

The DESIR facility at GANIL/SPIRAL2

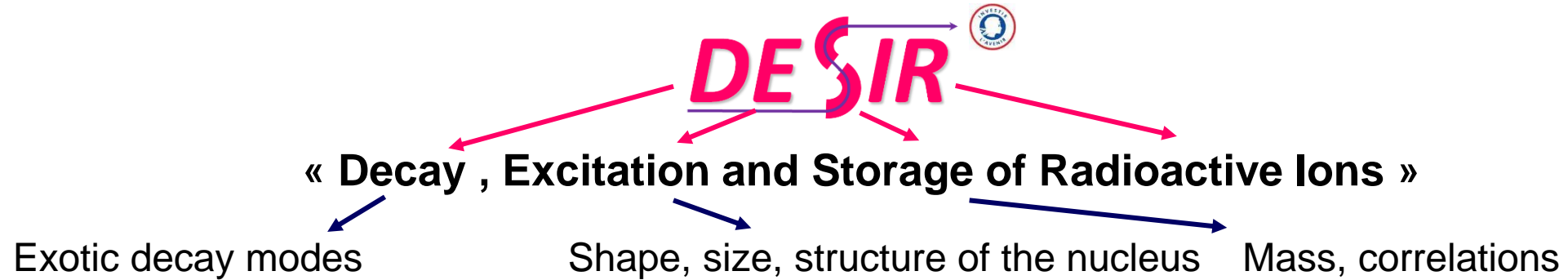
Bertram Blank

L2Pi Bordeaux



ISOLDE Workshop and Users meeting
2024

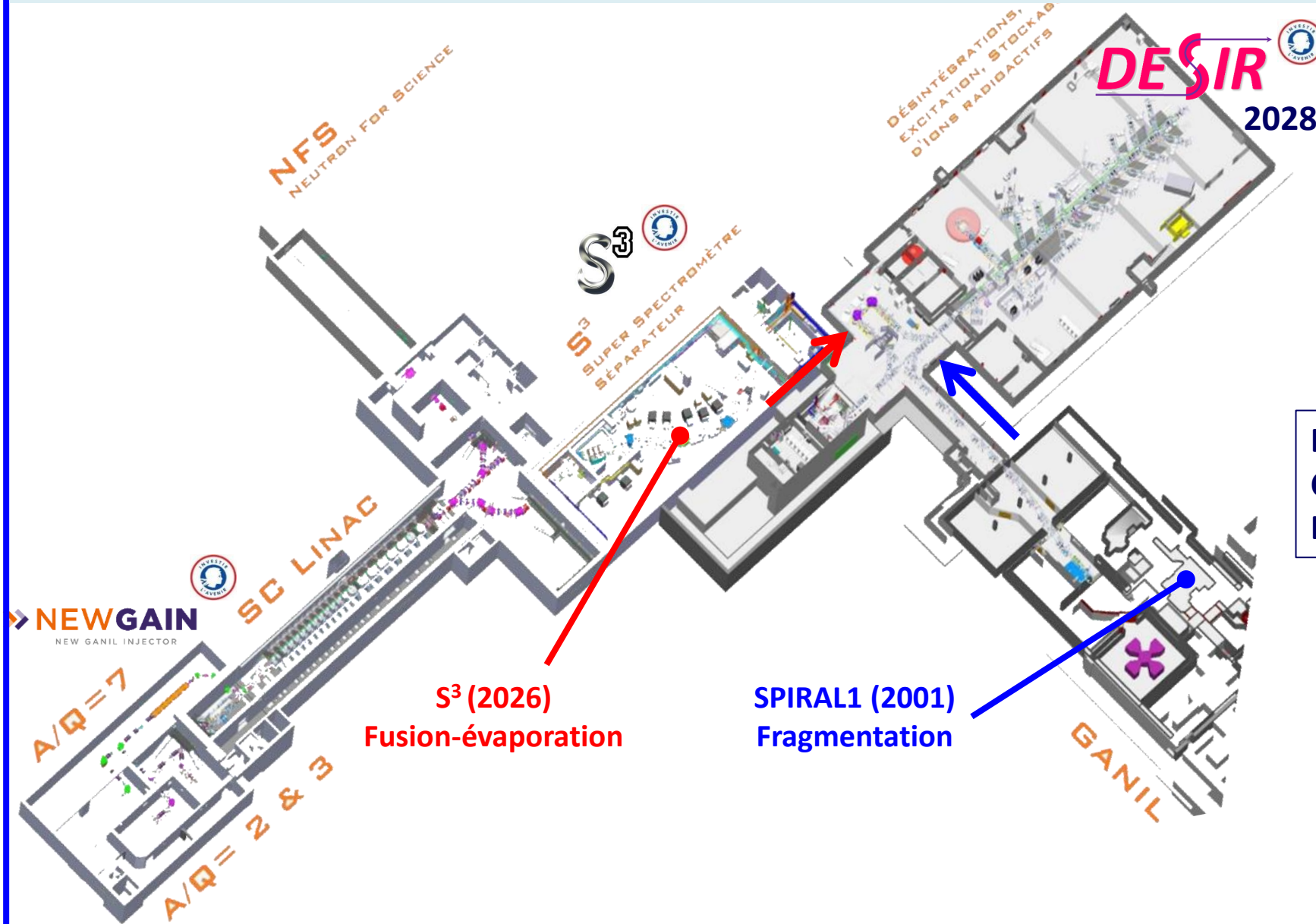
27-29 November 2024



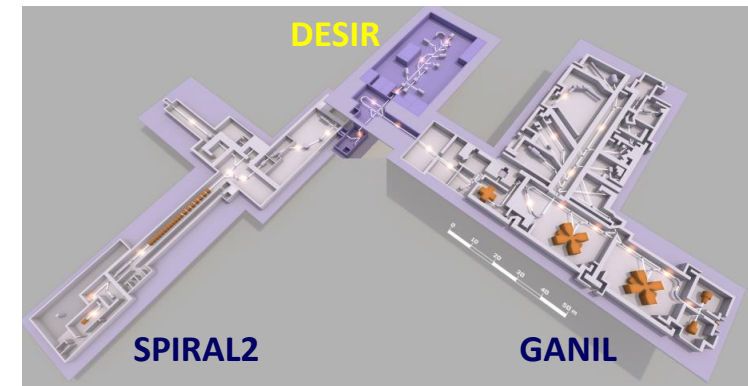
A new GANIL users facility

- Study of the fundamental properties of atomic nuclei and underlying forces
- With a high precision using ultra-pure samples of radioactive ions manipulated at very low energy
- Taking advantage of the various RIBs production methods
- In complementarity to $S^3(-LEB)$ and other GANIL installations

● ● ● DESIR at GANIL



Building delivery:	mid-2025
Commissioning (stable beams):	2027
Day 1 experiments (RIBs):	2028



DESIR physics programme

- Collinear laser-spectroscopy
- Correlations in β decay (MORA)
- Mass meas. (PIPERADE, MLLTrap)
- (Trap-assisted) decay spectroscopy

LUMIERE

DETRAP

BESTIOL

SPIRAL 1

Fragmentation

ECR source

FEBIAD

Surface ionization

TABLEAU PÉRIODIQUE DES ÉLÉMENTS

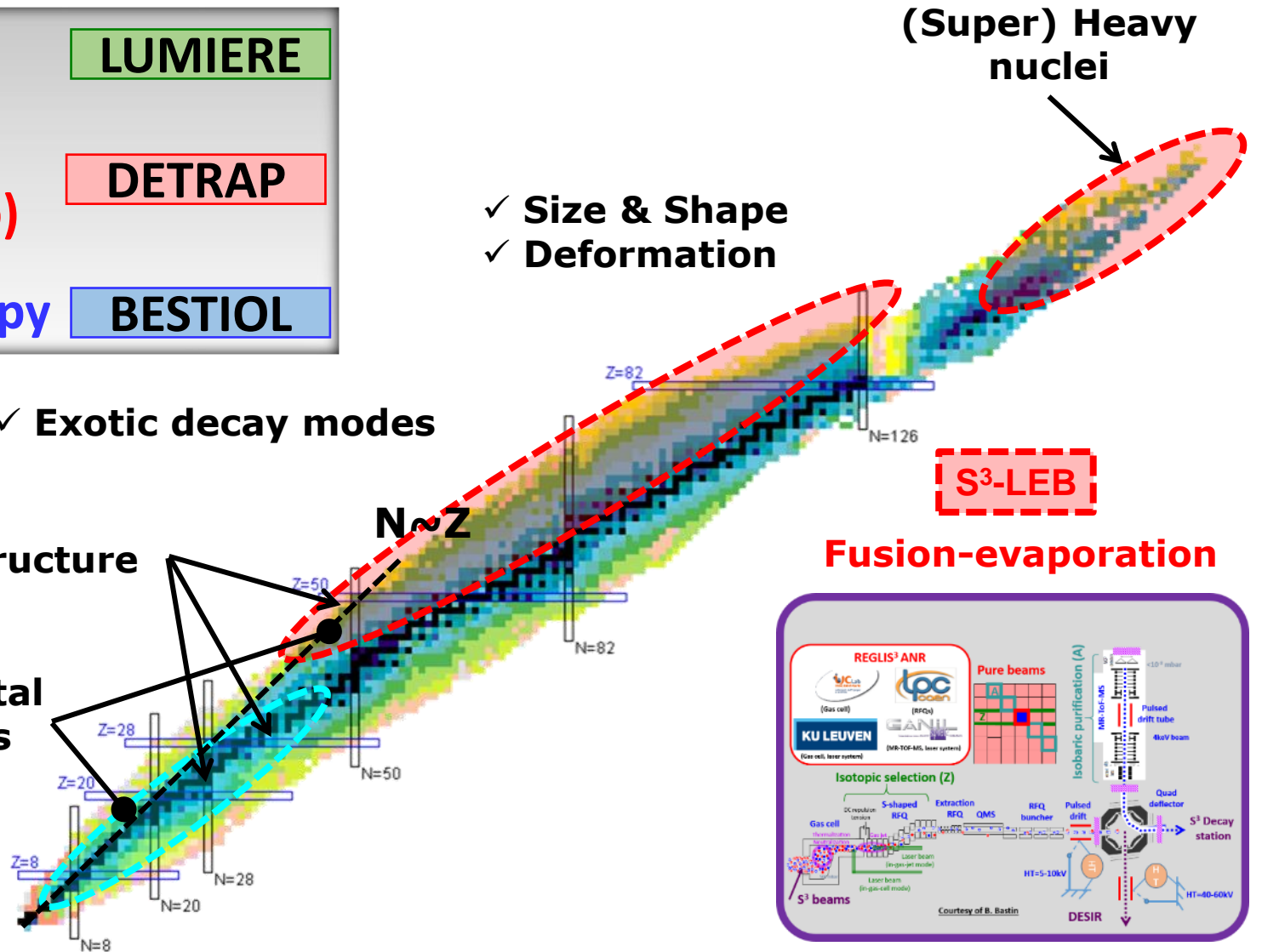
ECR: Ne, Ar, Kr, N, O, F
 Surface ionization: Li, Na, K, Rb
 FEBIAD: Mg, Al, P, S, Cl, Fe, Cu

