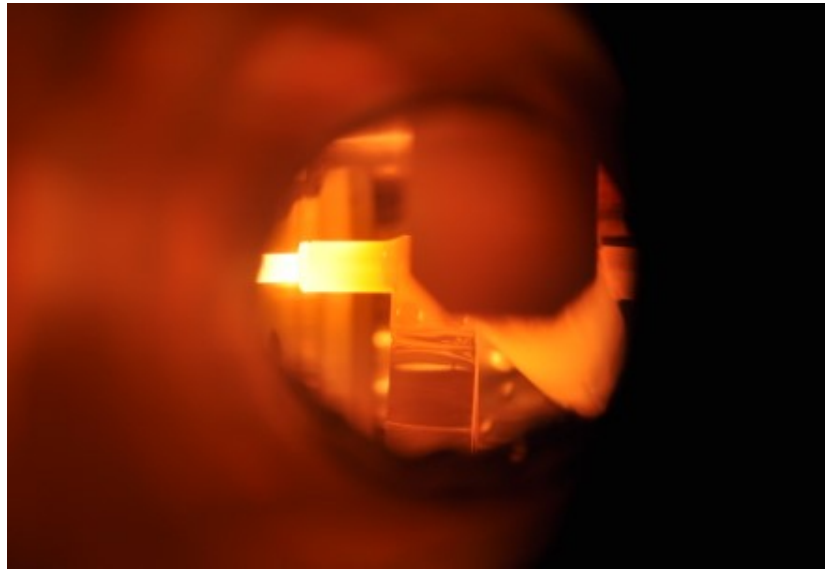
Target and ion source developments in 2019

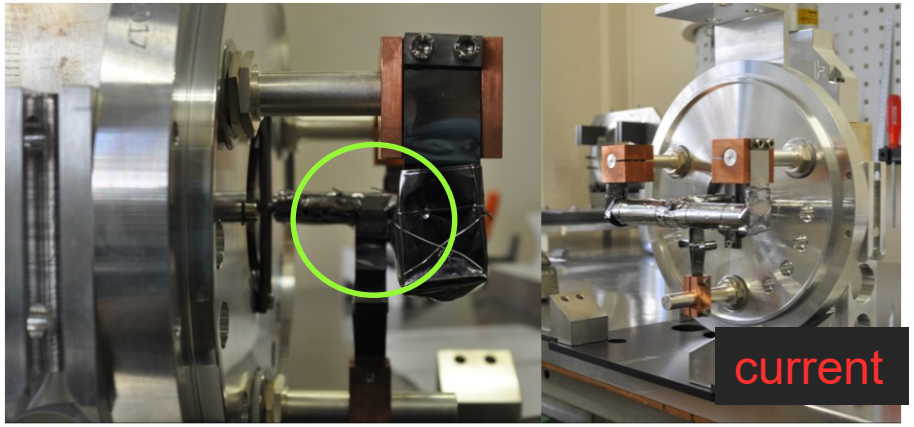


David Leimbach

on behalf of the target and ion source development teams

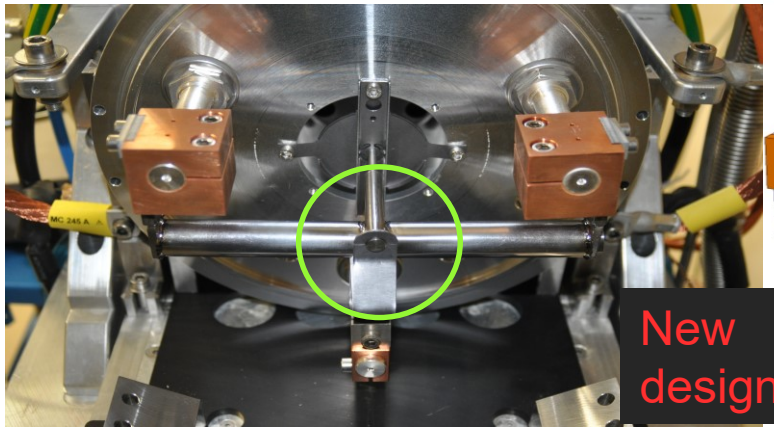
CERN | EN ENGINEERING DEPARTMENT

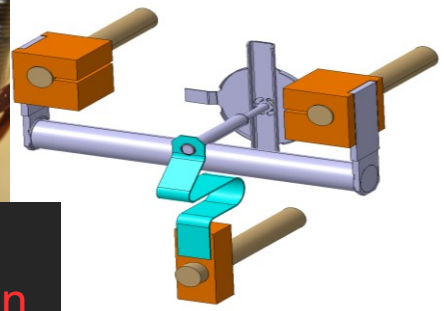
Temperature gradient issues- transfer line

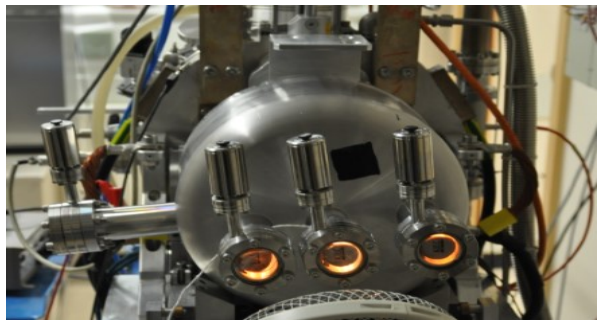


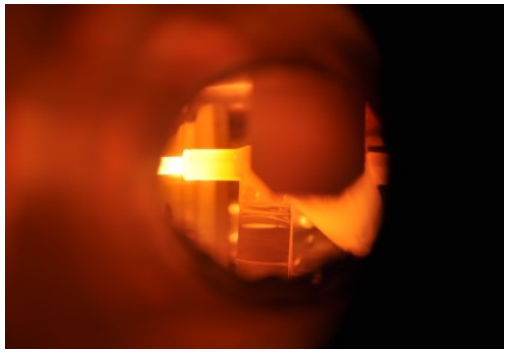
- Standard ISOLDE target: **613K temperature gradient** along the **transfer line**
  - 2051C in ion source vs 1536C at transfer line cap

