

Status of the DESIR facility

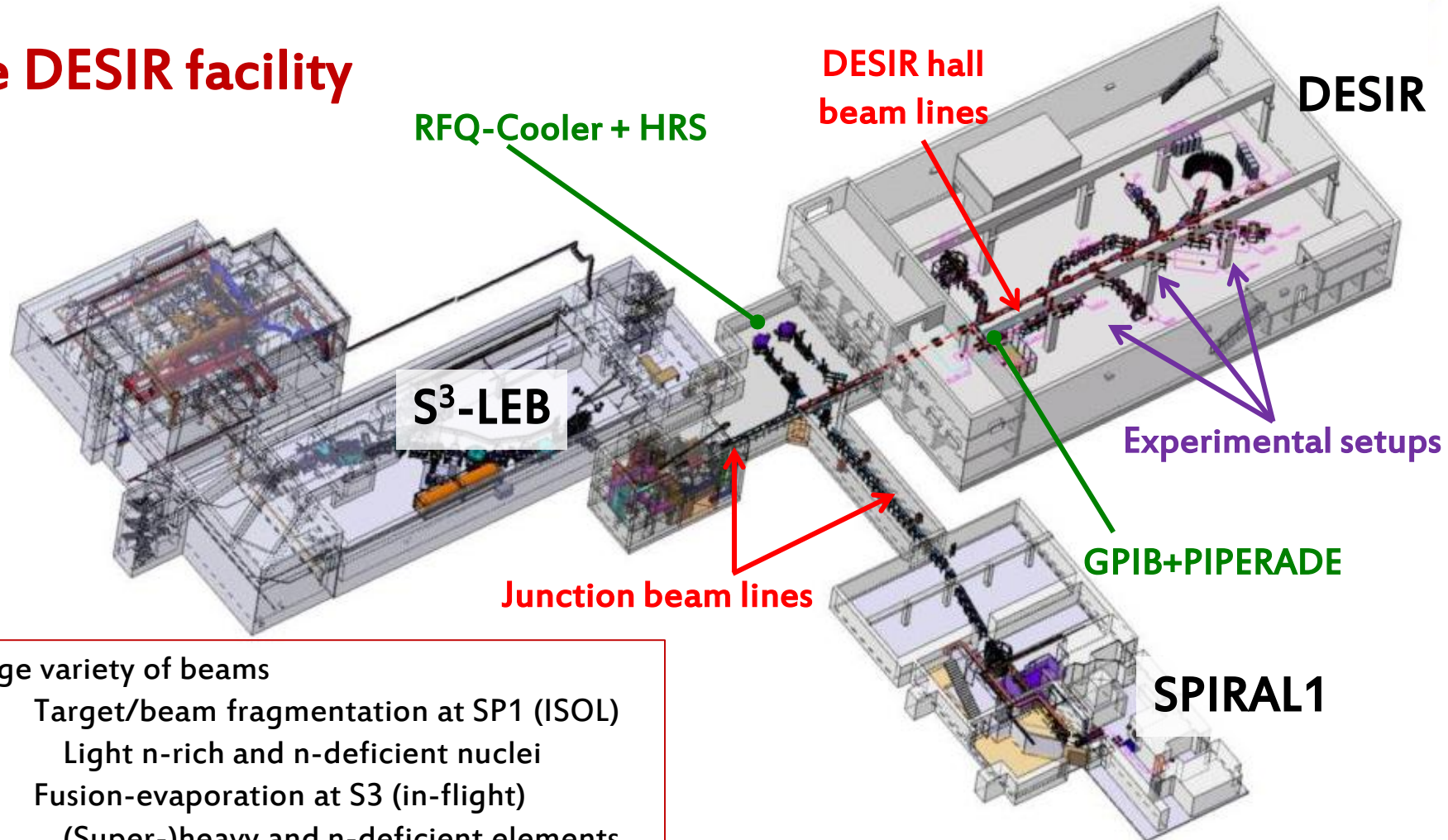
P. Ascher, for the DESIR collaboration and the SPIRAL2 Phase 1+ management

CEN Bordeaux-Gradignan

- Introduction of DESIR (physics motivations, instrumentation)
- Status and timeline of the project (2018-2023)
- Status and timeline of equipment development (2018-2023)
- First years of DESIR (2023-2026)

The logo for the DESIR facility. The word "DESIR" is written in a bold, pink, sans-serif font. A black arrow starts from the top of the letter 'S' and points to the right, passing over the top of the letter 'I'.

The DESIR facility

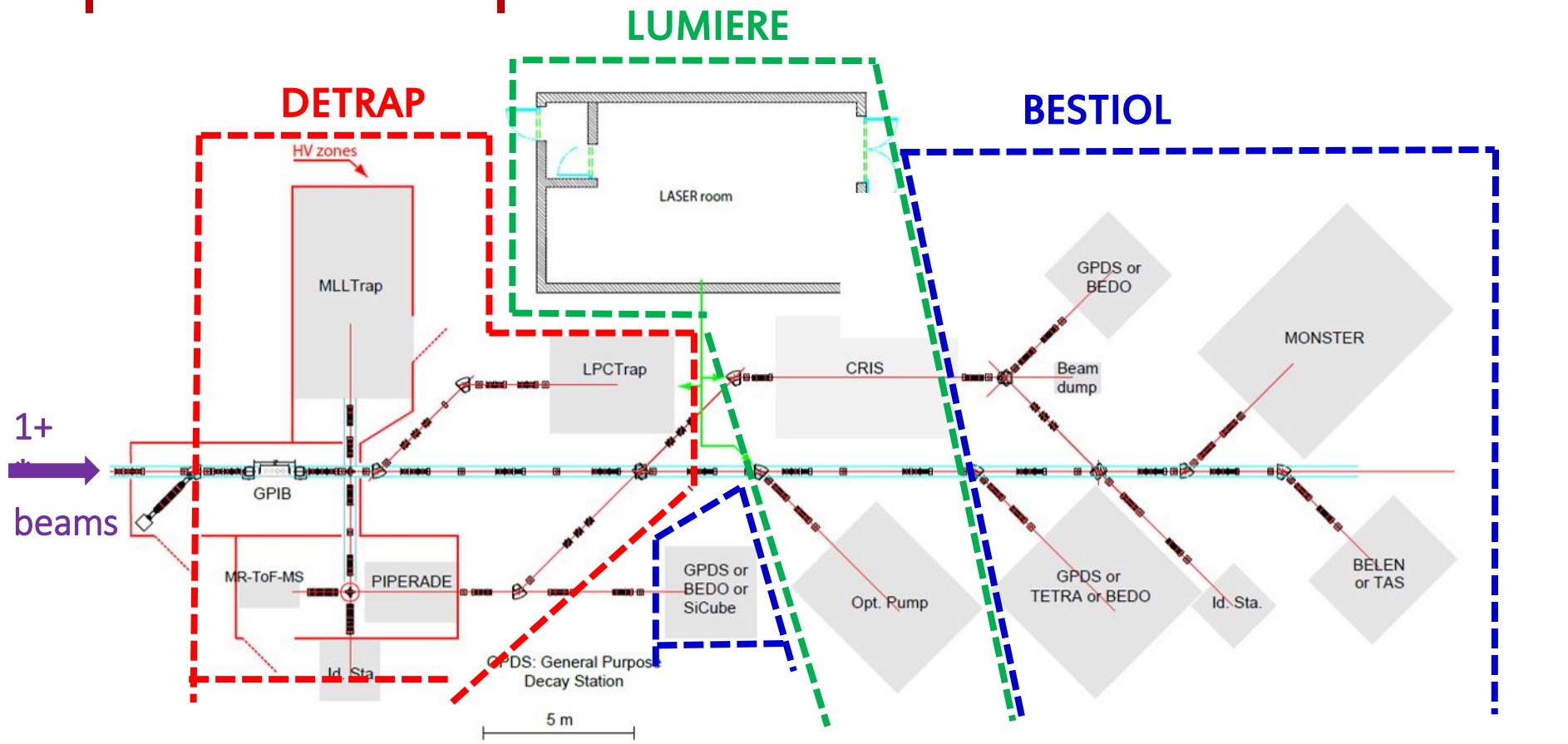


- ❑ Large variety of beams
 - Target/beam fragmentation at SP1 (ISOL)
Light n-rich and n-deficient nuclei
 - Fusion-evaporation at S3 (in-flight)
(Super-)heavy and n-deficient elements
Refractory elements
- ❑ High quality/purity beams (HRS, PIPERADE, SHIRaC, GPIB, MR-TOF)
- ❑ Complementary measurement techniques

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

Project Leader SPIRAL 2- DESIR : F. Varenne
Beam processes and beam line coordination:
H. Franberg Delahaye, L. Serani
Mechanical design beam lines: L. Perrot (IPNO)
RFQ Cooler design: J-F. Cam (LPC Caen)
HRS1P: L. Serani CENBG

