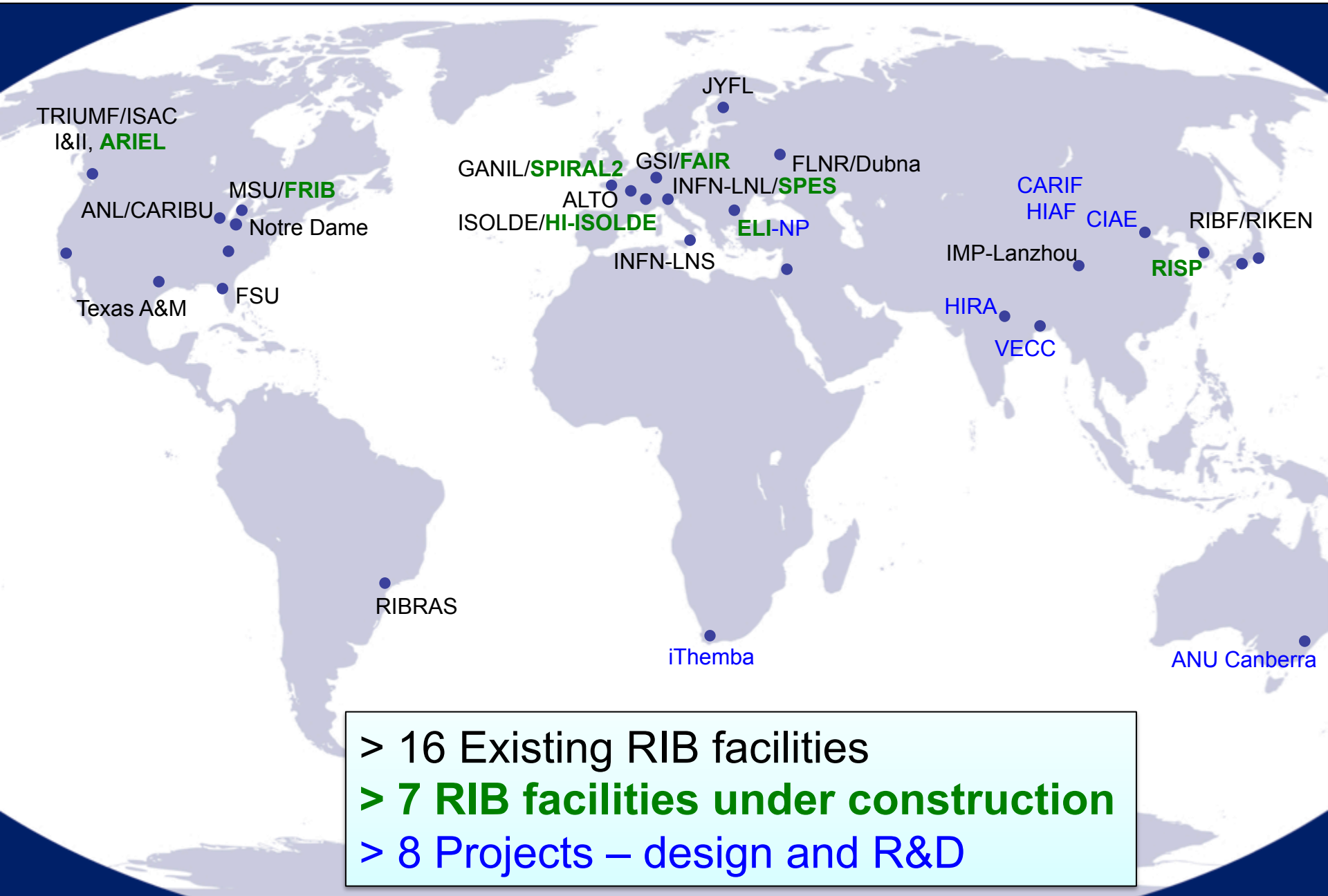
Present and future of RIB facilities in Europe

Marek Lewitowicz

GANIL, Caen, France

RIB FACILITIES WORLDWIDE

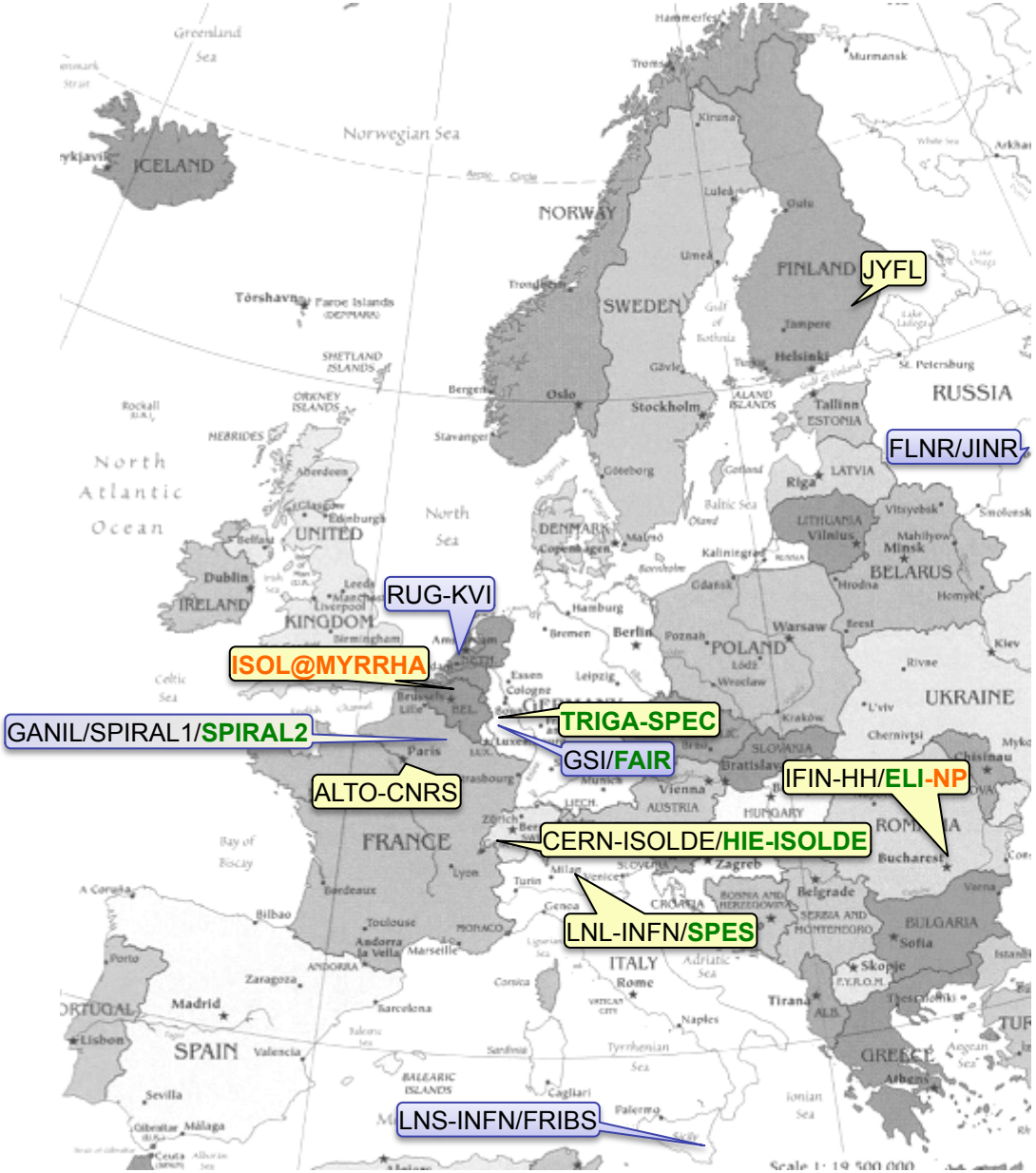


> 16 Existing RIB facilities

> 7 RIB facilities under construction

> 8 Projects – design and R&D

Radioactive Ion Beam Facilities in Europe



9 Existing RIB Facilities:

5 In-flight fragmentation

4 ISOL

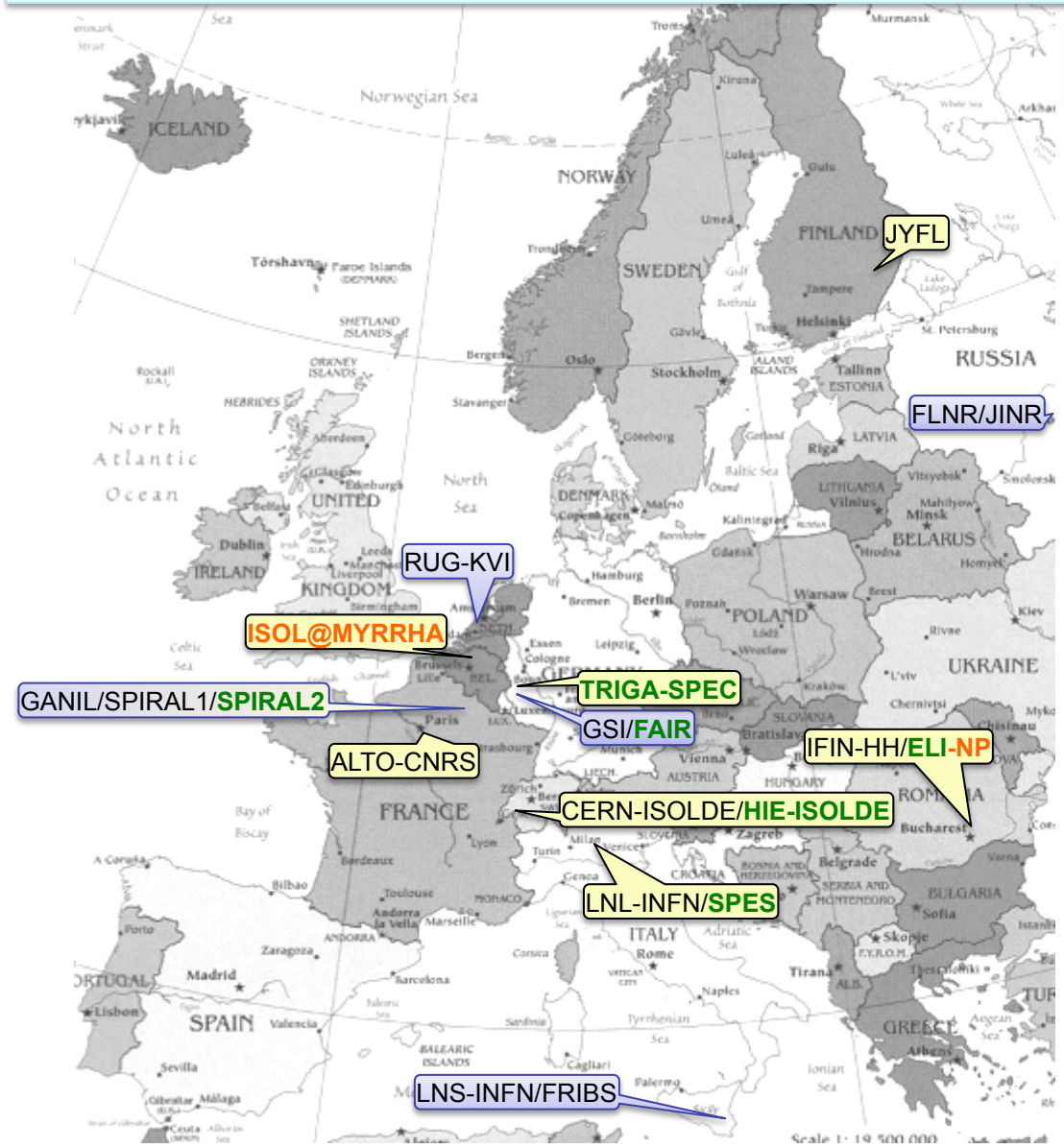
5 Facilities/upgrades under construction or commissioning

2 Projects under design

Community: 2700-3000 scientists and highly qualified engineers

Radioactive Ion Beam Facilities in Europe

In the following: facilities using RIB in NN collisions



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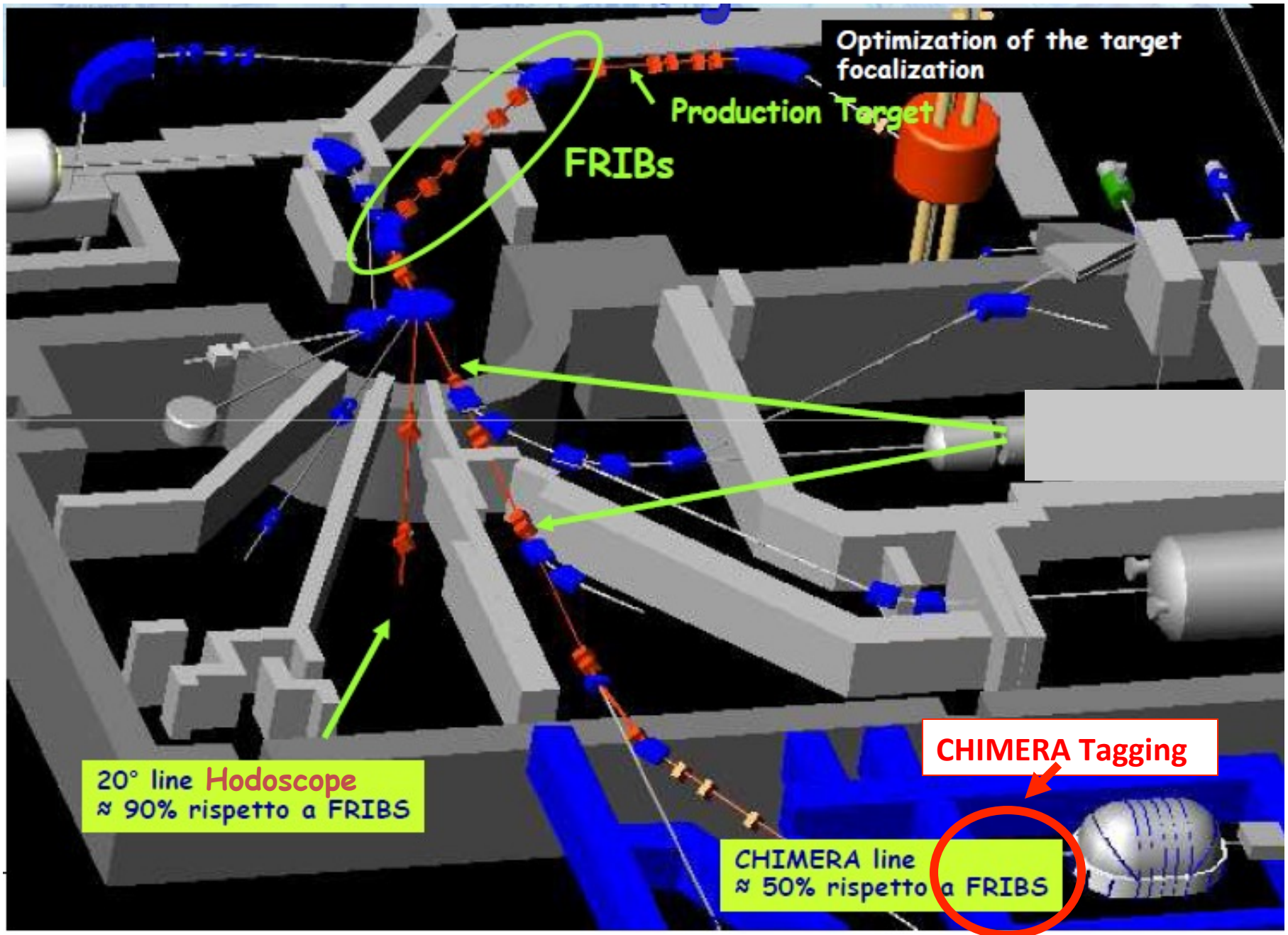
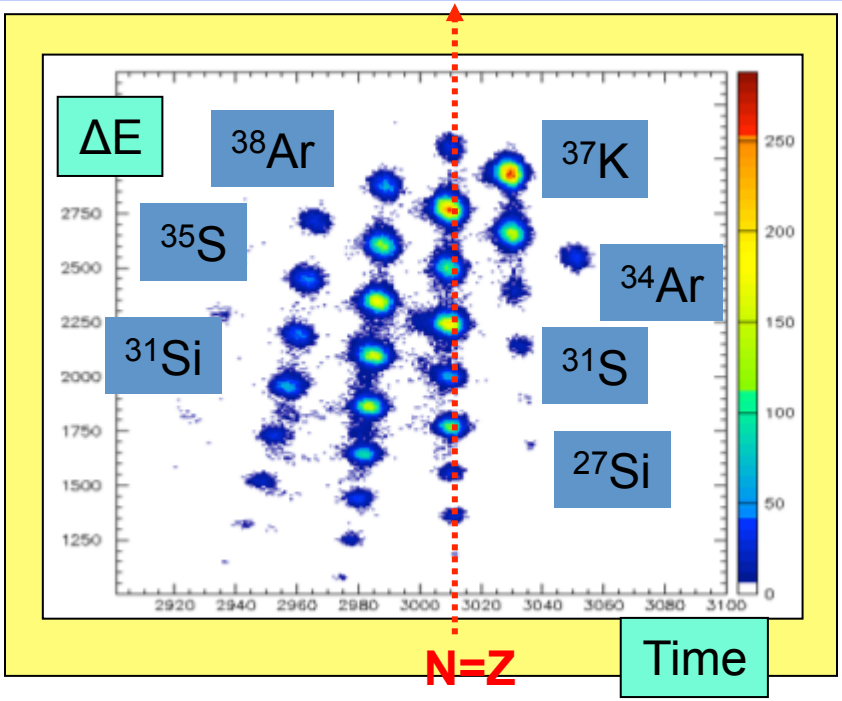
In-flight fragmentation beams @ LNS, Catania



