

Canada's national laboratory for particle and nuclear physics Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules







PROGRESS AND PLANS FOR THE HIGH MASS BEAM DELIVERY AT TRIUMF

Marco Marchetto | 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



- Introduction
 - ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- ⁷⁶Rb beam development
- Future development
- \circ Conclusion



 Accelerator division: Friedhelm Ames, Bob Laxdal , Marco Marchetto, Colin Morton (spoke-person)
 Science division: Barry Davids, Adam Garnsworthy, Greg Hackman
 Strong support from both the Accelerator and the Science division



Introduction

- ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- ⁷⁶Rb beam development
- Future development
- Conclusion



ISAC at **TRIUMF**



 <u>ISAC facility produce, post-accelerate and deliver RIB's (most intense of certain</u> <u>species) using the highest power driver beam (50 kW)</u>



ISAC in the world

| Lab | Facility | Туре | Driver | Post- accelerator | Voltage (MV) | Energy (MeV/u) |
|--------------|------------|-----------------|---------------------|----------------------|-----------------|-------------------|
| Existing | | | | | | |
| TRIUMF | ISAC | ISOL | 500MeV, 50kW | RFQ, DTL, SCL | 52.5 | 6.5-18 |
| CERN | ISOLDE | ISOL | 1.4GeV, 2.8 kW, p | RFQ, DTL | 13 | 3 |
| GANIL | Spiral-I | ISOL | 3kW HI | cyclotron | | ~5-25 |
| ORNL | Holifield | ISOL | 50MeV, 500W p,d | tandem | 25 | |
| ANL | CARIBU | Gas- catcher | Radio-active source | ATLAS sc linac | 52 | ~7-17 |
| Future | | | | | | |
| CERN | HIE-Isolde | ISOL | 1.4, 2.8kW, p | SCL | 40 | 6.5-18 |
| MSU/ NSCL | FRIB | Gas- catcher | 400kW HI | RFQ, SCL | | 12-20 |
| GANIL | SPIRAL-II | ISOL | 200kW d | cyclotron | | 5-25 |



ISAC driver



○ H⁻ cyclotron as proton driver;

- \circ ISAC proton accelerated to 500 MeV up to 100 $\mu\text{A};$
- \circ Cyclotron can operate at 300 $\mu\text{A};$

In the future one more proton line for RIB production
 (ARIEL)







Target stations and Mass separator

- Two underground target
 stations
 Proton beam sent to one
 of the target station at the
 time
- Pre-separator inside the shielded area to contain
- radiation
- o Mass separator on high
- voltage platform to increase
- resolution
- Charge breeder ECR type





Experimental facilities









◦ RFQ

- 8m long CW machine
- Resonant frequency 35 MHz
- Injection energy 2 keV/u
- Final energy 150 keV/u, 3≤A/q≤30
- high quality transverse and longitudinal emittance: $0.2 \pi \mu m$ and $1.5 \pi kev/u \cdot ns$.

 \circ DTL

- Separated functions design
- Five IH interdigital RF cavities
- Three split-ring bunchers
- Resonant frequency 106 MHz
- Variable energy machine
- 150 keV/u \leq E \leq 1.8 MeV/u, 2 \leq A/q \leq 7
- ISAC II injector 1.5 MeV/u

RIUMF



ISAC-II linac

- 40 QWR in 8 cryomodules operating at 4K
- 3 QWR families with different design beta
- 106 MHz for phase-I SCB cavities
- 141 MHz for phase-II SCC cavities
- 40 MV of accelerating voltage
- Final energy is A/q dependent : 18MeV/u for A/q=2
- Average 30 MV/m peak field at 7W







June 18, 2012

Progress and Plans for High Mass Beam Delivery at TRIUMF - HIAT 2012 conference



Introduction

ISAC facility

High Mass Beam Delivery

o The "toolkit"

- Accelerator filtration/selection
- Software
- Diagnostic
- ⁷⁶Rb beam development
- Future development
- Conclusion



RIB beam delivery

 ISAC at TRIUMF is one of the leading facility for production and delivery of RIB's and we plan to make it the leading ISOL facility (ARIEL)

