

International FAIR

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Scientific Managing Director,

FAIR / MEPhI

In-Kind Nov.2015



Finland



France



Germany



India



Poland



Romania



Russia



Slovenia



Sweden



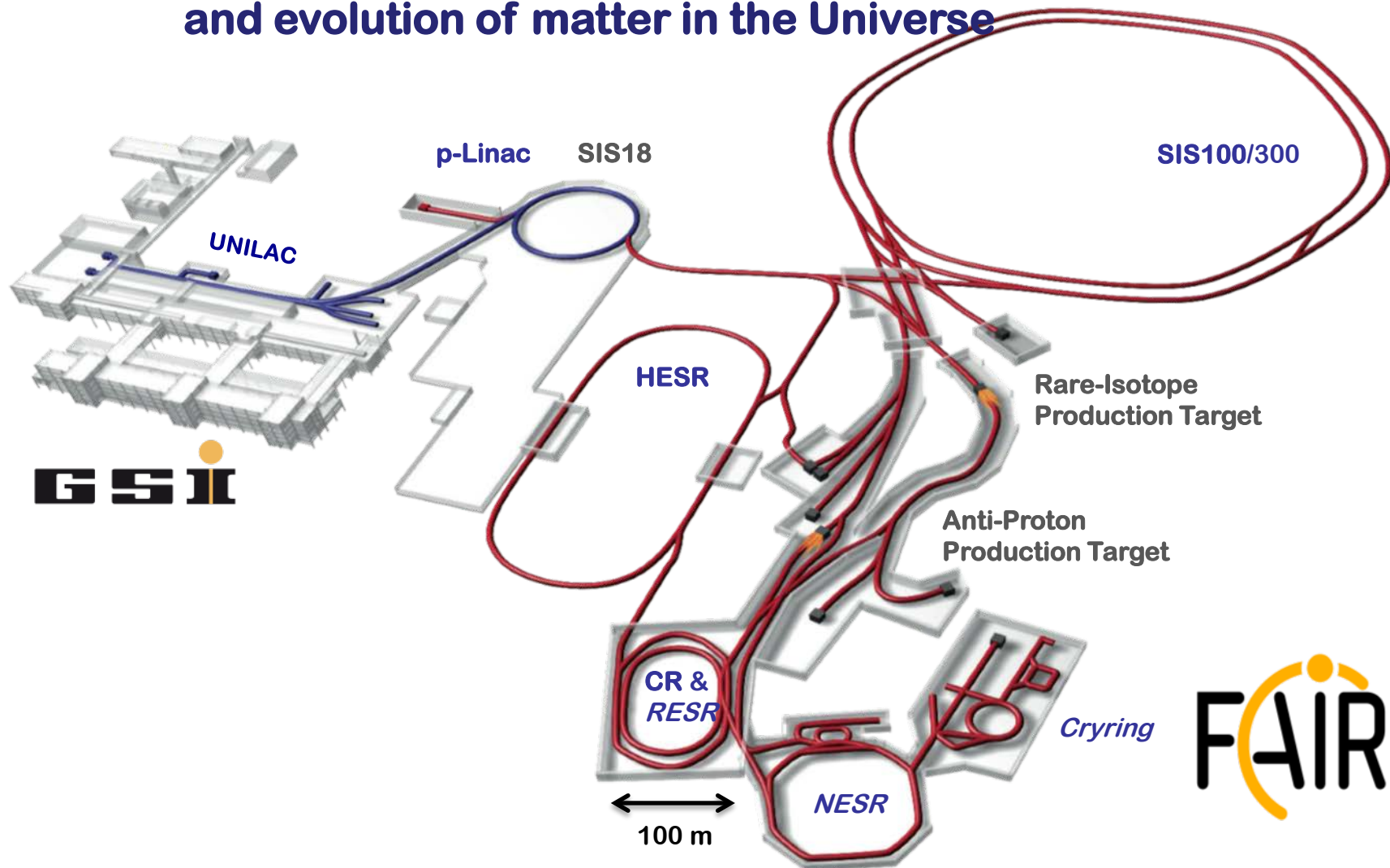
UK



Facility for Antiproton and Ion Research



FAIR – new international research laboratory to explore the nature and evolution of matter in the Universe



The FAIR Project



Primary Beams

- $10^{12}/s$; 1.5 GeV/u; $^{238}\text{U}^{28+}$
- $10^{10}/s$ $^{238}\text{U}^{73+}$ up to 35 GeV/u
- $3 \times 10^{13}/s$ 30 GeV protons

Secondary Beams

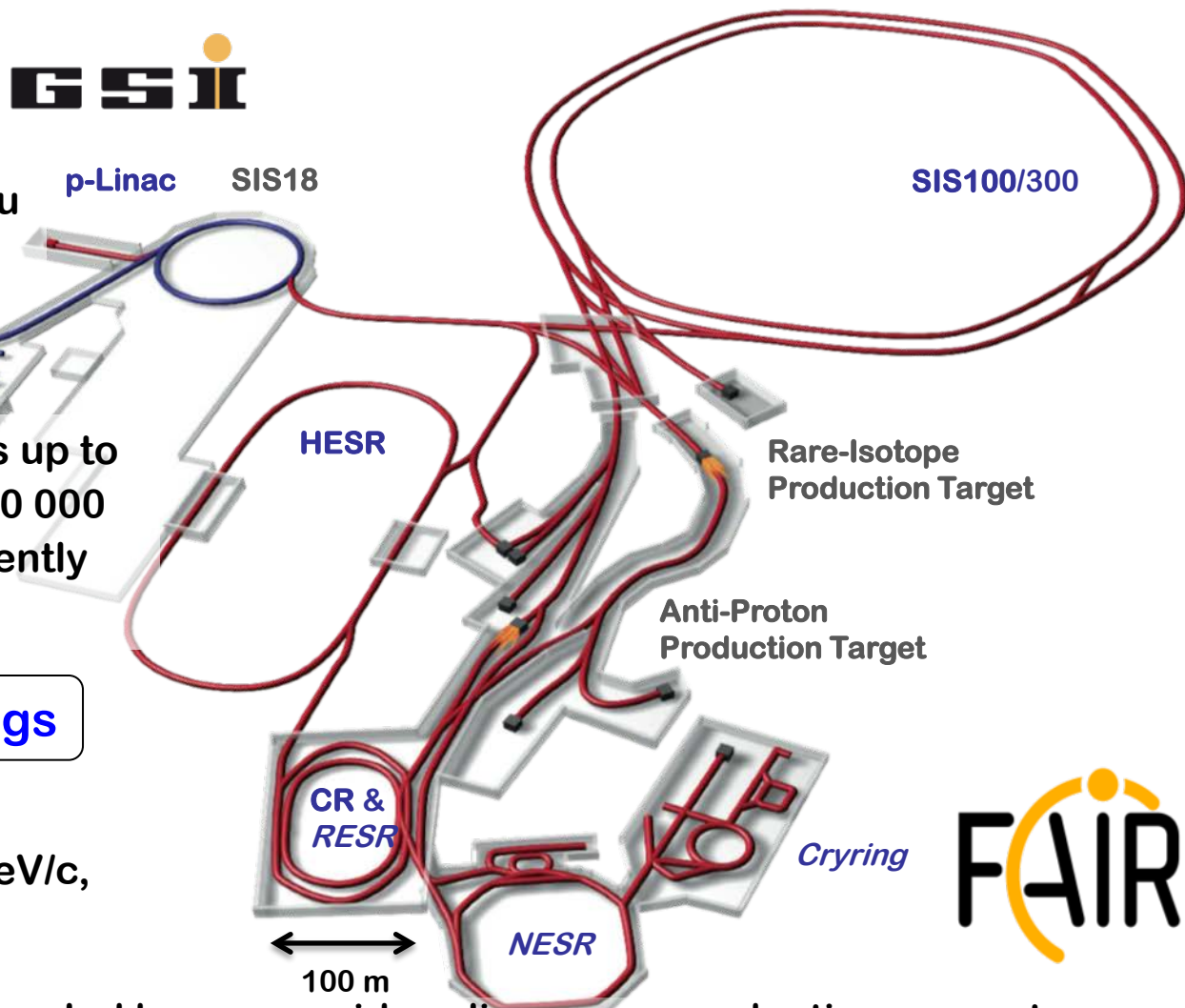
- range of radioactive beams up to 1.5 - 2 GeV/u; up to factor 10 000 higher in intensity than presently
- antiprotons 3 - 30 GeV

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 Antiproton & Ion Research

Nuclear Structure & Astrophysics
(Rare-isotope beams)

