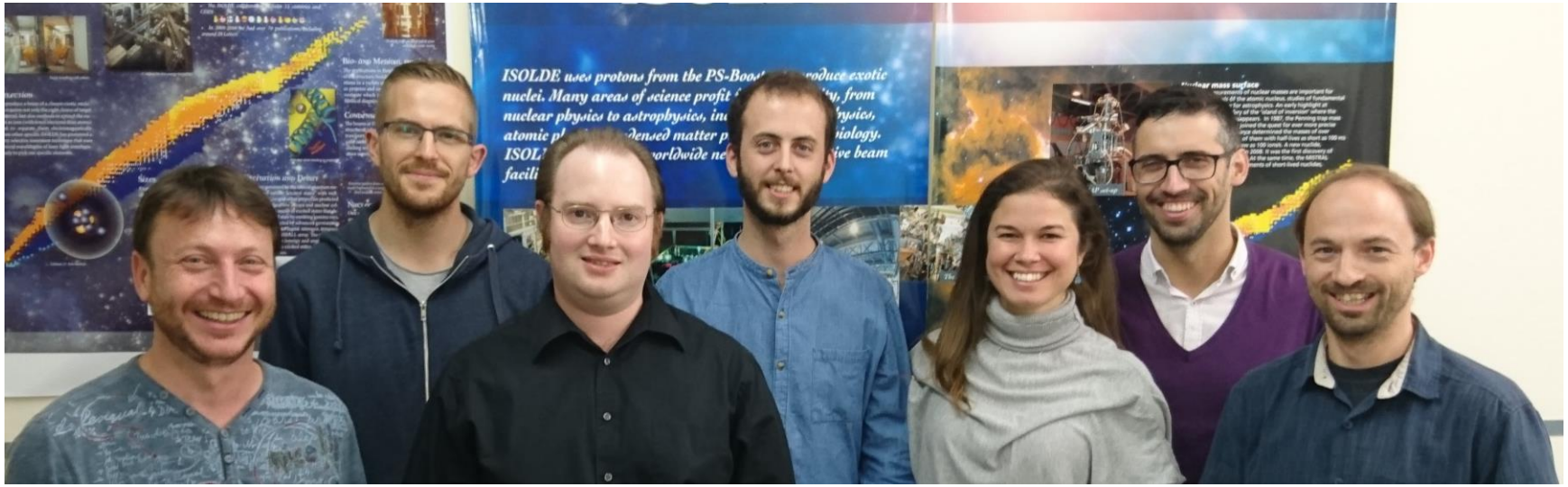
ISOLDE target production: Highlights of 2018

Sebastian ROTHE
for EN-STI-RBS

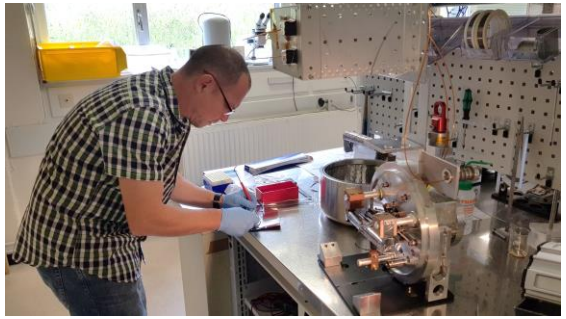
ISOLDE Target and Ion Source Development team



David Leimbach Ferran Boix Pamies Joao Pedro Ramos

Thierry Stora Jochen Ballof Yisel Martinez Sebastian Rothe

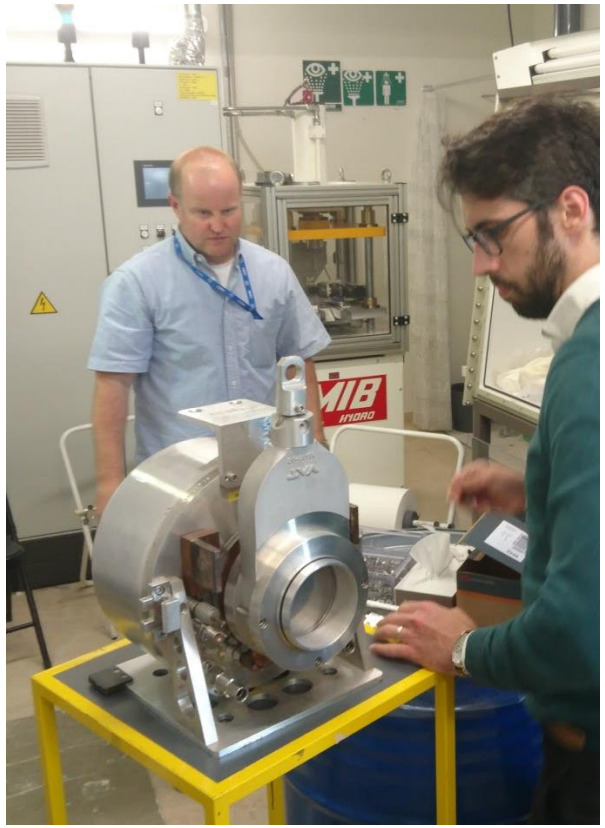
ISOLDE Target Production Team



Bernard Crepieux

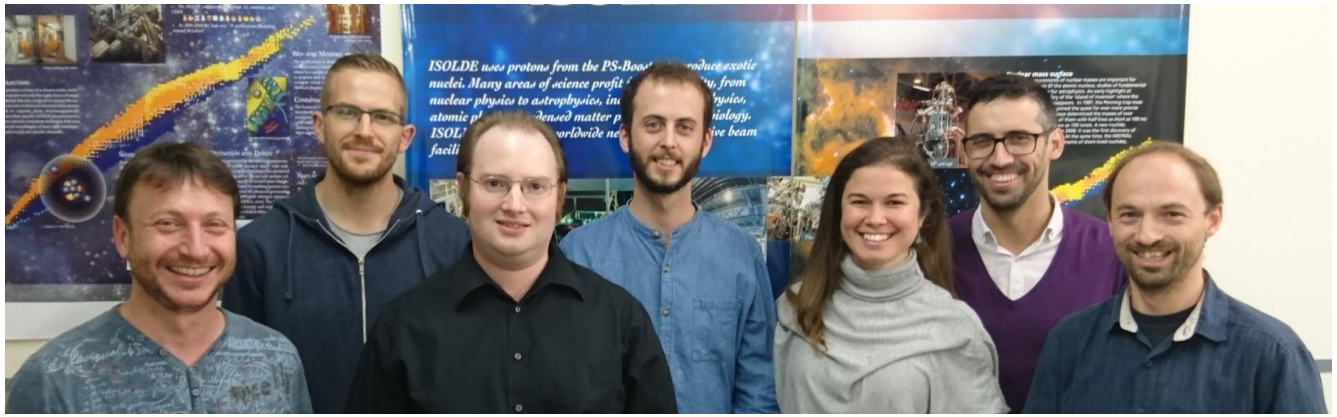
Andres Viéitez Suárez

Ermanno Barbero



Michael ‘Mike’ Owen

Target and ion Source Development (TISD) mandate



Providing a large choice of **intense** and **pure** radioactive beams

Constant development is required to keep ISOLDE at the forefront of RIB facilities

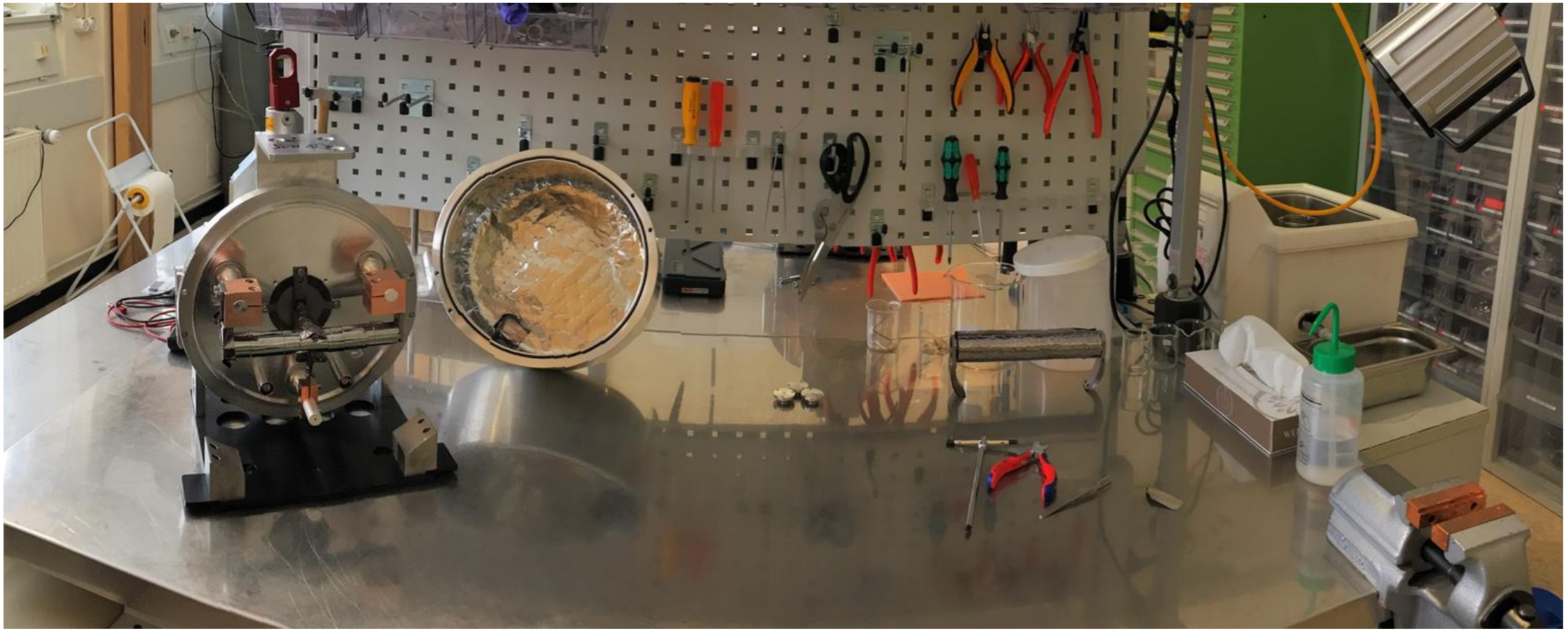
- target and ion source units
- target materials
- beam interactions (p2n converter)
- ion source design / mode of operation shared with ISBM group

- yield & release study
- ion source efficiency measurements
- prototype tests

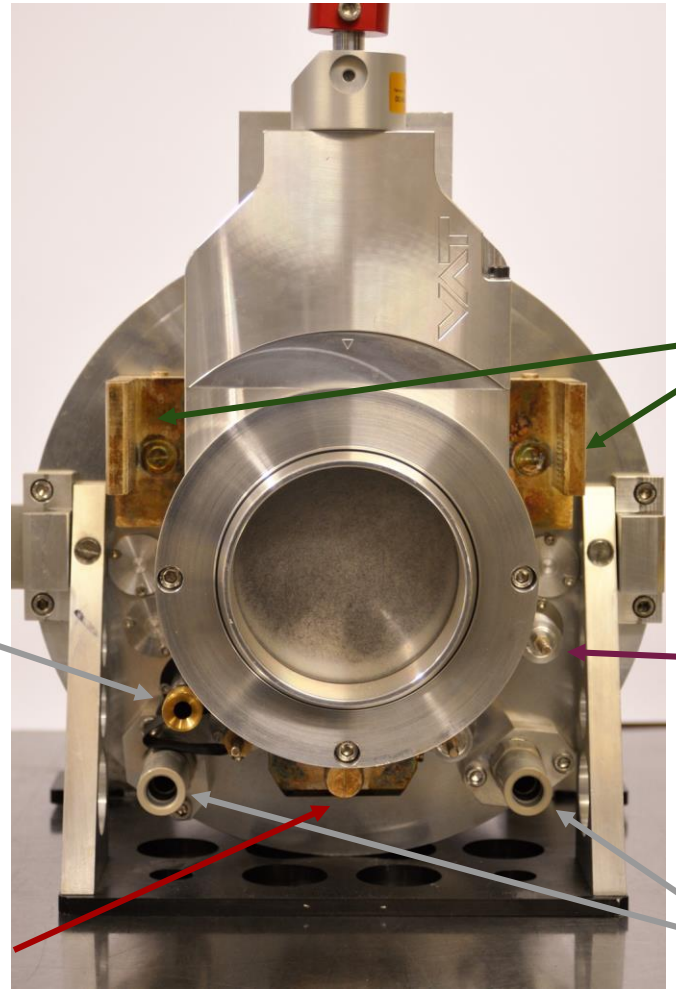
Sharing same resources as the ISOLDE physics program
- WORKSHOP: target unit production
- OFFLINE: target quality control
- ISOLDE: beamtime

ISOLDE Target production

Slides and photos by
Andrés Viéitez Suárez



Feedthrough connections



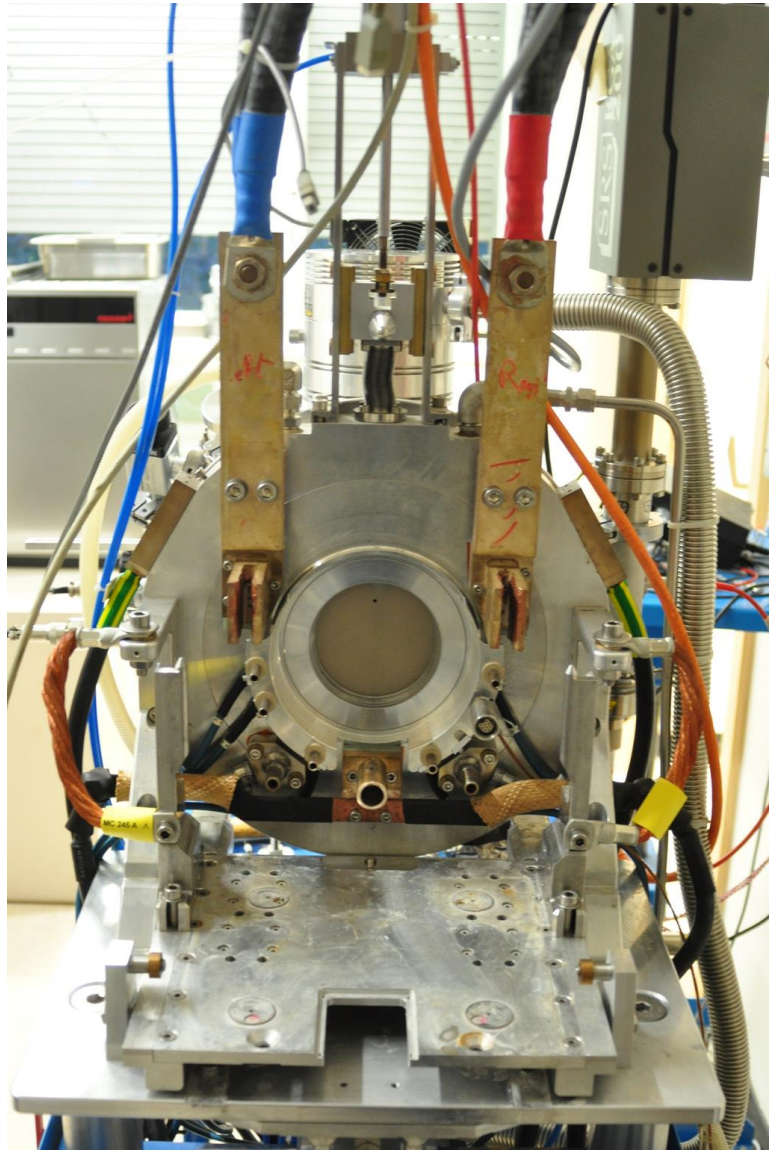
Target heating

Gas injection

Oven (mass marker)

Line heating

Water circuit connectors



A. Viéitez

Target Configurations

Ion sources

- MK1 surface source
- VD5 plasma source
- VD7 plasma source cold line
- MK4 negative source

…

Target Materials

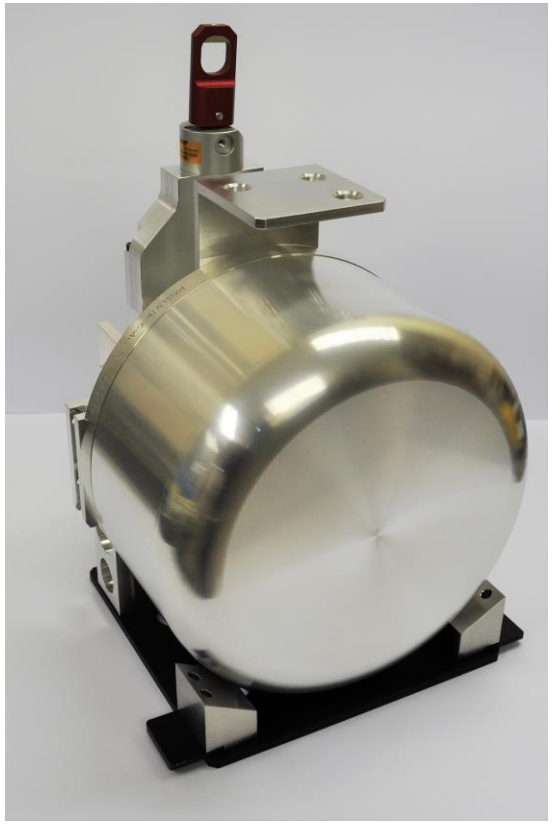
- UCx
- LaC2
- CaO
- SiC
- ZrO
- ThO
- Ta rolls
- Ti foils

...

