General advancement of Target & Ion Source studies in the BeamLab Task

Maher CHEIKH-MHAMED
on behalf of
the Beamlab Collaboration

2nd July2018

EURISOL Town Meeting, Pisa

Beamlab

EURISOL Town Meeting

chaired by Angela Bonaccorso (PI), Yorick Blumenfeld (CERN), Marek Lewitowicz (GANIL), Berta Rubio (CSIC Valencia)

from Monday, 2 July 2018 at **08:00** to Wednesday, 4 July 2018 at **18:00** (Europe/Rome)
at **INFN - Pisa (Aula 131)**
INFN - Pisa Bldg. C - ground floor Largo Bruno Pontecorvo, 3 I-56127 Pisa Italy

Monday, 2 July 2018

14:00 - 16:00 **Session 1: Target Studies**

Convener: Alberto Andrighetto (INFN - LNL)

14:00 **Highlights on target and ion source studies in the BEAMLAB task** *20'*
Speaker: Maher Cheikh Mhamed (IPN Orsay -CNRS)

14:20 **The SPES target, ion sources and beam transport** *25'*
Speaker: Mattia Manzolaro (LNL)

14:45 **Target Developments at SPIRAL** *20'*
Speaker: Predrag Ujic (GANIL, Caen, France)

15:05 **Target and ion source developments at CERN-ISOLDE** *20'*
Speaker: Sebastian Rothe (CERN)
Material: **Slides**

15:25 **FEBIAD ion source optimization at the ALTO facility** *20'*
Speaker: Ailin Zhang (IPN Orsay -CNRS)

15:45 **Activities on Beamlab at IFJ PAN in Krakow** *15'*
Speaker: Ryszard Misiak (IFJ PAN)

Beamlab

Main Scientific Objective :

producing nuclear beams which are challenging because of chemical reactivity of the nucleus element

Involved Laboratories:

CERN, GANIL, IFJ – PAN, IN2P3 – IPNO, INFN – LNL

Beamlab

- *Project Leader:*

  Maher Cheikh Mhamed (IN2P3 – IPNO)

  Laboratory Coordinators :

- CERN : T. Stora
- GANIL : P. Delahaye
- LNL-INFN : A. Andrighetto
- IFJ-PAN : J-W. Mietelski
- IPNO : M. Cheikh-Mhamed

Project task break-down (1)

Beamlab includes 4 subtasks:

- **Subtask #1: Efficient ion sources for difficult ISOL beams**
  - **Works focus on the plasma ion source behavior as a function of the injected vapors and optimization of key parameters of such ion sources**

Task leader: P. Delahaye (GANIL)

Involved partners: CERN, LNL-INFN, IPNO

- **Subtask #2: Material compatibility in reactive gas atmospheres**

Works focus on:

  - **Studies of the surface of material involved in the Target-Ion sources components**
  - **Studies on material and physicochemical properties as a function of the temperatures obtained during the operation of the Target-ion source unit.**

Task leader: A. Andrighetto (LNL-INFN)

Involved partners: GANIL, IJF PAN, IPNO

Project task break-down (2)

- **Subtask #3: New molecular beams**
  - **Developments are focusing on the production of molecule beams : by fluorination, by creating a volatile sulphide compound and creation of transition metal polycarbonyl complexes molecules**

Task leader: T. Stora (CERN)

Involved partners: GANIL, LNL-INFN, IPNO

- **Subtask #4: Specific targets designs for non-volatile elements**

Works focus on :

- Optimization of the target configuration

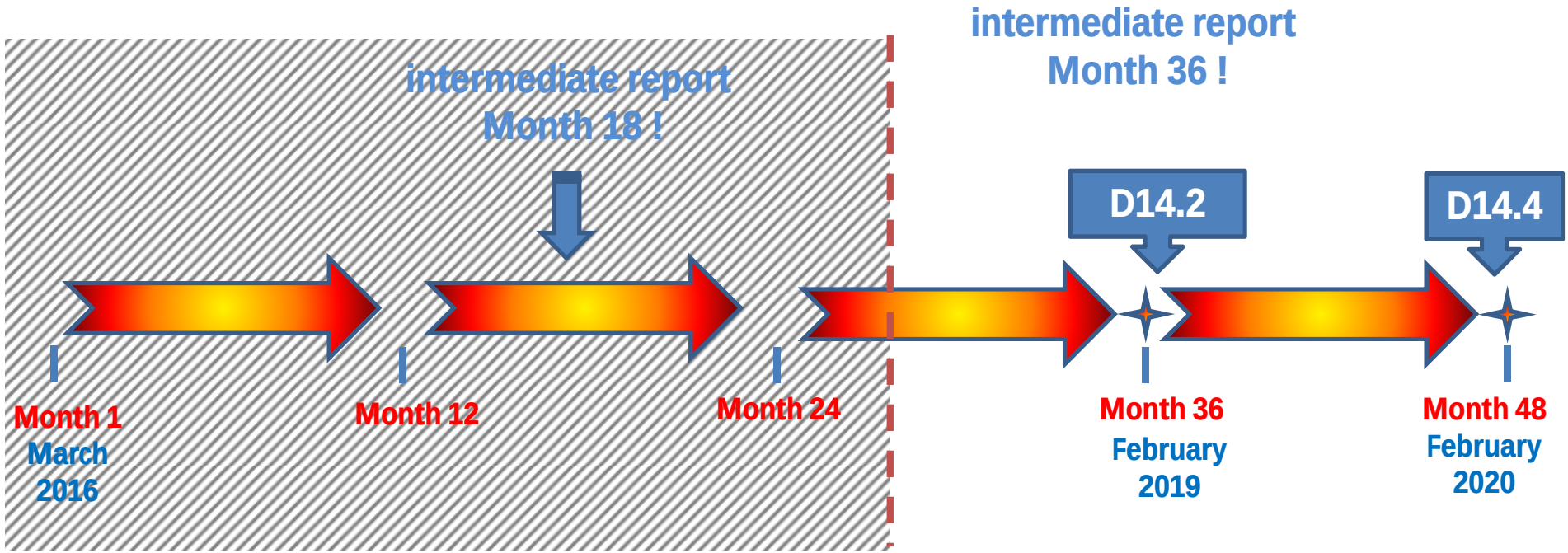
- Development of targets to catch the recoil fragments in a reactive gas

- Development of Light targets for the production of refractory beams

Task leader: M. Cheikh-Mhamed (IPNO)

Involved partners: CERN, GANIL, LNL-INFN, IPNO

Deliverables



D 14.2: Report on R&D on radioactive plasma ion sources (Month 36)