LNS CATANIA FRIBS UPGRADE

Increasing the primary beam intensity of the CS will produce an equivalent increase of the exotic nuclei intensity produced by in flight fragmentation in FRIBS



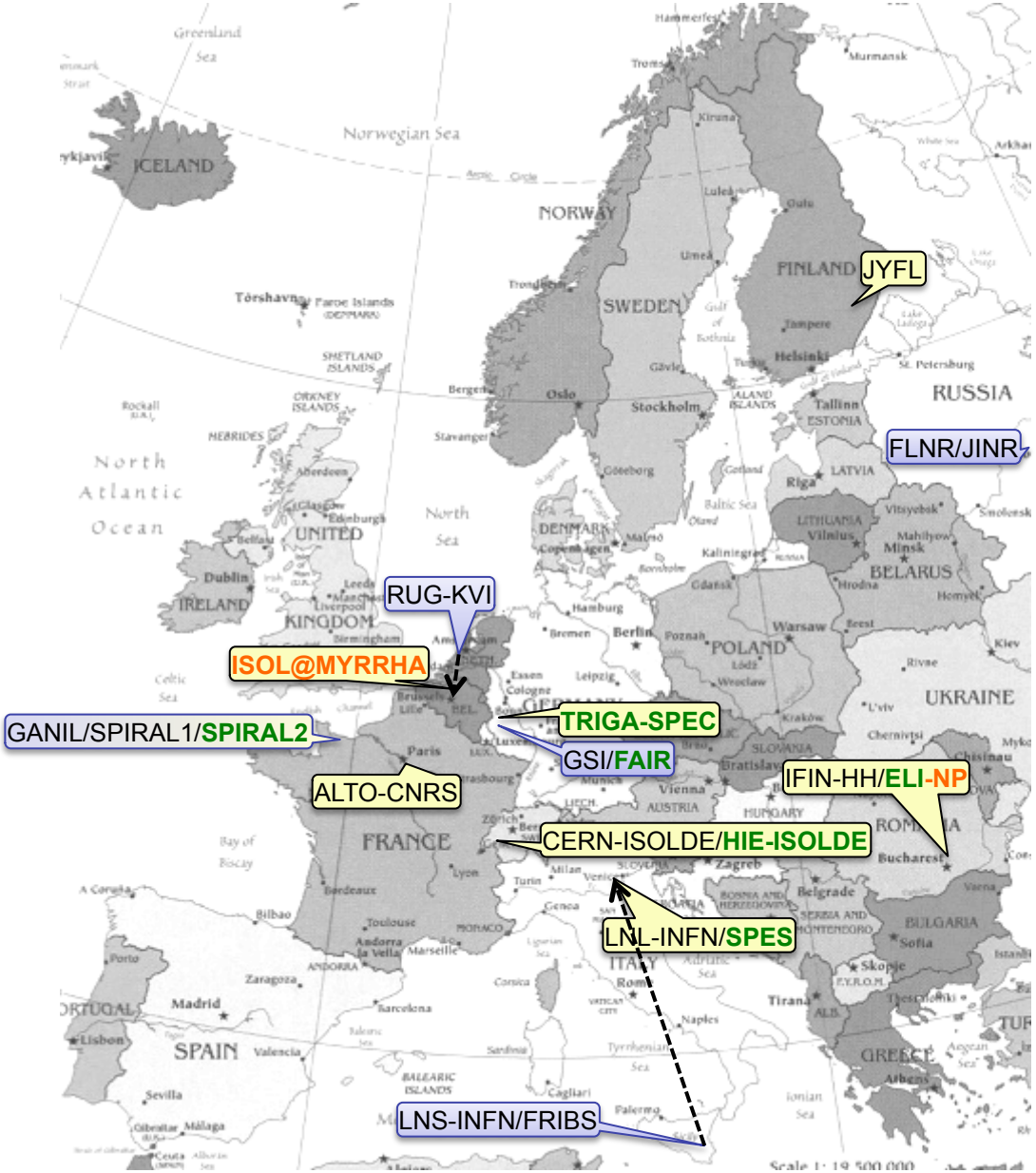
Some examples of future beams:

^{68}Ni 30 MeV/A 2·10^{6} p./s
^{34}Ar 30 MeV/A 1·10^{5} p./s
^{11}Be50 MeV/A 2·10^{6} p./s
^{12}Be 50 MeV/A 1·10^{5} p./s
^{14}Be 50 MeV/A 5·10^{3} p./s
^{11}Li 50 MeV/A 1·10^{5} p./s
^{8}He 50 MeV/A 2·10^{5} p./s

Primary beam power increase from 100W to 5-10kW

EXOTIC beams at intermediate energies (20-100 AMeV)

Radioactive Ion Beam Facilities in Europe



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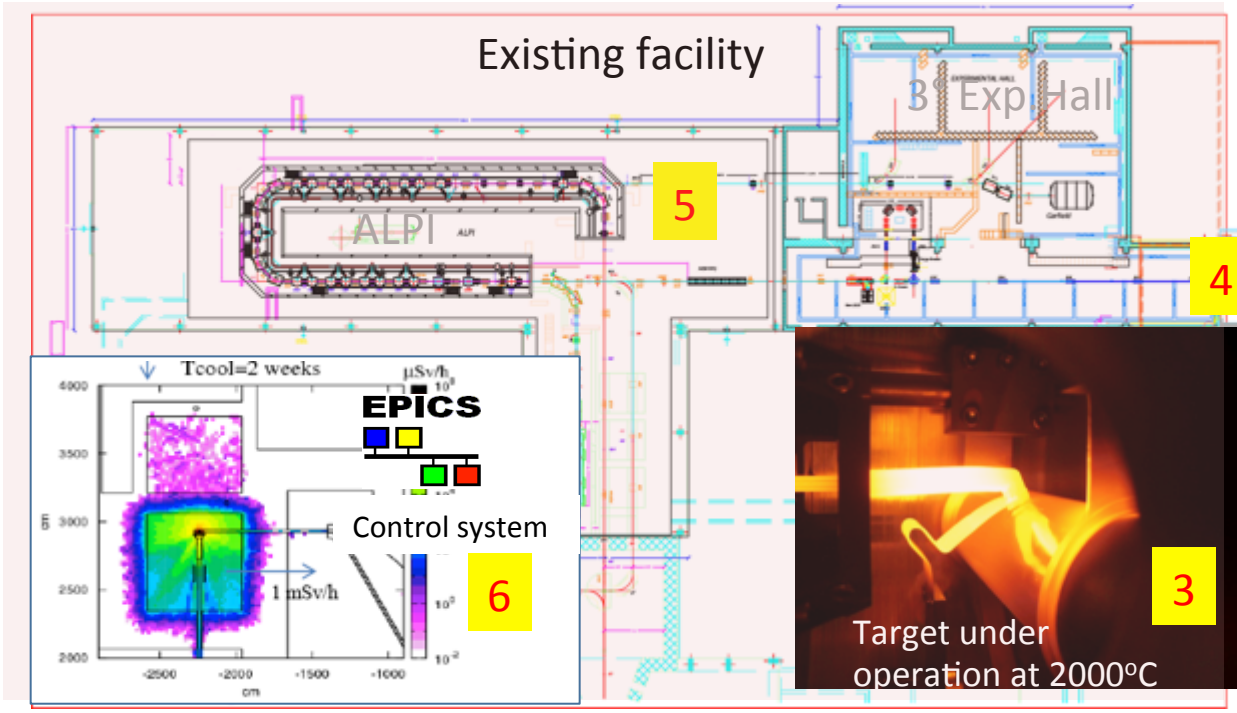
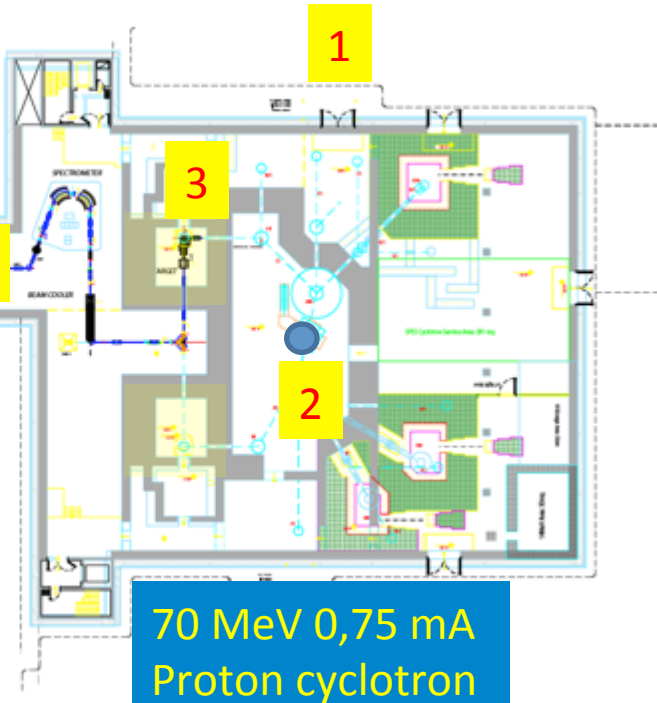
SPES Facility at LNL Legnaro





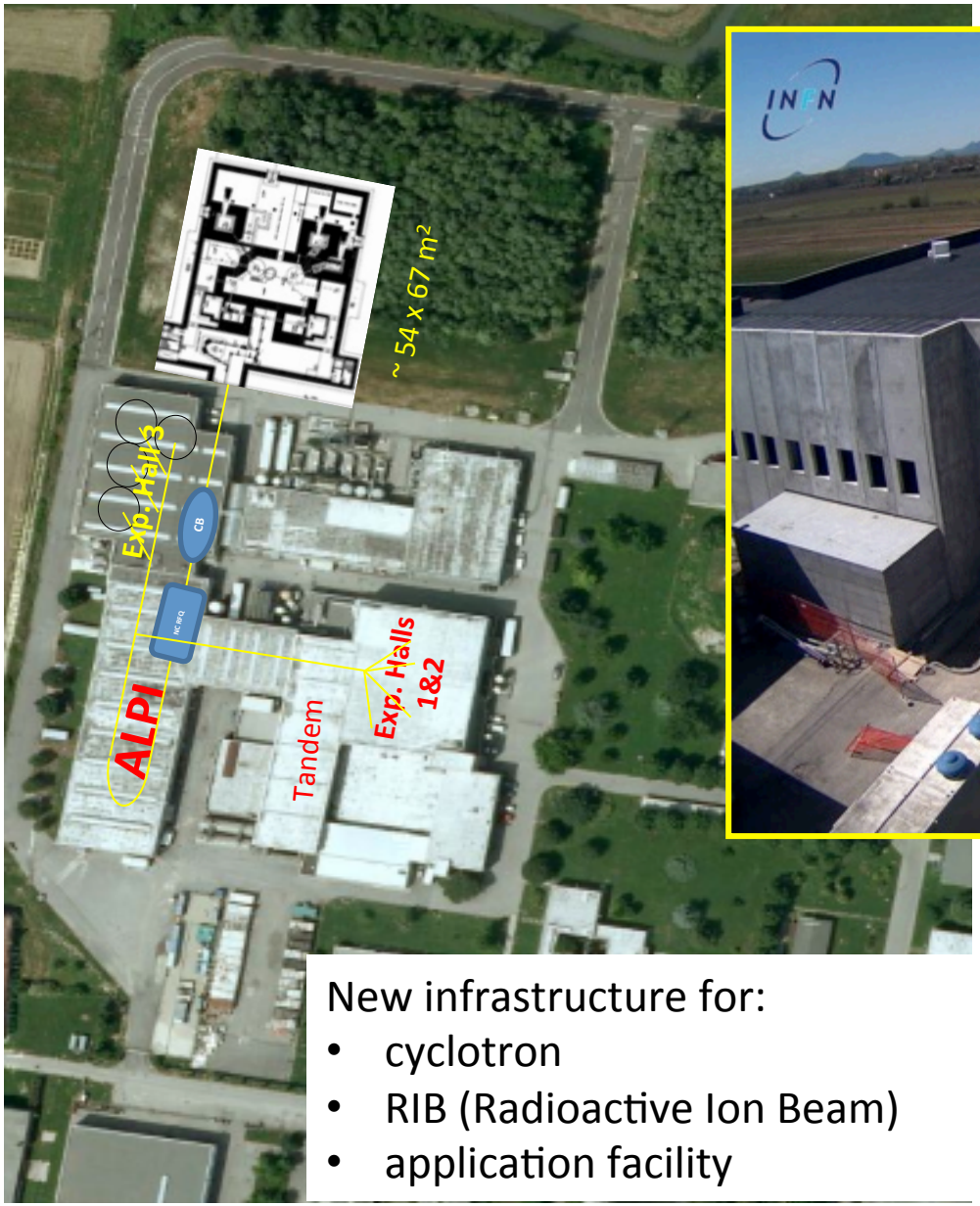
70 MeV 0,75 mA
Proton cyclotron

≥ 50 M€,
first beams by 2019

	SPES sub-systems
1	Building and infrastructures **with 2 ISOL bunkers for radioactive beam** and application area for radioisotopes and neutrons
2	Cyclotron 70 MeV protons with 2 independent exits
3	ISOL UCx target designed for 10^{13} f/s -**direct production with p**
4	Beam transport with **High Resolution Mass Separation**
5	**Reacceleration** with ALPI superconductive linac (10A MeV A=130)
6	Radioprotection, safety & controls

