



# NuPECC – presentation

## Long Range Plan for Nuclear Science in Europe

Angela Bracco – NuPECC chair



National Science Foundation  
WHERE DISCOVERIES BEGIN

DOE/NSF Meeting

TECHNICAL SUPPORT

DOE/NSF Nuclear Science Advisory Committee Meeting  
Bethesda North Marriott Hotel & Conference Center, Bethesda, MD

March 23, 2016

## Outline

- The NuPECC activities (in brief)
- Preparation of the new NuPECC long Range plan
  - Organization of the work
  - Thematic working groups
  - Facilities – status and plans

(materials from the last NuPECC meetings)

**ORGANIZATION**

- Contacts
- Map
- Committee Members
- Members' Addresses
- NUPECC Roadmap
- Terms of Reference
- Meetings
- Presidentialism
- Publications
- Members' Area
- Calendar of Events

**ACTIVITIES**

- Nuclear Physics Area
- Long Range Plan 2014
- NUFIT
- EUROPE WEB
- NuclearPhysics2014
- ENIGMA 1A
- Small Scale Facilities
- ECOS
- FRAN
- WUPEX
- Some Useful Links

**SEARCH**



Joint Institute for  
Nuclear Research  
Dubna-  
Recently joined

Request from  
Turkey and Israel

exchanges  
with

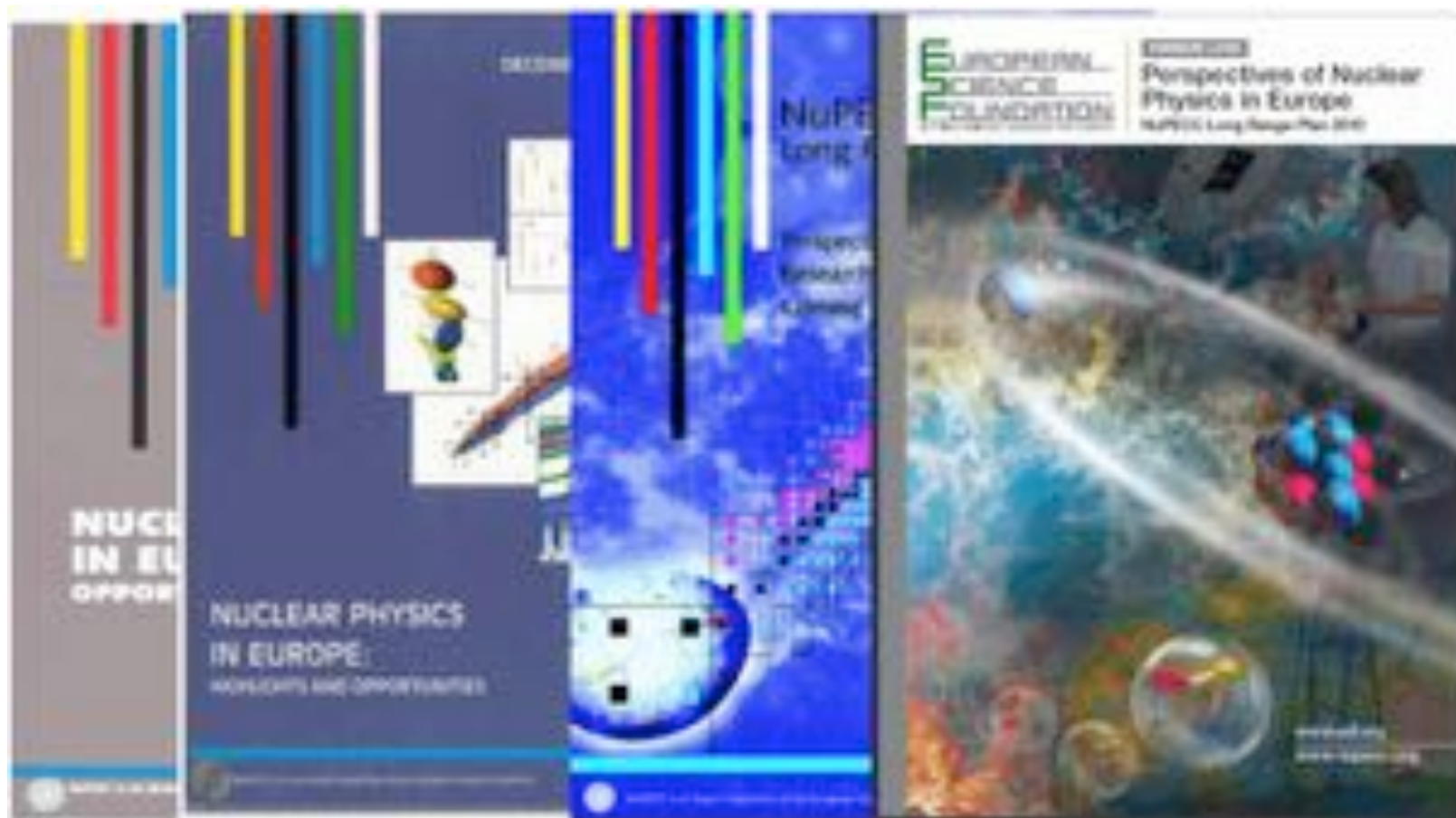
- AnPHA
- NSAC
- Canada

+ ALAFNA

**21 countries – 31 Members**



# Perspectives of Nuclear Physics in Europe

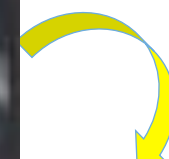


1991

1997

2004

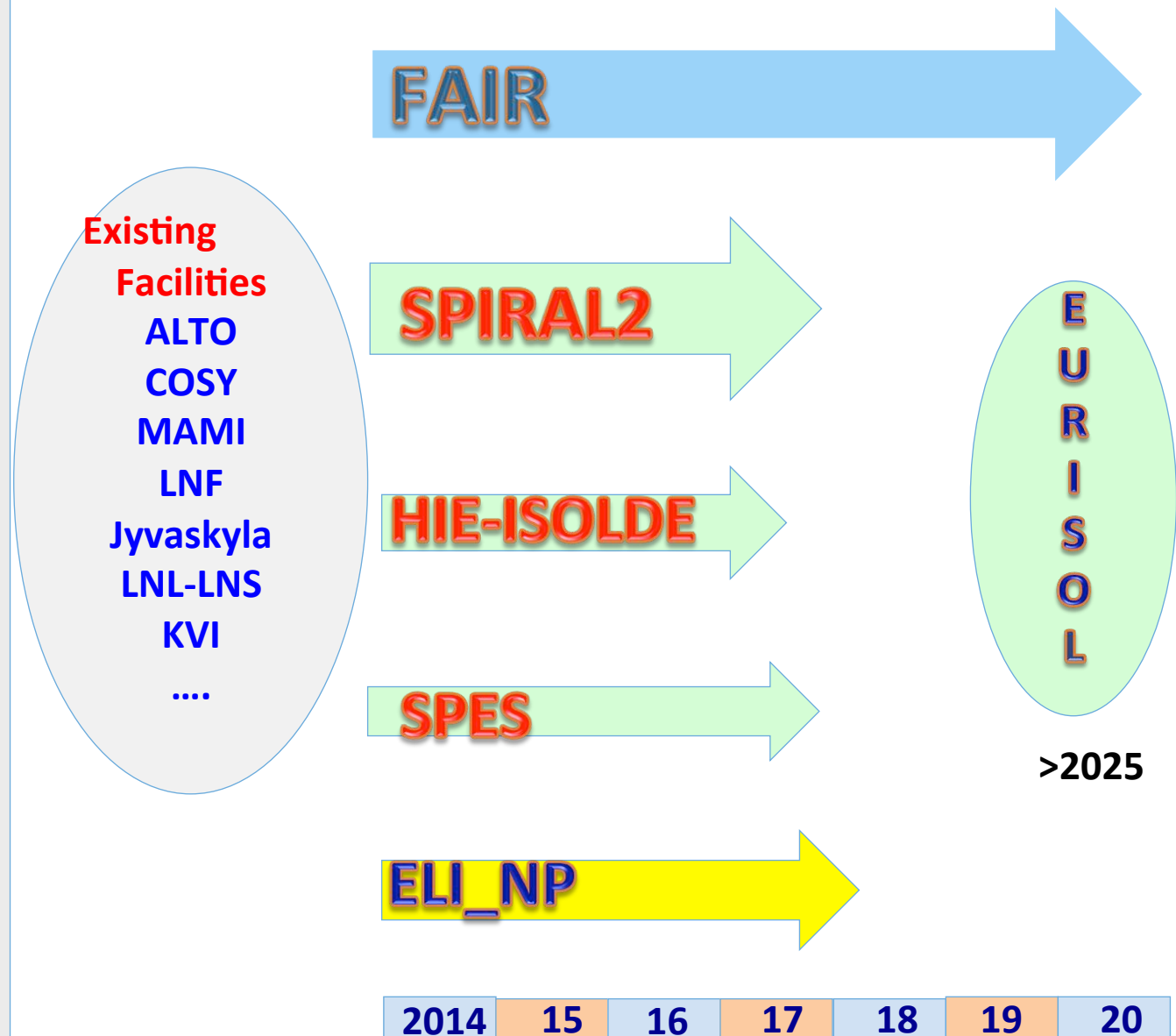
2010

  
Volume  
Brochure  
video

## NuPECC LRP (2010)

- FAIR and SPIRAL2 (ESFRI)
- HIE-ISOLDE and SPES
- ALICE at CERN
- Existing Laboratories + Luna
- Instrumentation (AGATA)
- Theory
- Applications
- New ESFRI fac.

## New Facilities and Major upgrades



Shifts in time as compared with 2009

## **After 6 years a new Long range plan is needed**

- The plans made in 2009 (published in 2010) are not yet fully realized –

- Changes and delays in the original plans for major facilities are ongoing.

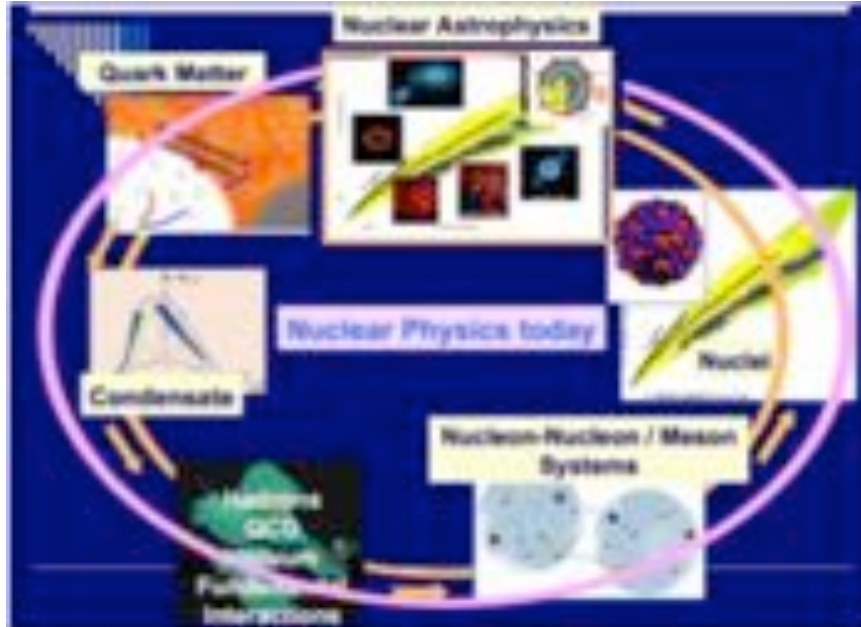
### **One needs urgently to :**

- re-assess programmes at the present conditions and re-affirm the existing great interest on infrastructures under construction

- prepare the instrumentation (including theory) in view of the progress in science and of the changed timeline

- **Review** status of the field
- Issue **recommendations** to advance
  - The science
  - Its applications in Europe
- Develop **action plan (roadmap)** for:
  - Building** new large-scale Research Infrastructures
  - Upgrading** existing Nuclear Physics facilities
  - Collaborate** closely with smaller scale facilities
  - support **EU** projects ( IAs, ERA-net .....
- Put European Nuclear Physics into **global context**
  - NSAC (DoE & NSF) in USA, ANPhA in Asia, ALAFNA in Latin America
  - IUPAP and OECD Global Science Forum -

