OntarioTech
Energy Systems
& Nuclear Science

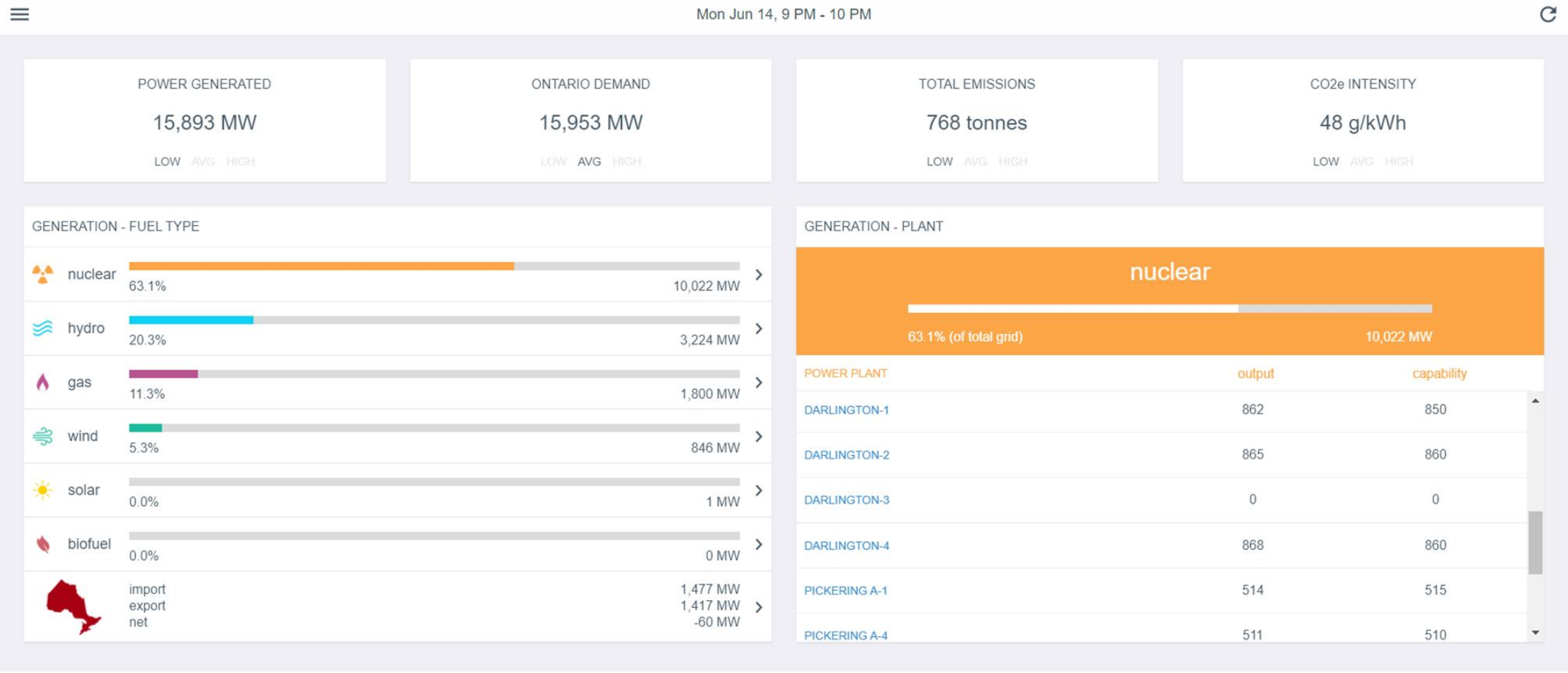
Nuclear @ Ontario Tech – Annual Update to DNHC

Dr. Kirk Atkinson (Director, Centre For Small Modular Reactors)

Background

- Ontario Tech University, officially the University of Ontario Institute of Technology (UOIT) is located in Oshawa, Ontario, in the far east end (70 km) of the Greater Toronto Area. It was founded in 2002 and opened to students in 2003. Enrolment today is around 10,000 (with 9,000 undergraduate and 1,000 graduate students) and growing.
- Is around 30 minutes drive from both OPG's Darlington and Pickering nuclear stations and provides a key regional focus on energy education and research.
- Hosts Canada's **only** accredited B.Eng degree in Nuclear Engineering (144 credit hrs, 48 courses), as well as a unique BASc program in Health Physics & Radiation Science.
- Most recent**ly ranked #2 in North America** (last two years) in terms of nuclear graduates at the Bachelor's level (over 850 since 2007).
- Hosts MASc, Ph.D., M.Eng & GDip programs in Nuclear Engineering/Technology, and delivers the Advanced Operations Overview for Managers (AOOM) program for OPG.
- Faculty of Energy Systems and Nuclear Science (FESNS) has 14 faculty members with specialties in nuclear engineering, radiation science and energy systems, which include three research chairs (2x Industrial Research Chairs, 1x Canada Research Chair).

