(GANIL Scientific Council)

Tape Station Systems for DESIR

Iolanda Matea Macovei (IJCLab)

Scientific Motivation – Decay Spectroscopy

Physics:

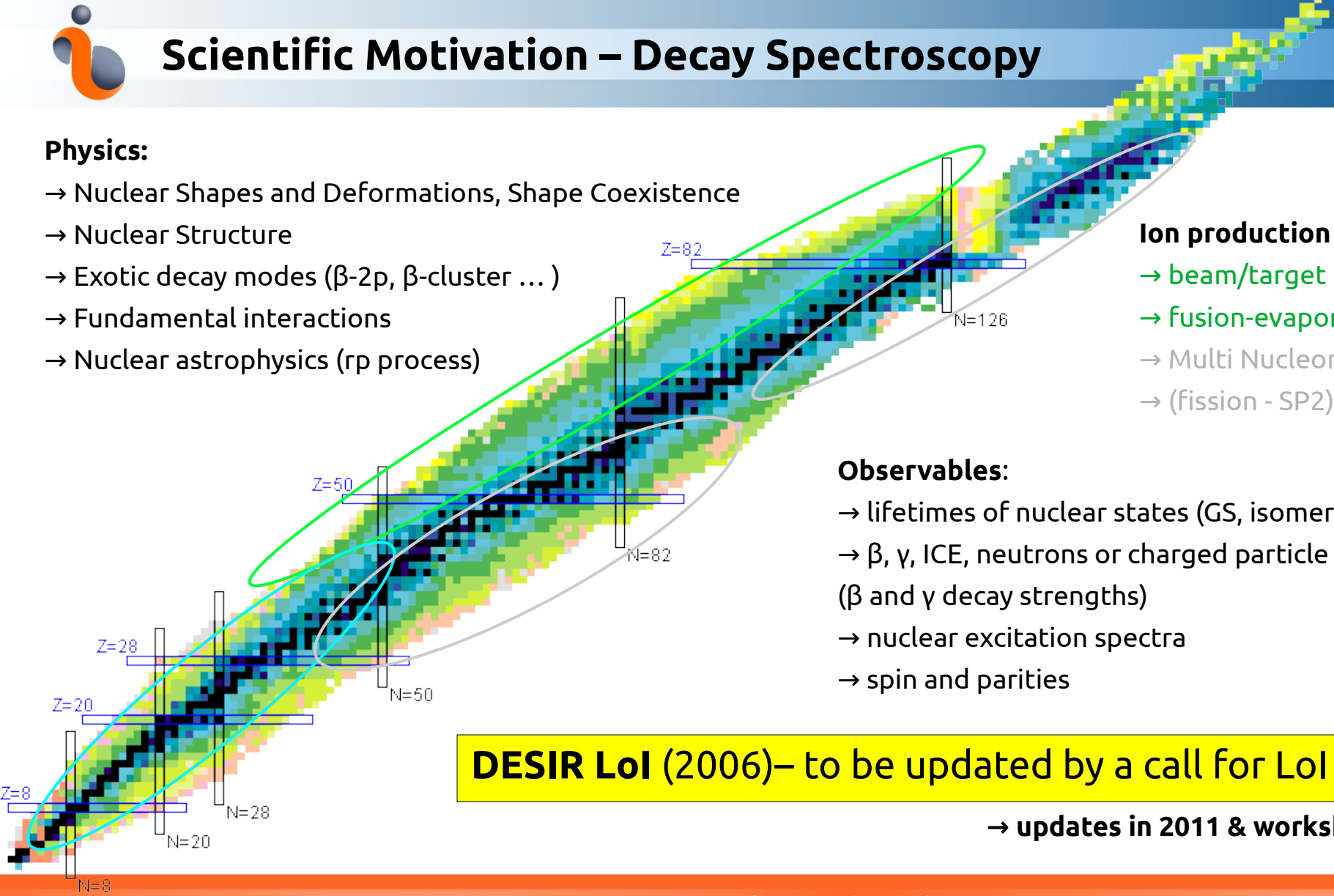
→ Nuclear Shapes and Deformations, Shape Coexistence

→ Nuclear Structure

→ Exotic decay modes (β-2p, β-cluster …)

→ Fundamental interactions

→ Nuclear astrophysics (rp process)



Ion production :

→ beam/target fragmentation (SPIRAL1)

→ fusion-evaporation (S3)

→ Multi Nucleon Transfer

→ (fission - SP2)

Observables:

→ lifetimes of nuclear states (GS, isomeric, ...)

→ β, γ, ICE, neutrons or charged particle spectra and/or BR (β and γ decay strengths)

→ nuclear excitation spectra

→ spin and parities

DESIR LoI (2006)– to be updated by a call for LoI at Spring 2025

→ updates in 2011 & workshops in 2014 and 2024

DESIR strength for BESTIOL

PRODUCTION

Beam/target fragmentation (SPIRAL1)

Fusion-Evaporation (S3)

Fission MNT

PURIFICATION (DESIR)

Device	Resolution (M0/ΔM)	Purification time (ms)
RFQ + HRS	~ 20000	few 0.001
GPIB + MR-ToF	~ 200000	~ 10
GPIB + PIPERADE (1st trap)	$\leq 10^5$	~ 100
GPIB + PIPERADE (2nd trap)	10^6 - 10^7	

LASAGN

MEASUREMENT

BESTIOL : β-decay STATIONS

β-decay Station – General

Measurements of :

→ lifetimes of nuclear states (GS, isomeric, ...)

