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MONOBOB II :

Lasted results of monocharged ions source for SPIRAL2 RIB

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Abstract

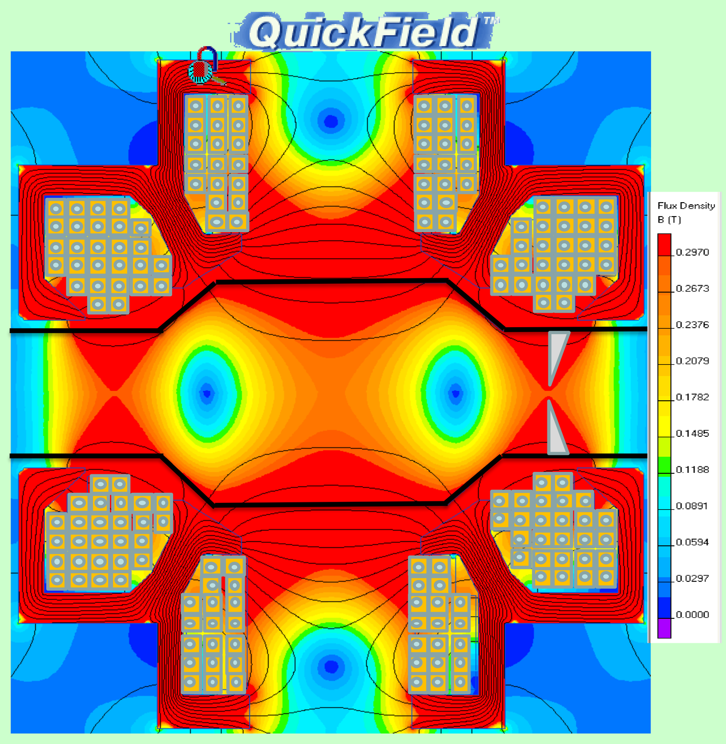
MONOBOB II, is an electron cyclotron resonance ion source (ECRIS) based on an axysymetric magnetic structure. It has been designed for the Spiral2 project in order to ionize radioactive elements coming out from the hot targets of the Target Ion Source System. The goal was to build a long-lived ECRIS able to operate three months in the hostile environment of the production module while keeping high ionization efficiencies for gas element.

In this paper, the design of the source made of four coils is described as well as its coupling with the SPIRAL II target.

A Target Ion Source System within the SPIRAL II framework has been constructed and ionization efficiencies on noble gases have been measured, with and without hot target. Results of these measurements will be presented.

Furthermore, the response time of the TISS is a relevant parameter for the SPIRAL II project in order to better estimate the total production efficiencies (isotope production, diffusion, effusion, ionization) especially for short life-time isotopes. Thus measurements using noble gas pulses were performed. Experimental results were obtained: effusion/ionization time of the Target Ion Source has been measured, in particular in the case of the ion source coupled with a hot target.