 ISAC-II project has two goals: reaching higher energies (above the Coulomb barrier) and delivering high masses (beyond 30, ISAC-I limit)

 $_{\odot}$ The Charge Breeder is instrumental to reach the mass goal by reducing the M/q of high mass beams within the ISAC-I accelerators acceptance

The <u>fact</u> is that the ECR type breeder produces
 a background of stable species that can hide

the RIB (10³-10⁶ particle/s)

 The issue is that the RIB need to be delivered relatively pure (free of contaminants)





- Introduction
 - ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- o ⁷⁶Rb beam development
- Future development
- Conclusion



ECR background improvement

- 14GHz Phoenix ECR source from Pantechnik
- Breeding efficiency 2-5%
- All RIBs come with contaminants from the background gas and vacuum chamber materials
- $\circ~$ Need to purify the beam at the source





See Colin Morton presentation at the High Mass workshop



Accelerator filtration overview





Pre-buncher RFQ filtration

- The pre-buncher is located 5 m upstream of the RFQ
- Source extraction voltage is fixed: different M/q are extracted with different velocities $v=(2 \cdot q \cdot V_{ext}/M)^{1/2}$
- Different velocities generated different time of flights
 between the pre-buncher and the RFQ.
- RFQ phase acceptance is 40° or $\delta t = 3 \cdot 10^{-9} s$
- So M/q's that are spaced more than $\delta t = 3 \cdot 10^{-9}$ s at the RFQ can be filtered by adjusting the pre-buncher phase (namely synchronizing one A/q with the RFQ buncket) • $^{19}F^{3+}$ and $^{38}Ar^{6+}$ arrive at the RFQ with a $\delta t = 3.7 \cdot 10^{-9}$ s (equivalent to a resolution of (M/q)/ Δ (M/q)=1115)







Stripper-degrader

Created velocity difference
(degrader) to select around the bender
Stripping to a different M/q to clean
the beam from contaminants
Two possible locations for carbon
foils to be used as stripper and
degrader (depending on the thickness)







DSB selection



selection SC linac VIB3 Degrader #2 DSB buncher **DSB** selection slit alternative position PRAGUE PSID5 magnet diagnostic Degrader #1 box



Software applications

 CSBassistant: web based application to identify all possible contaminants before the run

http://trshare.triumf.ca/garns/CSBExperts/

- Scaling routine: EPICS based application to scale the ISAC beam lines optics and RF
 - Voltages of the electrostatic quadrupoles and steerers
 - Currents of the magnetic quadrupoles
 and steerers
 - No hysteresis cycle around the final setpoint but approaching from the same side of the hysteresis curve
 - Hall probe measured magnetic field of the dipoles
 - RF amplitudes of all devices (prebuncher, RFQ, DTL, SClinac...)

