TRIUMF's new wave of research on medical isotopes

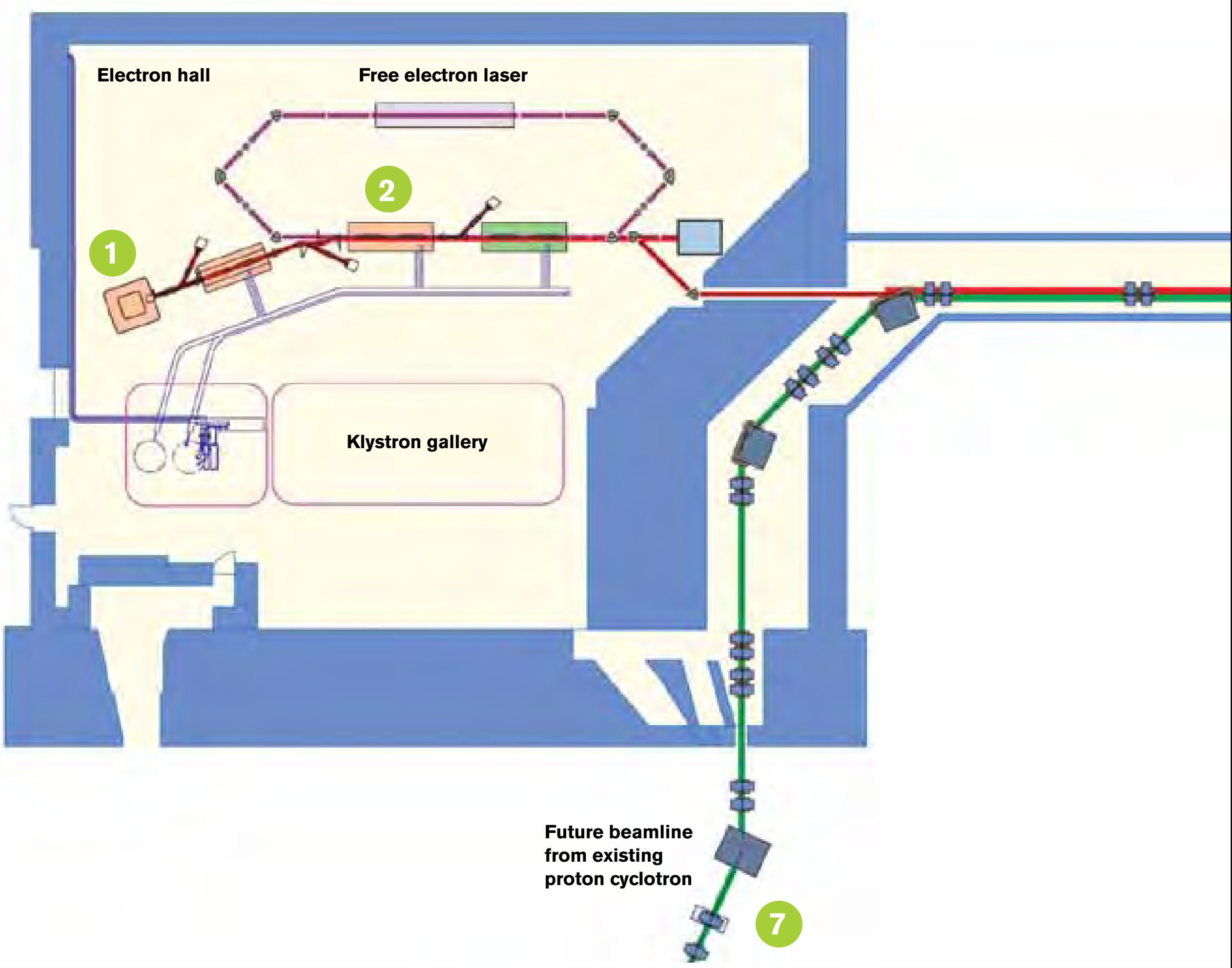
By Daisy Yuhas

Hundreds of thousands of patients around the world depend on medical imaging to reveal injuries, diagnose disease, or learn how a course of treatment such as chemotherapy is affecting their bodies. Physicians use the radioactive isotope technetium-99m in more than 80 percent of medical imaging procedures. But its global supply is in jeopardy.

Scientists at Canada's national laboratory, TRIUMF, are responding to the crisis with a plan to investigate alternative and more efficient ways to produce medical isotopes. The federal and provincial governments are supporting a new C$63-million facility to expand the research and development of isotopes for physics and medicine. The Advanced Rare IsotopE Laboratory, or ARIEL, will triple TRIUMF's current capacity for producing isotopes.

Every chemical element has isotopes that differ only in the number of neutrons in their atomic nuclei. Some isotopes have unstable nuclei that decay over time. When doctors want to study a patient's organs and tissues, they inject, or the patient ingests, short-lived medical isotopes, which then bind to biological molecules in the body. As the isotopes decay, they emit particles that illuminate tissues and blood flow. A scanner detects these particles and produces the desired image.

Most of the isotopes used in medicine are created in nuclear reactors. To get technetium-99m



ARIEL starts with electrons and ends with isotopes. How does it work?

1 First, an electron gun strips electrons from atoms and gives the electrons an initial kick of energy.

2 The electrons proceed to the e-linac, where devices known as superconducting radio-frequency cavities propel them to nearly light speed.