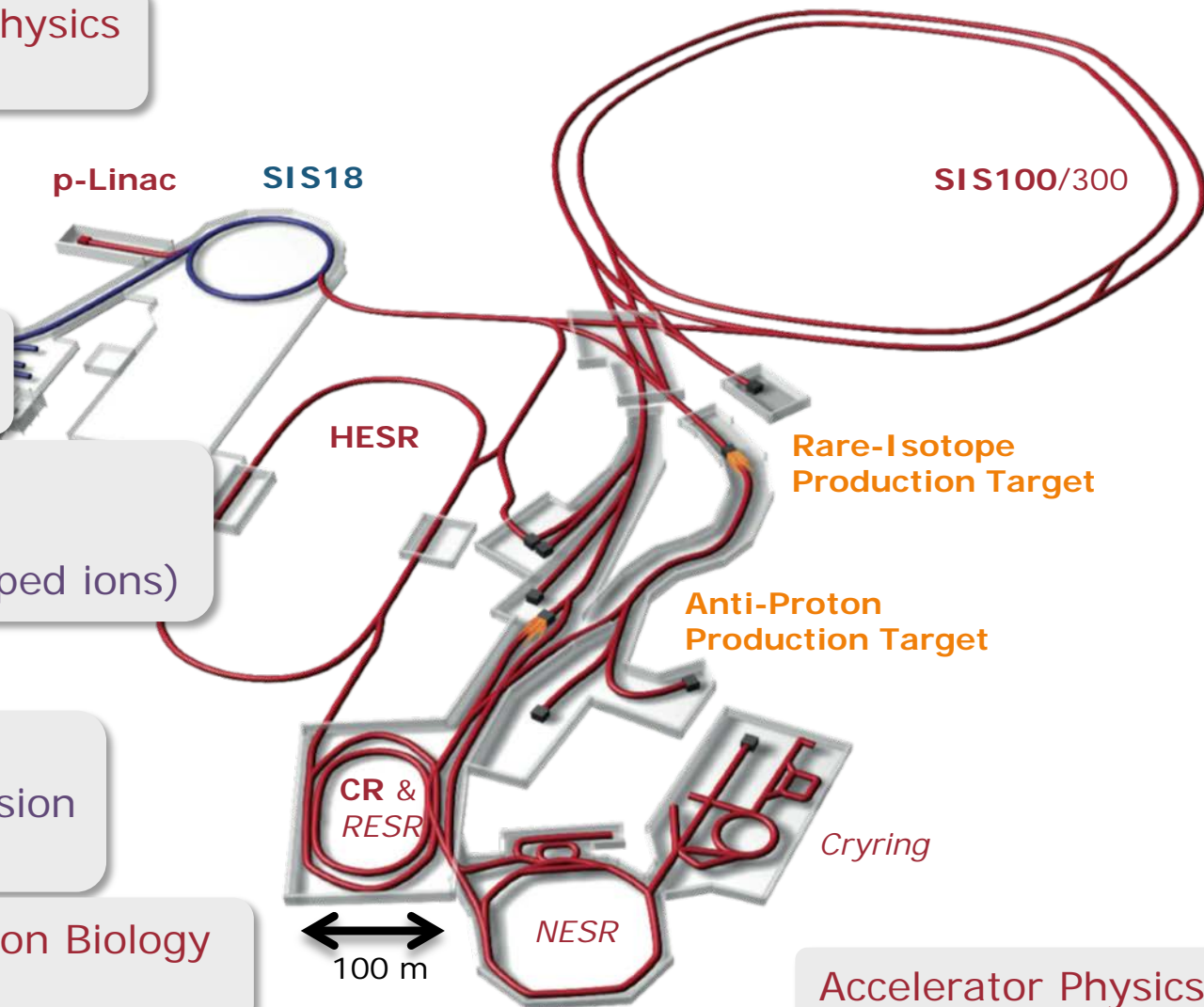
Hadron Physics
(Stored and cooled
14 GeV/c anti-protons)

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 4 Scientific Pillars of FAIR

APPA: Atomic, Plasma Physics and Applications

CBM: Compressed Baryonic Matter

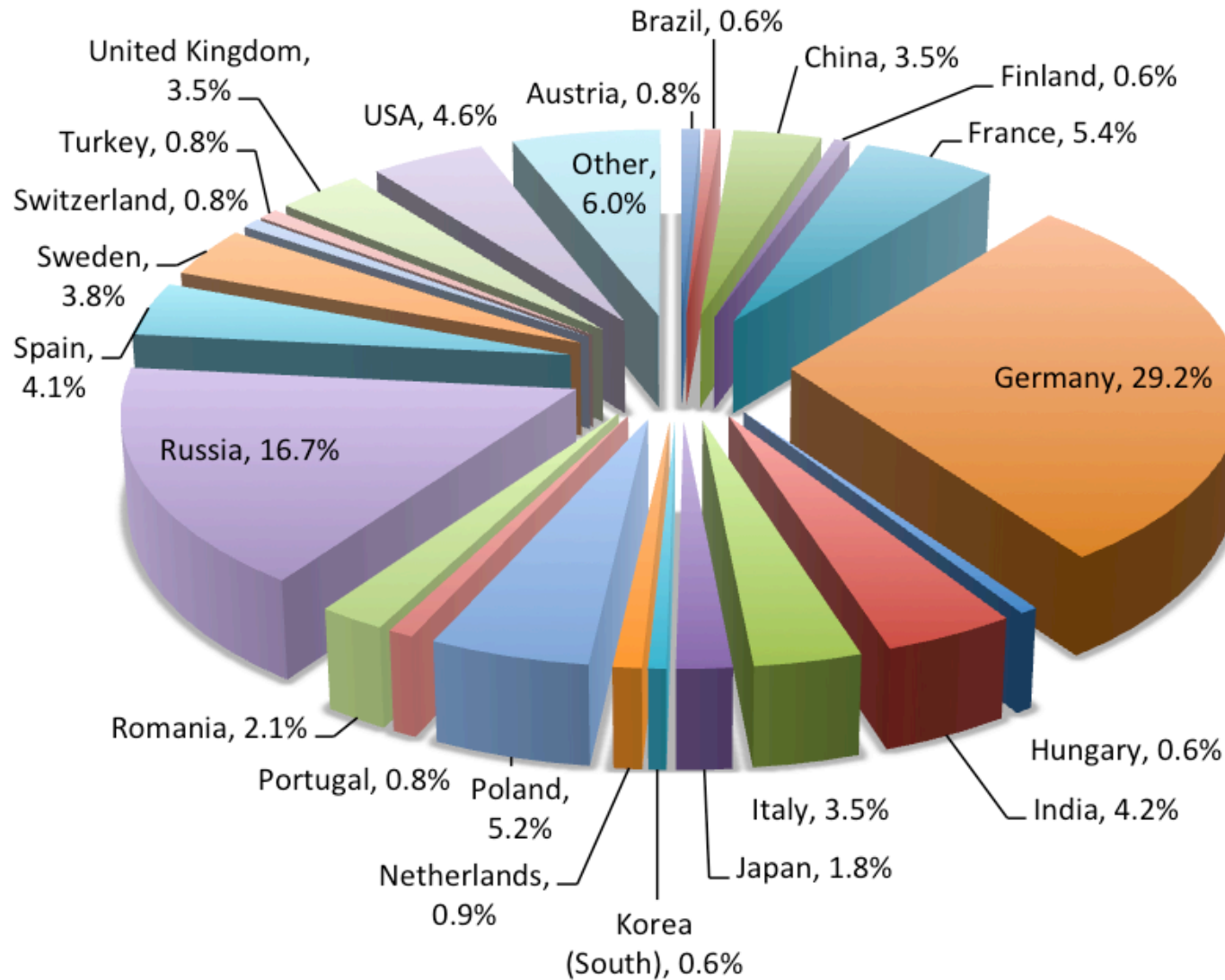
NUSTAR: Nuclear Structure, Astrophysics and Reactions

PANDA: Antiproton Annihilations at Darmstadt





Collaboration Members by Country



In total: 2500 – 3000 Users from about 50 countries ⁷

- Steering company
- International Convention
- Partners

Wiesbaden, 2010



Finland



France



Germany



India



Poland



Romania



Russia



Slovenia



Sweden



UK



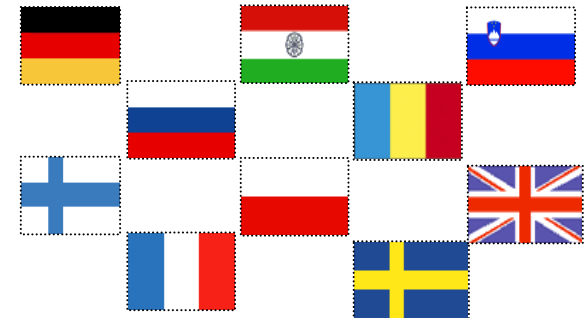
FAIR: an international endeavour

The FAIR Convention: contractual foundation of FAIR

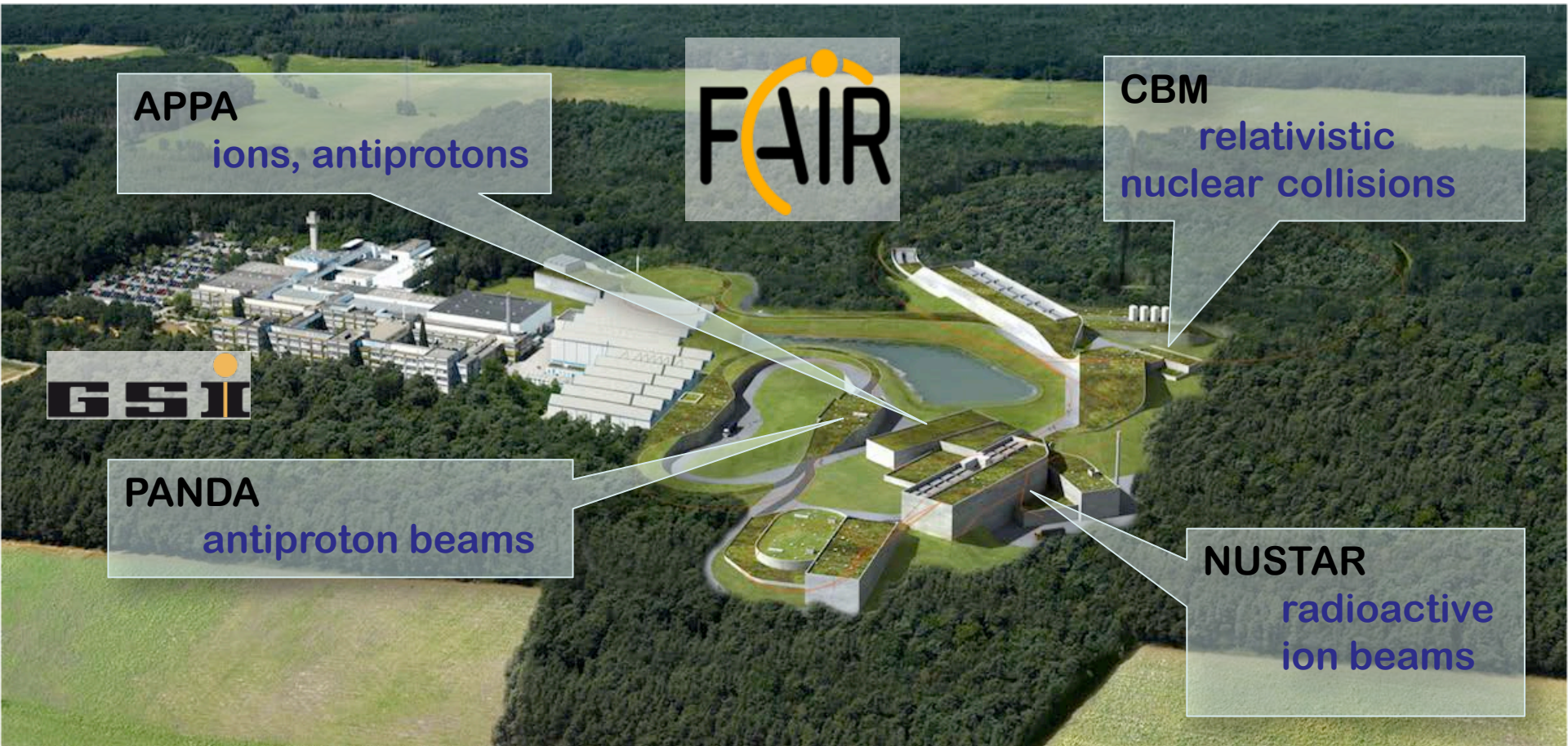
- International convention concerning the construction and operation
- The FAIR company and the GSI collaborate in the construction, commissioning and operation on the basis of long-term agreements.
- International partners provide an interest about 30 %
- Contributions to the construction costs may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

