

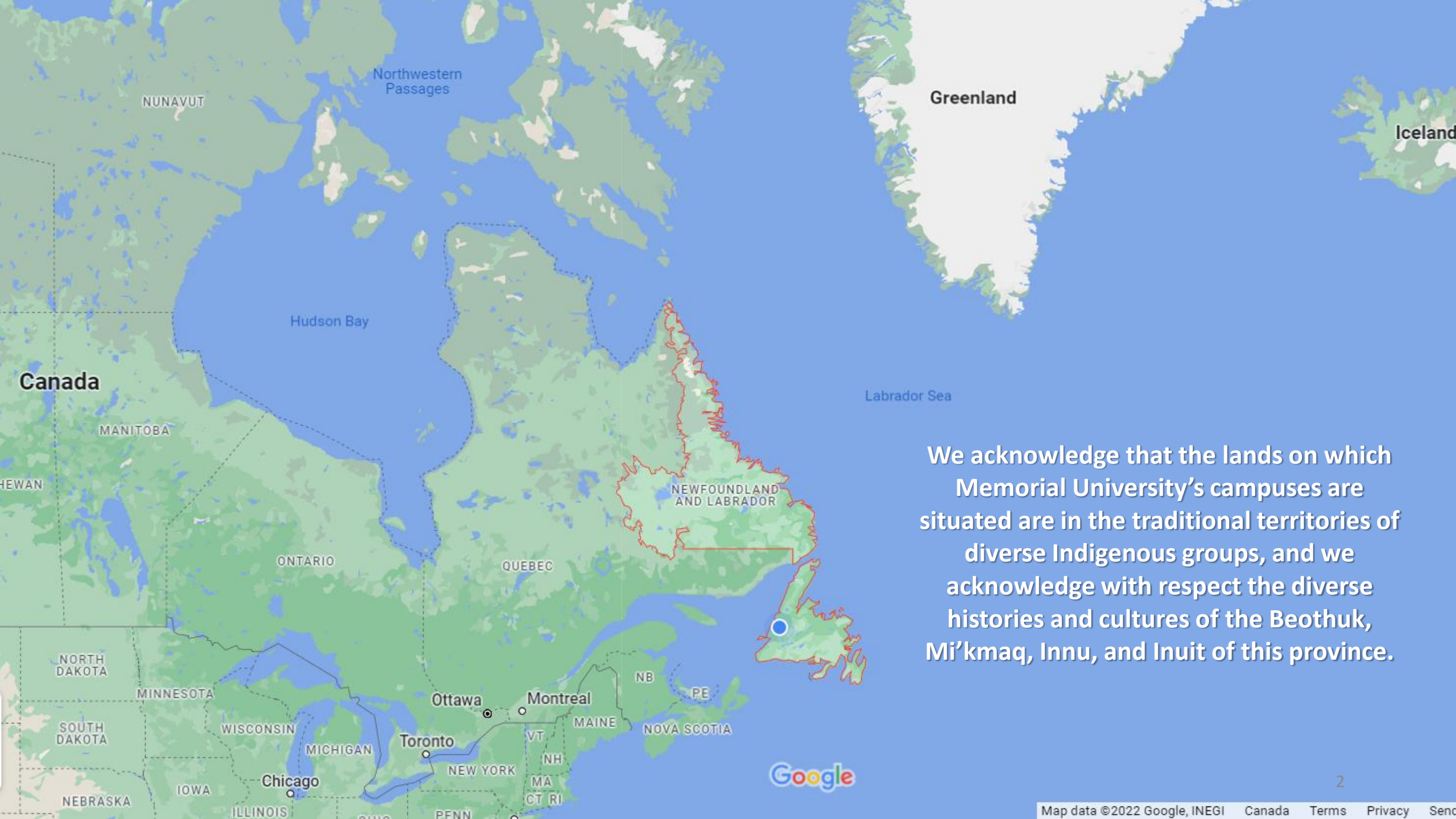
# Canadian Theory Community and the Electron-Ion Collider

Svetlana Barkanova  
Grenfell Campus, Memorial University of Newfoundland  
Corner Brook, NL, Canada

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Canadian Association of Physicists  
SUPPORTING PHYSICS RESEARCH AND EDUCATION IN CANADA



We acknowledge that the lands on which Memorial University's campuses are situated are in the traditional territories of diverse Indigenous groups, and we acknowledge with respect the diverse histories and cultures of the Beothuk, Mi'kmaq, Innu, and Inuit of this province.





“Vínland”, Norse settlement in Newfoundland, 1021 AD

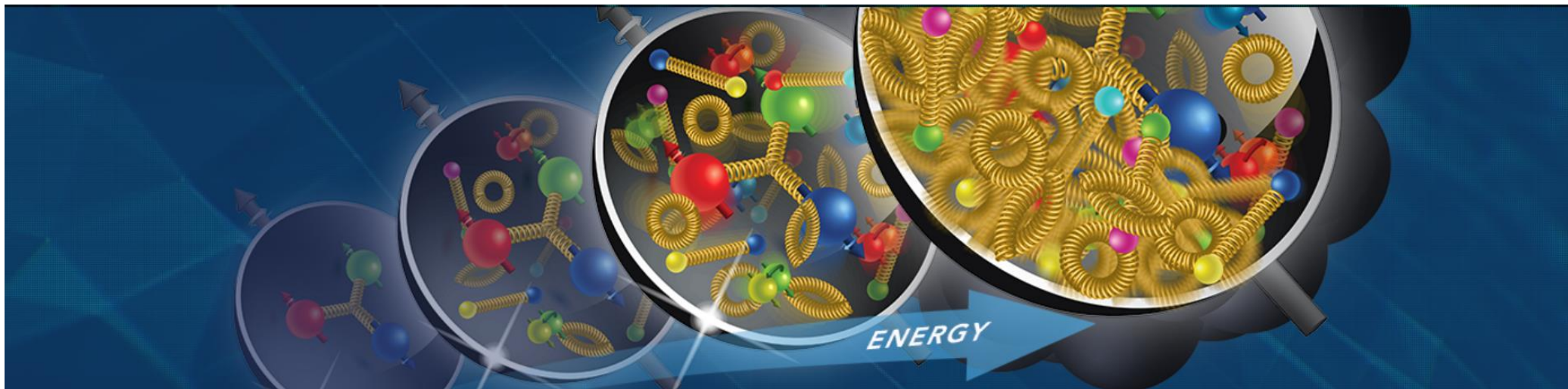


The Electron-Ion Collider (EIC) will uniquely address questions about the origin of nucleon mass and spin, properties of dense systems of gluons, as well as opportunities to connect to neutrino physics, astrophysics, and fundamental symmetries at higher energies.

