Status Report of SECRAL II Ion Source Development

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Outline

• Motivation of SECRAL II
• Perspectives of SECRAL II
   Latest Performance of SECRAL I
   SECRAL II design
• SECRAL II Magnet Status
• Summary
HIRFL Operation Scheme

- ECRIS + SFC
- ECRIS + SFC + SSC
- ECRIS + SFC + CSRm (CSRe)
- ECRIS + SFC + SSC + CSRm
- SCECR + LINAC + CSRm
**CSR-LINAC Project**

- **SECERAL II**
  - RFQ
  - KONUS-DTL
  - HEBT
  - CSRm

- **Parameters**
  - **A/q**: 3~7 \(^{238}\text{U}^{34+}\)
  - **Frequency**: 108.48/216.96/(325.44 ) MHz
  - **Kinetic energy**: 7(14) MeV/u
  - **Pulsed Beam current**: >1puA → ECR >2 puA
  - **Beam repetition rate**: 1~30 Hz
  - **Beam pulse duration**: 0.1~3 ms

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Backup of SECRAL

SECRAL: Highly charged ion beams heavier than Ar
Operation of SECRAL I

![Bar chart showing operation time of LECR3, SECRAL, and LAPECR1 from 2007 to 2013. Time is measured in hours.]
Operation of SECRAL I

Need contingency plan if SECRAL might fail to work
Pros
• Lower/simpler interaction forces;
• Smaller magnet size and cryostat;
• Simpler fabrication and somewhat a bit lower cost.

Con
Inefficient utilization of the radial field.

Courtesy of D. Xie
**SECRAL I**

**Fully superconducting magnet**
- Axial field: 3.7, 2.2T
- Sextupole Field at the wall: 2.0 T
- RF frequency: 18-24 GHz
- Warm bore: $\varnothing 140$ mm
- Extraction voltage: 25 kV
Production of intense highly charged heavy ion beams
Improved Oven Tech.

- Temp.: 650°C Max., continuous control
- Capacity: Ø 7mm×12 mm crucible → >2 g Max. for Bi grains
- No liquid metal spilling

Tech. idea from LBNL
Intense Bi Beam Production

Bismuth Beam Records with SECRAL

- Improved Cartridge Oven
- Cartridge Oven
- With normal resister oven

Q

Ion beam intensity (nA)

4.74 kW@24 GHz, 1.40 kW@18 GHz, \(710 \text{ euA Bi}^{20+}\)

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Intense Bi Beam Production

Bismuth Beam Records with SECRAL

- Improved Cartridge Oven
- Cartridge Oven
- With normal resister oven

400 eμA Bi\textsuperscript{31+}@10.91 mg/hr
Intense Bi Beam Production

Bismuth Beam Records with SECRAL

Intensity evolution of Bi$^{31+}$ vs. 24 GHz Power

4.74 kW@24 GHz, 1.40 kW@18 GHz, 710 euA Bi$^{30+}$
Intense Bi Beam Production

**Bismuth Beam Records with SECRAL**

- Improved Cartridge Oven

**Intensity evolution of Bi^{31+} vs. 24 GHz Power**

- 4.74 kW@24 GHz, 1.40 kW@18 GHz, **710 euA Bi^{30+}**

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Intense Bi Beam Production

Bismuth Beam Records with SECRAL

Intensity evolution of Bi$^{31+}$ vs. 24 GHz Power

1 kW/L

4.74 kW@24 GHz, 1.40 kW@18 GHz, 710 euA Bi$^{31+}$

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Production of HCIs

SECRAL I-24 GHz Bi results-2014

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<th>Q</th>
<th>Iq (eμA)</th>
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<tr>
<td>30</td>
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<td>57</td>
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SECRAL II

Parameters | Value
--- | ---
$\omega_{rf}$ (GHz) | 18-28
Axial Field Peaks (T) | 3.7 (Inj.), 2.2 (Ext.)
Mirror Length (mm) | 420 mm
No. of Axial SNs | 3
$B_r$ at Chamber Inner Wall (T) | 2.0
Coldmass Length (mm) | ~810
SC-material | NbTi
Magnet Cooling | LHe bathing
Warmbore ID (mm) | ~142
Chamber ID (mm) | ~126
Dynamic cooling power (W) | ~5
## NbTi Wire

### Rectangular wire from WST Co. Ltd

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<td>No. of Filaments</td>
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<td>Pitch size (mm)</td>
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</table>

### Loading factor analysis chart

- **SECRL Coils Analysis**
  - NbTi-WST
  - SECRL SEXT
  - SECRL INJ
  - NbTi @4.2 K
  - Loading factor analysis chart: ~86%
Cold Mass

Sextupole coil

Extraction solenoid

Middle solenoid

Injection solenoid

Al alloy ring

Iron yoke

Iron core (DT4)

End plate (DT4 iron)

Winding bobbin (SS)
Cold Mass Structure

SECRAL II Coldmass

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Solenoids

SNs ramped to **115%** of designed currents without any quenches
Sextupole Coils

Winding → Single Coil → 4 of the 6 Coils

Prepare for vacuum impregnation
Assembly

Sextupole Coils Pre-assembly  Finished Assembly  Finished with Al Clamping
Cold Mass Test @ 4.2 K

- Sextupole coils ramped to 85% with 6 quenches
- All coils ramped together to 90% with 8 quenches
Status of Magnet Fabrication

- Engineering design finished, and ready for factory fabrication
- Sumitomo GM coolers are ready to be delivered
- Cryogenics power supplies are to be delivered
- Total assembly is expected to be completed in Jan. 2015
Test Bench Setup

Features:

• Minimize the aberration caused by SN
• Short ECR beamline
• Double focusing large acceptance dipole magnet (28 cm W/18 cm H)
• Decoupling test of the beam in phase space
• Flexible setup to improve analyzed beam resolution
Summary

- 3rd G. ECRISs have been developed for more than 10 years, but still have great potentials
- Metal vapor supply is essential for a high performance ECRIS
- SECRAL II magnet cold mass fabricated successfully
Acknowledgement

Ion Source Group
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Magnet Group

Xi’an Superconducting Magnet Technology (XSMT) Inc.
Thanks !!
Emittance vs. Intensity

Emittance vs. beam intensity

Normalized RMS Emittance (πμm)

Bi^{31+} intensity (euA)
24 GHz, Bi$^{31+}$, Emittance ~600euA

24 GHz, Bi$^{31+}$, Emittance ~500euA