

# Present and future of the GANIL-SPIRAL2 facility

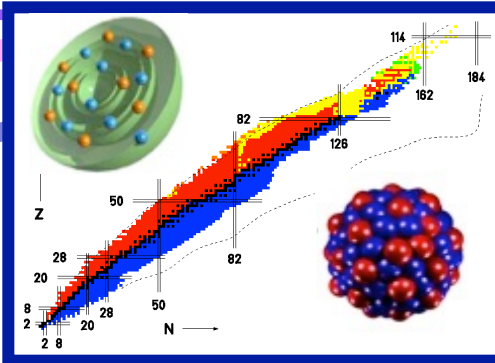
- Scientific program
- Evolution of GANIL-SPIRAL2



Nuclear structure

See talk by  
B. Blank

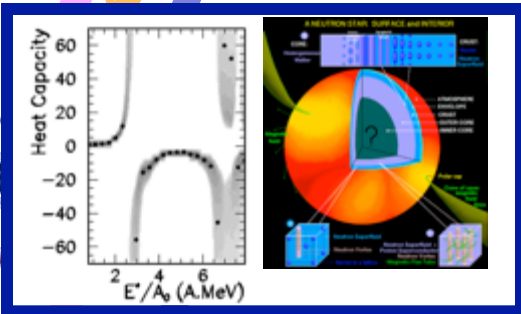
See talks by A. Chbihi,  
R. Bougault, G. Verde



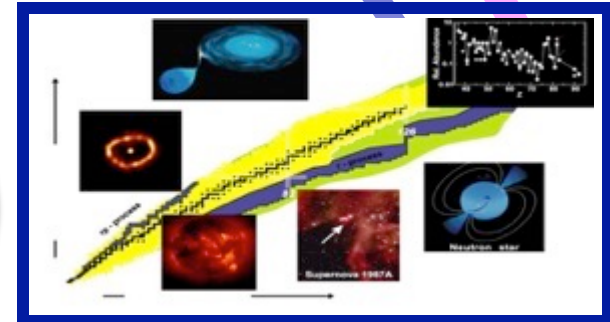
See talk by  
F. Hammache

EOS

Liquid-gas phase  
Isospin dependence

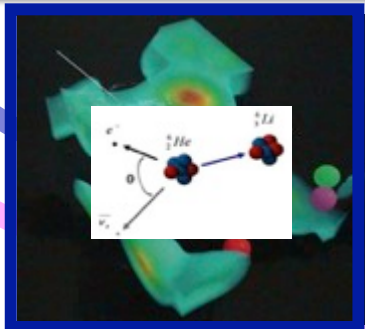


Nuclear Astrophysics

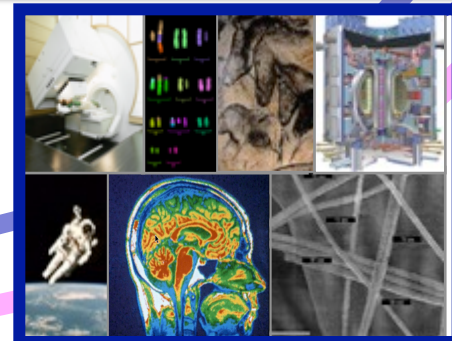


# GANIL/SPIRAL2 Science Exp. & Theory

Fundamental Interactions



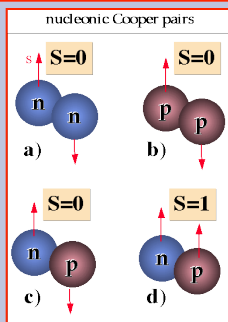
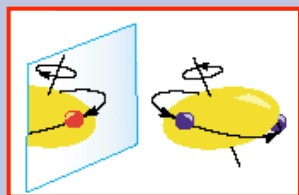
Multi-disciplinary research  
& Applications



# The physics of AGATA@GANIL is the in-beam high resolution $\gamma$ -ray spectroscopy of exotic nuclei populated by heavy-ions collisions

- *Nucleon-nucleon(-nucleon) interaction close to magic nuclei*
- *Astrophysical measurements*
- *Collective mode in nuclear matter*
- *Clusters in nuclear matter*

See talk by S. Lenzi



$^{100}\text{Sn}$

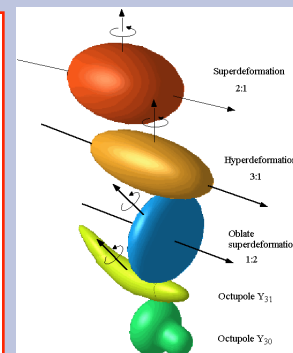
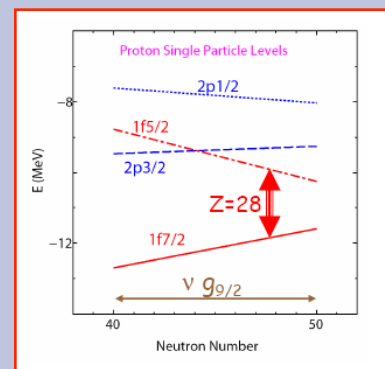
$^{132}\text{Sn}$

$^{68}\text{Ni}$

$^{78}\text{Ni}$

$^{48}\text{Ca}$

$^{208}\text{Pb}$

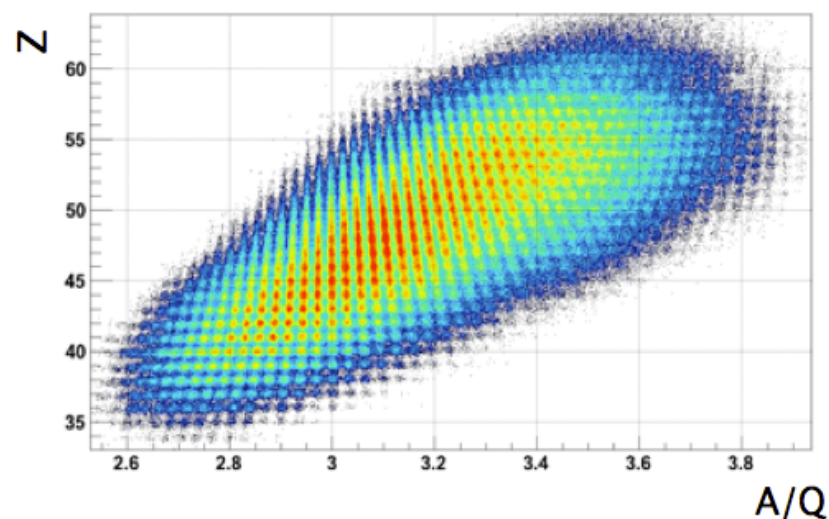
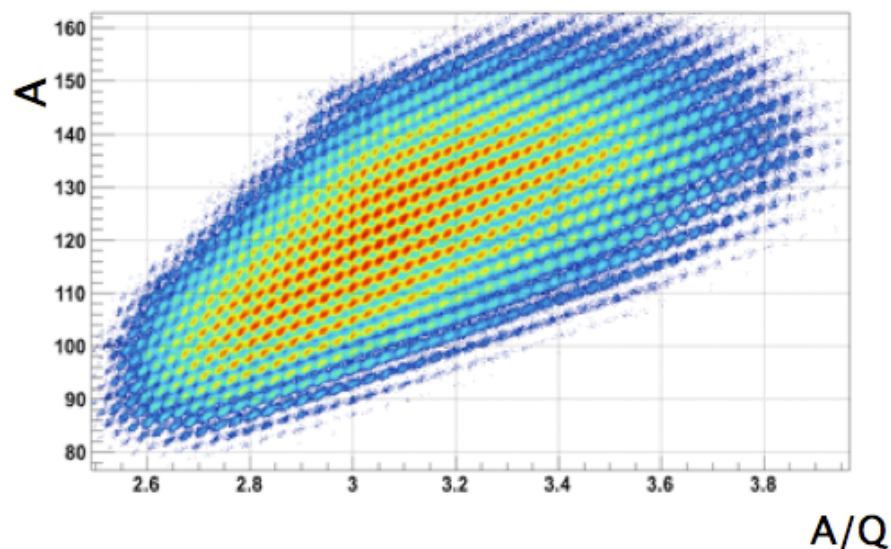
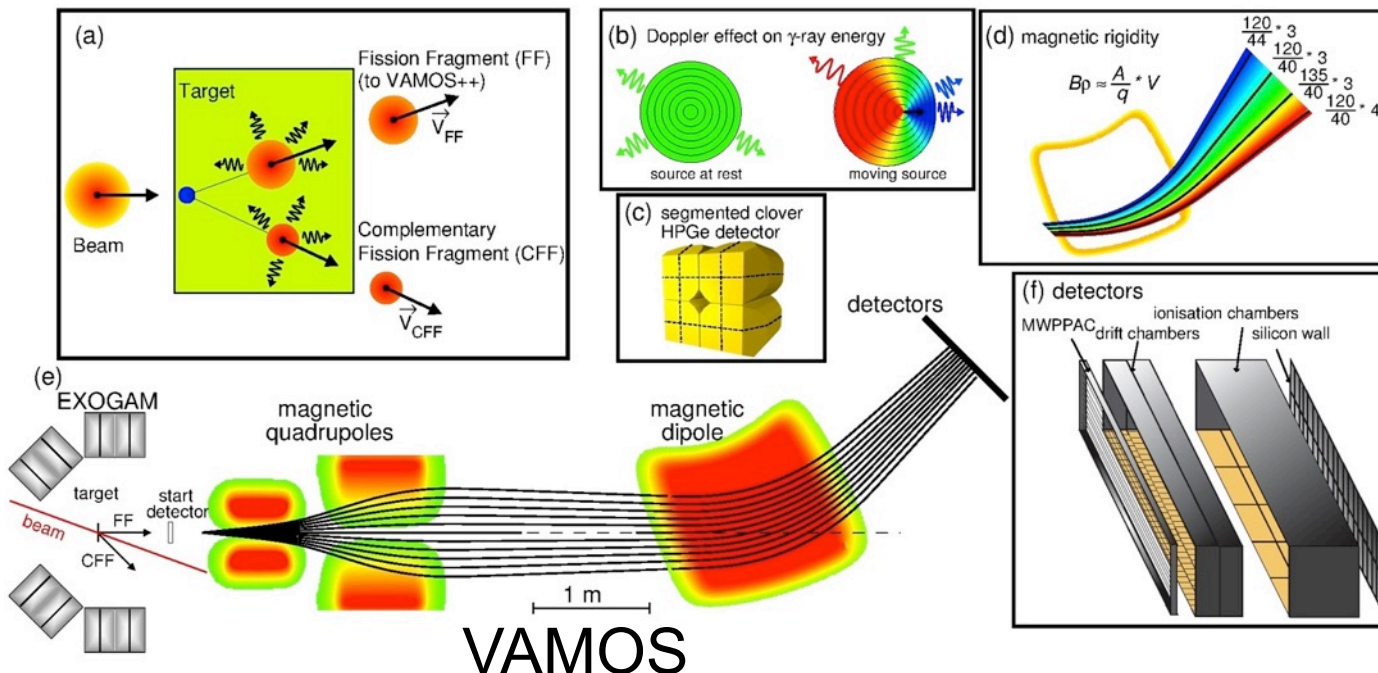