Partners

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

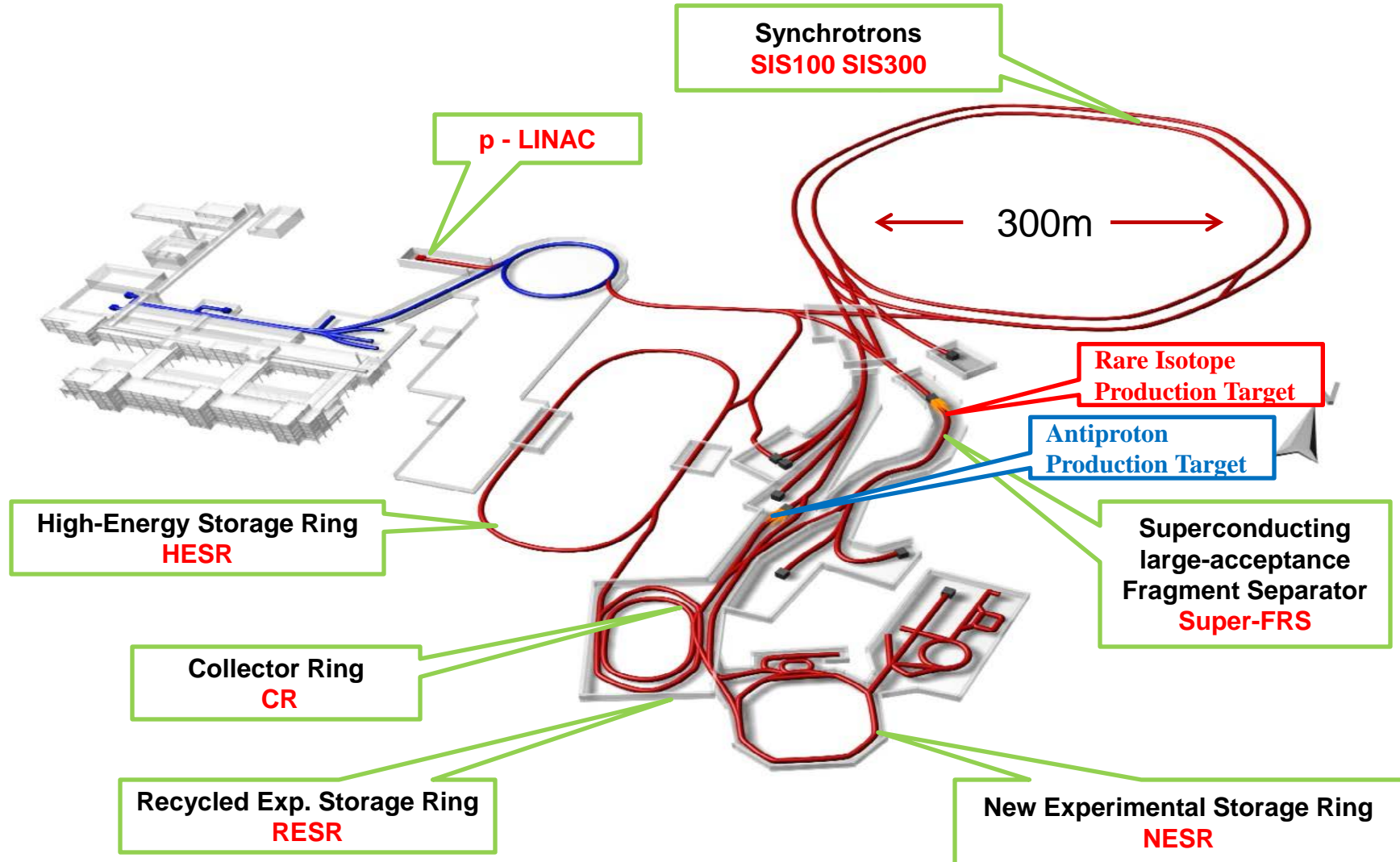


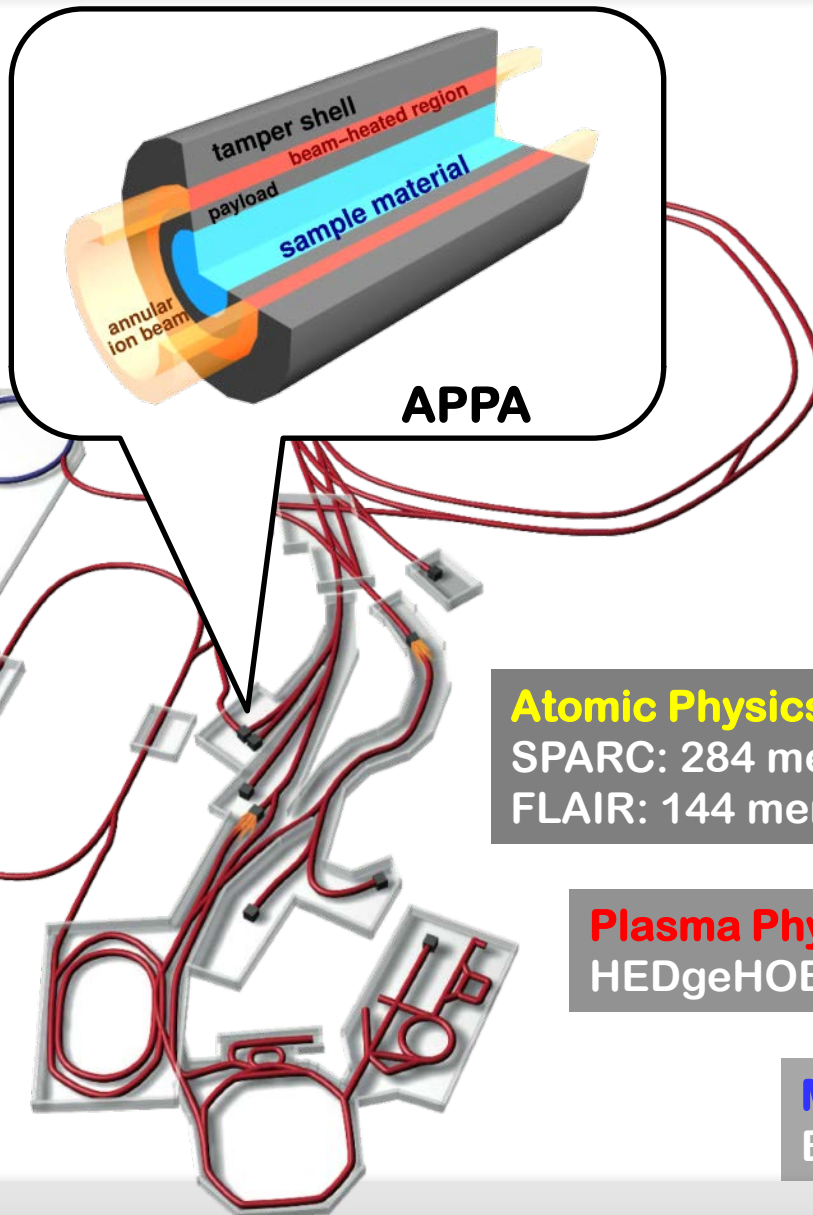
The FAIR Project



Facility for Antiproton and Ions Research – the light tower of the ESFRI Roadmap

New accelerator systems entered the construction phase in Darmstadt





- 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

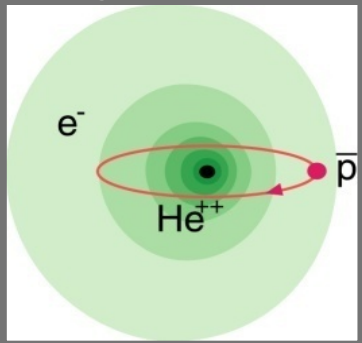
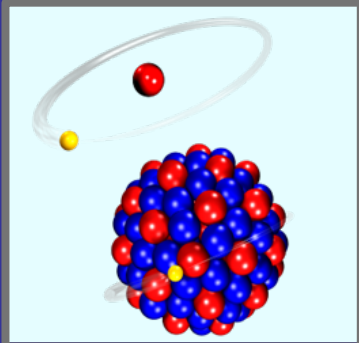
HEDgeHOB & WDM: 175 members from 16 countries

Materials Research and Biophysics

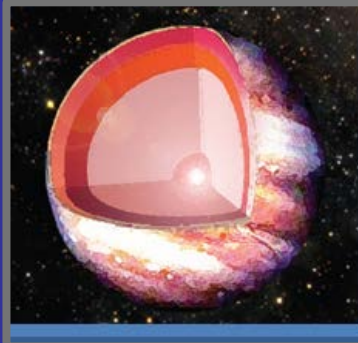
BIOMAT: 110 members from 12 countries

APPA Science Case

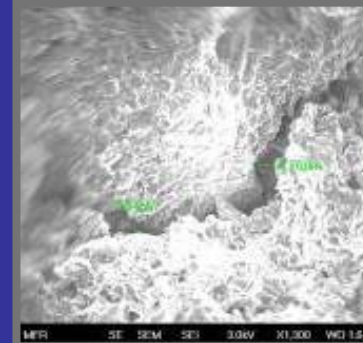
Atomic Physics



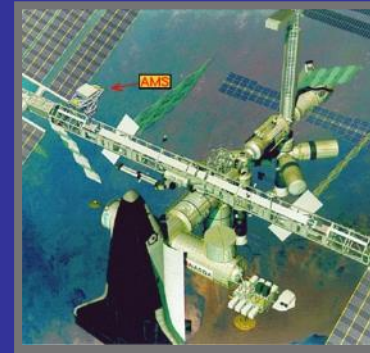
Plasma



Materials



Bio



SPARC

FLAIR

HEDgeHOB/WDM

MAT/BIOMAT

BIO/BIOMAT

**strong field
research**

anti-matter

**planetary
interiors**

**extreme
conditions**

**aerospace
engineering**

... probing of
fundamental laws
of physics

... matter / anti-
matter
asymmetry

... states of matter
common in
astrophysical objects

... radiation hardness
and modification of
materials

... radiation
shielding of cosmic
radiation

- Highest Charge States
- Relativistic Energies
- High Intensities
- High Charge at Low Velocity
- Low-Energy Anti-Protons

