SRC/CT@GlueX (ESCAPE) Status - 20 Feb 2023

Tim Kolar on behalf of SRC/CT@GlueX team

- **Calibration and data cooking are successfully finished.**
  - **2H, 4He**: done at NERSC,
  - **12C**: done on ifarm.
- **Launched 3 collective reaction skims (one for each target).**
- **6 students and postdocs.**
- **There are currently 9 active analyses:**
  - **SRC (3)**:
    - SRC probe universality (ρ^-),
    - SRC abundances and other properties (ρ^0),
    - np pair dominance in SRC (ρ^-,ρ^0),
  - **CT (1)**:
    - photon and color transparency in ^{4}He, ^{12}C using real photons (ρ^0),

- **OTHER (5)**:
  - branching ratio modifications (η, π^0, ...),
  - Σ beam-spin asymmetry for photoproduction of the π^- off deuterium,
  - cross section extraction of the π^-, p production from deuterium,
  - Axion-Like Particle search via the Primakoff Effect on nuclear targets ($\gamma\gamma$),
  - Φ production from neutron and coherent production on ^{2}H and ^{4}He.

- **ALP search is closest to publication, followed by SRC probe universality investigation.**

◦ SRC.1: Probe universality (Jackson Pybus, MIT)

Motivation: The main aim of this analysis is to test the universality of nuclear Short-Range Correlation (SRC) properties in hard factorized reactions using real photoproduction of ρ^- mesons as a complement to existing electron-scattering [1] and proton-scattering [2] measurements.

Status: SRC breakup selection cuts have been developed and exclusive $(\gamma np) \rightarrow (\rho^- pp)$ breakup events have been identified. Measurement of the fundamental $\gamma n \rightarrow \rho^- p$ cross section underway to use in factorized SRC breakup model (general-contact formalism - GCF) that was already tested with proton and electron probes. Figure shows preliminary results for comparison of data and said model.

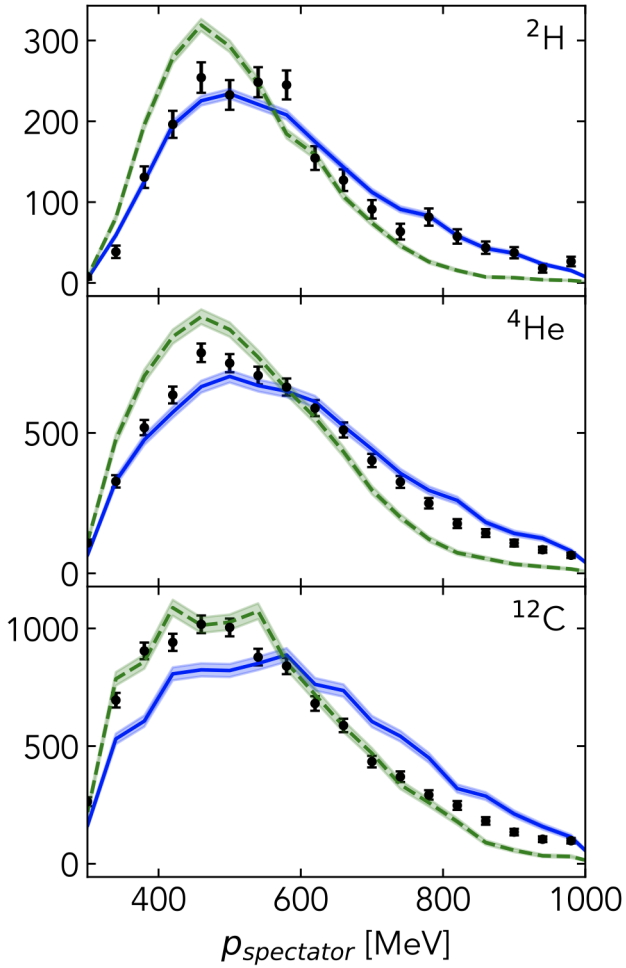

Figure 1: Preliminary results for momentum of the spectator proton. Points represent a subsection of our dataset ($\approx$ 10%), while lines represent simulations based on GCF using AV18 (blue) and NNLO (green) potentials.