Canadian theorists are valued collaborators complementing the experiment efforts worldwide, and they are currently taking roles in EIC working groups and committees and offer a broad range of contributions such as  $e+A$  gluon saturation, GPDs and TMDs, radiative corrections and Lattice QCD.

The talk will briefly outline related efforts and expertise of Canadian theory groups, and how Canadian subatomic physics community gathers to outline its vision for the next five years and beyond, placing Canadian contributions within a long-term international context.

[Electron-Ion Collider science goals \(bnl.gov\)](https://bnl.gov/eic/science-goals)

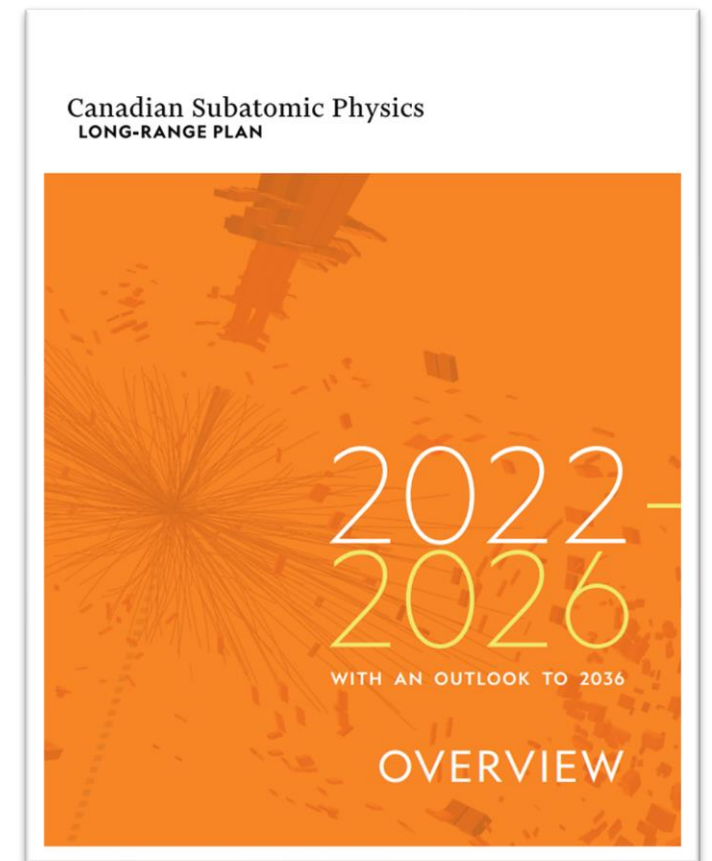
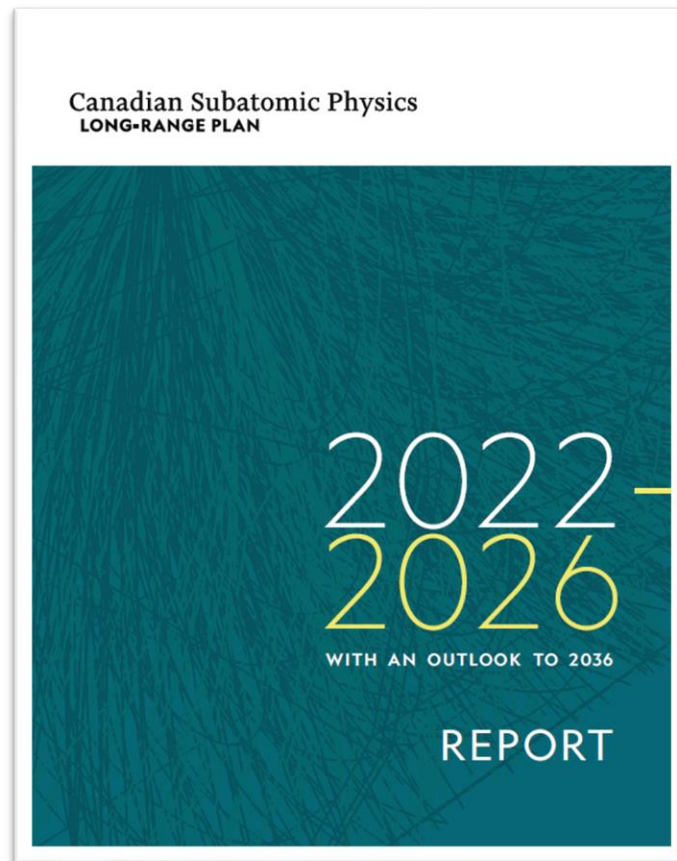




The Canadian subatomic physics community establishes its scientific and funding priorities through five-year Long-Range Plans. These plans advise the research community and relevant stakeholders on priorities for current and future endeavours. The current plan covers the period from 2022 to 2026, with an outlook to 2036.

It is jointly supported by the Institute of Particle Physics ([IPP](#)), the Canadian Institute of Nuclear Physics ([CINP](#)) and the Natural Sciences and Engineering Research Council ([NSERC](#)).

<https://subatomicphysics.ca>



## SCIENCE RECOMMENDATION 2 – **THEORY PROGRAMS**

*Critical mass and research breadth are vital for the theory community in Canada, to maximize the future impact of subatomic physics research. We recommend strong support for theoretical subatomic physics research over the next decade, both to explore new purely theoretical directions and to support the synergistic interaction between subatomic theory and experiment.*

LRP Report, p. 7, <https://subatomicphysics.ca>

## SCIENCE RECOMMENDATION

### 3 – EXPERIMENTAL PROGRAMS

*A broad experimental program is required to address the scientific drivers of subatomic physics research. We recommend pursuit of the following high-priority scientific directions.*

	<i>Flagship projects with broad physics outcomes</i>	<i>Flagship projects with strategic physics outcomes</i>
<b>FROM QUARKS AND GLUONS TO NUCLEI</b>	TRIUMF ARIEL-ISAC experiments, EIC	JLab 12 GeV program, Offshore RIB experiments
<b>MATTER IN THE WEAKLY COUPLED UNIVERSE</b>	T2K/HK, IceCube, SNO+	DEAP, PICO-500, SuperCDMS
<b>BEYOND THE ELECTROWEAK ENERGY SCALE</b>	ATLAS(LHC/HL-LHC), Belle II	ALPHA/HAICU, MOLLER, TUCAN

Jessica Strickland (LRP Report, p. 105) was the first MUN student to receive CERN/IPP summer scholarship, in 2014. Jonathan Barrett was selected in 2022; to be supervised at CERN by Matt LeBlanc, Acadia 2010 CERN/IPP award recipient.

