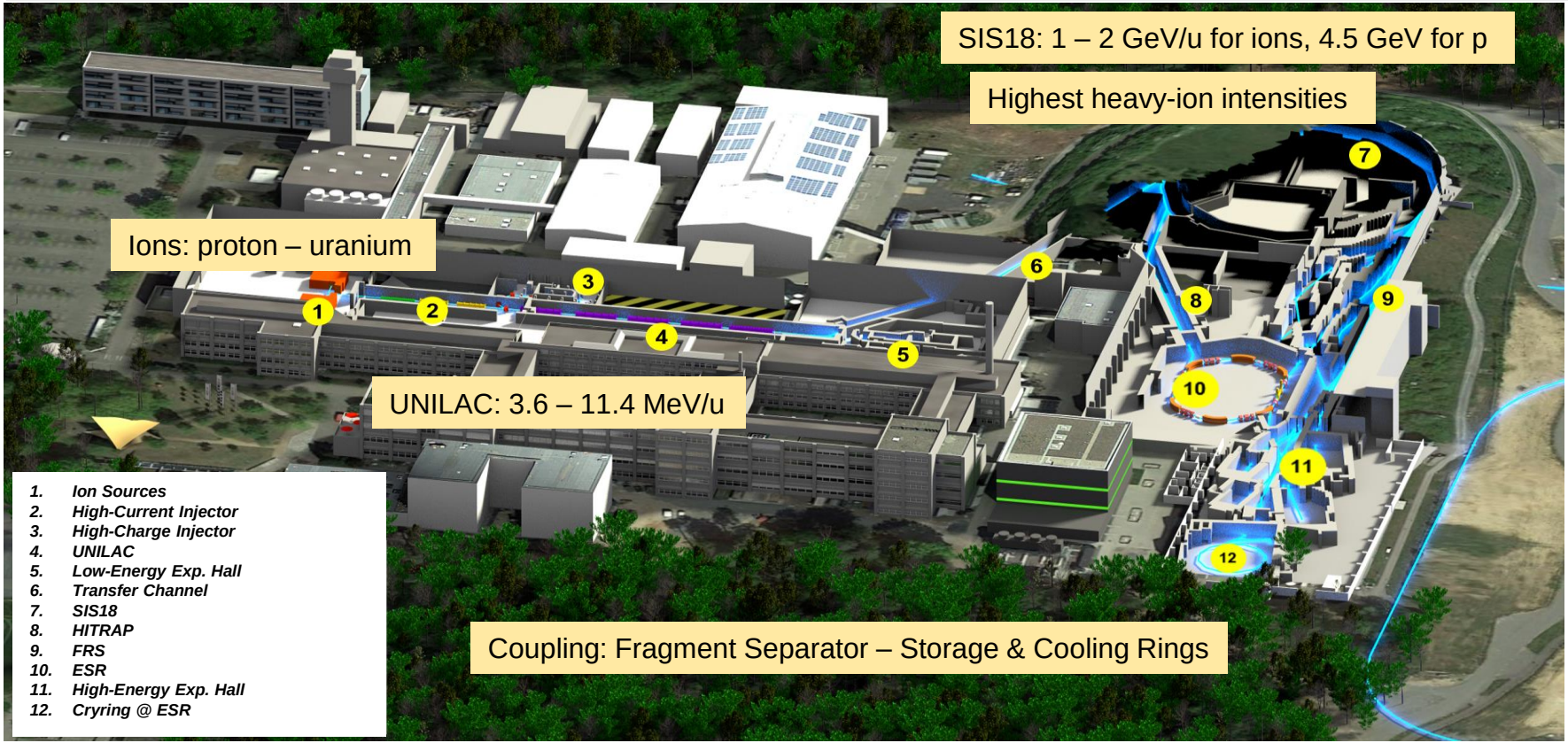
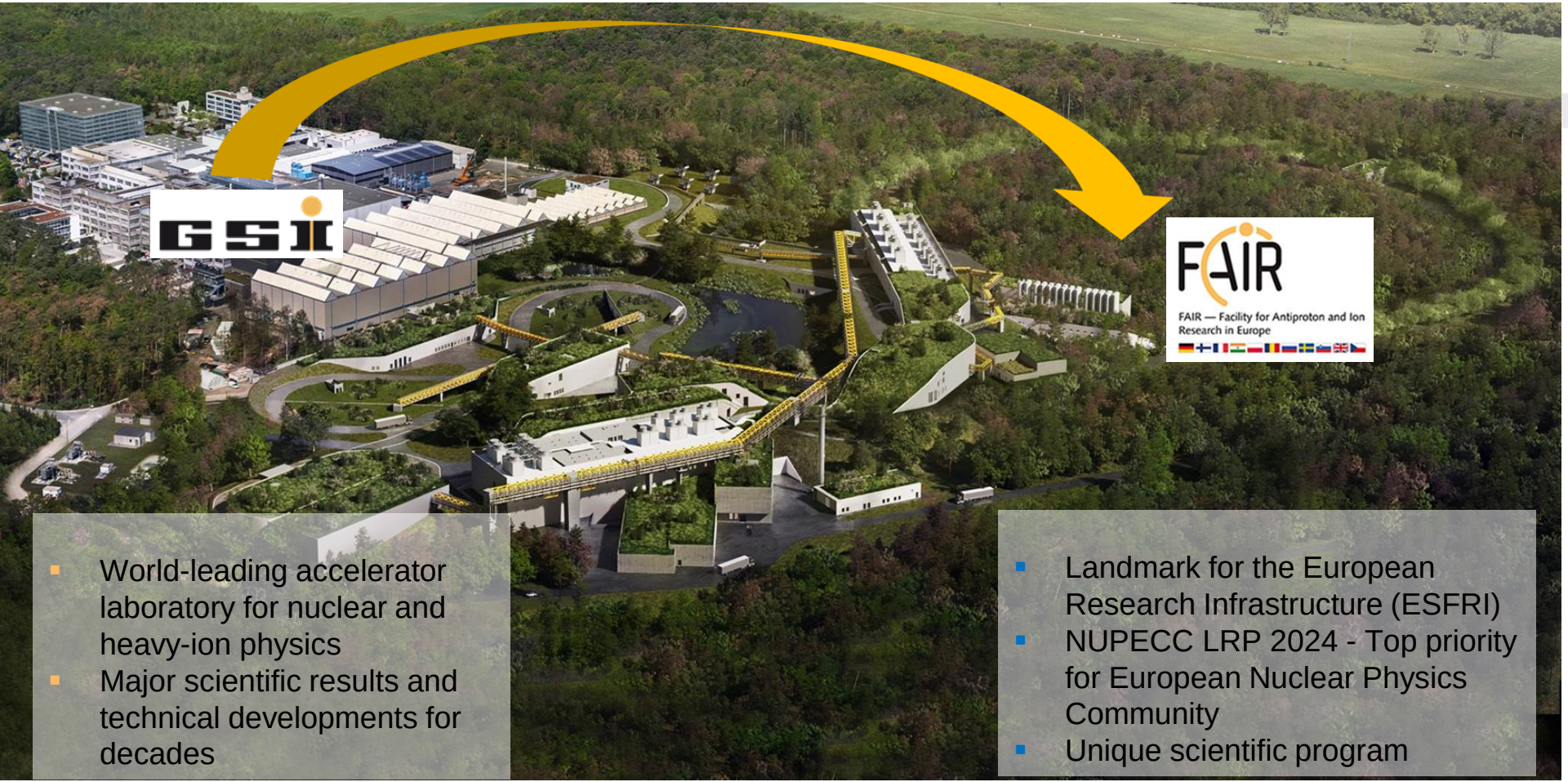
FAIR/GSI Update

