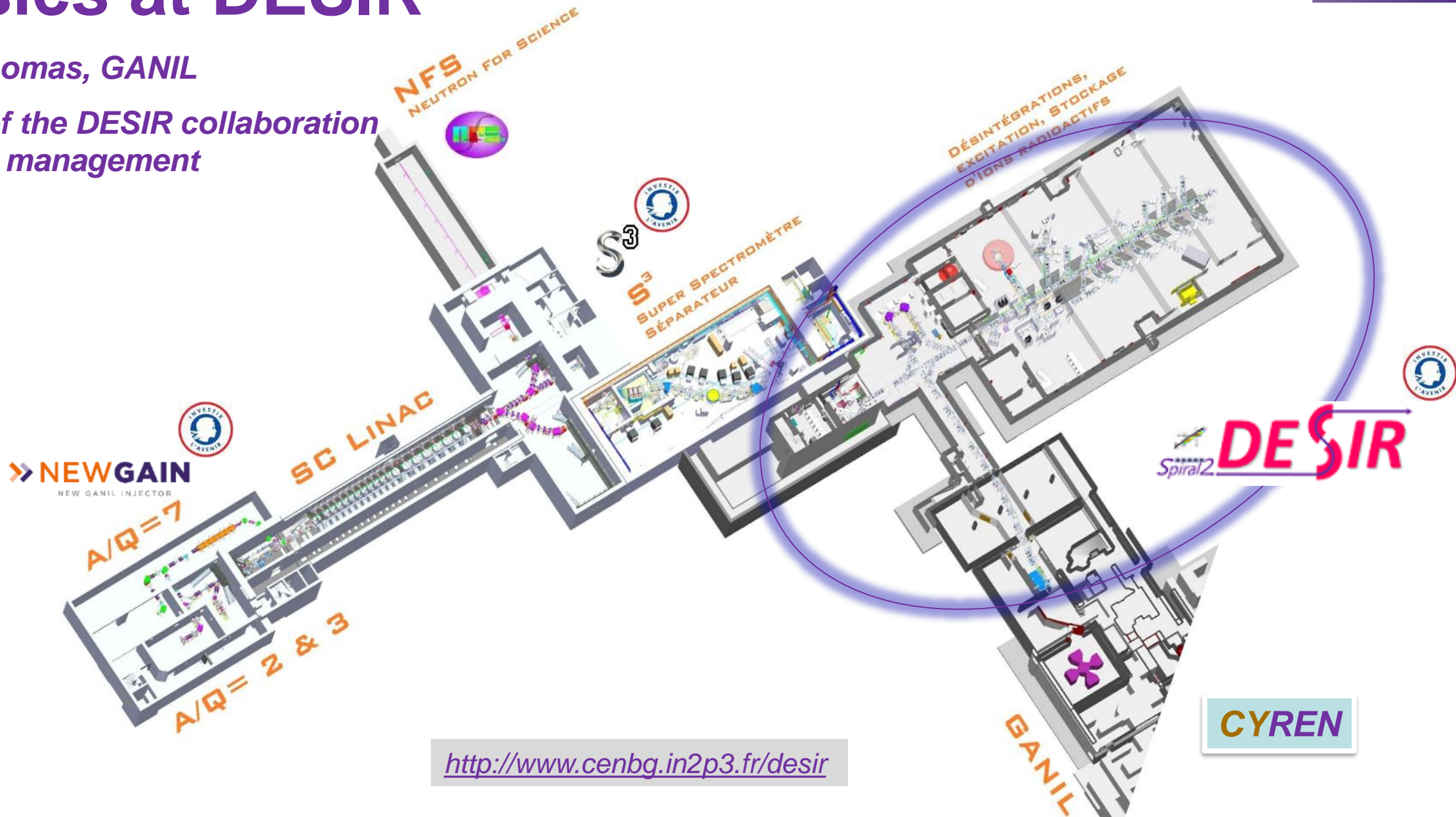


# Physics at DESIR

J.-C. Thomas, GANIL

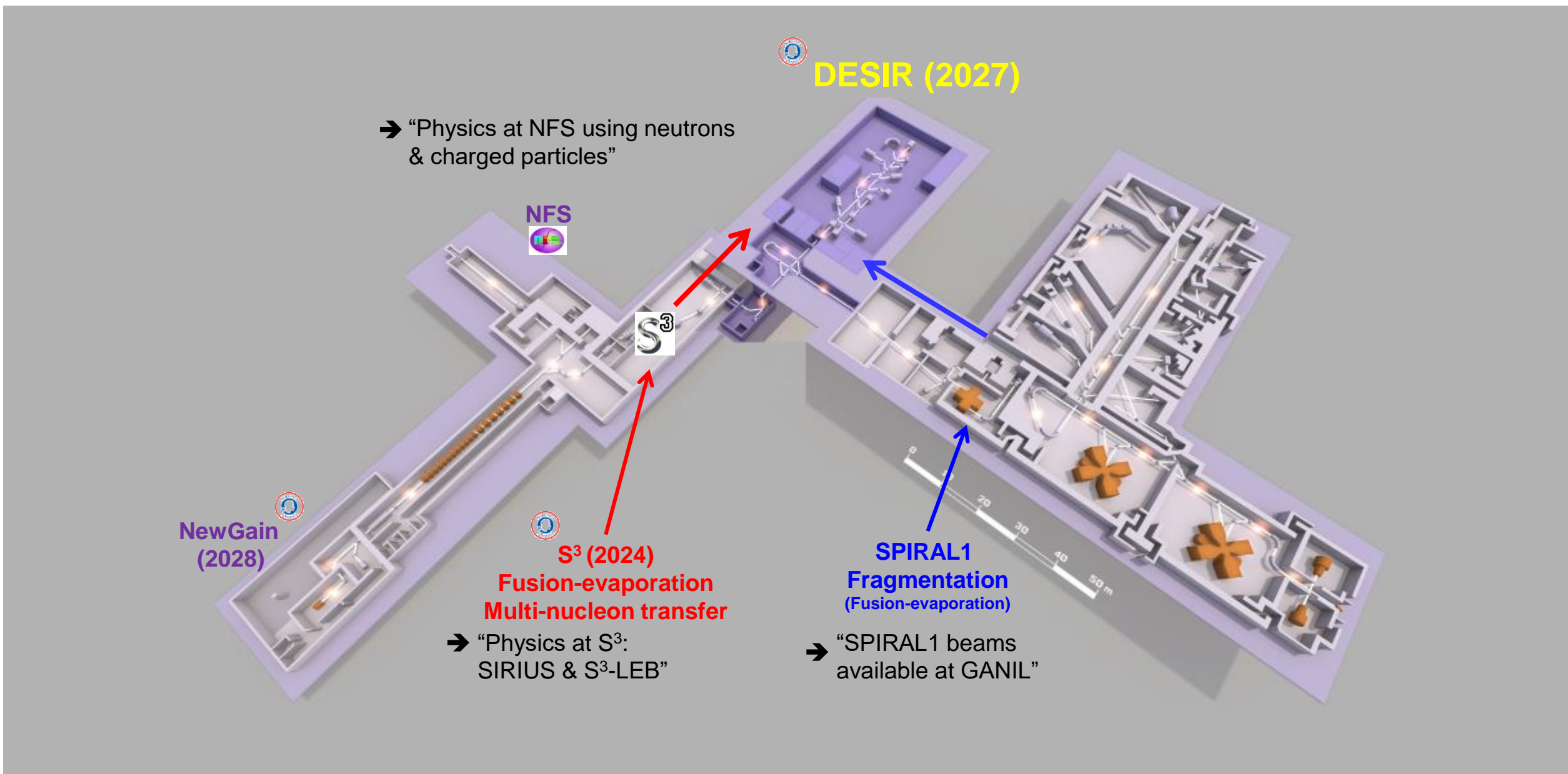
On behalf of the DESIR collaboration  
and project management



