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Studies of quasi-free proton knockout reactions with the CALIFA Calorimeter at the R3B/FAIR Setup

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A successful and widely used tool for the understanding of the single-particle structure and the role of nucleon-nucleon correlations is proton-induced quasi-free scattering reactions (QFS) at relativistic energies. This technique was successfully applied at the R3B/LAND setup (at GSI in Germany) and has been used with an upgraded setup for the future R3B program at FAIR/GSI. One of the key detectors of the R3B setup is CALIFA (the CALorimeter for In Flight detection of gamma-rays and light charged pArticles) to detect the knocked-out nucleon as well as the recoiled target proton originating from a QFS reaction. CALIFA is highly segmented and currently consist of 1528 scintillation CsI(Tl) crystals to facilitate measurement of the emission angle and energy of reaction products. CALIFA covers a large dynamic range to allow a coincidence measurement of γ -rays down to 100 keV and scattered protons up to 700 MeV. A special feature of Califa is the digital Quick Particle Identification (QPID) enabling gamma and charged particle identification through Pulse Shape Analysis (PSA) of the scintillation light output.

The QFS signature has been observed by angular correlations of the knocked-out nucleon and recoiled target proton. The high crystal granularity and large angular coverage of CALIFA allow to obtain angular correlations between the scattered particles with an angular resolution and a high detection efficiency. The γ -rays emerging from the excited nuclei are also measured with very high efficiency and a precise Doppler correction.

We present results from selected (p,2p) reactions in the frame of FAIR Phase-0 experiments. The discussion will include angular correlation of (p,2p) events and simultaneous measurement of γ -rays of the final bound states of the residual nuclei as well as QPID application to select (p,2p) protons for specific physics cases. It will be followed by a discussion of a benchmark (p,2p) experiment on a heavy nuclei ^{208}Pb as a proof of concept. The conducted experiment is the first successful measurement of a (p,2p γ) reaction for such heavy nuclei and hence a good test case for experiments planned at R3B/FAIR to investigate third r-process peak. The preliminary results will be presented and measured γ -ray spectra will be compared to the existing data in literature.

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Topic

Experiment

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