Status of the NEWGAIN Project:

The New Heavy Ion Injector for SPIRAL2

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on behalf of the NEWGAIN team

The NEWGAIN project benefits from State aid managed by the National Research Agency under the France 2030 program bearing the reference ANR-21-ESRE-0018

DAEJEON LINAC 2026

SUMMARY

- Context
- NEWGAIN Injector design
- Main challenges
- Milestones
- Conclusions

Context

- The NEWGAIN project aims to build **a second SPIRAL2 injector designed for A/q = 3 to 7 ions**, to produce very intense heavy ion beams up to uranium, far exceeding the performance of the existing injector

- **A new 28 GHz superconducting ion source** will be developed to complement the existing sources and achieve high-intensity uranium beam

- This improvement will allow the SPIRAL2 LINAC to deliver intense beams on a wide variety of ions ranging from protons to uranium and will strengthen GANIL's international competitiveness, both in fundamental sciences and in associated applications.

Comparison between different Labs

Estimated in 2021

Beam intensities pμA 100% enriched	SPIRAL2 GANIL, Caen		SHE factory FLNR, Dubna**	RIKEN Nishina Center Wako (Tokyo)		GSI Darmstadt
	LINAG A/q≤3 Phoenix v3	**NEWGAIN* A/q≤7 SC source**	DC-280	RILAC	RRC (RILAC(2) as injector)	UNILAC***
^{18}O	80	**300**	16	10	-	1
^{40}Ar	16	**38**	10	10	1	8
^{36}S	23	**30**	****	-	-	-
^{40}Ca	2.9	**16**	****	-	-	-
^{48}Ca	1.2	**16**	10	3	0.3	4
^{58}Ni	1.1	**6.4**	****	****	****	2.2
^{86}Kr	0.1	**16**	****	10	****	0.2
^{136}Xe	0.001	**>10**	16	10	0.3	1
^{238}U	<<0.001	**4.8**	0.008	0.2	0.5	0.06[i]

* 80% total transmission assumed
** http://flerovlab.jinr.ru/index.php/2017/03/23/she-factory/
*** for the cw-linac project with the assumption of a 50% total transmission, priv. comm. W. Barth et al., GSI
**** beams not delivered
i VARIS ion source, 80% Alvarez-transmission, mode: 2 Hz/0.1 ms, priv. com. W. Barth et al., GSI
- intensities not provided

Main parameters of the injector

NEWGAIN parameters		
Main Frequency	88.0525 MHz	
LEBT input energy	10 keV/A	
After RFQ2	590 keV/A	
HEBT	A/q=7: 7 MeV/A A/q=3: 14 MeV/A	
Reference beam	**$^{48}Ca^{11+}$**	**$^{238}U^{34+}$**
Normalised RMS ε (π.mm.mrad)	0.2	0.15
Beam intensity after analysis	20 pμA (210 μA)	10 pμA (340 μA)
LEBT beam power (W)	10	24
MEBT beam power (W)	540	1400
HEBT beam power (kW)	6.9	16.7

Context

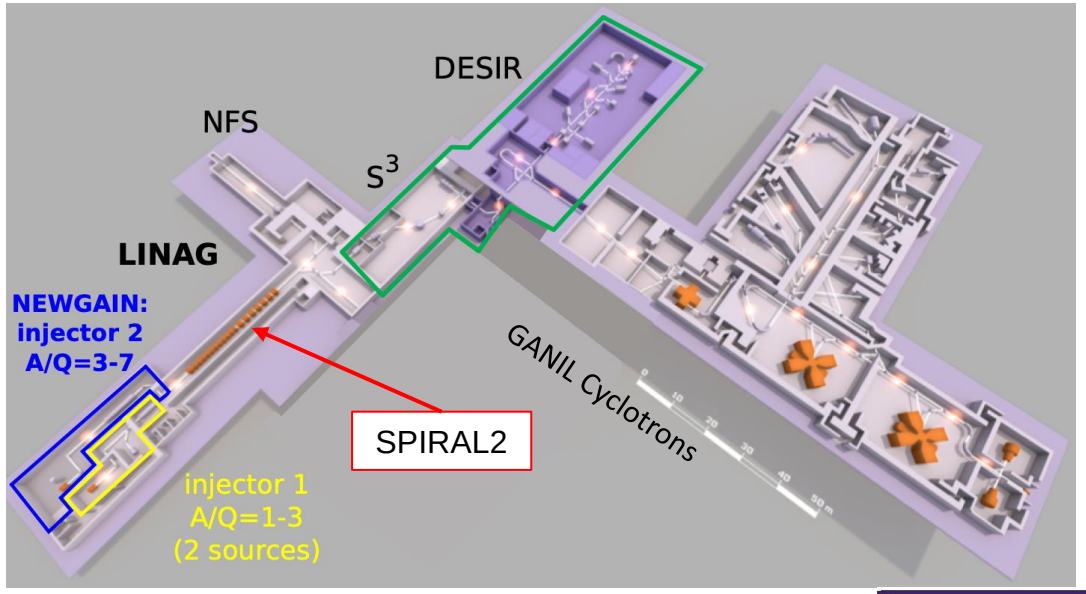
- **Since 1st Oct 2022, the French "EQUIPEX NEWGAIN" is launched for 6 years and 9 months (July 2029)**

