Saskatchewan Cyclotron Facility

Activity & Achievement Report

April 2022- March 2023

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Fedoruk Centre
SYLVIA FEDORUK CANADIAN CENTRE FOR NUCLEAR INNOVATION

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OPENING REMARKS

Message from the Chair

Tom Kishchuk,
Chair of the Fedoruk Centre Board of Directors

The Sylvia Fedoruk Canadian Centre for Nuclear Innovation, Inc. (Fedoruk Centre) operates the Saskatchewan Cyclotron Facility (the Facility) as a first-class scientific resource, making it accessible for researchers to advance life sciences with nuclear imaging methods. With baseline funding from Innovation Saskatchewan, and third-party revenue from the sale of products and services from the Facility, we can help build a new, multi-disciplinary community of experts in our province, enabling Saskatchewan people to generate, interpret, and apply knowledge from nuclear imaging, for social and economic benefits.

During the reporting period, we delivered a record amount of the nuclear imaging agent, FDG, to the Royal University Hospital, enabling diagnoses and treatment of more than 3,200 patients in Saskatchewan, an increase of 20 per cent compared to last year. We were pleased to secure a major contribution from Prairies Economic Development Canada to develop three new radio-isotope products that will address demands for research and applications in healthcare. Seventeen new agreements or extensions were executed for access to the Facility by users from industry and academia to advance their programs of innovation in the domain of nuclear imaging and therapies. For example, the Facility provided resources for Canadian Nuclear Laboratories to develop targets for production of the valuable isotope Actinium-225, destined for the treatment of prostate cancer worldwide.

The Board of Directors is proud of the achievements of the Facility team, and the accomplishments of the Saskatchewan research community they are supporting.

Message from the Facility General Manager

Dale Schick-Martin,

Saskatchewan Cyclotron Facility General Manager

Seven years after initial commissioning, the Saskatchewan Cyclotron Facility (Facility) has transitioned from an initial start-up phase into a resilient continuous operation. The number of agreements for user access increased from 43 in March 2022 to 60, including six private-sector clients, by March 2023. During the reporting period, there were three master supply agreements for delivery of FDG to hospitals in Saskatchewan, Alberta and Manitoba, plus one for the Western College of Veterinary Medicine. The Facility also manufactured radioisotope and radiochemical products for researchers, including FDG, $^{11}CO_2$, and ^{89}Zr-oxalate. Other isotopes were received and handled safely for researchers under the Facility license: ^{67}Cu, ^{99}Mo, ^{68}Ga, ^{111}In, ^{134}Ce, ^{177}Lu, ^{212}Pb and ^{225}Ac.

Our Facility workstations include a wide range of specialized equipment, all accessible through user-access agreements. During the reporting period, the Facility introduced a practice wherein qualified staff members will introduce new users to the operation of the specialized equipment at no charge to individual projects.

Many thanks to the Fedoruk Centre team, whose enthusiasm and cohesion are helping to build a reputation for the Saskatchewan Cyclotron Facility as a client-focused resource that is maintained in a competitive state of readiness for access by researchers from academia and industry.

The Saskatchewan Cyclotron Facility is Saskatchewan's sole producer of FDG (fluorodeoxyglucose), a radiopharmaceutical used in nuclear imaging to detect cancer.

INTRODUCTION

Facility Basics

The Sylvia Fedoruk Canadian Centre for Nuclear Innovation, Inc. (Fedoruk Centre) was established in 2011 to help place Saskatchewan among global leaders of nuclear research, development and training, through investment in partnerships with academia and industry for maximum societal and economic benefit. Besides funding research projects led by Saskatchewan scientists and partnering with Saskatchewan institutions to establish new faculty in nuclear subject areas, the Fedoruk Centre operates the Saskatchewan Cyclotron Facility (the Facility).

The Facility is owned by the University of Saskatchewan (USask) and located on campus. It is operated by the Fedoruk Centre under an Operating License Agreement with USask. The Facility encompasses the entire premises of 120 Maintenance Road including a 24MeV cyclotron (ACSI TR-24), hot cells, facilities to manufacture Health Canada-compliant radiopharmaceuticals, radiochemical research laboratories, facilities to host living specimens of plants and small animals, and PET-CT scanners for nuclear imaging to advance life sciences and advance preclinical studies. (See Figure 1.)