- **One part of the volume on science and Facilities**
- **Summary and recommendations**
- **6 more detailed chapters on the achievements and specific plans concerning the different themes of today Nuclear Physics**



- 1) Hadron Physics**
- 2) Phases of Strongly Interacting Matter**
- 3) Nuclear Structure & Dynamics**
- 4) Nuclear Astrophysics**
- 5) Fundamental Interactions**
- 6) Nuclear Physics Tools & Applications**



- Several meeting and workshops are ongoing which are organized by the working group members appointed by NuPECC and by the NuPECC liasons

1) **Hadron Physics** *D Bettoni(Ferrara) + H. Wittig(Mainz)-*  
**Mainz 18/19 February**

2) **Phases of Strongly Interacting Matter** *S Masciocchi(GSI) + F Gélis(CEA Saclay)....***May 11 CERN**

3) **Nuclear Structure & Dynamics** *J Simpson (Daresbury) + E Khan (Orsay)-* **5 APRIL ORSAY**

4) **Nuclear Astrophysics** *G Martinez Pinedo(TU Darmstadt) + A Laird (York)*  
**GSI on 16<sup>th</sup>/17<sup>th</sup> February 2016**

5) **Fundamental Interactions** *K. Kirch (PSI) + K Blaum(MPI Heidelberg)* **21-22 APRIL-PSI**

6) **Nuclear Physics Tools & Applications** *M Durante (TIFPA Trento) +D. Letournau (Saclay)*  
**ECT\* 10 March 2016**

- **NuPECC has organized a special meeting in January to discuss the status of European Facilities**

# European Strategic Forum Research Infrastructures

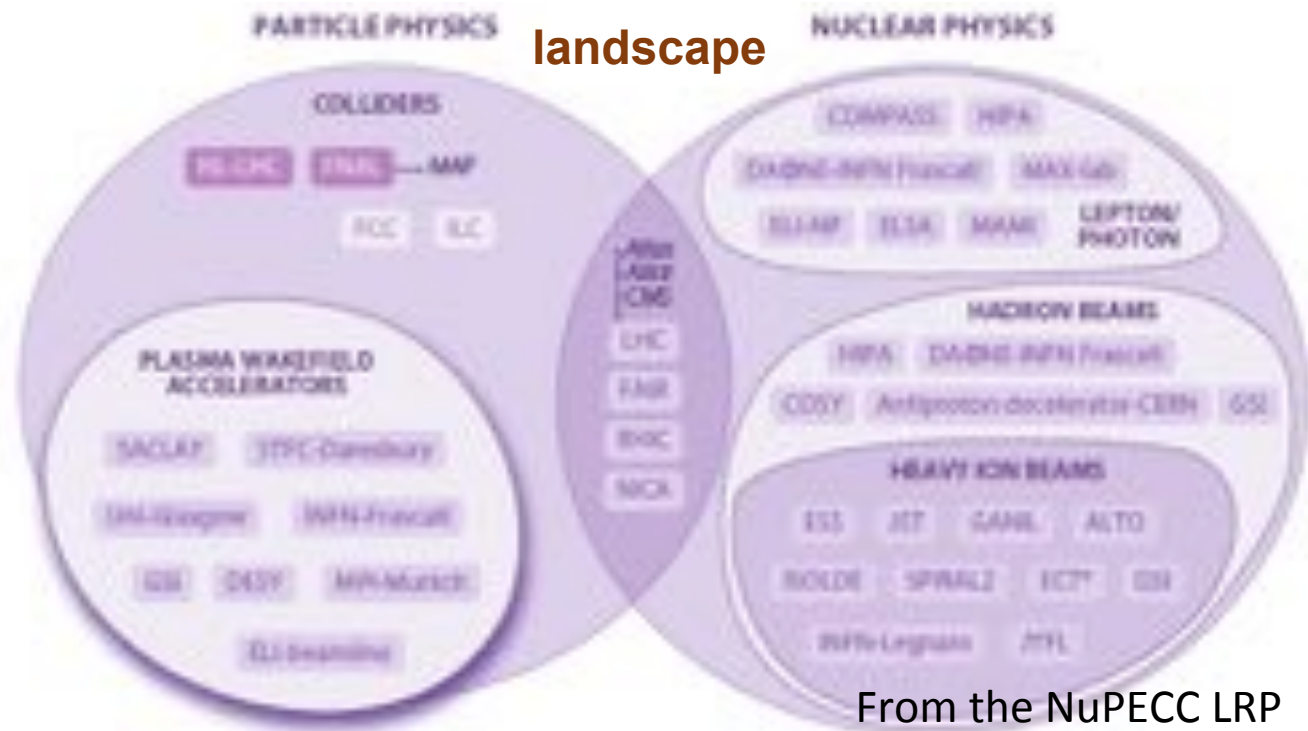
ESFRI

- NuPECC, APECC , CERN ....are observers and gave inputs for **STRATEGY REPORT ON RESEARCH INFRASTRUCTURES** - March 10 2016

[http://ec.europa.eu/research/infrastructures/index\\_en.cfm?pg=esfri](http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri)

## Landmark Facilities

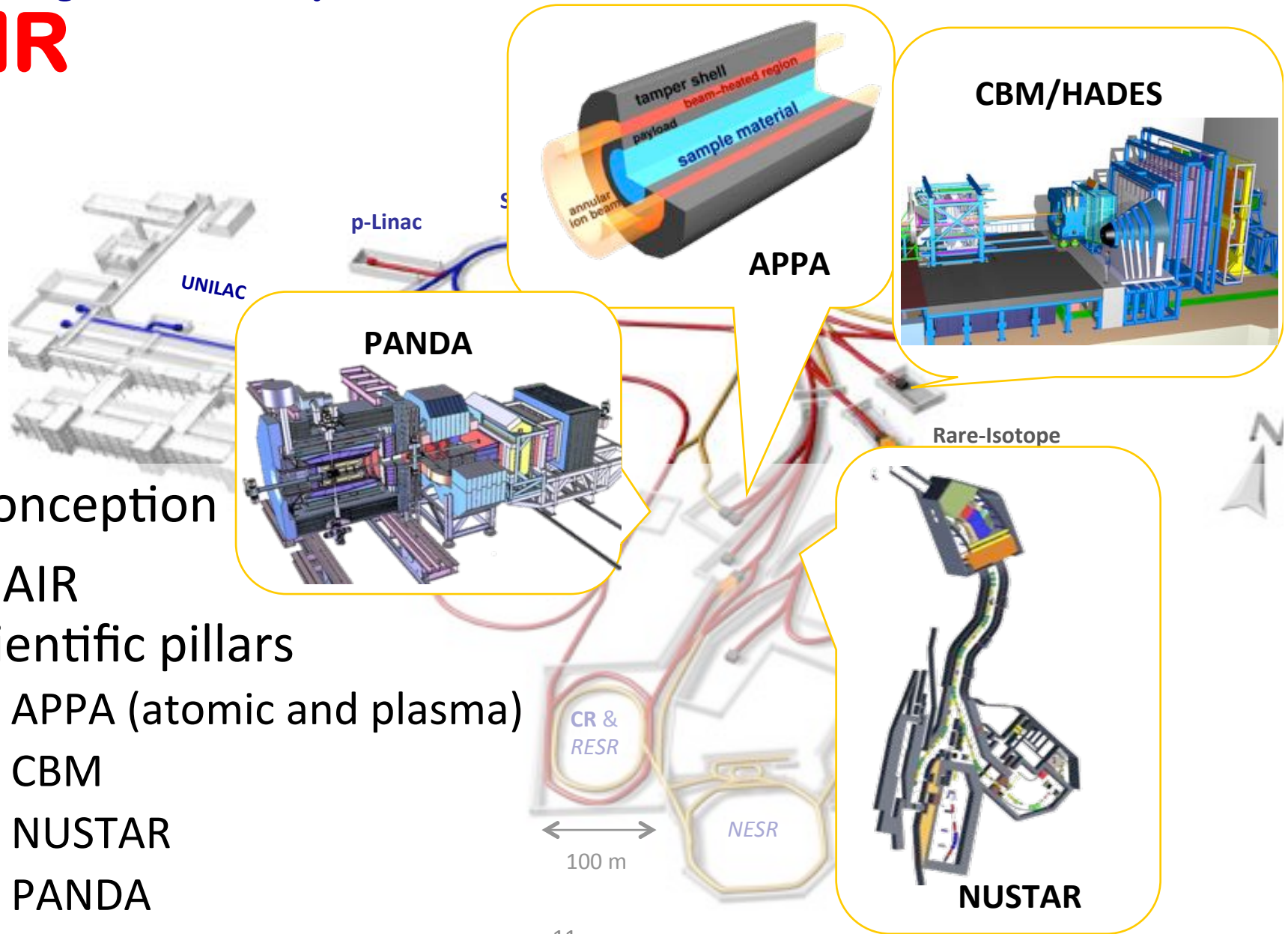
- FAIR -> synergies with NICA at JINR
- SPIRAL2
- ELI\_NP



In 2018 the list will be updated – a proposal from NP is in preparation



# Facility for Antiproton and Ion Research **FAIR**

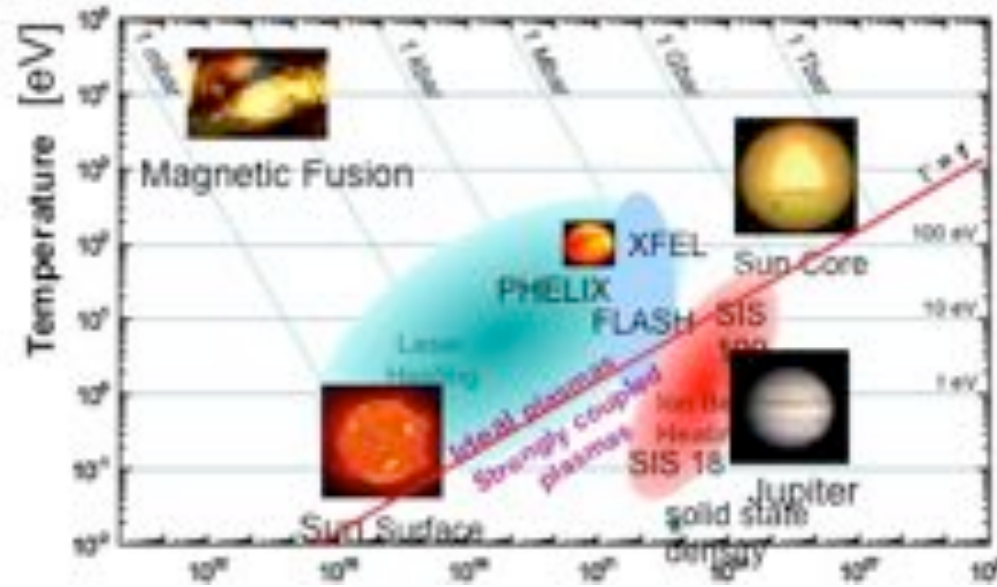


- Conception of FAIR

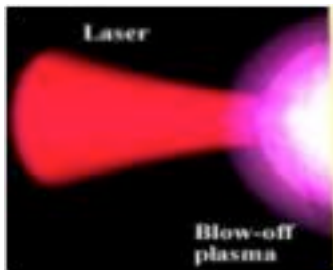
- 4 scientific pillars

- APPA (atomic and plasma)
- CBM
- NUSTAR
- PANDA

# APPA – Plasma physics



photon pulses (XUV) of highest brilliance (FLASH)

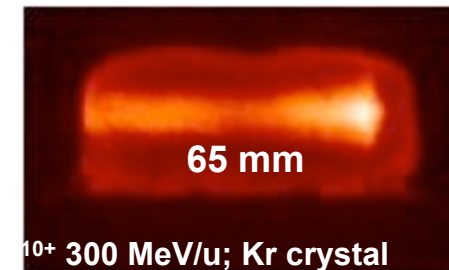


small volumes of non equilibrated environment ( $100\mu\text{m}^3$ )

Achieving high pressure and high temperature

**PHELIX**

intense, energetic beams of heavy ion (FAIR)



