

Introduction to TRIUMF

Reiner Kruecken | Science Division Head | TRIUMF

February 18, 2014

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



Canada's National Laboratory for Particle and Nuclear Physics



~ 500 people on site
~100 students & postdocs

Members

University of Alberta
University of BC
Carleton University
University of Guelph
University of Manitoba
Université de Montréal
Queen's University
Simon Fraser University
University of Toronto
University of Victoria
York University

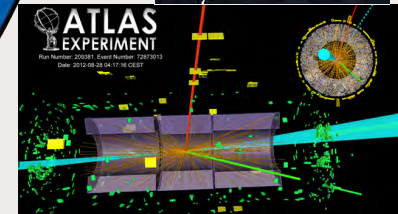
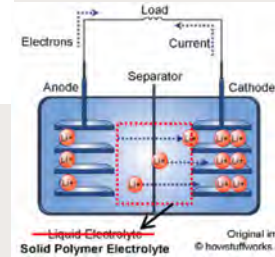
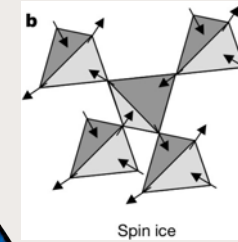
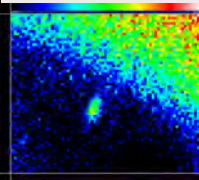
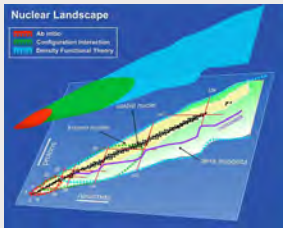
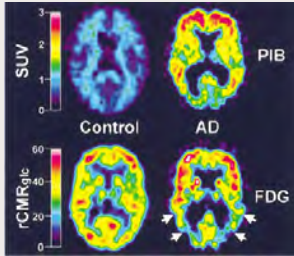
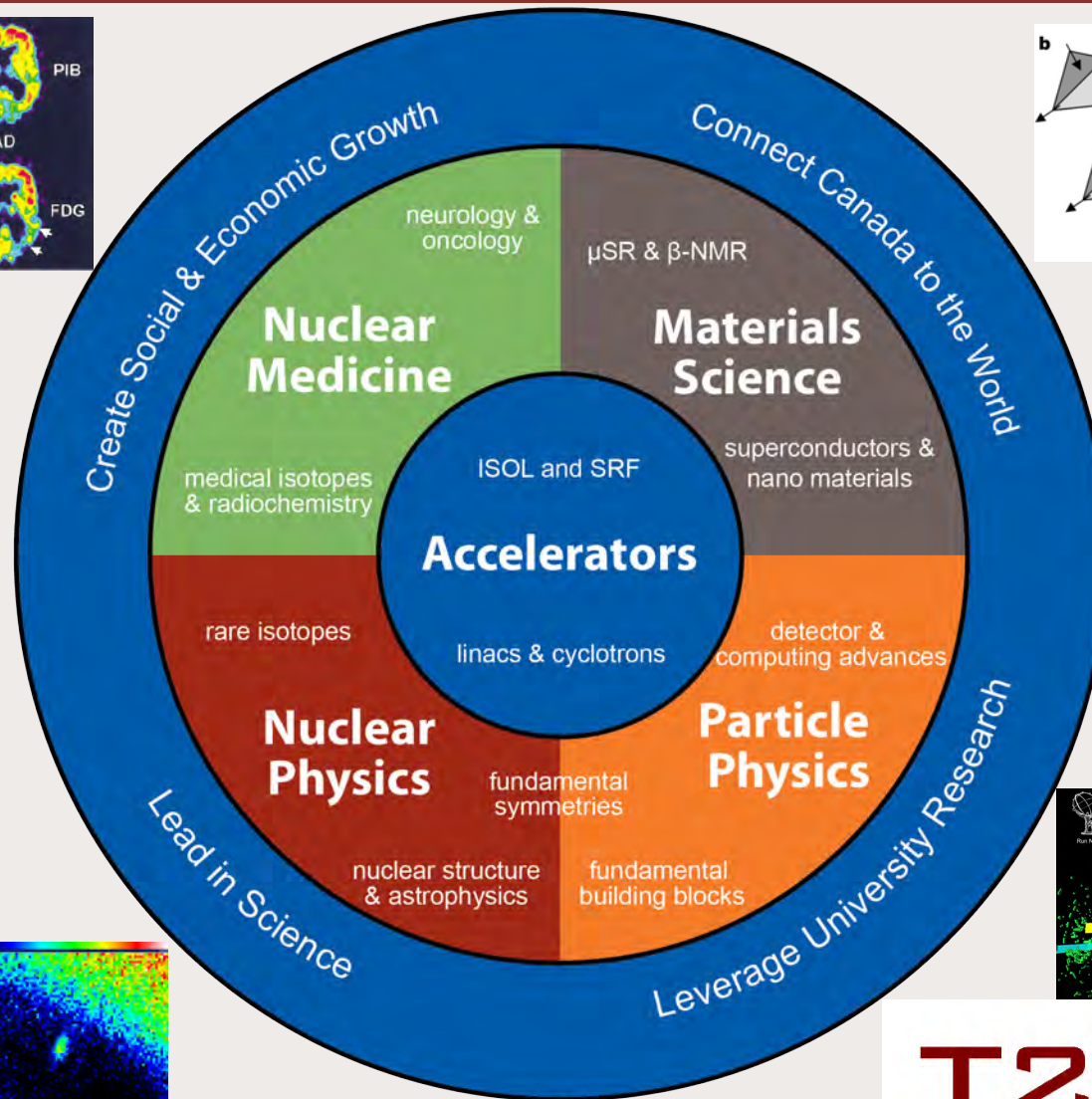
Associate Members

University of Calgary
McGill University
McMaster University
University of Northern BC
University of Regina
Saint Mary's University
University of Winnipeg