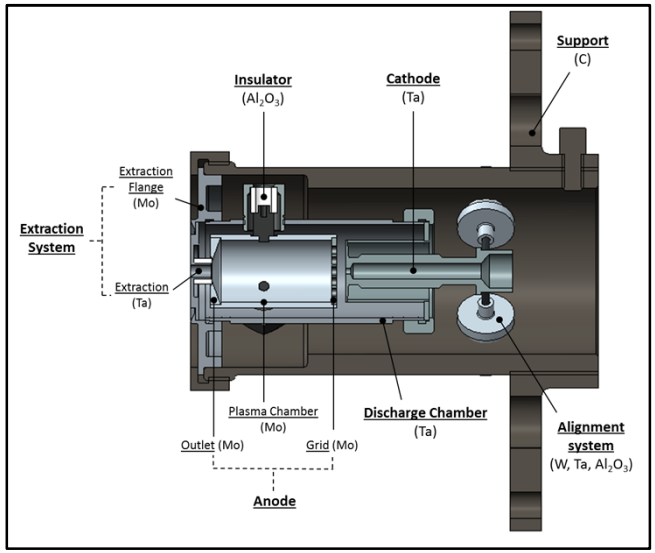
D14.4: New targets, ion sources and beams (Month 48)

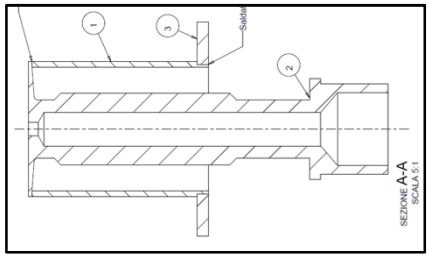
R&D on radioactive plasma ion sources (1)

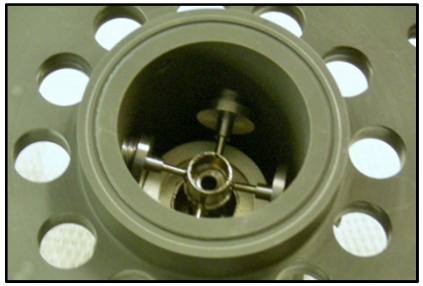
Works focus on the plasma ion source behavior as a function of the injected vapors and optimization of key parameters of such ion sources

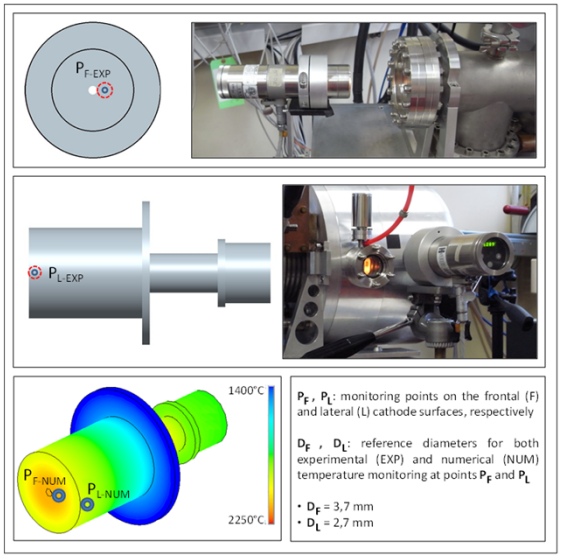
General improvement of the SPES Plasma Ion Source design: the optimized cathode and the alignment system

Ongoing characterization in terms of transversal emittance (varying different parameters) and ionization efficiency (for the following elements: Ar, Kr, Xe, Sn, Al, Ag, ...)









cathode optimized to avoid hot-spots and to maximize the anode current (electron current impinging the anode)

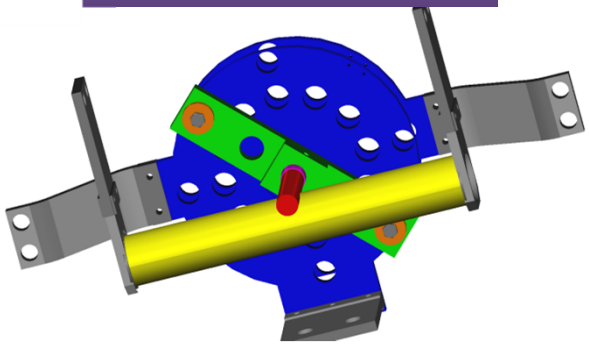
anode currents up to 250 mA (V_{anode} = 150 V)

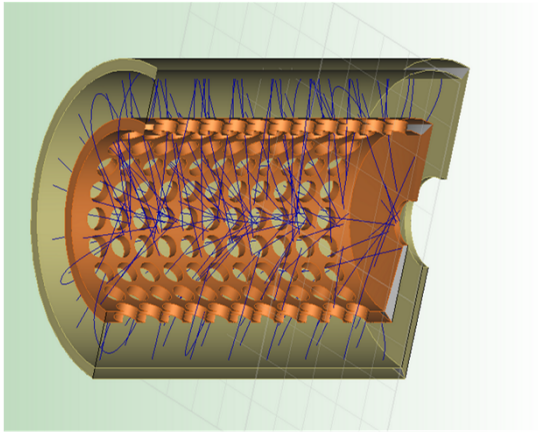
cathode alignment system reducing the thermal axial deformation of the cathode surface facing the anode

this is a good point to prevent the anode-cathode contact

R&D on radioactive plasma ion sources (2)