Ontario needs nuclear…

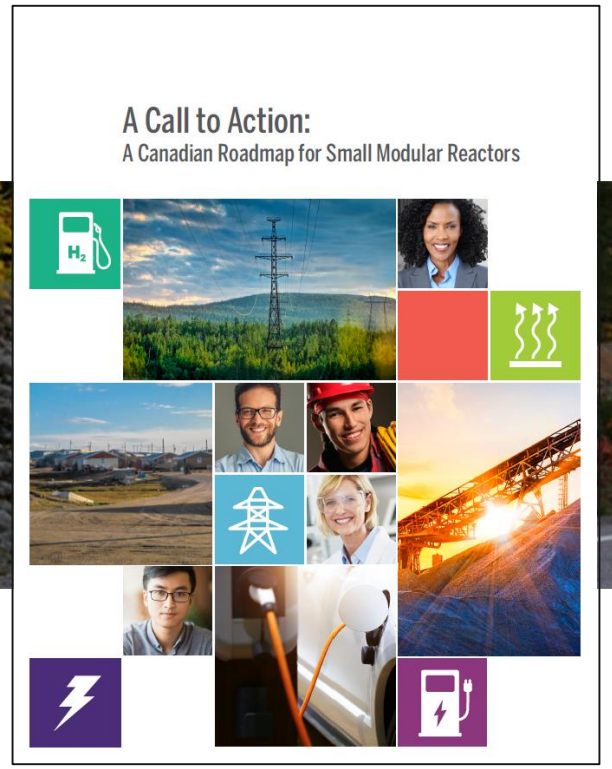


http://gridwatch.ca/

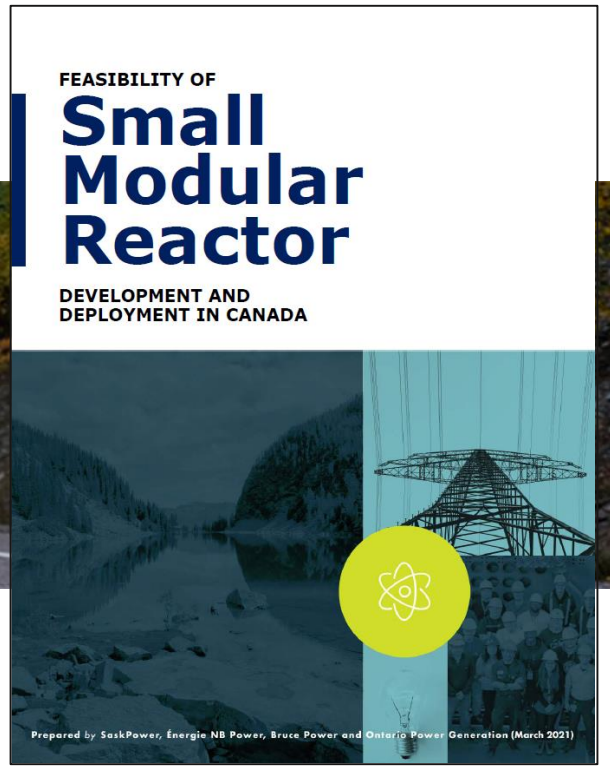
…as well as every other form of viable green energy and energy storage, to reach Net Zero 2050.