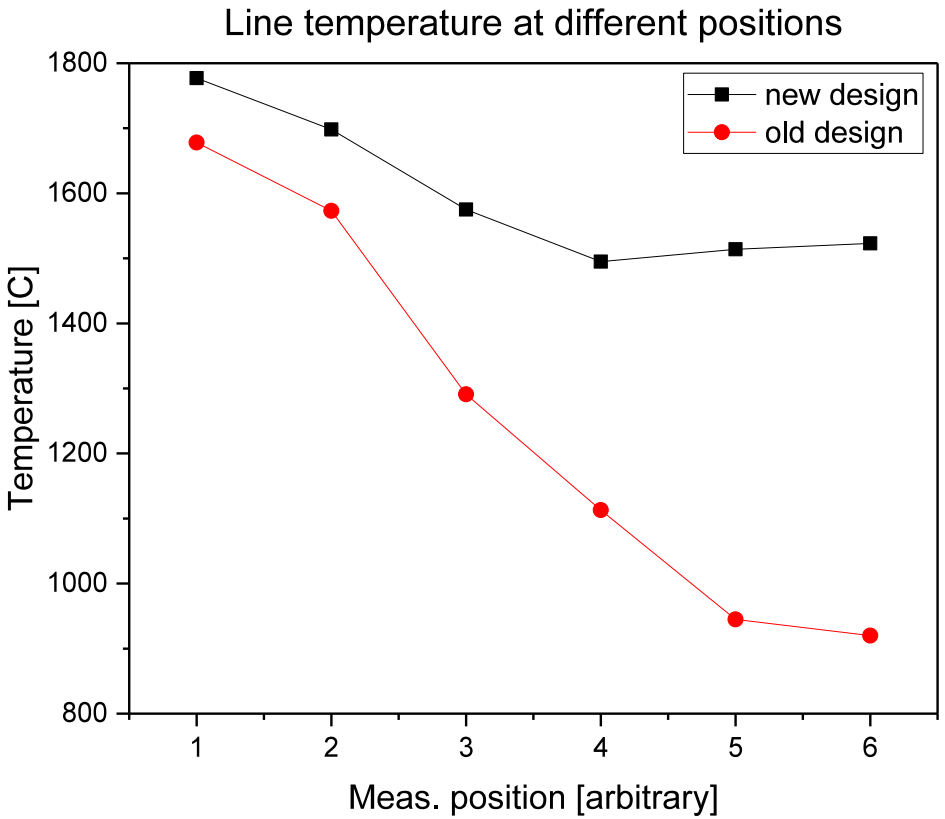
➡ New transfer line design: Connection from the back





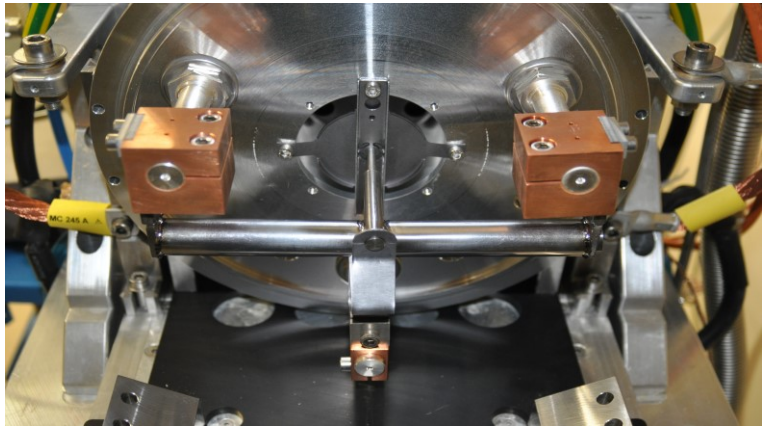


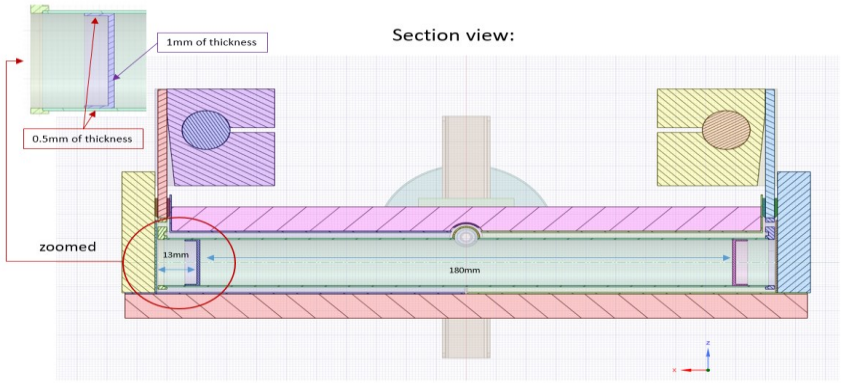


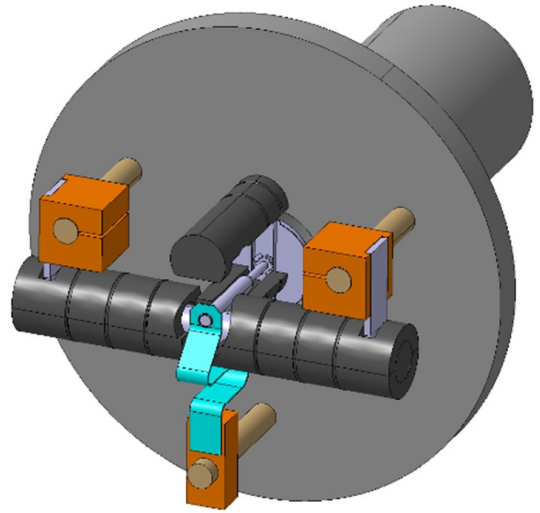


Vasileios Samothrakis

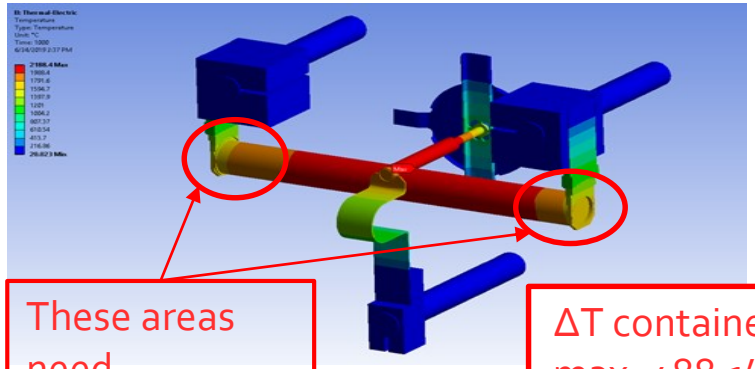
Temperature gradient issues- target container