Experimental set-ups



- Beam preparation
- Precise mass measurements
- In-trap decay spectroscopy
- β - v angular correlations
- Collinear laser spectroscopy
- Beam polarisation (decay spectroscopy, β -NMR, ...)
- β -delayed charge part.
- Full absorption spectroscopy
- (Trap-assisted) β -decay
- (Laser-assisted) β -decay

+ non-permanent set-ups, new ideas, new techniques... (ISOLDE-like)

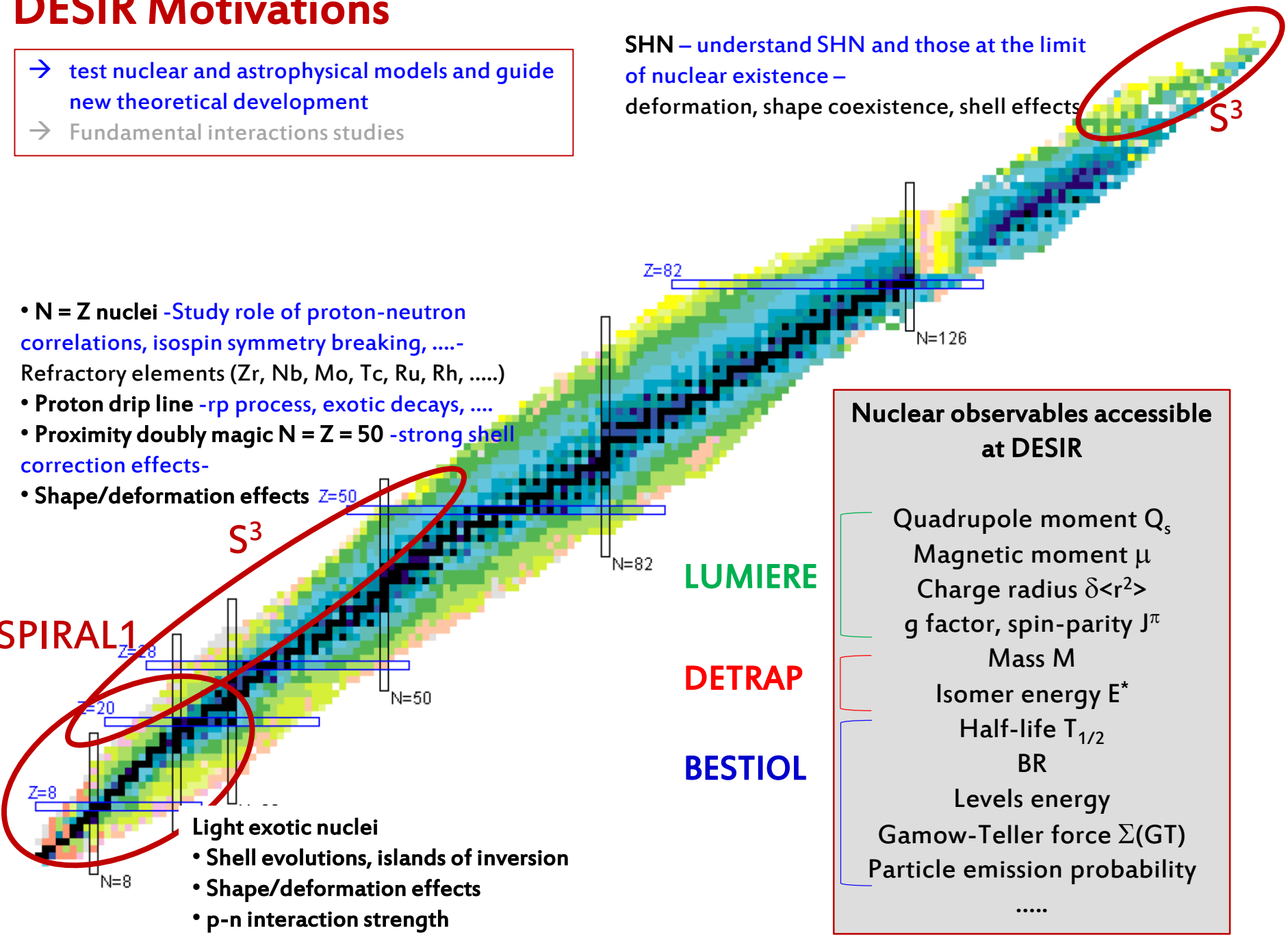
Facility coordinator experimental setups: J.-C. Thomas
 Scientific spokesperson: B. Blank

DESIR Motivations

- test nuclear and astrophysical models and guide new theoretical development
- Fundamental interactions studies

- **N = Z nuclei** -Study role of proton-neutron correlations, isospin symmetry breaking,- Refractory elements (Zr, Nb, Mo, Tc, Ru, Rh,
 - **Proton drip line** -rp process, exotic decays,
 - **Proximity doubly magic N = Z = 50** -strong shell correction effects-
 - **Shape/deformation effects**
- Light exotic nuclei**
- Shell evolutions, islands of inversion
 - Shape/deformation effects
 - p-n interaction strength

SHN – understand SHN and those at the limit of nuclear existence – deformation, shape coexistence, shell effects



- Nuclear observables accessible at DESIR**
- Quadrupole moment Q_s
 - Magnetic moment μ
 - Charge radius $\delta\langle r^2 \rangle$
 - g factor, spin-parity J^π
 - Mass M
 - Isomer energy E^*
 - Half-life $T_{1/2}$
 - BR
 - Levels energy
 - Gamow-Teller force $\Sigma(GT)$
 - Particle emission probability
 -

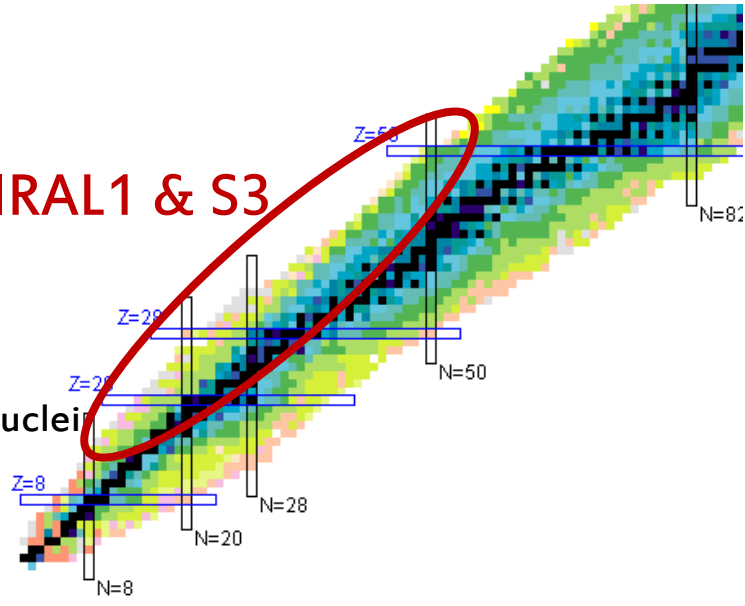
DESIR Motivations

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Unitarity test of CKM matrix and test the CVC hypothesis

- ✓ $0+ \rightarrow 0+$ super-allowed Fermi transitions: $T_z = 0, -1, -2$ nuclei
- ✓ Mirror transitions: $T_z = -1/2$ nuclei
- (→ modelization of isospin non-conserving effects)

SPIRAL1 & S3



Search for exotic currents (scalar, tensor, right-handed) in weak interaction

- ✓ β - ν angular correlation $a_{\beta\nu}$
- ✓ β - ν angular correlation using β -p decay
- ✓ β spectrum shape

Proof of principle with ^{32}Ar at CERN WISArD, B. Blank et al.

Test of time reversal symmetry in beta decay

- ✓ β - ν correlation with polarized beams (triple correlation)

Proof of principle with ^{23}Mg at JYFL (with an upgrade of LPCTrap) MORA, P. Delahaye et al.

BESTIOL

DETRAP

Nuclear observables accessible at DESIR

- Half-life $T_{1/2}$
- BR
- Q_{EC} value
- $a_{\beta\nu}$ correlation parameter
- A_β and D
- Fierz term b
- ...

