Internship in experimental nuclear physics

Tuning and calibration of the full FALSTAFF spectrometer

Basic research in nuclear physics remains necessary within the framework of the French program of renewal of nuclear energy. The development of nuclear deexcitation & fission models, phenomenological as well as microscopic has had a renewal of interest in the past decades. However, the capacity of these models to explain or predict fission observables such as mass yields, charge or kinetic-energy spectra of the fission fragments (FF), neutron or gamma multiplicities remains somewhat limited. The phenomenological models used for data evaluation or for the production of nuclear data bases necessary for nuclear reactor simulations use even more microscopic modelling in order, on the one hand, mass and charge yields of FF at scission or the sharing of the excitation energy between both FF or, on the other hand, level densities of FF de excitation through particle emission (neutrons, gammas). Parameters used in these modelling are not sufficiently known and need to be determined from measurements of experimental observables. Hence, more complete data are necessary combining fission-yield measurements with FF kinematics reconstruction on a large range of excitation energy.

Within this context, we have developed the FALSTAFF spectrometer, to study the fission of actinides, induced by neutrons in an energy ranging from ~0.5 to 40 MeV, available at the NFS facility (Neutron For Science), one of the experimental area of the GANIL/SPIRAL2 accelerator. FALSTAFF is based on the time-of-flight and residual-kinetic energy measurement technique. FALSTAFF is made of two identical detection arms (for coincidence measurement of FF on an event-by-event basis), which allows the determination of the velocity vectors and kinetic energies of both FF. We used the first arm in two experiments at SPIRAL2-NFS in 2022 & 2024. The results were promising and hence the basis of the motivation to build the second detection arm, which will be finished by end of 2025. We achieve a high time resolution with two secondary-electron detectors (SED) for the time-of-flight. An axial ionisation chamber permits the measurement of the FF residual kinetic energies. The combination of both observables gives access to the FF masses after neutron evaporation, through the EV method (energy-velocity). The FF coincidence detection provides information on the FF masses prior to their de excitation, through the 2V method. We will therefore be able to determine the neutron multiplicity on an event-by-event basis and correlate it to the FF masses. This is an experimental observable of great importance in order to study the sharing of the excitation energy between both FF.

The student will take part in the tuning up and final calibration of the FALSTAFF spectrometer in its full two-arm detection geometry, including final tests with a 252Cf two-fragment radioactive source. She/he will have thus the opportunity to get familiar with the detector and more generally with the different aspects of a nuclear physics experiment, such as detection, front-end electronics, data acquisition and on-line analysis. The student will have the opportunity to prepare a thesis on the subject afterwards.

Expected skills
Nuclear physics, particle detection, C++ programming &/or CERN/ROOT analysis

This work leads to a PhD-thesis.

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