

# RAPORT ȘTIINȚIFIC 2022

## PN-III-P4-PCE-2021-0595

### Rezumat executiv

For the theoretical part of the project we have developed the EDF+QPM model, in particular with focus on the description of  $^{56}\text{Fe}$ . It is seen that the theoretical predictions of the summed electric dipole strength follow closely the  $(\gamma, \gamma')$  experiment up to about  $E_x=7.5$  MeV. In the energy range  $E_x = 7.5 - 10$  MeV, the theory exceeds the electric dipole strength claimed from  $(\gamma, \gamma')$  experiments by about three times, while  $(p, p')$  data does not exist yet. For statistical models, we have also started evaluating the limits of applicability of the TALYS code for nuclei in the region of interest for PANDORA. Specific evaluation of the performance have been made in the  $N = 28$  region, where radiative proton-capture has been chosen as a reference reaction in the absence of large-scale photonuclear data.

From the experimental side, at the IFIN-HH facilities, we have developed a method for detector calibration at high energies, something that will be critical for the measurements of radiative branches relevant for the PANDORA project, due to the well known issues of detector non-linearities at high energies. Given a plutonium-beryllium (PuBe) source with a emission rate of  $2.2 \times 10^5$  neutrons per second, we achieve a surface flux of 9 MeV  $\gamma$ -rays of approximately  $2.5 \times 10^{-6} \text{ cm}^{-2}$  per emitted neutron, in a device that can be easily mounted in a detector array. We have, furthermore, carries out several experiments at the IFIN-HH facilities focusing on  $^{10}\text{B}$ ,  $^{12}\text{C}$ , and  $^{19}\text{F}$  that will used to benchmark *ab initio* calculations as well as develop experimental methods for the combination of scintillator detectors for  $\gamma$  rays and charged particle detectors in later phases of the project.

For iThemba LABS the status of the 200-MeV proton beam was tested in July after the installation of the third UPS in the accelerator chain. Further commissioning is on the way to be able to run the accelerator at full energy. In preparation for the coupling of African LaBr Array (ALBA) and Coincidence Array for K600 Experiment (CAKE), one experiment was carried out using the  $^{19}\text{F}(p, \alpha)$  reaction at the 3MV Tandem facility at IFIN-HH. By combining the ELIGANT Gamma Neutron (ELIGANT-GN) scintillator detectors and the ELI Silicon Strip Array (ELISSA) charged particle detectors in the same digital electronics system, we can develop readout and analysis procedures for ALBA and CAKE.

At RCNP, the commissioning of the beamline, including Grand Raiden, was performed during the summer. This included beam resolution check and spectrometer basic tests including the upgraded DAQ system. In preparation for the full experimental campaigns, analysis of experimental data only including Grand Raiden has been started.

The following scientific articles have been published, or are in teh process of being published, during this phase of the project:

- P.-A. Söderström, D. L. Balabanski, R. S. Ban, Gh. Ciocan, M. Cuciuc, A. Dhal, V. Fugaru, V. Iancu, A. Rotaru, A. B. Șerban, et al., Design and construction of a 9 MeV  $\gamma$ -ray source based on capture of moderated plutonium-beryllium neutrons in nickel, *Appl. Radiat. Isot.*, **191**:110559, 2023.
- A. Tamii, L. Pellegri, P.-A. Söderström, D. Allard, S. Goriely, T. Inakura, E. Khan, E. Kido, M. Kimura, E. Litvinova, et al., PANDORA project: photo-nuclear reactions below  $A = 60$ , *Eur. Phys. J. A*, submitted
- B. Wang, Y. Xu, and S. Goriely. Systematic study of the radiative proton capture including the compound, pre-equilibrium, and direct mechanisms, *Phys. Rev. C*, submitted