The
Physics Perspective
at the
Future Accelerator Facility
FAIR

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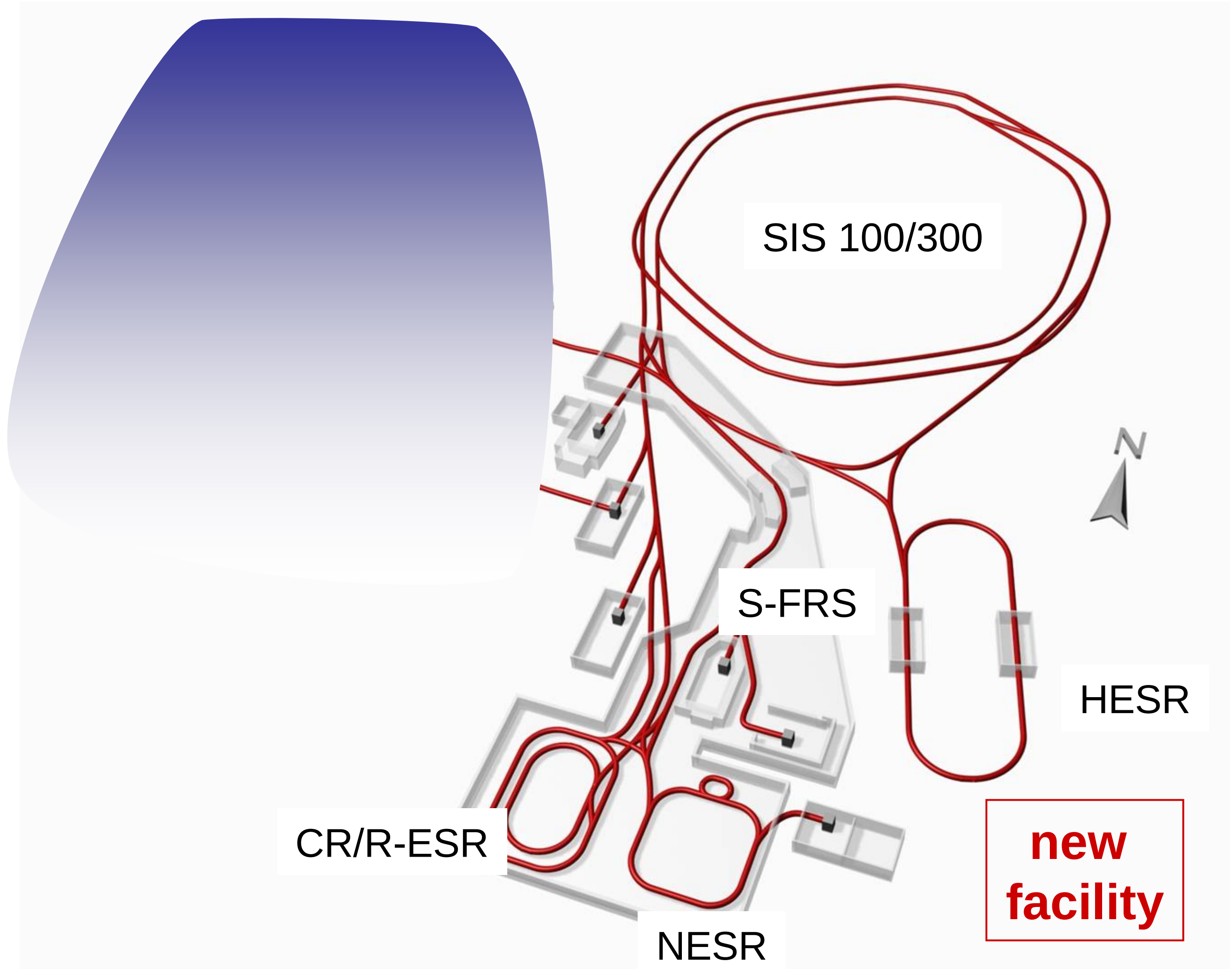
GSI

Layout of the future Accelerator Facility FAIR

Facility
for
Antiproton
and
Ion
Research



Key Features and Technologies

Key Features

- High primary beam intensity, e.g. **10^{12} 1/s ^{238}U at 1.5 GeV/u**
- Secondary beam intensities for radioactive nuclei: **gain up to factor 10,000**
- Maximum beam energy: ~ 30 GeV/u

Special Properties

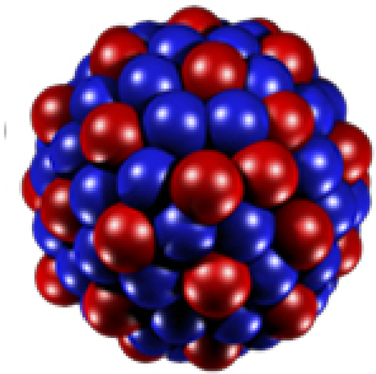
- Intense, fast **cooled** energetic beams of exotic nuclei
- **Cooled** / stored antiproton beams, 15 GeV
- Internal targets for high-luminosity in-ring experiments
- Electron-RIB collider

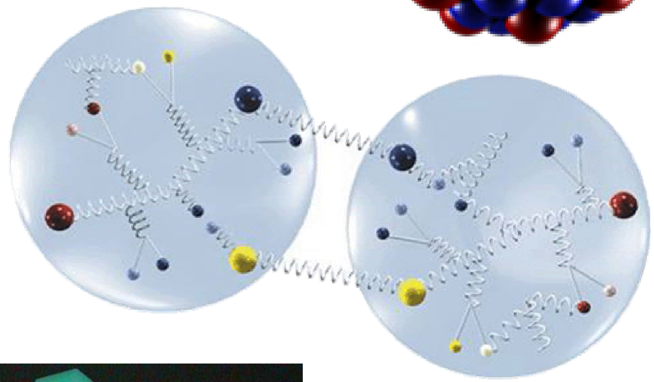
New Technologies

- Fast cycling superconducting magnets
- Electron cooling at high ion intensities and energies
- Fast stochastic cooling

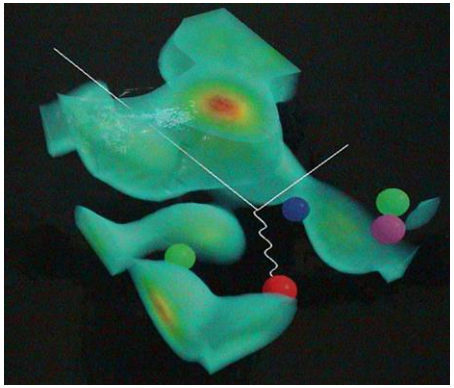
The physics of strongly interacting systems

Essential questions are not answered !





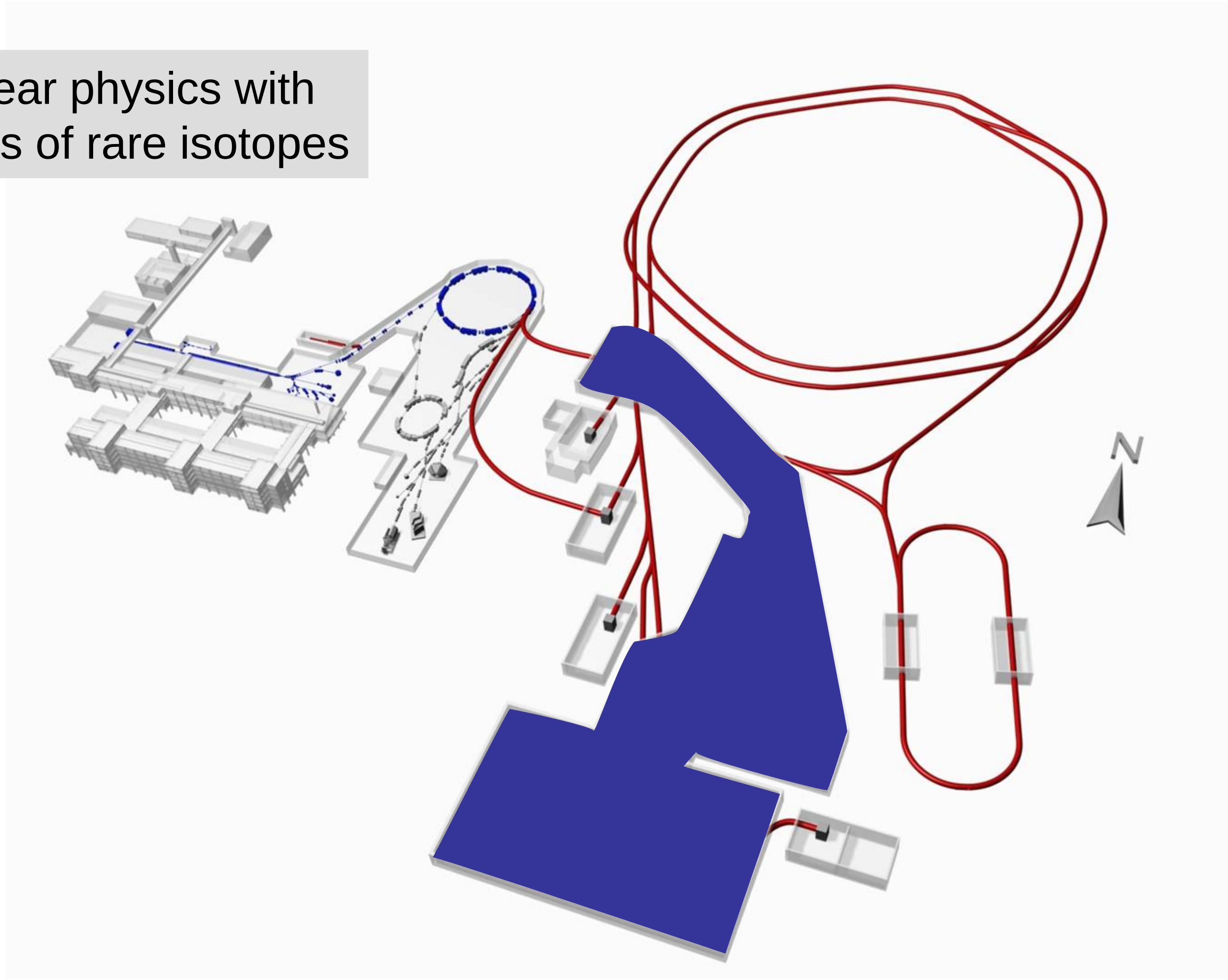
- What is the structure of nuclei with extreme isospin?
- How does the effective interaction responsible for this structure arise from the bare strong force?
- What is the role of confinement and chiral symmetry breaking in the generation of hadron masses?
- Where are the limitations of confinement?



