NuPECC– presentation

Angela Bracco –NuPECC chair
(Università di Milano and INFN)

WG9- Adelaide 11 September 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

Joint Institute for Nuclear Research Dubna- Recently joined

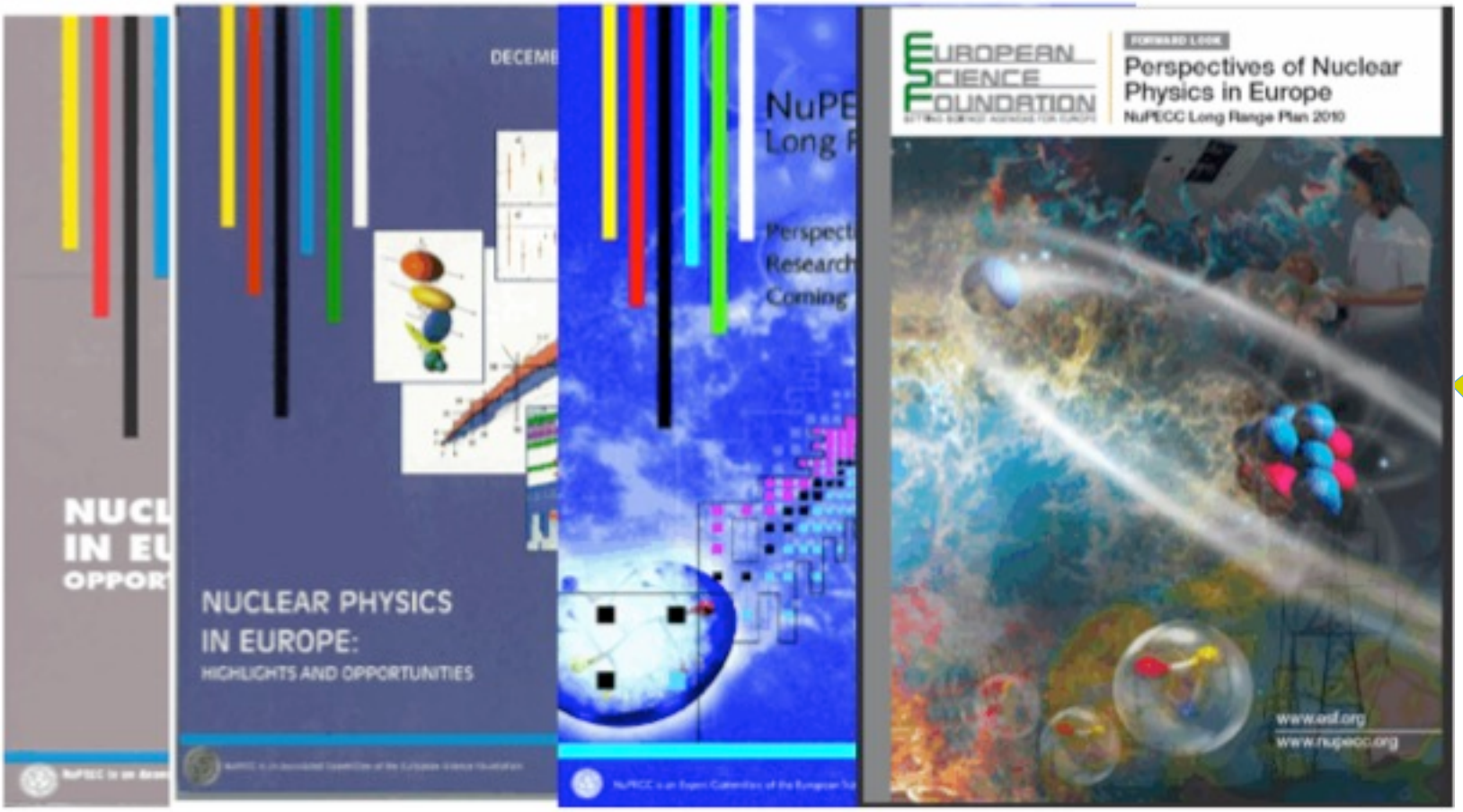
exchanges with

- AnPHA
- NSAC
- NSERC-Canada

+ ALAFNA

21 countries – 31 Members

Perspectives of Nuclear Physics in Europe



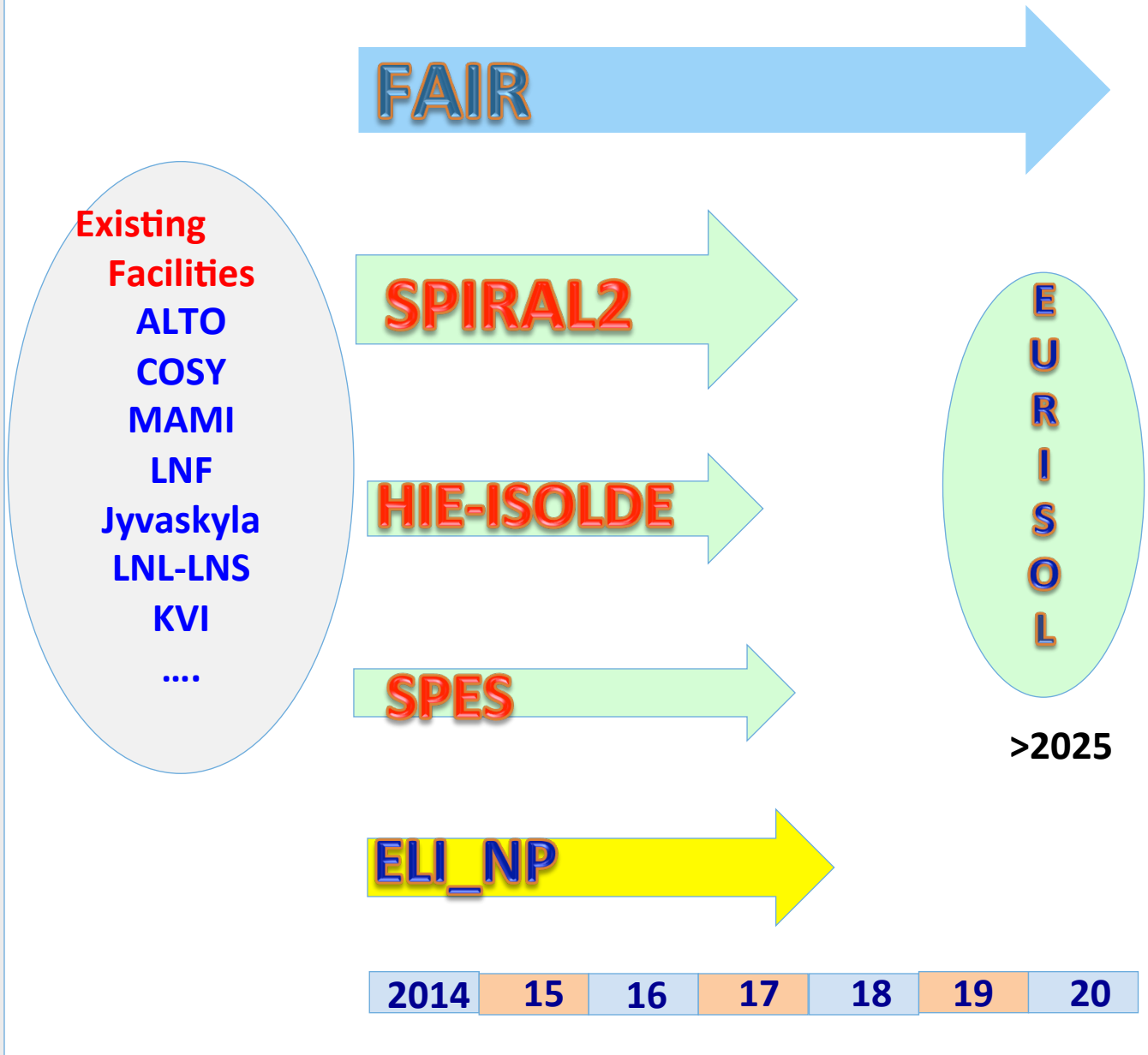
Volume
Brochure
video

1991 1997 2004 2010

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



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 interest on infrastructures under construction

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

LRP - Objectives

- **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**

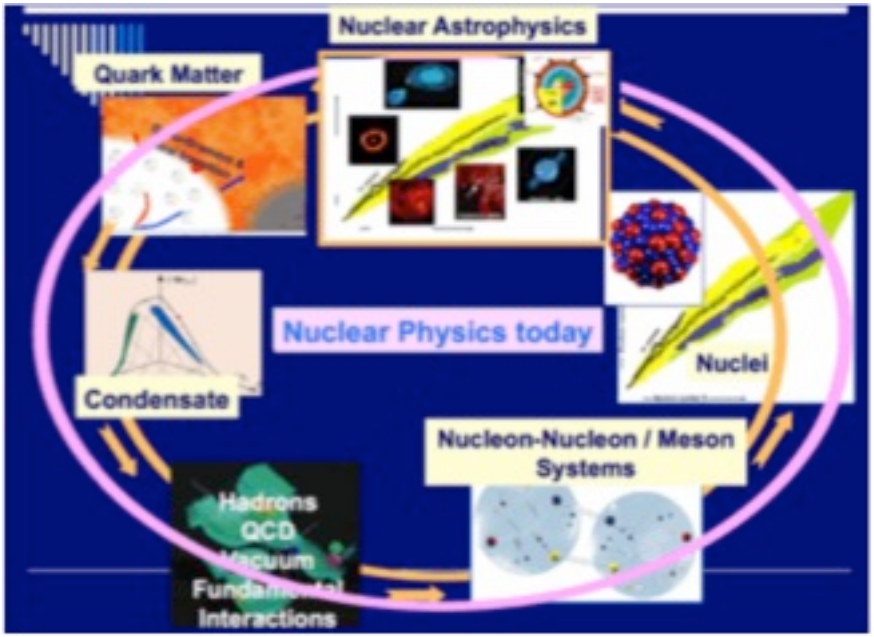
–NSAC (DoE & NSF) in USA, ANPhA in Asia, ALAFNA in Latin America

–IUPAP and OECD Global Science Forum -

LRP 2016 - structure

- **One part of the volume on science and Facilities**
- **Summary and recommendations**

- **6 more detailed chapters** on the achievments 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 worshops 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 16th/17th 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

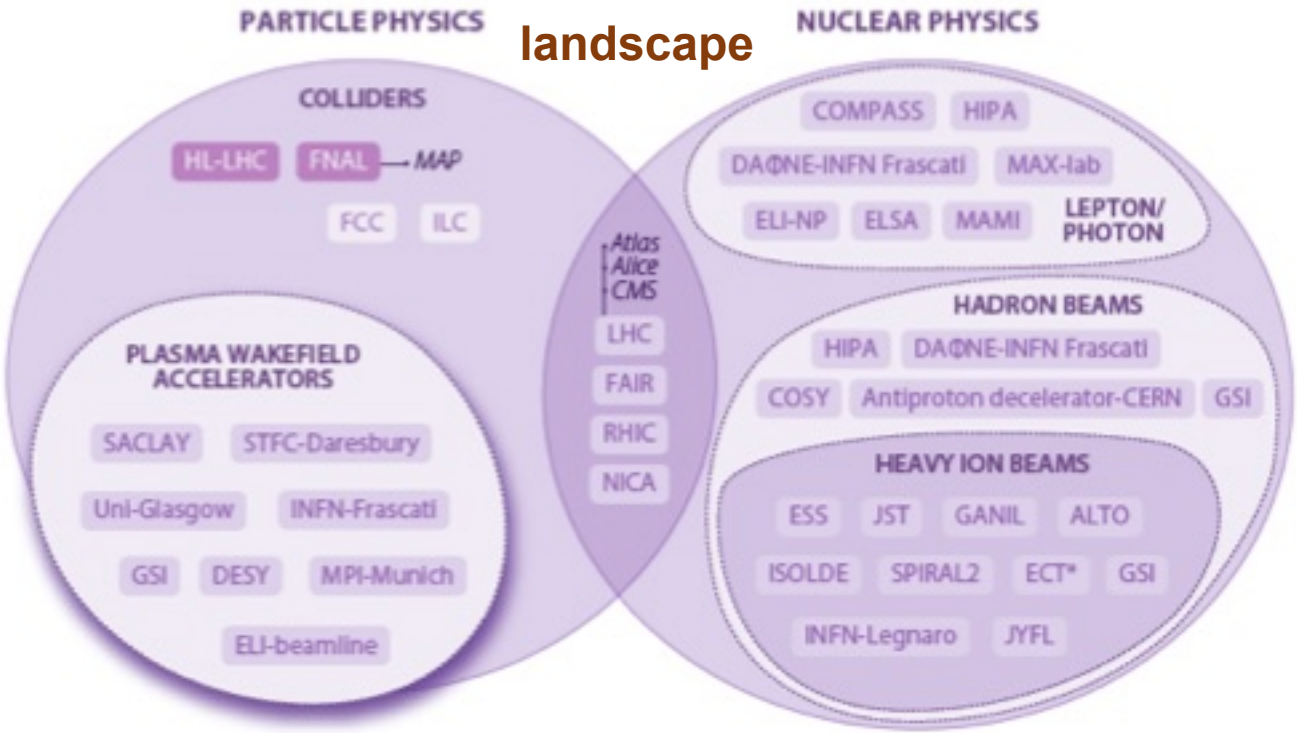
http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