- *High resolution  $\gamma$ -ray spectroscopy of very exotic nuclei*
- *Lifetime measurement of excited states in the range of fs to  $\mu$ s*

# Z, A & q identification at few MeV/nucleon

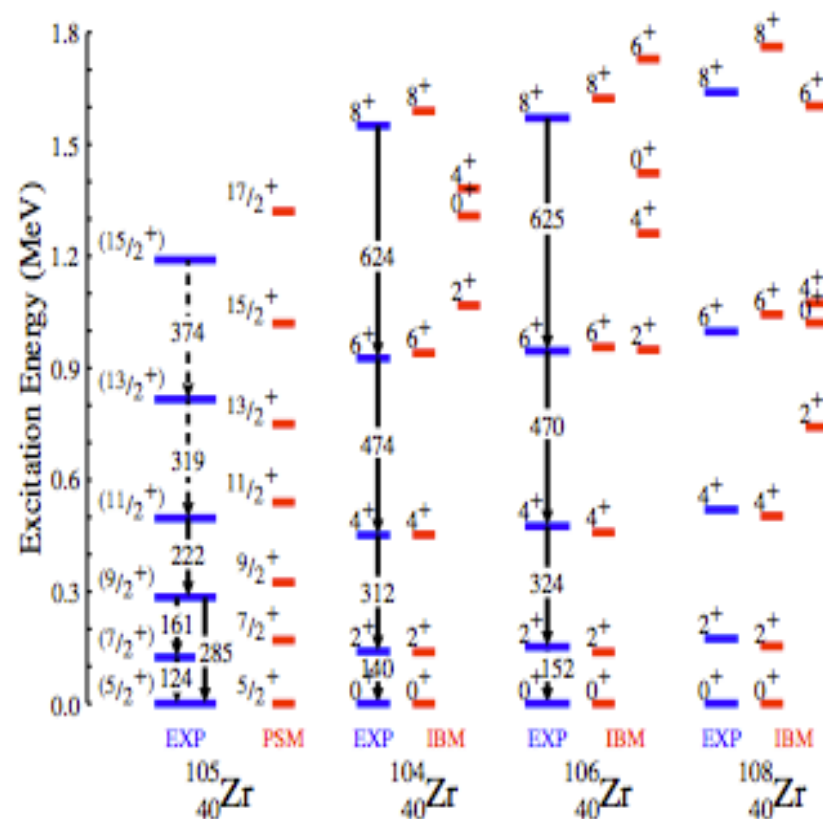
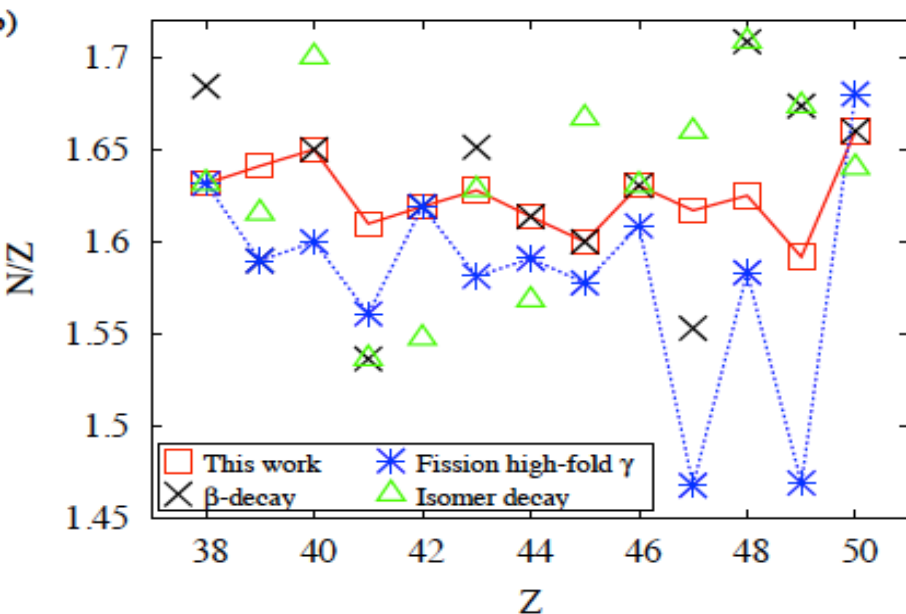
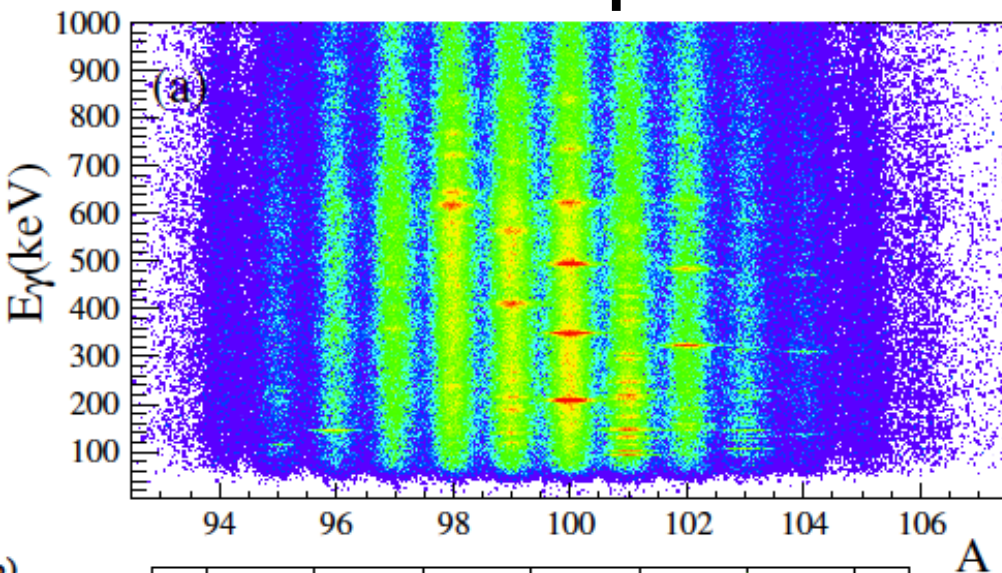
A. Navin and M. Rejmund  
McGraw-Hill Yearbook of  
Science & Technology (2014)

$\Delta A / A \sim 0.4\%$   
Z resolved up to 63  
Identified 450 nuclei  
and their excited states



# Study of Neutron Rich Zr isotopes

## Ion – gamma coincidences Zr isotopes



**N. Alahari, M. Rejmund et al.**  
**Phys. Lett. B728 (2014) 136-140**

# GANIL-SPIRAL2

- Scientific program
- **Evolution of GANIL-SPIRAL2**



## Phase1 (2015)

Increase the intensity of stable beams by a factor 10 to 100 –  
High intense neutron source

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A < 50$

**End of construction & commissioning**

## DESIR Phase1+ (2019?)

(low energy facility)

