EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Status Report to the ISOLDE and Neutron Time-of-Flight Committee

[IS483: Measurement of the magnetic moment of the 2^+ state in neutron-rich radioactive ^{72,74}Zn using the transient field technique in inverse kinematics]

[INTC-P-253. - 2008]

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Abstract

Experiment IS483 is aiming for the measurement of the sign and the magnitude of the g-factors of the first 2^+ states in radioactive neutron-rich ^{72,74}Zn applying the transient field (TF) technique in inverse kinematics. The results of this experiment allow to probe the $\nu g_{9/2}$ component of the wave function of the 2^+ state and therefore constitute a stringent test of different theories describing the interplay between collectivity and single particle structure in the region of N=40.

In 2011 the first part of this experiment was performed employing for the first time a new target chamber especially designed and constructed for TF transient field g-factor measurements with MINIBALL detectors at REX- and lateron HIE-ISOLDE. The value of $g(2^+)$ in ^{72}Zn was measured as described in detail in Ref. [1]. The remaining 11 shifts will then in the future be dedicated to the measurement of $g(2^+)$ in ^{74}Zn. Note that this experiment will be the very first application of the TF technique to a short-lived (half-life << measuring time) radioactive beam ($T_{1/2}$=96 s for ^{74}Zn).

Remaining shifts: 11 shifts

1. Motivation, experimental setup/technique

The TF technique in combination with Coulomb excitation in inverse kinematics has been proven in numerous experiments with stable beams in the past to be a very powerful tool to determine magnetic moments of short-lived excited states (see review articles [2,3]). With the availability of intense low-energy radioactive ion beams (RIBs) it is now desirable to apply this technique also to RIBs, for example at REX- and HIE-ISOLDE.

With this aim we designed and built a new target chamber including a magnetic circuit to polarize the ferromagnetic layer of the target, a system of flowing liquid nitrogen in order to keep the target at a temperature well below the Curie temperature of Gd and segmented Si detectors for particle detection. In the design of this chamber the peculiarities of the TF technique when applied to RIBs were taken into account. The new equipment was successfully used for the first time in 2011 at REX-ISOLDE in the first part of experiment IS483.

