Canadian Light Source | Centre canadien de rayonnement synchrotron

THE BRIGHTEST LIGHT IN CANADA™

CANADIAN LIGHT SOURCE INC.

ANNUAL REPORT 2021

www.lightsource.ca

MESSAGE FROM THE CHAIR OF THE BOARD

A lot has been said and written about this last year – a global collective *annus horribilis*. However, it was also a year of great resilience and determination, during which the CLS delivered a critical research program focused on COVID-19 with a much-reduced staff complement on site.

Working from home for a significant part of the time, our staff not only kept the science going, but also developed a conceptual design for a next generation light source for Canada. In March, the Board received a document entitled *Illuminating Canadian Innovation*, that sets the vision for the initiative. These documents will be circulated broadly in the future for comments and feedback.

The Board has also begun discussions about the future with University of Saskatchewan President Peter Stoicheff, and national and provincial stakeholders, to strategize about Canada's light source science needs and to ensure a concerted and united effort. It is crucial that the academic and industry science communities speak with one voice to ensure future critical investments.

This is my last report, as my term as Board Chair is coming to an end. I am privileged to have been associated with the CLS from its opening day, initially from a funder's (NSERC) perspective, then as a Member, and finally as Chair of its Board of Directors. I have witnessed the evolution and growth of the CLS from a six-beamline facility with a couple of hundred users to a 22-beamline centre hosting over 1,000 scientists per year. I continue to be amazed by the quality and breadth of the research this national gem supports. As a Canadian, I am proud of its national academic and industrial user base and the enthusiastic graduate students who learn and apply synchrotron techniques to address their research interests.

Finally, I extend my gratitude to the CLS CEO, Rob Lamb, the entire CLS executive team, as well as my fellow Directors for the opportunity to learn and contribute to making the CLS the vibrant research environment it is.

Au revoir, and I hope to be invited to the opening of the next generation light source in a few years.

Isabelle Blain, Chair
Board of Directors

VISION

Be recognized as a leading centre providing synchrotron light for research outcomes and the advancement of knowledge in health, agriculture, environment, and advanced materials.

MESSAGE FROM THE CEO

Resilience is the word that comes to mind when thinking of everything that has happened this past year.

In March 2020, CLS went into a warm standby mode, to protect staff and community as the pandemic state of emergency was declared in Saskatchewan. In May 2020, limited operations began, with very few staff on-site. Remarkably, over the next few months, with most employees working from home and very limited numbers of staff and local users allowed on-site, 811 users - including 766 graduate students and postdoctoral fellows from 13 countries, 9 provinces, and 39 Canadian Universities - collected data at CLS, remotely or through mail-in access. This was possible due to the enormous commitment and determination of CLS staff. From the science division who kept experiments and beamlines going to the health and safety team who worked tirelessly to keep us safe, and from the machine division who maintained systems and implemented maintenance to finance and administration who kept all our business processes operating, thank you.

A special call for proposals in the summer resulted in a range of ongoing work by scientists from across the country that included visualizing molecular structures of key proteins in the novel coronavirus, understanding how potential therapeutics and vaccines actually combat COVID-19, and analyzing ways to improve personal protective equipment (PPE), including the decontamination of face respirators. Importantly, these proposals required access to Canada's only macromolecular crystallography and biomedical imaging beamlines (unique in the Americas), in addition to CLS's world-leading scientists.

Lastly, it is with mixed feelings that I have notified the CLS Board that I will retire from the CLS, this fall.

I arrived at the CLS in September 2014 with a few ambitious goals: to restructure the management of operations, complete the last set of beamlines, develop a strategic plan that would strengthen and solidify CLS's position in Canadian and global science, and to establish a strong foundation for the future of light source science in Canada. Now, seven years later, with the help of brilliant staff, an enthusiastic and insightful Board of Directors, dedicated users and supportive funders, the storage ring is able to run in constant brightness (top-up) mode and 22 beamlines are operating in an innovative client-focused solution-provider business model. This has resulted in record numbers of user proposals and a workforce that has grown by 40%, supported by a 50% increase in annual operating income over that period, including a tripling of industrial revenue.

CLS has commercialised a first-in-world non-nuclear medical isotope production method and spun-off a Saskatchewan-based company - Canadian Isotopes Innovation Corporation - established a global-leading agricultural research program, created the first dedicated Indigenous light source education program, and strengthened international ties to sister facilities, through a number of initiatives, in the Middle East, Europe, Japan and in the Americas. Furthermore, crucially, planning for the next generation light source for Canada is well underway, with the publication of the conceptual design report outlining science drivers and machine options.

CLS's future is bright, and Canadian leadership in science at synchrotrons will continue for decades to come. CLS staff will continue to lead, grow and innovate, and Canadians will continue to benefit from the investment in our national light source capability.