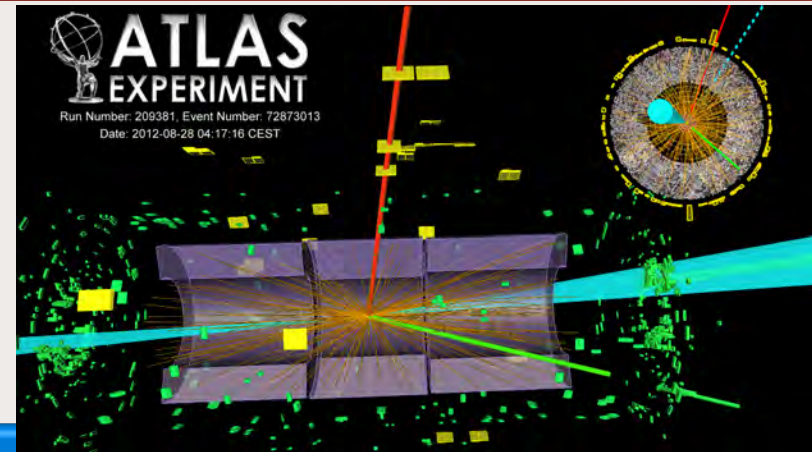
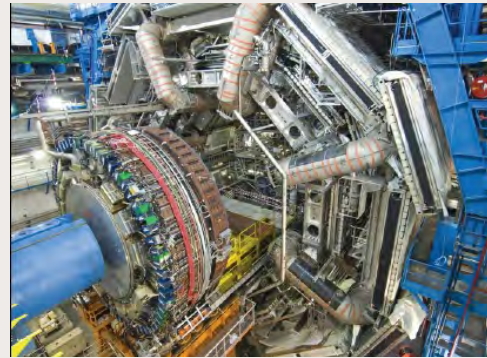
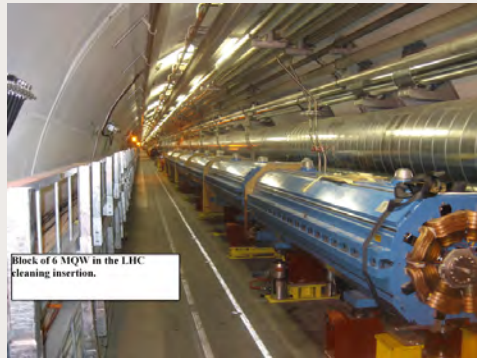
- Advancing isotopes for science and medicine
- Understanding the building blocks of matter and how they shape our universe
- Harnessing particles and beams to drive discovery and innovation

TRIUMF is owned & operated by a consortium of 18 universities
Founded 45 years ago in Vancouver, Canada

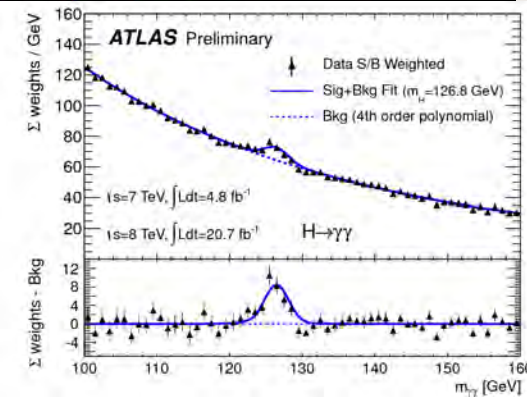
TRIUMF's Research Program



LHC and ATLAS



- Construction of LHC components and ATLAS sub-detector
 - LAr hadronic endcap, forward calorimeter, kicker magnets
- ATLAS Canada comprises ~200 scientists and students
- Leading involvement in physics exploitation, e.g. Higgs
- Tier-1 data centre, 10% of ATLAS data
 - 4832 cores, 7.2 PB disk, 5.5 PB tape.



Tokai to Kamioka (T2K) Canada - Long Baseline Neutrino Oscillations

Accelerator technologies

Detector Technologies & Electronics

- Fine grain detector and TPCs of near detector
- Front end electronics incl. cooling systems
- Data acquisition, slow control

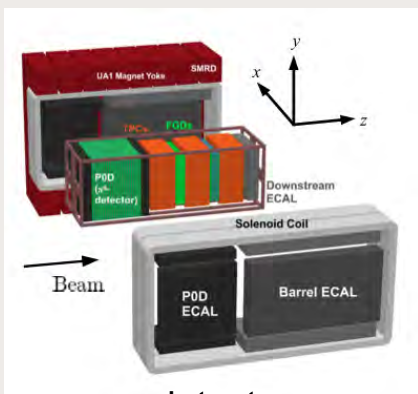
Analysis centre

- Tier-1 centre at TRIUMF
- Key oscillation analysis
- New Super-K analysis tools



T2K produces ν_μ and looks for:

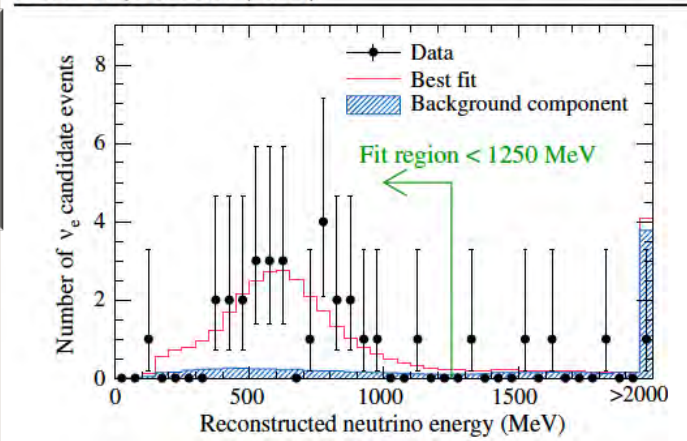
- disappearance of ν_μ
- appearance of ν_e



near detector

28 ν_e candidate events observed
 $\sin^2(2\theta_{23})=1.00$ & $|\Delta m_{23}^2|=2.44 \times 10^{-3} \text{ eV}^2$
 $\sin^2 2\theta_{13} = 0$ excluded with 7.5σ

