Electromagnetic transition strengths in ^{33}S

B. I. Dimitrov[1], N. Goutev[1], G. Tz. Gavrilov[1], D. Tonev[1], P. Petkov[1], G. de Angelis[2], F. Recchia[2], E. Farnea[3], C. A. Ur[3], S. Aydin[2,4], P. G. Bizzeti[5], A. M. Bizzeti-Sona[5], I. Deloncle[6], A. Gottardo[2], H. Laftchiev[1], S. Lunardi[3], D. Mengoni[2], C. Michelangoli[2], D. R. Napoli,[2],R. Orlandi[2], E. Sahin[2], E. A. Stefanova[1], J.J. Valente-Dobon[2], Tz. K. Marinov[1], M. S. Yavahchova[1]

[1]Institute for Nuclear Research and Nuclear Energy, BAS, BG–1784, Sofia, Bulgaria.
[2]INFN, Laboratori Nazionali di Legnaro, I–35020, Legnaro, Italy.
[3]Dipartimento di Fisica and INFN, Sezione di Padova, Padova, Italy.
[4]Aksaray University, Department of Physics, 68100 Aksaray, Turkey.
[5]Dipartimento di Fisica dell'Universitá and INFN Sezione di Firenze, Firenze, Italy.
[6]CSNSM, IN2P3/CNRS et Université Paris-Sud, Orsay, France.

Abstract. An experiment using the Doppler Shift Attenuation Method was performed for ^{33}S at Laboratori Nazionali di Legnaro using the multi-detector array GASP. Excited states were populated in the fusion-evaporation reaction ^{24}Mg(^{14}N,α p)^{33}S. The data were analyzed using the Differential Decay Curve Method with gates set on the shifted component of a directly feeding transition thus eliminating the problem of the unobserved feeding. Reliable and precise lifetimes were determined and the data derived for the reduced transition probabilities are going to be compared to the predictions of shell model calculations.

1. Introduction

The shell model calculations provide a good description of the level energies and transitions strengths in the nuclei around ^{33}S. For low spin states, sd-interactions are applicable but for higher spin states the fp shell has to be taken into account [2, 3, 4, 5]. As a part of the spectroscopy of high-spin states in ^{33}S, lifetimes were investigated using the Doppler-shift attenuation method (DSAM). These data provide absolute transition strengths which are crucial for testing the predictions of nuclear models. The data were analyzed using gates from above, set on shifted component of a directly feeding transition. In this way, the longstanding problem of the unknown (unobserved) feeding inherent to singles measurements is eliminated and much more reliable lifetimes are obtained [6]. The aim of the present work was to extract precise lifetime values of excited states in ^{33}S and to measure electromagnetic transition strengths in this nucleus.

2. Experiment

High-spin states of ^{33}S have been populated via the fusion-evaporation reaction ^{24}Mg(^{14}N,α p) at 40MeV bombarding energy. The beam, delivered by the LNL XTU-Tandem accelerator impinged on the target with an average beam current of 5 pnA. The target, 1mg/cm^2 thick, consisted of 99.7% isotopically enriched ^{24}Mg evaporated on a 8 mg/cm^2 gold foil. The γ rays emitted in the reaction were detected using the 4π-GASP array composed of 40 Compton-suppressed large-volume, high-purity Ge detectors arranged in seven rings at different angles with respect to the beam axis. Events were collected when at least two germanium detectors fired in coincidence. Energy and efficiency calibrations were performed with standard γ-ray sources of ^{56}Co and ^{152}Eu. After gain-matching and corrections for shifts, the data were sorted into 49 γ-γ matrices, corresponding to all possible combinations of pairs of detectors positioned at the seven rings at polar angles with respect to the beam axis of 34°, 60°, 72°, 90°, 120° and 146°.

3. Data analysis and results

In order to obtain lifetime information the data have been analyzed by applying a modern version of the Doppler-shift attenuation method.

