

**Canadian Institute of  
Nuclear Physics**

**Institut canadien de  
physique nucléaire**

# CINP's Mission

- preparing the research plans of the Canadian Nuclear Physics research community for presentation to bodies such as the NSERC Subatomic Physics Long Range Planning Committee and Subatomic Physics Evaluation Section.
- representing the interests of the Canadian Nuclear Physics community to relevant bodies, in Canada and abroad.
- providing a forum for the advancement of the interests of students and alumni of higher education programs in Nuclear Physics in Canada.
- organizing workshops or other initiatives of interest to the Canadian Nuclear Physics community.
- facilitating Canadian participation in new Nuclear Physics initiatives in Canada and abroad.

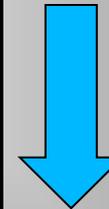
# CINP Governance

Institutional Members
McGill University
Mount Allison University
Saint Mary's University
TRIUMF
University of Guelph
University of Manitoba
University of Regina
University of Winnipeg



Pay Annual Dues and Elect Board

Board of Directors
Jens Dilling (TRIUMF) <i>President</i>
Jean Barrette (McGill)
Paul Garrett (Guelph)
Gerald Gwinner (Manitoba)
Rituparna Kanungo (St. Mary's)
Jeff Martin (Winnipeg)



Employs part-time Exec. Dir. to oversee daily affairs of CINP

Executive Director
Garth Huber (Regina)



# CINP Individual Membership

- **Two types of Individual Membership:**
  - **Faculty Level:** NSERC-eligible researchers at Canadian universities, institutes and laboratories.
  - **Associate:** Grad Students, PDFs, retired Faculty, and non-NSERC-eligible researchers.

As of April 30, 2014	Members
<b>Total Individuals</b>	<b>106</b>
Faculty Level	72
Associate	34
Experiment Major Interest	79
Theory Major Interest	26

# Scientific Working Groups (SWGs)

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

- **Individual Members are eligible to apply for membership in one or more SWGs.**

Working Group	Members	Chair
Nuclear Astrophysics	37	Iris Dillmann (TRIUMF)
Nuclear Structure	49	Adam Garnsworthy (TRIUMF)
Beyond the Standard Model	40	Gerald Gwinner (Manitoba)
Hadrons/QCD	29	Charles Gale (McGill)
Nuclear Physics Education & Training	35	Juliette Mammei (Manitoba)

# Joint CINP+IPP Create Grant

- We are investigating a joint CREATE application between CINP+IPP members, to provide enhanced HQP training opportunities for subatomic physicists, and also to relieve some pressure on the NSERC Subatomic Physics Envelope.
- **NSERC's Program Requirements:**
- Training initiative should provide a value-added experience to the university training environment, to better prepare the research trainees for their future careers in industry, government or academia.
- Need a **supportive Lead Institution**, committed to the application goals, willing to include the proposal as part of their quota of CREATE applications, and possibly provide cash or in-kind support.
- The team of co-investigators must provide the necessary expertise for the CREATE program, with specific roles and responsibilities, and their complementarity.
- The excellence of this team is one of the major criteria in the evaluation of whether the LOI proceeds to a full proposal.

# TRIUMF's CREATE Experience

- **ISOSIM – ISOtopes for Science and Medicine  
CREATE grant approved April, 2014.**
  - **PI: Reiner Kruecken, UBC**
  - **Co-applicants from:**
    - TRIUMF Science & Accelerator Divisions
    - UBC Faculties of Pharmacy, Physics, Chemistry, Earth Sciences
  - **Collaborators from:**
    - Helmholtz Inst., Max Planck Inst., DESY, Siemens Foundation, GE Research
    - UBC Marine Biology, Medicine, Journalism, Business
- **First two applications were not successful:**
  1. **Joint graduate training program in subatomic physics between TRIUMF, Helmholtz Institute and Julich FZ.**
    - Guaranteed German matching funds.
    - TRIUMF put in LOI, but decision made to exclude TRIUMF from CREATE program as not a degree-granting institution.
    - Impossible to know whether the application would have otherwise been successful.
  2. **UBC-centric program in nuclear medicine and nuclear physics.**
    - LOI did not make it through UBC's internal vetting process.
    - Underscores importance to have strong support from central administration.