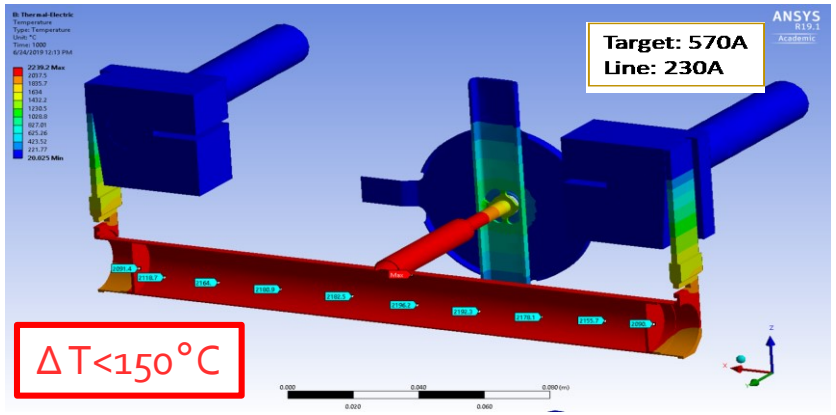


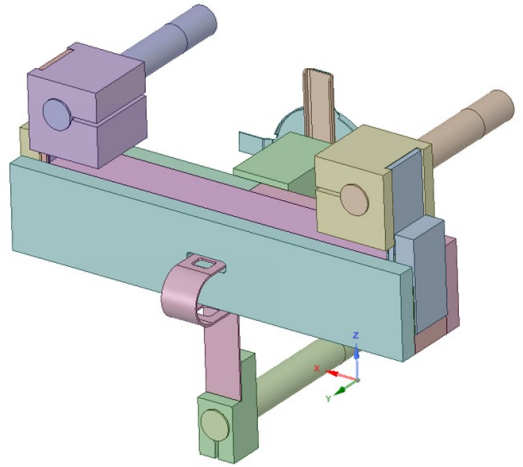




Simplified design to reduce the machining cost:







- Cold spots at the edges of the container ΔT=488°C
- **New caps** design +50% less material in the container extremities
- **SIGRATHERM® MFA as a new thermal insulation**

Vasileios Samothrakis

Optimization of UC_x production:

→ From 1 batch/ week to 1 batch/day

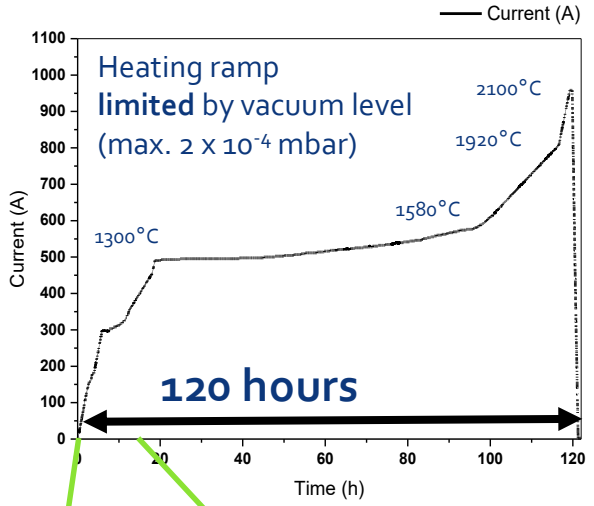
Annual production: 10-12 batch / year

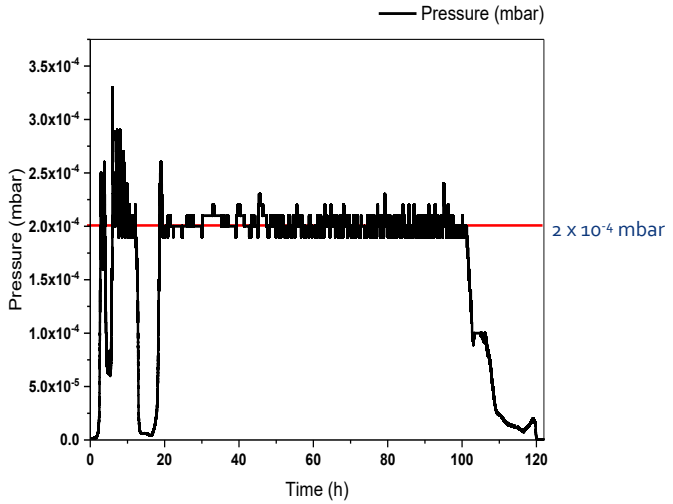
Process:

Mixing → Pressing → **Carbothermal Reduction**

1.5 hours | 2.5 hours | **120 hours**

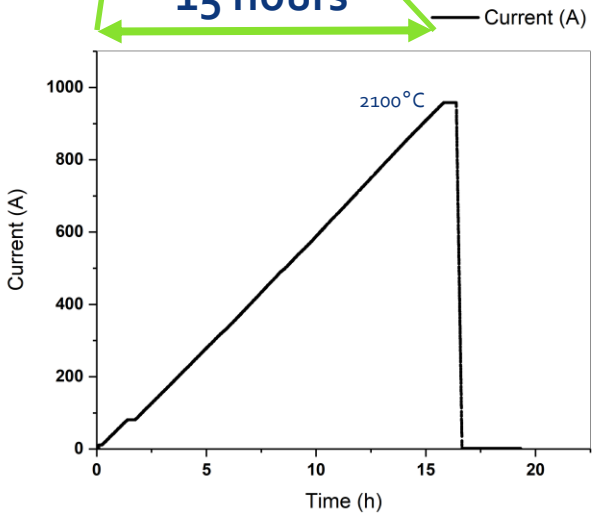
$UO_2 + 6\,C \rightarrow \mathbf{UC_2 + 2\,C} + 2\,CO\uparrow$

