



Canada's national laboratory
for particle and nuclear physics
and accelerator-based science

TRIUMF – Past, Present, Future

TARA AGM

September 21, 2017

Jonathan Bagger
Director





2016



2017



2018

Bienvenue à



UNIVERSITÉ DE SHERBROOKE

Owned & operated
by a consortium of
20 universities

● 12 MEMBERS

● 8 ASSOCIATE MEMBERS

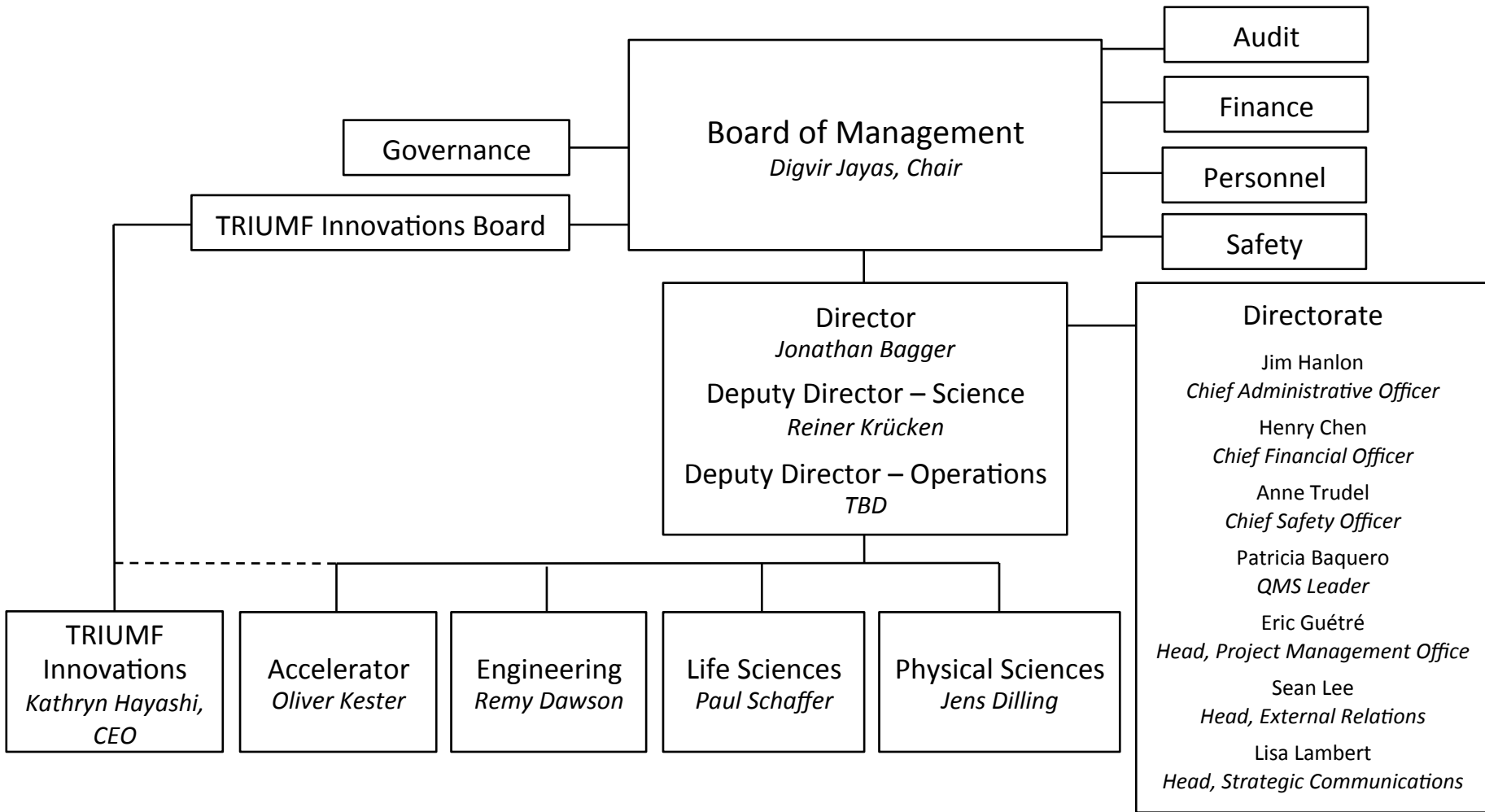


1. Operate safely and effectively
2. Produce world class science
3. Connect TRIUMF to the world



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- Queen's University – Joint Faculty in SNOLAB Science

- One position at Queen's, asymptotically at Queen's
- One position at TRIUMF, asymptotically at TRIUMF
- Initially in support of CPARC, funded by CFREF



- University of British Columbia – Joint Faculty in Quantum Matter

- One position at TRIUMF, asymptotically at TRIUMF
- Initially in support of CMMS



**CANADA
FIRST**
RESEARCH
EXCELLENCE
FUND

**APOGÉE
CANADA**
FONDS
D'EXCELLENCE
EN RECHERCHE

Searches underway!

- University of Tokyo – Joint Faculty in Neutrino Physics
 - One position at IPMU, asymptotically TBD
 - Held by Mark Hartz, member of T2K



- University of Washington – Postdoc in Nuclear Theory
 - One joint position at TRIUMF and INT
 - MOU in preparation



Major push to strengthen safety, quality and project management



International Technical Safety Forum

September 18-22, 2017

Topics

Incident investigation • Lessons learned
Technical risks • Risk assessment
Cryogenic • Laser Safety
New projects and challenges
Environmental protection • Sustainability
Safety culture and behaviour
Continuous improvement in HSE matters
Safety training • Web-based-training

International Committee

A. Trudel (TRIUMF)
J. Mildenerberger (TRIUMF)
K. Ardron (TRIUMF)
J. Anderson (FERMILAB)
E. Cennini (CERN)
A. Hoppe (DESY)
P. Jacobsson (ESS)
J. Kenny (SLAC)
S. Kozielski (XFEL)
B. Manzlak (JLAB)



