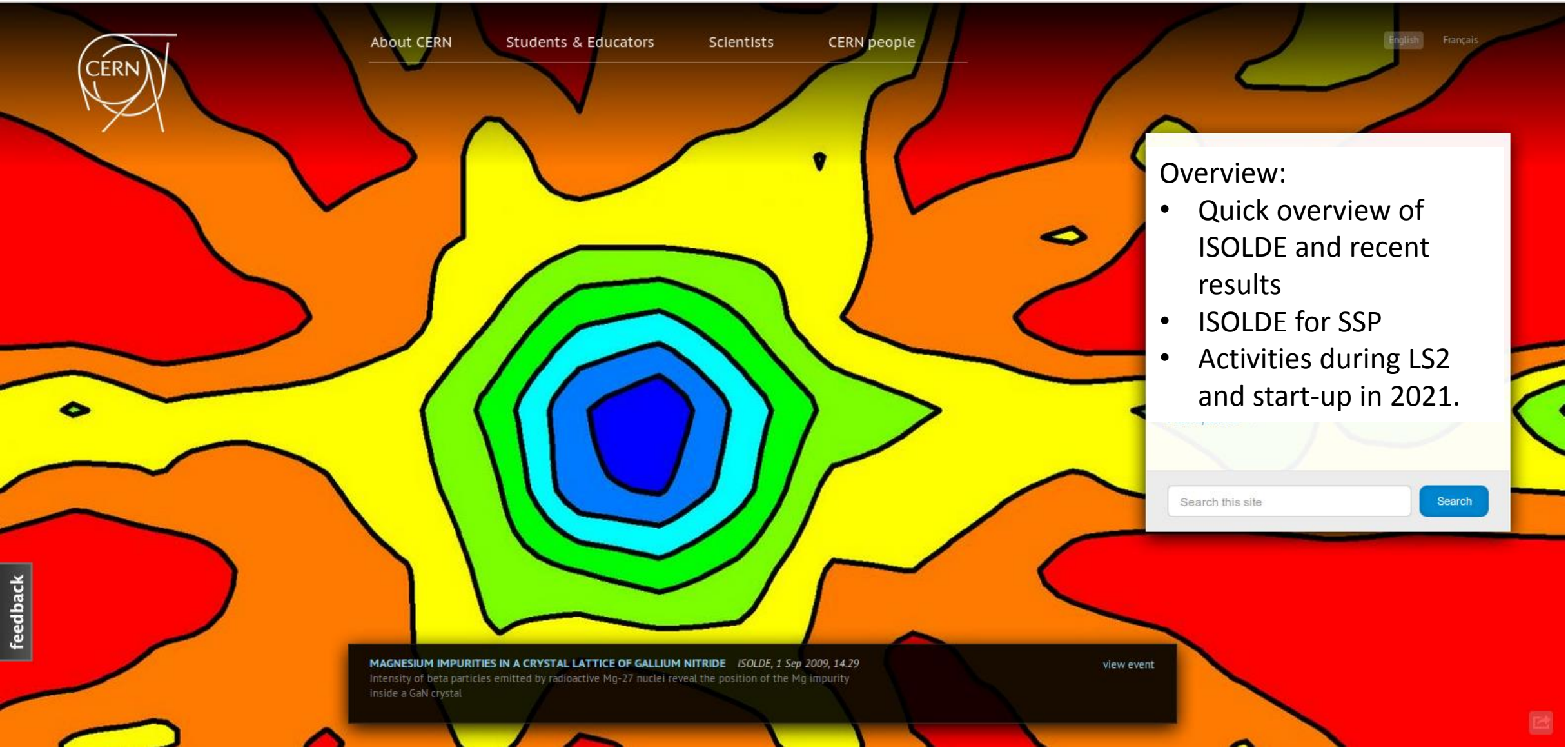
# Overview of ISOLDE and SSP @ ISOLDE




Karl Johnston

# What is ISOLDE?

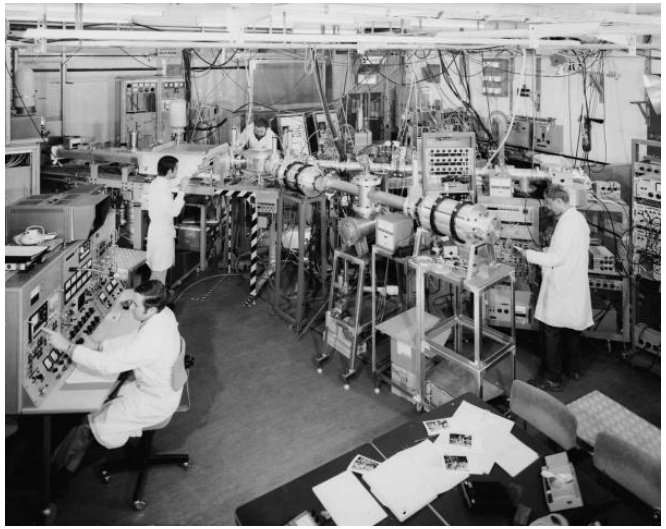
The On-Line Isotope Mass Separator ISOLDE is a facility dedicated to the production of a large variety of radioactive ion beams (RIBs)

# Isolde history

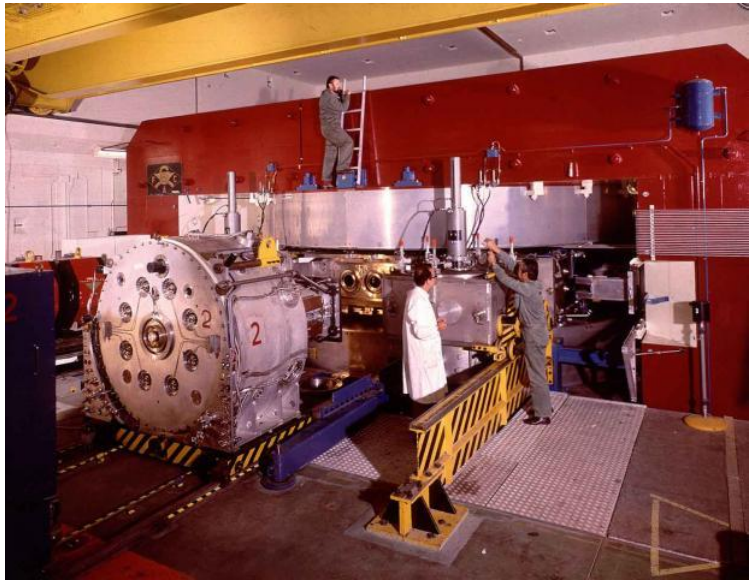
**Dec 1964: CERN approves the online separator project**

**May 1966: SynchroCyclotron shuts down for the construction of ISOLDE**

**Oct 1967: First proton beams at ISOLDE**



**1972: SC Improvement Program –** doubles the intensity
(now quite a nice museum)



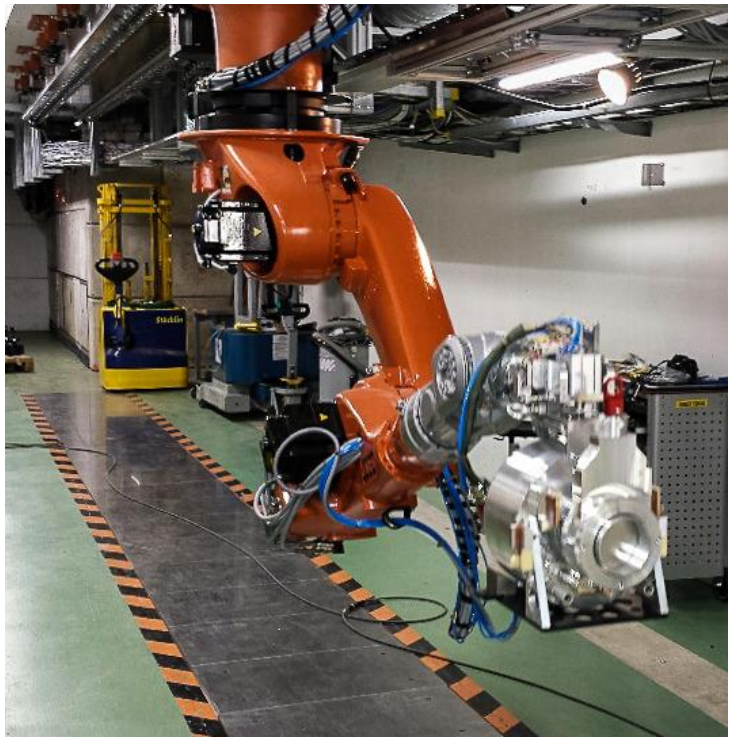
**1976: New experiments in ISOLDE II**

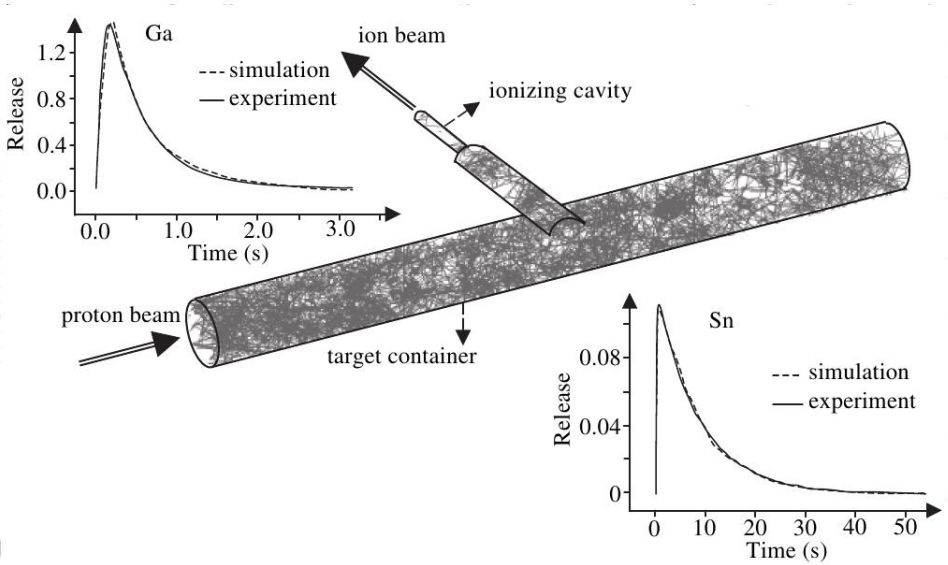
**June 1983: ISOLDE III approved –** two-stage high resolution separation using two magnets

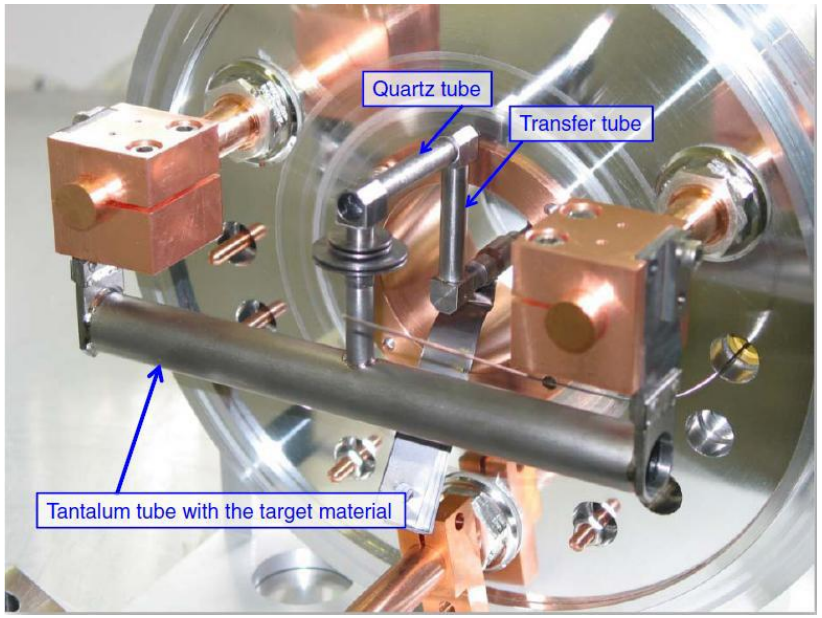
**Dec 1990: The Synchrocyclotron beam ends**
ISOLDE moves to PS booster to utilize CERN's spare proton capacity…

# ISOLDE Targets

- Main challenge: extracting the $10^{-1}$ – $10^{12}$ nuclei (one isotope) produced in the reaction from the $10^{23}$ nuclei in the target
- Targets:
  UCx, SiC, Ta, LaCx, CaO, ZrO….
- The diffusion into the ion source is controlled by the target and transfer line temperature



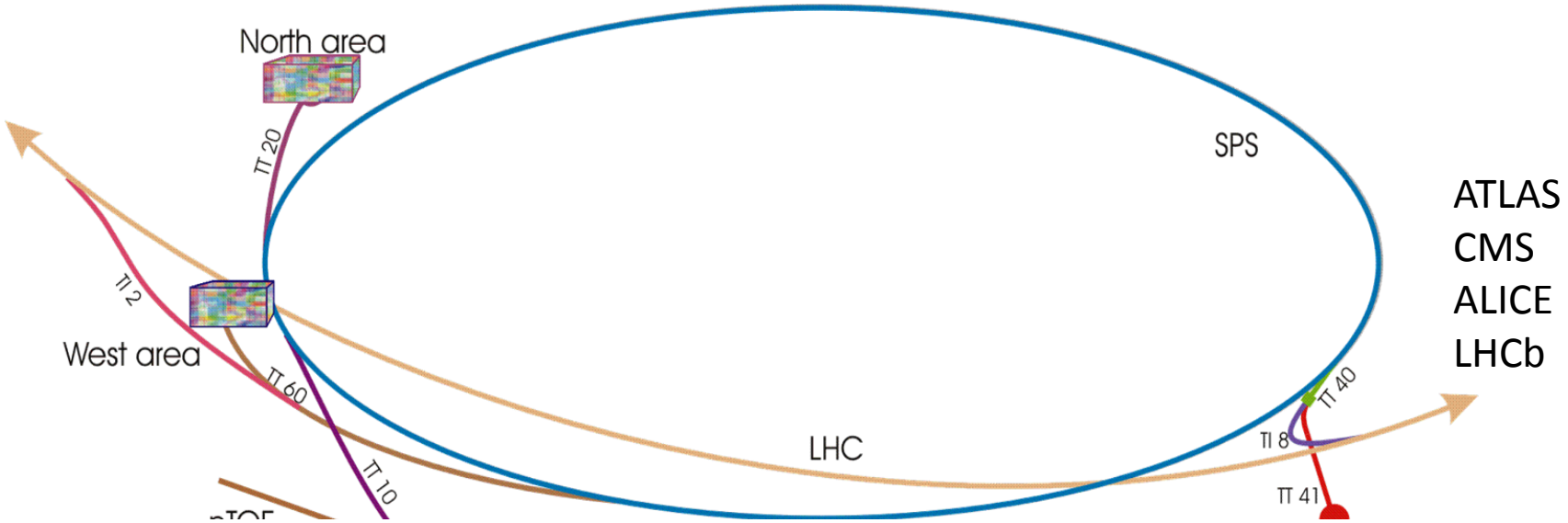


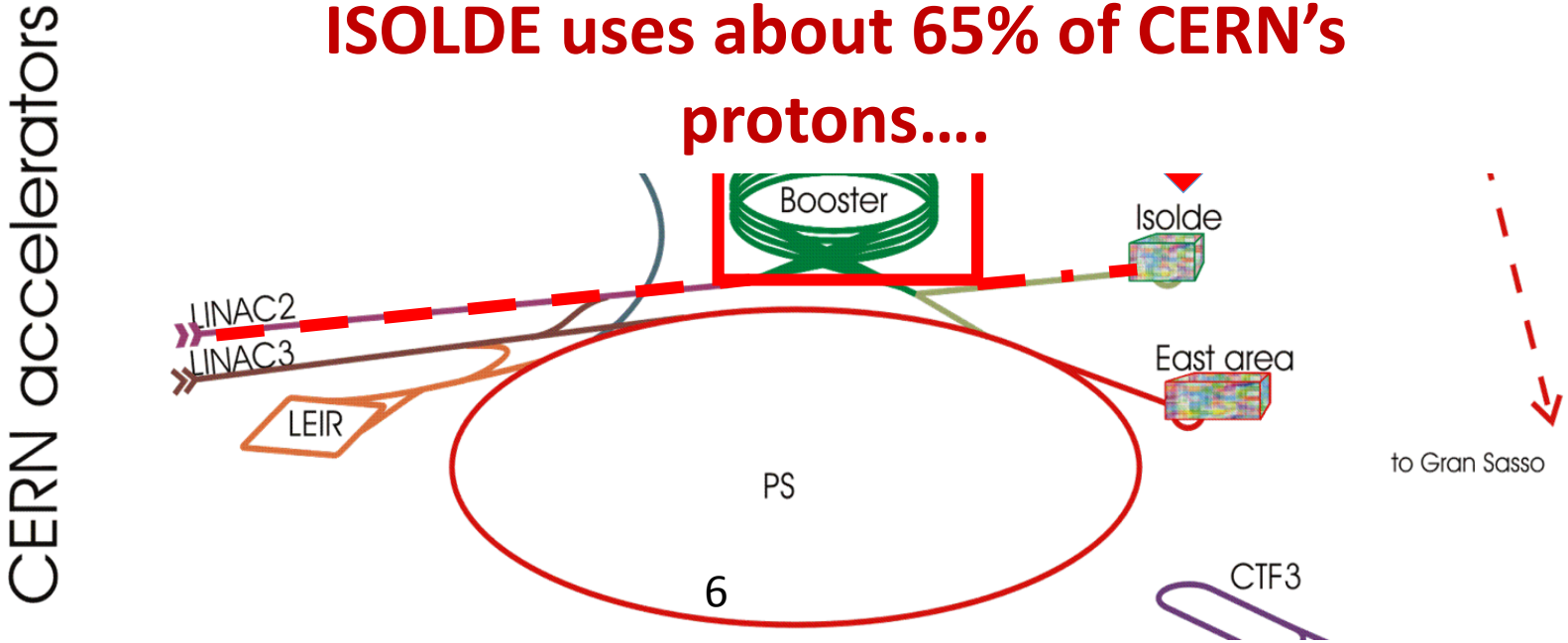
# Ion Sources

- **Hot-cavity**
  - W heated at > 2000 C
  - High ionization efficiencies for some nuclei
- **Plasma**
-

