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Monte-Carlo Simulation of ^{3}H$(\gamma, pn)n$ and ^{3}He$(\gamma, pp)n$ Experiments at HIγS*

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Abstract. We are developing an experiment to measure the two and three-body (γ, p) differential cross sections (DCS) for ^{3}H and ^{3}He. These data will be used to determine the $^1S_0$ nn scattering length (a_{nn}) and np scattering length (a_{np}) respectively. This paper describes features of the Monte-Carlo (MC) simulation that will aid in the optimization of the experimental design and the data analysis approach.

1 Introduction

Experiments to measure the differential cross sections for photodisintegration of ^{3}H and ^{3}He are being developed at the Triangle University Nuclear Laboratory (TUNL). The goal of this project is to provide data for assessing the theoretical treatment of meson-exchange currents in photodisintegration of nuclei and for investigating long-range features of three-nucleon interactions. Measurements will be performed using a linearly polarized gamma-ray beam at the High Intensity Gamma-ray Source (HIγS) at TUNL. The proton energy spectrum will be measured at several polar angles in the range from 45° to 135°. The first measurements will be performed with an incident γ-ray beam energy of 15 MeV. Higher energies may be investigated in future studies. In the conceptual experiment design, trajectories and energies of the emitted protons will be determined with wire chambers and silicon detectors located on either side of thin-walled gas targets.

2 Monte-Carlo Simulation Overview and Preliminary Simulation Results

The simulations are important for guiding the experiment design, the data acquisition strategy and for comparing theory to data for interpretation of results. The main focus of this work is to determine nucleon-nucleon scattering lengths from the photodisintegration data. The simulation is based on the GEANT4 toolkit. Using theoretical calculations by Witała and Skibinski [1,2], photodisintegration events are generated inside the gas targets, and the emitted protons are propagated from the

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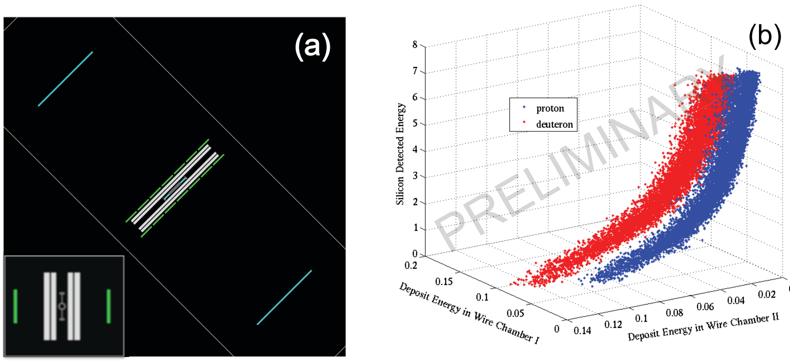

Figure 1. (a) Experiment geometry used in the simulation, includes two wire chambers (white), seven silicon strip detectors (green), and a neutron detector (blue) on each side. (b) Expected signal in silicon detector as a function of energy deposited in wire chambers without including finite detector resolution for protons (red) and deuterons (blue).

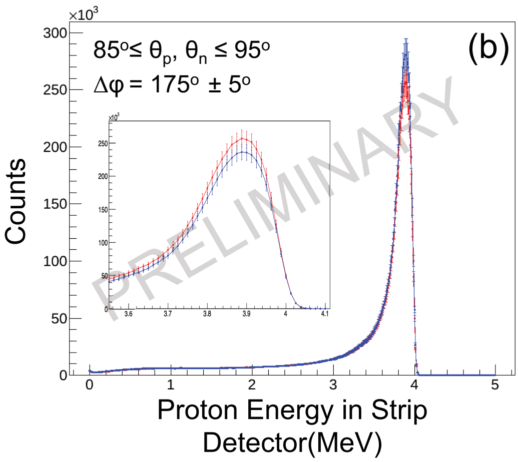

Figure 2. Simulated exclusive proton energy spectra for ^{3}H(γ, *pn*) of two different scattering length a_{nn}= -17.8fm (red) and a_{nn}= -19.8fm (blue) at the silicon detector. Events shown are constrained such that 85° < θ_p, θ_n < 95°, and $\Delta\phi$ = 175° ± 5°. The error bars are 3% for reference.

reaction site through the detection apparatus. The simulations of the proton energy spectra will allow direct comparison between measurements and theory. Count rate and background estimations will be performed with simulations, which are used in experiment planning and data analysis.

The goals of our simulation are as following: (a) to aid in comparing the measurements to theory; (b) to analyze systematic uncertainties; (c) to estimate count rate of the reactions of interest and background for projecting statistical accuracy for determining a_{nn}; (d) to evaluate the use of $\Delta E/E$ for charged particle identification.

References

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