TRIUMF

ELDG Update: Sub-atomic physics in Canada

Canadian SAP Long-range Plan and TRIUMF 20-year Vision

Nigel Smith
TRIUMF Executive Director

July 11th, 2023

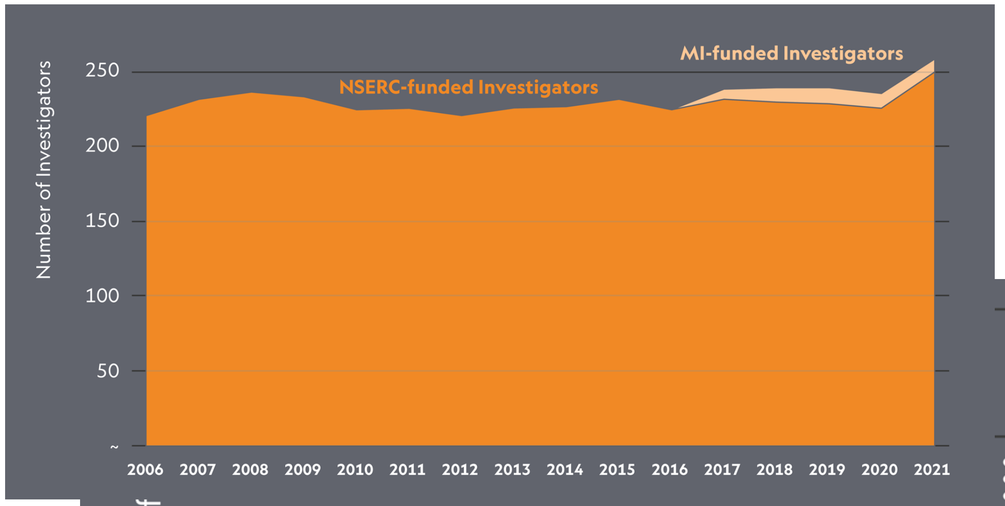
The view from Canada

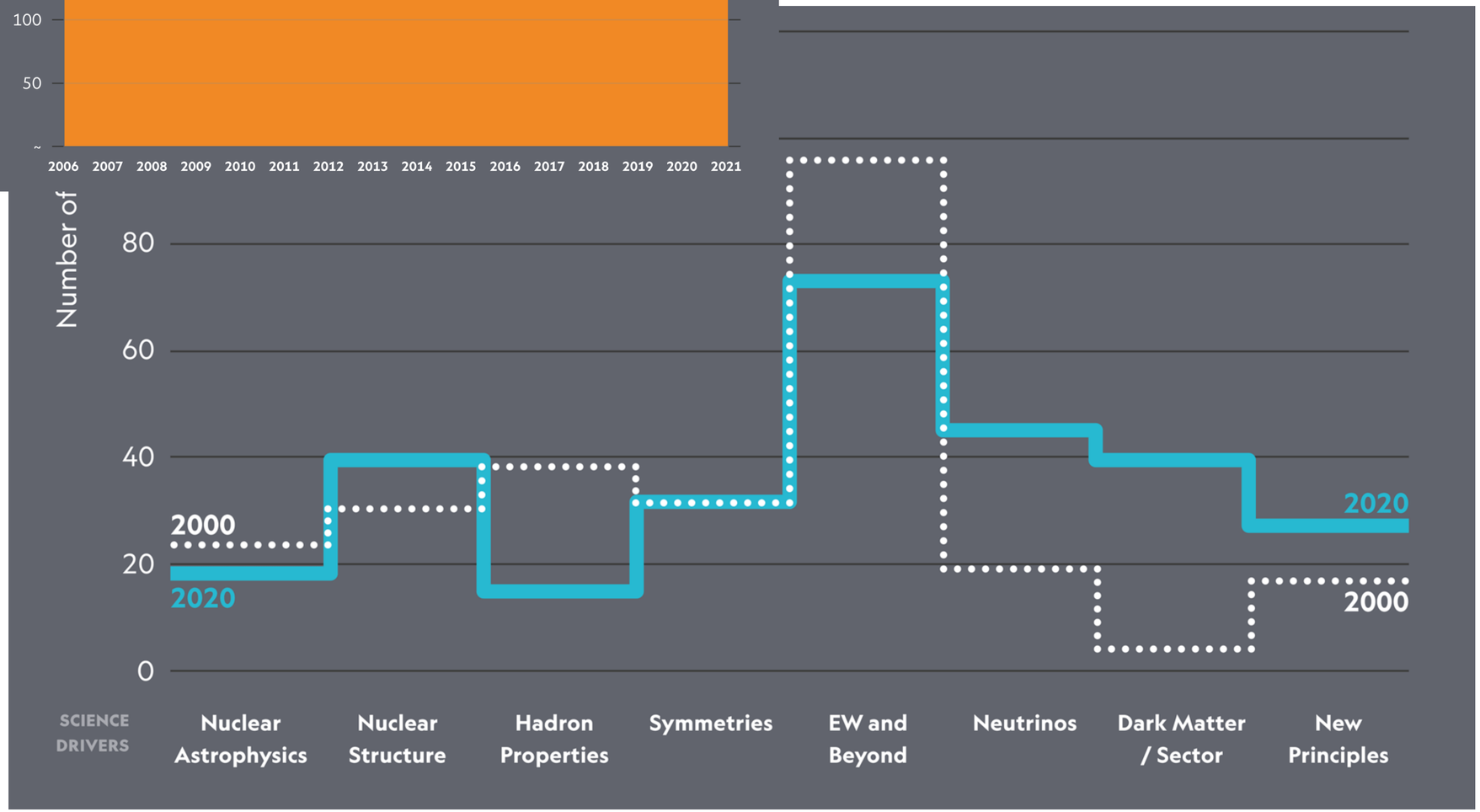
- Who are the Canadian Sub-Atomic Physics (SAP) community?
  - Academic community: University faculty, laboratory researchers
  - Community institutions: Canadian Institute for Nuclear Physics (CINP), Institute for Particle Physics (IPP), McDonald Institute (MI)
  - Laboratories / Platforms: TRIUMF, SNOLAB, Perimeter Institute
  - Funders: Tri-Councils (NSERC), Canada Foundation for Innovation (CFI), National Research Council, Provinces
- National plans are evergreen documents across both community and facilities
- The Canadian community has completed it’s five-year long range plan for 2022-2026 (and beyond)
  - https://subatomicphysics.ca/

Canadian Sub-atomic Physics (SAP) Community

- Canada funding structures support ‘sub-atomic physics’ covering HEP, NP, APP
- Coast to coast academic capability
- Canada uses a faculty driven ‘bottom-up’ approach to projects and infrastructure; grant-driven approach to research

Canadian Sub-atomic Physics (SAP) Community

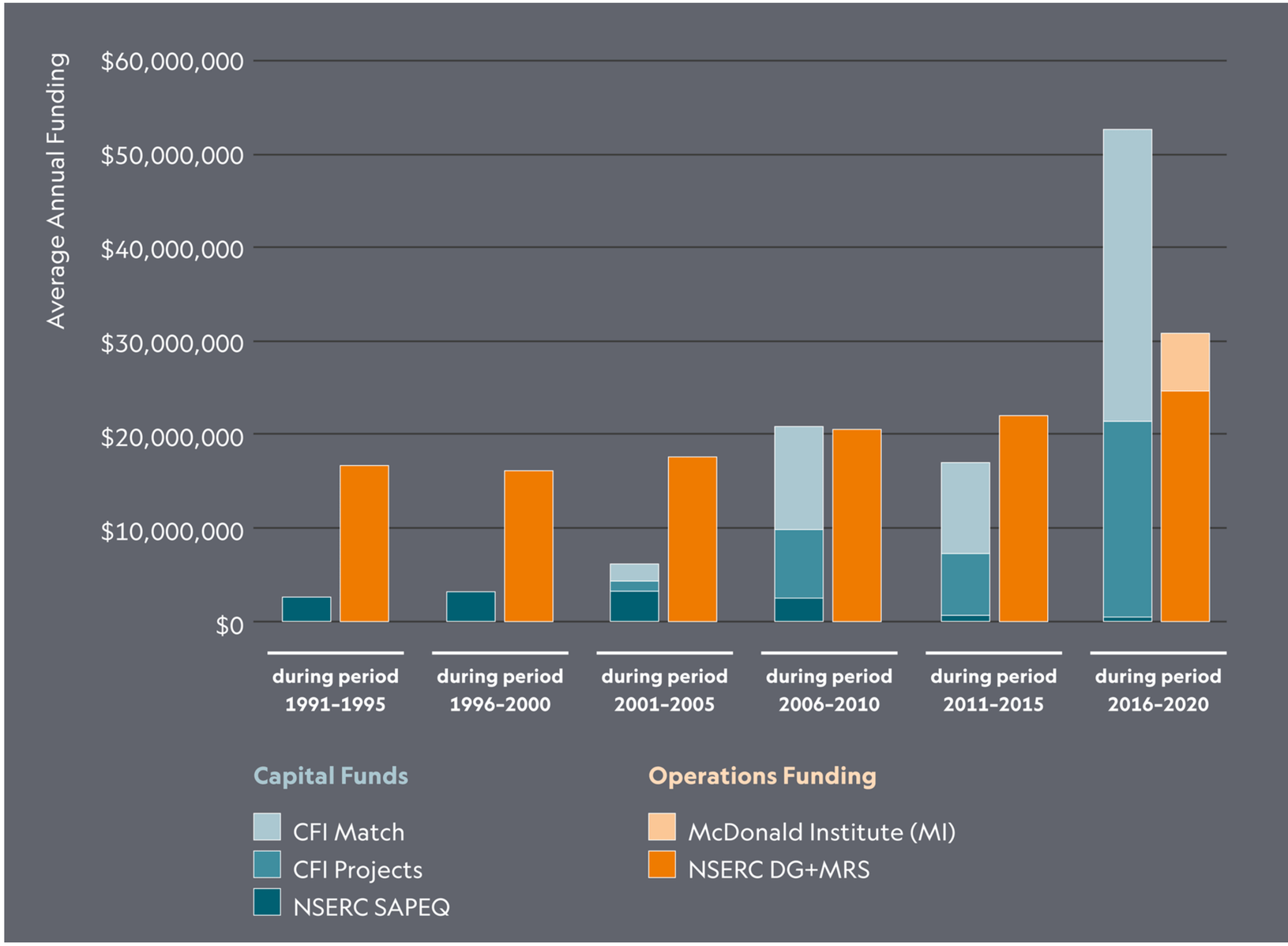




- Community of about 250 principal investigators
- Some transition over the last two decades away from ‘EW and beyond’ towards neutrino and dark matter studies
  - Reflects growth of the SNOLAB programme

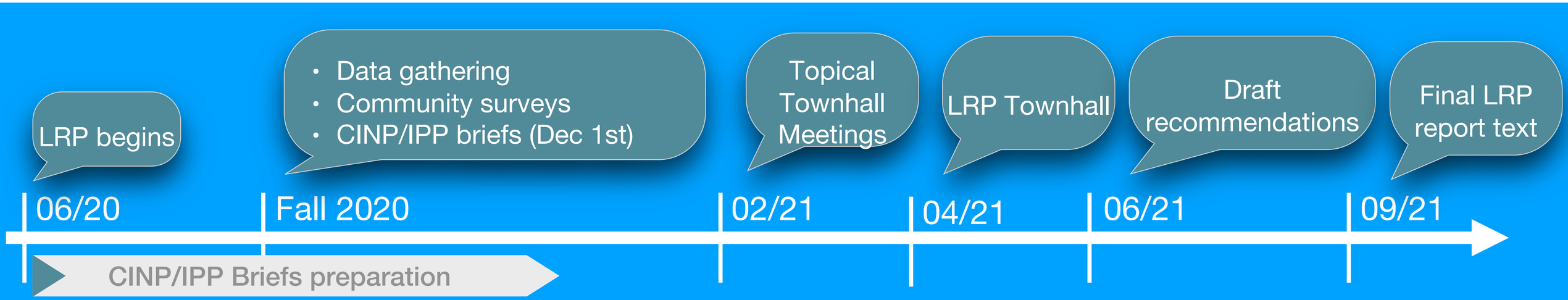
Canadian Sub-atomic Physics (SAP) Community

- Substantial growth in support to SAP programme, primarily through great success in capital requests through CFI (Canada Foundation for Innovation - still uses a bottom-up approach to resource allocation)
- McDonald Institute also provided substantial input over last five years (funding model changing)



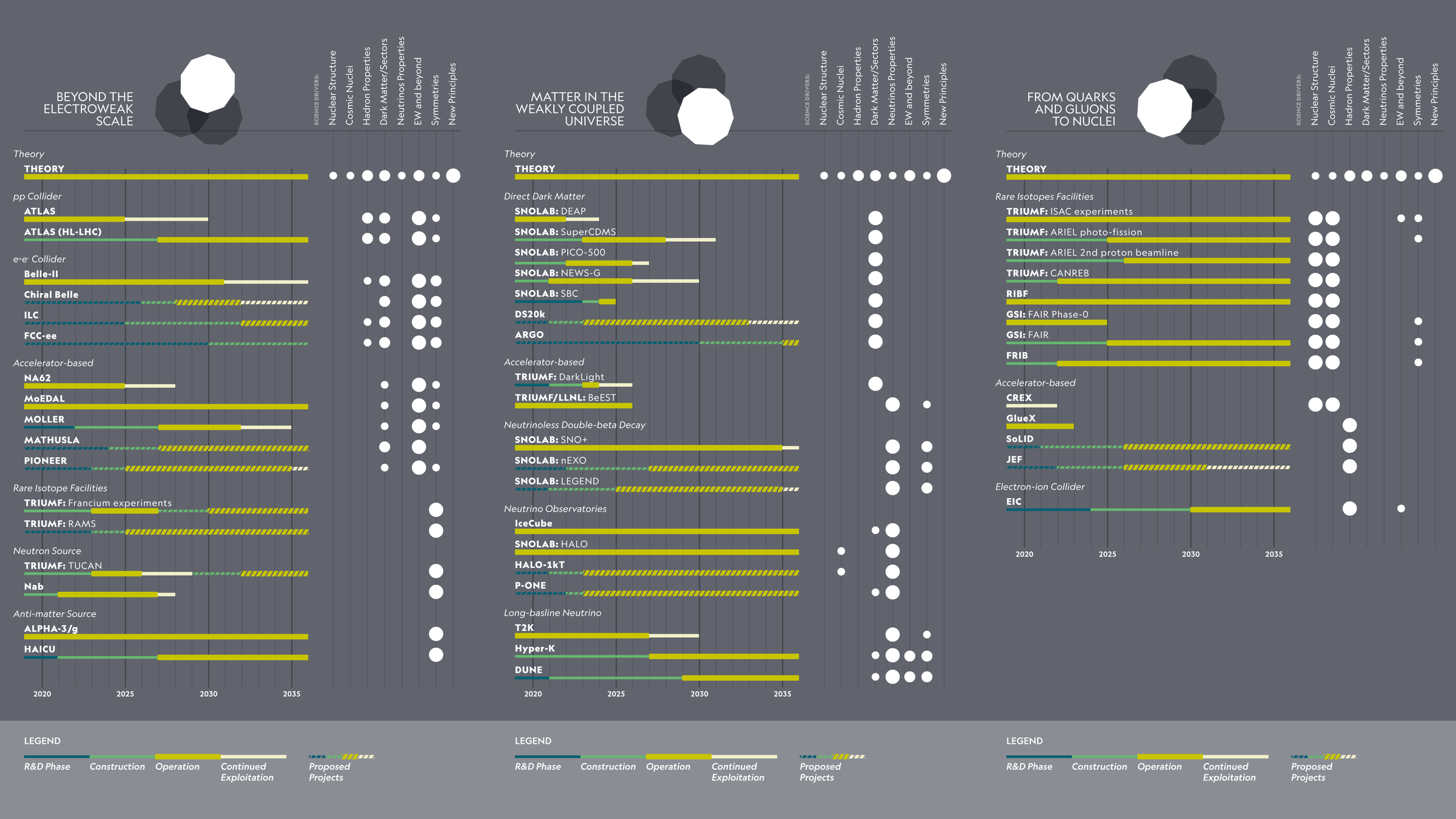
Canadian SAP Long Range Plan

- Aim to maximize Canadian impact in a global field, given limited resources...
- The LRP report informs funding agencies of the community's priorities for the field; however, funding agencies still hold broad peer-reviewed funding competitions.
- The report communicates to international partners (and policy makers) the Canadian plans and priorities, and resource requirements.
- An inclusive planning process that helps to strengthen and coordinate the Canadian SAP community.