The Five Research Pillars at FAIR

- Nuclear Structure Physics and Nuclear Astrophysics
- Hadron Physics with Antiproton Beams
- Physics of Hadronic Matter at high density
- Plasma Physics at very high p, ρ, T
- Atomic Physics and Applied Science

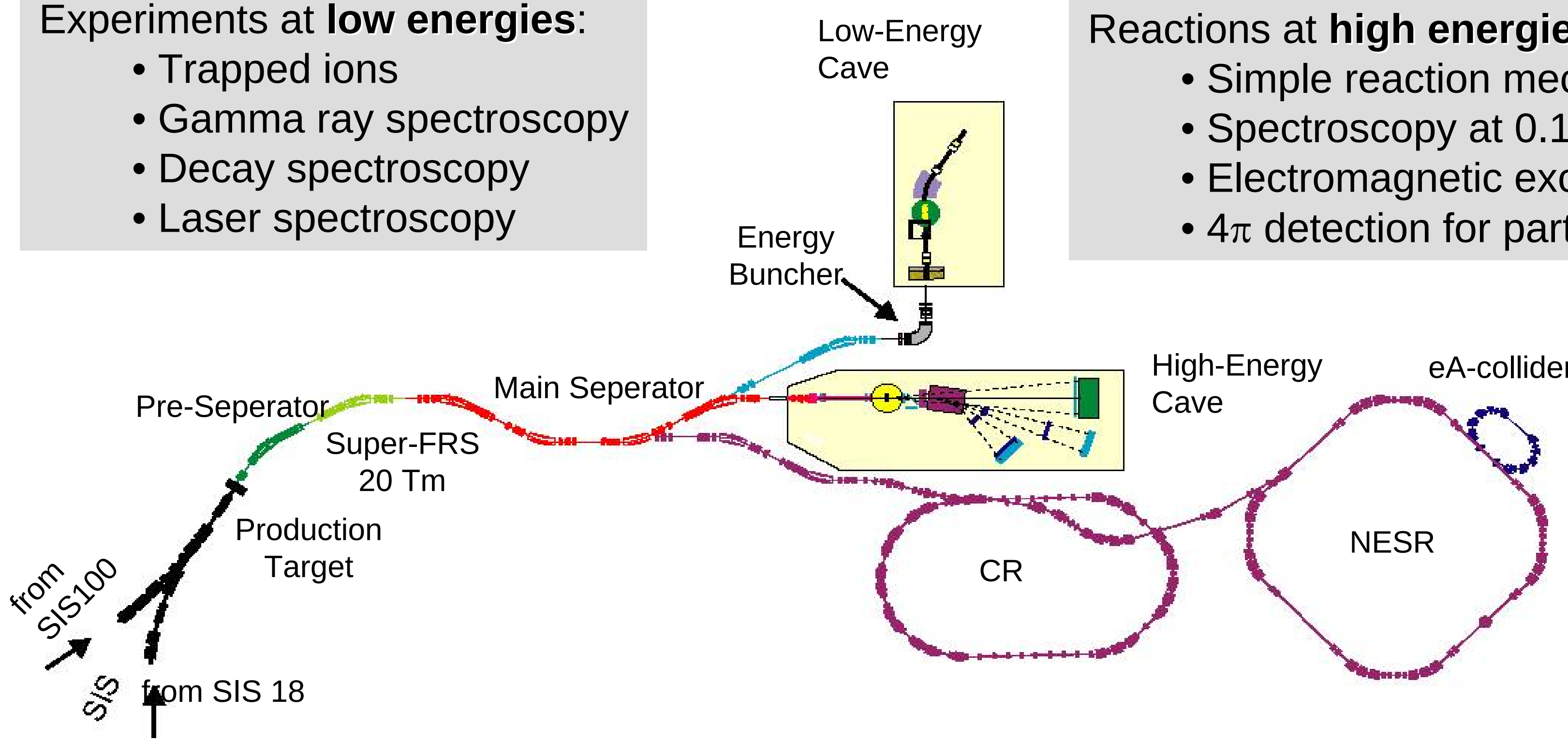
nuclear physics with
beams of rare isotopes



Nuclear structure of rare isotopes

Experiments at **low energies**:

- Trapped ions
- Gamma ray spectroscopy
- Decay spectroscopy
- Laser spectroscopy



Reactions at **high energies**:

- Simple reaction mechanism
- Spectroscopy at 0.1 fragment/s
- Electromagnetic excitation
- 4π detection for particles

Experiments with **stored beams**:

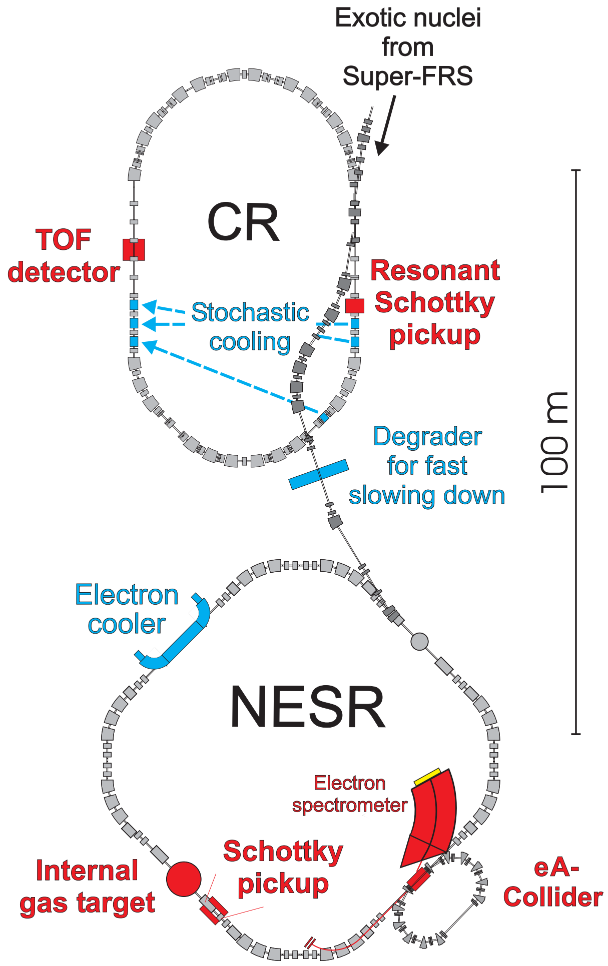
- Mass- and lifetime measurements
- Nuclear reactions in the internal target
- Electron scattering off exotic nuclei

Nuclear structure experiments with high precision and far from stability using secondary, unstable beams