# ISOLDE = Isotope Separator On Line




**ISOLDE uses about 65% of CERN's protons….**




6

**AD:** Antiproton Decelerator for antimatter studies

**AWAKE**: proton-induced plasma wakefield acceleration

**CAST, OSQAR**: axions

**CLOUD**: impact of cosmic rays on aeorosols and clouds → implications on climate

**COMPASS**: hadron structure and spectroscopy

**ISOLDE**: radioactive nuclei facility

**NA61/Shine**: heavy ions and neutrino targets

**NA62**: rare kaon decays

**NA63**: radiation processes in strong EM fields

**NA64**: search for dark photons

**Neutrino Platform:** **ν** detectors R&D for experiments in US, Japan

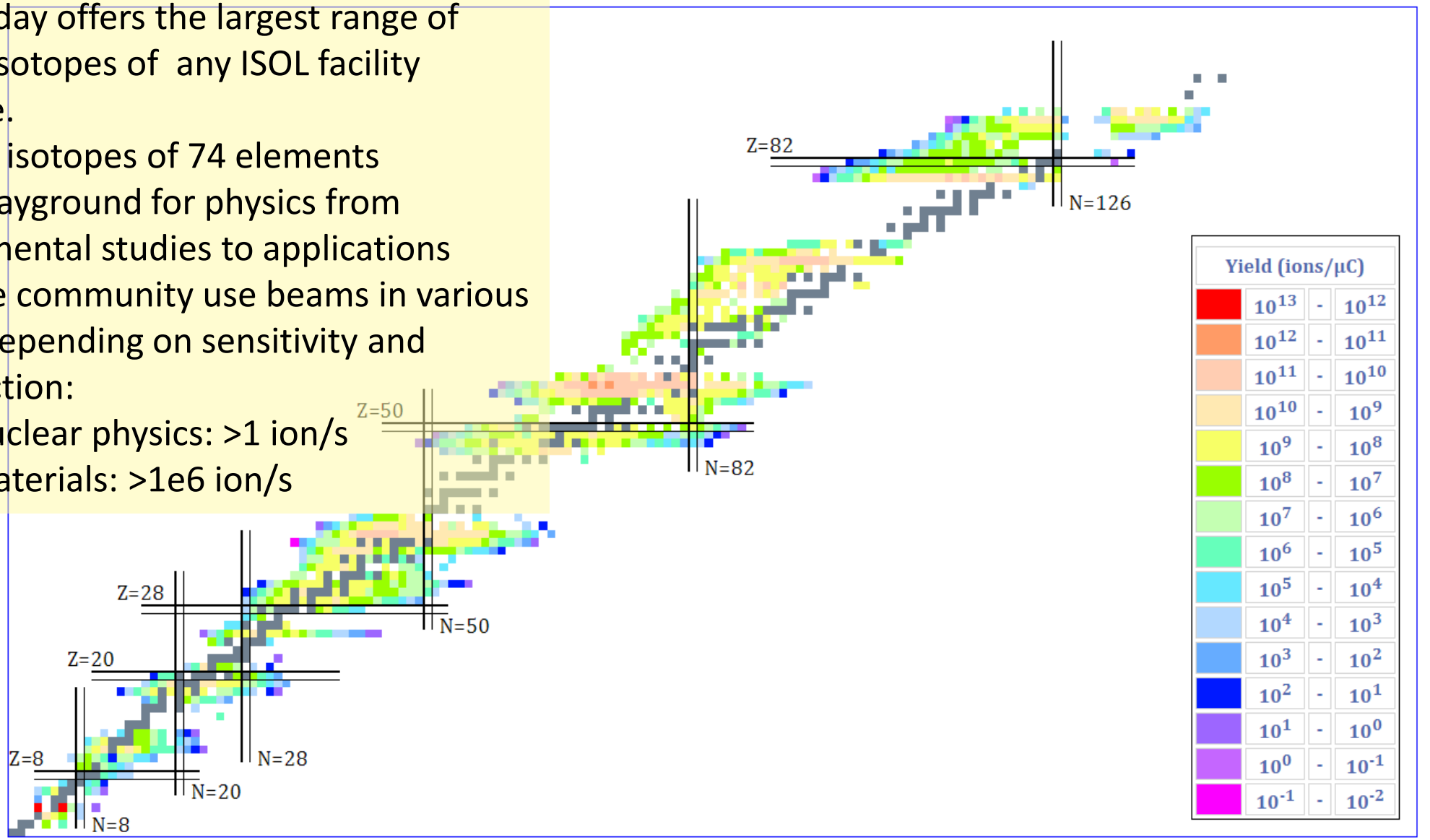
**n-TOF:** n-induced cross-sections

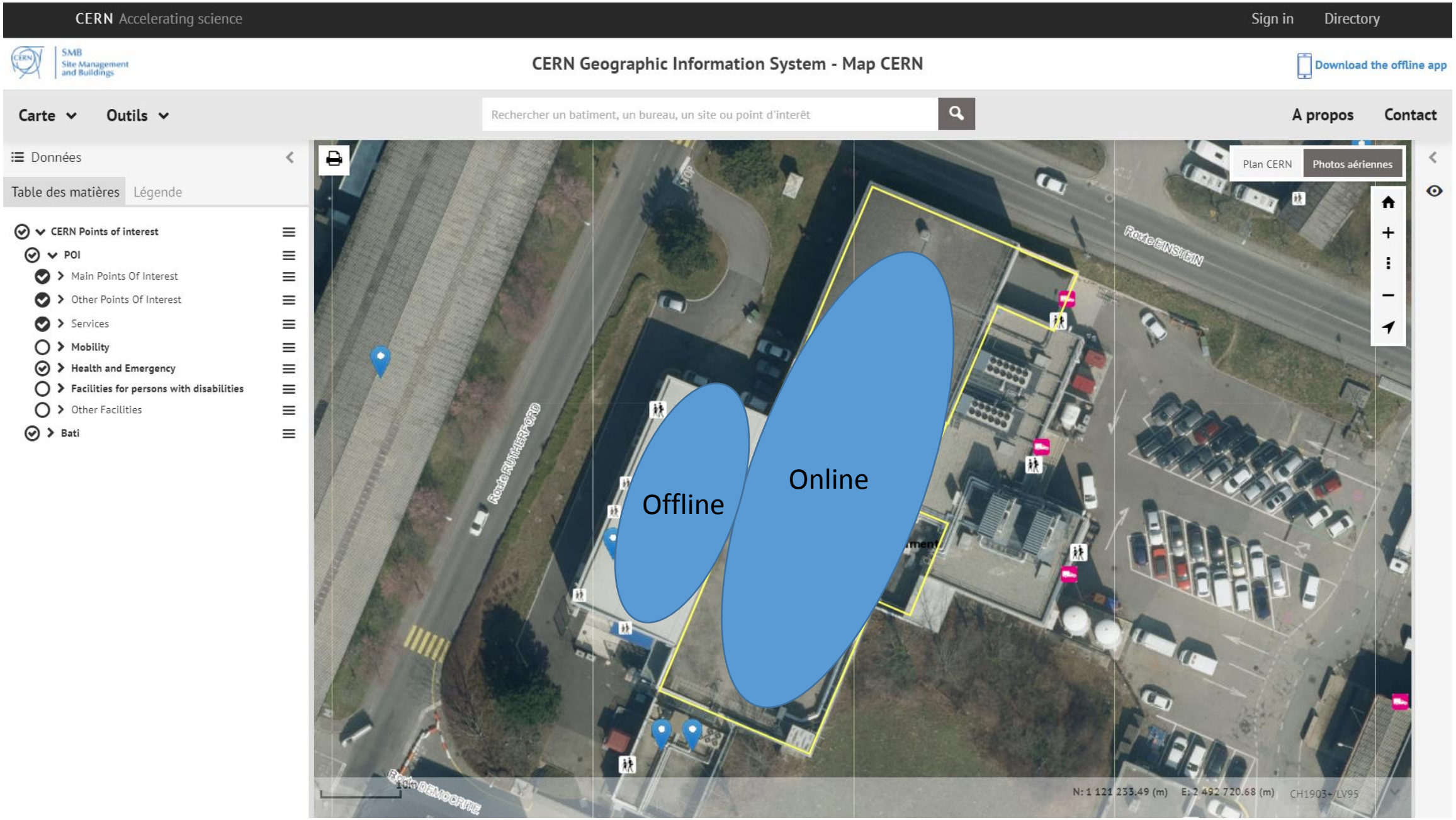
**UA9**: crystal collimation

# Nuclear chart for ISOLDE

ISOLDE today offers the largest range of available isotopes of any ISOL facility worldwide.

- ~ 1200 isotopes of 74 elements
- Rich playground for physics from fundamental studies to applications
- Diverse community use beams in various ways depending on sensitivity and production:
  - Nuclear physics: >1 ion/s
  - Materials: >1e6 ion/s




CERN Accelerating science
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Health and Emergency
Facilities for persons with disabilities
Other Facilities
Bati
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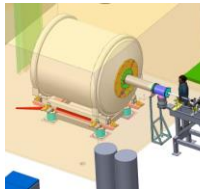
Online
N: 1 121 233.49 (m)
E: 2 492 720.68 (m)
CH1903+/LV95

ISOLDE

Belgium CERN Denmark Spain Finland France Germany Greece Italy Norway Romania Sweden S. Africa Slovakia U. Kingdom Poland

MINIBALL

SCATTERING EXPERIMENTS



ISS

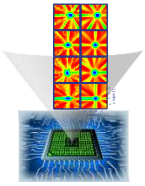
COLLAPS

ISOLTRAP

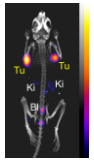
CRIS

IDS

VITO

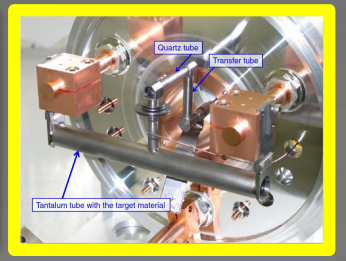


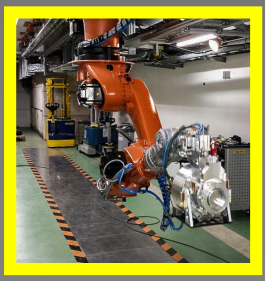
SSP



MEDICAL ISOTOPES

RILIS





MEDICIS

HRS

GPS

P+: 1.4 GeV

HIE-ISOLDE

WITCH

LUCRECIA

REX-EBIS

VITO

RILIS

SSP

SCATTERING EXPERIMENTS

ISS

MINIBALL

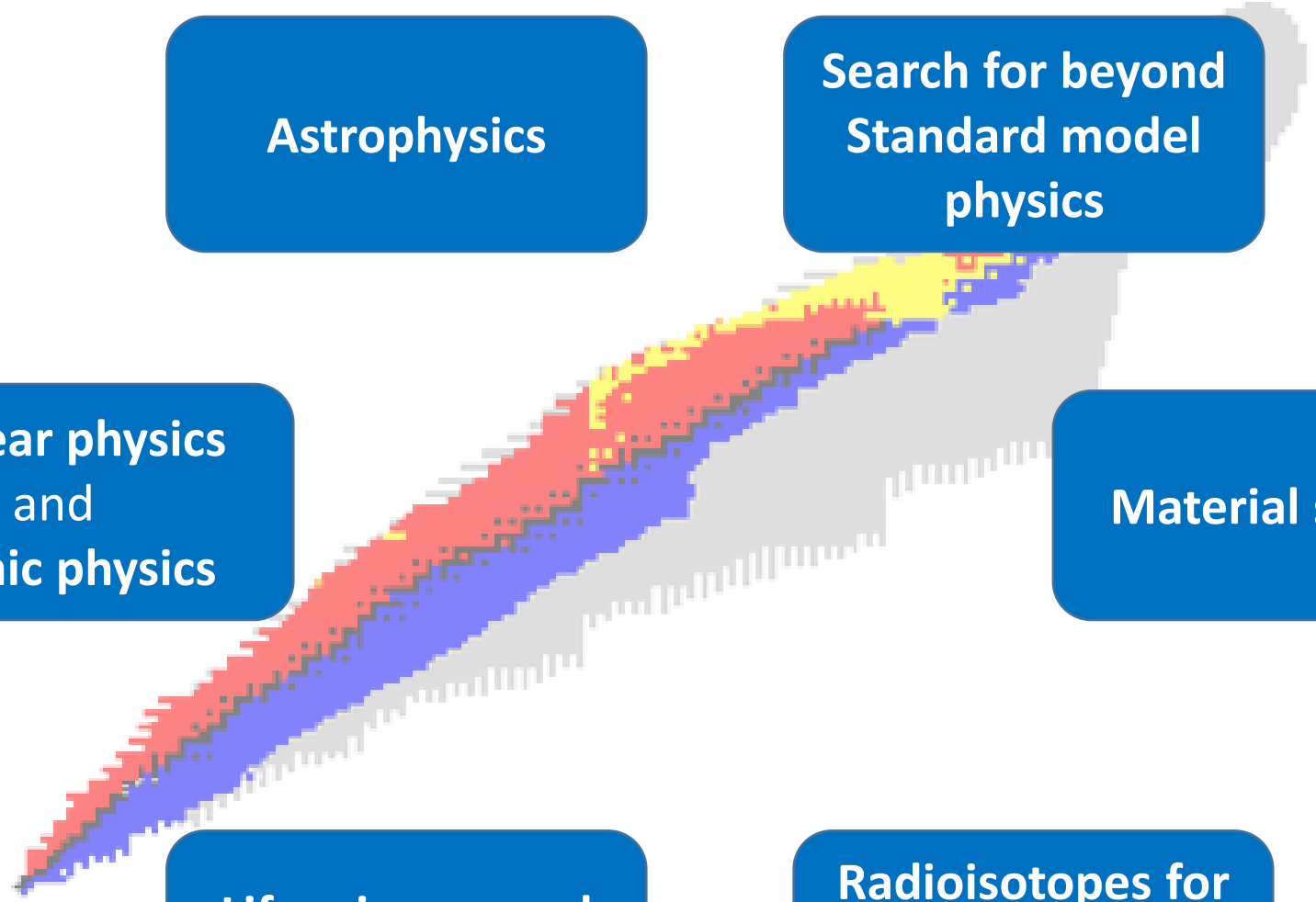
NICOLE

IDS

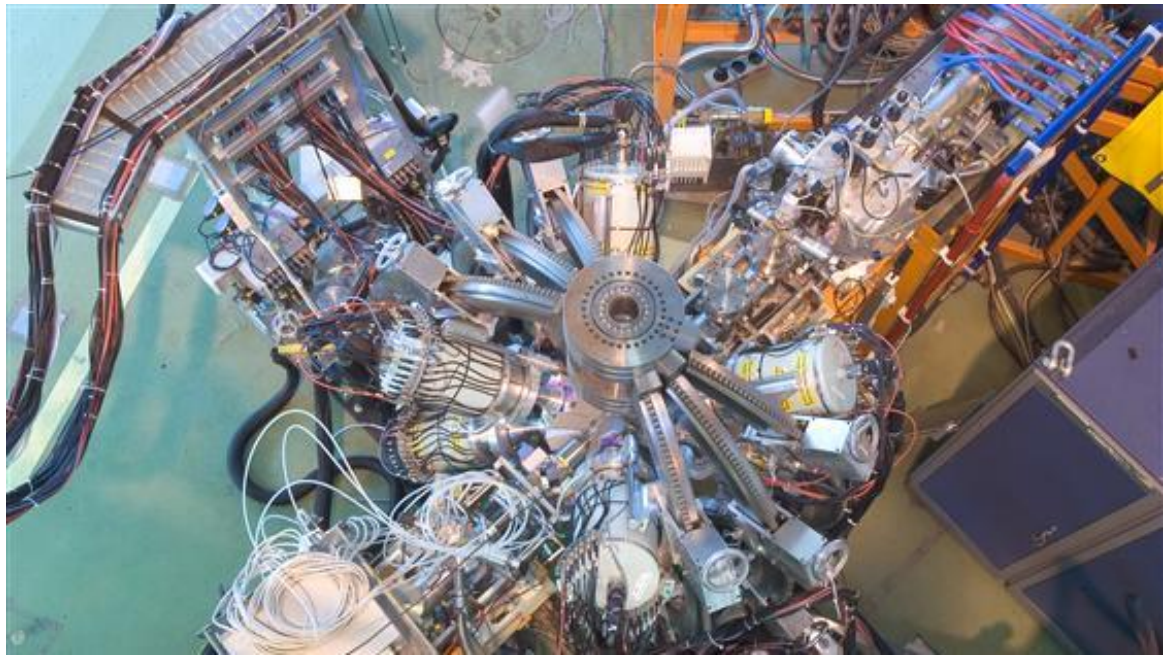
TRAVELLING SETUPS

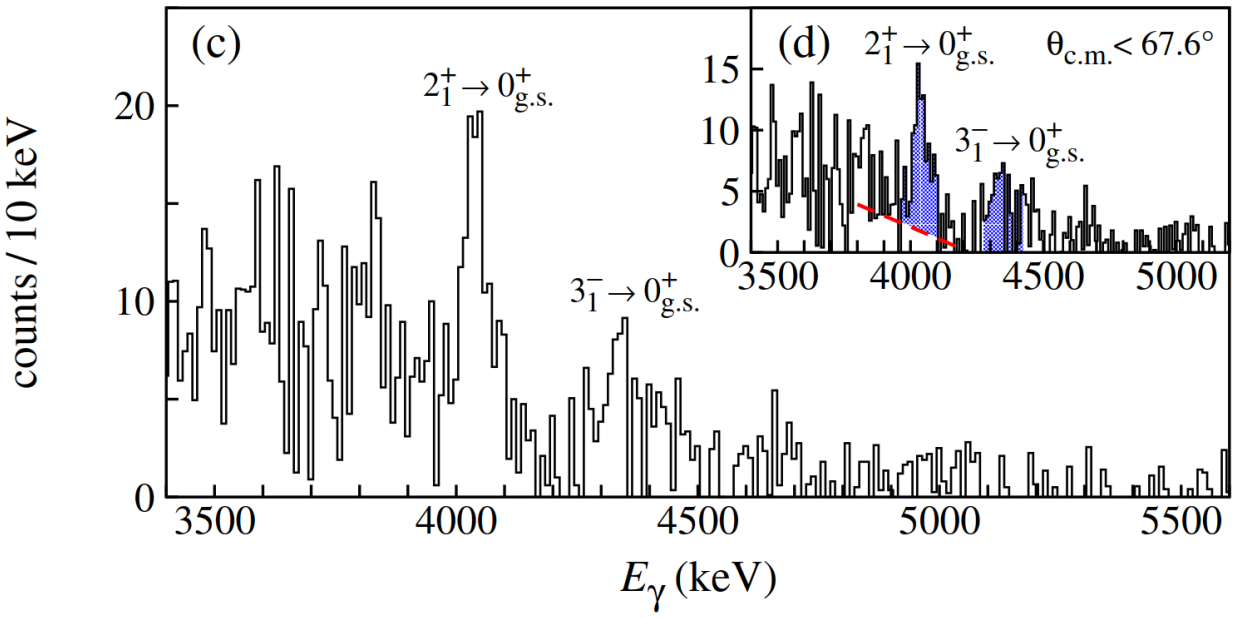
ISOLTRAP CRIS COLLAPS

# Research with radioactive beams at ISOLDE



# Recent output from HIE ISOLDE: Enhanced Quadrupole and Octupole Strength in Doubly Magic 132Sn






Confirmation of doubly magic nature of 132Sn

D. Rosiak *et al.* Phys. Rev. Lett. **121**, 252501

# Output from HIE ISOLDE: II

**HIE-ISOLDE + MINIBALL+CD July-August 2018**

**radon from ThC target; ionised using VADIS with cooled transfer line; separated in GPS**

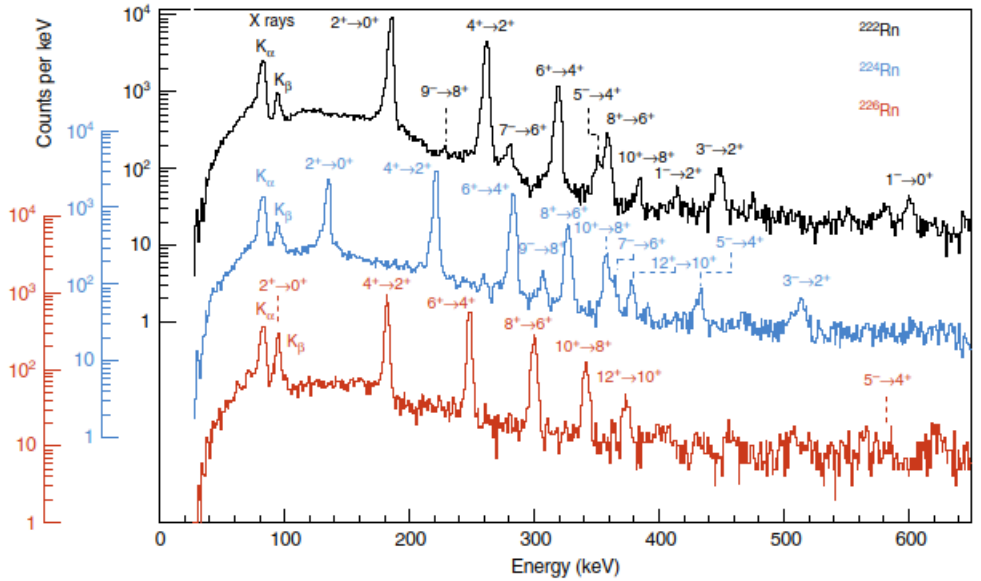
| | | |
|---|---|---|
| $^{222}$Rn $51^+$ | 4.23 MeV/u | $6 \cdot 10^5$ /s |
| $^{224}$Rn $52^+$ | 5.08 MeV/u | $1.1 \cdot 10^5$ /s |
| $^{226}$Rn $52^+$ | 5.08 MeV/u | $2 \cdot 10^3$ /s |

