

The State of TRIUMF

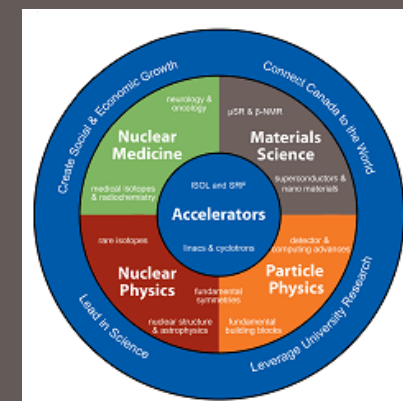
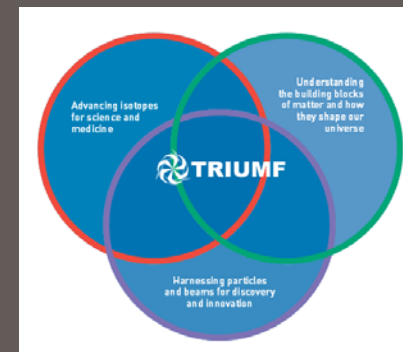
Accelerating Science and Innovation for Canada

CINP – IPP | June 15, 2015

Dr. Jonathan Bagger
Director
TRIUMF

Accelerating Science for Canada
Un accélérateur de la démarche scientifique canadienne

Owned and operated as a joint venture by a consortium of Canadian universities via a contribution through the National Research Council Canada
Propriété d'un consortium d'universités canadiennes, géré en co-entreprise à partir d'une contribution administrée par le Conseil national de recherches Canada



TRIUMF is performing well and much has happened since last year's meeting

In partnership with the subatomic physics community, the laboratory has

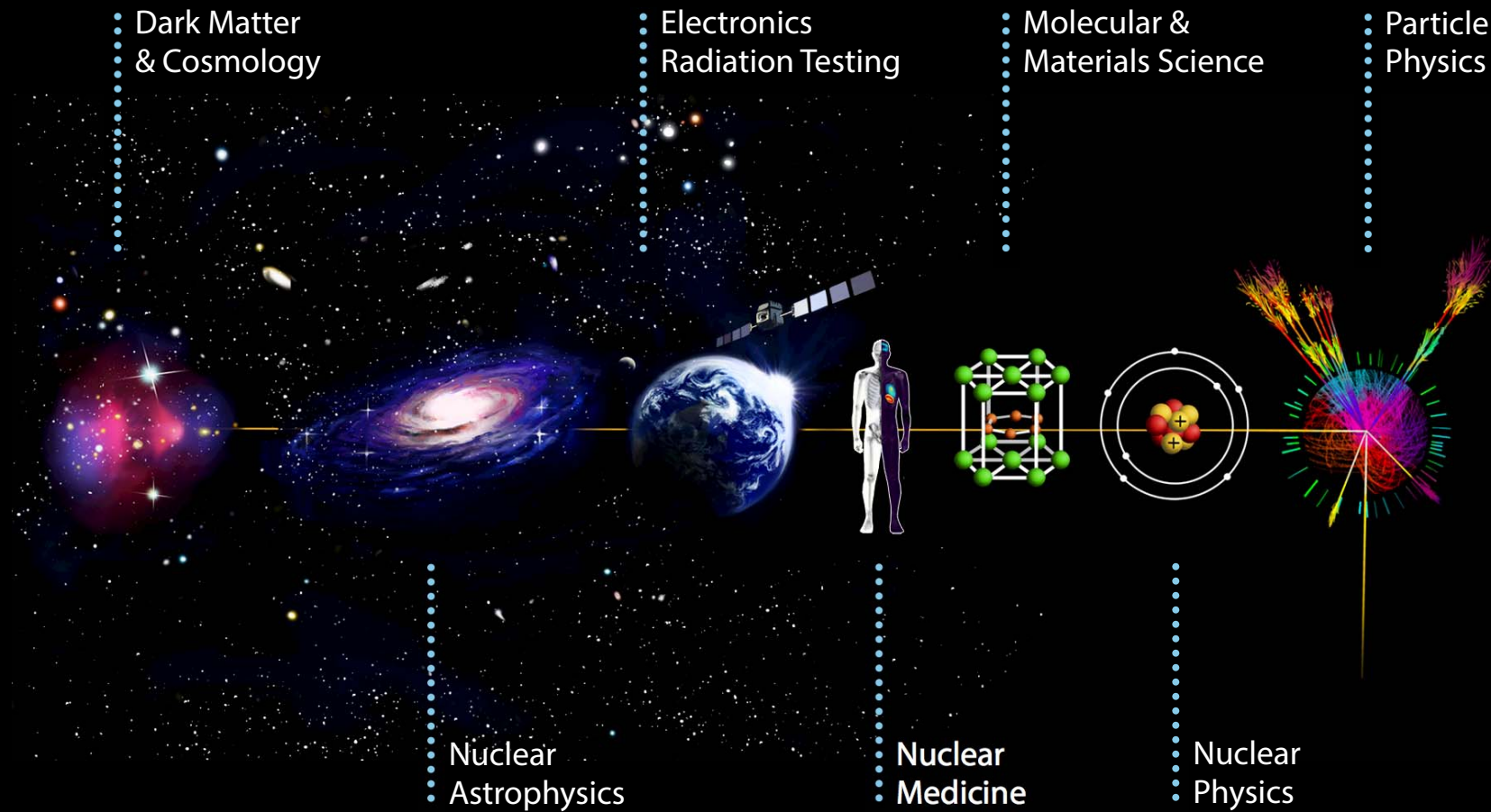
1. Made significant progress on high-profile projects
2. Increased its engagement with key stakeholders
3. Secured an increase to its operating budget
4. Received CFI funding for major capital projects
5. Finalized its priorities for the next five years