The pivot to SMRs

November 2018

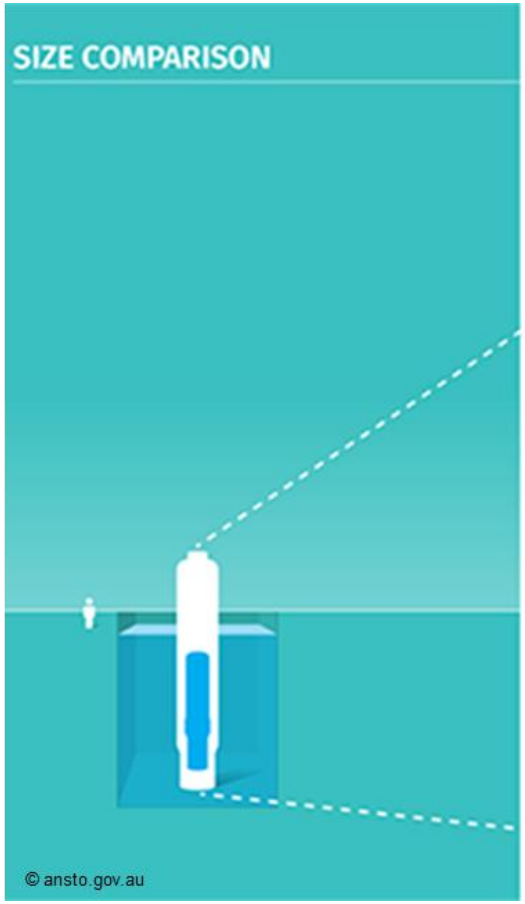


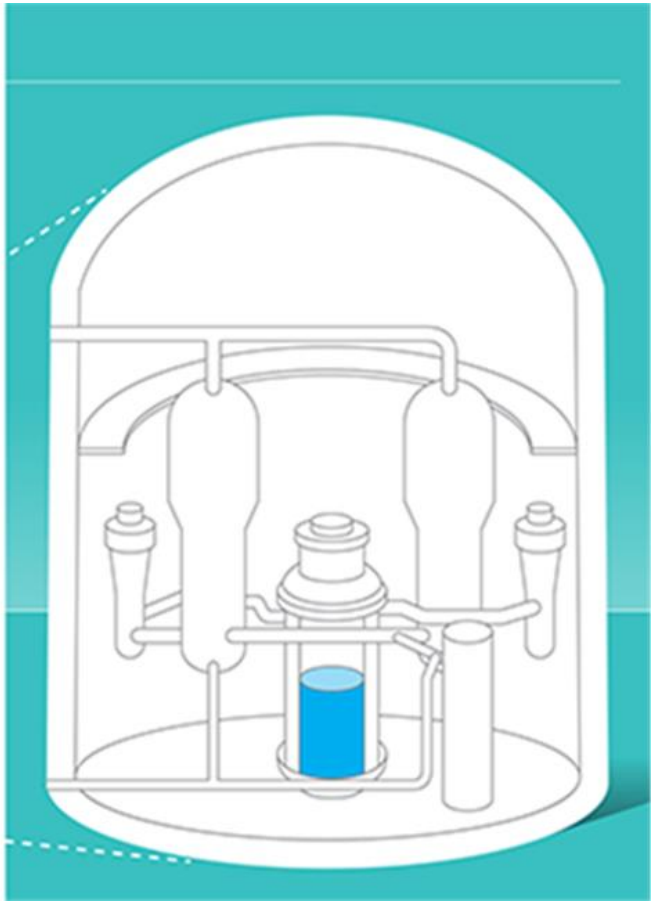
March 2021



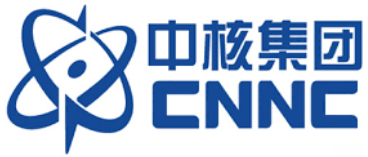
Whilst we continue to **generate the workforce** to support the operational CANDU reactor fleet and the decommissioning of retired plants, now that new nuclear capacity is a reality, Ontario Tech is responding to that.

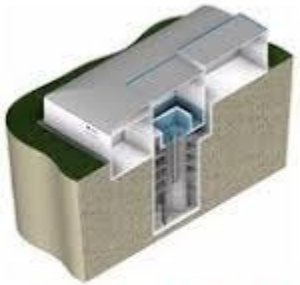
But what is an SMR?





Generally considered to have a generating capacity of <300 MWe.
Many are based on previously demonstrated concepts.





Simple ... Affordable ... Carbon free

SMRs are not new…

Factory-built

Reactors are built and/or assembled in factory facilities (modular-build).

Transported to site

Complete reactors are shipped to site for installation (representative image).

Site (e.g. HMS Tireless)

Most operational ‘SMRs’ to date have been small, sometimes integrated Pressurized Water Reactors (PWRs). Some liquid-metal cooled fast reactors have seen operational service.

Refueling and decommissioning

As submarine reactors have been operated for over 60 years, the infrastructure associated with their refueling and decommissioning is well proven.

Our place in the Canadian SMR Action Plan

- https://smractionplan.ca/content/ontario-tech-university
- …building on its core strengths and expertise, Ontario Tech pledges an **eight-point plan** of linked actions to support the SMR lifecycle from design to decommissioning:

1. Establish a Centre for Small Modular Reactors at Ontario Tech University.
2. Provide secure High-Performance Computing (HPC) capability to support SMR design and safety analysis in Canada.
3. Establish a full-scale, modular integral test facility for testing of light-water SMR safety systems.
4. Demonstrate efficient schemes for hydrogen co-generation using SMR-grade heat.
5. Promote and develop a common framework-based approach to coupled multiscale multiphysics modeling and simulation across the entire SMR lifecycle.
6. Introduce SMRs into the undergraduate nuclear engineering program at Ontario Tech.
7. Evolve Ontario Tech's model for remote delivery of education and training to support rapid development of the SMR workforce.
8. Expand awareness of the role SMRs could play in climate change and sustainability through non-engineering degree education.

Centre for Small Modular Reactors

Two-storey light water thermal-hydraulics loop

Neutronics and radiation characterization facilities

Engineering design visualization using VR/AR

SMR simulators

Secure high-performance computing

Seismic and shock testing

Working towards CSA N299

kirk.atkinson@ontariotechu.ca

Founded in February 2020, CfSMR is a **focal point** for Small Modular Reactor **research**, **consultancy**, **education** and **training** at Ontario Tech University located in the **Region of Durham**, Ontario, Canada.

"With members that have industry backgrounds in naval nuclear propulsion and SMR start-ups; CfSMR is the only academic research centre in Canada that has real-world experience of SMR design, manufacture, operation and decommissioning."

Independent verification & validation (V&V)

Environmental impact assessment & emergency response planning

Advanced manufacturing & materials characterization

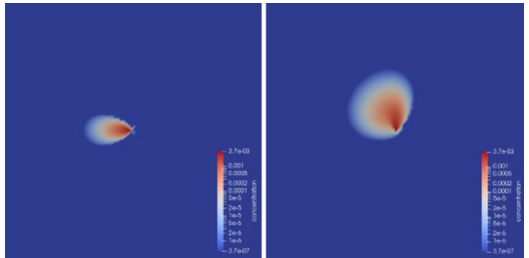
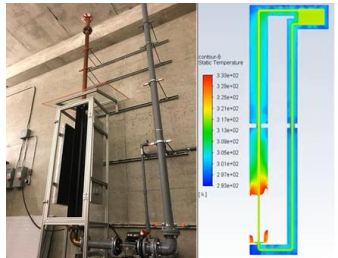
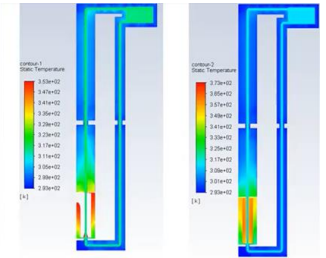
Safety case development