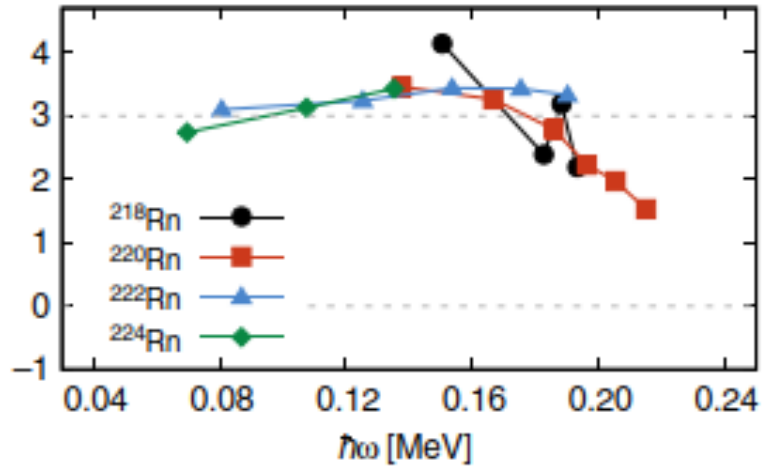
**radium from UC target; ionised using W surface ion source ; separated in HRS**

| | | |
|---|---|---|
| $^{222}$Ra $51^+$ | 4.305 MeV/u | $6 \cdot 10^5$ /s |
| $^{228}$Ra $53^+$ | 4.31 MeV/u | $6 \cdot 10^5$ /s |

**EBIS breeding time 500-700 ms**

Challenging beamtime (many changes in isotopes…energies)

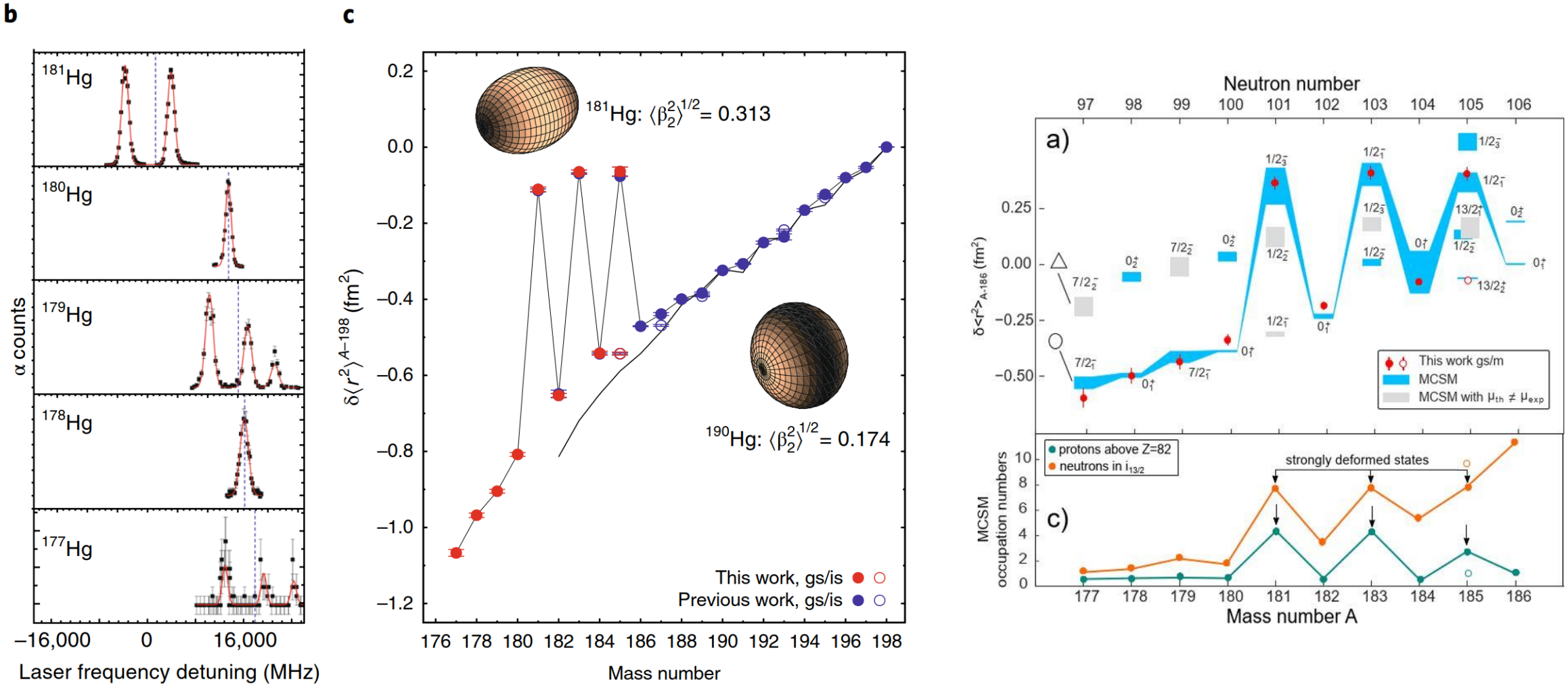



Rn isotopes undergo octupole vibrations but **not** static pear-shapes in their ground states

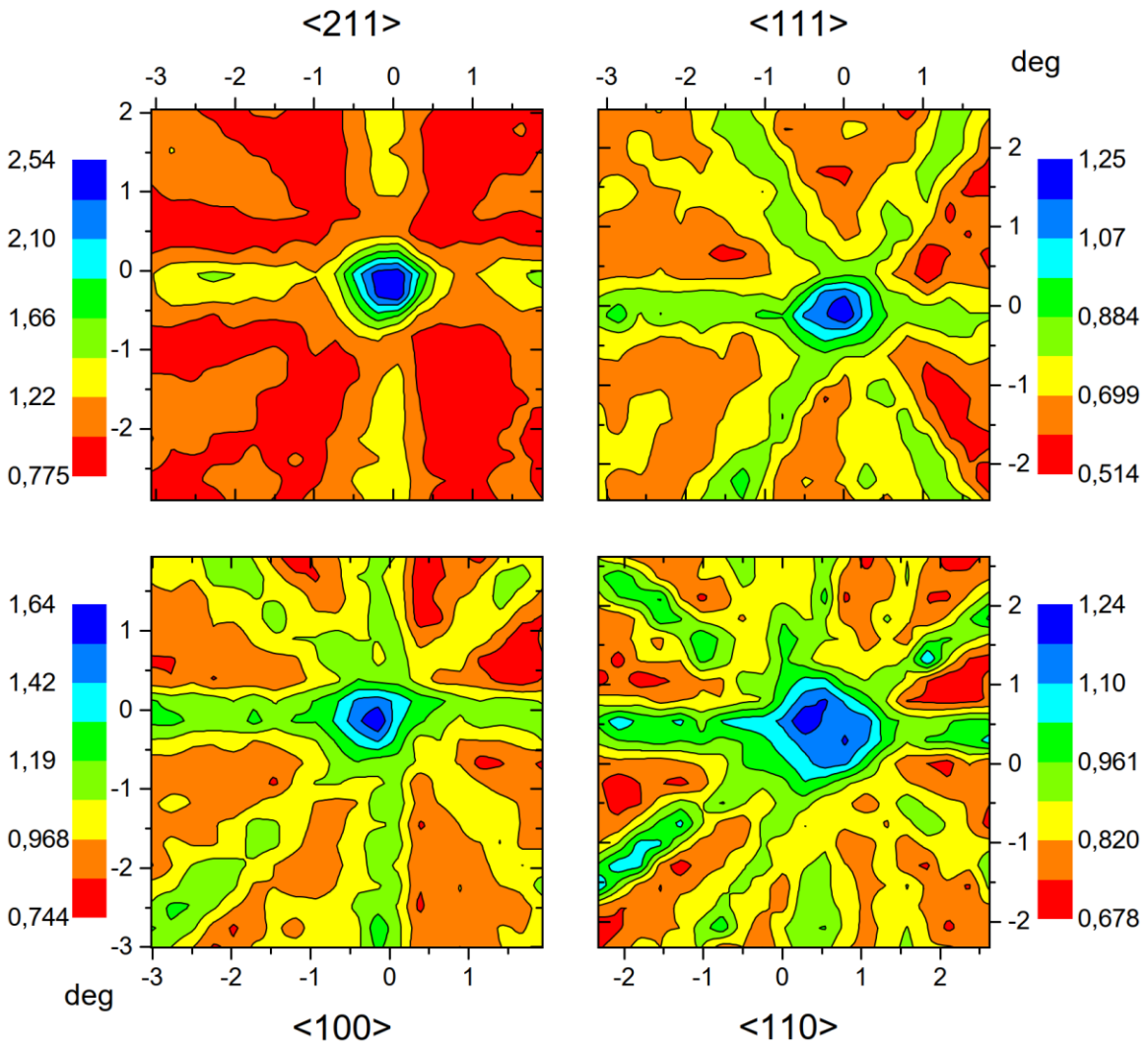
NATURE COMMUNICATIONS | (2019)10:2473 | https://doi.org/10.1038/s41467-019-10494-5 | www.nature.com/naturecommunications

# Characterization of the shape-staggering effect in mercury nuclei




B. Marsh et al., Nature Physics 14, 1163 (2018).

# Thorium clock: LOI198




Study of isomeric level by removing IC decay path. Check this with implantation into CaF (wide band gap material)

Preliminary data indicate from 229Ac beam that significant fraction on substitutional sites: study of isomer possible.

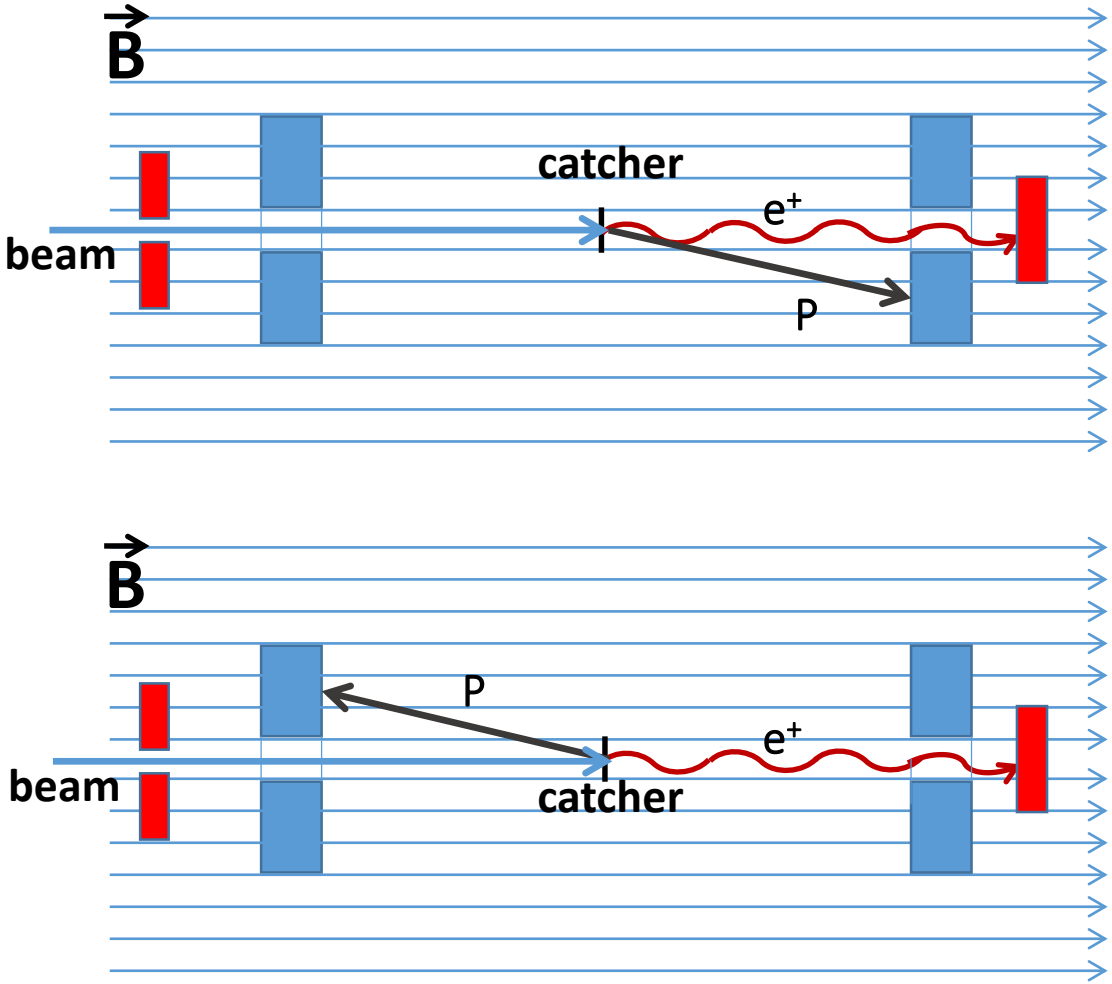
Complemented with new setup to measure low energy conversion electrons…

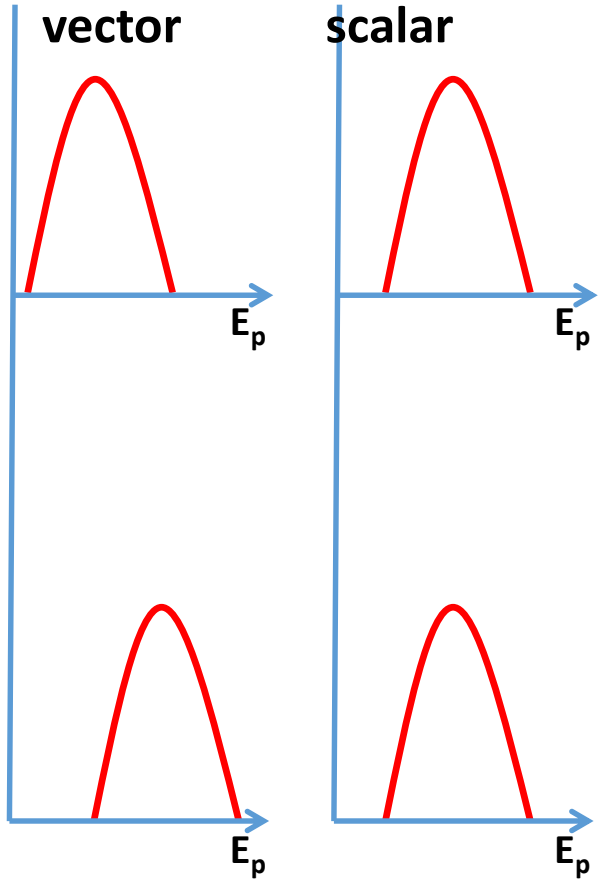
arXiv:1904.10245v1 & submitted to PRC (2019)

# WISArD = Weak-interaction studies with Ar32 decay

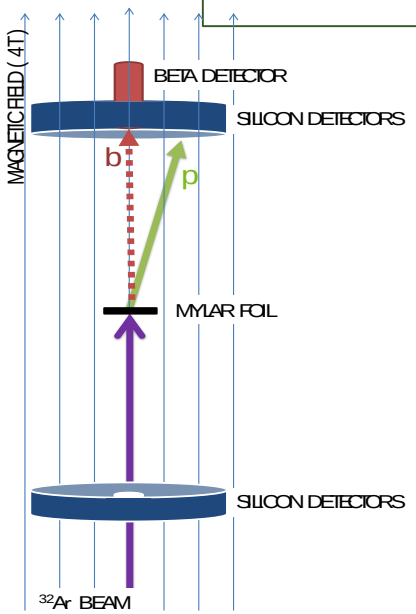
## coll. Bordeaux, Leuven, LPC Caen, NPI-Prague

➔ Measure kinematic shift using β-p coincidences in β-delayed p decay



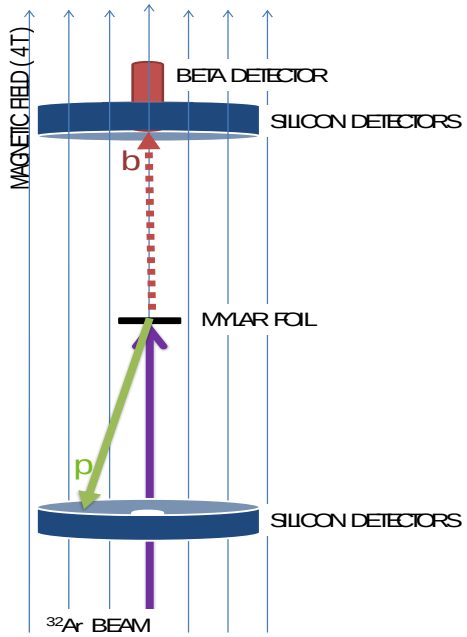



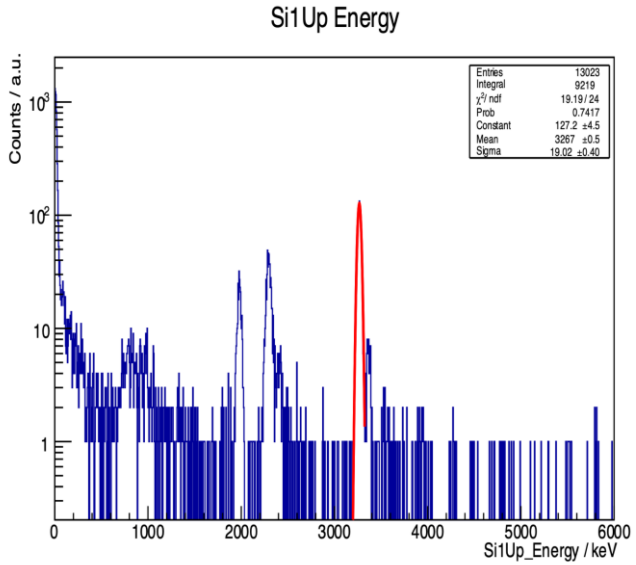
# Online proton spectra from the IAS after the $\beta$–decay of $^{32}$Ar




Positron up → recoil nucleus down → proton emitted upwards from downwards moving nucleus → lower energy

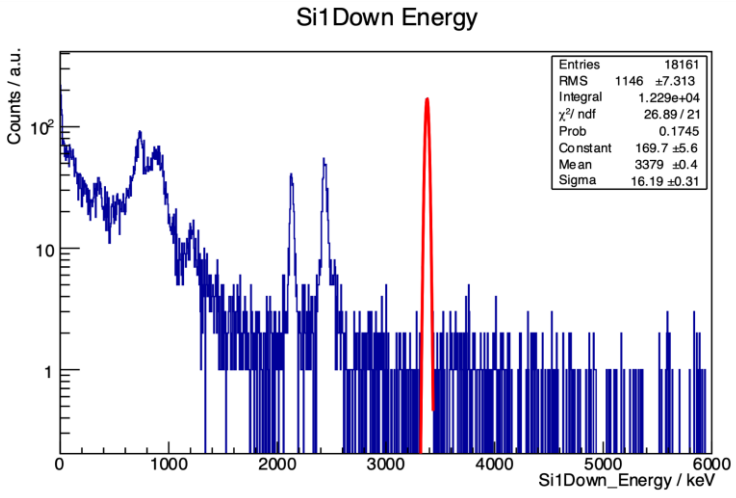
Positron up → recoil nucleus down → proton emitted downwards from downwards moving nucleus → higher energy



