GANIL ACCELERATOR FACILITIES : STATUS & PERSPECTIVES

NEWS FROM GANIL
SPIRAL1 Development
LINAC Commissioning
Status of SPIRAL2 Projects : NFS, S3, DESIR & NEWGAIN
Perspectives : beam-sharing between experimental halls CYCLOTRONS
AI for accelerators

Fanny Farget, Deputy Director of GANIL

*Special thanks to: Guillaume Normand, Marco Di Giacomo, Jean-Michel Lagniel ,
Angie Karina Orduz, Didier Uriot, Adnan Ghribi and* ***Bertrand Jacquot***

NEWS FROM GANIL

40^{th} Anniversary of first GANIL experiment

A brief history of GANIL

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

1983 First experiment

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

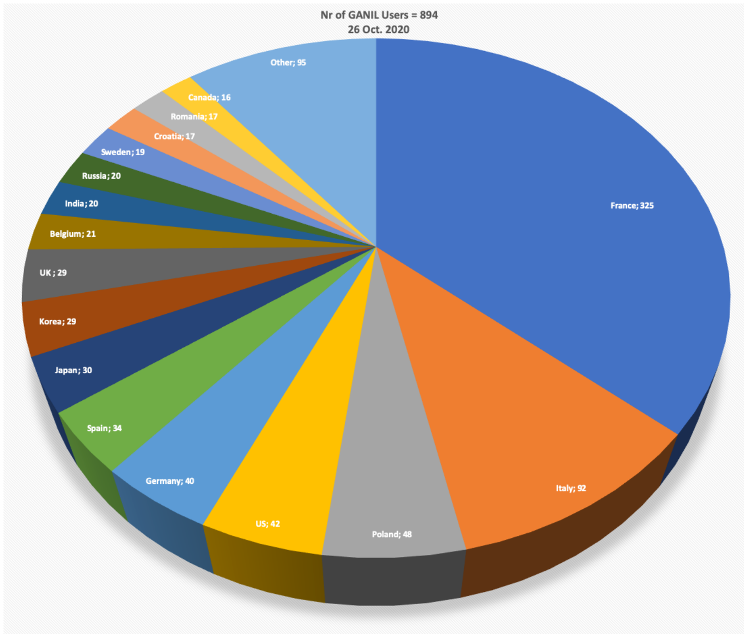
2022 First heavy ion beams at SPIRAL2

Some numbers

• 230 permanent staff members (28 CEA and CNRS researchers, engineers, technicians) + 70 temporary staff (20 PhD, 11 postdocs)

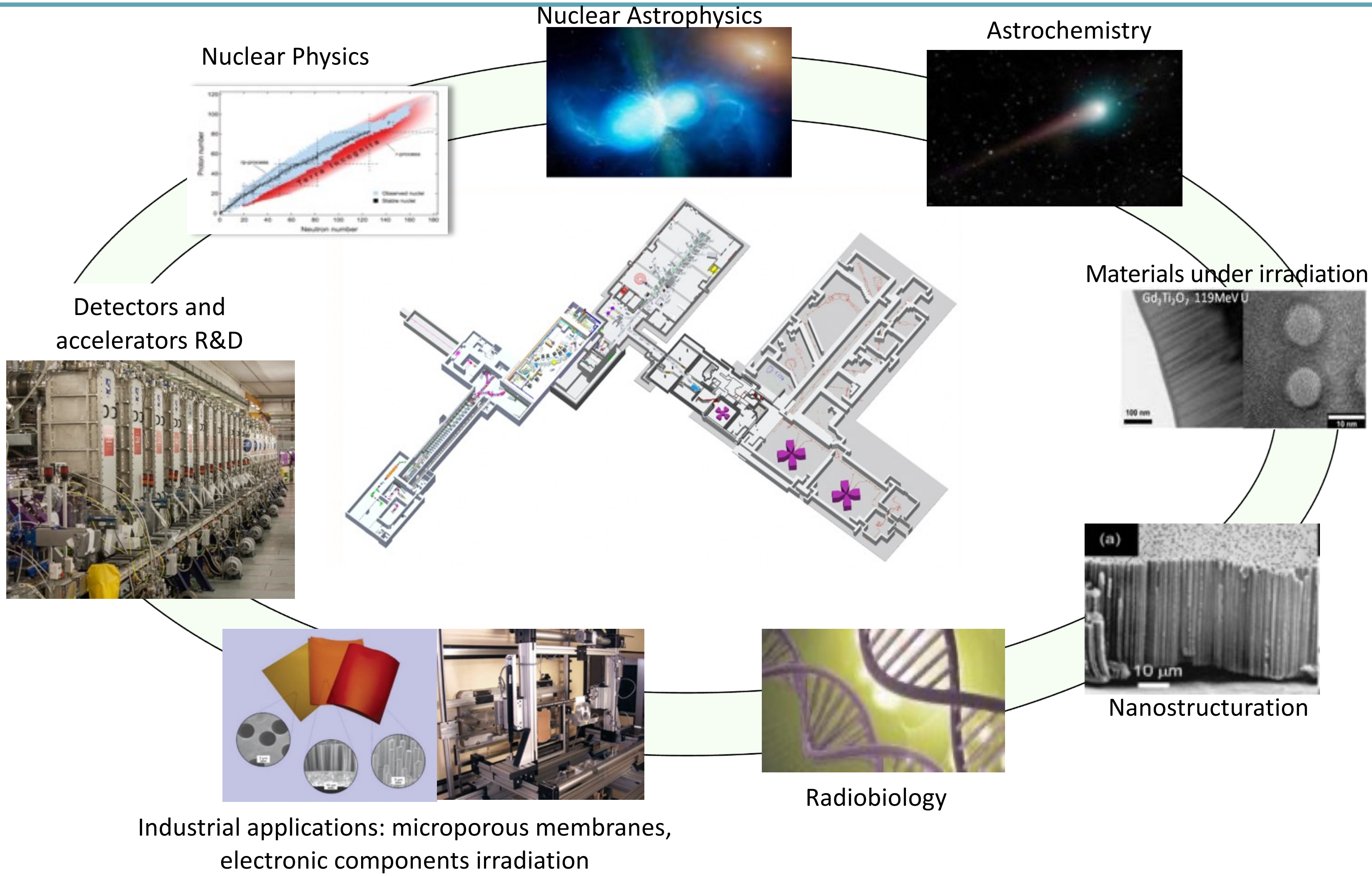
+ CIMAP = 24 permanent staff + 15 PhD + 8 postdocs

• An international scientific community of ≈ 1000 members



France
Italie
Pologne
USA
Allemagne
Espagne
Japon
Corée
Royaume Uni
Belgique
Inde
Russie
Suède
Roumanie
Canada

GANIL: a multidisciplinary and multi-users laboratory



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Secrétaire - Grégory LEBERTRE
Secrétaire adjoint – Maria BLAIZOT
Référent harcèlement – Jean-Eric DUCRET

Conseil d'Unité CNRS
Présidente – Fanny FARGET

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Adjointe à la Cheffe de l'UGP CEA - Christine TIQUET

Fonctionnaire Sécurité Défense - Nicolas Ménard
Foctionnaire Sécurité Défense adjointe - Christine Tiquet

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Fanny FARGET- Directrice adjointe

Stéphanie PUPIN - Assistante

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Cheffe d'Installation INB 113 – Fabienne LEMAIRE
Conseiller en radioprotection – Mathieu DUPUIS
Chargé de la Sécurité du Système d'Information – Nicolas MENARD
Conseiller à la Sécurité pour le Transport de Marchandises Dangeureuses - Jérôme DELAMARE
Préposé à la Garde des Matières Nucléaires – Yoann TREHUDIC
Correspondante Formation – Sandrine DUBROMEL
Responsable Qualité - Stéphanie PERRET-GATEL
Ingénieur environnement - Franck SOBRIO
Référent Développement Durable - Franck SOBRIO
Responsable de la Gestion des Déchets - Franck SOBRIO
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Cellule Sûreté Qualité
Vincent CINGAL - Responsable

Cellule Coordination des Programmes
Pascal ANGER - Responsable

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Alain SAVALLE - Resp. adjoint

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Christophe LESIGNE - Responsable
Jean-Claude FOY - Resp. adjoint

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Guillaume NORMAND - Responsable

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Mickaël DUBOIS - Responsable

Equipements Faisceaux
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Contrôle Commande et Automatisme
Christophe HAQUIN - Responsable
Nicolas SIMON-BAUDUIN - Resp. adjoint

Mécanique
Franck LUTTON - Responsable
Alexis LEFEVRE - Resp. adjoint

Opération
Olivier DANNA - Responsable
Omar KAMALOU - Resp. adjoint

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Romuald LEVALLOIS - Responsable
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FINDS
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Techniques d'Acquisition
Luc LEGEARD - Responsable
Gilles WITTWER - Resp. adjoint

Mise à jour du 15 janvier 2024

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Division Opération et Développements

Gilles SÉNÉCAL - Responsable
Alain SAVALLE - Resp. adjoint

Isabelle COME - Assistante
Joëlle LORUSSO - Assistante (10%), DESIR (90%)

Anthony DUBOIS
Assistant Responsable Exploitation et Qualité

Franck Esnault (40%)
Suivi d'actions techniques

Gestion et Ordonnancement des Installations

Christophe LESIGNE - Responsable
Jean-Claude FOY - Resp. adjoint

Instrumentation
Sébastien GAUTROT
Marius LECLUZE (Apprenti)
Thierry LEFROU

Mécanique & vide
Mickaël BOUCHARD (Opérateur)
Arnaud LECLUZE (Opérateur)
Franck MARIE-SAILLENFEST
Guilhem THERON

Electronique & automatisme
Djillali ALLAL
Arnaud GIRET
Charlie GOUYET
Fabrice LEPOITTEVIN (Opérateur)
Antoine WAGRET-QUATROMME

Opération

Olivier DANNA - Responsable
Omar KAMALOU - Resp. adjoint

Guillaume PESCHARD (GVC)
Vincent METAYER (GCS)
Mickaël BOUCHARD (GGOI)

Fabrice LEPOITTEVIN (GGOI)
Arnaud LECLUZE (GGOI)
Pierre LEDUC (G2CA)

Miguel BARBERA (G2i)
Wilfried BOUGY (G2CA)
Cyril PETIT VERNA (GCS)

Ghislain LEDU (GEF)
Frédéric DAVID (SSRE/Déchets)
Nicolas DEPIROU (GEF)

Stéphane LORET (GEF)
Cyril FINFE (GVC)
Sylvain AMESLANT (GO)

Christophe MAUGER (GEF)
Stéphane BONNEAU (G2CA)
Nicolas LECHARTIER (GCS)
Vincent MORIN (GEF)

Physique des Accélérateurs

Guillaume NORMAND - Responsable

Dynamique Faisceau
Bertrand JACQUOT
Mathieu LALANDE
Angie ORDUZ

Activité projet DESIR et NEWGAIN
Cyrille BERTHE
François HANCHIN
Mélanie LAMARCHE (80%)
Marie-Hélène MOSCATELLO
Eric PETIT
Franck VARENNE

Radio-Fréquence
Marco DI GIACOMO

AI pour les accélérateurs
Adnan GHRIBI
Charly LASSALLE (Doctorant)

Cibles et Sources

Mickaël DUBOIS - Responsable

Opération et développement faisceaux ions stables
Frédéric LEMAGNEN
Laurent GOULEUF
Vincent METAYER (Opérateur)
Benoît OSMOND (90%)

Opération et développement faisceaux ions radioactifs
Pierre CHAUVEAU (10%)
Samuel DAMOY
Romain FRIGOT
Stéphane HORMIGOS

Opération cibles
Benoît OSMOND (10%)

R&D faisdeaux ISOL
Vincent BOSQUET (Doctorant)
Pierre CHAUVEAU (90%)
Pascal JARDIN
Alexis RIBET

Opération et développement instruments associés
Arpan KHANDELWAL (Doctorant)

Support technique transverse
Nicolas LECHARTIER (Opérateur)
Cyril PETIT VERNA (Opérateur)

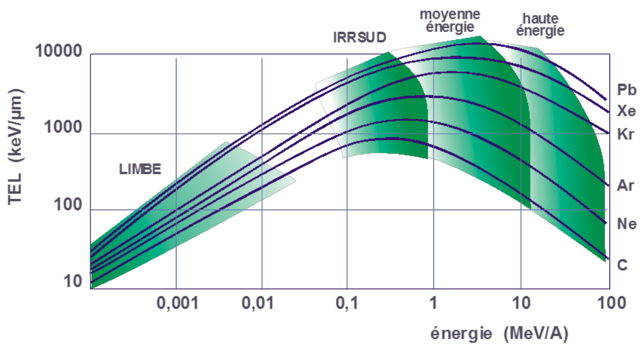
PhD Students :

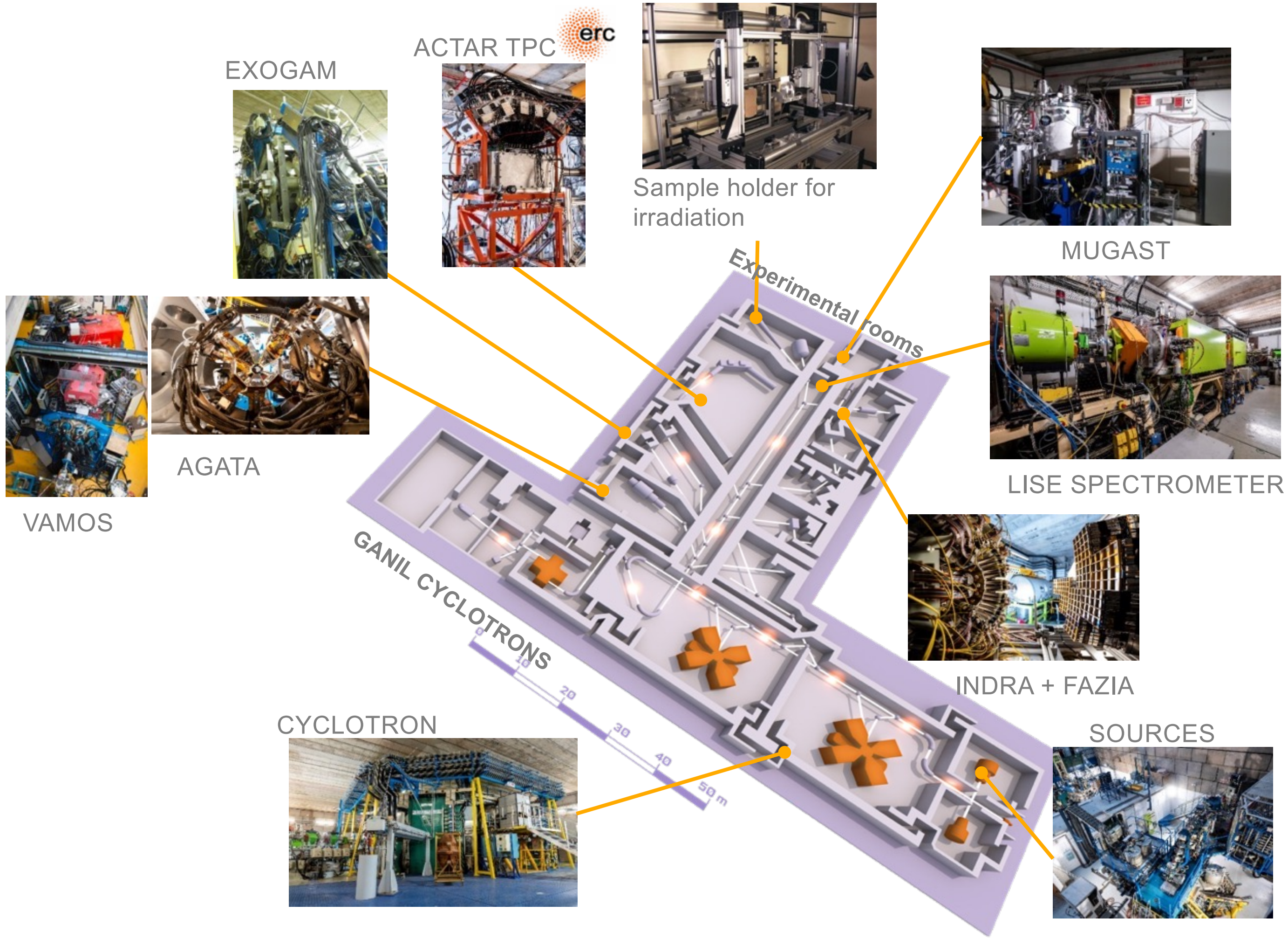
IA for automatic anomaly detection

Exotic beam production

Beam dynamics

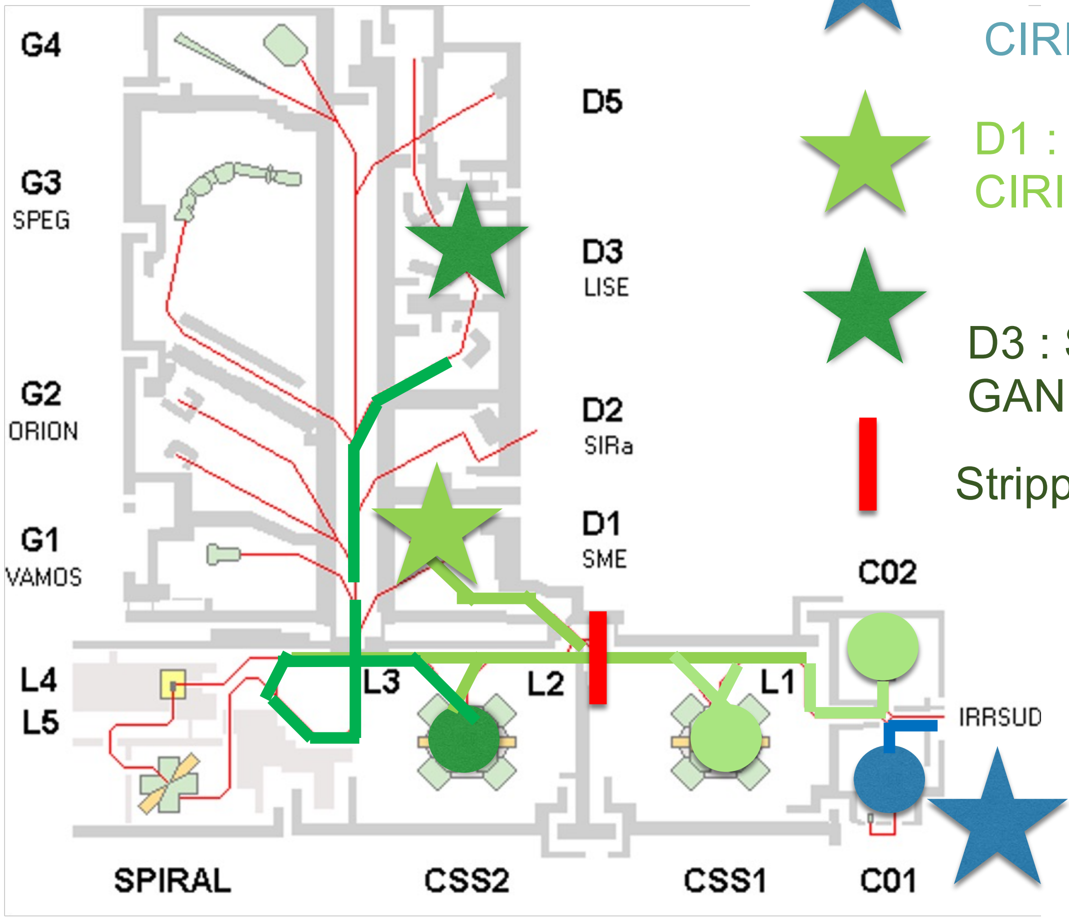
GANIL Cyclotrons and experimental equipment