- **The construction phase started in mid 2023**

- **25 M€ budget**

- **Partners**

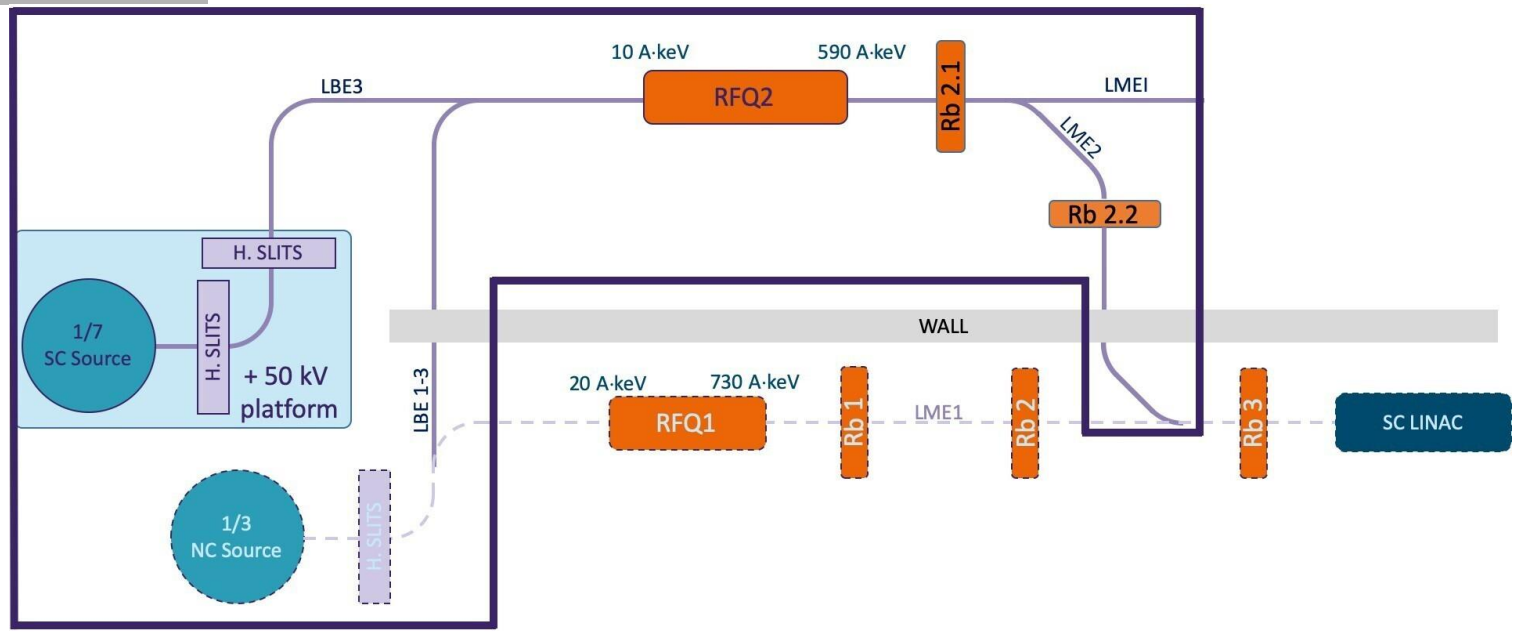
Principle Layout and Final Location @ GANIL