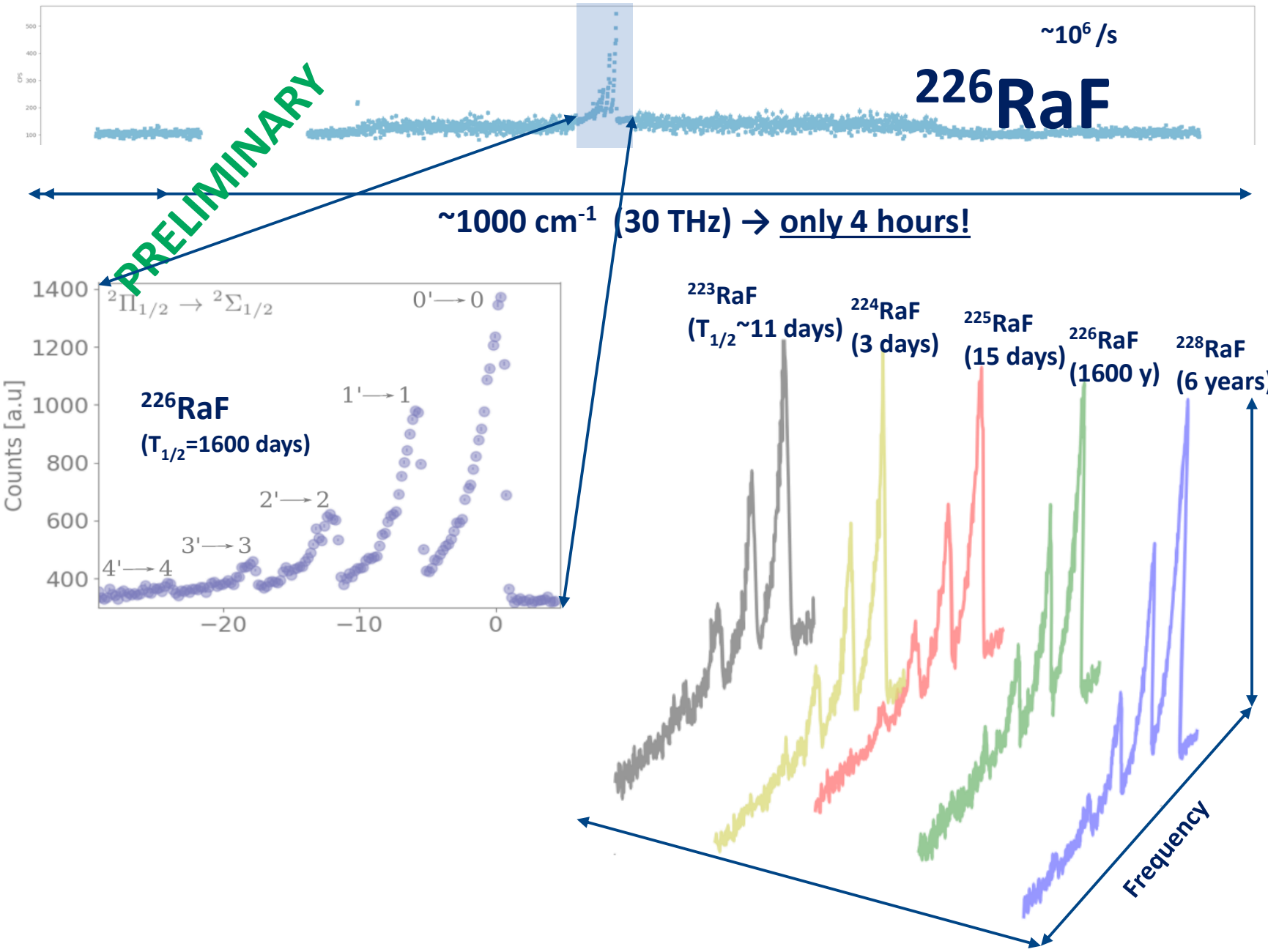

**PRELIMINARY**

*Submitted to PRL*



# CRIS RaF: Results (November 2018)





# Irradiations for ISOLDE at MEDICIS

MEDICIS collaboration board approved use of MEDICIS for non-medical applications, as long as they are approved by INTC. Used for irradiations in 2018…potentially useful for long-lived isotopes at ISOLDE e.g. 57Co

<u>$^{7}$Be (53.22d) at 5 MeV/u for IS554</u>

#635-UCx - 7.96E17 p (direct)

+4 indirect irradiations

2.2 days – EoB 23/10/2018

6 extra days of beamtime (16/11->21/11) for ISOLDE

IS554

<u>$^{223}$RaF (11.4d), $^{225}$RaF (14.8d), $^{226}$RaF (1600 a) for IS657</u>

#637-UCx - 6.74E17 p (direct)

3.4 days – EoB 19/10/2018

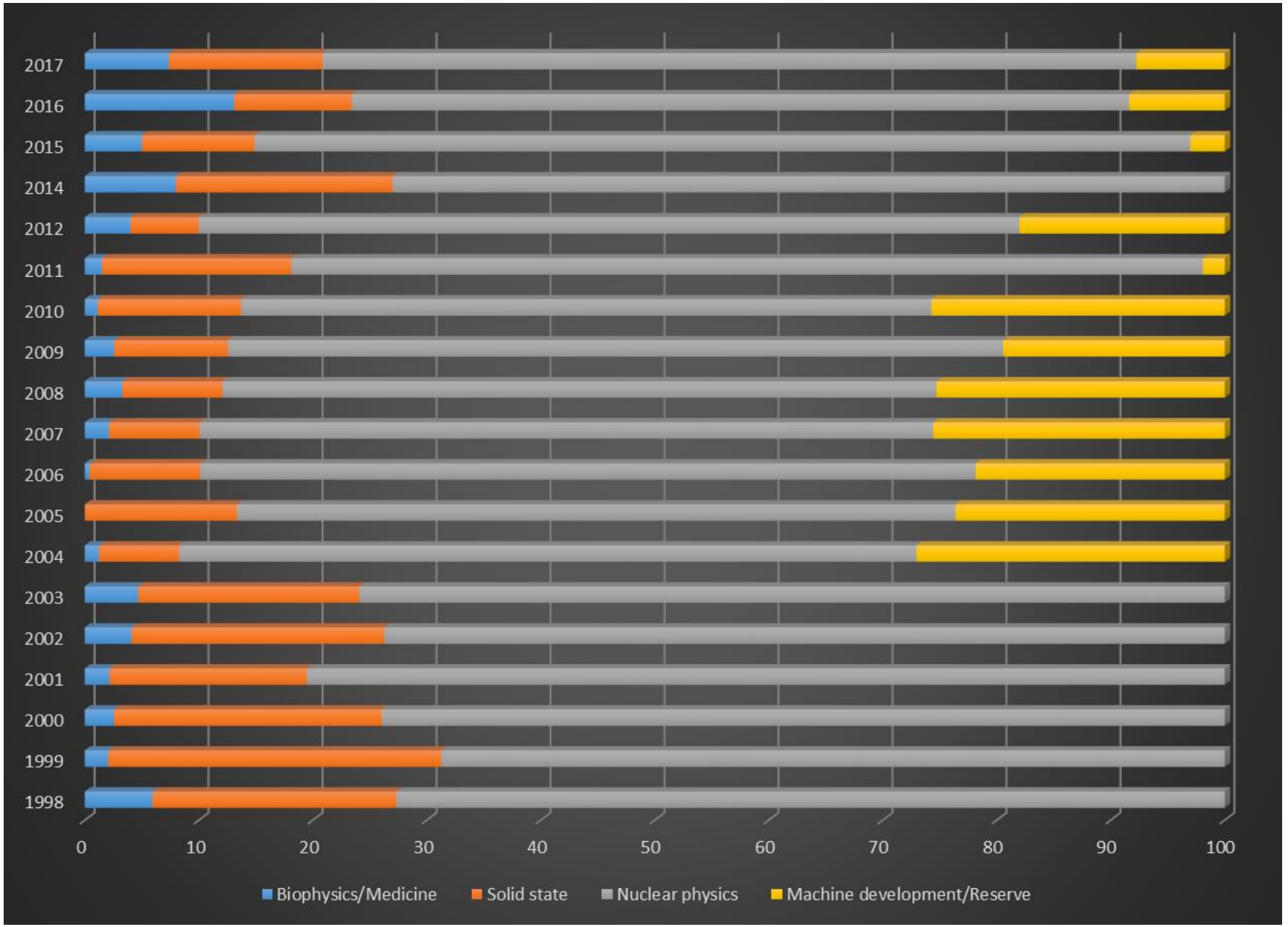
12 extra days of beamtime (21/11->03/12) for ISOLDE

IS657

Total of 18 days (~54 shifts) of extra beam time for ISOLDE physics thanks to MEDICIS!

Adapted from Ramos (ISOLDE workshop 2018)

# Applications: Solid state and biophysics/medicine long at the core of the ISOLDE programme



# GPS schedule 2018

| | April | | | | May | | | | June | | | | | July | | | | | August | | | | September | | | | October | | | | November | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WK | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| MO | 9 | 16 | #534/567 Sn VD5 23 | 30 | 7 | MD: FTS 14 | 21 | 28 | 4 | 11 | 18 | 25 | 2 | 9 | 16 | 23 | 30 | 6 | 13 | 20 | 27 | IS629 3 | #641 UC Ta 10 | 17 | 24 | 1 | 8 | #633 Th 15 | 22 | #638 UCW 29 | 5 | p* off 0600 12 |
| TU | | TISD | | May-01 | | MD:FTS | | | IS610 | | Tech Stop | Medical isotopes | | | | #665 53Mn | | | | | | IS634 | | Tech stop | #619 Pb VD5 | | | | #534 Sn VD5 | | | Prep for winter |
| WE | | TISD | | #599 Tl foils | IS634 | | | | | ISBM | #655 Ta - W | IS528 IS638 | #659 UC VD7 | | | | | | | | | | | (IS655) | | | | | | | (IS655) | Physics |
| TH | #513/ #650 | | IS611 IS640 IS647 IS652 IS653 | | Ascension | | | | | $^{22}$Mg to LA1 | | | | | | | | | XT03 IS616: 4.5MeV/u | #635 UC Ta | | | | (IS604) | | | | | | | | | |
| FR | | | | | | #653 UC - Ta n | | | #634 LIST | | | | | | | #632 ThC VD7 | | #650 513MWCNT | | | IS629: 11Be @ 7MeV/u (IS655) XT03 | Jeune | IS576 IS578 IS630 IS648 IS653 | | IS585 IS602 IS638 IS640 | | IS631 206Hg @ ~ 7.5MeV/u | Gandalph Negative run: IS615 | IS611 IS640 IS647 IS652 IS653 | XT03 IS561 9 Li @ 7.5MeV/u | LOI198 IS637 | |
| SA | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SU | IS633 | | IS622 | | | | | | | IS614 | IS528 | | | IS644 (LOI205) | IS644: 4.8MeV/u (IS506) | | IS552: 4.1MeV/u | | | | | | | | | | | | | | | |
| | | 8B: IDS | 111Cd | | RILIS: Mg | | RILIS: Cu | | RILIS: In | RILIS: Mg | RILIS: Dy | RILIS: Dy | | 96Kr / 212Rn | | | 22x Rn | | 8B | | RILIS: Be | RILIS: Be | RILIS: Mn | | 199Hg | | RILIS: Hg | RILIS: At | 111Cd | | RILIS: Ac | |
| | | | | | | | | | | | (night-time) | | | | | | | | | | | | | | | | | MD on HIE | | | (GLM/GHM/LA1) | |

Cu FT
In FT
Bi FT/in-source
Tl/Hg SPEDE

n-def In
n-rich K
n-def Sn

Sc/In
70Br

Ge + S
Sc
n-rich Sb

**Medical Biophysics**

119Sb for biopac
149Tb/152Tb
199Hg
Ac beam development

β-NMR on liquids

**Parallel Hg/Cd**

Mg,Be
Mn, Ac

Good Mn run

**Travelling**

8B @ LA1
22Mg @ LA1
Ac development
(2 setups)
GANDALPH (-ve)

**TISD/MD**

-ve beams
LIST
New n-conv
RFQ MD
HIE MD
FTS commissioning
(no LIEBE)

**HIE**

**XT03**

# HRS schedule 2018

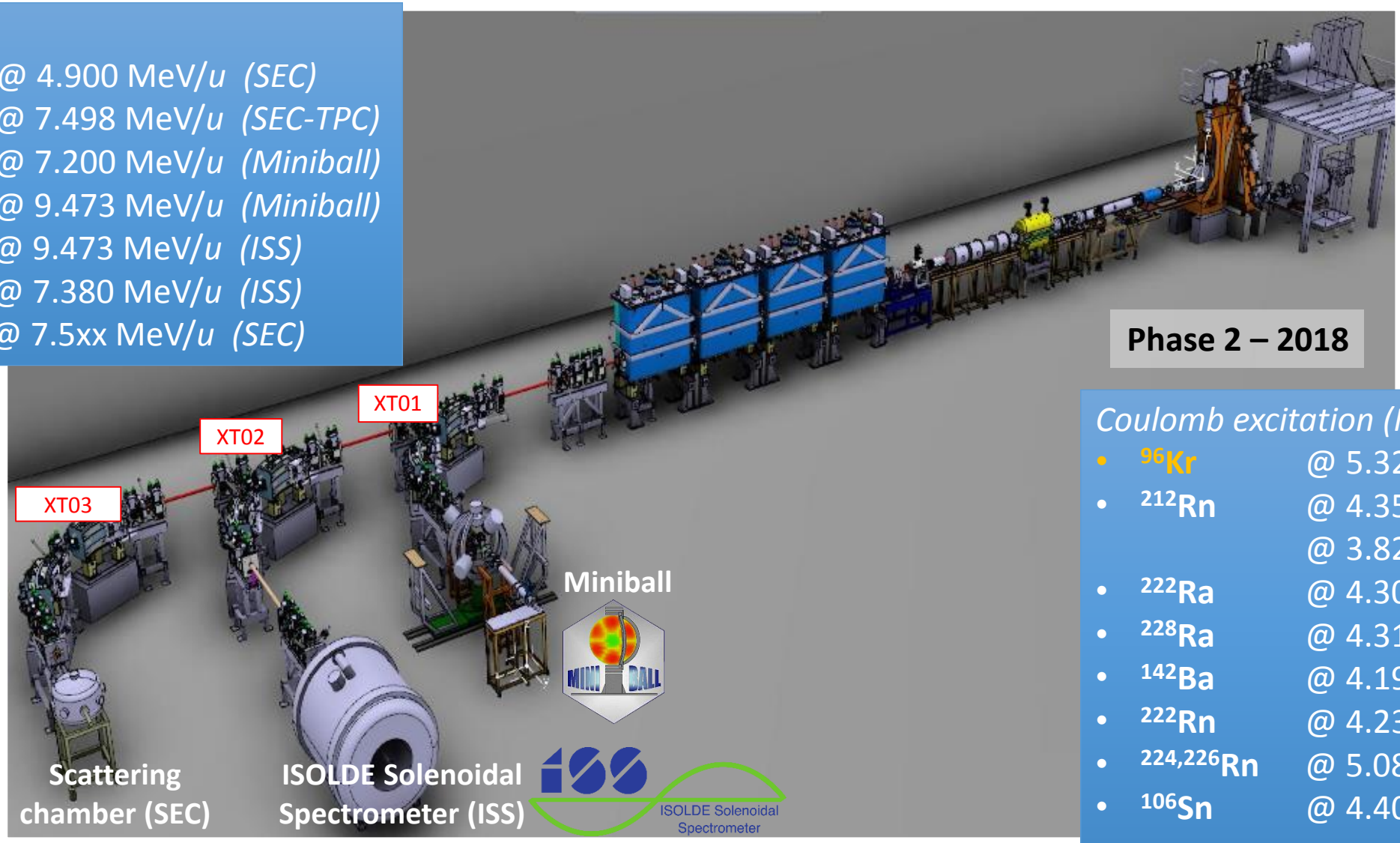
| | April | | | | May | | | | June | | | | | July | | | | | August | | | | September | | | | October | | | | November | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WK | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| MO | 9 | 16 | 23 | #651 ZrO HP 30 | #652 ZrO HP 7 | #618 UC - Ta/W 14 | 21 | 28 | 4 | 11 | 18 | 25 | #658 UC Ta (+CF4) 2 | 9 | 16 | 23 | 30 | 6 | 13 | 20 | 27 | 3 | 10 | 17 | 24 | #662 UC n 1 | IS638 8 | 15 | 22 | # 642 UC n(ew)-conv | TISD 5 | p* off 0600 12 |
| TU | | | | May-01 | | | | | #626 Ta - W | TBC | Tech Stop | Machine development | | | | | | | | | | | | Tech stop | | | | (tbc) UC | | TISD | TISD | Prep for winter |
| WE | | | | TISD | | | | | | | | | | | #637 UC W (+CF4 | | | | | | | | IS654 | | | | | | | #672 CaO VD7 | | |
| TH | | #627 Ta - W | | | Ascension | | #654 UC - W | | | | | | | | | | #631 LaC Ta | | #639 LaC Ta | | | Jeune | | | | | tuning IDS VITO | | | | Physics |
| FR | | | | | | | | | | | | | | | | IS552 IS553: 4.1MeV/u | | IS562: 4.4MeV/u | | | #643 UC + 34S | 134Sn @ 7.33MeV/u | #623 SiC | IS651 28Mg @ 9.5MeV/u | IS621 28Mg@9.5 MeV/u | | | IS645 | | | (separate file) |
| SA | | | | | | | | | | | | | | | | | | | | | | | | | | | | | IS641 (and Sat night) | | WISArD | |
| SU | IS639 | | IS532 | IS623 | IS642 | IS645 | | IS620 | IS649 | | | | IS650 IS637 IS608 | | | | | | IS613 | | | | | | | IS635 | | | | | LOI172 | |
| | In RILIS | | Sc RILIS | RILIS test | 70Br | 26Na | | K beams | Sc RILIS | | | | RILIS: Bi | | | 22xRa/142Ba | | Sn RILIS | Sn RILIS | | 134Sn+34S | | RILIS: Mg | | RILIS: Sb | | | RILIS: Tl | | RILIS: for TISD | |
| | (#640 LaC - n) | | In RILIS | Ge 34S | | | | | | | | | | | | | | | | | | | | | | | | MD on HIE | | | | |

# HIE-ISOLDE EXPERIMENTS 2018

reaching 9.5 MeV/u with HIE-ISOLDE

*Reactions:*

- $^{8}$**B**($^{64}$Zn) @ 4.900 MeV/*u* *(SEC)*
- $^{11}$**Be**(decay) @ 7.498 MeV/*u* *(SEC-TPC)*
- $^{132,134}$**Sn**(*d*,*p*) @ 7.200 MeV/*u* *(Miniball)*
- $^{28}$**Mg**(*t*,*p*) @ 9.473 MeV/*u* *(Miniball)*
- $^{28}$**Mg**(*d*,*p*) @ 9.473 MeV/*u* *(ISS)*
- $^{206}$**Hg**(*d*,*p*) @ 7.380 MeV/*u* *(ISS)*
- $^{9}$**Li**(*t*,*p*) @ 7.5xx MeV/*u* *(SEC)*

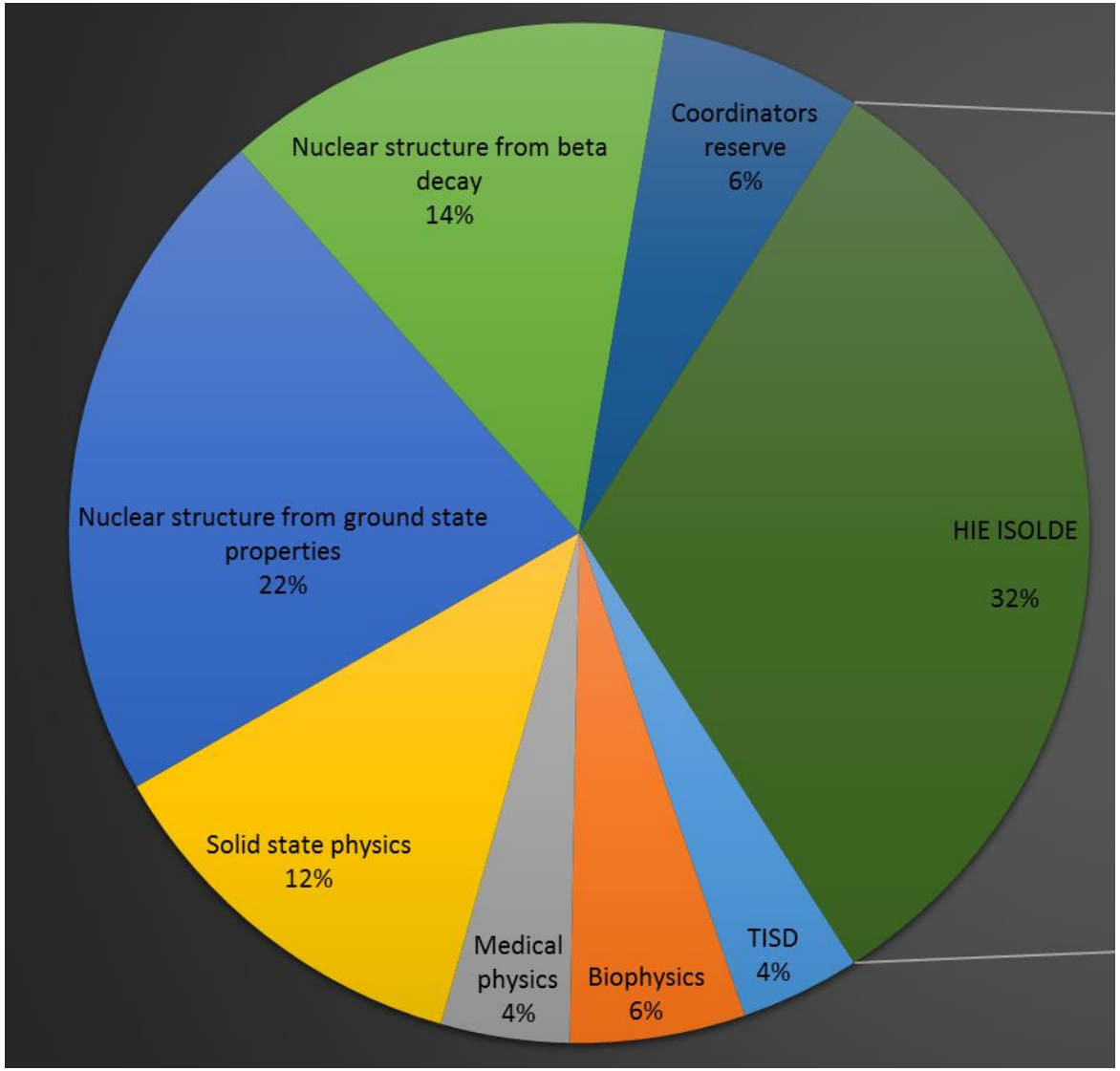



**Phase 2 – 2018**

*Coulomb excitation (Miniball):*

- $^{96}$**Kr** @ 5.325 MeV/*u*
- $^{212}$**Rn** @ 4.355 MeV/*u*
  @ 3.824 MeV/*u*
- $^{222}$**Ra** @ 4.305 MeV/*u*
- $^{228}$**Ra** @ 4.310 MeV/*u*
- $^{142}$**Ba** @ 4.190 MeV/*u*
- $^{222}$**Rn** @ 4.230 MeV/*u*
- $^{224,226}$**Rn** @ 5.080 MeV/*u*
- $^{106}$**Sn** @ 4.404 MeV/*u*

