ECRISs AT GANIL, TODAY AND TOMORROW

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GANIL,1982-1994

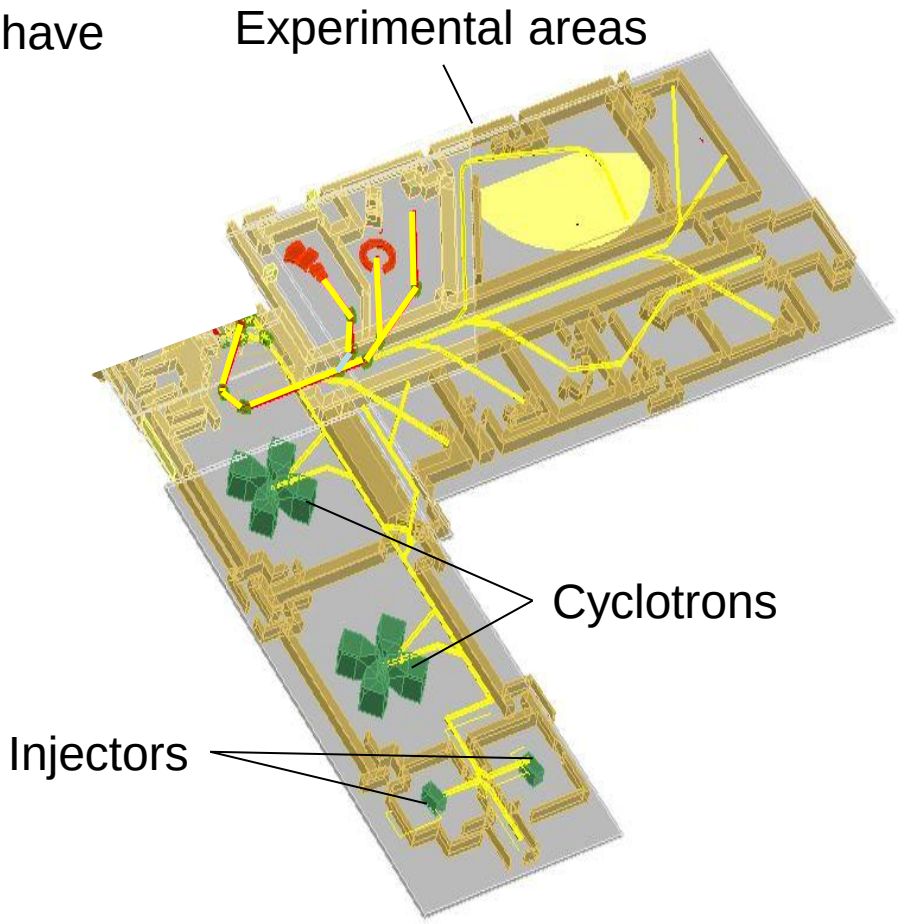
First ECRISs installed at GANIL: MINIMAFIOS (1983)
CAPRICE (1988)
ECR4 (1991) and (1995)

Advantages: reliability of the sources which have been working for 20 years and important operation feed back