# Joint CINP+IPP CREATE Grant

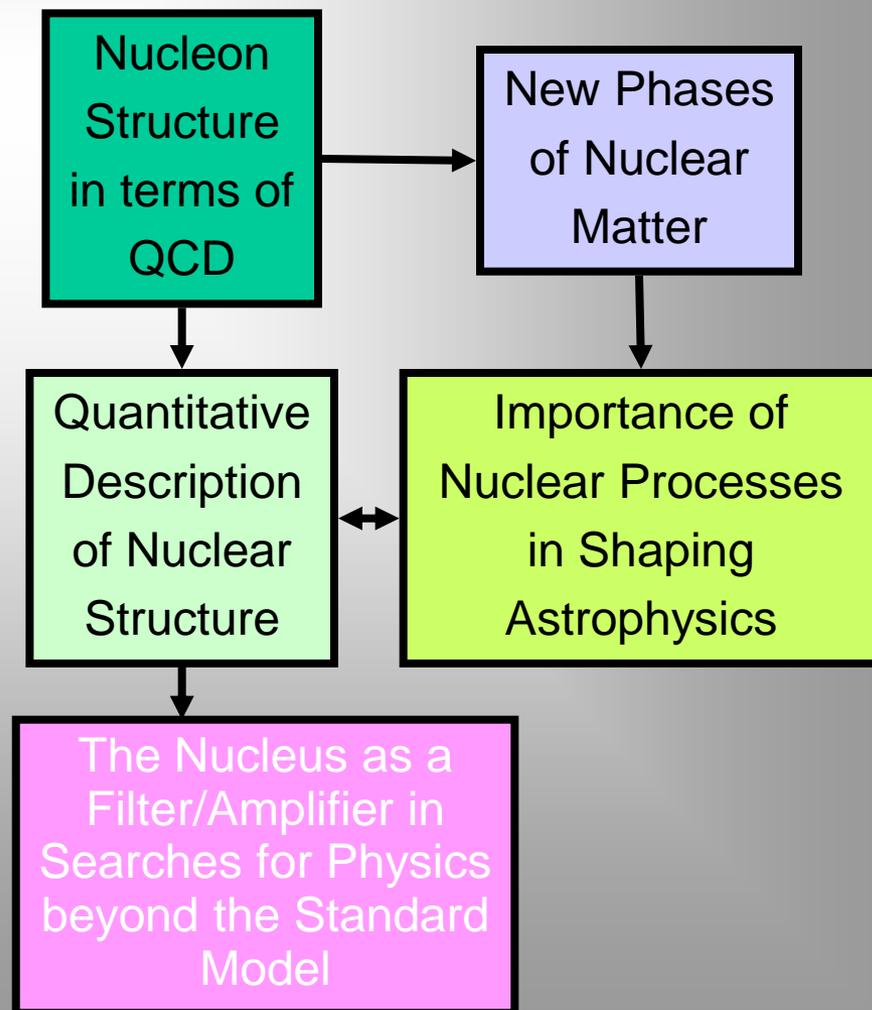
- **Important Immediate Items:**
- **Establish a Joint CINP+IPP Task Force to consider all aspects of the application.**
  - Would like Task Force to report back to CINP Board + IPP Council before end of year.
- **Consider which university might lead the CREATE program.**
  - Requires strong support from the central administration.
- Explore business schools that might already have a program or is prepared to create a program that translates the skill-set of a Ph.D. or postdoc in subatomic physics into the private sector economy.