IRENA Ion Source

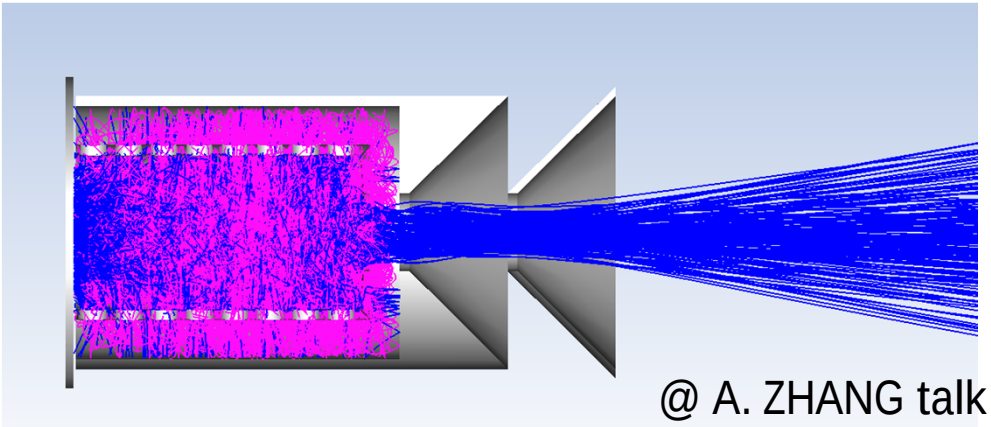


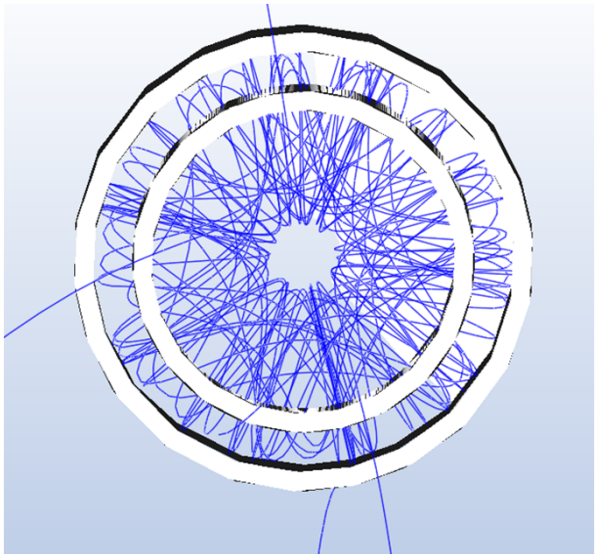


	IRENA2	FEBIAD MK5 @ ALTO
Ar	≥ 26 %	20 %
Kr	≥ 15 %	9 %
Xe	≥ 30 %	22 %

Motivations :

Very promising potentials of the 1st & 2nd prototypes → ***Optimized prototype:*** Thermionic emission studies, electron mean life time and beam extraction for IRENA ion source



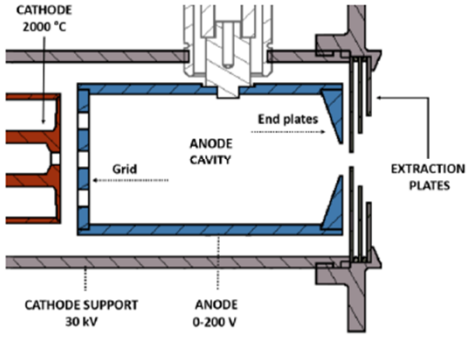


R&D on radioactive plasma ion sources (3)

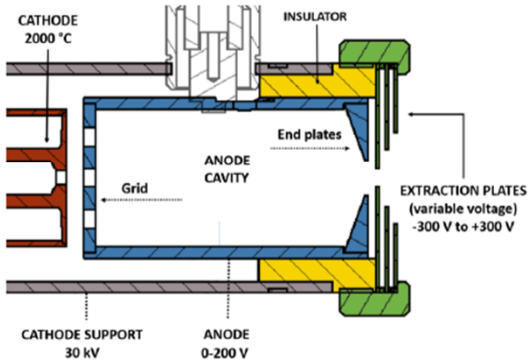
VADIS / VADLIS developments

RILIS

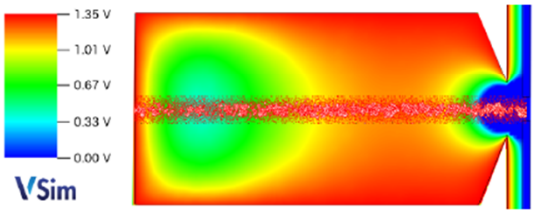
Standard VADIS



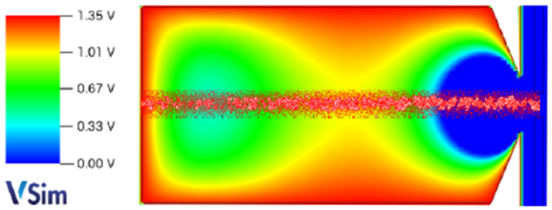
VADIS Dev. [2]



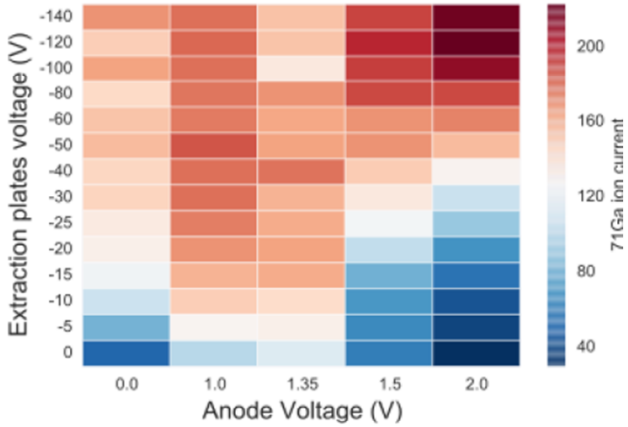
Extraction plates 0 V



Extraction plates -100 V



2D voltage scan (RILIS mode)



[2] *Y. Martinez et al. In preparation*

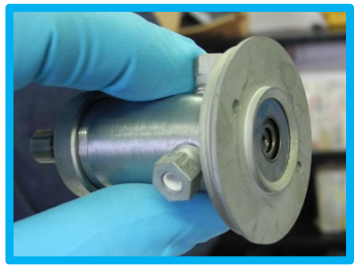
Successfully operated new VADLIS #630-MD

Y.Martinez

R&D on radioactive plasma ion sources (4)

GANIL Work :

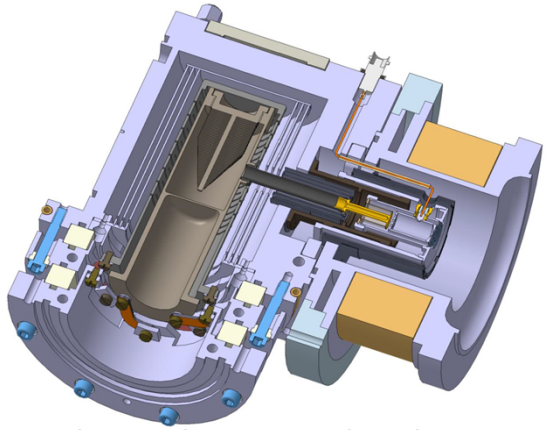
ISOLDE **VADIS**



1+ beams from metallic elements with T_{fusion} <2000°C

Different tests at SIRA and SPIRAL 1
Coupling of the SPIRAL 1 targets with the VADIS

Already 7 new elements
Na, Mg, Al, P, Cl, Cu, Fe
+ many more to come



O. Bajeat et al, NIM B 317(2013)411

- The FEBIAD source has been thoroughly tested and is ready for on-line operation
  - >3 weeks operation has been proven possible
  - Stable efficiencies, some improvements possible (?)