Extreme Static Fields

Extreme Dynamical Fields and Ultrashort Pulses

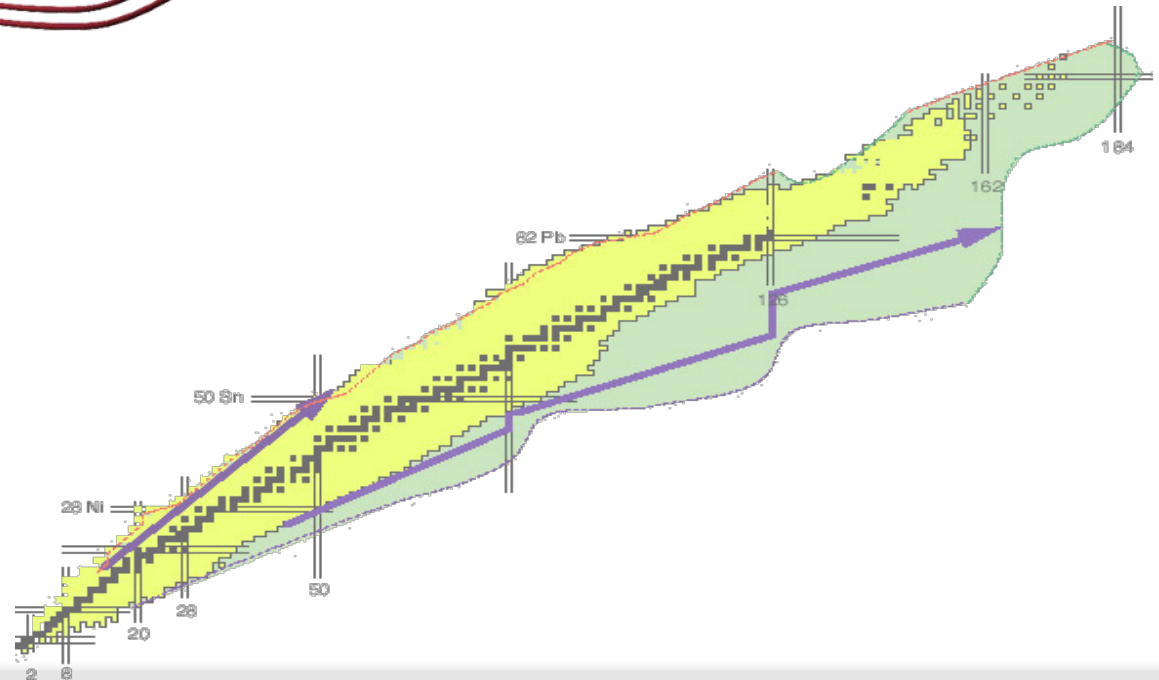
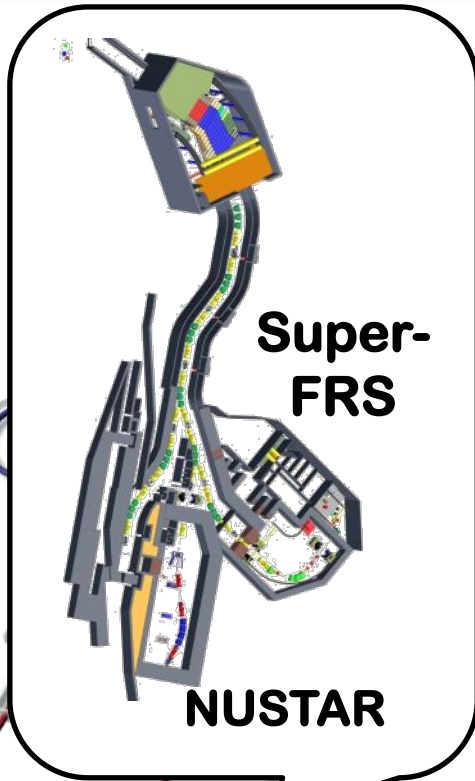
Very High Energy Densities and Pressures

Large Energy Deposition

Antimatter Research

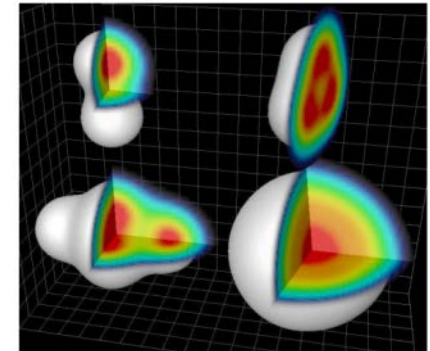


- Nuclear Structure, Astrophysics and Reactions
 - About 800 members



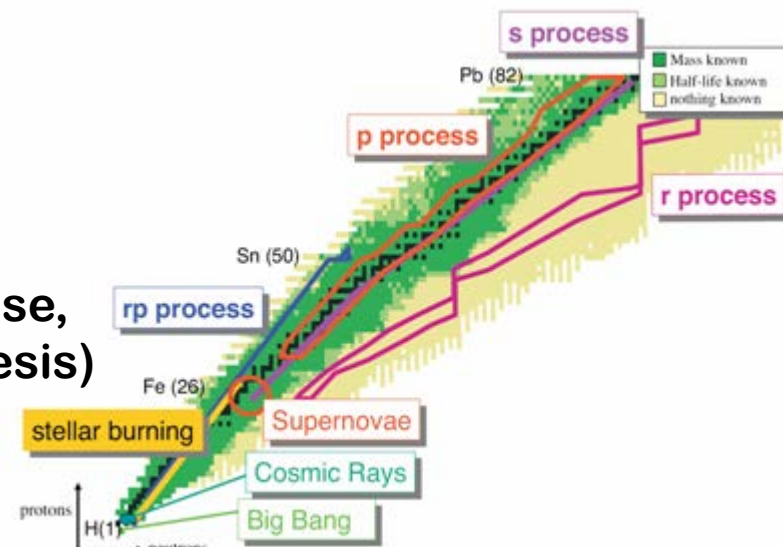
Nuclear structure

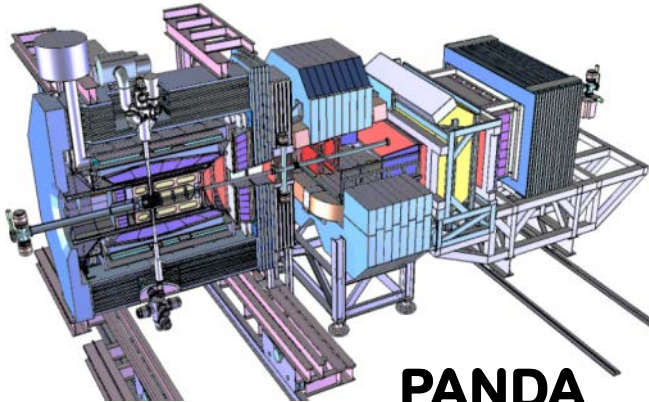
- Underlying QCD structure → complex nucleon-nucleon force
- Study of exotic short lived nuclei far off stability (proton/ neutron skins or halos, new magic numbers...)
→ Pave way for theoretical framework with predictive power for nuclei beyond experimental reach



Astrophysics

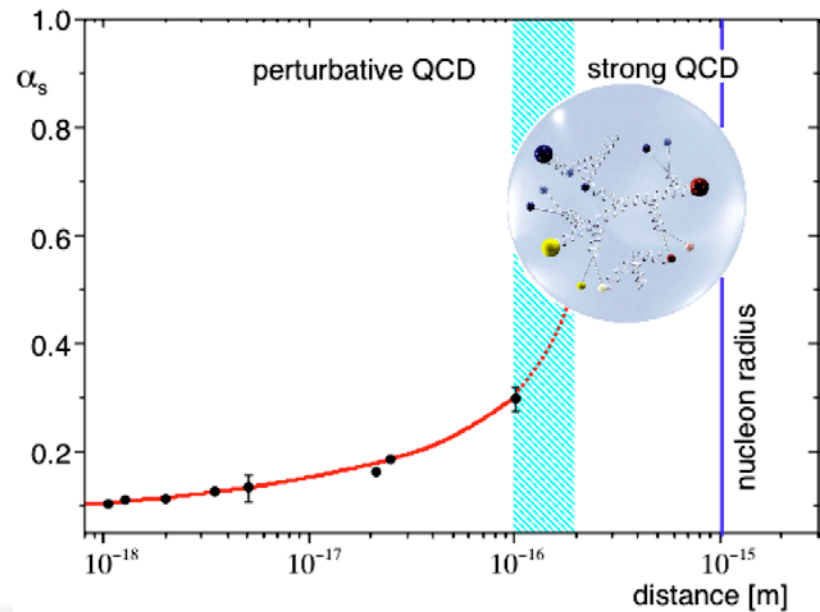
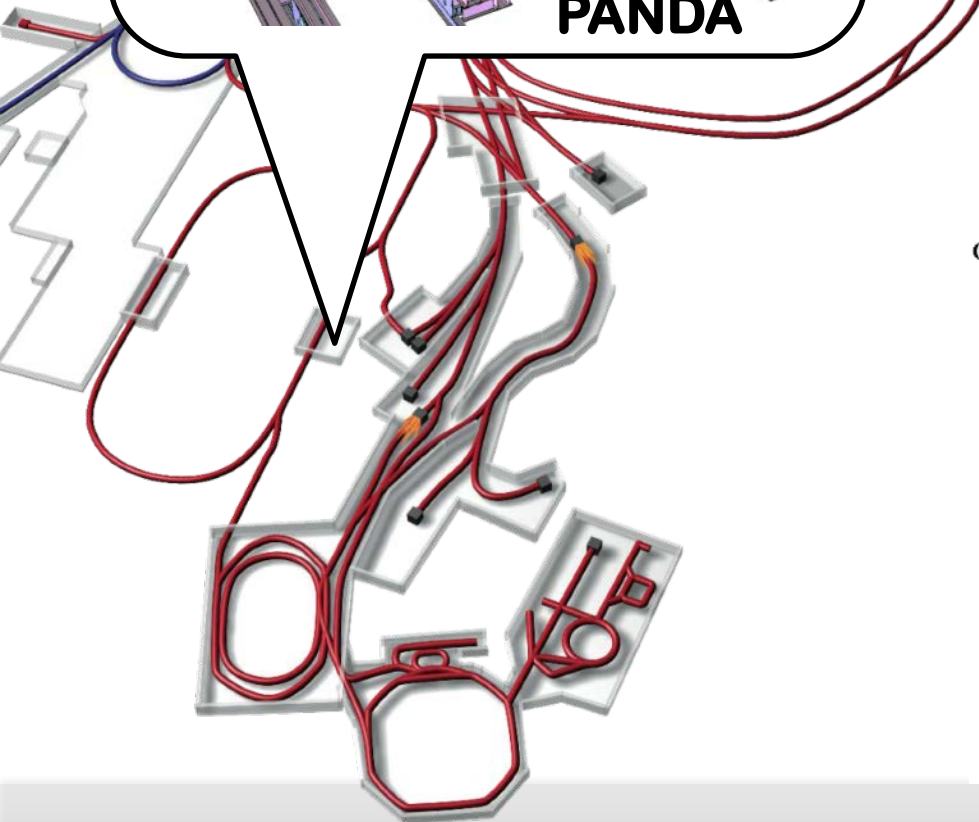
- Origin of the heavy elements?
- Physics of stellar explosions (core-collapse, thermonuclear supernovae, nucleosynthesis)
- Compact objects and the explosions on their surfaces (x-ray bursts)