See talks of E. Liénard and B. Blank

High precision needed

DESIR LOIs

List of DESIR (updated) LoIs presented at the DESIR – S³-LEB workshop held at GANIL in March 2014

In-trap decay studies

- DETRAP**
1. E. Liénard *et al.*, LPC Caen, “High precision measurement in mirror β decays to test the CVC hypothesis and the CKM unitarity”
 2. X. Flécharde *et al.*, LPC Caen, “Search for exotic couplings using precision measurements of nuclear β decay”
 3. P. Delahaye *et al.*, GANIL, “Test of the time reversal symmetry in the beta decay of ²³Mg and ³⁹Ca using an in-trap polarization method at DESIR”
 4. B. Blank *et al.*, CENBG, “Search for scalar currents with β -delayed proton emitters”
 5. S. Grévy *et al.*, CENBG, “In-trap decay spectroscopy to measure neutron energies”

SPIRAL 1 Upgrade

Radioactive decay studies

- BESTIOL**
6. T. Kurtukian Nieto *et al.*, CENBG, “High precision measurements of half-lives and branching ratios in mirror β decay”
 7. H. Guérin *et al.*, CENBG, “High precision studies of the super-allowed beta decay of $T_z = 0, -1$ and -2 nuclei”
 8. J. Giovinazzo *et al.*, CENBG, “Study of the beta-delayed two-proton decay”
 9. A. Algora *et al.*, IFIC Valencia, “Beta strength measurements in the ¹⁰⁰Sn region”
 10. B. Blank *et al.*, CENBG, “Search for cluster radioactivity in the region above ¹⁰⁰Sn”

SP1-U

S³-LEB

Laser spectroscopy

- LUMIERE**
11. T. Cocolios *et al.*, Univ. Manchester, “From $N=Z=28$ to the proton drip line at LUMIERE”
 12. M. Bissell *et al.*, IKS Leuven, “Collinear laser spectroscopy of neutron deficient isotopes of Ag and Sn across the $N=50$ shell closure”
 13. D. Yordanov *et al.*, IPN Orsay, “Laser spectroscopy of very neutron deficient indium and cadmium isotopes”

S³-LEB

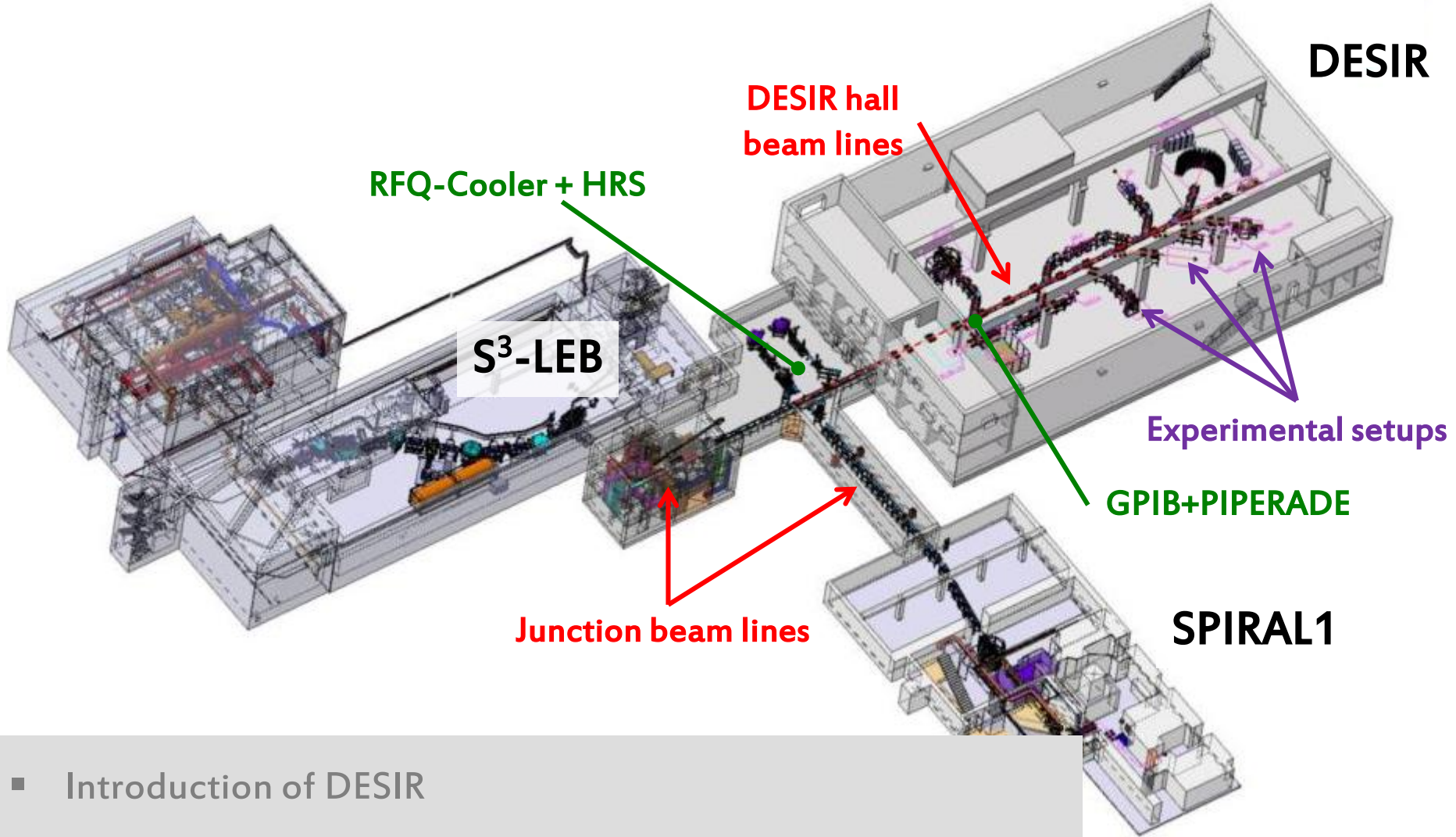
Mass measurements

- DETRAP**
14. Ch. Weber *et al.*, LMU Munich, “Mass Measurements with MLLTRAP at DESIR: Transfermium nuclides & super-allowed β emitters revisited”
 15. D. Lunney *et al.*, CSNSM Orsay, “The mass of ¹⁰⁰Sn and the extraordinary binding of $N = Z$ nuclides”
 16. M. MacCormick *et al.*, IPN Orsay, “High-resolution mass measurements of odd-odd $T=1$ nuclides”
 17. D. Lunney *et al.*, CSNSM Orsay, “Mass measurements for SPIRAL2 - phase 1+: mapping the proton drip line in the $A=150$ region”
 18. P. Ascher *et al.*, CENBG Bordeaux, “Mass measurement of light nuclei using an MR-TOF-MS or a Penning Trap @ DESIR”

S³-LEB

SP1-U

➤ 8 LoI SPIRAL1 upgrade and 10 LoI with S³-LEB



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- Status and timeline of equipment development (2018-2023)
- First years of DESIR (2023-2026)

Important dates

2015: Budget secured (23M€) (ANR, GSI-FAIR, CNRS, Région Basse Normandie)

2016: Decision to launch a new call for tender for the facility study/construction (inputs from the preliminary design); EQUIPEX financing extension till 2023

