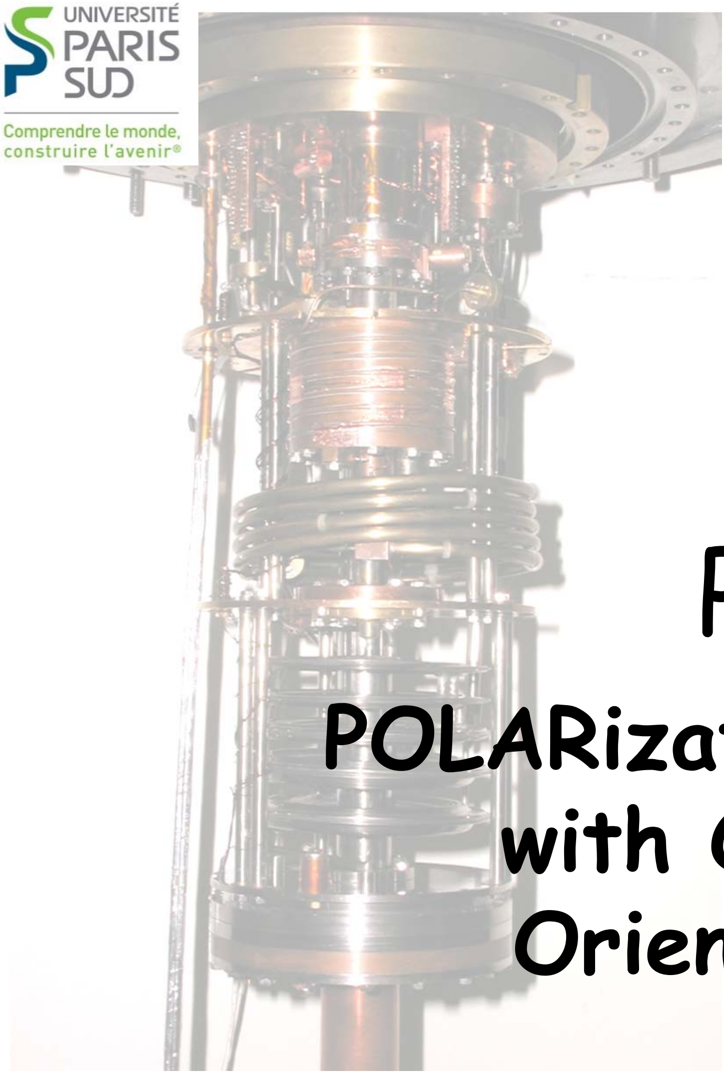
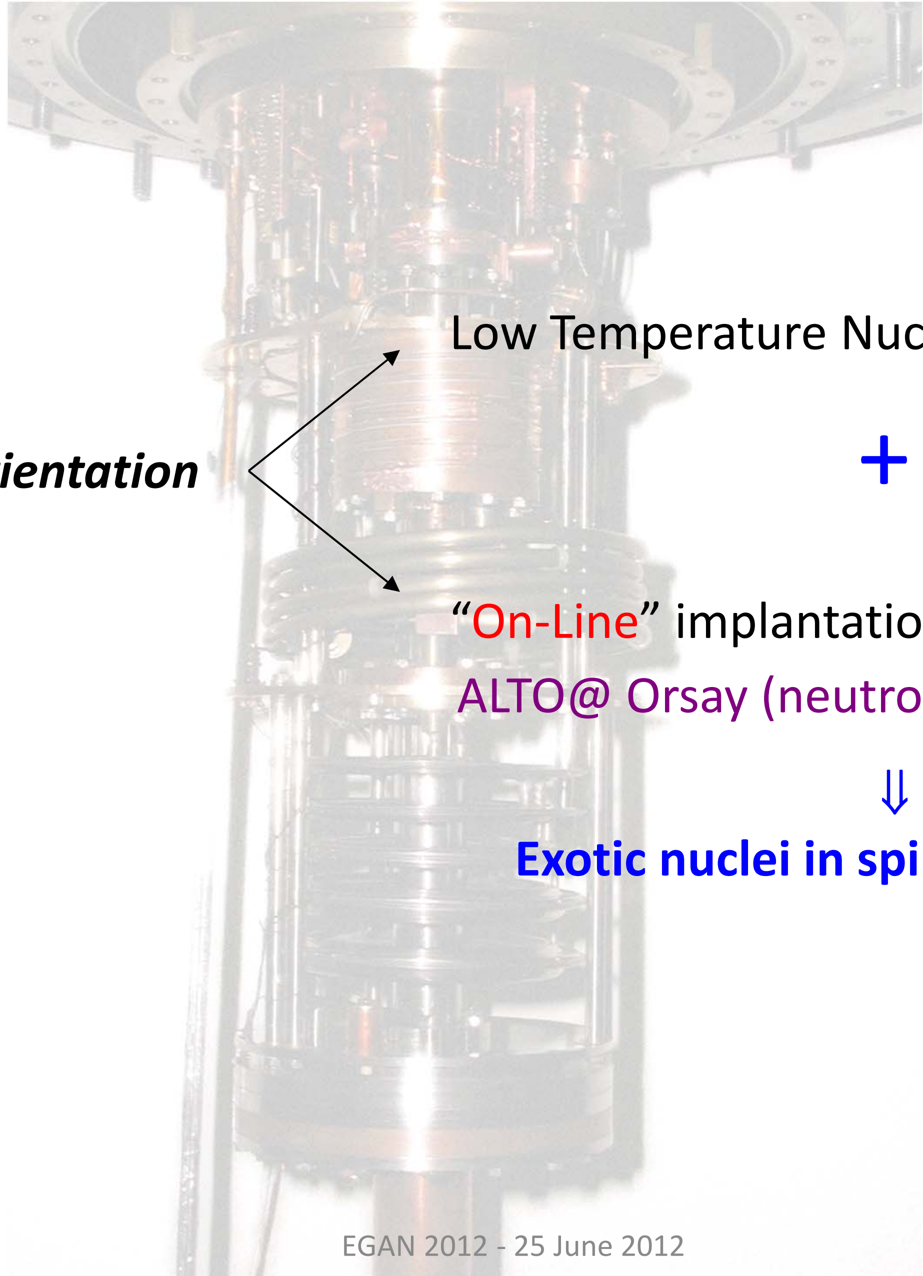


