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Neutron-reconstruction and break-up channel identification in dd scattering using Time-of-Flight information of BINA scintillators

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Abstract
In this paper, a novel approach was presented based on the Time-of-Flight information of detected neutrons in the three-body break-up dd scattering to reconstruct the kinematical parameters of the neutron. Since neutrons only can leave a trace in the BINA detection system, the yields of the energy spectrum of the neutrons obtained from PMTs of the scintillators are not reliable for the extraction of the neutron energy. Also, the MWPC can not see neutrons. Therefore, the X and Y coordinates and subsequently the scattering angles of neutrons are extracted using the hit positions of particles within the E scintillators and their TOF information. Having the information of the scattering angles of neutrons as well as the kinematical parameters of another charged particle, one can calculate neutron energies using momentum and energy conservation laws. The particle identification technique was also exploited to identify the dn combination from the pn combination of the three-body break-up channel. To validate the proposed approach, the kinematics of protons obtained through the aforementioned approach were compared with those obtained using merely ADC signals. Identifying and reconstructing the kinematics of final-state neutrons allows us to analyze different hadronic channels of the dd scattering process in which neutrons are detected as a final-state particle. As a result, Coulomb effects and isospin dependency on nuclear potential can be investigated.

Keywords: neutron, deuteron-deuteron scattering, three-body break-up channel, Time-of-Flight information

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