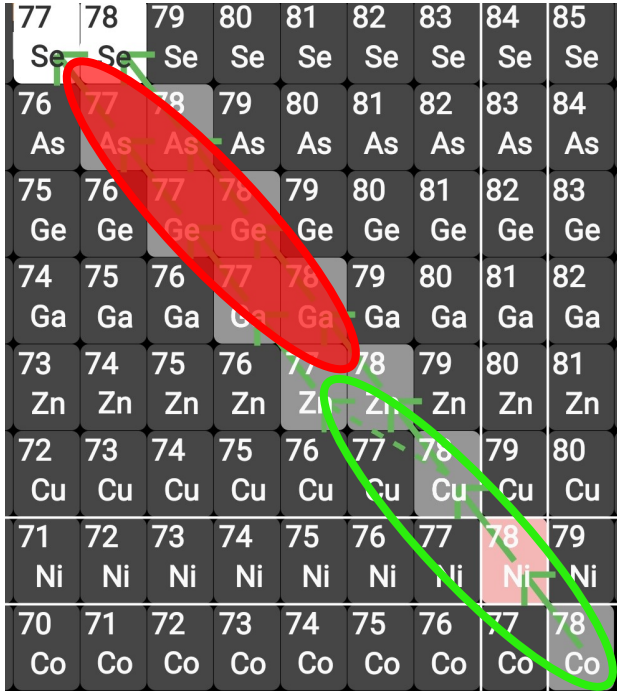
→ β-radiation, γ and X-rays, ICE

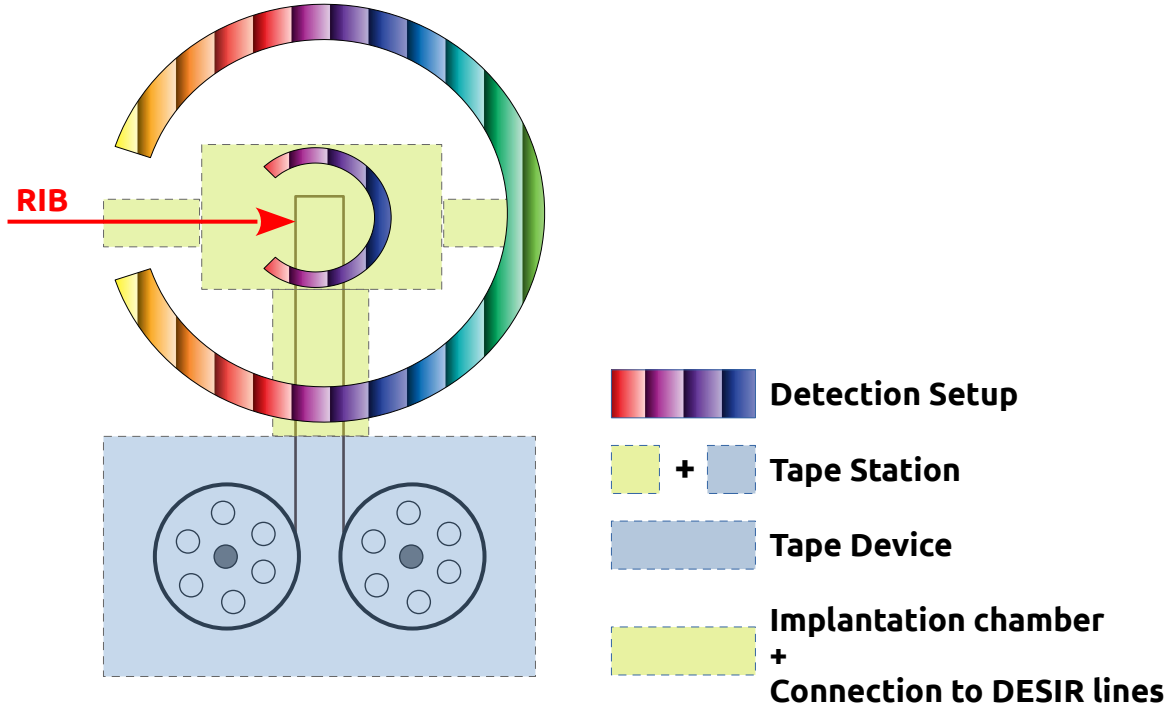
→ charged particles (proton rich side, SP1 and S3 beams)

→ neutrons (neutron rich side, SPIRAL 1 beams)

→ isotopes of interest : (very) **short lived / low production x-sect**
=> activity fast accumulates in long lived isotopes

→ long-lived activity : dominant background → to be removed
=> **tape station based decay spectroscopy setups**





Identification (ID) versus Decay Station

ID STATION (ISD):

→ simple and robust, fixed

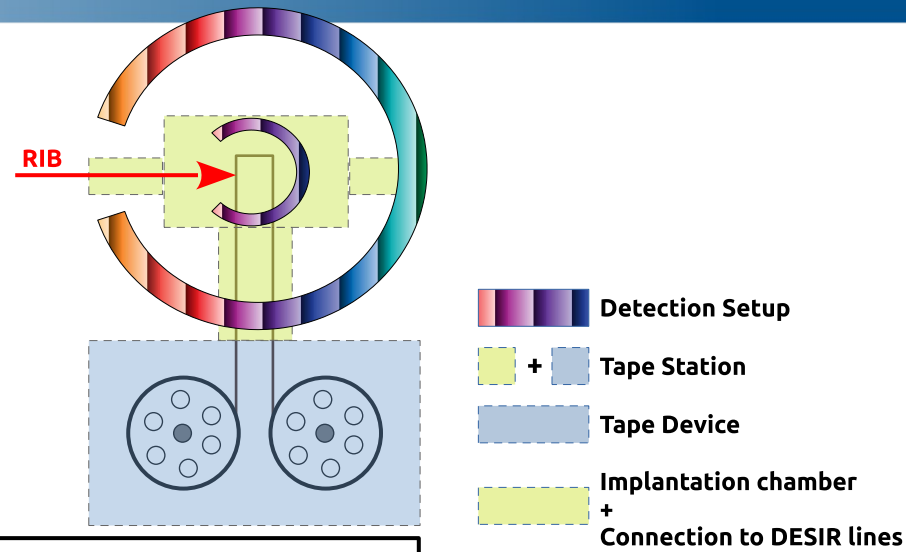
→ tape station with accum/decay (or not) cycles