Elements range from C to U
Energy up to 100 MeV/A

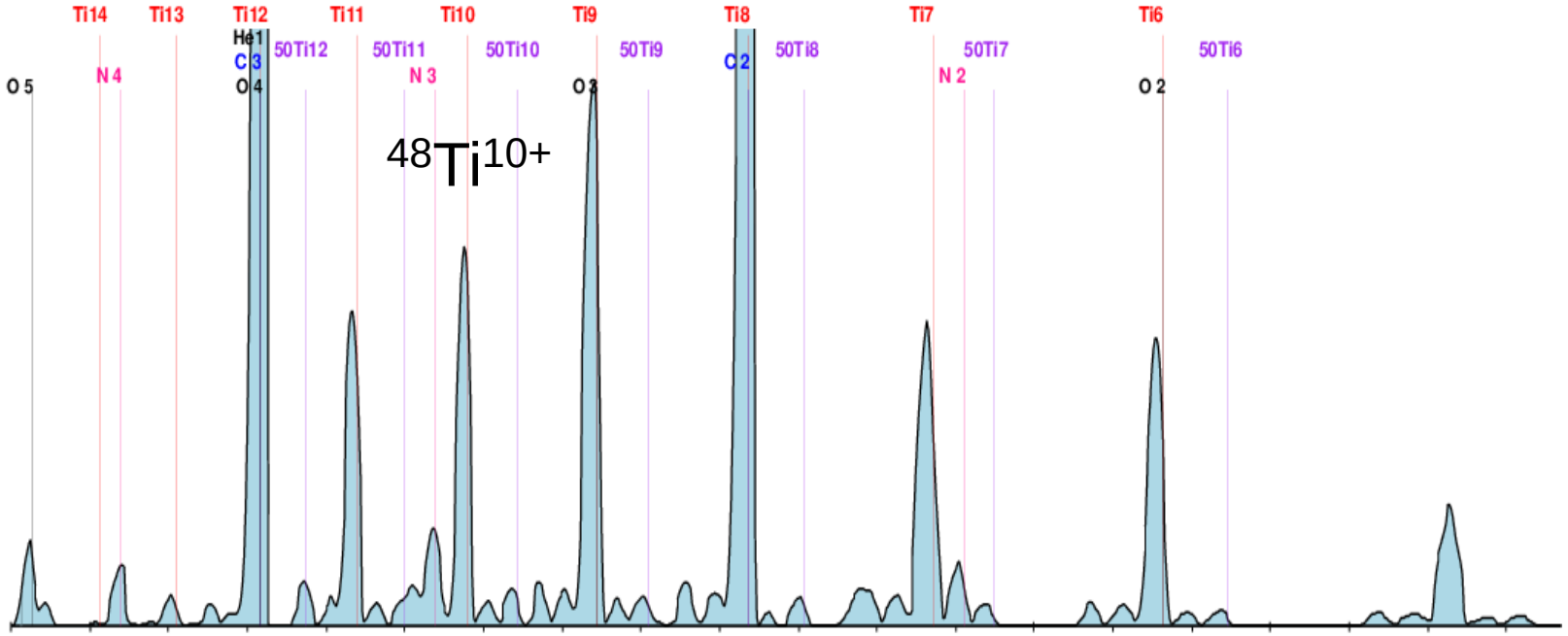
➔Still demands for physics experiments

Injectors still under improvement



Later beam developped

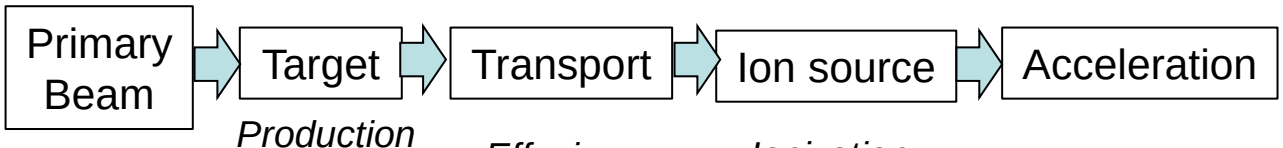
Beam of $^{48}Ti^{10+}$
Method : MIVOC
Compound : $(CH_3)_5C_5(CH_3)$ synthetized by B. Gall (IPHC/Strasbourg)
Good stability obtained by controling the temperature of the oven
Low consumption (0.23 mg/h) ➔ ionization efficiency close to 30%

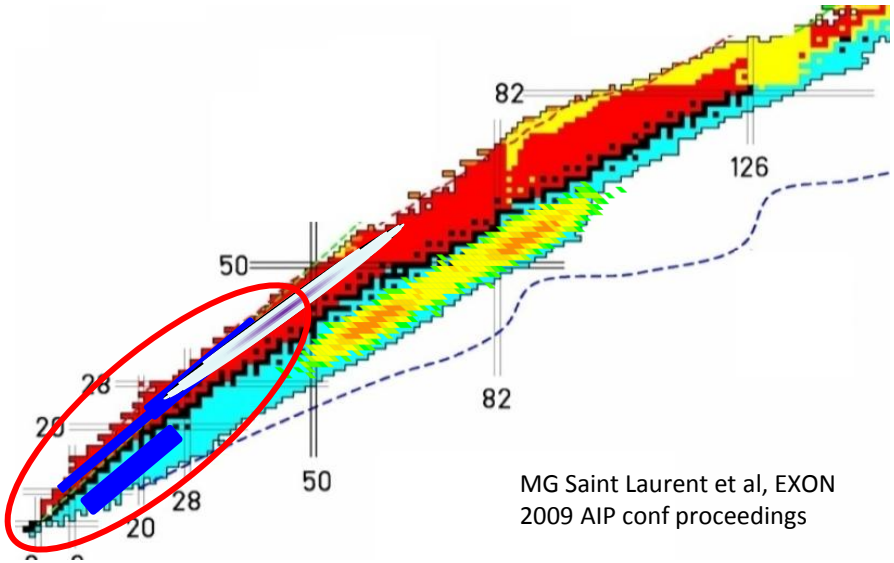


Charge state distribution of Ti. Optimized charge state : 10+ (20 µA±3 over 4 days). Mixing gaz He. RF power 170 W. Extraction voltage : 74 kV. Total extracted current from the source: 1.9 mA.