See Jonathan's talk "Fully Immersive VR in Teaching and Science Outreach" at 3:15pm on June 8 (W3-4 DPE V), <https://indi.to/x6Lsv>.



07/06/2022

LRP Report, p. 105, <https://subatomicphysics.ca>

A screenshot of a web browser displaying the "Canadian Subatomic Physics LONG-RANGE PLAN 2022-2026" website. The browser address bar shows "https://subatomicphysics.ca/lrp...". The website has a navigation menu with "français" and "home" buttons. A table of contents is visible on the left, listing sections from "Executive Summary" to "Section 4 - Benefits to Society". The main content area features a quote from Jessica Strickland, a PhD candidate at the University of Twente, Netherlands, who mentions her research and awards, including NSERC/IPP/CERN summer awards. The quote is enclosed in a light blue box with a large quotation mark at the top left. Below the quote, her name and affiliation are listed.

Canadian Subatomic Physics  
LONG-RANGE PLAN  
2022-2026

français home

Executive Summary

Introduction

Section 1 - Science Drivers and Canadian Research Impact

Section 2 - Canadian Subatomic Physics Research Plan

Section 3 - Realizing the Research Plan

Section 4 - Benefits to Society

“

*I'm currently a PhD candidate in the Netherlands using a supercomputer to simulate the atmospheric boundary layer and large-scale wind farms. However, my first research projects were in subatomic physics, with NSERC/IPP/CERN summer awards. Though the physics I do now is more applied, I wouldn't be here without the foundation that I received at the Grenfell campus of the Memorial University of Newfoundland. The professors always had an open door, put in the time, and genuinely wanted us to succeed. Not only did I gain research and computing skills which I use to this day, but I also learned that great things were not out of reach.*

— JESSICA STRICKLAND (BSC MEMORIAL UNIVERSITY, GRENFELL), PHD  
CANDIDATE AT UNIVERSITY OF TWENTE, NETHERLANDS

S. Barkanova, CAP Congress 2022

8



Please join us for DGEP  
 ([Division for Gender Equity in Physics](#))  
 Networking Session 3:15pm – 4:30pm  
 June 8 (W3-5)!

Everyone is very welcome!

The DGEP Executive Committee 2022:  
 Svetlana Barkanova – Chair  
 Carolyn Sealton – Vice Chair and Chair Elect  
 Juliette Mammei – Treasurer  
 James Botte – Past Chair



Canadian Association of Physicists  
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07/06/2022

14:00

MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ... MDCL 1... 13:15 ...

Health Break with Exhibitors | Pause santé avec exposants

15:00

McMaster University

W3-1 N... Evan M... W3-10 ... Steffon ... W3-2 Fr... Robert ... W3-3 C... Melanie... W3-4 DPE V (DPE) | DEP V (DEP) W3-5 P... James ... W3-6 M... Matthia... W3-7 Li... Robert ... W3-8 S... Robert ...

16:00

MDCL 1... 15:15 ... MDCL 1... 15:15 ... MDCL 1... 15:15 ... MDCL 1... 15:15 ... MDCL 1... 15:15 ...

W3-5 Panel Report on ICWiP Mtg + DGEP Networking Session (DGEP) | Rapport sur la réunion CIFEP et session de réseautage DGEP (DGEP) (W3-5)

Block

🕒 3:15 PM - 4:30 PM

📍 MDCL 1309 (McMaster University)

Session

W3-5 Panel Report on ICWiP Mtg + DGEP Networking Session (DGEP) | Rapport sur la réunion CIFEP et session de réseautage DGEP (DGEP)

Contributions 1

17:00

Student... CAP Pr... Robert ...

McMast... 16:30 ... CAP-le... MDCL 1... 16:45 ...

McMast... 16:45 ...

18:00

Break: (for those who purchased tickets) Pause pour sou...

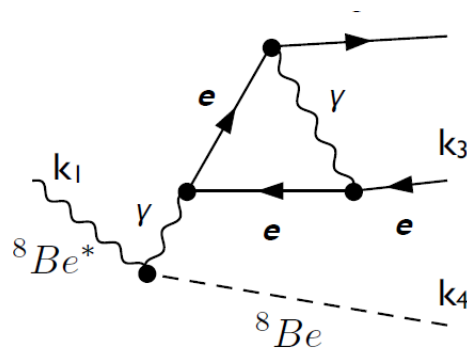
Front of MDCL, McMaster University 18:00 - 18:30

S. Barkanova, CAP Congress 2022

CAP Banquet + Fellows Recognition Dinner - Limited

Canadian theorists work on projects ranging from developing a predictive ab-initio theory of nuclear structure and nuclear reactions to phenomenological approaches guided by empirical data in close collaboration with experiment, and on everything in between.

Theorists offer a broad range of contributions such as  $e+A$  gluon saturation, generalised parton distributions (GPDs) and transverse momentum dependent parton distributions (TMDs), radiative corrections and Lattice QCD.