PolarEx :

POLARization of EXotic nuclei with On-Line Nuclear Orientation at ALTO

C. Gaulard

PolarEx : OLNO Technique



On-Line Nuclear Orientation

(OLNO)

Low Temperature Nuclear Orientation (LTNO)

+

"On-Line" implantation of radioactive beam

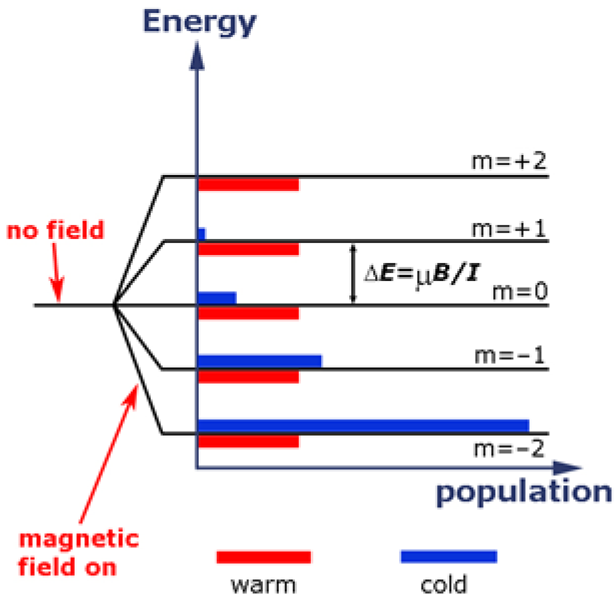
ALTO@ Orsay (neutron-rich nuclei)

⇓

Exotic nuclei in spin-oriented state

PolarEx: LTNO Principle

How one can polarize a nucleus?



Polarex in numbers

B_{ext} = 1.5 T

B_{tot} = 10-100 T

T = 6-20 mK

Main limitation of LTNO :

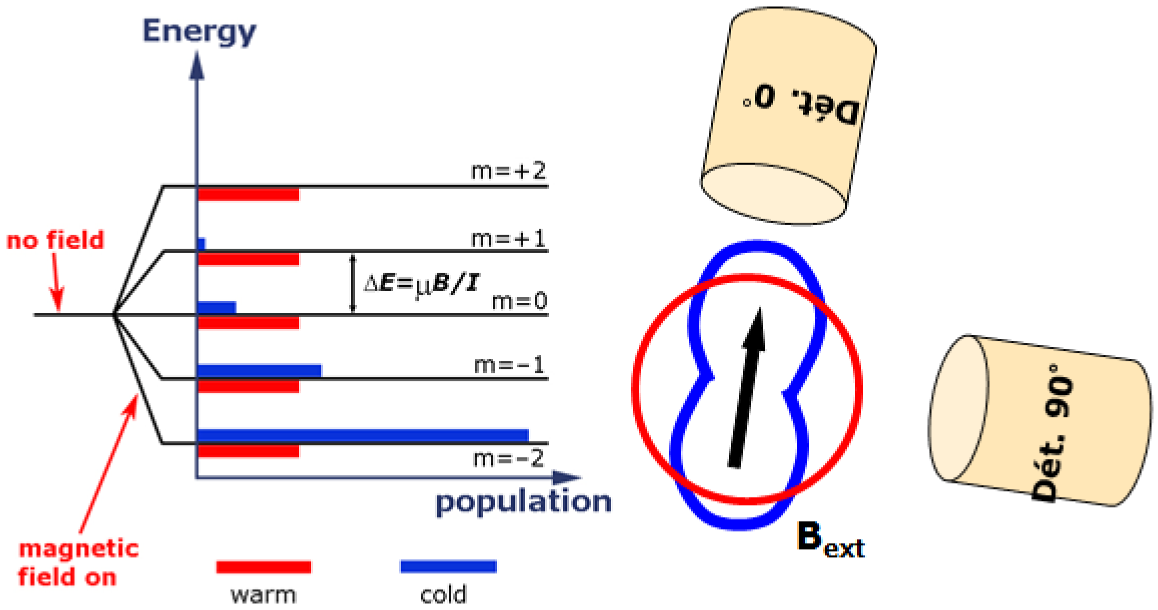
- Boltzmann distribution at Low Temperature

  → Time to reach thermal equilibrium depends on spin-lattice relaxation time

  → Radioactive nuclei should have long enough lifetimes

PolarEx: LTNO Principle

How one can polarize a nucleus?