Courtesy of P. Delahaye

✓ Exotic decay modes

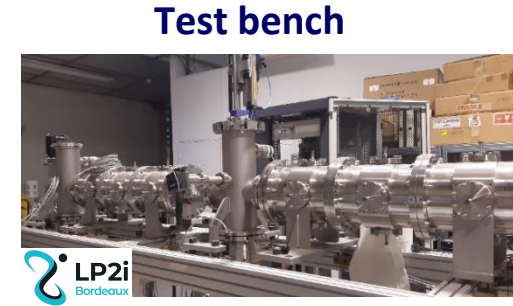
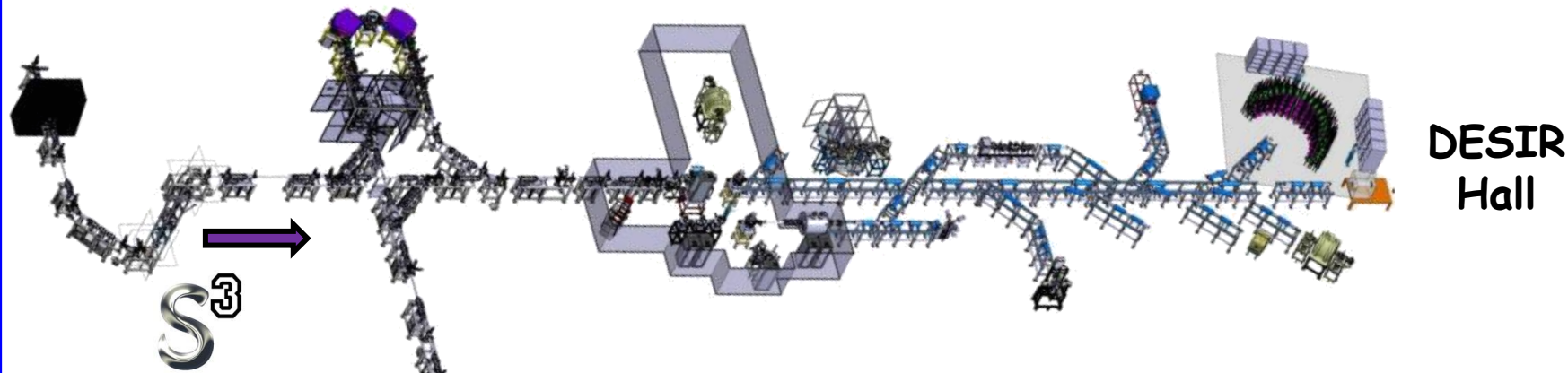
✓ Nuclear structure

✓ Fundamental interactions



● ● ● **Transpost beam lines**

1+ ions, < 60 keV, < 80 π.mm.mrad – fully electrostatic



Test bench

LP2i
Bordeaux

Ph. Alfaut, LP2iB

SP1 -> DESIR beam line



GANIL

V. Watt-Morel, GANIL

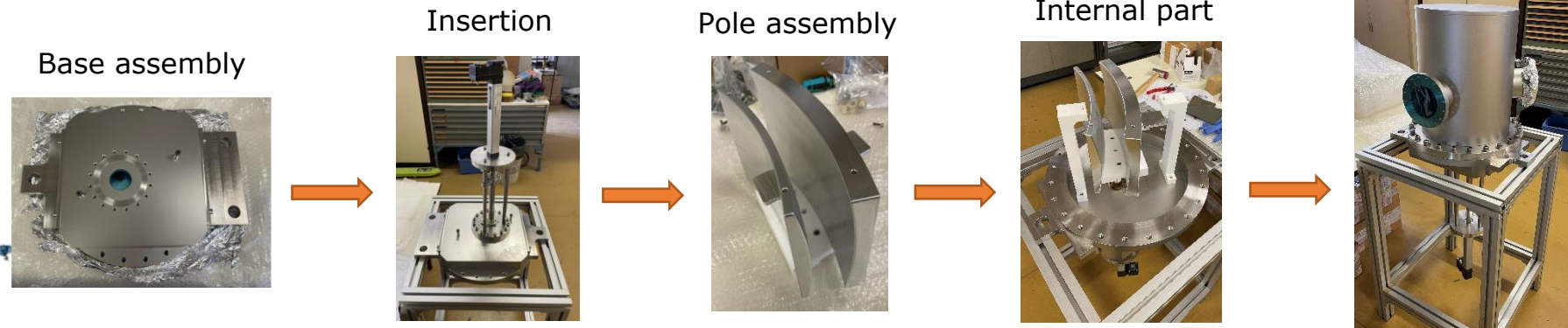


L. Perrot et al., IJCLab

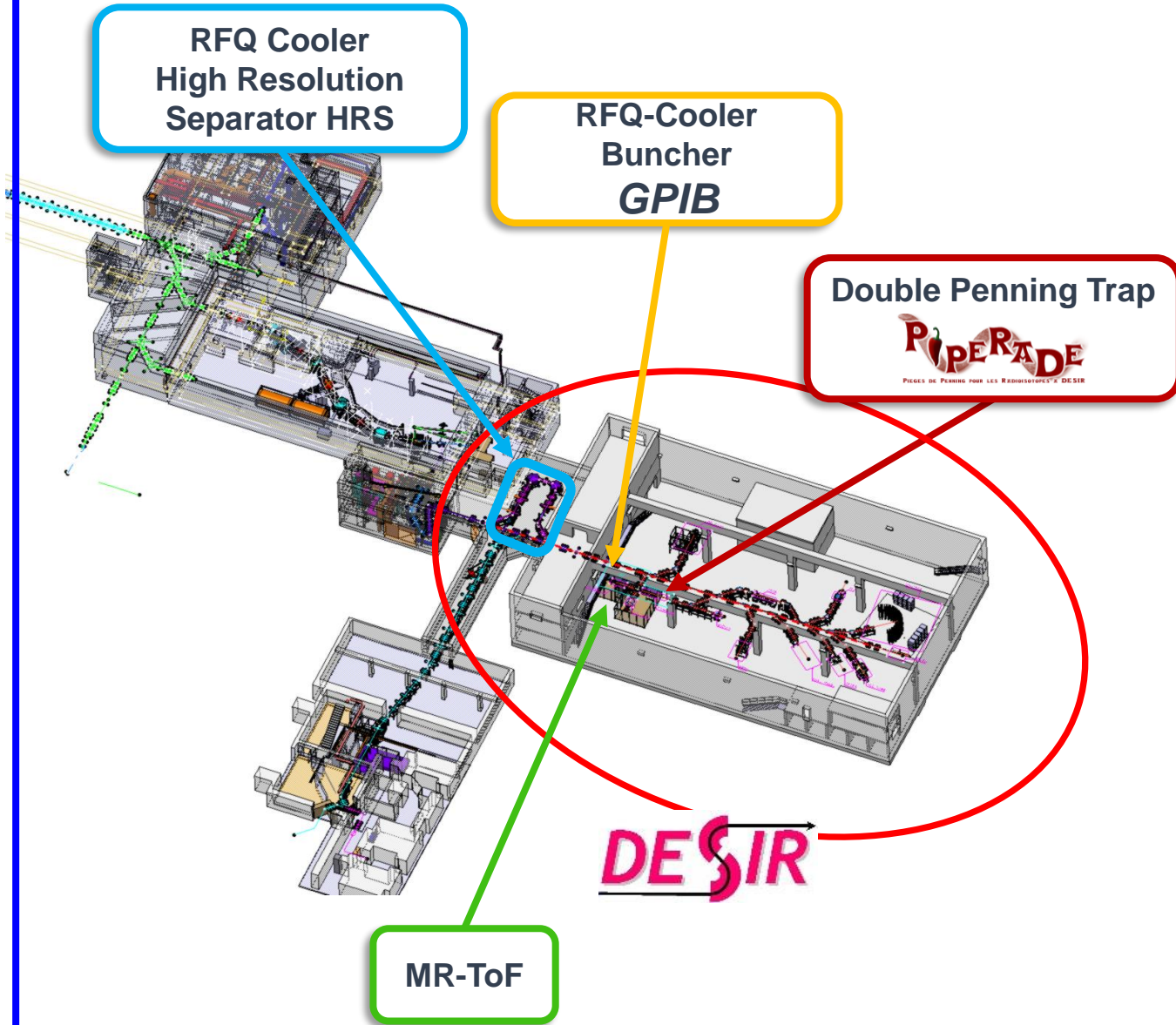
SP1RAL1

- Junction beam lines from SPIRAL1 and S3-LEB to the DESIR Hall: ~100 m
- Installation starting by the end of 2025