Landmark Facilities

– FAIR -→ synergies with NICA at JINR

– SPIRAL2

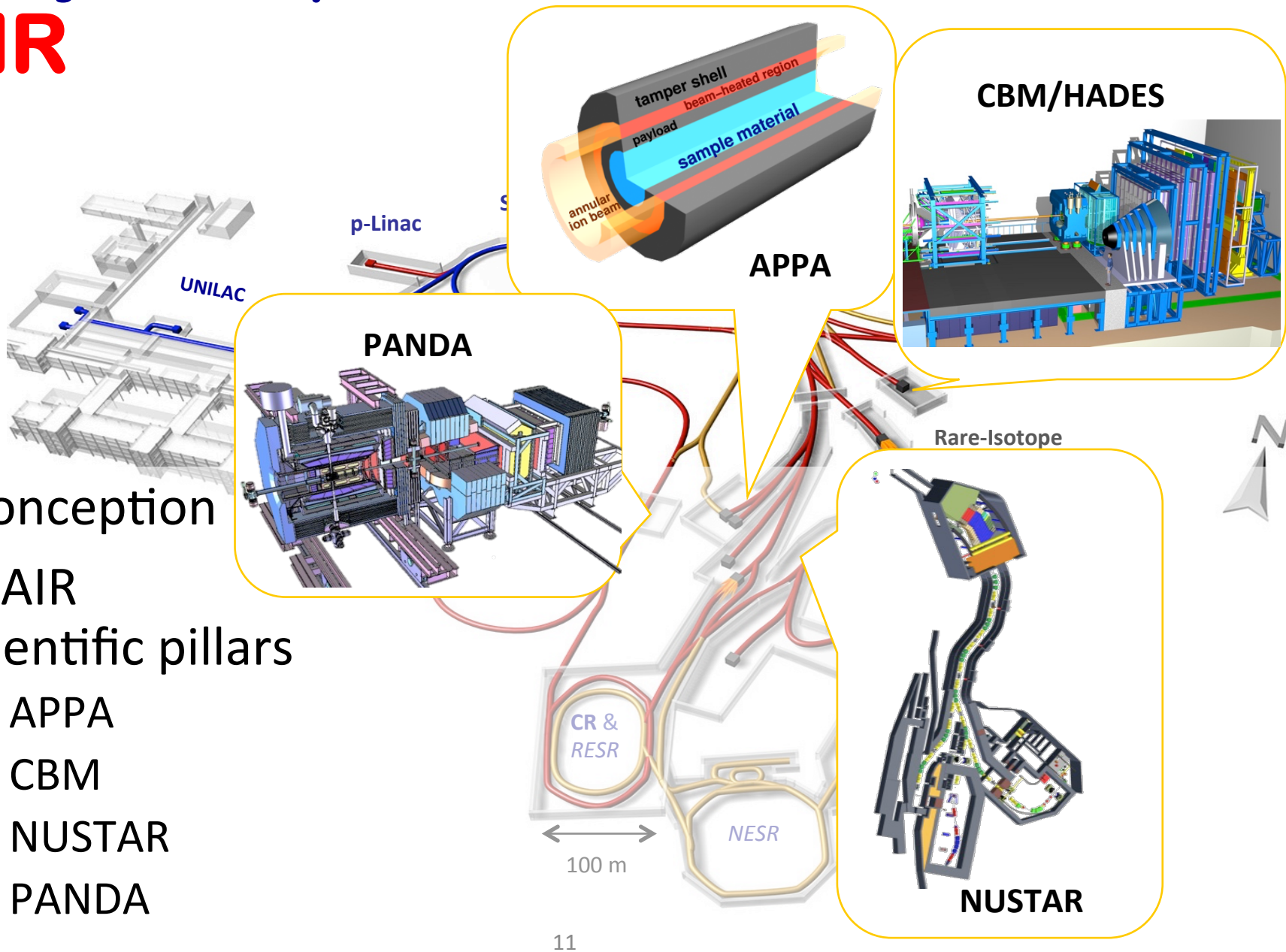
– ELI_NP



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

Facility for Antiproton and Ion Research

FAIR



- Conception

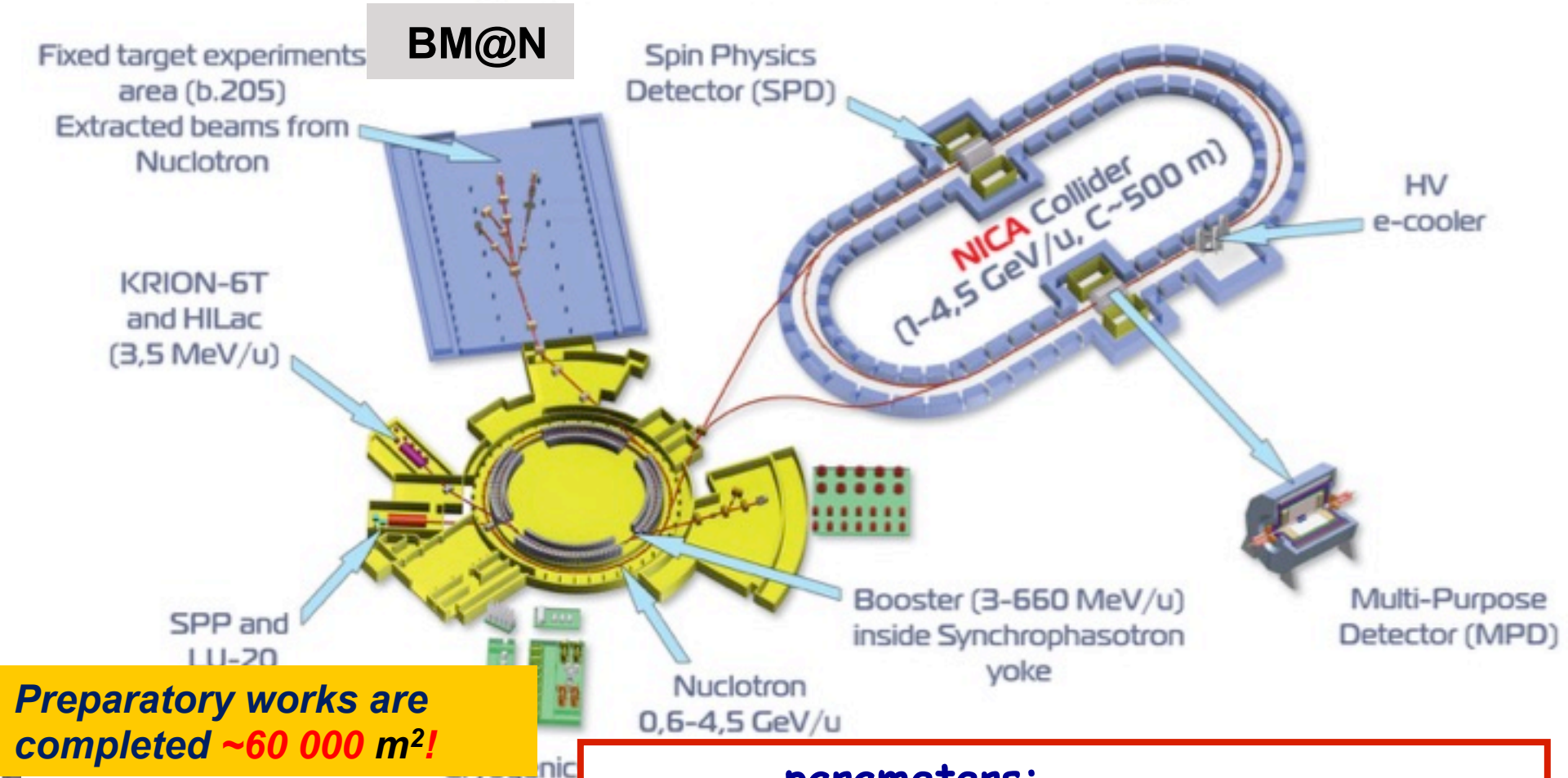
of FAIR

4 scientific pillars

- APPA
- CBM
- NUSTAR
- PANDA

Superconducting accelerator complex NICA

(Nuclotron based Ion Collider fAcility)



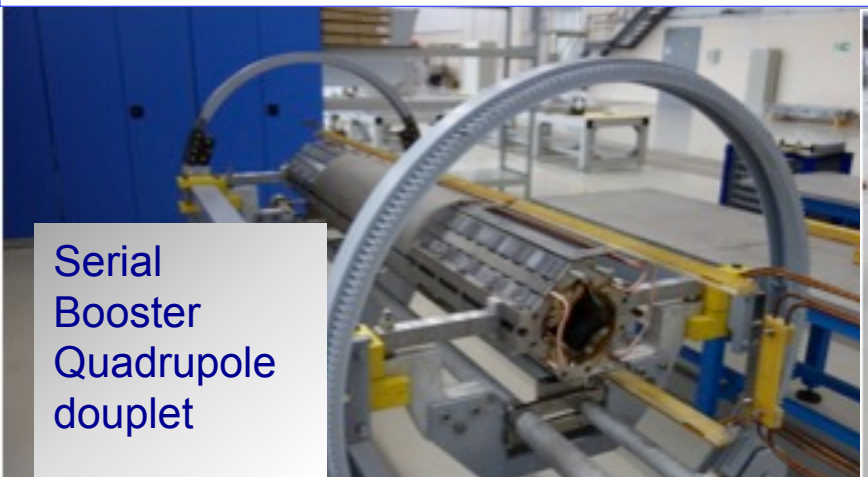
Preparatory works are completed ~60 000 m²!

parameters:

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

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

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



Serial Booster Quadrupole douplet

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	I
Booster																		
dipoles	40+3																	
quadrupoles	48+6																	
multipole correctors	40+4																	
Collider																		
dipoles	80+5																	
quadrupoles	86+5																	
multipole correctors																		
nonstructurals																		

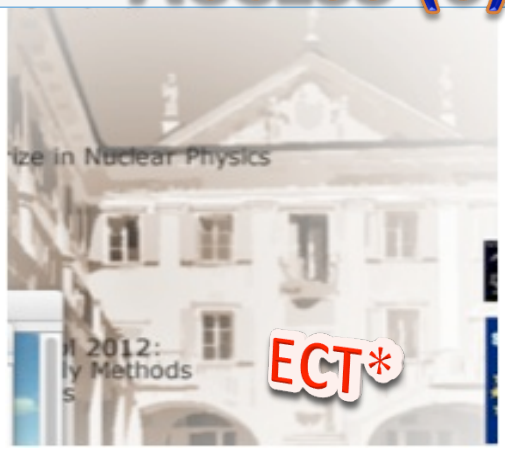
60 years of JINR Celebration 5 April 2016

Integrated activity

FACILITIES in

HadronPhysics HORIZON

TRANSNATIONAL ACCESS (6)

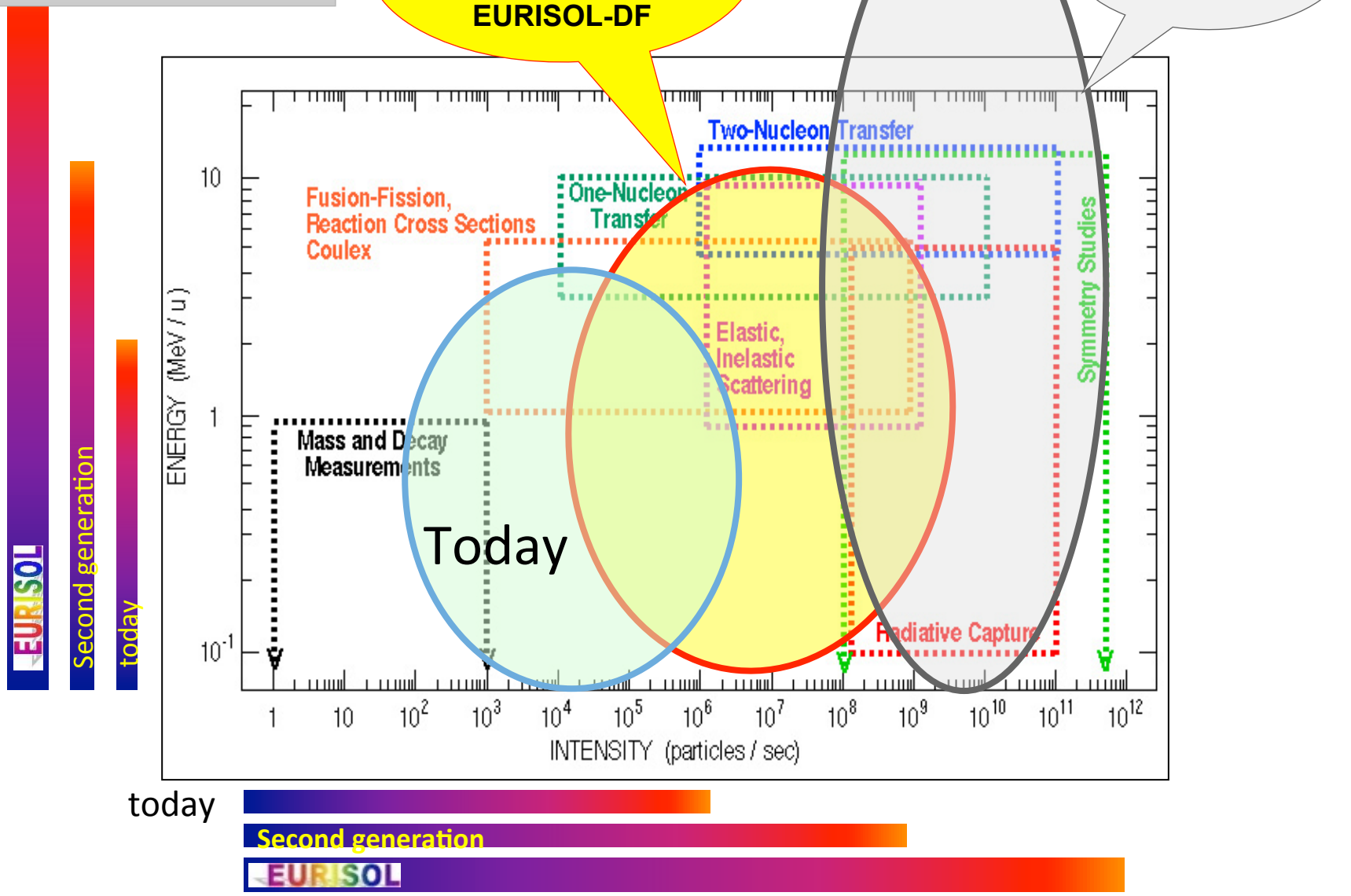


JOINT RESEACH ACTIVITIES (12)