TRIUMF: A National Laboratory

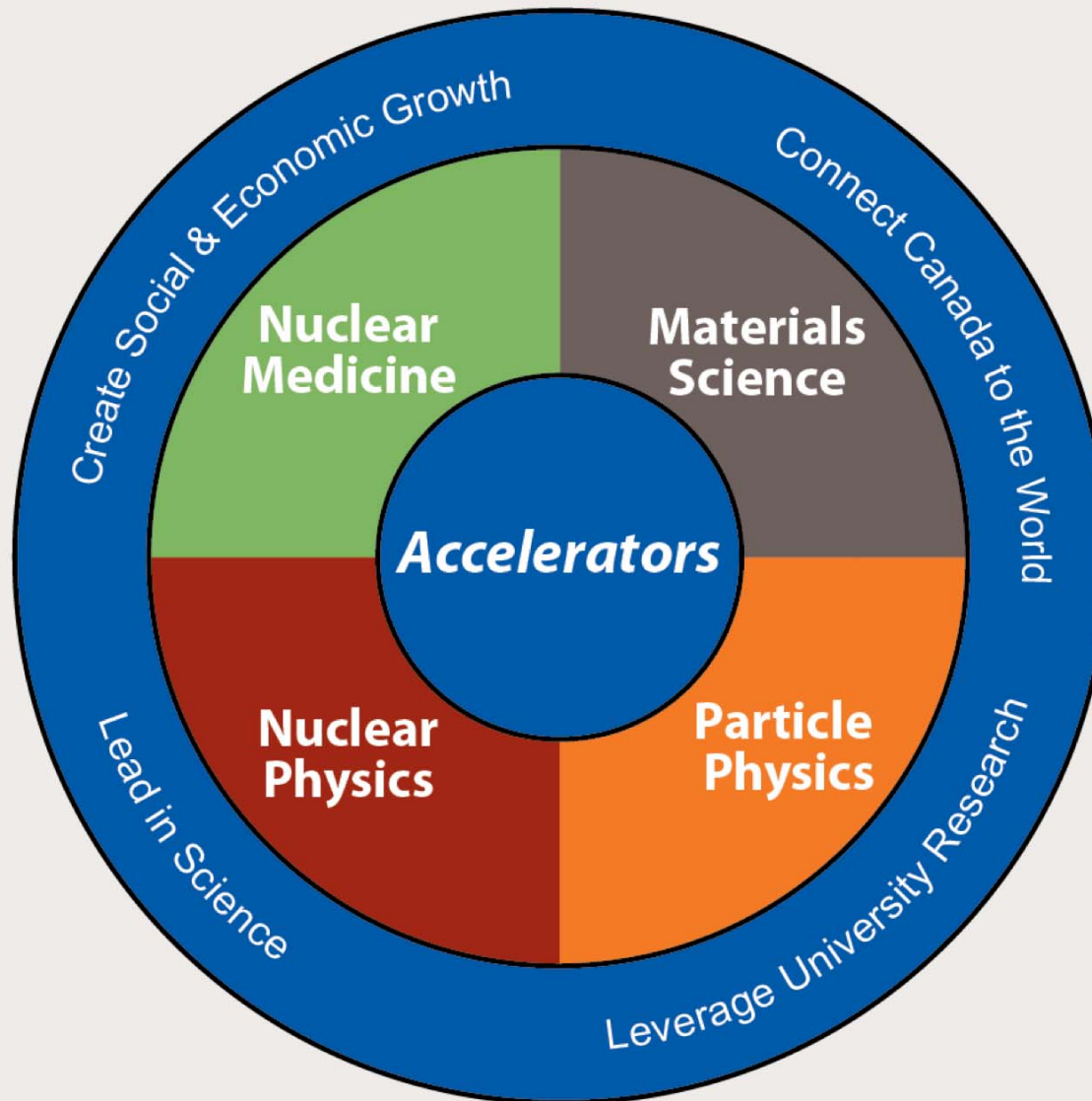


The state of the laboratory is strong!

