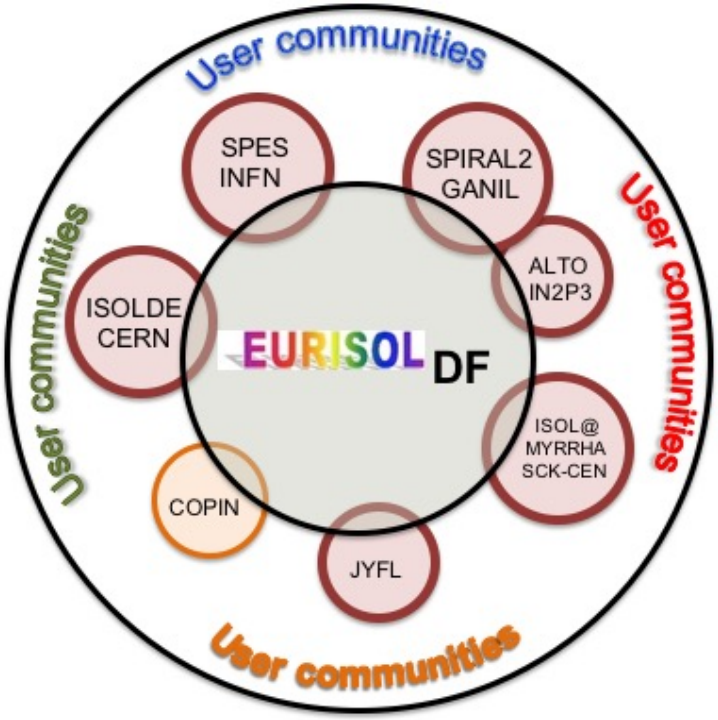
The EURISOL Distributed Facility Initiative

Marek Lewitowicz
On behalf of the EURISOL Steering Committee

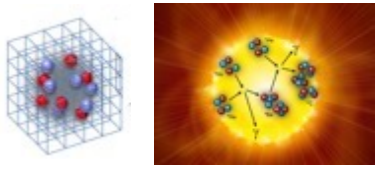
- Science case - examples
- What is EURISOL Distributed Facility Initiative?
- Further steps



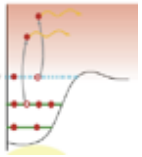
EURISOL DF

Structure of complex nuclei

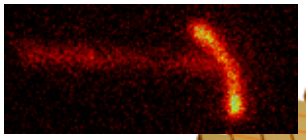
Lattice Effective Field Theory



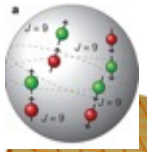
Coupling to continuum



1p, 2p radioactivity

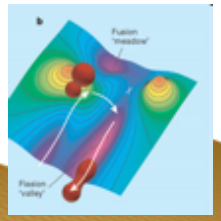


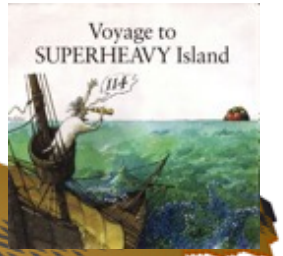
ν–π pairing

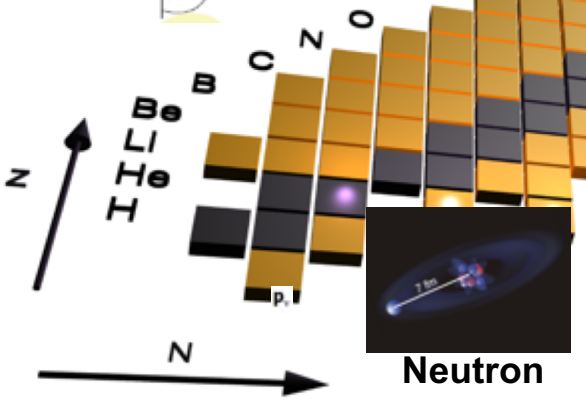


Equation of state

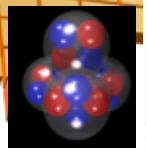
Fission dynamics



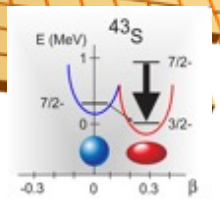




Neutron halos

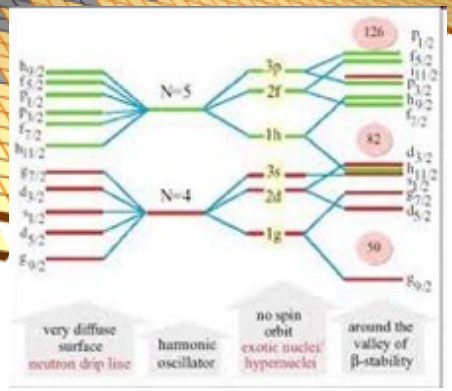


Clusters

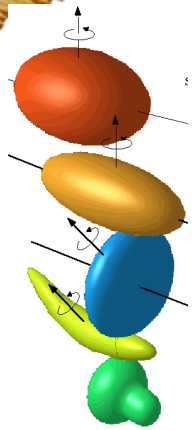


Shape Coexistence

Limits of existence



New magic numbers

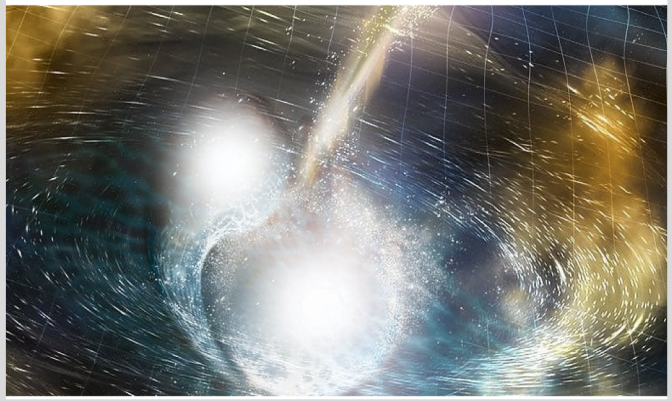


Exotic Shapes

Precision nuclear structure physics with high intensity and high optical quality RIB

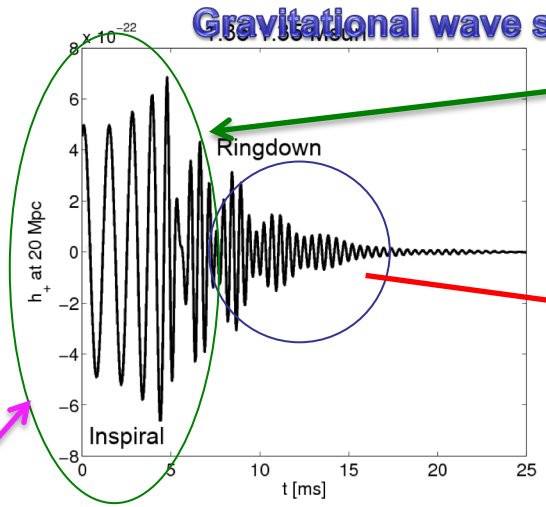
EURISOL DF

Neutron star mergers: gravitational waves and production of heavy elements



The messengers from neutron star mergers :

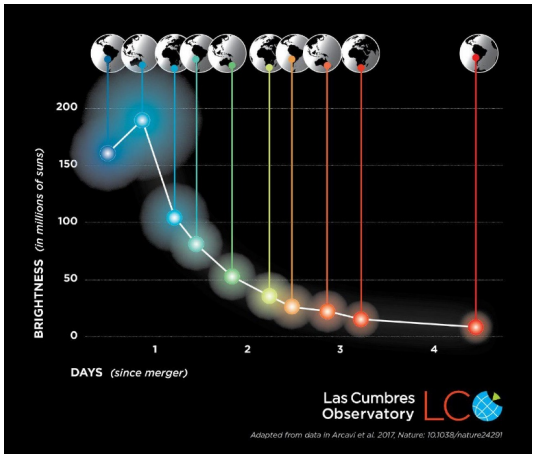
- **Gravitational waves**
- **Electromagnetic signals characterizing the nuclei in the ejecta**
- **neutrinos**



Neutron star mass

This depends on the Nuclear Equation of State

Gravitational wave emission seen together with electromagnetic signals

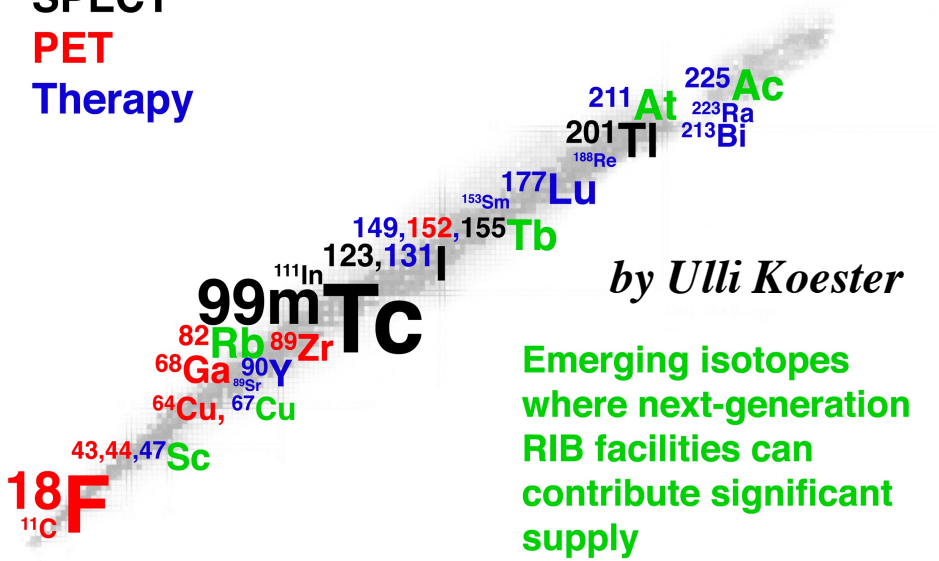


Time evolution determined by the radioactive decay of r-process nuclei (science drive of facilities with RIB)