Example: 45° deflector assembly



● ● ● Beam preparation and purification



Mass separation/beam purification:

- HRS+RFQ** • $\sim \frac{M_0}{\Delta M} = 20\,000$
- MR-ToF** • $\sim \frac{M_0}{\Delta M} = 200\,000$
- Piperade 1st trap** • $20\,000 < \frac{M_0}{\Delta M} \leq 10^5$
- Piperade 2nd trap** • $R \approx 10^6 - 10^7$

Beam preparation:

- GPIB** • Cooling and bunching
- Piperade 2nd trap** • Accumulation trap

Mass measurements:

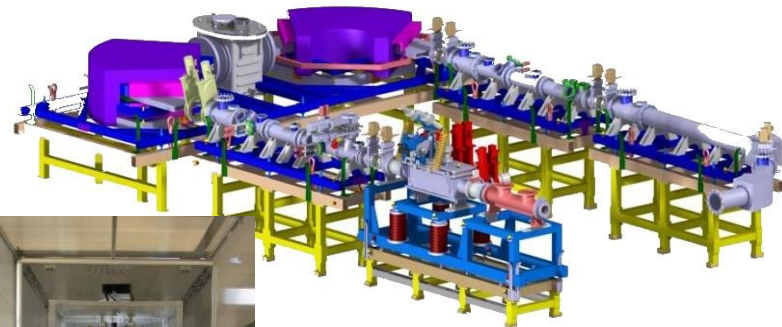
- Piperade 2nd trap** • Mass precision: $10^{-8} - 10^{-9}$

● ● ● Beam purification



RFQ + HRS

**$M/\Delta M = 20,000$ @
 3π mm.mrad / 30keV**



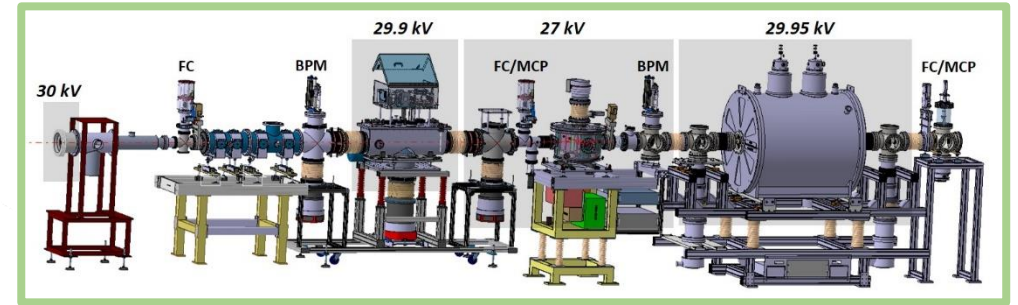
Commissioning at LP2iB



Refurbishment at LPC Caen

GPIB + PIPERADE

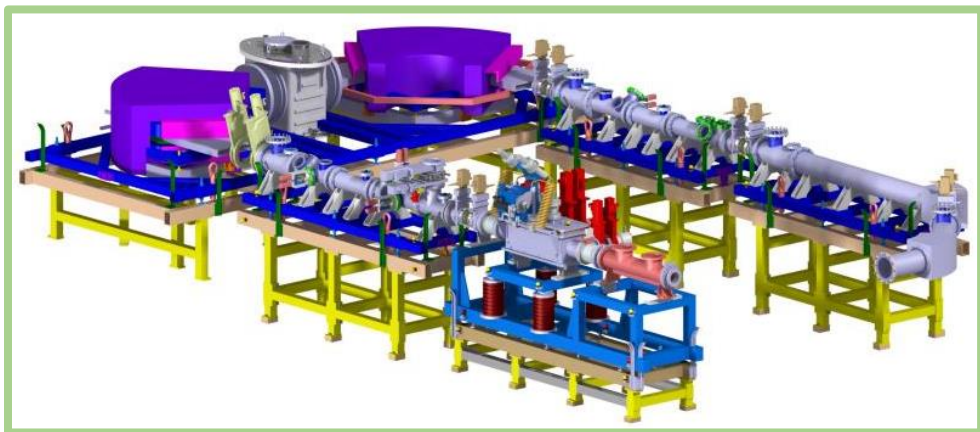
10^5 ions/bunch, 2-20 Hz $M/\Delta M = 10^5$



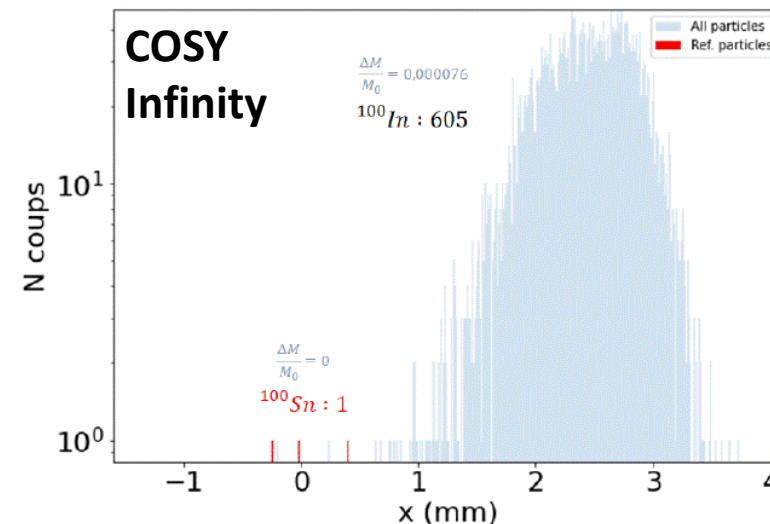
Commissioning at LP2iB

- Installation and commissioning: 2026-2027
- MR-ToF-MS for mass measurements and beam purification: 2026-2028

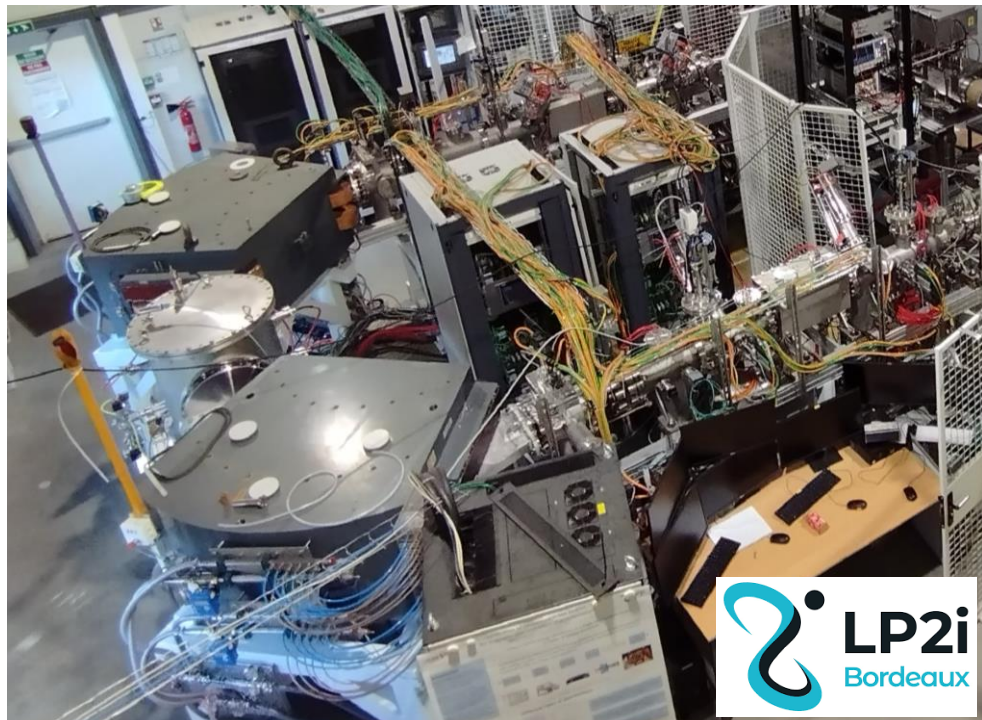
● ● ● Beam purification: High-resolution separator HRS



M/ΔM = 20 000 @ 3π mm.mrad / 30keV

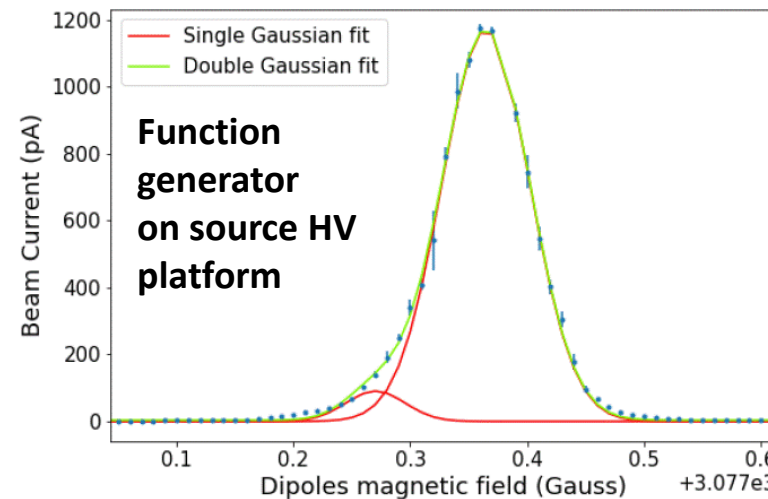
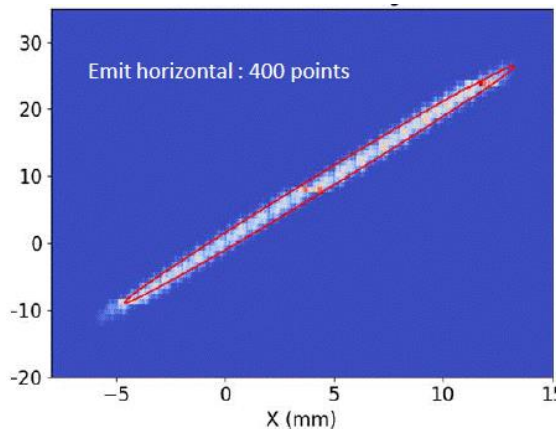