2017: new call for tender (study and construction), July 2017

→ Proposal analysis in February-April 2018 => Prime contractor selection

Important dates

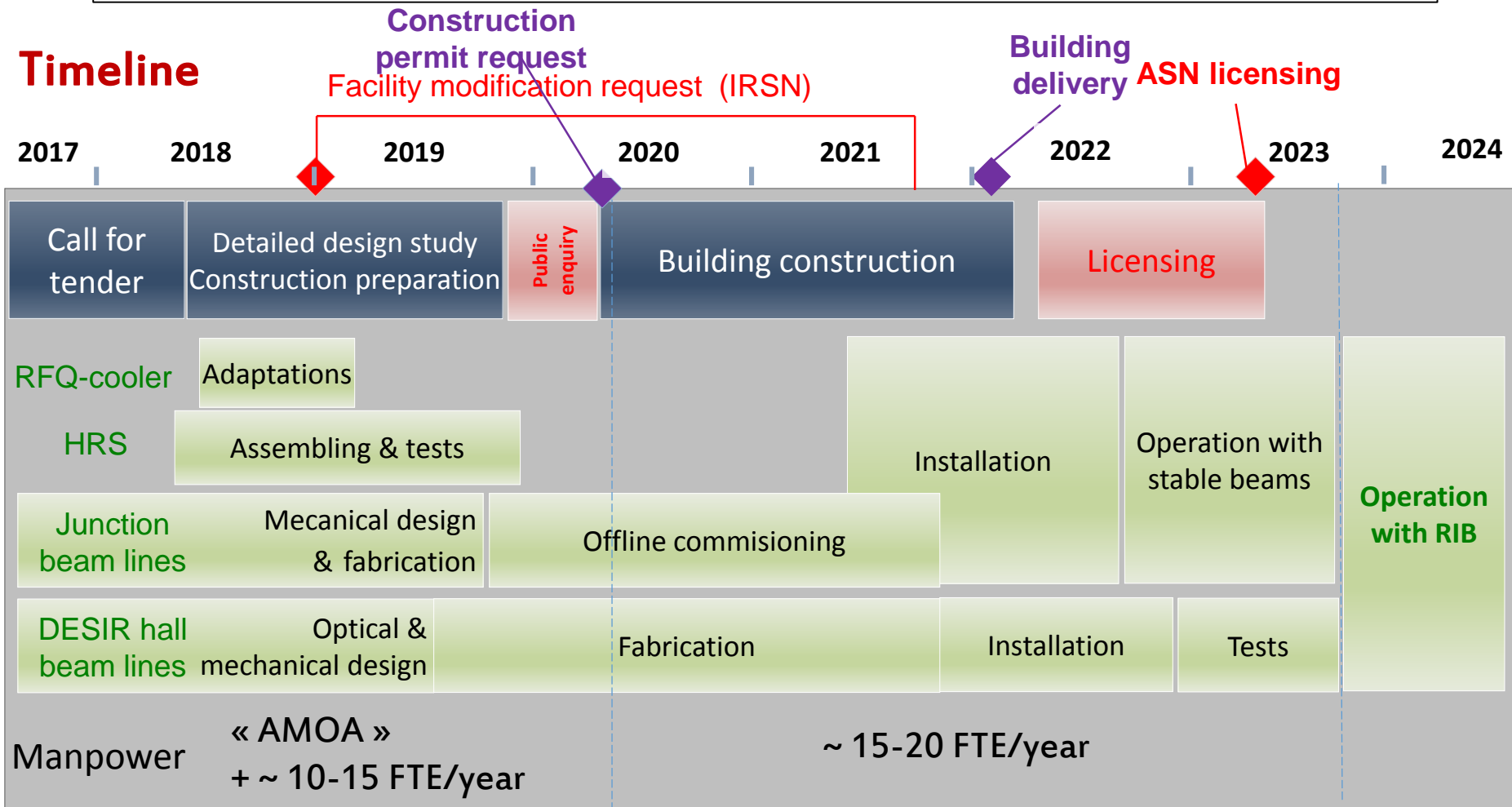
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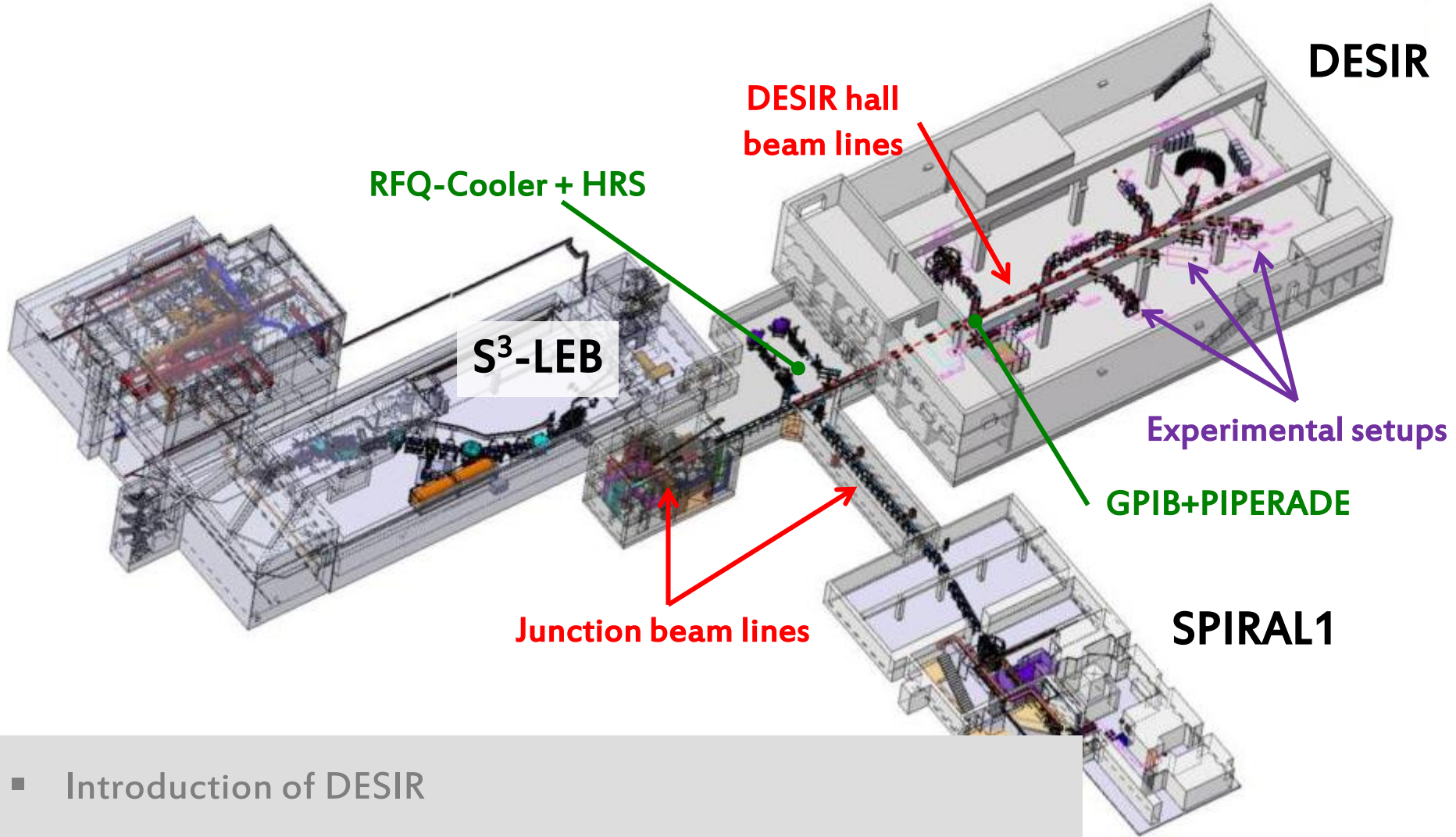
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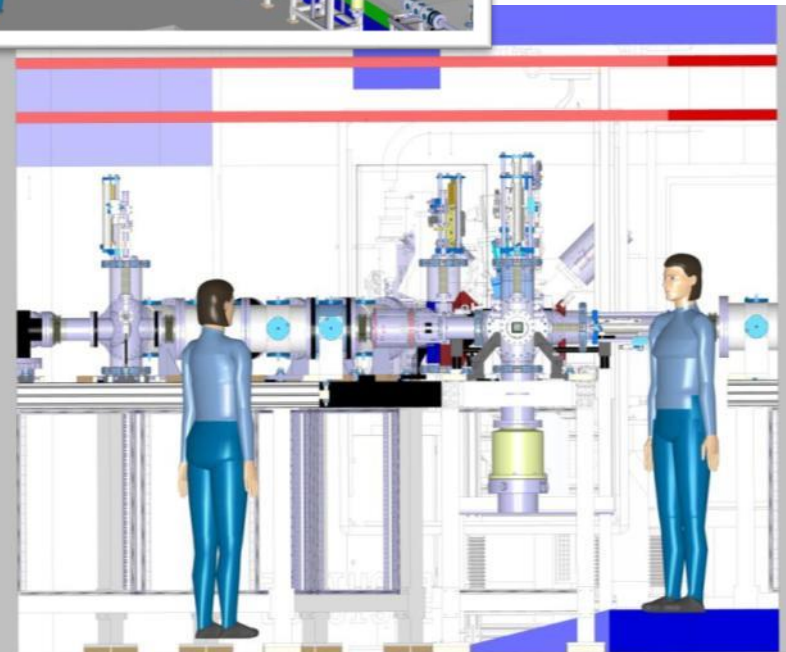
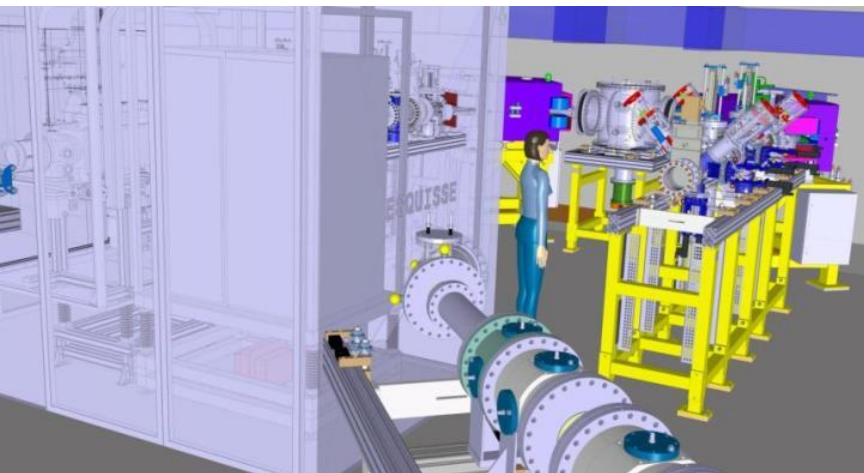
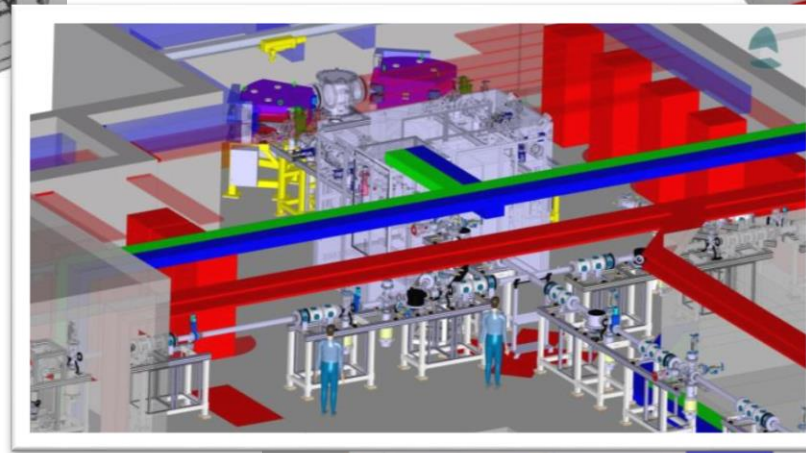
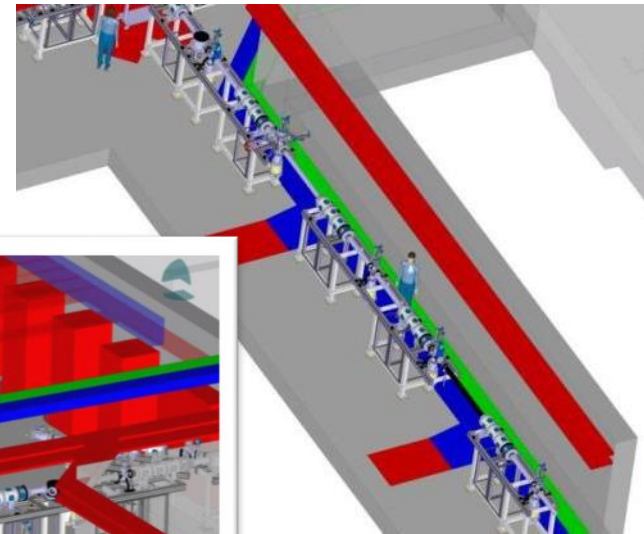
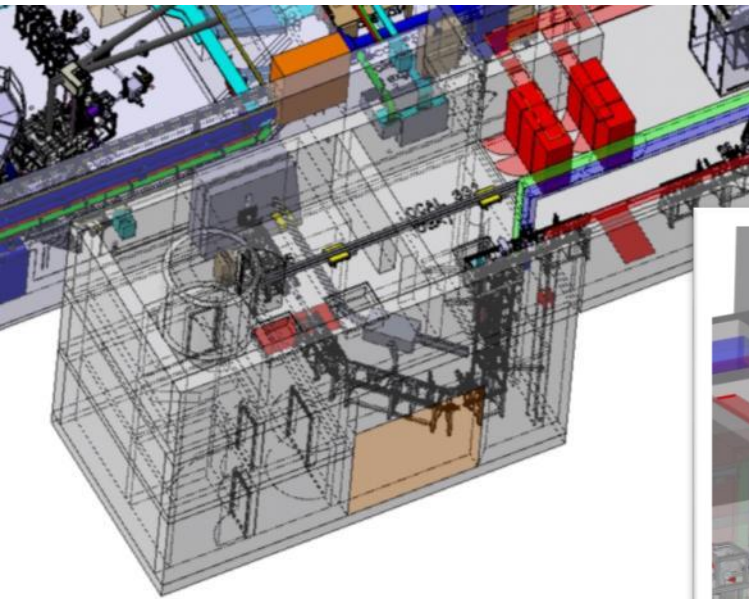
Timeline





