Nuclear Physics Working Group Report

CLAS Collaboration Meeting
Jefferson Lab

June 18th, 2016

Lamiaa El Fassi
(on behalf of Kawtar Hafidi)
Analyses' Review Update

Deeply Virtual Compton Scattering off $^4\text{He}$
By Mohammad Hattawy et al., IPN Orsay & ANL
Second round
Review committee: Michel Garçon (Chair), Sebastian Kuhn & Zein-Eddine Meziani

Differential cross sections for reactions $\gamma + \text{d} \to \pi^- \text{p} \text{p} \_\text{spec}$
N. Pivnyuk, ITEP
Second round
Review committee: S. Strauch (Chair), B. McKinnon and M. Mirazita

Measurements of the Fifth Structure Function of the Deuteron
By G. Gilfoyle, University of Richmond
First round
Review committee: S. Kuhn (Chair), A. El Alaoui and S. Gilad
Neutral pion electroproduction ratios off C, Fe, and Pb
By T. Mineeva, University of Connecticut

First round

Review committee: L. Weinstein (Chair), Y. Ilieva and M. Wood
Announcement:

- New NPWG chair election will start soon.
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- A nominating committee is formed by:
  - Stepan Stepanyan
  - Hovanes Egiyan
  - Lamiaa El Fassi (Chair)
NPWG Agenda

- No NPWG analysis talks this time (could be due to PAC work!?)

  But
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But

- Had three ALERT run-group proposals talks:

  16:05
  **Tagged EMC Measurements on Light Nuclei** 25’
  Speaker: Nathan Baltzell (JLab)
  Material: Slides

  16:30
  **Tagged Deeply Virtual Compton Scattering Off Light Nuclei** 25’
  Speaker: Whitney Armstrong (Argonne National Laboratory)
  Material: Slides

  16:55
  **Partonic Structure of Light Nuclei** 25’
  Speaker: Dr. Mohammad Hattawy (Argonne National Laboratory)
  Material: Slides
ALERT Run Group

Nuclear Exclusive and Semi-inclusive Measurements with a New CLAS12 Low Energy Recoil Tracker

• Comprehensive suite of studies of $^4$He nucleus
  – new measurements of SIDIS, DVCS, DVMP reactions
  – to study nuclear models of the EMC effect (including their treatments of off-shellness and FSI), and partonic (including gluonic) structure with GPDs
  – requiring detection of low energy $p$, $^3H$, $^3He$, $^4He$ recoils

• Three PAC-44 Proposals
  – Tagged EMC Measurements off Light Nuclei
  – Tagged DVCS Off Light Nuclei
  – Partonic Structure of Light Nuclei

• Detector System
  – CLAS12 Forward Detectors
  – New ALERT Recoil Detector

Primary Institutions:
• Argonne National Laboratory
• Institut de Physique Nucléaire d’Orsay
• Temple University
• Jefferson Laboratory

Run Group Contact: K. Hafidi
ALERT Detector

- Gas Target
  - 30 cm effective length, 6 mm radius
  - 3 atm, 25 um Kapton walls
- Hyperbolic drift chamber \((32 < R < 85 \text{ mm})\)
  - 30 cm longitudinal wires with \(10^\circ\) stereo
  - 8 ~circular layers of 2 mm hexagonal cells
  - Light gas mixture ~1 atm, insensitive to relativstics
  - 250 ns drift time, included in trigger
- Two Segmented Scintillator Cylinders
  - TOF and total energy measurements
  - Total thickness ~20 mm
  - SiPMs directly attached
  - 150 ps time resolution, can be included in trigger
- Full GEANT 4 Simulation
  - Used to optimize the detector design
  - Evaluate drift chamber occupancies, thresholds, time and tracking resolutions, PID of p, d, \(^3\)H, \(^3\)He, \(^4\)He
- To Do
  - Evaluate/finalize electronics
  - Mechanical integration ongoing
ALERT Tagged-EMC Proposal

Spokespeople: R. Dupré, G. Charles, K. Hafidi, G. Dodge, N. Baltzell

- 20 PAC days at 11 GeV on each of $^4\text{He}$ and $^2\text{H}$
  - shared with rest of ALERT Run Group L
- Definitive tests of
  - Spectator model and FSI effects
  - $x_B$ vs $Q^2$ rescaling of structure functions
  - Local EMC model offshellness
  - Flavor dependent EMC effect
Tagged DVCS Off Light Nuclei
An ALERT Run Group Proposal for JLab PAC 44