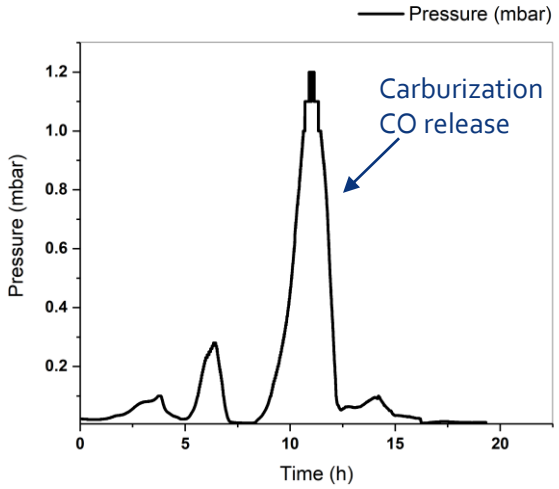




Increase of pressure limit → 2 mbar

15 hours





NEXT STEP: Control and Validation of new method

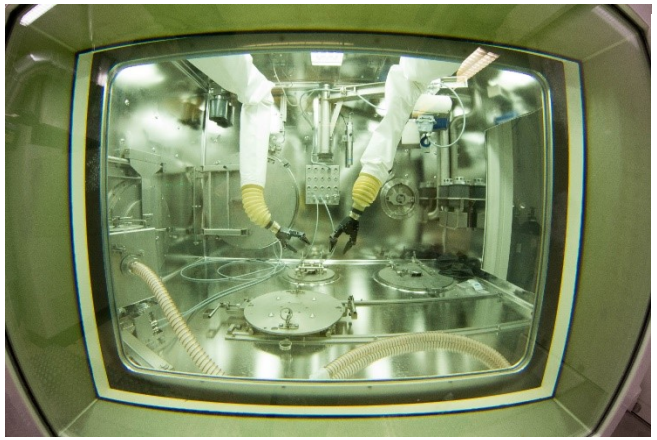
- ✓ Microstructural characterization
- ✓ Isotope release tests online

S. Rothe, N.-T. Vuong, M. Owen

Investigation for the disposal of current and next generation UC_x target waste

Temporary Storage

Dismantling

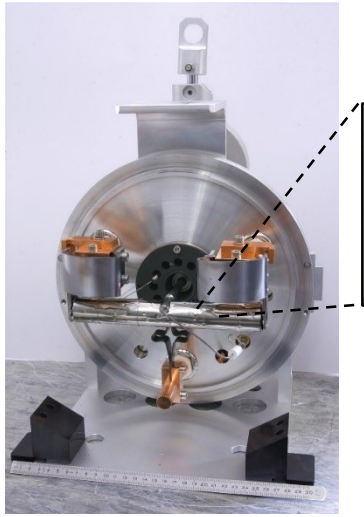


Oxidation

Cementation

Conditionning

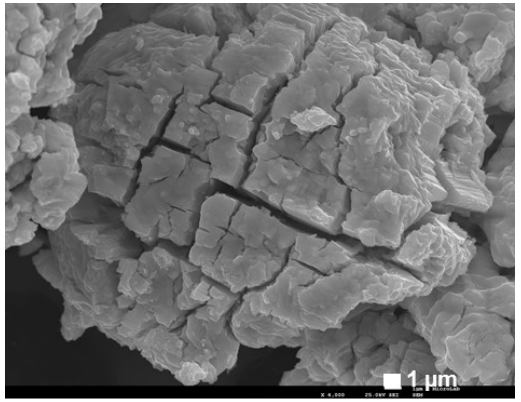
Target material



Uranium carbide pellets
d=14 mm
Thickness 1.5 mm

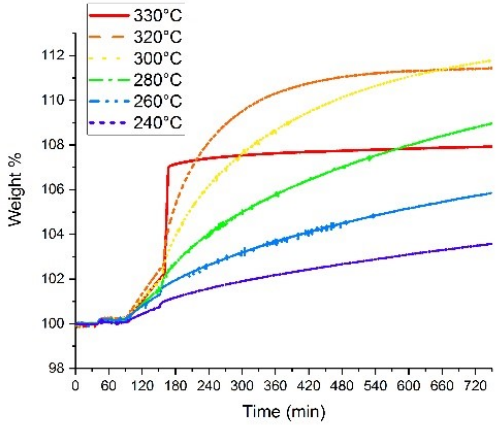
Thermal analysis

Microstructural analysis



Micro UC_x after oxidation (U_3O_8)
at 350°C under 10% O_2

Kinetic Model



EPFL Nhat-Tan Vuong

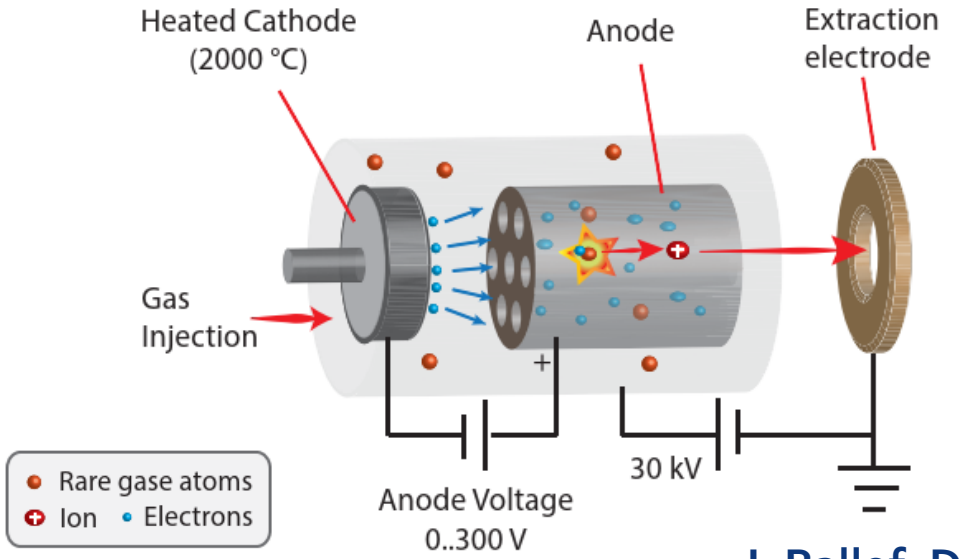
Ionization potential (IP) measurements with the VADIS source

