CERN-INTC-2018-029 / INTC-SR-058
11/10/2018

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Status Report to the ISOLDE and Neutron Time-of-Flight Committee

IS619: Effects of the neutron halo in ^{15}C scattering at energies around the Coulomb barrier

Submitted: 10-October-2018

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Abstract

The objective of the experiment is to study the low-energy dynamics of ^{15}C by measuring the angular distribution of the elastic scattering and ^{14}C production cross sections at Coulomb barrier energies. The carbon isotope ^{15}C is a rather unique nucleus as its ground state exhibits the only known pure S-wave halo configuration. This would be the first dynamical study carried out so far for the halo nucleus ^{15}C at low collision energies, which should bring information on the complicated coupling between elastic, neutron transfer and breakup channels, and the role of the continuum.

1. Motivation, experimental setup/technique

Motivation. The neutron-rich carbon isotope ^{15}C (t=2.45s) is a weakly bound system. The energy required for one-neutron removal S_{1n}=1218 keV is much smaller than for two-neutron removal S_{2n}=9395 keV [1, 2]. Experiments performed at high energies [3] suggest the formation of a halo, being thus the only known case of an almost "pure" $2s_{1/2}$ single-neutron halo ground state [4, 5].

Despite the great interest, the dynamics of ^{15}C at low collision energies is practically unknown. Important dynamical effects due to the halo have been theoretically predicted to appear in the scattering with heavy targets at Coulomb barrier energies [6]. However, there is no scattering data for testing the validity of the results and new experiments are needed to investigate the relevant reaction processes.

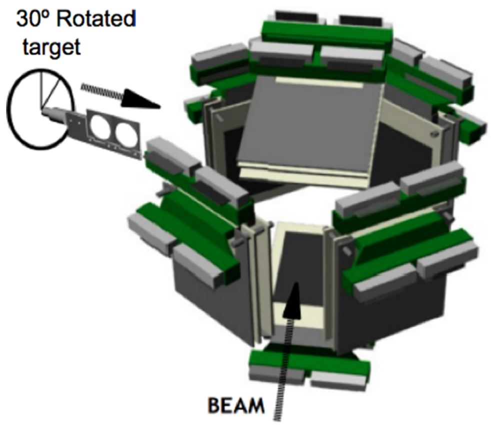

Figure 1. GLORIA silicon array.

Experimental setup. The measurements were carried-out with the particle detector GLORIA [7], a silicon array composed of six DSSSD telescopes and a tilted target system (Fig. 1). The detector allows to measure the angular distribution of elastic and reaction fragments in a continuous angular region from 15º - 165º (Lab), resolving mass and charge up to nitrogen. A total number of 30 shifts of post-accelerated ^{15}C were allocated for this experiment at a beam energy of E= 65 MeV.

2. Status Report

The experiment was carried out at the XT03 beam line of HIE-ISOLDE, where the GLORIA detector system was set-up in the SEC scattering chamber. Two high-purity ^{208}Pb targets (>98%) of 1.5 mg/cm^2 (thin target) and 2.1 mg/cm^2 (thick target) were used for the measurements. The ^{15}C beam was produced using a CaO_2 primary target on a hot-cathode plasma source. In order to maximize the $^{15}C^{5+}$ yield the mass-to-charge ratio was set to A/Q = 3.