Existing

Current project

Experiments



NEWGAIN perimeter

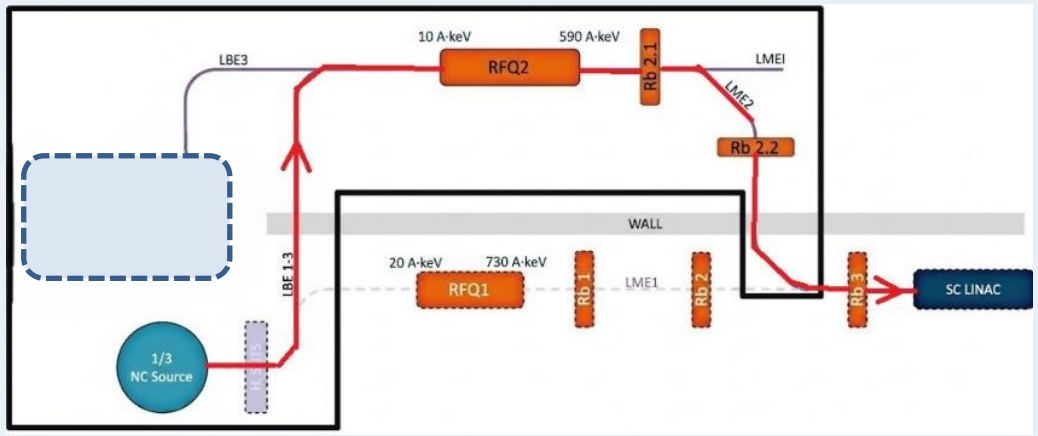
Equipment to be built

Existing equipment

Phasing Strategy

2029 First beams

@GANIL: First beam tests without SC source

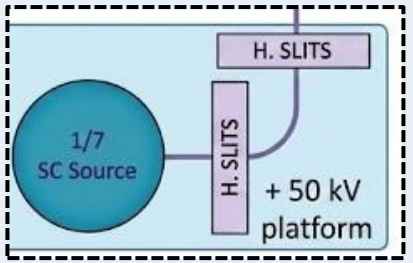


SPIRAL2

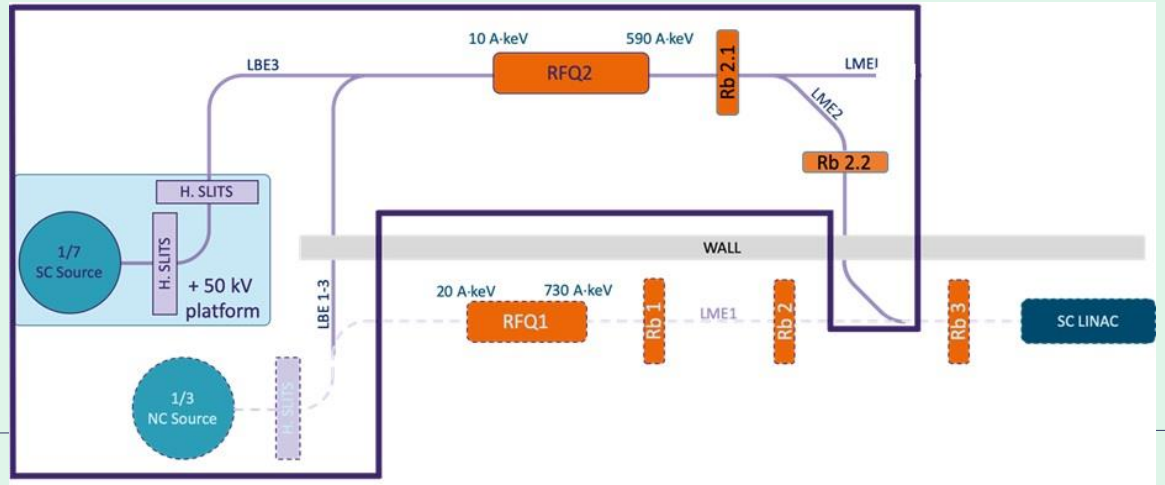
+

@LPSC, Grenoble

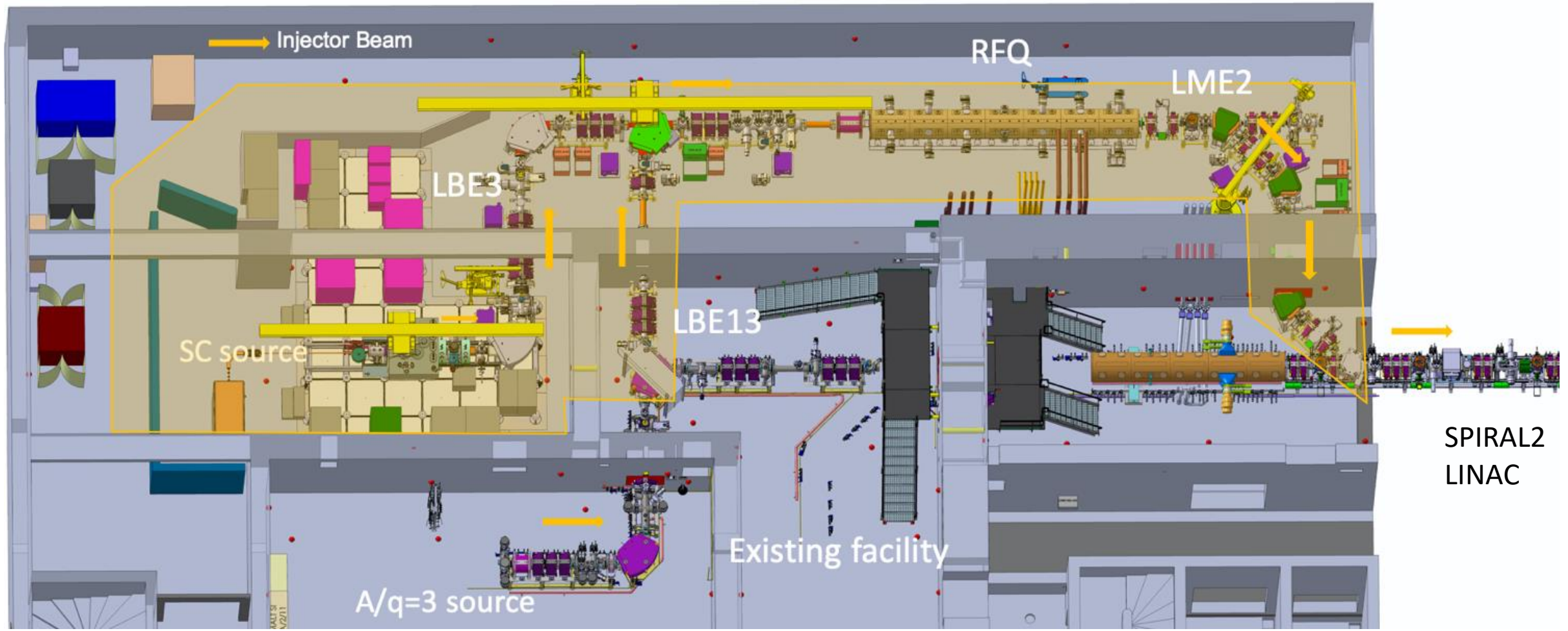
First beam tests up to Uranium at LPSC, Grenoble