# 2018 distribution




| Étiquettes de lignes | Nombre de Delivered 2018 |
|---|---|
| Biophysics | 4 |
| COLLAPS | 3 |
| COLLAPS; VITO | |
| Collections :7Be | |
| Collections: 163Ho | |
| CRIS | 4 |
| Gandalph | 1 |
| HIE | 12 |
| IDS | 5 |
| ISOLTRAP | 2 |
| la1 | 1 |
| MEDICAL | 2 |
| Medicine | |
| Miniball | |
| NICOLE | |
| REX | 1 |
| Special | 1 |
| SSP | 13 |
| TAS | |
| TISD | |
| VITO | |
| Windmill/IDS | |
| Windmill; ISOLTRAP | 1 |
| WITCH | 1 |
| (vide) | |
| Total général | 51 |

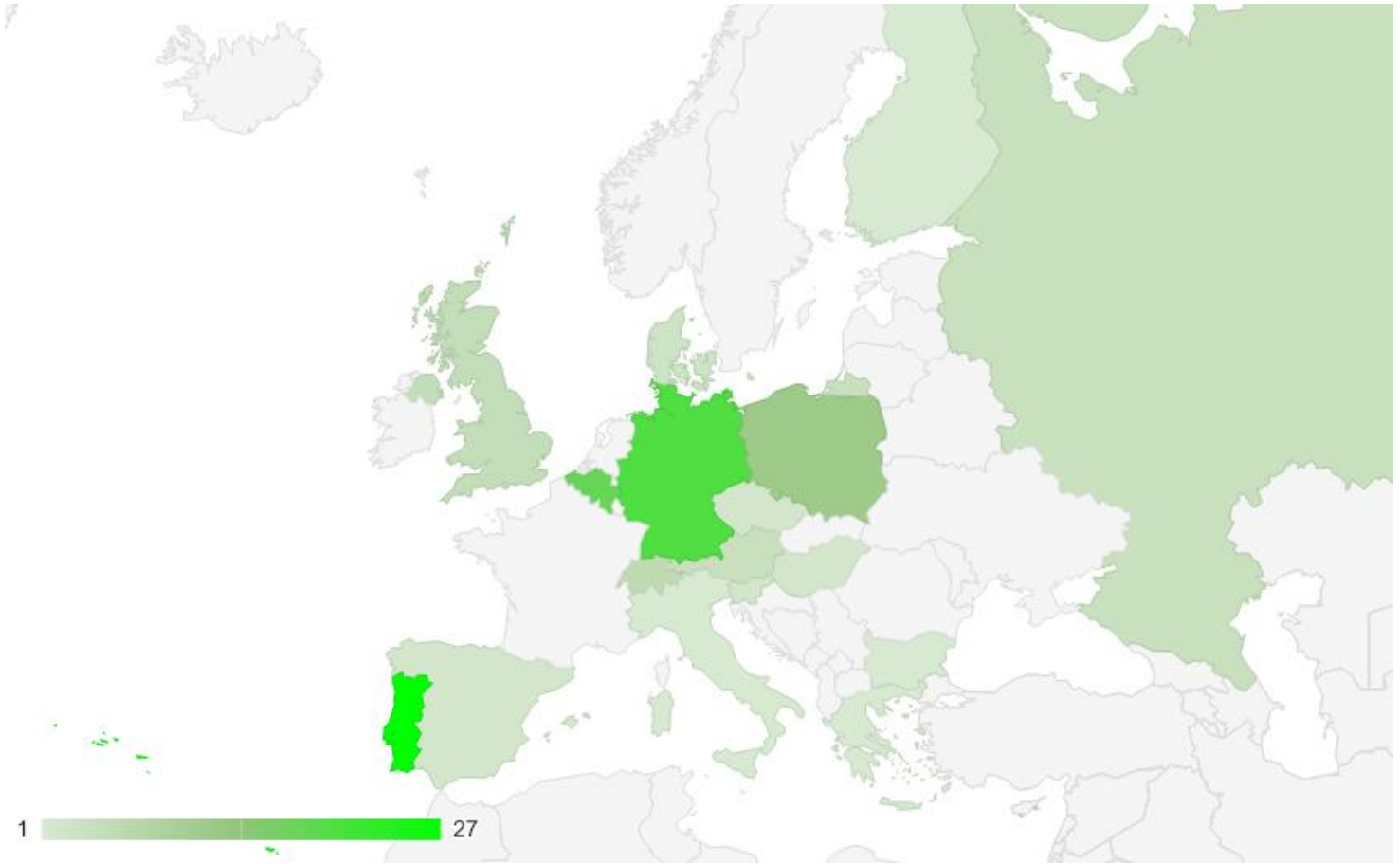
27 experiments/letters of intent in Solid state at ISOLDE. 1/6 of the overall programme.

# Solid state physics/Biophysics @ ISOLDE

**Solid State physics & materials science:**

Semiconductors, Metals, High Tc Superconductors, Multiferroic materials, topological insulators, surface physics.

**Biophysics:** structural properties & role of heavy metals in proteins, DNA.




## Collaborations

| | |
|---|---|
| Running experiments/letters of intent | 27 |
| Participating countries | 22 |
| Scientists | **134** |

Bundesministerium für Bildung und Forschung

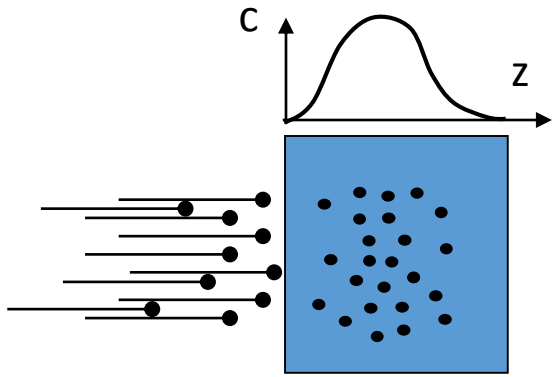
FCT Fundação para a Ciência e a Tecnologia

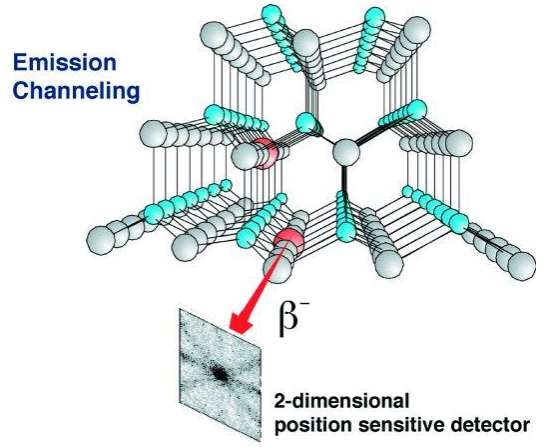
KU LEUVEN

fwo Research Foundation Flanders Opening new horizons

# Unique features of radioactive probe atoms for SSP applications

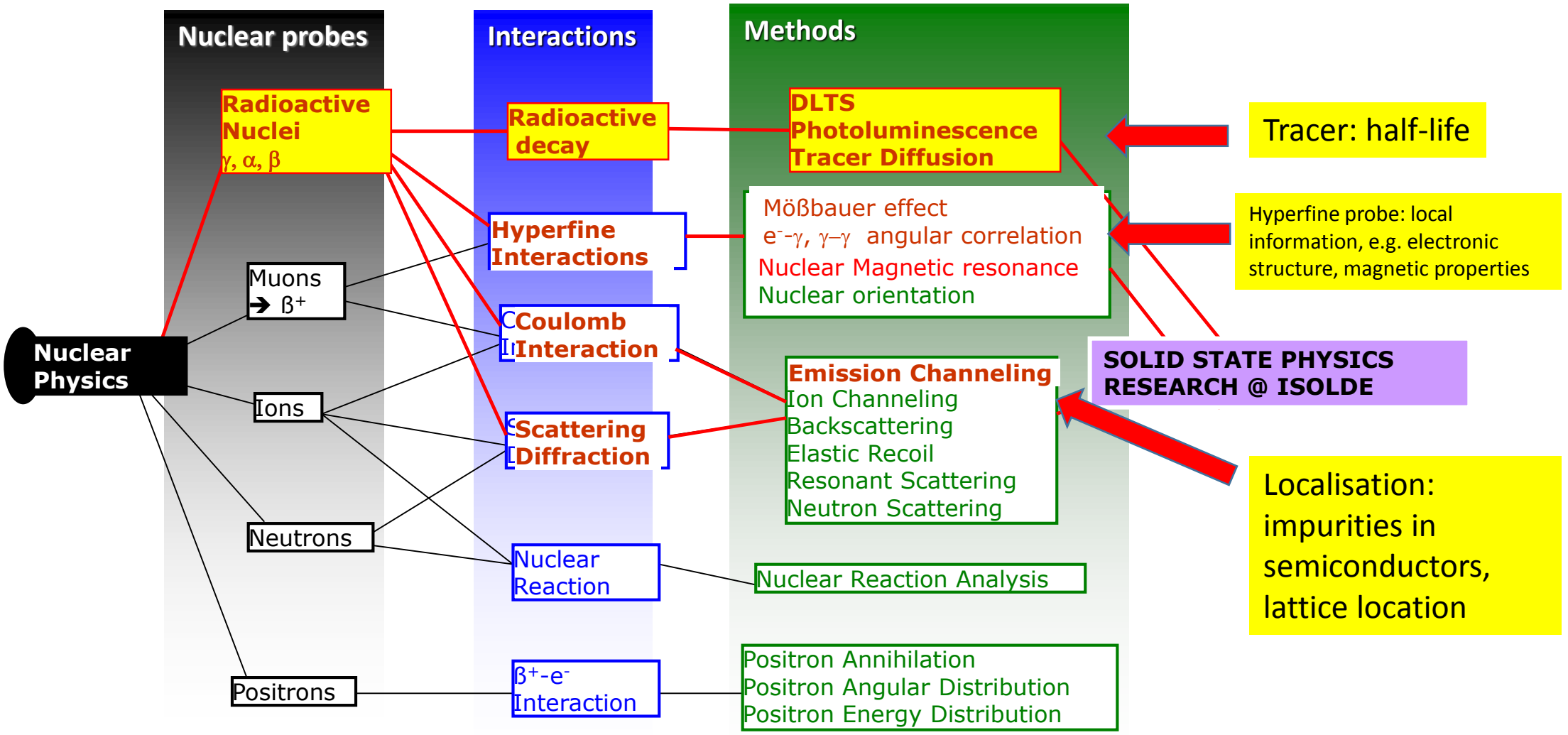
- **Chemically selective and isotope specific**
- **Extremely good detection limit**
  - among the most sensitive methods, no reaction cross section limitation
    - $10^{15}$ - $10^{18}$ probes/cm$^3$
    - $10^{11}$ - $10^{12}$ probe atoms
- **Depth distribution and concentration control**
  - Ion energy and ion fluence control
  - Circumventing solubility and diffusion limits
- **Highly local Information**
  - Nucleus-size sensors for **local** magnetic and electric fields
    Electric Field Gradient ~ r $^{-3}$
    Emission channeling: ~ 0.02 nm position resolution



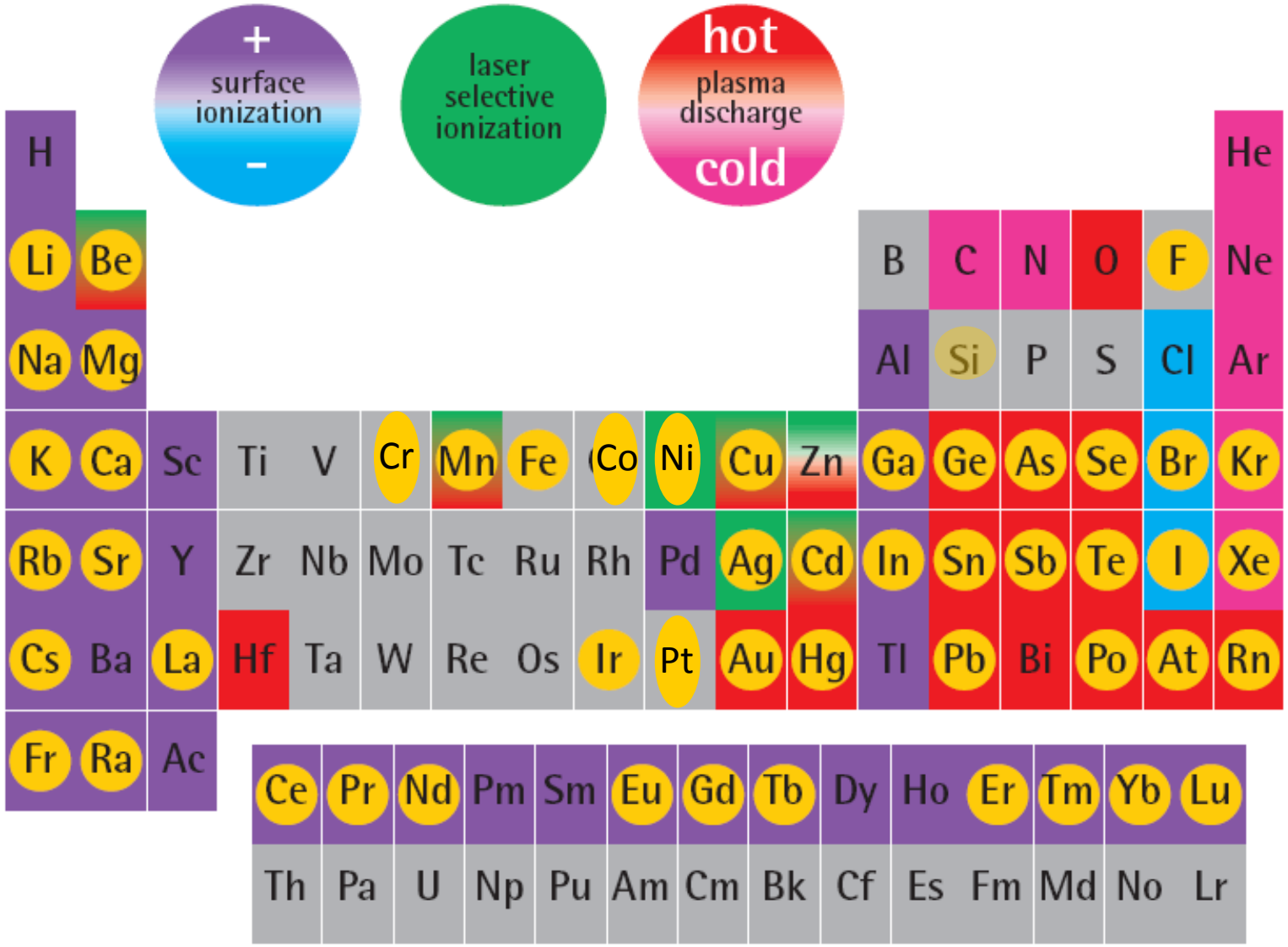




**Why radioactive probes ? Sensitive – Selective - Controllable – Local**
**Often relatively easy isotopes for RIB facilities to produce (not always a good thing…)**

# Applying radioactivity to solid state physics



# ISOLDE table of elements




Workhorse probes:

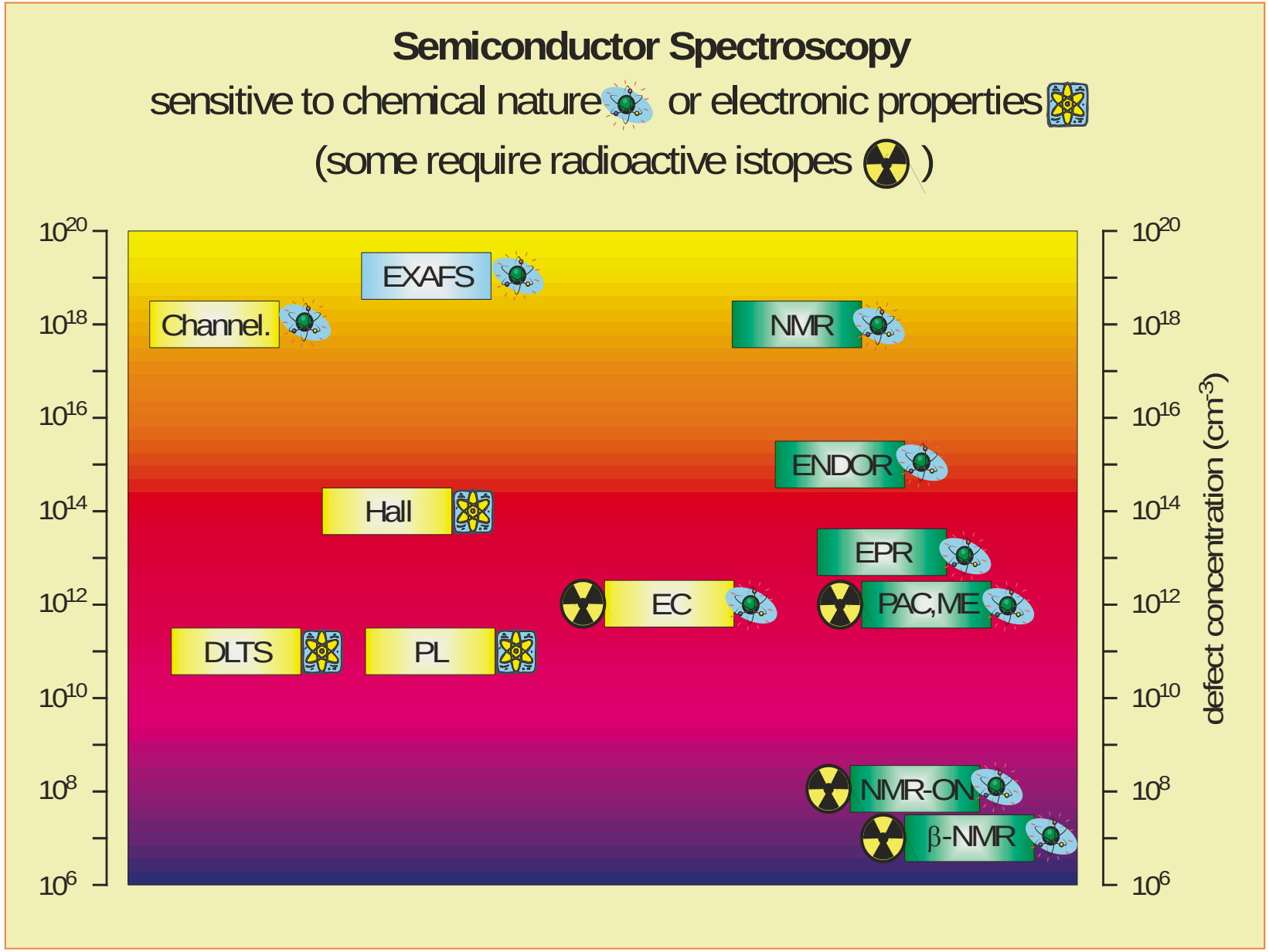
$^{111}$Cd, $^{199}$Hg, $^{117}$Cd, $^{57}$Mn, $^{73}$As

New promising probes:

$^{68}$Cu, $^{149}$Gd, $^{172}$Lu, $^{151}$Gd, $^{197}$Hg

**Isotopes of this element used for solid state physics or life science**

Solid state demands have been a driver in the development of new beams at ISOLDE




PAC, ME, EC, DLTS, PL and beta-NMR all available on-site

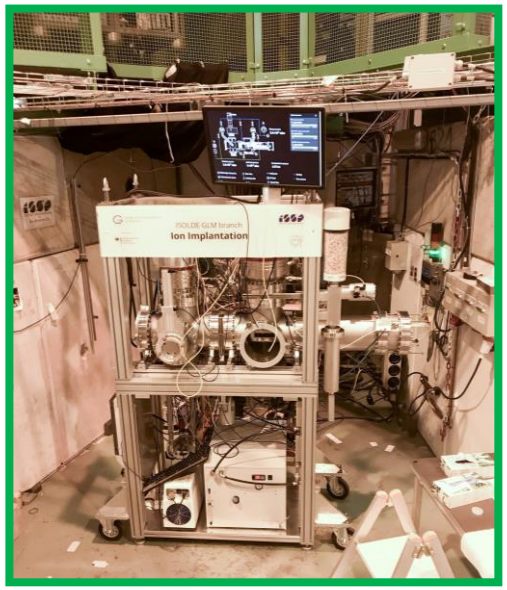
In addition: chemical and thermal processing labs for post-irradiation treatment.

