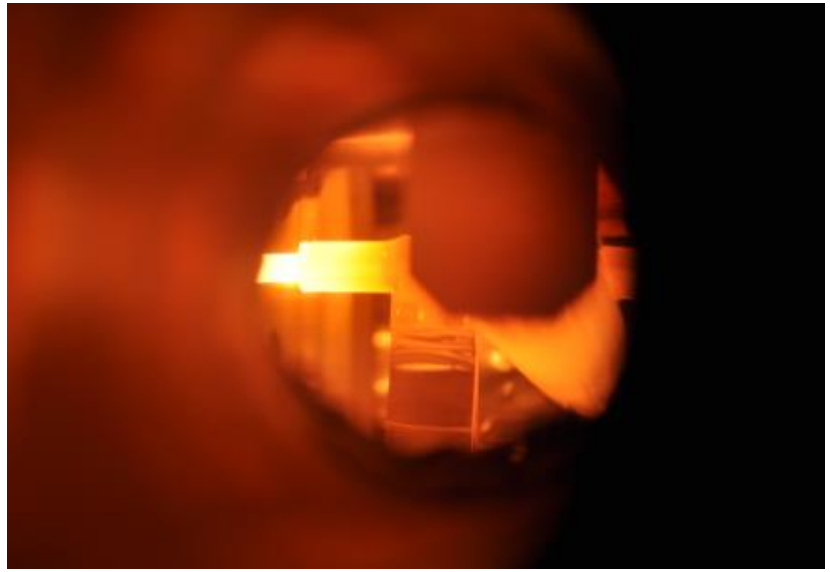
# Target and ion source developments in 2019

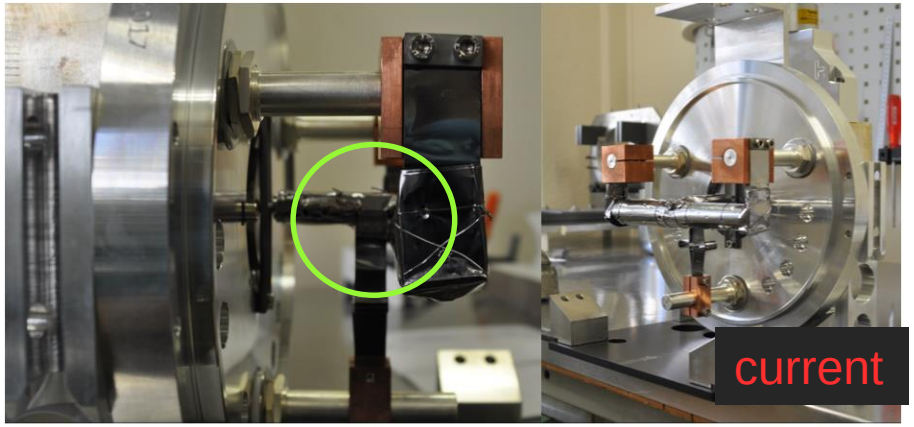


David Leimbach

on behalf of the target and ion source development teams

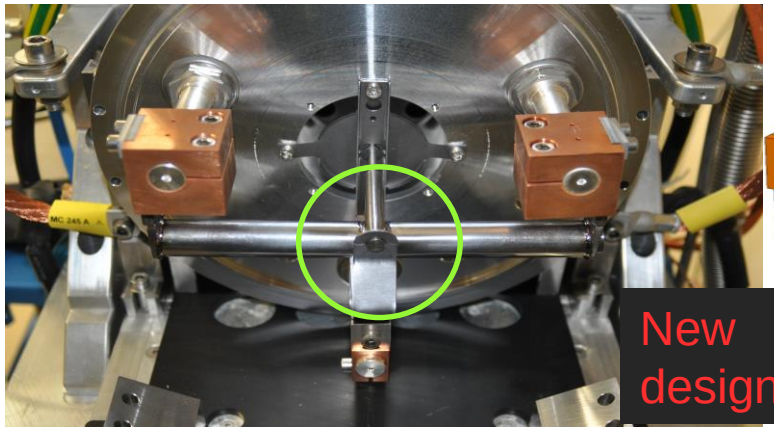
CERN | EN ENGINEERING DEPARTMENT

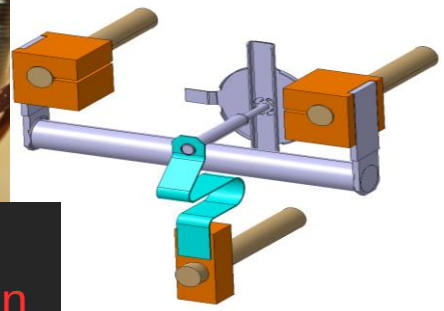
# Temperature gradient issues- transfer line

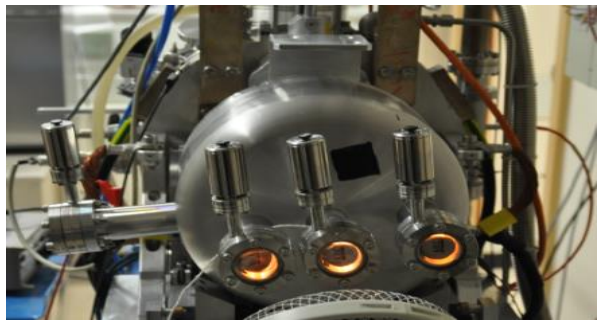


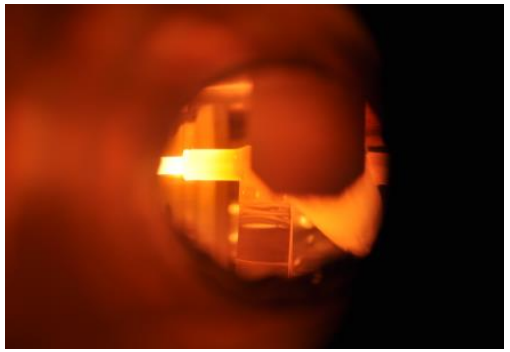

- Standard ISOLDE target: **613K temperature gradient** along the **transfer line**
  - 2051C in ion source vs 1536C at transfer line cap