Thomas Nilsson
GSI/FAIR Scientific Managing Director

IUPAP WG9 2026-04-15

GSI: Unique Accelerator Complex for Heavy Ions





- World-leading accelerator laboratory for nuclear and heavy-ion physics
- Major scientific results and technical developments for decades

- Landmark for the European Research Infrastructure (ESFRI)
- NUPECC LRP 2024 - Top priority for European Nuclear Physics Community
- Unique scientific program

Facility for Antiproton and Ion Research in Europe GmbH (FAIR)

2010
founded

61
Employees

3,3 G€
Construction budget

255,8 M€
Budget/year

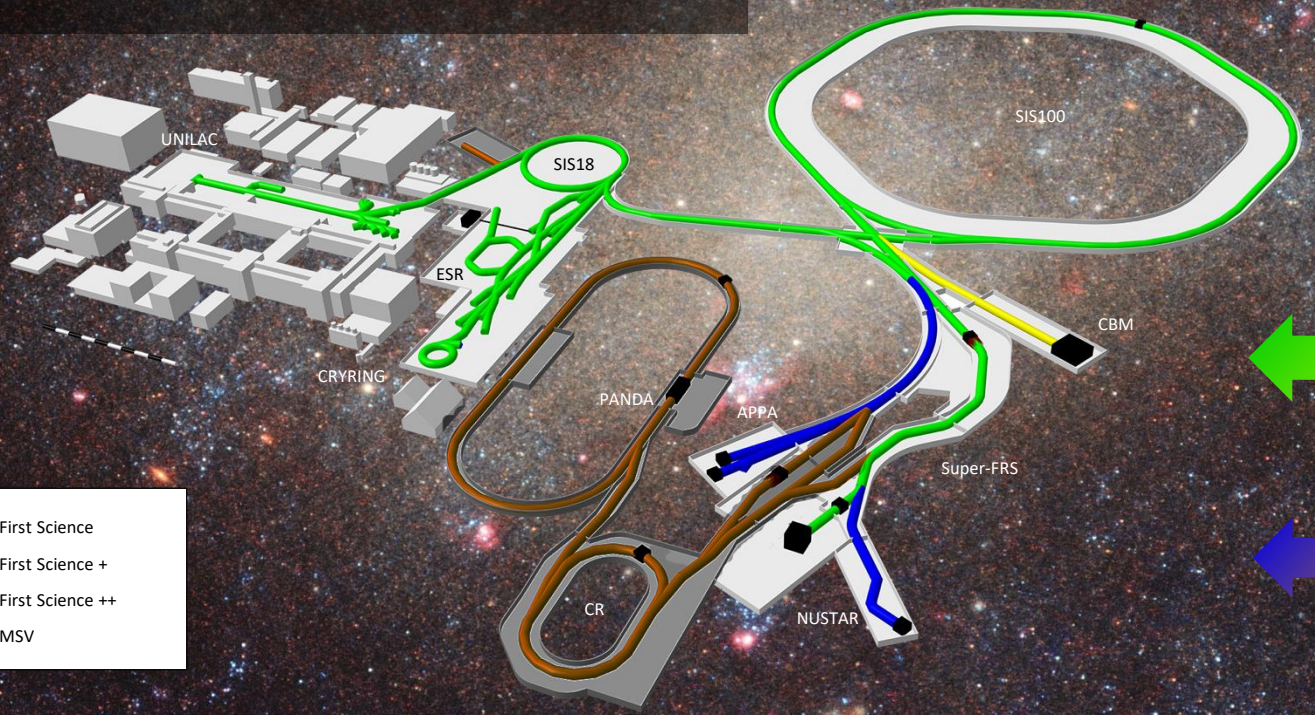
9
Shareholders

- **GSI GmbH** (Germany)
- **Helsinki Institute of Physics** (Finland)
- **CNRS & CEA** (France)
- **Bose Institute** (India)
- **Jagiellonian University** (Poland)
- **National Authority for Research** (Romania)
- **Rosatom** (Russia)
- **Ministry of Higher Education, Science and Innovation** (Slovenia)
- **Swedish Research Council** (Sweden)

Associated
- **United Kingdom Research and Innovation** (UK)

Aspirant
- **Nuclear Physics Institute of Czech Academy of Science** (Czech Republic)

FAIR 2028



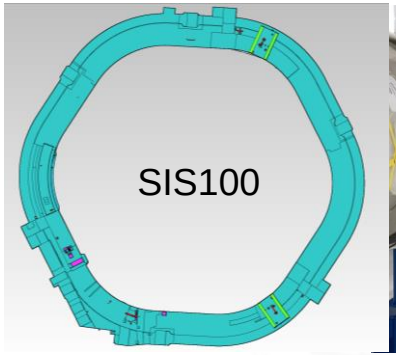
until 2028

after 2028

Foto: NASA Goddard

FAIR2028 Main Installations

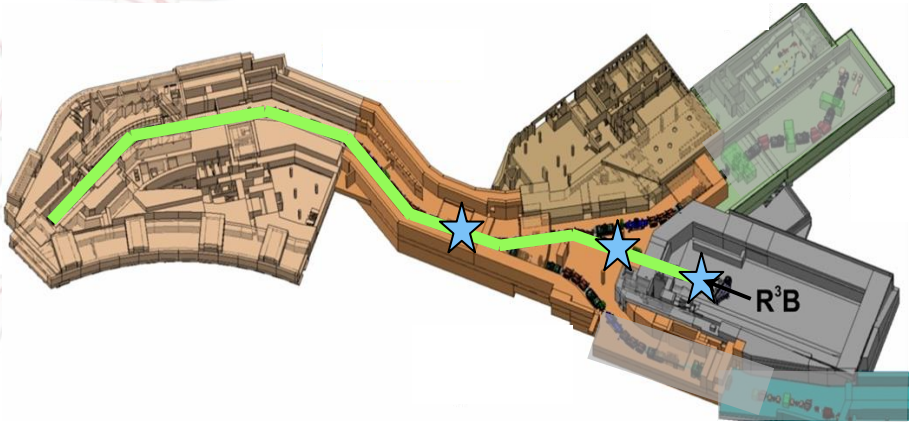
SIS100



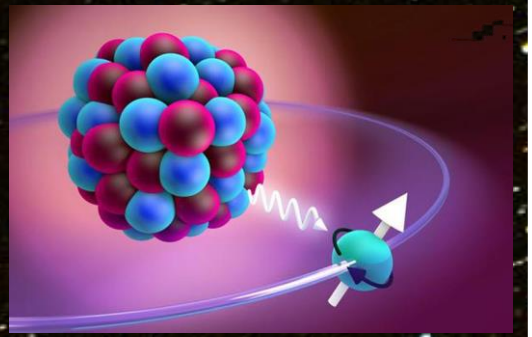
- **Core accelerator of FAIR**, which acts as a feeder for experimental stations (and storage rings)
- Circumference 1,100 m; rigidity: 100 Tm
  - maximum proton energy ~ 29 GeV
  - maximum Uranium U^{92+} ~ 10 GeV/u
- Optimized for intense beams of heavy ions
- Provides slow and fast extraction
- Superconducting fast-ramping dipole magnets

