Measurement of 3α+p states in ^{13}N via β-delayed charged-particle spectroscopy

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Clustering phenomena are prevalent in light nuclei and are an excellent test ground for understanding few-body systems that are theoretically accessible. These clustering phenomena have been well-studied in α-conjugate nuclei and are less-well studied off the line of stability. Of particular interest is the nucleus, ^{13}N, where 3α cluster states in ^{12}C are perturbed by the extra proton. Additionally, the well-clustered ^{9}B may be perturbed by an extra α-particle. Resonant $^{9}B+\alpha$ or α-transfer is not possible due to the extremely short half-life of the ^{9}B nucleus. Instead, one may use β-delayed charged-particle spectroscopy to populate states in ^{13}N via ^{13}O and observe the decays to a final state of 3α+p. The β-delayed proton channel has previously been studied for ^{13}O [1] where limited statistics showed only a very small sensitivity to populating the p+$^{12}C(0_2^+)$ (Hoyle state) which results in a 3α+p final state. Utilizing the TexAT TPC [2] to perform one-at-a-time β-delayed charged-particle spectroscopy, the β-**.**

Using a $^{14}N(^{3}He,xn)^{13}O$ production mechanism, an ^{13}O beam of typical intensity of 5 pps was implanted into TexAT. Using a small area Micromegas, 'MM Jr', the beam impurities (mainly ^{7}Be) were identified by their smaller energy loss upon the entrance to the TexAT chamber. Using the established technique with TexAT to provide one-at-a-time implantation [2], a total of 1.9 x 10^5 ^{13}O ions were stopped inside the sensitive region of TexAT. The cleanliness of the technique was demonstrated by a

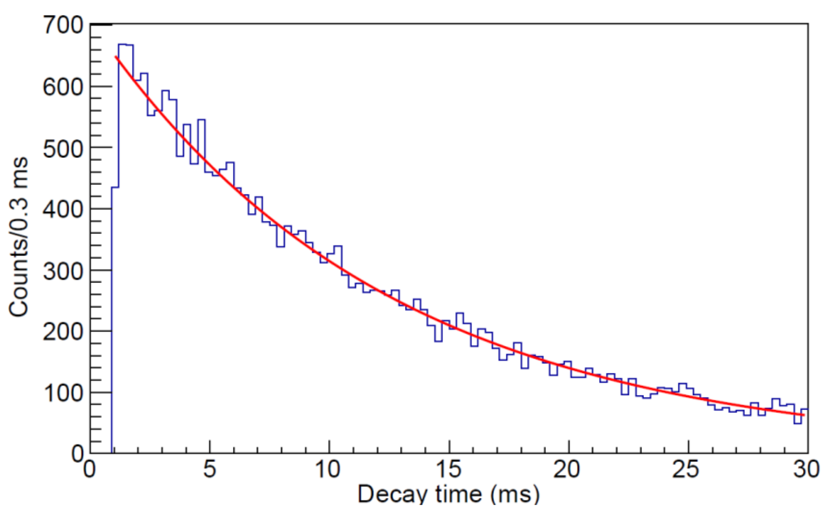

Fig. 1. Decay time for ^{13}O implanted inside of TexAT with an exponential decay curve in red. The value extracted from our data is 8.55±0.09 ms, in good agreement with the adopted value of 8.58±0.05 ms.

background-free half-life measurement of $t_{1/2}$=8.55±0.09 (stat.) ms, in good agreement with the adopted value of 8.58±0.05 ms. The decay curve is shown in Fig. 1.

In total, 1.86 x 10^4 β-delayed proton-decay events were identified (shown in Fig. 2) in addition to 150 β-delayed 3α+p events which were observed for the first time. The current analysis is working to identify the states these events originate from and identify the decay channel. The latest results suggest these events are dominated by ^{9}B+α decays with only around 10% arising from p+^{12}C(0_2^+).

Analysis is still ongoing and will be published in Summer 2022.

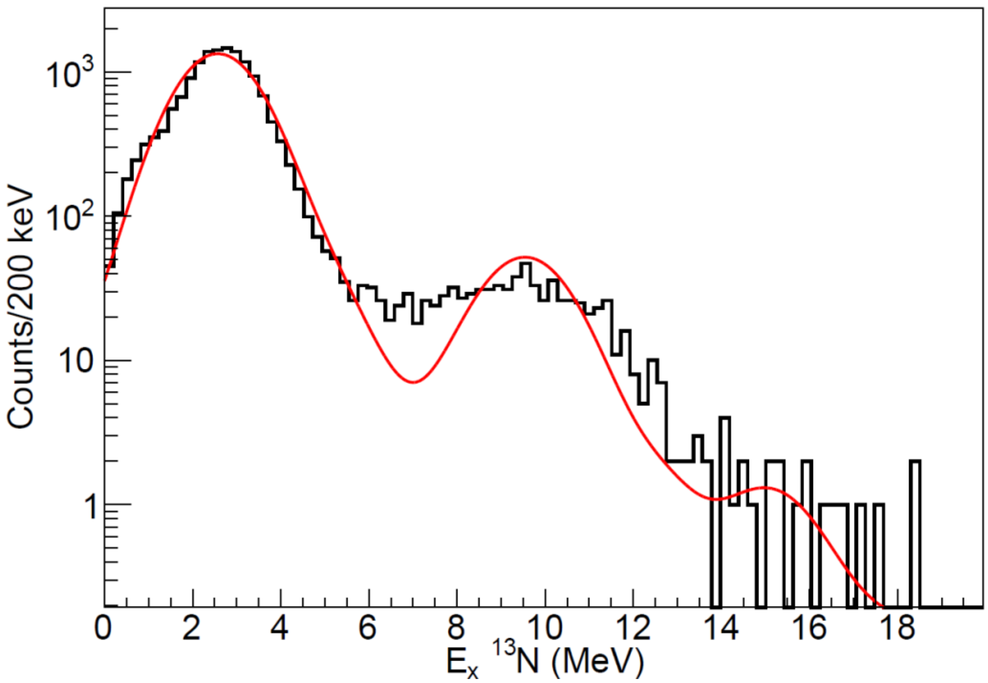

Fig. 2. Selection of (^{13}N, p) events. Proton energy spectrum from these data obtained from the ^{12}C recoil. The expected yield using previously-obtained branching ratios [1] is overlaid in red after being convoluted with a Gaussian profile to best replicate the data.

[1] H. H. Knudsen *et al.*, Phys. Rev. C **72**, 044312 (2005)

[2] E. Koshchiy *et al.*, Nucl. Instrum. Methods Phys. Res. **A957** 163398 (2020),

[3] J. Bishop *et al.*, Nucl. Instrum. Methods Phys. Res. **A964**, 163773 (2020)