- Introduction of DESIR
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- First years of DESIR (2023-2026)

Interfaces between building, infrastructure and beam lines

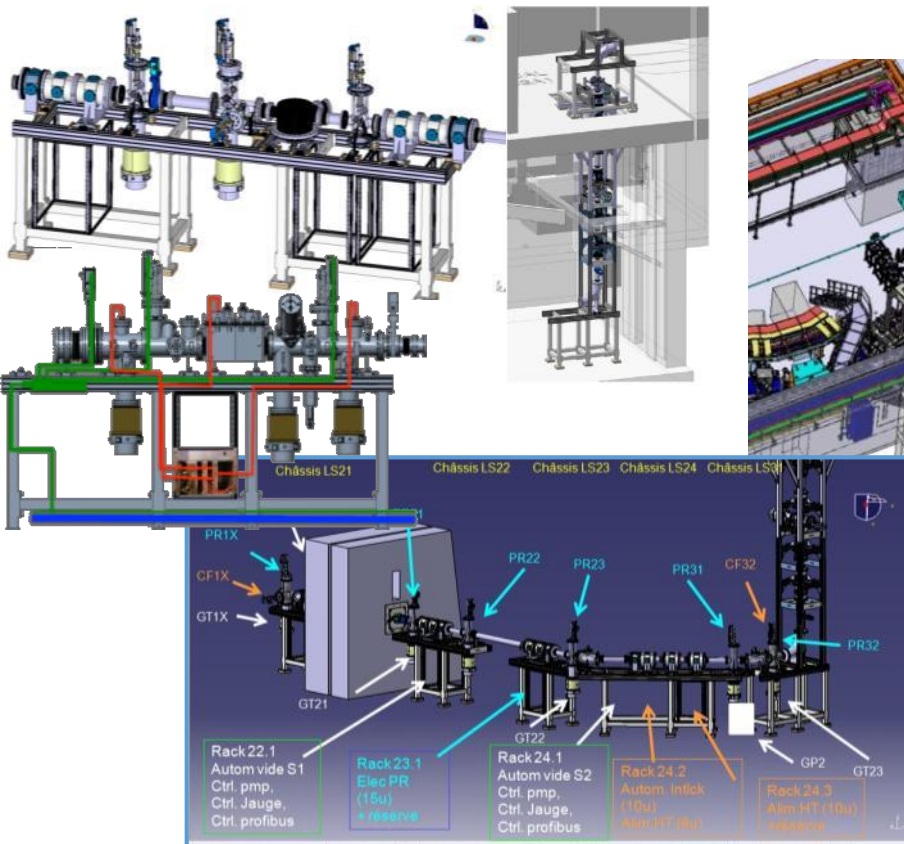


Regards to : H. Franberg Delahaye, C. Michel et S. Rousselot
Presentation GANIL/SPIRAL 2 week 2016

Status technical achievements

Design beam lines: L. Perrot (IPNO)

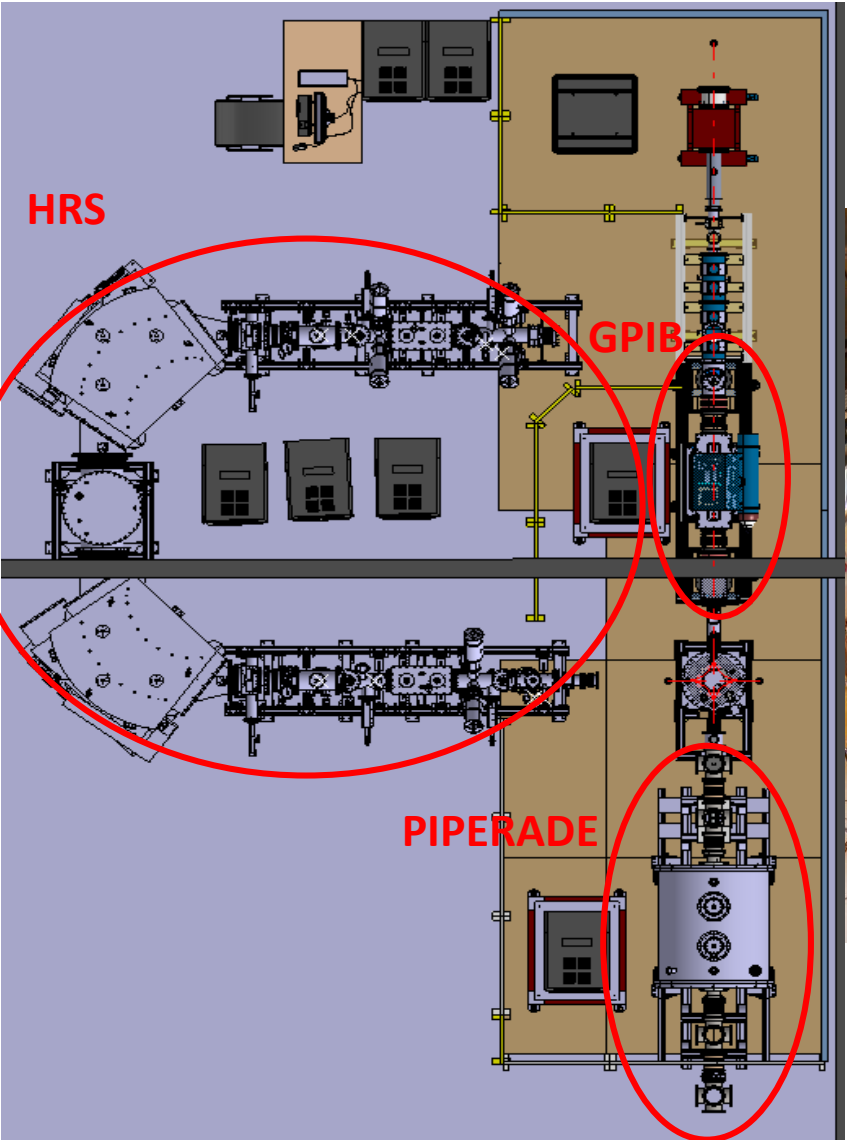
- ✓ Definitive mechanical design of transport beam lines
- ✓ Integration of beam lines and their operational servitudes into the building are in an advanced level
- ✓ Standardisation of mechanical objects, interfaces, servitudes, c/c and automatism are validated
- ✓ The call for tenders for fabrication of the first standard parts are ready to be launched