>2031 Final Installation @GANIL



3D Final Implementation @ GANIL



Strategy design

Due to the tight schedule and to reduce manpower time:

- We reproduce as much as possible the design of the SPIRAL2 equipment or slightly improved to reduce development times (diagnostics, vacuum system, power supplies, automation, safety equipments, rebunchers, etc.)

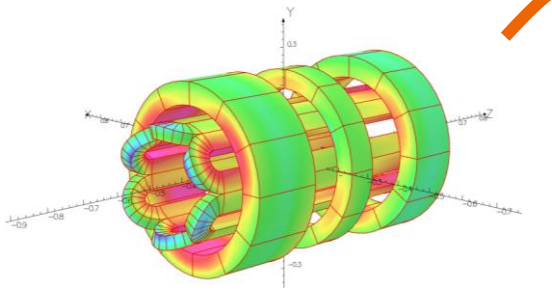
- Nevertheless, some equipment are upgraded: emittance-meter acquisition, RFQ power supply (solid state amplifiers)…

Two technological challenges for NEWGAIN

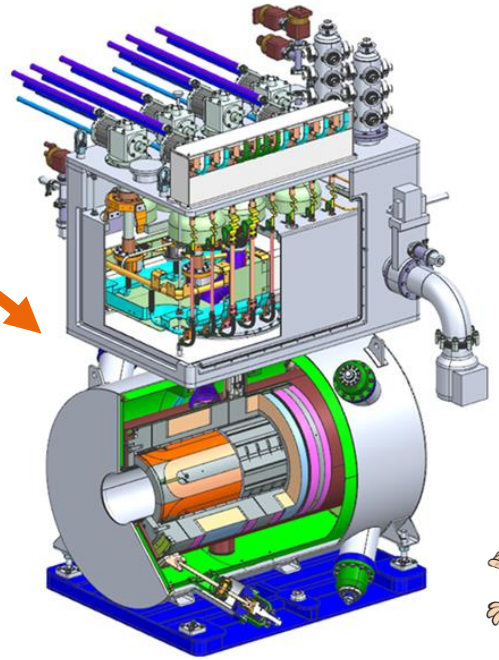
ASTERICS : **A**dvanced **S**piral **T**wo **E**lectron cyclotron **R**esonance **I**on **S**ource in **C**aen With **S**uperconducting magnet

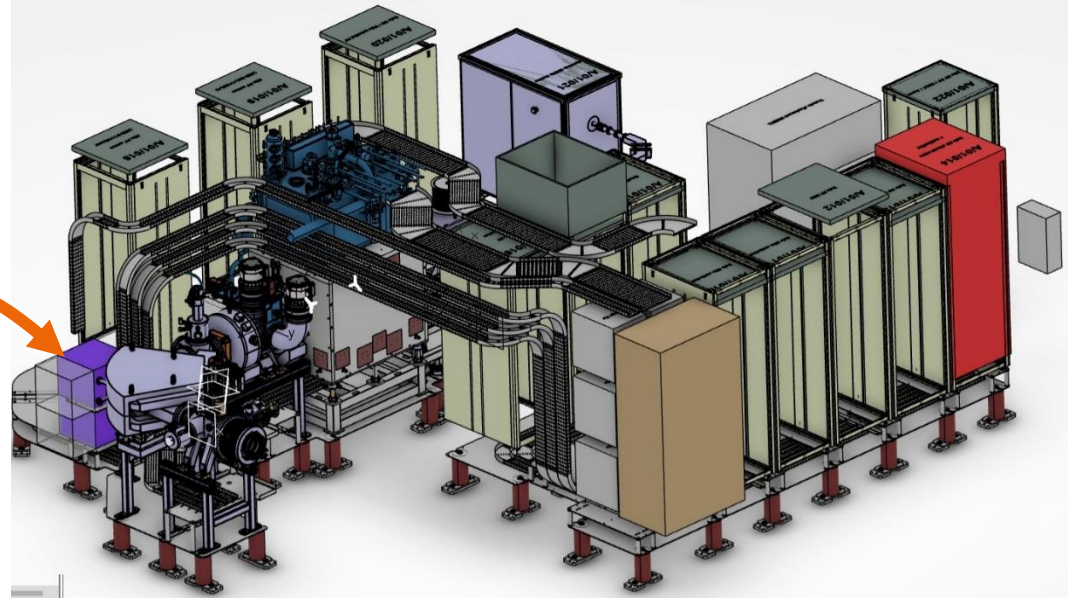
Superconducting Ion source

- **The first of its kind in France and in Europe**
- **The primary objective is to obtain at least the performance of similar sources existing in the United States and China, while maintaining identical reliability conditions**



