

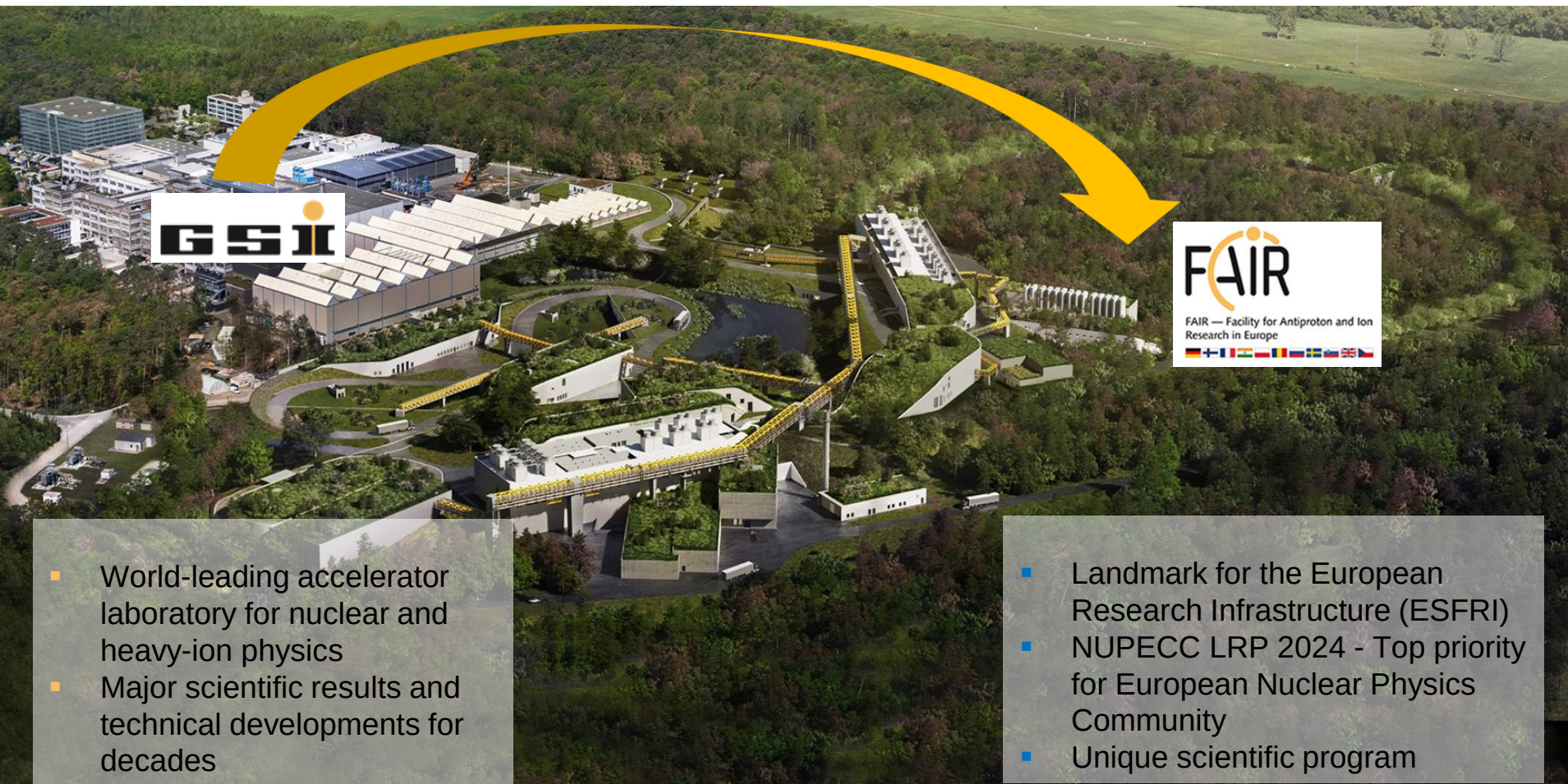
## **Welcome and FAIR/GSI Update**

Thomas Nilsson

GSI/FAIR Scientific Managing Director

MU Days, GSI

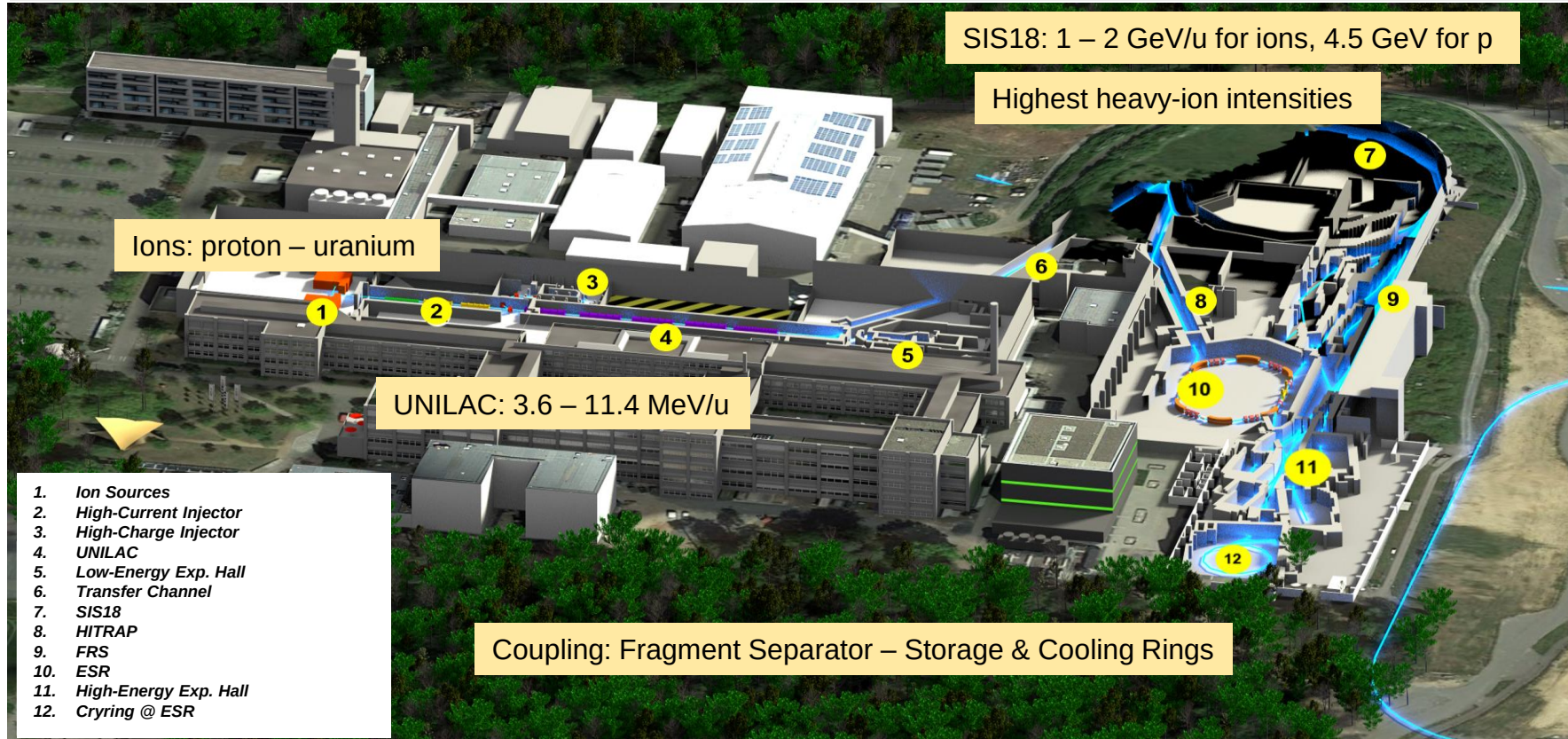
19-20 Oct 2026

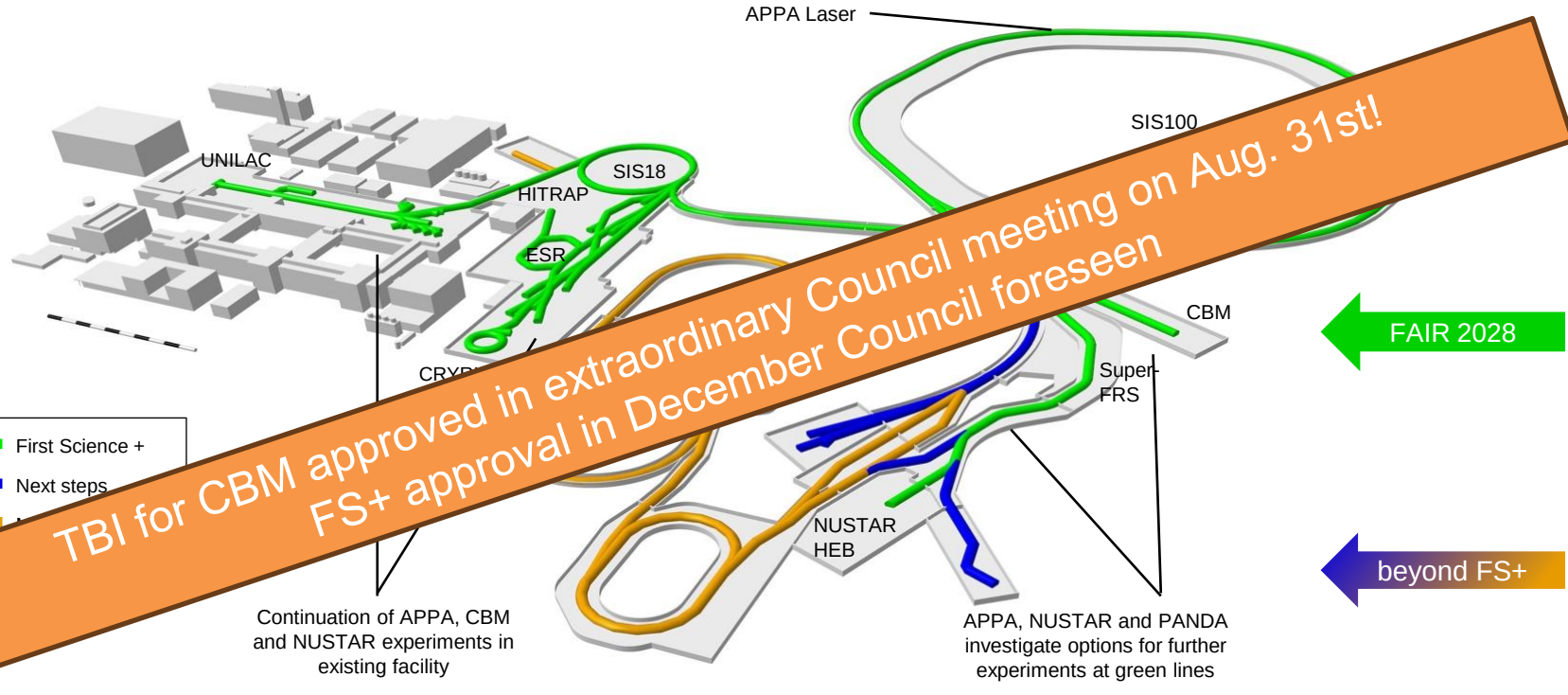