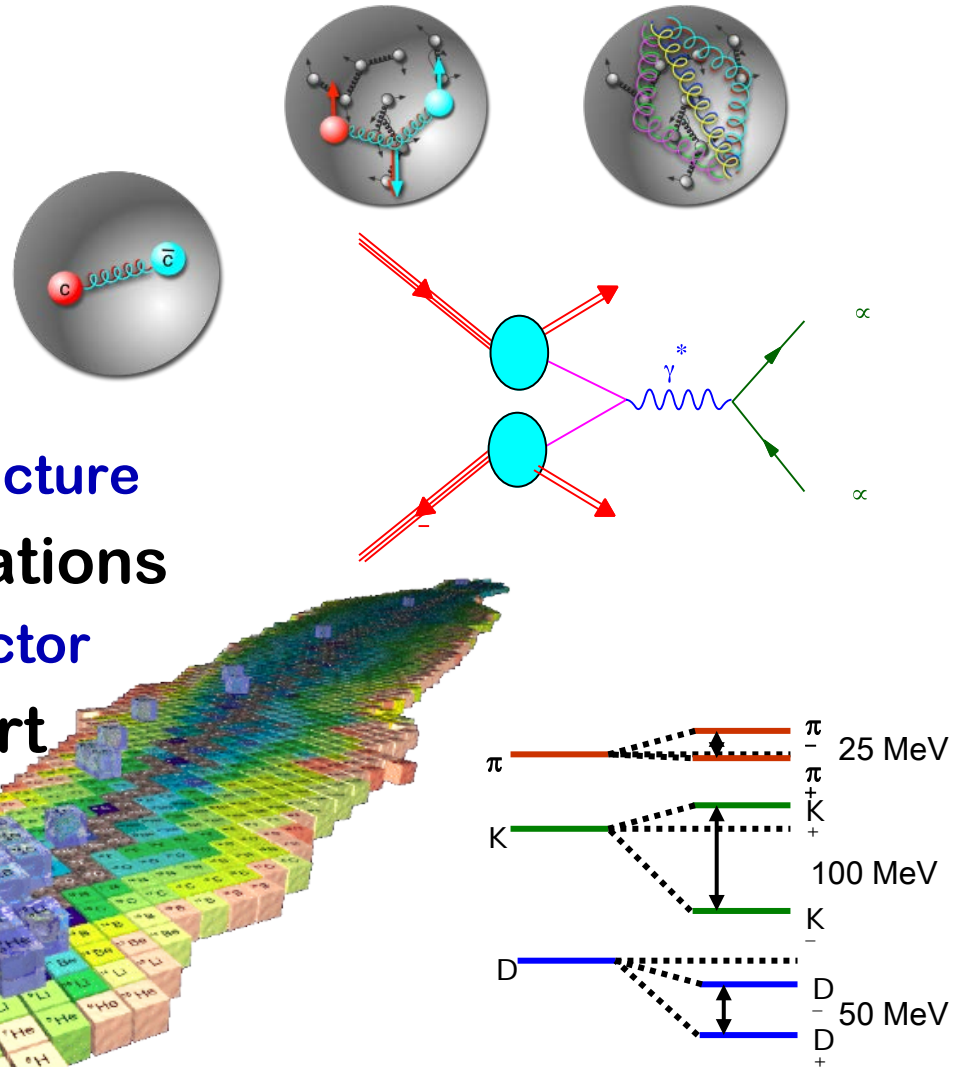
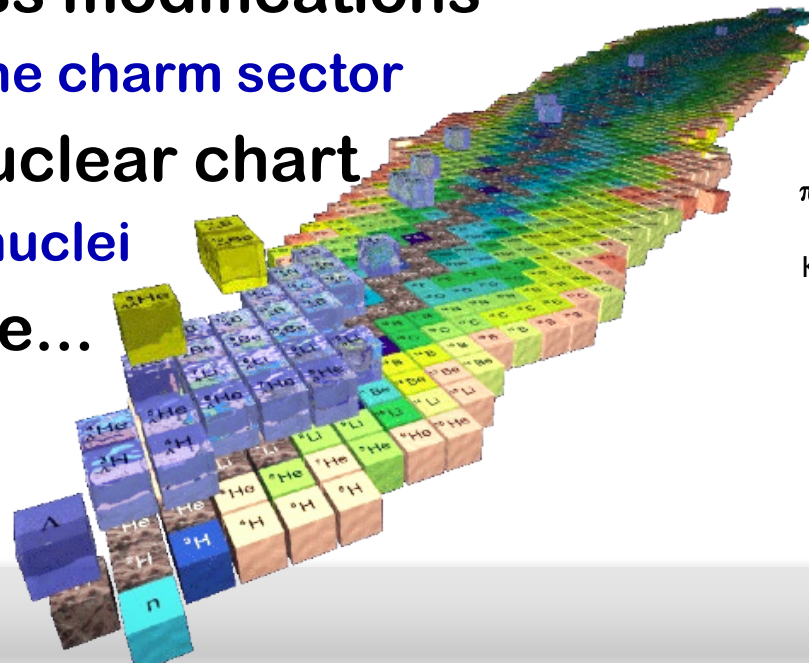


PANDA

- Antiproton Annihilations at Darmstadt
 - About 500 members

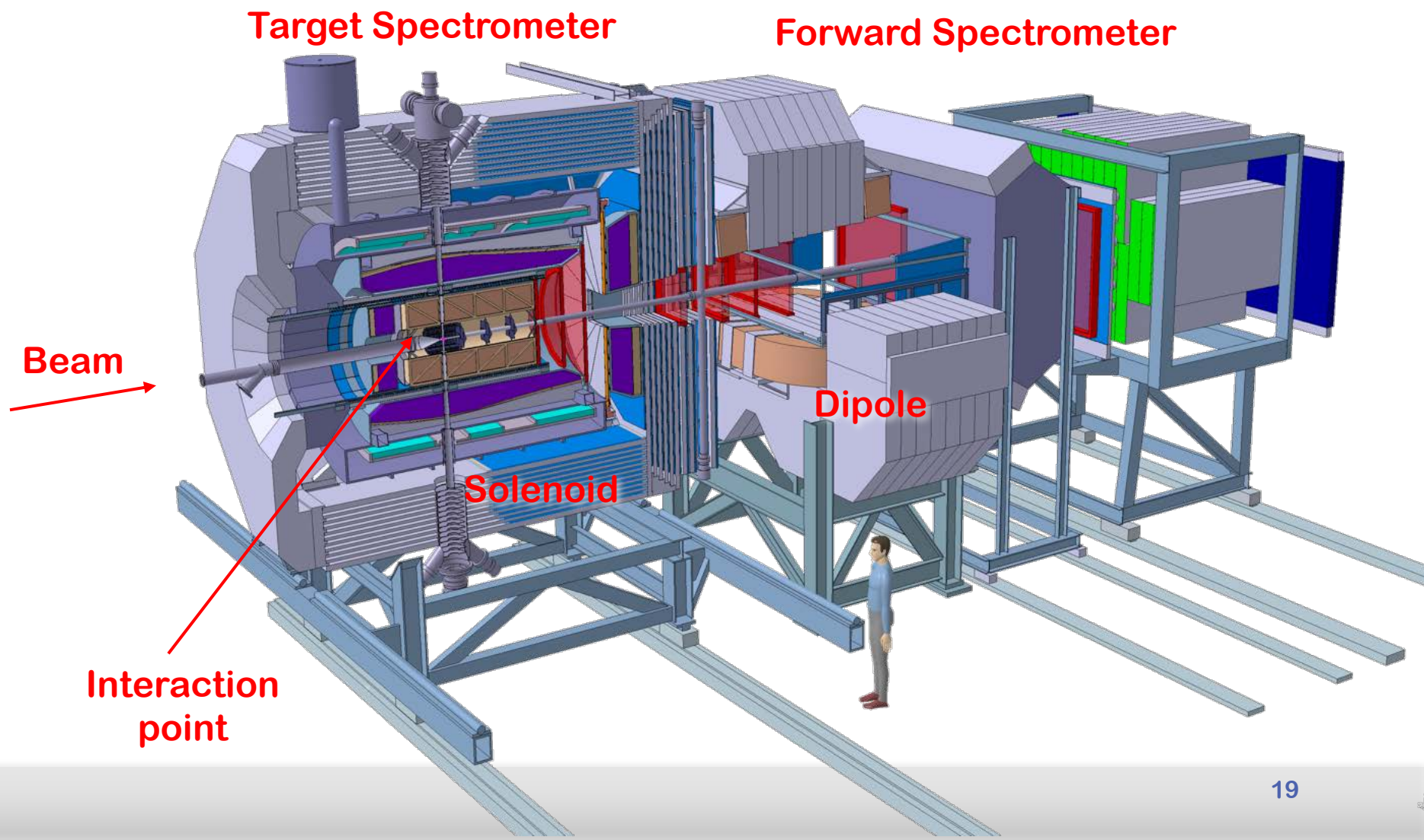


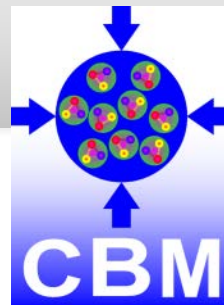
- Gluonic excitations
 - Hybrids, glueballs
- Charmonium states
 - Precision spectroscopy
- Time-like
 - Form factors, nucleon structure
- In medium mass modifications
 - Extension to the charm sector
- Extension of nuclear chart
 - Double hypernuclei
- And much more...