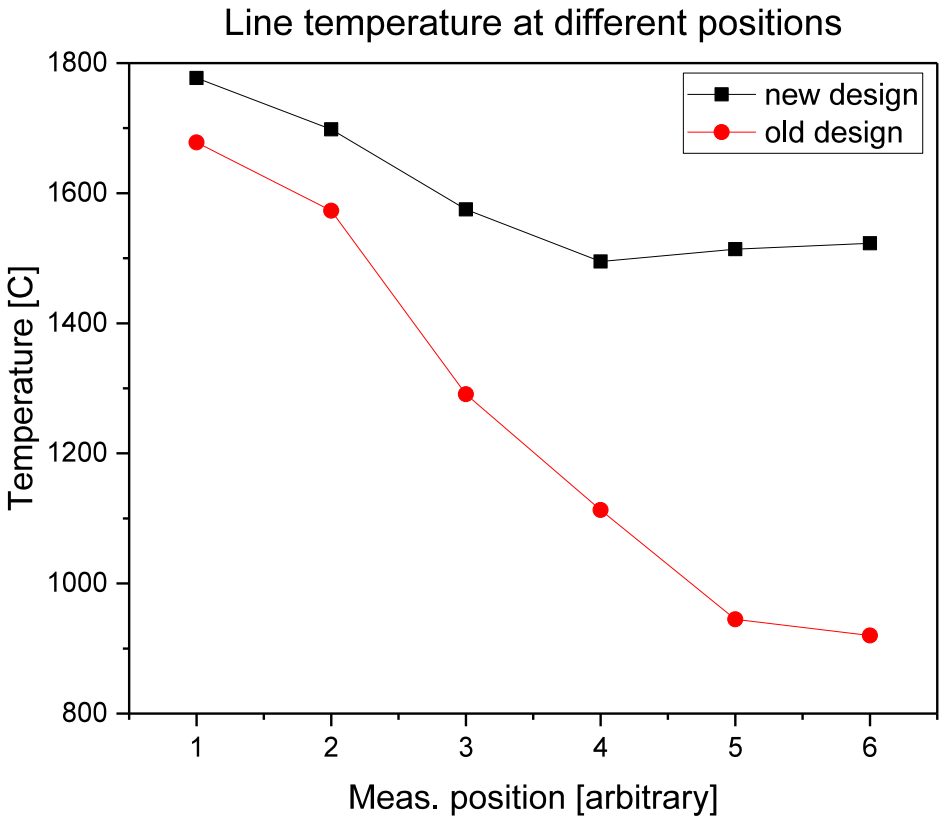
➡ New transfer line design: Connection from the back



