Exploring clustering in alpha-conjugate nuclei using the thick target inverse kinematic technique for multiple alpha emission

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Searching for alpha cluster states analogous to the ^{12}C Hoyle state in heavier alpha-conjugate nuclei can provide tests of the existence of alpha condensates in nuclear matter. Such states are predicted for ^{16}O, ^{20}Ne, ^{24}Mg, ^{28}Si etc. at excitation energies slightly above the multi-alpha particle decay threshold [1-3].

The Thick Target Inverse Kinematics (TTIK) [4] technique can be successfully used to study the breakup of excited self-conjugate nuclei into many alpha particles. A test run was performed at Cyclotron Institute at Texas A&M University to study the reaction ^{20}Ne+α at 10 AMeV. Here the TTIK method was used to study both single α-particle emission and multiple α-particle decays. Due to the limited statistics, only events with alpha multiplicity up to three were analyzed. The analysis of the three α - particle emission data allowed the identification of the Hoyle state and other ^{12}C excited states decaying into three alpha particles. Some results are reported in Refs. [5, 6] and compared with other data available in the literature.

The experiment has been recently repeated using an improved experimental setup

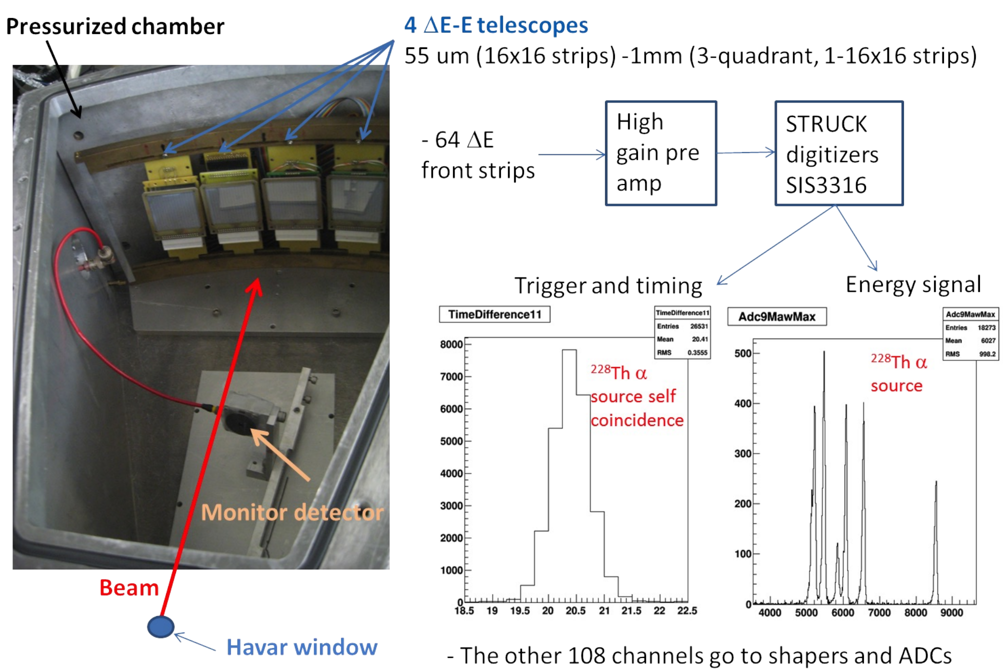

FIG. 1. Experimental setup and scheme of the electronics. Good energy and time resolution are obtained by using the STRUCK digitizers SIS3316.

covering a larger solid angle and having a better granularity. A picture of the new experimental setup is shown in Fig. 1.

In the new setup, four DeltaE-E telescopes placed at the end of the pressurized chamber allow the detection of the reaction products. The DeltaEs consist of 55 micron, double sided, 16x16 strip silicon detectors. The E are 1 mm thick quadrant silicon detectors. The signals from the front strips of the DeltaEs are sent to high gain pre-amplifiers from Indiana University and digitized using Struck SIS1366 Flash ADC. Those digitizers provide energy and time information relative to the cyclotron radio frequency. Particle identification is obtained from the two dimensional scatter plots Time-Energy and DeltaE-E. The signals from the back strips of the DeltaEs and from the E detectors are processed with high gain pre-amplifiers, shaping amplifiers and then acquired with peak sensing ADCs.

The new setup was tested on December 2014 using a ^{20}Ne beam at 13 AMeV provided by the TAMU K150 Cyclotron on ^{4}He gas at a pressure of 4964 mbar. The data analysis is still in progress. The overall statistics collected during this test run is 1/3 of that collected in the previous run. Fig. 2 shows the spectrum of elastically scattered alpha particles at 1.6 degrees, compared with the spectrum obtained at zero degrees in the previous experiment. The two spectra are consistent with each other. A full implementation of this experiment is being planned for the winter of 2015. Employment of the active target currently under development by the Rogachev group is also under consideration.

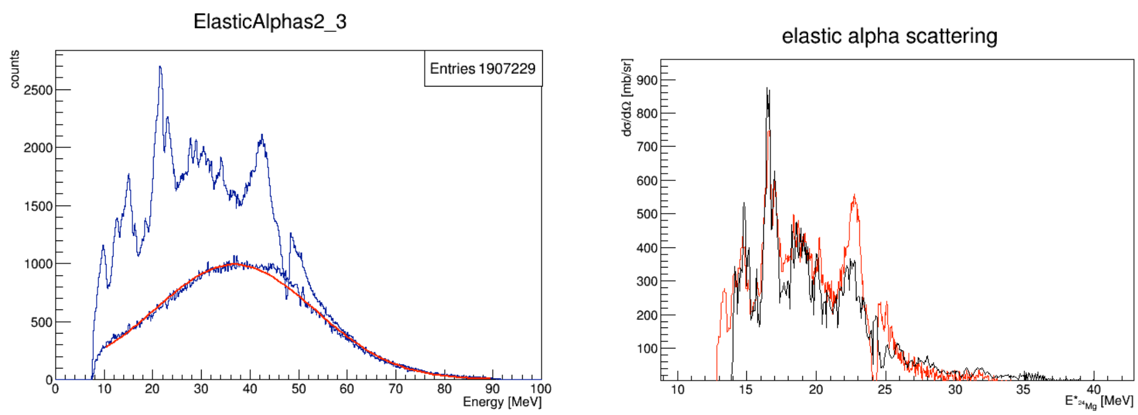

FIG. 2. Elastically scattered alpha particles. Left panel: alpha particle spectrum at 1.6 degrees in the laboratory. The resonances lie on top of a continuous spectrum. This contribution is subtracted using the alpha particle spectrum at 5.6 degrees properly normalized to match the tail of the energy distribution at 1.6 degrees and fitted with a Gaussian (red curve). Right panel: excitation energy of 24Mg at 1.6 degrees after subtraction of the continuum. The red curve shows the result from this experiment the black line shows the spectrum obtained at zero degrees in the previous experiment [5,6].

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