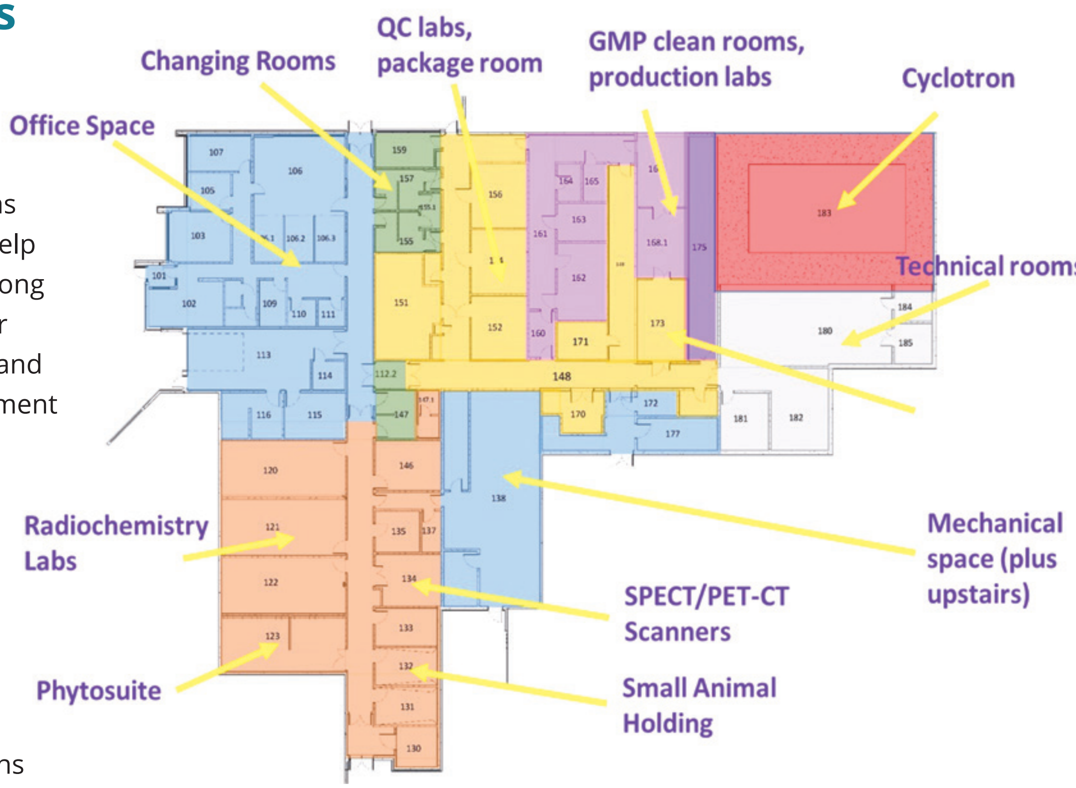


Figure 1 - Floor plan of the Saskatchewan Cyclotron Facility

Timeline from Construction to Operation

With capital contributions from Western Economic Diversification Canada (WD), Innovation Saskatchewan (IS) and the Fedoruk Centre, the initial cyclotron and nuclear-substances laboratories were commissioned in 2014. In 2016, the Facility was licensed to manufacture the nuclear imaging agent FDG for PET/CT scanning of human patients. In 2018, funding from WD, IS and the Fedoruk Centre was used to renovate and equip the Innovation Wing attached to the initial cyclotron facility. Completed in 2020, the renovated Innovation Wing bridges the gap between developing nuclear imaging drugs and proving their effectiveness in advancing human medicine, veterinary science and agriculture.

SAFETY

Licensing and Compliance

The Facility includes a TR24 Cyclotron, labs for the safe handling of nuclear substances, equipment to manufacture and qualify radiopharmaceuticals for clinical applications in humans, and capacity to hold living specimens for preclinical research and other life sciences. These activities are regulated under the authorities of the Canadian Nuclear Safety Commission (CNSC), Health Canada (HC), the Public Health Agency of Canada (PHAC) and the University of Saskatchewan, with key licenses and permits being:

Key licenses and permits include:

- CNSC Class II Facility and prescribed equipment License;
- CNSC Nuclear Substances and Radiation Devices (NSRD) License;
- HC Drug Establishment License (DEL);
- PHAC Pathogen and Toxin License; and
- USask Biosafety Permit.

The Fedoruk Centre professional and technical staff work together to ensure compliance with terms of all these permits, and comply also with the Canada Labour Code, and guidelines of the Canadian Council on Animal Care. We appreciate the cooperation of our users in helping us ensure the Facility is a safe, respectful workplace, compliant with the requirements of our licensing authorities. Some notable areas of growth include:

- On October 20th, Ra-226 targets were added to the Class II License, enabling Ac-225 targetry work, a first-in-Canada approval.
- Responding to a CNSC request for shipping information, it was determined the Facility shipped 501 packages totaling 9.61 TBq within the calendar year 2022.
- Over the calendar year 2022, no NEWs at the Facility (staff or users) received even 10% of the regulatory whole-body exposure limit (50mSv) for the year.

In 2021, the Canadian Nuclear Safety Commission renewed the Fedoruk Centre's licence for another 10 years.

Radiation Safety and Training

Our radiation protection program guides all the safety protocols at the Facility. The program includes an Occupational Health and Safety Committee that meets quarterly and biannual Facility inspections.