*Regards to : H. Franberg Delahaye, C. Michel
Presentation GANIL/SPIRAL2 week 2016*

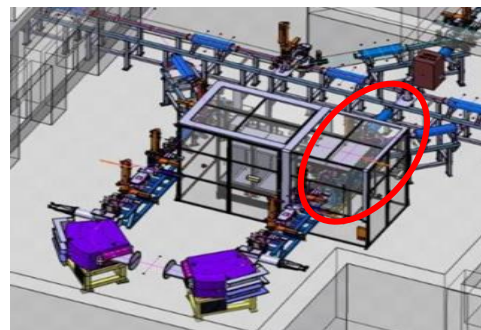
Development of beam preparation devices for DESIR at CENBG

«Hall de montage» CENBG



Status of HRS

- Global optical design published
T. Kurtukian-Nieto et al., NIMB 2013



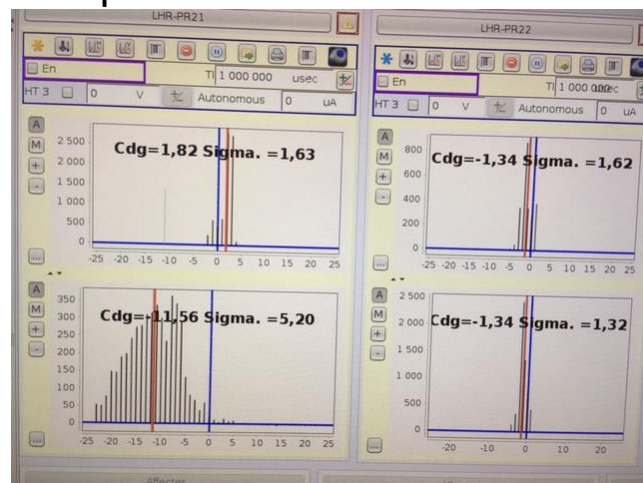
RFQ Cooler SHIRac



*R. Boussaid et al., 2014
JINST 9 P07009*

- Performance of the HRS studied considering misalignment/positioning precision of different elements
 $R > 20,000$ for a 3π .mm.mrad 60keV beam and energy spread ~ 1 eV (\rightarrow SHIRAC Cooler)

Plot profil: **Beam until mid Plane**



- Assembly, C/C: 2017
- First beam: July 2017
- Tests and optimizations @CENBG: 2017-2020



Status of GPIB

Transmission measurements

~ 80% for A=40 (⁴⁰Ar) in DC mode

Emittance measurements

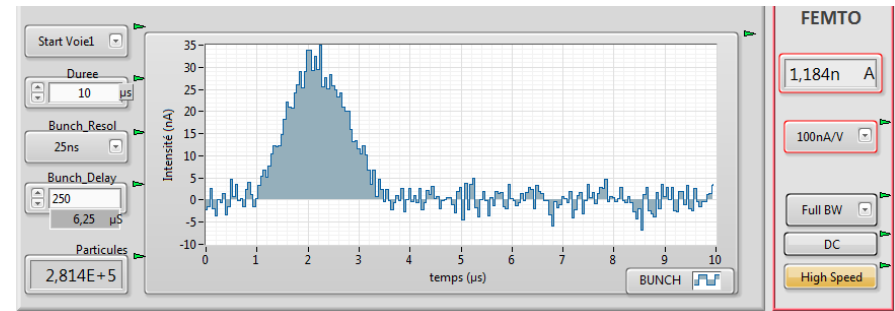
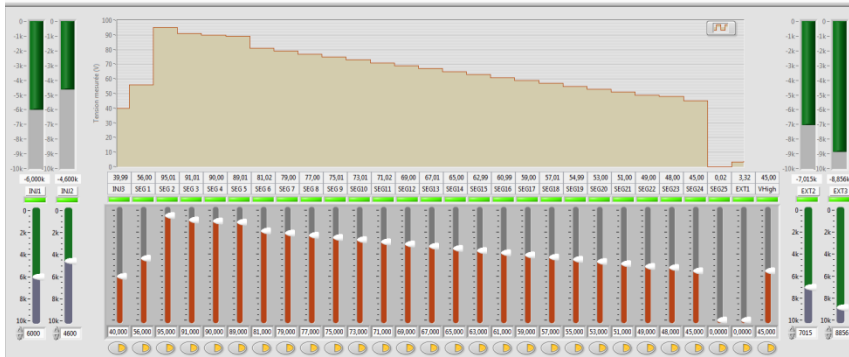
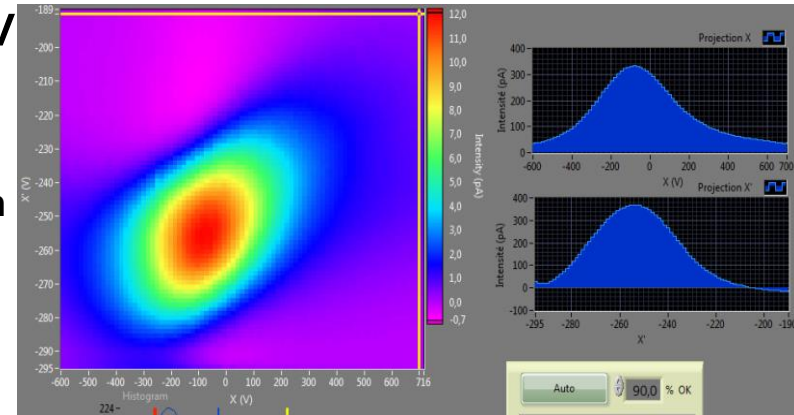
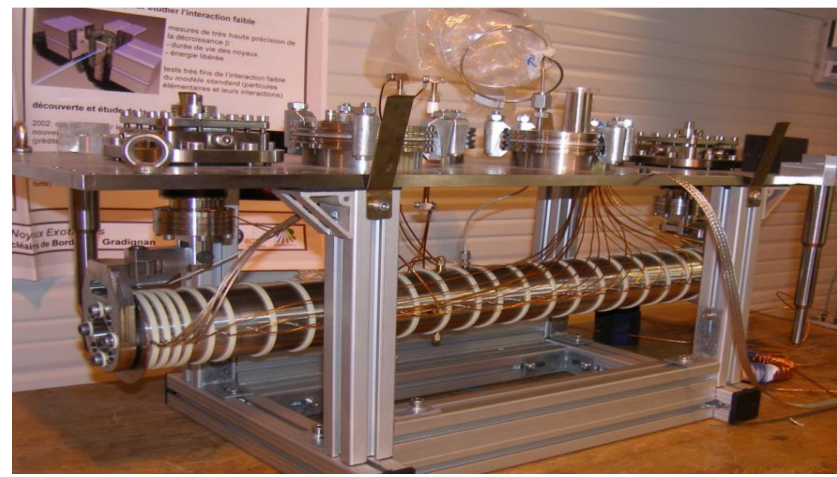
✓ Source emittance: ~ 30π .mm.mrad @ 30keV

✓ Cooled beam emittance: ~ 3π .mm.mrad @30keV

Bunching mode: First ion bunches (30 keV) last March

~ 80% transmission (Δt of ~3-4us)

Δt down to 1 us (40% transmission)



CW injection and 50 Hz extraction

Extraction at 3keV to be tested (for the injection into the trap)

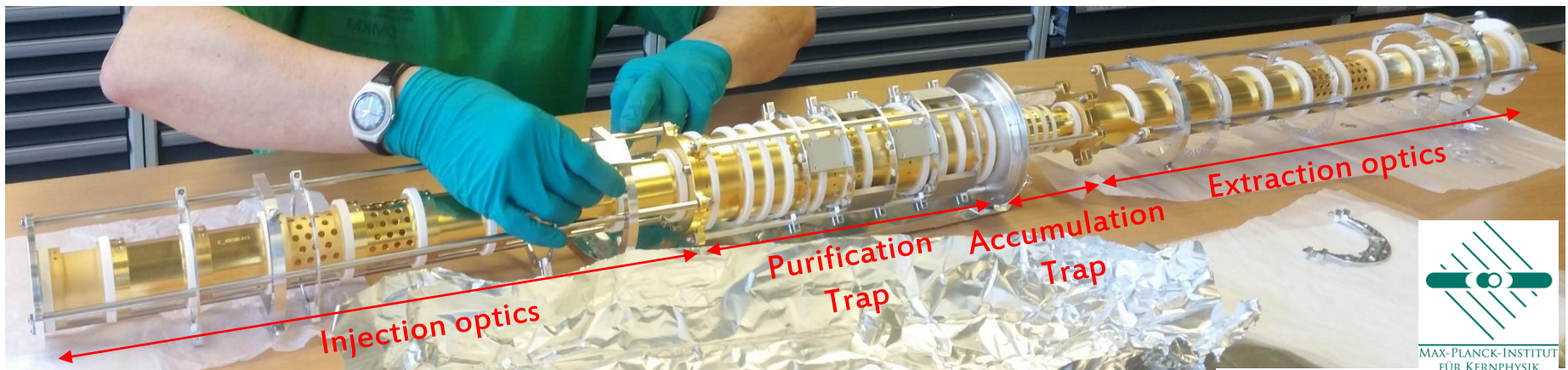
S. Grévy, M. Gerbaux, P. Ascher et al.