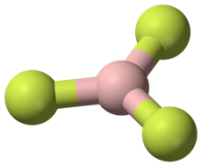
R&D on radioactive plasma ion sources (5)

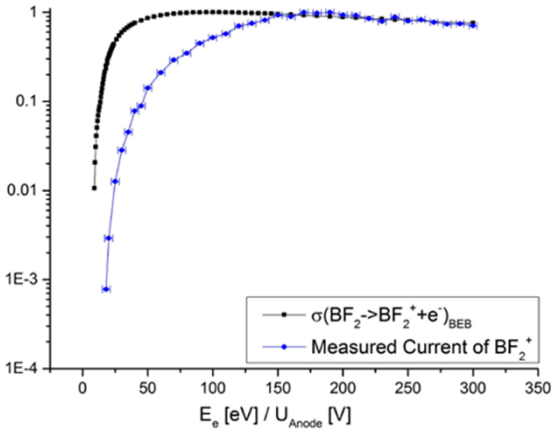
- At CERN, operational parameters of the radioactive plasma ion source VADIS have been optimized for the Boron beam productions.

Boron is difficult to extract:

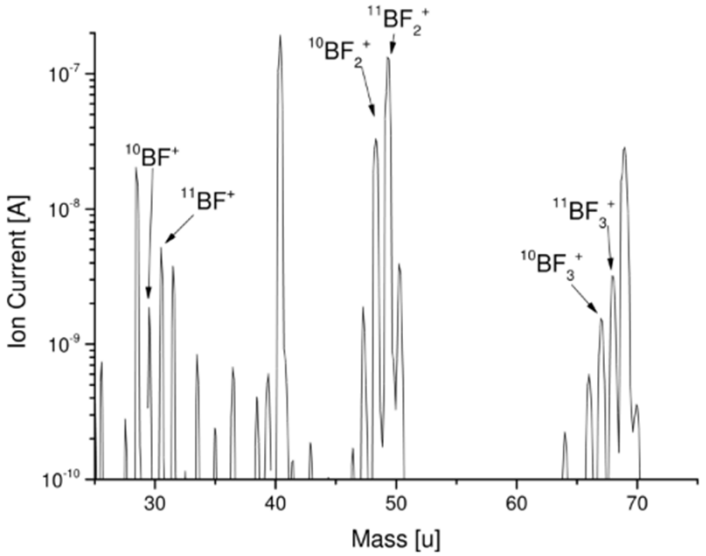
- Low Volatility (m.p. 2076 °C)
- Reactive, forms stable compounds with many materials

$^{8}B \xrightarrow{SF_6\ (g)} {}^{8}BF_3$





BF_3 ionization -> BF2+ is predominant

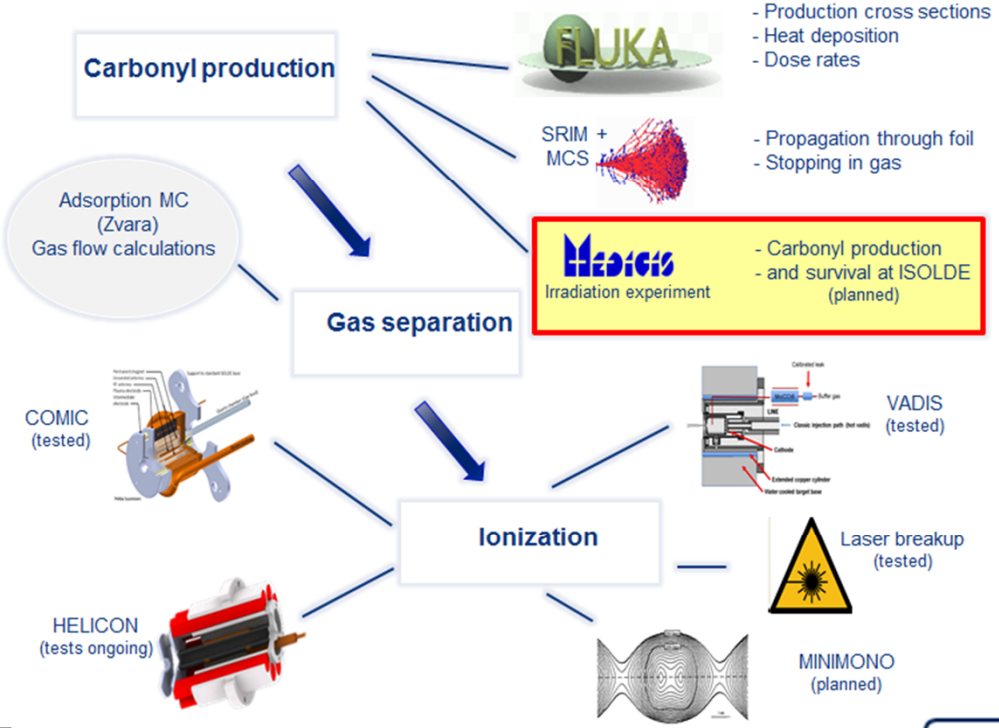


It was found that, higher anode voltages brought higher ionization efficiencies for BF2 beams.

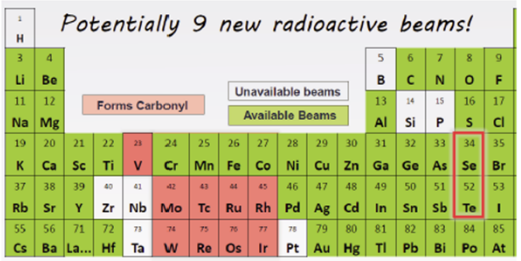
New targets, ion sources and beams(1)

