TRIUMF

Update on TRIUMF

Nigel Smith,
Executive Director & CEO

CINP-IPP Joint Session
2023-06-22

TRIUMF Governance Updates

- The amalgamation of TRIUMF Accelerators Inc and TRIUMF INC occurred as planned on July 1st, 2022. This allows TRIUMF INC to assume all liabilities of TAI which was created to hold our CNSC license
- The Joint Venture between the universities, which was the previous ownership and operations model, is in the process of being wound down.
- TRIUMF has increased it member count to 21 Members. The seven new universities that have joined were former Associate Members of the Joint Venture and all have joined the new structure, agreeing to take on liability for TRIUMF
    - A call for additional new members (which now includes technical universities) has also launched, and at least 3 additional institutions have expressed interest

Discovery, accelerated.

Our multidisciplinary community uses TRIUMF's world-class accelerator infrastructure to drive leading-edge research that delivers impact in **science, medicine, and industry, positioning Canada as a world leader.**

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

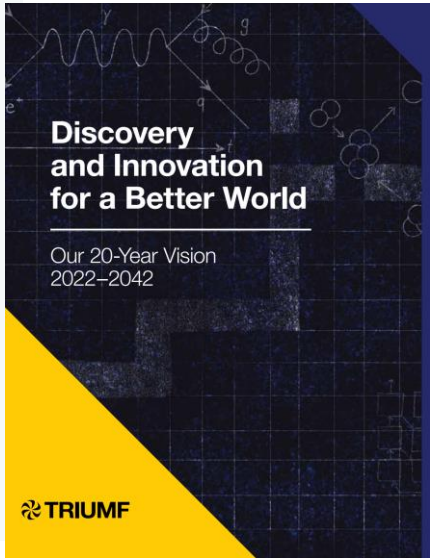
Catalyzing the success and growth of Canada's network of major research facilities

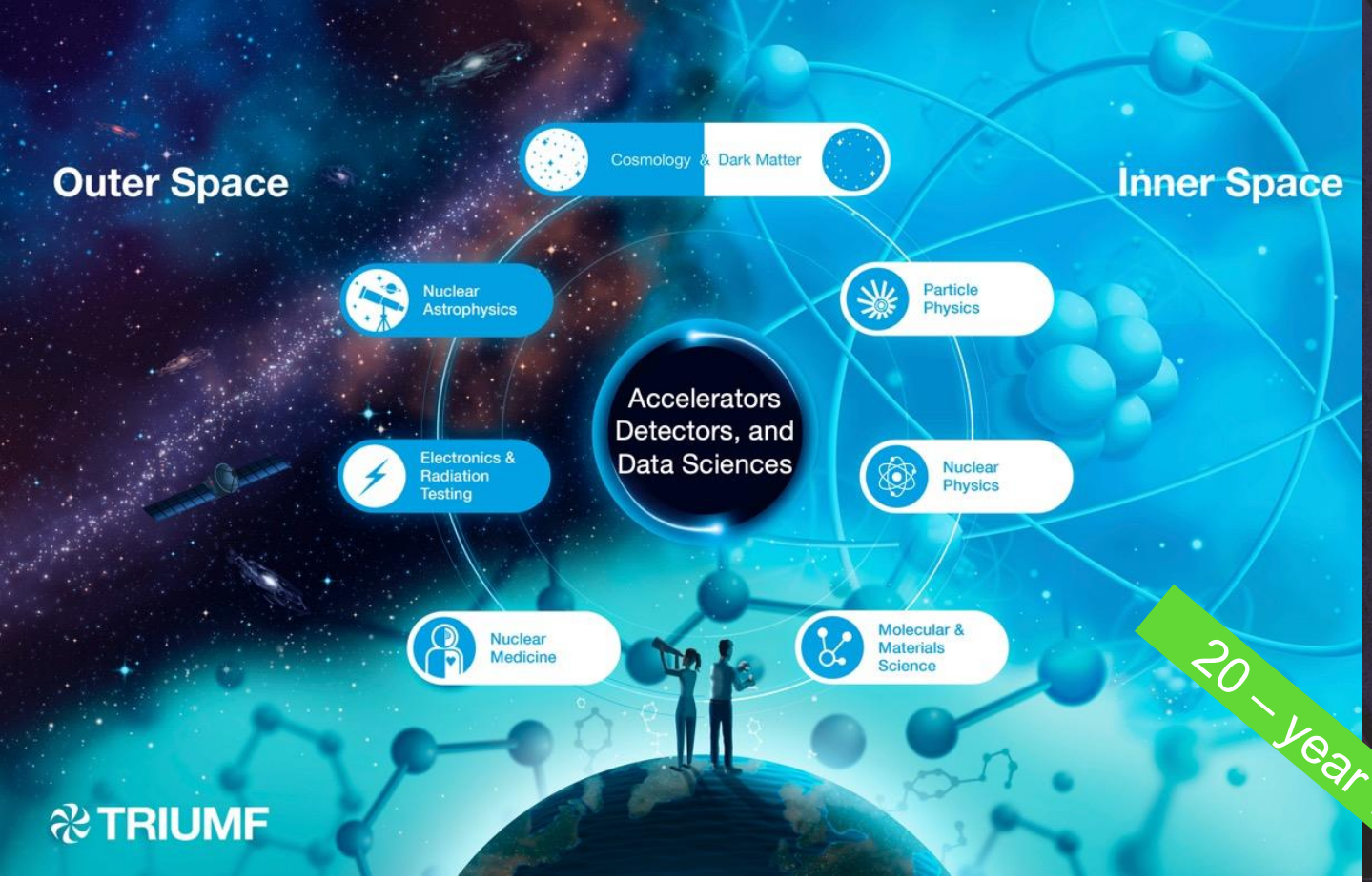
A national innovation hub translating discovery science into health and sustainability solutions

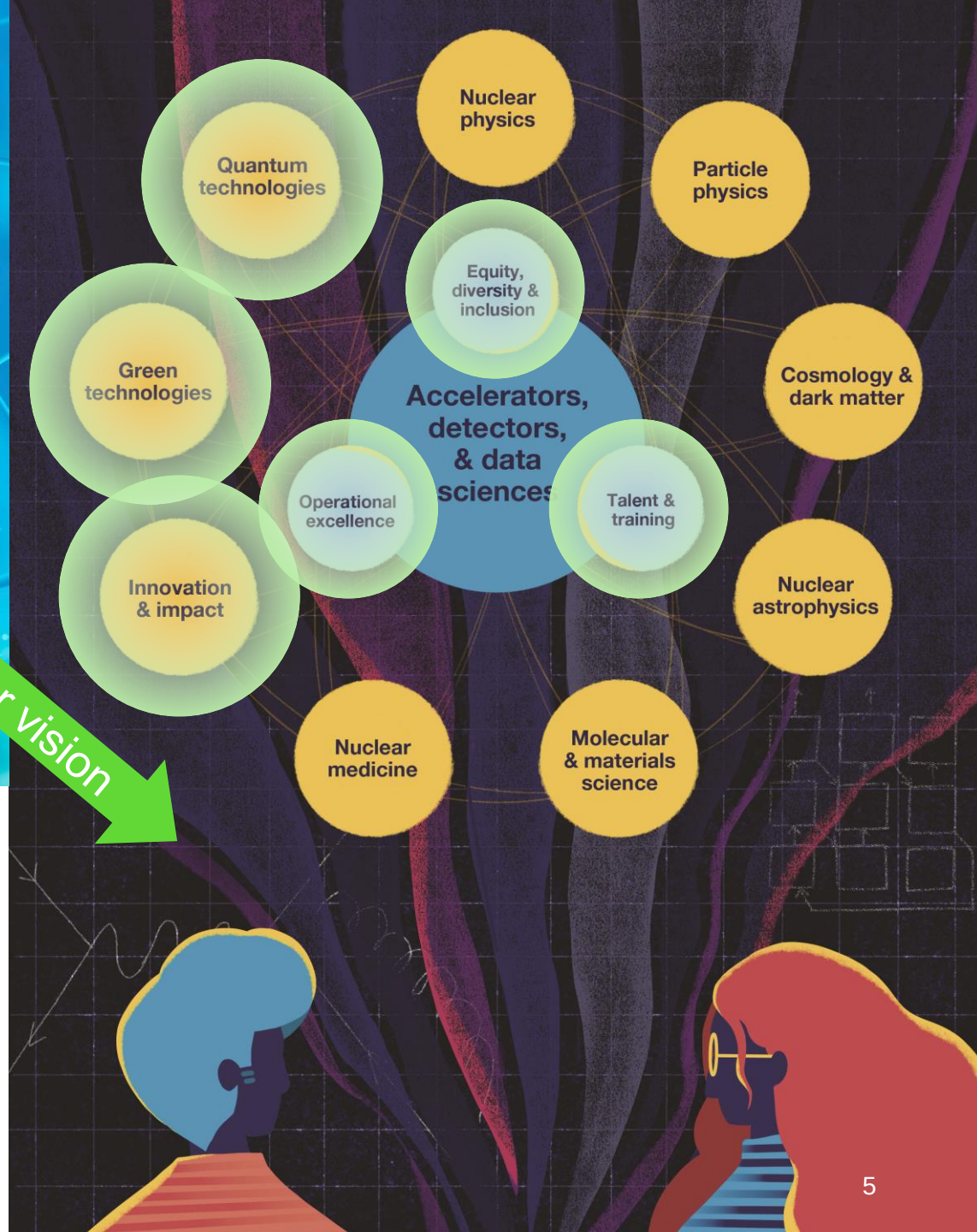
Responding nimbly to complex societal challenges for the benefit of Canadians

20-year vision for TRIUMF completed

- TRIUMF has now completed the 20-year vision process to define longer term planning requirements (TRIUMF is funded in five-year cycles)
- 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

5-Year Plan Proposal

- Using work completed on the 20-year vision (20YV) – and the sub-atomic community long range plan – as input to the proposal development, along with input from Divisions

- Various funding scenarios now being constructed, priorities as defined in 20YV, to highlight the science, innovation and infrastructure developments possible over the 5-year period

- Timeline for proposal development:
  - Feb - April: Divisional input to proposal, initial costing and scenario planning (underway)
  - June: ACOT discussion and input on concepts / draft proposal
  - June: Science Council / Board meeting discussion and input
  - Late July / Early August: Science week discussion and community input
  - July / August: Science Council input
  - September: TRIUMF Board and AGM, approval of final proposal
  - October: Agency Committee on TRIUMF approval to take forwards to Finance
  - Fall / Winter: Socialization with government, MPs, universities (high level visits already underway)
  - Post-Budget: Development of funded implementation plan with community (i.e., five-year strategic plan)

Scale of Operations

HIGHLY QUALIFIED PERSONNEL

~ 600 staff[1]

> 200 students & postdoctoral researchers[2]

1000+ scientist & researcher visits per year

KNOWLEDGE

~80% of Canada's subatomic physics research involves TRIUMF

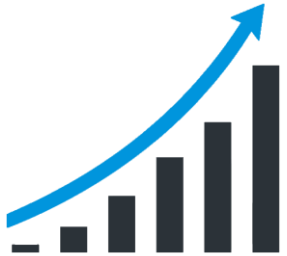
INTERNATIONAL ENGAGEMENT

75 international agreements & partnerships

Visitors from over 40 countries

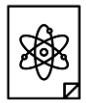
BUSINESS

Generated nearly $500M in economic activity from 2018 – 2022



1 – Total across funding sources
2 – Includes external students and post-docs

2020-25 NRC KPIs

Target	2020/21	2021/22	2022/23	2023/24	2024/25
 published scientific papers: 285 (CY) Source: Marcello	317	285	247	PENDING	PENDING
 highly qualified personnel trained: 156 (FY) Source: Marcello	223	301	275	PENDING	PENDING
 Canadian scientists & students using TRIUMF: 206 (CY) Source: Marcello	127	90	330	PENDING	PENDING
 Canadian scientists & students participating in research abroad through TRIUMF: 195 (CY) Source: Marcello / Directors	224	224	243	PENDING	PENDING
 international visiting scientists & students: 392 (CY) Source: Marcello	48	97	294	PENDING	PENDING
 informal science experiences to the public: 15,000 (FY) Source: Stu	8,375	10,327	10,780*	PENDING	PENDING
 commercial revenues: $3.0M (FY) (net) Source: Finance	$5.4M ($3.3M net)	$7.6M ($5.1M net)	$8.5M ($4.6M net)	PENDING	PENDING

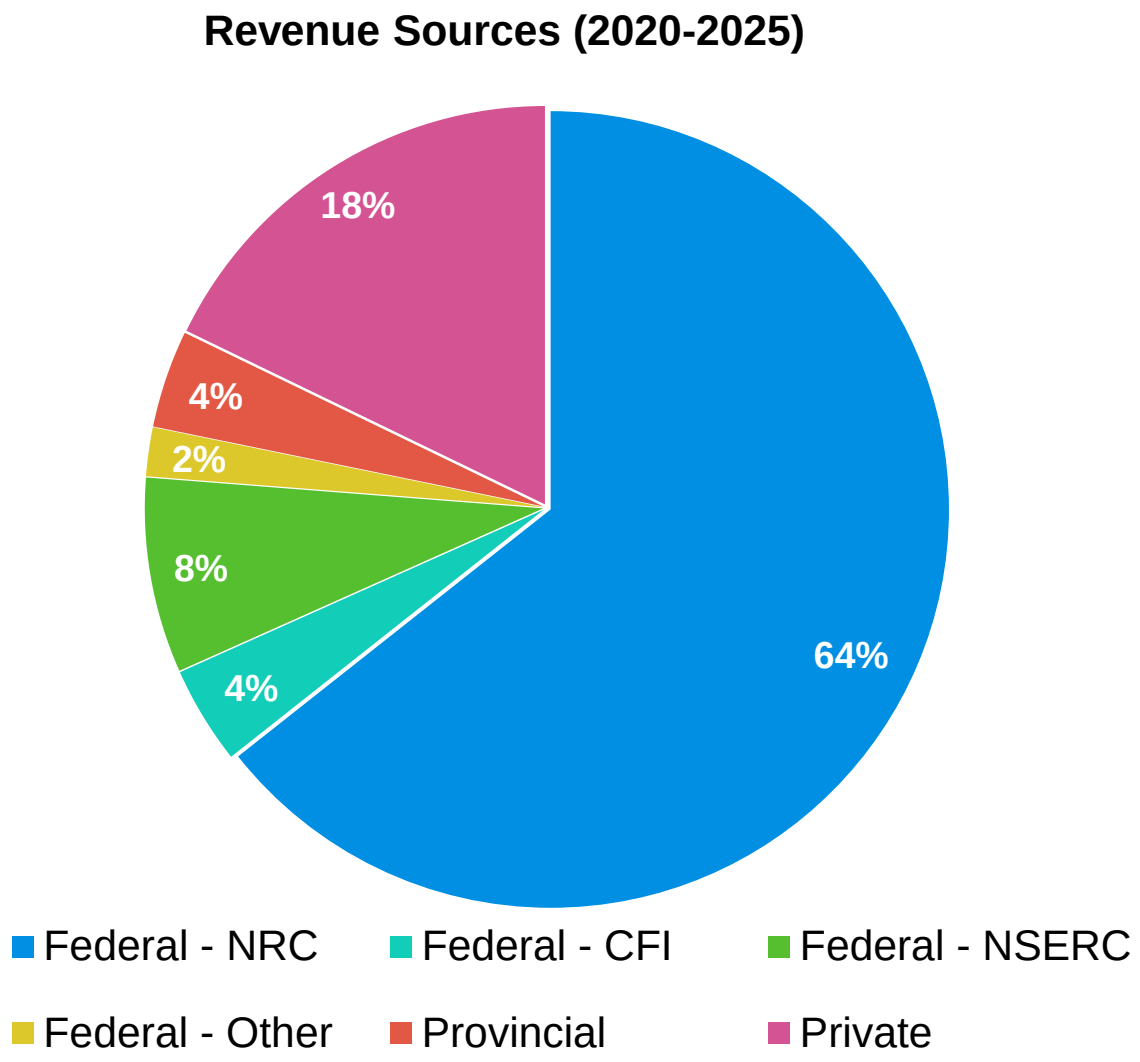
**This includes views from TRIUMF's YouTube channel but not views from TRIUMF-supported influencers and visitor videos which totaled over 2.1M in FY22/23*

Funding

Core operating funding for TRIUMF is allocated via the federal budget for five-year periods; $292.7M was provided for 2020-25 via Budget 2019 and this contribution is managed through the NRC.

TRIUMF expects to advance its next funding request to the federal government (in support of 5-Year Plan 2025 – 2030) as part of the 2024 budget cycle.