TRIUMF Science



TRIUMF Mission and Vision



TRIUMF Accelerators

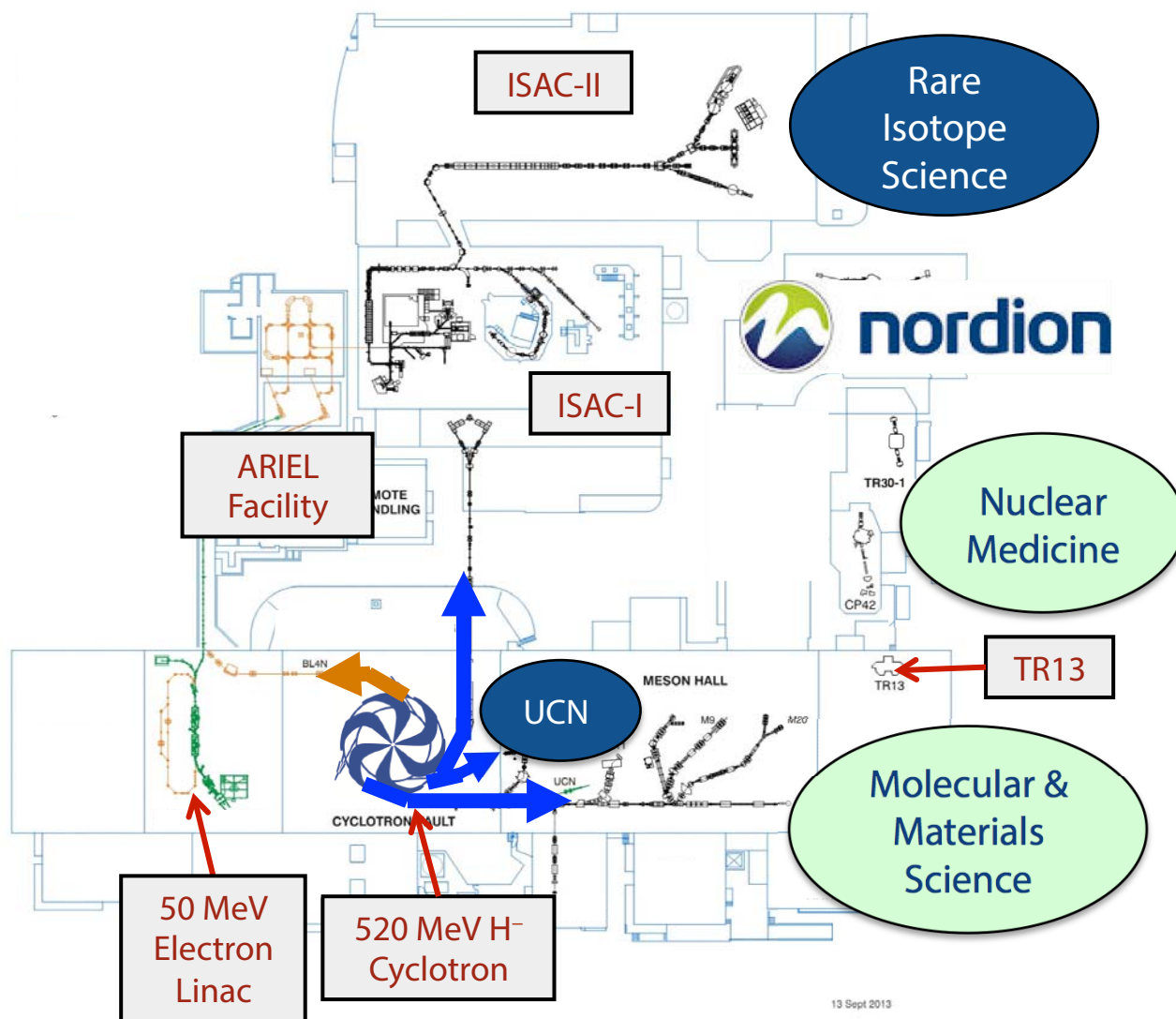
TRIUMF Accelerator Complex

Original 520 MeV, 350 μ A, H⁻ cyclotron

4 medical isotope cyclotrons

ISAC 50kW ISOL facility

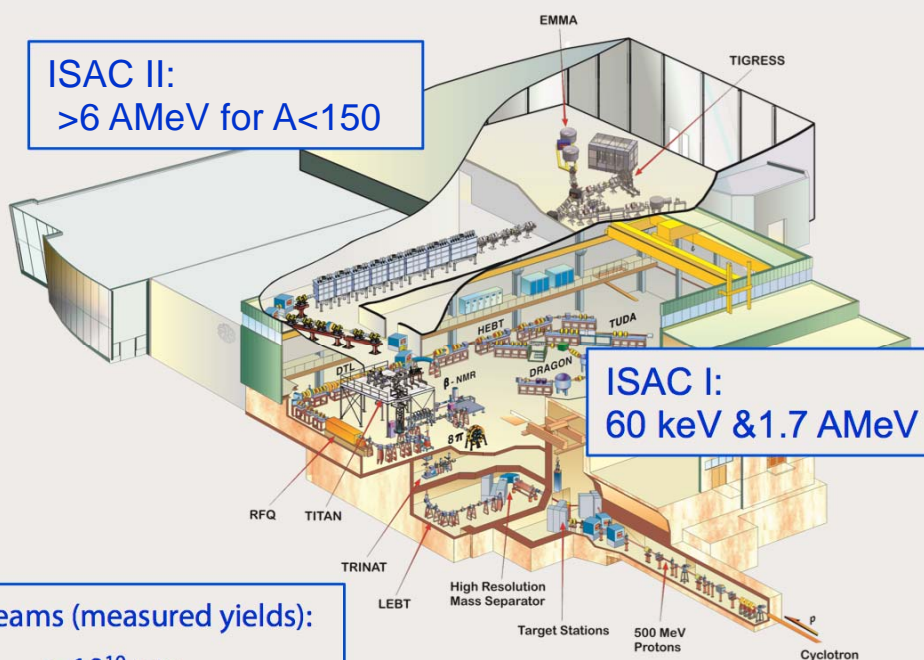
New ARIEL e-linac (10mA, 50 MeV)



13 Sept 2013

ISAC: Isotope Separator and Accelerator

ISAC: ISOL facility with world's highest primary beam intensity (100 μ A, 480 MeV protons)



ISAC II:
>6 AMeV for $A < 150$

ISAC I:
60 keV & 1.7 AMeV

Selected beams (measured yields):

^{26}Al	$> 10^{10}$ pps
$^{37,38}\text{mK}$	$> 10^9$ pps
$^{211-213}\text{Fr}$	$> 10^9$ pps
^{225}Ra	$> 10^8$ pps
^{103}Rb	3 pps

Select accelerated RIBs:

$^{95}\text{Sr}^{15+}$	10^7 pps
$^{11}\text{Li}^+$	3×10^3 pps
$^{11}\text{Be}^+$	10^5 pps

Programs in

- Nuclear Structure & Reactions
- Nuclear Astrophysics
- Fundamental Symmetries
- Material Science
- Nuclear Medicine

- ~ 3500 RIB hours / yr
- 600 user community, 2/3 international
- Factor 2-2.5 oversubscribed
- ~ 2 year backlog
- Complementary capabilities to in-flight facilities like FRIB

ISAC Experimental Facilities

TITAN Penning Trap facility



Nuclear Structure
Nuclear Astrophysics
Fundam. Symmetries
Materials Science

EMMA recoil mass analyzer



TIGRESS in-beam gamma-ray spectrometer

Laser polarizer line



β NMR/NQR



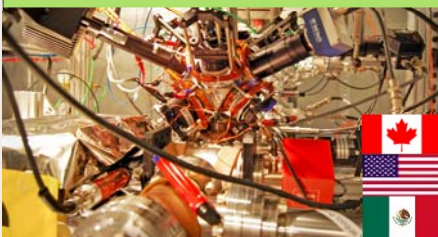
MTV Mott scatt. drift chamber



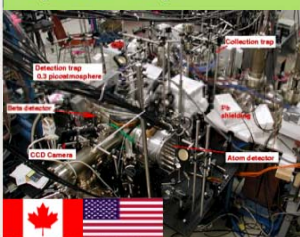
IRIS solid hydrogen reaction set-up



Francium trapping facility



TRINAT magneto-optical trap



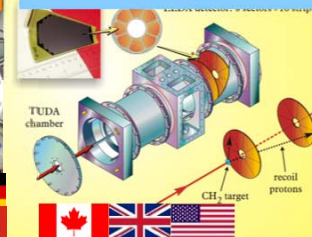
DESCANT neutr. det.