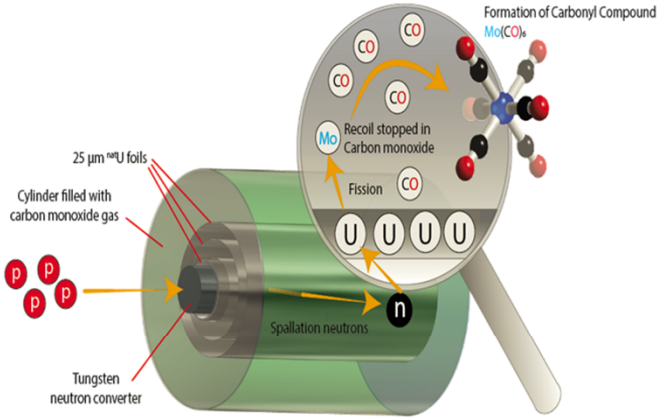
Carbonyl beams Project overview

New set of technologies needs to be developed



Motivation





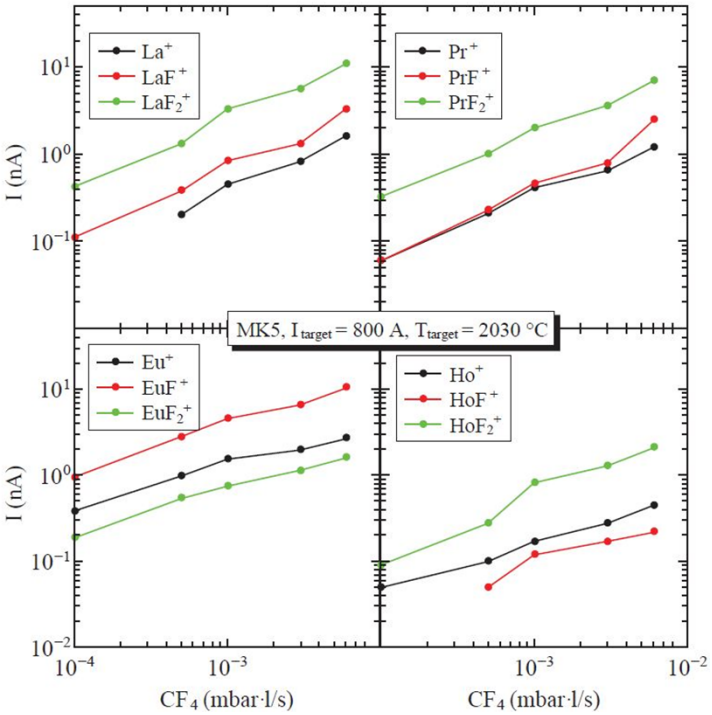
Principle: Mo —CO (g)→ $Mo(CO)_6$

b.p. 4369 °C — volatile!

J. Ballof, J.P. Ramos, S. Rothe, T. Stora
20/03/2018 Beam lab CERN contribution

New targets, ion sources and beams(2)

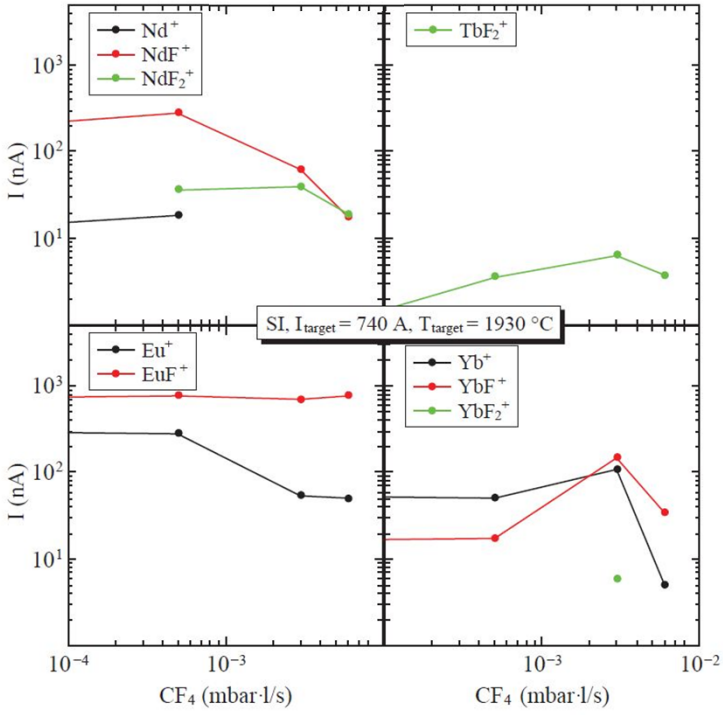
Fluorinated molecular beams

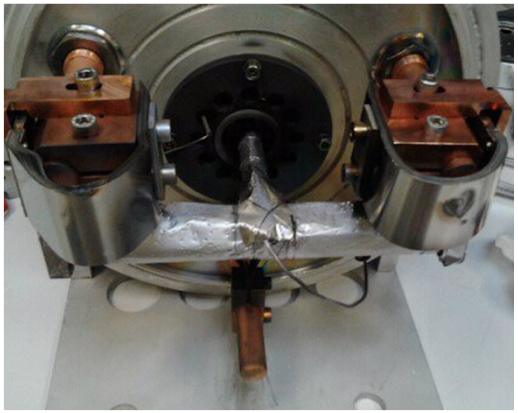


Off-Line tests

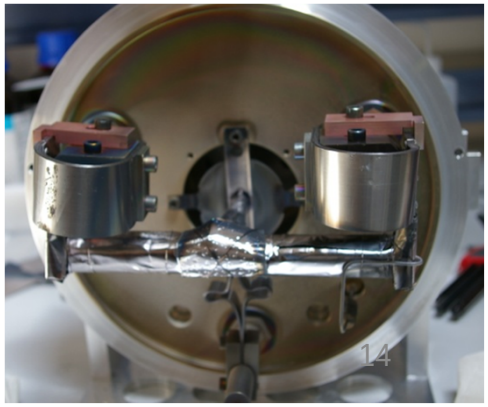
MK5: the more CF4 injected, the higher the intensity of the lanthanide beams

SI: more CF4 injected → beam intensities collapse





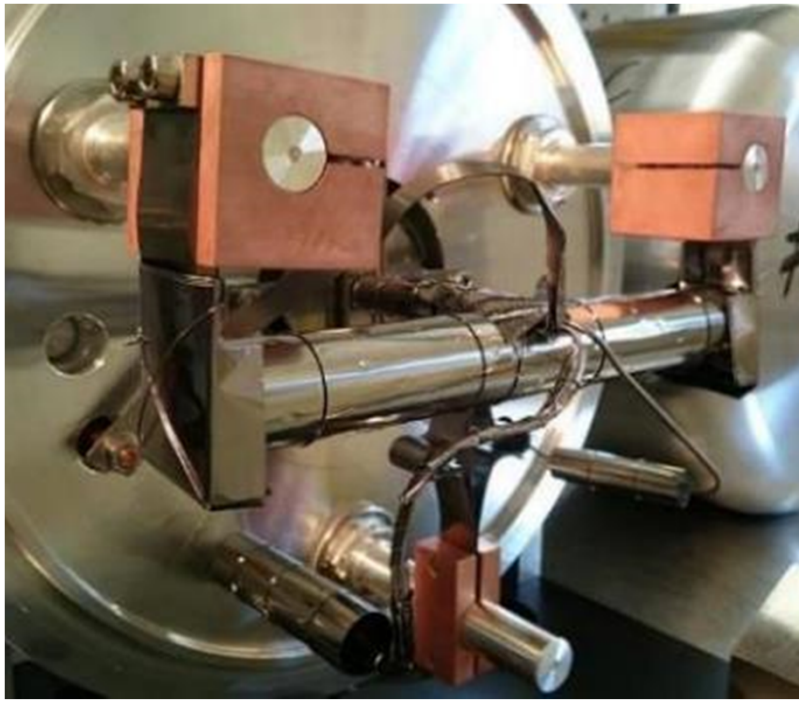
Measured beam intensities with the SI ion source are clearly higher than those measured with the MK5 ion source



