Saskatchewan Centre for Cyclotron Sciences

The Saskatchewan Centre for Cyclotron Sciences is the province's first cyclotron and radioisotope production facility. Now in full operation, the facility is supplying radiopharmaceuticals to Royal University Hospital for use in PET-CT scans for Saskatchewan patients being diagnosed and treated for cancer and other conditions. The cyclotron is becoming a hub for scientific and medical research requiring short-lived radioisotopes, including:

- Cancer diagnosis and therapy;
- Imaging biological processes in plants;
- Diagnosis and treatment of Parkinson's Disease and other neurodegenerative conditions; and
- Development of new imaging agents.

A view of the cyclotron and beamline inside the Saskatchewan Centre for Cyclotron Sciences.

The Project

The Saskatchewan Centre for Cyclotron Sciences building (top row) in April 2014 and April 2015. The cyclotron (bottom row) being lowered into place, April 22, 2014 (left) and ready for use, December 2014.

Construction of the $25-million facility began in August 2013 and was completed in November 2014. It was funded by the Government of Saskatchewan, Western Economic Diversification Canada and the Sylvia Fedoruk Canadian Centre for Nuclear Innovation. Owned by the University of Saskatchewan, the Saskatchewan Centre for Cyclotron Sciences is operated by the Fedoruk Centre.

The capital project team included staff from the Fedoruk Centre, the University of Saskatchewan's Facility Management Division, Finance and Administration Division, and the Office of the Vice President of Research, the Saskatoon Health Region, Innovation Saskatchewan and the Centre for Probe Development and Commercialization at McMaster University.

The project involved the refurbishment of the former Animal Resource Centre on the University of Saskatchewan campus, including the construction of an addition to house the cyclotron and its support equipment. Renovations included the construction of a commercial radiopharmaceutical production facility that meets Health Canada's Good Manufacturing Practice standards, as well as radiochemistry laboratories. Additional space to house laboratories and imaging equipment is in the process of being developed.

Milestones

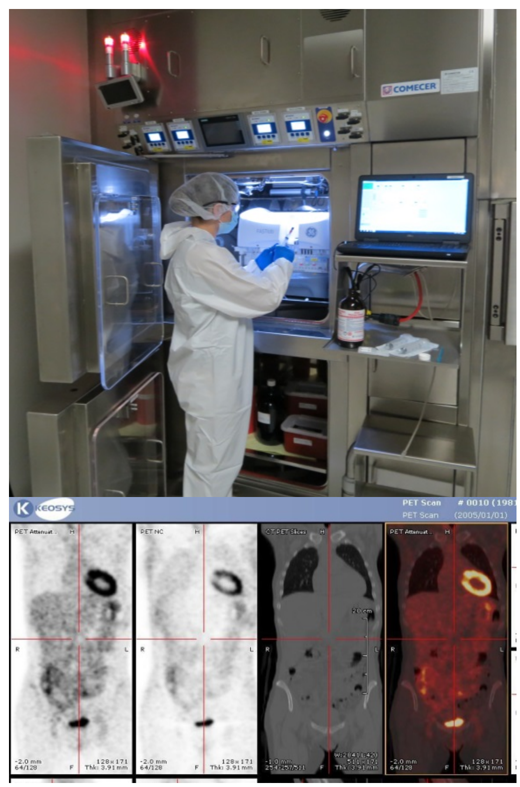
In less than three years the project moved from construction site, through equipment installation, to regulatory commissioning, to regularly supplying radioisotopes for medical and research use.

Date	Achievement
March 2011	Project funding announced
August 2013	Construction commenced
April 2014	Cyclotron installed
November 2014	Construction completed
January 2015	Commissioning started
June 2015	First isotopes produced
April 2016	Commissioning completed
May 2016	First radioisotopes used in research
June 2016	Radioisotope supply to Royal University Hospital begins

Impact and Opportunity

The Saskatchewan Centre for Cyclotron Sciences is already making a positive impact on patient care in Saskatchewan, with more patients having access to the life-saving information available from PET-CT scans. The presence of the cyclotron is also helping to grow the province's research community in the areas of medicine, pharmaceutical research, and medical imaging technology development. In the near future, Saskatchewan's cyclotron will also play a prominent role in the next generation of plant research for enhanced food security.

