, Pawel</td>
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<td>3:40</td>
<td>Probing Nuclear Color Fields with Phi and J/psi</td>
<td>Paolone, Michael</td>
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<td>Open Charm Photoproduction Comments</td>
<td>Nadel-Turonski, Pawel</td>
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<td>4:20</td>
<td>Charm Production with GlueX</td>
<td>Discussion</td>
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