TULIP project : status

ANR project, 2019-2024

Objectives:

Production of neutron-deficient short-lived ions

1 - Rb^+ ions, up to ^{74}Rb?

2 - Metallic ions, in the region of ^{100}Sn

3 – Make the system adaptable to other elements

How to reach the objective?

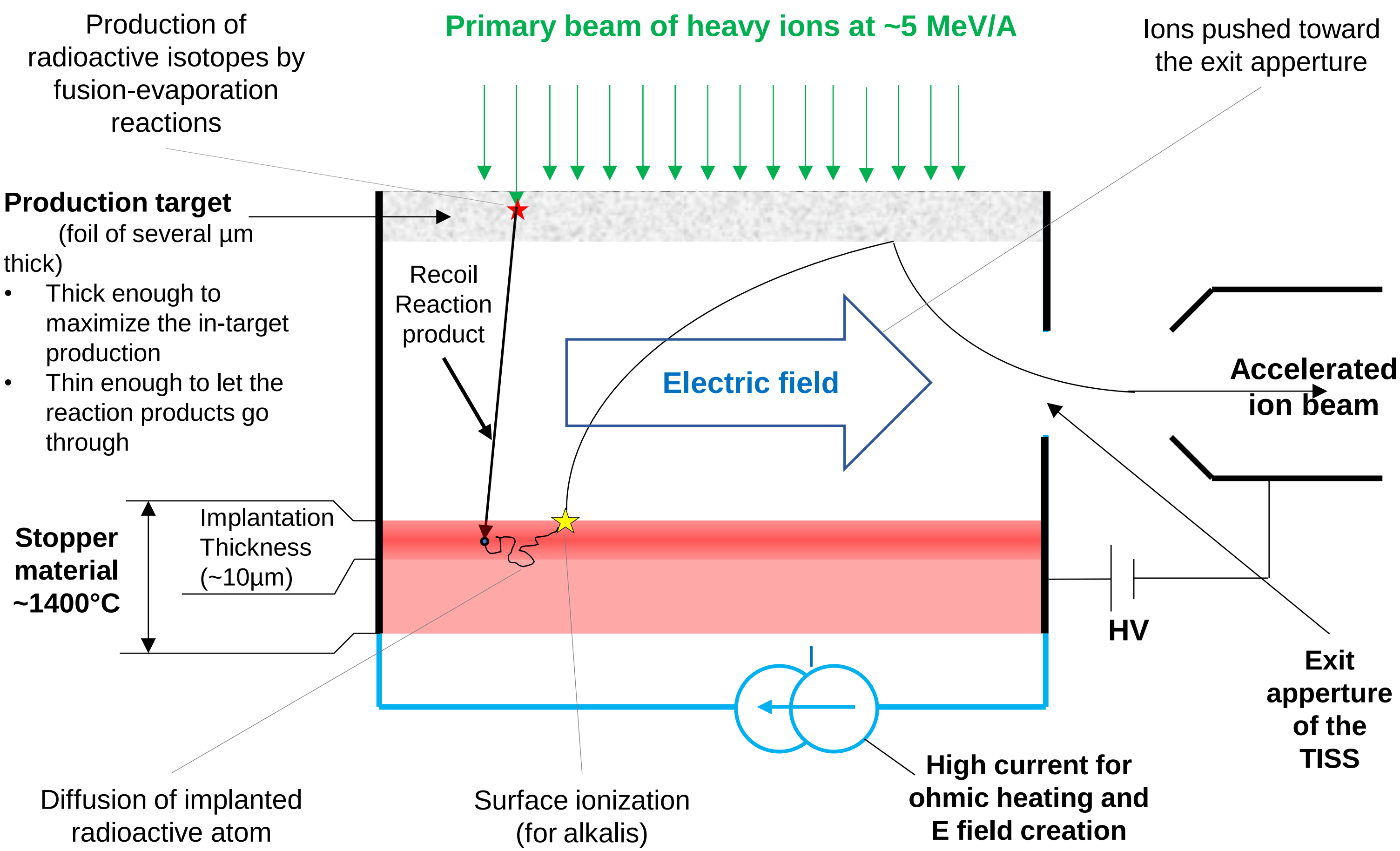
By optimizing the ion production within the SPIRAL1 possibilities

=> By maximizing the « *in-target prod x atom-to-ion transformation efficiency* » product

P. Jardin, M. MacCormick, V. Bosquet, P. Chauveau, S. Damoy, P. Delahaye, M. Dubois, M. Fadil, G. Frémont, M. Lalande, C. Michel, J-C. Thomas.