Masses, $T_{1/2}$, P_n, reaction rates, fission barriers

Applied science: Medicine & material studies

SPECT
PET
Therapy



by Ulli Koester

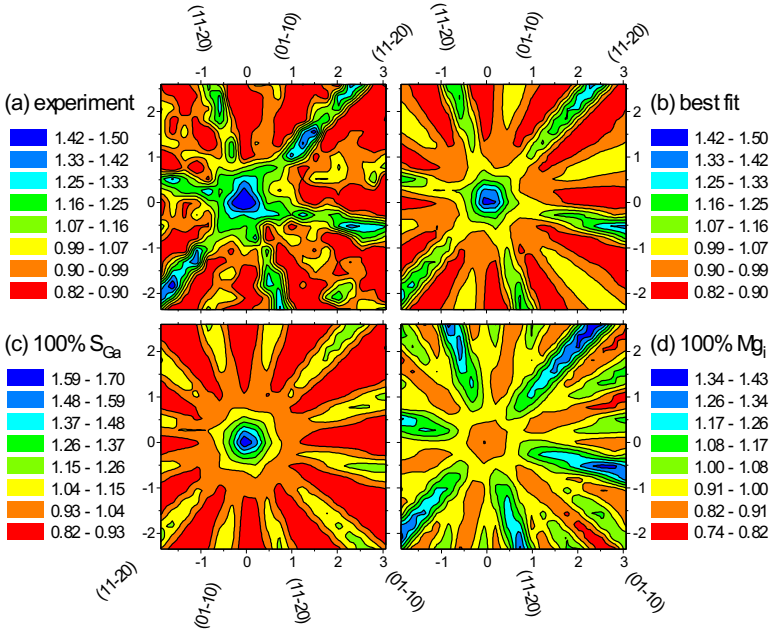
Emerging isotopes where next-generation RIB facilities can contribute significant supply

Radioisotopes in medicine. The size of symbols represents the number of exams per year.

Electron emission channeling patterns show mix of substitutional + interstitial ^{27}Mg

by Karl Johnston

Lattice sites of ^{27}Mg in different pre-doped GaN

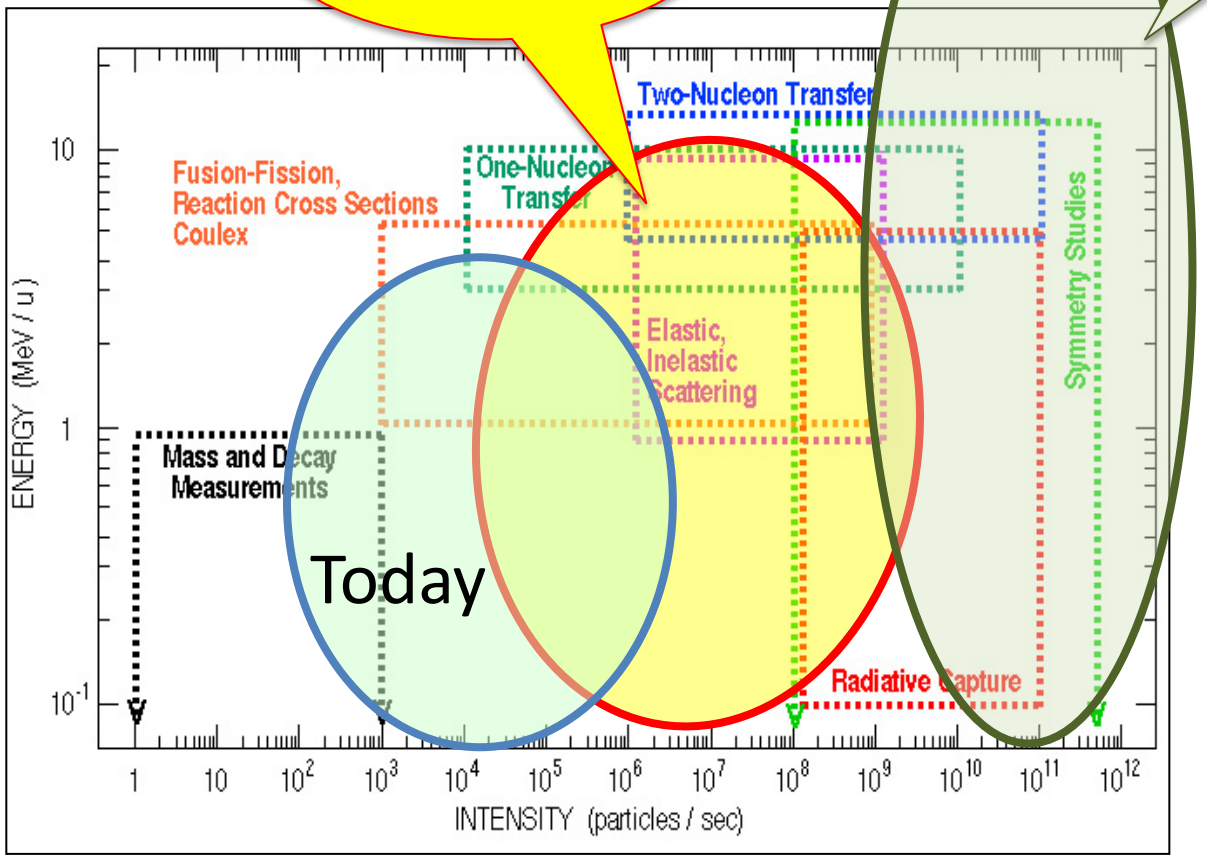


Physics with ISOL RIB Intensity & Energy domains

Precision nuclear structure physics & applications

HIE-ISOLDE,
SPES, SPIRAL2,
ISOL@MYRRHA
EURISOL-DF

EURISOL



EURISOL
Second generation
today

Second generation
EURISOL

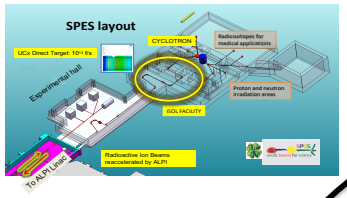
-> EURISOL-DF (Distributed Facility) Initiative from 2014 as an intermediate step towards EURISOL

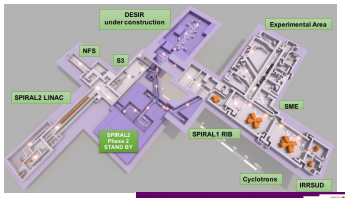
EURISOL DF

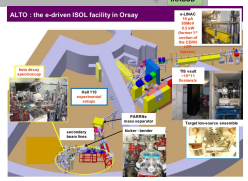
Support for construction, augmentation and exploitation of world leading ISOL facilities in Europe.

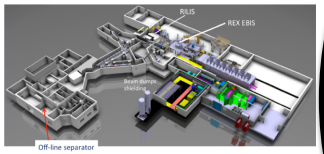
The urgent completion of the ESFRI facility SPIRAL2 along with SPES and the energy and intensity upgrade of HIE-ISOLDE (+ storage ring), including their unique instrumentation will consolidate the leading role of Europe. These ISOL facilities with low energy and reaccelerated exotic beams, offer extraordinary opportunities for scientific discoveries to probe questions that concern the atomic nucleus and nuclei in the cosmos. **The successful completion and exploitation of these facilities would be the major step toward the ultimate European ISOL facility, EURISOL. With this aim, a strong European collaborative initiative, the EURISOL-Distributed Facility, is strongly supported to maximize synergies to address and solve new scientific and technical challenges.**

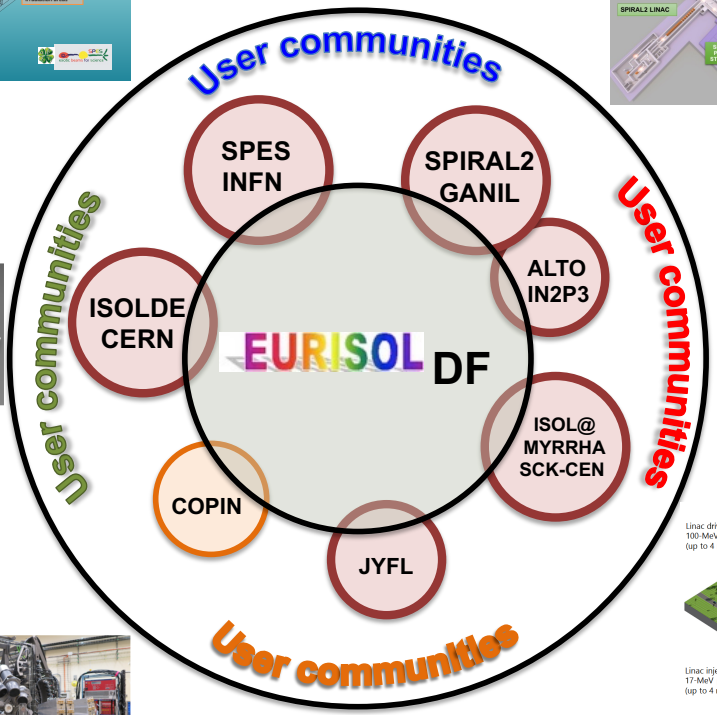
EURISOL – Distributed Facility (DF) Initiative

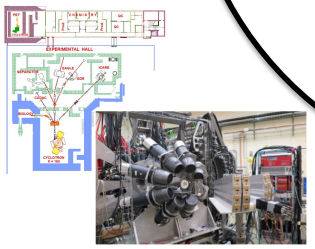


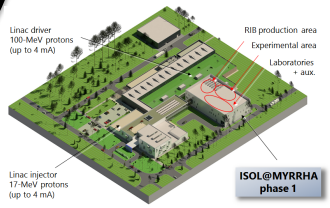


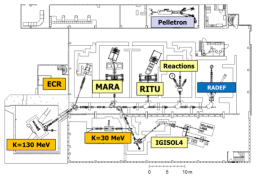












Members:

- HIE-ISOLDE/CERN
- SPES-INFN
- SPIRAL2-GANIL with ALTO
- JYFL
- ISOL@MYRRHA-SCK*CEN

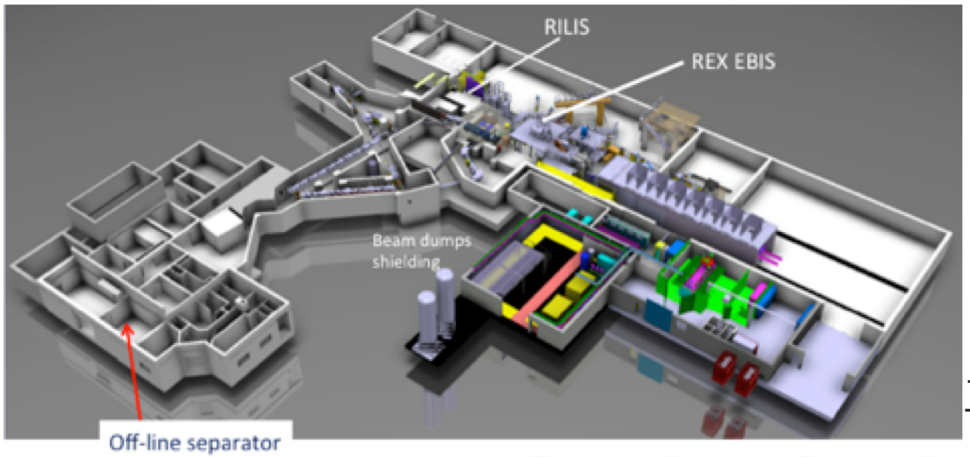
Associated Member:

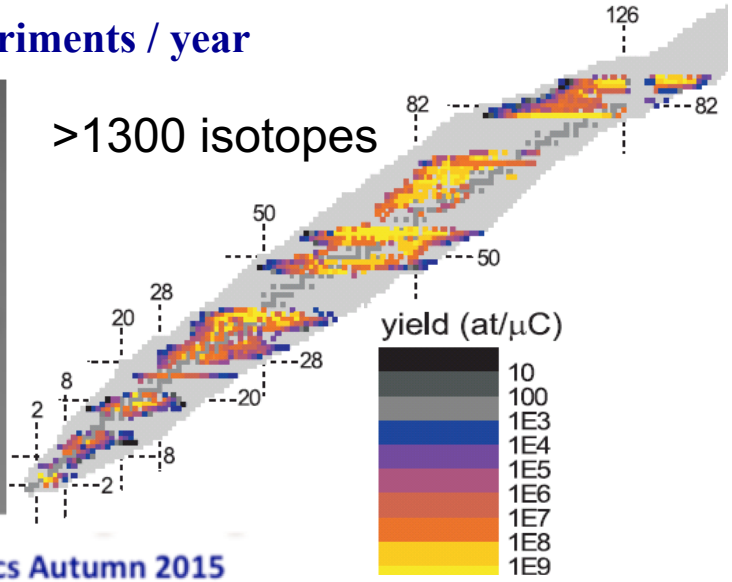
- COPIN Consortium, Poland

EURISOL DF

HIE-ISOLDE Facility, CERN

- ISOLDE is the CERN radioactive beam facility (approved 50 y ago!)
- 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**





✓ 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

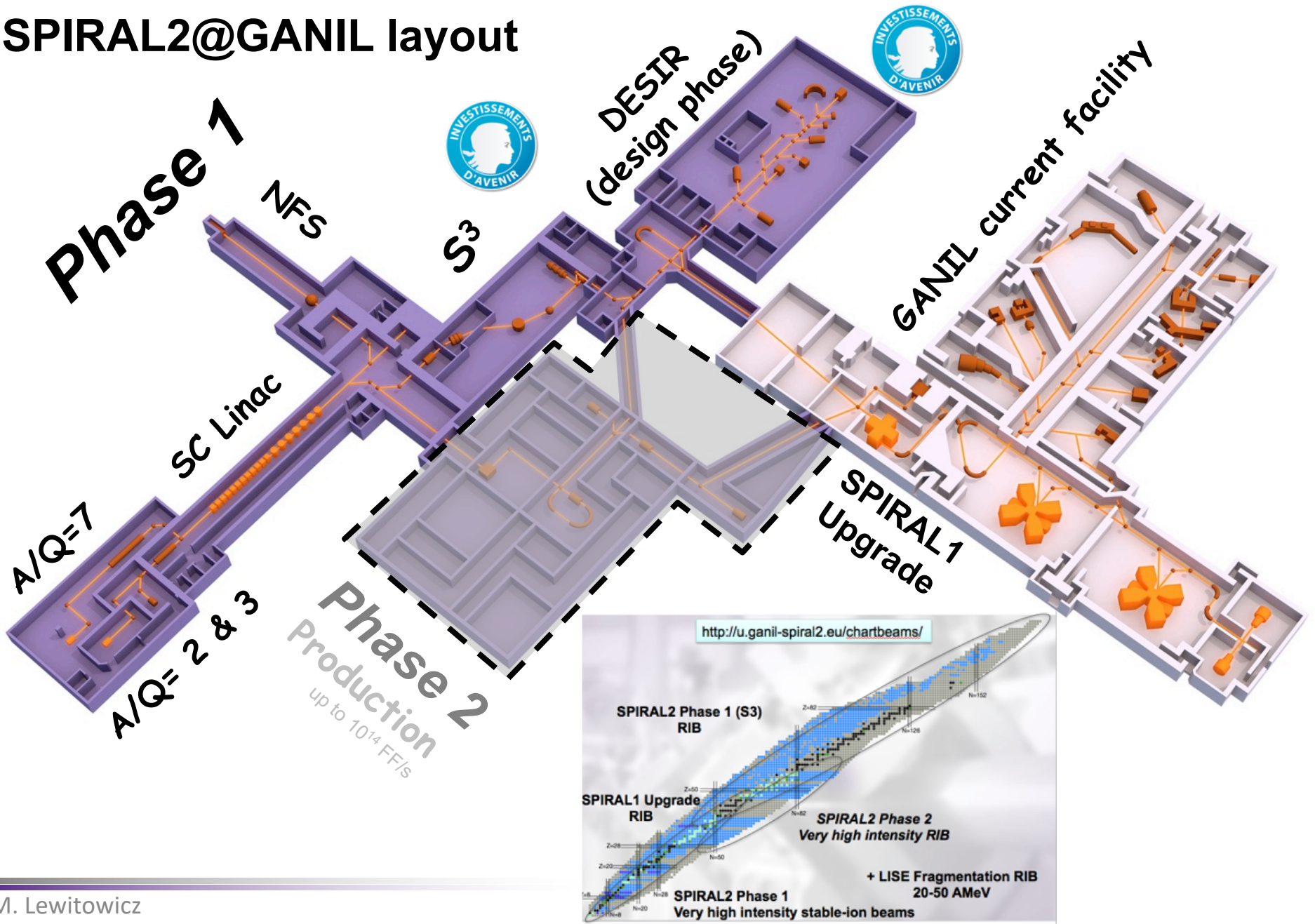
2017
10 MeV/A

✓ HIE STAGE 3 WITH CHOPPER LINE 2018 (LS2)

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

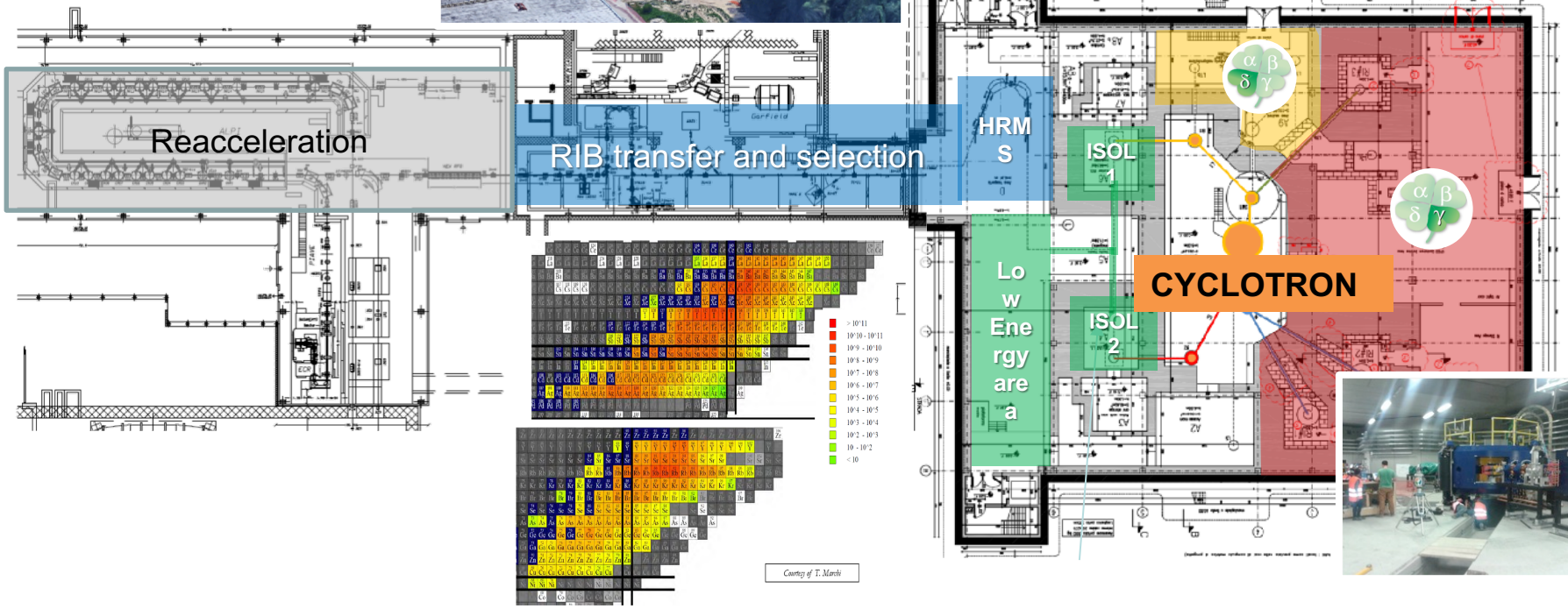
EURISOL-DF facilities

SPIRAL2@GANIL layout



EURISOL DF SPES Facility at LNL, Italy

Neutron production area (NEPIR)



