Longitudinal velocity distributions measured with FRS and fundamental ideas on fragmentation*

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The study of the longitudinal-momentum width, $\sigma_{P//}$, of the spectator fragments produced in relativistic heavy-ions collisions is of great interest not only for the fundamental understanding of nuclear reactions but also for predictions of energy losses in accelerator-driven reactors and for the design of RIB facilities.

The experimental information on $\sigma_{P//}$ was for long time limited to fragments with mass close to the projectile and, to the other extreme, to the lightest fragments produced in more central collisions by multifragmentation [1]. The two classes of experimental data were compared with two predictions: the Morrissey formula [2] and the Goldhaber model, respectively [3]. The Morrissey's formula is based on an empirical systematic extracted from the experimental data available at the time. It is applicable only for fragments produced in very peripheral collisions. In the Goldhaber's model the momentum width of the prefragment is determined from the Fermi momentum of the abraded nucleons. The abrasion is seen as simple geometrical cut, ruled by statistical considerations. The effect of the sequential evaporation on the momentum width is not considered. This fact makes that the Goldhaber picture holds only for masses very close to the projectile and for very light fragments, since in these cases the effect of the following evaporation is negligible. The aim of this work is to create of physical model capable to predict $\sigma_{P//}$, which would take into account all the stages in the nuclear reaction, namely the abrasion, the following evaporation and the possible intermediate thermal instabilities.

In the last decade, with the use of magnetic spectrometers, high quality data were obtained over the almost mass range. Recently, devoted experiments were performed with the FRS at GSI to get full identification and extremely precise measurements of the longitudinal velocity of the fragments [4]. In Fig. 1, the velocity spectra for three fragments produced in the reaction ^{197}Au + ^{197}Au at 1 A GeV are presented [4]. The central gaussian peak is attributed to the fragmentation process.

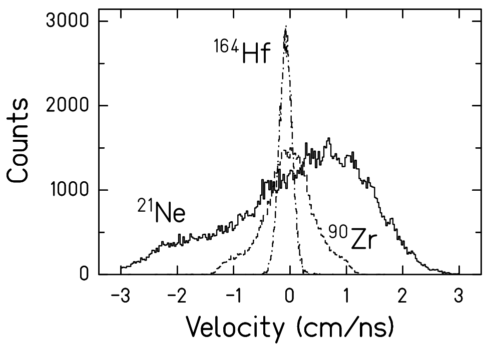

Figure 1: Velocity spectra for three fragments produced in the reaction ^{197}Au + ^{197}Au at 1 A GeV. Data are taken from [4].

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The other humps, observable in the lightest fragments, are due to fission events, in which the coulomb repulsion pushes the fragment to higher velocities. From the fit of the central peak one can extract the values of $\sigma_{P//}$. The preliminary results are presented in Fig. 2 as a function of the mass of the final fragment A_f.

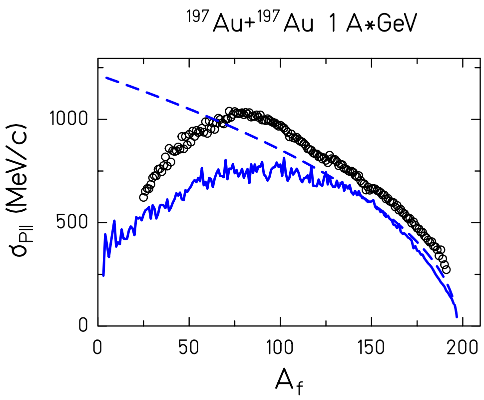

Figure 2: Preliminary data compared with the predictions of the Morrissey systematics (dashed line) and of ABRABLA (solid line).

A more careful analysis would include the simultaneous fit of all the components (fragmentation and fission humps). The simple fit, as performed in the present work, largely overestimates $\sigma_{P//}$ in the intermediate-mass region, where the presence of fission is not negligible. Nevertheless, the trend of the experimental data is correct. The data are compared with two predictions: the Morrissey systematic (dashed line) and the calculation ABRABLA. ABRABLA is an abrasion-evaporation statistical model. The momentum width acquired after the abrasion stage is calculated according to Goldhaber. Concerning the excitation energy reached by the prefragment, a limit is included to account for possible thermal instabilities. This limit corresponds to a temperature of 5 MeV. Beyond this limit, the nucleus breaks up simultaneously in several pieces. The prefragment finally decays by sequential evaporation of particles and very light nuclei, resulting in the enlargement of the momentum width due to the recoil of the nucleus when emitting particles. One can notice that for light fragment masses the Morrissey prediction deviates from the experimental data, as expected. Although the agreement between ABRABLA and the data is still not perfect, the model shows a right tendency, which reflects the physical content behind it.

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