**Fully funded**

## AGATA

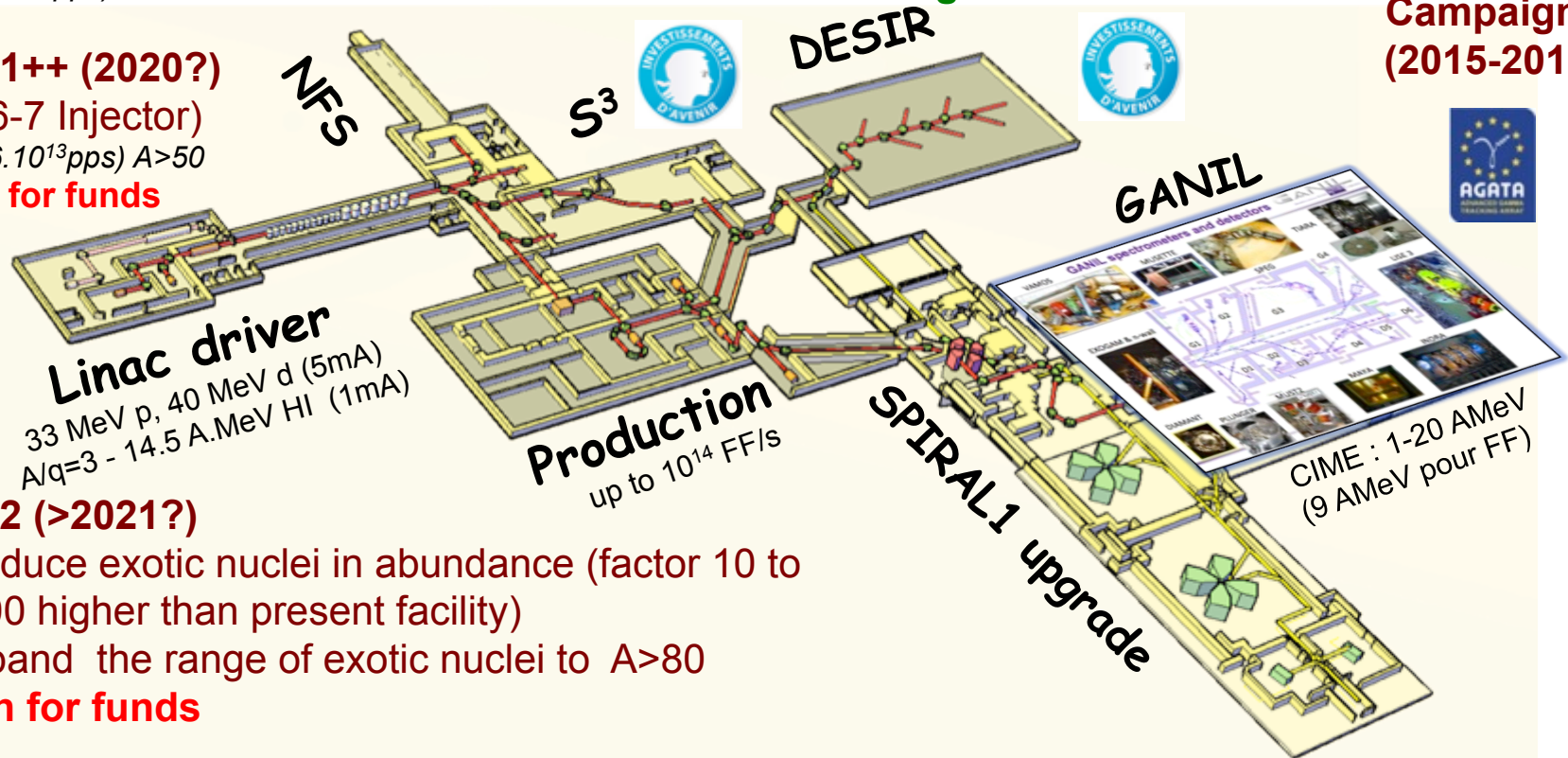
**Campaigns  
(2015-2018)**

## Phase1++ (2020?)

( $A/Q=6-7$  Injector)

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A > 50$

**Search for funds**



## Phase2 (>2021?)

- Produce exotic nuclei in abundance (factor 10 to 1000 higher than present facility)
- Expand the range of exotic nuclei to  $A > 80$

**Search for funds**

## Investment:

- SPIRAL2 Phase 1 (2015 secured): 100 M€
- New exp. halls and detectors (2014 secured)  $\geq 30$  M€

## SPIRAL1 Upgrade (2016)

New light RIBs

**Fully funded**

**SPIRAL2 is on the list of the European Strategy Forum on Research Infrastructures (ESFRI)**

# GANIL-SPIRAL1-SPIRAL2 Phase 1 Stable & RIB

**GANIL**  
laboratoire commun CEA/DSM  
**spiral2**  
CNRS/IN2P3

Z/Elem. Symbo Q

A  
X  
Z

☒ All facilities  
☒ Stable ions facilities  
☒ Cyclotrons  
☒ LINAC  
☒ Radioactive ions facilities  
☒ SPIRAL1  
☒ S3  
☒ SPIRAL2-Phase2-50kW

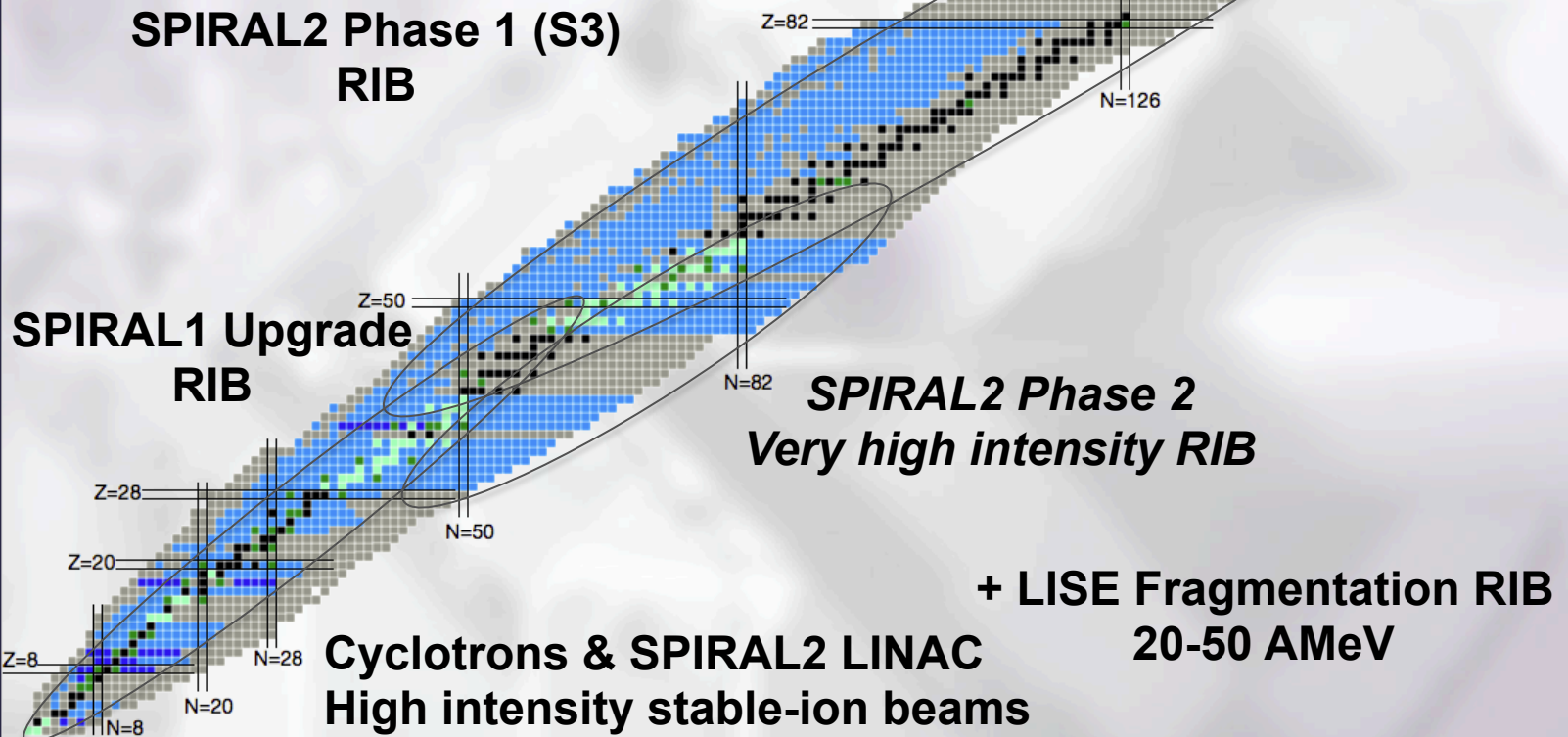
Stable Radioactive  
Produced ■ ■  
To Be Produced ■ ■  
Not Produced (yet) ■ ■

Help

©Chartbeams

Version 1.0 - 2015-10-01  
Last data update : 2015-10-06

<http://u.ganil-spiral2.eu/chartbeams/>



## Phase1 (2015)

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**End of construction & commissioning**

## DESIR Phase1+ (2019?)

(low energy facility)