Auxiliaries

- Mass markers
- Thermocouples
- p2n converter
- Gas injection

…



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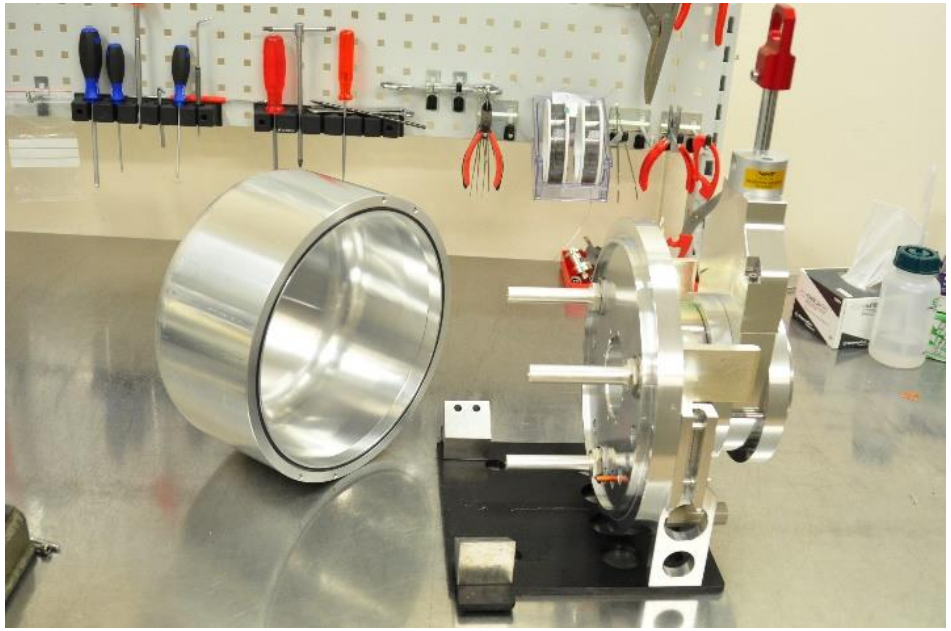
Target assembly



Target base

Target Container

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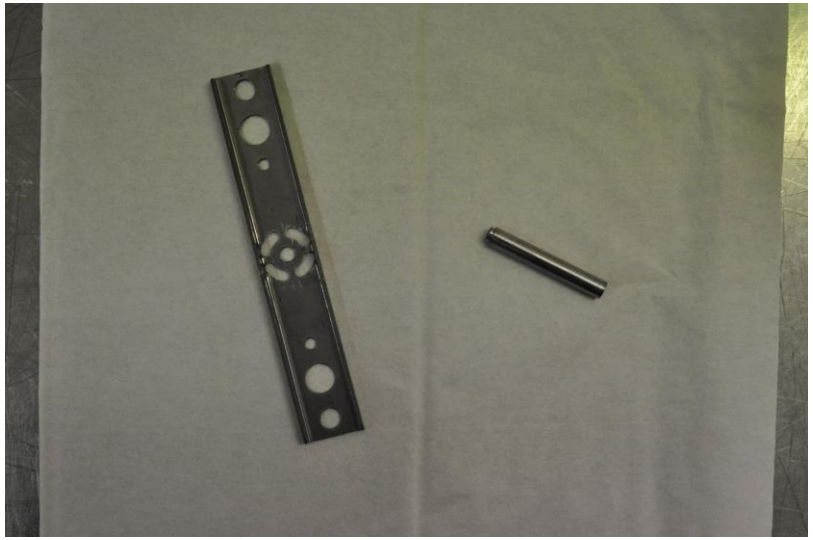
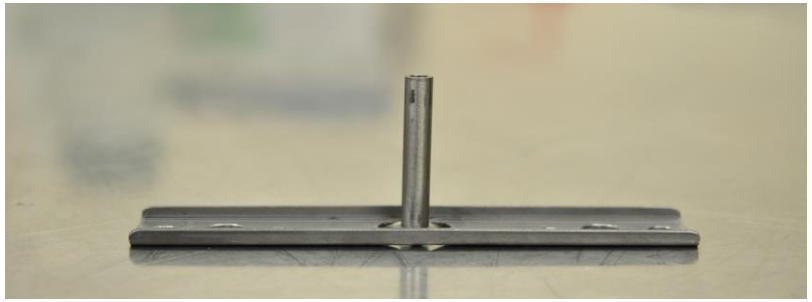
Target assembly

FEBIAD / VADIS

Surface source (MK1)
= RILIS hot cavity





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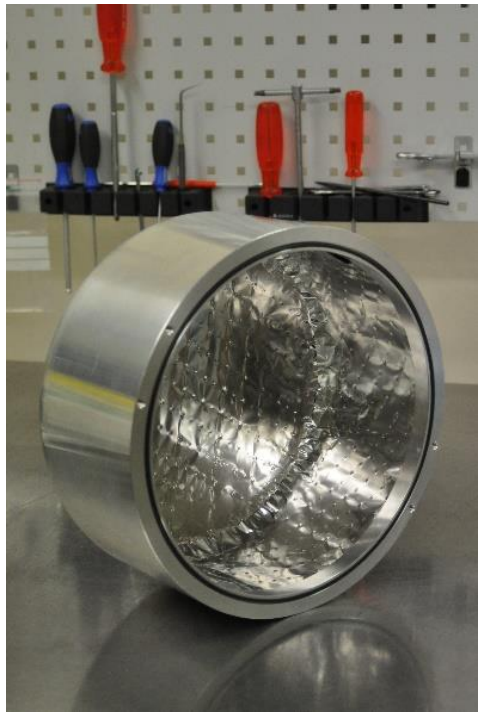
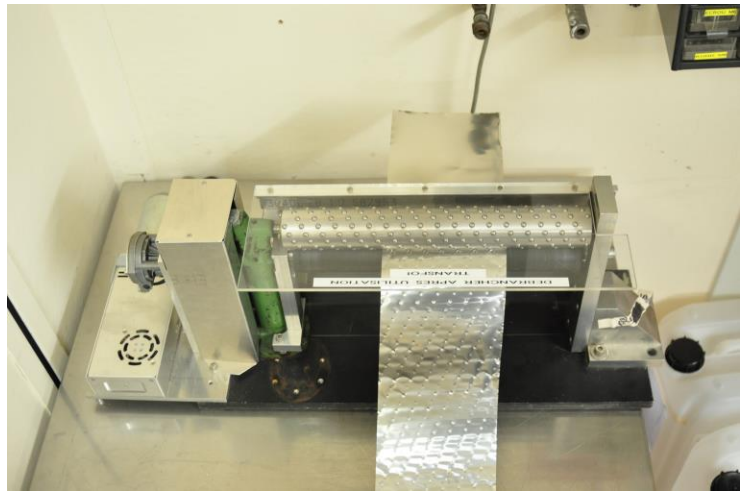
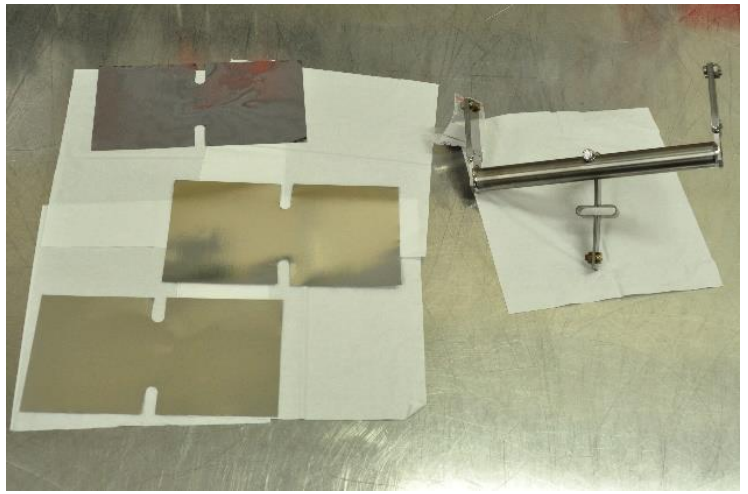
Target assembly

Thermal screens







Cover shielding (Inox sheet)

Container screens (Ta, Mo, W)

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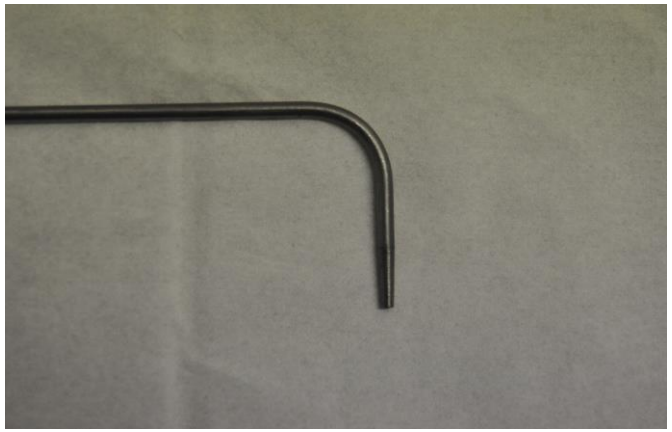
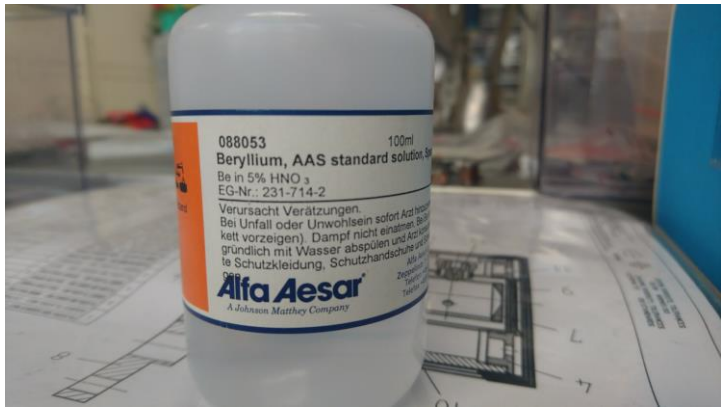
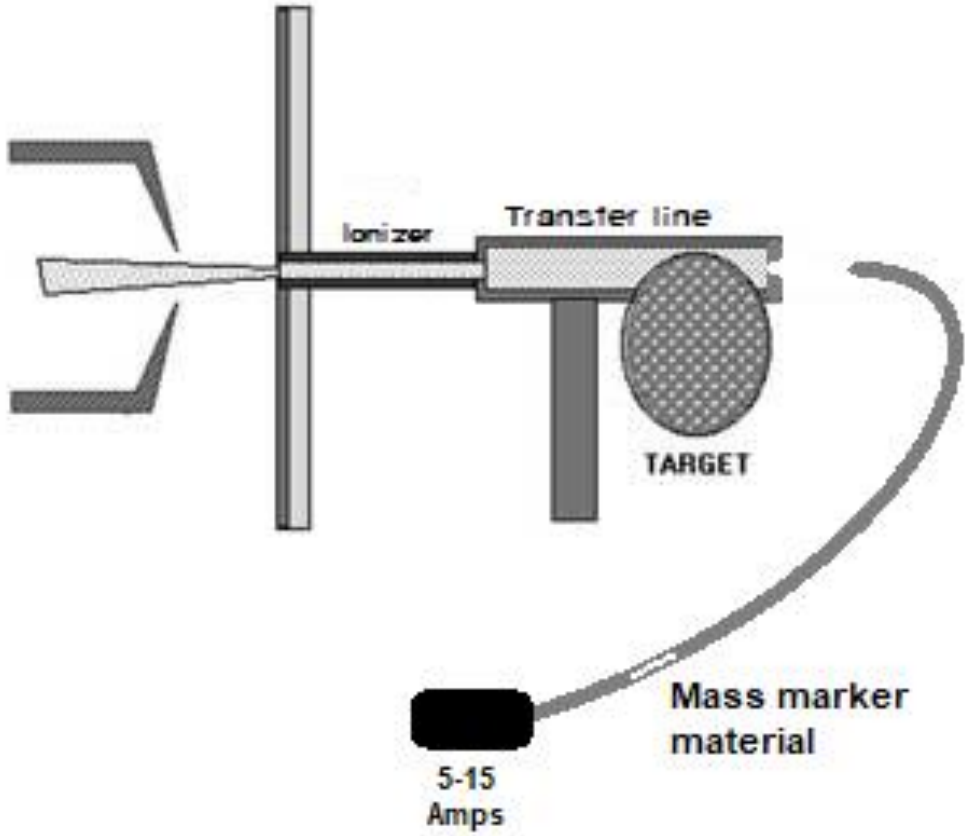
Target assembly

Accessories - Mass marker







µL of standard solution used to prepare a source of atoms

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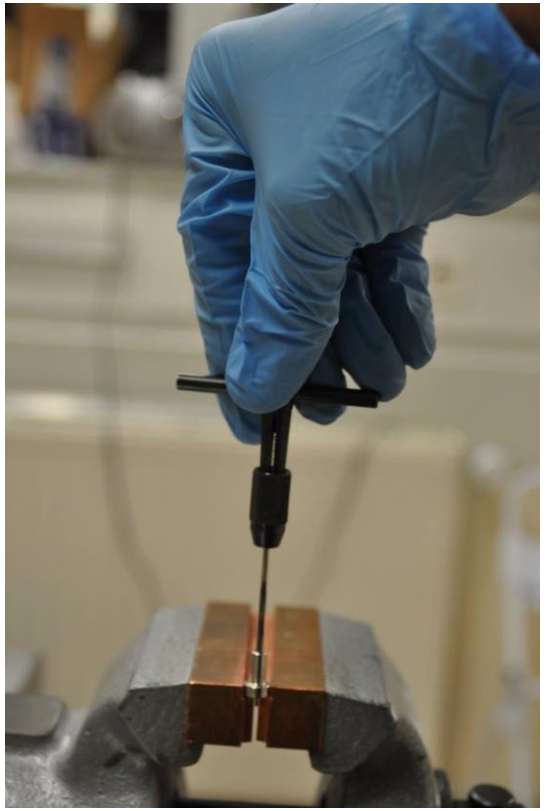
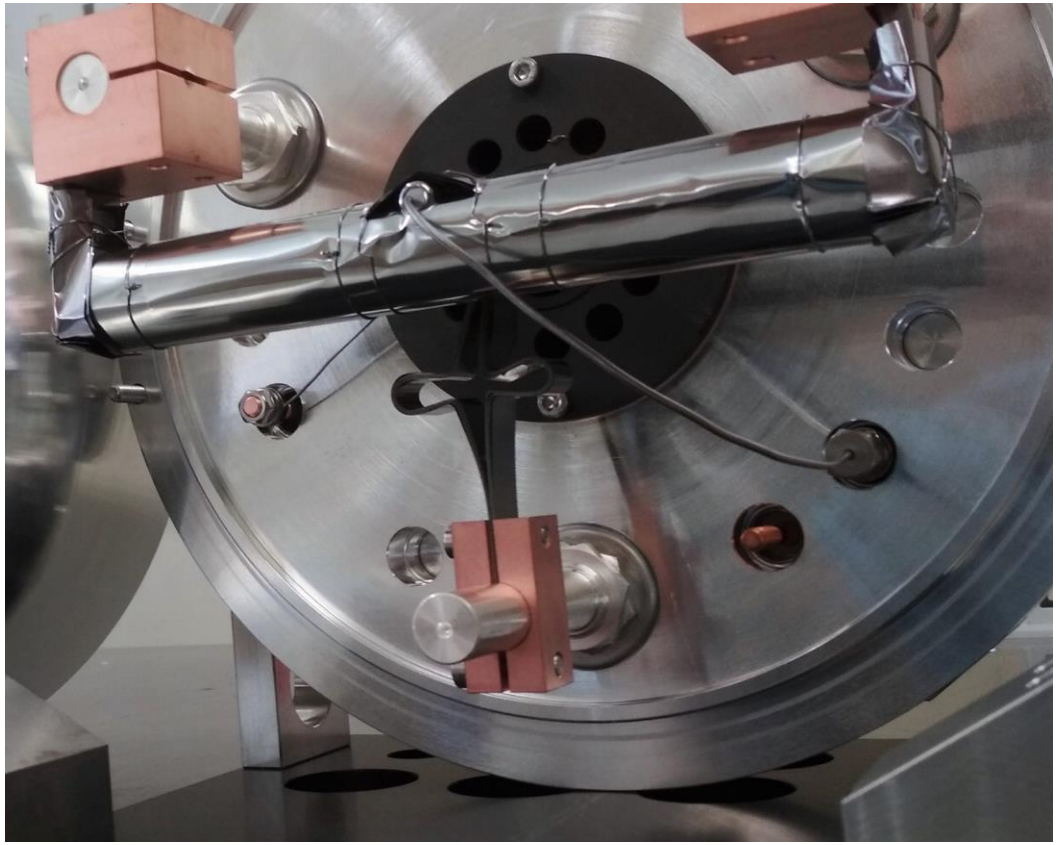
Target assembly

Accessories - Gas Injection





- Buffer gas for FEBIAD ion sources
- Efficiency measurement
- Add reactive gasses (SF6, CF4, …) for molecular beams