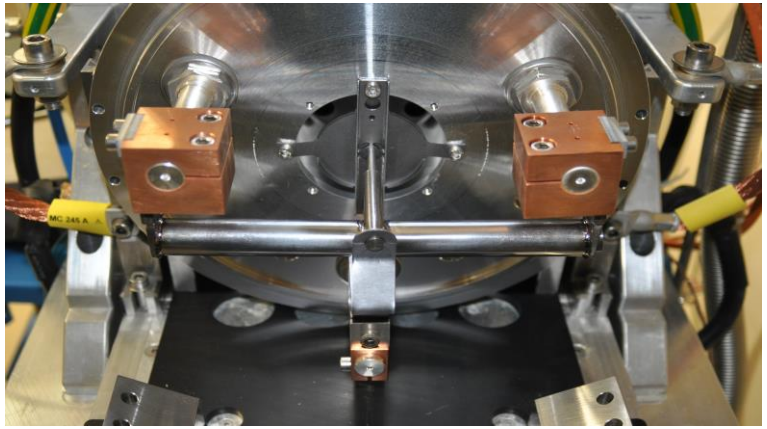


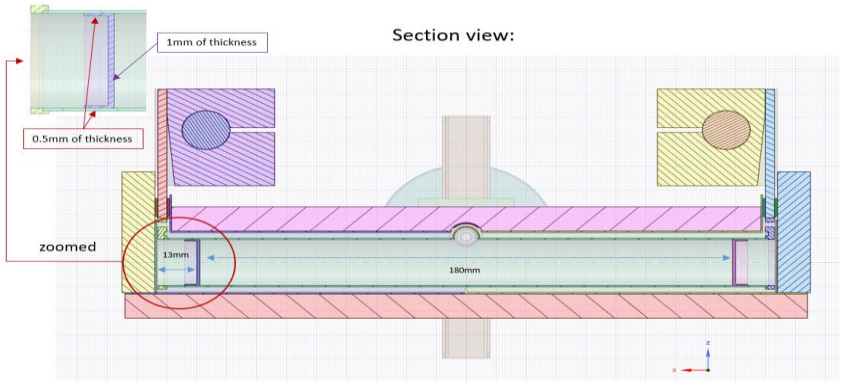


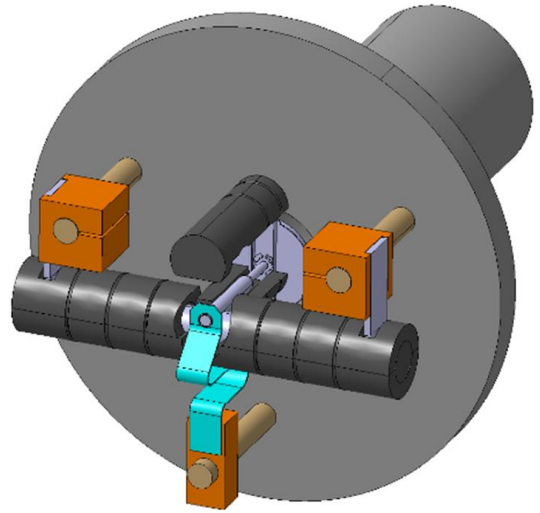



Vasileios Samothrakis

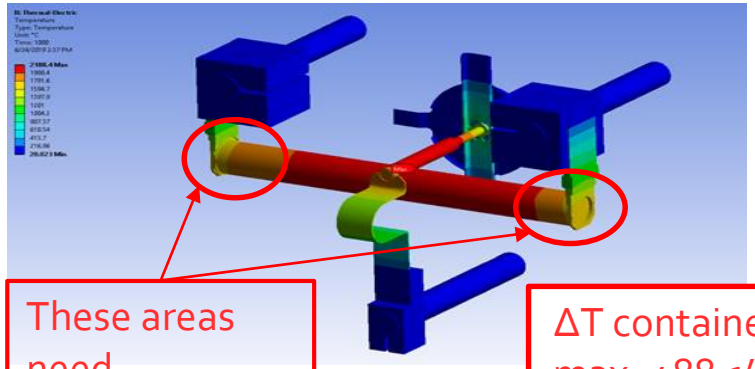
# Temperature gradient issues- target container

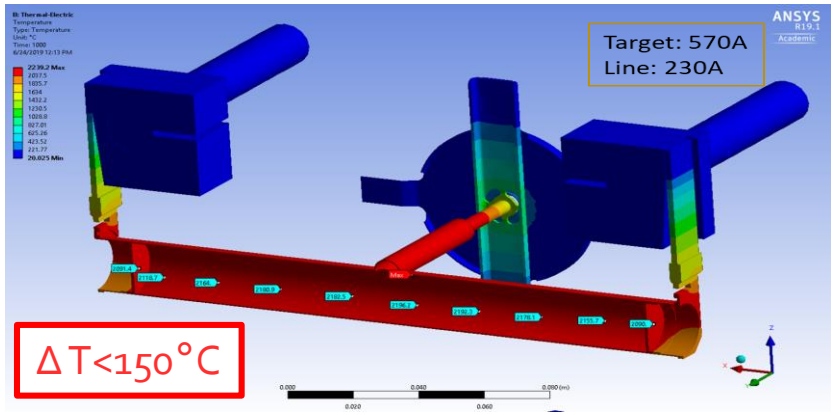


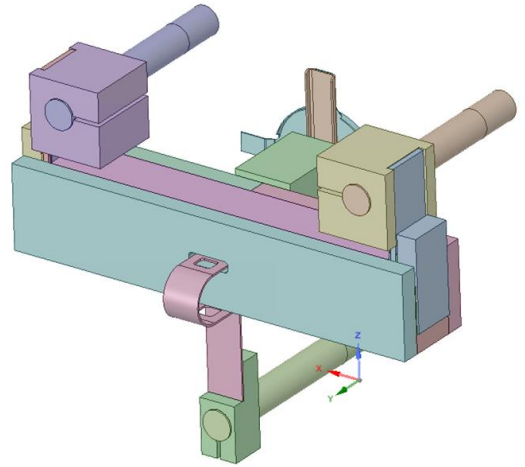


Simplified design to reduce the machining cost:



- 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:

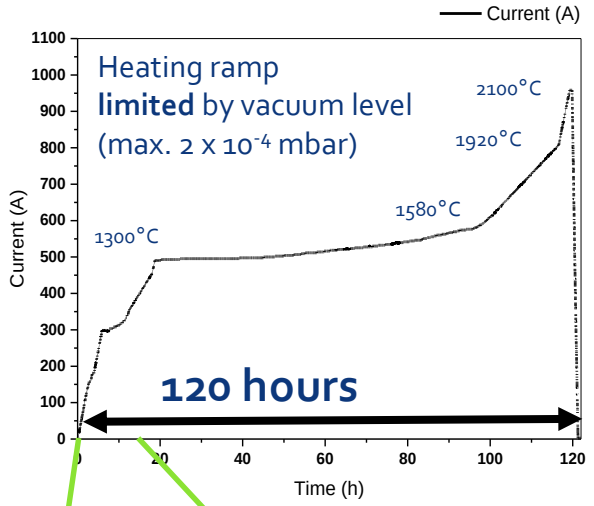
→ From 1 batch/ week to 1 batch/day

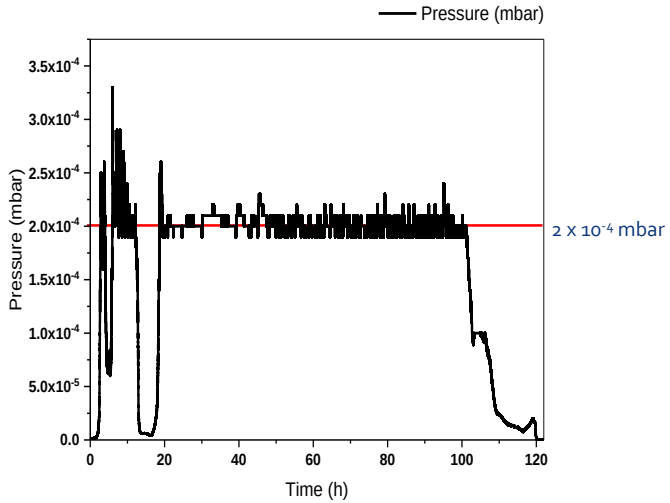
Annual production: 10-12 batch / year

Process:


| Mixing | Pressing | **Carbothermal Reduction** |
|---|---|---|
| 1.5 hours | 2.5 hours | **120 hours** |

