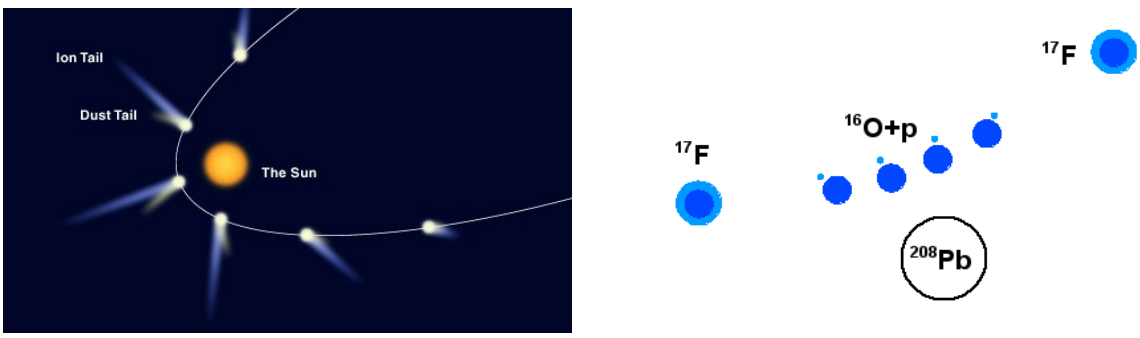
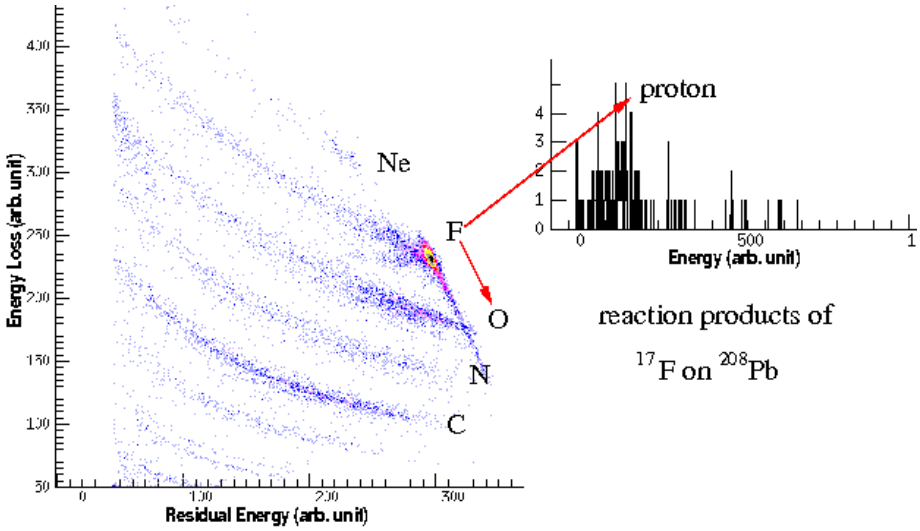
Probing cometary effects in proton-rich radioactive nuclei

When a nucleus is incident on a target nucleus with a large nuclear charge, it can get excited by the electrostatic Coulomb interaction. The Coulomb dissociation occurs when the excited states lie high in energy resulting in the separation of the outer most protons or neutrons from the core nucleus. It is a useful technique for studying radiative capture reactions when direct measurements are difficult, e.g., for exotic, short-lived nuclei contributing to astrophysical processes in which the elements are produced. In order to extract essential experimental information, mechanisms behind the breakup processes must be understood. As an example, extensive efforts have been devoted to study the reaction rate of $^{7}Be(p,\gamma)^{8}B$ taking place in the sun. Several experiments were performed by measuring the inverse reaction, Coulomb dissociation of ^{8}B ($^{8}B \rightarrow {}^{7}Be+p$). However, the so-called S factor which describes the energy dependence of reaction rate, systematically differs from that obtained by direct measurements. While Coulomb dissociation of loosely bound neutron-rich nuclei is quite well understood, this is not true for proton-rich nuclei such as ^{8}B as the loosely bound outermost (valence) protons actively participate in the reaction. Of particular importance is the dynamic polarization effect where the valence proton is displaced behind the nuclear core and shielded from the target. This is similar to the tail of a comet pointing away from the sun pushed by solar radiation and the solar wind. This effect manifests in the reduction of breakup probability and this effect is expected to increase with the target's charge. The phenomenon of dynamic polarization is well known in other fields of physics. An example of that is the different range of positively and negatively charged muons propagating in matter.



At the Holifield Radioactive Ion Beam Facility, we have measured and compared the Coulomb dissociation of ^{17}F by bombarding ^{58}Ni and ^{208}Pb targets to study the effects of dynamic polarization. Angular distributions of the reaction products, oxygen and proton, were measured in coincidence. A large reduction of breakup probability was observed for the ^{208}Pb target. This is the first experiment to demonstrate dynamic polarization in the collision of loosely bound proton-rich nuclei.