<http://www.cenbg.in2p3.fr/desir>

# DESIR @ GANIL/SPIRAL2





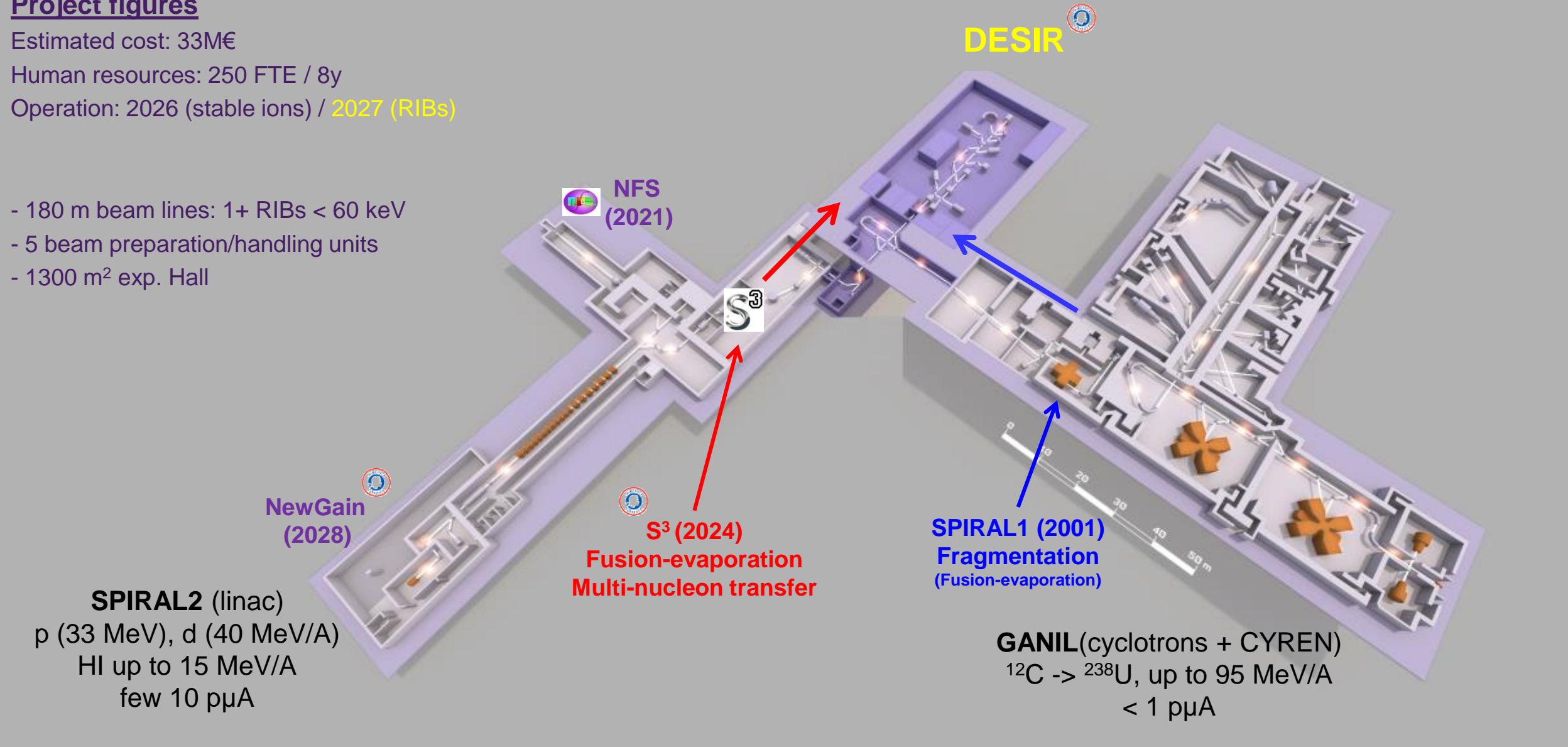
## Project figures

Estimated cost: 33M€

Human resources: 250 FTE / 8y

Operation: 2026 (stable ions) / 2027 (RIBs)

- 180 m beam lines: 1+ RIBs < 60 keV
- 5 beam preparation/handling units
- 1300 m<sup>2</sup> exp. Hall