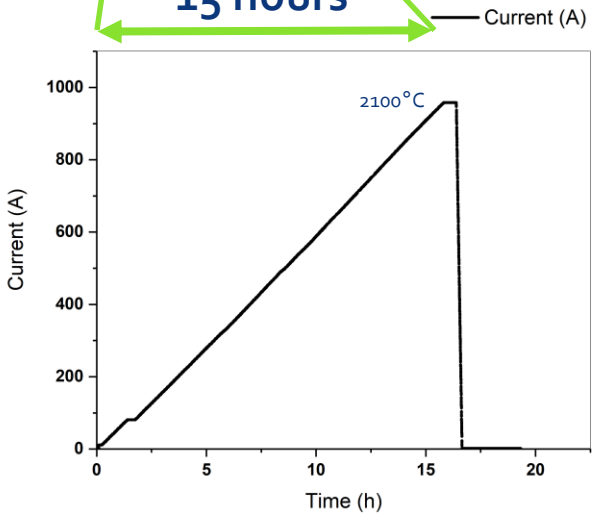
$$UO_2 + 6\,C \rightarrow \mathbf{UC_2 + 2\,C} + 2\,CO\uparrow$$

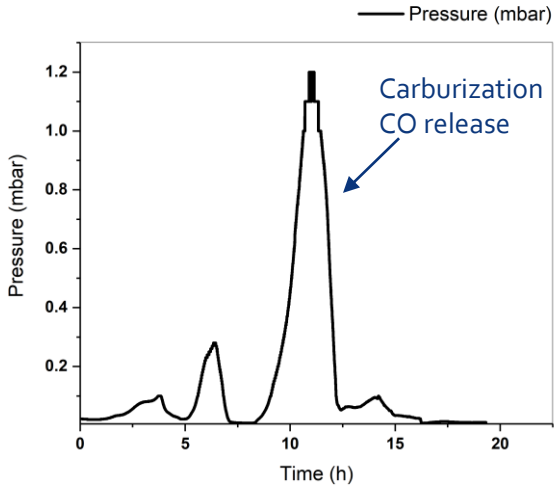



**Increase of pressure limit → 2 mbar**

**15 hours**




NEXT STEP: Control and Validation of new method

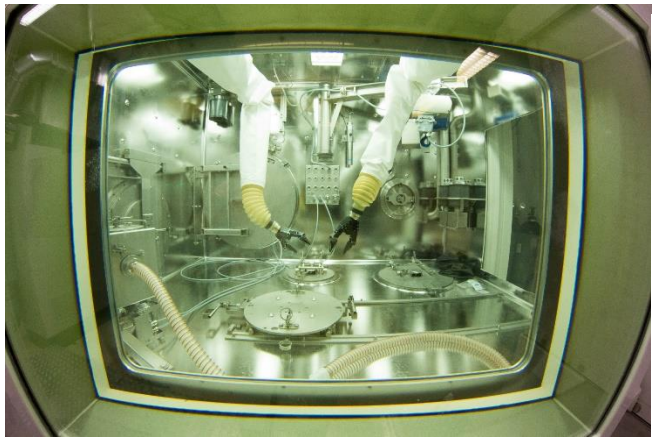
- ✓ Microstructural characterization
- ✓ Isotope release tests online

