A new approach to detect hyper nuclei in the phase space distributions generated by microscopic transport models *

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The process of production of complex fragments in heavy ion collisions is big challenge for transport models in which single particle propagation is the relevant degree of freedom. However, cluster formation affects the single particle spectra and should not be omitted. Identifying clusters within transport codes is all but simple. Quantum effects, the different parts of the nuclear potential, like bulk, asymmetry energy and pairing, acting in a complicated environment at finite temperatures influence the fragment yields. We developed an improved clusterisation algorithm which aims at predicting more realistically cluster yields in the framework of microscopic transport models. This new approach is able to reconstruct fragment [3] and hyper nuclei yields from single particle phase space distributions of various transport codes (QMD as well as BUU type codes).

It has been derived from the Simulated Annealing Clusterisation Algorithm [1]. Unlike commonly used coalescence models based only on the momentum-coordinate space proximity, it relies in addition on maximizing the overall binding energies of clusters. This method has the advantage of identifying fragments much earlier during the collision, typically just after the system ends its overlap ("passing time" t_{pass}). The fragment partitions can then reflect the early dynamical conditions. We cast the binding energy in analogy with the liquid-drop model but with a density dependence, with the following contributions: attractive and repulsive potential between nucleons V_{NN} (Skyrme mean field), a Yukawa surface correction, and optionally the asymmetry potential V_{asy} and other quantum effects. To create hyper nuclei, we consider the strange quark as inert and use $V_{\Lambda N} = \frac{2}{3} V_{NN}$.

Fig. 1 illustrates the crucial role of the phase-space overlap between the Λ's – peaked at mid-rapidity – and clusters – the bigger the closer to the spectators – in creating hyper nuclei. Hence, the yield ratios between ${}^3_\Lambda H$ and ${}^4_\Lambda H$ are very different at mid-rapidity (abs(y_0)<0.5) and in the projectile spectator region (y_0>0.7), resp. 8.2±1.7 and 1.4±0.2. Fig. 2 shows the influence on the hyper nucleus yields of the clusterisation time: like for normal clusters, in the tiny (1-2)t_{pass} time interval, at mid-rapidity they are at the highest and strongly decrease afterwards, whereas they are stabilized in the spectator regions.

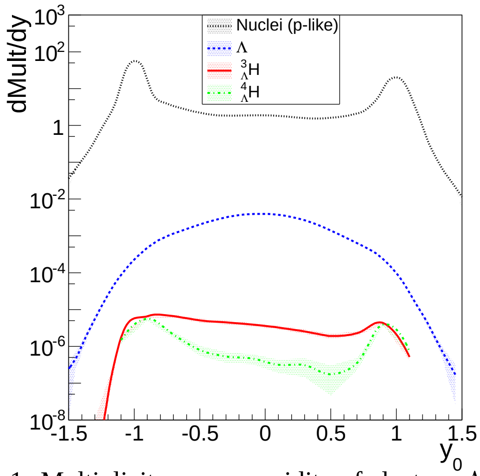

Figure 1: Multiplicity versus rapidity of clusters, Λ's, ${}^3_\Lambda H$ and ${}^4_\Lambda H$ hypernuclei as predicted by our clusterisation algorithm applied at $2t_{pass}$, on events generated by the IQMD transport model [2] for the ^{6}Li+^{12}C collisions at 2 $A.GeV$ incident energy, all impact parameters. The rapidity y_0 is expressed in the NN reference frame, scaled to the projectile rapidity.

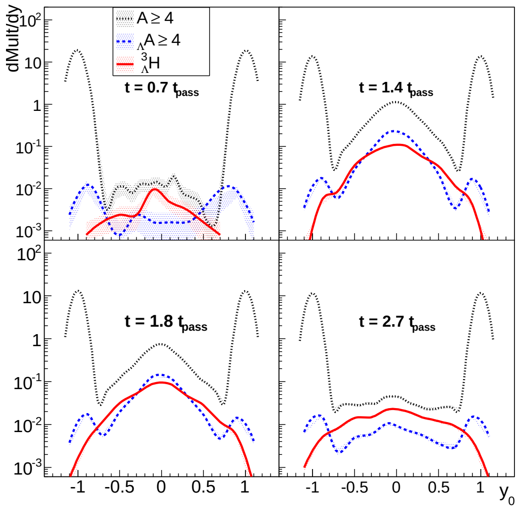

Figure 2: Same as Fig. 1 for heavy ($A \geq 4$) (hyper)clusters and ${}^3_\Lambda H$, at various clusterisation times, applied on pHSD [4] event predictions of the collisions of ^{197}Au +^{197} Au at 11.45 A.GeV incident energy and 6 fm impact parameter.

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