BC Hydro
Power smart



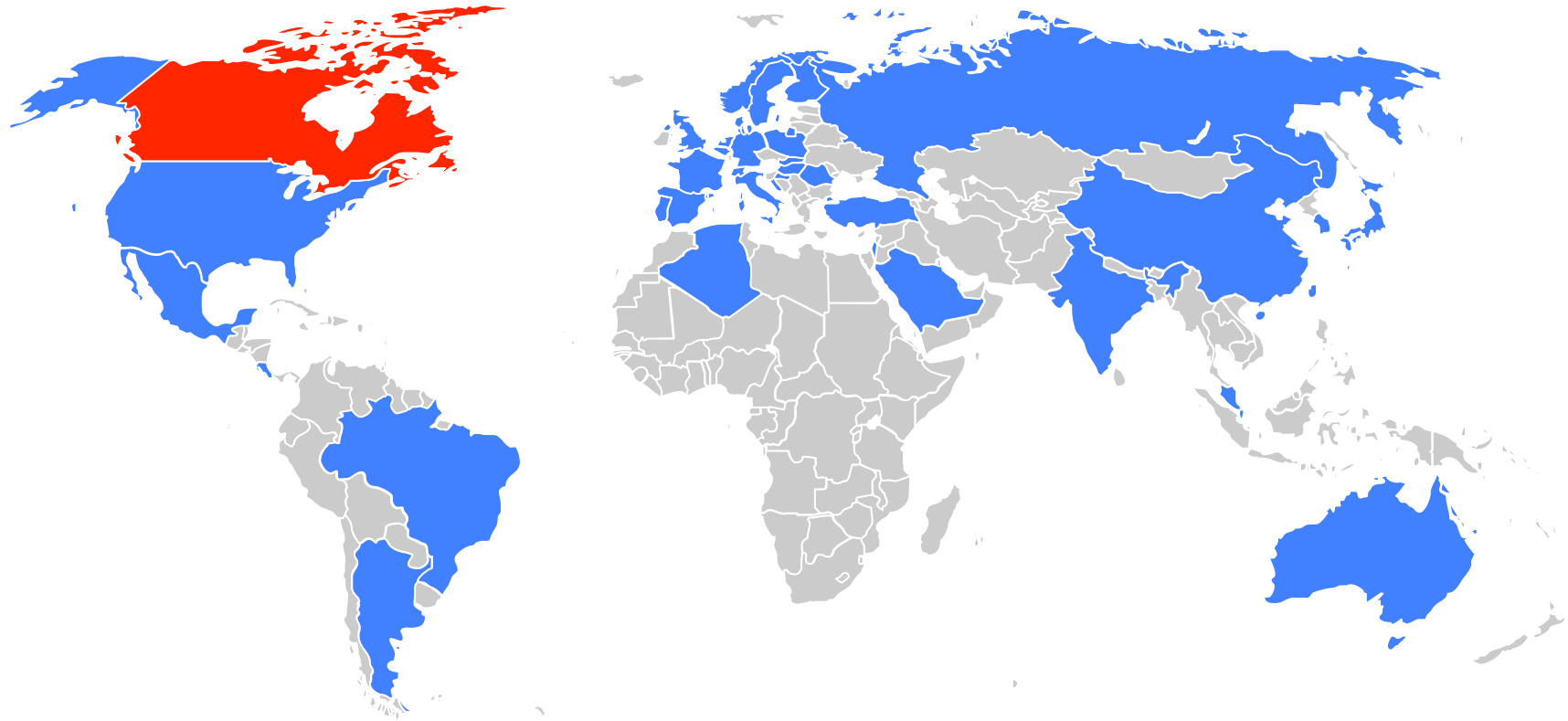
August 5, 2017

Role	Personnel
Project Leader	Vladimir Zvyagintsev
Floor Captain	Bhalwinder Waraich
System Expert	Nikolai Avrelina
Facility Coordinator	Yuri Bylinsky
HPRF Engineer	Yanyun Ma, Zhengting Ang, Thomas Au
HPRF Technician	Nebosja Jakovljevic, Sean Wang
SRF Engineer	Zhongyuan Yao
SRF Technician	Devon Lang, James Keir, Ben Matheson
Remote Handling	Maico Dalla Valle, Dan McDonald
Machine Shop	George Sun, Mike Wicken
ATG Supporters	Max Heilemann, Cory Kiffiak, Jim Young, Yetvart Hosepyan, Jozef Orzechowski
Beamlines	Bruno Gasbarri
Design Office	Tim Emmens

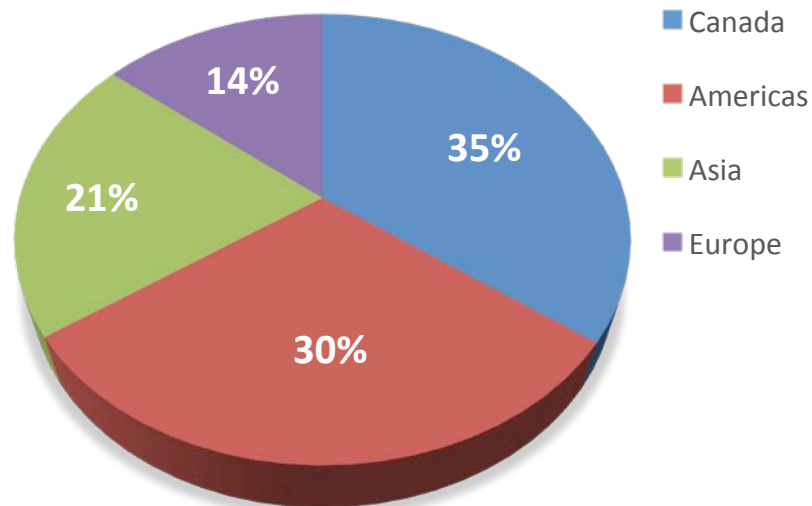


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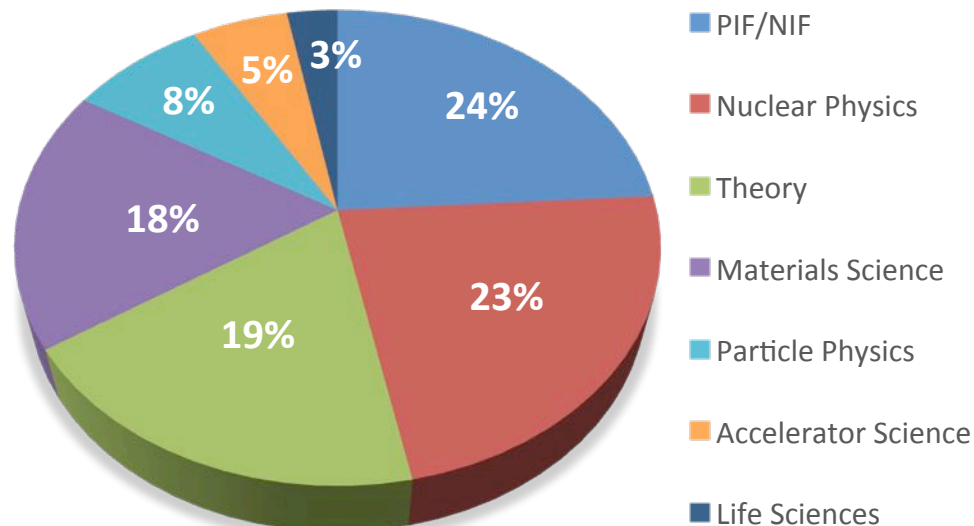




Scientific Visitors & Users by Region (645)

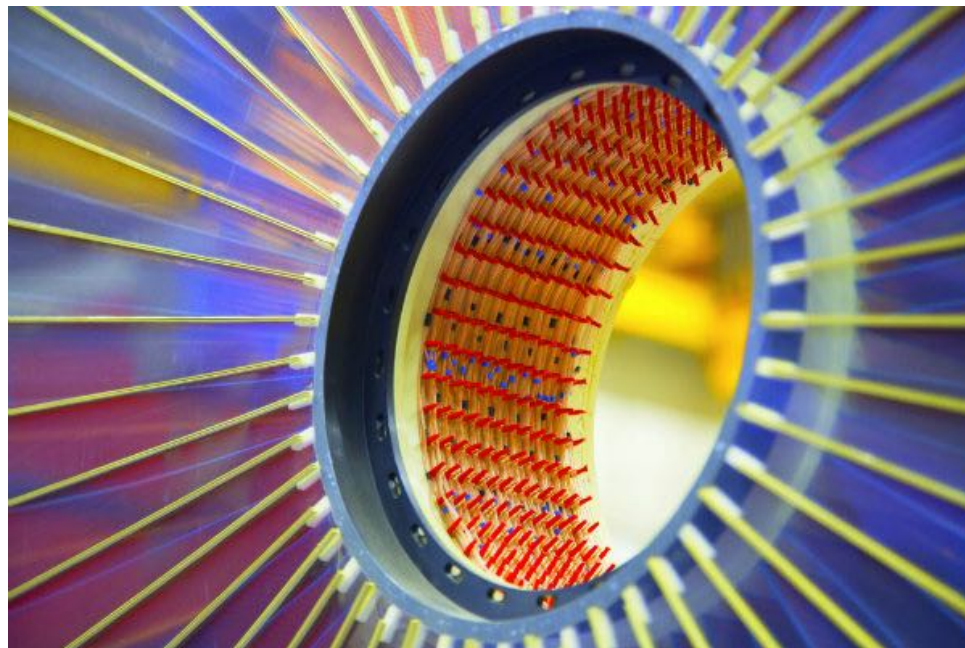


Scientific Visitors & Users by Field (645)



TRIUMF is a fully international, multidisciplinary facility!

