

NSERC/TRIUMF five year plans

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The Long-Range Plan for Canadian Subatomic Physics: 2011-2016

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Canadian Subatomic Physics Long Range Plan

Context

- Under NSERC's aegis, the Canadian Subatomic Physics community establishes its scientific priorities through five-year Long Range Plans (LRPs).
- The LRP process is driven by the community through extensive consultations (briefs, town hall meetings, etc.).
- Particle and Nuclear Physics sub-communities work together in establishing the LRP.
- A Blue-ribbon committee reviews the community's input and formulates the Long-Range Plan.
- The latest recent Long-Range Plan covers the period 2011-2016, and includes a look ahead to 2021.

The Subatomic Universe: Canada in the Age of Discovery 2011-16
(www.subatomicphysics.ca)

Canadian Subatomic Physics Long Range Plan

Context

- TRIUMF is Canada's national laboratory for Nuclear and Particle Physics research and related sciences.
- Establishes five-year plans for its scientific priorities and operations through extensive consultations with community.
- Timing of TRIUMF's five-year plan offset (1 year) with respect to community LRP.
 - Feed into each other; TRIUMF is an active contributor to LRP.
 - Well integrated.

Canadian Subatomic Physics Long Range Plan

End of 2010: Highlights of Canadian Contributions in Nuclear Physics

- TRIUMF's ISAC-II accelerator operational along with major new spectrometers and auxiliary devices.
 - TRIUMF-ISAC Gamma-Ray Escape-Suppressed Spectrometer (TIGRESS).
 - TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN).
- TRIUMF Weak Interaction Symmetry Test (TWIST) collaboration completed the most precise measurement of the muon decay distribution.
- Key measurements of nuclear reactions important in cataclysmic binary systems by TRIUMF's Detector of Recoils And Gammas Of Nuclear reactions (DRAGON).
- Q_{weak} experiment started data taking following the commissioning of the Canadian-funded solenoidal spectrometer.
- Active participation in experiments at JLab (e.g., G-Zero); hardware contributions to Halls C and D.

Canadian Subatomic Physics Long Range Plan

2011-16: Priorities in Nuclear Physics

- Contributions that will build on strengths of Canadian community in complementary research topics.
 - Fundamental symmetries.
 - Hadronic physics.
 - Nuclear structure.
 - Nuclear mass.
 - Nuclear astrophysics.
- Expand Canada's capabilities to produce and study rare isotopes.

Canadian Subatomic Physics Long Range Plan

2011-16: Priorities in Nuclear Physics

- Continue and expand full exploitation of TRIUMF's ISAC-I and ISAC-II facilities, with unique suite of measurement tools, including new spectrometers and devices.
 - EMMA (ElectroMagnetic Mass Analyser).
 - GRIFFIN (Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei).
 - TACTIC (TRIUMF Annular Chamber for Tracking and Identification of Charged Particles).
- Participate in 2 major experimental initiatives in hadronic physics at JLab following 12 GeV upgrade.
 - GlueX.
 - Pion form factor (F_{π} -12).

Canadian Subatomic Physics Long Range Plan

2011-16: Priorities in Nuclear Physics

- Participate in complementary initiatives on testing fundamental symmetries, at TRIUMF and international facilities.
- Build TRIUMF's Advanced Rare Isotope Laboratory (ARIEL) to triple Canada's capabilities to produce and study rare isotopes.
 - Includes a new electron LINAC based on SRF technology.
 - Will provide for a second proton beam line for rare isotope production.

Canadian Subatomic Physics Long Range Plan

2011-16: Budgetary Context and Priorities

- Current NSERC Subatomic Physics (NP + PP) Envelope: \$22.7M
 - Complementary to funding of Canada's national laboratories
 - Complemented by Canada Foundation for Innovation beyond R&D, for the final purchase of major capital equipment
- LRP recommendations regarding NSERC Envelope:
 - Ensure R&D activity directed at the next generation of discovery projects through effective funding of equipment
 - Ensure continuous research support of flagship projects in which Canada is actively participating
 - Increase Envelope funding by \$3.5M

Report from TRIUMF

June 1st , 2013

Probing the structure and origins of matter
Advancing isotopes for science and medicine

JM Poutissou | Science Division | TRIUMF
|Emeritus Scientist



TRIUMF: A National Science Laboratory



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

Research focus:

- Advancing isotopes for science & medicine
- Probing the structure & origins of matter

TRIUMF is owned & operated by a consortium of 18 universities
Founded 44 years ago in Vancouver

