

## Study of reactions with proton emission at $E_{\max} = 20$ MeV on natural and enriched hafnium targets

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The study of the cross-sections and yields for the population of high-spin isomeric states in reactions with the charged particles emission makes it possible to get information on the exciting levels' structure in the continuous and discrete regions of excitation as well as on the mechanisms of the nuclear reaction occurrence. Therefore, our work aims to investigate the production yields of Lu-(179m+g) and Lu-178m in reactions with bremsstrahlung gamma quanta for energies in the giant dipole resonance region.

The weighted average yields were measured by the activation method using  $\gamma$ -quanta bremsstrahlung for electrons with the 20 MeV maximum energy on targets of natural metallic hafnium and enriched hafnium Hf-180 in powdery form.

The spectra of irradiated targets were measured by the Canberra and Ortec HPGe spectrometers with the (15-40)% detection efficiency compared to the 3'x3" NaI (Tl) detector. The spectrometers' energy resolution was 1.8–2.0 keV on the Co-60 1332 keV  $\gamma$ -line.

The gamma transitions from the Lu-(179m+g) and Lu-178m decays are reliably distinguished in the studied spectra.

The Lu-179m+g weighted average population yield was measured for the ( $\gamma$ , p)-reaction on Hf-180, and Lu-178m weighted average population yield was measured for the ( $\gamma$ , p)-reaction on natural hafnium at the 20 MeV maximum value of the  $\gamma$ -ray bremsstrahlung for the first time.

The following values of the weighted average yields were obtained: for  $180\text{Hf}(\gamma, p)179\text{m} + \text{gLu}$ -reaction 185(49)  $\mu\text{bn}$ , for  $179\text{Hf}(\gamma, p)178\text{mLu}$ -reaction 12.7 (21)  $\mu\text{bn}$ .

We stated the dominance of non-statistical processes as a modeling result within the framework of the TALYS-1.9 program code. The obtained data are discussed.

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**Primary author:** ZHELTONOZHSKAYA, Marina (Lomonosov Moscow State University)

**Co-authors:** Prof. ZHELTONOZHSKY, Viktor (Lomonosov Moscow State University); Dr SAVRASOV, Andrij (Institute for Nuclear Research of National Academy of Sciences of Ukraine ); Mr REMIZOV, Pavel (Lomonosov Moscow State University); Prof. CHERNYAEV, Alexander (Moscow State University)

**Presenter:** Dr SAVRASOV, Andrij (Institute for Nuclear Research of National Academy of Sciences of Ukraine )

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