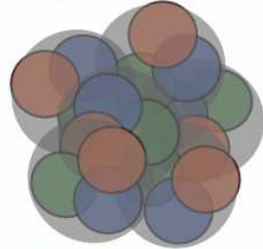


C I N P



I C P N

**Canadian Institute of  
Nuclear Physics**

**Institut canadien de  
physique nucléaire**

**2016 Individual Members AGM**

**June 12, 2016**

**Ottawa, ON**

# Agenda



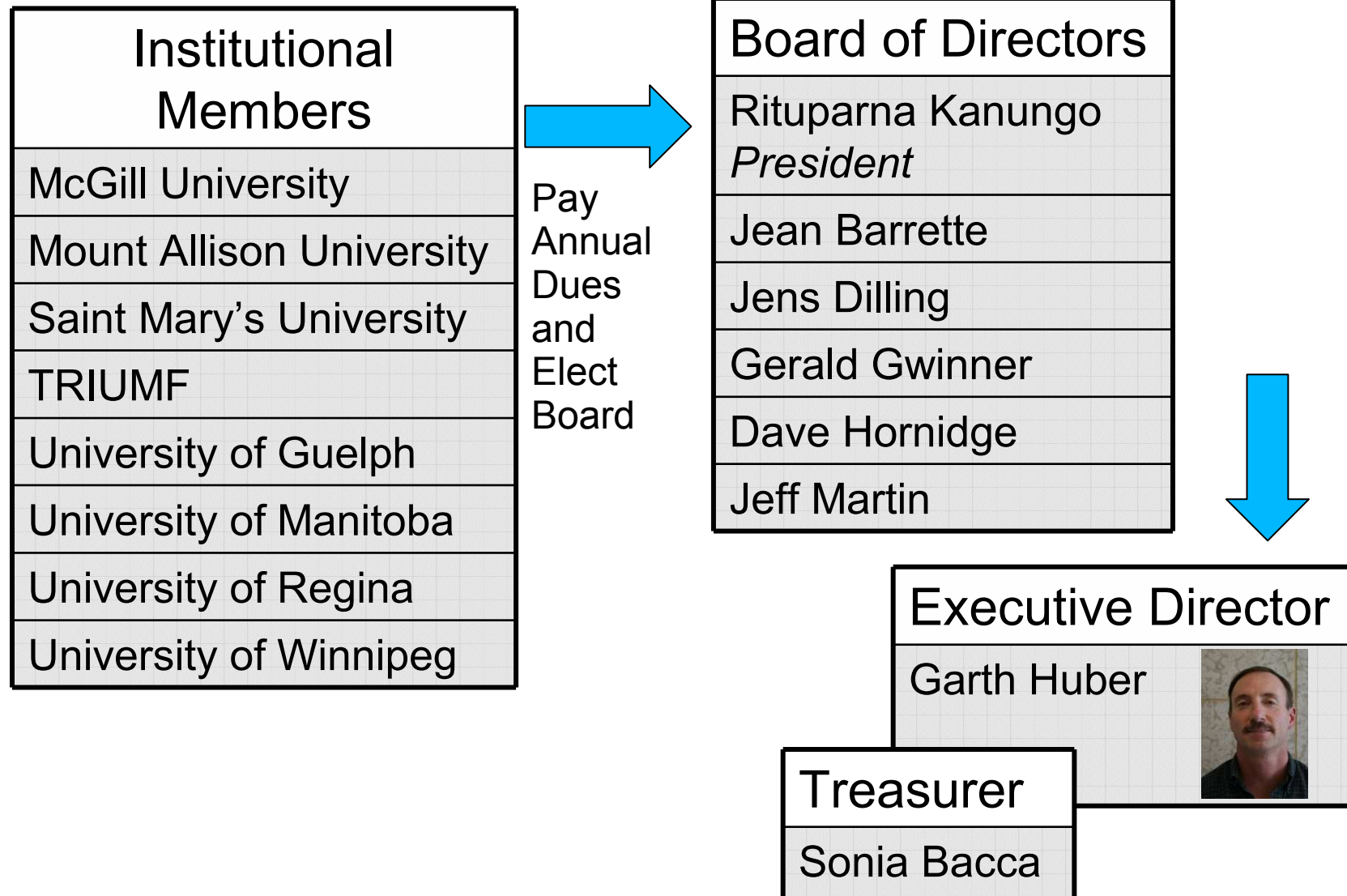
- 1. Approval of Agenda**
- 2. News from TRIUMF Science Technology Department**
  - Fabrice Retiere
- 3. Executive Director's report**
- 4. Financial Report**
  - Sonia Bacca
- 5. Discussion items**
  - Undergraduate Research Scholarships
  - Research Scientists
- 6. Updates from the Scientific Working Groups**
- 7. Comments and Suggestions from the Membership**
- 8. CINP Scientific Summary from Large Projects Day**
- 9. Adjourn**

# What is the CINP?

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- 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



# Our thanks to:

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- **A very special thank you to Jean Barrette (McGill) who is stepping down from the CINP Board after many years of service.**
  - Two terms as Board member.
  - Assisted with the initial incorporation and set-up of CINP in 2005-07.
- **Please welcome incoming Board member Sangyong Jeon (McGill), who was elected at the CINP Institutional Members meeting on May 6.**

# CINP Individual Membership



- This is the first year that did not show growth.
  - 8 new members offset by 8 associates who did not renew (left field and no longer eligible, or unable to contact), and loss of 2 faculty (one death and one retirement).
- Please encourage your grad students and PDFs to join and contribute to the activities of the CINP!

## New Faculty Members:

Jonathan Bagger (TRIUMF)  
Thomas Brunner (McGill)  
Kim Maltman (York)  
Dennis Muecher (Guelph)

## New Associate Members:

Liliana Cabalero (Guelph)  
Matthias Holl (St. Mary's)  
Satbir Kaur (Dalhousie)  
Jenna Smith (TRIUMF)

As of April 30, 2016	Now	1 Year Ago	Change
<b>Faculty Level</b>	<b>70</b>	<b>69</b>	<b>+1</b>
<b>Associate</b>	<b>43</b>	<b>46</b>	<b>-3</b>
<b>Experiment Major Interest</b>	<b>83</b>	<b>85</b>	<b>-2</b>
<b>Theory Major Interest</b>	<b>29</b>	<b>29</b>	<b>0</b>

# Scientific Working Groups

Working Group	Members	Chair
<b>Nuclear Astrophysics</b>	<b>40</b>	<b>Iris Dillmann (TRIUMF)</b>
<b>Nuclear Structure</b>	<b>50</b>	<b>Adam Garnsworthy (TRIUMF)</b>
<b>Fundamental Symmetries</b>	<b>44</b>	<b>Gerald Gwinner (Manitoba)</b>
<b>Hadrons/QCD</b>	<b>34</b>	<b>Charles Gale (McGill)</b>
<b>Nuclear Physics Education &amp; Training</b>	<b>38</b>	<b>Juliette Mammei (Manitoba)</b>

## SWG Chair Duties:

- be the main point-of-contact for the SWG membership.
- help facilitate the CINP scientific program, e.g. contribute material to or suggest authors for the CINP website and newsletter, and help organize workshops.
- help write the CINP Brief for input to the NSERC Subatomic Physics Long Range Plan, and to provide input on other CINP activities, such as the annual presentation at NSERC Large Projects Day and the AGM.
- act as an advisor to the CINP Executive Director on related scientific issues.
- work together with the CINP Executive Director and other SWG Chairs on issues related to funding, long-range planning, and outreach.
- encourage people to join CINP, and to participate in the SWG.

# CINP 2015-16 Accomplishments



- **Nuclear Physics Representation.**

- The CINP has been vital in giving the nuclear physics community a coherent and strong voice.
- “Context Document” for SAPES Fall Policy Meeting.
- NP Community Representative at Advisory Committee on TRIUMF (ACOT), spring and fall annually.
- Joint CINP+IPP White Paper on High Performance Computing to Compute Canada, updated Feb, 2016.
  - Several of the theoretical Nuclear Physics projects are very numerically intensive, with demands exceeding those of some of the major experiments. The advent of High Performance Computing has been a game-changer: people can now hope to tackle realistic simulations, large basis spaces, etc.
- Meetings with NSERC, CFI, etc. on issues of importance to the nuclear physics community.
- Formal observer to NuPECC (Nuclear Physics European Collaboration Committee)
  - Plan to attend one NuPECC meeting a year, particularly if a CINP representative is already in Europe on other business.

