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ILEANA and ALADIN

a fortunate concurrence

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Ileana Iori has been a member of the ALADIN Collaboration since the late 80's, when the first experiments were planned for the SIS 18 accelerator at GSI and during this time more than 20 publications appeared. Through all the years we have benefitted from her experience and encouragement, from the support of her institute and most of all from her caring and always helpful personality. We will never forget Ileana.

The ALADIN spectrometer was planned for the investigation of nuclear fragments resulting from peripheral heavy ion collisions, but it was difficult to convince the Program Advisory Committee because these experiments were not in the focus of interest at the time. Indeed, a nearly identical experiment, the HISS spectrometer, had been in operation at the BEVALAC at Berkeley since many years and, compared with facilities designed for the study of central collisions, like the plastic ball or the streamer chamber, HISS had a long and difficult start. That despite of this negative experience, the proposed ALADIN spectrometer finally was accepted was partly due to the fact that very heavy beams like Au were foreseen at SIS already in the very beginning, but mostly due to the strong international collaboration which supported the project and whose experience in physics and in the development of the necessary detectors and electronics promised to make the experiment a success.

Already from the first measurements several new and interesting insights into the reaction mechanism of peripheral collisions of heavy nuclei at relativistic energies were obtained:

- Despite of the high incident energy, the decay pattern of the emitted fragments showed nearly no sign of dynamic contributions (flow) so that the results could be interpreted in the framework of statistical models.
- The excitation energies of the emerging residual nuclei were much higher than expected from a simple participant-spectator model. This, together with the observed absence of flow, indicated that the spectator nuclei were heated up predominantly by their own recoil nucleons and not so much by those originating from the collision partner.
- The yield of intermediate mass fragments (IMF) showed a maximum at intermediate impact parameters. This result was published as "Rise and fall of multifragment emission" [1] as one of the first papers obtained at SIS18.

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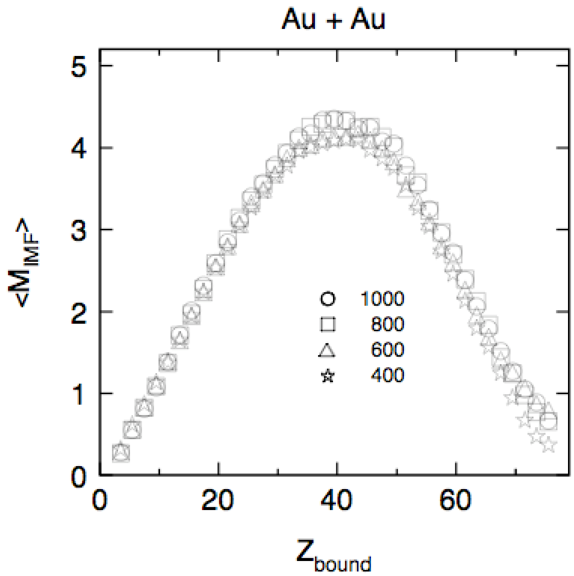

Fig. 1: Multiplicity of intermediate mass fragments (IMF) with Z≥ 3 as a function of Z_{bound} for the system Au on Au at different incident energies. Z_{bound} is the sum of the charges of all fragments with Z≥2. High values of Z_{bound} correspond to large impact parameters and low excitation energies, small values to smaller impact parameters and high excitation energies.

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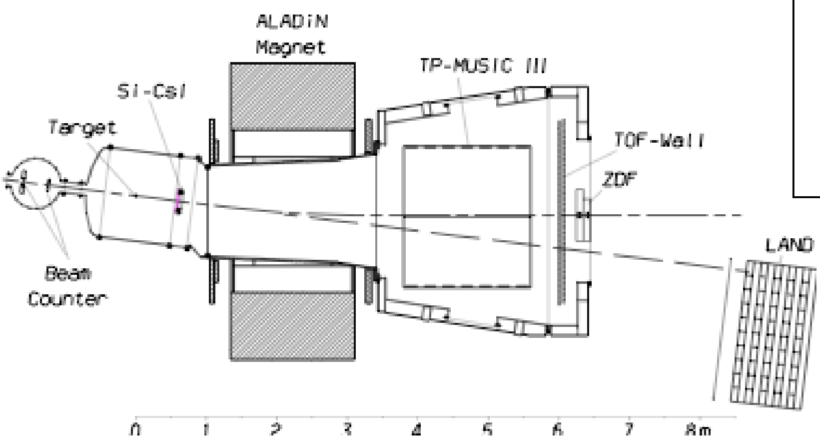
During a workshop which Ileana Iori had organized in the beautiful ambiance of the Villa Feltrinelli in Gargnano the success of the first experiments encouraged us to plan an upgrade of the MUSIC detector in order to increase the angular acceptance and to improve the resolution and the detection efficiency for He-fragments. For this purpose the back planes of the field cage were read out with a combination of ionisation chambers and proportional counters. The latter were read out on top and on bottom so that the position of the tracks in the non bending plane could be determined from the ratio of the two signals. The necessary fast preamplifiers with a dynamic range well above 2000 were developed by Roberto Bassini in the institute of Ileana Iori in Milano. Further improvements were an increase of the size of the forward hodoscope from Catania and the combination with LAND, so that also protons and neutrons could be recorded. With the new setup, shown in fig.2 we could now determine the excitation energy and from the measured isotope yields of light elements also the temperature of the decaying spectator.