Rule of thumb: $10^{10}$ – $10^{11}$ atoms for most experiments.

Allows sensitivity without interference of the host material

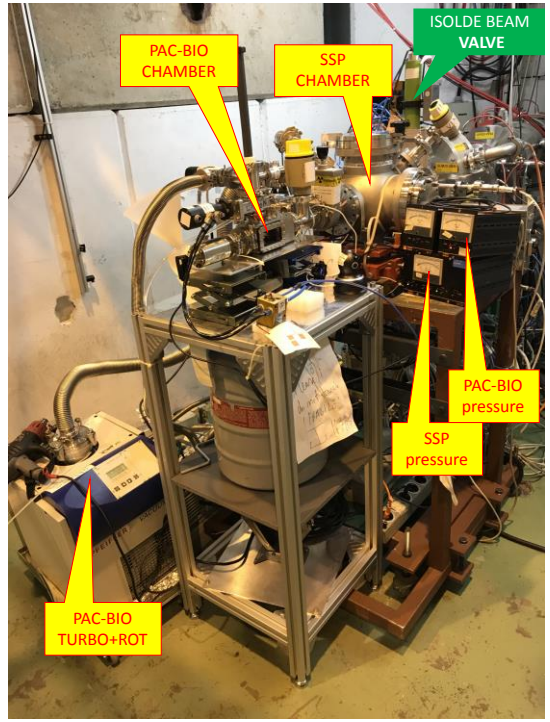
**Experimental techniques used with radioactive isotopes at ISOLDE**

# Overview of setups at ISOLDE



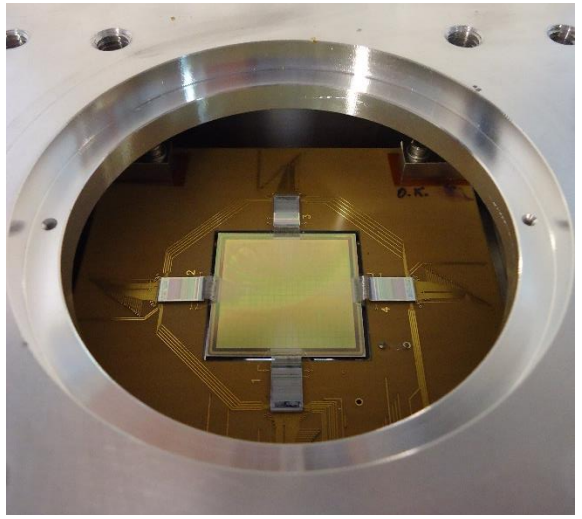

Old and new collection chambers for solid state physics and similar. Existing chamber being replaced by more efficient and ergonomic chamber. Load lock system. **No longer used for strong collections e.g. medical isotopes.**

Dedicated well-shielded chamber for medical physics collections.




Bespoke chamber for collections of isotopes for biophysics

# Emission Channeling Experiments ONLINE



NEW FAST VATAGP7 > 8 kHz
PAD detector

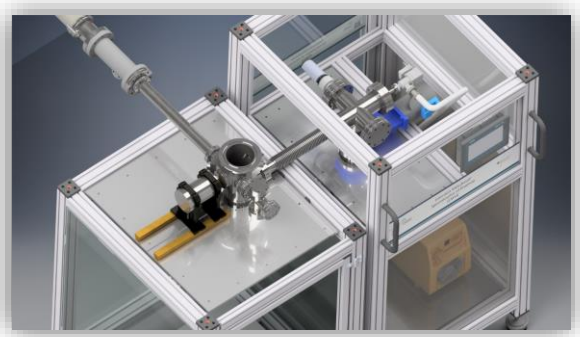
Online setup for emission channeling with short-lived isotopes. No manipulation/handling (t1/2 <2h). Intervention at setup for adjusting crystal direction.

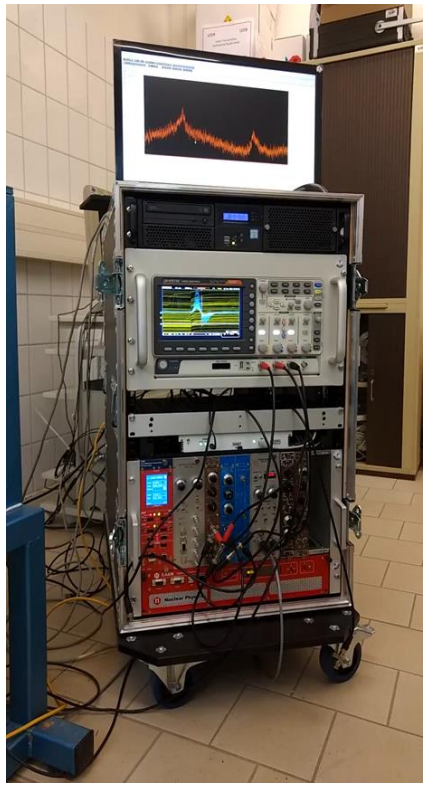
Annealing up to 900°C

And cooling down to 50K

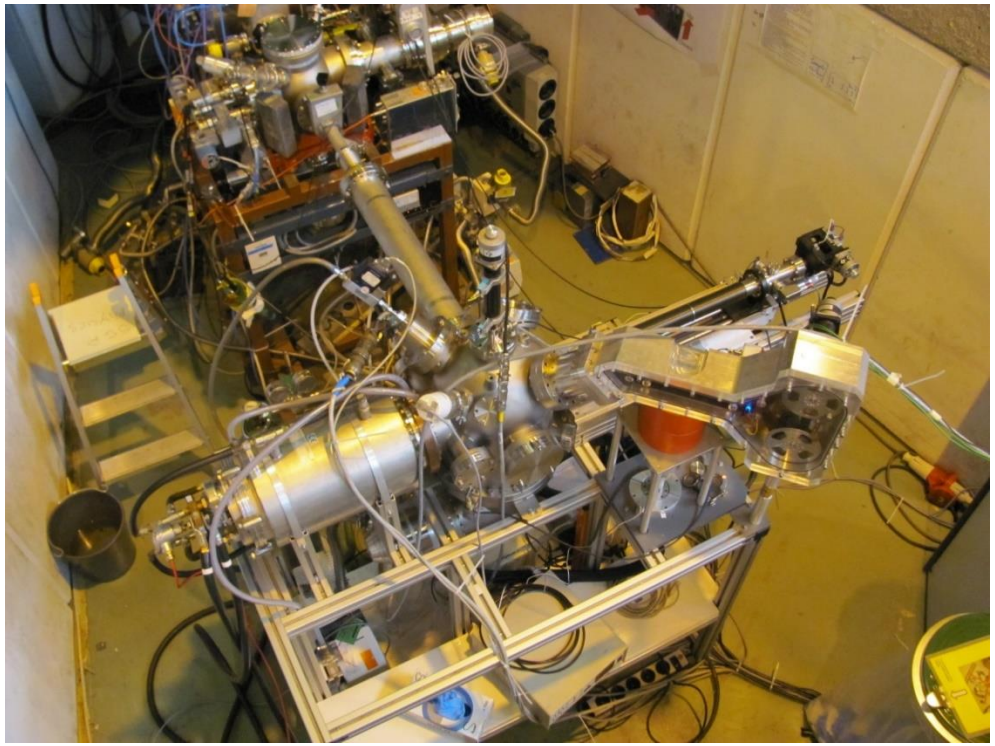
Online setup for PAC

Online Mossbauer spectroscopy

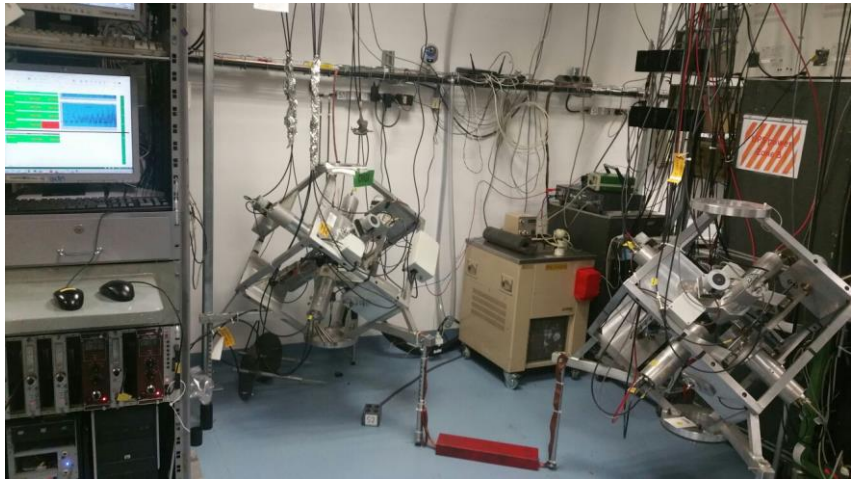




Online diffusion studies



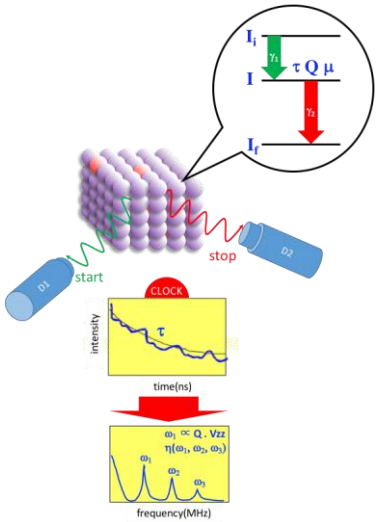
# Offline labs at ISOLDE: chemistry; spectroscopy; characterisation



# Probe elements

Available at ISOLDE

NOT available at ISOLDE




P → Perturbed Angular Correlations
M → Mössbauer Effect
β → Mössbauer Effect

**Wish for PAC !**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | | | | | | He |
| Li β | Be | | | | | | | | | | | B | C | N | O | F P | Ne |
| Na β | Mg β | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| K M | Ca | Sr | Ti | V P | Cr | Mn | Fe M | Co | Ni P M | Cu P | Zn M | Ga | Ge P M | As P | Se P | Br P | Kr P M |
| Rb | Sr | Y | Zr | Nb | Mo | Tc P M | Ru M | Rh P | Pd | Ag | Cd P | In P | Sn P M | Sb M | Te M | I M | Xe M |
| Cs P M | Ba M | La M | Hf M | Ta P M | W M | Re M | Os M | Ir P M | Pt M | Au M | Hg P M | Tl | Pb P | Bi | Po | At | Rn |
| Fr | Ra | Ac | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ce | Pr P M | Nd M | Pm M | Sm M | Eu P M | Gd M | Tb M | Dy M | Ho M | Er M | Tm M | Yb P M | Lu M | | |
| Th M | Pa M | U M | Np M | Pu M | Am M | Cm | Bk | Cf | Es | Fm | Md | No | Lr | | |

only g- g PAC

only e⁻-g PAC

only g-e⁻ PAC

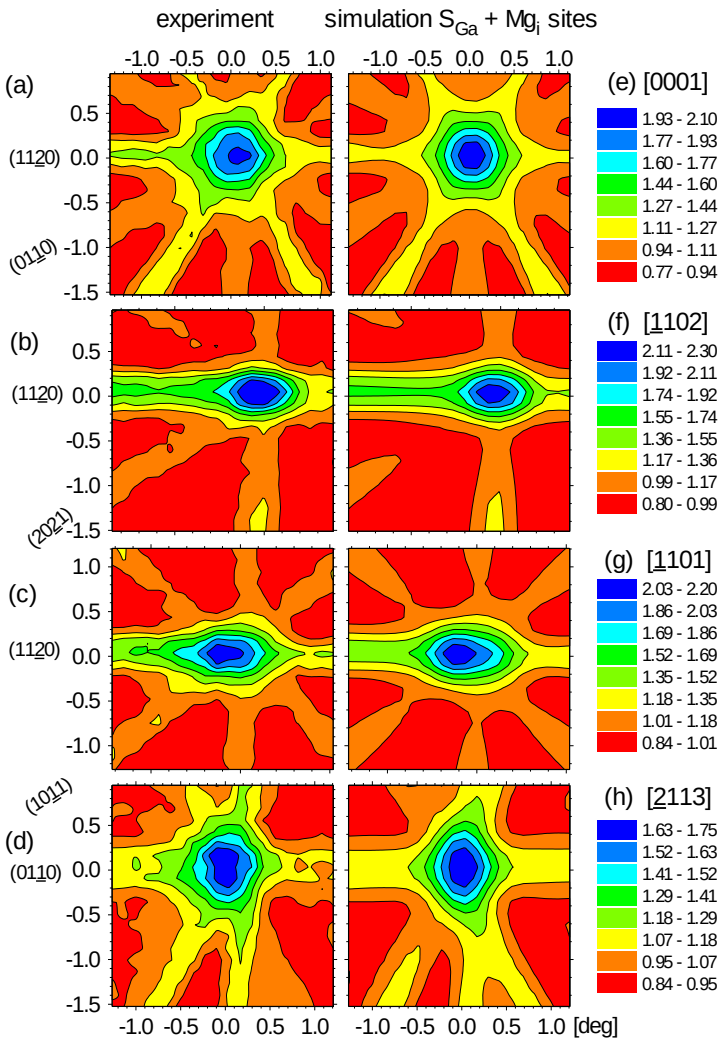
g- g & g-e⁻ PAC

g- g & e⁻-g PAC

PAC elements already used with current, I, greater than 1pA ($6x10^6$ pps)

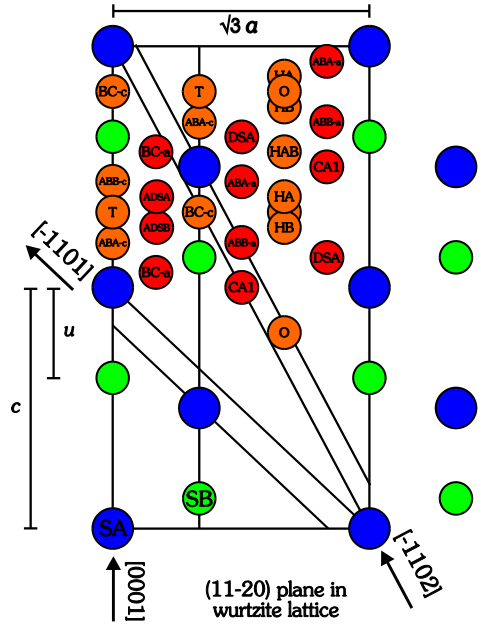
**PAC short lived elements, ($^{19}O$ 27s and $^{22}Mg$ 3.9 s) $2x10^6 > I > 5x10^5$ at/s**

# p-type dopants in GaN




*Phys. Rev. Lett.* **118**, 095501 (2017)

High-symmetric sites in wurtzite structure



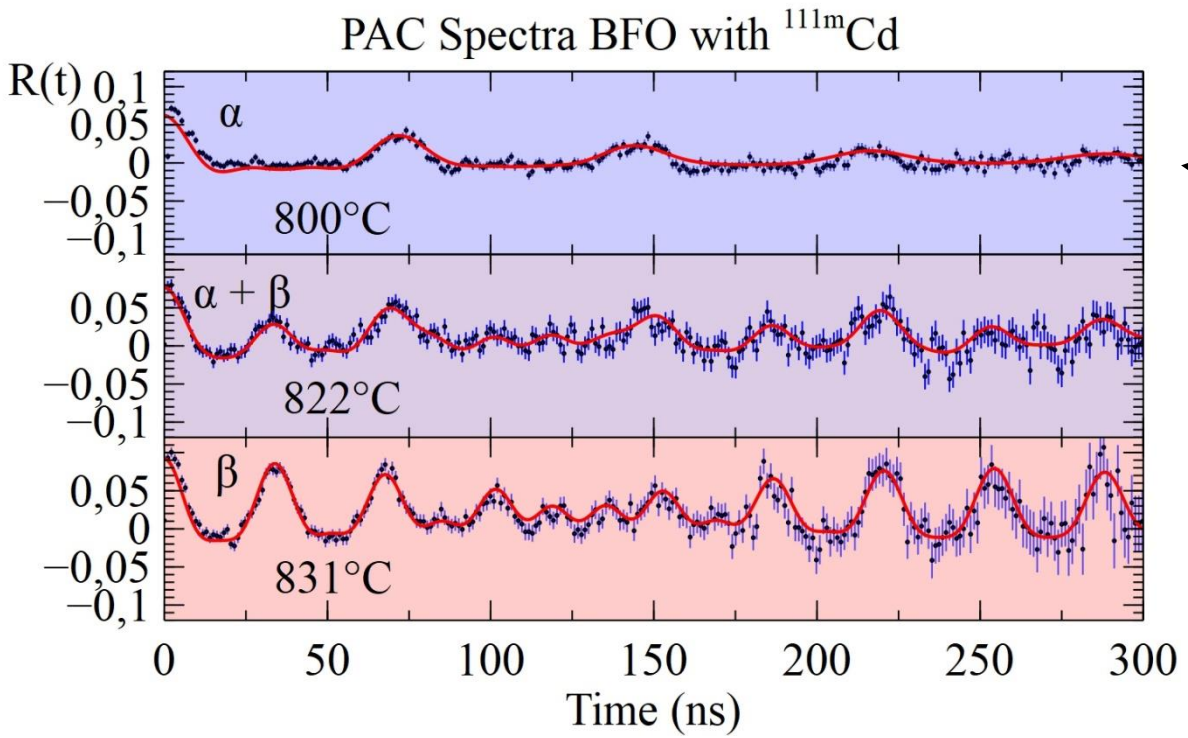

$C_{3v}$ symmetry:
SA, SB: substitutional
BC-c: bond-centered c-axis
ABA-c, ABB-c: anti-bonding c-axis
T, O: wide open interstitial
HA, HB, HAB: "hexagonal"

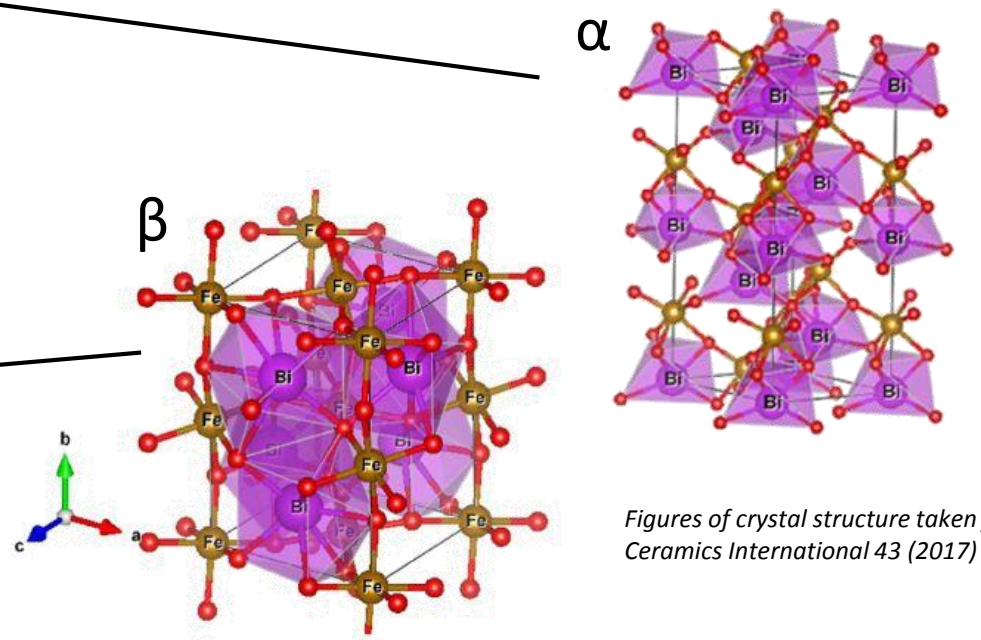
lower symmetry
off c-axis:
BC-a: bond-centered
ABA-a, ABB-a: anti-bonding
DSA, ADSA: symmetric
coplanar with A-B bonds

emission channeling with $^{27}$Mg (9.5 min) (on-line)