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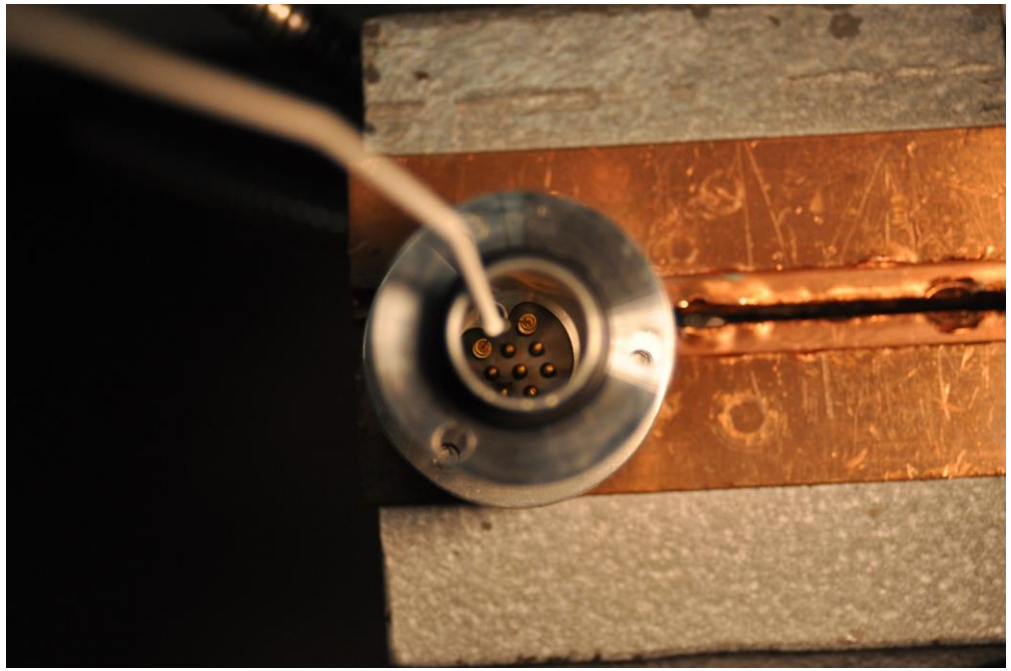
Target assembly

Accessories - Thermocouple



- Multi-Pin connector (4 thermocouples)
- Important for molten metal targets and development units

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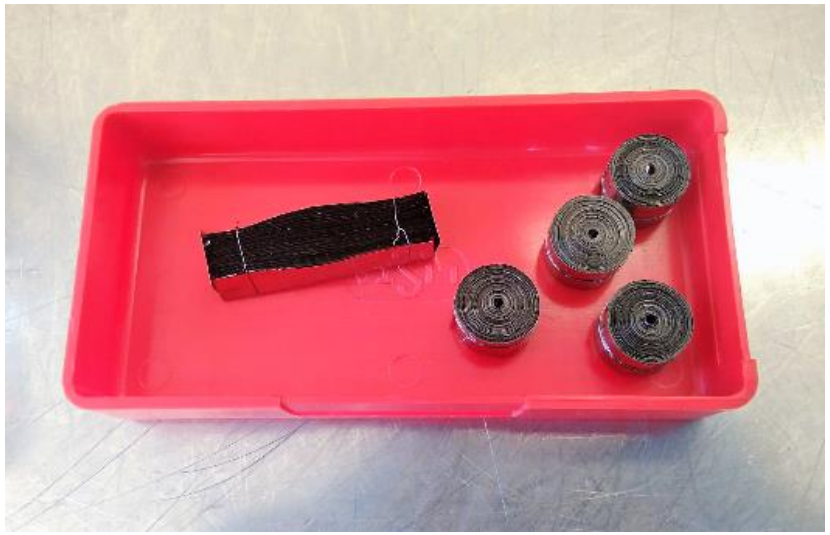
Target material production: metal foils



- Titanium, tantalum, thorium

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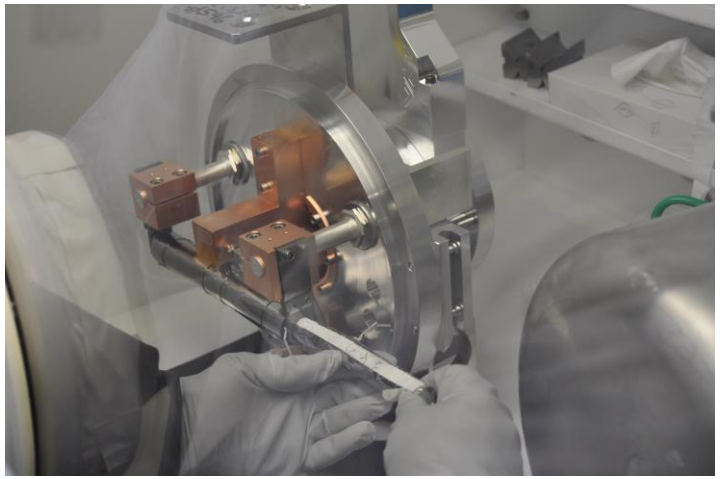
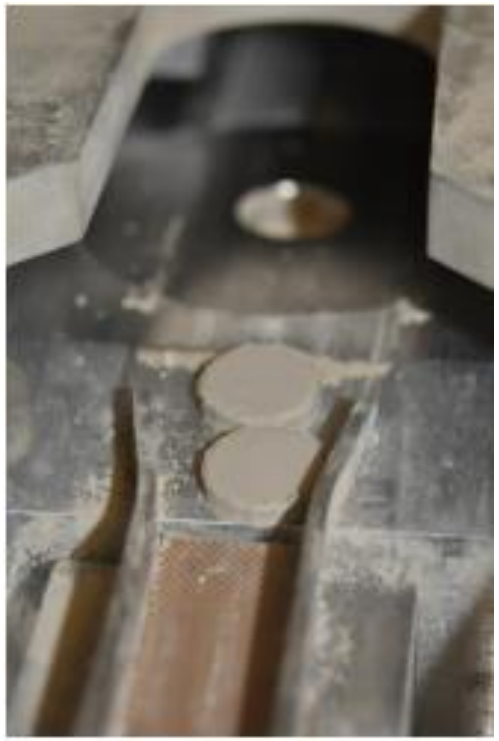
Target material production: oxides, carbides





- SiC
- LaC
- CaO

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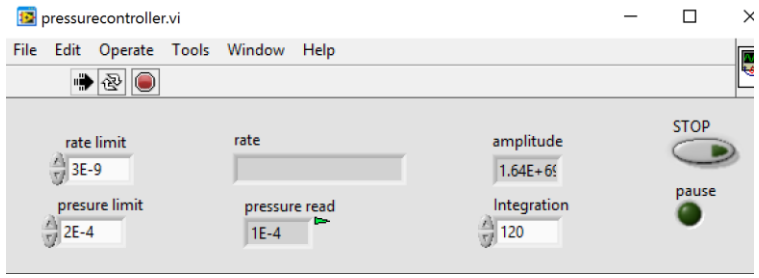
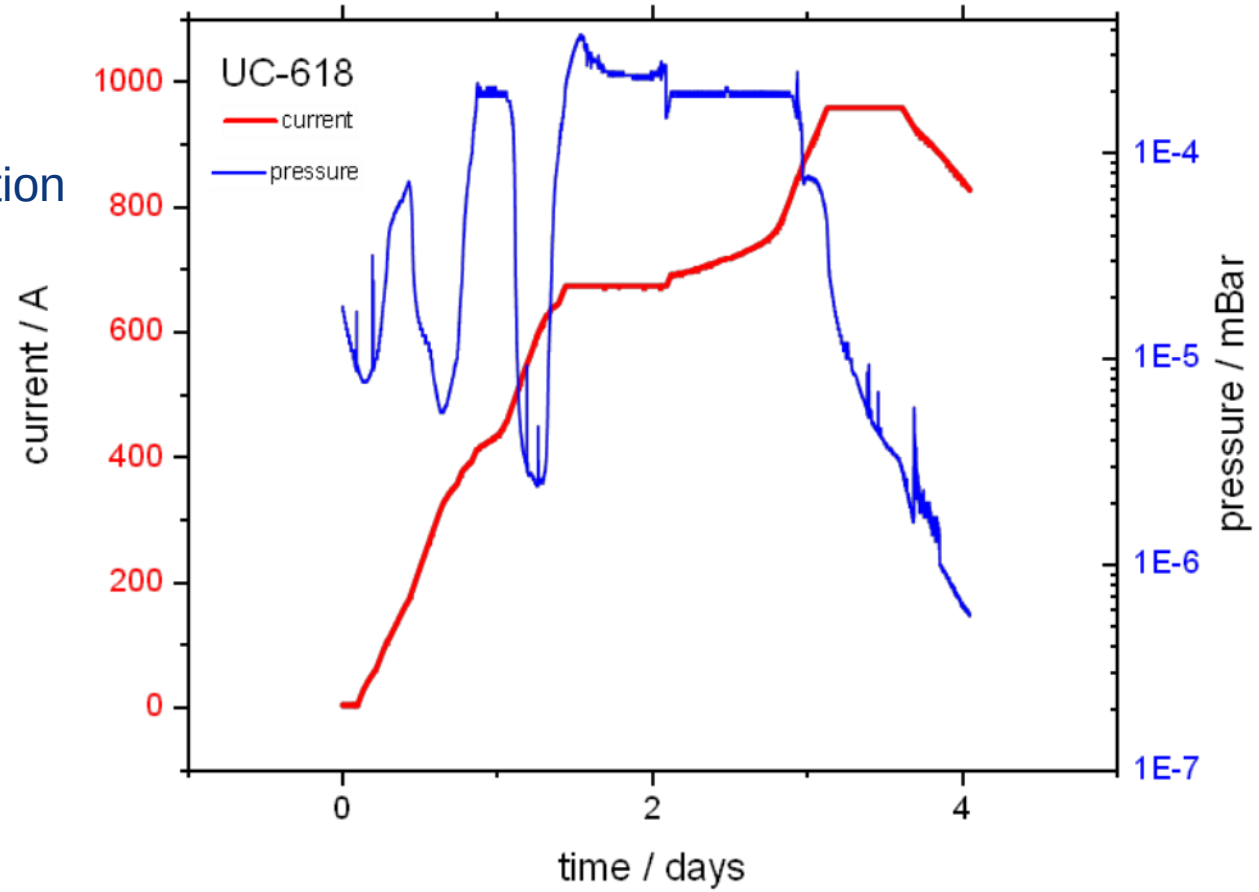
Target material production: UCx carburization



- Setting a ramp
- Set thresholds
- Start carburization

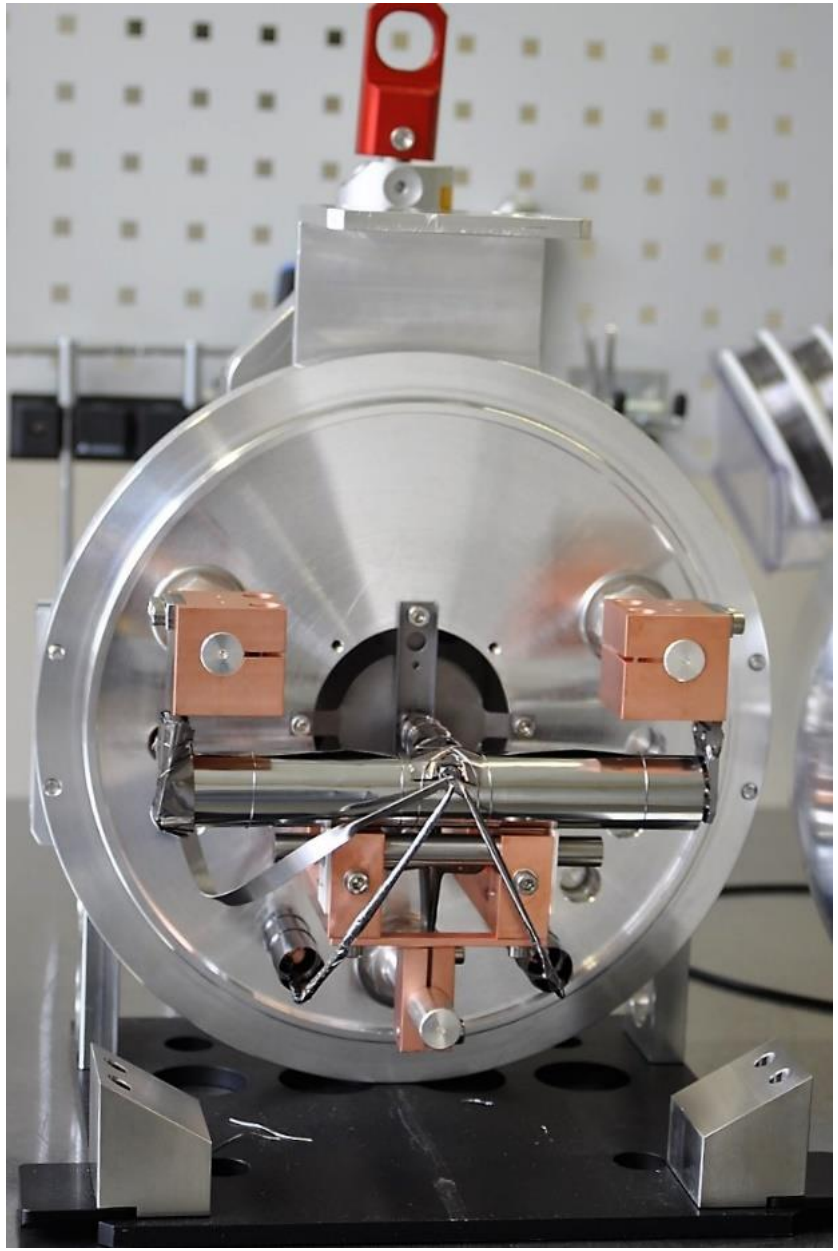


UC-618 Finished in **4 days** without human intervention

Used for UC and ThC production throughout 2018

Quality control

Visual inspection



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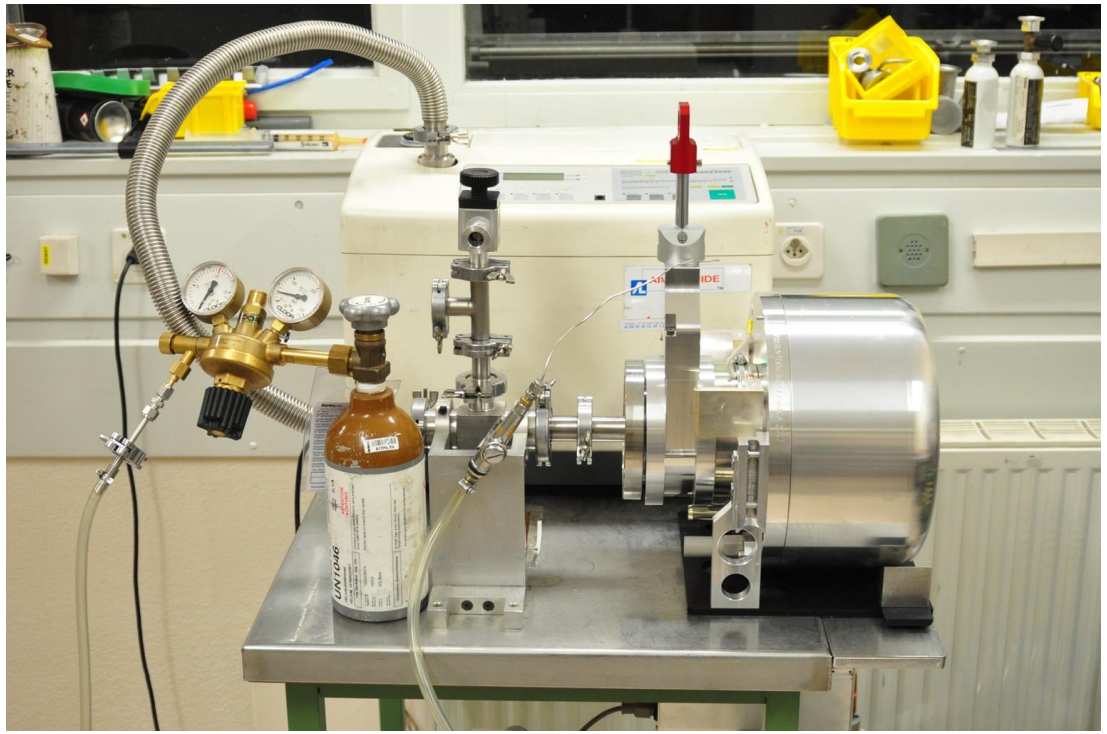
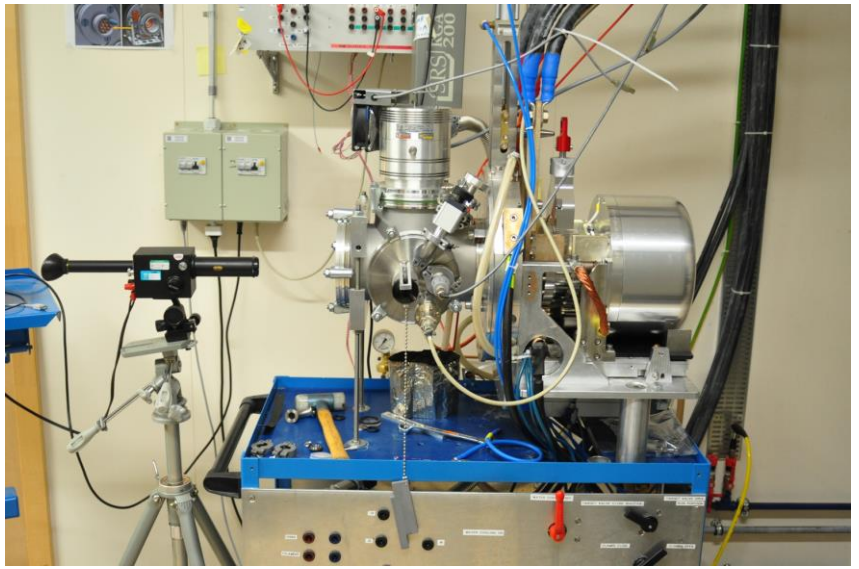
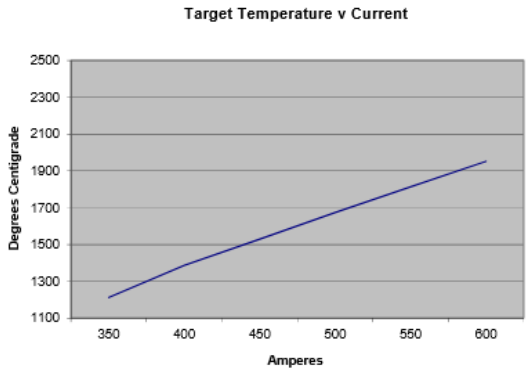
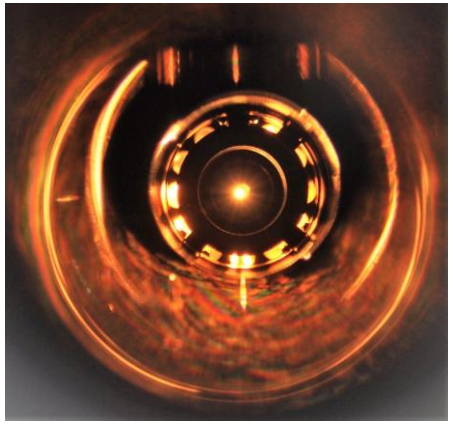
Quality control