# 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.

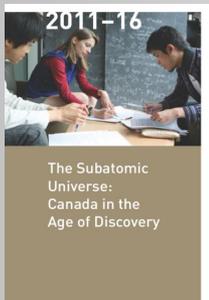
- A far reaching mission that requires a *balanced program* of experimental and theoretical effort.
- Broad international consensus on the key questions of significance to the broader community.



# Hadrons/QCD

## – Big Questions

- How do the nucleon's properties (mass, spin, charge radius, etc.) arise from its quark and gluon constituents?
  - Transition from pQCD to Strong QCD needs data with high precision for a quantitative understanding of confinement.
- What is the phase diagram of QCD?
  - Nuclear collisions are the only way to probe QCD at high temperature/density in the laboratory.



### Examples of key Canadian initiatives from 2011-16 LRP:

- Search for exotic hybrid mesons (qqg states) with unique quantum numbers (JLab - Hall D/GlueX).
- Determine the structure of the pion at small distance scales to better understand the transition of QCD from short- to long-distance scales (JLab – Hall C/Pion Form Factor Expt).

# Nuclear Structure

## - Big Questions

- Where are the limits of nuclear existence and can these limits be understood and/or predicted from first principles?
- How do the properties of nuclei evolve as a function of the neutron-proton asymmetry and also as a function of proton and neutron number?
- What are the mechanisms responsible for the organization of individual nucleons into the collective motions that are observed?



The Subatomic  
Universe:  
Canada in the  
Age of Discovery

### Examples of key Canadian initiatives from 2011-16 LRP:

- Precision nuclear mass measurements (ISAC - TITAN).
- Studies of nuclear spectroscopy (ISAC - TIGRESS, GRIFFIN, EMMA spectrometers + auxiliary devices).
- Laser spectroscopy studies.

# Nuclear Astrophysics

## – Big Questions

- How, when, and where were the chemical elements produced?
- **What role do nuclei play in the liberation of energy in stars and stellar explosions?**
- How are nuclear properties related to astronomical observables such as solar neutrino flux, rays emitted by astrophysical sources, light emitted by novae and X-ray bursts, etc.?

### Examples of key Canadian initiatives from 2011-16 LRP:

- Measurements of key nuclear reaction rates and to understand the nature of relevant nuclear resonances (ISAC - DRAGON, TUDA, TACTIC).
- Study origin of heavy elements via spontaneous fission of  $^{252}\text{Cf}$  (Argonne - CARIBU facility).



The Subatomic Universe:  
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# Beyond the Standard Model

## – Big Questions

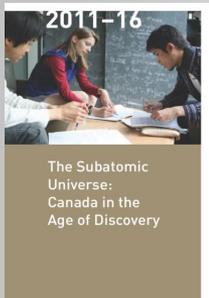
- **Studies of fundamental symmetries via very precise low and intermediate-energy experiments have been part of nuclear physics since its inception.**
- **Complementary to direct probes by high energy physicists since precision lower-energy experiments indirectly probe mass scales and parameter spaces not otherwise accessible.**
- **Is there additional CP & T violation beyond that identified in Kaons and B-mesons?**
- **What is the structure of the Weak Interaction?**
- **Can we find violation of CPT and Lorentz invariance?**