| CSB Assistant - Mozilla Firefox | | | | | |
|---|--|---|--|---|--|
| jie Edit Yew Higtory Bookmarks Bo | sis <u>H</u> elp | | | | |
| 🗢 🔅 🔹 🚱 🖸 👘 http://o | share.triumf.ca/ | -garns/CSBExperts/ | | 습· 💽 | |
| Most Visited 🔻 🛞 Scientific Linux 🔅 Di | stros 🔻 🍓 TRIUI | HF Phone List 🎓 TRIUMF email list 🕌 Google 🕽 | HMTF Si Telescope | | |
| Charge-State B | noster | Раде | | | |
| onarge-balle b | 005101 | ruge | | | |
| UNDER DEVELO | OPME | NT - PLEASE REPO | ORT ERRORS O | R SUGGES | TED |
| MPROVEMENT | S | | | | |
| | Ŭ | | | | |
| he Charge-State Booster (CSB) i roduced by this device so must | s intended to be considere | produce radioactive ion beams in cha d when selecting which beam to extra | arge states greater than 1+. St ct. This page may help identify v | able isotopes are also io which charge-state migh | onized and at be the cleanest. |
| Select CSB liner ma | iterial: Aumini | um t | | | |
| Select Mass and Ele | ement: 76 | Rb C Show A/Q values | or Enter A/Q Va | lue: Show Species | |
| Enter resolving | power: 100 | | | | |
| Rb has an atomic number: 37 | | | | | |
| 6Rb has an atomic mass of: 75.9 (on have selected an Aluminium) | 350722 amu liner for the (| SB FCB source | | | |
| 'ou have selected a resolving pov | ver of 100 | | | | |
| due font indicates species which | can currently | be delivered to ISAC II (i.e. have an | A/Q value between 5 and 6.4 or | dy). | |
| Possible Companions" includes a | iny stable spe | cies with an A/Q value within +/- 0.5% | Grades (I.e. have an A/Q value (1/100 resolving power of mag | net) of the species of in | terest. Obviously |
| ot all of these stable species will is well as the recent CSB history | be present a (i.e. isotopes | nd the amount of each species will dep recently injected into the device). | pend on the operating condition | is of the CSB (temperati | ure/pressure etc.) |
| ted font indicates elements which the masses used here to calculat | h are known t | to come from the CSB. (Residual gases | s and the material of the CSB its mass evaluation available at http: | self). Withouse and c hal gostime | |
| inc manages used here to calculat | c , yq values ; | are sason it one the Post2003 diofilie it | 1992 Connarion available at uni | | |
| speciesCharge A/Q Value | P | ossible Companions | | | |
| State 76Rb 1 | 75.93 | 15 | | | |
| 76Rb 2 37.967 76Rb 3 25.311 | | | | | |
| 6Rb 4 18.983 | | | | | |
| 6Rb 6 12.655 | | | | | |
| 6Rb 7 10.847 6Rb 8 9.491 | | | | | |
| 6Rb 9 8.437 6Rb 10 7.502 | | | | | |
| 6Rb 11 6 903 | 62 | 94 | 76- 11+ 83 12+ | | |
| | | | | | |
| 0 | | Cara (Destars | Select Deam Dath | (Drily once after | |
| Save | | Open / Restore | Select Beam Path | (Crity once after modifying rfg files) Param | eters |
| Save 120612_2324.snapitedragon | | Deen / Restore | Select Beam Path | Generate files (Divy once after modifying (fg files) Param Reference 5.30.40000000000000000000000000000000000 | eters Scaling 20520 20520 |
| Save 120612_2324.snapitedragon Save with Standard name +Timestam | 2 | Open / Restore Select time Sie Select time Sie Select time Sie Select time Sie Select time Sie Select time Sie Select time Sie Select time Sie Select time Sie Select t | Extr Willage Source (V): Extr Willage Source (V): | Generate files (Crily once after modifying (fig files) Param Reference 5.30400000000000000000000000000000000000 | East eters 26520 26520 1.0331 1.03364 |
| Save 120612_2324.snapitedragon Save with Standard name +Timestam | p | Open / Restore Select tarv file 120612_2224 trapitedragon 120612_2224.snapitedragon 120612_2224.snapitedragon Open Tune | Extr Voltage Source (V): Extr Voltage Source (V): Extr Voltage CSB (VCSB): DTL Energy in MeV/u (ED): | Generate files C (City once after modifying (fig files) Param Reference 5.30400000000000000000000000000000000000 | Eters Scaling 26520 26520 1.033t 1.03364 1.500 1.600 |