**$^{100}\text{Sn}/^{100}\text{In}$ separation:
simulation and measurement**

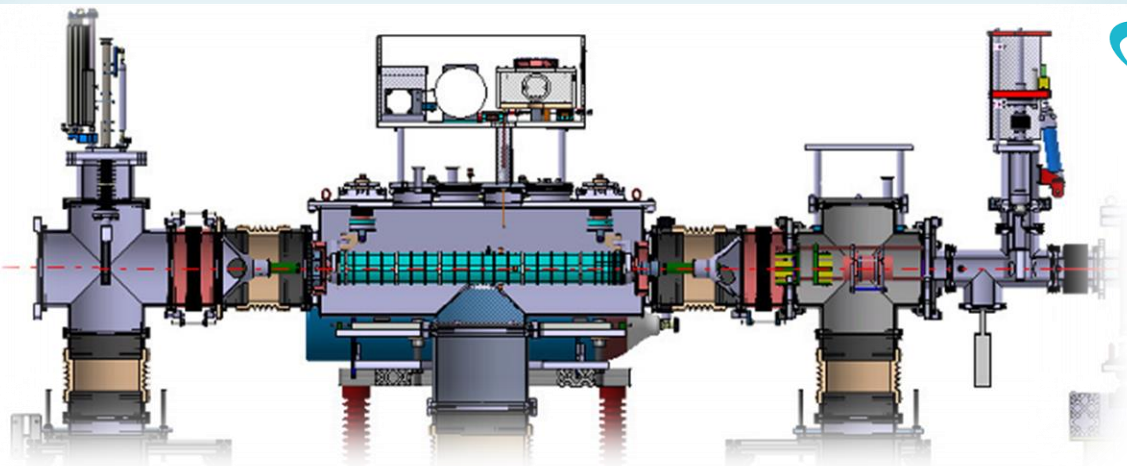


Pepperpot emittance meter

→ beam emittance



● ● ● Beam preparation: General purpose ion buncher GPIB



Emittance:

- 3π .mm.mrad at 30 keV

Continuous mode:

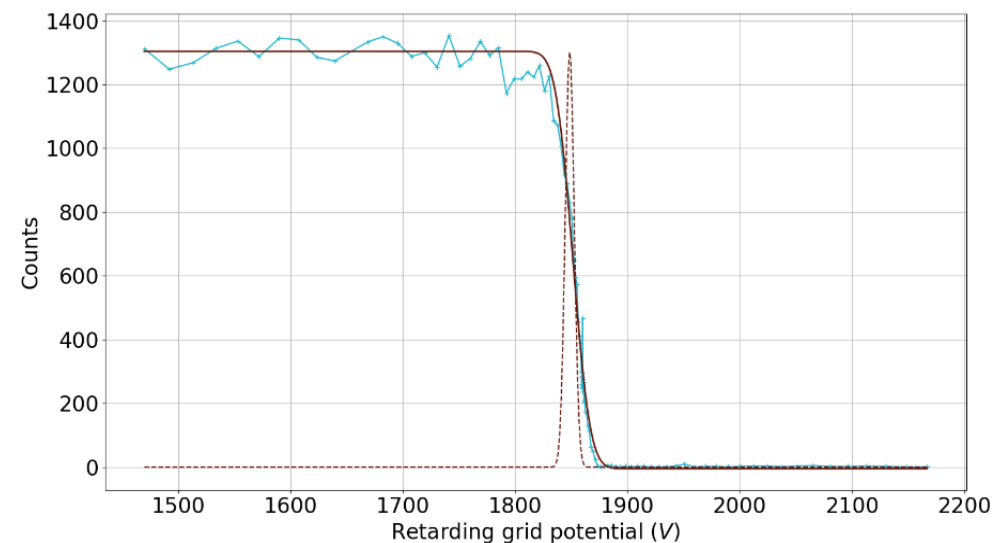
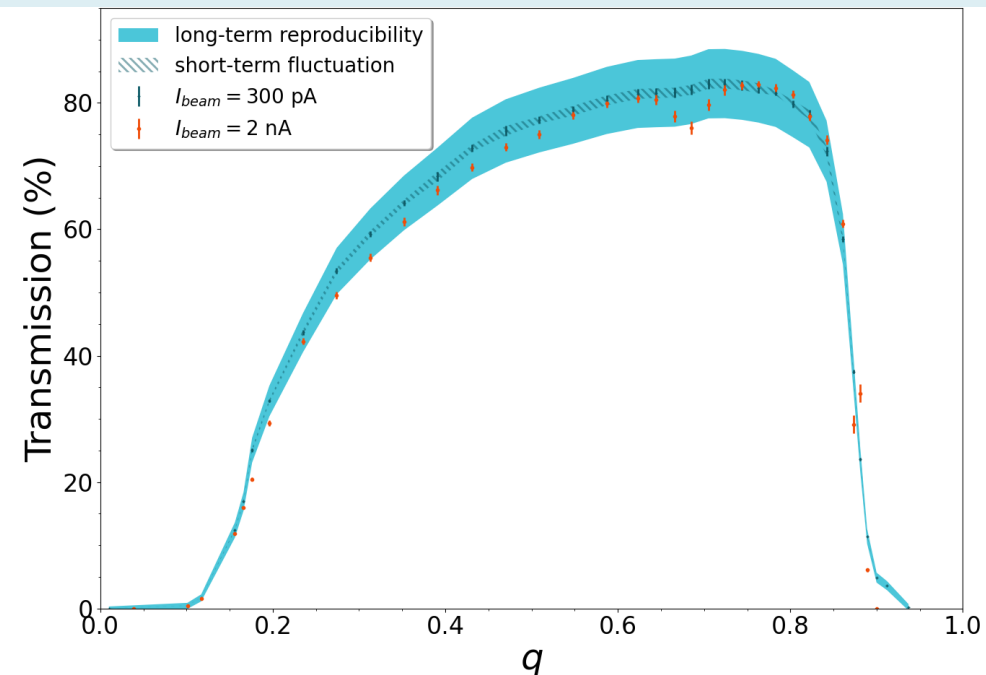
- Transmission for K^+ ions is routinely over 75 %
- Careful optical tuning yields transmission >90 %

Bunching mode:

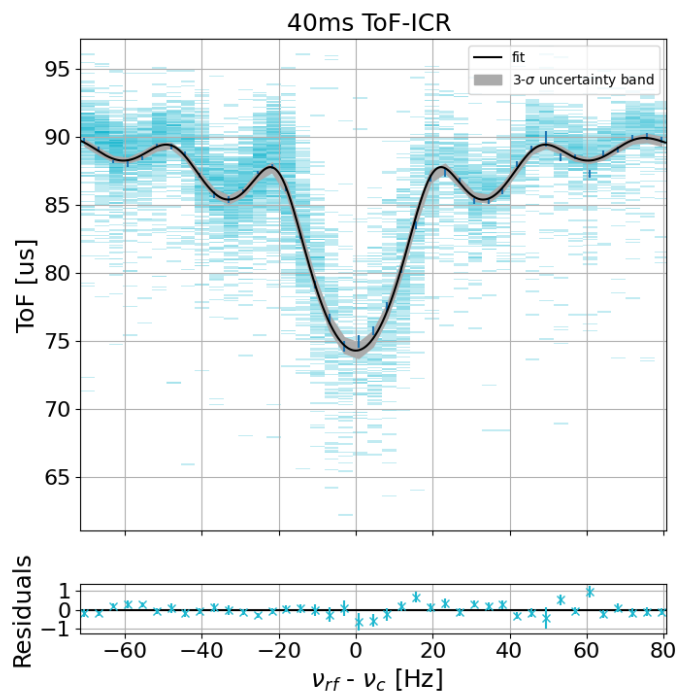
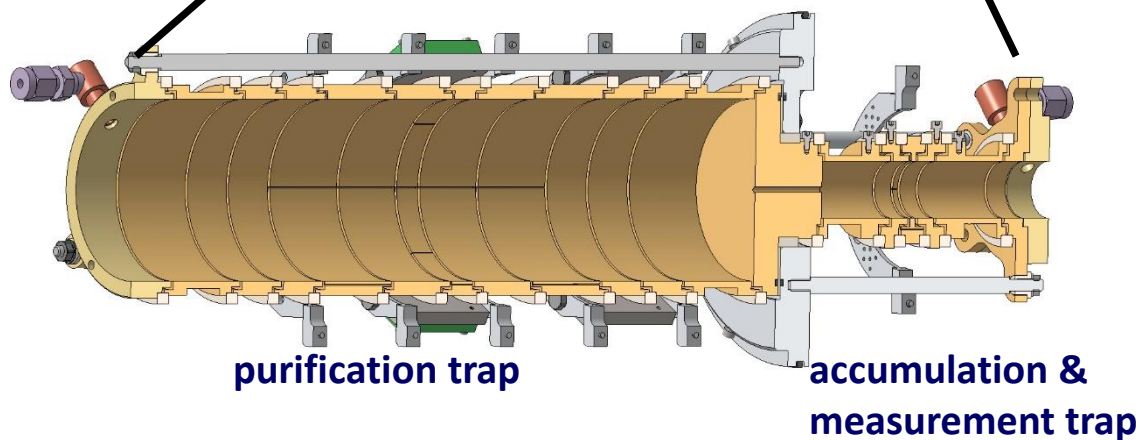
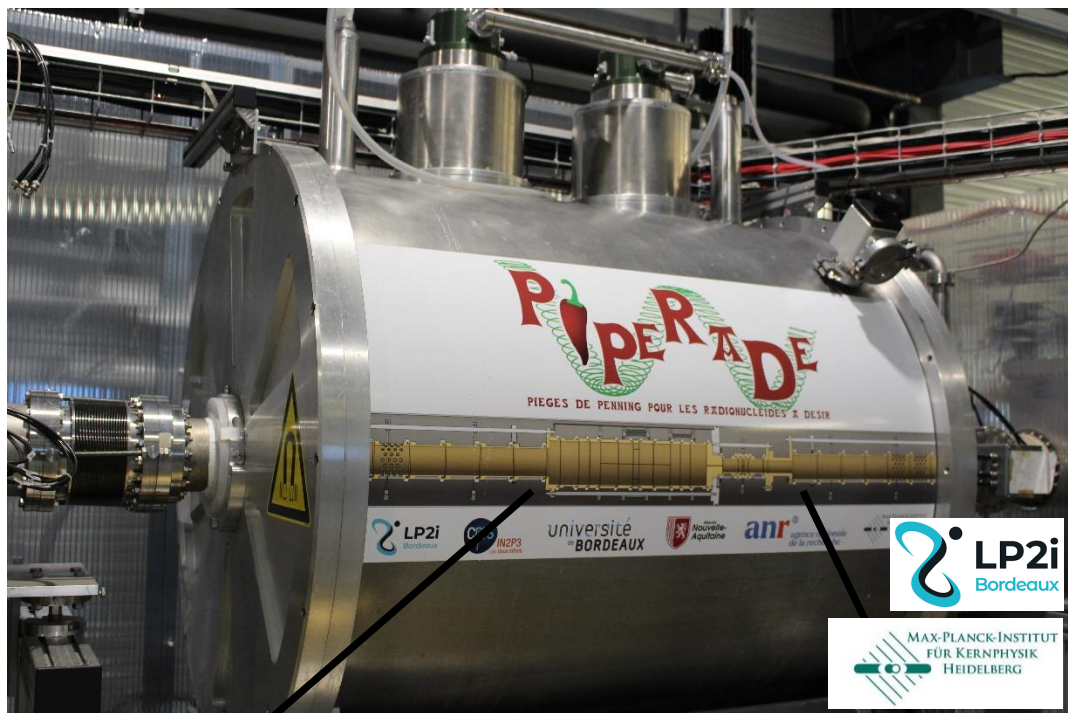
- 100 % transmission up to 10^6 ions/bunch
- ~ 50 % transmission with 10^8 ions/bunch