**SIS100**

large volumes of equilibrated uniform environment ( $\sim\text{mm}^3$ ) <sup>12</sup>



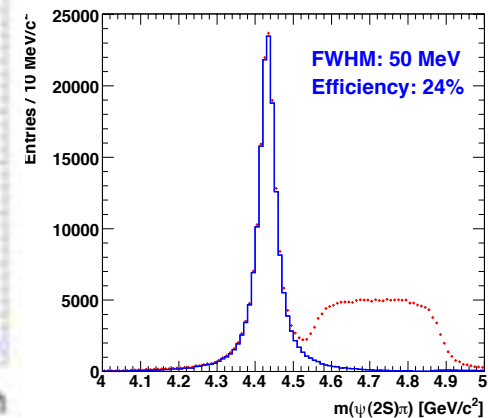
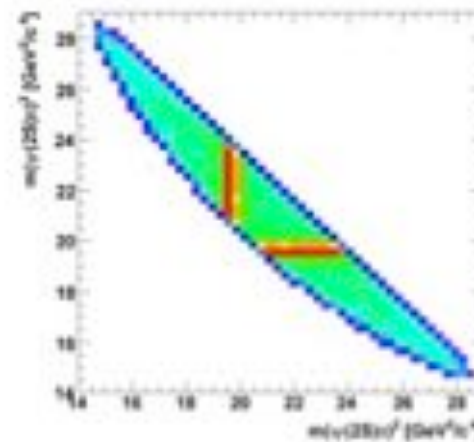
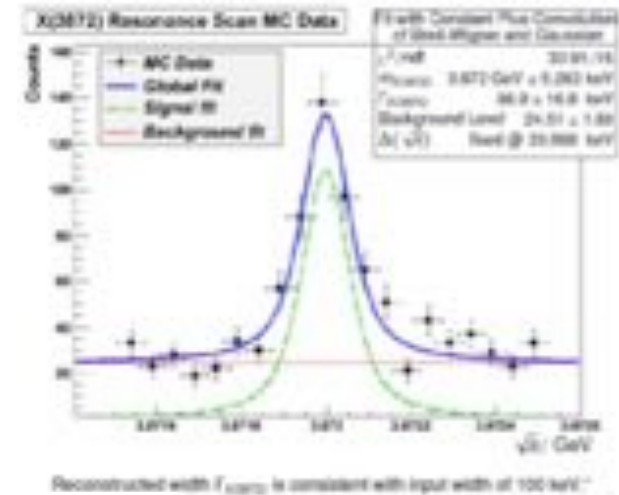
# PANDA Day-One Science

- **Science re-assessed, sharpened and day-one experiments defined**

- Scrutiny Group (reports)
- EMMI Rapid Reaction Taskforce
- Physics Workshop Uppsala

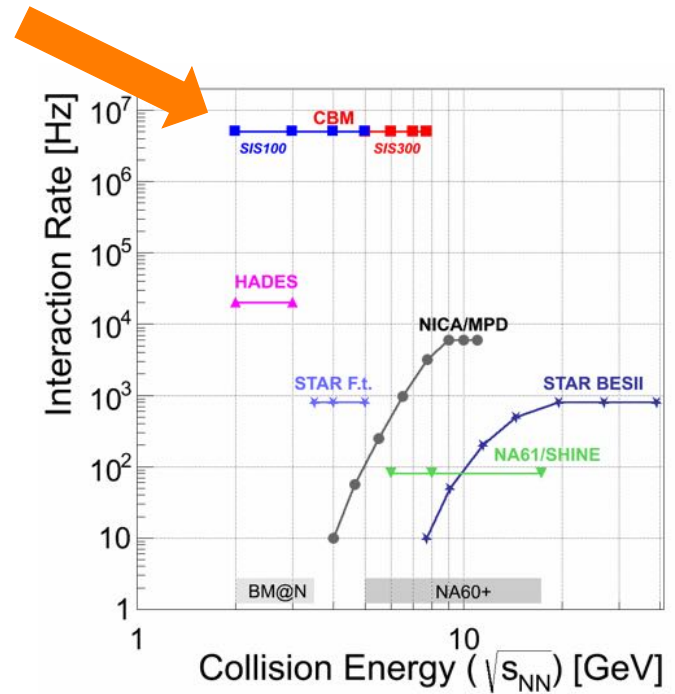
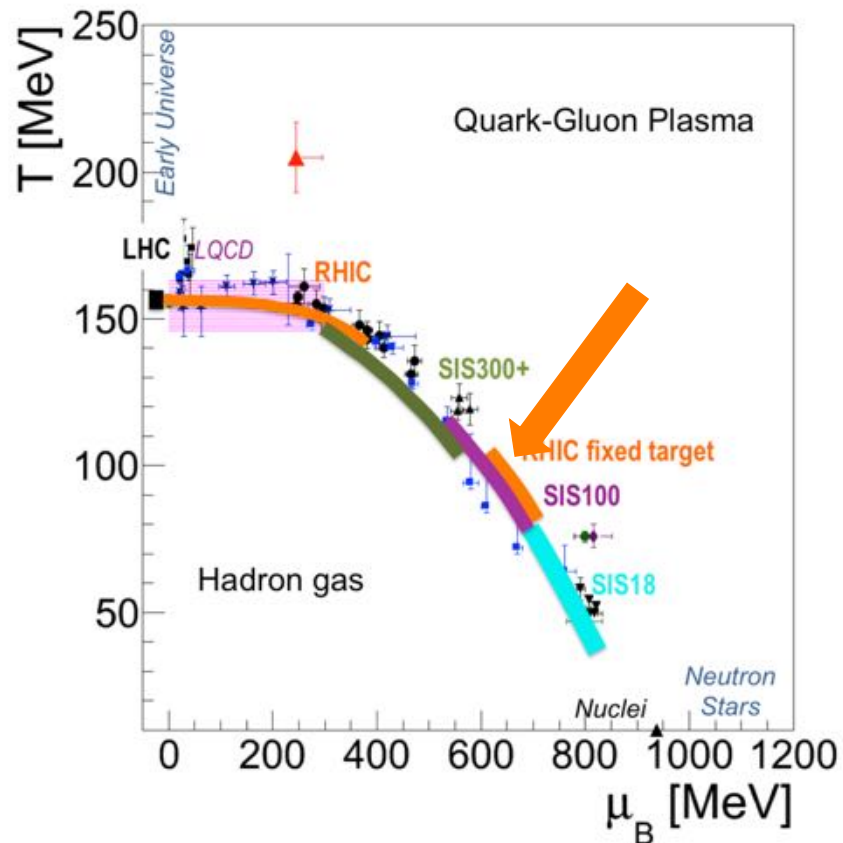
- **Key experiments (initial conditions)**

- **Scan of narrow resonances**  
X(3872) and newly discovered narrow states and study of radiative decays
- **Formation experiment of Z-resonances**  
using a deuterium target
- **Additional day-one measurements**
  - Time-like form factors
  - Excited hyperons
  - Precision charmonium spectroscopy e.g.  $\chi_{c1,2}$
  - Delta – Delta content of Deuteron
- Requirements:  
**Target, Tracking and Calorimetry**



# CBM – Exploring the QCD phase diagram using rare probes

**Key experimental requirement:  
operation at  
unprecedented high rates !**



## CBM physics program:

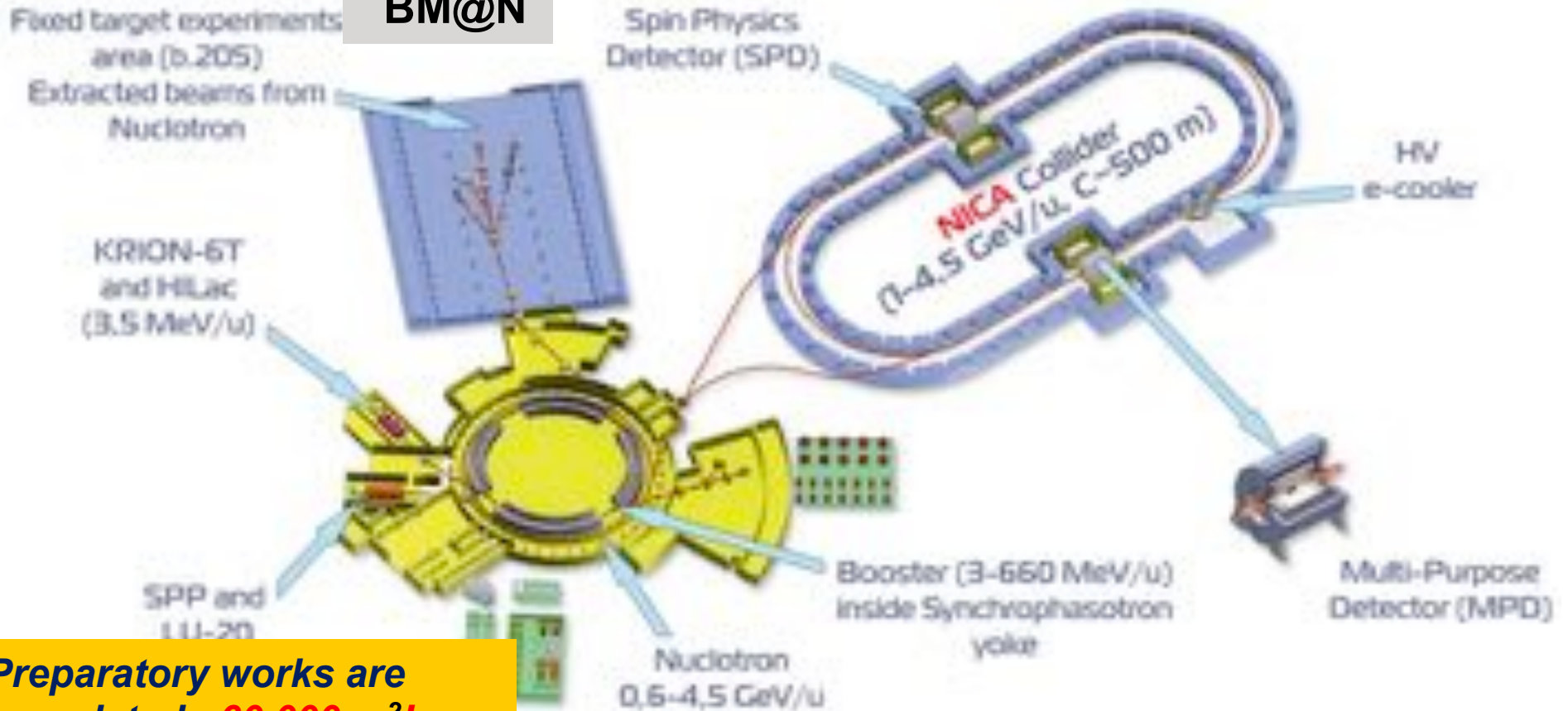
- exploring the QCD matter equation-of-state at very high net baryon densities
- search for phase boundaries and for new forms of QCD matter
- search for the onset of chiral symmetry restoration

## CBM observables:

- dileptons and fluctuations
- charmonium production
- and ....

