Experimental report

12/02/2026

Proposal: **3-01-724** **Council:** 4/2023

Title: Magnetic moments of isomeric states in the Te isotopes

Research area: Nuclear and Particle Physics

This proposal is a new proposal

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Samples:

Instrument	Requested days	Allocated days	From	To
PN1	20	13	24/10/2023	31/10/2023
			12/03/2024	18/03/2024

Abstract:

The aim of the present proposal is to measure the magnetic dipole moments of several isomeric states in the neutron-rich Te isotopes. Those include the 4+ isomeric state in 134Te, the 6+ isomeric state in 132Te and the 6+ isomeric state in 130Te. The Time Dependent Perturbed Angular Correlation (TDPAC) technique will be applied using either an external magnetic field or after implantation into ferromagnetic (Fe or Ni) hosts. The results will be compared to large scale shell model calculations.

Experimental report for exp_3-01-724

The main goal of experiment 3-01-724 was to re-measure the magnetic dipole moment of the isomeric 4^+ ($T_{1/2} = 1.36(11)$ ns) state in ^{134}Te ($Z = 52, N = 82$), sitting just two protons above the doubly-magic ^{132}Sn. The secondary aim of the proposal was to improve the precision on the magnetic dipole moment of the 6^+ isomer ($T_{1/2} = 145(8)$ ns) in ^{132}Te. The magnetic moments of these excited states will provide crucial information on their wave function composition to explore the validity of the seniority scheme when moving away from ^{132}Sn.

The magnetic dipole moment is the product of the nuclear spin and the gyromagnetic factor g, known also as the g factor, which is the experimental observable. The method of choice is the Time Dependent Perturbed Angular Correlation (TDPAC) method, which is suitable for measuring g factors of isomeric states with nanosecond half-lives. In this technique the nuclei of interest are placed in a magnetic field and the γ rays populating (feeder) and depopulating (decay) the isomeric state of interest are registered in detectors placed in a plane perpendicular to the magnetic field axis.

The experiment was performed in two parts: data was collected for ^{134}Te in October 2023 (exp_3-01-724), and for ^{132}Te in March 2024 (exp_3-01-724_2). The $A = 134$ and $A = 132$ fission fragments were selected for with the LOHENGRIN mass separator after neutron irradiation of a ^{235}U target in the reactor. For the measurement on ^{134}Te seven $LaBr_3$ detectors were used in the experimental setup around the focal plane of LOHENGRIN, schematically represented in Fig. 1, however, for ^{132}Te three of the detectors were removed leaving a total of four detectors. The mass $A = 134$ fission fragments were implanted in a Fe foil at the center of the setup, placed between permanent polarizing magnets with an applied field of $B = 110(40)$ mT, in order to make use of the hyperfine field of Te in Fe of 68.1(4) T [Krane, K.S., Hyperfine Interact 16, 1069–1079 (1983)]. Due to the much longer half-life of the 6^+ state in ^{132}Te, the $A = 132$ fission fragments were implanted first in a lead foil, and then in a gold foil, placed between permanent magnets providing an external magnetic field of 0.38 T.

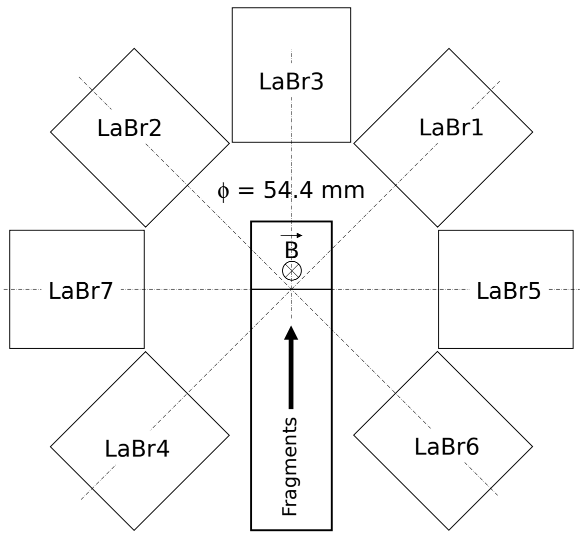

Figure 1: The detector setup at the focal plane of the LOHENGRIN mass separator used for the TDPAC measurement on the 4^+ state in ^{134}Te. Detectors 3, 5 and 7 were removed for the TDPAC measurement on the 6^+ state in ^{132}Te

The partial level schemes of ^{132,134}Te, populated in the β decay of ^{132,134}Sb, are shown in Fig. 2. In the case of the TDPAC measurement in ^{134}Te, the cascade of interest is the coincidence between the 115-keV transition ($6^+ \to 4^+$) and the 297-keV transition ($4^+ \to 2^+$). However, due to the much shorter lifetime of the 2^+ state, compared to that of the 4^+ state, it is possible to use also the

$2^+ \rightarrow 0^+_{\mathrm{g.s.}}$ (1279 keV) transition instead of the 297-keV transition.