He gas leak detection







Thermal calibration

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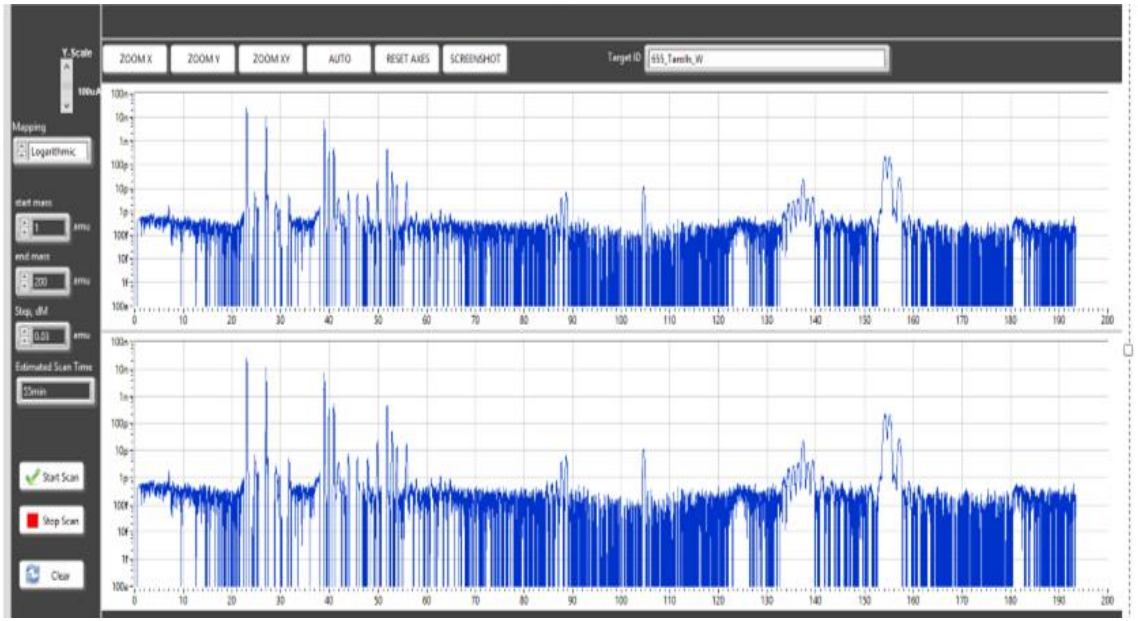
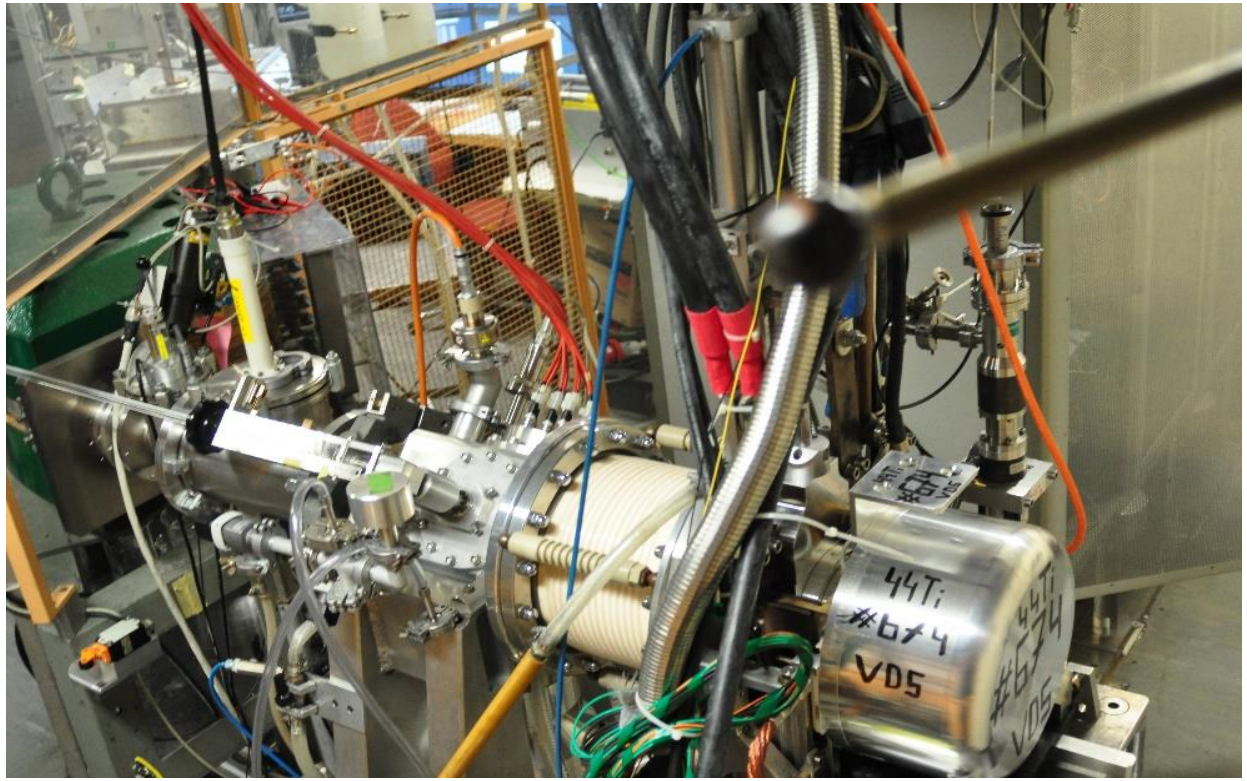
Quality control

- Targets coupled to offline 1 frontend
- Check performance of ion source
- Identify stable contaminants





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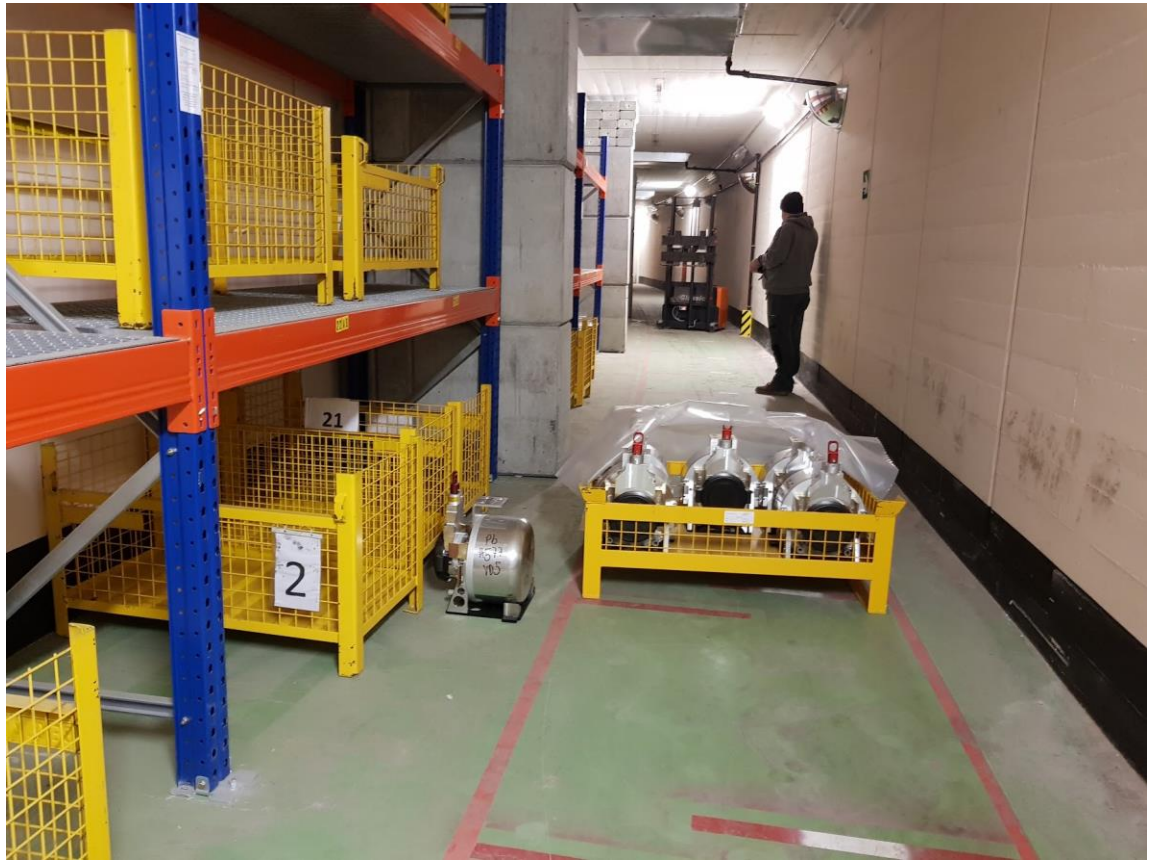
Target long term storage and dismantling

Target storage shelves in ISR



Paul Harwood

Hot cells

- dismantling of targets
- Post mortem analysis

Microtomograph for post mortem analysis

ZEISS METROTOM 1500/225 kV

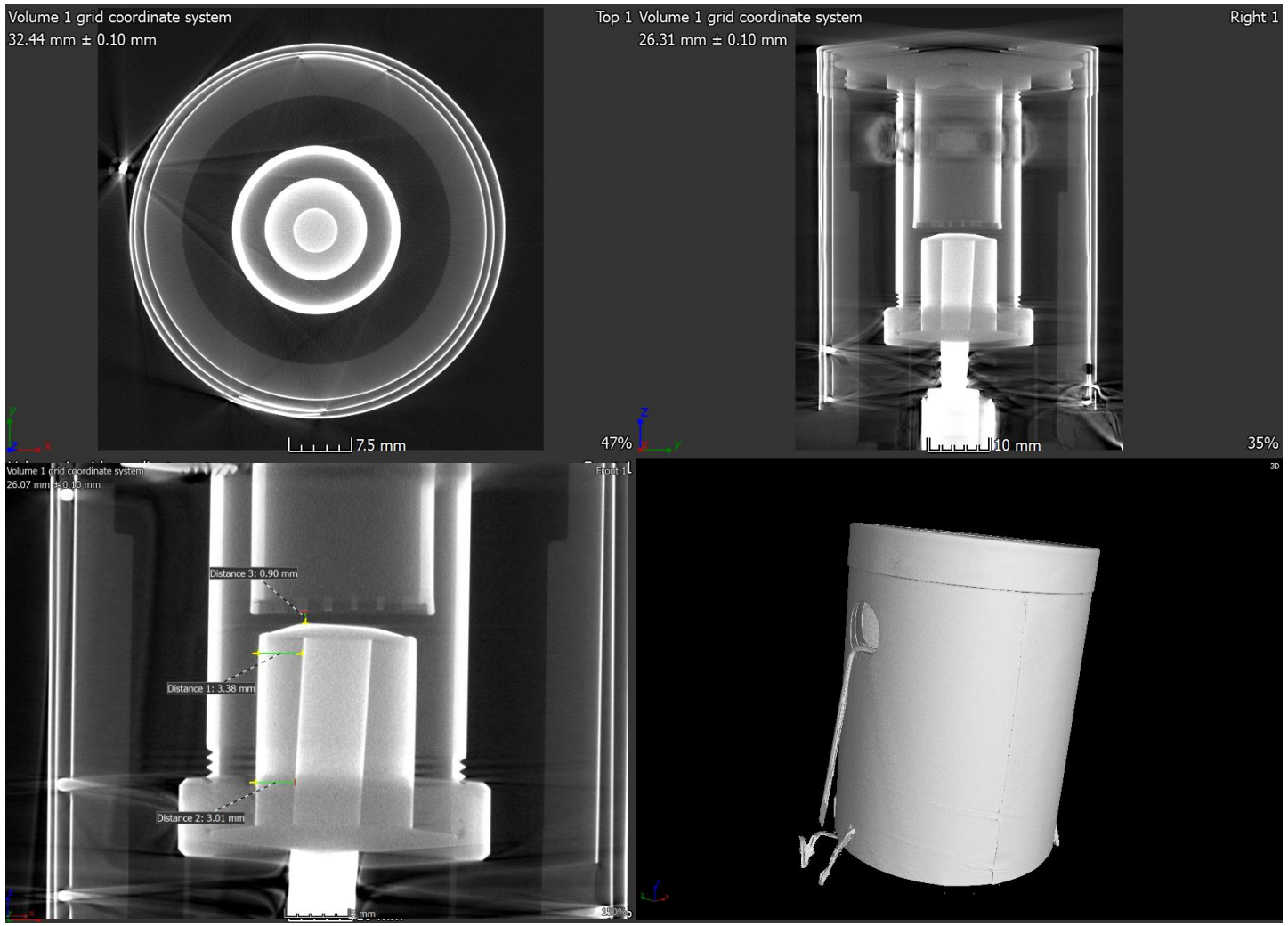
- Non destructive 3D reconstruction by X-ray computed tomography