Staff and users are trained and qualified as Nuclear Energy Workers (NEWs). Everyone is expected to conduct their work in a manner to ensure radiation exposures are below the administrative limits established through the Radiation Protection Program, respecting the principle of ALARA (As Low As Reasonably Achievable) and well under CNSC regulatory limits for all Nuclear Energy Workers.

Table 1 - Nuclear Energy Worker (NEW) Statistics

Metric	2019	2020	2021	2022	Regulatory Limit
Number of NEWs Monitored at the Facility	49	65	45	69	N/A
Maximum Effective Whole-Body Dose for an individual NEW in the calendar year (mSv)	2.04	1.10	1.65	2.85	50
Maximum Equivalent Extremity Dose for an individual NEW in the calendar year (mSv)	27.80	17.81	40.44	61.50	500

Figure 2 - A Fedoruk Centre Technologist loads a sample into the high-purity germanium gamma spectrometer.

Figure 3 - A Fedoruk Centre Technologist assembles a cassette for automated purification.

Production of FDG and Other Isotopes

The Saskatchewan Cyclotron Facility (Facility) manufactures the nuclear imaging agent fluorodeoxyglucose (FDG) for daily delivery to the PET-CT scanner at the Royal University Hospital (RUH) in Saskatoon. Typically, production begins at 4:00 am each morning with proton-irradiation of an 18O-enriched water target, to generate the positron-emitting isotope 18F, followed by chemical processing and testing for quality control. Delivery of FDG is made to the RUH by 8:00 am for patient diagnoses. Early in 2022, the staff at the Facility developed a method of producing batches which can be split into a morning delivery at the usual time, then a subsequent afternoon delivery to support an extended day of patient scanning at RUH.

During the reporting period, the Facility team made 444 FDG deliveries to the RUH. This included 14 extra-delivery days scheduled to reduce the PET-scan patient waitlist. The Facility also provided 8 deliveries of FDG to the Western College of Veterinary Medicine and 31 batches of FDG to hospitals in Alberta and Manitoba. The number of PET-CT scans received by patients at the RUH with FDG produced at the Facility is pictured in Figure 5.

Figure 4 - Fedoruk Centre Technologists assess centrifuge samples.

Number of PET-CT scans at RUH

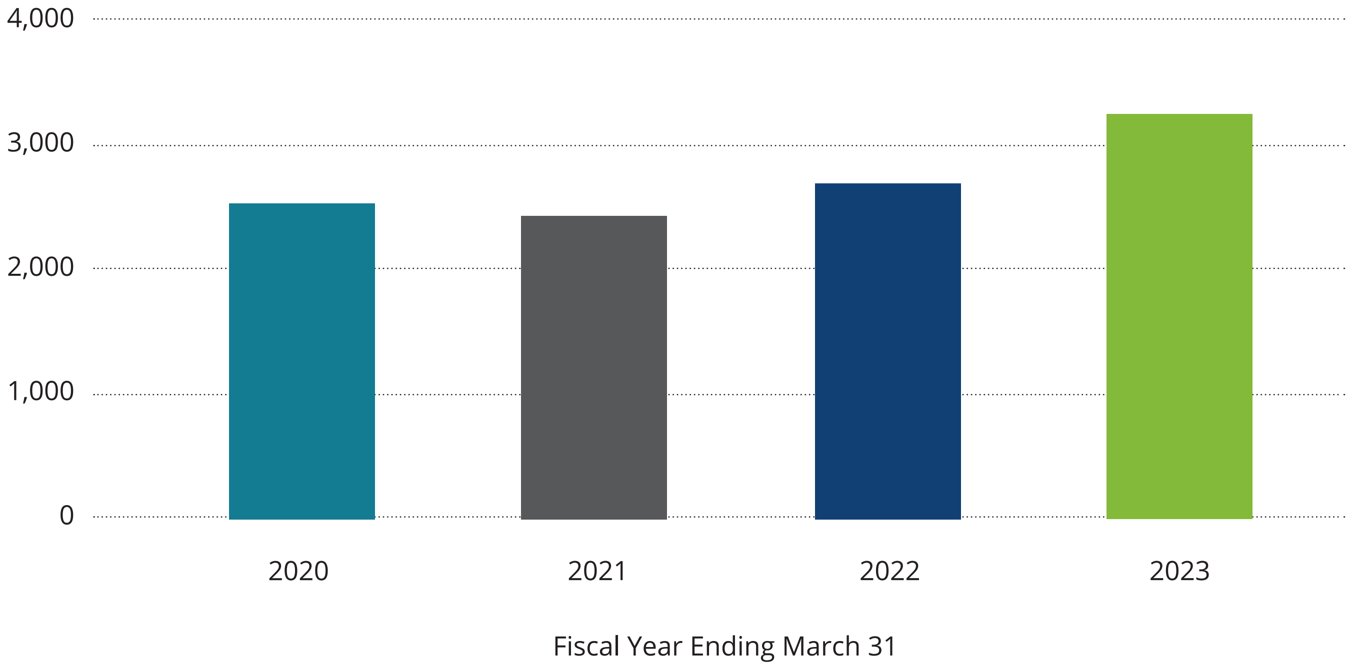


Figure 5 – Number of patient PET/CT scans at RUH with FDG produced by the Facility