PRL 112, 061802 (2014) PHYSICAL REVIEW LETTERS

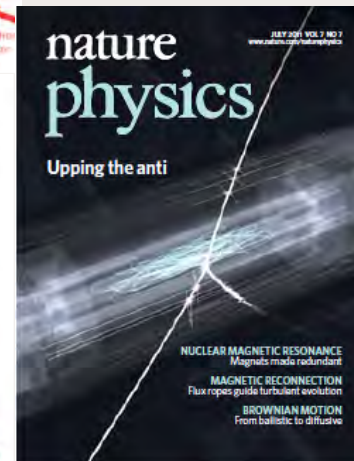
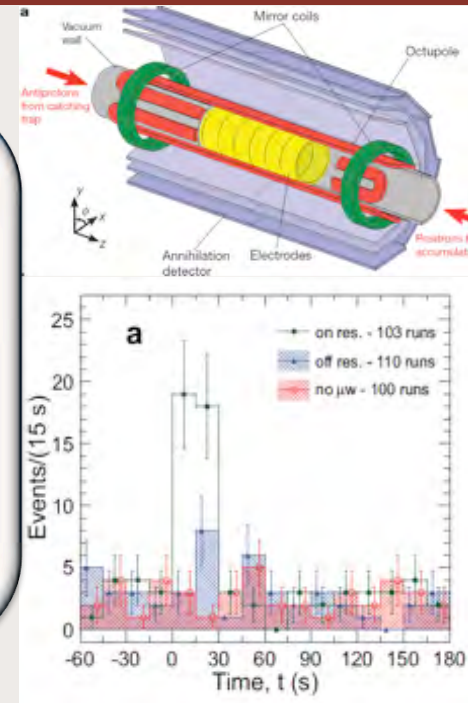


ALPHA – antihydrogen trapping and spectroscopy

- create and trap cold antihydrogen
- perform microwave and laser spectroscopy
- compare to hydrogen for test of CPT

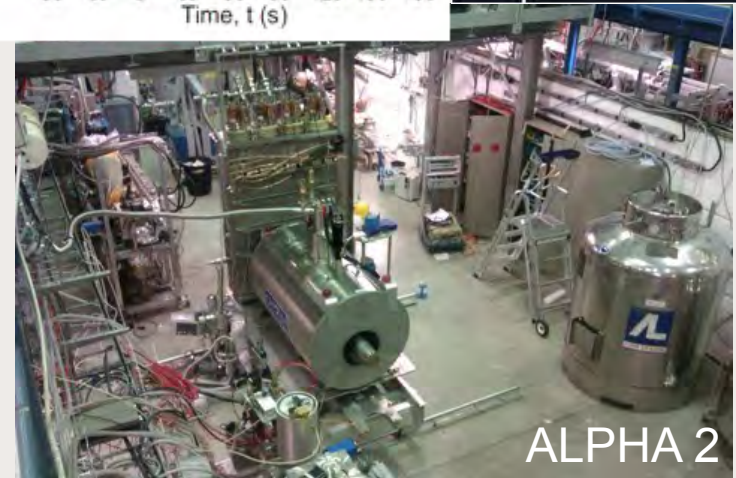
Highlights:

- First trapping in 2010 (1000s storage achieved!)
- First microwave spectroscopy in 2012



ALPHA 2 ready for beam

- Decoupling of trapping and spectroscopy
- laser and more sensitive microwave spectroscopy