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

Parallel operation

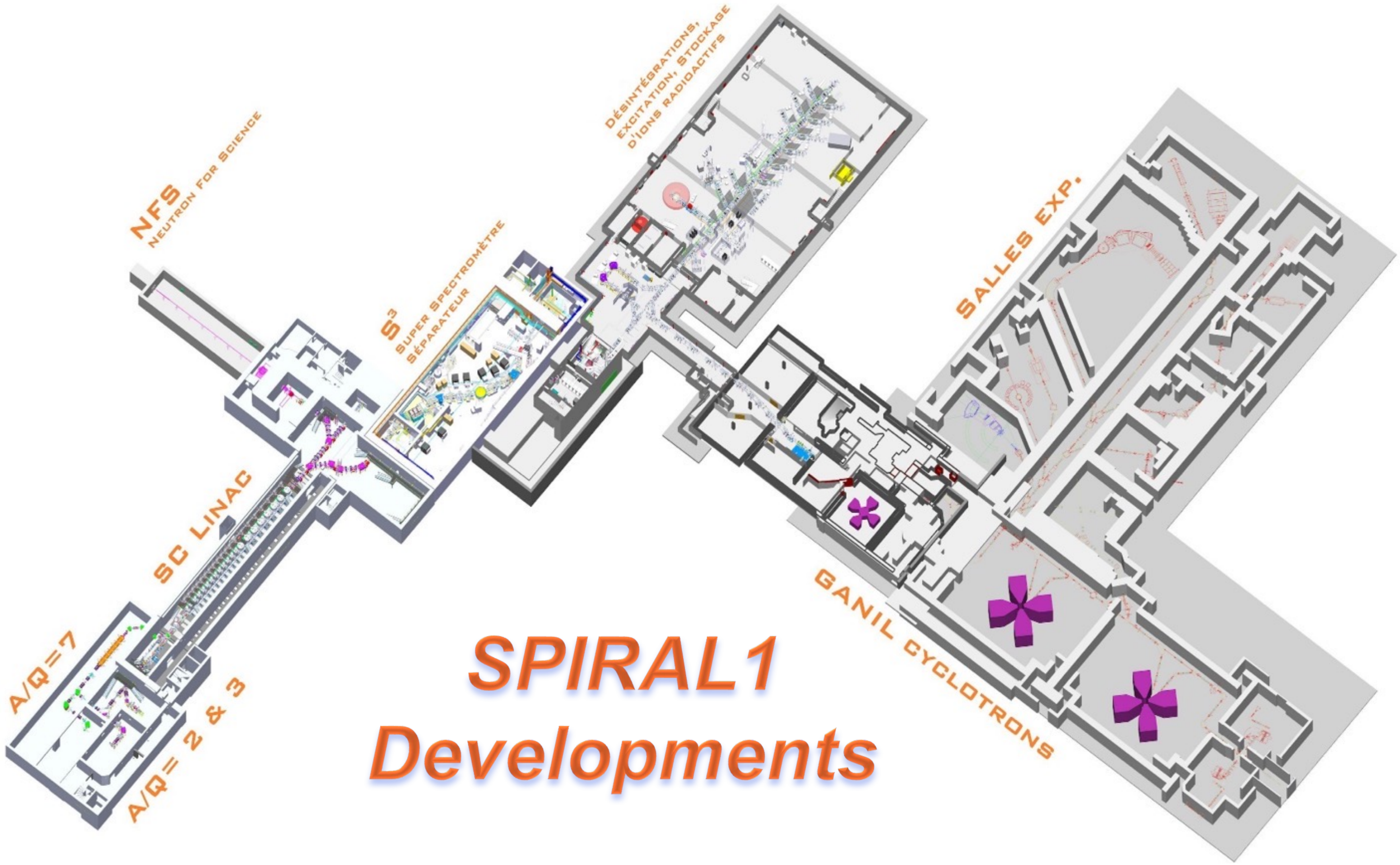


IRRSUD : Stable beams with E< 1 MeV/u
CIRIL

D1 : Stable beam 5-10 MeV/u
CIRIL

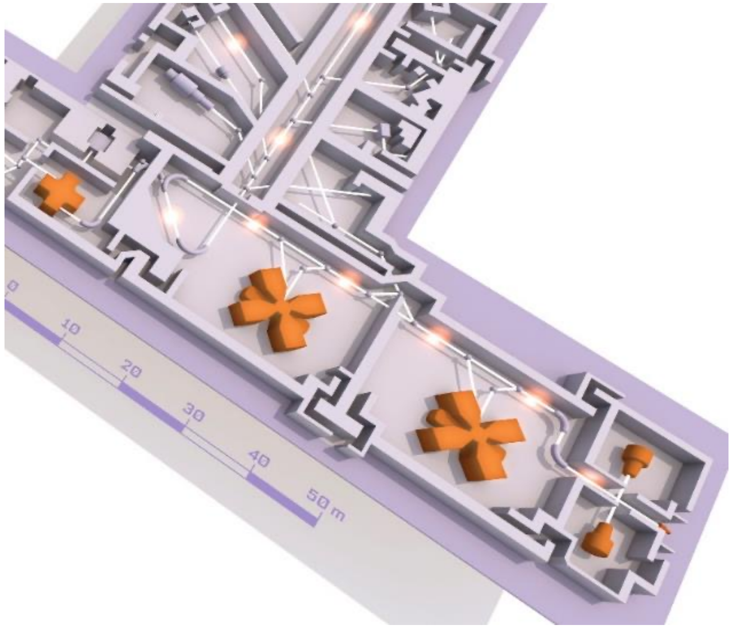
D3 : Stable beam 25-95 MeV/u
GANIL -

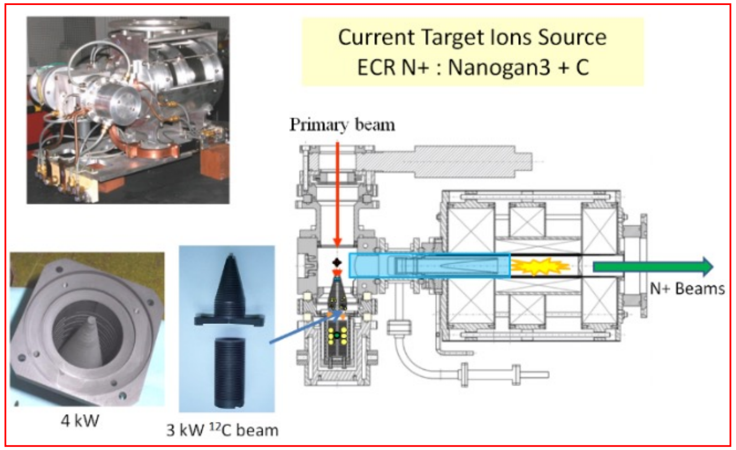
Stripper foil



SPIRAL1 Developments

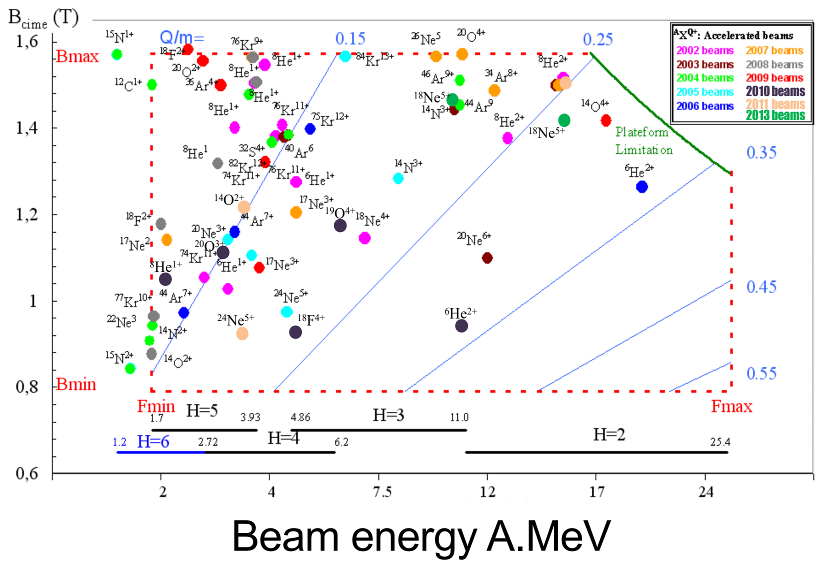
SPIRAL1





Key figures:

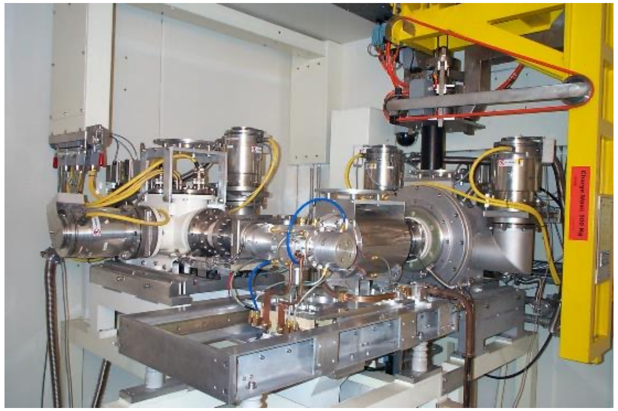
- 80 experiments with SPIRAL1 beams since 2001
- 35 isotopes delivered > 1^{E}+4pps
- $T_{1/2}$ min : 100ms (^{8}He)
- 62 Target ion sources (Production or R&D)
- >90 publications

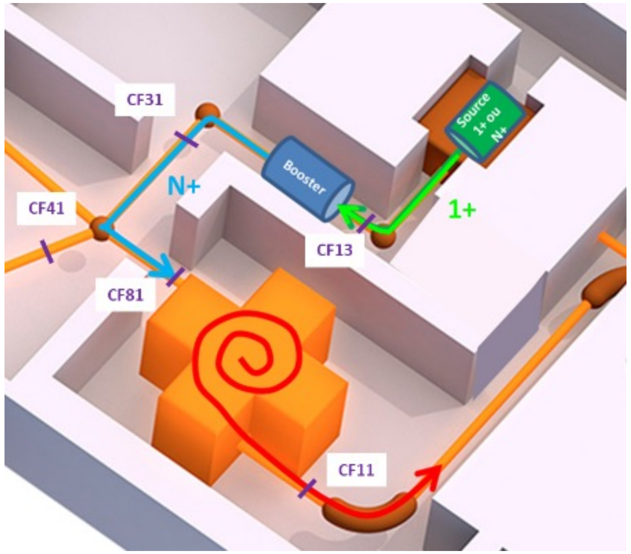


SPIRAL1

1rst Step : 1+ ion beam production

Versatil installation able to used several target ion sources

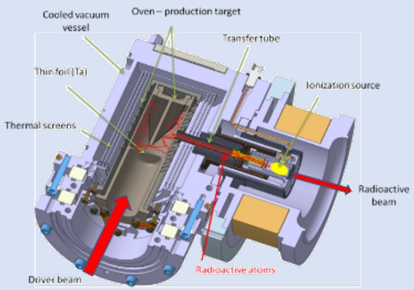




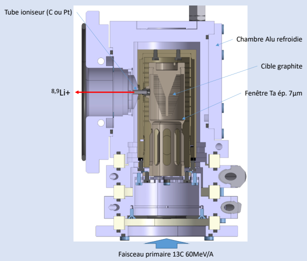
2nd Step : Charge breeder

Step necessary for CIME acceleration

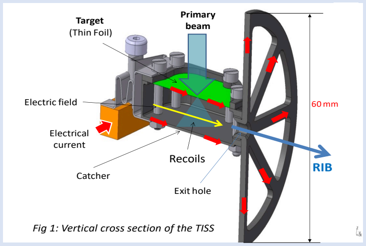
1+ Target Ion source



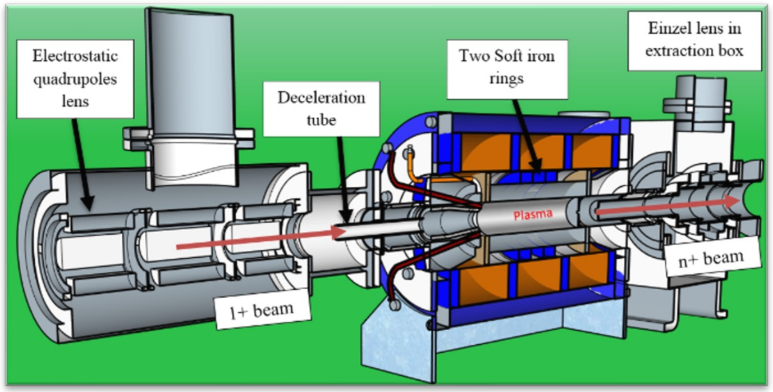
FEBIAD
Metallic beams



Surface Ionization
Alkaly beams



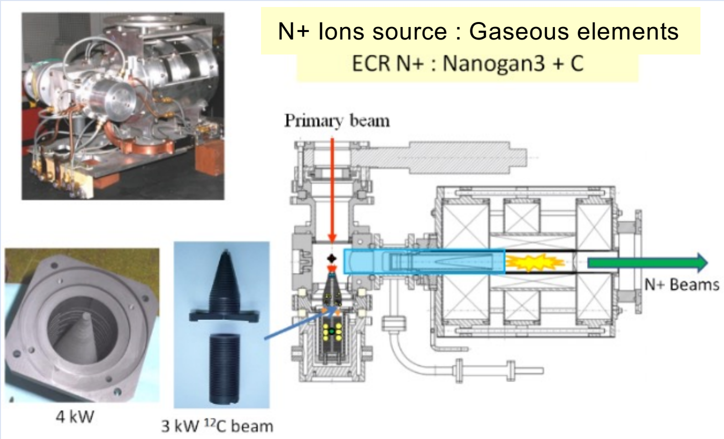
TULIP
Fusion evaporation process
Short lived isotopes

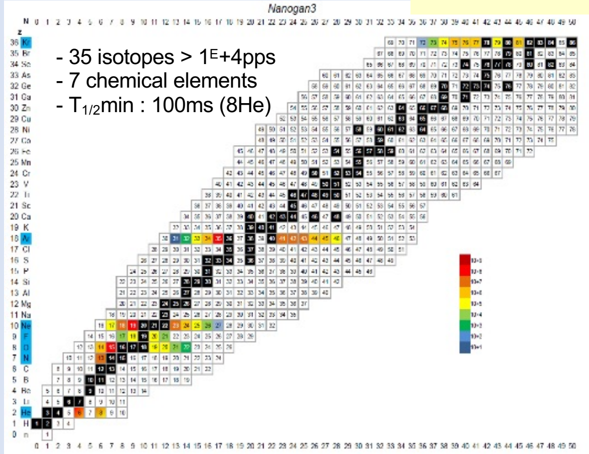


SPIRAL1

ECR Ion sources

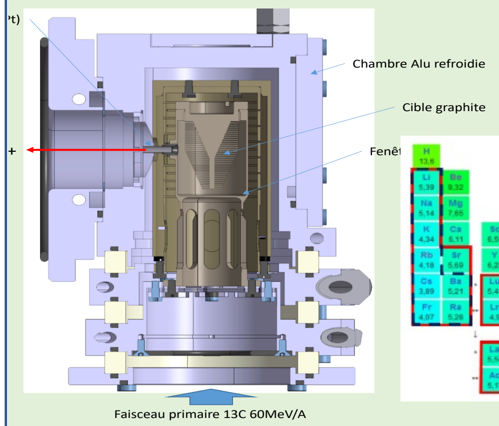
Production





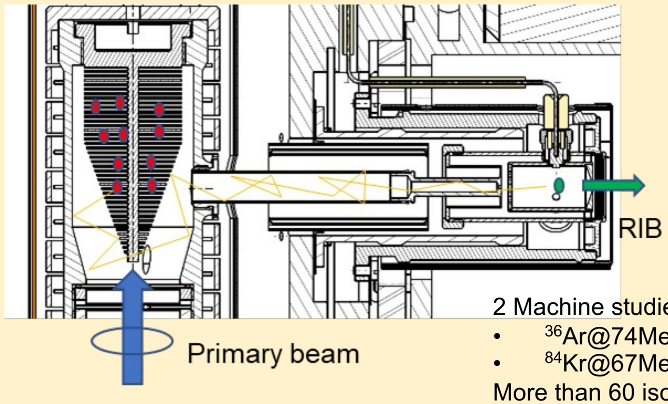
Surface Ion sources

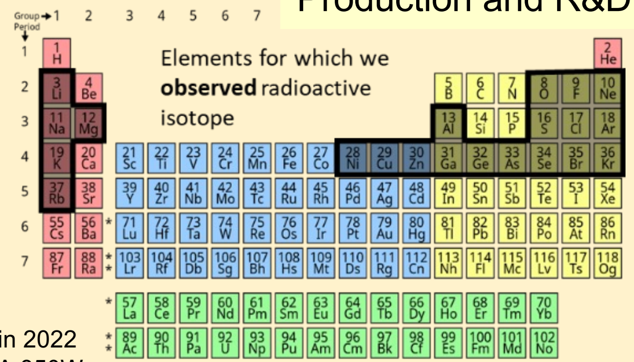
R&D



FEBIAD Ion sources

Production and R&D





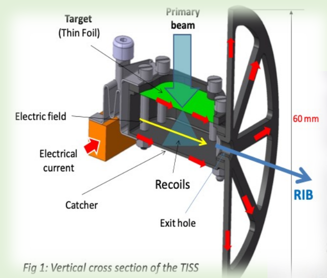
2 Machine studies in 2022

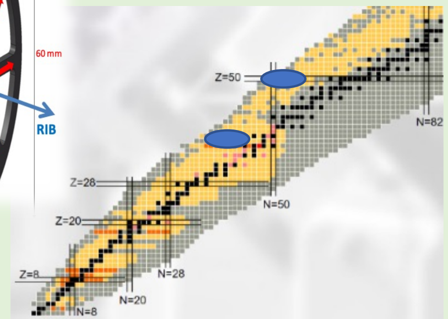
- ^{36}Ar@74MeV/A 850W
- ^{84}Kr@67MeV/A 10W

More than 60 isotopes measured, including +30 for the first time

Fusion-Evaporation Process

R&D





CYREN

- Cyclotrons maintenance and refurbishment reduced to the strict minimum for ten years due to the GANIL manpower dedicated to :
  - ✓ SPIRAL2 building then commisionning
  - ✓ Compliance projects following the 1st safety review

➔ Aging ↗ Reliability ↘ Manpower for curative maintenance ↗

➔ Strong recommandation to lead an ambitious refurbishment program to be started as soon as possible

- *Launch of the pre project CYREN :* 17th march 2022

  - Objective n°1:
  keep the facility in operational condtions for at least 20 years (Maintenance in Operating Conditions (MOC))

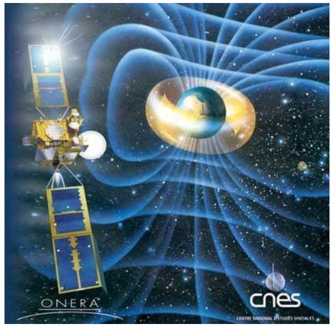
  - Objective n°2:
  optimize manpower needed for maintenance after refurbishment

Minsiter of Research announced in 2024 40 M€ for GANIL projects: DESIR, NEWGAIN, CYREN

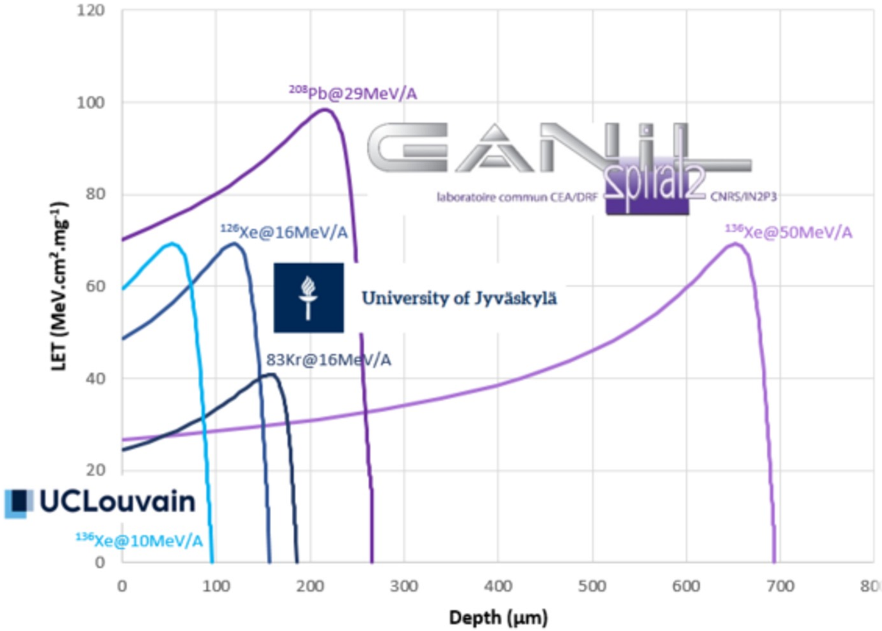
Industrial applications at GANIL : SAGA

SAGA : spatial applications @ GANIL Accelerators

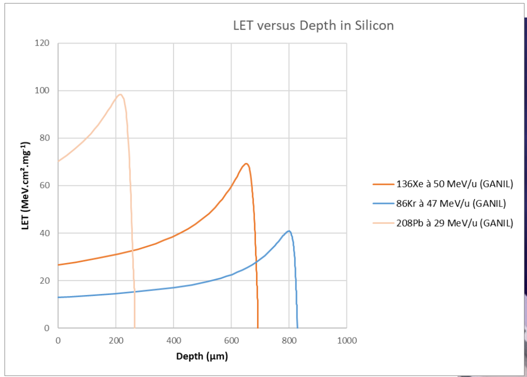
Project under discussion with CNES aiming at increasing the beam time for industrial users at GANIL.