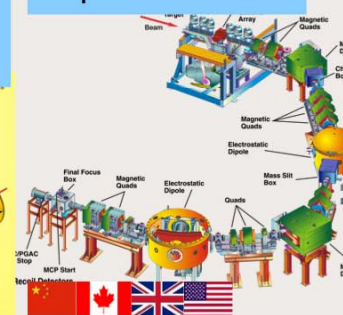
GRIFFIN decay spectrometer



TUDA reaction setup

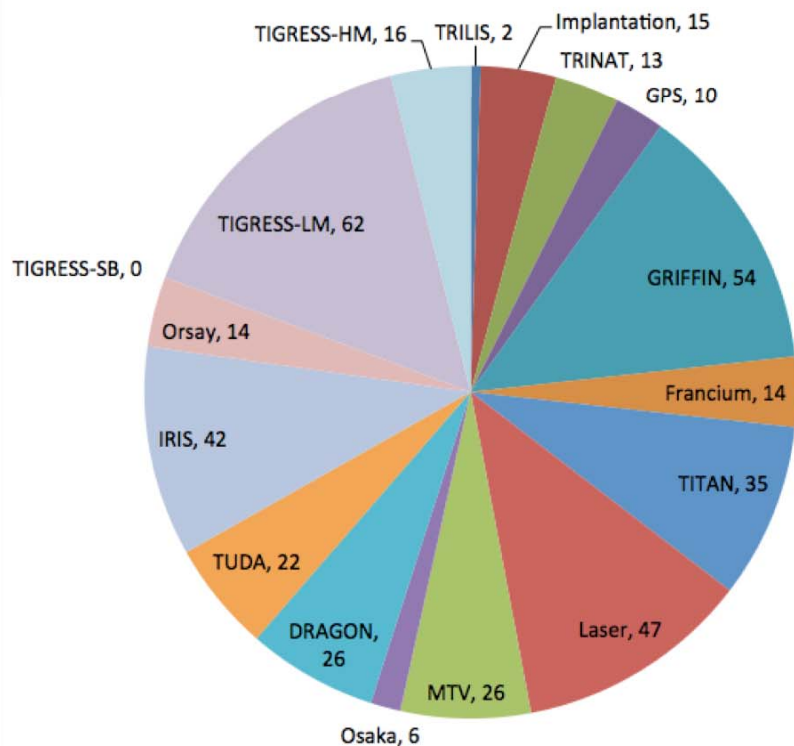


DRAGON recoil separator

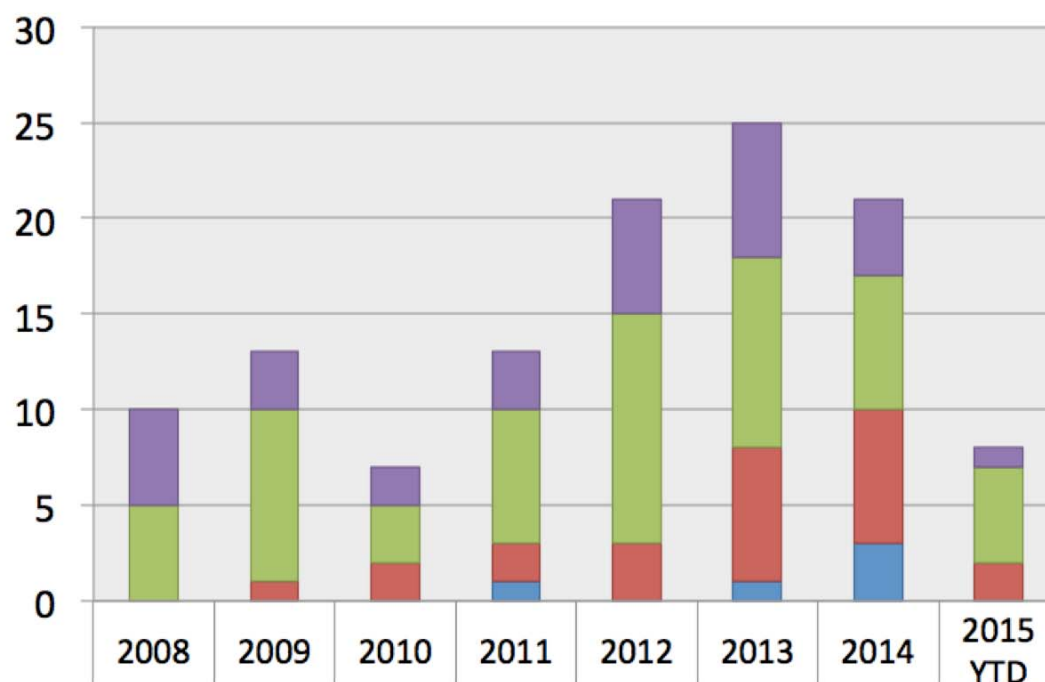


ISAC Productivity

Approved high-priority RIB shifts



ISAC publications



Not including: ISAC/ARIEL
Hyperfine Interactions: 31 articles
 in 2014

Letters	5	3	2	3	6	7	4	1
Phys. Articles	5	9	3	7	12	10	7	5
Tech. articles		1	2	2	3	7	7	2
Reviews			0	1	0	1	3	

Beyond Rare Isotopes

Beyond its work in Rare Isotope Physics, TRIUMF supports select experiments in particle physics

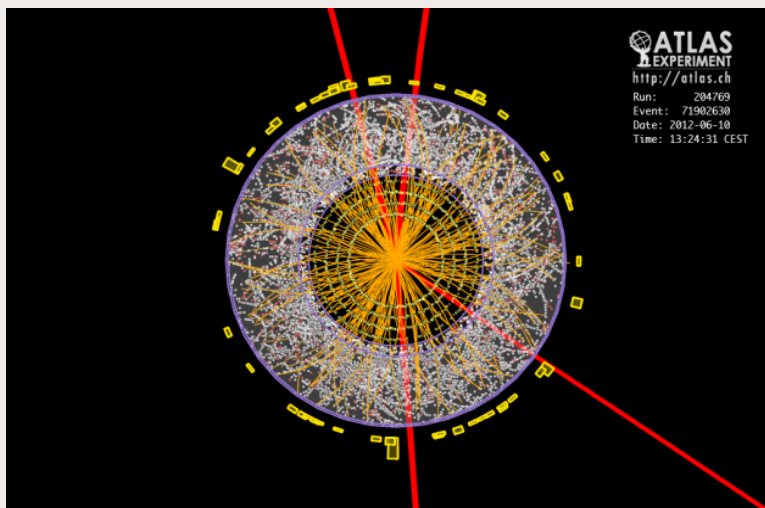
- PIENU – Test of e-mu universality
- UCN – Measurement of neutron EDM

TRIUMF also supports the Canadian subatomic physics community in its work at other laboratories, at home and abroad

- SNOLAB – SNO+, Super CDMS, DEAP, HALO, (nEXO)
- ATLAS ...
- ALPHA and ALPHA-g
- T2K – Measurement of θ_{23} ,
CP phase δ_{CP}



LHC & ATLAS



- The Higgs discovery had huge impact across Canada
 - It attracted attention from the press, the public, and the government
- With the LHC restart, new attention is being paid to Canada's contributions to CERN

ATLAS Computing

- Excellent Tier-1 performance; smooth 24x7 operations
- ~ 12% of global Tier-1 grid production tasks



- CERN-TRIUMF link increased to 10 Gbps
- Planning underway towards integration within Compute Canada



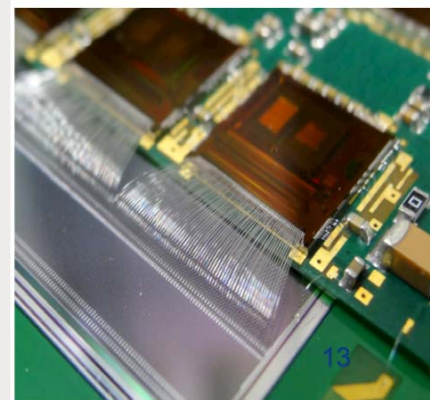
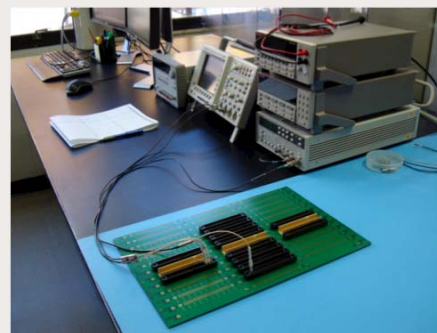
ATLAS Upgrades

- The LHC will be upgraded to higher luminosity during shut downs in 2018-19 and 2022-23 to provide 300 /fb and 3000 /fb by 2035
- ATLAS must be upgraded to cope with up to ~ 200 pile-up events