With warmth and gratitude,

Dr. Robert Lamb
Chief Executive Officer

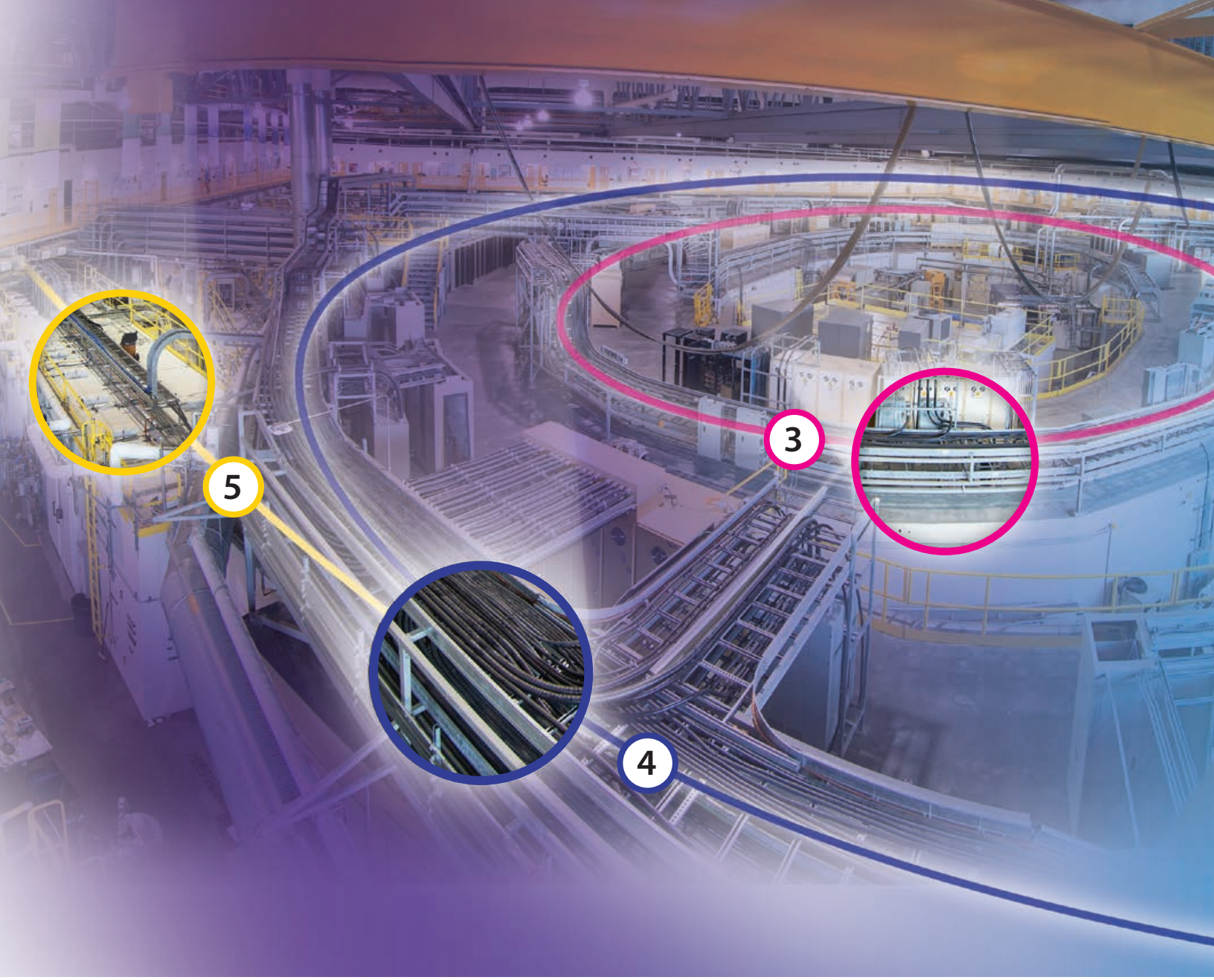
How the Light Source *Works*

1 ELECTRON GUN

Bursts of electrons are injected into an ultra-high vacuum stainless steel tube.

2 LINEAR ACCELERATOR

Microwaves increase the speed of the electrons to 99.9998 per cent of the speed of light.



3 BOOSTER RING

In the ring, microwaves continue to accelerate the electrons; they travel around the ring 1.5 million times in 0.6 seconds.

4 STORAGE RING

Magnets bend the electron beam many times, producing a super bright light.

5 BEAMLINES

Beams of light are directed down the beamlines to experimental stations.

OUR YEAR IN **NUMBERS**

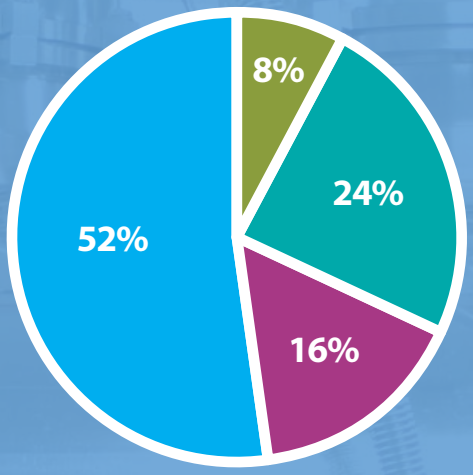
3,544 SHIFTS DELIVERED

USERS FROM 14 COUNTRIES AND 9 PROVINCES

812 DISTINCT USERS

458 SCIENCE PUBLICATIONS

USER DISCIPLINES



SHIFTS DELIVERED BY STRATEGIC AREA

- Agriculture
- Environment
- Health
- Materials

USERS FROM

39

CANADIAN UNIVERSITIES

OUR **LIGHT** IS MILLIONS OF TIMES **BRIGHTER** THAN THE **SUN**

ELECTRONS IN THE BOOSTER RING TRAVEL FAST ENOUGH TO REACH THE **MOON** IN

1.3 SECONDS

64

INTERNATIONAL COLLABORATIONS

534

HIGHLY QUALIFIED PERSONNEL

260 STAFF

900 BILLION ELECTRONS

CIRCULATING IN THE STORAGE RING

THE YEAR IN **TWEETS**

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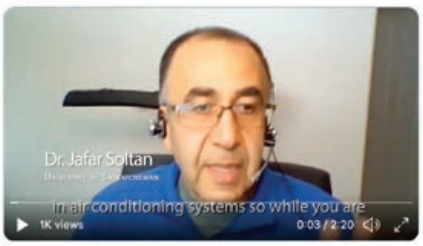
It's been over a year since the #pandemic began. We've been #workingfromhome, wearing #masks, #socialdistancing & more to keep our communities safe. As the world faces #pandemicfatigue, we encourage you to remain vigilant. #Science gives us all hope for the future. #staysafe

CanadianLightSource
@CanLightSource

Scientists @usask designed an air sanitizing device that could help protect us from airborne #pathogens like the ones that cause #COVID19 & the common #flu. The team is using the CLS to gain a deeper knowledge of the #sanitation process & optimize its performance. #CLSvsCOVID



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CO2 gas triggers important functions in a vast array of organisms. Dr. Dustin King @SFU @SFU_Science & colleagues are using our #CMCF beamlines to get a better understanding of how #CO2 gas could provide an opportunity to therapeutically to boost our #immune systems.

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CFI awards CLS $76.9M to stay on the leading edge of research
As announced today by Minister @NavdeepSBains, the CLS was awarded funding through the @InnovationCA's Major Science Initiatives Fund.
Full story: buff.ly/3firpZH
@ISED_CA @usask @VIDOInterVac @SuperDARNCanada

CanadianLightSource
@CanLightSource

Announcing the CLS Bison Project - a research experience that centers Traditional Knowledge. Following the medicine wheel, we are pleased to announce our Eastern collaborators: @nature_org, @aicchicago & @Fermilab buff.ly/3kVgkzG

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NEWS RELEASE: Turning straw into gold?
@UCalgary scientists used our #HXMA beamline to help use sunlight to turn straw into #biofuel and value-add chemicals.
Full story: buff.ly/2Vsq9dX
@UofC_Science @NSERC_CRSNG @CIHR_ICRH @SSHRC_CRSH #CFREF

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NEWS RELEASE: Protecting our soil and food from mercury contamination
One size does not fit all when it comes to using biochar for soil remediation, according to @UWaterloo researchers who used #SXRMB at CLS.
Story: buff.ly/32TVbjo
Funders: @NSERC_CRSNG @DuPont_News

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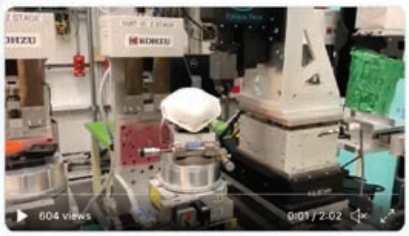
NEWS RELEASE: Extending the lifespan of N95 #masks
Researchers are studying how decontamination procedures affect the structure & potential reuse of #N95 masks.
buff.ly/3mMjXsZ