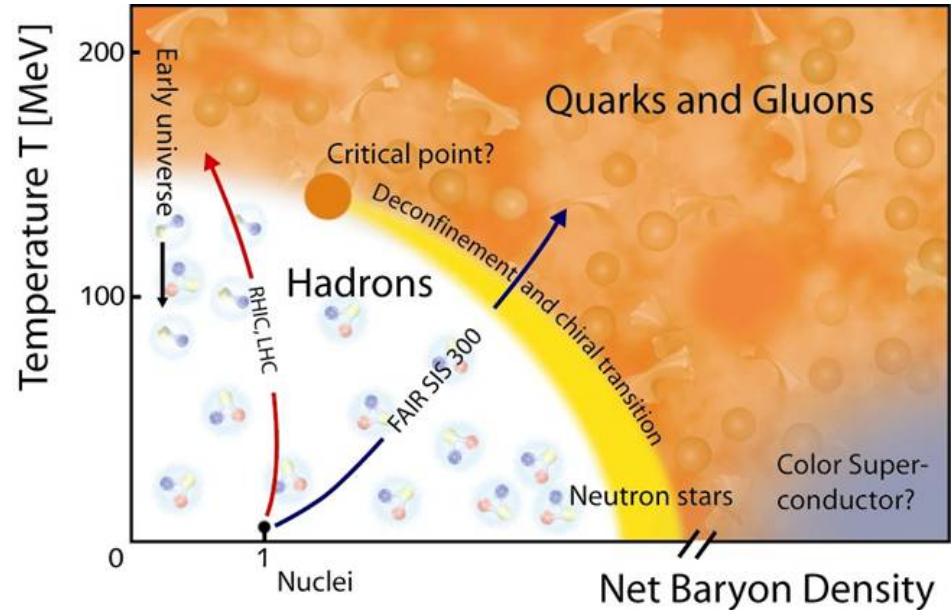
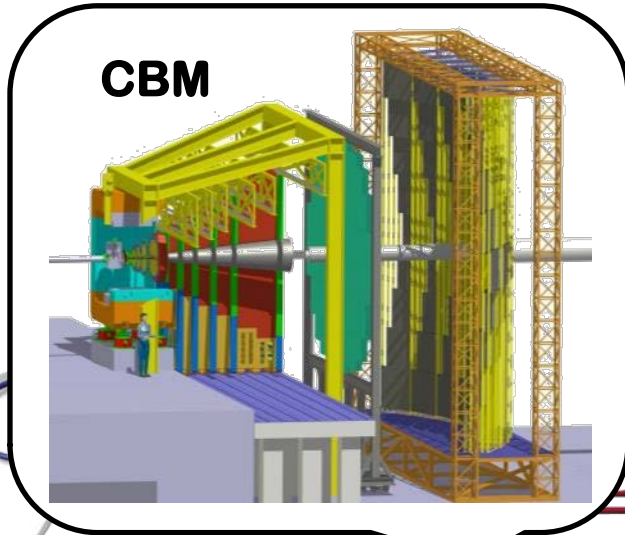
PANDA Experimental Set-Up

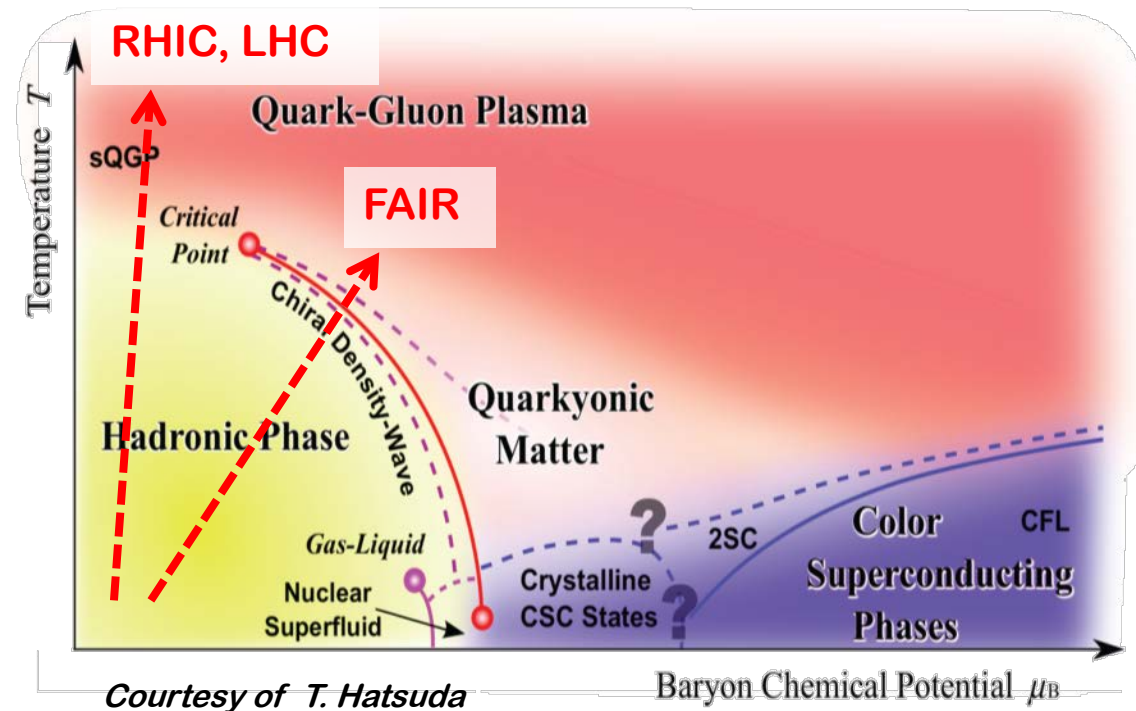
- Fixed target magnetic spectrometer experiment





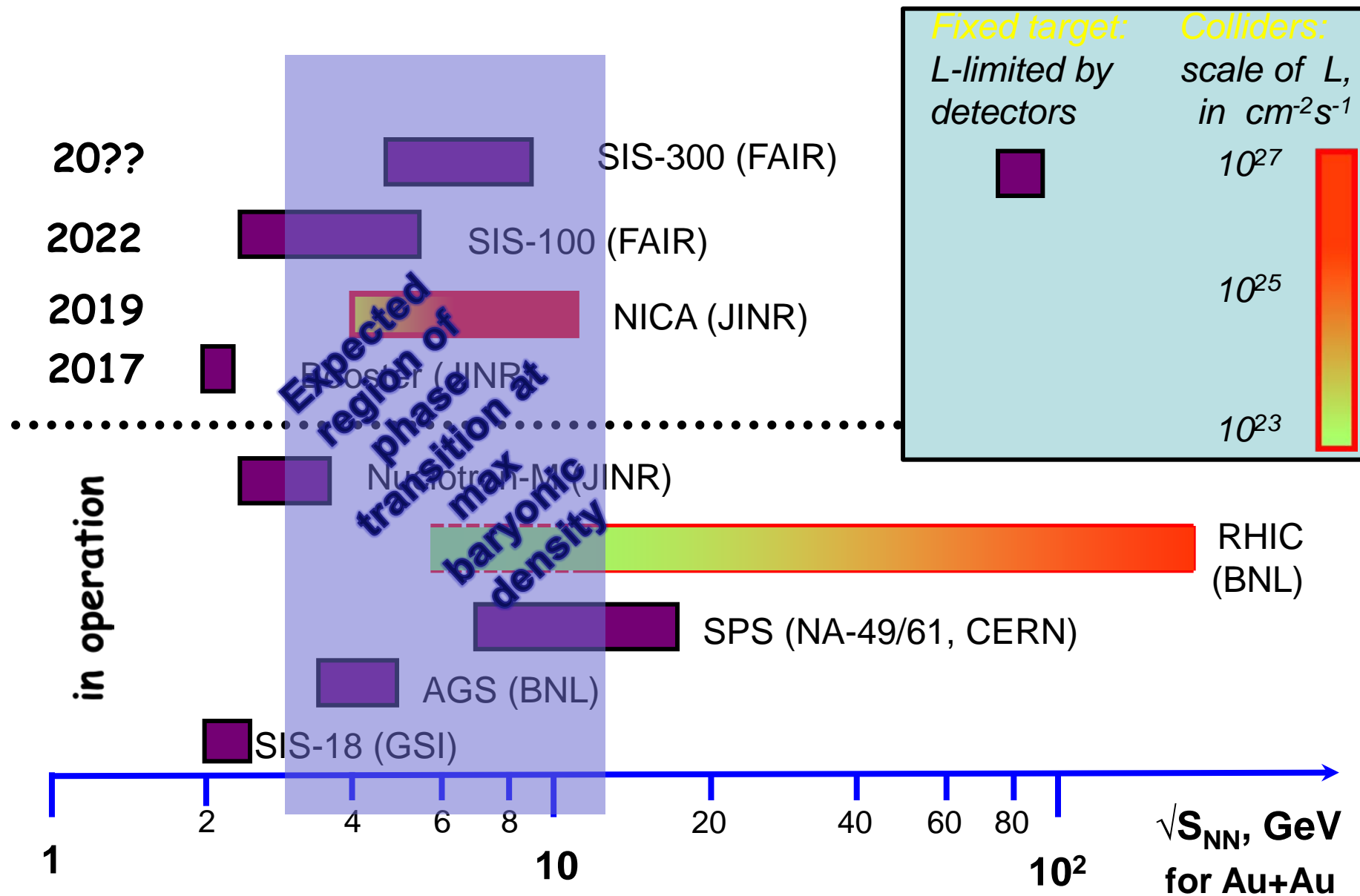
- **Compressed Baryonic Matter**
 - **About 400 members**