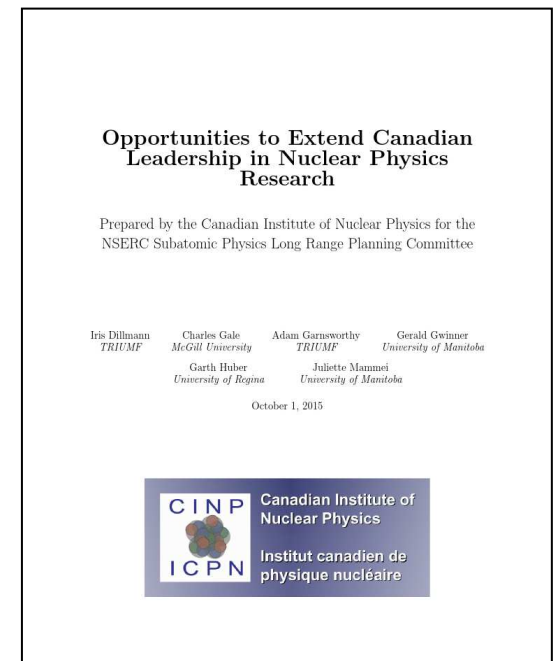


# CINP 2015-16 Accomplishments



- **CINP coordinated Nuclear Physics input to 2017-21 Long Range Plan.**

- Brief Writing Committee: GH and 5 SWG Chairs.
- Any Canadian nuclear physics researcher could submit input, whether or not a CINP member.
  - Input also sought from other related groups, such as Accelerator Physics.
- CINP Town Hall meeting held June 13-14 at Univ of Alberta, Edmonton, AB.
  - Written briefs submitted to committee by June 26.
- Brief writing committee met by phone over the course of the summer, as well as in person at TRIUMF August 6,7 to finalize the CINP Brief.
- Two rounds of input sought from CINP membership: Aug 28, Sept 18.
- Final CINP Brief submitted to LRPC on Oct 1.
  - 135 pages, used extensively by LRPC in their discussions.
- CINP Brief presented at LRPC Town Hall at TRIUMF, Dec 12/15.



# CINP 2015-16 Accomplishments

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- **Successful programs to assist students in presenting their Nuclear Physics research at domestic conferences.**
  - 4 undergraduates supported to Canadian Undergraduate Physics Conference (CUPC) at Trent Univ, Peterborough, ON in October, 2015.
  - 4 graduate students supported to Winter Nuclear and Particle Physics Conference (WNPPC) at Banff, AB in February, 2016.
- **Conference Support Program remains in high demand.**
  - CUPC 2015
  - International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions 2015, Montreal, QC
  - Symposium on Symmetries in Subatomic Physics 2015, Victoria, BC
  - Precision Radiative Corrections Workshop 2016, JLab
  - Direct Reactions with Exotic Beams 2016, Halifax, NS

# CINP 2015-16 Accomplishments



- **CINP Undergraduate Research Scholarships (URS)**

- A supervisor can nominate only their best student for the award. The selection is competitive, with only the top ~1/3 nominees selected.
- \$3400 student stipend which must be matched by supervisor to at least \$7k (typically \$8.5k).
- \$1300 travel supplement available if the supervisor intends to send the student to a laboratory or to work with a second collaborator for an extended period.

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

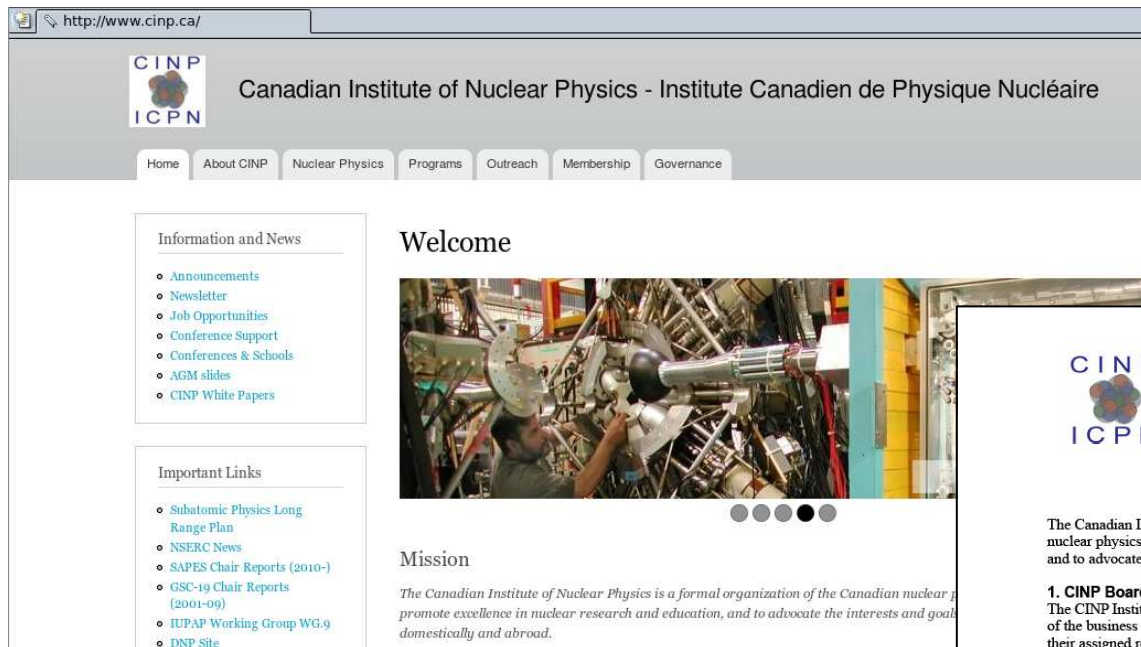
- 1) Gifted international students studying in Canada are eligible to apply for the CINP URS, but not the NSERC USRA.
- 2) An important element of the URS is the optional Travel Award, which allows the supervisor to send student to a lab or work with second collaborator for an extended period. This can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

# CINP 2015-16 Accomplishments



- **Community Outreach.**

- **CINP facilitates new connections and allows the disparate Canadian nuclear physics community to develop a common identity.**
- Revamped CINP website launched in 2015.
- 2 Newsletters annually.



**Canadian Institute of Nuclear Physics  
Institut canadien de physique nucléaire**

*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.*

## April 2015 Newsletter

### 1. Subatomic Physics Long Range Plan and CINP Town Hall Meeting

As was announced on March 25, NSERC will soon be embarking on a new Subatomic Physics Long Range Planning (LRP) exercise. NSERC is in the final stages of selecting the LRP Committee (LRPC) membership, which is expected to be announced at the upcoming CAP Congress at the University of Alberta, in Edmonton.



**Canadian Institute of Nuclear Physics  
Institut canadien de physique nucléaire**

## November 2015 Newsletter

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 (2015-16)

The CINP Institutional Members had their annual meeting via teleconference on May 20. One of the business was to elect two new Board members. The new Board is listed below, along with their assigned responsibilities.

Name	Institution	Role	E-mail	Term Ends
Rituparna	Saint Mary's	President	ritu@triumf.ca	June, 2016

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g Group Chairs

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n)

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goal is to leave

# CINP Financial Statements

- Prepared by Sonia Bacca



NSERC Account FY15 (actual)	
FY14 Carry forward	-1,246
FY15 Installment	42,000
<b>SAP Long Range Plan</b>	
Town Hall Meeting	650
Brief Writing Committee	6,198
LRPC Meetings	1,076
<b>Representation Travel</b>	
ACOT (2 trips)	2,945
SAP Large Projects Day	1,390
Other (Ottawa, NuPECC)	244
<b>Conference Sponsorship</b>	
DREB 2016	4,000
CUPC 2015	500
<b>Undergrad Scholarships</b>	20,900
<b>Student Conf Support</b>	
CUPC 2015	2,000
WNPPC 2016	2,000
<b>Misc</b>	367

NSERC Account FY16 (budgeted)	
FY15 Carry forward	-1,516
FY16 Installment	44,000
<b>Representation Travel</b>	
ACOT (2 trips)	2,500
SAP Large Projects Day	1,500
Other (Ottawa, NuPECC)	3,700
<b>Conference Sponsorship</b>	
TBA	3,500
Radiative Corrections 2016	1,500
CUPC 2016	500
<b>Undergrad Scholarships</b>	21,400
<b>Student Conf Support</b>	
CUPC 2015	2,000
WNPPC 2016	2,000
<b>New Initiative</b>	2,000
<b>Misc</b>	450

# Financial Statements

- Prepared by Sonia Bacca & Paul Garrett



Private Account FY15 (actual)	
FY14 Carry forward	\$68,512
FY15 Dues assessed	\$20,000
Board Meeting Expenses	\$470
Executive Director	\$20,000
Finance Expenses	
Bank	\$263
Industry Canada	\$30
Multi-year audit	\$10,260
Total FY15 Expenses	\$30,923
Year End Balance	\$57,590

Private Account FY16 (projected)	
FY15 Carry forward	\$57,590
FY16 Dues assessed	\$20,500
Board Meeting Expenses	\$100
CAP Congress AGM	\$300
Executive Director	\$22,000
Finance Expenses	
Bank	\$100
Industry Canada	\$20
Total FY16 Expenses	\$22,520
Projected Year End Balance	\$55,570



# Undergraduate Research Scholarships

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- The CINP URS program has run successfully for the last 3 years. It is thus a good time to review the program.
- Discussion Points:
  - should the application criteria be changed?
  - should we allow a student/supervisor to defer an award to the fall?
  - should we allow a student to hold the award for less than 16 weeks?