# Beyond the Standard Model

## - Answering the Big Questions

### Examples of key Canadian initiatives from 2011-16 LRP:

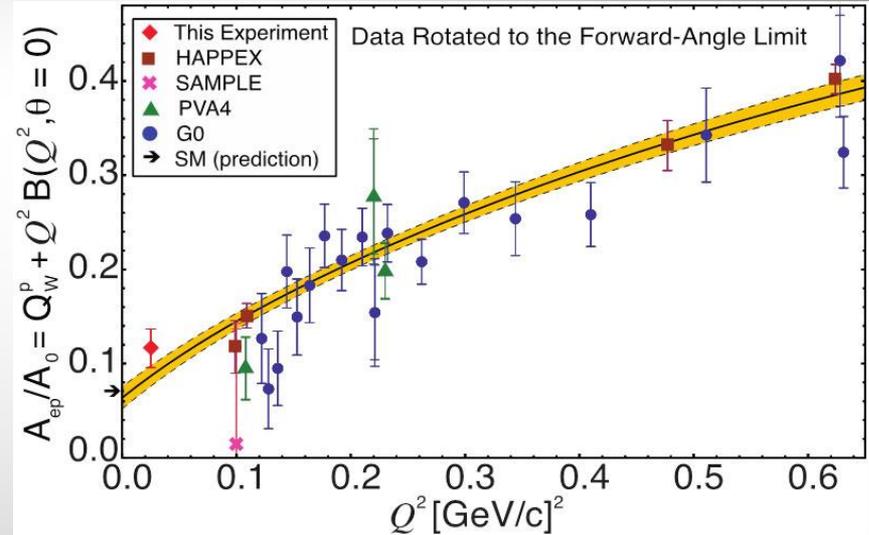
- Probe electroweak coupling and its dependence on distance scale in ISAC - Francium Parity Non-Conservation experiment.
- Probe CP/T-violation in ISAC - Radon Electric Dipole Moment experiment (new GRIFFIN  $\gamma$  array is CFI funded).
- CKM unitarity tests in nuclear  $\beta$ -decay (ISAC - TITAN, GRIFFIN).
- Constrain weak scalar interactions via  $\beta$ - $\nu$  correlations from spin-polarized trapped atoms (ISAC - TRINAT).
- Measure the electron weak charge and the running of  $\sin^2\theta_w$  at intermediate energy in the MOLLER Experiment (JLab - Hall A).
- Search for CPT Violation in trapped Antihydrogen (CERN - ALPHA).



# 2013 Research Highlights

## - Proton Weak Charge ( $Q_{\text{weak}}$ ) @ JLab

- Very significant contributions by Manitoba/Winnipeg/UNBC/TRIUMF groups.
  - Co-spokesperson S. Page and other key collaboration leadership positions.
  - \$3M total funding from NSERC, and many detector components including magnetic toroid coils.
- First results on reported in Oct/13 Phys. Rev. Lett. consistent with Standard Model prediction.
- Final result will use 25x more data, yielding uncertainties small enough to seriously constrain possible physics beyond Standard Model.



# 2013 Research Highlights

## - Canadian Penning Trap @ Argonne

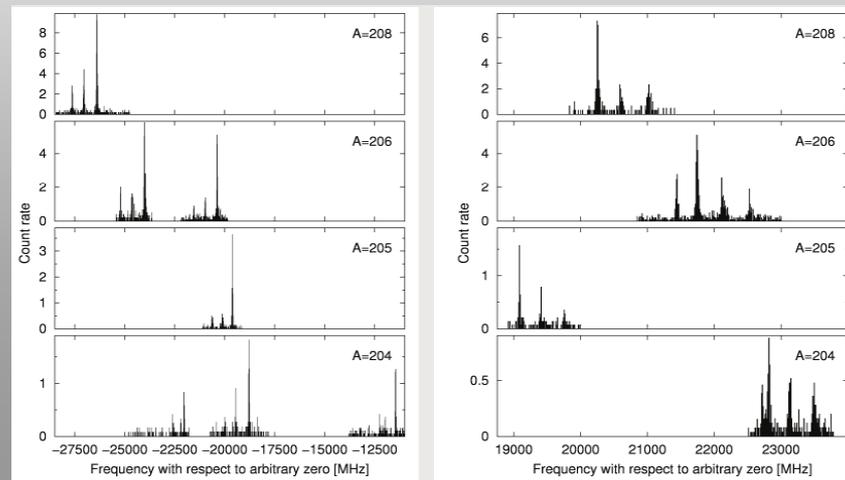
- Manitoba/McGill group had extraordinarily successful year.
- Three Phys.Rev.Letters:
  - Van Scheldt, et al., PRL 111, 061102 (2013)
    - *Mass measurements of neutron-rich exotic nuclei on the r-process path*
    - **Highlighted article by Physics World**
  - Li, et al., PRL 110, 092502 (2013)
    - *Stringent placed on Tensor Interactions from the  $\beta$ - $\nu$  correlation measurements in decay of trapped  $\text{Li}^8$*
    - **Note: Li was a McGill Ph.D. student, awarded 2012.**
  - Yee, et al., PRL 110, 092501 (2013)
    - *Novel method to study delayed neutron emission in decay of neutron-rich nuclei using trapped radioactive ions*
    - *Interesting from both fundamental and applied nuclear physics viewpoints (advanced fuel cycles and other reactor physics)*



