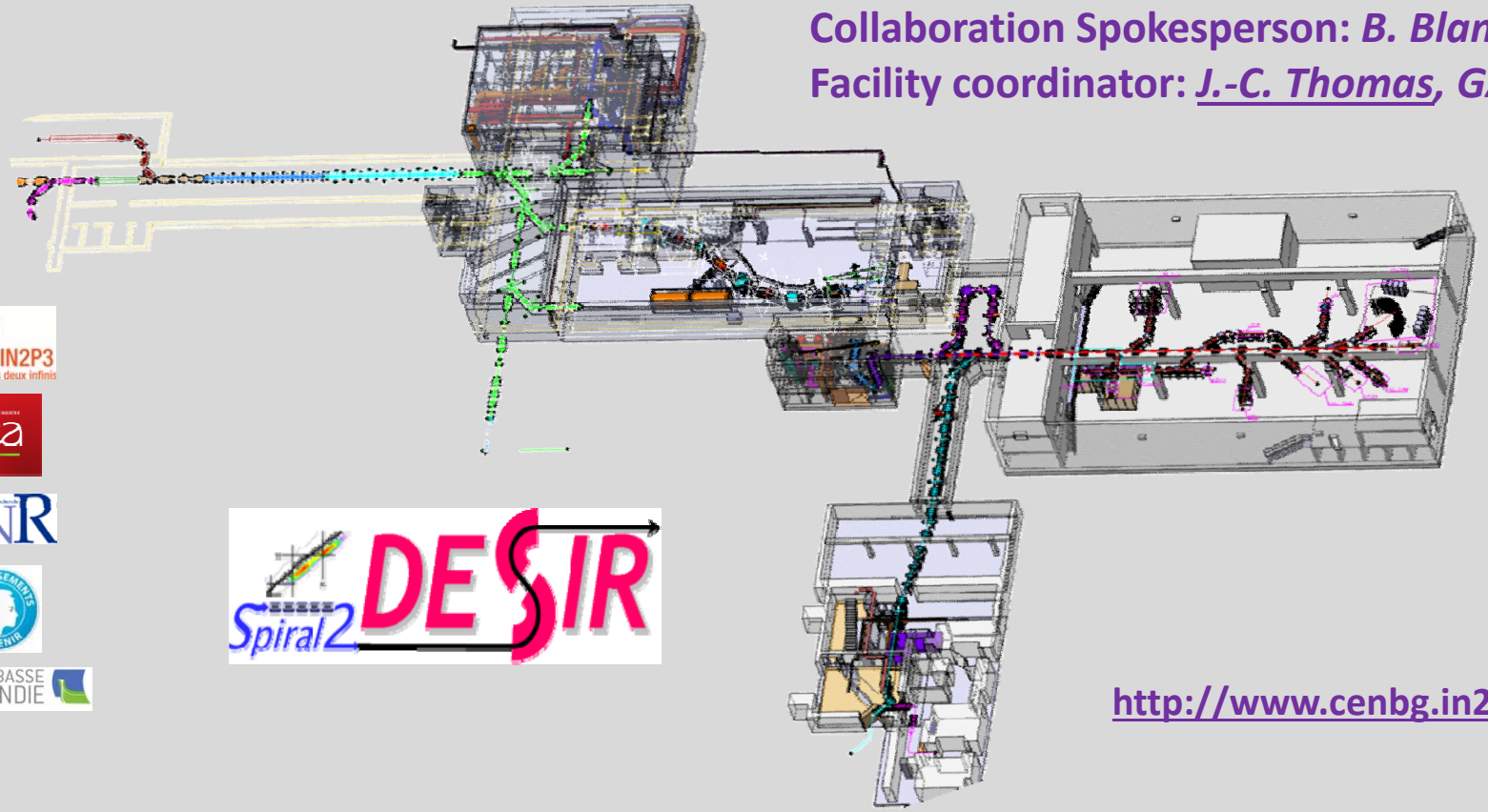
The DESIR facility @ GANIL-SPIRAL2

Collaboration Spokesperson: ***B. Blank, CENBG***
Facility coordinator: ***J.-C. Thomas, GANIL***