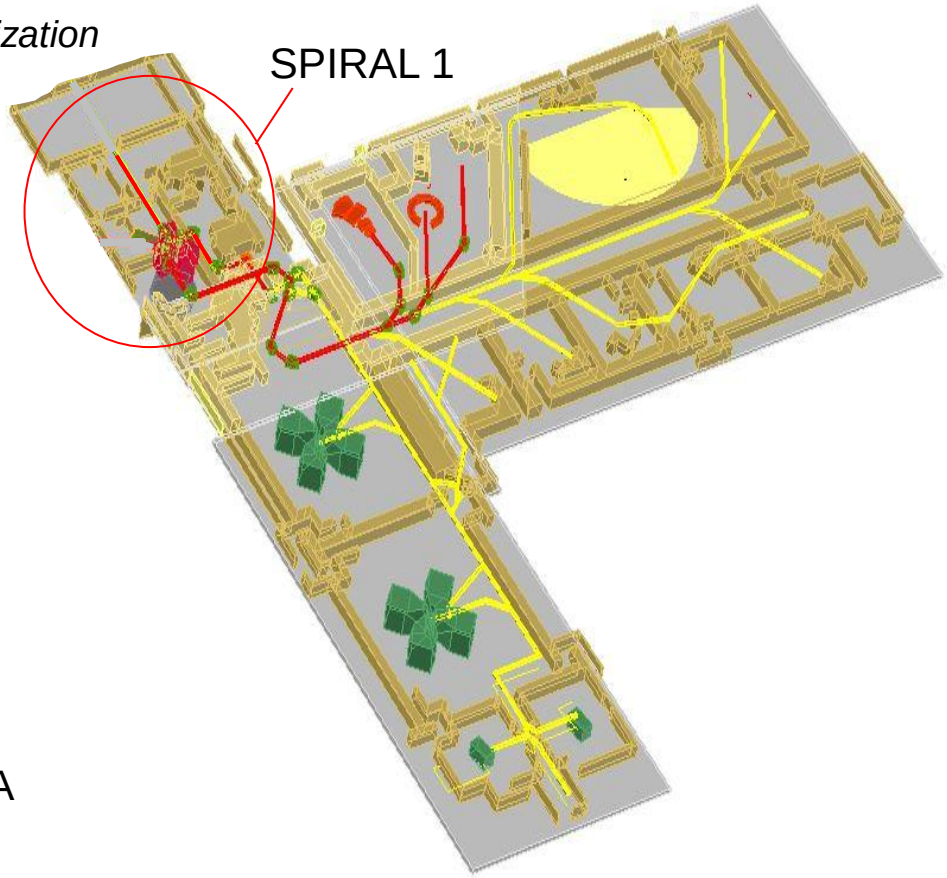
1994 ➔SPIRAL1

GANIL decided to extend its ion beam range to radioactive ion beams using the ISOL method





MG Saint Laurent et al, EXON 2009 AIP conf proceedings



Isotopes ranging from He to Kr
Post accelerated energy up to 25MeV/A

SPIRAL1 Target Ion Source System

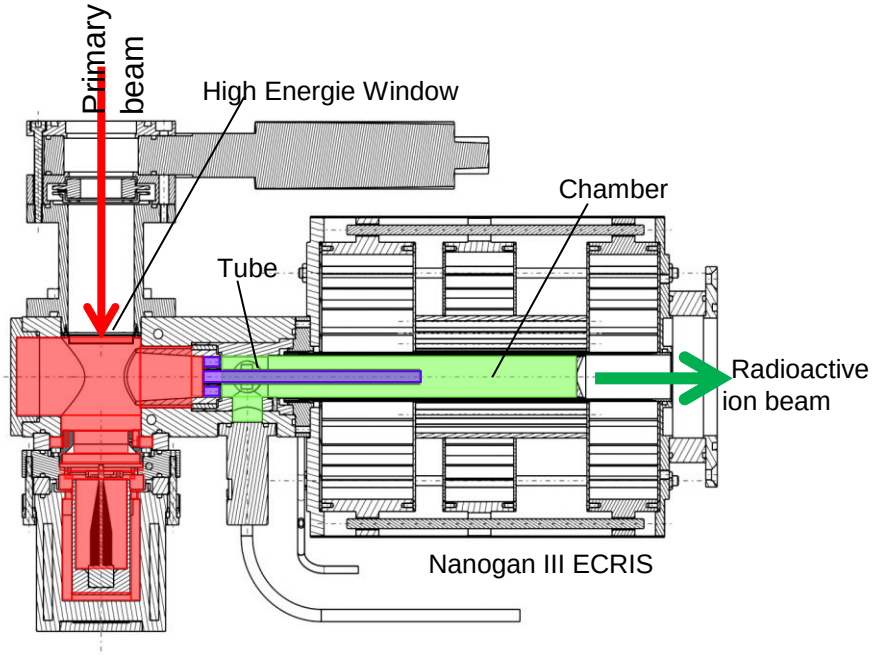
Radioactive ion production ➔ ECRIS design is specific

What is important?
The ionization efficiency (and not the current)
The radiation hardness (radiation damage reduce the lifespan)
To be conformed to the safety regulation
To be reliable and simple
To be cheap (replaced every ~15 days)

Building, services, operation and maintenance process must conform to the safety regulation

