ISAC Facility Report

January 23, 2015

• ISAC performance
• Beam development activities
• Backlog and current proposals

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Professor of Physics | University of British Columbia
ISAC performance
Isotope Landscape at ISAC

Yield Chart of Nuclides

- RIB Intensity Measurement at the ISAC Yield Station:
  - $\alpha$, $\beta$, $\gamma$-decay (HPGe, Plastic-Scintillator, Si)
  - Beam current (Faraday Cup, Channeltron)

- Light target elements: spallation, fragmentation $\rightarrow$ neutron-deficient
- Uranium: fission $\rightarrow$ neutron-rich

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Update on TRILIS beams

- T RILIS isotopes on-line: status is 12/2014
- tested TiSa schemes (incomplete): status is 10/2014
- TiSa network: Mainz, TRIUMF, ORNL, JYFL, GANIL, ISOLDE
- TiSa laser ionization scheme on paper (theory)

Orange denotes elements ready to go online

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TRILIS beam delivery

• TRILIS ITW laser beam transport system upgraded

• TRILIS beams (2014):
  • Be, Sn, Ca, Sr, Ac, Al, Mg, Ga, Ag, At
  • Ca: higher efficiency laser scheme - more than x10 yield increase from lasers
  • Ag: successful spin-isomer separation with lasers

• beam development:
  • Ti, Y, Sb, Tb, Yb: ready for online test & yield with proper target ion source combination
3333 hours RIB delivery
3143 hours experiment run time
168 hours development
<table>
<thead>
<tr>
<th>Facility</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP Ta LIS/SIS TM4 ITW</td>
<td>First run of LIS after laser transport upgrade to ITW. ¹²Be to IRIS. LIS development for Sn.</td>
</tr>
<tr>
<td>HP TiC LIS/SIS TM3 ITE</td>
<td>First charge bred beam to DRAGON ³⁸K. New laser scheme for Ca: increase by factor 100 compared to Ta target and old laser scheme.</td>
</tr>
<tr>
<td>LP UCx LIS/SIS TM1 ITW</td>
<td>Charge bred ⁹⁵/⁹⁶Sr beams to TIGRESS, yields about 1-2 orders of magnitude higher than in previous runs.</td>
</tr>
<tr>
<td>HP SiC FEBIAD TM3 ITE</td>
<td>⁸He to new TAMU chamber. Problems with high voltage stability of target module.</td>
</tr>
<tr>
<td>LP Ta LIS/SIS TM1 ITW</td>
<td>¹¹Be to TIGRESS, ⁸Li to BMNR.</td>
</tr>
</tbody>
</table>
### ISAC targets 2014 (cont.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Description</th>
</tr>
</thead>
</table>
| LP UCx LIS/SIS TM4 ITE | $^{31}\text{Na}$ to **OSAKA**, exceptionally high yield Mg isotopes to TITAN, Fr isotopes to collinear spectroscopy  
$^{213}\text{Fr}$ implantation for nuclear medicine |
| LP ZrC LIS/SIS TM1 ITW | **GRIFFIN** commissioning with $^{26}\text{Na}$  
No LIS beams (Ga) possible due to blockage of extraction electrode |
| HP Ta LIS/SIS TM4 ITE | $^8\text{Li}$ to BMNR, $^{21}\text{Na}$ to GPS3 |
| LP ThO LIS/SIS TM1 ITW | Test target |
| LP UCx LIS/SIS TM4 ITE | $^{32}\text{Na}$, $^{46,47}\text{K}$ to **GRIFFIN**, $^{211}\text{Fr}$ to Fr trap  
Stable Mg to collinear spectroscopy  
Broken target container after a few days of running reduced yields by factor 100 |
Target problems (and recovery)

• LP ZrC/TRILIS failure
  • cancelled 3 experiments
    • S1518 - 11 shifts of $^{62}$Ga (GRiFFIN)
    • S1332 - 8 shifts of $^{62}$Ga (Laser Spectroscopy)
    • S1326 - 2 shifts of $^{76}$Sr (Laser Spectroscopy)
  • delivered 39 shifts to $\beta$NMR from HPTa/SIS

• LP UCx/TRILIS broken target container
  • dramatically lower beam intensities:
    • GRIFFIN’s S1507
      • received only 5/11 shifts of $^{32}$Na
      • delivered $^{46-47}$K instead
    • Francium S1218 ran for 1 day but was cut short by internal problem, demonstrated transfer from collection to science trap
    • Laser spectroscopy S1329’s of exotic Mg isotopes not feasible but methodological developments carried out with $^{26}$Mg

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Beam Development Activities
• 240 composite ThO$_2$/Nb foils
• 12.0 g/cm$^2$ ThO$_2$ / 5.2 g/cm$^2$ Nb total thickness
• Max. Beam current 10 µA p+
• Total beam charge on target 2053 µAh p+
• Max. Core Temperature 1800 ºC
ThO target - Alkali metal yields

Yields similar to regular UCx target
ThO target
Astatine – Isotope shift and HFS

SES isotope shift of At

I=9/2

I=1

I=9/2

SES (cm\(^{-1}\))

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• High yields for $^{223}\text{Ra}$ and $^{224}\text{Ra}$
• Actinium isotopes are not released from the target
• half-life of $^{230}\text{Ra}$ measured with unprecedented accuracy.
Rotating a proton beam of reduced width (and smaller tails) on the ISAC high power targets would contribute to a more homogeneous temperature distribution across the target and enable operating at higher average temp.