Overall, TRIUMF is home to over $1B in investment and scientific infrastructure



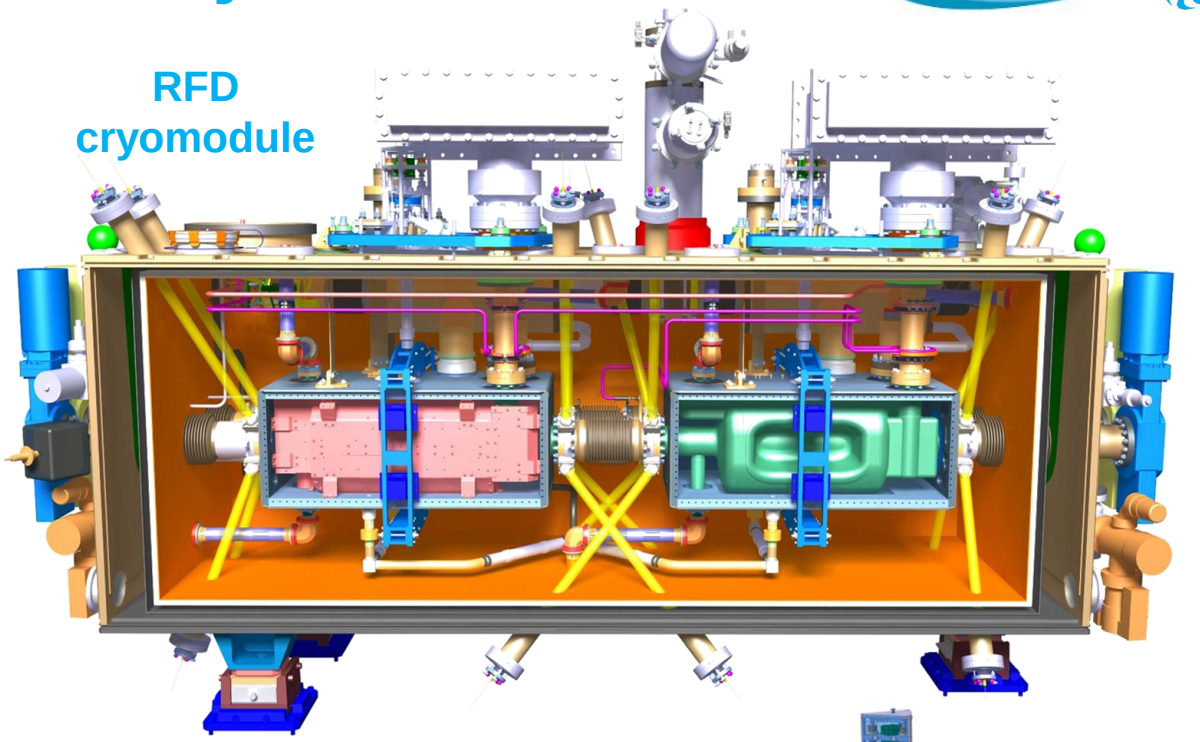
Science & Technology – High-Luminosity-LHC

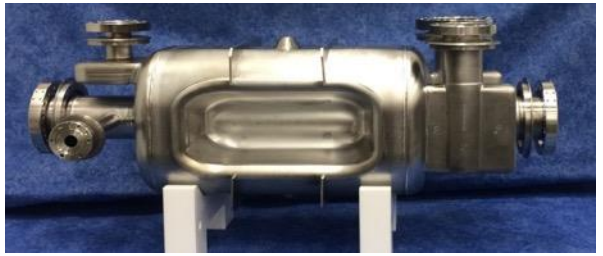
- CERN will install a crab cavity cryomodule upstream and downstream of each interaction region, ATLAS and CMS, in each ring
- The crab cavities give transverse skewing of the bunches to increase the luminosity
- TRIUMF is producing five cryomodules housing two crab cavities per cryomodule as a Canadian contribution to the Hi-Lumi project

Science & Technology – High-Luminosity-LHC

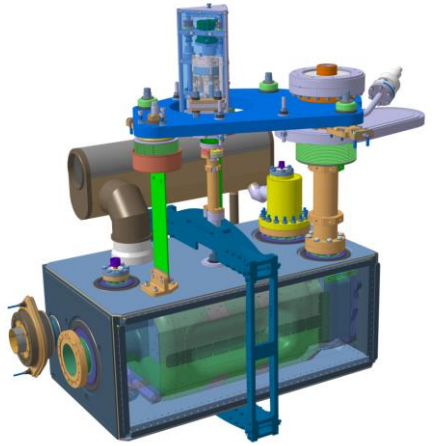
- TRIUMF to receive and qualify 10 RF Dipole (RFD) cavities from USA
- TRIUMF to assemble and qualify 5 cryomodules as an in-kind contribution to CERN
- TRIUMF has initiated procurements for the prototype cryomodule (TCM0) and to receive first cavities in late 2023
- Series production CMs will follow in 2024-2025

RFD cryomodule





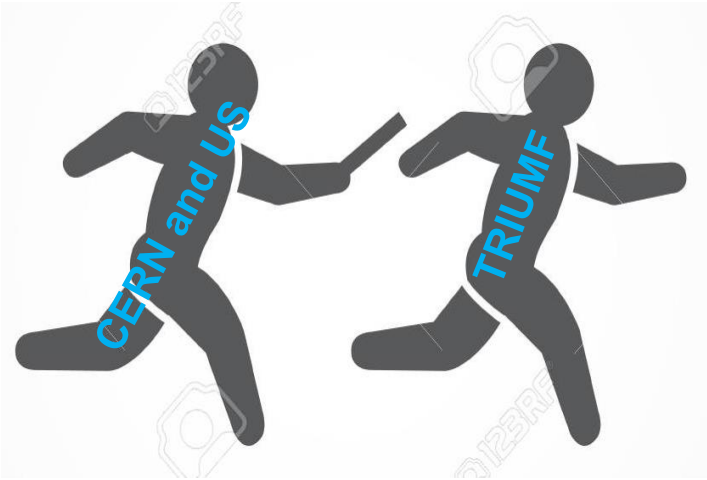
RFD Crab Cavity



Fully Dressed cavity system

Science & Technology – High-Luminosity-LHC

- The funding for the deliverables was written into the present NRC contribution agreement spanning from April 2020 to March 2025
- Due to COVID, design completion at CERN, cavity delivery from the US and project end dates have slipped by two years
- TRIUMF is still waiting final sign off from CERN for major cryomodule design packages
- The first cavity for TCM0 from the US is not expected until late this year
- As such spending on key components is delayed with respect to original estimates
- TRIUMF's challenge will be to procure all components before the end of the present FYP



Science & Technology – ARIEL

ARIEL Status and Project Highlights

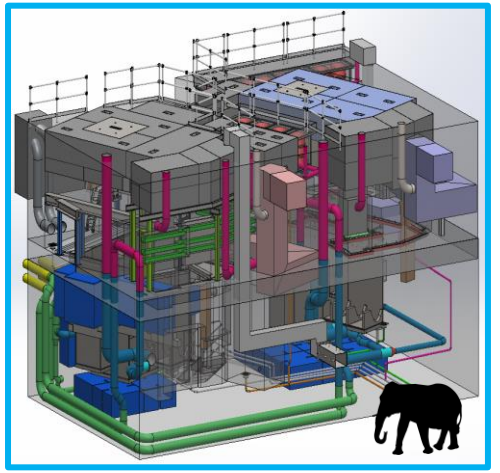
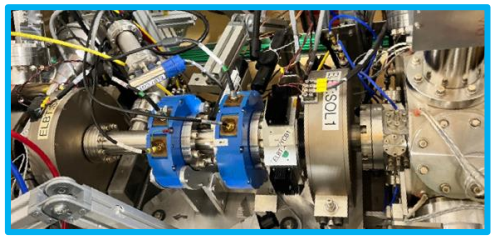
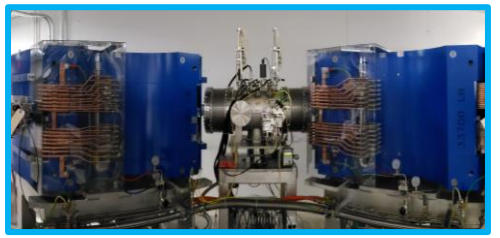
Recent Achievements:

- Targetry and RIB systems protype testing completed
- Hot cell completed.
- Proton and electron beam production proven
- Target station shielding construction:
  - Levels 1-7 completed (most complex)
  - Levels 8-9 design completed
  - Levels 10-11 design progressing (simple)
- CANREB EBIS HV improvements successful
  HRS commissioning on track to reach design performance.
- Full cost and schedule evaluation completed. Project is now funded and resourced until completion within the next 5YP

Planned Dates:

- 2023: CANREB back in user operation
- 2026: first beam from AETE
- 2027: first beam from APTW
- 2028: first therapeutic isotopes from ARIEL

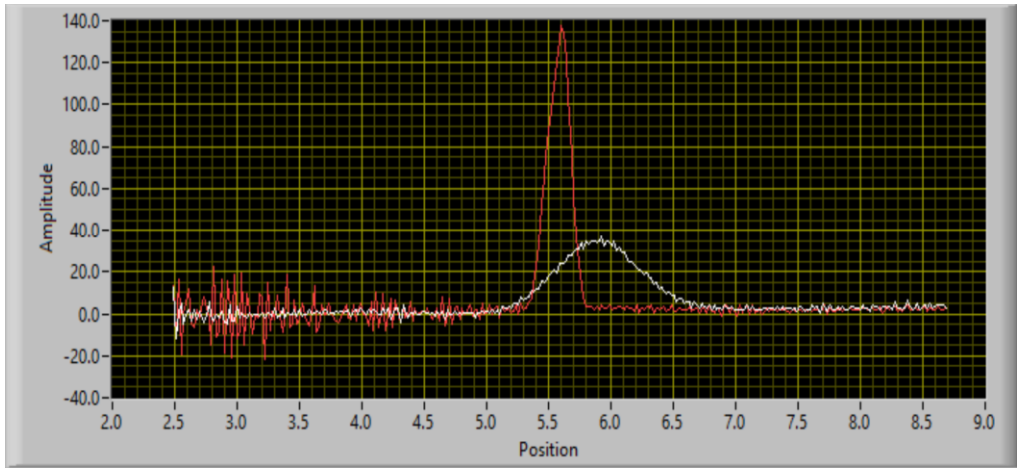


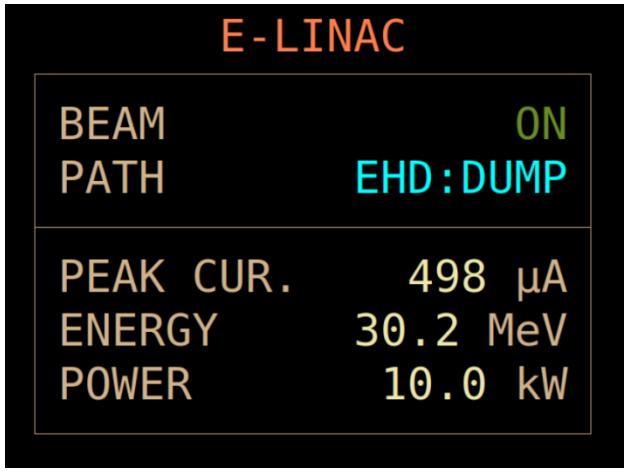





Science & Technology – ARIEL

Hot cell and driver accelerators

- The ARIEL Hot cell is largest single capital investment for the project. Hot cell installation completed 2022.
- ARIEL primary beam drivers – SC e-linac and the 520 MeV cyclotron:
  - Cyclotron has again 4 beam extraction ports. Proton beam extracted successfully into BL4N vault section
  - 30 MeV, 10 kW electron beam delivered to beam dump with increase reliability and better beam quality.
    → reliability road map action plan execution

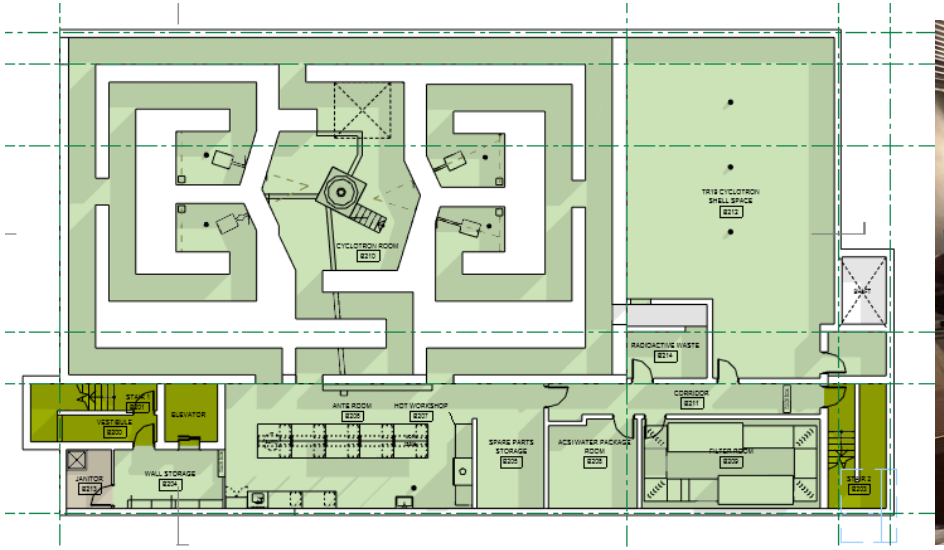




Profile of beam extracted into the vault section of BL4N

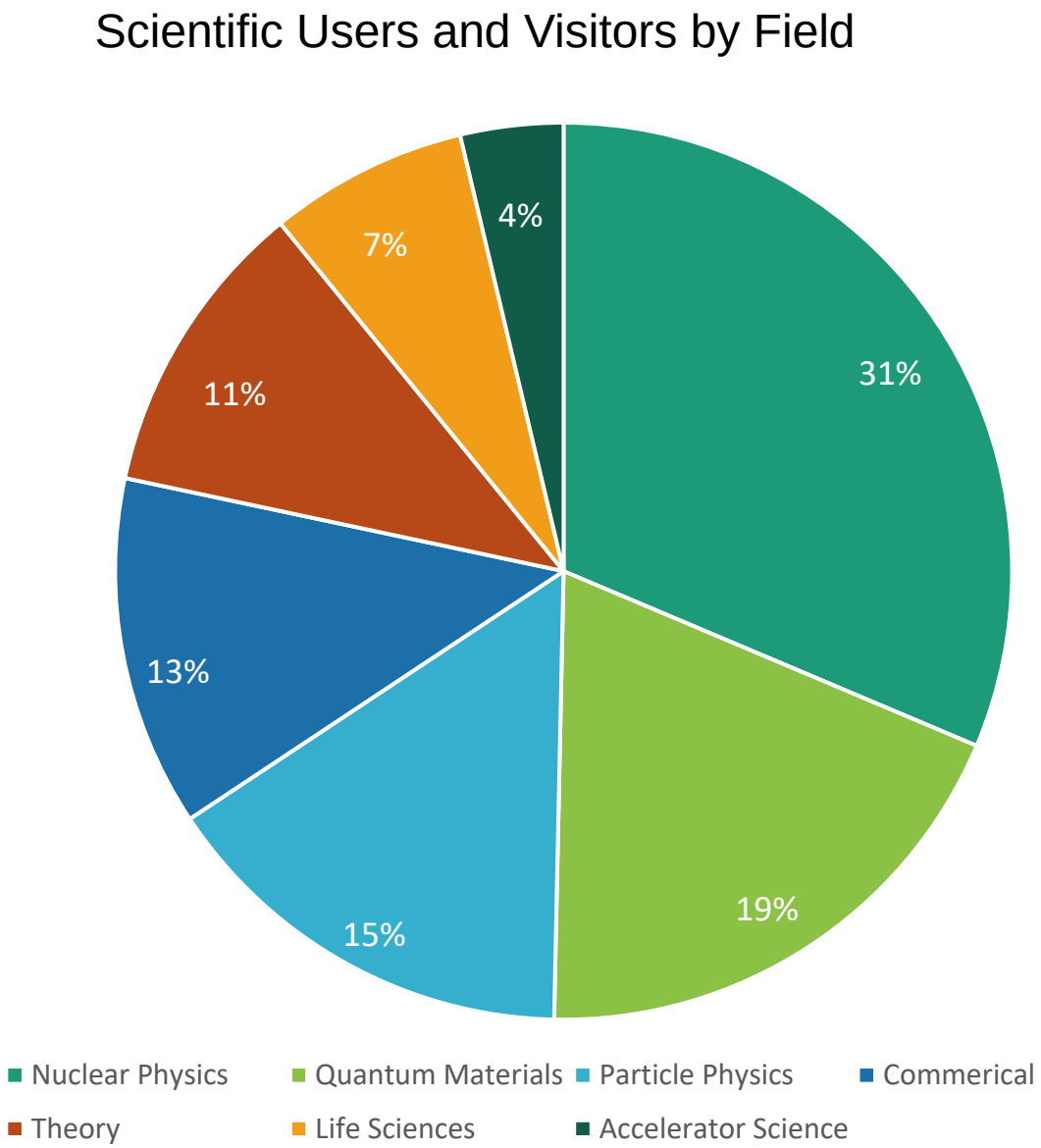
TRIUMF's Accelerators

- **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



Multidisciplinary

In 2019*, TRIUMF welcomed 1186 scientific users and visitors to the site



* As the last full year before the outbreak of the COVID-19 pandemic, these values are most representative of TRIUMF's community

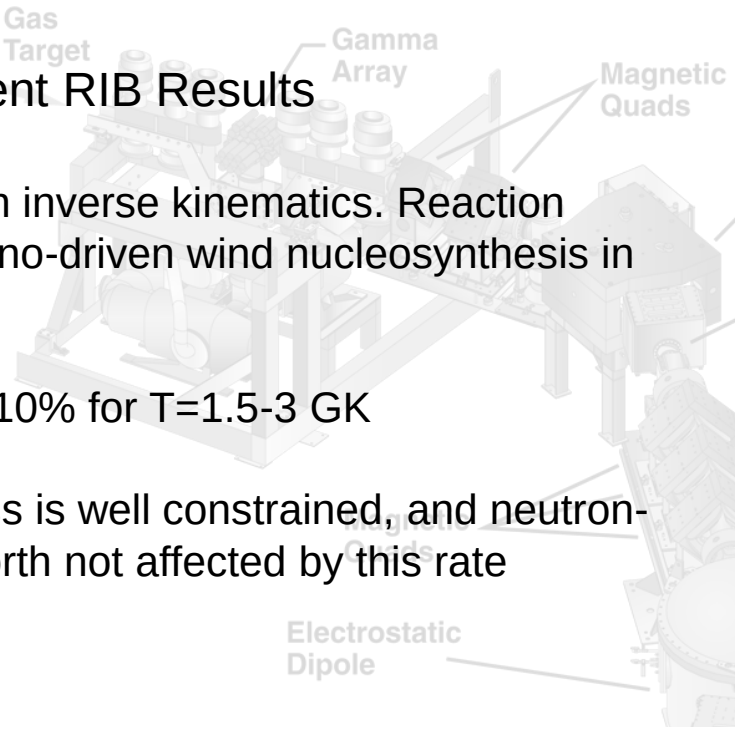
Science Highlights: Nuclear Astrophysics

DRAGON Direct Measurement RIB Results

First measurement of ^{7}Be(α,γ) in inverse kinematics. Reaction affects nucleosynthesis in neutrino-driven wind nucleosynthesis in core-collapse supernovae.

