Kinetic Parameters of Emission Sources for ^{40}Ar + ^{27}Al, ^{48}Ti and ^{58}Ni at 47 MeV/nucleon

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Recent heavy ion collision experiments with 4π detectors have demonstrated that in many heavy ion collisions in the intermediate energy domain below 100 MeV/nucleon, the reaction mechanism is dominated by dissipative binary collisions accompanied by mid-rapidity particles. A wide range of impact parameter from the central to peripheral collisions results in the formation of two excited emission sources, a projectile-like fragment (PLF) source and target-like fragment (TLF) source and a third mid-rapidity (Nucleon-Nucleon) source.

Based on the three source assumption, the kinetic energy spectra for light charged particles (LCP) in the different laboratory angles have been extensively fitted with three source fits. From these fits, the kinetic parameters, such as the kinetic temperature, source velocity and particle multiplicity, etc., can be obtained, which helps us to understand the thermal behavior of emission sources.

In this work, we focus on light system reactions, namely, ^{40}Ar + ^{27}Al, ^{48}Ti, and ^{58}Ni at 47 MeV/nucleon, studied with the NIMROD detector.

Impact parameter bins can be sorted by different global variables such as (1) the heaviest fragment charge, (2) the total multiplicity of charged particles, (3) the correlation of the total multiplicity of charged particles and neutrons, (4) the total transverse energy, etc. One of the principal goals in choosing the impact parameter selector is to avoid auto-correlations between the investigated quantities and the global variable. Since we are studying kinetic energy spectra here, we should not take the total transverse energy as an impact parameter selector due to the obvious auto-correlation. Instead, we use a two-dimensional cut on total multiplicities of charged particles (Mcp) and neutrons (Mn) to select impact parameter windows based on the geometric prescription of association of impact parameter with the cross section. Five nearly equal impact parameter zones have been sorted: from the most peripheral collisions, where there are the fewest M_{cp} and M_n, to the most

central collision, where there are the most M_{cp} and M_n. For simplicity, we label these impact bins B1 (the most central) to B5 (the most peripheral).

In each impact parameter zone, the kinetic energy spectra of light particles (p, d, t, ^{3}He, α, Li) were reproduced by the three source fits.

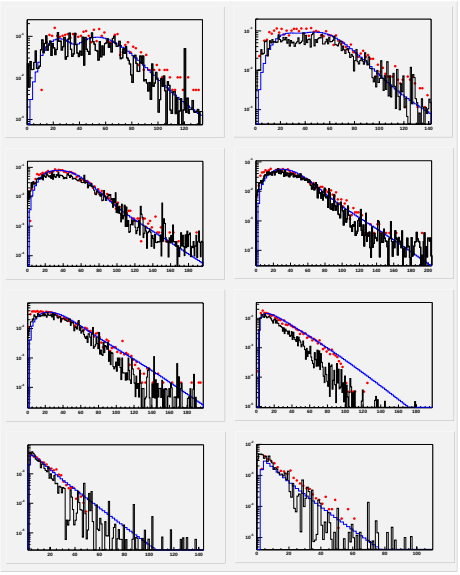

Figure 1: Three source fits for p emitted from 47MeV/nucleon ^{40}Ar + ^{27}Al in different laboratory angles (upper left to bottom right: θ_{lab} ~ 4.3°, 9.43°, 18.15°, 24.45°, 32.08°, 61.17°, 120°, 152.5°). The selected impact parameter is B1. The solid circles show experimental data and the lines represent the sum of the three source fit. The histograms show the simulated results using AMDv + GEMINI. The X-axis is E_{lab} (MeV) and the Y-axis is $d^2N/dE_{lab}d\Omega$.

Fig. 1 shows some examples of fits for p emitted from the central collisions (B1) of ^{40}Ar + ^{27}Al at 47MeV/nucleon in different laboratory angles. The solid circles show experimental data and the lines show the sum of the three source fit for 47MeV/nucleon ^{40}Ar + ^{27}Al. The fit parameters of multiplicities *M*, slope temperatures *T*, and source velocity V_{source} for different particles are shown in Fig. 2.

Roughly speaking, the slope temperature is about 7 MeV for TLF, 14 MeV for NN and 7 MeV for PLF. The source velocity is about 2.5cm/ns for TLF, 5 cm/ns for NN and 8.5 cm/ns for PLF. The multiplicities show increases with decreasing impact parameter. Protons and alphas are dominant. The NN components are especially important in central collisions.

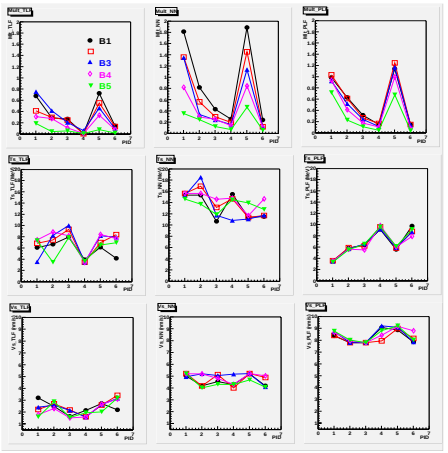

Figure 2: The fit parameters of multiplicities *M* (first row), slope temperatures *T* (second row), and source velocity V_{source} (third row) of different particles (the dots from left to right in each panels represent p, d, t, ^{3}He, α, and Li, respectively).

We have also used the Anti-symmetric Molecular Dynamics Model (AMDv) plus an afterburner (GEMINI) to calculate the energy spectra of LCP. The histograms in Fig. 1 show the final simulated results including the sequential evaporation. Note that the simulated results are absolute values as are the experimental data (i.e., no normalization to the data is used). An overall very good consistency is obtained between the data and the simulation. This is important in validating the code as a tool for more extensive investigations.