- Three major projects currently underway
 - ARIEL II
 - UCN Facility
 - IAMI: Institute for Advanced Medical Isotopes



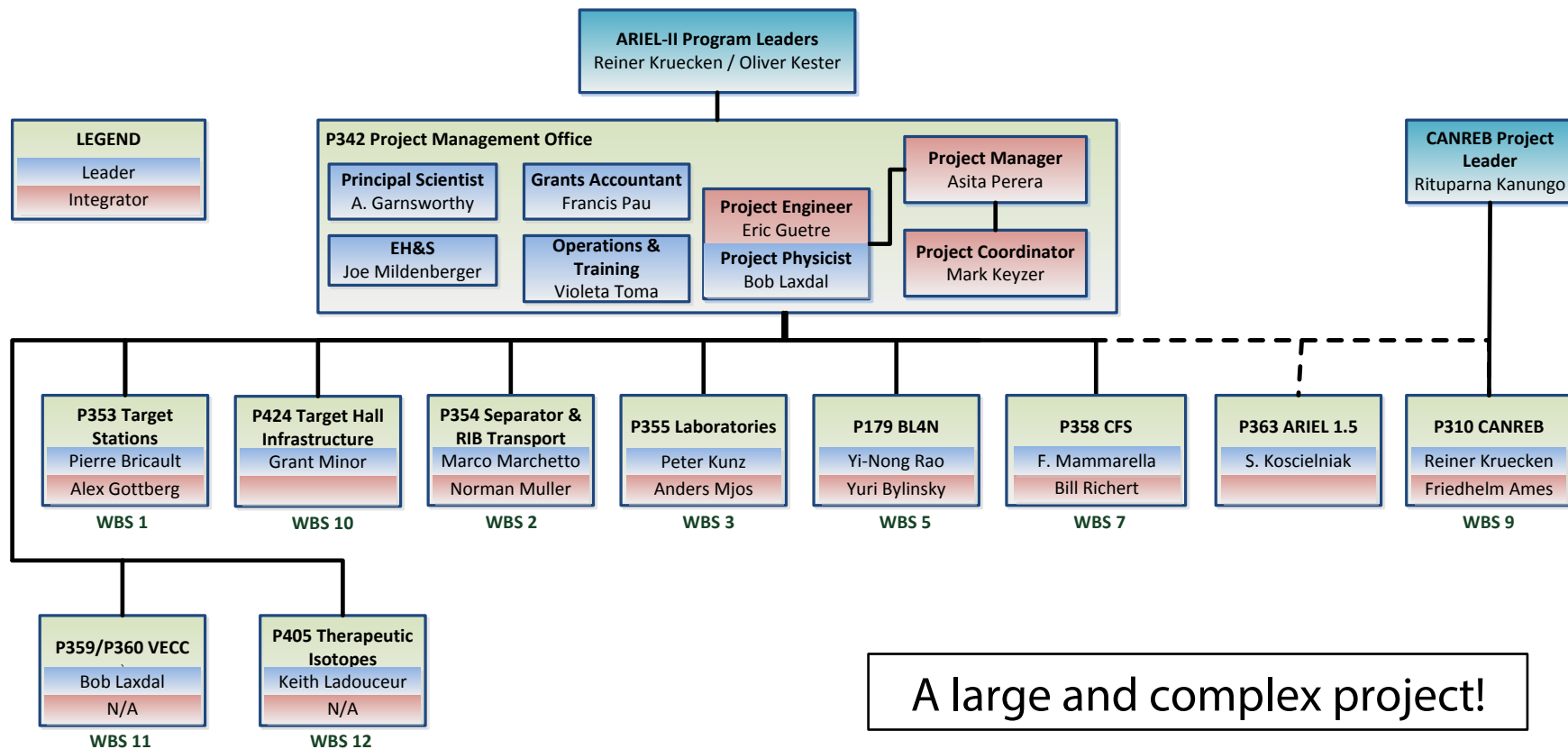


ARIEL

- ~\$100M project, supported by 19 universities, led by the University of Victoria, that will triple TRIUMF's rare isotope production
- Second phase: ARIEL II, \$38M CFI project. Awarded \$8.7M from the BC Knowledge Development Fund – the last piece of the puzzle!
- Investment by five provinces: AB, BC, MB, ON, QC



ARIEL is the future of TRIUMF



Milestones, as presented during ARIEL Town Hall, January 10, 2017

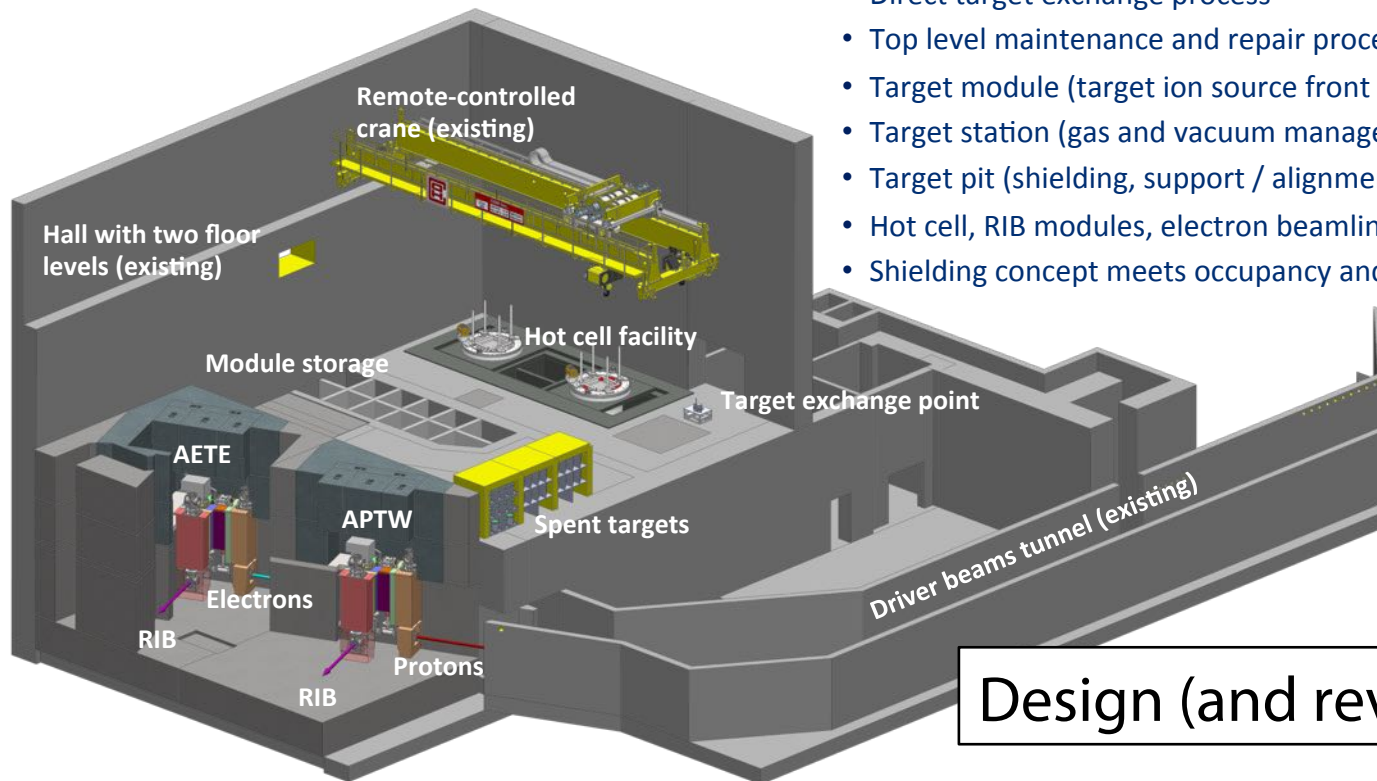
	Science Milestone	Month/Year
PHASE 3	First EEC approved experiments with high-mass accelerated beams from ISAC utilizing the CANREB/ARIEL EBIS charge breeder	10/2020 
PHASE 1	First EEC approved beta-NMR experiments with photo-produced ^8Li	03/2022
PHASE 2	First EEC approved experiments with photo-fission RIBs from the e-Linac	06/2022
PHASE 4	First EEC approved experiments with RIBs from ARIEL Proton target	03/2023

ISAC-ARIEL-ISAC in 2019?

