FAIR –NICA 16.11.2016

FAIR as Center of International Cooperation

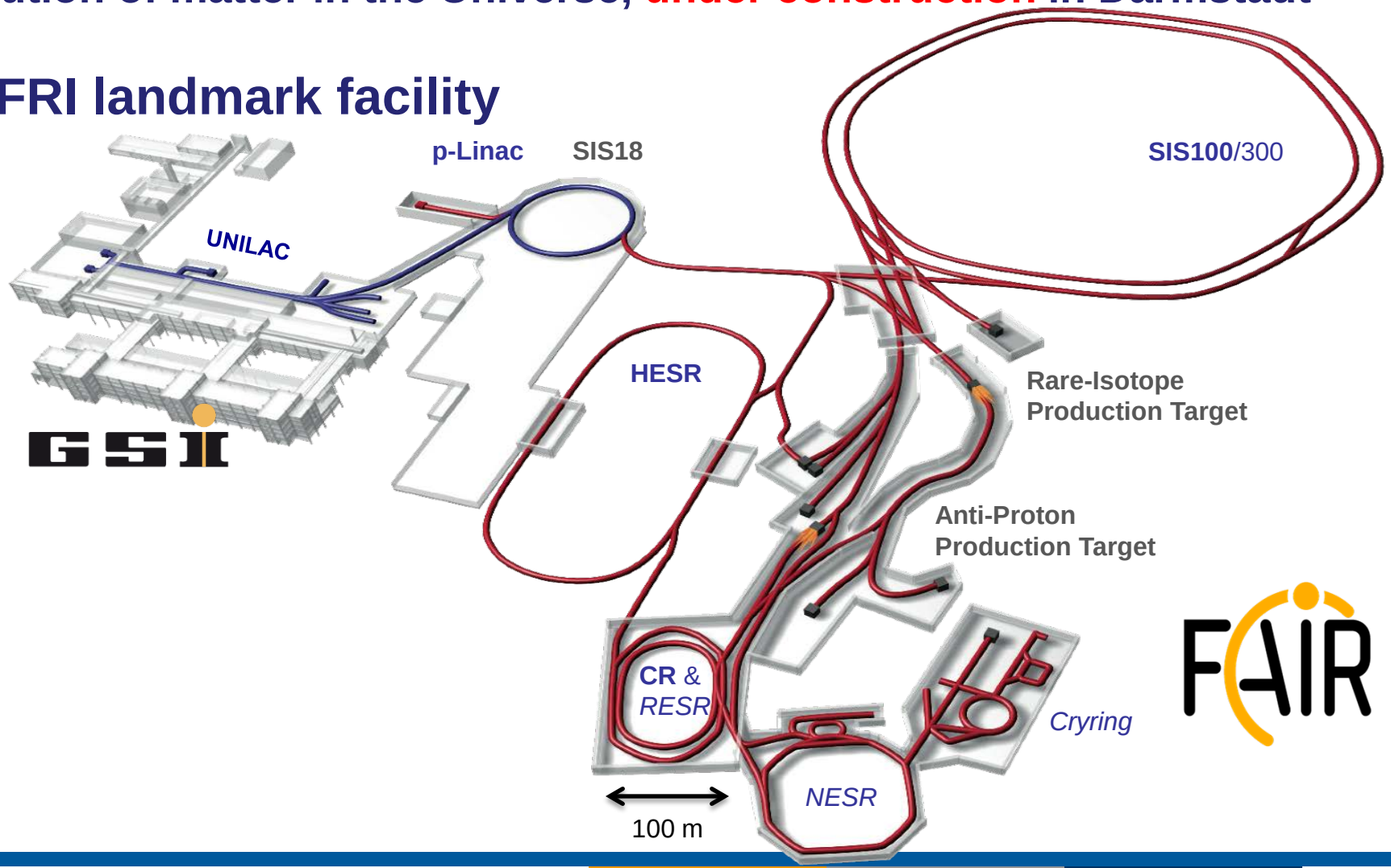
Boris Sharkov – Scientific Managing Director

Finland France Germany India Poland Romania Russia Slovenia Sweden UK

Facility for Antiproton and Ion Research

– new international research laboratory to explore the nature and evolution of matter in the Universe, **under construction** in Darmstadt

ESFRI landmark facility



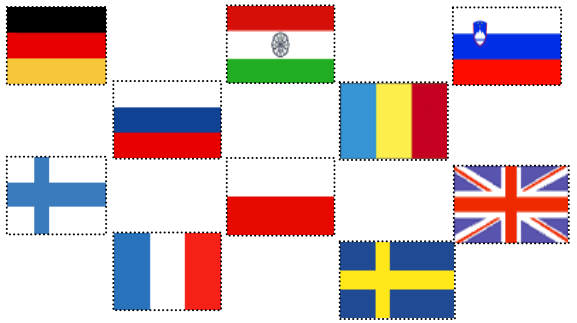
FAIR: an international endeavour

The FAIR Convention: contractual foundation of FAIR GmbH

- International convention concerning the construction and operation
- International partners provide an investment contribution about 30 %
- Contributions to the construction costs may be provided in-kind or in-cash
- Shares are costbook based, fixed to 2005 values
- The FAIR company and GSI collaborate in the construction, commissioning and operation on the basis of long-term agreements

Partners Countries

Germany, Russia, India, Poland,
Romania, France, Slovenia,
Sweden, Finland, United Kingdom



Facility for Antiproton and Ion Research

Primary Beams

- 5x10^{11}/s; 1.5 GeV/u; $^{238}U^{28+}$
- 10^{10}/s $^{238}U^{73+}$ up to 35 GeV/u
- 3x10^{13}/s 30 GeV protons

Secondary Beams

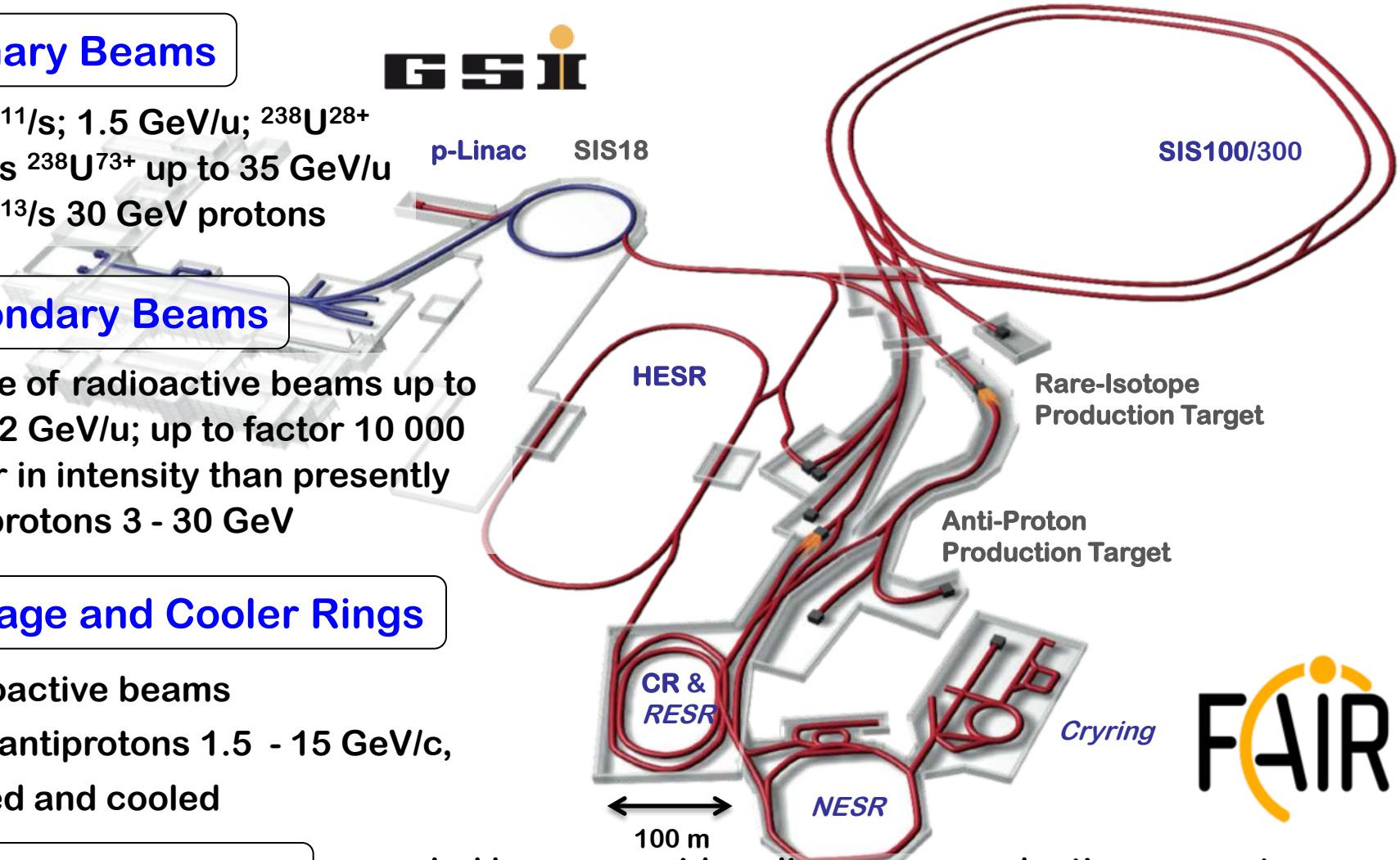
- range of radioactive beams up to 1.5 - 2 GeV/u; up to factor 10 000 higher in intensity than presently
- antiprotons 3 - 30 GeV

Storage and Cooler Rings

- radioactive beams
- 10^{11} antiprotons 1.5 - 15 GeV/c, stored and cooled

Technical Challenges

- cooled beams, rapid cycling superconducting magnets



Facility for **A**ntiproton & **I**on **R**esearch

Nuclear Structure & Astrophysics
(Rare-isotope beams)

