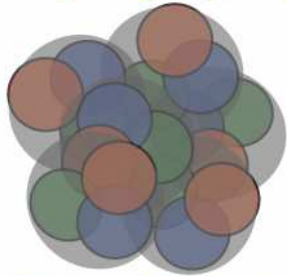


C I N P



I C P N

**Canadian Institute of
Nuclear Physics**

**Institut canadien de
physique nucléaire**

**NSERC Subatomic Physics Context Session
December 10, 2024**

What is the CINP?

- 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

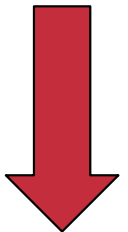
CINP Governance


Institutional Members
McGill University
Memorial University of Nfld
Mount Allison University
Saint Mary's University
Simon Fraser University
TRIUMF
University of Calgary
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 <i>President</i>
Thomas Brunner
Liliana Caballero
Rituparna Kanungo
Russell Mammei
Chris Ruiz



Executive Director
Garth Huber 

Treasurer
Greg Hackman

Scientific Working Groups



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
- SWG leadership played a major role in the preparation of CINP Brief for the 2022–26 Long Range Plan.

SWG	Chair	Institution
Nuclear Structure	Paul Garrett	Guelph
Nuclear Astrophysics	Nicole Vassh	TRIUMF
Fundamental Symmetries	Jeff Martin	University of Winnipeg
Hadron Structure/QCD	Svetlana Barkanova	Memorial University of Newfoundland
Nuclear Theory	Alexandros Gezerlis	University of Guelph
Nuclear Physics Education and Training	Ruben Sandapen	Acadia University

CINP Individual Membership

CINP Membership December 1, 2024	
Total Membership	179
Faculty (Full) Members	92
Associate Members (Grad Students, PDFs, Professor Emeriti)	87
Experimentalists	134
Theorists	43

SWG Membership	
Nuclear Astrophysics	73
Nuclear Structure	76
Fundamental Symmetries	86
Hadrons/QCD	55
Nuclear Theory	37
Nuclear Physics Education & Training	62

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 Canadian Subatomic Physics Long Range Plan (LRP).
- **In preparation for the next LRP process, we reviewed all SWGs, including elections for new Chairs within each SWG in spring 2024.**
 - This puts CINP in good stead for new LRP to begin in spring of 2025 with report submitted in fall 2026.
- We are also looking to develop a stronger role for the SWGs, including enhanced funding for activities, etc.

CINP role in 2027–34 Long Range Plan



- **CINP and IPP have drafted the Terms of Reference (ToR) for the next Canadian Subatomic Physics LRP and are consulting with NSERC, CFI on the ToR and LRPC membership**
- **After consultation with NSERC staff, CINP and IPP have requested funds for LRPC operations in their respective SAP-MRS grant applications**
- **CINP and IPP will prepare Briefs to the LRPC, following a fair and rigorous process**
 - CINP Brief will summarize the scientific vision and priorities of the Canadian nuclear physics research community, including both experimental and theoretical facets
 - The first stage of this consultation will be a CINP Town Hall meeting in spring 2025
- **CINP Brief writing committee consists of the six SWG Chairs with the Executive Director as lead editor**
 - After input is received, Brief writing committee will meet in person at TRIUMF in August to finalize the Brief and our recommendations
 - CINP Executive Director is also an ex-officio (non-voting) member of and resource to the LRP Committee

CINP 2024 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
- 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 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 competitive process, supervisors can nominate only their best student for the award. i.e. at most, one per faculty member.**
 - **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.

2024 program demand was much greater than usual. CINP increased the number of awards from 6 to 10, to maintain a historic success rate of 65%.

Selection Committee: Bary Davids (TRIUMF), Chair, Peter Blunden (Manitoba), Greg Christian (Saint Mary's), Zisis Papandreou (Regina)

CINP 2024 Undergraduate Research Scholarships



Student	Supervisor	Project Title
Rylen De Vries (Winnipeg)	Russell Mammei (Winnipeg)	First diamond-like-carbon UCN coated guides from the UCN guide coating facility at UofW
Allison Frayne (Calgary)	Timothy Friesen (Calgary)	Microwave spectroscopy of anti-hydrogen
Sarah Littlejohn (Mt. Allison)	David Hornidge (Mt. Allison)	Analysis of CPP-NPP data from GlueX @ JLab
Karalee Reimer (Manitoba)	Savino Longo (Manitoba)	Neutron-Antineutron production in e+e- annihilations at Belle-II
Claire Sauze (Saint Mary's)	Rituparna Kunungo (Saint Mary's)	Determination of neutron skin thickness in neutron-rich Ca isotopes
Benjamin Scully (UBC)	Jason Holt (TRIUMF)	Ab-initio theory for superallowed Fermi transitions and constraints on CKM unitarity
Dhruval Shah (Regina)	Gwen Grinyer (Regina)	Beta-delayed charged particle emission of ^{20}Mg
Zachary Sullivan (Regina)	Garth Huber (Regina)	Probing nuclear matter via Deep Exclusive π^+ production with JLab electron beams
Portia Switzer (Winnipeg)	Ellie Korkmaz (UNBC)	Instrumenting a new Pulsed Laser Deposition Vacuum Chamber for UCN Coating Applications
Ethan Taylor (Western Ontario)	Ania Kwiatkowski (TRIUMF)	Commissioning of laser ablation ion source for TITAN-TRIUMF

CINP Graduate Fellowship (GF)



- **Intended to attract or retain very gifted Ph.D. candidates to conduct nuclear physics research in Canada**
- **Award: \$13,000 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 \$33,000
 - 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
- **CINP redirected funds saved from little COVID–19 Travel to enable 2 GF to be awarded, rather than the 1 awarded in 2021**
- 9 applications received; competition was very tight. Based on quality of applicants, we could easily justify further doubling of #awards
- FY25: Proposing to increase fellowship to \$15k, to be supplemented to a value not less than \$35k

CINP 2024 Graduate Fellowships



• Zarin Ahmed (Guelph)

- Zr isotopic chains show dramatic shape evolution, garnering significant theoretical and experimental interest. This phenomenon challenges nuclear theory and requires advanced experimental techniques.
- Her research on ^{96}Zr at ISAC aims to provide spectroscopic data and constraints on quadrupole and octupole correlations, crucial for both experimental and theoretical studies.
- Zarin works under the supervision of Paul Garrett (Guelph)

• Nathan Heinrich (Regina)

- A significant advance in the field of QCD/hadron physics is the development of Generalized Parton Distributions (GPDs), which are a cohesive framework for describing quark-gluon structure.
- His work with the PionLT experiment at Jefferson Lab seeks to determine the viability of extracting GPDs via a new method, known as Deep Exclusive Pion Electroproduction.
- Nathan works under the supervision of Garth Huber (Regina)

Selection Committee: Chris Ruiz (TRIUMF), Chair, Sangyong Jeon (McGill), Ruben Sandapen (Acadia), Paul Garrett (Guelph), recused from application in conflict

CINP 2024 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
Institut Canadien de Physique Nucléaire

Home About CINP Nuclear Physics Programs Outreach Membership Governance

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 ?



