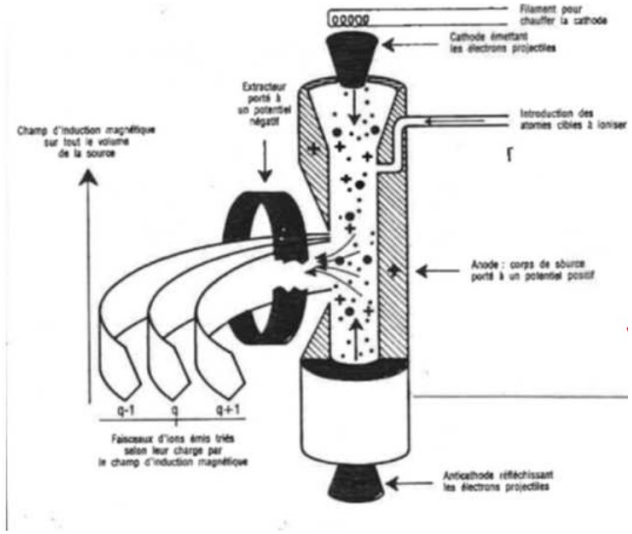
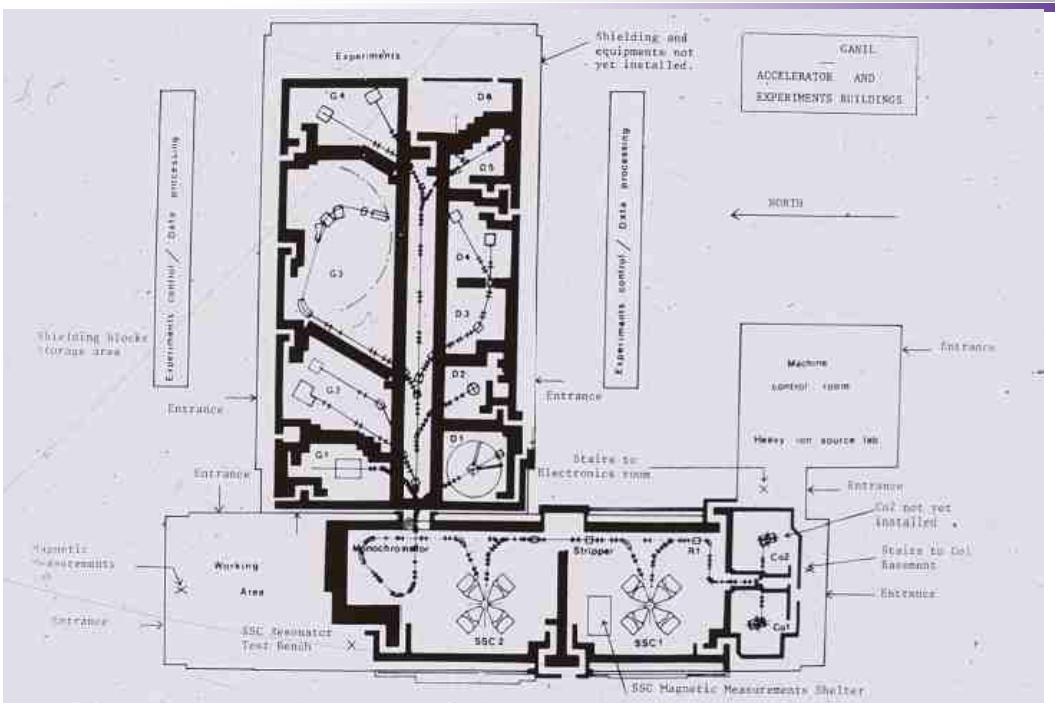
GANIL-SPIRAL2
Introduction

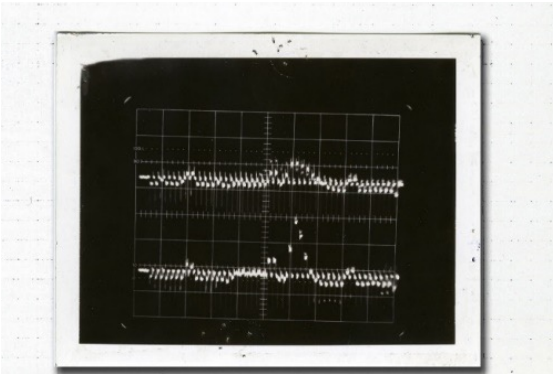
40th Anniversary of first GANIL experiment

GANIL-SPIRAL2





$^{40}Ar^{16+}$ 5 nA were ejected from 150 nA injected, starting from 200 nA $^{40}Ar^{4+}$ ejected of SSC1 from a PIG source



41st Anniversary of first GANIL extracted beam

A brief history of GANIL and SPIRAL2

1976 Creation of GANIL GIE
(Grand Accélérateur national d'ions lourds)

2001 SPIRAL1 exotic beams

2006 SPIRAL2 Project signature of convention for construction
Inclusion on European Strategy Forum for Research Infrastructures (ESFRI) roadmap