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

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

## Temporary Storage


## Dismantling

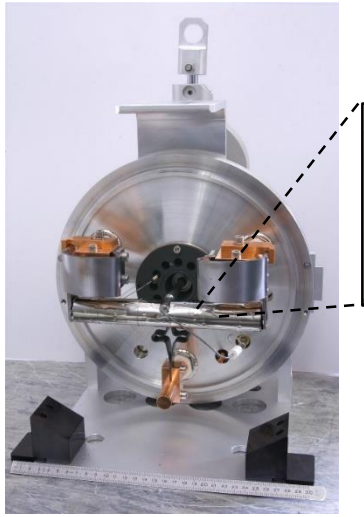


## Oxidation

## Cementation

## Conditionning

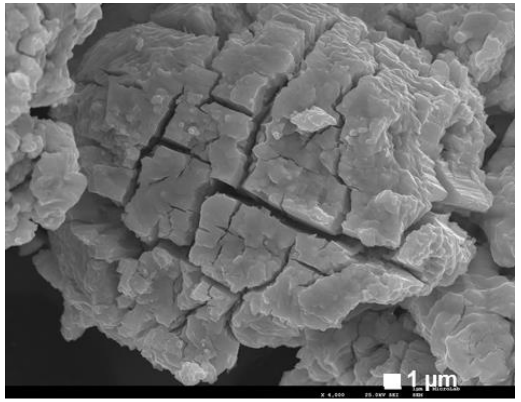
## Target material



Uranium carbide pellets
d=14 mm
Thickness 1.5 mm

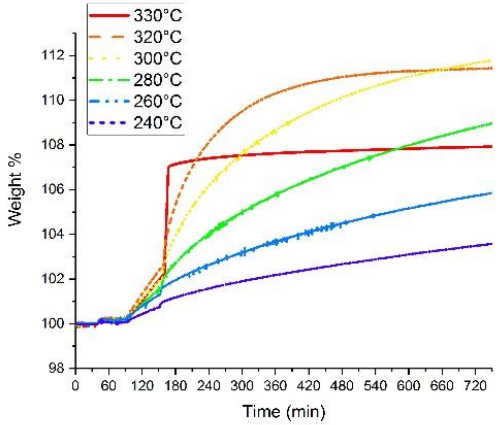
## Thermal analysis


## 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

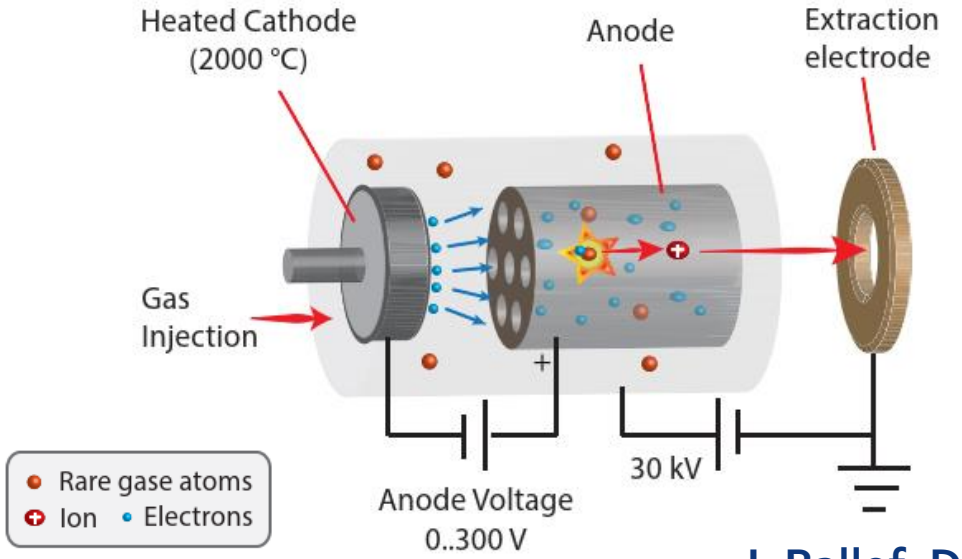
## Motivation: IP measurements for superheavy elements

- 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**

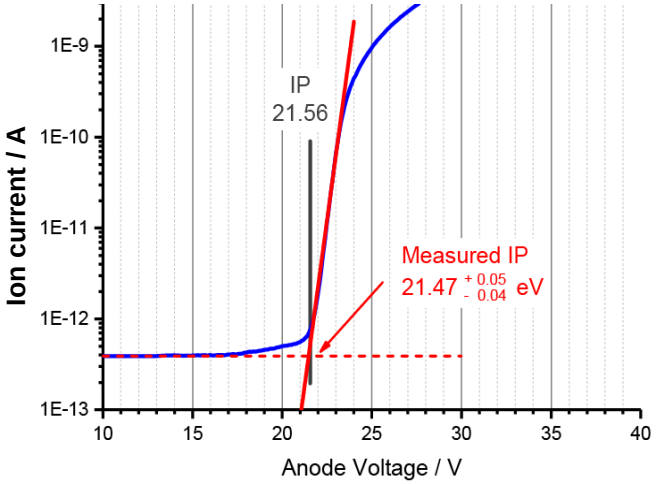
➡ **Electron impact ionization needed**

## 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

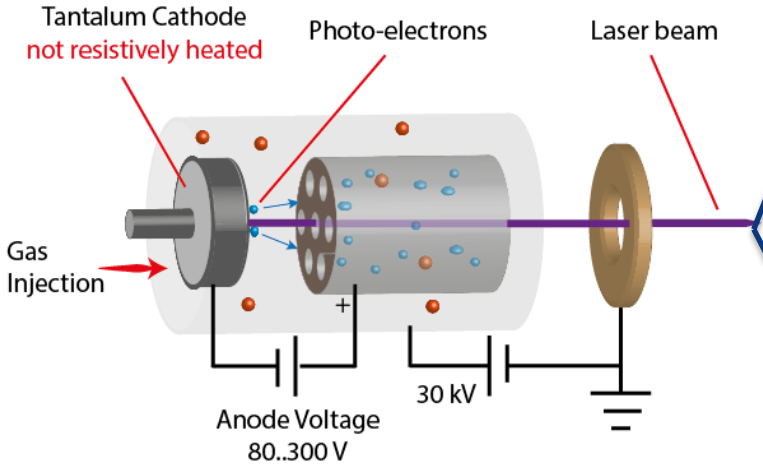
## VADIS source at ambient temperature

Electron generation by laser, not thermal evaporation

## Motivation

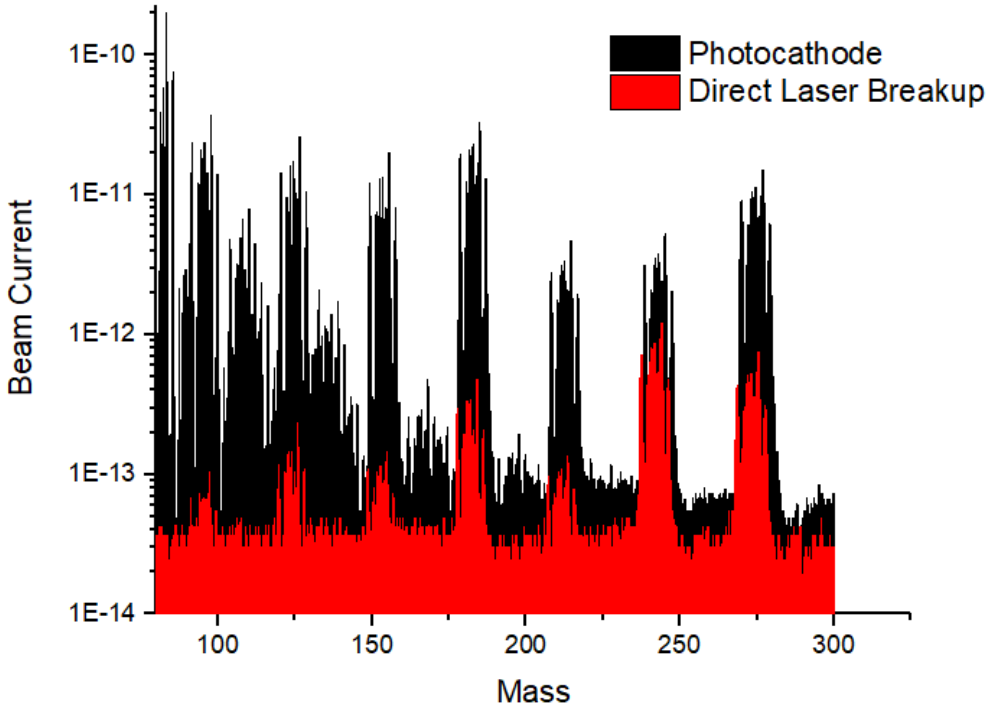
- Ionization of fragile molecules
- No decomposition on hot surfaces
- Diagnostic tool to measure ionization properties

