Letter of Intents to the ISOLDE and NTOF committee

Study of ^{9}C excited states by Inverse Kinematics Inelastic Scattering

M.G. Pellegriti[1,2], P.Descouvemont[3], A. Di Pietro[1,2], P.Figuera[1,2], M.Fisichella[1,4], M.Lattuada[1,2], M.Milin[5], A.Musumarra[1,2], V.Scuderi[1,2,] D.Torresi[1,2], E.Strano[1,2], N.Soic[6], M.Zadro[6].

1)INFN-Laboratori Nazionali del Sud, Catania, Italy
2)Università di Catania, Catania, Italy
3) Universitè Libre de Bruxelles, Brussels, Belgium
4) Universita' di Messina, Messina, Italy
5)Department of Physics Faculty of Science University of Zagreb, Zagreb, Croatia
6)Division of Experimental Physics Ruder Boskovic Institute, Zagreb, Croatia

Spokesperson: M.G. Pellegriti

Abstract

By this letter of intent, we underline the importance of the study of the neutron deficient ^{9}C isotope. Its structure is poorly known and the inelastic scattering of radioactive ^{8}B on protons gives the opportunity to investigate in details the level scheme. Inelastic cross section is free from Coulomb interference [1] and for this reason a clean information on the energy position and total width of the resonances can be obtained. In order to investigate the properties of the ^{9}C resonances, and in particular at E_x=3.6 MeV and 4.1 MeV [2], we ask for a ^{8}B beam development at E=29 and 28 MeV and intensity ~10^4pps. The proposed energies will soon be available with the HIE-ISOLDE. The ^{8}B beam will be sent onto a stack of thin CH_2 targets to measure the outgoing channels: $^{8}B_{g.s.}$+p and $^{8}B^*_{0.77MeV}$+p'. An appropriate choice of CH_2 target thickness will allow the disentangling of inelastic from elastic protons. Scattered protons will be measured by ΔE-E silicon detectors. In order to obtain the resonance parameters, the elastic and the inelastic cross sections will be analyzed by using the R-matrix formalism as in [1].

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1)**Physical Motivation**

The study of light nuclei is important in nuclear physics because they represent the simplest case where to study experimentally and theoretically the nuclear structure. A special interest must be devoted to the study of ^{9}C since his level structure is poorly known. ^{9}C is an exotic neutron drip line isotope of Carbon which has a lifetime of 0.1265 s and is proton unbound by 1.3 MeV. The ground and the first excited state (2.2 MeV) of ^{9}C were identified by the $^{12}C(^{3}He,^{6}He)^{9}C$ reaction respectively in [3] and [4] .Thanks to the use of radioactive beams, the structure of ^{9}C has been recently studied via inverse kinematics elastic scattering of ^{8}B beam on protons [2]. In this work, a new broad excited state was observed at 3.6 MeV and spin $5/2^{-}$ which should correspond to a mirror state in ^{9}Li. At such excitation energy (see fig.1), the decay on ^{8}B first excited state (E_x=0.77 MeV) is allowed.

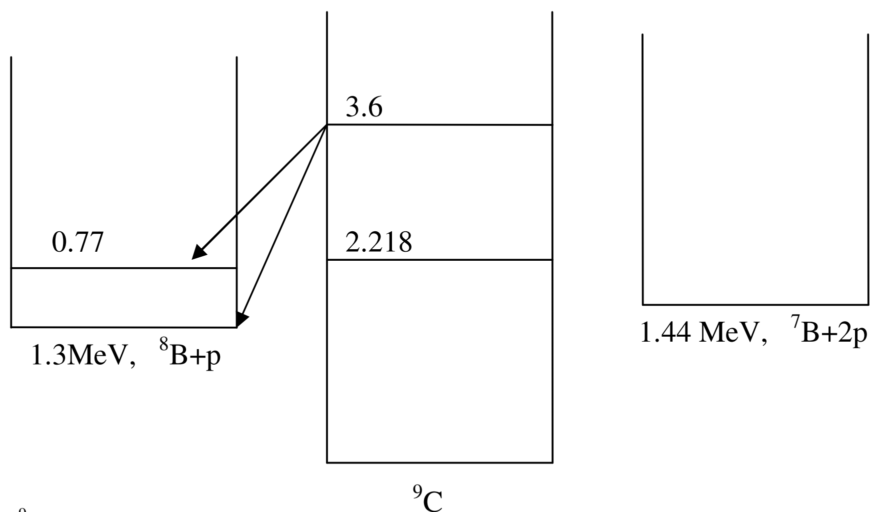

Fig.1: Sketch of ^{9}C level scheme.

