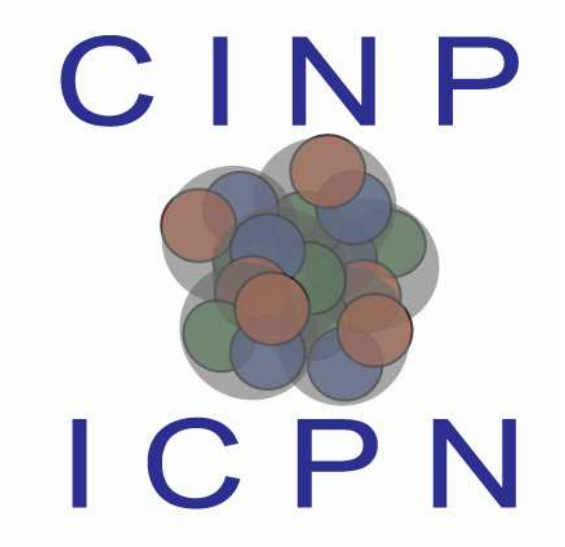


Canadian Institute of Nuclear Physics

Institut canadien de physique nucléaire

NSERC Subatomic Physics Context Session
December 15, 2023

What is the CINP?

CINP ICPN

- The CINP is a formal organization of the Canadian nuclear physics research community to promote excellence in nuclear research and education, and to advocate the interests and goals of the community both domestically and abroad
  - Federally incorporated under the Canada Not–for–profit Corporations Act
- Represents researchers covering all aspects of experimental and theoretical nuclear physics. Co–ordinates planning on a national scale and exchanges information within and between the various sub–fields of nuclear physics
- Leads initiatives to strengthen the level and quality of nuclear physics research in Canada, including fellowships, undergraduate research scholarships, student travel awards, and targeted conference support

CINP Governance

CINP ICPN

Institutional Members
McGill University
Memorial University of Nfld
Mount Allison University
Saint Mary's University
Simon Fraser University
TRIUMF
University of Guelph
University of Manitoba
University of Northern B.C.
University of Regina
University of Winnipeg

Pay Annual Dues and Elect Board

Board of Directors
Gwen Grinyer *President*
Thomas Brunner
Liliana Caballero
Rituparna Kanungo
Russell Mammei
Chris Ruiz

Executive Director
Garth Huber

Treasurer
Greg Hackman

Scientific Working Groups

CINP ICPN

SWGs facilitate collaboration among researchers with common interests, and to enhance the profile of a specific research area within Canada

- Provide input to CINP external scientific briefs
- Hold topical workshops or other initiatives
- Encourage new collaborative efforts

- **Individual Members may belong to one or more SWGs**
- **Nuclear Theory SWG was created in 2021 in follow up to Long Range Planning consultations**

SWG	Chair	Institution
Nuclear Structure	Adam Garnsworthy	TRIUMF
Nuclear Astrophysics	Iris Dillmann	TRIUMF
Fundamental Symmetries	Gerald Gwinner	University of Manitoba
Hadron Structure/QCD	Svetlana Barkanova	Memorial University of Newfoundland
Nuclear Theory	Alexandros Gezerlis	University of Guelph
Nuclear Physics Education and Training	Juliette Mammei	University of Manitoba

SWG 5 Year Review

- CINP bylaws require each SWG be reviewed every 5 yrs.
- Ensures the SWG remain scientifically relevant and that no urgent issue related to CINP mission is neglected.
- One major duty of SWG Chair is to help write the CINP Brief for input to the NSERC Subatomic Physics Long Range Plan (LRP).
- **In preparation for the next LRP process, we have begun the formal review of all SWGs, including elections for new Chairs within each SWG spring 2024.**
  - Working under the assumption LRP to begin in spring of 2025 with report submitted to NSERC in fall 2026.
- We are also looking to develop a stronger role for the SWGs, including enhanced funding for activities, etc.

CINP Individual Membership

CINP Membership December 1, 2023	
Total Membership	171
Faculty (Full) Members	89
Associate Members (Grad Students, PDFs, Professor Emeriti)	82
Experimentalists	123
Theorists	46

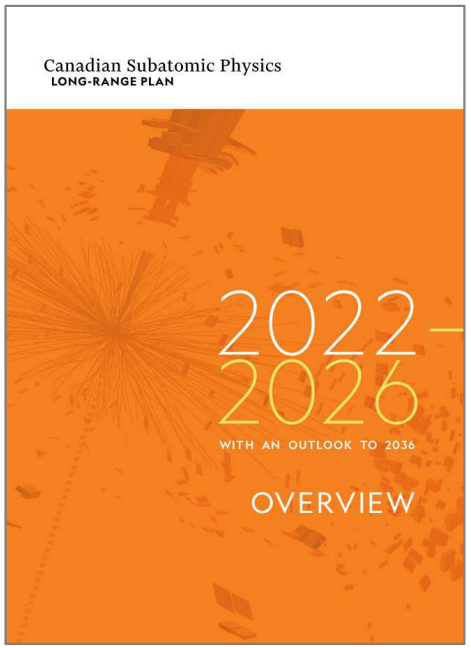
SWG Membership	
Nuclear Astrophysics	**71**
Nuclear Structure	**73**
Fundamental Symmetries	**76**
Hadrons/QCD	**55**
Nuclear Theory	**33**
Nuclear Physics Education & Training	**56**

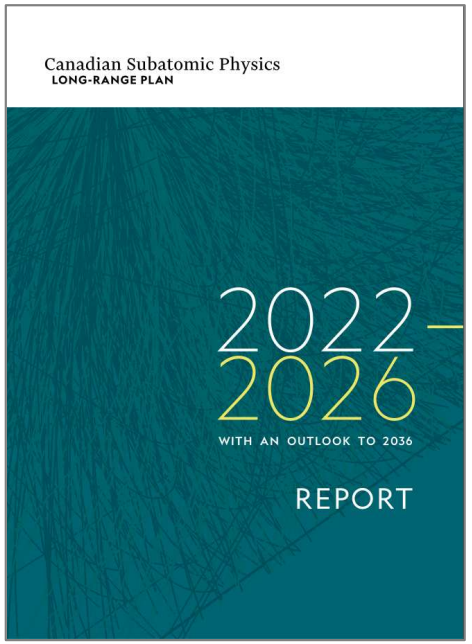
CINP 2023 Accomplishments

- **Nuclear Physics Representation**
  - **The CINP has been vital in giving the nuclear physics community a coherent and strong voice**
  - Periodic meetings with senior leadership of NSERC, CFI, ISED, TRIUMF on matters of importance to NP
  - Advocated to PMO, Finance re. TRIUMF 5 year funding request for 2025–2030
  - Suggests new members for SAPES
  - NP Community Representative at Advisory Committee on TRIUMF (ACOT), April and November annually
  - NP input to Pan–Canadian MRS Resource Planning Board ~6 meetings/yr
  - Formal observer to NuPECC (Nuclear Physics European Collaboration Committee)

CINP role in 2022–26 Long Range Plan

- **CINP was one of three commissioning bodies** (with NSERC, IPP) **of Canadian Subatomic Physics Long Range Plan**
- CINP Exec Dir is an Ex–Officio member on LRPC, CINP leaders Rituparna Kanungo, Jeff Martin, Juliette Mammei voting members
- **CINP undertook broad consultation with the Canadian Nuclear Physics Research community**
- Produced a substantial White Paper: 187 pages that fed into the LRP. Available from cinp.ca





CINP Commitment to EDI

- CINP Board approved statement:

  "CINP is committed to ensuring equitable access to its resources, and promoting EDI in the Canadian nuclear physics community, recognizing that this will contribute to more robust research and education outcomes"

- By far the largest component of the CINP's MRS grant is devoted to HQP support. Diversity is taken into consideration in the awarding of funds

- CINP Graduate Fellowship has an explicit EDI component, where applicants are asked:
  - What does EDI mean to you in the context of research and education in Canada?
  - What role could a PhD student and CINP Graduate Fellow play in promoting and advancing EDI in our community?
  - Describe any relevant EDI activities you have undertaken

CINP Undergraduate Research Scholarships (URS)

- **Allows gifted undergraduates to work with supervisor on nuclear physics research for 16 weeks in summer**
- **A supervisor can nominate only their best student for the award. Process is competitive, with only top ~50% nominees selected.**
- **Award:**
  - $5500 student stipend, matched by supervisor to at least $9500
  - $1300 travel supplement available if supervisor intends to send student to a laboratory or to work with a second collaborator for an extended period

– **CINP URS is complementary to NSERC USRA in several key aspects:**

1) Gifted international students studying in Canada are eligible to apply for the CINP URS, but not the NSERC USRA.
2) An important element of the URS is the optional Travel Award, which allows the supervisor to send student to a lab or work with second collaborator for an extended period. This can have a significant impact on the quality of the research experience for some undergrads. NSERC USRA has no such component.

CINP 2023 Undergraduate Research Scholarships

Student	Supervisor	Project Title
Bui Trang (Manitoba)	Savino Longo (Manitoba)	Ultracold neutron detector for the TUCAN experiment at TRIUMF
Jason Froats (Guelph)	Paul Garrett (Guelph)	Study of beta-decay of ^{110}Ag to ^{110}Cd with GRIFFIN spectrometer
Gabriela Gelinas (Calgary)	Michael Wieser (Calgary)	Development of laser ablation source to assess ^{222}Rn exposure in biological materials
Laura Hubbert (Mt Allison)	David Hornidge (Mt Allison)	Elastic Compton scattering from ^{12}C with the CATS detector
Zachary Saunders (Saint Mary's)	Rituparna Kunungo (Saint Mary's)	Viewing Borromean nuclei with transfer reactions
Zu Ying Yu (SFU)	Krzysztof Starosta (SFU)	Fusion–evaporation reaction rate predictions for TIGRESS and TIGRESS integrate plunger

2020 MRS grant renewal allowed CINP to increase # scholarships and $ amount

Selection Committee: Juliette Mammei (Manitoba), Adam Garnsworthy (TRIUMF), Garth Huber (Regina)

CINP Graduate Fellowship (GF)

- **Intended to attract or retain very gifted Ph.D. candidates to conduct nuclear physics research in Canada**
- **Award:** $12,500 scholarship to PhD student of high merit
  - Awardee's supervisor or home institution must agree to supplement the GF from institutional or research funds to a value of not less than $32,500
  - During fellowship period, the awardee is eligible to access conference travel funds by application to CINP Junior Scientist Travel program
- **Criteria:** In addition to academic and scientific criteria, application has EDI component
  - applicants write 1 page description of what role a PhD student and CINP Graduate Fellow can plan in promoting and advancing EDI in our community
- **A new initiative, proposed in CINP's 2020 MRS grant application. Awarded funds allow 1 GF to be awarded**
- **CINP redirected funds saved from little COVID–19 Travel to enable 2 GF to be awarded for the next 3 years**
- 9 applications received; competition was very tight. Based on quality of applicants, we could easily justify further doubling of #awards

CINP 2023 Graduate Fellowships

- **Gareth Smith (UBC, TRIUMF)**
  - Working with ALPHA Collaboration towards measuring graviational force on trapped antihydrogen atoms, in direct test of symmetry between matter and antimatter.
  - Research focuses on implementation of a time–of–flight scintillator detector to reject cosmic ray background that would otherwise obscure the antihydrogen signal.
  - Splits his time between TRIUMF and CERN.
  - Gareth works under the supervision of Makoto Fujiwara (TRIUMF)

- **Alicia Postuma (Regina)**
  - Jefferson Lab KaonLT experiment, which measured charged meson electroproduction to study QCD in the transition from long distance (confinement) to short distance (asymptotic freedom) regimes.
  - Presently analyzing Beam Spin Asymmetry for exclusive π^+ production.
  - Next project: u–channel data provides novel access to the meson cloud of the progon, specifically the *qqq–qqbar* part of the proton wave function.
  - Alicia works under the supervision of Garth Huber (Regina)

Selection Committee: Juliette Mammei (Manitoba), Jason Holt (TRIUMF), Sangyong Jeon (McGill), Jeff Martin (Winnipeg)

CINP 2023 Accomplishments

- **Community Outreach:**
  - **CINP facilitates new connections and allows the disparate Canadian nuclear physics community to develop a common identity**
  - CINP website http://cinp.ca/ updated regularly
  - 2 Newsletters, May and November annually

Canadian Institute of Nuclear Physics
Institute Canadien de Physique Nucléaire

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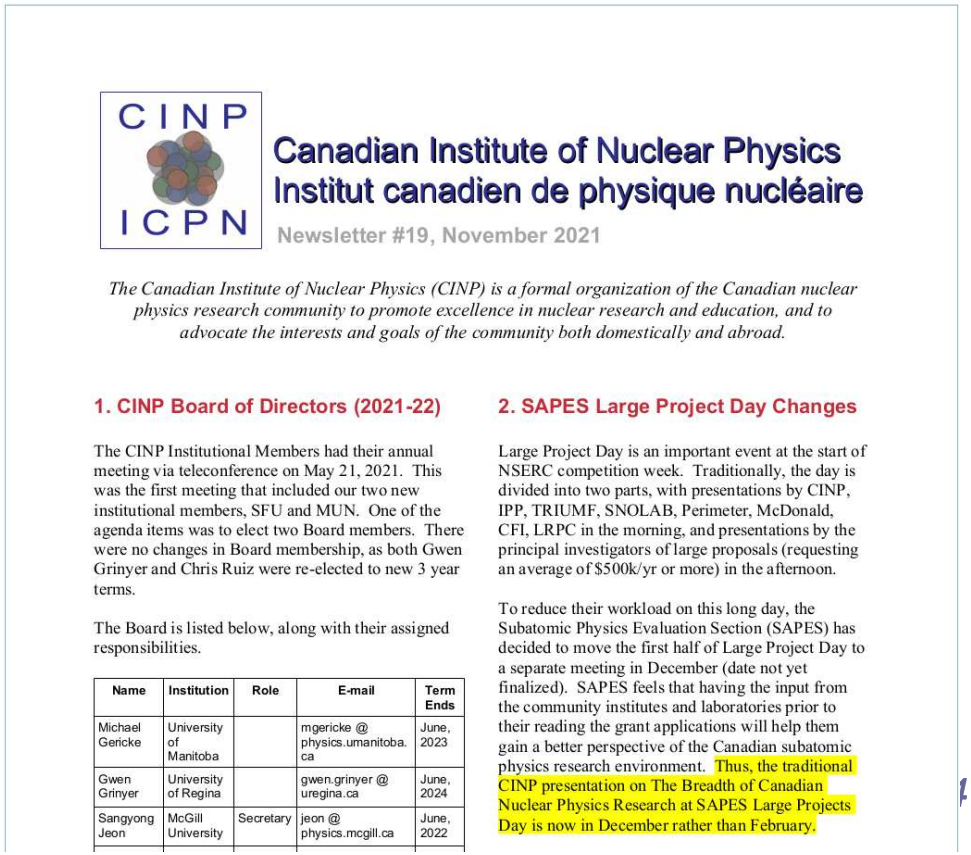
Information and News
- Jobs / Announcements
- Newsletters
- Conference Support
- AGM slides
- CINP White Papers

Scientific Working Groups
- Overview
- Nuclear Astrophysics
- Nuclear Structure
- Fundamental Symmetries
- Hadronic Physics/QCD
- Education and Training

Important Links
- Subatomic Physics Long Range Plan
- NSERC News
- SAPES Chair Reports (2010-)
- GSC-19 Chair Reports (2001-09)
- IUPAP Working Group WG.9

GRIFFIN with DESCANT and SCEPTAR

The Canadian Institute of Nuclear Physics is a formal organization of the Canadian nuclear physics research community to promote excellence in nuclear research and education, and to advocate the interests and goals of the community both domestically and abroad.