SPES
exotic beams for science

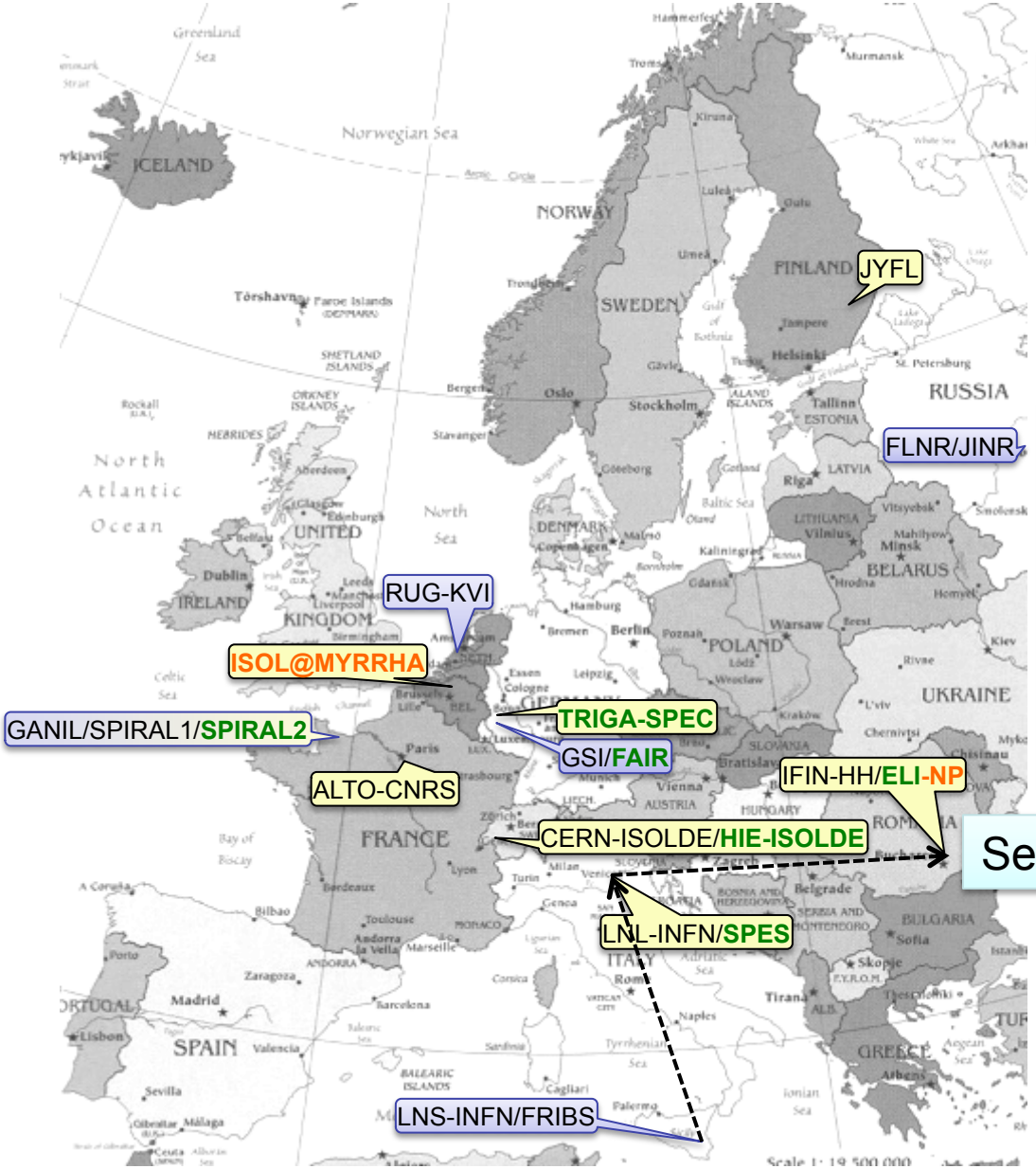
SPES Facility Layout



New infrastructure for:

- cyclotron
- RIB (Radioactive Ion Beam)
- application facility

Radioactive Ion Beam Facilities in Europe



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See talk of V. Zamfir

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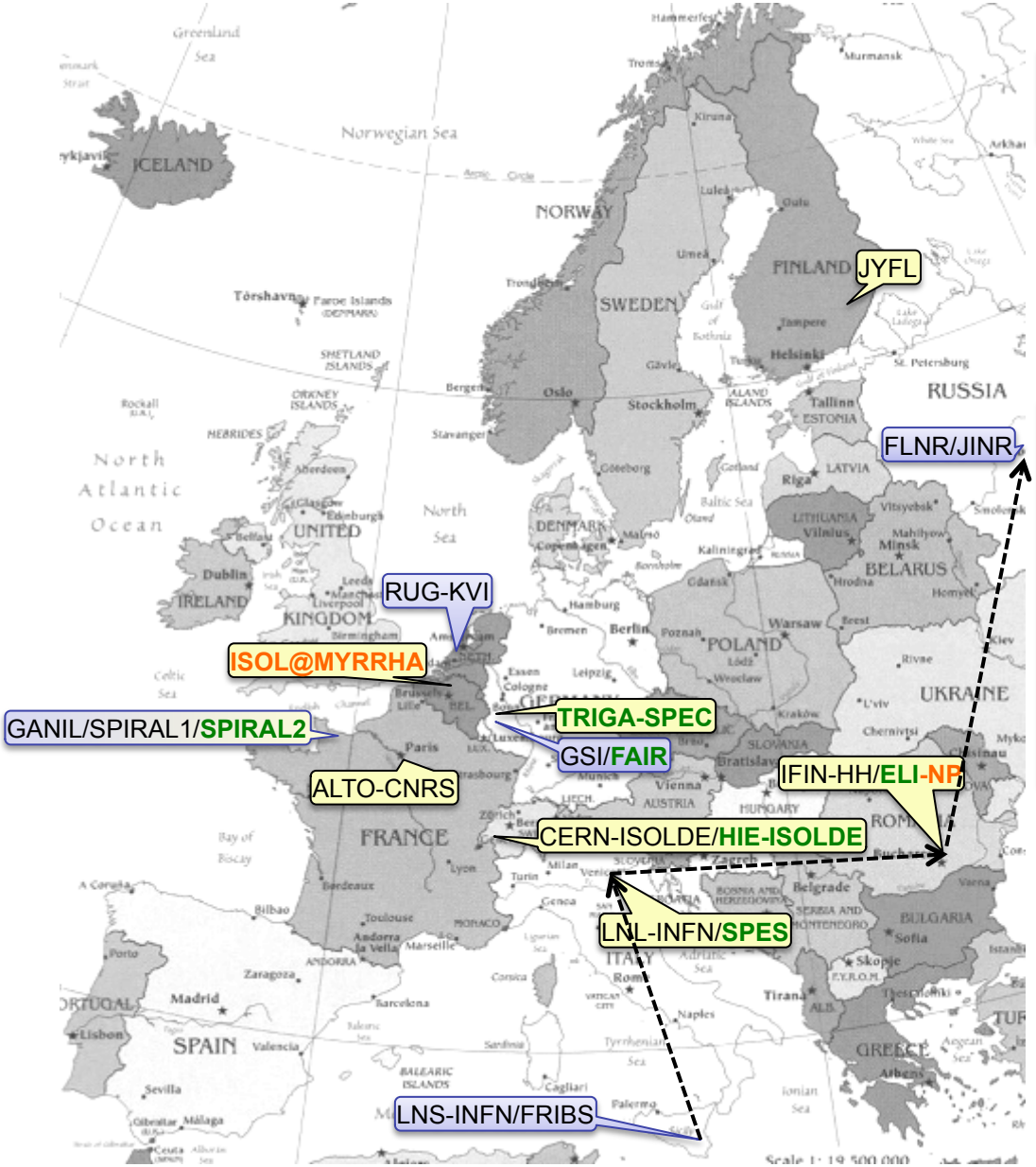
Radioactive Ion Beam Facilities in Europe



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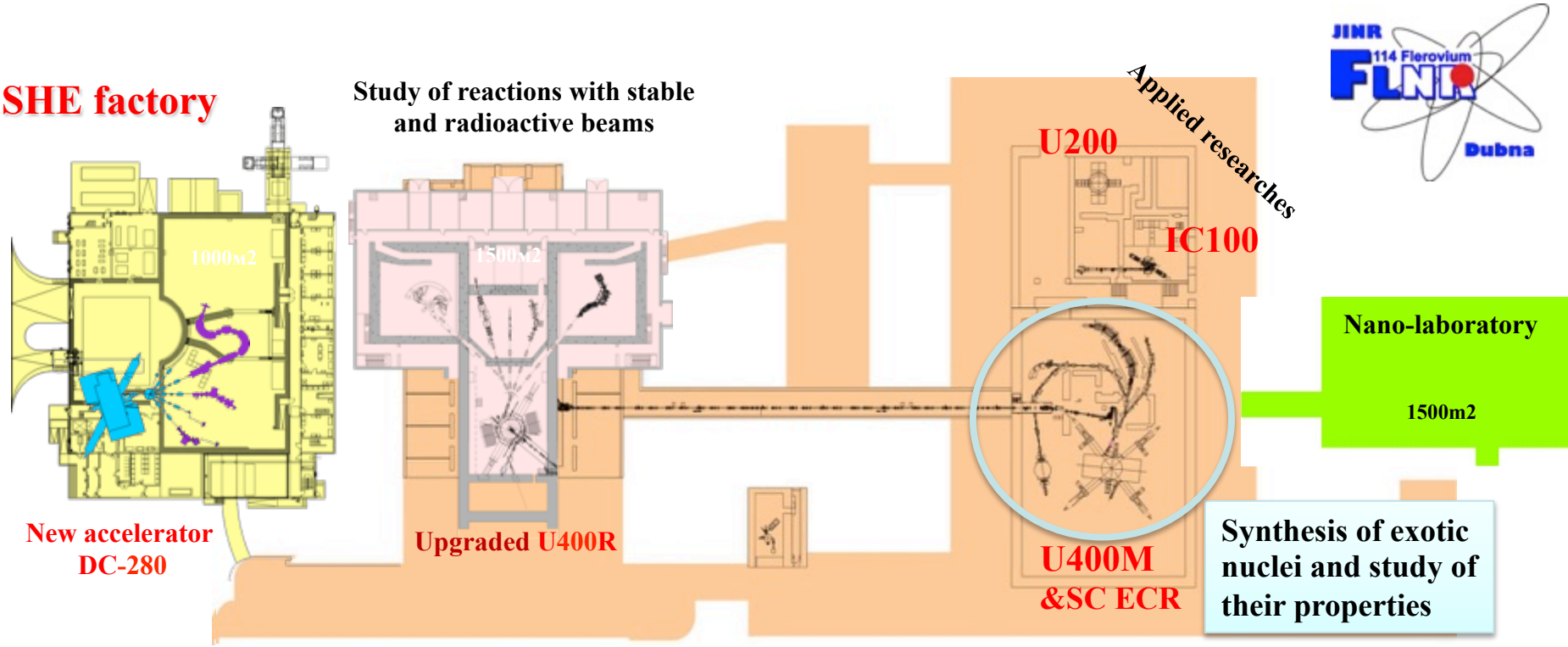


FLNR's basic directions of research:

1. Heavy and superheavy nuclei:

- synthesis and study of properties of superheavy elements;
- chemistry of new elements;
- fusion-fission and multi-nucleon transfer reactions;
- nuclear- , mass-, & laser-spectrometry of SH nuclei.

2. Light exotic nuclei:

- properties and structure of light exotic nuclei;
- reactions with exotic nuclei.

3. Radiation effects and physical groundwork of nanotechnology.

ACCULINNA-2: Plans and prospects

2015/16: *commissioning test, 1st runs*

- Searching for 2*p* decay of the first excited state of ^{17}Ne in 1H(18Ne,d)17Ne reaction
- Study of 26S in the reaction 1H(28S,t)26S

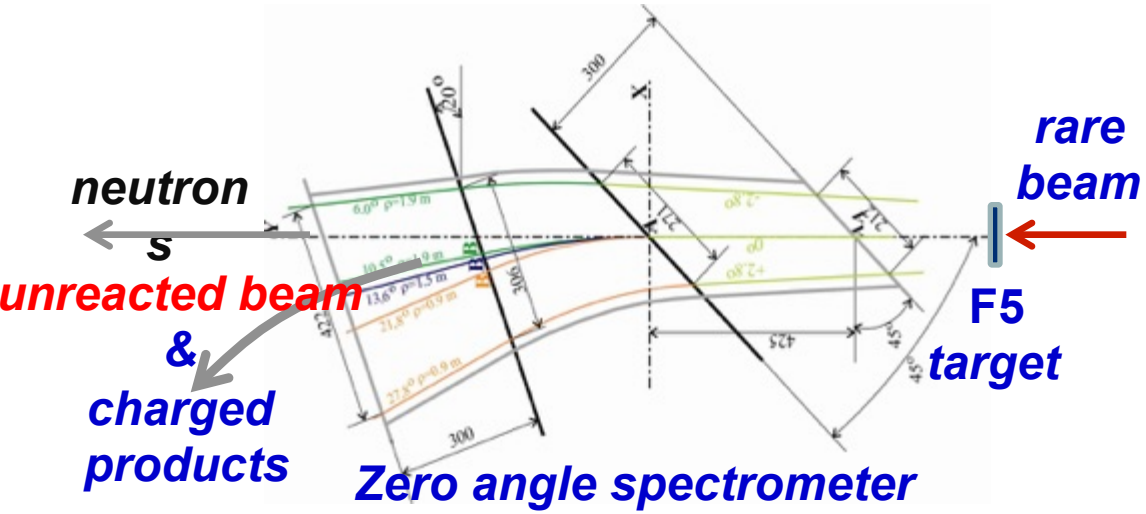
2016: *zero angle spectrometer at F5*

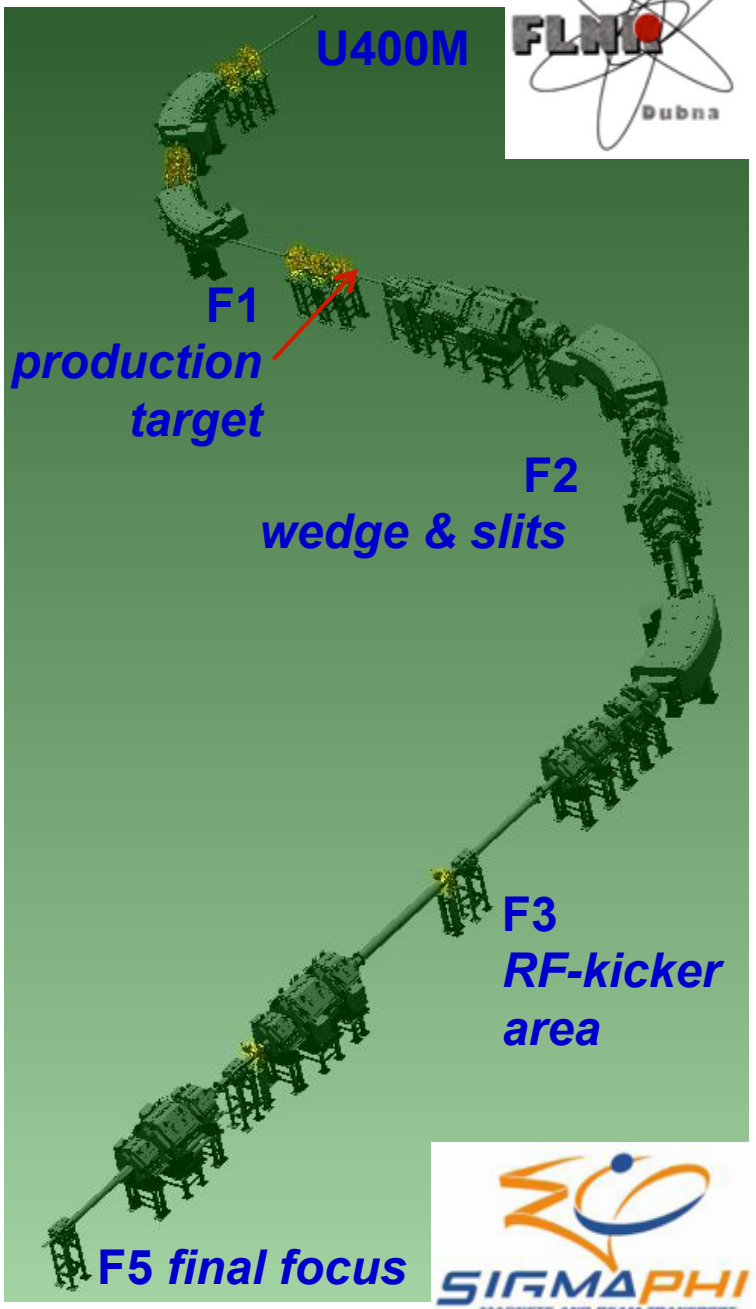
^{7}H - observation with the use of 11Li projectile