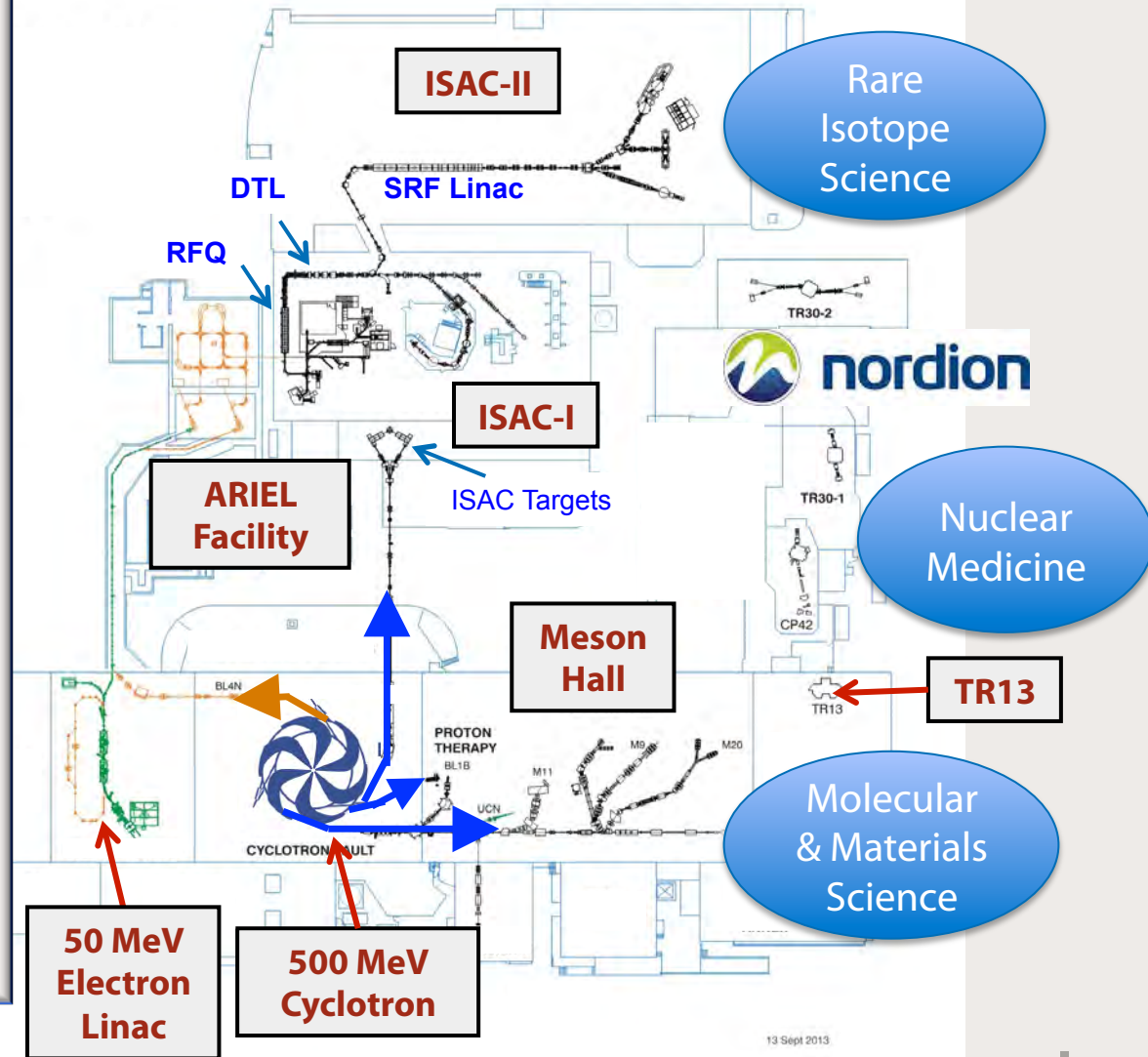
ALPHA 2

Major thrust: Isotopes for Science and Medicine

- Isotopes for developing a standard model for nuclear physics;
- Isotopes to determine how and where the heavy elements were produced in the universe;
- Isotopes as laboratories to search for new forces in nature;
- Isotopes as probes of magnetism at interfaces and surfaces of new functional materials; and
- Isotopes for molecular imaging of diseases and treatment of cancer.

TRIUMF accelerator complex

- 500 MeV H⁻ cyclotron (1974)
 - 4 medical isotope cyclotrons
 - ISAC heavy ion LINAC
-
- **Isotope Separator and Accelerator (ISAC) Facility**
 - highest power Isotope Separation On-Line (ISOL) facility worldwide
 - only ISOL in North America
 - only ISOL with > 5 MeV/u accelerated beams
-
- **Advanced Rare Isotope Laboratory (ARIEL)**
 - 50 MeV 500 kW electron LINAC
 - new proton beamline for ISOL



Future Ultra Cold Neutron facility

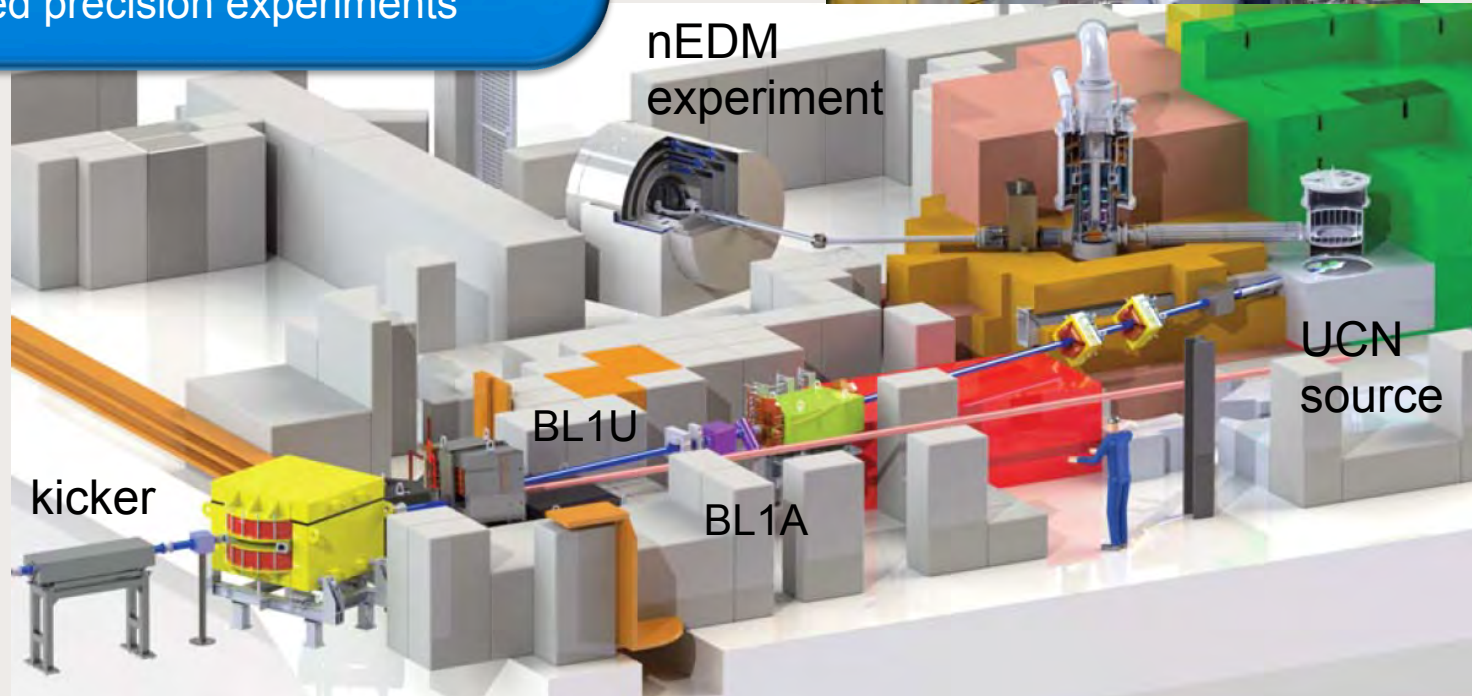
- Japan-Canada collaboration
- Source concept and EDM apparatus developed and being tested at RCNP Osaka
- Installation of new beam line and source at TRIUMF 2014/5, source in 2016
- Builds on TRIUMF extensive experience in accelerator based precision experiments



2016:
start of program
(1-20 μA)

