ISOL Physics in Belgium

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and
ISOLDE Physics Group Leader, CERN, Zwitzerland

- The beginning: Leuven Isotope Separator On-Line (LISOL)
  at the Cyclotron Research Centre at Louvain-la-Neuve

- Present: ISOL physics (and applications) at ISOLDE-CERN

- Future: ISOL physics also at SPIRAL2 (GANIL, Caen)

KU LEUVEN

Cyclotron Research Centre at Louvain-la-Neuve

- K=110 cyclotron “Cyclone”
- Programme:
  - nuclear physics research
  - applications
  - neutron therapy
- **LISOL = Leuven Isotope Separator On-Line operational 1974-2014**
- Second cyclotron (1987): H^- 30 MeV, 500 μA
- **Post-accelerated RI beams (1989-2008)**

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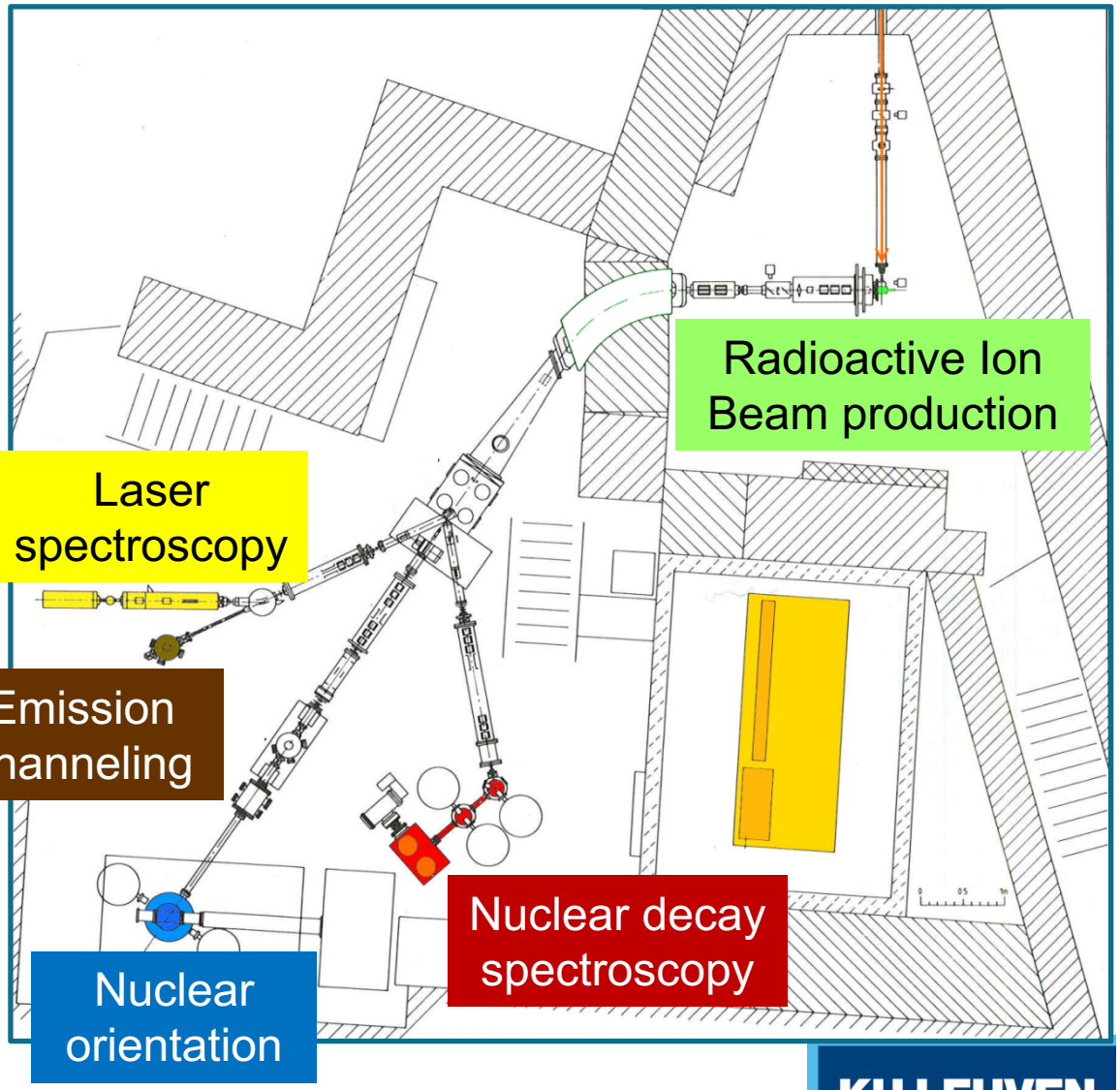
Cyclotron Research Centre at Louvain-la-Neuve

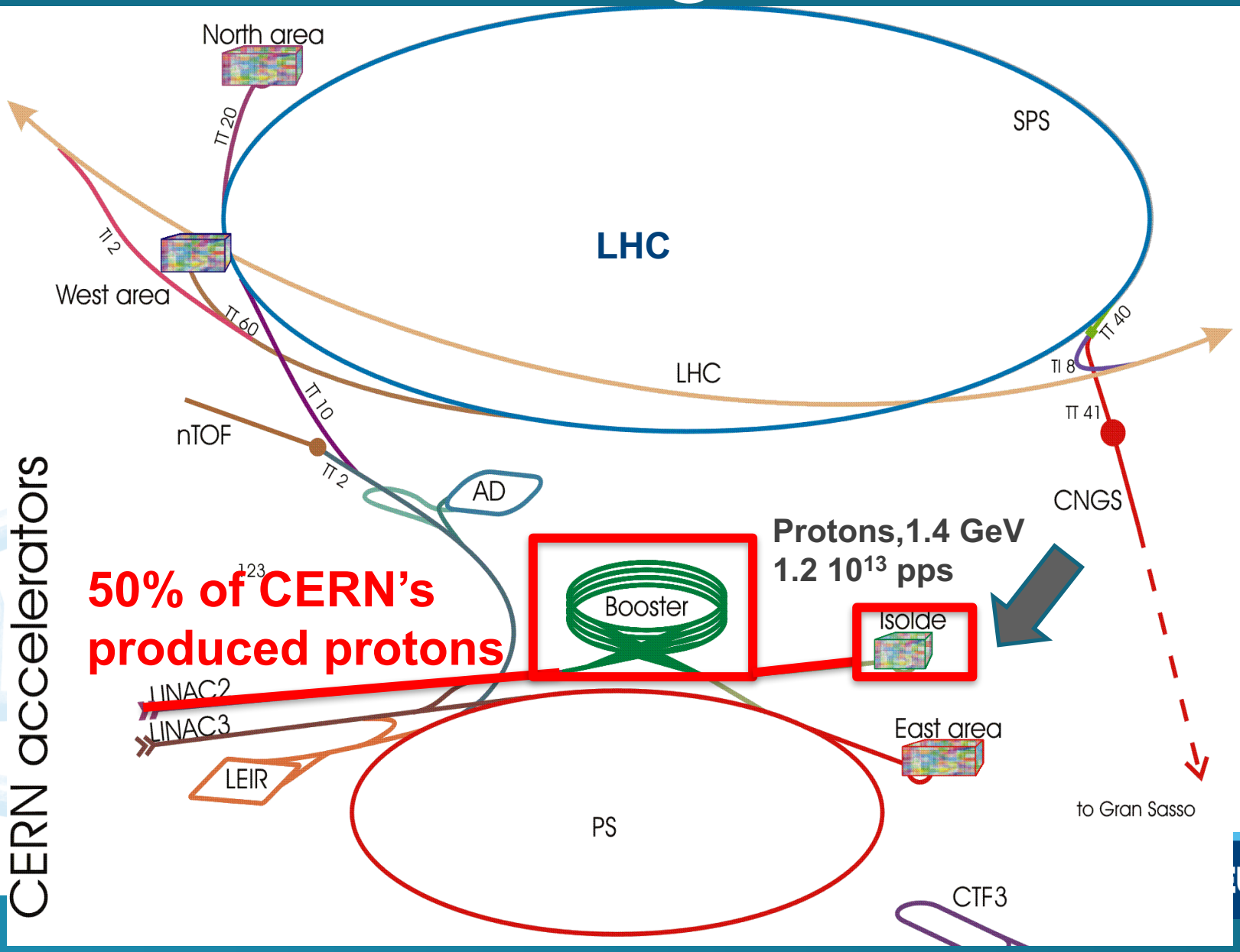
LISOL facility (1974-2014)

