Slope temperatures in Kr + C

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Reactions of ^{78,86}Kr + ^{12}C @ 15, 25, 35 MeV/u have been carried out. Light charged particles were measured with the Forward Array Using Silicon Technology (FAUST), and heavy residues were measured in the Quadruple Triplet Spectrometer. The aim of the measurement is to investigate the asymmetry dependence of the nuclear caloric curve observed in [1-4].

Calibration of the data recorded for the reactions of ^{78,86}Kr + ^{12}C @ 15, 25, 35 MeV/u is well underway. Particle identification (PID) has been achieved for several detectors in rings C, D, and E of FAUST. Preliminary energy calibrations of the silicon detectors were obtained using ^{228}Th alpha source data and elastically scattered hydrogen and helium beams to calibrate the silicon detectors. Preliminary energy calibrations for the thallium-doped cesium iodide detectors coupled to photodiodes were obtained using the silicon calibration, the PID, and energy loss calculations. Preliminary calibration of the velocity of the heavy residues in the QTS has been carried out using cable timing delays anchored by the peak corresponding to elastically scattered beam particles.

Fig. 1 shows the 2-dimensional velocity distribution (transverse and parallel to the beam direction) of alpha particles measured in the calibrated detectors of rings C, D, and E of FAUST for reactions of ^{78}Kr + ^{12}C @ 35 MeV/u. There is an obvious Coulomb ring centered around 7.5 cm/ns, which

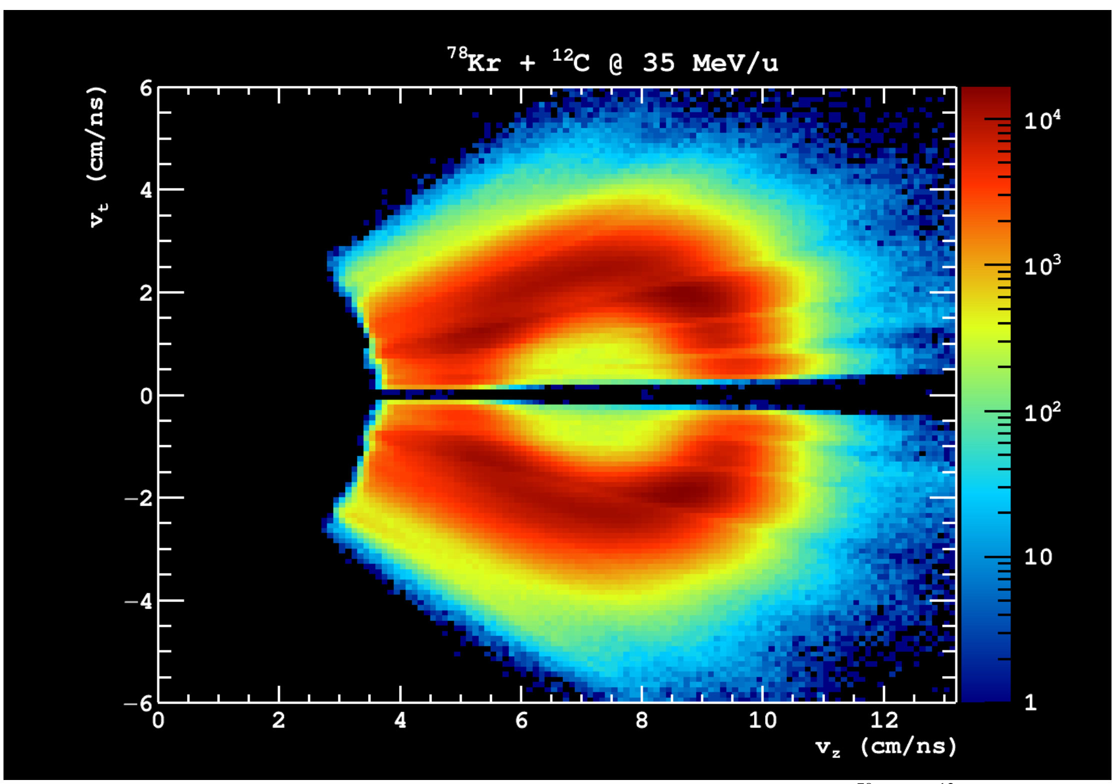

Fig. 1. 2D velocity distribution for alpha particles produced in reactions of ^{78}Kr + ^{12}C @ 35 MeV/u measured in FAUST.

is slightly damped from the 8.2 cm/ns beam velocity. Such a structure is expected when incomplete fusion takes place followed by charged particle evaporation. The evaporated charged particles are emitted with a Boltzman-like momentum distribution and receive a boost due to Coulomb repulsion from the heavy residue. This gives rise to a ridge centered around the average velocity of the residue with a de-populated Coulomb hole inside.