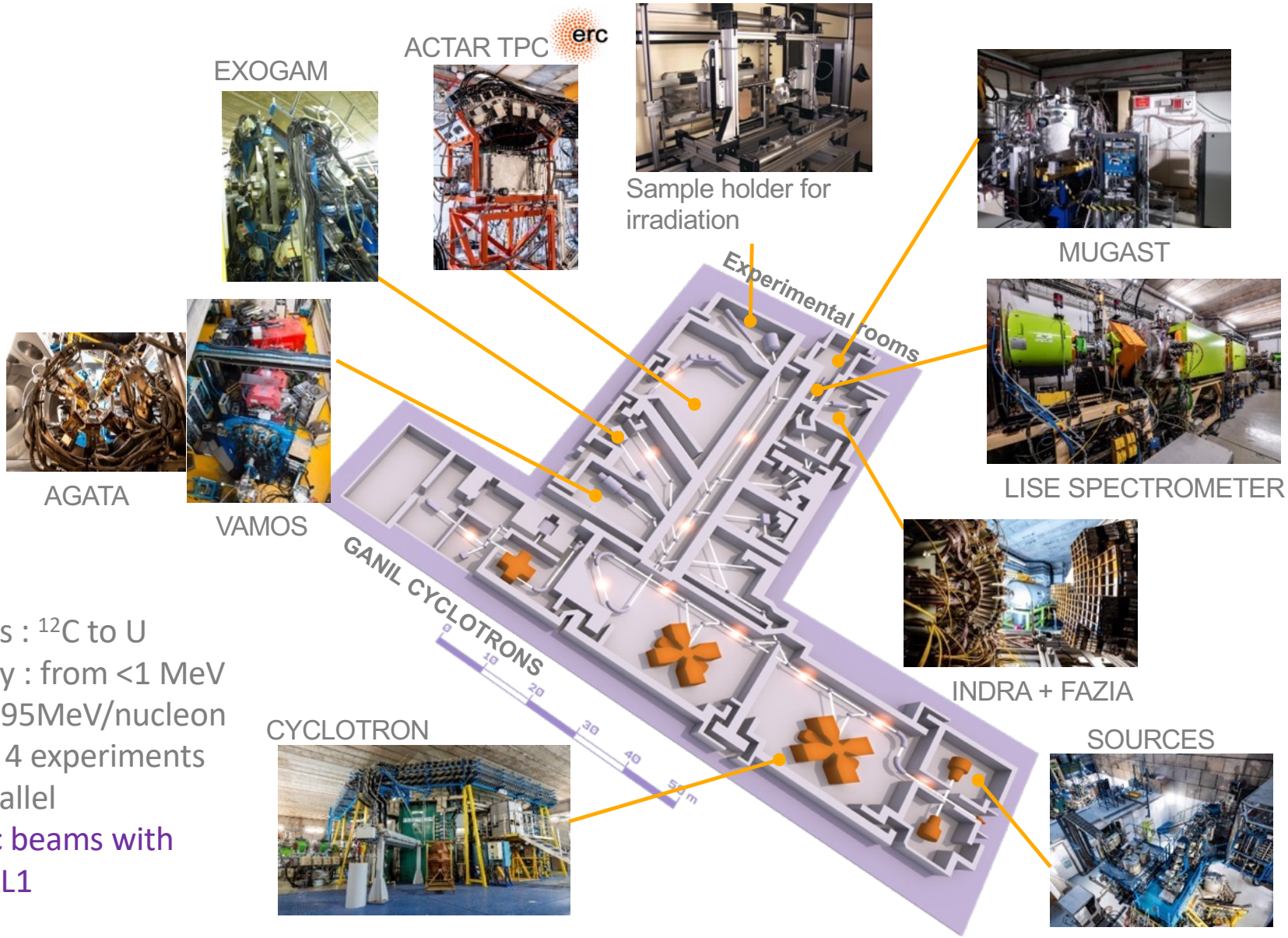
2011 Start of SPIRAL2 Construction

2019 Start of the SPIRAL2 commissioning

2020 First neutron beams at SPIRAL2

2022 First heavy ion beams at SPIRAL2

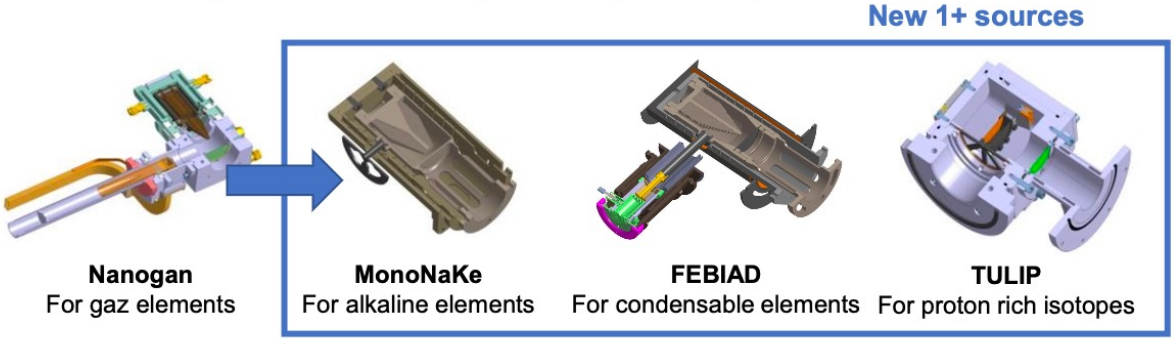
GANIL Cyclotrons and experimental equipment



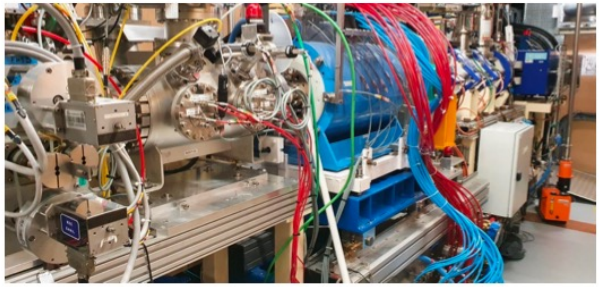
- Beams : ^{12}C to U
- Energy : from <1 MeV up to 95MeV/nucleon
- Up to 4 experiments in parallel
- Exotic beams with SPIRAL1