# CINP Research Scientists ?

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- As SAGES asked us this question at both the 2014 and 2015 Large Project Days, we decided to proactively raise the issue in 2016.

## Points raised at Previous AGMs:

- Concerns on lack of flexibility and financial sustainability.
  - Research Scientist salaries put significant strain on the envelope and “lock in” the support of certain programs over a long time frame.
  - 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 faculty-member’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.



# CINP Research Scientists ?

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## Points Raised at Previous AGMs:

- CINP Bridge Faculty Positions would be a better fit for the needs of Nuclear Physics research.
  - Would allow a strategic building of highly promising research areas within Canada in a more economic fashion.
- It would also be better to secure an alternate source of funding.
  - Avoids the NSERC exemption problem.
  - Avoids long-term tie-up of funds in SAP envelope.

- Some CINP Members have privately expressed concern with the IPP Research Scientist recommendation in the LRP, but I am not aware of any comments to the LRPC.
- I think the CINP can be constructive and work with IPP toward a long-term solution which will be of benefit to the entire SAP community.

# Agenda Items

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- 6. Updates from the Scientific Working Groups**
- 7. Comments and Suggestions from the Membership**

# CINP Scientific Summary

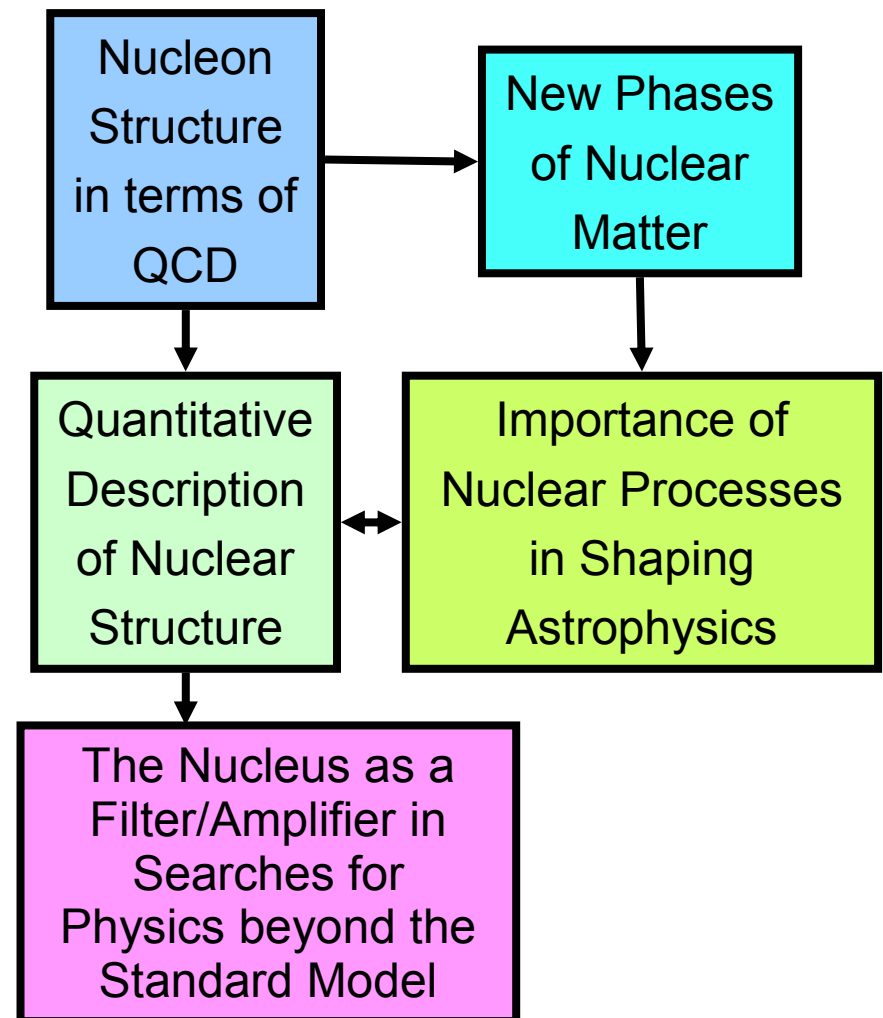
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**A Few Slides on:**  
**The Breadth of Canadian Nuclear**  
**Physics Research**  
**and**  
**Important Current and Future**  
**Priorities**

# **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 does the internal structure of nucleons proceed from QCD?



- 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.

## What are the phases of strongly interacting matter, and what roles do they play in the cosmos?

- 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.

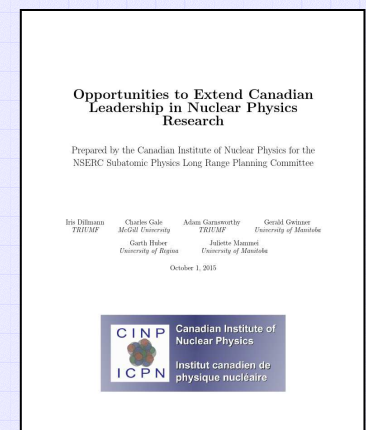
# How does the internal structure of nucleons proceed from QCD?



Canadians have made substantive detector contributions to the JLab 12 GeV Upgrade, and are now moving to data collection and analysis mode.

- **GlueX (exotic hybrid mesons) in new Hall D.**
  - \$5.0M Barrel Calorimeter constructed in Canada, funded by DOE and NSERC, large-array SiPM development, leadership roles.
- **Proton Form Factors up to  $Q^2=12 \text{ GeV}^2$  using SBS in Hall A.**
  - SBS Coordinate Detector.
- **Pion and Kaon Form Factors using SHMS in Hall C.**
  - Leadership roles, Heavy Gas Cherenkov.

**Next 5 years: Canadians will capitalize on the considerable infrastructure investment in the JLab 12 GeV Upgrade, whose completion is imminent.**



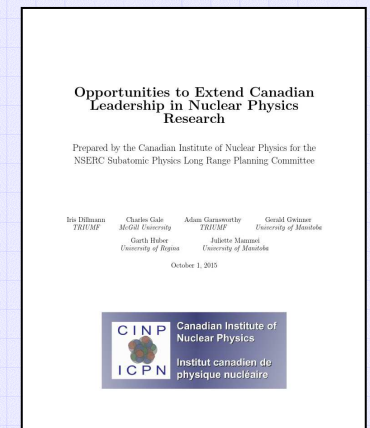
# What is the nature of the nuclear force that binds nucleons into stable nuclei and rare isotopes?

- 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.
- **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?**

# What is the nature of the nuclear force that binds nucleons into stable nuclei and rare isotopes?

**Next 5 years: Highest priority is to capitalize on the recent investments in new world-class detector infrastructure at ISAC (DESCANT, EMMA, GRIFFIN, IRIS, TIGRESS, TITAN)**

- Preparations also needed to make prompt and full use of additional rare-isotope beams that will be available from new ARIEL facility.
- These investments will allow studies to proceed more rapidly in:
  - Neutron halos in light-mass systems
  - Evolution of nuclear shell structure vs.  $N, Z$
  - Studies of nuclear collectivity, shape coexistence
- High quality work off-shore at Argonne (Canadian Penning Trap in  $N=126$  neutron-rich mass region), GSI ( $\sim 1$  GeV/nucleon), JLab (PREX/CREX), RIKEN
- New nuclear theory hires are at the fore-front of their field, utilizing latest techniques in high performance computing.





# What is the role of nuclei in shaping the evolution of the universe?

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- 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.