# Superconducting accelerator complex **NICA** (**N**uclotron based **I**on **C**ollider **f**Acility)

BM@N



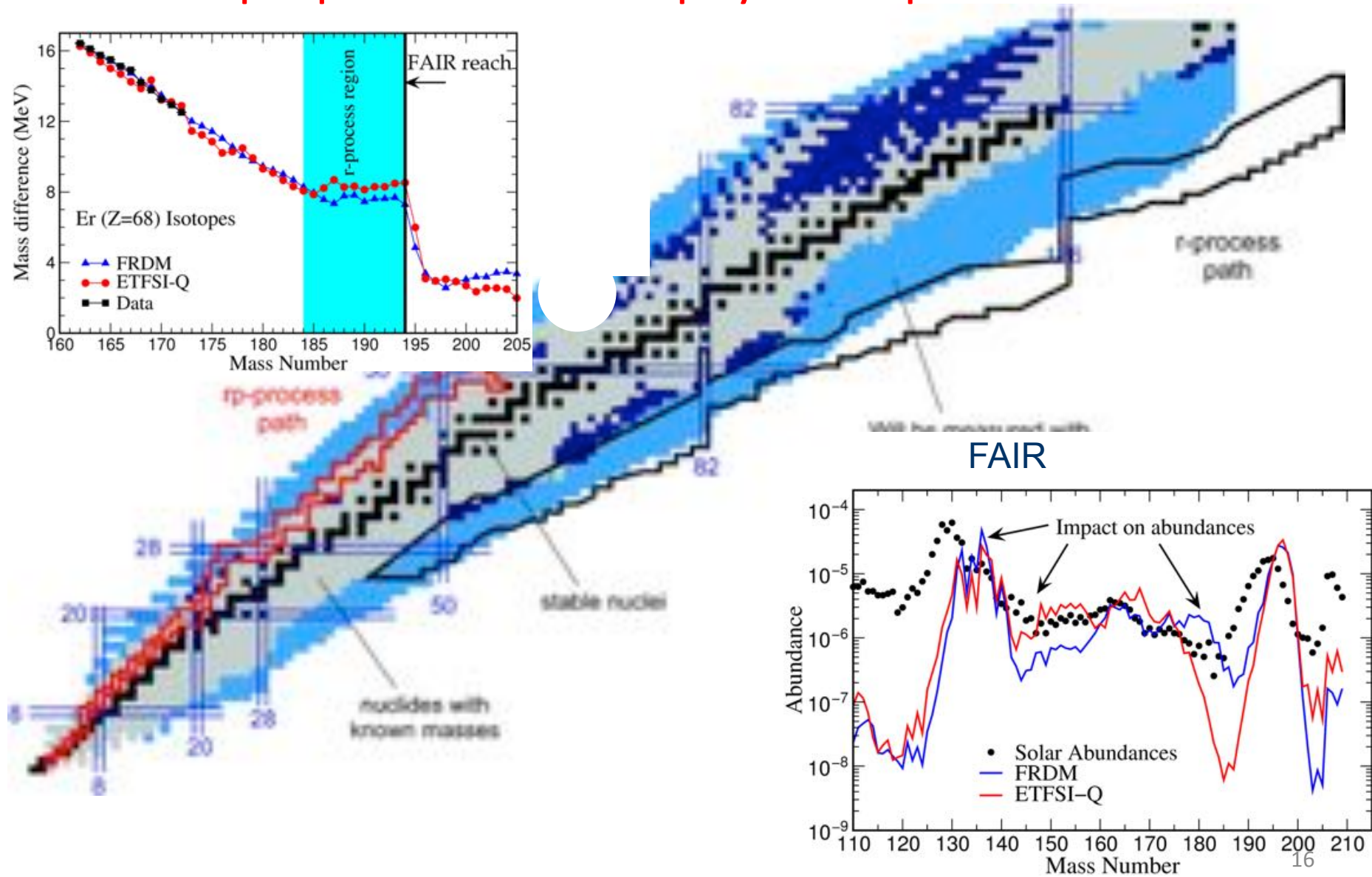
**Preparatory works are completed ~60 000 m<sup>2</sup>!**



- parameters:**
- Energy range:  $\sqrt{s_{NN}} = 4-11 \text{ GeV}$
  - Beams: from p to Au
  - Luminosity:  $L \sim 10^{27} \text{ (Au)}, 10^{32} \text{ (p)}$
  - Detectors: MPD (ions), SPD (spin physics)



# NUSTAR – Nuclear properties for astrophysical r-process



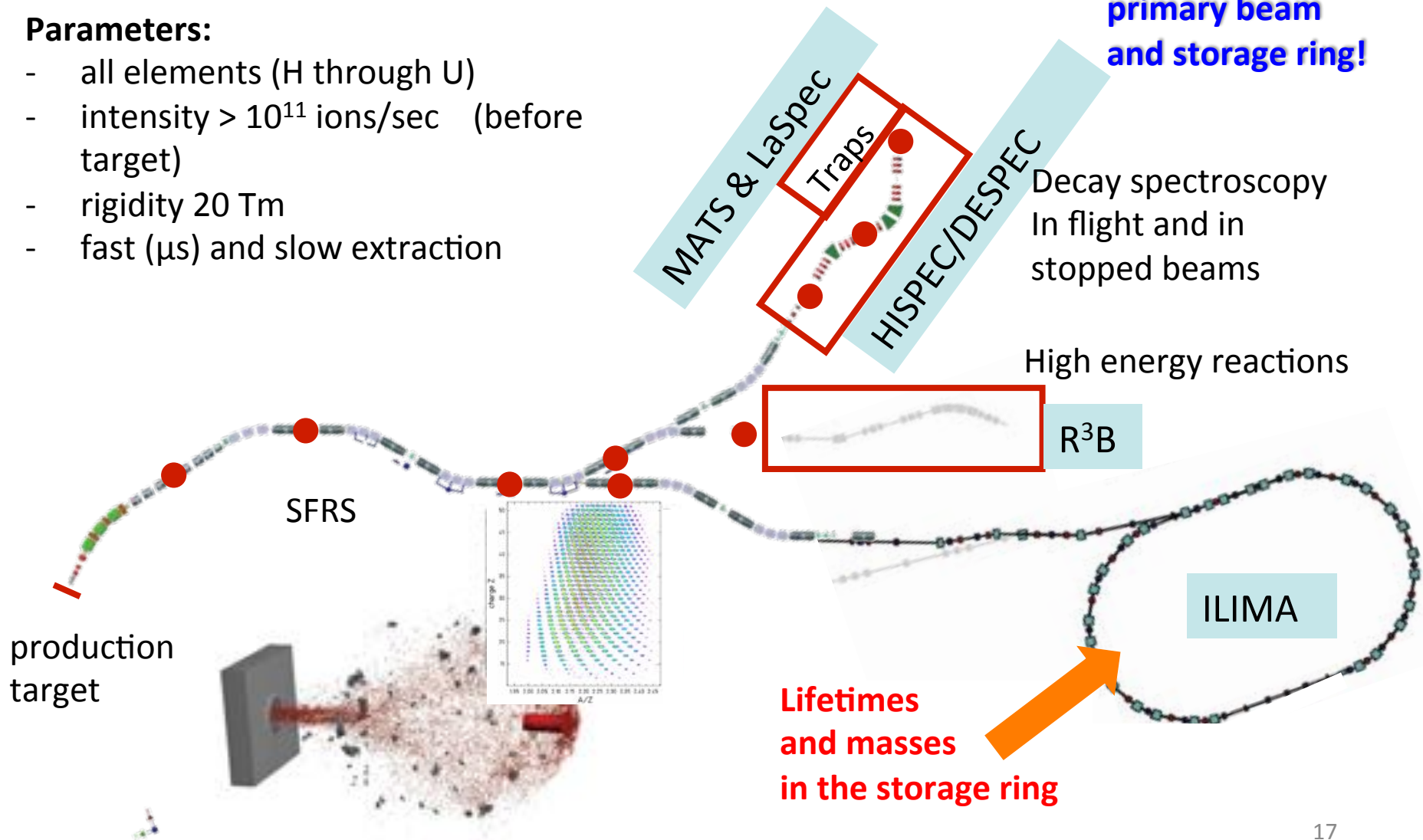


# NUSTAR - FAIR asset – rings and instrumentation

## Parameters:

- all elements (H through U)
- intensity  $> 10^{11}$  ions/sec (before target)
- rigidity 20 Tm
- fast ( $\mu$ s) and slow extraction

high energy of the primary beam and storage ring!



Decay spectroscopy  
In flight and in stopped beams

High energy reactions

Lifetimes and masses in the storage ring

# High Level Schedule of the MSV



From January 2017  
new director  
Paolo Giubellino

# Test Facility for SC magnets of NICA and FAIR: excellent collaboration of JINR and Germany (BMBF).



1<sup>st</sup> cold test of Booster dipole with magnetic measurements in December'14  
 Cold test of serial quadrupole duplet – Feb-March 2015



Serial  
Booster  
Quadrupole  
duplet



Pre-serial  
collider dipole

Serial production of Booster dipoles and quadrupoles started in Oct 2014

		2015				2016				2017				2018			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
<b>Booster</b>																	
dipoles	40+3																
quadrupoles	48+6																
multipole correctors	40+4																
<b>Collider</b>																	
dipoles	80+5																
quadrupoles	86+5																
multipole correctors																	
nonstructural's																	

**60 years of JINR  
 Celebration  
 5 April 2016**





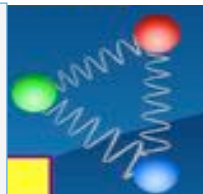
# FACILITIES in HadronPhysics HORIZON



## TRANSNATIONAL ACCESS (6)



JOINT RESEARCH  
ACTIVITIES (12)



NETWORKING  
(10+1)

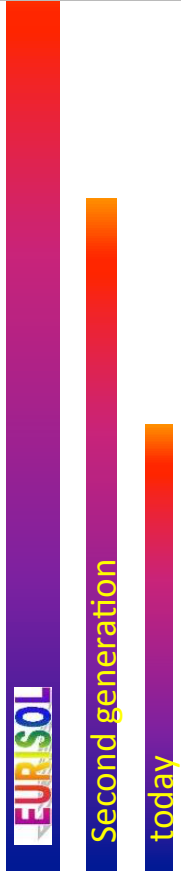
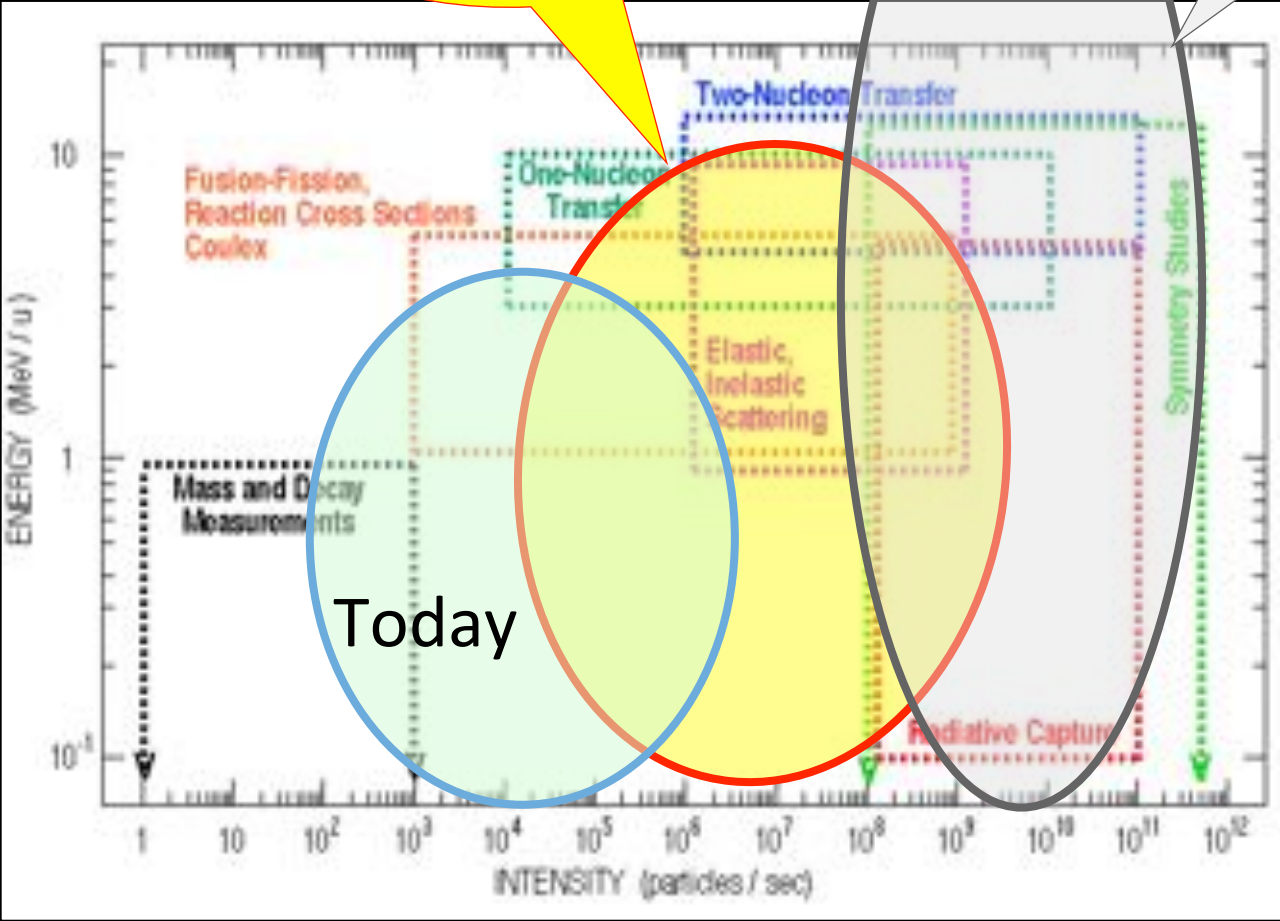