Superconducting magnet





High voltage platform

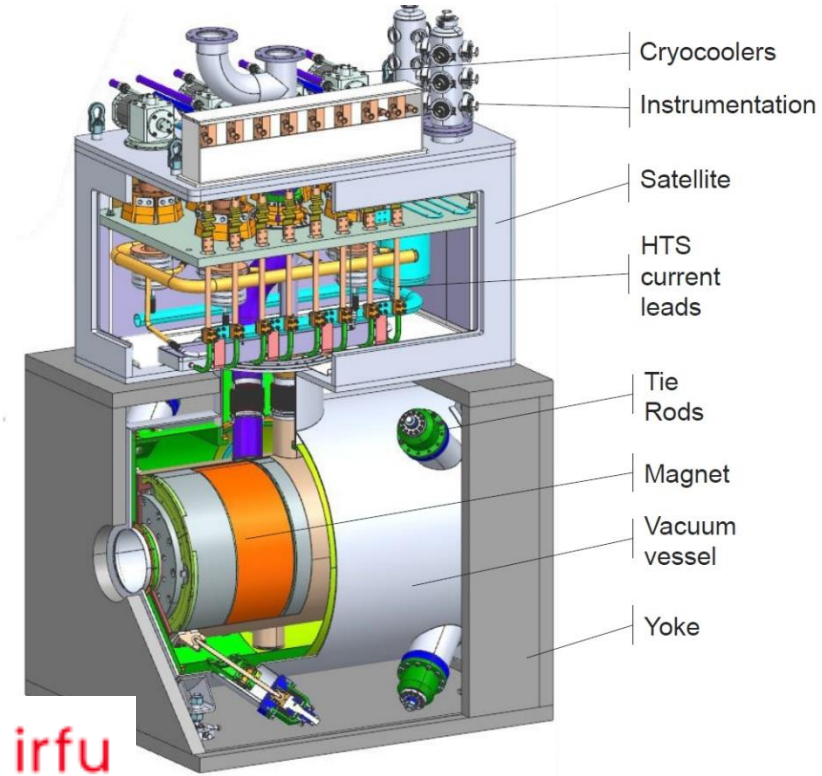
This source will be integrated and tested at the LPSC (CNRS/IN2P3) before transfer to GANIL

ASTERICS SC-source

Parameters	Values	vs VENUS
ECR frequency	28 GHz	
Max Axial Mirror Peak Field	3.7 – 0.1 – 2.5 T	
Radial Peak Field	2.55 T	
Chamber length	600 mm	**+20%**
Chamber radius	91 mm	**+26%**
Chamber volume	15.6 liter	**+92%**
ECR Length @ B_{min}=0.3 T	220 mm	**+15%**
ECR volume @ B_{min}=0.3 T	1.9 liter	**+58%**
Cooling power@ 4.2 K	10.8 W	
SC Cable	Nb-Ti	

The design is inspired by the VENUS/FRIB source.

Plasma chamber volume: multiplied by 1.9 (26% inner radius, 20% length) to meet the physics requirement: 10 pμA of U34+ (6 pμA obtained with VENUS).



LPSC Grenoble cea irfu

ASTERICS SC-source coils

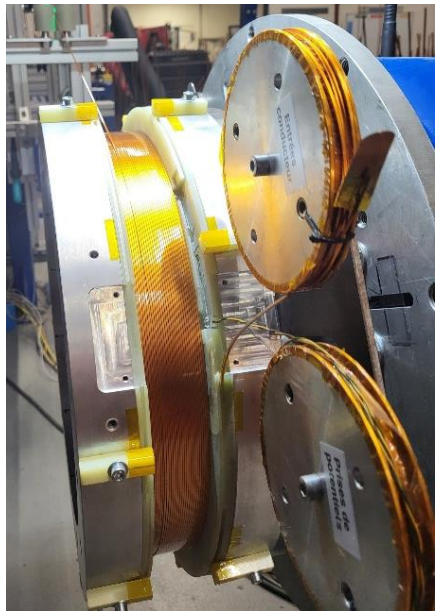
Industrial Strategy for the SC-coils:

- Order only the magnet without the ancillary components
- Supply the conductor, vacuum equipment and cryocoolers to the manufacturer (saving time and money)
- Provide a functional design of the magnet
- Impose certain technologies to be used (conductor, B&K, cryogenics, etc.)
- Ask the manufacturer to produce the detailed design, taking over responsibility for design and manufacturing
- Conduct cold tests of the magnet alone at the CEA and then of the cryostatized magnet at the LPSC