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

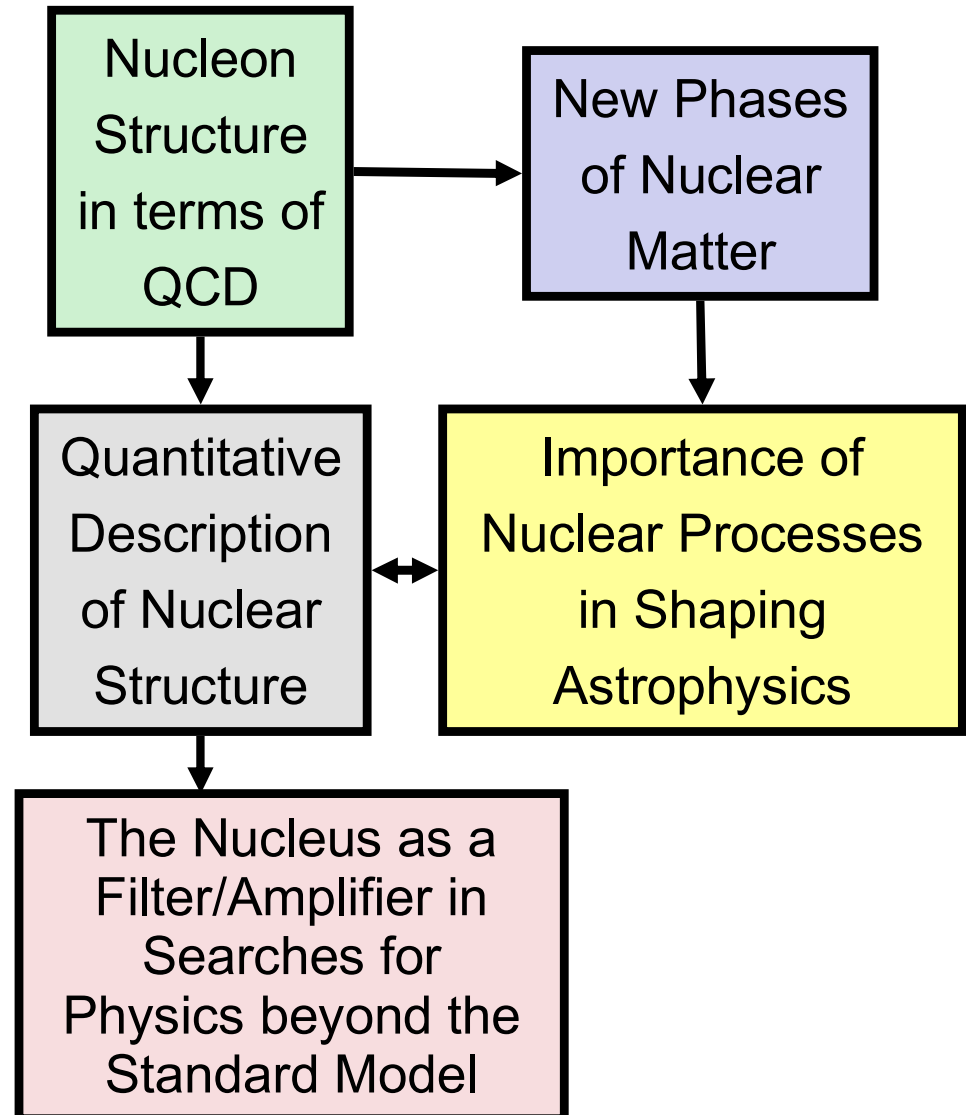


A Few Slides on:

**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

- **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?



- **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?



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
- Medium term (2022–26): **Canadians involved in data taking and analysis of data. JLab Eta Factory (JEF) is planned with upgraded GlueX equipment for 2024–26**
- Longer term (2027–36): **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**



2024 Research Highlights

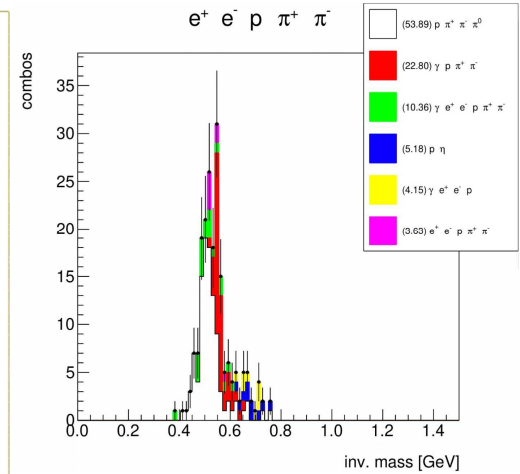
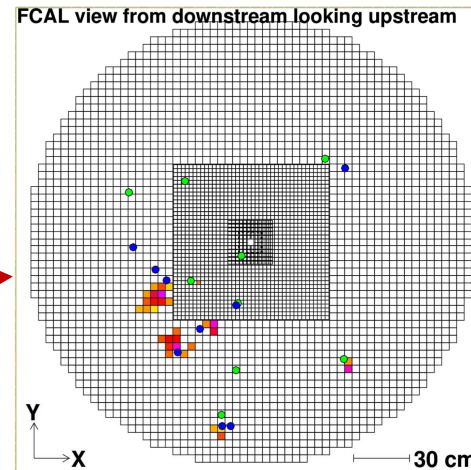
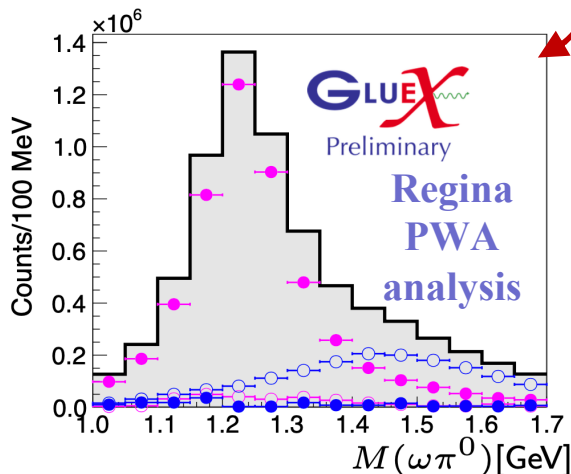
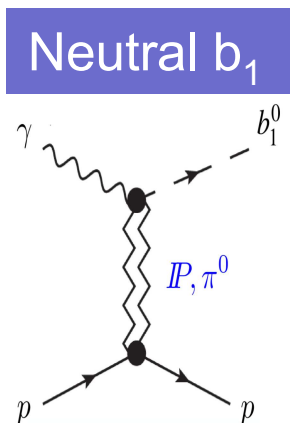
- GlueX @ JLab: Hybrid Mesons and Rare Eta Decays

Physics Analyses

- **Physics Convenor:** Beam Asymmetry Working Group
- **Rare η Decays:** SM (ChPT $\eta \rightarrow \pi^0 \gamma \gamma$) and P/CP ($\eta \rightarrow \pi^+ \pi^- e^+ e^-$)
- **$b_1 \pi$ exotics doorway:** axial vector decay, LQCD predictions; xsections, angular moments and pioneering **PWA**
 $\gamma p \rightarrow p b_1(1235) \rightarrow p[\omega] \pi^0 \rightarrow p \pi^+ \pi^- 2 \pi^0$