Polarex in numbers

B_{ext} = 1.5 T

B_{tot} = 10-100 T

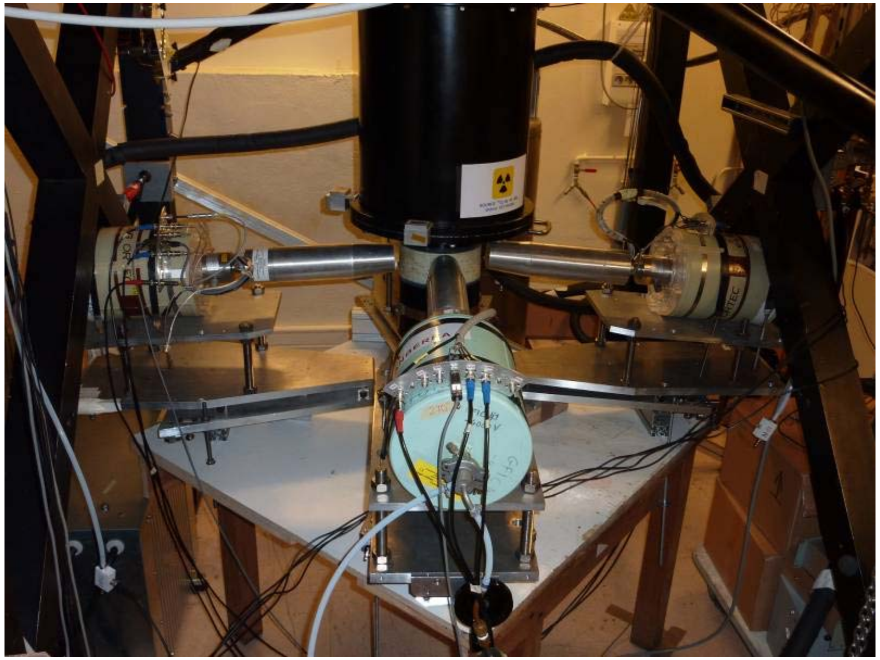
T = 6-20 mK

- The spins show a preferential direction with respect to $\vec{B}$
- Anisotropic angular distribution of the radiation emitted

PolarEx: LTNO requirements

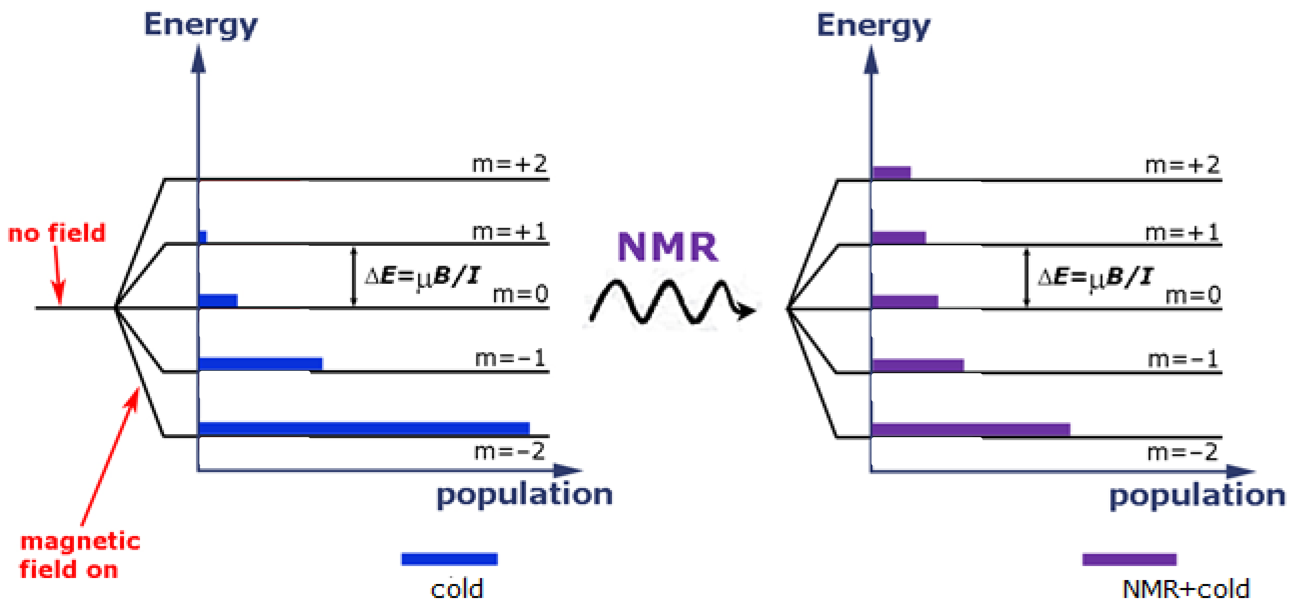
- ✓ Very low temperature (≤ 15 mK) → ^{3}He-^{4}He dilution refrigerator
- ✓ Superconducting magnet in cryostat (~1.5 T)
- ✓ Ferromagnetic foil to host exotic nuclei → Hyperfine magnetic field (10 – 100 T)
- ✓ Nuclear thermometer : ^{60}Co
- ✓ Detectors

Anisotropic gamma emission
→ 4 germanium detectors
(1@0°, 2@90°, 1@180°)



- ✓ NMR

How one can play with the nucleus spin?



Magnetic field + low temperature + resonant frequency

$\Rightarrow$ Nuclear magnetic moment

PolarEx : Objectives

A wide range of objectives have formed the basis of OLNO work:

- level spin
- nuclear structure from gamma multi-polarity
- parity non-conservation in nuclear gamma decay
- nuclear magnetic dipole moment
- *g*-factor
- weak interaction beyond the Standard Model
- hyperfine field

PolarEx : National and International situation

- ➢ The first of its kind in France
- ➢ The association with the nuclides from ALTO