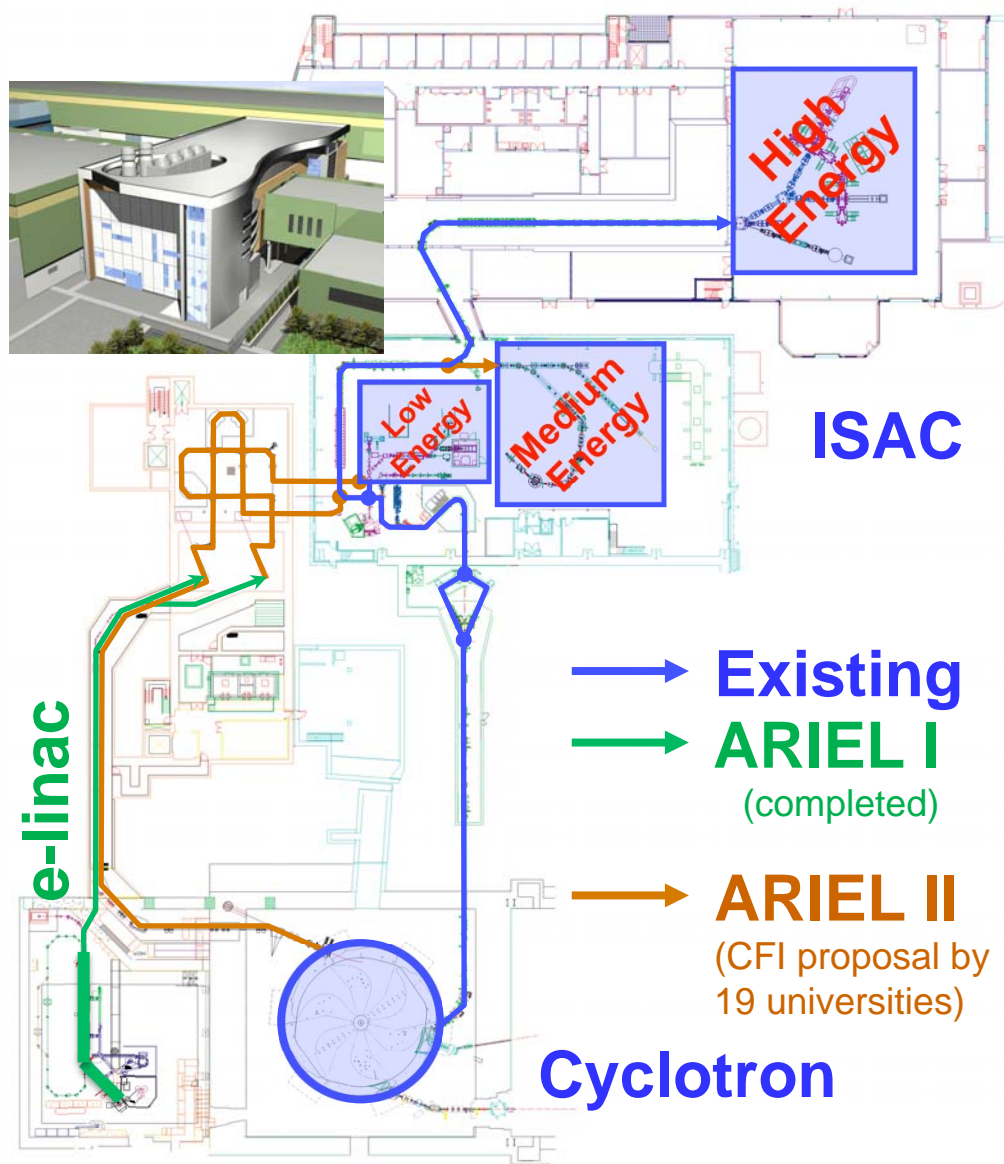
- **Canadian contributions to ATLAS Phase 1 upgrade**
 - High Precision Calorimeter Level-1 Trigger
 - Muon New Small Wheels with improved trigger
- **During Phase 2, ATLAS will install a new fully-Silicon based inner tracker.**
 - TRIUMF supports the ATLAS-Canada expression of interest for building parts of the new inner tracker
 - TRIUMF, SFU, UBC groups have started to prepare for production of silicon strip modules at TRIUMF



New Small Wheel
9 m



ARIEL: Advanced Rare Isotope Laboratory



TRIUMF's flagship project

Isotopes for Science, Medicine and Business

Expanding Canadian capabilities

- three simultaneous beams
- more "time" for science
- more and new isotopes
- more national & international users
- phased implementation
- interleave science with construction
- compete with the best in the world



- In 2014, the ARIEL-I project was completed on-time and on-budget



ARIEL Team

Engagement

- The TRIUMF-led NRCan ITAP consortium set new world records for the cyclotron-based production of Technetium-99m (Tc-99m)
- In recognition of its achievements, the team was awarded the 2015 NSERC Brockhouse Prize



ITAP Team

Engagement



Ed Holder, MP

Engagement



Chris Hadfield

Engagement

Over the past year, TRIUMF received letters of support from its network of commercial and community partners, including:

- Advanced Cyclotron Systems Inc.
- BC Cancer Agency
- BC Innovation Council
- Cisco Systems
- **Canadian Institute of Nuclear Physics**
- Centre for Probe Development and Commercialization
- D-Pace
- General Electric Healthcare Technologies
- IKOMED
- **Institute of Particle Physics**
- iROC Technologies
- Lawson Health Research Institute
- MacDonald, Dettwiler and Associates (MDA)
- Nordion
- Northstar Medical Radioisotopes
- PAVAC
- Science World British Columbia
- UBC PET / Djavad Mowafaghian Center for Brain Health



Budget 2015

- Released on April 21, 2015, Economic Action Plan 2015 contained \$45M in new funding for TRIUMF, and also reaffirmed the government's commitment to the laboratory
- Although CAPTURE did not receive the full \$68M requested, the funding we received will preserve TRIUMF's capacity for the next five years





Investing in Canada's Premier Strengths in Physics

Economic Action Plan 2015 proposes to provide an additional \$45 million over five years, starting in 2015–16, to enable TRIUMF to continue to advance its world-leading research activities.

TRIUMF, located in Vancouver, is Canada's premier physics laboratory and home to the world's largest cyclotron particle accelerator. The facility brings together leading scientists, postdoctoral fellows and graduate students from across Canada through a unique 18-member university alliance, and connects these talented individuals with leading counterparts from around the world to explore the fundamental structure and origins of matter. Through TRIUMF's ambitious international partnerships, Canadian researchers have been at the centre of some of the most important international research projects, most recently making critical contributions to the discovery of the Higgs Boson particle at the Large Hadron Collider at the European Organization for Nuclear Research.

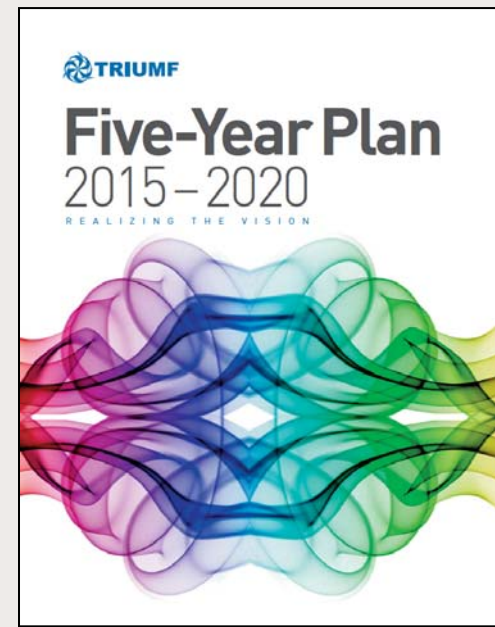
TRIUMF has also forged highly successful partnerships with industry leaders in order to commercialize its scientific breakthroughs. It is recognized globally for its innovative work in the production of the world's most popular medical isotopes with Nordion, used for treating thyroid, breast and other cancers. TRIUMF's contribution to the safe and reliable production of medical isotopes in hospitals has earned one of its research teams the Natural Science and Engineering Research Council's 2015 Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering.

Economic Action Plan 2015 proposes to provide \$45 million over five years, beginning in 2015–16, to enable the continuation of world-leading research taking place at TRIUMF. The Government expects TRIUMF's research partners and end-users, including health care organizations and businesses, to also increase their contributions towards the continued success of the facility, in order to fully capture the scientific and economic opportunities arising from public investments to date.