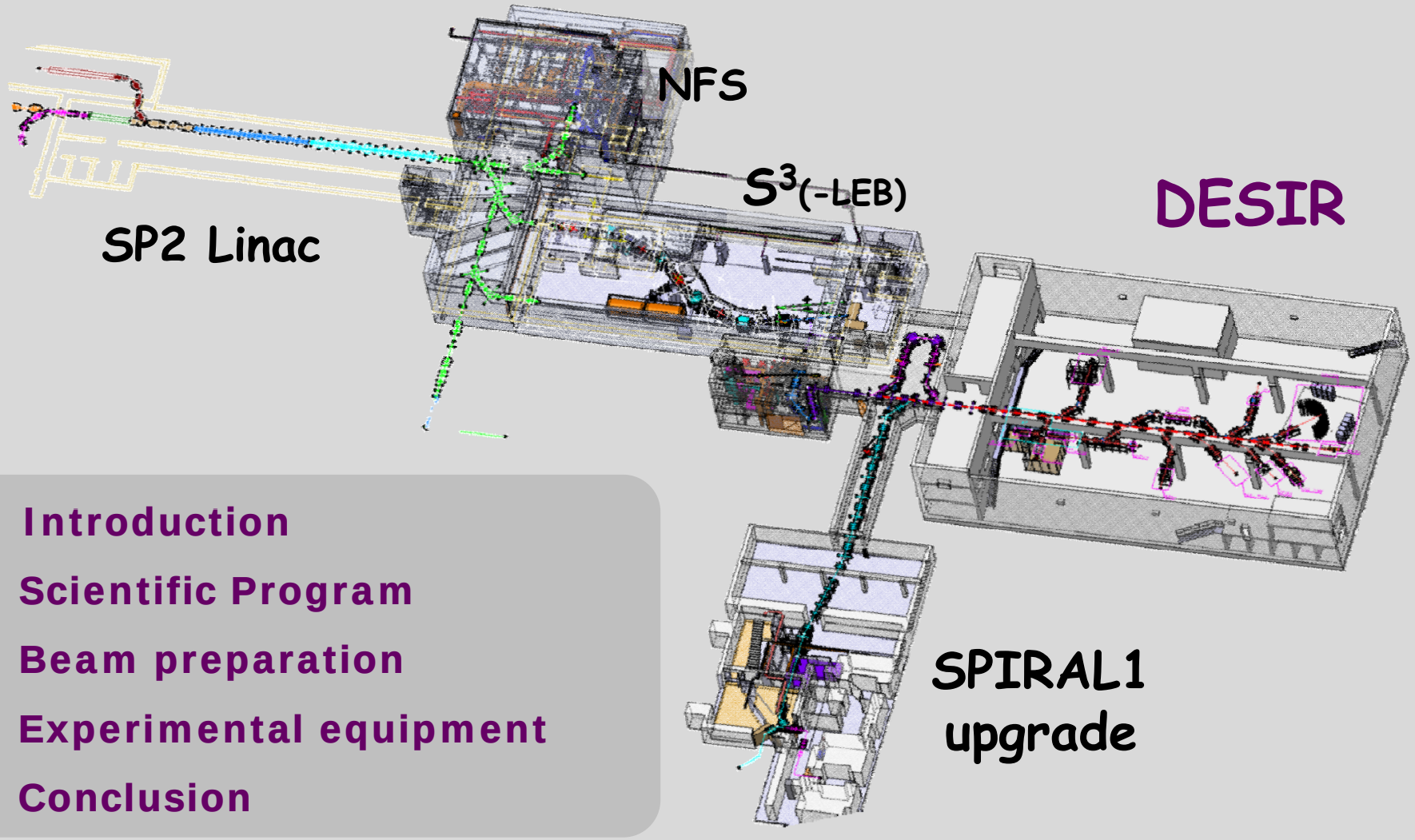


http://www.cenbg.in2p3.fr/desir

Joint LIA COLL-AGAIN, COPIGAL, and POLITA Workshop
(French-Italian-Polish Collaborations)

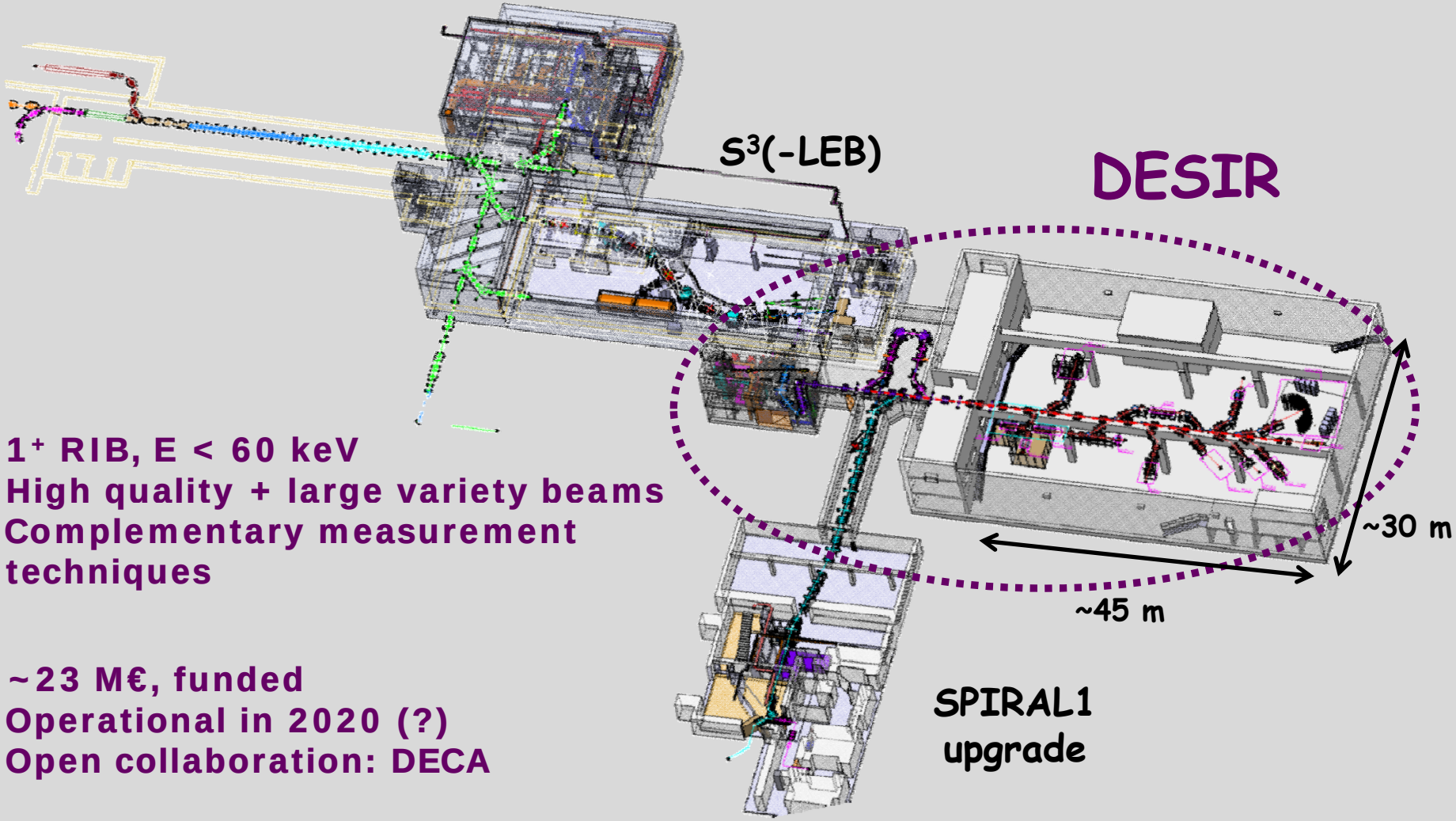
26-29 April 2016 *INFN-Laboratori Nazionali del Sud, Catania,Italy*

The DESIR facility @ GANIL-SPIRAL2



- Introduction
- Scientific Program
- Beam preparation
- Experimental equipment
- Conclusion

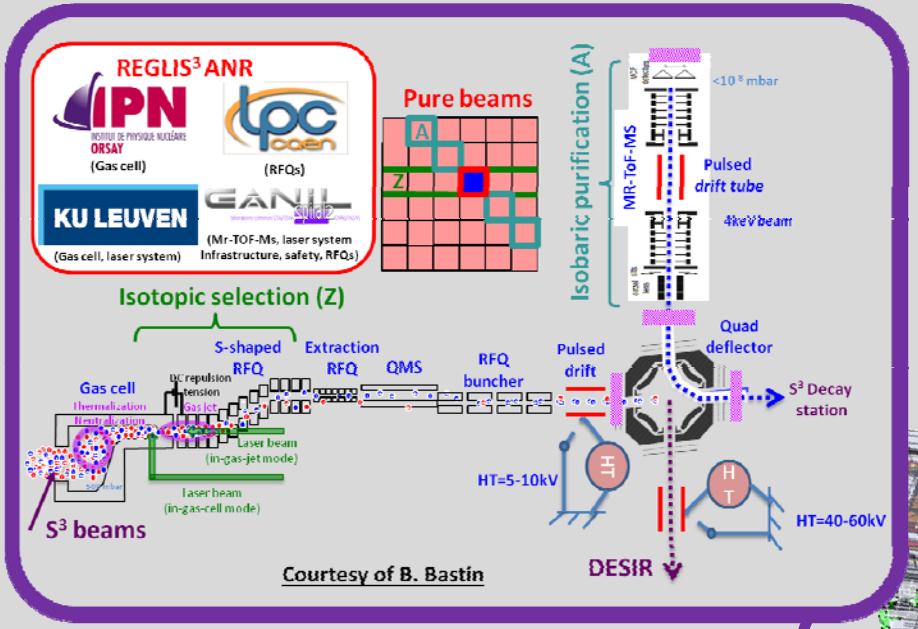
Decay Excitation and Storage of Radioactive Ions