- All dates based on Monte Carlo analysis of schedule
- Current best estimates
- Efforts under way to accelerate schedule

Continuous discussions with user community

Targets



Concepts finalized:

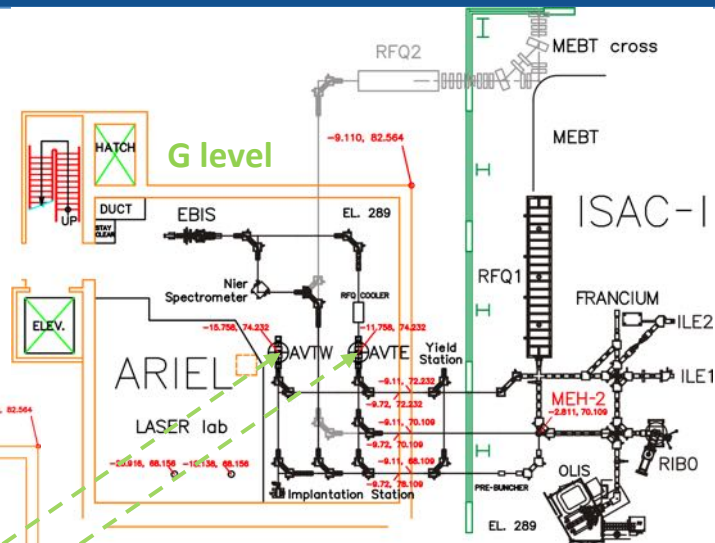
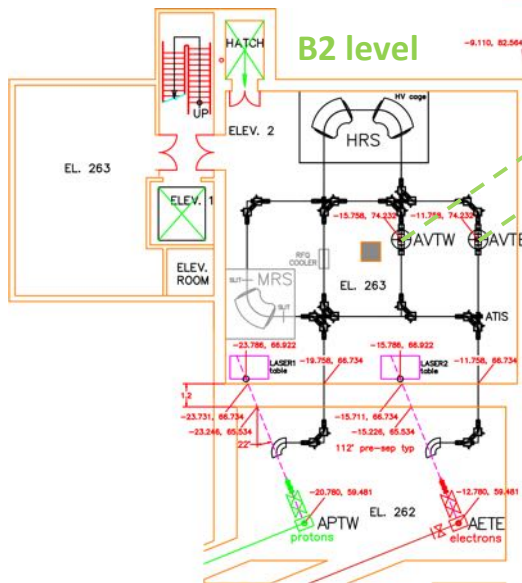
- Operational model
- Direct target exchange process
- Top level maintenance and repair processes
- Target module (target ion source front end, high voltage path, shielding)
- Target station (gas and vacuum management, module interfaces)
- Target pit (shielding, support / alignment structure, main services voids)
- Hot cell, RIB modules, electron beamline
- Shielding concept meets occupancy and dose rate requirements

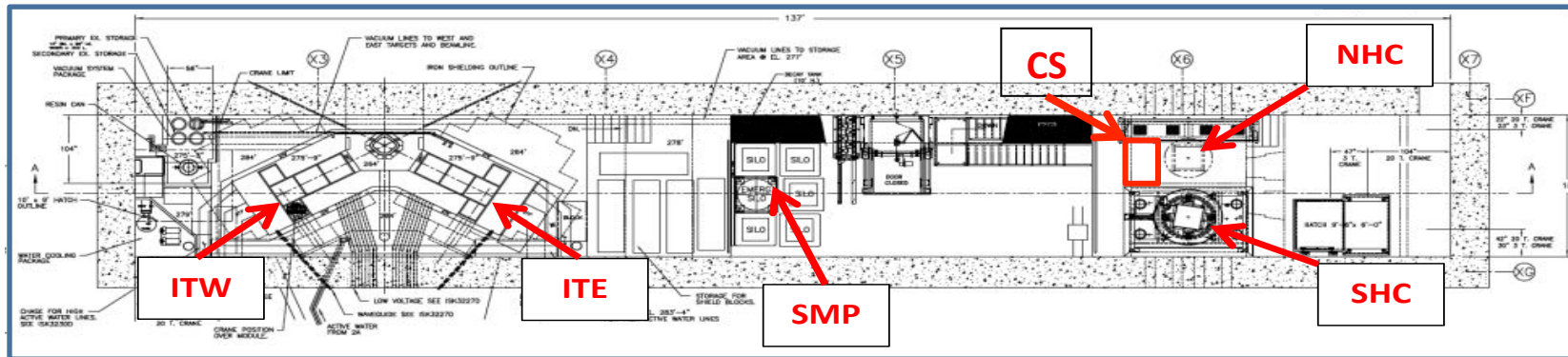
Design (and reviews) underway!

RIB Transport

Status:

- HRS magnet finished
- Prototype section installed
- Vendors qualified
- Design validated

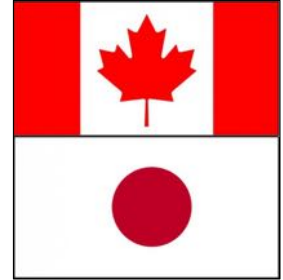
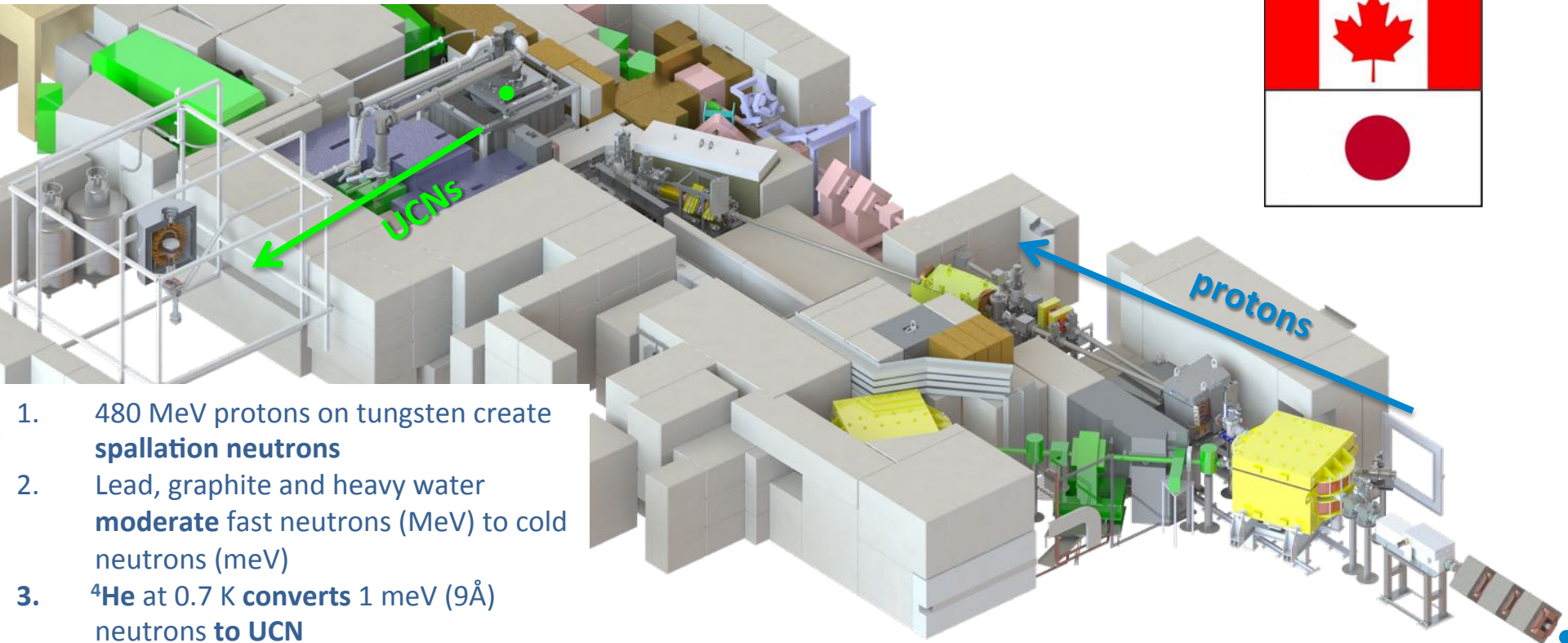