## 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



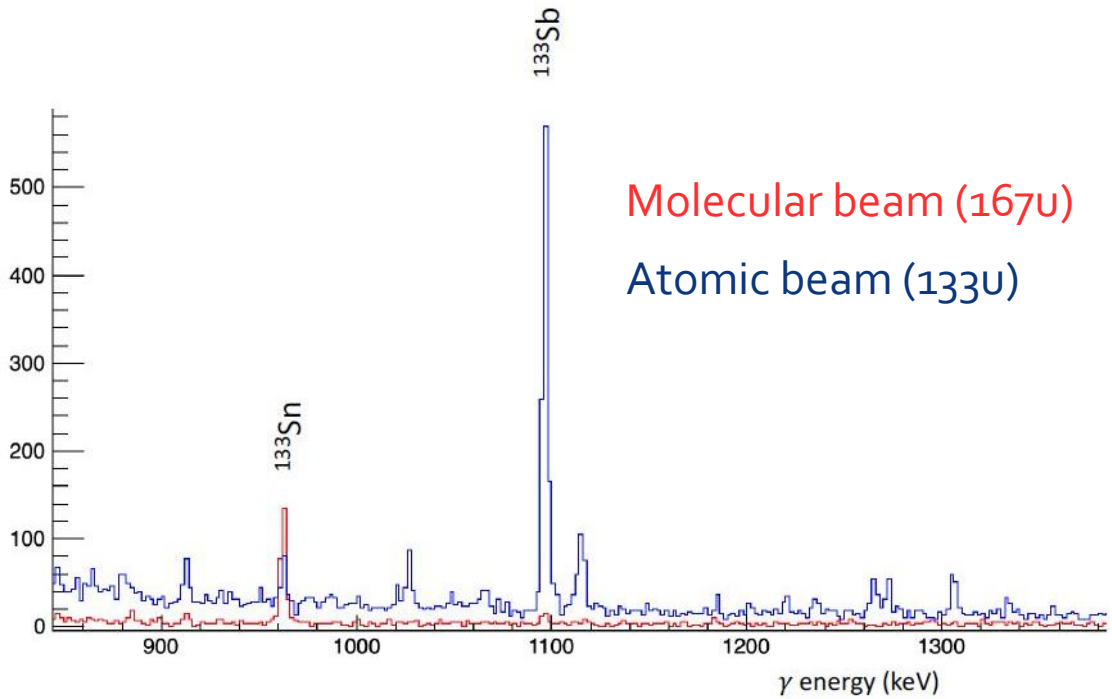

## Two operation modes found

| 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

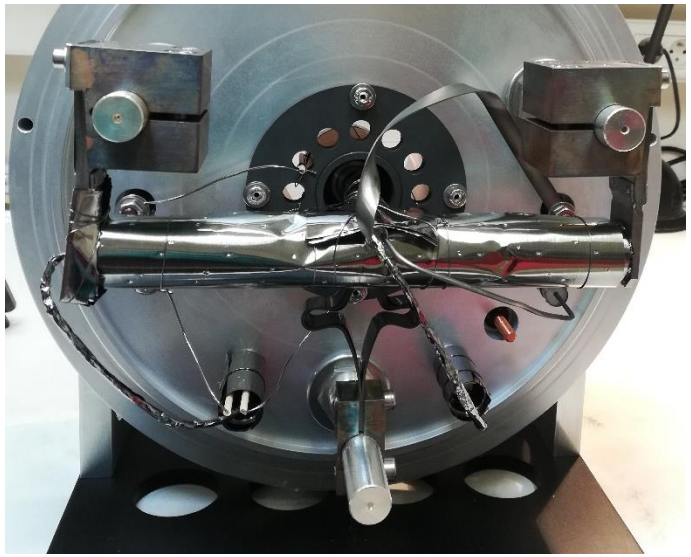
- **Beamlab JRA in ENSAR 2**:
  - Efficient extraction of Sn as SnS molecule
- Controlled release of S from mass marker necessary
  - S oven in BN cylinder heated externally with Ta wire
- **Offline tests at ISOLDE Offline 1**
  - 5-7% efficiency for SnS




Molecular beam (167u)

Atomic beam (133u)

