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The ^{25}Mg(α,n)^{28}Si reaction studied at LNL

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The observation of ^{26}Al in the Milky Way is a clear hint of recent nucleosynthesis ($\tau \sim$1 My). The ^{26}Al distribution is a robust parameter to control the predictions of stellar evolution models. A recent sensitivity study demonstrated that the ^{25}Mg(α,n)^{28}Si is the reaction with the strongest impact on ^{26}Al during explosive neon and carbon burning. Its cross section was measured by several experiments reporting discrepancy of more than a factor of 3. In order to improve the experimental knowledge of the ^{25}Mg(α,n)^{28}Si cross section, a new direct measurement has been performed at Laboratori Nazionali di Legnaro. Neutron spectroscopy is provided by the time of flight technique and pulsed beam. γ- n discrimination is achieved applying the Pulse Shape Analysis technique. Preliminary results of differential cross section in a range of angle from 17 up to 106 degrees will be presented.

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1. Introduction

The standard model of stellar evolution predicts that the synthesis of isotopes occur in massive stars during both quiescent nuclear burning and nova and supernova explosions [1]. One of the few observational evidences of the presence of such isotopes in the Milky Way was provided by the detection of 1809 keV γ-ray associated with the decay of ^{26}Al ($T_{1/2} \sim 7.2 \cdot 10^5$ years) [2]. All-sky surveys in the γ energy range [3] discovered a clumpy ^{26}Al distribution confined to the galactic plane. These observations are consistent with a stellar origin of ^{26}Al, but the inferences on the amount of ^{26}Al that can be synthesized in massive stars are strongly affected by the uncertainties on the cross sections of the nuclear reactions involved in the nucleosynthesis network. A recent investigation by Iliadis et al. (2011) [4] pointed out that the nuclear reaction with the strongest impact on the uncertainty of ^{26}Al yield in explosive Ne/C burning is the ^{25}Mg(α,n)^{28}Si, which destroys ^{25}Mg seeds.

The ^{25}Mg(α,n)^{28}Si cross section has been already measured in the energy range from E_α^{Lab} = 1 to 6 MeV ([5] - [9]). All measurements are characterised by large uncertainties due to the contribution of background reactions on light nuclei, present as contaminants in the setup (mainly ^{13}C(α,n)^{16}O, ^{18}O(α,n)^{21}Ne, and ^{19}F(α,n)^{22}Na). The reaction rate reported by NACRE [10] at energies below 2.2 MeV is based on the cross sections reported in the unpublished thesis of Wieland [7]. Recently, a new measurement at energies between 1 and 2.5 MeV, performed at the Nuclear Structure Laboratory of the University of Notre Dame by Falahat et al. [8], provided a cross section which is at least one order of magnitude smaller than the values measured by Wieland [7]. In both these measurements the neutrons were thermalized and detected with a 4π detector and could only determine the total cross section. The most recent measurement [8] pointed out the extreme importance of an improved target technology, able to pin down the background contributions to the very limit of inclusive measurements and showing the necessity of a future investigations using for example the γ-n coincidence technique.

2. Experimental setup

The experimental setup was installed at the end of the 0° beam-line at the CN accelerator of the INFN Legnaro National Laboratories (LNL). The setup is shown in Figure 1. MgO targets (enriched in ^{25}Mg up to 95.75%) were bombarded with a pulsed α-beam. The beam passed through a cold trap, before reaching the target, in order to suppress any contamination on the ^{25}MgO surface. The target holder was made of copper and cooled down to 14°C. Two silicon detectors, inside the chamber, were used to determine the beam current and to check the target stability. The neutron detectors [11] were placed at 2 m distance from the target covering an angular range from 17.5° up to 106° (laboratory system). The Time Of Flight (TOF) technique was used to perform neutron spectroscopy. Using this methods is possible to separate the neutrons produced by the (α,n) reactions on contaminants from the neutrons emitted by the ^{25}Mg(α,n)^{28}Si reaction. The beam induced background signal was negligible during the experiment.

3. Results

By implementing the Pulse Shape Analysis it was possible to distinguish the γ rays from the