**DESIR**

**NFS (2021)**

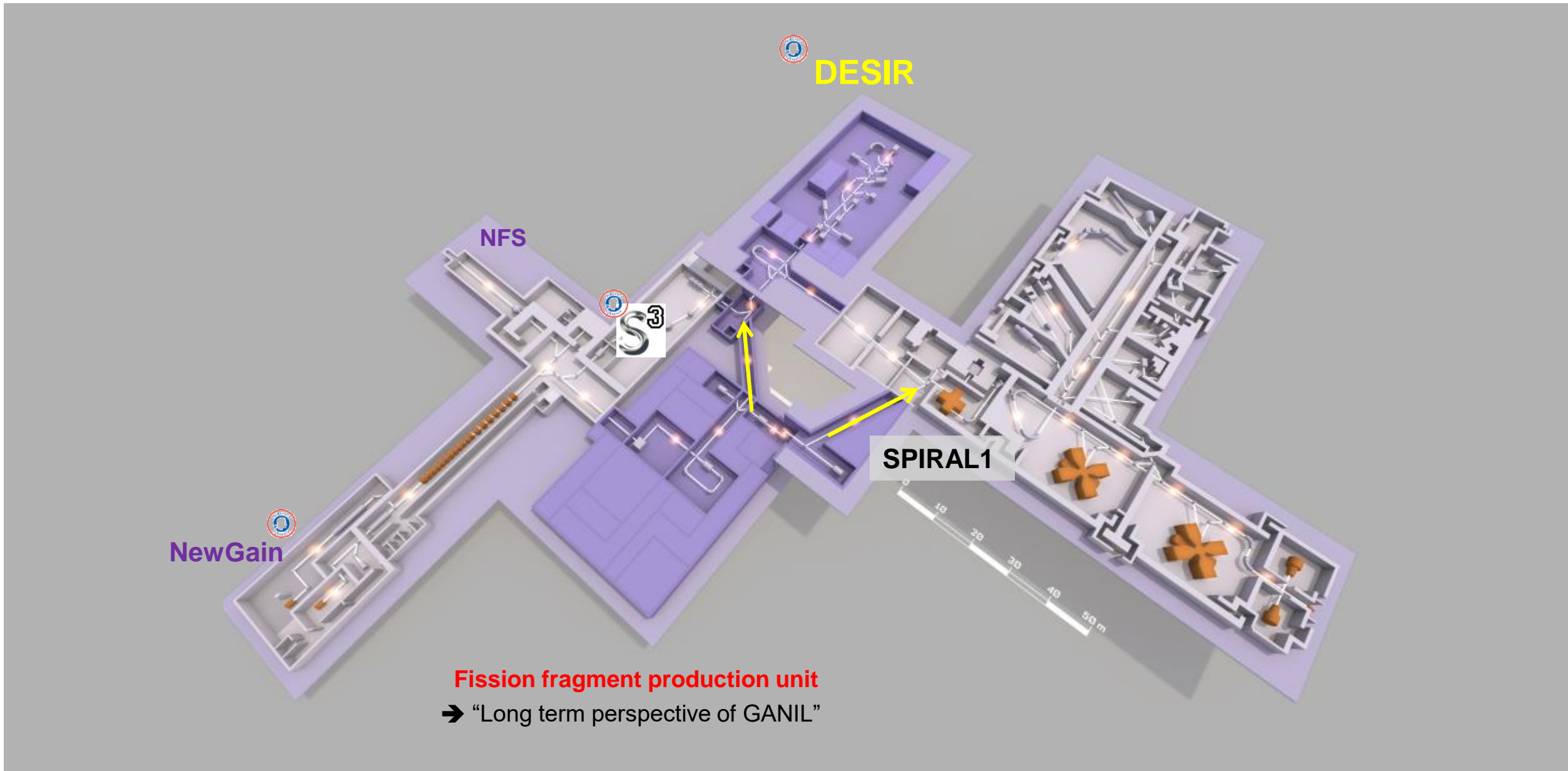
**NewGain (2028)**

**S<sup>3</sup> (2024)**  
Fusion-evaporation  
Multi-nucleon transfer

**SPIRAL1 (2001)**  
Fragmentation  
(Fusion-evaporation)

**GANIL**(cyclotrons + CYREN)  
 $^{12}\text{C} \rightarrow ^{238}\text{U}$ , up to 95 MeV/A  
< 1  $\mu\text{A}$

**SPIRAL2** (linac)  
p (33 MeV), d (40 MeV/A)  
HI up to 15 MeV/A  
few 10  $\mu\text{A}$



**Fission fragment production unit**  
→ “Long term perspective of GANIL”

# DESIR scientific objectives

# DESIR

## « Decay, Excitation and Storage of Radioactive Ions »

Exotic decay modes  
High-precision  $\beta$ -decay studies

**BESTIOL**

Magnetic and quadrupole moments  
Mean-square charge radii  
Spins

**LUMIERE**

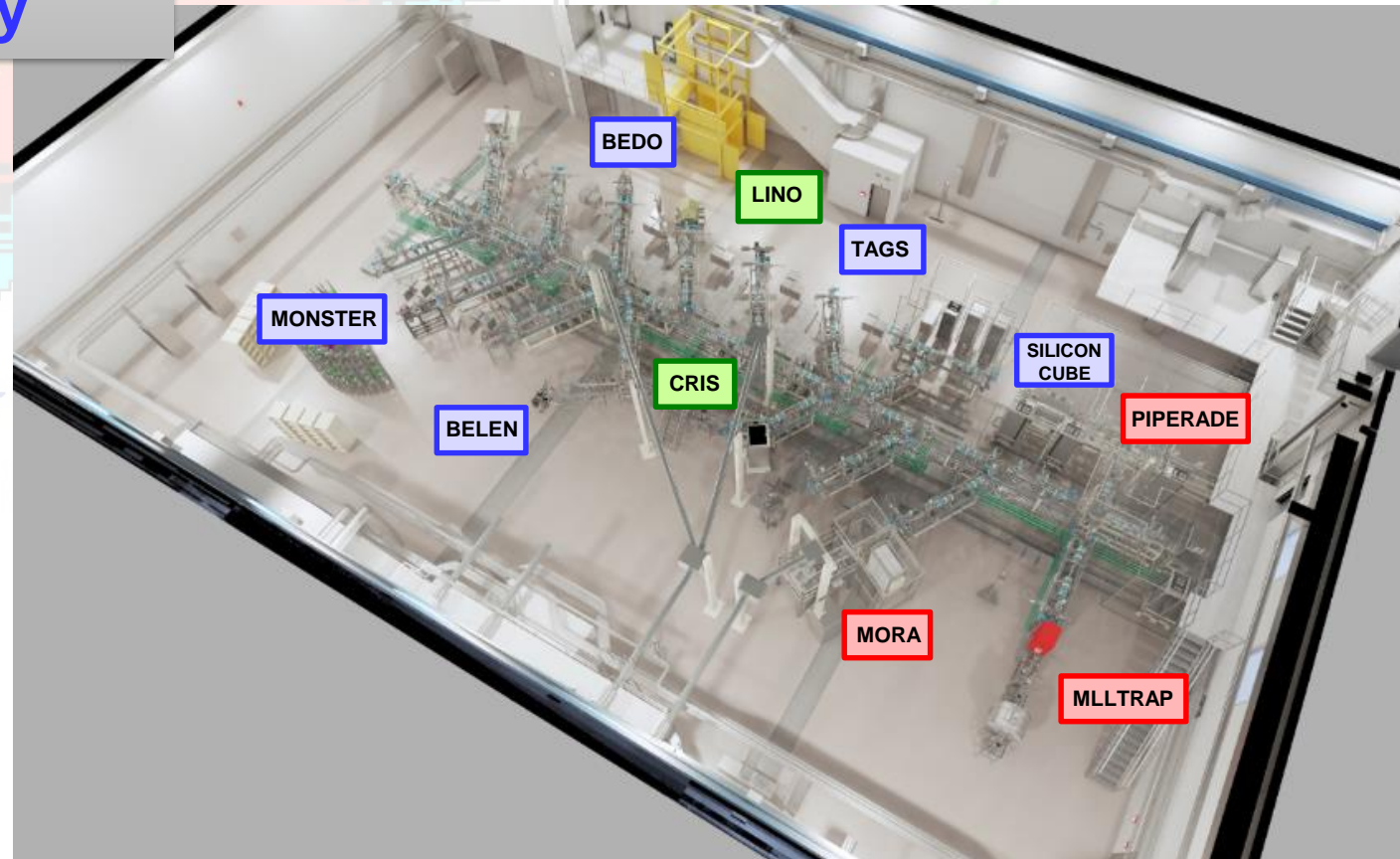
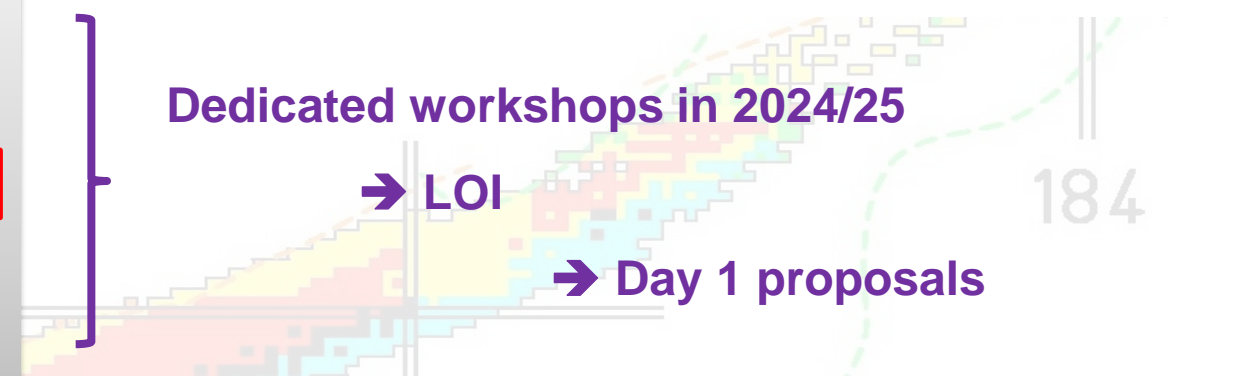
Masses  
Trap-assisted spectroscopy  
Correlation measurements