TULIP : principle

Ideal production reaction for Rb production: ^{20}Ne (~4MeV/A) + ^{58}Ni target



P. Jardin, ISOL-France, 20-22 March 2023
Presented by P. Chauveau

TULIP project : setup

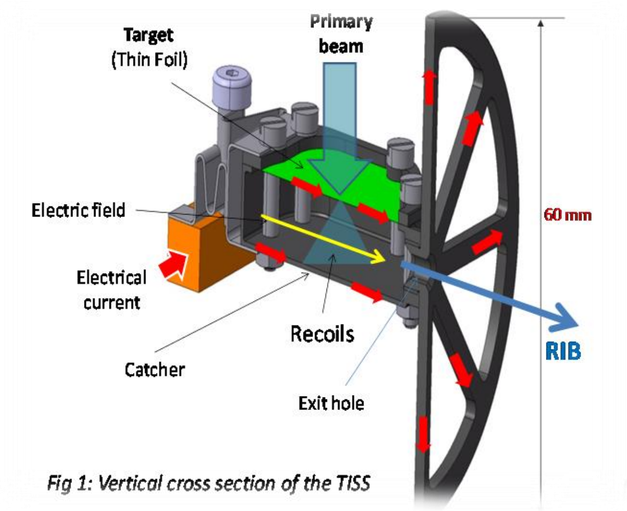


Fig 1: Vertical cross section of the TISS

Evaluation of the contribution of the processes involved in the production:

- Diffusion of Rb out of the catcher materials. Experiment performed at IJCLab.

Extraction of diffusion coefficients from the study of Rb release in different carbon catchers. J.Guillot et al., NIM B 526 (2022) 9–18

$T_{catcher\ release}$ *~10 ms (deduced from measurement)*

Short release time due to small range of recoils in the catcher material

- Effusion of Rb out of the TULIP cavity and ionization

Development of an innovative system for the production of short-lived neutron-deficient ions, V. Kuchi, PhD thesis, University of Caen, 2018

$T_{effusion\text{-}ionization}$ *~ 12 ms (measured)*

Short release time due to the small effusion volume, the reduced number of contact with the wall, the short sticking time per contact (high temperature), the extraction of the ions by the inner electric field.

TULIP: thermal behavior of the target

Initial appearance of the target

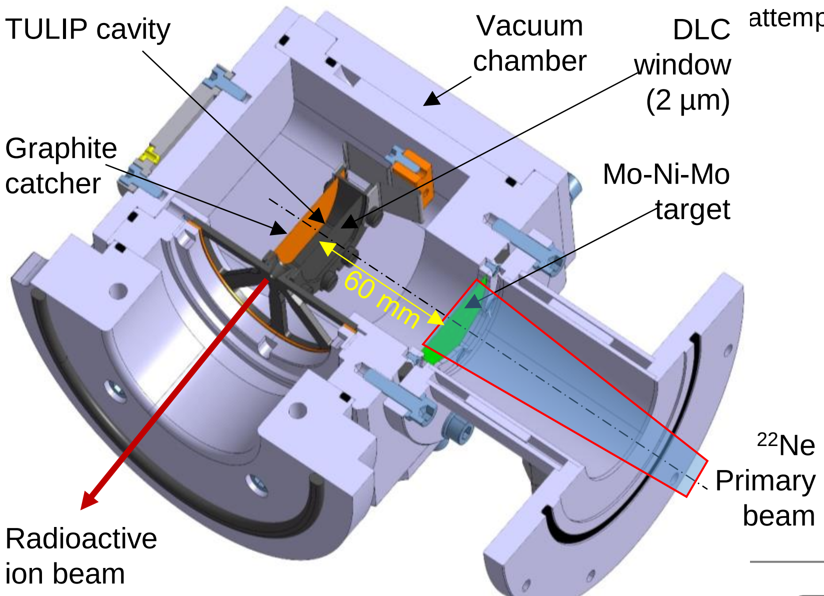
Appearance after the first thermal test

Ni foil after heating at 2240W 6th of August 2019

7th of August Ni target broken after second response time measurement attempt)