Safer but Expensive

- February – October 2026: Magnet prototyping
- October 2026: Magnet production
- November 2027: Magnet testing
- June 2028: Magnet + satellite assembly
- November 2028: Transport to LPSC Grenoble for source assembly
- April 2029: Commissioning and production

Solenoid



Sextuple

Radio-Frequency Quadrupole

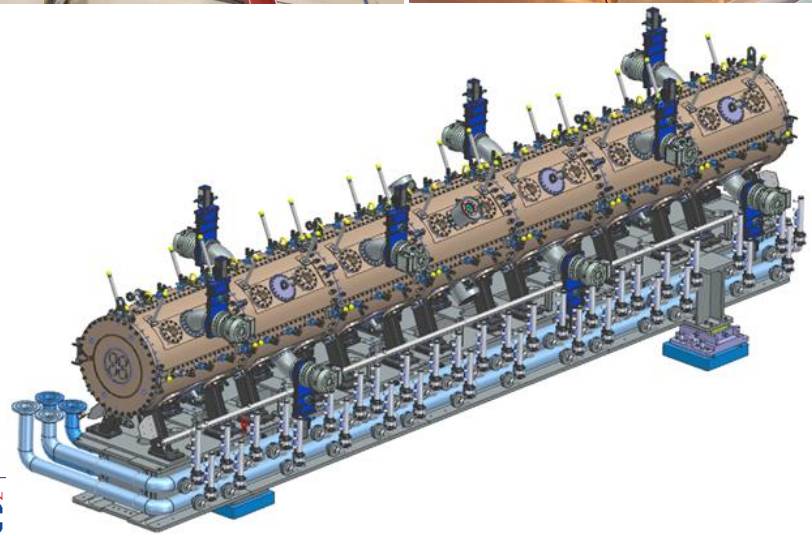
- **First RFQ of this type for heavy ions (solid copper) in Europe, allowing a very high transmission (> 98%)**
- **Same technology as the 1st RFQ of SPIRAL2 (risk reduction)**

Key Features:

- 7 sections
- 7 m long
- 0.8 m diameter
- 14 tons of copper
- Machining accuracy = ± 20 µm
- Assembly accuracy = ± 50 µm

- Vacuum level = 10^{-9} mbar
- 150 kW RF power
- 100 m^3/h of water for cooling

- March 24 – October 2026: Cavity manufacturing and assembly tests
- November 2026: RFQ installation @GANIL
- March 2027: Beadpull testing + Sizing of copper pistons
- July 2028: RFQ conditioning
- November 2028: RFQ ready for beam

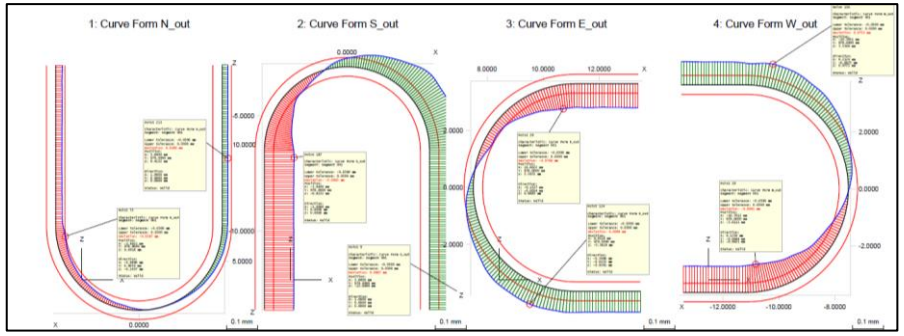


RFQ : Identified issue

One of the vanes of section T5 does not meet the required output tolerances : deviation between 80 and 100 µm

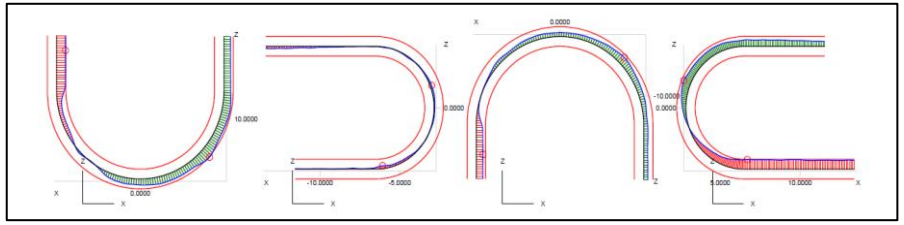
Very limited impact with no significant consequence expected on the final performance of the RFQ

Section T5 Meas.



Corrective Action : Search for a new assembly procedure on section T4 -> Validated ->To be confirmed on section T3

Section T4 Meas.



