Titolo: R&D for FAZIA (4π A and Z Identification Array)

Linea di ricerca: *Fisica Nucleare Sperimentale*

Docenti di riferimento: Elio Rosato, Ivano Lombardo, Antonio Ordine (INFN), Giulio Spadaccini, Mariano Vigilante.

A sound knowledge of the nucleon behaviour inside nuclear matter is of paramount importance for understanding nuclear forces. The N-N effective interaction, the nuclear effective mass and the competition between mean-field potential and two body collisions clearly depend on the charge and mass of the systems. Hence the isospin degree-of-freedom opens a new field for getting a deeper insight into the nuclear equation of state (NEoS) and the associated phase diagram. It is thus possible to investigate the properties of asymmetric nuclear matter and to access thermodynamic and dynamics of exotic nuclei and asymmetric systems. In fact, heavy ion collisions represent a unique tool to test nuclear structure and dynamics far away from stability conditions. In this respect nucleus-nucleus collisions induced by radioactive nuclear beams (RNB) in the range of 10 to 100 A.MeV provide the opportunity to study the isospin dependence of NEoS which is largely unknown. The reaction dynamics in nucleus-nucleus collisions appears quite complicate and the role of isospin in the reaction mechanisms, from the formation of compound systems up to the multifragmentation and vaporization of nuclear matter, needs to be clarified. In this way it is possible to study several interesting effects such as isotopic content of pre-equilibrium emission, isospin fractionation, fragment isotopic distribution, collective flow, … and the thermodynamic properties of the complex sources formed during the collisions. Moreover looking at the multifragmentation reactions would allow to reveal new phenomena related to the isospin composition of very excited and exotic nuclear matter. The scientific goal is the study of the coexistence region and the liquid-gas phase transitions in finite systems, which are of a broad scientific interest and are closely connected with quark-gluon plasma, Bose condensates and melting of solid clusters.

That is also of great importance for nuclear structure studies as well as for a microscopic picture of nuclear physics in a wide sense. Nuclear physics interests focus on isospin-symmetry breaking effects in heavy nuclei, on the open question of a proton-neutron pairing phase as well as the study of rare decay modes. On the other hand, the weaker binding may lead to a more diffuse mean field and a modified spin-orbit interaction, all of which lead to a modification of the shell gaps. Such modifications of shell structure have an influence on the evolution of nuclear shapes and collective modes that should be investigated in detail. Investigations of the most exotic isotopes offer direct access to the relevant astrophysics paths, leading to a fruitful synergy of nuclear structure and nuclear astrophysics.

There are basically two requirements on an experimental basis to meet the needs imposed by this kind of studies: the availability of both stable and radioactive beams and a detection system allowing to detect and fully identify all the reaction products over the largest dynamical range and with the lowest possible thresholds. This will demand very powerful detection systems. The FAZIA collaboration (fazia2.in2p3.fr/spip) is carrying out an intensive R&D on detection and identification techniques aiming at designing detection arrays for the envisaged needs of the heavy-ion reaction isospin oriented physics of next decades. Mass and charge identification are normally measured by time of flight and energy loss techniques. The former requires long flight paths which translate into large, expensive and somewhat cumbersome arrays. The latter implies relatively high thresholds which preclude the identification of both low energy and very fast particles. In recent years pulse shape analysis of both current and charge signals, produced by charged particles penetrating solid state detectors, has been widely tested by the FAZIA collaboration as a particle identification tool and the results got for both Silicon and CsI detectors are excellent. The main challenges in the case of nuclear physics stem from the large energy ranges of the detected particles and the upper mass

limit. The FAZIA prototypes got unprecedented charge and mass resolution with low identification thresholds, well beyond the capability of the existing instrumentation. The final goal will be a charge (mass) resolution of one unit over 92 (50 -70).
The Naples team is engaged in mechanics, front-end electronics, slow control and acquisition system of the FAZIA array. The student will participate to the R&D phase of the FAZIA prototypes and/or test experiments that will be carried out both in Italy and abroad.