Beta-decay of ^{156}Tm measured by total absorption spectroscopy

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The β decay of the 2^- ground-state of ^{156}Tm (N=87, Z=69) is characterized by transitions to the Gamow-Teller resonance in ^{156}Er. A reliable measurement of this resonance requires the use of a total absorption spectrometer for detecting the entire γ-ray cascades following β decay. Two different experiments were carried out at GSI to perform such a measurement. In the first experiment we used a total absorption spectrometer developed at the PNPI, St. Petersburg (PNPI-TAgS). Details of this experiment as well as the analysis of the data and the results are given in Ref. [1]. In the second experiment an improved total absorption spectrometer (TAS) [2], was used. In this report we present the results obtained by using the TAS and compare them with the previous work [1].

The PNPI-TAgS represented a big step forwards at the time it was designed [3]. It was the first large size NaI spectrometer which covered a solid angle of almost 4π around the source and for the first time a beta detector was placed inside such a spectrometer. This has the triple advantage of suppressing the room background, selecting the β^+ component and defining the emission direction of the positrons, thus avoiding their penetration into the crystals of the spectrometer. In comparison, the TAS presents further improvements:

1. It consists of one single NaI crystal (and a plug detector) with bigger volume than the two NaI crystals that formed the PNPI-TAgS, which corresponds to a sizeable increase in detection efficiency.

2. It has a better energy resolution, mainly due to the use of better photo-multiplier tubes.

3. It has, in addition to beta detectors, a small germanium detector which allows to select the EC component of the decay by demanding coincidences with characteristic X-rays and to suppress isobaric contaminants. In the PNPI-TAgS the EC component of the decay was obtained as the difference between singles and β^+-coincident spectra.

Fig. 1 shows the B(GT) distributions obtained for the ^{156}Tm decay from the two experiments. Both analyses yielded the same total B(GT) value of 0.48 $g_A^2/4\pi$. However there are two main differences in the experimental B(GT) distributions. One is that the TAS data show a more detailed structure of the resonance. The other one is the small shift of about 80 keV observed for the centroid of the resonance (see Fig. 1). Both these features are related to differences in the detectors and the data treatment. The measurement performed with the PNPI-TAgS was analyzed using the "peel-off" algorithm developed at PNPI [4] to deconvolute the measured spectra, whereas

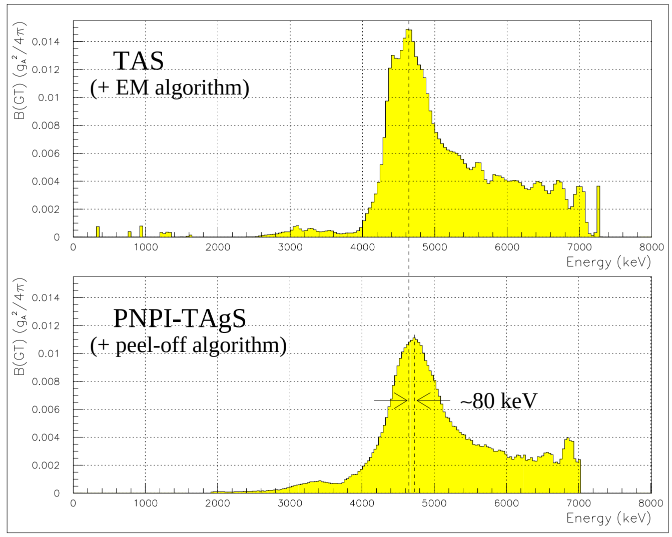

Figure 1: Gamow-Teller strength distribution in the decay of ^{156}Tm obtained with the TAS (upper panel), and with the PNPI-TAgS (lower panel). The algorithm to analyze the data was different in both cases.

in the case of the TAS measurement the Expectation-Maximization method adapted to the TAS problem at IFIC [5] was applied. For both analyses the response function of the detector was calculated by means of Monte Carlo simulations. In the case of the PNPI-TAgS analysis the simulations were performed assuming that the light produced in the scintillator is proportional to the γ-ray energy. In reality it is not proportional but roughly linear with the energy. This was taken into account to calculate the TAS response function and explains the $\approx$80 keV shift.

It is also interesting to compare the B(GT) distribution of the ^{156}Tm decay presented here with that of the ^{152}Tm 2^- decay discussed in [6]. We observe that the spreading width of the resonance is wider as we increase the number of neutrons. This is probably due to the increase of 2p-2h and 3p-3h states that become accessible in the final state.

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