New targets, ion sources and beams(3)

Sulphide molecular beams: SnS , GeS

^{132}SnS for HIE ISOLDE



Contaminations expected on atomic ^{132}Sn:

Mass	Yield / uC	Cond.
^{132}Cs	7.1e+09	WSI-SC
^{132}Te	7.0e+08	MK5-SC
^{132}I	2.7e+08	MK5-SC
^{132}Sb	1.0e+08	MK5-SC
^{132}Sn	3.0e+07	MK5-SC

➡ Contaminations too high for experiment

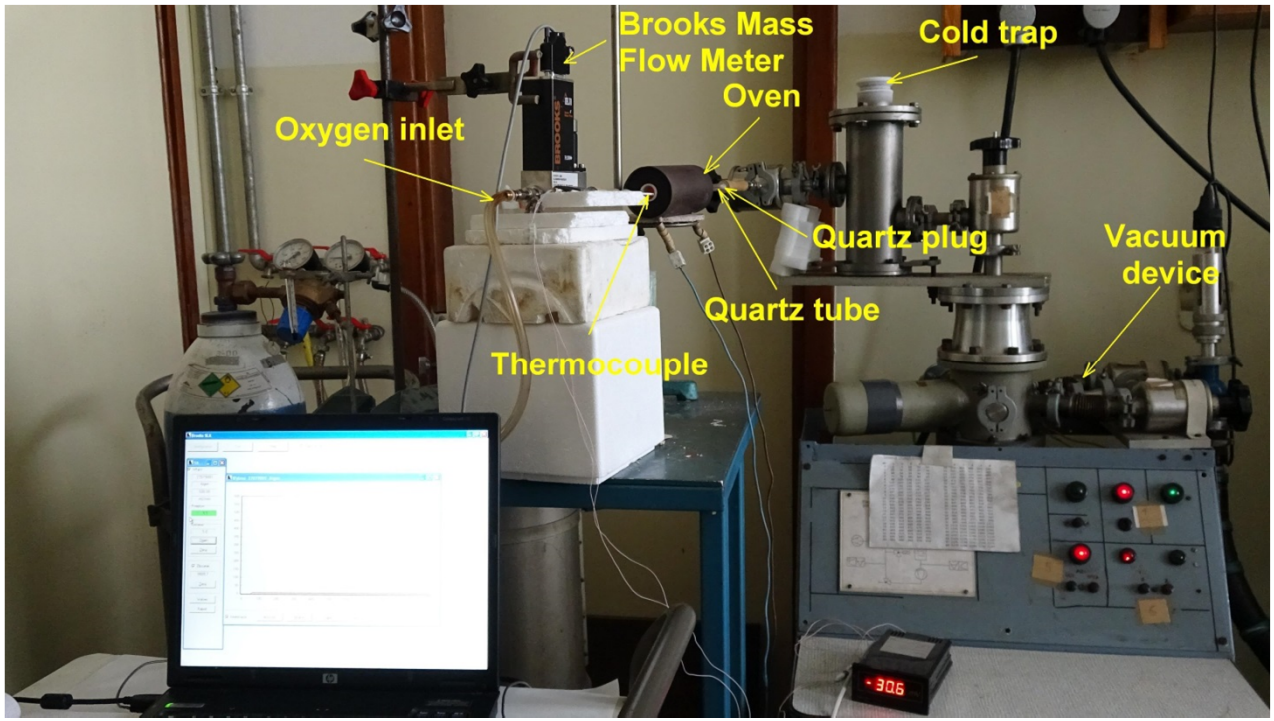
Clean beams required

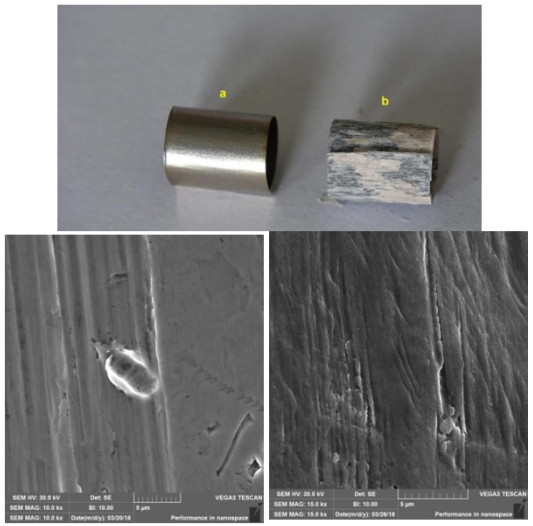
- Some preparatory tests and observations are going on
- A join experiment between different partners at IPN Orsay for SnS production is forseen in 2019

New targets, ion sources and beams(4)

Reaction kinetics of oxidation Ta in vacuum

IFJ PAN





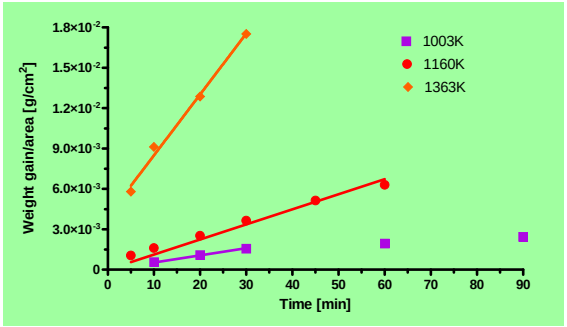
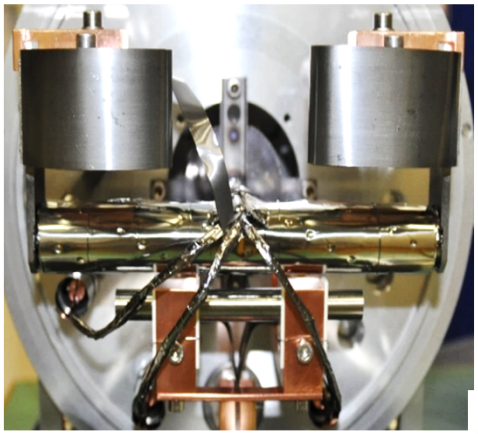


Figure. Weight gain/area *vs.* oxidation time for different temperature.