Ion produced : from gases

SPIRAL1full permanent magnet ECRIS

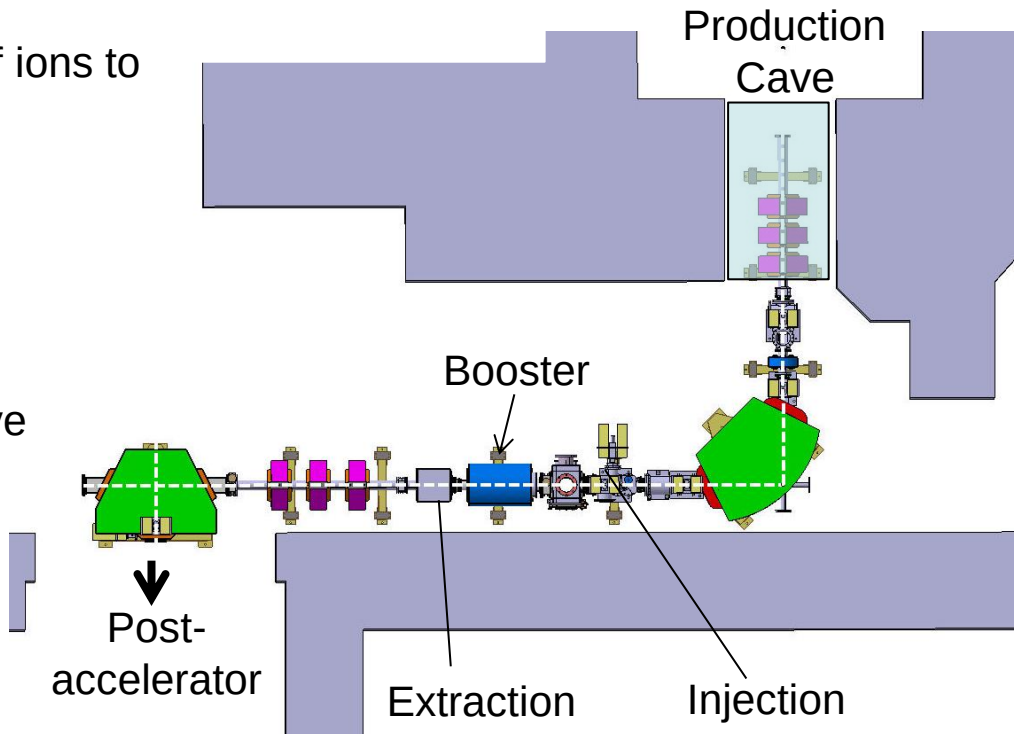


SPIRAL1 Upgrade

2011, GANIL decided to extend the pallet of ions to condensable elements

Using IS suited to the elements
(SIS, FEBIAD, LASER ➔ exiting IS)
All singly charged ion sources
➔Charge breeding necessary in case of post acceleration. Not possible in the cave

➔Separation of ionization process in two steps:
• 1+ in the production cave (less restrictive)
• N+ out of the cave, behind shielding



Principle developed at LPSC Grenoble with the Phoenix ECRIS
Already tested on line at ISOLDE, TRIUMF, MSU, …
Performances increase and could be still improved…

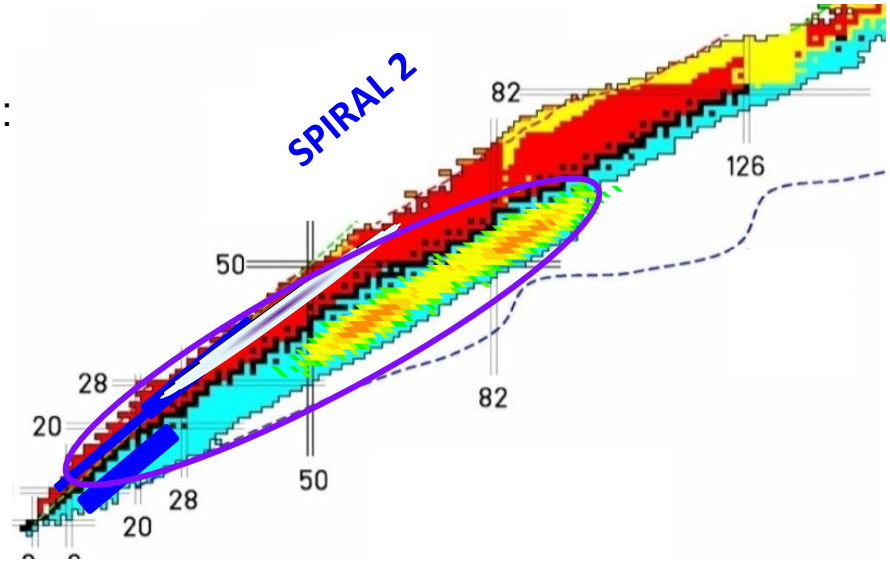
➔To be installed on SPIRAL 1 by the end of 2014

2006 ➔ SPIRAL 2

Facility dedicated to the production of radioactive ion beams using the ISOL method.