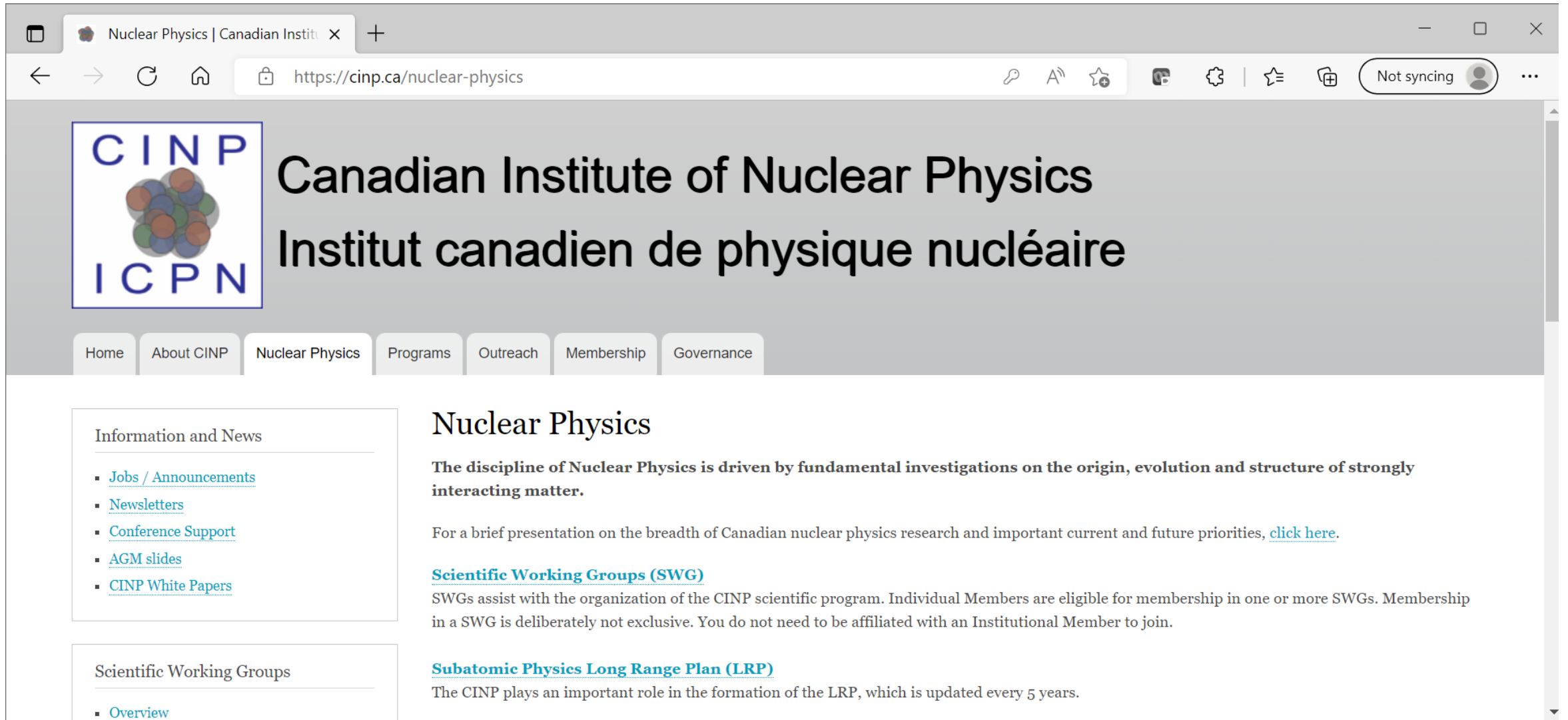
[LRP, p. 40](#)

## Canadian Contributions and Achievements

*Canadians are at the forefront of the quest to understand the properties of hadrons, on both the experimental and theoretical fronts. Canadian achievements in the past five years include the following.*

- The Canadian theoretical community leverages a range of calculational approaches, including Lattice QCD, Light Front Holographic QCD and Chiral Perturbation Theory to advance the field and to support the Canadian experimental efforts. For example, recent achievements include the first direct lattice QCD calculation predicting the existence of tetraquarks with valence content  $ud\bar{b}\bar{b}$ , and calculations of the Standard Model predictions for the differential branching ratio of the rare decay  $B_s \rightarrow \phi\mu^+\mu^-$ .

CINP plays an important role and the formation of LRP. See [CINP 2020 LRP Brief \(600dpi\)](#).



The screenshot shows a web browser window with the URL <https://cinp.ca/nuclear-physics>. The page features the CINP logo (ICPN) and the text "Canadian Institute of Nuclear Physics" and "Institut canadien de physique nucléaire". A navigation menu includes "Home", "About CINP", "Nuclear Physics", "Programs", "Outreach", "Membership", and "Governance". The "Nuclear Physics" section is highlighted, containing the following text:

## Nuclear Physics

**The discipline of Nuclear Physics is driven by fundamental investigations on the origin, evolution and structure of strongly interacting matter.**

For a brief presentation on the breadth of Canadian nuclear physics research and important current and future priorities, [click here](#).

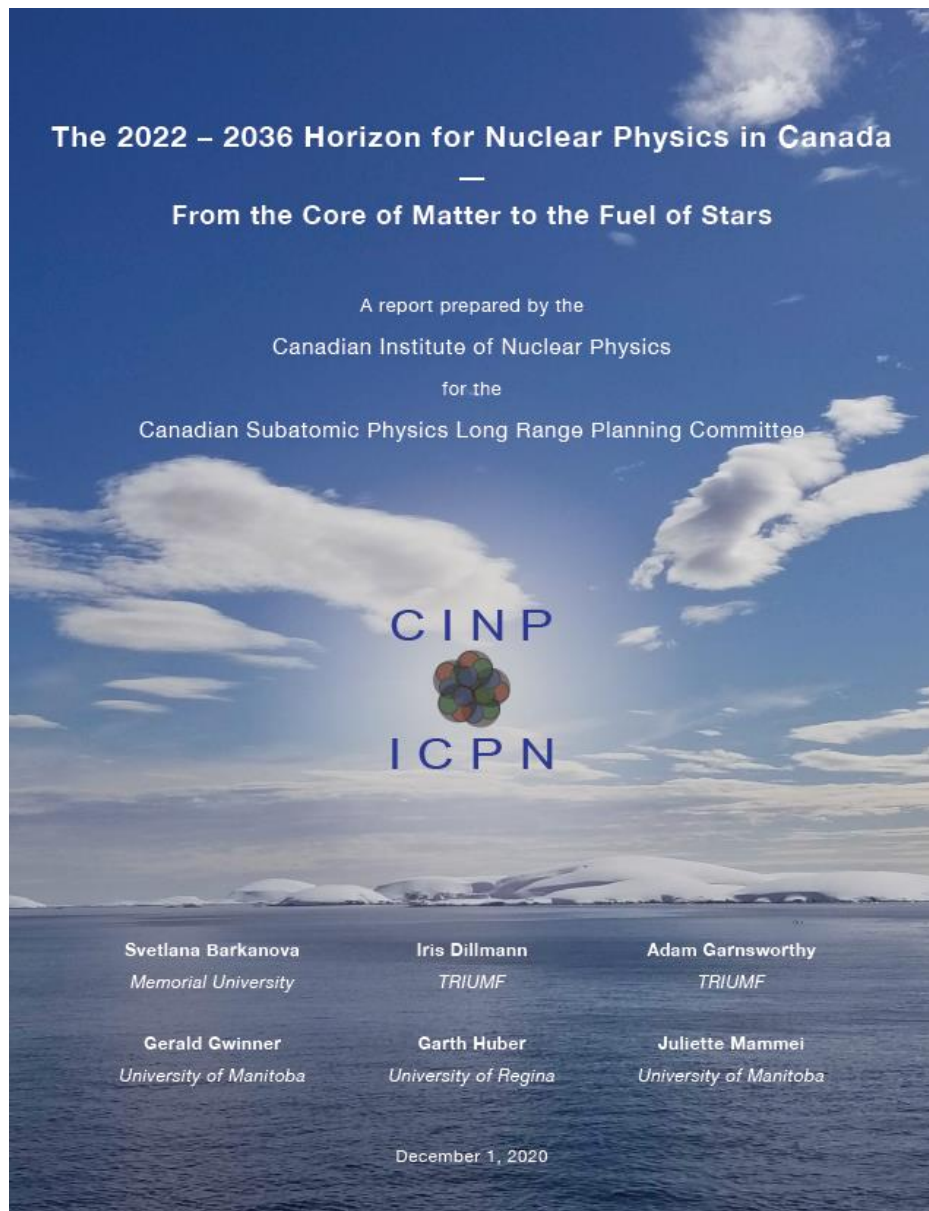
**[Scientific Working Groups \(SWG\)](#)**  
SWGs assist with the organization of the CINP scientific program. Individual Members are eligible for membership in one or more SWGs. Membership in a SWG is deliberately not exclusive. You do not need to be affiliated with an Institutional Member to join.