10Li - low energy states via 1H(11Li,d)10Li

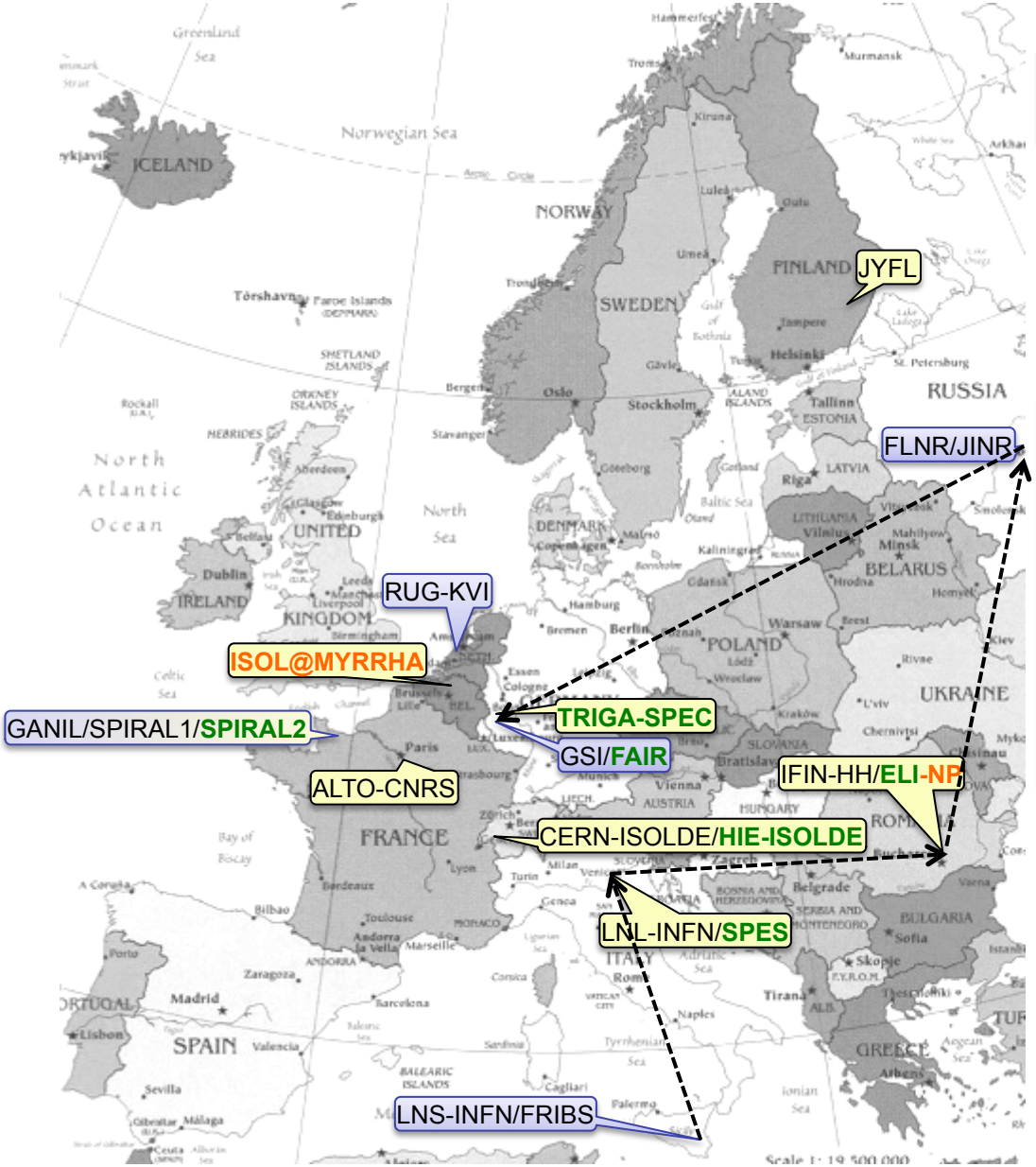
2017: *cryogenic tritium target*

^{10}He, ^{11}Li, ^{16}Be – *E*, *Γ*, J^{π} for excitation states, search for new decay modes *n*, 2*n*, 4*n*





Radioactive Ion Beam Facilities in Europe



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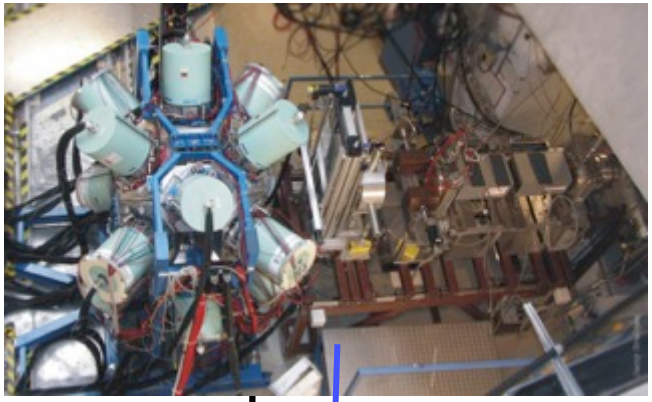
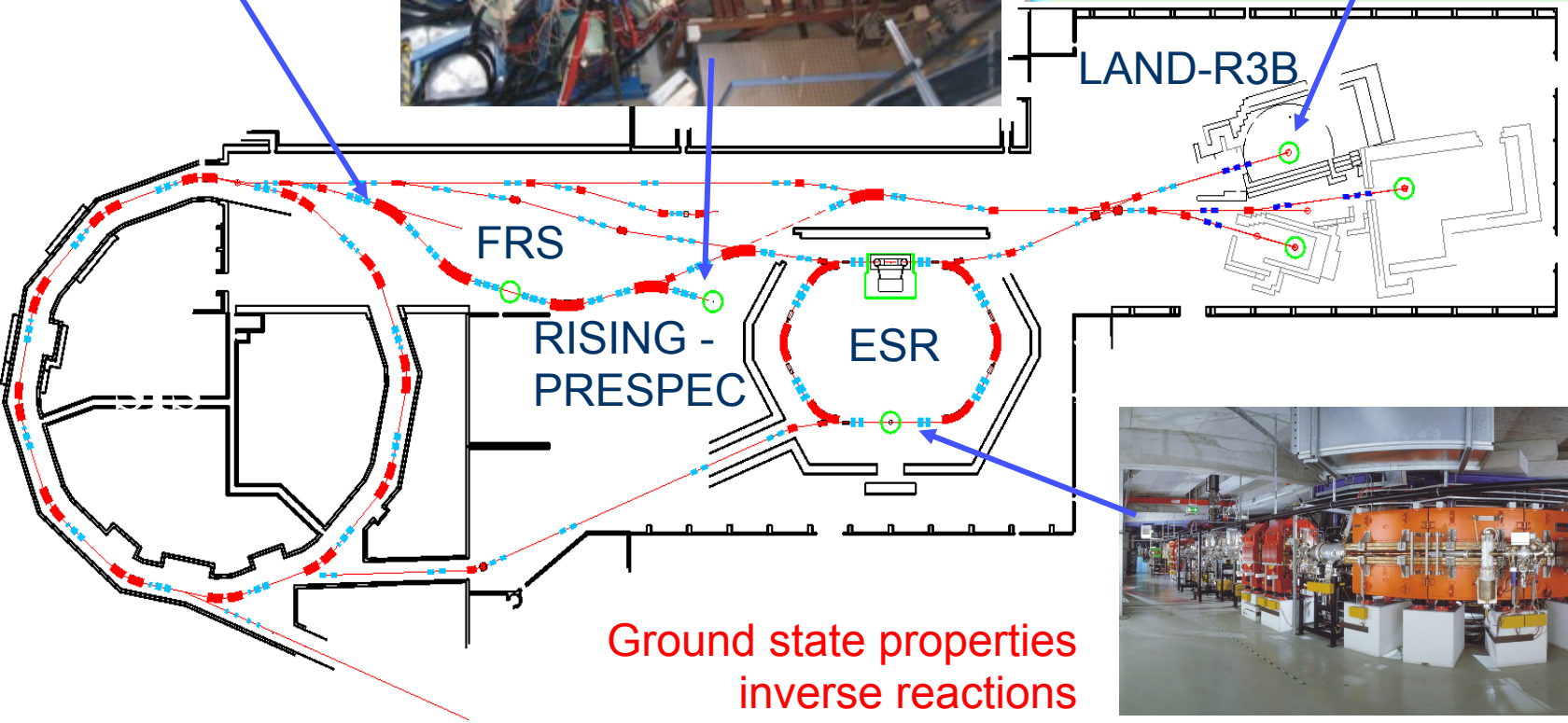
Existing research opportunities at GSI
…evolving towards NUSTAR@FAIR!

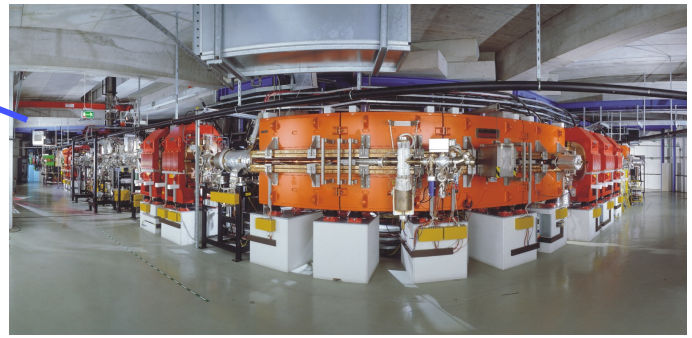
Decay studies, in-beam spectroscopy

Reaction studies

production and separation of exotic nuclei



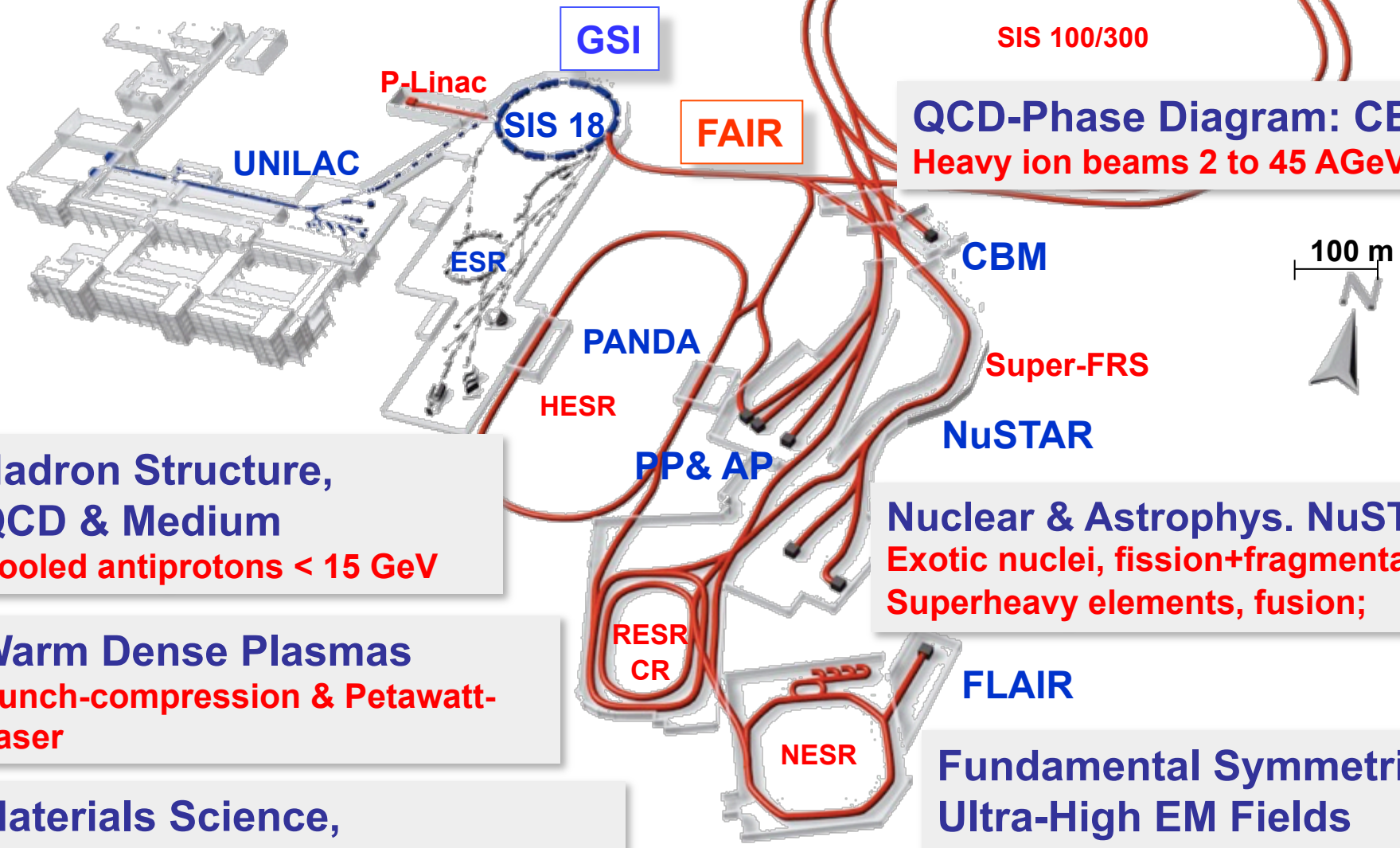




Ground state properties
inverse reactions

FAIR: project and physics pillars

1,5-2 B€, first beams by 202x



Accelerator Physics:
Eight Rings & two Linacs

QCD-Phase Diagram: CBM
Heavy ion beams 2 to 45 AGeV

Hadron Structure, QCD & Medium
Cooled antiprotons < 15 GeV

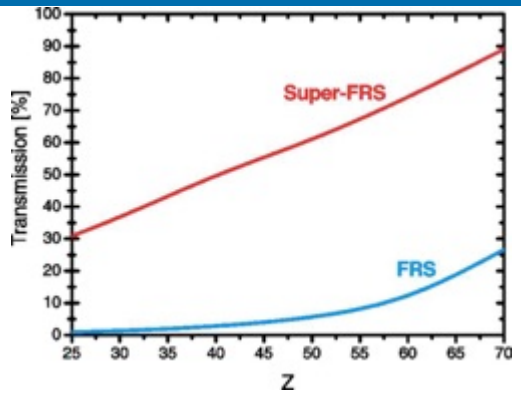
Nuclear & Astrophys. NuSTAR
Exotic nuclei, fission+fragmentation;
Superheavy elements, fusion;

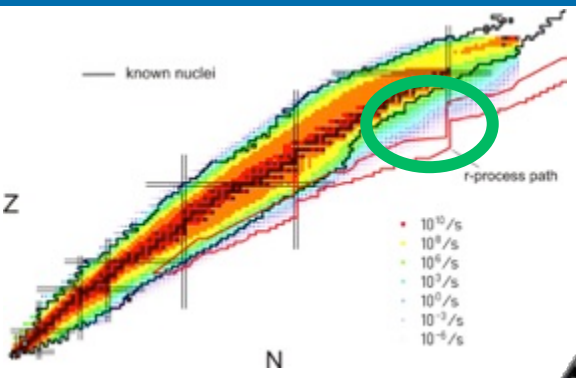
Warm Dense Plasmas
Bunch-compression & Petawatt-Laser