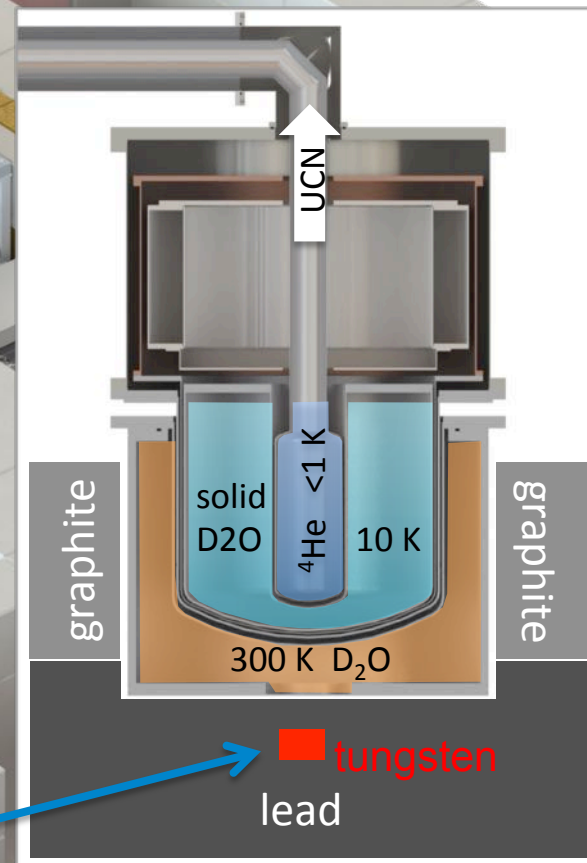
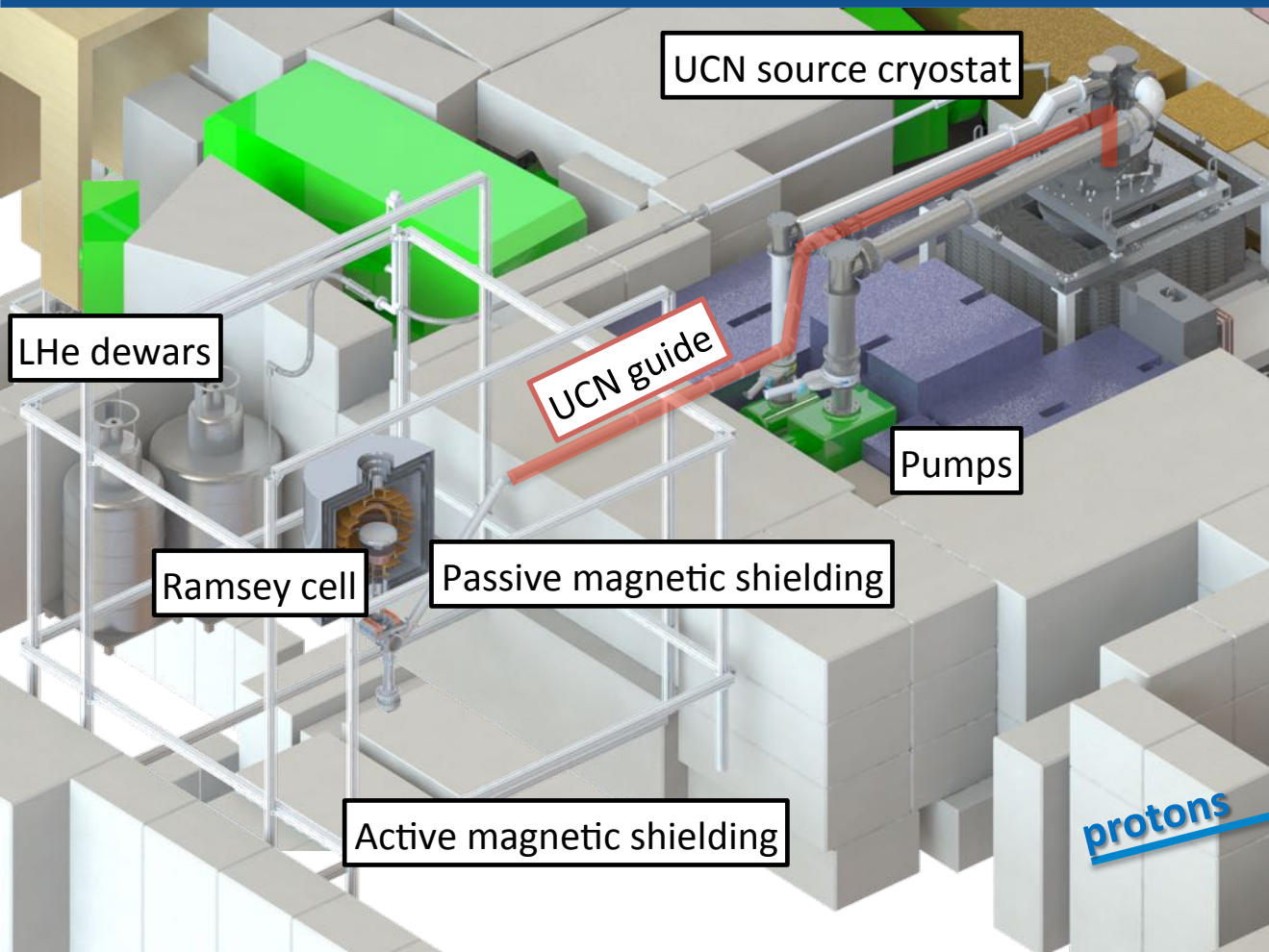
Infrastructure upgrades to ISAC as well as ARIEL. New Target Module will add redundancy. Refurbished Target Modules will add reliability. Safe Module Parking and North Hot Cell will speed work by removing bottlenecks

- Now that funding is secured, ARIEL II can proceed at full bore
- ARIEL will transform TRIUMF. With it, ISAC will realize its full potential
- TRIUMF is on track to become an isotope factory with a renewed focus on excellence, quality, consistency, reliability, and the user experience





1. 480 MeV protons on tungsten create **spallation neutrons**
2. Lead, graphite and heavy water **moderate** fast neutrons (MeV) to cold neutrons (meV)
3. ^4He at 0.7 K **converts** 1 meV (9Å) neutrons **to UCN**
4. **Material guides** transport UCN to experiments



UCN Status

First proton injection (Nov. 2016)

First beam on target and neutron production (Nov. 2016)

First cold neutron production (Nov. 2016)

Vertical source installed (Spring 2017)

First ultra cold neutrons – coming soon!

Future Plan

High intensity horizontal source

Neutron EDM experiment

Second port?



- IAMI – Institute for Advanced Medical Isotopes – will build on TRIUMF's long history in the field of medical isotopes
- Today, TRIUMF produces 2M doses of medical isotopes per year in partnership with Nordion
- A tremendous success story: A public-private partnership that returns value to TRIUMF, to Canada and the world



- IAMI will house a TR24 cyclotron and GMP laboratories to position TRIUMF life sciences for the 21st century
 - Producing isotopes for clinical use at UBC Hospital and the BC Cancer Agency
 - Producing isotopes and tracers for biomedical research and drug development, including both diagnostics and therapeutics

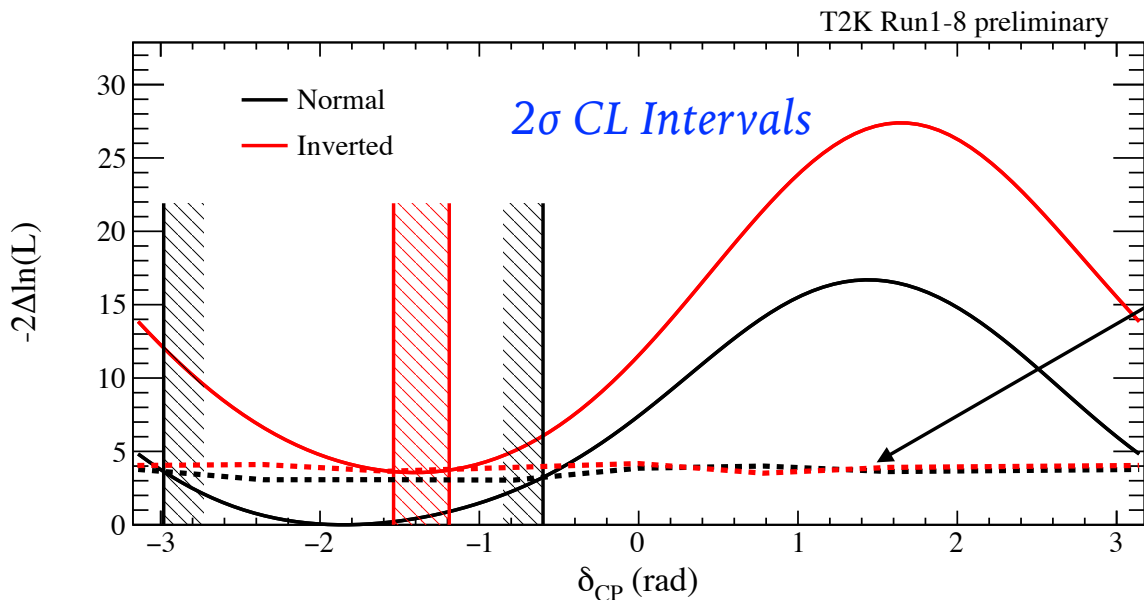


- IAMI project is moving ahead – TR-24 has arrived!
- IAMI facility schematic design is complete
- Work continues planning IAMI operations and seeking private-sector partners
- BC funding secured! Now the focus shifts back to Ottawa...