**DETRAP**

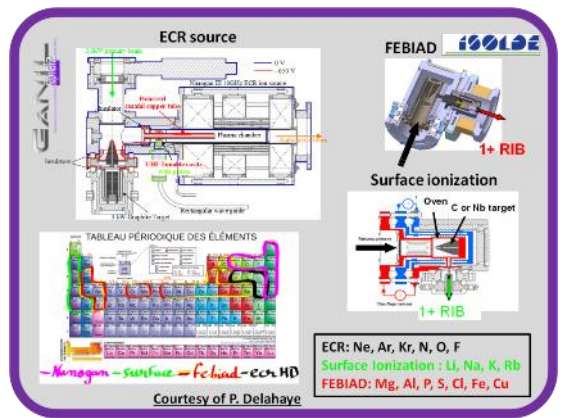
- Fundamental properties of nuclei in their ground and long-lived isomeric states
- Ultra-pure samples for high-precision measurements
- Ion manipulation using traps and laser
- Complementarity with S<sup>3</sup>-LEB and other GANIL/SPIRAL2 facilities



- **Collinear laser-spectroscopy** LUMIERE
- **Laser polarisation (LINO)**
- **Paul trap (MORA)** DETRAP
- **Penning traps (PIPERADE, MLLTrap)** BESTIOL
- **(Trap-assisted) decay spectroscopy**



Low energy (< 60 keV) 1+ RIBs from SPIRAL1 and S<sup>3</sup>



*P. Chauveau et al., NIM B 541 (2023) 61*  
 “Latest improvements of the SPIRAL1 facility at GANIL”

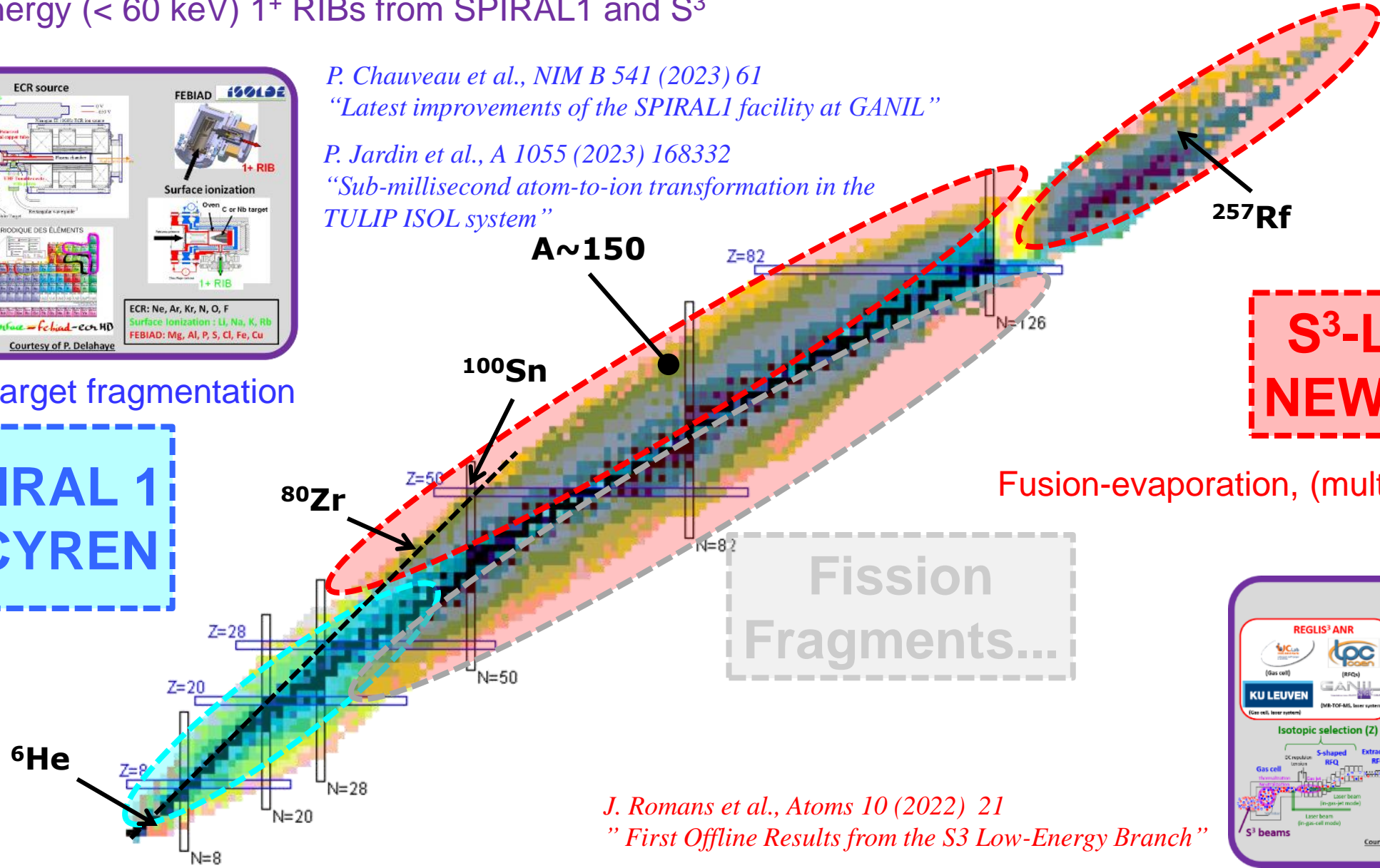
*P. Jardin et al., A 1055 (2023) 168332*  
 “Sub-millisecond atom-to-ion transformation in the TULIP ISOL system”