@InnovationCA @nserc_crsng @usask @SKGov @nrc_cnrc @CIHR_IRSC @VIDOInterVac #BMIT #COVID19



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Fatemeh Keivaninahr, a postdoc @usask @agbiousask , used #MidIR to look for a healthier substitute for pork fat in meat products. "Here in Saskatchewan, we have plenty of pulses and #canola and I want to find more applications for them." buff.ly/2YAmiNC
@SKGov @SaskCanola

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Dr. Paul Godin, a @yorkuniversity planetary scientist, uses spectra from our Far-IR beamline to find clues to how ancient Mars' atmosphere could have the conditions to support liquid water and life on the surface.
#Mars

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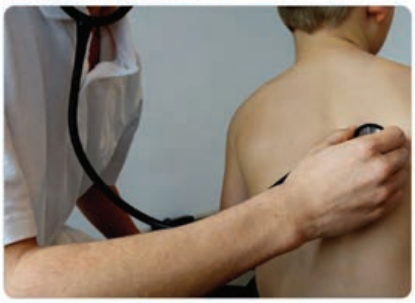
NEWS RELEASE: Scientists discover potential method to starve the bacteria that cause #Tuberculosis, one of the leading causes of death worldwide. The @uofg team used #CMCF to image the bacteria in fine detail. Story: buff.ly/3m8lnhk
Thank you @NSERC_CRSNG!



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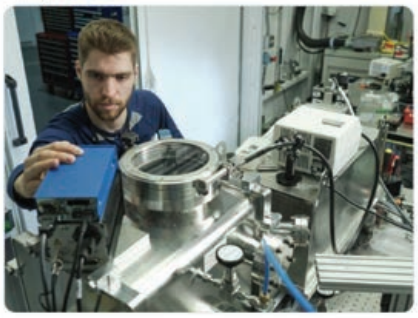
.@usask and @oranocanada researchers have developed a method for determining the precise location and chemical form of uranium in McLean Lake tailings, findings that will help Orano better protect the downstream environment from even trace metals. buff.ly/37j4Hzm



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#cardiovascular diseases take the lives of 17.9 million people every year, according to @WHO. In honour of #worldheartday, we're putting a spotlight on researchers from @mcgillu @sickkids who used our #SXRMB beamline to help prevent #heartattacks. Project: buff.ly/2RRqrJH

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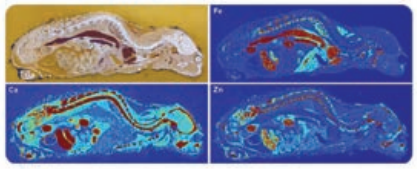
Dr. Michael Kelly, a neurosurgeon at #RUH, and @usask colleagues are using @BioXASImg_CLS to study how the brain is affected by stroke and to try to improve care for #stroke patients. #Onthebeamlines @HeartandStroke @CIHR_IRSC @SaskHealth
Full story: buff.ly/2Hs9t2l



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#CLSvsCOVID: Dr Ken Ng, professor at the Department of Biological Sciences at the @UCalgary, is working with colleague Dr. Chang-Chun Ling to develop therapeutics for COVID-19. The CLS is supported by @NSERC_CRSNG, @CIHR_IRSC @InnovationCA

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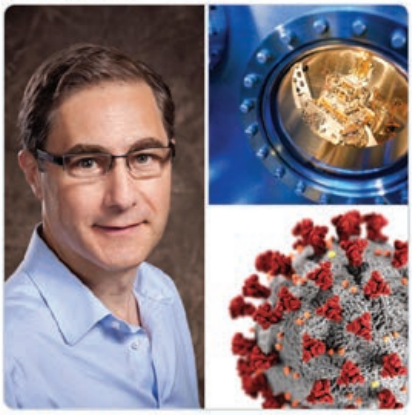
Dr Rini @UofT & colleagues developed antibodies that could protect frontline health workers, or help patients with #COVID19. They will use #CMCF to see in detail how the antibodies work against #coronavirus, which could guide vaccine design. #CLSvsCOVID
buff.ly/3khZI5W



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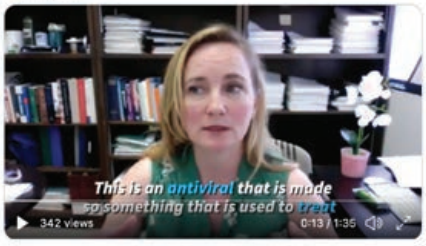
.@UofAResearch scientist Joanne Lemieux explains how structural biologists use synchrotron data to develop treatments for COVID-19. #CLSvsCOVID #structuralbiology
Translate Tweet



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#CLSvsCOVID: From his lab @UAlberta Dr. Jiang Yin is using the Canadian Light Source to find new therapies that will help treat #COVID19

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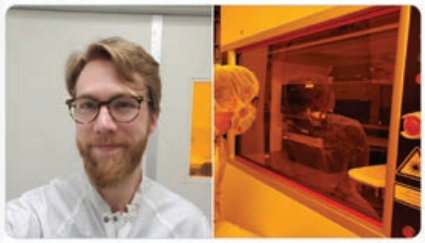
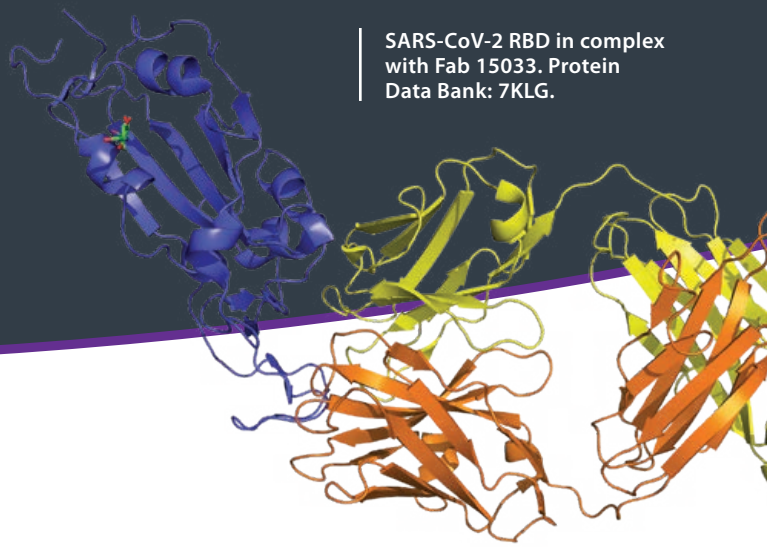
Children across Canada can participate in a free, nation-wide #science project to learn the secrets #trees can tell about their communities. Learn more about the TREE program here: bit.ly/3tEb4VW #intlforestday #forest #tree #forestday

CanadianLightSource
@CanLightSource

Imagine a doctor's office, with multiple rooms for #COVID19 testing, that could fit on a postage stamp. CLS & @universitelaval scientists are trying to create a device that would work similarly to this. buff.ly/3gHxo9X
@InnovationCA @nserc_crsng @usask @SKGov @CIHR_IRSC



SCIENCE
HIGHLIGHTS



SARS-CoV-2 RBD in complex with Fab 15033. Protein Data Bank: 7KLG.