Super-FRS

- **High-acceptance two-stage separator (Bρ-ΔE-Bρ)** for production, separation and identification of **radioactive nuclear beams**
  - Length 350 m; rigidity: 2-20 Tm
  - Pre- (normal conducting) and main (superconducting) separator stages
- Three branches (low-energy, high-energy, ring)



APPA

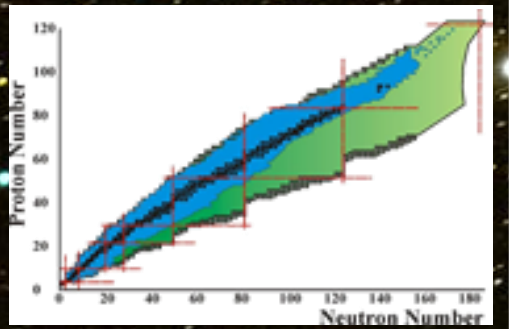


- Precision tests of QED
- Cosmic ray simulator for irradiation studies
- Materials under high pressure

CBM HADES

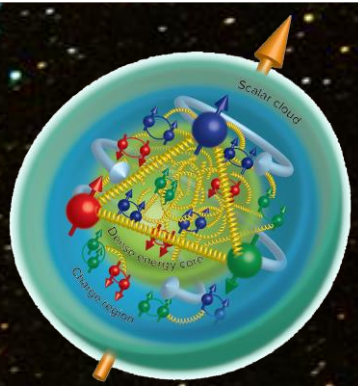
- QCD matter at high baryon densities
- Phase transition and critical point
- Particles in dense medium

NUSTAR



- Nucleosynthesis of heavy elements
- Structure of exotic nuclei (e.g. hypernuclei)
- Neutron matter equation of state

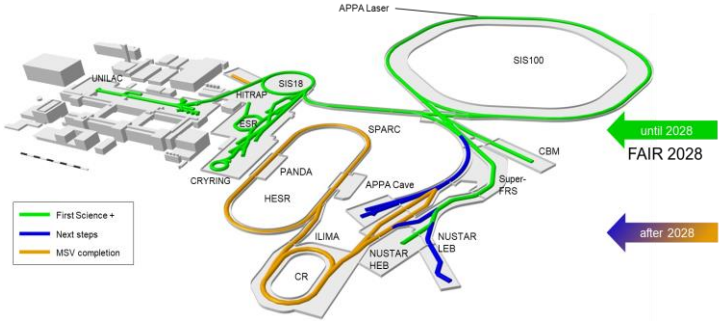
panda



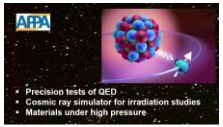
- Gluonic excitations: Hybrids, glueballs
- Precision spectroscopy of charmonium states
- Time-like form factors, nucleon structure

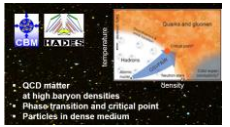
Scientific vision: FAIR 2028

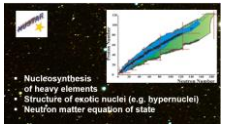
- FAIR in 2028 will feature the most valuable science program which can be hosted in the FS(+) infrastructure.

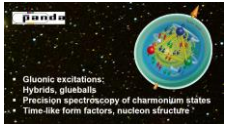


- The ”**FAIR 2028**“ science program will include:
  - **APPA** experiments ***at the low-energy rings***, ***at SIS100***, at the ***caves at SIS18 and UNILAC*** with and at ***PHELIX*** and a limited set of experiments which could be hosted at all the ***caves served by SIS100***
  - **NUSTAR** at the ***Super FRS with SIS100 beams***, plus ***SHE experiments at UNILAC*** and ***ILIMA at the low-energy rings***
  - **CBM** at the ***new cave with SIS100 beams***, and ***HADES at SIS18***
  - **PANDA** is developing a hadron physics program to be carried as bridge towards the program with antiprotons, when possible ***using the caves and beams available at GSI/FAIR*** and synergies with other experiments.