Uncertainty now constrained to 10% for T=1.5-3 GK

→ Nucleosynthesis in νp-process is well constrained, and neutron-deficient heavy p-nuclei henceforth not affected by this rate



PHYSICAL REVIEW LETTERS

Highlights Recent Accepted Collections Authors Referees Search Press About Editorial Team

Accepted Paper

Direct measurement of resonances in ^{7}Be(α,γ)^{11}C relevant to νp-process nucleosynthesis

Phys. Rev. Lett.

A. Psaltis, A. A. Chen, R. Longland, D. S. Connolly, C. R. Brune, B. Davids, J. Fallis, R. Giri, U. Greife, D. A. Hutcheon, L. Kroll, A. Lennarz, J. Liang, M. Lovely, M. Luo, C. Marshall, S. N. Paneru, A. Parikh, C. Ruiz, A. C. Shotter, and M. Williams

Accepted 24 August 2022

PHYSICAL REVIEW C

covering nuclear physics

Highlights Recent Accepted Collections Authors Referees Search Press About Editorial Team

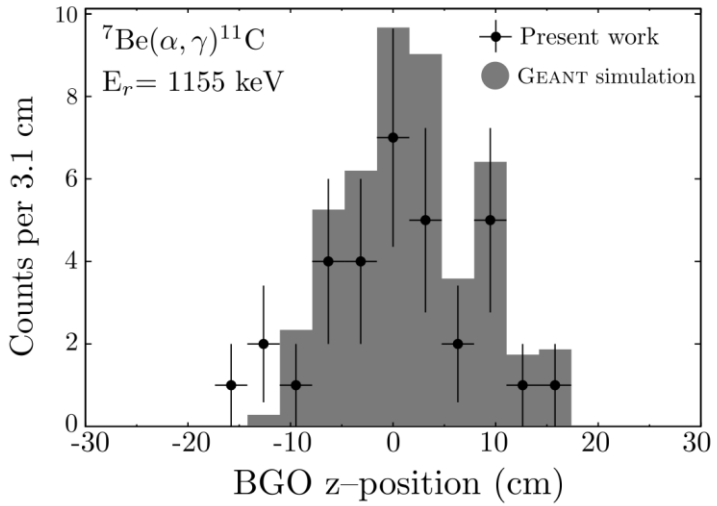
Accepted Paper

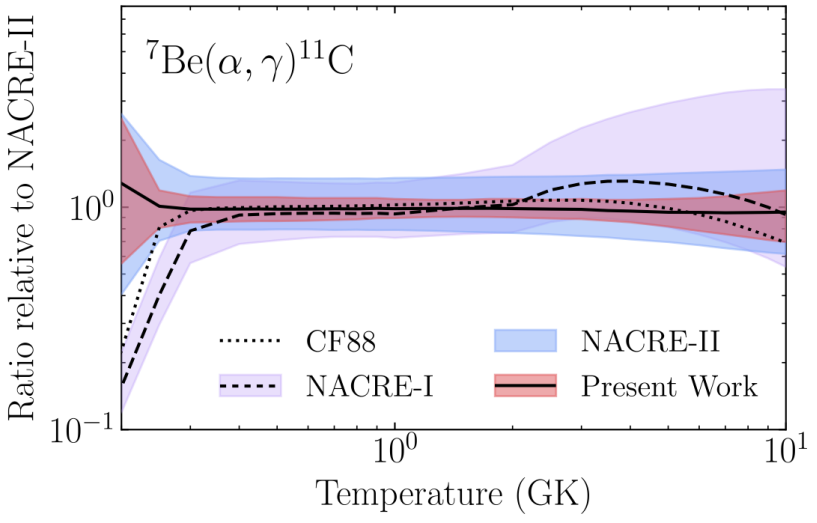
First inverse kinematics measurement of resonances in ^{7}Be(α,γ)^{11}C relevant to neutrino-driven wind nucleosynthesis using DRAGON

Phys. Rev. C

A. Psaltis, A. A. Chen, R. Longland, D. S. Connolly, C. R. Brune, B. Davids, J. Fallis, R. Giri, U. Greife, D. A. Hutcheon, L. Kroll, A. Lennarz, J. Liang, M. Lovely, M. Luo, C. Marshall, S. N. Paneru, A. Parikh, C. Ruiz, A. C. Shotter, and M. Williams

Accepted 12 September 2022





18 publications by DRAGON/TUDA group 2018-2022

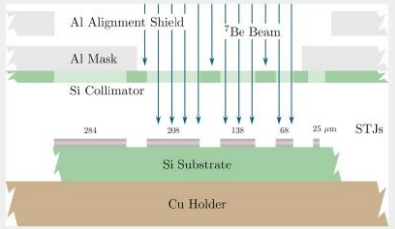
Multiple data sets under analysis & 2+ planned RIB experiments for 2023

Beryllium Electron capture in SC Tunnel junctions

A search for keV – MeV scale sterile neutrinos using ^{7}Be decay in superconducting Tunnel Junction quantum sensors

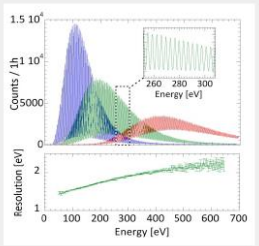
- Highlight publications in Physical Review Letters

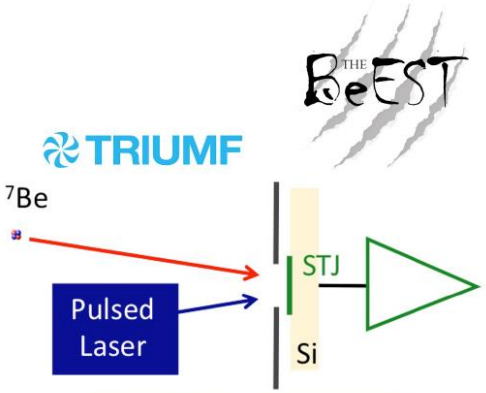
Implanted ^{7}Be Sample



Simultaneous Laser Calibration

Provides energy calibration to <0.01 eV



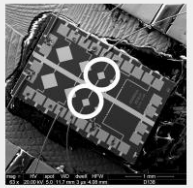


Lawrence Livermore National Laboratory

Ta-Based STJ Detectors

"Test" chips with 10 pixels of 5 sizes

Phase-I



Phase-II

Cooled to 100 mK in an adiabatic demagnetization refrigerator (ADR)

PHYSICAL REVIEW LETTERS **125,** 032701 (2020)

Direct Measurement of the ^{7}Be L/K Capture Ratio in Ta-Based Superconducting Tunnel Junctions

S. Fretwell,[1] K. G. Leach,[1,*] C. Bray,[1] G. B. Kim,[2] J. Dilling,[3] A. Lennarz,[3] X. Mougeot,[4] F. Ponce,[5,2] C. Ruiz,[3] J. Stackhouse,[1] and S. Friedrich[2]

PHYSICAL REVIEW LETTERS **126,** 021803 (2021)

Limits on the Existence of sub-MeV Sterile Neutrinos from the Decay of ^{7}Be in Superconducting Quantum Sensors

S. Friedrich,[1,*] G. B. Kim,[1] C. Bray,[2] R. Cantor,[3] J. Dilling,[4] S. Fretwell,[2] J. A. Hall,[3] A. Lennarz,[4,5] V. Lordi,[1] P. Machule,[4] D. McKeen,[4] X. Mougeot,[6] F. Ponce,[7,1] C. Ruiz,[4] A. Samanta,[1] W. K. Warburton,[8] and K. G. Leach[2,†]

- Capitalizing on ISAC beam and set-up to execute proof-of-principle and science experiments: BeEST collaboration formed.
- Novel technologies developed for quantum sensors together with partners

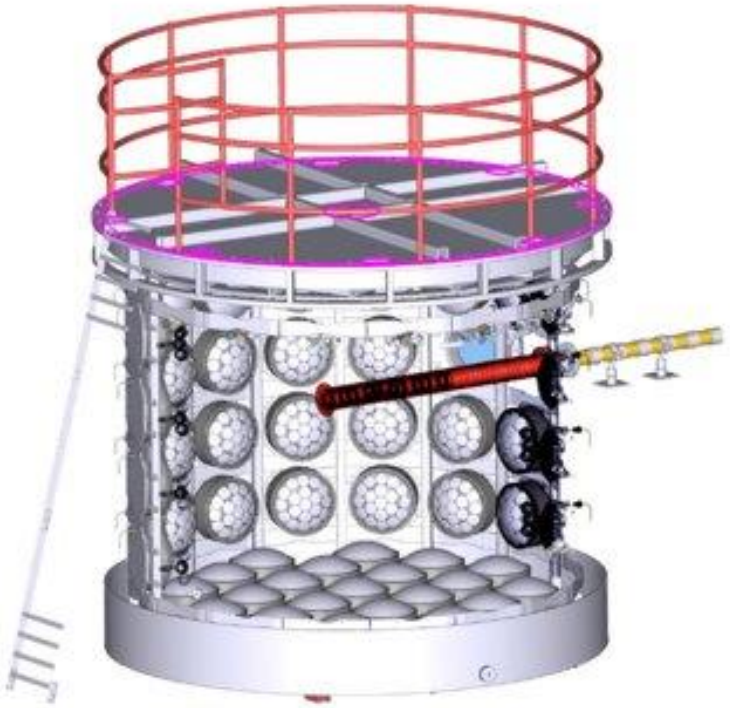
Particle Physics Highlights

Hyper-K

Development and testing of prototypes for multi-PMT proceeding well

TRIUMF led formation of WatChMaL machine learning effort for water Cherenkov detectors

Water Cherenkov Test Experiment (WCTE) approved by CERN Research Board, expected operation in 2024



ALPHA

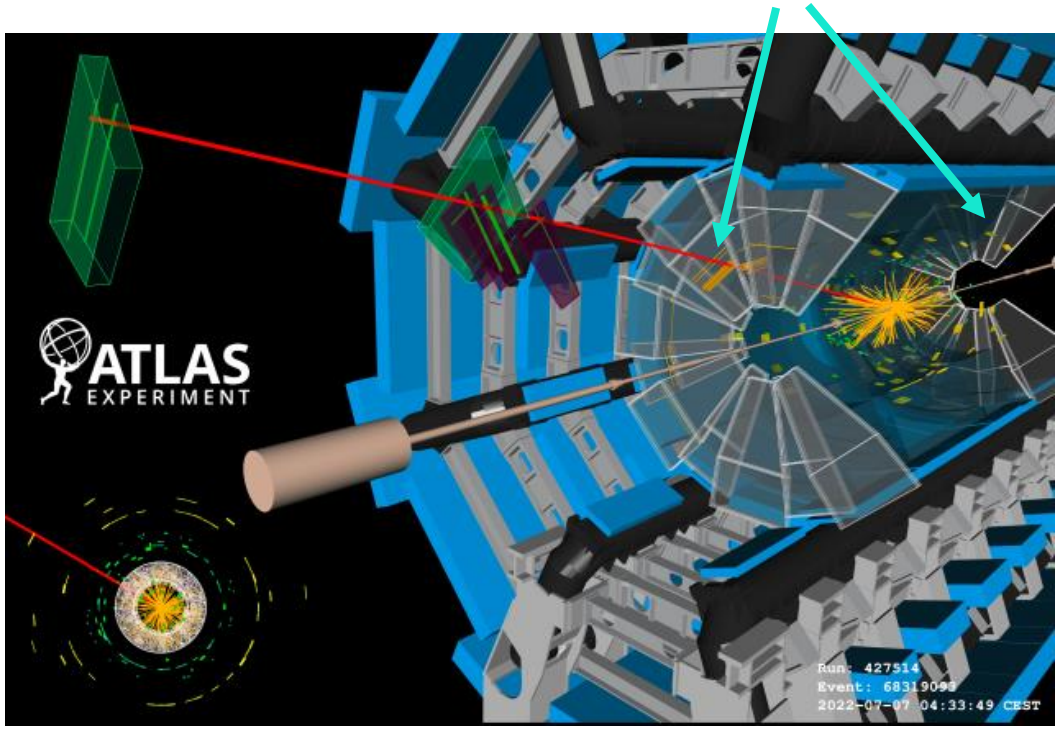
Commissioning of ALPHA-g

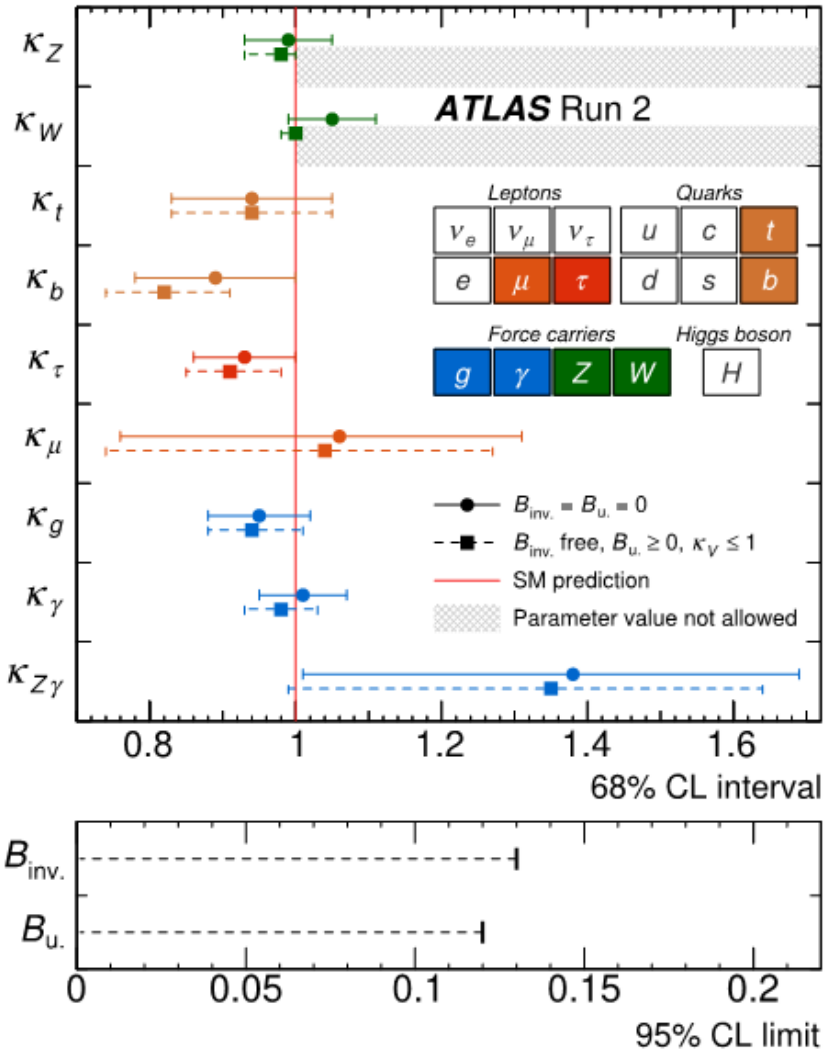
First data being analyzed

Particle Physics - ATLAS

LHC Run 3 has started in 2022 and the New Small Wheels are taking data

New Small Wheels



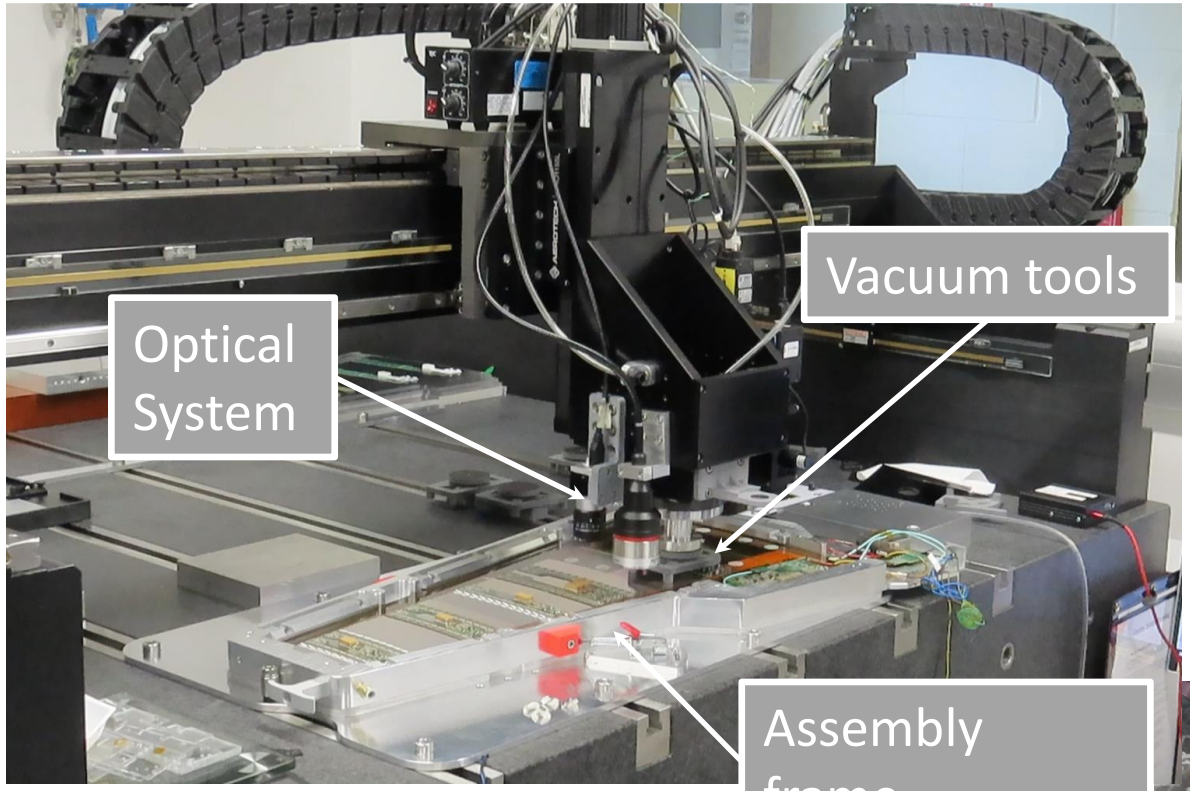


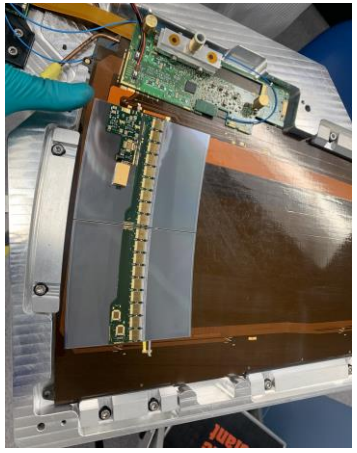
Milestone measurements of Higgs boson properties, couplings to matter

