Searching for a candidate for the hypothetical Efimov state in ^{12}C

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The structure of ^{12}C is of extreme importance for nuclear astrophysics. Notably, the Hoyle state enhances the production of ^{12}C through the 3α process. There is a significant interest in the properties of other states in ^{12}C, such as the possible breathing mode excitation of the Hoyle state [1], the 2^+ Hoyle-state rotational excitation [2] and a hypothetical additional state which could exist in a 3-boson system, known as an Efimov state. Past studies at TAMU and Argonne National Laboratory have cast doubt on the existence of this Efimov state [3] but other measurements, including at LNS Catania have claimed to have observed a signal which may correspond to this state.

A collaboration has been formed to search for the possible Efimov state using other reactions, since beta decay is rather selective and, while unlikely, it is possible that the Efimov state might not have been populated in those experimental studies. At the centre of this collaboration is a new high-resolution study of $^{12}C(p,p')$ with the Enge SplitPole magnetic spectrometer at the Triangle University Nuclear Laboratory. This reaction provides a high-resolution, low-background population of ^{12}C without strong structural selectivity [4]. This experiment will be combined with already published studies of ^{12}C with the K600 magnetic spectrometer at iThemba LABS and an additional $^{12}C(p,p')$ dataset from the K600 to provide stringent constraints on the possible energy or cross section for the Efimov state using these different reactions. Proving that the state does not exist is a logical impossibility. Providing data which can be used to confront theoretical models of the Efimov state in terms of its energy and cross section for these different reactions with exceptional energy resolution and background rejection is vital. These data build on the past study by Bishop *et al*. [3], in expanding the number of population mechanisms used to search for this state.

Fig.1 shows the position spectrum from the $^{12}C(p,p')$ reaction using the TUNL SplitPole magnetic spectrograph. A full calibration of the spectrum has not yet been performed but the strong peak at around channel 2650 is the Hoyle state. Some $^{13}C(p,p')$ contamination is expected in this spectrum which may be the other small peaks at around channels 450 and 2950.

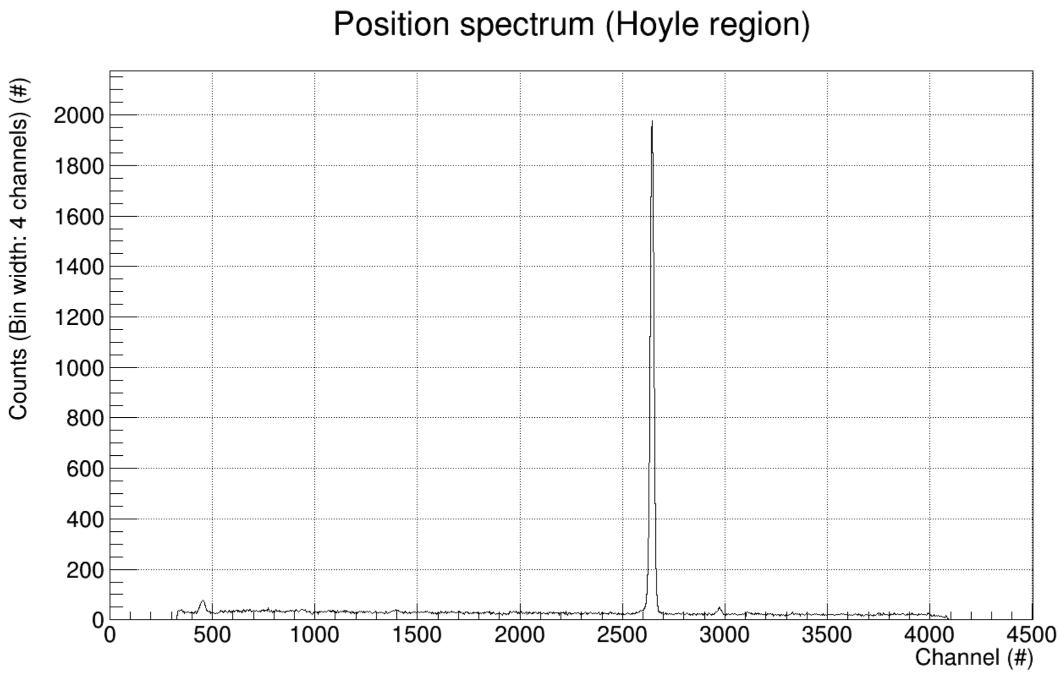

FIG. 1. Position spectrum from the 12C(p,p') reaction.

[1] K.C.W. Li *et al.*, Phys. Lett. B **827**, 136928 (2022).
[2] E. Epelbaum *et al.*, Phys. Rev. Lett. 109, 252501 (2012).
[3] J. Bishop *et al.,* Phys. Rev. C **103**, L051303 (2021).
[4] S. Benamara *et al.*, Phys. Rev. C **89**, 065805 (2014).