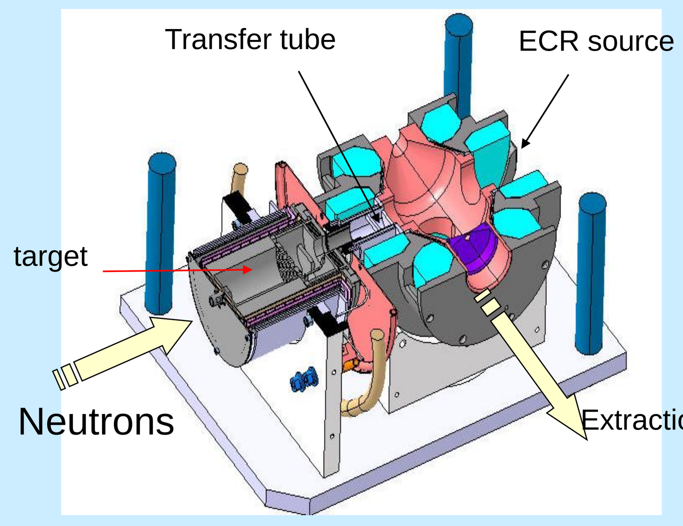
Monobob II

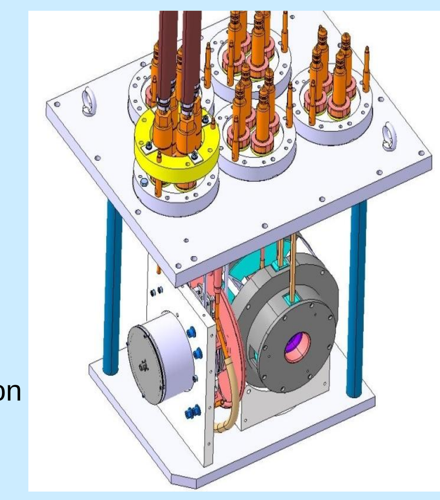


- Radiation hard ion source
- No multipôle – 4 coils
- Max magnetic field = 0,25T
- Freq = 2,45GHz
- Chamber volume = 560 cm^3

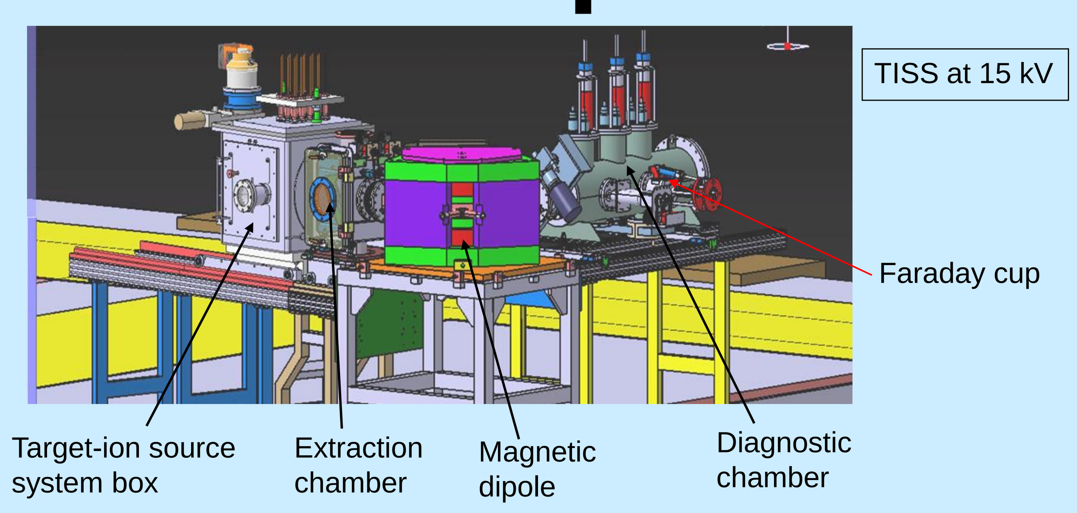
SPIRAL2 Set up

A high flux of neutrons (coming from the breaking down of deuterons impinging a carbon target called « converter ») induces the fission of the uranium target. The fission fragments diffuse out of target material and effuse up to the ECRIS where they will be ionize and extract in the low energie beam line. For safety reasons, in the frame of SPIRAL2 operation, the TISS will be installed in a vacuum chamber where the pressure must be lower than 10^{-5}mbar after outgassing.





