2 - 29 Study of Spallation Reaction by High Energy Protons and Carbons*

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The spallation reaction was studied with 250 MeV proton beam and 400 MeV/u carbon beam at the HIRFL-CSR in Lanzhou. The neutron and residual radionuclide production were measured by using the off-line γ-spectroscopy method. The radiation dose induced in spallation reaction was studied by using the thermoluminescent detectors. Moreover, an on-line neutron measurement method was developed by using a digital pulse shape discrimination system. All of the experimental method will be used to study the neurotics of the ADS system.

(1) The thick target of Pb was irradiated with 250 MeV protons. The neutron production was measured with the water-bath gold method. The thermal neutron distributions in the water were determined according to the measured activities of Au foils. Corresponding results calculated with the Monte Carlo code MCNPX were compared with the experimental data. It was found out that the Au foils with cadmium cover significantly changed the spacial distribution of the thermal neutron field. The corrected neutron yield was deduced to be (2.23 ± 0.19) n/proton by considering the influence of the Cd cover on the thermal neutron flux[1].

(2) A Pb foil was irradiated with 400 MeV/u carbon beam and the experimental data was acquired by the off-line c-spectroscopy method. 32 radioactive residual nuclides had been observed and their cross sections were determined. The measured results were compared with the results simulated by Monte Carlo code MCNPX2.7.0. The comparison shows that the simulated cross sections were underestimated for the fragments from $A = 20$ to 41 and $A = 110$ to 175. By fitting the measured and simulated cross sections to Rudstams semi-empirical formula, it was found that the charge distribution of products was asymmetric for the residual nuclides with a high mass number[2].

(3) The Cu, W and Pb targets were bombarded with 250 MeV proton beam. The data were obtained by the off-line c-spectroscopy method. Six nuclides in Cu, twenty-eight nuclides in W and thirty-four nuclides in Pb target were identified and their cross sections were determined. Corresponding calculated results by using the MCNPX transport code with different intranuclear cascade (INC) and de-excitation models were compared with the experimental data to check the validity of the models. The comparison indicated that the simulated results from those models were generally consistent with the experimental data in the target-near mass region. However, significant discrepancies between experiment and simulation were found in the medium mass region. For the production of fission products, the CEM03-generated values gave a better agreement with experimental results than other models[3].

(4) A digital pulse shape discrimination system based on a programmable module NI-5772 has been established and tested with EJ-301 liquid scintillation detector. The module was operated by means of running programs developed in LabVIEW with the sampling frequency up to 1.6 GS/s. Standard ^{22}Na, ^{137}Cs and ^{60}Co γ sources were used to calibrate the EJ-301 liquid scintillation detector, and the γ response function has been obtained. Digital algorithms for charge comparison method and zero-crossing method were explored. The experimental results showed that both digital signal processing (DSP) algorithms could discriminate neutrons from γ-rays. Moreover, the zero-crossing method shows better n-γ discrimination at 80 keV and lower, whereas the charge comparison method is better at higher thresholds through comparing the quality of n-γ separation of these two algorithms. In addition, the figure-of-merit (FOM) of two different dimension detectors were extracted at 9 energy thresholds, and it was found that the smaller one presented a better n-γ separation property for fission neutrons.

(5) The characteristics of nat., ^{7}LiF:Mg, Cu, P thermoluminescent detectors exposed to high-energy ^{12}C (165 MeV/nucleon) ions and ^{60}Co γ-rays have been investigated. Through a careful analysis of the glow curves by the GlowFit program, it is found that the relative amplitude of satellite peaks 3, 5, 6 and 7 to peak 4, measured after irradiated with high-energy ^{12}C ions, is higher than that with ^{60}Co γ-rays for both types of thermoluminescent (TL) detectors. It is observed that nat.,^{7}LiF:Mg, Cu, P TL detectors would also exhibit a good linear dose response when the delivered dose of high-energy ^{12}C ions is in the range from 100 to 1 600 mGy. Furthermore, the relative efficiency of the nat., ^{7}LiF:Mg,Cu,P TL detectors is independent of the absorbed dose in the linear dose response range. Compared to previously published data, the relative efficiency of the ^{7}LiF:Mg, Cu, P TL detectors decreases with increasing LET values.

References

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