Modeling & simulation

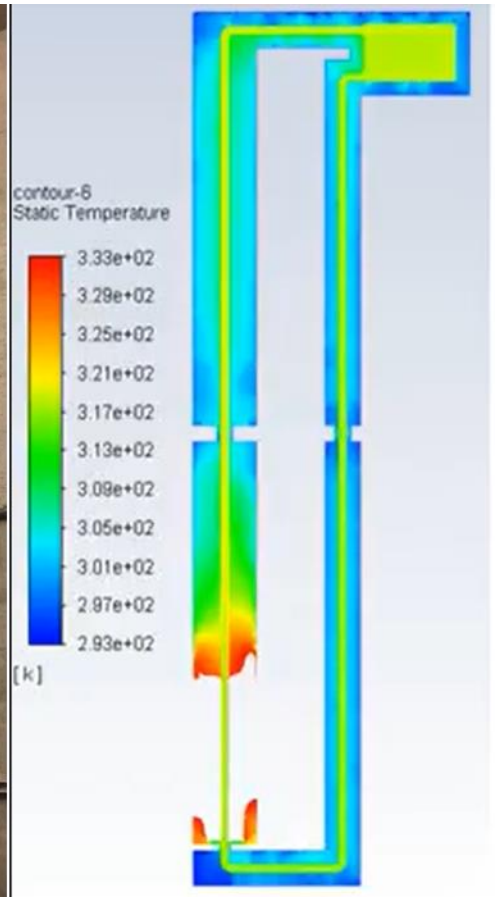
Human factors modeling & assessment

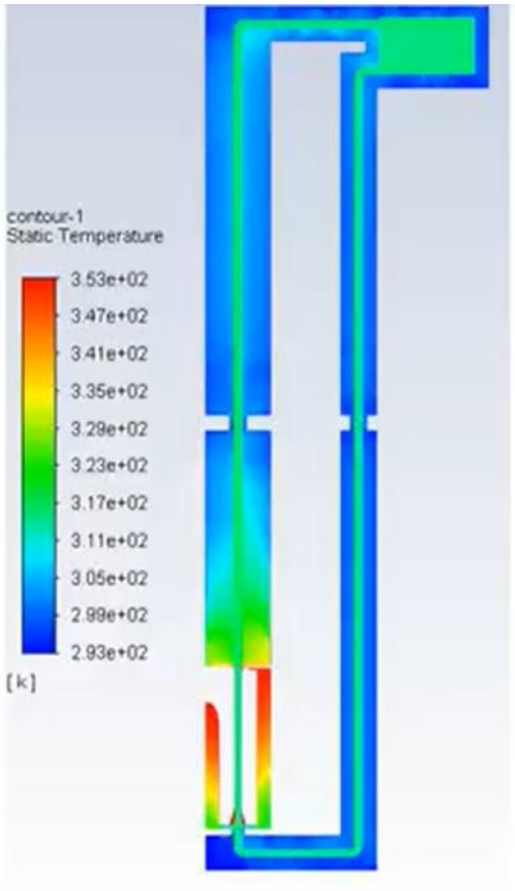
Detector & instrumentation development

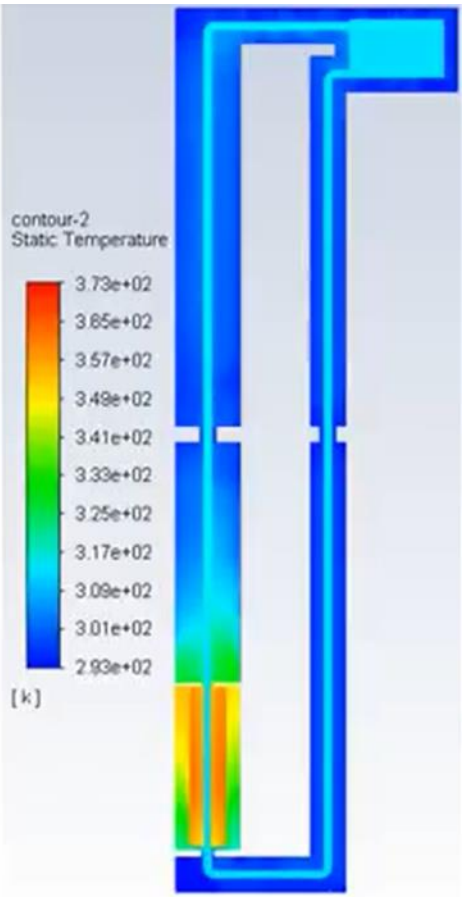
Training & (micro)credentials

Integral test facilities





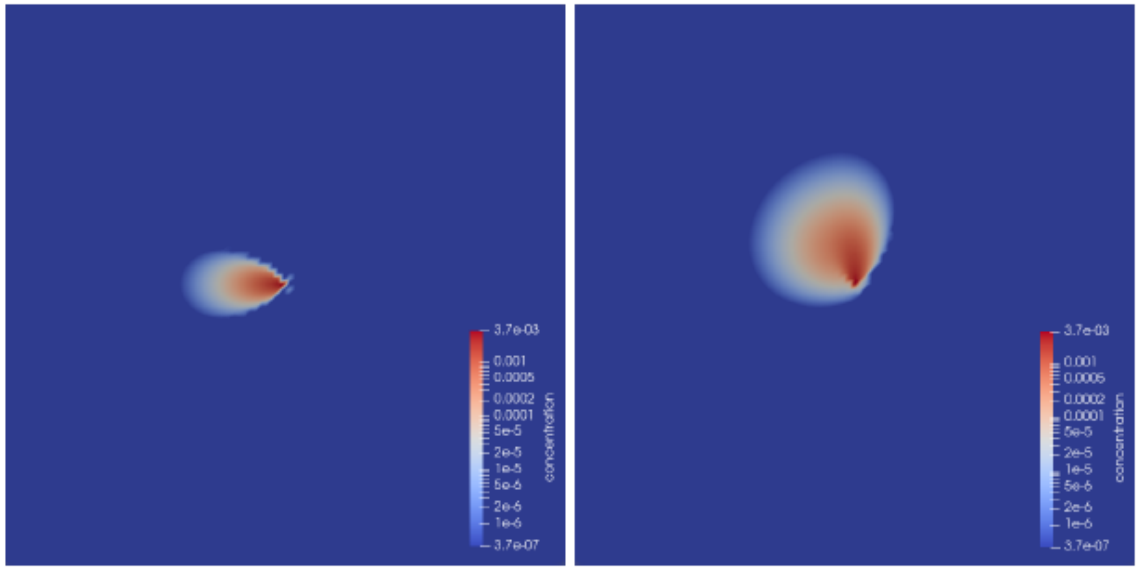


Unique-in-Canada two-story, light-water, natural circulation thermal-hydraulics (TH) loop

Used for validation and verification (V&V) of TH computer codes and testing of components.

