2 - 30 Isotope Yields Ratio Temperatures

Lin Weiping, Liu Xingquang, Huang Meirong, Zhang Suyalatu, Han Rui, Liu Jianli
Shi Fudong, Jin Zengxue, Ren Peipei, Jia Baolu, Chen Zhiqiang and Roy Wada

The isotopic thermometer was used in our study to extract the temperature in our experiments. The experiment was performed at the K-500 superconducting cyclotron facility at Texas A&M University. ^{64,70}Zn and ^{64}Ni beams were used to irradiate ^{58,64}Ni, ^{112,124}Sn, ^{197}Au, and ^{232}Th targets at 40 AMeV. The detector setup is same as that in Ref. [1].

The isotopic thermometer, which was first introduced by Albergo at 1985[2], assuming chemical and thermal equilibrium at freeze-out, has been employed in investigations over a wide range of bombarding energies[3-6]. The temperatures were extracted from the double ratios of yields of neighboring isotopes using the expression[2,7]:

$$T = \frac{B}{\ln(aR)}. \tag{1}$$

Here,

$$R = \frac{Y(A_i, Z_i)/Y(A_i+1, Z_i)}{Y(A_j, Z_j)/Y(A_j+1, Z_j)},$$

is the measured ratio of isotopic yields, $Z_{i(j)}$ and $A_{i(j)}$ represent the charge and mass number of fragment, respectively. B correspondsto a binding energy parameter, and a depends on nuclear spins.

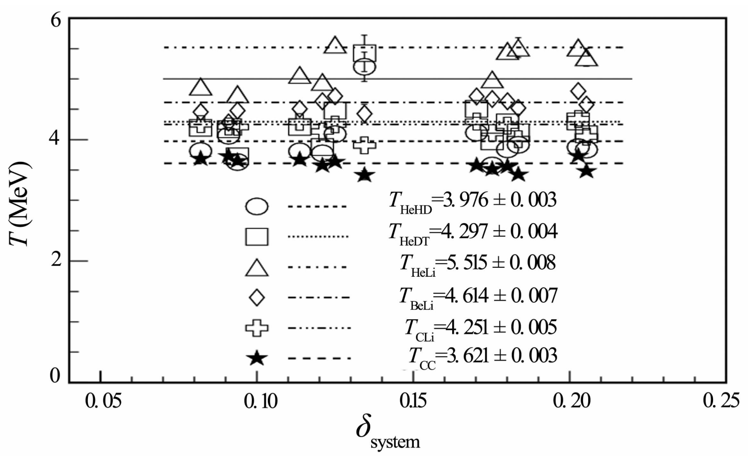

Fig. 1 Measured isotope temperatures as a function of δ_{system}. The different symbols correspond to the double ratio temperature with different isotopes. The solid line is temperature equal 5 MeV. The average temperatures for each thermometer are extracted by a constant fit (the lines).

We applied the double ratio temperatures to the experimental data. In Fig. 1 the measured isotope temperaturesare plotted as a function of δ_{system} (neutron excess of the system, $(N-Z)/A$, N, Z and A are neutron number, charge number and mass number, respectively). Six thermometers[6], based on H/D and ^{3}He/^{4}He, D/T and ^{3}He/^{4}He, ^{3}He/^{4}He and ^{6}Li/^{7}Li, ^{9}Be/^{8}Li and ^{7}Be/^{6}Li, ^{6}Li/^{7}Li and ^{11}C/^{12}C, ^{12}C/^{13}C and ^{11}C/^{12}C, respectively, was used to extracted the temperatures for thirteen systems. The results are consistent with each other for each thermometer. The average temperatures for each thermometer are extracted by a constant fit. The solid line corresponds to the temperature equal 5 MeV. The extracted temperatures differ from different thermometers suggesting a better thermometer to get more precise temperatures in heavy-ion reactions is a must.

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2 - 31 Analysis on Products of Proton-induced Spallation Reactions by INCL+ABLA Model

Han Rui, Chen Zhiqiang, Zhang Suyalatu, Liu Xingquan, Lin Weiping, Jin Zengxue
Liu Jianli and Shi Fudong

Spallation reactions have recently gained considerable interest due to their importance in technical applications. They can be used for the production of neutrons in spallation neutron sources of and act as an intense neutron source an accelerator driven subcritical reactors and so on[1]. The design of an accelerator-driven system (ADS) requires precise knowledge of nuclide production cross sections in order to be able to predict the amount of radioactive isotopes produced inside the spallation target[2]. Therefore the study about products of proton-induced spallation reaction is very important.

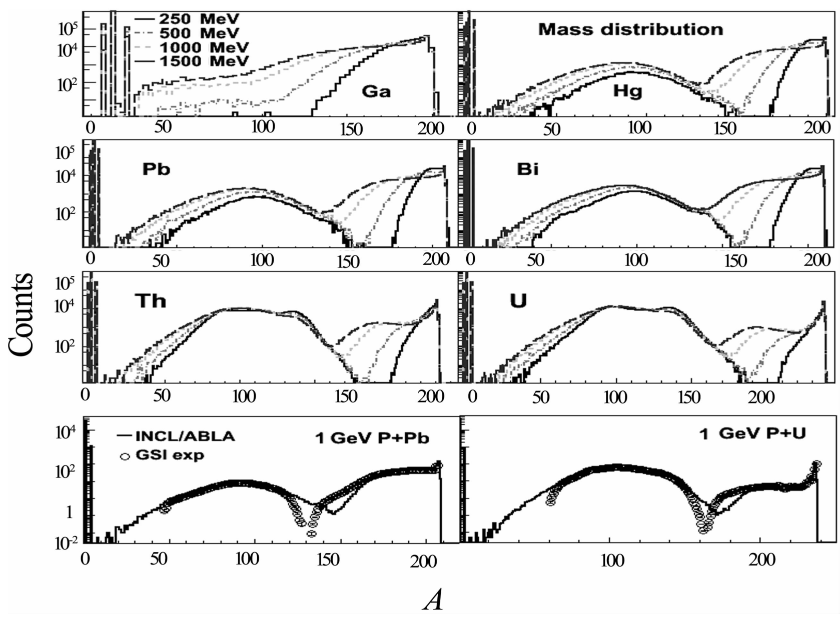

Fig. 1 Mass distributions of spallation product in various targets irradiated by protons with various energies, and the data of Pb and U targets compared with experiment value.

In this work, the spallation products from spallation reaction of spallation target triggered by high energy protons in accelerator-driven system were calculated under different material targets and various energy incident protons respectively using INCL+ABLA model. Then the radiological toxicity of spallation products was studied. In Fig. 1, mass distributions of spallation product in Pb and U targets are agreement with experimental data. And it shows that the calculation with INCL+ABLA model is reliable. From Fig. 2 we can see that the toxicity of spallation producs increase with increasing incident energy and mass number of targets. It reveals that the toxicity of the spallation products is often on high-rate, especially those alpha emitting rate earths caused by the incident proton under the ADS required energy largely contribute into overall toxicity of spallation targets. These nuclides will exert a radiological hazard on the biotic environment, if do not transmute them in the radiant field.

ADS techniques gave access to long-lived residues only, and thus mainly cumulative yields were deter-