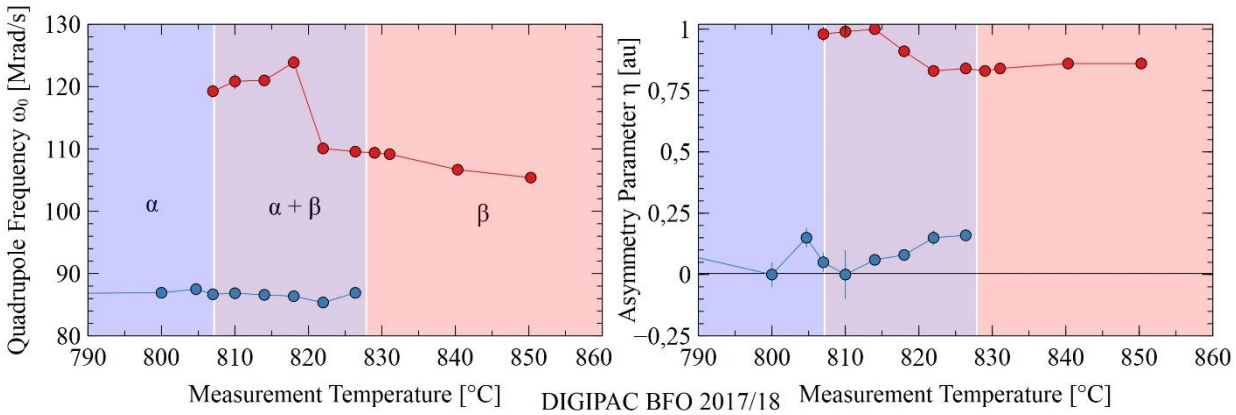
- First direct observation of Mg interstitials
- Identification of the lattice position: interstitial positions +0.6 Å from O sites
- Interstitial migration with migration energy = 1.3 - 2.0 eV
- Is interstitial Mg the origin of the p-type doping limit?
  - Complementary techniques required

# IS647 - Local probing of multiferroic compounds



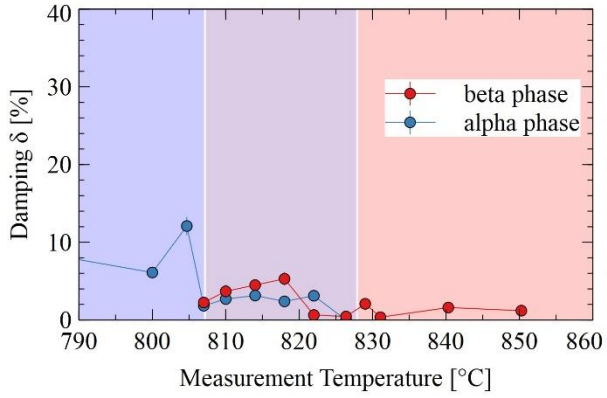

*Figures of crystal structure taken from Ceramics International 43 (2017) 1256–1264*

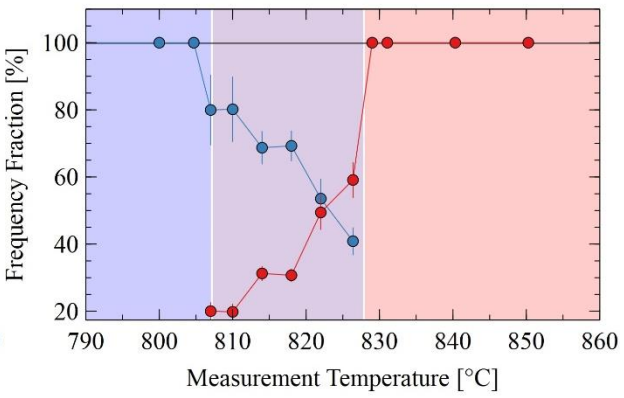






DIGIPAC BFO 2017/18




Georg Marschick, Juliana Schell – IS647 collaboration

ISOLDE Solid State Physics

Bundesministerium für Bildung und Forschung

UNIVERSITÄT DUISBURG ESSEN

TU WIEN TECHNISCHE UNIVERSITÄT WIEN

# Status January 2019

| Étiquettes de lignes | Sum of Shifts remaining (Feb 2018) | Sum of Delivered 2018 | Count of Delivered 2018 | Count of Exp. no. | Sum of Shifts remaining 2018 | Sum of Shifts remaining Jan 2019 |
|---|---|---|---|---|---|---|
| Biophysics | 79,5 | 31 | 4 | 6 | 48,5 | 48,5 |
| COLLAPS | 69 | 35,5 | 3 | 6 | 33,5 | 33,5 |
| COLLAPS; VITO | 13 | | | 1 | 13 | 13 |
| Collections :7Be | 24 | | | 1 | 24 | 24 |
| Collections: 163Ho | 6 | | | 1 | 6 | 6 |
| CRIS | 85,5 | 57 | 4 | 8 | 28,5 | 28,5 |
| Gandalph | 17 | 9 | 1 | 2 | 8 | 8 |
| HIE | 746,5 | 152,5 | 12 | 48 | 594 | 585 |
| IDS | 92 | 36 | 5 | 12 | 56 | 56 |
| ISOLTRAP | 51 | 17 | 2 | 8 | 34 | 34 |
| la1 | 37 | 10 | 1 | 6 | 27 | 27 |
| MEDICAL | 25 | 20,5 | 2 | 2 | 4,5 | 0 |
| Medicine | 4 | | | 3 | 4 | 4 |
| Miniball | 2 | | | 1 | 2 | 2 |
| NICOLE | 29 | | | 2 | 29 | 29 |
| Special | 3 | 3 | 1 | 1 | 0 | 0 |
| SSP | 138,5 | 66,5 | 13 | 27 | 72 | 72 |
| TAS | 11,5 | | | 3 | 0 | 0 |
| TISD | 14 | | | 3 | 14 | 14 |
| VITO | 0 | | | 1 | 0 | 0 |
| Windmill/IDS | 22,5 | | | 1 | 22,5 | 22,5 |
| Windmill; ISOLTRAP | 3 | 3 | 1 | 1 | 0 | 0 |
| WITCH | 15 | 5 | 1 | 1 | 10 | 10 |
| (vide) | 0 | | | 2 | 0 | 0 |
| REX | 47 | 8 | 1 | 6 | 39 | 6 |
| Total général | 1535 | 454 | 51 | 153 | 1069,5 | 1023 |

INTC meetings in 2019

776.5 shifts requested to be retained (some may be released after collaboration meetings in 2019…)

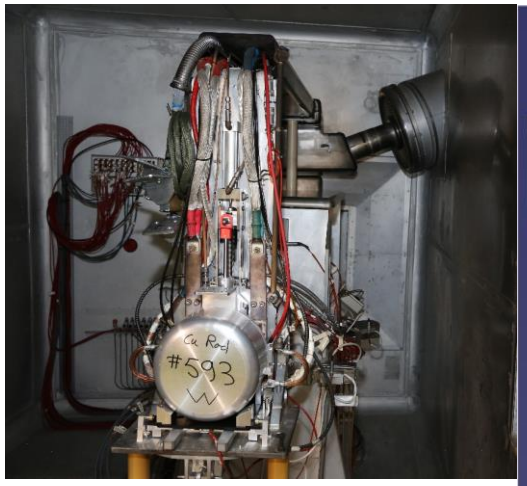
Effective backlog now ~776.5 shifts, some experiments may change after collaboration meetings.

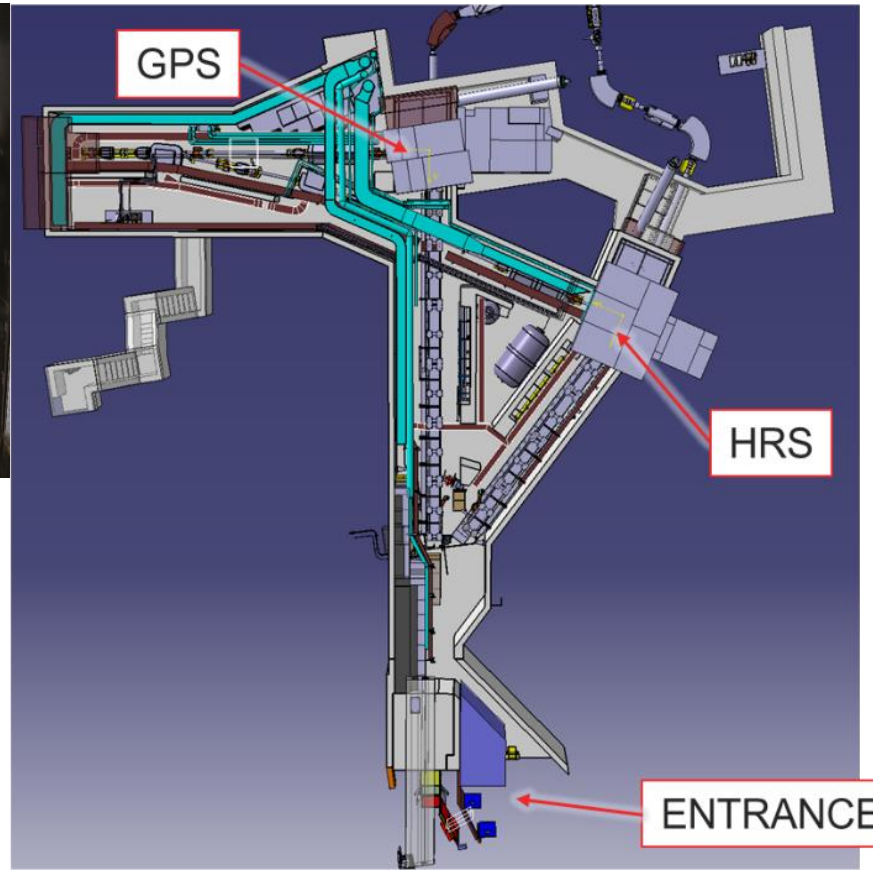
New proposals may be accepted in early 2020 (tbc).

SSP proposals will bbe reviewed in Feb 2020 → new proposals only in July 2020. New proposals strongly favoured over addenda.

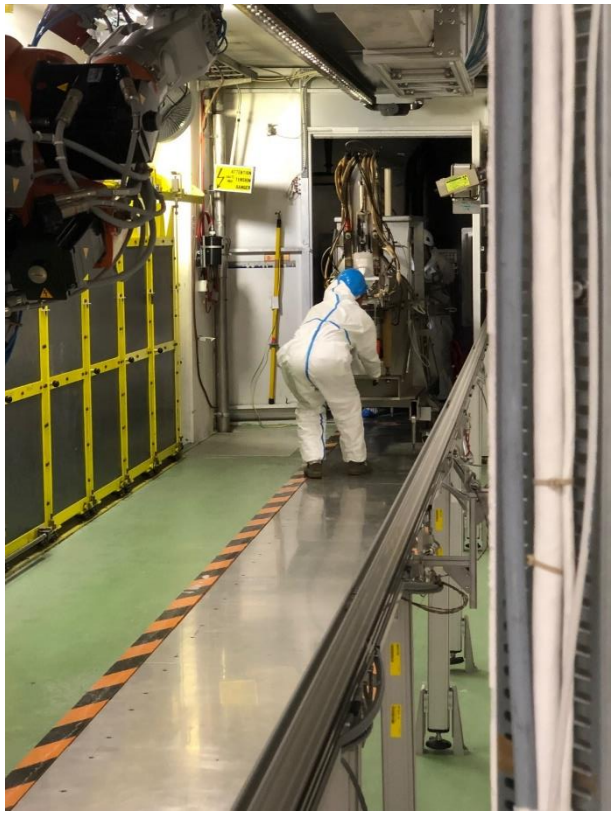
| Étiquettes de lignes | Sum of Shifts remaining Jan 2019 |
|---|---|
| Biophysics | 48,5 |
| COLLAPS | 23 |
| Collections :7Be | 24 |
| Collections: 163Ho | 6 |
| CRIS | 23,5 |
| Gandalph | 8 |
| HIE | 461 |
| IDS | 33 |
| ISOLTRAP | 22 |
| la1 | 20 |
| Miniball | 2 |
| NICOLE | 29 |
| SSP | 43 |
| TISD | 11 |
| Windmill/IDS | 22,5 |
| Total général | 776,5 |

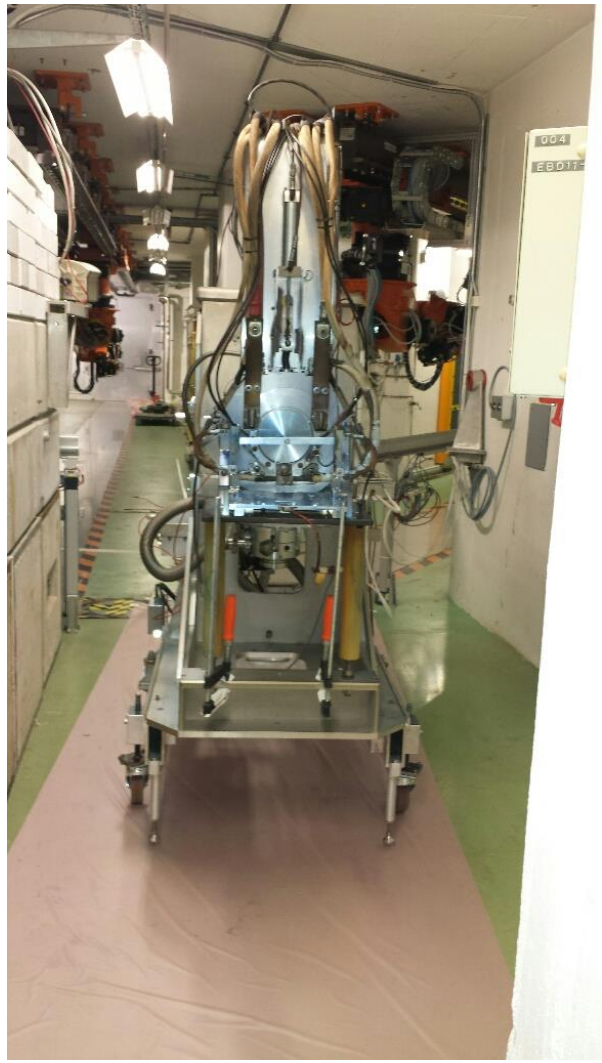
# TARGET AREA



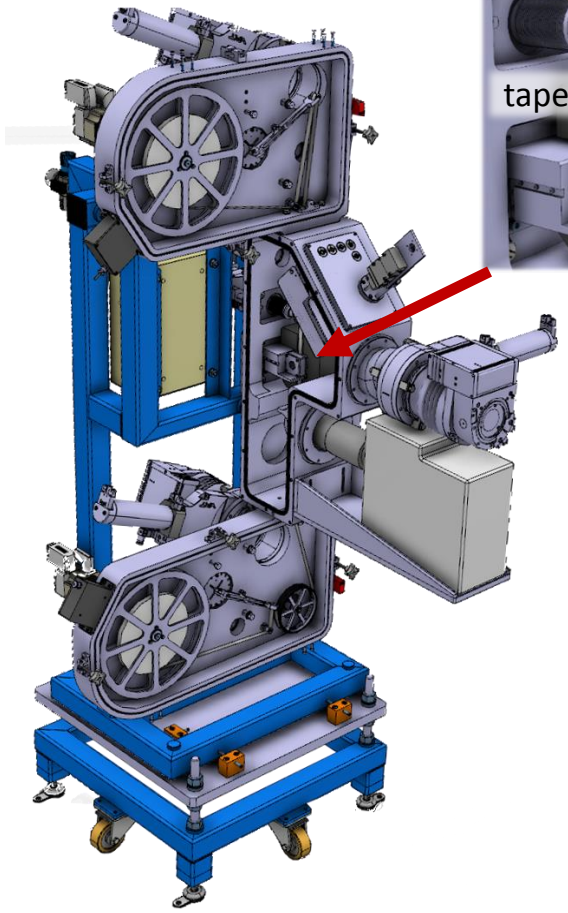
# Old HRS FE status

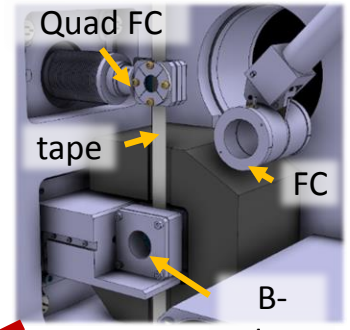


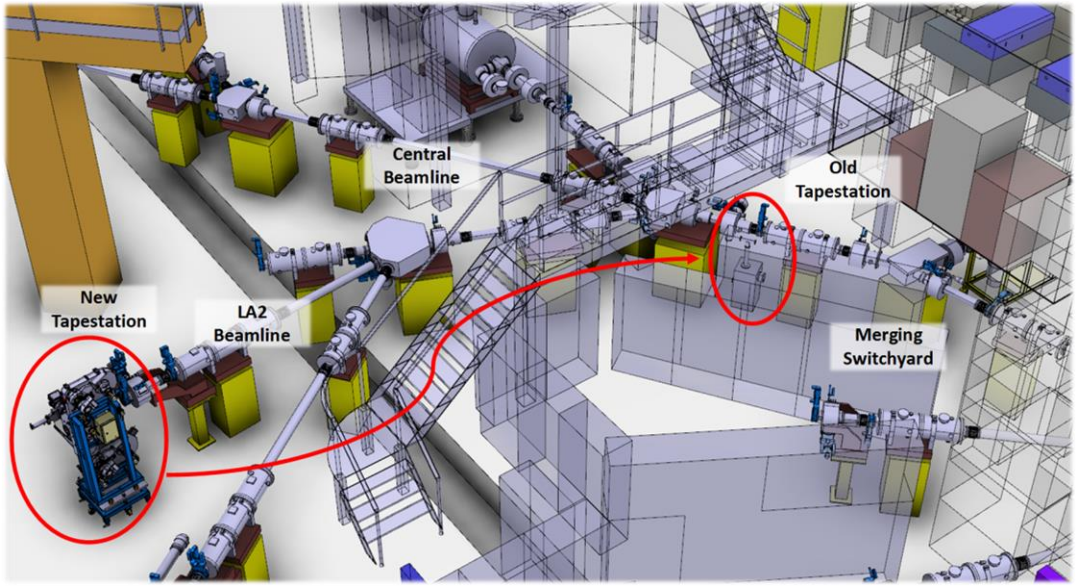


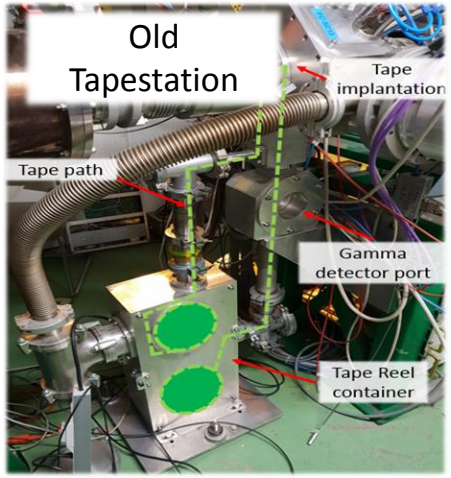
- FE successfully extracted from Faraday cage and sprayed for fixing contamination.