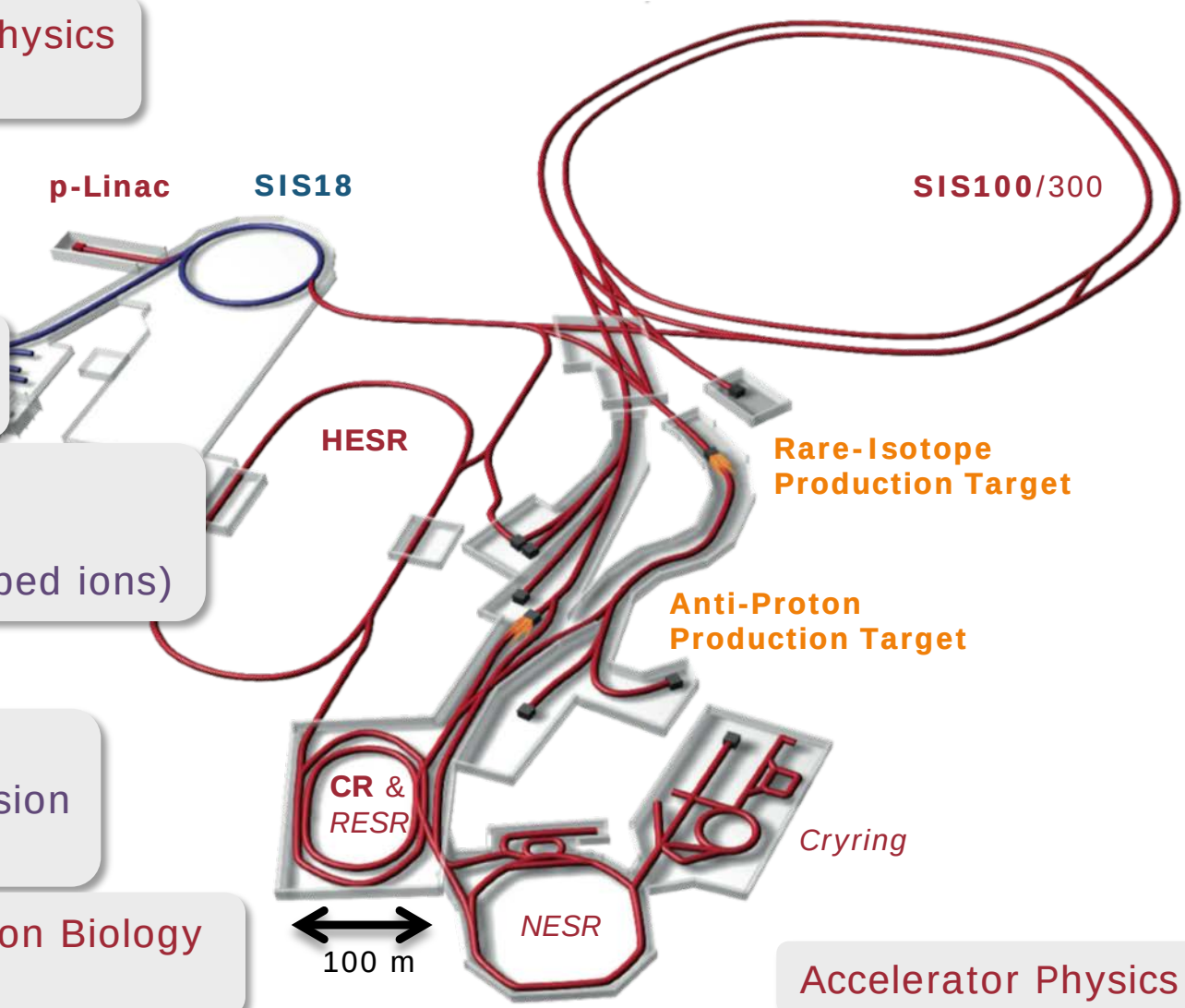
Hadron Physics
(Stored and cooled
14 GeV/c anti-protons)

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

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

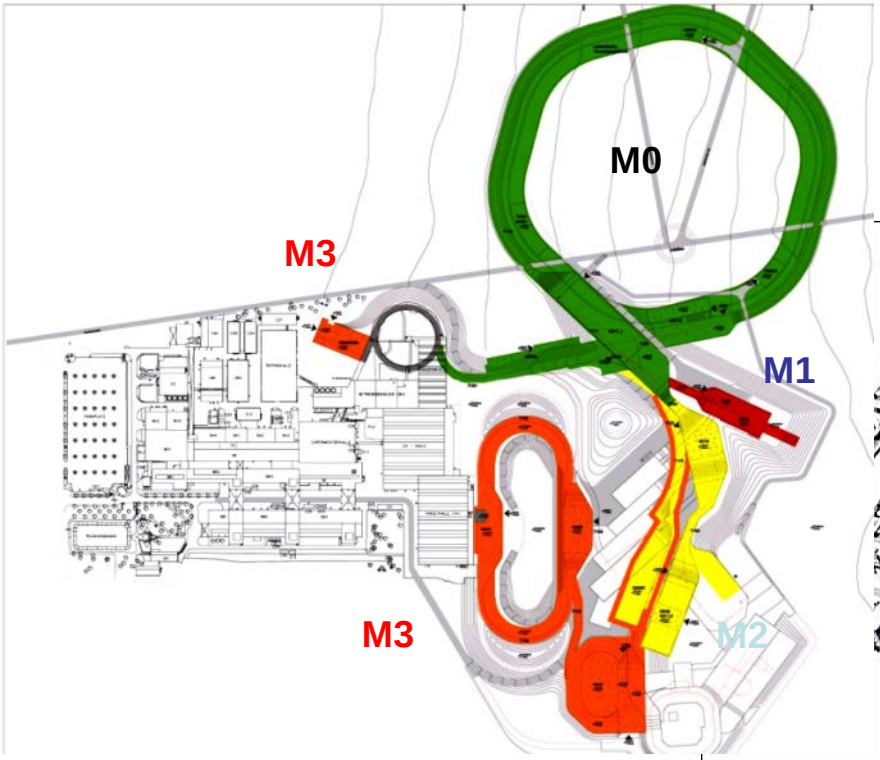
Dense Bulk Plasmas
(Ion-beam bunch compression
& petawatt-laser)

Materials Science & Radiation Biology
(Ion & antiproton beams)

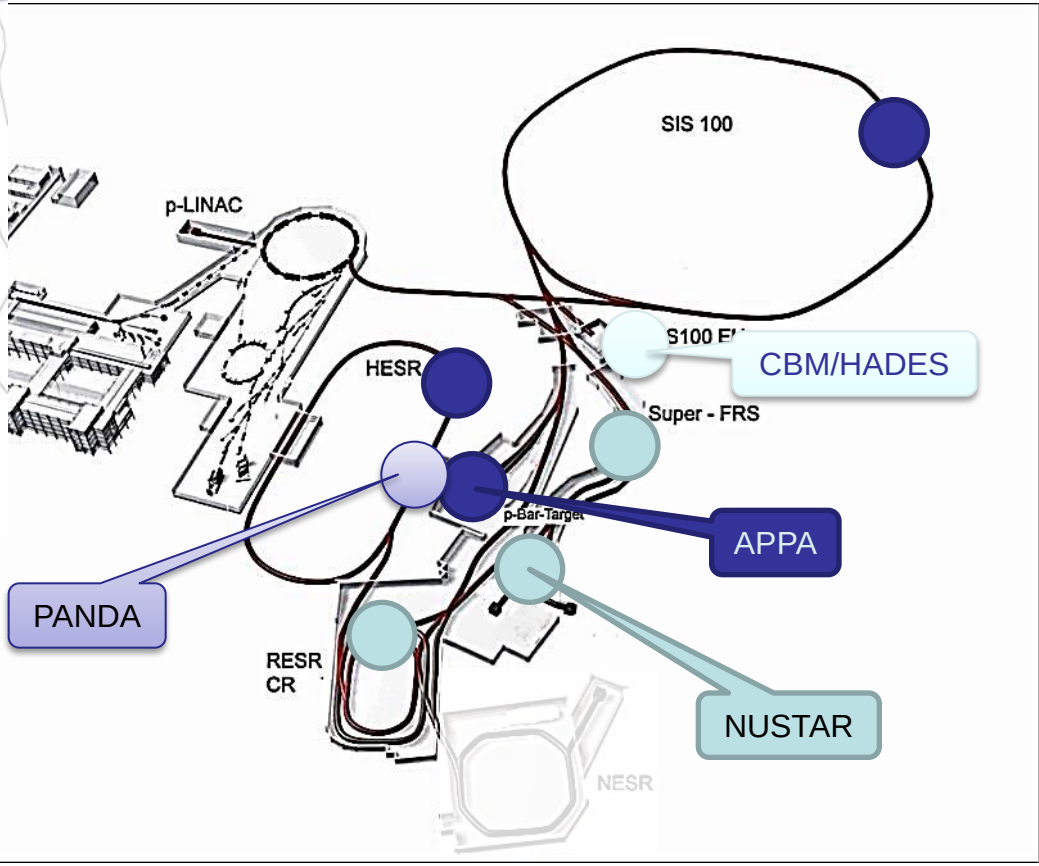


Accelerator Physics

Modularised Start Version (MSV)



Cost about **1.6 billion by 2018**
(1 billion 2005 Euros)



Modules

M0: SIS100

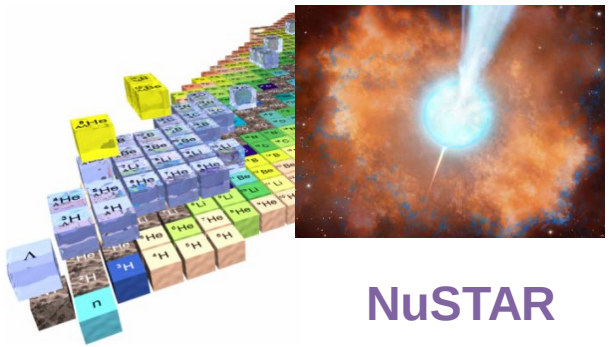
M1: APPA

M1: CBM/HADES

M2: NUSTAR

M3: PANDA, NuSTAR, APPA

Heavy ion accelerator chain



NuSTAR

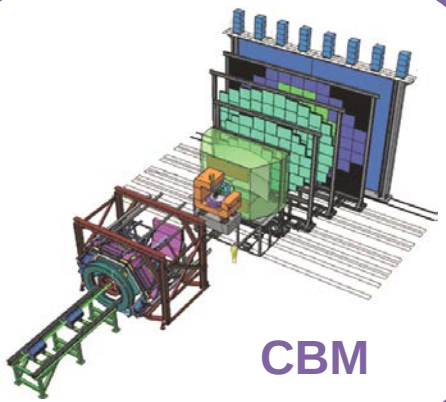
SIS 100

Collector Ring

CBM

Super-FRS

APPA



CBM

The 4 Scientific Pillars of FAIR

APPA: Atomic, Plasma Physics and Applications

CBM: Compressed Baryonic Matter

NUSTAR: Nuclear Structure, Astrophysics and Reactions

PANDA: Antiproton Annihilations at Darmstadt

MSV provides for outstanding and world-leading research programmes in all four scientific areas, Biomedicine and Materials Science for in total 2500 - 3000 users

