Measurement of the Gamow-Teller strength in ^{116}Sn and ^{122}Sn in the S452 experiment

C. A. Douma[1], N. Kalantar-Nayestanaki[1], M. N. Harakeh[1], H. Akimune[2], H. Ejiri[3], D. Frekers[4], T. Agodi[5], M. Alanssari[4], D. Carbono[5], M. Cavallaro[5], F. Diel[6], H. Fujita[7], Y. Fujita[7], M. Fujiwara[3], G. Gey[3], F. Hattori[2], K. Hatanaka[3], K. Heguri[2], M. Holl[4], A. Inoue[3], P. Puppe[4], P. Ries[8], A. Tamii[3], V. Wemer[8] and K. Zuber[9]

[1]*KVI-CART, University of Groningen, The Netherlands*

[2]*Konan University, Kobe, Japan*

[3]*Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka, 567-0047, Japan*

[4]*IKP, University of Münster, Germany*

[5]*Istituto Nazionale di Fisica Nucleare, Catania, Italy*

[6]*Köln University, Germany*

[7]*Department of Physics, Osaka University, Japan*

[8]*TU Darmstadt, Germany*

[9]*IKTP, TU Dresden, Germany*

1 Introduction

Accurate knowledge of Gamow-Teller matrix elements is vital to our understanding of nuclear astrophysics. These matrix elements play important roles in the core-collapse of type II supernovae and in the rp-process for nucleosynthesis [1]. Accurate knowledge of these matrix elements can also provide us with new detection techniques of solar neutrinos and provide hints to physics beyond the Standard Model [4]. In the present work, we measured the Gamow-Teller matrix elements of ^{116}Sn and ^{122}Sn by a $(^3\mathrm{He}, t)$ charge-exchange reaction. In particular, the measurement on ^{122}Sn was performed with the aim to determine the matrix elements of relevance for neutrino-less double-beta decay [2], [3].

Our measurements were part of the S452 experiment conducted at RCNP in May 2016. During this experiment, a 140 MeV/u ^{3}He beam impinged on a fixed Sn target of about 2 mg/cm^2. The outgoing tritons were detected and momentum analyzed by the Grand Raiden Spectrometer [5]. For further details on the S452 experiment, the reader is referred to [6].

The Gamow-Teller states can be identified in the excitation-energy spectrum of the recoil nucleus through their characteristic $\Delta L = 0$ angular profile. In this report, we will discuss the steps to obtain the excitation-energy spectrum.

2 Analysis

The tritons were momentum analyzed by the Grand Raiden spectrometer and their position and angle of incidence were determined with the multiwire drift-chamber detectors at the focal plane [5]. The measured position and angle of incidence at the focal plane were transformed to the triton's kinetic energy and scattering angle at the target. However, to perform this transformation one must correct for the ion-optical aberrations of Grand Raiden. Finally, the excitation-energy spectrum is obtained from simple relativistic kinematics.

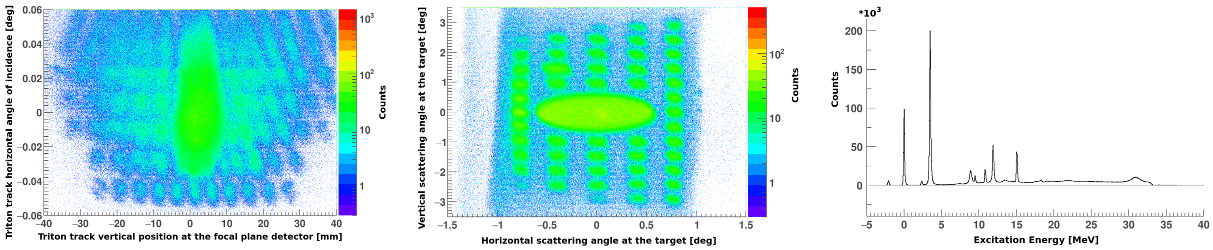
The experimental data were gathered and event-built following the procedure of Ref. [7]. The triton tracks through the focal plane detectors were reconstructed from the data with G. Gey's (email: `gey@rcnp.osaka-u.ac.jp`) analyzer program, which is an updated version of A. Tamii's analyzer to provide output in the ROOT data format. All our consecutive analysis was also performed in ROOT (version 5).