Oxidation of tantalum has been studied at 1003-1363 K and at oxygen pressures from $1x10^{-3}$ to $2,5x10^{-4}$ mbar (which corresponds to the flow rate of oxygen from 7,2 mL/min to 1,8 mL/min).

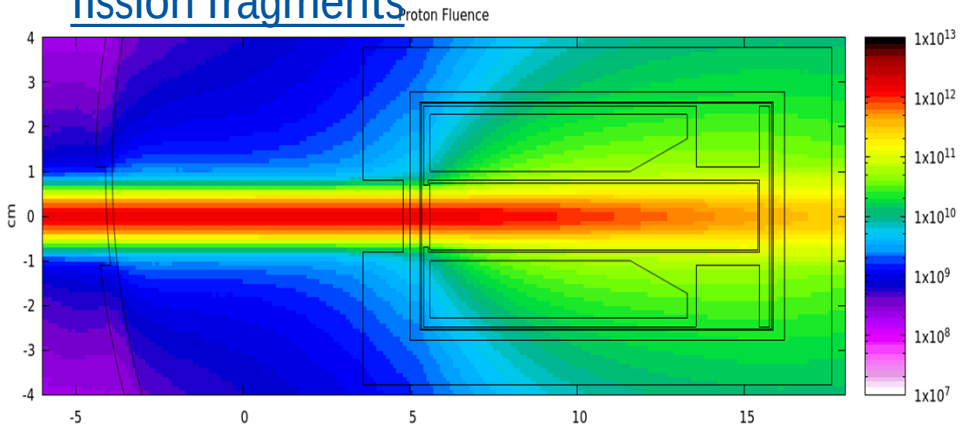
New targets, ion sources and beams(5)

p2n-converter

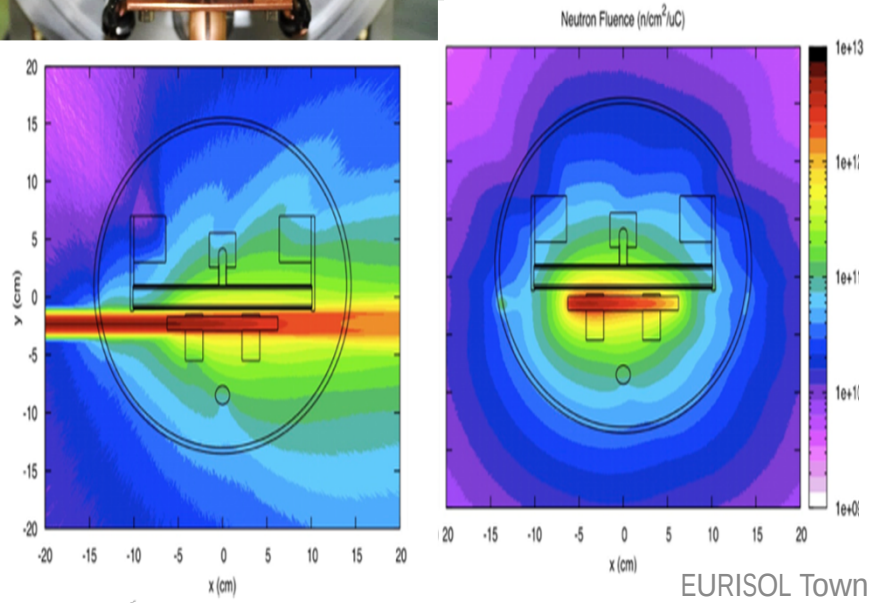


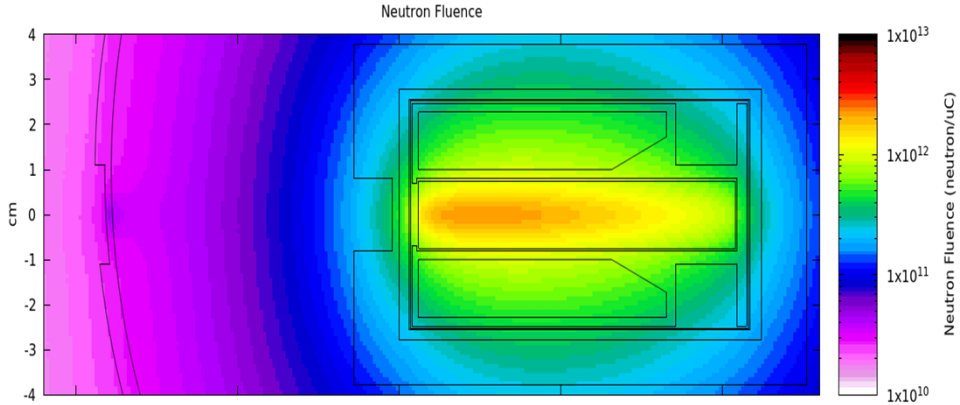
1.4 GeV	2.0 GeV
2 µA	6 µA
pulsed	pulsed
2.8 kW	**12 kW**

Brings high purity neutron-induced fission fragments



Converter very close to uranium carbide – high neutron flux!