Fighting COVID-19

Studying key COVID-19 virus enzyme

Researchers from the University of Calgary are working to develop therapeutics for COVID-19 by studying the polymerase of the SARS-CoV-2 virus that causes COVID-19. This enzyme copies the genetic material of the virus and is crucial to the creation of new viruses. The goal is to use the enzyme data to design new drugs that will inhibit the polymerase, which will prevent the virus from making new viruses and stop the infection in its tracks.

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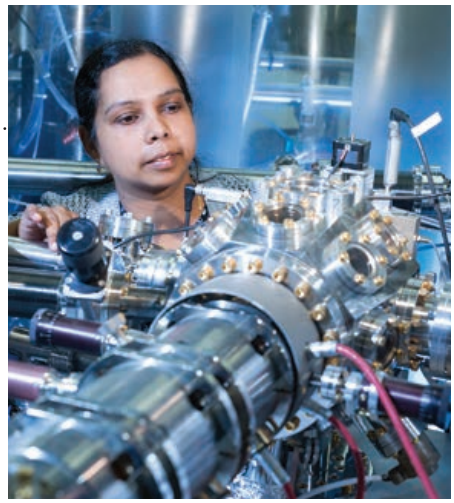


Antibodies made in a lab

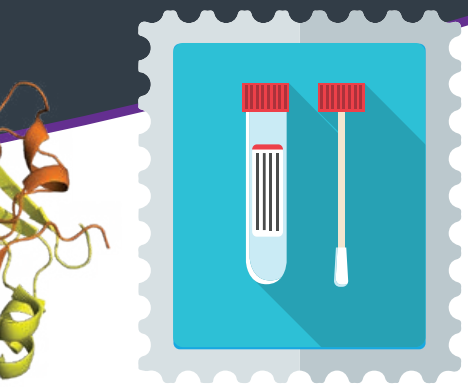
Researchers have developed antibodies that can neutralize COVID-19. Once exposed, humans create antibodies to fight viruses but the same antibodies can also be created in the lab. A team led by University of Toronto scientists has developed synthetic antibodies that could be used to protect people, or as therapeutics for patients struggling to fight the virus. They will use the CLS to see in detail how the antibodies work against the coronavirus, foundational information that could lead to improved antibody therapeutics and guide vaccine design.

www.lightsource.ca/covid19_research

Securing the supply of N95s

A collaboration between the CLS and the Vaccine and Infectious Disease Organization—both national research facilities at University of Saskatchewan—has scientists trying to understand the structural changes happening inside N95 respirator masks after being sterilized for reuse. Unique synchrotron tools allow them to study the tightly woven, microscopic fibres for changes or degradation after sterilization, key to being able to turn N95s from single-use to reusable and secure the supply of these important personal protective devices.

www.lightsource.ca/covid19_research



COVID testing goes tiny

Imagine a COVID-19 testing site so small that it could fit on a postage stamp. Researchers from the CLS and Université Laval are trying to create a device with multiple miniscule channels through which a small fluid sample from a patient could flow along with an accessory that could systematically run various tests through the channels to determine if the patient has coronavirus. A prototype of the device has been produced that will be refined and replicated. If successful, this project could improve Canada's testing and contact tracing performance.

www.lightsource.ca/covid19_research

Antiviral development

A University of Alberta researcher is using data collected at the CLS to develop treatments for COVID-19. CLS technology allows scientists to look at the 3D shape of proteins to see how drugs bond. The scientist is working on a drug validated for use in cats that has proven to be effective against the SARS-CoV-2 virus. The goal of the study is to advance the development of more effective inhibitors and possibly more effective antivirals.

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Inhibiting protein key to new therapies

From their lab at the University of Alberta, scientists are using the CLS to find new therapies to treat COVID-19. With the help of the CLS, they will analyze the papain-like protease, a protein the SARS-CoV-2 virus needs to establish a COVID-19 infection. This important protein cuts a long chain of viral proteins into smaller functional parts and is the first protein that the virus makes when it enters a cell. The team is looking for small molecules that could bind to the proteins and inhibit its activity.

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Clearing the air of COVID

A University of Saskatchewan research team has designed a device that can sanitize the air and could help protect people from catching the virus that causes COVID-19. The scientists are testing how effective their device is at inactivating the airborne pathogens and looking at the feasibility of integrating it into current ventilation systems. The team is using the CLS to take high-resolution images of their device while it is in action to gain a deeper knowledge of the sanitation process and optimize its performance.

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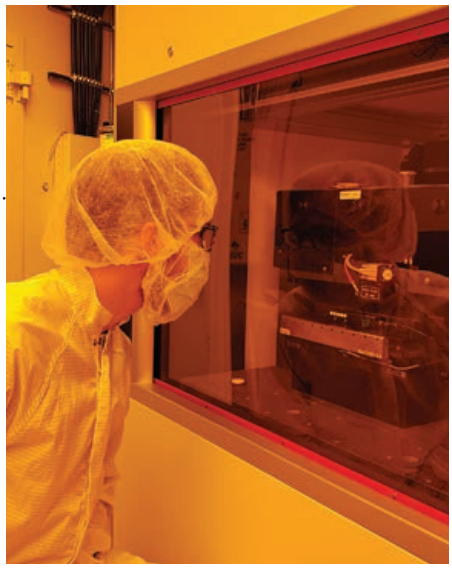
Protecting the health of Canadians



Bioengineering new therapeutics

Researchers from McGill University and Yale University used CLS technology to open the door to future therapeutic drugs. The research team studied how mega-enzymes, known as nonribosomal peptide synthetases (NRPSs), create potent antibiotics, immunosuppressants and other modern drugs. By visualizing NRPS's mechanical system on the CMCF beamline, the team reported on the enzymes' ability to take small molecules and build them into natural, biologically active, potent compounds, many of which are drugs. Seeing the system works improves the possibilities of future bioengineering to create new therapeutics.

DOI:10.1038/s41589-020-0481-5

Getting to the heart of the matter

Researchers from McGill University have uncovered new information about heart disease using the CMCF beamline. The scientist analyzed the build up of minerals in damaged heart values but, to their surprise, found there is a difference in the mineral composition between male and female samples. Key findings include that the growth of mineral deposits is slower in women and that different type of mineral are deposited on the surface of the valves in the hearts of females. Because current diagnostics are skewed toward heart disease primarily in men, this information may lead to diagnostics and therapeutics that target women.