beam/target fragmentation

**SPIRAL 1 + CYREN**

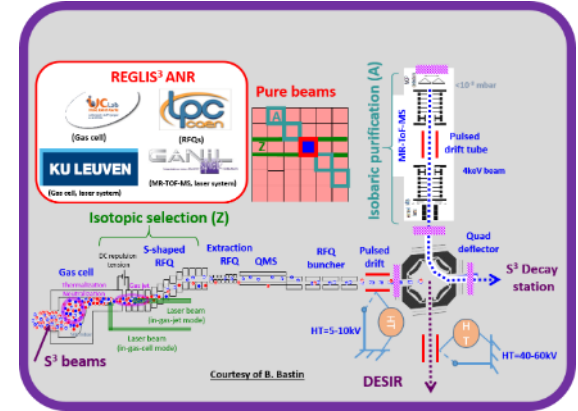
**S<sup>3</sup>-LEB + NEWGAIN**

Fusion-evaporation, (multi-nucleon) transfer



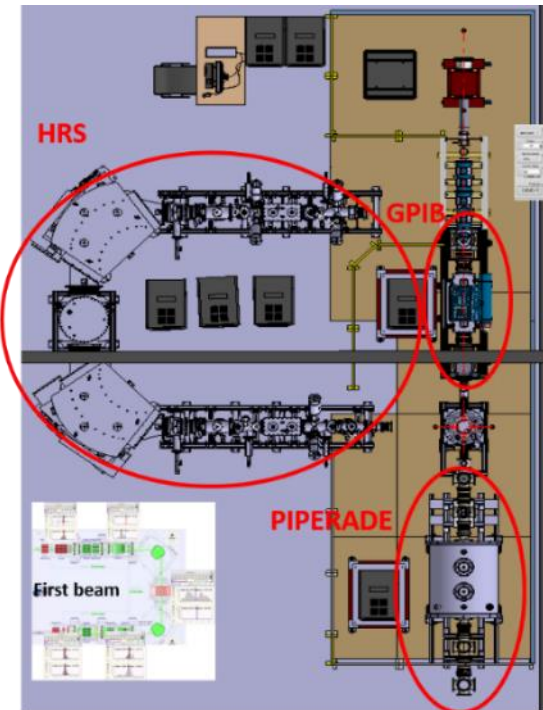
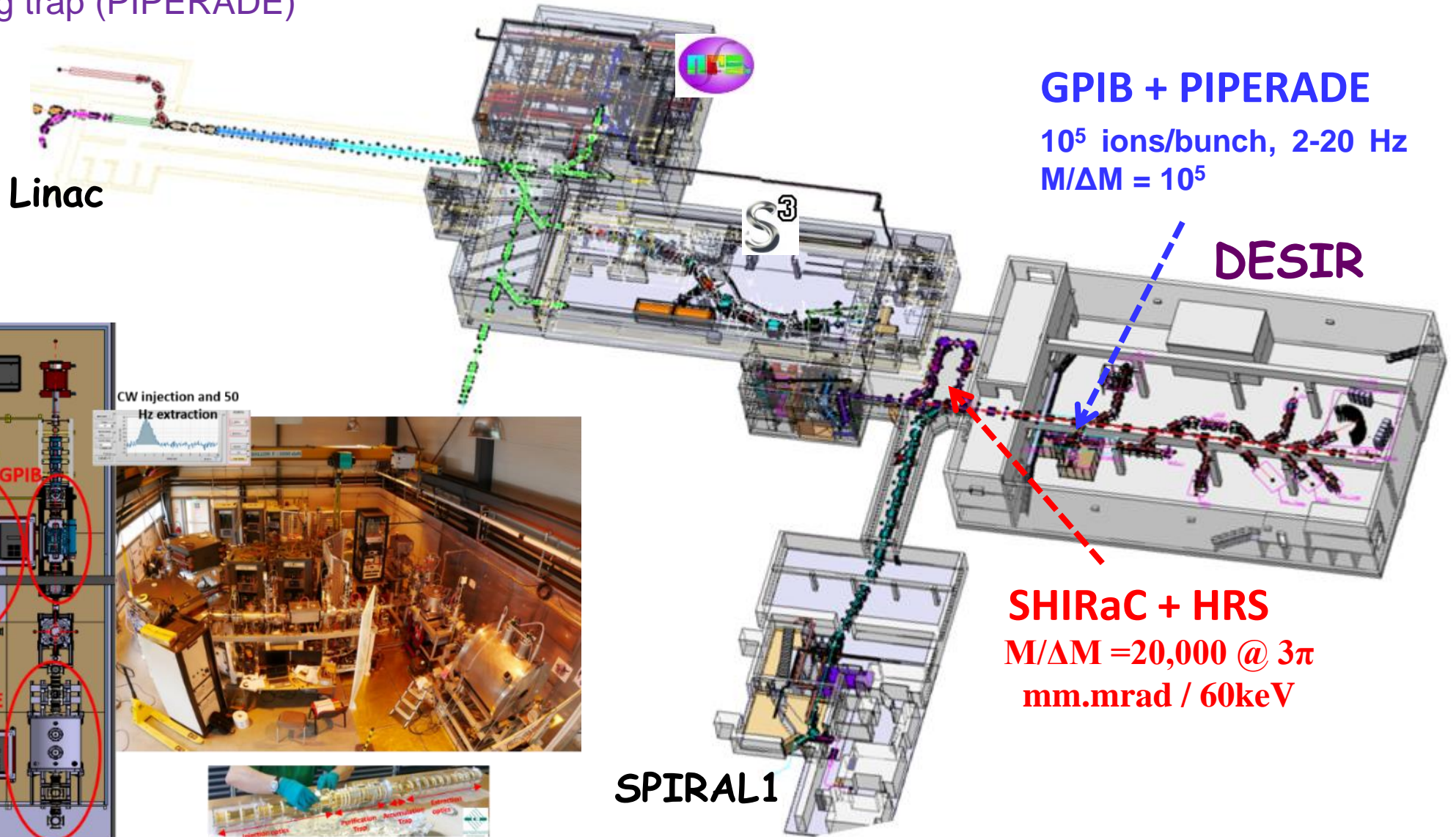
Fission Fragments...

*J. Romans et al., Atoms 10 (2022) 21*  
 ” First Offline Results from the S3 Low-Energy Branch ”



# DESIR beam purification and sampling

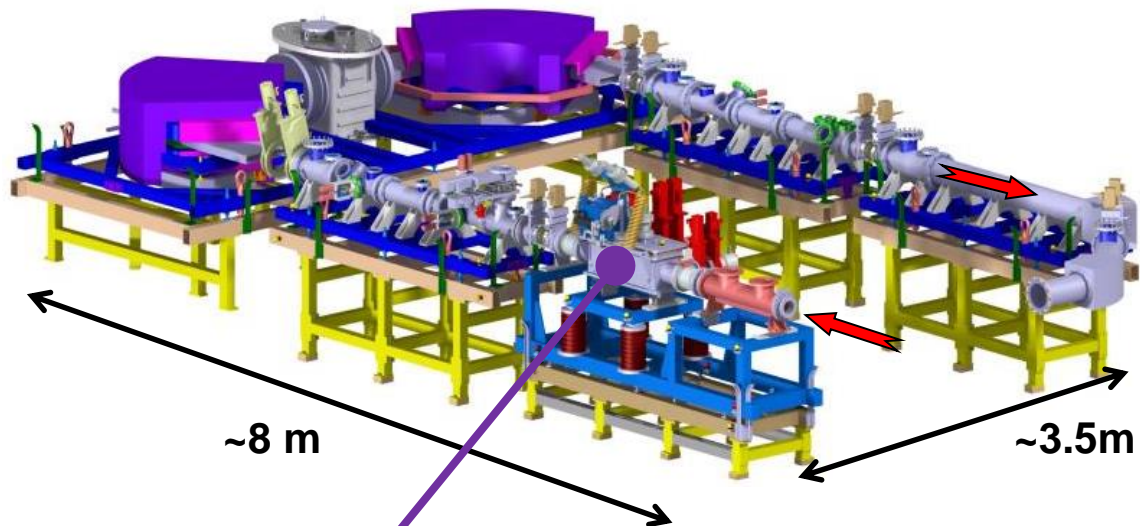
→ Beam Cooler + High-resolution mass separator (HRS); General purpose ion buncher and cooler (GPIB); Double Penning trap (PIPERADE)