- Out present-day research was initiated here:
  - decay spectroscopy
  - ground-state properties
    (laser spectroscopy, nuclear orientation)
  - fundamental interactions
    (nuclear orientation)
  - solid-state physics
    (emission channeling)

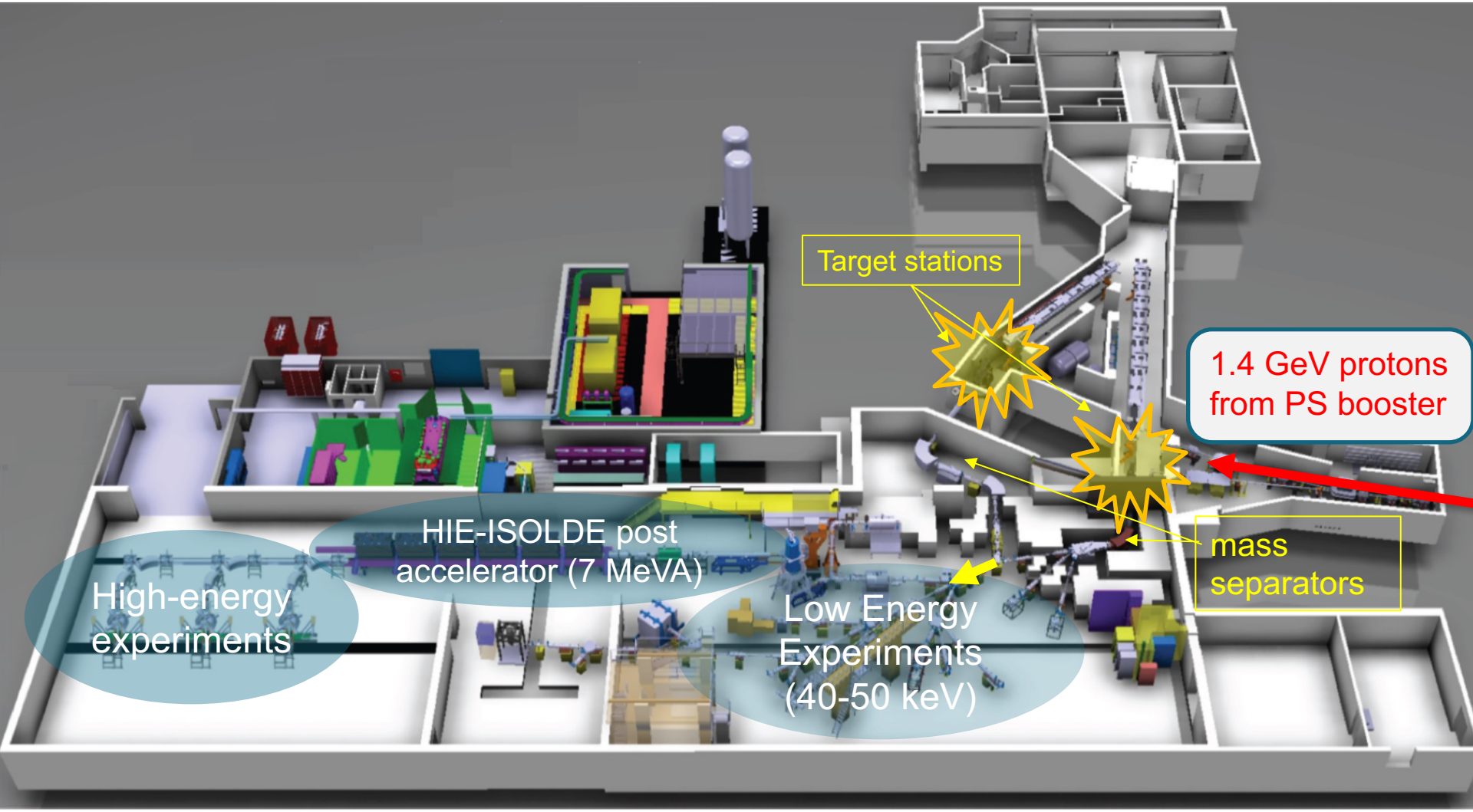
- RIB production: in-gas recoil from thin target or laser ion source



NOW: MOST nuclear physics EXPERIMENTS (90%) at ISOLDE@CERN



The ISOLDE facility



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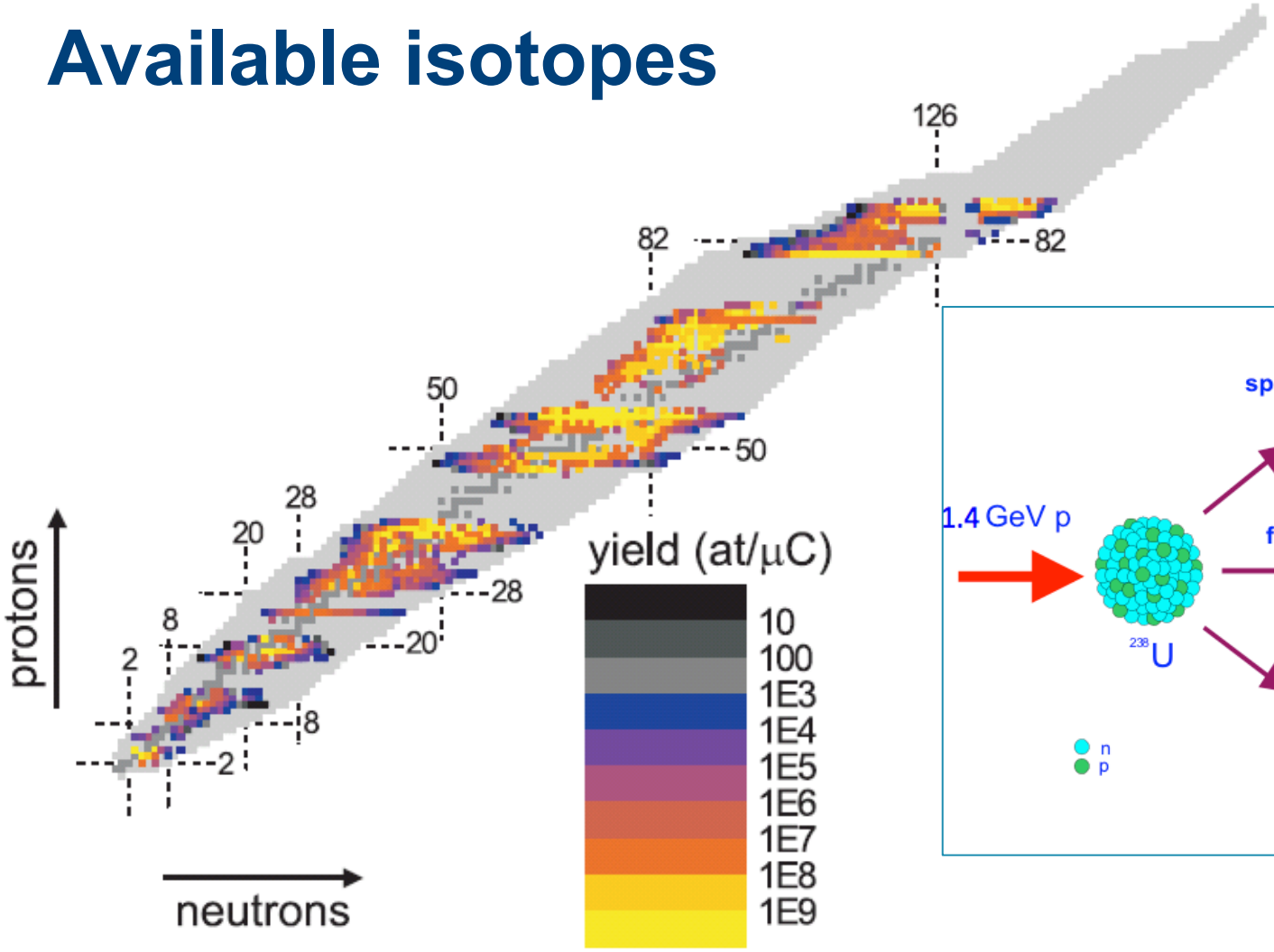
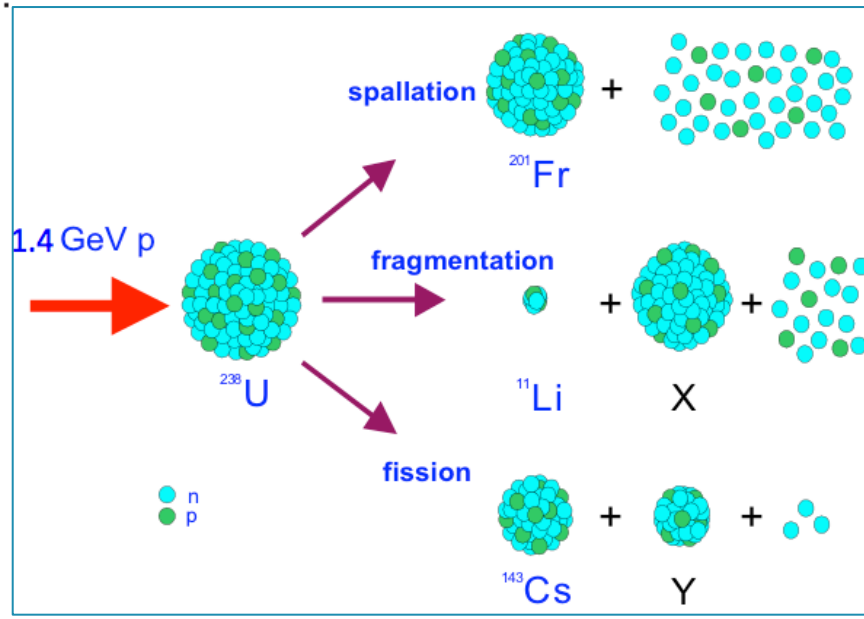
Available isotopes





