LABORATÓRIO ABERTO DE FÍSICA NUCLEAR
PAC 2018

Proposal	N°
Title: Study of fusion reaction of ^{8}B in ^{9}Be and ^{27}Al targets using γ -particle coincidences.	
Responsible: Uiran Umbelino da Silva (IFUSP)	e-mail: uiran@if.usp.br
Participants: Osvaldo Camargo, André Serra, Brett Vern Carlson, Juan Carlos Zamora, Julian Marco Barbosa Shorto, Alinka Lépine-Szily, Kelly Cristina Cezaretto Pires, Marlete Assunção, Erick Zevallos, João Paulo Picchetti, Michel Skolowski Calazans Pontes Adriana Barioni, Valdir Bruneti Scarduelli, Juan A. Alcantara-Núñez, Vinicius A. B. Zagatto, and the RIBRAS collaboration.	
Spokesperson: Uiran Umbelino da Silva (IFUSP)	e-mail: uiran@if.usp.br
Telephone: (11) 95279-0150	Skype:
Number of days for experiment:	15
Period planned for the experiment (are the setup ready for beam time?): 2019	

Technical information

Ion source			Accelerator			Experimental Area	
Beam	Cathode	$I_{mínima}$	V_{min}	V_{max}	Bunched beam?	Beam line	Target
6Li		500 nA	6 MV	8MV		45B	9Be
6Li		500 nA	6 MV	8MV		45B	27Al

Other relevant/needed information:

PAC - 2018

Study of fusion reaction of ^{8}B in ^{9}Be and ^{27}Al targets using γ-particle coincidences.

Uiran Umbelino da Silva

September 21, 2018

Advisor: Prof. Dr. Rubens Lichtenthäler Filho

Requested beam time: 15 days.

Spokes person: Uiran Umbelino da Silva, Rubens Lichtenthäler Filho

Collaborators: Osvaldo Camargo, André Serra, Brett Vern Carlson, Juan Carlos Zamora, Julian Marco Barbosa Shorto, Alinka Lépine-Szily, Kelly Cristina Cezaretto Pires, Marlete Assunção, Erick Zevallos, João Paulo Picchetti, Michel Skolowski Calazans Pontes Adriana Barioni, Valdir Bruneti Scarduelli, Juan A. Alcantara-Núñez, Vinicius A. B. Zagatto, and the RIBRAS collaboration.

Abstract

This project consists in an experimental study of elastic scattering and fusion of the ^{8}B+^{27}Al and ^{8}B+^{9}Be systems. The exotic beams will be produced in the RIBRAS system using the superconducting solenoids to select and focus the secondary beams. The elastic scattering will be measured in the central scattering chamber using the usual Si detectors. The fusion will be measured by detecting the protons from the coumpound system. Possibly, a coincidence with gamma-rays coming from the compound nuclei de-excitation and the evaporated protons will be performed by detecting the gammas in the LYSO detectors, recently mounted.

1 Introduction:

The study of the nuclear structure of weakly bound nuclei has acquired enough importance in last years [1]. These systems have several interests in nuclear models as well as in astrophysics. One of most important discoveries in this field is the nuclear halo structure [2, 3, 4, 5] like ^{11}Li, ^{11}Be, ^{6}He, ^{14}Be, ^{8}B and ^{17}Ne. In general, it is expected that proton halos are less pronounced than neutron ones. However, some proton halo effects have been observed, like a significant increase of fusion and total reaction cross sections near the Coulomb barrier, compared to stable nuclei, indicating a greater reaction distance, with a larger radius than expected [6].

The elastic scattering is the simpler process in a collision of two nuclei [7, 8, 9] and the most immportant in terms of cross section, at low energies. The second most important reaction channel is the fusion. Fusion at low energies provides important information about tunneling process in the Coulomb barrier [6]. In complete fusion reaction, there is a formation of a compound nucleus in high excitation level, followed by a gamma ray and particle evaporation. The fusion reaction can be measured by a γ-particle coincidence system. In a proton halo nucleus, it is more likely to observe proton evaporation since the coumpound nucleus is a proton rich one.

In RIBRAS [10, 11] it is possible to produce unstable beams. The ^{8}B secondary beam will be produced through a di-proton transfer reaction between the ^{6}Li primary beam and a ^{3}He gaseous target that will be mounted before the first solenoid. The gas target is already mounted and operating.

2 Experiment Details:

2.1 Elastic Scattering:

For the elastic measurements, a detection system will be mounted in the central scattering chamber. The array will be composed of four Silicon Surface Barriers detectors. In this experiment the ^{8}B interest beam cannot be separated by a ΔE-E telescope, because the beam cannot be exceed the ΔE detector. However it can be easily separated in single E detectors by the energy (see Fig. 2). The detection system can be observed in Fig. 1.