The use of the infinite thick target method [2], leads to a contamination of the elastic scattering excitation function with the inelastic protons (see Fig.2). In order to solve this problem, the amount of inelastic scattering due to the presence of the $^{8}B^{*}$(0.77MeV) excited state has been estimated in [2] by using a Monte Carlo simulation (Fig.2, shadowed histogram). The absolute value of the inelastic cross section has been experimentally constrained by using the total cross section (elastic + inelastic), see [2] for details.

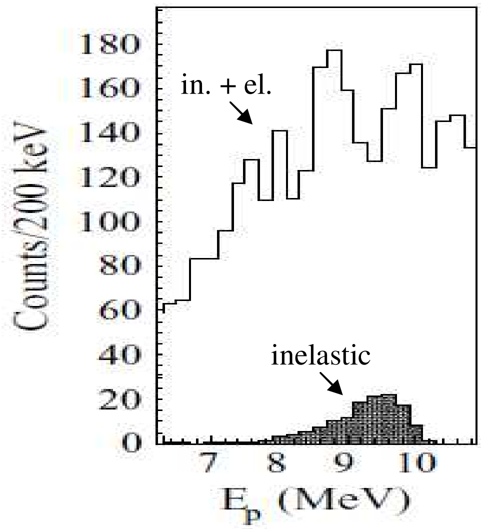

Fig. 2: ^{8}B+p data from [2] obtained with an infinite thick target at laboratory proton at energies from 6 up to 11 MeV.

To solve experimentally the problem of the superposition of elastic on inelastic events an opportune target thickness has to be used. The feasibility of such method has been demonstrated in [1] (see Fig. 3). In this paper the ^{19}Na nucleus has been studied by measuring the elastic scattering H(^{18}Ne,p)^{18}Ne(g.s.) and inelastic scattering H(^{18}Ne,p')^{18}Ne(2^+,1.887 MeV) cross sections.

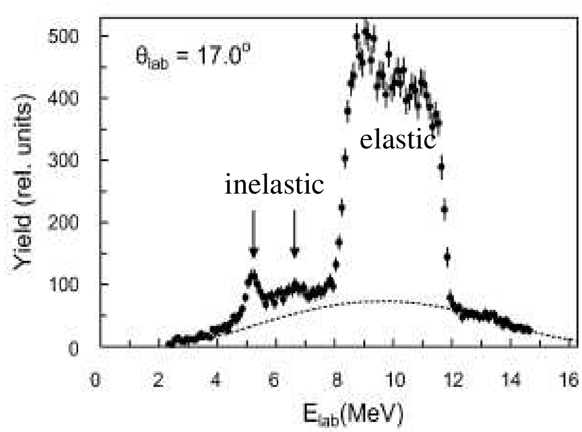

Fig. 3: ^{18}Ne+p data [1] obtained with an appropriate target thickness. As it can be seen, it is possible to experimentally disentangle elastic from inelastic events.

Measuring the inelastic cross section is intrinsically interesting since it is free from Coulomb scattering: thus there is no interference between the nuclear and the Coulomb part of the interaction. This implies that it is easier to get the position and total width of the resonance as it was done in [1]. Moreover, a simultaneous R-matrix analysis of the elastic and the inelastic cross sections leads to the determination of the reduced proton widths for the elastic and inelastic channels, thus providing complete information on the structure of the analyzed state. This technique has allowed the discovery of two new states in ^{19}Na (see fig.3).

