Multiplicity of light-charged particles investigated with proton-induced fission of ^{208}Pb at different kinetic energies

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Spallation reactions produce large quantities of light-charged particles (hydrogen and helium isotopes) which are a concern in spallation target design. For instance, the production of tritium is a concern for radioprotection, especially in the case of liquid targets from which it can escape easily. Therefore, a reliable prediction of the light-charged particle yields by high-energy transport codes [1] becomes important for the design of spallation targets. Furthermore, light-charged particle emission has been well established as a sensitive tool in probing the dynamics of heavy-ion-induced nuclear reactions and it could help to investigate some fundamental questions about fission such as the dissipative and transient effects in the last stages of the fission process [2].

In the present work, we report on the first results of a new generation of accurate measurements on multiplicities of light-charged particles in spallation reaction of ^{208}Pb at different relativistic energies: 370A, 500A and 650A MeV. The experiment takes advantage of the inverse kinematics technique, in which fission fragments and light particles are emitted in forward direction. Time coincidence with the fission fragments discriminates the particles produced during fission from other reaction channels.

The experiment [3] was performed at the ALADIN-LAND cave at GSI. Measurements were performed with a hydrogen target isolated by two windows consisting of aluminized mylar foils of 35 μm. Fission events were selected in a double multi-sampling ionization chamber (Twin MUSIC) [4]. Between the target and the Twin MUSIC a pipe filled with helium gas was placed to transmit the fission fragments. A Time-of-Flight Wall detector (ToF Wall), based on plastic-scintillator paddles and two photomultipliers (PM) per paddle, was placed in front of the Twin MUSIC to detect the light-charged particles. It consists of two orthogonally-oriented planes with six paddles each (60×6×1 cm^3), which leave a square hole (12.5 × 12.5 cm^2) in the middle to transmit the fission fragments. Because the reaction kinematics, while most of the fission fragments go through the Twin MUSIC, a large fraction of the light-charged particles escape the target to reach the ToF Wall. The time and charge of the scintillator signals are registered by using a TDC and a QDC, respectively. The particle multiplicity is provided by the number of fired paddles in each plane and the particle identification is obtained by using the time and the charge signals as shown in the inset of Fig. 1. Detection efficiency was determined from GEANT4 simulations [5] using INCL4.6-ABLA07 [1, 6] for the particle kinematics and the ToF Wall dimensions.

Figure 1 shows the multiplicity for hydrogen-like particles measured at different energies. The multiplicity is strongly correlated with the impact parameter, so that central collisions lead to high multiplicities whereas low multiplicities are related to peripherical reactions that are the major contribution [7]. The average value of the distribution increases with the bombarding energy, as expected because the reactions are more violent.

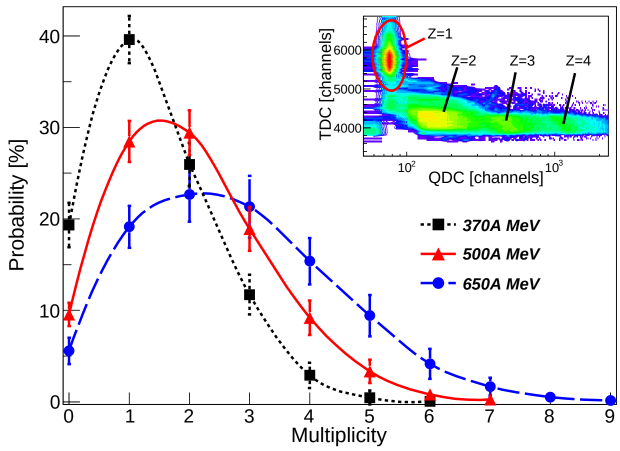

Figure 1: Multiplicity of hydrogen-like particles for ^{208}Pb+p at 370A (dotted line), 500A (solid line) and 650A (dashed line) MeV. The inset shows the identification of particles for evaporation residues. The solid elipse indicates the selection of particles with $Z = 1$, also used for fission.

References

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