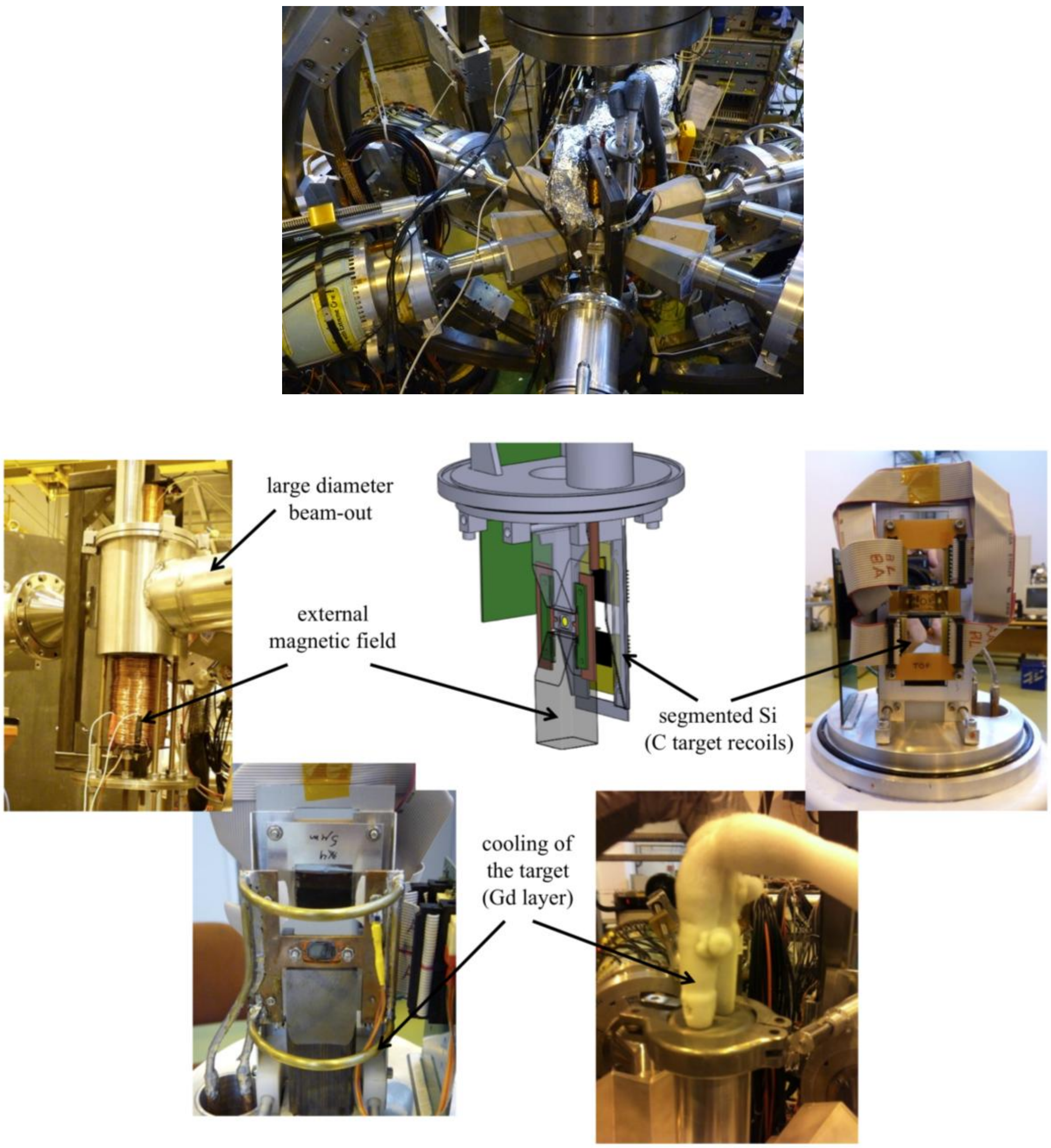

Fig. 1: Photographs of the new TF target chamber taken during the first part of IS483 in 2011.

2. Status Report

Accepted isotopes: ^{72,74}Zn - Performed studies: ^{72}Zn

In 2011 we performed the first part of experiment IS483 and measured the g factor of the first excited 2^+ state in ^{72}Zn. Although a good result was obtained this experiment has to be considered as a test since we used it to investigate the overall feasibility of the TF technique with RIBs using different targets and in the beginning also different Zn beam (with different half-lifes from 46.5 h for ^{72}Zn down to a few seconds for ^{76}Zn). The main problem when using the thick multiplayer targets (8-14 mg/cm^2) necessary for g-factor measurements is the accumulation of activity close to the target area due to the straggling of the beam in the target. Therefore the parameters of the multilayer target have to be optimized for each particular case (depending on the half-lives of the isotope under study and of all nuclei in the decay chain, the beam intensity, the gamma multplicity in the decay chain etc.). For ^{72}Zn we performed two runs, one with a thinner target and a higher beam intensity and the other with a thicker target and a lower beam intensity to study the advantages and disadvantages of the two options. Using a target thin enough to allow the Coulomb excited beam ions to leave the target implies the loss of anisotropy of the angular correlation (and therefore sensitivity) due to recoil-in-vacuum effects, while a target with a thick Gd layer allows to maximize the precession effect but on the other hand limits the beam intensity due to more straggling. We obtained a nice agreement for the g-factor values measured in the two runs and obtained as final result g(2+)=+0.47(14). The experience gained from this experiment will allow us to choose the right parameters for the successful application of the TF technique in future experiments.