Science Drivers

- Three broad areas of research encompass eight science drivers of the Canadian programme
  - Beyond the electroweak scale
  - Matter in the weakly coupled Universe
  - From quarks and gluons to nuclei


BEYOND THE ELECTROWEAK SCALE
SCIENCE DRIVERS:
Nuclear Structure
Cosmic Nuclei
Hadron Properties
Dark Matter/Sectors
Neutrinos Properties
EW and beyond
Symmetries
New Principles
Theory
THEORY
pp Collider
ATLAS
ATLAS (HL-LHC)
e+e- Collider
Belle-II
Chiral Belle
ILC
FCC-ee
Accelerator-based
NA62
MoEDAL
MOLLER
MATHUSLA
PIONEER
Rare Isotope Facilities
TRIUMF: Francium experiments
TRIUMF: RAMS
Neutron Source
TRIUMF: TUCAN
Nab
Anti-matter Source
ALPHA-3/g
HAICU
2020
2025
2030
2035
MATTER IN THE WEAKLY COUPLED UNIVERSE
SCIENCE DRIVERS:
Nuclear Structure
Cosmic Nuclei
Hadron Properties
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Theory
THEORY
Direct Dark Matter
SNOLAB: DEAP
SNOLAB: SuperCDMS
SNOLAB: PICO-500
SNOLAB: NEWS-G
SNOLAB: SBC
DS20k
ARGO
Accelerator-based
TRIUMF: DarkLight
TRIUMF/LLNL: BeEST
Neutrinoless Double-beta Decay
SNOLAB: SNO+
SNOLAB: nEXO
SNOLAB: LEGEND
Neutrino Observatories
IceCube
SNOLAB: HALO
HALO-1kT
P-ONE
Long-basline Neutrino
T2K
Hyper-K
DUNE
2020
2025
2030
2035
FROM QUARKS AND GLUONS TO NUCLEI
SCIENCE DRIVERS:
Nuclear Structure
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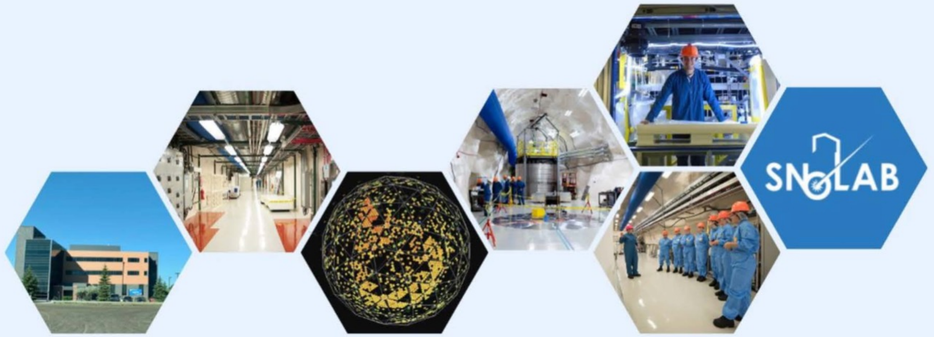
THEORY
Rare Isotopes Facilities
TRIUMF: ISAC experiments
TRIUMF: ARIEL photo-fission
TRIUMF: ARIEL 2nd proton beamline
TRIUMF: CANREB
RIBF
GSI: FAIR Phase-0
GSI: FAIR
FRIB
Accelerator-based
CREX
GlueX
SoLID
JEF
Electron-ion Collider
EIC
2020
2025
2030
2035
LEGEND
R&D Phase
Construction
Operation
Continued Exploitation
Proposed Projects
LEGEND
R&D Phase
Construction
Operation
Continued Exploitation
Proposed Projects
LEGEND
R&D Phase
Construction
Operation
Continued Exploitation
Proposed Projects

Underpinning national capabilities

- Canadian research programme is supported by several institutions and laboratories, all having national and international relevance
  - TRIUMF - Canada’s particle accelerator centre, centred on the 520 MeV cyclotron and ISOL targets, additional capability being installed. Supports detector development, data management and science, medical isotopes
    - Acts as conduit for investment in international commitments (eg HL-LHC)
  - SNOLAB - Canada’s deep underground research facility. 2km depth, lowest cosmic ray background in the world, broadening science programme around low background science
  - Perimeter Institute - theoretical physics institute supporting research threads across several drivers (Quantum, PP, strong gravity and cosmology)

10
years of SNOLAB science

#SNOLAB10



SNOLAB

NEWS-G
DEAP-3600
DEAP-I
PICO-2
DAMIC
MiniCLEAN
PICO-500
Tonne-scale Double Beta
SBC
SENSEI
HALO
SuperCDMS
PICASSO-III
REPAIR
FLAME
PICO-40
CUTE (SCDMS Test)
PUPS
SNO+ TeBD
SNO+ TeA
SNO+
Low Background Assay Facilities

TRIUMF Accelerator Centre

TRIUMF is Canada's particle accelerator centre. We are a world-class hub of research, education, and innovation that is home to ~600 staff and students

Founded in 1968 by the University of British Columbia, Simon Fraser University, and the University of Victoria, TRIUMF is a cornerstone of Canada's innovation ecosystem, driving impact locally, nationally, and around the world

Discovery, accelerated.

TRIUMF has recently developed its governance structure to an incorporated not-for profit (charitable), with membership from Canadian universities. All associate member universities have transitioned to full members.

Member Universities:

University of Alberta
University of British Columbia
University of Calgary
Carleton University
University of Guelph
University of Manitoba
McGill University
McMaster University
Université de Montréal
University of Northern British Columbia
Queen's University
University of Regina
Saint Mary's University
Université de Sherbrooke
Simon Fraser University
University of Toronto
University of Victoria
University of Waterloo
Western University
University of Winnipeg
York University

A global leader in discovery science, delivering breakthroughs that unlock the deepest mysteries of the universe

Strengthening Canada's leadership in groundbreaking particle and nuclear physics

A world-class accelerator centre driving use-inspired research – from the life sciences to quantum and green technologies

Leveraging our unique infrastructure to pursue research in Canada that will change the world

An inclusive multidisciplinary talent incubator, attracting and developing the best people from around the world

Producing Canada's future science leaders and innovators

A leader in a flourishing national Big Science ecosystem

Catalyzing the success and growth of Canada's network of major research facilities

A national innovation hub translating discovery science into health and sustainability solutions

Responding nimbly to complex societal challenges for the benefit of Canadians

TRIUMF's Research Programme - our 20-year vision

- In summer 2022, TRIUMF has completed the 20-year vision process to define longer term planning requirements
  (TRIUMF is funded in five-year cycles and the next funding proposal is presently being developed)

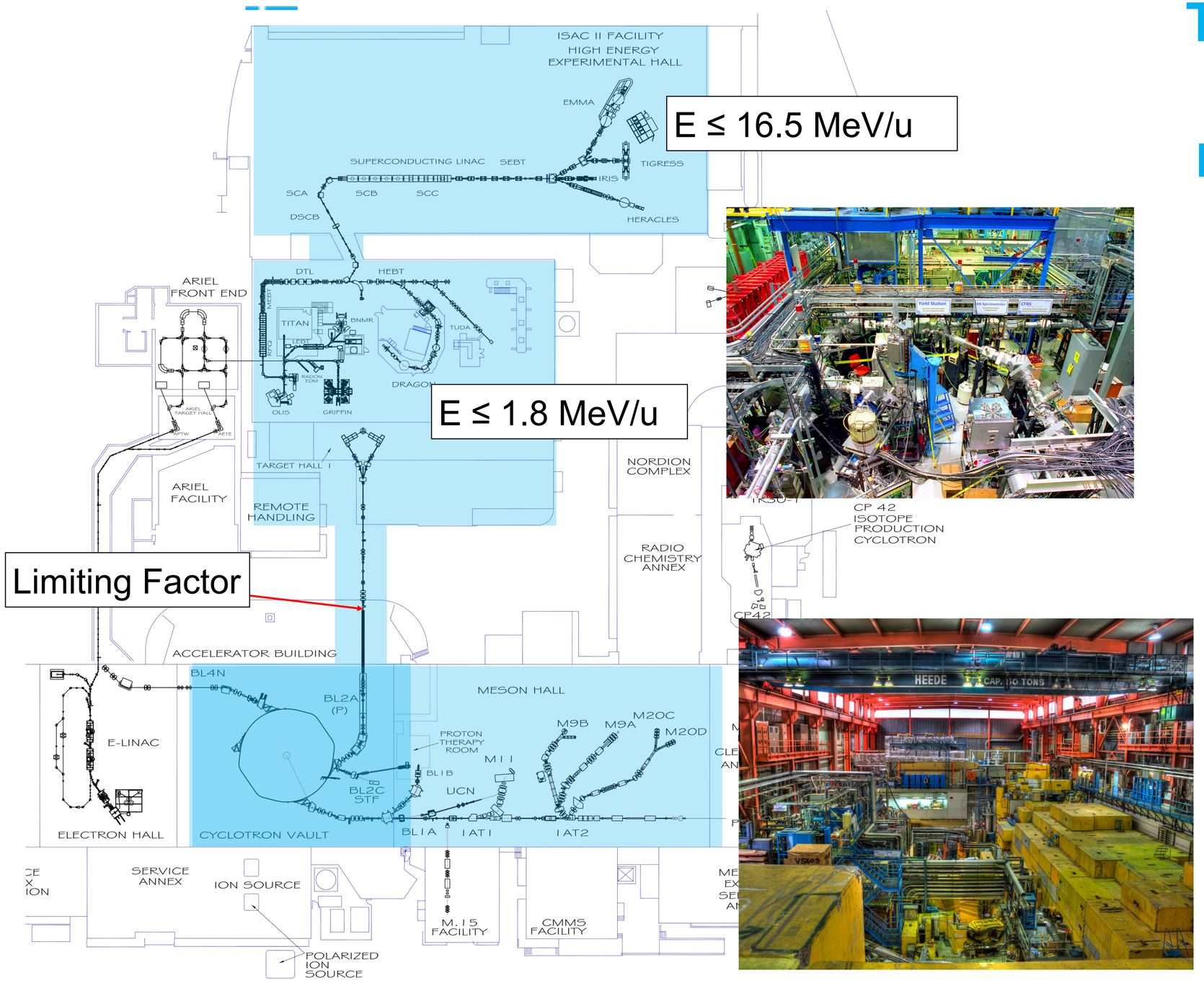
- An 18-month process engaging a broad research and stakeholder community, leading to five core themes

- All previous work leading to the Vision is available on the TRIUMF web site

- Includes input from focus groups, interim pillars and themes, and theme development

- Core themes remain on nuclear / particle physics and life / material science
- Additional themes to be developed around green and quantum technologies
- Innovation and societal benefit called out directly
- Strengthened focus on EDI, our people and operational excellence as enablers

TRIUMF's Accelerators



Beamline 2A

- ISAC I Facility
  - Nuclear Astrophysics
  - Electroweak Physics
  - Materials Science βNMR
  - Life Science βNMR
- ISAC II Facility
  - Nuclear Structure

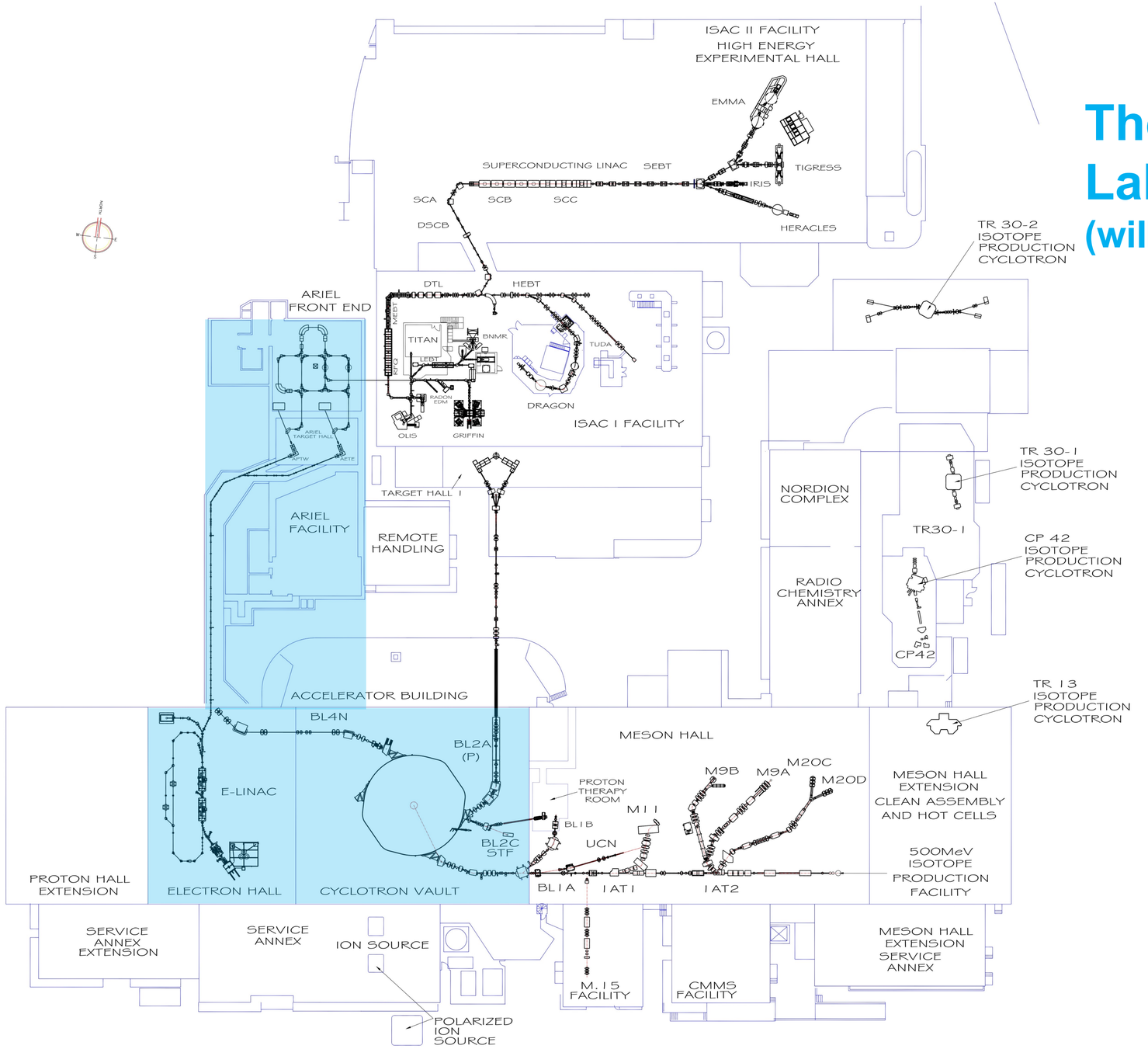
Beamlines 1A, 1B, 2C

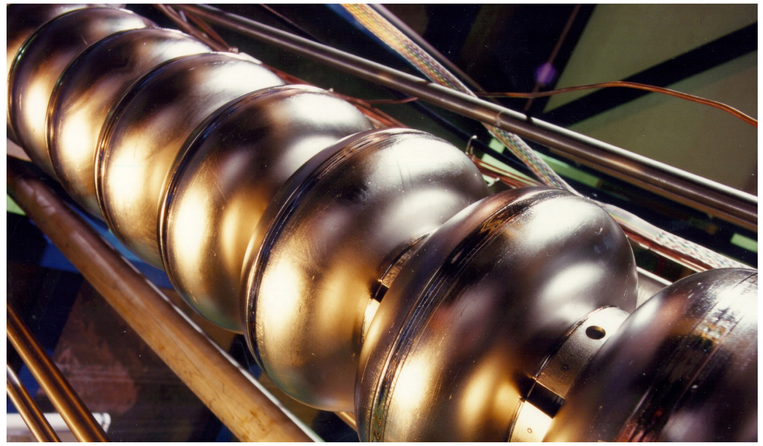
- Materials Science μSR
- Ultra Cold Neutron Facility
- Isotope Production
- Irradiation Services
- (Proton Therapy)