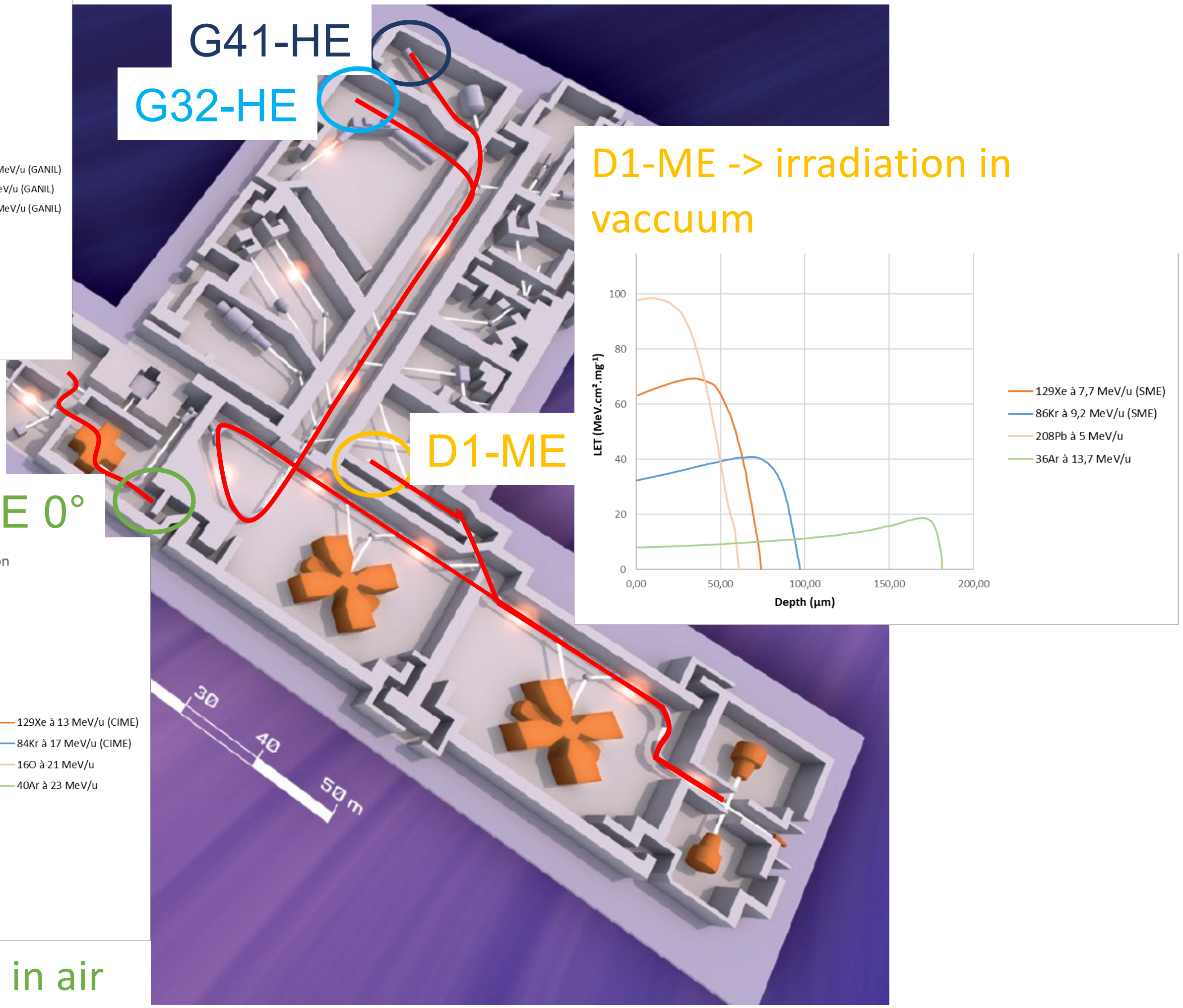
Strong increase of beam time request for tests of electronic components for spatial industry since 2022. Only 1/3 of the requests could be accepted in 2023, even with an increase of 2 of the dedicated beam time



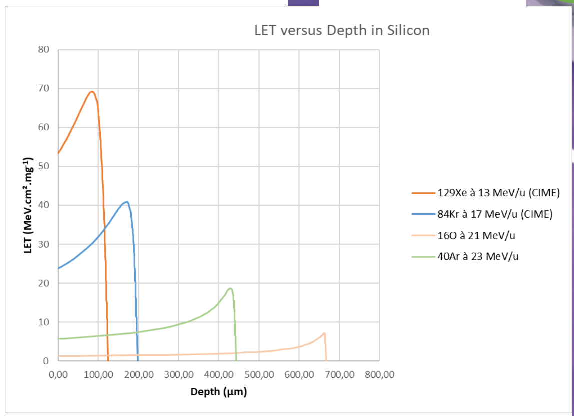
Perspectives installation 2028



G41-HE + G32-HE
-> irradiation in air

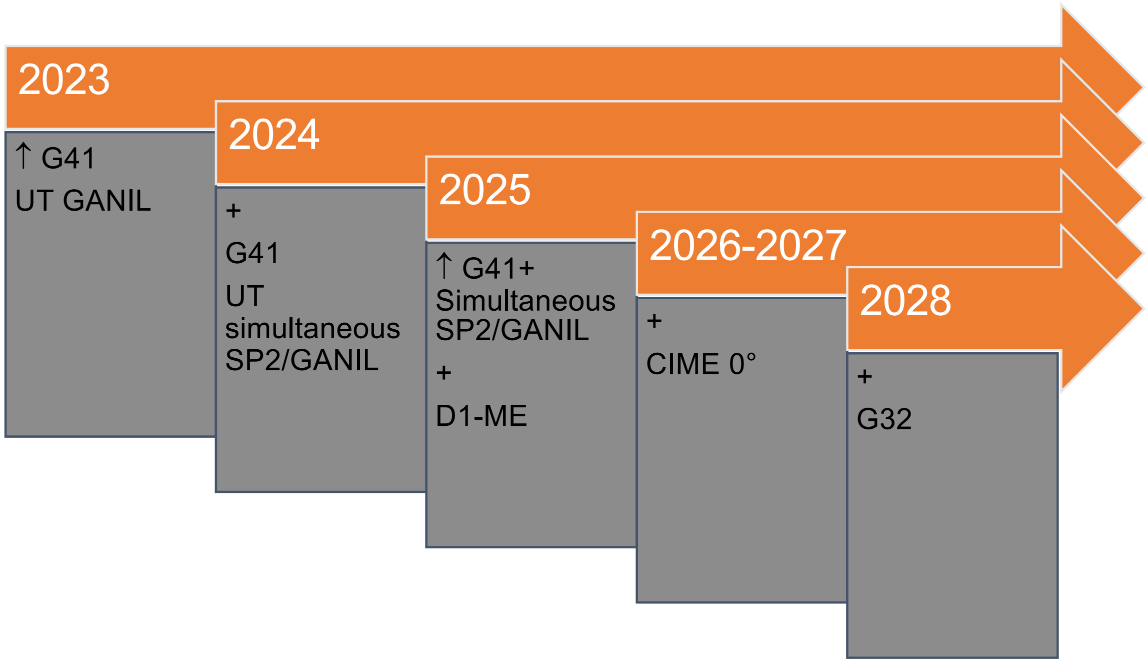


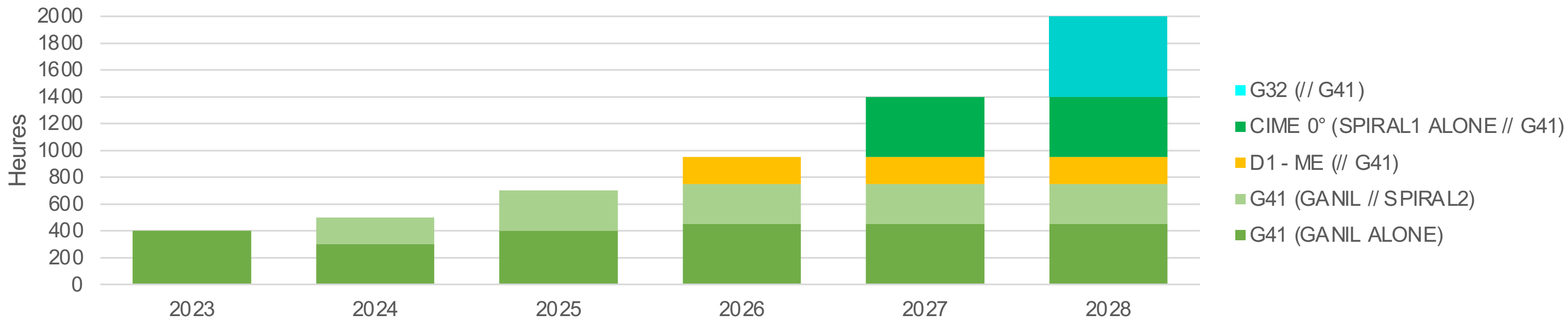
D1-ME -> irradiation in vaccuum

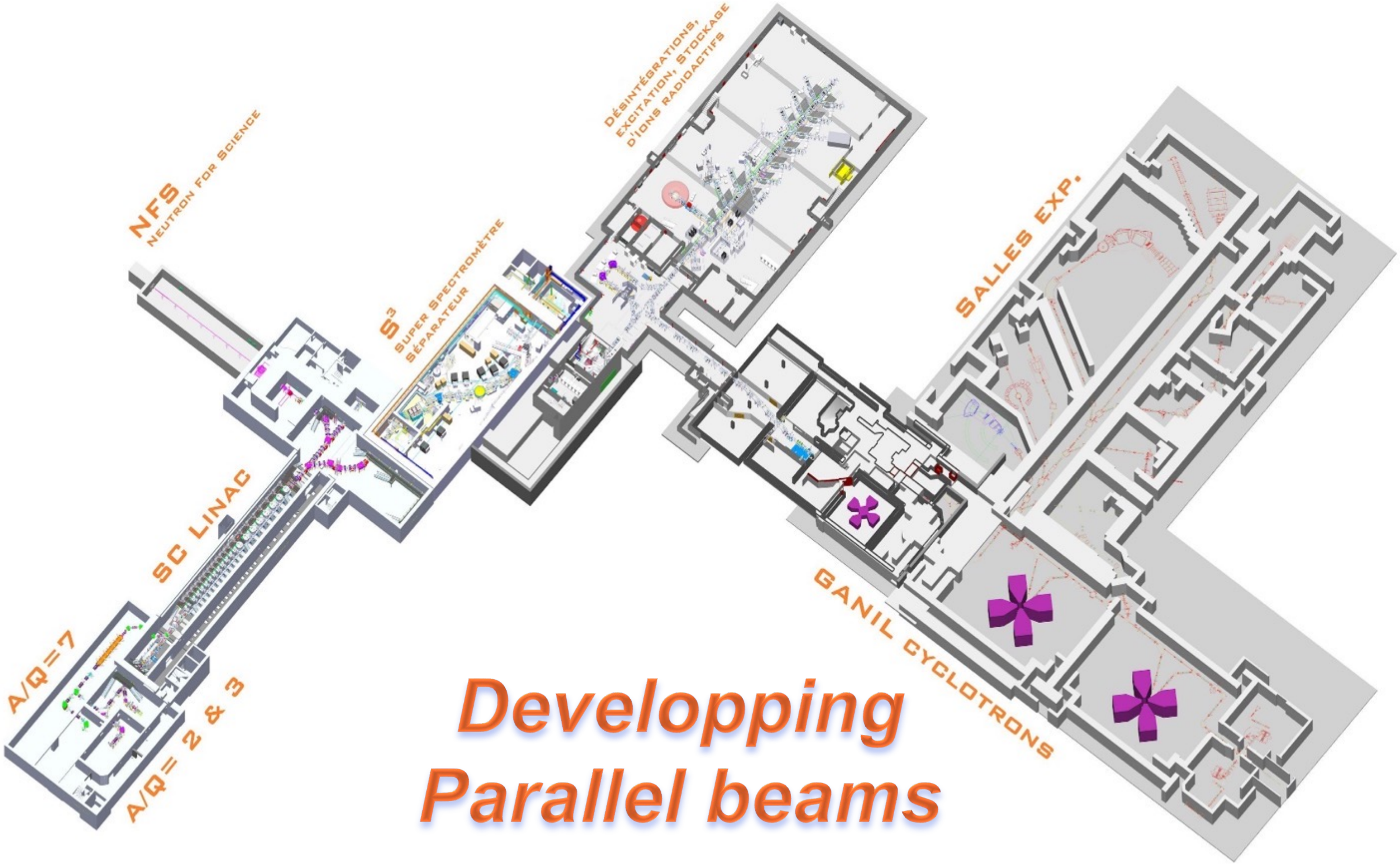


CIME 0° -> irradiation in air

Roadmap 2023-2028





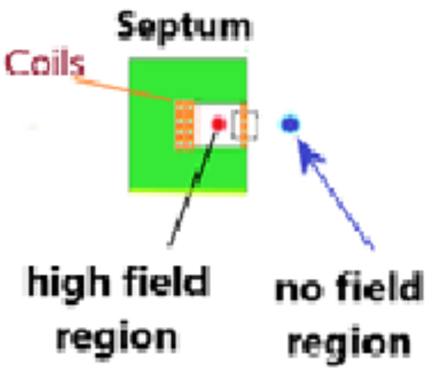


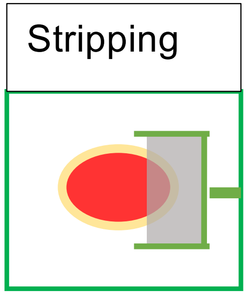
Developping Parallel beams

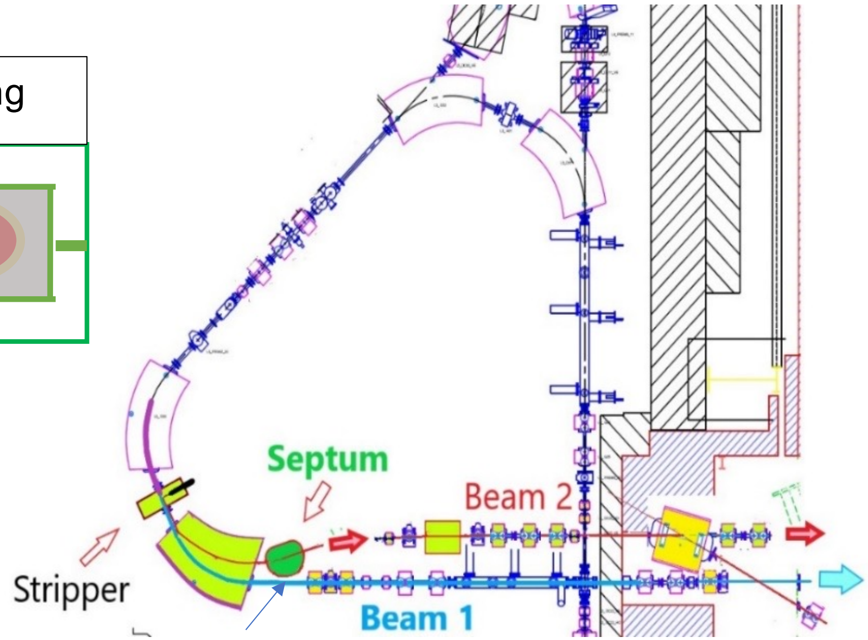
Project N°1 on the cyclotrons facility

- Separation by partial stripper/degrader at 100 A.MeV

DC septum to be develloped : GSI support ?







Project N°2 on the cyclotrons facility

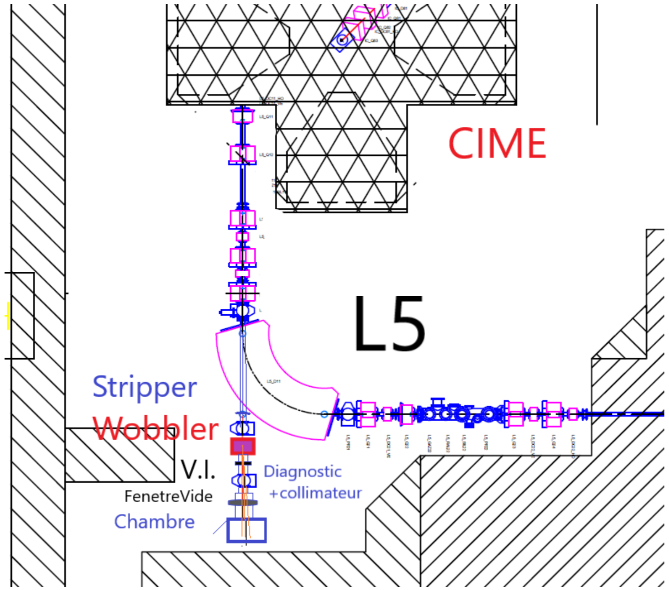
- Irradiation Beam line for radiobiology/ industrial applications

devellopement beam wobbler (10-100Hz)

Beam uniformity with

a multipolar beam wobbler

(want to join us ?)

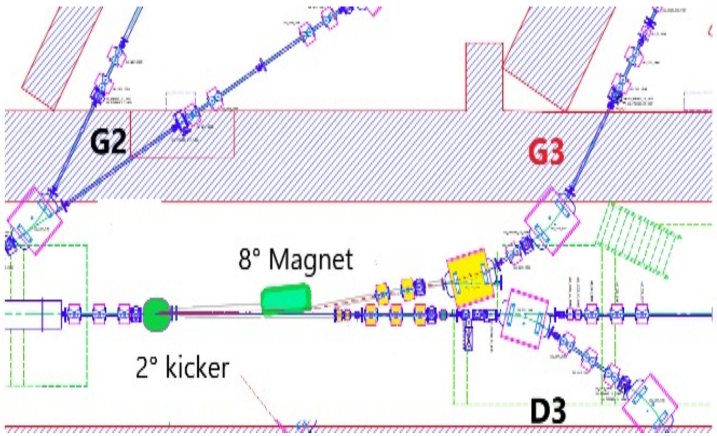


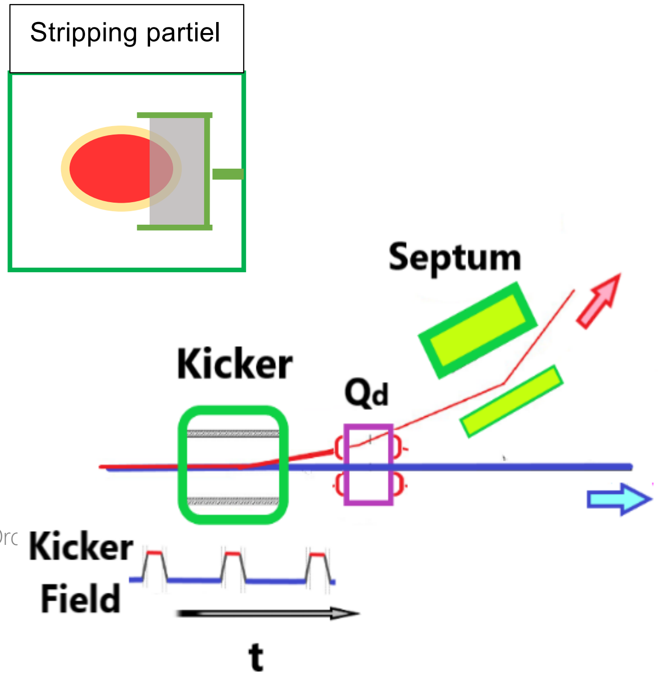
Project N°3 on the cyclotrons facility

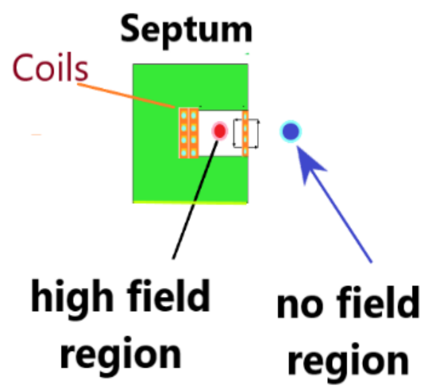
- Beam sharing with « fast kicker » under discussion ?

Fast kicker (20-50 Hz) to be developed : GSI support ?

DC septum to be developed : GSI support ?