IAMI Founding Partners





Hint of CP violation: $\delta_{CP} = 0, \pi$ excluded at 2σ



First laser spectroscopy on anti-H

M. Ahmadi et al., *Nature* 541 (2017)

LETTER

OPEN

doi:10.1038/nature21040

Observation of the 1S–2S transition in trapped antihydrogen

M. Ahmadi¹, B. X. R. Alves², C. J. Baker³, W. Bertsch^{4,5}, E. Butler⁶, A. Capra⁷, C. Carruth⁸, C. L. Cesar⁹, M. Charlton³, S. Cohen¹⁰, R. Collister⁷, S. Eriksson³, A. Evans¹¹, N. Evetts¹², J. Fajans⁸, T. Friesen², M. C. Fujiwara⁷, D. R. Gill⁷, A. Gutierrez¹³, J. S. Hangst², W. N. Hardy¹², M. E. Hayden¹⁴, C. A. Isaac³, A. Ishida¹⁵, M. A. Johnson^{4,5}, S. A. Jones³, S. Jonsell¹⁶, L. Kurchaninov⁷, N. Madsen³, M. Mathers¹⁷, D. Maxwell¹, J. T. K. McKenna⁷, S. Menary¹⁷, J. M. Michan^{2,18}, T. Momose¹², J. J. Munich¹⁴, P. Nolan¹, K. Olchanskij⁷, A. Olin^{7,19}, P. Pusa¹, C. Ø. Rasmussen⁷, F. Robicheaux²⁰, R. L. Sacramento⁹, M. Sameed¹, E. Sarid²¹, D. M. Silveira⁷, S. Stracka²², G. Stutter², C. So¹¹, T. D. Tharp²³, J. E. Thompson¹⁷, R. I. Thompson¹¹, D. P. van der Werf^{3,24} & J. S. Wurtele⁸

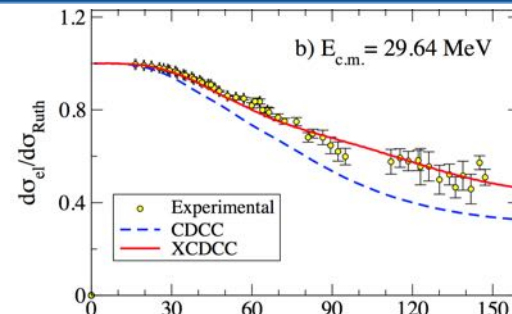


- First demonstration:
 - Precision already 2×10^{-10}
 - $\Delta f \sim 400$ kHz
 - Sensitive to antiproton internal structure at 20% level
- Major Canadian contributions
 - Cryostat with laser access
 - TRIUMF/Calgary
 - Annihilation detection
 - TRIUMF
 - Magnetometry
 - SFU/UBC
 - Laser cooling development
 - UBC/TRIUMF
 - Operation & Run Coordination

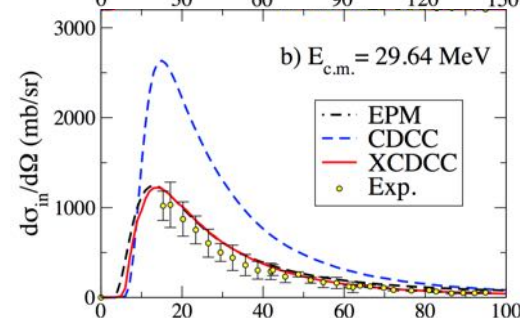
- Exclusive measurement of halo nucleus ^{11}Be scattering from high-Z target
- Differential cross sections understood if excited ^{10}Be core structure is taken into account
- Possible at TRIUMF-ISAC because of
 - Intense ^{11}Be from ISAC-TRILIS, high-quality acceleration with ISAC-II
 - TIGRESS experimental infrastructure capable of coupling to dedicated external detectors

V. Pesudo et al, Phys. Rev. Lett. 118, 152502 (2017)

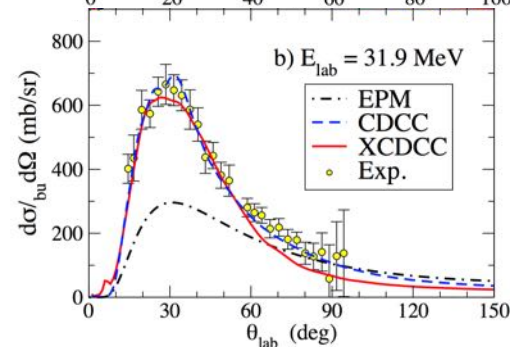
Elastic
→ ^{11}Be



Inelastic
→ $^{11}\text{Be}^*$
→ $^{11}\text{Be} + \gamma$

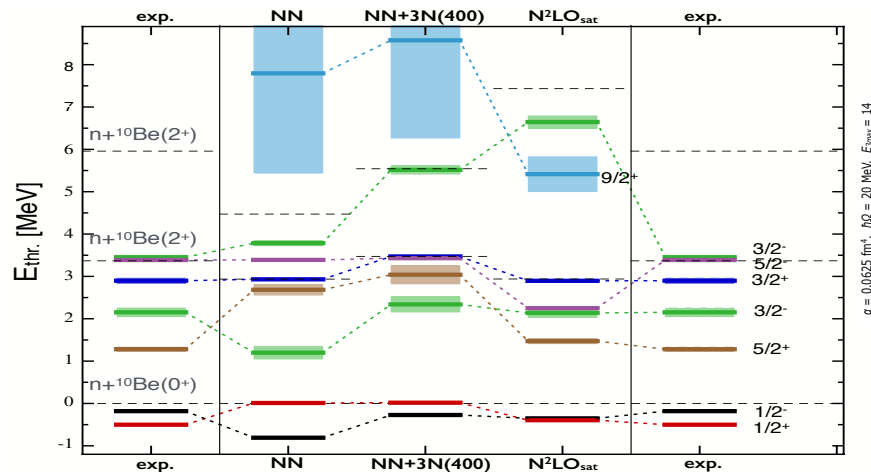


Breakup
→ $^{10}\text{Be}(+n)$



First-principles study of ^{11}Be . *Ab initio* calculations demonstrate:

Contributions from chiral nuclear forces



PRL 117, 242501 (2016)

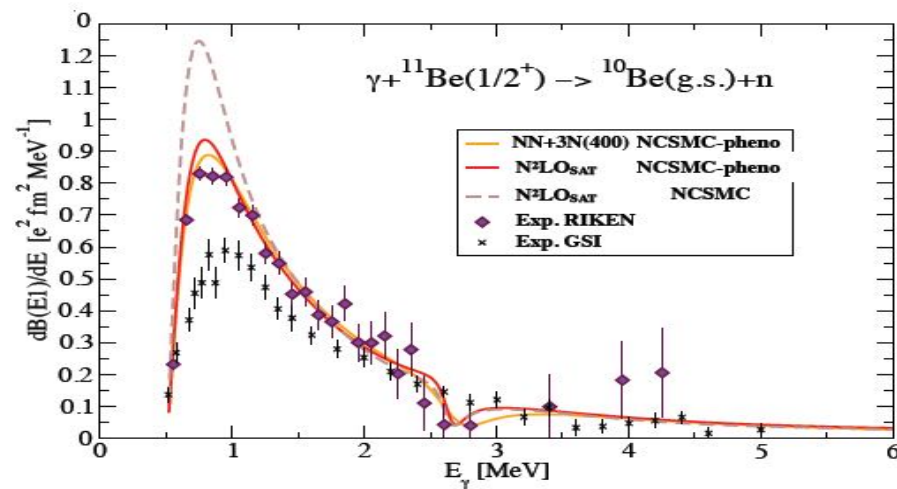
PHYSICAL REVIEW LETTERS

week ending
9 DECEMBER 2016

Can *Ab Initio* Theory Explain the Phenomenon of Parity Inversion in ^{11}Be ?