TRIUMF's Accelerators

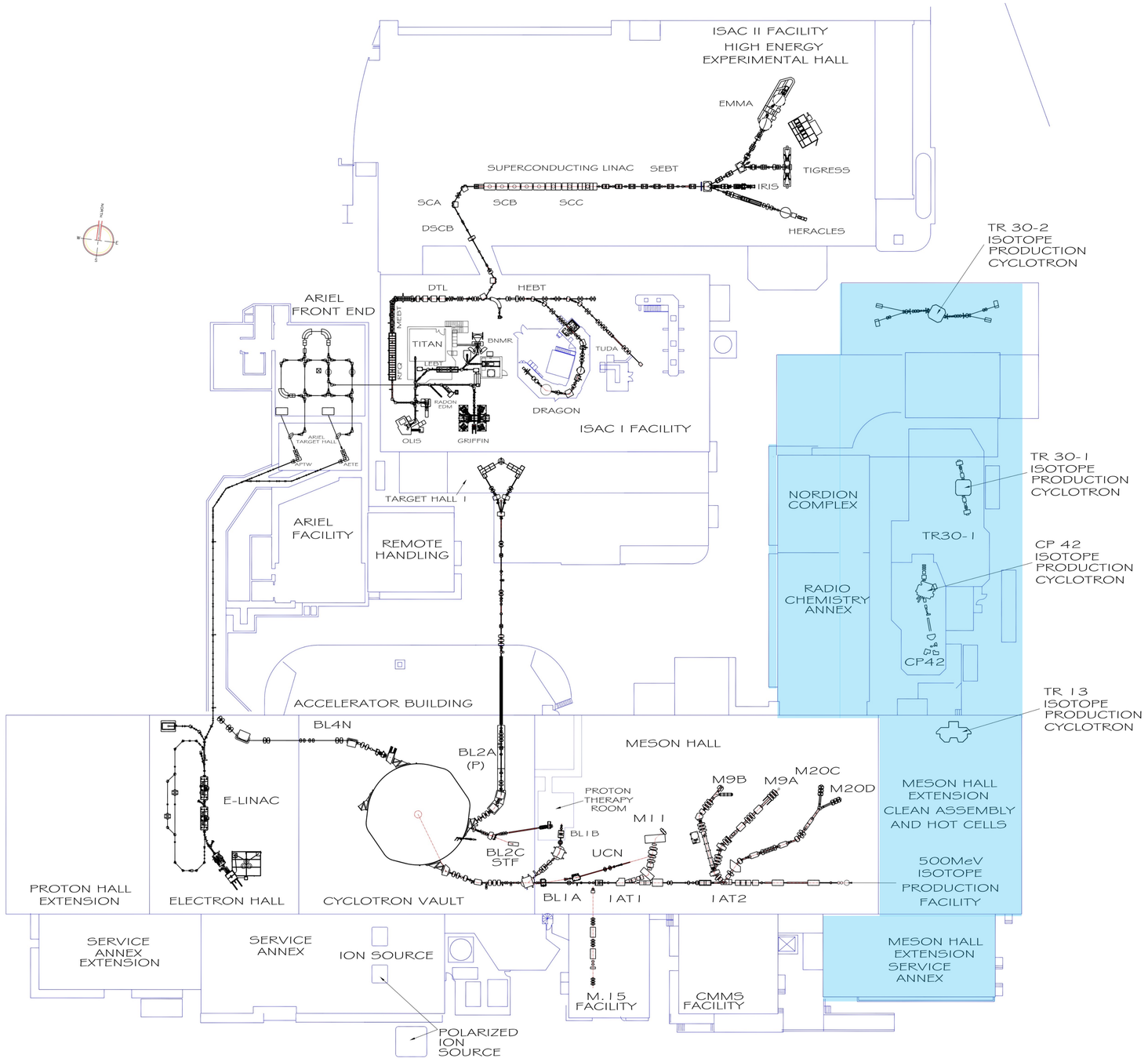
The Advanced Rare IsotopE Laboratory – ARIEL
(will start operation within the next LRP)

- Multi-user, multi-disciplinary RIB Facility
- Intense, clean RIB beams into ISAC experiments (from 2027 on)
  - New 30 MeV 300 kW super-conducting CW electron linac
  - New electron beamline and 100 kW target station
  - New 50 kW proton beamline and target station



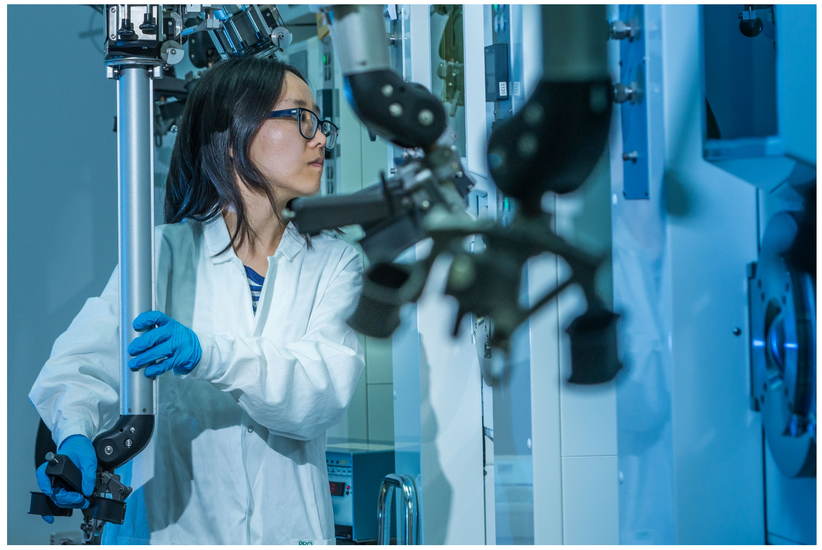


TRIUMF's Accelerators



Nuclear Medicine

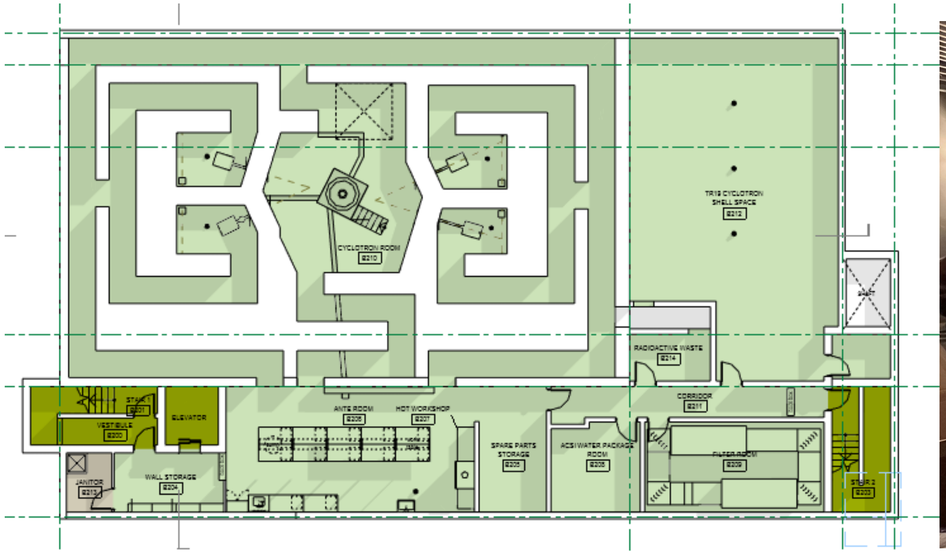
- Five H^- medical cyclotrons (including new IAMI TR 24)
  - Isotope production and R&D
- Radiochemistry
  - BWXT
    - ~2M doses annually
  - UBC
    - Centre for Brain Health



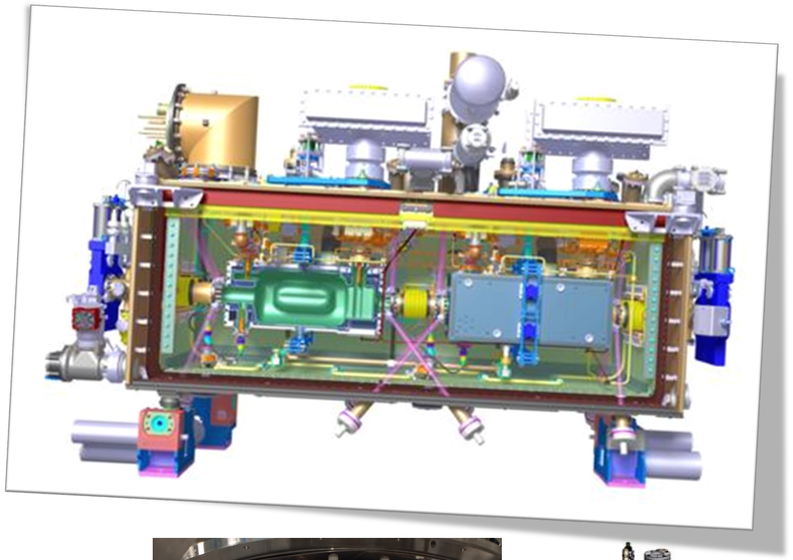
TRIUMF's Accelerators

Institute of Advanced Medical Isotope research – IAMI

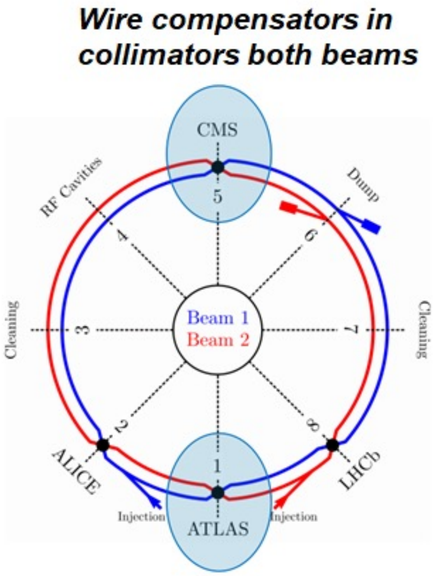
- New $50M facility to support production and research into next generation medical isotopes & radio-pharmaceuticals
  - Provides isotope security
  - Enables R&D + clinical trials
- Funding announced by Prime Minister on November 1st, 2018
  - Contributions from Federal and BC governments, BC Cancer, BC Cancer Foundation, UBC and TRIUMF
- Building substantial completion reached this past summer; soft commissioning underway

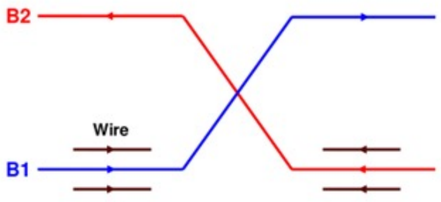


Involvements international Accelerator projects – HL-LHC and in the future EIC



- HL-LHC crab cavity cryomodules
  - TRIUMF to work with CERN and UK colleagues to develop RF-Dipole (RFD) cryomodule design, assembly tooling and fixtures as well as assembly procedures

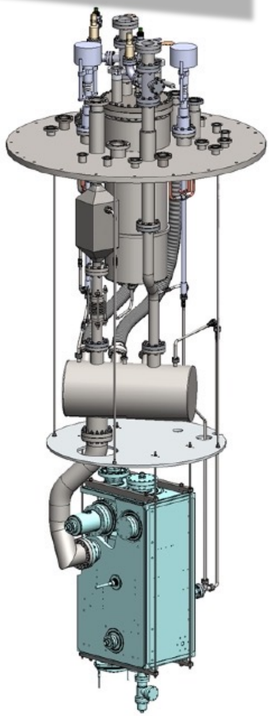




- TRIUMF multi-purpose test cryostat upgraded to allow qualification of RFD cavities at 2K
  → Ready for qualifying US AUP cavities!
- Tender for cryomodule Outer Vacuum Chamber (OVC) released

- HL-LHC long range beam – beam effect → wire compensation simulation, wire design and LHC machine development with wire prototypes.