NETWORKING (10+1)

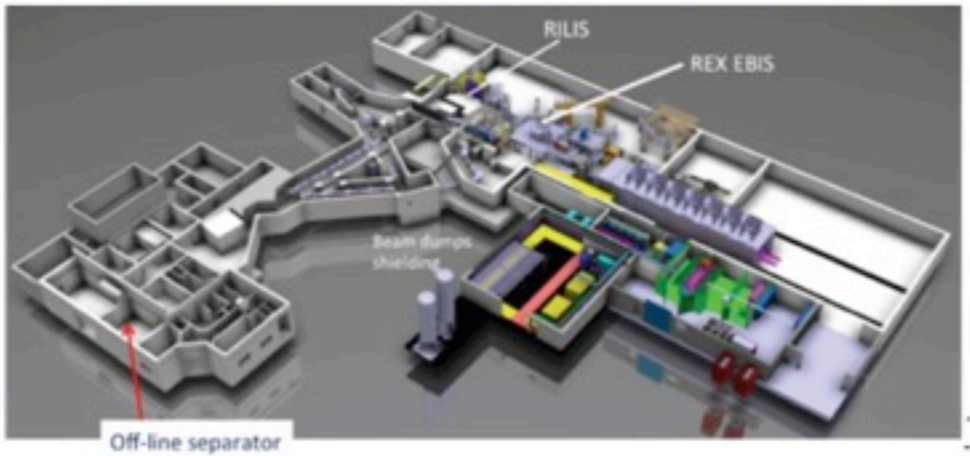
ISOL FACILITIES

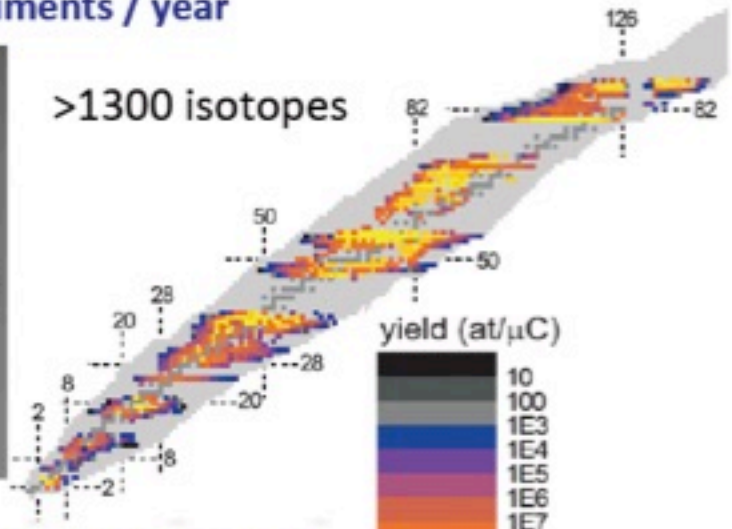
Physics with ISOL RIB Intensity & Energy domains



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** (B, CERN, Dk, E, F, Ge, Gr, I, India, N, R, S, UK)
- **> 500 Users from 100 Institutions, 50 experiments / year**





110Sn beam Sept. 2016

✓ HIE STAGE 1

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

✓ HIE STAGE 2

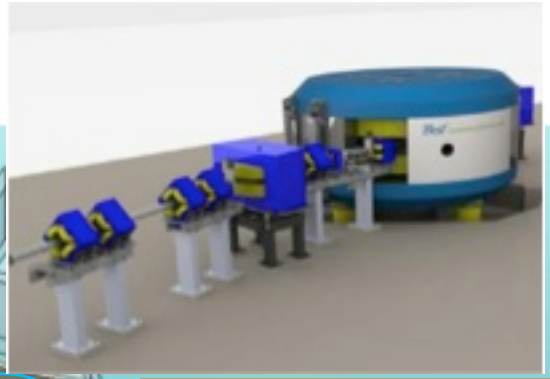
RFQ | IHS | 7G1,2,3 | 9GP | HB-1 | HB-2 | HB-3 | HB-4 — 2017, 10 MeV/A

Started Jan 2010
Budget 35 M€

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

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

SPES layout (LNL –INFN)



Driver : cyclotron high intensity proton

ISOL target Fission Products

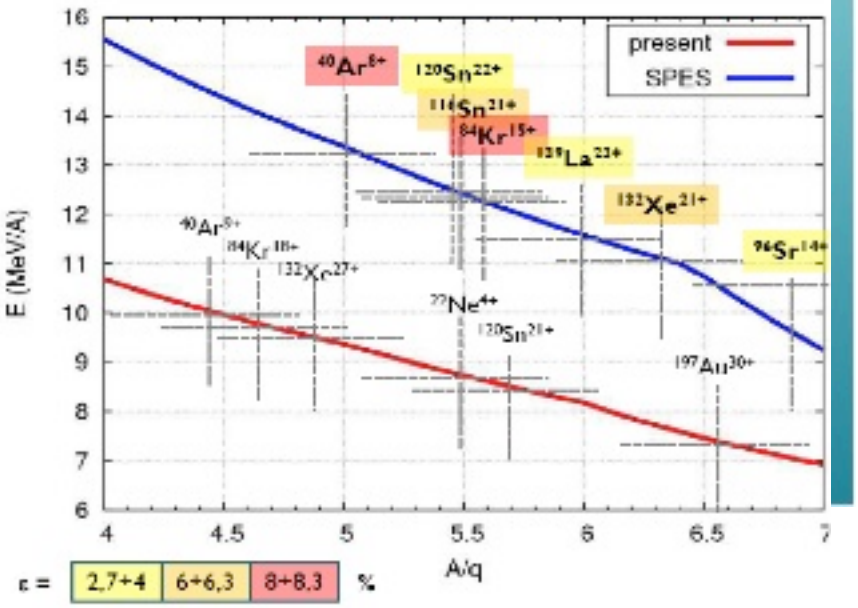
Post acceleration : ALPI linear accelerator
Upgraded (e.g. lower-β part (from 3 to 5,5 MV/m)

Applied physics

ISOL FACILITY

RIB Beams in 2019-20

SPES Final Performance (Phoenix charge- bred beams)



GANIL-SPIRAL2

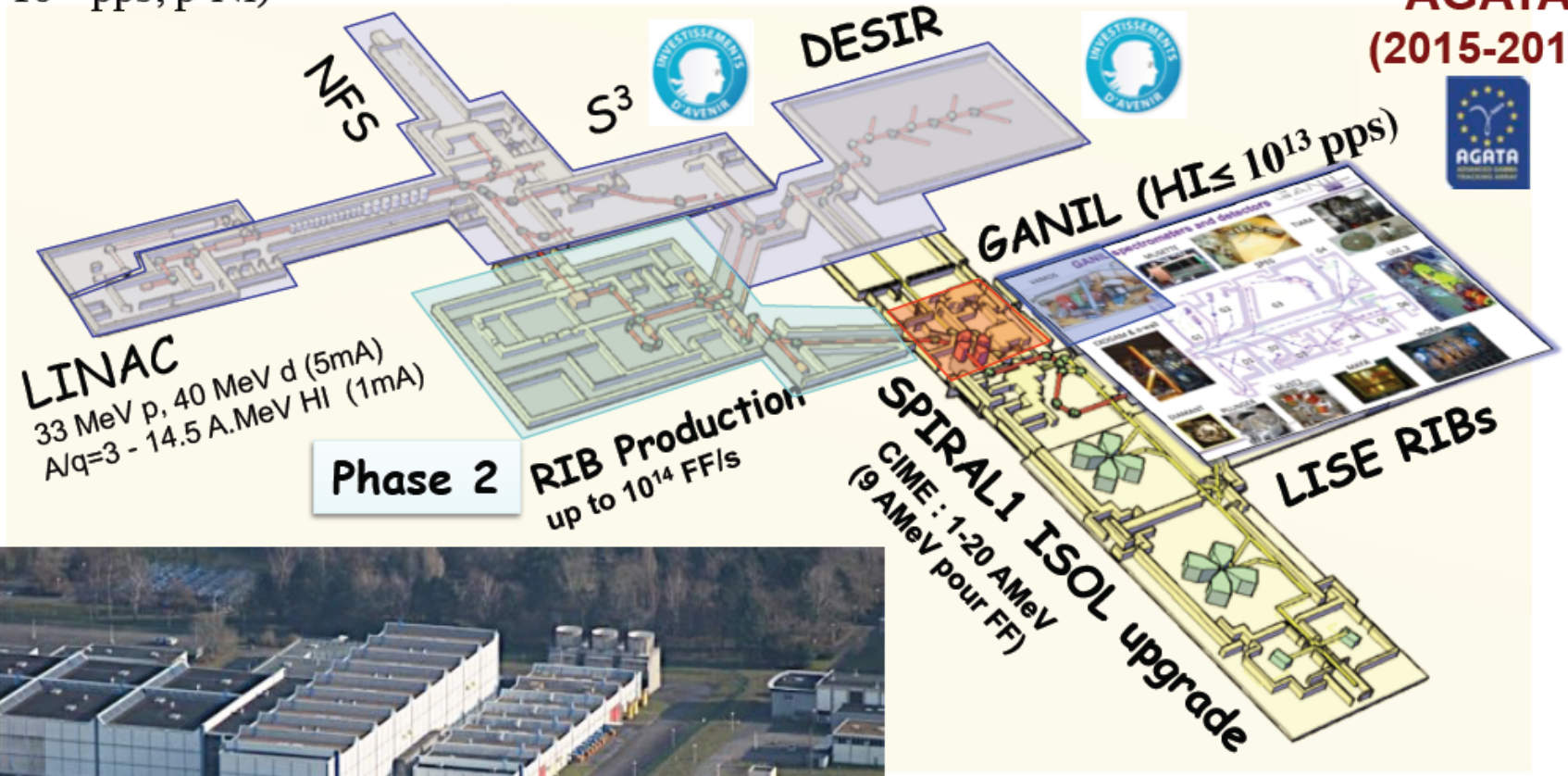
Phase1 (2016-)

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)



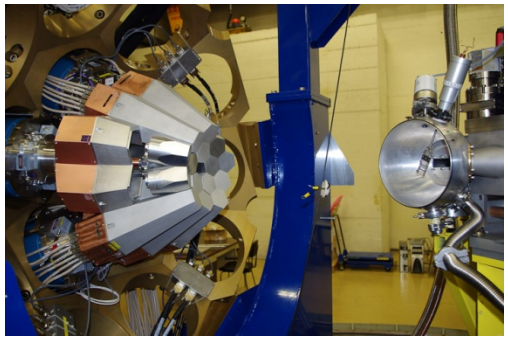
SPIRAL1 Upgrade (2017-)

