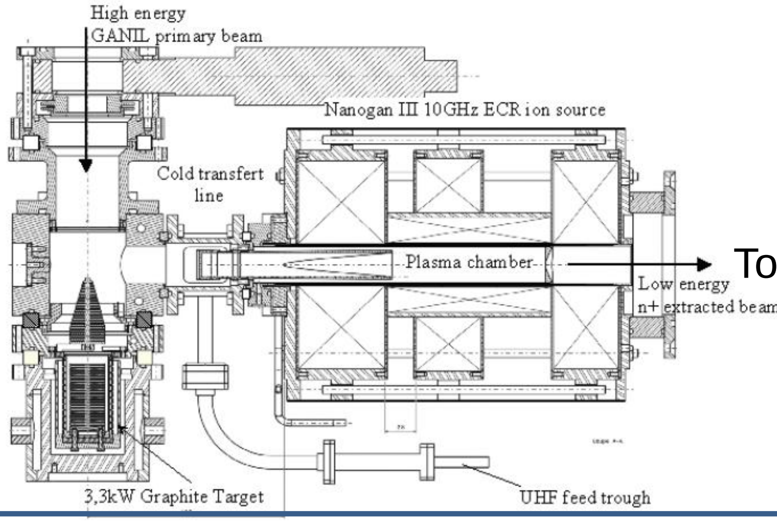
Development of Target Ion Source Systems for radioactive beams at GANIL

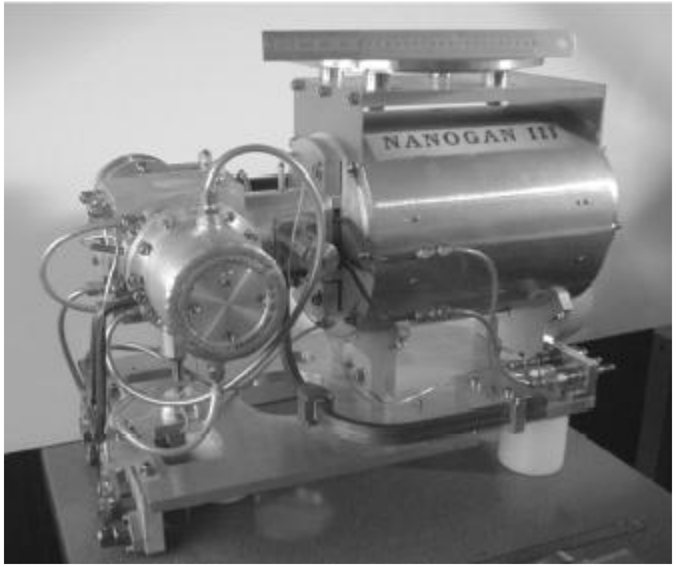
- **Spiral 1 upgrade**
  - A new TISS using a Febiad ion source

- **Spiral 2 phase 2**
  - The oven for the UCx target
  - The ECR ion source
  - The Laser ion source

Spiral 1 in exploitation since 2001: production of radioactive gases



To post-acceleration by cyclotron CIME



The Spiral 1 Target Ion Source System

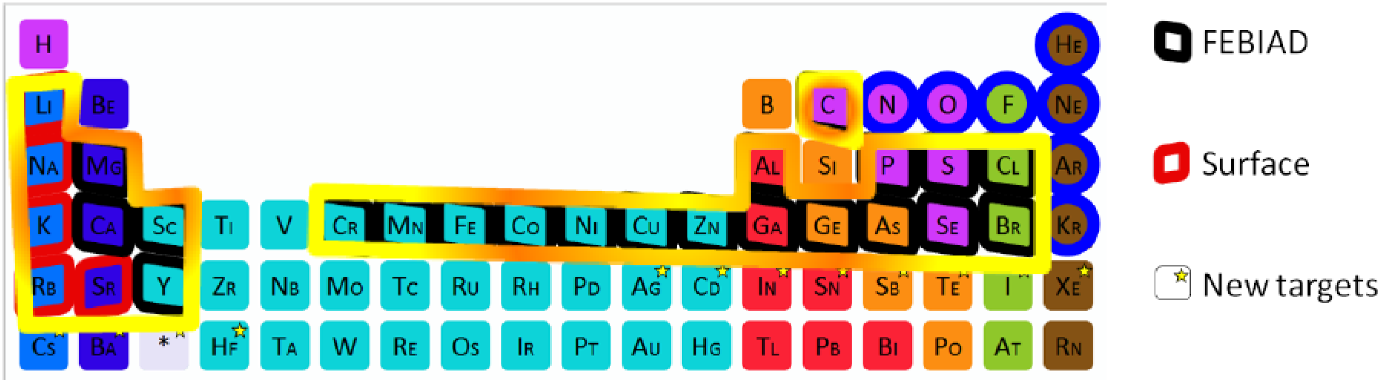
Production target for Ne, Ar, Kr, N, O and F isotopes

Production and diffusion target for He

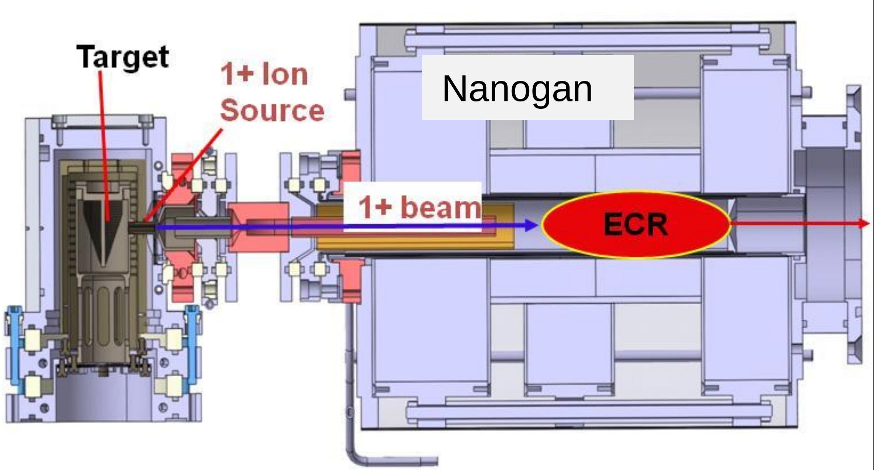
A.C.C. Villari et al. *Nuclear Physics A 787 (2007)*