DOI:10.1016/j.actbio.2020.02.030

Identifying a vaccine target in deadly illnesses

Using CMCF, researchers from the University of Guelph have identified a new family of enzymes that put us at risk for deadly diseases like pneumonia and sepsis. The increasingly antibiotic-resistant bacteria responsible for these illnesses has a large molecule on its outer surface known as lipopolysaccharides (LPS). This molecule allows the bacteria to survive attacks from our own immune system but can also be used as a target for vaccines. Understanding what enzymes are involved in making this molecule can help scientists create vaccines and help prevent a variety of deadly illnesses.

DOI:10.1038/s41589-020-0494-0

Starving TB bacteria

By using CLS technologies to uncover how Tuberculosis-causing bacteria feed themselves, University of Guelph researchers have identified a potential target for drug treatment. Researchers know the bacteria that causes TB uses the body's cholesterol – a steroid – as a food source. In this study, the team identified the structure of an enzyme (acyl CoA dehydrogenase) involved in steroid degradation in another member of the same bacteria family. Determining the structure of enzymes that metabolize steroids moves scientists and pharmaceutical companies closer to creating drugs that can effectively starve TB of its food source.

DOI:10.1073/pnas.1717015115

Delivering targeted therapeutics

A collaboration between Western University and the Chinese Academy of Sciences has resulted in a promising drug carrier to deliver cancer treatments and therapeutics for severe injuries. The work focused on using calcium phosphate 'buckets' to deliver treatment precisely to a tumour or to allow slow release of medicine at an injury site. This non-toxic nanostructure drug delivery system solves the limitations of other carriers, including biocompatibility with the human body and toxicity. Their CLS work allowed the team to observe interactions between drug molecules and the calcium phosphate delivery systems at a molecular level.

DOI:10.1039/D0CP00797H

Advancing agricultural research

Moooo-ning over chickpeas

While hummus used to be an exotic spread enjoyed only in the Middle East, it has become a staple in grocery stores everywhere and now has new fans – cows. Chickpeas not suitable for human consumption are being used in cattle feed, explained Dr. Peiqiang Yu with the University of Saskatchewan. Yu and colleagues showed the MidIR beamline can effectively image the molecular structure of chickpea seeds to determine varieties with the highest nutritional value for feed for beef and dairy cattle before they are produced on a mass scale.

DOI:10.1021/acs.jafc.0c04446

Turning straw into gold

Like the Rumpelstiltskin fable, scientists are using sunlight to turn straw into something more valuable. With the aid of the HXMA beamline, University of Calgary researchers used solar power to convert biomass like wheat straw into hydrogen fuel and value-add biochemicals. This method is efficient, eco-friendly and lucrative, and uses a straw pre-treatment that resulted in a high production of green hydrogen fuel and lactic acid typically used in the food, chemical and medical industries. The study also opens up opportunities for turning other plant materials into value-add products.

DOI:10.1021/acssuschemeng.0c06282.

New source for nitrogen-rich fertilizer

With the help of the SGM beamline, Cornell University researchers have proven it is possible to create nitrogen-rich fertilizer from human waste. This has the potential to increase crop yields in developing countries and better protect the environment from groundwater contamination. By combining liquid waste with solid waste, the researchers were able to increase nitrogen in the recycled fertilizer. They used biochar, a charcoal substance that was able to soak up nitrogen-rich ammonia from the liquid waste crating a nitrogen-rich solid material.

DOI:10.1021/acssuschemeng.0c01

Great balls of soil

Scientists from the University of California Riverside used the SGM beamline to analyze carbon in the soil. They focused on a practice know as cover crops, where a crop is planted for soil fertilization, not consumption. The work found soil forms balls of different sizes that are held together by compounds like carbon. A larger ball can hold more water for plants. New carbon from cover crops was seen to accumulate in the larger soil balls but there was little difference in the sizes formed in soil with or without cover crop.

DOI:10.3390/soilsystems4010006

Cleaning up mercury

Mercury is used in a variety of industries, but when released into the environment, this highly toxic element causes widespread contamination of soil. As mercury enters rivers, lakes and oceans, it is converted to methylmercury, a neurotoxin that moves into the food chain through fish and seafood, posing a serious risk to human health. However, recent research by the University of Waterloo found biochar, a charcoal produced by superheating agriculture or forestry waste in the absence of oxygen, holds promise as a low-cost "green" solution; the addition of sulfurized hardwood biochar was very effective for removing mercury from aqueous solution.

DOI:10.1016/j.chemosphere.2020.127794

Protecting the environment

Harnessing the potential of hydrogen

The global quest for clean energy is being championed by researchers from the University of Toronto who are focused on harnessing the potential of hydrogen. The scientists were able to improve the efficiency of hydrogen production through a promising technology called Polymer Electrolyte Membrane (PEM) water electrolysers. PEM electrolysers take liquid water and electrical energy—preferably from renewable resources—to generate hydrogen and oxygen gas. PEM electrolysers can store energy as renewable hydrogen, which can be used to provide on-demand power with fuel cells, vehicles and could potentially provide electricity to homes.