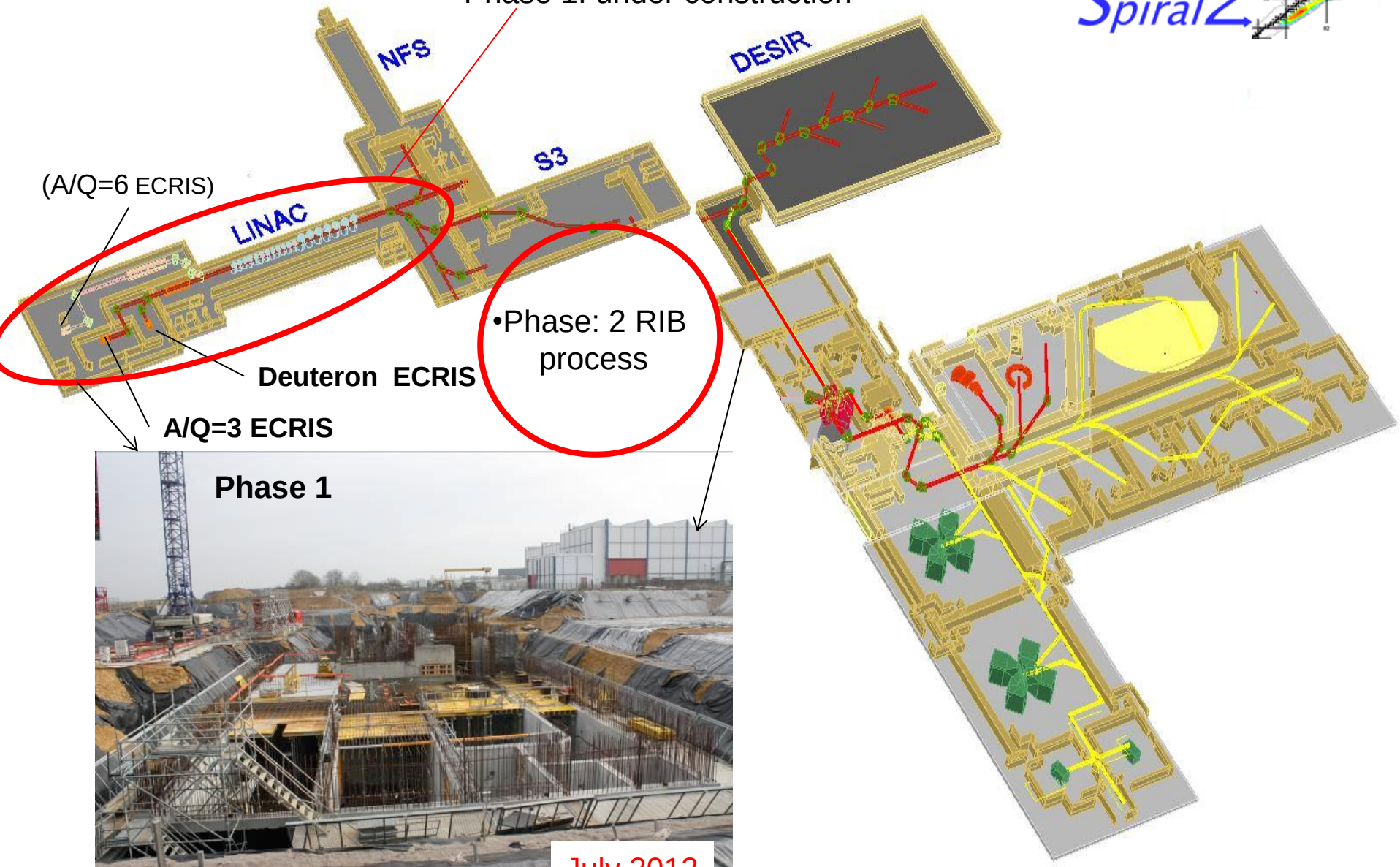
Compared to SPIRAL 1,
➔Larger range of ion masses
➔Higher intensities

Different nuclear production processes:
•Fragmentation
•Fusion-evaporation
•Transfer
•Fission induced by neutrons



SPIRAL2 Phase 1

Construction divided in to phases :
•Phase 1: under construction



SPIRAL 2 : Deuteron ECRIS

D (5mA@40 MeV) ➔ C converteur ➔ neutrons ➔ UC target

- 2.45GHz ECRIS developped at IRFU/Saclay
- Source existing, already tested
- Performances match with the SPIRAL 2 specifications

Will be installed by Spring 2013 at GANIL

Deuteron ECRIS

Deuteron beam line

SPIRAL2 : A/Q=3 ECRIS

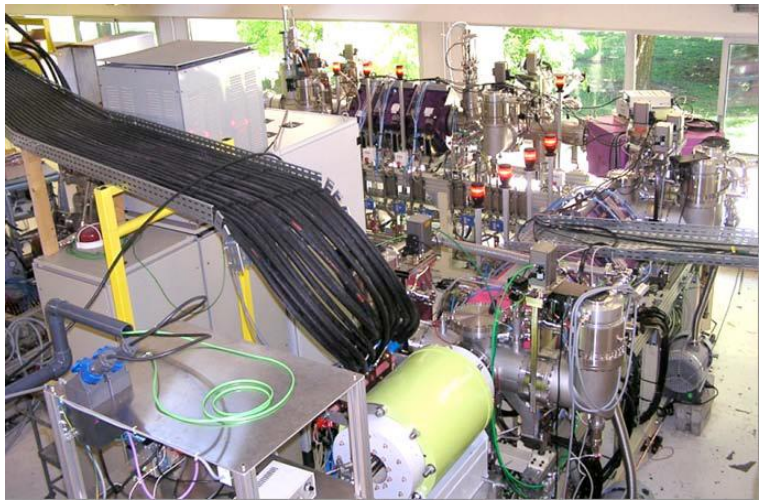
For nuclear production processes other than U fission