1- Spiral 1 upgrade

To extend the range of radioactive beams



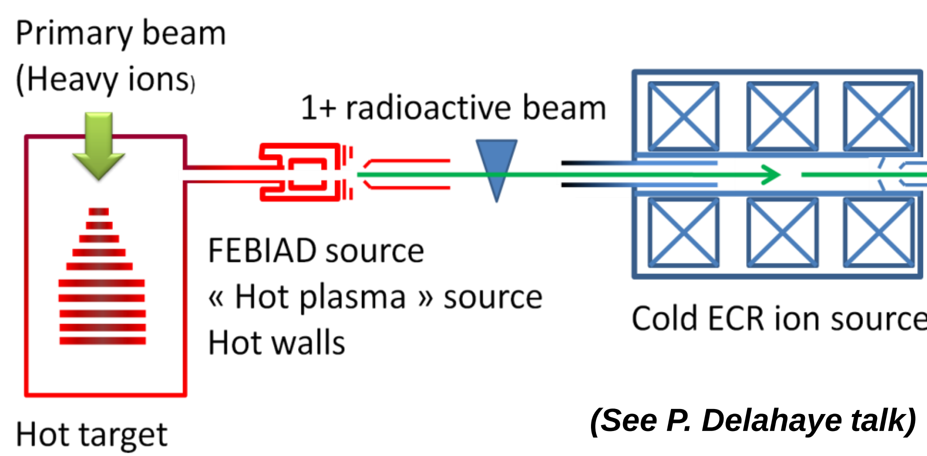
NanoNaKe: for alkali elements



Previous development

C. Eléon et al. NIM B 266 (2008) 4362–4367

A febiad source + charge breeder after separation

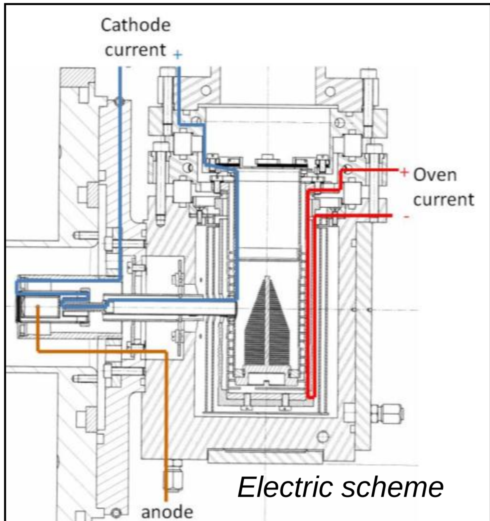


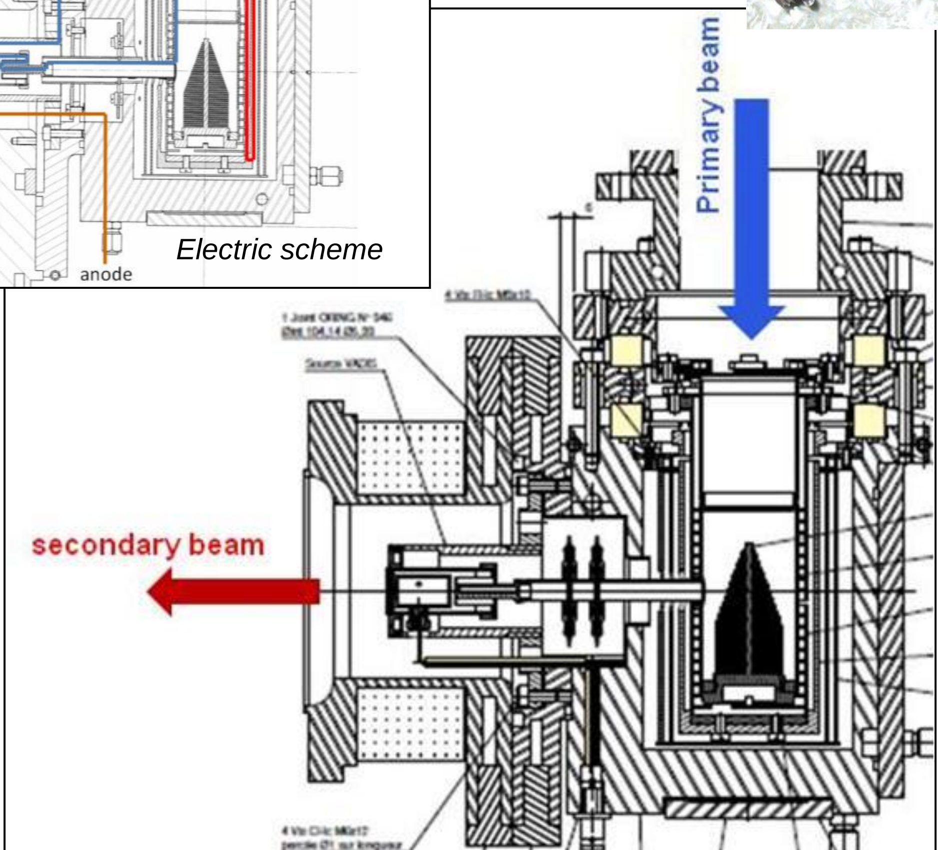
(See P. Delahaye talk)

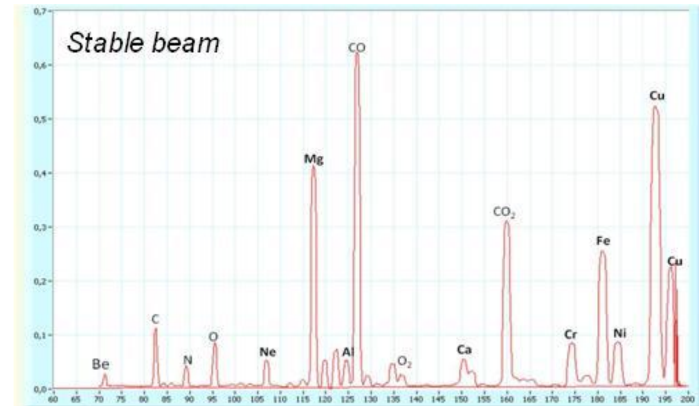
Under construction for operation

A first prototype of a Febiad ion source tested on line

The VADIS (supplied by CERN) is connected to the Spiral C target in a Ta container .







TISS has worked for several days

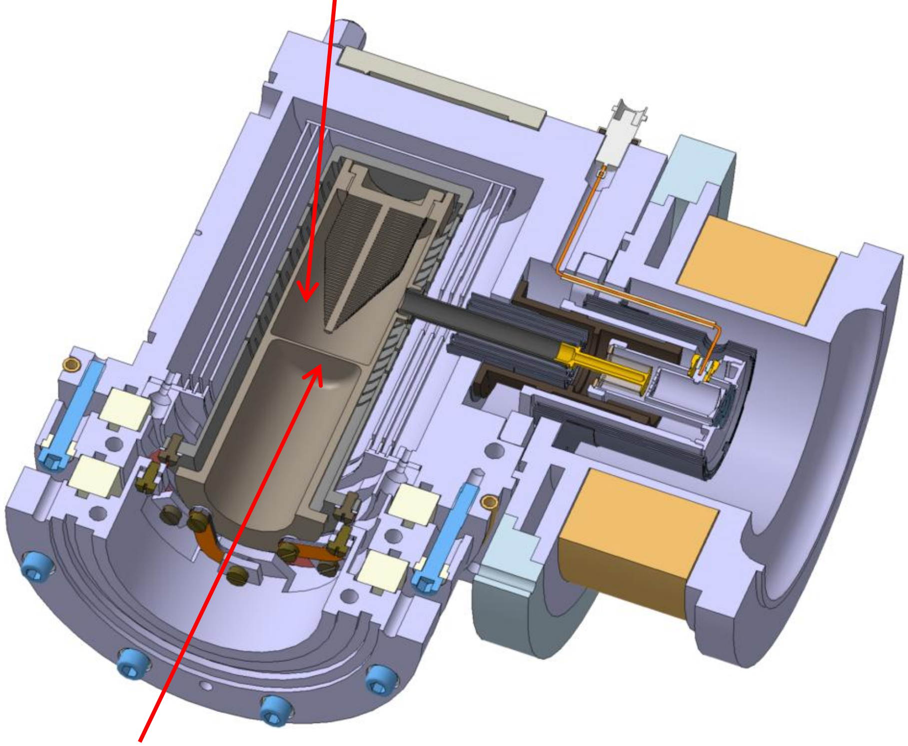
Isotope	Half life	Primary beam	Power (W)	Measured 1+ intensity
38K	6.3min	58Ni	4	3.80E+04
38mK	923ms	58Ni	4	-
53Fe	8.51 min	58Ni	34	6.60E+04
53mFe	2.526min	58Ni	34	1.40E+04
58Cu	3.204s	58Ni	37	4.30E+03
58Mn	3s	58Ni	37	5.70E+04
59Cu	81.5s	58Ni	38	7.30E+04