→ simple detection setup :

→ weak decay tagging (beta)

→ γ-decay detector(s)

→ fixed/known efficiency (production/transmission rates, purity)



Decay STATIONs (DSD, MP-DSD):

→ tape station with possibly 2 decay measurement points

→ fast and versatile cycles for the tape movement

→ mobile (DESIR hall)

→ versatile, high efficiency, scalable detection setup :

→ weak decay tagging (beta or charged beta-delayed particles)

→ high efficiency γ-ray detection

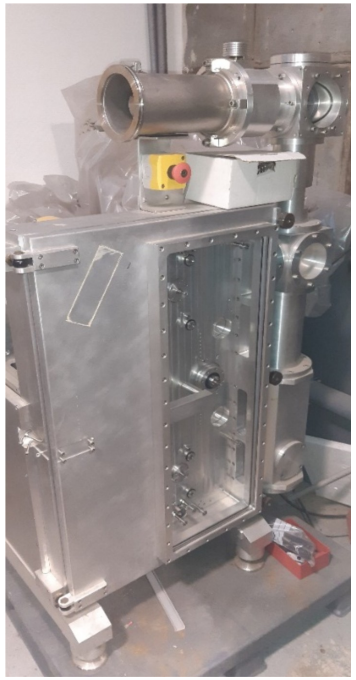
→ ICE, charged particles, neutron … detection

→ sky is the limit …

Available Tape Devices for DESIR

→ Built by IPHC (Ph. Dessagne) following the same design

@ ISD



~2000?

Currently located at LP2iB

@ DSD

2024 (DESIR EQUIPEX)

Currently installed/tested at GANIL
(V. Watt-Morel, J.-C. Thomas, B. Rebeiro)

@ MP-DSD

2011 (VS3 ANR)

Currently installed at GANIL
(V. Watt-Morel , J.-C. Thomas, B. Rebeiro)

Status of different β-decay stations for DESIR

	Decay Stations			
	ISD	DSD	MP-DSD	
Tape device	yes	yes	yes	tape station
Tape device c/c	no	yes	yes	
Vacuum system (pumps …)	no	yes	yes	
Vacuum c/c	no	no	no	
Mechanics (vacuum chamber, connection to TS and DESIR lines)	no	no	no	
Beam control (FC, MCP or Si detector)	no	no	no	detection setup
Beta-detector (plastic scintillator)	yes	no	no	
Beta and charged particle detectors (Si)	-	yes	no	
Gamma detectors (HPGe Coaxial)	no	-	-	
Gamma detectors (HPGe Clovers)	-	no	no	
Gamma detectors (scintillators)	no	no	no	
Beta-VETO detectors	-	no	no	
Mechanics (for detector support)	no	no	no	
Electronics (HV, PA, SiPM …)	no	no	no	
Digitizers / daq	no	no	no	

Identification Station for DESIR (ISD)

Funding secured

→ part of SP2/DESIR equipment (funded within DESIR project)

→ IDS is planned to be prepared and installed by LP2I Bordeaux (detailed WP distribution in discussion)

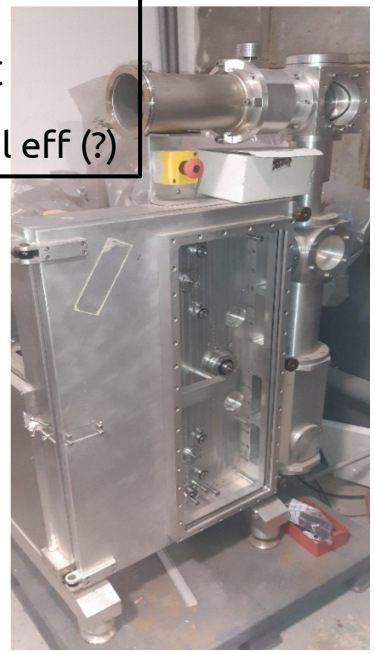
Existing parts

→ Tape Device :

→ Decay tagging detection :

- Plastic scintillators from IPHC

→ HPGe coax det from SP1, 40% rel eff (?)



FTE / budget (to be calc)

~85k€

To be designed/constructed/acquired

→ Control/Command (C/C) for :

- Vacuum
- Tape station (work ongoing @ LP2iB)

→ Vacuum

→ implantation chamber

- System for retraction of the tape from beam line ?

→ detector for beam tuning purposes

→ HPGe coaxial detector

→ DAQ/Electronics

Decay Station for DESIR (DSD) – “alpha version” & MP-DSD

“alpha version” : high β-γ efficiency

Existing parts

→ FTS/VS3 tape device

To be designed/constructed/acquired/adapted

→ Implantation chamber and connections to DESIR

- Several for several setups !
- “alpha version” (IJCLab?)