IUPAC Poster Prize TAN 2019

Motivation: IP measurements for superheavy elements

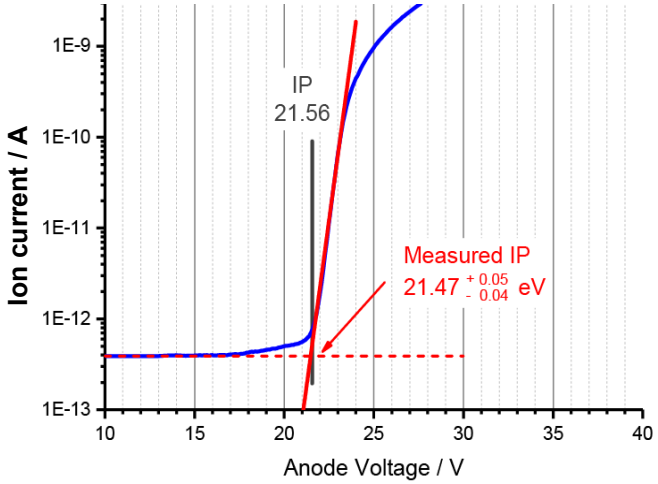
- Heavy actinide IPs recently measured by surface ionization ***-> T. Sato et al, JACS 140, 2018, 14609***
- IPs predicted to significanly increase for early transactinides
  - ➡ **Surface ionizer efficiency too low**
  - ➡ **Electron impact ionization needed**

Ionization by electron impact - The ISOLDE - VADIS source



How to measure IPs with the VADIS source?

- Precise measurement of Ion current vs. Anode voltage
- Extrapolation of efficiency curve



Obtained accuracy

- Obtained IPs within ± 0.1 V (± 0.3 V for Xe) in agreement with spectroscopic values

IP / eV	He	Ne	Ar	Kr	Xe
Lit.	24.59	21.56	15.76	14.00	12.13
Meas.	24.55	21.47	15.83	14.10	11.80

J. Ballof, D. Leimbach, B.A. Marsh, A. Ringvall-Moberg, S. Rothe, T. Stora, S. Wilkins

Photocathode source

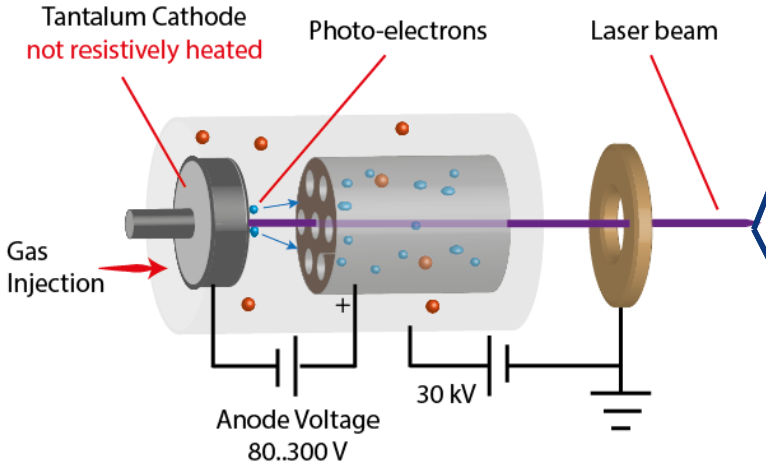
VADIS source at ambient temperature

Electron generation by laser, not thermal evaporation

Motivation

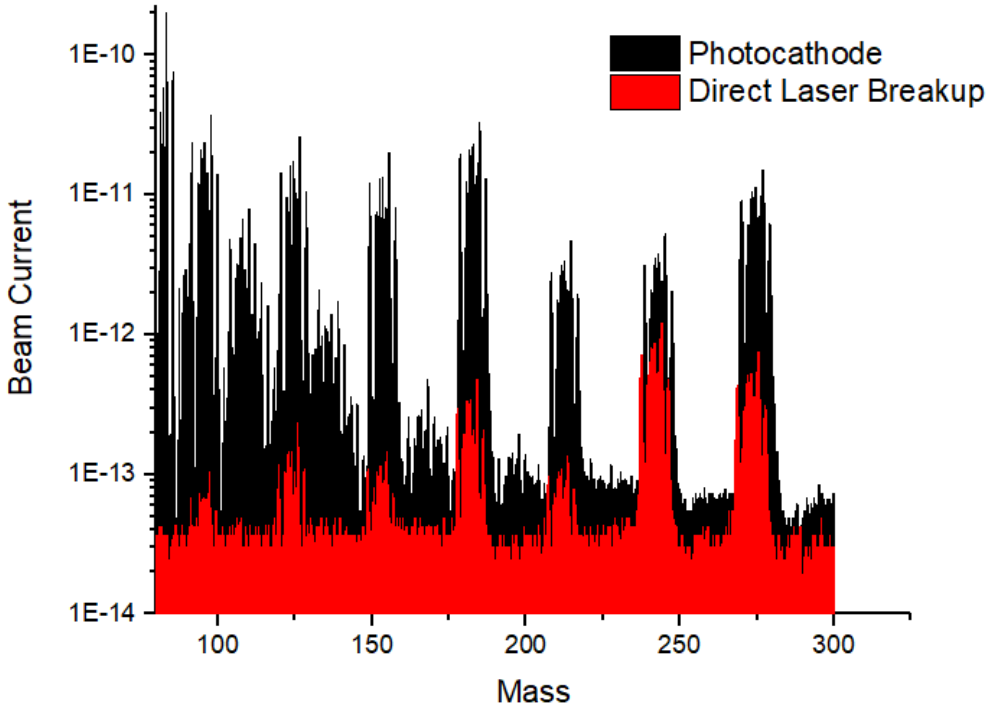
- Ionization of fragile molecules
- No decomposition on hot surfaces
- Diagnostic tool to measure ionization properties

