Systematic investigation of the spectator response to the participant blast in the reactions $^{197}Au+^{27}Al$, ^{197}Au at 0.5 *A* GeV and $^{197}Au+^{197}Au$ at 1.0 *A* GeV

V. Henzl* for the CHARMS collaboration, GSI, Darmstadt, Germany

Recent theoretical work [1] suggested the longitudinal velocities of the fragmentation residues produced in relativistic heavy-ion collisions as an observable sensitive to the momentum dependent (MD) properties of the nuclear mean field (MF). Under certain conditions, the spectator remnant can acquire on average even a positive momentum during the collision This phenomenon has been named ***spectator response to the participant blast*** since the action of the expanding participant matter has been identified within this theoretical work [1] as the main source of the spectator reacceleration.

In several experiments performed at the Fragment Separator (FRS) at GSI, this theoretically predicted phenomenon was clearly observed [2,3]. In the present work [4], the dependence on the collision parameters such as projectile energy and reaction geometry was systematically studied. This may subsequently allow for better understanding the considered process and possibly contribute to the use of this observable for more detailed investigations of the MD aspects of the nuclear MF.

Three experiments were dedicated to the precise determination of the longitudinal velocities v_z of the fragmentation residues produced in the reactions $^{197}Au+^{197}Au$ at 1 *A* GeV and $^{197}Au+^{27}Al$, ^{197}Au at 500 *A* MeV at GSI with use of the FRS as the high-resolution magnetic spectrometer allowing for very precise measurements of complete longitudinal velocity distributions of fully isotopically resolved reaction residues. Fig.1 displays the measured longitudinal velocity of the reaction residues in the frame of the projectile. The main ridge in these contour plots corresponds to the residues produced in fragmentation, while the edges are mainly composed of the residues produced in fission. A more quantitative insight is gained when the mean v_z is determined for the residues produced only by fragmentation, such as displayed in Fig.2. Projectile residues with masses A_{frag} > 150 produced in very peripheral collisions are decelerated in the reaction and follow the well established Morrissey systematics [5], however the $\langle v_z \rangle$ of the lighter residues level off, and progressively increase with decreasing mass and reach positive values with respect to the original projectile velocity (for $A_{res} < 85$).

Comparing the quantitative results of $\langle v_z \rangle$ with respect to A_{res} with the theoretical calculation, the differences between individual experiments are surprisingly small despite the great variation of the projectile energy or the size of the target nucleus. Therefore, we rather interpret the phenomenon as being the consequence of the dynamical evolution of the spectator matter itself, e.g. enhanced backward emission of nucleons and light clusters, possibly triggered (but not fully ruled) by the blast of the participating matter. Intensive theoretical investigations and additional experiments are underway to improve the understanding of the reacceleration of the fragmentation residues in mid-peripheral heavy-ion collisions.

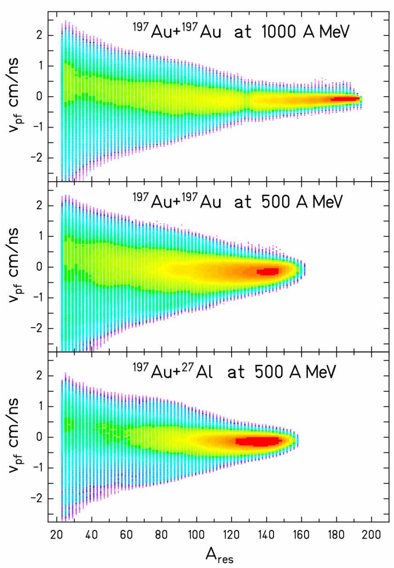

Fig.1: v_z of the projectile residues as a function A_{res} in the projectile frame. The color scale is logarithmic, and adjusted for illustrative purposes for each plot separately. The experiments performed at 500 *A* MeV did not cover residues with A_{res}>160.

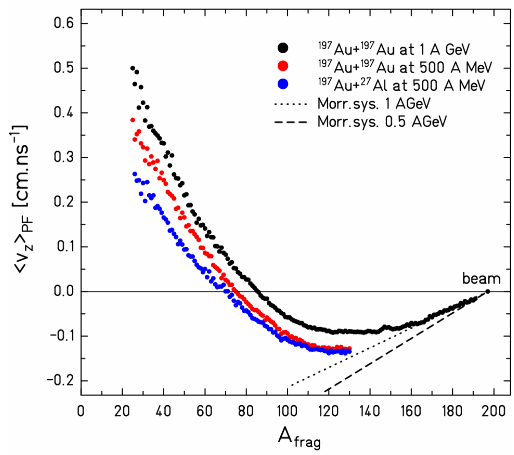

Fig.2: Mean longitudinal velocities of the fragmentation residues as a function of their mass A_{frag} in the reference frame of the corresponding primary beam. The black line represents the Morrissey systematics [5]. Experimental uncertainties typically do not exceed 0.01cm/ns.

References

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