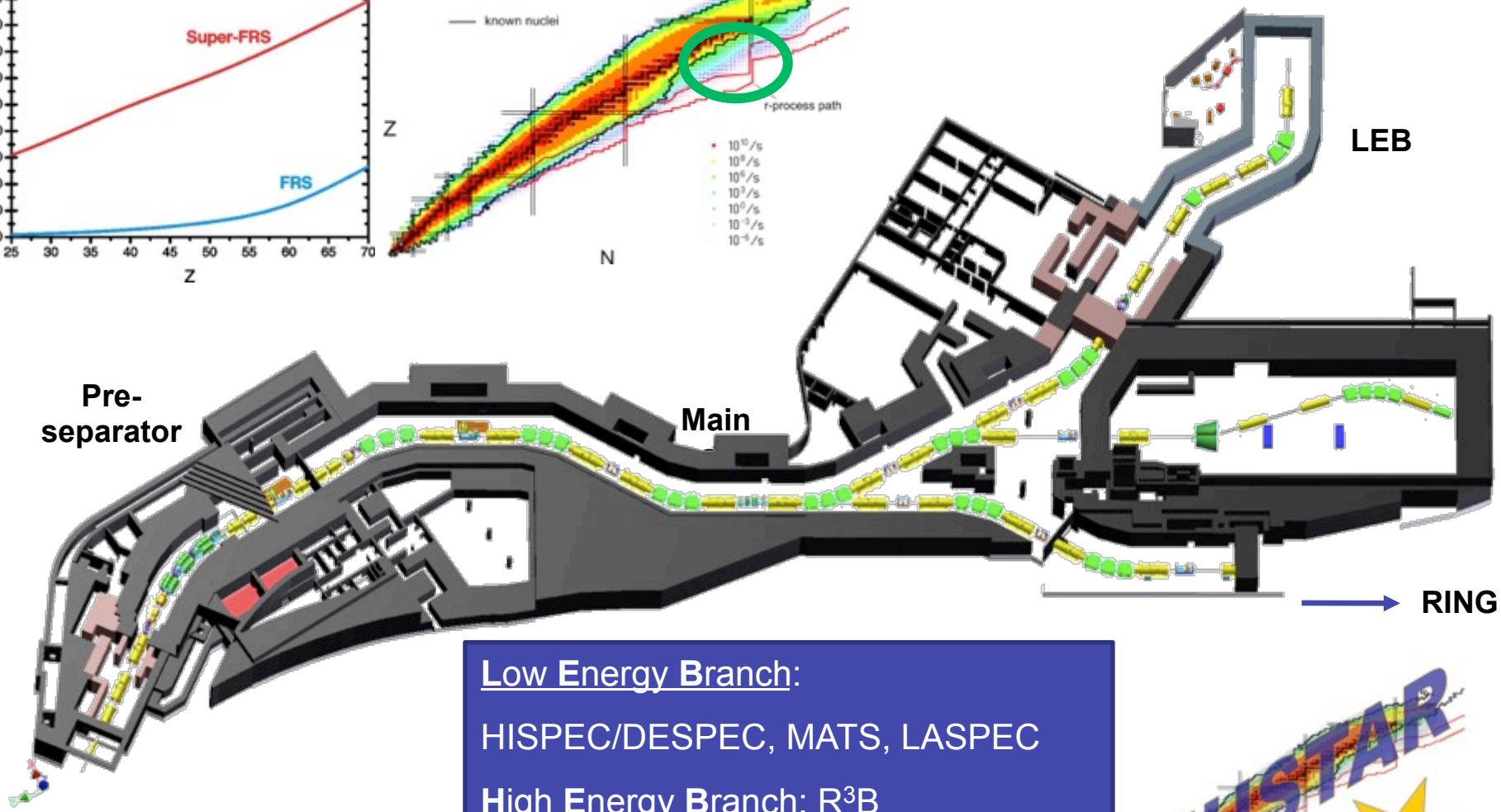
Materials Science, Space- and Radiation Biology
Ion- & antiproton-beams

Fundamental Symmetries
Ultra-High EM Fields
SPARC; FLAIR
Antiprotons, high-Z ions

NUSTAR - The Facility







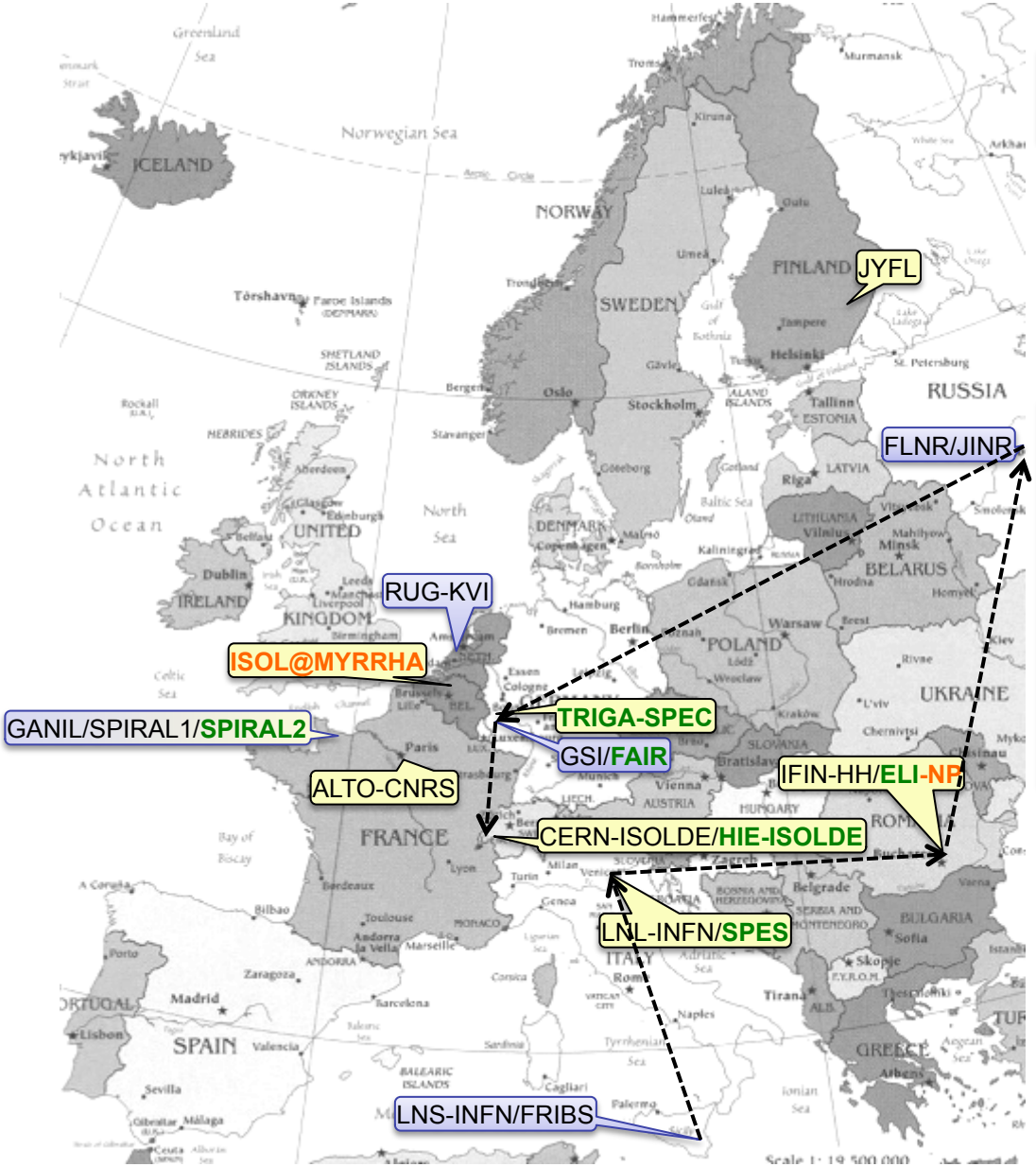
Low Energy Branch:

HISPEC/DESPEC, MATS, LASPEC

High Energy Branch: R^3B

Ring Branch: EXL, ILIMA, ELISE

Radioactive Ion Beam Facilities in Europe



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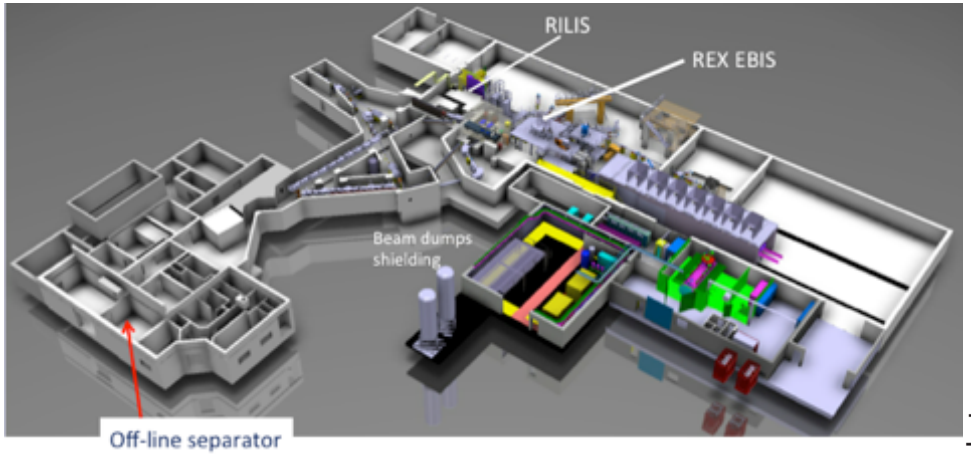
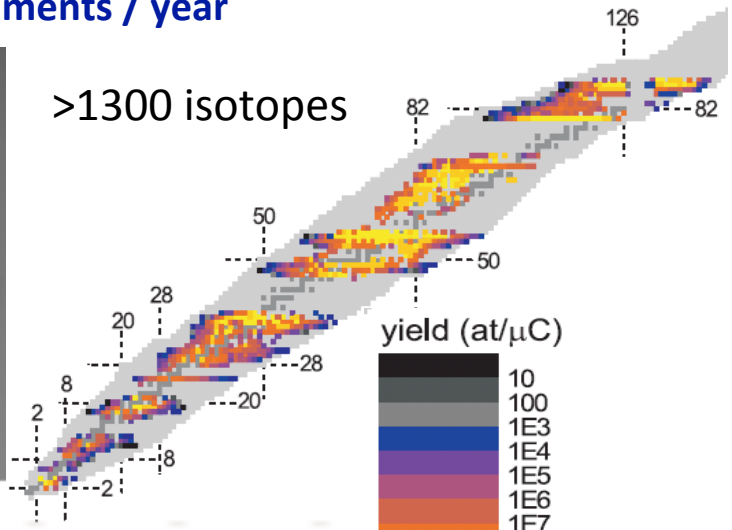
HIE-ISOLDE Facility

See M. Borge's talk

- ISOLDE is the CERN radioactive beam facility (approved 50 y ago!)
- Provides low energy or post-accelerated beams
- Run by an **international collaboration since 1965. Presently 13 members** (B, CERN, Dk, E, F, Ge, Gr, I, India, N, R, S, UK)
- **> 500 Users from 100 Institutions, 50 experiments / year**



>1300 isotopes



✓ HIE STAGE 1

RFQ | IHS | 7G1,2,3 | 9GP | HB-1 | HB-2

Physics Autumn 2015
@ 4.3 MeV/u
Spring 2016 5.5 MeV/A

✓ HIE STAGE 2

HB-1 | HB-2 | HB-3 | HB-4

2017
10 MeV/A

Started Jan 2010
Budget 35 M€

✓ HIE STAGE 3 WITH CHOPPER LINE **2018 (LS2)**

CHOPPER | LB-1 | LB-2 | HB-2 | HB-3 | HB-4 | HB-1

HIE-ISOLDE status

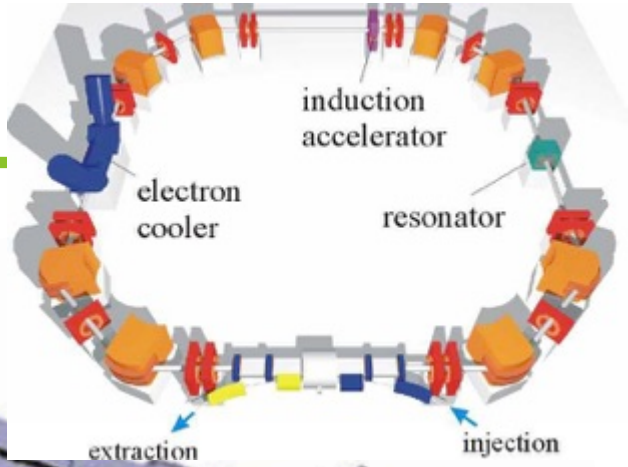
1st Cryomodule being cooled down in ISOLDE in June

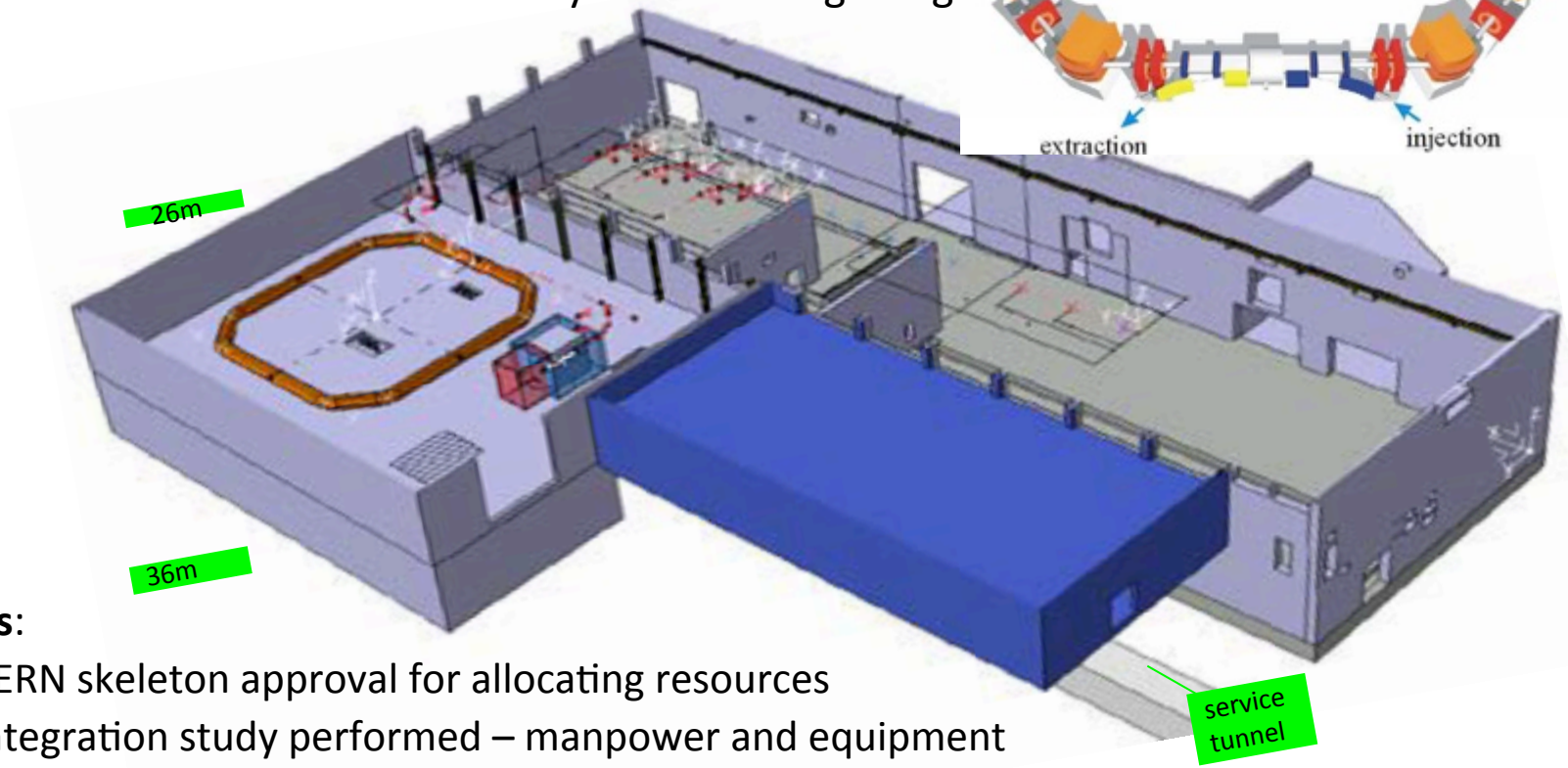
Getting ready for physics in October 2015