Angelo Calci,^{1,*} Petr Navrátil,^{1,2} Robert Roth,² Jérémy Dohet-Eraly,^{1,2} Sofia Quaglioni,³ and Guillaume Hupin^{4,5}
¹TRIUMF, 4004 Westbrook Mall, Vancouver, British Columbia V6T 2A3, Canada

Discrimination between conflicting photo-dissociation experiments



PRL 117, 222501 (2016)

PHYSICAL REVIEW LETTERS

week ending
25 NOVEMBER 2016

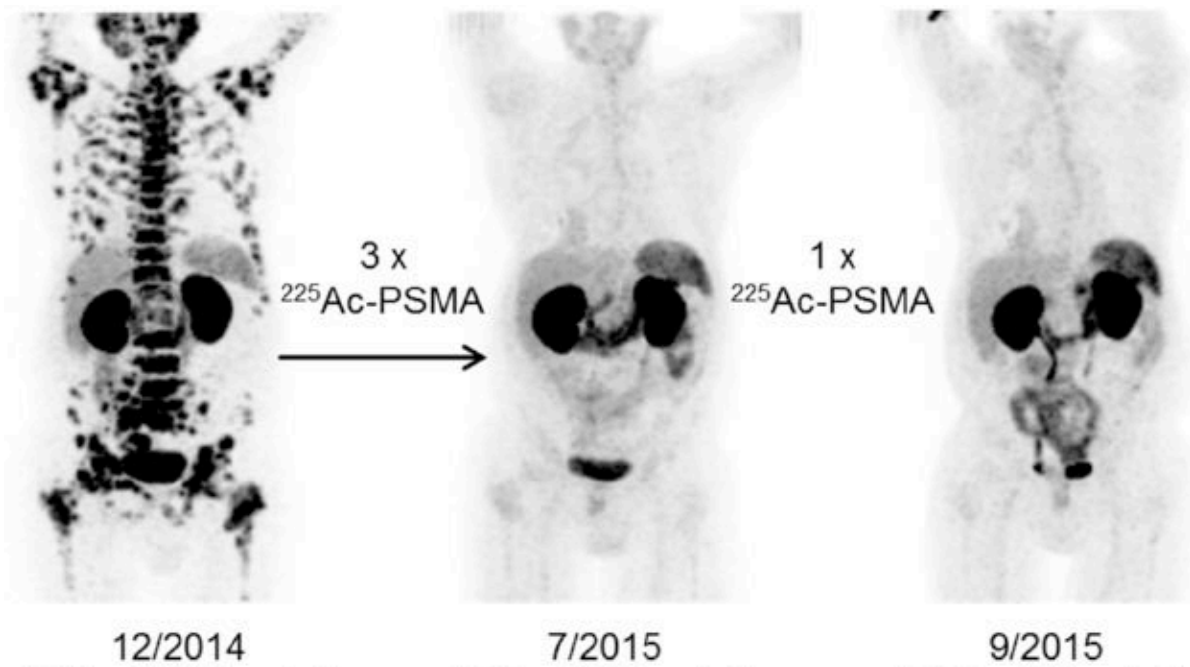
How Many-Body Correlations and α Clustering Shape ^6He

Carolina Romero-Redondo,^{1,*} Sofia Quaglioni,^{1,2} Petr Navrátil,^{2,3} and Guillaume Hupin^{3,4}

Also ^6He

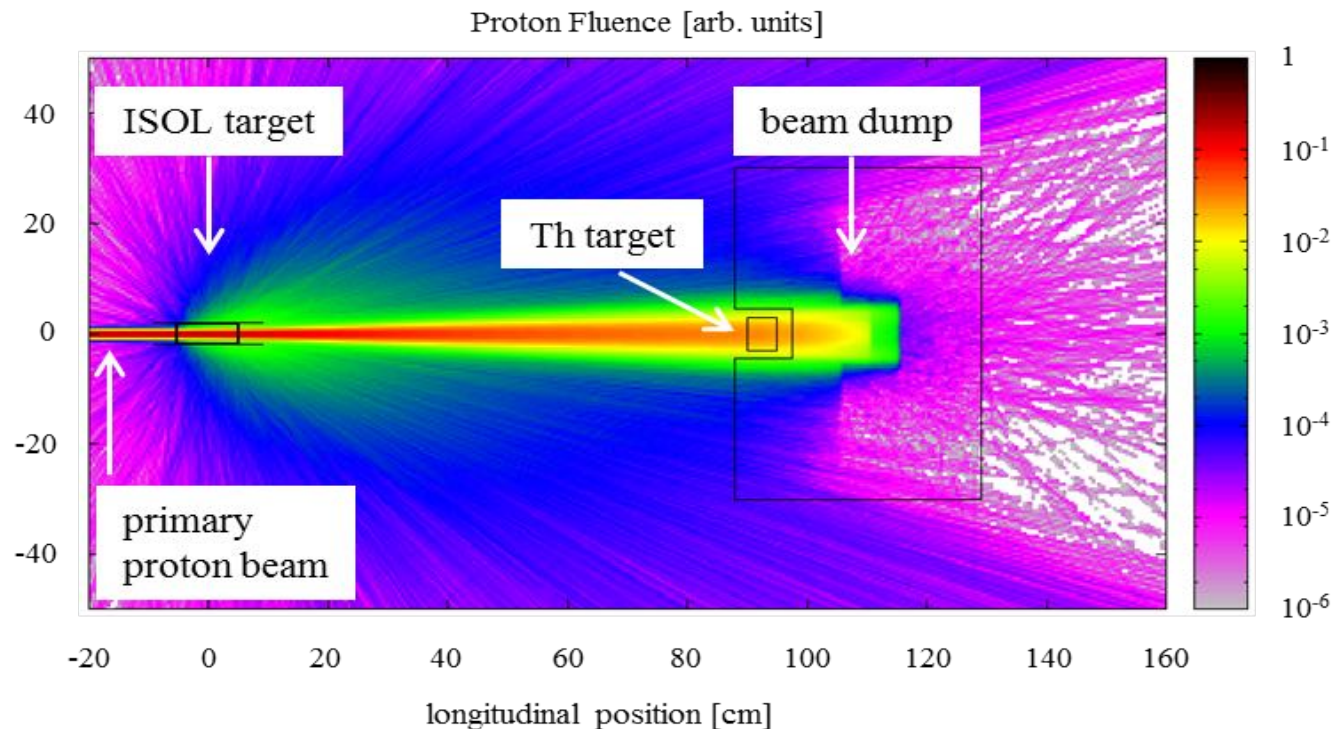
Prostate cancer patient before and after treatment with ^{225}Ac -PSMA

C Kratochwil, et al, J Nuc Med (2016) doi:10.2967/jnumed.116.178673



Right now, progress is limited by isotope supply

Exciting Opportunity: ARIEL Symbiotic Target



Canadian Nuclear
Laboratories

Laboratoires Nucléaires
Canadiens



U.S. DEPARTMENT OF
ENERGY

1. Operate safely and effectively
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DNP2016

Fall Meeting of the American Physical Society
Division of Nuclear Physics

October 13-16, 2016
Sheraton Vancouver Wall Centre
Vancouver, BC Canada



American Physical Society DNP Annual Meeting held in Vancouver

- 668 registered participants
- 168 undergraduate students!