Set up



Laser properties (PHARROS)	
Pulse length	265 fs
Power	4.5 W
Wavelength	343 nm
Rep. Rate	50 kHz

First Results:
Mass spectrum of $Mo(CO)_6$ + Kr



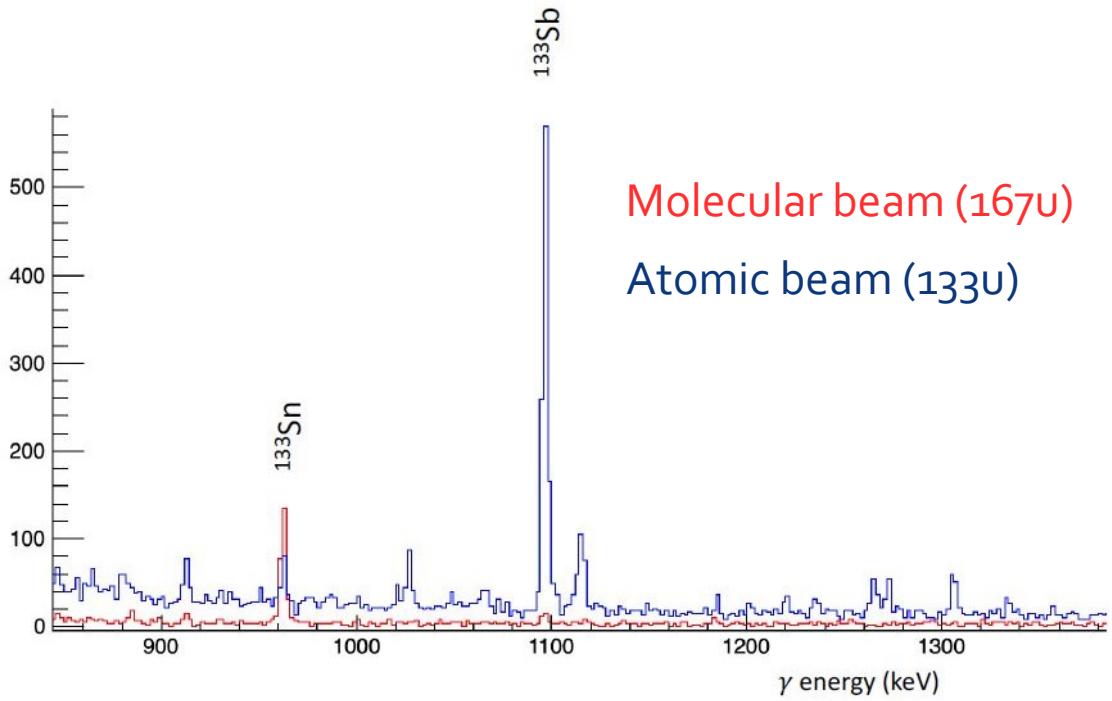
Two operation modes found

Photo cathode	Direct laser breakup
Anode biased	Anode off
Magnet 6A	Magnet off
Krypton ionized	Krypton not ionized
$Mo(CO)_3$ predominant	$Mo(CO)_5$ predominant

J. Ballof, D. Leimbach, B.A. Marsh, A. Ringvall-Moberg, S. Rothe, T. Stora, S. Wilkins

SnS beam development

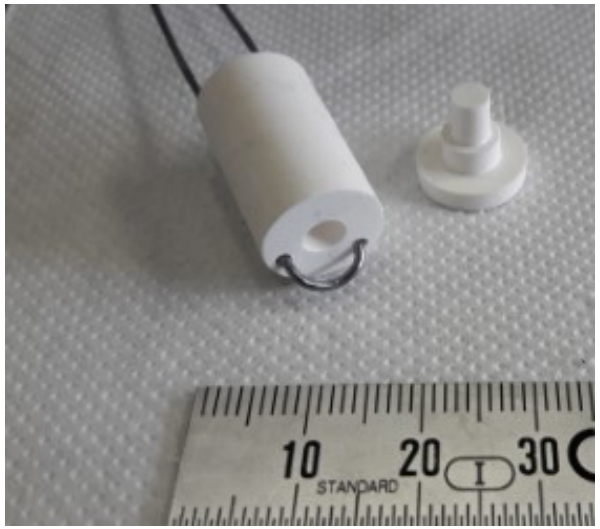
- **Beamlab JRA in ENSAR 2**:
  - Efficient extraction of Sn as SnS molecule
- Controlled release of S from mass marker necessary
  - S oven in BN cylinder heated externally with Ta wire
- **Offline tests at ISOLDE Offline 1**
  - 5-7% efficiency for SnS

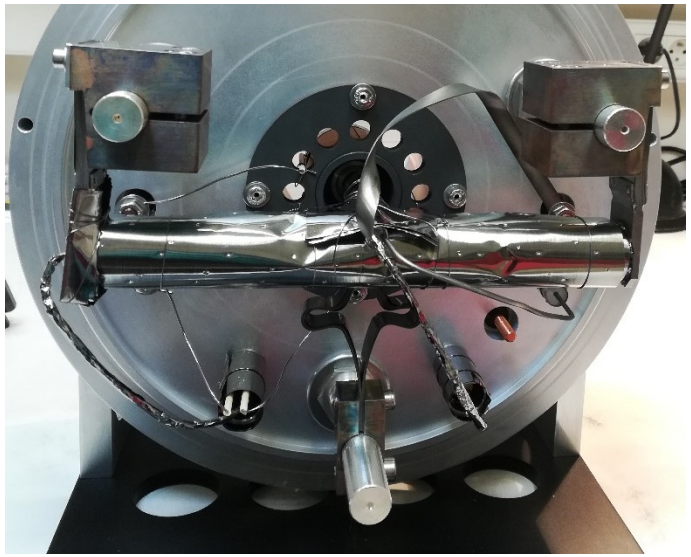


Molecular beam (167u)

Atomic beam (133u)