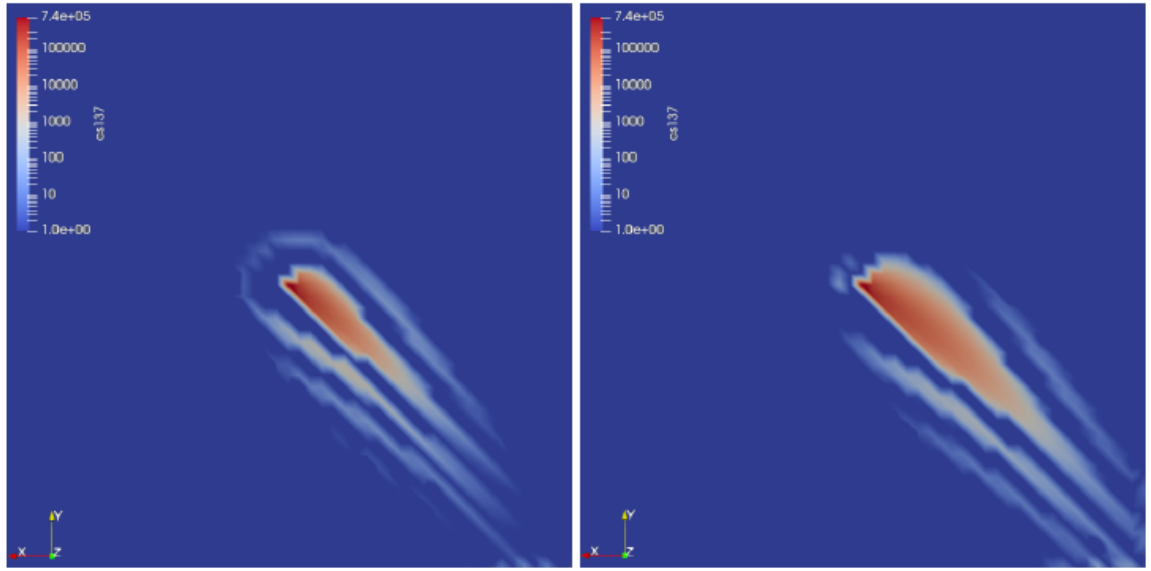
CARIBOU: A new emergency planning and consequence analysis code for an SMR world

Time-varying fields



Made-in-Canada MOOSE-based multiphysics code for predictive multiscale modelling of static and transient radiological events, esp. involving radionuclide transport in atmospheric, aquatic and soil-groundwater systems.

Chernobyl accident



Whilst still under active development, the first attempt at modeling a real event in 3D was undertaken in summer 2020.

K.D. Atkinson, K. Sawatzky, in-preparation.

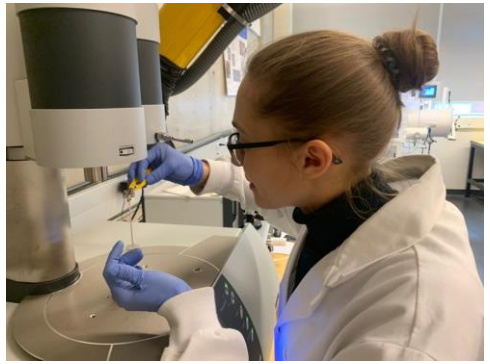
Collaborators: UNENE, INL, OPG, COG.

Funded through NSERC/UNENE Industrial Research Chair

Emerging Fuel Technologies (CRC Tier II)

Experimental

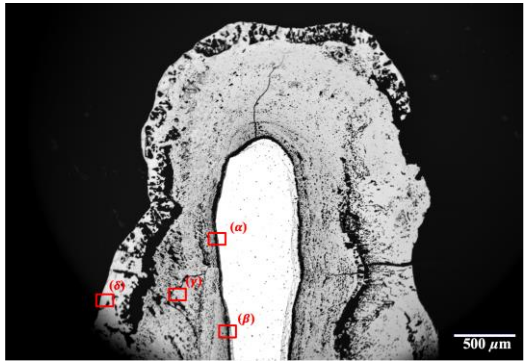
Molten salt fuel & fission product fabrication & chemistry



A sample of LiF-CsF is prepared for thermal analysis measurements.

K. Lipkina, MASc Thesis, Ontario Tech (2020).

Accident Tolerant Fuels (FeCrAl-ODS)

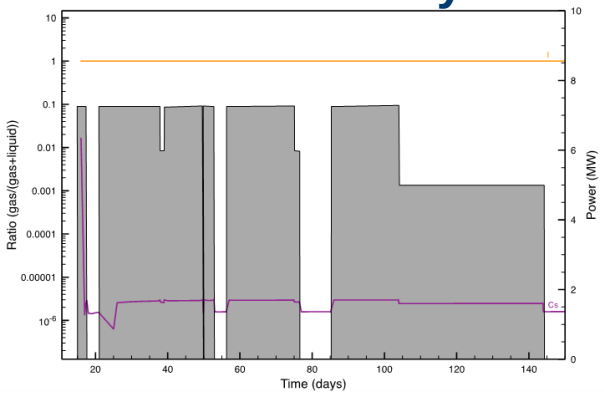


Oxidized ATF FeCrAl-ODS specimen at high temperature and high purity steam.