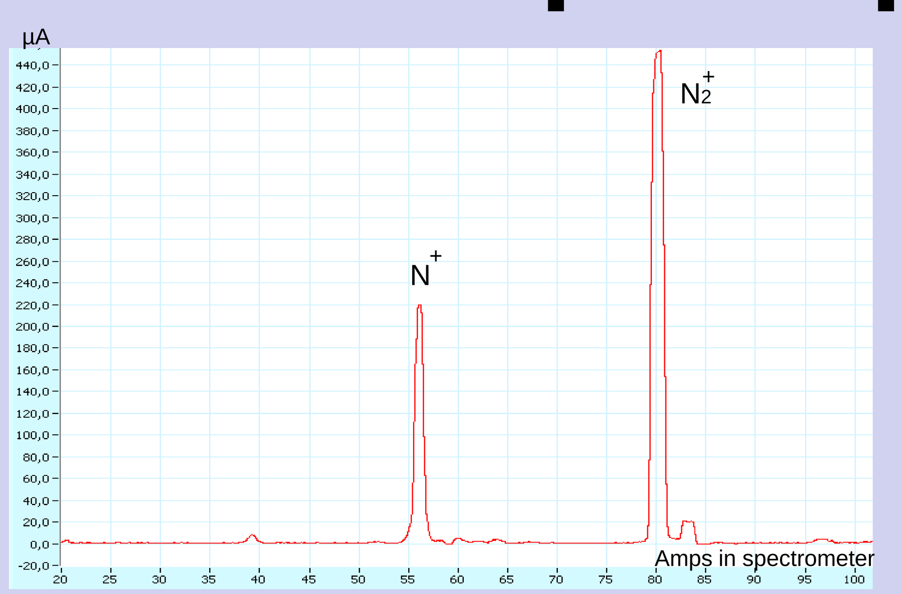
Tests Set up



To qualify the TISS, two fast valves were mounted on the TISS : One at the opposite of the plasma electrode hole and one on the target container, at the opposite of the apperture toward the IS to measure the contribution of the target to the response time of the TISS.

After acceleration (15kV), the beam is transported through an electrostatic lens (with moveable position), a magnetic mass spectrometeer, an emittance meter (removable), before reaching a Faraday cup.

Transport optimisation



Typical spectrum after mass spectrometer after outgassing

The transport of the beam from exit of the ECRIS up to the Faraday cup has been estimated by comparing the current of the most abundant elements and the total current delivered by the ECRIS. The position of the extraction lens and the voltage and position of the Einzel lens were tuned.

The optimal distance between the extraction and plasma electrode has been found equal to 31mm for 15kV of extraction voltage.

~100% of transport was approached for a total current delivered by the source between 640µA and 810µA.

Emittance measurement

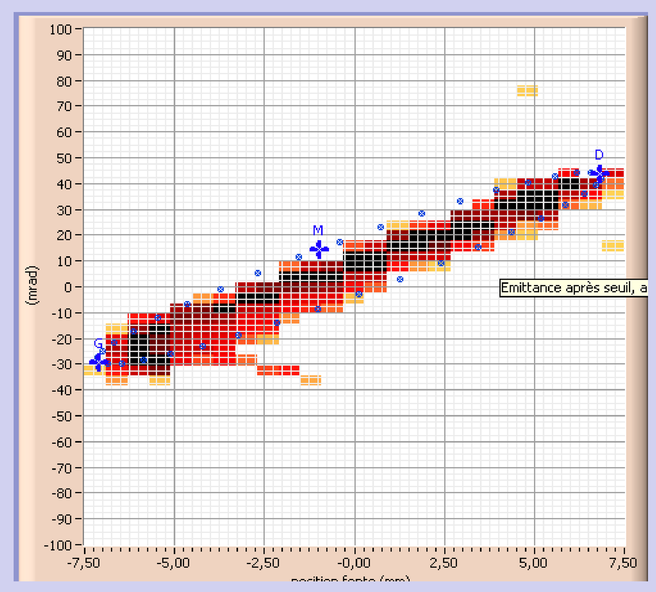


Fig 1 : Emittance of the Ar+ beam

When the optimum transport was obtained, emittance measurement was performed for Ar1+ beam @ 15keV. As show in the figure n°1, more than 85% of the beam is include in an ellipse of 80π.mm.mrad which correspond to the acceptance af the low energy beam line for SPIRAL2.

The same measurement was performed for N2+ beam and the emittance was less than 80π.mm.mrad