Canadian Institute of Nuclear Physics
Institut canadien de physique nucléaire

Newsletter #19, November 2021

The Canadian Institute of Nuclear Physics (CINP) is a formal organization of the Canadian nuclear physics research community to promote excellence in nuclear research and education, and to advocate the interests and goals of the community both domestically and abroad.

1. CINP Board of Directors (2021-22)

The CINP Institutional Members had their annual meeting via teleconference on May 21, 2021. This was the first meeting that included our two new institutional members, SFU and MUN. One of the agenda items was to elect two Board members. There were no changes in Board membership, as both Gwen Grinyer and Chris Ruiz were re-elected to new 3 year terms.

The Board is listed below, along with their assigned responsibilities.

Name	Institution	Role	E-mail	Term Ends
Michael Gericke	University of Manitoba		mgericke @ physics.umanitoba.ca	June, 2023
Gwen Grinyer	University of Regina		gwen.grinyer @ uregina.ca	June, 2024
Sangyong Jeon	McGill University	Secretary	jeon @ physics.mcgill.ca	June, 2022

2. SAPES Large Project Day Changes

Large Project Day is an important event at the start of NSERC competition week. Traditionally, the day is divided into two parts, with presentations by CINP, IPP, TRIUMF, SNOLAB, Perimeter, McDonald, CFI, LRPC in the morning, and presentations by the principal investigators of large proposals (requesting an average of $500k/yr or more) in the afternoon.

To reduce their workload on this long day, the Subatomic Physics Evaluation Section (SAPES) has decided to move the first half of Large Project Day to a separate meeting in December (date not yet finalized). SAPES feels that having the input from the community institutes and laboratories prior to their reading the grant applications will help them gain a better perspective of the Canadian subatomic physics research environment. Thus, the traditional CINP presentation on The Breadth of Canadian Nuclear Physics Research at SAPES Large Projects Day is now in December rather than February.

CINP Research Scientists ?

As SAPES frequently asks us:

"If there are IPP research scientists, why do you not propose CINP research scientists?"

we feel it is best to address it here.

- The option to have Research Scientists funded by NSERC is not open to CINP.
  - The ability to apply for funds and build up an independent research program is vital to attracting good applicants. But if NSERC funds are used to pay part of a researcher's salary, that person is not eligible to apply or co–apply for NSERC grants.
  - The IPP Research Scientist program received an exemption from this rule many years ago, when circumstances were very different.
- This causes a certain inequity, places significant strain on the SAP envelope, and "locks in" the support of certain programs for a very long time frame.

CINP Research Scientists ?

CINP ICPN

Some consensus has emerged within CINP:

- Bridge Faculty Positions are a better model.
  - Would allow a strategic building of highly promising research areas within Canada in a more economic fashion.
  - Avoids the long term tie–up of funds towards a specific program.
- Need to secure an alternate source of funding.
  - Avoids the NSERC applicant exemption problem.
  - More fiscally sustainable, avoids strain on SAP envelope.
  - No source for such funds presently available.

CINP would like to be constructive and work with IPP toward a long–term solution which will be of benefit to the entire SAP community.

CINP Scientific Summary

CINP
ICPN

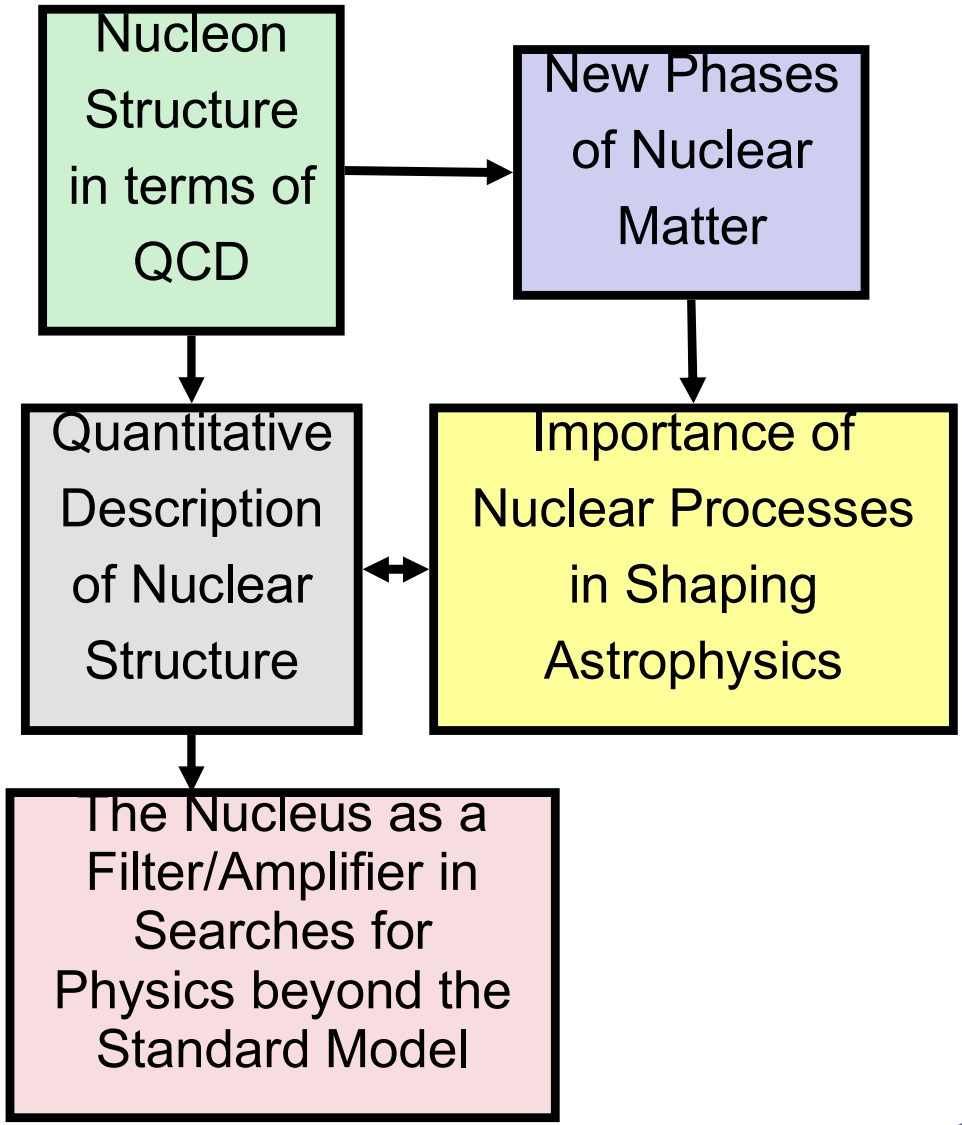
A Few Slides on:

The Breadth of Canadian Nuclear Physics Research
and
Important Current and Future Priorities

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

CINP ICPN

- **Broad international consensus on the key questions of significance to the broader community**
- **Driven by the criteria of research excellence and critical mass of effort, Canadian nuclear physicists have *self–selected* their efforts to make substantive contributions to these "big questions"**



How do Quarks and Gluons give rise to the Properties and Phases of Strongly Interacting Matter?

