Gamma-ray spectroscopy at TRIUMF-ISAC: recent highlights and future plans

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The availability of a wide variety of intense beams of exotic nuclei from the next generation of radioactive ion beam facilities such as the Isotope Separator and Accelerator (ISAC) facility at TRIUMF provides an unprecedented opportunity to address key questions of current interest in nuclear astrophysics, nuclear structure physics and fundamental symmetries. Gamma-ray spectroscopy is a powerful and versatile tool that is essential to all three areas of research at ISAC.

Short-lived isotopes are produced at ISAC by the ISOL (on-line isotope separation) method using a beam of up to 100uA of 500 MeV protons from the TRIUMF H^- cyclotron to bombard thick production targets. The targets can be coupled to a wide variety of ion sources including: surface, laser (TRILIS) and plasma (FEBIAD) sources, to produce the world's most intense RIB beams for certain isotopes such as ^{11}Li. The first UC_x production target was run in December 2010. This target produced high yields of short-lived neutron-rich and actinide isotopes. A license upgrade to operate UC_x targets at beam currents up to 10 μA for a total of 5000μA hr was obtained in Dec 2012.

An RFQ and variable energy DTL provide reaccelerated radioactive beams at energies from 0.15-1.8A MeV for nuclear reaction studies of importance in explosive nucleosynthesis environments such at Novae and X-ray bursts. Since January 2007 a superconducting LINAC installed at ISAC-II has made nuclear reaction studies possible at energies up to 7A MeV for A < 150.

Over the past decade the 8π gamma-ray spectrometer has been dedicated to β-decay studies with stopped radioactive beams at ISAC-I. The 8π is an array of 20 Compton-suppressed HPGe detectors used in combination with a suite of ancillary detectors including plastic-scintillators for beta coincidences, LN2-cooled Si(Li) detectors for conversion electron measurements and an array of BaF_2/$LaBr_3$ scintillators for fast-timing measurements. Recent experimental highlights include: a high precision branching ratio measurement for the superallowed β-emitter ^{74}Rb, and a study of the properties of neutron-rich Sr isotopes along the r-process path.

The recent funding of GRIFFIN (Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei) will dramatically upgrade the decay spectroscopy capabilities at ISAC-I. GRIFFIN will consist of an array of sixteen large-volume HPGe clover detectors arranged in a close-packed configuration with a total singles absolute efficiency of ~17% at 1.3 MeV. It has been designed to couple to all existing 8π ancillary detector systems and the new digital data acquisition system will operate at large data through-put in a semi-triggerless mode to facilitate precision measurements to the level of better than 0.05%.

The gamma-ray spectroscopy program at ISAC-II is centered on TIGRESS, a next generation array of high-efficiency segmented HPGe detectors with digital signal processing that is specifically designed to meet the challenges of experiments with high-energy radioactive ion beams at high energies. A number of auxiliary detectors are also under development for use with TIGRESS including: a DSSSD barrel for detecting charged particles SHARC, an array of neutron detectors DESCANT, the TIGRESS Integrated Plunger TIP, a conversion electron spectrometer SPICE and a recoil mass spectrometer EMMA. During the past three years, the experimental studies included: Coulomb excitation of $^{10\text{-}11}$Be to test recent *ab inito* calculations of light halo nuclei and the first experiments with SHARC including 1) a measurement of the ^{25}Na(d,p)^{26}Na reaction as part of a program to follow the evolution of shell structure of neutron-rich *sd*-shell nuclei and 2) investigating halo effects in the ^{11}Be(p,d)^{10}Be transfer reaction.

An overview of these facilities and recent results from the diverse program of nuclear structure, nuclear astrophysics and fundamental interaction studies they support, will be presented.

*The 8pi/TIGRESS international collaboration is a consortium of researchers from 43 institutions in Canada, USA, Europe, Asia, Australia and Africa.