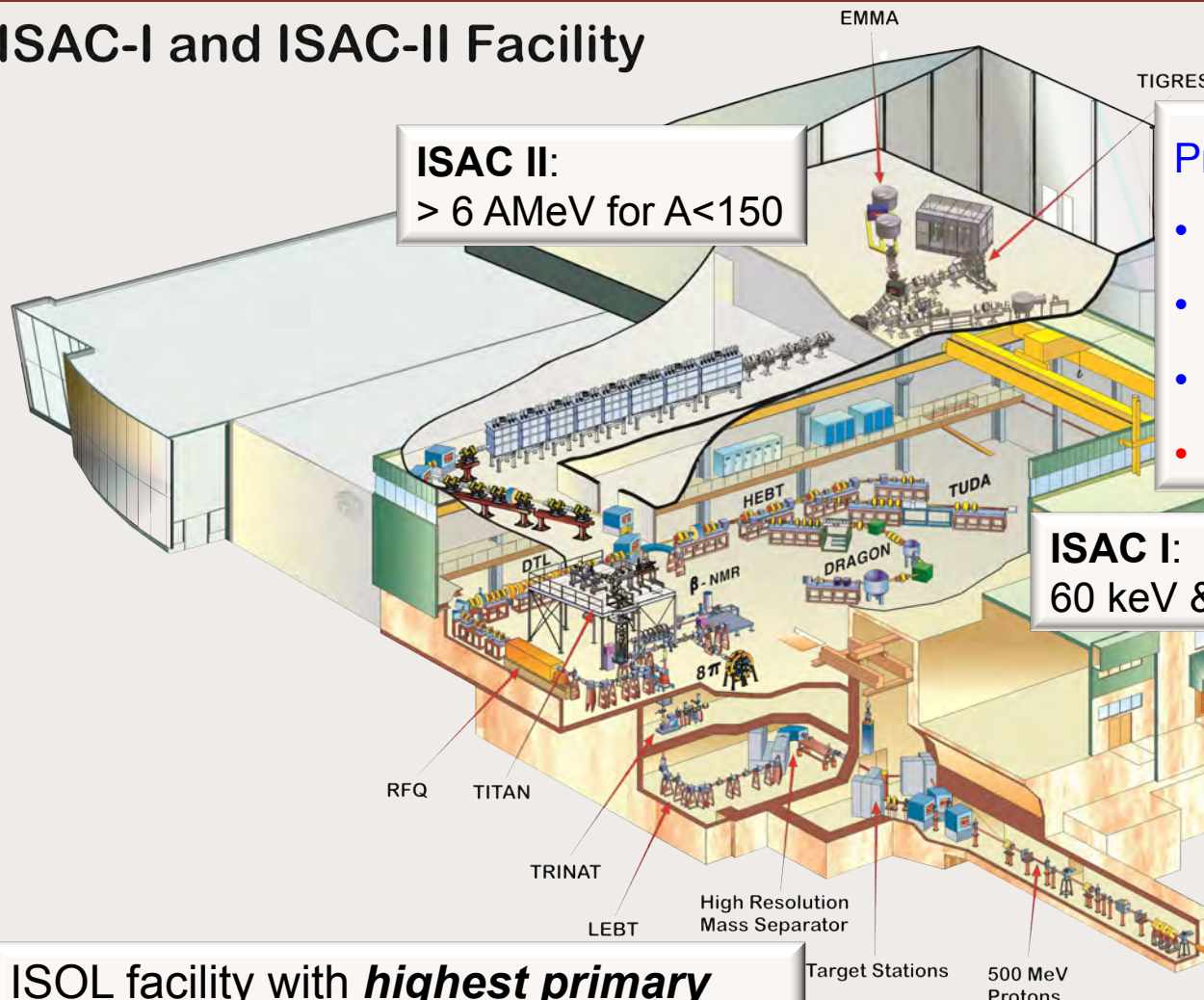
2017-18:
Expand cooling
capacity
(40 μA)

~ 2020:
world leading nEDM
sensitivity



ISAC rare isotope facility

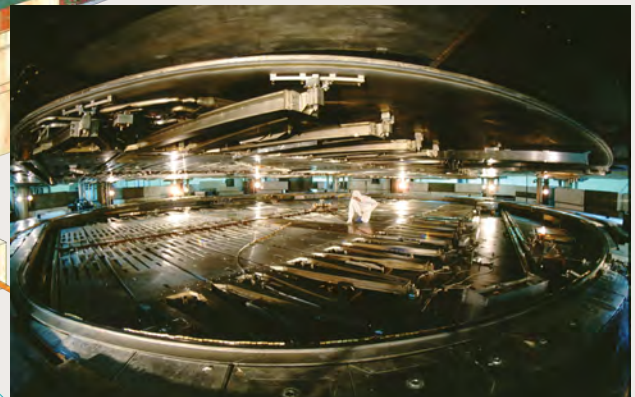
ISAC-I and ISAC-II Facility



ISAC II:
 $> 6 \text{ AMeV for } A < 150$

- Programs in
- Nuclear Structure & Dynamics
 - Nuclear Astrophysics
 - Electroweak Interaction Studies
 - **Material Science**