Goals: π_1 exotic decay to vector-pseudoscalar $b_1 \pi$ and η_1 to two-pseudoscalar $\eta \eta$



• **Particle reconstruction:** conventional and machine learning algorithms for classification of photons and hadronic split-offs

• **Channel reconstruction:** identify final state and extract asymmetry plane between $\pi^+ \pi^-$ and $e^+ e^-$ planes (P/CP violation, ALPs)

Service Contributions

- **Calorimeter Coordinator**
- **Barrel Calorimeter:** Monitoring & calibration each run period (LEDs, π^0 gain, cosmics)
- **Calorimetry upgrade:** FCAL-II for rare eta decays & BSM-Dark Sector experiment (2025)
- **Machine Learning:** applied to particle ID and photon-neutron discrimination

2024 New Research Capabilities

Electron-Ion Collider – Project Update

First major collider to be built in North America in the 21st century:

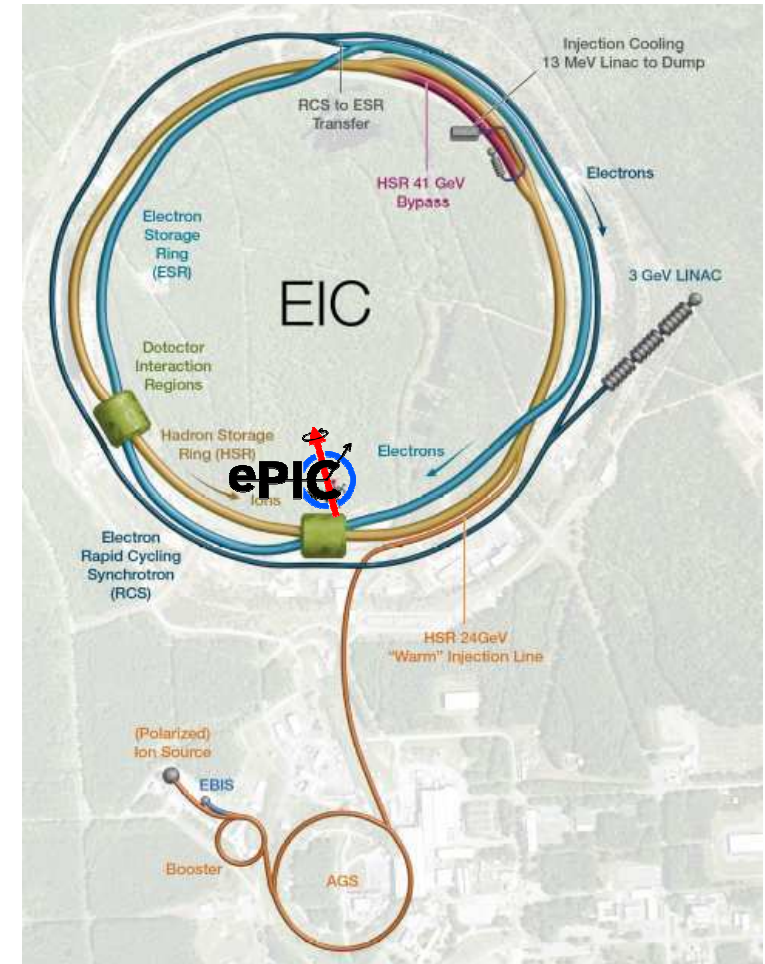
- **Polarized electrons**, 5-18 GeV
- **Polarized light ions** (p, d, ^3He), unpolarized to U, 50-250 GeV
- Center-of-mass energy of 28-140 GeV
- **High luminosity** 10^{33} – 10^{34} $\text{cm}^{-2} \text{s}^{-1}$

Project milestones, achieved and scheduled:

- **Critical Decision CD-3a** (2023): long-lead procurement, part 1 (magnet, SiPMs, optical fibers)
- **Critical Decision CD-3b** (2025): long-lead procurement, part 2
- **Critical Decision CD-2/3** (2026): baseline, **construction start**
 - Combined review, with full technical design report
 - 2024: intensive preparation of full detector pre-TDR
 - v1 of full detector-scope pre-TDR is available now

EIC Canada Collaboration activities:

- Expanded with new institutions: focus areas on hadron storage ring crab cavities and high-granularity barrel EM calorimetry



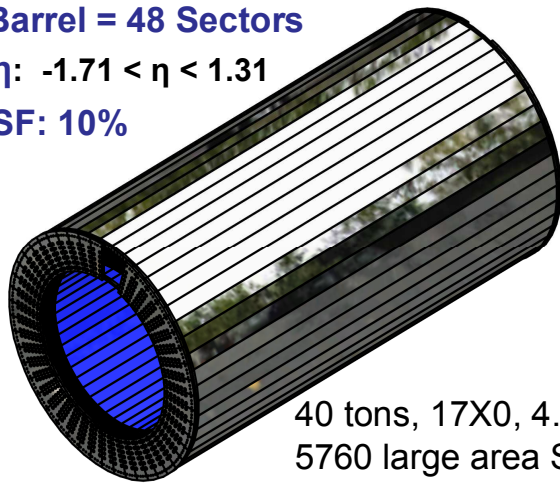
2024 New Research Capabilities

- **BIC @ EIC**: Novel Hybrid Imaging Calorimeter

3D Shower Imaging

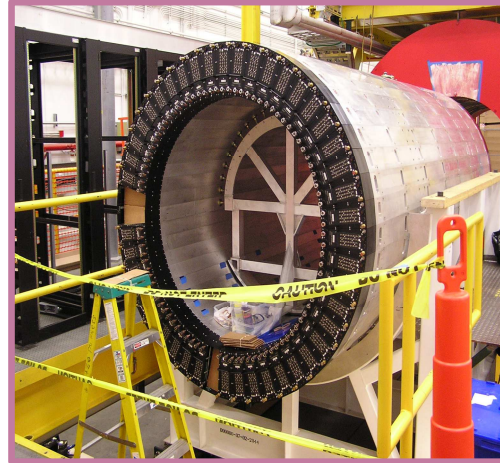
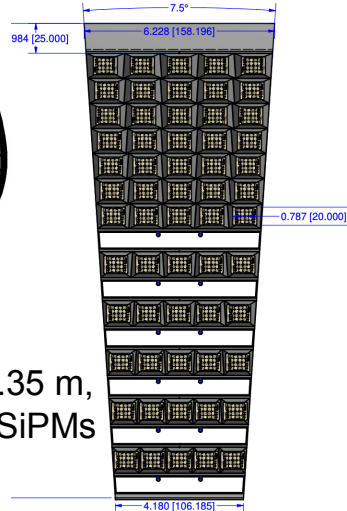
- **PbSciFi**: modeled after GlueX BCAL
- **AstroPix**: Monolithic Active Pixel Sensors