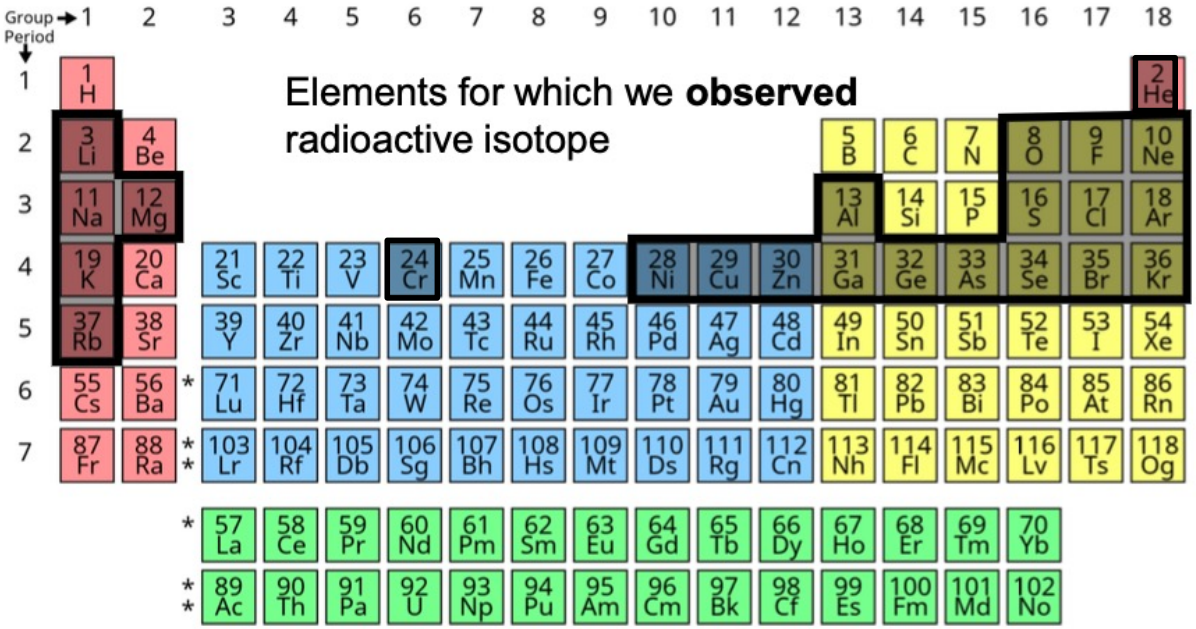
SPIRAL1 upgrade

- New target Ion Source Systems (FEBIAD)



- The charge breeder





50 new isomers/isotopes
With intensities suitable for acceleration

CYREN – Cyclotron Renovation

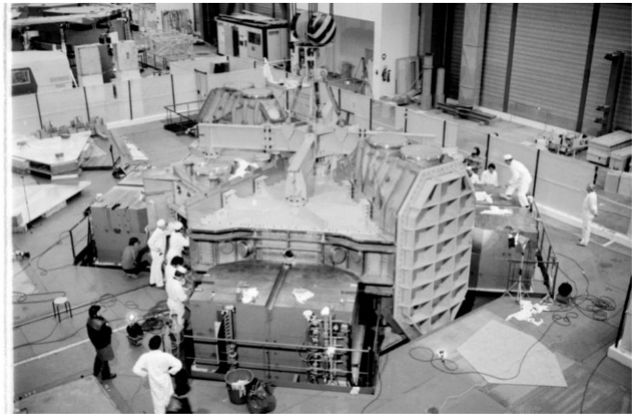
Last 10 years : Cyclotrons maintenance and refurbishment reduced to the strict minimum.
GANIL manpower dedicated to SPIRAL2 building then commissioning.
Aging ↗ Reliability ↘ Manpower for curative maintenance ↗

Launch of the pre project CYREN : march 2022
1: keep the facility in operational conditions for at least 20 years
2 : optimize manpower needed for maintenance after refurbishment

Scope : full installation
Cyclotrons and experimental areas, infrastructure and utilities, safety, security, radioprotection

Conclusion: 2 scenarios
One new accelerating cavity/ 4 new cavities

Implementation:
Dedicated funding from Minisitry, 2024-2030,
facility available during renovations with possible shutdowns during some phases



Cyclotrons et experimental rooms
Power Supplies and Magnets
RF cavities and systems
Remote control
PLCs
Vacuum systems
Diagnostics
Production targets
Ions Sources

Infrastructures and utilities
Electricity Distribution
Cooling systems
HVAC
Buildings
Various networks (water, air, gas)
Computer Infrastructures

Safety / Security / Radioprotection Systems

Radioprotection devices *(radiation detectors, active dosimeters, gamma spectrometers, …)*

Access Management System

Fire Safety System

SPIRAL2 LINAC and the new experimental rooms

EXPERIMENTAL ROOM NFS
(NEUTRONS FOR SCIENCE)