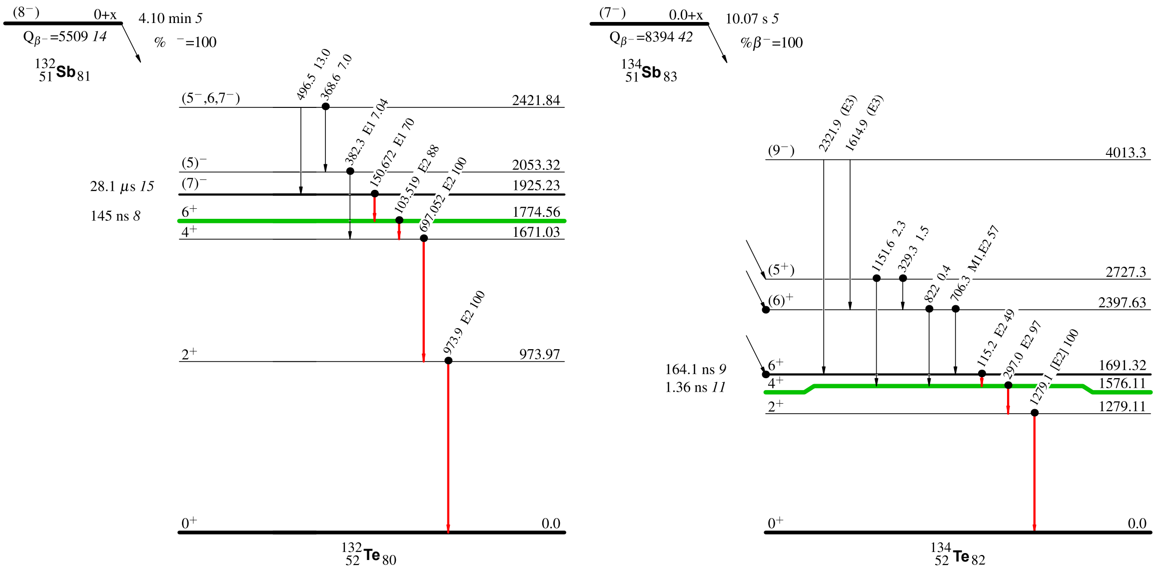

Figure 2: Partial level scheme of ^{130}Te, populated in the β decay of ^{130}Sb, showing the 6^+ state of interest marked in green and the relevant γ-ray transitions in red. Plot adapted from ENSDF database.

The observed γ-ray coincidences were separated in two groups based on the angle between the detector that registered the feeder and decay γ rays - either 90° or 180° angles. An experimental ratio function was then constructed: $R(t) = (I_{180} - I_{90})/(I_{180} + I_{90})$, which was fitted with a cosine function to extract the g factor of the state of interest via the Larmor frequency of precession. The preliminary $R(t)$ function obtained for the 4^+ state in ^{134}Te is shown in Fig. 3. The preliminary results indicate a value of the g factor close but slightly higher than the theoretical expectations (≈ 0.8) which is very promising. This preliminary result is consistent with our preliminary results from another experiment performed at LOHENGRIN (exp_3-01-735) targeting the g factor of the 6^+ state in ^{130}Te, which yields a similar preliminary value. However, in the current case, the preliminary result obtained using the 1279-keV transition instead of the 297-keV transition, is slightly lower than theoretical expectations. Therefore the formal data analysis needs to be finalized first before conclusions can be drawn.

