

LABORATÓRIO ABERTO DE FÍSICA NUCLEAR

PAC 2016

Proposal	N°
Title: New multidetector system for particle-gamma coincidence measurements	
Responsible: J.R.B. Oliveira	E-mail: zero@if.usp.br
Participants José Roberto Brandão de Oliveira, Nilberto Heder Medina, Leandro Gasques, Marcos Aurélio Gonzalez Alvarez, Maurício Morales, Juan Antonio Alcantara Núñez, Vinicius Antonio Bocaline Zagatto, Kumar Raju, André Freitas, Vitor Angelo Paulino de Aguiar, Rafael Escudeiro	
Spokesperson: J.R.B. Oliveira	e-mail: zero@if.usp.br
Telephone: (11)3091-7053 (11)99194-2445	Skype: zeroit
Number of days for experiment:	7
Period planned for the experiment (are the setup ready for beam time?): 6 months, beginning in August 2016.	

Technical information

Ion source			Accelerator			Experimental Area	
Beam	Cathode	I _{mínima}	V _{min}	V _{max}	Bunched beam?	Beam line	Target
^{6,7} Li		10 nA	6.5	7.5	no	30A	²⁷ Al, ^{nat} Au, ¹²⁰ Sn
⁹ Be		10 nA	6.5	7.5	no	30A	¹⁵⁴ Sm
¹² C, ¹⁶ O		10 nA	6.5	7.5	no	30A	²⁷ Al, ^{nat} Au
²⁸ Si		10 nA	7	8	no	30A	⁹ Be
⁸ Li		10 ⁵ pps	6.5	7.5	no	45B	¹²⁰ Sn, ¹⁵⁴ Sm

Other relevant/needed information:

New multidetector system for particle-gamma coincidence measurements

J.R.B. Oliveira *et al.*

IFUSP/DFN

A new multidetector array is going to be built for particle-gamma coincidence measurements. The component detectors have to be tested, as well as the front-end, pulse processing, and data acquisition electronics.

A FAPESP and a CNPq projects have been submitted for the financial support of the equipment. Details of the system and scientific motivation can be consulted at:

<https://drive.google.com/open?id=0B9S9IDqbhRKlbWNIcUcWd04ybE0>.

The particle detectors (ΔE -E) will be made of plastic *phoswich* scintillators (similarly to the present *Saci* [1] detectors) attached to Silicon Photomultipliers (SiPM), which consist of 4 x 4 pixels (about 3mm x 3mm each) with several subpixels (avalanche photodiodes). The gamma-ray detectors will be made of LYSO(Ce) scintillators and will also be coupled to the same type of SiPM devices. Presently, 3 SiPMs are available at the Laboratory, and two LYSO(Ce) crystals have been recently bought and await delivery. Detectors of exactly these characteristics have never been used in basic nuclear physics research and all of their characteristics (energy and time resolution, efficiency, noise, cross-talk, count rate limitations, particle type response, etc.) have to be experimentally investigated for the specific applications. For this purpose 7 days of beam time are requested, to be distributed in units or in pairs during the first 6-8 months. Additional tests will be done during basic research experiments which are included in other beam time requests (see request by V.A. B. Zagatto). If the funding projects are approved additional beam time will be probably necessary for supplementary equipment tests.

The electronics system of the full array will be very complex, but in these preliminary experiments, with a few detectors, it might be very simple. Initial tests, however, will be made so as to test possible alternatives for the full system, such as for the multiplexing of signals.

This project is important because of its connection with the on-going research line of particle-gamma coincidence measurements at the Laboratory [2,3], mainly focused on weakly bound stable and unstable beam reactions. In addition, it

has strong connections with the NUMEN project [4], developed in collaboration with the LNS-INFN (Catania, Italy), for the measurement of double charge exchange matrix elements. These measurements are fundamental for neutrinoless double-beta decay issues, including the possible determination of the neutrino masses. The advanced phases of the NUMEN project involve the construction of a gamma-ray calorimeter (probably also made with LYSO(Ce) scintillators coupled to SiPMs), in order to perform particle-gamma coincidence measurements with the MAGNEX spectrometer. The experience with this type of detectors will be extremely valuable for the collaboration. Both Laboratories will profit from the exchange of personnel and knowledge, and technical solutions could be shared between the two implementations.

Planned tests:

- 1- Test and characterization of SiPM with plastic scintillators. Several beams such as ${}^6\text{Li}$, ${}^9\text{Be}$, ${}^{12}\text{C}$, ${}^{16}\text{O}$ (6.5-7.5 MV) - measure bi-parametric spectra and Z discrimination for fusion evaporation (${}^{27}\text{Al}$ target), or elastic scattering on ${}^{\text{nat}}\text{Au}$: (1 day)
- 2- In-beam test and characterization of LYSO(Ce) detectors ${}^{16}\text{O} + {}^{154}\text{Sm}$ (if available) and ${}^{120}\text{Sn}$ (~7 MV) - inelastic scattering: (1 day)
- 3- Tests of particle-gamma coincidences and timing resolution ${}^7\text{Li} + {}^{120}\text{Sn}$ (6-7 MV): (2 days)
- 4- Tests of detectors in RIBRAS environment ${}^8\text{Li} + {}^{154}\text{Sm}$ or ${}^{120}\text{Sn}$ (inelastic scattering and/or transfer): (1 day)
- 5- Additional in-beam tests and tests of possible signal multiplexing circuits – reactions to be chosen/and/or test of inverse reaction: ${}^{28}\text{Si}+{}^9\text{Be}$ (~8 MV): (2 days)

References

- [1] J.A. Alcántara-Núñez; J.R.B. Oliveira *et al.*, Nucl. Inst. Meth. A 497, 429, 2003.
- [2] V.A.B. Zagatto, J.R.B. de Oliveira *et al.*, Nucl. Inst. Meth. A 749 p.19–26, 2014.
- [3] V A B Zagatto *et al* 2016 J. Phys. G: Nucl. Part. Phys. 43 055103
- [4] F. Cappuzzello *et al.*, Eur. Phys. J. A (2015) 51.

Previous Information on Project

Proposal approved	N: E-109
Period of beam time (date)	5 dias (não utilizados)
Results or problems: Em virtude do projeto Universal CNPq solicitado para financiamento do equipamento não ter sido aprovado, não foi possível realizar os experimentos. Novo pedido foi feito, para um projeto reformulado e com vários melhoramentos, tanto à FAPESP como ao CNPq e aguardam aprovação.	

Proposal approved	N: E-81-c
Period of beam time (date)	15 dias – datas: 27/10/14 31/10/14 03/11/14 07/11/14 03/08/15 07/08/15
Results or problems: Os experimentos foram bem sucedidos resultando em 2 artigos publicados (NIM e JPG), além de uma tese de Mestrado (André Freitas) e uma de doutorado (Vinicius Zagatto), e início do trabalho de Doutorado de André Freitas: [1] V.A.B. Zagatto, J.R.B. de Oliveira <i>et al.</i>, Nucl. Inst. Meth. A 749 p.19–26, 2014. [2] V. A. B. Zagatto, Tese de Doutorado, Universidade de São Paulo, IFUSP, 2015 (online version: http://www.teses.usp.br/teses/disponiveis/43/43134/tde-06052015-053049/en.php). [3] V A B Zagatto <i>et al</i> 2016 J. Phys. G: Nucl. Part. Phys. 43 055103 [4] A. S. Freitas, Dissertação de Mestrado, Universidade de São Paulo, IFUSP, 2013 (online version: http://www.teses.usp.br/teses/disponiveis/43/43134/tde-24092014-151254/en.php).	