TRIUMF's Nuclear Physics program

- ISAC I and II
- ARIEL
- UCN
- Theory
- Nuclear Science applications

ISAC rare isotope facility

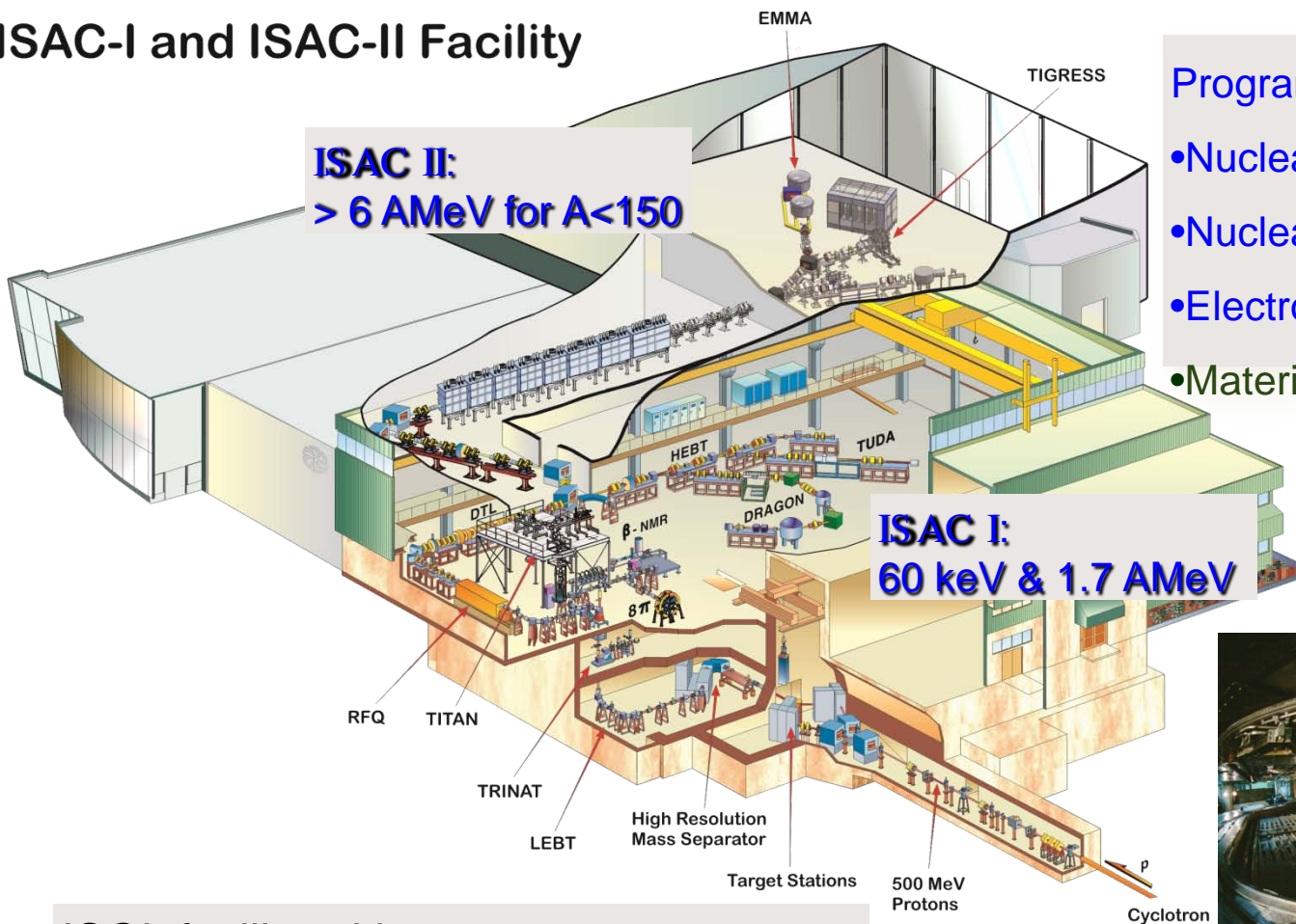
ISAC-I and ISAC-II Facility

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

ISAC I:
 60 keV & 1.7 AMeV

Programs in

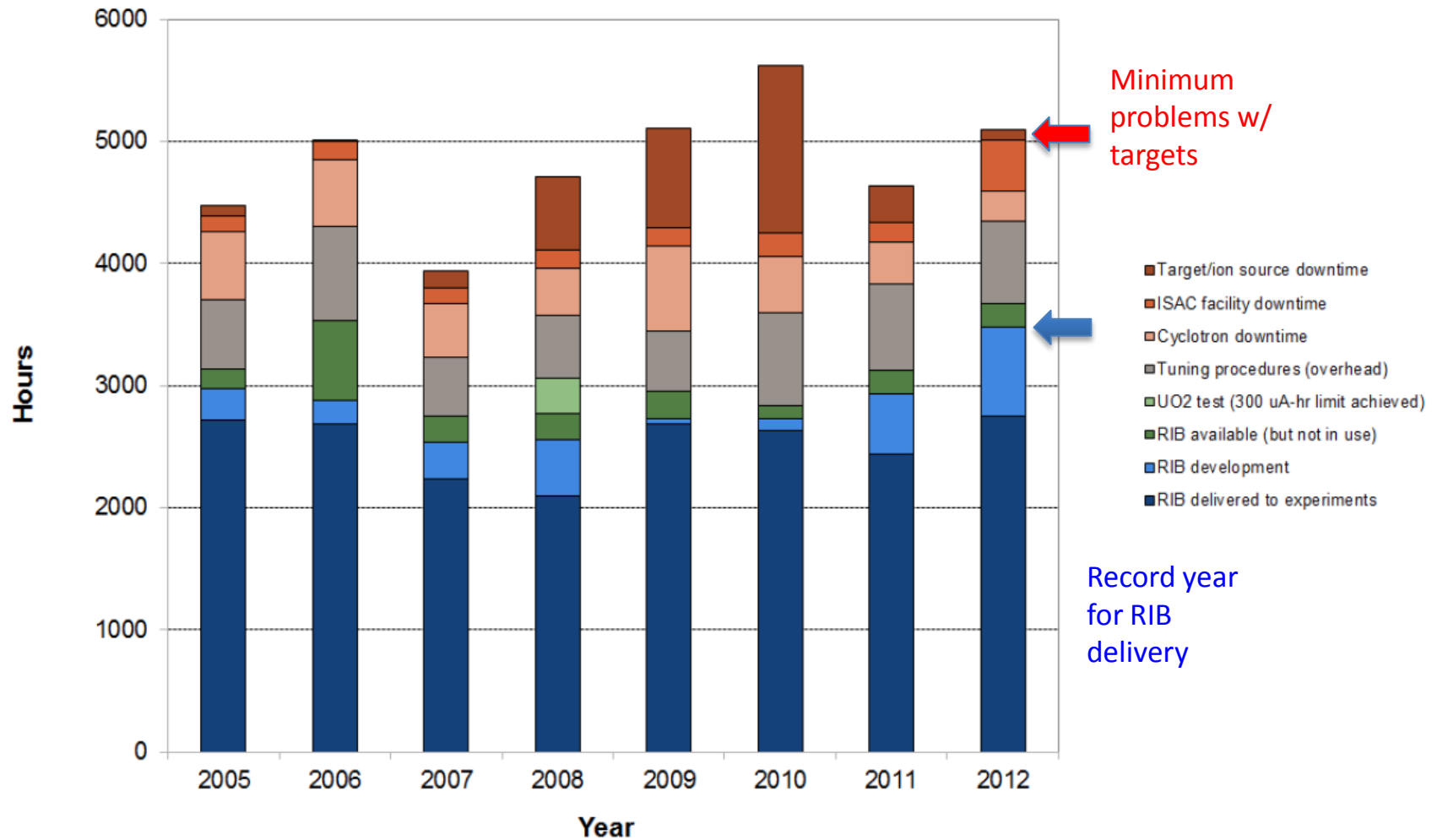
- Nuclear Structure & Dynamics
- Nuclear Astrophysics
- Electroweak Interaction Studies
- Material Science



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

Record ISAC Performance

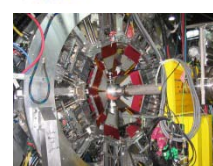
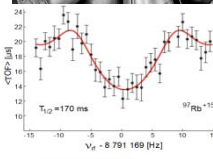
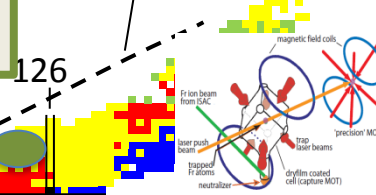
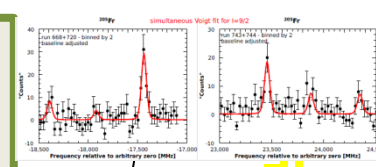
ISAC Performance: 2005 - 2012



Recent ISAC highlights

Nuclear Structure
Nuclear Astrophysics
Fundamental Symmetries

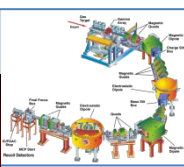
(2) **Actinide weak interaction program: w/ UC_x target**
 Laser ionization and spectroscopy of At → towards Rn EDM
 Fr PNC experiment commissioned successfully, first trapping
 First Fr Hyperfine spectroscopy done, PNC measurements
 (2013)



Unitarity test of CKM matrix: superallowed β -emitter ^{74}Rb

- precision branching ratios of ^{74}Rb , ^{26}Al from 8π (PRL, PRC)
- precision measurement of the of $^{74}\text{Rb}^{8+}$ mass with TITAN (PRL)
- charge radius of ^{74}Rb from collinear laser spectroscopy (PRL)