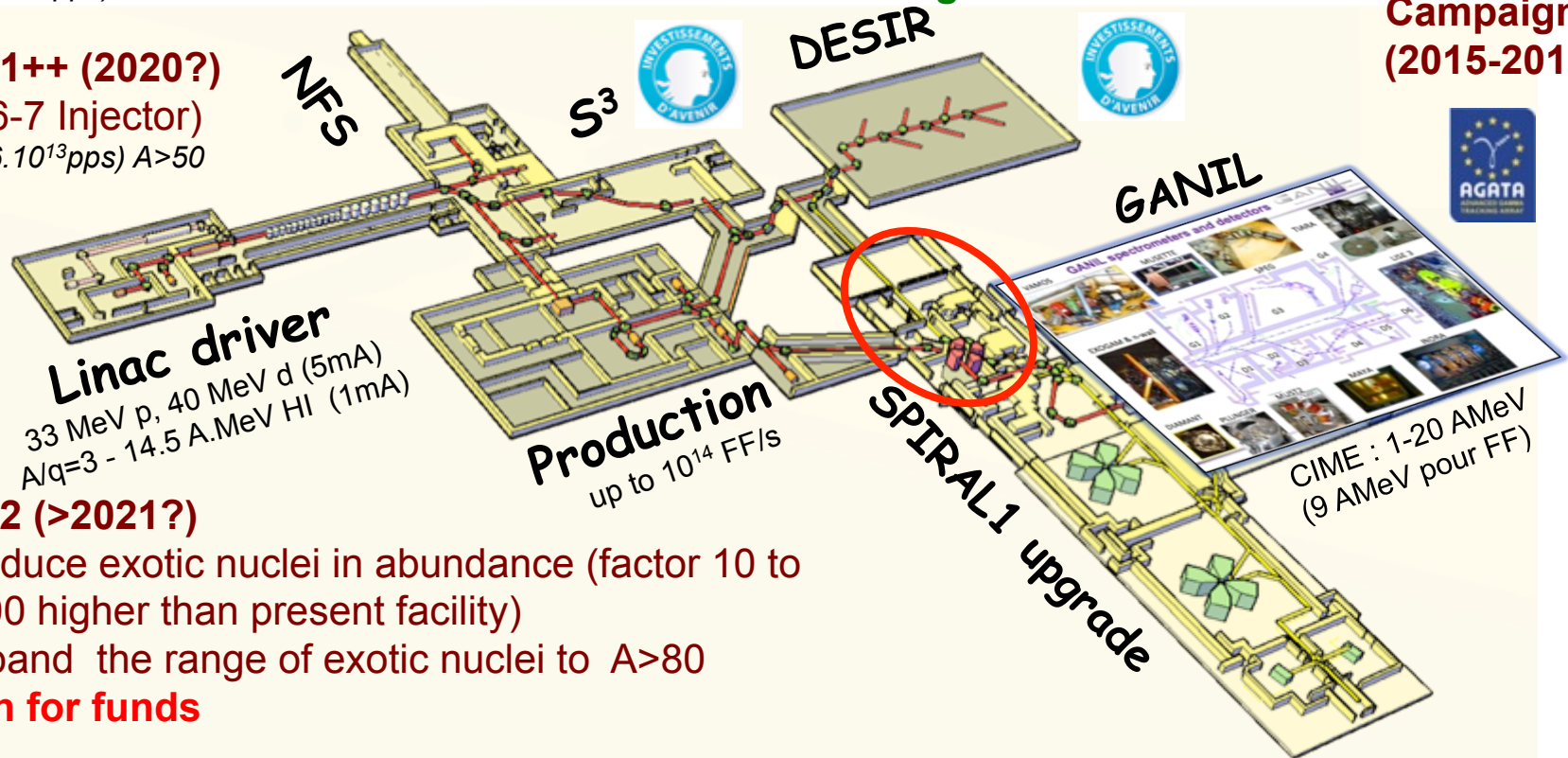
**Fully funded**

**AGATA  
Campaigns  
(2015-2018)**

## Phase1++ (2020?)

( $A/Q=6-7$  Injector)

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A > 50$



**Linac driver**  
33 MeV p, 40 MeV d (5mA)  
 $A/q=3$  - 14.5 A.MeV HI (1mA)

**Production**  
up to  $10^{14}$  FF/s

**SPIRAL1 upgrade**

CIME : 1-20 A MeV  
(9 A MeV pour FF)

## Phase2 (>2021?)

- Produce exotic nuclei in abundance (factor 10 to 1000 higher than present facility)
- Expand the range of exotic nuclei to  $A > 80$

**Search for funds**

## SPIRAL1 Upgrade (2016)

New light RIBs

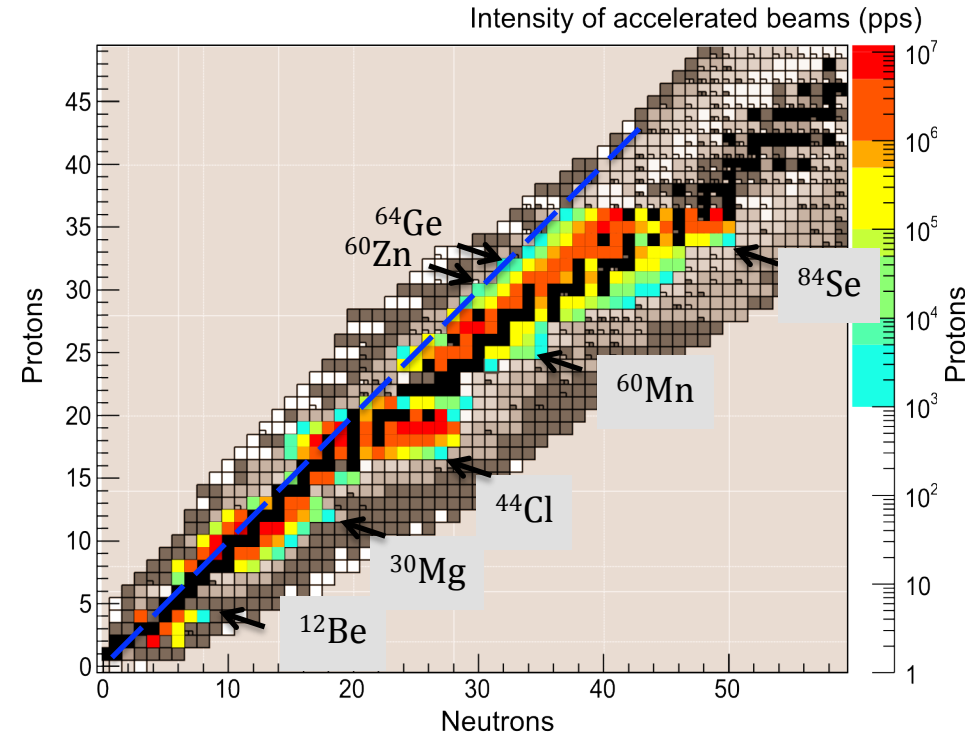
**Fully funded**

## Investment:

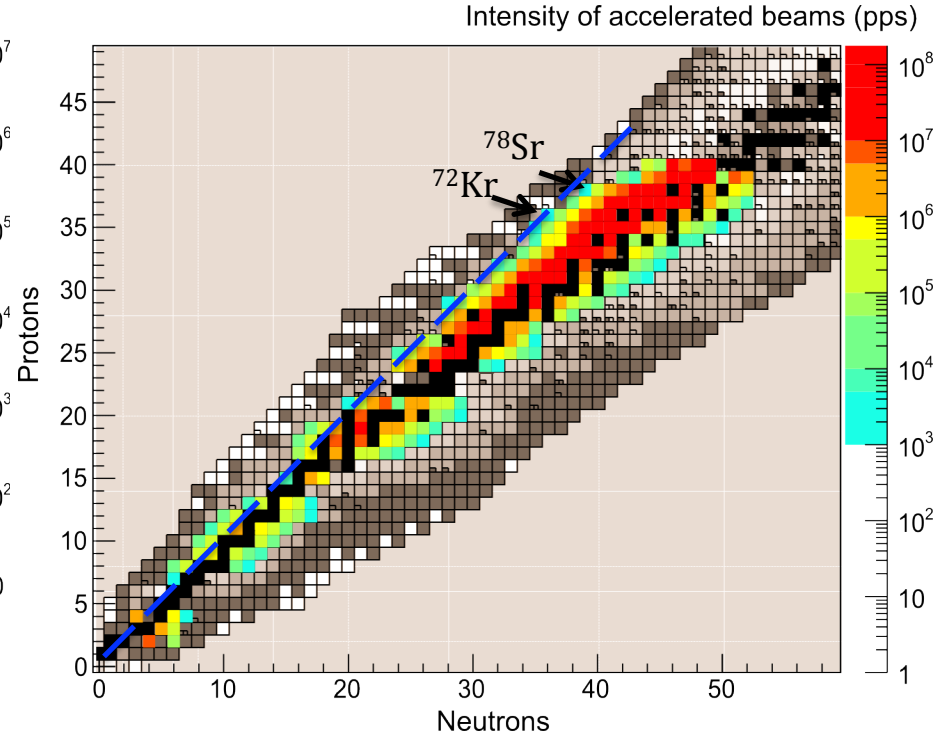
- SPIRAL2 Phase 1 (2015 secured): 100 M€
- New exp. halls and detectors (2014 secured)  $\geq 30$  M€

**SPIRAL2 is on the list of the European Strategy Forum on Research Infrastructures (ESFRI)**

# SPIRAL 1 upgrade



SPIRAL: Expected production from  $^{12}\text{C}$  target



SPIRAL: Expected production from Nb target



New beams beginning of 2017 available in particular for AGATA@GANIL and ACTAR-TPC experiments

- Nanogan - surface - fchad - ecr HD

P. Delahaye

## Phase1 (2015)

Increase the intensity of stable beams by a factor 10 to 100 –  
High intense neutron source

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A < 50$  **End of construction & commissioning**

## DESIR Phase1+ (2019?)

(low energy facility)