To be confirmed on section T3

Review of the rework on section T5 on sept. 26

1. Financial Risk: An additional cost of 25k€
2. Significant risk of damage during the handling and disassembly of the copper vanes

Building

06/01/2026

19/06/2026

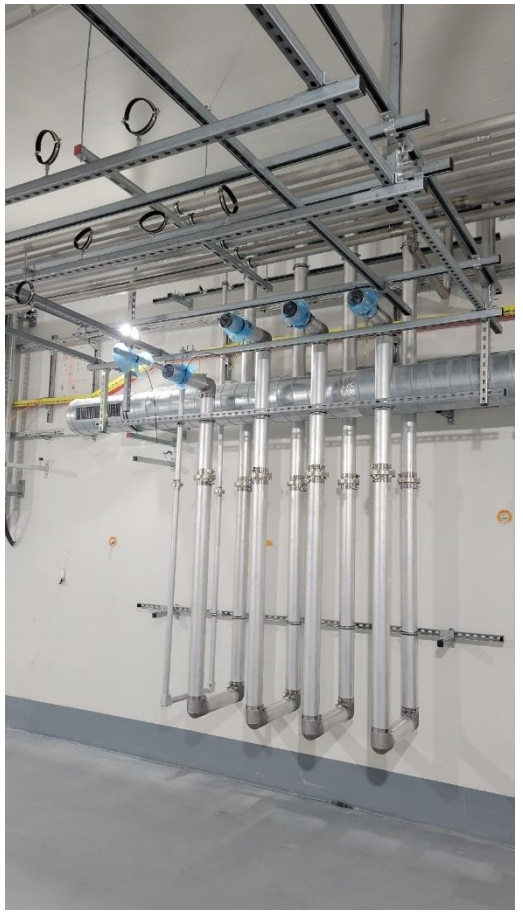
24/06/2024

Today ready to drilling

Facilities installation prior process installation

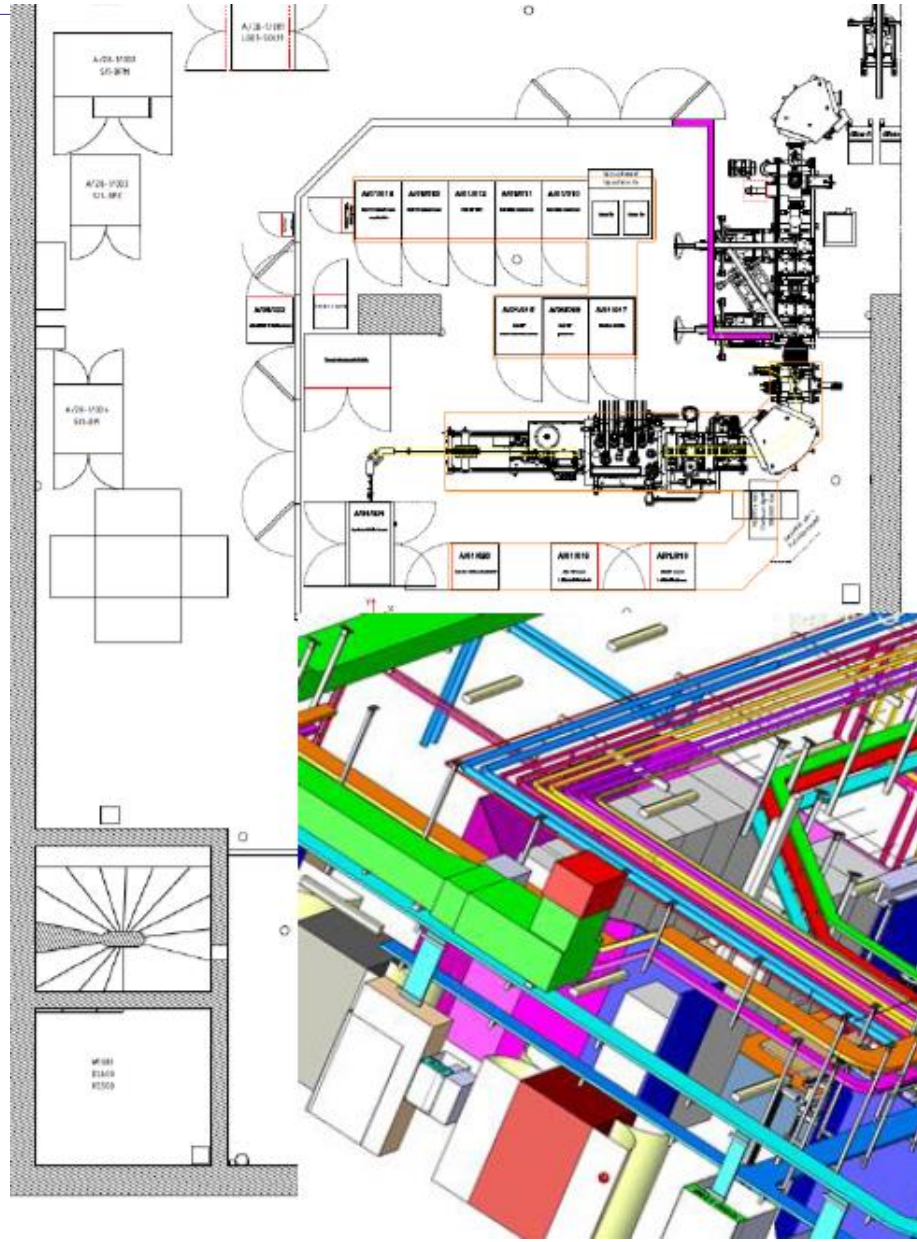
Drilling through the SPIRAL2 wall for the NEWGAIN beamline