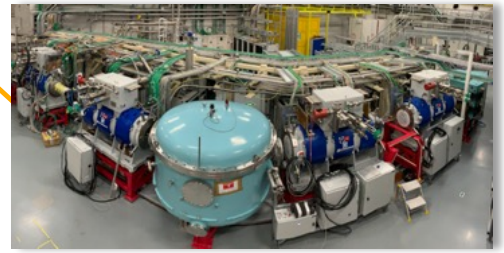
Convertor room

Time of Flight room

EXPERIMENTAL
ROOM DESIR
(Desintegration,
Excitation and
Storage of
Radioactive Ions)

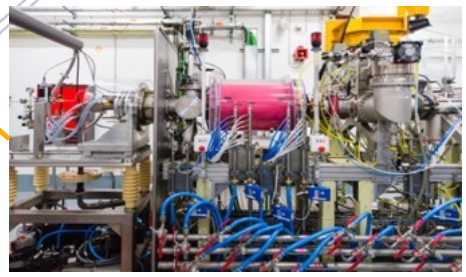
FRANCE 2030

LINEAR accelerator
(LINAC)



EXPERIMENTAL ROOM
S3 (SUPER
SEPARATOR
SPECTROMETER)

FRANCE 2030



ION SOURCE

NEWGAIN
NEW GANIL INJECTOR

FRANCE 2030

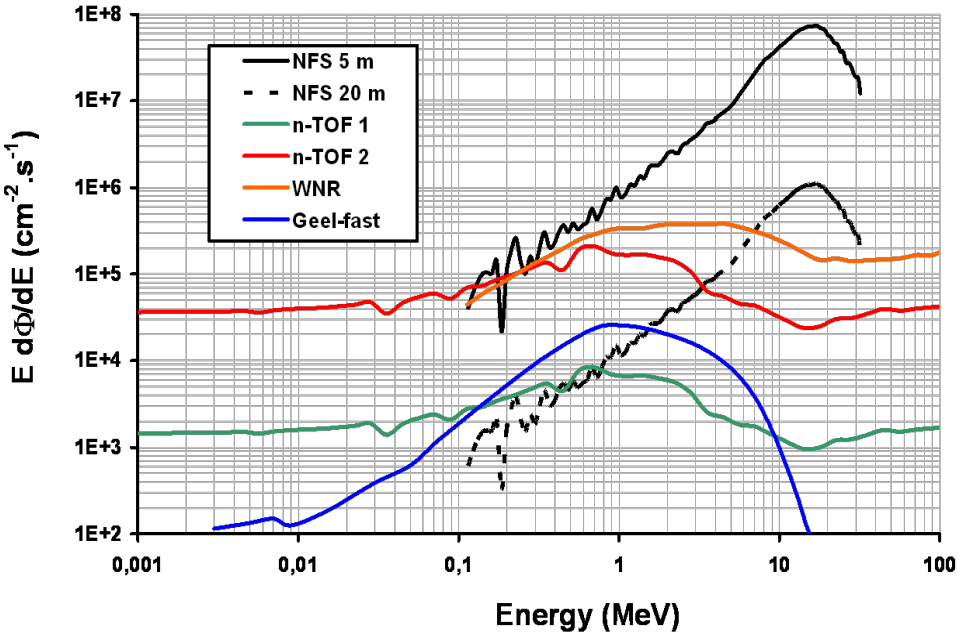
High intensity beams :
5 mA, 33 MeV protons
5 mA, 40 MeV deutons
1 mA, <14,5 MeV/A heavy ions

