Study of IMF Sources in Reaction ^{114}Sn+^{28}Si at projectile energy 28 MeV/u

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We studied the reaction ^{124}Sn+^{28}Si at projectile energy 28 MeV/u using the 4π detector array NIMROD. The reaction studied is inverse to the one we studied recently [1, 2, 3] using the forward detector array FAUST (^{28}Si+^{124}Sn at 30 MeV/u). The data from the peripheral collisions proved to be in agreement with the two step process where isospin and excitation energy of the quasiprojectiles are determined by deep inelastic transfer which is later followed by multifragmentation of the quasiprojectile. Knowledge of the isospin and excitation energy of the quasiprojectiles allows one to study the effect of isospin on multifragmentation. An open question remaining was the multiplicity of neutrons emitted from the quasiprojectile which is crucial for the determination of the quasiprojectile isospin. The simulation that successfully described a wide range of observables, implied that the multiplicities of neutrons are relatively low. However, a further experimental study is of great interest. This was a primary aim of the present study since the 4π detector array NIMROD incorporates also a 4π neutron ball.

A ^{124}Sn beam with energy 28 MeV/u was delivered by the K500 superconducting cyclotron. A ^{28}Si target of the thickness 1 mg/cm^2 was used in the experiment. In order to select peripheral events corresponding to projectile multifragmentation we used the detected charged particles to construct an event observable called longitudinality

$$\lambda = <\cos^2\left(\theta_{CP}^{cms}\right)> \qquad (1)$$

where θ_{CP}^{cms} is the angle of the detected charged particle in the center of mass system which was determined using the kinematic simulation where both projectile and target with excitation energy from 0 to $E^*_{\max}$ were scattered ($E^*_{\max}$ value 150 MeV was used for ^{28}Si and 500 MeV for ^{124}Sn). In Fig.1 are given multiplicities of charged particles in the whole NIMROD array (squares) and in the rings 8 to 13 which by the angle coverage in c.m.s. correspond to the multidetector FAUST in normal kinematics ("anti- FAUST", circles). To select hot quasitarget nuclei at least one intermediate mass fragment was required in the rings 8 and/or 9. One can see that multiplicity in the anti-FAUST coverage peaks at λ=0.5-0.65. This region was selected for further analysis.

In Fig.2 is given a distribution of neutron multiplicities for events with λ=0.5-0.65 and one or more IMFs detected in the rings 8 and 9. A high charged particle multiplicity trigger was used in order to obtain sufficient statistics. When using minimum bias trigger the

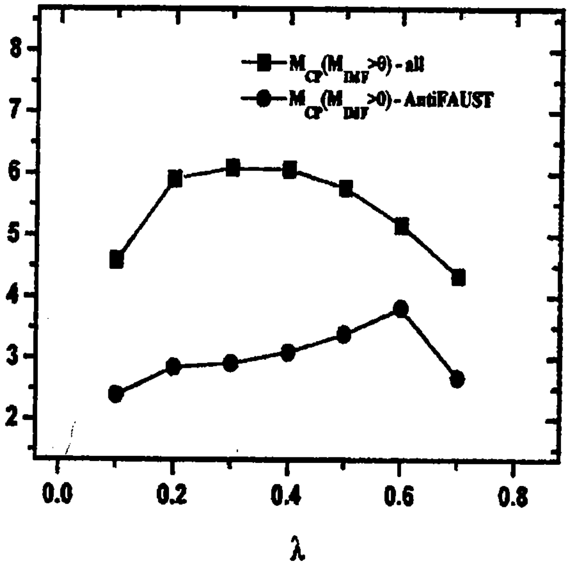

Figure 1: Multiplicities of charged particles in the whole NIMROD array (squares) and in 5the rings 8 to 13 which by the angle coverage in cms correspond to the multidetector FAUST in normal kinematics ("anti-FAUST", circles) as a function of λ.

statistics is very low but the mean value is just slightly lower. One can notice the double humped structure implying two principal sources of IMFs. The first one with lower neutron multiplicities corresponds to the peripheral collision leading to highly excited quasitarget nucleus. The second component with higher neutron multiplicities should be attributed to much more central collisions, where particular pattern of charged particle emission complies to the λ selection criterium.