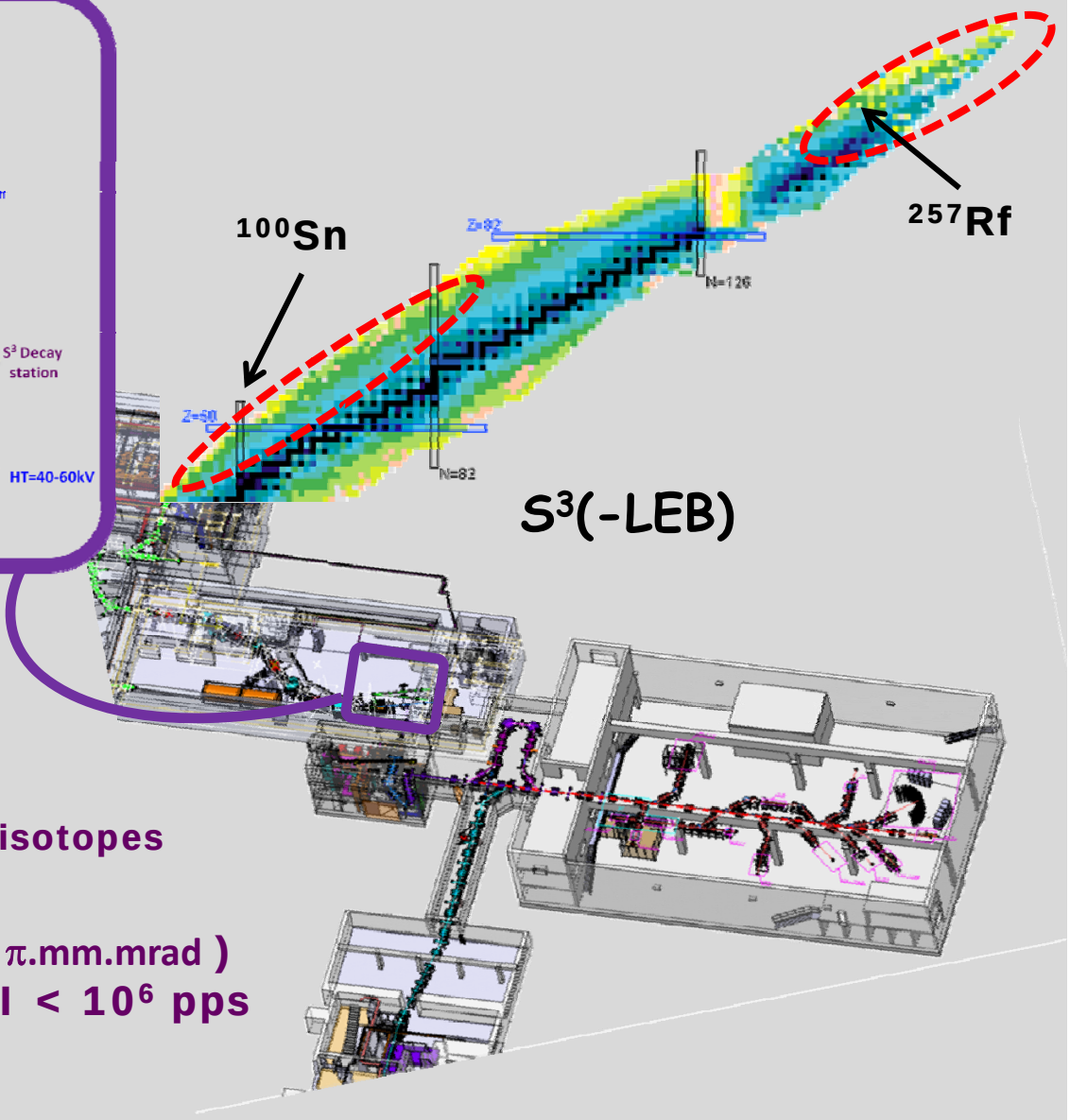


- 1^+ RIB, E < 60 keV
- High quality + large variety beams
- Complementary measurement techniques

- ~23 M€, funded
- Operational in 2020 (?)
- Open collaboration: DECA

S³-LEB production site





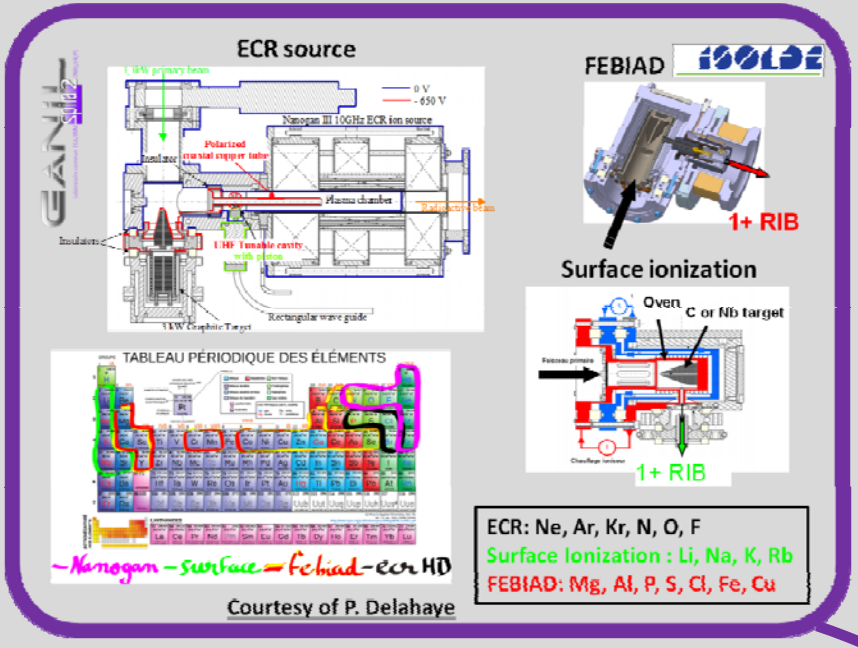
- (Multi-)nucleon transfer
- Fusion-evaporation