CW injection and 50 Hz extraction



## HRS1P



*J. Michaud et al., NIM B 541 (2023) 161  
Commissioning of the DESIR high-resolution mass separator”*

**HRS**

Conception: QQSQD-M-DQSQQ

Specification:  
 $M/\Delta M = 20,000 @ 3\pi \text{ mm.mrad @ } 60\text{keV}$

Achievement:  
 $M/\Delta M = 25,000 @ 1-2\pi \text{ mm.mrad @ } 25 \text{ keV}$

**Commissioning at LP2iB**

## SHIRaC RFQ1P



**SHIRaC**

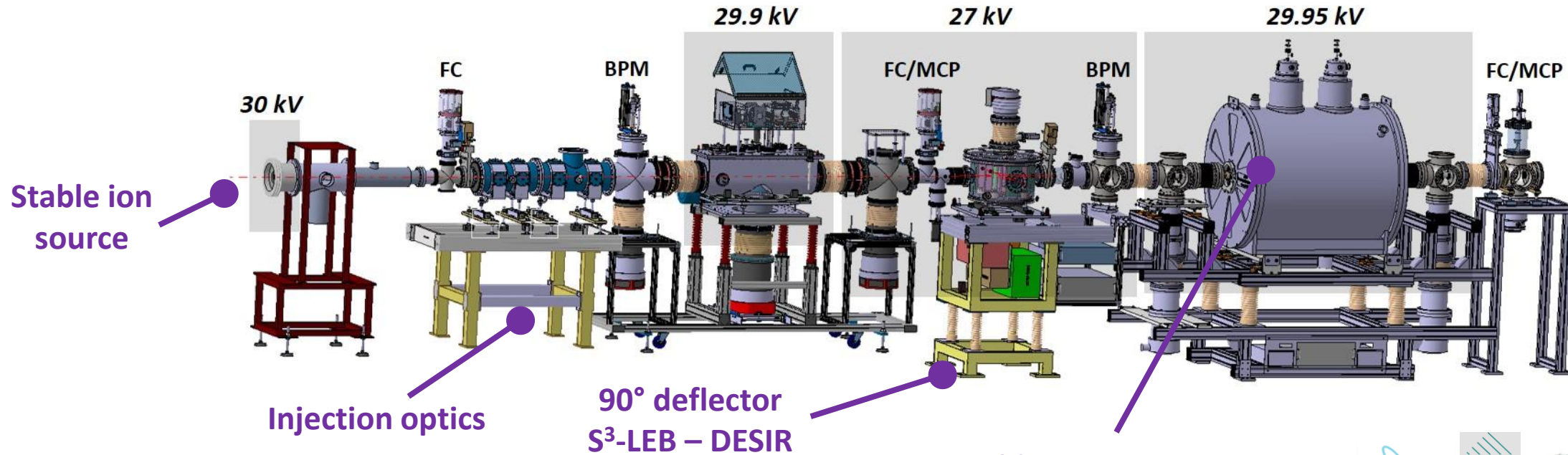
Emittance reduction of high intensity beams  
Transmission ~70 % @ 1μA

**Refurbishing at LPC Caen**

*R. Boussaid et al., JINST 9 (2014) P07009  
“Simulations of high intensity ion beam RFQ cooler for DESIR/SPIRAL 2: SHIRaC”*

## General Purpose Ion Buncher and cooler (GPIB)

- $10^6$ - $10^7$  ions/bunch, < 100 Hz
- emittance reduction



- ### Double Penning trap
- $10^5$  ions/bunch, 2-20 Hz
  - $M/\Delta M = 10^5$



*M. Gerbaux et al., NIM A 1046 (2023) 167631*

*“The General Purpose Ion Buncher: A radiofrequency quadrupole cooler-buncher for DESIR at SPIRAL2”*

*P. Ascher et al., NIM A 1019 (2021) 165857*

*“PIPERADE: A double Penning trap for mass separation and mass spectrometry at DESIR/SPIRAL2”*

**Commissioning at LP2iB**

# DESIR experimental equipment

## MORA

*P. Delahaye, GANIL, L. Hayen, LPC Caen*

- RFQ-CB associated with a Paul trap
- >  $\beta$ -n angular correlation coefficient
- > D correlation with laser polarized beams



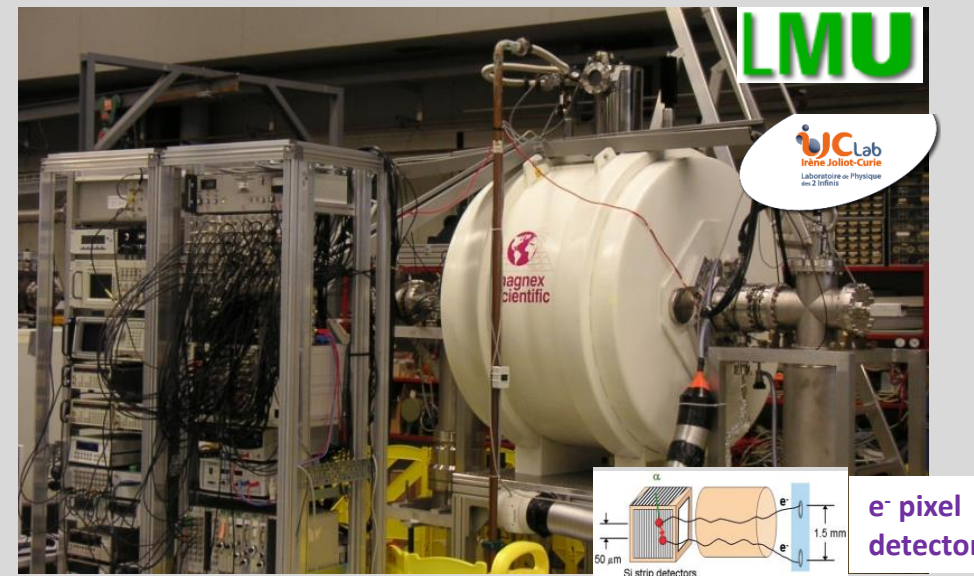
*P. Delahaye et al., Hyperfine Interaction 240 (2019) 63*

- ⇒ Fundamental interaction physics
  - exotic currents, CVC,  $V_{ud}$ , CP-violation
- Commissioning at JYFL**

## MLLTrap

*P. Thirolf, LMU Munich – E. Minaya Ramires, IJCLab*

- 7T double Penning trap
- > mass measurements ( $DM/M \sim 10^{-8}$ ) of pure samples
- > in-trap e- and a spectroscopy