First test of pure Ni target mounted on the cavity at working temperature (~1300°C):

-> three tests, three target destroyed



To make the Ni target able to sustain the thermal constraints*:

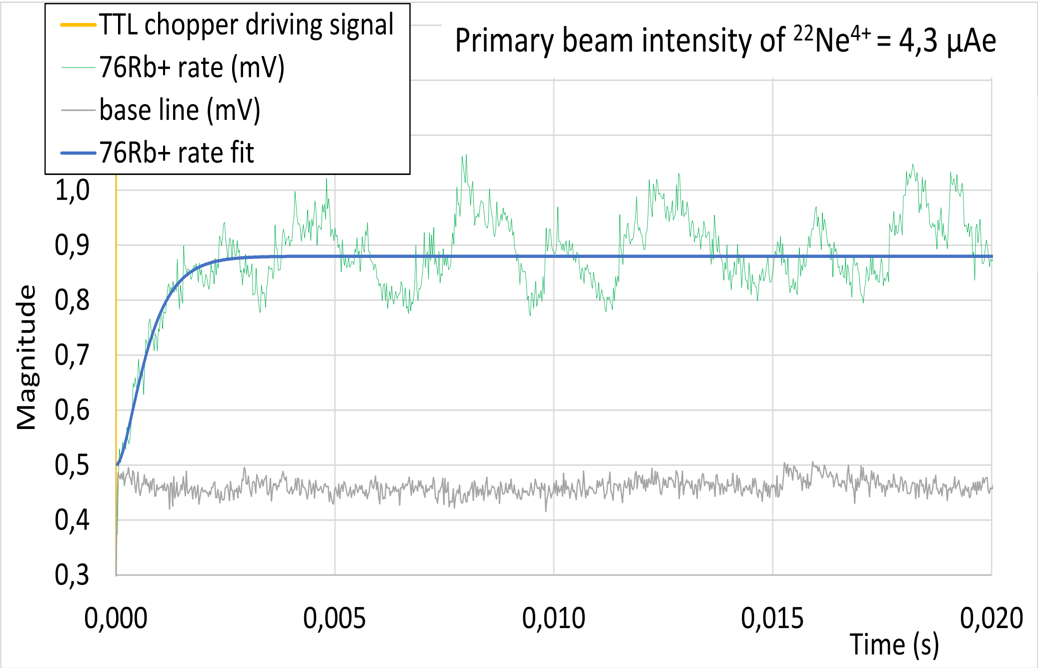
- 60 mm displacement from the cavity
- 0,3 µm Mo layer on both faces of 4 µm Ni
- Diamond Like Carbon (DLC) foil in place of the target at the entrance of the cavity

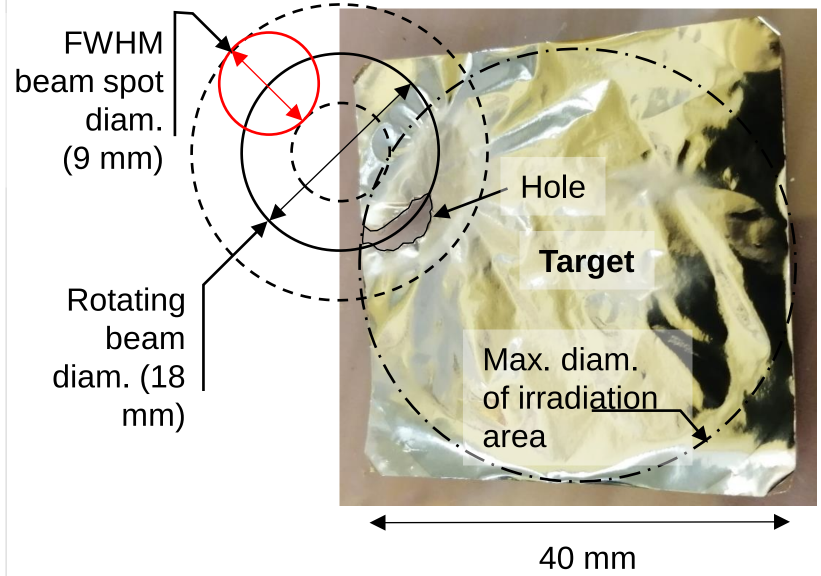
Max. Temperature expected,

- without beam: 650°C
- with beam (150 W of Ne@4,5MeV/A) : < 1150°C

**Ni target development for the TULIP project, P. Jardin et al., Proceedings of the INTDS conference, PSI, 2022*

TULIP: on-line test for Rb^+ production





Results*:

- 4×10^3 atoms per sec. of ^{76}Rb are transformed into ions in a time shorter than 1 ms (6×10^4 for ^{78}Rb), but the beam was not centered and atoms were produced close to the exit
- Efficiency: 1 to 10% ? Difficult to estimate as the reaction cross sections are not well known
- Damage of the target: over focussing? and misalignment of the primary beam?

Next step: July 2023

- On-line test with a ^{20}Ne @ 4,5 MeV/A primary beam to measure the performances with optimized working conditions

**Sub-millisecond atom-to-ion transformation in the TULIP ISOL system. P. Jardin, submitted to NIM A*

TULIP: towards metallic ion production in the region of ^{100}Sn

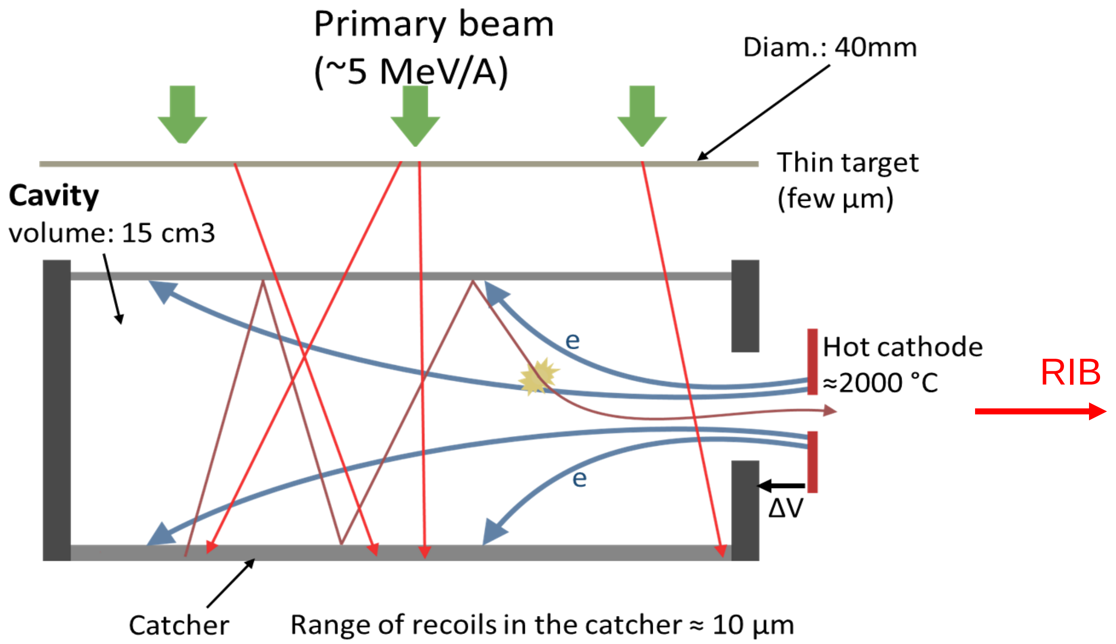
How to adapt the cavity to the production of metallic ions?

TULIP: towards metallic ion production in the region of ^{100}Sn

→ **By coupling an electron impact ion source to the TULIP cavity**

Principle: injection of electrons in the cavity to ionize the atoms immediately after their release from the catcher (as it is in the case of Rb ion production)

→ **SPEED project*** (V. Bosquet project, PhD)
(Système de Production d'Eléments Exotiques Déficients en neutrons)