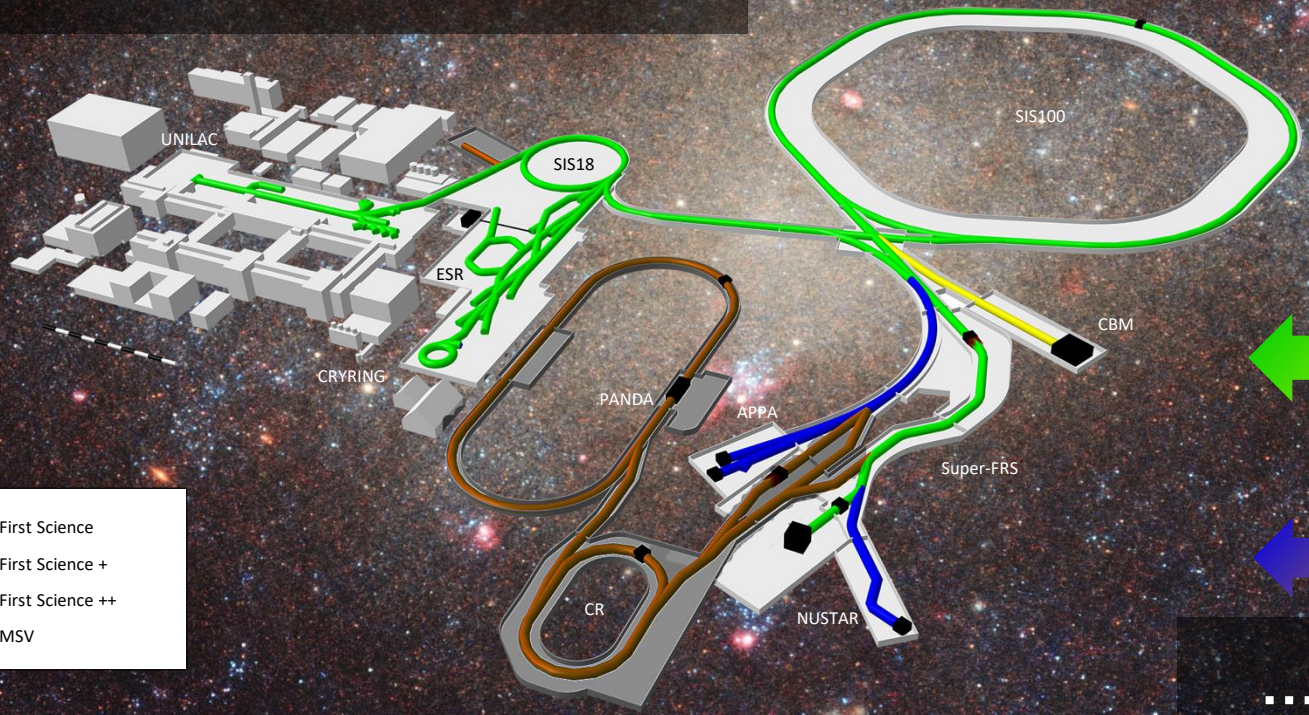








FAIR 2028 – vision…



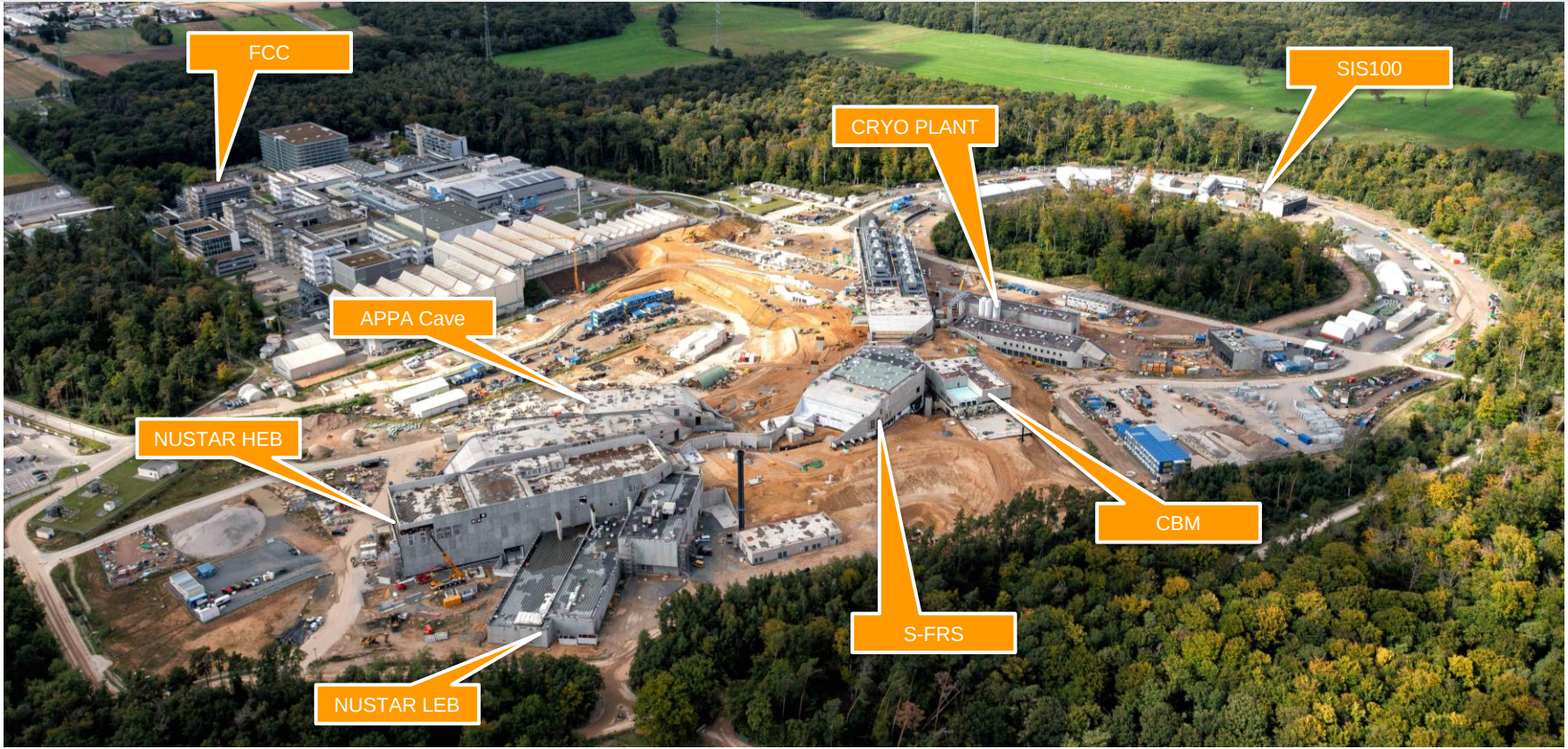
until 2028

after 2028

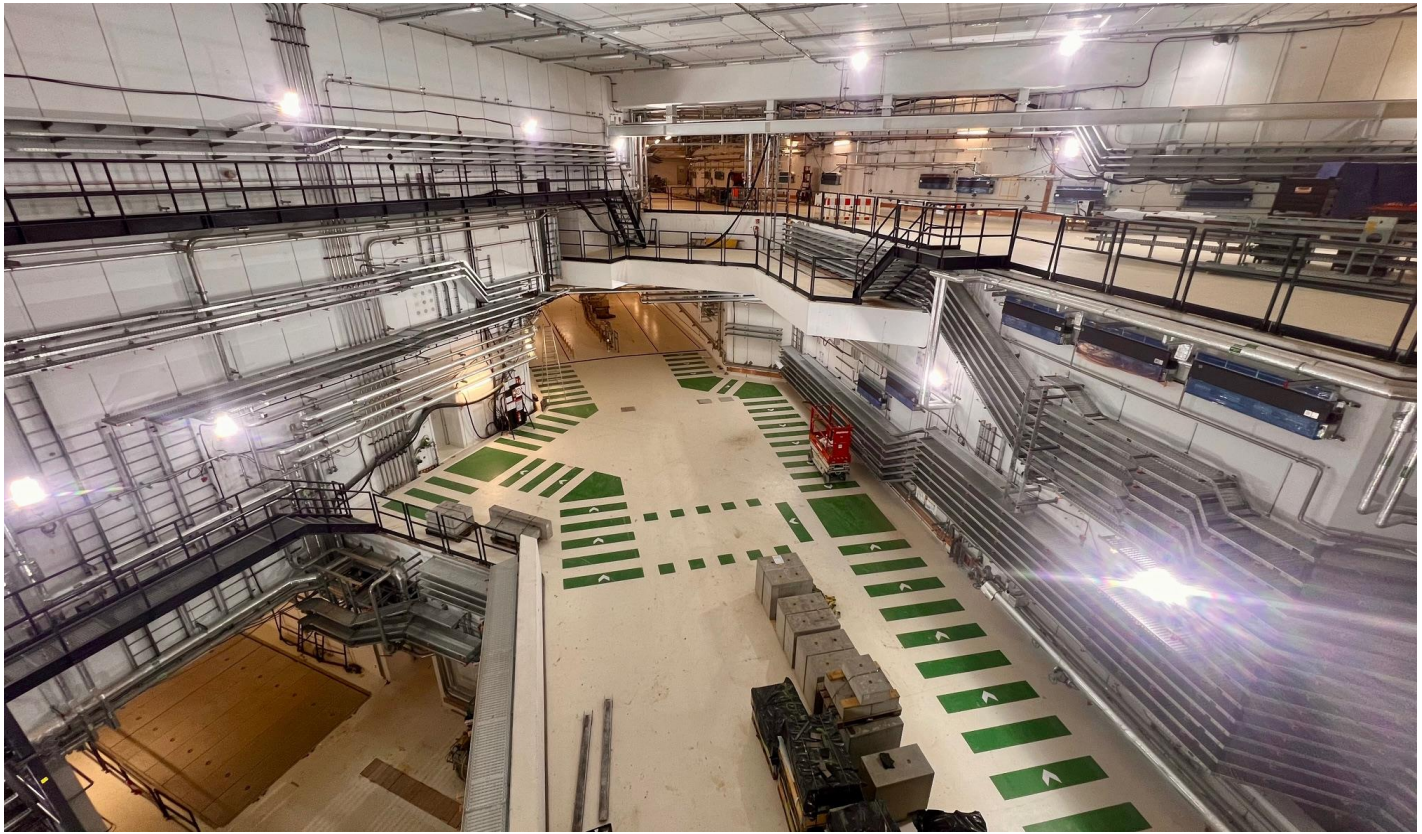
…to reality

Foto: NASA Goddard

FAIR Project Progress – Civil Construction
- Construction site view



FAIR Project Progress – Civil Construction
- Central Transfer building



SIS100 tunnel

© J. Hosan, GSI/FAIR

SIS100 dipoles

Inside the FAIR Control Center (FCC)

FAIR Project Progress – Experimental Caves

Example: CBM cave

- Crane and platform available
- Access roads built
- Magnet foundation poured
- Magnet holding structure accepted

FAIR Commissioning ongoing!

- Q3 2025: Start of commissioning of cryo-plant and cooling water system
- Q4 2025: Initial steps for HEBT commissioning
- Q1 2026: Takeover of main control room in FAIR Control Centre (FCC)

Fire incident at GSI on February 5, 2026

- On February 5, 2026, at around 6:00, a major fire broke out at GSI.