# **ISOL FACILITIES**

Physics with ISOL RIB  
Intensity & Energy domains

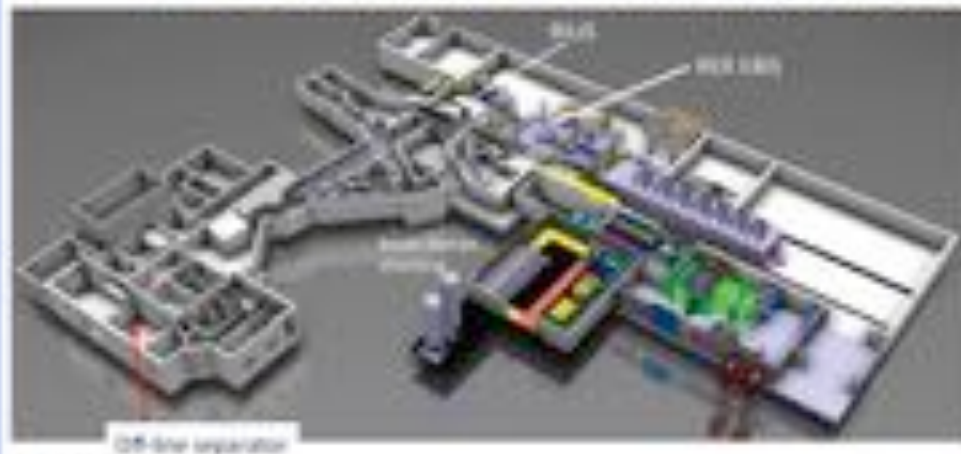
HI-ISOLDE,  
SPES, SPIRAL2,  
ISOL@MYRRHA  
EURISOL-DF

EURISOL

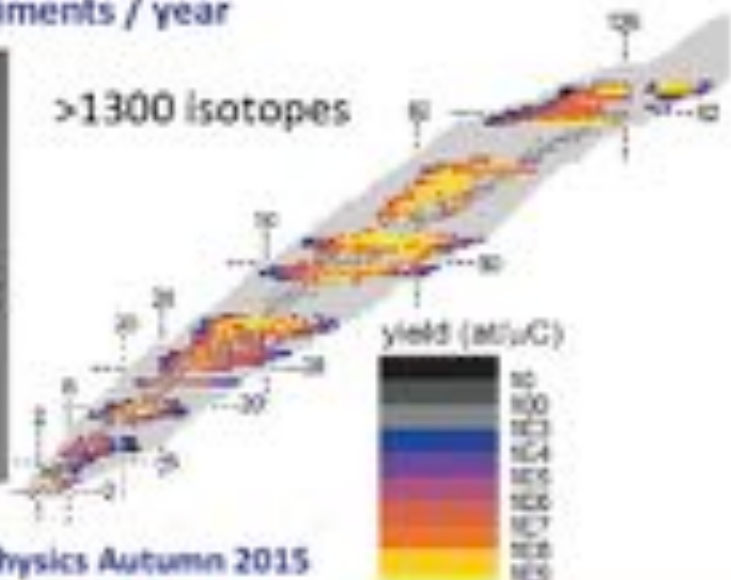


# HIE-ISOLDE Facility

- 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 (8, 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



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

✓ HIE STAGE 2



2017  
10 MeV/A

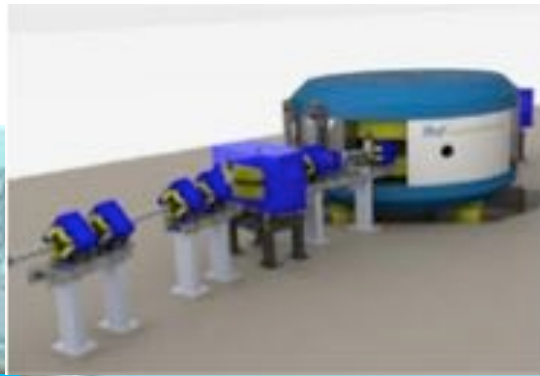
Started Jan 2010  
Budget 35 M€

✓ HIE STAGE 3 WITH CHOPPER LINE 2018 (LS2)





# SPES layout (LNL - INFN)



**Driver** : cyclotron high intensity proton

**ISOL** target Fission Products

**Post acceleration** : ALPI linear accelerator

Upgraded (e.g. lower- $\beta$  part (from 3 to 5,5 MV/m)

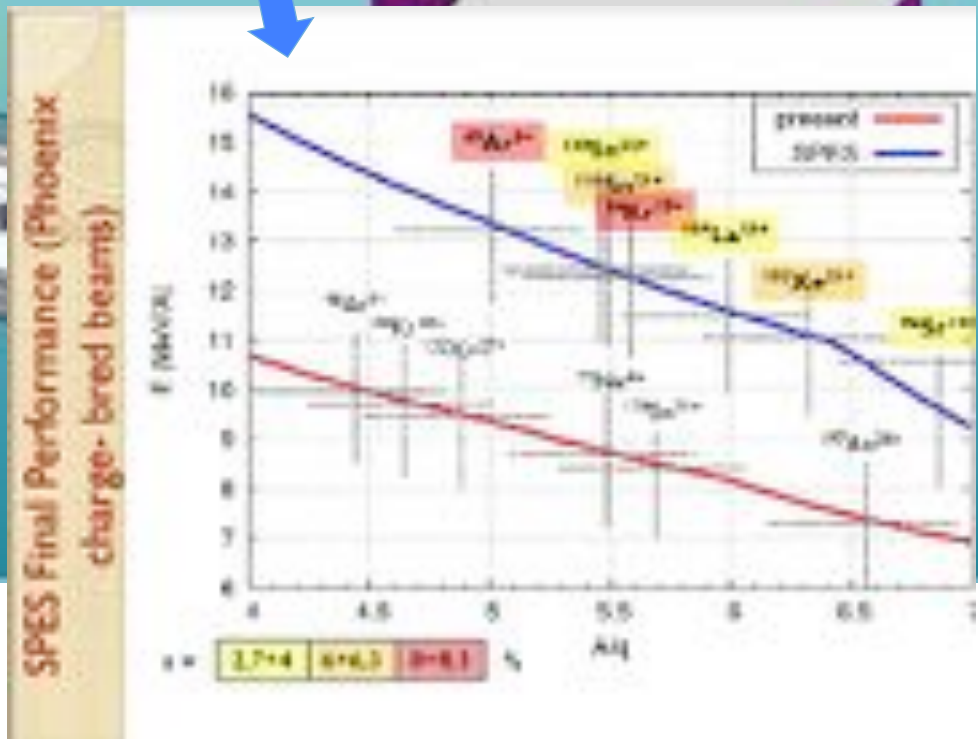
Re-furbishing of accelerating cavities of ALPI

Applied physics

ISOL FACILITY



RIB Beams in 2018-19





**Phase1 (2016-)**

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

**DESIR Phase1+ (2020-)**

Low energy facility



**SPIRAL1 Upgrade (2017-)**

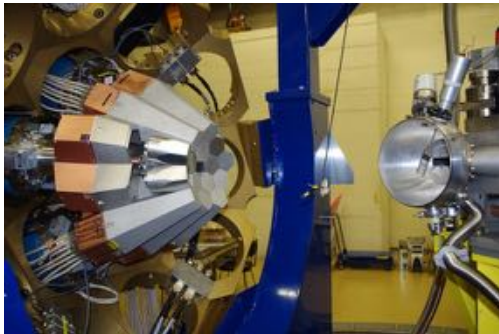
New light RIBs from  
 beam/target fragmentation