NFS is the first operational experimental area of SPIRAL2

International collaboration
50 physicists
15 laboratories
6 partners

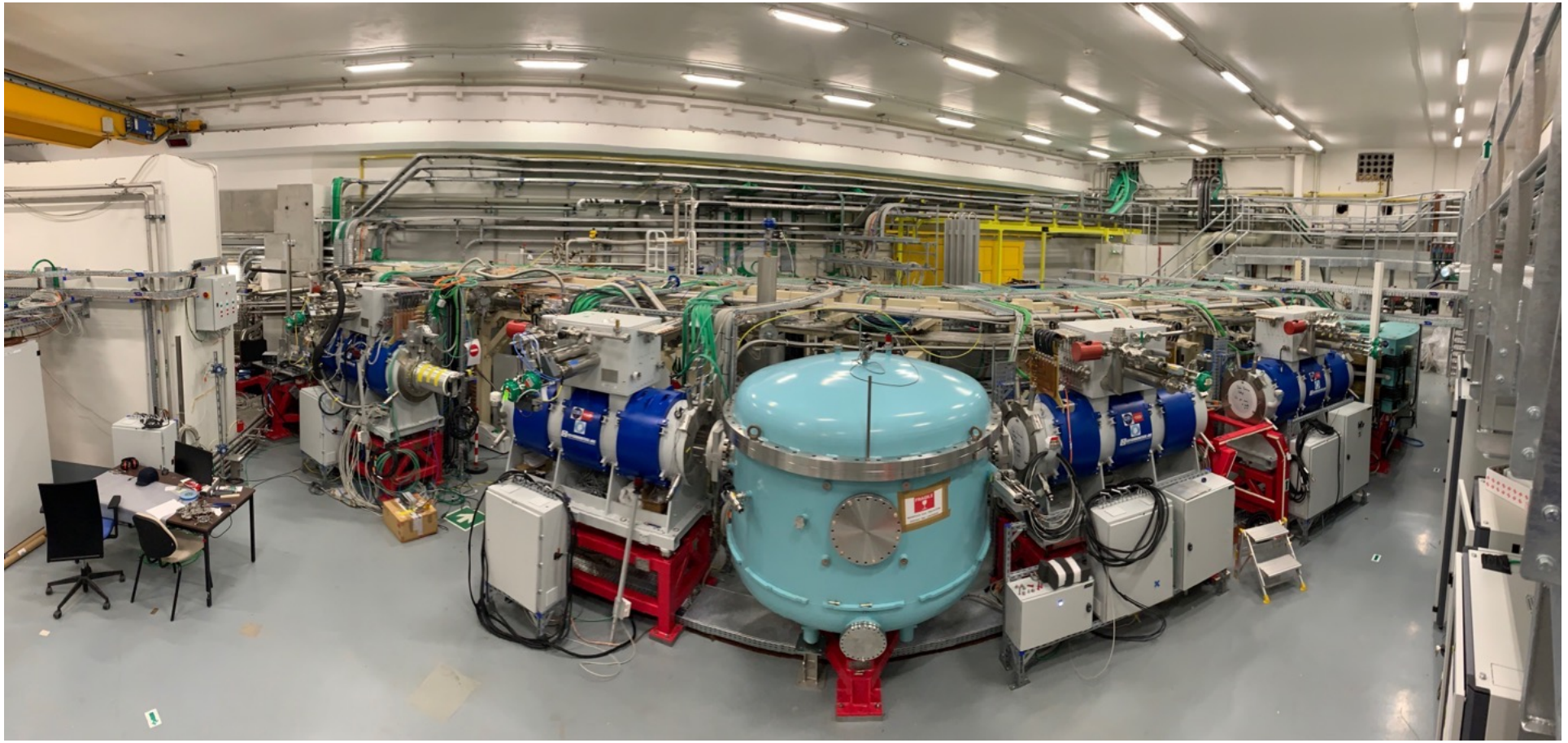
Physics case

- ❑ Fundamental physics
- ❑ Astrophysics
- ❑ New generation of reactor
- ❑ Fusion technology
- ❑ Radioisotopes production for medical applications
- ❑ Biology (cells irradiation..)
- ❑ Development and characterization of new detectors
- ❑ Study of the single-event upsets



High neutron flux and good complementarity with other facilities

S3: the Super Separator Spectrometer



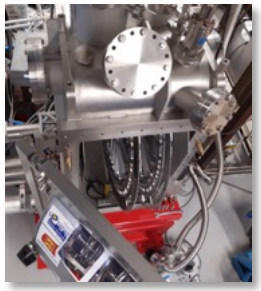
S3: the Super Separator Spectrometer

Fundamental research in **Nuclear & Atomic physics**

- High selectivity > 10^{13} beam rejection
- High efficiency 50%
- Mass resolution > 350
- Versatility : high resolution, high transmission, high beam rejection modes…
- Unique instrumentation : SIRIUS for p, α, electron and γ spectroscopy, and S3-LEB with gas catcher, RFQ and MR-ToF-MS

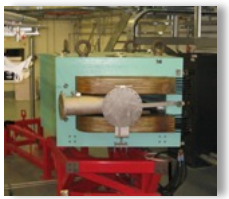
Optical
Commissioning
Planned end 2024
SIRIUS commissioning in 202

Target system



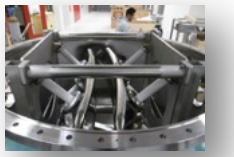
High power rotating targets

3 × M-dipoles



Large H & V gaps

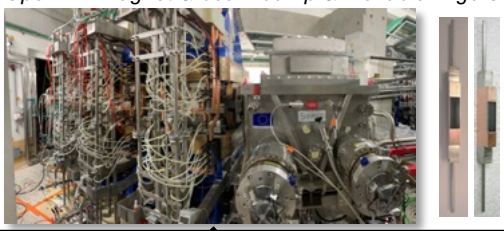
E-Dipole

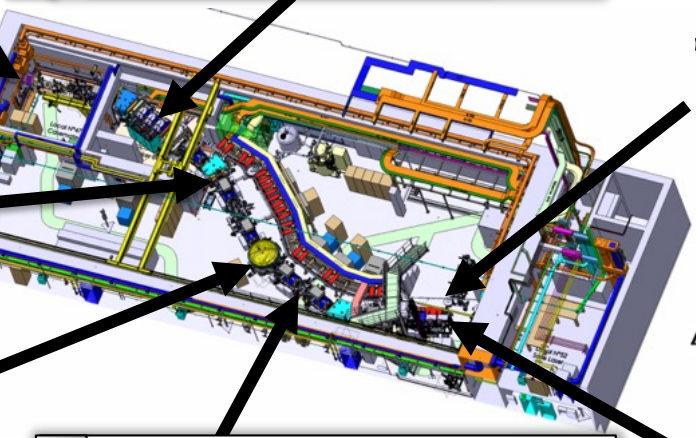


20 cm gap & +/- 300 kV
Open slit in the anode

Dispersive zone

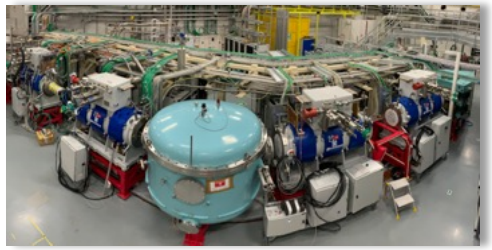
Open RT magnet & beam dump & Movable fingers