K. Lipkina, et al, J. Nucl. Mater., 541 (2020).

Computational

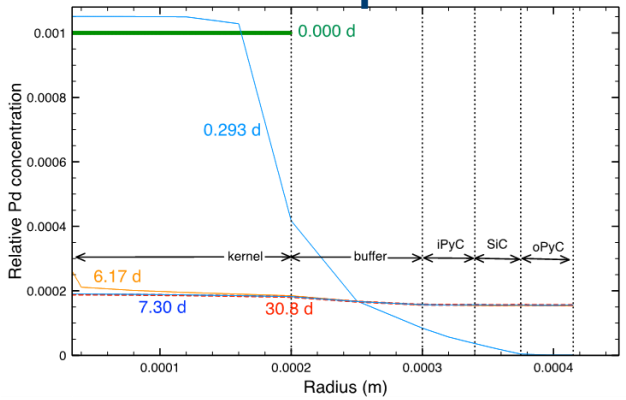
Molten Salt Material Accountancy



Iodine and Cesium off-gassing in MSRE wrt burnup (demonstration, work in-progress).

B. Fitzpatrick, **M.H.A. Piro**, to be published.

TRISO fission product transport



Pd transport from fuel kernel to surrounding layers (work in progress).

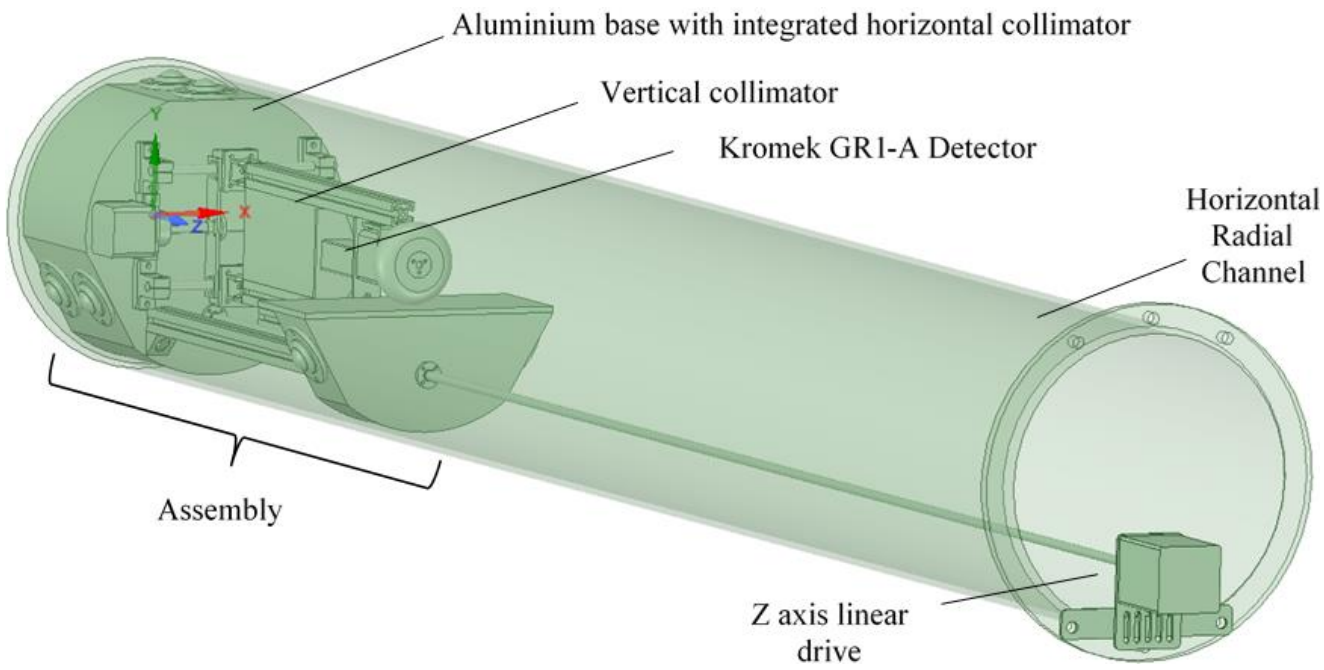
B. Fitzpatrick, M. Poschmann, T. Besmann, S. Simunoivc, M. Piro, in-preparation.

Collaborators: U. South Carolina, ORNL, MIT, U. Texas San Antonio, Nippon Nuclear Fuel Dev.

Collaborators: ORNL, INL, U. South Carolina, SAMOSAFER (European Commission), SNL.

Reactor and Radiation Monitoring

Imaging of extended objects and reactor cores

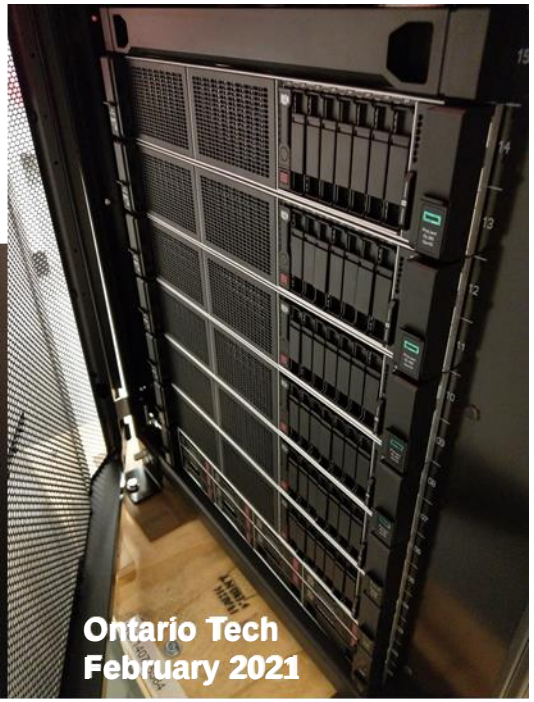


Spent fuel imaging

Funded through NSERC/UNENE Industrial Research Chair and Discovery Grant

Collaborators: OPG, COG, UNENE (previously RR, Wood).