RIB reacceleration:

- new RFQ
- ALPI

1/20.000 Mass separator
(Beam Cooler + HRMS)
Elettrostatic beam transport
Charge Breeder (n+)
1/1000 mass separator

ISOL bunkers
1/200 mass separator
low energy experimental area

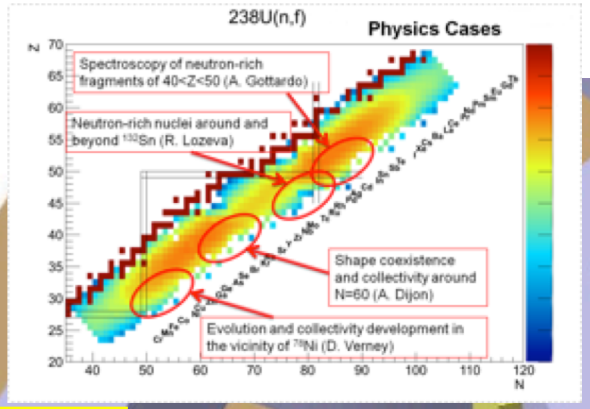
Radioisotopes production area (LARAMED)

Cyclotron: 70 MeV – 500 μA proton beam

EURISOL-DF facilities

INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

ALTO

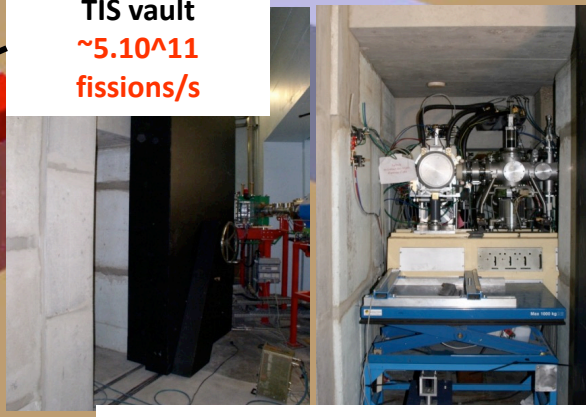


ALTO

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

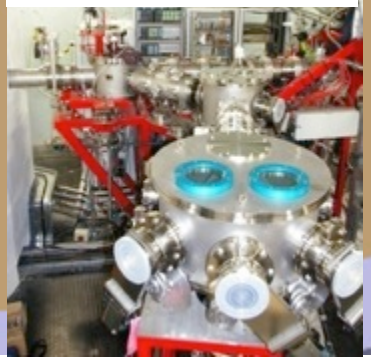
BEDO
beta decay spectroscopy

TIS vault
~5.10^11 fissions/s

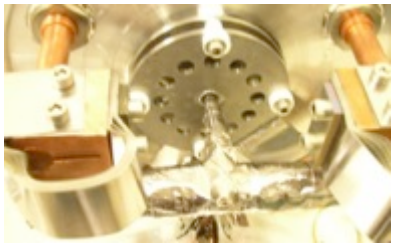


PARRNe mass separator

kicker - bender



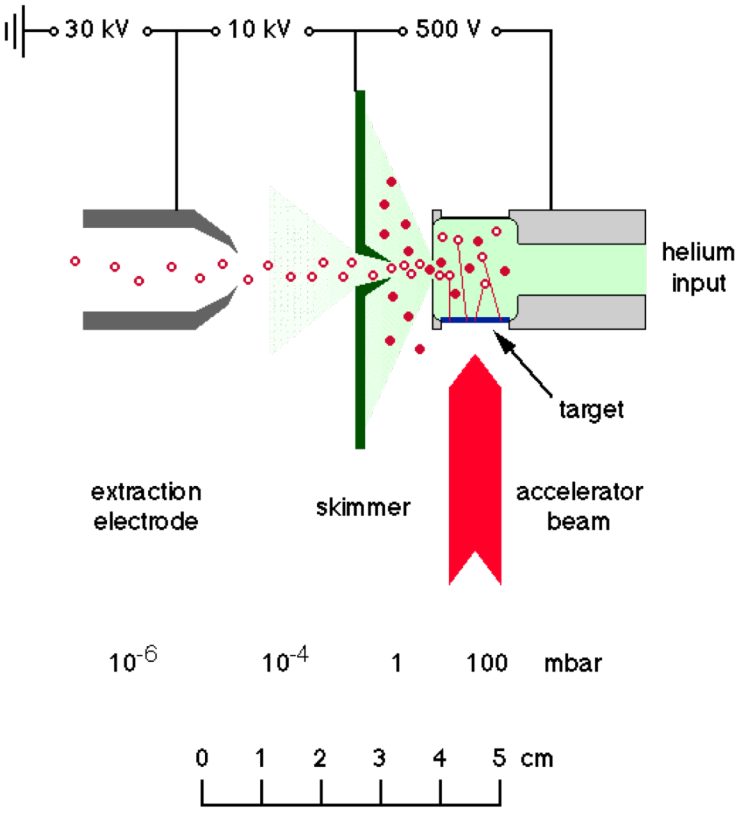
Target Ion-source ensemble

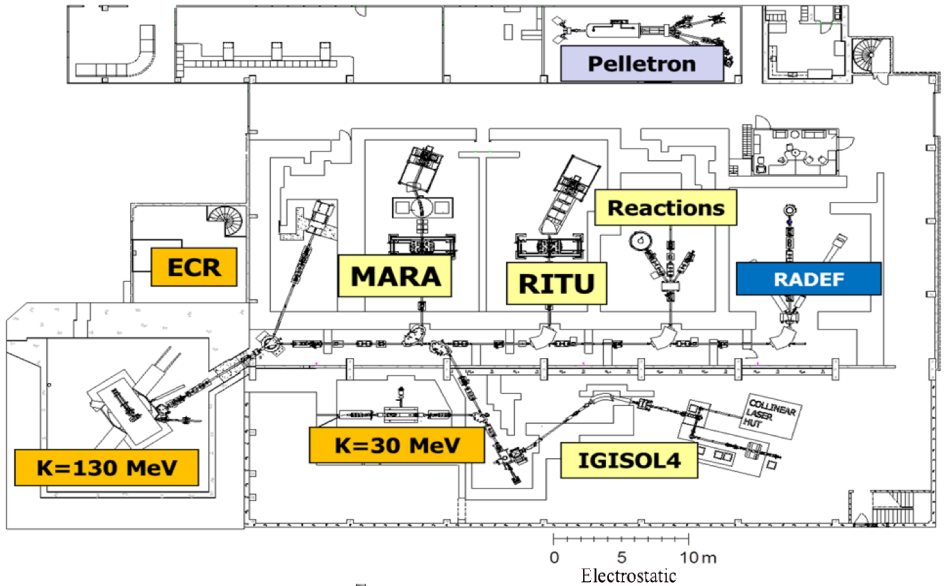


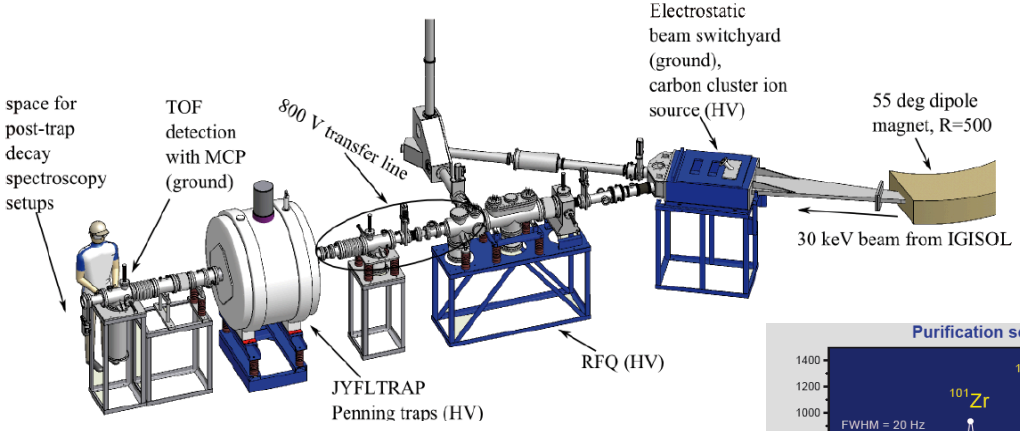
identification station

JYFL & IGISOL at Jyväskylä

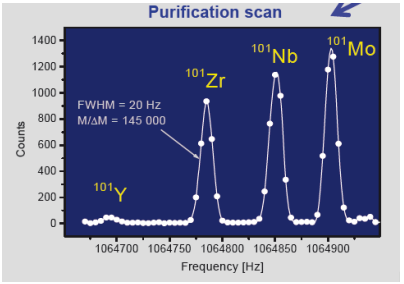
Ion Guide Technique,
Chemically independent
and fast





