Resonances in ^{11}C above ^{10}B+p threshold using thick target in inverse kinematics

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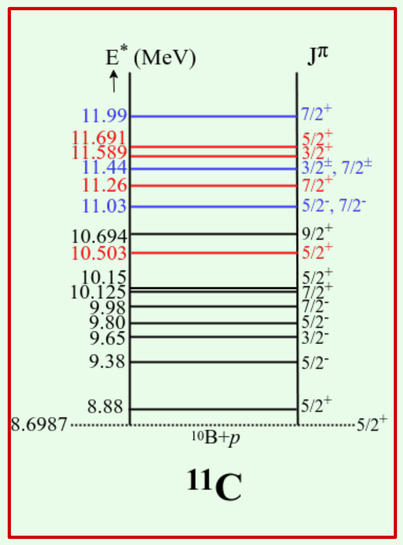
ABSTRACT

Spectroscopy of ^{11}C has been investigated by the resonant scattering of ^{10}B + p with thick target inverse kinematic (TTIK) method. The ^{10}B(p, p)^{10}B reaction was measured at θ_{cm} = 180°, 170°, 160°, 150° and 140° using a 35.93 MeV ^{10}B beam. Resonances in ^{11}C between the excitation energy E*= 9.6 and 11.6 MeV are observed. The excitation function spectra are also compared to the direct kinematic measurement. To describe the obtained excitation functions, a multichannel R- matrix calculation under the kinematics assumption of resonant elastic scattering is performed and the resonant parameters such as the resonant energy E*, the spin-parity J_π , and the proton-decay partial width Γ_p are extracted.

INTRODUCTION

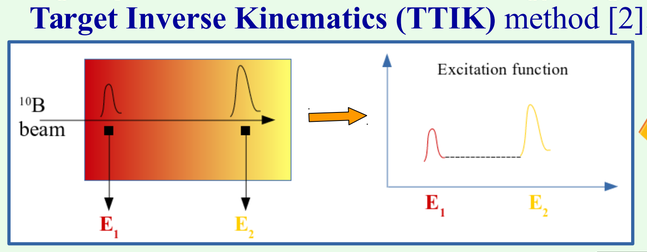
- Structural study of exotic nuclei has estalished new phenomena, such as halo structure, soft excitation modes, and rare β-delayed particle decays etc.
- Above the particle threshold: inconsistencies between various reports on the properties, e.g. for a mirror pair of ^{11}C and ^{11}B.
- Possible resonance at 200 keV above the ^{10}Be+p threshold in ^{11}B- associated to strong beta decay of ^{11}Be and dark matter production [1].
- Resonance structure in ^{11}C has important implications:
  (1) ^{7}Be(α,γ) for astrophysics in the pp-chain of Sun
  (2) ^{10}B(p,α)^{7}Be as the contamination of the candidate of aneutronic fusion reaction ^{11}B(p,2α)^{4}He
  (3) For the ^{10}B(p,γ) as competing reaction for the ^{10}B(p,α)^{7}Be reaction.



EXPERIMENTAL DETAILS

➡ Resonances are more visible in spectra at θ_{cm}=180⁰ - impractical in direct kin.

➡ To get spectra at 180⁰ and for entire energy range with one incident energy- **Thick Target Inverse Kinematics (TTIK)** method [2].



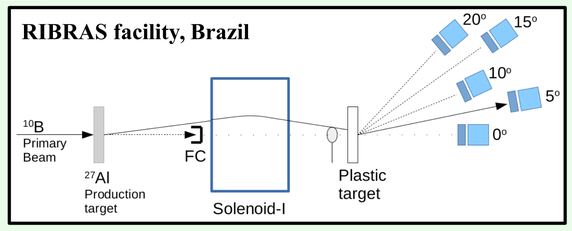
◆ E_{lab} of pure ^{10}B beam= 38.4 MeV.

◆ The production target acts as an intensity degrader, producing elastically scattered ^{10}B beamat 37.2 MeV with intensity of 10^7 pps.

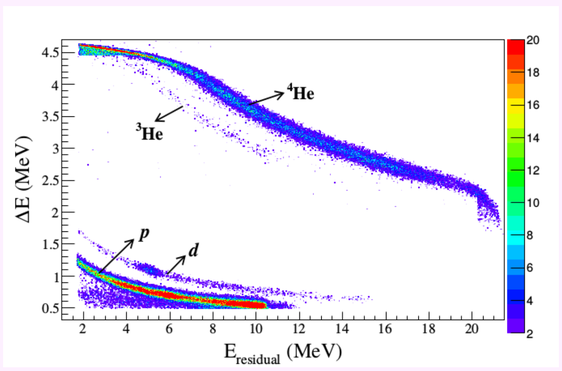
◆ Target: polyethylene plastic foil $[CH_2]_n$ 100 μm thick.

◆ For normalization, a ^{197}Au target run was performed for short interval of time with a periodic repetition during the whole experiment.

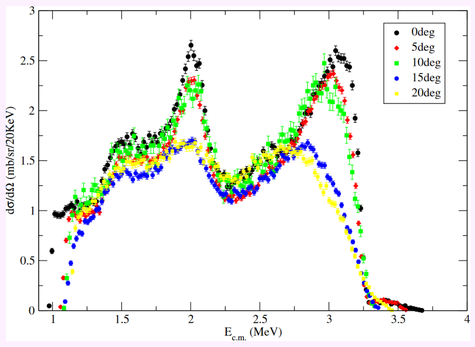
◆ Natural carbon target runs were also performed to subtract the contribution from the reactions of the ^{10}B beam with the carbon present in the polyethylene foil.