- The fire originated in the area of the radiofrequency (RF) supply for the UNILAC linear accelerator at GSI.
- The reporting chains and the GSI/FAIR crisis management team functioned efficiently. Cooperation with the fire brigade and the authorities proceeded smoothly.
- Approximately 200 emergency personnel were on site.
- The fire was completely extinguished by Friday morning, February 6, 2026.

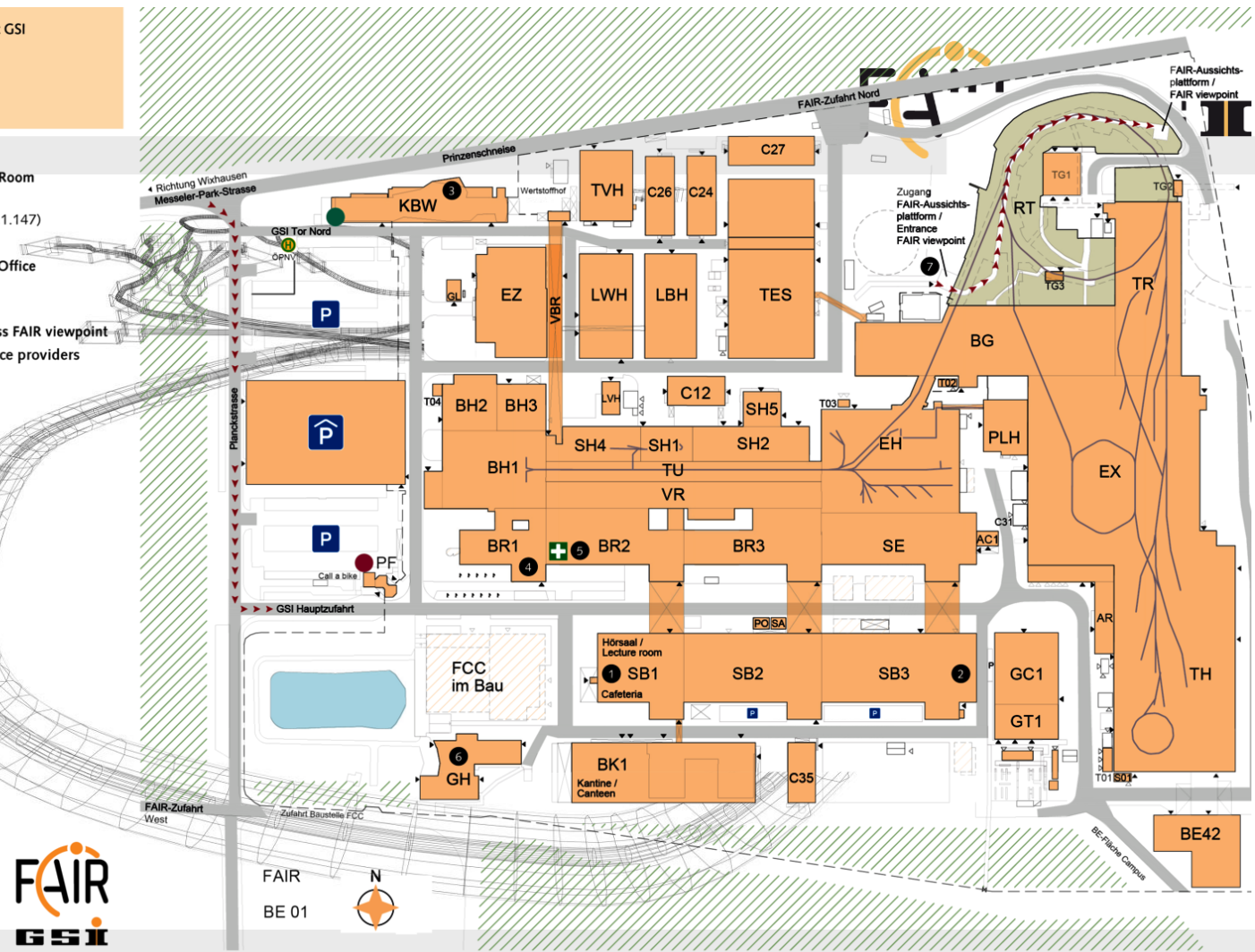
Raumnummern bei GSI I **Room numbering** at GSI
Beispiel I Example **SB2.4.123**

SB2 Gebäude I Building
4 Ebene I Level
123 Raumnummer I Room number

1. **Hörsaal I Lecture Hall** (SB1.1.201)
2. **Seminarraum Theorie I Theory Seminar Room** (SB3.3.170a)
3. **KBW Hörsaal I KBW Lecture Hall** (KBW.1.147)
4. **Welcome Office** (BR1.1.144)
5. **Betriebsärztin/arzt I Company Medical Office** (BR2.1.147)
6. **Gästehaus I Guesthouse**
7. **Zugang FAIR-Aussichtsplattform I Access FAIR viewpoint**
- **Eingang Dienstleister I Entrance service providers**
- **Eingang Gäste I Entrance guests**