Nuclear reactions in Sun, ancient stars & novae
DRAGON: $^{18}\text{F}(p, \gamma)^{19}\text{Ne}$, $^{26}\text{Mg}(p, \gamma)^{27}\text{Al}$, $^{33}\text{S}(p, \gamma)^{34}\text{Cl}$,
 $^{16}\text{O}(p, \gamma)^{17}\text{F}$ (PRC), $^{17}\text{O}(p, \gamma)^{18}\text{F}$ (PRC), $^3\text{He}(\alpha, \gamma)^7\text{Be}$ (NIM)
TUDA : $^{18}\text{F}(p, \alpha)^{15}\text{O}$, $^{21}\text{Na}(p, \alpha)^{18}\text{Ne}$ (PRL), $^{26}\text{Al}(d, p)$



Towards the r-process: w/ UC_x target
 masses of $^{96,98}\text{Rb}$ w/ TITAN (PRC)
 decay spectroscopy of $^{96,98,100,102}\text{Sr}$ w/ 8π

EC branching ratios for double-beta decay:
 completion and commissioning of TITAN-EC

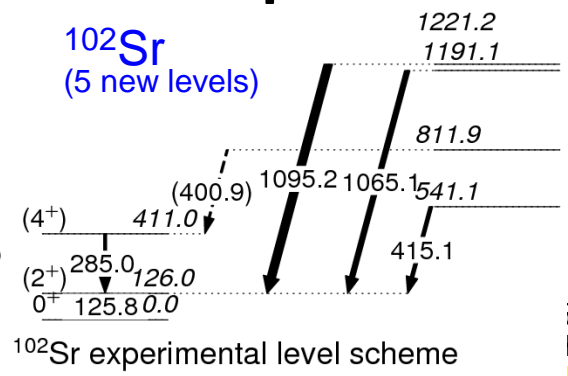
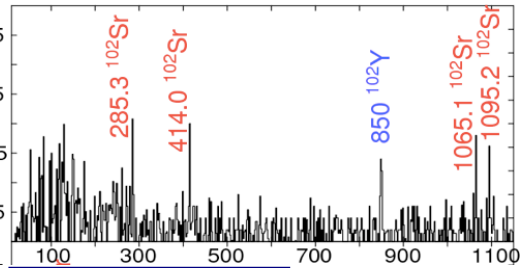
Probing shell evolution and 3-body forces:

- masses in neutron-rich Ca, K w/ TITAN (PRL)
- Masses in the island of inversion w/ TITAN
- decay spectroscopy of spin-polarized ^{28}Na (PRC)

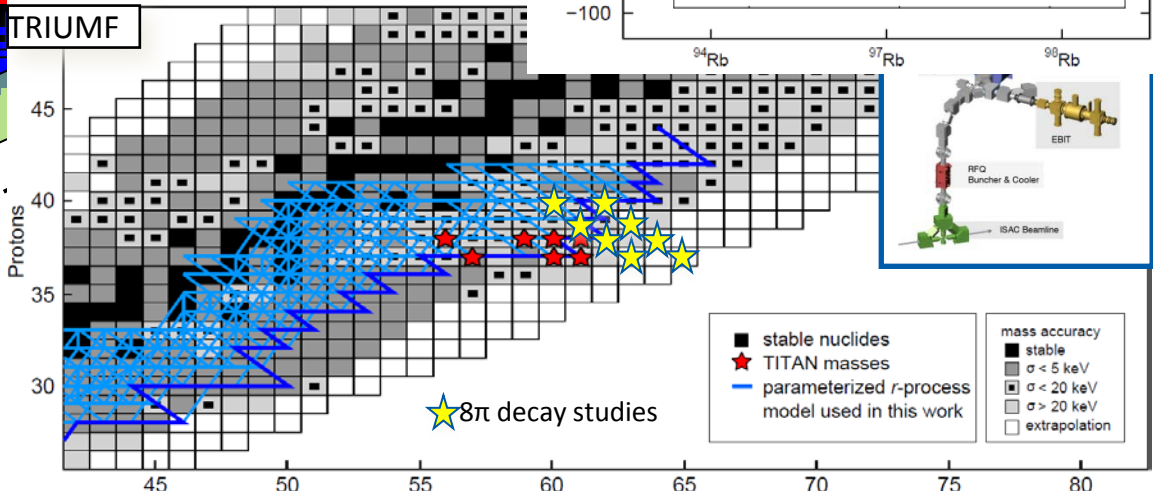
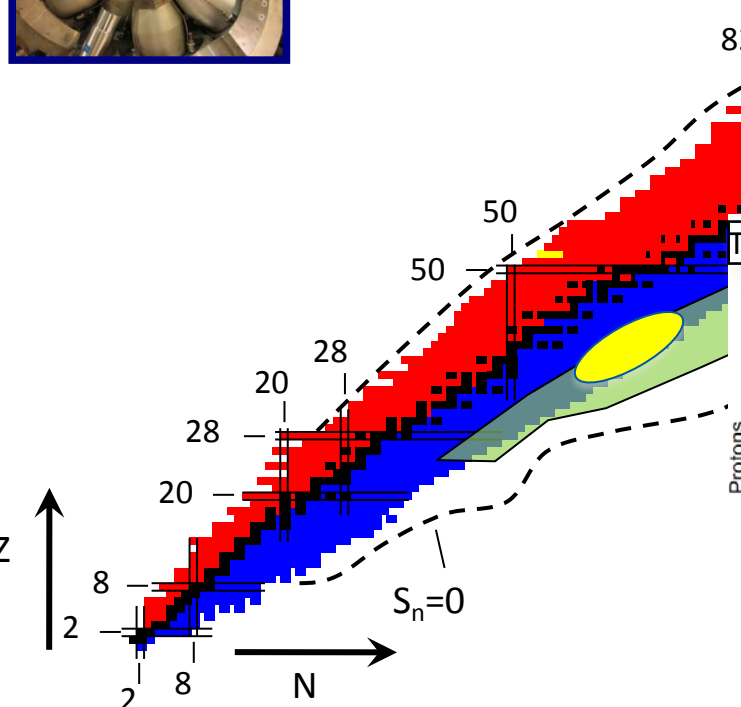
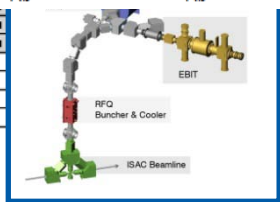
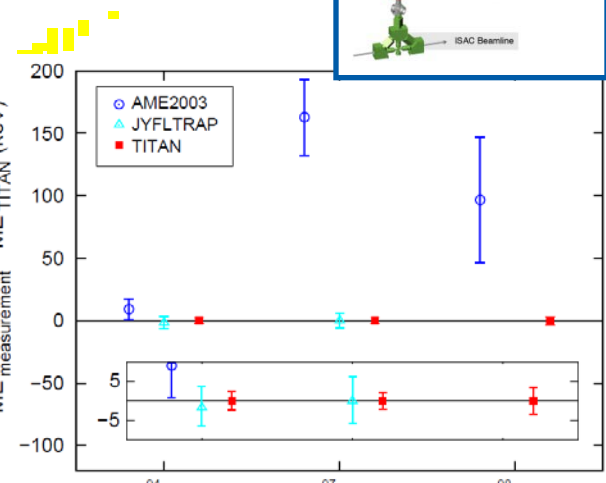
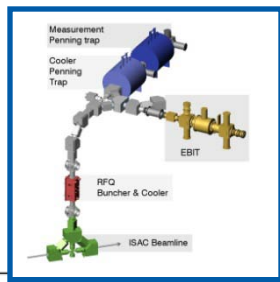
Test of ab-initio nuclear theory