Additional radioisotopes were produced at the Facility for researchers, including Carbon-11, Nitrogen-13, Fluorine-18 and Zirconium-89. A summary and multi-year comparison of isotope production for research is presented in Table 2.

Table 2 – Number of Isotope Batches Produced at the Facility for Researchers

Isotope	Calendar Year			
	2019	2020	2021	2022
^{11}C	45	25	41	74
^{13}N	0	0	3	0*
^{18}F	101	42	83	161
^{64}Cu	12	10	0	0
^{89}Zr	28	31	29	11
^{68}Ga	0	0	3	0

Some C-11 productions were performed with the intention of using the co-produced N-13

Several other isotopes were received and handled safely for researchers under the Facility license, including: Copper-67, Molybdenum-99, Gallium-68 (from a generator), Indium-111, Cerium-134, Lutetium-177, Lead-212 and Actinium-225.

CAPABILITY AND PERFORMANCE

Infrastructure Upgrades

The Facility established a new Workstation to fulfill a long-standing interest of the Saskatchewan Health Authority to bring 'cold kit' manufacture into the province, to support a wide range of nuclear medicine procedures with high reliability. All the required equipment has been installed and qualified. Workstation 162 is now available for users, including staff from the Royal University Hospital, to produce the non-active components of nuclear imaging radiopharmaceuticals in a laboratory that complies with Health Canada's requirements for Good Manufacturing Practice (GMP).

A purification/separation unit for [C-11]CO_2 and [N-13]N_2 was installed in the Phytosuite, the Facility's plant and soil science laboratory, and made available to users for plant dosing with radioactive gases.

Products

The isotope ^{89}Zr has been produced at the Facility and supplied to users sporadically for over 2 years. The capability has allowed the Fedoruk Centre to participate in a Collaborative Research Project (CRP) with the International Atomic Energy Agency (IAEA), and work with leading ^{89}Zr producers from around the world. In September 2022, the second meeting of the CRP was held in Italy with the Fedoruk Centre as the sole representative of Canadian ^{89}Zr innovation in attendance.

- On January 13, the Fedoruk Centre secured a contribution of $410,650 for "Commercializing Capabilities at the Saskatchewan Centre for Cyclotron Sciences (Facility)" from the Regional Innovation Ecosystems (RIE) program of Prairies Economic Development Canada (Prairies Canada). This new project is comprised of three key activities: (1) to proceed with development of three products with immediate market opportunities, $^{68}GaCl_3$, $Na^{18}F$, and ^{18}F-PSMA; (2) to perform a market study and analysis of further prospects for new products; and (3) to apply the experience gained through these initial developments and the outcome of the market analysis to identify, prioritize and plan further development.

Trends

Indicators of operational performance reveal trends in demand for user access, success in maintaining a state of readiness for access, and reliability of equipment, including the cyclotron itself. Production days can be lost by an outage of the cyclotron as well as some other critical outage in the balance of the Facility. At the outset of the COVID-19 pandemic in 2020, access of users for research was strongly curtailed, leading to a disruption of most academic and industrial R&D activities that would require Facility access for a year or more. The trends of Facility performance are presented in Table 3.

Table 3 – Trends in Facility Performance Indicators

Performance Indicator	Fiscal Year Ending March 31			
	2020	2021	2022	2023
Workstation availability – ready for user access (percentage of total time)	90.3%	95.8%	97.0%	98.2%
Workstation occupancy by users (percentage of available time)	36.1%	14.7%	15.3%	13.2%
Unplanned outages of cyclotron (days)	9	4	5	4
Unplanned outages of Facility production (days)	9	5	6	6

Figure 6 – Fedoruk Centre Technologists at the cyclotron power system.

FACILITY USER INNOVATIONS

User Access

The Fedoruk Centre offers access for researchers and students from academia and industry to advance their programs of innovation in nuclear imaging, therapies or life sciences at Facility workstations. Workstation access is arranged through a user agreement and preparatory discussions described at our webpage on Facility services.

For research in the public domain, rates for workstation access are set to recover the full cost of Facility operation if a single user occupied all workstations full time. Rates are increased, to recover the full cost of operating the entire Fedoruk Centre (including Project funding and Program partnership investments), if a single user occupied all workstations full time for proprietary research. This pricing rationale respects the principles that taxpayer funds are not applied to the benefit of individuals or single companies outside a fair and open decision-making process, and that the Fedoruk Centre is a not-for-profit corporation, delivering societal and economic benefits to Saskatchewan.