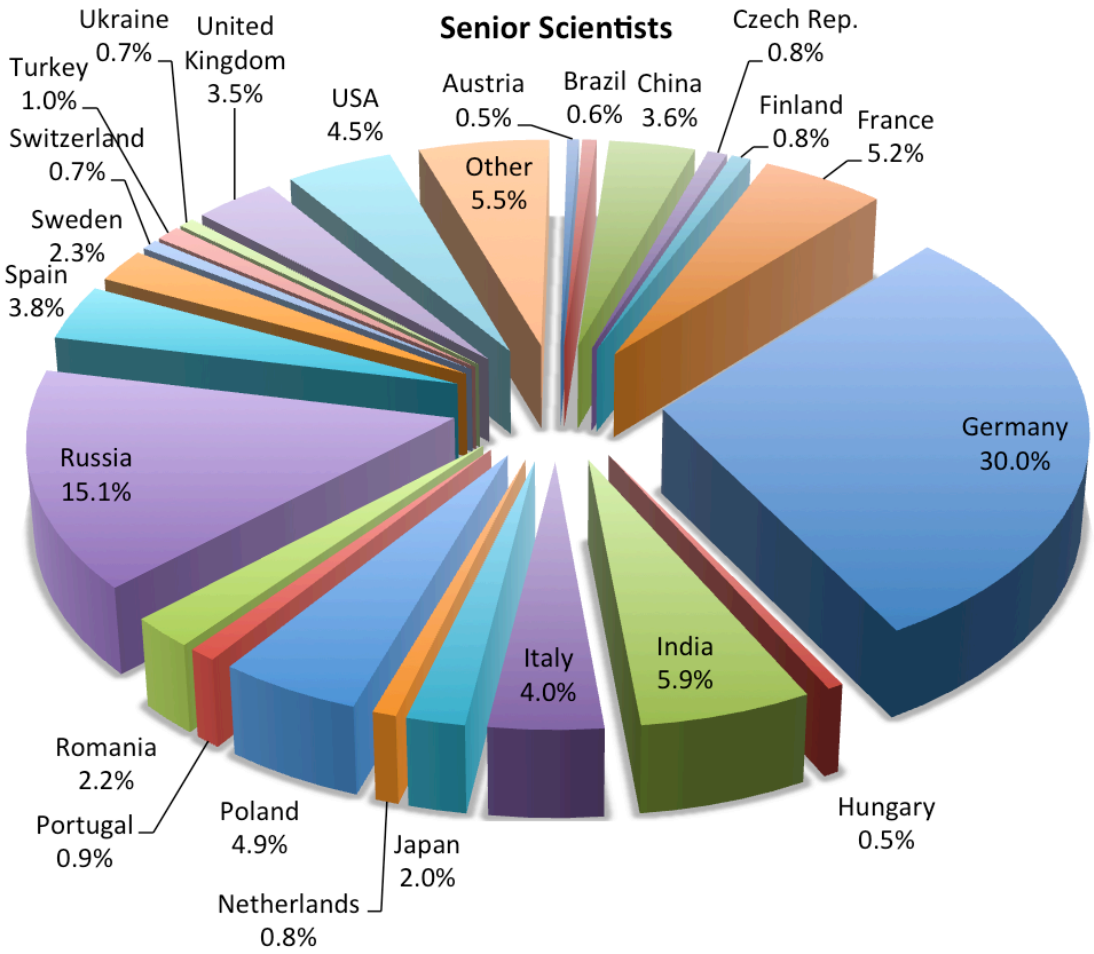
Scientific program is competitive and world class

International participation in FAIR Experiments

FAIR RD supports international research community in setting up the experiments

FAIR RD tasks

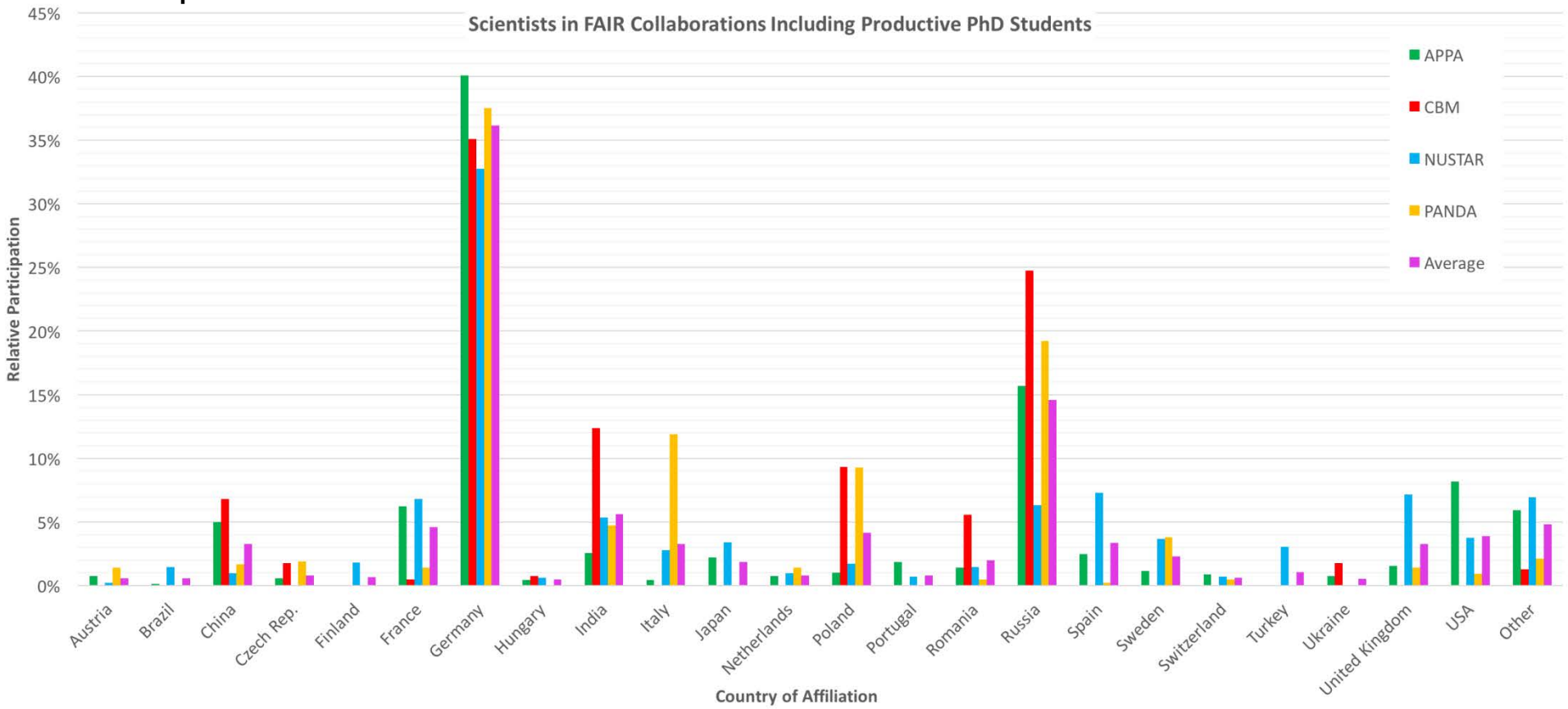
- **Scientific**
  - *Scientific Council*
- **Technical**
  - *Expert Committee Experiments*
  - *Technical Coordinators*
- **Resources**
  - *Resources Review Boards*
  - *Resources Coordinators*
- **Computing and simulation**
  - *IT Coordinator*



Collaborations finalize design and construct components of the FAIR Experiments

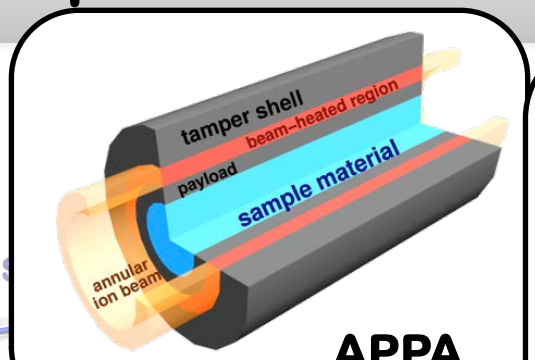
Scientific Community

- More than 1800 senior scientists (ca. 3000 in total) members of the FAIR Collaboration
  - Collaborations finalise design and construct components of the FAIR experiments



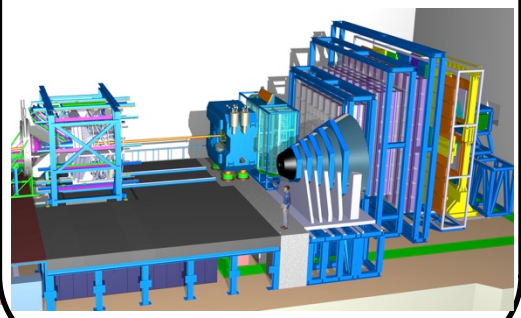
Status of the FAIR Experiments

- Conception of FAIR experiments (Convention)
- 4 scientific pillars
  - APPA
  - CBM
  - NUSTAR
  - PANDA