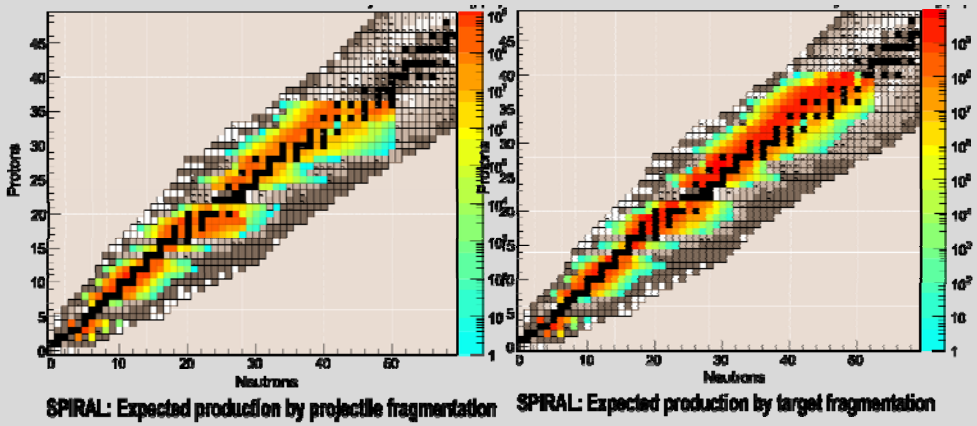
  -> refractory elements

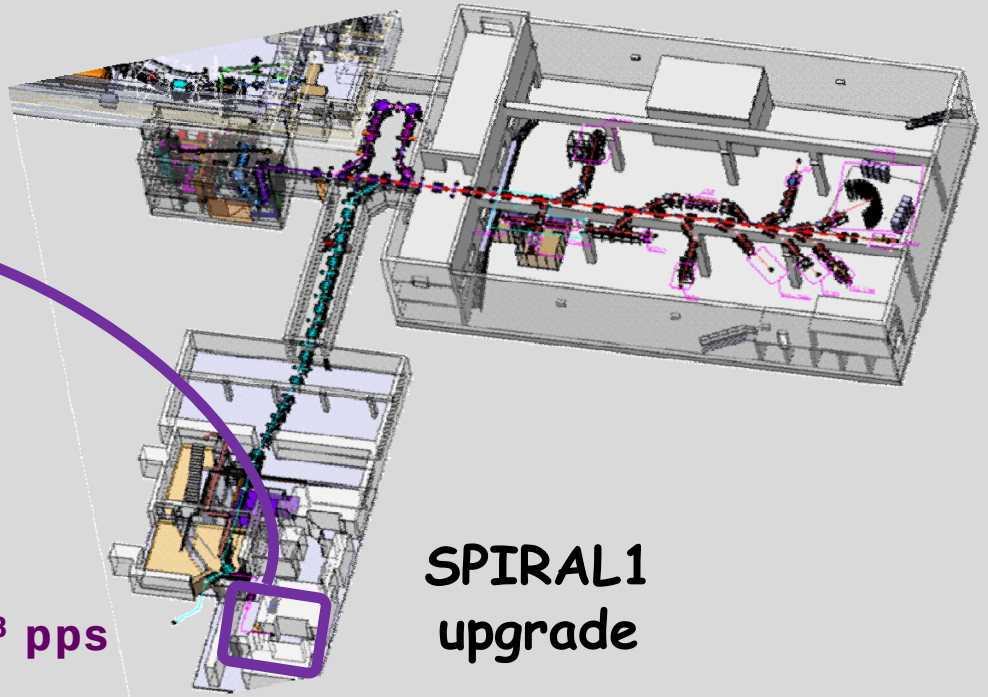
  -> n-deficient and (super-)heavy isotopes

- High purity, high quality (< 5 π.mm.mrad)
- 1 µs, 100 Hz pulsed beams, I < 10^6 pps
- E ~30 keV

(Upgraded) SPIRAL1 production site







SPIRAL1 upgrade

- **Beam & target fragmentation**
- **ECR, FEBIAD, Surface ionization**
  -> (light) n-rich / n-deficient

- **E ~10-30 keV, CW beams, I < 10^8 pps**
- **3 to 80 π.mm.mrad**

DESIR LoIs (2011, 2014 - http://www.cenbg.in2p3.fr/desir/-DESIR-S3-LEB-workshop-*)*

In-trap decay studies

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. Fléchard *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 ^{23}Mg and ^{39}Ca 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

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 ^{100}Sn region"*
10. B. Blank *et al.*, CENBG, *"Search for cluster radioactivity in the region above ^{100}Sn"*

SP1-U

S³-LEB

Laser spectroscopy

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

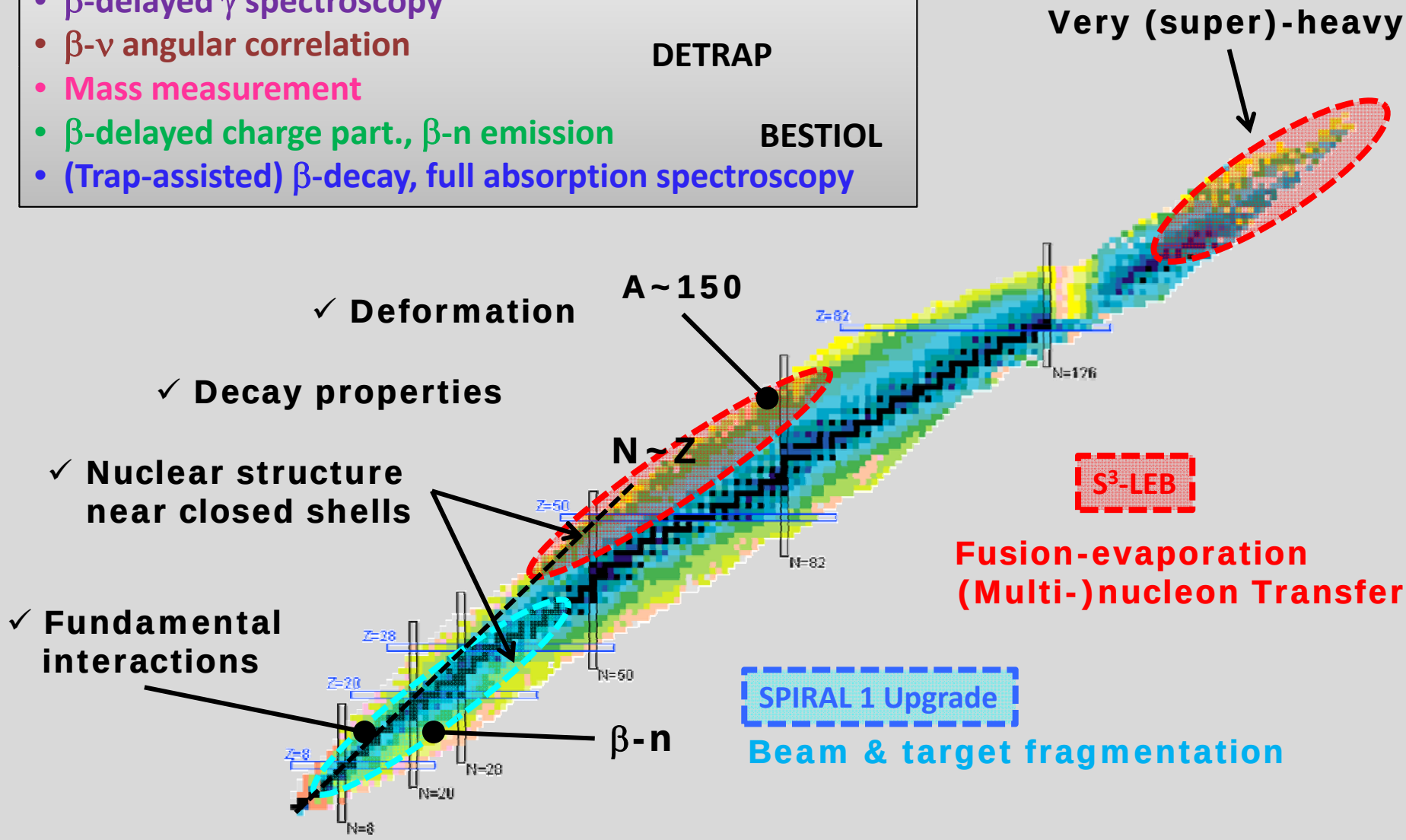
14. P. Thirolf *et al.*, LMU Munich, *"Mass Meas. with MLLTRAP at DESIR: Transfermium nuclides & super-allowed β emitters"*
15. D. Lunney *et al.*, CSNSM Orsay, *"The mass of ^{100}Sn and the extraordinary binding of N = Z nuclides"*
16. M. MacCormick *et al.*, IPN Orsay, *"High-resolution mass measurements 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, *"Mass measurement of light nuclei using an MR-TOF-MS or a Penning Trap @ DESIR"*