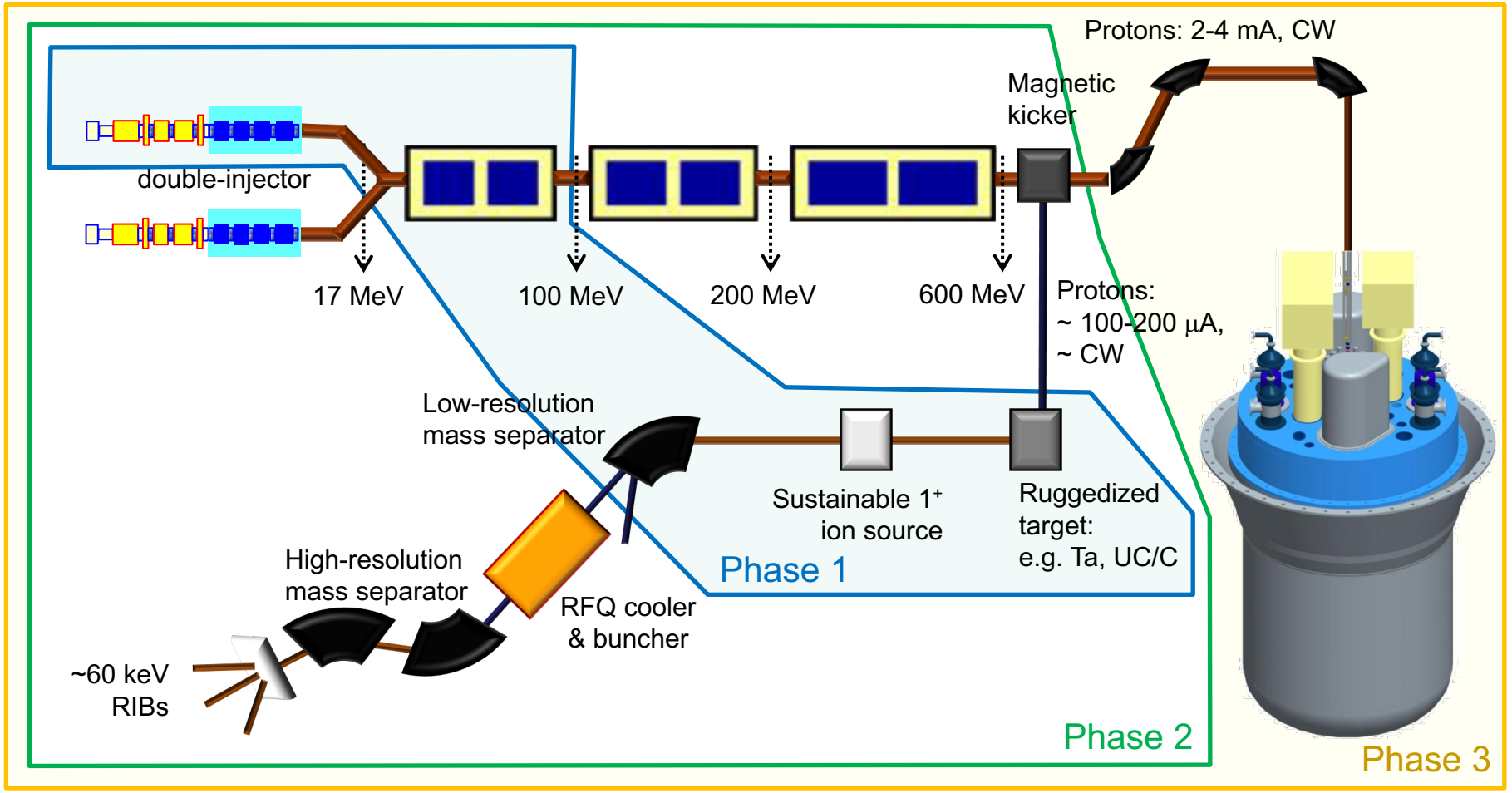


Jyväskylä TRAP



ISOL@MYRRHA - Concept

In phase 1 (2016-2024): ISOL Target Station at the 100-MeV accelerator



- Driver-beam power on ISOL@MYRRHA target: up to 120 kW
- Low-energy RIBs
- Experimental programme complementary to other ISOL facilities

The goals of EURISOL-DF project (1/3)

- Implement a **new scientific policy** tackling major problems in nuclear physics at ISOL-based European facilities and in particular:
  - organise **experimental campaigns** using all available observables, techniques, facilities and theoretical approaches to answer key questions in nuclear structure and astrophysics);
  - have a **single-entry point for physics programmes** that require beam from at least two EURISOL-DF facilities ;
  - the EURISOL-DF facilities agree to provide **a significant fraction of the Radioactive Ion beam time** dedicated for such physics programmes, for which beam time will be distributed via the EURISOL-DF Program Advisory Committee

EURISOL DF

RIBs and Beam Time

Beam Time for users & simultaneous operation

# of Months of RIB/year*	Today	In the next few years	Nominal	Nominal # of simultaneous RIB
ISOLDE	7	7	**7**	**2**
GANIL-SPIRAL2	1	4	**8**	**2**
SPES		4	**8**	**1**
ISOL@MYRRHA			**4,5**	**2**
ALTO	0,7	1,2	**1,2**	**1**
JYFL	2	2,5	**2,5**	**1**
Total	**10,7**	**18,7**	**31,2**	**9**

RIB energy range 0(keV) - 10 MeV/nucl.

** Including beam preparation & development time*

The goals of EURISOL-DF project (2/3)

- promote and coordinate the development, construction and operation of the ISOL RIB facilities in Europe;
- develop **R&D on RIB** production and instrumentation towards EURISOL and in particular
- promote user driven policy with an **important role played** by the **EURISOL User Group and the EURISOL Instrumentation Coordination Committee** in order to organise and optimize the campaigns of travelling detectors and arrays;

Traveling detectors (examples)

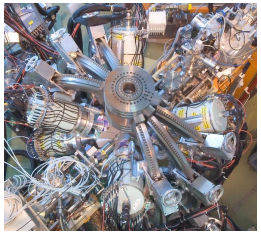
EURISOL-DF Instrumentation Coordination Committee (**EICC**)

The role of the EICC is to reinforce the synergies and coordinate efforts between the facilities and the major collaborations on existing and new detectors in order to carry on **R&D** and to **reach construction milestones** and **coordinate experimental campaigns** at all RIB facilities which are members of EURISOL-DF.

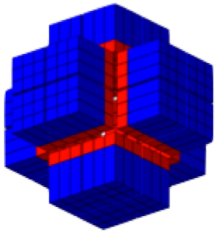
Gamma arrays

AGATA

MINIBALL

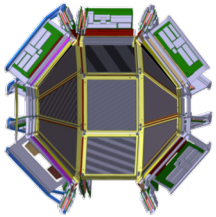


PARIS

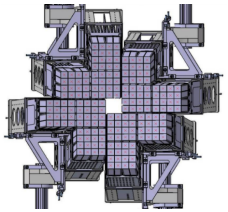


Charged-particle arrays & TPC

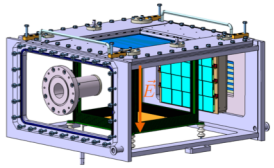
MUGAST/GRIT



FAZIA

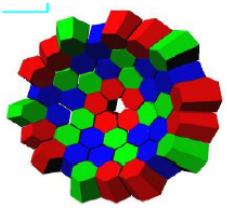


ACTAR-TPC

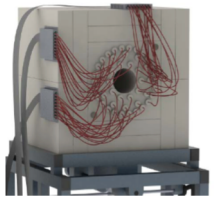


Neutron arrays

NEDA

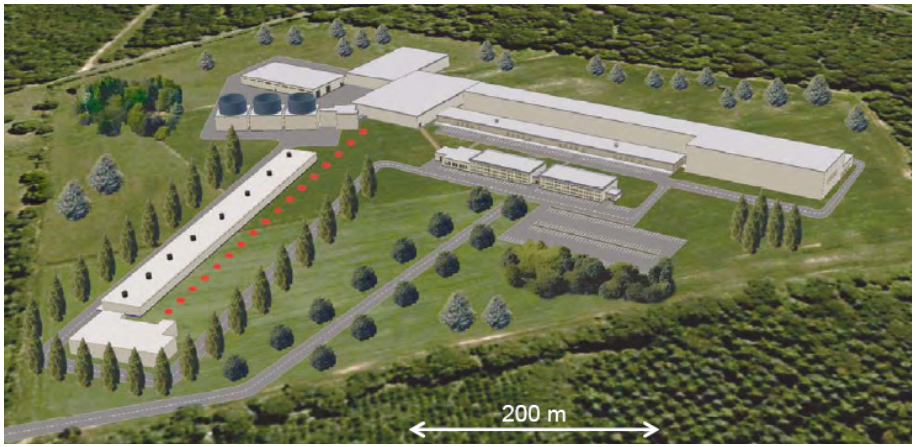


BELEN



The goals of EURISOL-DF project (3/3)

- Have **EURISOL-DF included on the ESFRI list by 2020** and attract additional member states and EU funds
- Establish a **joint strategy in education and training in nuclear science** (eg. organising joint summer schools, hands on training, topical workshops and conferences);
- Develop **EURISOL as a single site facility as a long-term goal**.



Layout of EURISOL Design Study 2009

Collaboration agreement between FAIR/NUSTAR and EURISOL-DF under discussion

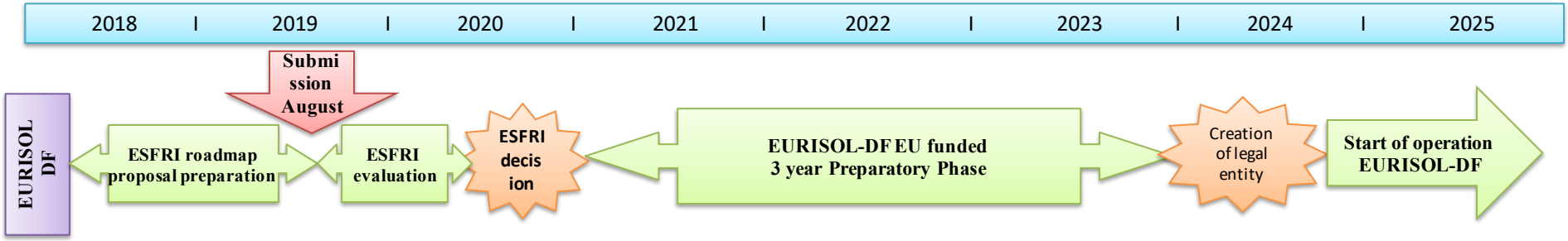
EURISOL DF

EURISOL – Distributed Facility (DF) Initiative – next steps

- First draft of the full EURISOL-DF recommendations is ready
  - Writing Committee (A. Bracco, Y. Blumenfeld, B. Rubio and M. L.) in a close collaboration with the EURISOL Steering Committee and EURISOL UEC

➢ ***Executive Summary finalised in few weeks***

➢ *Meetings with funding agencies in order to ensure a support from at least 3 EU countries (France, Italy, CERN and also Belgium, Finland, Poland,…) – from October 2018*



EURISOL-DF in the H2020 IA project beyond ENSAR2?

