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.

Researchers

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Experimental Study of Nuclear Reactions for Astrophysics

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Objectives

Following its experimental work in nuclear reactions relevant for primordial and stellar nucleosynthesis (hydrogen burning) [1,2], the group is focusing now in later stages of stellar nucleosynthesis, namely alpha, carbon and oxygen burning and p-process. Some of the studies will proceed within international collaborations, making use of facilities such as ERNA, FAIR, ISOLDE. Other studies will be conducted at ITN, taking advantage of the heavy ion beams available at the 3 MV Tandem accelerator and of the accelerator mass spectrometry (AMS) line.

In the short term, studies will be made of the oxygen+oxygen fusion reaction and in relation to the AMS technique our aim is the study of reactions that lead to the production of ^{10}Be and ^{26}Al, also in order to open new perspectives of applied work.

Results

A new reaction line has been installed at the 3 MV Tandem facility. During this year, alignment and vacuum tests were performed. The line is now ready for operation with a Ge (HP) detector and PIP particle detectors.

In relation to the AMS line some technical difficulties have retarded the predicted plans. Realignment and reassembling of some parts were necessary to improve the beam intensity and stability.

Future Work

During 2009, sulphur isotopic ratios will be remeasured to complete the tests of the AMS line (fig. 1 and 2), namely to assess the bouncing system, and afterwards a period of target testing and preliminary nuclear reaction measurement will follow. In relation to the recently assembled reaction line, target testing and preliminary nuclear reaction measurement of the oxygen+oxygen fusion reaction will proceed.

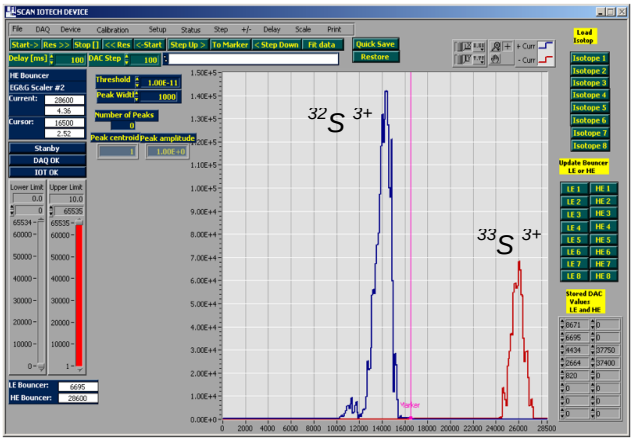

Fig. 1 Part of the mass spectrum of a sulphur target.

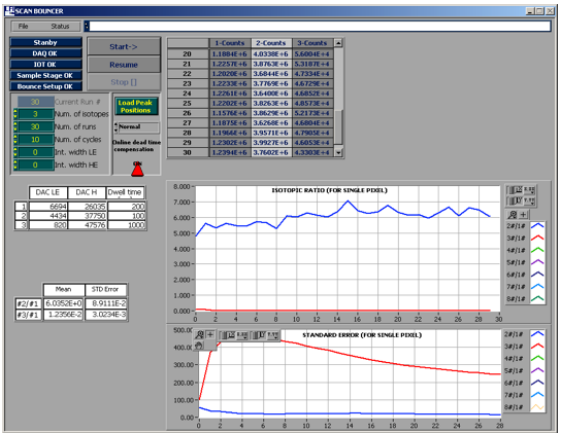

Fig. 2 Labview control of the bouncing system, showing ratios relative to mass 34 isotope of the 33 and 36 isotopes.

Published Work

LUNA Collaboration; D. Bemmerer, F. Confortola, A. Lemut, R. Bonetti, C. Broggini, P. Corvisiero, H. Costantini, J. Cruz, A. Formicola,;Zs. Fülöp, G. Gervino, A. Guglielmetti, C. Gustavino, Gy. Gyürky, G. Imbriani, A. P. Jesus, M. Junker, B. Limata, R. Menegazzo, P. Prati, V. Roca, C. Rolfs, D. Rogalla, M. Romano, C. Rossi-Alvarez, F. Schümann, E. Somorjai, O. Straniero, F. Strieder, F. Terrasi, H. P. Trautvetter, Nuclear Physics A779, 297-317 (2006).

J. Cruz, H. Luis, M.Fonseca, Z. Fülöp, G. Gyürky, F. Raiola, M. Aliotta, K. U. Kettner, A. P. Jesus, J. P. Ribeiro, F. C. Barker, C. Rolfs, Journal of Physics G 35, 014004 (2008).

Development of a PIGE Set-up

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The aim of this work is the extension to all light elements of previous work in order to install an analytical set-up for light element analysis, based on the detection of the gamma radiation induced by low energy protons, PIGE. This technique will open new perspectives of applied work in environment and health problems.

A precise method based on a code [4] that integrates the nuclear reaction excitation function along the depth of the sample was implemented for thick and intermediate samples. For that purpose some reaction excitation functions were measured in the same analytical conditions. The energy steps needed to define accurately the excitation function were used as energy intervals for the integration procedure.
After the work done for F, Li, B and Na, the excitation functions for $^{27}Al(p,p'\gamma)^{27}Al$ and $^{25}Mg(p,p'\gamma)^{25}Mg$, were obtained to introduce as input. Thick target gamma yields for several samples containing Al and Mg were measured to be compared with calculated yields. Results for Al have already been published [5] and the analysis of Mg (gamma spectrum in figure) was concluded (preliminary results in table).

A nuclear reaction line was assembled at the 3 MV Tandem accelerator in order to extend the present work to higher energies and be able to quantify C, N and O.