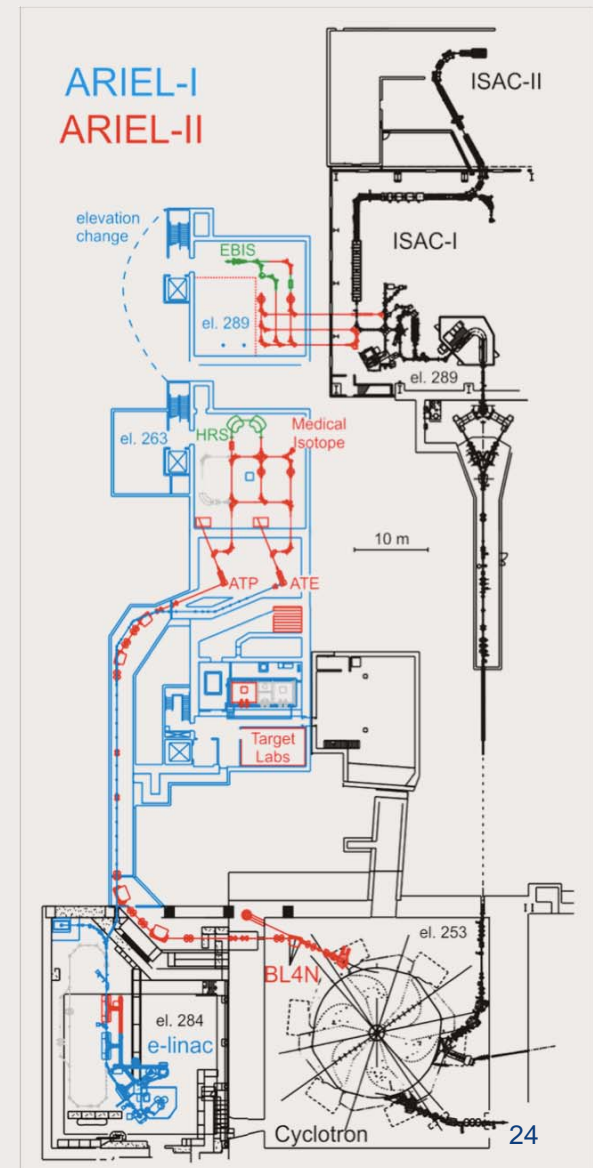
“The Government expects TRIUMF’s research partners and end-users, including health care organizations and businesses, to also increase their contributions towards the continued success of the facility, in order to fully capture the scientific and economic opportunities arising from public investments to date”

Five-Year Plan 2015 – 2020

- With operational funding confirmed at ~\$269M for the next five years, we are now in position to set firm priorities for the next Five-Year Plan
 - TRIUMF's activity over the next five years will be focused in the following priority areas:
 - ARIEL-II
 - Nuclear and Particle Physics
 - Nuclear Medicine
 - Materials Science
 - Commercialization
- as well as
- Safe and Efficient Operation



Priority: ARIEL-II



- Bringing together all 19 member universities, ARIEL represents TRIUMF's future
- Advancing ARIEL will be TRIUMF's highest priority project over the next five years

ARIEL-II Phases

Phase 1: Beta-NMR

- Design, construct and commission the electron target station plus the required shielding and RIB transport beam lines, to deliver beam to ISAC I's Beta-NMR experiment.

Phase 2: Photo-fission

- Design, construct and commission the necessary upgrades for the electron target station to utilize an actinide target for photo-fission. The upgrades will include nuclear ventilation, the ALIS, actinide radio-chemistry lab, and additional safety systems.

Phase 3: CANREB

- Design, construct and commission the RIB transport beam lines to support the P0310 CANREB project deliverables. The CANREB project's main deliverables are the HRS, the EBIS, and the Nier Spectrometer.

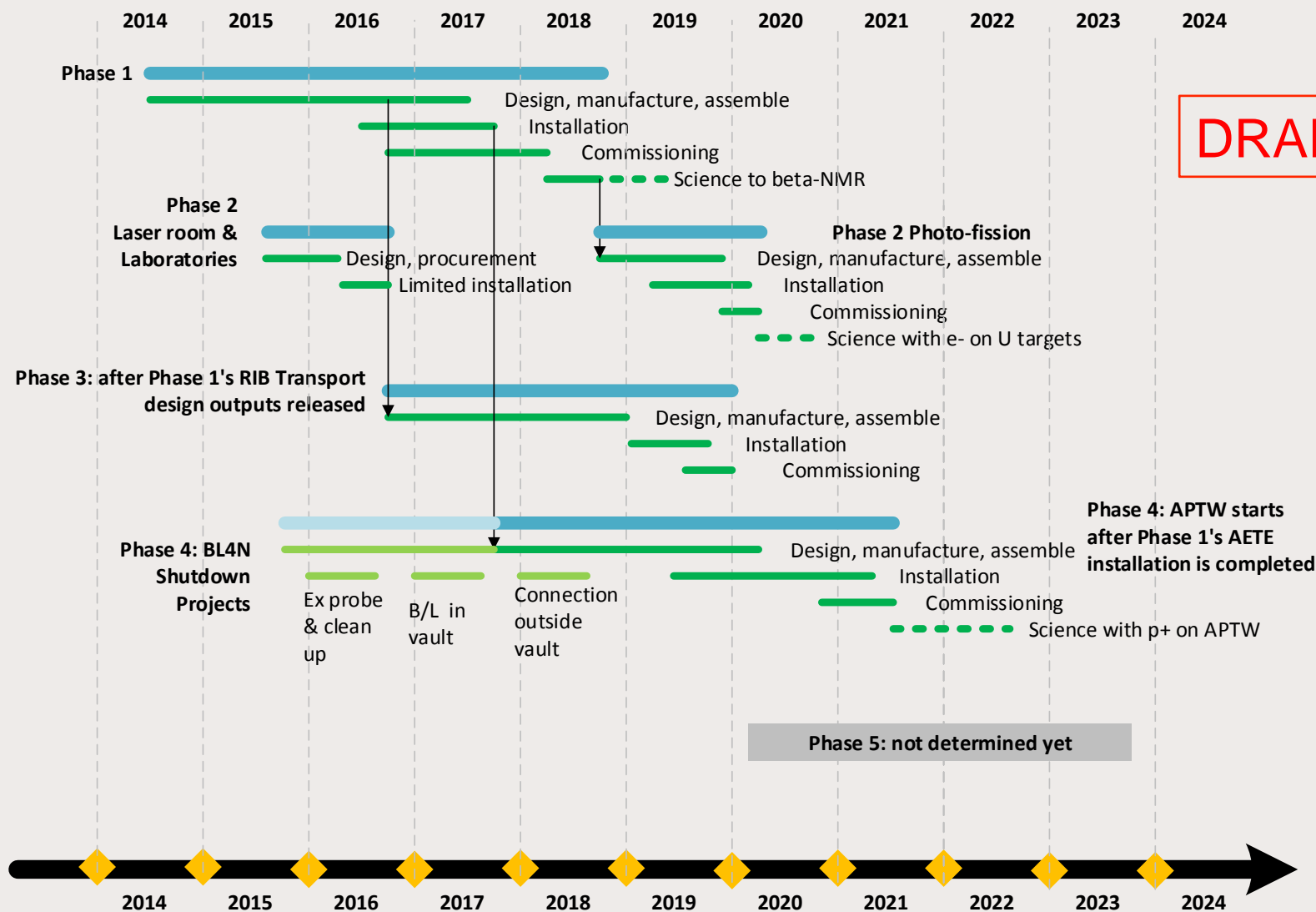
Phase 4: BL4N

- Design, construct and commission the proton target station and the required RIB transport beam lines to connect to the beam lines constructed in Phase 1 and Phase 3. Construct the BL4N proton driver beam line from the cyclotron 4N extraction port to the proton target station.

