Yield studies of nuclei in the waiting-point regions of the rp process at ISOLDE

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The astrophysical rapid proton capture process (rp process) [1] is a part of the explosive hydrogen burning occurring during astrophysical events such as accretion in a close binary system. In high temperature and density conditions of $T_9 > 1$ and $\rho > 10^4$ g/cm^2 the rp process can proceed beyond $A = 64$ and $Z = 32$ [2] and may continue possibly up to $A = 100$ via two-proton capture reactions bridging the waiting-points [3]. The speed of the process beyond $A = 64$ is defined largely by two of such waiting points along the process path at ^{68}Se and ^{72}Kr. Thus, experimental data on beta-decay half-lives and, in particular, nuclear masses and proton separation energies from this region are needed for reliable modelling of the process path, the resulting isotopic abundances and energy production.

In this paper we report on the status of the studies of the $N \sim Z$ nuclei close to the described bottleneck region at the ISOLDE on-line mass separator [4] concentrating on the yields of the isotopes of interest. The recent upgrade of the primary proton beam energy at ISOLDE from 1.0 GeV to 1.4 GeV was complemented by a test with 600 MeV energy at the beginning of December 2000. Particularly, the aim of this test measurement was to produce neutron-deficient Kr isotopes via spallation reactions in a Nb-foil target. In addition to their significance for near future experiments at ISOLDE, the results will possibly have significant consequences concerning the usable energies for producing the neutron-deficient isotopes in the future proton driver accelerators at ISOL facilities. A comparison of the yields to the available experimental and theoretical data will be given. In addition, the relevance of these tests for the future studies with nuclear spectroscopy and atomic mass measurements at ISOLDE [5] on the rp process will be discussed.

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