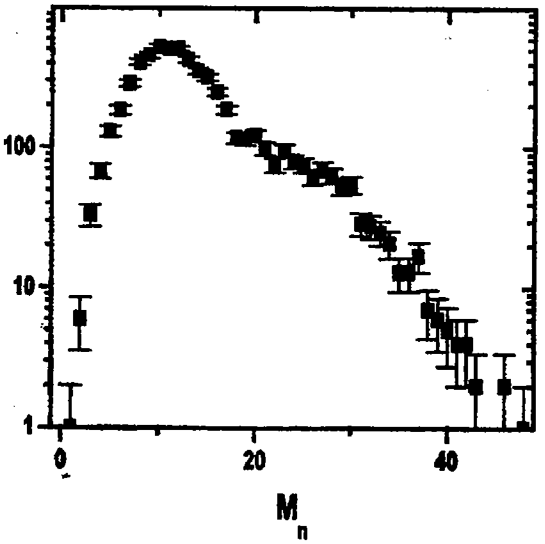

Figure 2: Distribution of neutron multiplicities for events with λ=0.5-0.65 and one or more IMFs detected in the rings 8 and 9.

For the low neutron multiplicity component we estimated the multiplicity of neutrons emitted from hot quasitarget by subtracting the half of the average neutron multiplicity from the reaction ^{124}Sn+^{124}Sn at projectile energy 28 MeV/u, corresponding to the measured charged particle multiplicity out of the anti-FAUST coverage, from the mean neutron multiplicity of the low multiplicity component. After correction for a neutron detection efficiency of about 70 % we obtained the value 2.2±0.6. This value is consistent with the value of 1.2 in normal kinematics since the value obtained here should be considered as an

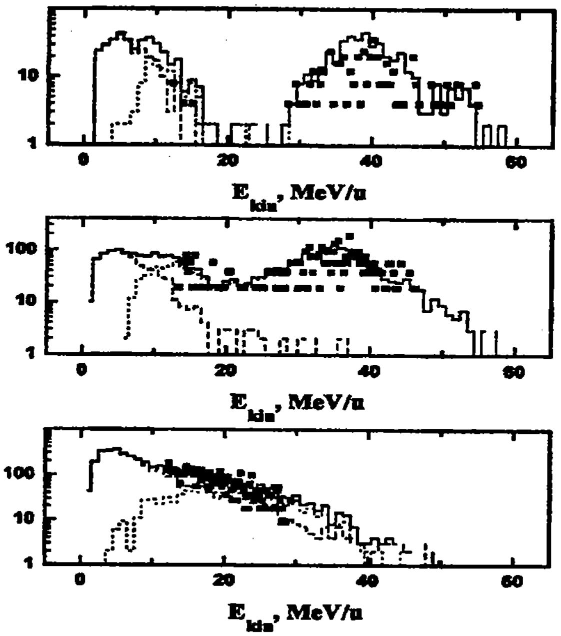

Figure 3: Experimental (squares) and simulated (full), dashed and dotted histogram - sum, target-like and projectile-like component) spectra of ^{7}Li in the rings 3, 5 and 8 (angles from 5.1 to 35.5 degrees).

upper limit. The selection used in the present work may still contain significant contribution from excitation energies below 3 MeV/u where neutron multiplicities from a compound nucleus are typically higher. Also no correction for the undetected multiplicity of charged particles at very forward angles in the inverse kinematics was made.

In order to understand the possible origin of the second source we compared the ^{7}Li spectra of in rings 3, 5 and 8 (angles from 5.1 to 35.5 degrees) to the results of the simulation. The simulation that was used is described in detail in [4] and employs the concept of deep inelastic transfer for peripheral collisions and phenomenological treatment of preequuibrium emission combined with incomplete fusion of participant zone with typically the heavier of the spectators for central collisions. The statistical multifragmentation model [5] was used for de-excitation. In Fig.3 are given both experimental spectra (squares) and simulation (full, dashed and dotted histogram-sum, target-like and projectile-like component). One can see very good agreement at all angles. The empty regions at the forward angles are caused by the effect of the emitting source which allows only the IMFs emitted at forward and backward direction to reach low angles. Thus, the simulation appears to describe quite well the kinematic properties of the emitting hot projectile-like source. The backtracing of contributing events shows that central collision with $l<100$ contribute to the spectra of IMFs. The contributing angular momenta decrease with increasing emission angle of IMFs emitted from projectile-like source. This agrees well with the shift of the dip in the IMF spectra towards lower energies with increasing emission angle.

References

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