Phase 5: High Power Photo-fission

- Upgrade the e-linac driver to deliver a high power electron beam to the electron target station, and develop a high-power photo-converter to accept this high power beam.

ARIEL-II Phase Logic



ARIEL-II Funding

- Building on the successful completion of ARIEL-I, the ARIEL-II project was recently approved and fully funded by CFI (\$13.6M)
- TRIUMF is awaiting decisions from the five provinces (AB, BC, MB, ON, QC) approached to match the CFI funding. \$4.16M has already been announced by ON.

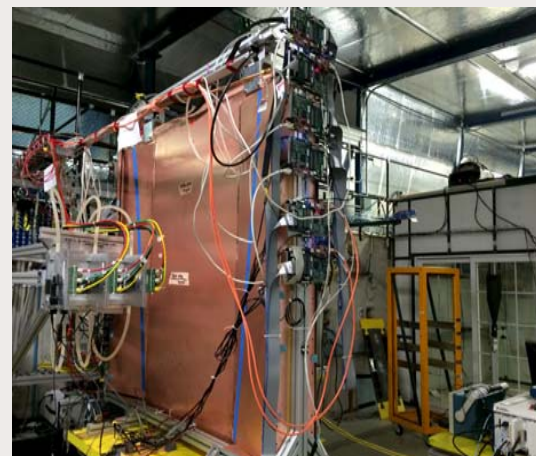
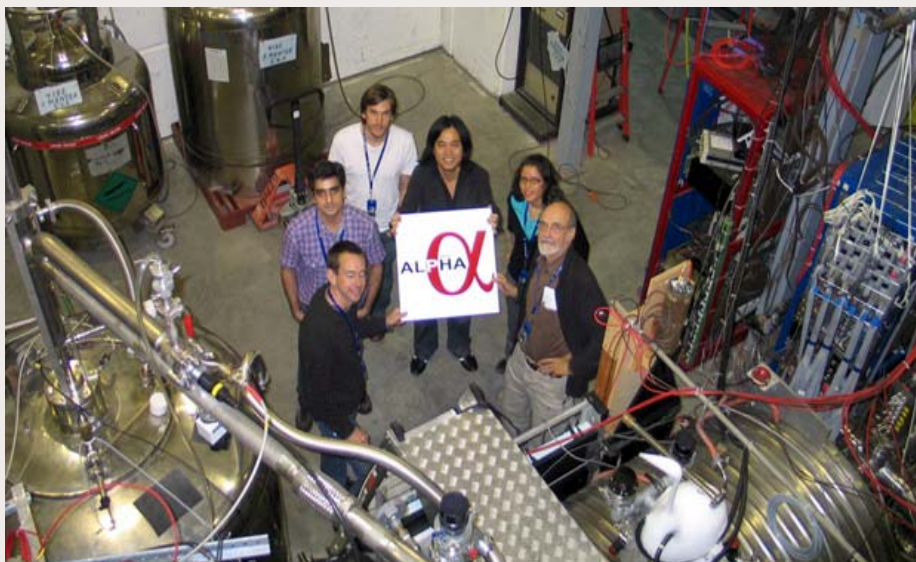


Priority: Nuclear and Particle Physics

- TRIUMF will serve the community as Canada's national laboratory for particle and nuclear physics
- High-level goals for the next five years include
 - Reinforcing TRIUMF's position as a world leading ISOL RIB facility (and the only one in North America)
 - Supporting Canadian participation in international particle physics experiments
 - Completing the UCN facility

CFI Funding

- Recent CFI Wins:
 - ATLAS Upgrades – \$6.1M
 - ALPHA-g – \$6.3M
 - GRIFFIN Upgrades – \$1.4M



Four joint positions with member universities –
bridging to faculty appointments over 5-6 years

- Carleton
 - Razvan Gornea (Bern). EXO
- Guelph
 - Dennis Muecher (TU Munich). ISAC
- McGill
 - Thomas Brunner (Stanford). EXO, TITAN
- Winnipeg
 - Offer imminent. UCN

Priority: Safe and Efficient Operation

- Over the next five years, TRIUMF will continue to emphasize safe and efficient operation. Safety is and will be TRIUMF's highest priority
 - A recent incident highlighted need for focused attention, on the part of employees and users alike
- Safety improvements are already underway, and will continue over the next five years
 - Laboratory is moving from a reactive to proactive stance
 - New identity management system and visitor policies are being developed
 - ✓ Everyone needs to take site-wide safety training

Priority: Safe and Efficient Operation

- In addition, TRIUMF will continue to build its site-wide risk registry, and use it to guide investments in key physical infrastructure, including
 - Site power, equipment, and mechanicals
 - Cyclotron refurbishing and power supply
 - ISAC refurbishment
 - Beamline 1A engineering study
 - Meson hall roof and facilities
 - Space expansion (including replacing trailers)

Example: 2015 Shutdown

Cyclotron

- Installed 5 new safety platforms for cyclotron elevating system
- Implemented Oxygen Deficiency System in cyclotron vault
- Implemented new cryo-generator compressor
- Replaced RF Dee-voltage cables (~50)
- Developed PLC-based controls for T1/T2 systems
- Released specs for Main Magnet PS

ISAC

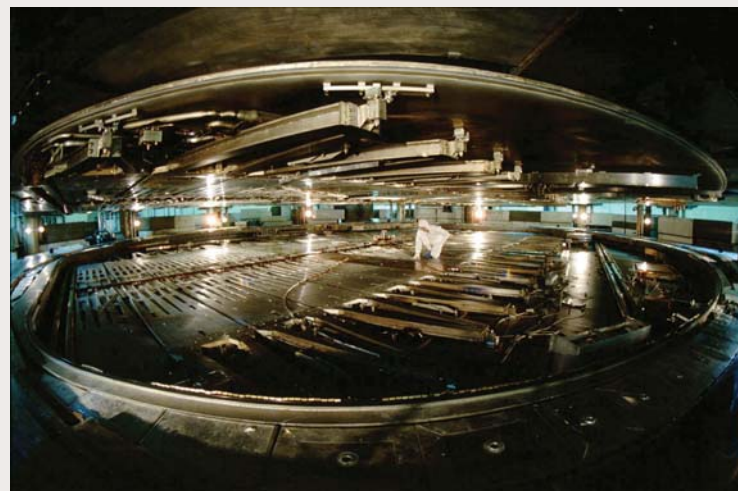
- Refurbished two ISAC-II cryomodules
- Upgraded ISAC-II LN2 infrastructure
- Added safety guardrails around targets

