Nuclear Reactions

Adelaide Pedro de Jesus

This group has been involved in the experimental study of nuclear reactions relevant to nuclear astrophysics and also to ion beam analytical techniques.

The on-going work is related to the development of the AMS line to study reactions relevant to nuclear astrophysics.

Also a new line has been installed in the new Tandem 3MV accelerator, for nuclear reaction studies both for fundamental nuclear physics and nuclear astrophysics and for applied PIGE work.

Research Team

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Development of a Reference Database for Particle-Induced Gamma ray Emission (PIGE) Spectroscopy – Concerted Project IAEA

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Objectives

The aim of this work is to contribute to the improvement of data to PIGE analysis (bulk analysis and profiling) by assessment of available data, measurement of new data, evaluation of compiled and measured data, validation of cross section data through benchmark experiments, improvement of our ERYA code.

Results

Following the previous work to establish a methodology for standard-free PIGE analysis [1, 2], the group has joined a Concerted Research Project of the International Atomic Energy Agency, with the above described goals. During this year we have focused in the improvement of ^{23}Na(p,p´γ)^{23}Na reaction data, trying to resolve the discrepancies found in comparison with Caciolli et al [3, 4]. An experiment was run to obtain cross sections of the reactions on ^{23}Na, (p,p´γ): γ – 440 keV and (p,p´γ)+(p,αγ): γ – 1636 and 1634 keV. Fig. 1 show results obtained for ^{23}Na(p,p´γ): γ – 440 keV reaction cross-sections, showing that the mentioned discrepancy with the published Caciolli et al results still persists. This work was presented as a Master Thesis to New University of Lisbon.

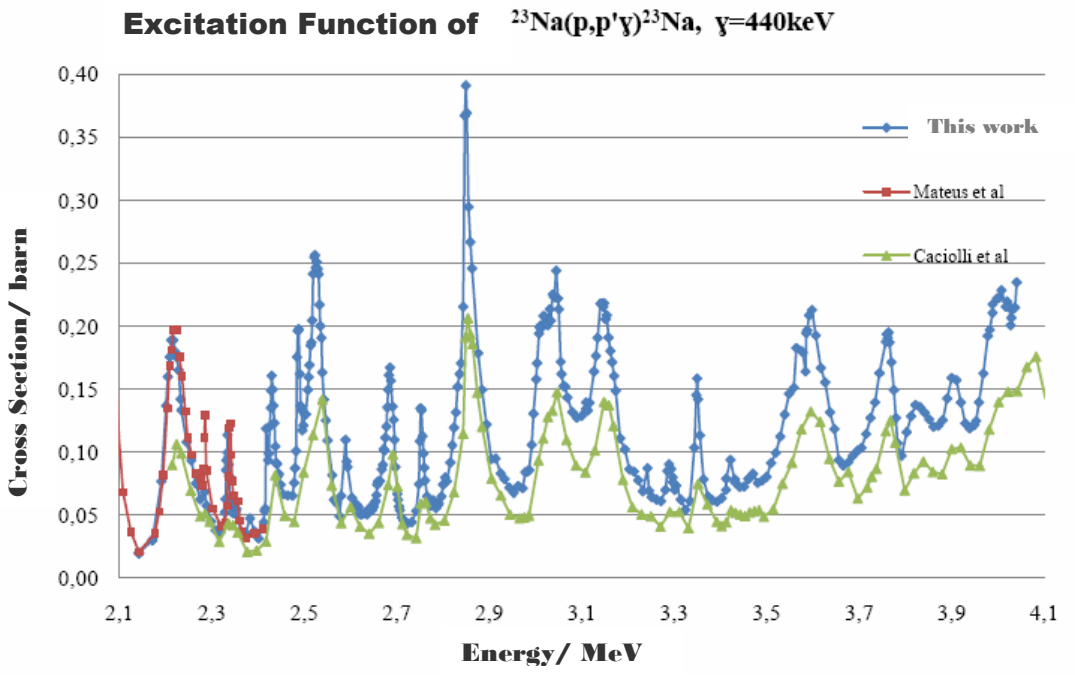

Fig. 1 Cross sections of the ^{23}Na(p,p´γ): γ – 440 keV reaction, compared with previous work.

Future work

This project will continue till 2014 covering the study of other gamma-producing reactions on F, Li, P, including also the development of depth analysis within the ERYA code.

References

[1] R. Mateus, A. P. Jesus, J. P. Ribeiro, Nucl. Inst. and Meth. B229, 302-308 (2005)
[2] M. Fonseca, H. Luís, N. Franco, M. A. Reis, P. C. Chaves, A. Taborda, J. Cruz, D. Galaviz, N. Fernandes, P. Vieira, J.P. Ribeiro, A.P. Jesus; Nucl. Inst. and Meth. B 269, 3060-3062 (2011)
[3] R. Mateus, A.P. Jesus, J. Cruz, J.P. Ribeiro, Nucl. Inst. and Meth. B 219 – 220, 307 – 311 (2004)
[4] Caciolli A, Calzolai G, Chiari M, Climent-Font A, Fernández-Jiménez MT, García-López G, Lucarelli F, Nava S. Nucl. Inst. and Meth. B266,1392 – 1396 (2008)

Study of nuclear reactions producing ^{36}Cl by AMS.

