The FAIR Accelerator – Construction and Installations

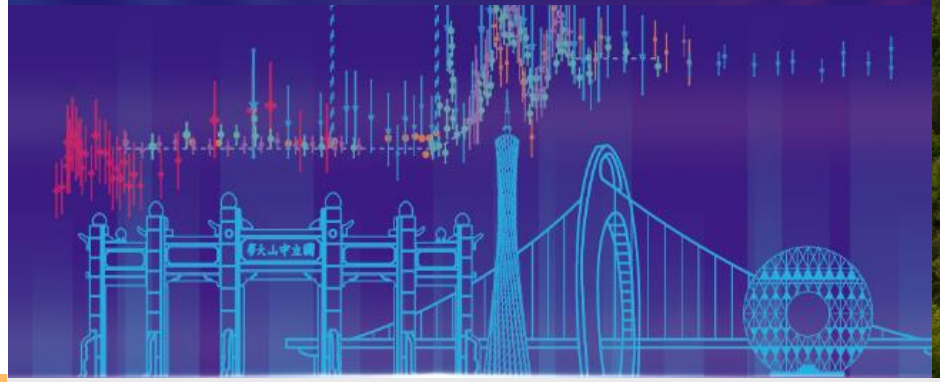
The 6th International Workshop on Future Tau Charm Facilities