**Fully funded**

## AGATA

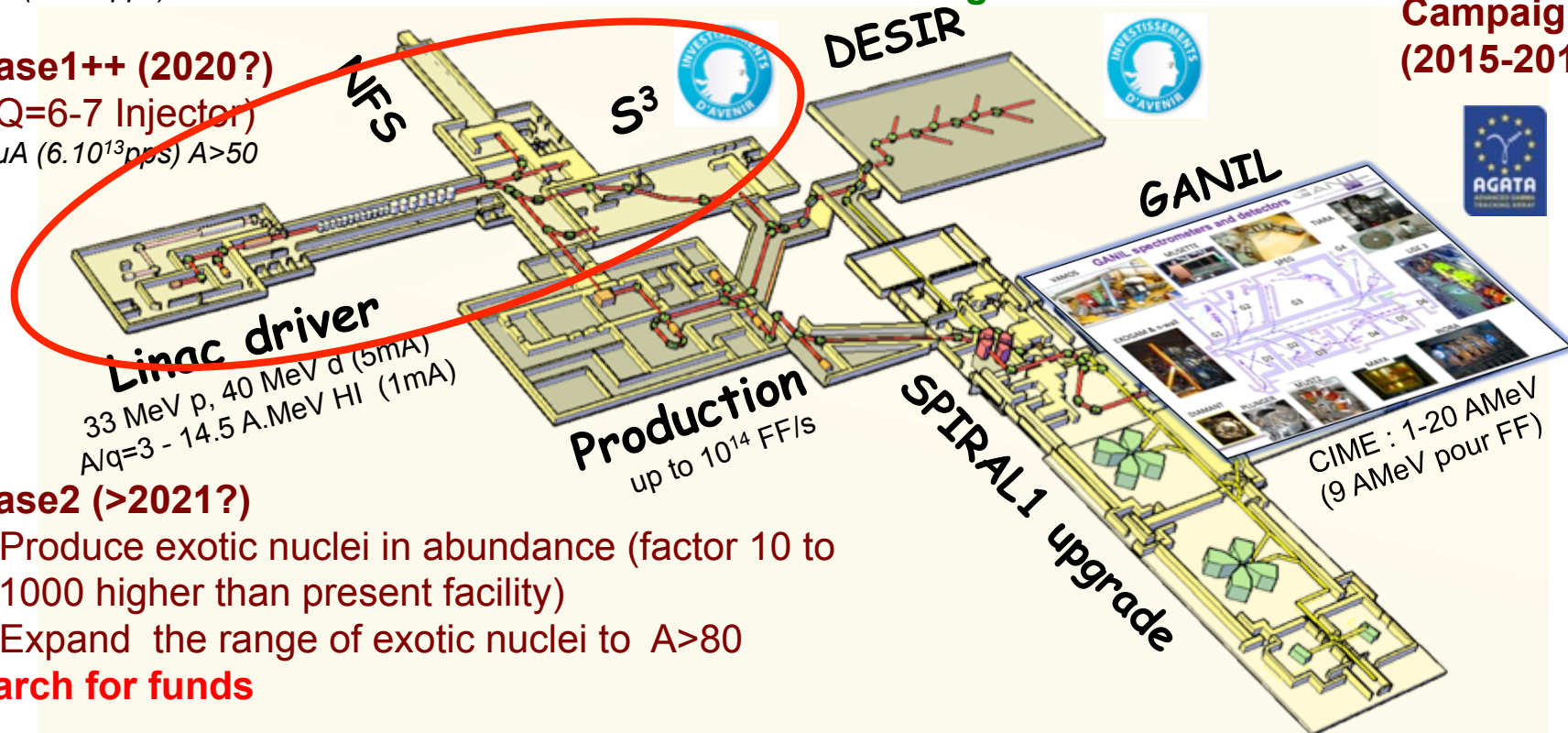
Campaigns

(2015-2018)

## Phase1++ (2020?)

( $A/Q=6-7$  Injector)

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A > 50$



## Phase2 (>2021?)

- Produce exotic nuclei in abundance (factor 10 to 1000 higher than present facility)
- Expand the range of exotic nuclei to  $A > 80$

**Search for funds**

## SPIRAL1 Upgrade (2016)

New light RIBs

**Fully funded**

## Investment:

- SPIRAL2 Phase 1 (2015 secured): 100 M€
- New exp. halls and detectors (2014 secured)  $\geq 30$  M€

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# Installation & Commissioning of LINAC

Low energy beam : Dec 2014  
RFQ beam : Dec. 2015: protons 5mA  
4He beam in March 2016, HI May 2016  
LINAC beam : End of 2016

Beam lines & support

SC Cavities

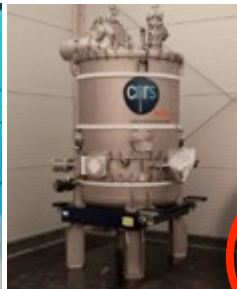
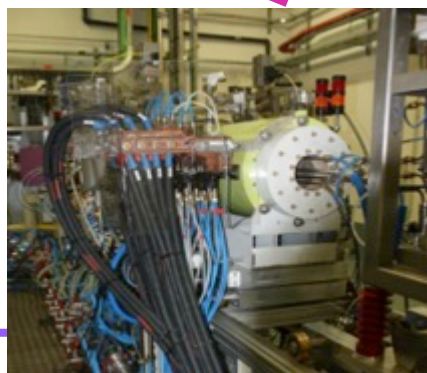
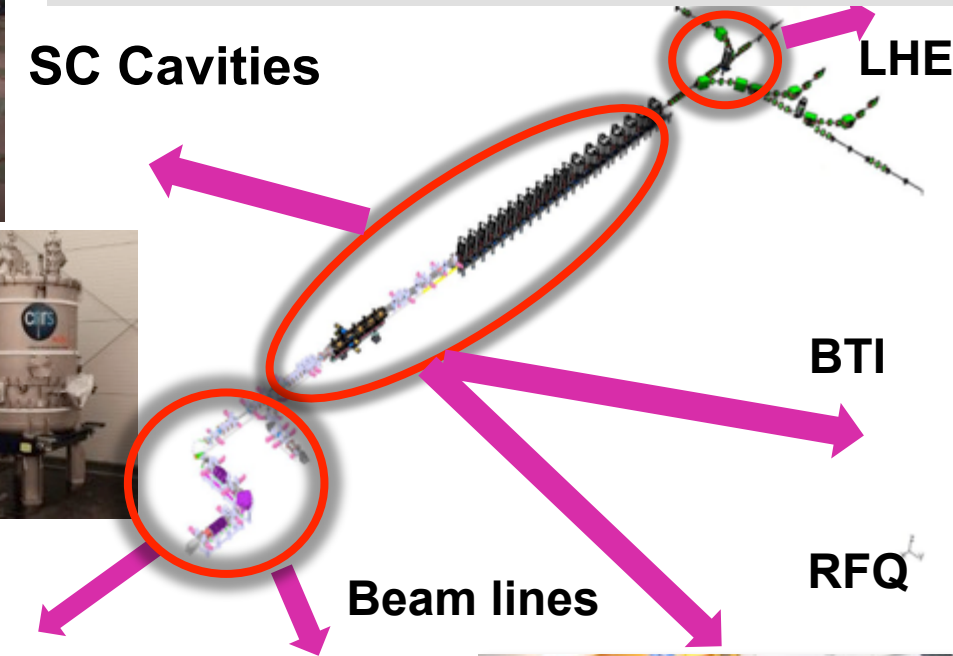
LHE

BTI

RFQ

Beam lines

Ion Sources



## Phase1 (2015)

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High intense neutron source

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A < 50$

**End of construction & commissioning**

## DESIR Phase1+ (2019?)

(low energy facility)

**Fully funded**

## AGATA

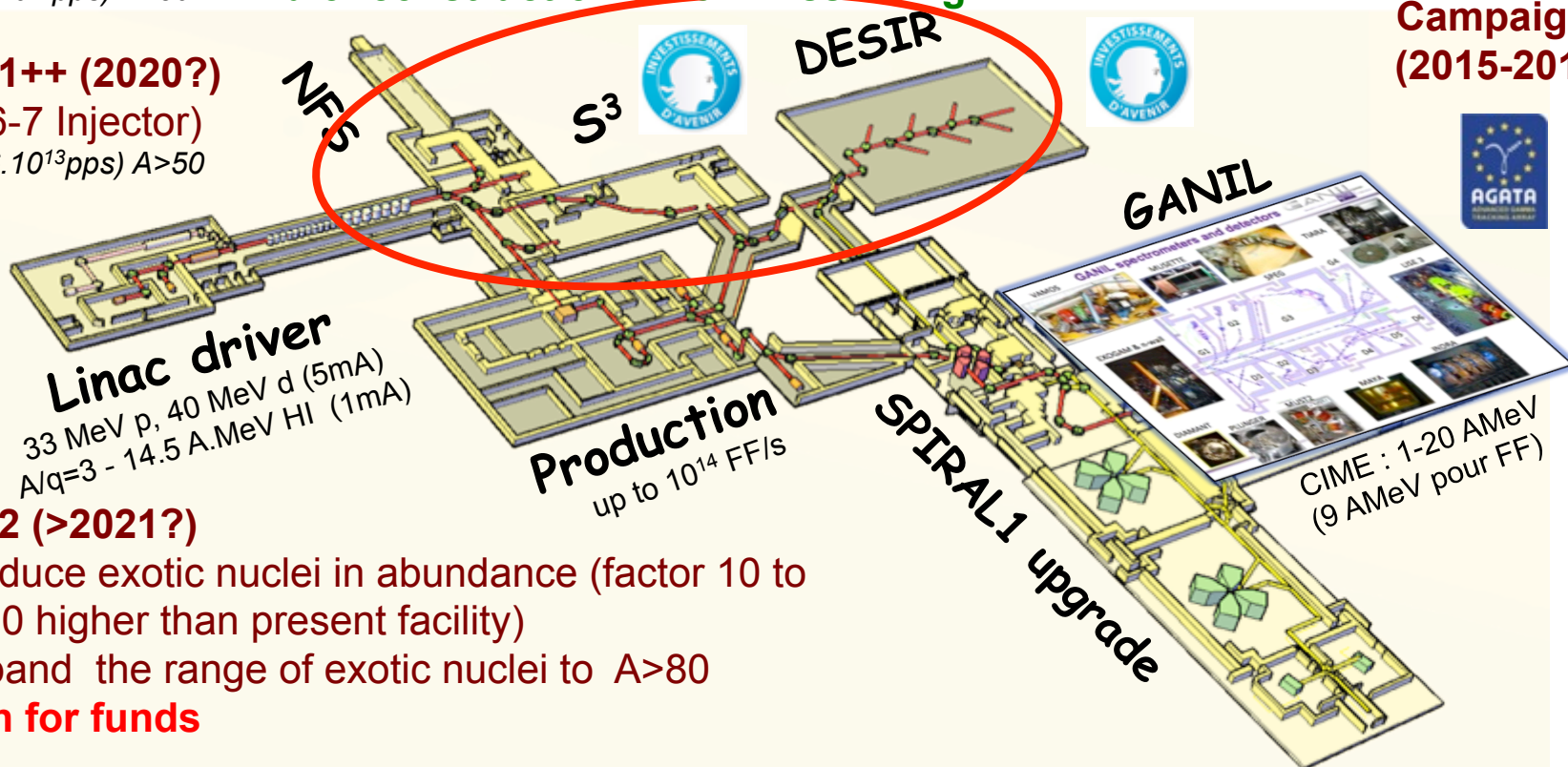
Campaigns

(2015-2018)