- Both topics are relevant for EIC
  - 394 MHz crab cavities
  - Long range beam-beam effects and compensation



Increased engagement in nEXO double-beta decay

- CFI funding development work in Canada; new award contingent on DOE investment
- NJTS appointed as inaugural convenor of funding agency task force to develop European-North American tonne-scale programme
- Theory group engaged in ab initio calculations of nuclear matrix elements
- nEXO collaboration recently published a paper in the EPJC on VUV SPM
  - Effort lead by TRIUMF SciTech dept
  - Lead author Giacomo Gallina

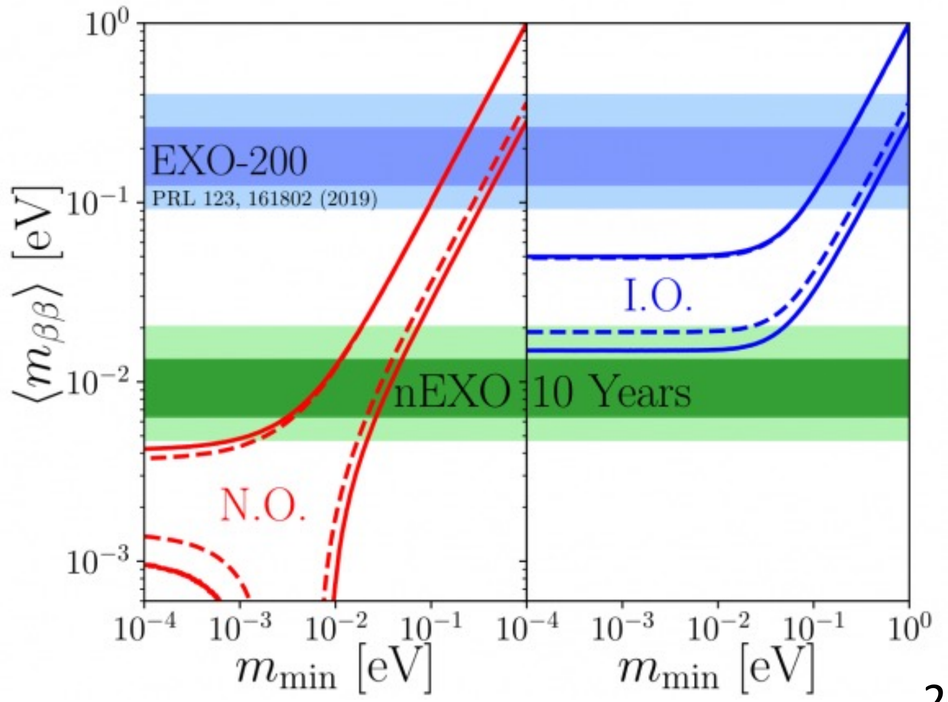
Eur. Phys. J. C (2022) 82:1125
https://doi.org/10.1140/epjc/s10052-022-11072-8

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Performance of novel VUV-sensitive Silicon Photo-Multipliers for nEXO

G. Gallina[1,35,a], Y. Guan[2,36], F. Retiere[1], G. Cao[2,36,b], A. Bolotnikov[3], I. Kotov[3], S. Rescia[3], A. K. Soma[4], T. Tsang[3], L. Darroch[5], T. Brunner[1,5], J. Bolster[6,37], J. R. Cohen[6], T. Pinto Franco[6], W. C. Gillis[6], H. Peltz Smalley[6], S. Thibado[6], A. Pocar[6], A. Bhat[7], A. Jamil[7,35], D. C. Moore[7], G. Adhikari[8], S. Al Kharusi[5], E. Angelico[9], I. J. Arnquist[10], P. Arsenault[11], I. Badhrees[12,38], J. Bane[6], V. Belov[13], E. P. Bernard[14], T. Bhatta[15], P. A. Breur[16], J. P. Brodsky[14], E. Brown[17], E. Caden[5,18,19], L. Cao[20], C. Chambers[5], B. Chana[12], S. A. Charlebois[11], D. Chernyak[21], M. Chiu[3], B. Cleveland[18,19], R. Collister[12], M. Cvitan[1], J. Dalmasson[9], T. Daniels[22], K. Deslandes[11], R. DeVoe[9], M. L. di Vacri[10], Y. Ding[2], M. J. Dolinski[4], A. Dragone[16], J. Echevers[23], B. Eckert[4], M. Elbeltagi[12], L. Fabris[24], W. Fairbank[25], J. Farine[12,18,19], Y. S. Fu[2,36], D. Gallacher[5], P. Gautam[4], G. Giacomini[3], C. Gingras[5], D. Goeldi[12,40], R. Gornea[12], G. Gratta[9], C. A. Hardy[9], S. Hedges[14], M. Heffner[14], E. Hein[26], J. Holt[1], E. W. Hoppe[10], J. Hößl[27], A. House[14], W. Hunt[14], A. Iverson[25], X. S. Jiang[2], A. Karelin[13], L. J. Kaufman[16], R. Krücken[1,28,39], A. Kuchenkov[13], K. S. Kumar[6], A. Larson[29], K. G. Leach[30], B. G. Lenardo[9], D. S. Leonard[31], G. Lessard[11], G. Li[2], S. Li[23], Z. Li[8], C. Licciardi[12,18,19], R. Lindsay[32], R. MacLellan[15], M. Mahtab[1], S. Majidi[5],



Next Five-year Funding

- Having completed the 20-Year Vision, we are in development of our next operations funding proposal to government including the completion and operation of the new research platforms ARIEL and IAMI
- The 20-Year Vision lays out the long-term priorities for the laboratory, and Five-Year Plan 2025 – 2030 will mark the first effort to lay the groundwork to achieve this
- Canadian government support for operations of Major Research Facilities is in evolution, though this submission will follow previous processes. TRIUMF is fully engaged in the MRF discussions, which engage ISED, funding agencies, and the Chief Science Advisor.
- Objective to complete proposal and have approval through September, with resolution by end of this fiscal year (March 2024)

Canadian planning and connection to US (and international) programme

- Canadian SAP programme is highly international
  - International collaborations across multiple continents and countries, including projects located within Canada
  - International connections between laboratories (US Labs, CERN, KEK)
  - Dialogue between agencies as appropriate and possible (given timescales and different processes adopted)
- National planning naturally incorporates the international and US connections and research drivers to ensure strong collaboration with US institutes and researchers
  - https://subatomicphysics.ca

TRIUMF

Thank You!

Merci!

www.triumf.ca
@TRIUMFLab

Science Highlights

Science & Technology – Accelerators

First results from new `beta-SRF' facility at beta-NMR

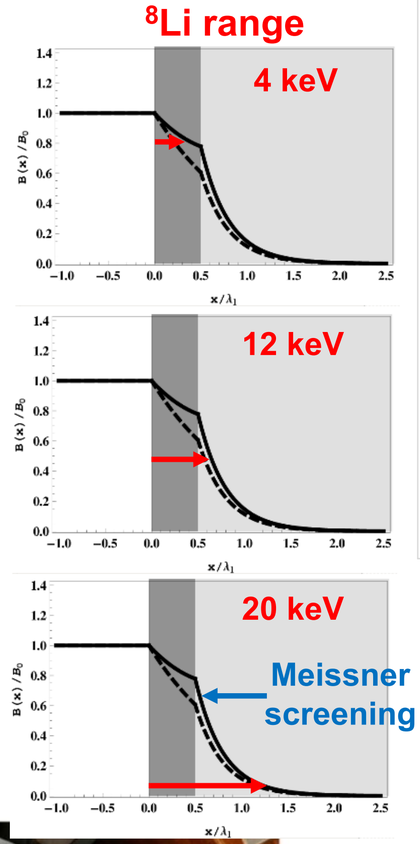
- Unique facility in the world for depth profiling materials in parallel magnetic fields up to 200mT – SRF regime
- First results show clear differences in the Meissner screening between a baseline sample and an oxygen doped sample
- O-doped sample has a longer penetration depth but better high field screening compared to baseline

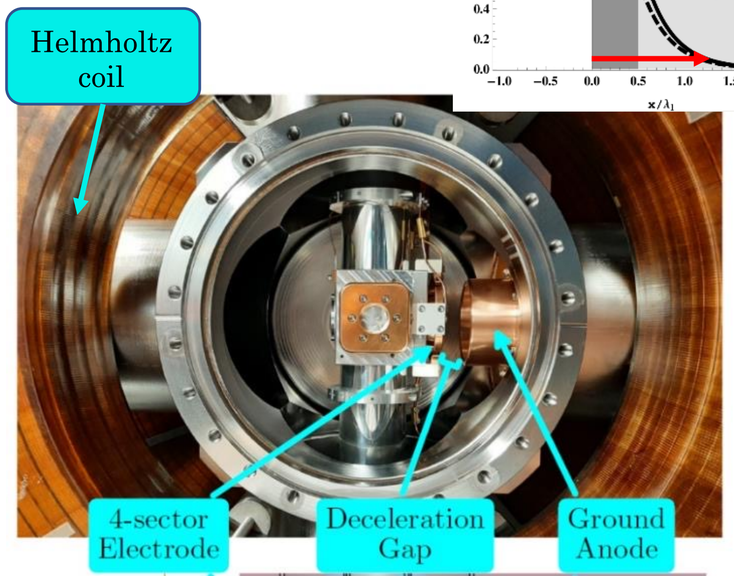
First paper

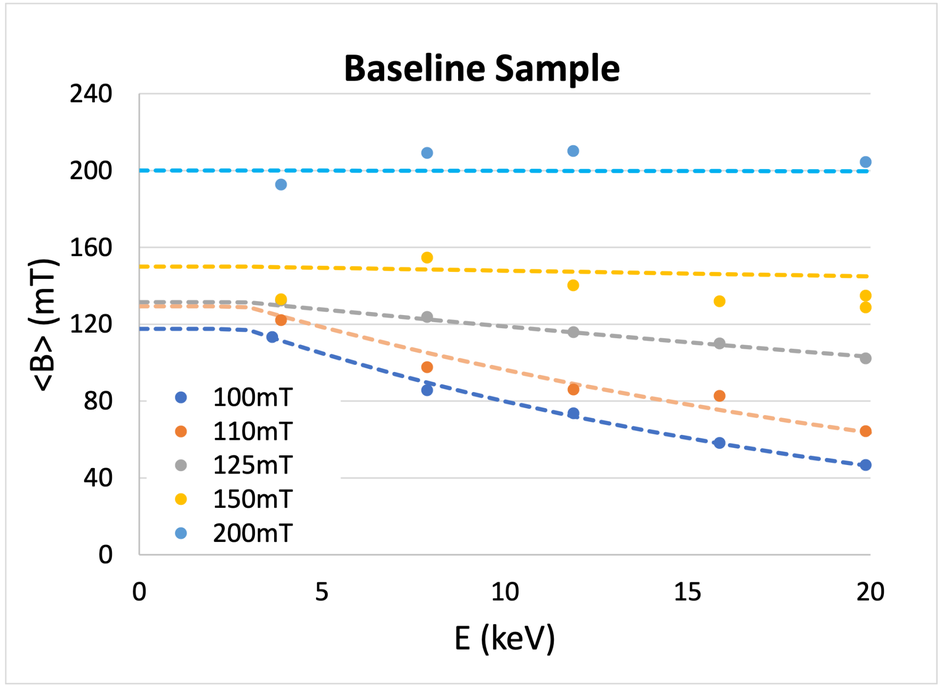
https://doi.org/10.1063/5.0137368

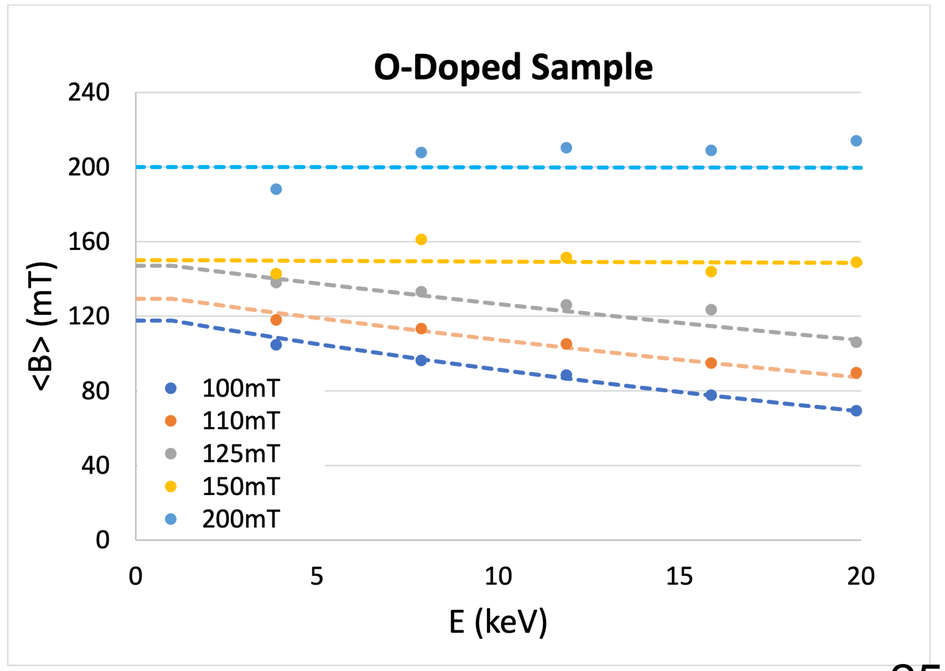
A New High Parallel-Field Spectrometer at TRIUMF's β-NMR Facility

E. Thoeng, R.M.L. McFadden, S. Saminathan G.D. Morris, P. Kolb, B. Matheson, M. Asaduzzaman, R. Baartman, S.R. Dunsiger, D. Fujimoto, T. Junginger, V.L. Karner, S. Kiy, R. Li, M. Stachura, J.O. Ticknor, R.F. Kiefl, W.A. MacFarlane, and R.E. Laxdal, *Rev Sci Instrum* 94, 023305 (2023)





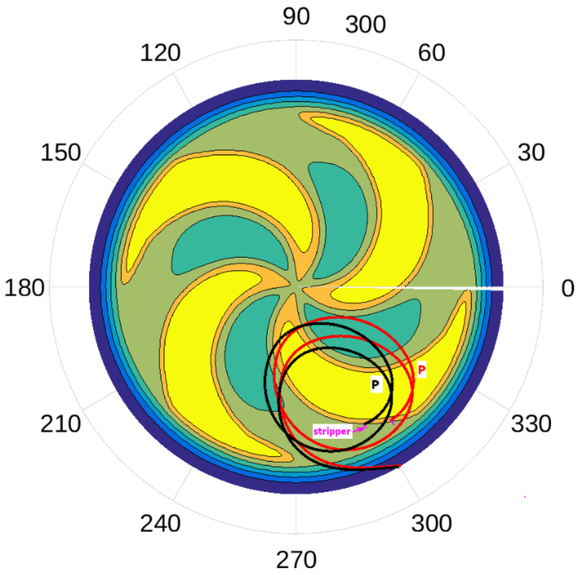


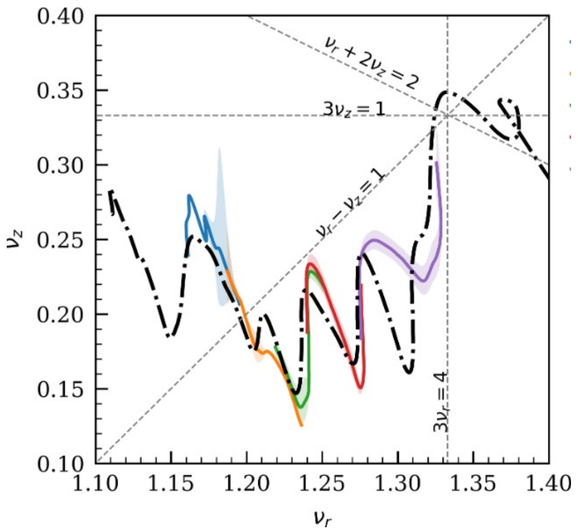


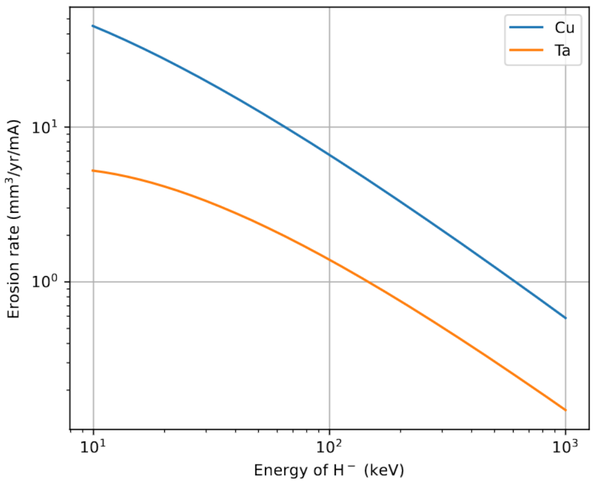
Science & Technology – Accelerators

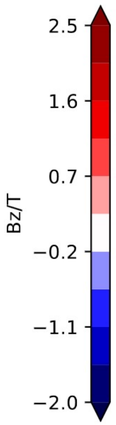
Special Beam Dynamics Issue on Cyclotrons
International Committee for Future Accelerators

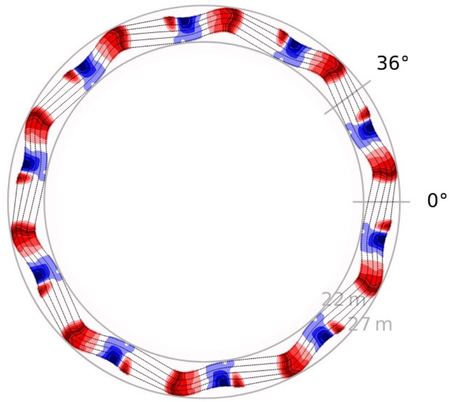
- TRIUMF Beam Physics Department Head, Rick Baartman, was invited by the beam dynamics subgroup to coordinate and edit a special issue on cyclotrons' energy and intensity limits.
- 15 peer-reviewed papers were published in Journal of Instrumentation, of which 8 from TRIUMF, reinforcing TRIUMF as a center of excellence for cyclotron physics and beam dynamics.
- Contributions from the TRIUMF teams to the newsletter included: future high-energy and high-power cyclotrons, exploration of fundamental intensity limits, constant-tune cyclotrons, H_2^+ and H_3^+ beam acceleration and stripping extraction, etc.