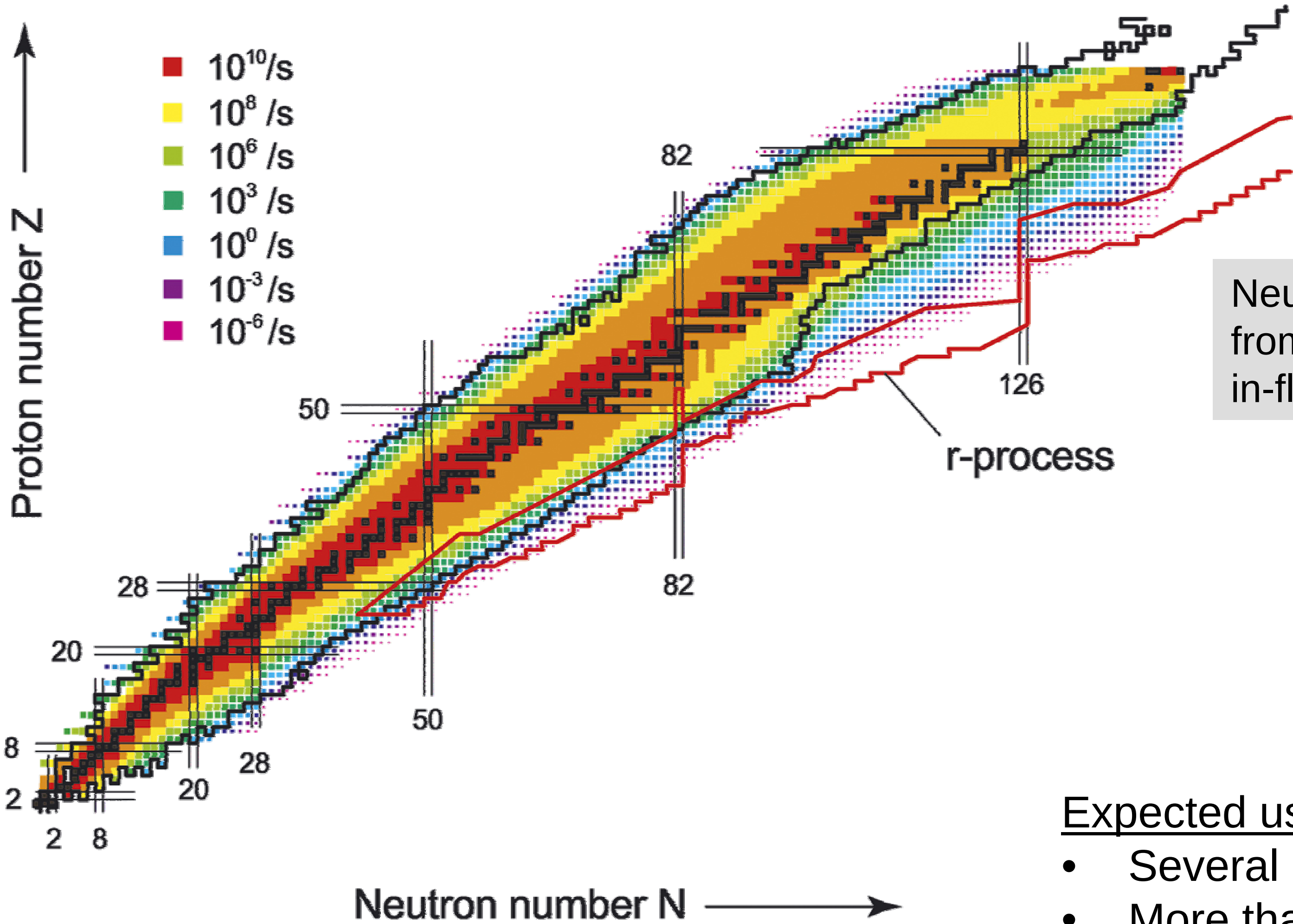
Nuclear structure physics in rings

New Methods and Concepts for Exotic Nuclei :

- ✓ Light hadron (p,d,He..) scattering
  - ➔ *internal-target experiments (NESR)*
- ✓ Electron scattering
  - ➔ *Electron-Ion Collider*
- ✓ Rapid transfer + fast cooling
  - ➔ *Shortest-lived isotopes*
- ✓ Energy-/Range-compression
  - ➔ *Implantation; capture into Traps ..*



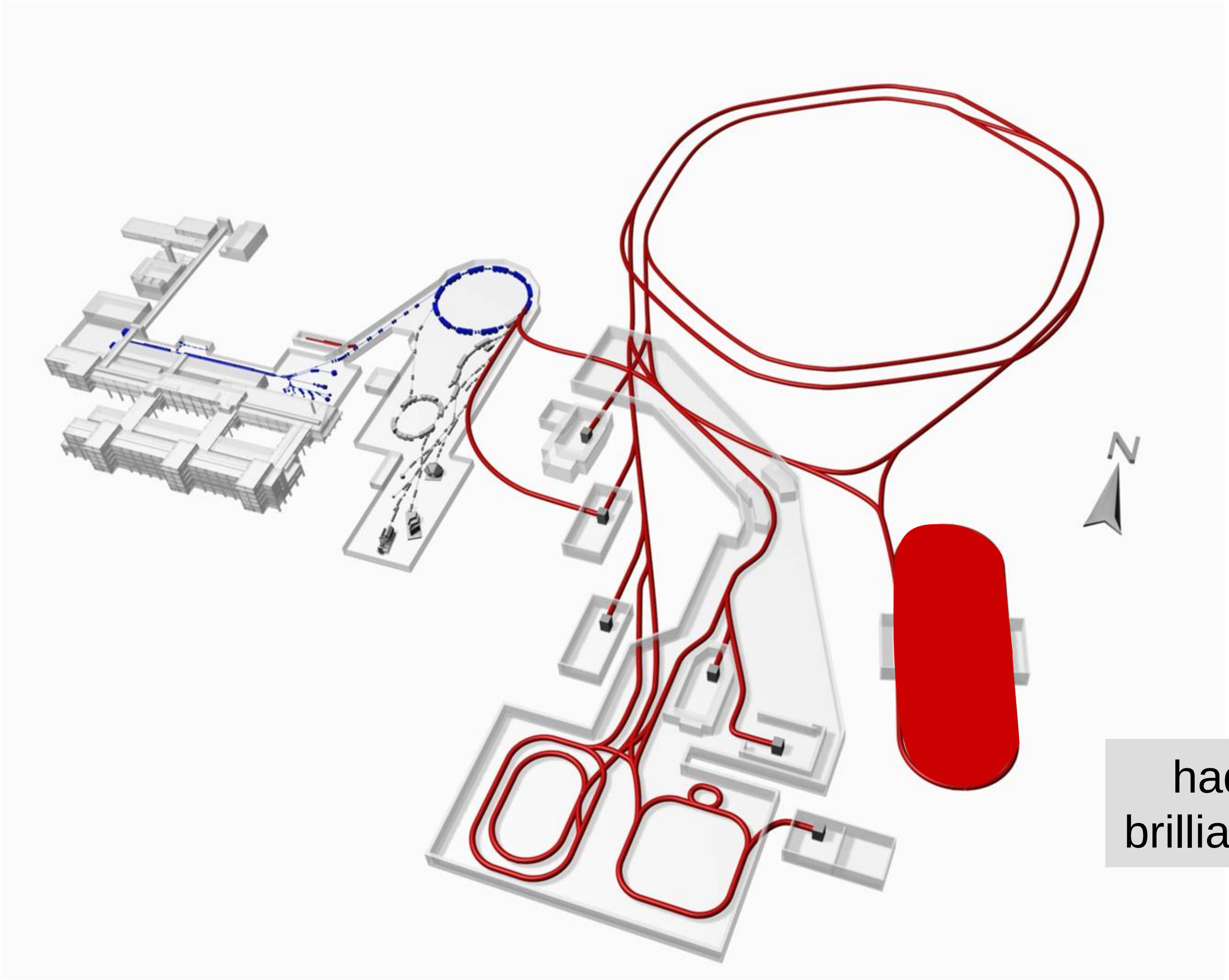
Anticipated production rates



Neutron-rich isotopes from fragmentation and in-flight fission:

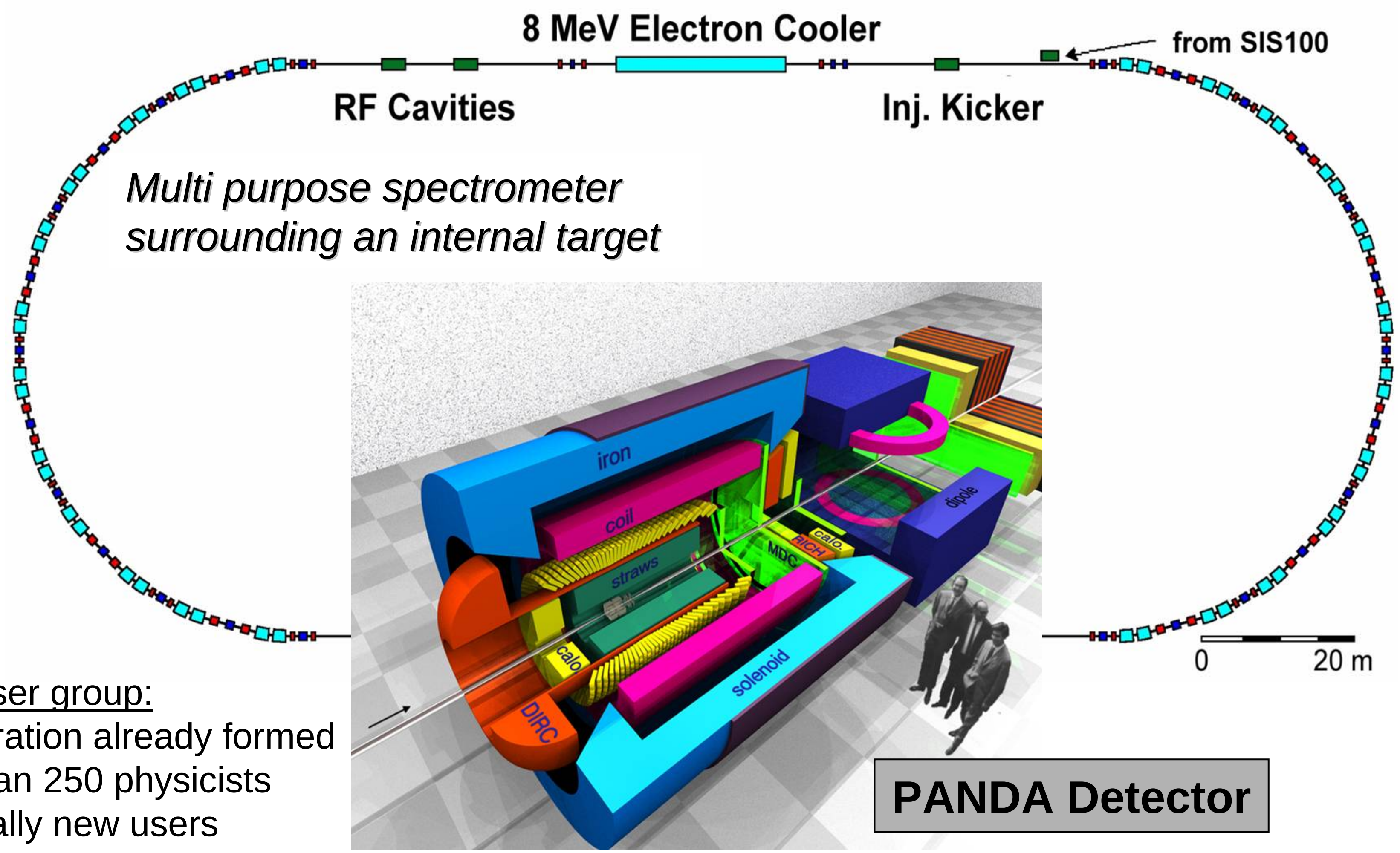
Expected user group:

- Several collaborations
- More than 600 physicists



hadron physics with brilliant antiproton beams

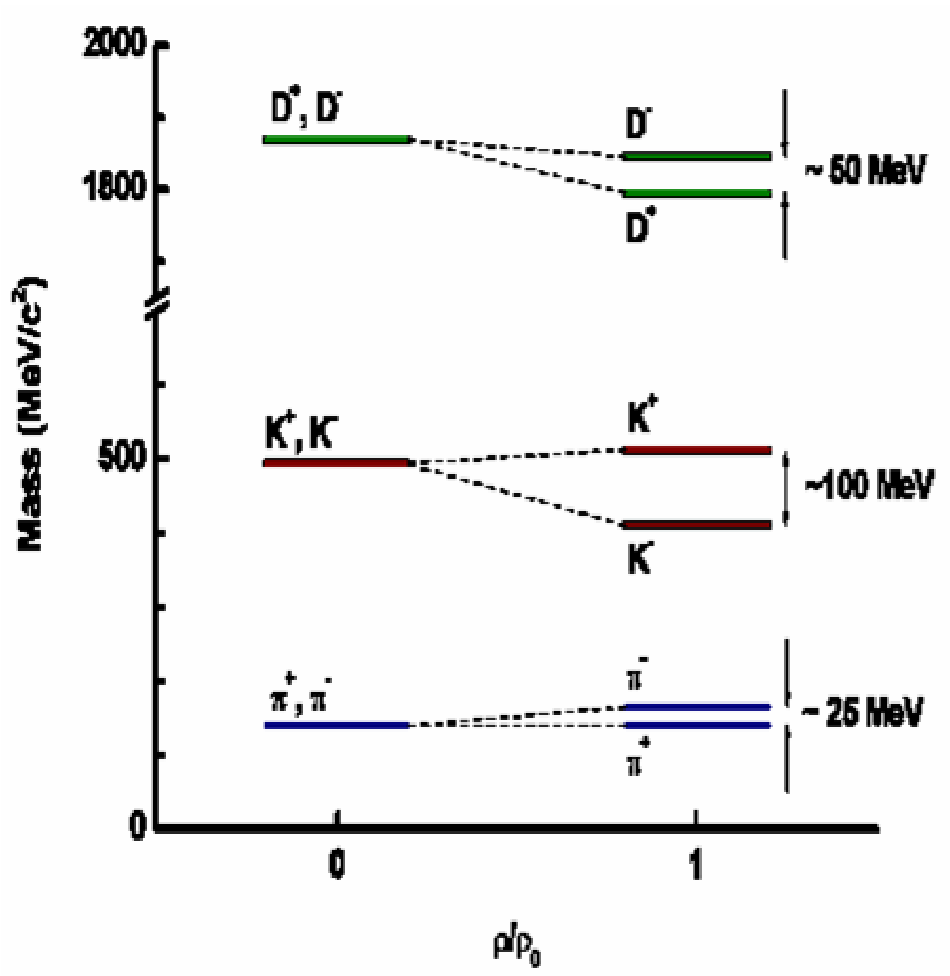
Hadron physics with brilliant antiproton beams



Expected user group:

- Collaboration already formed
- More than 250 physicists
- Essentially new users

The physics program of PANDA

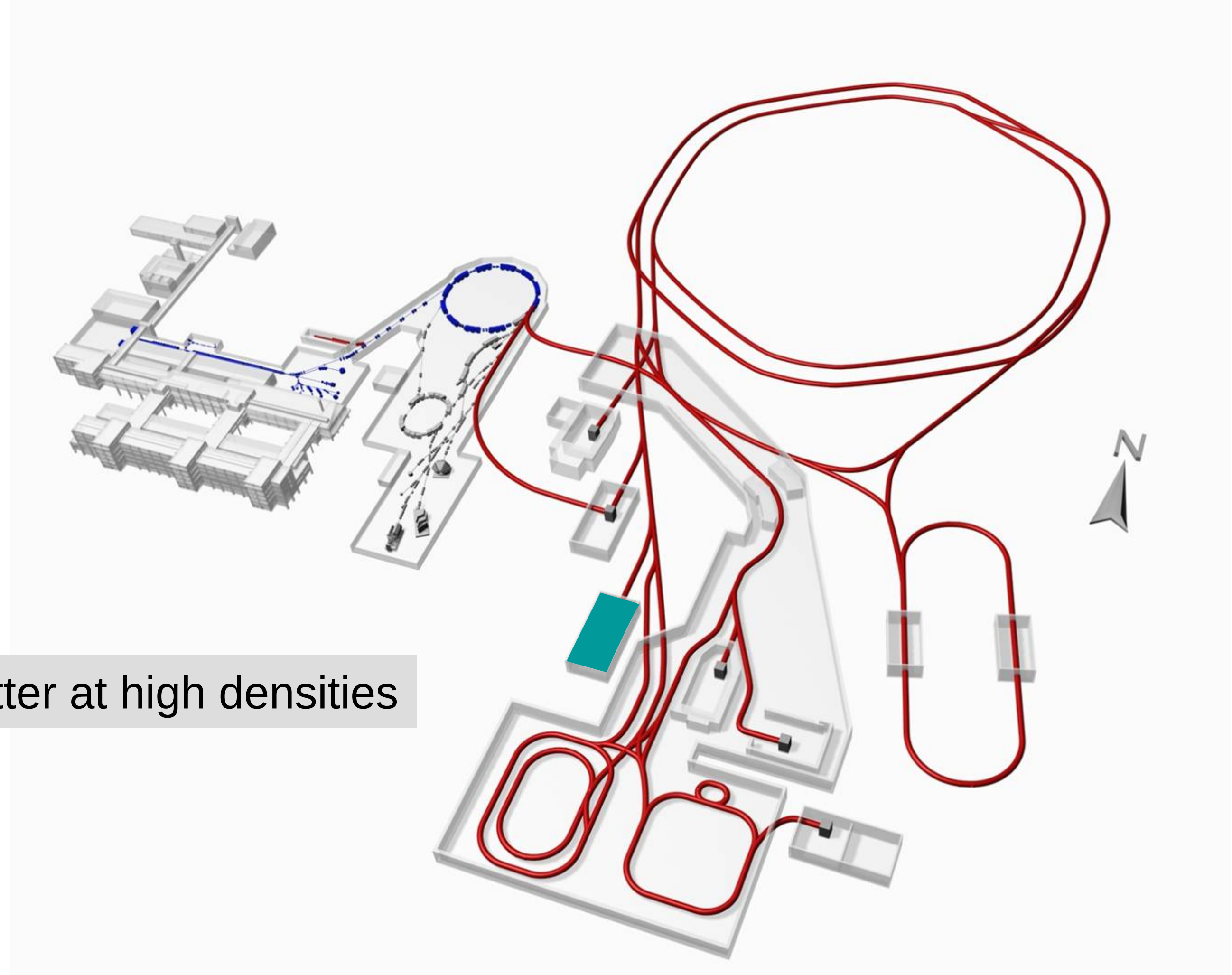


- Hypernuclei

and at highest luminosities

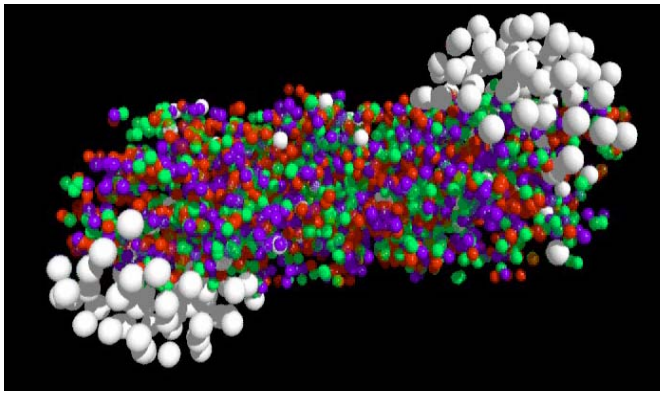
- CP violation in the charm sector

- (Generalized parton distributions)