DOI:10.1021/acsaem.0c01239

Curbing contamination at mines

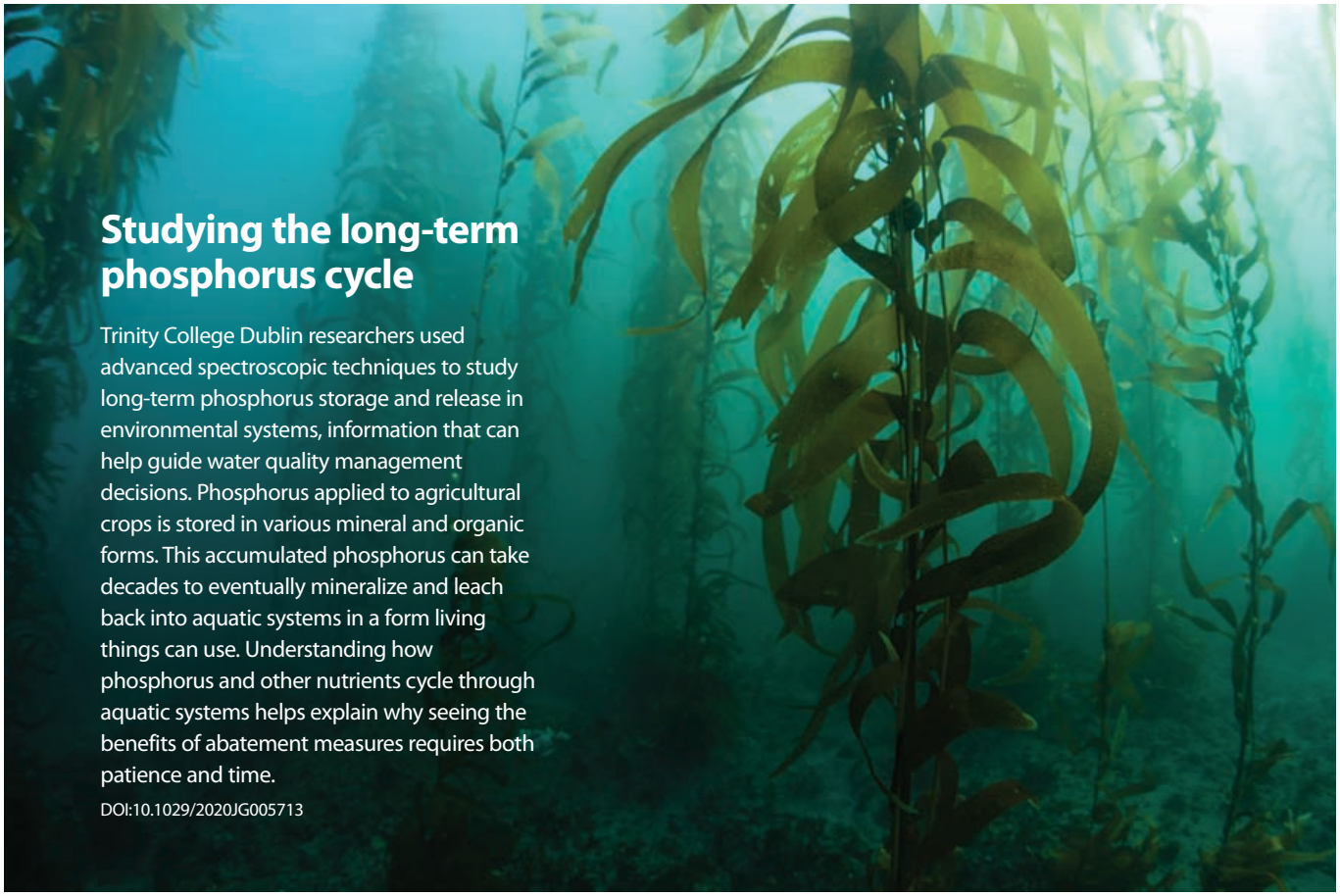
Mining companies work to extract as much uranium as possible from processed ore but small amounts remain in the residue—called tailings—of the milling process. These extremely low concentrations have been hard to detect, until now. Working with tailings and experts from Orano Canada's McClean Lake mine, University of Saskatchewan researchers developed a method of precisely locating uranium in tailings and determining its chemical form. It is a new tool for monitoring tailings that will allow Orano and others to make informed decisions about how tailings are managed in order to protect the environment.

DOI:10.1016/j.elspec.2020.146992

Neutralizing greenhouse gases

A team of scientists from Canada and China used CLS beamlines to better understand the catalytic activity of their novel affordable and efficient electrocatalyst. Electrocatalysts help to collect CO2 pollution and convert it into more valuable carbon monoxide gas, but precious metals are often used in electrocatalysts so a less expensive alternative is needed. In the new design, the team introduced titanium and built a three-dimensional nano-structure to improve the activity, selectivity and stability. The end goal is to try to neutralize the greenhouse gases that worsen climate change.

DOI:10.1002/anie.202004149



Studying the long-term phosphorus cycle

Trinity College Dublin researchers used advanced spectroscopic techniques to study long-term phosphorus storage and release in environmental systems, information that can help guide water quality management decisions. Phosphorus applied to agricultural crops is stored in various mineral and organic forms. This accumulated phosphorus can take decades to eventually mineralize and leach back into aquatic systems in a form living things can use. Understanding how phosphorus and other nutrients cycle through aquatic systems helps explain why seeing the benefits of abatement measures requires both patience and time.

DOI:10.1029/2020JG005713

Minimal energy to produce maximum ethanol

University of Toronto researchers used CLS beamlines to improve their technique of converting CO_2 emissions to ethanol. Ethanol is a valuable chemical used in industrial applications and is an attractive alternative energy source. The group aims to produce high outputs of the target chemical, in this case ethanol, using minimal energy inputs. Transforming harmful greenhouse gases into useful products has a positive impact on the environment and by creating renewable fuel from greenhouse gases, there is less pressure on using farmed food, the traditional source of ethanol fuel.

DOI:10.1038/s41560-020-0607-8

Creating next generation materials

Shining a light on new LEDs

More efficient lighting can have a huge environmental impact. A University of Saskatchewan team's latest research combines powerful mathematical modeling with cutting-edge techniques at CLS to build insight into two types of light-emitting crystals for next-generation LEDs. They're also working with industry to bring this knowledge to real-world applications as an important way to cut greenhouse emissions - lighting accounts for 15-20% of global electricity consumption, or roughly 5% of worldwide greenhouse gas emissions.

DOI:10.1002/adom.202000504.

Building capacity in Li-Ion batteries

In the ongoing quest to build a better battery, University of Manitoba researchers used the CLS to identify the potential of polymer composites as electrode matrices to increase the capacity of rechargeable lithium-ion (Li-ion) batteries. The composition of the adhesive and conductive framework for batteries has not changed in years. Because current capacity of Li-Ion batteries is nearing its maximum, new technology is needed to prepare for the next generation of batteries.

DOI:10.1016/j.powera.2020.100033

Brightening up TVs

A breakthrough in blue quantum dot technology could make the colours on TVs and screens more pristine. Quantum dots are tiny crystals that glow and could be used to develop next-generation LEDs. Compared to the films made with long chain molecules, quantum dot film has 100 times higher conductivity, sometimes even 1000 times higher. University of Toronto researchers used the CLS to verify the structures in the quantum dot films and to validate their results. Their remarkable achievements are a key benchmark in bringing these nanocrystal LEDs to a living room near you.

DOI:10.1038/s41565-020-0714-5.