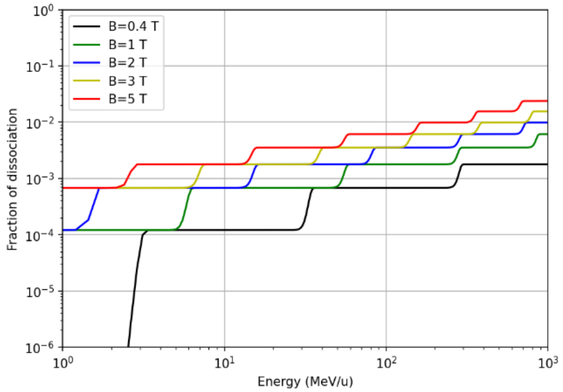








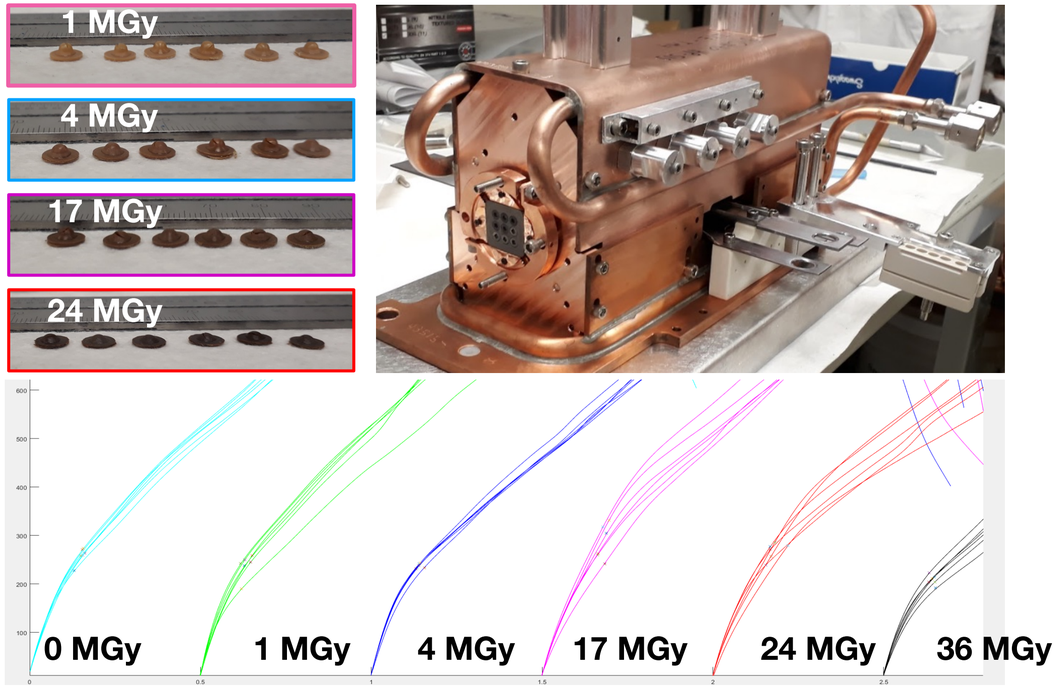




(b) Total dissociation of all state at B = 1, 2, 3 and 5 T

Targets and Ion Sources Research Highlights

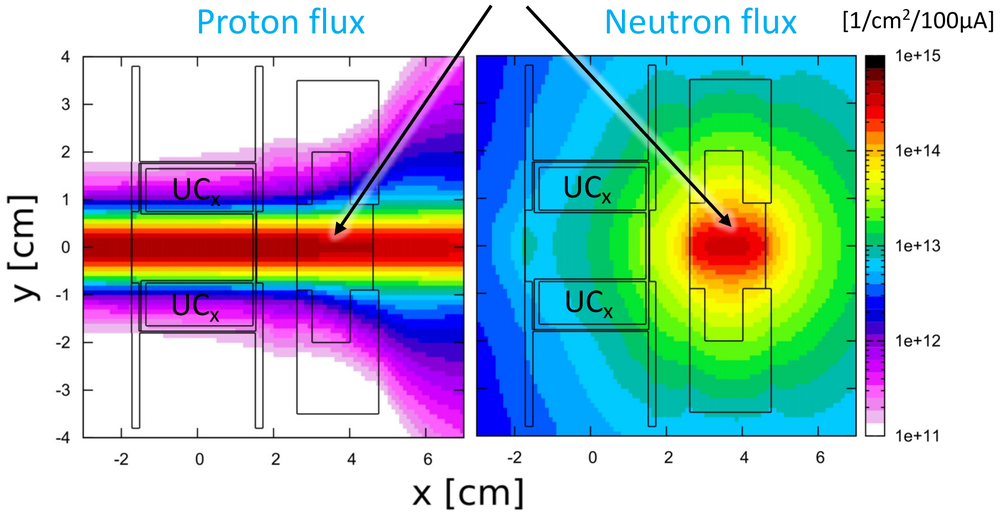
Example 1: PEEK irradiation damage studies - tensile and fracture properties



Research focus:

- Target materials for intense radioisotope release
- Ionization schemes and laser ionization efficiency
- Material irradiation damage for accelerator and nuclear applications
- Applications of accelerators and radioisotopes in nuclear medicine

Example 2: Proton-to-neutron converter target



Recent PH.D. thesis work:

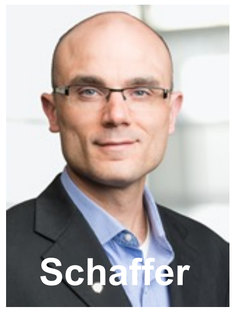
- **Luca Egoriti**, PhD (December 2022, UBC Chemistry) - Transport phenomena in radioisotope beam production targets
- **Nolan Esplen**, PhD (April 2023, UVIC Physics and Astronomy) – Development of Enabling Technologies for Ultra-high Dose Rate
  and Spatially Fractionated Radiation Therapy (FLASH)

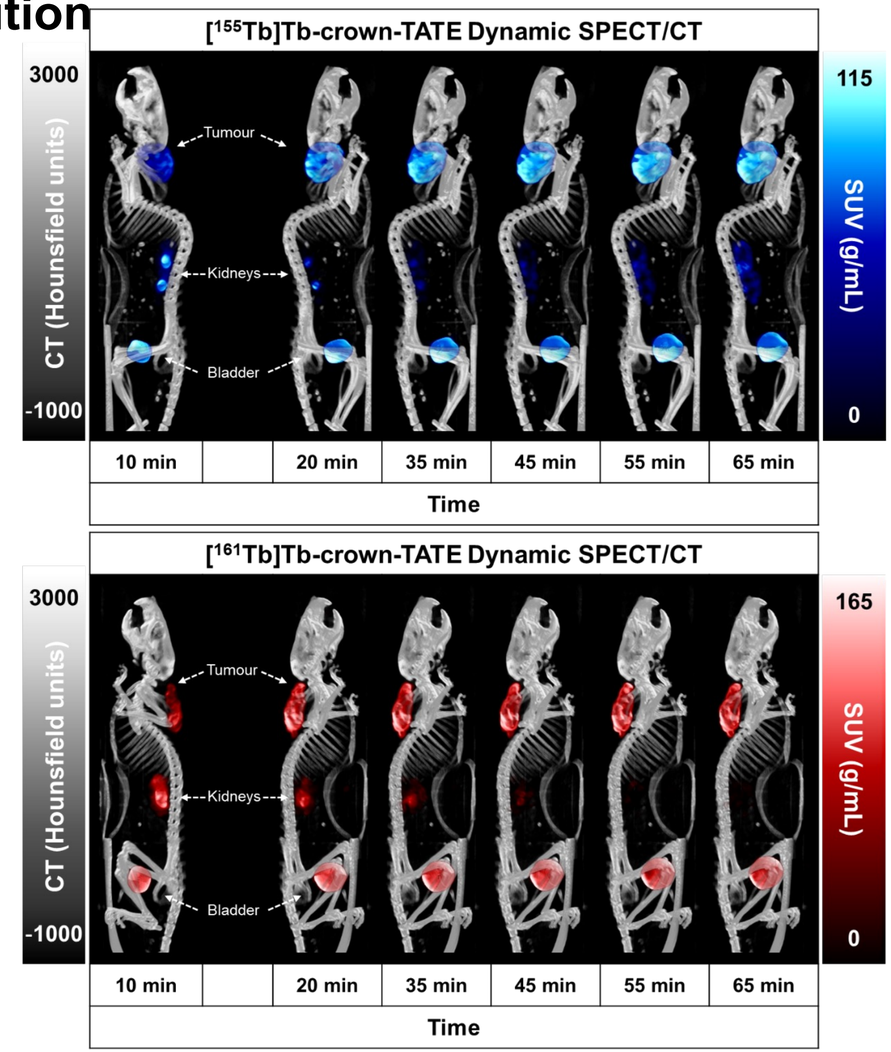
Science & Technology – Life Sciences

TRIUMF continues development of novel therapeutic isotopes

[$^{161/155}$Tb]Tb-crown-TATE: in vivo SPECT imaging and biodistribution

- Theranostic isotope development: ^{155}Tb (SPECT imaging or Auger therapy); ^{161}Tb (SPECT imaging or β-therapy)
- TRIUMF produces ^{155}Tb in ISAC; ^{161}Tb obtained from SCK CEN; animal studies completed in collaboration with BC Cancer, UBC
- TRIUMF-developed chelator and radiopharmaceutical (see structure below) targeting neuroendocrine (pancreatic) tumours (NETs)
- Results show high tumour uptake and low uptake in normal tissues and organs



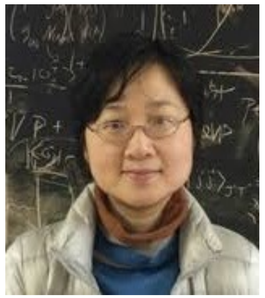


SPECT imaging of ^{155,161}Tb in AR42J (pancreatic) tumour mice

Bio beta-NMR: Optical Pumping of Ac^+ Isotopes

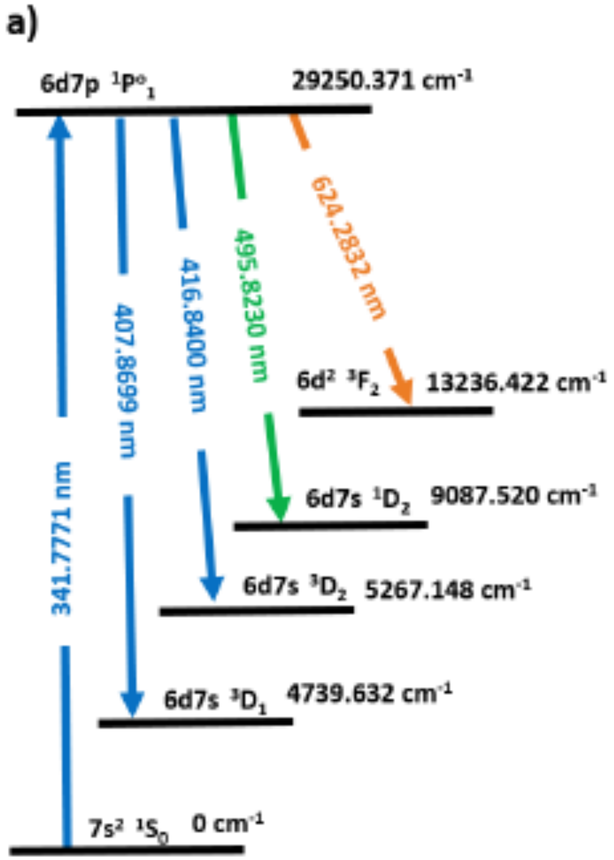
Interdivisional endeavor:

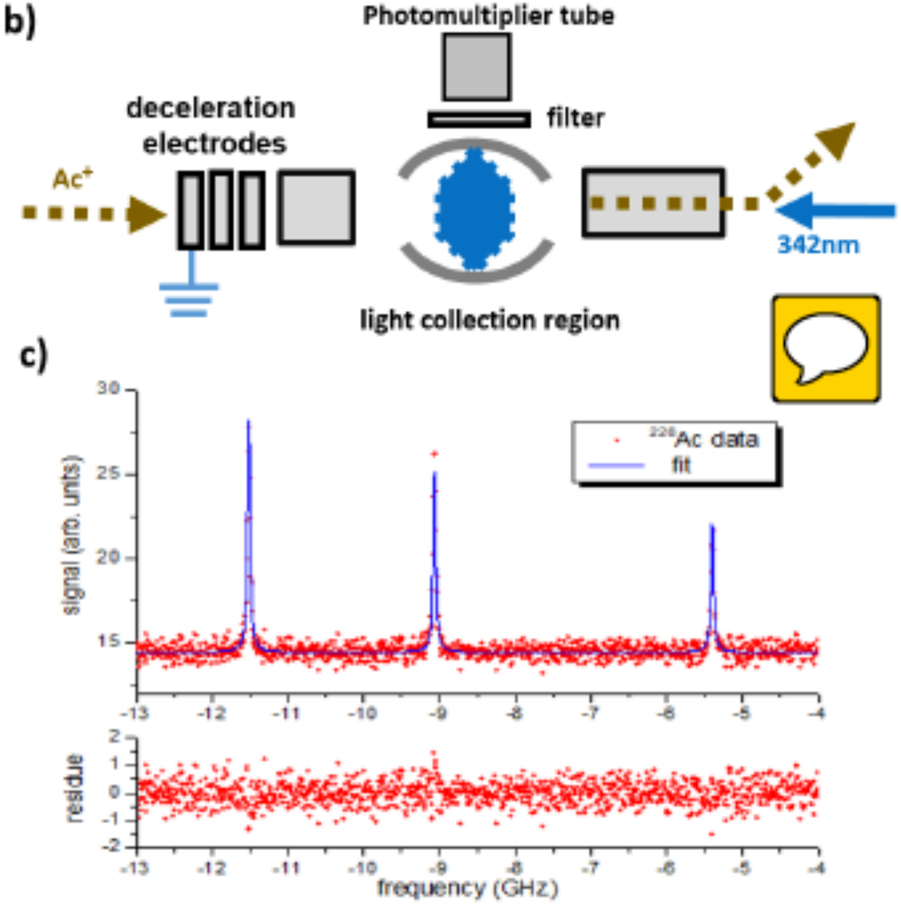
M. Stachura
Life Sciences Div.