So far ~ 700 radioactive isotopes of > 60 elements @ 40-60 keV
> 80 accelerated isotopes (now up to 7 MeV/u)

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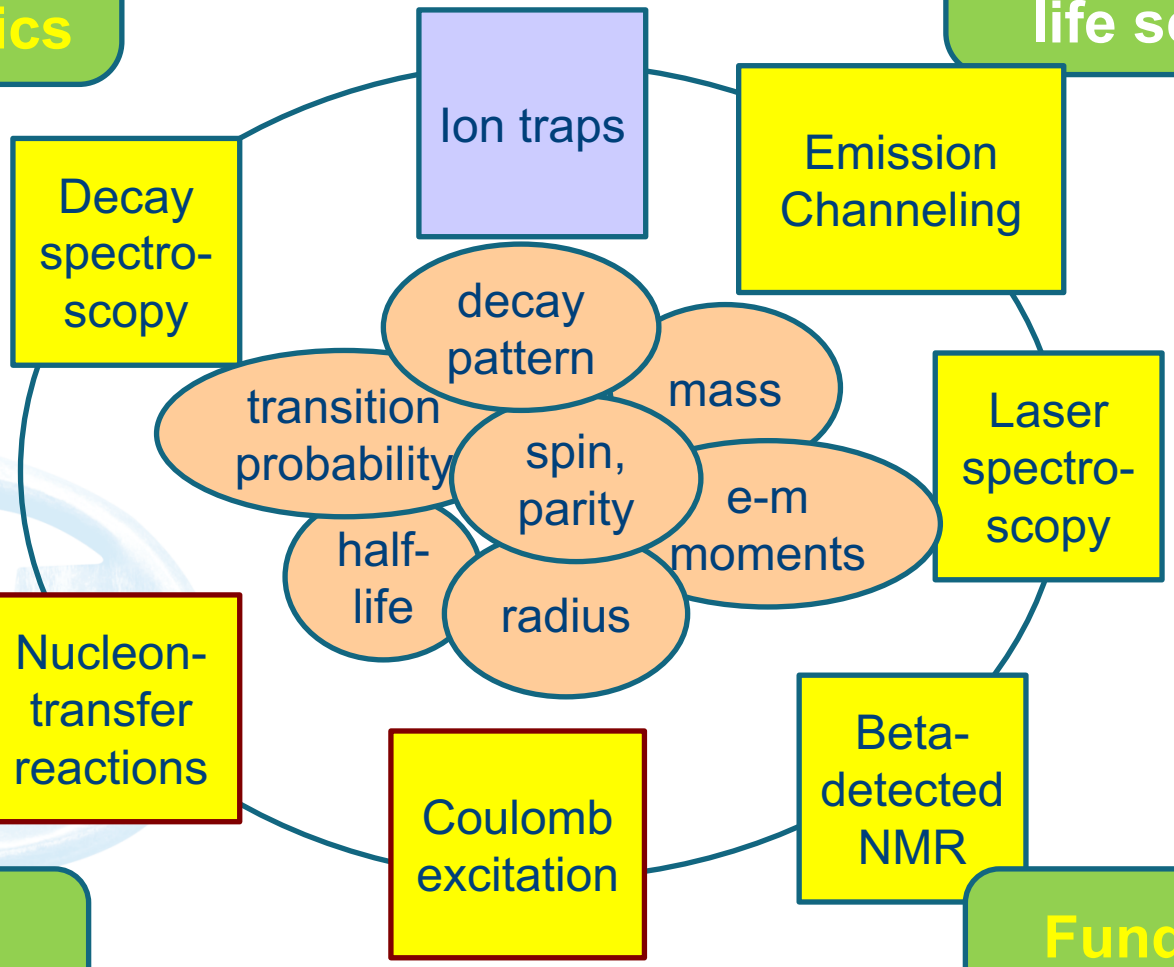
Research with radioactive nuclides @ ISOLDE