TSR@ISOLDE

Test Storage Ring from Heidelberg

ISOLDE would become 1st ISOL facility with a storage ring



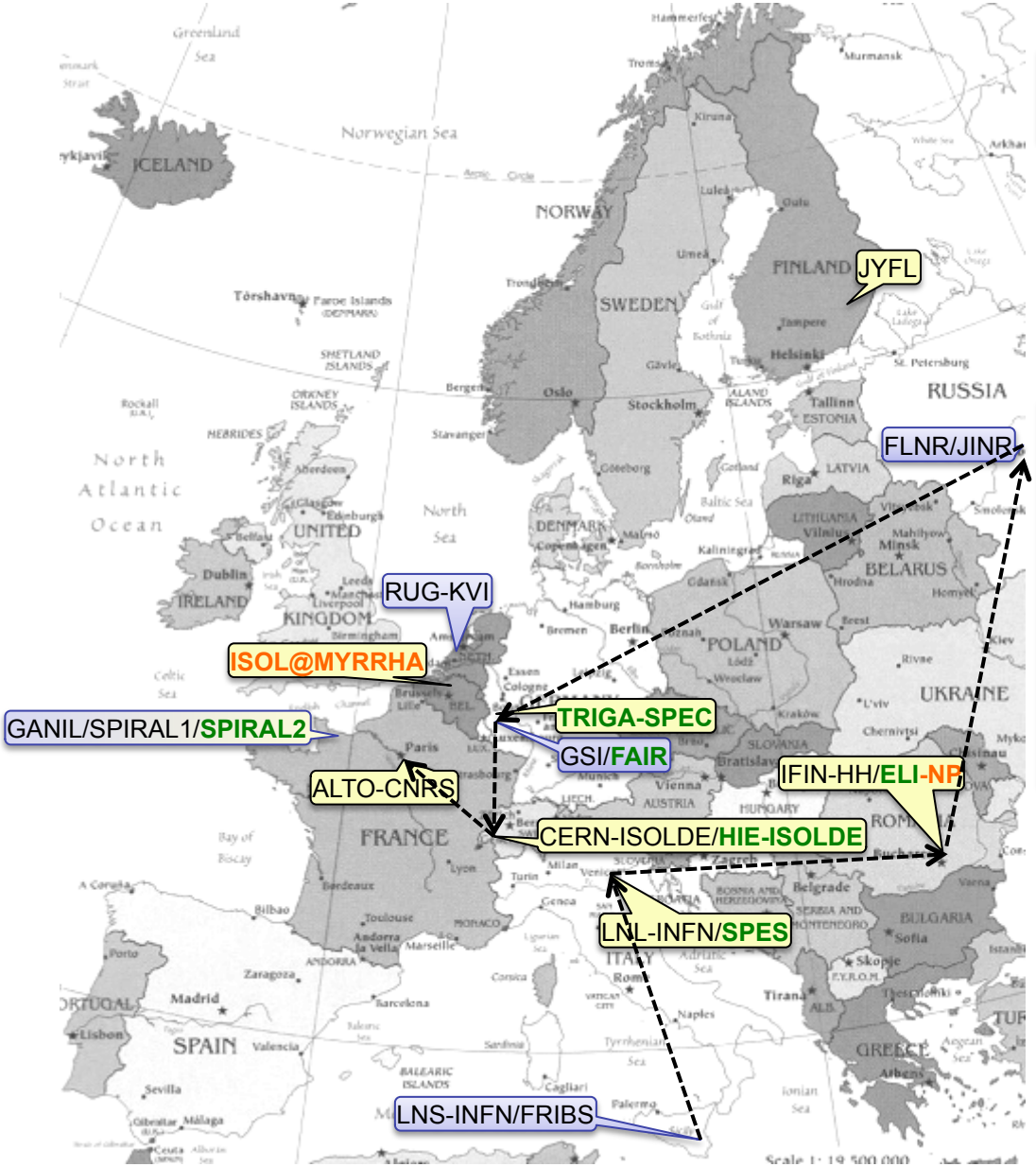


Status:

- CERN skeleton approval for allocating resources
- Integration study performed – manpower and equipment
- Aim: be included in MTP 2015-2019, **probable** timeline:
  - Building – before LS2 (CERN long shutdown 2, starting in 2018)
  - Installation and CERN-standardization of the ring – during LS2
  - Physics – after LS2 – 2020?
- External funding: UK grant, 4.8 MGBP

E. Siesling

Radioactive Ion Beam Facilities in Europe



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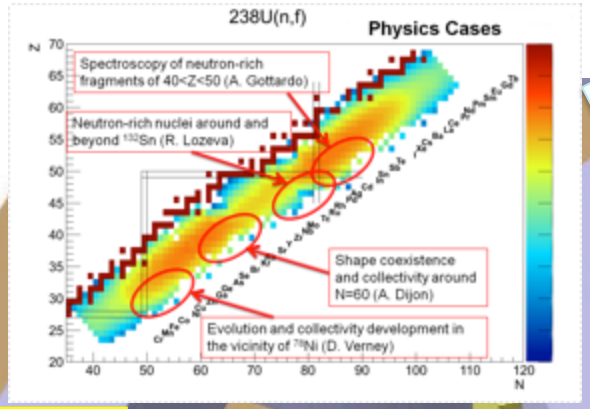
ALTO facility

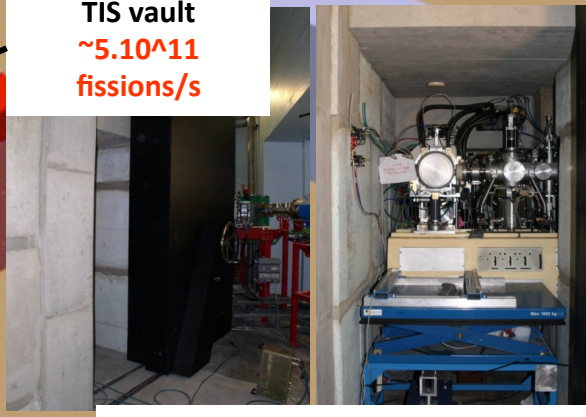
See talk of F. Azaiez



e-LINAC
10 µA
50MeV
(former 1st section of the LEP injector)

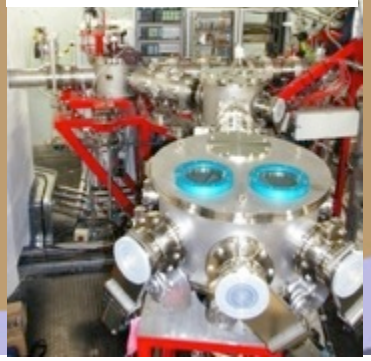
BEDO
beta decay spectroscopy

TIS vault
~5.10^11 fissions/s

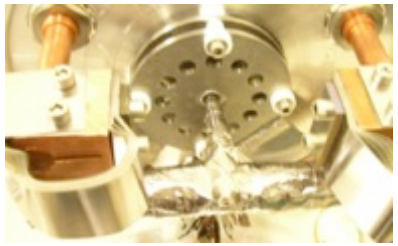


PARRNe mass separator

kicker - bender

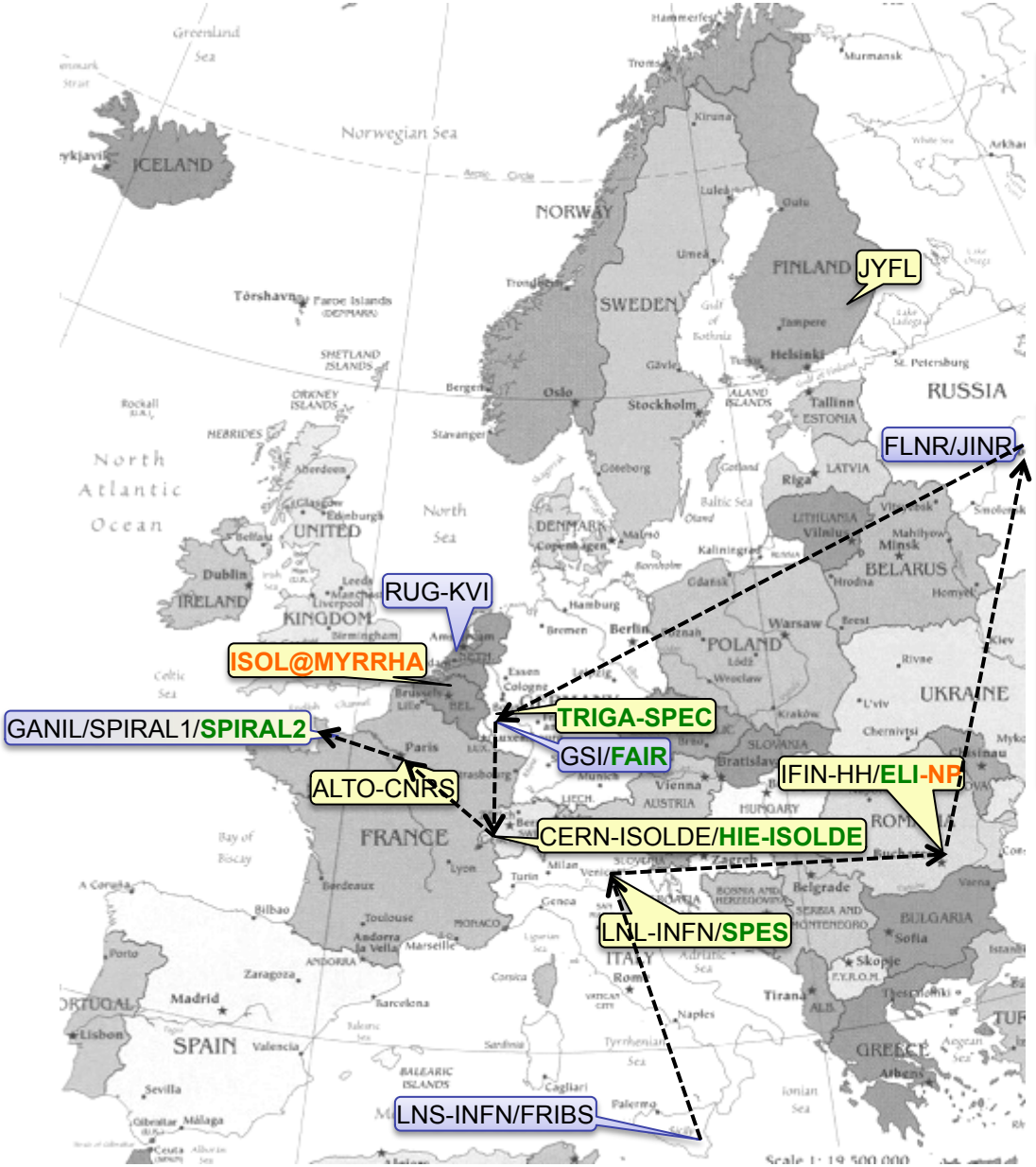


Target Ion-source ensemble



identification station

Radioactive Ion Beam Facilities in Europe



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GANIL-SPIRAL2 Mid-term Roadmap

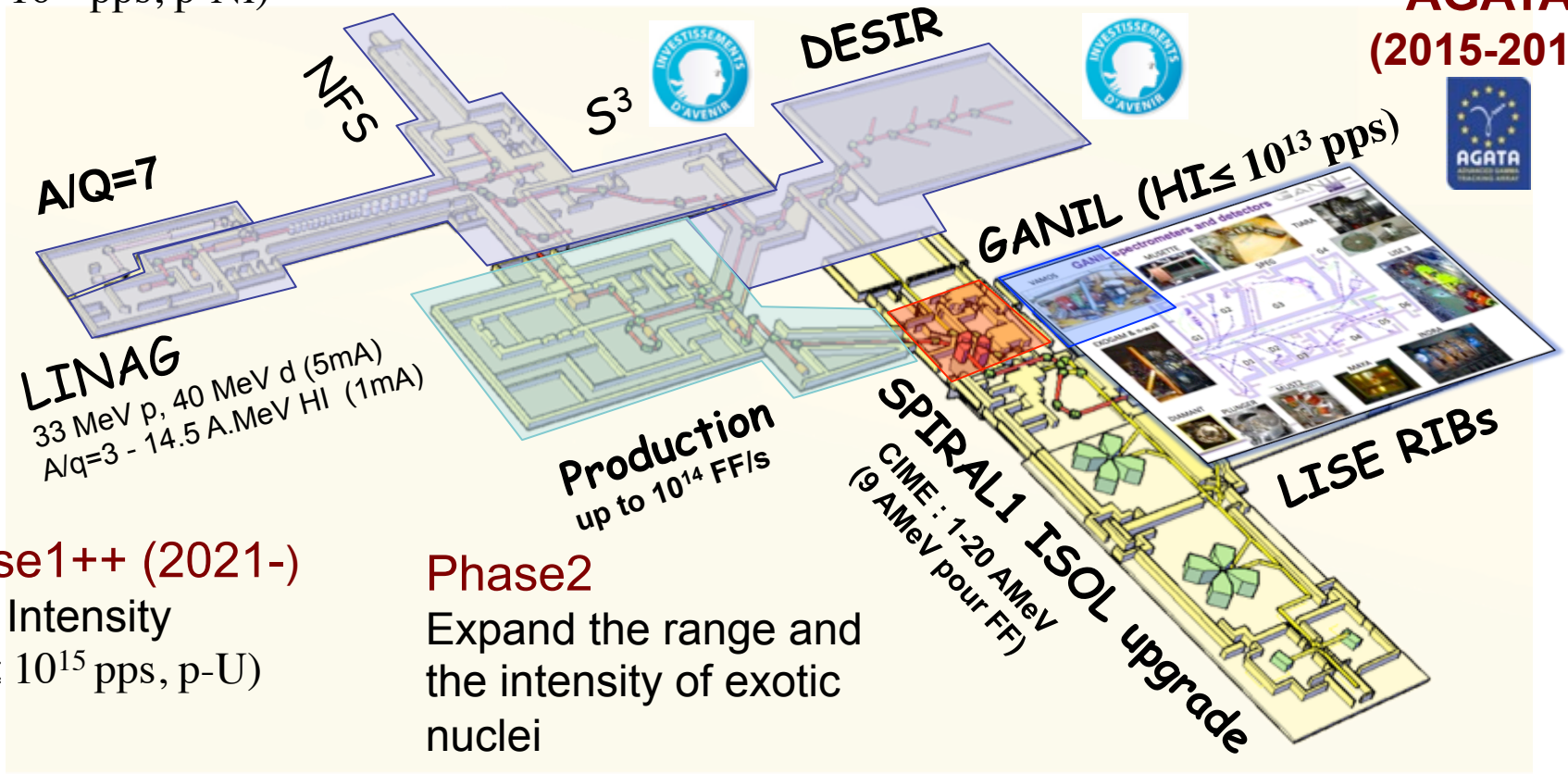
Phase1 (2016-)

Increase the intensity of stable beams
High intense neutron source
(HI≤ 10^{15} pps, p-Ni)

DESIR Phase1+ (2020-)

Low energy facility

AGATA (2015-2018)



Phase1++ (2021-)

High Intensity
(HI≤ 10^{15} pps, p-U)

Phase2

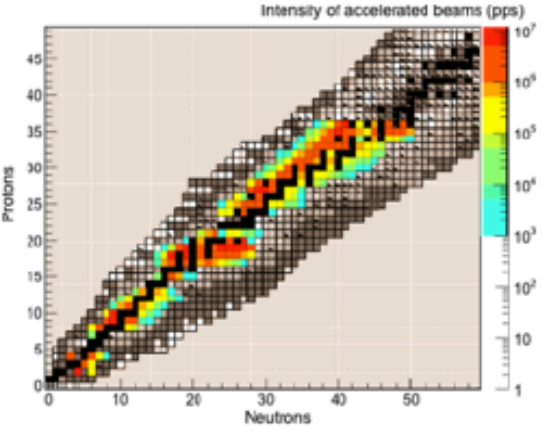
Expand the range and the intensity of exotic nuclei

SPIRAL1 Upgrade (2017-)

New light RIBs from beam/target fragmentation

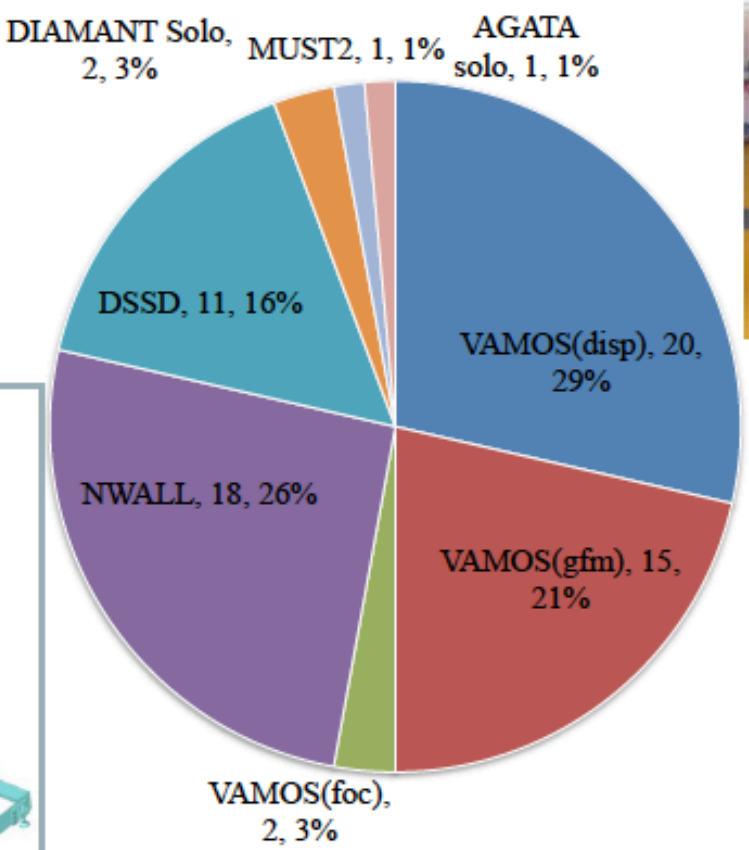
AGATA @ GANIL campaigns (2015-2018)