- World-leading accelerator laboratory for nuclear and heavy-ion physics
- Major scientific results and technical developments for decades

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

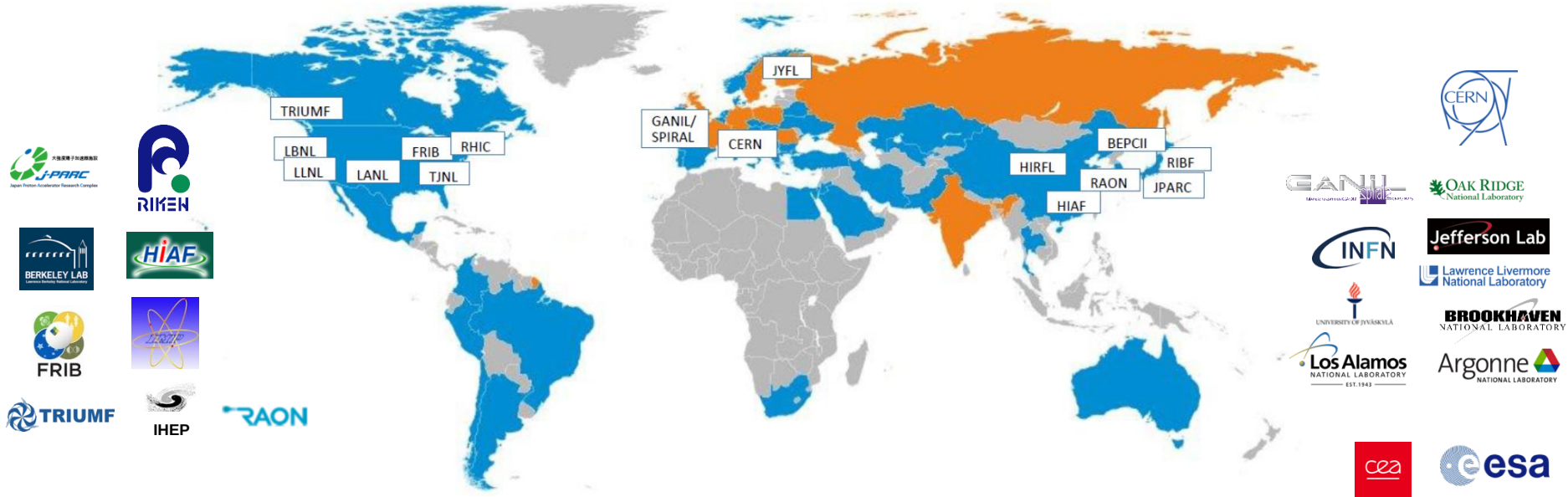
# GSI: Unique Accelerator Complex for Heavy Ions