Barrel = 48 Sectors
 $\eta: -1.71 < \eta < 1.31$
 SF: 10%

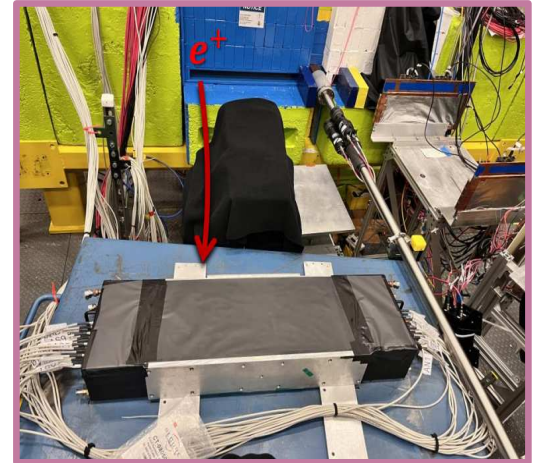


40 tons, 17X₀, 4.35 m,
 5760 large area SiPMs

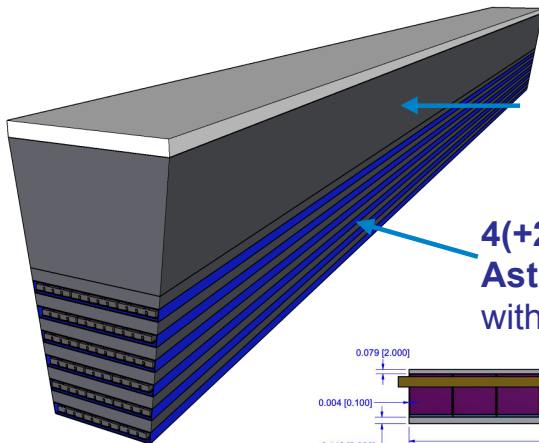
Sector End View



• **GlueX E/M BCAL**: 24 tons, 17X₀, 3.9m, 3840 large area SiPMs, exceptional performance since 2016; used as model for BIC

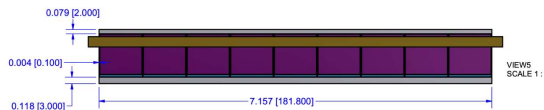


• **GlueX BabyBCAL**: 60-cm long prototype used to extend energy resolution constant term to 6 GeV at JLab; now at FNAL for tests with AstroPix



Bulk Pb/SciFi section

4(+2) layers of AstroPix interleaved with 5 Pb/SciFi layers



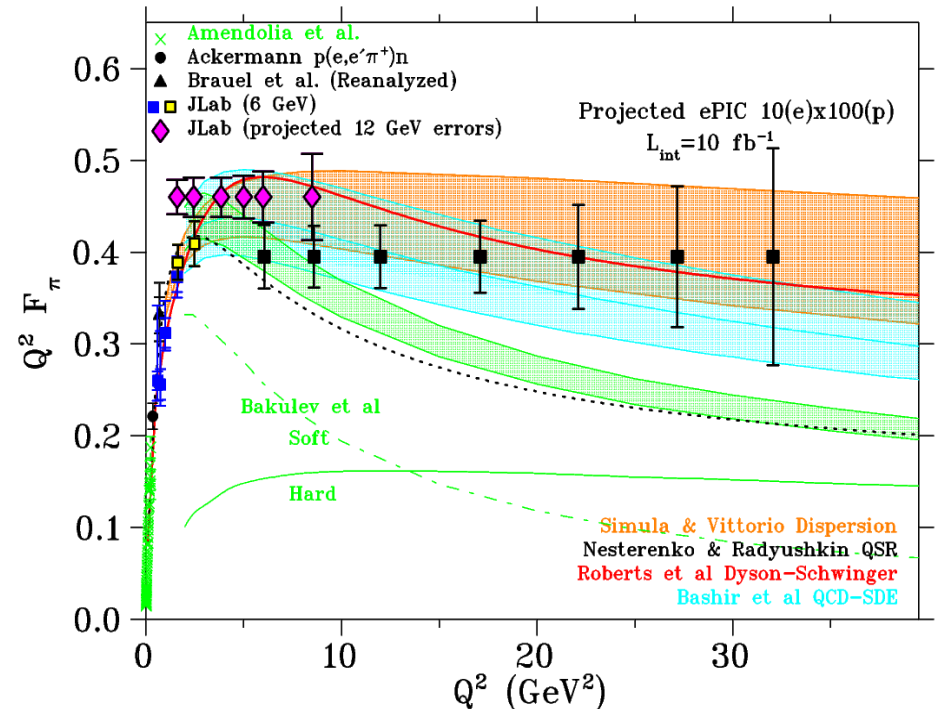
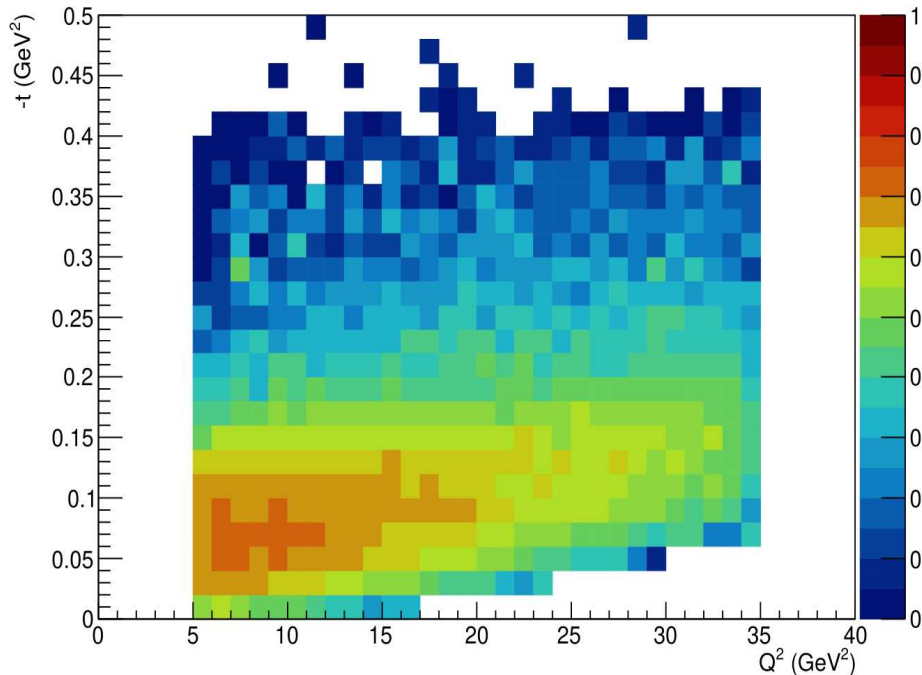
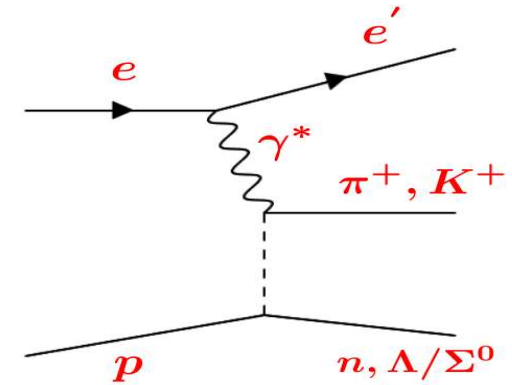
Regina Leadership

- **Detector Systems Coordinator**: define fiber system specs and evaluate fibers at UofR:
 - Attenuation length using LED+Photodiode
 - No Photoelectrons: using ⁹⁰Sr+SiPM
- **End-of-Sector Boxes**: 96 production boxes, lightguides, SiPMs, cooling, gain stabilization, FPGA streaming readout electronics at UofR/CFI

2024 Research Highlight

- Pion form factor projections for the EIC

- Developed Monte Carlo event generator, DEMPgen, to simulate DEMP events - <https://doi.org/10.1016/j.cpc.2024.109444> Computer Physics Communications 308 109444
- Processed $p(e, e' \pi^+ n)$ events through ePIC detector simulations
 - High detection efficiency in crucial low $-t$ region
 - Projections show EIC can push to very high Q^2 in π^+ form factor
 - Even higher Q^2 than previous studies look feasible
- K^+ form factor studies are in advanced progress
- Study drives design and reconstruction methods for ePIC far forward detectors



How does the structure of nuclei emerge from nuclear forces?