Encouraging results but reliability has to be improved

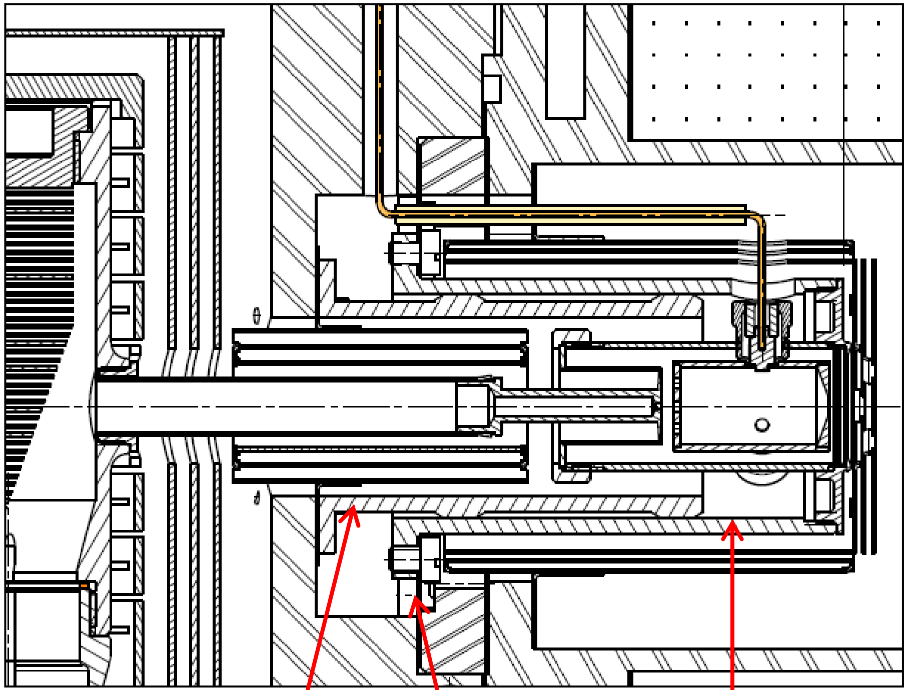
New prototype design

The ion source is now mobile in the direction of secondary beam :

Carbon container used as common way for ion source current and oven current



Thin windows



Fixed part

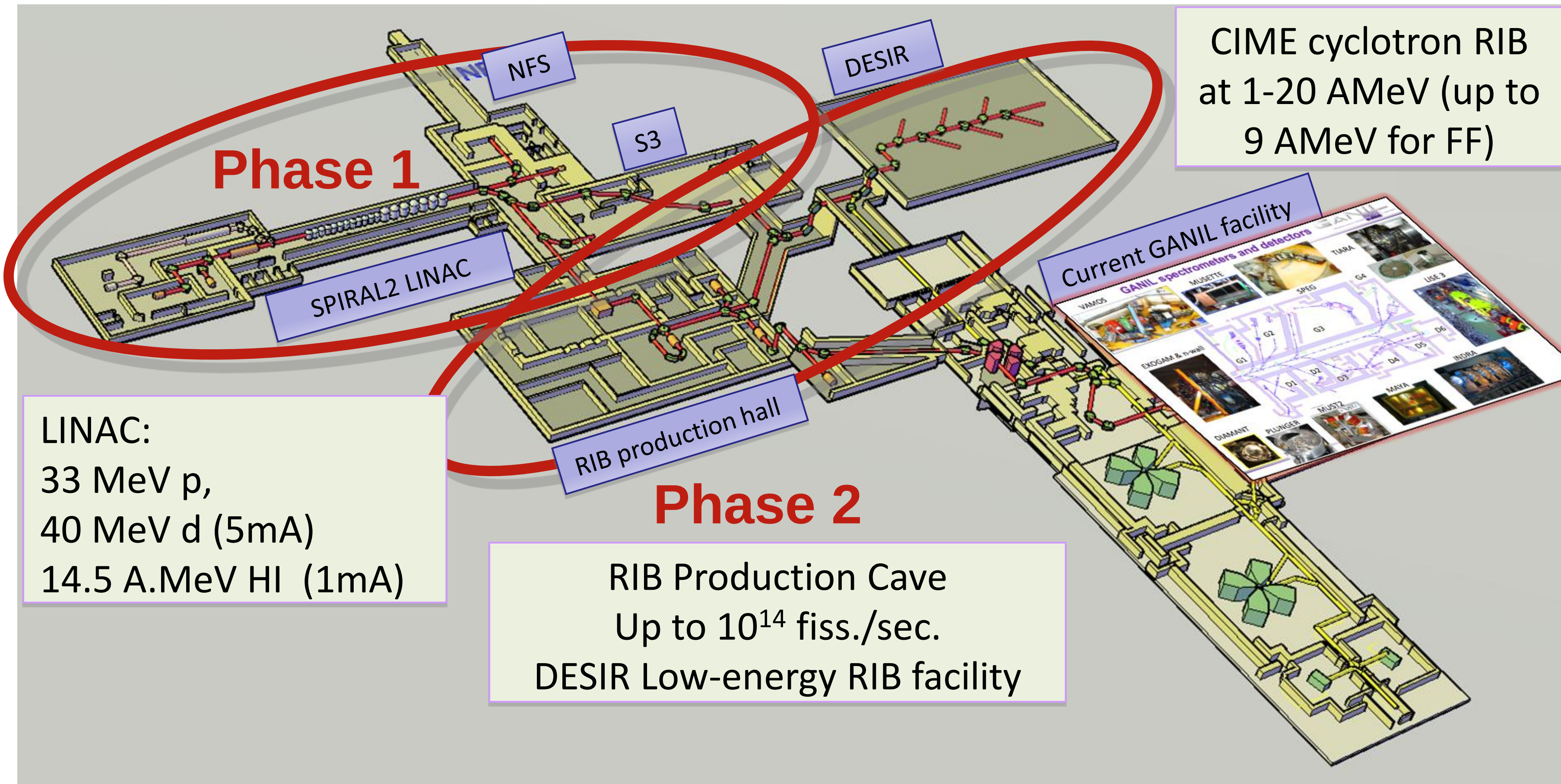
Mobile part

Papyex connection

Under construction : tests in April 2013

2- Spiral 2 phase 2

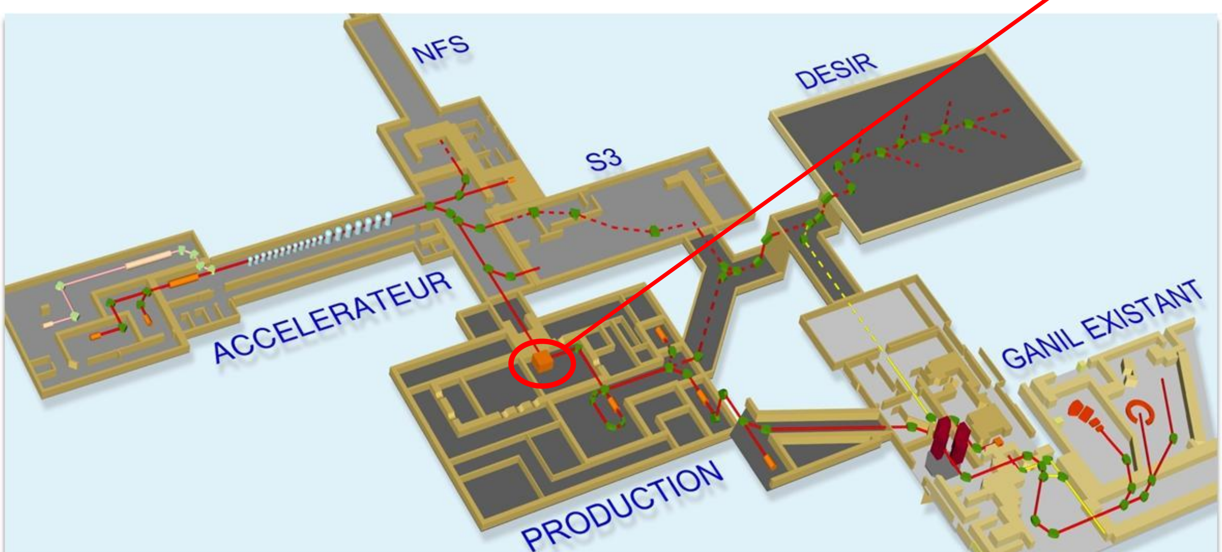
Phase 1: High intensity stable beams + Experimental rooms (S^3 + NFS) (First beam Sept 2014)
Phase 2: High-intensity low-energy (DESIR) & post-accelerated Radioactive Ion Beam facility