ISOLDE today offers the largest range of nuclei of any ISOL facility worldwide

Nuclear physics and **atomic physics**

Material science and **life sciences**



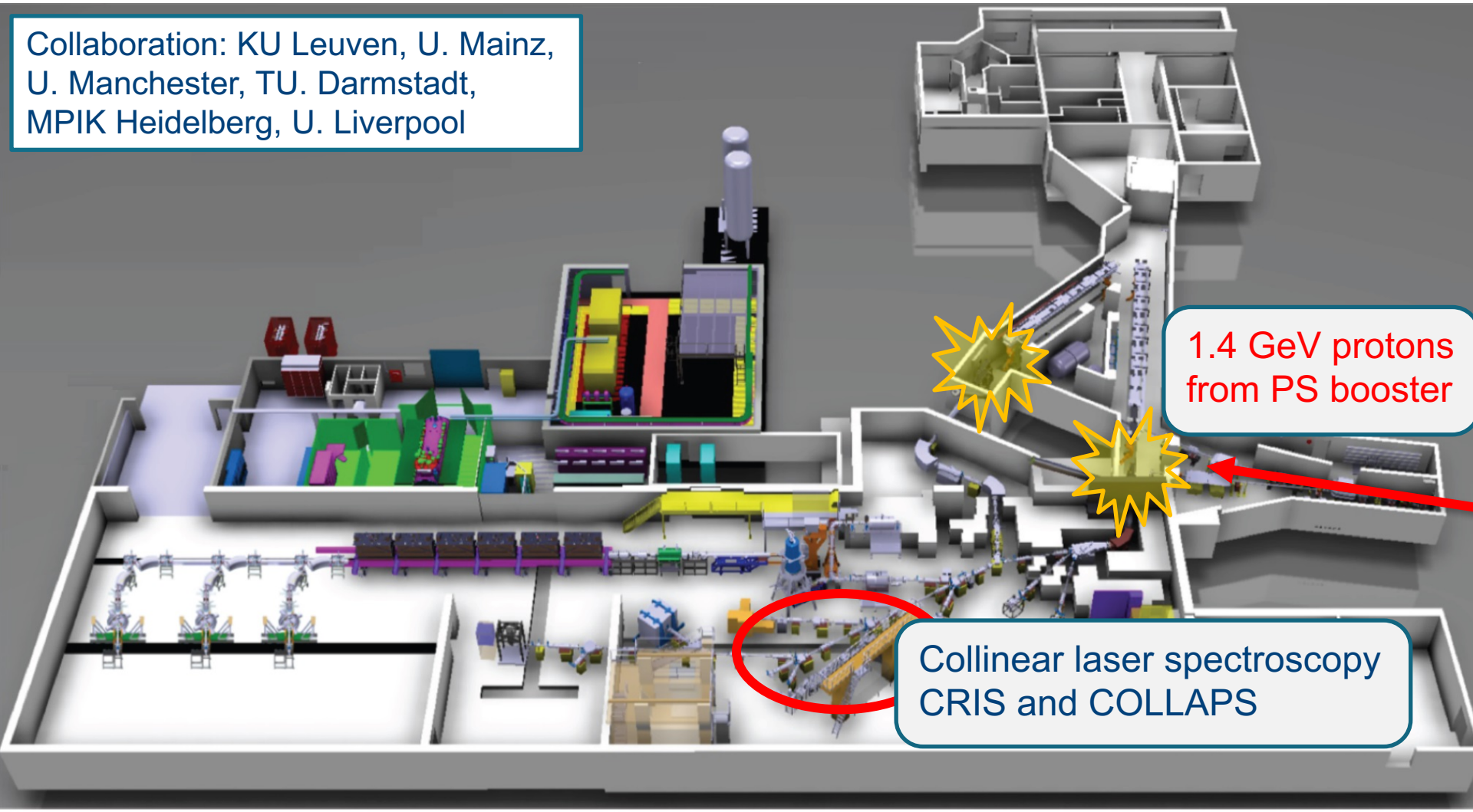
Nuclear astrophysics

Fundamental interactions

Leuven involved/leading

Collinear laser spectroscopy at ISOLDE

G. Neyens

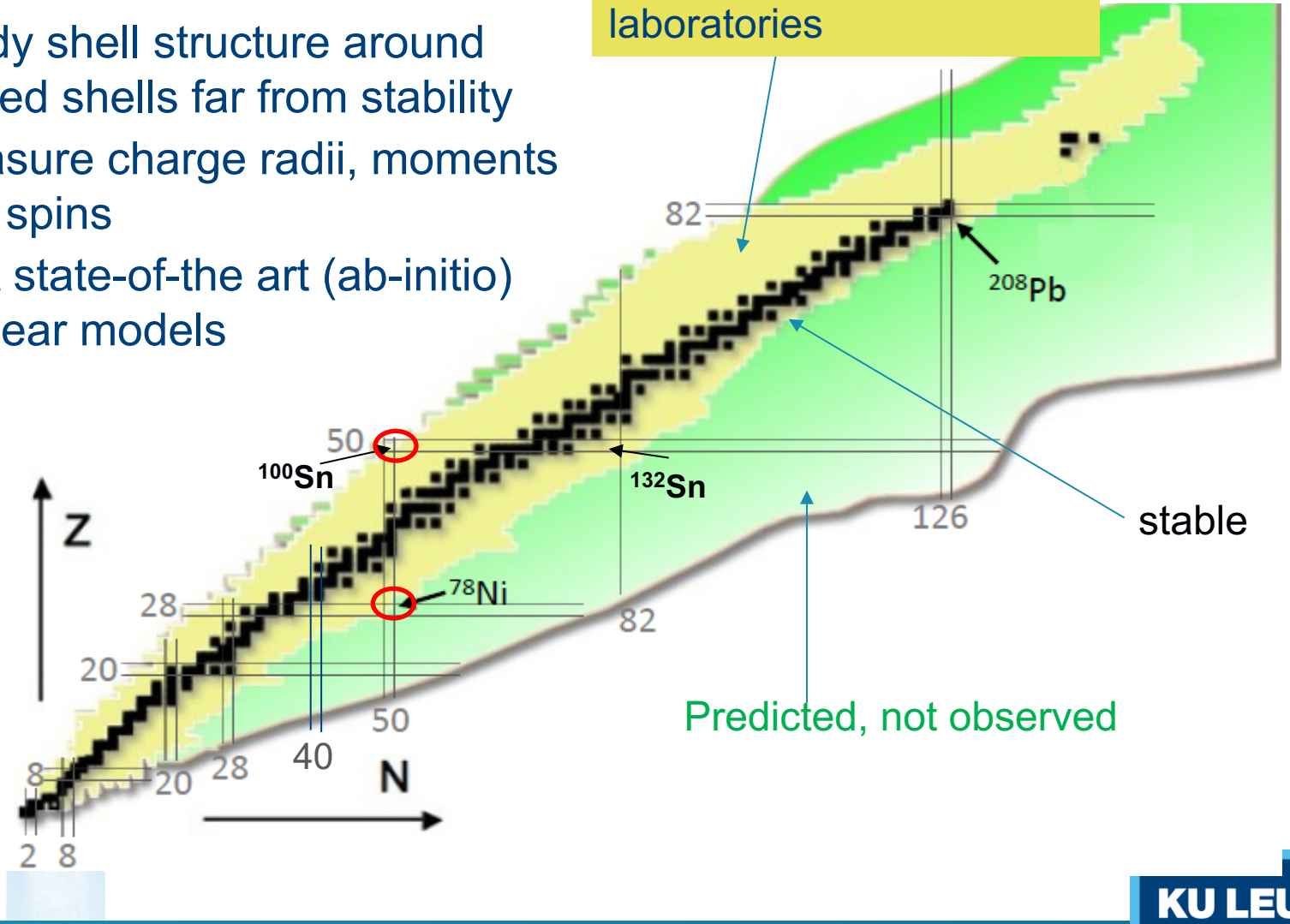


Collinear laser spectroscopy at ISOLDE

G. Neyens

Current focus

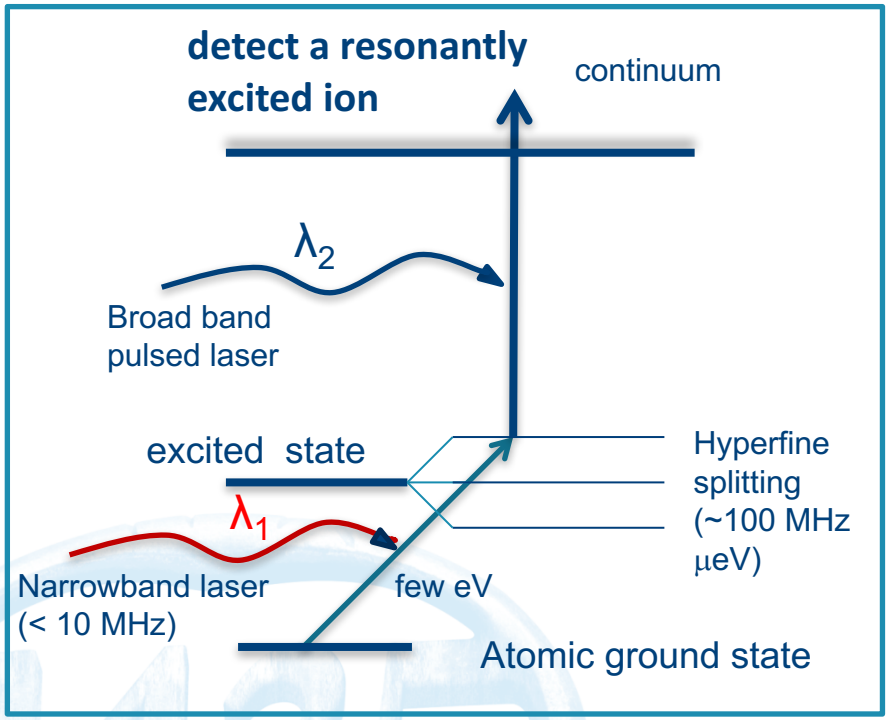
- Study shell structure around closed shells far from stability
- Measure charge radii, moments and spins
- Test state-of-the art (ab-initio) nuclear models