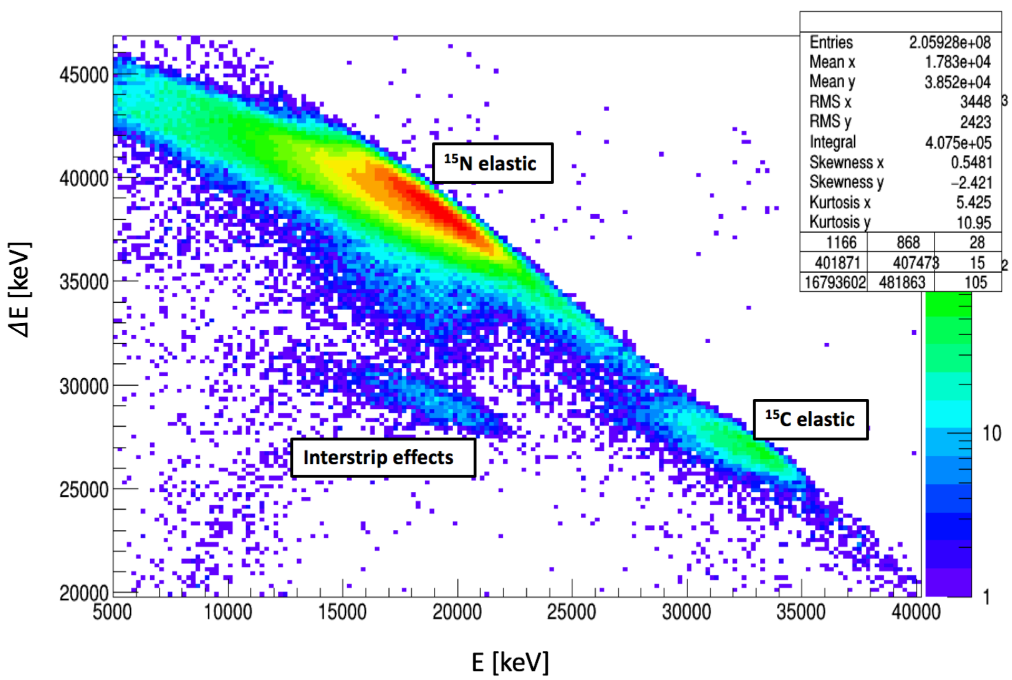

Figure 2. ΔE vs E plot for the forward telescope “A” of the GLORIA array. The areas corresponding to the elastic channels of ^{15}C and ^{15}N isotopes have been identified. See text for discussion.

The observed beam contaminants were N and O, which are present in the residual gas of the accelerator system. Their relative yields were reduced by using a carbon stripper of 75 μg/cm^2 thickness, and the energy of the ^{15}C beam increased to 4.37 MeV/u to compensate for the corresponding energy loss (~ 300 keV); the estimated beam energy with the foil was 4.35 MeV/u.

The detector system GLORIA can easily identify the light beam contaminants and/or reaction products owing to the thin ΔE-stage (40 μm)of the telescopes. A typical raw spectrum of the forward telescope "A" is shown in Fig. 2. It contains ΔE -E coincidence data of a total of 16x16 pixels and covers a wide angular region from 15° to 65° (Lab). Despite the large kinematical spread, the elastic scattering of ^{15}C, ^{15}N and the region associated to interstrip effects (cross-talking) are clearly separated. Using this spectrum we obtained an intensity of the ^{15}N component of $6*10^4$ pps and an average ratio carbon/nitrogen of ~ 0.03, which is consistent with a ^{15}C beam intensity of I = $1.8*10^3$ pps at the reaction target.

As the Coulomb barrier for the scattering of nitrogen and oxygen with a ^{208}Pb target is much higher than the nominal 65 MeV beam energy, only pure Rutherford scattering is expected with no contribution to other reaction channels. The presence of light beam contaminants was very useful for tuning the beam through the detector system and for monitoring the data acquisition process. On the other hand, the Rutherford scattering of ^{15}N will be used for cross-checking the scattering angles and the normalization of the ^{15}C elastic cross section. The data is presently under analysis.

References

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Theses

The data is being analysed by the PhD students J.D. Ovejas [a] (Supervisor: O. Tengblad[a]) and A. Knyazev [b] (Supervisor: J. Cederkall[b]).

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Publications

A publication [J.D. Ovejas et al.] is in preparation from a poster presentation at the International Scientific Meeting "La Rábida: Basic concepts in Nuclear Physics: theory, experiments and applications". La Rábida (Spain) 18th-22th June 2018.