CINP ICPN

- **Although much is known about QCD in the perturbative regime, one of the central problems of modern physics is the connection of observed hadron properties to QCD**
- This is a major research effort internationally, and the Canadian experimental efforts are concentrated off shore
- Canadian theory contributions in Lattice QCD, Radiative Corrections, and other areas
- Exotic nuclear matter existed during the first moments after the Big Bang, and can be recreated in relativistic nuclear collisions at RHIC and LHC
- There are some very active Canadian theorists contributing to our understanding of the phase diagram of nuclear matter using intensive high performance computing techniques

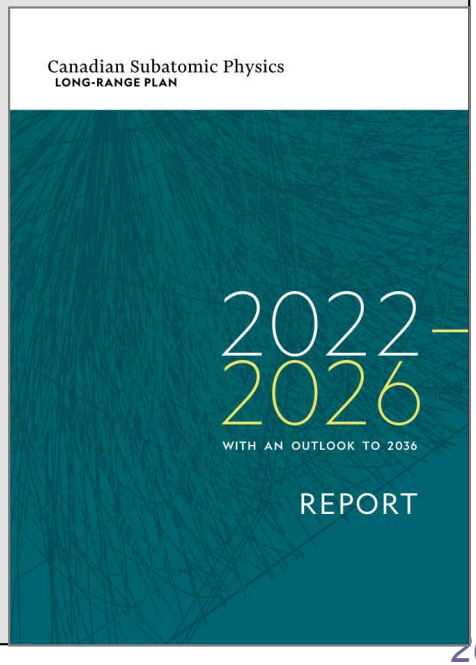
How do Quarks and Gluons give rise to the Properties and Phases of Strongly Interacting Matter?

CINP ICPN

Canadians have made substantive detector contributions to the JLab 12 GeV Upgrade, and have moved to data collection and analysis mode

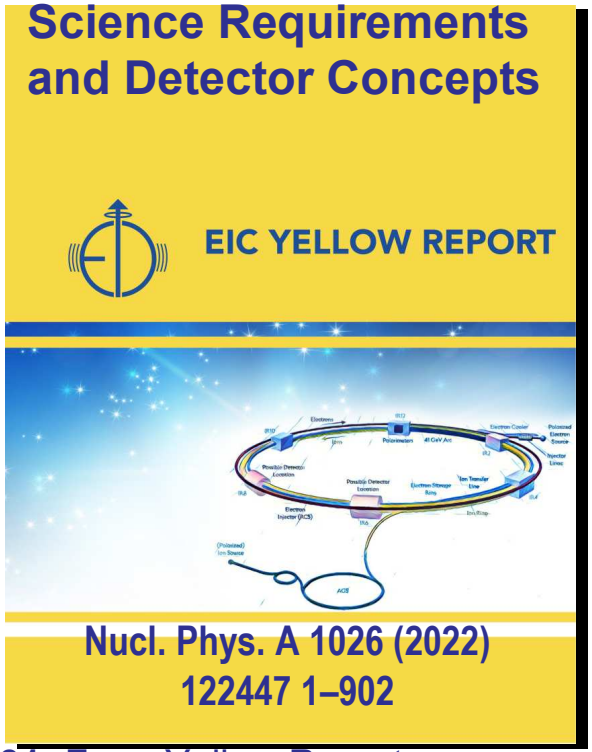
- **GlueX (exotic hybrid mesons) Hall D**
- **Pion and Kaon Form Factors Hall C**

- **<u>Medium term (2022–26):</u> Canadians involved in data taking and analysis of data. JLab Eta Factory (JEF) is planned with upgraded GlueX equipment for 2024–26**
- **<u>Longer term (2027–36):</u> SoLID experiment at JLab**
- **Canadian participation at Electron–Ion Collider will uniquely address profound questions about nucleons, including the origin of hadronic mass, the origin of nucleon spin, and the emergent properties of dense systems of gluons**



2023 New Research Capabilities
– Canadian Involvement @ Electron–Ion Collider

CINP ICPN



2021: From Yellow Report…
… **to two large detector proposals** with Canadian involvement
2022: Proposal Selection
… **to one large EIC Project detector Collaboration (ePIC)**
2023-24: Development of TDR
… **with Canadian involvement in leadership roles**

EIC Canada focus areas

Hardware:

- **Calo:** Si–pixel imaging + SciFi hybrid barrel
- **Barrel ECAL System Coordinator**: Z. Papandreou
- Building towards significant CFI–IF proposal for Calorimetry in 2025 competition
- SiPM End-of-Sector Boxes with NSERC-MRS

Simulations:

- **Software operations coordinator**: W. Deconinck
- **Software framework:** community–oriented (dd4hep, edm4hep, ACTS)
- **Novel AI work:** inner tracker design optimization, calo design using hierarchical density-based clustering
- **Event generators:** far forward region studies (ZDC, B0)
- **Physics:** Meson Form Factors at high Q^2
  XYZ Spectroscopy
  Charged lepton universality ($e \rightarrow \tau$)

University of Manitoba · Mount Allison University · University of Regina

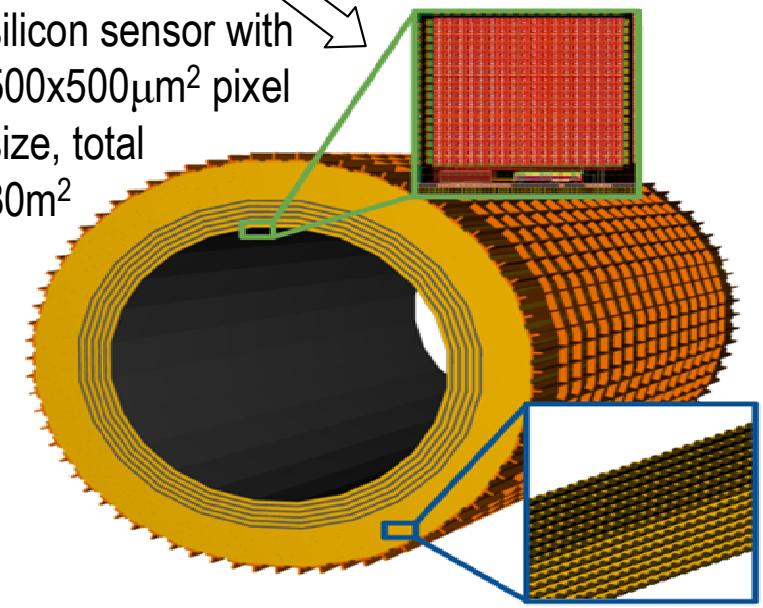
2023 New Research Capabilities
– EIC Barrel Electron Calorimeter Development

CINP ICPN

Energy resolution – Primarily from Pb/SciFi layers (+ Imaging pixels energy information)