Meson Hall

- Replaced M15 magnets power supplies
- Establish alignment reference at M9/T2

UCN-driven

- Added beamline 1B steering magnet
- Installed UCN in-vault and BL1U components
- Decommissioned BL M1

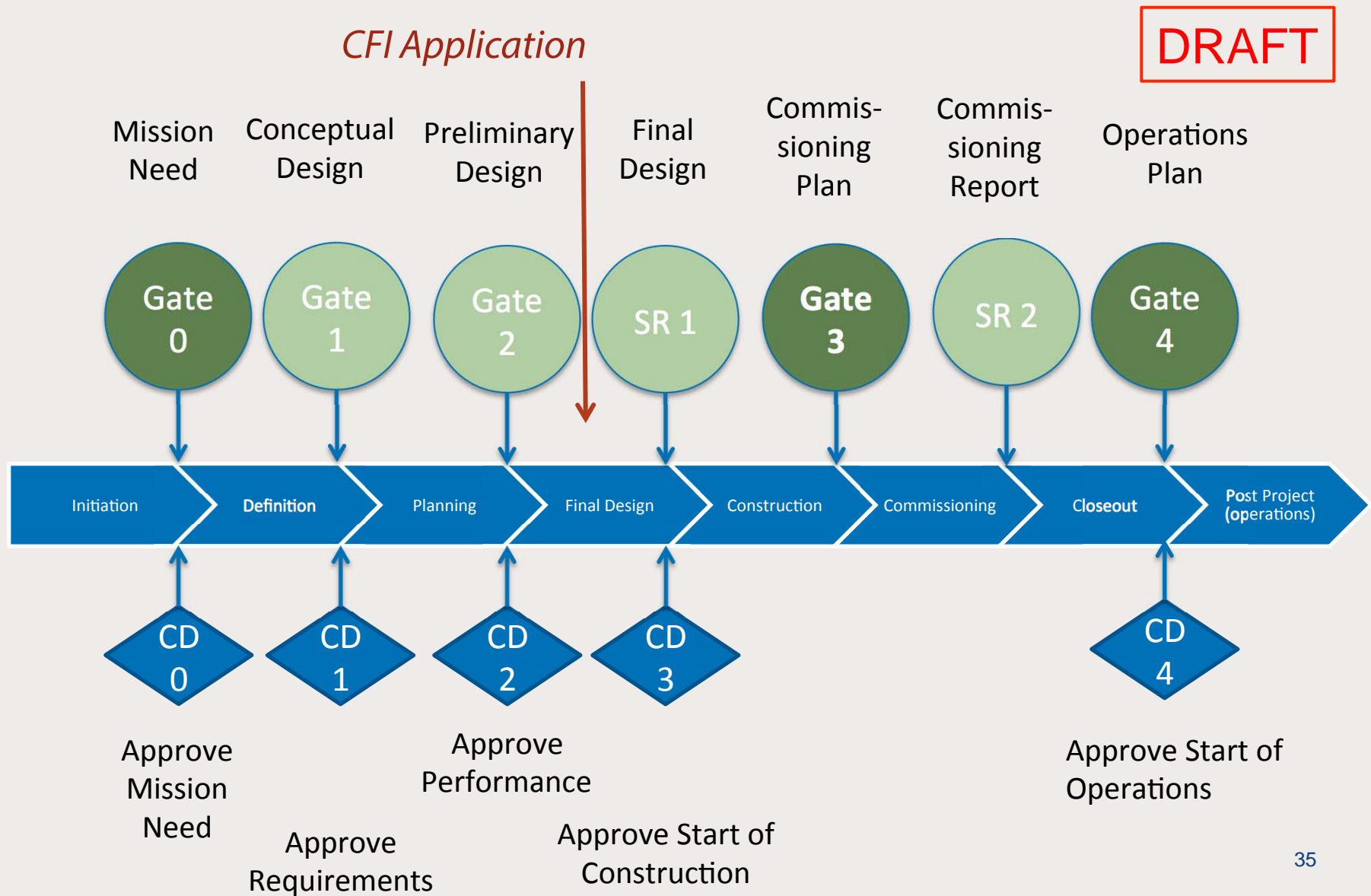


103 Tasks, 39 Projects

Priority: Safe and Efficient Operation

- Going forward, TRIUMF will require more effective project management
 - We will require additional Gate Reviews
 - New Readiness Review before start of commissioning
 - New Preliminary Design Review before CFI proposal submission
 - This will require more advance planning ...
 - Watch for a call for proposals this fall
 - (TRIUMF will align with Subatomic Long Range Planning process)

Project Management

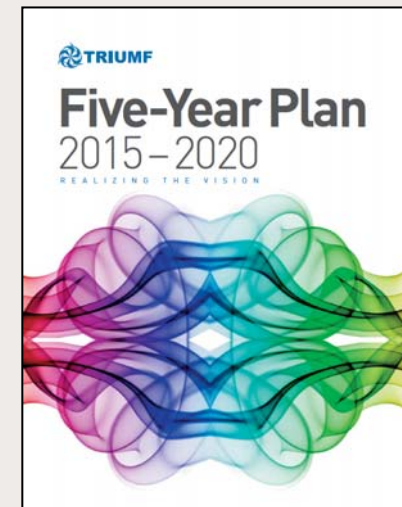


NRC Contribution Agreement (DRAFT)

- In Particle Physics, TRIUMF will support the Canadian community in alignment with the subatomic physics Long Range Plan. In particular, TRIUMF will support extracting and analyzing the physics from the T2K experiment in Japan and the ATLAS and ALPHA experiments at CERN. TRIUMF will complete the installation and commissioning of the UCN source at TRIUMF
- In Nuclear Physics, TRIUMF will support the Canadian and international community in alignment with the subatomic physics Long Range Plan. In particular, TRIUMF will exploit its rare-isotope beam capabilities from the ISAC targets and carry out first experiments with rare-isotope beams from the e-linac. TRIUMF will also complete the upgrade of the GRIFFIN spectrometer
- With respect to the Advanced Rare Isotope Laboratory, the ARIEL-II project will enable:
 - Delivery of e-linac-driven rare isotope beam for the betaNMR program;
 - Delivery of e-linac-driven rare isotope beam from photofission on actinide targets; and
 - Installation and commissioning of the CANREB infrastructure

Conclusions

- TRIUMF is a strong laboratory. It has a compelling mission, a clear vision and achievable goals. It is an organization of which Canada should be proud
- With its funding secured, TRIUMF is prepared to execute upon its Five-Year Plan
 - ARIEL-II
 - Nuclear and Particle Physics
 - Nuclear Medicine
 - Materials Science
 - Commercialization
- TRIUMF is refining processes and procedures to ensure safe and efficient operation



Thank you!

Merci!

TRIUMF: Alberta | British Columbia |
Calgary | Carleton | Guelph | Manitoba |
McGill | McMaster | Montréal | Northern
British Columbia | Queen's | Regina |
Saint Mary's | Simon Fraser | Toronto |
Victoria | Western | Winnipeg | York