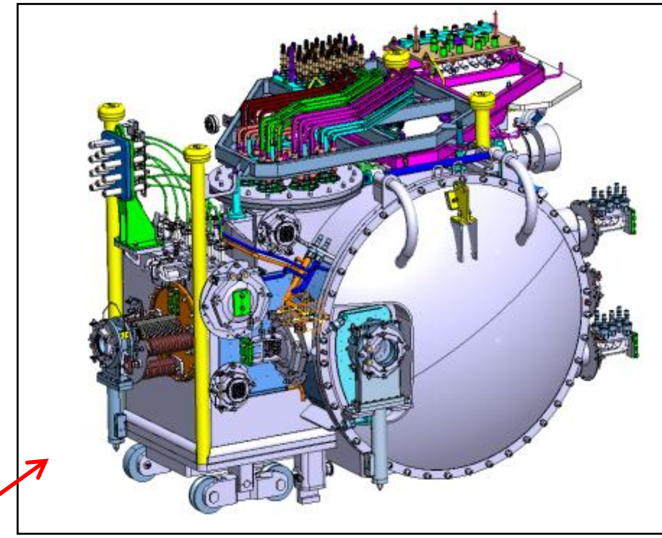


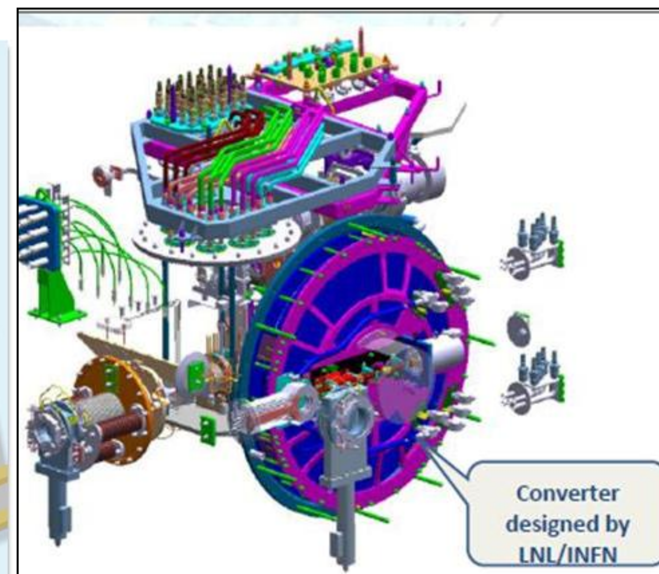
The production module

- ❑ **Deuteron beam on neutron converter**
  - •UCx target + ECRIS
  - •UCx target + LIS
  - •UCx target + Febiad

- ❑ **Other beams / other targets**

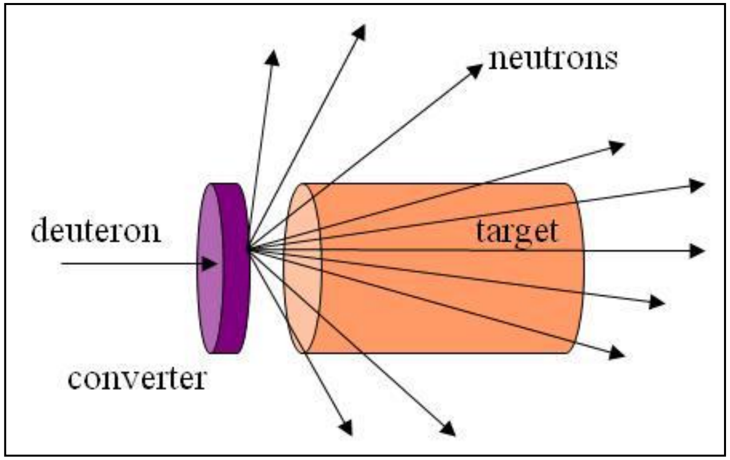




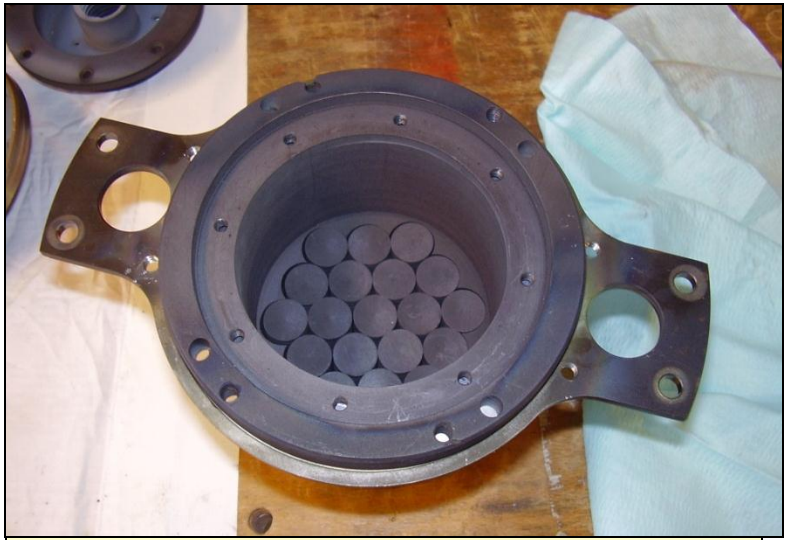


The UCx target

- Designed to produce up to 5.10^{13} fission/s with 5 mA / 40 MeV deuteron on carbon converter.
- Coupled with ECRIS, LIS or Febiad ion source
- For good diffusion/effusion the target has to be maintained at 2000°C
- Must work during 3 months
- The reference target (Ø 80; L 80) is constituted of 19 series of uranium carbide (UCx) disks (Ø 15; thickness 1mm).



For optimized production, the converter must be as close as possible to the target.

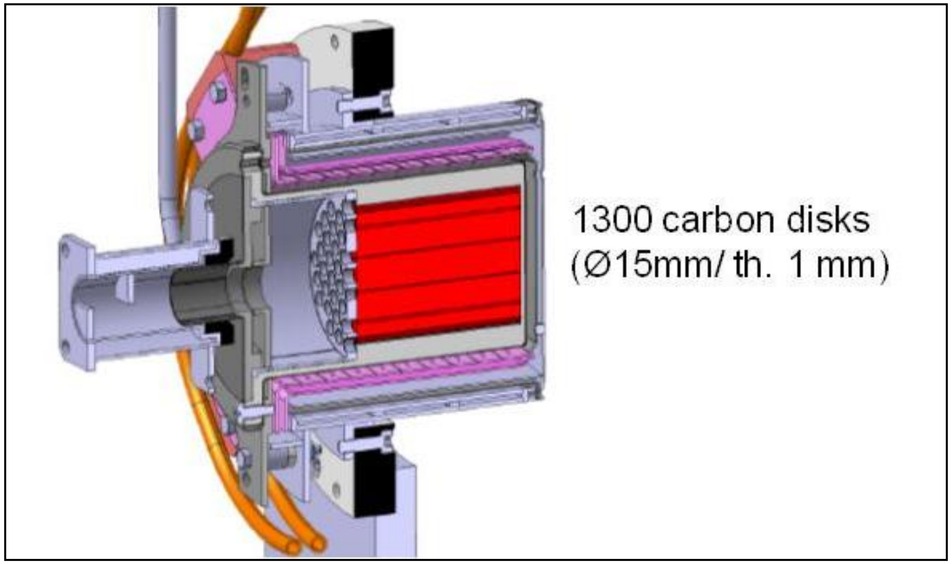


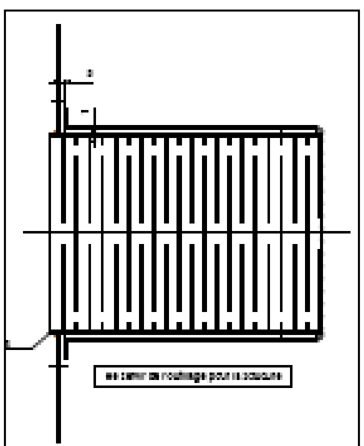
Reference target : L 80 mm / Ø 80 mm. For the oven development UCx is replaced by carbon

O. Bajeat et.al NIM A 562 (2006) 634–637

A first oven prototype in tantalum

•Choice of tantalum because of the specification of long duration at 2000°C





Thickness 0,1 mm with slits; surrounded by 2 tantalum screens
750 A / 11,8 V (8800 W) → 1500°C in the target

This prototype has been used during several months up to **1500°C** with a ECRIS.

