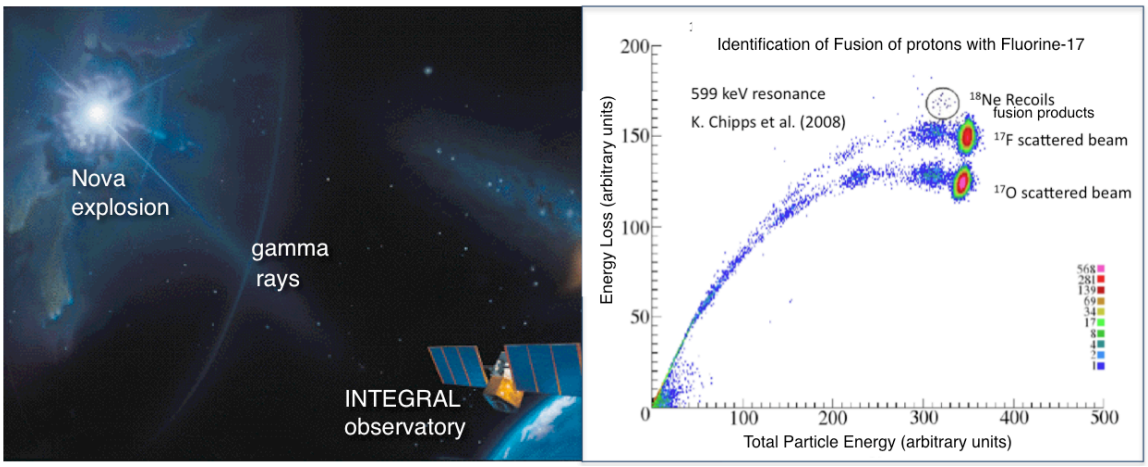
Improving our Gamma-Ray Vision in Space with an ORNL Measurement of Thermonuclear Proton Capture by Radioactive Fluorine-17



Nova explosions are caused by runaway thermonuclear reactions on the surface of tiny “white dwarf” stars. These reactions synthesize some of the chemical elements of life, and eject these as part of 100 trillion trillion pounds of material into space. The energy of these blasts are enormous, equivalent of 0.1 trillion trillion Megatons of TNT, with a tiny but distinct portion of it in gamma rays. Satellite telescopes such as the INTEGRAL observatory are hunting for these gamma rays, but the observations must be interpreted by simulations that require, as input, the rates of thermonuclear reactions on radioactive nuclei. It is crucial to determine these rates via lab experiments that reproduce the reactions in a controlled way. One particularly important reaction is the capture of protons on radioactive Fluorine-17. For the first time, this fusion reaction has been measured in an accelerator laboratory – the Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory. In this work, five million Fluorine-17 nuclei per second moving at 4 percent of the speed of light blasted a dense target of hydrogen gas, and the products of each fusion reaction were separated from a trillion other particles and individually detected and counted. The fusion yield was found to be a factor of two larger than previous estimates at the most important energy. This new fusion rate was found to increase the amount of Oxygen-17 [a small fraction of the oxygen in your body] by over 400 times, and increase the amount of Fluorine-18 [one source of the hunted gamma rays] by a similar factor, in the hottest regions of the nova as predicted by certain simulations. Such improved nuclear measurements are providing the data necessary to dramatically improve our gamma-ray vision of these explosions in space.