*E. Minaya-Ramires et al., NIM B 463 (2020) 315*

*P. Chauveau et al., NIMB 463 (2020) 371*

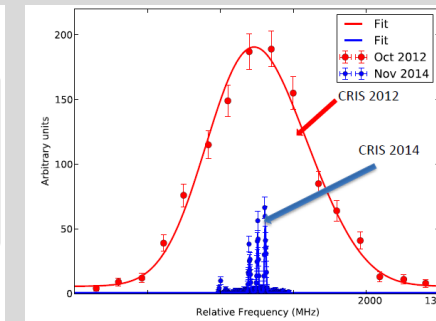
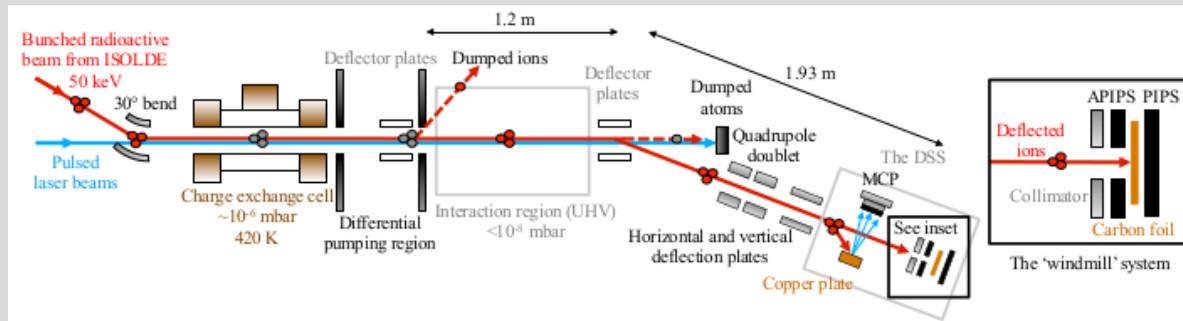
- ⇒ Nuclear structure & Decay properties
  - shell evolution, deformation
  - (super-) heavy nuclei decay spectroscopy
- Commissioning at ALTO (IJCLab)**



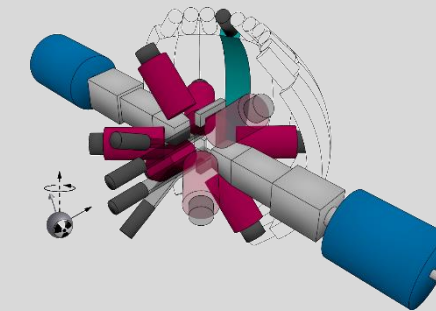
## Laser Utilization for Measurement and Ionization of Exotic Radioactive Elements

➤ 2 laser lines:

- Collinear laser spectroscopy (CRIS like, ISOLDE)
  - > hyperfine structure (magnetic and quadrupole moments, mean square charge radii)



- Optical pumping line (LINO at IJCLab, *D. Yordanov et al.*)
  - >  $\beta$ -NMR,  $\beta$ -decay study of laser polarized beams (spins)



*D.T. Yordanov et al., JINST 15 (2020) P06004*

⇒ Static moments, shape evolution, nuclear structure

## BETA decay STUDIES at the SPIRAL2 IsOL facility

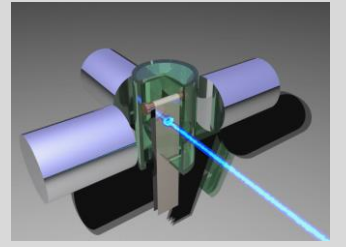
Beam cooling and purification using PIPERADE for (trap-assisted) decay spectroscopy

-> High-precision measurements with ultra-pure samples using:

- $\beta$ - $\gamma$  decay stations (BEDO, ...)
- total absorption spectrometers (DTAS)
- neutron detection arrays (BELEN, MONSTER, ...)

⇒ Fundamental interaction, nuclear structure, decay properties

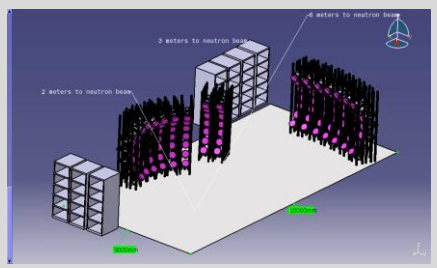
- CVC,  $V_{ud}$
- lifetimes,  $P_{(2)n}$
- exotic decays ( $\beta$ -2p, cluster emission)
- Gamow-Teller strength