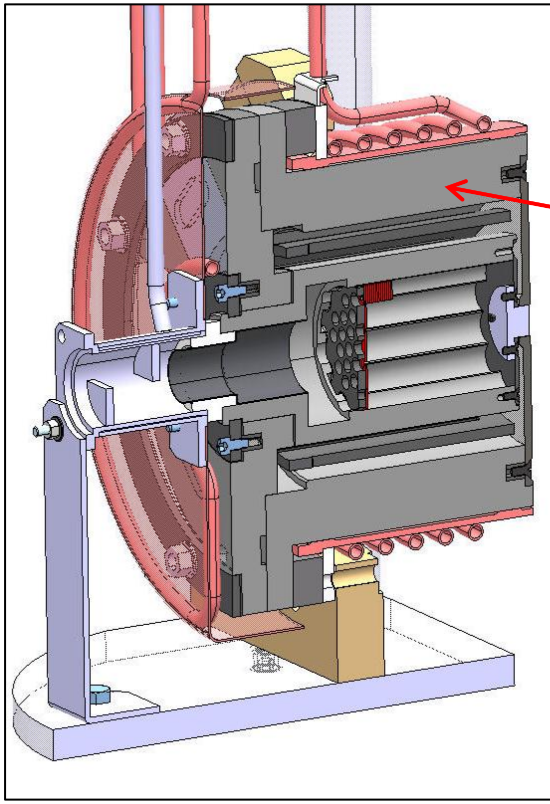
A prototype in carbon

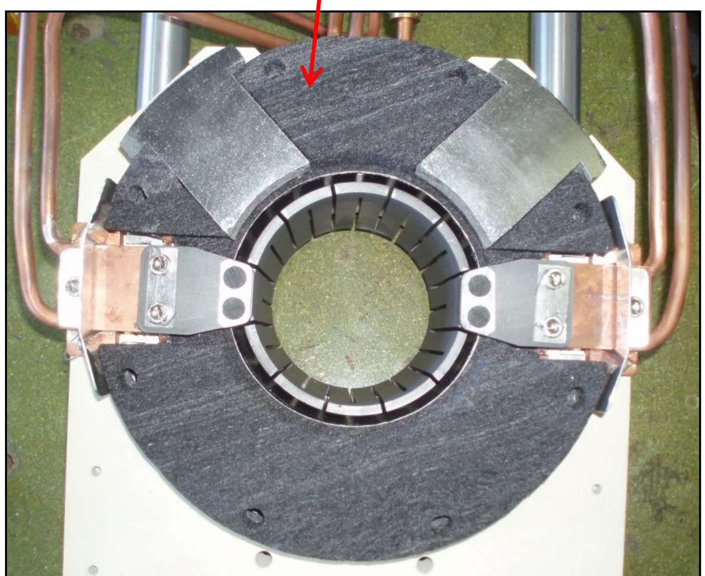
- Easier than Tantalum to reach more than 2000°C
- Lifetime lower due to high evaporation rate of carbon

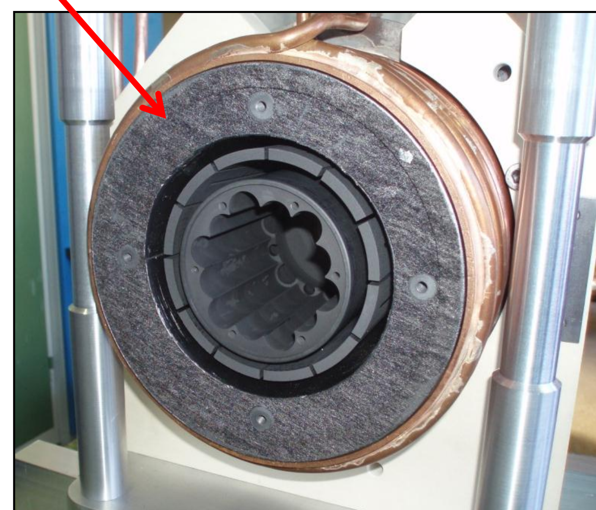
Ø int 98; length 121; thickness 5

Graphite Toyo Tanso

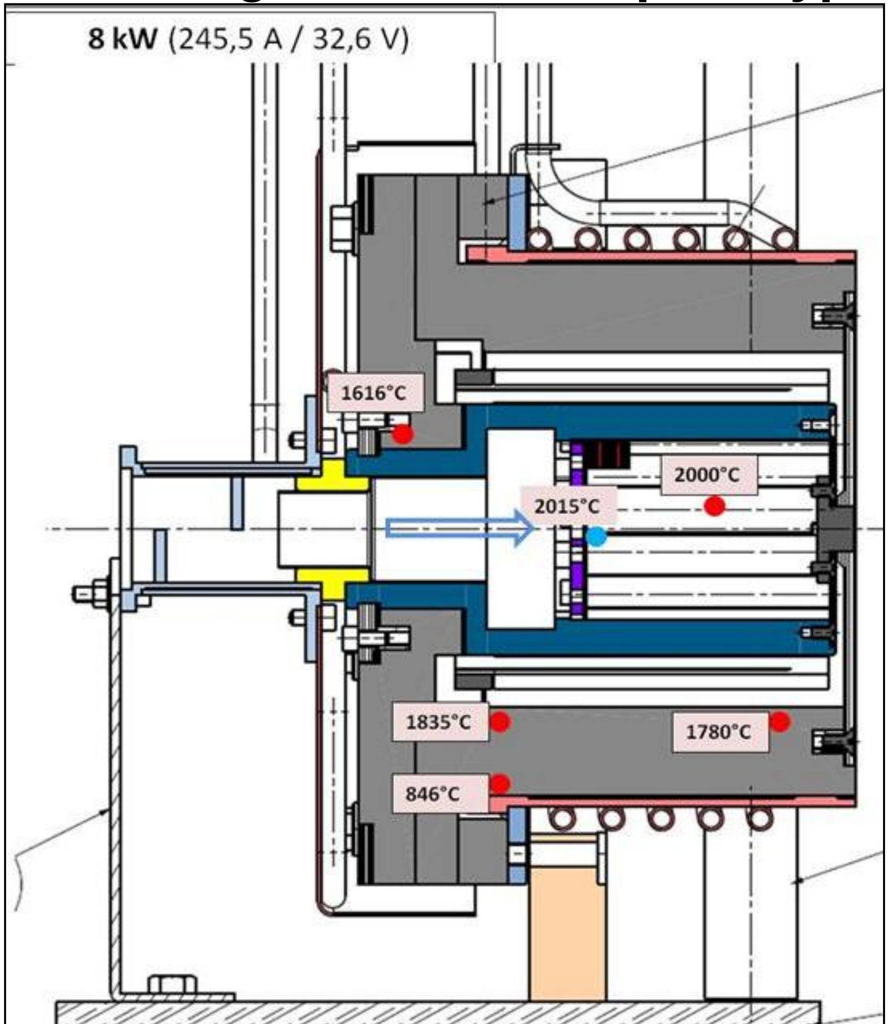
Graphite fiber insulation material (GRAFSHIELD GRI from GrafTech)





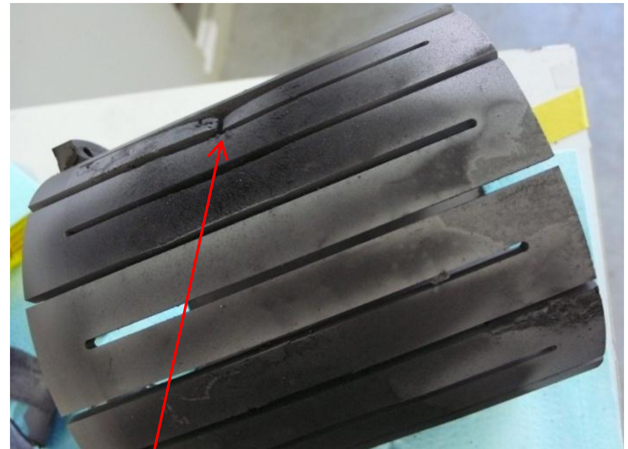


1st heating of the carbon prototype



Temperature measurement made with a pyrometer and several thermocouples W/W-Re in HfO_2 sheath

- Failure after about 13 days at T > 2000°C with many interruptions.



