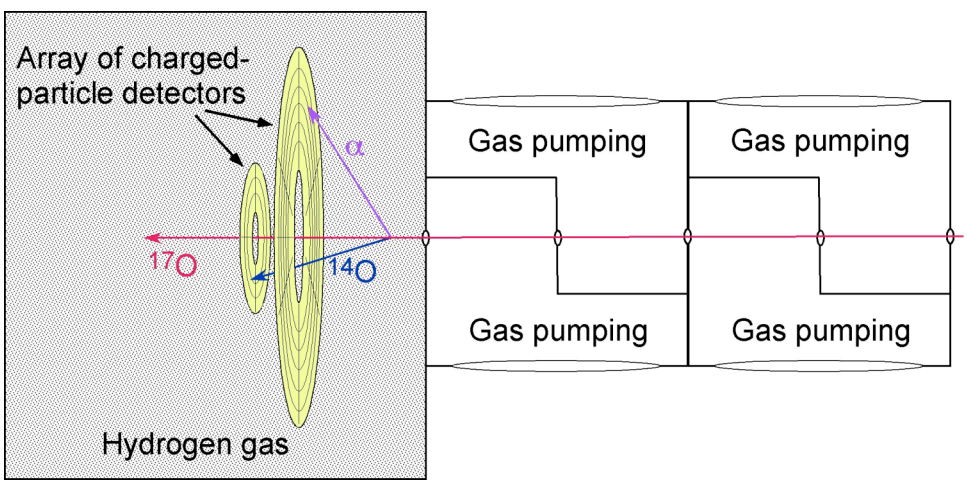
New approach to measuring charged-particle reactions developed at the HRIBF

Novae and x-ray bursts are the most common stellar explosions in the Galaxy and are believed to occur when hydrogen gas undergoes a thermonuclear explosion on the surface of a compact star. Large uncertainties persist in many of the nuclear reactions that power these events since the reactions often involve short-lived radioactive nuclei and are highly dependent on the energies of the involved particles. A new experimental approach has been developed at the Oak Ridge National Laboratory's Holifield Radioactive Ion Beam Facility that offers greatly increased sensitivity for laboratory measurements of low energy nuclear reactions that produce light charged ions like protons or alpha particles. In this approach, a heavy ion beam bombards a large chamber filled with a target gas, typically hydrogen or helium. All the reaction products are detected by a large array of charged-particle detectors operating inside the gas. The point of origin of each nuclear reaction is deduced from the measured properties of the detected particles. This new technique was demonstrated using a beam of ^{17}O and a target gas of hydrogen as illustrated in Figure 1. Alpha particles and ^{14}N nuclei resulting from nuclear reactions were detected. The high yields observed imply a rate of nuclear reactions in novae that is a factor of 20 larger than previously believed, providing the first confirmation of surprising results from a recent French study performed using a more traditional technique. These results significantly change our understanding of the reactions occurring in novae and imply that orbiting gamma ray observatories are less sensitive to some novae than previously believed. A proposal was recently approved to apply this new technique to study nuclear reactions that are important in novae using a beam of short-lived ^{18}F nuclei.



<u>Figure 1</u>: Diagram of the demonstration experiment for a new approach to charged-particle reactions at the HRIBF. A beam of ^{17}O bombarded a chamber filled with hydrogen gas. The beams passed through 5 apertures and four stages of pumping to reach the target gas. A large array of detectors measured the yield of charged particles, implying a rate of reactions in novae that is factor of 20 greater than previously believed.