**[Subatomic Physics Long Range Plan \(LRP\)](#)**  
The CINP plays an important role in the formation of the LRP, which is updated every 5 years.

On the left side of the page, there are two sidebar sections:

- Information and News**
  - [Jobs / Announcements](#)
  - [Newsletters](#)
  - [Conference Support](#)
  - [AGM slides](#)
  - [CINP White Papers](#)
- Scientific Working Groups**
  - [Overview](#)





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**New in 2021** – CINF Nuclear Theory working group, lead by Alexandros Gezerlis, with 27 members so far:



The screenshot shows a web browser window with the URL <https://cinp.ca/scientific-working-groups>. The page features the CINF logo (a cluster of colored spheres) and the text "Canadian Institute of Nuclear Physics" and "Institut canadien de physique nucléaire". A navigation menu includes "Home", "About CINF", "Nuclear Physics", "Programs", "Outreach", "Membership", and "Governance".

**Information and News**

- [Jobs / Announcements](#)
- [Newsletters](#)
- [Conference Support](#)
- [AGM slides](#)
- [CINF White Papers](#)

**Scientific Working Groups**

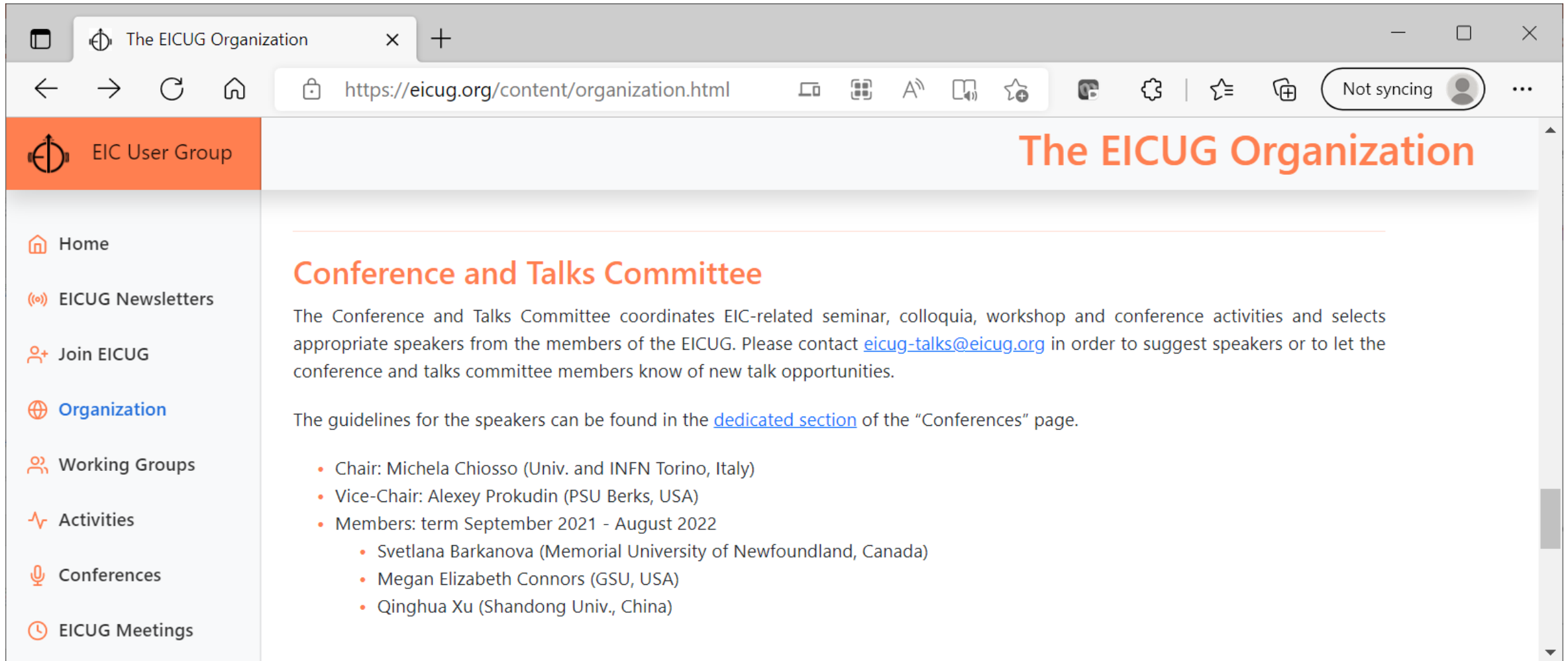
The CINF bylaws allow for the creation of Scientific Working Groups (SWGs) to assist with the organization of the Institutes scientific program.