→ detection setup

- Mechanics, “alpha version” (IJCLab?)
- Beta tagging (or charged particles with Silicon Cube)
- Gamma detection (clovers and beta-VETO)
- Second deported point for spectroscopy of longer lived isotopes ?

→ DAQ/Electronics

MP-DSD

→ same status as DSD

→ mechanics : Subatech Nantes for TAGS (?)

→ adapted to special detection setups

(TAGS, CoeCO, MONSTER ...)

Preparation Phase (2025-2027)

TS performance studies @ GANIL **Estimated time : < 1 year**

→ mechanics for test bench (design and construction); IJCLab design and material could be used ...

→ C/C for ISD (DSD and MP-DSD have their own C/C)

→ tests (speed, max distance in one step, breaking frequency – air and vacuum, control of the decay point position ...)

Mechanics for TS (implantation chamber, connections with DESIR, tape trajectory ...) **Estimated time : ~ 2 year**

→ not designed/constructed

→ IJCLab manifested interested in the design of DSD mechanics (alpha version); availability of Design office : 2026

→ Subatech Nantes manifested interested in the design of MP-DSD mechanics (to be consolidated)

Support mechanics for the detection setup **costs and FTE to be estimated**

→ not designed/constructed

→ IJCLab manifested interested in the design of DSD mechanics (alpha version); availability of Design office : 2026

Detection & Electronics **> 900 k€ & ~ 1 year**

→ ISD : ~85 k€

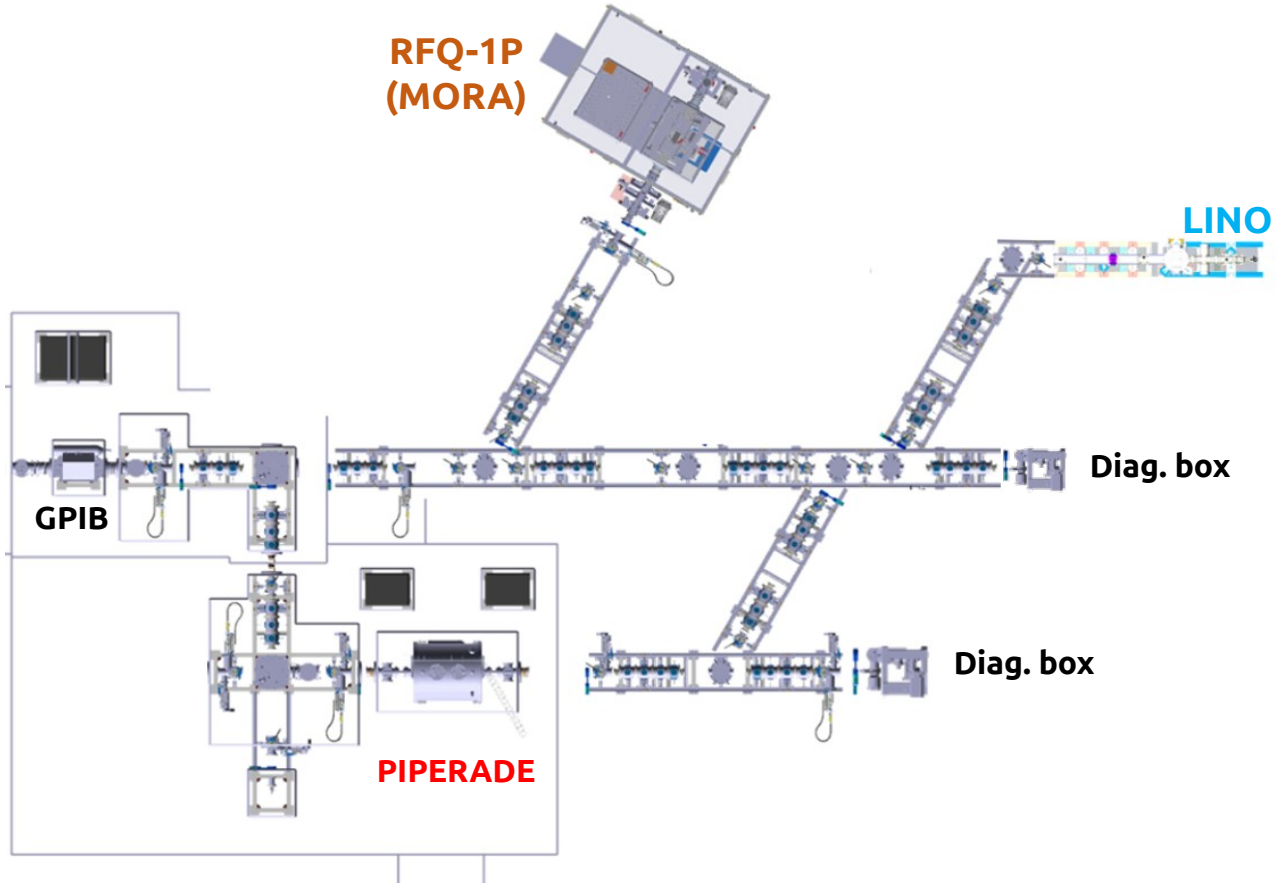
→ DSD : ~ 800 k€ (4 clover detectors, ~170k€/clover with 4crystals x 50 mm diam x 70 mm length)