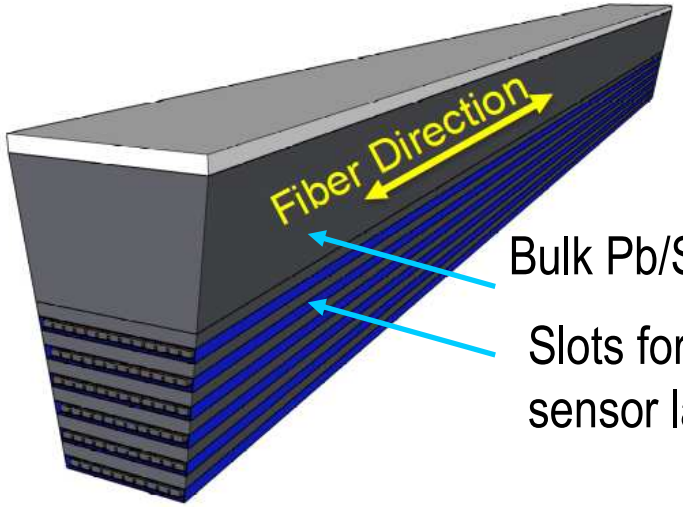
Position resolution – Primarily from Imaging Layers (+ 2-side Pb/SciFi readout)

AstroPix: silicon sensor with 500x500μm^2 pixel size, total 80m^2



48 azimuthal sectors

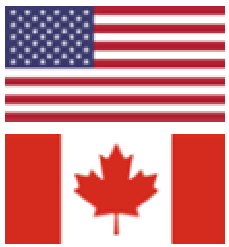
SciFi Layers with two sided SiPM readout



Inner: interleaved layers of imaging Si sensors with PbSciFi (SFIL – SciFi imaging layers)

Outer: bulk Pb/SciFi section

Key Institutions



- Bulk at Argonne Nat. Lab.
- SFIL layers at UManitoba
- SiPM Boxes at URegina

How does the structure of nuclei emerge from nuclear forces?

CINP ICPN

- **A key goal of nuclear physics research is the development of a comprehensive, predictive theory of complex nuclei**
- This has driven the recent development of high quality radioactive beams, allowing both neutron and proton numbers to vary over a wide range
- Areas of active inquiry include:
  - Studies of neutron halos and skins
  - Tests of *ab-initio* theories in light and medium mass systems
  - Evolution of nuclear shell structure as a function of the neutron-proton asymmetry proton and neutron number
  - Studies of nuclear collectivity, shape coexistence, and nuclear shape transition

How does the structure of nuclei emerge from nuclear forces?

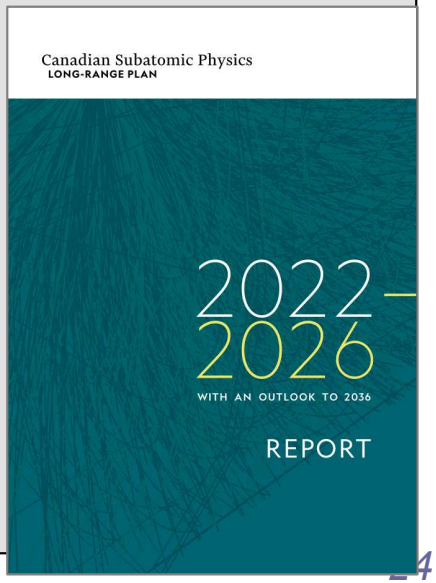
CINP ICPN

Medium term (2022–26): **Highest priority is to capitalize on the recent investments in new world–class detector infrastructure at ISAC. New detector systems, such as EXACT-TPC and RCMP, will begin physics prgrams at ISAC**

- **High quality work off–shore at GSI, RIKEN, FRIB, JLab. Increasing interational users @ ISAC**

Longer term (2027–36): **ARIEL will be a next generation rare–isotope beam facility, new beam species, higher intensities, cleaner beams, longer beam periods**

- **Global ab–initio calculations of all nuclei may become possible in next 5–15 years, making statistical analyses of properties and limits of nuclei from first principles a reality**
- **Nuclear structure investigations relevant to 0νββ may become a future direction**



2023 Research Highlight

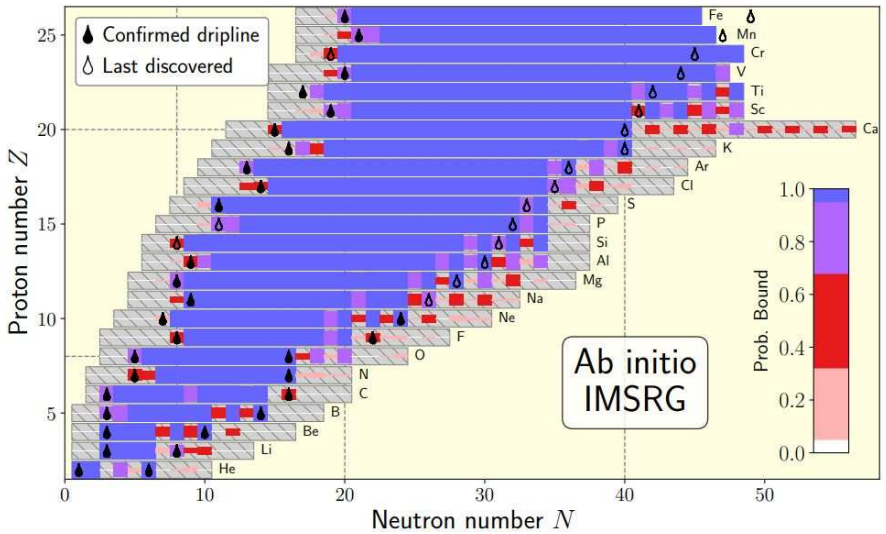
- Global Ab Initio Calculations + Heavy ^{208}Pb Region

CINP ICPN

2021: **All** nuclei He → Fe predicted ab initio (~700 total) from few-body data

First global ab initio analysis – well reproduce proton dripline

Predictions for neutron dripline Ne → Ca key motivation for next-gen RIB facilities



2022: Ab initio predictions extended to ^{208}Pb!

Previous limit A~100 (memory for 3N forces)

"Neutron skin" linked to neutron star properties

$R_{skin}(^{208}Pb)$= 0.14-0.20fm (68% conf. level)

Featured in Physics | Editors' Suggestion

Ab Initio Limits of Atomic Nuclei

S. R. Stroberg, J. D. Holt, A. Schwenk, and J. Simonis
Phys. Rev. Lett. **126**, 022501 – Published 12 January 2021

Physics See synopsis: Predicting the Limits of Atomic Nuclei

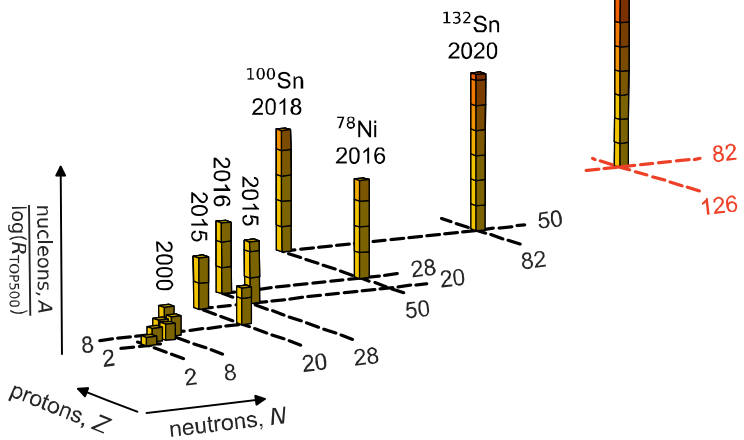
nature physics ARTICLES https://doi.org/10.1038/s41567-022-01715-8