ISOL RIB from SPIRAL 1 from 2016



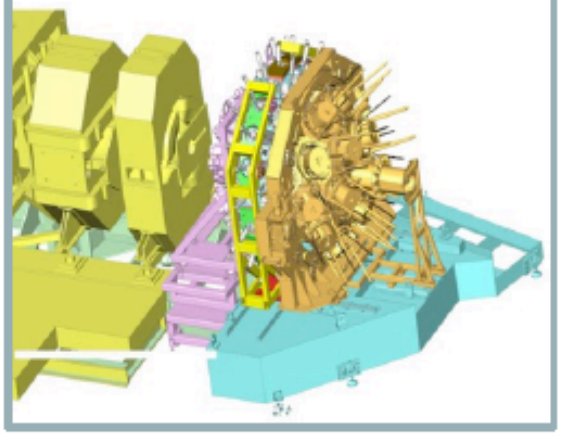
SPIRAL: Expected production from 12C target

See talk of Caterina MICHELAGNOLI

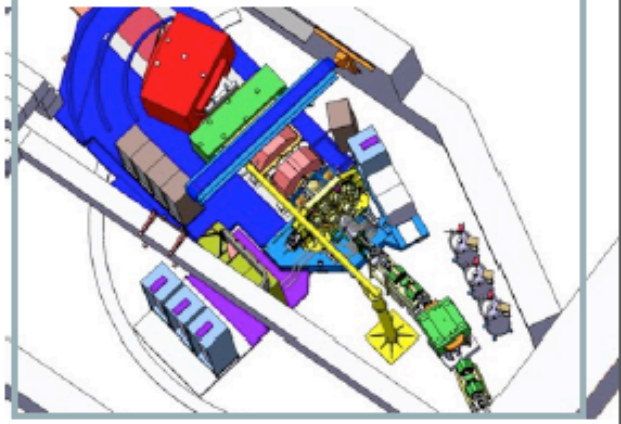


VAMOS vacuum mode

NEDA on-going (NEDA0@LNL) DIAMANT starting upgrade



VAMOS Gas-Filled From 2016



SPIRAL2 Phase 1 civil construction is finished (Sept. 2014)

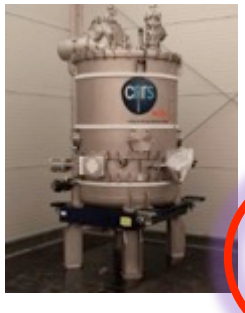
Installation is going on

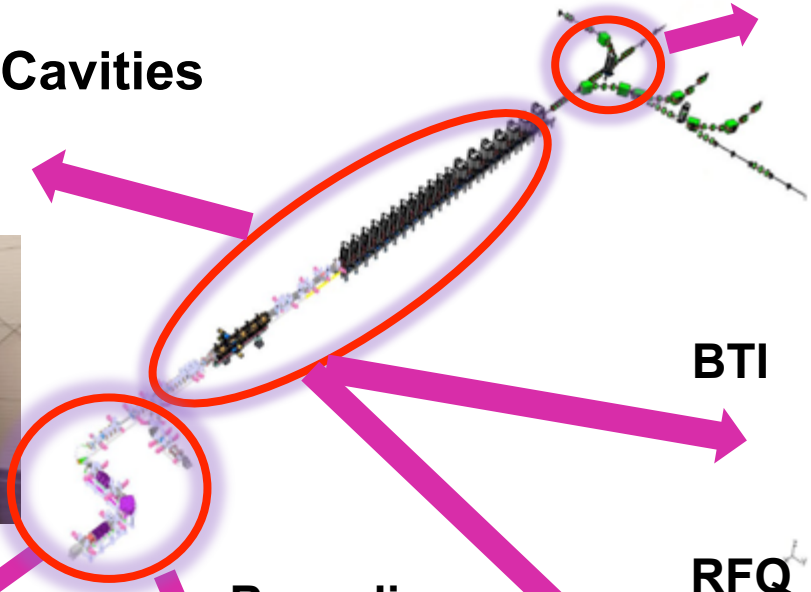
Low energy beam : Dec 2014
RFQ beam : August 2015
LINAC beam : March 2016

Beam lines & support

LHE

SC Cavities

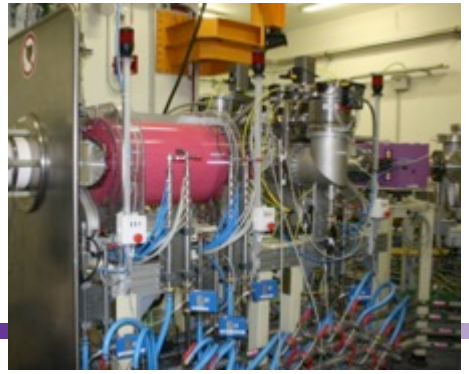




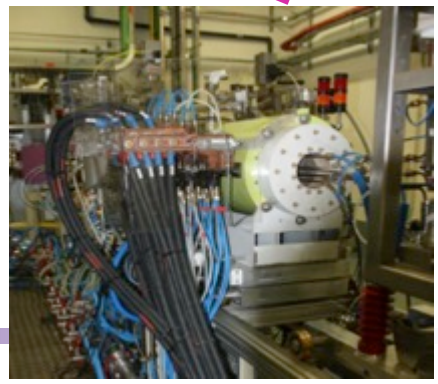
BTI

RFQ

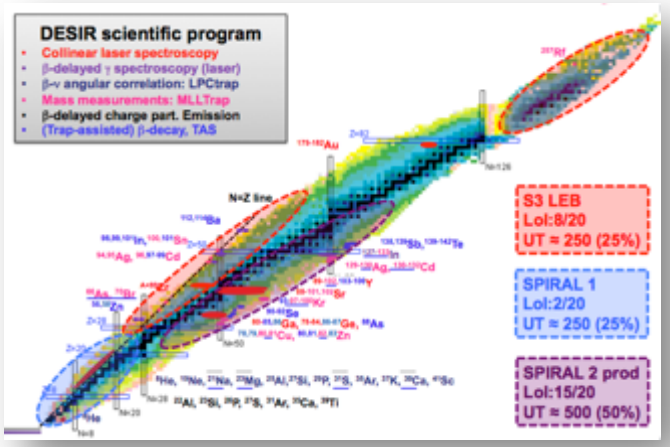
Ion Sources

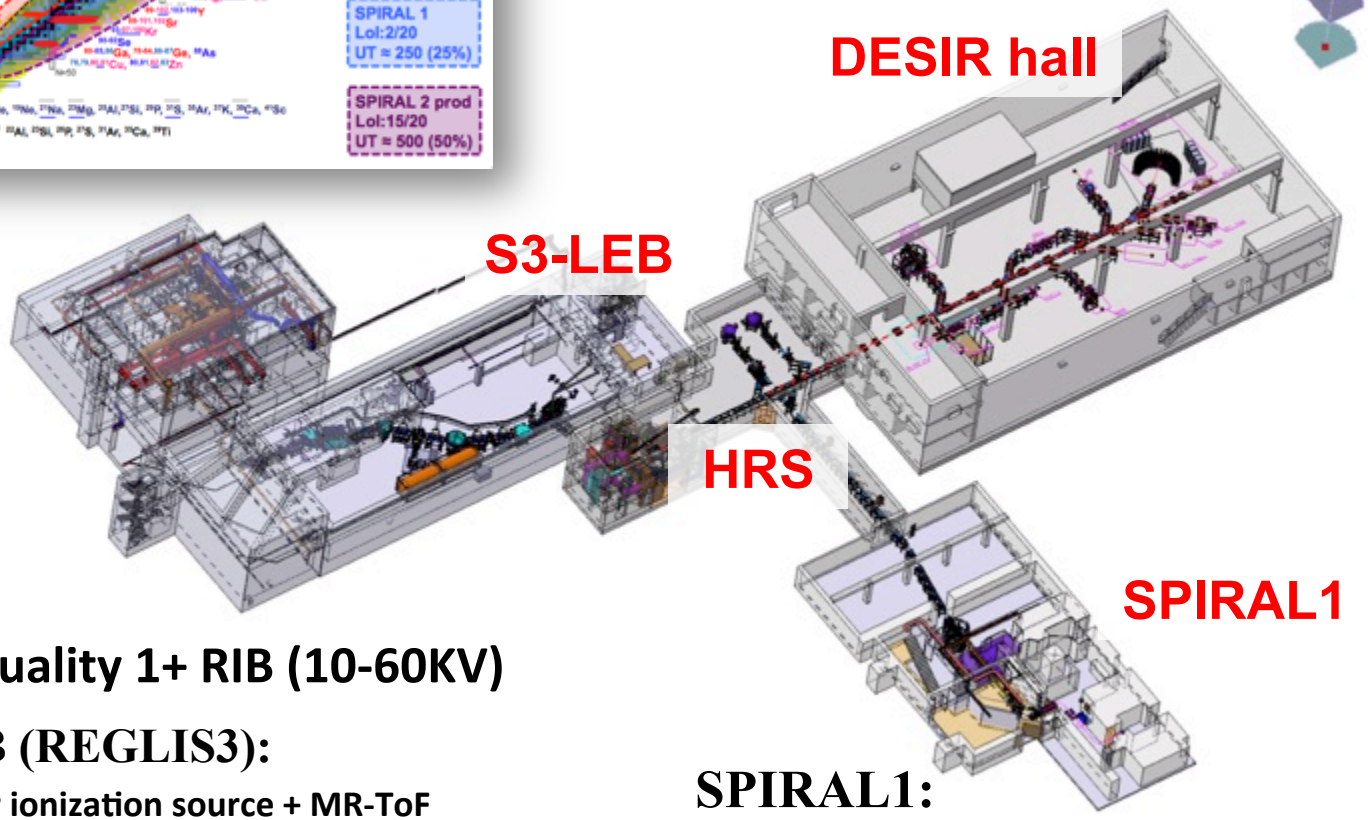


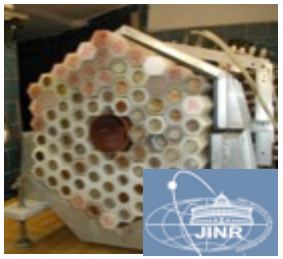
Beam lines

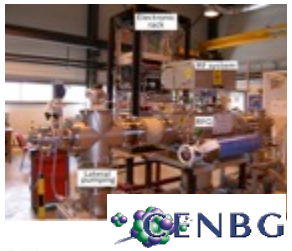


Facility – SPIRAL2 Phase 1+









High quality 1+ RIB (10-60KV)

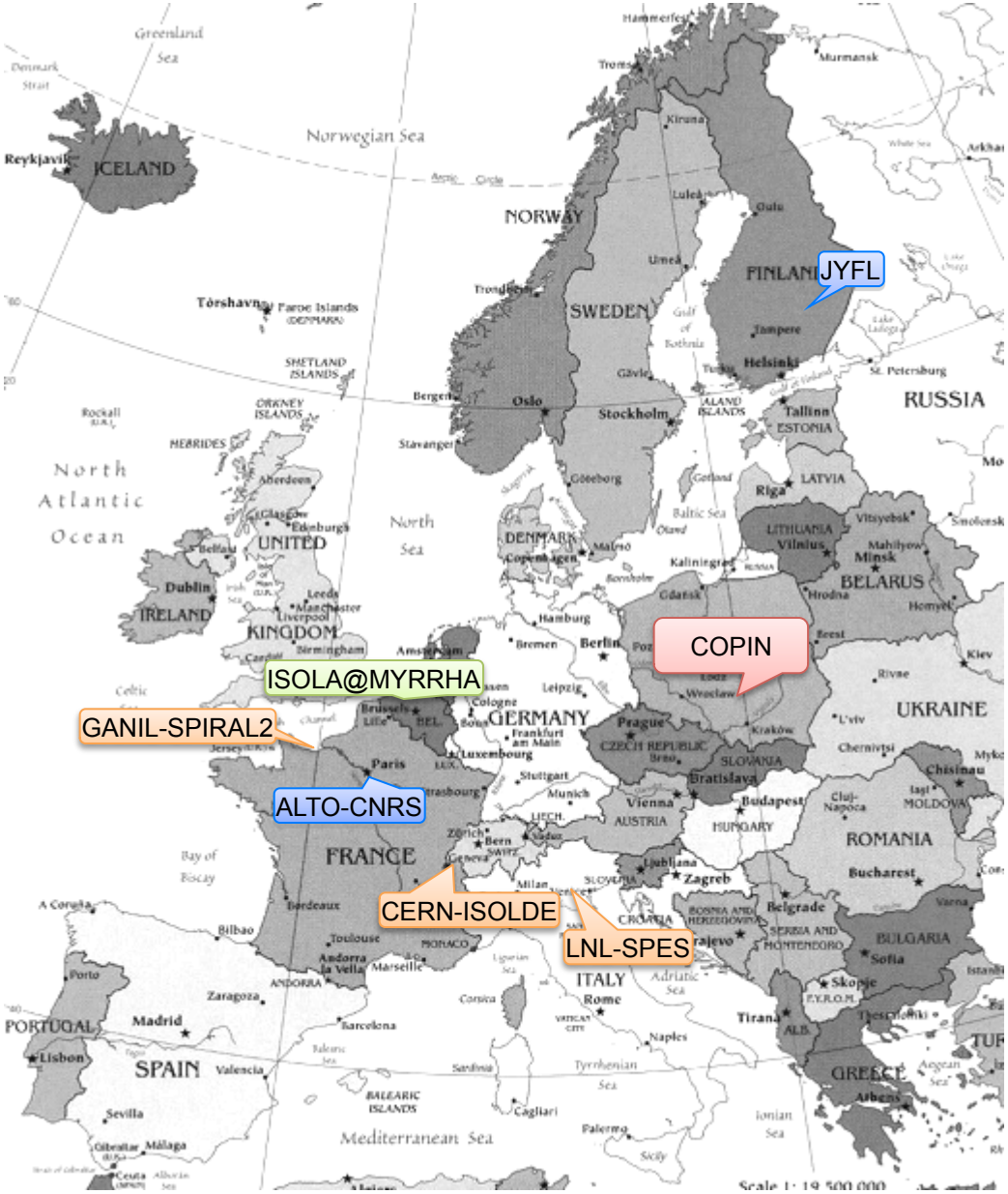
S³ LEB (REGLIS3):

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

SPIRAL1:

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

EURISOL – Distributed Facility (DF)