nuclear matter at high densities

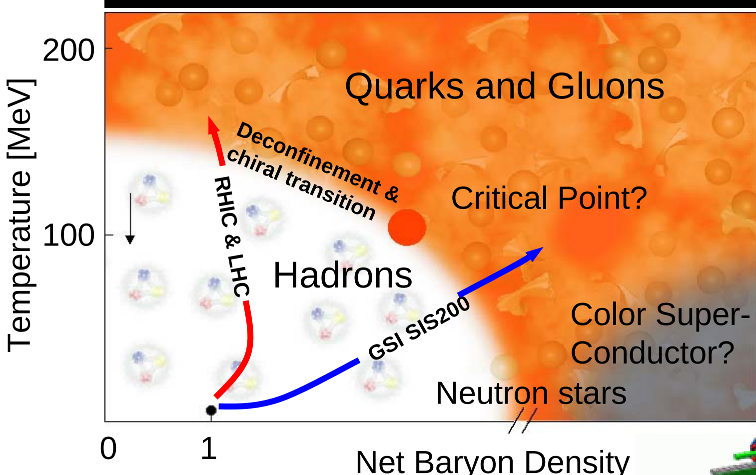
The properties of dense baryonic matter

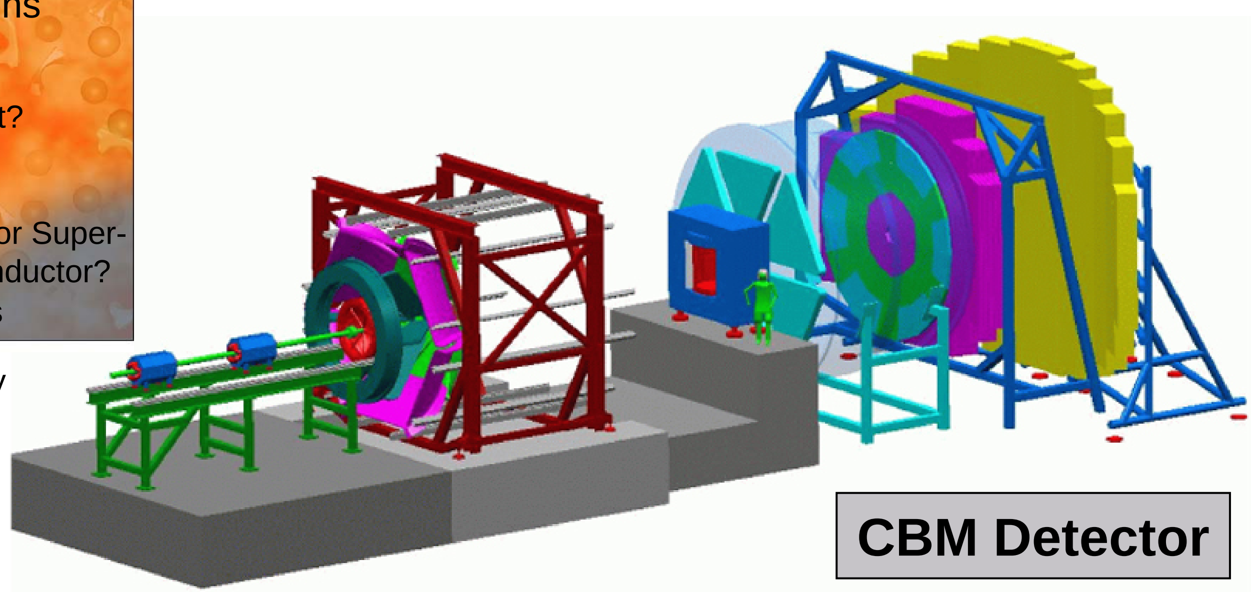


Heavy ion collisions
at interaction rates of up to 10^7 Hz

and

beam energies from 2 to 35 GeV/u





Expected user group:

- Proto-collaboration formed
- About 300 physicists

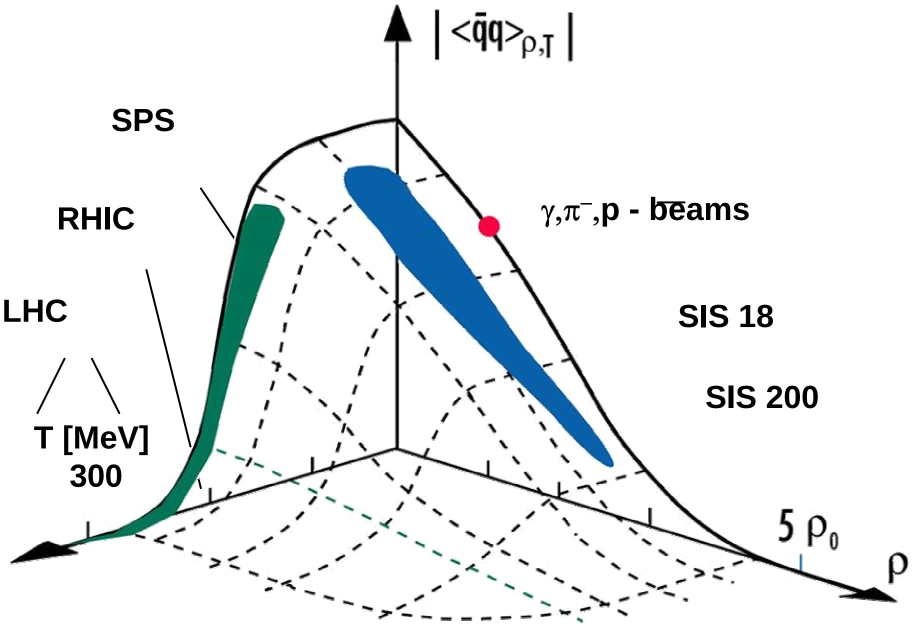
The physics program of CBM

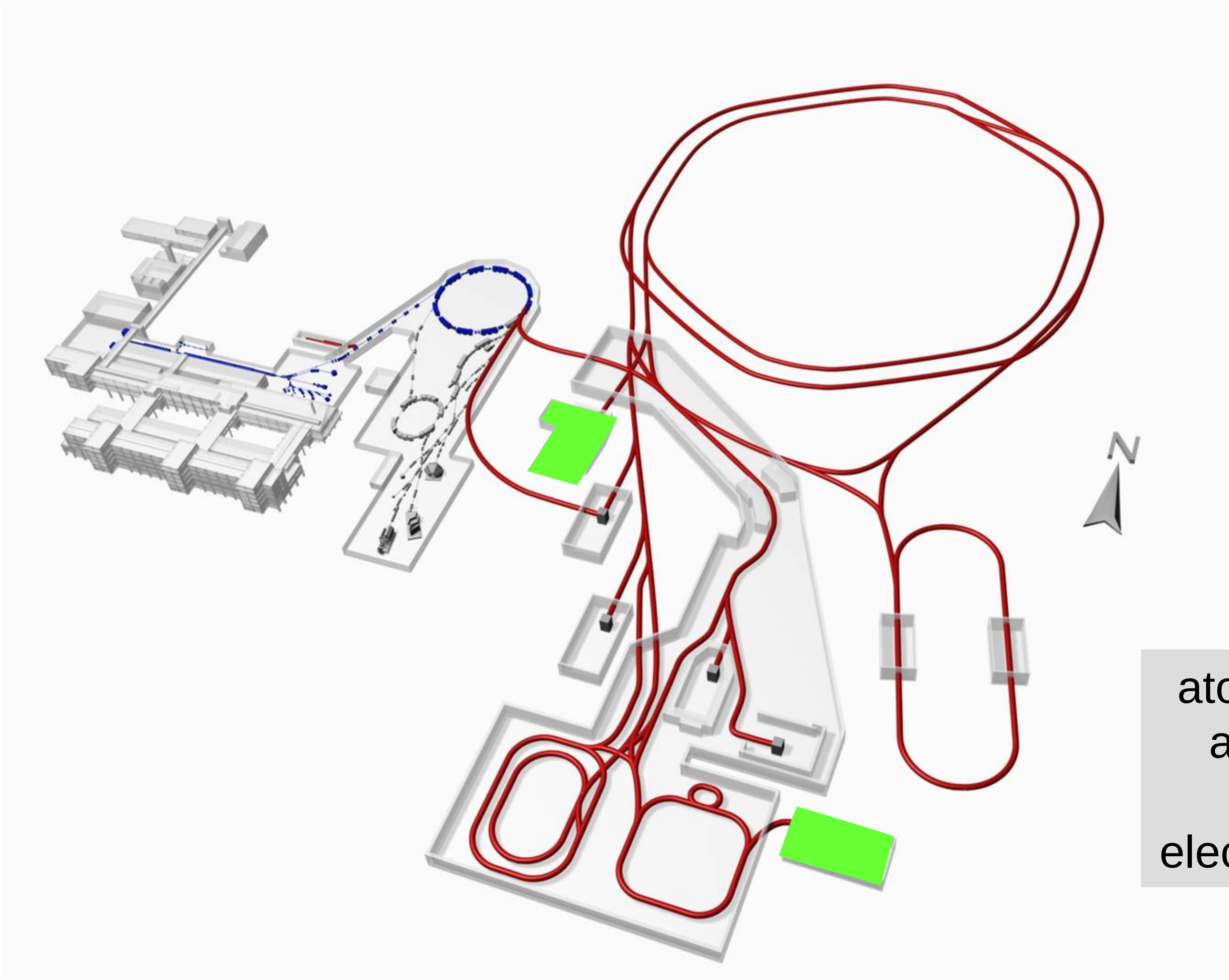
Search for ...