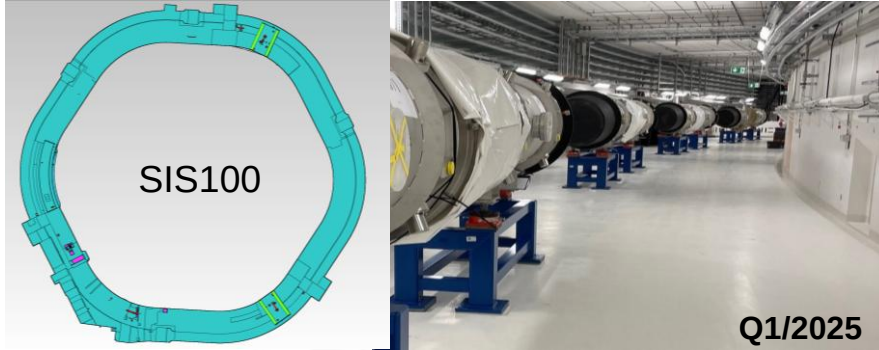
FAIR international facility: 9 shareholders + 1 associated partner + 1 aspirant partner

# Worldwide Collaboration & Competition



- With major research facilities / institutions / projects from all over the world
- With Scientists from more than 200 institutions from 53 countries (Orange + Blue)
  - **Orange:** countries, which are shareholders of FAIR
  - **Blue:** countries contributing to research and technical development projects at GSI and FAIR
- In total more than 3000 scientists and engineers are involved in R&D for GSI and FAIR

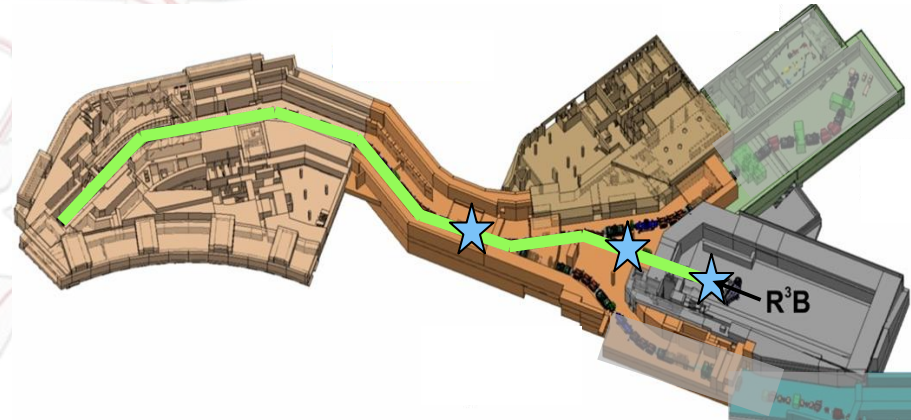
## SIS100



- **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  $\sim 29$  GeV
  - maximum Uranium  $U^{92+} \sim 10$  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 ( $B\rho$ - $\Delta E$ - $B\rho$ )** 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)

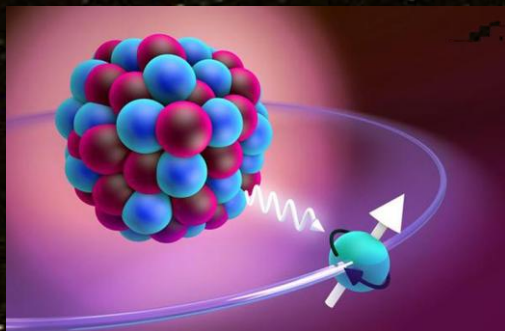


# View to the future : SIS100

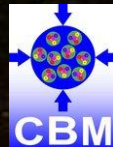
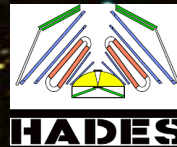


# View to the future : Super-FRS

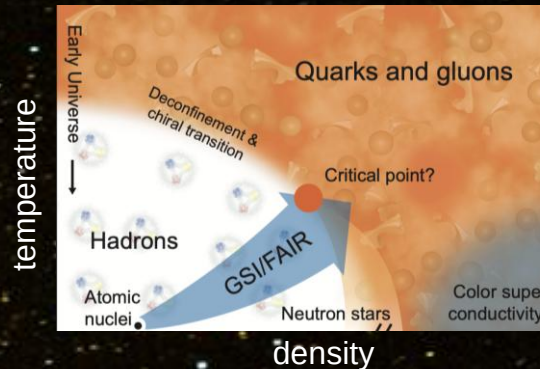
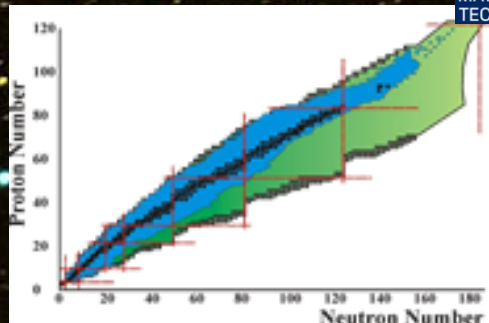




- Precision tests of QED
- Cosmic ray simulator for irradiation studies
- Materials under high pressure



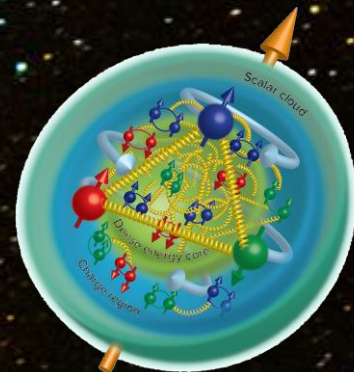
- QCD matter at high baryon densities
- Phase transition and critical point
- Particles in dense medium