COLLINEAR LASER SPECTROSCOPY

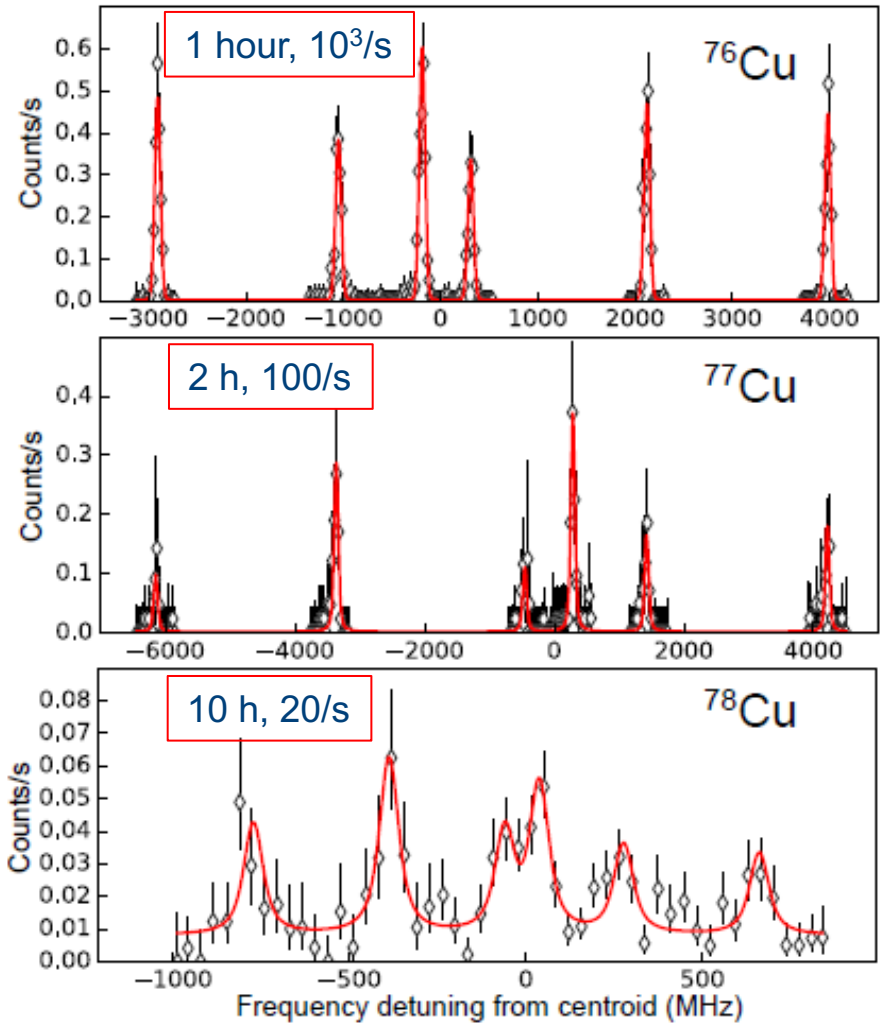
Since 2008 → sensitivity improved by factor 100.000 using CRIS on bunched beams!

Collinear **Resonance Ionization** Spectroscopy



- ultra-low background (1 event /10 min)
- high efficiency (~1-5 %)
- high resolution (~ 20-60 MHz)
- current sensitivity 20 ions/s

Most recent result @ ISOLDE
HFS of 63-78Cu
(R.P. de Groote et al., to be published)

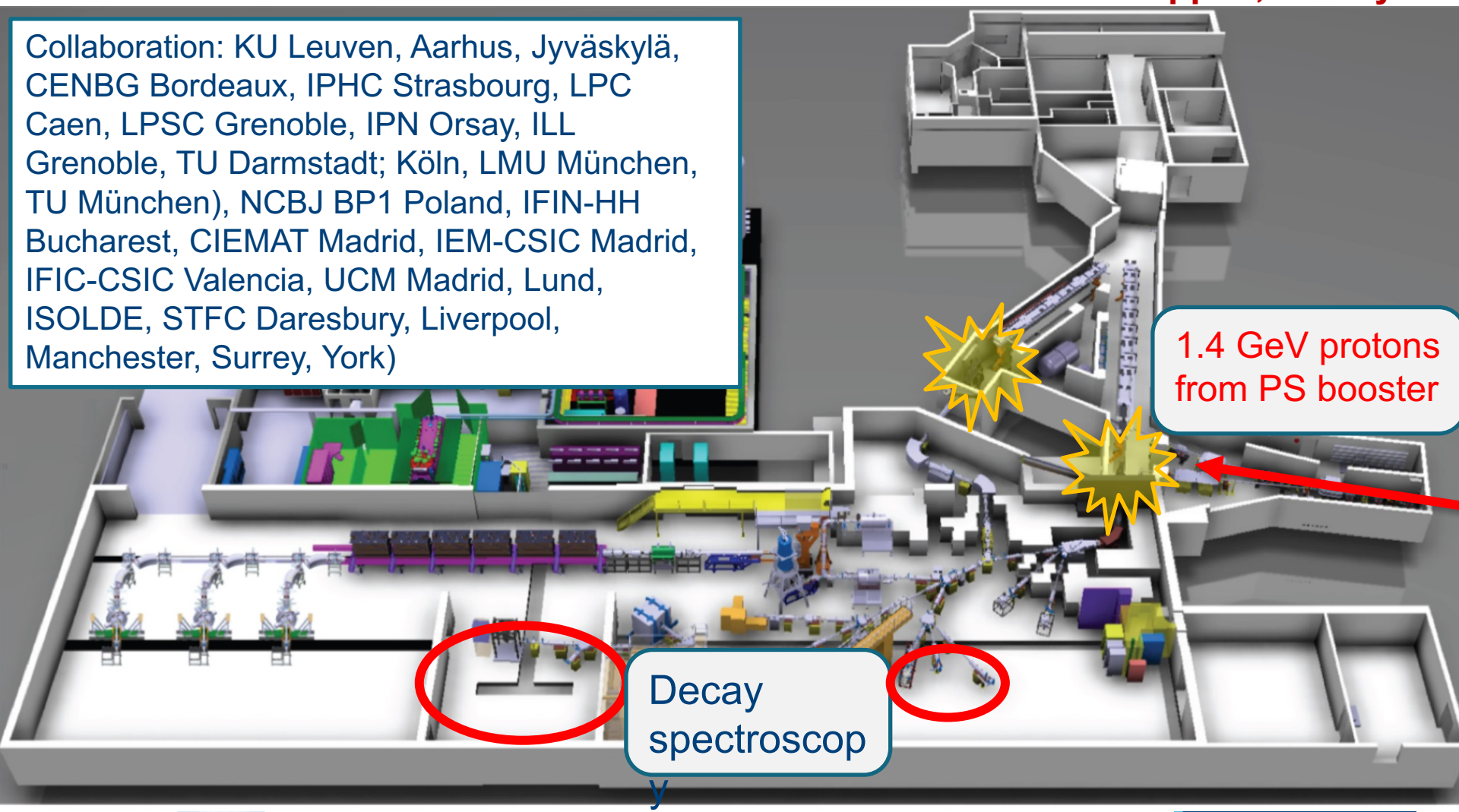


K.T. Flanagan et al., PRL 111, 212501 (2013)
R.P. de Groote et al., PRL115, 132501 (2015)

Decay spectroscopy: ISOLDE Decay Station IDS

P. Van Duppen, M. Huyse

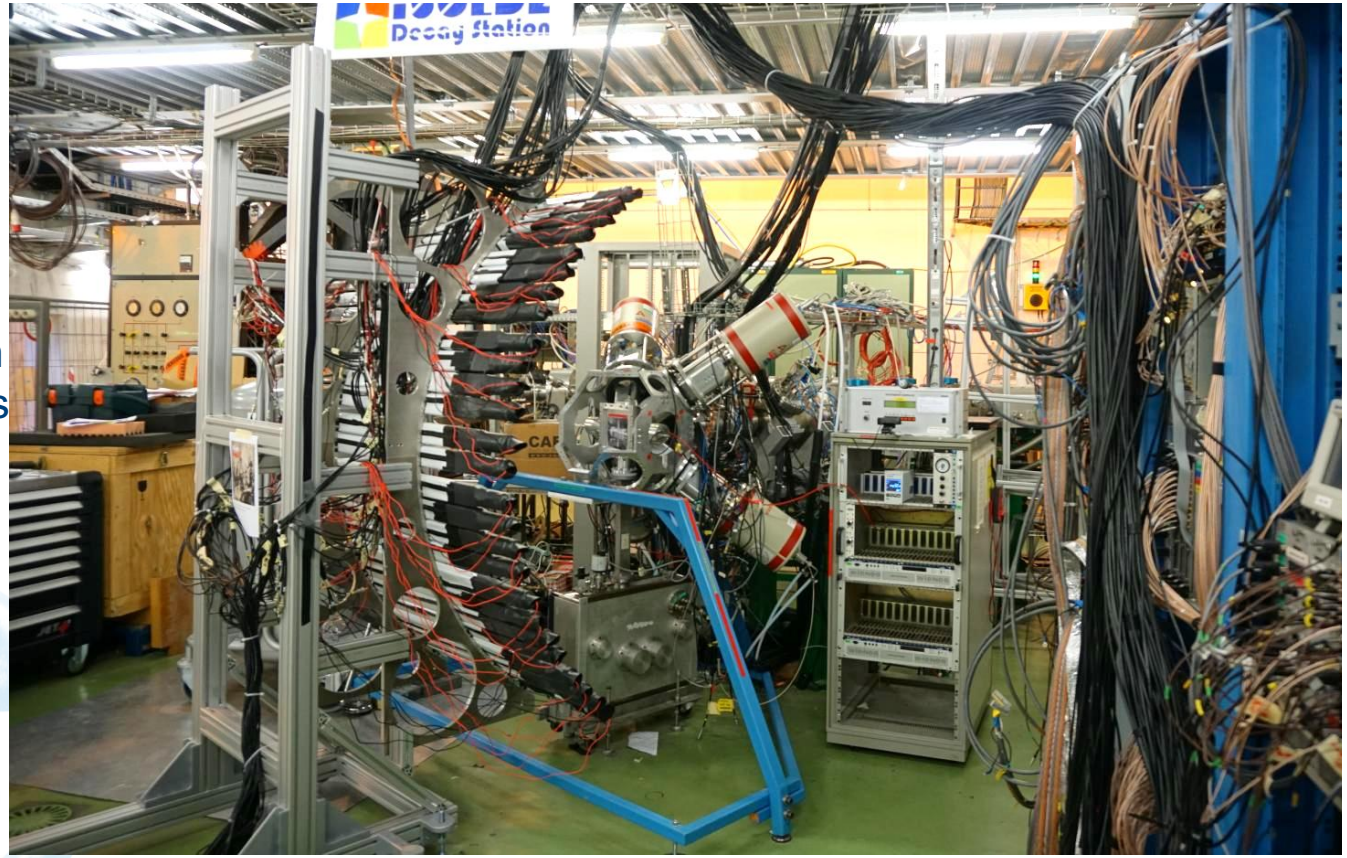
Collaboration: KU Leuven, Aarhus, Jyväskylä, CENBG Bordeaux, IPHC Strasbourg, LPC Caen, LPSC Grenoble, IPN Orsay, ILL Grenoble, TU Darmstadt; Köln, LMU München, TU München), NCBJ BP1 Poland, IFIN-HH Bucharest, CIEMAT Madrid, IEM-CSIC Madrid, IFIC-CSIC Valencia, UCM Madrid, Lund, ISOLDE, STFC Daresbury, Liverpool, Manchester, Surrey, York)