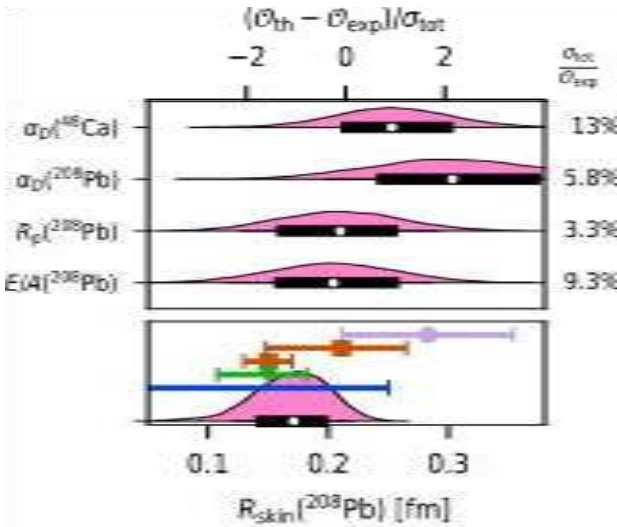
OPEN

Ab initio predictions link the neutron skin of ^{208}Pb to nuclear forces

Baishan Hu[1,11], Weiguang Jiang[2,11], Takayuki Miyagi[1,3,4,11], Zhonghao Sun[5,6,11], Andreas Ekström[2], Christian Forssén[2✉], Gaute Hagen[1,5,6], Jason D. Holt[1,7], Thomas Papenbrock[5,6], S. Ragnar Stroberg[8,9] and Ian Vernon[10]

Heavy atomic nuclei have an excess of neutrons over protons, which leads to the formation of a neutron skin whose thickness is sensitive to details of the nuclear force. This links atomic nuclei to properties of neutron stars, thereby relating objects that





2023 Research Highlight

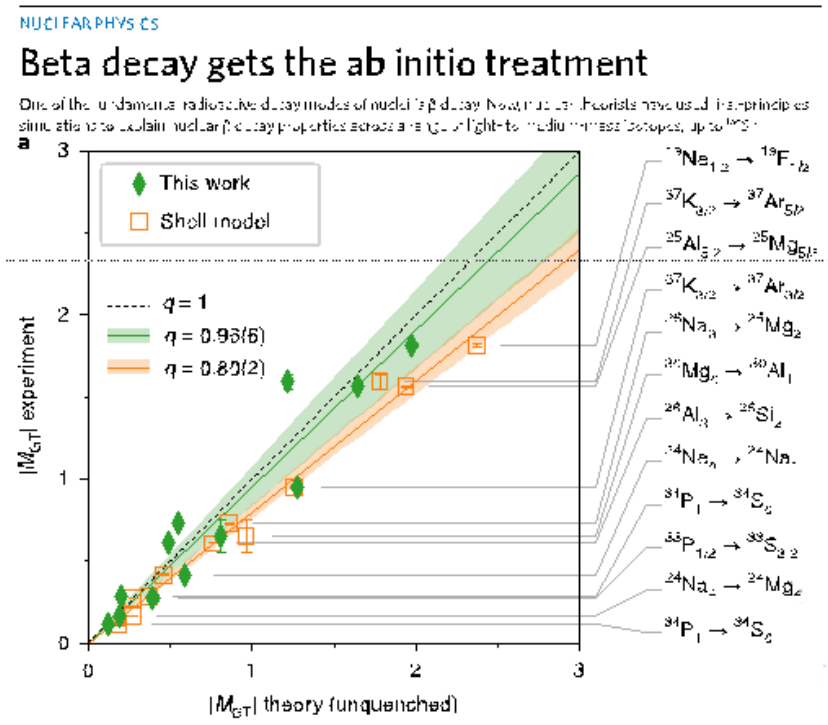
- Solution to g_A quenching + double-beta decay

CINP ICPN

2019: **50+ year-old** puzzle in nuclear physics - is g_A quenched in nuclear beta decays?

Phenomenology needs ~0.75 quenching factor for single-beta decays

Ab initio: no quenching for He to ^{100}Sn w/ two-body currents + many-body correlations



LETTERS
https://doi.org/10.1038/s41567-019-0450-7
nature physics

Discrepancy between experimental and theoretical β-decay rates resolved from first principles

P. Gysbers[1,2], G. Hagen[3,4*], J. D. Holt[1], G. R. Jansen[3,5], T. D. Morris[3,4,6], P. Navrátil[1], T. Papenbrock[3,4], S. Quaglioni[7], A. Schwenk[8,9,10], S. R. Stroberg[11,12] and K. A. Wendt[7]

The dominant decay mode of atomic nuclei is beta decay (β-decay), a process that changes a neutron into a proton (and vice versa). This decay offers a window to physics beyond the

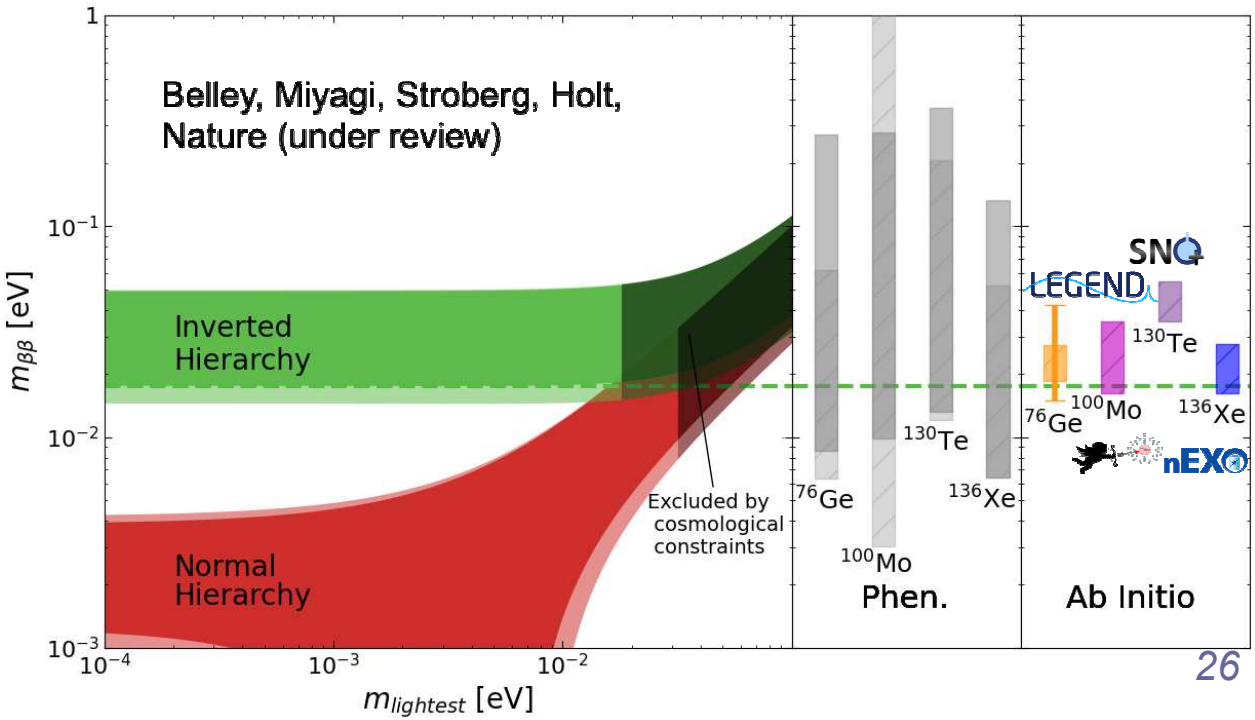
data, and precision, from the systematically improvable EFT expansion. Moreover, EFT enables a consistent description of the coupling of weak interactions to two-nucleon via two-body currents

2023: 0νββ decay matrix elements

Phenomenology: large spread in results

First ab initio calculations for all major players

Refines limits for next-generation searches



What is the role of radioactive nuclei in shaping the visible matter in the universe?