S³-LEB

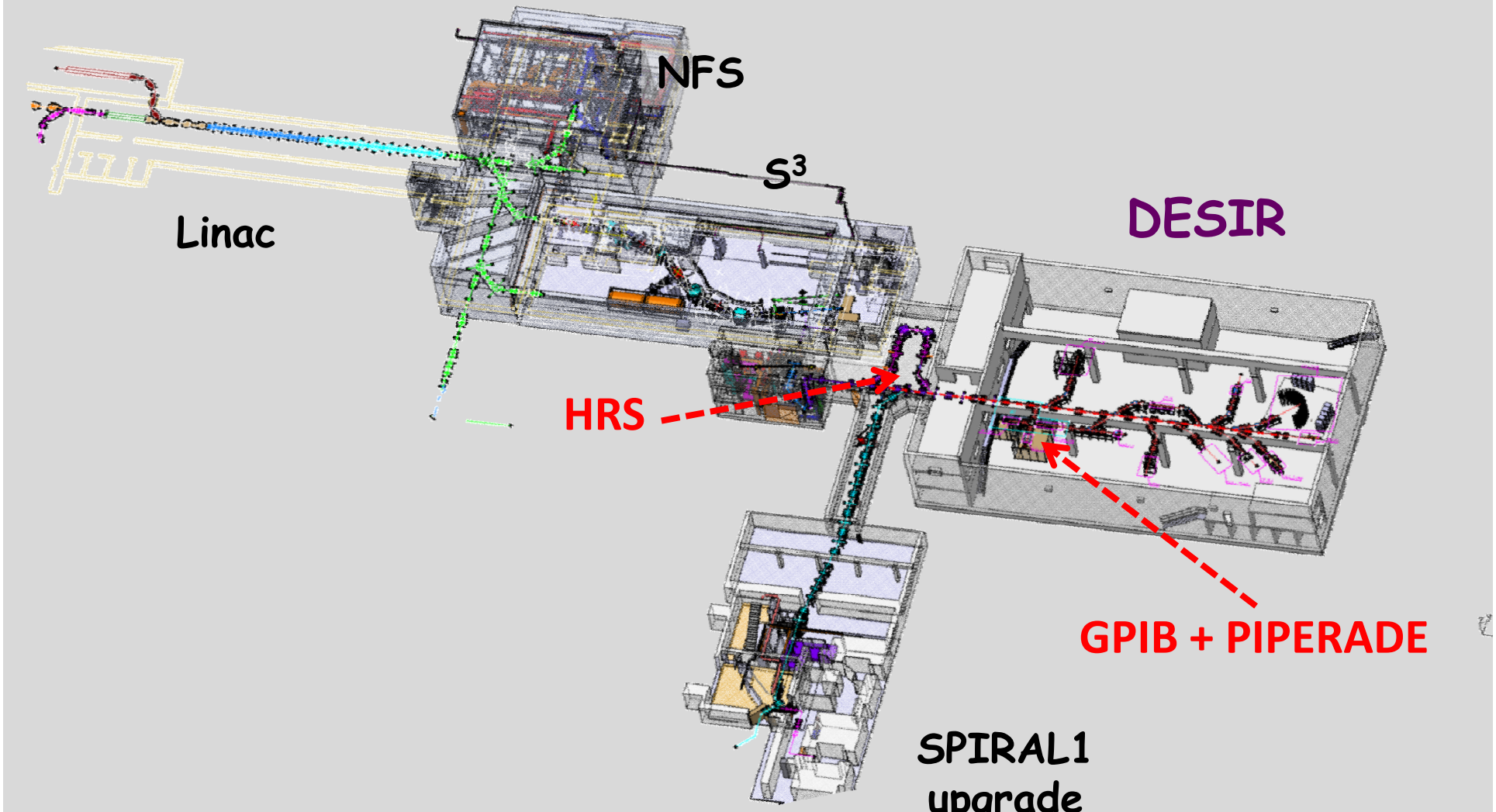
SP1-U

DESIR Scientific Program

- Collinear laser spectroscopy — LUMIERE
- β-delayed γ spectroscopy
- β-ν angular correlation — DETRAP
- Mass measurement
- β-delayed charge part., β-n emission — BESTIOL
- (Trap-assisted) β-decay, full absorption spectroscopy



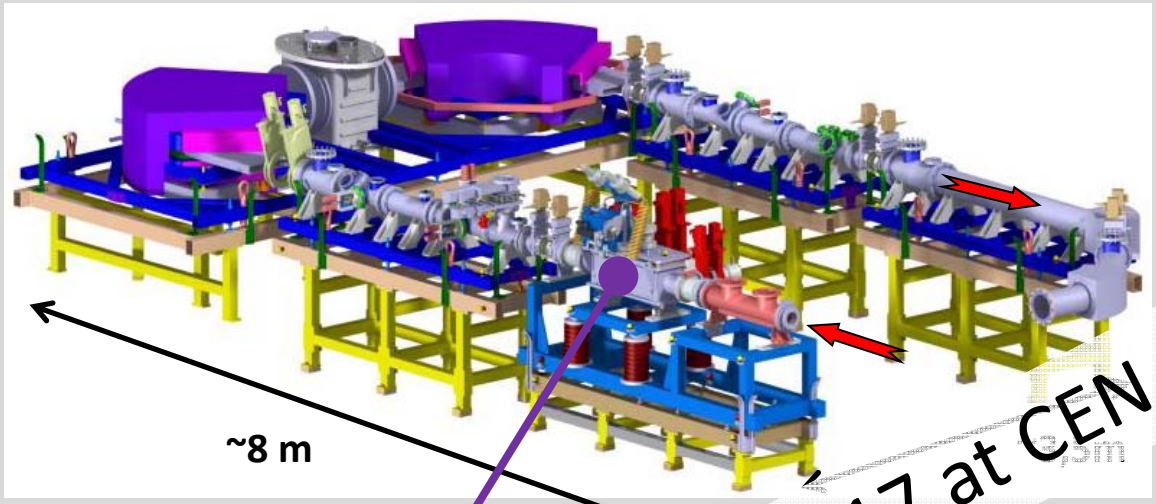
Beam purification & preparation



High Resolution mass Separation

HRS

CENBG



T. Kurtukian Nieto et al., NIM B 317 (2013) 284
R. Boussaid et al., 2014 IN[illegible]7009

HRS

Design: QQSQD-M-DQSQQ
(x|δ) = -31.5 cm/%
Mirror symmetric
(x,y) point-to-point transport
Field homogeneity ~10^{-5}

