Development and Simulation of a Phoswich Plastic Scintillator ΔE-E Telescope for Charged Particle Identification in In-Beam Gamma-Ray Spectroscopy

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In-beam ɣ-ray spectroscopy techniques benefit significantly from charged-particle tagging, which enhances channel selectivity in complex fusion-evaporation reactions. This work presents the design, computational modeling, and optimization of ΔE-E phoswich plastic scintillator telescope system tailored for proton and α-particle identification. The detector design couples a thin, fast scintillator layer (BC400) to a thicker, slower-decay scintillator (BC444) via vacuum thermal pressing. Light readout is performed using Silicon Photomultipliers (SiPMs) combined with custom light guides, while digitial acquisition modules process pulse shape analisys (PSA). Theoretical reaction channels for the $^{16}O + ^{55}Mn$ system leading to states in ^{67}Ga were evaluated using NuDat 3 [1] and statistical model calculations with the PACE4 [2] code. PACE4 [2] simulations mapped excitation functions up to 90 MeV, establishing an optimal beam energy around 72 MeV at the 8UD Pelletron accelerator (LAFNA-IFUSP) to maximize particle evaporation channels. Three-dimensional CAD modeling of the setup in FreeCAD [3] was directly implemented into Geant4 [4] Monte Carlo simulations to assess energy deposition profiles and efficiency. The resulting simulated matrix ΔE-E demonstrates clear separation bands between emitted protons and α particles, validating the geometric and physical feasibility of the proposed setup. Experimental validation will include benchmarking with a ^{241}Am source, followed by in-beam experiments aimed at integrating this telescope into particle-ɣ coincidence measurements for nuclear structure studies.

Keywords: Phoswich detector, ΔE-E telescope, Particle identification, Geant4, Fusion-evaporation reactions, In-beam ɣ-ray spectroscopy.

[1] NATIONAL NUCLEAR DATA CENTER (NNDC). *NuDat 3: Nuclear Structure and Decay Data*. Brookhaven National Laboratory. Disponível em: https://www.nndc.bnl.gov/nudat3/.

[2] GAVRON, A. Statistical model calculations in heavy ion reactions (PACE). *Physical Review C*, v. 21, n. 1, p. 230–236, 1980.

[3] RIEGEL, J. et al. *FreeCAD: Your own 3D parametric modeler*. Software de código aberto. Disponível em: https://www.freecad.org/.

[4] AGOSTINELLI, S. et al. Geant4—a simulation toolkit. *Nuclear Instruments and Methods in Physics Research Section A*, v. 506, n. 3, p. 250–303, 2003.