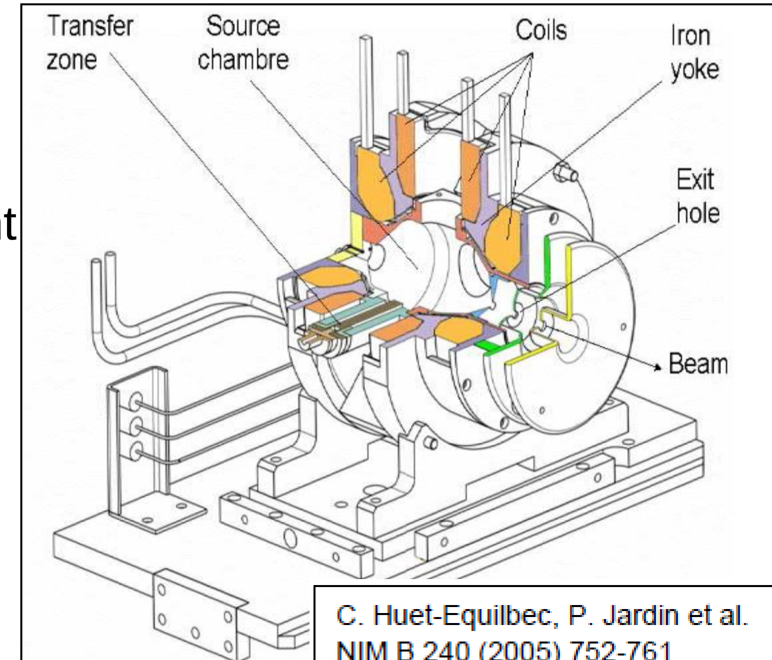
Resistance failure

Some contact has caused local over-heating

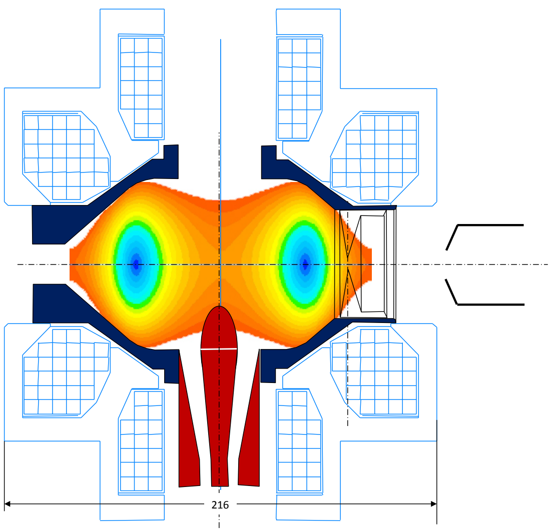
ECR ion source 2.45 GHz

→ *used for gaseous elements*

- Symmetry of revolution
- Cooled chamber in stainless steel
- Magnetic confinement by the coils (no permanent magnet)
- Injection of the RF with an antenna
- Radiation hard (only mineral and metallic materials)



C. Huet-Equilbec, P. Jardin et al.
NIM B 240 (2005) 752-761



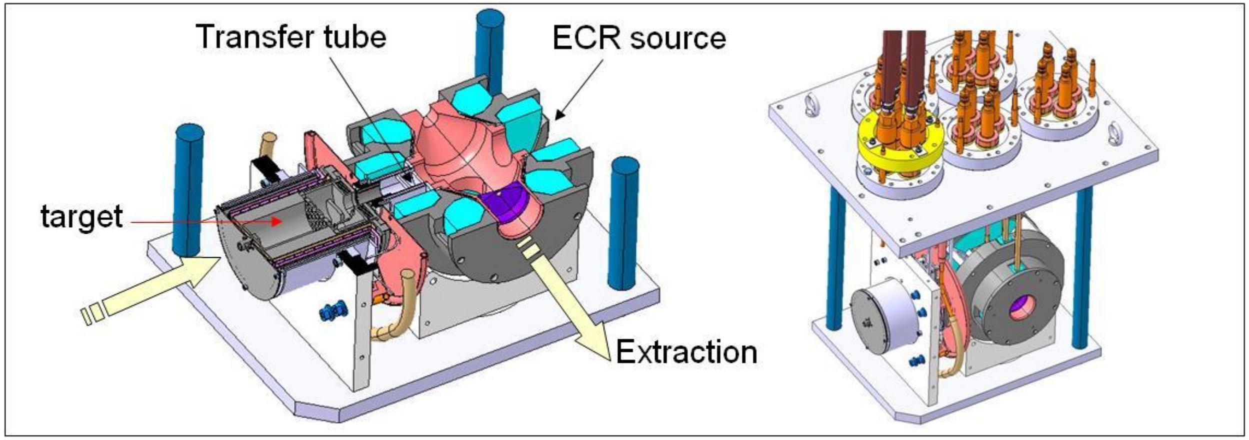
Magnetic confinement in the source

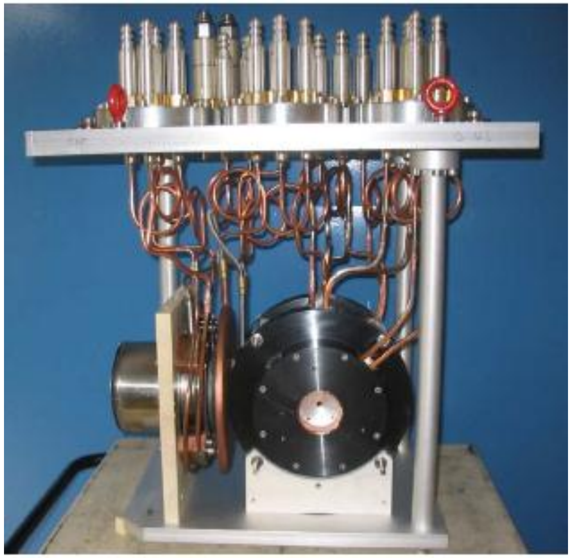
	He	Ne	Ar	Kr	Xe
ε_{ion} 1+ (%)	7	35	52	55	67

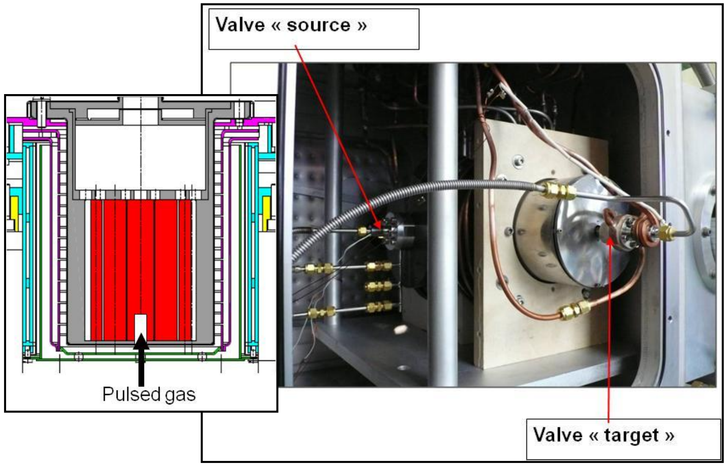
1+ ionization efficiencies (data from A. Pichard thesis - Université de Caen - 26/11/2010)

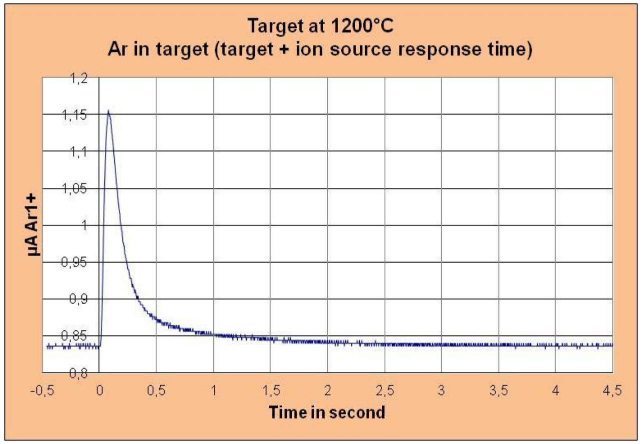
Current extracted from the source < 1 mA

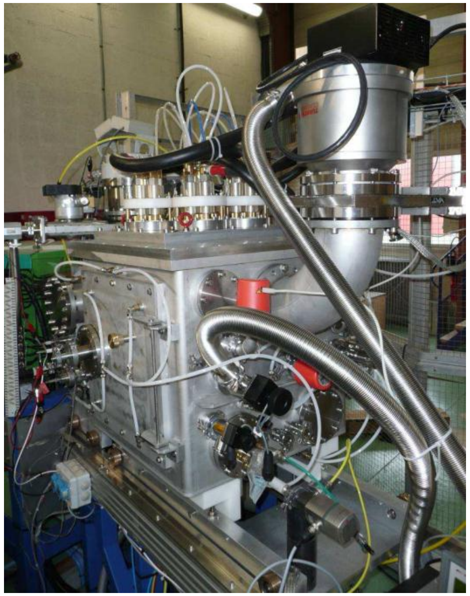
1st prototype oven (Ta) heated up to 1500°C coupled with Monobob. Beam measured on an off-line test bench (banc 2).