  ⇒ Unique worldwide

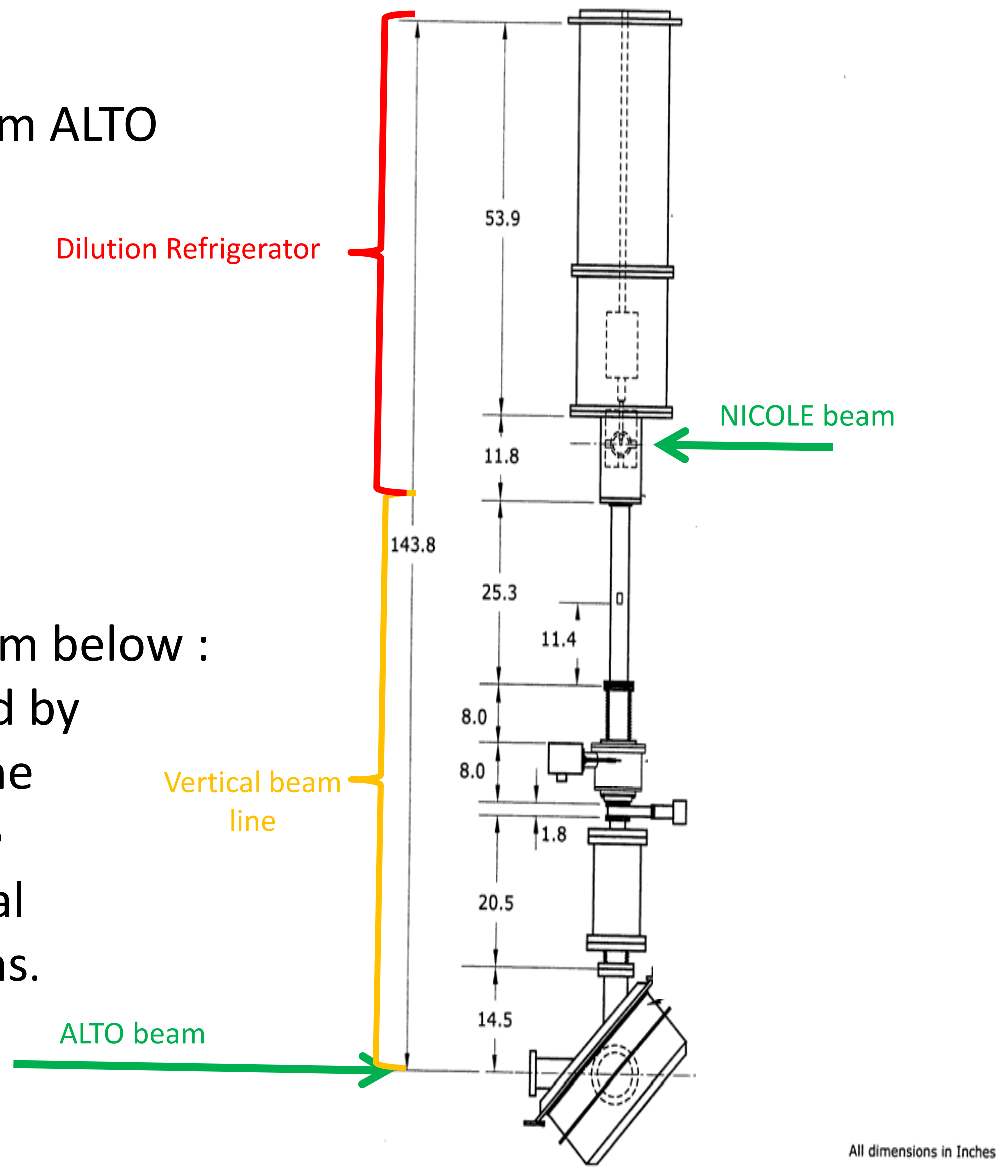
- ➢ NICOLE@ISOLDE ≠ POLAREX@ALTO

- ✓ Different nuclei productions
- ✓ Beam line connected to POLAREX from below :

  The implantation region is surrounded by a ring of detectors in a horizontal plane

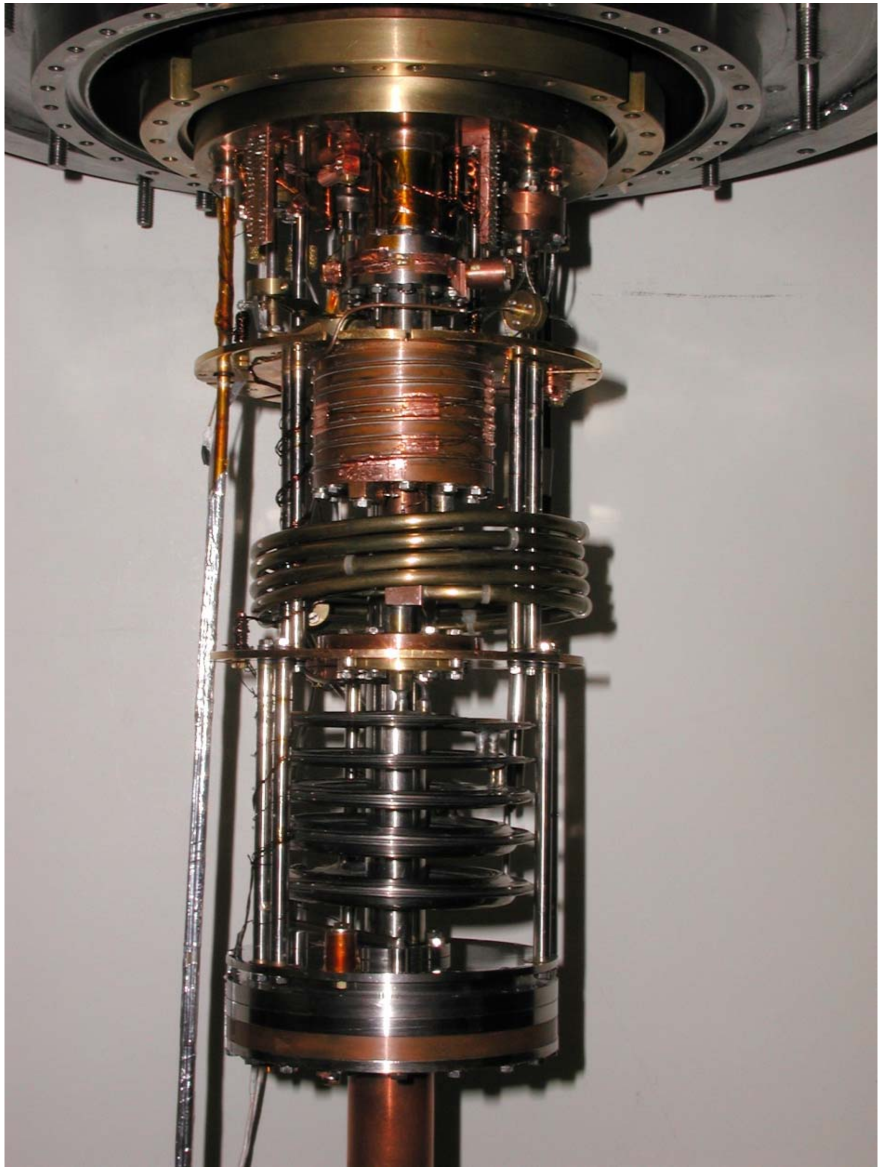
  ⇒ more detectors around the sample

  ⇒ more accurate picture of the spatial anisotropy of the emitted radiations.