Developped at LPSC/Grenoble (see presentation of C. Peaucelle about Phoenix ECRIS)

Intensity (eμA)

Ion	SPIRAL 2 specifications	Phoenix V2	Other ECRIS	Reference
$^{18}O^{6+}$	1000	1300	2850 ($^{16}O^{6+}$)	VENUS
$^{40}Ar^{14+}$	420	50	514	VENUS
$^{36}S^{12+}$	240			
$^{48}Ca^{16+}$	160	1	70	SECRAL
$^{58}Ni^{19+}$	57	19	50	SUSI

Non exhaustive list of ion intensities expected at the exit of the Q/A=1/3 ECRIS of SPIRAL 2

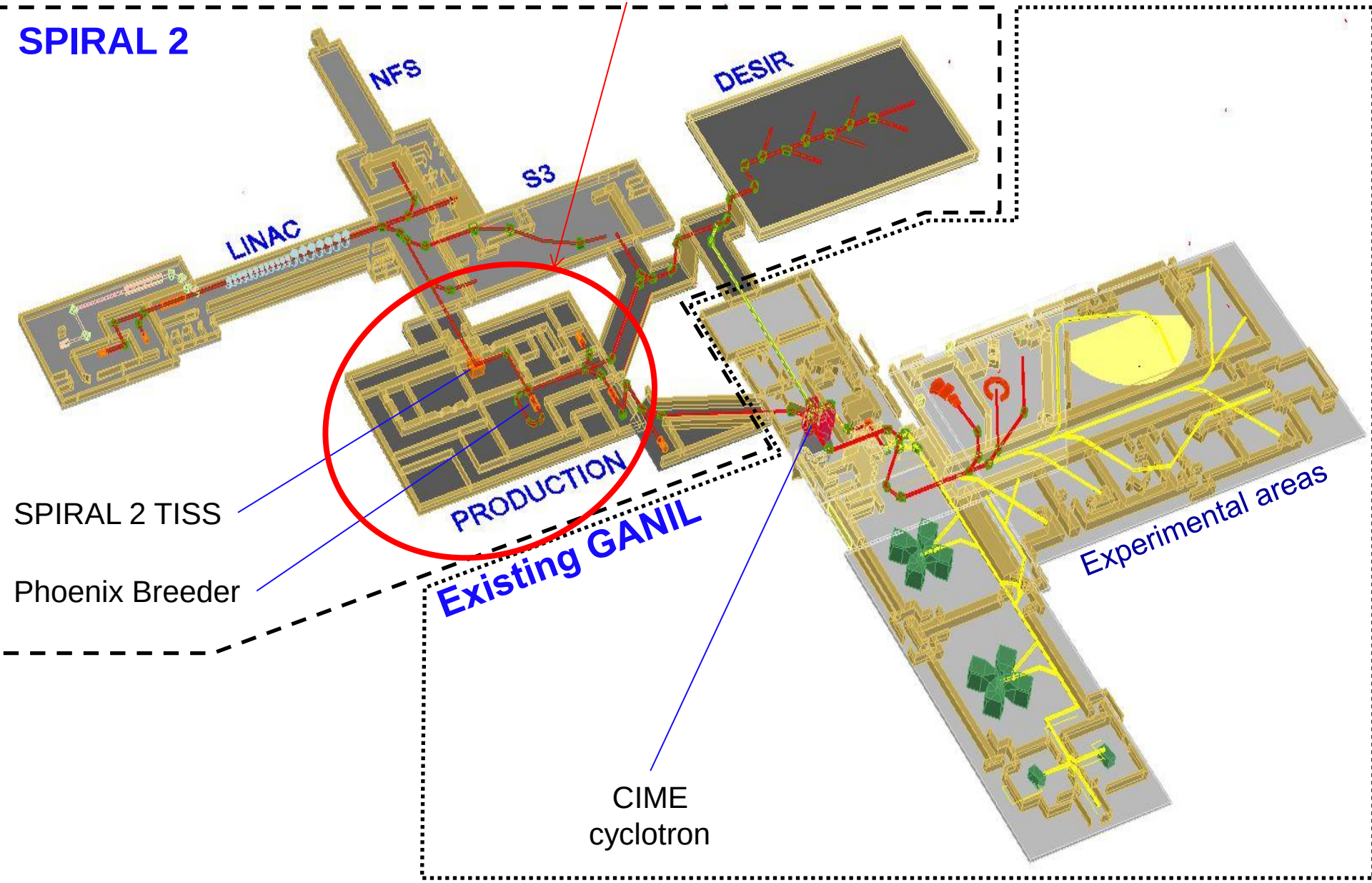


Several intensities requested by SPIRAL 2 can not be produced, even with the most performing ECRISs.