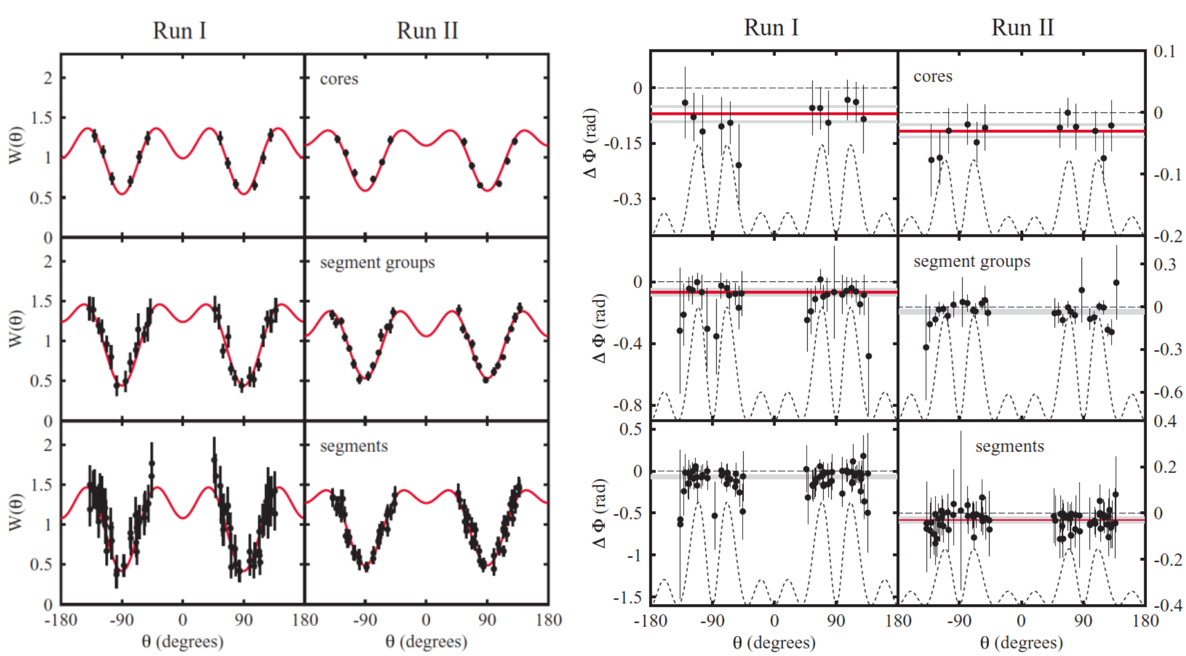

Fig. 2: Angular correlation functions W(Θ) (left) and precession angles ΔΦ (right) measured for the 653 keV, 2^+-0^+ transition in ^{72}Zn with four MINIBALL cluster detectors positioned in a horizontal plane (taken from Ref. [1]).

3. Future plans

Future plans with <u>available</u> shifts:

(i) Envisaged measurements, beam energy, and requested isotopes

The second part of the experiment IS483 will study the magnetic moment of the 74Zn (11 shifts). This measurement requires the standard UCx target source in conjunction with the laser ionization source (RILIS). The beam energy should be 2.94 MeV/u which is the same that in the first part of the experiment.

(ii) Have these studies been performed in the meantime by another group?

No.

(iii) Number of shifts (based on newest yields and latest REX-EBIs and REX-trap efficiencies) required for each isotope

isotope	yield (/uC)	target – ion source	Shifts (8h)
^{74}Zn	6.9E+07	UC_x RILIS	11