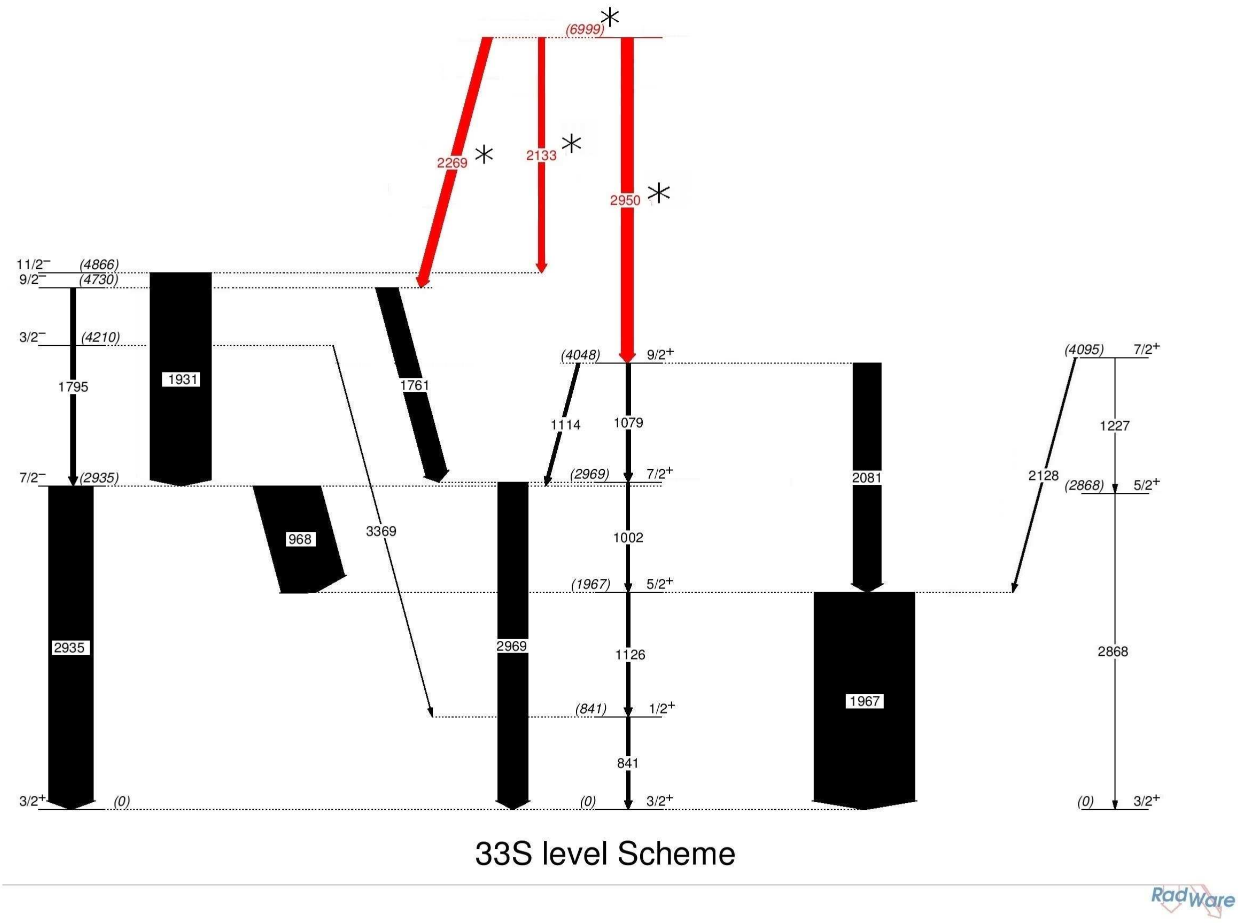

Figure 1. The analysis is based on the extended level scheme of ^{33}S. The new level is marked with a star as are the three new γ -ray transitions.

Figure 1 shows the extended level scheme of ^{33}S. More information can be found in [1] The gate was set only on the shifted component of a directly feeding transition. This component corresponds to emission during the slowing down of the recoiling nucleus in the target or the stopper and thus contains useful timing information. The resulting line-shape of the γ-transition depopulating the level of interest is then decomposed into shifted component associated with emission during the slowing down (SS), and unshifted component associated with emission at rest (U). The lifetime τ_a of the level of interest can be derived from the areas A_u and A_{ss} of these components through [8]:

$$\tau_a = \{B_{ss}, A_u\}/(d\{B_{ss}, A_{ss}\}/dt_s) \quad (1)$$

where t_s is the time at which the recoil comes to rest.