**Modern Tools
For Nuclear
Astrophysics**

**Vancouver BC
Canada**

**July 24
to
August 4**

TSI2017

**TRIUMF
Summer
Institute**





June 30, 2017 – H.E. Sergio Mattarella, President of Italy, visited TRIUMF

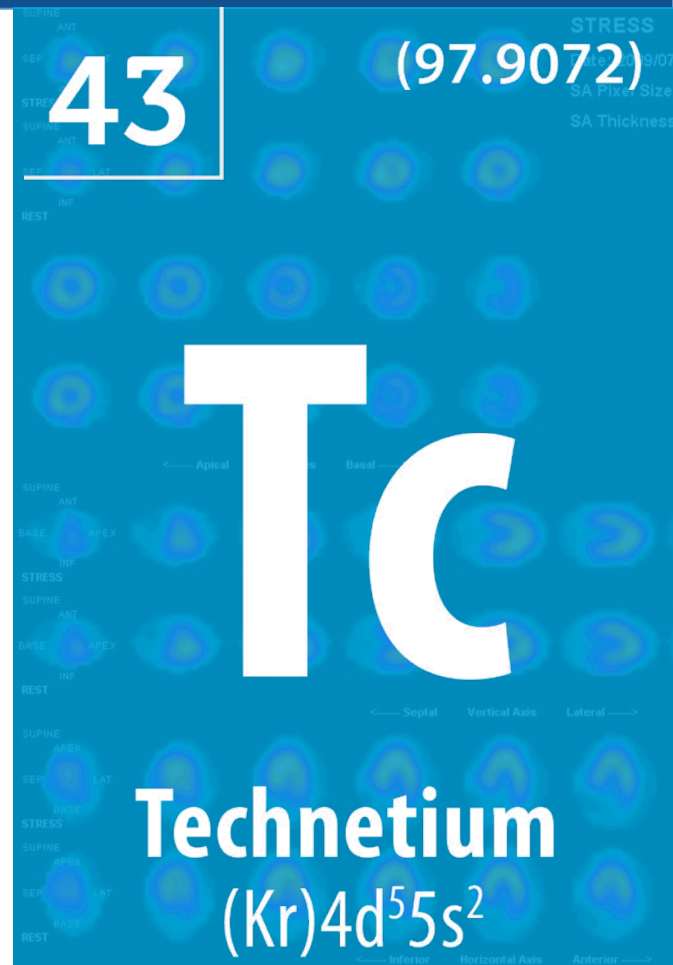


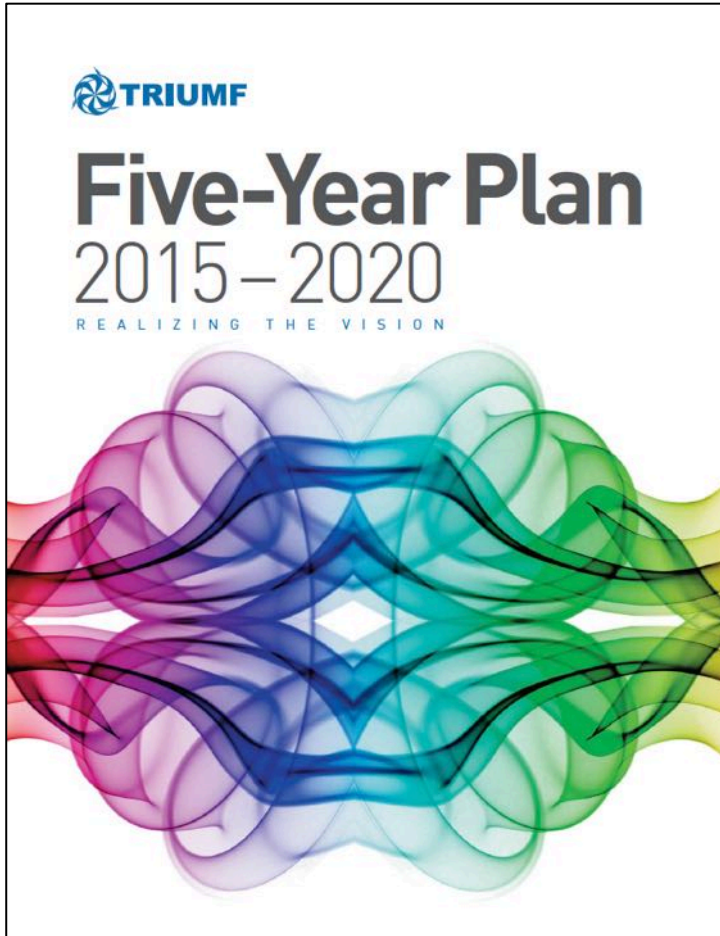
TRIUMF
I N N O V A T I O N S

- TRIUMF's business-facing arm
- Deeply integrated into TRIUMF
- Links science and technology to tangible business opportunities

**nordion****TOYOTA**

- A TRIUMF spin-off company devoted to Tc-99m production using medical cyclotrons
- IAMI will supply Tc-99m to British Columbia using ARTMS technology
- About to receive its first infusion of venture capital



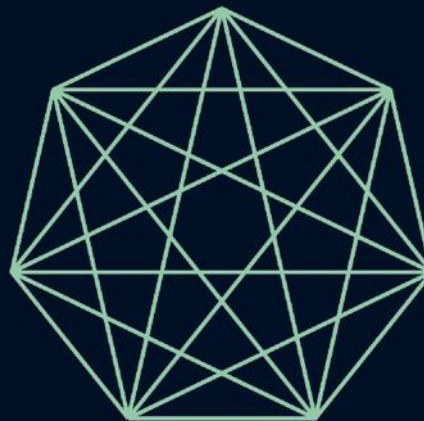


Five-Year Plan 2020-2025

Boundary condition: consistent with SAP Long Range Plan

Canadian Subatomic Physics Long Range Plan

2017-2021



- **Consultation:**
 - **Internal strategic planning exercises**
 - Divisional and institutional
 - **Broad community consultation**
 - Science Week, July 10-14
 - Submissions to PPAC, TRIUMF's Policy and Planning Advisory Committee
- **Governance:**
 - **Executive Committee** drives planning
 - **Steering Committee** oversees the process
 - **PPAC** evaluates projects and commitments
 - **ACOT** reviews main elements of the plan
 - **Board of Management** approves the plan

Charge and Members

- Oversee the consultation process and solicit input from the relevant stakeholder communities
- Provide critical feedback on the priorities and initiatives, ensuring that they align with stakeholder interests
- Act as review panel for the final plan and the associated communications strategy

Name	Title	Institution
Jonathan Bagger	Director	TRIUMF
David Castle	Vice President Research	University of Victoria, Vice Chair TRIUMF Board
Rod Clark	Division Deputy	Lawrence Berkeley Lab, former SAP-EEC Chair
Robert Dunlop	Former ADM (retired)	(Industry Canada)
Kathryn Hayashi	President and CEO	TRIUMF Innovations
Ritu Kanungo	Professor	Saint Mary's University
Oliver Kester	ALD - Accelerator Division	TRIUMF
Suzanne Lapi	Associate Professor	University of Alabama, Birmingham
Kyle Leach	Assistant Professor	Colorado School of Mines, TUEC Chair
Graeme Luke	Professor and Chair	McMaster University
Scott Oser	Professor	University of British Columbia
Nigel Smith	Director	SNOLAB
Brigitte Vachon	Associate Professor	McGill University
Michelle Wong	Director, Research	University of British Columbia

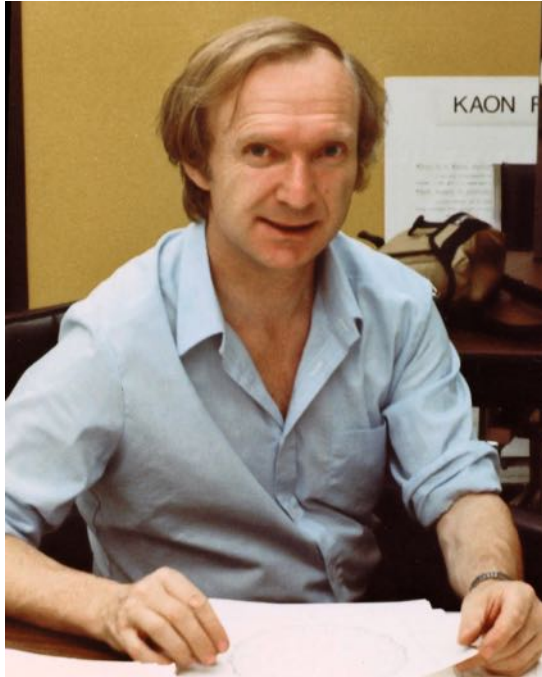
January 11, 2017	ARIEL Town Hall
May 26, 2017	Call for PPAC Proposals
July 10-14, 2017	Science Week
October 16, 2017	PPAC deadline
Fall 2017	PPAC review of proposals
Winter 17/18	Formulation of plan
Winter 2018	Consultation on plan
Spring 2018	ACOT review / Board approval
September 2018	Release of FYP 2020-2025
Fall 2018	International Peer Review
Fall 2018	Lobbying push in Ottawa

- Five-Year Plan 2020-25 will contain
 - A high-level summary for Ministers
 - A 20 page strategic plan for Analysts
 - A 50 page implementation plan for ACOT, Peer Review Committee
- Additional background on a new TRIUMF website
 - Facility information
 - Science highlights 2013-2018
 - CVs of Research Scientists

Plan will go public in September 2018

Communication and promotion will be done with 50th Anniversary Celebration in 2018

<http://www.triumf.ca/FYP2020-25>



The Michael Craddock
Endowment



The Grant Sheffer
Endowment



TRIUMF