EURISOL DF

Acknowledgements

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EURISOL SC members

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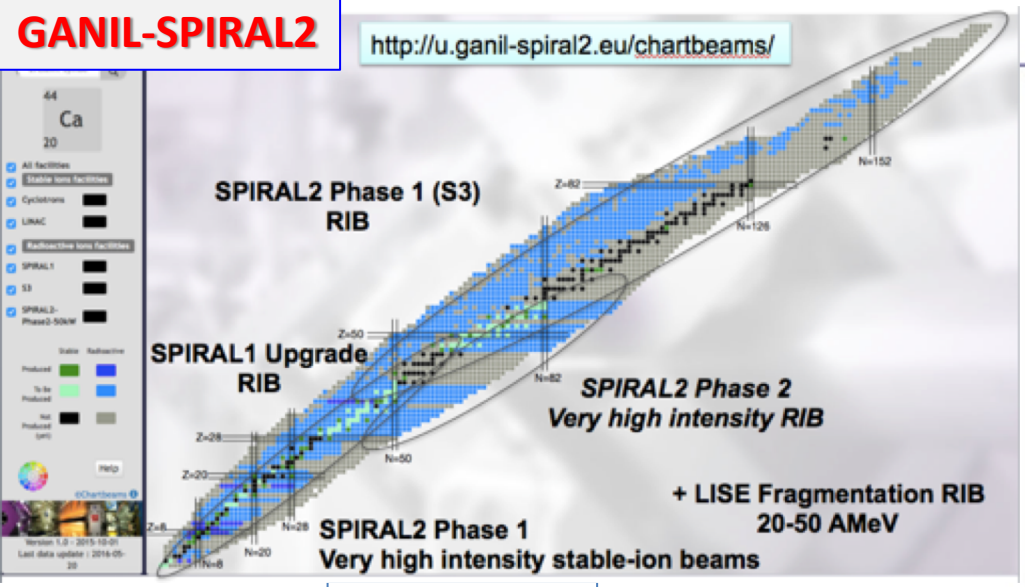
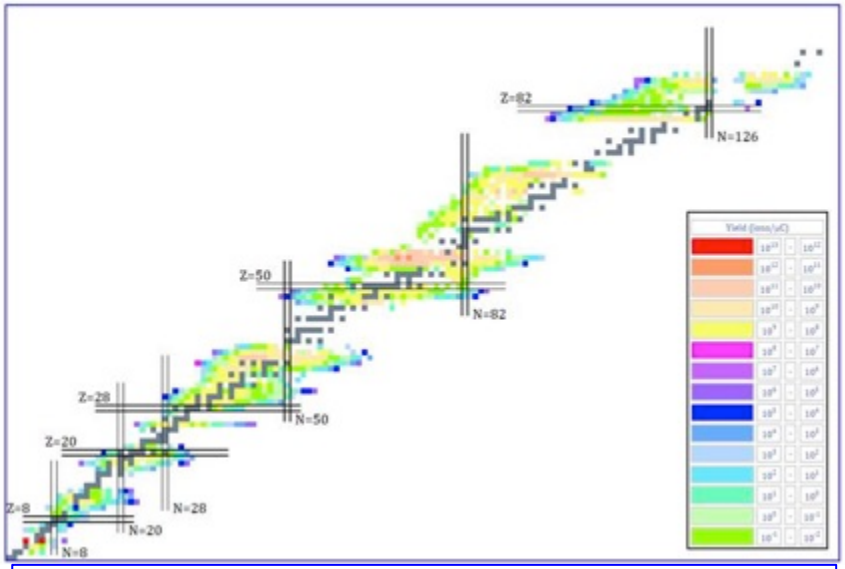
BACKUP SLIDES

RIBs and Beam Time

GANIL-SPIRAL2

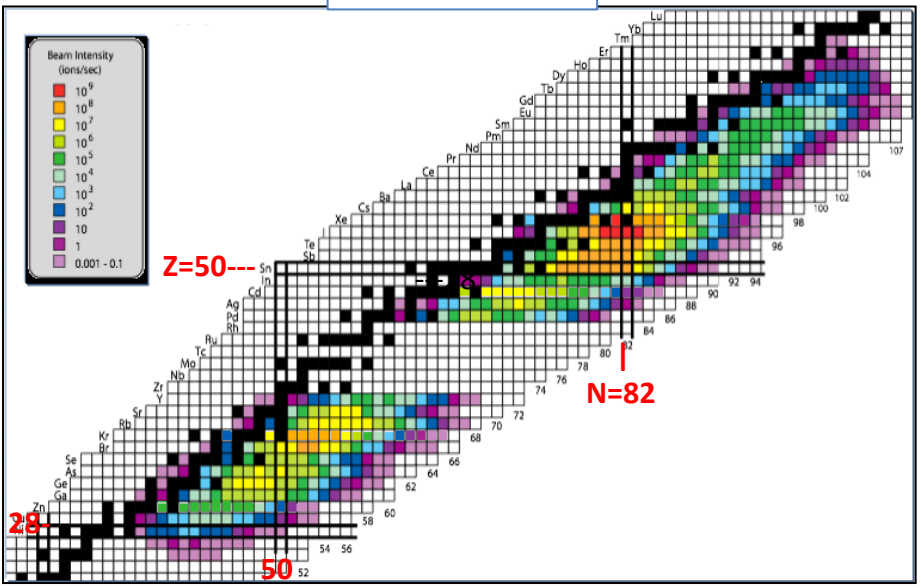


ISOLDE-CERN



http://test-isolde-yields.web.cern.ch/test-isolde-yields/query_tgt.htm

INFN - SPES

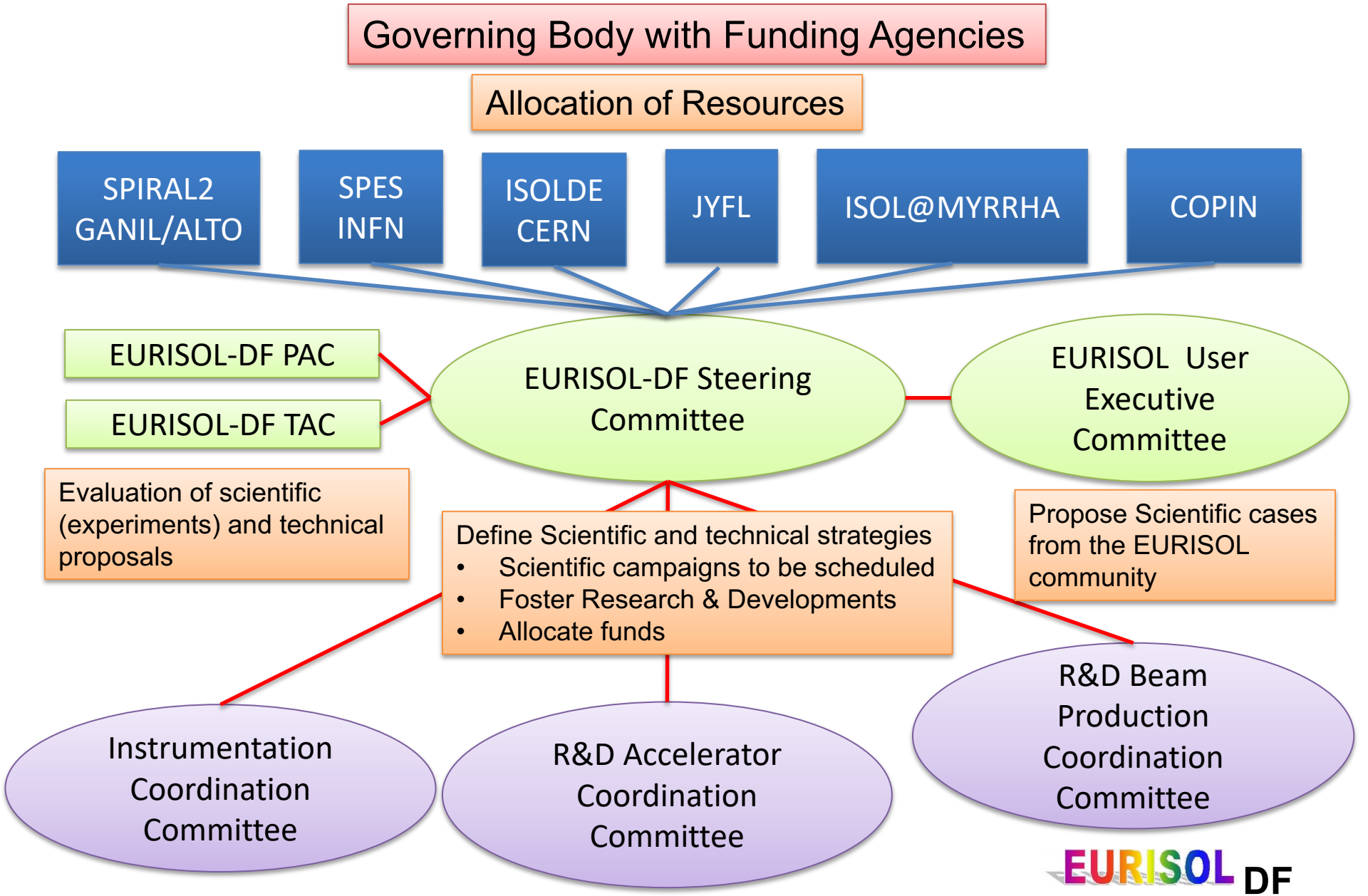


https://web.infn.it/spes/index.php/news/spes-beam-tables

EURISOL-DF:
Enhance complementarities
&
avoid duplication of efforts in the beam developments

EURISOL DF

EURISOL-DF Organisation (Preliminary)