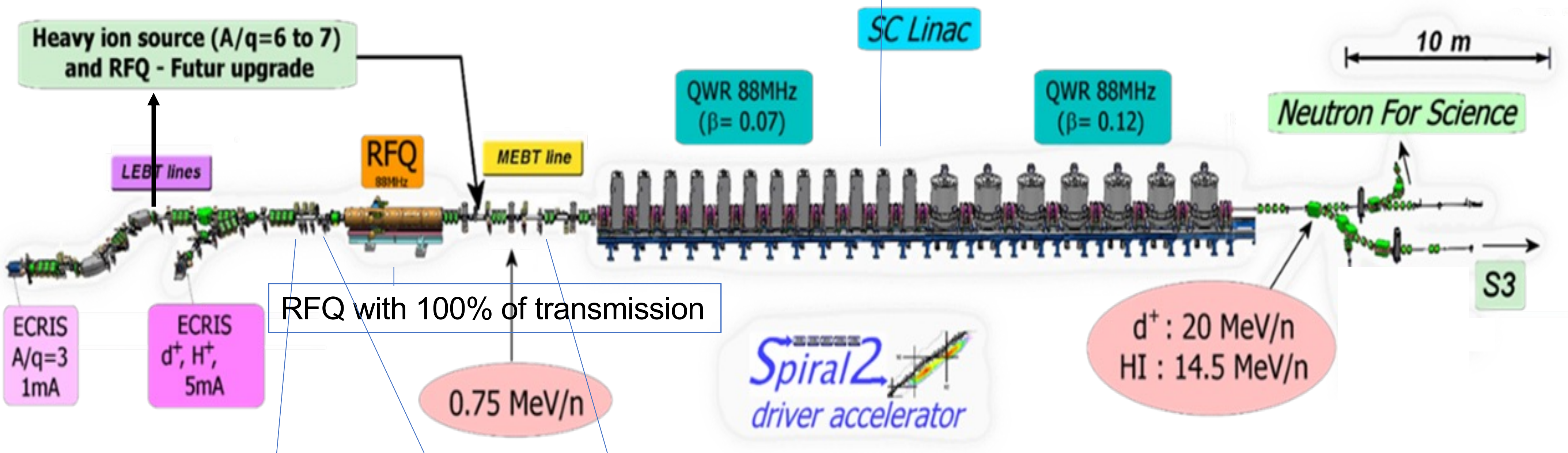




SPIRAL2 Commissioning

Spiral2 CW LINAC

26 Quarter wave resonator accelerating cavities



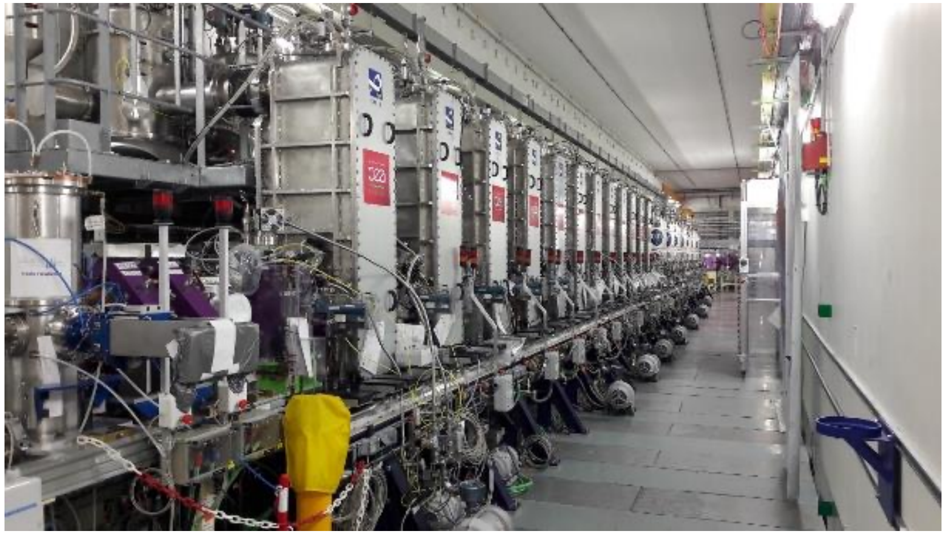
RFQ with 100% of transmission

Slow chopper for lowering power (1ms/sec)

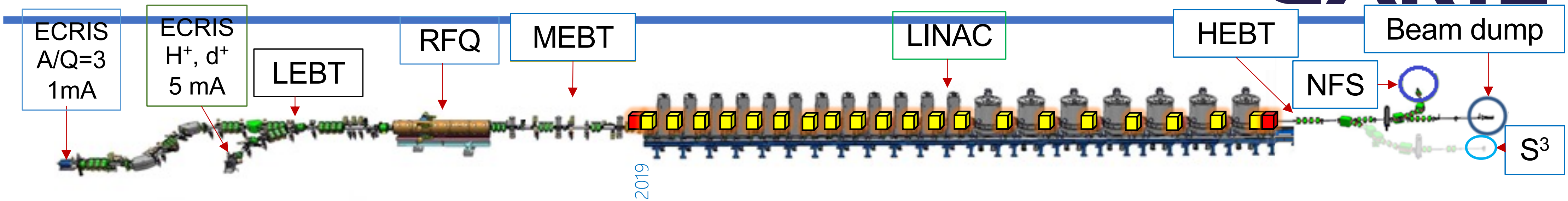
3 slit pairs for reducing emittance : very useful. Tuning for peak-intensity

3 bunchers and quadrupoles to prepare the beam.
Most complicated part of tuning and optics

SPIRAL2 LINAC



Commissioning timeline



Qualification of the ion sources and LEBT
(LPSC-Grenoble and CEA-Saclay)

Construction building and tools

Qualification of the injector on a Diagnostic Plate (GANIL)

- RFQ performance
- 2014 1st H^{+} beam @2 mA H/D (Dec)
- 2015 1st Ar^{9+} beam @ 230 μA HI source (Jul) / 1st RFQ H^{+} (Dec)
- Beam characteristics at RFQ exit

Authorization to operate SPIRAL2, Jul 8th, 2019

SC linac beam commissioning up to the main beam dump

1st beam in the linac, Oct. 28th
1st beam in NFS, Dec. 11th
33 MeV H^{+} (2019)
40 MeV $^{4}He^{2+}$, D^{+} (2020)
50 μA D^{+} NFS (2021)

First year of SPIRAL2 operation in NFS room

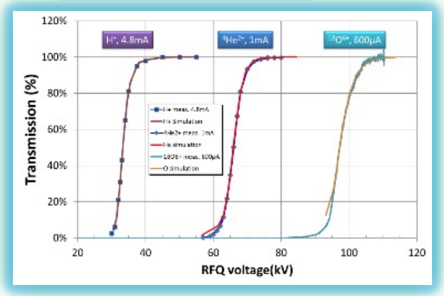
50% beam time for physics
Pre-commissioning for S^{3}
7 MeV/A $^{18}O^{6+}$, $^{18}O^{7+}$, $^{40}Ar^{14+}$
0.73 MeV/A $^{18}O^{6+}$, $^{18}O^{7+}$, $^{40}Ar^{14+}$
First cavity failure test

SPIRAL2 operation

65% beam time for physics
14% for studies
Pre-commissioning for S^{3}
14.5 MeV/A $^{18}O^{6+}$
Cavity failure test and pressure variation in warm sections

2009-2012

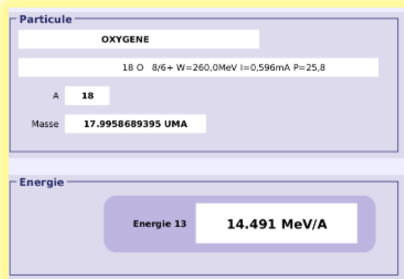
2014-2018



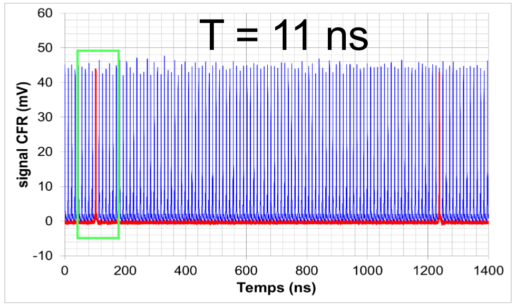
2019-2021

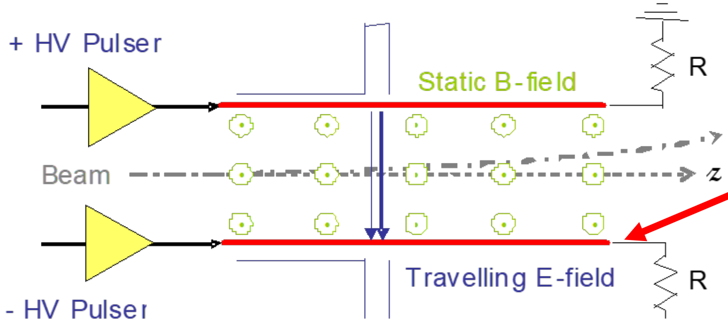
2022

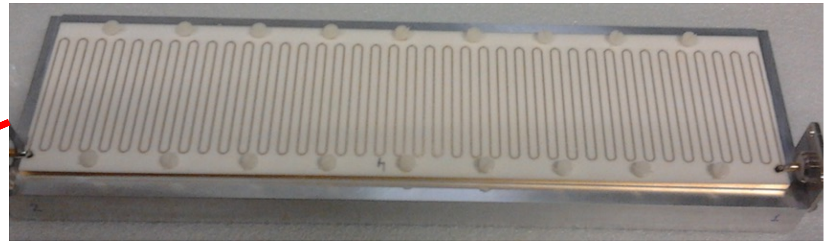
2023



Single bunch selector (MEBT), scattering issue

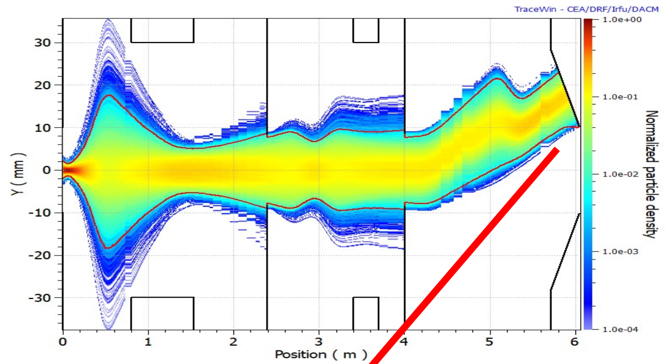






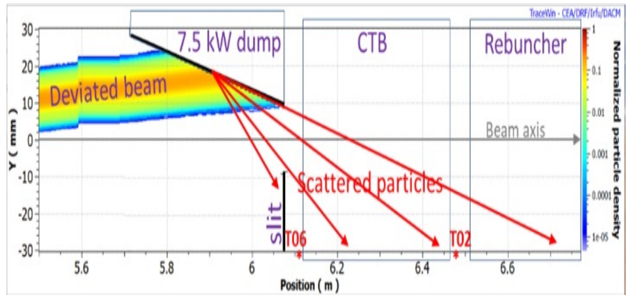
SBS meander line to slowdown the E wave

1 bunch selected (~ ns) on 100 (until 10000), for time of flight purpose



SBS beam dump

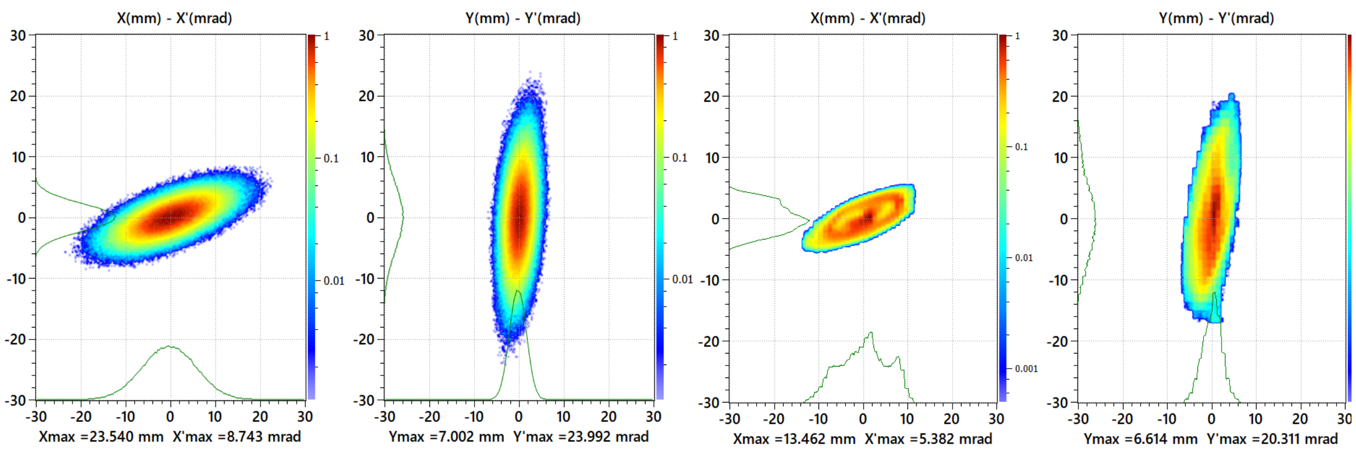
- The beam dump receiving the bunches deviated by the SBS (until 7.5 kW) was affected by Coulomb scattering which has created important heating and beam current measurements issues ($\approx 100\mu A$ in 2019).
- The beam dump was redesigned (surface changed from flat to staircase), which has successfully decreased the temperature and the current offset.



Simulation code Tracewin (IRFU-CEA)

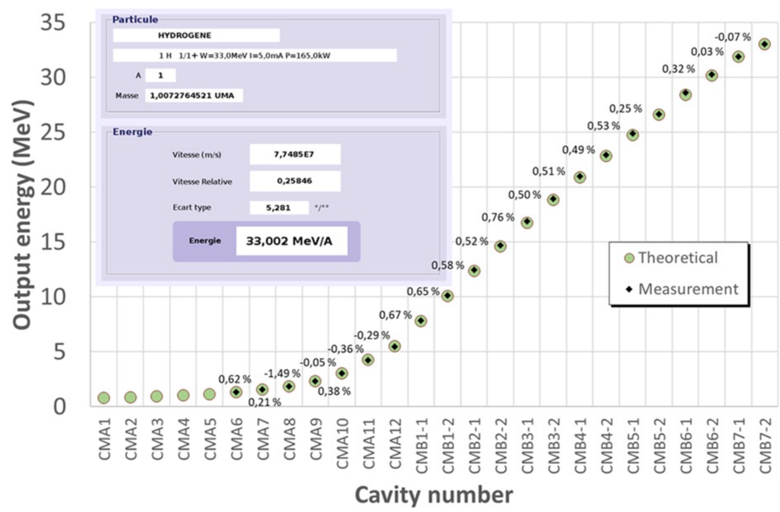
- This code predicts very well the beam behavior after the RFQ if the starting beam distribution is accurate (emittancemeter in MEBT + backtracing).
- Starting from calculated parameters in the machine, very few matching changes, with 4 quadrupoles and one rebuncher, are needed to obtain a well matched beam to the linac with very low losses.

Reference simulation 600 µA $^{18}O^{6+}$ Measurement 600 µA $^{18}O^{6+}$



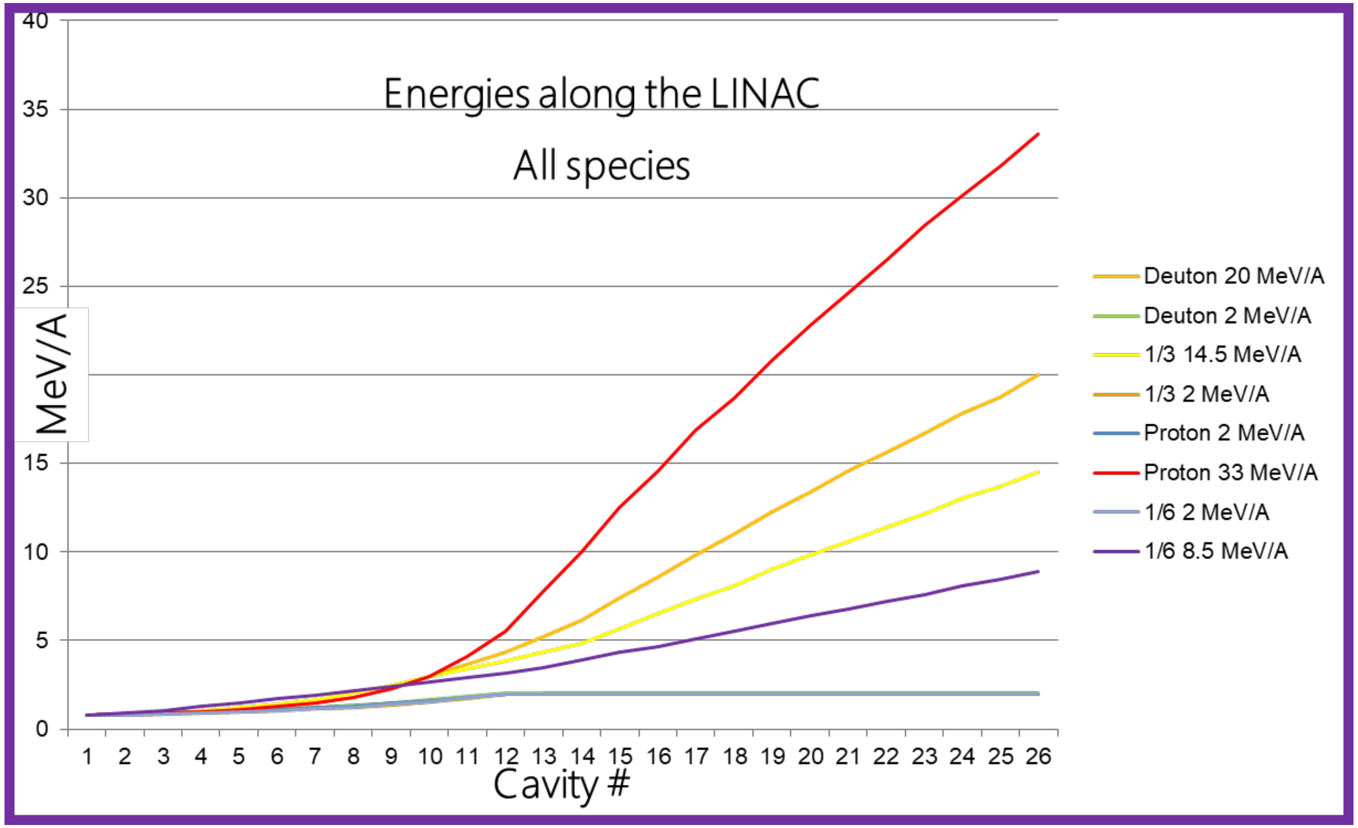
Transversal emittances in the MEBT

Proton 33 MeV



Energy along the LINAC
(Measurement vs Simulation)

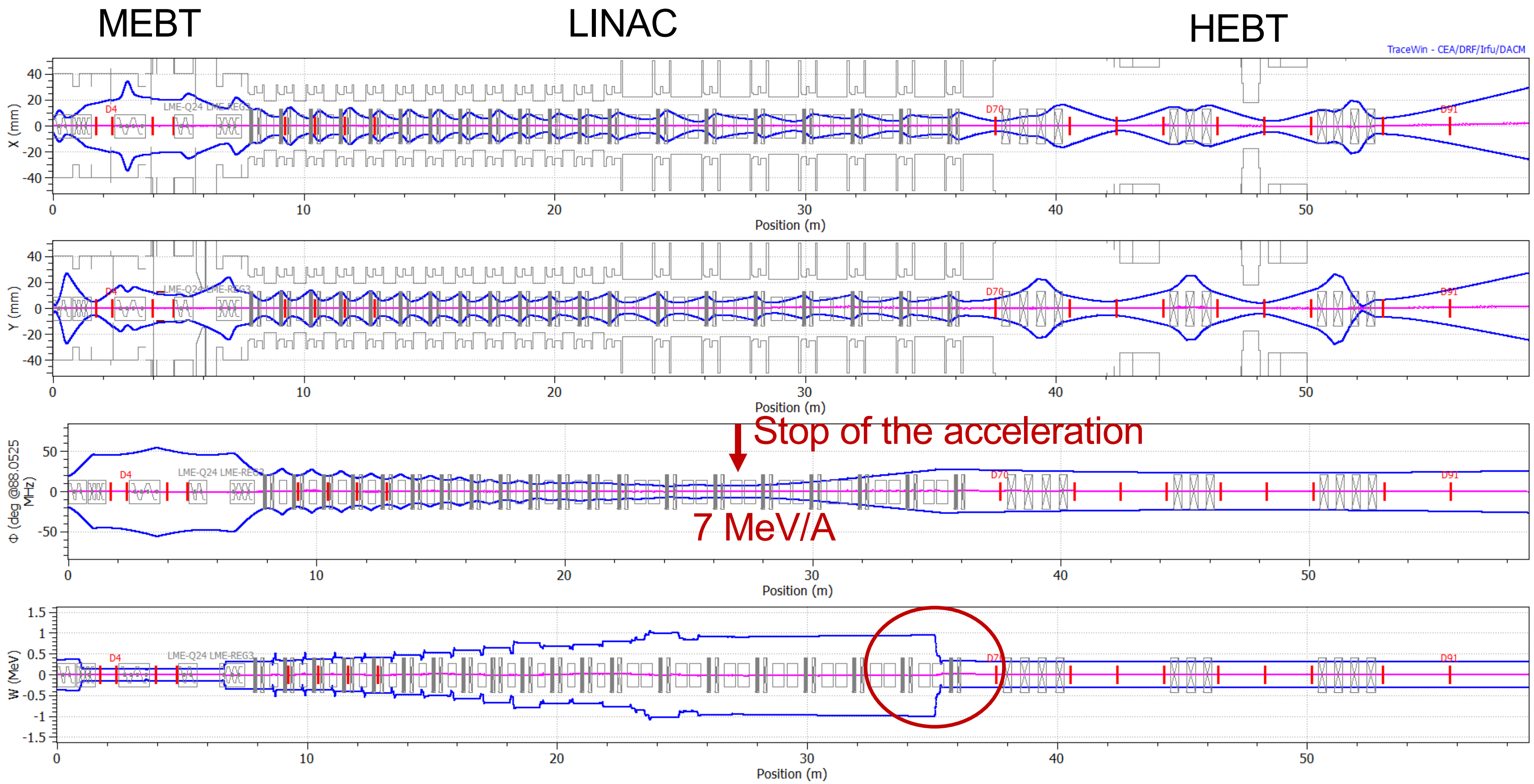
Maximum/minimum energies



Minimum energy : 0.73 MeV/A (id output energy of the RFQ)