Total shifts: 11

As already mentioned in Section 2, during the run in 2011 we already had about four hours of ^{74}Zn beam with an intensity of about $3x10^6$ pps on the thinner of the two targets (Run II in Fig. 2). From this data we obtained the γ-ray spectrum shown in Fig. 3 with about 400 counts in the 606 keV line corresponding to the 2^+-0^+ transition in ^{74}Zn. Due to the short half-lifes of ^{74}Zn (96 s) and its β-decay daughter ^{74}Ga (8.1 min) the activity in the chamber already reached equilibrium during the four hours of measurement. The counting rate in the individual Ge crystals were in the range 3-5 kHz. We can therefore expect that a beam with an intensity of $6x10^6$ pps can be accepted during a full run of 11 shifts, leading to the estimate of a total of 17.600 counts in the 606 keV line summing all four MINIBALL cluster detectors. This number has to be compared to the 11.500 counts accumulated with the same target in Run II of the ^{72}Zn experiment. Taking furthermore into account that with the planned upgrade of the MINIBALL readout the acceptable rate of the MINIBALL detectors will increase by a factor of three (note that the achievable statistics in this TF experiment is not limited by the available beam intensity but rather by the count rate limit for the Ge detectors) we expect that $g(2^+)$ in ^{74}Zn can be determined with a precision of about 20%.

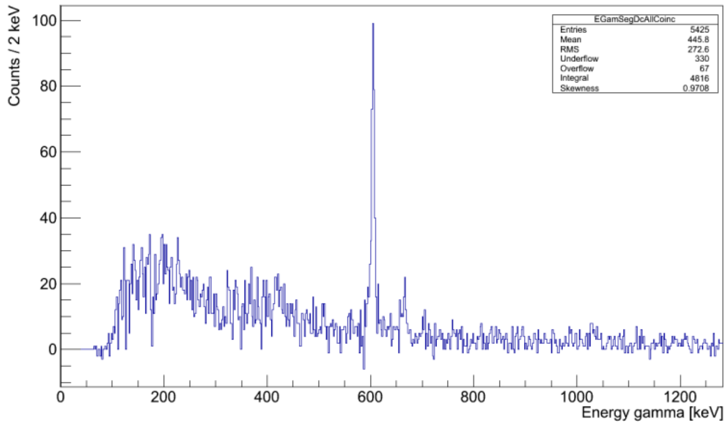

Fig. 3: Spectrum of γ-rays obtained during four hours of ^{74}Zn beam on target.

References:

[1] A. Illana, A. Jungclaus, R. Orlandi, A. Perea, C. Bauer, J. A. Briz, J. L. Egido, R. Gernhäuser, J. Leske, D. Mücher, J. Pakarinen, N. Pietralla, M. Rajabali, T. R. Rodríguez, D. Seiler, C. Stahl, D. Voulot, F. Wenander, A. Blazhev, H. De Witte, P. Reiter, M. Seidlitz, B. Siebeck, M. J. Vermeulen, and N. Warr

"Low-velocity transient-field technique with radioactive ion beams: g factor of the first excited 2^+ state in ^{72}Zn"

Physical Review C89, 054316 (2014)

[2] K.-H. Speidel et al., Prog. Part. Nucl. Phys. 49, 91 (2002)

[3] N. Benczer-Koller, et al., J. Phys. G: Nucl. Part Phys. 34, R321 (2007)

Appendix

Publications

- A. Illana, A. Jungclaus, R. Orlandi, A. Perea, C. Bauer, J. A. Briz, J. L. Egido, R. Gernhäuser, J. Leske, D. Mücher, J. Pakarinen, N. Pietralla, M. Rajabali, T. R. Rodríguez, D. Seiler, C. Stahl, D. Voulot, F. Wenander, A. Blazhev, H. De Witte, P. Reiter, M. Seidlitz, B. Siebeck, M. J. Vermeulen, and N. Warr

  "Low-velocity transient-field technique with radioactive ion beams: g factor of the first excited 2^+ state in ^{72}Zn"

  Physical Review C89, 054316 (2014)

- A. Illana, A. Perea, E. Nácher, R. Orlandi, A. Jungclaus

  "New reaction chamber for transient field g-factor measurements with radioactive ion beams"

  submitted to Nucl. Instr. Meth. A

Theses [including link to CDS]

Andrés Illana Sisón

"Medida de momentos magnéticos mediante campos transitorios con haces radiactivos en REX-ISOLDE"

Universidad Complutense de Madrid, 18 June 2014

http://cds.cern.ch/record/1981486