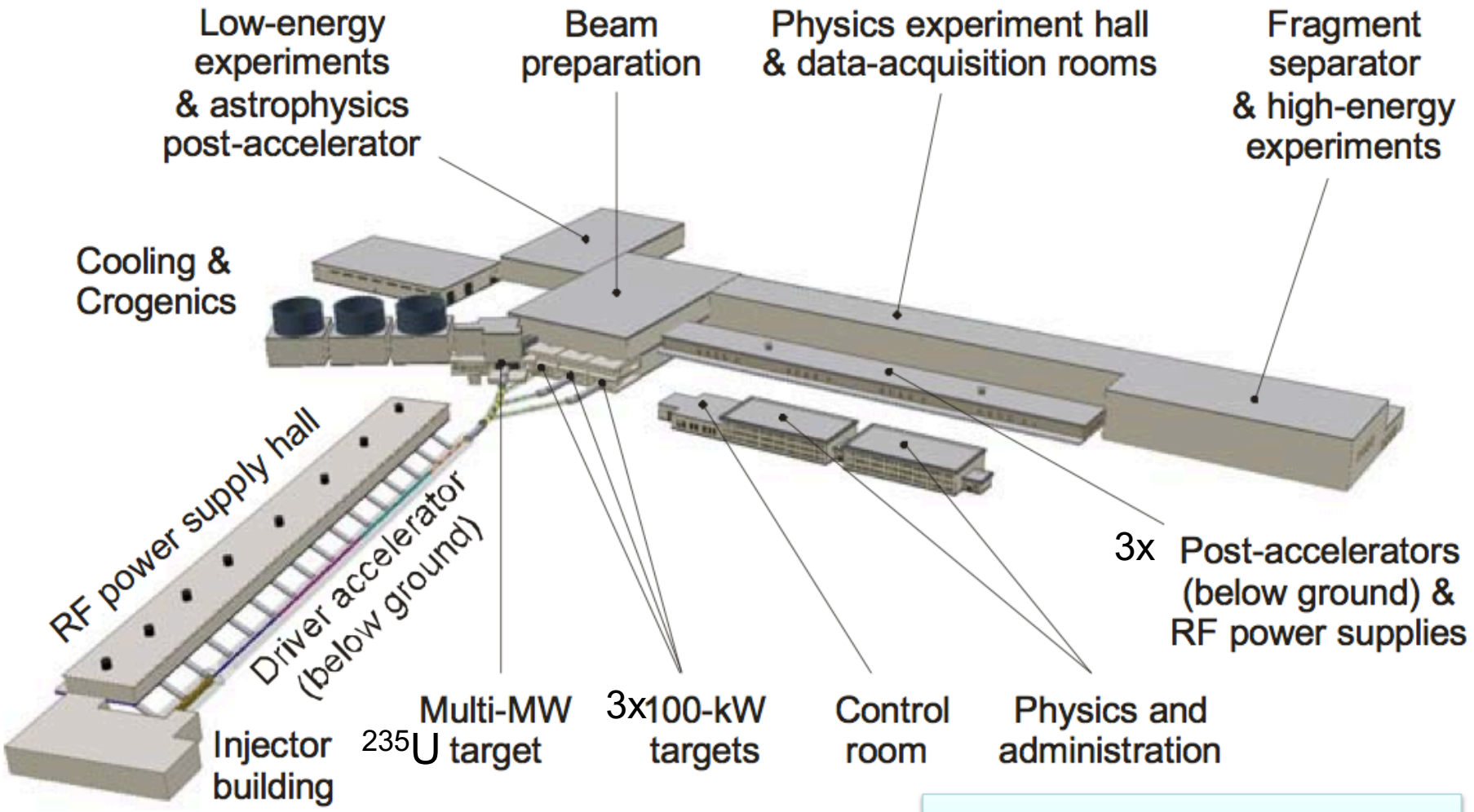
Close collaboration and synergies FAIR/NUSTAR – EURISOL-DF

- **Unified approach to the nuclear physics topics (examples):**
  - Nuclear structure and reactions for explosive nucleosynthesis
  - Modifications of shells closures
- **Synergies in the construction and campaigns of (moving) arrays and detectors**
- **Collaborative approach of the whole European nuclear structure and reactions community**
  - Joint input and support for the ESFRI (FAIR, GANIL-SPIRAL2, MYRRHA, *EURISOL-DF* and EU projects (ENSAR2 and beyond)
  - Joint conference (EURORIB) and topical meetings

Collaboration agreement between FAIR/NUSTAR and EURISOL-DF under discussion

What is EURISOL DF ?

Up to 150 AMeV for ^{132}Sn



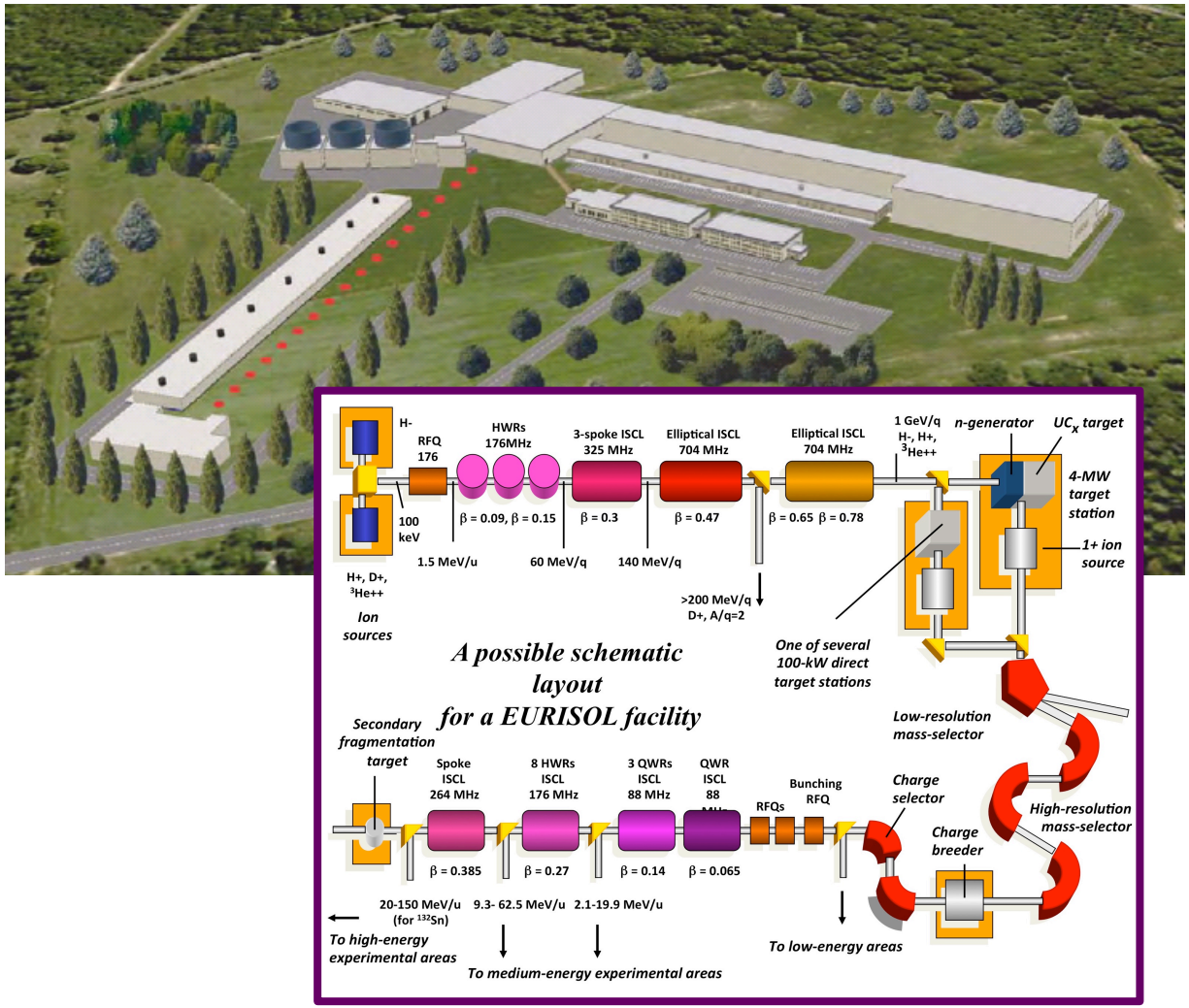
LINAC: H, D, He and A/q=2 ions up to 1 A GeV

Multi-user capabilities

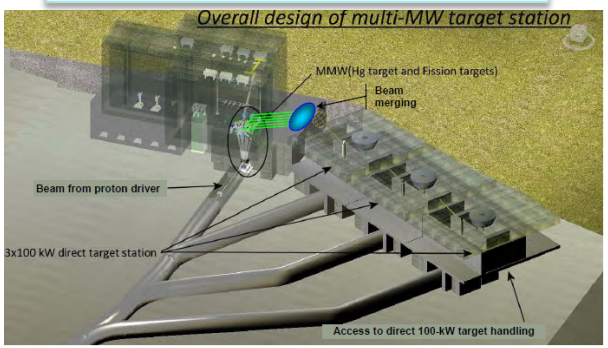
Cost: > 1.3B€

What is EURISOL ?