FTCF, 17-21 Nov 2024, Guangzhou

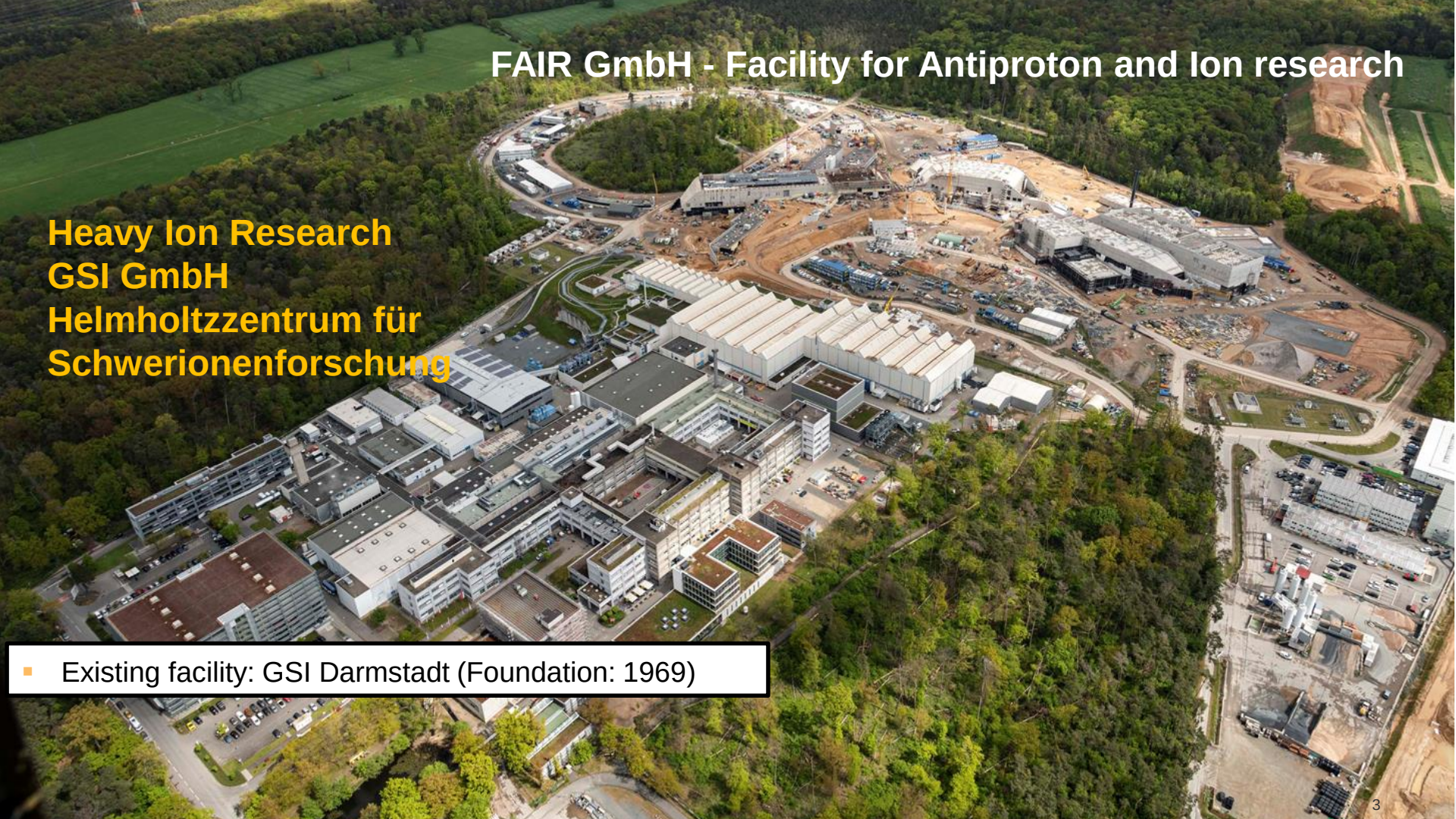
Anastasios Belias, GSI/FAIR

Overview

- Introduction to FAIR
- Status of construction
- Start of installations
- Plans of commissioning
- Summary & Outlook



FAIR GmbH - Facility for Antiproton and Ion research



Heavy Ion Research
GSI GmbH
Helmholtzzentrum für Schwerionenforschung

- Existing facility: GSI Darmstadt (Foundation: 1969)

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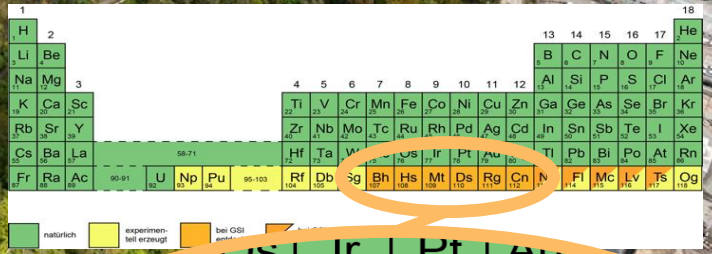
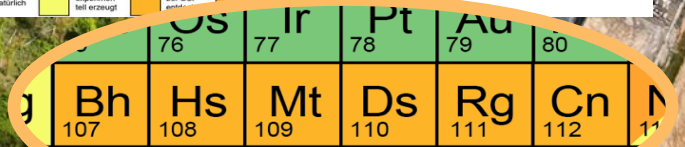
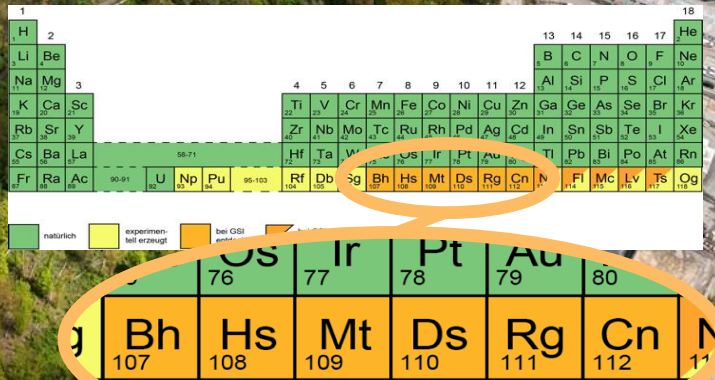




