

# 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 100  $\mu$ A 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. Since Dec. 2011 UCx production targets operating at up to 10  $\mu$ A produce high yields of short-lived neutron-rich and actinide isotopes. A superconducting LINAC installed in 2007 has made nuclear reaction studies with reaccelerated RIBs possible at energies up to 7A MeV for  $A < 150$ .

Over the past decade the  $8\pi$  gamma-ray spectrometer has been dedicated to  $\beta$ -decay studies with stopped radioactive beams at ISAC-I. The  $8\pi$  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<sub>2</sub>/LaBr<sub>3</sub> scintillators for fast-timing measurements. Recent experimental highlights include: a high precision branching ratio measurement for the superallowed  $\beta$ -emitter <sup>74</sup>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 with a total singles absolute efficiency of 17% at 1.3 MeV. It has been designed to couple to all existing  $8\pi$  ancillary detector systems and the new digital data acquisition system will operate at large data through-put in a semi-triggerless mode.

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: an array of neutron detectors DESCANT, a conversion electron spectrometer SPICE and a recoil mass spectrometer EMMA. During the past three years, the experimental studies included: Coulomb excitation of <sup>10-11</sup>Be to test recent ab initio calculations of light halo nuclei and the first experiments with a DSSSD charged particle detector SHARC including a measurement of the <sup>25</sup>Na(*d, p*)<sup>26</sup>Na reaction as part of a program to follow the evolution of shell structure of neutron-rich sd-shell nuclei.

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