- Expected to allow beam current increase up to 50% of present levels*
- Increased temperature => enhance diffusion and effusion of the isotopes
- Higher currents will boost production

=> both will contribute to higher yields of radioactive ion beams.

*TRI-DN-08-19 `Rotating proton beam simulations for optimization of the ISAC target temperatures’ – P. Jones, M. Trinczek, R. Laxdal
ISAC – AC Raster Magnet

- Magnets and power supplies installed at ITE
- Tested locally
- Beam Profile Monitor installed
- Tests with beam done December 2014
  data analysis ongoing
Implementation plan

- Install controls for magnets in shut down

- Proposed targets for development: (~1 week each)
  
  1. Low power Ta with surface source D (or egg shaped) foils can be used for non rotating beam
     - Develop parameters for beam rotation
     - Test diagnostics
     - Implement and test interlocks
     - Measure yields
  
  2. Ta or SiC target annular shaped foils only useful for rotating beam
     - Optimize parameters
     - Measure yields
Target ion source development for 2015 (proposal)

1. Rotating beam development
2. Graphite target container/insert for UC
   • Off line tests to be done in January, February
3. Modified center block for low power target containers
   • Can be combined with 2nd target for rotating beam
Modified Centre Block for low power targets

**continued dev.: temperature modeling for target ion sources**

**thermal simulations for standard target (2.5kW internal heating)**

- ISAC standard with surface ion source (235A heating)
  - 1320 °C, 1270 °C
  - J. Lassen (2014)

- ISAC new: with short, heated transfer tube (300 A heating) for IG-LIS
  - 1290 °C, 1114 °C
  - 1505 °C, 1540 °C

**under development:**
- ISAC new with surface ion source
  - better release for short lived isotopes
1. Rotating beam development
2. Graphite target container/insert for UC
   • Off line tests to be done in January, February
3. Modified center block for low power target containers
   • Can be combined with 2\textsuperscript{nd} target for rotating beam
4. (IG)LIS Lanthanides
   • High power Ta target
   • Other elements depending on target schedule
5. New UC\textsubscript{x} processing technique
   • Shorter processing time
6. High temperature W target design
   • For short lived isotopes
7. FEBIAD beams
   • requires TM2
   • Cold transfer line (depending on failure analysis review)
8. n – converter target
   • Concept to be reviewed
   • requires contributions from ISOLDE collaborators
Backlog and current proposals
## ISAC target modules

### January 2015

<table>
<thead>
<tr>
<th>TM</th>
<th>HV</th>
<th>Sources</th>
<th>availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24 kV</td>
<td>SIS/LP</td>
<td>ready</td>
</tr>
<tr>
<td>2</td>
<td>~57 kV</td>
<td>FEBIAD/SIS/HP</td>
<td>End of June 2015</td>
</tr>
<tr>
<td>3</td>
<td>15 kV</td>
<td>FEBIAD/SIS/HP</td>
<td>Not ready (broken steerers, unstable HV)</td>
</tr>
<tr>
<td>4</td>
<td>&gt;50 kV</td>
<td>SIS/IGLIS/HP</td>
<td>ready</td>
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## Backlog by Target / Ion Source combination

<table>
<thead>
<tr>
<th>High Target</th>
<th>RILIS</th>
<th>SIS</th>
<th>IGLIS</th>
<th>FEBIAD</th>
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<tr>
<td>Nb</td>
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<tr>
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<table>
<thead>
<tr>
<th>Medium Target</th>
<th>RILIS</th>
<th>SIS</th>
<th>IGLIS</th>
<th>FEBIAD</th>
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<td>Nb</td>
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<td>5</td>
<td>0</td>
<td>0</td>
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<td>9</td>
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<tr>
<td>ZrC</td>
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<td>0</td>
<td>0</td>
<td>13</td>
</tr>
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</table>

- **Ta SIS/RILIS:** 106 shifts (8 weeks + bNMR) ➔ 2-3 targets
- **UC SIS/RILIS:** 106 shifts (8 weeks) ➔ 2 targets
- **UC IGLIS:** 45 shifts (3 weeks) ➔ 1 target
- **ZrC SIS/TRILIS:** 23 shifts (incl. Nb) + bNMR ➔ 1 target
- **SiC SIS/RILIS:**
  - **28Mg TIGRESS needs 56kV ➔ TM 2**
  - **Al implantation possible w/ TM4 (12 shifts approved, under review)**
  - **Additional shifts being requested (26Al implantation, 20Mg IRIS)**
- **SiC FEBIAD:**
  - needs optimal FEBIAD performance ➔ TM2 (at the earliest in Fall Schedule)
Operational plan:
8 months operation per year (240 days, 8 targets, 5 days ovhd/tgt)
→ 176 days RIB delivery (4224 hours)
→ 35 days Materials Science (20%)
→ 15-20% beam development
→ ~ 105-110 days RIBs for SAP

Dec 2014:
404 RIB shifts with H priority (1.9 yrs)
89 RIB shifts with M priority (0.5 yrs)

ISAC-RIB shifts quota: 105 shifts

RIB oversubscription factor 1.5

<table>
<thead>
<tr>
<th></th>
<th>ISAC-RIB</th>
<th>ISAC-SIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Reports/Addenda</td>
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<tr>
<td>New Proposals</td>
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<tr>
<td>Sum</td>
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<td>58</td>
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Thank you!
Merci