10 Year anniversary paper in nature

Discovery, accelerated

Particle Physics - ATLAS



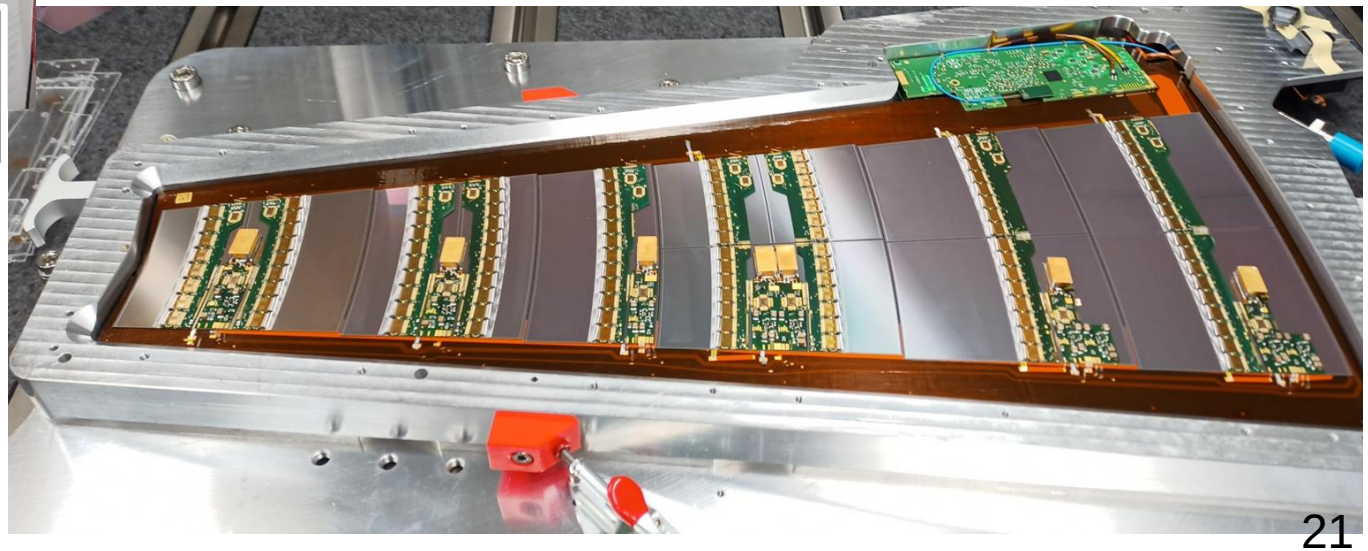


- Single module PPB petal assembled at special request
- Sent to DESY for system test Preparation and readout (FELIX) development at NIKHEF

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



TUCAN
TRIUMF Ultra Cold Advanced Neutron source

UCN

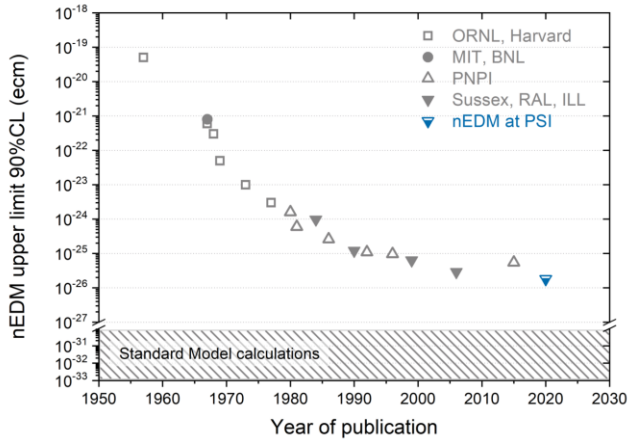
Search for a neutron electric dipole moment (EDM) with a sensitivity of 10^{-27} e cm

Progress towards the world's strongest ultracold neutron source

Liquid He transfer & return lines tested

EDM storage cell tests at J-PARC completed

Magnetically Shielded Room for EDM experiment taking shape



Liquid helium transfer line

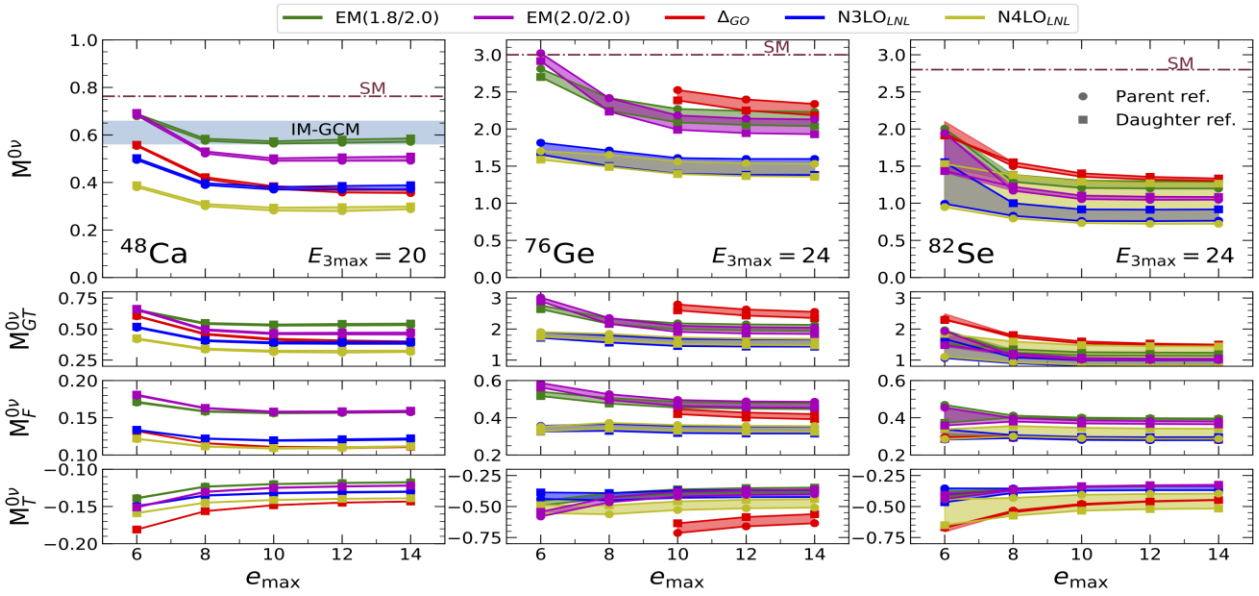
Science & Technology – Theory

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**

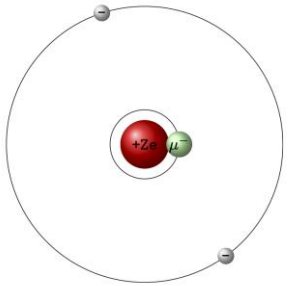
A. Belley, C. G. Payne, S. R. Stroberg, T. Miyagi, and J. D. Holt

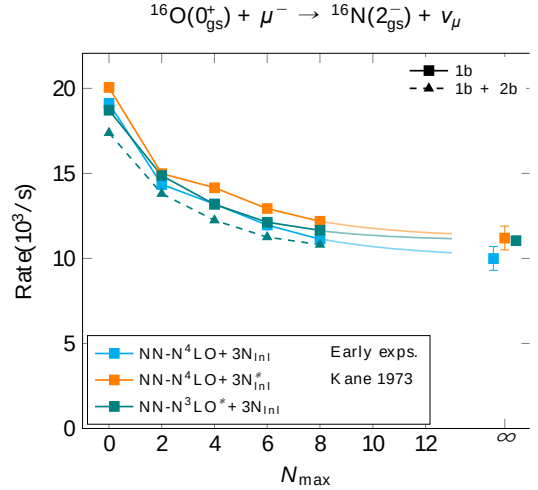
Physics Letters B 838 (2023) 137689
Contents lists available at ScienceDirect
Physics Letters B
journal homepage: www.elsevier.com/locate/physletb

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

L. Jokiniemi, B. Romeo, C. Brase, J. Kotila, P. Soriano, A. Schwenk, J. Menéndez

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





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, T. Miyagi, S. R. Stroberg, J. D. Holt, J. Kotila, and J. Suhonen

TRIUMF

Thank You!

Merci!

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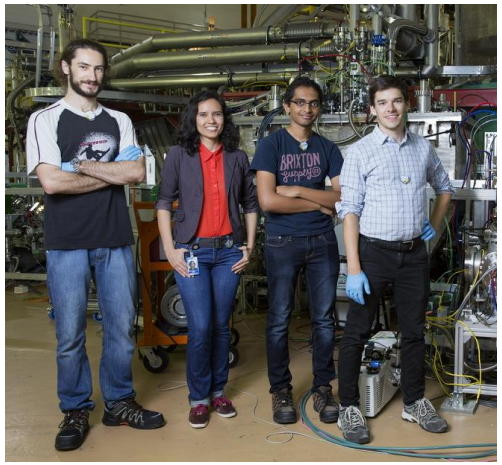
@TRIUMFLab

Additional Science Highlights

Science & Technology – ARIEL




Supporting the ARIEL Program Towards Completion

Cost and schedule review – outcome, requests and actions

- Total ARIEL integrated work over the full project (2013 - 2026): 480 FTE years (within initial projections).
- Current level of FTE availability below request, due to operations and refurbishment priorities.
- Additional 15 FTE and $5.7M required to complete project on time (2026/27)
- Requests supported by Board of Governors and granted by Senior Leadership; ramp-up and re-baselining in progress

Greater support and visibility of the project at all levels

- Increased support from Senior Leadership
  - Regular alignment between Program and Executive Director.
  - Status discussed at weekly senior management meetings
- International advice through ARIEL Scientific Steering Committee (ASSC)

Science & Technology – Accelerators

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

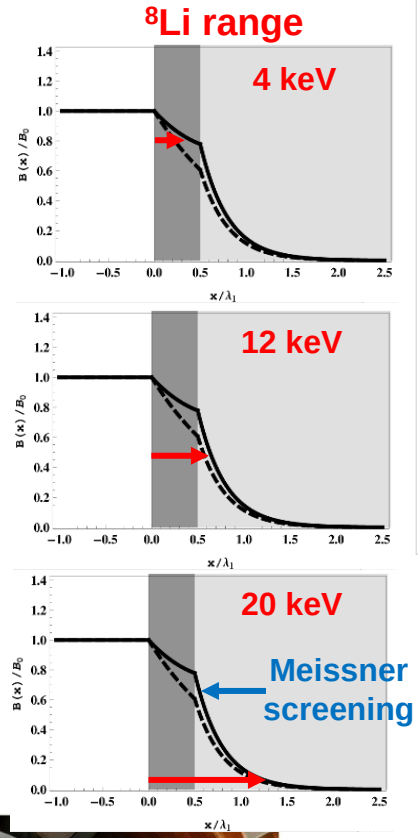
- Unique facility in the world for depth profiling materials in parallel magnetic fields up to 200mT – SRF regime
- First results show clear differences in the Meissner screening between a baseline sample and an oxygen doped sample
- O-doped sample has a longer penetration depth but better high field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

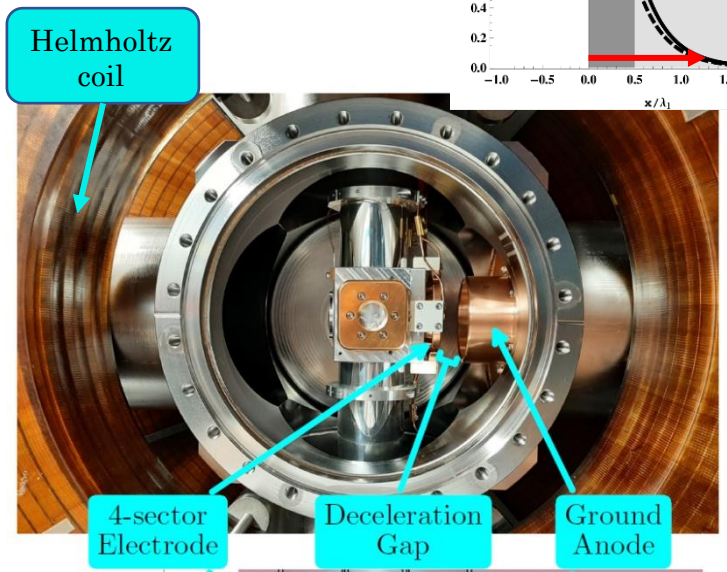
First paper

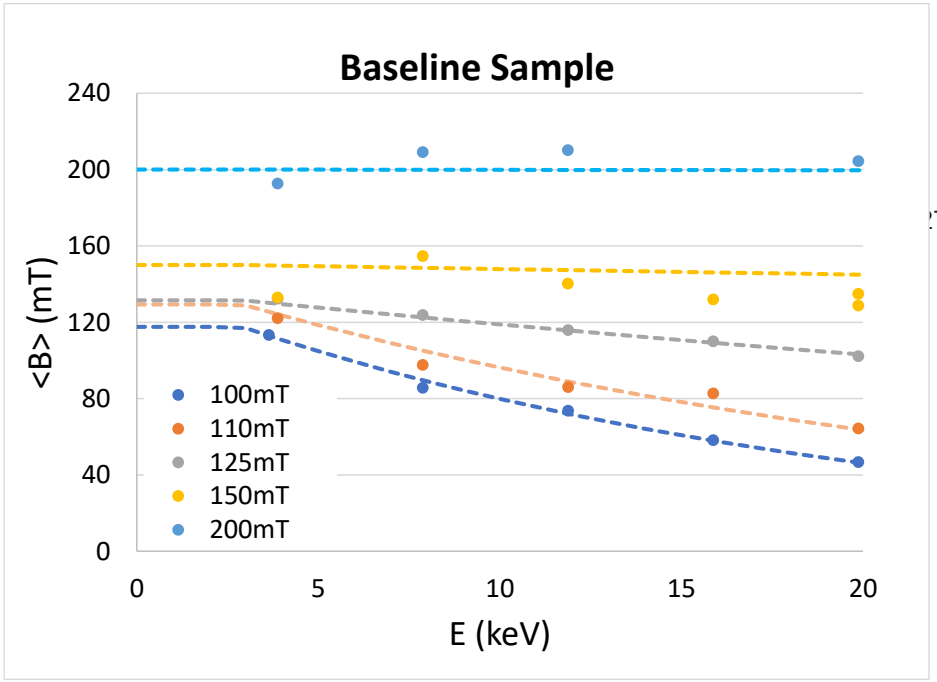
https://doi.org/10.1063/5.0137368

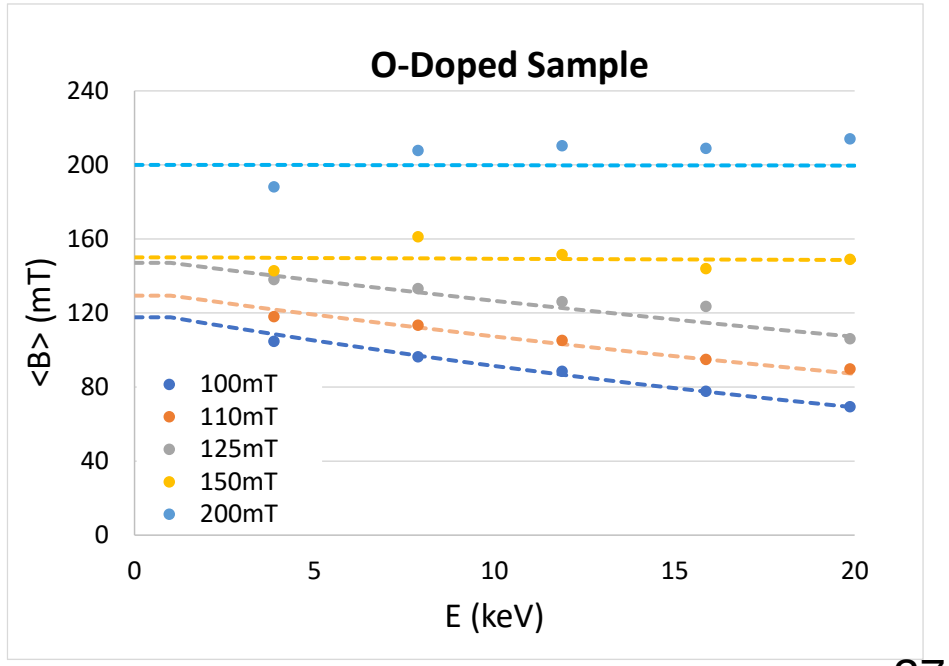
A New High Parallel-Field Spectrometer at TRIUMF's β-NMR Facility

