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238U IN THE NEUTRON FIELD AND THE BREMSSTRAHLUNG RADIATION FIELD ON THE BEAMS OF PROTONS AND ELECTRONS OF THE ACCELERATORS AT JINR: CALCULATIONS AND EXPERIMENTS

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In the framework of the "Energy and Transmutation of RAW"collaboration [1], the experiments were carried out at the accelerators: Nuclotron, Phasotron and LINAC of JINR and have studied deeply of nuclear inelastic processes using gamma spectroscopy techniques and HPGe detector.
The neutron fields on the proton beam were created using the lead and uranium targets. The field of the secondary bremsstrahlung radiation during the irradiation of the samples on the electron beams was obtained with the use of the lead (or bismuth) converter. The gamma spectra were measured and studied with the HPGe detectors on the spectrometric complex at YASNAPP-LNP and LHEP JINR.
As the result of the study, the yields of the products of the secondary reactions: (n, f), (γ, f) –fission reactions in the 238U samples; (γ, xn) –photonuclear reactions in the 238U, 209Bi samples and also (n, γ) for all the samples.
For the theoretical interpretation of the studied reaction, the simulation programs were used: FLUKA, GEANT4 and MCNP. As the result of simulating, the calculations were made: the distribution of neutrons emitted from the lead targets by energies and coordinates on the proton beam (figure 1); the distribution of the secondary bremsstrahlung radiation (and the secondary neutrons) on the electron beam produced using the Pb or 209Bi converters; the quantitative results of the (n, f) fission reaction products on the proton beams in the 238U samples; the quantitative results of the photonuclear reaction products (n, γ)on the electron beams in the 238U and 209Bi samples.
The calculation estimates of the yields of the capture and fission products in the reactions on the actinide nuclei were made at the energy of the incident charged particles with E > 1 GeV.

Fig. 1. The distribution of the neutron emitted from the lead target on the proton beam with E = 660 MeV.
[1] S.I. Tyutyunnikov, V.I. Stegailov et al., "NUCLEUS-2020". St-Petersburg, 117-118 (2020).

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