Extending battery life and power

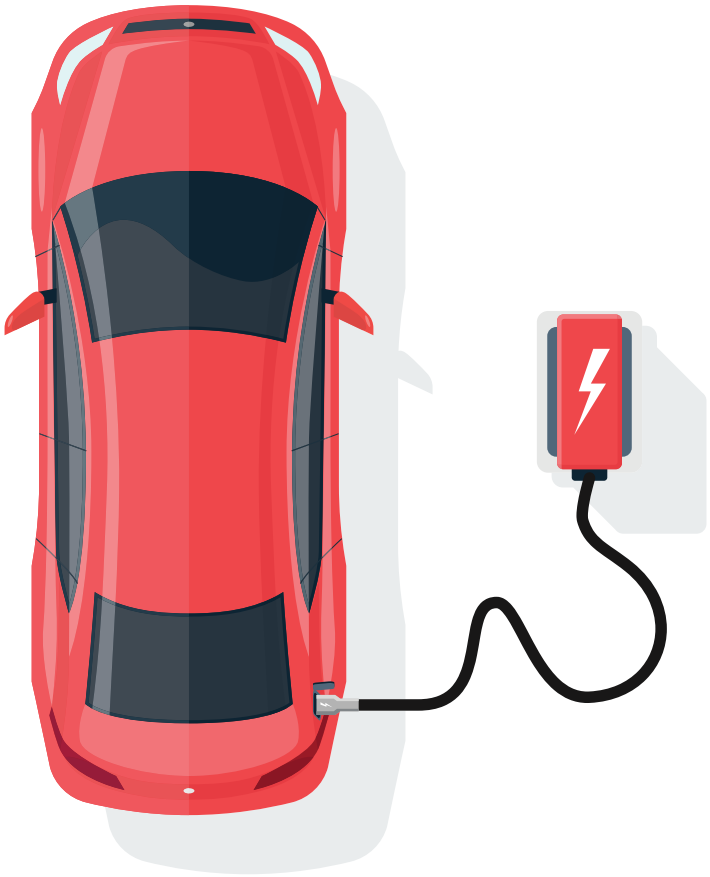
Western University researchers partnered with CLS scientists for battery studies that can address the limitations of electric vehicles and cell phone battery life. The team were investigating if phosphorene, a material made of black phosphorus, is a promising material for extending the life and power of lithium ion batteries. CLS beamlines played a role in understanding how phosphorene degrades and allowed the team to apply a new process that can produce a low cost black phosphorous which would make it a more economically feasible material.

DOI:10.1021/acs.chemmater.9b04811.

EV efficiency improved with inexpensive cathode materials

McGill researchers have shown that affordable materials can be key to increasing the efficiency of batteries in electric vehicles (EVs). Current rechargeable batteries use expensive non-abundant metals like cobalt that have negative impacts on the environment and are often sourced from mines with poor labour conditions. As an alternative, the team is focused on abundant and inexpensive iron and silicon for the cathode. By applying an electronically conducting polymer (PEDOT) on the surface of the cathode, the team found battery capacity and performance improved over charging cycles.

DOI:10.1002/admi.202000226



IT'S TIME FOR CLS2

Keeping Canada at the forefront of innovation

Around the world, brighter and higher performance light sources are being built: next generation facilities. While the CLS will remain globally competitive and a crucial resource for the Canadian scientific community for at least a decade, the national light source science community is developing plans for the next generation of Canadian synchrotron science.

Based on consultations with international machine- design experts as well as on extensive engagement with the Canadian user community, a conceptual design for CLS 2 has been developed. CLS2 will be among the best light sources in the world and will enable the Canadian scientific community to remain world-leading. It will enable scientists to see samples much more clearly, collect better data much faster, enhance the competitiveness of Canada's industry, and enable better scientific outcomes to improve the lives of all Canadians.

BRIGHTER.

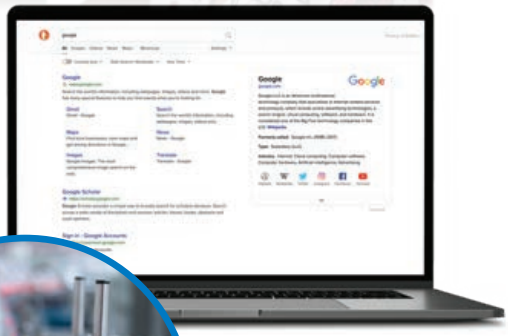
LIGHT | MINDS | FUTURE

- Faster drug and vaccine development
- Improved cereal, grains, pulses and legume crops
- Novel insights into cancers, heart disease, stroke, diabetes, Alzheimer's, and bone diseases
- Strengthened mining remediation
- More efficient solar cells
- Optimized food processing methods
- Stronger new materials for aerospace and automotive sectors
- New and improved biofuels

FASTER.

DATA | DISCOVERIES | INNOVATIONS

- More powerful batteries for smartphones, laptops, and cars
- Improved understanding of infectious diseases
- Better detection of air pollutants and aerosols
- Safer materials for nuclear waste storage
- Innovative nano-pharmaceuticals to fight cancer
- Enhanced oil recovery
- Higher quality food and feed production



BETTER.

SCIENCE | OUTCOMES | LIVES

- More sustainable agricultural practices
- New renewable energy materials
- Optimized carbon capture technologies
- Remediated manufacturing waste
- New and improved medical implants and nano devices
- Improved land management
- Superconductivity advances could lead to radically new technologies
- Enhanced environmental and water quality monitoring

FINANCIAL HIGHLIGHTS

Financial Highlights for the year ended March 31, 2021

(in thousands of dollars)

Funding for fiscal 2021 totaled $34,290, comprised of Federal, Provincial, University of Saskatchewan, and CLS self-generated revenue sources.

Federal grants, representing 77% of overall operating funding, totaled $26,541 and included funding from a variety of Federal funders including CFI, NSERC, and CIHR.

Provincial and University of Saskatchewan funding remained consistent with the prior period, representing 12% and 7% of overall operating funding for the facility.

Industrial and other revenue decreased $786 in the current fiscal year. This decrease was due to planned maintenance on a beamline with high industrial use as well as reduced beamline operation time due to the pandemic.

Operating expenditures totaled $34,467, consisting of salaries and benefits, repairs and maintenance, supplies and services, and utilities.

Salary expenditures totaled $23,918 in the period, an increase of $1,265 over the prior period and representing 69% of operating costs. The increase is due to CLS implementing its work force plan, increasing salary positions in order to ensure world class beam and service is provided to our users.

Repairs and maintenance expenses totaled $3,599, representing 11% of operating expenditures. Repairs focus on maintaining and improving the core facility (LINAC, booster and storage rings), as well as the operating beamlines at the CLS.

Supplies and services costs totaled $4,211, representing 12% of operating expenditures. Supplies and services are key to operating the facility, providing consumables for the facility and necessary consulting and service contracts.

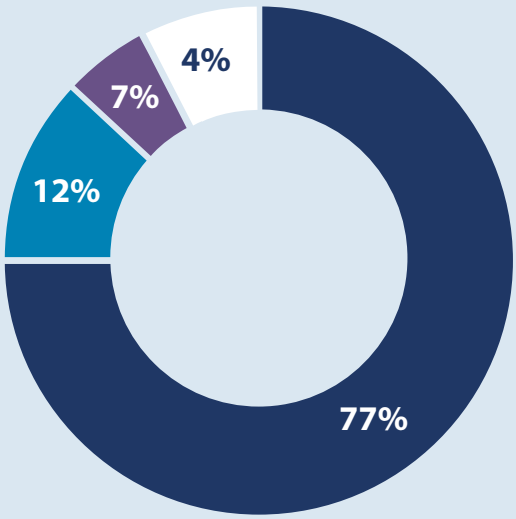
Utilities in the year represented 8% of operating costs for a total of $2,739, a decrease of $567 from the prior period. The decrease from the prior period is a result of reduced operating time of the machine due to the pandemic.