# 2013 Research Highlights

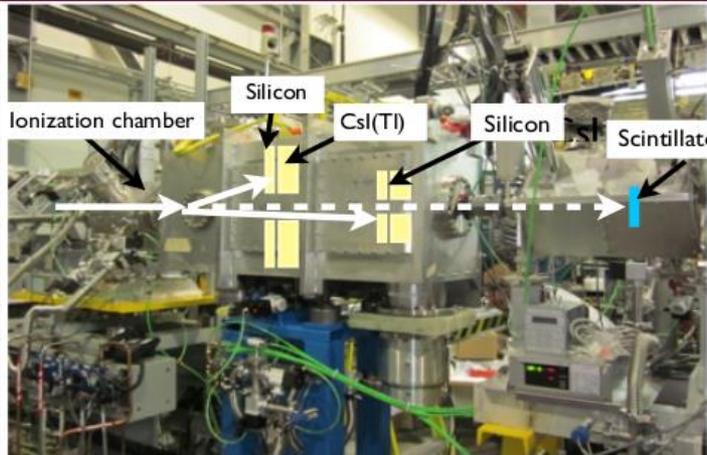
## - Collinear Fast Beam Spectroscopy @ ISAC

- **Currently the only group in the world capable of performing laser spectroscopy on heavy elements with sufficient resolution to extract nuclear spins, changes in charge radii and ground state moments.**
  - Voss, et al., PRL 111, 122501 (2013)
    - *First use of High-Frequency Intensity Modulation of Narrow-Linewidth Laser Light and Its Application in Determination of  $^{206,205,204}\text{Fr}$  Ground-State Properties.*
    - *Positively identified two low lying isomers in each of  $^{204}\text{Fr}$  and  $^{206}\text{Fr}$ .*
  - Voss, et al., J. Phys G 41, 015104 (2014)
    - *New, high resolution variant on beta detected NMR that has allowed the ratio of the  $^9\text{Li}/^{11}\text{Li}$  nuclear quadrupole moments to be determined to high precision.*

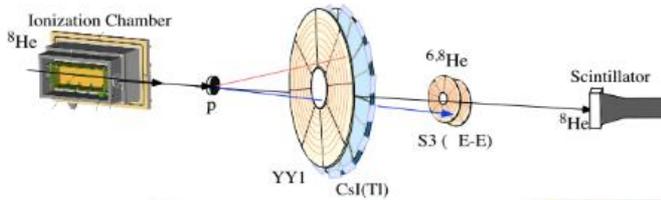


# 2013 New Research Capabilities

## - IRIS begins operation @ ISAC



Overview of IRIS beamline @ TRIUMF



Pioneered in use of **Solid H<sub>2</sub>/D<sub>2</sub> target** for RI beam transfer reactions