During the reporting period, the Fedoruk Centre and USask executed 14 new agreements for academic user access to Facility capabilities. Three user access agreements were executed with industry clients for proprietary research. Actual Facility access during the reporting period enabled 10 individual research leaders and their teams to occupy Facility workstations for about 8,000 hours in total.

Trends of user access to the Facility to advance their research programs are revealed in Table 4. During the reporting period, six individuals accessed the Facility for other purposes, such as tours or training.

Figure 7 – Fedoruk Centre Technologists operate the micro-PET/CT scanner for preclinical imaging.

Table 4 – Users Accessing the Facility to Perform Research

User Type	Fiscal Year Ending March 31			
	2020	2021	2022	2023
Industry Researchers	5	3	6	12
Faculty Researchers	10	4	3	2
Post-doctoral Research Associates	20	10	14	8
Graduate Students	18	11	18	22

User-Driven Research

In Table 5, some examples are listed to illustrate the public-domain research that was led by USask scientists with support from the Facility.

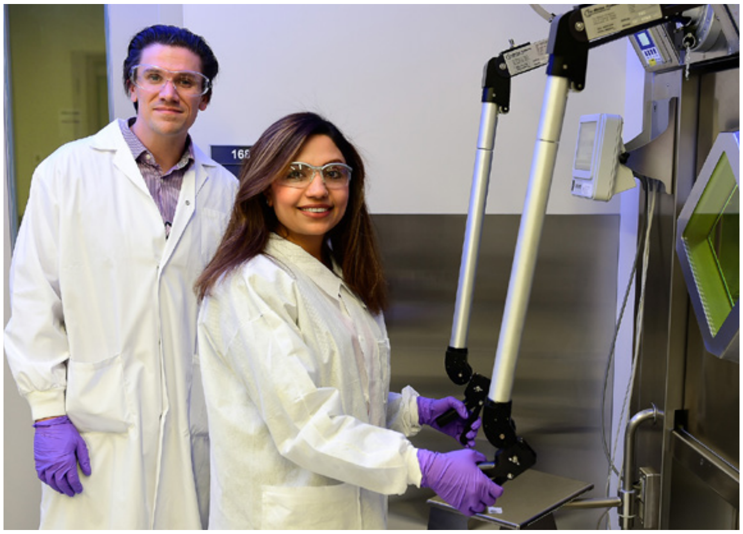
Table 5 – Examples of research led by USask scientists during the reporting period

Project Title or Description	Project Leader
Development of novel radioimmunotherapies for the treatment of invasive fungal infections	Dadachova
Radiolabelled Imaging Agents for Cancer in Mice	Fonge
Development of new capabilities for manufacturing cold-kits drug	Fonge
PET Imaging Pancreatic Cancer	Price
Multi-Centre Development of Radionuclides	Price
Detecting Responses to Anti-cancer Therapies	Geyer
3′-^{18}F-ABA: a PET Probe to Image ABA Transport in Plants	Phenix
Towards Radiotracers for GCase	Phenix
Synthesis of Fluorinated Cannabinoid derivatives	Phenix
General Proofing of a system to separate ^{11}C for plant imaging	Siciliano
Wheat and Lentil Root Carbon Allocation in Soils	Lamb
^{225}Ac and ^{67}Cu for Cancer Theranostics	Fonge
Radioimmunotherapy for cancer and multiple schlerosis	Dadachova
Radiosynthesis targeting alphasynuclein (Parkinson's Disease)	Krol
Commercialize new imaging agents with Zr-89 NimotuzumAb	Geyer
Nitrogen fixation and root system carbon allocation	Lamb
[18F]F(aq) /[18F]-FDG Soil Core Dosing and Imaging	Siciliano
Use of PET for imaging of root N_2 fixation	Hallin

HIGHLIGHTS OF USER RESEARCH AND DEVELOPMENT

Designing radiopharmaceuticals for real-world application: Eric Price's research group

The Price Research Group operates out of USask's Chemistry Department. Group members include a diverse mixture of members including undergraduates, M.Sc. and Ph.D. students, postdoctoral fellows, and research associates. The group is focused on using chemistry and radiochemistry to solve real-world problems in diagnosing and treating a variety of diseases, such as cancer. To achieve this, the Price group performs multi-/inter-disciplinary research with a primary focus in chemical synthesis and subdisciplines including organic, inorganic, bioconjugate, computational modeling, and peptide chemistry. They also actively research in the fields of radiochemistry, molecular imaging, and radionuclide therapy. The team strives to find innovative solutions to real-world problems using fundamental chemical principles, including the creation of new radiopharmaceuticals and new chemical tools/reagents,