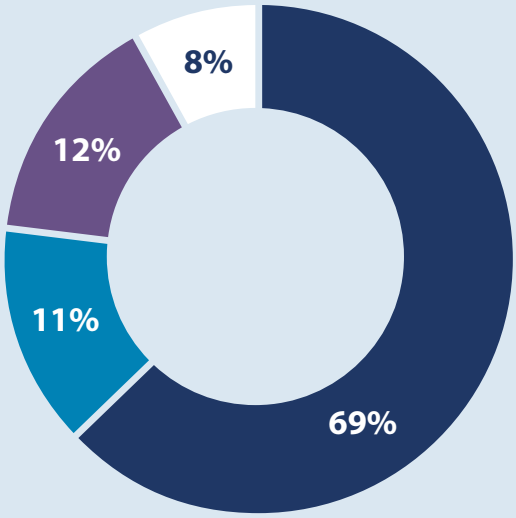
REVENUE

Federal Operating Grants	$	26,541
Provincial Operating Grants		4,100
Grant from University of Saskatchewan		2,438
Other Revenue		1,211
	$	**34,290**

EXPENSES

Salaries and Benefits	$	23,918
Repairs and maintenance		3,599
Supplies and services		4,211
Utilities		2,739
	$	**34,467**





- Federal operating grants
- Provincial operating grants
- Grant from University of Saskatchewan
- Other revenue

- Salaries and benefits
- Repairs and maintenance
- Supplies and services
- Utilities

Thank **You**

VISIT CLS VIRTUALLY!

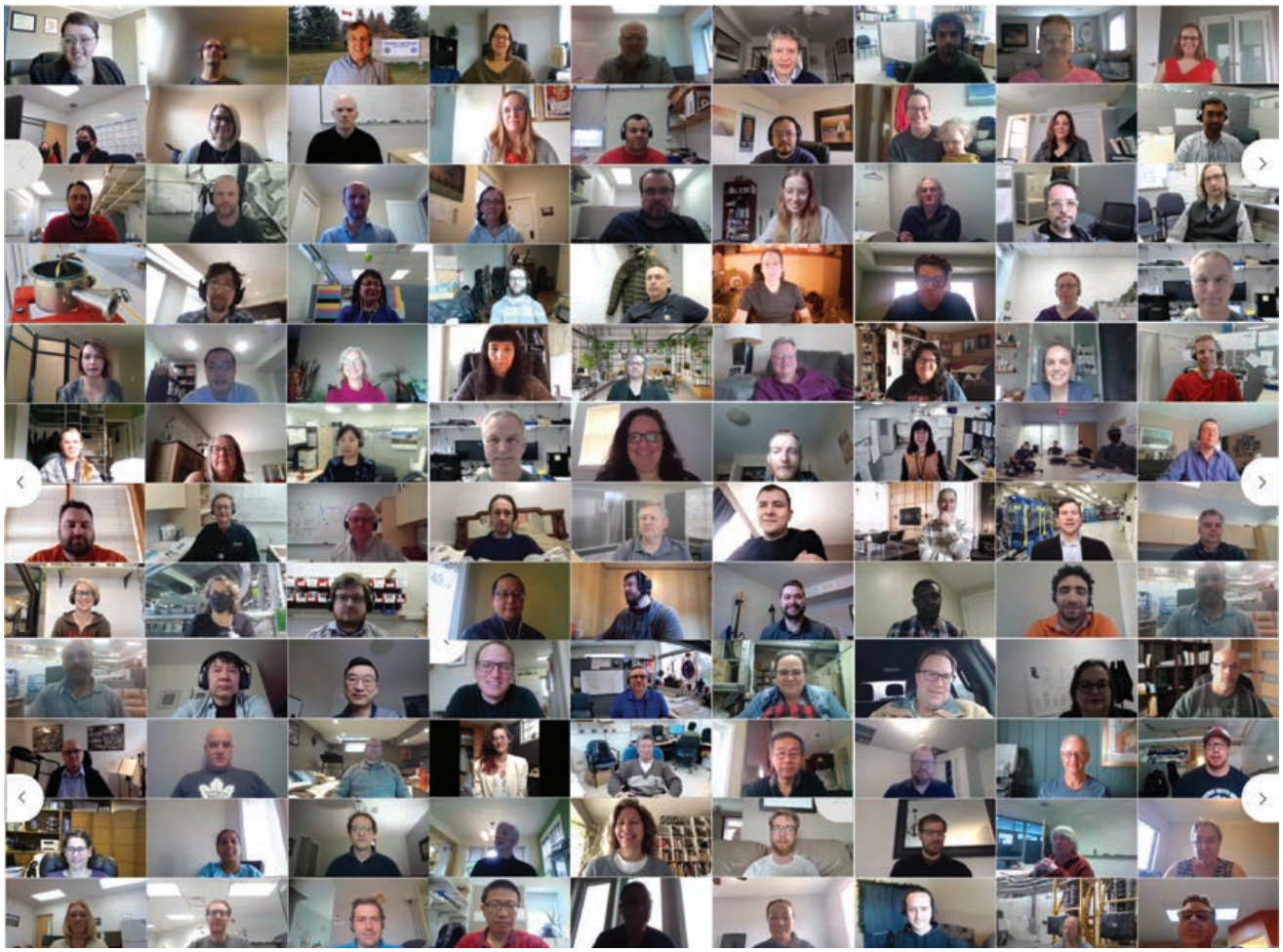
Thank you to our government, academic and corporate funding partners for their investment in Canadian science and discovery.

OPERATING

INNOVATION.CA CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION
NSERC CRSNG
UNIVERSITY OF SASKATCHEWAN
Government of Saskatchewan
NRC·CNRC
CIHR IRSC Canadian Institutes of Health Research | Instituts de recherche en santé du Canada

CAPITAL

INNOVATION.CA CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION
Government of Saskatchewan
UNIVERSITY OF SASKATCHEWAN
Western Economic Diversification Canada | Diversification de l'économie de l'Ouest Canada
Canada
Ontario
BRITISH COLUMBIA The Best Place on Earth
Natural Resources Canada | Ressources naturelles Canada
NRC·CNRC
IBM
City of Saskatoon
SaskPower
Québec
SHRF SASKATCHEWAN HEALTH RESEARCH FOUNDATION
RUH FOUNDATION
SASKATCHEWAN CANCER AGENCY
HEART & STROKE FOUNDATION OF SASKATCHEWAN
Saskatoon City Hospital FOUNDATION
BREAST CANCER SOCIETY of Canada
Government of Alberta
Western
UNIVERSITY OF ALBERTA
Canadian Cancer Society | Société canadienne du cancer
Alberta CANCER FOUNDATION
Manitoba



The Canadian Light Source is a national research facility of the University of Saskatchewan.

UNIVERSITY OF SASKATCHEWAN

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