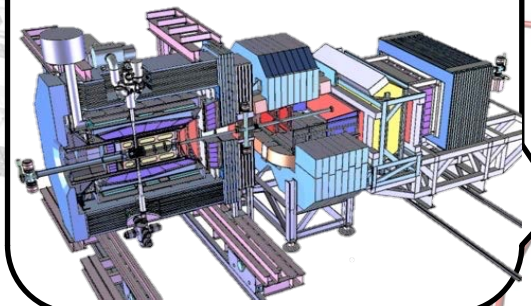


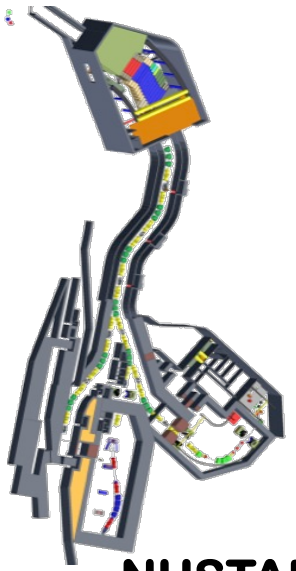
APPA

CBM/HADES



PANDA

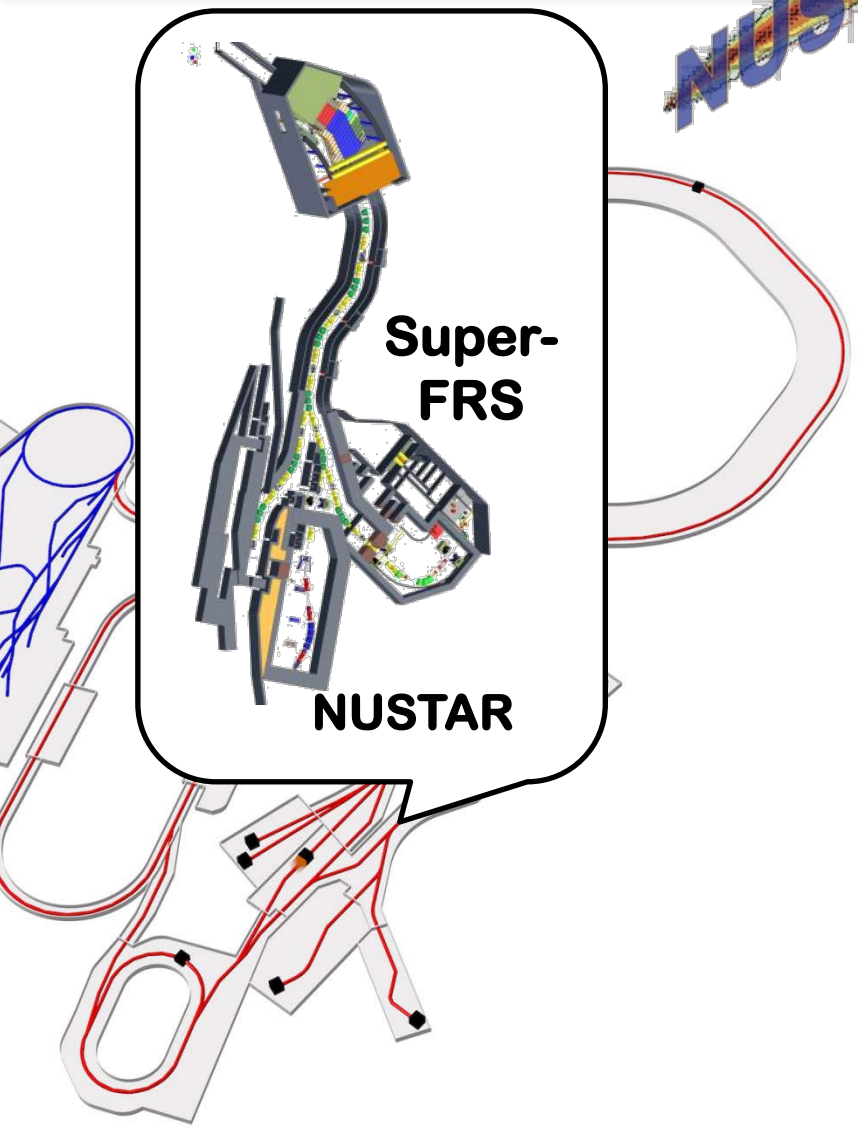




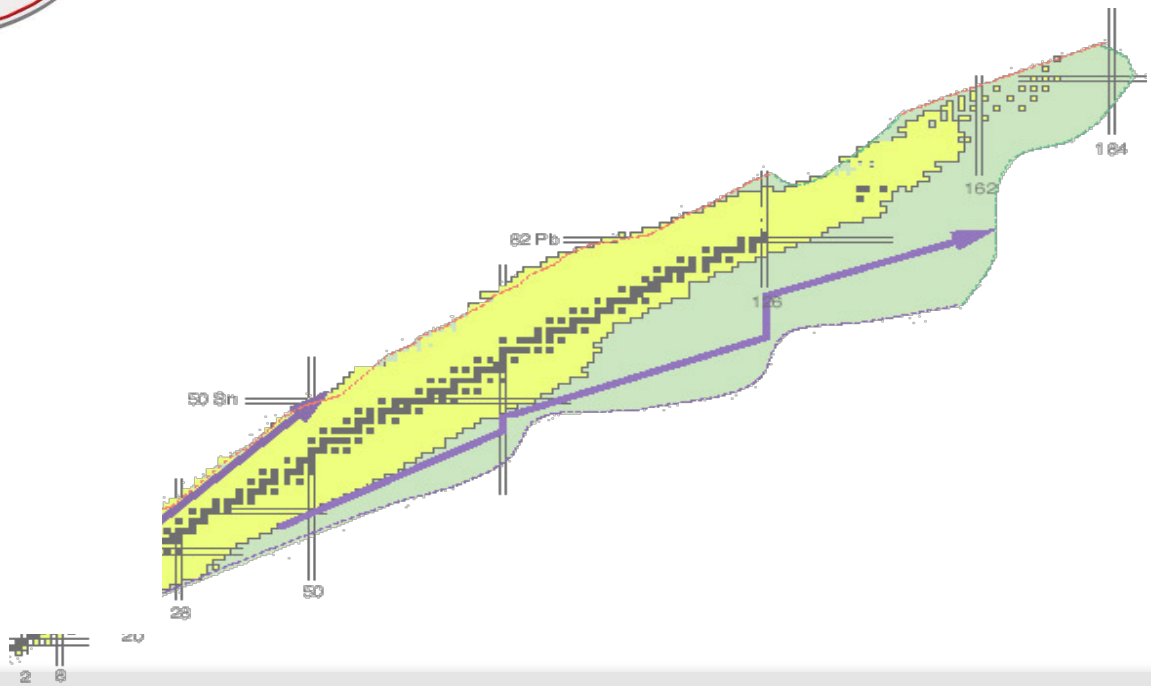
NUSTAR

- Experiments funded
  - by 78 M€ through shares
  - remaining 2/3 by additional funds from shareholders and non-shareholders

NUSTAR



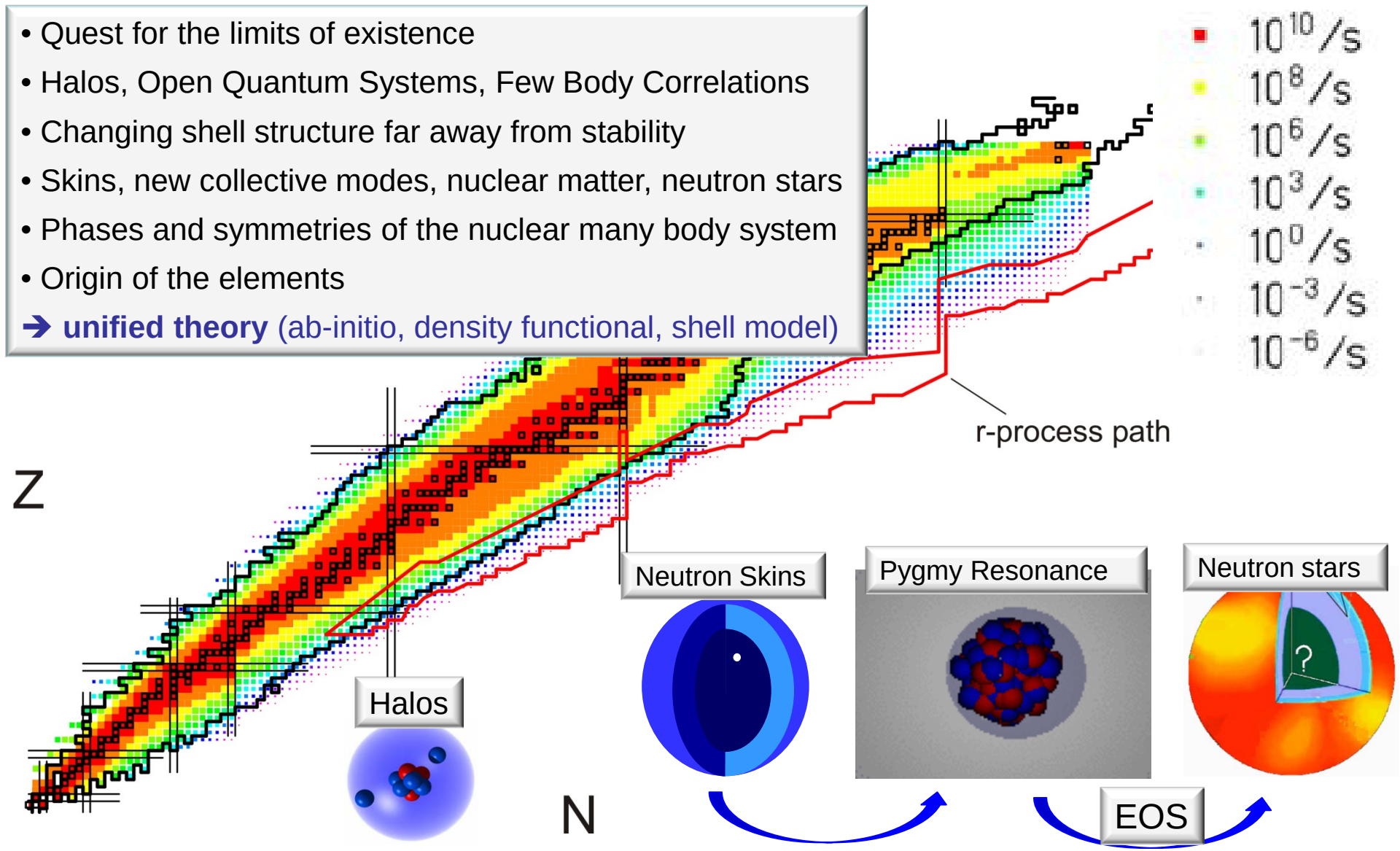
- Nuclear Structure, Astrophysics and Reactions
  - About 800 members