# Tracking array for gamma spectroscopy

## High-sensitivity for nuclear structure of exotic nuclei

2010 → 2011  
LNL : 5TC

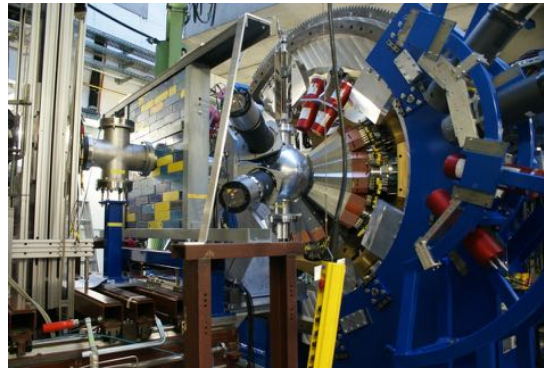


AGATA D.+PRISMA

Total Eff<sub>Nominal</sub> ~2.6%



2012 → GSI/FRS  
6TC+3 DC

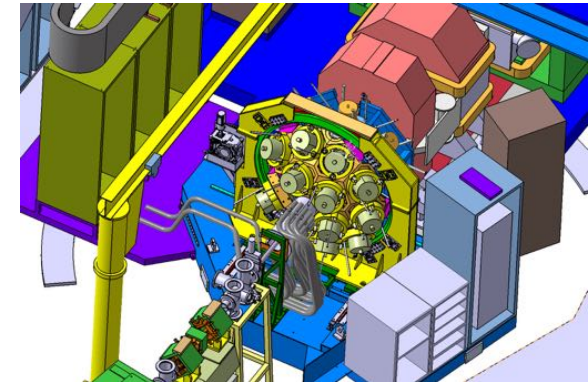


AGATA @ FRS

Total Eff. ( $\beta=0.5$ ) ~ 10%



2014 → GANIL/SPIRAL1  
15TC



AGATA @G1

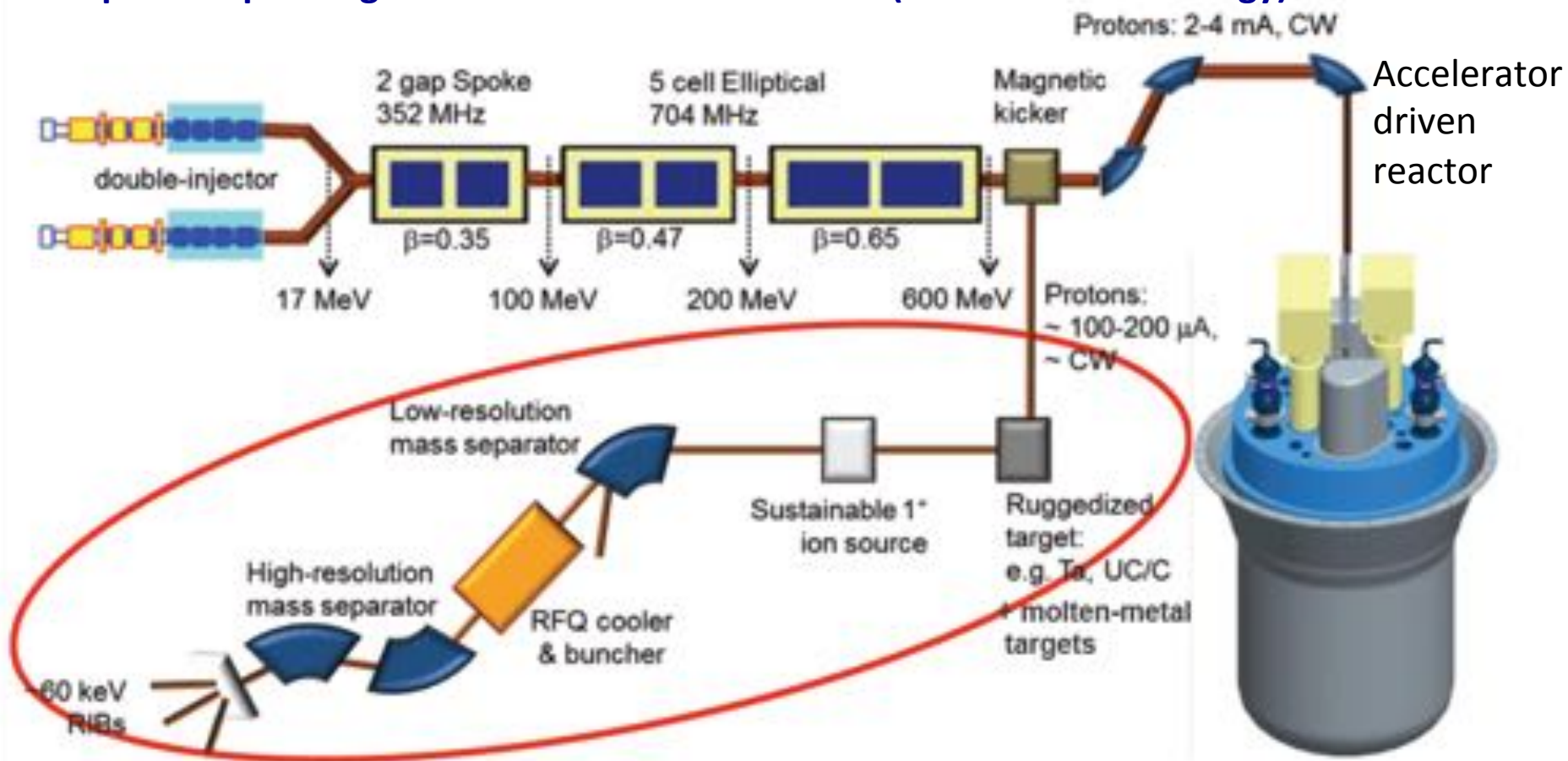
Total Eff ~ 8% to 14%

**The European sister of GRETA progressing in phases!!**



# ISOL@MYRRHA - Concept

Proposal depending on the realization of MYRRHA (in ESFRI list for Energy)

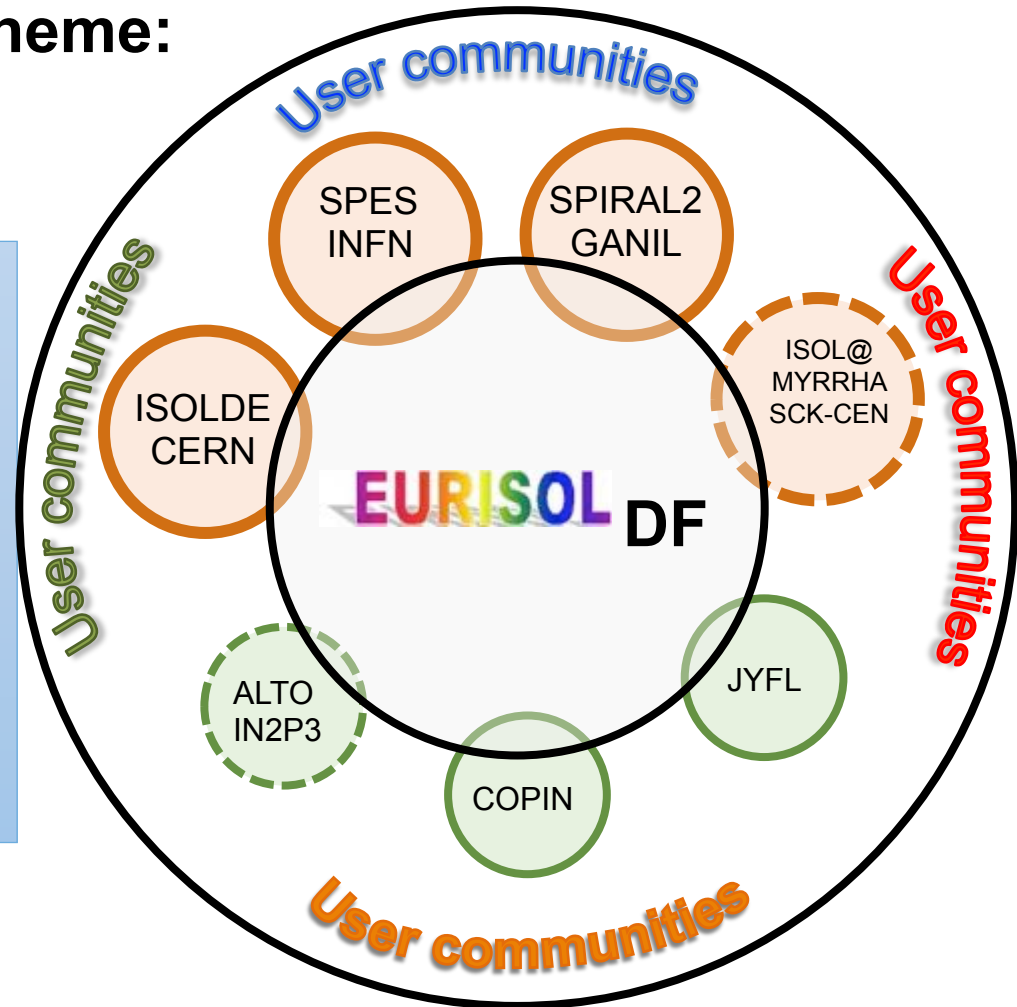


- Driver-beam power on ISOL@MYRRHA target: 60-120 kW
- Low-energy RIBs
- Experimental programme complementary to other ISOL facilities – long-run experiments

# 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,...)**



Main and Satellite facility structure

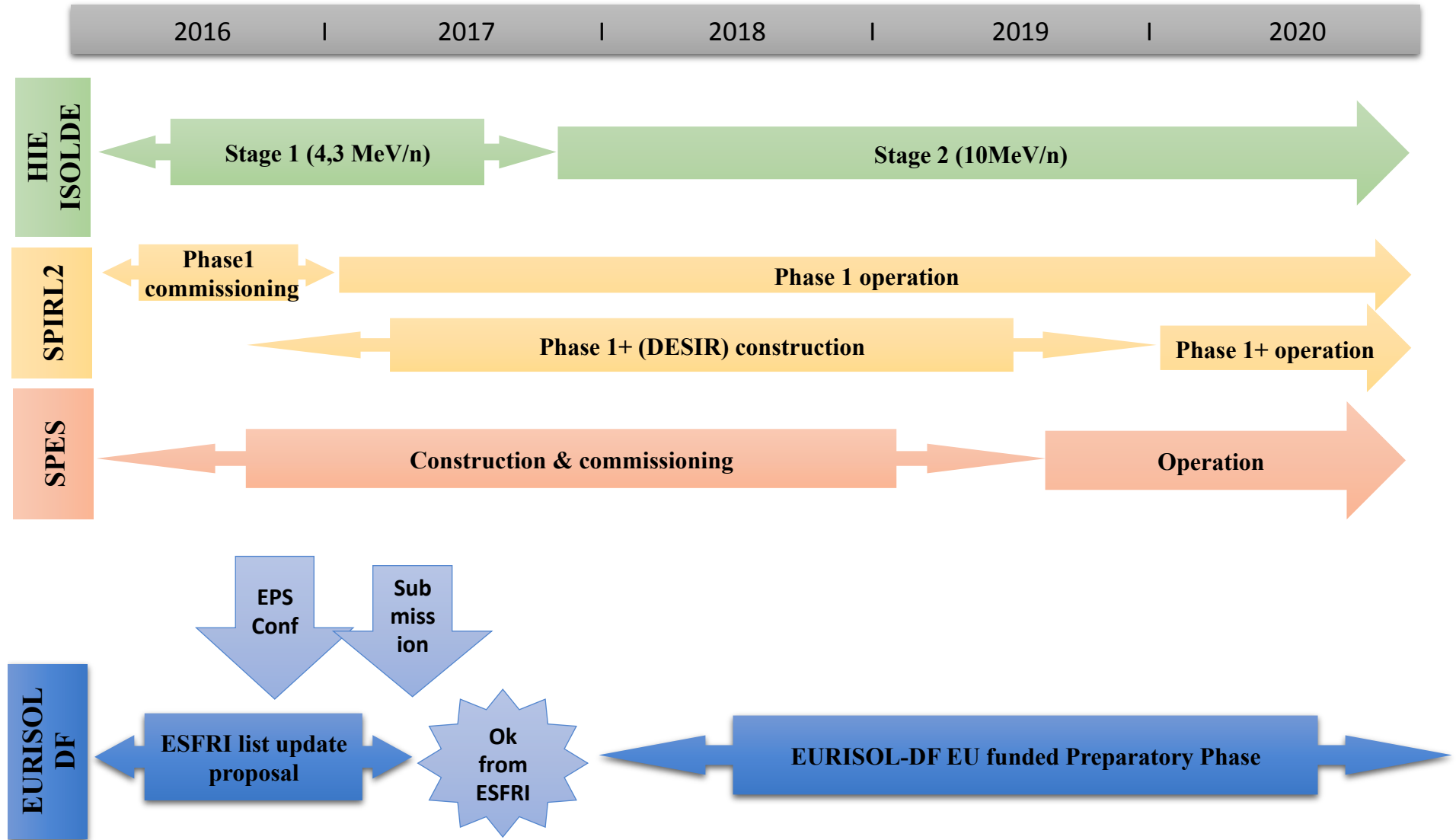
Interaction with EURISOL JRA in ENSAR 2 and EURISOL User group

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

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



# Timeline EURISOL-DF





# PS Conference: Towards EURISOL Distributed Facility

## EURISOL DF 2016

- 18-21 October 2016
- Leuven
- Expecte attendance:  $\geq 200$  participants

Promotiezaal KU Leuven  
(385 places)



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



# Future Facilities- NuPECC LRP 2010

- The inclusion of Nuclear Physics programmes at the multi-purpose facilities ELI and ESS.

**ELI (distributed facility)  
ESFRI ROAD MAP  
see ESFRI Report 2010**

**ELI-NP within the  
Rumanian pillar**



## Large equipments:

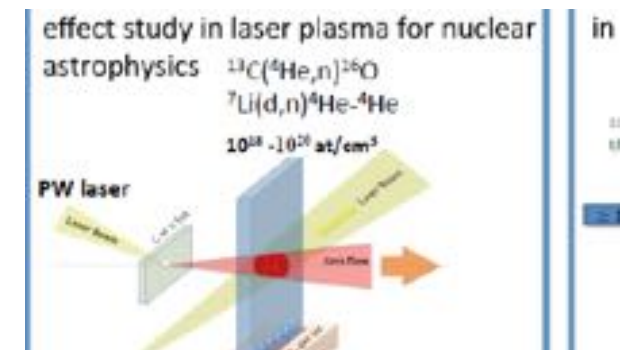
- Ultra-short pulse high power laser system,  $2 \times 10\text{PW}$  maximum power  
0.5% band width  $10^4$  photons/eVs.
- **Gamma beam**, high intensity, tunable energy up to 20MeV, produced by **Compton scattering of a laser beam on a 700 MeV electron beam produced by a warm LINAC**

Buildings: 33000sqm total

## Experiments:

- 8 experimental areas,  
Interaction chambers, Beam transportation
- 8 auxiliary laboratories
- **Nuclear Structure- Nuclear Astrophysics and Applications**

Peak brilliance  
photons/s·mm<sup>2</sup>·mrad<sup>2</sup>·0.1%bwd  $10^{20}-10^{23}$







# ENSAR 2

## Nuclear Structure FACILITIES



TRANSNATIONAL ACCESS (10)- also outside EU

JOINT RESEARCH ACTIVITIES (7)

NETWORKING (12)



