Identification of proton sources in $^{12}C+^{197}Au$ at 1000 AMeV

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The protons, as light particles, have the peculiarity of being emitted at each stage of a heavy-ion reaction. The initial fireball, preequilibrium, evaporation, and other secondary decay modes, all contain a strong proton component. The 4th INDRA campaign carried out at the GSI was the occasion to study proton sources in the reaction $^{12}C+^{197}Au$ at incident energies from 95 to 1800 MeV per nucleon. The INDRA detector telescopes, consisting of ionisation chambers, silicon layers and CsI(Tl) crystals, are arranged in 17 azimuthally symmetric rings in a 4π geometry [1]. The protons are identified in the CsI crystals by pulse-shape analysis. Their energy spectra present two components believed to correspond, at high energies, to the early emission before equilibrium and, at low energies, to the multifragmentation emission.

To compare our experimental results with theory, the ideal tool is a model producing protons at low and high energies, in other words simulating the reaction from the early light particle emission to the multifragmentation stage and maybe secondary decays. A combination of models, the Liège IntraNuclear Cascade coupled with the Dresner evaporation code [2] or the SMM code [3], is employed in this aim. A percolation code provides the transition between the cascade and the statistical codes. The cascade code treats the colliding nuclei as clouds of nucleons, up to a certain time after which the percolation procedure is used to construct fragments. The excitation energy of these clusters is then released by means of an evaporation code.

In Fig.1 and 2, we show the comparison between the experimental proton spectra and the Liège cascade coupled to the Dresner evaporation code and to the multifragmentation model SMM, respectively. The spectra are in absolute cross-section. One can observe a good agreement between data and theory for the high energy part of the proton kinetic energy spectra corresponding to the cascade code for central C+Au reactions at 1000 AMeV at $45^o \leq \theta_{lab} \leq 110^o$. Whereas the evaporation overestimates the data at low energies, SMM gives predictions in good agreement with the data because of a higher fragment production. This effect is visible for $3^o \leq \theta_{lab} \leq 176^o$ [4]. According to these comparisons, the favoured scenario of proton production would be an intranuclear cascade followed by a statistical multifragmentation emission. This overall good agreement between the Liège cascade code coupled with SMM and the INDRA experimental data allows the quantitative identification of the proton sources.

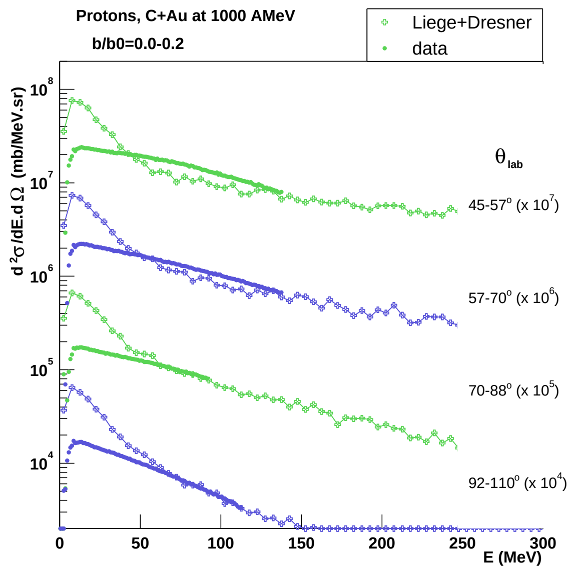

Figure 1: The proton kinetic energy spectra (full circles) for C+Au at 1000 AMeV are compared to the Liège cascade model coupled to the Dresner evaporation code for b/b0=0.0-0.2 (central collisions) at $45^o \leq \theta_{lab} \leq 110^o$.

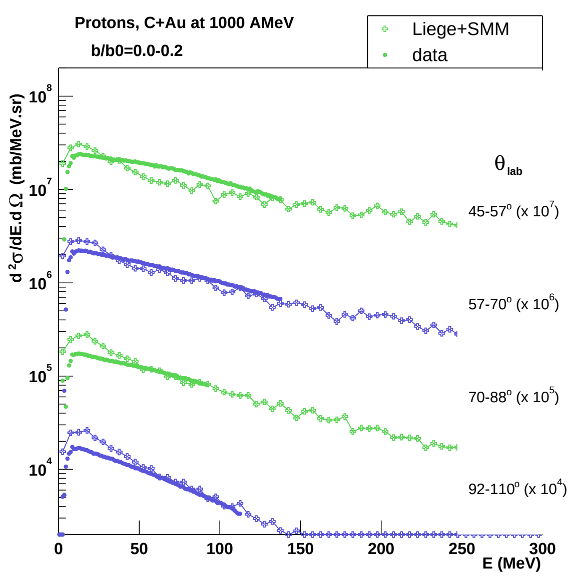

Figure 2: The proton kinetic energy spectra (full circles) for C+Au at 1000 AMeV are compared to the Liège cascade model coupled to SMM for b/b0=0.0-0.2 (central collisions) at $45^o \leq \theta_{lab} \leq 110^o$.

References

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