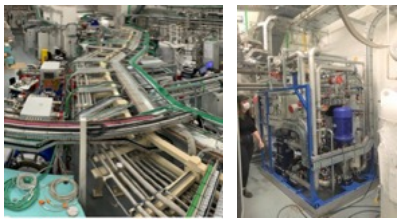
SC Multipoles

SMT, PSS, Coldbox & LTC



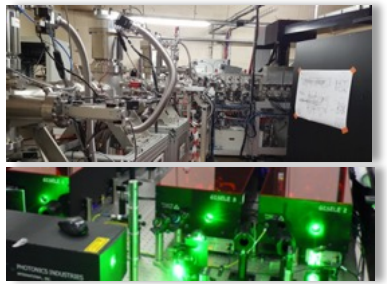
Infra / Interface

Cooling system, Laser room …



LEB

LEB @ LPC & GISELE Laser Lab

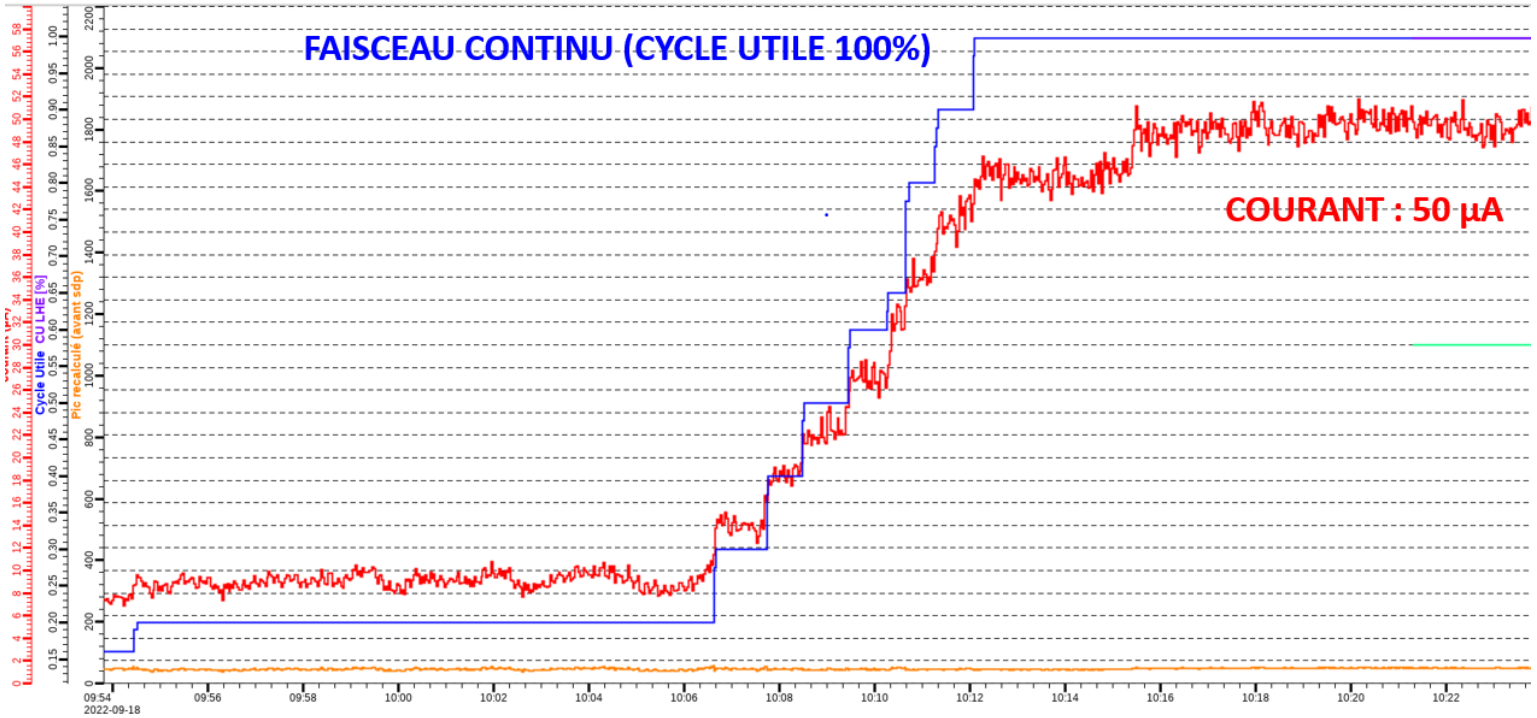


SIRIUS

DSSD, SSD, FEE/BEE, DAQ & Diagbox

Heavy-ions in SPIRAL2-LINAC

September 2022 : First beams of $^{18}O^{6+}$ 50μA, 7 MeV/nucleon
LINAC Transmission 98%
Quasi-automatic change of different charge states for acceleration