Reaching the expected intensities of SPIRAL 2 needs to improve existing ECRISs or to develop new ones

Commissioning of the LINAC (2014) made with Phoenix V2 (less performing but existing)

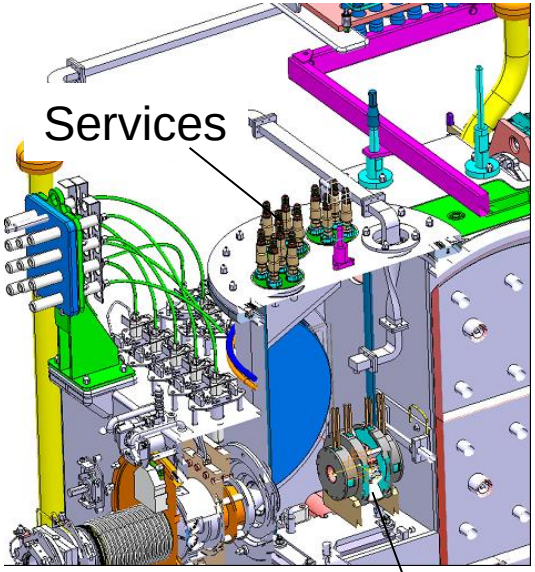
SPIRAL 2 Phase 2

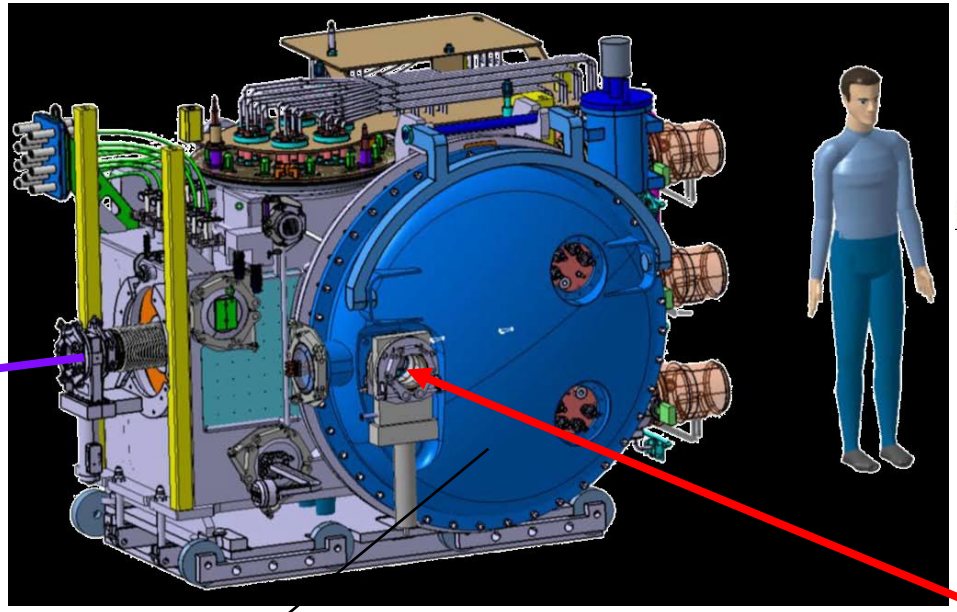


SPIRAL2 : Production module

After 3 months of operation under high primary beam intensity

➔ Important contamination
➔ Confinement of the TISS (3 barriers)
➔ TISS installed under vacuum





Vacuum chamber under construction at Bilbao

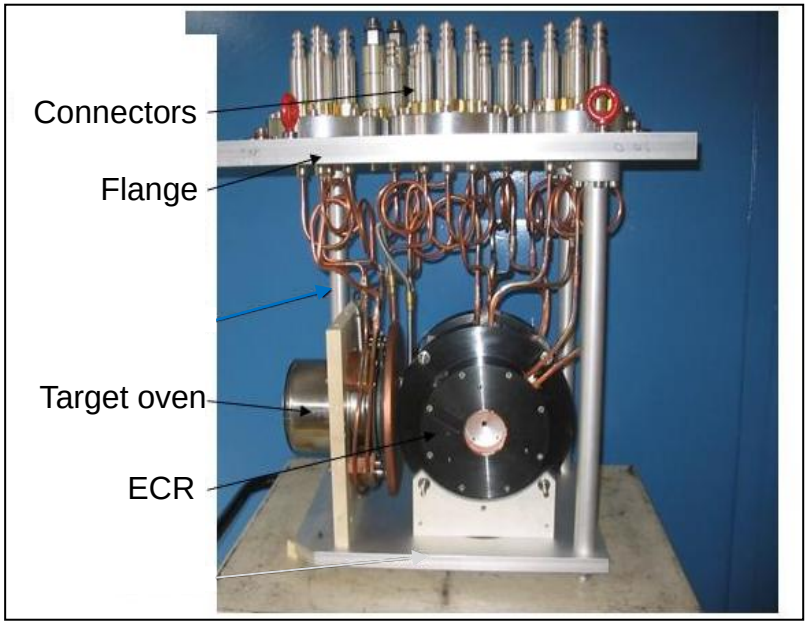
SPIRAL2 : TISS for gas ionization

Submitted to a high radiation dose rate

➔The 1+ ECRIS built with radiation hard materials only. Principle tested off line (alone and with target at 1500°C).