New light RIBs from
beam/target fragmentation

Tracking array for gamma spectroscopy

High-sensitivity for nuclear structure of exotic nuclei

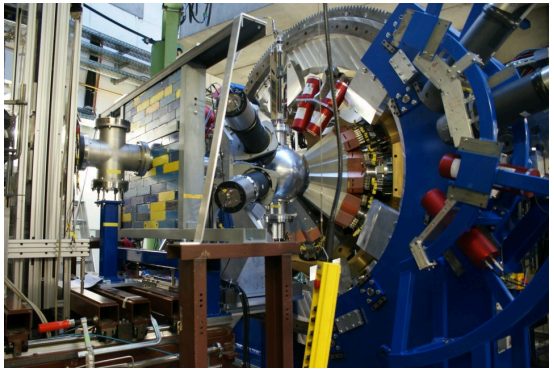
2010 → 2011
LNL : 5TC



AGATA D.+PRISMA

Total Eff $_{Nominal}$ ~2.6%

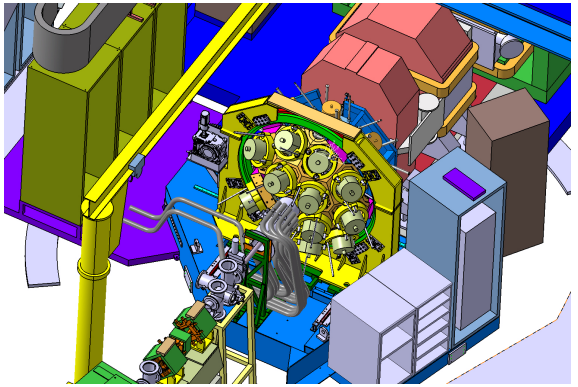
2012 → GSI/FRS
6TC+3 DC



AGATA @ FRS

Total Eff. (β=0.5) ~ 10%

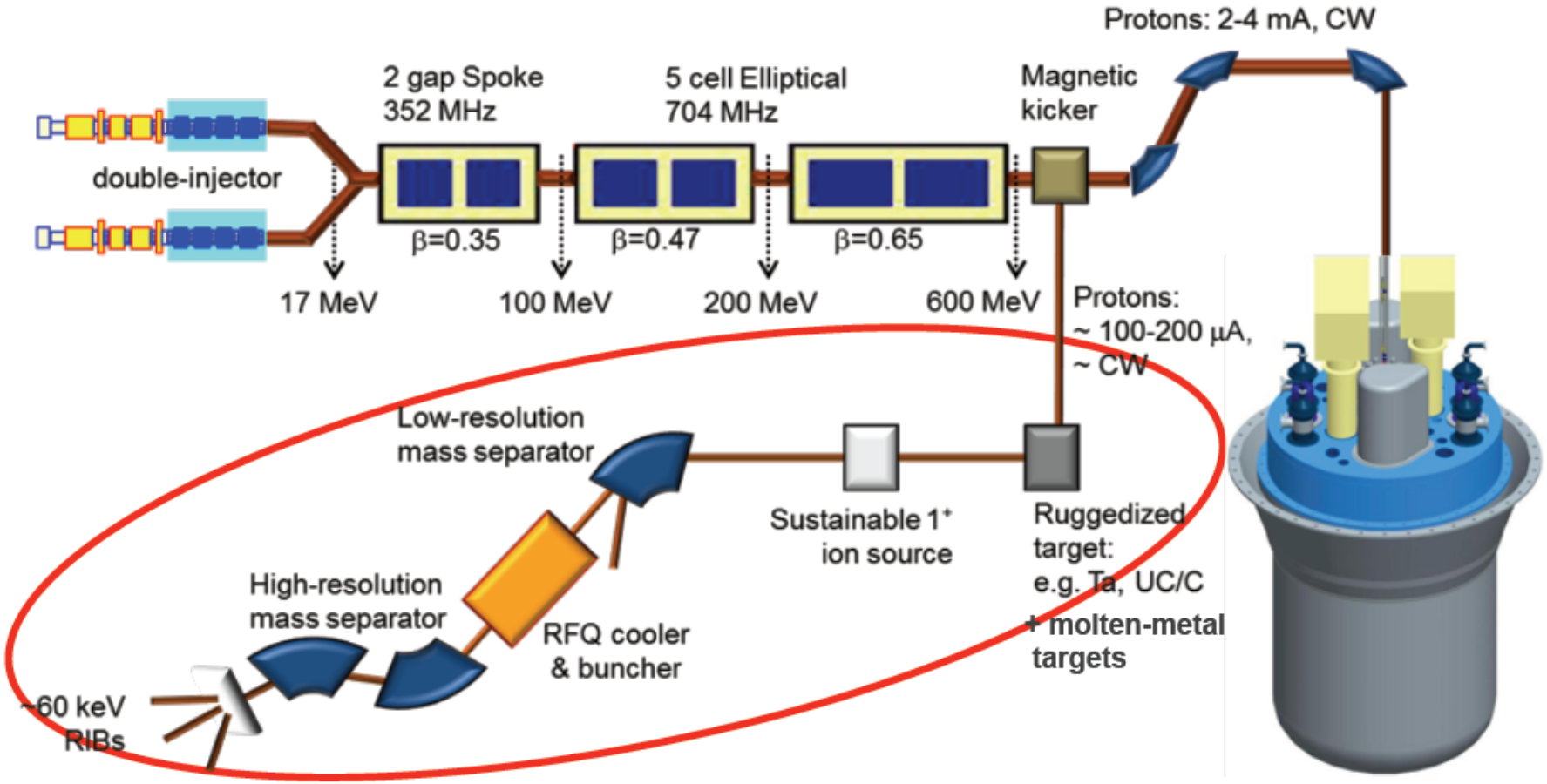
2014 → GANIL/SPIRAL1
15TC



AGATA @G1

Total Eff ~ 8% to 14%

ISOL@MYRRHA - Concept



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

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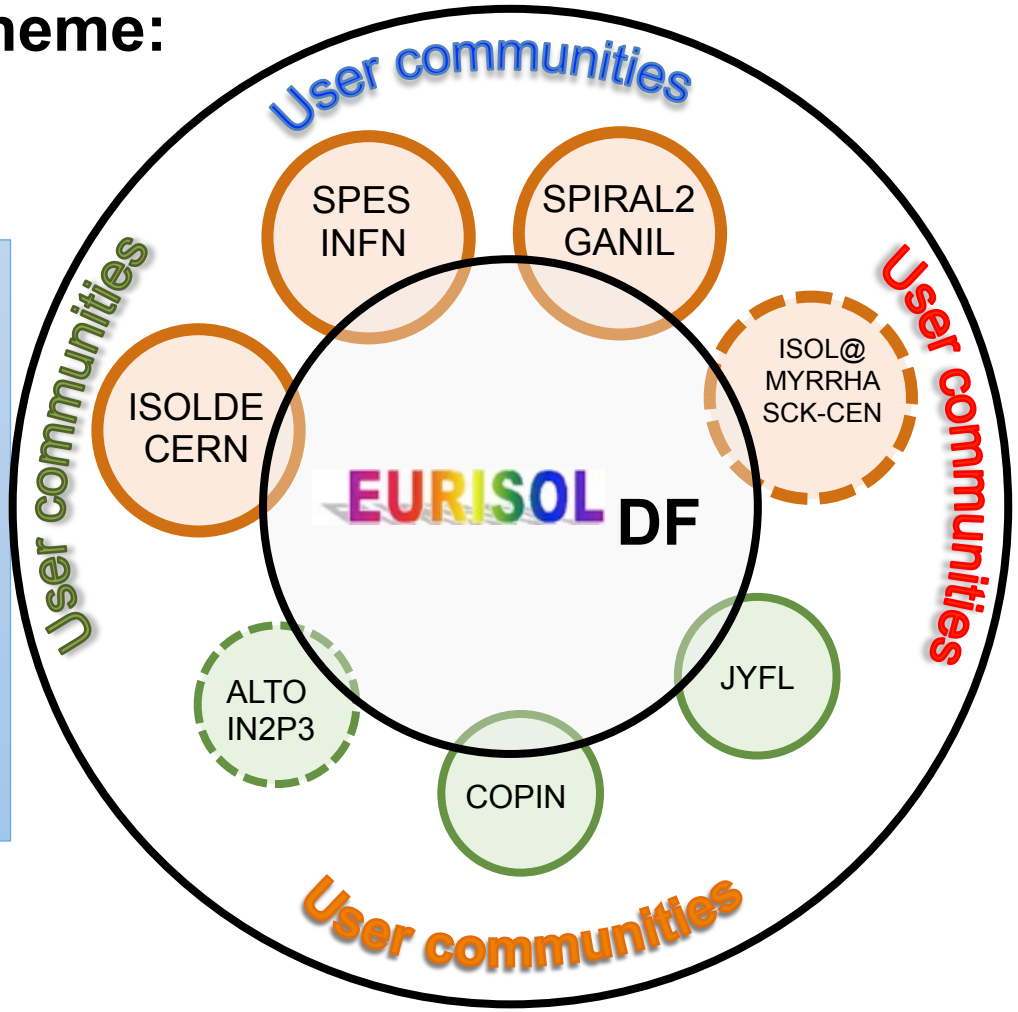
SCK•CEN

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,…)**

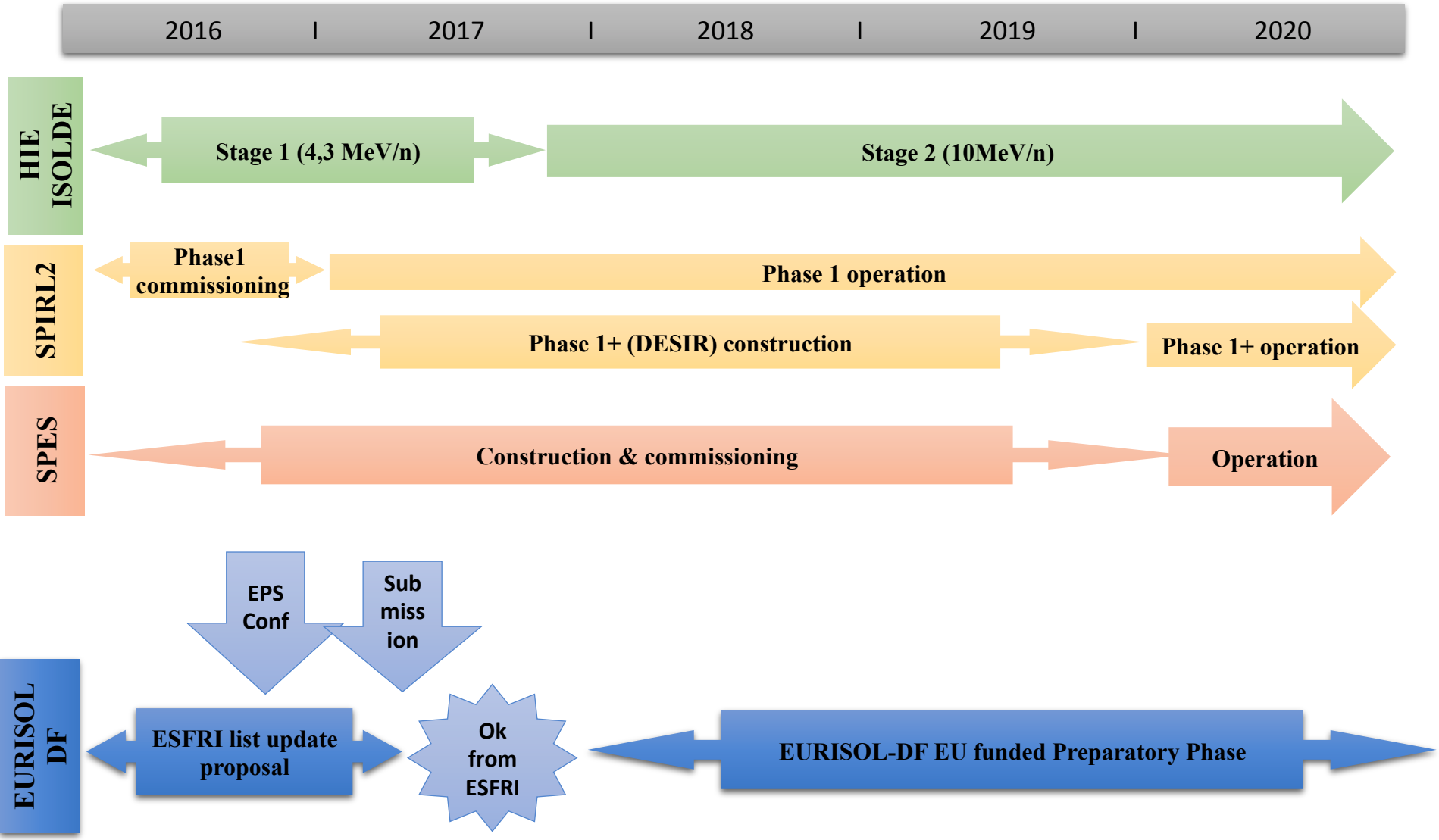


Interaction with EURISOL JRA in ENSAR 2 and EURISOL User group

http://www.eurisol.org/eurisol_df/

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

Timeline EURISOL-DF



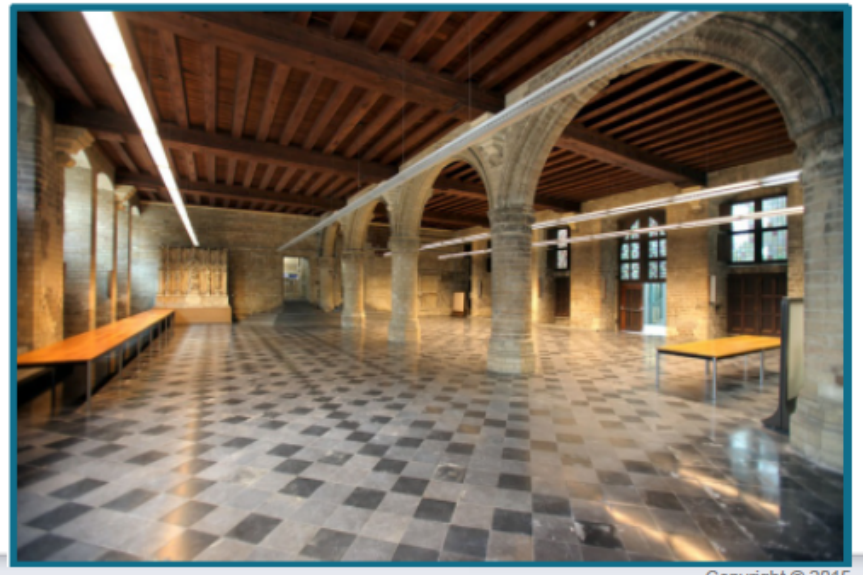
EPS Conference: Towards EURISOL Distributed Facility

EURISOL DF 2016

- 18-21 October 2016
- Leuven
- Expecte attendance: ≥ 200 participants

Promotiezaal KU Leuven
(385 places)

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



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Future Facilities- NuPECC LRP 2010