https://indico.cern.ch/event/760652/

mariusz.jedrychowski@cern.ch

EN-MME

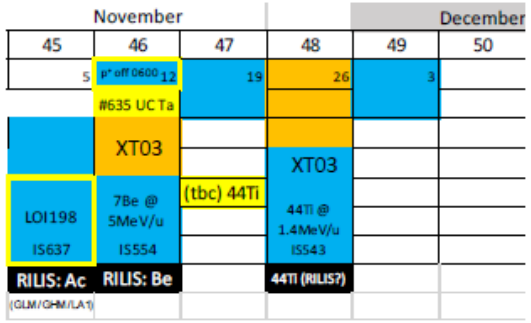
FEBIAD ion source after use



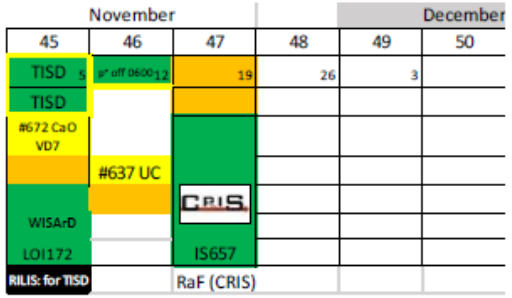
ISOLDE Schedule 2018

Winter Physics

GPS

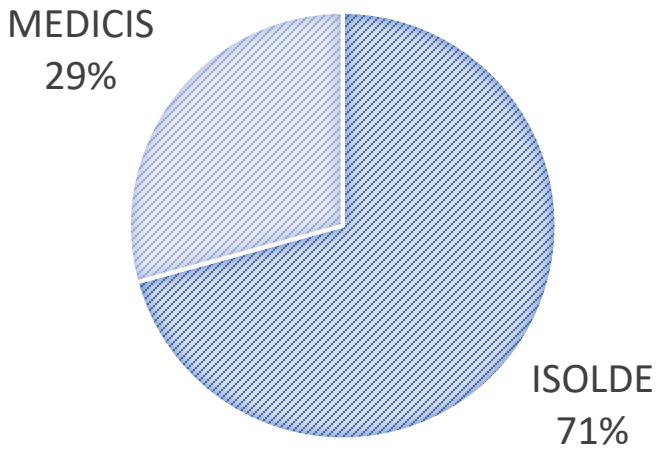


HRS

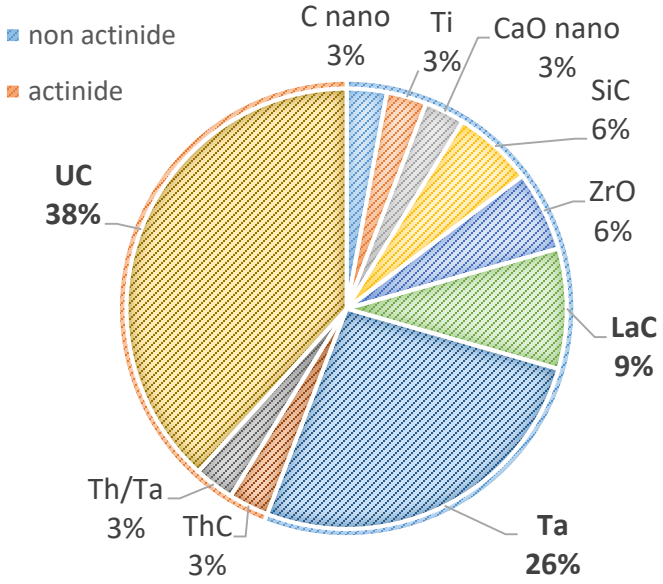


ISOLDE Target Production 2018

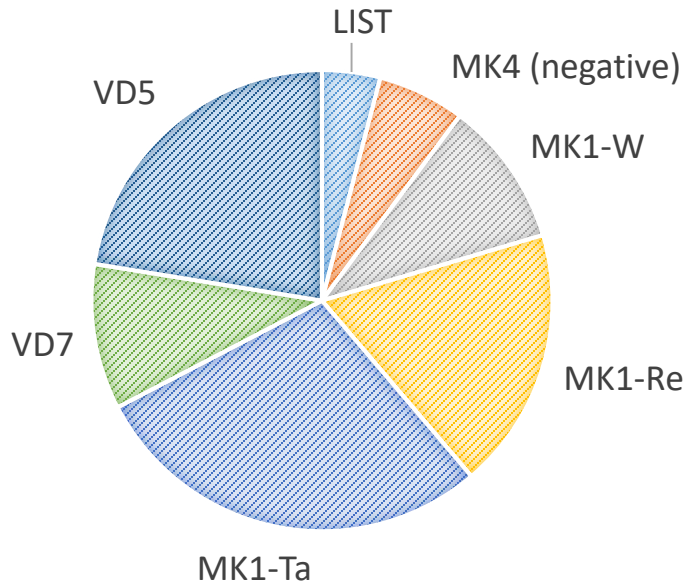
TARGET DESTINATION



TARGET MATERIALS



ION SOURCES



Total targets assembled end of 2018 : **49**

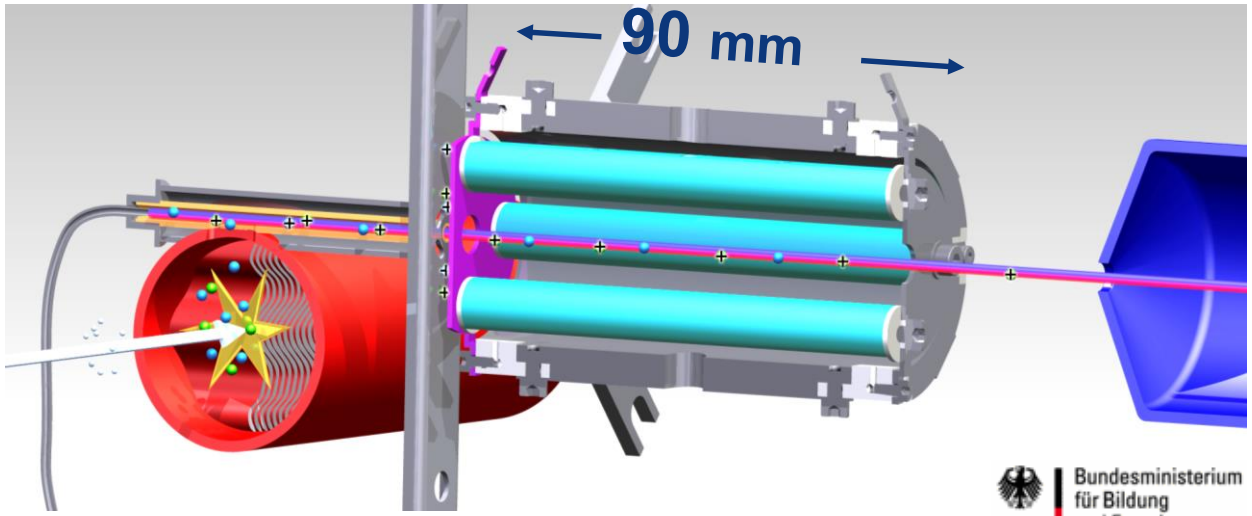
- Delivered to ISOLDE: **29**
- Delivered to MEDICIS: **10** + 2 in December
- Used for development: **8** (16%)

- **10 different materials**
- Mostly carbides and metal foils
- Most popular: **uranium carbide**

- **7 different ion sources**
- LIST and negative ion source back in action

LIST v 1.0

HFS studies of polonium / supression of francium (IS456, September 2012)

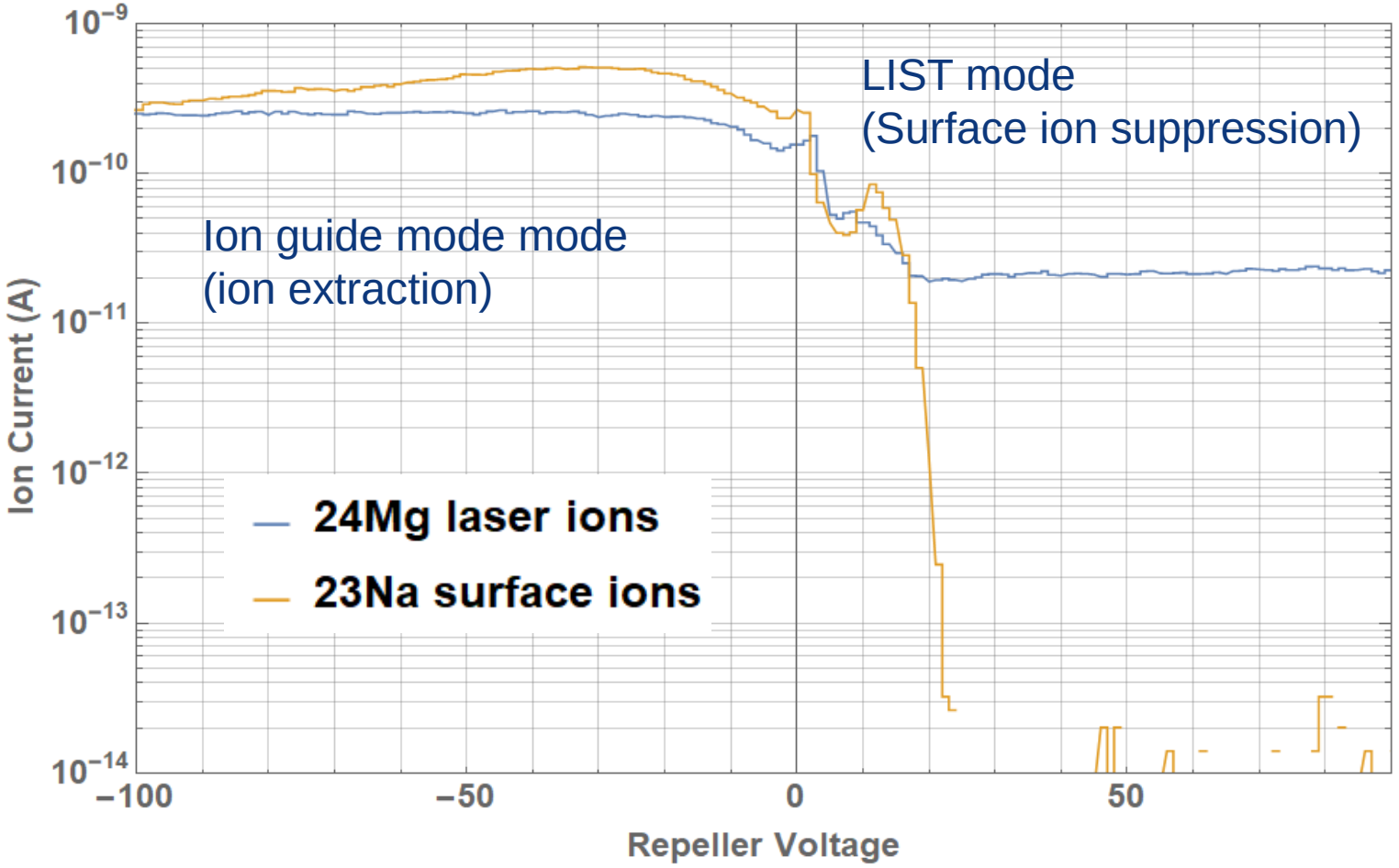


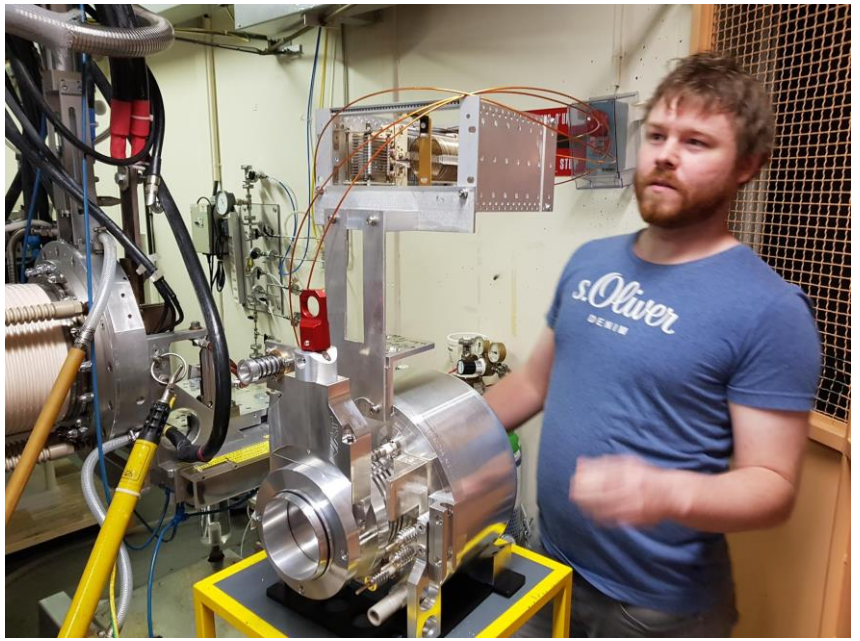
Isobaric suppression > 1000, efficiency loss ≈ 50

On-line implementation and first operation of the Laser Ion Source and Trap at ISOLDE/CERN, D. Fink et al**., NIMB 344**, 83-95 (2015)

In-Source Laser Spectroscopy with the Laser Ion Source and Trap: First Direct Study of the Ground-State Properties ^{217,219}*Po*, D. Fink et al., **PRX 5**, 011018 (2015)

Results: 90mm „standard“ LIST /w 2 repeller electrodes @ ISOLDE





Final on-line characteristics with SiC target:

- Suppression factor: **1E6** (^{21}Na)
- Laser ion loss factor: **27** (on ^{22}Mg)
- No ^{22}Na seen in IS614 detectors

Boron fluoride beams

Principle: $B + 3\,F \rightarrow BF_3$ *Volatilization of refractory boron by injection of SF_6 gas*

First prototype #499

- Small gas leak (3.7e-5 mbar L / s)
- Absence of TaF_x and SF_x in mass spectra

→ Unit did not produce BFx beams
no fluorine saturation

Second prototype #513

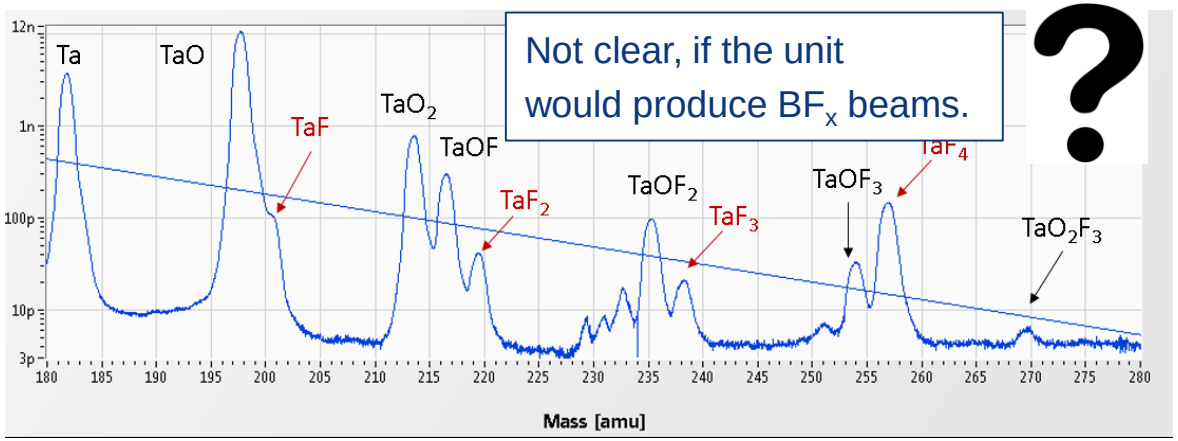
- Increased leak (1.84e-4 mbar L/s)
- Strong TaF_x and SF_x peaks
- No TaO peaks

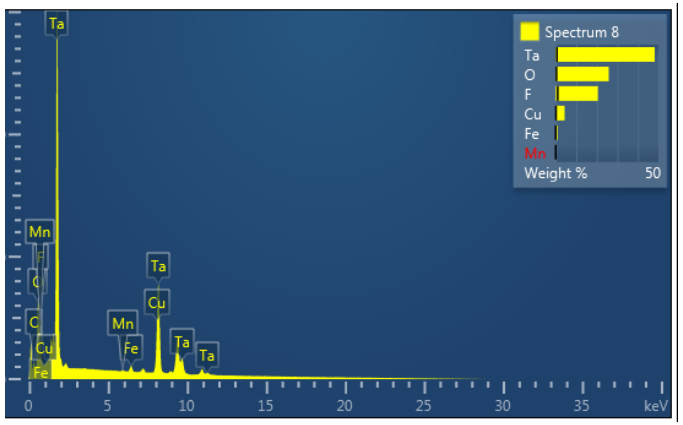
→ Stable and intense 8BFx beams

First production unit #606

Despite high injection,

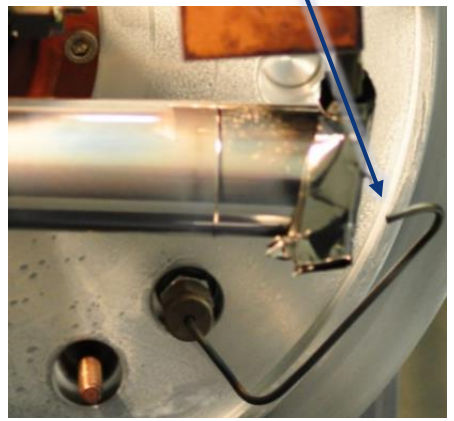
low fluorination, and presence of oxygen. H_2O or air leak?