Energy and time dispersion:

- Energy dispersion measurement currently limited by detection system (< 6 eV)
- Minimum time dispersion currently down to ≈ 250 ns (FWHM) at 3 keV

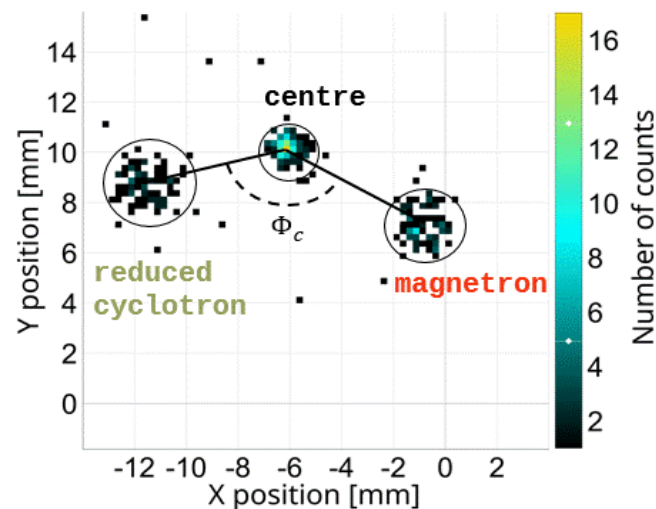


● ● ● Beam purification: PIPERADE



accuracy: $\frac{\Delta m}{m} \approx 9.5 \times 10^{-10}$

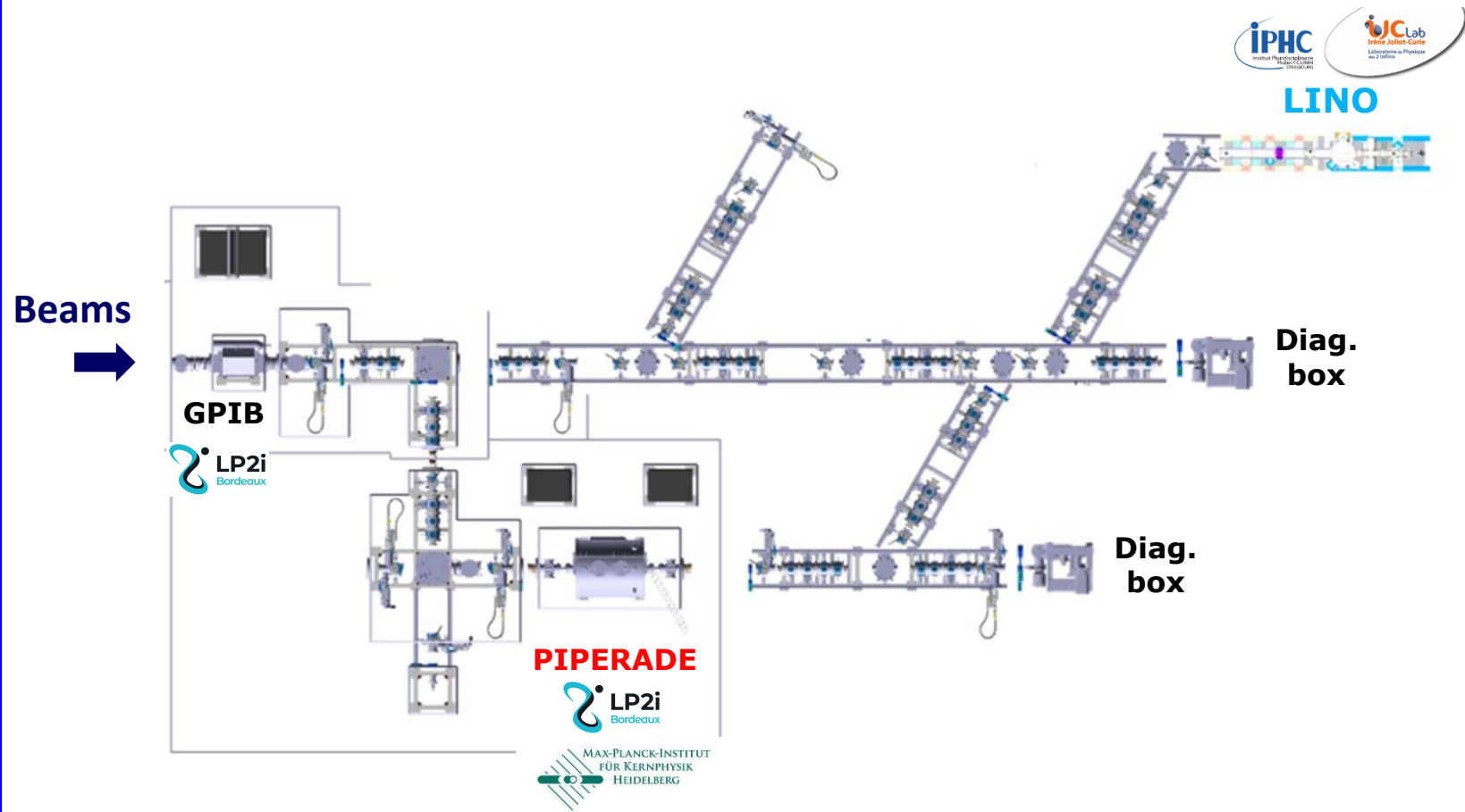
precision: $\frac{\delta m}{m} \approx 3 \times 10^{-9}$