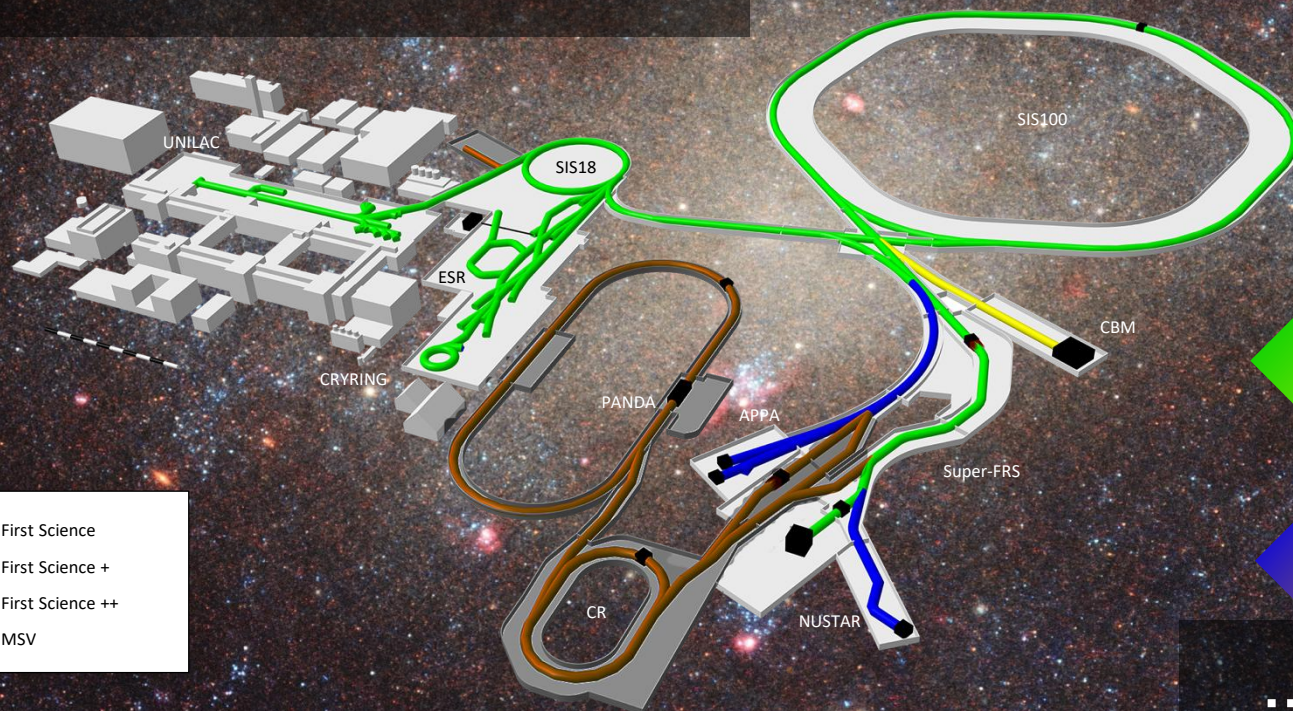
- Nucleosynthesis of heavy elements
- Structure of exotic nuclei (e.g. hypernuclei)
- Neutron matter equation of state