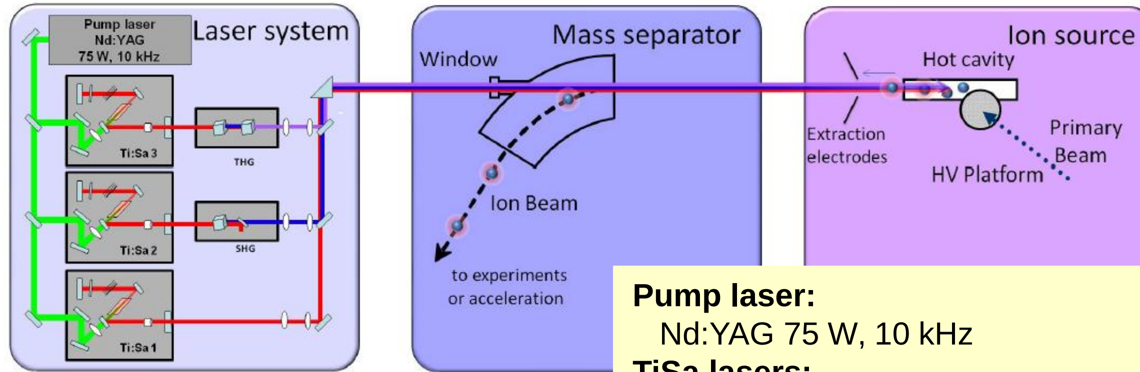






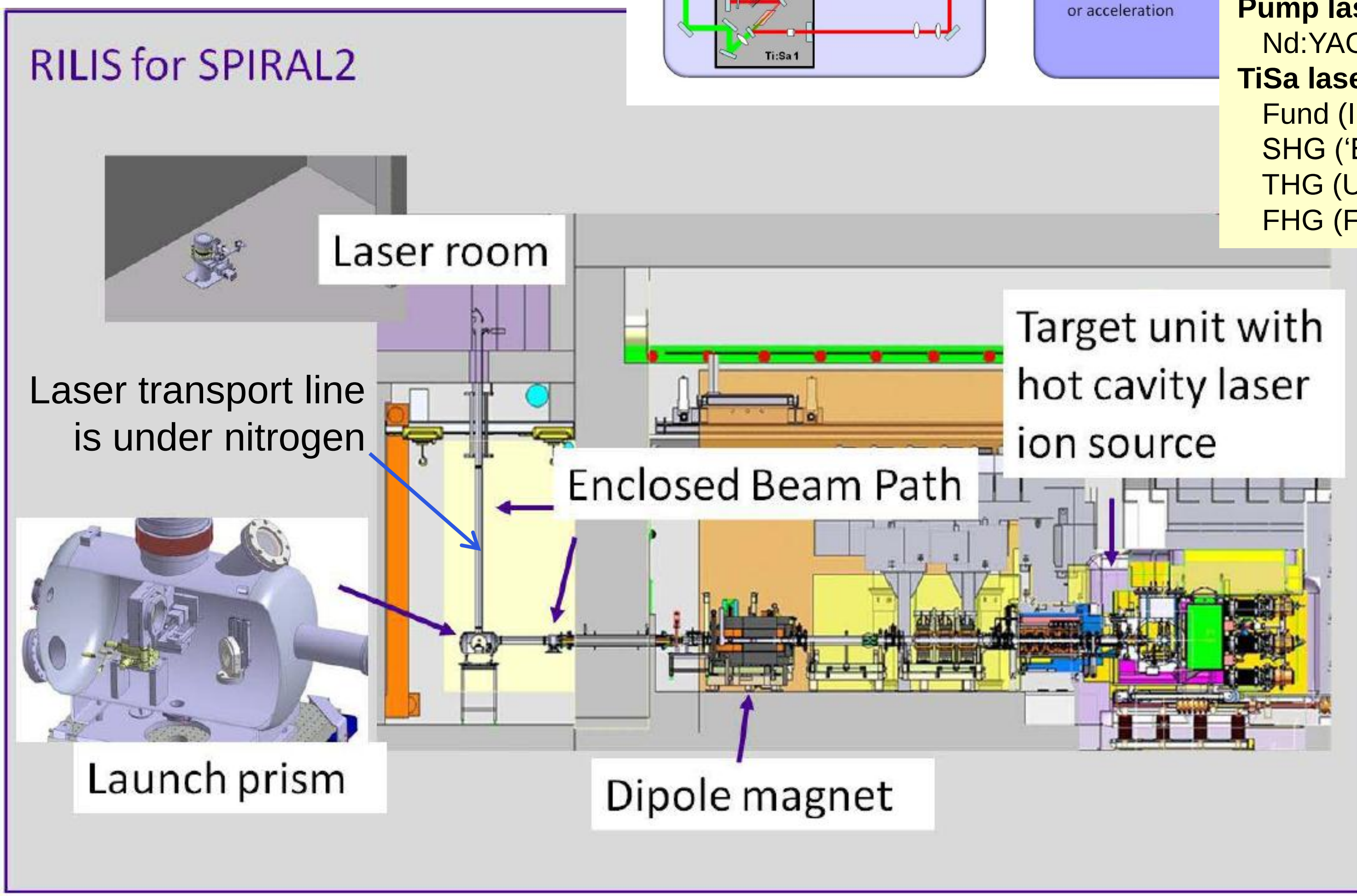
- Functioning of the TISS in a box similar to the production module and experience feedback for Spiral 2
- Effusion measurement for rare gazes