Courtesy of M.Cheikh Mhamed

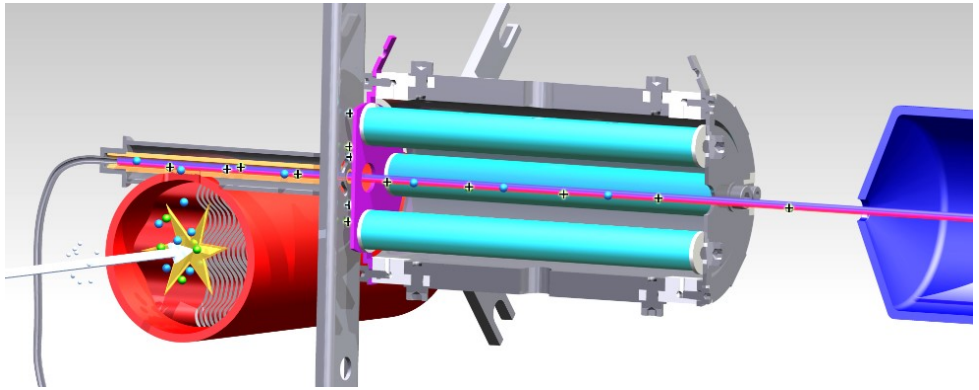




- **Successfully tested on-line at ALTO**
  - radioactive SnS delivered
  - ^{134}Sn detected for the 1st at ALTO

J. Ballof, D. Leimbach, A. Ringvall-Moberg, S. Rothe, T. Stora

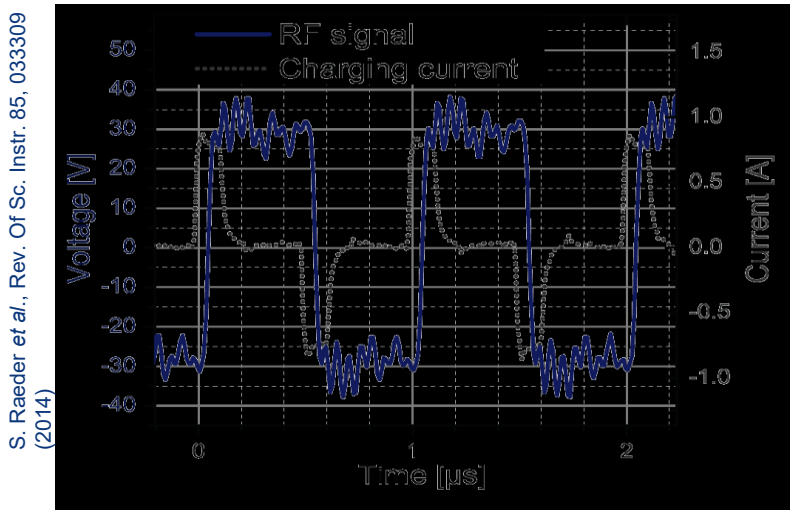
LIST developments



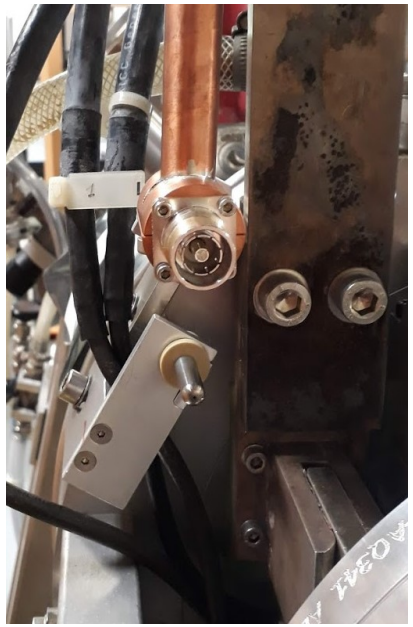
- LIST delivers very pure beams at ISOLDE: More and more requests
- LS2: More reliable rad. hard RF connector designed, integrated to FE
- Square wave driven RFQ needs to be verified, respective hardware purchased and installed

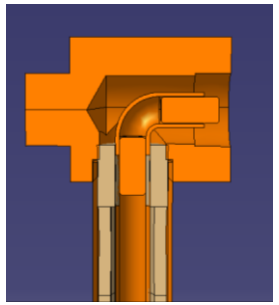
Objectives for after LS2:

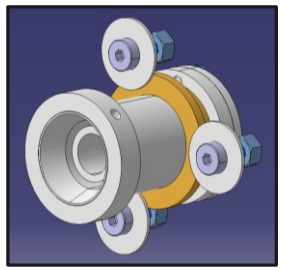
- **both Frontends** will be compatible to LIST
- 2 RF lines **reduce complexity** of the target
- **LIST** offered **as standard ion source** to users