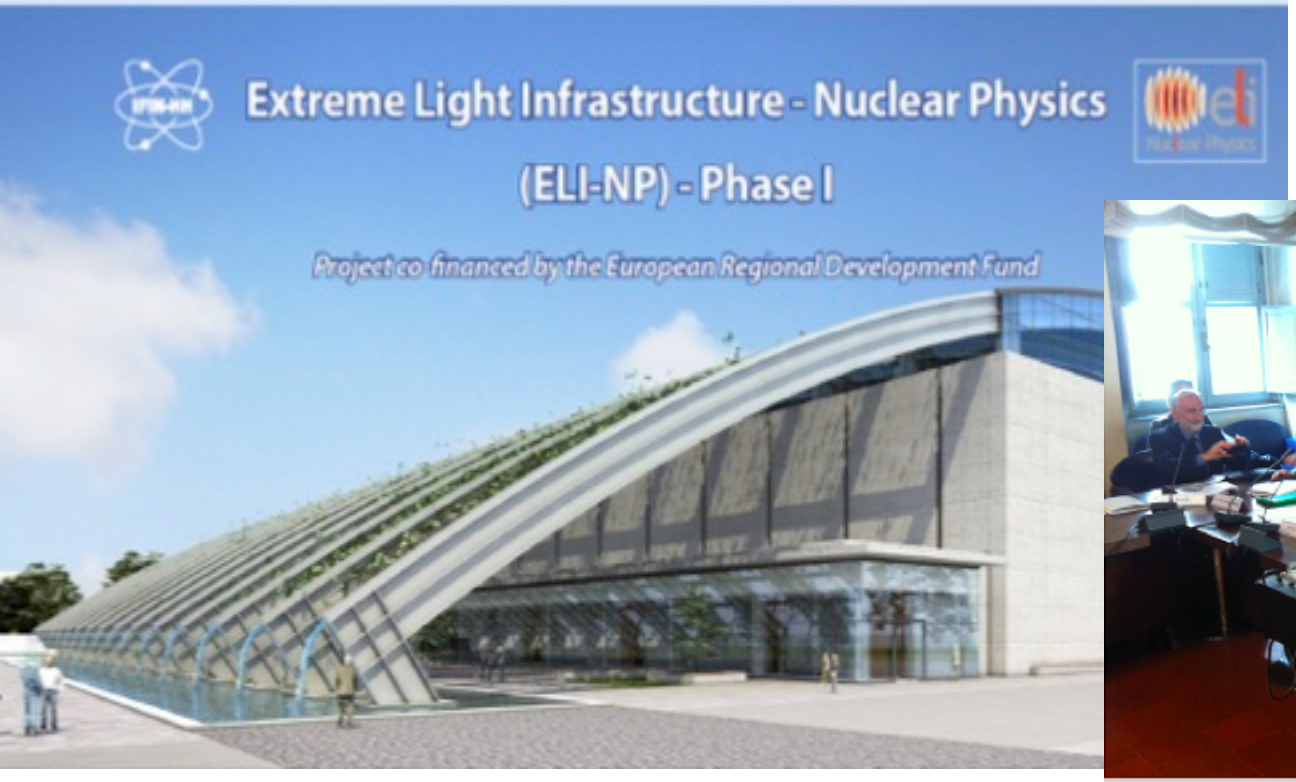
- **The inclusion of Nuclear Physics programmes at the multi-purpose facilities ELI and ESS.**

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

ELI-NP within the Rumanian pillar

eli Nuclear Physics

Bucharest-Magurele
National Physics Institutes

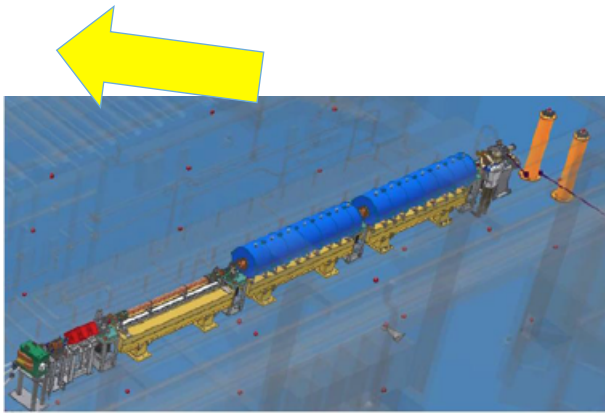


ELI-Nuclear Physics

Large equipments:

- *Ultra-short pulse high power laser system, 2 x 10PW 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***

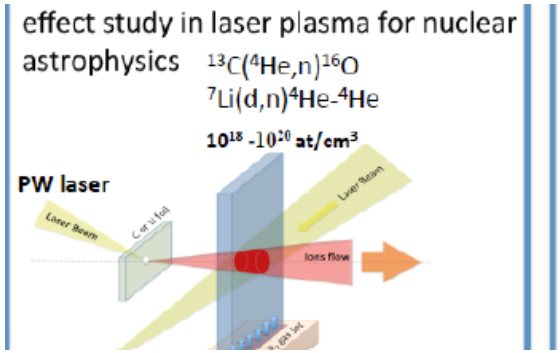


Buildings: 33000sqm total

Experiments:

- *8 experimental areas,*

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



ENSAR 2

Nuclear Structure FACILITIES

TRANSNATIONAL ACCESS (10)- also outside EU

JOINT RESEACH ACTIVITIES (7)

NETWORKING (12)

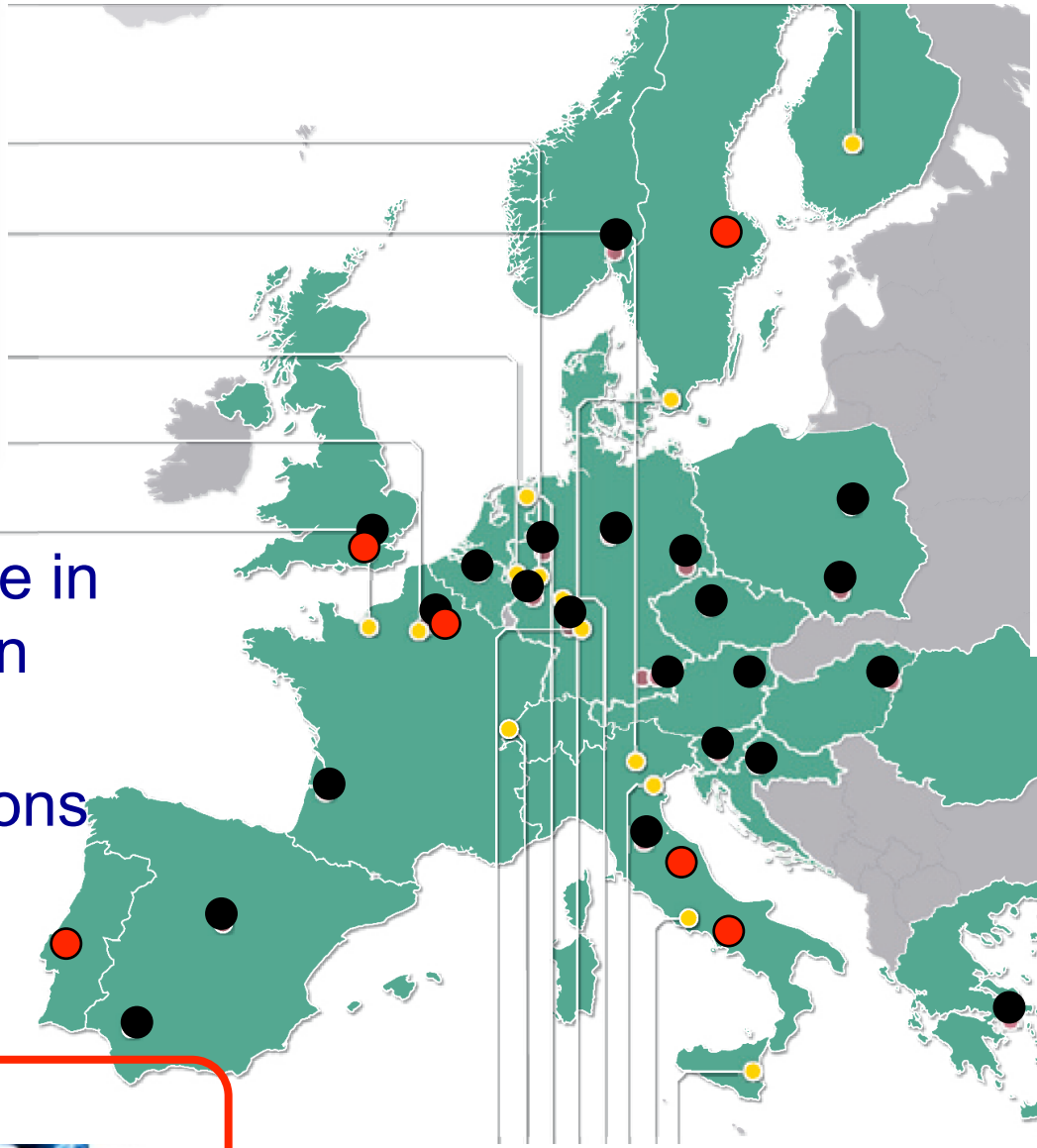
- **SLCJ-HIL / IFJ PAN (Poland)**
- **ELI-NP / IFIN-HH (Romania)**
- **ECT* (Italy)**

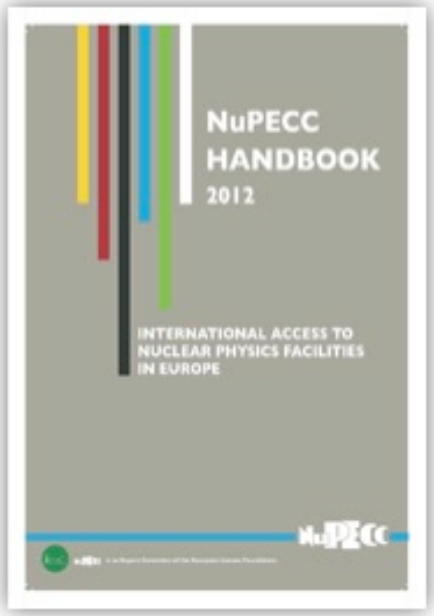
Small scale facilities

European Small-scale Accelerator Facilities

"Fully exploit smaller scale national and university Nuclear Physics laboratories across Europe dedicated to nuclear structure and astrophysics experiments, fundamental interactions and nuclear applications."

European Small-scale Accelerator Facilities





Specific role in

- Education
- R&D
- Applications

European Networ
Accelerator
ENSAR 2

30 small scale facilities

LUNA AT LNGS-NEW ACCELERATOR

LUNA site

LUNA MV
(approved)
$U_{terminal}$ = 350 – 3500kV
I_{max} = 500μA (on target)
ΔE = 0.7keV
Allowed beams: H^+, ^4He, ^{12}C

LUNA 1
(1992-2001)
50 kV

LUNA 2
(2000 – …)
$U_{terminal}$ = 50 – 400kV
I_{max} = 500μA (on target)
ΔE = 0.07keV
Allowed beams: H^+, ^4He, (^3He)

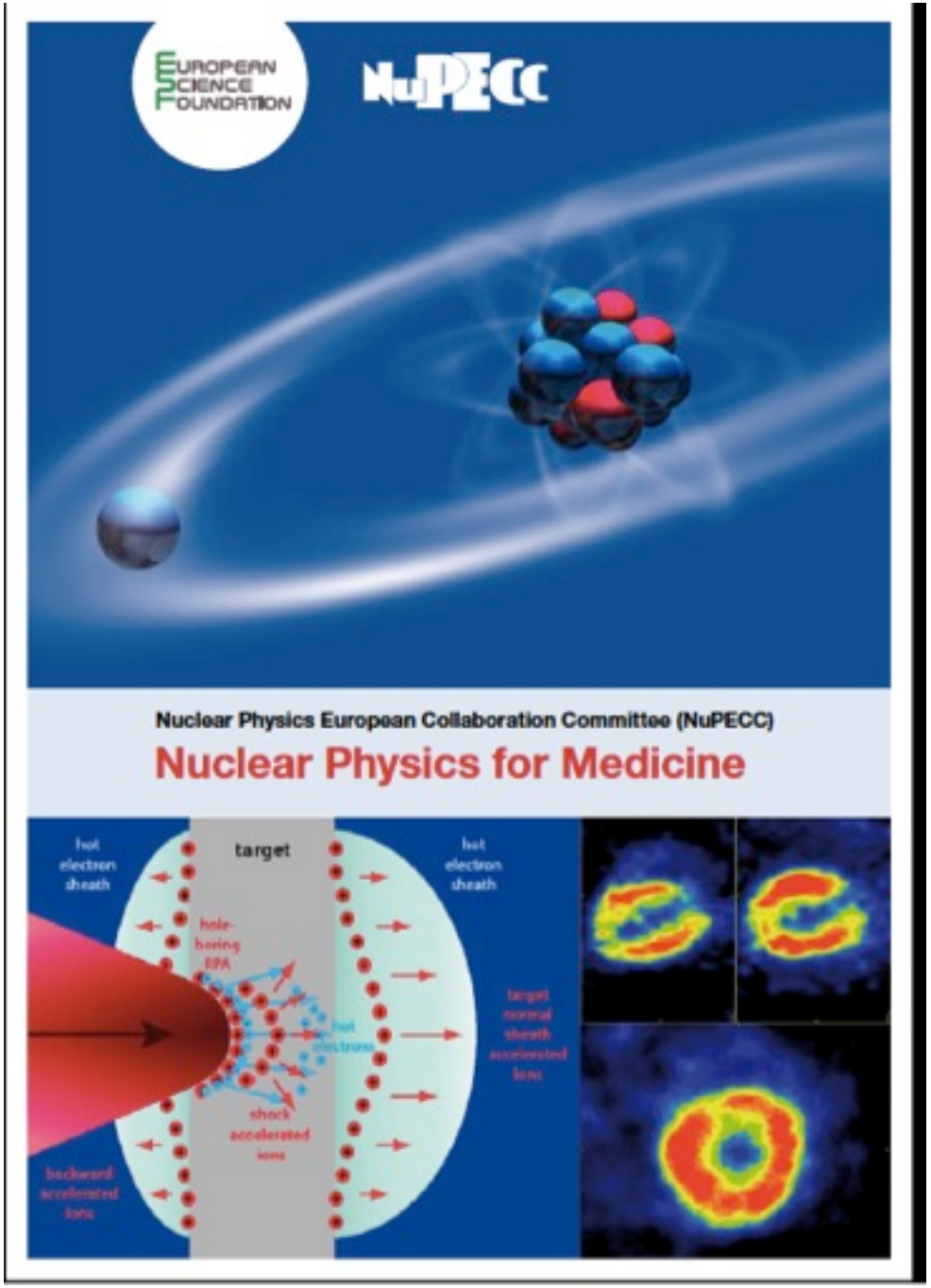
Nuclear reactions at stellar energies
for nucleosynthesis-
star evolution, energy production

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

European Small-scale Accelerator Facilities

ENSAR2 ENSAF European Network of Small-scale Accelerator Facilities

OBJECTIVES	
1	**Organize extended data bases of resources available** at small-scale accelerator facilities, and increase the community awareness of the capabilities of these facilities and identify niches for scientific research.
2	**Develop good practices and exchange know-how** related to a) the operation of accelerators and ion sources, b) target preparation and recycling, c) detector and instrumentation maintenance, d) laboratory management and coordination of users.
3	**Elaborate and formulate action plans aiming at an effective use of small-scale accelerator facilities for training young scientists.** In this context, small-scale facilities should complement the early stages of the formation of future generations of experimentalists and serve, when necessary, as introductory laboratories to TA facilities.
4	Develop and coordinate **common scientific efforts with emphasis on projects around** the Transnational Access facilities of ENSAR2 and furthermore around the upcoming **ESFRI infrastructures**.