Central Topics for NuSTAR at FAIR *How are nuclei made?*

- Quest for the limits of existence
- Halos, Open Quantum Systems, Few Body Correlations
- Changing shell structure far away from stability
- Skins, new collective modes, nuclear matter, neutron stars
- Phases and symmetries of the nuclear many body system
- Origin of the elements

➔ **unified theory** (ab-initio, density functional, shell model)



Nuclear Astrophysics at FAIR

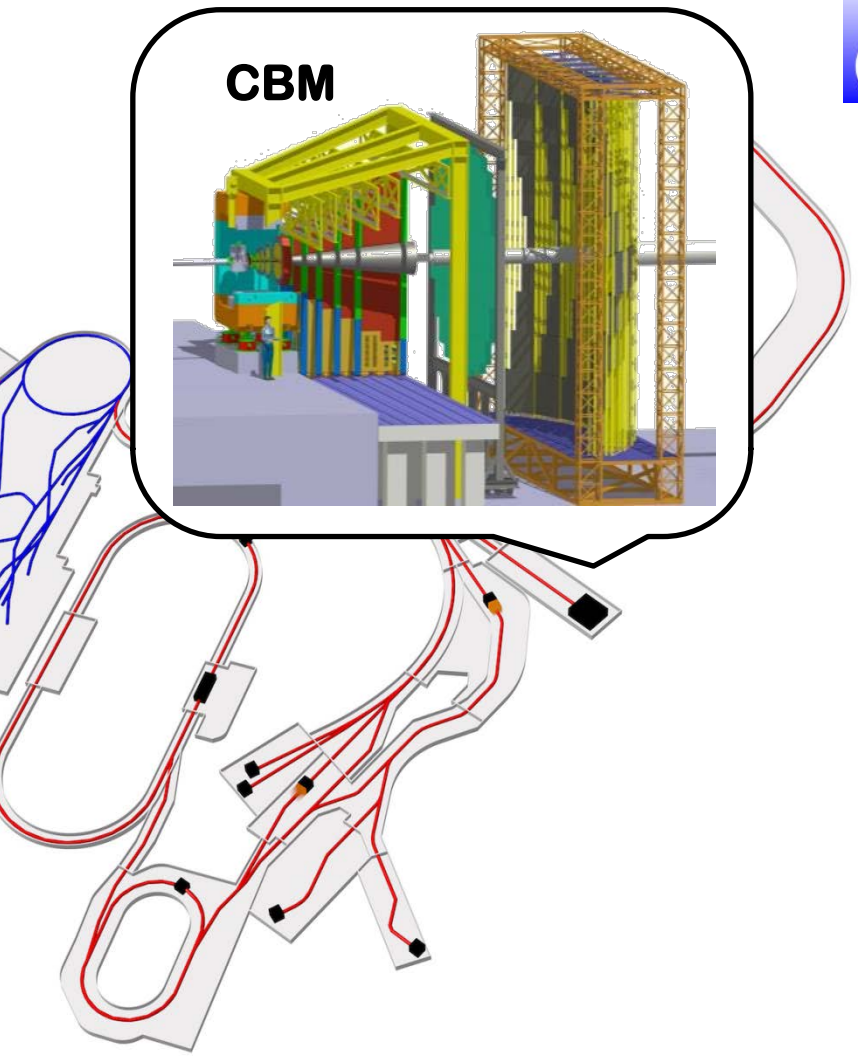
FAIR will provide unique access to many nuclei relevant in explosive nucleosynthesis

rp-, p-process:
- masses at & beyond the proton drip-line
- (p,g), (g,p) rates

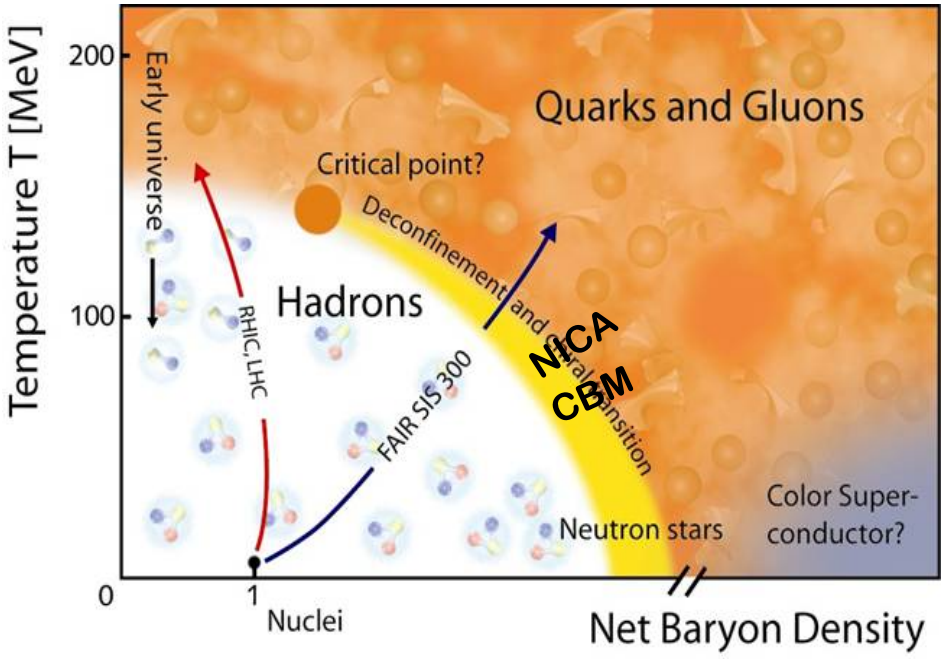
r-process:
- masses, half-lives
- b-delayed neutron emission
- (g,n), (n,g) rates
- shell structure

➔ Combine accurate **nuclear physics** with precision **astronomy** to **constrain astrophysical scenarios**

CBM



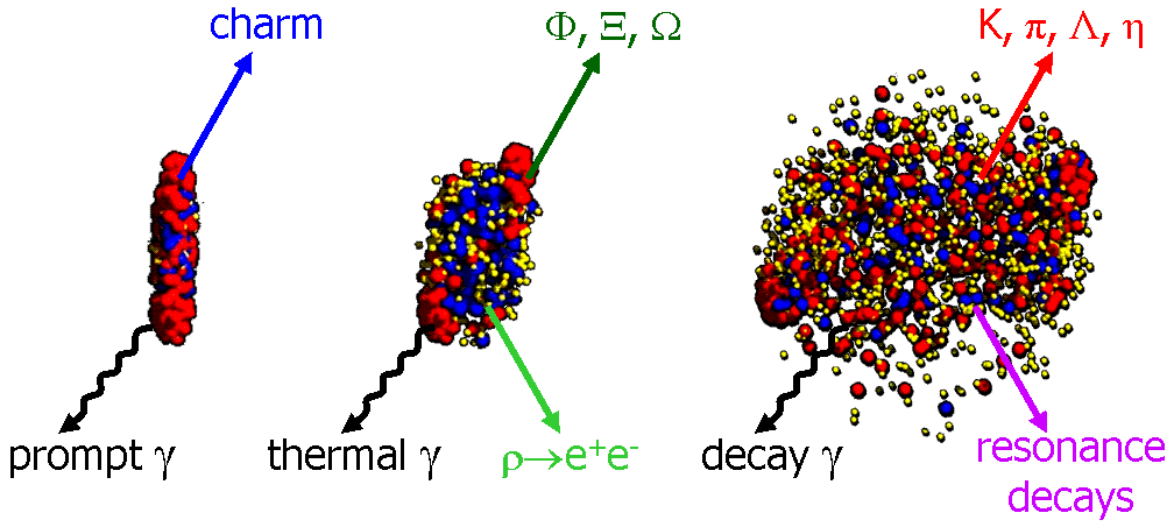
- **Compressed Baryonic Matter**
  - **About 400 members**



Exploring the properties of dense nuclear matter looking into the fireball

The CBM physics case:

- The equation-of-state at high ρ_B
- Searching for the deconfinement phase transition
- QCD critical endpoint
- Chiral symmetry restoration



Diagnostic probes of the high-density phase:

- open charm, charmonia
- low-mass vector mesons
- multistrange hyperons
- flow, fluctuations, correlations

Future projects to explore the QCD phase diagram at large μ_B:

RHIC energy-scan, NA61@SPS, MPD@NICA ..... bulk observables

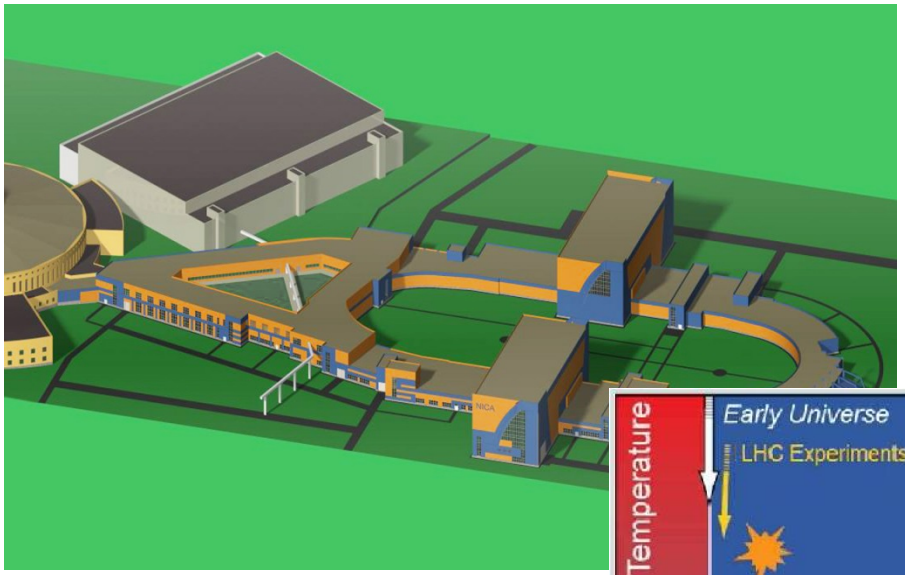
CBM@FAIR .... bulk and **rare observables**