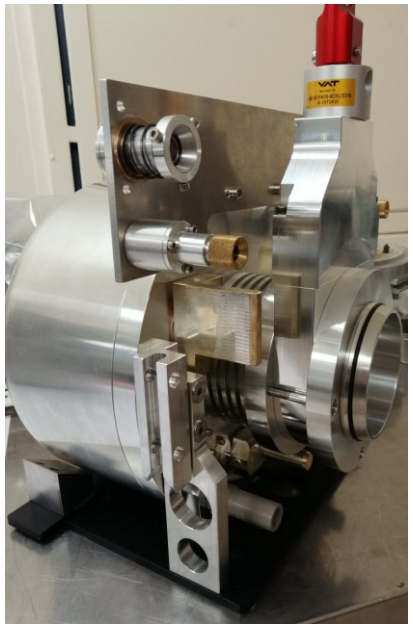


S. Raeder *et al.*, Rev. Of Sc. Instr. 85, 033309 (2014)







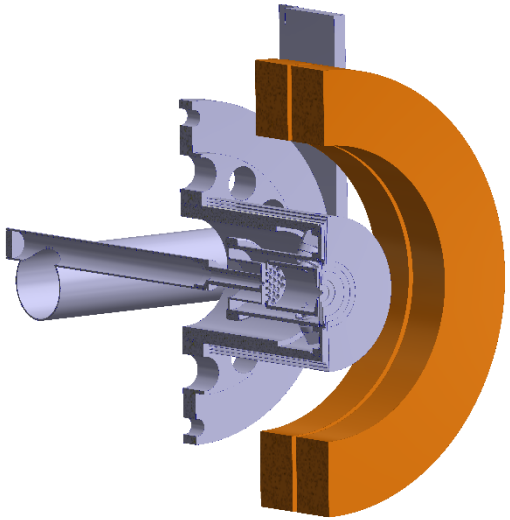


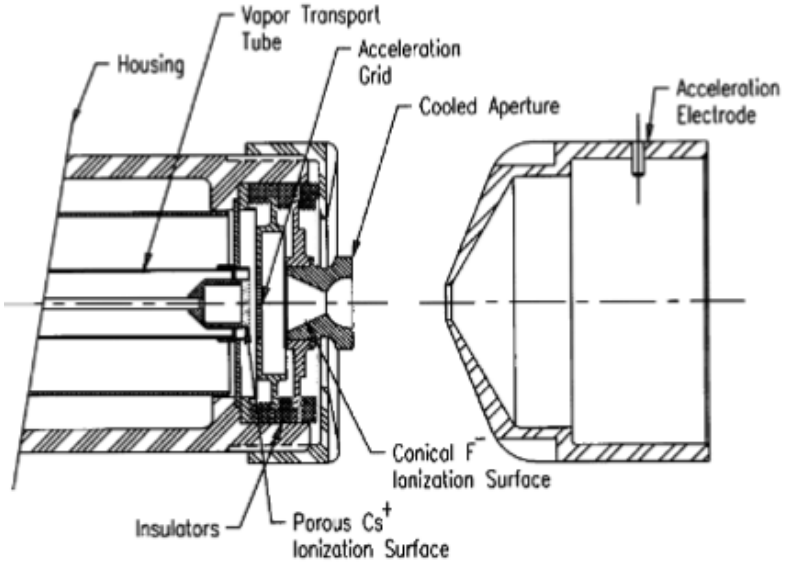
LIST RF connectors: frontend and target side

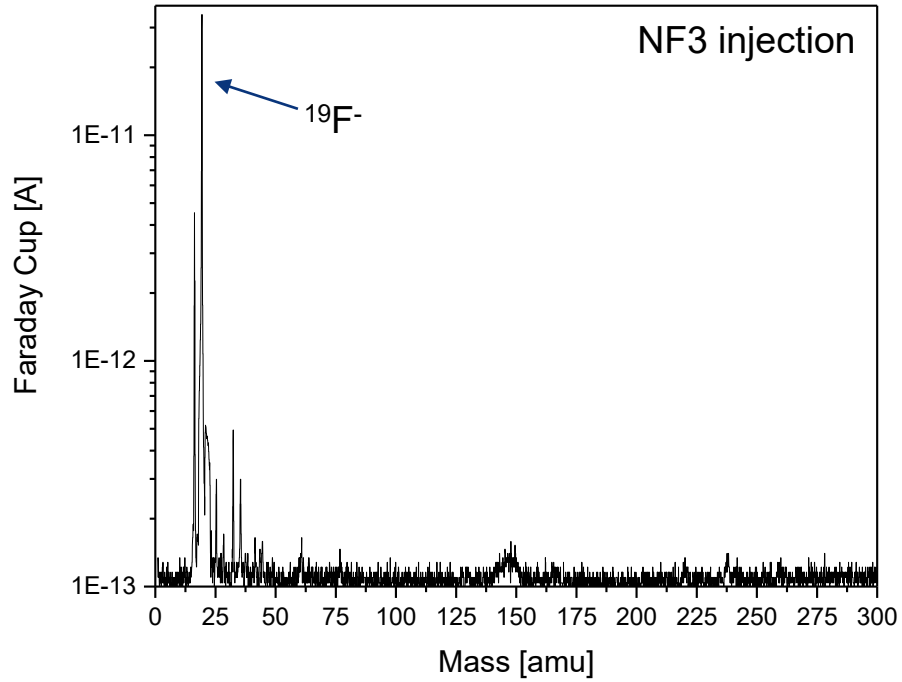
J.Cruikshank, R.Heinke, S.Rothe

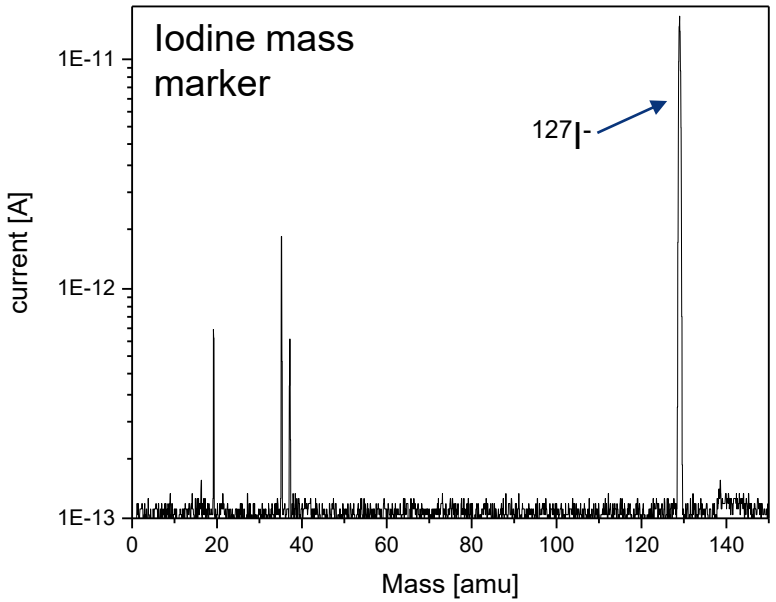
negative ion beams

- **Kinetic Ejection Negative Ion Source (KENIS)**
  - Cs^+ accelerated onto cooled aperture
  - Condensed neutrals ejected and negatively ionized
  - Reactivated, 10% efficiency for F^- reported
- **FEBIAD/VADIS** has similar geometry
  - Cs mass marker showed some surface ionized beams
  - F and molecular beams and extracted with NF_3 injection
- Developments **ongoing**









D. Leimbach

Thanks to the TISD teams

Thank you for your attention!