Response time

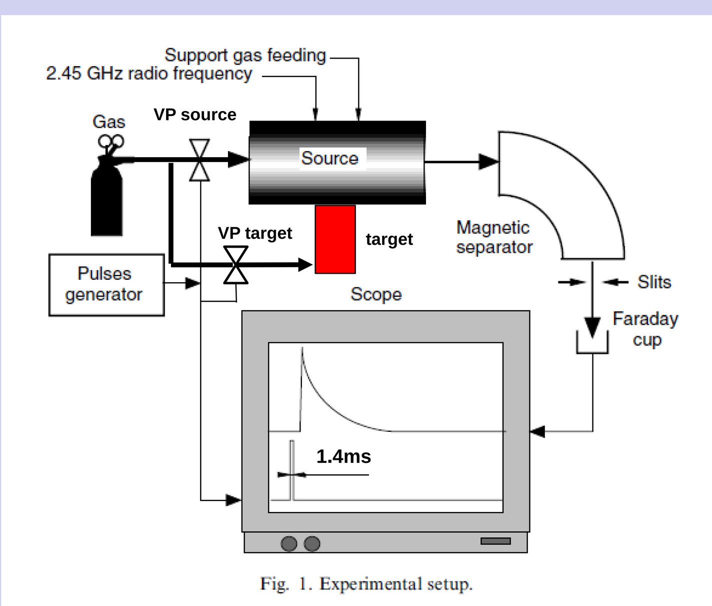


Fig. 1. Experimental setup.

Principle : The source was fed with N_2 and ~50 W of RF power to reach a total current between 640 µA and 810 µA at the exit of the source. Gas pulses of ~1.4 ms long were injected in the source (VP source) or in the target (VP target), containing natural He, Ne, Ar, Kr and ^{129}Xe. The ion beam of interest was selected with the mass spectrometer and the shape of the ion pulses was recorded on the Faraday cup. The intensities of the ion pulses being of the order of 10 nA.

During the following measurements, the temperature of the target was maintained at 1000 K.

We recorded the response time of the atom-to-ion transformation for different gases in the same running conditions of the source, as gases were simultaneously injected. The response time increases with the mass of the gas (Fig.3).

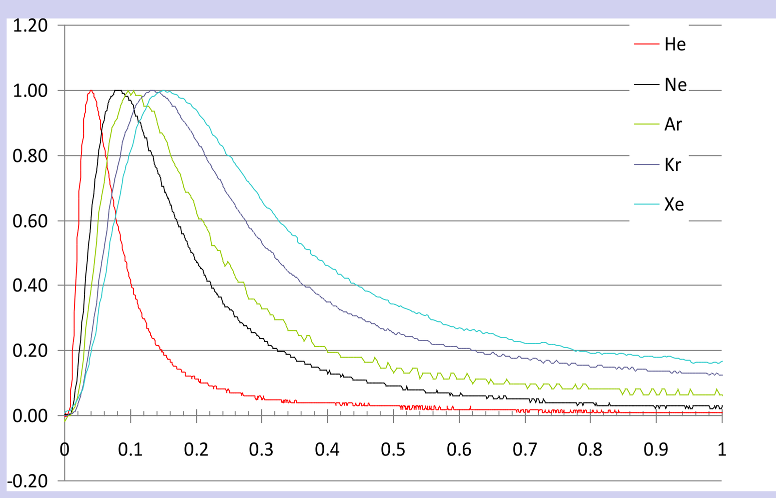


Fig 3 : Time responses of the TISS for He, Ne, Ar, Kr and Xe in the same plasma conditions. Injection gas by the target (Vp target)

This effect is mainly attributed to the effusion of the atom in the whole cavity of the TISS, and should then depend on the square root of the mass of the element considered. If the time scale of each response is compressed according to the ratio $\sqrt{M_{He}/M_X}$ (where M_X corresponds to the mass of the gas X and M_{He} is the mass of He), the different responses should be identical if only effusion governed the time responses.

In fact, within this compressed scale representation, the time response decreases with the mass of the element [Fig. 4].

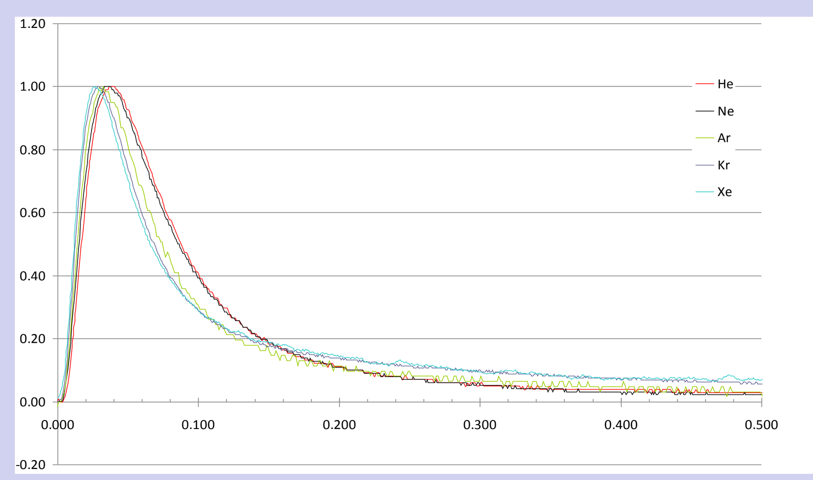


Fig 4 : time responses of the TISS after time scale transformation. Injection has by the target.

