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Excited State Lifetime Nuclear Metrology: Precision Half-life Measurements in 164Dy and 166Dy and Reaction Channel Selection Techniques using the NuBALL Spectrometer

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Results are presented from the first in-beam experiment using the NuBALL hybrid HPGe-LaBr3 gamma-ray spectrometer at IPN, Orsay, performed in November 2017, with the physics aim of determining the electromagnetic transition rates to the ground state of the N=100 nucleus 166Dy. In this first configuration, the NuBALL spectrometer comprised 24 Compton suppressed HPGe Clover detectors, 10 coaxial HPGe Compton suppressed spectrometers, and 20 single-element LaBr3 detectors supplied by the FATIMA and UK Nuclear Data Network collaborations. These detectors were read out using a fully-digital data acquisition system. Excited states in 166Dy were populated via the 164Dy(18O,16O)166Dy two-neutron transfer reaction using a 6.3 mg/cm2 164Dy gold-backed target of 95% purity and a pulsed 18O beam with energies of 71, 76 and 80 MeV provided by the tandem Van de Graaff accelerator at IPN Orsay. The ultimate physics goals of this work are to determine excited state lifetimes in the vicinity of the valence maximum nucleus 170Dy104 [1], using the HPGe-gated, LaBr3-LaBr3 fast-timing time-difference technique. The states identified as populated in 166Dy are compared with results from previous spectroscopic studies of this quadrupole deformed nucleus, using deep-inelastic reactions to populate high-spin cascades [2,3], and (t,p) transfer reactions on 164Dy [4] and β-decay from 166Tb [5] which are more selective for lower-spin states. A value for the previously unknown half-life of the first excited 2+ state in 166Dy is presented. Values for the half-lives of the first excited 2+ and 4+ states in 164Dy are also presented, obtained from direct gamma-gamma time differences for the first time [6]. Methods of channel selection used to enhance the peak-to-total ratio for the 166Dy and to discriminate these from the 178W populated via the competing fusion-evaporation channel [7,8] will be demonstrated. In particular, the effects of total energy-total gamma multiplicity and prompt-delayed coincidence timing will be discussed.

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