Chapter I
Hadrontherapy

Conveners: **Marco Durante** (GSI) – **Sydney Galès** (Orsay, FAIR, ELI)

Chapter II
Medical Imaging

Conveners: **José Manuel Udias** (Madrid) – **David Brasse** (Strasbourg)

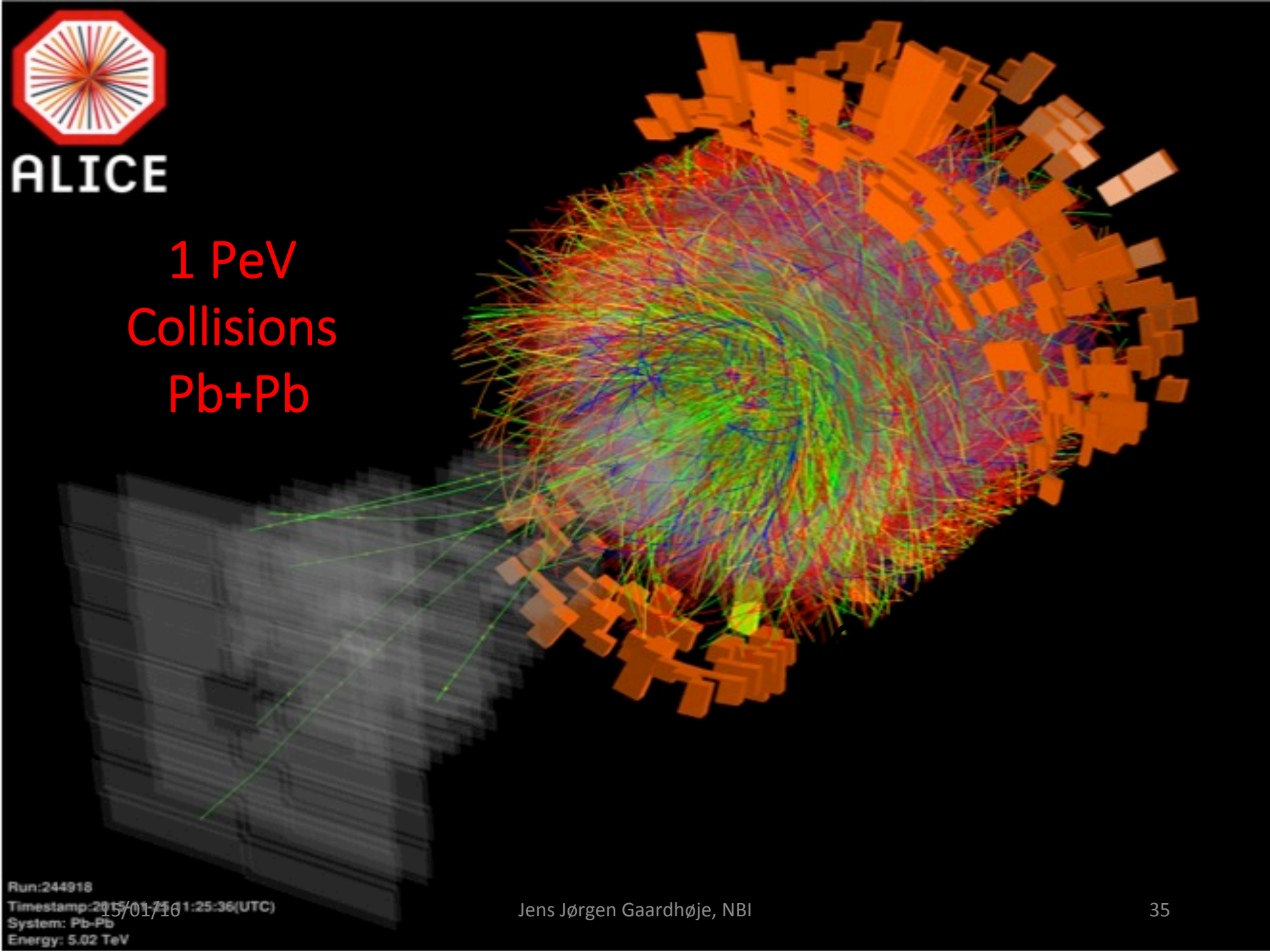
Chapter III
Radioisotope Production

Conveners: **Ulli Köster** (ILL) – **Marie-Claire Cantone** (Milano)

http://www.nupecc.org/npmed/npmed2014.pdf

ALICE at CERN

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


ALICE
1 PeV
Collisions
Pb+Pb
Run:244918
Timestamp:2015-01-21 01:25:36(UTC)
System: Pb-Pb
Energy: 5.02 TeV

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 x10^{27} cm^{-2} s^{-1}

Upgraded ALICE will run <u>at least to 2029</u>

PHASE II Upgrade
ATLAS, CMS major upgrade

HL-LHC, pp luminosity from 10^{34} (peak) to 5 x10^{34} (levelled)

INTERNATIONAL COOPERATIONS

EUROPEAN SCIENCE FOUNDATION

NuPECC

ECT*

FONDAZIONE BRUNO KESSLER

Technische Universität München

TECHNISCHE UNIVERSITÄT DARMSTADT

RIKEN

Japan

NAOJ

National Astronomical Observatory of Japan

APCTP

Asia Pacific Center for Theoretical Physics

Korea

INSTITUTE for NUCLEAR THEORY

USA

JINR Dubna

Russia

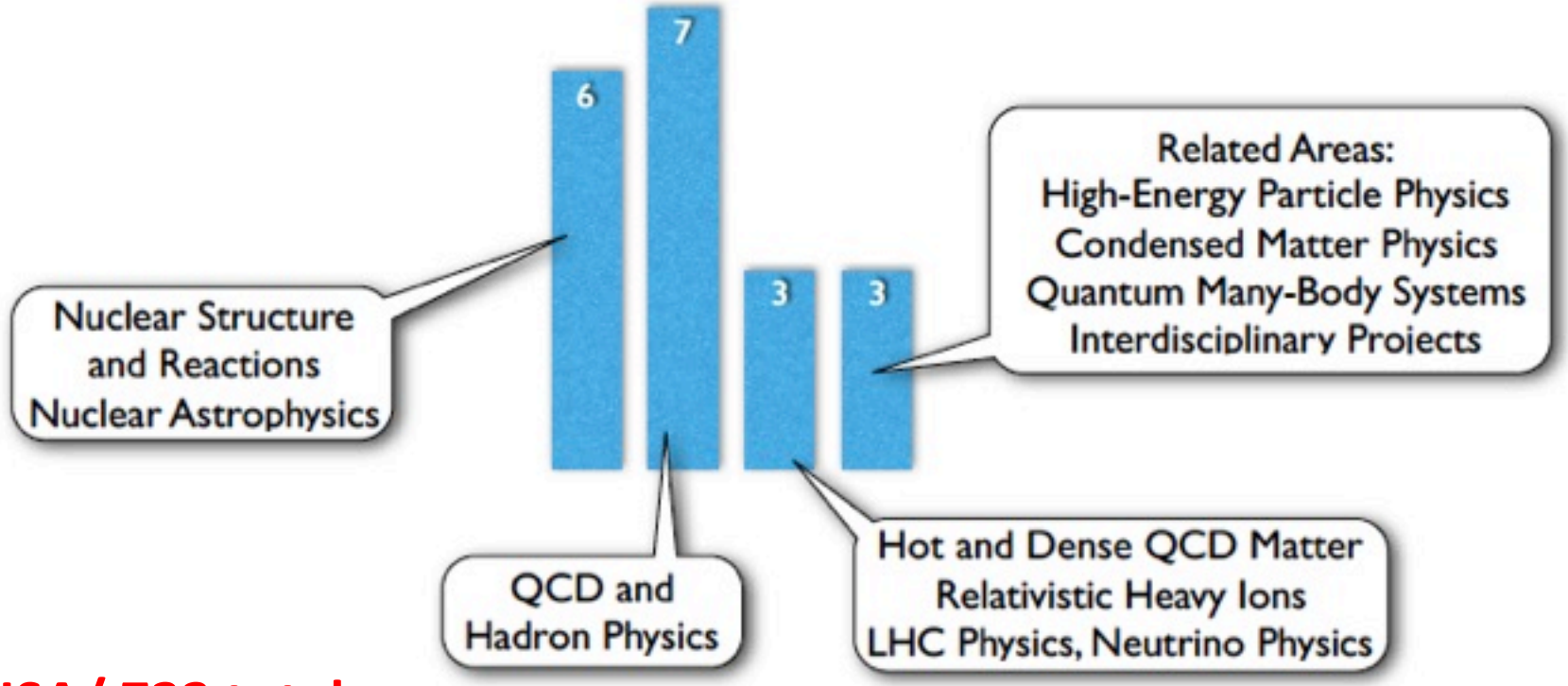
ITP

Chinese Academy of Sciences

China

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

Facility for Antiproton and Ion Research FAIR

Nuclear Structure & Astrophysics
(Rare-isotope beams)

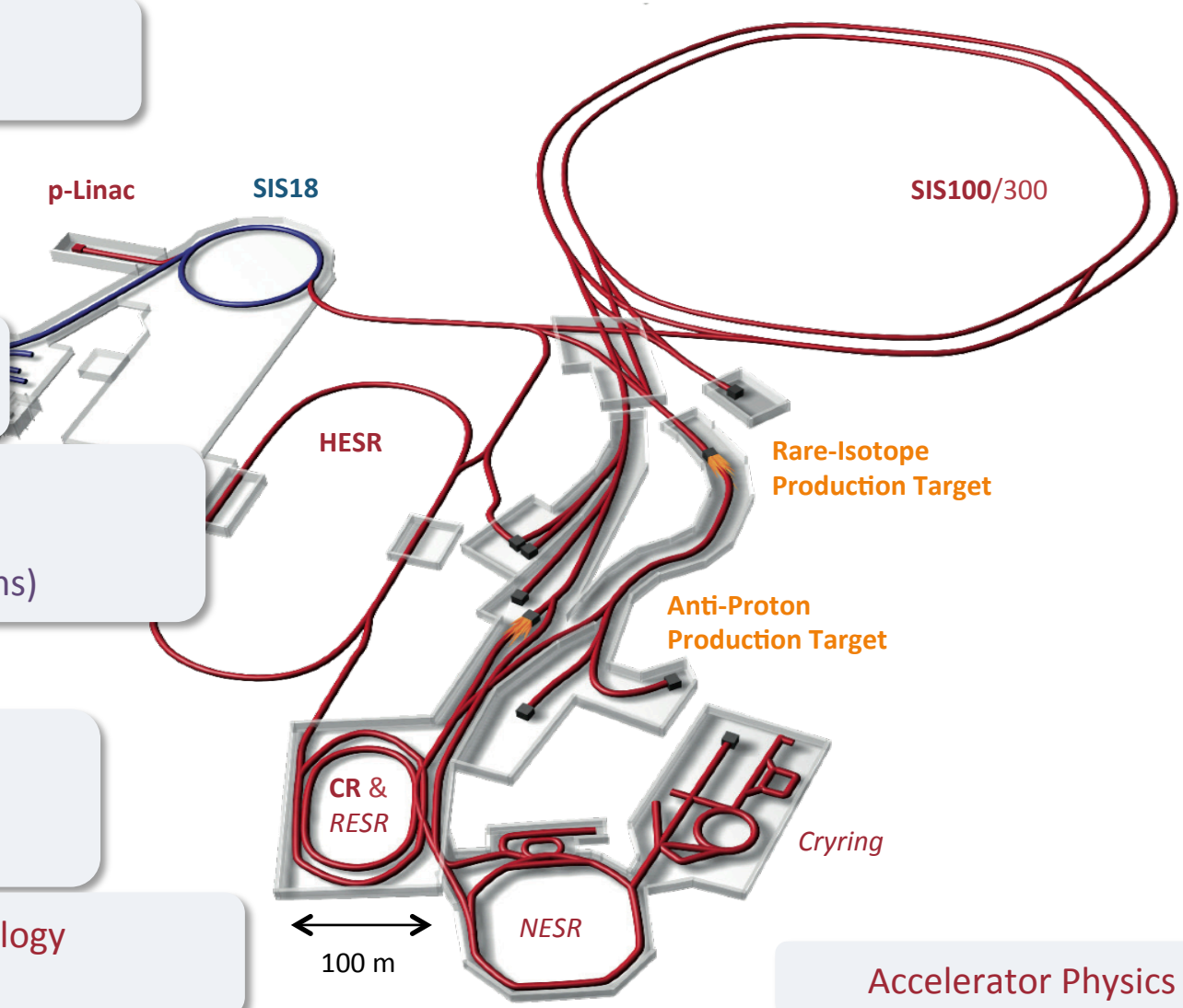
Hadron Physics
(Stored and cooled
14 GeV/c anti-protons)

QCD-Phase Diagram
(HI beams 2 to 45 GeV/u)

Fundamental Symmetries
& Ultra-High EM Fields
(Antiprotons & highly stripped ions)