CINP ICPN

- Nuclear astrophysics addresses many fundamental questions including: the origin of the elements, the connection of observed solar abundances and nuclear structure phenomena, the structure of neutron stars, the equation of state for asymmetric nuclear matter, etc.
- Interdisciplinary: New era in nuclear astrophysics has opened with use of radioactive beam facilities, improved astronomical observation and modeling
- Multi–messenger nuclear astrophysics is already being carried out, with the aim to better understand various aspects of the creation of nuclei in stellar events. e.g. Observation of GW170817 and follow up observations gave much new informationabout the rapid neutron capture process

What is the role of radioactive nuclei in shaping the visible matter in the universe?

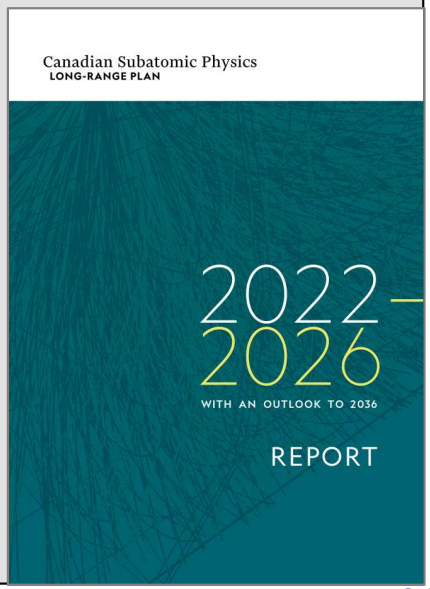
CINP ICPN

Medium term (2022–26): **Majority of domestic program is carried out at ISAC, complemented with off-shore activities at GSI (Germany), RIKEN (Japan), FRIB (USA), GANIL (France)**

- The flexibility of several ISAC detectors to be combined allows a wide coverage of experiments that are not easily possible elsewhere, e.g. EMMA + TIGRESS, GRIFFIN + DESCANT, TITAN EBIT + 8π, DRAGON + GRIFFIN, detectors.

Longer term (2027–36): **Canadian program will profit from full implementation of ARIEL facility at TRIUMF**

- New detectors planned to take full advantage of upcoming photofission beams and intense re–accelerated heavy nuclear beams from ARIEL, e.g. EXACT–TPC
- **TRIUMF Storage Ring (TRISR)** Proposal for a low–energy storage ring with a neutron generator at ISAC is underway



What Physics Lies Beyond the Standard Model?

CINP ICPN

- **Studies of fundamental symmetries via very precise low and intermediate energy experiments have been part of nuclear physics since its inception**
- Complementary to direct probes by high energy physics since precision lower energy experiments indirectly probe mass scales and parameter spaces not otherwise accessible

The Canadian NP program is very active, addressing:

- **Time Reversal and CP violation:**
  - **TUCAN n–EDM search; Radioactive Molecules @ ISAC**
- **Neutral Current Weak Interactions**
  - **MOLLER PV e^- Scattering @ JLab; Francium Atomic Parity Violation @ ISAC**
- **Neutrinos:**
  - **$0\nu\beta\beta$ studies @ SNOLab; BeEST search for keV–scale ν @ ISAC**
- **CPT, Lorentz and Weak Equivalence Principle violation: ALPHA @ CERN**
- **CKM Matrix Unitarity: GRIFFIN, TITAN @ ISAC**
- **Beta–Neutrino Correlations: TRINAT neutral atom trap @ ISAC**

What Physics Lies Beyond the Standard Model?

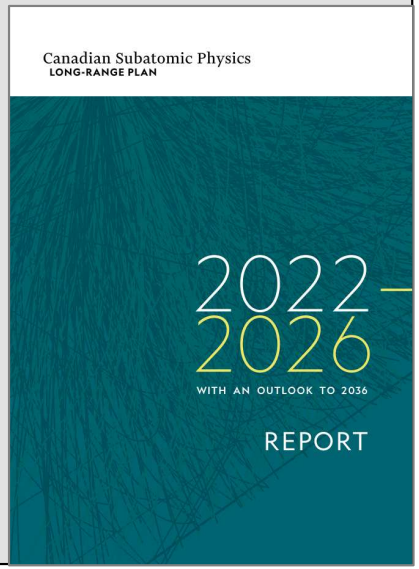
CINP ICPN

Medium term (2022–26):

- ISAC program: Laser–trapped Francium, GRIFFIN β–decay, TRINAT, TITAN
- TUCAN and ALPHA–g upgrades completed
- NaB cold neutron experiment underway
- MOLLER @ JLab construction begun, run to ~2030
- Positive funding decision on nEXO 5 tonne detector

Longer term (2027–36):

- Precision spectroscopy with radioactive molecules will be major new effort @ ISAC
- FrPNC to start atomic PV run @ ISAC
  - Possible extension to cold Fr, Ag molecules
- Deployment of HAICU by ALPHA Collaboration
- Fundamental Symmetries @ EIC



2023–24 Research Highlight

- ALPHA: Antihydrogen Symmetry Tests

ALPHA-Canada: UBC, BCIT, SFU, Calgary, York, TRIUMF
- A leading group in ALPHA Collaboration at CERN
- >1/3 of the Collaboration; *est*. 2005

ALPHA-g TPC built at TRIUMF

ALPHA Objectives
- Test of CPT symmetry (ALPHA-2)
- Weak Equivalence Principle for antimatter (ALPHA-g)
- R&D on Quantum Techniques for antimatter (HAICU, CFI)

New Faculty/Scientists
- Andrea Capra, TRIUMF [Detector]
- Chukman So, TRIUMF/Ucalgary [Trap]
- Alex Khramov, BCIT [Laser]

HQP news
- Gareth Smith: won CINP Graduate Fellowship
- Ashley Ferreira, Dick Azuma Fellow, won 1st prize in Canadian Astro-particle Student Talk on Machine Learning for ALPHA-g

ALPHA project grant up for renewal this year

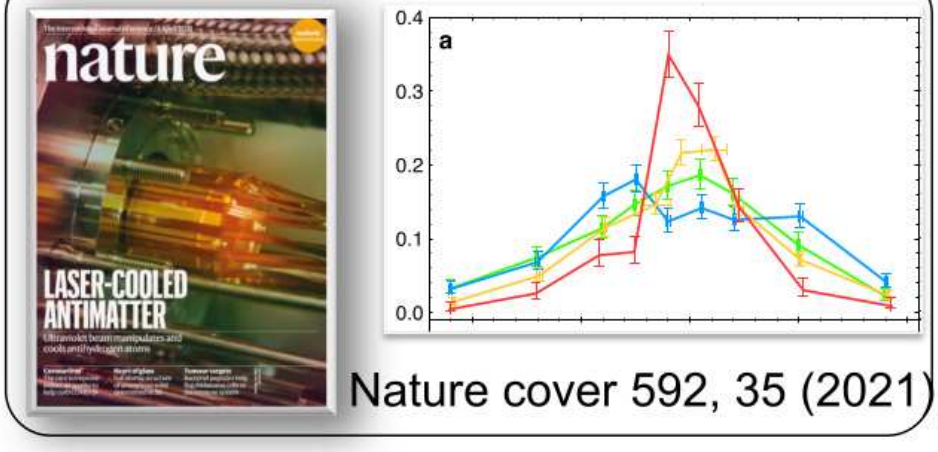
2023–24 Research Highlight

- ALPHA: Science Results

CINP ICPN

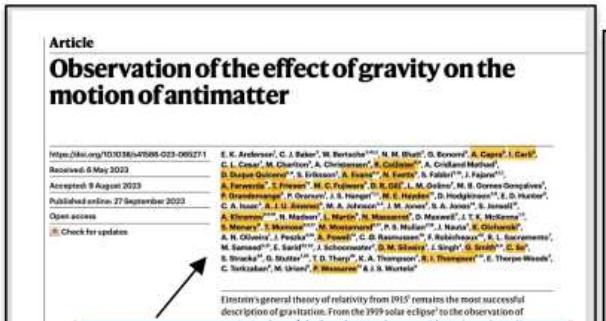
Recently two "dreams" of the field came true