Working Group	Chair	Institution	Contact
Nuclear Structure	Adam Garnsworthy	TRIUMF	<a href="mailto:garns@triumf.ca">garns@triumf.ca</a>
Nuclear Astrophysics	Iris Dillmann	TRIUMF	<a href="mailto:dillmann@triumf.ca">dillmann@triumf.ca</a>
Fundamental Symmetries	Gerald Gwinner	University of Manitoba	<a href="mailto:gwinner@physics.umanitoba.ca">gwinner@physics.umanitoba.ca</a>
Hadronic Physics/QCD	Svetlana Barkanova	Memorial University	<a href="mailto:sbarkanova@grenfell.mun.ca">sbarkanova@grenfell.mun.ca</a>
Nuclear Theory	Alexandros Gezerlis	University of Guelph	<a href="mailto:gezerlis@uoguelph.ca">gezerlis@uoguelph.ca</a>
Nuclear Physics Education and Training	Juliette Mammei	University of Manitoba	<a href="mailto:jmammei@physics.umanitoba.ca">jmammei@physics.umanitoba.ca</a>

**Scientific Working Groups**

- [Overview](#)

Canadian theorists are valued collaborators complementing the experiment efforts worldwide, and they are currently taking roles in EIC working groups.



The screenshot shows a web browser window with the URL <https://eicug.org/content/organization.html>. The page title is "The EICUG Organization". The left sidebar contains a navigation menu with the following items: Home, EICUG Newsletters, Join EICUG, Organization (highlighted), Working Groups, Activities, Conferences, and EICUG Meetings. The main content area features the heading "Conference and Talks Committee" in orange. Below the heading, the text states: "The Conference and Talks Committee coordinates EIC-related seminar, colloquia, workshop and conference activities and selects appropriate speakers from the members of the EICUG. Please contact [eicug-talks@eicug.org](mailto:eicug-talks@eicug.org) in order to suggest speakers or to let the conference and talks committee members know of new talk opportunities." Below this, it says: "The guidelines for the speakers can be found in the [dedicated section](#) of the "Conferences" page." A bulleted list of committee members follows:

- Chair: Michela Chiosso (Univ. and INFN Torino, Italy)
- Vice-Chair: Alexey Prokudin (PSU Berks, USA)
- Members: term September 2021 - August 2022
  - Svetlana Barkanova (Memorial University of Newfoundland, Canada)
  - Megan Elizabeth Connors (GSU, USA)
  - Qinghua Xu (Shandong Univ., China)

[The EICUG Organization](#)

[Talk Guidelines](#)



Seven Canadian universities are institutional members of EIC User Group:

The screenshot shows a web browser window with two tabs: 'The EICUG Organization' and 'Electron-Ion Collider Users Group'. The address bar shows the URL 'https://phonebook.sdcc.bnl.gov/eic/client/'. The page title is 'PhoneBook: Electron-Ion Collider Users Group'. A search bar at the top right contains the text 'canada'. Below the search bar is a table with four columns: 'Full name of the institution', 'Institution acronym', 'Country', and 'Region of the World'. The table lists seven Canadian universities. A footer at the bottom of the page reads 'EIC User Group, 2015-2016'.

Full name of the institution	Institution acronym	Country	Region of the World
Acadia University		🇨🇦 CANADA	NORTH AMERICA
Dalhousie University		🇨🇦 CANADA	NORTH AMERICA
McGill University		🇨🇦 CANADA	NORTH AMERICA
Memorial University of Newfoundland, Grenfell Campus	MUN	🇨🇦 CANADA	NORTH AMERICA
Mount Allison University	MTA	🇨🇦 CANADA	NORTH AMERICA
University of Manitoba		🇨🇦 CANADA	NORTH AMERICA
University of Regina		🇨🇦 CANADA	NORTH AMERICA

Showing 1 to 7 of 7 entries (filtered from 267 total entries)

EIC User Group, 2015-2016

[The EICUG Organization](#)

LRP, p. 57 : “There is significant synergy between the EIC and 12 GeV JLab program, with a rich and diverse set of experiments capable of precisely studying QCD, from the nature of the finite temperature many-body problem, to mapping the transition from hadronic to partonic degrees of freedom.”

The input from theorists is especially essential in the study of fundamental symmetries with parity-violating electron scattering.

Canadian groups have a long history of working with JLab (QWeak, MOLLER, SoLID) studies of the evolution of the fundamental electroweak coupling and search for physics beyond the Standard Model.

An EIC would naturally extend this program, studying fundamental at symmetries higher energies.



The advancement of nuclear physics is strongly dependent on interplay between theory and experiment, and many Canadian research programs are the excellent examples of such successful collaboration.

The Canadian effort is distributed in several groups coast-to-coast, from British Columbia to Newfoundland and Labrador, building intellectual capacity in their regions and pursuing a broad range of initiatives.



LRP, p. 78



Progress in nuclear theory, both from a fundamental point of view, and in its connection with experimental measurements, is proceeding on several fronts at once, and it is thus imperative to maintain a vibrant and diverse theoretical program.

LRP, p. 87: “Full pursuit of the proposed research plan, including (a–c) above require a growth in research capacity and HQP over the next five years. Indeed, there is recognition that the community has the capacity to train 40% more graduate students.”