TaO_xF_y deposits in target

Gas line rupture

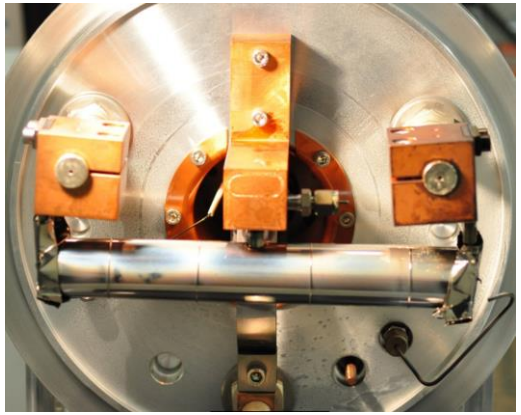


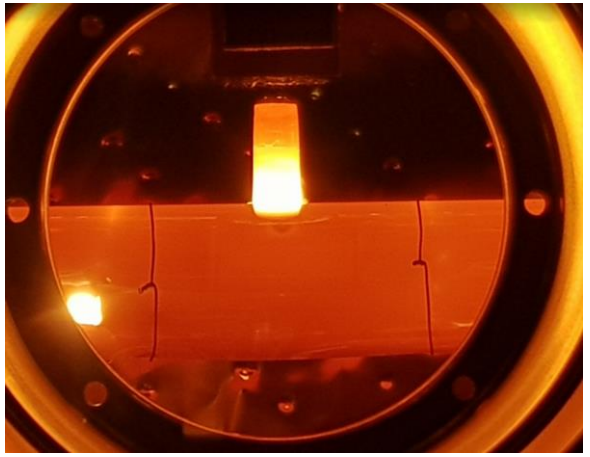
Target #606 -> #650

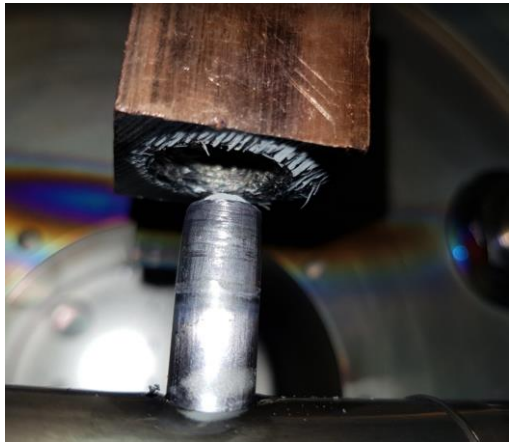
MWCNT for $^{8}B^{19}F_2$ beams at IDS

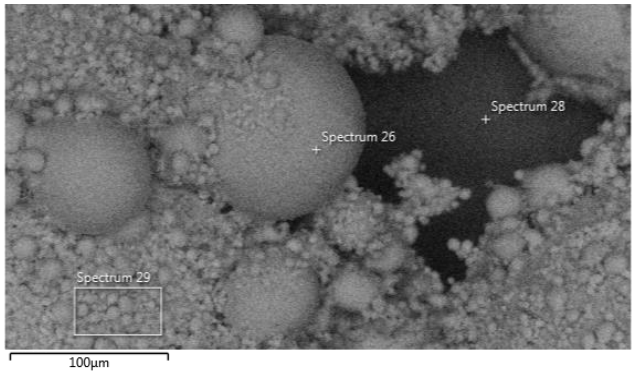
- 2017: #606 Target could not be delivered, #513 was used
- No infrastructure available to handle C nano tubes
- Decided to recuperate charge from #606 for #650
- Disassembly: transferline found clogged with AlF
- Target outgassed to remove contaminants
- Found macroscopic amount of Aluminum in transfer line

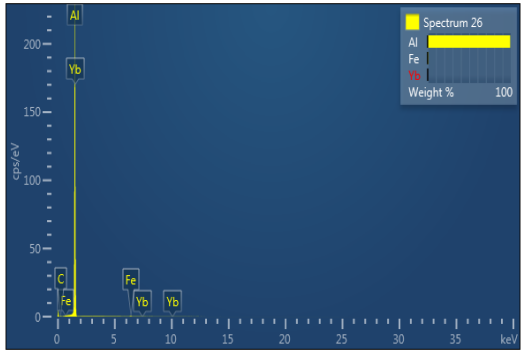
- Successfully used #650 for IDS run
- Factor 10 yield increase compared to #513
- CF4 can be used
- **> #650 rescheduled for HIE ISOLDE,**
  - **line broke, used #513 again**



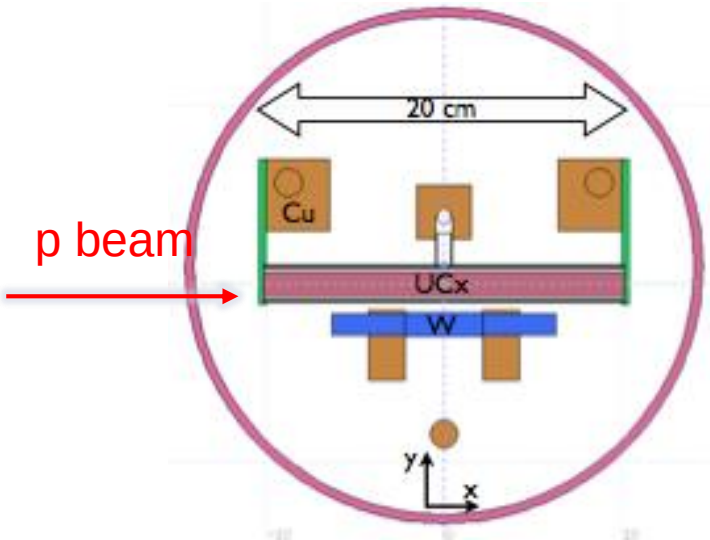


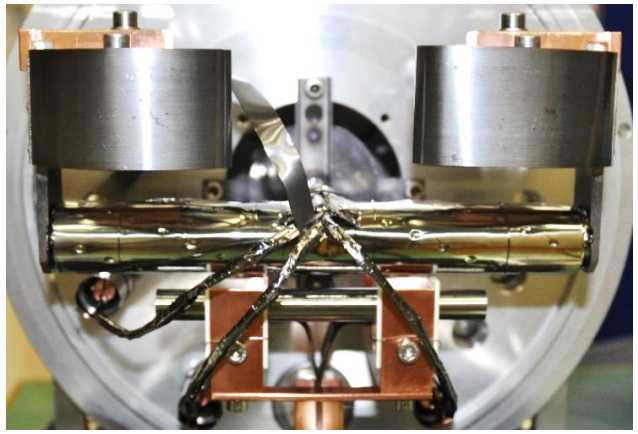


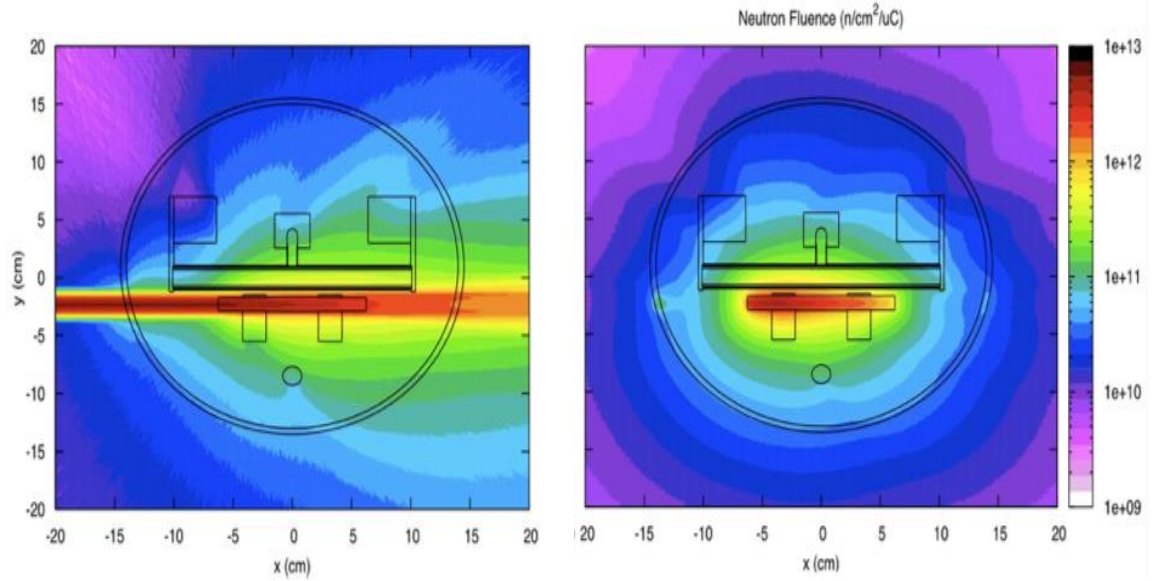




p2n-converter







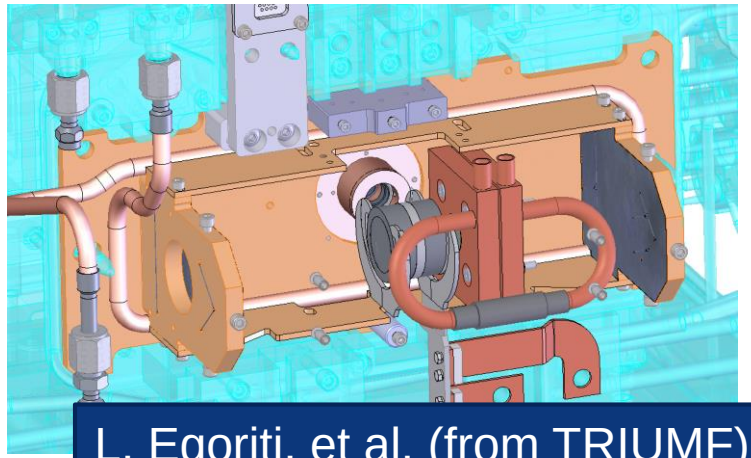
Brings high purity neutron-induced fission fragments

TRIUMF ISOLDE

500 MeV	1.4 GeV	2.0 GeV
100 µA	2 µA	6 µA
cw	pulsed	pulsed
50 kW	**2.8 kW**	**12 kW**

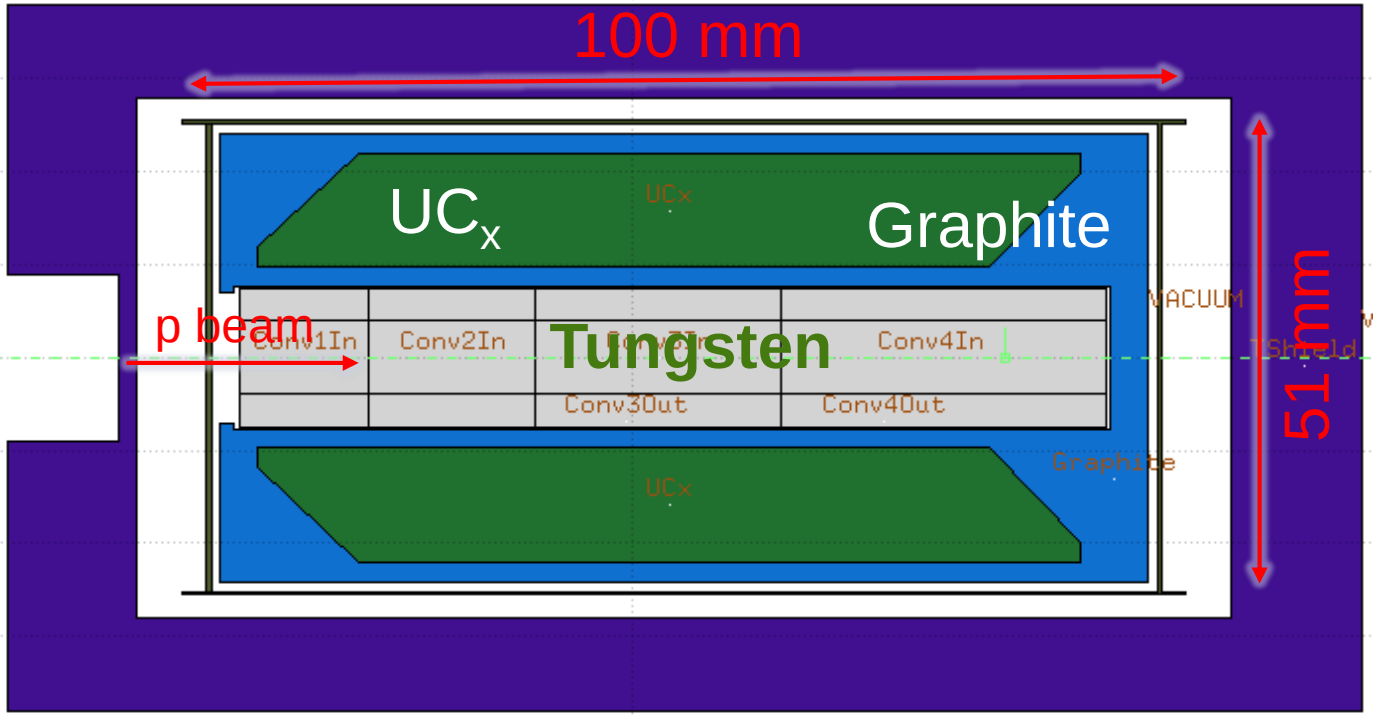
Collaboration started to design two p2n-converters:

- Improve the one of ISOLDE
- Design one for TRIUMF ISAC



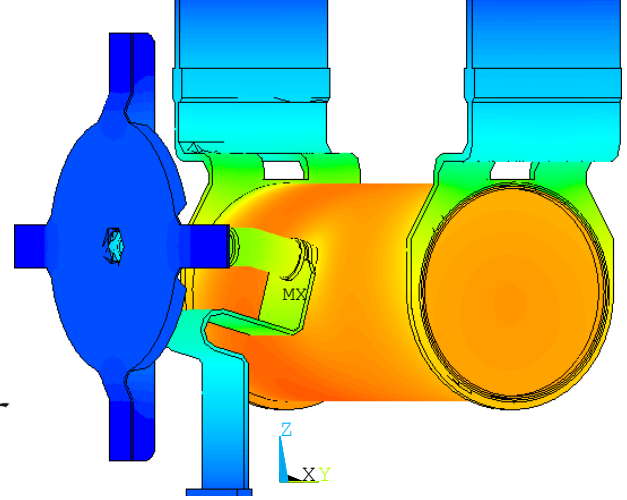
L. Egoriti, et al. (from TRIUMF)

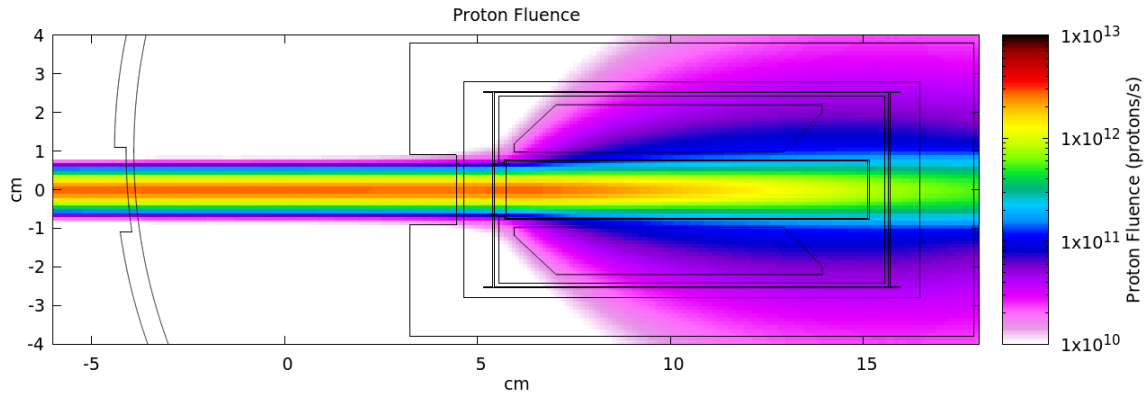
p2n-converter

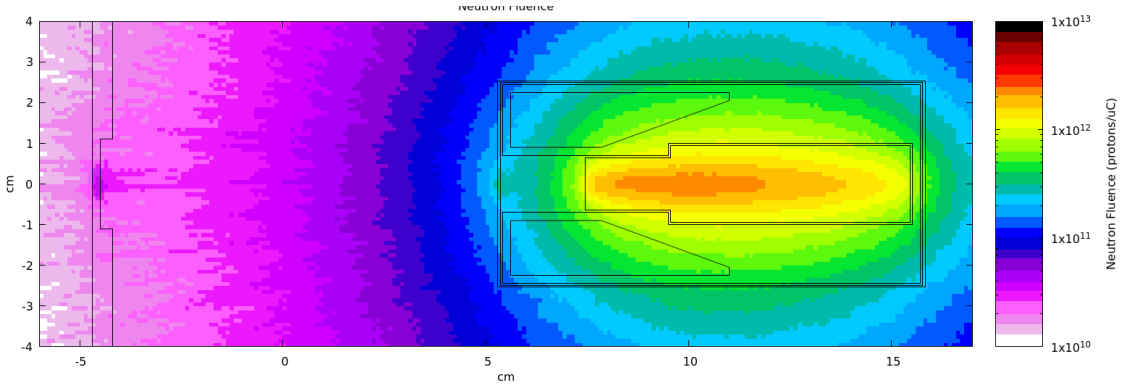


- Normal shielding – several metal foils stacked
- **New shielding: Sigratherm material – 1 cm thick**

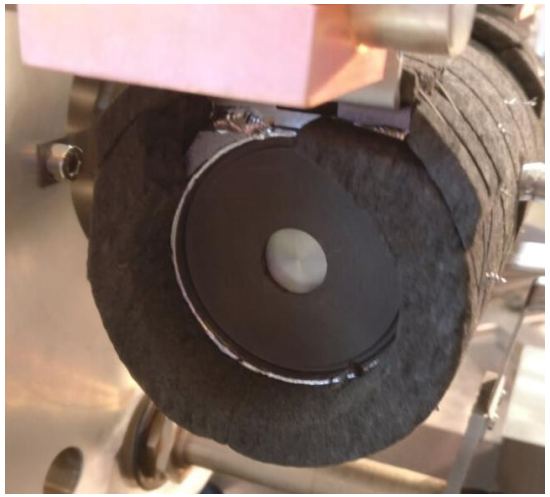
Converter will act as internal heat source