- **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?

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 programs 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 $0\nu\beta\beta$ may become a future direction

Canadian Subatomic Physics
LONG-RANGE PLAN

2022–
2026
WITH AN OUTLOOK TO 2036

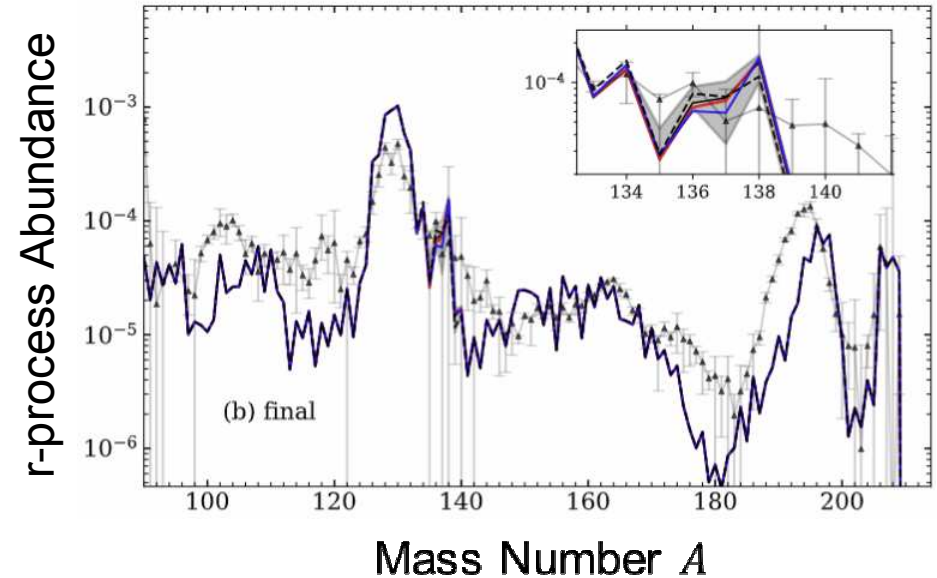
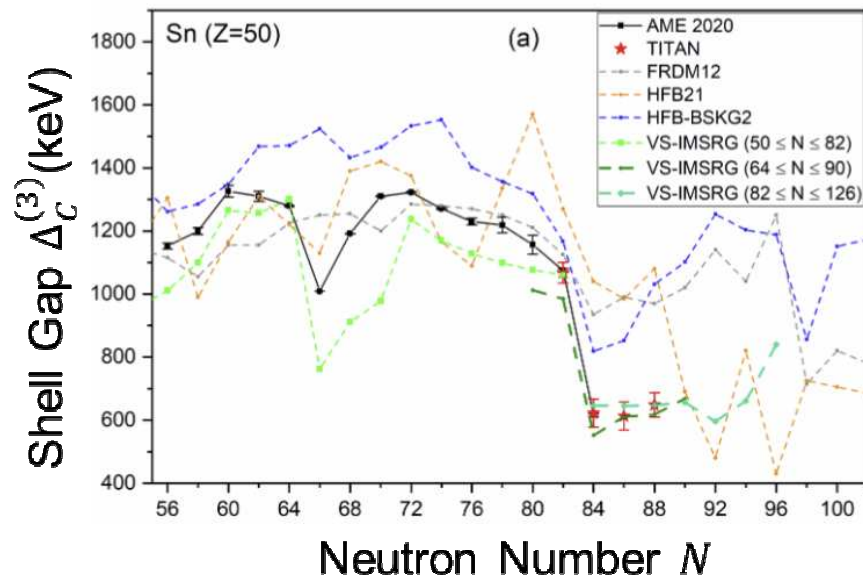
REPORT

2024 Research Highlight

- 1st $^{136-138}\text{Sn}$ mass spec. submitted to Phys. Rev. Lett.

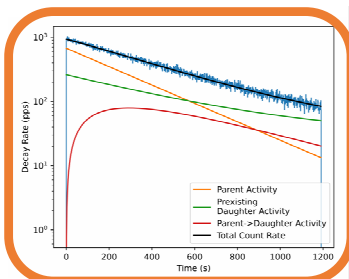
Precision mass measurements reveal low neutron pairing in tin beyond $N = 82$ and its impact on stellar nucleosynthesis

A. Mollaebrahimi,^{1,2,*} C. Walls,^{3,2} T. Dickel,^{4,1} T. Miyagi,^{5,6,7,8} A. Sieverding,^{9,10} C. Andreoiu,¹¹ J. Ash,² B. Ashrafxhani,^{12,2} I. Belosevic,² J. Bergman,¹ C. Brown,¹³ T. Brunner,¹⁴ J. Cardona,^{3,2} G. Gelinas,^{12,2} G. Gwinner,³ Z. Hockenbery,^{14,2} J. D. Holt,^{2,14} A. Jacobs,^{15,2} S. Kakkar,^{3,2} B. Kootte,^{3,2} J. Lassen,² E. M. Lykiardopoulou,^{15,2} S. Malbrunot-Ettenauer,^{2,16} G. Martinez-Pinedo,⁴ S. F. Paul,² W. R. Plaß,^{4,1} M. P. Reiter,¹³ A. Ridley,² C. Scheidenberger,^{4,1,17} R. I. Thompson,¹² Y. Wang,^{15,2} M. E. Wieser,¹² and A. A. Kwiatkowski^{18,2}