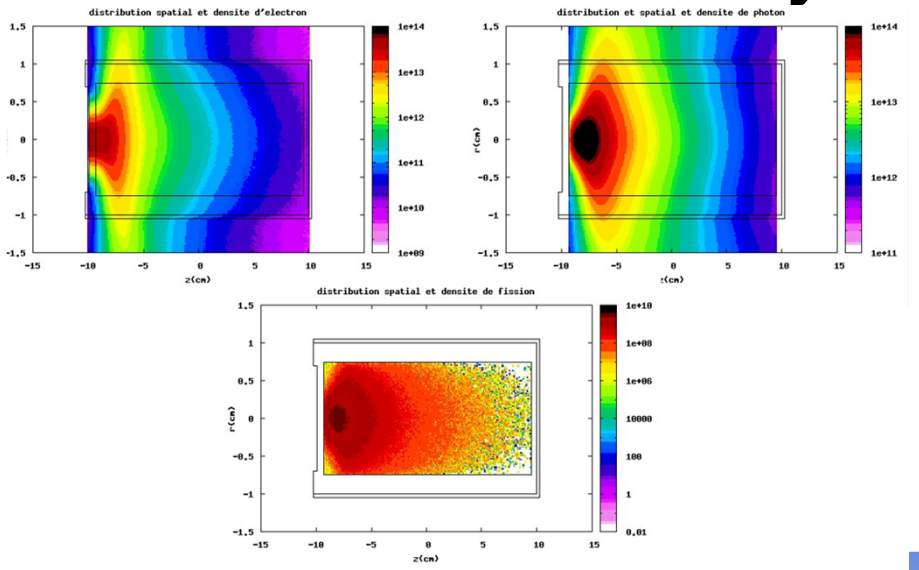


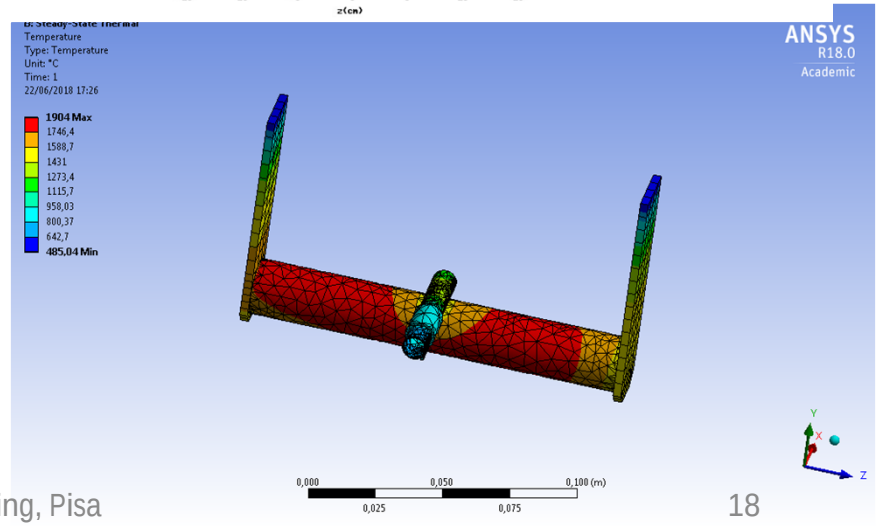
Collaboration with SPES for the oven solution

New targets, ion sources and beams(6)

New photofission target for the ALTO Facility

- New protocol of fabrication for larger pellets is under investigation
- ANSYS thermal simulations to investigate target thermal behavior and benchmarking measurements are going on
- On-line tests @ ALTO facility with the collaboration of the nuclear physics group Nester are foreseen for the end of 2019.





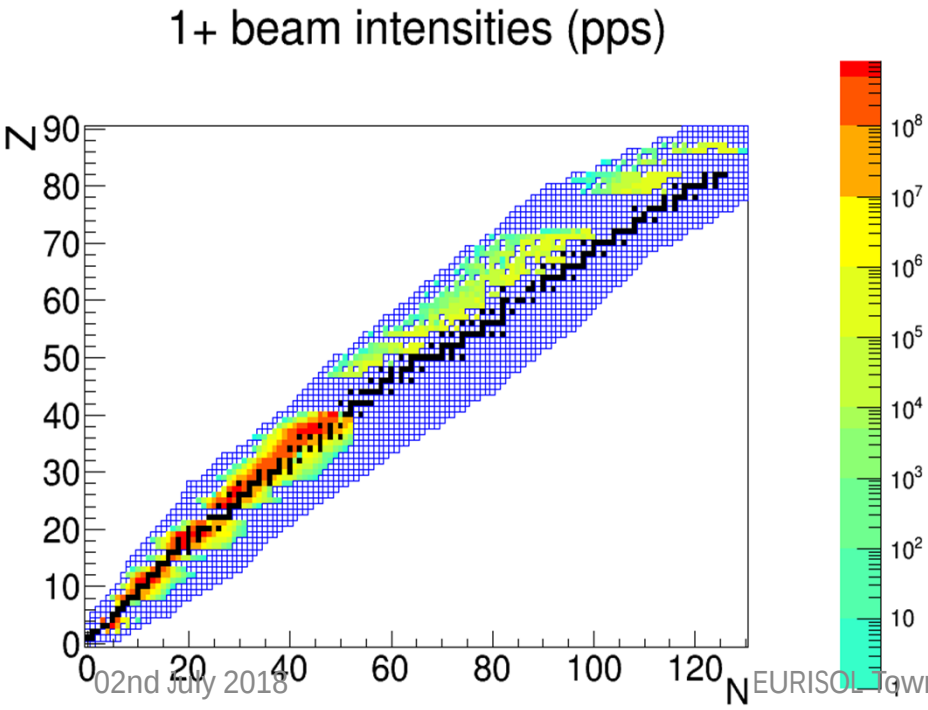
New targets, ion sources and beams(7)

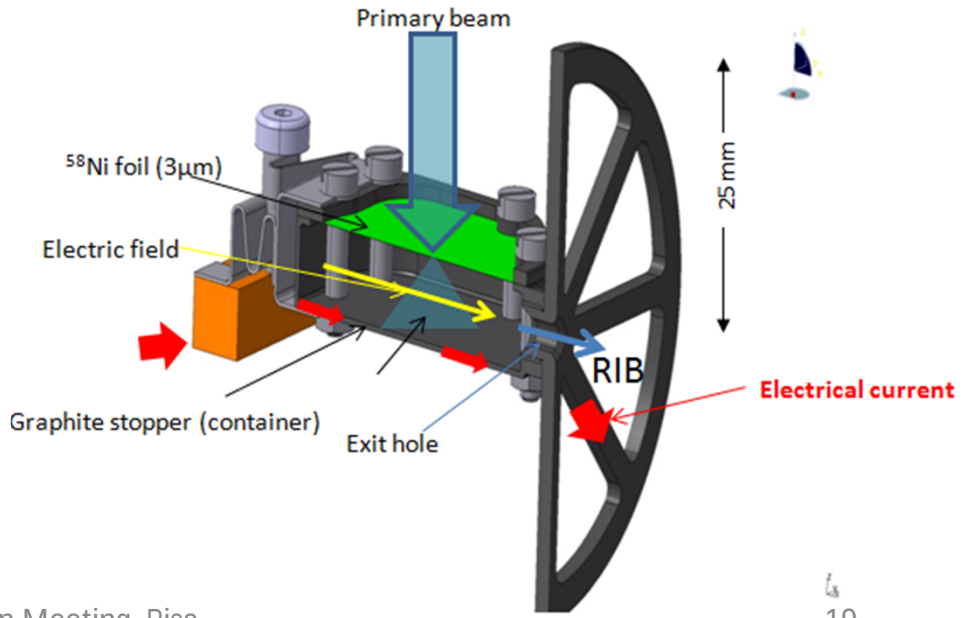
Fusion evaporation targets

Ongoing developments
To be tested at SPIRAL at the earliest in 2020
Fusion evaporation target ion source development

- neutron deficient isotopes such as ^{74}Rb, ^{114}Cs, N=Z for DESIR

Offline test 2017-2018
Ionisation efficiency and rapidity measurement
Online test at ALTO earliest 2019
Online test at SPIRAL earliest 2020





ECS fusion evaporation V. Kuchi, P. Jardin

Thank you!