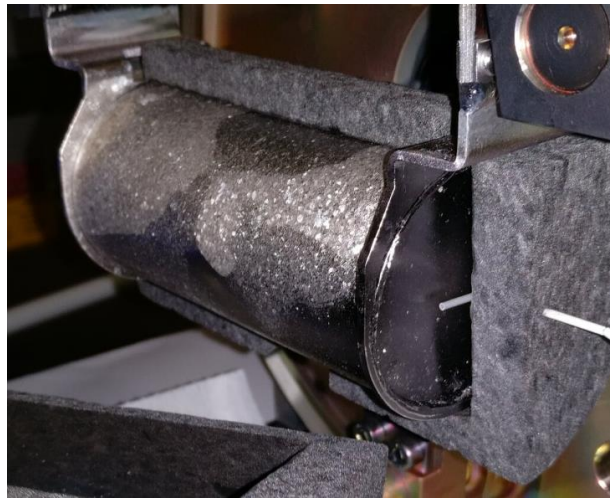




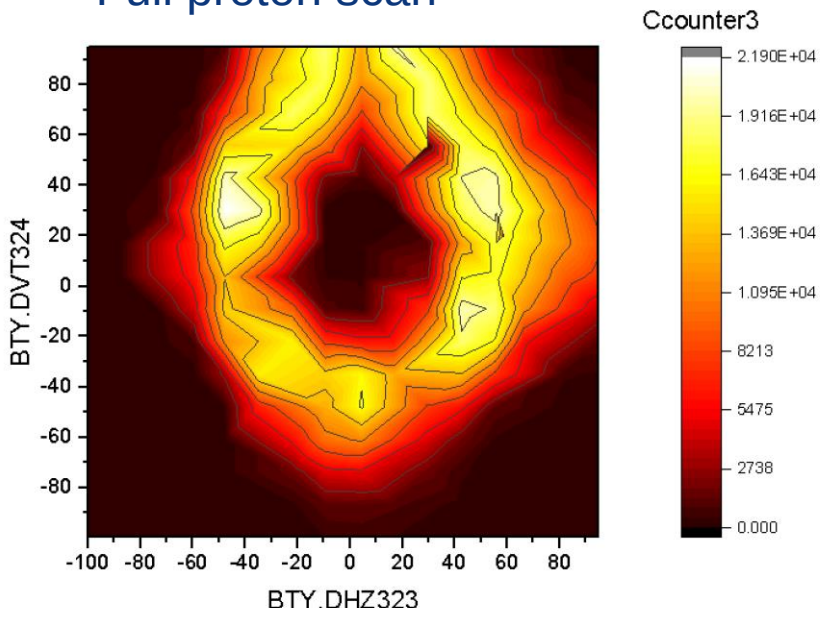


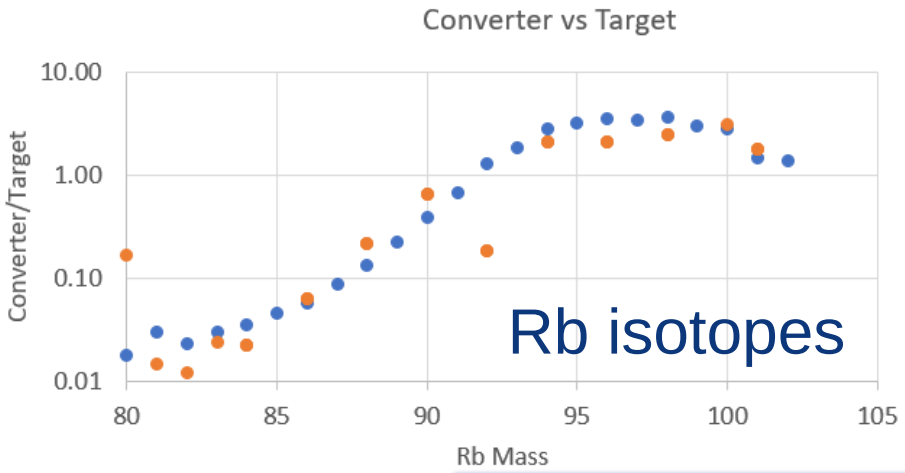
p2n-converter



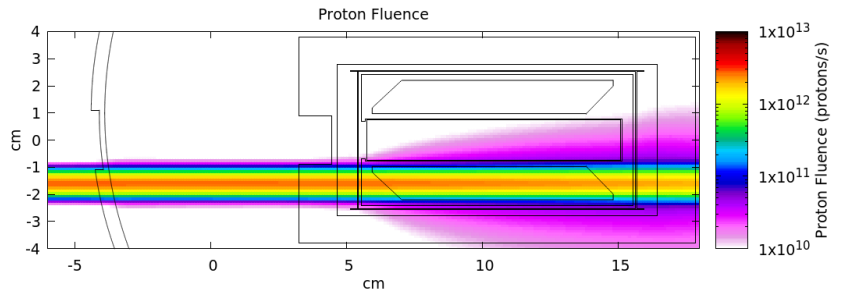


Full proton scan





Very short-lived isotopes extracted!



Isotope data:

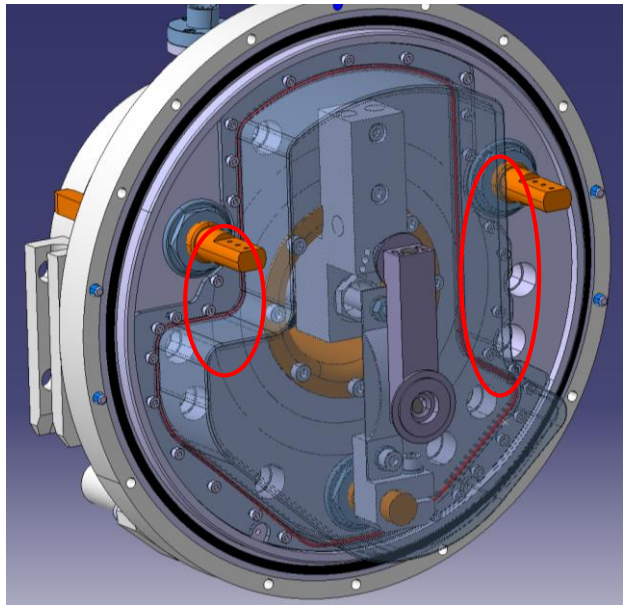
- Cs, Rb, Fr
- Laser ionized - Ga, Zn, In
- More than 100 yields extracted
- Protons on target and converter

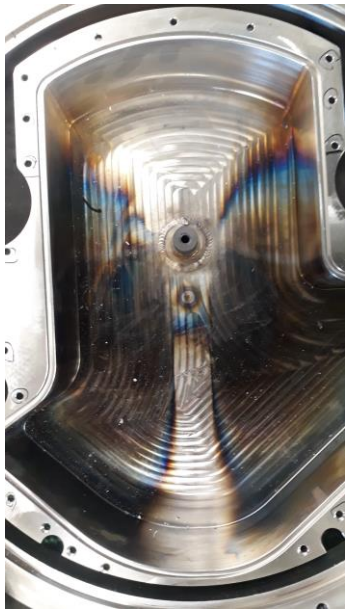
Data under analysis

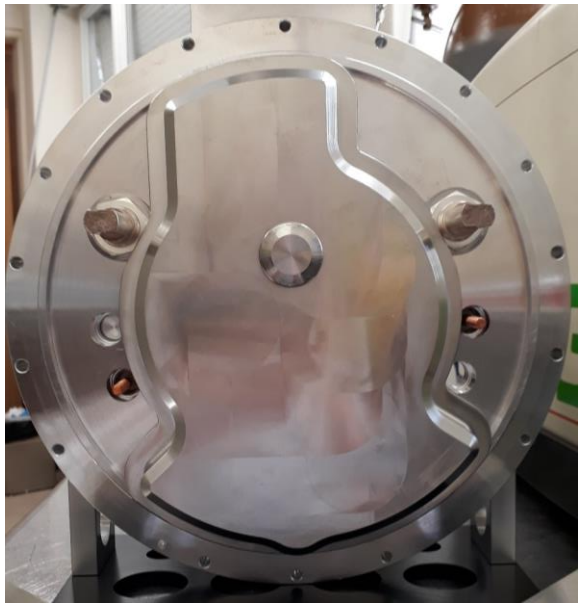
J.P. Ramos, et al.

LIEBE: offline commissioning

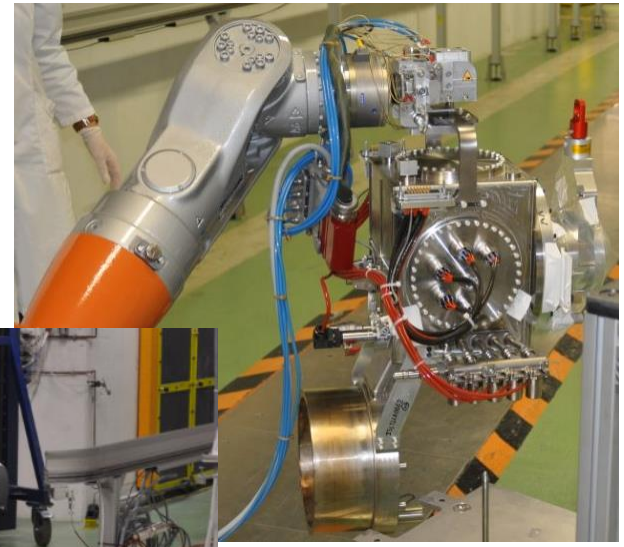
Leaks on the vessel containing the ion source impeded further offline commissioning in 2017

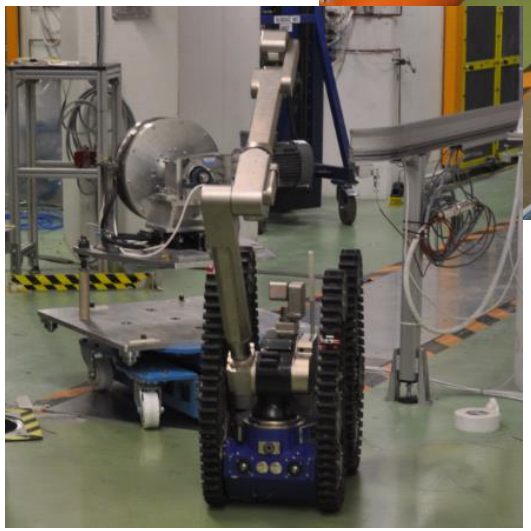






Full installation tests on GPS front-end during YETS2018





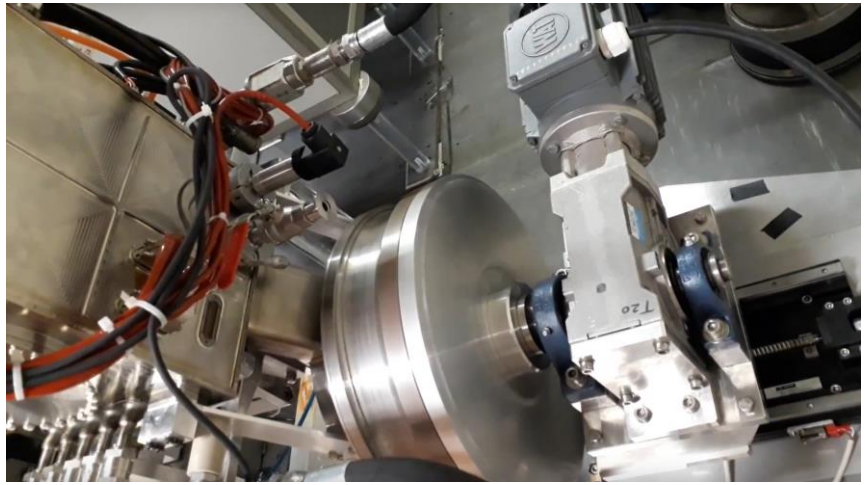
Successful replacement of the target base.

Standard operation of the VADIS ion source achieved.

Ferran Boix Pamies, et al.

LIEBE: offline commissioning

- Full operational tests with LBE on the offline mass separator



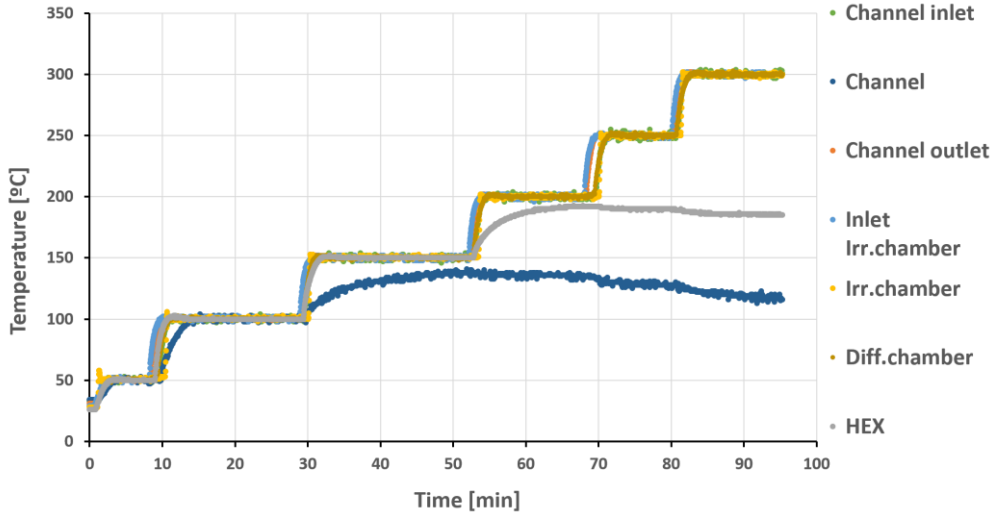
Unsatisfactory results:

- Insufficient heating power on channel and HEX
- Plugs of solid LBE lead to spilling of the liquid metal → not ready before LS2

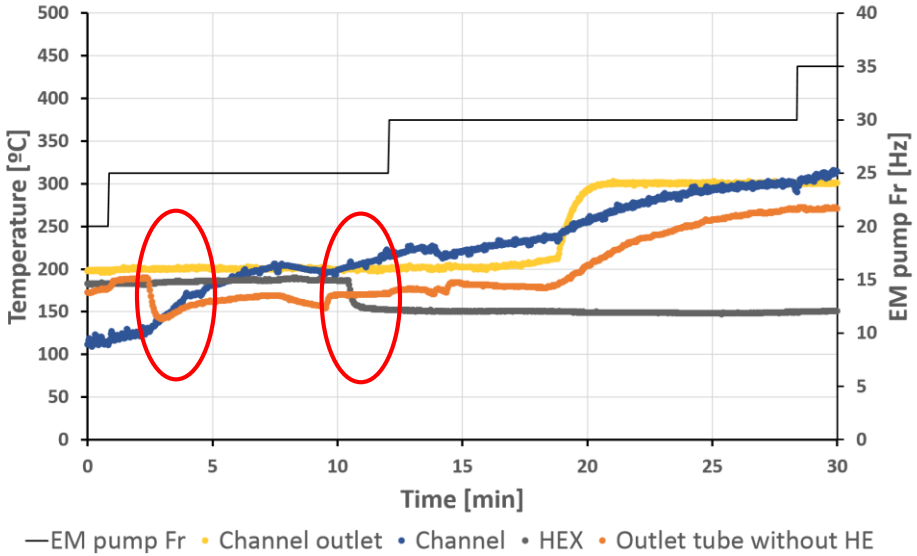
Review & next steps:

- Heating element redesign and replacement
- Further hydraulic tests of the loop plus EM pump
- Can LIEBE with molten Lanthanum cover 100Sn region for HIE ISOLDE ?

Outgassing sequence

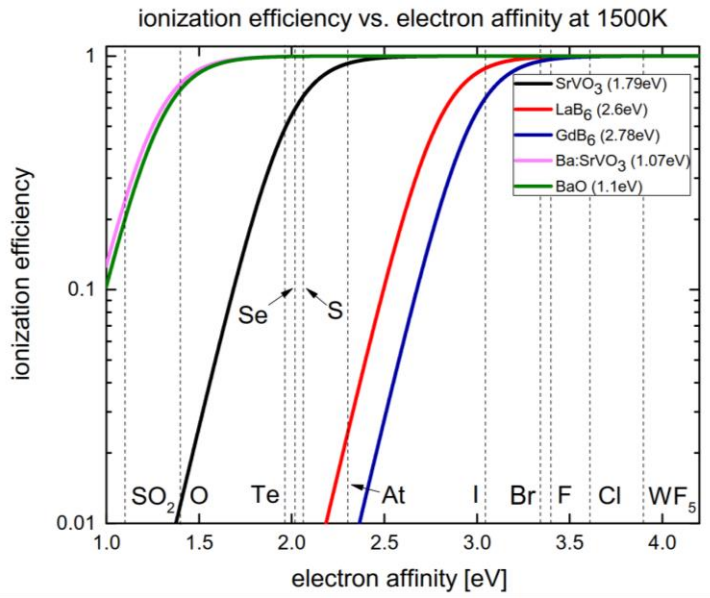


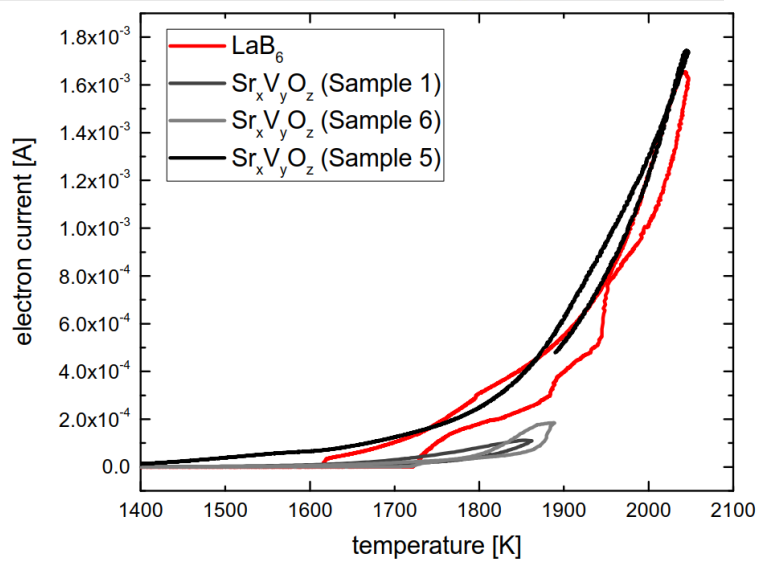
De-plugging detected during post-analysis



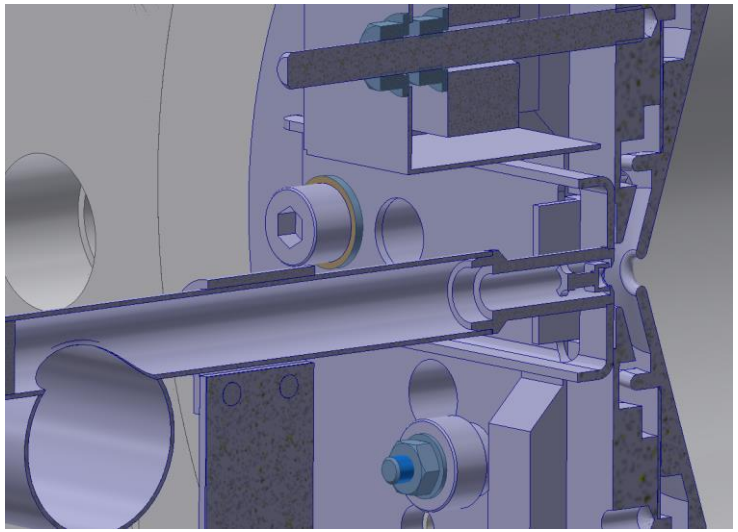
Ferran Boix Pamies, et al.