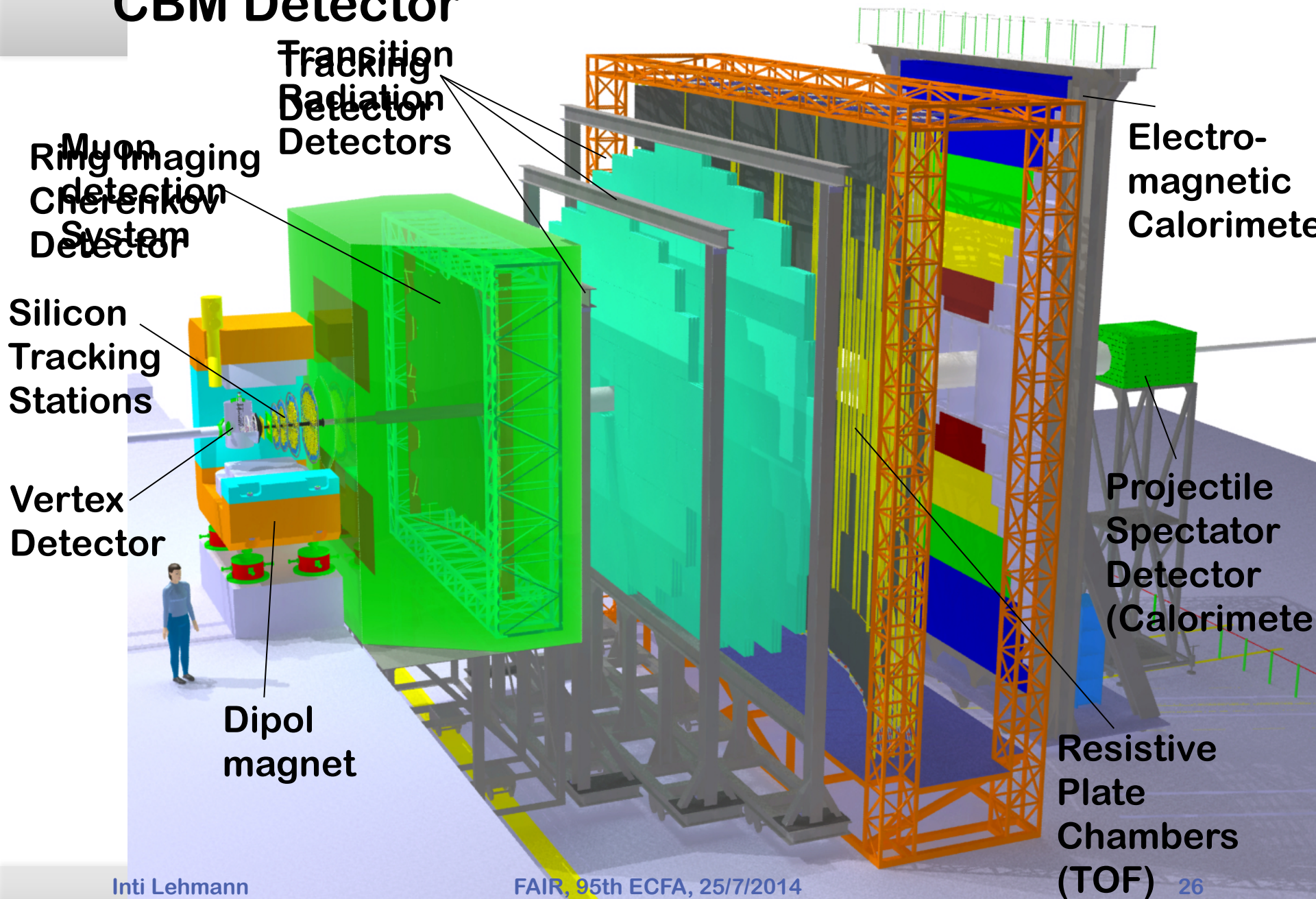
- The equation-of-state at high baryonic density
- New phases of strongly-interacting matter
- Deconfinement phase transition at high baryonic density
- QCD critical endpoint
- Onset of chiral symmetry restoration at high baryonic density

Existing and future HI accelerators



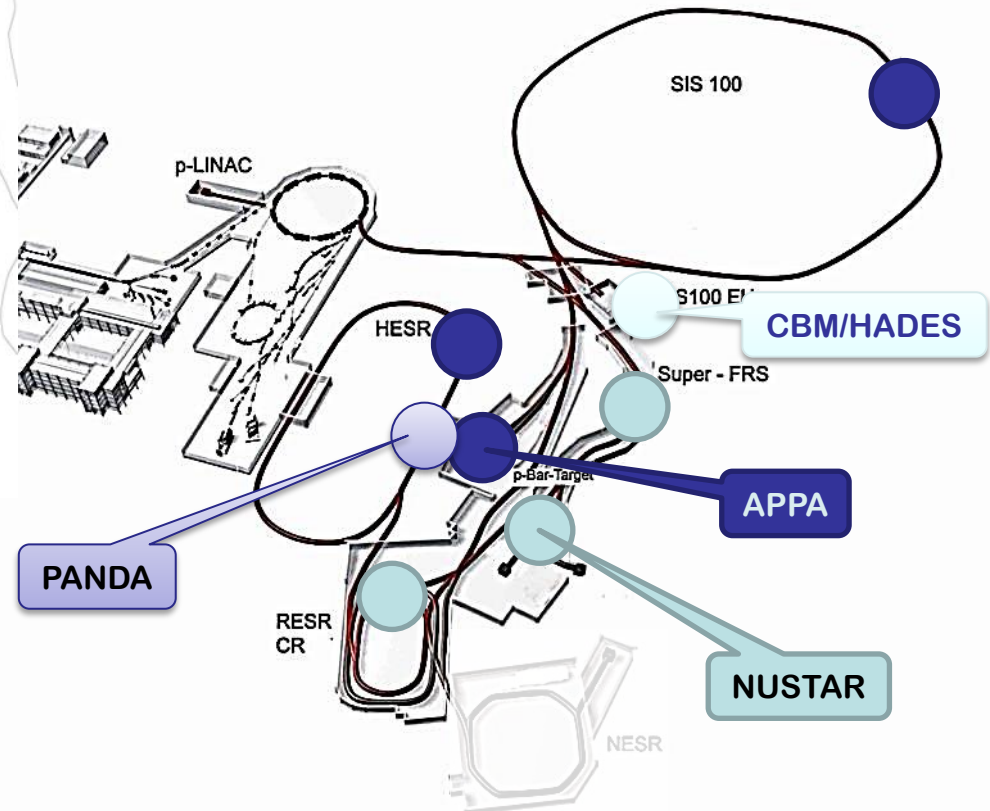
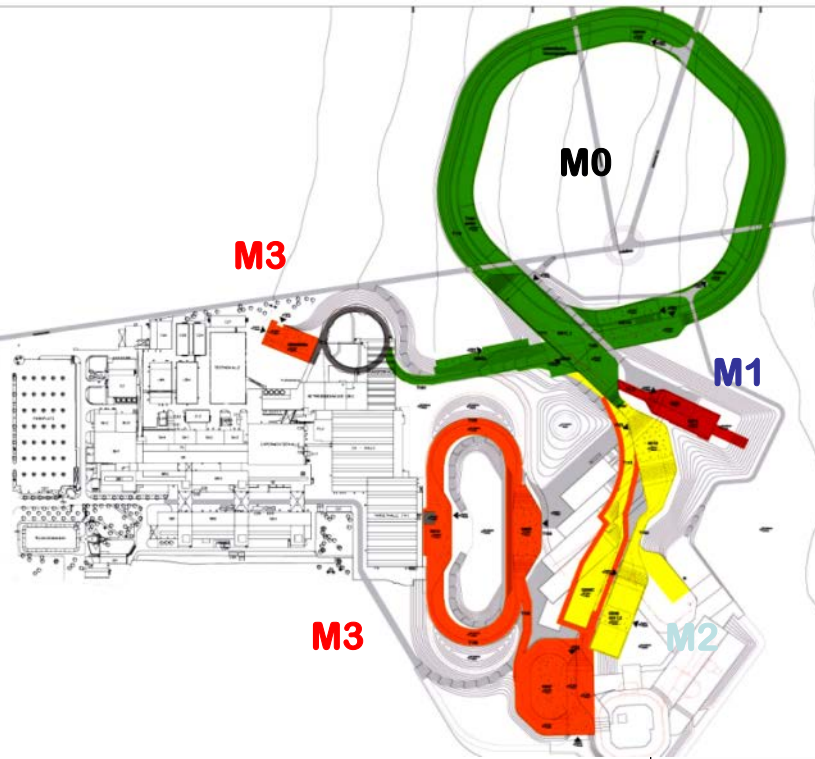
CBM – NICA co-operation agreement

CBM Detector



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

Funding Modules 0-3

Contracting Party	Contribution (in 2005 M€)
Finland	5.00
France	27.00
Germany	705.00
India	36.00
Poland	23.74
Romania	11.87
Russia	178.05
Slovenia	12.00
Sweden	10.00
Total	1.008,66