M/ΔM =20,000 @ 3π mm.mrad, 60keV & ΔE ~eV (R^{max} = 31500)

Off-line tests in 2016-2017 at CEN Bordeaux-Gradignan

SHIRaC RFQ

SHIRaC

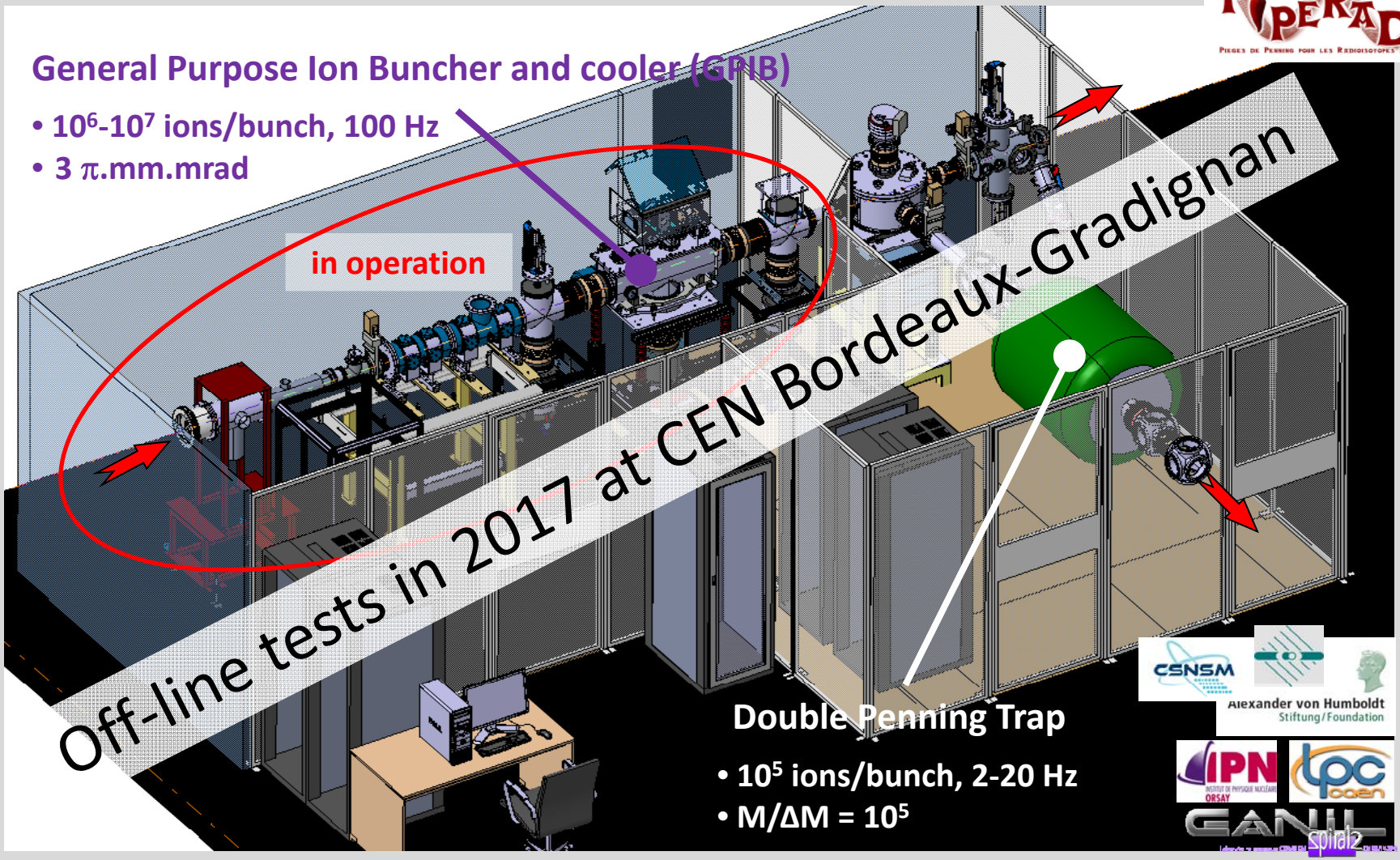
RF: 2.1-4.9 MHz; V_{pp}: 8kV
Emittence: ~3π mm.mrad
ΔE ~eV

Transmission ~70 % for 1eμA beam

Courtesy of T. Kurtukian Nieto (CENBG) and J.F. Cam (LPC Caen)