Heavy ions

$^{18}O^{6+}$



3RMS envel

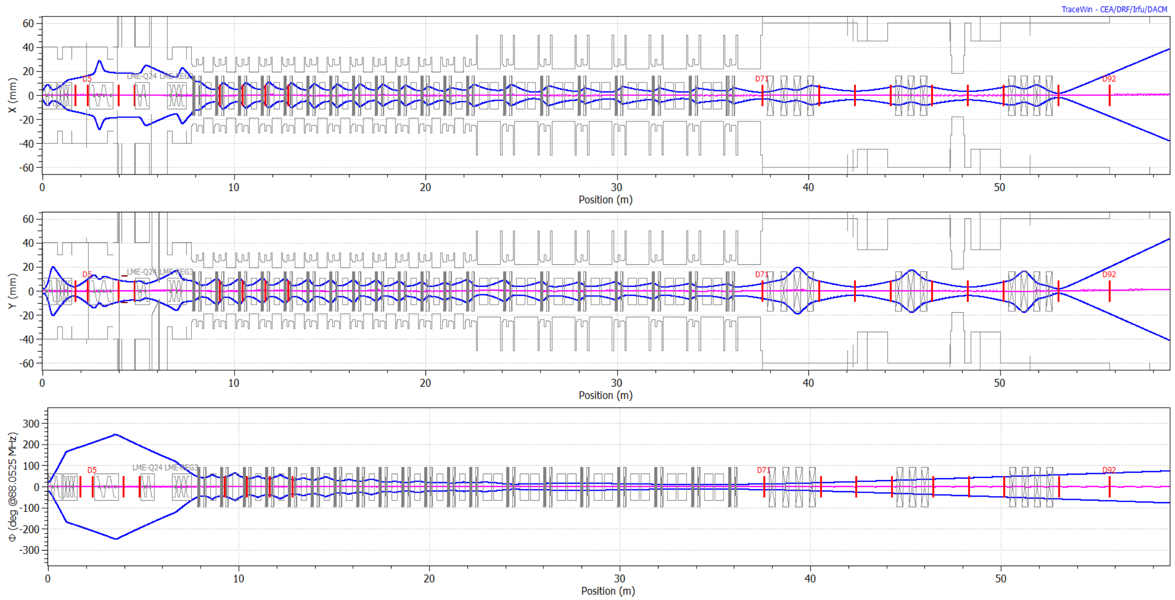
ΔE/E = 0.1 MeV rms / 126 MeV = 0.08 %

Accelerated with success in 2022

« Invisible » beams.

GANIL

Objective : tune the accelerator even for species with very low intensities not seen by some diagnostics (< 10 µA).



Simulation of $^{18}O^{7+}$ in MEBT, linac and HEBT using the scaling method

From $^{18}O^{6+}$ to 7+ (test case):

(A1/Q1) / (A2/Q2) = 0,86

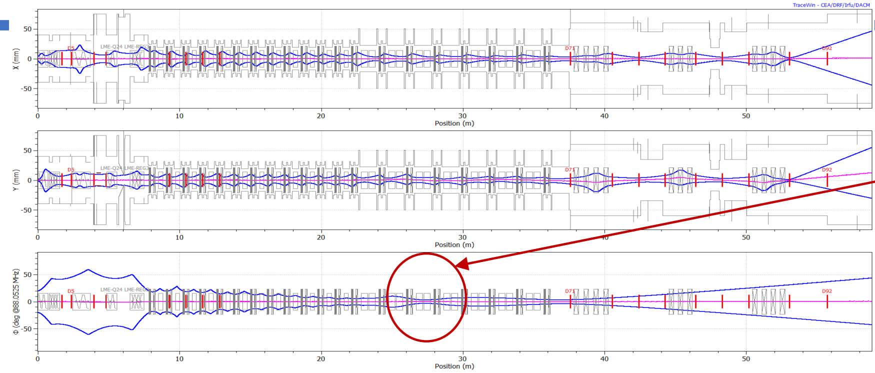
Method : multiply all magnetic and electric fields from source voltage until the last quadrupole before the target by this factor.

Used with success in 2022

Linac tuning if a cavity is out of order

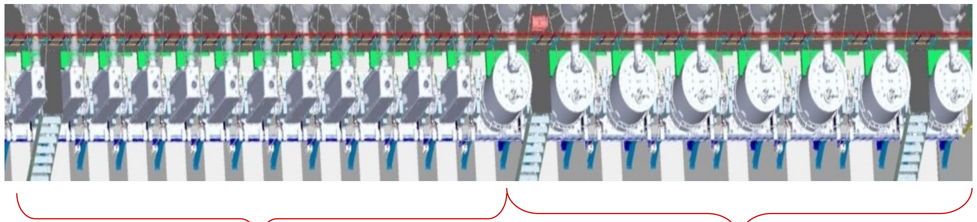
As the energy ↑ the debunching ↓

- High β cavity failure: solution easy to find.
- Last low β cavity failure, possible to recover a beam dynamics without losses but not obvious.
- Low β cavity failure: very difficult to tune at low energy due to a high debunching between two cavities.



Deutons
CMB1 cav 2 out of order

Work is currently underway :



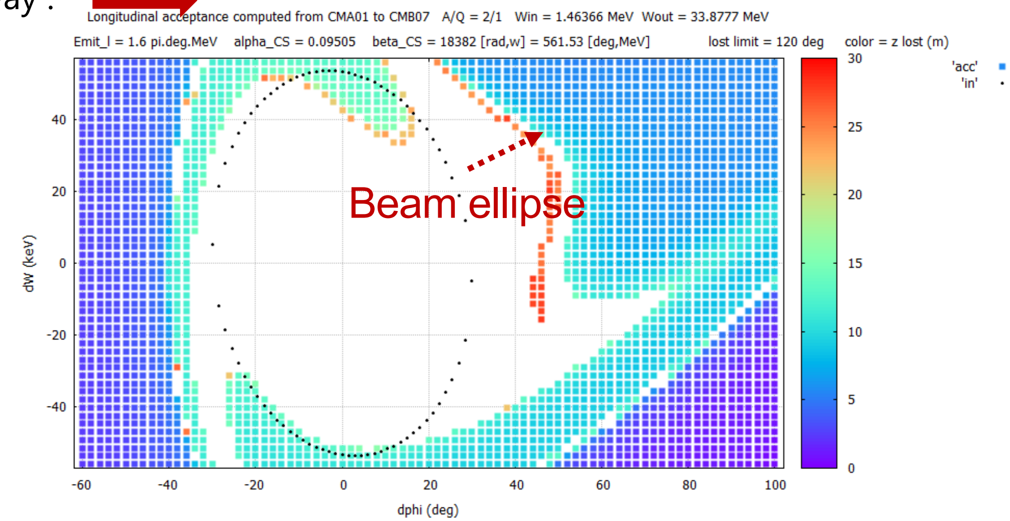
Low β section

High β section

Retune the up and downstream cavities

- Phase acceptance reduction (more losses, but if 2 KW are requested instead of 200 kW, some margins)
- Reduction of the final energy or/and an increase of the cavity voltages (8 MV/m available now vs 6.5 MV/m at the beginning).

Longitudinal acceptance (in white)



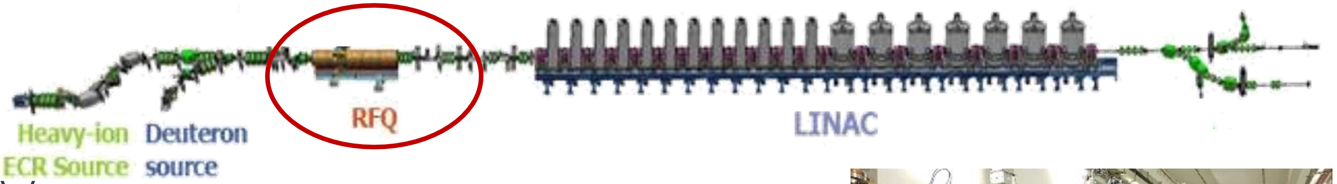
Cavity A6 out of order :
900 µA $^{4}He^{2+}$ @ 64 MeV (instead of 80)
2 kW produced with success in 2023

Other questions / Projects

- Operators and engineers continue to develop their skills
- (Automatic) tunning with a cavity down
- Low-energy beam in S3 target area
- Beam sharing

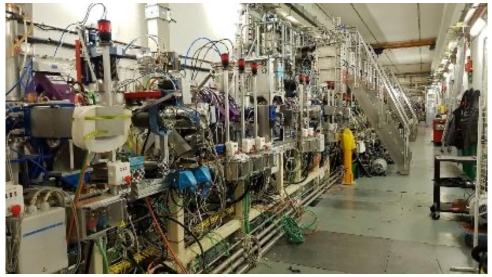
Developping beam sharing at the LINAC ?

- Status of our CW linac :



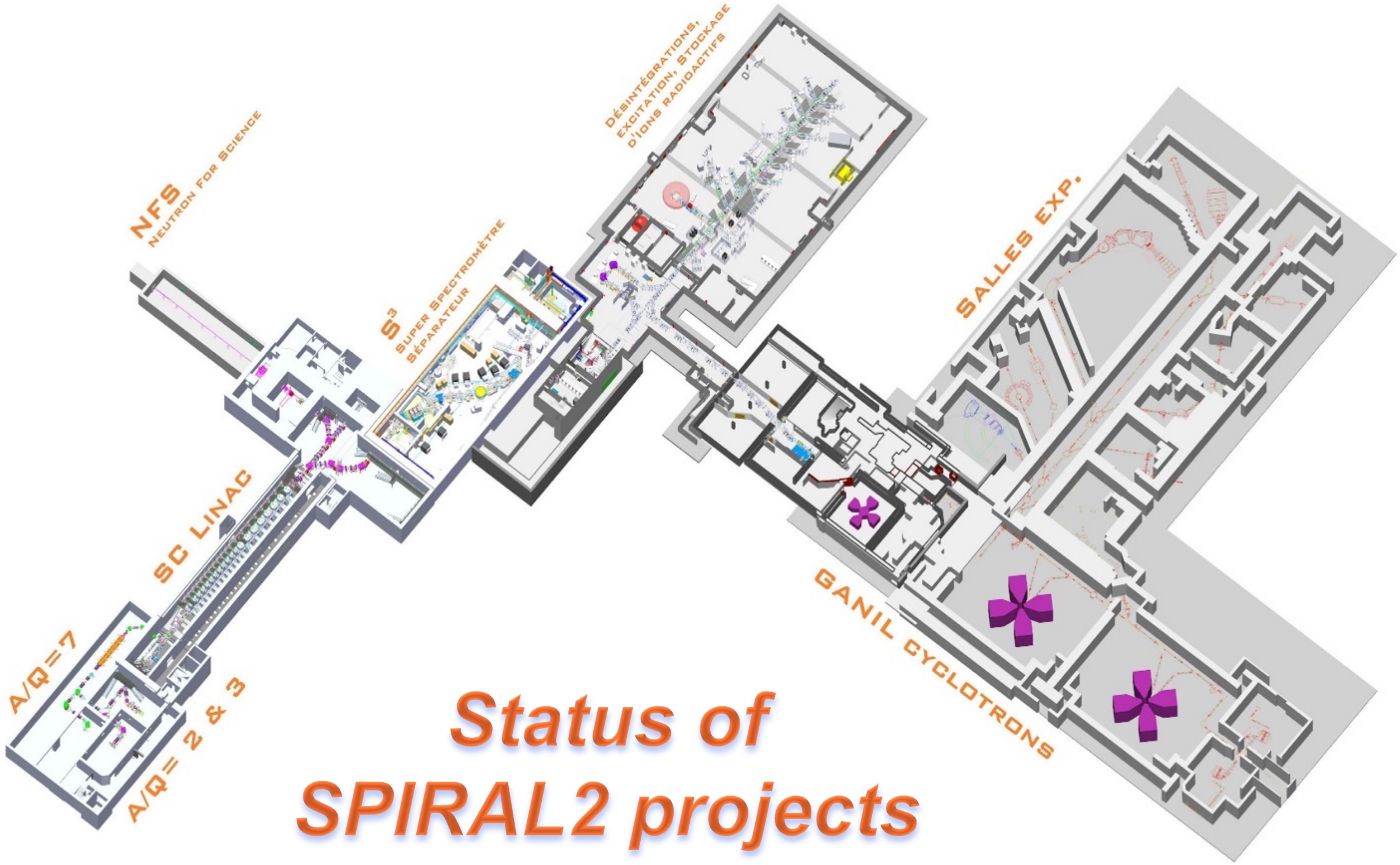
p/D pulsed beams at 40 MeV

or Heavy ions at ~5 MeV/A



Only one user … Capability of the cw-Linac not fully exploited

Developping time sharing ? : idea, discussion needed



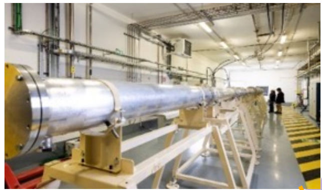
Status of SPIRAL2 projects

SPIRAL2 LINAC and the new experimental rooms

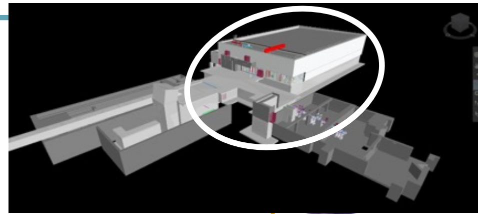
GANIL

EXPERIMENTAL ROOM NFS
(NEUTRONS FOR SCIENCE)

Convertor room

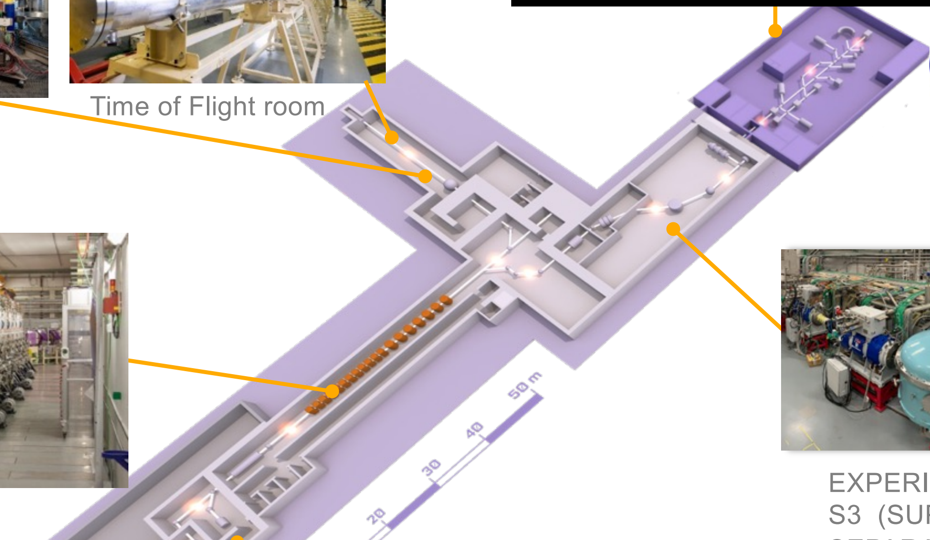


Time of Flight room



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

FRANCE 2030



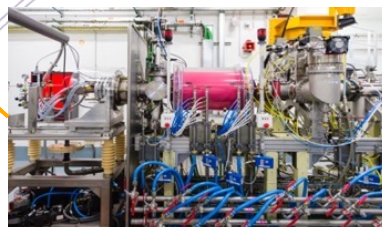
LINEAR accelerator
(LINAC)

FRANCE 2030

EXPERIMENTAL ROOM S3 (SUPER SEPARATOR SPECTROMETER)

NEWGAIN
NEW GANIL INJECTOR

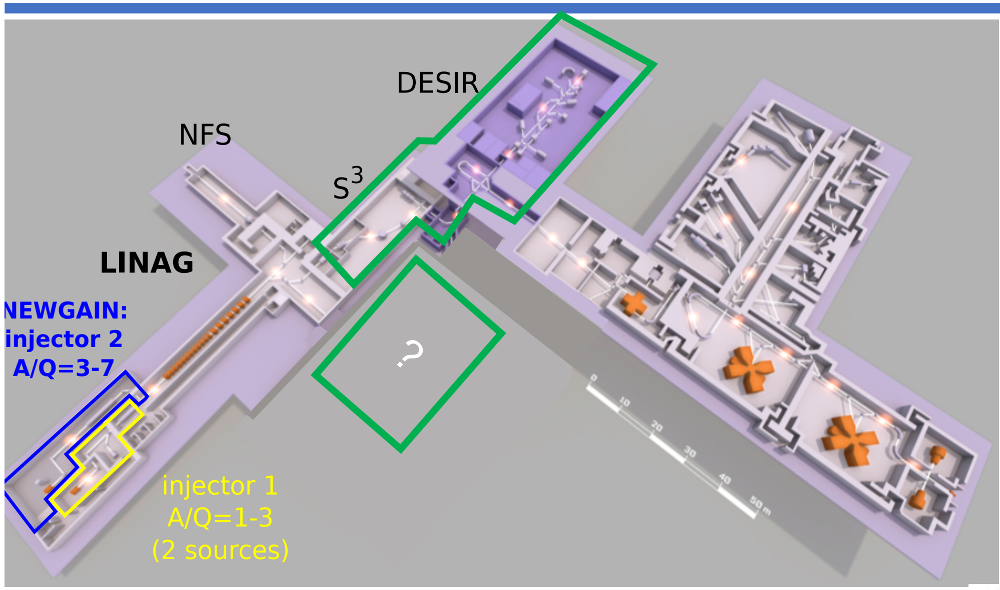
FRANCE 2030



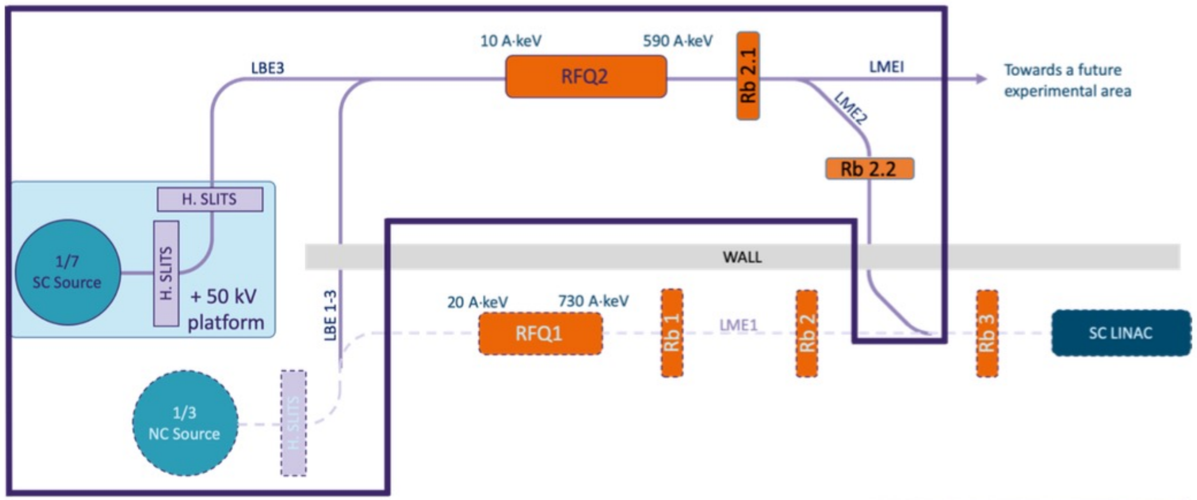
ION SOURCE

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

NEWGAIN project

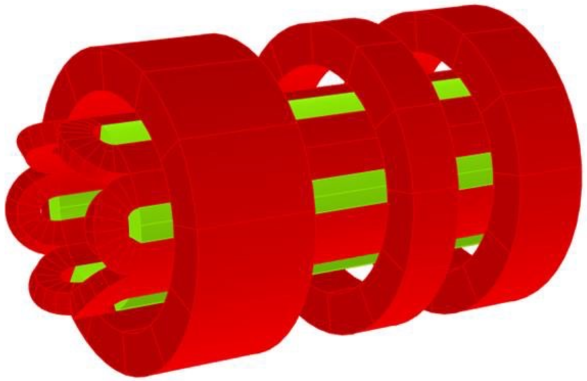


- Existing (yellow)
- NEWGAIN (blue)
- Main User (green)