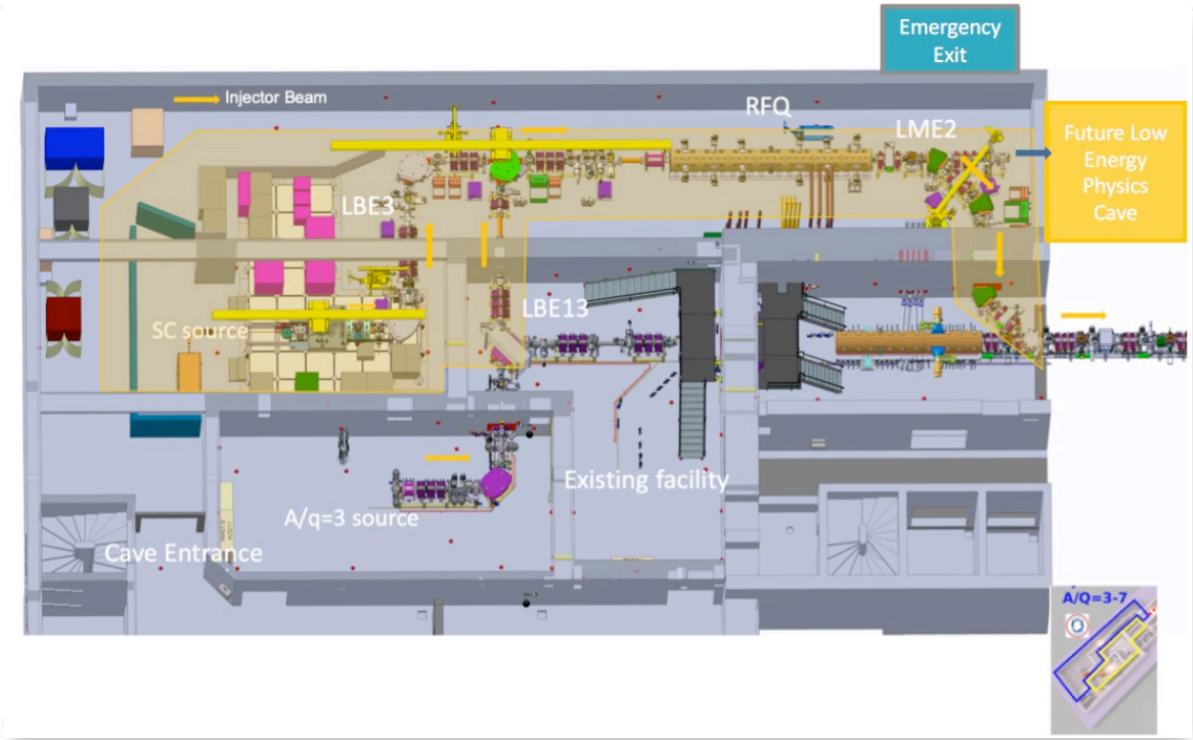
November 2022 : $^{40}Ar^{14+}$ 80μA, 7 MeV/nucleon

Getting ready for S3 scientific programme …

New injector for SPIRAL2: NEWGAIN

NEWGAIN
NEW GANIL INJECTOR

Floorplan, design intensities and time line



beam intensities	injector1 2023	NEWGAIN (injector2) 2028	NEWGAIN (injector2) ≥ 2030
Ions	Intensity (pμA) Phoenix V3 RFQ A/Q≤3	Intensity (pμA) Phoenix V3 RFQ A/Q≤7	Intensity (pμA) SC Ion Source RFQ A/Q≤7
^{18}O	80	*	375
^{19}F	>15	>40	>40
^{36}Ar	16	70	45
^{40}Ar	3.6	70	45
^{36}S	2.3	*	*
^{40}Ca	2.9	10	20
^{48}Ca	1.2	10	20
^{58}Ni	1.1	4	**8**
^{84}Kr	0.1	10	**20**
^{139}Xe	0.001	7	**>10**
^{238}U	<<0.001	0.1	**6**

Measured | Estimated

* -> no estimation

NEWGAIN *White Book*

https://www.ganil-spiral2.eu/scientists/ganil-spiral-2-facilities/accelerators/newgain/

NEWGAIN *time line*

2020	2021	2022	2023	2024	2025	2026	2027	2028
Study Phase			Construction Phase					*first beam*

Courtesy of MH Moscatello, D. Ackermann

NEWGAIN Project – intensity

Comparison between different installations relevant to SHE studies

Beam intensities puA **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]

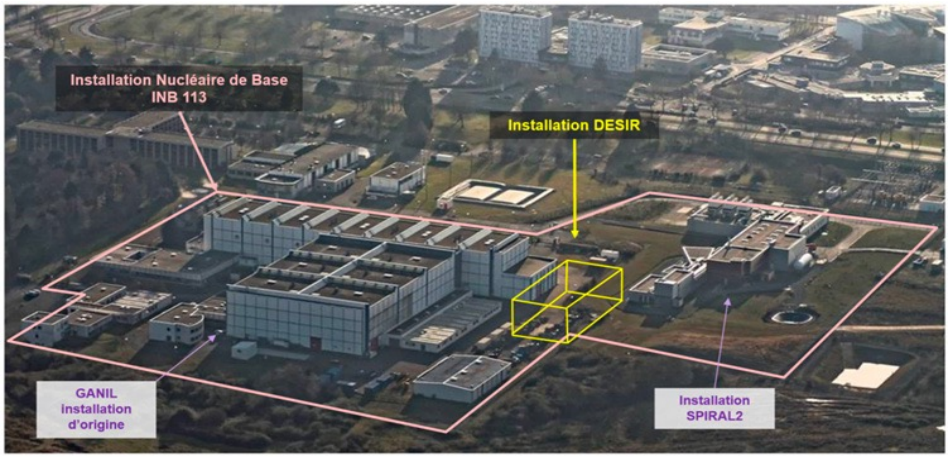
* 80% total transmission assumed
** http://flerovlab.jinr.ru/index.php/2017/03/23/she-factory/
*** for the cw-linac project with the assumption of a 50% total transmission, priv. comm. W. Barth et al., GSI
**** beams not delivered
i VARIS ion source, 80% Alvarez-transmission, mode: 2 Hz/0.1 ms, priv.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