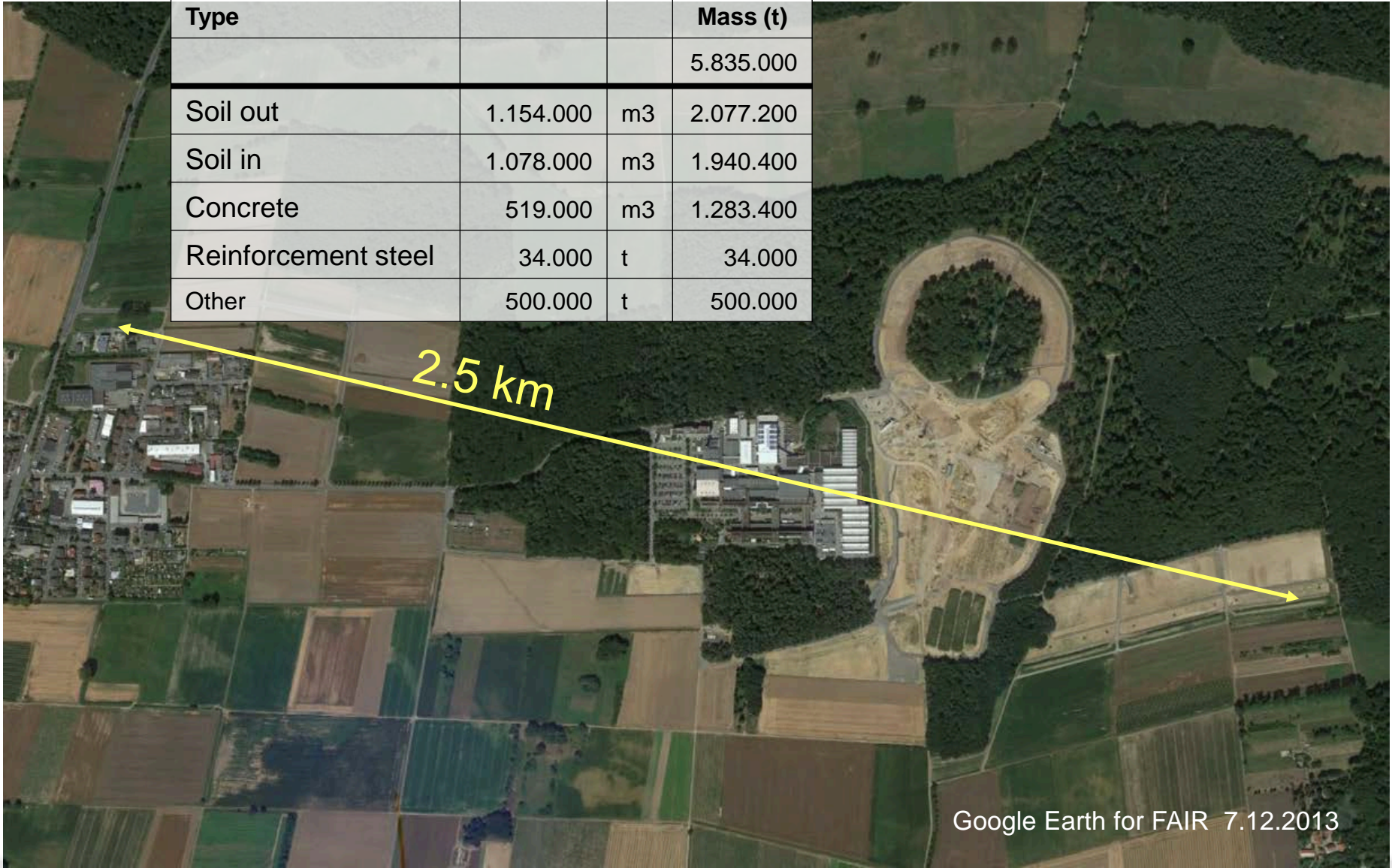
- All numbers in 2005 € escalation until 2018 ca. +50%
i.e. about € 1.6 billion
- Most contributions in-kind
- Discussions with Spain and Italy on-going
- Interested parties
 - ESA, Saudi Arabia, Netherlands, China, Turkey, Brazil, Ukraine, S Korea, Japan, USA

The Modularized Start Version should enable realization of outstanding forefront research program to all four scientific communities of FAIR



Civil Construction: Satellite's View

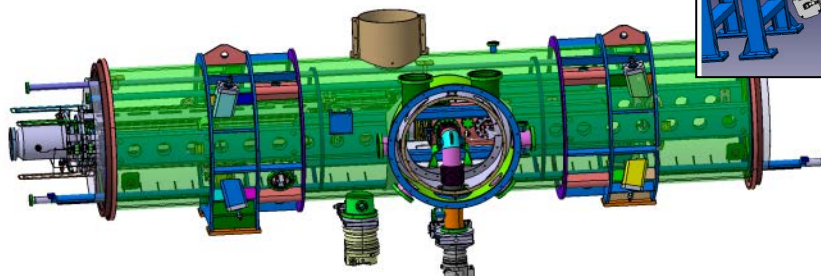
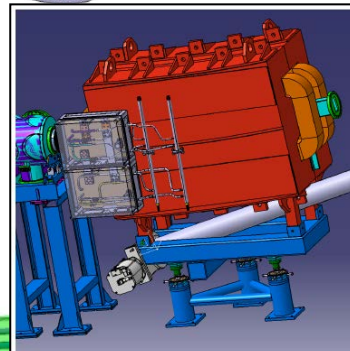
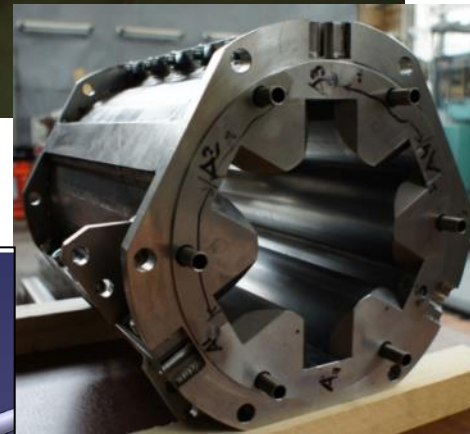
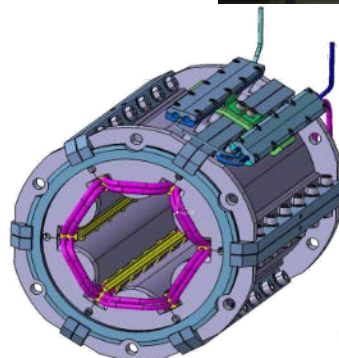
Type			Mass (t)
			5.835.000
Soil out	1.154.000	m3	2.077.200
Soil in	1.078.000	m3	1.940.400
Concrete	519.000	m3	1.283.400
Reinforcement steel	34.000	t	34.000
Other	500.000	t	500.000



Google Earth for FAIR 7.12.2013

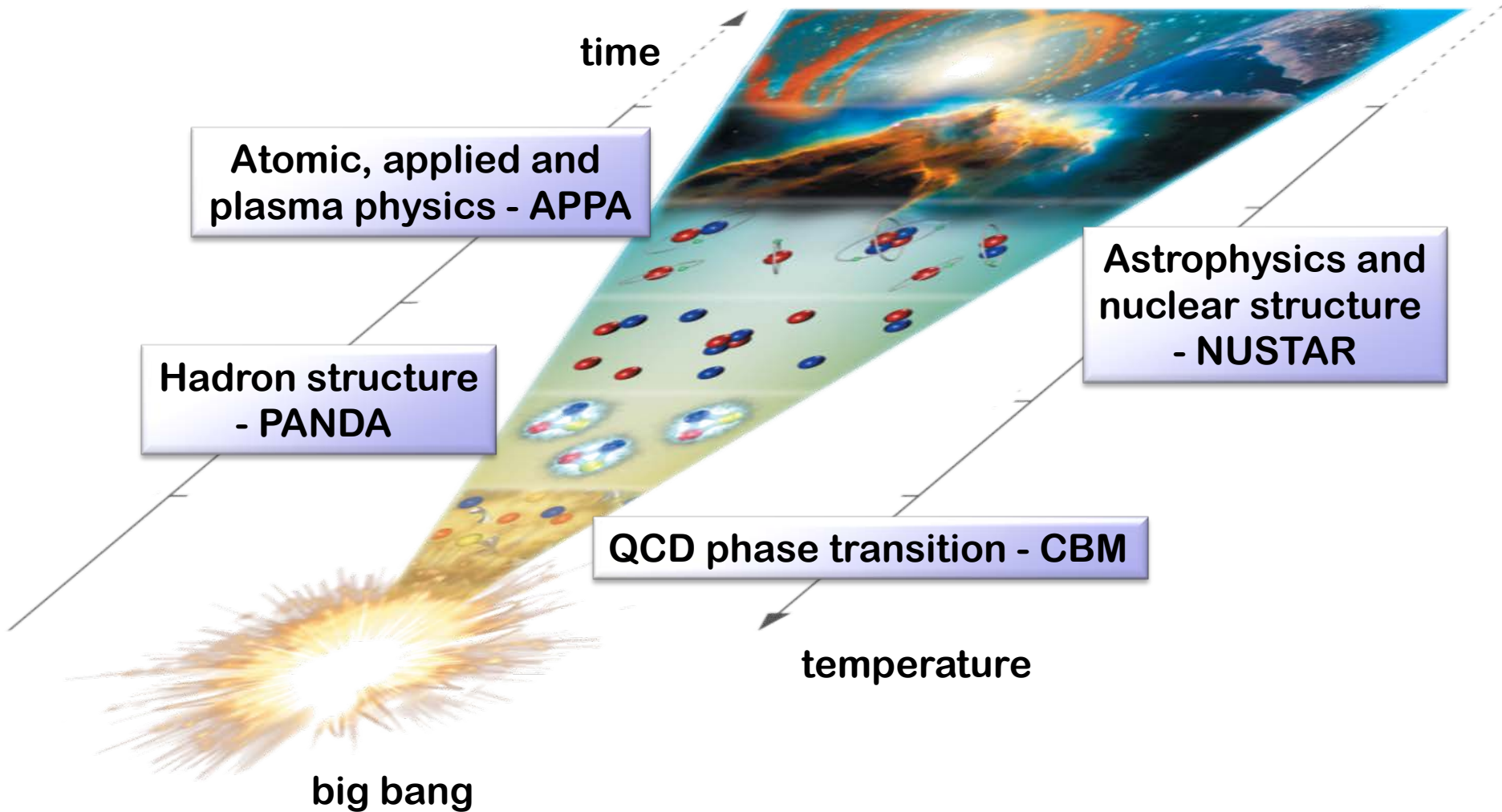
Accelerator's Status

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



Conclusions

- Despite of certain delay FAIR is progressing well.
- Rich scientific program and discovery potential already at MSV with beams from SIS100.
- FAIR will explore "unknown territory" of the QCD phase diagram with unprecedented precision.
- Versatile detector configurations for optimal performance are under construction.
- Day-one physics with start version for high interaction rates in preparation.
- Strong and experienced international collaborations are active, more scientists expected to join in the coming years.



Thank you for attention !