FAIR GmbH - Facility for Antiproton and Ion research

Heavy Ion Research
GSI GmbH
Helmholtzzentrum für Schwerionenforschung

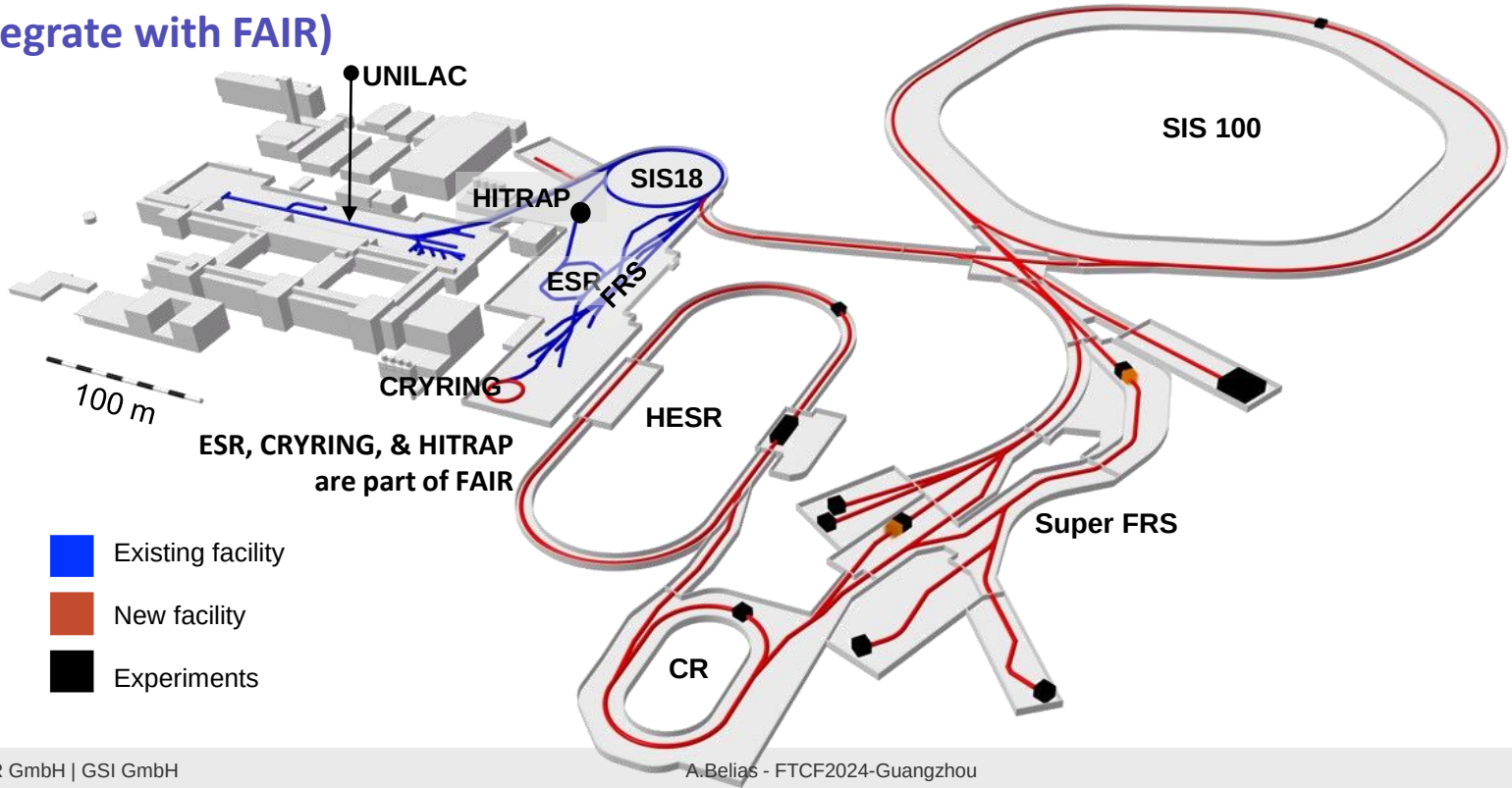
- Existing facility: GSI Darmstadt (Foundation: 1969)
- Future facility: FAIR (Foundation: 2010)
- Landmark in the European research roadmap (ESFRI)
- Employees on location: approx.1580