2)Proposed experiment

In order to extract the resonance parameters of the ^{9}C first excited state, we propose to study the elastic scattering of ^{8}B on proton target by using the same method used in [1] which is able to disentangle elastic from inelastic event by a choice of an appropriate target thickness.
Due to the small excitation energy of the ^{8}B first excited state, we need to use CH_2 having a thickness less then 0.8 mg/cm^2 in order to avoid inelastic-elastic superposition.
With this target thickness, we can scan a center-of-mass energy region of ~250 KeV per incident beam energy. To scan a wider range of excitation energy a set of different beam energies needs to be used (see for example [5]).
In order to save beam time, we propose to use a stack of targets and to measure all at once the full excitation energy range of interest thanks to the degradation of the beam energy in the different targets.
Starting with an initial beam energy E_b=29MeV, by using a stack of four target, the full explored excitation energy range is 3.4 MeV<E_x< 4.4 MeV
The proposed set-up is sketched in Fig. 4.

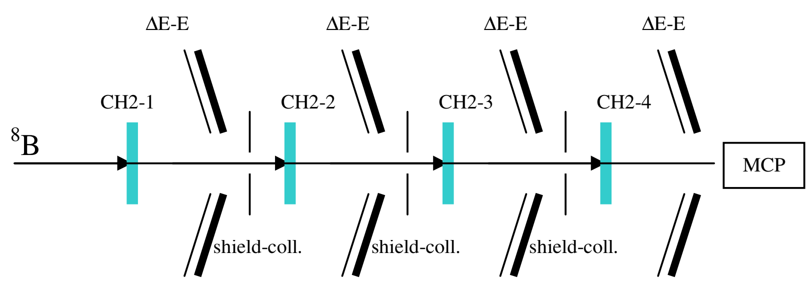

Fig.4: Sketch of the experimental set-up. A stack of four targets allows the measurement in a wider energy range. For each target a couple of ΔE-E silicon detectors can be used, the E stage being a double sided silicon strip detector. A shield can be placed after each two telescopes in order to avoid scattering events from a target to reach the next one. A beam monitor (MCP) will count the beam particles for normalization.

As regard as the angular straggling that will enlarge the beam spot on the last target, we have estimated that if we start with a beam opening of ϕ=4mm on the first target we will have a ϕ=6mm on the fourth (by considering a distance ~80cm from the 1st to 4th target).
For each target, we have kinematically calculated maximum and minimum elastic (inelastic) proton energies, blue (pink) bars in Fig. 5. Maximum energies correspond to elastic (inelastic) protons scattered at the initial beam energy while minimum energies correspond to the beam energy after passing each target. As we can see, elastic and inelastic energies ranges are separated.

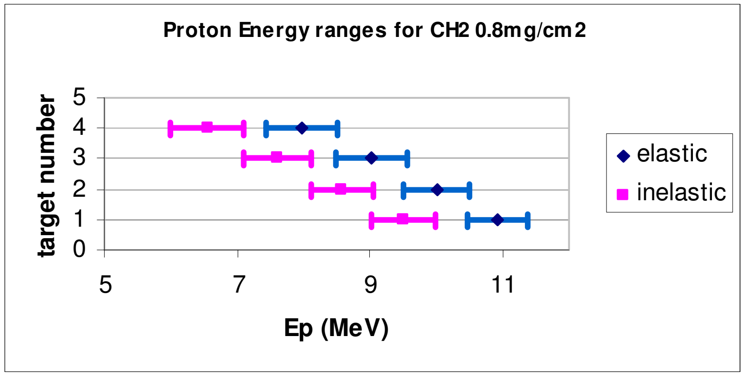

Fig.4: Energy ranges at θ=0° of elastic (blue) and inelastic (pink) protons in the different targets. Initial beam energy is 29 MeV. As it can be seen in the picture, the use of 0.8 mg/cm^2 target thickness allows for each target the disentangling of elastic for inelastic events.

When we will recover the full excitation function, we will match the results from the different targets. We are planning to change the beam energy (E_b= 28 MeV) to overlap the matching points regions.

3)Counting rate estimation

As it can be deduced from [2], we can assume a maximum cross section for the inelastic scattering of 20 mb/sr. Considering a solid angle ΔΩ~25 msr and a beam intensity of 10^4 pps, we expect a counting rate of 0.3 p/h per bin of 50 keV in E_x when the beam intensity is 10^4pps. In 7 days per each beam energy of E_b= 29, 28 MeV, which will soon be available with the HIE-ISOLDE, we can get a total of about 50 counts per bin.

Bibliography

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