- Reaction studies of halo nuclei ^{11}Li & $^{10,11}\text{Be}$ w/ TUDA and TIGRESS at ISAC-II (PRC)
- ^6He , ^8He mass measurement w/ TITAN (PRL)

Towards the r-process path: $10 \left[\text{A } 500\text{MeV protons on } 16 \text{ mg/cm}^2 \right]$



$10\mu\text{A}, 500 \text{ MeV protons on } \text{UC}_x$

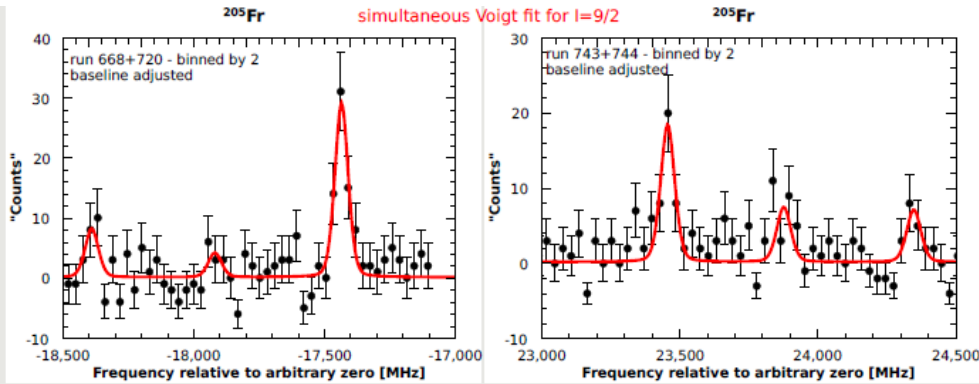


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ISAC Overview - GANIL visit

V. Simon et al., PRC 2012

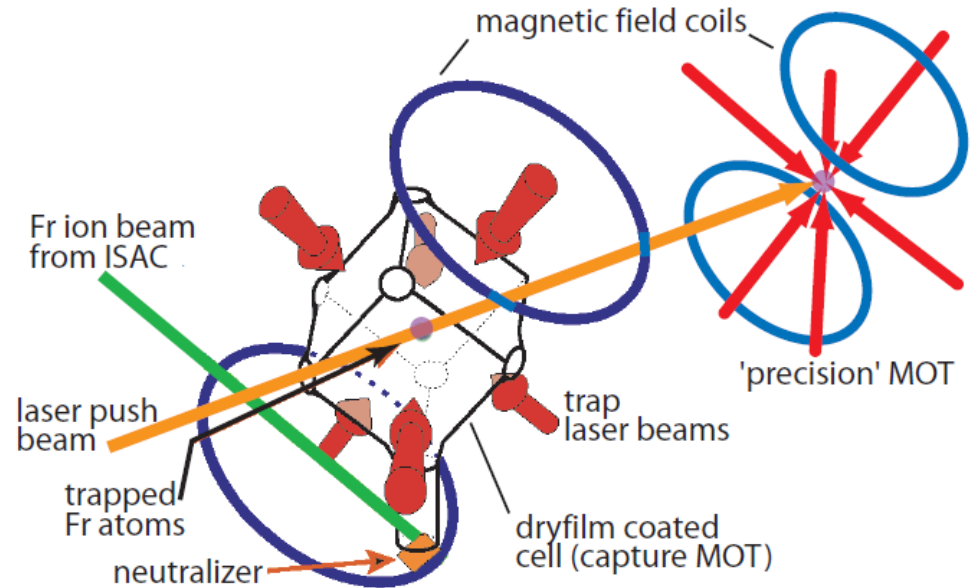
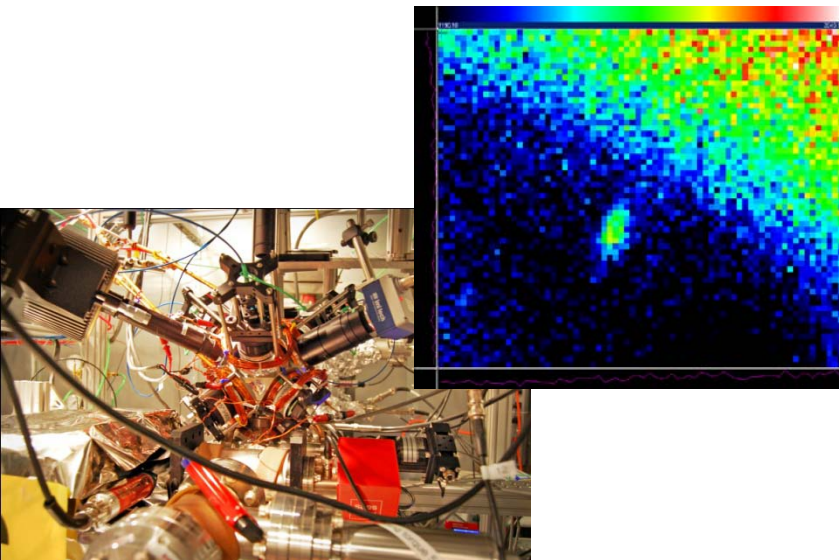
Francium trapping facility commissioned