Decay spectroscopy: ISOLDE Decay Station IDS

P. Van Duppen, M. Huyse

- Permanent, flexible setup
- Tape station
- Ge clovers + Ge Miniball + ancillary: LaBr3, neutron detectors, silicon detectors
- β-γ, α-γ, fast timing, electron spectroscopy…
- Focus from our groups:
  n-rich Ni region
  n-deficient Pb region
  asymmetric fission



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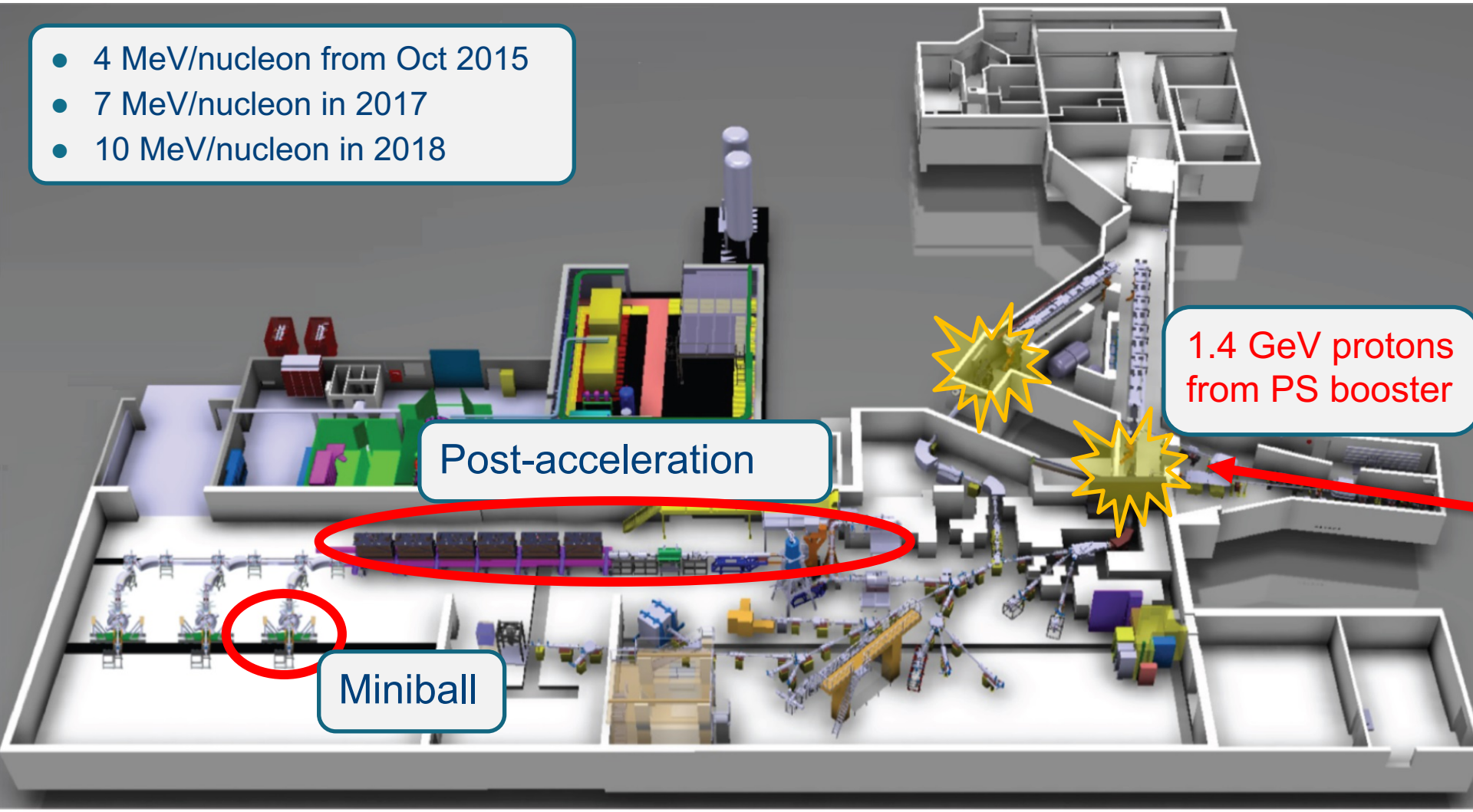
Post-accelerated ion beams: HIE-ISOLDE