GEBÄUDE

AC1	Annex – Container
AR	Annex – Radiologie
BE	Baustelleneinrichtungen
BG	Betriebsgebäude
BH	Betriebshalle
BK	Büro- und Kantinengebäude
BR	Betriebsräume
C	Container
EH	Experimentierhalle
EX	Neue Experimentierhalle
EZ	Energiezentrale
GC1	Green IT Cube I Rechenzentrum
GT1	Green IT Cube I Technikgebäude
GH	Gästehaus
GL	Gefahrstofflager
KBW	Konferenz- und Bürogebäude West
LBH	Leichtbauhalle
LVH	Lager- und Vorfertigungshalle
LWH	Lager- und Werkstatthalle
MP	Wertstoffhof
PF	Pforte
PLH	Phelix
RT	Ringtunnel
SB	Südbau
SE	Schnelle Experimente
SH	Stripperhalle
TES	Testinghalle
TH	Targethalle
TR	Transferhalle
TU	Tunnel
TVH	Tankverkupferungshalle
VR	Versorgungsräume
VBR	Versorgungsbrücke



Information regarding the fire incident

- **No persons were injured**, neither on the GSI site at the time of the fire nor among the emergency personnel.
- The fire department conducted measurements at the fire site and throughout the city. **No hazardous substances were detected during the entire operation**. There was no danger to the public.
- **Damage assessment is ongoing**
- **Fire safety systems operated as planned**
- Many experimental and infrastructure areas at GSI **were not (directly) affected**, including:
  - **SIS18 synchrotron** and its associated **experimental facilities** (ESR, FRS, CRYRING, HITRAP, HADES, R3B…)
  - **PHELIX high-power laser** and the **GreenITCube** data center
  - The vast majority of offices remain usable (entire South Building, KBW, and BK1), as well as the cafeteria and canteen
  - The **FAIR construction site was not affected**. On-site work resumed without restrictions on Friday, 06.02.2026

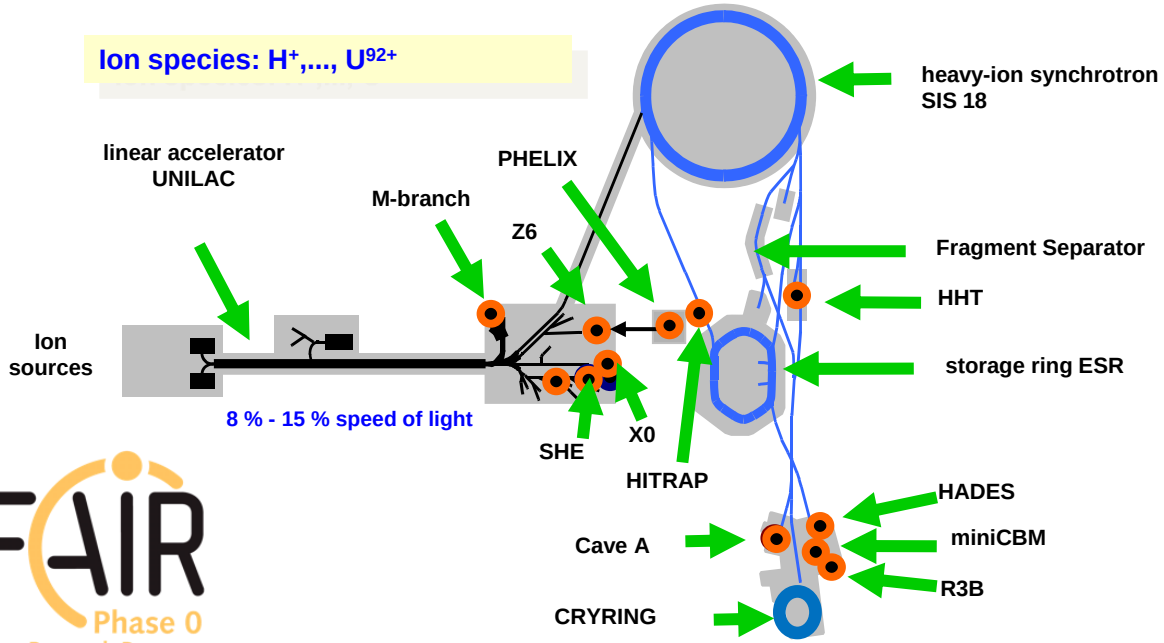
- The overarching objective is to rapidly **identify solutions for the continuation of research** in close collaboration with the scientific community. Objectives:
  - Beams for FAIR commissioning by Q4 2027
  - Intermediate injector for FAIR2028 by Q4 2028

FAIR Phase-0 Scientific Programme

- Started in 2019, annual runs of ~110 days until FAIR operation
- Supported by FAIR partners, so far: Finland, France, Germany, (Romania*), Sweden and the UK

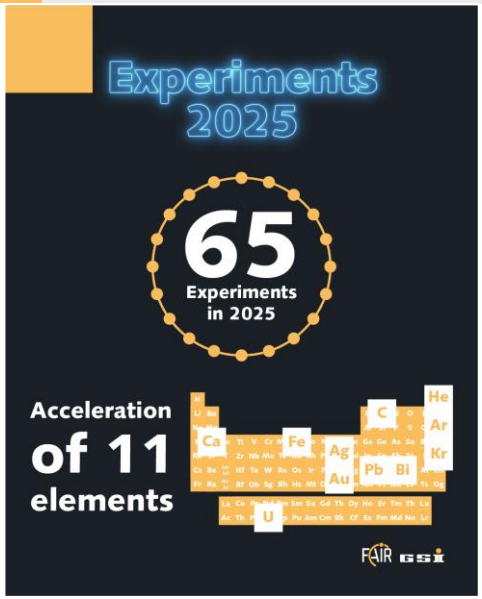
*Romania contributed 2019-22

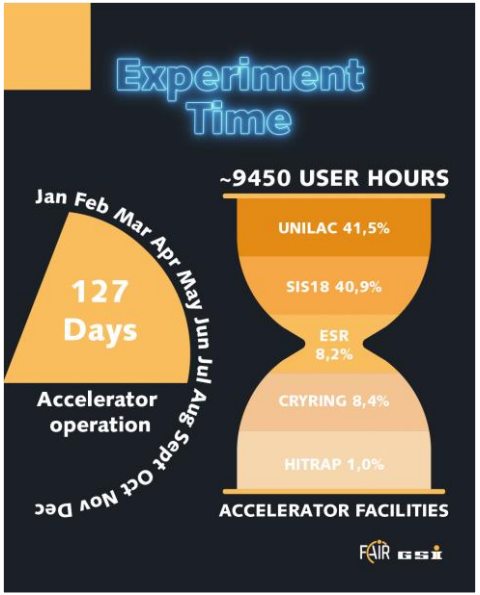
- Harvesting rich results of data taking
- Beam time 2025
  - Extremely successful data taking for experiments and machine studies
  - Record number of physics days
  - Minimal downtimes