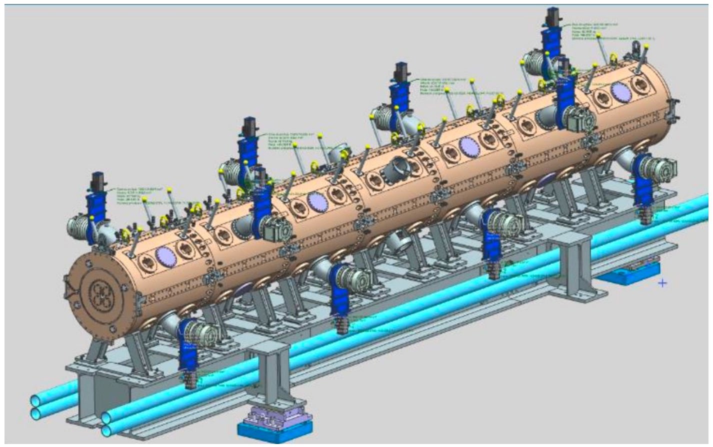


- NEWGAIN perimeter
- Equipment to be built
- Existing equipment

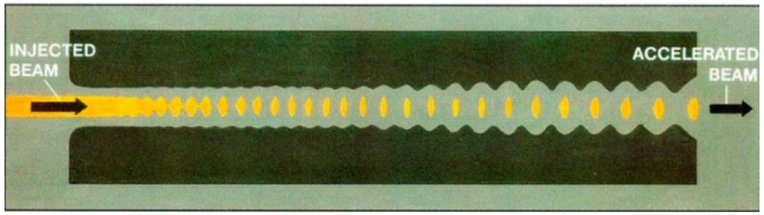
NEWGAIN project

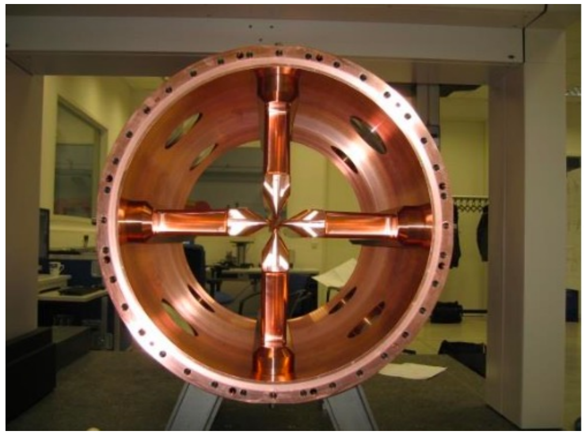


Supraconducting Ion source **ASTERICS**
Based on VENUS FRIB Ion-source
With a larger plasma chamber (*1,5)



RFQ adapted to heavy-ions





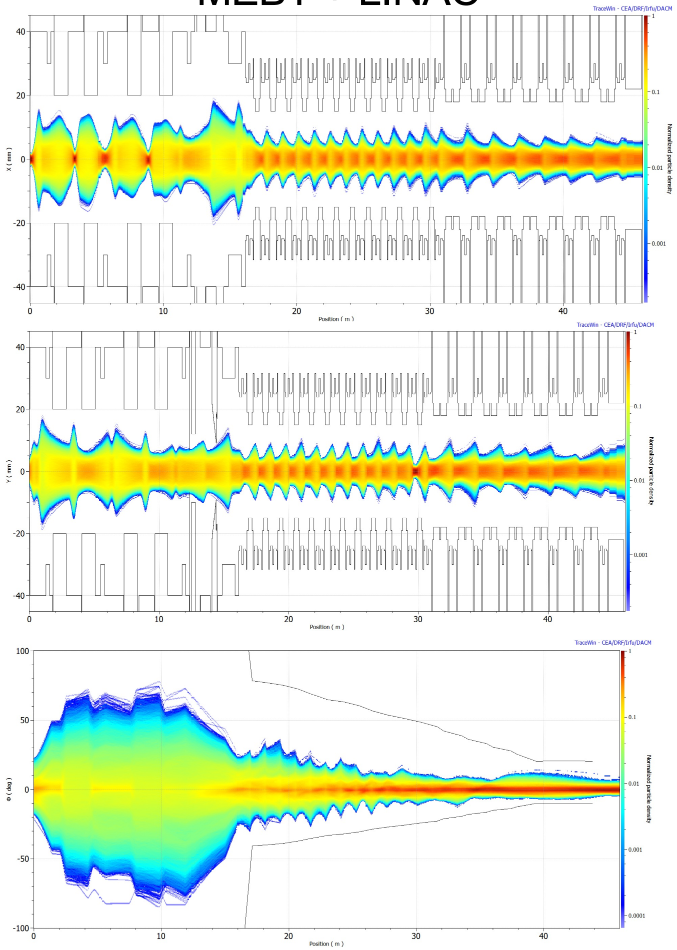
NEWGAIN

MEBT + LINAC

x

y

Phi



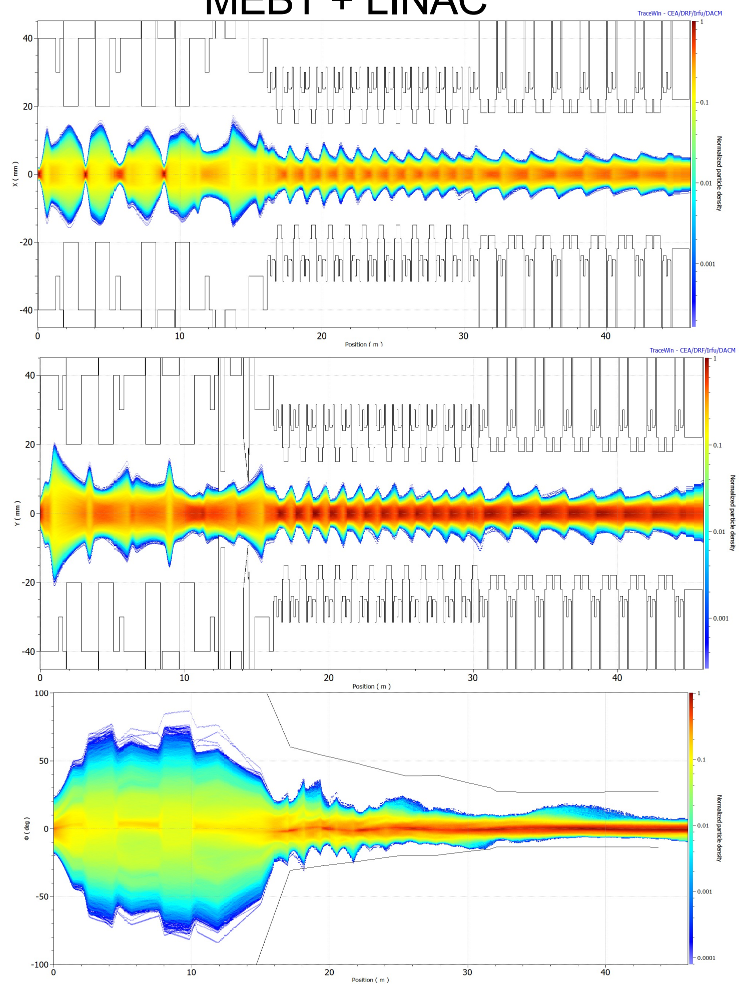
$^{48}Ca^{11+}$ $^{238}U^{34+}$

MEBT + LINAC

x

y

Phi



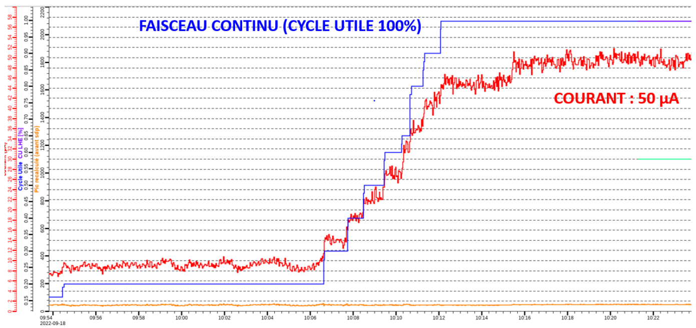
The construction phase has just started

(NEWGAIN beam dynamic team's simulations)

Heavy ions

GANIL

	Q/A =1/3 AVAILABLE NOW	Q/A = 1/6 (NEWGAIN) 2028	Q/A = 1/7 (NEWGAIN) >2030
Energies	0.73 to 14.5 MeV/A	0.73 MeV/A to 8.5 MeV/A	0.73 to 6.33 MeV/A, or maybe 7 MeV/A
Maximum power	(if 1 mA) 43.5 kW	<6 kW	(Uranium) 15 kW



First heavy ion beam : $^{18}O^{6+}$ 50µA, 7 MeV/nucleon
LINAC transmission 98%
Other charge states accelerated by (quasi)automatic accelerator tuning
Also $^{40}Ar^{14+}$ 80µA, 7 MeV/nucleon

INTENSITIES

beam intensities	*injector1* 2023	NEWGAIN *(injector2)* 2028	≥ 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

Thanks to the ion source GANIL and the NEWGAIN teams

Improving Ions source stability

- Optical spectroscopy developed at GSI seems very interesting for GANIL

STABLE AND INTENSE ^{48}Ca ION BEAM PRODUCTION WITH A MICROWAVE SHIELDED OVEN AND AN OPTICAL SPECTROMETER AS DIAGNOSTIC TOOL

F. Maimone†, A. Andreev, R. Hollinger, R. Lang, J. Mäder, P. T. Patchakui, and K.Tinschert
GSI-Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

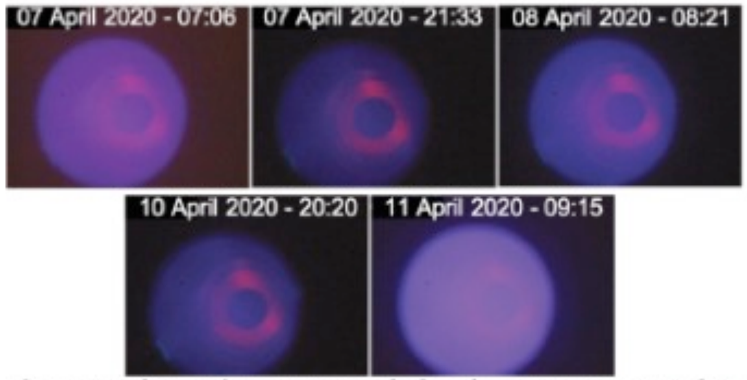
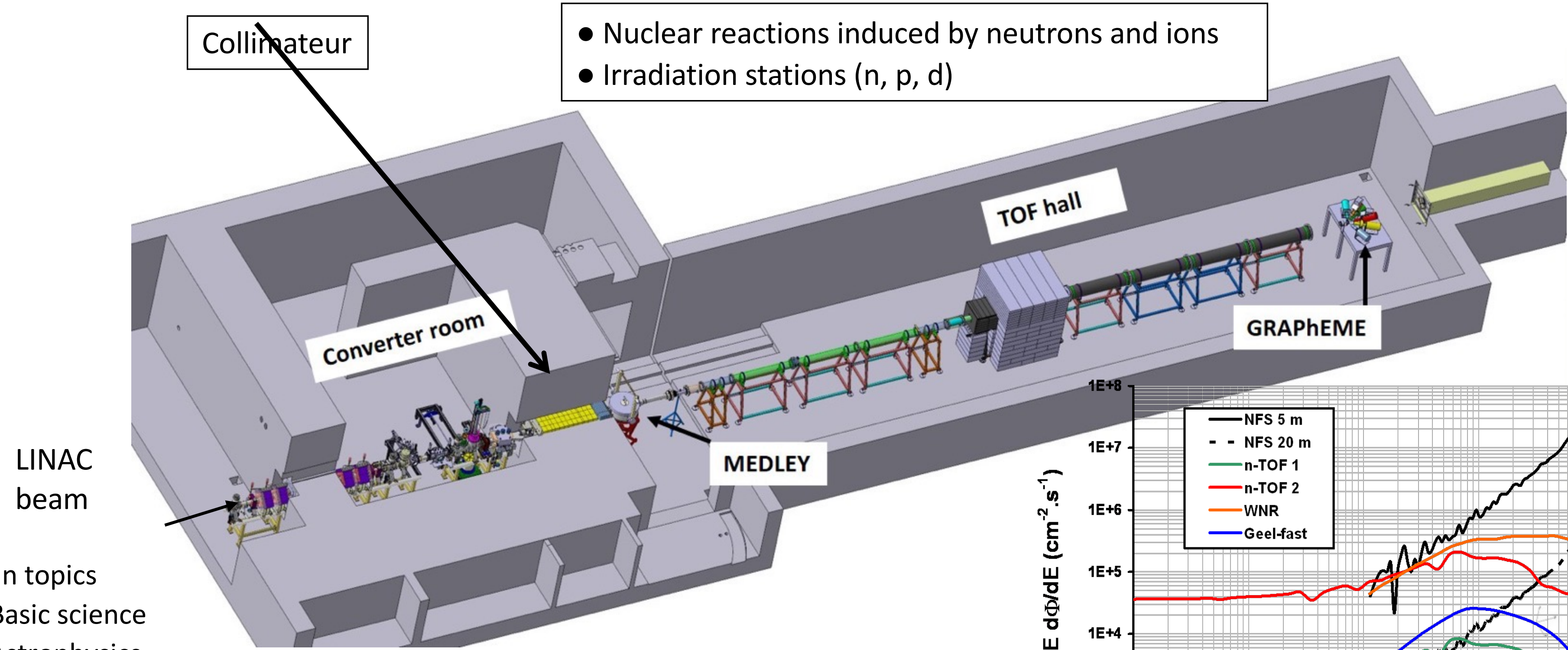


Figure 6: Plasma images recorded at the CCD camera when the optimizations of the ECRIS were requested.

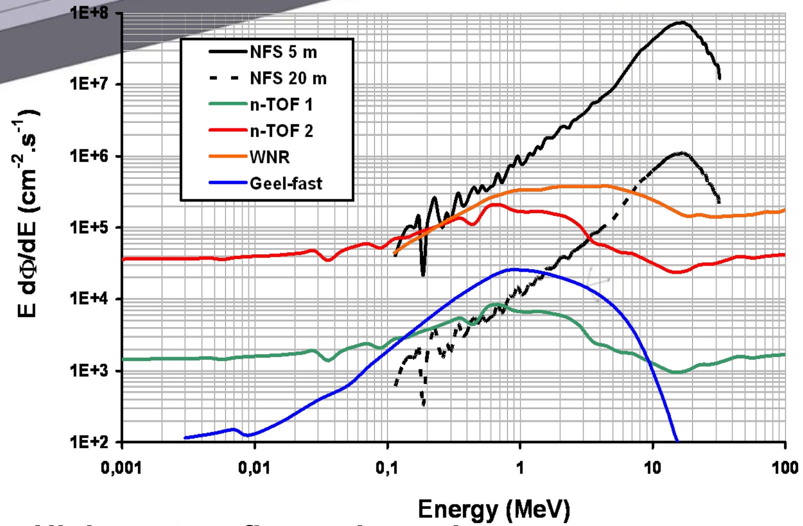
Advices ,Help, Collaboration needed

Neutrons for Science

- Nuclear reactions induced by neutrons and ions
- Irradiation stations (n, p, d)



Main topics
- ❑ Basic science
- ❑ Astrophysics
- ❑ New generation nuclear power plants
- ❑ Fusion technologies
- ❑ Radioisotopes for medical applications
- ❑ radiobiology
- ❑ Instrumentation development
- ❑ Spatial application



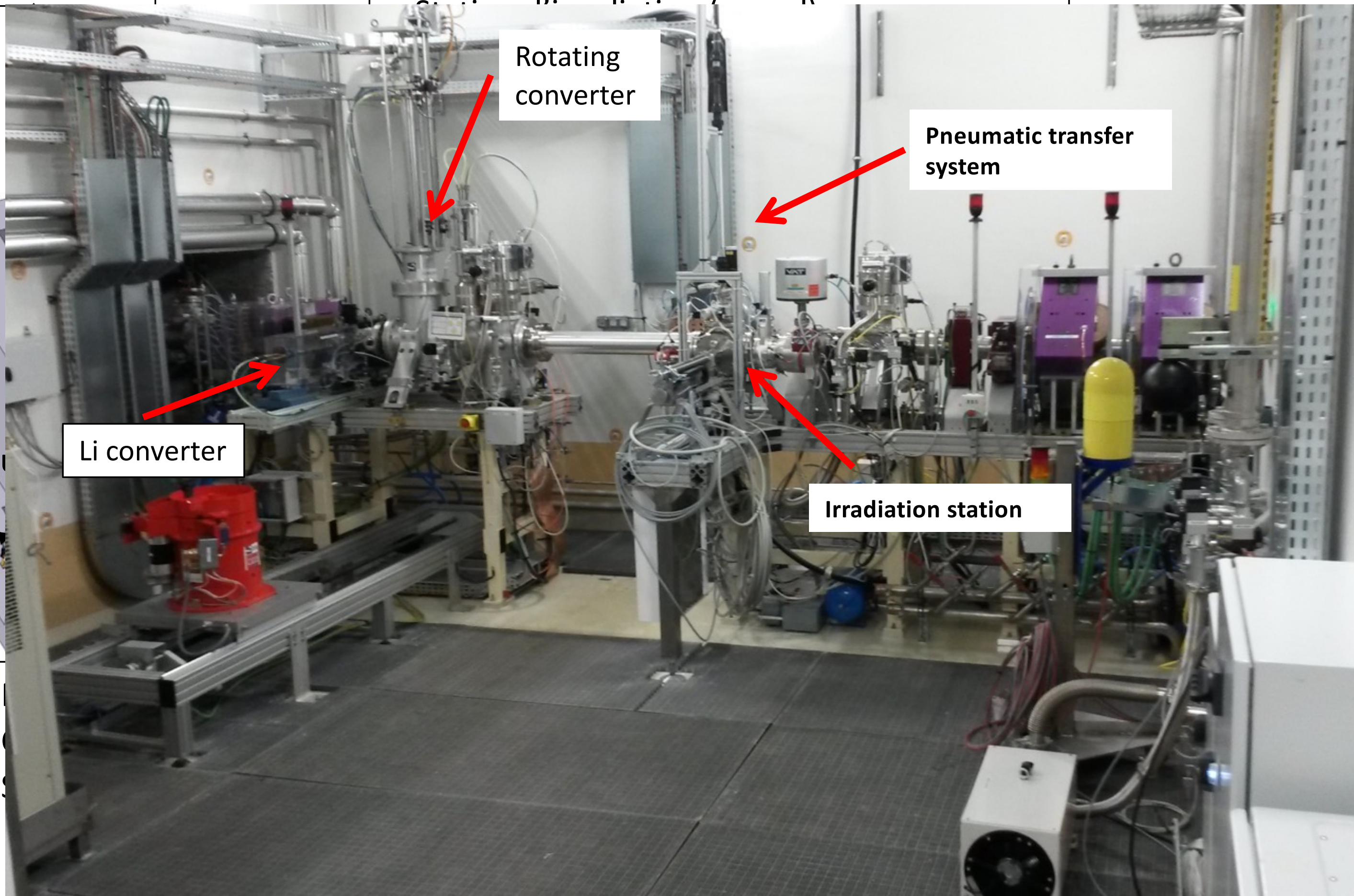
High neutron flux and good complementarity with other facilities

Neutrons for Science

Collimateur

- Réactions induites par neutrons et ions

Faisceau
LINAC



dicales

❑ Développement et caractérisation de nouveaux détecteurs

❑ Etude de “single event upset”