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



# FAIR 2028 – vision...

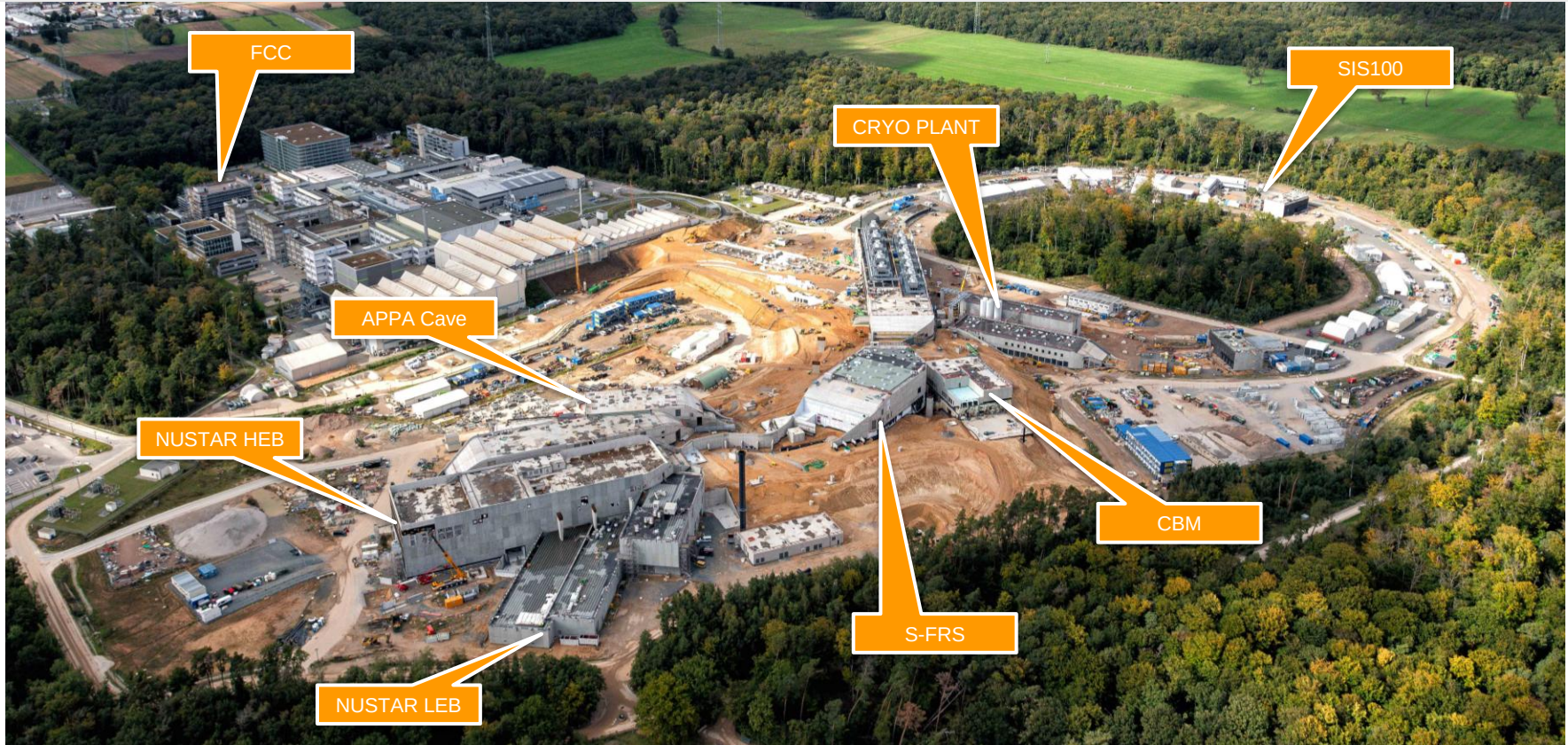


- First Science
- First Science +
- First Science ++
- MSV

...to reality

# FAIR Project Progress – Civil Construction

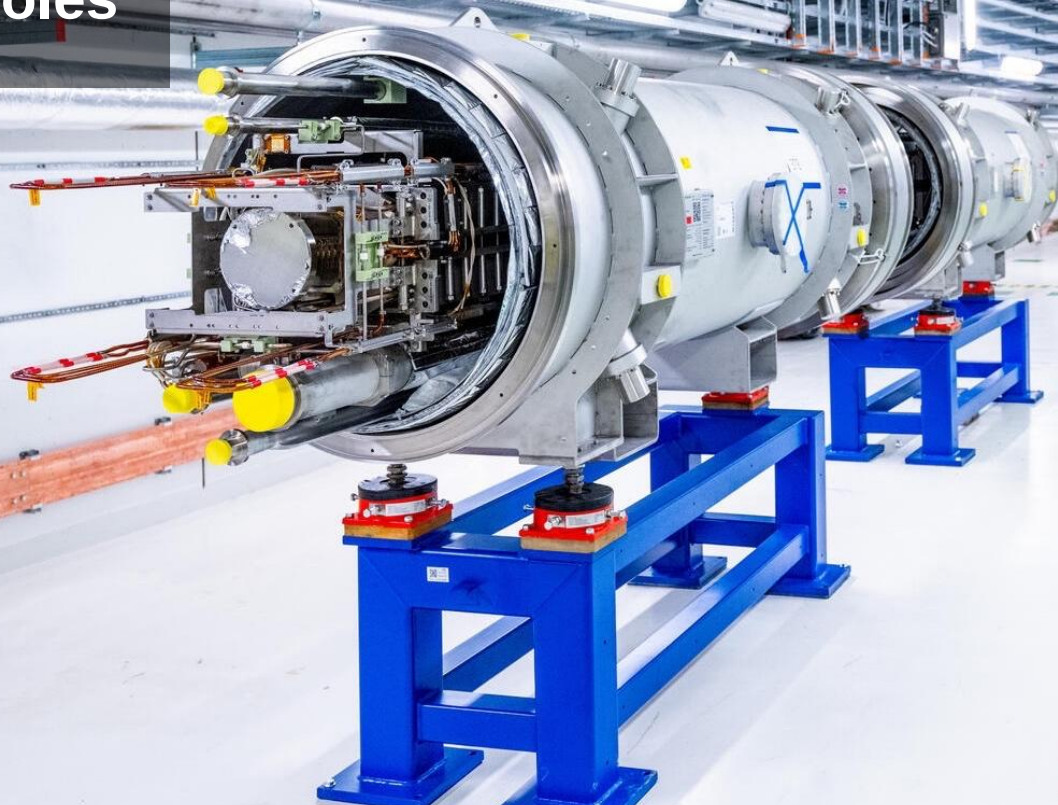
## - Construction site view



# SIS100 tunnel



# SIS100 dipoles



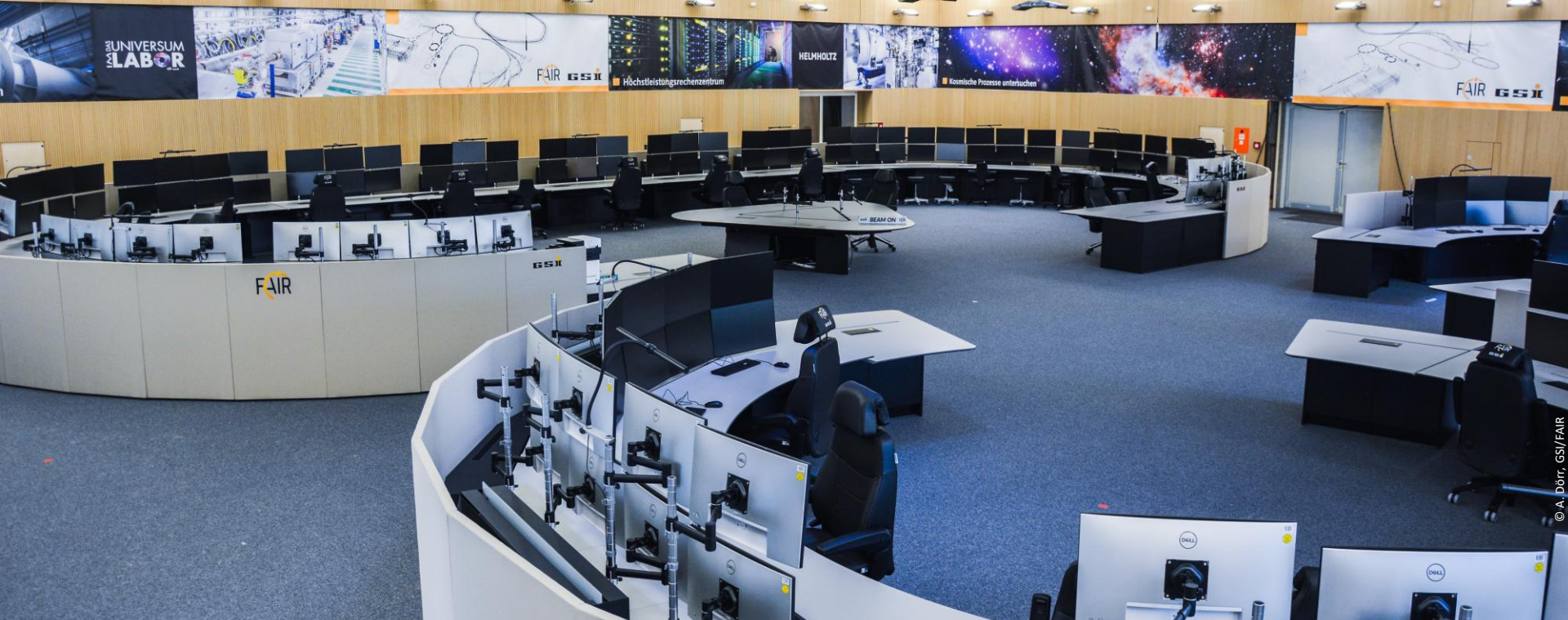
# Commissioning Cryoplant



# Super-FRS SC Magnet



# Inside the FAIR Control Center (FCC)



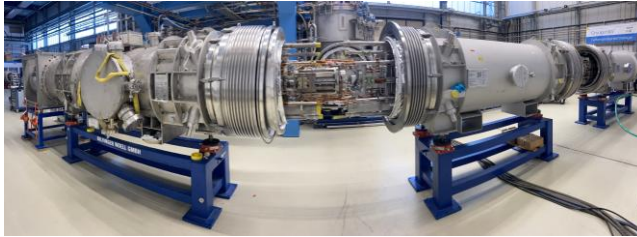
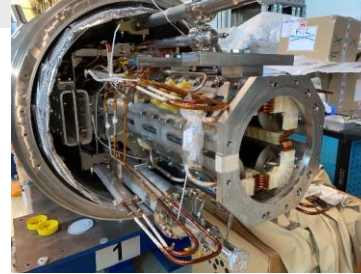
# FAIR Highlights