# What is the role of nuclei in shaping the evolution of the universe?



## Next 5 years:

**Canadian program will profit from completion of ARIEL facility at TRIUMF and the JLab 12 GeV upgrade**

- Completion and commissioning of EMMA recoil separator @ ISAC.
- New GRIFFIN spectrometer with auxiliary detectors like DESCANT will allow  $\gamma$ ,n-spectroscopy.
- IRIS to reach out to n-rich Sn isotopes beyond N=82 with ARIEL.
- New TITAN capabilities with MR-TOF (multi-reflection time-of-flight) for precision mass measurements further from the line of stability.
- PREX/CREX @ JLab probe neutron star equation of state.

**High quality work off shore at RIB facilities such as GSI (Germany), BRIKEN (Japan) and Argonne (USA)**

- BRIKEN measurement of yet unknown  $\beta$ n-emitters.
- Nuclear radii measurements at GSI.
- Canadian Penning Trap (CPT) to move to new location at ANL to allow measurements with higher-mass isotopes.

### Opportunities to Extend Canadian Leadership in Nuclear Physics Research

Prepared by the Canadian Institute of Nuclear Physics for the NSERC Subatomic Physics Long Range Planning Committee

Bin Ellmann  
TRIUMF

Charles Gale  
McGill University

Adam Gurevitch  
TRIUMF

David Orland  
University of Manitoba

Guth Baker  
University of Regina

Johanne Massam  
University of Manitoba

October 1, 2015



# 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:**

- **Why is there an imbalance of matter over antimatter?**
  - UCN n-EDM search; ALPHA2/g
- **What is the nature of *super weak* forces that disappeared from view when the universe cooled?**
  - $\beta\nu$  correlations @ ISAC, ANL; PV  $e^-$  Scattering (Qweak, MOLLER); Atomic Parity-Violation @ ISAC
- **What is the nature of the observed neutrino oscillations?**
  - $0\nu\beta\beta$  studies @ SNOLab

# What physics lies beyond the Standard Model?



## Next 5 years:

### ISAC:

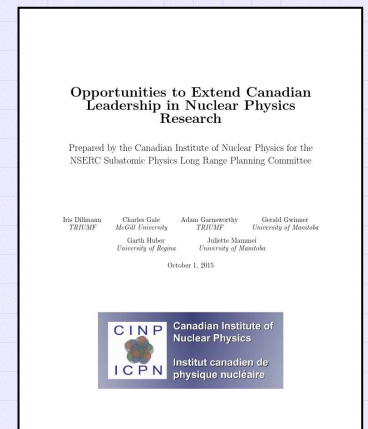
- Exploit new GRIFFIN in superallowed  $\beta$ -decay program.
- Francium trapping facility aims to observe PV amplitude by 2018.
- GRIFFIN study of  $^{221,223}\text{Rn}$  structure in preparation of Rn EDM expt.

### Offshore:

- ALPHA-g will start first measurements.
- UCN @ TRIUMF will begin first n-EDM measurements.
- Ion trap  $\beta$  correlation expt at ANL will push to 0.001 accuracy for Gamow-Teller decays

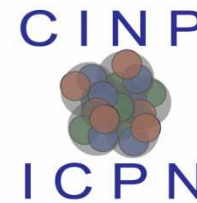
## Positive funding decisions awaited on:

- MOLLER @ JLab to enter construction phase by 2017.
- nEXO will prepare for launch of 5 tonne detector



# New Research Capabilities

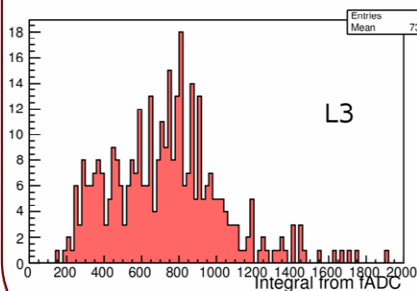
## - GlueX @ JLab 12 GeV Commissioning



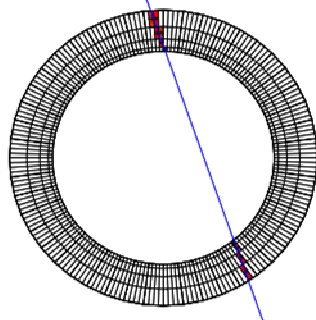
- **URegina**: built the 30 ton barrel calorimeter, drives calibration and neutral channel analyses.