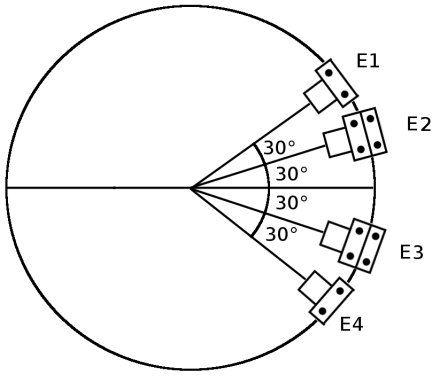

Figure 1: Detection system mounted in primary scattering chamber.

The elastic scattering for ^{8}B+^{27}Al has already been measured [9] at RIBRAS. The elastic ^{8}B+^{9}Be scattering will be measure at energies around 20 MeV. The cinematic calculations already been made by the UPAK package [12]. The expected spectrum is similar to that obtained for the ^{8}B+^{27}Al system [9] (see Fig. 2).

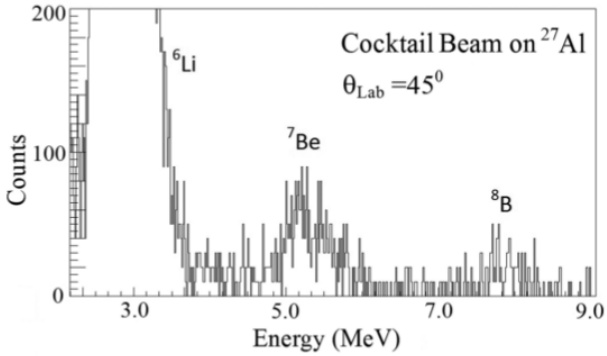

Figure 2: ^{8}B+^{27}Al spectrum obained in a E$_{lab}$ =18 MeV [9].

2.2 Fusion

Preliminary calculations have been performed, using the GEMINI++ code [13, 14], to provide information about the ^{8}B+^{9}Be$\rightarrow^{17}$F. The results show that a large yield of protons are evaporated from the coumpound system (see Fig. 4). It is easy to detect this protons in RIBRAS using the usual ΔE-E setup with 50 microns ΔE detectors. To detect the gammas we will use LYSO(Ce) crystals placed around the target. This γ-particle system (see Fig. 3) will provide several information about complete and incomplete fusion reactions, and will be mounted in the last scattering chamber using the second solenoid to provides a cleaner ^{8}B beam. In April, 2018, a similar detection array was mounted for a ^{8}Li+^{120}Sn Coulomb excitation measurement, this data is still being analyzed [15].

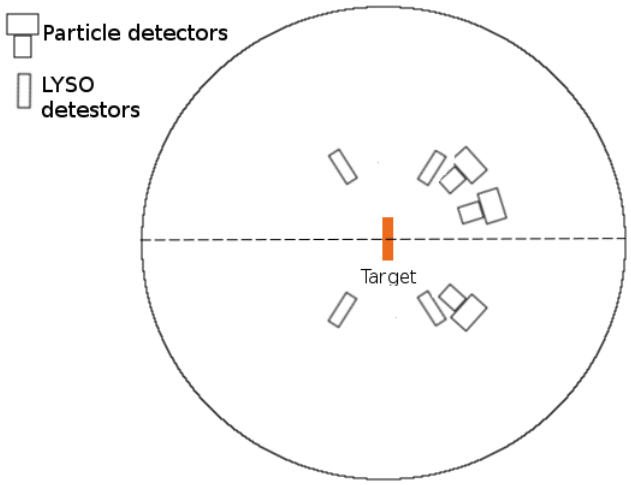

Figure 3: Detection system mounted in secondary sacattering chamber.

These calculations resulted a total fusion cross section of 1550 mb. The results show a proton evaporation cross section of 1380 mb with an angular distribution peaked around 45 degrees in the lab, indicating that the proton evaporation is a good candidate to be measured. In addition, alow yield of alpha particles (cross section of 134 mb) are also evaporated around 45 degrees which can provide more information from fusion. We believe that a simple experiment measuring only the protons and their energy distribution and angular distribution can provide some reliable information of the fusion cross section.