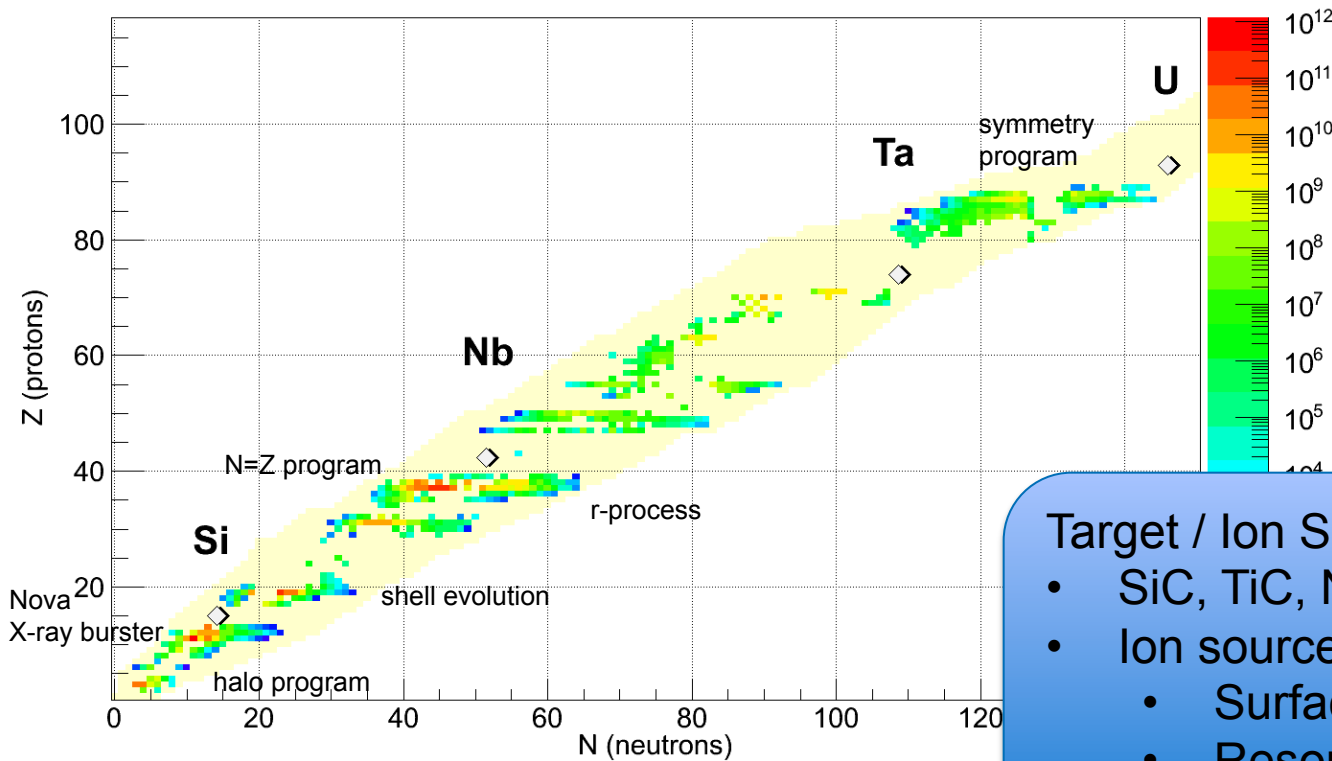
ISAC I:
 $60 \text{ keV} \ \& \ 1.7 \text{ AMeV}$



ISOL facility with **highest primary beam intensity** ($100 \mu\text{A}, 500 \text{ MeV}, p$)

Isotopes delivered at ISAC

Yield Chart of Nuclides

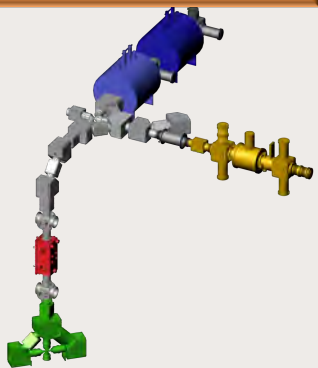


Target / Ion Sources:

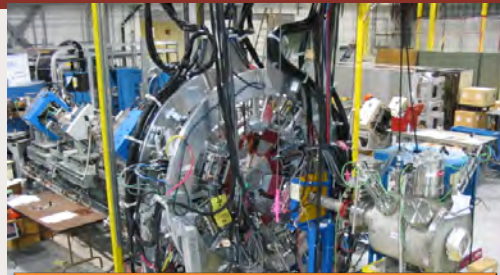
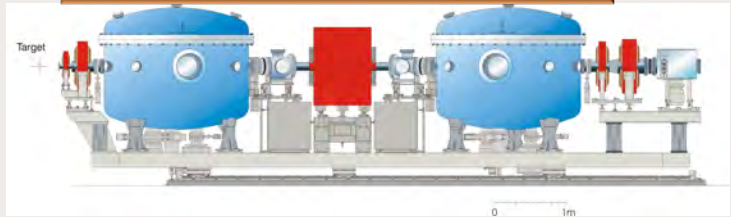
- SiC, TiC, NiO, Nb, ZrC, Ta, UC
- Ion sources:
 - Surface
 - Resonant Laser
 - FEBIAD

Leading edge ISAC experiments

TITAN Penning Trap facility



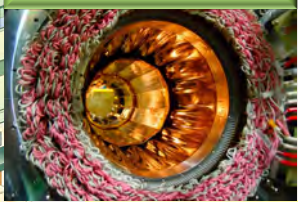
EMMA recoil mass analyzer (2015)



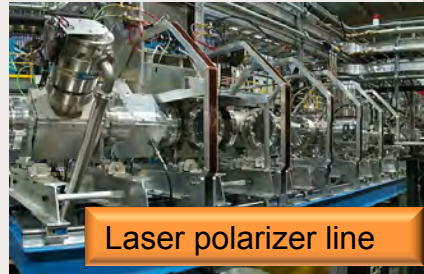
TIGRESS in-beam gamma-ray spectrometer

- Nuclear Structure
- Nuclear Astrophysics
- Fundam. Symmetries

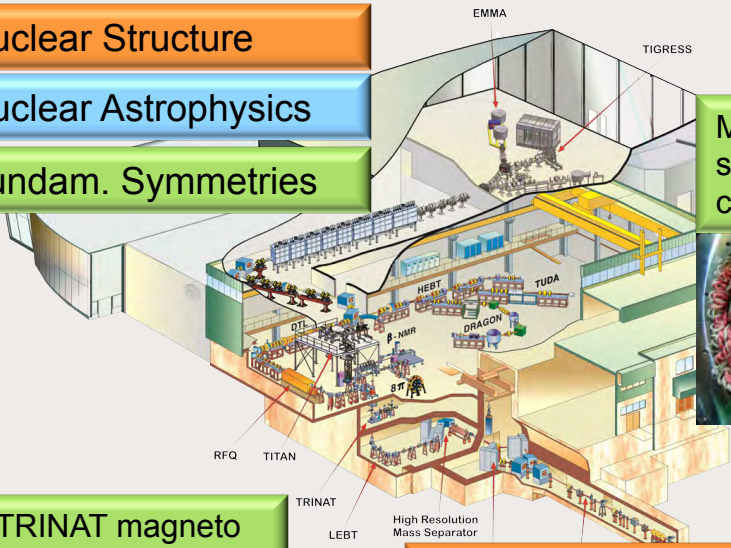
MTV Mott scattering drift chamber



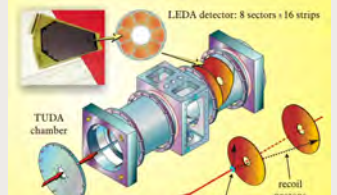
IRIS solid hydrogen reaction set-up (2012)



