New Achievements at TRIUMF and Future Plans

P. W. Schmor & Accelerator TEAM
ISAC/TRIUMF

Cyclotrons 2007
TRIUMF Driver

500 MeV H- Cyclotron

Provides Simultaneous, Independent, Variable Energy, Protons to Multiple Locations

Routinely Accelerates 275 \( \mu \text{A} \)

Capable of 400 \( \mu \text{A} \)
ANNUAL TOTAL CHARGE DELIVERY

CHARGE (mAh)

YEAR


BL2A is ISAC beam line

BL2A
BL2C4
BL1A

0 100 200 300 400 500 600 700 800 900 1,000
BEAM PRODUCTION 2007 to mid-September

Delivered 1A Charge
(221.5 mAhrs)

Delivered 2C4 Charge
(41.8 mAhrs)

Delivered 2A Charge
(123.2 mAhrs)

WEEKLY BEAM CHARGE (mA*Hrs)

TOTAL BEAM CHARGE (mA*Hrs)

SHUTDOWN

WEEK
Downtime 2007 to mid-September

TOTAL = 296.6 Hours
TRIUMF Upgrades/Refurbishment
[MOPPRA05]

I CYCLOTRON
- RF Systems (to reduce yearly down time)
- Vacuum (to reduce yearly down time, improve vacuum & reduce residual radiation with increased current)
- Solid Target Facility (to improve servicing & power handling capability)
- Cabling (replace radiation damaged cables)
- Ion Source & Injection System (Enhance high current ability)
- Beam Improvements (Meet ISAC requirements of quality & stability)

I ISAC
- Rotating proton beam on target
- High Beta completion & experimental installation
Many Vault Cables have Radiation damage & replacements must be carried out without moving other damaged cables.
Cable Tray System for Cyclotron Re-cabling Project
Inductive Beam Position Monitor [WEPPRB17]

- Proton current instabilities at the ISAC targets is magnified in observed isotope flux and is both a tuning & experimental rate concern.
- This monitor is to achieve better control of beam size, position, and current on ISAC targets.
- Inductive loop beam position monitor. The monitor is built for high current operation. It is a non-intercepting device capable of measuring beam position with a 0.1mm relative resolution and 0.5mm absolute accuracy. It will be used for continuous monitoring of the high current beam profile and current. It is intended to be used for beam position feedback to ensure beam position stability on ISAC Targets.
ISAC Accelerators
ISAC I & II

I ISAC (ISOL + ACCELERATORS)

♦ ISAC-I
  • Funded in 1995 [1995-2000]
  • Low Energy
    * $E \leq 60$ keV & $A_{\text{max}} \approx 240$
      • First RIB Experiment in November 1998
    • ‘High’ Energy (Accelerated with RFQ & DTL)
      * Variable Energy from 0.15 to 1.8 MeV/u for $q/A \geq 1/30$
        • First Beam in December 2000

♦ ISAC II
  • Funded in April 2000 [2000-2005-2010]
    • Variable Energy from 1.5 to 6.5 MeV/u for $A \leq 150$
      • First Beam December 2006 (4.3 MeV/u)

♦ Upgrades Proposed for 2010-2015
ISAC Target & Ion Sources

Pierre Bricault

[MOZCR02]
ISAC-I Accelerator

- OLIS
  - Stable beams
- LEBT
  - All-electrostatic (2 keV/u)
  - 11.8 MHz multi-harmonic pre-buncher
- 35 MHz cw RFQ
  - E=2± 153 keV/u
  - A/q<=30
- MEBT
  - Stripping foil
  - 35 MHz rebuncher
- 105 MHz cw Variable Energy DTL
  - E=0.15-1.8 MeV/u
  - A/Q<=6
- HEBT
  - Diagnostic section
  - 11.8/35 MHz rebunchers
ISAC 35MHz Split-ring RFQ

Accelerates ions with $A/q \leq 30$
from 2 keV/u to 150 keV/u

ISAC 106MHz Separated Function DTL

Accelerates ions with $A/q \leq 6$ to final energies fully variable from $0.15 < E < 1.8$ MeV/u
ISAC I → ISAC II

PHYSICS NEEDS HEAVIER MASSES

I Ion Source
- Many $1 \leq A \geq 150$ are ionized but with $q = 1$

I MASS SEPARATOR
- Selects a Particular $1/A$ where $A \leq 240$ with energy $\leq 60$ keV

I Accelerators
- RFQ Requires $q/A \geq 1/30$
- DTL & SC LINAC Requires $q/A \geq 1/6$

I CHARGE STATE BOOSTER (CSB)
- Required to accelerate masses greater than $A = 30$
- Boosts Isotope Charge from 1+ to n+
- Goal is to efficiently achieve $q/A \approx 1/6$
- Charge Boosting Time Should be Small Compared to Isotope Lifetime
- Installation in 2008
Schematic of the ISAC Facility At TRIUMF
Charge State Booster & Mass Selector Location In Mass Separator Cave
ISAC-II (Phase I - Medium Beta Section) Commissioned in 2006

Stage 0

E=4.5 MeV/u A/q=6

S0
MEBT1
IH-DTL1

HEBT1-Exp.