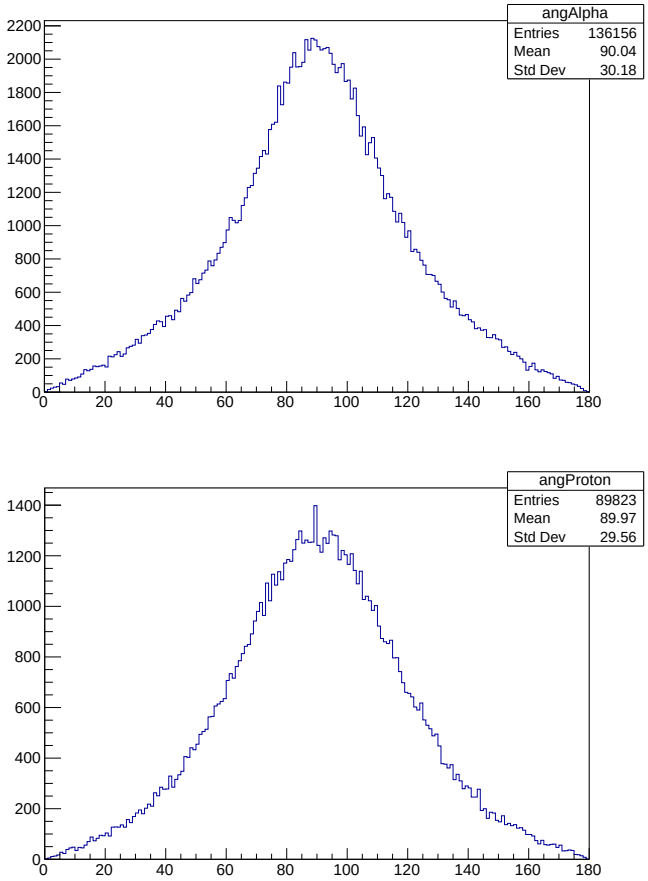

Figure 4: Angular distribution of evaporated alpha and protons.

With these results, and assuming a I(^{8}B)= 10^4 pps, we obtain a detection rate of γ-proton of a few coincidences per hour which can in principle be measured.

3 PAC-E120

Some measurements of the PAC-E120 project have performed over the last year. A ^{10}Be+^{9}Be elastic scattering for E_{lab} = 21.5 and 26.4 MeV was measured, where the secondary ^{10}Be interest beam was produced by a ^{11}B+^{9}Be proton transfer. The detection system was the same explained in section 2.1. The data still under analysis, but a previous results for the 21.5 MeV scattering can be observed in Fig. 5

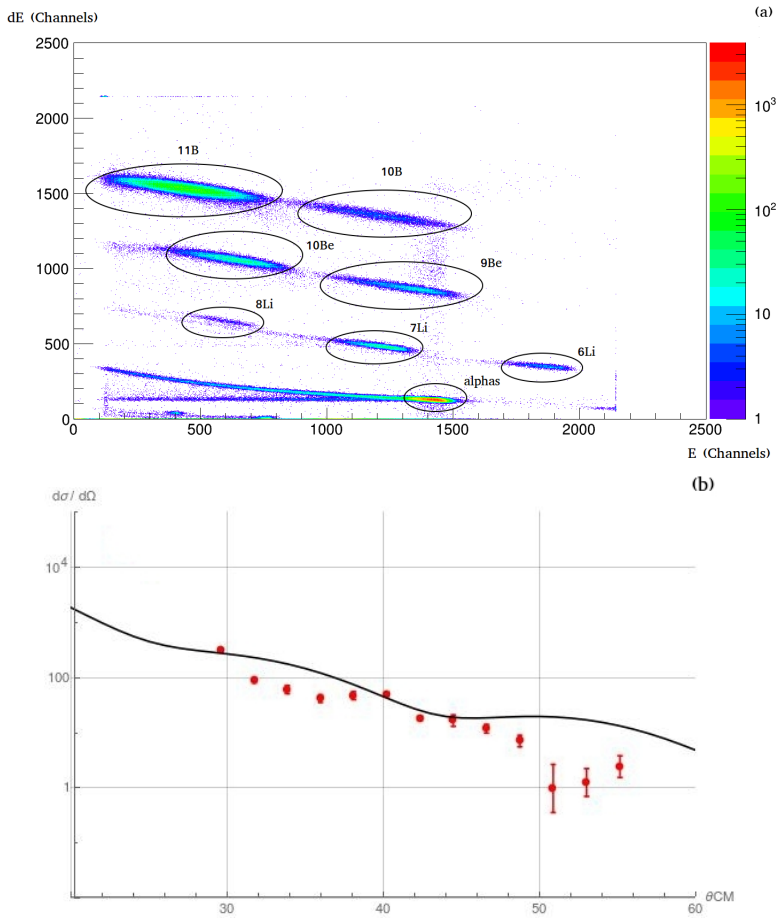

Figure 5: (a) ^{10}Be+^{9}Be spectrum obained and (b) preliminary angular distribution compared with São Paulo [16] potential calculations in a E_{lab} =21 MeV.

References

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