→ MP-DSD : to be estimated

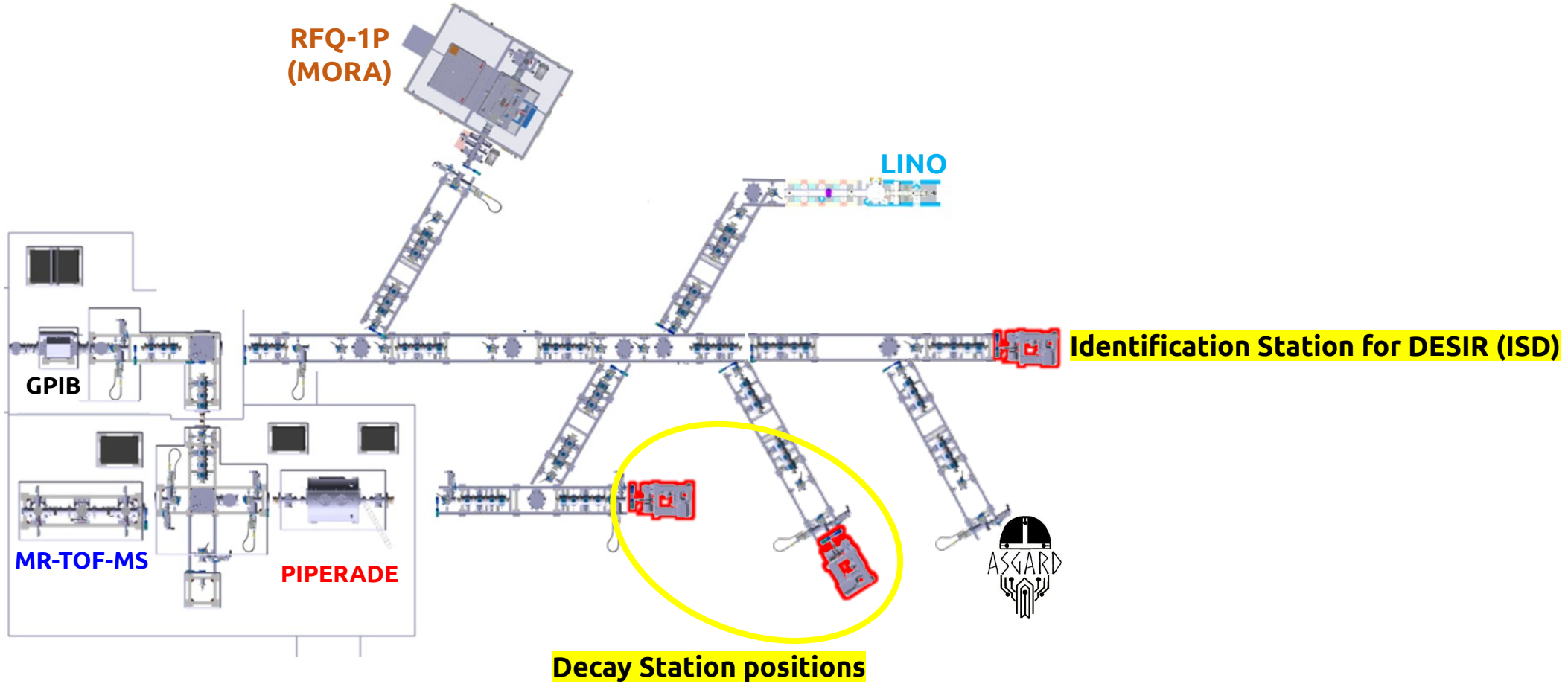
→ acquisition, testing and implementing

DESIR hall installation timeline

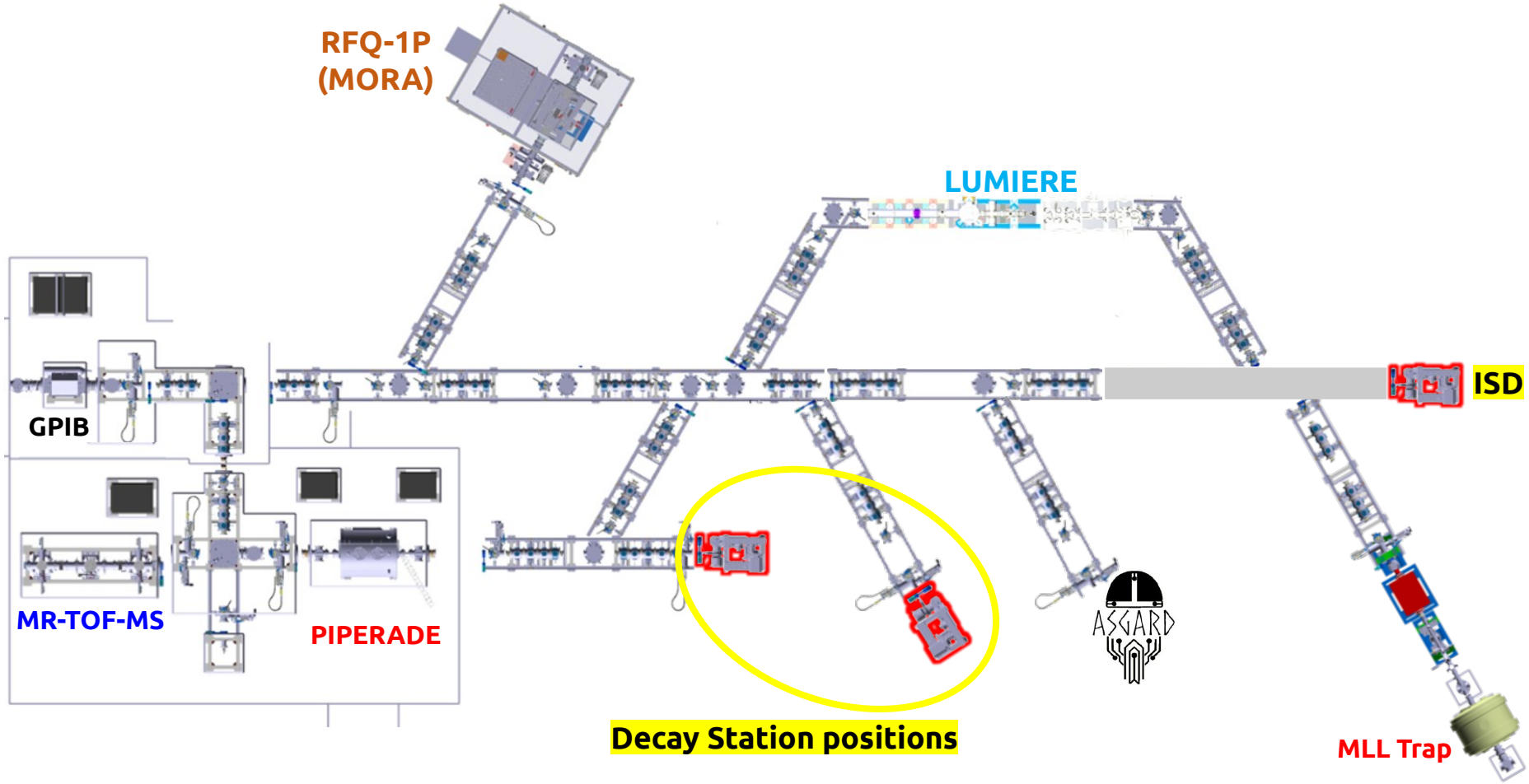
S1-2027 (Stable Ion Beams)