## Phase1++ (2020?)

( $A/Q=6-7$  Injector)

$10\mu\text{A}$  ( $6 \cdot 10^{13}\text{pps}$ )  $A > 50$



## Phase2 (>2021?)

- Produce exotic nuclei in abundance (factor 10 to 1000 higher than present facility)
- Expand the range of exotic nuclei to  $A > 80$

**Search for funds**

## SPIRAL1 Upgrade (2016)

New light RIBs

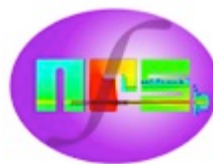
**Fully funded**

## Investment:

- SPIRAL2 Phase 1 (2015 secured): 100 M€
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**SPIRAL2 is on the list of the European Strategy Forum on Research Infrastructures (ESFRI)**

# Neutrons For Science



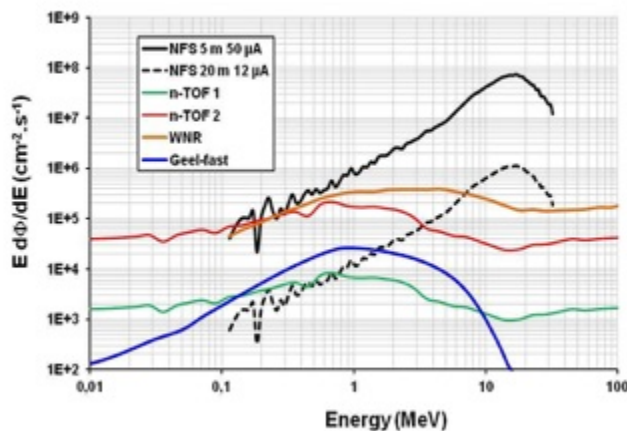
## NFS Physics case (11 Lols)

- Fission reactors of new generation
- Fusion technology
- Studies related to hybrid reactors (ADS)
- Basic data for evaluated data bases
- Nuclear medicine and biology
- Development of new detectors

- Beam at 0°
- Collimator ↔ beam quality
- Size (L x l) = (28m x 6m)
  - **TOF measurements**
  - free flight path

**I < 50  $\mu$ A**  
**P < 2 kW**

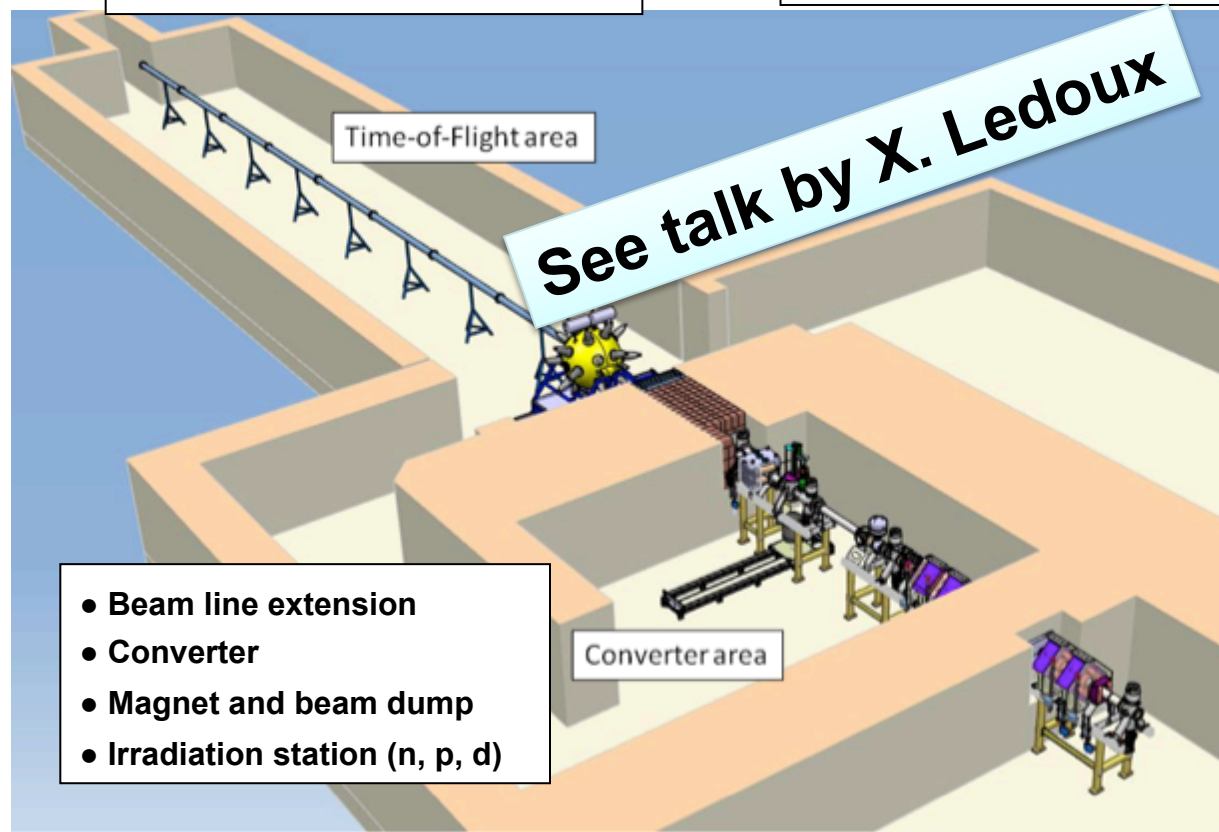
Use of **radioactive samples**  
A < 1 GBq for thin layers  
A < 10 GBq for thick samples



High intense neutron flux :

$$\Phi > 1,5 \cdot 10^{13} \text{ n/s in } 4\pi$$

Continuous or mono energetic spectra  
Well collimated neutron beam



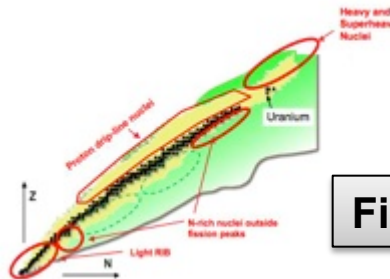
- Beam line extension
- Converter
- Magnet and beam dump
- Irradiation station (n, p, d)

PAC June 2016

First experiment in 2017

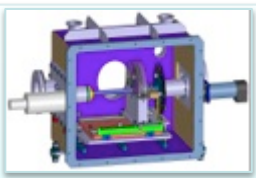
## S3 Physics case (16 Lols)

- VHE – SHE elements
- Proton drip-line and  $N=Z$
- Nuclear astrophysics
- Atomic physics

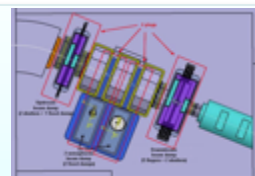


First experiment in 2017-18

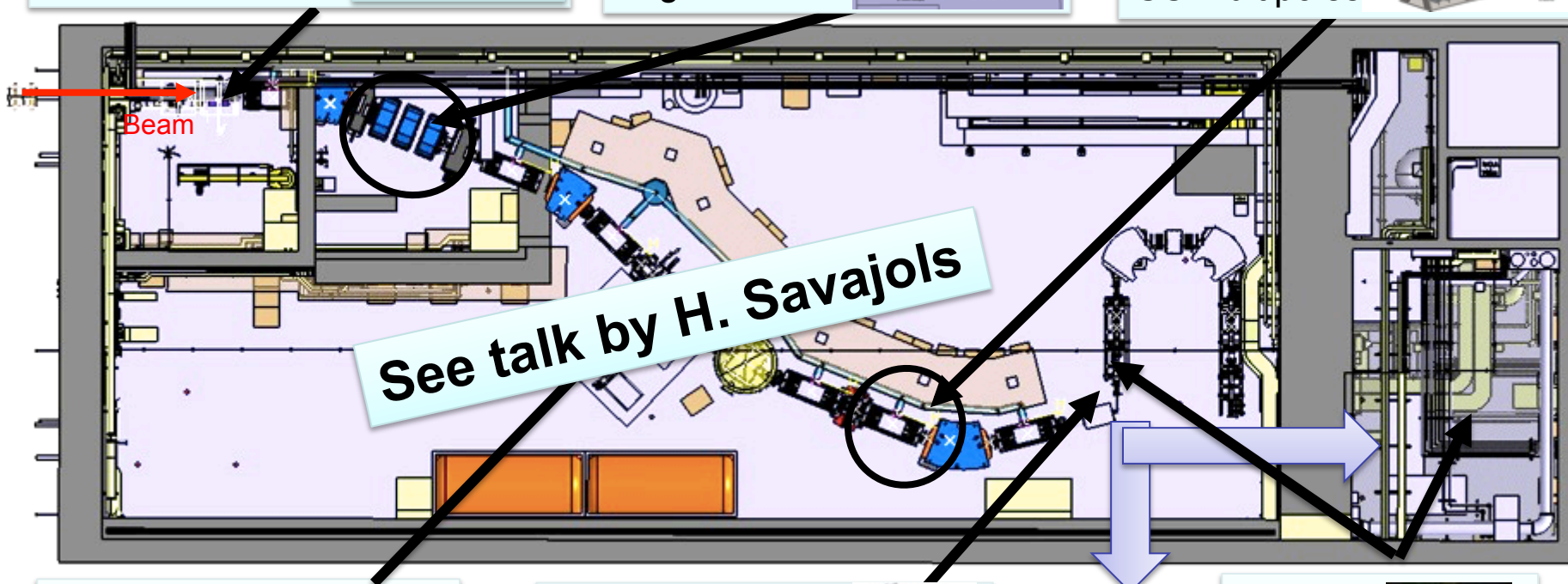
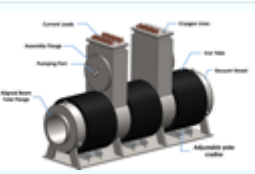
High power  
Rotating targets  
including actinides