R. Li
Accelerator Div.

A. Teigelhoefer
Physical Science Div.



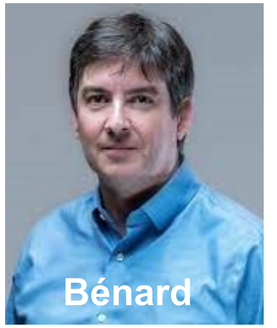


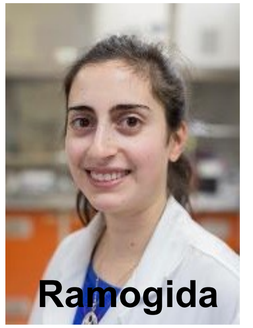
R. Li et al., Recent upgrades and developments at TRIUMF's laser nuclear-spin-polarization facility. NIM B, under revision

Science & Technology – Life Sciences

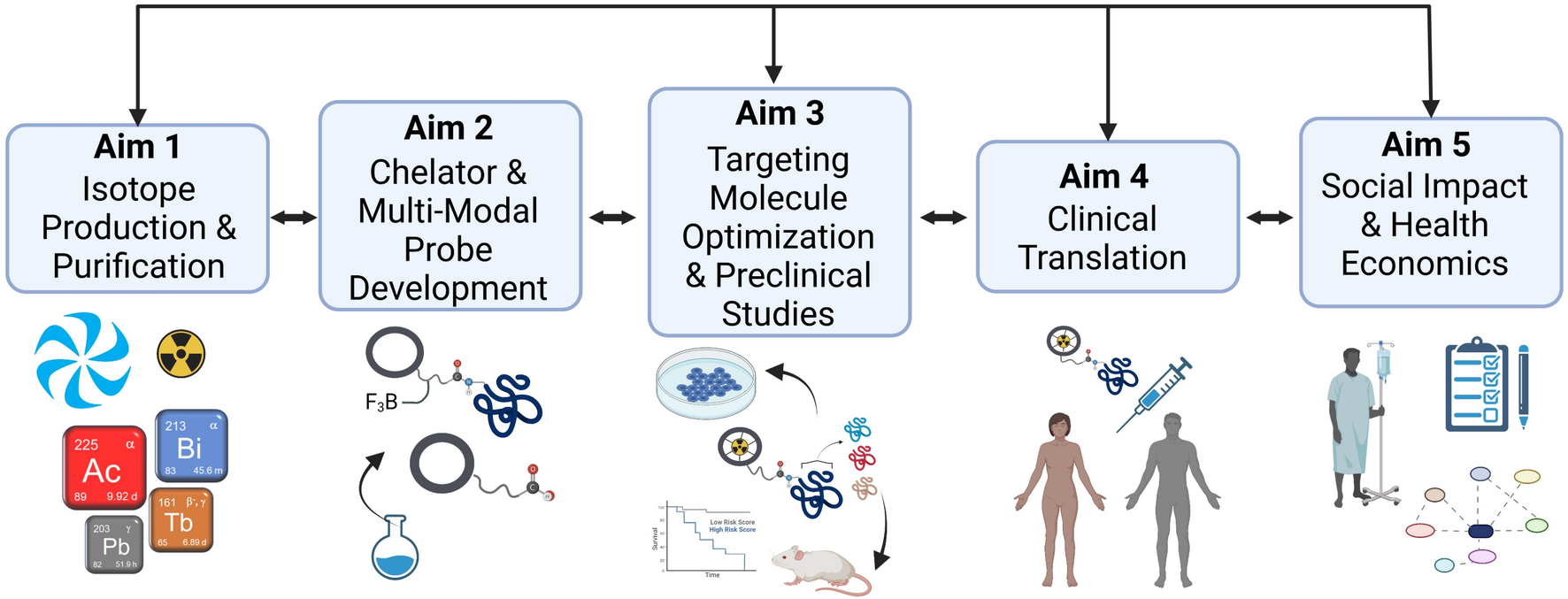
Looking Ahead: NFRF-Transformation

Rare Isotopes to Transform Cancer Therapy





- **Awarded:** $23.7 mil over 6 years
- Nominated PI: F. Bénard (UBC/BC Cancer); co-PI: Ramogida (SFU/TRIUMF)
- TRIUMF Team: Hoehr, Radchenko, Schaffer, Yang
- Utilizes 520 MeV, 24 MeV, 13 MeV cyclotrons to produce a portfolio of isotopes



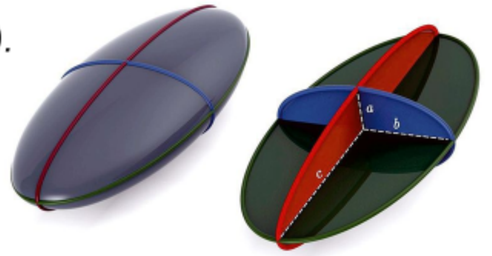
National partners:

UBC · BC Cancer · Western · TRIUMF · SFU · University of Alberta · Université de Sherbrooke · BC Children's Hospital · Université Laval · University of Toronto

Science & Technology – Nuclear Physics

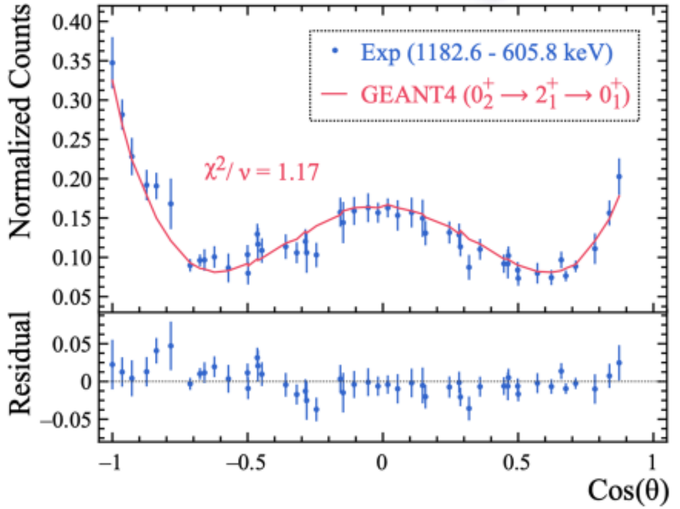
First Evidence of Axial Shape Asymmetry and Configuration Coexistence in ^{74}Zn: Suggestion for a Northern Extension of the N = 40 Island of Inversion

M. Rocchini, P.E. Garrett, M. Zielińska, S.M. Lenzi, D.D. Dao, F. Nowacki, et al., Phys. Rev. Lett. 130, 122502 (2023).

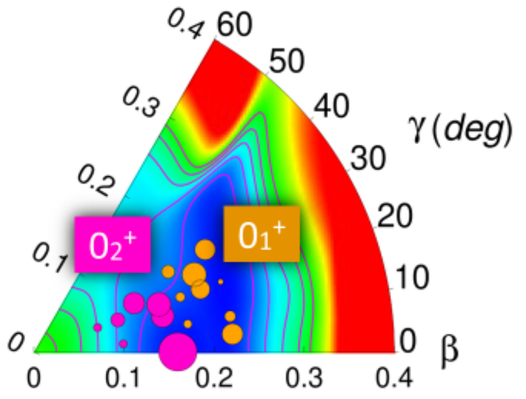


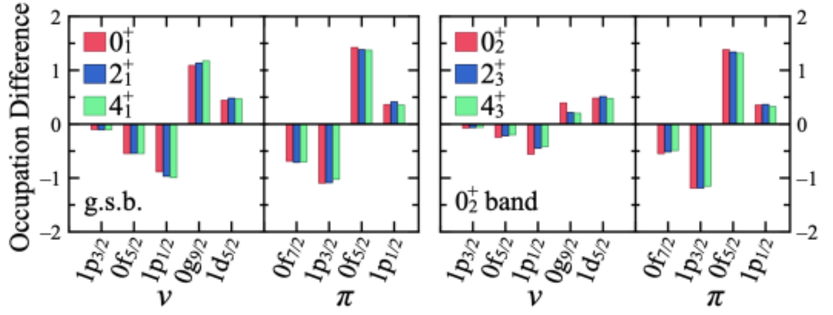
- ^{74}Zn investigated at GRIFFIN following ^{74}Cu β decay
- γ-γ angular correlation analysis ⟹ Firm spin assignments for 2_2^+, 3_1^+, 0_2^+, 2_3^+ states
- Two new transitions observed ⟹ $2_3^+ \longrightarrow 0_2^+$ and $2_3^+ \longrightarrow 4_1^+$
- From measured γ-ray branching and *E2/M1* mixing ratios for transitions de-exciting the 2_2^+, 3_1^+, 2_3^+ states ⟹ Relative B(*E2*) values
- A rotational-like structure appears at low energy in ^{74}Zn

A shore of the N = 40 "island of inversion" appears to manifest above Z = 26, previously thought as its northern limit in the chart of the nuclides



- New microscopic Large-Scale Shell-Model calculations
  - Shapes of individual states
  - Wave-function compositions
- The ground state is found to have enhanced
- axial shape asymmetry (triaxiality)
- Configuration-coexisting 0_2^+ state





Science & Technology – Nuclear Physics

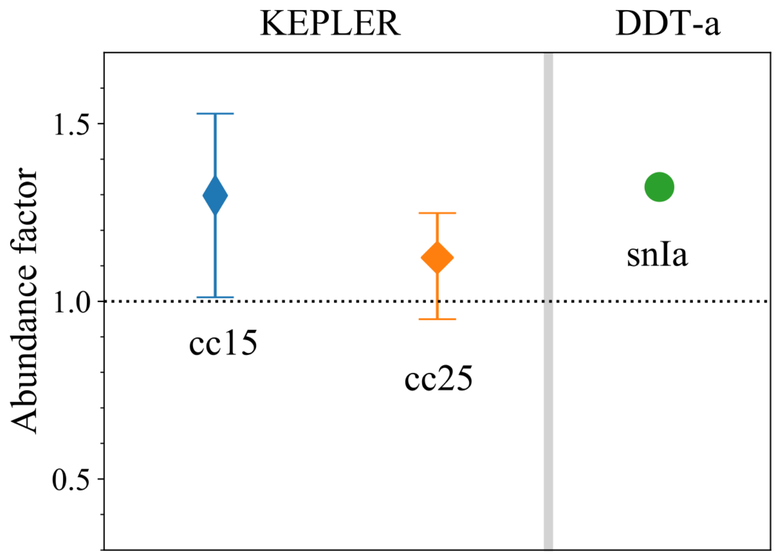
New EMMA-TIGRESS Paper

PHYSICAL REVIEW C **107**, 035803 (2023)

Cross sections of the ^{83}Rb$(p,\gamma)^{84}$Sr and ^{84}Kr$(p,\gamma)^{85}$Rb reactions at energies characteristic of the astrophysical γ process

M. Williams,[1,2] B. Davids,[1,3] G. Lotay,[4] N. Nishimura,[5,6] T. Rauscher,[7,8] S. A. Gillespie,[1,*] M. Alcorta,[1] A. M. Amthor,[9] G. C. Ball,[1] S. S. Bhattacharjee,[1] V. Bildstein,[10] W. N. Catford,[4] D. T. Doherty,[4] N. E. Esker,[1,†] A. B. Garnsworthy,[1] G. Hackman,[1] K. Hudson,[1,3] A. Lennarz,[1] C. Natzke,[1,11] B. Olaizola,[1,‡] A. Psaltis,[12,§] C. E. Svensson,[10] J. Williams,[1] D. Walter,[1,13] and D. Yates[1,14]

[1]*TRIUMF, Vancouver, British Columbia V6T 2A3, Canada*
[2]*Department of Physics, University of York, Heslington, York YO10 5DD, United Kingdom*
[3]*Department of Physics, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada*
[4]*Department of Physics, University of Surrey, Guildford GU2 7XH, United Kingdom*
[5]*Astrophysical Big Bang Laboratory, CPR, RIKEN, Wako, Saitama 351-0198, Japan*
[6]*Nishina Center for Accelerator-Based Science, Wako, Saitama 351-0198, Japan*
[7]*Department of Physics, University of Basel, Klingelbergstr. 82, CH-4056 Basel, Switzerland*
[8]*Centre for Astrophysics Research, University of Hertfordshire, Hatfield AL10 9AB, United Kingdom*
[9]*Department of Physics and Astronomy, Bucknell University, Lewisburg, Pennsylvania 17837, USA*
[10]*Department of Physics, University of Guelph, Guelph, Ontario N1G 2W1, Canada*
[11]*Department of Physics, Colorado School of Mines, Golden, Colorado 80401, USA*
[12]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4L8, Canada*
[13]*Department of Astronomy and Physics, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada*
[14]*Department of Physics and Astronomy, University of British Columbia, Vancouver BC V6T 1Z4, Canada*



Measurements of cross section of ^{83}Rb(p,γ)^{84}Sr reaction relevant to γ process nucleosynthesis in supernovae carried out with TIGRESS and EMMA in ISAC-II by a TRIUMF & University of Surrey (UK) collaboration; astrophysical modelling by Swiss and Japanese collaborators

The amount of ^{84}Sr produced in supernovae is enhanced in model calculations based on the EMMA-TIGRESS measurement by 12-32% for different models with respect to previous theoretical estimate; all experimental and theoretical uncertainties included in error bars

Models: core collapse supernovae of 15 and 25 solar masses (left) & double detonation of a Chandrasekhar-mass white dwarf (right)

Science & Technology – Nuclear Physics

New Doppler Shift Lifetimes Facility Paper

Physics Letters B 839 (2023) 137801

Contents lists available at ScienceDirect

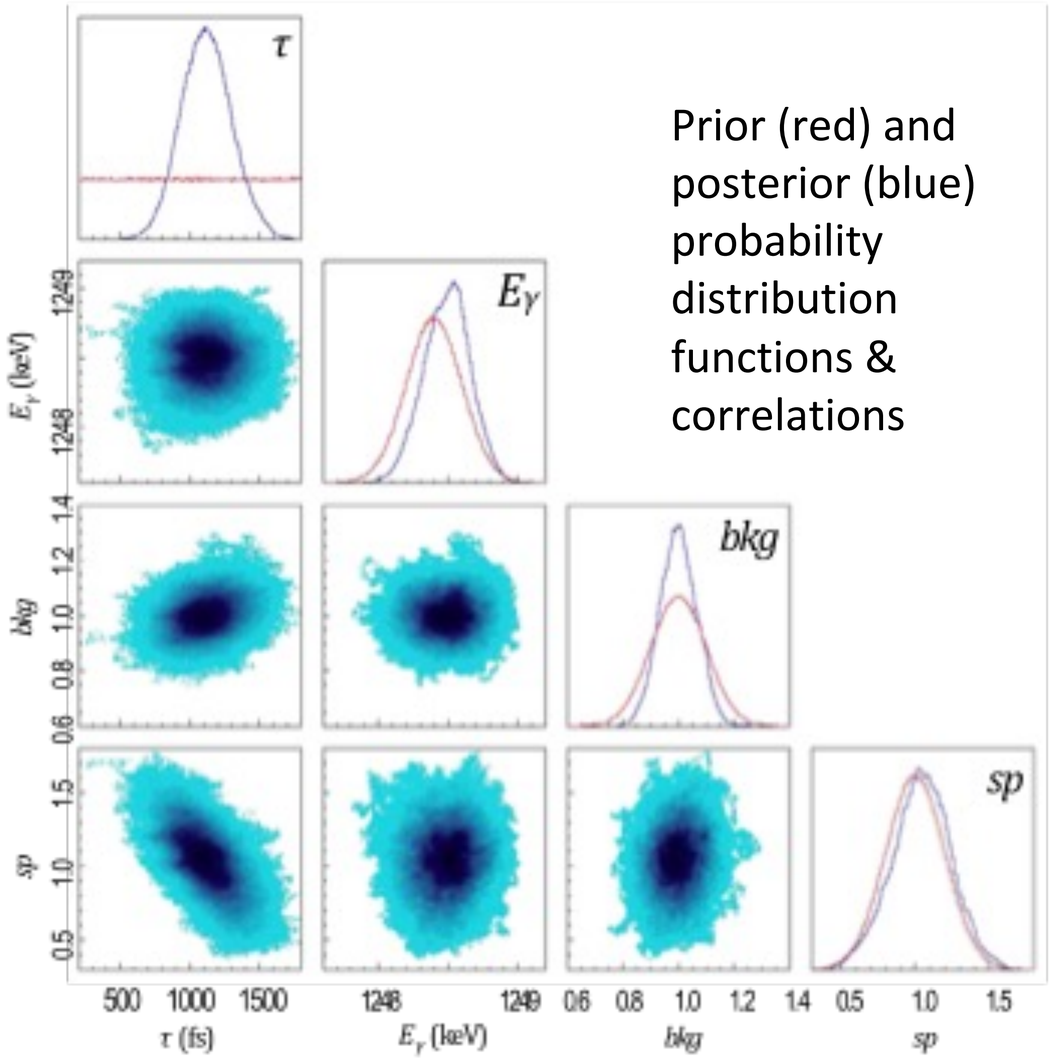
Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