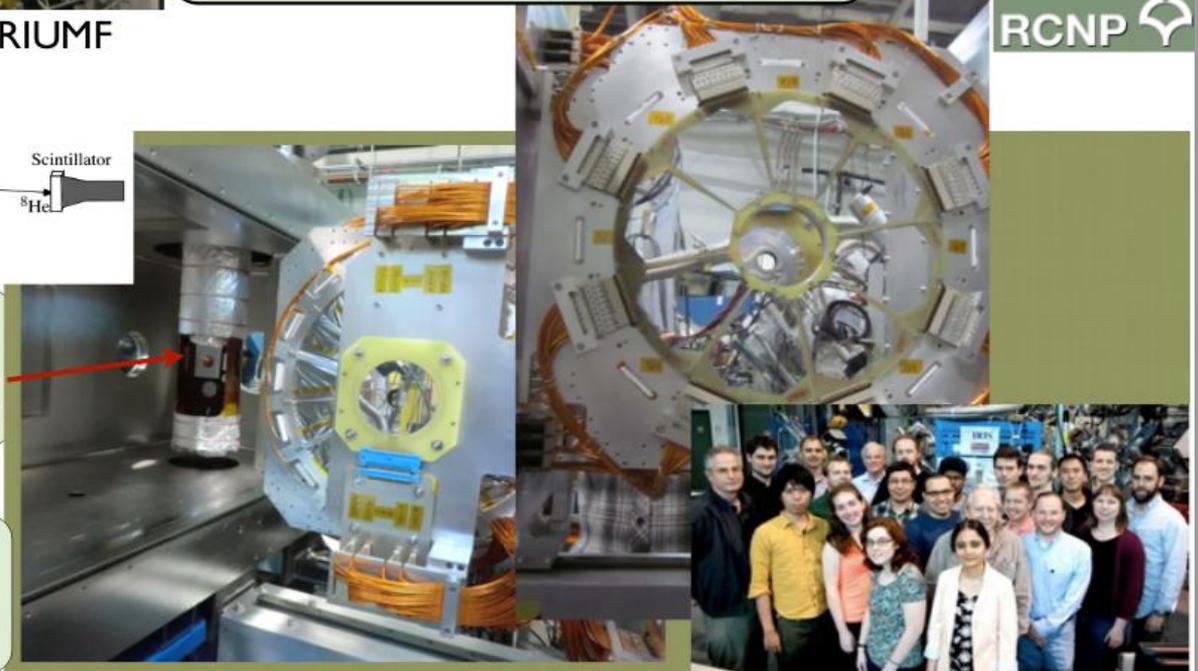
**Ionization Chamber**  
First time incoming beam event by event detection at ISOL experiment

- High priority experiments**
- S1147 : <sup>11</sup>Li soft dipole resonance
  - S1203 : <sup>11,12</sup>Li resonance search
  - S1338 : <sup>12</sup>Be pairing correlation
  - S1396 : <sup>10</sup>C : Investigating 3N force
  - S1449LoI : <sup>20</sup>Mg resonances for nuclear structure and nuclear astrophysics