Driving CBM experimental requirements in precision and rates

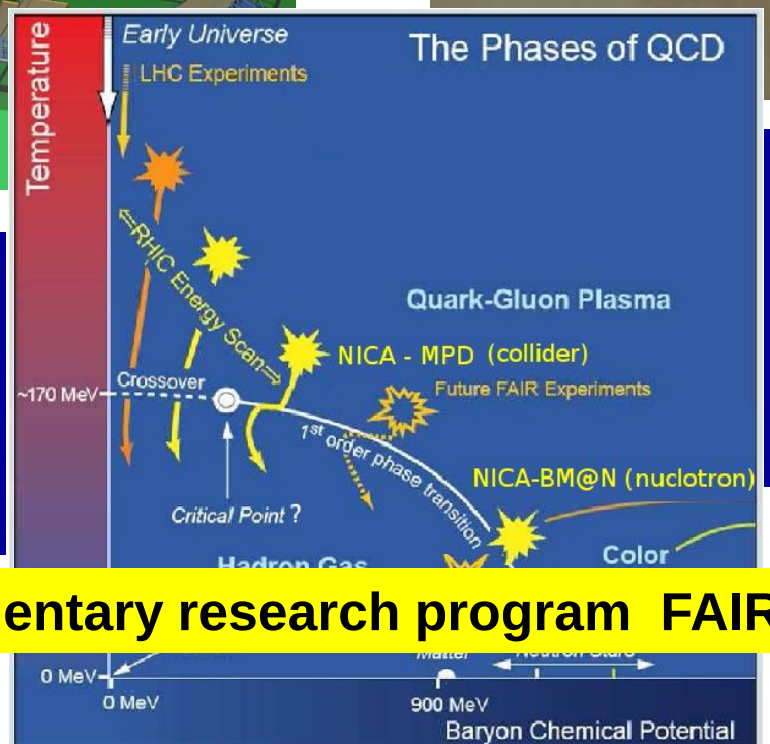
FAIR + NICA : extreme state of nuclear matter

NICA/MPD

***N**uclotron-based **I**on **C**ollider f**A**cility*



FAIR/CBM



E_{lab} < 60 GeV/n

√sNN = 4 ÷ 11.0 GeV/n

Average luminosity

$10^{27} sm^{-2}s^{-1}$ Au x Au

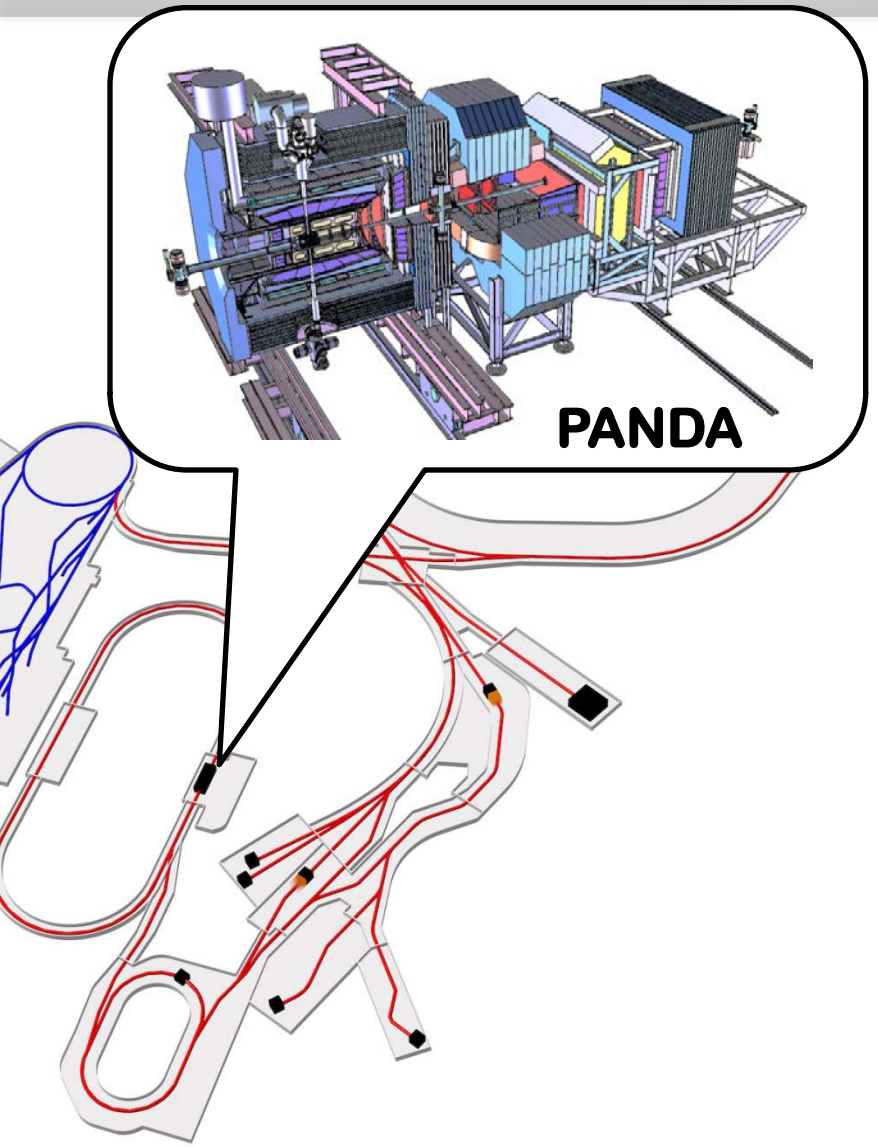
E_{lab} ~ 34 GeV/n

√sNN = 8.5 GeV

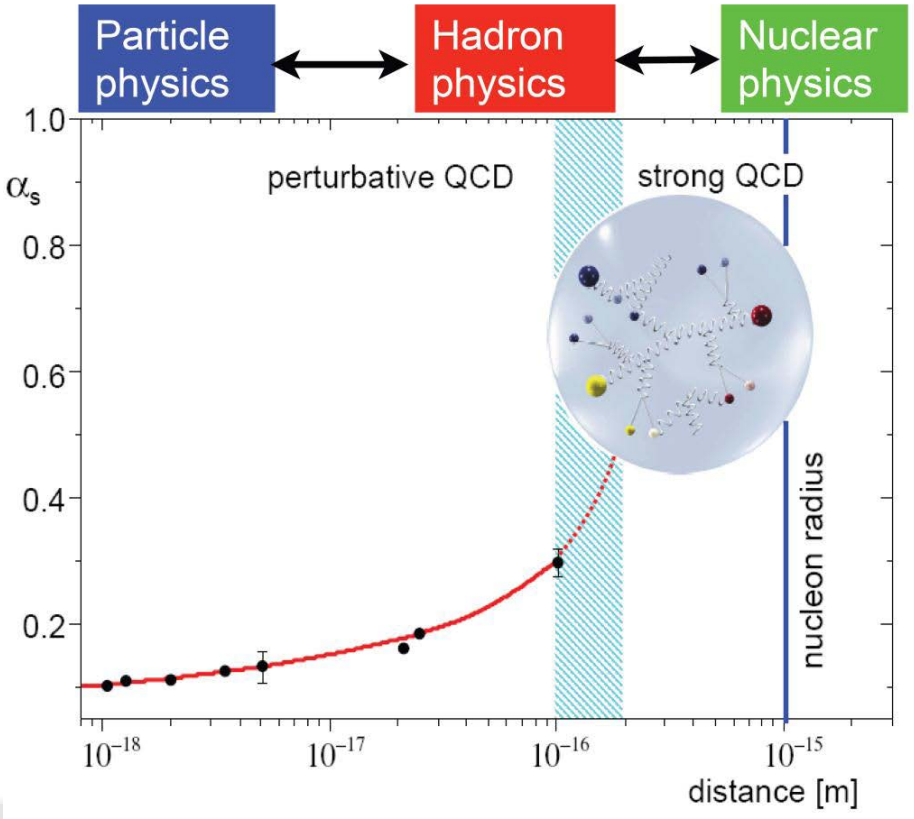
Particle intensity (for U) up to 10^{11} ppp