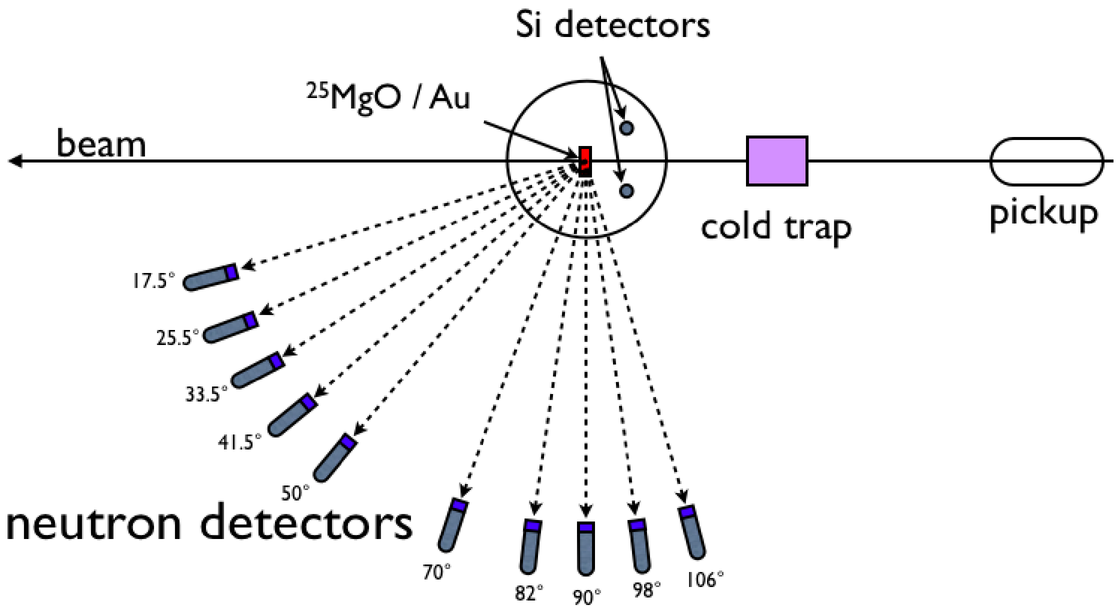

Figure 1: Sketch of the experimental setup

neutrons, reducing the background in the spectra. It allows to reach a statistical uncertainty is below 15% at all energies. In Figure 2 the results for the differential cross section for neutrons which populate two different states (the ground state and the first excited state at 1.78 MeV) of the ^{28}Si are shown. The analysis is still ongoing and it will be finished in 2014. A carefully study of the target characteristics has to be performed in order to deduce an absolute value for the differential cross section.

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References

[1] R. Ramaty & R.E. Lingenfelter, ApJ 213: L5-L7 (1977).

[2] W.A. Mahoney *et al.*, ApJ, 286:578-585 (1984).

[3] S. Plüschke *et al.*, Proceedings of the 4th INTEGRAL workshop, ESA SP-459,55.

[4] C. Iliadis *et al.*, ApJSS 193:16 (2011).

[5] L. Van der Zwan & K.W. Geiger Nucl. Sci. Eng. 79, 197-201 (1981).

[6] M.R. Anderson *et al.*, NPA 405, 170-178 (1983).

[7] O. Wieland, thesis, IFS-University of Stuttgart (1995).

[8] S. Falahat, PhD thesis, Johannes Gutenberg University-Mainz (2010).

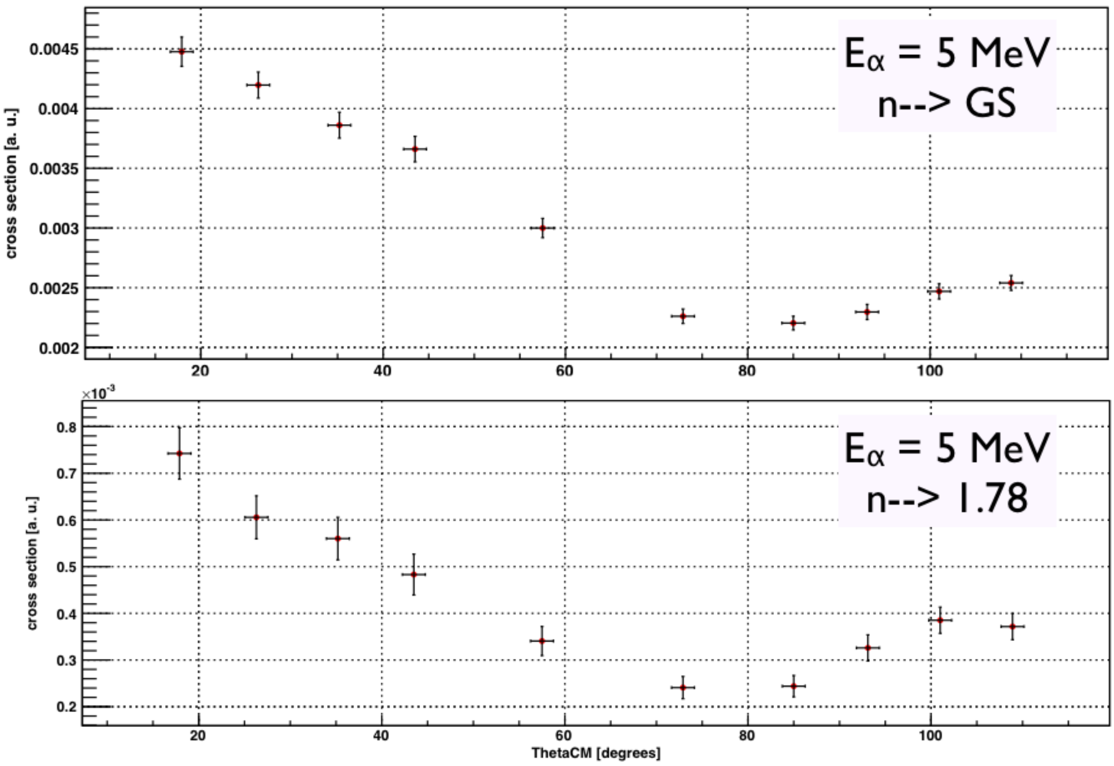

Figure 2: Preliminary results on differential cross section measured at a beam energy of 5 MeV for the neutron which populate the ground state (up) and the first excited state (down) of ^{28}Si. The error bars reported are only statistical for the y-axis. On the x-axis, the angular dimension of the detector is used as uncertainty.

[9] S. Küchler, thesis, IFS-University of Stuttgart (1990).

[10] C. Angulo *et al.*, NPA 656, 3-187 (1999).

[11] N. Colonna *et al.*, Nucl. Instr. Meth. A381, 472 (1996).

[12] J. K. Bair & F. X. Hass, Phys. Rev. C 7, 1356 (1973).

[13] M. Balakrishnan, S. Kailas & M. K. Mehta, Pramana, 10, 329 (1978).

[14] S. Harissopulos *et al.*, Phys. Rev. C, 72, 062801(R) (2005).

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