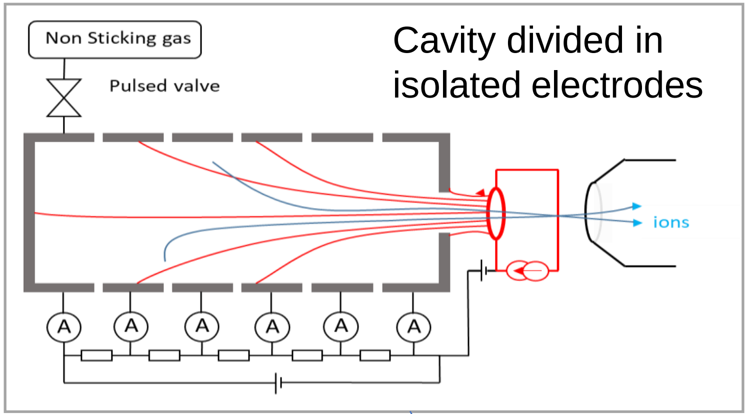


*The TULIP project : first on-line result and close future
V. Bosquet, Proceedings of the EMIS conference, Vancouver, 2022

SPEED project

(Système de Production d'Eléments Exotiques Déficients en neutrons)

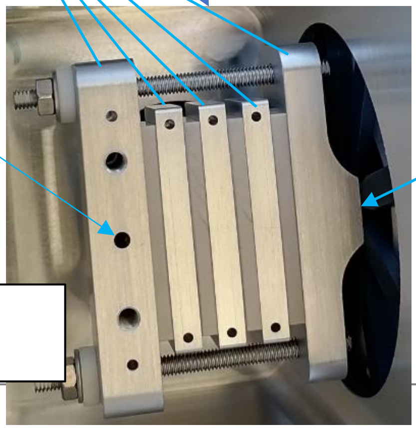
Room temperature prototype developed to ease off-line tests



Electrodes allow to roughly reproduce the inner electric field present in the hot version

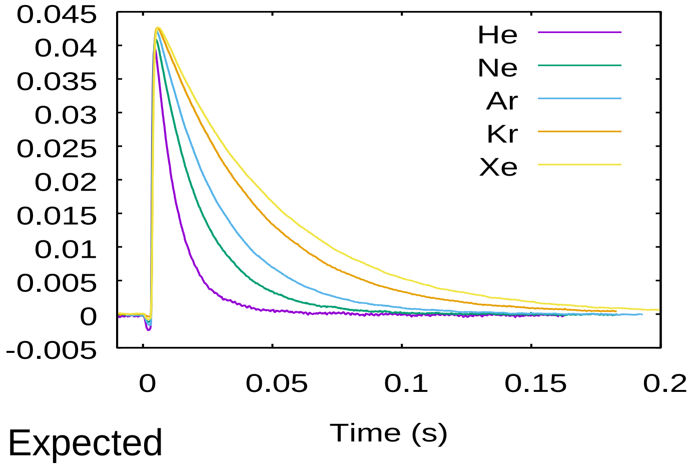
Gas injection (calibrated leak or via pulsed valve)

Exit

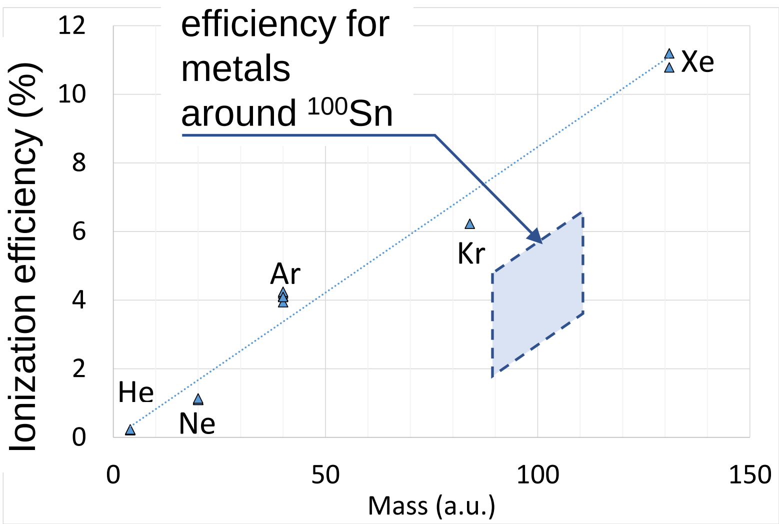


Room temperature SPEED version

Effusion-ionization time for noble gases at room temperature (will be divided by 2 at 1300°C)