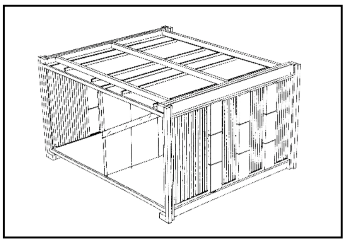


Fig. 2: The ALADIN spectrometer with the new MUSIC-detector, the neutron detector LAND and the Catania hodoscope (Si-Csi). The insert on the right shows the new MUSIC-detector. The three-fold segmented boxes are the proportional counters, in between are the ionisation strips.

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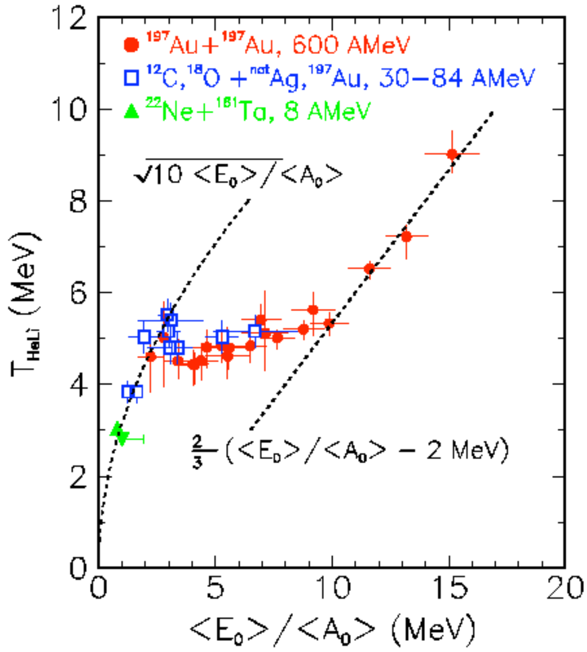

Fig.3: Caloric curve of hot nuclei. The full dots are derived from the double ratio $^3He/^4He$ over $^6Li/^7Li$ of fragments from the projectile spectator.The determination of the excitation energy is described in the text. For the other symbols see ref. [3].

The excitation energy was derived from the Q-value of the system and from the measured kinetic energies of all particles. For the temperature we followed a suggestion of Albergo et al. [2] using the double yield ratio of two pairs of neighboring isotopes, one with very different and one with similar binding energies. In this way we could determine the caloric curve of hot nuclei shown in fig.3, the most innovative publication of the AL ADIN collaboration [3].

A further feature of peripheral collisions worth mentioning is that in collisions of a symmetric system, e.g. Au-Au, the projectile and the target spectators are on the average identical. This opens up the possibility to determine some quantities, e.g. the total yield of isotopes or the charge sum $Z_{bound,}$ from the projectile spectator and others like the population of excited states from the target spectator. In fig. 4 temperatures determined from isotope ratios (full symbols) and excited-states temperatures (open symbols) are plotted as

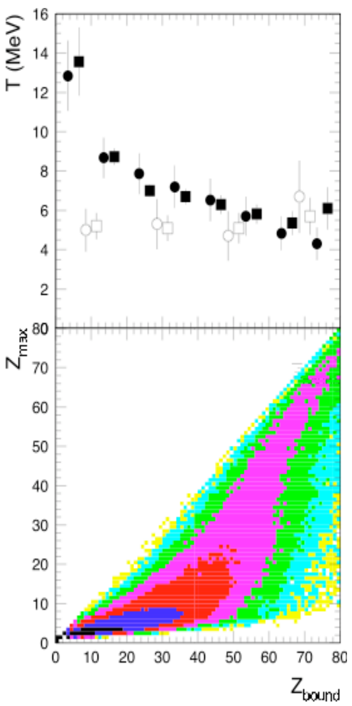

Fig. 4: Results for Au on Au at E/A=1GeV taken from ref. [4].
Upper part: Measured isotope temperatures T_{HeLi} from projectile (full squares) and target (full circles) decays and excited-states temperatures (open circles for ^5Li, open squares for ^4He) as a function of Z_{bound}.
Lower part: Distribution of the largest fragment Z_{max} as a function of Z_{bound} after removing conventional fission events. The shadings follow a logarithmic scale. In events close to the diagonal, where Z_{max} is similar to Z_{bound}, most of the mass is contained in one leading fragment (surface emission), whereas in events further away, the mass is distributed over several fragments (volume emission).

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a function of Z_{bound}. The isotope temperatures agree well with each other, indepent of whether they are determined for the projectile (squares) or the target (circles) spectator. They increase continuously with the centrality of the collision (decreasing values of Z_{bound}). The excited-states temperatures, on the contrary, remain almost constant. For large values of Z_{bound} all temperatures agree with each other, whereas for small values of Z_{bound} (high excitation energies) the isotope temperatures are much higher [4]. This can be attributed to the transition from surface to volume emission, where in case of surface emission thermal and chemical freeze-out occur at the same time, whereas for volume emission chemical freeze-out is earlier. Indeed, from the lower part of fig. [4] it can be seen that in the region, where all temperatures agree with each other, the largest fragment contains almost the whole mass, as is expected for surface emission. For lower values of Z_{bound}, however, where excited-states and isotope temperatures differ, the leading fragment has disappeared and the whole nucleus has broken up.

During the 30 years when Ileana Iori was a member of the ALADIN collaboration, she has supported the experiment in all possible ways. But most important for us was her organisation of the Winterschool at Bormio. It was here, where new collaborations, e.g. with INDRA or with MSU have started and it was here, where in highly engaged discussions many of the initially opposing interpretations slowly converged to a common and better understanding of the underlying physics. Bormio was and hopefully will remain the ideal place where physicists from different fields can meet and exchange their ideas in a wonderful surrounding and atmosphere.

Thank you, Ileana.

References

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