- ... exotic states of matter

As probes will be used

- Low-mass vector mesons
- Charmonium
- D-mesons
- Multi-strange baryons

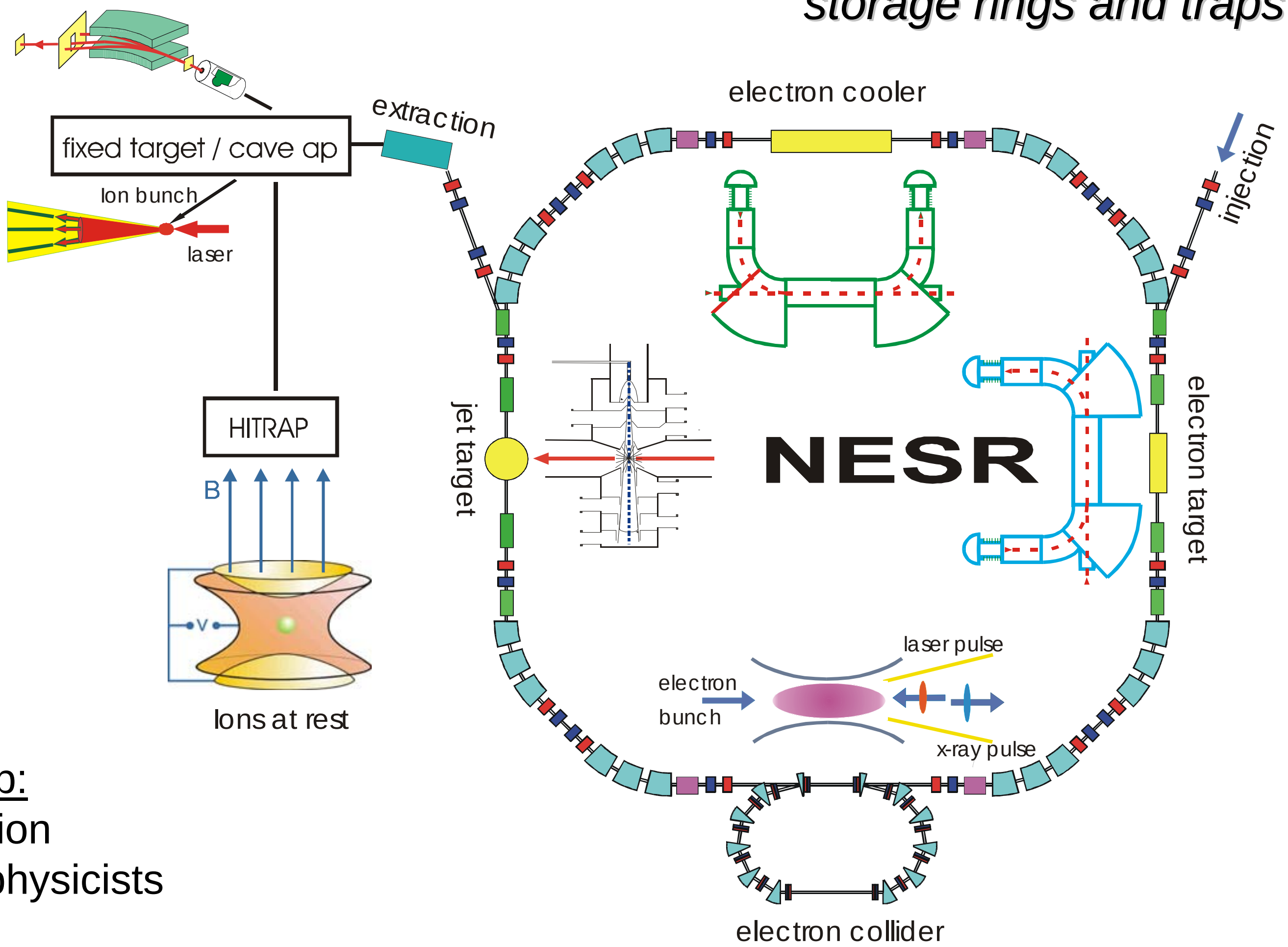




atomic physics with antimatter and of very strong electromagnetic fields

Fundamental interactions

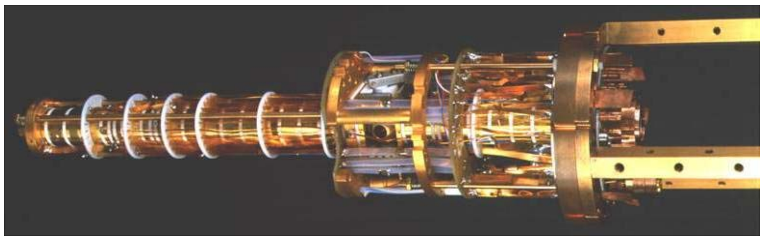
Precision experiments in storage rings and traps