# New Tapestation






<u>Final steps in the new fast tapestation project.</u>

- It has been a lengthy project, lots of different specialist skills required.
- Project stalled due to lack of manpower and other projects of greater importance in 2016-18.
- S.Warren was asked to take over project in July 2018.
- Systems must be fully operational start-up 2020

Richard Catherall, Tim Giles, Stuart Warren

# Installation of the HT modulators

Thierry Gharsa, Jan Schipper TE-ABT

- High precision 60kV D.C. HV Power Supply
  - 2 operational HVPS units installed on HT1 & HT2 and 2 spares available.

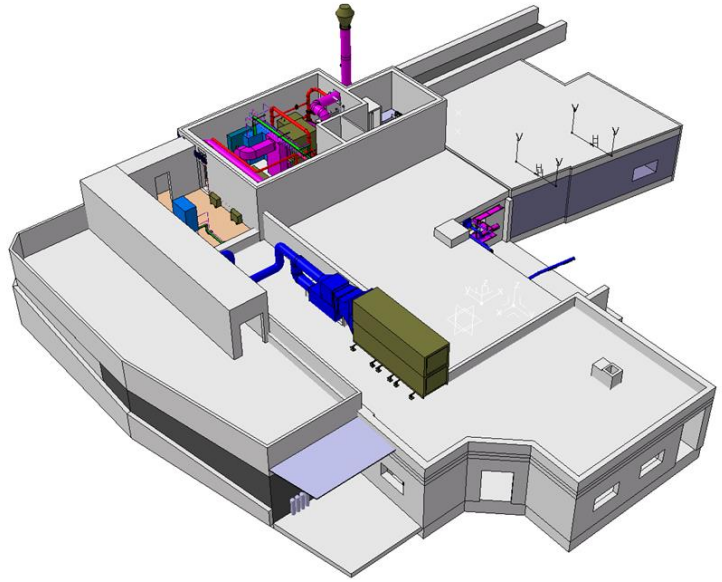
- Target Modulators
  - 2 operational HT fast recovery systems installed on HT1 & HT2, 1 spare in b867.
  - Improved HT ripple on HT1. Measured to < 1 Vpp @30kV (to be done on HT2).
  - Capable of recovery time to 1 Vpp in 1 ms (load dependent but not only…).
  - HV dividers need fine compensation adjustment of the frequency response to truly get precise recovery time < ~ 5 ms. Tested but not yet performed.

- FESA3 compliant control systems deployed
  - PXIe controllers and acquisition boards replace the FEC LynxOS + GM (discarded).
  - Power Control Units with HT safety interlocks, 1 spare available in b867.
  - No more water cooling. Only oil circulation pumps integrated in the control.
  - HT1/HT2 start modulator triggers auto managed based on the HRS/GPS HT switch position.

- On site test load and HT calibration tools for troubleshooting
  - Dynamic test load for testing HT1/HT2 only when disconnected from targets.
  - External commercial HT divider for DC calibration.
  - Ripple measurement to $10^{-5}$.

- To be done
  - HT2 maintenance, fine compensation adjustment of the dividers, cleaning (LS2).
  - Old control decabling (YETS21-22).
  - Negative polarity (2021).

# General Layout of the Nanolab

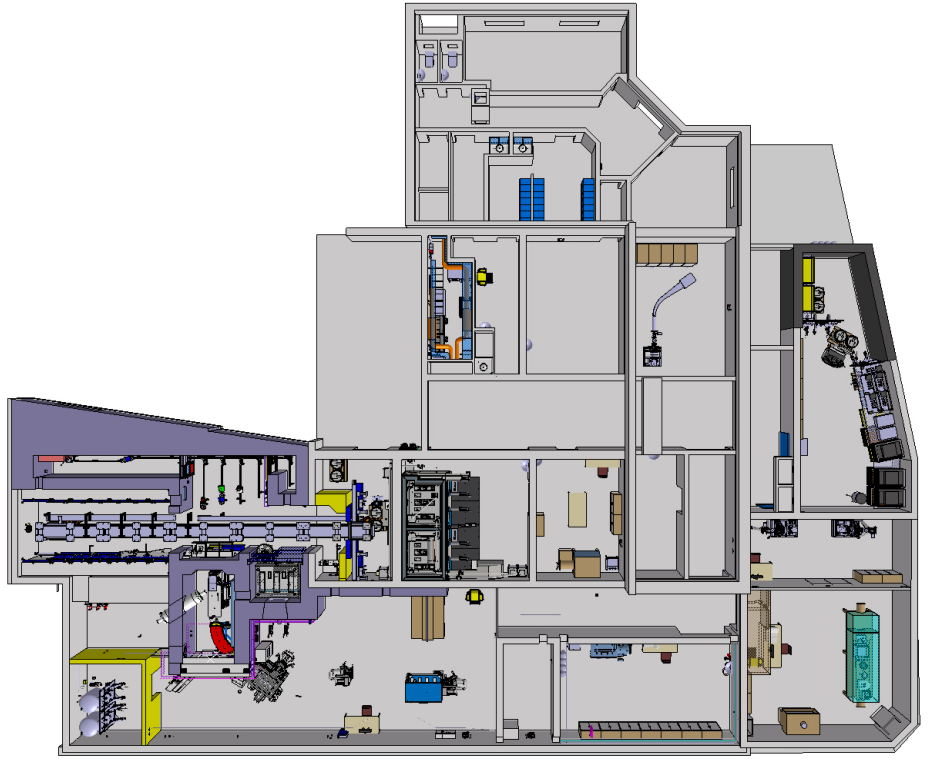


Phase 1: Jan 2020 – Oct 2020
Overseen by SMB /civil engineering:

- Technical corridor to be approved by CV
- Final finishing of walls and ceiling including first coat of paint
- Passages in walls for services will be done

Phase 2: Nov 2020 – May 2021
Installation of services:

- CV
- EL
- Finalising civil engineering work by SMB
- IT / DI/ CA/ Gaz



Richard Catherall

# HIE ISOLDE CM4 repair

**Dis-mounting CM4:**

- Warm-up of the HIE SC LINAC as of 7th December until max 18th December (cooling water stop)
- Gave enough time to finish all planned 'Winter-Physics' + TRAP, EBIS & REX tests (Niels Bidault)
- Preparations CM4 dismount as of January. It involved dismounting of all services connected to the Cryo Module:
- Taken the heavy LS2 workload of all support groups in account the planning was adapted when necessary. The transport of CM4 took place as scheduled Thursday, March 14th to SM18 (cleanroom)

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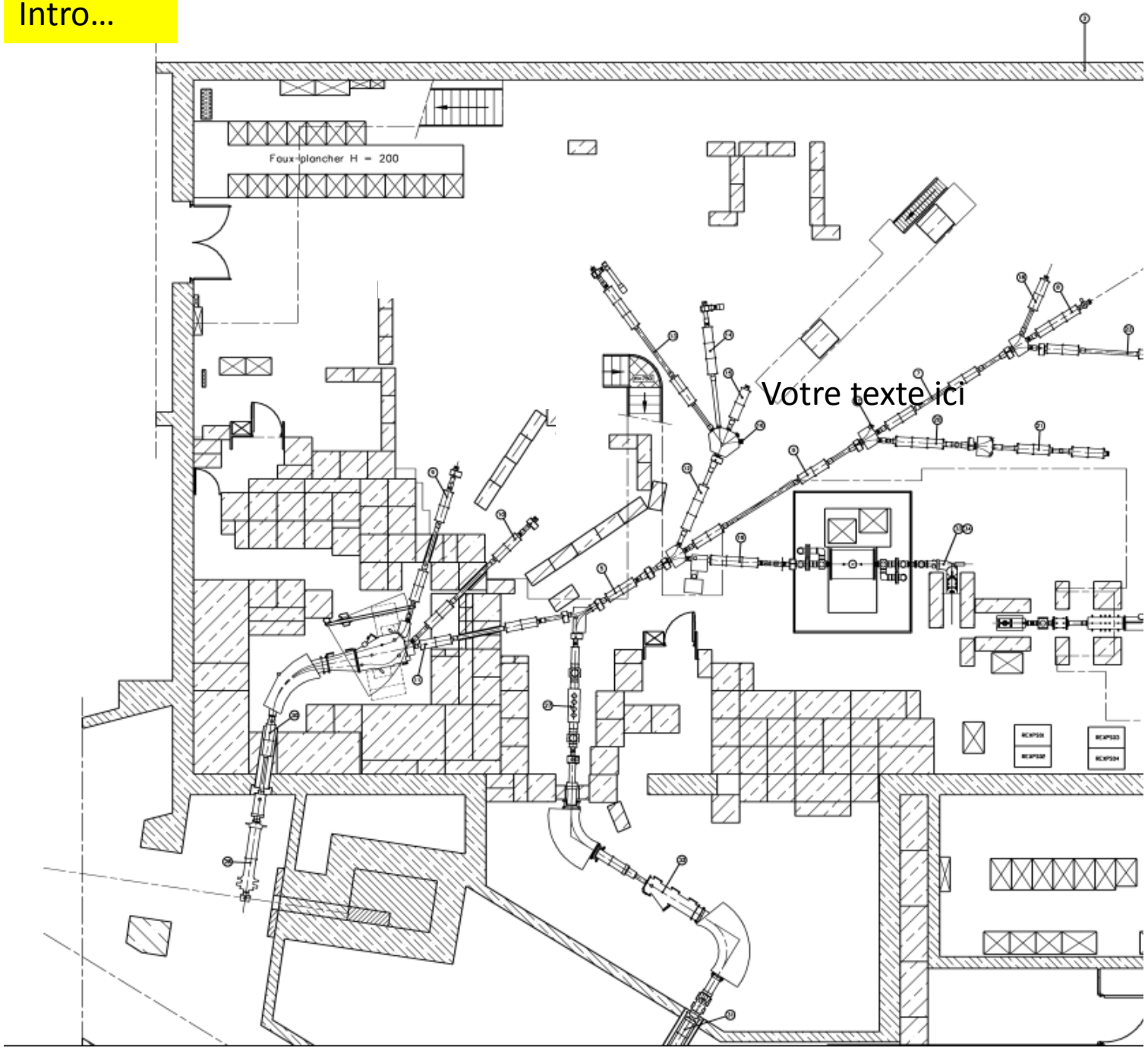
- CM4 expected to come back to the ISOLDE hall January 2020
- Aiming to finish installation and start re-commissioning by April 2020. Cooling water will be available and the Cryo plant will be able to start up. Tests with stable beam in parallel with ISOLDE Low Energy start-up.

# Update on the GLM area upgrade

Intro…




- New collection chamber
- Additional Fast tape station to allow for transparent TISD work while HRS performs physics
- Retain need for travelling experiments to be installed…e.g. biophysics chamber; mossbauer; detector setups such as windmill, Gandalph etc

- Reconfigure blocks to allow for removal of samples without exposing other users to risk of contamination.
- Avoid installing a roof for many reasons…
- Design work starts Q2 2019.

# Why a consolidation project?

- These activities (some > 1LA, but always < 100 LA) should be done in **Work Sector Type C**
- ISOLDE Hall is classified as such, but it is **not fully compliant** with Swiss ordinances
- All CERN Work Sector should be **audited** once a year (existing RP procedure), but ISOLDE Hall has never been audited
- **Risk of coactivity** with visitors and the other experiments present in the hall
  - **Risk of contamination and radiation** in the surrounding of the working area

# Expected improvements

- **Improve delimitation of the zone** (lack of fully closed perimeter, no access control)
  - Specific PPE might be required
  - Possibility to temporary classify as Limited Stay Controlled Area

# Expected improvements

- **Improve ergonomics of the zone** (narrow working spaces and not easy access)

# Consolidation proposal

Closing GHM and GLM beam lines plus fume hood zone in a **Work Sector Type C**

- Creation of a **local shielding** for the collection chambers and a **general shielding of the area** (concrete blocks and lead)
- The idea is to isolate the collection and handling activities to **protect the surrounding area** (other experiments, visitors)

# Consolidation proposal

- Installing a door with **access control** system (dosimeter, approved IMPACT)
- Placing an **hand and foot monitor** (with a probe) inside the zone to control potential contamination before exit
- **Evacuate all non necessary objects** and leave the area as “empty” as possible
- No permanent working station inside

Need to check that these proposals comply with the OFSP requirements

Restricted | Europe/Zurich | K. Johnston

# Review of the GLM/GHM consolidation project

Wednesday 12 Jun 2019, 09:00 → 12:30 Europe/Zurich

508 (CERN)

**09:00** → 09:05 **Presentation of the review** 5m

**Speaker**: Fabio Pozzi (CERN)

ISOLDE - Review pre... ISOLDE - Review pre...

**09:05** → 09:20 **Overview of ISOLDE activities** 15m

**Speaker**: Karl Johnston (CERN)

ISOLDE.pdf ISOLDE.pptx

**09:20** → 10:20 **Visit of the ISOLDE hall and of the GLM/GHM collection points** 1h

**Speaker**: Karl Johnston (CERN)

**10:20** → 10:40 **Coffee break** 20m

**10:40** → 12:30 **Presentation of the consolidation project + discussion** 1h 50m

**Speakers**: Elodie Aubert (CERN), Letizia Di Giulio (CERN)

ISOLDE Review_GH... ISOLDE Review_GH...

# Outcome from review meeting

- Consultant Jerome Daumet: head of RP group at IRA/CHUV (and familiar with CERN)
- Since project was launched, Swiss ORAP has changed (Feb 2019)
  - Areas can now be classified as «zones»
  - This could replace the more strict «work sector» e.g. Class C
  - Difficult to convert area to Class C with current infrastructure and funding
  - Allows for more flexibility and tends to be better appreciated by OFSP: specific RP aspects can be addressed.



*Annexe 10*
(art. 80, al. 2, let. b, 82, al. 1 et 2, 85, al. 2, let. b)

## Types de zones et de domaines

1. Les zones sont classées selon les types suivants en fonction du niveau de contamination présent ou attendu:

| Type de zone | Contamination de surface $C_{surf}$ | Contamination de l'air $C_{air}$ |
|---|---|---|
| 0 | $C_{surf} < 1 \cdot CS$[61] | $C_{air} < 0{,}05 \cdot CA$[62] |
| I | $C_{surf} < 1 \cdot CS$ | $0{,}05 \cdot CA \leq C_{air} < 0{,}1 \cdot CA$ |
| II | $1 \cdot CS \leq C_{surf} < 10 \cdot CS$ | $0{,}05 \cdot CA \leq C_{air} < 0{,}1 \cdot CA$ |
| III | $10 \cdot CS \leq C_{surf} < 100 \cdot CS$ | $0{,}1 \cdot CA \leq C_{air} < 10 \cdot CA$ |
| IV | $C_{surf} \geq 100 \cdot CS$ | $C_{air} \geq 10 \cdot CA$ |

Dans le cas où les degrés de contaminations des surfaces et de l'air ne conduisent pas au même type de zone, c'est le facteur le plus restrictif qui s'applique.

2. A l'intérieur des zones présentant un débit de dose ambiante élevé et en vue de planifier et de réglementer les doses individuelles, les domaines suivants doivent être signalés en fonction du débit de dose ambiante maximal admissible:

| Type de domaine | Débit de dose ambiante $D$ aux endroits accessibles |
|---|---|
| V | $D < 0{,}01$ mSv/h |
| W | $0{,}01 < D < 0{,}1$ mSv/h |
| X | $0{,}1 < D < 1$ mSv/h |
| Y | $1 < D < 10$ mSv/h |
| Z | $D > 10$ mSv/h |

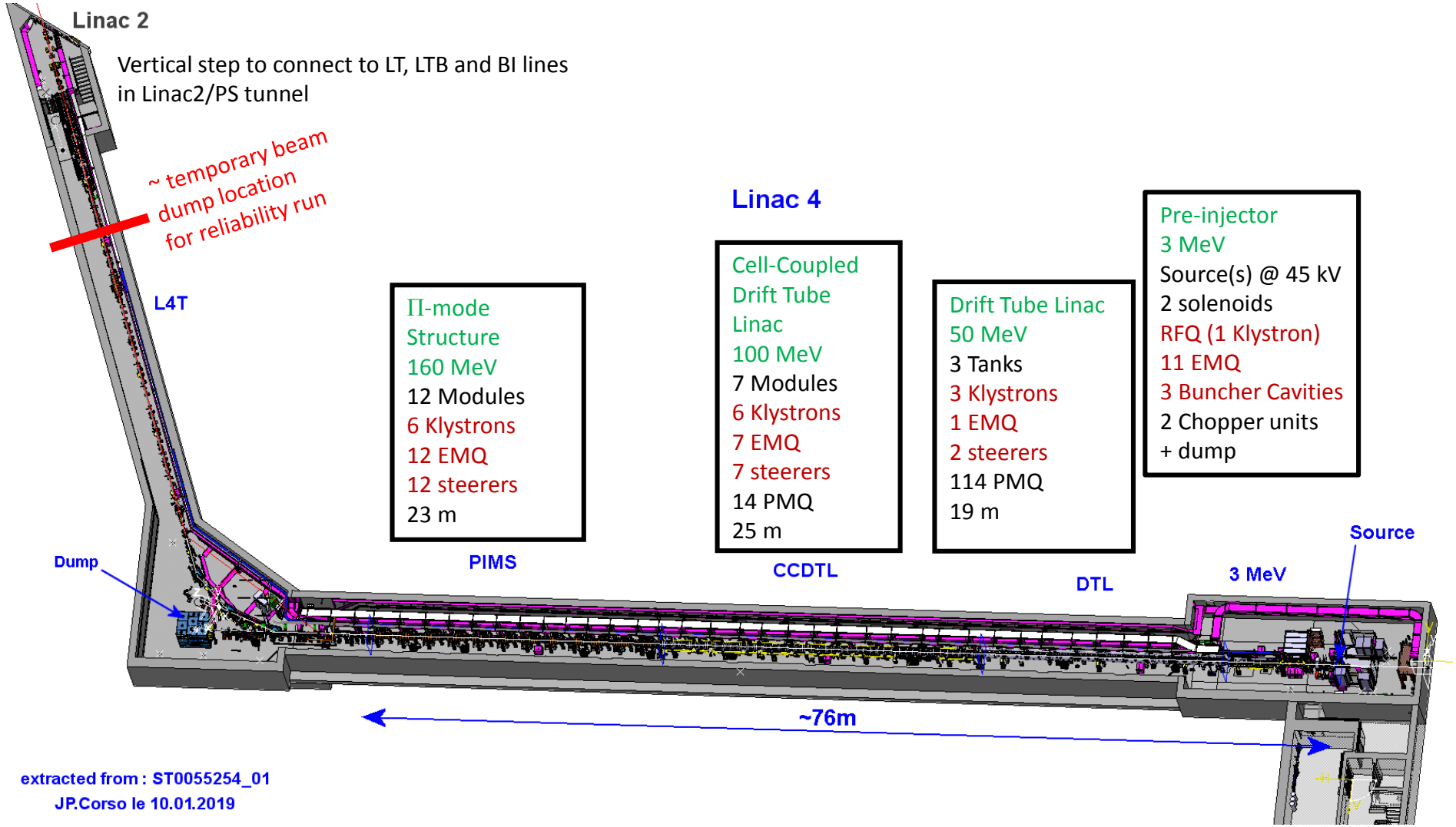
# Recommendations

- Suggestion to *only* consider recently installed fume cupboard as a type C work sector.
- Focus on the specifics of activities at other beamlines and classify in terms of zones
- Strengthen training/ restrict user access for certain identified activities e.g. volatile Hg collections.
- Reduce clutter in the space and remove workspaces outside the zone
- Stairs at GLM should be removed….instead land between LA1/LA2
- Increase users awareness of emergency prodcures/training for these activities.
- Install cleanable walls in the area…e.g. perspex plates to allow for cleaning after contamination.
- Careful coordination of project needed.

Next Steps

- RP assessing the recommendations:requires a change of «culture» at CERN…
- Based on these assessments, EP safety and ISOLDE will launch re-design.
- For online MS no real change….for chemistry may have to negotiate a new procedure with CERN and/or the authorities…(TBD)

# Changes after LS2 LINAC4….+ upgraded booster…



# Start-up in 2021

- Stable beams expected during 2020 from both HRS and GPS (GPS later than HRS)
- Long commissioning period for HIE-ISOLDE…aim to run HIE as early as possible
- Protons are foreseen from mid-April 2021 with ISOLDE being one of the first users.
- Expect teething problems! LINAC4; upgraded booster; new front ends; new controls etc etc
- CERN currently has financial constraints…resources will be reduced especially in terms of personnel (fellows, project associates). Target production could be affected. Nanolab may compromise UCX production for first half of year.