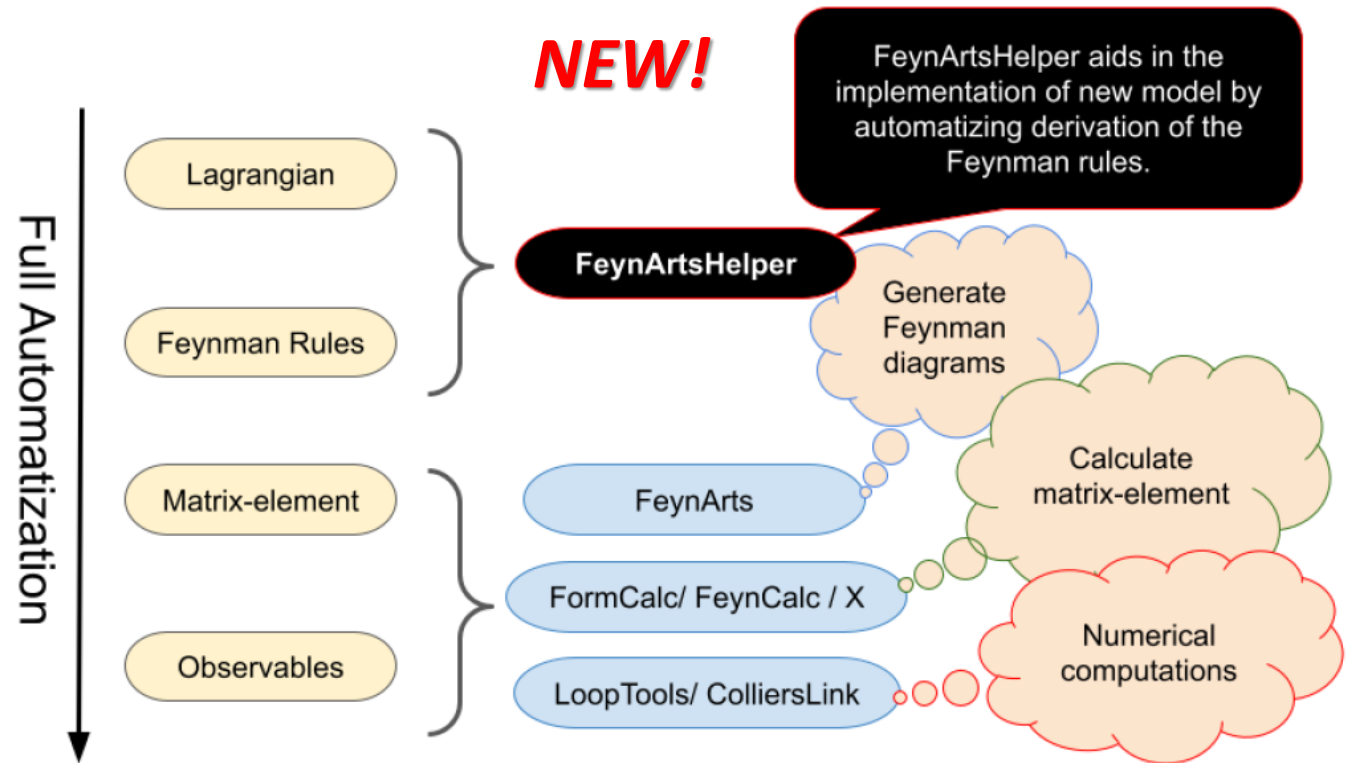
TABLE 1. The number of NSERC-funded subatomic physics investigators in 2011, 2015 and 2021, broken down by geographical region. The subatomic physics community continues to be vibrant with strength across all regions in Canada, and significant recent growth in Ontario.

Region	2011	2015	2021
British Columbia (BC)	86	88	88
Prairies (AB, SK, NB)	38	38	40
Ontario (ON)	60	66	81
Quebec (QC)	35	31	32
Atlantic (NL, NB, NS, PE)	6	8	8
<b>Total</b>	<b>225</b>	<b>231</b>	<b>251</b>

LRP, p. 78



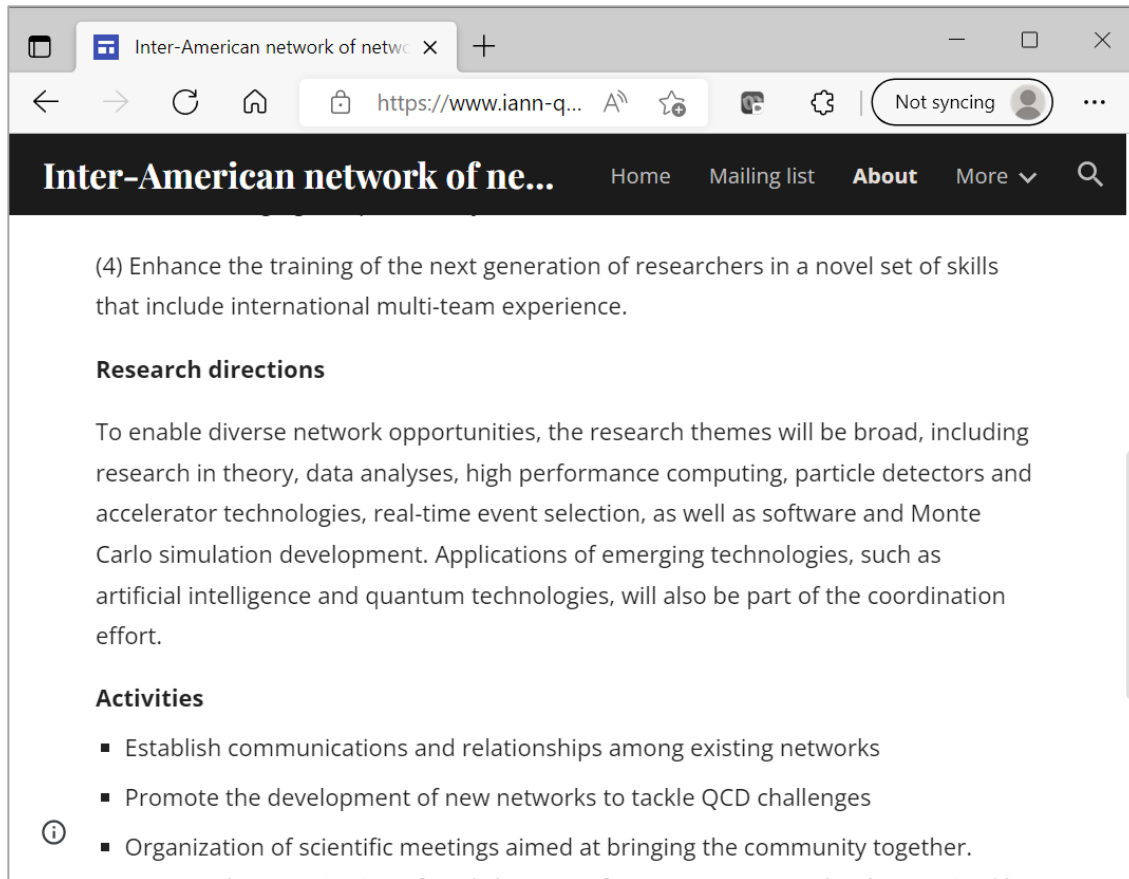
MUN group at Deer Lake Airport, June 4, 2022



FeynArtsHelper, Reefat, MUN, CAP2022, <https://indi.to/M67Ld>.