→ *used for metallic elements with high selectivity*



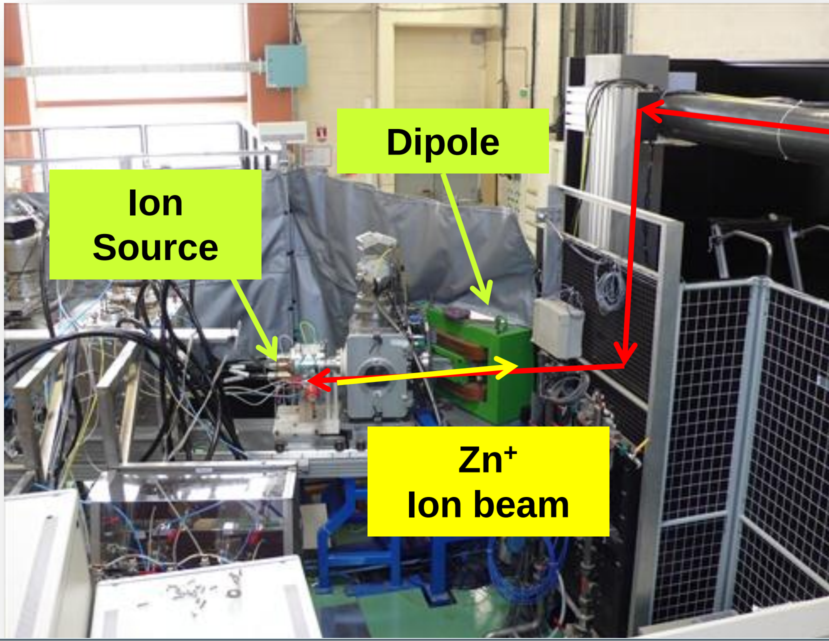
Pump laser:
Nd:YAG 75 W, 10 kHz

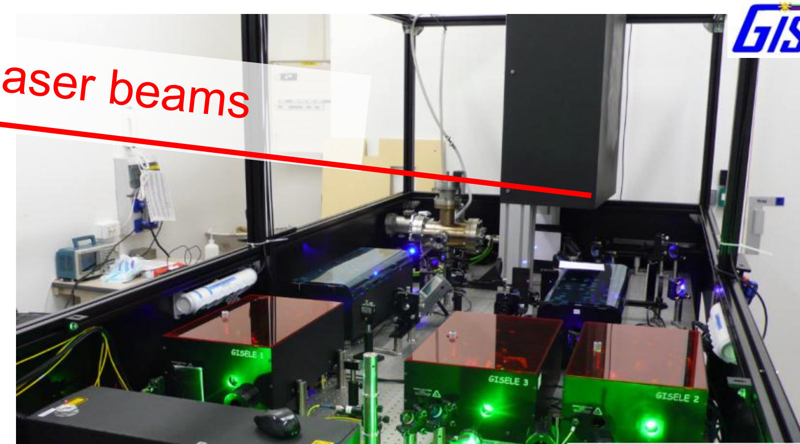
TiSa lasers:
Fund (IR) 700-1000 nm ≤ 5W
SHG ('Blue') 350-500nm ≤ 1W
THG (UV) 230-320nm ≤ 200mW
FHG (Far UV) ~213 nm

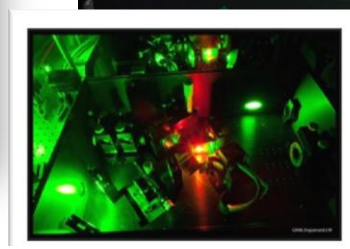


Laser Ion Source

GANIL Ion Source using Electron Laser Excitation
ANR 2009-2013, 510k€, GANIL-IPNO-Mainz Univ

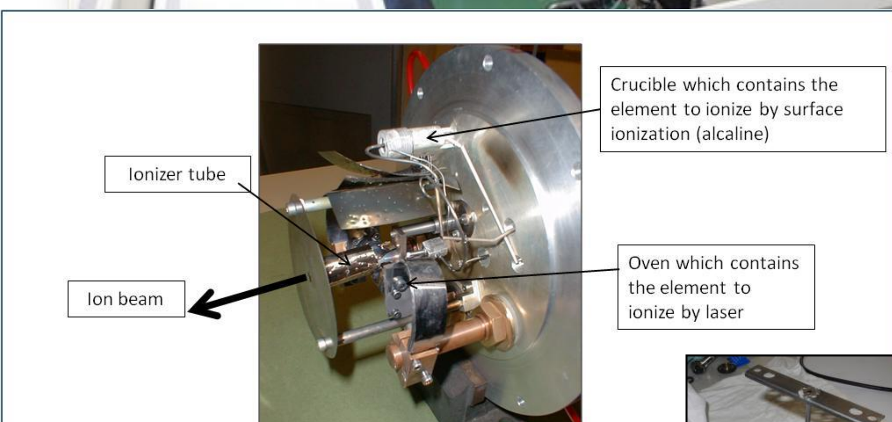




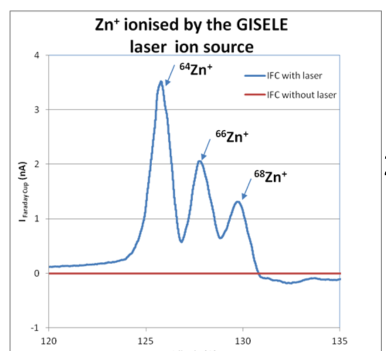


3 *TiSa Cavities (TRIUMF)*

2 Frequency Conversion Cavities (Mainz Univ)



The source SOMEIL for the optimization of the ionizer tube and efficiencies measurement.



July 2011: <u>1st Ga^+ beam</u>

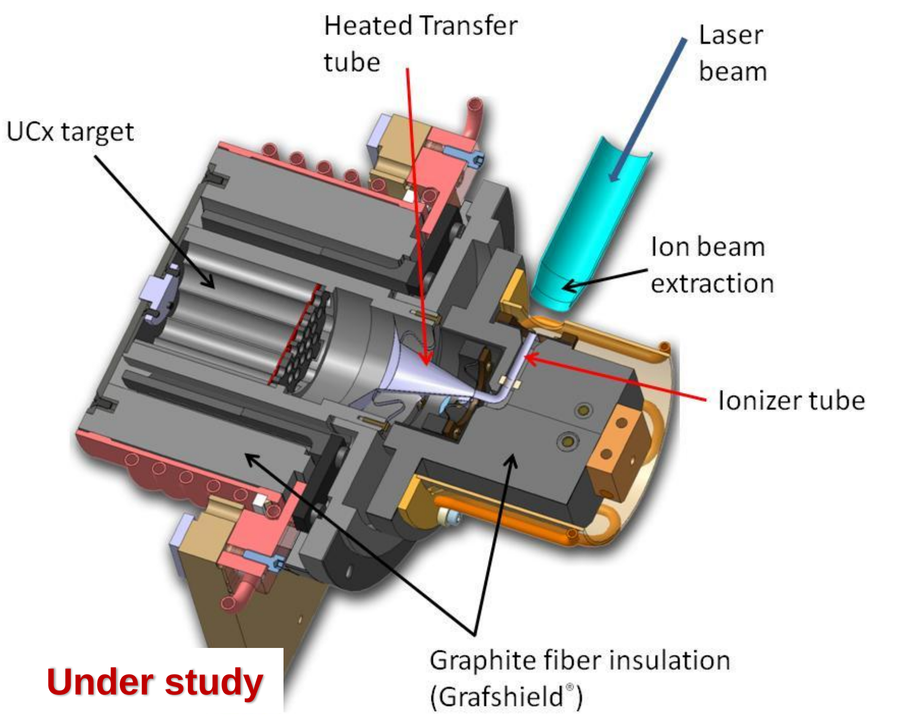
Nov 2012: <u>Scheme dvt of Zn^+</u>

2013-2014: <u>Sn, In, Y</u> (Day1 SPIRAL2 φ2)

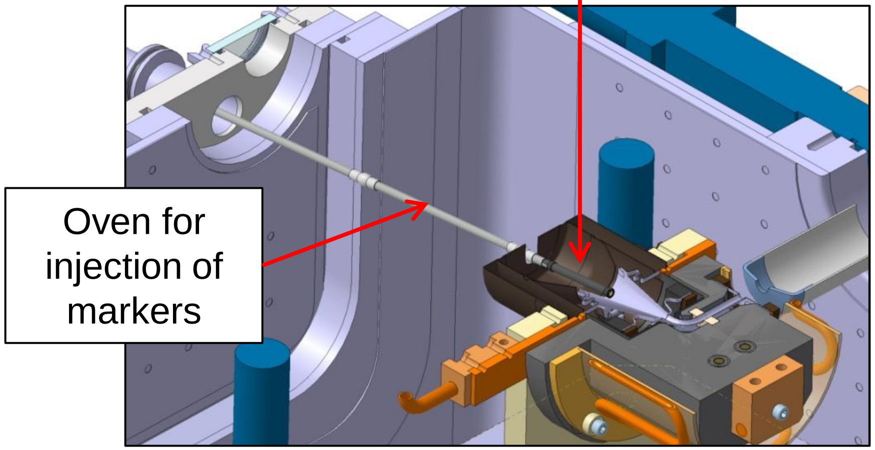
N. Lecesne et al. RSI 81, 02A910 2010
Sjödin et al, Hyperfine Interaction, accepted

The laser TISS for Spiral 2

- UCx target heated up to 2000°C
- Elements to ionize by Laser : Ga, Zn, Sn, In, Y…
- All the surfaces could be maintained at 1500-2000°C.
- The transfer tube and the ionizer tube are heated independently → polarities could be reversed to slow down the radioactive ions produced in the transfer tube by surface ionization.



An intermediate prototype without the target :



Thank you for your attention !