### BCAL Calibration (1536 energy-summed, large-area SiPM channels)

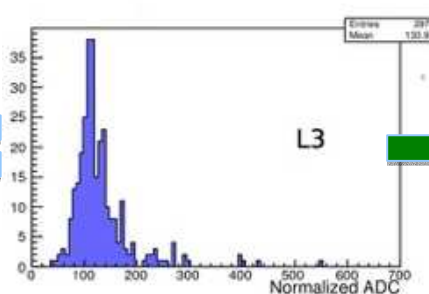
Energy Deposition



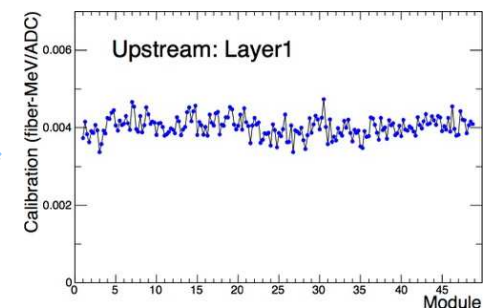
Tracking info



Normalized ADC

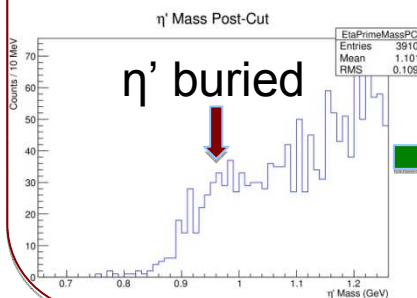


Calibration Constants

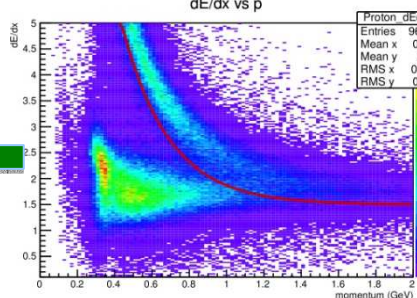


### $\eta'$ Physics Analysis (23 hrs of data)

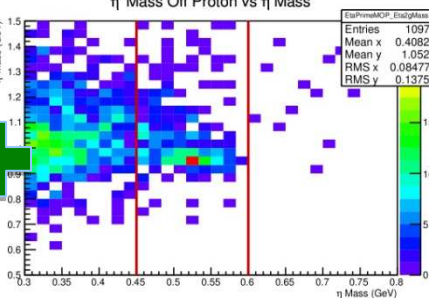
Spectrum



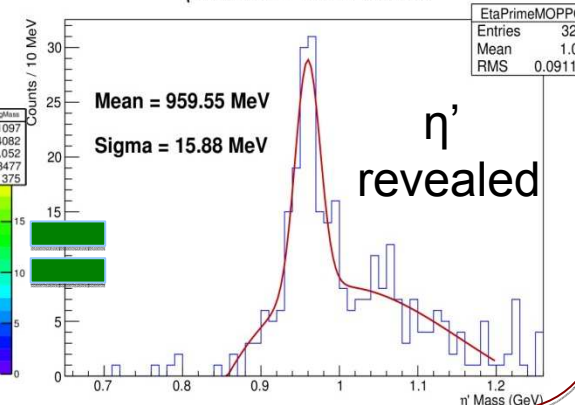
Cuts



Kinematic Fitting



$\eta'$  Mass Off Proton Post-Cut





# 2015 Research Highlight

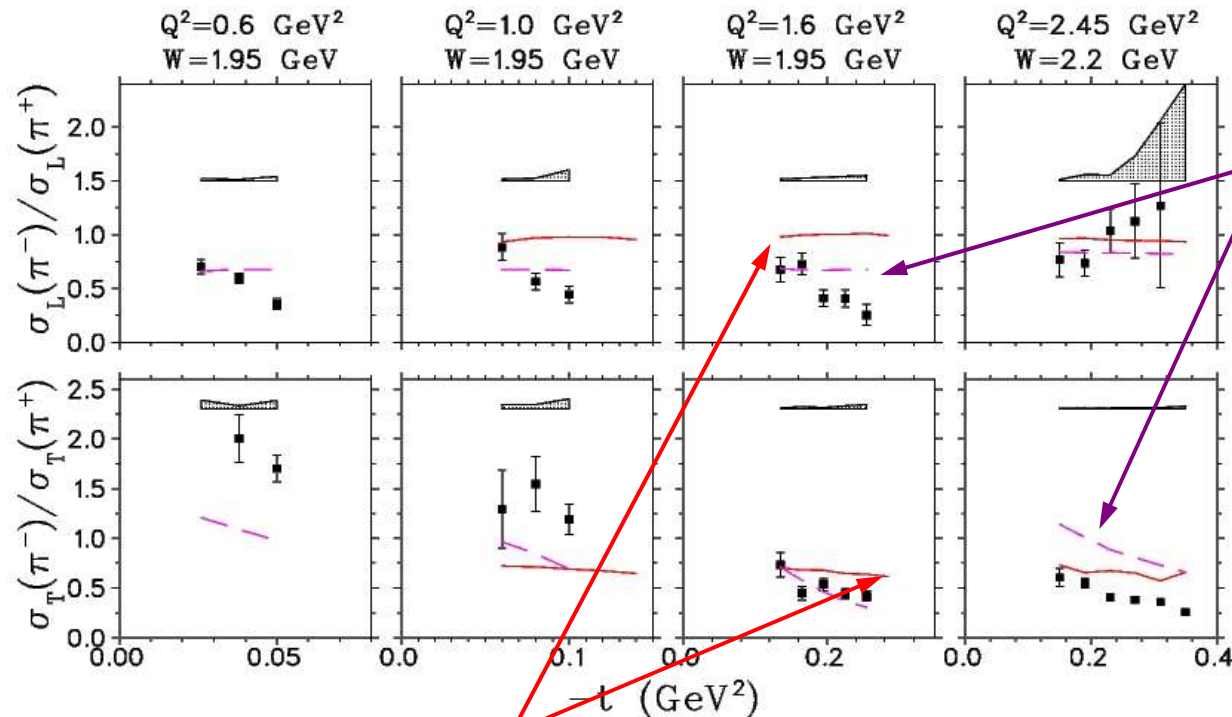
## - Deep Exclusive $\pi^\pm$ Production from $^2\text{H}$ (JLab 6 GeV)



PHYSICAL REVIEW C **91**, 015202 (2015)

Separated response functions in exclusive, forward  $\pi^\pm$  electroproduction on deuterium

G. M. Huber,<sup>1,\*</sup> H. P. Blok,<sup>2,3</sup> C. Butuceanu,<sup>1</sup> D. Gaskell,<sup>4</sup> T. Horn,<sup>5</sup> D. J. Mack,<sup>4</sup> D. Abbott,<sup>4</sup> K. Aniol,<sup>6</sup> H. Anklin,<sup>4,7</sup>  
C. Armstrong,<sup>8</sup> J. Arrington,<sup>9</sup> K. Assamagan,<sup>10</sup> S. Avery,<sup>10</sup> O. K. Baker,<sup>4,10</sup> B. Barrett,<sup>11</sup> E. J. Beise,<sup>12</sup> C. Bochna,<sup>13</sup>  
W. Boeglin,<sup>7</sup> E. J. Brash,<sup>1</sup> H. Breuer,<sup>12</sup> C. C. Chang,<sup>12</sup> N. Chant,<sup>12</sup> M. E. Christy,<sup>10</sup> J. Dunne,<sup>4</sup> T. Eden,<sup>4,14</sup> R. Ent,<sup>4</sup> H. Fenker,<sup>4</sup>



### MAID Isobar Model:

$R_L < 0.8$  indicates small resonant contributions in longitudinal channel.

### GK GPD-Based Model:

- $R_T \rightarrow 0.25$  when hard scattering from u,d quarks dominates.
- Model optimized for JLab kinematics should be sensitive to transverse GPD,  $H_T$

# 2015 Research Highlight

- Soft Dipole Resonance observed in  $^{11}\text{Li}$  @ IRIS-ISAC

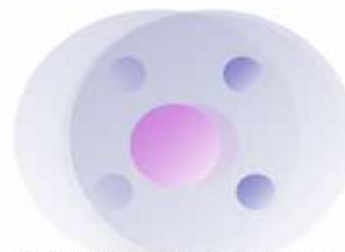
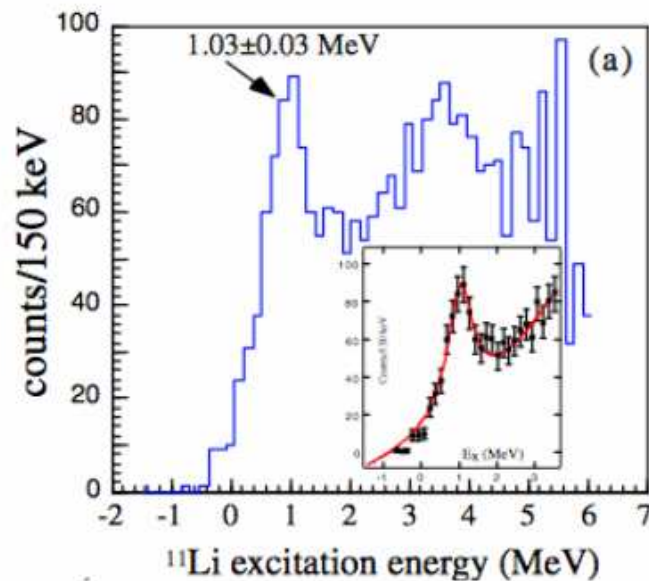
PRL 114, 192502 (2015)

PHYSICAL REVIEW LETTERS

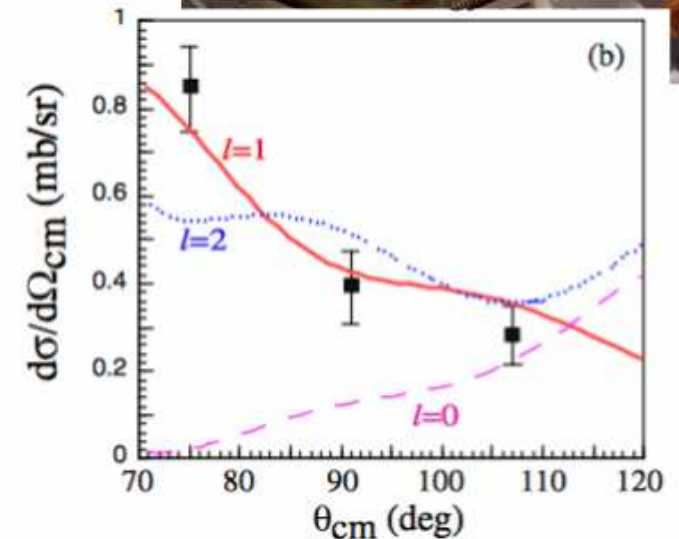
week ending  
15 MAY 2015

## Evidence of Soft Dipole Resonance in $^{11}\text{Li}$ with Isoscalar Character

R. Kanungo,<sup>1</sup> A. Sanetullaev,<sup>1,2</sup> J. Tanaka,<sup>3</sup> S. Ishimoto,<sup>4</sup> G. Hagen,<sup>5,6</sup> T. Myo,<sup>7</sup> T. Suzuki,<sup>8</sup> C. Andreoiu,<sup>9</sup> P. Bender,<sup>2</sup> A. A. Chen,<sup>10</sup> B. Davids,<sup>2</sup> J. Fallis,<sup>2</sup> J. P. Fortin,<sup>1,11</sup> N. Galinski,<sup>2</sup> A. T. Gallant,<sup>2</sup> P. E. Garrett,<sup>12</sup> G. Hackman,<sup>2</sup> B. Hadinia,<sup>12</sup> G. Jansen,<sup>5,6</sup> M. Keefe,<sup>1</sup> R. Krücken,<sup>2,13</sup> J. Lighthall,<sup>2</sup> E. McNeice,<sup>10</sup> D. Miller,<sup>2</sup> T. Otsuka,<sup>14</sup> J. Purcell,<sup>1</sup> J. S. Randhawa,<sup>1</sup> T. Roger,<sup>15</sup> A. Rojas,<sup>2</sup> H. Savajols,<sup>15</sup> A. Shotter,<sup>16</sup> I. Tanihata,<sup>3,17</sup> I. J. Thompson,<sup>18</sup> C. Unsworth,<sup>2</sup> P. Voss,<sup>9</sup> and Z. Wang<sup>2,9</sup>



Oscillation of halo neutrons and core



$^{11}\text{Li}$  halo nucleus has an extended size similar to  $^{208}\text{Pb}$

# 2015 Research Highlight

## - *Ab initio* nuclear structure and reactions

PRL 114, 212502 (2015)