Complimentary research program FAIR - NICA

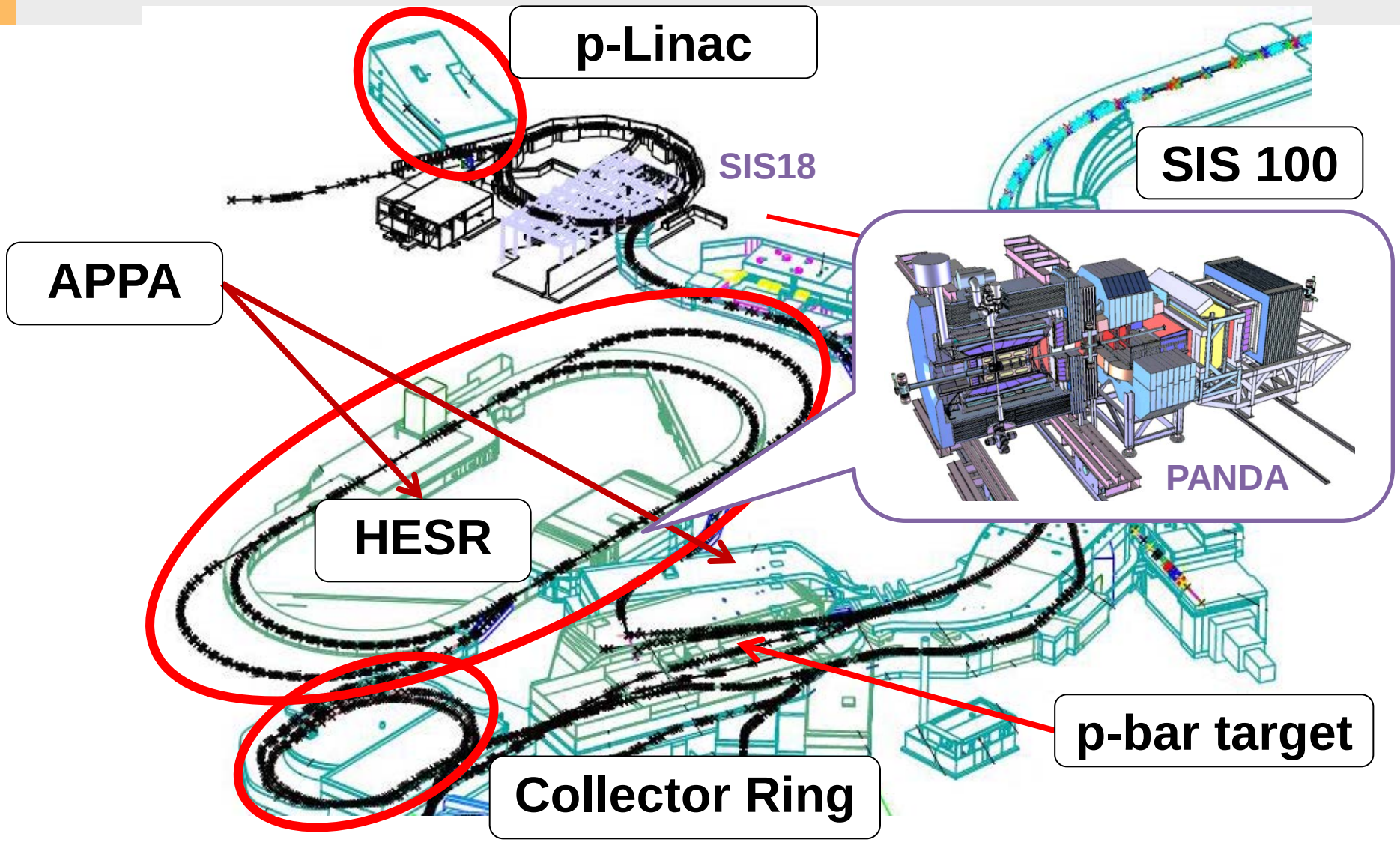
PANDA



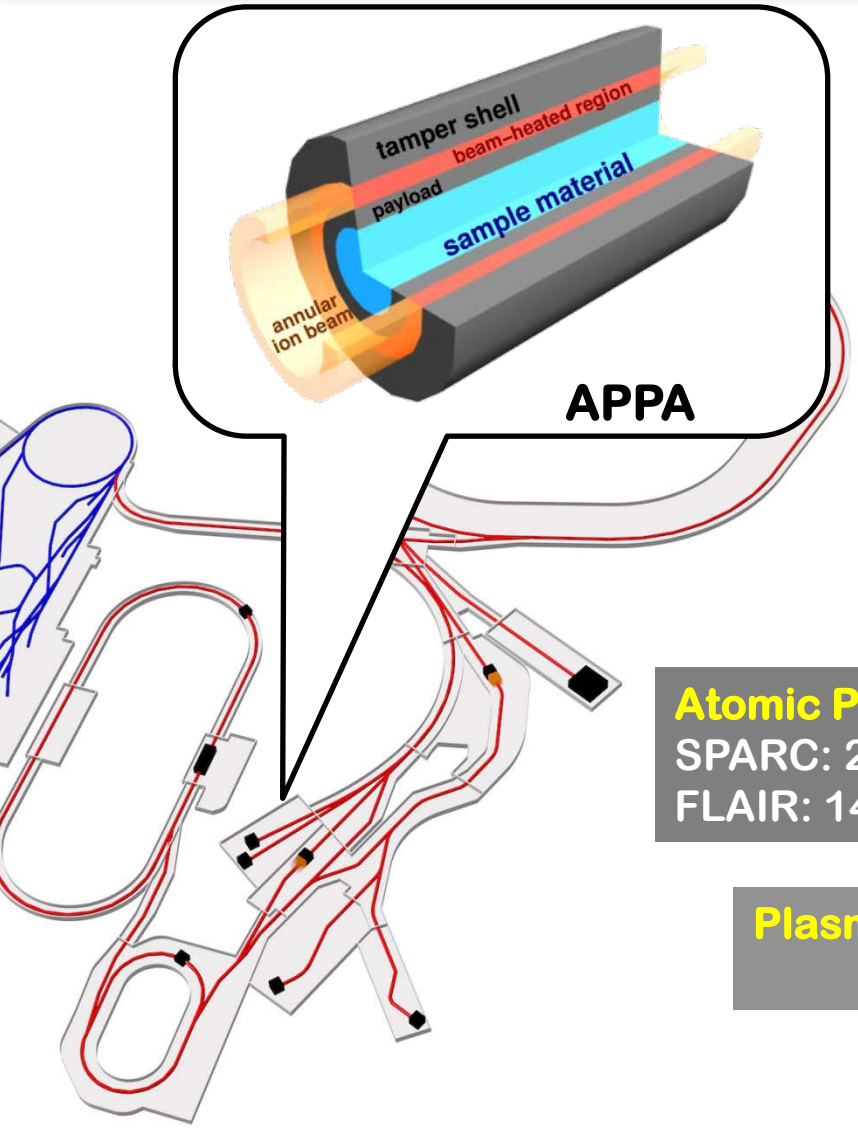
- **Antiproton Annihilations at Darmstadt**
  - **About 500 members**



Anti proton accelerator chain



APPA



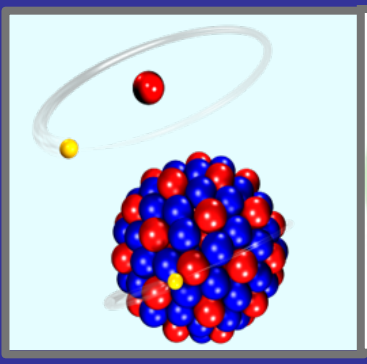
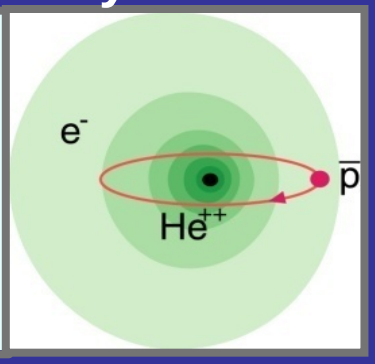
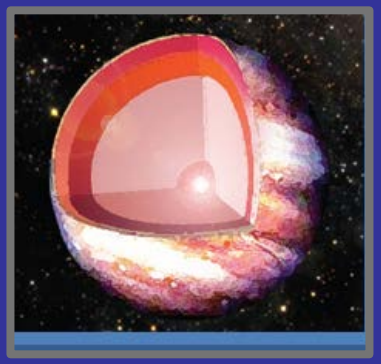
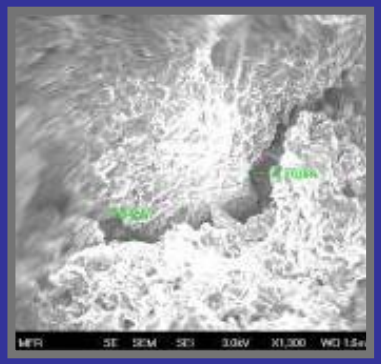
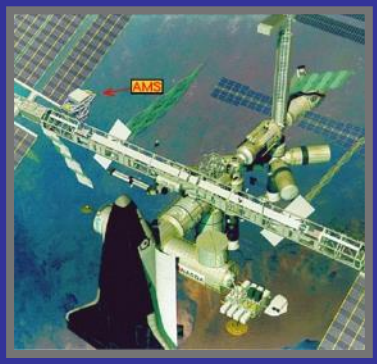
- Atomic, Plasma Physics and Applications
  - About 700 members
  - Wide field of science
    - basic research to material, biological and medical applications

Atomic Physics
SPARC: 284 members from 26 countries
FLAIR: 144 members from 15 countries

Plasma Physics
175 members from 16 countries

Materials Research and Biophysics
BIOMAT: 110 members from 12 countries

APPA Science Case

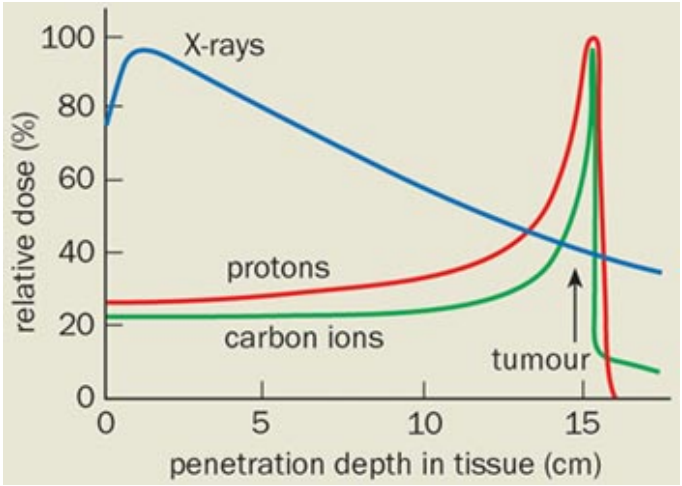
Atomic Physics	Plasma	Materials	Bio
 			
SPARC	**FLAIR**	**HEDgeHOB/WDM**	**MAT/BIOMAT**	**BIO/BIOMAT**
strong field research ... probing of fundamental laws of physics	**anti-matter** ... matter / anti-matter asymmetry	**planetary interiors** ... states of matter common in astrophysical objects	**extreme conditions** ... radiation hardness and modification of materials	**aerospace engineering** ... radiation shielding of cosmic radiation

- **Highest Charge States** — ***Extreme Static Fields***
- **Relativistic Energies** — ***Extreme Dynamical Fields and Ultrashort Pulses***
- **High Intensities** — ***Very High Energy Densities and Pressures***
- **High Charge at Low Velocity** — ***Large Energy Deposition***
- **Low-Energy Anti-Protons** — ***Antimatter Research***

APPA – Biophysics

Heavy ion therapy

- 4d scanning
- moving organs
- non-cancer diseases



Ions in the Bragg peak deposit energy in a much smaller volume than electrons or X-rays

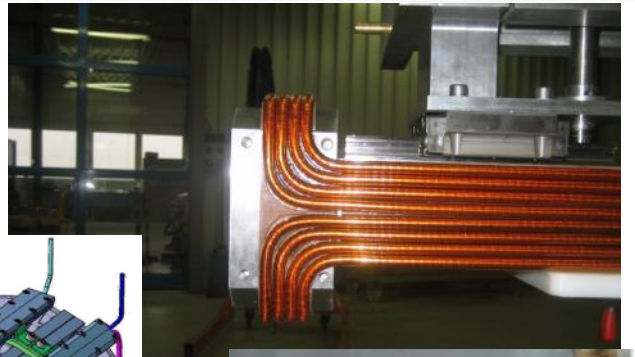
Space radiation

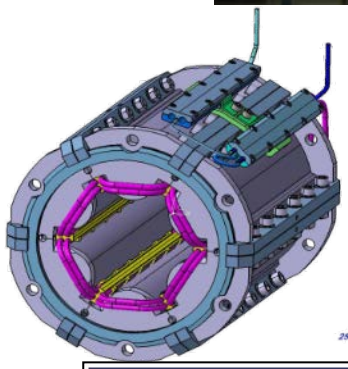
- mission preparations
- biological effects
- passive shielding
- GSI/FAIR ESALAB