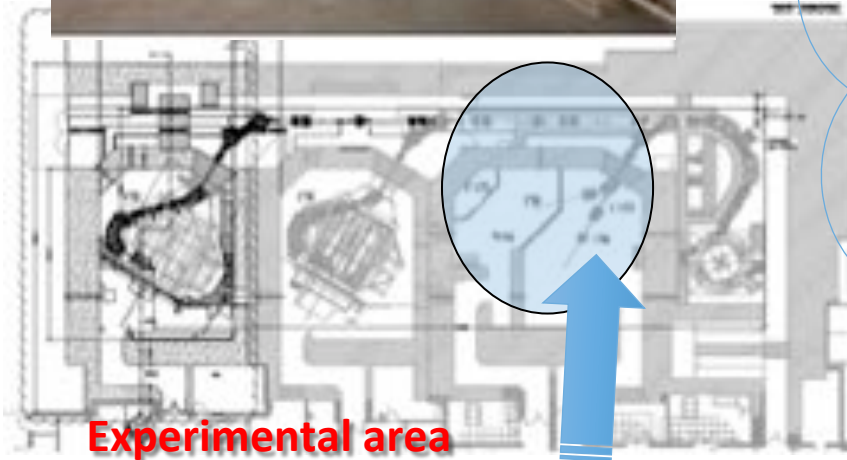
➤ SLCJ-HIL / IFJ PAN (Poland)

➤ ELI-NP / IFIN-HH (Romania)

➤ ECT\* (Italy)



# The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences



Experimental area

Although the primary objective of the facility is proton cancer therapy, extensive research program at this cyclotron is planned **in the field of nuclear physics, radiobiology, dosimetry and medical physics.**

**Exp on Giant Resonances  
Few body (nucleon) interaction**

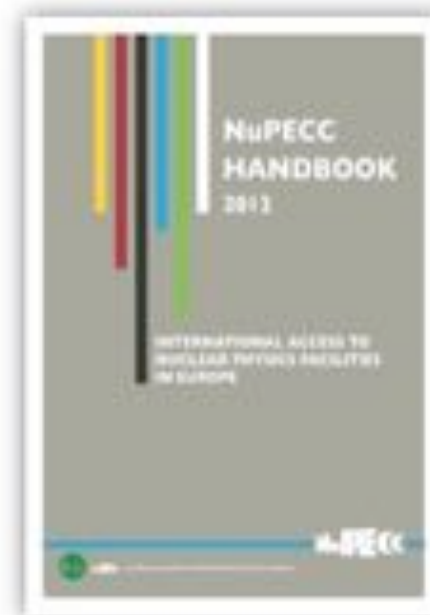
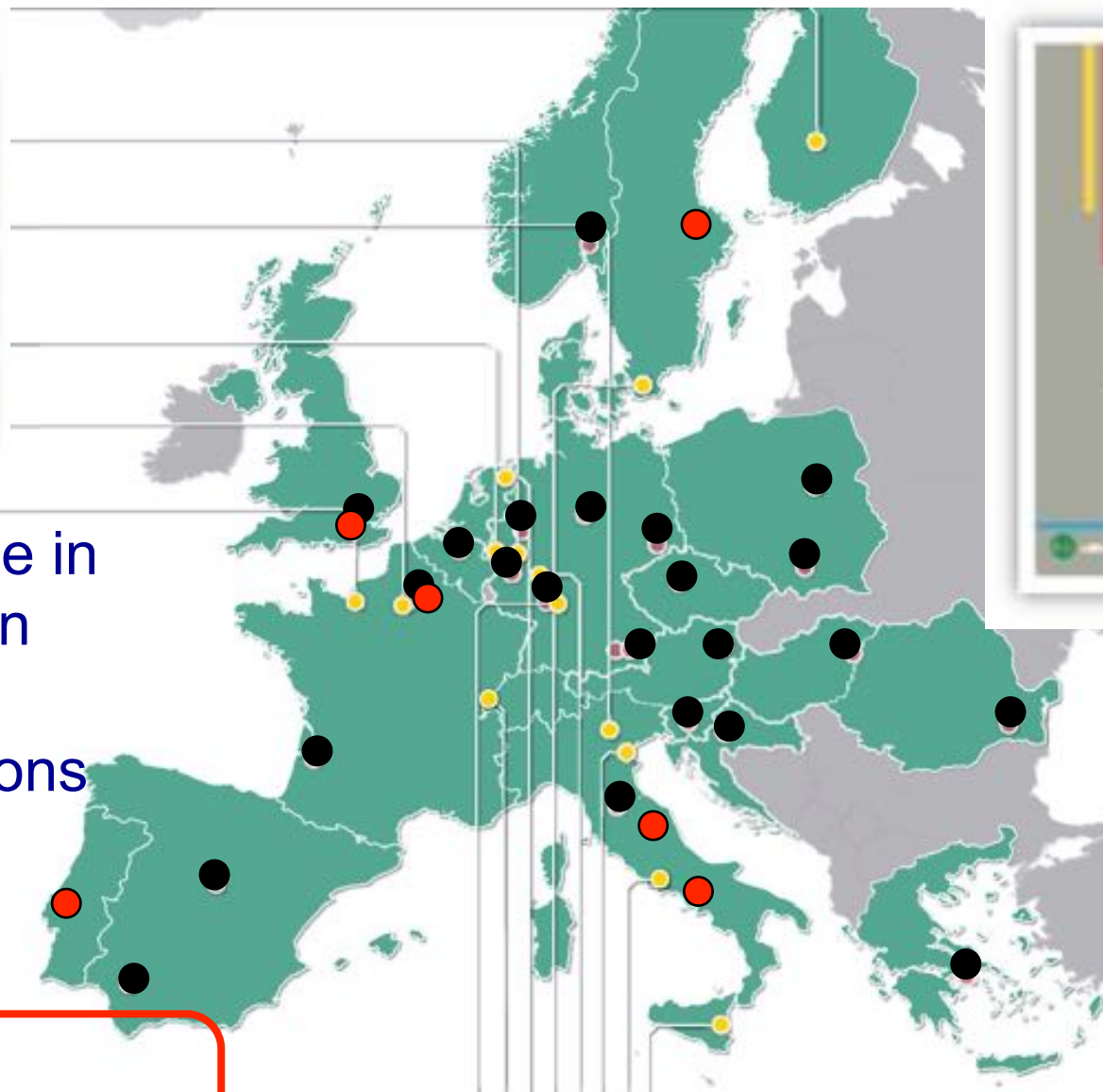
## Cyclotron PROTEUS C-235 (IBA Company)

beam: protons 70 – 230 MeV  
beam current: 0.1 nA ( $6.6 \times 10^8$  p/s) - 500 nA ( $3.3 \times 10^{12}$  p/s)

# Small scale facilities



# European Small-scale Accelerator Facilities



Specific role in

- Education
- R&D
- Applications



30 small scale facilities



# LUNA AT LNGS-NEW ACCELERATOR

LUNA site

LUNA MV  
(approved)

$U_{\text{terminal}} = 350 - 3500\text{kV}$

$I_{\text{max}} = 500\mu\text{A}$  (on target)

$\Delta E = 0.7\text{keV}$

Allowed beams:  $\text{H}^+$ ,  $^4\text{He}$ ,  $^{12}\text{C}$

LUNA 1  
(1992-2001)  
50 kV

LUNA 2  
(2000 - ...)

$U_{\text{terminal}} = 50 - 400\text{kV}$

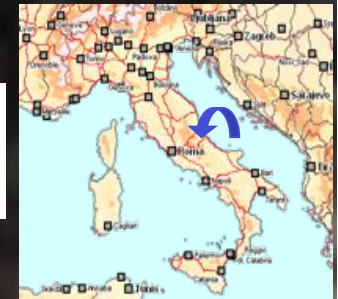
$I_{\text{max}} = 500\mu\text{A}$  (on target)

$\Delta E = 0.07\text{keV}$

Allowed beams:  $\text{H}^+$ ,  $^4\text{He}$ , ( $^3\text{He}$ )

Nuclear reactions at stellar energies  
for nucleosynthesis-  
star evolution, energy production