PHYSICAL REVIEW LETTERS

work ending  
29 MAY 2015

### Unified Description of ${}^6\text{Li}$ Structure and Deuterium- ${}^4\text{He}$ Dynamics with Chiral Two- and Three-Nucleon Forces

Guillaume Hupin,<sup>1,\*</sup> Sofia Quaglioni,<sup>1,†</sup> and Petr Navrátil<sup>2,‡</sup>

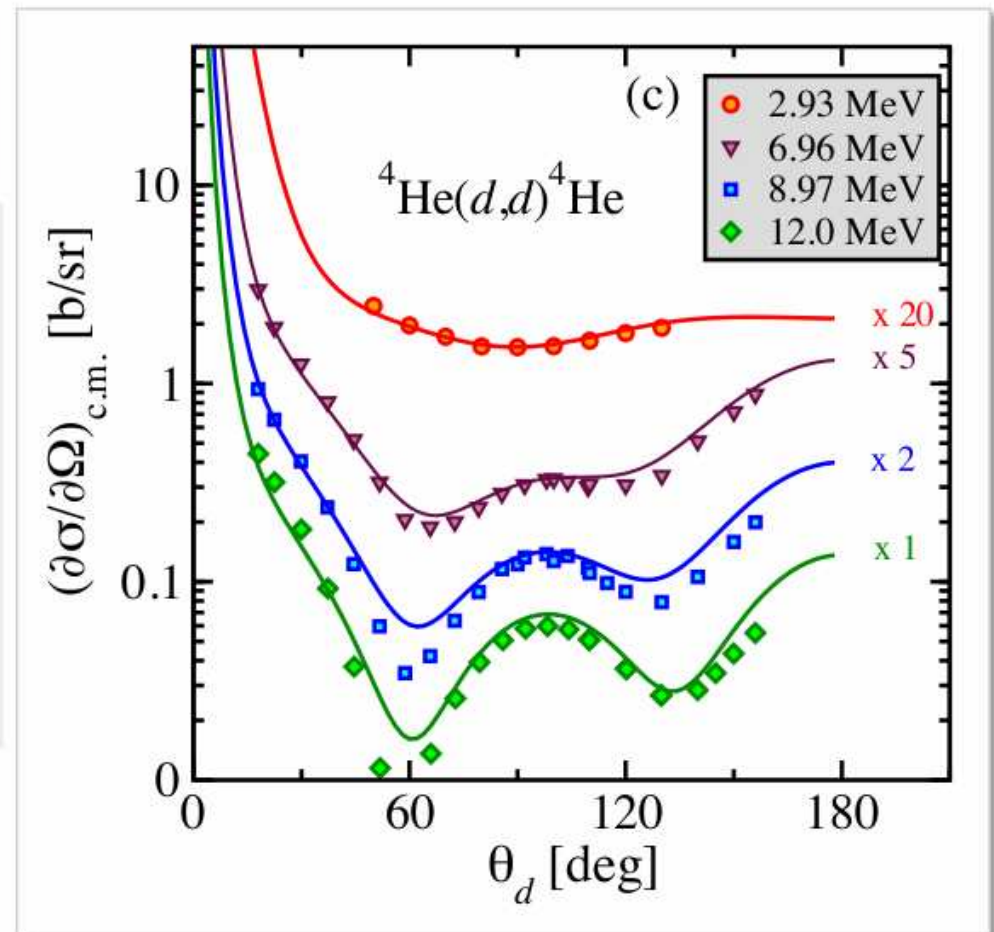
#### Unified description of ${}^6\text{Li}$ states and $d$ - $\alpha$ scattering

*Ab initio* no-core shell model with continuum (NCSMC) approach with chiral  $NN+3N$  forces was used to simultaneously calculate properties of  ${}^6\text{Li}$  ground state, its resonances and the  $d$ - $\alpha$  cross sections.

The determined asymptotic  $D$ - to  $S$ -state ratio of the  ${}^6\text{Li}$  g.s. wave function in the  $d$ - $\alpha$  configuration discriminates between two contradicting experiments.

Calculations of the capture reaction  ${}^2\text{H}(\alpha, \gamma){}^6\text{Li}$  important for astrophysics are under way.

${}^6\text{Li}(\text{g.s.})$	NCSMC	Experiment
E [MeV]	-32.01	-31.994
$C_0$ [ $\text{fm}^{-1/2}$ ]	2.695	2.91(9) 2.93(15)
$C_2$ [ $\text{fm}^{-1/2}$ ]	-0.074	-0.077(18)
$C_2/C_0$	-0.027	-0.025(6)(10) 0.0003(9)





# 2015 Research Highlight

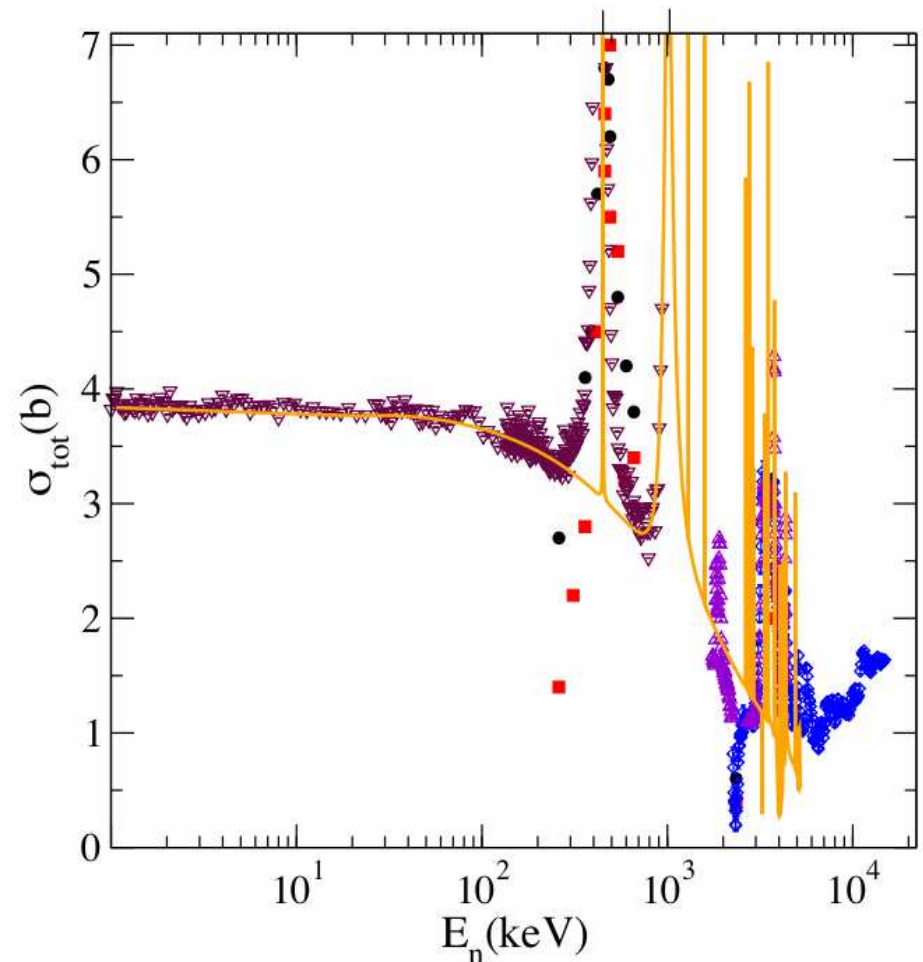
## - Multi-Channel Algebraic Scattering (MCAS)



**J. Svenne, et al.**

Most recent calculation is nucleon scattering from  $^{16}\text{O}$ , leading to structure and scattering results, and the compound nuclei,  $^{17}\text{O}$  and  $^{16}\text{F}$ .

**Figure:** total scattering cross section of neutrons on  $^{16}\text{O}$  for 0 to 1.4 MeV. The yellow line shows the calculated result, a near perfect fit of the data up to 1 MeV.