S2
Medium β

E=1.5 MeV/u

A/q≤6
E=0.15–1.5MeV/u
Medium Beta Cryomodule

- LHe Header
- LN2 Shield
- Cavity
- Diagnostic Box
- Solenoid
Medium Beta Cryomodules Assembly
Cavities tested initially in single cavity cryostat

Average peak surface field at operating power of 7W is now $E_p=38\text{MV/m}$ corresponding to a voltage gain of $1.4\text{MV/cavity}$ and a magnetic field of $B_p=75\text{mT}$ and a gradient $E_a=7.5\text{MV/m}$
Superconducting LINAC
Energy Measurement – Time of Flight (TOF)

Medium Beta

9.07m

TOF1

TOF2

85nsec

ION BEAM

~2.5kV

~2kV

MCP
Energy after each cryomodule for C12(3+) with an injection energy of 1.5MeV/U.
Beam Profile of full energy beam
SEBT2 & SEBT3 Beamlines
January 05, 2007
First RIB in ISAC II
Near Term Plans for ISAC I & II

1. Complete Installation of the ISAC II experimental stations & Beamlines
   - TIGRESS, EMMA, Heracles, ..

2. Operation with Actinide Targets
   - Initial tests in 2008
   - Obtain fission produced neutron rich isotopes

3. Completion of ISAC II Accelerators
   - High Beta cavities planned for 2009
   - To reach design energy of 6.5 MeV/u for all masses

4. Installation of Charge State Booster in 2008
   - Heavier masses can be accelerated
Stage 1 - 2009

Stage 0

Stage 1

E=6.5MeV/u A/q=7

HEBT2—Exp.

S2

Medium β

High β

E=1.5MeV/u

A/q≤6
E=0.15–1.5MeV/u

HEBT1—Exp.

MEBT1
IH–DTL1

CSB
TRIUMF/ISAC

Beyond ISAC II → ISAC III

(2010 -2015)

Proposals & Plans
The TRIUMF cyclotron driver could provide another proton beam (~ 200 µA) from a presently unused beam line (BL4AN) to new target stations,

These target stations would then provide a place to perform systematic development of exotic beams,

- Ion Source development,
- Characterization of new targets

An additional Radioactive Nuclear Beam could be simultaneously accelerated from these new target stations for experiment.
Proposed New Driver Beam
New Targets & Simultaneous Post Acceleration

ISAC 2015 Spallation?
The proposed new facility for TRIUMF

Proposal:
- A new electron accelerator produces 50 MeV electrons
- Electrons impinge on converter and photos are generated
- Photons hit target and photo-fission occurs
- New, very exotic, neutron rich isotopes are produced
- Isotopes are delivered to existing state-of-the-art ISAC complex and experimental facilities
ISAC = ISOL & POST-ACCELERATORS (2008)

Accelerated RIB Experiments @ 1.5 MeV/u in ISAC I (2001)

ISAC I (1998)

Med β
SCRF

DTL1

RFQ

A/q ≤ 30

2008

Ion Source

1A

2C

2A

4A

TRIUMF
500 MeV Cyclotron DRIVER
ISAC = ISOL & POST-ACCELERATORS (2009)

Accelerated RIB Experiments @ 1.5 MeV/u in ISAC I (2001)

TRIUMF 500 MeV Cyclotron DRIVER

ISAC I (1998)

ISAC II (2007)

2009

High β SCRF

Med β SCRF

Exp. A/q ≤ 30

DTL1

RFQ

Ion Source

Thick/Hot Target Beam Dump

1A
2C
4A
2A

2008
ISAC = ISOL & POST-ACCELERATORS (2010+)

Accelerated RIB Experiments @ 1.5 MeV/u in ISAC I (2001)

TRIUMF 500 MeV Cyclotron DRIVER

ISAC I (1998)

DTL1

RFQ

Ion Source

2008

A/q ≤ 30

High β SCRF

Med β SCRF

Experiments ISAC II (2007)
ISAC = ISOL & POST-ACCELERATORS (2015-)

Accelerated RIB Experiments @ 1.5 MeV/u in ISAC I (2001)

ISAC I (1998)

ISAC II (2007)

TRIUMF 500 MeV Cyclotron DRIVER

1A

2C

4A

2A

Ion Source

1A

2C

Beam Dump

Thick/Hot Target

DTL1

RFQ

S1

Low β SCRF

Med β SCRF

High β SCRF

A/q ≤ 30

2008
ISAC = ISOL & POST-ACCELERATORS (2015)

Accelerated RIB Experiments @ 1.5 MeV/u in ISAC I (2001)

ISAC I (1998)

Ion Source

Photo Fission Target

50 MeV Electron

TRIUMF 500 MeV Cyclotron DRIVER

Triumf 500 MeV Cyclotron DRIVER

DTL1

RFQ

DTL2

High β SCRF

Med β SCRF

Low β SCRF

A/q ≤ 30

2008

CSB

2A

1A

2C

4A

Accelerations Experiments ISAC II (2007)
SUMMARY

I CYCLOTRON DRIVER

♦ PROVIDES MULTIPLE BEAMS FOR MESON PRODUCTION, MEDICAL ISOTOPE PRODUCTION, PROTON IRRADIATION FACILITY & ISAC
  • REFURBISHMENT PROGRAMME IN PLACE TO ENSURE THE CYCLOTRON REMAINS RELIABLE & CAPABLE OF HIGH CURRENT OPERATIONAL DEMANDS
  ♦ CAPABLE OF PROVIDING SIMULTANEOUS, VARIABLE INTENSITY, STABLE, MULTIPLE HIGH POWER BEAMS TO ISOL TARGETS
  • EXTRACTION BY STRIPPING PERMITS EASY ADJUSTMENT OF PRIMARY BEAM POWER TO MEET TARGET REQUIREMENTS

I ISAC

♦ ISAC I & II IN OPERATION
  • ISAC II OPERATIONAL AT 4.3 MeV/u NOW & 6.5 MeV/u IN 2009
  ♦ 3 SIMULTANEOUS INDEPENDENT RIBs PROPOSED FOR FUTURE

I ELECTRON DRIVER FOR PHOTOFISSION PROPOSED

♦ 3rd SOURCE OF RIB FOR ISAC
 ♦ COMPLIMENTARY TO SPALLATION PRODUCED RIBs