## SIS100



Status 21.09.2026

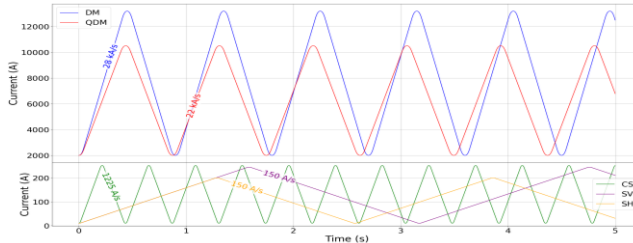
Number of Cycles: 4.75 Million



Series production of gamma-t-jump magnets at Partzsch completed. Cold test under preparation



Series production of star-shaped quadrupole chambers at Research Instruments (RI) completed



- Dipole Cycle Repetition Rate 1.1 Hz
- Maximum Dipole Current 13 200 A
- Dipole Ramp Rate 28 000 A/s



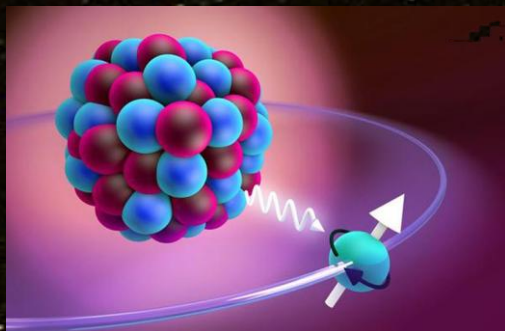
Feed-in line box 30 manufactured at Kriosystem and delivered

# CBM – Compressed Baryonic Matter

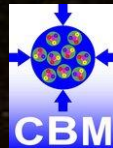
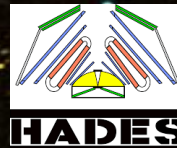
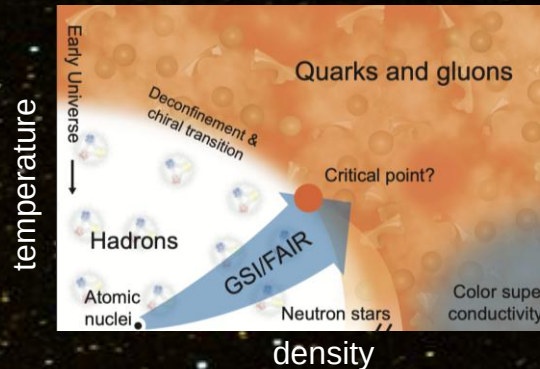
Final setup in cave including HADES

# NUSTAR-R3B at the Super-FRS

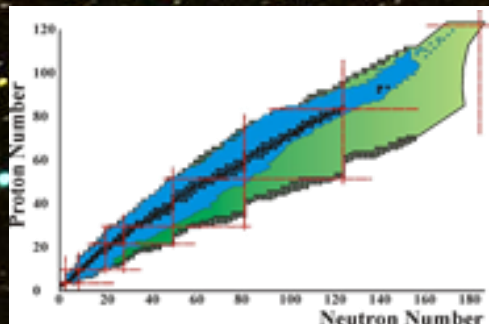




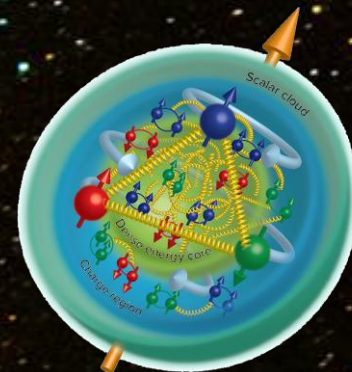
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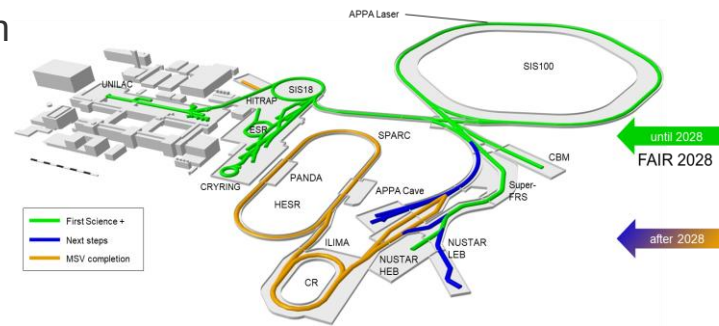
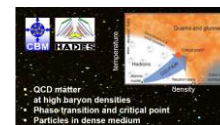
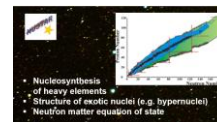
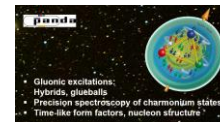
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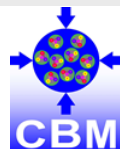
# Scientific vision: FAIR 2028

- 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.



# Recent FAIR Experiment Highlights

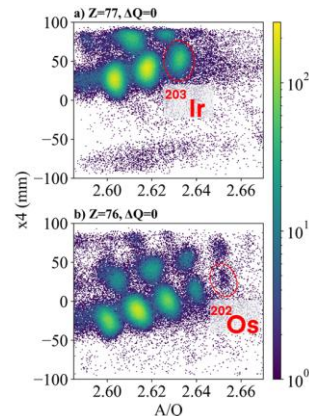
- CBM
  - Technical Building Infrastructure for CBM approved
  - STS: all modules assembled, first half-unit assembly
  - Magnet: FAT of the power supply
  - New CBM physics performance paper:  
<https://arxiv.org/pdf/2606.16395>



- APPA
  - Artemis-II Moon mission used a camera that had previously been tested at GSI Cave A by the BIO group
  - BIOMAT setups at the SFRS (ES/FS) and in the CBM cave (FS+) have been approved by the FAIR Council



- NUSTAR
  - Start of experiment infrastructure installation (e.g. vertical storage system in HEC)
  - Results of investigations on structure of semi-magic  $^{203}\text{Ir}$  and  $^{202}\text{Os}$  nuclei using DEGAS array accepted for publication (G. Bertram et. al., Phys. Lett. B 2026)

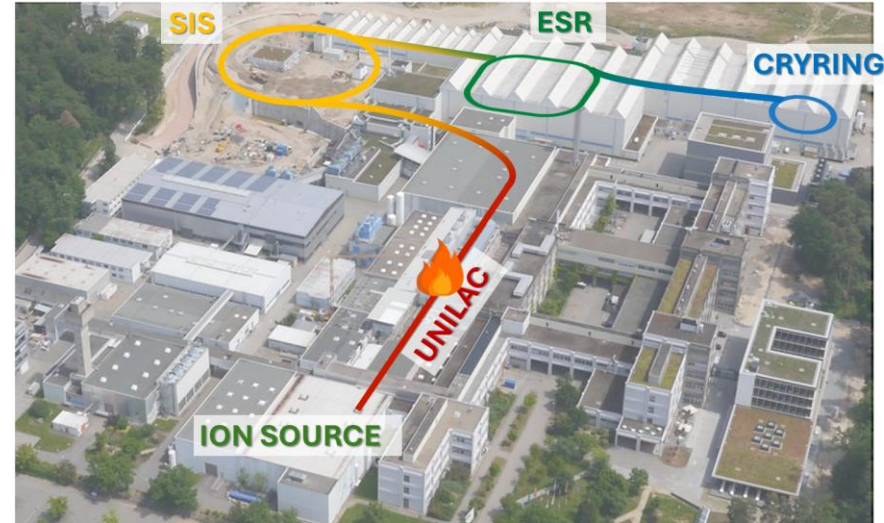


- PANDA
  - Preparations: INSIGHT at ELSA and KOALA at GSI



# Consequences of the fire incident (1)

- UNILAC currently not operational
- Impact on experimental hall (EH)
- 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