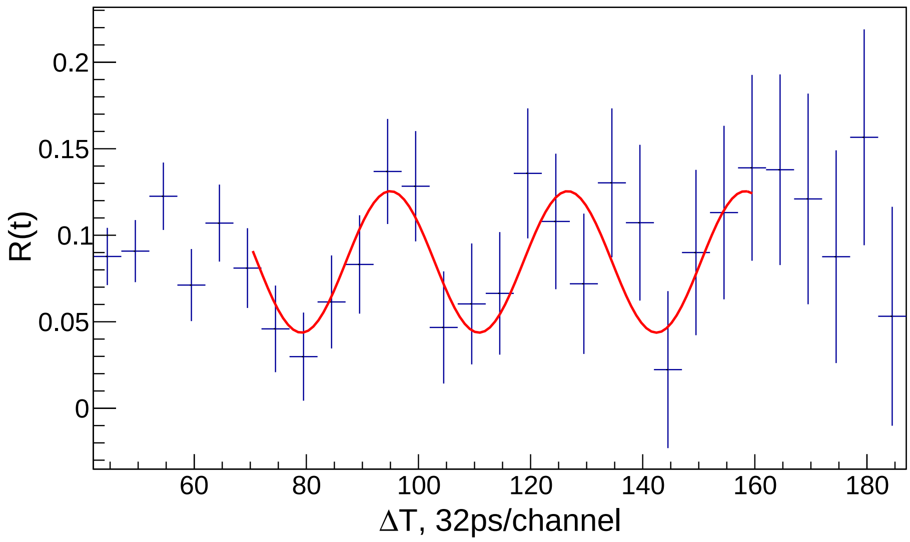

Figure 3: Preliminary fit of the experimental $R(t)$ function for the 4^+ state in ^{134}Te obtained by selecting the coincidences between the 115-keV ($6^+ \rightarrow 4^+$) transition and the 297-keV ($4^+ \rightarrow 2^+$) transition. The histogram has been rebinned by a factor of 5 to 160 ps/channel before performing the fit.

For the TDPAC measurement in ^{132}Te, the cascade of interest is the coincidence between the 151-keV transition ($7^- \to 6^+$) and the 104-keV transition ($6^+ \to 4^+$). However, due to the much shorter lifetimes of the 4^+ and 2^+ states, compared to that of the 6^+ state, it is possible to use either of the $4^+ \to 2^+$ (697 keV) or $2^+ \to 0^+_{\mathrm{g.s.}}$ (974 keV) transitions, or both, instead of the 104-keV transition. The region around the 104-keV and 151-keV transitions is dominated by Compton-scattered γ rays (see Fig. 4), therefore selecting the higher energy transitions would produce cleaner results. A large fraction of the low-energy background is thought to be due to the internal activity of the $LaBr_3$ detectors, which has become quite significant as the activity from implanted $A = 132$ was quite low due to the deterioration of the U target over time. The low statistics has not allowed for a reliable g-factor value to be obtained from the collected data so far. A re-measurement with a fresh U target might be required in order to achieve the goals of the proposed measurement in ^{132}Te.

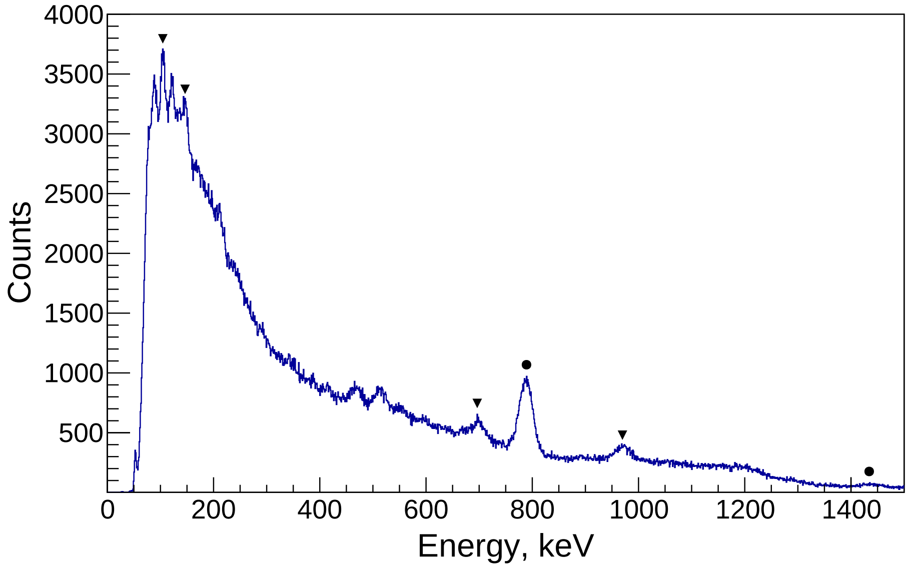

Figure 4: Energy spectrum of one $LaBr_3$ detector from the ^{132}Te data with the transitions from ^{132}Te marked with triangles, and the transitions from the internal activity of the detectors marked with circles. As is visible, the spectrum is dominated by Compton-scattering events.