ALPHA-2: Laser cooling of anti-H



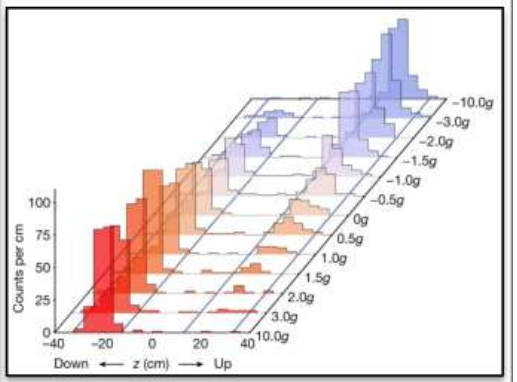
Nature cover 592, 35 (2021)

ALPHA-g: Observation of free-fall effect


Article

Observation of the effect of gravity on the motion of antimatter

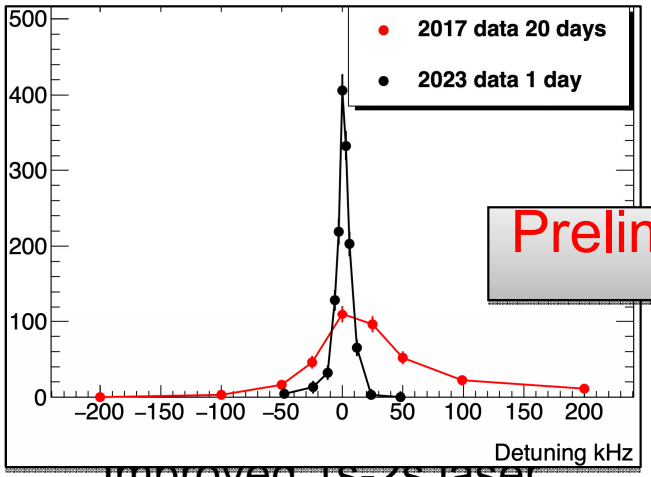
ALPHA-Canada authors: 26/71, incl. 18 current or former HQPs



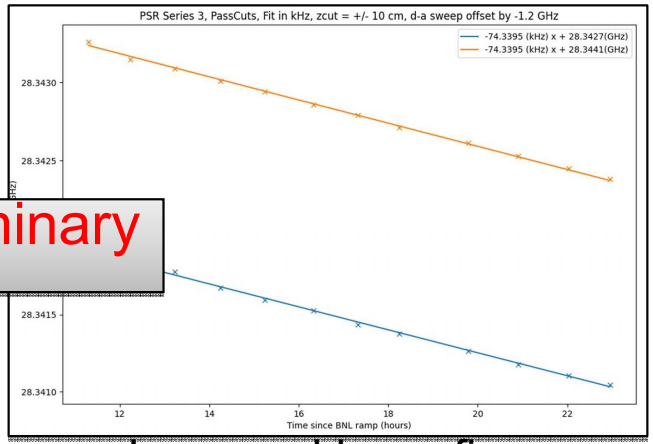
Nature 621, 716 (2023)

Latest news!

- Very successful ALPHA-2 run just completed in Nov 2023 (preliminary)
- Will give more detailed updates at Large Project Day



Improved 1s-2s laser spectroscopy



Improved hyperfine spectroscopy

2023 New Research Capabilities
- TUCAN installation

- **Measurement of the neutron electric dipole moment with an uncertainty approaching 10^{-27} e cm, an order of magnitude better than present world's best**
- **Recent progress (2023):**
  - Installation of superfluid helium cryostat for ultracold neutron (UCN) source (summer 2023) and completion of first cryogenic testing at TRIUMF (September 2023)
  - Completion of magnetically shielded room (MSR) for the neutron EDM experiment (fall 2023).
  - Key safety and gate reviews completed, and approval for construction of liquid deuterium neutron moderator system received from Technical Safety BC (fall 2023).
- **Plans:**
  - Remaining Components of UCN source installed and first UCN production summer 2024
  - UCN delivery to EDM experiment in 2025
  - Development of efficient, background-free, high-rate UCN detectors (S. Longo, U. Manitoba).
  - Development of new magnetometers based on nitrogen vacancy centres in diamond (M. Bradley, U. Sask.)
- **Current team:** 12 faculty members, 5 postdocs, and 13 grad students from UBC, U. Manitoba, U. Winnipeg, UNBC, U. Saskatchewan, and TRIUMF. Strong collaboration with Japan, matching contributions for CFI IF project.

Japanese superfluid helium cryostat installed in the cryostat pit on the UCN beamline at TRIUMF. Now undergoing cryogenic testing.

MSR installation completed at TRIUMF, Oct. 2023. Now characterizing and preparing for precision magnetic field experiments.

2023 New Research Capabilities

- DarkLight @ ARIEL progress

- **Construction underway, Installation June-2024, Eng. Run Fall-2024**
- **First 2 GEM tracking detectors shipped to TRIUMF**
  - HV and leak tested, now working on readout
- Trigger detector construction almost done (Mike + SciTech)
  - 18 scintillators and 216 light guides finished polishing, gluing, wrapping
  - New readout boards tested, expect full shipment mid-Dec
- HQP news:
  - New Masters student Gabby Gelinas started at UBC in Sept. Gabby holds NSERC CGSM and won IAEA Marie Skłodowska Curie fellowship for women in nuclear physics to support her 2nd year.
  - New postdoc Laura Miller joined TRIUMF in August. Starting role as software coordinator for DarkLight as of next month.
- Talks & results: Kate Pachal (DL co–spokesperson) gave invited plenary talk at IEEE NSS conference in Vancouver highlighting DarkLight and TRIUMF, and DarkLight overview at APS/JPS DNP. Laura will give DarkLight talk at Lake Louise Winter Institute

Laura and Ethan testing GEMs


Clayton and Ben after a job well done

2023 Honours Received by Members

Svetlana Barkanova

(Memorial)

- *selected by NSERC as inaugural Co–Chair for Inclusion in Science and Engineering, Atlantic Region. TRIUMF and SNOLAB are the partners*
- *Svetlana is Chair of the QCD/Hadrons Scientific Working Group of CINP*

Nuclear Physics High–Priority Science

- **Flagship Projects with Broad Physics Outcomes:**
  - TRIUMF ARIEL–ISAC Experiments
  - Electron–Ion Collider
- **Flagship Projects with Strategic Physics Outcomes:**
  - JLab 12 GeV Program
  - Offshore RIB Experiments
  - ALPHA/HAICU, MOLLER, TUCAN