Status of PIPERADE

Superconducting magnet delivered and cooled down (July 2017)



Magnet charged to 7T and shimmed (July 2017)



Trap tower developed in collaboration with MPIK Heidelberg
Electronics developed by Stahl Electronics

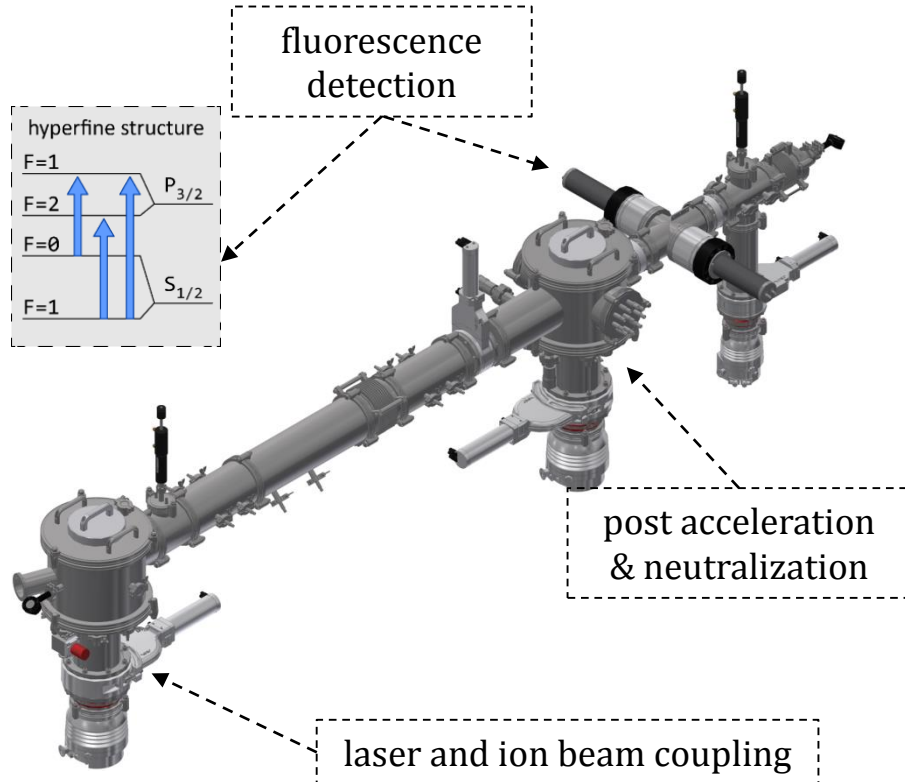
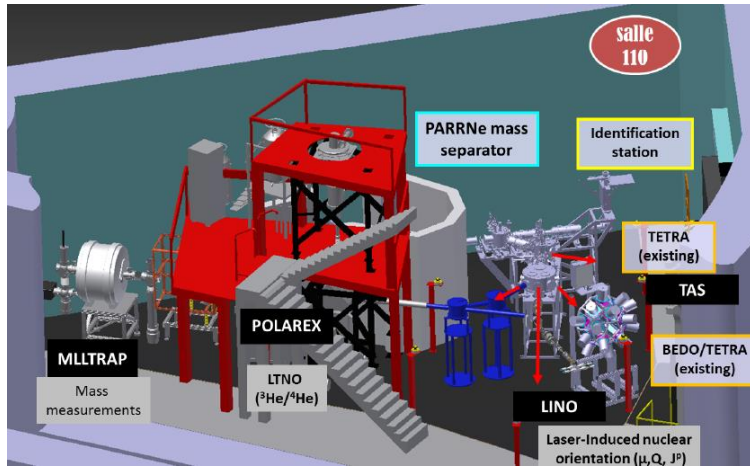


2017-2018: Alignment, Installation of traps, c/c development, ...

Autumn 2018: Start the tests with stable ion source

S. Grévy, M. Gerbaux, P. Ascher, et al.

Status of MLLTRAP and LINO at ALTO



MLLTRAP (E. Minaya Ramirez et al.)

- Magnet installed IPNO/CSNSM
- 2017-2018: Cooling and shimming of the magnet, traps installation and construction of RFQ-CB, offline tests
- 2019: First on-line experiments

LINO (D. Yordanov et al.)

- Under construction
- Completed in spring 2018
- 2019: First on-line experiments

March 2016 : "Charting Terra Incognita of Exotic Nuclei"



"Reaching Terra Incognita of Exotic Nuclei" requested in 2017



Experimental set-ups at DESIR

Under development

- SHIRaC (LPC)
- HRS (CENBG)
- GPIB, PIPERADE (CENBG, MPIK)
- MLLTRAP (IPN, LMU, CSNSM)
- LINO (IPN)
- LPCTrap2 (LPC)
- Identification station (IPHC)