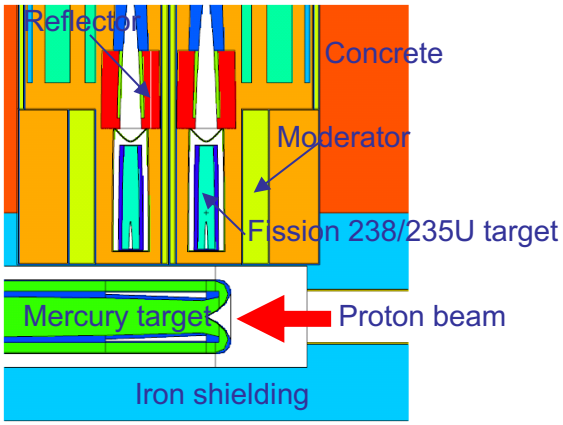
Facility as defined in the 2005-2009 EU funded Design Study



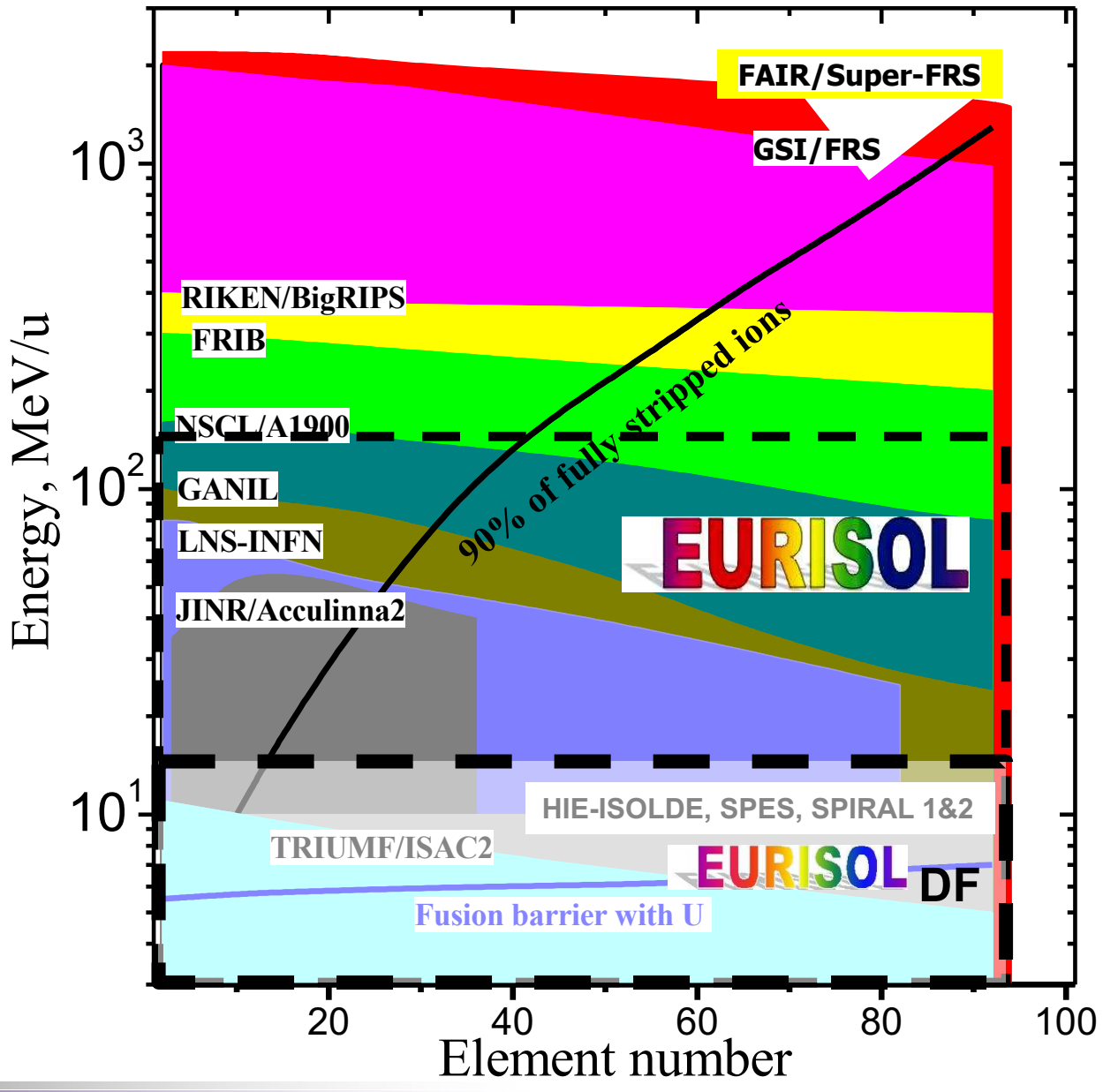
4 target stations: Multi-user capabilities



5MW target



Energy domain



Recommendations for European facilities

Complete urgently the construction of the ESFRI flagship FAIR and develop and bring into operation the experimental programme of its four scientific pillars APPA, CBM, NUSTAR and PANDA.

Support for construction, augmentation and exploitation of world leading ISOL facilities (ISOLDE, GANIL-SPIRAL2, SPES) in Europe towards EURISOL (EURISOL-DF).

Support for the full exploitation of existing and emerging facilities.

Support for ALICE and the heavy-ion programme at the LHC with the planned experimental upgrades.

Support to the completion of AGATA in full geometry.

EURISOL-DF Pan-European added value

- Optimal approach to study major questions in modern nuclear structure physics, nuclear astrophysics and related applications
- European coordination of EURISOL related physics and technical R&D
- Secured resources for operation of the ISOL facilities and additional resources for R&D and detectors
- Clear strategy for upgrades of the complementary EU ISOL facilities towards EURISOL

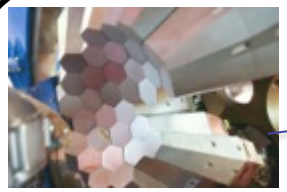
User driven policy: Example EICC

EURISOL-DF Instrumentation Coordination Committee (**EICC**)

The role of the EICC is to reinforce the synergies and coordinate efforts between the facilities and the major collaborations on existing and new detectors in order to carry on **R&D** and to **reach construction milestones** and **coordinate experimental campaigns** at all RIB facilities which are members of EURISOL-DF.

Traveling detectors (examples)

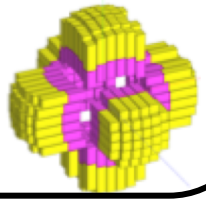
Gamma-ray detectors



AGATA

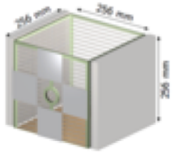
EXOGAM 2

PARIS



Charged particle detectors

ACTAR-TPC

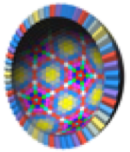


GASPARD

FAZIA

Neutron detectors

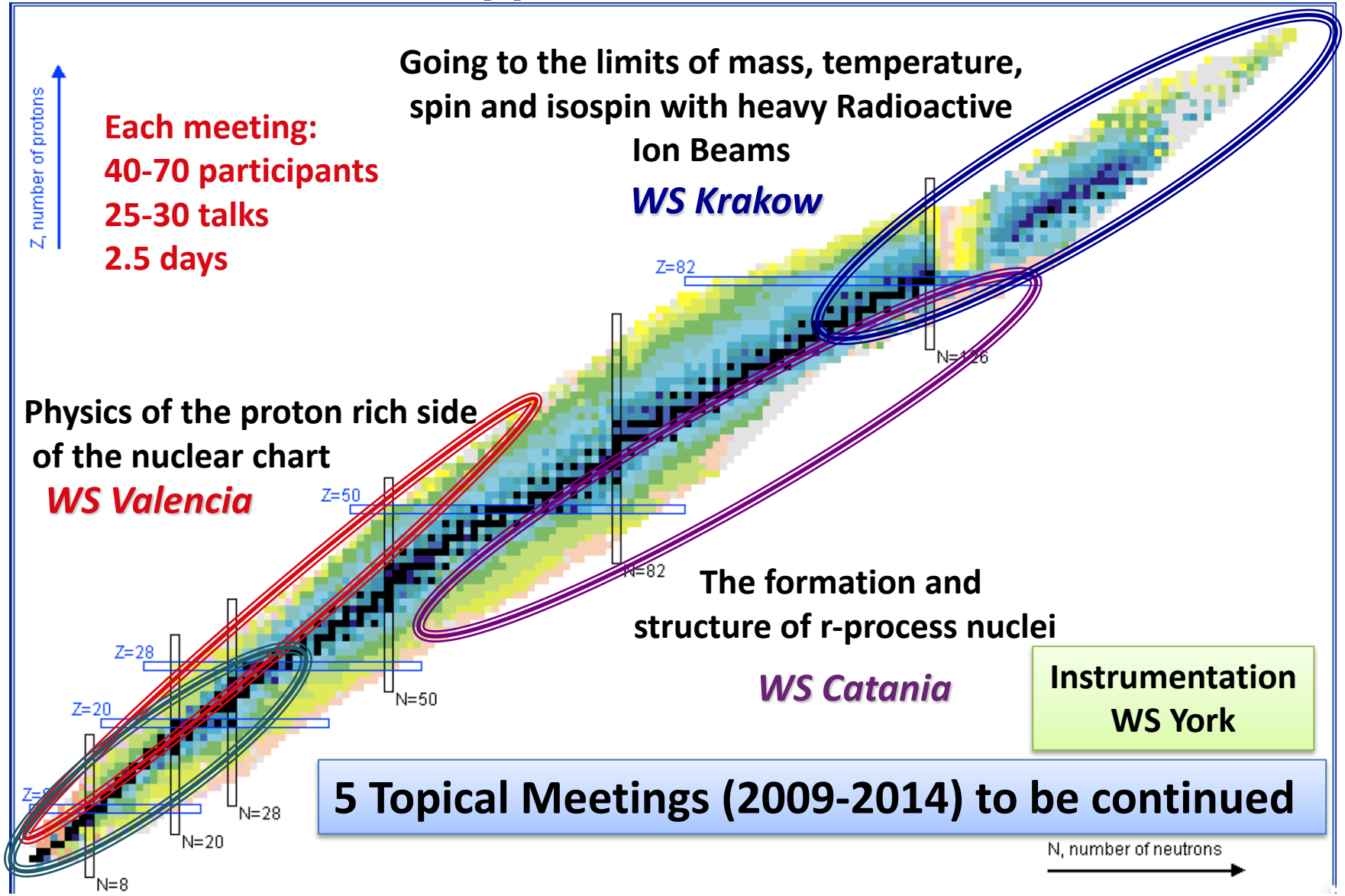
NEDA



DEMON

Strong scientific case for RIB science and applications

EURISOL User Group



http://www.ensarfp7.eu/projects/eurisol-net/documents

Electric dipole moment search in exotic octupole deformed systems

.At present the most sensitive EDM search is performed on ^{199}Hg and the upper limits already constrain various extension of the Standard Model. Being the expected EDM proportional to the square of the octupole deformation, very promising cases are octupole deformed nuclei in the actinide region like ^{223}Rh, ^{225}Ra or ^{229}Pa nuclei with enhancement factors calculated up to the order of 10^4 respect to Hg nuclei. EURISOL-DF offers a unique possibility to study in a coherent and complementary way such systems through high energy reaction (HIE-ISOLDE), performing nuclear structure characterization (SPES) and production (SPIRAL2 and ISOL@MHYRRA).