PolarEx

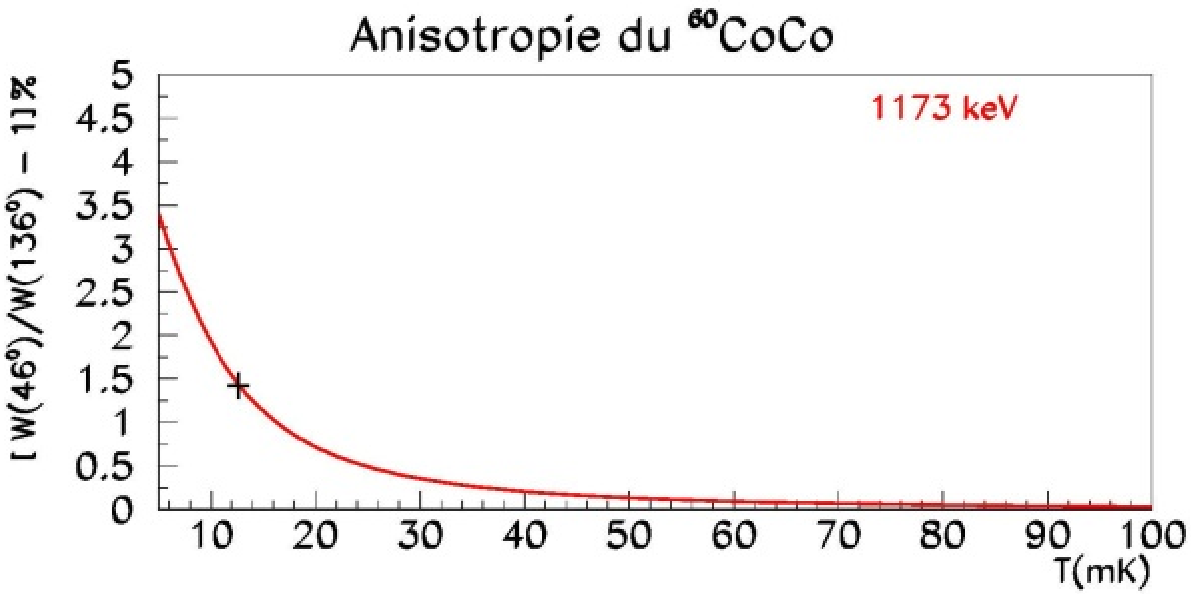
- ☑ Renovation of the dilution refrigerator
- ☑ Thermometry
- ☑ Electronics
- ☑ NMR
- ☑ Acquisition control
- ☑ All subsystems together