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)





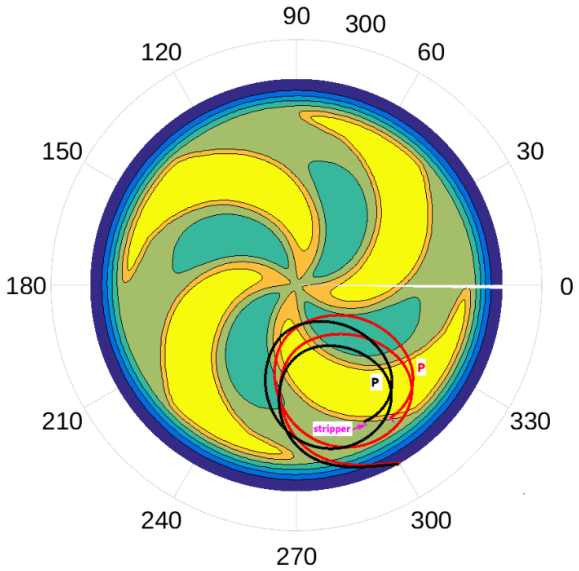


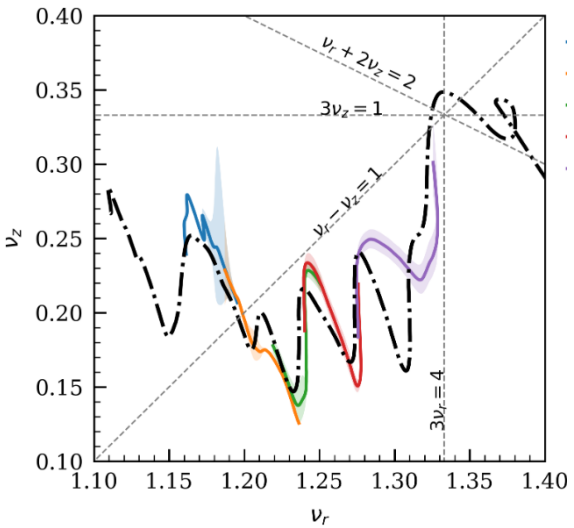


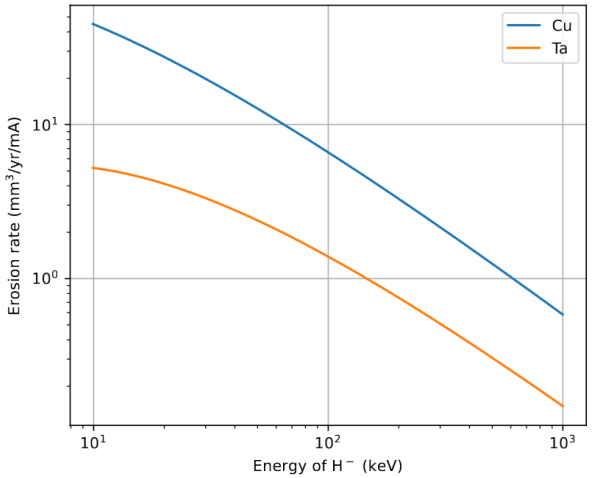
Science & Technology – Accelerators

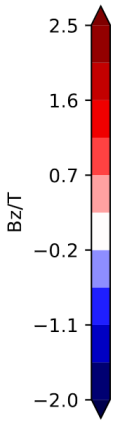
Special Beam Dynamics Issue on Cyclotrons
International Committee for Future Accelerators

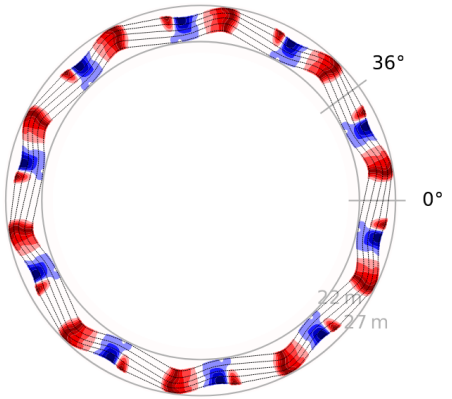
- TRIUMF Beam Physics Department Head, Rick Baartman, was invited by the beam dynamics subgroup to coordinate and edit a special issue on cyclotrons' energy and intensity limits.
- 15 peer-reviewed papers were published in Journal of Instrumentation, of which 8 from TRIUMF, reinforcing TRIUMF as a center 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.

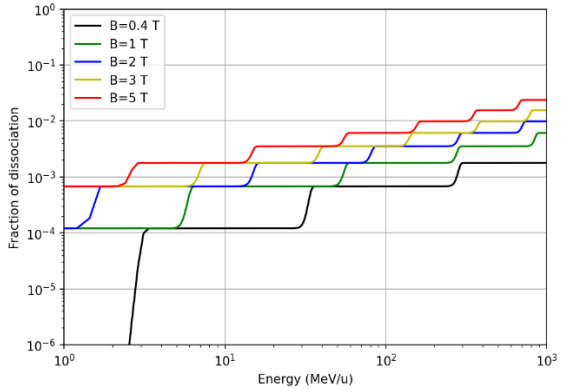








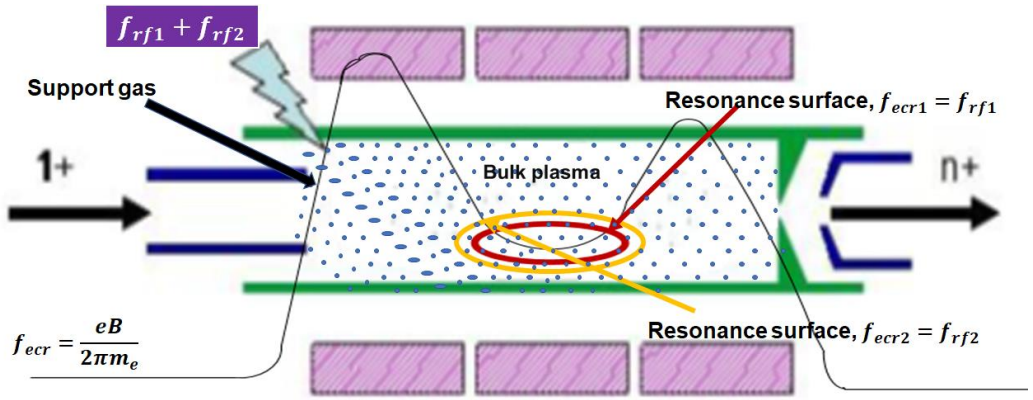


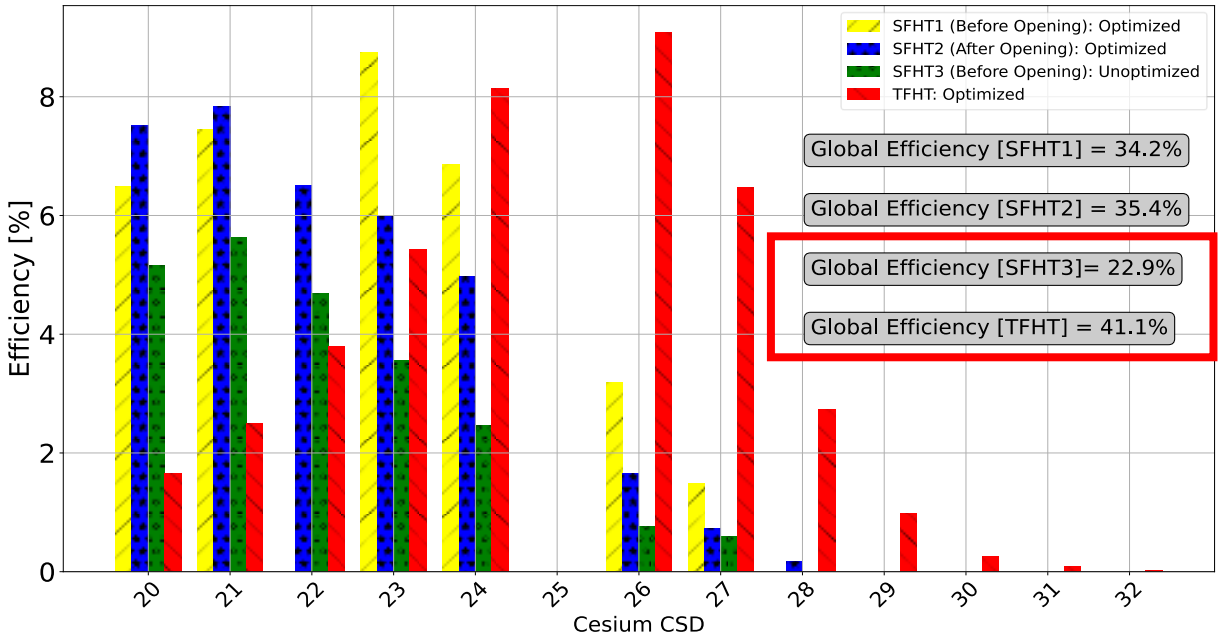


(b) Total dissociation of all state at B = 1, 2, 3 and 5 T

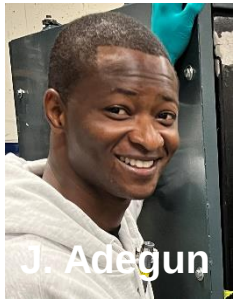
Science & Technology – Accelerators

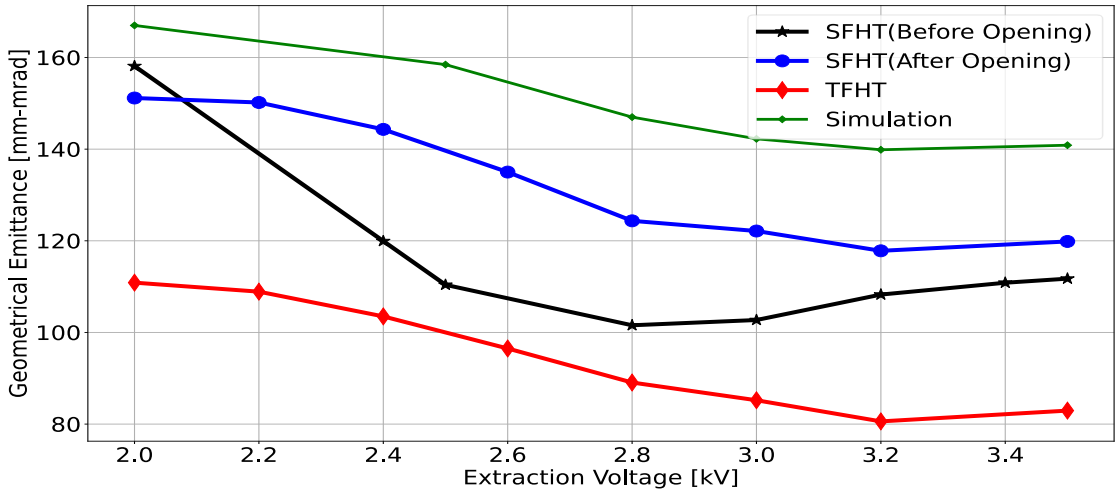
TRIUMF Charge State Booster (CSB) improvements





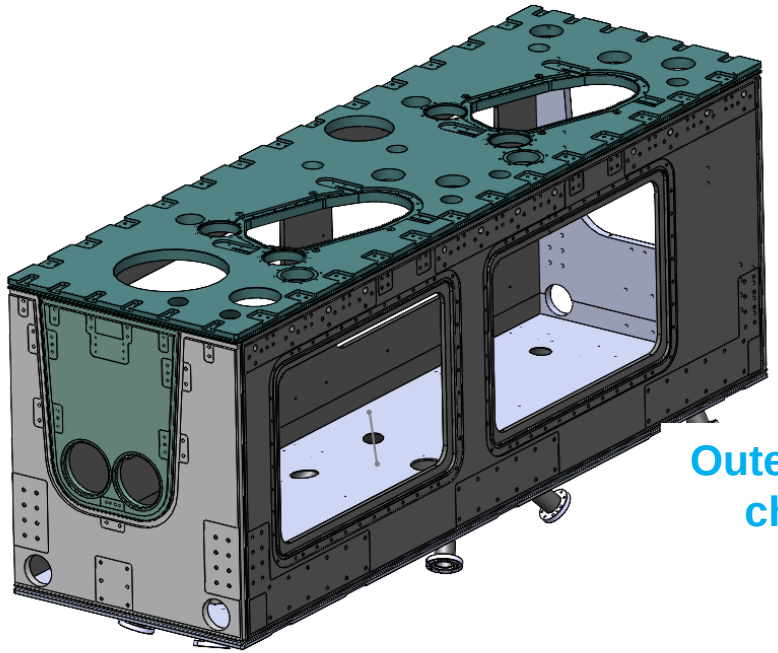
- The CSB is a 14.5 GHz Electron Cyclotron Resonance Ion Sources (ECRIS) that uses microwave plasma heating and magnetic confinement to produce highly charges ions.
- Increase of charge breeding efficiency by implementing two-frequency heating (TFHT)
  → provides two resonance heating zones
- Optimized all beam transport, ion extraction system and the charge state separator via detailed modeling and benchmarking via beam tests.



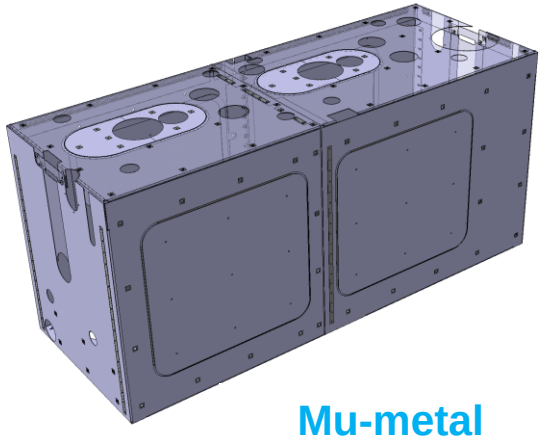


Science & Technology – Accelerators (HL-LHC)

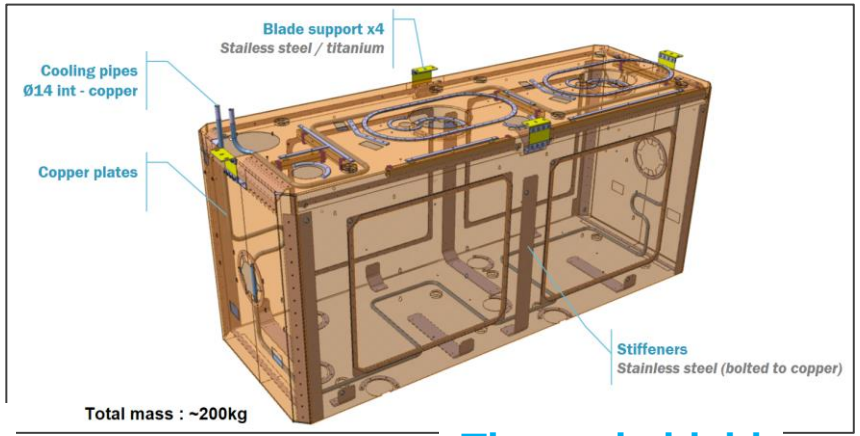
- Tender for Outer Vacuum Chamber (OVC) released
- Next procurements (mu-metal and thermal shield) in the queue
- Clean room infrastructure upgraded
  - Upgraded clean room diagnostics and garments
  - Upgraded cavity testing infrastructure