Whitney R. Armstrong

Argonne National Laboratory

June 17, 2016

On behalf of spokespersons,
R. Dupré, K. Hafidi, Z.-E. Meziani,
and the ALERT Collaboration
Using p-DVCS to cleanly measure n-DVCS

\[
^4\text{He} + \gamma^* \rightarrow \gamma + p + ^3\text{H}
\]

Bound Nucleon

\[
^4\text{He} + \gamma^* \rightarrow \gamma + (n) + ^3\text{He}
\]

Quasi-Free neutron

\[
^2\text{H} + \gamma^* \rightarrow \gamma + (n) + p
\]

Test PWIA FSI

CLAS12

\[
\begin{align*}
t_q &= t_p? \\
\gamma^* &\rightarrow \gamma \\
N &\rightarrow N'
\end{align*}
\]

ALERT

- Use pDVCS to study FSIs and test the PWIA.
- Identify kinematics without FSIs
- Use charge symmetry \( \rightarrow \) n-DVCS similarly free of FSI

\[
A_{LU}^{sin \phi} = \frac{1}{\pi} \int_{-\pi}^{\pi} d\phi \sin \phi = \alpha
\]

Off-forward EMC Ratio

\[
R_\alpha^n = \alpha_{n^*}^{(4}\text{He}) / \alpha_n^{(2}\text{H})
\]
Tagged DVCS Off Light Nuclei Summary

Colors indicate the different $t$ bins which are shifted horizontally for clarity

Separated mean field nucleon EMC Effect and SRC nucleon EMC Effect

Observed deviations from $1 \rightarrow$ medium modifications of nucleons at the partonic level

- Tagged DVCS has unique ability to study FSIs in a model independent way
- Determine unambiguously if mean field nucleons are modified in nuclei
- $^4$He is the lightest of nuclei where this could easily be done
- Tagged DVCS BSA and FSI measurements complementary to a wide variety of existing and proposed experiments
Nuclear Exclusive and Semi-inclusive Measurements with a New
CLAS12 Low Energy Recoil Tracker

Partonic Structure of Light Nuclei

M. Hattawy (Argonne National Lab)
(On behalf of: N. Baltzell, R. Dupre, K. Hafidi, Z.-E. Meziani, M. Paolone)

NPWG - CLAS Collaboration Meeting - Friday, 17 June 2016
DVCS off He-4: Projected precisions

The statistical error bars are calculated for:
- 20 days at a luminosity of $3.0 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$.
- 10 days at a luminosity of $6 \times 10^{34} \text{ cm}^{-2} \text{s}^{-1}$.

$e^- + ^4\text{He} \rightarrow e^- + ^4\text{He} \gamma$

$A_{UL}$

$H_A$ projections

$\rho(x, 0, b_\perp) = \int_0^\infty J_0(b\sqrt{t}) H_A(x, 0, t) \frac{\sqrt{t}}{2\pi} d\sqrt{t}$

Projected charge profile precisions
φ production off He-4: Gluon profiles

\[ e + ^4He \rightarrow e' + ^4He + \phi(K^+ + K^-) \]

\[ \frac{d\sigma_L}{dt} = \frac{1}{(\varepsilon + 1/R)\Gamma(Q^2, x_B, E')} \frac{d^3\sigma}{dQ^2 dx_B dt} \]

R can be extracted from the angular distribution of the kaon decay.

In the phi helicity frame, assuming s-channel helicity conservation:

\[ W(\cos \theta_H) = \frac{3}{4} \left[ (1 - r^{04}_{00}) + (3r^{04}_{00} - 1) \cos^2 \theta_H \right] \]

Angular distribution amplitude

Spin-density matrix coefficient:

\[ r^{04}_{00} = \frac{\varepsilon R}{1 + \varepsilon R} \]

Angle of kaon decay

In phi helicity frame

Gluon density calculation:

\[ \rho_g(x, 0, b_{\perp}) \rightarrow \int_0^\infty J_0(b\sqrt{t}) \sqrt{\frac{d\sigma_L}{dt}} \frac{\sqrt{t}}{2\pi} d\sqrt{t} \]

- 0.18 < x_{\phi} < 0.25
- 2.0 < Q^2 < 3.0 GeV^2

Normalized cross-section

Input \[ r^{21}_{00} : 0.26 \]

Fit \[ r^{04}_{00} : 0.27 \]

0.18 < x_{\phi} < 0.25

2.0 < Q^2 < 3.0 GeV^2