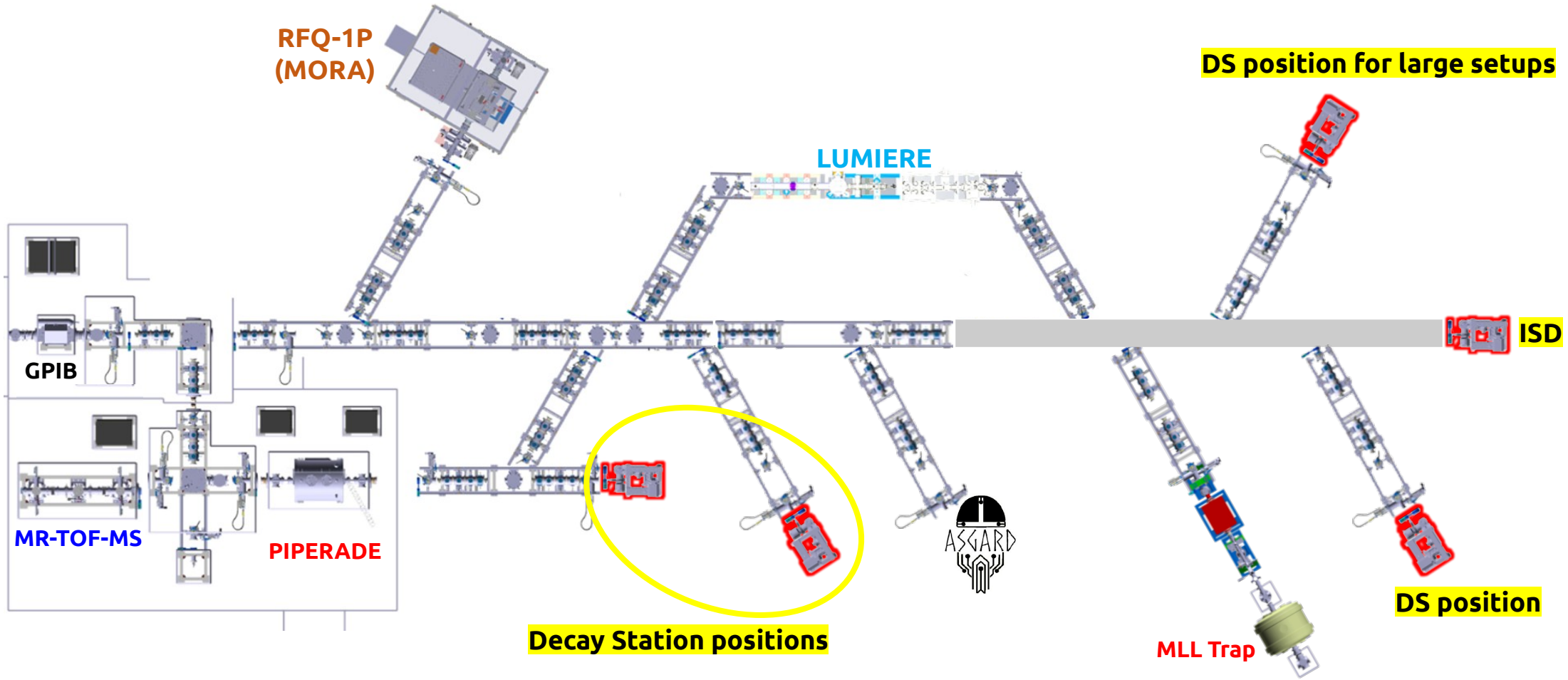


S2-2027 (Stable Ion Beams) / 2028 (RIBs)



2029 – …


RFQ-1P
(MORA)
LUMIERE
ISD
GPIB
MR-TOF-MS
PIPERADE
ASGARD
Decay Station positions
MLL Trap


RFQ-1P
(MORA)
LUMIERE
DS position for large setups
ISD
GPIB
MR-TOF-MS
PIPERADE
ASGARD
Decay Station positions
DS position
MLL Trap

γ-detection

~ 75% of the cost for the ID & DS for DESIR !