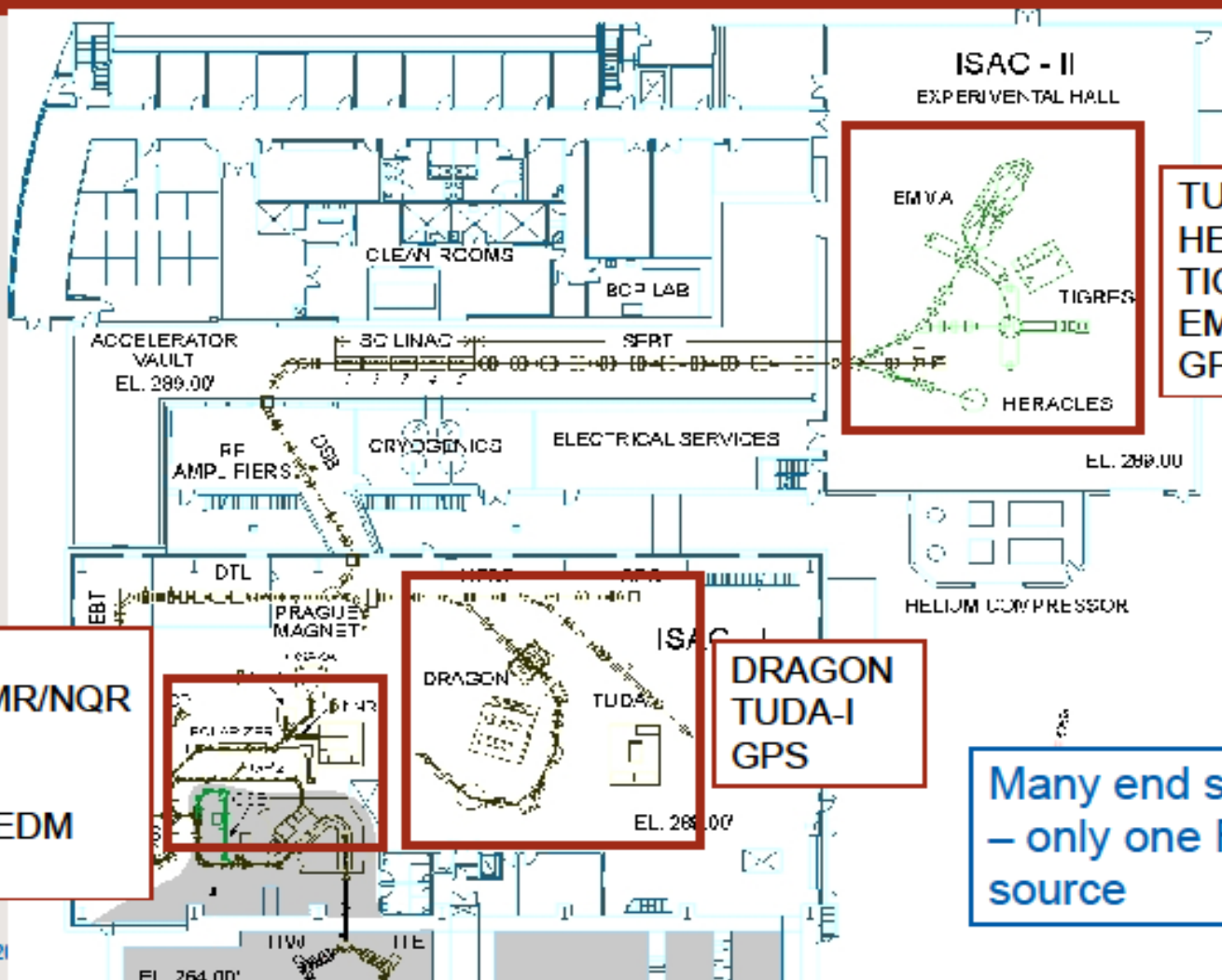
First collinear laser spectroscopy on Fr

- ^{208}Fr used as a frequency reference
- ^{206}Fr new measurement \rightarrow discovered isomer
- \rightarrow Moments, spin, charge radii for ^{206}Fr g.s. /isomer
- **First ever laser spectroscopy of ^{205}Fr**

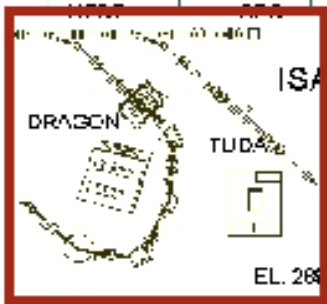
Successful Francium trapping of $^{207,209,221}\text{Fr}$ in new Magneto Optical Trap (MOT)



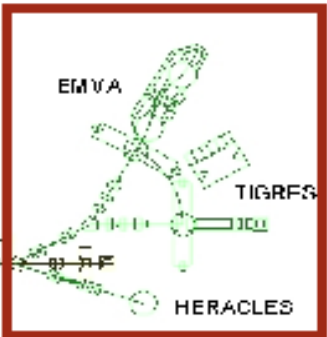
ISAC RIB Facility – End stations



TITAN
beta-NMR/NQR
8PI
GPS
Radon-EDM
Osaka



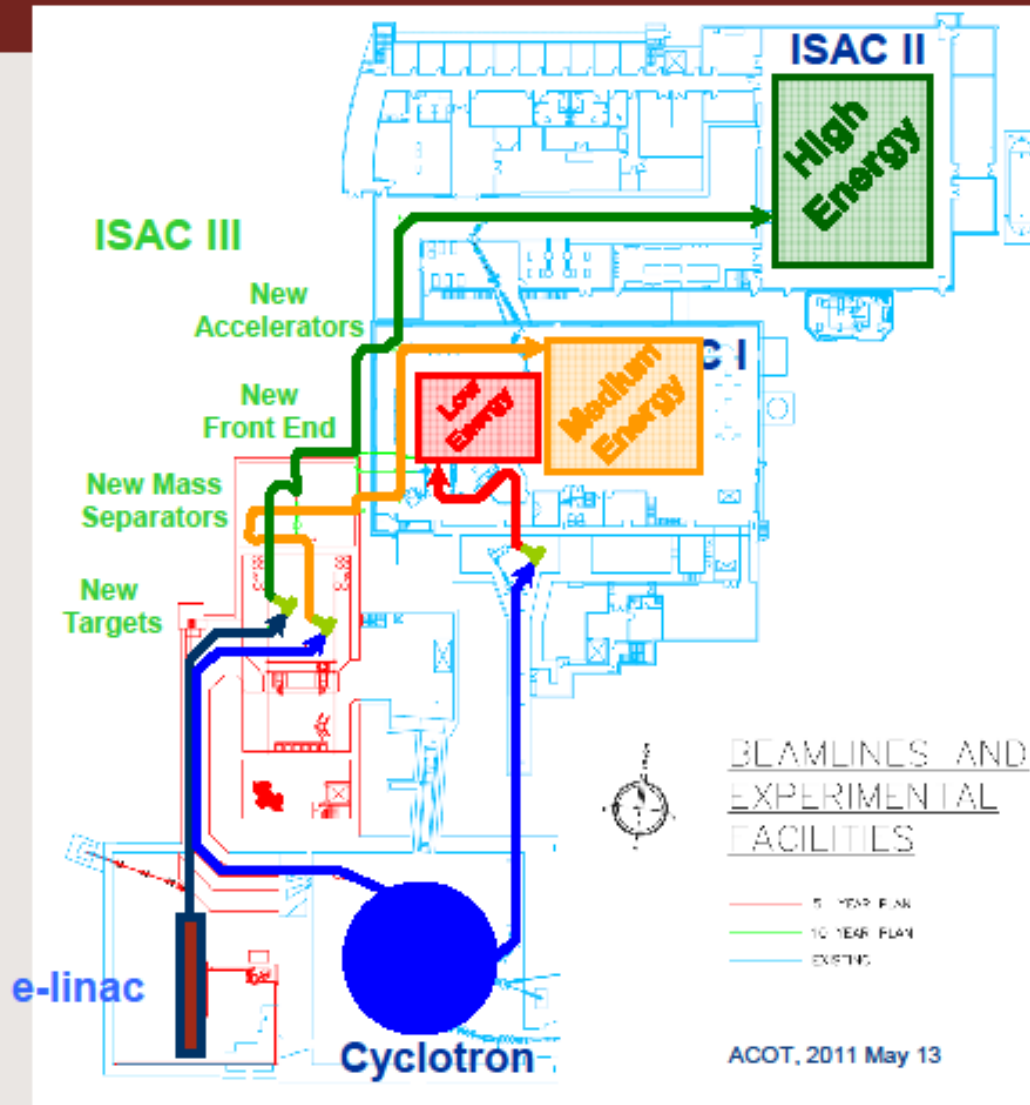
DRAGON
TUDA-I
GPS



TUDA-II
HERACLES
TIGRESS,
EMMA
GPS

Many end stations
– only one RIB
source

ARIEL Project 10-Year Plan: Motivation



- To substantially expand RIB program with:
 - 3 simultaneous beams
 - increased number of hrs/yr delivered
 - new beam species
 - increased beam development capabilities
- New complementary electron linac (e-linac) driver for photo-fission
- New proton beamline
- New target stations and front end
- Staged installation