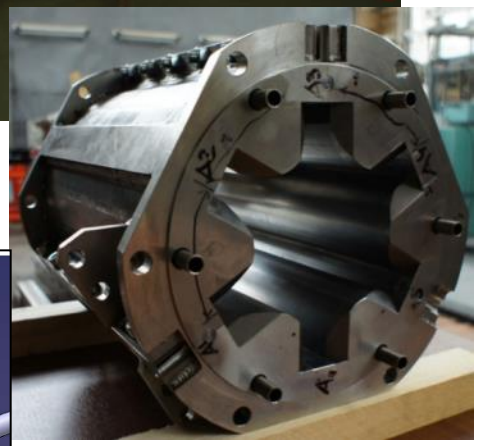
Accelerator's Status

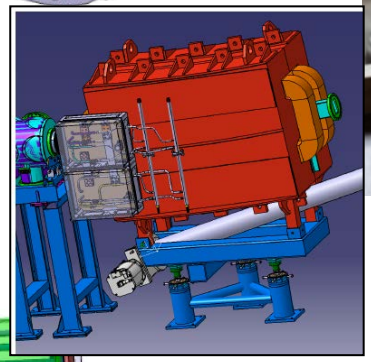
- **Progressing well**

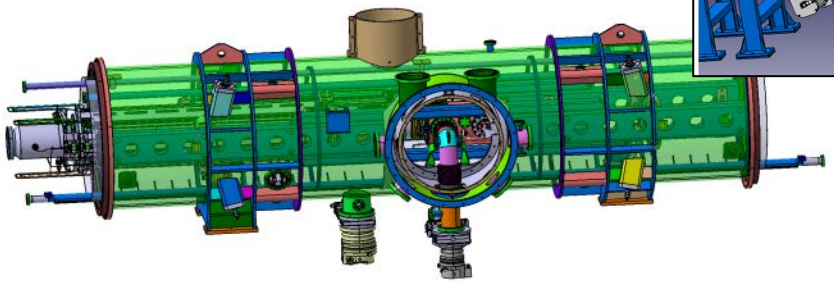
- SIS 100 dipoles
  - First series del.+tested
- SIS 100 sextopoles
  - *Dubna prototype*
- HEBT magnets
  - Efremov, St Petersburg
- SIS 100 quadrupoles
  - *JINR, Dubna*





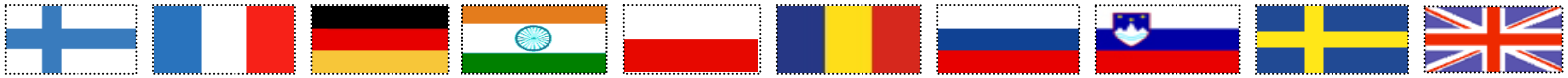






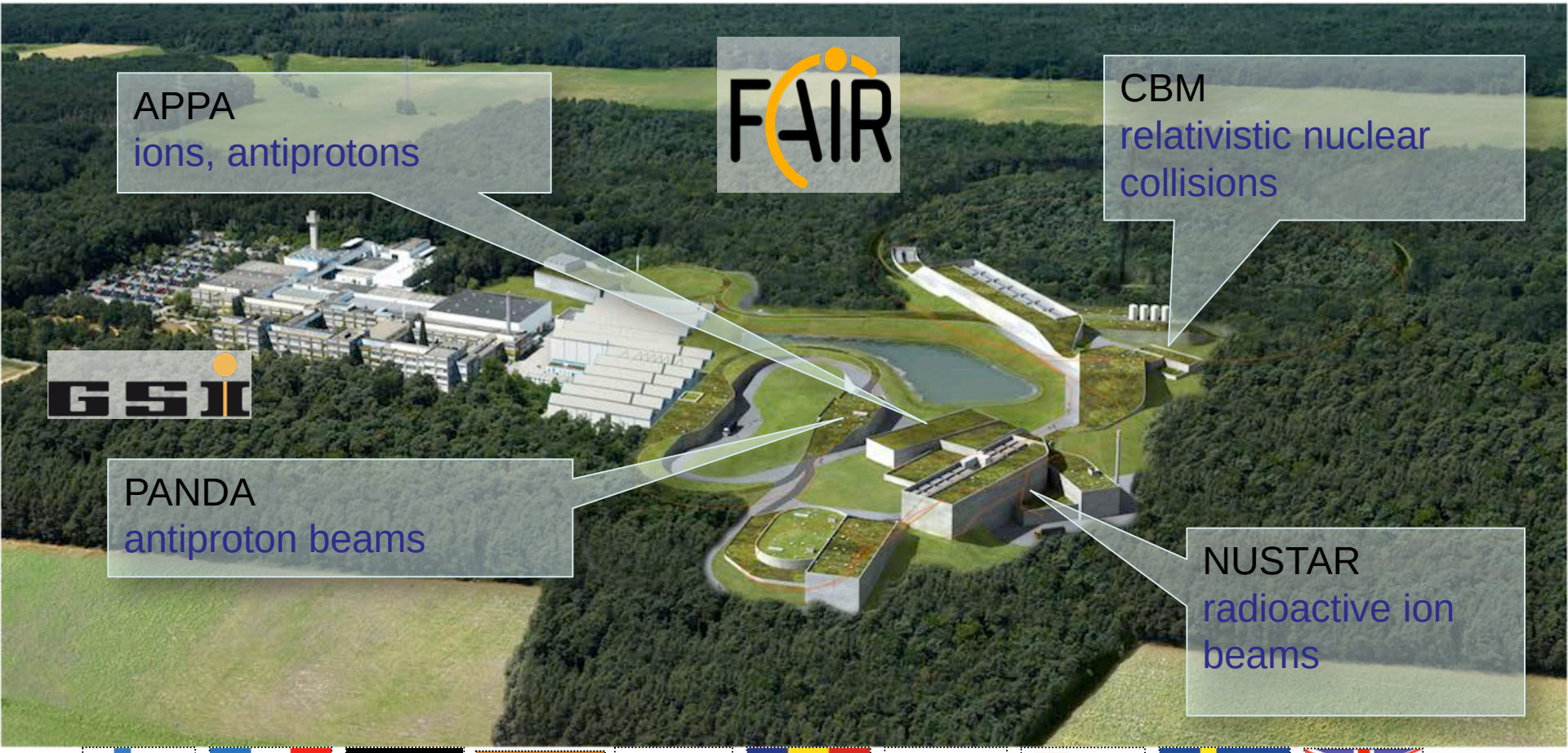
Conclusions

- Technical design and construction of FAIR acc. and FAIR exp. is progressing well.
- FAIR will allow for unique measurements in many fields and remain competitive for decades.
- Rich scientific program and discovery potential with MSV with beams from SIS100.
- Day-one physics with start version in preparation.
- Intermediate (Phase 0) research program of high importance and quality, which also keeps the scientific communities alive.
- More scientists expected to join in the coming years.
- **Cooperation FAIR-NICA is of paramount importance**



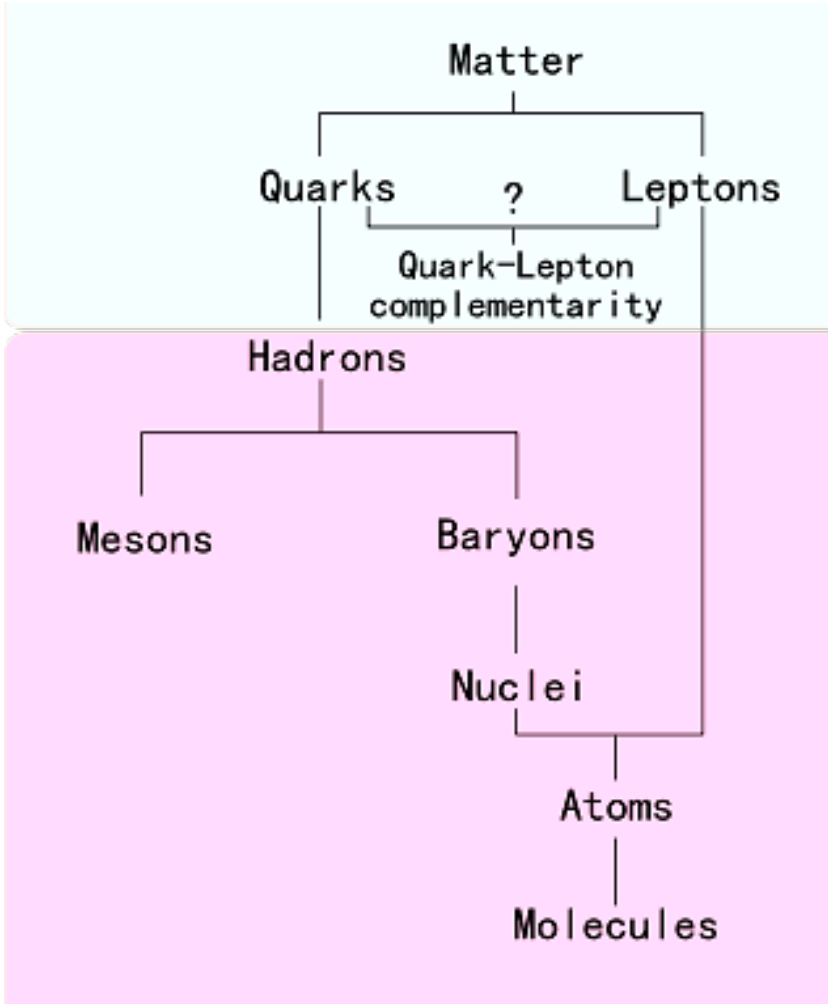
The FAIR Project

Thank you very much !



Finland France Germany India Poland Romania Russia Slovenia Sweden UK

Structure of (Quantum) Matter



LHC @ CERN

FAIR + NICA