Expected efficiency for metals around ^{100}Sn



P. Jardin, ISOL-France, 20-22 March 2023
Presented by P. Chauveau

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Production of metallic ions around ^{100}Sn

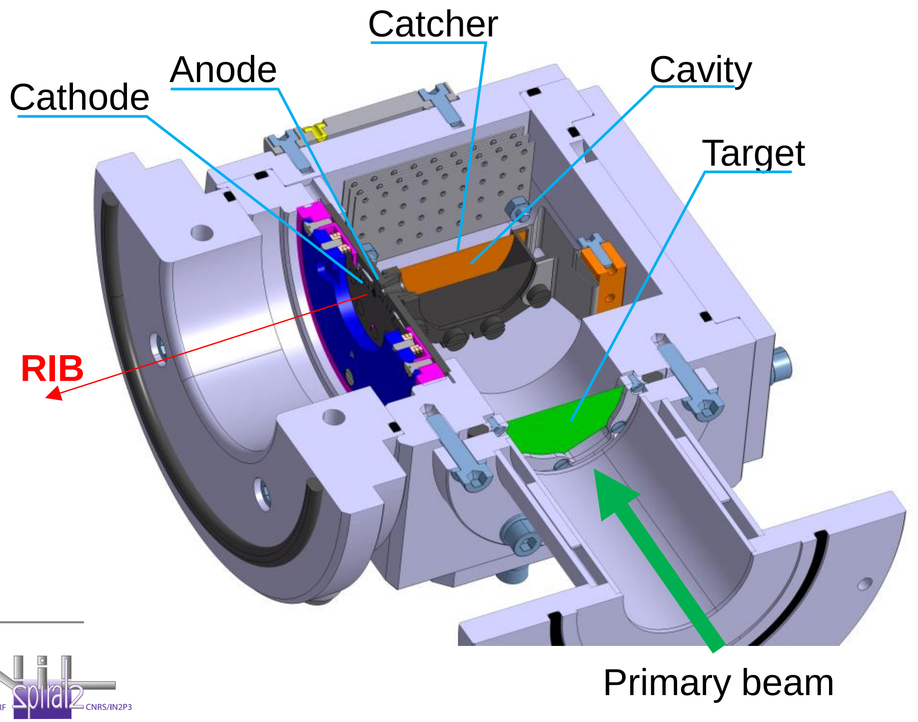
Production under estimation. Several encouraging facts regarding the atom-to-ion transformation efficiency of Sb, Sn, In, Cd

- Half-lives > 1 s for 47 < Z < 51 and 50 < N < 56 (to be compared to AIT time of tens of ms)
- Ionization efficiency of the source should be close to 8%
- First ionization potential of Sb, Sn, In, Cd significantly lower than that of noble gases → Larger ionization XS by electron impact and thus larger ionization efficiency expected
- Relatively short sticking time → limited decay losses during the atom-to-ion transformation process

Hot SPEED version already built, ready for on-line test

Need of a primary beam of ^{50}Cr at ~5 MeV/A

Next possibility expected by Spring 2024

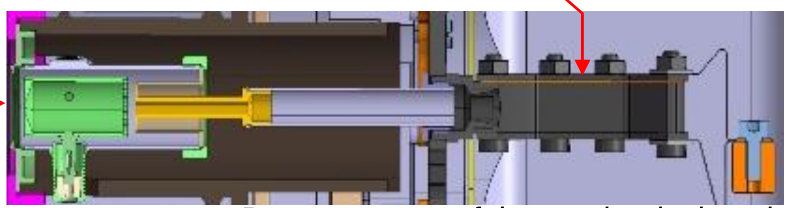


Short term evolutions beyond TULIP project

Other targets and others beams can be used to reach other neutron deficient elements
Main constraint is the ability of the target to sustain the temperature and the beam irradiation

Ionization of metals

- improvement of the present SPEED efficiency (4% for Sn)
- or coupling a FEBIAD to the TULIP cavity (→ 40 %). Mechanics designed. Thermal simulations must be done.



Present status of the mechanical study

Ionization of rare earth elements. Considered by coupling the TULIP cavity to a platinum ionizer. Proof of principle scheduled by May 2023 within the framework of ^{8,9}Li+ beam production

Thank you for your attention