3 Magnets steer the electron beam into an underground target hall, where robotic equipment handles thin slabs of target material.

for medical imaging, for instance, reactors produce the parent isotope molybdenum-99, which decays into technetium-99m.

In the past few years, nuclear reactors in Canada and the Netherlands have unexpectedly had to shut down multiple times for repair. These reactors produce 64 percent of the world's molybdenum-99, and the United States has no facilities that can generate this isotope to make up for the shortage. Though Canada's Nuclear Safety Commission will soon restart the Chalk River reactor, the vast majority of reactors producing medical isotopes are more than 40 years old and more shutdowns can be expected.

At TRIUMF, the world's biggest cyclotron and an array of other particle accelerators have been producing isotopes for more than 30 years. Scientists use those isotopes in both physics and medical research, and send medical isotopes directly to the British Columbia Cancer Agency and University of British Columbia Hospital for use in imaging and treatment.

In addition to developing new technology for producing technetium-99m, ARIEL will research a range of target materials for creating unusual and never-before-studied isotopes for physics and medicine. Then it would be up to industry to turn those isotopes into commercial products.

In the realm of more basic physics, ARIEL physicists aim to understand how unusual nuclei hold together by studying the exotic isotopes they create. Isotopes also provide clues for astrophysicists and cosmologists who want to understand how the elemental byproducts of stars and supernovae became the wide range of elements on our planet today.

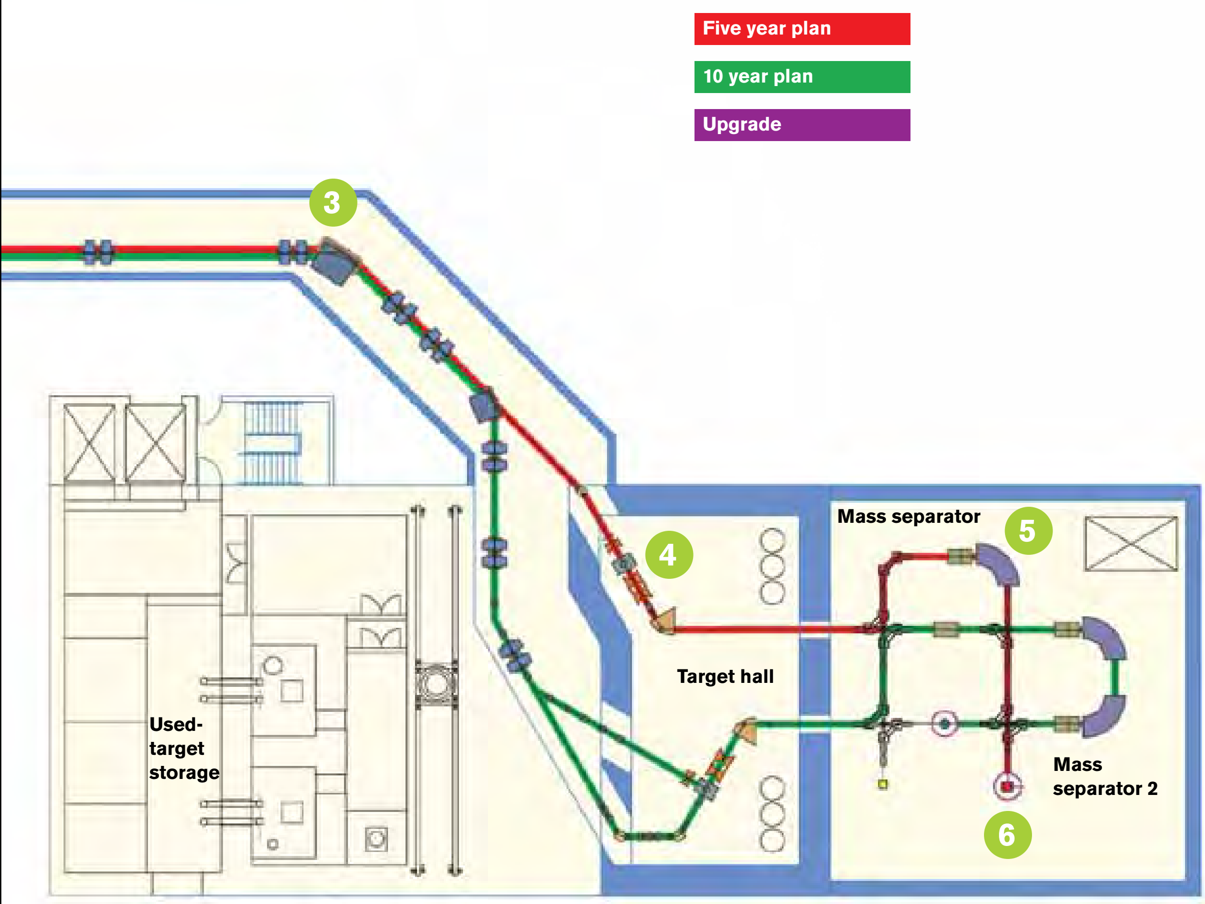


Image courtesy of TRIUMF

4 The beam strikes a target, producing a shower of photons that shatter atomic nuclei in the target material, creating isotopes.

5 The isotopes travel to separator magnets that sort them by charge and mass, according to experimenters' needs.

6 Magnets focus the separated isotopes into particle beams, which travel up one story to the experimental halls.

7 A future beamline will bring protons from TRIUMF's cyclotron, the largest one in the world, into ARIEL to produce isotopes.