Further evidence for this mechanism is shown in Fig. 2. Here the yield of alpha particles is plotted as a function of the energy of the alpha particle in the frame of the coincidently measured heavy residue. This yield is shown for all alpha particles measured between 0 and 140 degrees in polar angle in the source frame (top distribution). This yield is also shown below for angular ranges every 10° (0-10°, 10-20°, 20-30° etc.). The shape, and particularly the exponential slope, does not show a dependence on

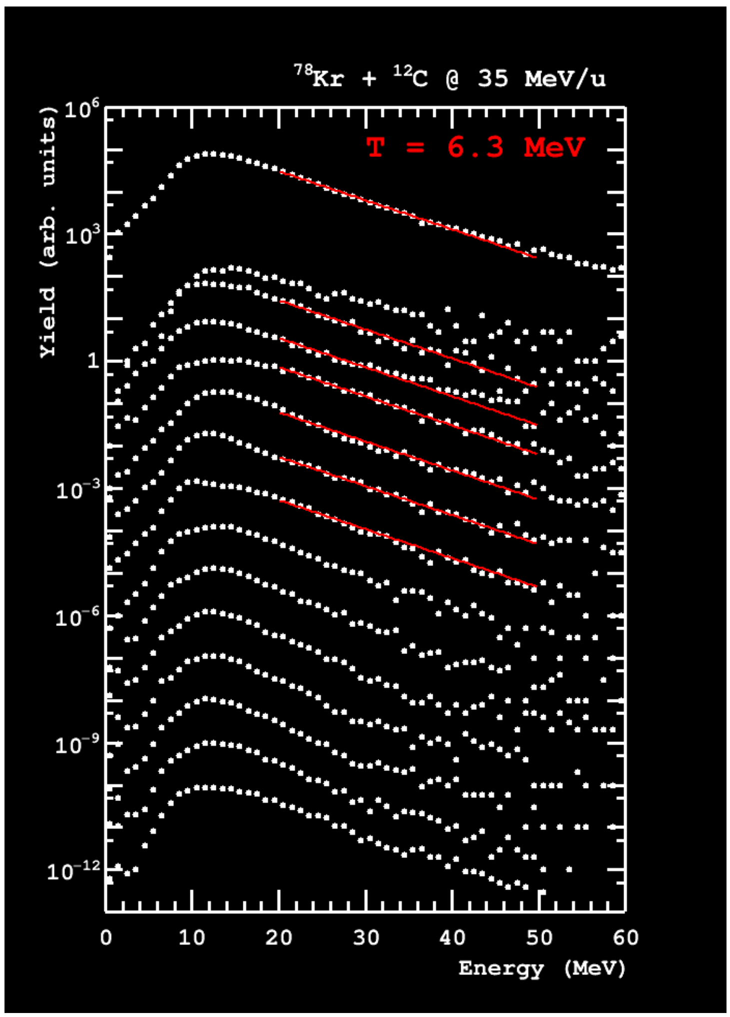

Fig. 2. Energy distributions of alpha particles in the frame of the heavy residue for reactions of ^{78}Kr + ^{12}C @ 35 MeV/u. Uppermost data points are integrated from 0° to 140° in polar angle in the source frame. Successively lower series of data point span the angular ranges 0-10°, 10-20°, 20-30° etc. up to 130-140°. Each data series is scaled by some factor to allow the shapes of the distributions to be compared. The red line corresponds to an exponential fit in between 20 and 50 MeV; these indicates a slope temperature of 6.3 MeV.

the angle. The yields are scaled by an arbitrary factor to allow comparison of their shape. The red overlaid line corresponds to an exponential fit between 20 and 50 MeV, with a slope temperature indicating 6.3 MeV.

