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Nuclear physics at Saint-Petersburg state university: from fundamental research to nuclear medicine applications

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In modern nuclear physics there is growing interest in nuclear reactions at low interaction energies, particularly in studying the mechanisms of medium-mass nuclei formation and decay. This interest came from both fundamental research questions and the significant role these reactions play in nuclear physics, nuclear astrophysics, and the industrial production of radionuclides. Despite the extensive experimental data available today, spanning a wide range of energies and interacting nuclei, gaps remain in nuclear data, particularly concerning the excitation functions of nuclear reactions. This is especially take place for reactions involving projectile particles with energies exceeding 20 MeV in the entrance channel and those producing one or more neutrons in the exit channel. Given the significant interest in such reactions (particularly of (p,n)-type) for producing isotopes used in nuclear medicine [1], the accurate estimation of the corresponding radionuclide yields is essential. In diagnostic procedures these radionuclides are used for both planar imaging and single-photon emission computed tomography (SPECT) with gamma cameras. Pharmaceuticals labeled with positron-emitting radionuclides are used for positron emission tomography (PET). Imaging in nuclear medicine gives visualization of anatomical, functional, and metabolic processes within the human body. An equally important application is the targeted delivery of radiopharmaceuticals to cancer cells for non-surgical tumor treatment. The integration of diagnostic imaging and radionuclide therapy in theranostics (therapy + diagnostics) offers exceptional potential for early, effective diagnosis and treatment of localized tumors and metastatic cancers while minimizing side effects.

This overview presents investigations of medium-mass nuclear reactions along with new technologies for nuclear medicine isotope production developed at Saint-Petersburg State University. The experimental setups for studying beam and detector characteristics are described. These detectors and sensors are being developed for novel tracking systems to investigate superdense nuclear matter in experiments at the NICA accelerator-storage complex. In applied physics, these detectors are implemented in PET scanners and Proton Computer Tomography (diagnostic tool for hadron therapy methods) complexes.

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1. Zherebchevsky V.I., Alekseev I.E., Maltsev N.A. et al., Modern Technologies for Producing Radionuclides for Nuclear Medicine, Bull. Russ. Acad. Sci. Phys., vol. 87, iss. 8, 2023, p. 1207.

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