PolarEx: Measurements

- **^{60}CoCo (Done)**

  Absolute temperature $\Rightarrow$ **11 mK**

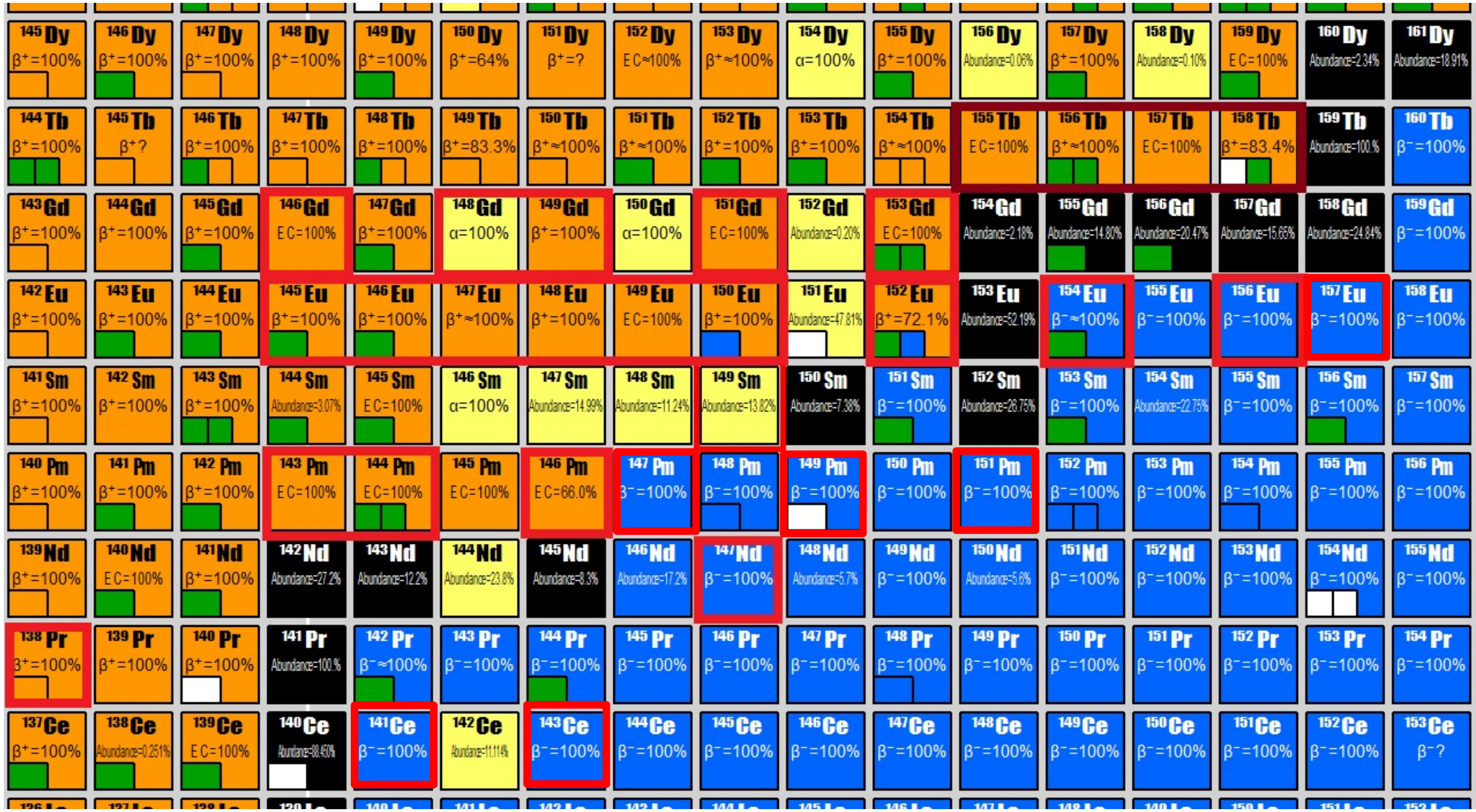


- **^{125}SbFe + ^{60}CoCo (on going)**

  Ph.D. of A. Etilé

PolarEx: OFF-Line Program

Study of lanthanides implanted either at ALTO or ISOLDE



Why?
- ✓ Hyperfine interactions are strong
- ✓ Region still not well-known

Ph.D. of A. Etilé

N=82 shell closure on the neutron rich side in the Lanthanide area

- Study of ^{149}Pm :

  μ is unknown

  B_{hf} in Fe is badly known : 400 $\pm$100 T

  (modern ab-initio methods give ~ 395 T, D. Torumba, P. Novák and S. Cottenier)

  How to get B_{hf} ?

  ✓ $\mu(^{147}Pm)$ is known by laser spectroscopy

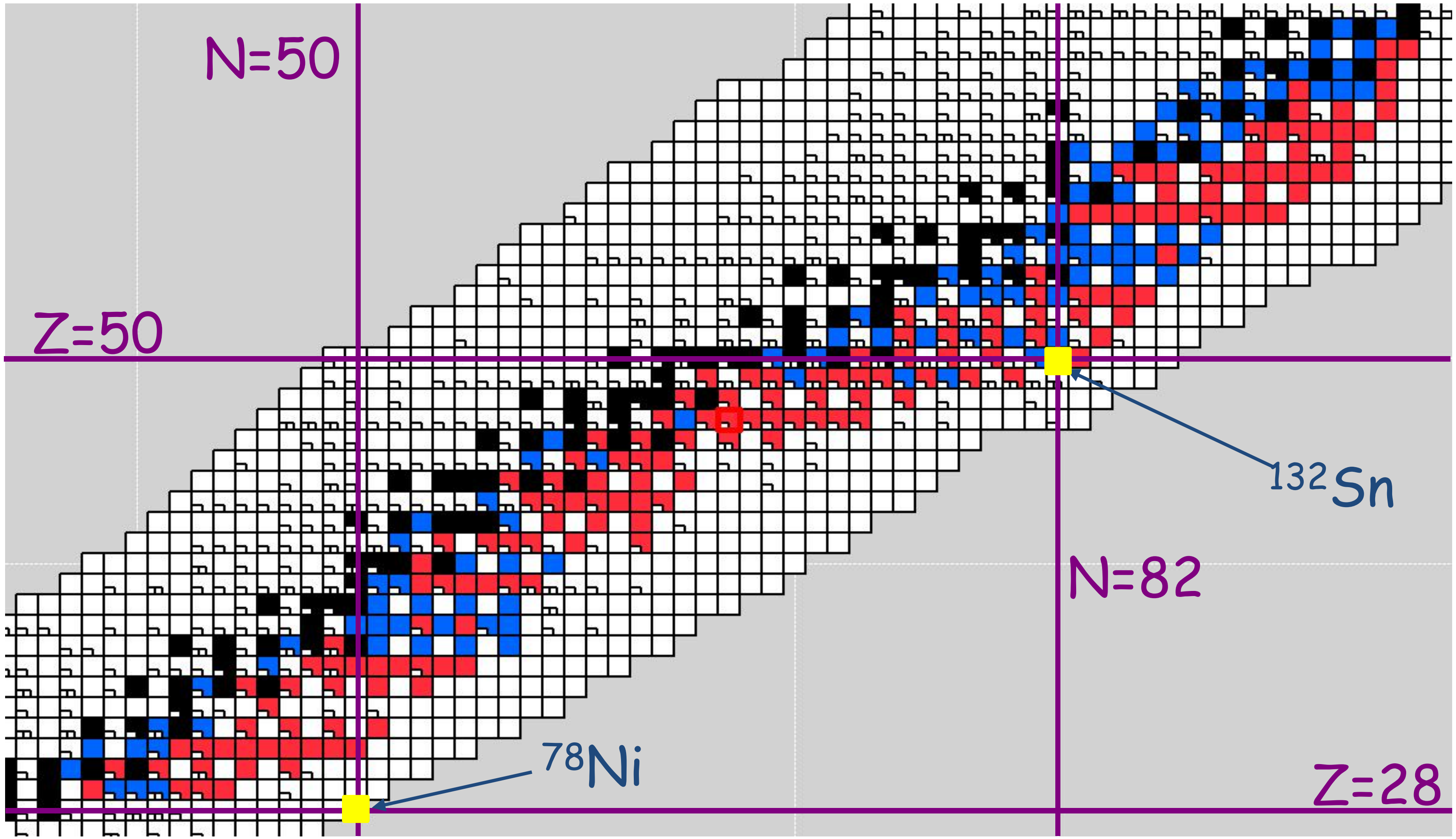
  $\Rightarrow$ Measurement of its resonant frequency by LTNO