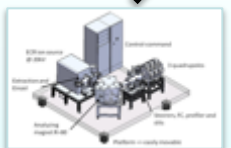
Beam dump  
& Movable  
fingers



Large  
acceptance  
SC Multipoles



FISIC setup  
Fast Ion Slow  
Ion Collisions

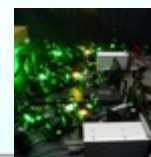


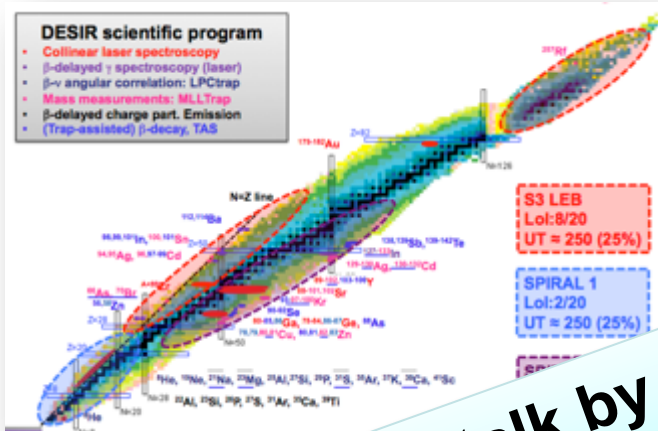
Implantation-decay  
station at the mass  
dispersive plan



**DESIR**

Low  
Energy  
Branch





See talk by J.C. Thomas

**DESIR hall**

**S3-LEB**

**HRS**

**SPIRAL1**

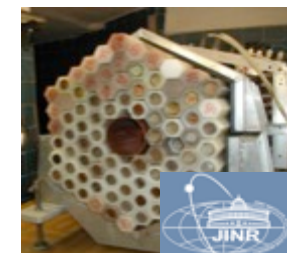
**High quality 1+ RIB (10-60KV)**

**S<sup>3</sup> LEB (REGLIS3):**

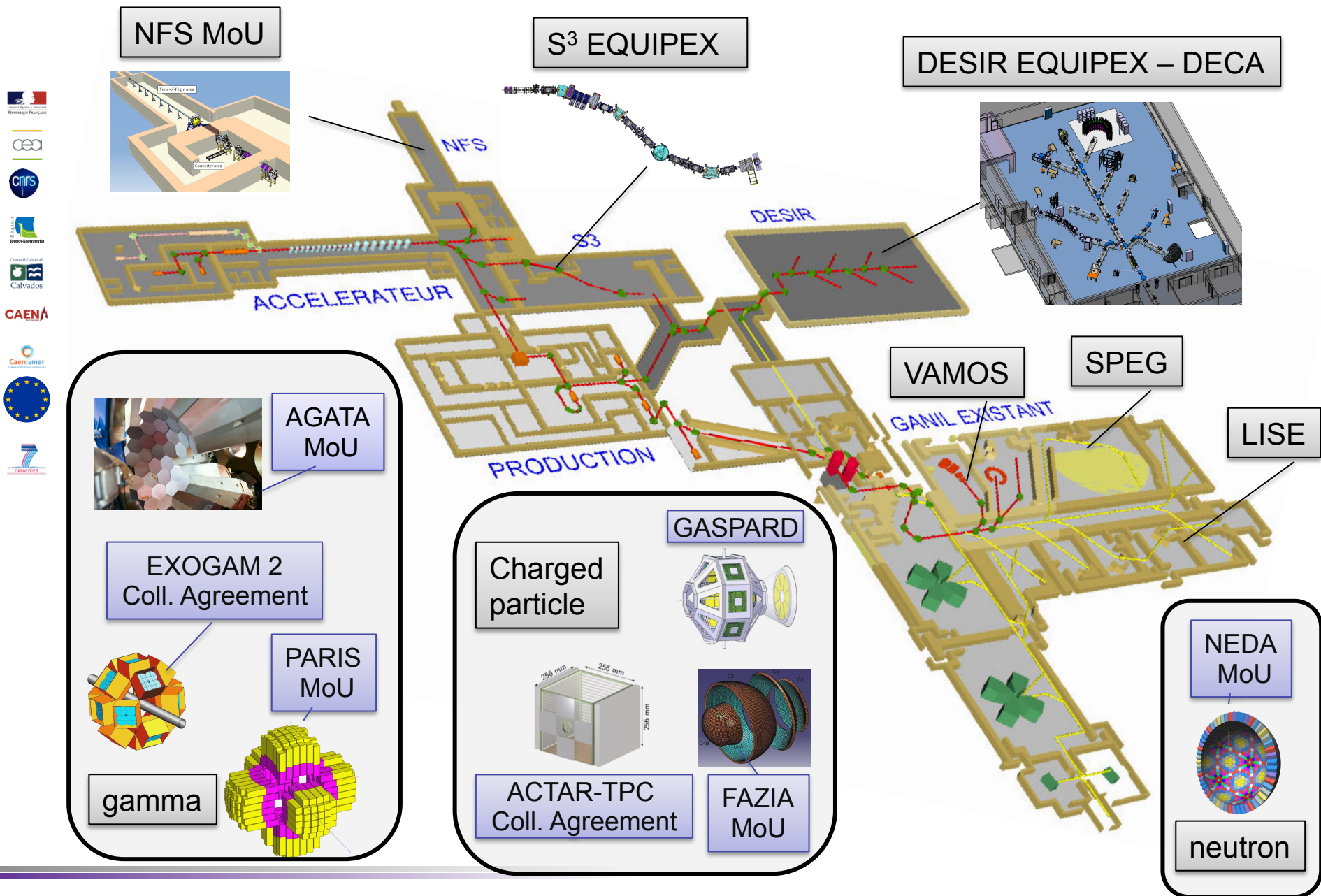
- laser ionization source + MR-ToF
- refractory elements
- n-deficient nuclei & very heavy nuclei