Coaxial HPGe detectors

→ mostly for ID station (simple)

→ electrical cooling is a plus

→ ~70% relative efficiency

→ there are several ID stations/projects in GANIL :

- SPIRAL 1
- IDEAS3 (for S3-LEB)
- ISD (for DESIR)

with fixed setups => one should count 3 differents γ-det setups

→ ~80 k€ / HPGe

Clover detectors

→ Decay station setups

→ Nomad withing GANIL (and outside ?)

→ at least 4 clovers / decay station during an experiment

→ a 6 clover Pool could be a good start …

→ ~180 k€ / Clover (~160 k€ if buying min 5)

→ share between SIRIUS, SEASON, IDEAS3, DSD …

GANIL γ-Pool ?

Proposed collaboration*

GANIL

Subatech

IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

LP2i Bordeaux

Phase1

→

Identified services / persons* :

(so far ...)

→ LP2iB : B. Blank, Ph. Alfaurt

→ GANIL : J.-C. Thomas, B. Rebeiro, V. Watt-Morel

→ IJCLab : I. Matea, xxx (Design Office)

→ Subatech Nantes : M. Fallot, xxx (Design Office)

IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

Design/production of Tape Devices : DONE

Other France → Phase2?

EU, UK … → Phase3?

…

*to be consolidated

Thank you!

The BESTIOL facility

BEta decay STudies at the SPIRAL2 IsOL facilty

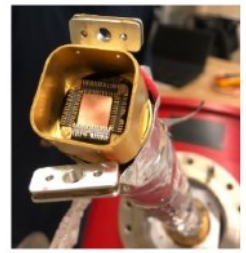
Beam cooling and purification using PIPERADE for (trap-assisted) decay spectroscopy
-> High-precision measurements with ultra-pure samples for fundamental interaction, nuclear structure, nuclear astrophysics etc

- β-γ decay stations (BEDO, …)
- total absorption spectrometers (DTAS)
- neutron detection arrays (BELEN, MONSTER, …)
- electron and proton detection (COeCO, SiCube, b-STILED
- recoil detection (ASGARD)

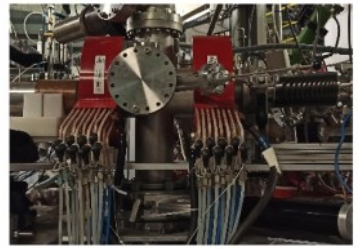
for

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

BELEN

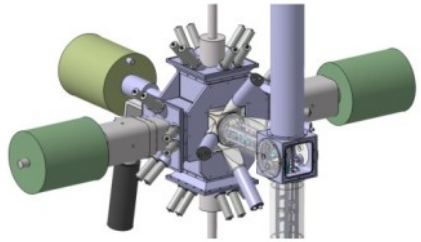


ASGARD

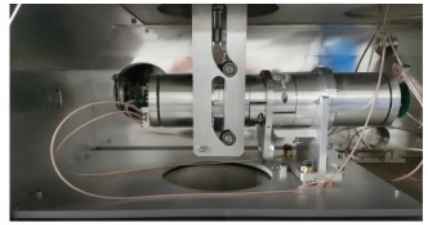


COeCO

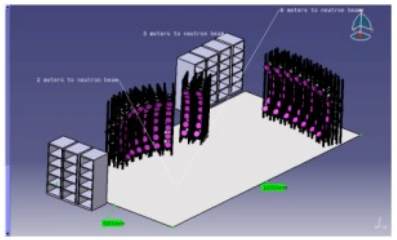
SiCube



BEDO



b-STILED



MONSTER

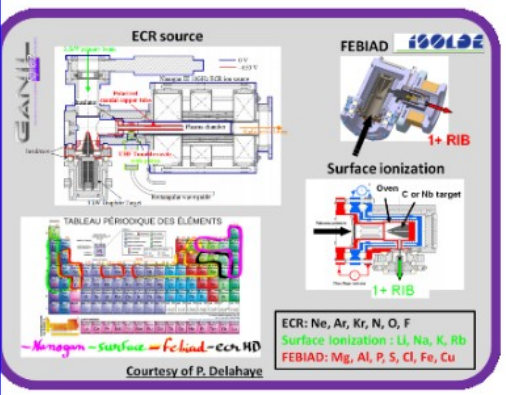
DTAS

DESIR physics programme

- Collinear laser-spectroscopy — **LUMIERE**
- Correlations in β decay (MORA)
- Mass meas. (PIPERADE, MLLTrap) — **DETRAP**
- (Trap-assisted) decay spectroscopy — **BESTIOL**