$$\nu_c = \frac{\phi_c + 2\pi n}{2\pi t}$$

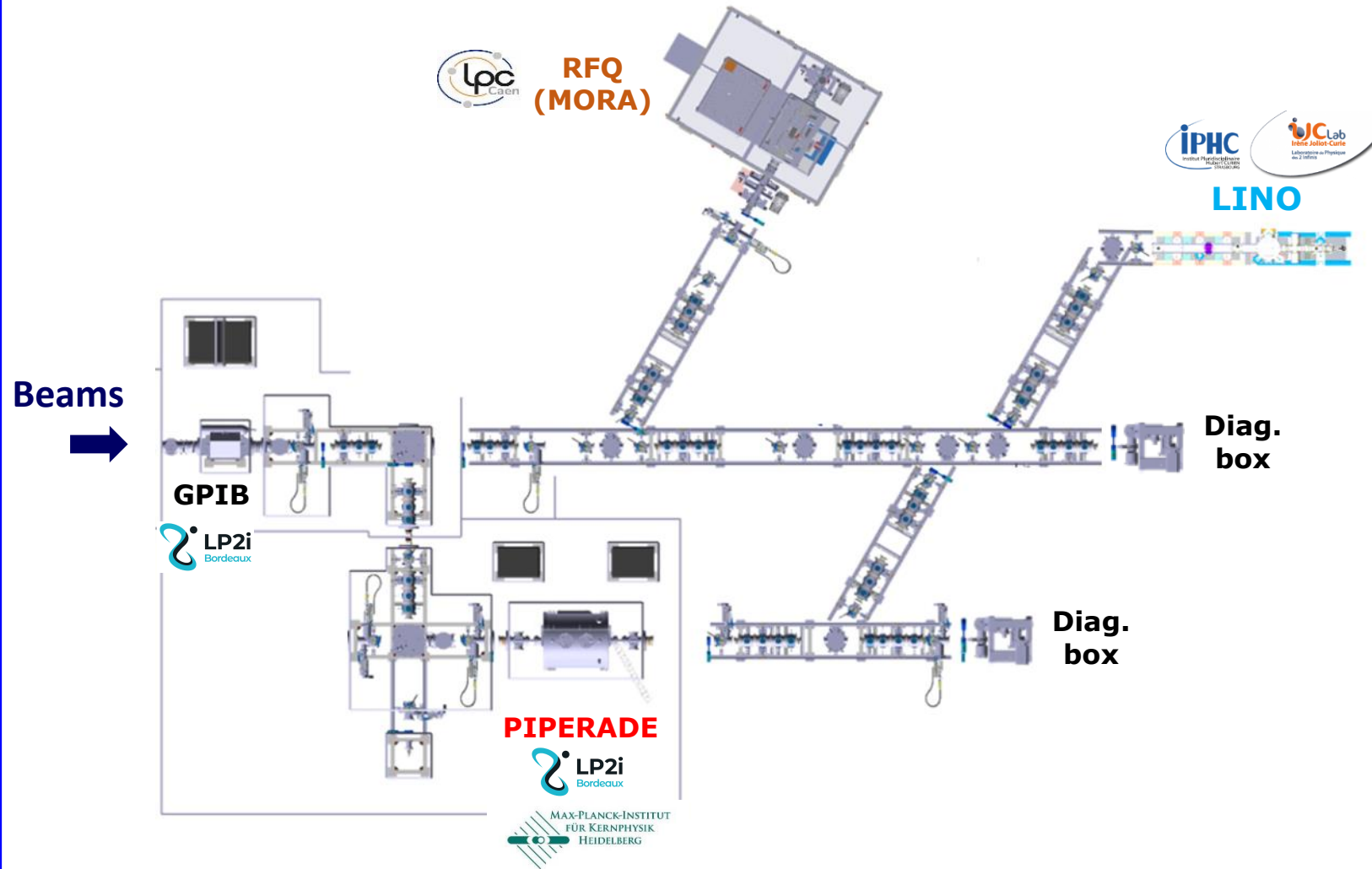
● ● ● Experimental equipment: time line

S2 - 2026: GPIB + PIPERADE + fluorescence laser line (LINO)



● ● ● Experimental equipment: time line

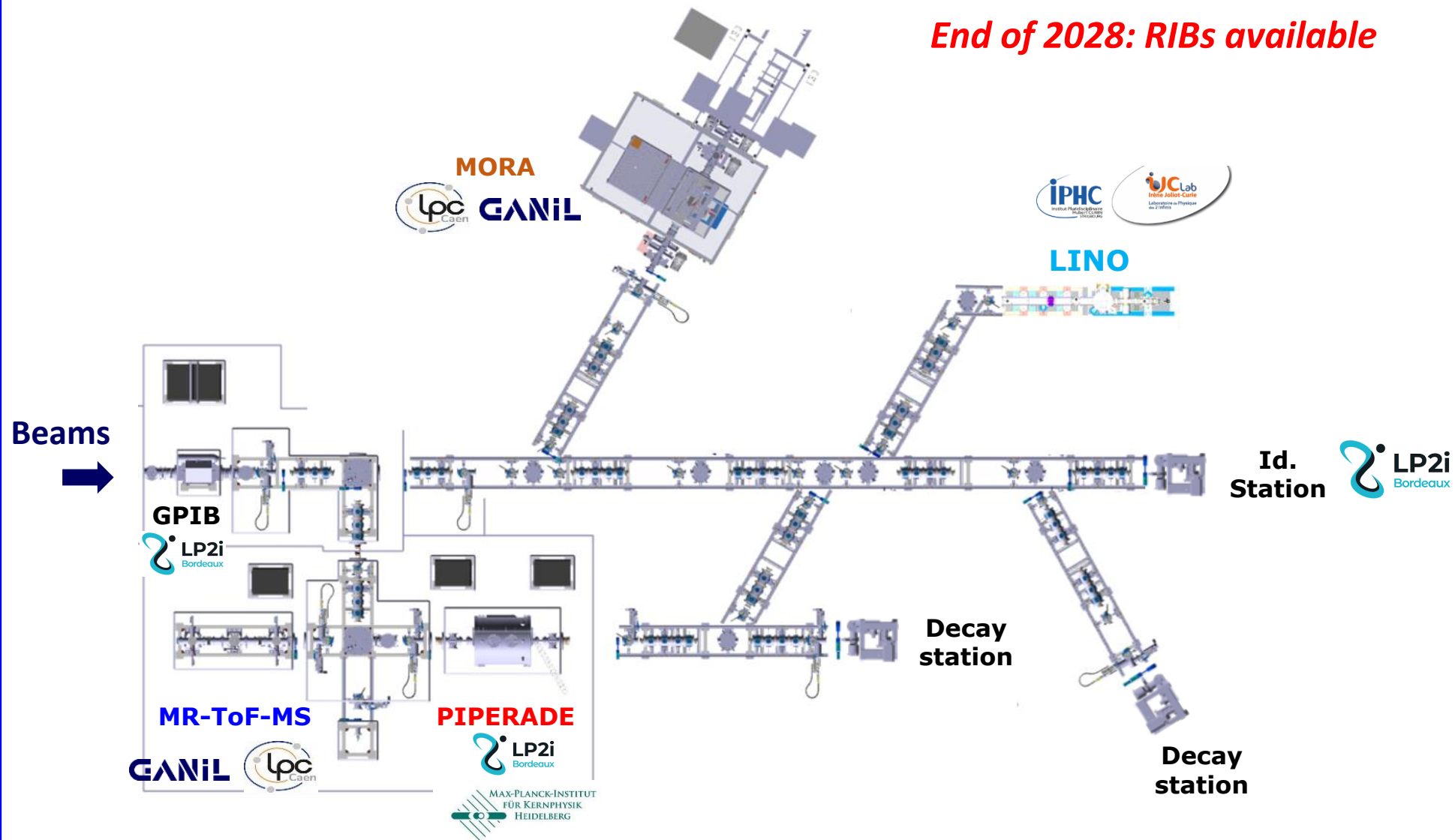
S1 - 2027: MORA cooler-buncher (RFQ)



● ● ● Experimental equipment: time line

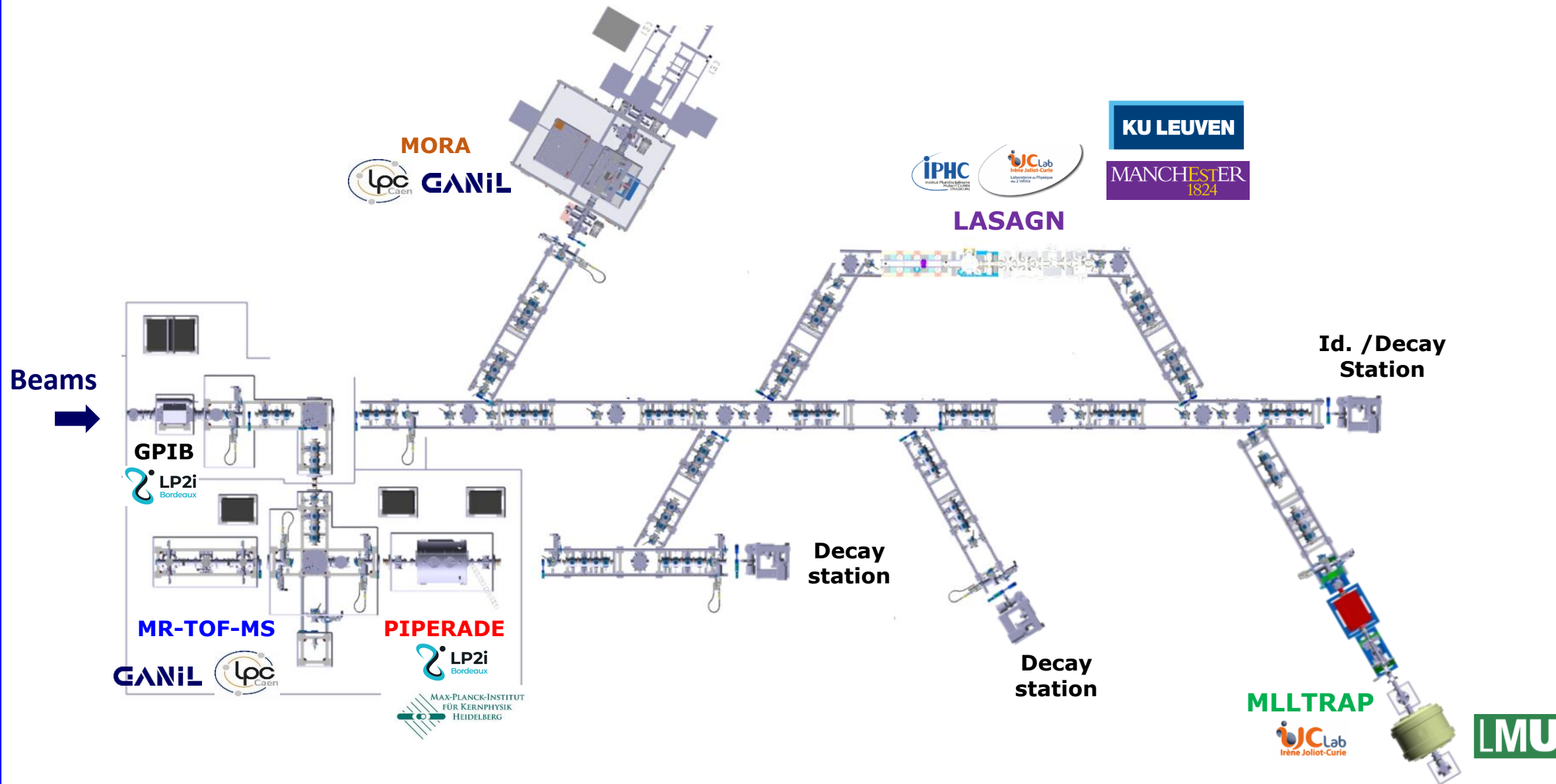
2028: **MORA** completed, **MR-ToF-MS**, decay stations