2024 New Research Capabilities

- Several upgrades at TITAN-TRIUMF



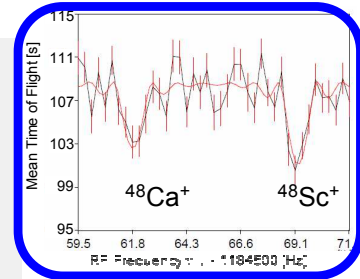
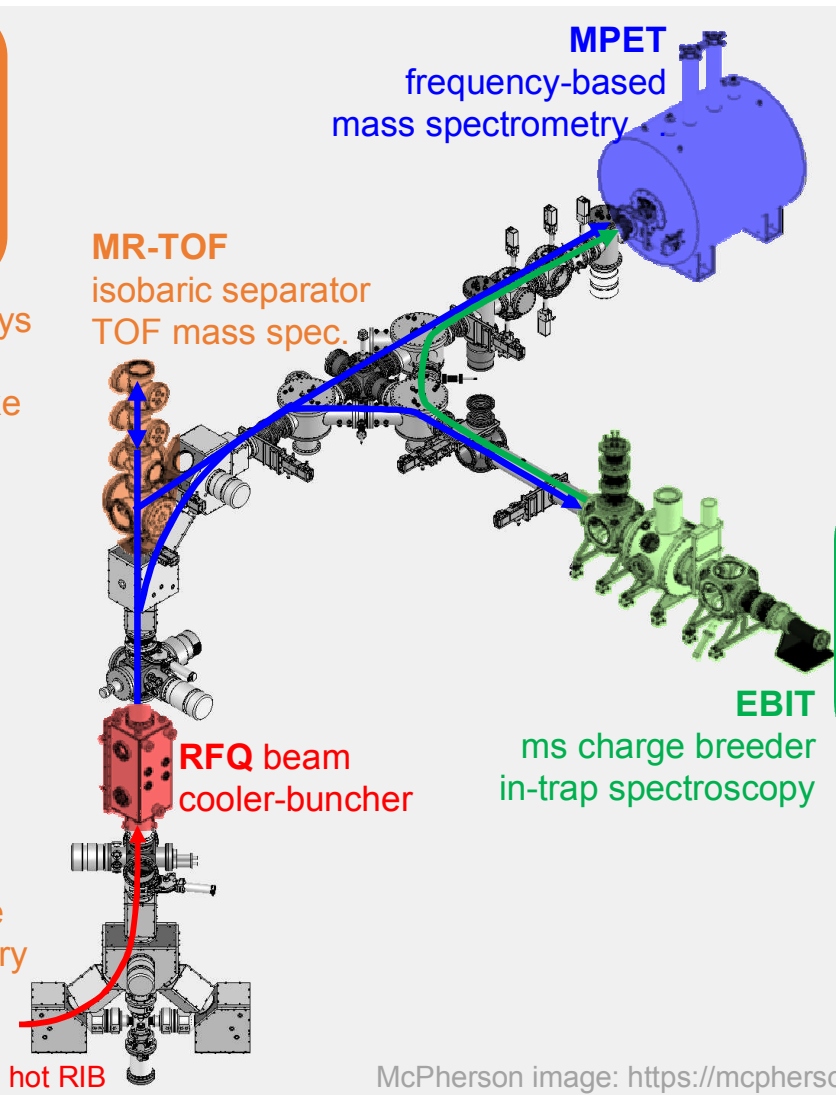
$T_{1/2}$ determinations 3 ways

Identify species or make 1st determinations for nuclear structure



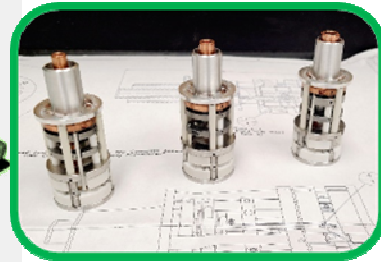
Laser Ablation Source commissioned in Calgary

for better calibrants & isotope science



Cryogenic upgrade done
→ better vacuum → better $\delta m/m$ → Standard Model tests

1st RIB experiment!



new e-gun machined being tested
→ Improved performance & control → new studies of weak interaction

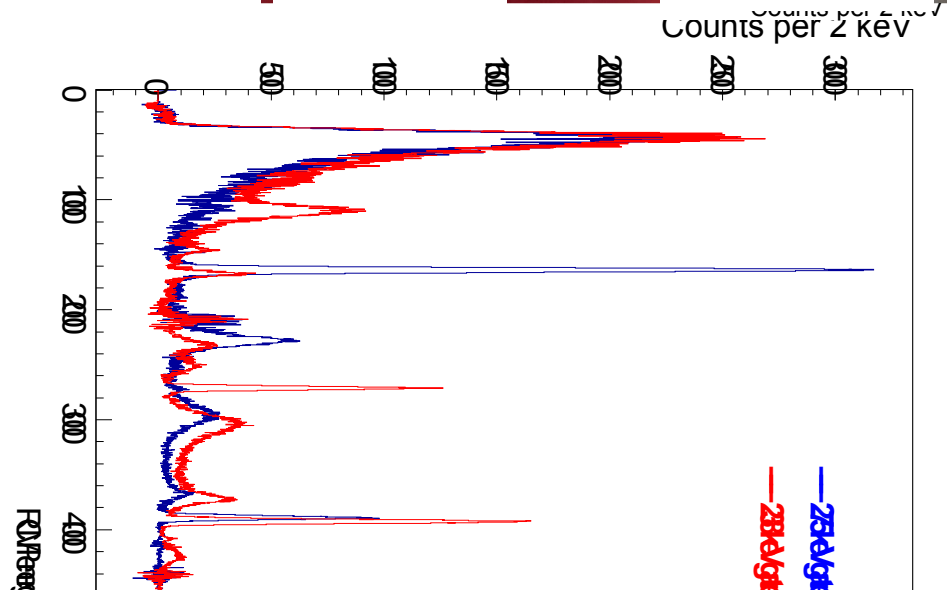
Prototype for CANREB EBIT

McPherson image: <https://mcphersoninc.com/spectrometers/xuhvvuvuv/model251mx.html>

2024 New Research Capabilities

- Regina Cube for Multiple Particles (RCMP)

- **New ancillary silicon detector cube for GRIFFIN successfully commissioned at ISAC (July 2024)**
- **Design and construction led by the University of Regina**
 - CFI JELF program (\$130k), PI: Gwen Grinyer
 - CFI, Innovation Saskatchewan, UofR
 - UofR team: 1 faculty, 3 postdocs, 10 students (since 2018)
- **6 DSSD detectors (micron BB7)**
 - Active area: 64 x 64 mm²
 - 6 x (32+32) strips = 384 channels
 - Thickness: 1 mm (12 MeV protons)
 - Strip pitch: 2 mm (0.5° angular resolution)
- **RCMP characteristics**
 - Energy resolution: 35 to 50 keV (FWHM)
 - Efficiency: 77% for protons and alpha particles
 - Successfully commissioned with ²⁰Mg beam (July)
- **Creates new opportunities in Canada**
 - Studies of nuclei at the limits of existence (proton)
 - Beta-delayed charged particle emission and alpha
 - Was not possible with GRIFFIN at ISAC until now
 - RCMP is fully operational and ready for future exp



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



- 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 information about the rapid neutron capture process**

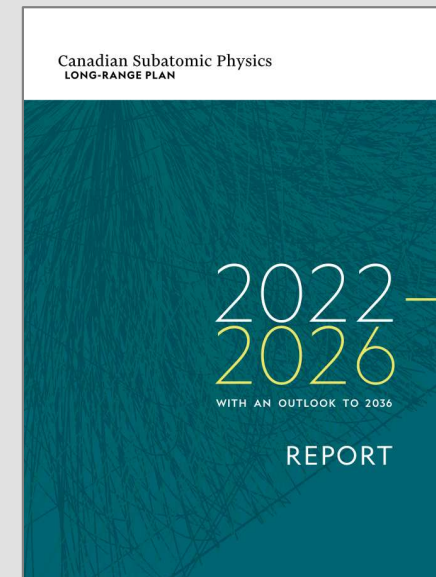
What is the role of radioactive nuclei in shaping the visible matter in the universe?