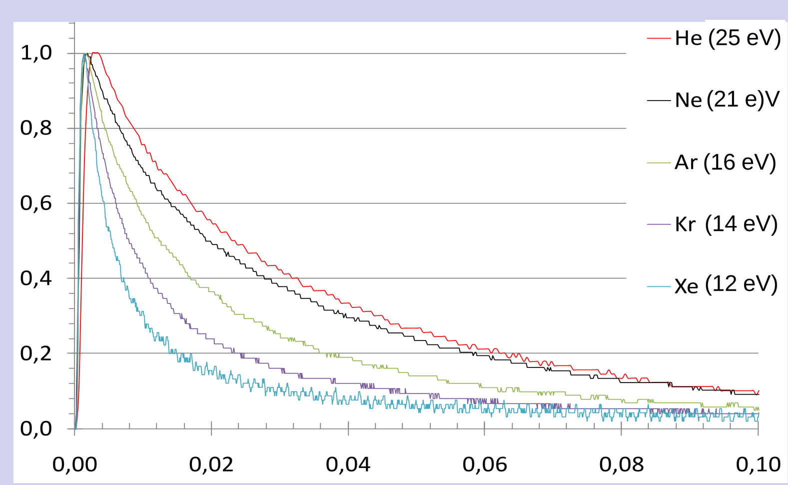


Fig 5 : Time responses of the source for He, Ne, Ar, Kr and Xe in the same plasma conditions, after time scale transformation. Injection gas by source (VP source)

To understand it, measurements were performed with injection of gas directly in the source (VP source). After time scale transformation [Fig.5], the result show is due to the first ionization potential which decreases with the mass and leads to ionization rates higher for heavier elements.

The contribution of this effect to the reduction of the global response time is relatively small (some tens or hundreds of ms) compared to the effusion time of the isotopes out of the target labyrinth. But in case of short lived isotopes, the size of the target could be reduced to limit the inner-target effusion time.

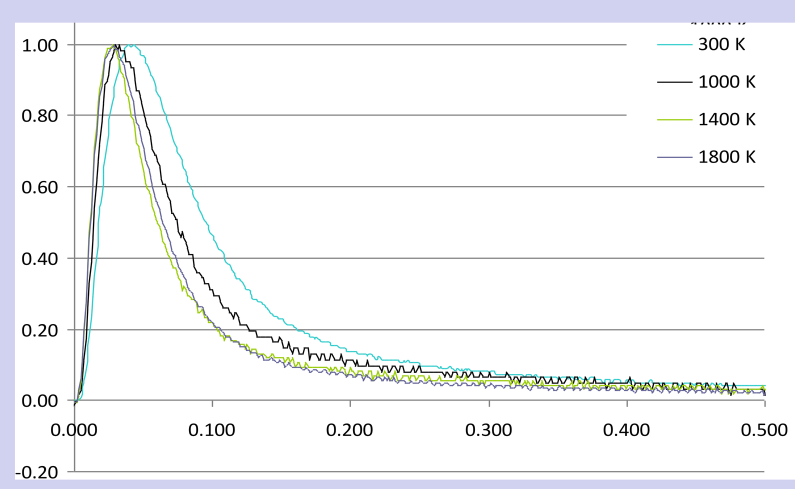


Fig 6 : Time response of the TISS with Ar beam at different temperature of the target.

Measurements were performed with injection of Ar by VP target, the temperature of the target was increased and the response time was measured. The result [Fig.6] show temperature have an influence on the time response of the TISS. The effusion time through the target is reduce due to the increase thermal excitation of the atom.