ARIEL: Civil construction and eLINAC

ISAC

RIB front end

Target Hall

Electron Hall

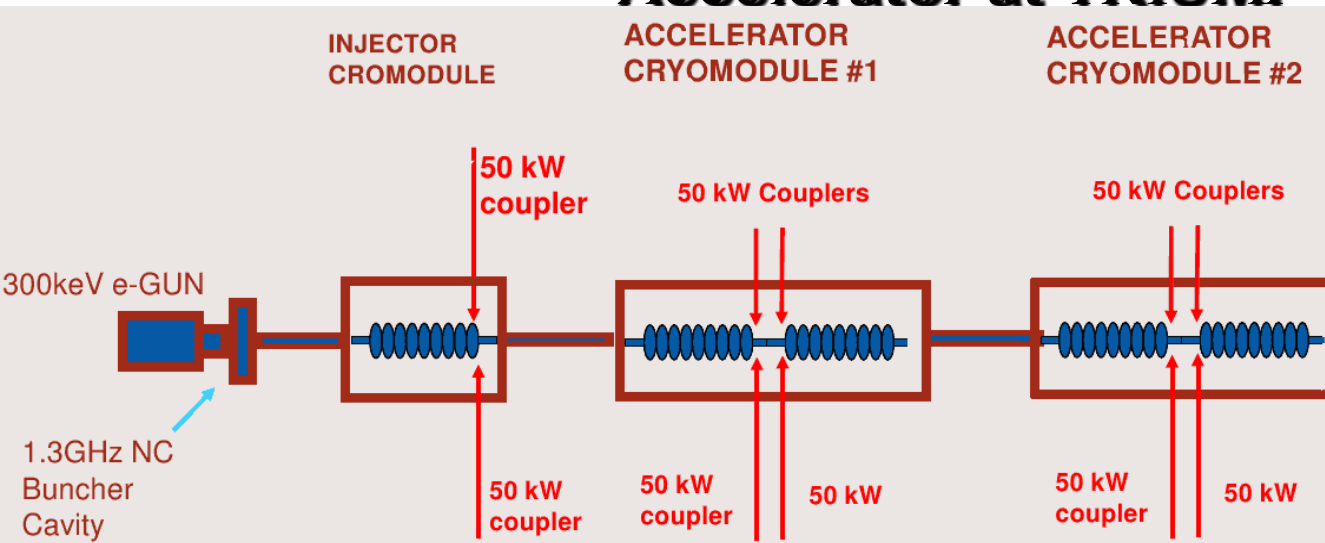
Cyclotron vault

Tunnel

Preparations for Phase-II CFI starting

- targets, remote handling
- beam delivery infrastructure

e-Linac: MW-class Superconducting Electron Accelerator at TRIUMF



Kinetic energy (MeV)	50
Average current (mA)	10
Duty Factor	100%
Beam Power (MW)	0.5

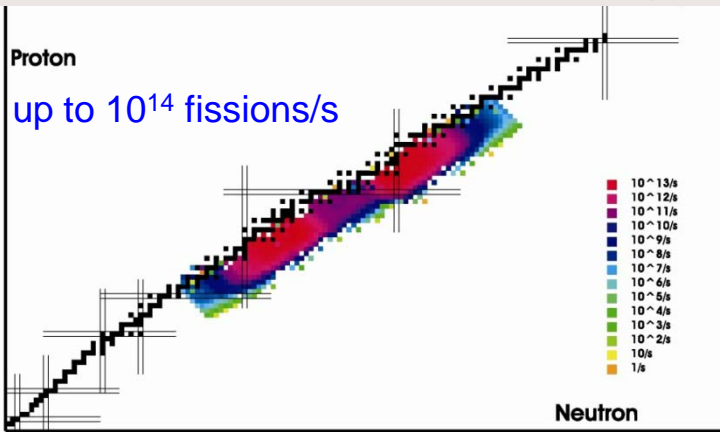
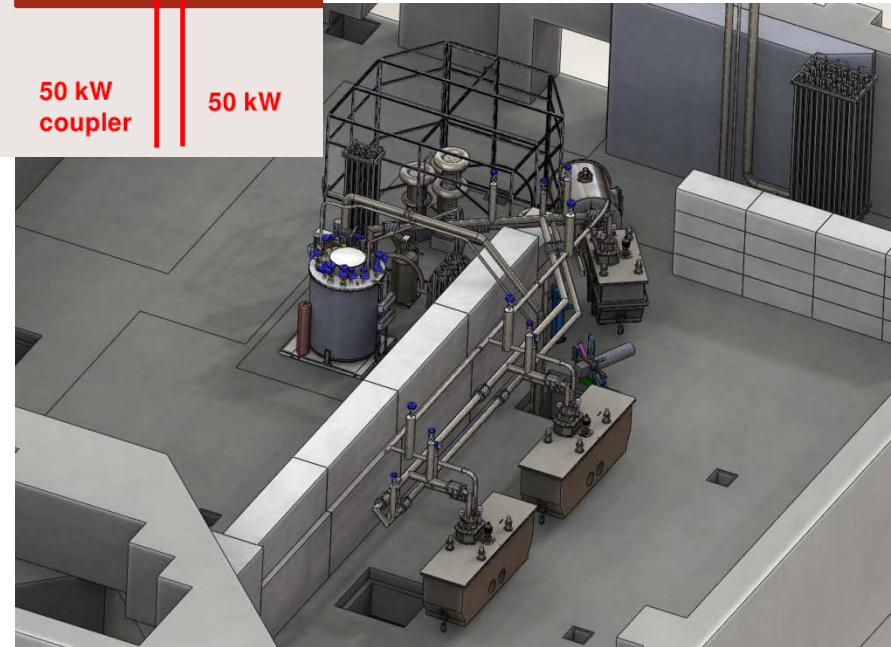
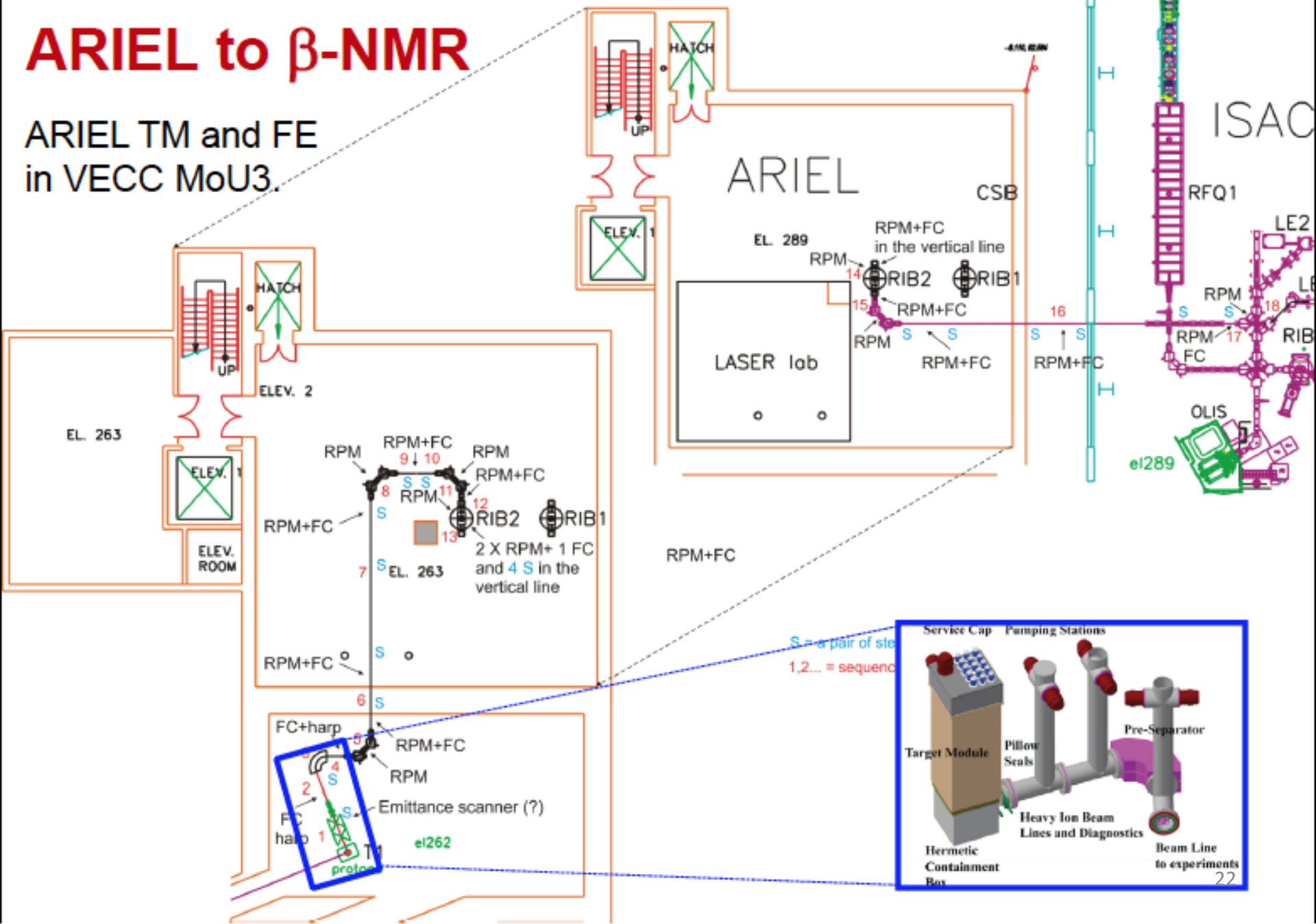