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

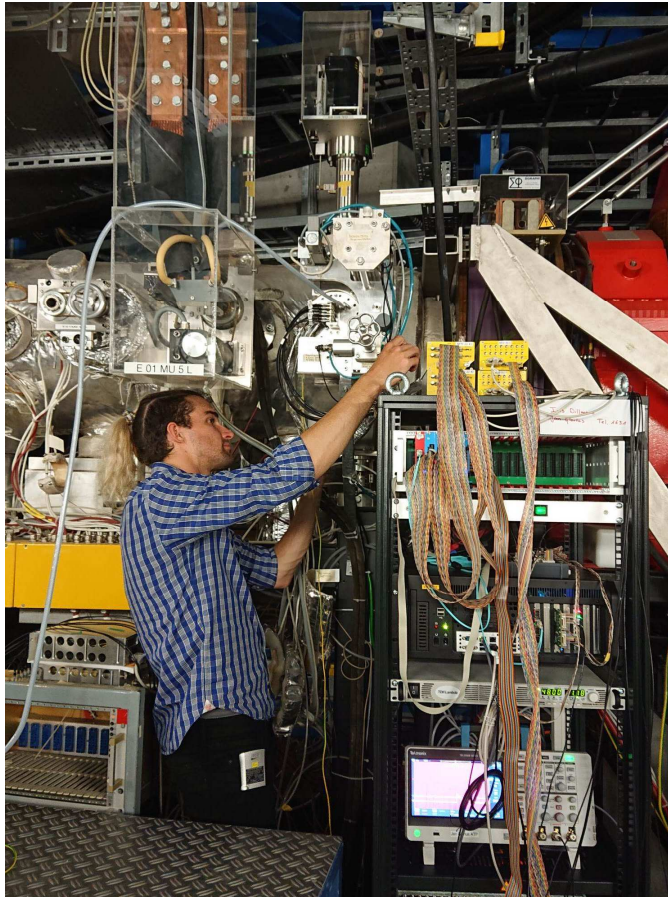


2024 Research Highlight

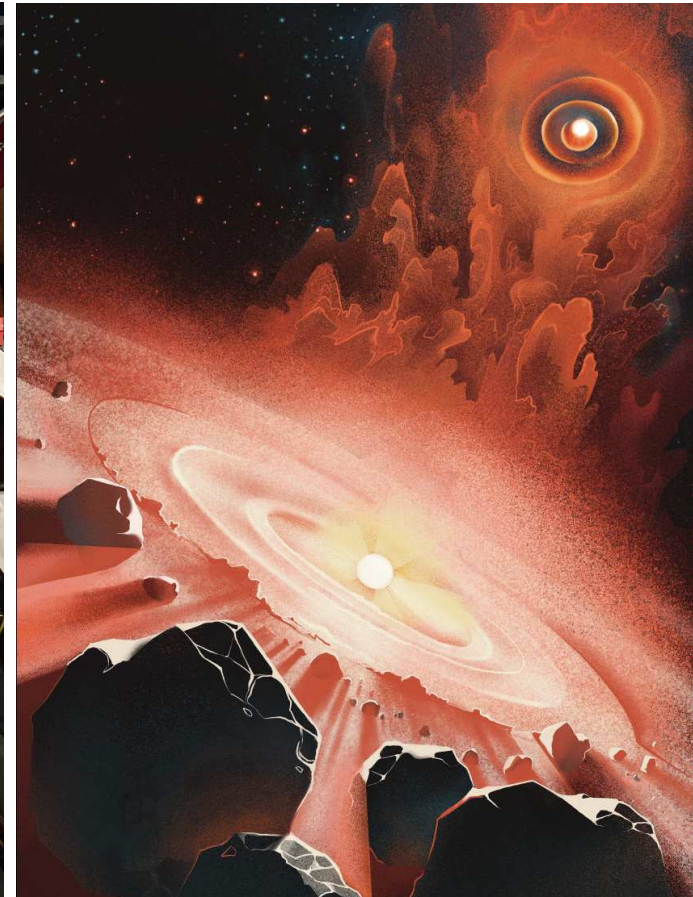
- Bound β decay $^{205}\text{Tl}^{81+}$ for early Solar System dating

April 2020: rare stellar decay mode (bound-state β decay) of bare $^{205}\text{Tl}^{81+}$ measured at the Experimental Storage Ring at GSI, Darmstadt.

- High impact on ^{205}Pb as a **radioactive clock in the early Solar System** and for geochemical measurement of solar neutrinos (LOREX).
- Analysis and impact on ^{205}Pb **lead by TRIUMF/ UBC PhD student Guy Leckenby.**
- ^{205}Pb impact [published in Nature](#).
- LOREX impact accepted in PRL.
- Artwork by Danielle Adams commissioned by TRIUMF.