➔ Last version to be built by end of 2013 (minor modifications)

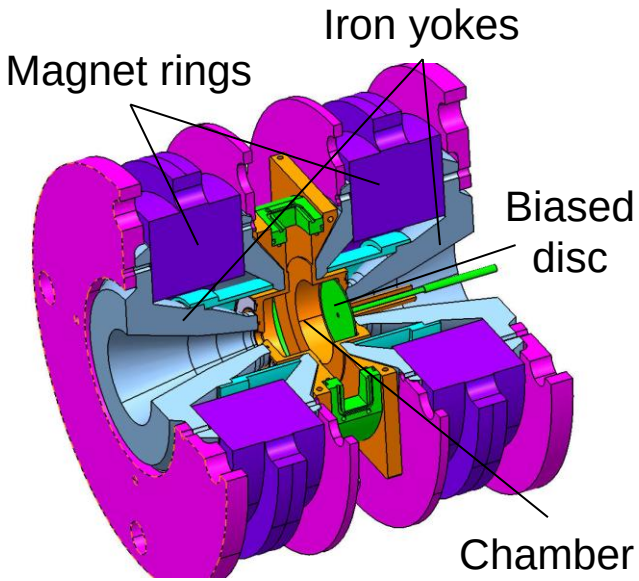
Ion	Support Gaz	Eff_{1+} (source extraction)	I
		%	µA
Ar+	N_2	31	934
Ar+	N_2+He	38	892
CO+	Ar	34	816
Kr+	N_2	73	843
Kr+	Ar	82	764
Xe+	Ar	100	798



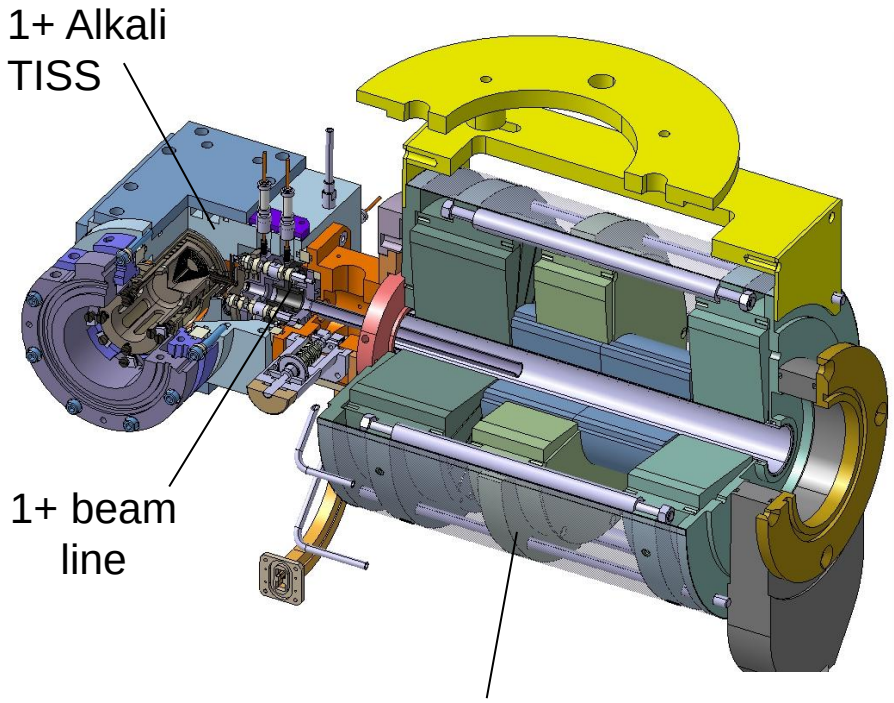
Alternatives solutions to the « standard » 1+/N+ method (*i.e.* with mass analyser)

In case of moderate radiation dose rate, and typical charge state of 8+ for Ar

ECRHD
For production of multi-charged short lived ions



NanoNaKE
Compact TISS for multi-charged ion production from alkalis



NanoGan III (present SPIRAL 1 ECRIS)

Conclusion

Today, 5 ECRISs are under operation at GANIL.
Stable and radioactive ion beams are routinely delivered to physicists.
New ECRISs are under test, under construction, development or study

Tomorrow, 5 additional highly specialized sources will start.

In the frame of SPIRAL2,

- One has already been tested (Deuteron source)
- One is under developpement (Phoenix V2 as charge breeder)
- One has never been tested under high radiation dose rate (1^+ ECR)
- One does not exist (Q/A=1/3), and has to be designed.

All suggestions are welcome…

Thank you for your attention