| Save 120612_2324_snapitedragon Save with Standard name + Timestam Timesta-Company State | p | Copen / Restore Setet have file: Setet have file: Setet have file: Setet have file: Setet file to file note: Setet file have file: Setet file have file: | Extr Voltage Source (V): Extr Voltage Source (V): Extr Voltage C30 (VCS0): DTL Energy in MeVia (ED): SC Linac Energy Mevia (E3) | Generate rises (C) (City over the modifying ring files) Param Reference 5.30 40000000000000+04 1.033600000000000+04 1.500 1.500 5.000 5.000 5.000 | Edit Scaling 26520 26520 1.0331 1.033044 1.500 1.500 5.000 5.000 |
| Save 120612_2324.snapitedragon Save with Standard name +Tanestan Re-csb-dragon.snap | p | Open / Restore | Extr Voltage Source (V): Extr Voltage Source (V): Extr Voltage C30 (VC30): DTL Energy in HeV/ar (E3): 3C Lana: Energy Mev/ar (E3) | Generate files: C Generate files: C Generate files: C Param Reference S.30 00000000000000000000000000000000000 | Edit |
| Save 120612_2324.snapitedragon Save with Standard name + Timestan Re-csb-dragon.snap Save Ref with Standard name + Time | e stamp | Open / Restore | Extra Vittage Source (V): Extr Vittage Source (V): Extr Vittage CSD (VCSD): DTL Exergy in MeVit (ED): SC Lina: Exergy Mevita (ES) Element (ex. 160): | Generate files City or state (04) or state Param Reference 5.00-000000000+04 1.03300000000000+04 1.0330000000000+05 1500 1.500 2000 S.000 Catualste Hass H: 12.00000 | Edit Scaling 26520 26520 1.0337 1.0338e4 1.500 1.600 5.000 5.000 2660 75.939072 |
| Save 120612, 2324 snapitedragon 3ave with Standard name + Tanestae Re-csb-dragon.snap Save Ref with Standard name + Tanes (*narved protected) | e stamp | Open / Restore Serie tave its 1081 X = 2024 rangehet rangen Tote tore its more Totes IT, 2024 rangehet rangen Open Tawe Start IT or to Ber Cho Sagan range Type IT for to its more Ber Cho Sagan range Open IT and | Extra Vallage Source (V): Extr Vallage Source (V): Extr Vallage Source (V): DTL: Extry MeVia (ES) 3C Lass: Exergy MeVia (ES) Element (ex. 160): Charge 103 (d1): | Generate Res C (CP) one start Red Pty of the Param Reference 5.0000100000000+04 1.0330000000000+04 1.033000000000+04 1.033000000000+04 1.03000 5.000 Calculate Mass 12C H-12.00000 2 MrG1: 6.00 | Scaling 28520 26520 1.0338-41 1.0338-41 1.500 1.600 5.000 5.000 Calcutate 2080 708b 75.935072 0 inf |
| Save 120612_2324.snapitedragon 3ave with Standard name + Timestan Re-csb-dragon.snap Saven filt with Standard name - Time (Parcerd policity) Convert | P stamp nent run | Open / Restore Site to the second sec | Extra Vallage Source (V): Extr Vallage Source (V): DT. Exercy in MeVia (ED): SC Lass: Energy MeVia (ED): SC Lass: Energy MeVia (ED): Composition (ES): Composition (CO): Composition (CO): Compo | Generate files City or site (City or site) Param Heference 5.000000000000-04 1.033000000000000-04 1.03300000000000-04 1.033000000000000-04 5.000 2000 5.000 2000 5.000 2000 5.000 2000 5.000 2000 5.000 2000 5.000 2000 5.000 2000 5.000 2000 M/02: 51 2000 M/02: 51 | Ection eters Scaling 26520 26520 1.0324 1.030e4 1.500 1.500 Calculate 756b 75.03007 0 inf 1.75,035 1.500 5.000 |
| Save T20612_2224.snaple.dragon T20612_2224.snaple.dragon Save with Standard name - Tomestan Re-Cab-dragon.snap Save field with Standard name - Tome (Paramet protected) Savemet Save field with Standard name - Tomes (Paramet protected) The beam development Save field with try | 9 stamp sent run | Open / Restore Simon and Simon American Simon Ameri | 2000 doing 1000 Extr Vallage Source (V): Dit Vallage CSB (VCB): DT, Earry Medvin (CD): S C Lass Earry Mervin (CS): Dame (CS (CS)): Dame (CS) (CS): Dame | Generate Res C CPV over stars Param Reference 5.00 5.00 0.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 MC01: 6.000 MC02: Inf MC03: Inf MC03: 6.000 | Eating Scaling 26520 25520 1.0334 1.0338e4 1.500 1.500 5.000 5.000 7.0560 7.5.0507 0 inf 1 7.5.0537 0 inf 1 7.5.0537 15 5.062 |