Higher-Order Leptonic Corrections (relevant to EIC, MUSE, MOLLER etc.), Mahumm Ghaffar, CAP2022, <https://indi.to/r44GF>.

Launched in December in 2021: [The Inter-American Network of Networks of QCD Challenges](#) to develop strategic partnerships across the United States, Canada and Latin America to address QCD challenges. It will provide collaborative research opportunities and enable the training of students and early-career scientists in international multi-team nuclear and particle physics projects.



Inter-American network of ne... Home Mailing list About More ▾

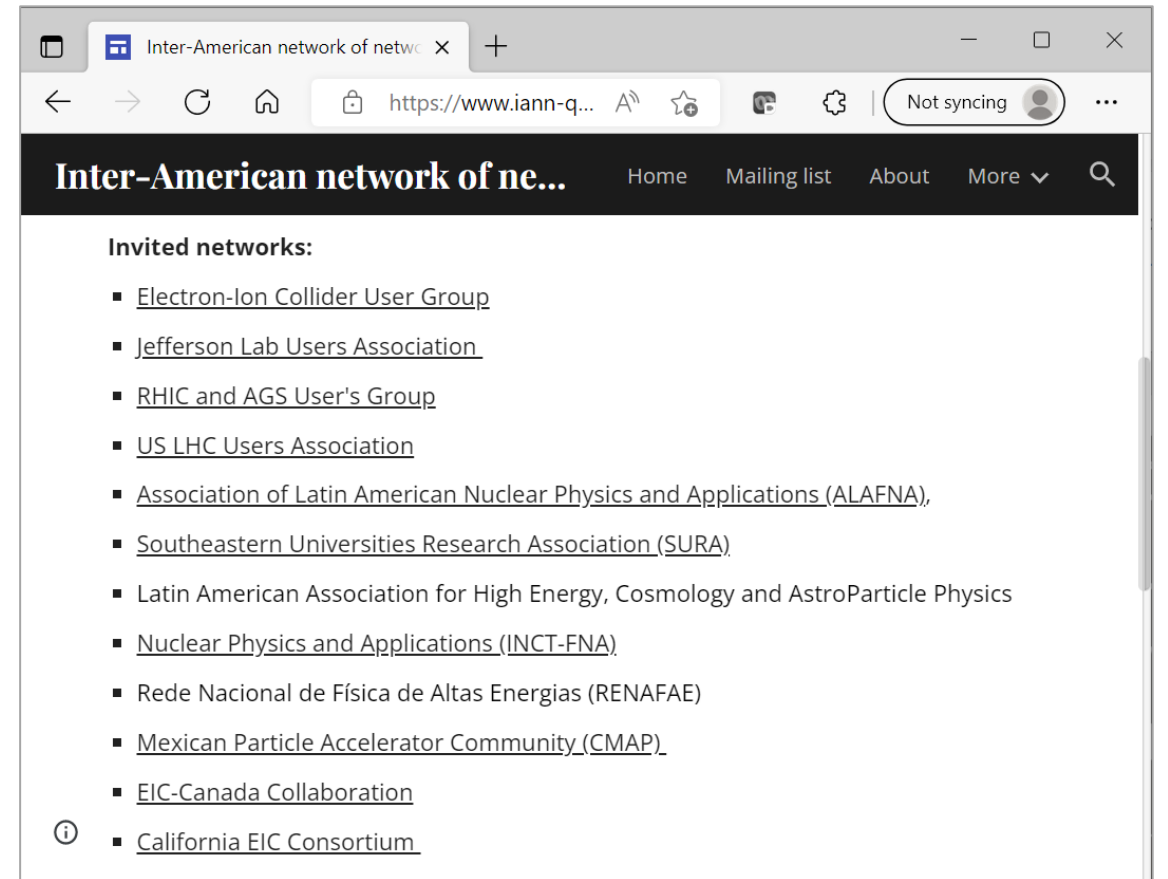
(4) Enhance the training of the next generation of researchers in a novel set of skills that include international multi-team experience.

**Research directions**

To enable diverse network opportunities, the research themes will be broad, including research in theory, data analyses, high performance computing, particle detectors and accelerator technologies, real-time event selection, as well as software and Monte Carlo simulation development. Applications of emerging technologies, such as artificial intelligence and quantum technologies, will also be part of the coordination effort.

**Activities**

- Establish communications and relationships among existing networks
- Promote the development of new networks to tackle QCD challenges
- Organization of scientific meetings aimed at bringing the community together.



Inter-American network of ne... Home Mailing list About More ▾

**Invited networks:**

- [Electron-Ion Collider User Group](#)
- [Jefferson Lab Users Association](#)
- [RHIC and AGS User's Group](#)
- [US LHC Users Association](#)
- [Association of Latin American Nuclear Physics and Applications \(ALAFNA\)](#),
- [Southeastern Universities Research Association \(SURA\)](#)
- Latin American Association for High Energy, Cosmology and AstroParticle Physics
- [Nuclear Physics and Applications \(INCT-FNA\)](#)
- Rede Nacional de Física de Altas Energias (RENAFAE)
- [Mexican Particle Accelerator Community \(CMAP\)](#)
- [EIC-Canada Collaboration](#)
- [California EIC Consortium](#)



# Thank You! Questions?

**Svetlana Barkanova**  
**Grenfell Campus, Memorial University of Newfoundland**  
**Corner Brook, NL, Canada**

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<https://doi.org/10.1038/s41586-021-03972-8>  
[Evidence for European presence in the Americas in ad 1021](https://doi.org/10.1038/s41586-021-03972-8)  
[\(nature.com\)](https://doi.org/10.1038/s41586-021-03972-8)

Kuitemans, M., Wallace, B.L., Lindsay, C. *et al.* Evidence for European presence in the Americas in AD 1021. *Nature* **601**, 388–391 (2022).

Until 2021, it was believed the Norse settlement at L'Anse aux Meadows in Newfoundland was established around AD 1000.

The original date was based on radiocarbon techniques, but 2021 study based on mass spectrometry identified wiggly tree rings caused by a solar storm in AD 993, which allowed to determine the year the trees were cut down as AD 1021.