NEWGAIN room ready for installation, awaiting drilling of the emergency exit



RFQ feeders pre-installation

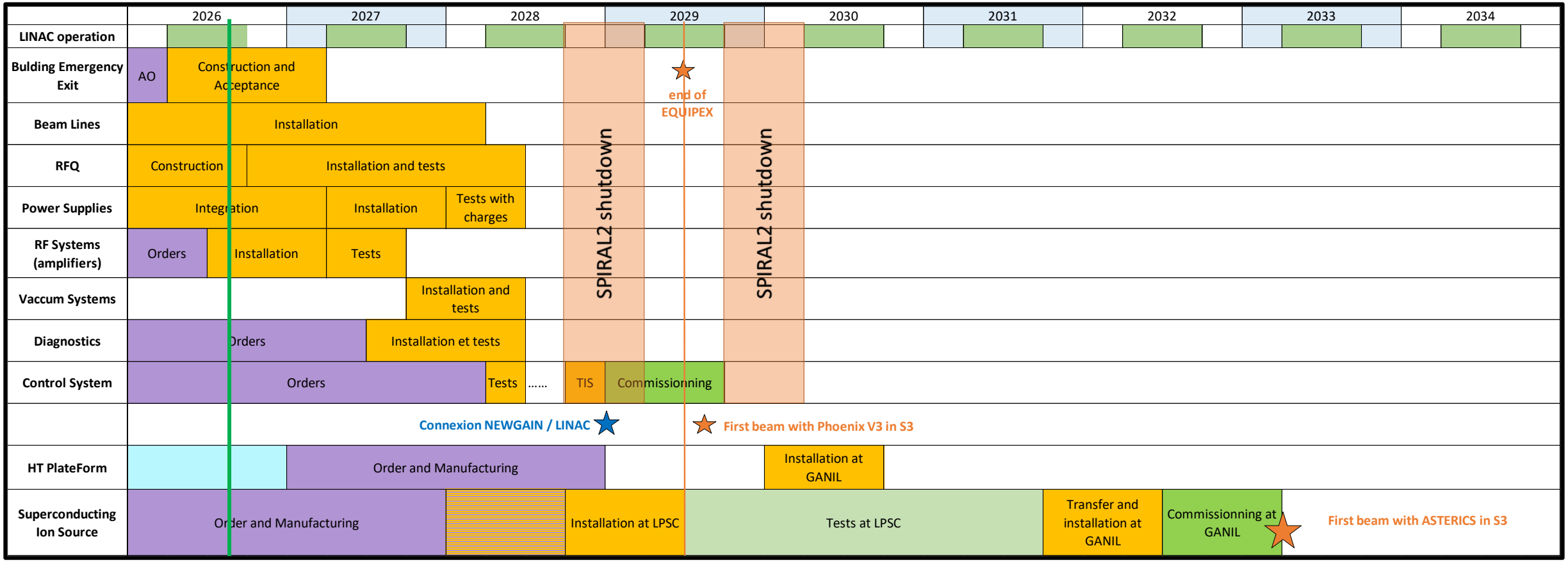
3D integration tools



Very complex interface with existing SPIRAL2 machine.

A lot of equipment to insert into an already very constrained space

Schedule


2026
2027
2028
2029
2030
2031
2032
2033
2034
LINAC operation
Bulding Emergency Exit
AO
Construction and Acceptance
end of EQUIPEX
Beam Lines
Installation
RFQ
Construction
Installation and tests
Power Supplies
Integration
Installation
Tests with charges
RF Systems (amplifiers)
Orders
Installation
Tests
Vaccum Systems
Installation and tests
Diagnostics
Orders
Installation et tests
Control System
Orders
Tests
.....
TIS
Commissionning
SPIRAL2 shutdown
SPIRAL2 shutdown
Connexion NEWGAIN / LINAC
First beam with Phoenix V3 in S3
HT PlateForm
Order and Manufacturing
Installation at GANIL
Superconducting Ion Source
Order and Manufacturing
Installation at LPSC
Tests at LPSC
Transfer and installation at GANIL
Commissionning at GANIL
First beam with ASTERICS in S3

Conclusions

Achievements & Milestones (On Track)	Points of Attention & Risks
• **May 2025:** SPIRAL2 line modified (vacuum chamber / LBE12 dipole) • **NEWGAIN Project:** Progressing well, still on time. • **2029:** First beams in GANIL and start-up of **ASTERICS** source (LPSC).	• **Civil Engineering (August):** Emergency exit drilling critical for equipment installation -> **Delay** • **Human Resources:** Strict workload plan being consolidated @GANIL • **> 2031:** SC source integration @GANIL

THANK YOU FOR YOUR ATTENTION