β-Detected Nuclear Magnetic Resonance (β-NMR) at ISOLDE to Determine the Distribution of Magnetisation in Halo Nuclei *

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^{11}Be is of interest because it is a single neutron halo nucleus and gaining access to the nuclear magnetization distribution in this nucleus would directly allow to investigate the extent of its halo structure. To achieve this goal experimentally, one requires measuring the magnetic moment with much improved accuracy and combining it with an already measured precise hyperfine A factor [1]. This contribution describes the experimental setup at ISOLDE which will be employed to reach the above goal [2].

Our method for measuring the nuclear magnetic moment of unstable nuclei is β-detected Nuclear Magnetic Resonance (β-NMR) that we apply at the VITO beamline at ISOLDE [3]. β-NMR allows investigations of short-lived isotopes with a sensitivity unattainable to conventional NMR. This increased sensitivity is gained by combining hyperpolarization of the nuclear spin generated through optical pumping and an efficient detection exploiting the asymmetry in emission of β-particles from the decaying polarized isotopes.

The ISOLDE VITO beamline has undergone several upgrades and extensions in the past, such as the installation of a superconducting solenoidal magnet with sub-ppm homogeneity and the capability to measure in liquid samples [4]. A recent upgrade that we present here is a new pair of β detectors which add the capability of measuring the energies of the detected β-particles. The energy resolution was optimized by simulating light transport within the detector volume using Geant4. The optimized detector design based on these simulations is using organic scintillators and silicon photomultipliers, it collects the scintillation light via total internal reflection.

It is planned to use the new detector setup for all upcoming beam-times including investigations of ^{11}Be. In ^{11}Be energy resolution is particularly useful because in ^{11}Be the two most intense transitions, the transition to the ground state and the first excited state have opposite β asymmetry parameters and partially cancel each other out. Measuring only the higher energy decay to the ground state should result in an increased measured β-decay asymmetry.

[1] A. Takamine, et al., Physical Review Letters, 112:1-5, (2014)
[2] M Bissell, M Kowalska, et al. Magnetic moment of 11Be with ppm accuracy. CERN-INTC-P-655-ADD-1, (2025)
[3] Gins, W. & Harding, R et al., NIM A: 24, 925 (2019)
[4] J. Croese, M. Baranowski, et al., NIM A: 1020, 165862 (2021)

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