The facility builds on a legacy of nuclear medicine research, led by trailblazers such as Harold Johns and Sylvia Fedoruk, whose work developing cobalt-60 radiotherapy has been credited with saving millions of lives around the world. The same potential exists today in molecular imaging research in nuclear medicine and related fields in biology, chemistry and physics—research enabled by the Saskatchewan Centre for Cyclotron Sciences.



A technician prepares equipment to produce the radiopharmaceutical FDG (top) used in PET-CT scans (bottom).

Quick Facts

Cyclotrons and Nuclear Imaging:
The Saskatchewan Centre for Cyclotron Sciences and other cyclotrons commonly produce the radioisotope fluorine-18, the active ingredient in the imaging agent required for PET-CT scans. When the imaging agent (called a radiopharmaceutical) is injected into a patient it is absorbed by the patient's cells – the more active the cells, the more imaging agent is absorbed. As the radioisotope decays, it releases radiation that is detected by the PET-CT scanner. This is combined with a three-dimensional, high-resolution X-ray image to provide physicians with a picture of where the most active cells in a patient's body are located. These images are vital for detecting and tracking cancers.

Radioisotopes are unstable atoms that become stable by emitting radiation through the process of radioactive decay. There are many different radioisotopes. Many Canadians know about the medical isotope molybdenum-99, produced by the NRU nuclear reactor at Chalk River. Cyclotrons produce a number of radioisotopes, the most common being fluorine-18. Medical isotopes are radioisotopes used in nuclear medicine procedures. Molybdenum-99 decays into technetium-99m, which is used to image the heart and bones. Fluorine-18 is the main radioisotope used in PET-CT scans, important for imaging cancer tumours.

Medical isotope shortage: In 2009 a shortage of molybdenum-99 due to the shutdown of the NRU reactor, aging research reactors around the world, and pressure from the U.S. government to cease production of medical radioisotopes with highly-enriched uranium triggered research efforts to develop other ways to produce molybdenum-99 or its product technetium-99m. This included the Medical Isotope Project at the Canadian Light Source (CLS) in Saskatoon. Canadian Isotope Innovations, a spin-off of the CLS, continuing this research and development work. Vancouver's TRIUMF facility is spearheading another approach, using cyclotrons to produce technetium-99m.

How a cyclotron works: Cyclotrons produce radioisotopes by bombarding a target material with a beam of subatomic particles (protons). Nuclear reactions resulting from collisions of the beam with the atoms in the target convert them into radioisotopes. The resulting radioisotope is separated and chemically tagged to an imaging agent for clinical and research use.

HOW IT WORKS

1 A stream of negatively-charged hydrogen ions (atoms with one proton and two electrons) are injected into a vacuum chamber between two D-shaped plates – called 'dees' – enclosed between the poles of an electromagnet.

2 An alternating positive and negative charge between the dees moves the ion back and forth from one dee to the other. The ion accelerates every time it crosses the gap between the dees, gaining energy. The magnetic field holds the ion within the horizontal plane, resulting in the accelerating ions moving in a spiral path out towards the edge of the dees.

3 At the edge of the dee, the ions pass through a graphite foil that strips away the electrons, leaving a beam of high energy protons that are steered down a beamline to a target. Target materials can be liquids, solids or gases, depending on the radioisotope being made.

4 When a high energy proton from the cyclotron collides with an atom in the target, other sub-atomic particles are knocked out of the target atom's nucleus converting the atom into a radioisotope.

5 The radioisotope is separated from the target material in the facility's production laboratory. The radioisotope is tagged on to a molecule such as a sugar, creating a radiopharmaceutical. The completed drug is then shipped to a hospital or used in research.

6 In the hospital nuclear medicine department, the radiopharmaceutical is injected into a patient who is then placed in a PET-CT scanner. As the radioisotope in the radiopharmaceutical decays, it releases energy that is detected by the scanner which generates an image that is used by doctors to diagnose diseases such as cancer.