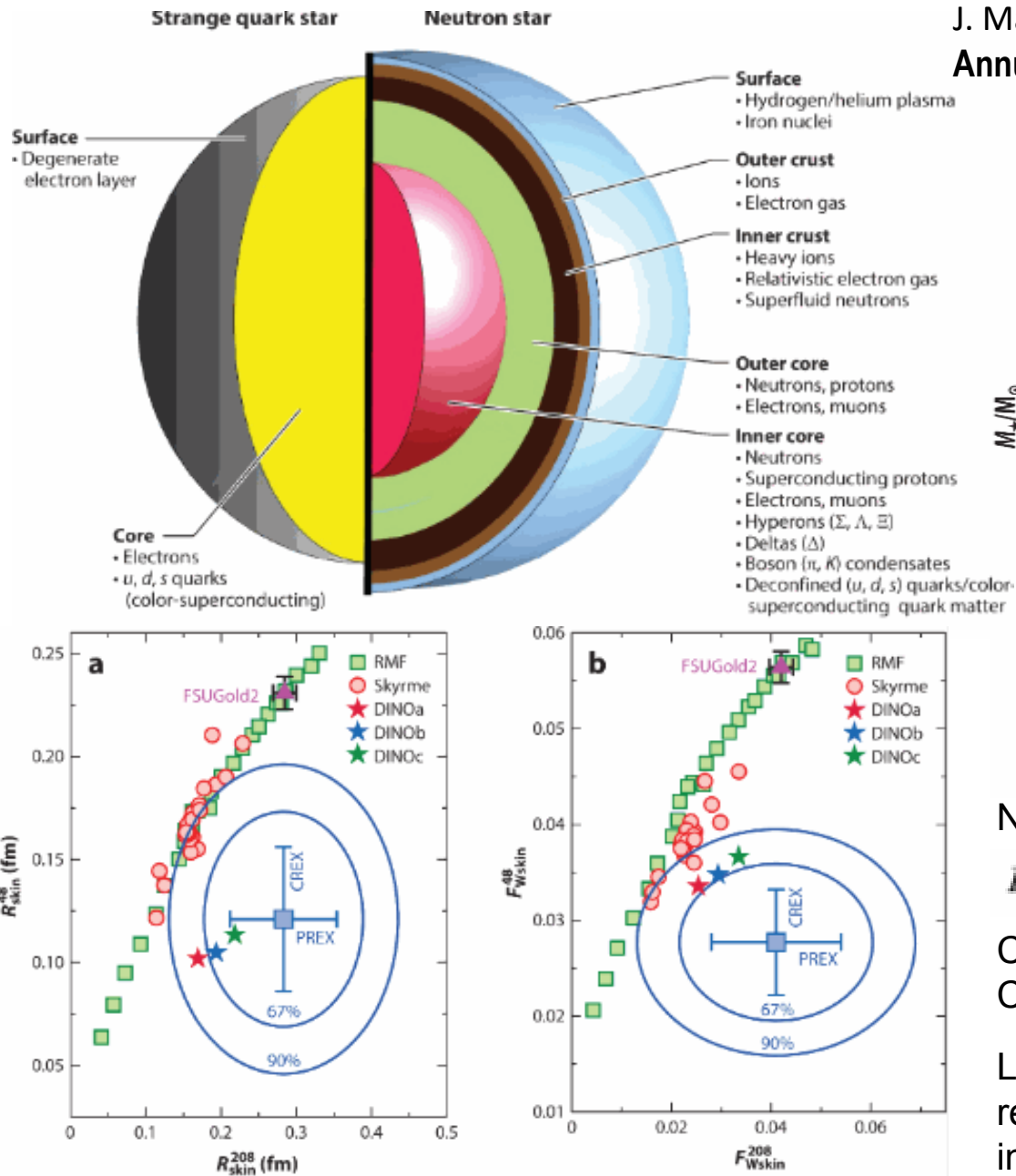
Guy working at the ESR



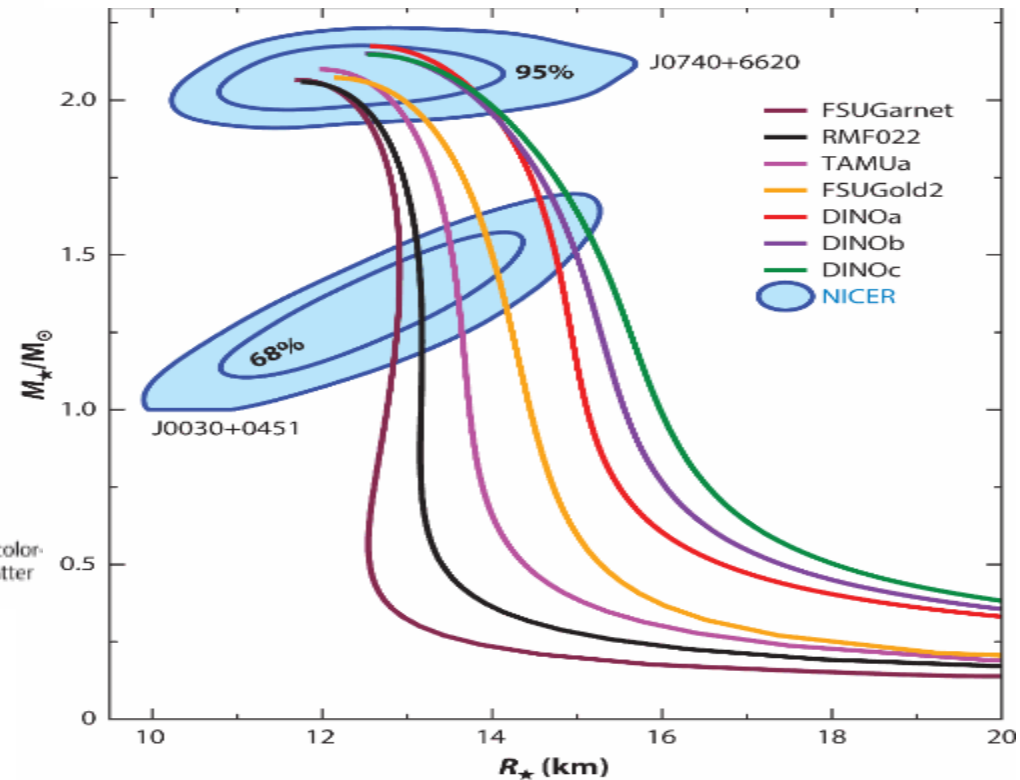
AGB star & early Solar System 32

2024 Research Highlight

Neutron Skins: Weak Elastic Scattering and Neutron Stars



J. Mammei, C. Horowitz, J. Piekarewicz, B. Reed and C. Sfienti.
 Annual Reviews of Nuclear and Particle Science 74 (2024)



Neutron skin of ^{208}Pb is large

$$R_n - R_p = 0.278 \pm 0.078(\text{exp.}) \pm 0.012(\text{theor.}) \text{ fm}$$

Challenging to find a model that fits both PREX and CREX; DINO models are plausible

Large neutron skin of lead with neutron star data could reflect a fascinating underlying dynamics, perhaps indicative of an exotic phase transition

What Physics Lies Beyond the Standard Model?



- **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?

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):

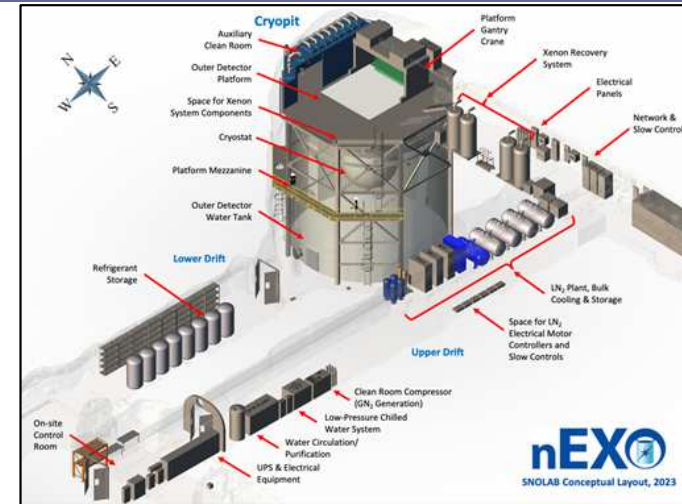
- Precision spectroscopy with radioactive molecules will be major new effort @ ISAC
- FrPNC to start atomic PV run @ ISAC
 - Possible extension to cold Fr, Ag molecules
- Deployment of HAICU by ALPHA Collaboration
- Fundamental Symmetries @ EIC



2024 Research Highlight

- nEXO's search for neutrinoless double beta decay

- The nEXO-Canada team welcomes new collaborating institutions:
 - University of Windsor (2023)
 - Queen's University (2023)
 - SNOLAB (2023)
 - McMaster University (2024)
- The US Nuclear Science Advisory Committee published community's Long Range Plan 2023, ranking support of a neutrinoless double beta decay program as the highest priority for new experiment construction. *"An independent portfolio review committee has deemed these experiments [CUPID, LEGEND-1000, nEXO] ready to proceed now."*
- Director's Review at LLNL with prominent Canadian participation:
 - Eva Luc from ISED
 - Directors from TRIUMF and SNOLAB
 - Dora Jordan from McGill's VPRI office



- Erica Caden elected as one of two ombudspersons in the nEXO collaboration (2024)
- Thomas Brunner elected as chair of the nEXO Institutional Board (2024)

2024 Research Highlight

- Honours Received by Members

Juliette Mammei

(University of Manitoba)

- Inducted into the Royal Society of Canada College of New Scholars, Artists and Scientists (2024-2031) for the emerging generation of Canadian intellectual leadership
- Her research is in the field of parity-violating electron scattering, focusing on nucleon structure and testing critical theories of the standard model of particles and interactions.



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