Highest intensity

Rates (pps)	S3 LEB (A/Q=3)	S3 LEB (A/Q=7)	FRIB1	FRIB2	FRIB Final
^{100}Sn	7	34	0.05	0.2	4
^{101}Sn	170	850	3	10	161
^{97}In	0.2	2.6	0	0	0
^{98}In	4	11	0.02	0.09	4
^{99}In	80	800	2.7	13	316
^{100}In	740	7400	231	1150	18400
^{98}Cd	3600	18000	505	2520	105000
^{97}Cd	19	95	6.4	32	2030
^{96}Cd	3	15	0.24	1.2	89
^{95}Cd	0.4	2	0.004	0.02	1.6
^{94}Ag	136	680	0.04	0.2	20
^{95}Ag	870	4350	30	152	14700
^{91}Pd	81	405	0.02	0.12	27
^{92}Pd	810	4050	1.7	8	1870
^{90}Rh	210	1050	0.02	0.09	52

N=Z nucleus | **Highest intensity**

Courtesy Iulian Stefan

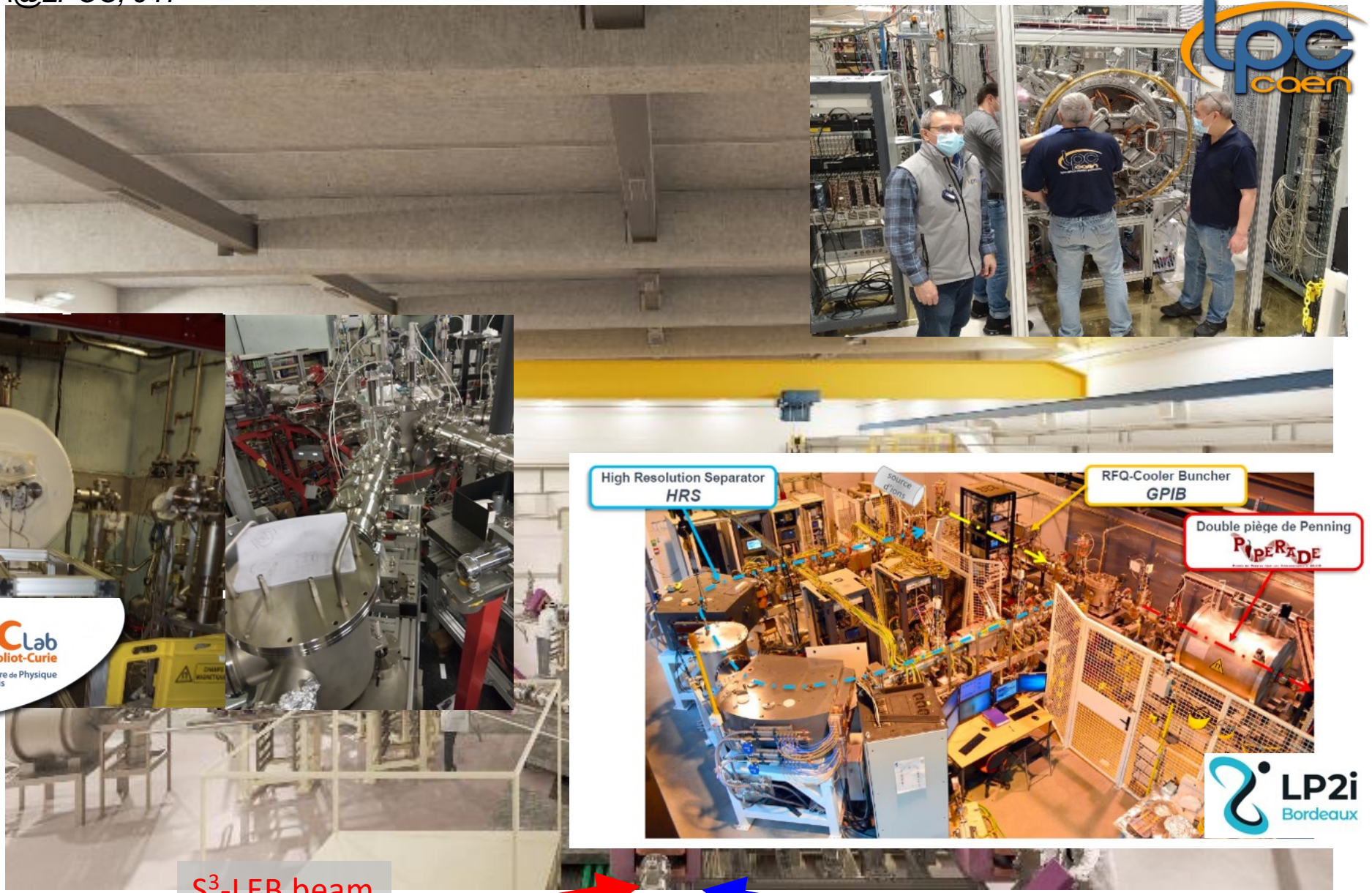


Contracts for construction signed in September 2022

Authorisation obtained from Nuclear Safety Authority and Environmental Authority

- public inquiry April 24-May 26
- permit for construction received in June,
- First experiments 2027

MLLTRAP@IJCLab
GPIB, PIPERADE@LP2IB
MORA@LPCC, JYF



Welcome

GANIL is a unique facility for

- R&D for ion manipulation, trapping, boosting, laser ionisation…
- challenging scientific programs with high intensity stable and exotic beams and thin targets

We thank the organisers, the initiators and the participants of the workshop to discuss and develop the so important fields of ion sources and targets, at this very special moment where so many projects are about to start and need this crucial emphasize on this very particule R&D

Wishing all of you a very fruitful meeting !

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A tribute to….

Rodolphe Clédassou