End of 2028: RIBs available



● ● ● Experimental equipment: time line

2029: collinear laser spectroscopy (LASAGN) completed, MLLTrap



MORA

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

- RFQ-CB associated with a Paul trap
- > β - ν angular correlation coefficient
- > D correlation with laser polarized beams



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

⇒ Fundamental interaction physics

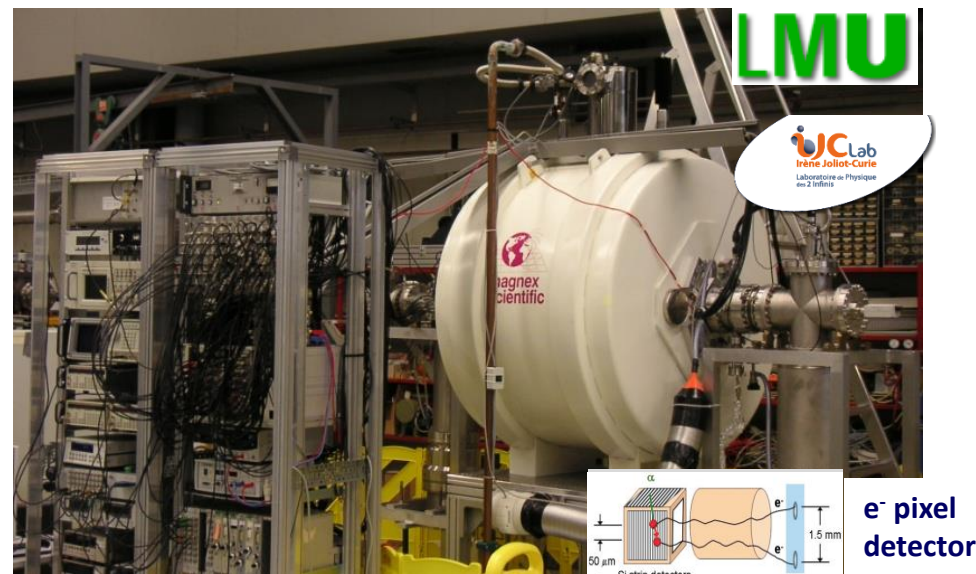
- exotic currents, CVC, V_{ud} , CP-violation

Commissioning at JYFL

MLLTrap

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

- Double Penning trap
- > high precision mass measurements
- > in-trap decay



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

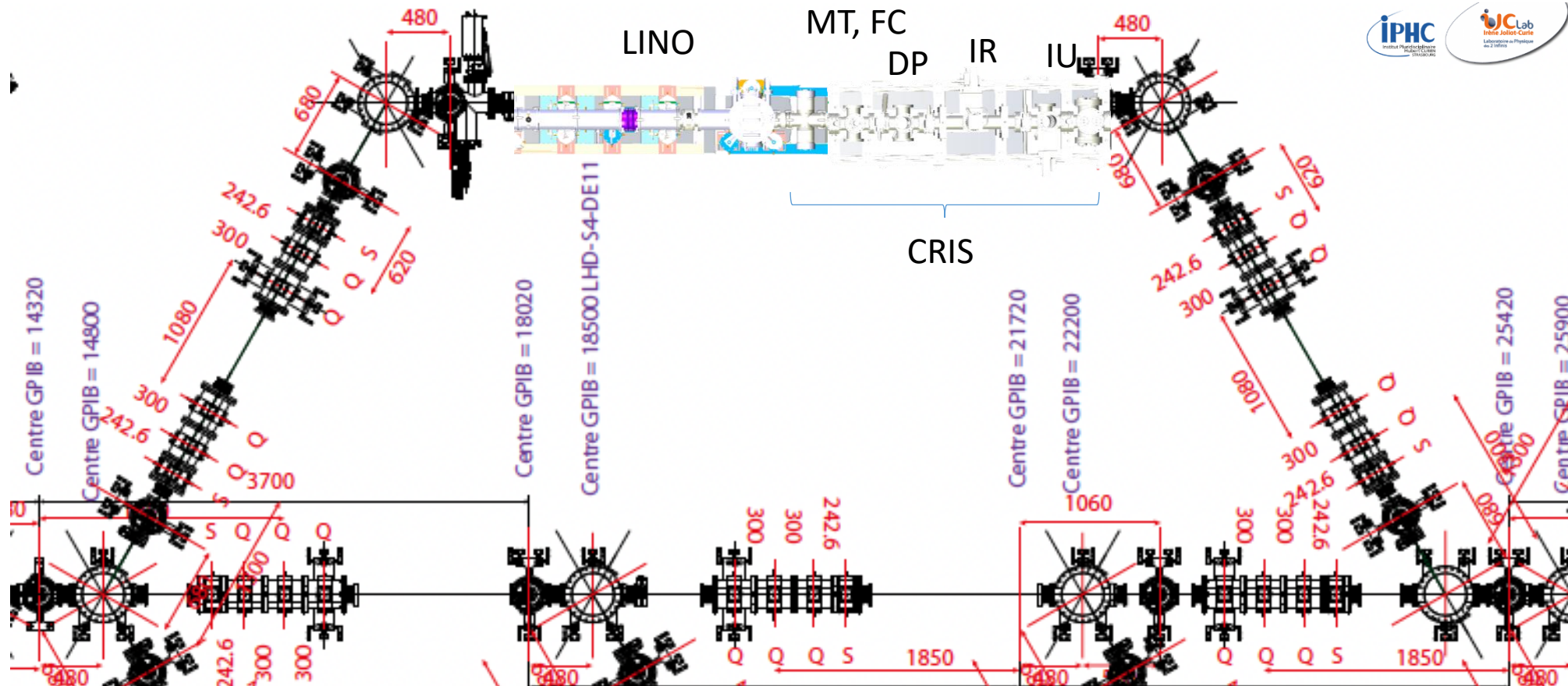
Commissioning at ALTO (IJCLab)

• • • The LUMIERE facility

Laser Utilization for Measurement and Ionization of Exotic Radioactive Elements

LASAGN (L. Lalanne, IPHC)

- Collinear laser spectroscopy (CRIS like)
 - > hyperfine structure (magnetic and quadrupole moments, mean square charge radii)
- LINO commissioned at ALTO, IJCLab, *D. Yordanov et al.*



● ● ● The BESTIOL facility

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:

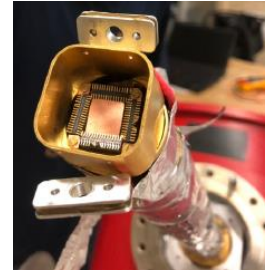
- β - γ decay stations (BEDO, ...)
- total absorption spectrometers (DTAS)
- neutron detection arrays (BELEN, MONSTER, ...)

-> Fundamental interaction, nuclear structure, decay properties

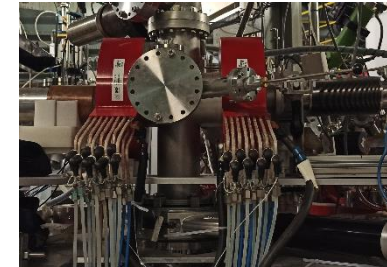
- CVC, V_{ud}
- beta shapes
- lifetimes, $P_{(2)n}$
- exotic decays (β -2p, cluster emission)
- Gamow-Teller strength



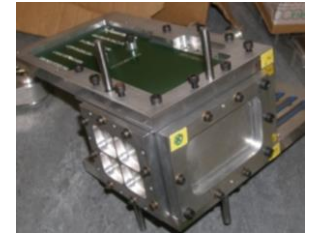
BELEN



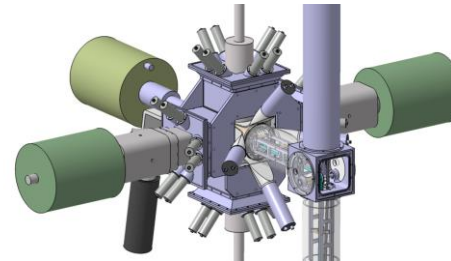
ASGARD



COeCO



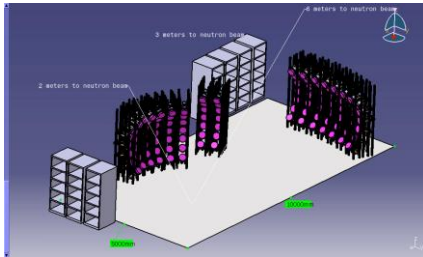
SiCube



BEDO



b-STILED



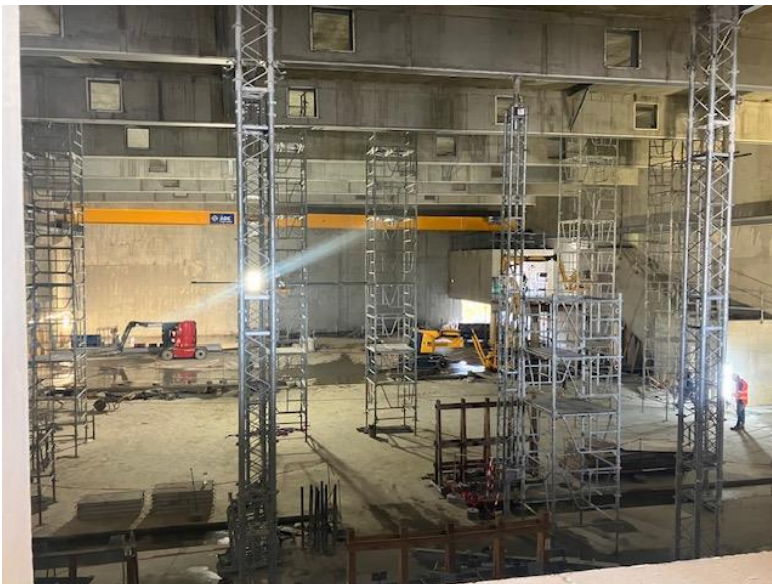
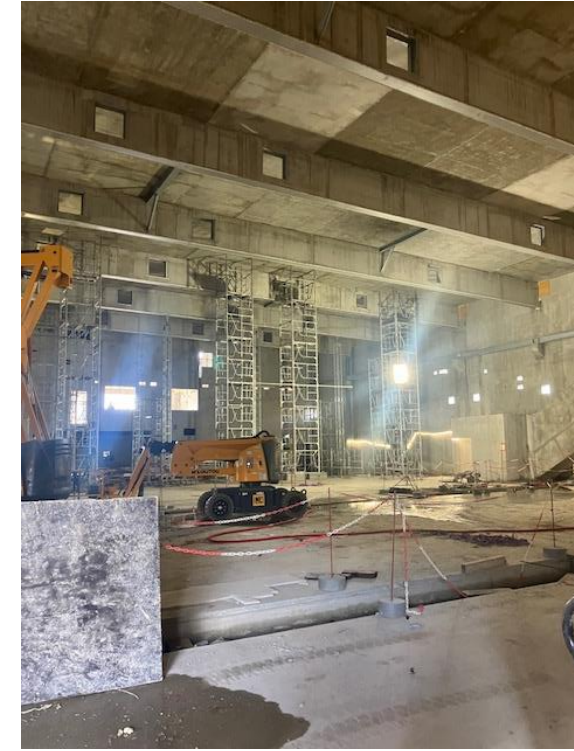
MONSTER