At the position of ICARUS  
Start with beams of the new accelerator in 2018



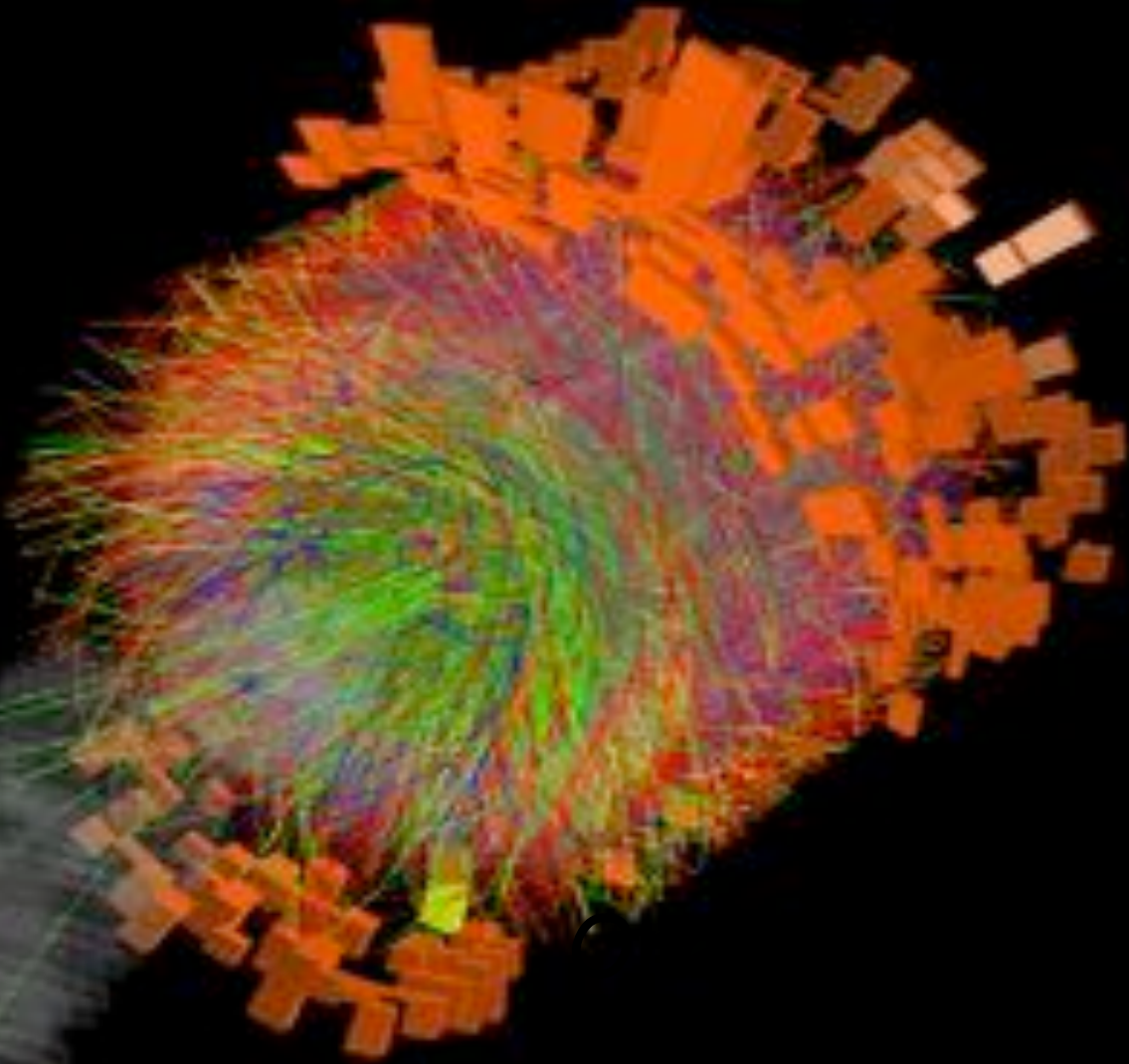
# ALICE at CERN

- Upgrade the nuclear beams and the detector to expand physics reach



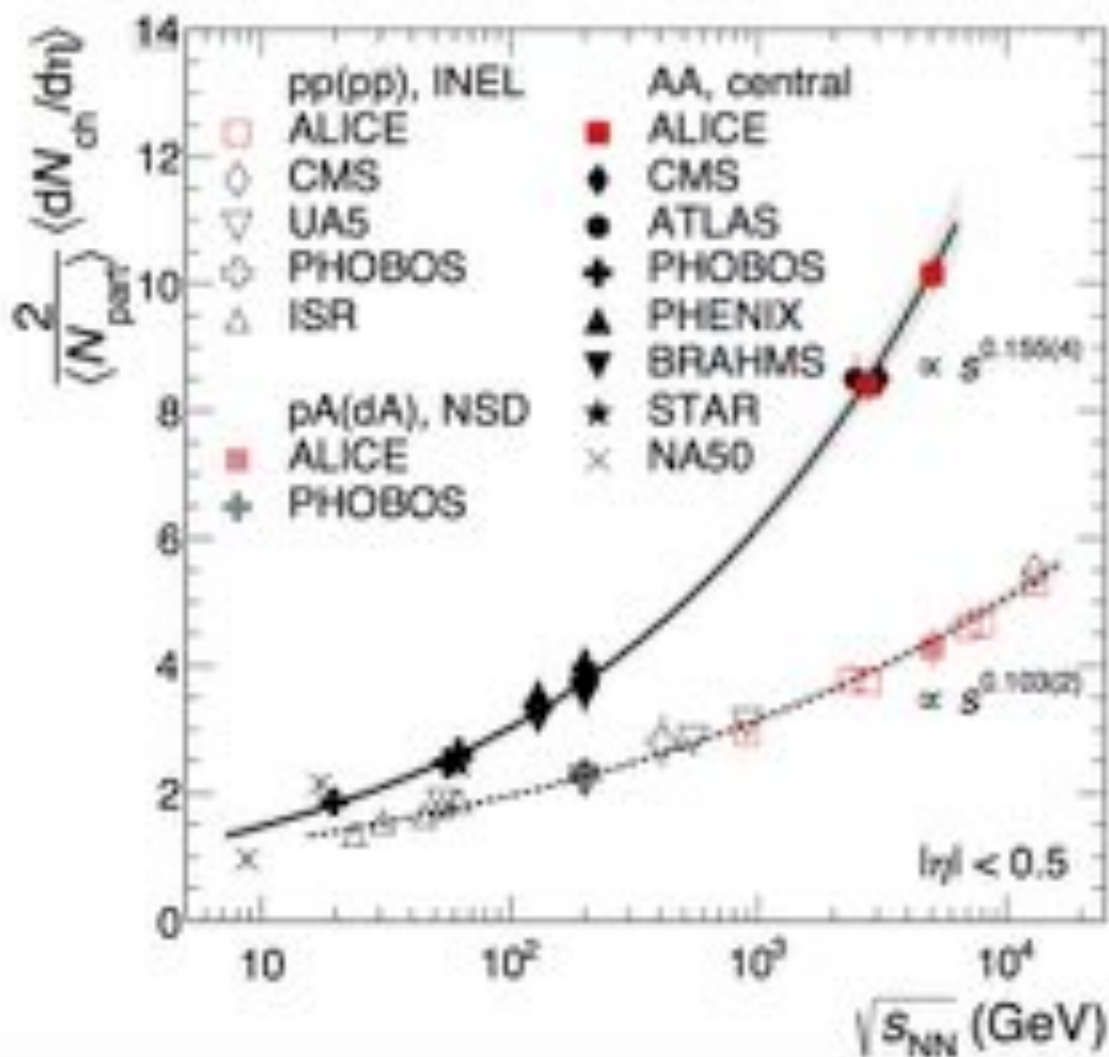
ALICE

1 PeV  
Collisions  
Pb+Pb



Run: 244818  
Timestamp: 15/01/16 16:36:47  
System: PbPb  
Energy: 5.02 TeV

First result from Pb+Pb at  $\sqrt{s_{NN}}=5.02\text{TeV}$



ALICE: arXiv:1512.06104

Data taking started on 25/11/2015.

Submitted to PRL on 18/12/2015

arXiv:1512.06104

$dN/d\eta=1953$  at  $\eta=0$

$\epsilon > 20 \text{ GeV}/\text{fm}^3$

>25.000 charged particles in most central collisions.

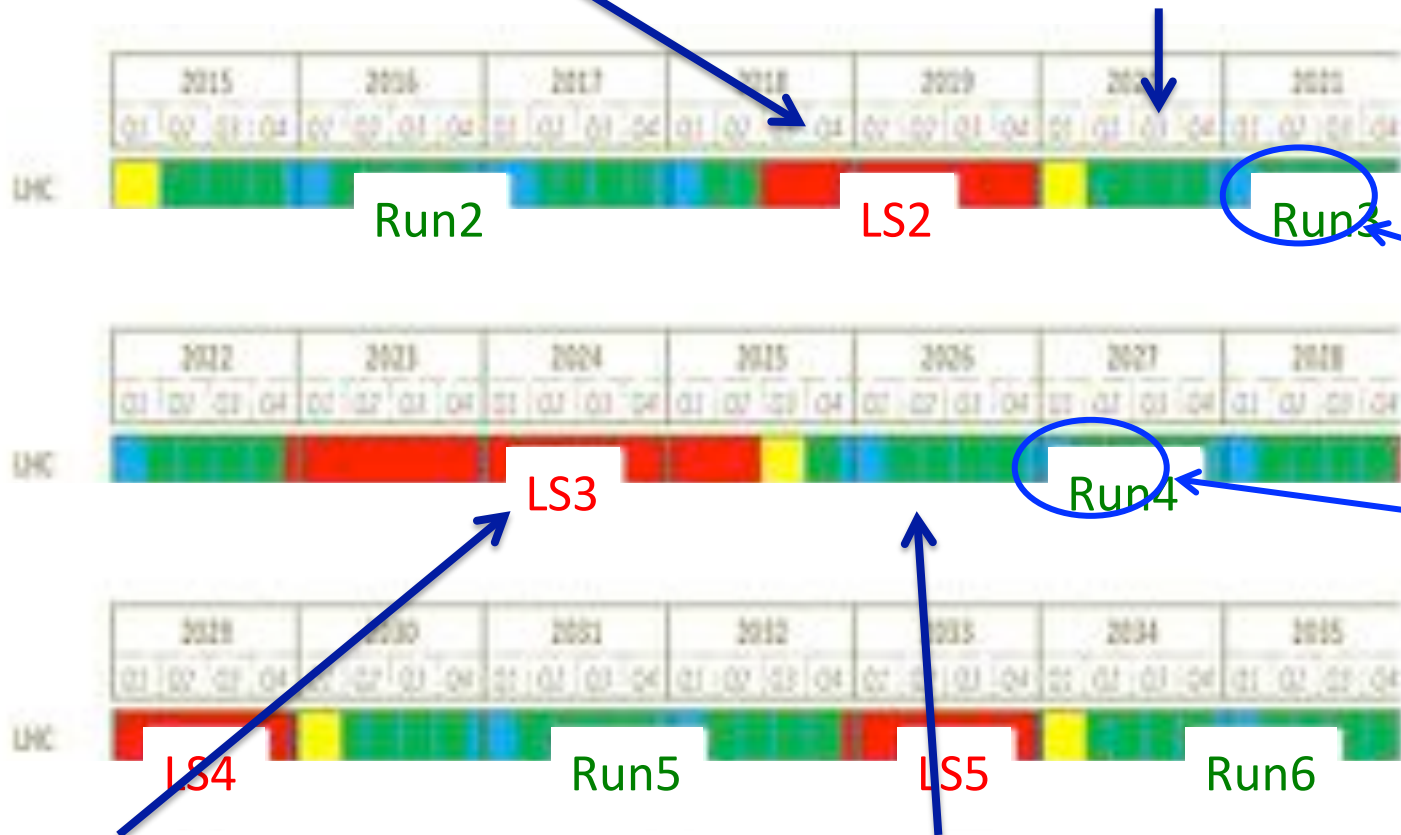


# Long Term Schedule: ALICE will run *at least* until LS4



**PHASE I Upgrade**  
**ALICE, LHCb major upgrade**  
 ATLAS, CMS ,“minor“ upgrade

Heavy Ion Luminosity from  
 $10^{27}$  to  $7 \times 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$



**Upgraded ALICE will run at least to 2029**

**PHASE II Upgrade**  
 ATLAS, CMS major upgrade

**HL-LHC, pp luminosity**  
 from  $10^{34}$  (peak) to  $5 \times 10^{34}$  (levelled)

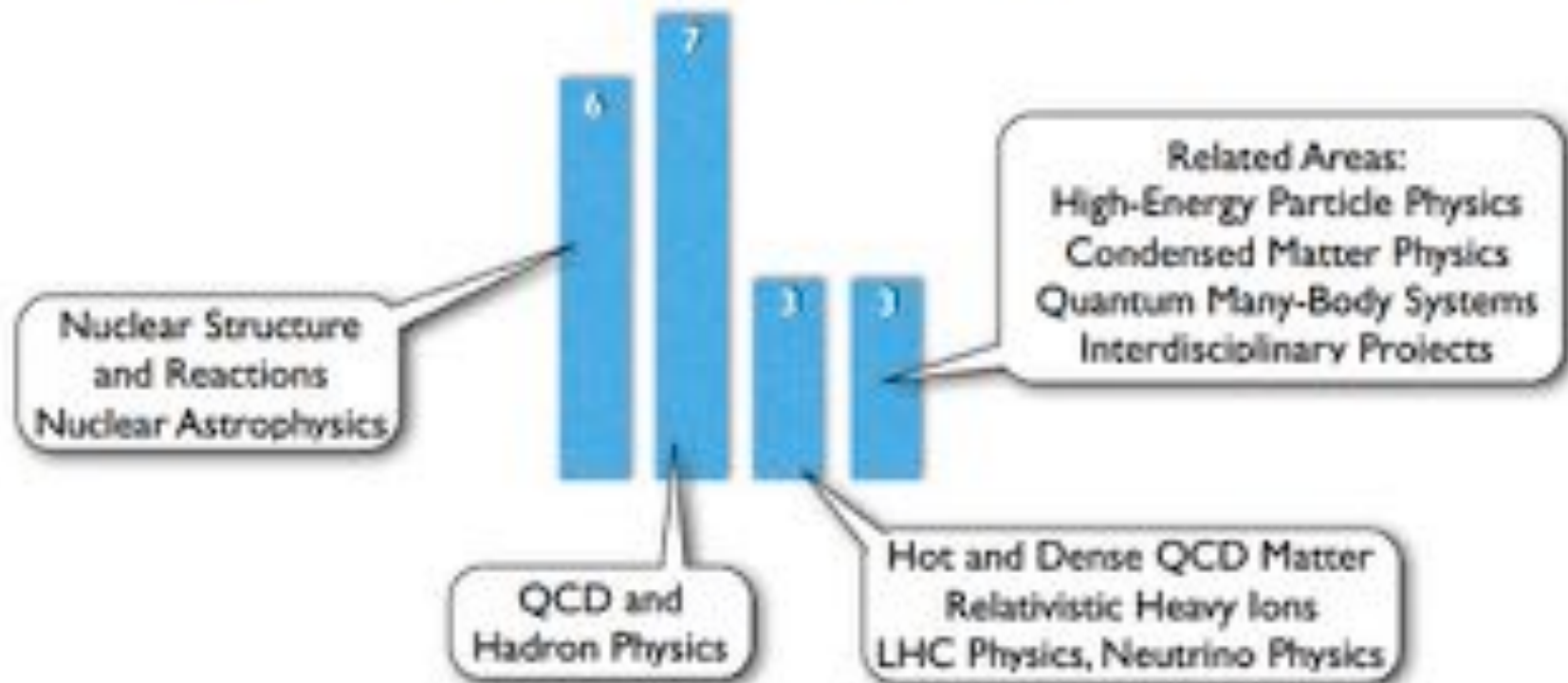




## ECT\* Scientific events 2016



- 18 accepted Workshops (out of 24 proposals)



105 USA/ 733 total

- ECT\* Doctoral Training Program:  
"Nuclear, Neutrino and Relativistic Astrophysics"  
student application process ongoing

# Conclusion

**Nuclear Physics is in general a very vital field**

The new facilities under constructions for nuclear physics will engage the community for several years-

Delays in the construction !!!

The community needs to push for the realization of the scientific objectives with no further delays and to update and reformulate them when needed

**NuPECC has launched the LRP**

This will play a role for Nuclear science in giving it the deserved visibility towards the funding agencies and towards other communities in the international landscape



**Town meeting for LRP of  
NuPECC  
at GSI  
11-13 January 2017**