◦ SRC.2: SRC abundances and other properties (Phoebe Sharp, GWU)

Motivation: The main task is to study various properties of SRC pairs in different nuclei using real photon beam. Using different combinations of A(γ, ρ^0p) and A(γ, ρ^0pp) channels, our analysis will be sensitive to different underlying phenomena. For example, we can do studies similar to those in [1] and [2], and determine not only relative aboundances of pp SRC pairs but also probe tensor-to-scalar transition in strong nuclear force.

Status: The selection and cleanup of ρ^0p events is being done in tandem with Bhesha who is using it to probe color transparency. While a lot of ρ^0pp event selection criteria resembles the one of Jackson's SRC analysis with ρ^-, not all of them are the same either requiring different approach or fine-tunning. Because of this I am undertaking more comprehensive study of this reaction, its kinematics, and detector response with monte carlo simulation using general contact formalism for event generation. Immediately after I establish how to best isolate SRC events I plan to move on the data analysis.

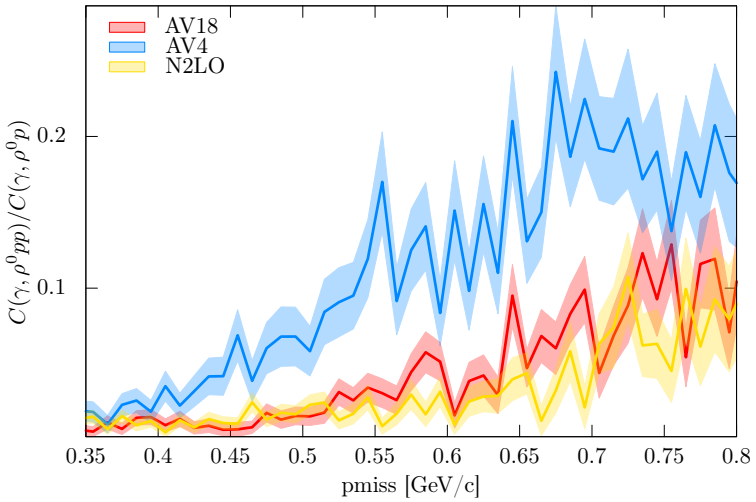

Figure 2: Simulation predictions based on GCF model using AV18, AV4, and N2LO potentials for the SRC pp-pair abundance as a function of p_{miss}.

◦ SRC.3: np-pair dominance (Phoebe Sharp, Jackson Pybus)

Motivation: With formation of ratios between yields from A(γn, ρ^-pp) and A(γp, ρ^0pp) reactions, we are able to probe ratio of np to pp SRC pairs in given nucleus and provide an alternative perspective on strong coupling between nucleons as a function of p_{miss}.

Status: This analysis is being done in parallel with analyses SRC.1 and SRC.2 since the same reactions are used there.

◦ CT.1: Photon and color transparency in nuclei using real photon probe (Bhesha Devkota, MSU)

Motivation: The goal of this analysis is to study nuclear transparency using real photon probe through $A(\gamma, \rho^0 p)$ reaction. There are several factors that can influence nuclear transparency [1], one of them being predicted phenomena of color transparency (CT) [2].

Status: Working on event selection to isolate signal as much as possible. Currently the main focus is on optimization of PID for charged tracks in the reaction's final state (mainly p and π^+ misidentification).

◦ OTHER.1: Branching Ratio Modification (Tim Kolar, TAU)

Motivation: The nucleon is a complex system that can be described in QCD at any given moment as a superposition of different Fock states as

$$|\mathrm{N}\rangle = \alpha_{3q}|3q\rangle + \alpha_{3qg}|3q+g\rangle + \alpha_{3qqq^-}|3qqq^-\rangle + \alpha_{3q\pi}|3q\pi\rangle + \dots$$

or for a bound one

$$|\mathrm{N}^*\rangle = \alpha^*_{3q}|3q\rangle + \alpha^*_{3qg}|3q+g\rangle + \alpha^*_{3qqq^-}|3qqq^-\rangle + \alpha^*_{3q\pi}|3q\pi\rangle + \dots ,$$

where $\alpha^{(*)}$ represents the amplitude of each state.