Modeling and simulation



Ontario Tech is the only university in Canada to host a full-scope CANDU control room simulator

A decade of experience of experience in delivering secure high-performance computing for nuclear modeling and simulation

Active made-in-Canada code development: CARIBOU, Yellowjacket, and more…

Collaborators: Ontario Power Generation (OPG).

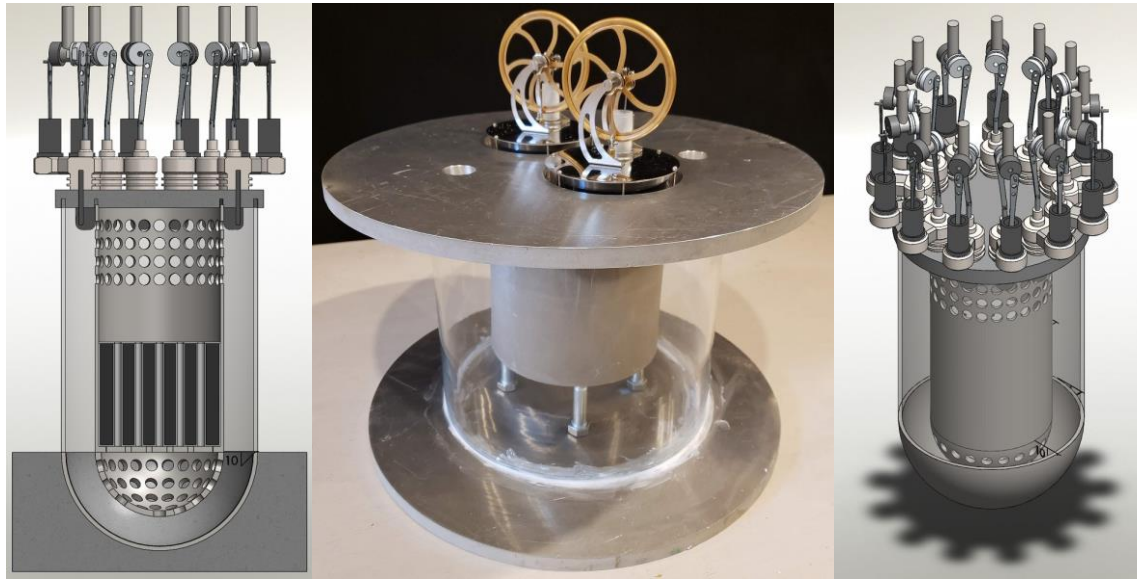
Collaborators: Phase 1 **funded by** the Centre for SMRs.

Successful students

Prize-winning capstone students

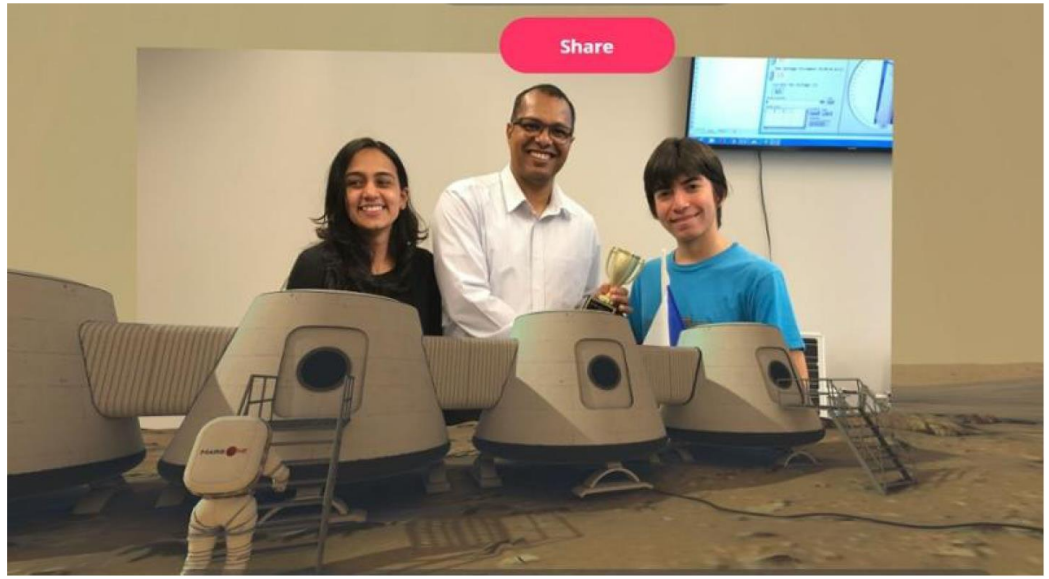
Jordan Crowell (class of 2020) won 2nd place in the American Nuclear Society's student design competition for his work with Prof. Eleodor Nichita (ex-AECL) on the ZAN4(e) micro-reactor for Canada's North. He is now a Junior Engineer with X-Energy.

ZAN4(e) microreactor



The ZAN4(e) microreactor uses advanced, inherently-safe, passive liquid-metal core cooling and rugged Stirling engines to drive electrical generators.