## Consequences of the fire incident (2)

- **FAIR construction site was not affected:** on-site work resumed without restrictions on Friday, 06.02.2026
- Overarching objective: rapidly **commence solutions for the continuation of research** in close collaboration with scientific community.
- Objectives:
  - Beams for FAIR commissioning by Q4 2027
  - Intermediate injector for FAIR2028 by Q4 2028
  - Restoring UNILAC injector capability by 2030/2031
- **Funding has been secured**



D. Fehrenz, GSI/FAIR

## Short term (1-2 years):

- Experiments with **available beams, alternatives for science**

## Mid term (3-5 years):

- Resumption of the full physics program
- **FAIR2028** (possibly delayed)

## Long term (>5 years):

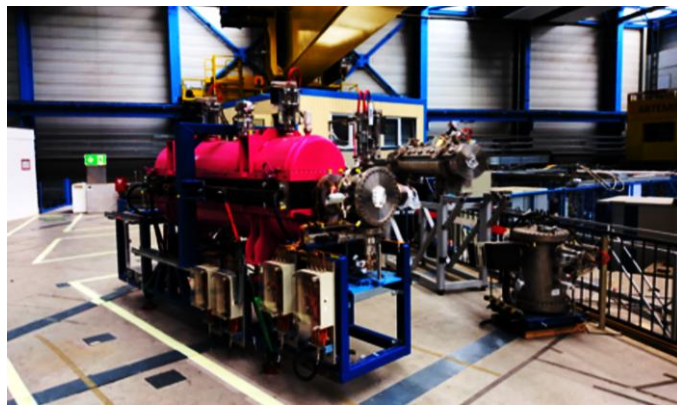
- Ensuring research dependent on long beam-pulse structure - **superheavy elements, parts of materials research and fusion-related research** and redundancy of the injector chain

- Beams for commissioning the FAIR machines and detectors (min.  $^{12}\text{C}$ ) in Q4/2027
- Heavy ion beams (up to Xe or heavier) for an intermediate science program latest Q4/2028 until Q4/2030
- Full GSI/FAIR capabilities with UNILAC as a high-intensity short-pulse machine within Q4/2030
- HELIAC for long-pulse operation as of 2032

# 2027: start FAIR Commissioning with beam

min.  $^{12}\text{C}$ -beam at low intensity ( $1\text{E}7\text{-}1\text{E}8/\text{spill}$ ,  $^{12}\text{C}^{5+}$  up to  $1,5\text{GeV}/u$ )  
(PARTI H I HITRAP in transfer channel)

- Main focus: **technical commissioning** with beam of FAIR HEBT (beam transport lines) and Super-FRS
- Beam parameters not sufficient for a broad competitive user beamtime, focus is on detector tests and selected experiments (e.g. BIO, R3B)



# Interim solutions

## (A) PARTIH – (B) InterLAC



To SIS-18 and FAIR

(A) PARTIH beam Q4 2027

Relocation HiTRAP

15 meter device in TK

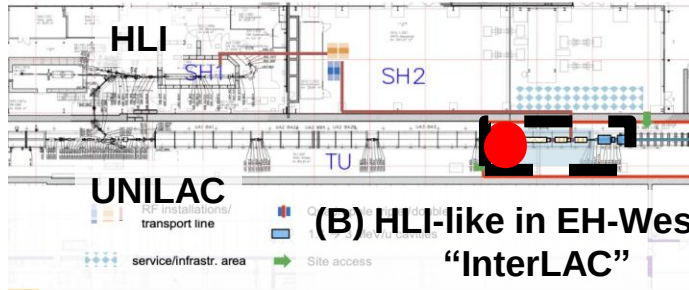
Beam for SIS-18 and FAIR

(B) InterLAC beam Q4 2028

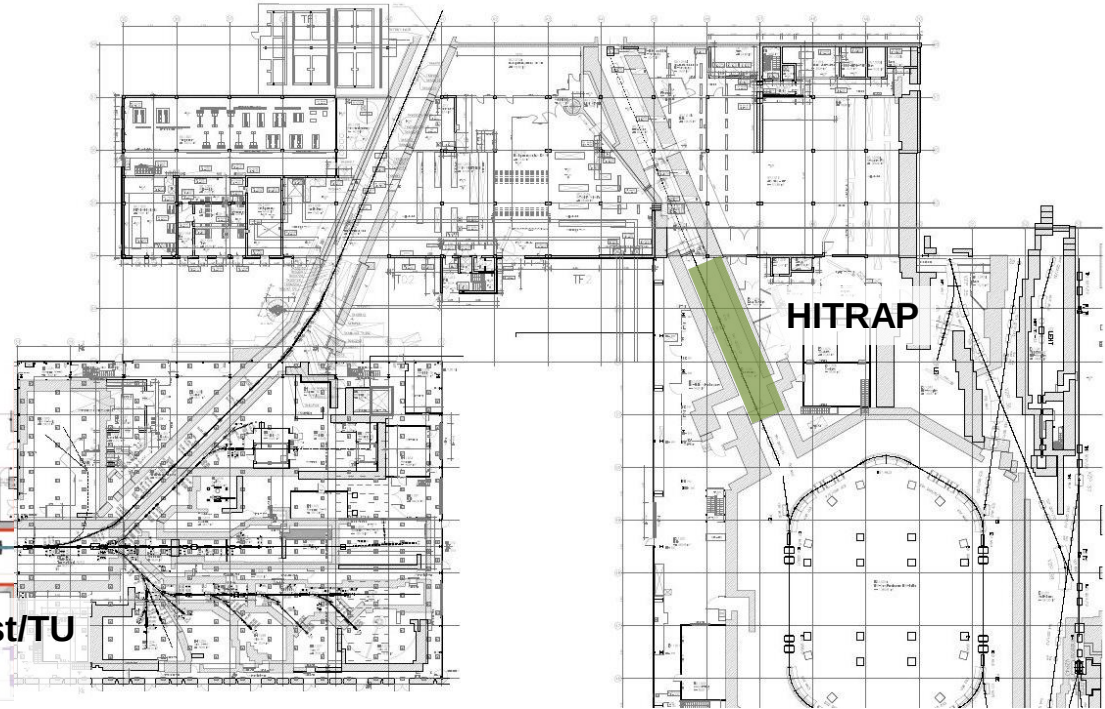
Setup HLI copy in EH West/TU

About 10 m plus ion source

Beam to EH, SIS-18 and FAIR



(B) HLI-like in EH-West/TU  
“InterLAC”