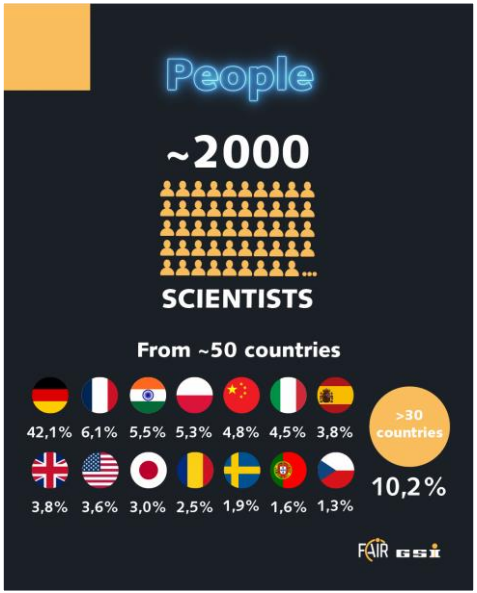


FAIR Phase 0 Research Program

FAIR Phase 0 - Beamtime 2025







Conclusions

- FAIR is steadily progressing towards delivering science
  - Construction and commissioning on a good path
  - GSI UNILAC fire not to delay the start of FAIR2028
- The scientific scope of FAIR2028 will entail a world-leading scientific programme
  - Full exploitation of the approved construction scope
- Moderate further steps will lead to a strong scientific payback
  - APPA and NUSTAR LEB caves
  - HELIAC superconducting cw-LINAC
- Future path towards science with storage rings and antiprotons/PANDA
  - Remains construction goal of FAIR convention

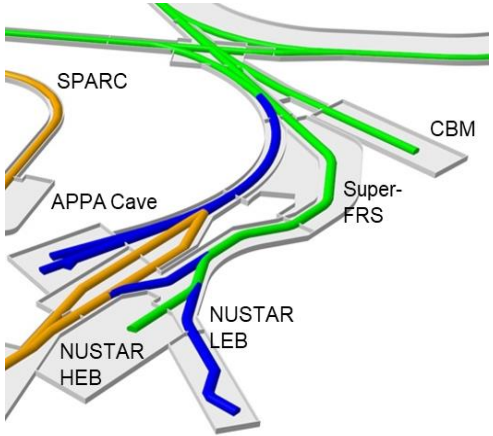

Thank you for your attention!

Next steps FS++

APPA cave serving:

- atomic physics
- plasma physics
- biophysics
- material science
- …

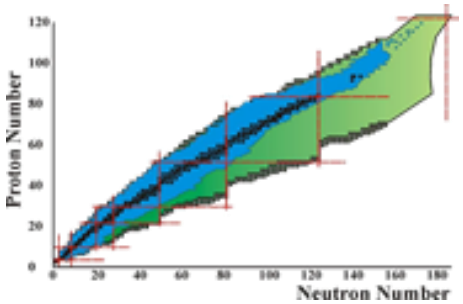
Strong relevance for fusion research!



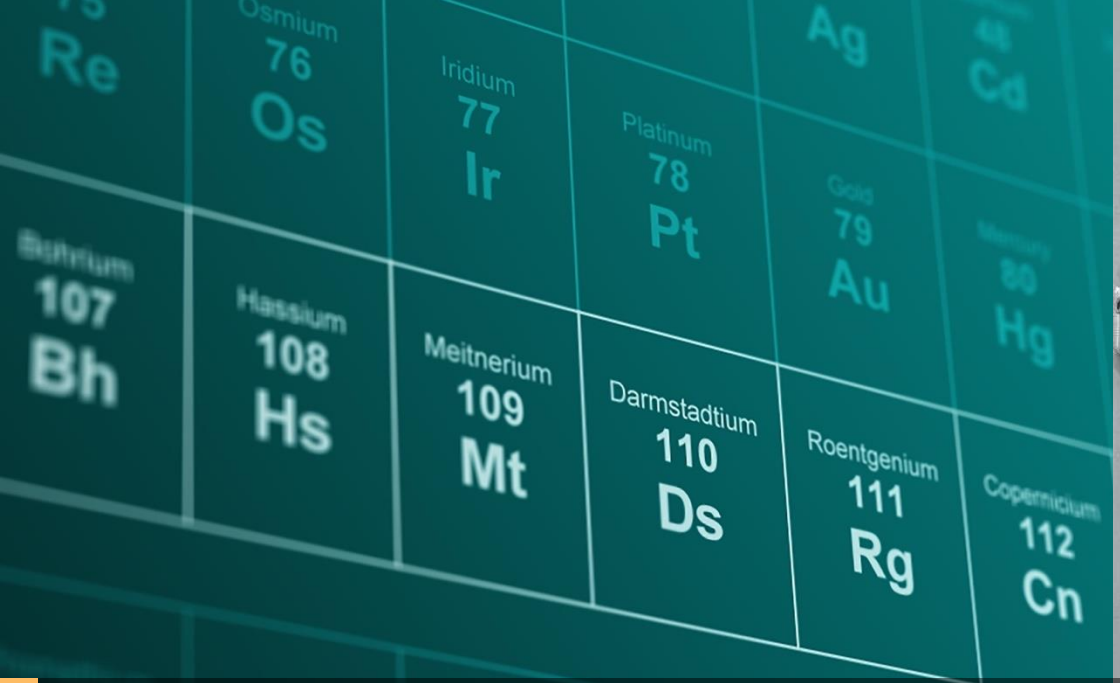
NUSTAR LEB serving:

- high-resolution gamma-ray spectroscopy with AGATA
- decay spectroscopy
- mass measurements
- laser spectroscopy

…

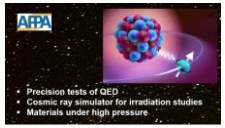


Next steps: Superheavy elements research and Materials Science with HELIAC cw-LINAC