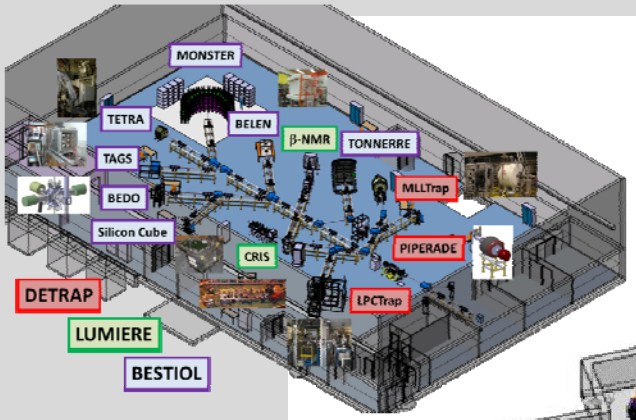
Beam preparation in the DESIR hall

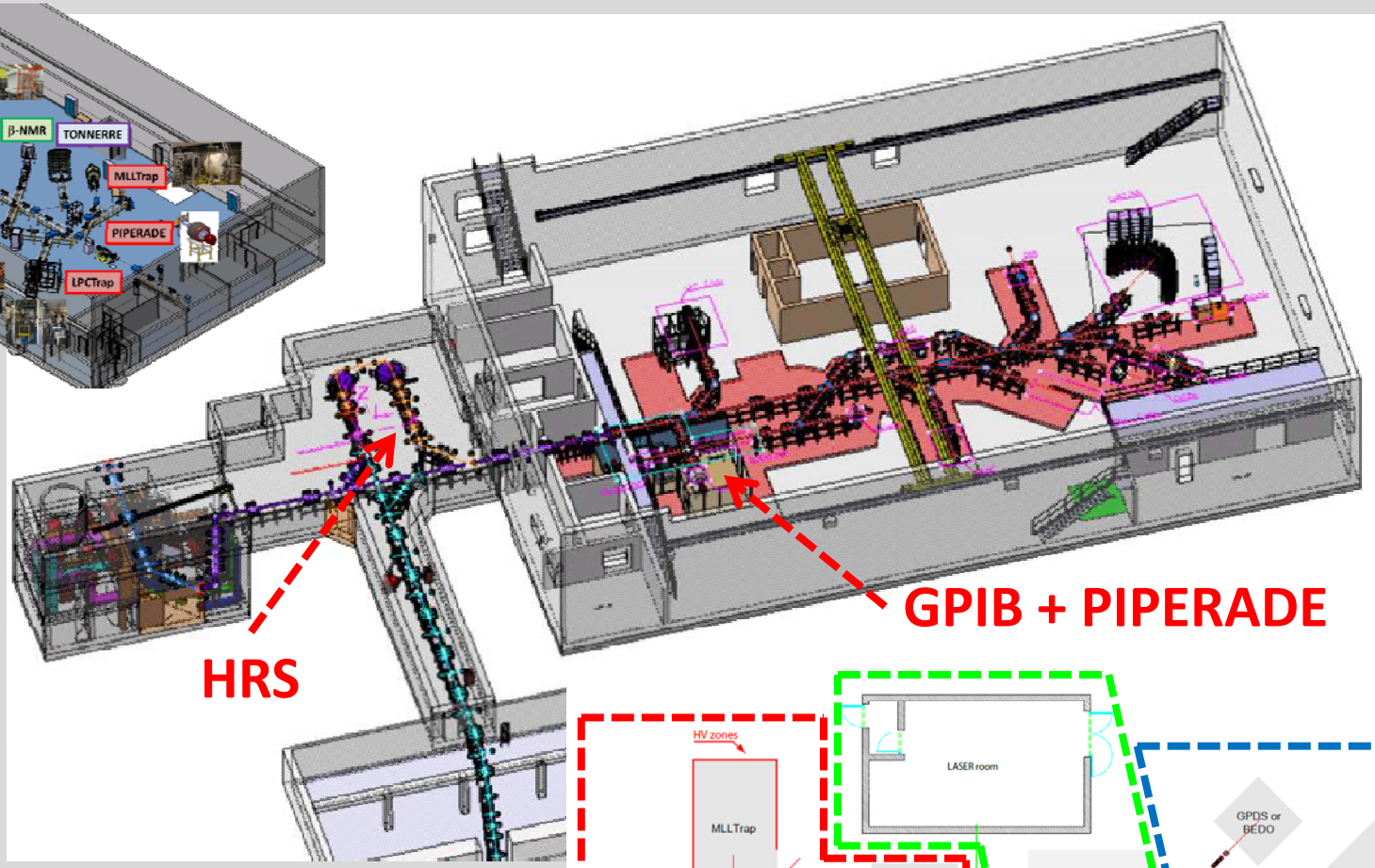
P. Ascher et al., EPJ Web of Conf 66 (2014) 11002
E. Minaya Ramirez et al., to be published in NIM B

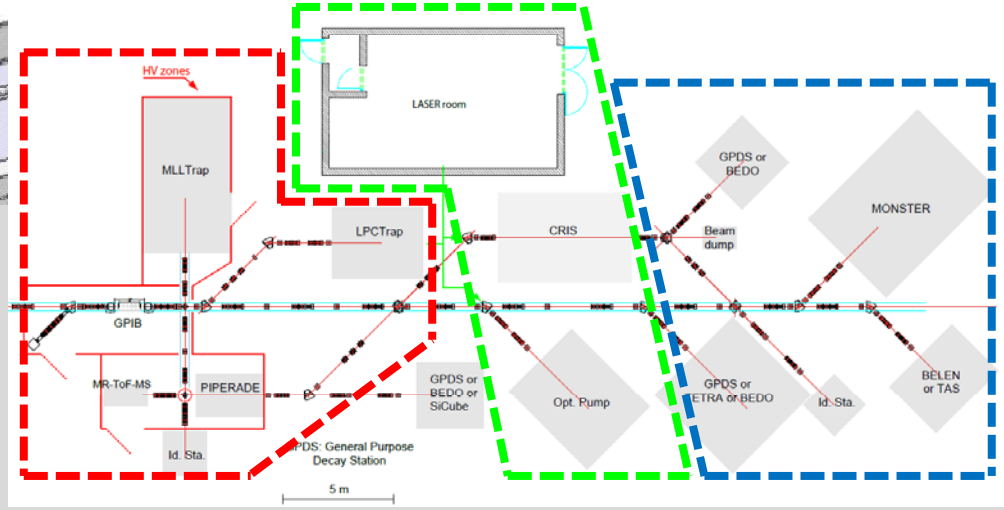


Courtesy of P. Ascher (CENBG)

DESIR experimental equipment







- 3 groups:
  - DETRAP
  - LUMIERE
  - BESTIOL

The D(esir)TRAP facility

LPCTrap

E. Liénard, X. Fléchard et al., LPC Caen

- RFQ-CB associated with a Paul trap

-> β-ν angular correlation coefficient

-> Shake-off probability in β decay

D correlation with laser polarized beams

http://pro.ganil-spiral2.eu/laboratory/detectors/lpctrap/

⇒ Fundamental interaction physics

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

Efficiency upgrade + polarization (P. Delahaye et al., GANIL)