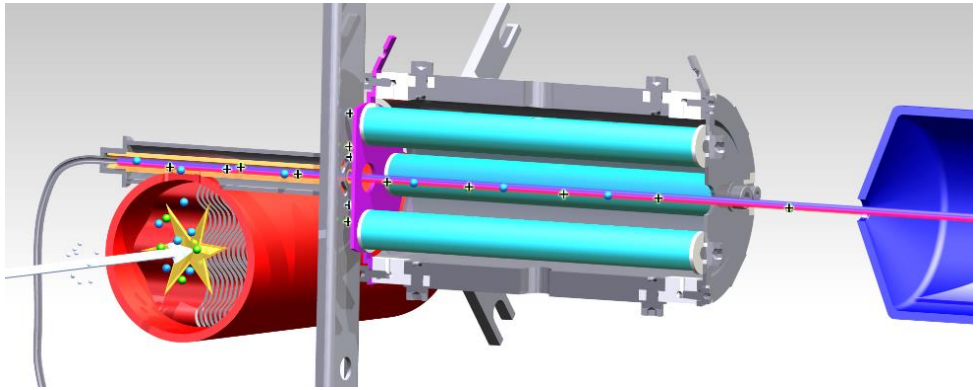
Courtesy of M.Cheikh Mhamed

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

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

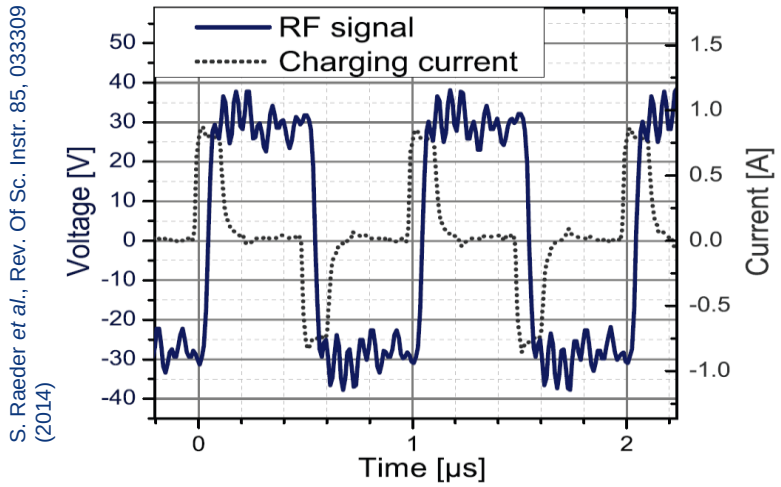
# LIST developments

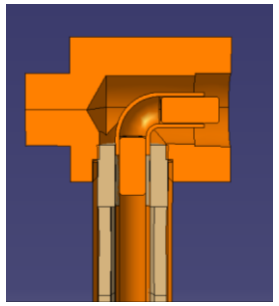


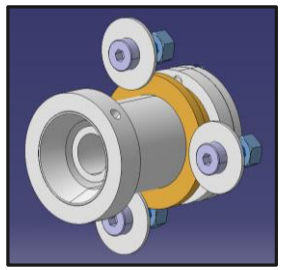
- LIST delivers very pure beams at ISOLDE: More and more requests
- LS2: More reliable rad. hard RF connector designed, integrated to FE
- Square wave driven RFQ needs to be verified, respective hardware purchased and installed

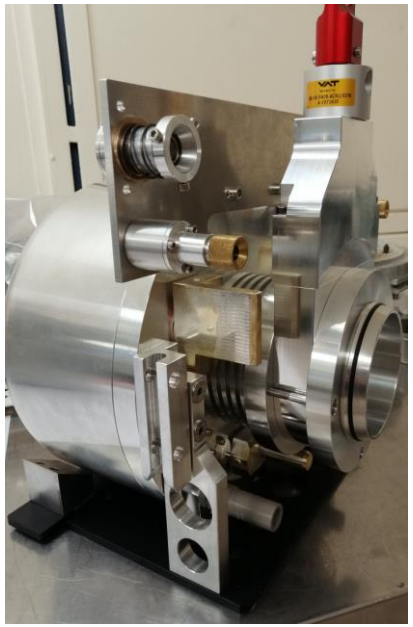
Objectives for after LS2:

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





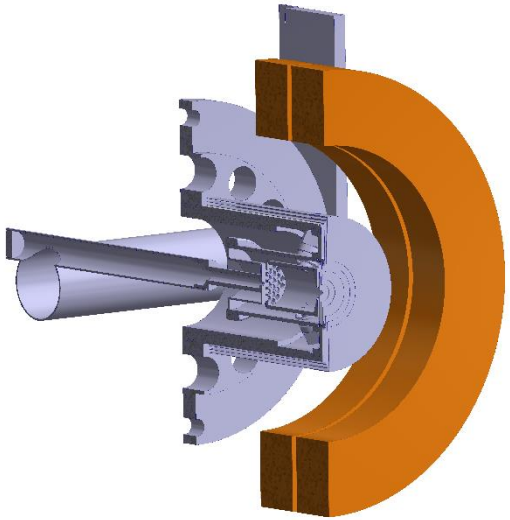


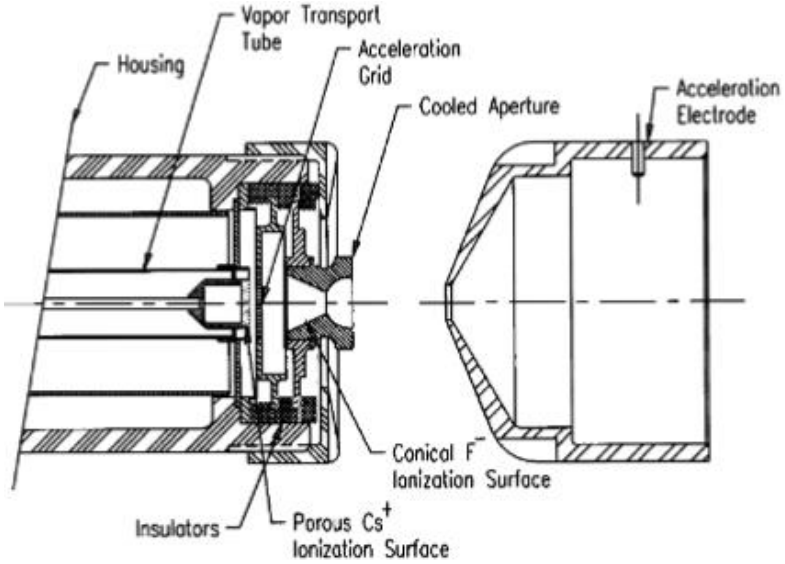
LIST RF connectors: frontend and target side