Neutrons for Science

Faisc
LINAC

les

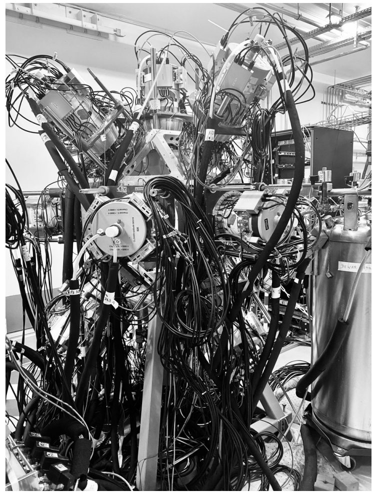
rs

❑ Etude de “single event upset”

2022-23 NFS Experiments

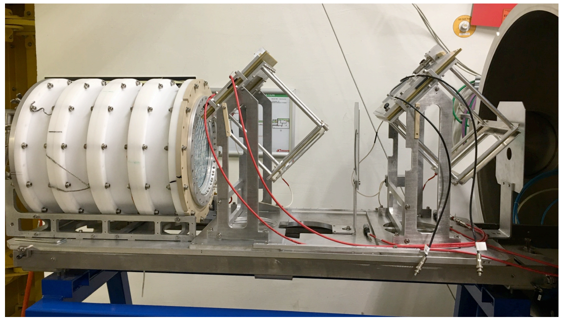
GANIL

- Pygmy dipole resonance in ^{140}Ce using the (n,n'γ) reaction, Marine Vandebrouck et al
- LIONS: Light ions production studies with MEDLEY at the NFS facility, Diego Tarrio et al
- GARIC: Gas pRoduction in Chromium, Iron by neutrons, Diego Tarrio et al
- (n,xn γ) reaction cross section measurements for nuclear energy, M. Kerveno



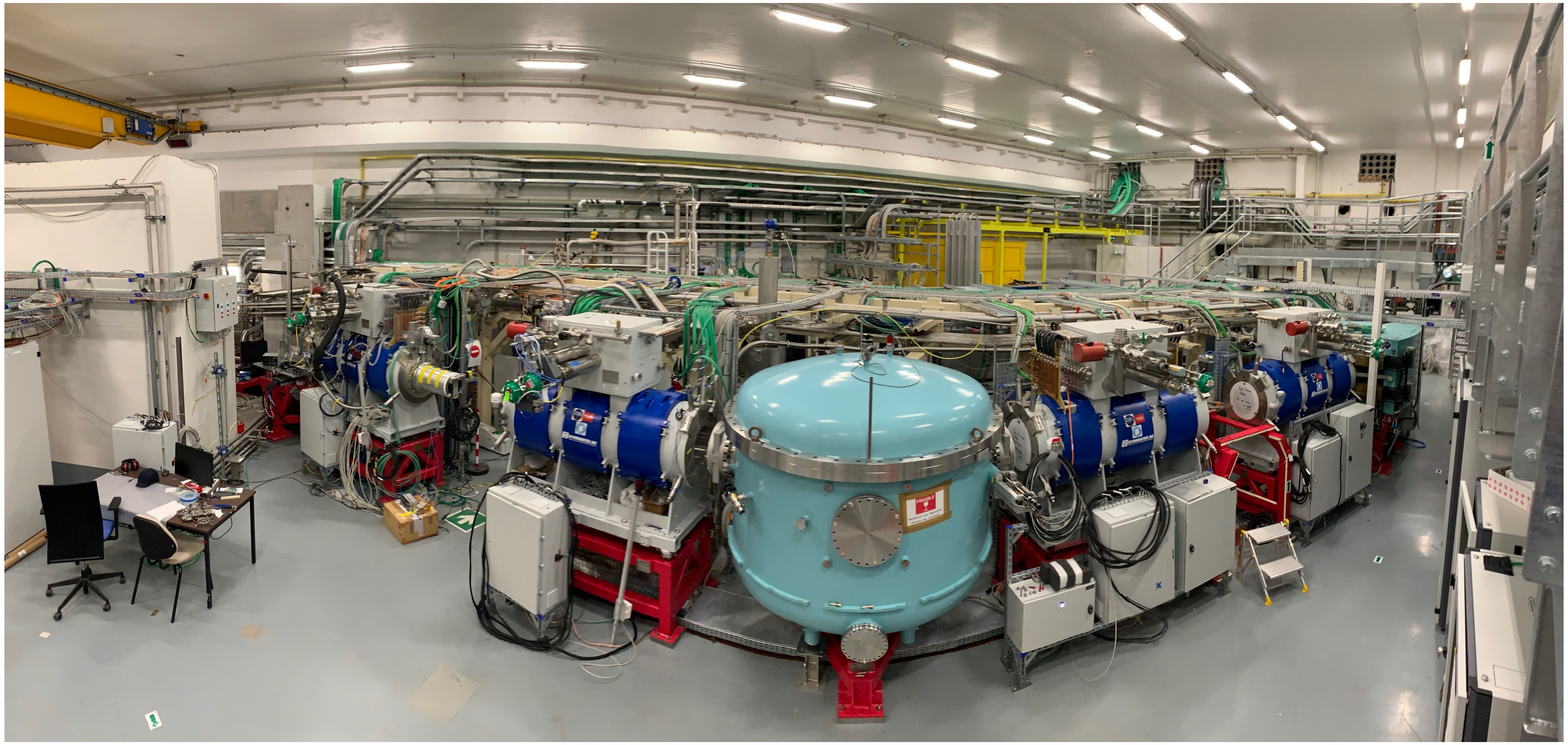
- Shedding new light on the structure of ^{56}Ni using (n,3n) reaction at NFS, E. Clement et al

MEDLEY



^{235}U fission fragment study with FALSTAFF at NFS, D. Doré et al.

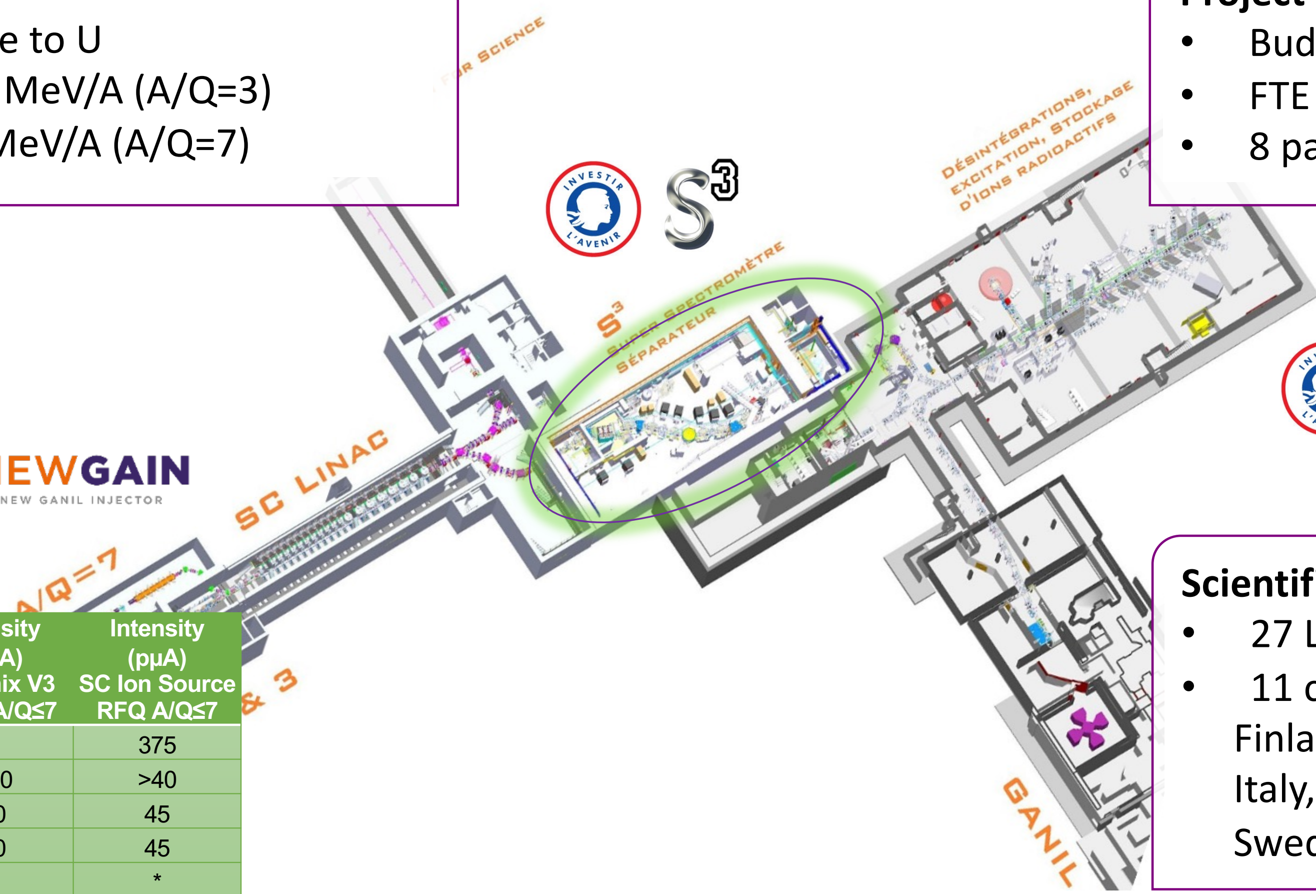
S3: the Super Separator Spectrometer



S3 Super Separator Spectrometer

LINAC beams : He to U
- 1 mA, < 14,5 MeV/A (A/Q=3)
- 1 mA, < 7,5 MeV/A (A/Q=7)

Project :
- Budget ≈ 23.3 M€
- FTE ≈ 450 (32,8 FTE 2022)
- 8 partner laboratories



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
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^{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**

Scientific collaboration:
- 27 Laboratories
- 11 countries : France, Finland, Germany, Hungary, Italy, Poland, Slovakia, Spain, Sweden, U.K., USA

S^3 has a very strong and diverse community → Full synchronisation among all team is essential

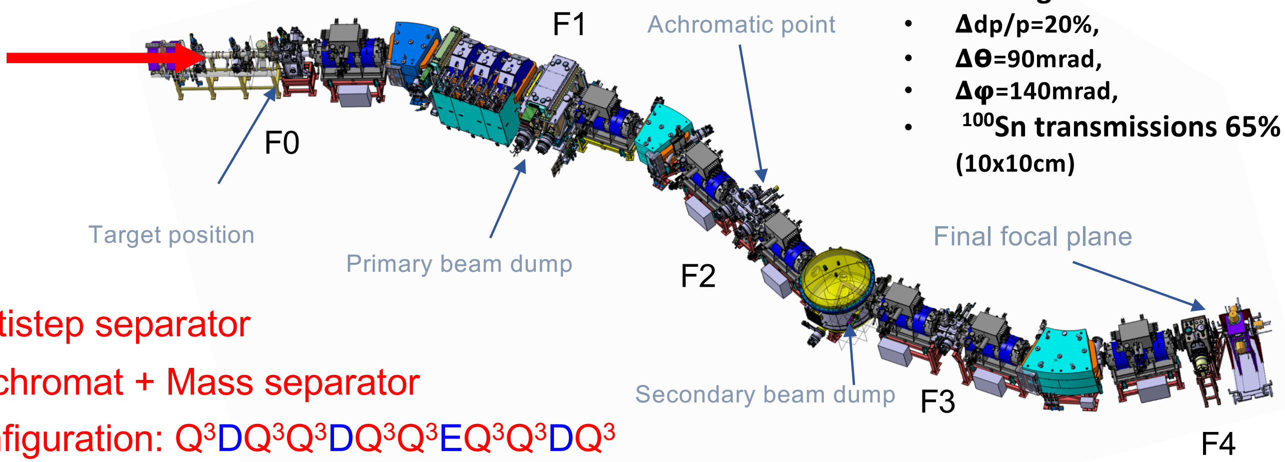
Optics and performances

Basic properties and functionalities

Reference beam :
A=100, Q=24+, σ_p = 3.7%, σ_θ = 18mrad

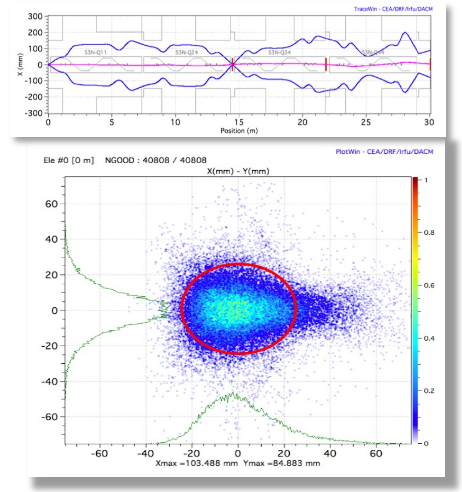
High beam intensity

High power target: >> 1pµA (= 6.10^{12}p/s)



Convergent Mode (CM)

- **No mass resolution**
- **6 charge states**
- **Δdp/p=20%,**
- **Δθ=90mrad,**
- **Δφ=140mrad,**
- **^{100}Sn transmissions 65% (10x10cm)**



Versatile multistep separator

Momentum achromat + Mass separator

Ion optics configuration: $Q^3DQ^3Q^3DQ^3Q^3EQ^3Q^3DQ^3$

F1 : R16=1.15cm/%

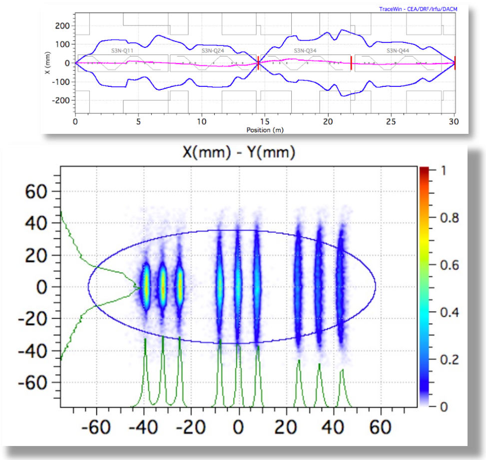
F2/F4 : R16 = R26 = 0

F3 : R16 = -1.73 cm/% / -1.59 cm/%

Two basic optical modes of operation:
High transmission vs high mass resolution

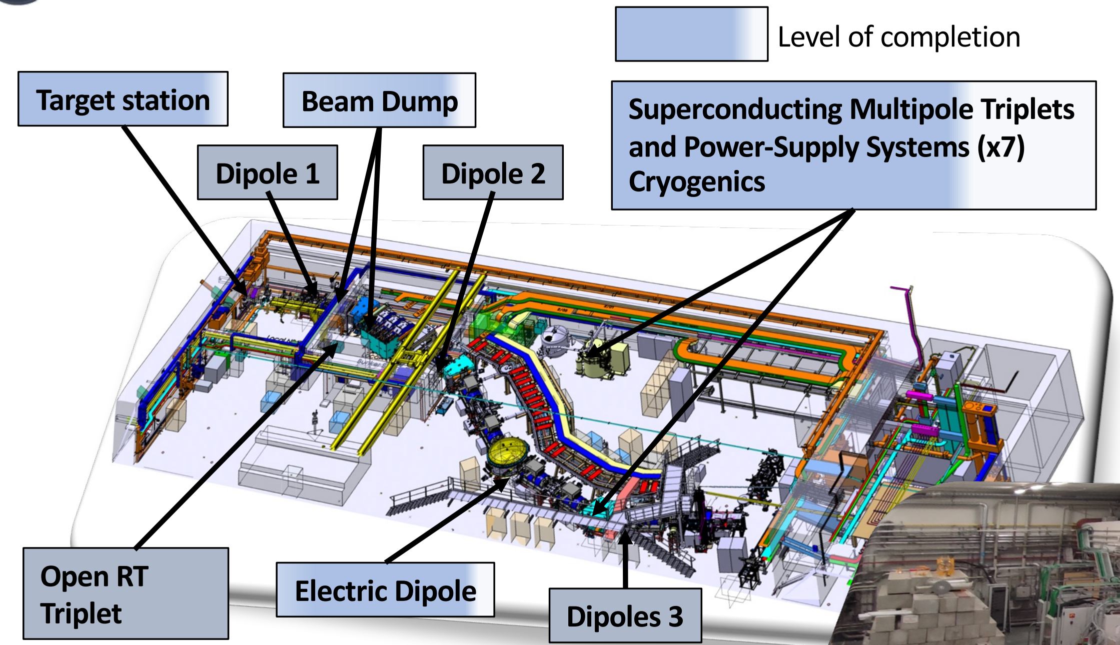
High Resolution Mode (HRM)

- **m/q dispersion = 8 mm/%**
- **3 charge states & M/ΔM = 500**
- **Δdp/p=16%**
- **Δθ=45mrad**
- **Δφ=140mrad)**
- **^{100}Sn transmissions 40% (10x10cm)**

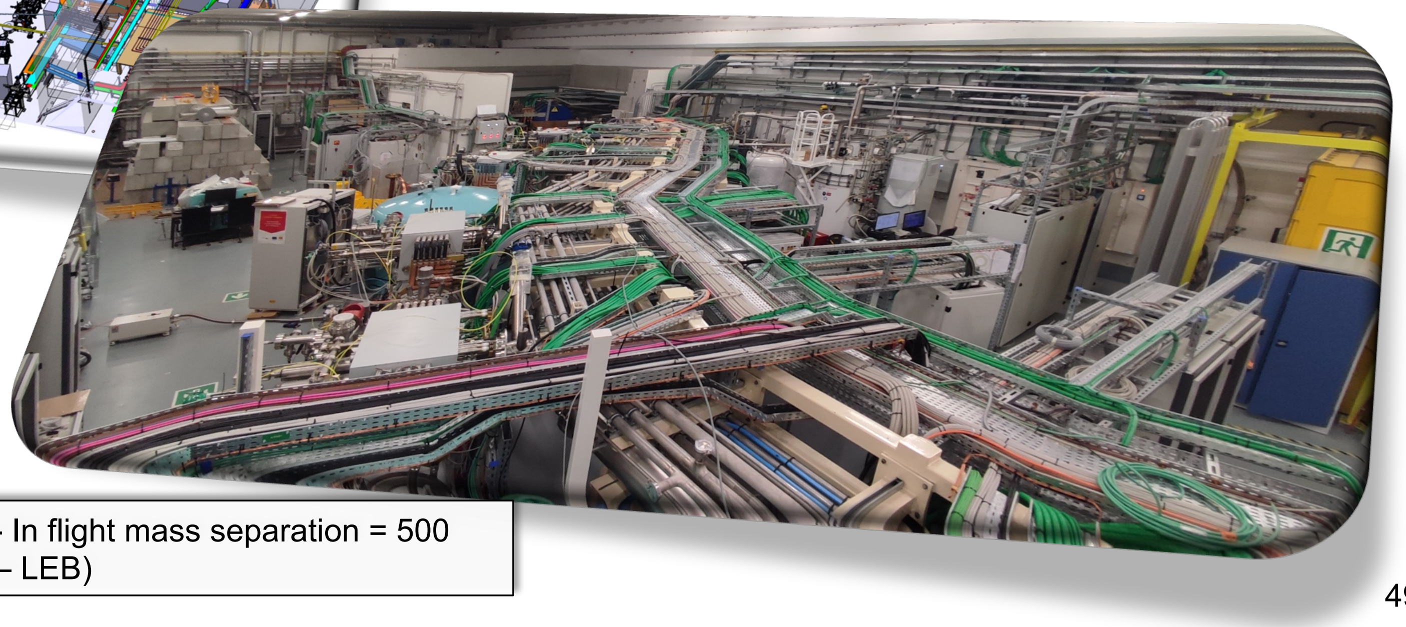


→ The momentum achromat (MA) optic is common to all modes

Status of the beamline



Level of completion ≈ 85 %
First beam on target : September 24

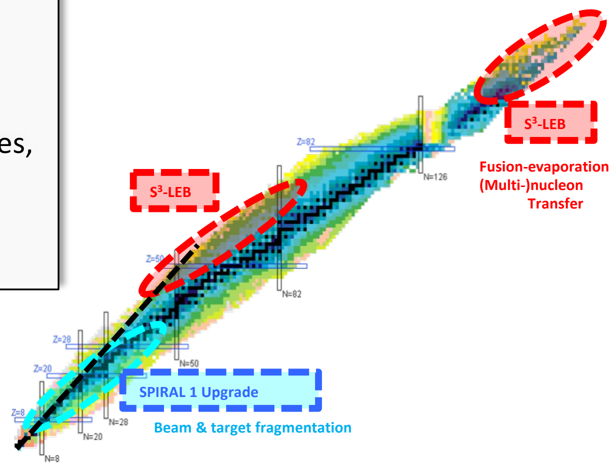


- High selectivity > 10^{13} - High efficiency 50% - In flight mass separation = 500
- Versatility & unique instrumentation (SIRIUS – LEB)