# New Research Capabilities

## - EMMA Commissioning @ ISAC

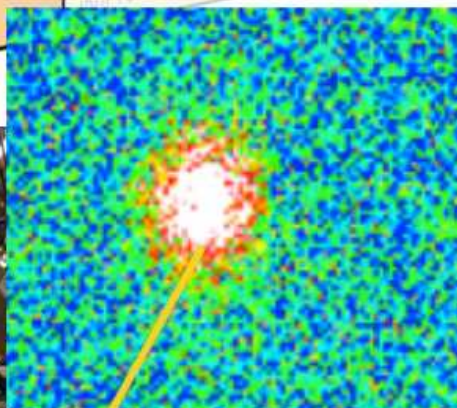
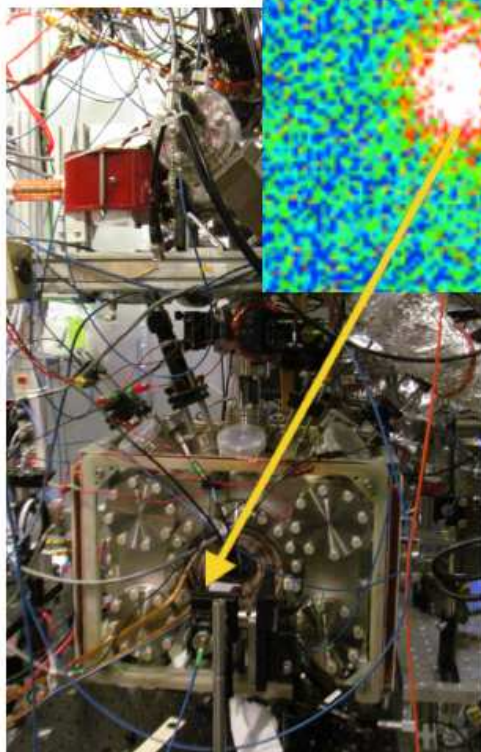
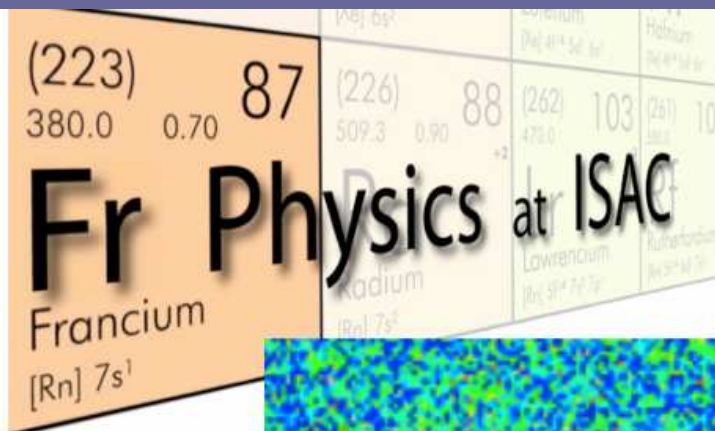


### **EMMA, The ISAC-II Recoil Mass Spectrometer:**

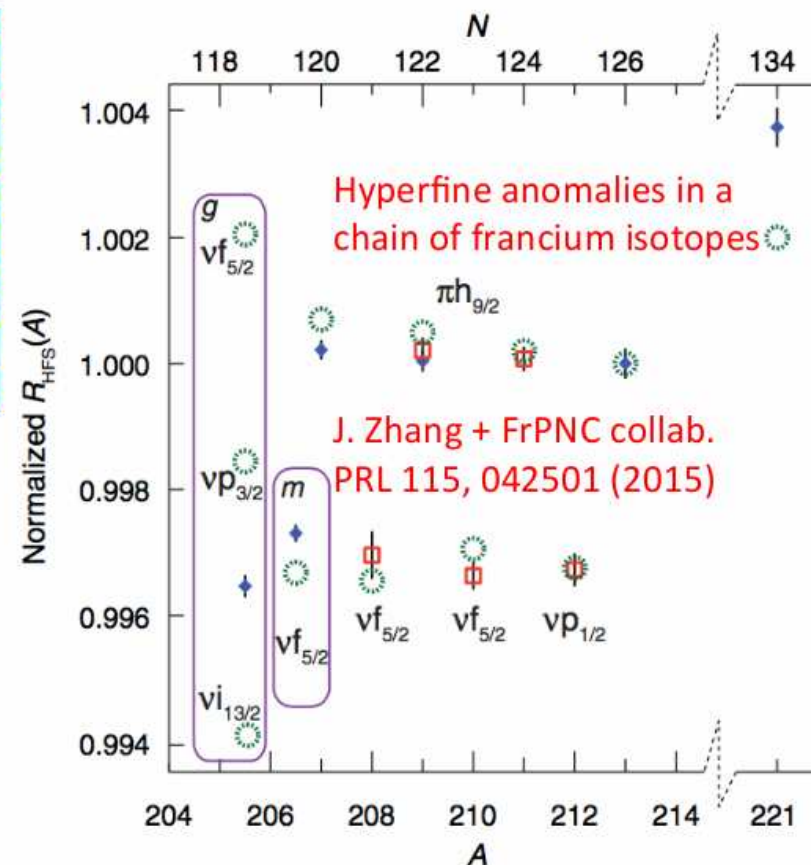
- All major electromagnetic components and vacuum chambers received from vendors and TRIUMF machine shop
- Focal plane detectors built and tested
- Beam line leading to EMMA under construction
- First experimental proposal, direct study of  $^{83}\text{Rb}(p,\gamma)^{84}\text{Sr}$  reaction for p-process nucleosynthesis, approved with high priority by TRIUMF experiment evaluation committee
- Cleaning, assembly, alignment, testing, & calibration of components proceeding; estimated completion of stable beam commissioning in December 2016

# New Research Capabilities

## - Francium APV Commissioning @ ISAC



August 2015: Demonstration of efficient ( $\approx 50\%$ ) transfer of laser-cooled ( $\mu K$ ) francium atoms from the capture trap into a magneto-optic trap in the science chamber  
 $\rightarrow$  first measurements towards atomic parity violation experiments will start in 2016



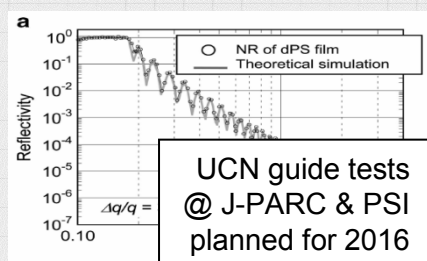
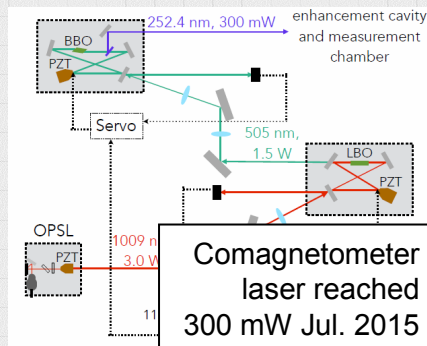


# New Research Capabilities

## - UCN/nEDM Installation @ TRIUMF

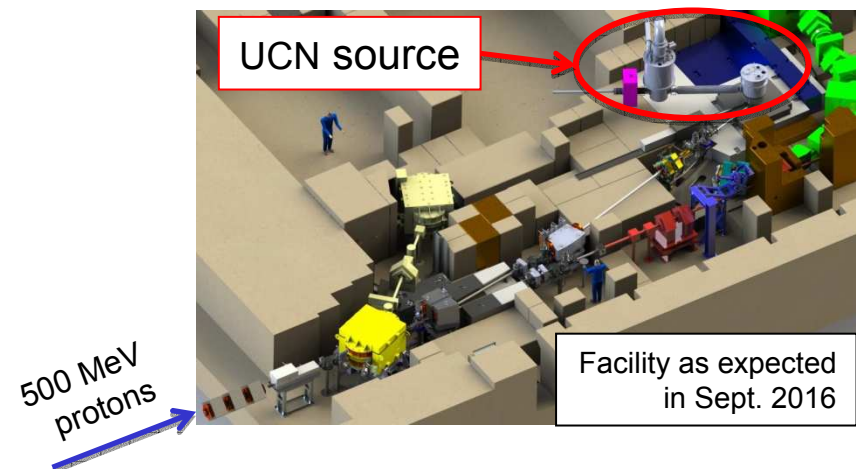
### • Overview:

- Spallation-driven superfluid-helium UCN source connected to room-temperature nEDM experiment.
- Goal sensitivity:  
 $\delta d_n \sim 10^{-27}$  e-cm (2018-2020)  
 $\delta d_n \sim 10^{-28}$  e-cm (beyond)



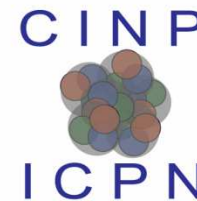
### • Recent/upcoming progress:

- Ongoing nEDM R&D: magnetic fields, comagnetometry with  $^{129}\text{Xe}$ - $^{199}\text{Hg}$ , UCN guides, EDM cell/HV.
- Installation at TRIUMF. Most components (incl. cold moderator cryostat from Japan) to be installed by Mar. 2016.
- Superfluid cryostat by Sept. 2016.
- CFI IF proposal for source upgrade and nEDM expt. in prep.