H. Luis, J. Cruz, N. Franco, M. Fonseca, D. Galaviz, A.P. Jesus, E. Alves

^{36}Cl is one of several short to medium lived isotopes (as compared to the earth age) whose abundances at the earlier solar system may help to clarify its formation process. There are two generally accepted possible models for the production of this radionuclide: it originated from the ejecta of a nearby supernova (where ^{36}Cl was most probably produced in the s-process by neutron irradiation of ^{35}Cl) and/or it was produced by in-situ irradiation of nebular dust by energetic particles (mostly, p, α, ^{3}He -X-wind irradiation model). In order to contribute to clarify this matter, we started the development of the AMS technique for ^{36}Cl detection and quantification, to measure reactions producing ^{36}Cl.

Samples of pure AgCl were irradiated at the Portuguese National Reactor, choosing irradiation times and sample masses in order to obtain ^{36}Cl to ^{35}Cl ratios in the order of 10^{-9} to 10^{-6} and ^{110}Ag activities under 1 MBq. This procedure had two purposes: measure the cross section of neutron capture by ^{35}Cl normalizing it to the well known cross section of neutron capture by ^{109}Ag, and to obtain ^{36}Cl standards for the AMS measurement of X-wind relevant reactions, testing also the linearity of the measurement process.

In order to obtain the referred neutron capture cross section the gamma-ray activity of ^{110}Ag was measured (Fig.1). The ^{36}Cl to ^{35}Cl ratio was obtained (Fig. 2), employing a micro-AMS system at the ITN's Ion Beam Laboratory.

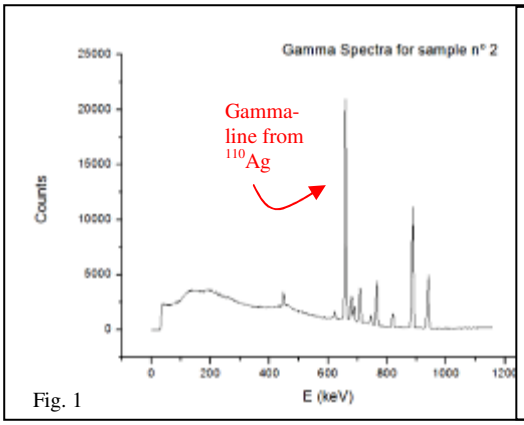

Fig. 1

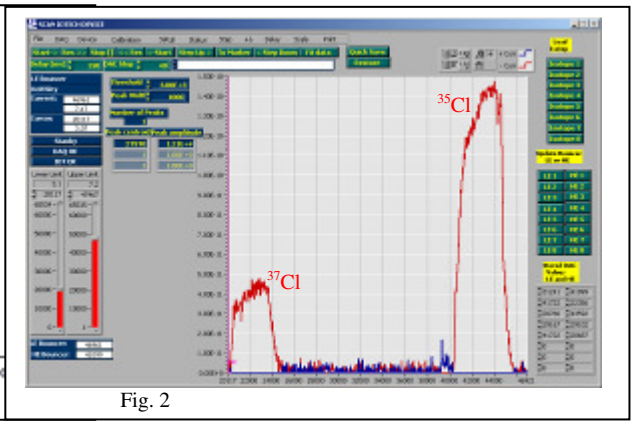

Fig. 2

Determination of (p,n) reaction cross sections of astrophysical interest

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Motivated by the work of G. Kiss et al. [1], we aim at measuring (p,n) reactions cross sections in medium-heavy mass nuclei, at energies of astrophysical interest, for channels with negative Q-value, will allow the characterization of the nuclear potentials involved in the process in conditions similar to those of the astrophysical environment.

In particular, we want to take advantage of the PIGE setup in order to measure, via the activation technique, (p,n) reactions for which the resulting product has a short half live (lower than 30 minutes), providing an experimental challenge for this kind of measurements.

The first nucleus we investigated at ITN was ^{128}Te through the reaction ^{128}Te(p,n)^{128}I. This reaction has a Q-value of -2.04 MeV, and the resulting nucleus decays with a half-life of 24.5 minutes. Taking advantage of the PIGE setup, the decay of the ^{128}I was observed with the available HPGe detector. In order to be able to discriminate the prompt background from the measurement, the data was recorded on an event-by-event basis.

At present only one data set, J.P. Blaser et al. [2], contains information close to the astrophysical energy range (between 2 MeV and 4 MeV). In order to proof the principle of the technique, we have performed a measurement covering the energy range between 3.8 MeV and 4.2 MeV. The data is still under analysis, although the signature of the decay of ^{128}I, a photon at 743 keV, was clearly observed. This work was performed in collaboration with the group at the University Complutense of Madrid (Spain), namely L. M. Fraile, J. M. Udías, J. Cal, B. Olaizola, E. Herranz

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[2] J. P. Blaser et al., Helv. Phys. Acta 24, 441 (1951)