  $\Rightarrow$ Precise B_{hf} in Fe at Pm site

- Moments of $^{143,144,146,151}Pm$ with an accuracy of a few percent

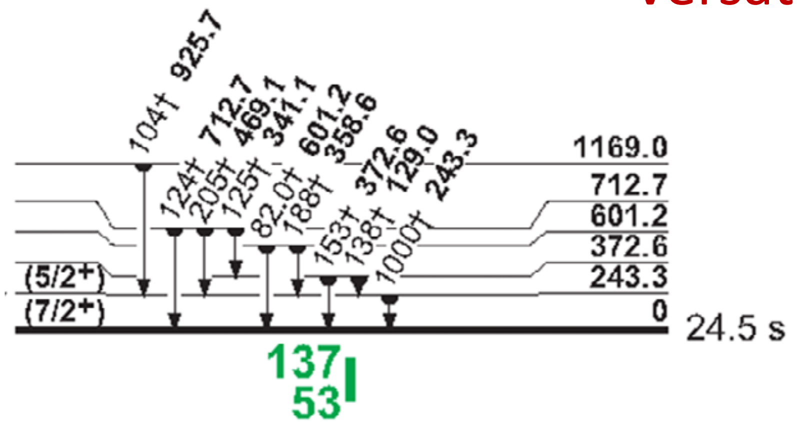
PolarEx: ON-Line Program

Structure around the doubly-magic neutron-rich nuclei : ^{78}Ni and ^{132}Sn



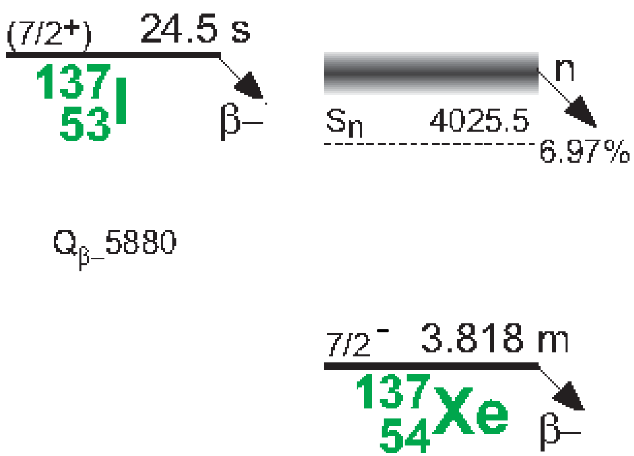
PolarEx: ^{137}I

Versatility of POLAREX



- Measurement of magnetic moment of the odd proton $7/2^+$ state

γ-decay of $^{137}Xe^*$ and β-delayed neutron emission from ^{137}Xe



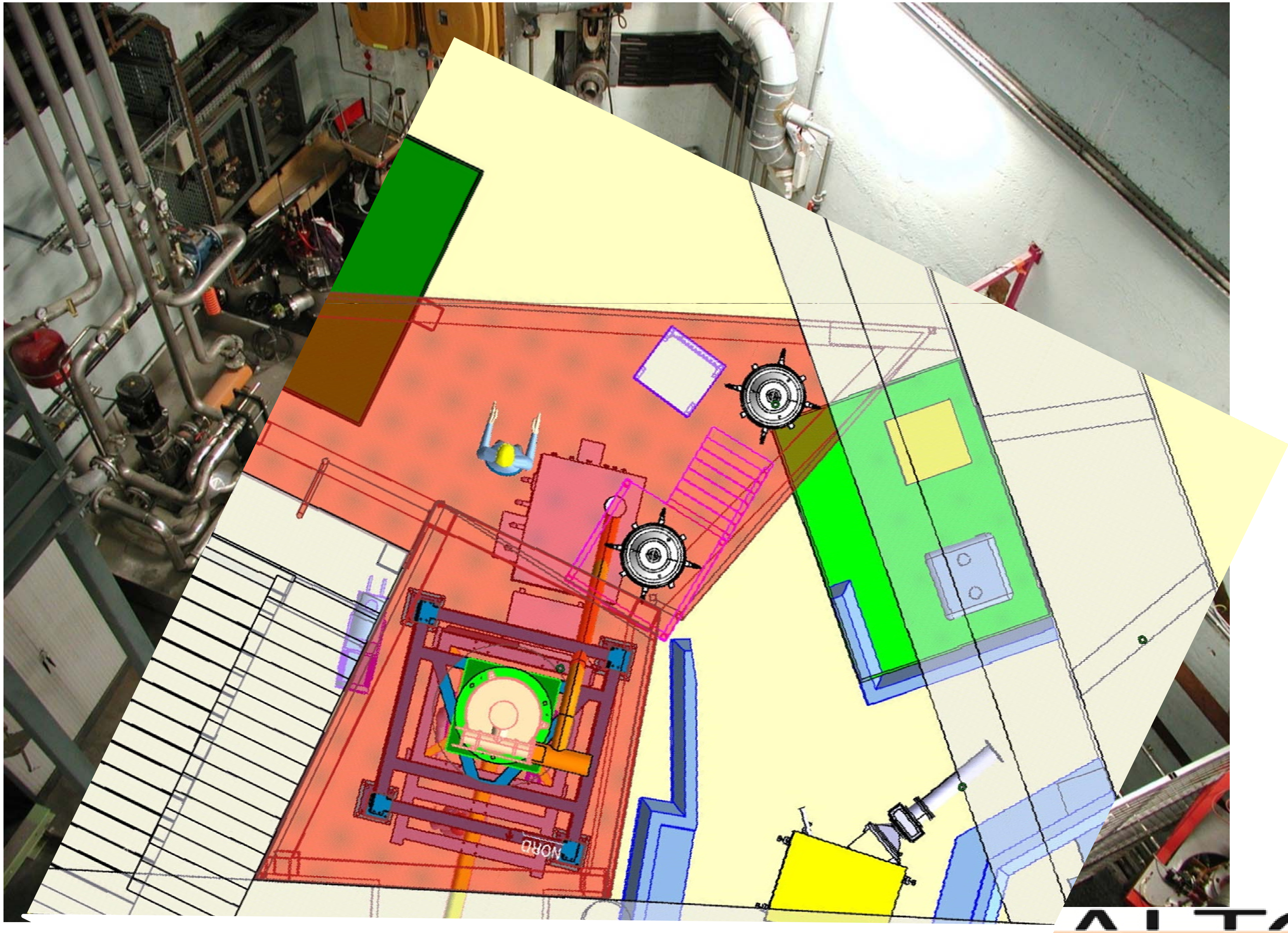
- Anisotropy of γ emission
  High density of $7/2^+$ and $7/2^-$ states in ^{137}Xe
  ⇒ strong parity admixture