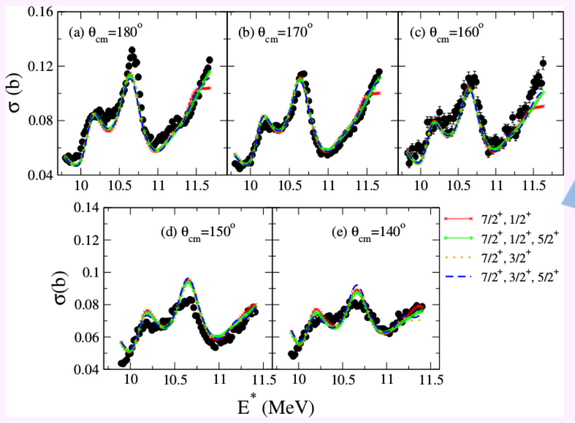
MEASURED DATA, ANALYSIS & RESULTS



Two-dimensional spectrum (DE-E_{RES}) measured at 0°.



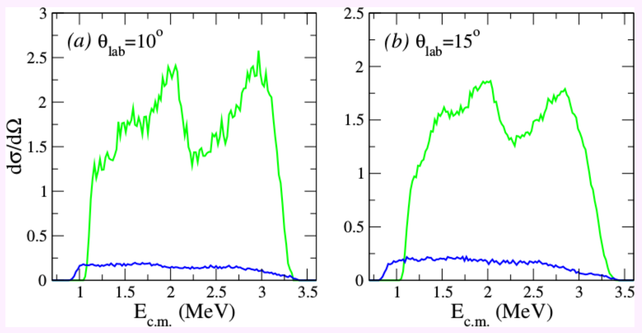
Excitation function for the 10B(p,p) reaction in the range of 1.2 to 3.3 MeV (E* =9.9 to 11.7 MeV)



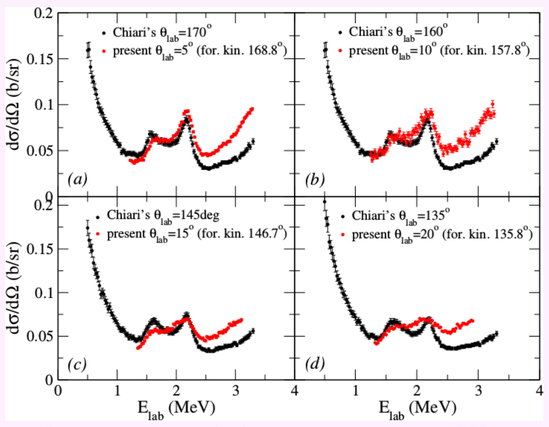
☆ Excitation function has been analyzed with the multichannel R-matrix code AZURE2 [4].

R-matrix calculations performed simultaneously for all the measured angles.

The R-matrix calculation of ^{10}B(p,p) reaction for the data measured at $\theta_{c.m.}$ = 180° in inverse kinematics: the results obtained with different spin-parity combination for a resonance at E*=11.44 MeV, 11.75 MeV (variable parameters) apart from 11.26 MeV [7/2+], 10.679 MeV [9/2+] and other lower states reported in ref. [5].



Comparison of the excitation function for C_2H_4 (green) and only ^{12}C background (blue).



Comparison with direct measurement [3].

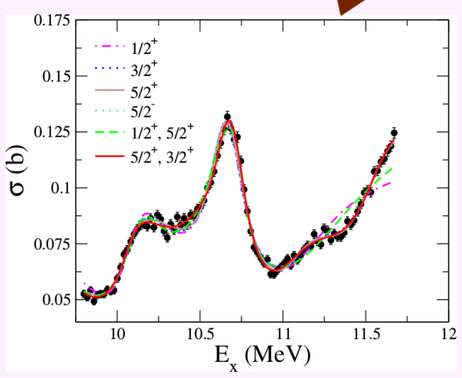


TABLE ☆: Resonance properties for ^{11}C from the best fit.

E_x (MeV)	J^π	l	s	Γ_p (keV)
11.26	$7/2^+$	2	5/2	692.2
		0	7/2	34.2
		2	7/2	211.7
11.589	$3/2^+$	2	5/2	31.9
		2	7/2	519.2
10.503	$5/2^+$	0	5/2	583.6
		2	5/2	17.8
		2	7/2	31.7
11.6910	$5/2^+$	0	5/2	60.9
		2	5/2	48.7
		2	7/2	3.8

DISCUSSIONS AND CONCLUSION

➡ Four new states have been put in evidence above E*=10.5 MeV in ^{11}C, and their spin and parity have been proposed.

➡ While doing such measurements, the angular coverage should be as small as possible to reduce the broadening of peaks in the resonance structure.

➡ Concludes the validation of the data measured with TTIK technique with respect to the direct kinematics data.

➡ Method will be further useful to investigate the complex resonance structure of other exotic nuclei such as ^{11}B through ^{10}Be+p resonant elastic scattering measurement, which is our planned future work.

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