FAIR: a World-wide project

- FAIR governed by international convention
  - 9 shareholders from:
  - + 1 associated partner:
  - + 1 aspirant partner:
  - Over 3000 Scientists and Engineers from all over the world
- More than 200 institutions from 53 countries are involved with their scientists (orange + blue)

GSI, existing (upgraded to integrate with FAIR)



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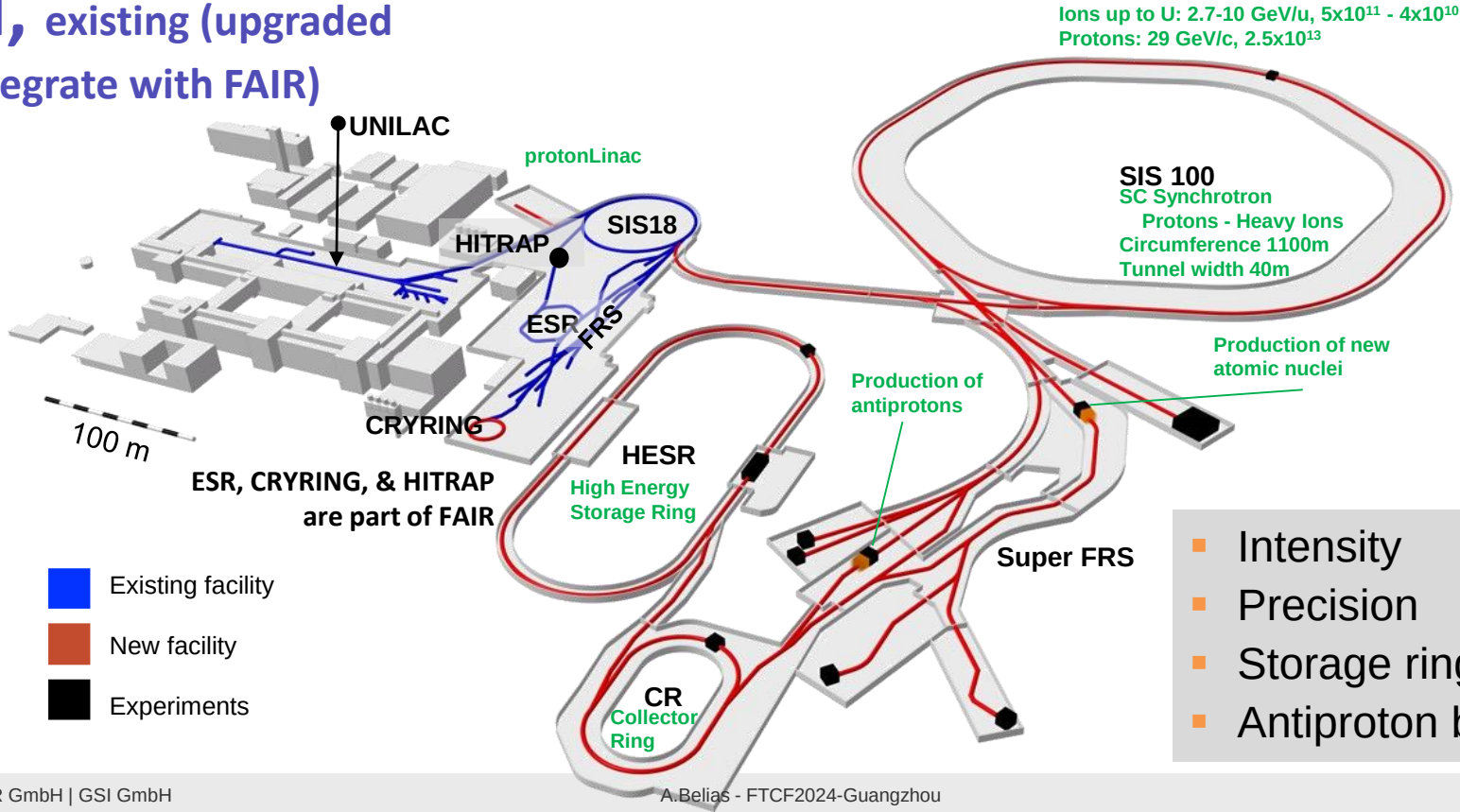
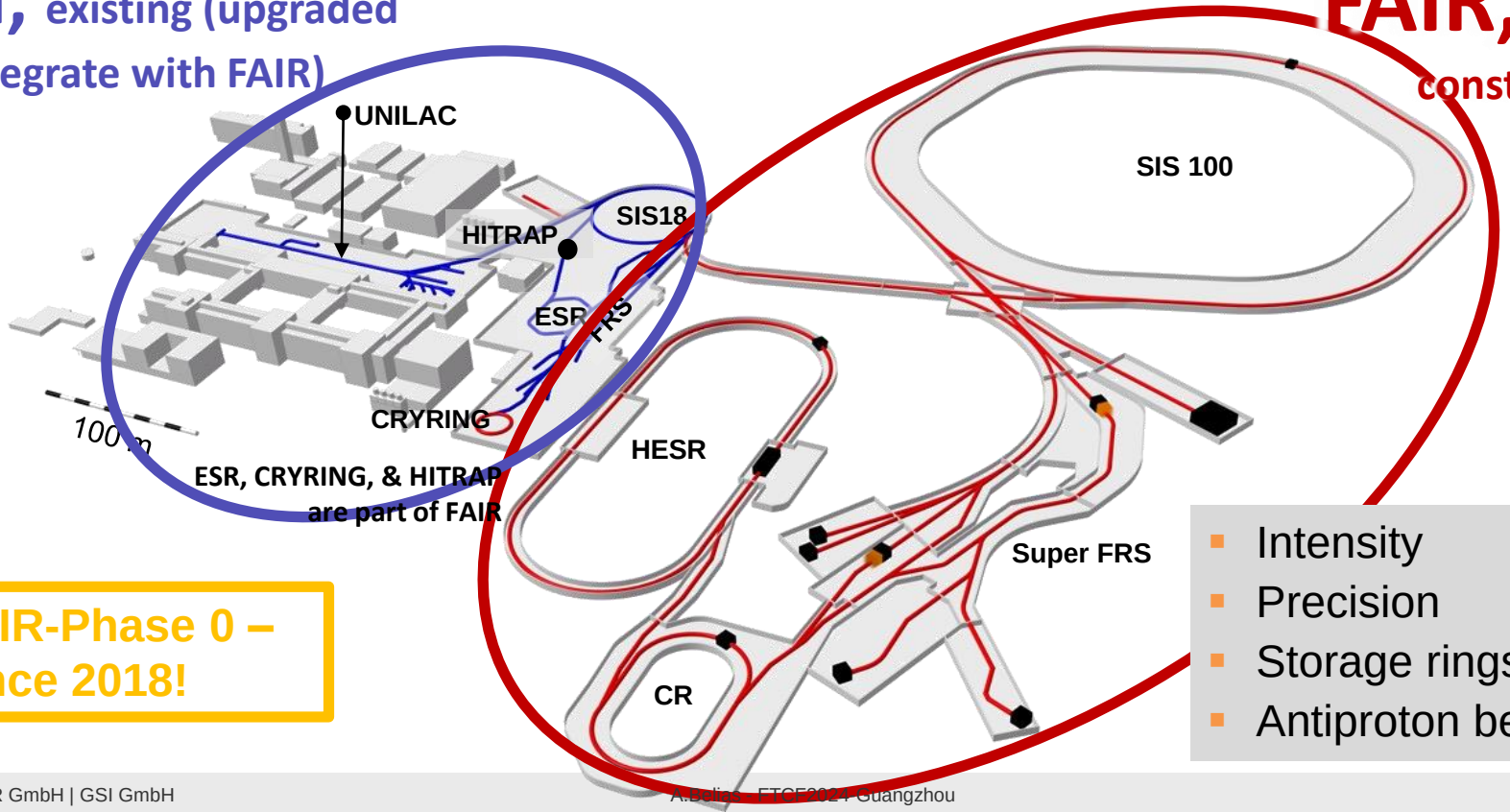