| Save 120012 2023 snipled ragon 3ave with Standard more - Time And Percent problem (Percent problem) Convert (Percent problem) | e stamp | Open / Restore (Seat Ara Ki Seat Ara Ki Se | Entrylard yr chwl Goet Chwlang Sowred (Y) Def Ynhlag Sowred (Y) Dr. Inawy a Meffa (23) (YGB): D'L Barry & Meffa (23) D Lawr (16) D Lawr (1 | Generate Res CC CDV core state Parameter CDV core state Parameter Parameter Parameter S-30 000000000000-0-64 1.0330000000000-0-64 S-300 S.300 S-200 S.300 S-300 S.300 S-3 | Eating Scaling 26520 25509 1.0331 1.038e4 1.500 1.500 5.000 5.000 Catolitic 76F0 75.538072 0 inf 1. 75.538072 1.5 5.062 1.5 5.062 |
| Save 1 120(12, 2274 anaptoring on 120(12, 2274 anaptoring 120(12, 2274 anaptor | g stamp | Depth / Restore Depth / Restor | Detroited y and the second sec | Construction Construction Construction Parama Reference Submotion Submotion Submotion | Control Contro |
| Save 120012, 2024 snaphedragon 120012, 2024 snaphedragon 120012, 2024 snaphedragon 12004 state 12004 s | g stamp | Open / Restore Service and Ser | Entry Mary 1 Source That Sources (Y) Entry Vallage Sources (Y) Entry Vallage Call (VCRIB) DT. Exercy as MoVA (VCR) (S) Exercised (S) Comp (CS (O)): Comp (CS (O)): Comp (CS (O)): Comp (CS (O)): Comp (CS (CS)): Comp (C | General Res CO Control Control Control Control Contro Control | eters Scaling 26520 26520 10333 1.03804 5.000 5.000 5.000 5.000 100 1.080 100 1.080 100 1.080 100 1.080 100 1.080 100 1.080 110 1.0 |
| Save 1 TOOL7 2224 snaphedrogen TooL7 2224 snaphedrogen Save for known - Towardan Re-ctb-dragon.snap Save for known - Towarda - Towarda ("Version Science") Convers ("Versi | p stamp meet run | Company A Restore Company Compa | Entryline 7(1) Sect Vallage Source (7); Ext Vallage Source (7); D.L. vallage C3B (7(28)); D.T. Inserg M M6VA (20); B. Chase Enserg Model (20); Dange ICS (21); Dange ICS (20); Dange ICS (20); Dange ICS (20); Dange MEIT step fiel (20); Dange MEIT step fiel (20); Dange MEIT step fiel (20); Dange SEET step fiel (20); Dange SEET step fiel (20); | Control Control Control < | Scaling Colorador 26520 26520 1.0334 1.033e4 1.003 1.000 5.000 5.000 Colonate 76.33561 7.650 7.633511 1.755 5.002 1.75 5.002 1.5 5.002 1.5 5.002 1.5 5.002 1.5 2.073 3.2 2.373 |
| Save 1 20(12,22)4 anaptedragon 120(12,22)4 anaptedragon Save with Stander anne - Timerkan Bie-cith-dragon.snap Save fiel with Stander name - Time ("Saver anapted Saver an | e stamp stamp ment run | Company American C | Comparison (Control (Contro) (Control (Contro) (Contro) (Contro) (Contro) (Cont | Generalization Generalization University Param Science Science | ECO Colored Colored C |
| Save Save (12001): 2024 snapled region (12001): 2024 snapled region (12002): 2024 snapled region (12004): 2024 snapled region (12004 | stamp | Section of 7000 OF Television | Control (1) Contrestorter Contr | Comparison Comparison University Param December Param Reference Second Second Second Calculated IX Second | Scaling 12520 26533 12520 26533 12321 1.03344 12032 2.0335 12032 2.0336 1500 1.060 15 5.062 16 5.0624 17 5.062 18 5.062 |
| Save and the sense of the sense | e stamp nerd run encutors seators Selectes Jan 7 142534 | Company Analysis Comp | Comparison (Control (Contro) (Control (Contro) (Cont | Conserver the second | LCI sclers Scaling 1550 2630 1500 1500 1500 1500 1500 1500 1500 1500 1500 1500 1775357 17553007 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 15 5.002 17 2.0373 |