First application of Markov chain Monte Carlo-based Bayesian data analysis to the Doppler-shift attenuation method

L.J. Sun [a,b,*,1], C. Fry [a,c,d,*,1], B. Davids [e,f,**], N. Esker [e,g], C. Wrede [c,a,***], M. Alcorta [e], S. Bhattacharjee [e], M. Bowry [e], B.A. Brown [a,c], T. Budner [a,c], R. Caballero-Folch [e], L. Evitts [e], M. Friedman [a,h], A.B. Garnsworthy [e], B.E. Glassman [a,c], G. Hackman [e], J. Henderson [e], O.S. Kirsebom [i], J. Lighthall [e], P. Machule [e], J. Measures [e], M. Moukaddam [e], J. Park [e,j], C. Pearson [e], D. Pérez-Loureiro [k,a], C. Ruiz [e], P. Ruotsalainen [e], J. Smallcombe [e], J.K. Smith [e], D. Southall [e], J. Surbrook [a,c], L.E. Weghorn [a,c], M. Williams [e,l]

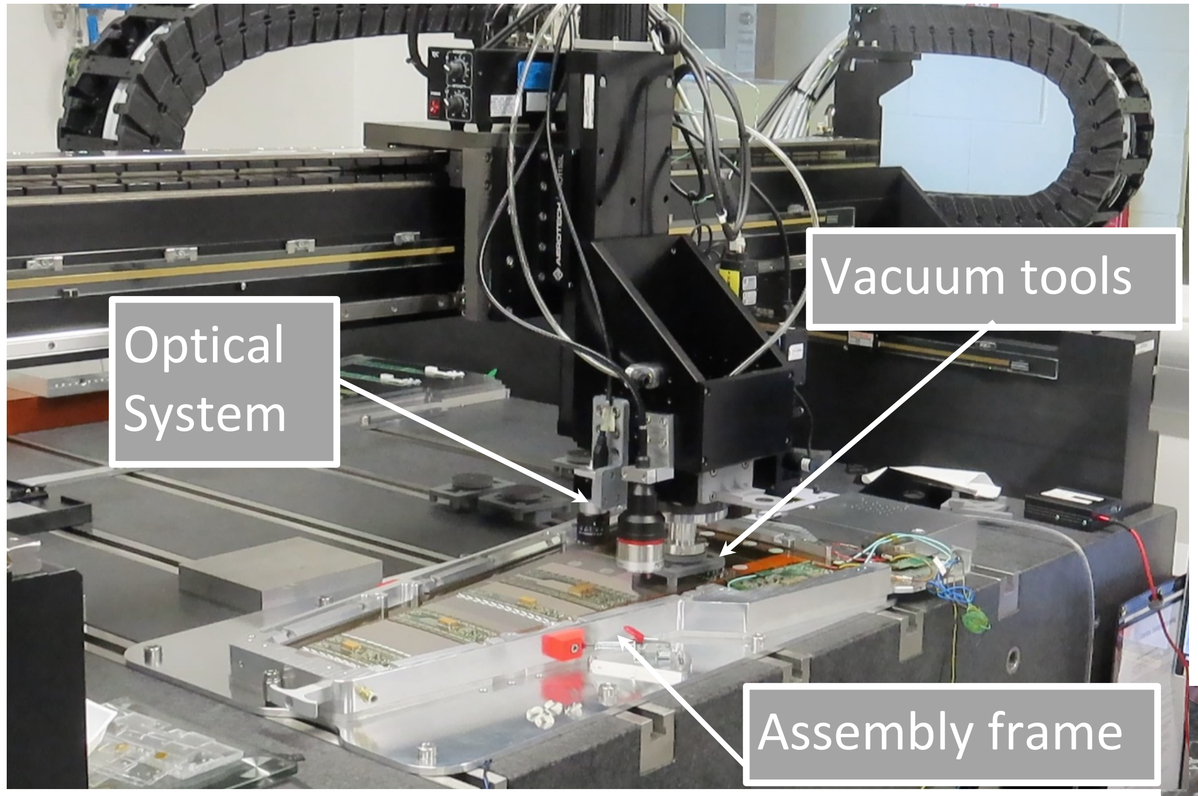
L.J. Sun, C. Fry, B. Davids et al.



Prior (red) and posterior (blue) probability distribution functions & correlations

- Measurements of lifetimes of excited nuclear states relevant to nuclear reaction rates in classical nova explosions carried out with GRIFFIN detectors at the DSL facility in ISAC-II by a TRIUMF & Michigan State University collaboration
- Modern Bayesian statistical analysis techniques applied to γ–ray lifetime data obtained via the Doppler shift attenuation method for the 1st time
- Enables reliable quantification of systematic uncertainties in multidimensional, correlated parameter space

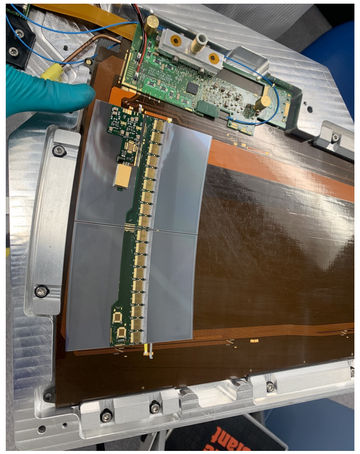
Science & Technology – Particle Physics



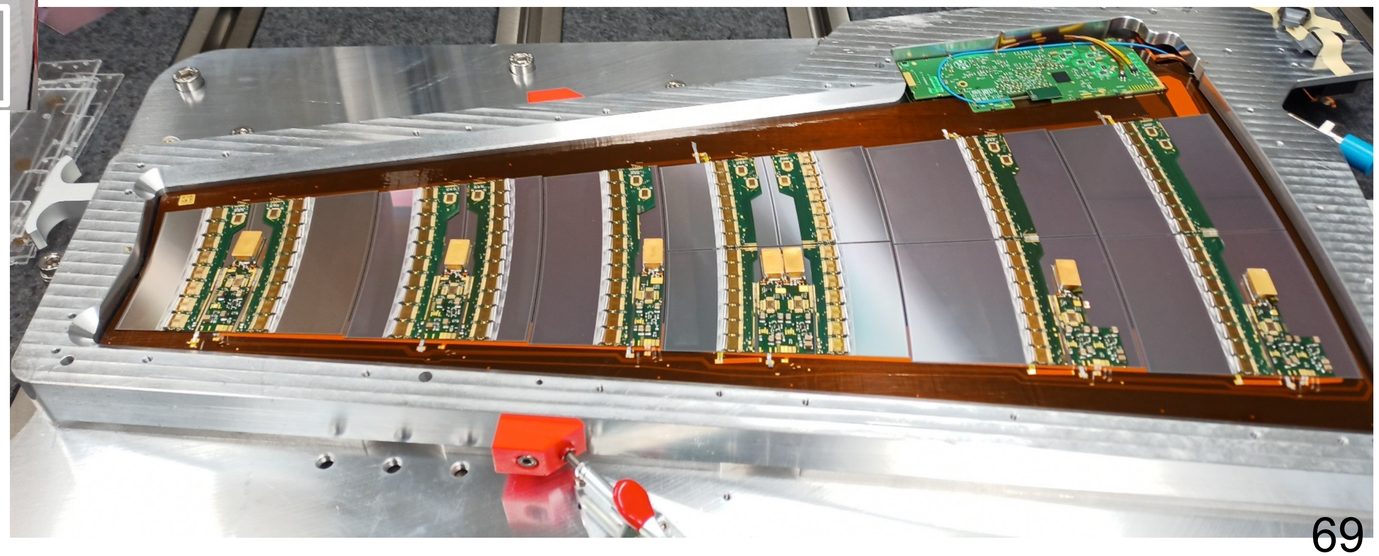
ATLAS-ITK

ITk Petal assembly milestone

- Assembly of three petals recently
- First Pre-Production A (PPA) petal in ATLAS
- Vancouver/Canada is first ITk EC site to qualify
  - Automated loading using robotic gantry
  - All placements within specification ±50μm
  - Exercised full Canadian production workflow
  - Assembly of first PPB petal in preparation



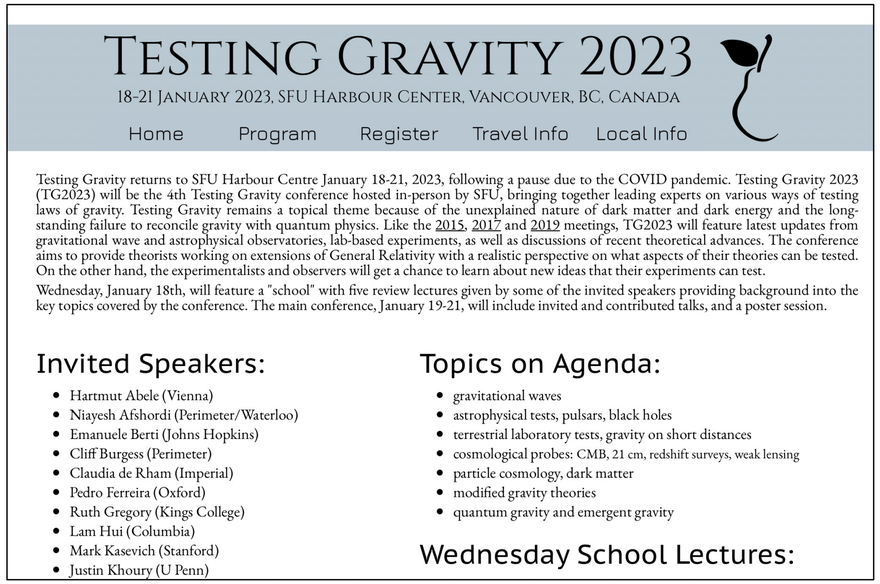
- Single module PPB petal assembled at special request
- Sent to DESY for system test Preparation and readout (FELIX) development at NIKHEF



Science & Technology – Particle Physics

ALPHA

- Helped organization of Testing Gravity Conference at SFU Downtown, Jan 18-21, 2023
- Collaboration meeting at U. Brescia, Italy, Feb 2-4
- Discussion with Frederic Sirois (Montreal) on HiTc superconducting magnet R&D for HAICU
- CERN new year reception, Jan 30
- Physics Colloquium at U Manitoba this week
- ALPHA-g first data being analyzed



TESTING GRAVITY 2023

18-21 JANUARY 2023, SFU HARBOUR CENTER, VANCOUVER, BC, CANADA

Home Program Register Travel Info Local Info

Testing Gravity returns to SFU Harbour Centre January 18-21, 2023, following a pause due to the COVID pandemic. Testing Gravity 2023 (TG2023) will be the 4th Testing Gravity conference hosted in-person by SFU, bringing together leading experts on various ways of testing laws of gravity. Testing Gravity remains a topical theme because of the unexplained nature of dark matter and dark energy and the long-standing failure to reconcile gravity with quantum physics. Like the 2015, 2017 and 2019 meetings, TG2023 will feature latest updates from gravitational wave and astrophysical observatories, lab-based experiments, as well as discussions of recent theoretical advances. The conference aims to provide theorists working on extensions of General Relativity with a realistic perspective on what aspects of their theories can be tested. On the other hand, the experimentalists and observers will get a chance to learn about new ideas that their experiments can test.

Wednesday, January 18th, will feature a "school" with five review lectures given by some of the invited speakers providing background into the key topics covered by the conference. The main conference, January 19-21, will include invited and contributed talks, and a poster session.

Invited Speakers:

- Hartmut Abele (Vienna)
- Niayesh Afshordi (Perimeter/Waterloo)
- Emanuele Berti (Johns Hopkins)
- Cliff Burgess (Perimeter)
- Claudia de Rham (Imperial)
- Pedro Ferreira (Oxford)
- Ruth Gregory (Kings College)
- Lam Hui (Columbia)
- Mark Kasevich (Stanford)
- Justin Khoury (U Penn)

Topics on Agenda:

- gravitational waves
- astrophysical tests, pulsars, black holes
- terrestrial laboratory tests, gravity on short distances
- cosmological probes: CMB, 21 cm, redshift surveys, weak lensing
- particle cosmology, dark matter
- modified gravity theories
- quantum gravity and emergent gravity

Wednesday School Lectures:

CERN new year reception

ALPHA collab meeting in Brescia U.

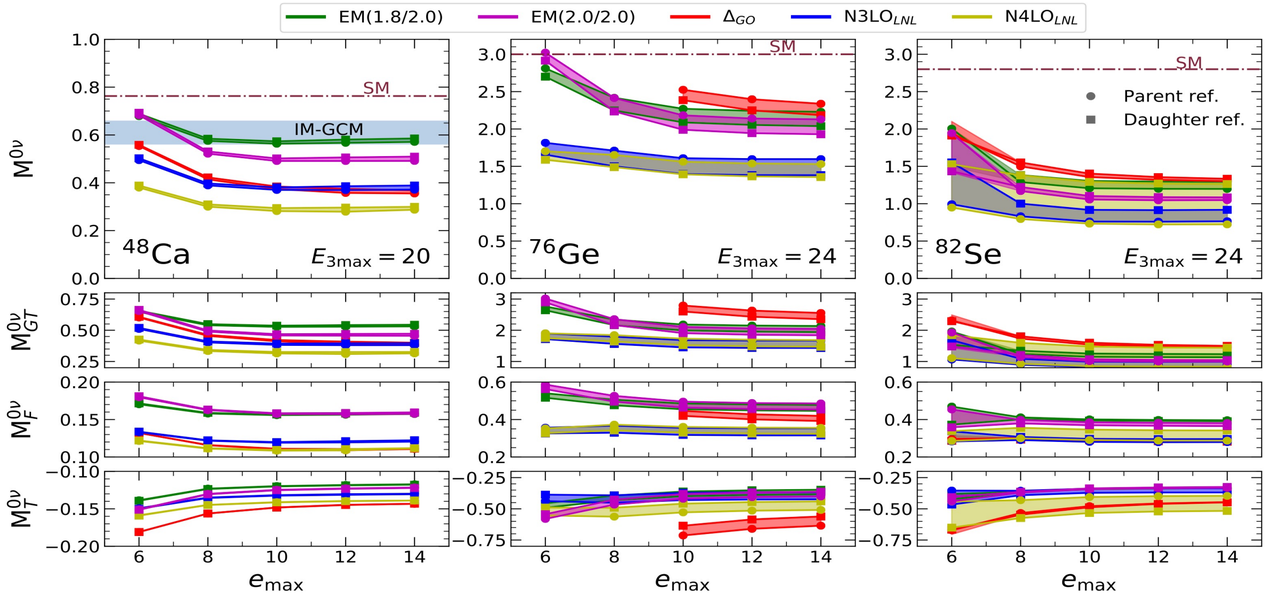
Science & Technology – Theory

Neutrinoless double beta decay & muon capture on nuclei – theory insights

Nuclear theory needed to extract the neutrino mass from the neutrinoless double beta decay half-life measurements

Ab Initio 0νββ Decay: ^{48}Ca, ^{76}Ge and ^{82}Se

Results with 5 different input hamiltonians to study uncertainty from interaction choice.