**SPIRAL1:**

- beam + target fragmentation
- ECR + FEBIAD + Surface ionization
- light nuclei

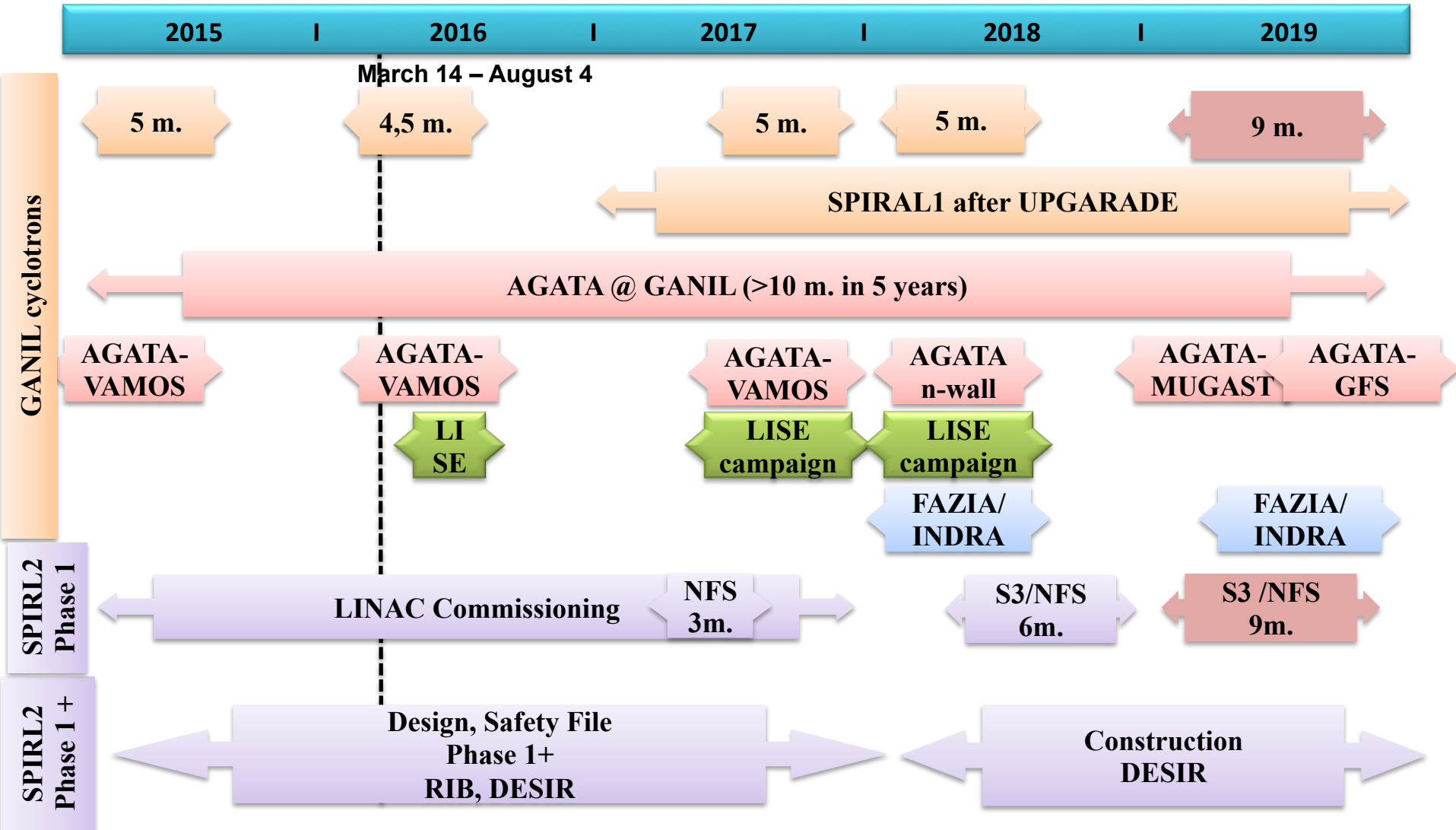


**GANIL**  
laboratoire commun CEA/DSM **Spiral2** CNRS/IN2P3



# Timeline GANIL & SPIRAL2 (goal)

PAC June 9-10





# EURISOL – Distributed Facility (DF)



**Members Initially:**  
**HIE-ISOLDE/CERN**  
**SPES-INFN**  
**SPIRAL2-GANIL**

**Candidate - future facility:**  
**ISOL@MYRRHA**

**EURISOL MoU member:**  
**COPIN Consortiumum Poland**

**JYFL has joined recently**

**Participation of ALTO in the  
project elaboration**

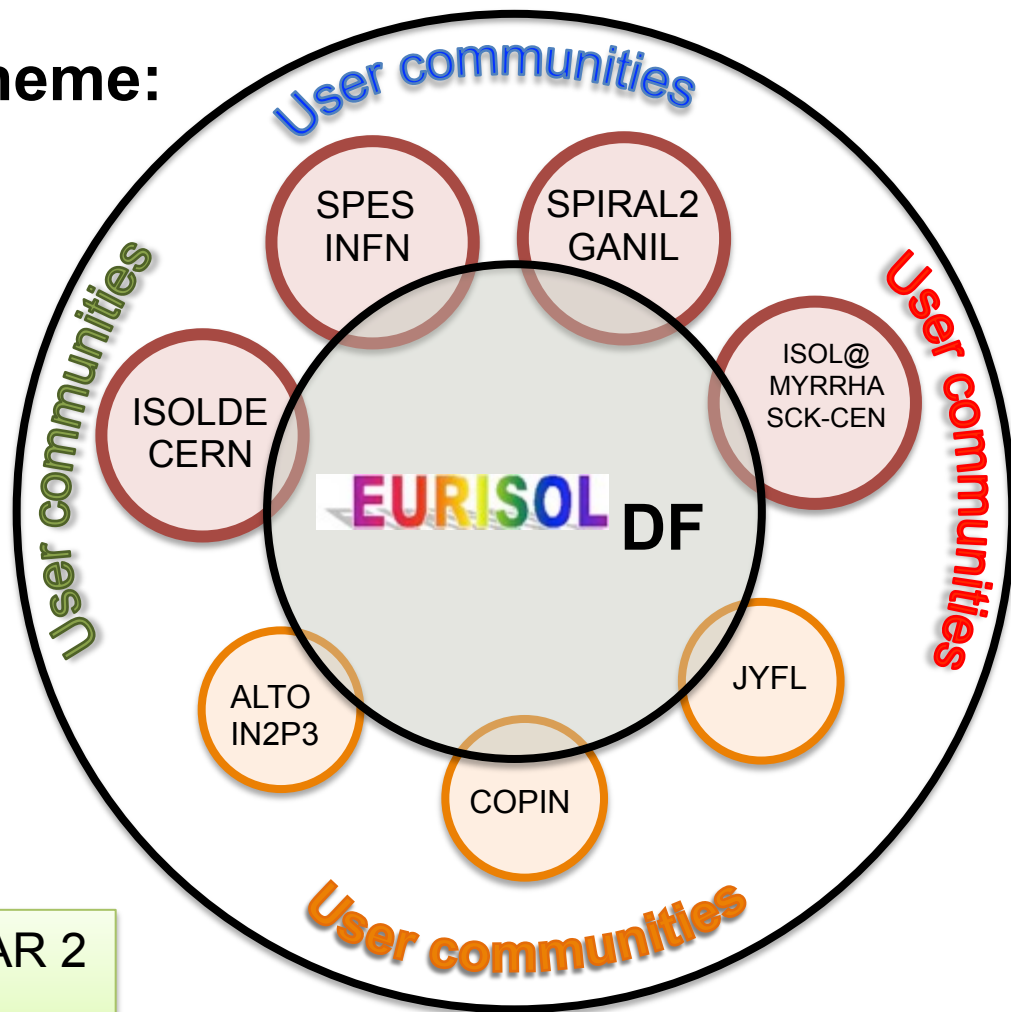
# EURISOL – Distributed Facility (DF) Initiative

## Proposed EURISOL-DF scheme:

- **EURISOL Science Case & Experiments**
  - Dedicated beamtime for EURISOL-DF experiments
  - Dedicated EURISOL-DF user organisation
- **R&D for EURISOL**
- **Legal entity (ERIC,...)**
- **EURISOL as a long term goal**

Interaction with EURISOL JRA in ENSAR 2 and EURISOL User group

[http://www.eurisol.org/eurisol\\_df/](http://www.eurisol.org/eurisol_df/)



Project to be submitted for the 2018 update of the ESFRI roadmap



# EPS Conference: Towards EURISOL Distributed Facility

<http://eurisoldf2016.be>

- October 18-21, 2016
- Leuven, Belgium
- Expected attendance:  $\geq 200$  participants

Promotiezaal KU Leuven  
(385 places)



Jubileumzaal: coffee breaks, reception,  
lunch and poster session(s)

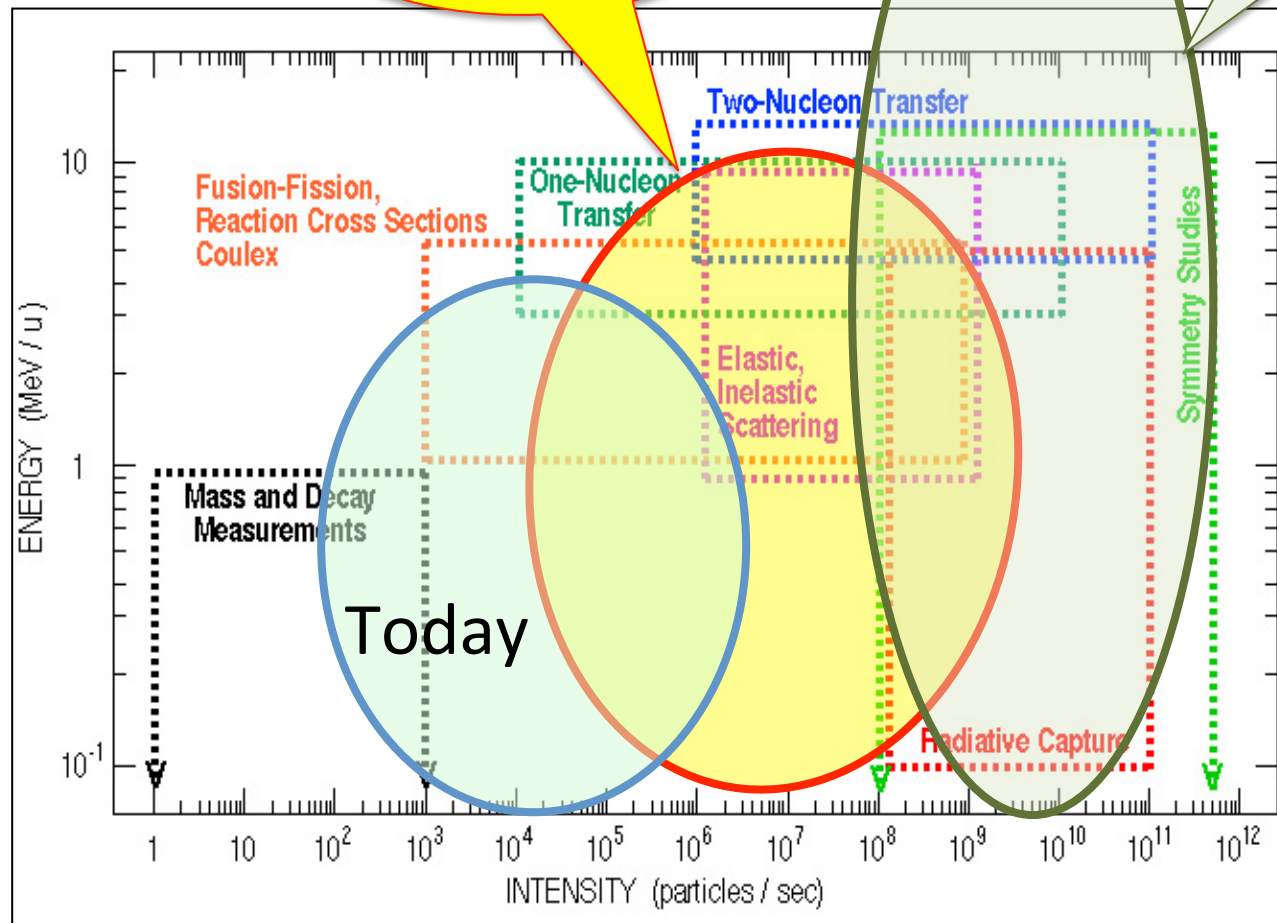




# Physics with ISOL RIB Intensity & Energy domains

HI-ISOLDE,  
SPES, SPIRAL2,  
ISOL@MYRRHA  
**EURISOL-DF**

**EURISOL**



today

Second generation

EURISOL

**EURISOL DF**

# SPIRAL2 Phase 1

Average beam intensity equivalent to that of ESS or EURISOL driver

	Q/A	I (mA)	Energy (Mev/u)	Max beam Power (KW)
Protons	1/1	5	2 - 33	165
Deuterons	1/2	5	2 - 20	200
Ions	1/3	1	2 - 14.5	45
Ions (option)	1/7	1	2 - 8	48

Commissioning is going on



NFS

BD

Future extension

S3

Towards RIB production

Towards DESIR