CFI+partners ~ \$1.3M

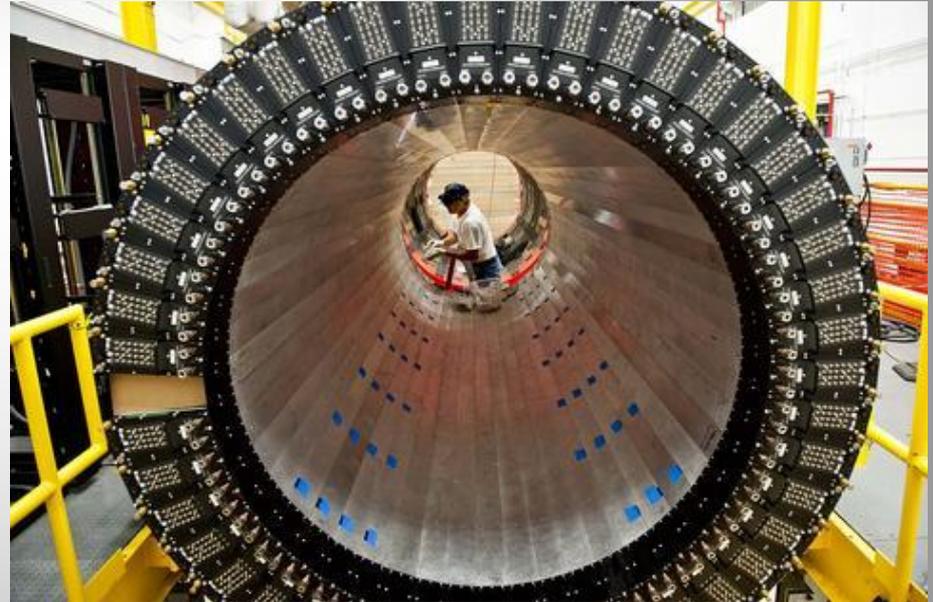
RI beam operation from 2013



# 2013 New Research Capabilities

## - Canadian Detectors @ JLab 12 GeV

- **Hall D Barrel Calorimeter.**
  - \$2.3M detector funded by USDOE and NSERC.
  - Designed and constructed in Regina, 5 months ahead of schedule.
  - BCAL installed in bore of superconducting solenoid in September and cabling completed in December.
  - Commissioning to begin in February.
- **Hall C Heavy Gas Cherenkov.**
  - Funded by NSERC.
  - Designed and constructed by Regina group.
  - Detector assembly at JLab in August.

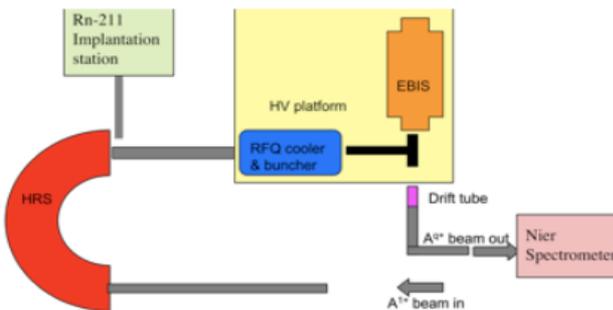


# 2013 New Research Capabilities

- CANREB@ISAC funded in recent CFI-NIF cycle

CFI + partners ~ \$4.2 M

The CANREB project is led by Saint Mary's University, Halifax in partnership with the University of Manitoba, TRIUMF and in collaboration with Simon Fraser University and the University of Guelph



Purifying and accelerating isotopes for discovering fundamentals of rare isotopes in nature and progressing nuclear medicine