Low-energy radioactive-ion-beam facility

- Beams from SPIRAL1 and S^3
- Important beam preparation and purification capabilities
- High resolution/precision experiments
- Study of fundamental properties of nuclei : mass, life time, decay modes, spin, magnetic and quadrupolar moments
- Nucleosynthesis
- Fundamental interactions, tests of weak interaction standard model

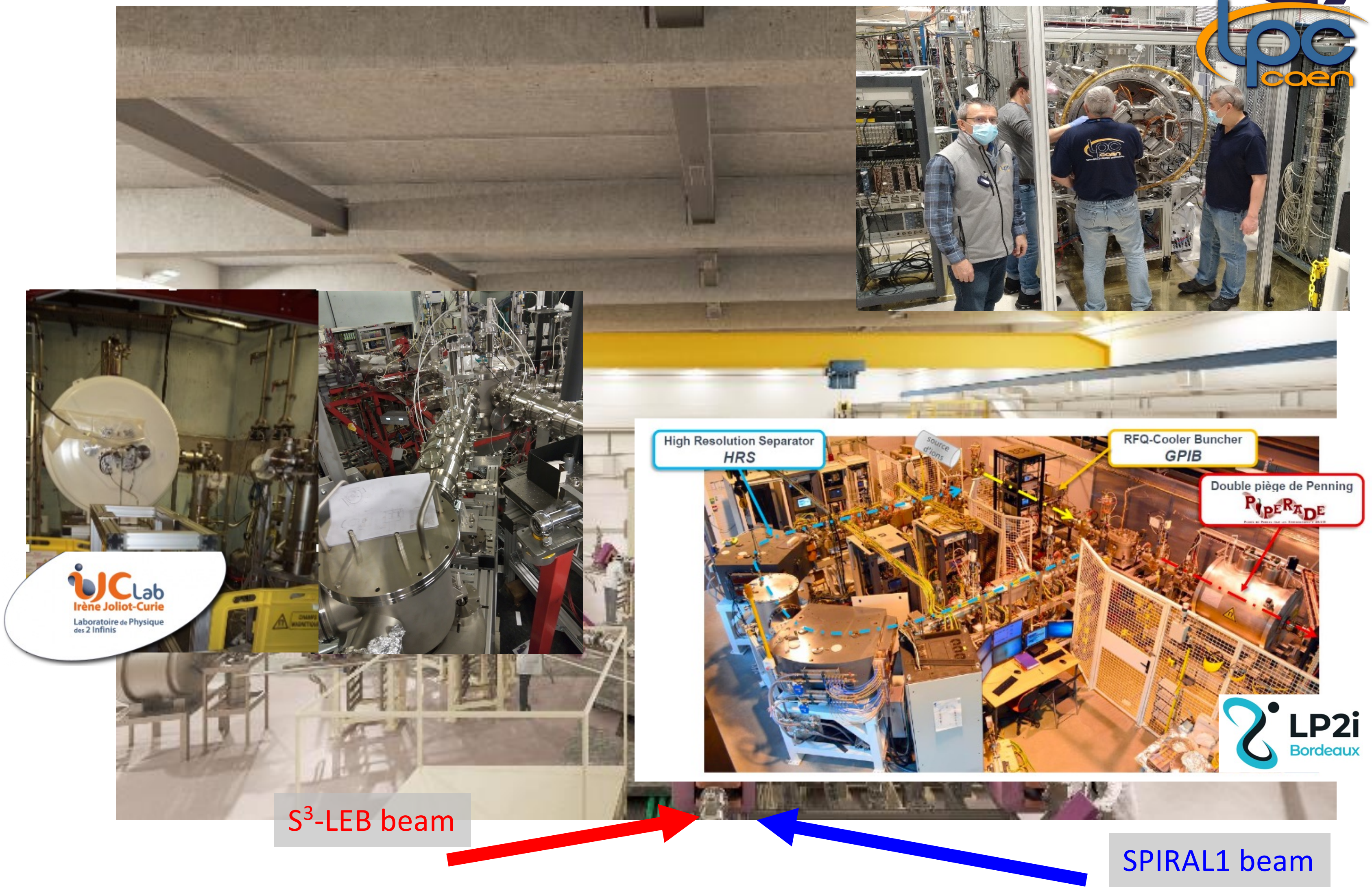
➢ Site Inauguration November 10th 2023
➢ First tests with stable beams 2026
➢ First experiments 2027



DESIR building inauguration, November 10th, 2023

GANIL

- Building permit received in June 2023
- Authorisation for S3 safety exit boring through


High Resolution Separator
HRS
RFQ-Cooler Buncher
GPIB
Double piège de Penning
PIPERADE
IJCLab
Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis
LP2i
Bordeaux
S3-LEB beam
SPIRAL1 beam

GANIL 2030

Neutrons for Science (NFS) started to work in 2021 (first exp).
Neutrons produced from protons and deuterons accelerated from the LINAC: mainly fission, but also low-energy excitations, …

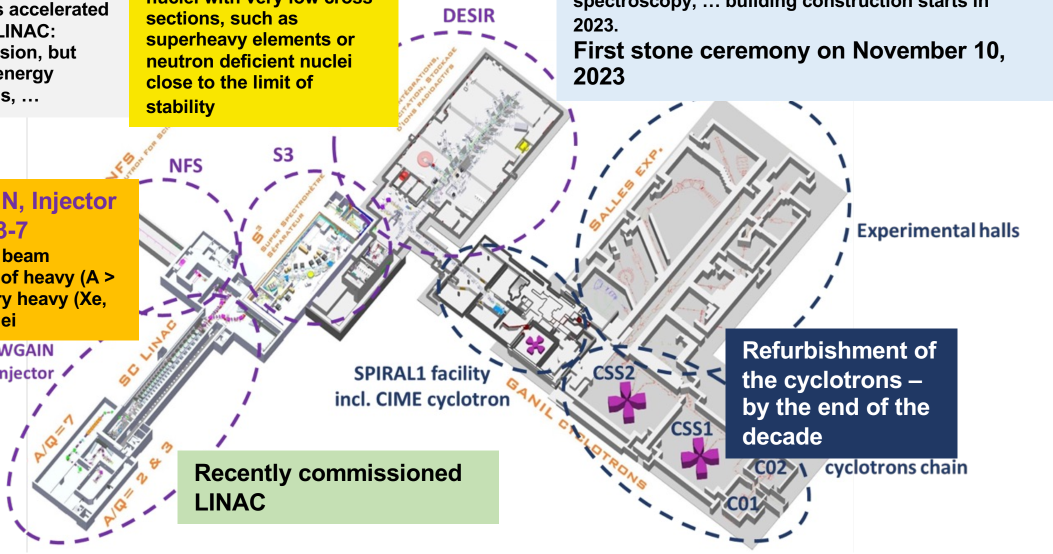
Commissioning of the Super Separator Spectrometer (S3) planned in 2024:
nuclei with very low cross sections, such as superheavy elements or neutron deficient nuclei close to the limit of stability

DESIR in 2027-2028
unique opportunities in terms of selection of exotic nuclei and/or beam purity.
masses, laser spectroscopy, beta-decay spectroscopy, … building construction starts in 2023.
First stone ceremony on November 10, 2023

NEWGAIN, Injector 2: A/Q =3-7
Increasing beam intensities of heavy (A > 40) and very heavy (Xe, Pb, U) nuclei

Refurbishment of the cyclotrons – by the end of the decade

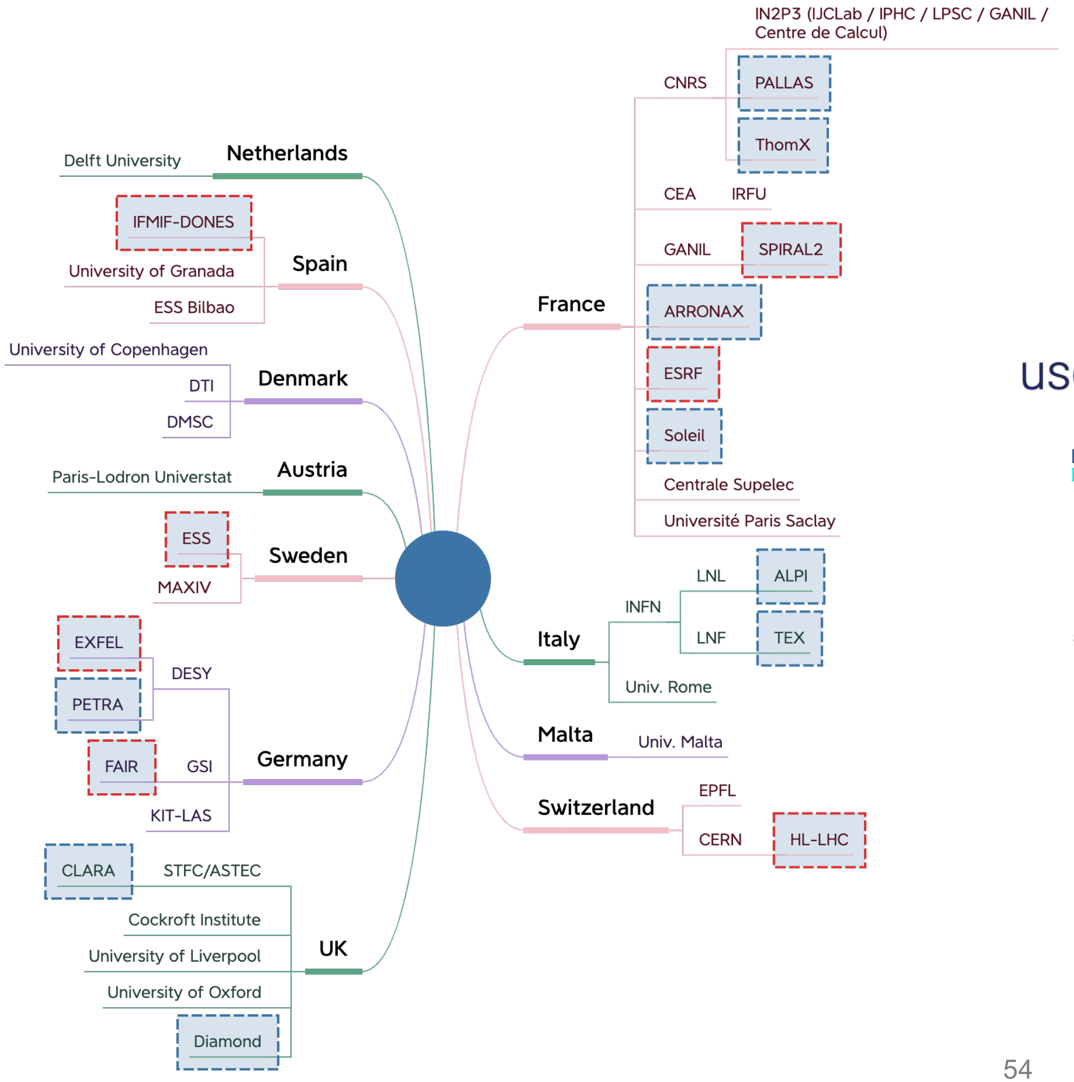
Recently commissioned LINAC



Courtesy M. Grasso

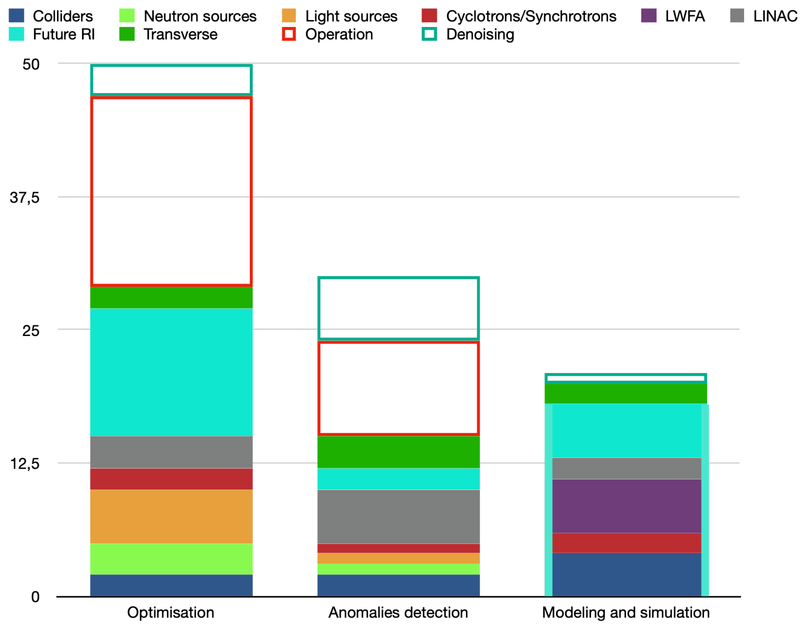
AI for accelerators

HORIZON-INFRA-2022-TECH-01-01
March, 2024



artifact

ARTifical **I**ntelligence **F**or **A**ccelerators,
user **C**ommunities and associated **T**echnologies



Purpose

And how can AI help ?

- operation and `reliability` ;
- Detecting, preventing `anomalies` ;
- `Optimising` beam time ;
- `Frugal` complex physics simulation ;
- Improved models.

> ! Several groups have been trying but there are locks to making global impact in the community !

Purpose

so, how do we unlock the use of AI for our RI ?

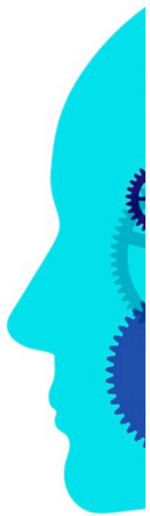
- We bring the missing piece of FAIRness

  in data, methods and tools in ML for RI
- We build upon existing

  knowledge and experience
- And we push it to its edge`(s)`

  in an integrated smart pilot/prototype
- Making sure the challenge stays realistic

  within a given time frame and budget.



Scope

Expected outcomes

- Enhanced scientific competitiveness of Research Infrastructures ;
- Enhanced RI capacities to address research challenges EU policy priorities ;
- Increased collaboration of research infrastructures with universities, research organisations and industry ;
- Increase of technological level of industries through the co-development of advanced technologies of research infrastructures and creation of potential new markets ;
- Integration of research infrastructures into local, regional and global innovation systems and promotion of entrepreneurial culture.

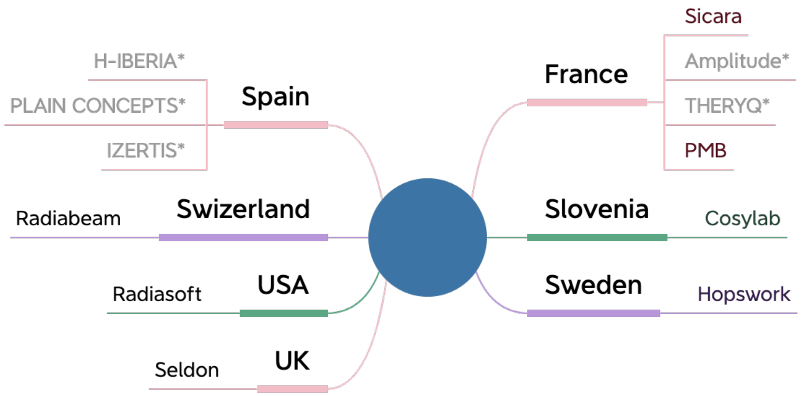
Scope

Fields of application

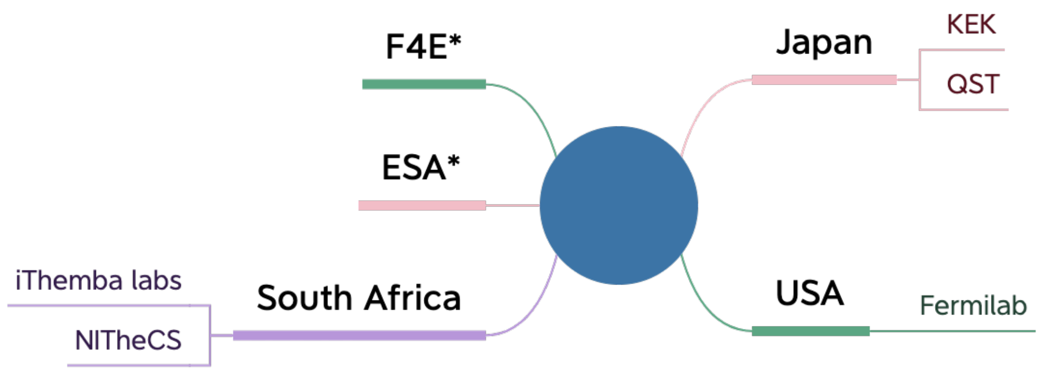
- Main field : Accelerator physics and technologies and user communities ;
- Spans across different applications ;
  - → Particle physics ;
  - → Nuclear physics ;
  - → Light and Neutron sources ;
  - → Medical and industrial applications ... ;
- Connects several projects and links to transverse applications.

ARTIFACT

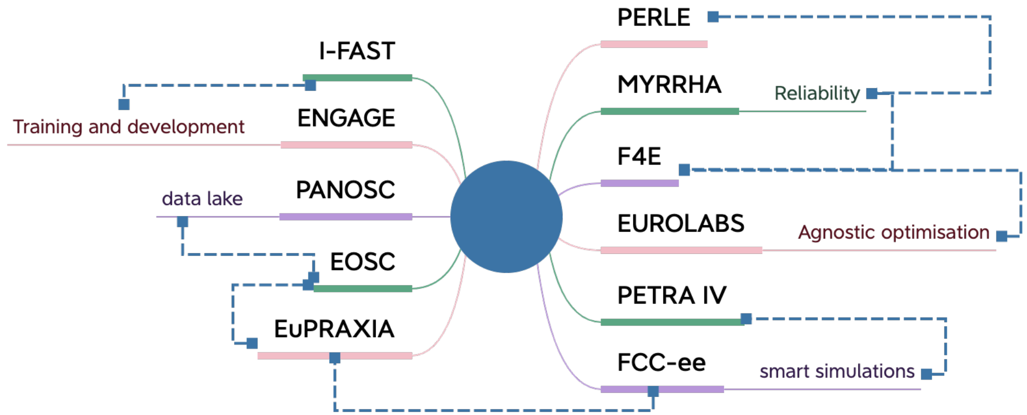
Industrial partners



Observers

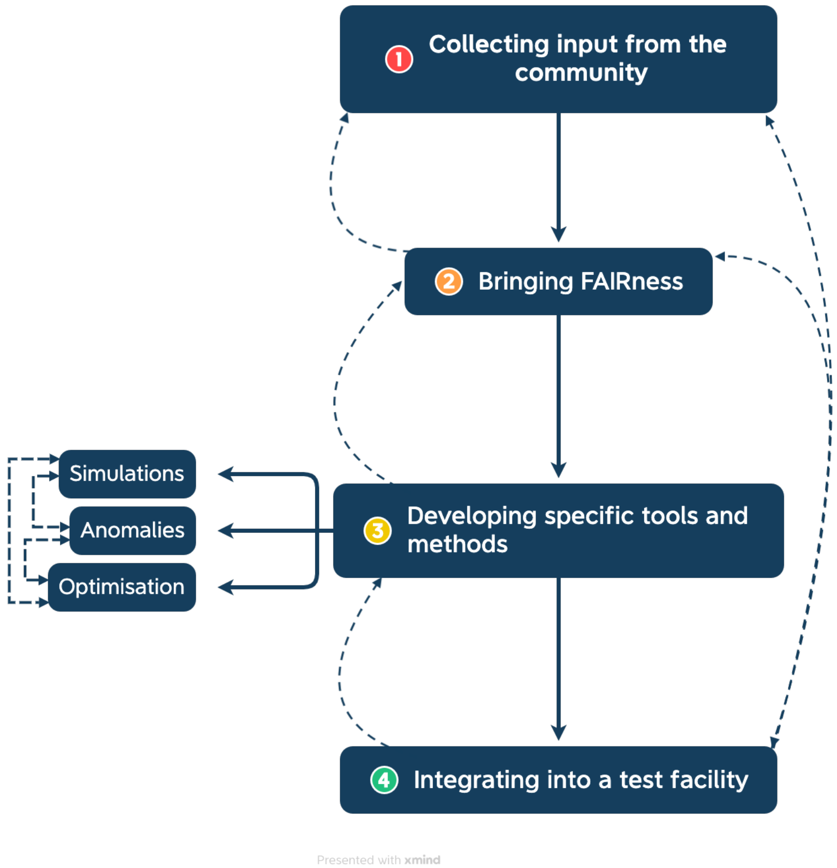


Directo connection to other projects



ARTIFACT

Strategy



Standardisation, Best practises,

Raw data, curation, structuration, model training,publication ..

New methods and innovative tools, existing facilities and designed facilities, community driven developments

TEX & CLARA Link with the user community

Thank you for your attention