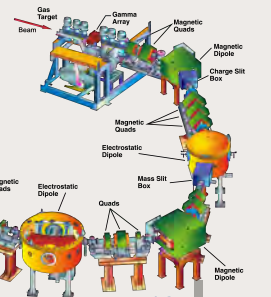
Laser polarizer line



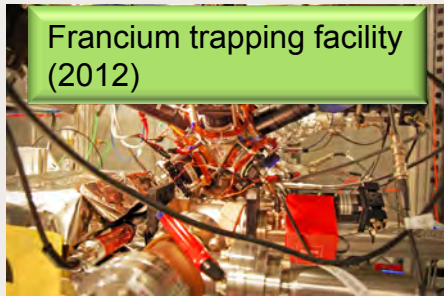
DRAGON recoil separator



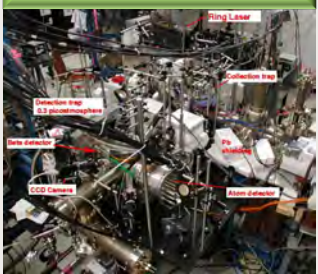
TUDA reaction setup



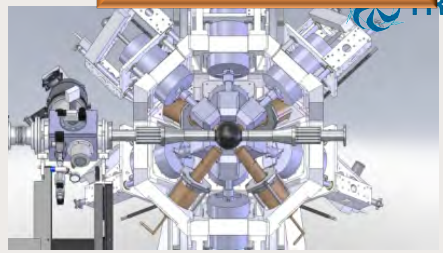
Francium trapping facility (2012)