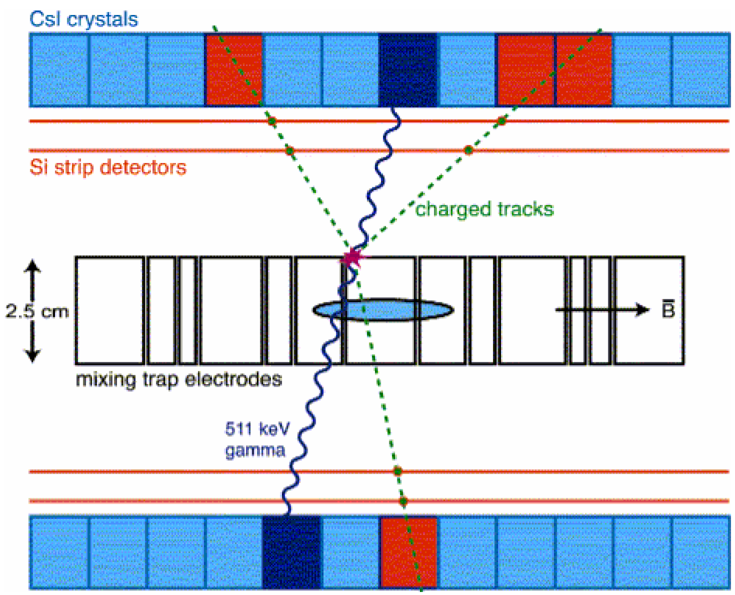


<u>Expected user group:</u>

- many collaboration
- more than 300 physicists

Tests of fundamental physics



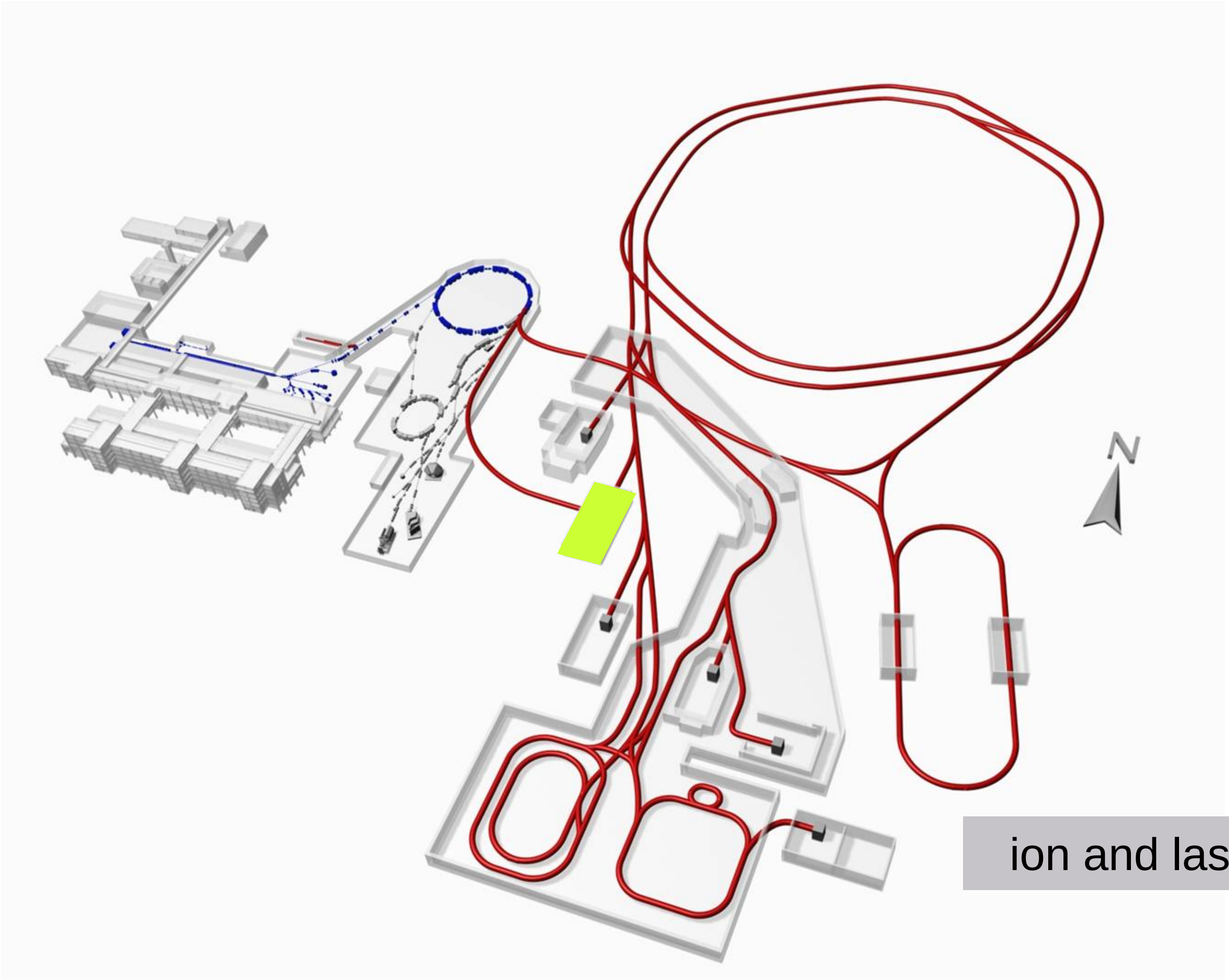


QED in strong fields

- at SIS 100
  Laser cooling and laser spectroscopy of Li-like relativistic ions.