| Save Save (12012, 2204 snaphedragen (12012, 2204 snaphedragen (12012, 2204 snaphedragen (12014, 2201 | el stamp nert run bestore Selectes Lates Ture 1 Jan 7142543 | Company Construction Company Comp | Statution y Statution y Statution y Ext 'Intege Source (Y); Ext 'Intege Source (Y); D1: Listency is MoVb (103); D1: Listency is MoVb (103); Ourge (| Construction Construction Scheduler Param Varianti Param Scheduler Scheduler | Langer Standing Sealing 24558 26638 15081 10308 1 1508 1 2008 1508 1 2008 1 1508 1 2008 1 1508 1 2008 1 1508 1 2008 1 1518 5682 1 151 5682 1 |
| Save in TOOLT 2024 single-dragon TOOLT 2024 single-dragon face with Standard some - Tomestan Re-col-dragon.snap Save fire with Standard some - Tomestan (Proceedings) Save fire with Standard some - Tomestan (Pro | e de | Open / Restore Tell 2283 (replace and | Description (V) Edit Vallage Source (V): Edit Vallage Source (V): Drt. Insergy & Meth. (CO): Drt. Insergy & Meth. (CO): Dress (V): Dress (V): D | Control Res CO Substrate intervention Parama Varianti Status Substrate intervention Substrate intervention Substrate intervention <t< td=""><td>LE33 sclors Scaling 1555 3668 1500 1369 1500 1369 1500 1369 155 5.662 156 5.662 157 5.662 158 5.662 159 5.6</td></t<> | LE33 sclors Scaling 1555 3668 1500 1369 1500 1369 1500 1369 155 5.662 156 5.662 157 5.662 158 5.662 159 5.6 |
| Save 1 120(12,2274 snaphedragen 120(12,2274 snaphedragen 120(12,2274 snaphedragen 120(12,274 | e stamp stamp ment run ment run Sections Selecter Jan 714:25:43 0 0 10.0000 | State Open / Restore Immune and immune Immune and immune Immune and immune Immune I | Categories (Categories) Categories (Categories) Extr Vallage Source (V) Extr Vallage Source (V) Extr Vallage Source (V) Extr Vallage Source (V) Categories (Categories) Categories (Categorie | Construction Construction Construction Parama Telerance Sold Sold Sold Sold Sold Sold Sold Sold | Scaling Scaling 2552 2683 1555 2683 1568 3.08 1569 3.08 1569 3.08 1575 5.86 15 5.86 15 5.86 15 5.86 12 2.37 12 2.37 12 2.37 12 2.37 |
| Save Save 120(12, 2014 anapted ragon 120(12, 2014 anapte | e stang stan | Company A Restore Company Compa | Comparison (V) Comparis | Same of the second se | Control Control <t< td=""></t<> |
| Save 1 20012 2224 anaptedragon 20012 2224 anaptedragon 2002 2012 2224 anaptedragon 2012 2012 2014 | Enclose E | Solutions of ADB OX Soluti | Comparison (Construction) C | Construction Reference 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12500 1.400 12600 1.400 < | Control Control Control < |
| Save 1 120(12, 2224 anapted ragan 120(12, 2224 anapted ragan 120(12, 2224 anapted ragan 120(12, 2224 anapted ragan (120(12, 222 | Electron | Dept / Restore Dept / R | Description (CO) Description | Construction Construction University Param Variant Param Scatter Scatter Scatter | Constraint Constraint 1950 7.000 1950 7.000 1950 7.000 1950 7.000 1950 5.000 195 5.000 195 5.000 195 5.000 192 2.030 194 7.000000 195 5.000 192 2.030 |
| Save in TOGE7 2024 snaphedrogen TOGE7 2024 snaphedrogen Save fir With Standard some - Tomerlan Re-cell-dragot, snap Save fir With Standard some - Tomerlan ("Parent Johnson") Save fir With Standard some - Tomerlan ("Parent Johnson") Save fir With Standard some - Tomerlan ("Parent Johnson") Save fir With Standard some - Tomerlan S | | State Open / Restore Immune Immune Immune Immune Immune | Description (V) Edit Vallage Source (V) Edit | Comparison Comparison Comparison Comparison <t< td=""><td>Scaling Scaling 2020 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 1230 2020 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 2020 2022 2020 2022 2020 2022 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2</td></t<> | Scaling Scaling 2020 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 1230 2020 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 2020 2021 2020 2022 2020 2022 2020 2022 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2020 2 |