Photo-fission products using 50 MeV 10 mA electrons on to Hg convertor & UC_x target.



First ARIEL Science: ARIEL to β -NMR

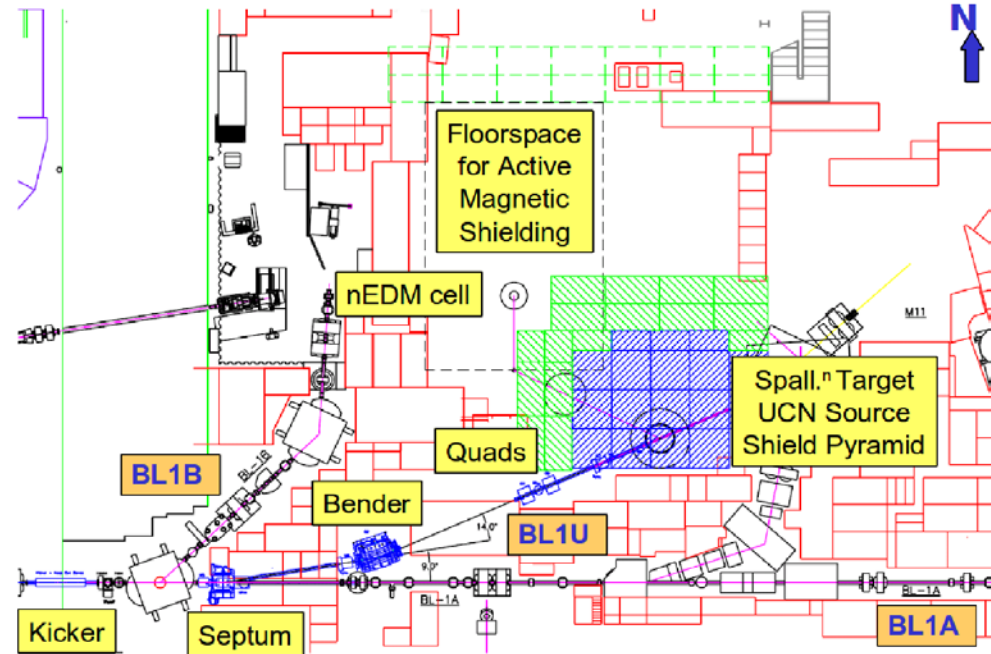
ARIEL TM and FE
in VECC MoU3.



S = a pair of side
1,2... = sequence

UCN/nEDM

- UCN facility construction (clean up) beginning in Meson Hall
 - New TRIUMF/Canadian leadership in key parts of nEDM experiment (co-magnetometer, magnetic shielding, HV, UCN detector).
 - International nEDM review at KEK (Dec. 29-30, 2012) endorsed RCNP/KEK/TRIUMF nEDM project.
 - New UCN research scientists TRIUMF (R. Picker), Wpg (R. Mammei), Asst. Prof. MB (J. Mammei) this year
- ➔ **Towards world's best measurement at TRIUMF by 2017.**



Neutron EDM experiment

Complementarity

Project	H ₀ field	magnetometer	EDM cell	magnetic shielding
KEK / RCNP / TRIUMF	<i>spherical coil</i>	<i>¹²⁹Xe buffer gas co-magnetometer</i>	<i>small T = 300 K</i>	<i>finemet/ superconductor</i>
Sussex / RAL / ILL	solenoid	n at E = 0 magnetometer	large T ~ 0.5 K	μ metal superconductor
SNS	cosθ coil	³ He co-magnetometer	large T ~ 0.5 K	μ metal superconductor
PSI	cosθ coil	Cs multi- Magnetometer Hg-199	large T = 300 K	μ metal

UCN sources are *totally* different.