Low work function materials for negative ion production

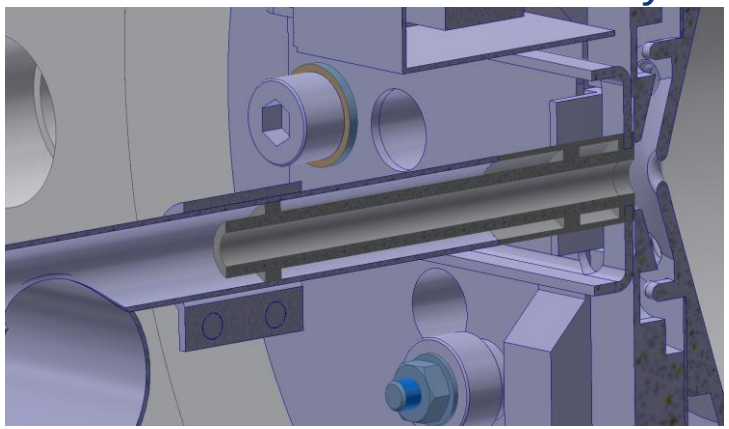




MK4 – Pellet source



Tubular low workfunction cavity



Improvement of ionization efficiency:

- Elements with low affinities are not efficiently ionized by LaB_6
- New compounds needed:
  - $SrVO_3$ with expected work function <2eV

First steps:

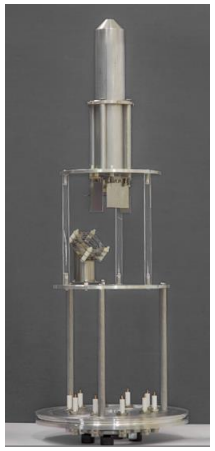
- Production of suitable candidates
- Electron emission tests with LaB_6 as benchmark
- Performance studies

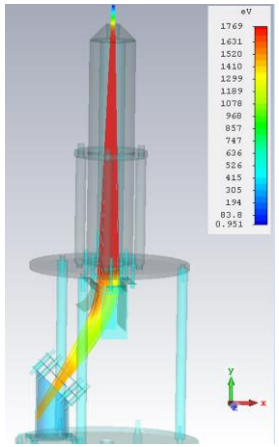
Next steps:

- Compare geometries offline

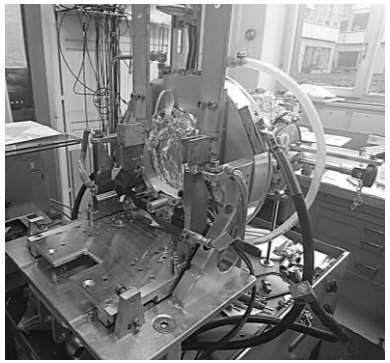
D.Leimbach: Presentation at 12:20

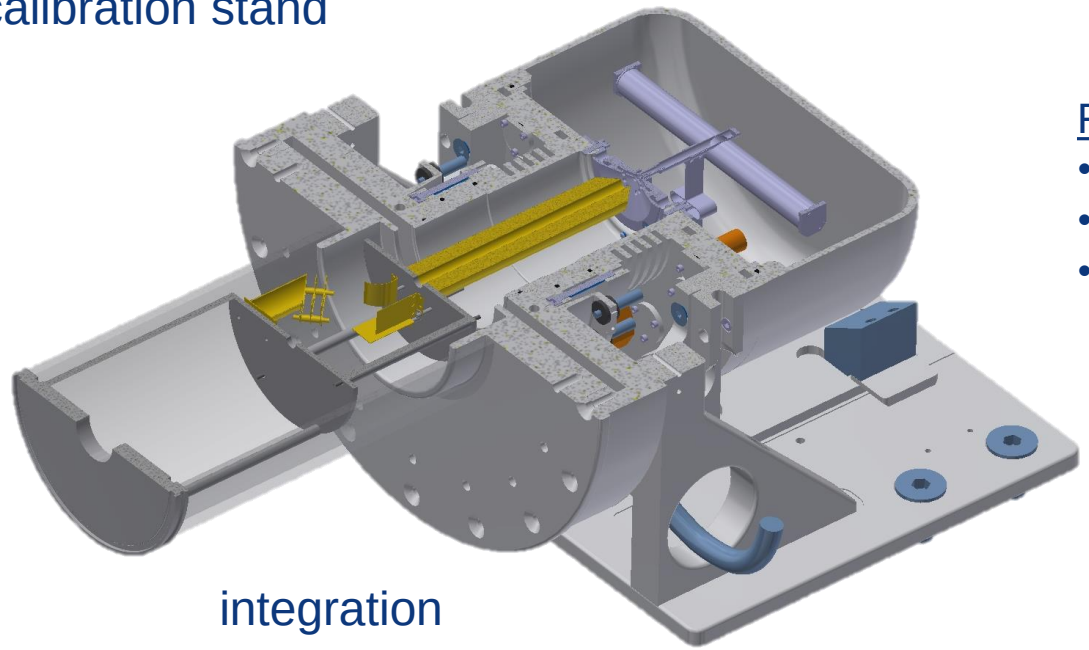
Dedicated test stand for ion source development





ISOLDE calibration stand





integration

Main features:

- ion **beam extraction** and detection
- residual gas analyzer (RGA)
- **automated control and data recording (LabVIEW)**

First application:

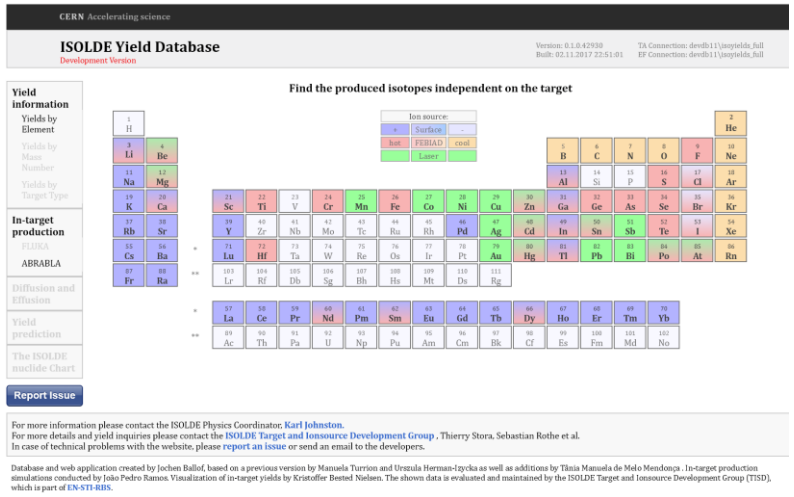
- **negative ion source** development
- investigation of source poisoning and regeneration

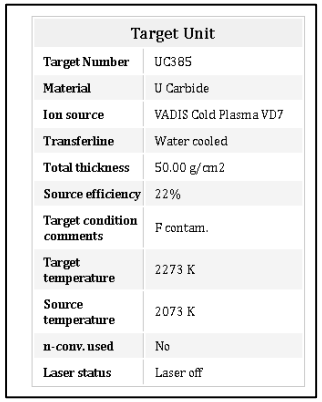
Future plans:

- long-term performance studies
- thermal stress tests
- destructive tests
  - **operational limits**
  - **failure mode analysis**

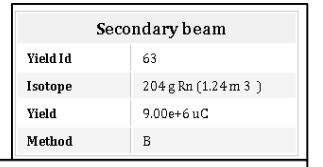
D.Leimbach

ISOLDE Yield Database YYDB(https://isoyields2.web.cern.ch)

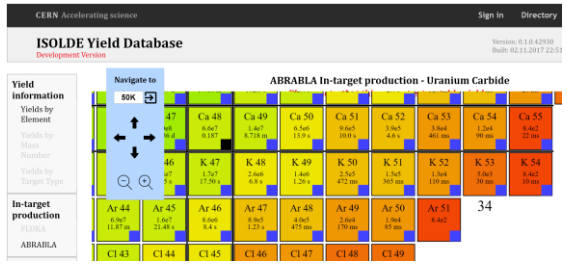


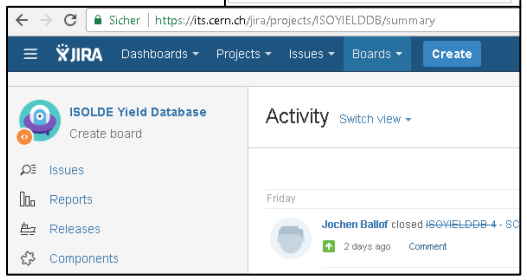


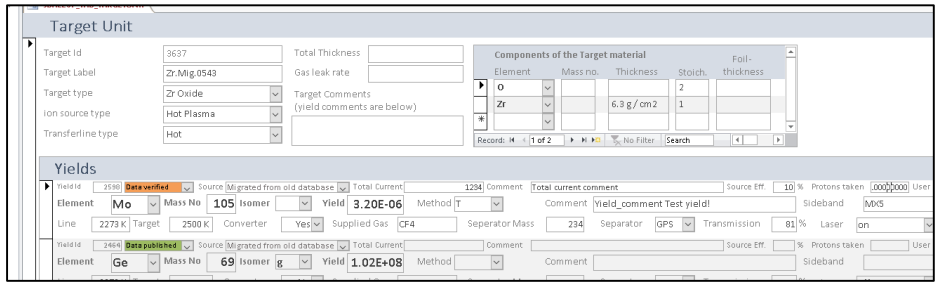
Target Unit	
Target Number	UC385
Material	U Carbide
Ion source	VADIS Cold Plasma VD7
Transferline	Water cooled
Total thickness	50.00 g/cm2
Source efficiency	22%
Target condition comments	F contam.
Target temperature	2273 K
Source temperature	2073 K
n-conv. used	No
Laser status	Laser off

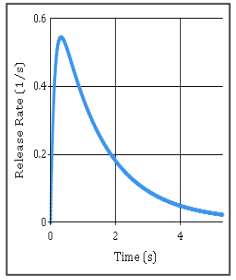


Secondary beam	
Yield Id	63
Isotope	204 g Rn (1.24 m 3)
Yield	9.00e+6 uC
Method	B









Features

- CERN SSO
- New Database design
- In target production (ABRABLA, FLUKA)
- Release curves available
- More target details visible
- Issue tracking

Philosophy

- All measurements (TISD, USERS) get entered into YYDB
- Manually change attribute (measured -> validated -> published)
- Attribute determines visibility

Future

- Web based interface allows entering of yields to registered users
- Add yield prediction
- Establish link to CRIBE database

J.Ballof

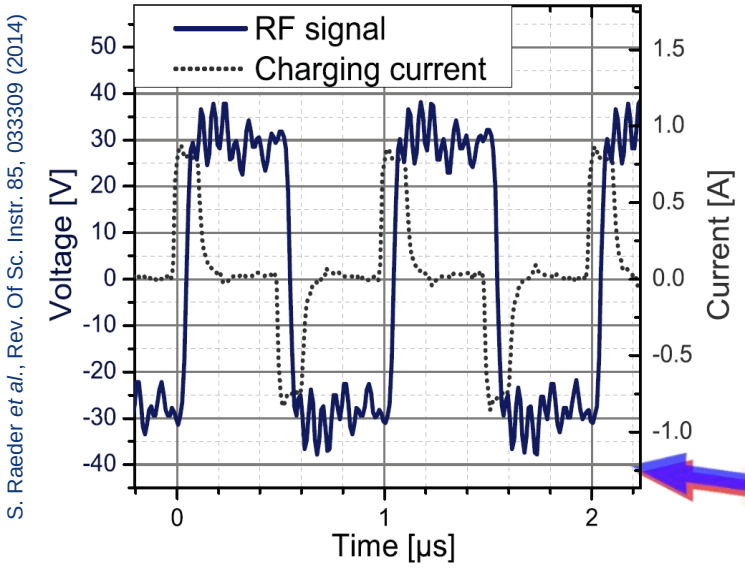
ENGINEERING
DEPARTMENT

Thanks to the TISD team

Ongoing developments

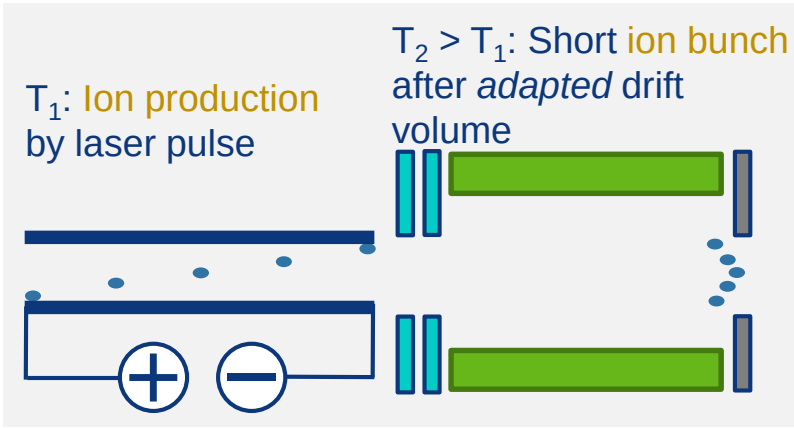
Square wave RF confinement by MHz switching:

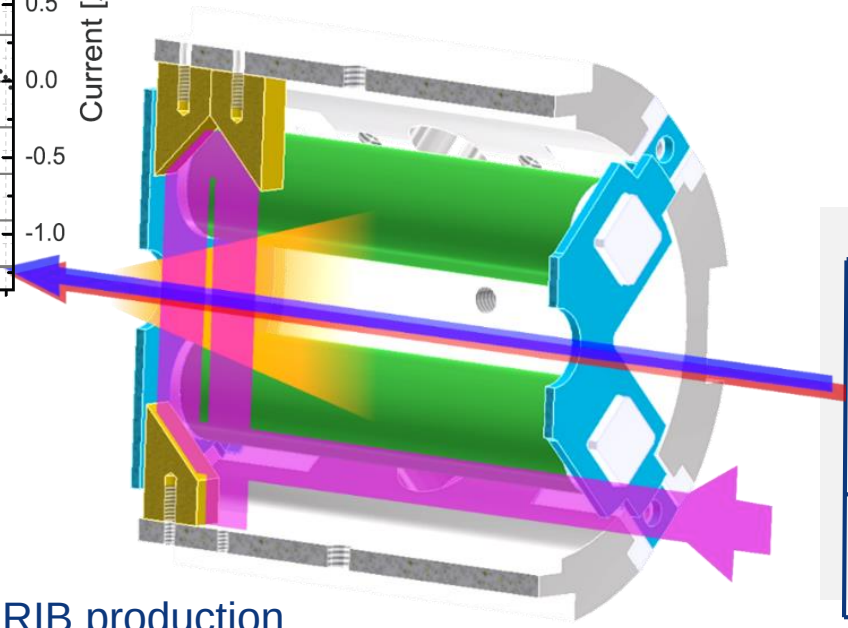
- suppression of RF box attached to target unit
- simplified control of symmetricity, amplitude, offset
- Supply to source via multipin connector



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

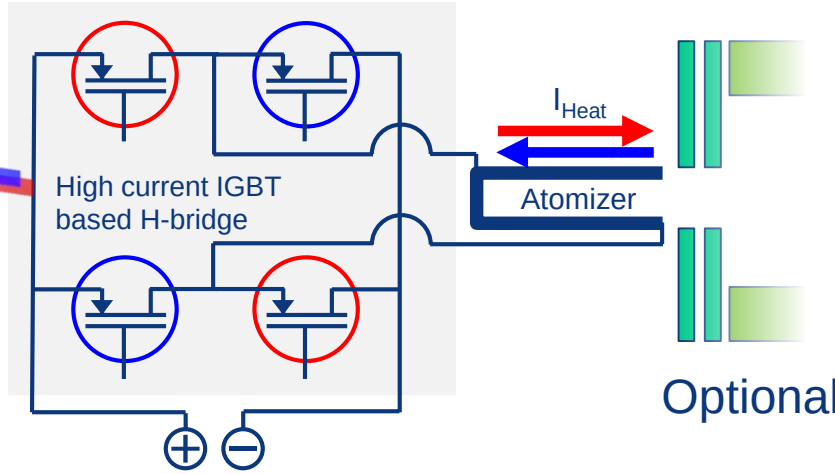
ToF-LIS: Field-free drift volume (= LIST)





Perpendicular laser irradiation:
Doppler-free spectroscopy and RIB production

In-situ heating current switching:
Fast polarity swapping and pulsing



Optional LIST