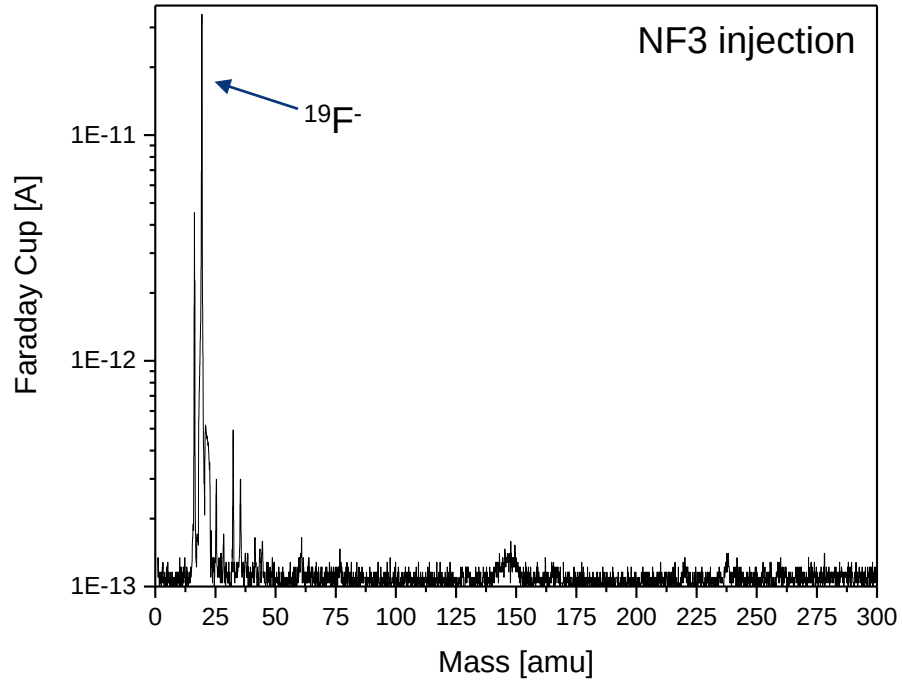
**J.Cruikshank, R.Heinke, S.Rothe**

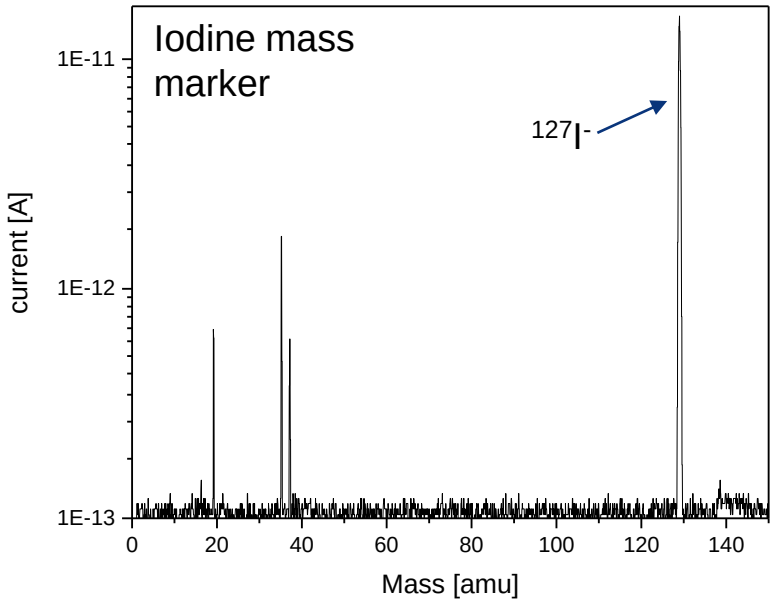
# negative ion beams

- **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**

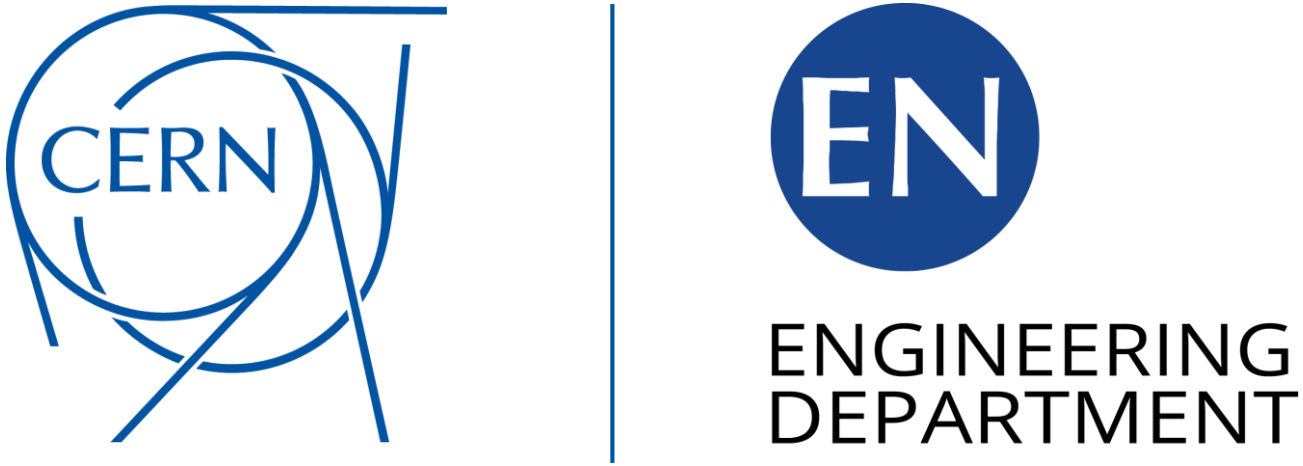





D. Leimbach




Thanks to the TISD teams

Thank you for your attention!