Theory group



The Role of TRIUMF

ISAC/ARIEL

World-unique combination of high intensity neutron-rich beams (from protons and electrons on actinide targets) with the tools to measure

- Masses → TITAN
- Charge radii → laser spectroscopy
- Beta decay half lives → GRIFFIN
- Moments from Coulomb excitation → TIGRESS
- Transfer reactions: e.g. (d,p) as surrogates for (n, γ) → IRIS, TIGRESS, TUDA, EMMA

This will enable testing theoretical models to delineate the structural evolution of very neutron-rich nuclei in the light, medium and heavy mass regime.

THEORY

Expect more work in:

- pushing the limits of *ab-initio* methods towards medium-mass nuclei
- developing a unified description of structure and reaction properties
- understanding the role of nuclear forces from χ EFT as one moves closer to the drip line

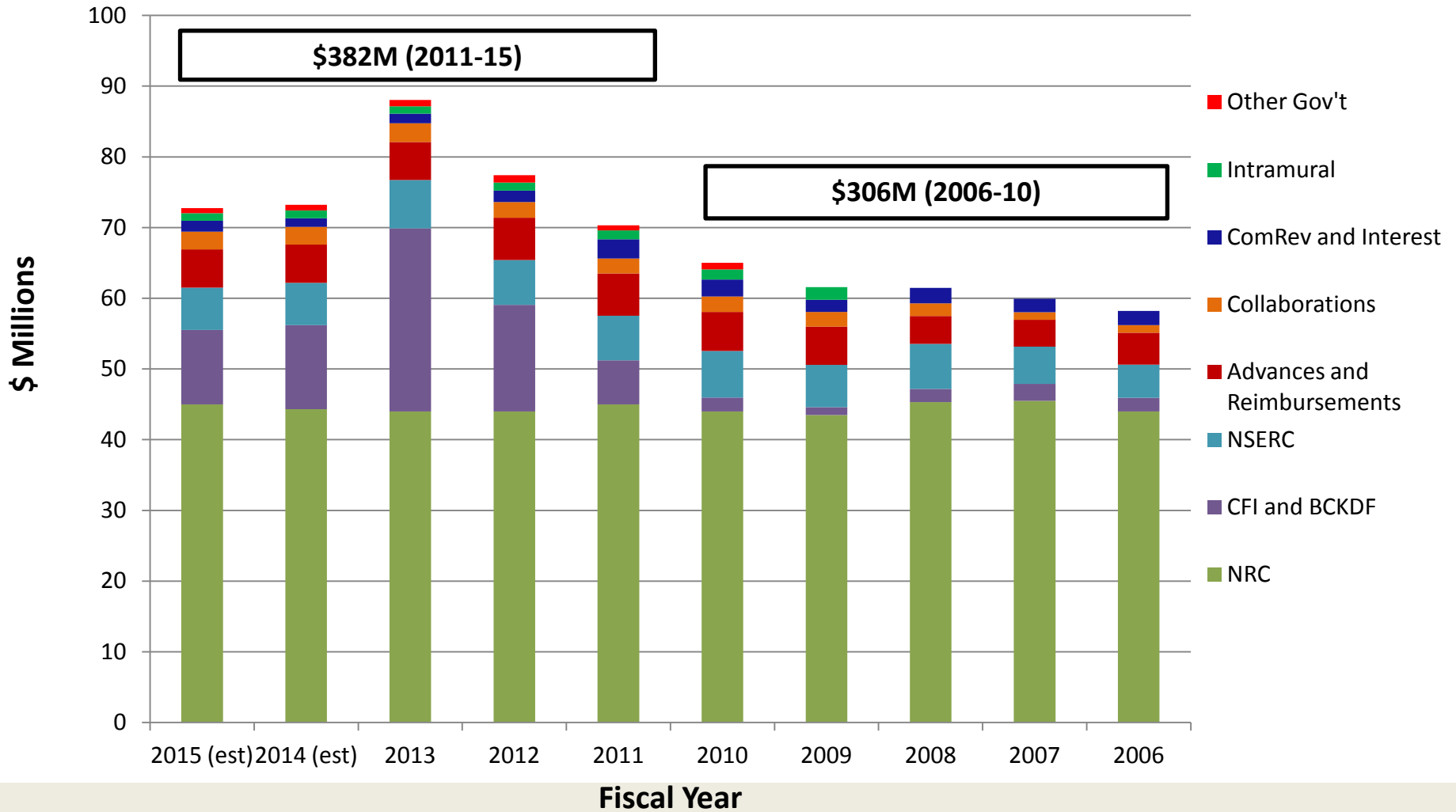
SNOLAB

Experimental Programme



Experiment	Solar nu	OnuBB	Dark Matter	SuperNovae	Geo nu	Other	Space allocated	Status
SNO+	√	√		√	√		SNO Cavern	Underway
PICASSO-III			√				Ladders Labs	Underway
DEAP-1			√				J'-Drift	Underway
DEAP-3600			√				Cube Hall	Underway
MiniCLEAN			√				Cube Hall	Underway
HALO				√			Halo Stub	Underway
PUPS						Seismicity	Various	Completed
SuperCDMS			√				Ladder Labs	Request
EXO-gas		√					Ladder Labs	Request
COUPP			√				Ladder Labs	Underway
DarkSide			√				Ladder Labs	Request
COBRA		√					Ladder Labs	Request

10-Year Funding History



Vision for the next 5 years and beyond

- **TRIUMF, will continue to advance Canada's impact in particle and nuclear physics and build upon its already significant world-wide reputation for top level science and innovation.**
- **Isotopes for science and medicine** will be synonymous with the name TRIUMF.
- **Completion of the ARIEL project is highest priority**
 - Beams for advanced materials research, nuclear physics, nuclear astrophysics, fundamental symmetries, and tomorrow's medical isotopes
 - train the future scientists, engineers, technicians and students
- ARIEL project is positioning Canada and its industries with some of the most **advanced accelerator technologies** in the world, ready to make substantial contributions to projects on the world stage (e.g. ILC)

Vision for the next 5 years and beyond

- CERN continues to be at the forefront of particle physics and TRIUMF is Canada's link to CERN. The **ATLAS Tier-I** center plays a key role in this.
- The new particle-physics paradigm has major international laboratories in some regions, such as CERN in Europe, supported by a network of **regional laboratories like TRIUMF**.
- Over the next decade, **TRIUMF, along with the Perimeter Institute, and SNOLAB**, will provide Canada with a unique combination of facilities to unravel the leading questions in subatomic physics, such as what is the nature of dark matter.
- The existing **strong partnership with Japan** in neutrino science, accelerator physics, and fundamental symmetries will lead to several programs that are jointly managed and coordinated; Japan's leading high-energy physics lab KEK will establish a field office at TRIUMF, the first of its kind;

TRIUMF NRC Audit and Evaluation

- International Peer Review Chair: Sam Aronson
 - Former Director of Brookhaven Nat Lab
- Evaluation questions and methods largely defined with living document w/steering committee
- Evaluation questionnaire sent to the user community at large (~900)
- FYP to be submitted in late summer 2013
- TRIUMF review in the fall 2013
- Decision on next 5 Years (2015-2020) NRC contribution in March 2015 federal budget

Thank you!

Merci

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



TRIUMF commitments into the next 5yr plan