Dr. Eric Price (left) and Dr. Elaheh Khozeimeh (right)

Two of the major families of radiopharmaceutical "chemical tools" the Price group designs, synthesizes, and studies are "chelators" and "linkers". Chelators bind with radioactive metal ions and tether them onto drugs, which allows them to be delivered selectively to cancer cells and tumors for nuclear imaging and therapy of cancer. Linkers are chemical leashes that attach the chelator and radiometal onto the drug. In recent years, they have designed, synthesized, and evaluated several new chelators for zirconium-89 and demonstrated significantly improved stability compared with the clinical gold standard, resulting in less radiometal uptake into healthy tissues and less unwanted radiation dose. We have also developed and patented a very unique kind of linker that provides a "biological non-stick" onto radiopharmaceuticals to help lower uptake into healthy organs such as the kidneys. These biological non-stick linkers are modular and can be applied to many different radiopharmaceuticals and can therefore help improve nuclear imaging and therapy of many cancers. The group is currently focusing on these unique biological non-stick linkers and developing them in several cancer-targeting peptide systems. The team is working on this with Prof. Ron Geyer in the College of Medicine (Pathology and Laboratory Medicine) and his team.

The group use the Fedoruk Centre's Saskatchewan Centre for Cyclotron Sciences and its Innovation Wing to perform radiochemistry experiments using radionuclides such as gallium-68, zirconium-89, lutetium-177, and fluorine-18.

"Without access to cutting-edge radiochemistry facilities my research group could not function, and I couldn't have built my research program here at USask," said Dr. Eric Price (PhD), Associate Professor Chemistry and Canada Research Chair in Radiochemistry. "My Canada Research Chair in Radiochemistry could also not have been awarded without access to radiochemistry facilities."

The "deep technology" the Price group is developing in these biological non-stick linkers is modular and can be applied to many types of drugs beyond just radiopharmaceuticals as a strategy for optimizing the benefits of drugs while minimizing the side effects. By preventing drugs from sticking in the wrong places in the body and causing side effects, these linkers help the drugs to become more "stealth". Long term success would mean generation of a new generation of radiopharmaceuticals with improved outcomes to cancer patients with less side effects. This could contribute to growing a biotechnology hub in Saskatoon with a spin-out company and even local clinical trials so that Saskatoon residents would get first access to this cutting-edge nuclear medicine.

The Price group is working on synthesizing and testing several new radioactive peptide drugs that contain this "biological non-stick" linker for which we have submitted a patent. These new radiopharmaceutical candidates target breast cancer, pancreatic cancer, prostate cancer, and neuroendocrine tumors. Together with Prof. Ron Geyer they are building a motivated and highly trained team of undergraduate and graduate students, professional science technicians, postdoctoral fellows, and research associates to setup a pipeline to synthesize, evaluate, and eventually bring these new cutting-edge medicines into the clinic. They are also working to form a company in the future to commercialize these new discoveries, create new jobs in the province, and hopefully supply Canadians with highly needed solutions to detecting and treating cancer.

Enhancing radioimmunotherapy efficacy: Dadachova's research group

Dr. Kate Dadachova is a professor of pharmacy at the College of Pharmacy and Nutrition and the Fedoruk Centre for Nuclear Innovation Chair in Radiopharmacy.

Her team includes two master students, two PhD students, one postdoctoral fellow, two research associates and one senior technician (lab manager). The team has expertise in radiochemistry, radiopharmaceuticals design and evaluation, radiobiology and animal models of cancer, infectious diseases and autoimmune disorders.

Dr. Kate Dadachova

"There are serious challenges in treatment of such diseases as cancer, opportunistic fungal infections and multiple sclerosis affecting people in Saskatchewan which makes it important for Saskatchewan researchers to find innovative solutions to address these challenges," said Dadachova.

In 2022-23 Dadachova's group developed radioimmunotherapy of osteosarcoma in murine and canine models, performed proof-of-principle experiments in treating experimental multiple sclerosis with radiolabeled antibodies, and demonstrated radioimmunotherapy efficacy against mucormycosis-causing fungus that affects immunocompromised patients.

"These experiments which involve imaging and treating experimental animals with radionuclides would be impossible to perform without the access to the Saskatchewan Cyclotron Facility," said Dadachova.

Dadachova's team hope that their encouraging results will be translated into pre-clinical and clinical work in the near future.