| Stevel Stevel Tool12_2224_snaphedragen Tool12_2224_snaphedragen Seventherigen Seventhe | e starup sert run sert run sert run Latest Ture (Jun 7 1425:42 0 5.0000 10.0000 10.0000 3.00000 3.0000 3.00000 3.00000 3.00000 3.00000 3.000 | Company Analysis Comp | Comparison (Control (Contro) (Contro) (Contro) (Contro) (Contro) (Cont | Control Res CO Description Param Version Param Science Science | State Control 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 12502 2.0050 |
| Save T 19617 2224 sinapited regen 19617 2224 sinapited regen 19618 2017 2224 sinapited regen 1971 2017 2017 2017 2017 2017 2017 2017 20 | Exercise | Depart Restore Depart Restore Depart Restore Depart Restore Depart Restore Depart Rest Depart Res | Comparison (V) Comparis | Control Res CO Substrate (1) Param Varianti (1) Param Substrate (1) Substrate (1) Substrate (1) Apply (1) Apply (1) Apply (1) Apply (1) Apply (1) Apply (1) Apply (1) | Image: section is a section in the section in the section is a section in the section in the section is a section in the section in the section is a section in the section in the section is a section in the section in the section is a section in the section in the section in the section is a section in the section in the section is a section in the section in the section in the section is a section in the section in the section in the section is a section in the section in the section in the section is a section in the section in the section in the section is a section in the section ine |
| Save Save Save Save Save Save Save Save | Earry E | State Open / Restore Immune Immune Immune | Comparison (Control (Contro) (Control (Contro) (Contro) (Contro) (Contro) (Cont | Construction Construction Understand The Construction 3.348 Construction 4 3.348 Construction 5 3.348 Constru | Interface Interface |
| Save III 20(12, 22)24 anapted region 120(12, 22)24 anapted region 120(12, 22)24 anapted region 22) | Excession | 333 Opport / Restore Image: Section of the section | Comparison (Y) Comparis | Control Res CO Description Param Version Param Scatter Scatter Catter Scatter Catter Scatter Scatter Scatter Catter Scatter | Constraint Constraint Section 2,052 Secti |
| Save II 19017 2224 snaphedragen 19017 2224 snaphedragen Iller tilt Stander kome - Tomritan Re-cab-dragen.snap Save Re rub Stander kome - Tomritan (Parcell Annual - | ECCOD E | Company American Company American Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) Image: Section 2014 (Section 2014) | Comparison (Control (Contro) (Control (Contro) (Control (Cont | Constraints Refere Constraints USANDYRY Param V Param 1000 Science | Control C |
| Sever 11 Sev | Extern | Solution Open / Restore Immune an emiliant Immune an emiliant Immune an emiliant <td< td=""><td>Comparison (Control (Contro) (Contro) (Contro) (Contro) (Contro) (Cont</td><td>Control Res CO Description Param Description Secondary Secon</td><td>Control Control <t< td=""></t<></td></td<> | Comparison (Control (Contro) (Contro) (Contro) (Contro) (Contro) (Cont | Control Res CO Description Param Description Secondary Secon | Control Control <t< td=""></t<> |
| Save in 1997 19017 2224 single-dragen 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 20017 20017 19017 19017 | Extensi Extensi | Solution Open / Restore Immune Law Immune Law | Company (V) Company | Control Res CO Substrate intervention Param Varianti Statuto Substrate intervention Substrate intervention Substrate intervention Apply: Theor Volues Calculated EX | sectors Calling Very Set Sectors Very |