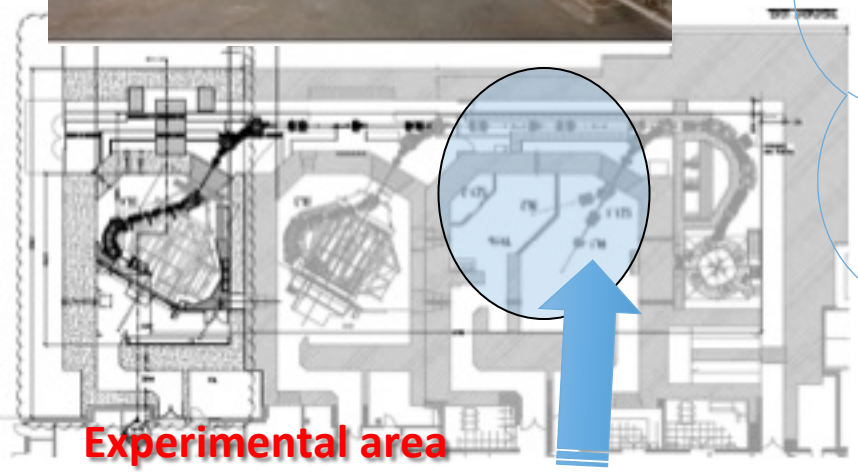
Dense Bulk Plasmas
(Ion-beam bunch compression
& petawatt-laser)

Materials Science & Radiation Biology
(Ion & antiproton beams)



Accelerator Physics

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 x 10^8 p/s) - 500 nA (3.3 x 10^{12} p/s)

FAIR - Universe in the laboratory

CBM
nuclear matter at high densities

Spectrum magazine

APPA
ions in extreme electro-magnetic fields

PANDA
hyperon-hyperon interaction

NUSTAR
neutron-rich nuclei

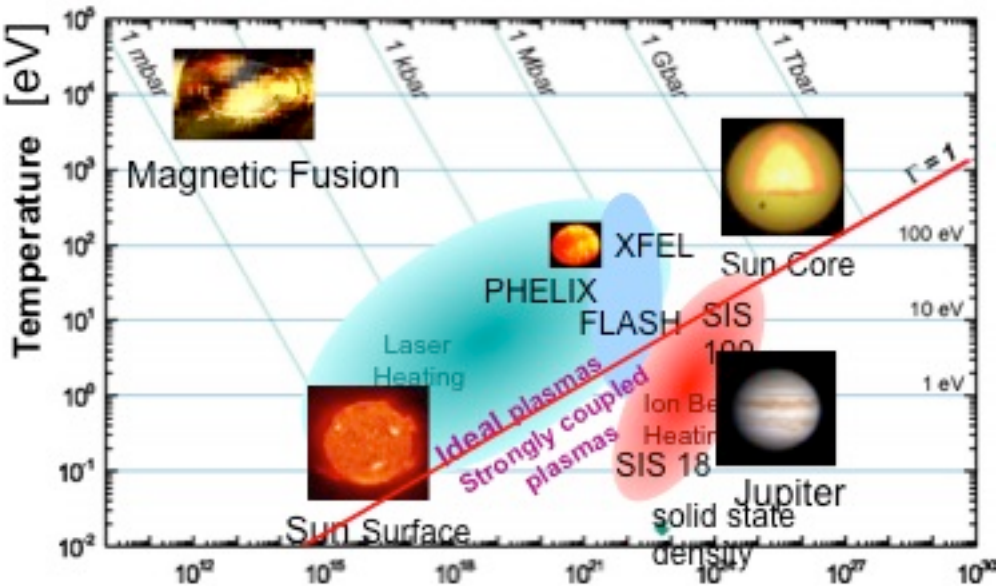
Tools

- Powerful accelerators
- Novel experimental instrumentation
- Expertise

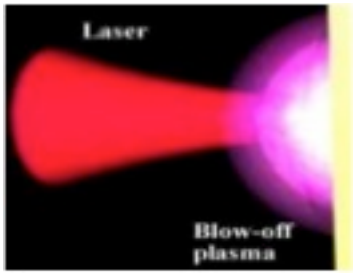
Neutron stars – lab of exotic matter in the Universe

K. Langanke

APPA – Plasma physics



photon pulses (XUV) of highest brilliance (FLASH)



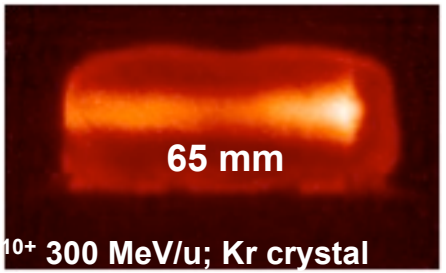
small volumes of non equilibrated environment (100μm^3)

Achieving high pressure and high temperature

PHELIX

SIS100

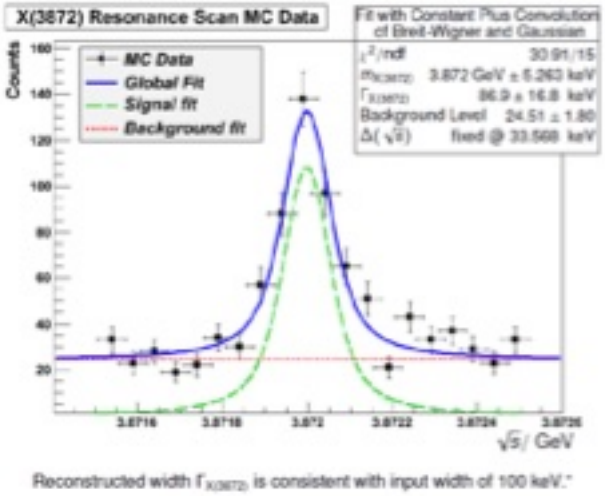
intense, energetic beams of heavy ion (FAIR)

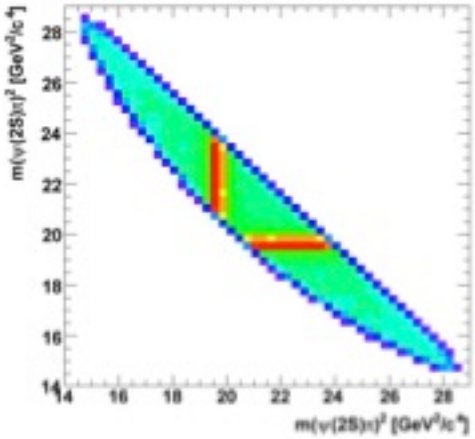


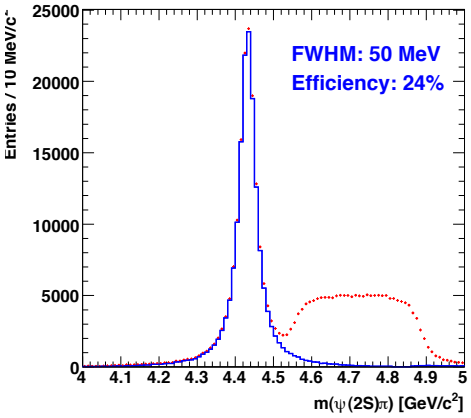
large volumes of equilibrated uniform environment (~mm^3)

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**

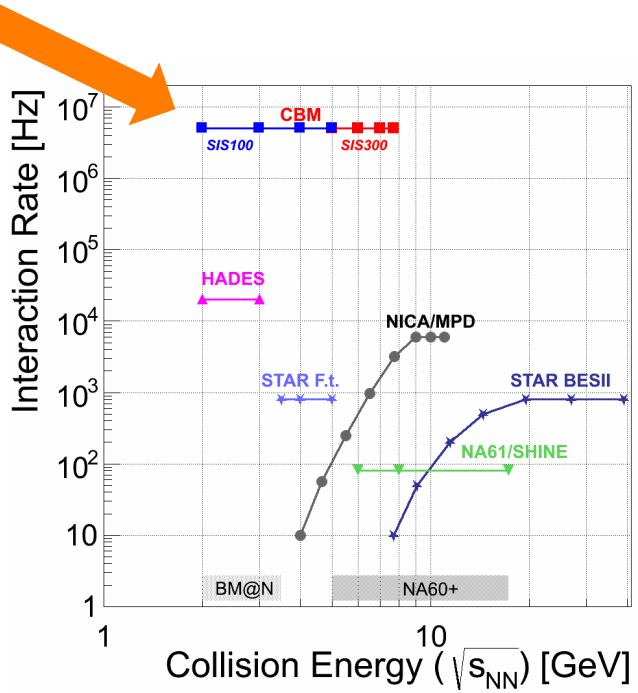


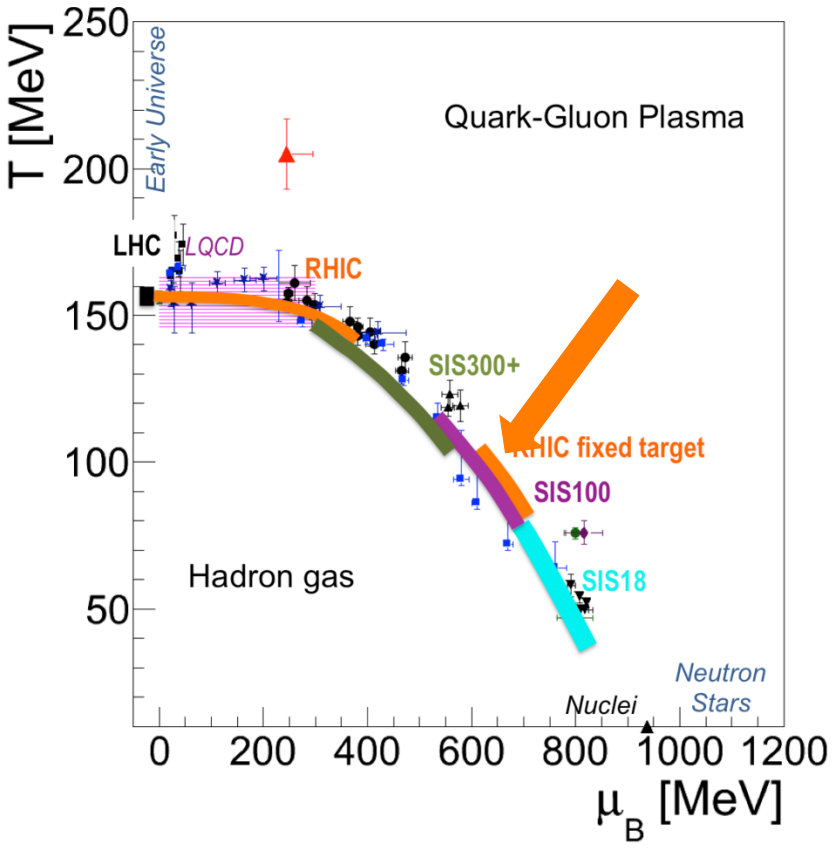




CBM – Exploring the QCD phase diagram using rare probes

Key experimental requirement: operation at unprecedented high rates !





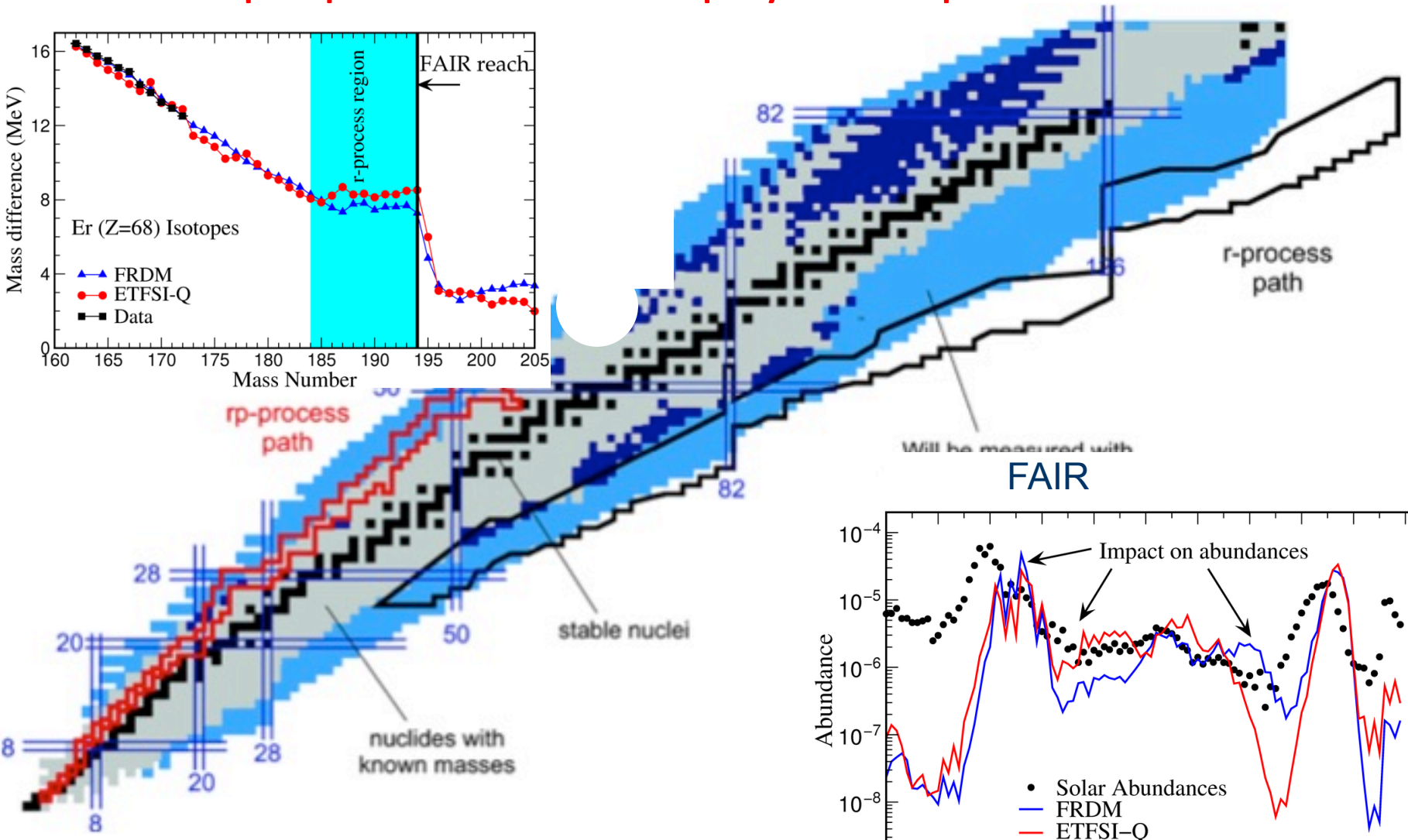
CBM physics program:

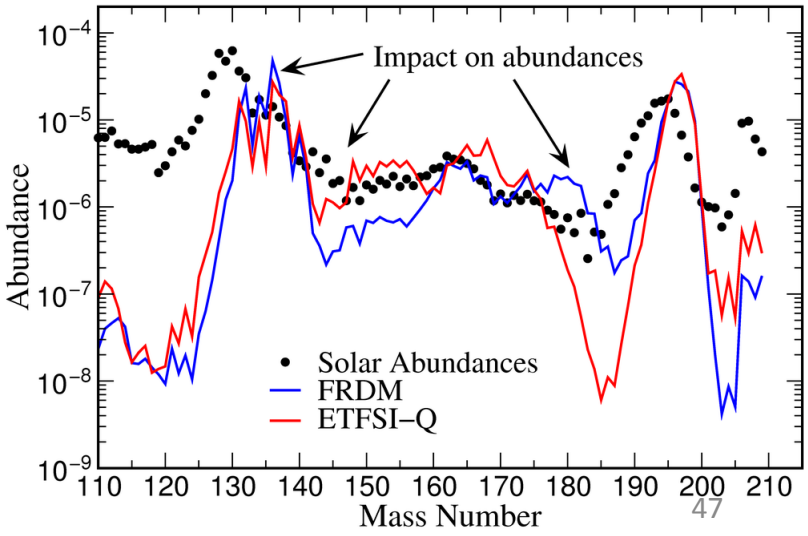
- **exploring the QCD matter equation-of-state at very high net baryon densities**
- search for phase boundaries and for new forms of QCD matter
- **search for the onset of chiral symmetry restoration**

CBM observables:

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

NUSTAR –
Nuclear properties for astrophysical r-process



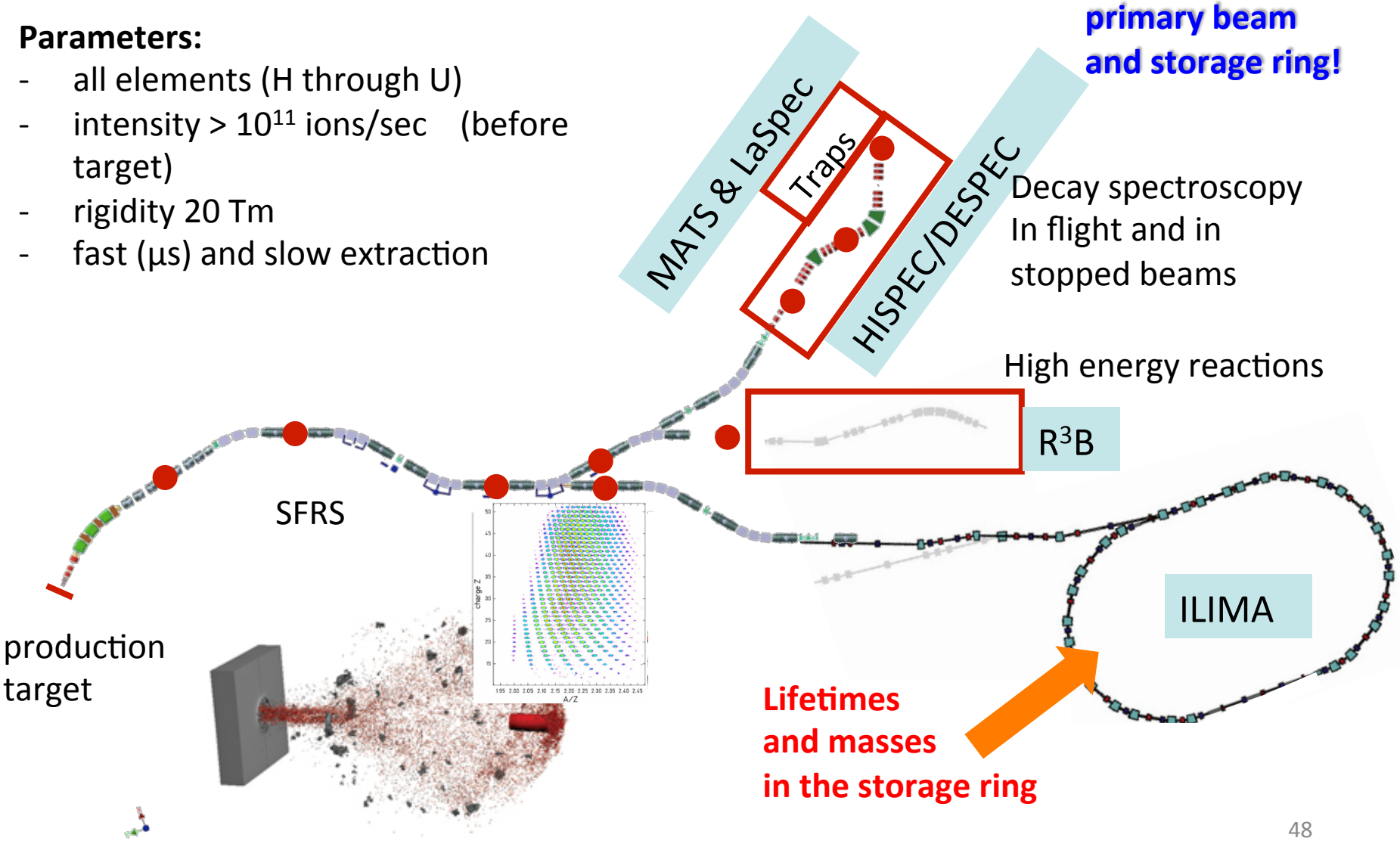


NUSTAR - FAIR asset – rings and instrumentation

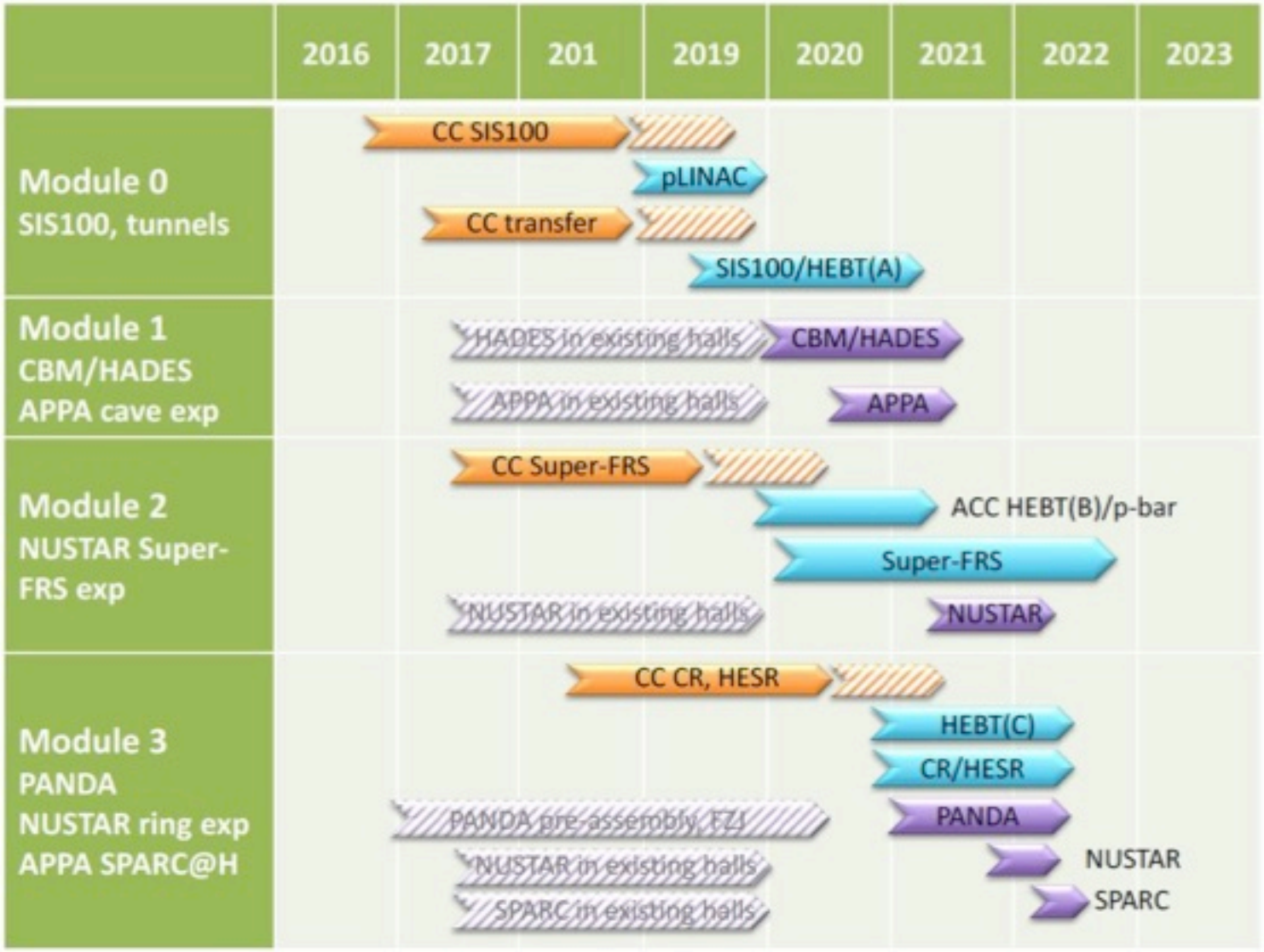
Parameters:

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

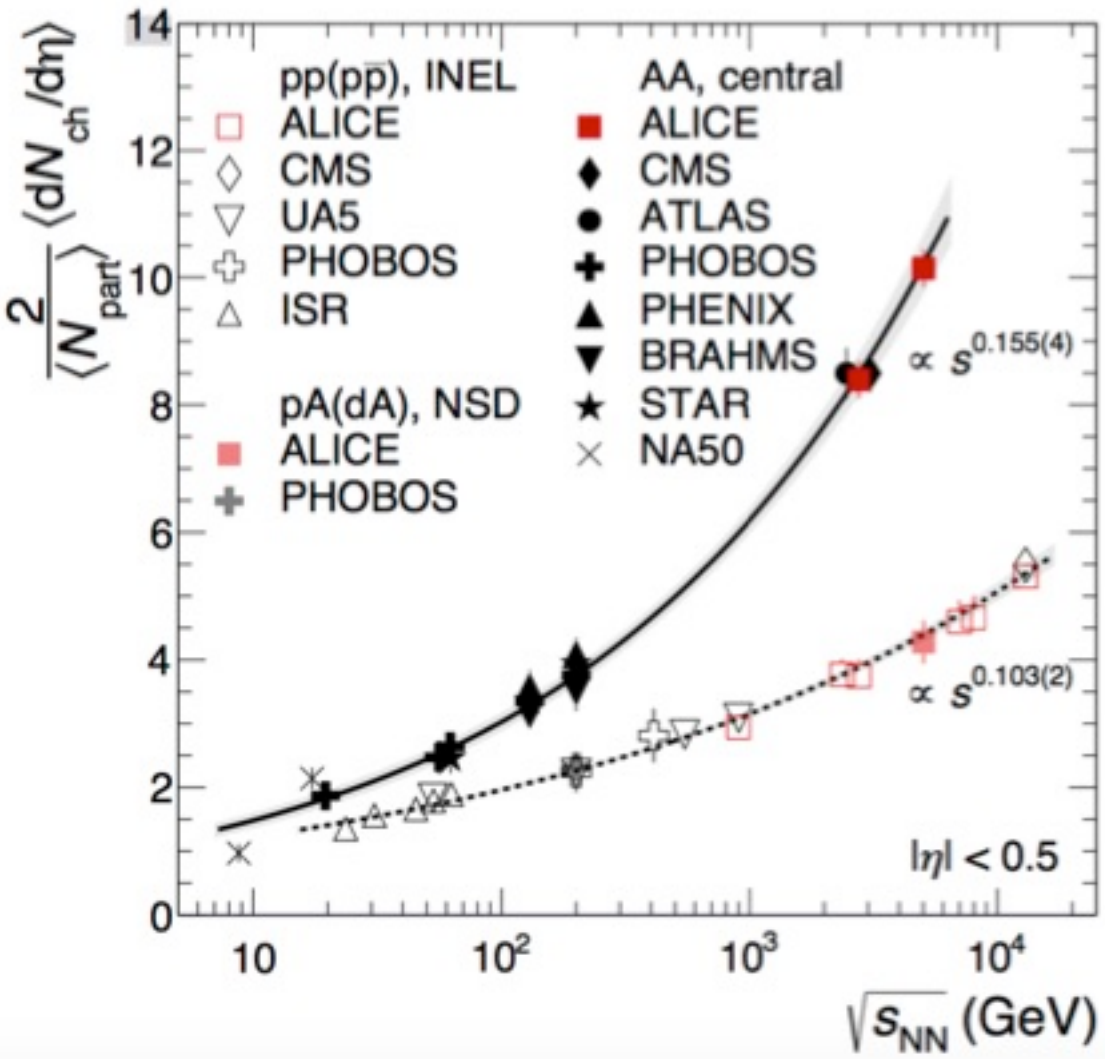
high energy of the primary beam and storage ring!



High Level Schedule of the MSV



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



ALICE: arXiv:1512.06104

Data taking started on 25/11/2015.

Submitted to PRL on 18/12/2015

arXiv:1512.06104

dN/dη=1953 at η=0

ε > 20 GeV/fm³

>25.000 charged particles in most central collisions.