An example use of such an effect can be found in the 'Point Line Configurations Suppression' model [1] or the 'Blob-Like Configurations Enhancement' model [2] that propose an explanation to the EMC effect in which the contribution from valence-only ($|3q\rangle$) part of the bound nucleon is different than in a free one. In Ref. [1] $|\alpha^*_{3q}/\alpha_{3q}|^2 - 1$ is proportional to the nucleon off-shellness (approximately to the square of the nucleon momentum in nucleus).

We expect that different Fock states will absorb high-energy photons differently and lead to different branching ratios (BR) for various final states (e.g., $\gamma\mathrm{p} \rightarrow \rho^0\mathrm{p}; \eta\mathrm{p}; \dots$)

◦ OTHER.1:

Status: We have started with an analysis of $\gamma p \to \pi^0 p$ and $\gamma p \to \eta p$ since the two mesons differ in strangeness but they result in the same final state of $(\gamma\gamma p)$ for which GlueX is an excellent detector.

We successfully cleaned the two channels and have already preliminary results for deuterium (shown in Fig. 3). Because this is a novel approach we still have a long way to go in order to make sure that the effect we are seeing is indeed real and relevant.

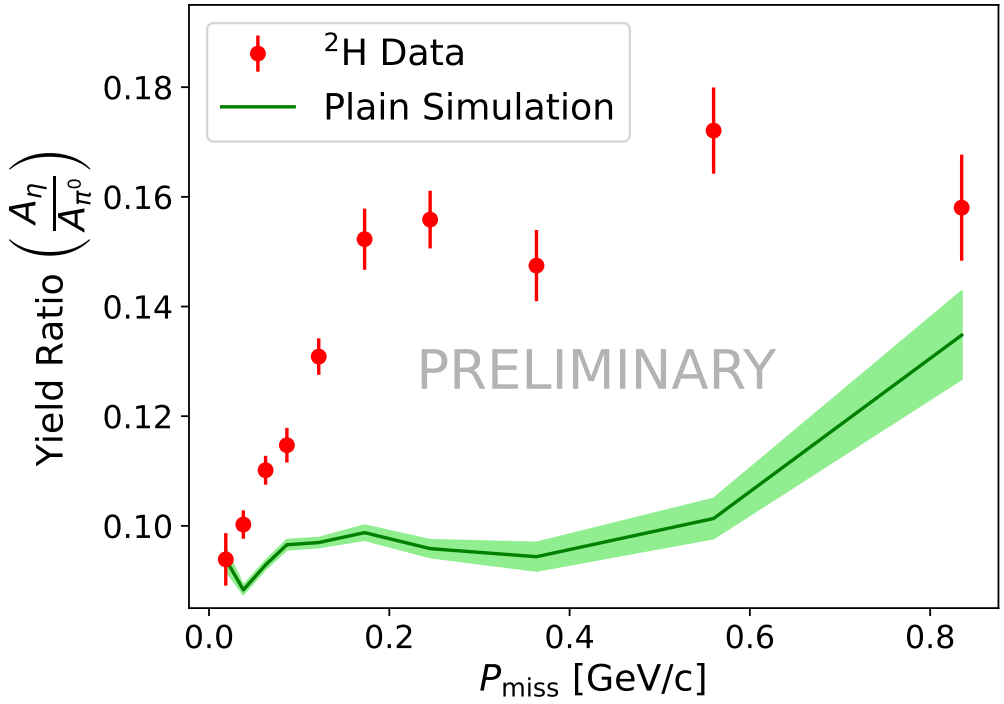

Figure 3: Yield ratio for production of the π^0 and η mesons off a proton bound in deuterium. The curve shows a result from simulation using a simple PWIA with constituent counting rule as an input for the cross-section.