Outer vacuum chamber



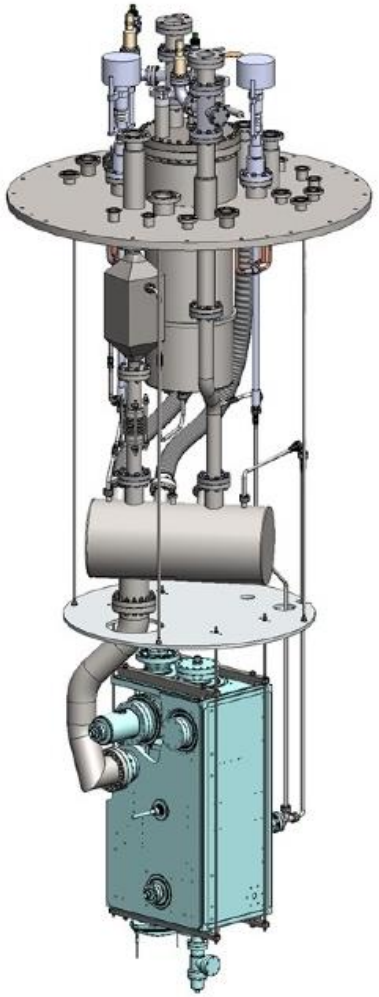
Mu-metal



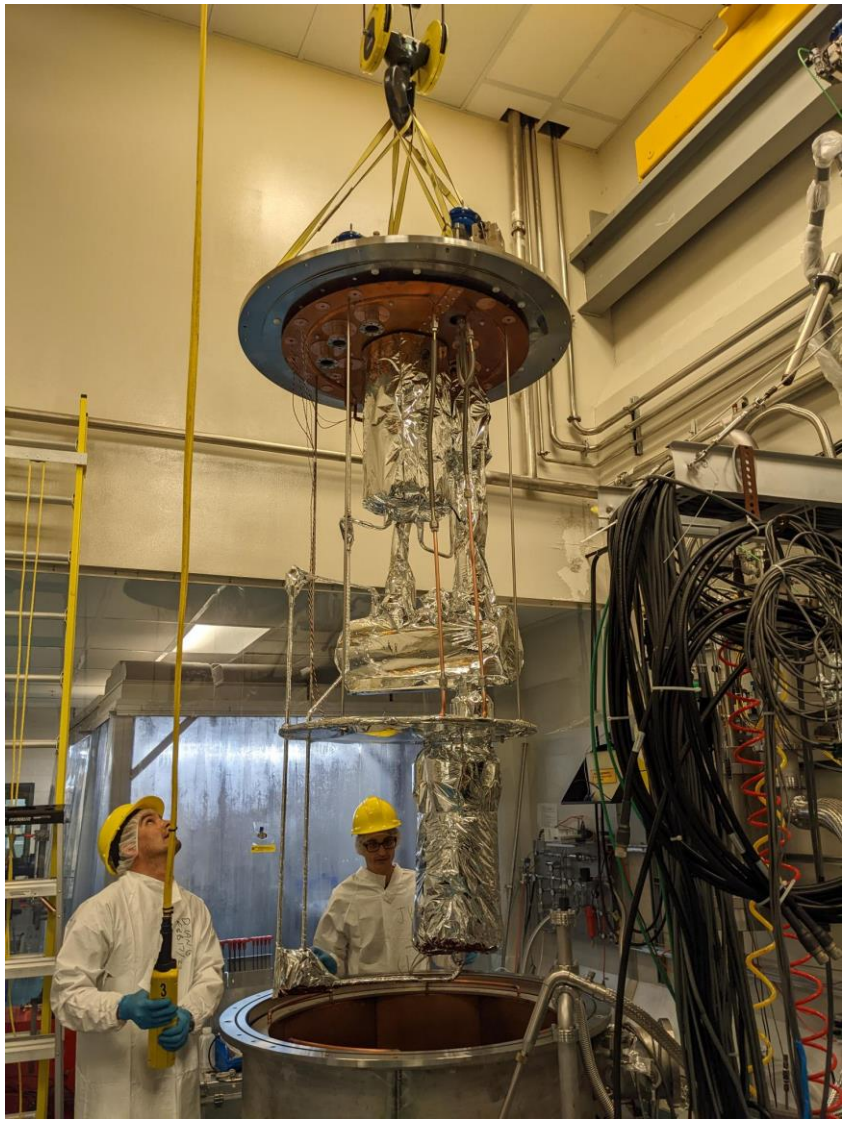
Thermal shield

Science & Technology – Accelerators (HL-LHC)

- TRIUMF multi-purpose test cryostat upgraded to allow qualification of RFD cavities at 2K
- New insert tested and meets specification
- Upgraded 2K pumping capacity
- Ready for qualifying US cavities at 2K



4K/2K vertical test unit

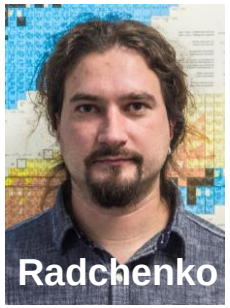


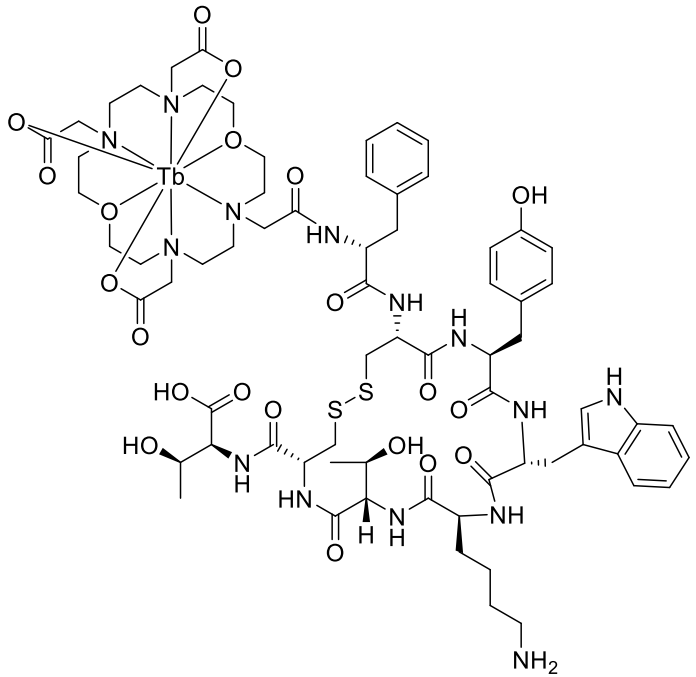
Science & Technology – Life Sciences

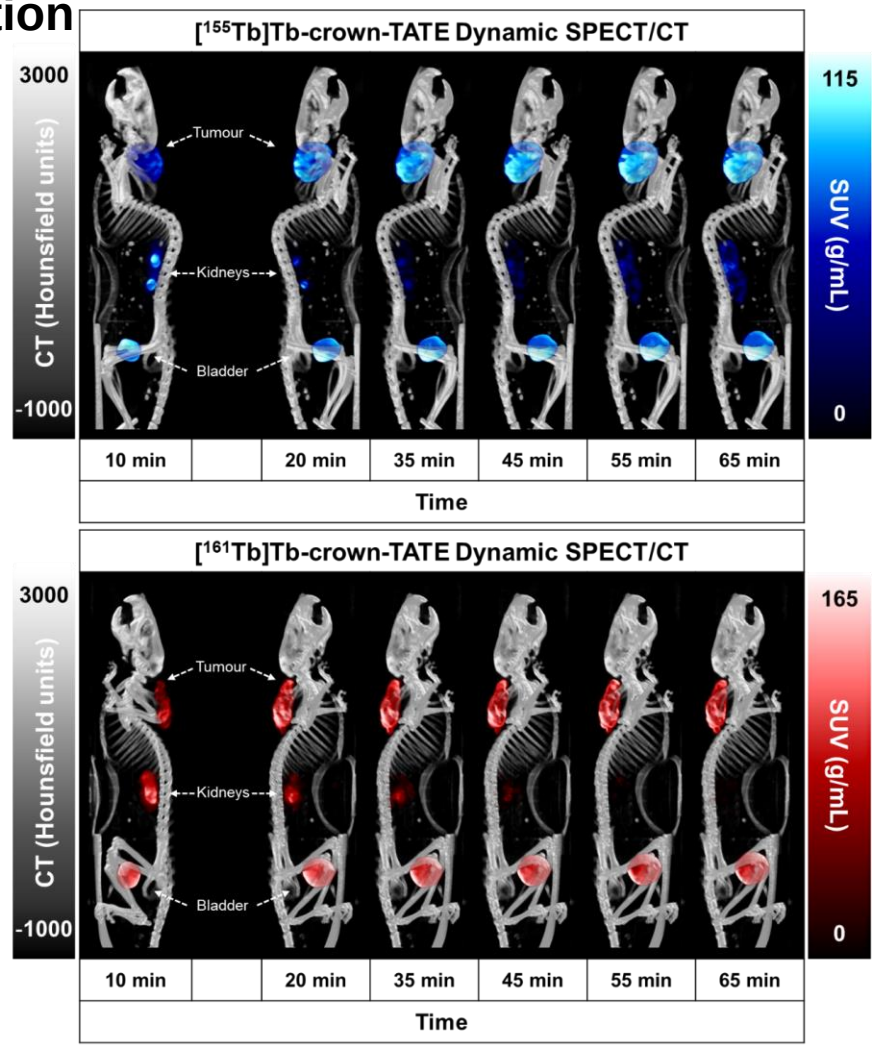
TRIUMF continues development of novel therapeutic isotopes

[$^{161/155}$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





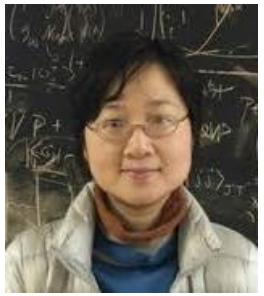


SPECT imaging of ^{155,161}Tb in AR42J (pancreatic) tumour mice

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

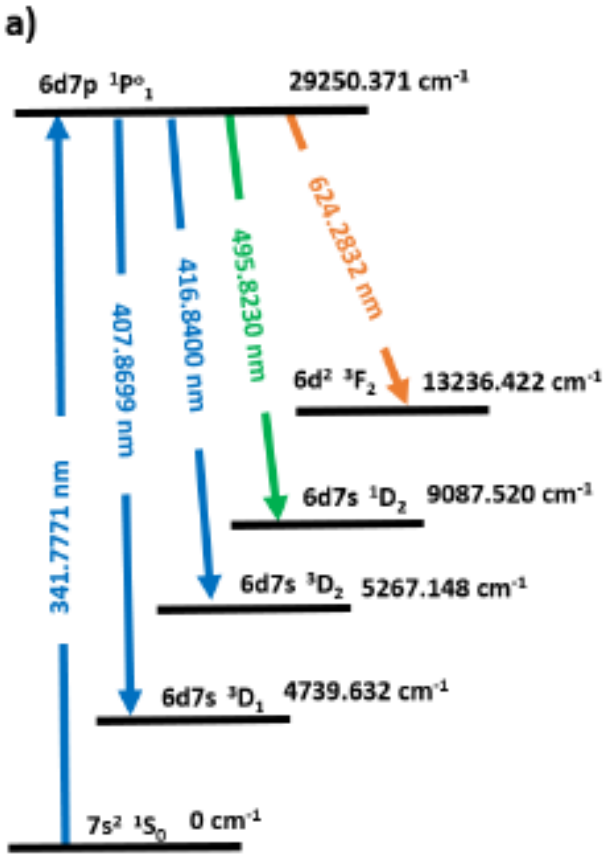
Interdivisional endeavor:

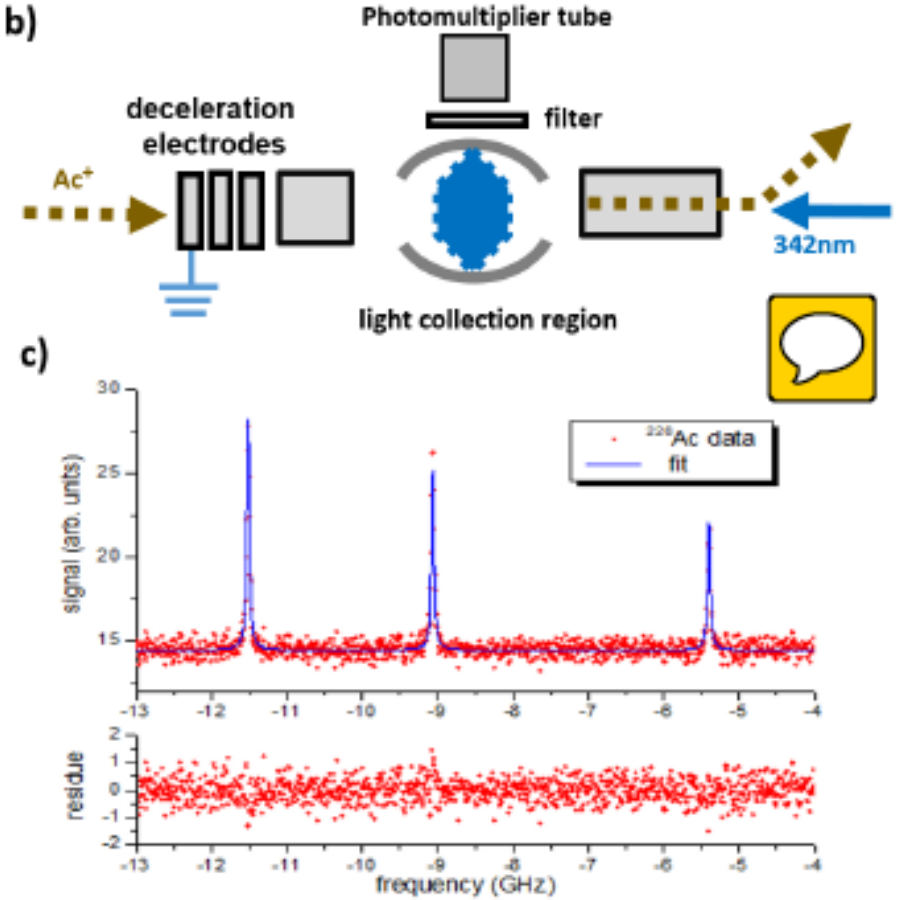
M. Stachura
Life Sciences Div.



R. Li
Accelerator Div.

A. Teigelhoefer
Physical Science Div.



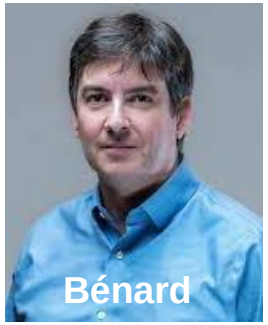


R. Li et al., Recent upgrades and developments at TRIUMF's laser nuclear-spin-polarization facility. NIM B, under revision

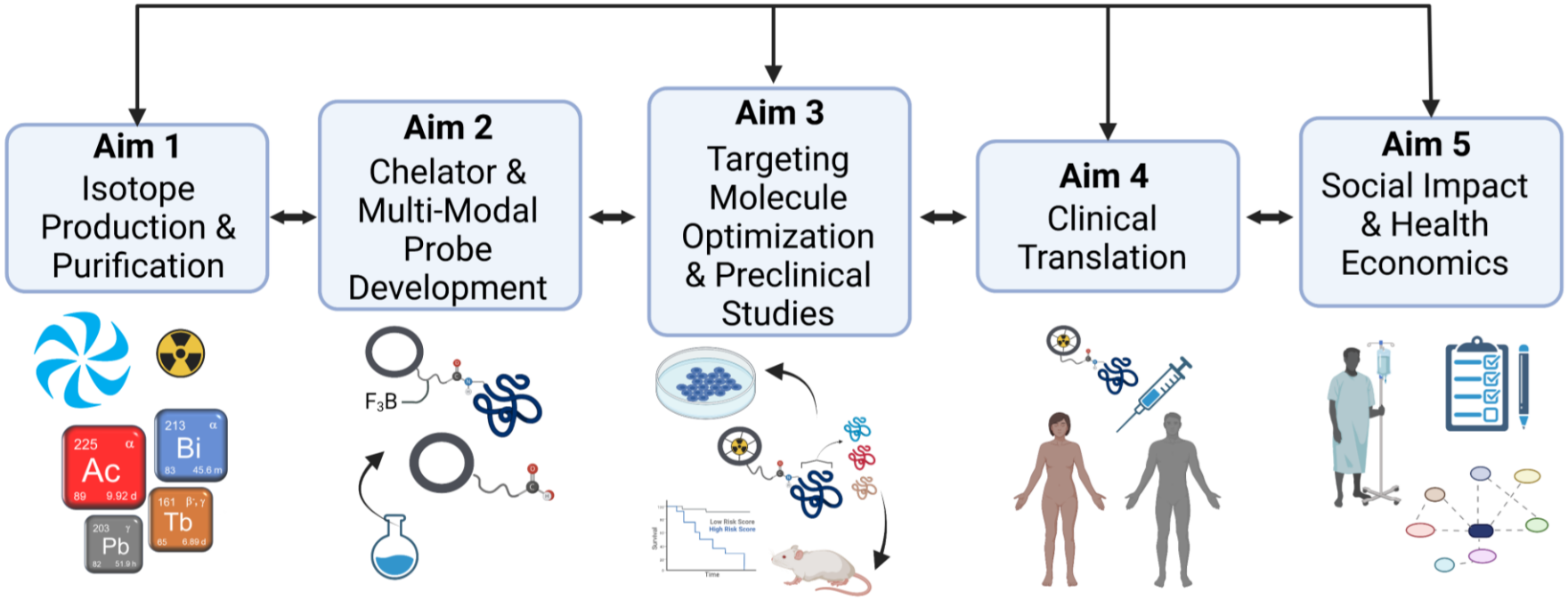
Science & Technology – Life Sciences

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



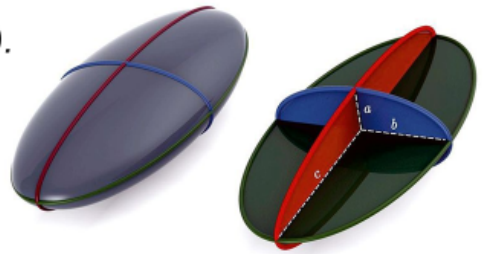
National partners:

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

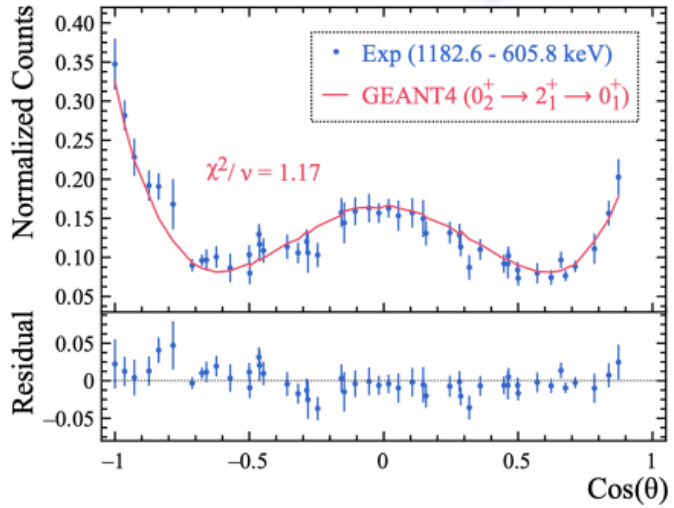
First Evidence of Axial Shape Asymmetry and Configuration Coexistence in ^{74}Zn: Suggestion for a Northern Extension of the N = 40 Island of Inversion

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

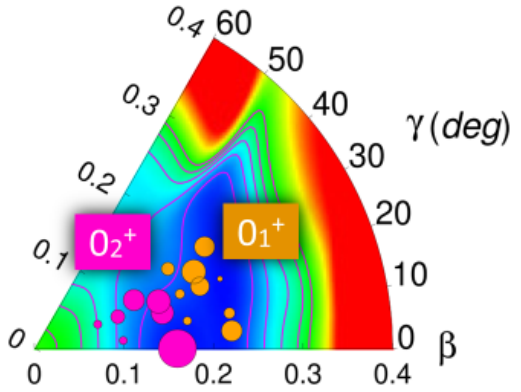


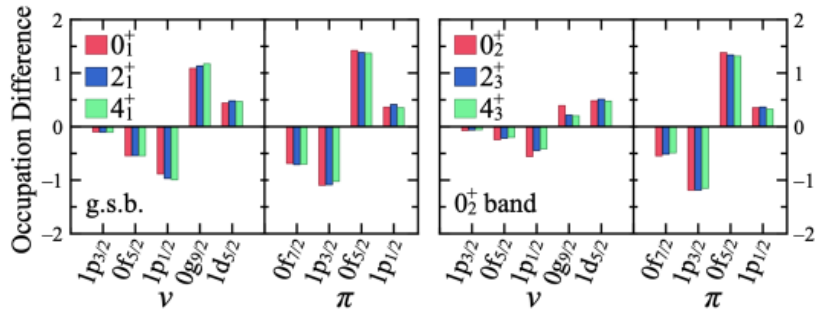
- ^{74}Zn investigated at GRIFFIN following ^{74}Cu β decay
- γ-γ angular correlation analysis ⟹ Firm spin assignments for 2_2^+, 3_1^+, 0_2^+, 2_3^+ states
- Two new transitions observed ⟹ $2_3^+ \longrightarrow 0_2^+$ and $2_3^+ \longrightarrow 4_1^+$
- From measured γ-ray branching and *E2/M1* mixing 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

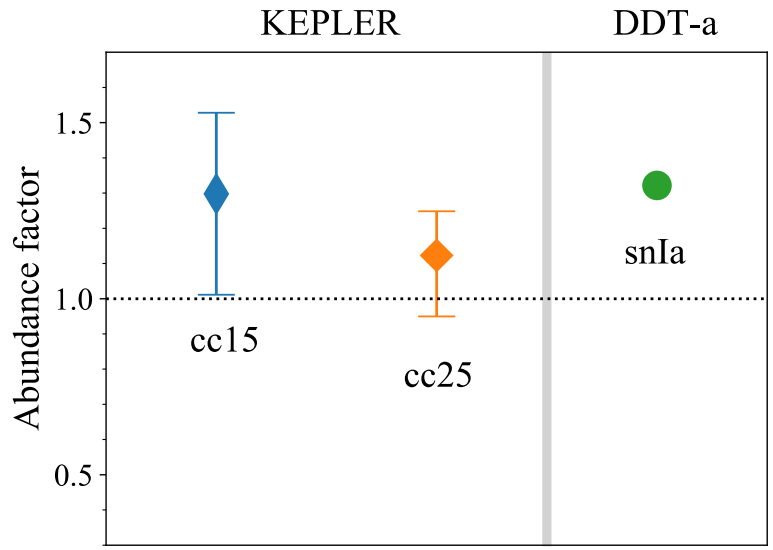
New EMMA-TIGRESS Paper

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*

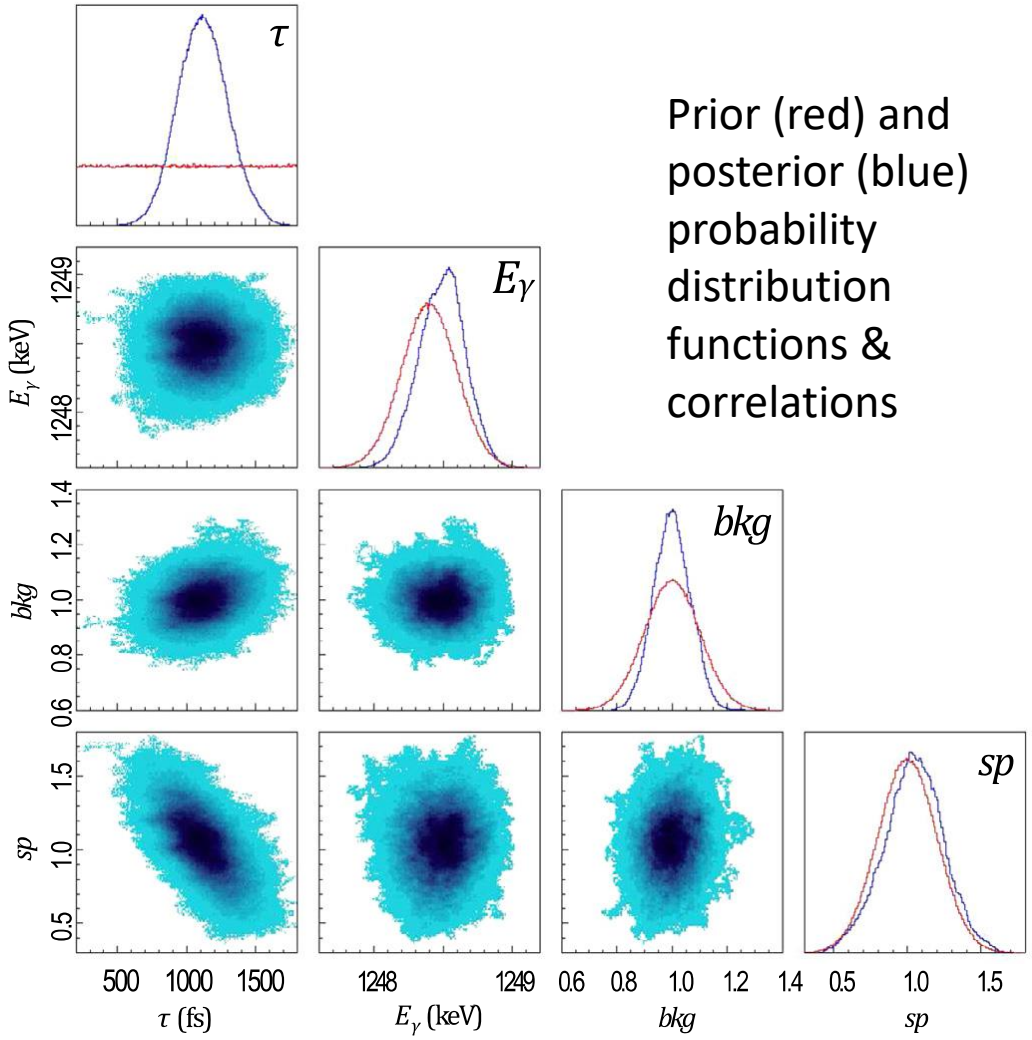


- Measurements of cross section of ^{83}Rb(p,γ)^{84}Sr reaction relevant to γ process nucleosynthesis in supernovae carried out with TIGRESS and EMMA in ISAC-II by a TRIUMF & University of Surrey (UK) collaboration; astrophysical modelling by Swiss and Japanese collaborators
- The amount of ^{84}Sr produced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

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



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

Physics Letters B 839 (2023) 137801

Contents lists available at ScienceDirect

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

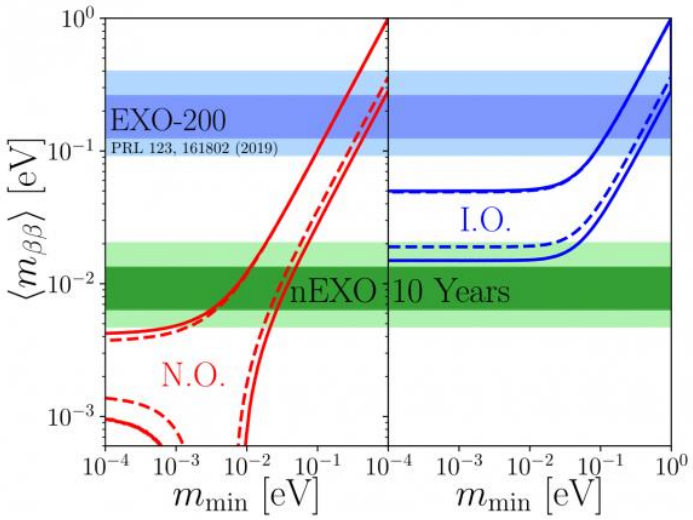
First application of Markov chain Monte Carlo-based Bayesian data analysis to the Doppler-shift attenuation method

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]

- 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

Neutrinoless double beta decay experiment nEXO

- nEXO collaboration 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

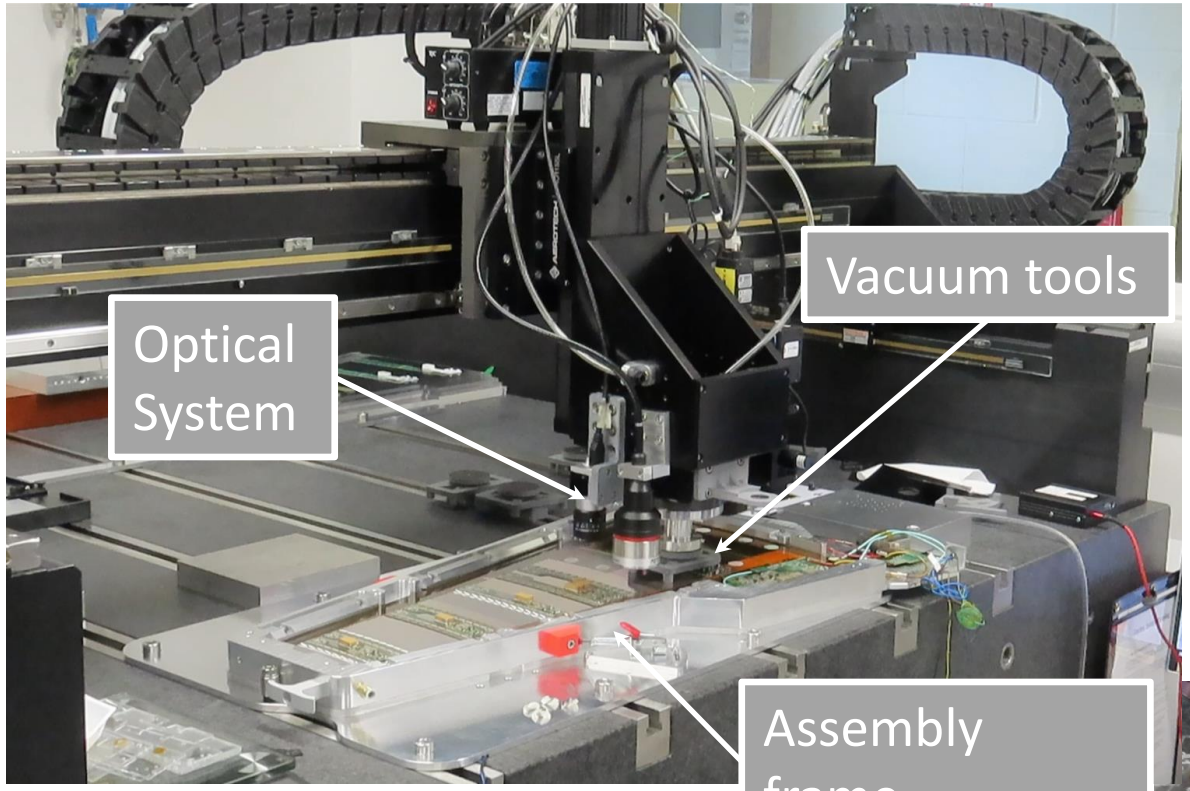
Regular Article - Experimental Physics

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], C. Malbrunot[1], P. Margetak[1], P. Martel-Dion[11], L. Martin[1], J. Masbou[33], N. Massacret[1], K. McMichael[17], B. Mong[16], K. Murray[5], J. Nattress[24], C. R. Natzke[30], X. E. Ngwadla[32], J. C. Nzobadila Ondze[32], A. Odian[16], J. L. Orrell[10], G. S. Ortega[10], C. T. Overman[10], S. Parent[11], A. Perna[18], A. Piepke[21], N. Pletskova[4], J. F. Pratte[11], V. Radeka[3], E. Raguzin[3], G. J. Ramonnye[32], T. Rao[3], H. Rasiwala[5], K. Raymond[1], B. M. Rebeiro[5], G. Richardson[7], J. Ringuette[30], V. Riot[14], T. Rossignol[11], P. C. Rowson[16], L. Rudolph[5], R. Saldanha[10], S. Sangiorgio[14], X. Shang[5], F. Spadoni[10], V. Stekhanov[13], X. L. Sun[2], A. Tidball[17], T. Totev[5], S. Triambak[32], R. H. M. Tsang[21], O. A. Tyuka[32], F. Vachon[11], M. Vidal[9], S. Viel[12], G. Visser[34], M. Wagenpfeil[27], M. Walent[18], K. Wamba[26], Q. Wang[20], W. Wang[21], Y. Wang[2], M. Watts[7], W. Wei[2], L. J. Wen[2], U. Wichoski[12,18,19], S. Wilde[7], M. Worcester[3], W. H. Wu[2], X. Wu[20], L. Xie[1], W. Yan[2], H. Yang[20], L. Yang[8], O. Zeldovich[13], J. Zhao[2], T. Ziegler[27]

TRIUMF engagement in the project increasing

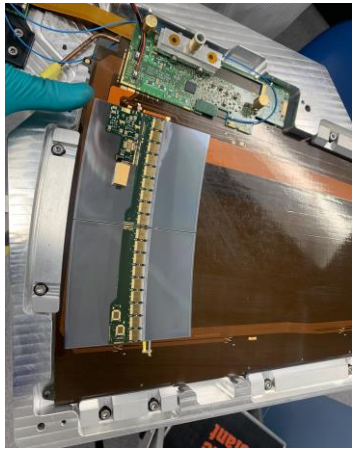
Science & Technology – Particle Physics



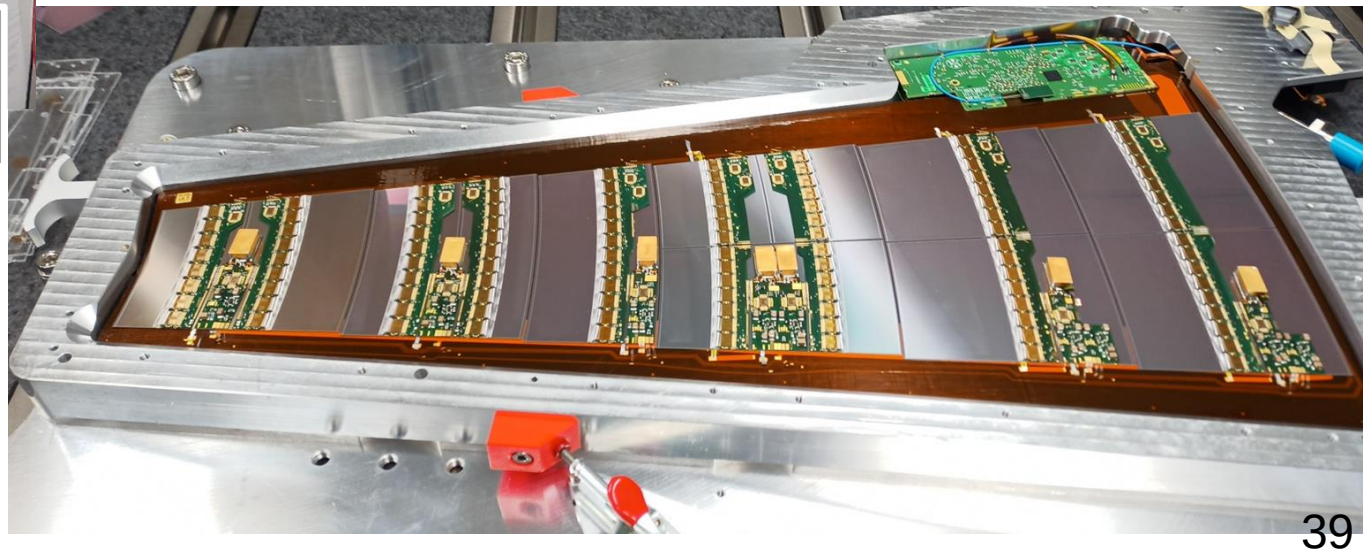
ATLAS-ITK

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



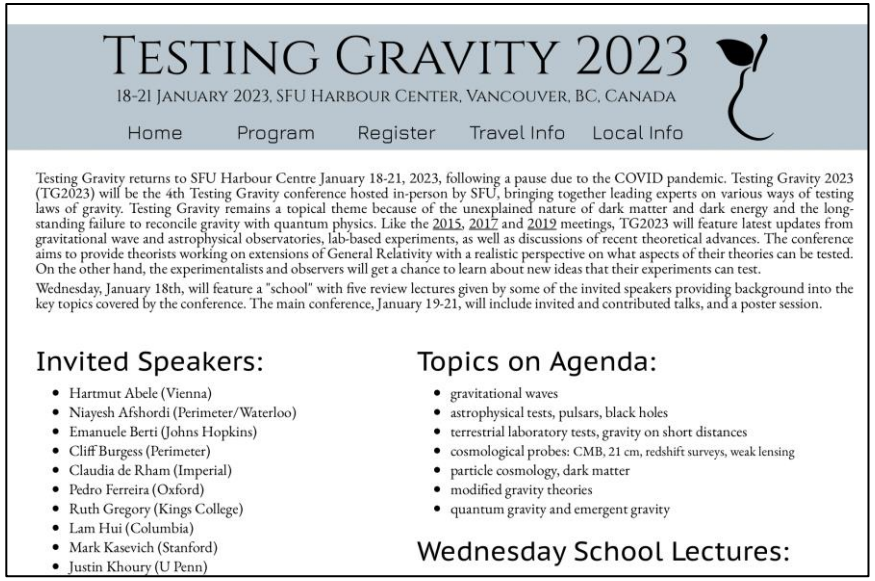
- Single module PPB petal assembled at special request
- Sent to DESY for system test Preparation and readout (FELIX) development at NIKHEF



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.