SPIRAL 1

Fragmentation

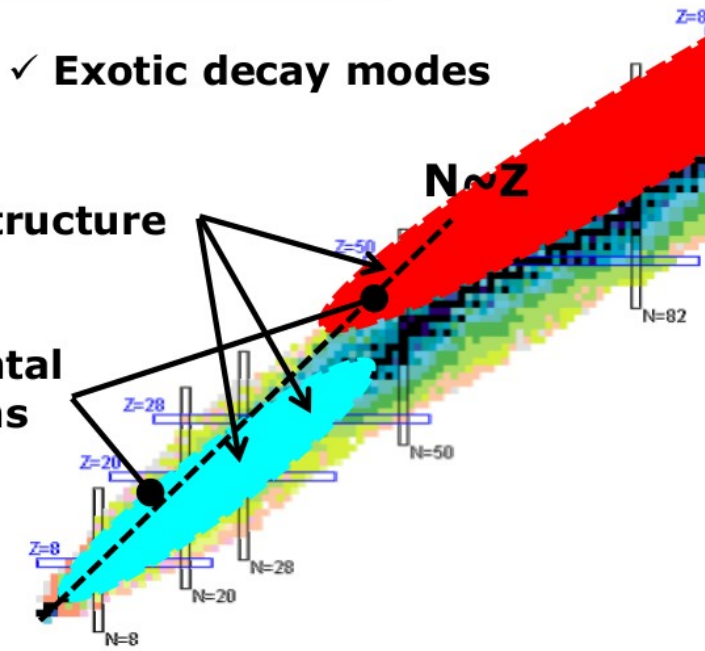


✓ Nuclear structure

✓ Fundamental interactions

✓ Exotic decay modes

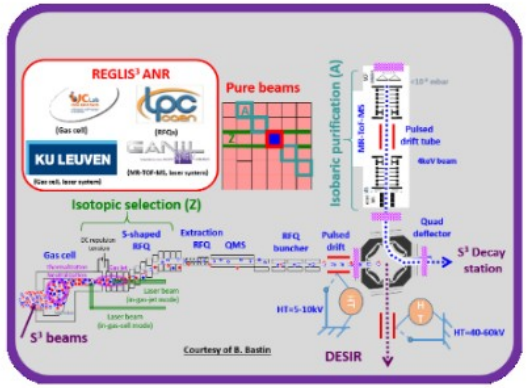
N≈Z



(Super) Heavy nuclei

✓ Size & Shape
✓ Deformation

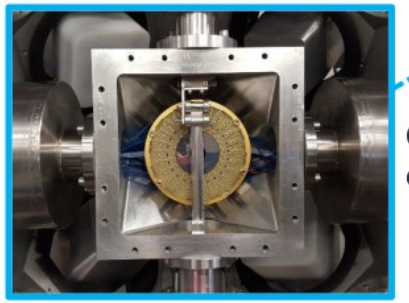
Fusion-evaporation



Ancillary systems

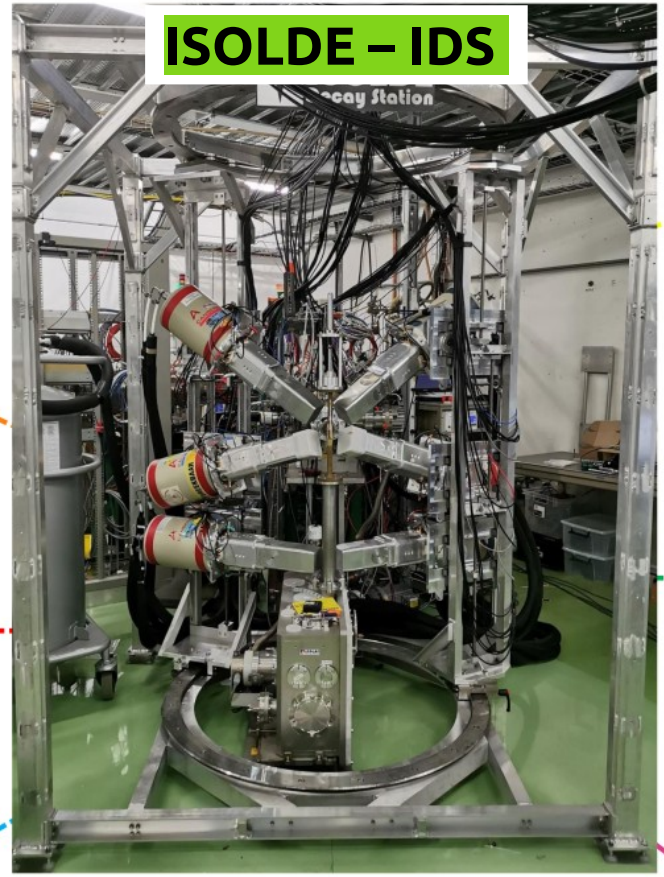
High β-γ efficiency

Fast-timing



Conversion electrons

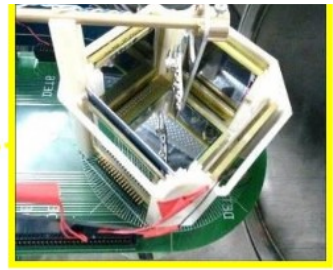
ISOLDE – IDS



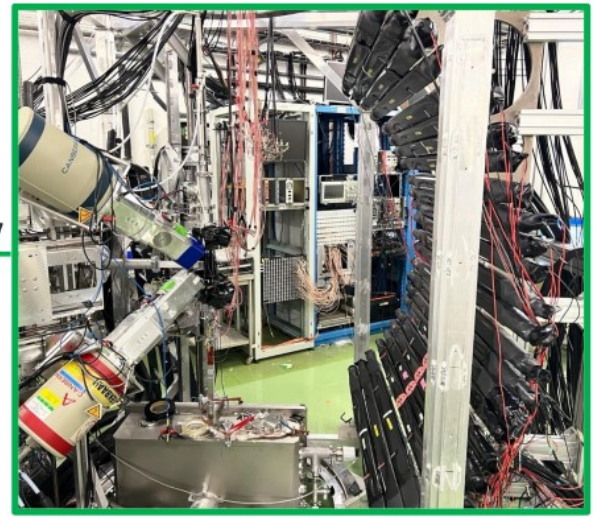
TD-PAC – Coming soon

- System "specialized" to needs of particular experiment
- Easily interchangeable, and compatible with each other

Charged-particle Spectroscopy



Neutron Spectroscopy



Plastic scints. (β tagging)