# 2028 – 2030: Further commissioning and intermediate science



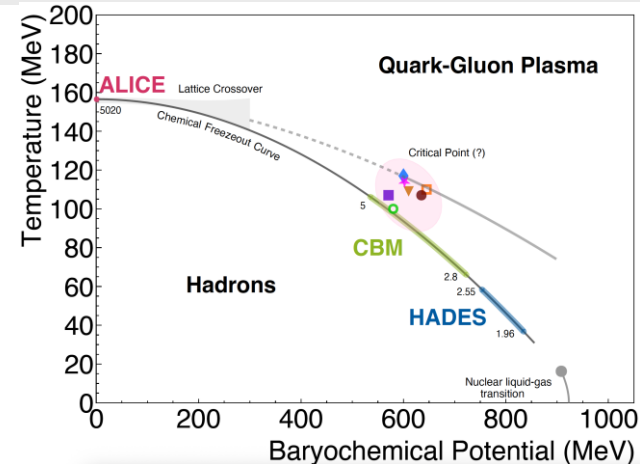
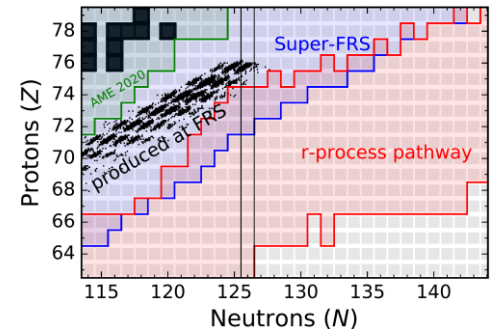
min. Xe-beam at medium intensity (InterLAC)

## ■ Commissioning

- accelerators Super-FRS, SIS100 commissioning
- detectors for NUSTAR (Super-FRS, R3B), CBM and APPA-Laser experiments

## ■ Adapted FAIR 2028 science programme for all communities. Examples are:

- Measurements with light and medium heavy beams at CBM
- Galactic cosmic ray simulator at 10 GeV/u (biophysics/ESA)
- Adapted NUSTAR ES/FS program with focus on R3B with light and medium heavy RIBs



 Physics-1      *NUSTAR utilising S-FRS, Biophysics, Detector tests with light beams*

 Physics-2      *NUSTAR, APPA, HADES with medium heavy beams*

 Physics-3      *CBM, NUSTAR and APPA utilising SPS100*

 Physics-4      *heavy ion campaigns (Au-beams for CBM, U-beam for NUSTAR)*

 Physics-5      *restart of SHE and MAT with long-pulse operation*

...

 Full FAIR

**feedback received from collaborations,  
endorsed by GSI/FAIR JSC,  
beam requirements to be detailed**

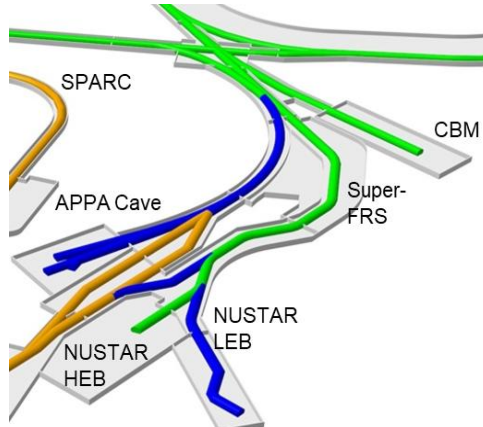
*Cumulative steps, i.e. all science in addition in each step*

## Next steps FS++

APPA cave serving:

- atomic physics
- plasma physics
- biophysics
- material science
- ...

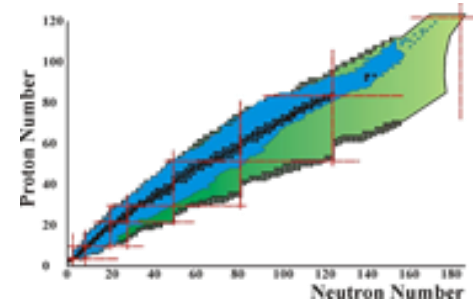
*Strong relevance for fusion research!*



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



- FAIR is steadily progressing towards delivering science
  - Mitigation programme following the GSI UNILAC fire incident well underway
- The scientific scope of FAIR2028 will entail a world-leading scientific programme
  - Full exploitation of the approved construction scope including adaptations
- Moderate further steps will lead to a strong scientific payback
  - APPA and NUSTAR LEB caves constructed – to be equipped
  - HELIAC superconducting cw-LINAC
  - **Feasible within PoF V!**
- Long-term perspectives - science with storage rings and antiprotons/PANDA

# Nobel Prize in Physics 2026

Francis Halzen · University of Wisconsin–Madison, USA



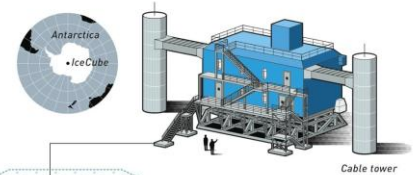
III. Niklas Elmehed © Nobel Prize Outreach

*“for decisive contributions to the IceCube Neutrino Observatory and the discovery of high-energy neutrinos of astrophysical origin”*



## An observatory in the ice

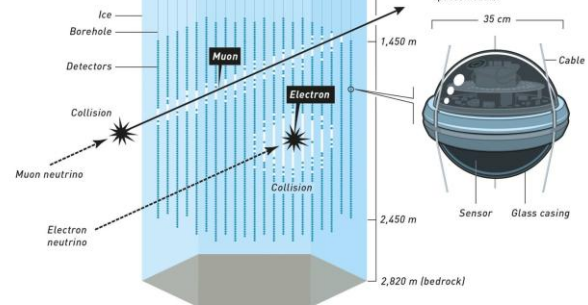
IceCube is a cubic kilometre of ice equipped with light sensors on long cables, as well as a building on the surface where the signals from the ice are collected. Data are then forwarded via satellite for analysis.



### PARTICLES AND LIGHT

Most neutrinos that reach IceCube travel straight through it without registering. The few neutrinos that collide with an atomic nucleus create light that can be captured and analysed.

There are three different types of neutrinos that create different patterns in IceCube. When an electron neutrino or tau neutrino collide with an atomic nucleus, they cause a cascade of particles that illuminate the area around the collision. A muon neutrino that collides not only creates a cascade, it also creates a particle, a muon, that makes a long trail of light through the ice.





**Thank you for your attention!**