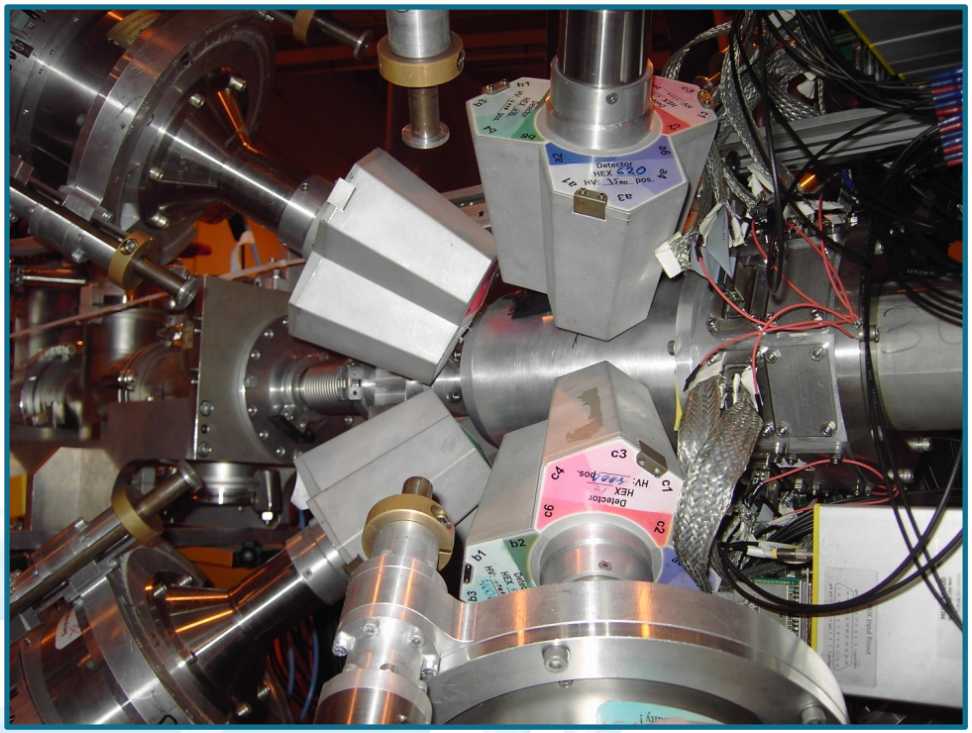
R. Raabe, P. Van Duppen, M. Huyse



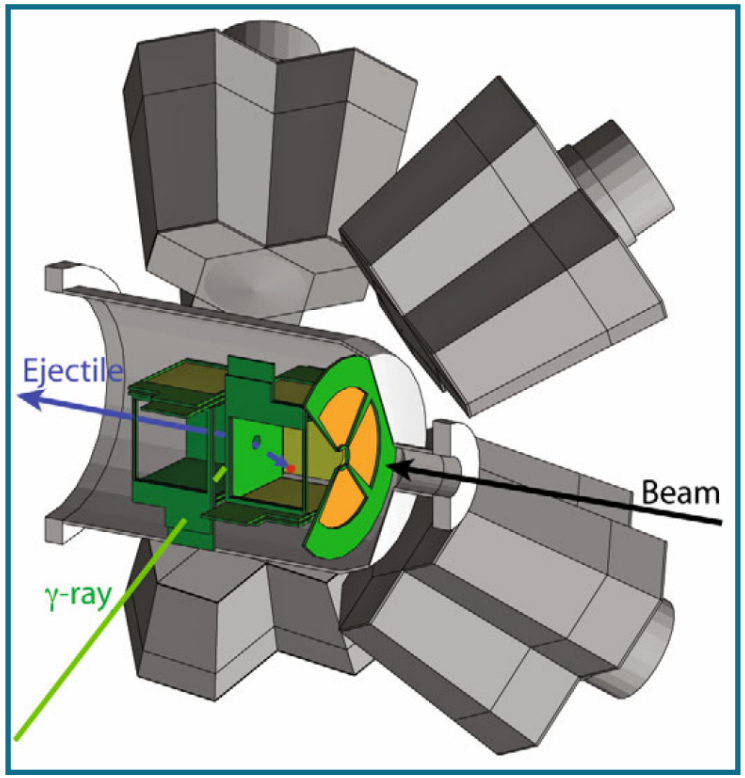
Miniball + Si: Coulomb excitation, transfer reactions

R. Raabe, P. Van Duppen, M. Huyse

Miniball Ge detector array



T-rex Si barrel



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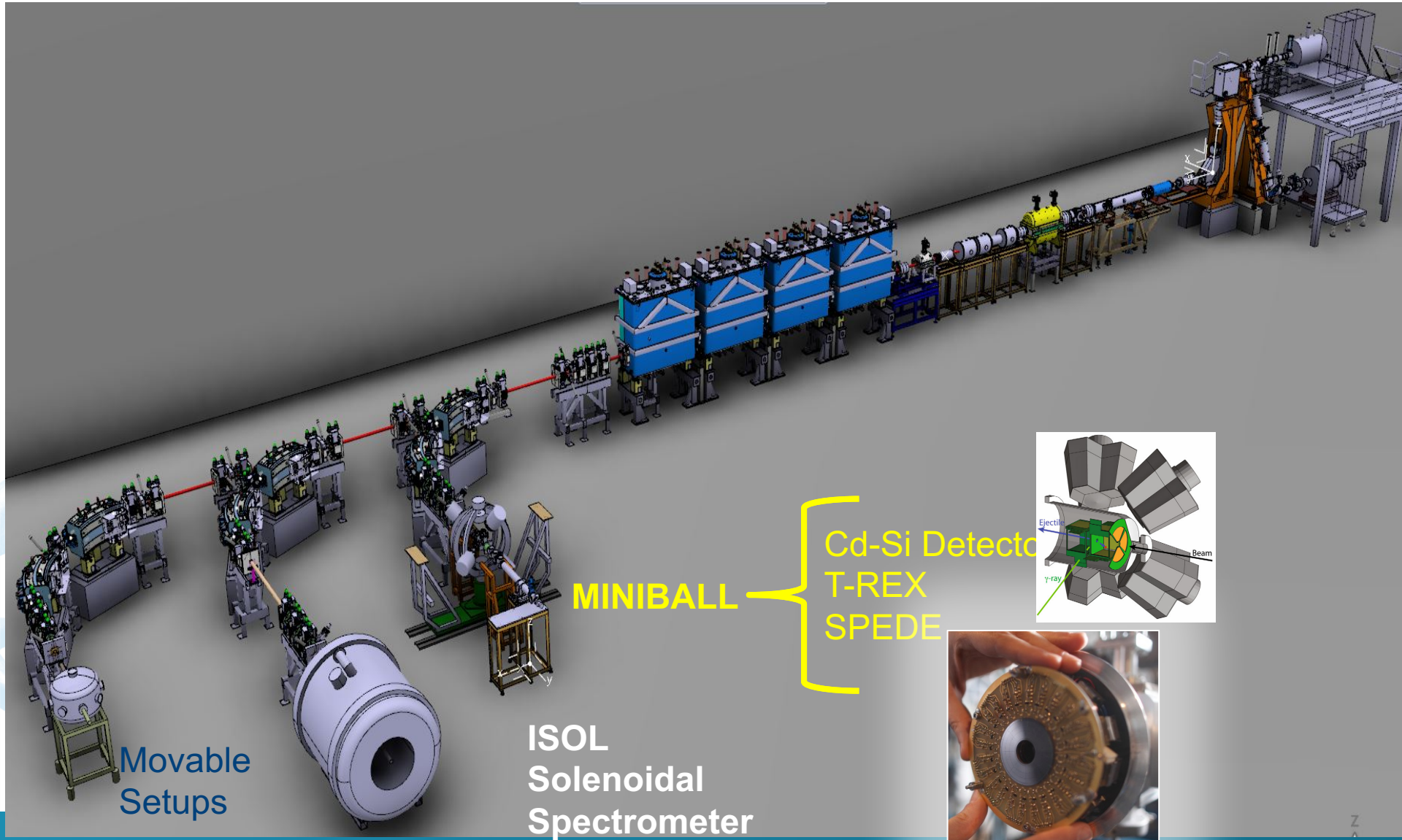
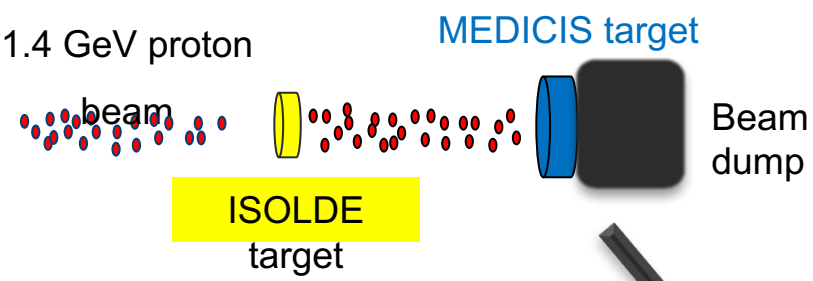
HIE-ISOLDE Phase 2 (2017-2018) to 10 MeV/u



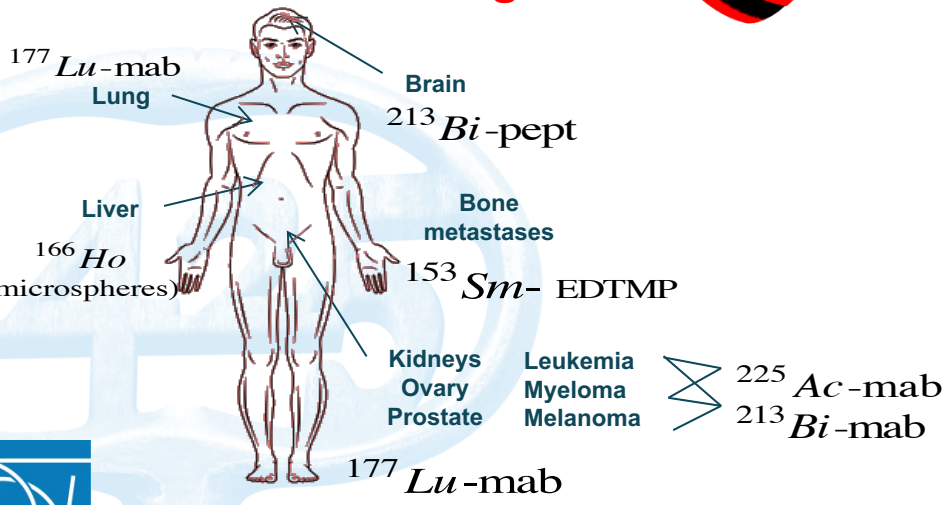
LISOL separator now at CERN ➔ MEDICIS (2016)