Preliminary slope temperatures for alpha particles have been calculated also for $^{78}Kr + ^{12}C$ @ 15, 25 MeV/u as well, and all are plotted on the vertical axis in Fig. 3. The excitation energy for each system is deduced from the velocity damping according to the following equation [5,6]

$$\frac{E^*}{A} = \frac{1}{2}(v_B - v_R)v_R + Q$$

using the measured mean velocity of the heavy residues v_R (using a rough preliminary estimate), the velocity of the beam v_B and the Q value of the reaction that forms the compound nucleus from the target and projectile. The slope temperature clearly rises with the excitation energy.

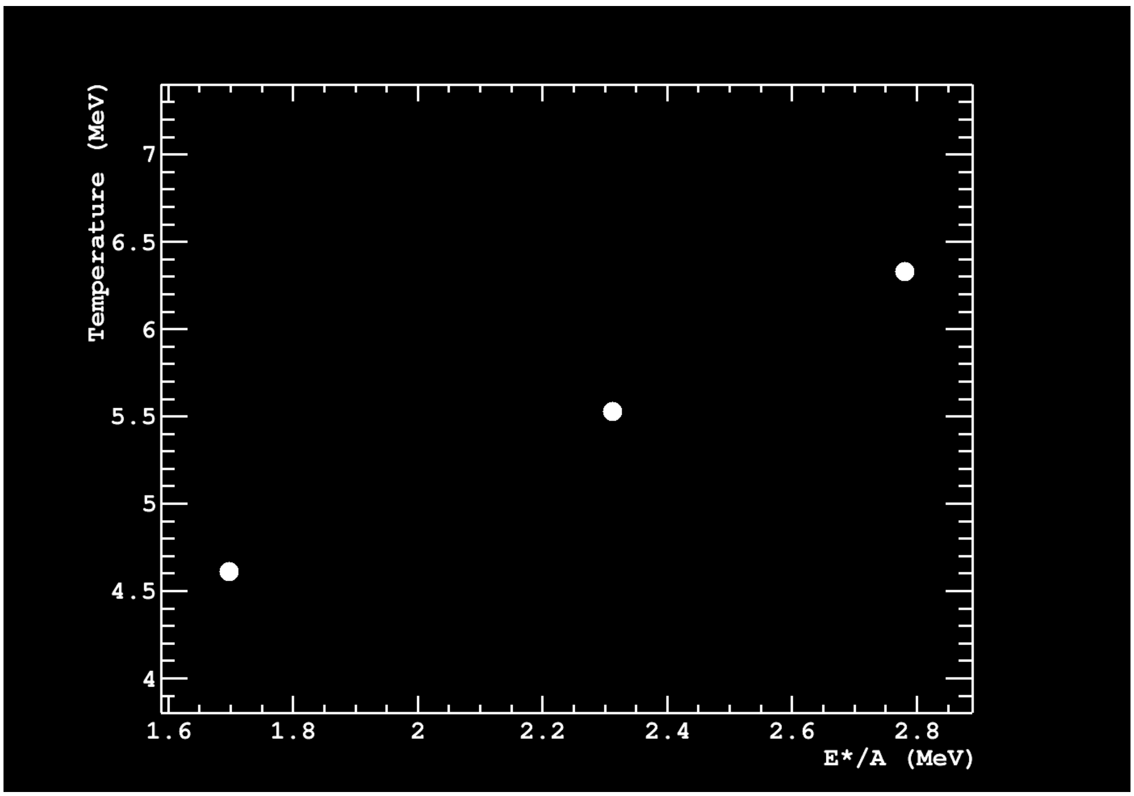

Fig. 3. Preliminary slope temperatures for alpha particles versus the excitation energy of the compound nucleus for $^{78}Kr + ^{12}C$ @ 15, 25, 35 MeV/u. Uncertainties have not been extracted since the calibrations are at this point preliminary.

Further work is underway to obtain reliable calibrations for all light charged particles and light intermediate mass fragments for all possible detectors, both for the $^{78}Kr + ^{12}C$ systems and the ^{86}Kr systems. This will then allow comparison of thermometric data for the neutron rich and neutron poor systems.

[1] A.B. McIntosh *et al.*, Phys. Lett. B **719**, 337 (2013).
[2] A.B. McIntosh *et al.*, Phys. Rev. C **87**, 034617 (2013).

[3] A.B. McIntosh *et al.*, Eur. Phys. J. A **50**, 35 (2014).
[4] A.B. McIntosh *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018) p. IV-27
[5] W. Bohne *et al*., Phys. Rev. C **41**, R41 (1990).
[6] K. Hagel, Ph.D Thesis, Texas A&M University, 1986.