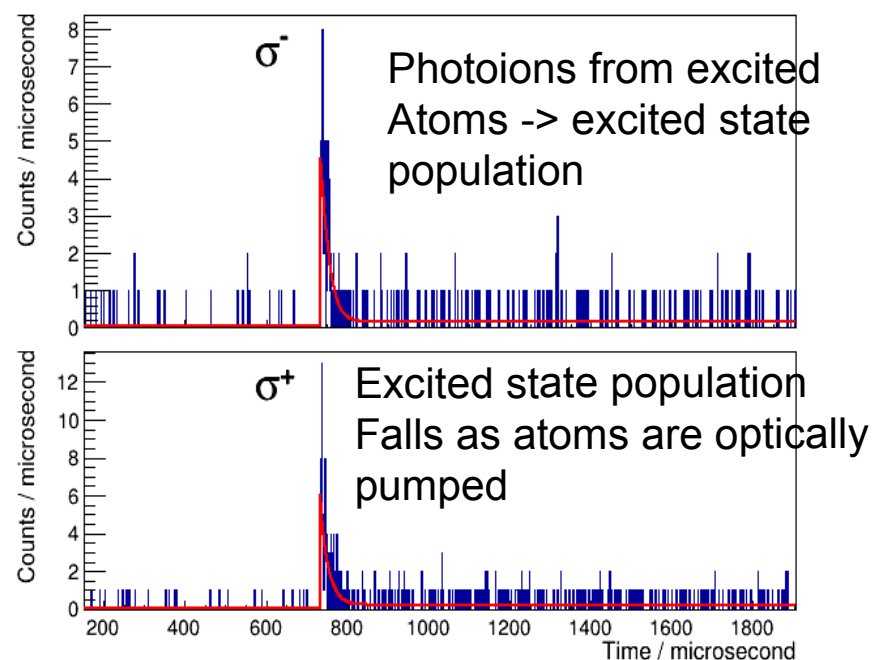
# 2015 Research Highlight

- TRINAT Progress in  $^{37}\text{K}$  beta decay since Nov 2015



**$^{37}\text{K}$  Polarization determined  
with in-situ atomic probe of the  
decaying nuclei:  
 $P = 99.13 \pm 0.08\%$  for  
June 2014 data set**

- \* Submitted to New Jour Phys
- \* B. Fenker arXiv:1602.04526



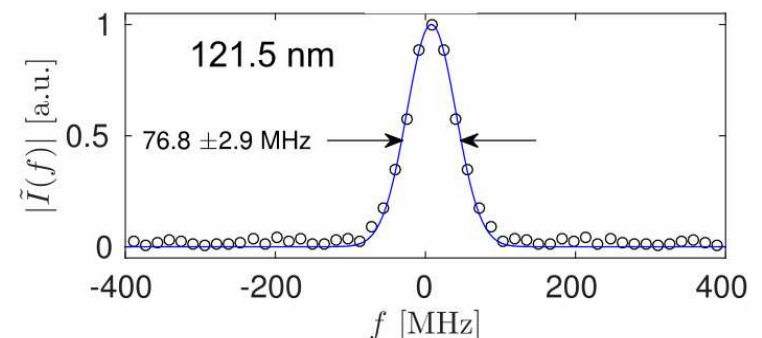
**Enables ongoing TRINAT program of precision spin-polarized  
beta-neutrino angular distributions to potentially reach  $<0.1\%$   
accuracy, needed to be complementary to higher-energy  
searches for non-Standard Model interactions**

# 2015 Research Highlight

## - ALPHA Anti-Hydrogen Trapping @ CERN



- ALPHA-2 trap fully operational!
  - Major Canadian contributions
- First physics result, published in *Nature*, Jan 2016
  - York, Berkeley PhD theses
  - Charge neutrality of anti-H, improved to  $7 \times 10^{-10}$
  - Knowledge of positron charge improved by x 25
  - Precision era is starting!
- Towards anti-H laser cooling
  - Entirely Canadian initiative!
  - Will provide cold, dense sample of anti-H; necessary for precision symmetry tests
  - Narrow-line Lyman-alpha laser deployed at CERN
  - Now working on improving the laser power



Frequency width of Ly-alpha pulses

# 2015 Research Highlight

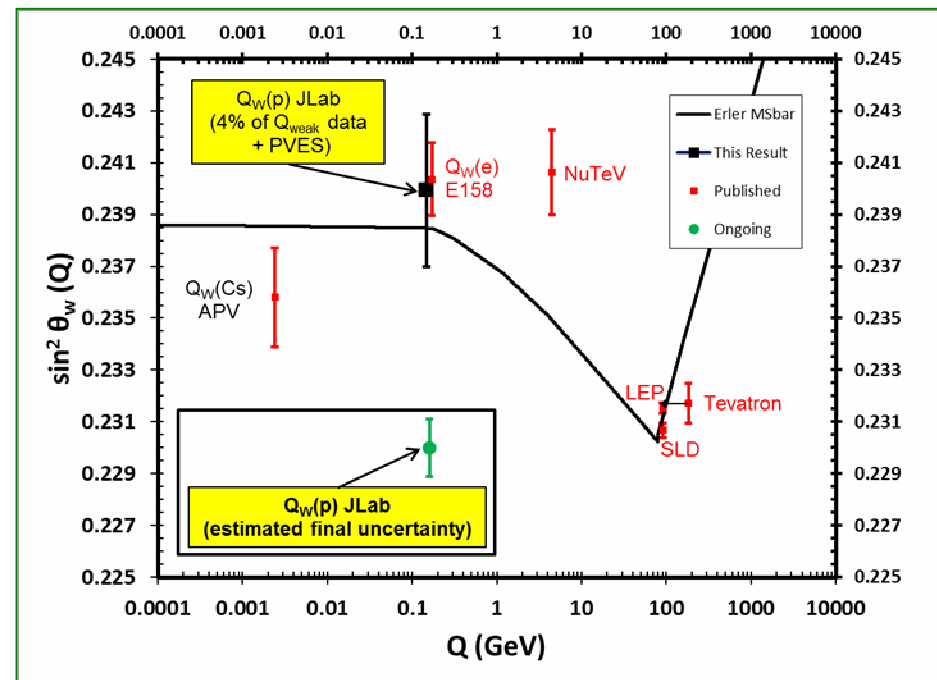
## - Measurement of the proton's weak charge at JLab



Full  $ep$  data set almost ready for unblinding, 25x more data than published earlier (PRL 111, 141803)

### Additional physics under analysis:

- Parity-violating e-C and e-Al analyzing powers;
- Parity-allowed transverse analyzing powers of H, C and Al;
- Parity-violating and allowed analyzing powers on H in the  $N \rightarrow \Delta(1232)$  region and in pion photoproduction;
- Transverse asymmetry in the PV inelastic scattering region (3.3 GeV);
- Non-resonant inelastic measurement at 3.3 GeV to constrain the  $\Upsilon$ -Z Box uncertainty;

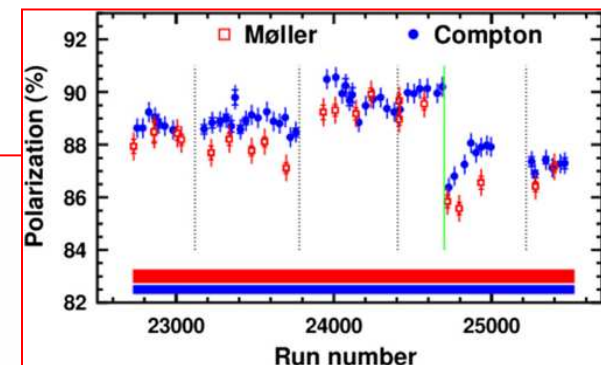


### Precision Electron-Beam Polarimetry at 1 GeV Using Diamond Microstrip Detectors

A. Narayan *et al.*

Phys. Rev. X **6**, 011013 – Published 16 February 2016

PRX 2016: NSERC-funded contribution



# CINP Summary



- The Canadian nuclear physics community's work addresses the most important open questions as identified by broad international consensus.
- In the 2016-26 time period, we are primed to leverage scientific discoveries from the investments already made into research equipment and infrastructure at TRIUMF, and at international facilities where Canadians lead high priority programs (e.g. JLab, ALPHA).
- Strong case for increased support to maximize Canadian scientific output in nuclear physics research.

## Opportunities to Extend Canadian Leadership in Nuclear Physics Research

Prepared by the Canadian Institute of Nuclear Physics for the NSERC Subatomic Physics Long Range Planning Committee

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October 1, 2015