Diagnostic: purity monitor

RIUMF

- Purity monitor (PSID5) downstream of the DTL:
 - · Beam scattering through a gold foil to a silicon detector
 - · Spectrum based on total energy (need to be calibrated)
 - Elements with same mass but different Z are indistinguishable
 - Stand high current (few enA)





DSB _

SC linac



Diagnostic: ∆E-E detector

- Silicon telescope downstream of the SC-linac:
 - Provides ΔE -E information: distinguished different mass and different Z
 - Current limited (few 10³ particle/s)
- Gas detector:
 - ΔE -E information
 - Not current limited









- Introduction
 - ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- o ⁷⁶Rb beam development
- Future development
- Conclusion



Rb beam development

- The radioactive beam chosen is ⁷⁶Rb based on future approved experiment
- Charge state selected (⁷⁶Rb¹⁵⁺) based on accelerator acceptance and best purity calculated by the *CSBassistant*
- Tune the linac with ¹²C²⁺ up to the DSB stripper-degrader then stripped to ¹²C⁵⁺
- Scaling routine used to scale the linac in the 2-3 M/q range
- The scaling routine has been demonstrated to step precisely through M/q's
- The reference starting point (initial tune) must be defined





Rb beam development

- The radioactive beam chosen is ⁷⁶Rb based on future approved experiment
- Charge state selected (⁷⁶Rb¹⁵⁺) based on accelerator acceptance and best purity calculated by the *CSBassistant*
- Tune the linac with ¹²C²⁺ up to the DSB stripper-degrader then stripped to ¹²C⁵⁺
- Scaling routine used to scale the linac in the 2-3 M/q range
- The scaling routine has been demonstrated to step precisely through M/q's
- The reference starting point (initial tune) must be defined





Rb beam development

- The radioactive beam chosen is ⁷⁶Rb based on future approved experiment
- Charge state selected (⁷⁶Rb¹⁵⁺) based on accelerator acceptance and best purity calculated by the *CSBassistant*
- Tune the linac with ¹²C²⁺ up to the DSB stripper-degrader then stripped to ¹²C⁵⁺
- Scaling routine used to scale the linac in the 2-3 M/q range
- The scaling routine has been demonstrated to step precisely through M/q's
- The reference starting point (initial tune) must be defined





- Measured the charge state distribution of the "cocktail" beam: ⁶¹Ni, ⁵⁶Fe and al.
- ⁷⁶Rb not present in the cocktail since it was stopped at the source
- Selected the measured M/q to use as starting point for scaling: ⁶¹Ni²¹⁺ (M/q=2.902) peak was measured at M/q=2.821
- Scaled the linac chain from ⁶¹Ni²¹⁺ to ⁷⁶Rb²⁶⁺
- Introduced ⁷⁶Rb in the system





- Introduction
 - ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- ⁷⁶Rb beam development
- Future development
- Conclusion



"PRAGUE" diagnostic box

- The DSB buncher function is to match the beam into the SC linac
- With the stripper-degrader in the second location the DSB buncher is used to compensate for the energy loss moving away from the linear region
- As consequence the beam is not properly match into the linac leading to loss in transmission
- \circ The first location is better for the foil
- The energy is going to be compensated with the DTL and the DSB buncher keep matching the beam properly into the SC linac



 The DTL analyzing magnet (PRAGUE) can be use as spectrometer for charge state distribution measurement (instead of the SClinac), energy loss and energy spread
 Adding a beta counter in the PRAGUE diagnostic box to detect the presence of RIB



- Introduction
 - ISAC facility
- High Mass Beam Delivery
- o The "toolkit"
 - Accelerator filtration/selection
 - Software
 - Diagnostic
- ⁷⁶Rb beam development
- Future development
- \circ Conclusion



Conclusion

- Phase selection in the accelerator chain can be use as M/q resolution
- Dedicated diagnostic is fundamental to tune RIB
- $\circ~$ Precise scaling set the beam lines on the right M/q
- CSBassistant type of calculator is important to predict the contaminants
- $\circ~$ The first results of delivering high masses at ISAC are promising
- Remains clear that the delivery of such beams is not going to be effortless
- Every new beam will required development time



Thank you Merci