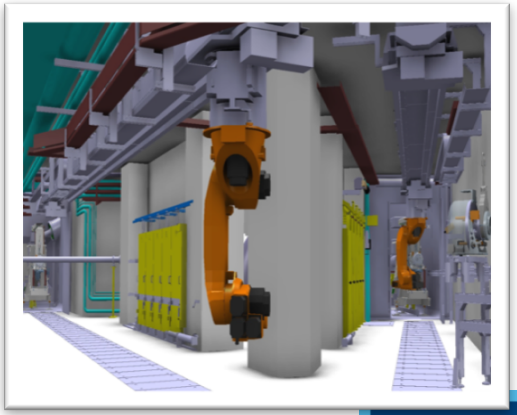


Mass separator
LISOL magnet

Chemical separation

Shipment to hospital



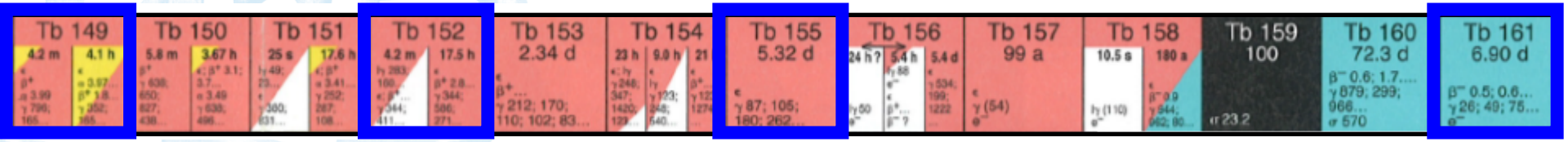


- Exotic nuclei → Innovative radioisotopes for Medicine

Terbium: a unique element for nuclear medicine

α ($T_{1/2}$=4.1 h)

γ ($T_{1/2}$=5.32 d)



β⁺/EC($T_{1/2}$=17.5 h)

β⁻ ($T_{1/2}$=6.9 d)

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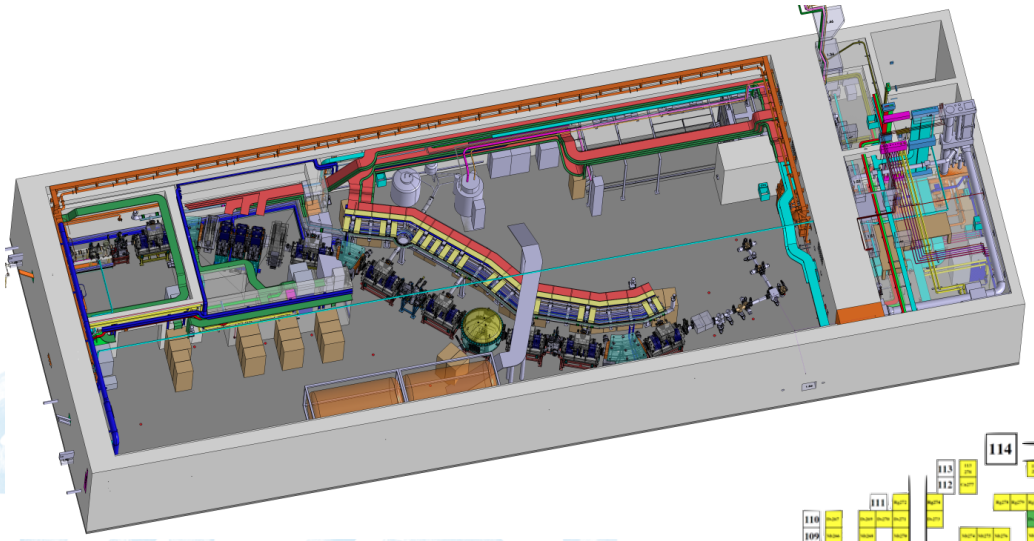
courtesy U. Köster

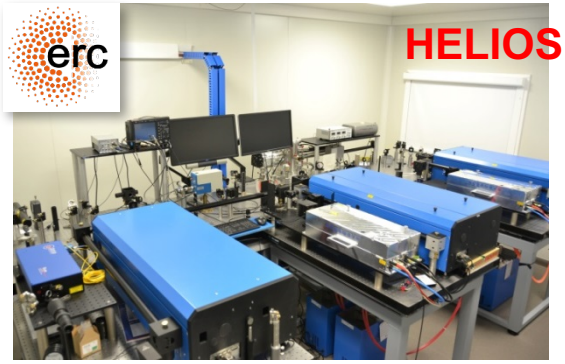
HELIOS at S^3 in GANIL

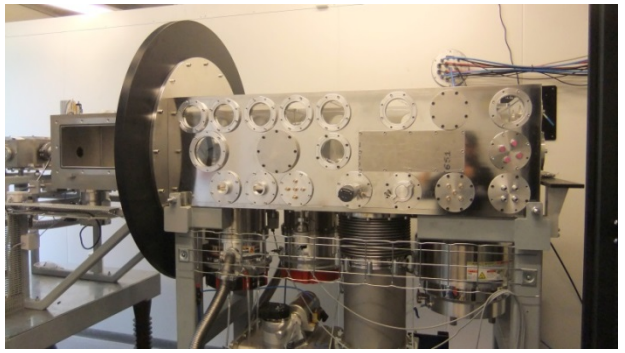
P. Van Duppen

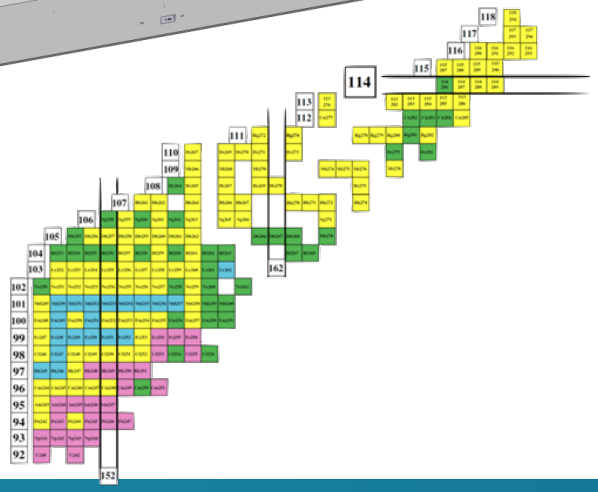
S3 Low-Energy Branch of SPIRAL2 at GANIL

- Production at the Super Separator Spectrometer S3 (GANIL)
- Laser resonance ionization spectroscopy in the heavy element region
- Mass measurements, isomeric beams, decay studies…









GANIL spiral2

IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

lpc caen

JG|U

JYFL

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Neutron EDM experiment at Paul Scherrer Institute

N. Severijns

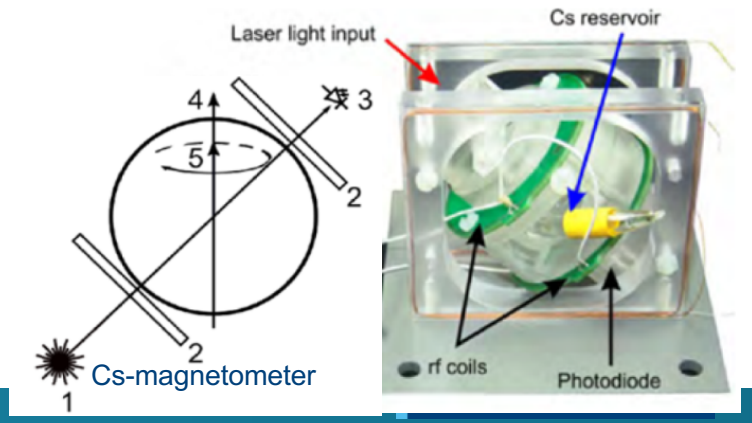
Goal:
improve the sensitivity of the neutron Electric Dipole Moment experiment to the 10^{-27} *e*.cm level

- **Main methods:**

- Improvements to ultracold neutron source

- Double neutron precession chamber

- Cs, He and K-based magnetometry



Summary

- Belgian experimental nuclear physicists have expertise in
  - RIB production and handling (including laser ion sources)
  - decay spectroscopy (α, β, γ)
  - laser spectroscopy and laser polarization
  - Coulomb excitation and direct reactions
  - Ion trapping

- For the study of
  - nuclear structure far from stability (shell evolution, shape coexistence)
  - properties of weak interaction (beyond Standard Model research)
  - nuclear solid state physics (emission channeling, PAC, …)

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