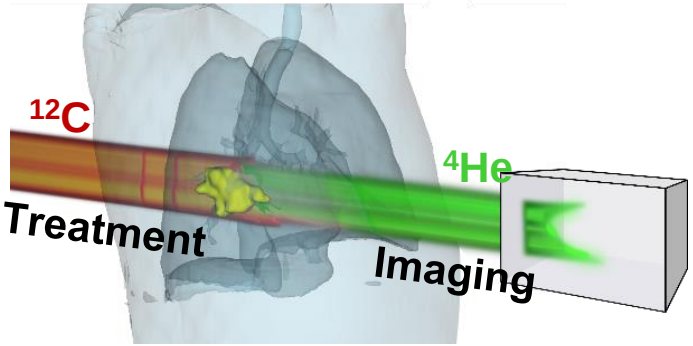


Grafik: J. Hosan, GSI/FAIR, Zeitrausch

Some highlights
… Imaging with mixed C- and He beams

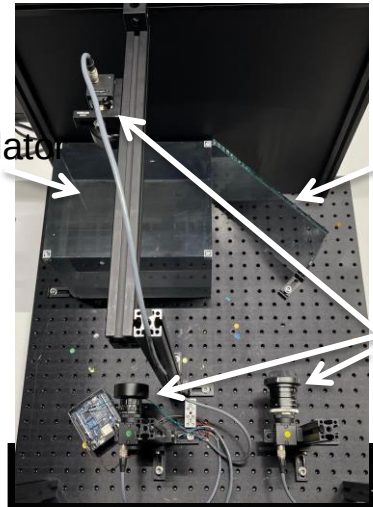


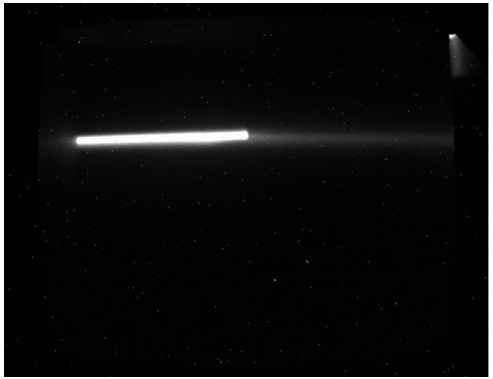
C- and He ions simultaneously accelerated

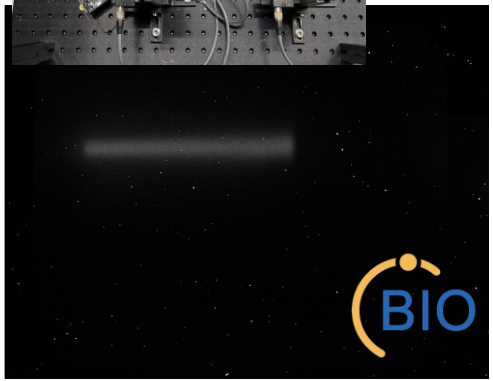


May 2025 – First images with a scintillator-camera system (UCL)

Carbon beam stopped with rangeshifter





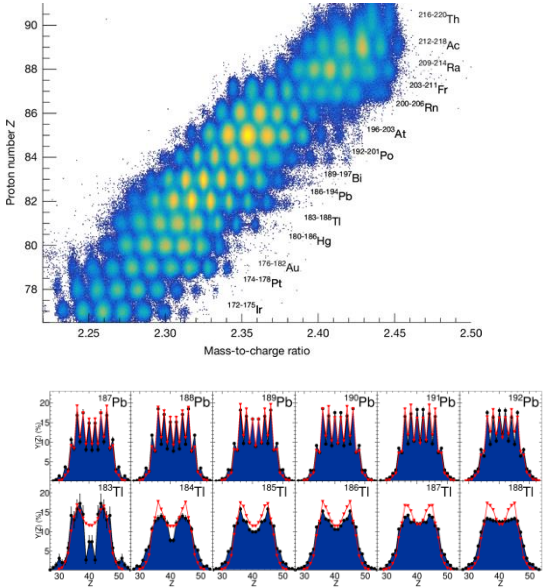


ERC Christian Graeff

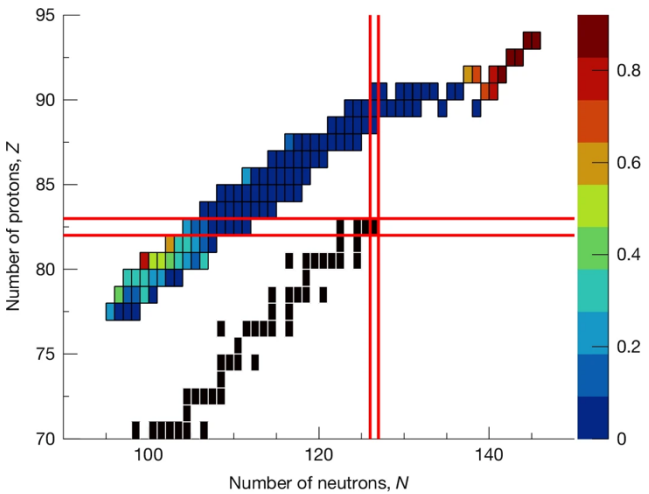
Some highlights
… New island of asymmetric fission

Fission of exotic nuclei

- Important in r-process nucleosynthesis:
  fragment distributions + fission barriers
- Experiment: Charge distributions for for 100 neutron-deficient isotopes produced in Coulomb fission
- **New asymmetric fission island in the sub-lead region discovered**



Map of evolution of asymmetric fission

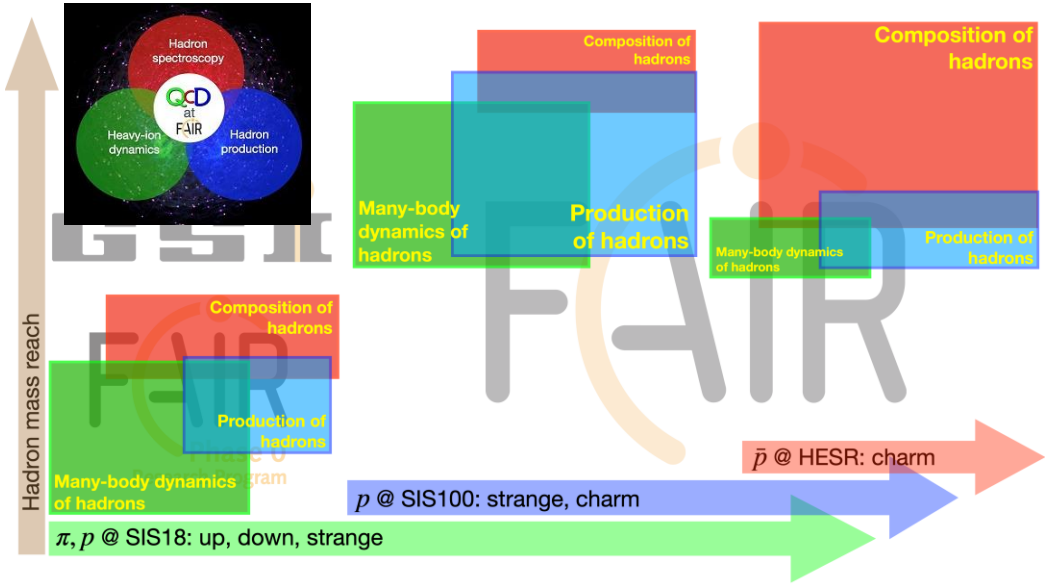


First Science at R³B

P. Morfouace, Nature doi:10.1038/s41586-025-08882-7 (2025)

- (p,2p) induced fission enables measurement of excitation energy (-> fission barriers)
- Charge- and mass-distributions + fission barriers towards r-process nuclei

Pion- and proton-induced QCD studies at GSI/FAIR
Hadron physics with CBM, HADES, and NUSTAR



Roadmap

- **Versatile** program during the various phases of FAIR
- **FAIR Phase0**: pions/protons at HADES@SIS18
  - **FS+**: protons at CBM@SIS100
    - …towards antiprotons at HESR

Hadron Physics at GSI and FAIR: Prospects for the Next Decade


Contents

Strongly endorsed by JSC (Joint Scientific Council)