Ram Mullur (CNL)

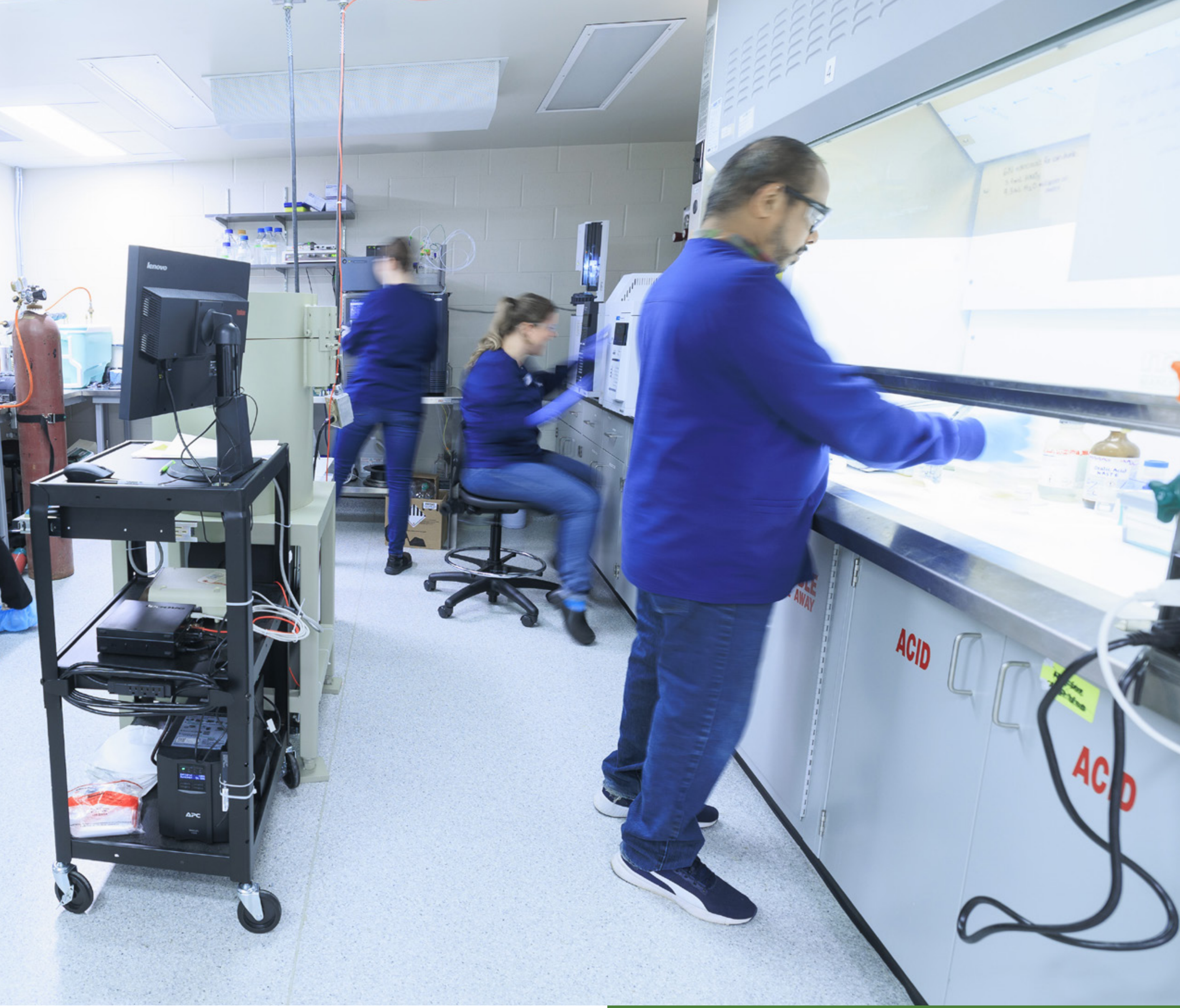
Canadian Nuclear Laboratories and Ac-225 isotopes

Canadian Nuclear Laboratories (CNL) is immensely proud to have been able to work with Sylvia Fedoruk Centre on the development of the scalable (p, 2n) production process for the production of the critically needed [by medical and radiopharma community] Ac-225 isotope. CNL has conducted key irradiation experiments at the Fedoruk cyclotron facility during this period. This working relationship has been instrumental in paving the way to advance a long-term service agreement between both organizations. This agreement will be deployed once the technology is ready to scale up for commercial production.

Ac-225 is well-poised to be a promising isotope for the newly emerging Targeted Alpha Therapy (TAT) technology that is currently being clinically evaluated in many parts of the world to treat deadly cancers, some of which are highly prevalent forms of the disease.

"It is especially inspiring that a novel isotope technology developed in Canada, including through work done in Saskatchewan will also have key elements of its early production scale performed in Saskatchewan's Fedoruk Centre," said Ram Mullur, Vice-President CNL Isotopes Business.

CNL has conducted important validation experiments to develop and optimize the (p, 2n)



technology process target design during the past year. The Saskatchewan Cyclotron Facility has provided several batches of service (surrogate) irradiation for the experiments. During the upcoming year, CNL will conduct more advanced experiments on the actual target material and will conduct the allied service irradiation tests at the Facility. Upon completion of these experiments, the Facility will be deployed for target irradiations that will be used for the commercial scale supplies.