New calculations of $0\nu\beta\beta$ matrix elements improving on 2021 PRL

PHYSICAL REVIEW LETTERS **126,** 042502 (2021)

***Ab Initio* Neutrinoless Double-Beta Decay Matrix Elements for ^{48}Ca, ^{76}Ge, and ^{82}Se**

A. Belley,[1,2,3] C. G. Payne,[1,3,†] S. R. Stroberg,[4] T. Miyagi,[1] and J. D. Holt[1,2,*]

Physics Letters B 838 (2023) 137689

Contents lists available at ScienceDirect

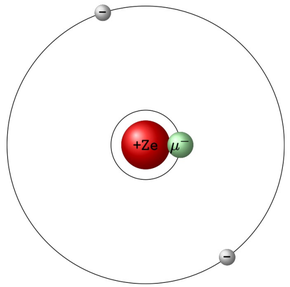
Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

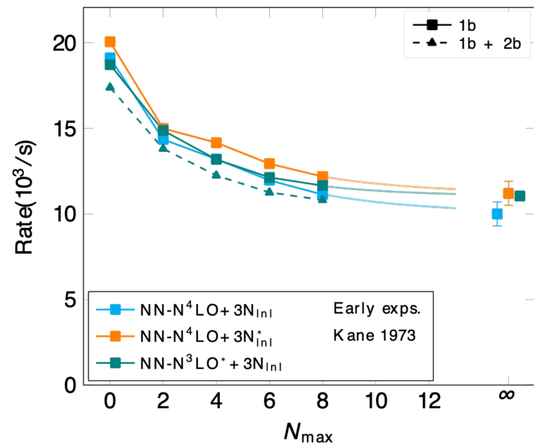
Two-neutrino $\beta\beta$ decay of ^{136}Xe to the first excited 0^+ state in ^{136}Ba

L. Jokiniemi[a,*], B. Romeo[b], C. Brase[c,d,e], J. Kotila[f,g,h], P. Soriano[i,j], A. Schwenk[c,d,e], J. Menéndez[i,j]

μ capture calculations validate $0\nu\beta\beta$ predications - related physics



$^{16}O(0^+_{gs}) + \mu^- \rightarrow {}^{16}N(2^-_{gs}) + \nu_\mu$



Published (^{24}Mg) and ongoing (^{16}O) *ab initio* calculations

PHYSICAL REVIEW C **107,** 014327 (2023)

***Ab initio* calculation of muon capture on ^{24}Mg**

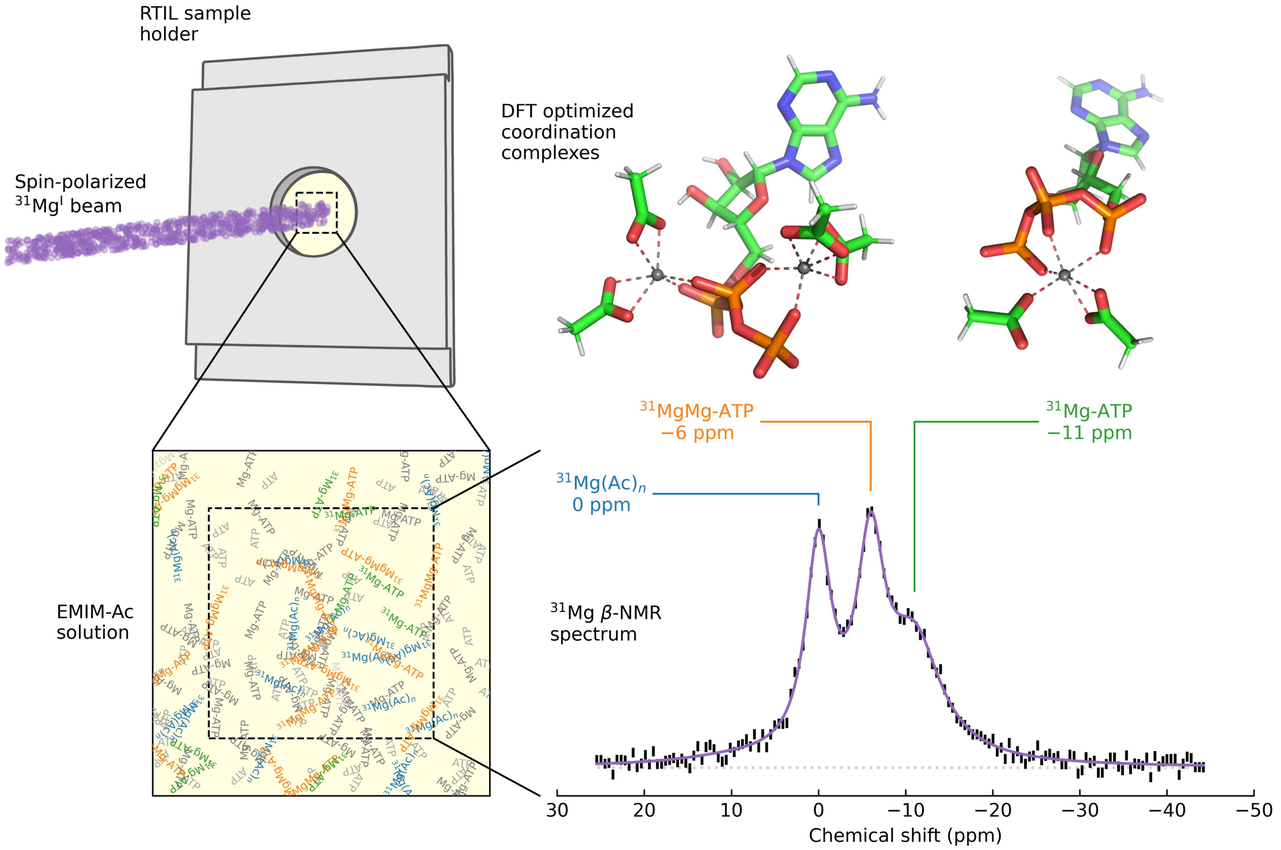
L. Jokiniemi,[1,2,3] T. Miyagi,[3,4,5] S. R. Stroberg,[6,7] J. D. Holt,[3,8] J. Kotila,[9,10,11] and J. Suhonen[11]

Science & Technology – Materials Science

R. M. L. McFadden, D. Szunyogh, N. Bravo-Frank, A. Chatzichristos, M. H. Dehn, D. Fujimoto, A. Jancsó, S. Johannsen, I. Kálomista, V. L. Karner, R. F. Kiefl, F. H. Larsen, J. Lassen, C. D. P. Levy, R. Li, I. McKenzie, H. McPhee, G. D. Morris, M. R. Pearson, S. P. A. Sauer, R. K. O. Sigel, P. W. Thulstrup, W. A. MacFarlane, L. Hemmingsen, and M. Stachura

Angewandte International Edition Chemie

Magnesium(II)-ATP Complexes in 1-Ethyl-3-Methylimidazolium Acetate Solutions Characterized by ^{31}Mg β-Radiation-Detected NMR Spectroscopy

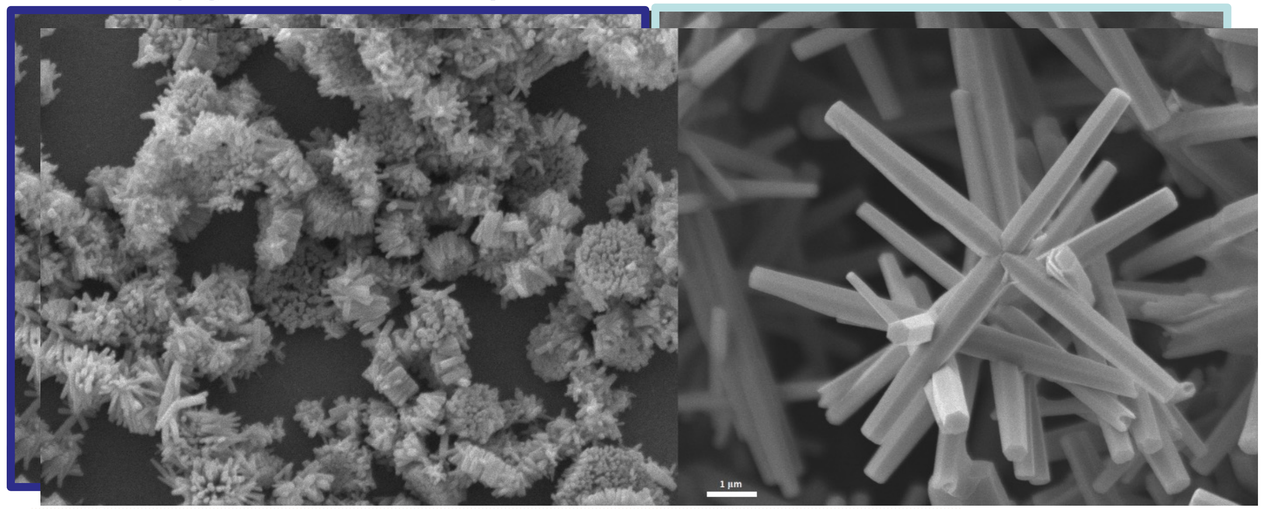


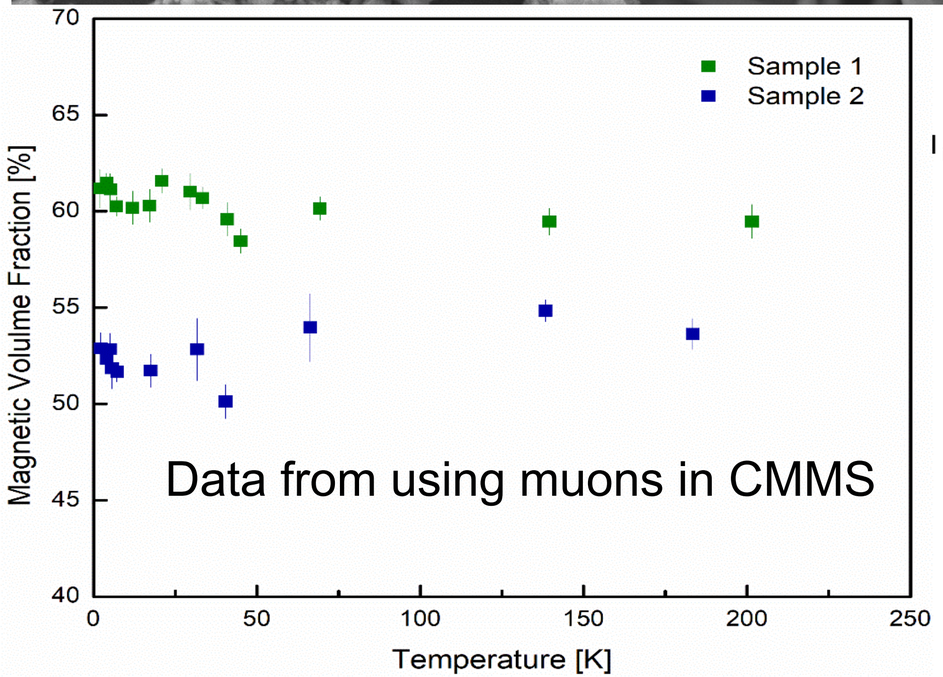
- This highlight showcases a novel use of β-NMR spectroscopy to study coordination chemistry in solution.
- The resonance of the spin-1/2 β-emitter ^{31}Mg reveals distinct Mg^{2+} binding modes with the biomolecule adenosine triphosphate (ATP).
- The measured chemical shifts are in good agreement with quantum chemical calculations, confirming their assignment.
- This work constitutes an important advancement towards the application of β-NMR spectroscopy in *biochemistry*.

Science & Technology – Materials Science

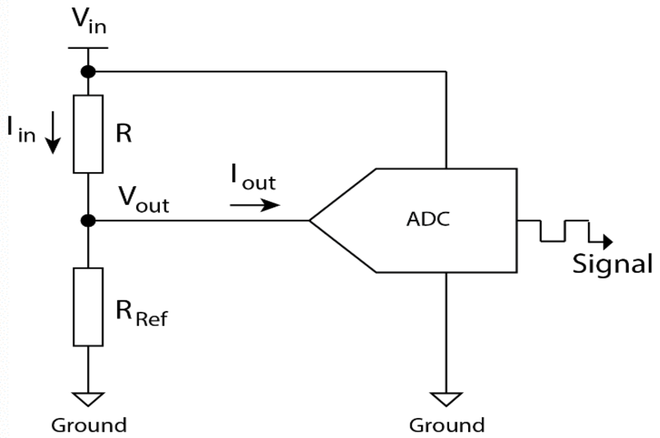
(-g**k** N, -850 G**)**

(-g**k** N, 0 G)





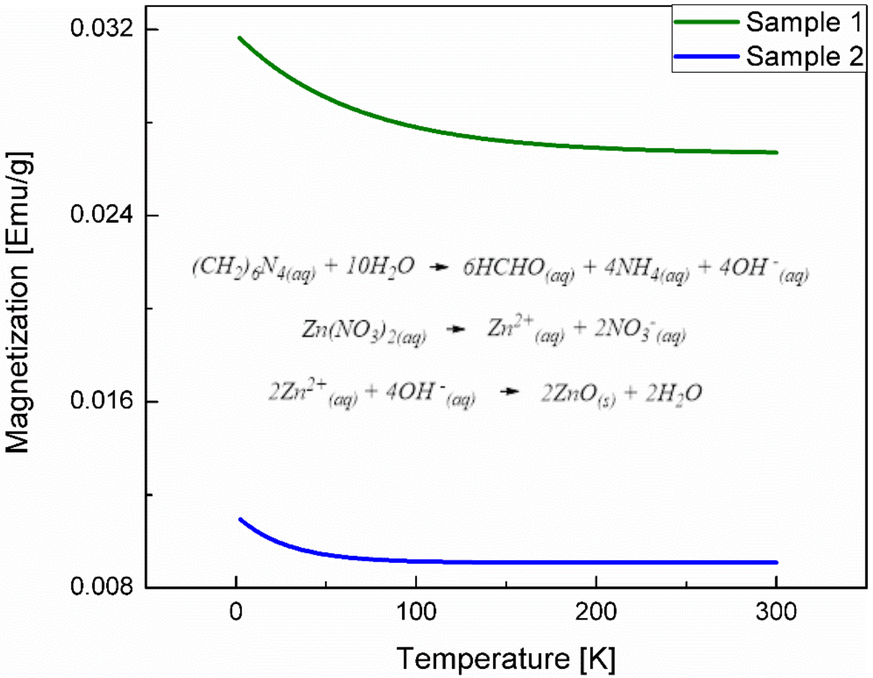
Data from using muons in CMMS



Apply these materials in biosensing

C. Landry; *et al*. *Nanomaterials* **2022**, *12*, 184. https://doi.org/10.3390/nano12020184

Basic science at CMMS/TRIUMF nourished nanomaterial innovations



Most important result:
CMMS data when used along with lots of other characterization techniques helped us to solve the puzzle of why with magnetic field and gravity, we could change the magnetic properties of an otherwise inherently diamagnetic material. This resulted in developing biosensors for different pathogens based on the control of magnetic properties.