The ion-optical properties of Grand Raiden were determined with a sieve slit. A sieve slit is a multi-hole aperture which is placed right behind the target to cut the triton stream into a collection of small pencil beams. Such pencil beams are easily identified at the focal plane detectors. Since the scattering angles at the target are known from the sieve-slit geometry, this measurement shows us how triton tracks at the detectors correspond to triton tracks at the target.

The sieve-slit measurement was performed with the $(^3\mathrm{He}, t)$ charge-exchange reaction on a ^{13}C target with Grand Raiden in its 0° position [5]. This target was chosen because the excitation-energy spectrum is known [8]. Hence, the sieve-slit data also provide energy calibration.

The analysis of the sieve-slit measurement was performed according to Ref. [7]. The results are illustrated in Fig. 1. The success of our analysis becomes evident when Fig. 1c is compared to results of Ref. [8].

Applying the same optical corrections to our data on the ^{116}Sn and ^{122}Sn targets (obtained with Grand Raiden at 0°) results in the excitation-energy spectra of Fig. 2.

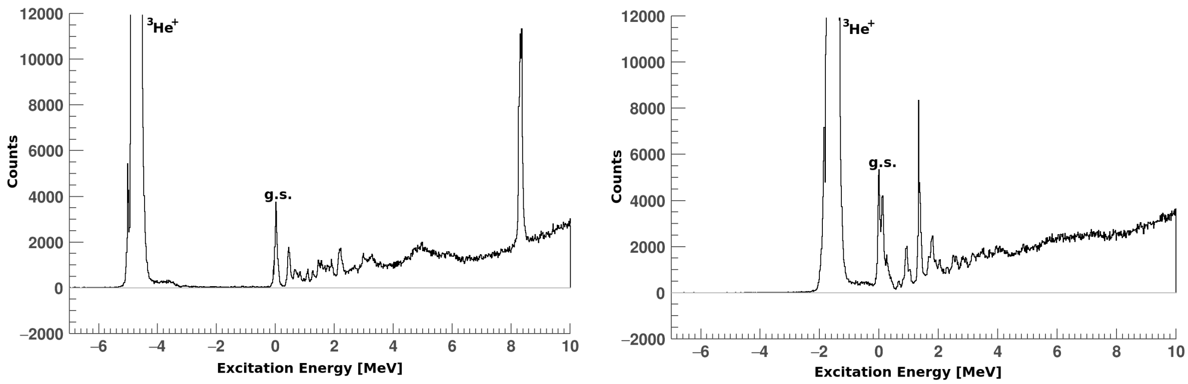


(a) Measured triton tracks at the focal plane.

(b) Reconstructed scattering angles at the target.

(c) Reconstructed excitation-energy spectrum.

Figure 1: Overview of the sieve-slit data taken with a ^{13}C target.



(a) ^{116}Sn(^{3}He$, t)^{116}$Sb

(b) ^{122}Sn(^{3}He$, t)^{122}$Sb

Figure 2: Excitation-energy spectra of ^{116}Sn(^{3}He$, t)^{116}$Sb (a) and ^{122}Sn(^{3}He$, t)^{122}$Sb (b) after having performed ion-optical corrections.

3 Outlook

The analysis of the ^{116}Sn and ^{122}Sn data is in progress. Removal of some background in the spectra of Fig. 2 will be done following Ref. [7]. Data taken on Mg and Cd isotopes will be used to provide a more precise energy calibration in the spectra of Fig. 2. Finally, the Gamow-Teller transitions will be identified in the spectra by selecting the $\Delta L = 0$, $\Delta S = 1$ states in Fig. 2 through their angular distributions.

References

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