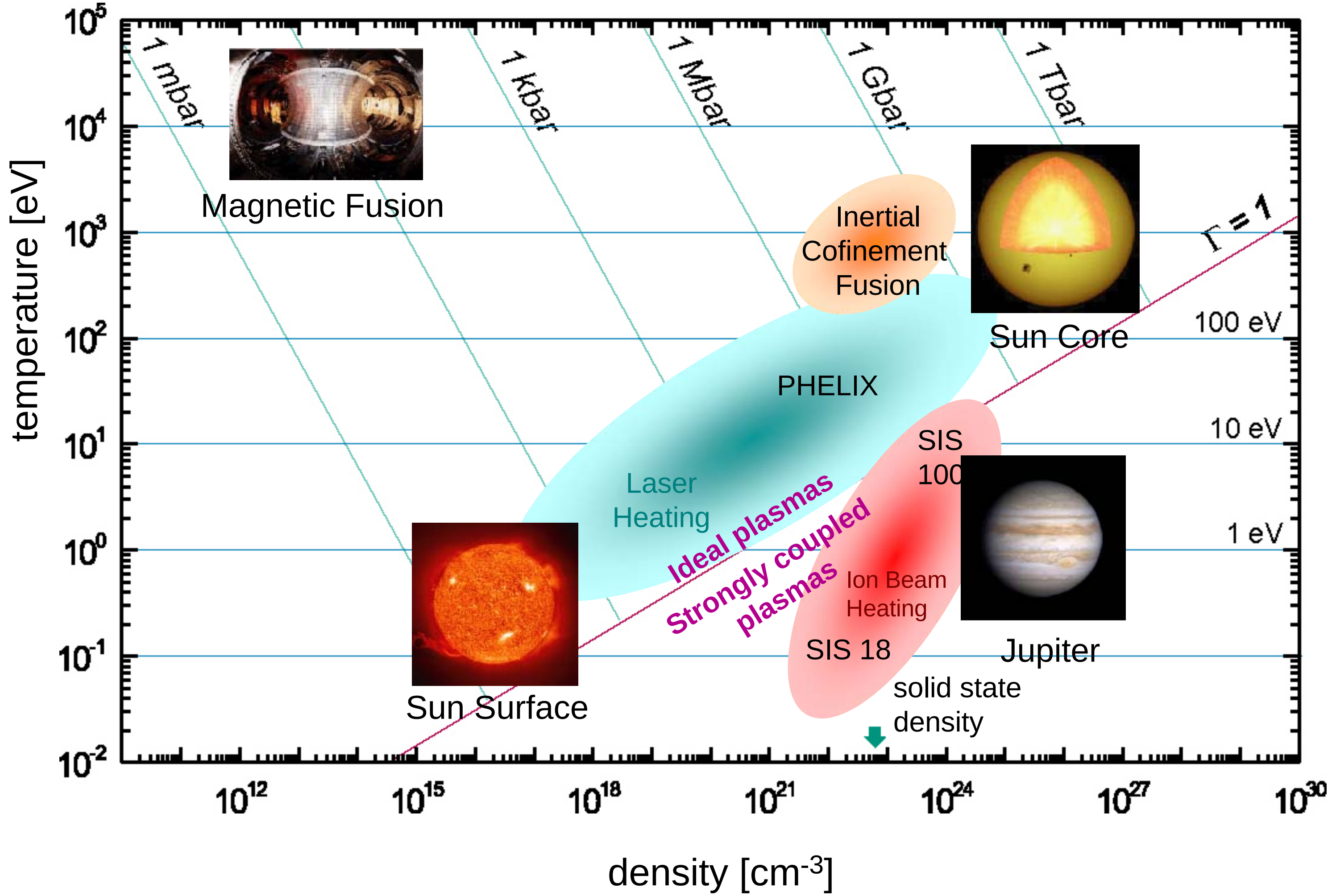
Stored antimatter

- CPT invariance
- Gravity of antimatter
- Atomic collision studies

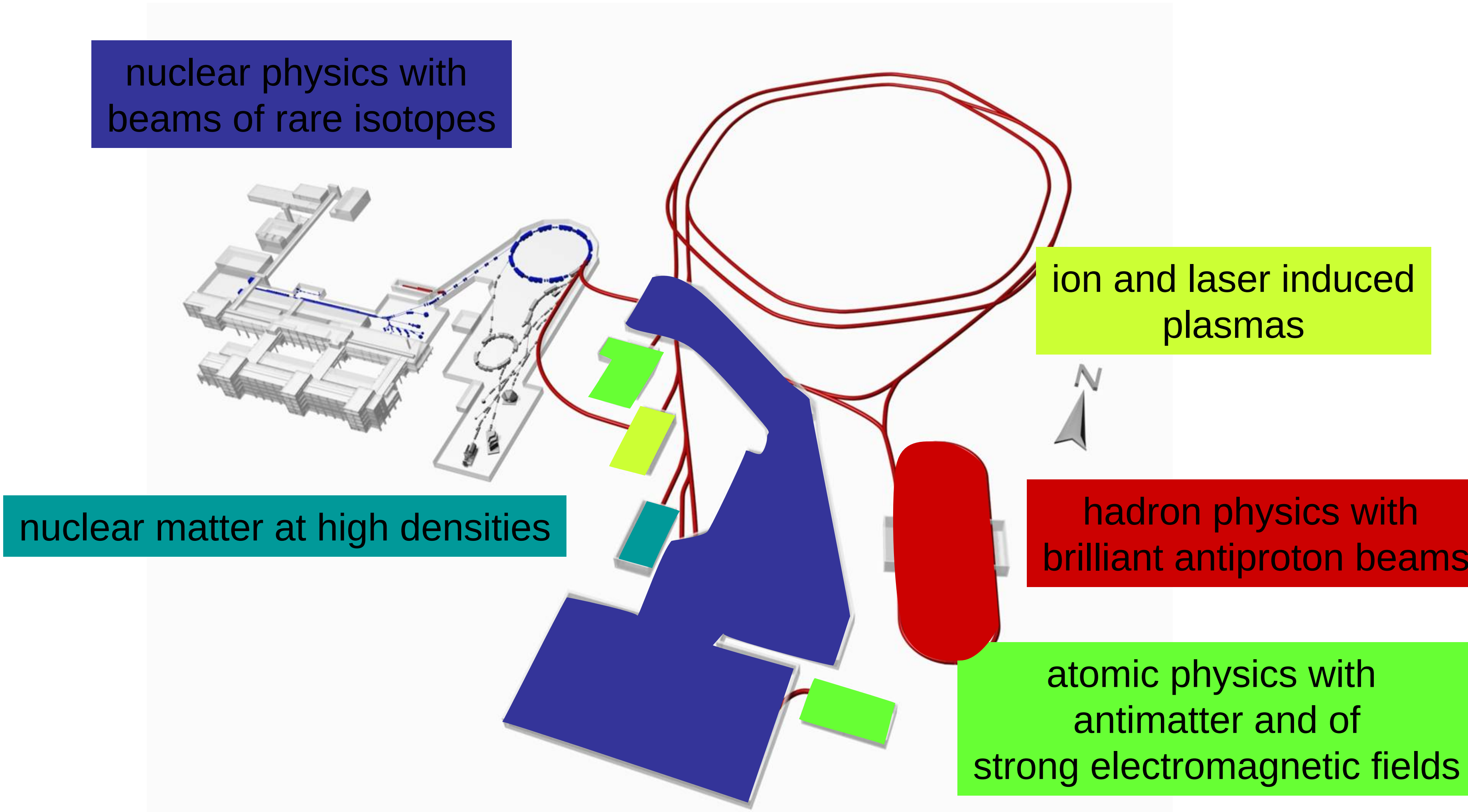


ion and laser induced plasmas

The physics of strongly coupled plasmas



The 5 pillars of the research at the future facility



Structure of matter

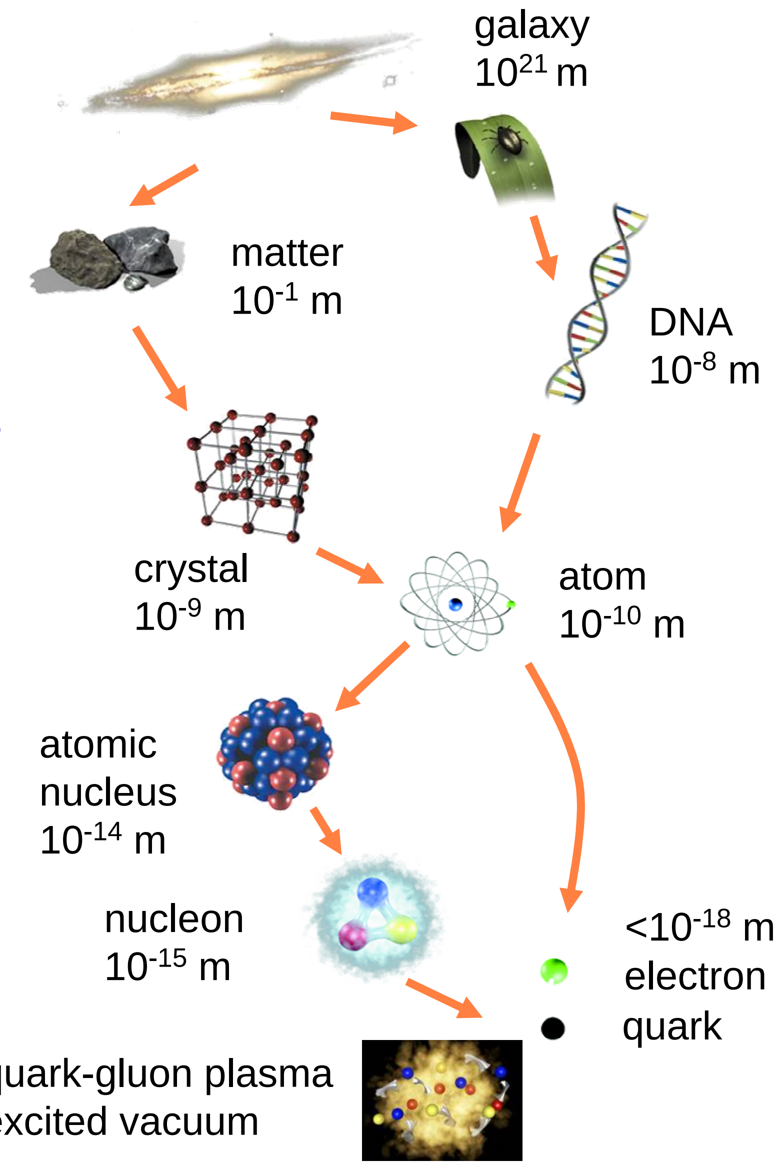
Gravitational Force
General Relativity

Electromagnetic Force
QED

Electroweak Force

Weak Force
Standard Model

Strong Force
QCD



Research with Beams of Hadrons and Ions
Ion-Matter Interactions
Dense Plasmas

HI Beams → 12 TW/g

Ultra High EM Fields

Highly charged ions

Nuclei at the Extremes

RIBs → 1.5 - 2 GeV/u

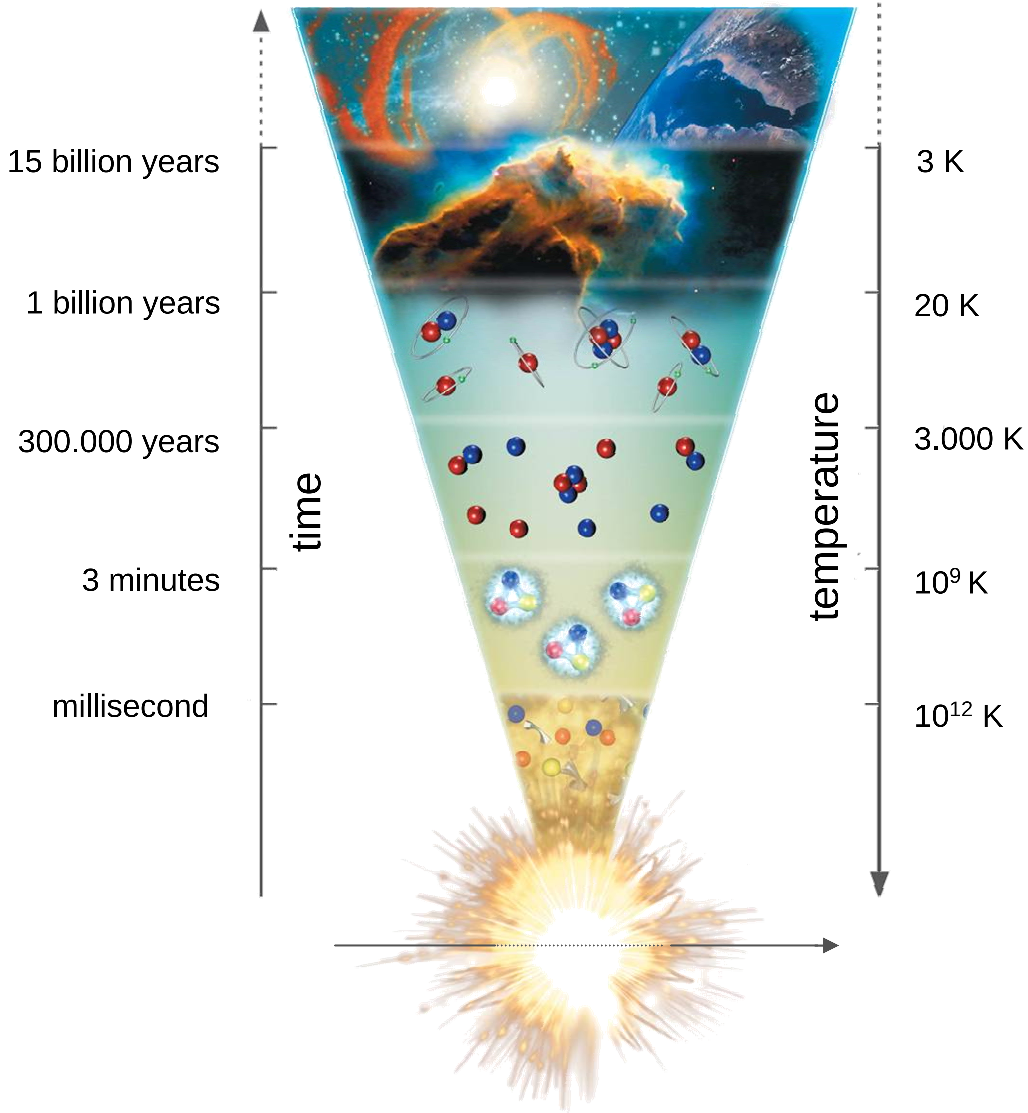
Quark Gluon Structure of Hadrons

Antiprotons 0-15(30) GeV

Quark Matter

Relativ. HI → 35 GeV/u

Nuclear physics of the universe



RESEARCH WITH ION BEAMS

- Novae, supernovae compressed nuclear matter

Relativ. HI → 35 GeV/n

- Ion-Matter/Dense Plasmas

HI Beams → 12 TW/g

- r-process and rp-process

RIBs → 2 GeV/n

- Neutron stars – strange matter
- Synthesis of light elements
- Dark matter
- Chiral symmetry breaking

Antiprotons 0-15(30) GeV

- Quark-gluon plasma