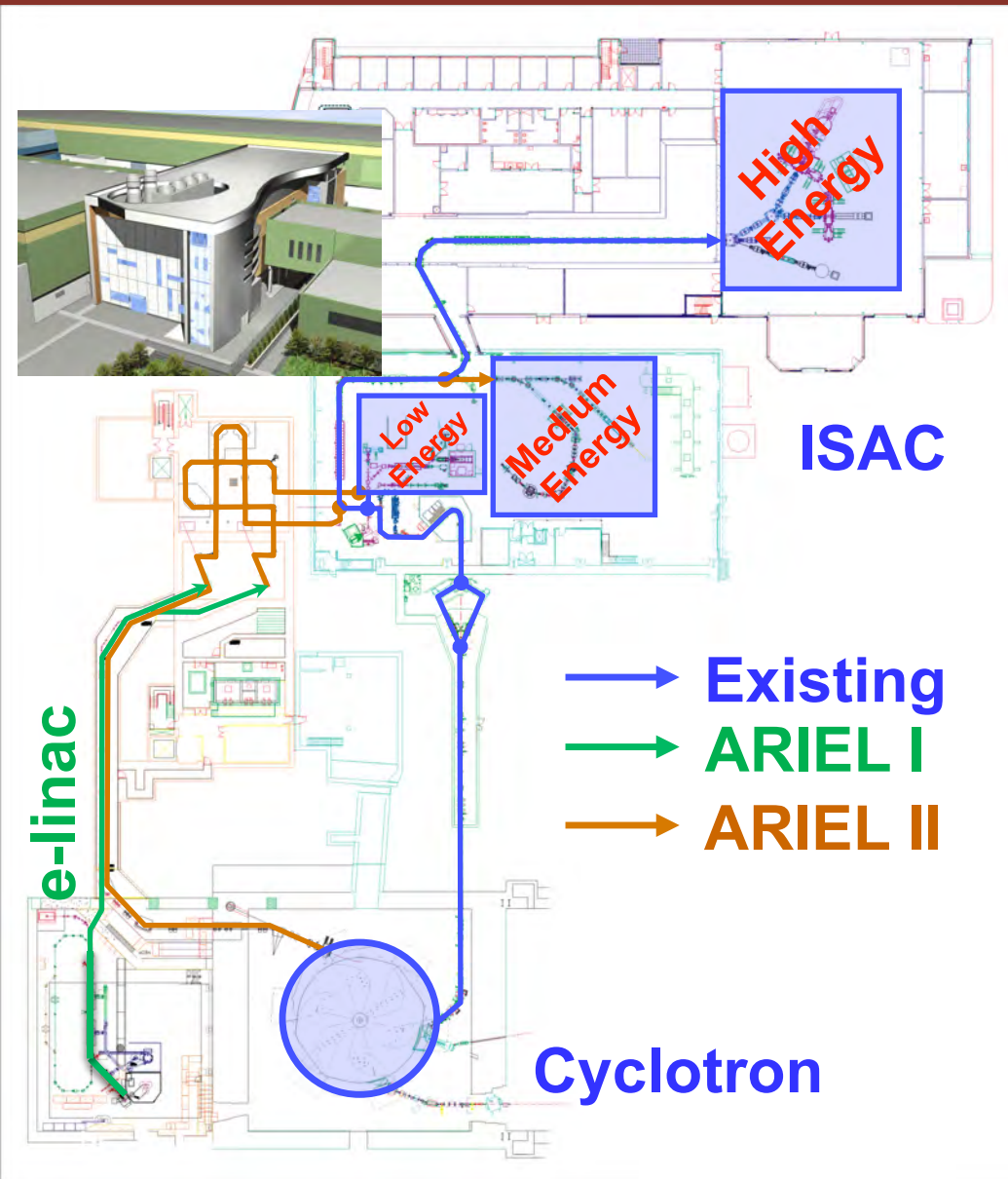
TRINAT magneto optical trap



GRIFIN gamma-ray decay spectrometer



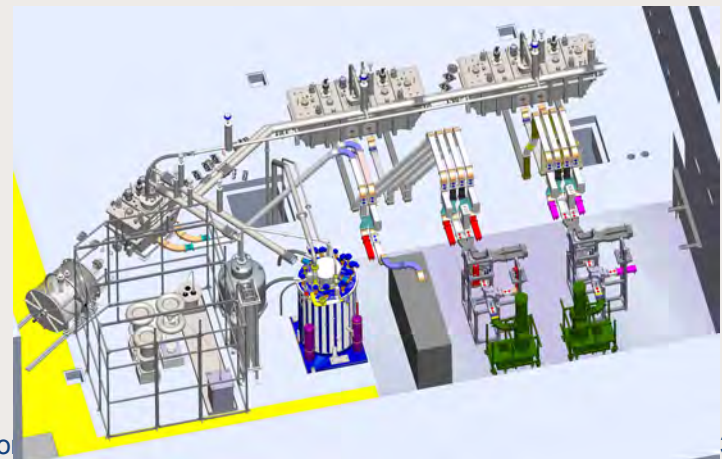
Advanced Rare Isotope Laboratory



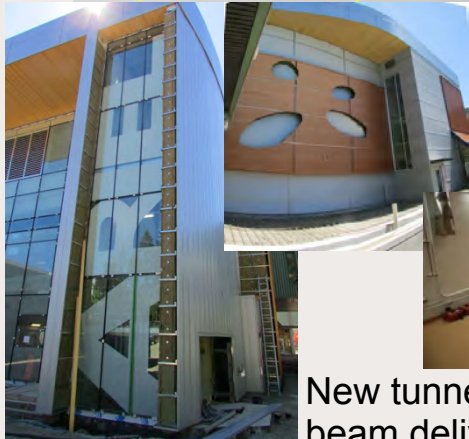
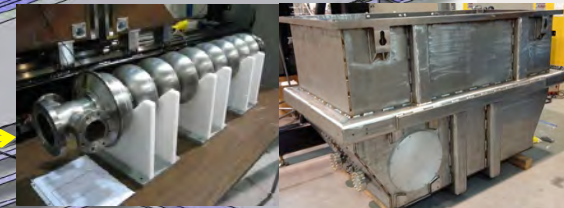
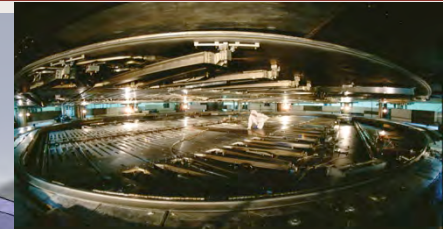
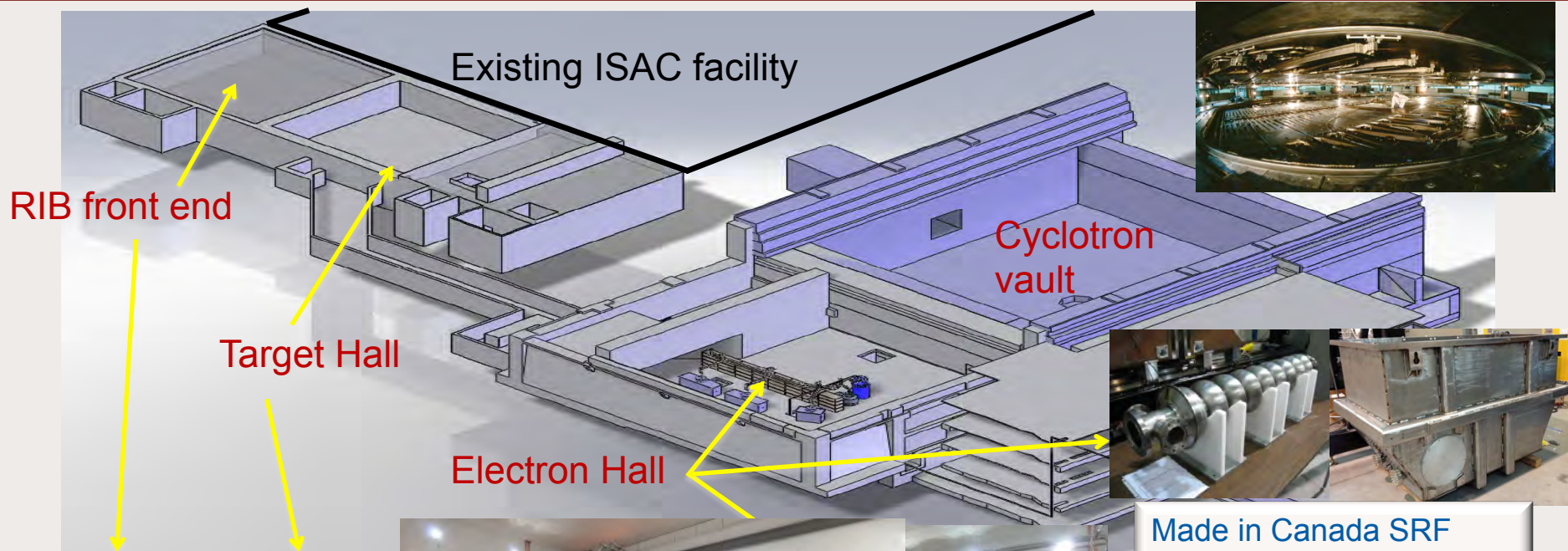
ARIEL is TRIUMF's flagship: isotopes for science & medicine

Substantially expands RIB capabilities

- Three simultaneous beams
- More "time" for science
- More and new isotopes
- More national & international users
- Phased implementation
- Interleave science with construction



ARIEL construction



New tunnel and target / beam delivery building



Made in Canada SRF technology (PAVAC)

100 kW, 25 MeV electrons by end of **2014**

500 kW, 50 MeV electrons by **~2020**

- Reconfigured hall for e-linac
- Cryo-systems, klystron installed
- Beam line installation started
- First operation of injector cryo module in May



Thank you!

Merci!

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