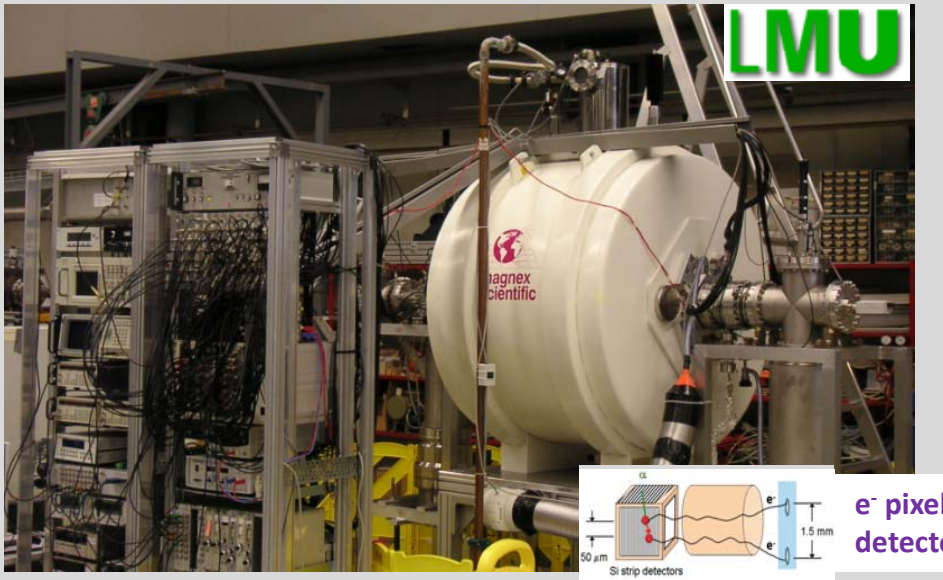
MLLTrap

P. Thirolf et al., LMU Munich – E. Minaya Ramires et al., IPNO

- MR-ToF-MS associated with a 7T Penning trap

-> mass measurements ($\Delta M/M \sim 10^{-8}$) of pure samples

In-trap e- and α spectroscopy



e⁻ pixel detector

C. Weber et al., Int. J. Mass Spectrom. 349 - 350, 270 (2013)

⇒ Nuclear structure & Decay properties

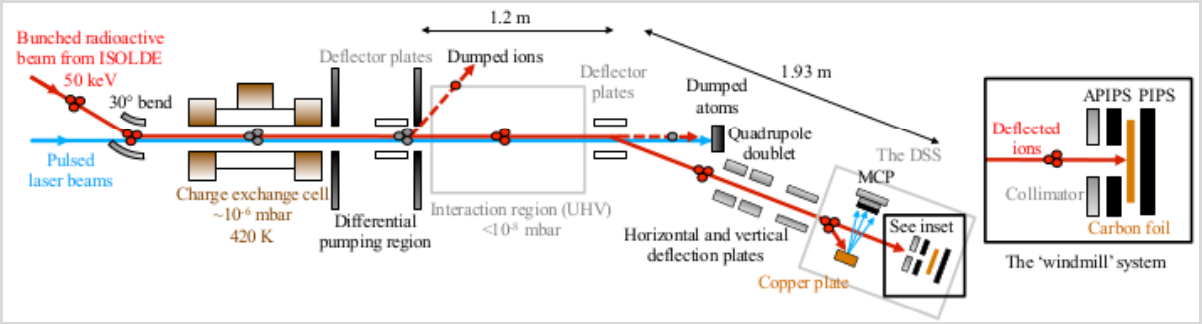
- shell evolution, deformation
- (super-) heavy nuclei decay spectroscopy

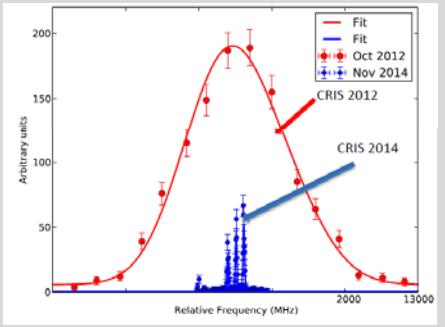
Implementation at ALTO

The LUMIERE facility

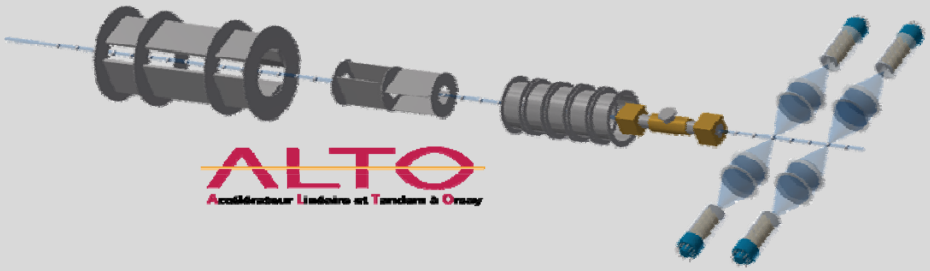
Laser Utilization for Measurement and Ionization of Exotic Radioactive Elements

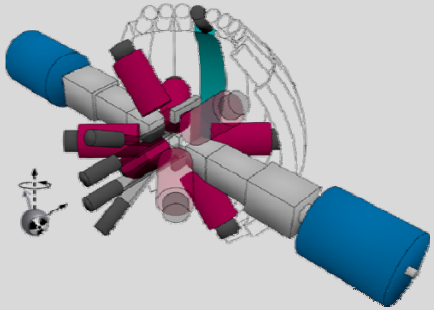
- **2 laser lines:**
  - **Collinear laser spectroscopy (CRIS like, ISOLDE, *G. Neyens et al., IKS Leuven*)**
    -> hyperfine structure (magnetic and quadrupole moments, mean square charge radii)





  - **Optical pumping line (LINO project at IPNO, *D. Yordanov et al.*)**
    -> β-NMR, β-decay study of laser polarized beams (spins)





- **ConeTraps: laser spectroscopy on trapped ions (JYFL, *P. Campbel et al.*)**

⇒ Static moments, shape evolution, nuclear structure

The BESTIOL facility

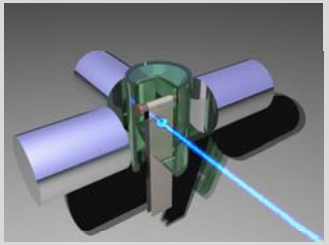
BEta decay STudies at the SPIRAL2 IsOL facilty

M.J.G. Borge, CSIC Madrid - Coll. France, Spain, Russia

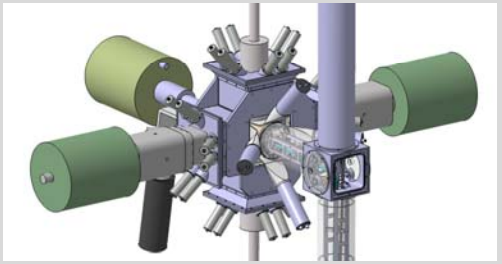
Beam cooling and purification using PIPERADE for (trap-assisted) decay spectroscopy

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

- **β-γ decay stations (BEDO, …)**
- **full absorption spectrometers (DTAS)**
- **neutron detection arrays (BELEN, TETRA, MONSTER, …)**



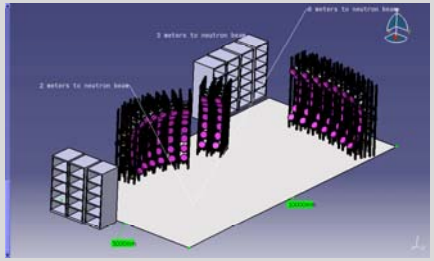
DTAS



BEDO

BELEN

SiCube



MONSTER

⇒ Fundamental interaction, nuclear structure, decay properties

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

TETRA

Conclusions

- **Scientific program**
  - Fundamental properties of radioactive nuclei and nuclear forces
  - High purity samples; poorly known regions of the nuclear chart
  - Up-to-date combined measurement techniques

- **Timeline**
  - Building construction: 06/2018 -> 12/2019
  - Setup installation: 09/2019 -> …
  - Operation: mid-2020 at best

- **Scientific strategy**
  - Synergies with other installations (S^3-LEB, ALTO, ISOLDE, JYFL,…)
  - Collaboration -> DESIR DECA

Thank you for your attention!

…and to the contributors from the DESIR collaboration