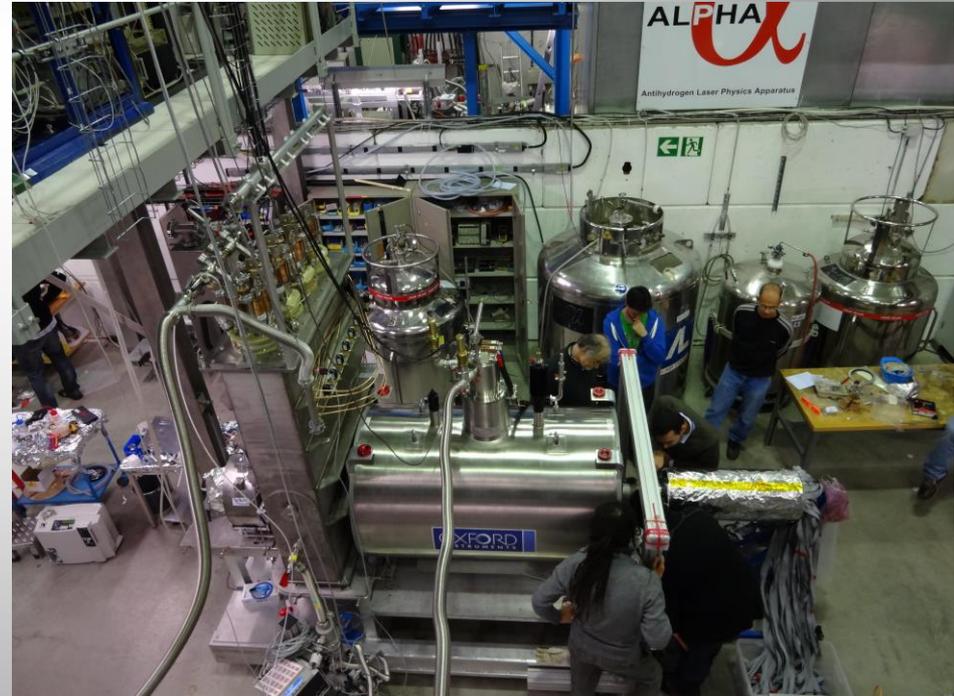
## Media captures CANREB

- Frontpage news The Chronicle Herald
- Radio Canada International
- CFI press release in The Hill Times
- Global TV maritimes

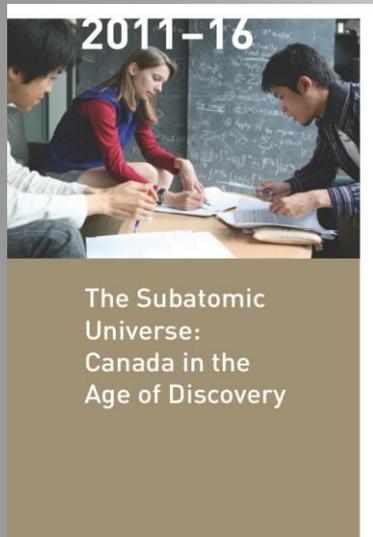
# 2013 New Research Capabilities

## - Anti-Hydrogen Trap ALPHA @ CERN

- Very significant Canadian contributions supported by NSERC, TRIUMF and the universities.
- Recently completed construction and commissioning of ALPHA-2 trap, a major upgrade to the original ALPHA trap.
- Preparing for next round of anti-Hydrogen trapping experiments.



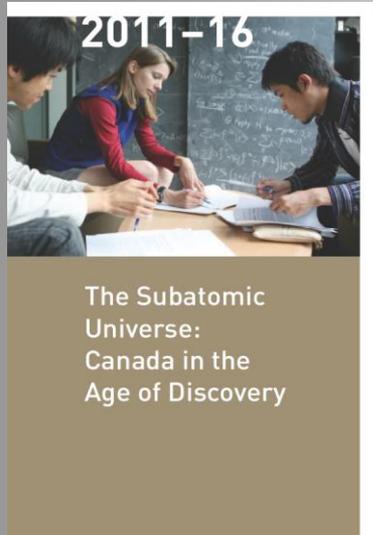
# Canadian Subatomic Physics LRP 2011-16: Priorities in Nuclear Physics



- Continue and expand full exploitation of TRIUMF's ISAC-I and ISAC-II facilities, with unique suite of measurement tools, including new spectrometers and devices.
- Support key experimental initiatives offshore where Canadians lead. Examples:
  - Jefferson Lab Halls D,C,A following 12 GeV Upgrade.
  - Canadian Penning Trap at Argonne.
  - ALPHA at CERN.
- Maintain a vibrant and diverse theoretical community pursuing the most actively pursued questions in nuclear physics.

# Canadian Subatomic Physics LRP

## 2017-21: Upcoming Nuclear Physics Projects



- **Implementation of ARIEL project at TRIUMF, including second ISAC proton beam line and new actinide target stations, has tremendous potential for scientific discovery and advancement of the field.**
- **Movement of the Ultra-Cold Neutron (UCN) source from RCNP to TRIUMF would make it the world's most intense source of cold neutrons and allow the current limit on the neutron EDM to be improved by a factor of  $\sim 3$ .**