BELEN



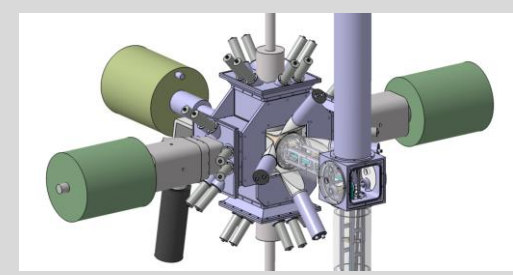
SiCube



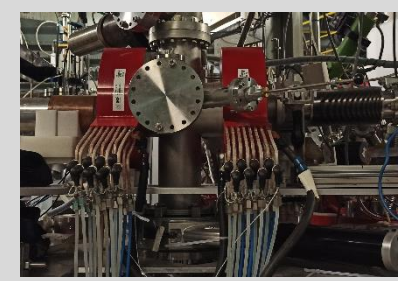
MONSTER



DTAS

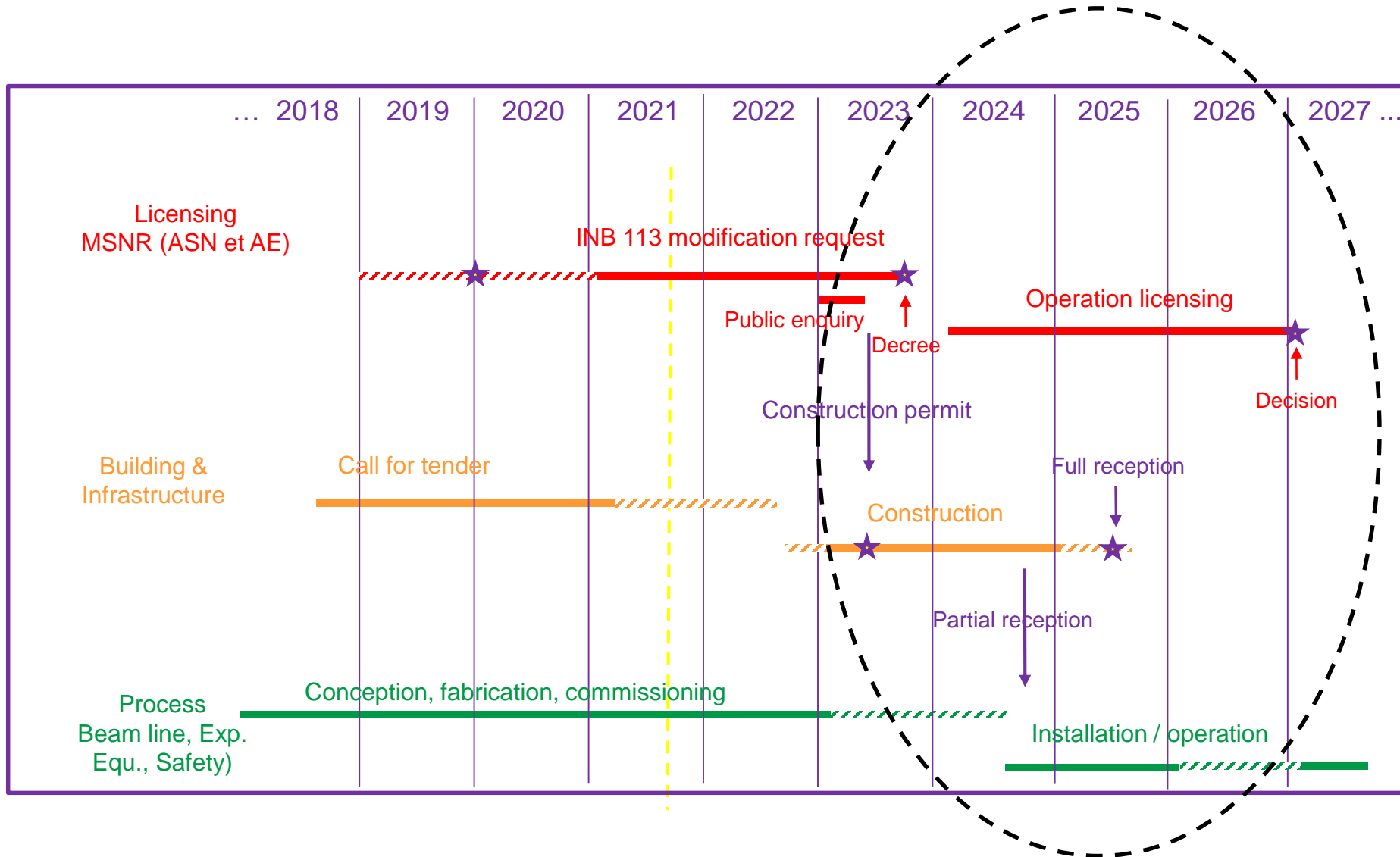


BEDO

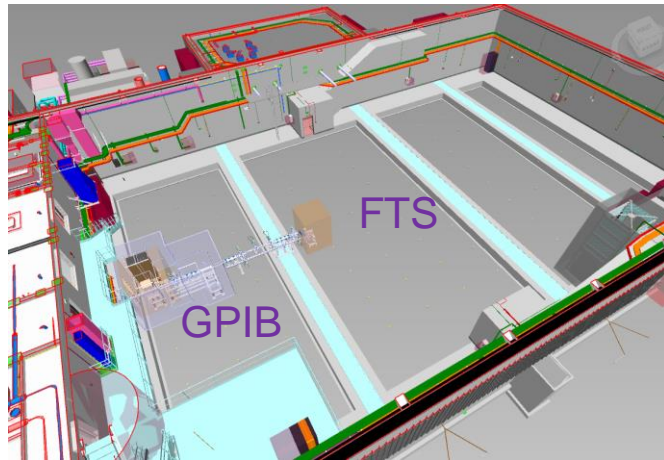


COeCO

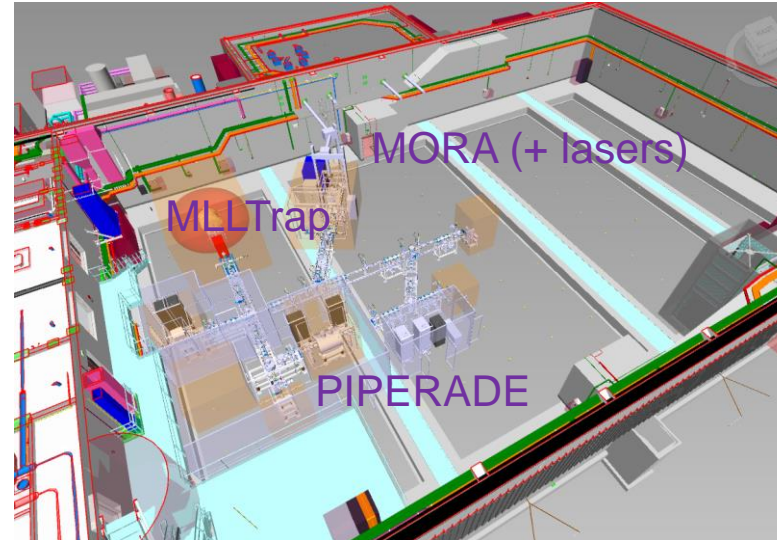
# DESIR project timeline



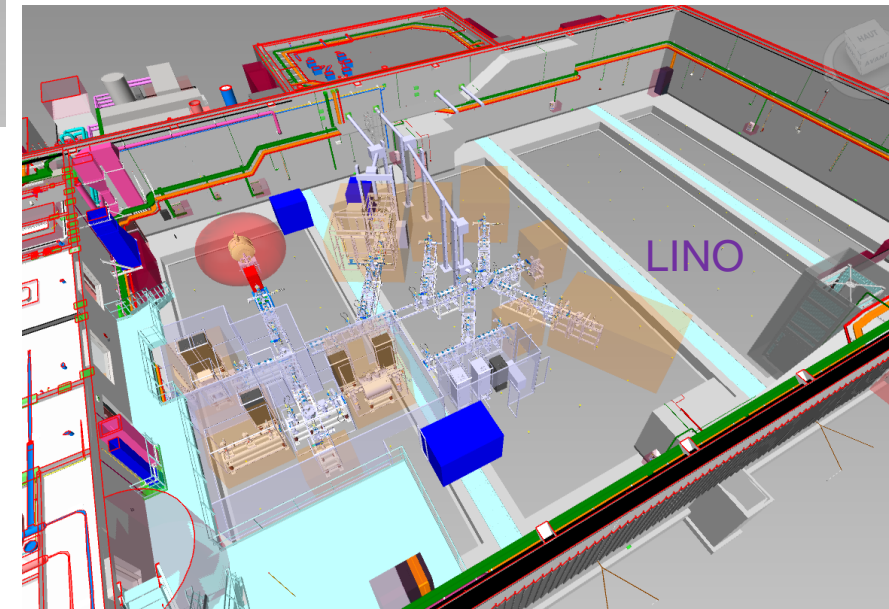
**Step 0 - 2026 →** : GPIB commissioning  
(stable beams)



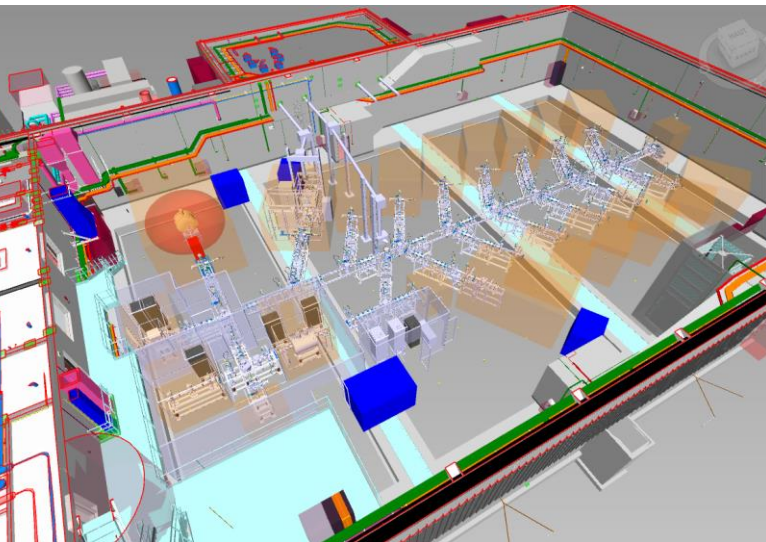
**Step 1 - 2027-28 →** : **DETRAP** (+ **BESTIOL**)  
First physics experiments with RIBs



**Step 2 - 2028-29 →** : **LUMIERE**  
LINO operation + CRIS?



**Step 3 - 2030 →** :  
**DETRAP** , **LUMIERE** , **BESTIOL** operational



***Thanks for your attention***