◦ OTHER.2: Σ beam-spin asymmetry for photoproduction of the π^- off deuterium (Logan Earnest, GWU)

Motivation: My main goal is to obtain a measurement of the sigma beam spin asymmetry for photoproduction of the π^- meson off deuterium. Only measurements currently available were done at much lower energies (1.82 to 2.22 GeV) [1] than those available to us through this experiment (approximately 8.0 to 8.8 GeV).

Status: Currently, my $\gamma d \rightarrow \pi^- pp$ analysis is focused on background subtraction and determining the binning scheme for the Σ beam-spin asymmetry measurement (BSA). I have done accidental subtraction and cuts on the reaction's missing $x-$ and y-momentum. Over the course of this week, I plan to begin fitting background of missing z-momentum and finalize BSA uncertainty estimates.

◦ OTHER.3: Cross section extraction of the π^-, p production from deuterium (Bo Yu, DUKE)

Motivation: Study the transition from nucleon-meson to quark-gluon degrees of freedom (related refs: [1], [2]).

Goal: Extract the differential cross section.

Status: The acceptance is extracted. More elaborate data cleaning is underway to suppress the background.

◦ OTHER.4: Axion-Like Particle Search via the Primakoff Effect on nuclear targets (Jackson Pybus, MIT)

Motivation: The aim of this analysis is to demonstrate the viability and limitations of a proposed [1] method of producing Axion-Like Particles via the Primakoff Effect on nuclear targets.

Status: To establish the analysis procedure a small data subset ($\approx$ 7%) was used. In order to pin down this procedure and get expert opinion an detailed analysis note was prepared. Currently we are in the process of unblinding the full dataset to complete the limit-setting procedure.

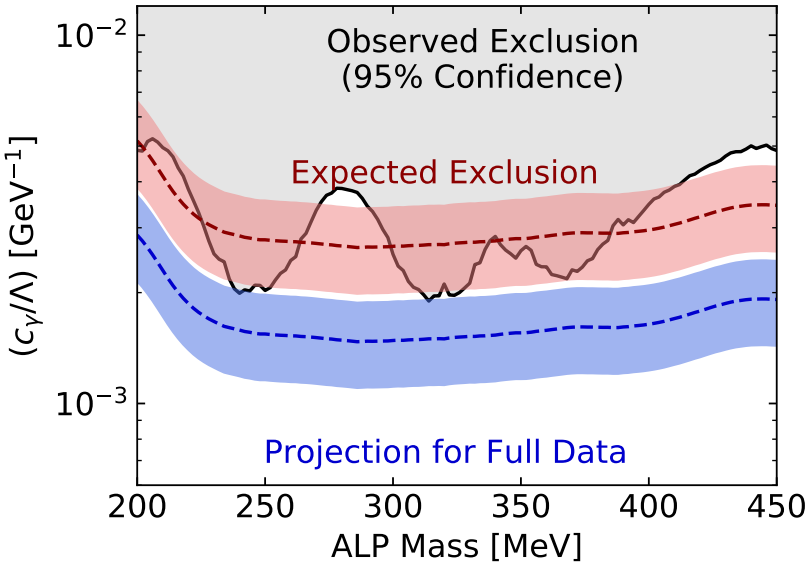

Figure 4: 95% exclusion range on the ALP-photon coupling as a function of ALP mass. The black line and shaded region show the exclusion limits set by the current subset of the data. The red band shows the range of expected exclusion of the current dataset given the background-only hypothesis. The blue band shows the projections for the limits set by the full dataset.

◦ OTHER.5: Φ production from neutron and coherent production on ^{2}H and ^{4}He (Bo Yu, DUKE)

Motivation: To study Pomeron exchange and strange sea quark in the nucleon. (related refs: [1], [2])

Goal: Get a ratio of cross section on proton to neutron. Extract cross section for coherent production.

Status: Cross section of the phi production on proton from deuterium is being extracted as a base point for the production on neutron and coherently on nucleus.