ACTIVE TARGET - TIME PROJECTION CHAMBERS FOR THE STUDY OF NUCLEAR REACTIONS WITH RADIOACTIVE BEAMS

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Reactions leading to bound and unbound states in systems with very unbalanced neutron-to-proton ratios are used to understand the properties of weakly bound nuclear systems that can be considered as a good testing-ground of our understanding of non-perturbative quantum systems. Radioactive beams with energies from below the Coulomb barrier up to several hundreds MeV/nucleon are now available, and a broad variety of studies of nuclei near and beyond the drip-line can be performed. To compensate for the low intensity of secondary beams as compared to primary beams, thick targets and high efficiency detection are necessary. In this context, a new generation of detectors was developed, called active target detectors: the detector gas is used as target, and the determination of the reaction vertex in three dimensions allows for good resolution even with thick targets. The physics explored with these detectors together with the technology developed will be described. The physics comprise a large variety of themes, from the excitation of giant resonances in high energy secondary beams to physics near the Coulomb barrier with transfer reactions, fusion reactions and resonant reactions. Examples will be shown, as obtained by various detectors of this type, and in particular with the AT-TPC and its prototype that became recently operational at the NSCL. A candidate for linear-chain alpha-cluster states in the neutron-rich nucleus ^{14}C was found. Some aspects of a very recent experiment with an ^{8}He beam on ^{4}He will be shown. Fusion excitation functions of ^{10}Be+^{40}Ar were obtained. Fusion-fission measurements are in progress to explore the reaction mechanism with exotic beams.