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

Candidate - future facility:
ISOL@MYRRHA

EURISOL MoU member:
COPIN Consortium Poland

Smaller scale ISOL facilities:
ALTO, JYFL

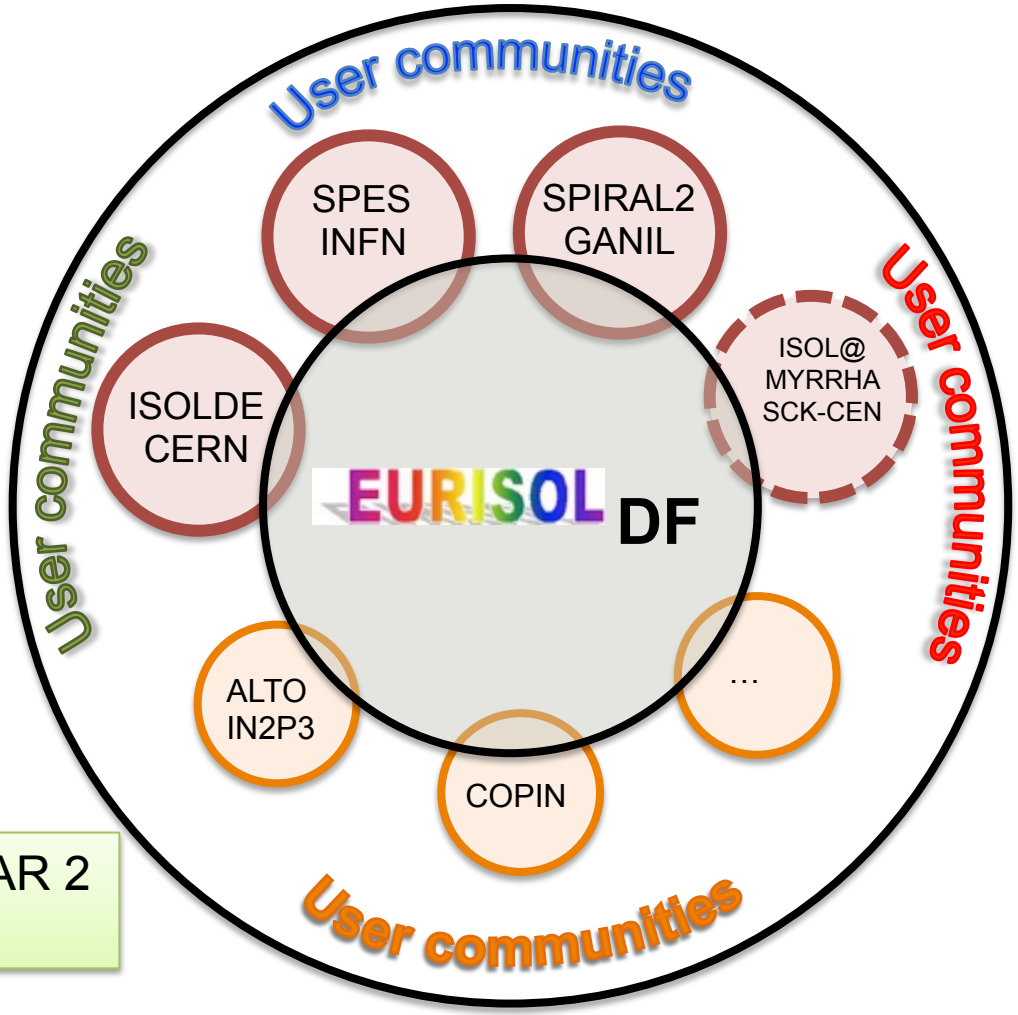
Project to be submitted for the 2018 update of the European Strategy Forum For Research Infrastructures (ESFRI) roadmap

EURISOL DF

EURISOL – Distributed Facility (DF) Initiative

Proposed EURISOL-DF scheme:

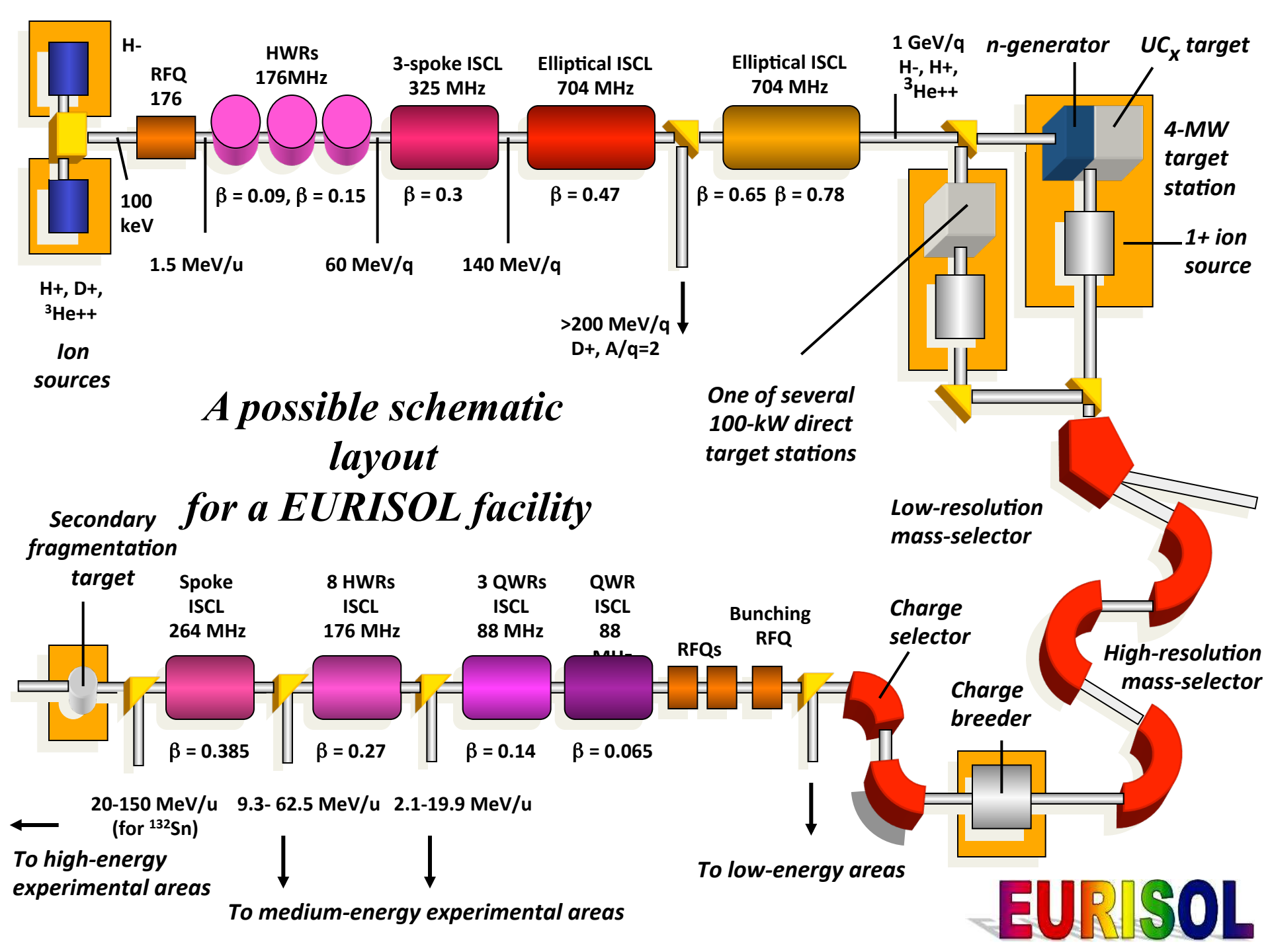
- **EURISOL Science Case & Experiments**
  - Dedicated beamtime for EURISOL-DF experiments
  - Dedicated EURISOL-DF Scientific Council & PAC
- **R&D for EURISOL**
  - Dedicated Technical Advisory Committee
- **Legal entity (ERIC,…)**
- **Get EURISOL-DF on the ESFRI list as a candidate project by 2018**



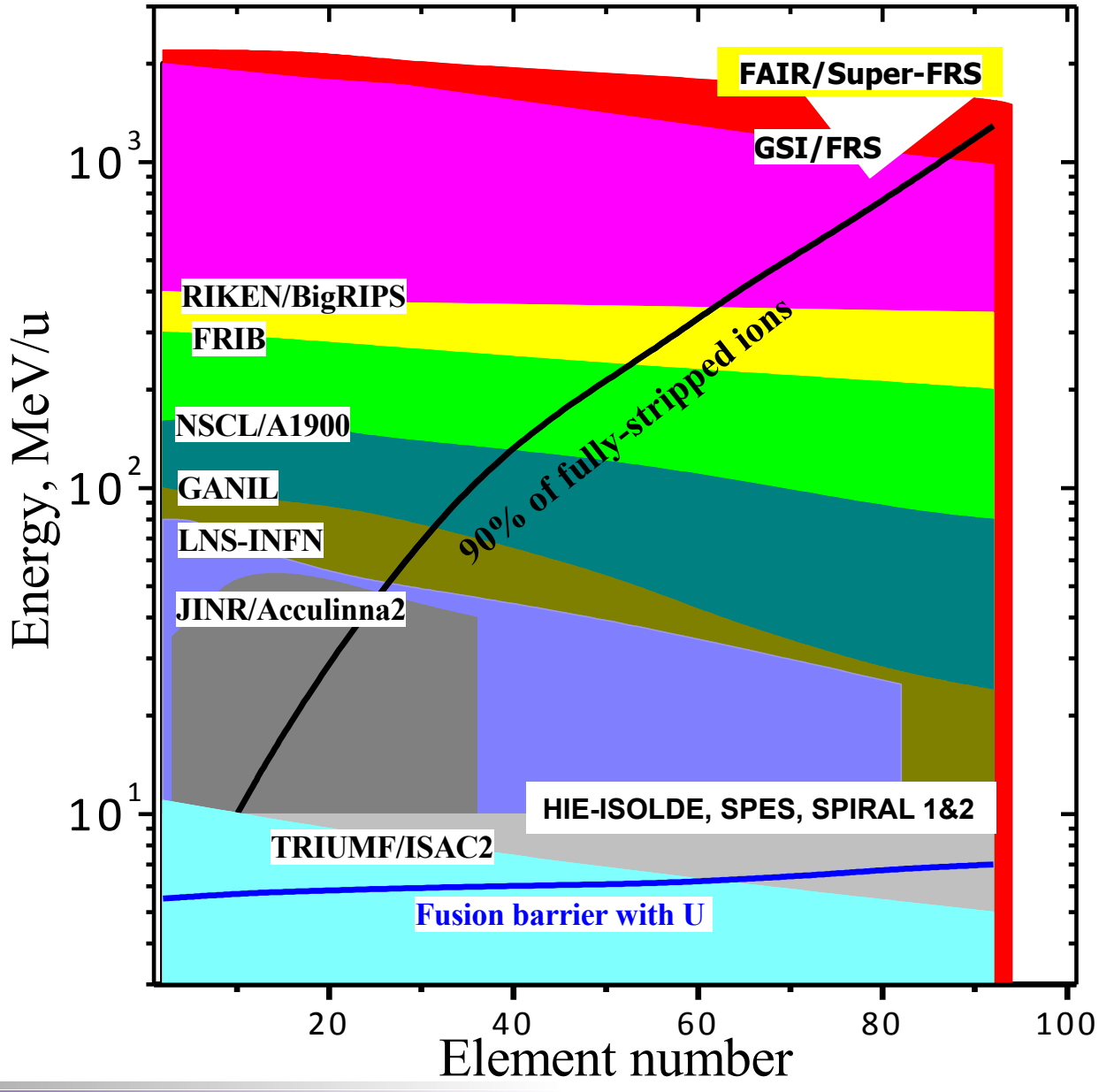
Interaction with EURISOL JRA in ENSAR 2 and EURISOL User group

Discussions with GSI/NUSTAR

EURISOL DF

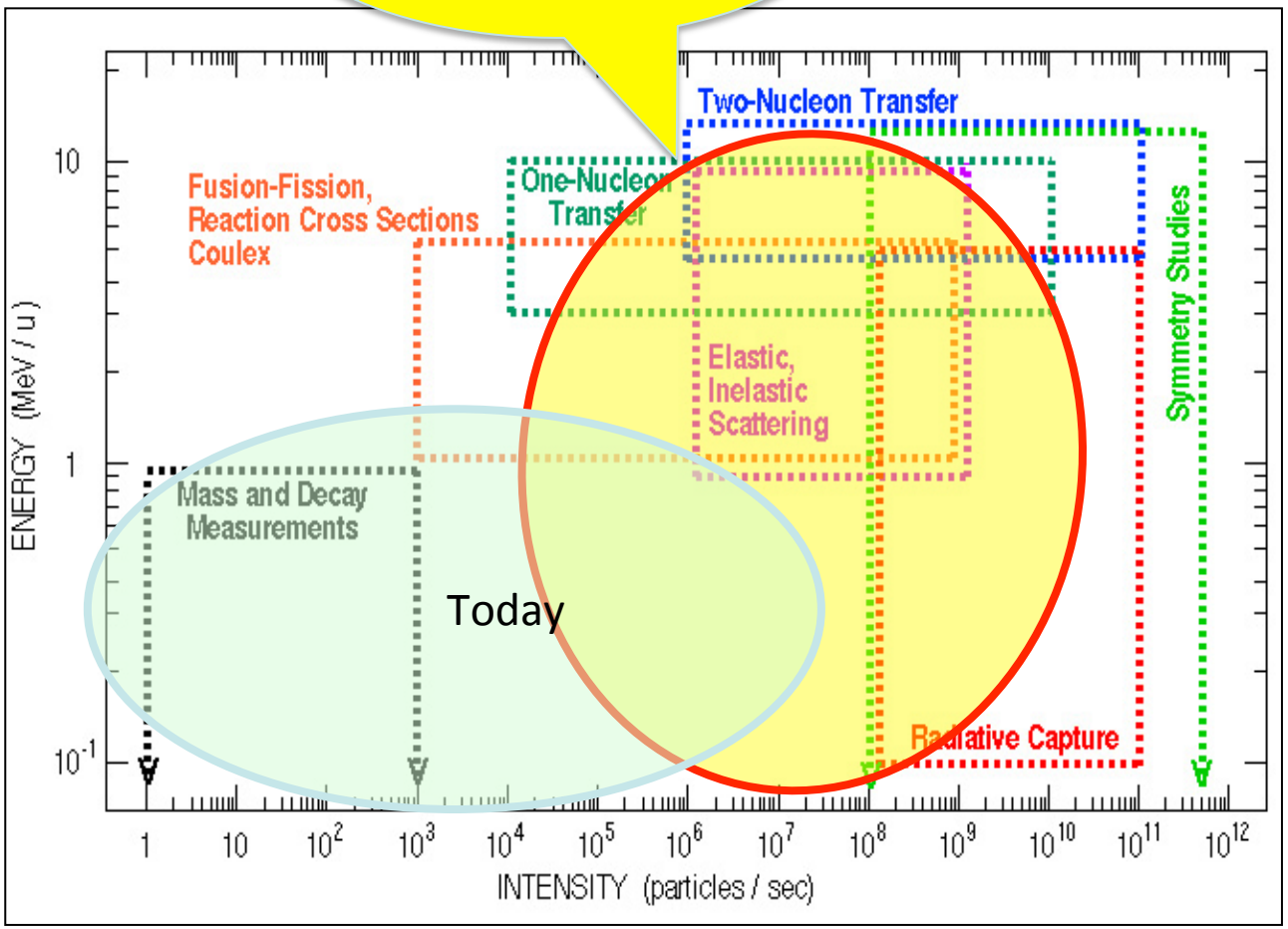

H-
RFQ
176
HWRs
176MHz
3-spoke ISCL
325 MHz
Elliptical ISCL
704 MHz
Elliptical ISCL
704 MHz
1 GeV/q
H-, H+,
3He++
n-generator
UCx target
4-MW
target
station
1+ ion
source
100
keV
β = 0.09, β = 0.15
β = 0.3
β = 0.47
β = 0.65 β = 0.78
1.5 MeV/u
60 MeV/q
140 MeV/q
H+, D+,
3He++
Ion
sources
>200 MeV/q
D+, A/q=2
One of several
100-kW direct
target stations
A possible schematic
layout
for a EURISOL facility
Secondary
fragmentation
target
Spoke
ISCL
264 MHz
8 HWRs
ISCL
176 MHz
3 QWRs
ISCL
88 MHz
QWR
ISCL
88
RFQs
Bunching
RFQ
Charge
selector
Low-resolution
mass-selector
High-resolution
mass-selector
Charge
breeder
β = 0.385
β = 0.27
β = 0.14
β = 0.065
20-150 MeV/u
(for 132Sn)
9.3- 62.5 MeV/u
2.1-19.9 MeV/u
To high-energy
experimental areas
To medium-energy experimental areas
To low-energy areas
EURISOL

Physics with RIB – Energy domain



Physics with RIB
Intensity domain

HI-ISOLDE, SPES,
SPIRAL2 Phase 2,
ISOL@MYRRHA
(EURISOL-DF)



Conclusion

- **Accomplishment of FAIR/NUSTAR – high energy RIB experiments, heavy n-rich nuclei, physics with storage rings,…**
- **Joint initiative of the EU ISOL facilities EUROSOL-DF – precision nuclear structure physics with RIB and societal applications,… towards EURISOL**
- **New opportunities for RIB physics with ELI-NP**

NuPECC Long Range Plan:

starting now to be ready by early 2017

Warm thanks to all colleagues contributing to this talk:

Maria Borge, Magda Kowalska – CERN/ISOLDE
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Sara Pirrone – LNS-INFN
Lucia Popescu - SCK•CEN & BEC
Hervé Savajols – GANIL

THANK YOU FOR YOUR ATTENTION