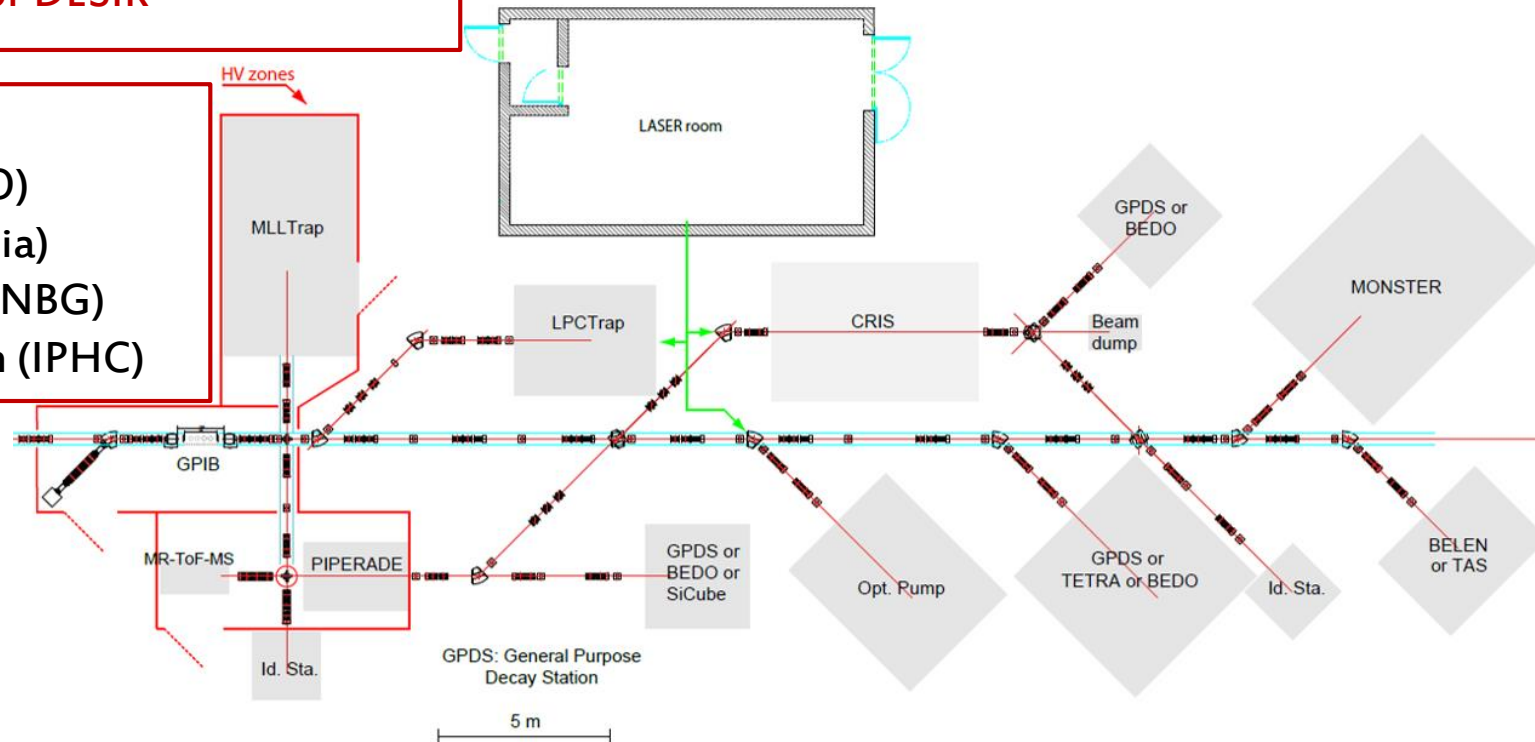
Will be ready for DESIR

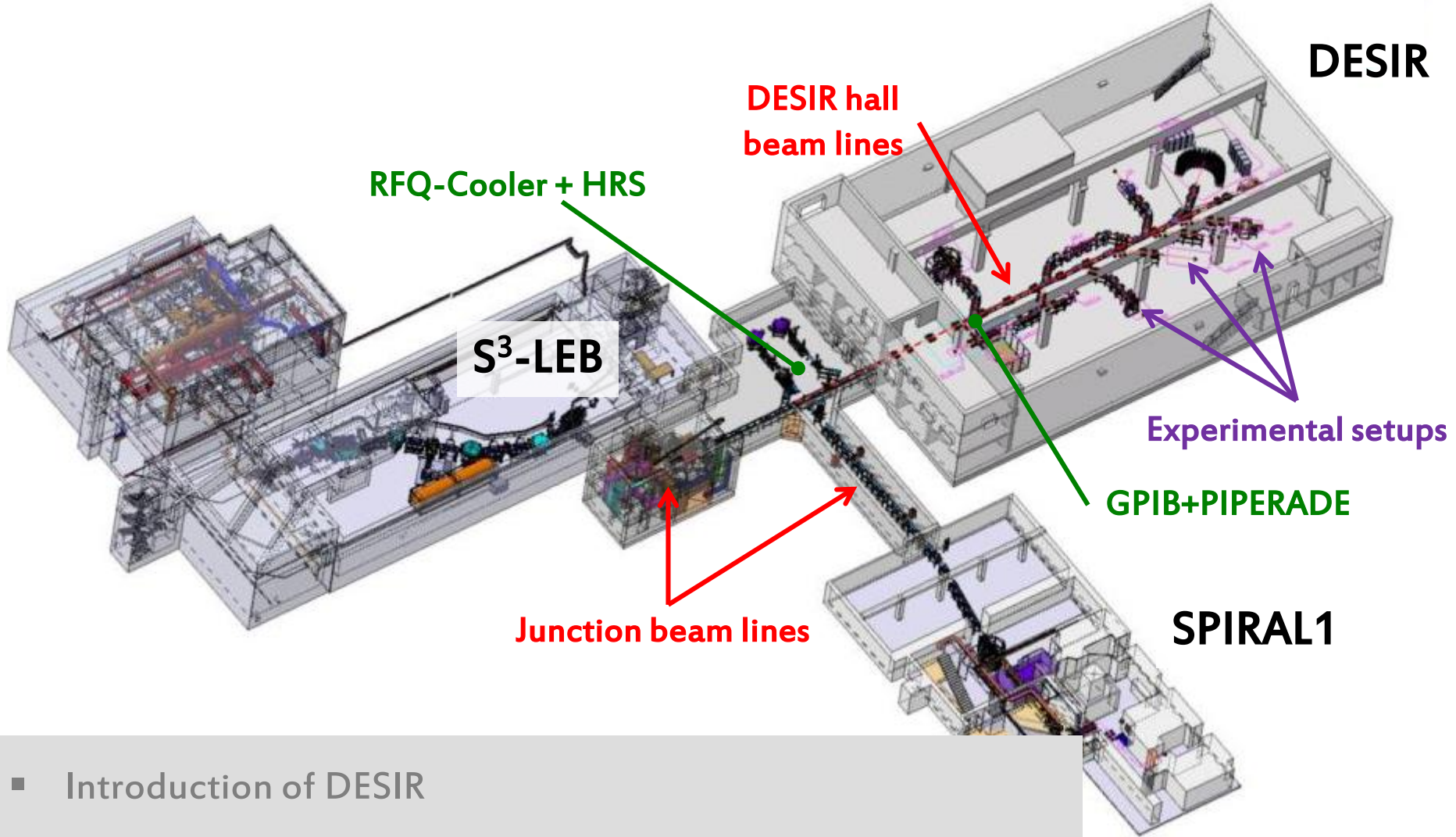
To be developed/discussed

- CRIS (Leuven, Manchester)
- MR-TOF (GANIL, Univ. Greifswald)
- New universal gas cell at S3?
(full benefit from the S3/DESIR coupling)
- New ideas....

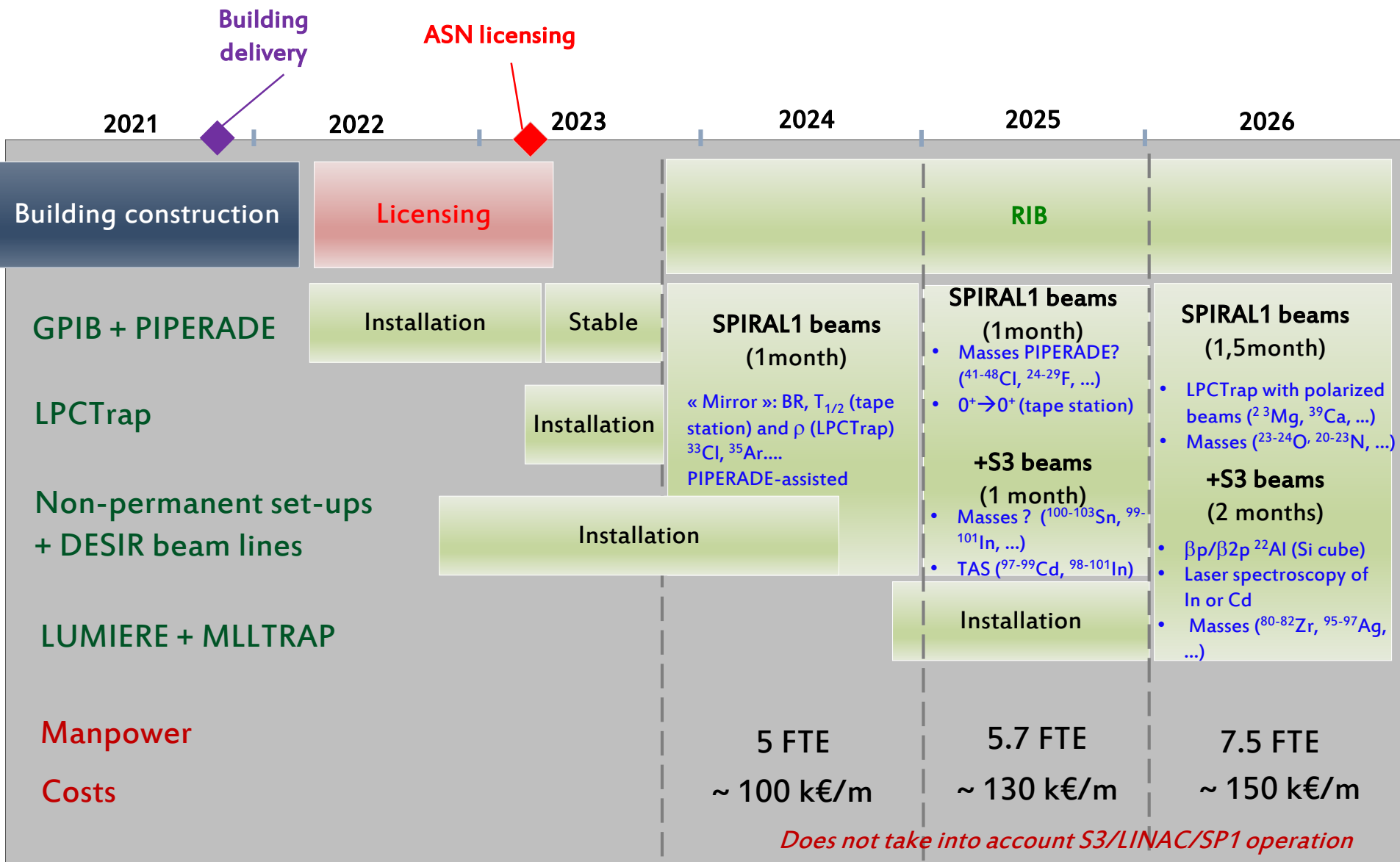
Ready

- BEDO (ALTO)
- TAS (Valencia)
- Si-Cube (CENBG)
- Tape station (IPHC)





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- **First years of DESIR (2023-2026)**



Day-one experiments will be discussed later within the collaboration (too early now), here is just an example Detailed timeline of the setups installation as well.....

Conclusions

❑ DESIR will be unique in terms of

- ✓ Complementary accessible beams
- ✓ Quality/purity of beams
- ✓ Variety of experimental set-ups

❑ Project is on track now

- ✓ Budget secured
- ✓ Call for tender launched

❑ Development of equipment for DESIR

- ✓ Progressing well and will be ready
- ✓ BUT need to discuss now further developments
- ✓ A lot of investment from IN2P3 laboratories and international laboratories

❑ Other crucial discussions to have in the next years

- ✓ coordination of DESIR beam time and S3 campaigns
- ✓ available beam time, manpower, ...



Thanks a lot to the contributors to this talk

J.-C. Thomas, H. Franberg-Delahaye, F. Varenne, L. Serani,
D. Yordanov, E. Minaya-Ramirez, S. Grévy, B. Blank

And thank you for your attention!