- Anisotropy of β-delayed neutron emission
  ⇒ access to quantum barrier penetration studies
  ⇒ neutron wave function

World first experiment

ALTO
Accélérateur Linéaire et Tandem à Orsay

PolarEx: ALTO



ALTO
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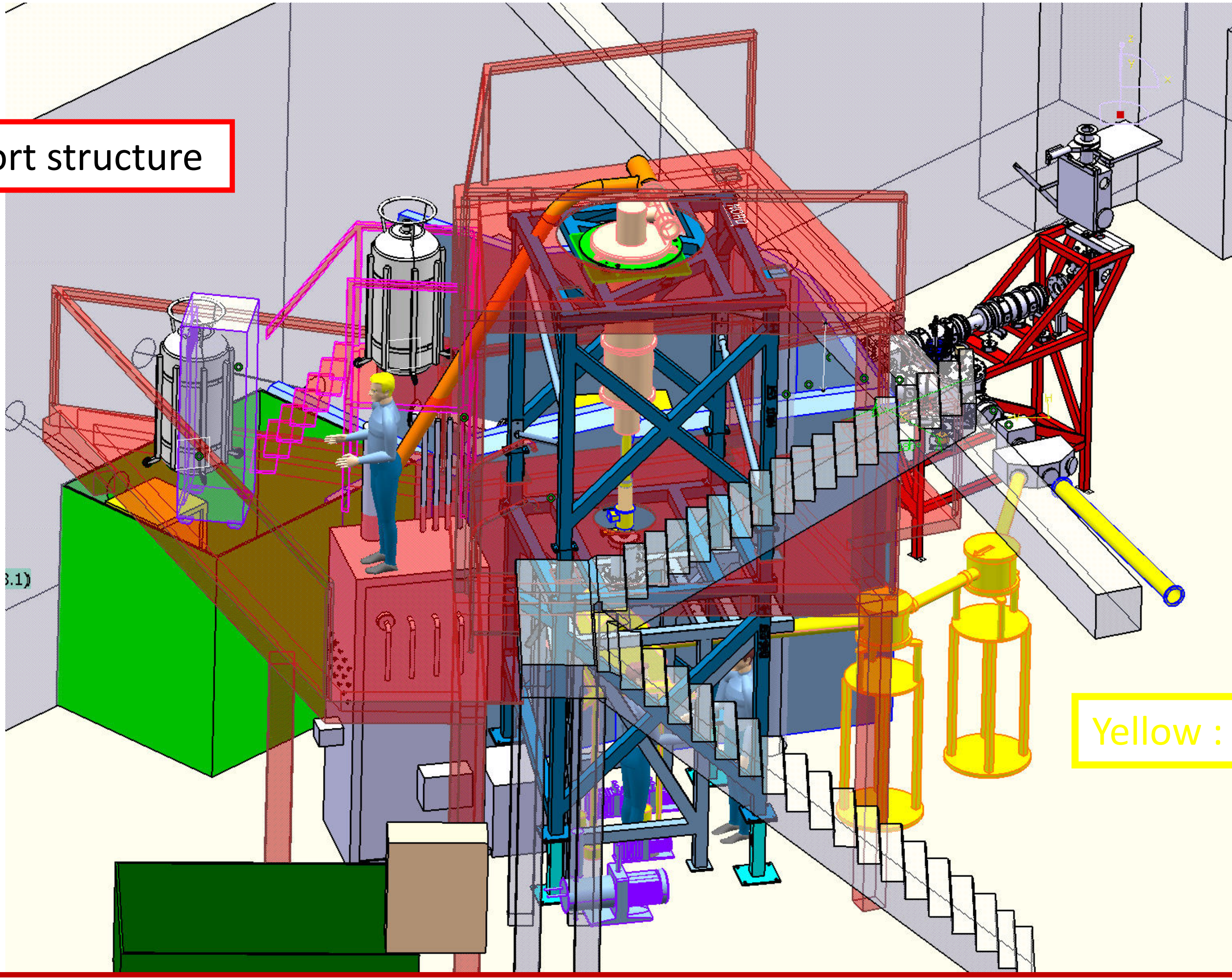
PolarEx: ALTO

Red : Support structure



Yellow : Beam Line

Unique combination of a **NMR/LTNO** setup together with a **Neutron-rich** beam

ALTO
Accélérateur Linéaire et Tandem à Orsay

PolarEx: Collaboration

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G. Simpson

IPNO **:**
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University of Oxford
N.J. Stone

University of Maryland
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University of Novi Sad **:**
M. Veskovic, J. Nikolov

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