The Facility is quickly emerging as a world-class resource enabling USask researchers to develop "made in Saskatchewan" next-generation radiopharmaceuticals with significant potential to impact crop, animal and human health sciences.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PUBLICATIONS ARISING FROM FACILITY ACCESS (2022)

1. Deficiency of Leukocyte-Specific Protein 1 (LSP1) Alleviates Asthmatic Inflammation in a Mouse Model

   Nguyen Phuong Khanh Le, Amanda Florentina do Nascimento, David Schneberger, Chi Cuong Quach, Xiaobei Zhang, Gurpreet K. Aulakh, Wojciech Dawicki, Lixin Liu, John R. Gordon and Baljit Singh

   Respiratory Research 23 (165): (2022) https://doi.org/10.1186/s12931-022-02078-7

2. Design, Synthesis, and Evaluation of DFO-Em: A Modular Chelator with Octadentate Chelation for Optimal Zirconium-89 Radiochemistry

   Akam K. Salih, Shvan J. Raheem, Moralba Dominguez Garcia, William K. Ahiahonu, and Eric W. Price

   Inorg. Chem. 61: 20964−20976 (2022)

3. Effects of Melanized Bacteria and Soluble Melanin on the Intestinal Homeostasis and Microbiome

   Zhang YG, Malo ME, Tschirhart T, Xia Y, Wang Z, Dadachova E,

   In Vivo. Toxics. 23: 11(1):13 (2022)

4. Highlights of the Latest Developments in Radiopharmaceuticals for Infection Imaging and Future Perspectives

   Dadachova E, Rangel DEN

   Frontiers in Medicne 9: 819702 (2022) doi: 10.3389/fmed.2022.819702

PUBLICATIONS ARISING FROM FACILITY ACCESS (2022)

5. Human Monoclonal Antibodies Against Staphylococcus aureus Surface Antigens Recognize in vitro and in vivo biofilm

   de Vor L, van Dijk B, van Kessel K, Kavanaugh JS, de Haas C, Aerts PC, Viveen MC, Boel EC, Fluit AC, Kwiecinski JM, Krijger GC, Ramakers RM, Beekman FJ, Dadachova E, Lam MG, Vogely HC, van der Wal BC, van Strijp JA, Horswill AR, Weinans H, Rooijakkers SH.

   Elife 11: E67301 (2022)
   doi: 10.7554/eLife.67301

6. In Vitro and In Vivo Characterization of 89-Zirconium-Labeled Lintuzumab Molecule

   Allen, K.J.H.; Jiao, R.; Li, J.; Beckford-Vera, D.R.; Dadachova, E.

   Molecules 27: 6589 (2022)

7. Localization of Nucleobindin2/nesfatin-1-like immunoreactivity in human lungs and neutrophils

   Hui J, Aulakh GK, Unniappan S, Singh B.

   Ann Anat. 239: 151774 (2022)
   doi: 10.1016/j.aanat.2021.151774

8. Mitigating Effects of Sublethal and Lethal Whole-body Gamma Irradiation in a Mouse Model with Soluble Melanin

   Malo ME, Frank C, Khokhoev E, Gorbunov A, Dontsov A, Garg R, Dadachova E.

   J Radiol Prot. 42(1): (2022)
   doi: 10.1088/1361-6498/ac3dcf

9. Positron-emitting Radiotracers Spatially Resolve Unexpected Biogeochemical Relationships Linked with Methane Oxidation in Arctic Soils

   Michael P. Schmidt, Steven D. Mamet, Curtis Senger, Alixandra Schebel, Mitsuaki Ota, Tony W. Tian, Umair Aziz, Lisa Y. Stein, Tom Regier, Kevin Stanley, Derek Peak, Steven D. Siciliano

   Glob Change Biol. 2022   doi: 10.1111/gcb.16188

10. Risk, “Radiophobia,” and Social Learning: Applying Lessons from the Literature

    Larissa Shasko, Michaela Neetz, Margot Hurlbert, Jeremy Rayner & Dazawray Landrie-Parker

    Nuclear Technology 208(6): 935-946 (2022)
    https://doi.org/10.1080/00295450.2021.1996842

11. Regulation of TLR10 Expression and Its Role in Chemotaxis of Human Neutrophils

    Yadu Balachandran, Sarah Caldwell, Gurpreet Kaur Aulakh, Baljit Singh

    Journal of Innate Immunity 2022
    doi: 10.1159/000524461

12. Targeting Melanin in Melanoma with Radionuclide Therapy

    Allen KJH, Malo ME, Jiao R, Dadachova E

    Int J Mol Sci. 23 (17): 9520 (2022)

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