SMR Hackathon



Grade 12 teams were challenged to build (in a VR environment) the reactor-based primary energy supply for a Martian colony. Under the guidance of a mentor, each team designed a component of the nuclear site (e.g. security, containment, b/u power, waste storage) using a range of software and design solutions.

New facilities are coming

Subcritical Assembly

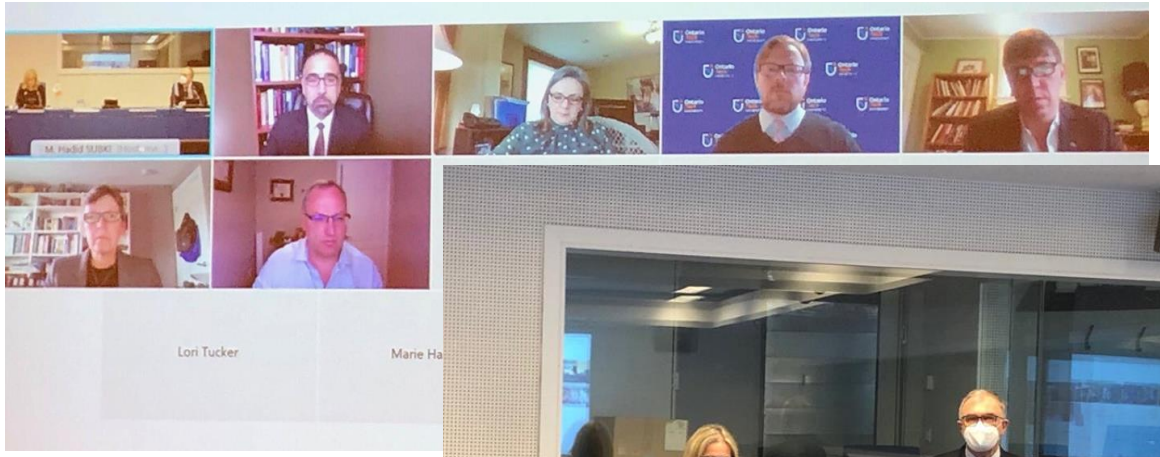
Basically a zero power nuclear reactor that **cannot ever go critical**. Will be used for teaching and research. Comprises natural uranium fuel and graphite moderator, and is being transferred from another university in Canada by CNL.

Cs-137 irradiator

330 Ci interlocked system for irradiating samples at higher dose rates (up to around 200 Sv per hour).

IAEA Collaborating Centre

Ontario Tech is the first Canadian institution to be awarded this prestigious designation

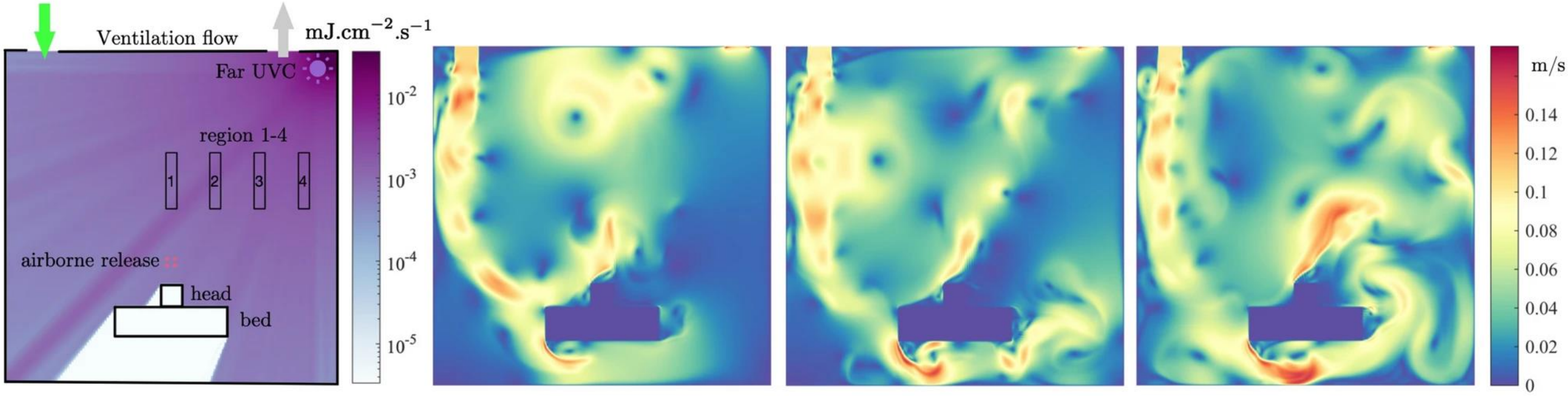


Virtual ceremony in Vienna, Austria, April 22, 2021.

Photo shows Heidi Hulan, Ambassador of Canada to Austria, and Chair, IAEA Board of Governors and Mikhail Chudakov, UN IAEA Deputy Director General and Head of the Department of Nuclear Energy holding the plaque confirming Ontario Tech as an IAEA Collaborating Centre.

https://news.ontariotechu.ca/archives/2021/05/un-international-atomic-energy-agency-designates-ontario-tech-as-a-collaborating-centre.php

Applying nuclear engineering to COVID-19



Left to right: Two-dimensional hospital or long-term care home room with bed and patient regions with superimposed far-UVC intensity field (units mJ cm^{-2} s^{-1}): Flow velocity profiles at 10, 50 and 100 s following viral release.

https://www.nature.com/articles/s41598-020-76597-y

Point of contact:

Kirk Atkinson kirk.atkinson@ontariotechu.ca