Production of $^{48}$Ca and $^{48}$Ti ion beams at the DC-280 cyclotron

Superheavy Elements (SHE) Factory – the Goals

- Experiments at the extremely low ($\sigma<100$ fb) cross sections:
  - Synthesis of new SHE in reactions with $^{50}$Ti, $^{54}$Cr ...;
  - Synthesis of new isotopes of SHE;
  - Study of decay properties of SHE;

- Experiments requiring high statistics:
  - Nuclear spectroscopy of SHE;
  - Study of chemical properties of SHE.

To carry out the scientific program, the DC-280 has to provide the following parameters of ion beams:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Ion energies (smooth variation)</td>
<td>4 - 8 MeV/n</td>
</tr>
<tr>
<td>Ion masses</td>
<td>10 - 238</td>
</tr>
<tr>
<td>Intensities (A~50)</td>
<td>&gt;10 pµA</td>
</tr>
<tr>
<td>Efficiency of beam transfer from ion source to physical facility</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>
Main parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHF frequency</td>
<td>14 GHz</td>
</tr>
<tr>
<td>Binj</td>
<td>$\geq 1.3 , T$</td>
</tr>
<tr>
<td>Bmin</td>
<td>0.4 T</td>
</tr>
<tr>
<td>Bextr</td>
<td>1.0 $\div$1.1 , T</td>
</tr>
<tr>
<td>Br</td>
<td>1.05 $\div$1.15 , T</td>
</tr>
<tr>
<td>Plasma chamber internal diameter</td>
<td>70 mm</td>
</tr>
</tbody>
</table>

Magnetic structure of DERIS-PM.
1÷5 – PM rings; 6, 7 – soft iron rings;
8÷11 – soft iron plates,
12÷14 - auxiliary elements,
15 - hexapole, 16 – coil.
Production of $^{48}\text{Ca}$ beam

- Oven 1: 1300 °C
- Oven 2: 500 °C

Reduction of calcium from calcium oxide

$3^{48}\text{CaO} + 2\text{Al} \rightarrow 3^{48}\text{Ca} + \text{Al}_2\text{O}_3$

CaO + Al

Crucible

Heater

Holder

Helium

Helium + Ca

Helium + Ca + UHF Power > 300 W

The $^{48}\text{Ca}$ ion spectrum, optimized for Ca$^{10+}$

Microoven temperature vs power

$P_{\text{Vapor Pressure}} \approx 2.3 \times 10^{-3}$ Torr

$T^\circ C$

$P$ (W)

$I$, $\mu$A

$I_{magn}$, A

$^{48}\text{Ca}^{1+}$, $^{48}\text{Ca}^{2+}$, $^{48}\text{Ca}^{3+}$, $^{48}\text{Ca}^{4+}$, $^{48}\text{Ca}^{5+}$
Production of $^{48}$Ti beam

$(\text{CH}_3)_5\text{C}_5\text{Ti}($CH$_3)_3$

$^{48}$Ti + UHF Power 350 W

The $^{48}$Ti ion spectrum, optimized for Ti$^{7+}$
Conclusion

• During the work was obtained $^{48}\text{Ca}$ and $^{48}\text{Ti}$. The $^{48}\text{Ca}$ beam was accelerated, the average extraction efficiency from the ion source to output from the cyclotron is $\approx 50\%$. The average consumption for the $^{48}\text{Ca}$ is $0.7\text{ mg/h}$, for $^{48}\text{Ti}$ is $0.55-0.65\text{ mg/h}$.

• The operation of the DECRIS-PM ion source was stable and reproducible.

• The intensity of the calcium and titanium beams produced by the DECRIS-PM meets the requirements of the DC-280 cyclotron.
Thank you for your attention!