New stable beam developments

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Summary:

I- Facility and equipments for the tests

II- Silicon beam production

III -Tungsten beam production

IV: Tellurium beam production

V: Thorium beam production

VI: The First beams tests with HT oven

VII: Conclusion
I- Facility and equipments

ECR4 ion source : platform 100kV
ECR4-M ion source : 25KV

Tests beams production in parallele of experiments
→ tests 24/24H
Oven method

- A lot of isotopically enriched elements are evaporated by oven (oxyde and metallic form)
- Control of evaporation
- High charges states can be optimized
**MIVOC method**

- Equipment to inject organometallic compound

**Metallic beams with MIVOC:**
- Ni, Fe, Mg, Cr, Ti

For natural elements: Several Commercial compounds can be found.

R&D to obtain synthesis with the isotopically enriched element.

=> B.GALL’s team IPHC- Strasbourg

Several syntheses could be developed to replace the evaporation of element with high vapor pressure (difficulties of evaporation control with oven)

**In progress:** synthesis of Uranocene
- First test in March 2022 without success
- Second test in 2023
Upgrade of MIVOC system (2021-2022)

Goal:

⇒ Optimization of regulation
⇒ Increase conductance between MIVOC chamber and plasma chamber
⇒ Design to stop the insulator metalization

RUN with $^{58}\text{Ni}^{11+}$:
20 e.µA for 31UT with better stability
Upgrade of MIVOC system (2021-2022)

Results for 4 days before and after upgrade with $^{58}\text{Ni}^{11+}$

- Intensity a little bit higher (20e.µA compare to 15e.µA)
- More stable beam
- Reduce tuning interventions along the experiment
II- Silicon beam production

**Compound**: SiO natural  
**Vapor pressure**: $10^{-2}$ mbars for 1080°C  
**Interest of using**: Several isotopically enriched samples with this compound ($^{30}$SiO, $^{29}$SiO)  
**Consumption**: 0.59 mg/h of Si (0.89 mg/h of SiO)  
**Efficiency**: 6%

**Example of beams available for physics**

$^{28}$Si $^{7/14+}$ at 95 MeV/A → 0.4 p.µA on the target  
$^{30}$Si $^{7/14+}$ at 85 MeV/A → 0.4 p.µA on the target
III-Tungsten beam production

**Compound:** tungsten hexacarbonyl $W(CO)_6$

**Consumption:** 0.49 mg/h of W (0.97 mg/h of $W(CO)_6$)

**Efficiency:** 4.9%

$^{186}W^{20+} = 1.4e.\mu A$ (in the Faraday cup after source)

**Compound:** tungsten trioxide- $WO_3$ natural

**Vapor pressure:** $10^{-2}$ mbars for 1176°C

**Consumption:** 3.5 mg/h of W (4.5 mg/h of $WO_3$

**Efficiency:** 1.4%

$^{186}W^{20+} = 2.8e.\mu A$ (in the Faraday cup after source)

$^{186}W^{24+}$ at 6 MeV/A $\rightarrow$ 11 p.nA on the target
IV-Tellurium beam production

**Compound:** $^{130}\text{Te}$ (99,8% enriched sample)

**Vapor pressure:** $10^{-2}$ mbar for $360^\circ$ C

**Melting point:** 452$^\circ$ C

**Consumption:** 0.52mg/h of $^{130}\text{Te}$

**Efficiency:** 7.5%

$^{130}\text{Te}^{20+}=6\text{e.}\mu\text{A}$ (on the faraday cup after ion source)

$^{130}\text{Te}^{19+}$ at 8 MeV/A $\rightarrow$ 50p.nA on the target
V-Thorium beam production

**Compound:** $^{232}\text{ThF}_4$

**Vapor pressure:** $10^{-2}$ mbar for $950$° C

**Melting point:** $1100$° C

**Consumption:** $0.1$ mg/h of $^{232}\text{Th}$

**Efficiency:** 8%

- **VAMOS experiment proposal:**
  $^{232}\text{Th}^{30+}$ at $6.1$ MeV/A $\rightarrow$ 12 p.nA on the target

- **An other example of intensity**
  $^{232}\text{Th}^{34+}$ at $8$ MeV/A $\rightarrow$ 2 p.nA on the target
VI- The first beam tests with HT OVEN

The goal of HT oven development

✓ For Ganil-Cyclotrons in ECR4 source:
  → increasing metallic beams intensities which are produced today by sputtering method ($^{238}\text{U}$, $^{181}\text{Ta}$, ….)

✓ For Spiral 2 in Phoenix V3* ECR IS:
  → $^{50}\text{Ti}$ or $^{50}\text{V}$… ~ $1.2 \times 10^{13}$ pps

- Removable head
- Operate in the magnetic field
- Remove of sample without to break the vacuum

*developed by LPSC (Grenoble)
Test of vanadium in ECR4-M ion source

- 4 days of continue running with V and 25 days total operation in 2021
- Oven validated to evaporate Uranium

\[ 50 \text{V}^{10+} = 9 \text{e.\(\mu\)A} \]
\[ 10^{-2} \text{ mbar for 1820}^\circ \text{C} \]
Test of uranium in ECR4-M ion source

- Choice of crucible: Y\textsubscript{2}O\textsubscript{3} for compatibility with \textsuperscript{238}U
- Yttrium pollution due to evaporation of crucible
- Intensity of Uranium interesting despite the pollution and the lower of ion source ‘s perform (modification of RF injection with HT oven)
- Next test with UO\textsubscript{2}
V-Conclusion

- Four new ions beams availables (Si, W, Te, Th)
- Carbonyl compounds: New way to produce other metallic elements.
- News organometallic syntheses could be developed depending of physics request.
- HT oven up to 2000°C is a successful and useable for operation

Thank you for your attention!