DTAS



● ● ● The DESIR building



- **Building delivery: September 2025**
- **October 2025 to September 2026: Beam line & experiment installation**
- **June 2026 to January 2027: Cabling**
- **October 2026 to June 2027: Technical commissioning**
- **March to October 2027: Stable beam commissioning**
- **November 2027: Facility ready for radioactive beams**

Thanks for your attention



Backup slides

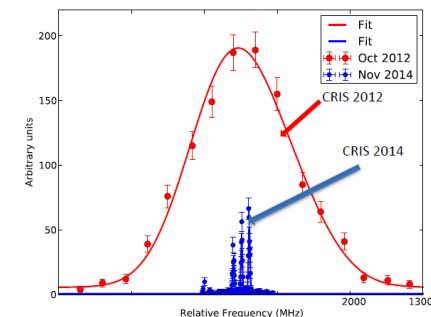
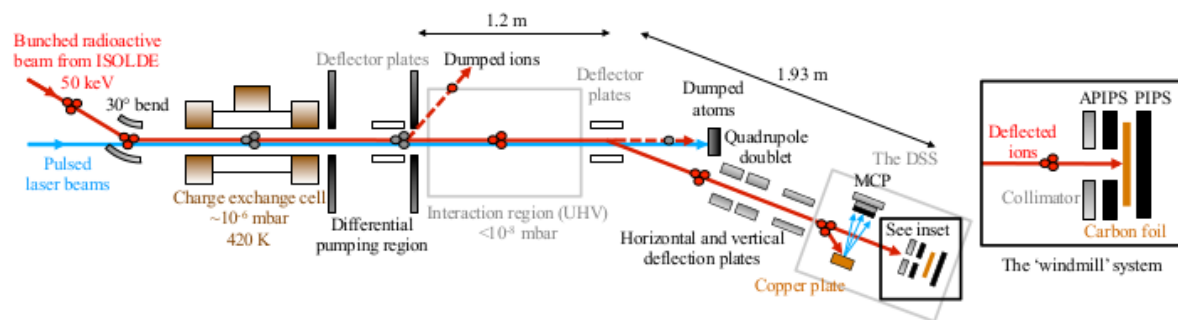
● ● ● The LUMIERE facility

Laser Utilization for Measurement and Ionization of Exotic Radioactive Elements

➤ LASAGN (L. Lalanne, IPHC)

▪ Collinear laser spectroscopy (CRIS like, ISOLDE)

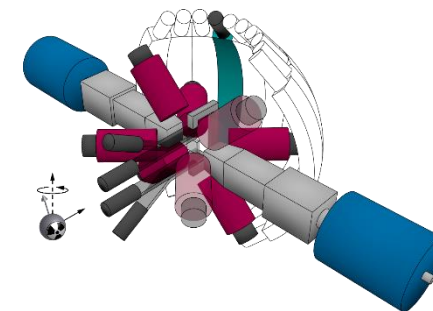
-> hyperfine structure (magnetic and quadrupole moments, mean square charge radii)



▪ Optical pumping line (LINO, D. Yordanov et al.)

-> β -decay study of laser polarized beams

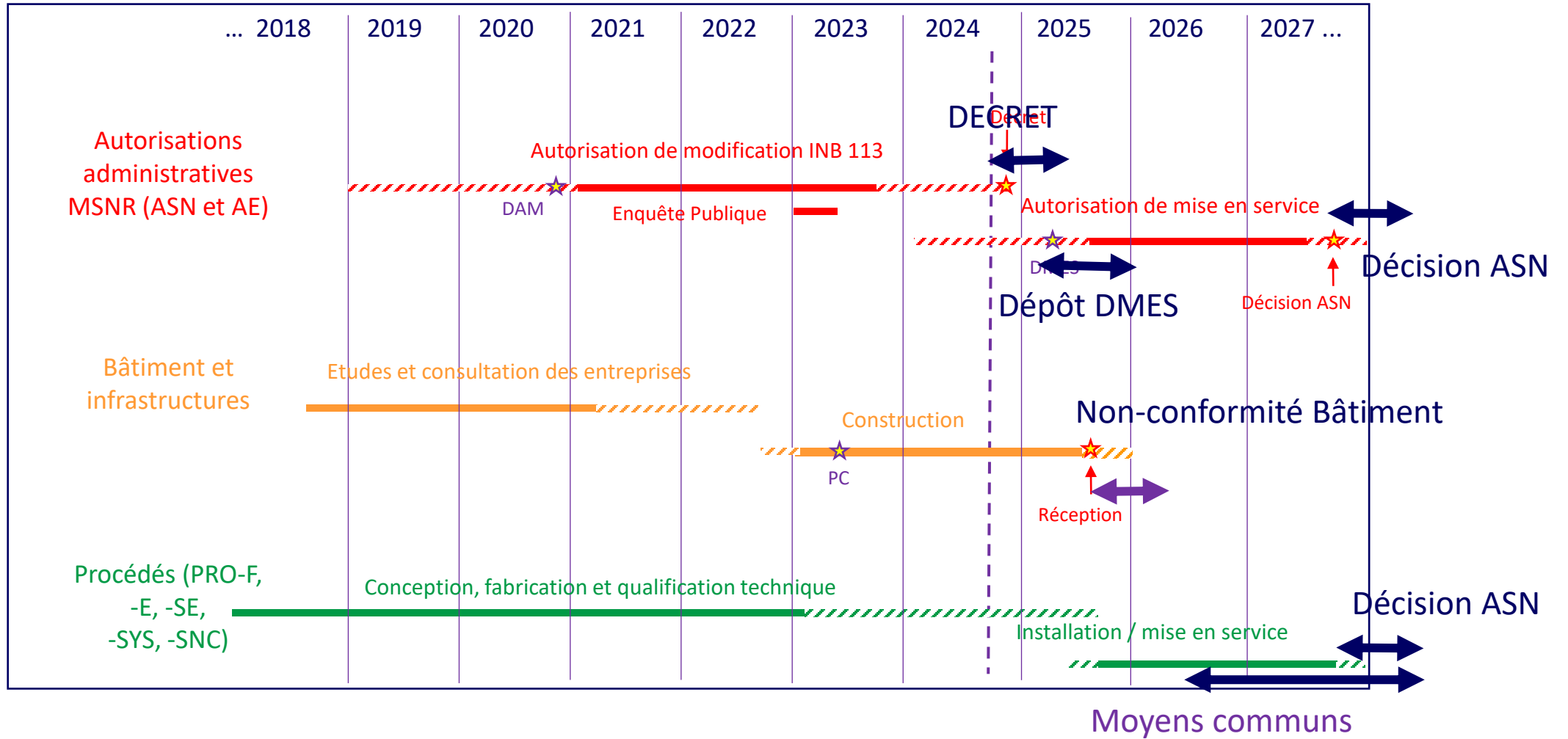
Commissioned at ALTO (IJCLab)



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

⇒ Static moments, shape evolution, nuclear structure

DESIR time line



ASGARD CaeSAR opportunities



First **precise recoil spectroscopy** after beta/EC decays, planned at DESIR (28-)

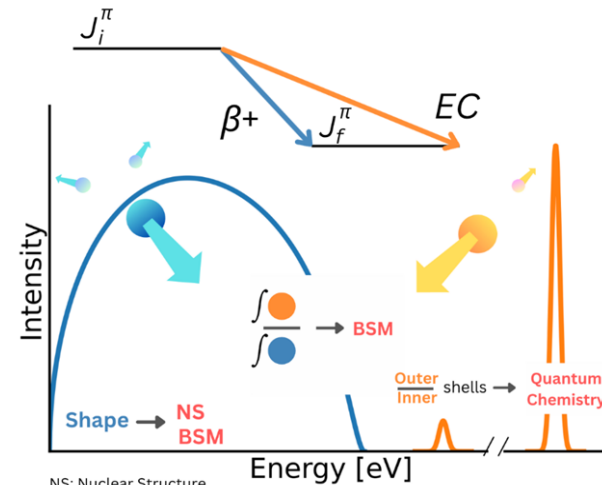
Beyond Standard Model searches

Open doors to:

- Nuclear structure
- Auger spectroscopy for medical studies

Submitted for ERC, support from Label D'Excellence de Normandie

Unique project, HR gets training in **quantum sensors**



NS: Nuclear Structure
BSM: Beyond Standard Model

- Proposed Type-I isotopes
- Proposed Type-II isotopes
- Isotopes of interest

