Characterization of a strongly Coulomb-excited state at an excitation energy above 4 MeV in ^{136}Te

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In April 2015, the experiment NP1306-RIBF98R1 was performed aiming for a methodical study of the systematic uncertainties inherent to the analysis of Coulomb excitation experiments at relativistic energies, using ^{136}Te as a high-statistics test case. The analysis of the obtained data is finished and the results are published.[1–3] In that experiment, besides the known 607-keV, $2_1^+ \rightarrow 0_1^+$ transition, additional γ strength in the range 3.0–4.5 MeV was observed in the inelastic excitation of ^{136}Te on a gold target.[4] The experimental spectra are nicely described assuming that two γ rays are detected, whereas the bump at high energy is too broad to be described by one single transition. However, due to the limited in-beam energy resolution of the DALI2 spectrometer, the individual γ-ray energies can only be determined with rather large uncertainties. The intensity ratio between the two lines clearly depends on the γ-ray multiplicity of the event. The line at higher energy has a higher yield when only one γ ray is detected, while the one at lower energy is more intense for events with γ-ray multiplicity two. From this observation, it can be concluded that the γ ray with higher energy is emitted in cascades with lower multiplicity. Unfortunately, however, due to random coincidences with background γ rays, it is not possible to go beyond this qualitative statement. Based on the available experimental information it is not possible to determine whether the two transitions populate the 4_1^+ and 2_1^+ or the 2_1^+ and 0_1^+ states of ^{136}Te.

The large cross section measured for the excitation of a state above 4 MeV in a heavy nucleus such as ^{136}Te in the inelastic scattering on a gold target is difficult to explain. Whatever the spin of the newly identified state is, the corresponding transition probability is exceptionally large. Theoretical studies suggest that the new excited state in ^{136}Te may be related to the existence of loosely-bound neutrons outside the ^{132}Sn core. It is therefore of utmost interest to better characterize this unusual state.

The availability of the HiCARI array at RIKEN in 2020 offered the unique opportunity to further investigate this interesting case. The superb position resolution of the tracking detectors translates into a very good in-beam energy resolution for high-energy γ rays. Therefore, the inelastic excitation of ^{136}Te on a gold target was measured again with the goal to determine the energies of the two high-energy γ rays emitted in the decay of the new state with sufficient precision in order to establish to which low-lying levels of ^{136}Te the decay proceeds. In addition, also the inelastic excitation on a Be target was studied in order to allow for a determination of the nuclear deformation length from the measured cross section. The aim of this part of the experiment was to obtain further information with respect to the spin of the new state above 4 MeV in ^{136}Te.

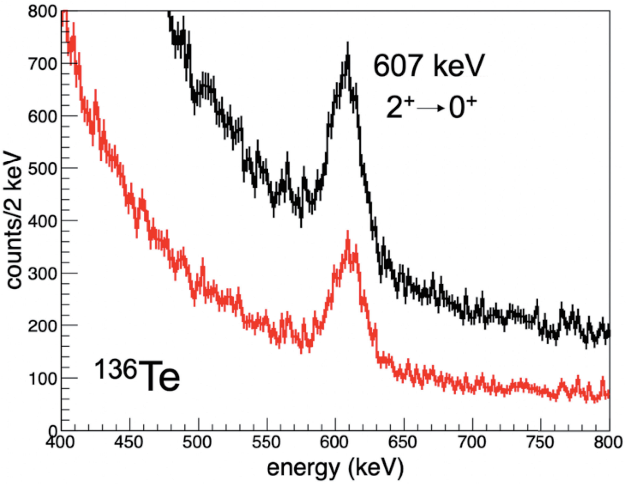

Fig. 1. HiCARI γ-ray spectrum of ^{136}Te populated via inelastic excitation on a gold target, considering either all γ-ray multiplicities (black) or $M_\gamma = 1$ (red).

The experiment NP1912-RIBF193 was performed during the HiCARI campaign in November 2020. For both the Au and Be targets the expected counting statistics was accumulated and the taken data in the experiment is currently under analysis. The selection of the reaction channel was achieved via event-by-event ion identification in the BigRIPS and ZeroDegree spectrometers. A preliminary γ-ray spectrum of ^{136}Te in the region around the known $2_1^+ \rightarrow 0_1^+$ transition, taken with the HiCARI array following the inelastic excitation on a gold target, is shown in Fig. 1.

References
1) V. Vaquero *et al.*, Phys. Rev. Lett. **118**, 202502 (2017).
2) V. Vaquero *et al.*, Phys. Lett. B **795**, 356 (2019).
3) V. Vaquero *et al.*, Phys. Rev. C **99**, 034306 (2019).
4) V. Vaquero, PhD thesis, Universidád Autónoma de Madrid, 2018.

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