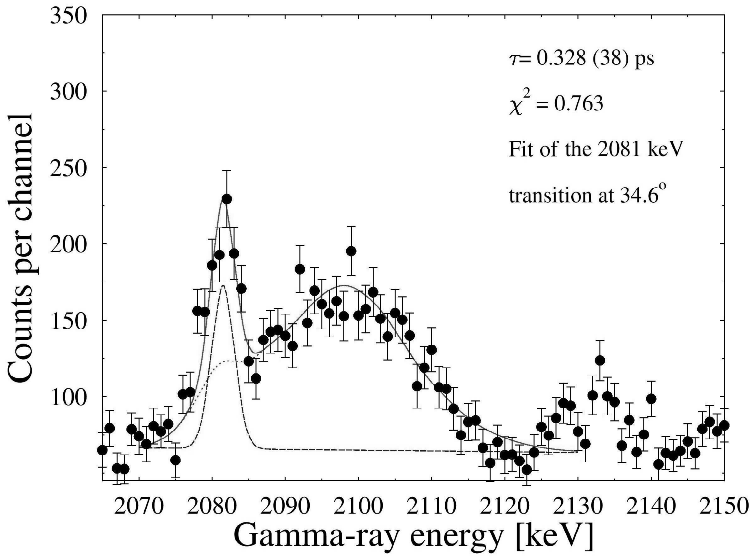

Figure 2. Line-shape of the 2081 keV transition at 34.6° generated by the sum of gates set on the shifted component of 2951 keV and determination of the lifetime.

The analysis was carried out within the framework of the Differential decay curve method (DDCM) [7] according to the procedure outlined in [8, 9] where details about the Monte-Carlo simulation of the slowing down process, determination of stopping powers and fitting of line shapes can be found. To increase the statistics, we used equivalent gates set at the four rings with appreciable Doppler-shifts and summed-up the resulting spectra. Thus, lifetimes were derived independently at these four rings. In this way, with two forward and two backward rigs, four values for the lifetime τ were determined. The final value of τ was derived by averaging the individual results.

In Figure 2 is shown an example of the line-shape analysis of the transition of 2081 keV at 34.6°. The derived value for τ for the $9/2^+$ level is shown too. In Figure 3 is shown again an example for the same transition at 145.4°. Our analysis confirms previously known lifetimes. More details on the lifetime analysis will be given in a forthcoming paper.

4. Summary and conclusions

For the investigation to the level-scheme of ^{33}S we have performed a DSAM experiment at the Laboratori Nazionali di Legnaro, Italy with the GASP array. For the data analysis, the Differential Decay Curve Method was used in coincidence, with a gate from above, set on the shifted component of a directly feeding transition. Two previously known lifetimes in ^{33}S were confirmed. Further work on the lifetime measurement is in progress.

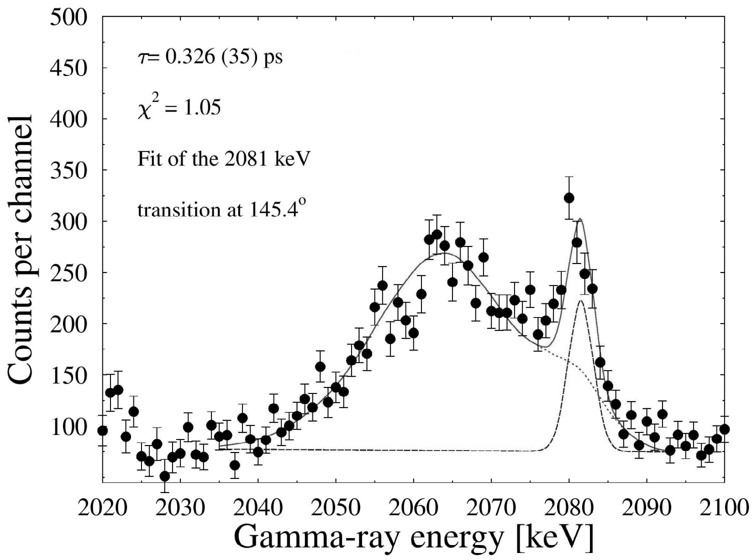

Figure 3. Example of the line-shape of the 2081 keV transition at 145.4° generated by the sum of gates set on the shifted component of 2951 keV and determination of the lifetime.

5. Acknowledgment
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