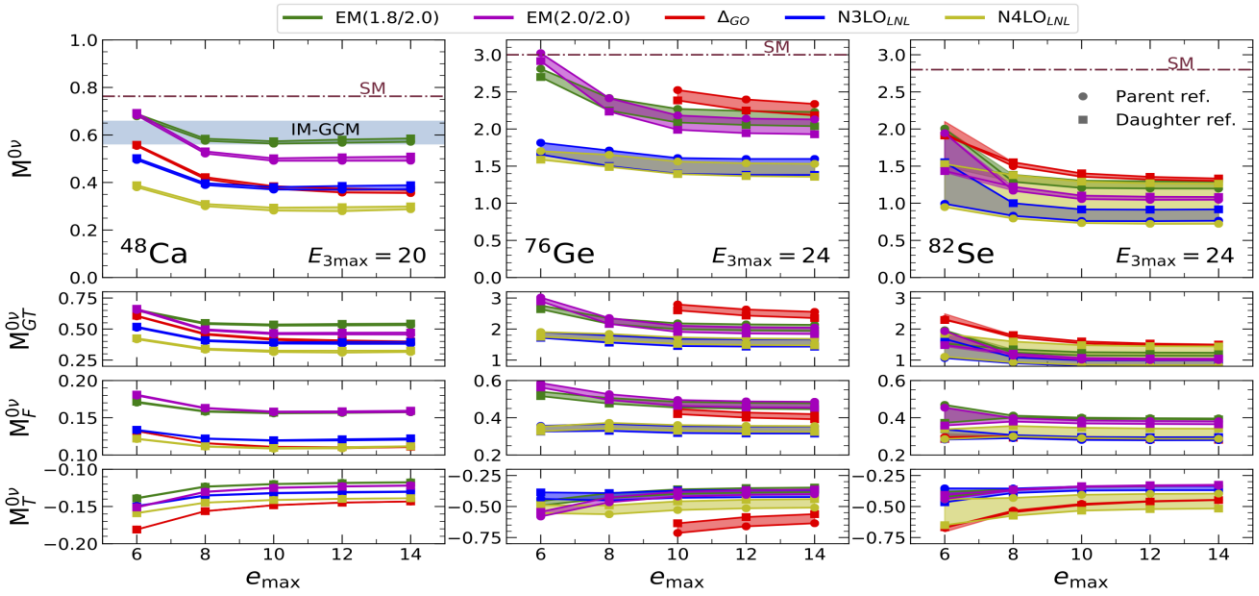
Science & Technology – Theory

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, C. G. Payne, S. R. Stroberg, T. Miyagi, and J. D. Holt

Physics Letters B 838 (2023) 137689

Contents lists available at ScienceDirect

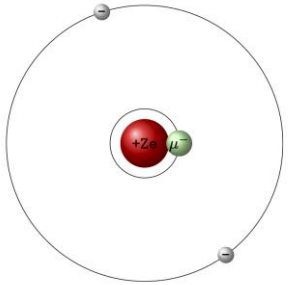
Physics Letters B

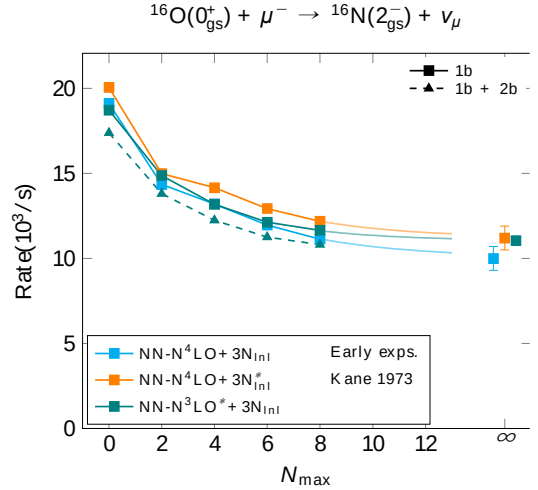
journal homepage: www.elsevier.com/locate/physletb

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

L. Jokiniemi, B. Romeo, C. Brase, J. Kotila, P. Soriano, A. Schwenk, J. Menéndez

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





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

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

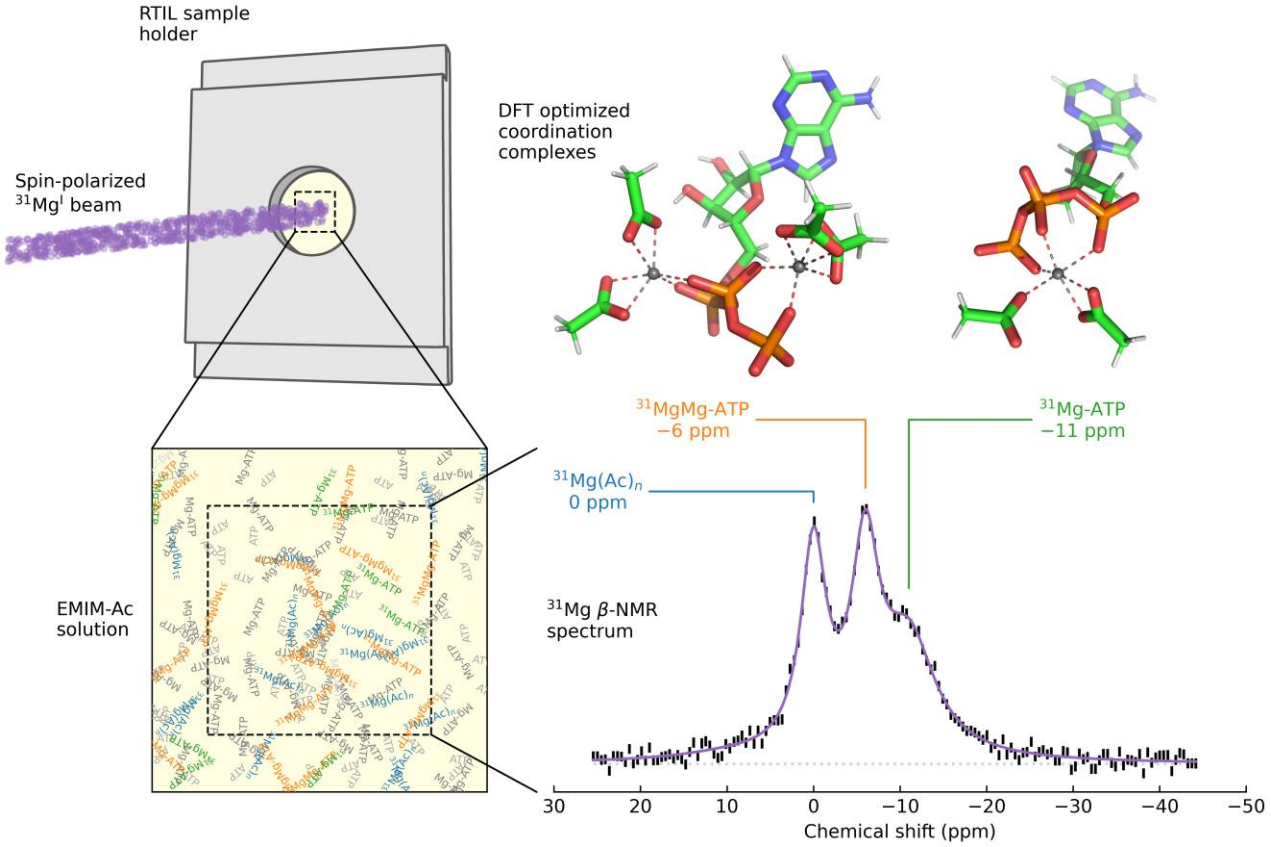
***Ab initio* calculation of muon capture on ^{24}Mg**

L. Jokiniemi, T. Miyagi, S. R. Stroberg, J. D. Holt, J. Kotila, and J. Suhonen

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

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

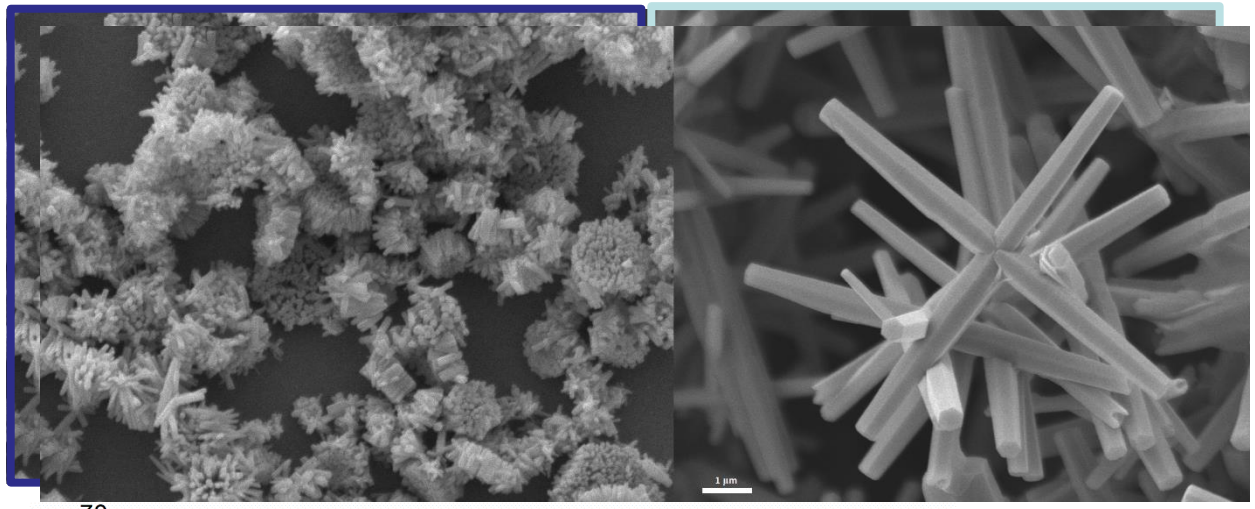


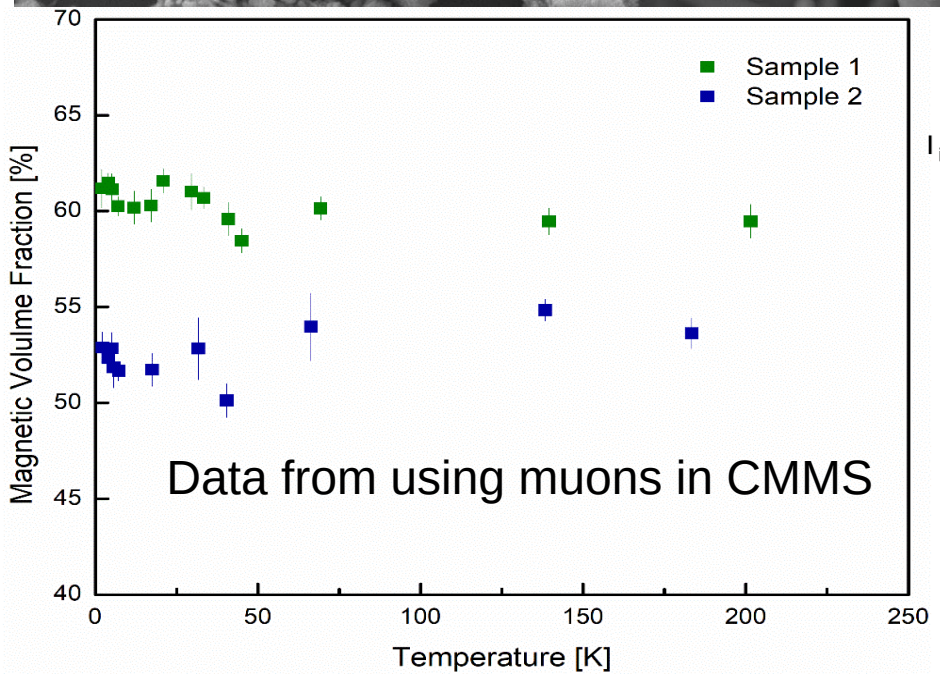
- This highlight showcases a novel use of β-NMR spectroscopy to study coordination chemistry in solution.
- The resonance of the spin-1/2 β-emitter ^{31}Mg reveals distinct Mg^{2+} binding modes with the biomolecule adenosine triphosphate (ATP).
- The measured chemical shifts are in good agreement with 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

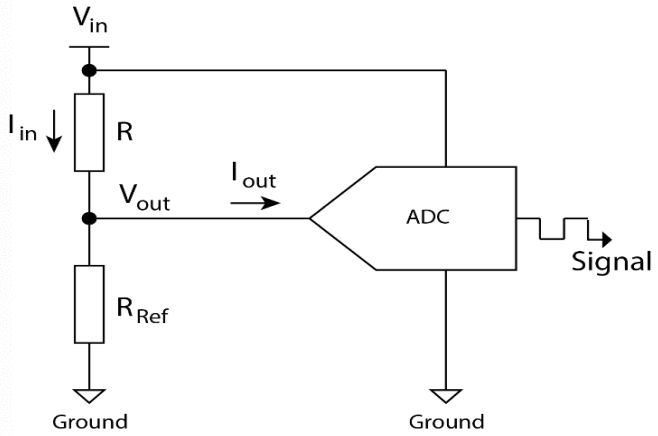
(-g**k** N, -850 G**)**

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





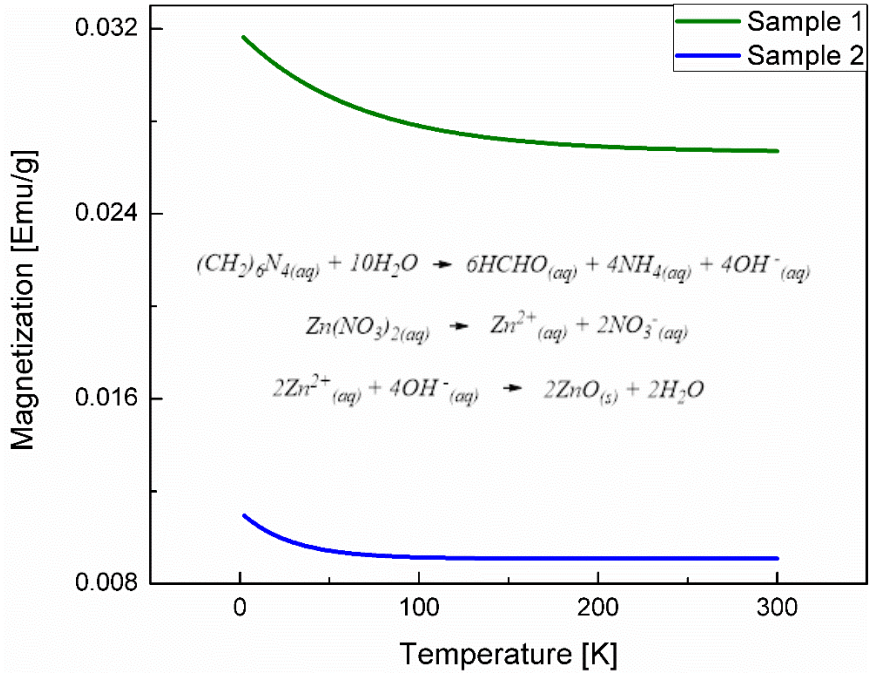
Data from using muons in CMMS



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.