- Intensity
- Precision
- Storage rings
- Antiproton beams

GSI, existing (upgraded to integrate with FAIR)

FAIR, under construction



FAIR-Phase 0 – since 2018!

- Intensity
- Precision
- Storage rings
- Antiproton beams

FAIR – The Facility

FAIR

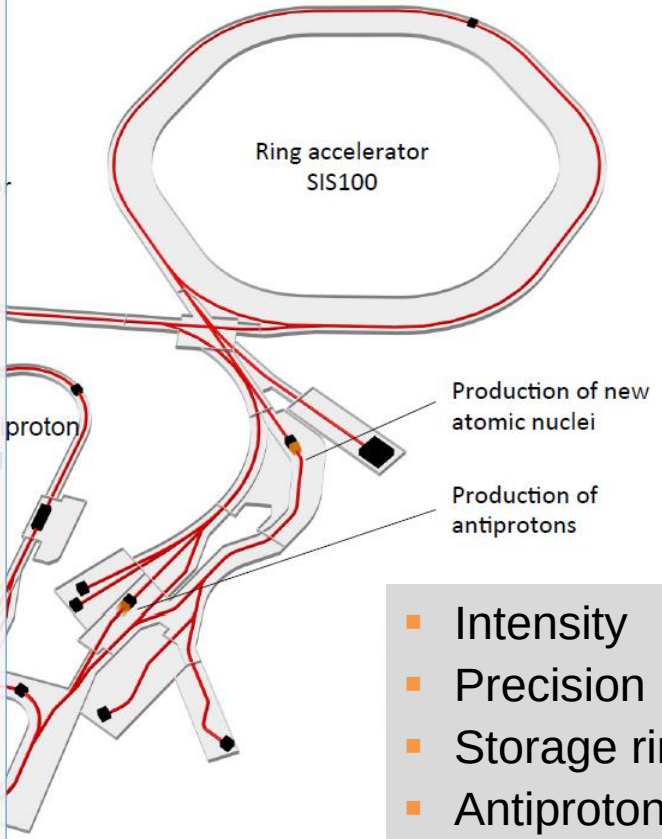
... accelerates particle beams from (anti)protons up to uranium ions with

- very high intensities
  - up to a factor of ~100 increase for primary Uranium beams (~ 5 x 10^{11} U^{28+} ions /s),
  - up to a factor of ~10.000 increase for secondary rare isotope beams
- high pulse power (up to ~ 50 kJ / 50 ns)
- suite of storage cooler rings equipped with stochastic and electron cooling for brilliant beam quality

... develops and exploits innovative particle separation and detection methods, as well as novel computing techniques

... to perform forefront experiments towards the production and investigation of

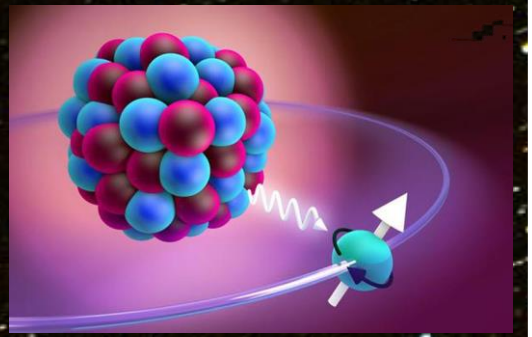
New Extreme States of Matter.



- Intensity
- Precision
- Storage rings
- Antiproton beams

APPA

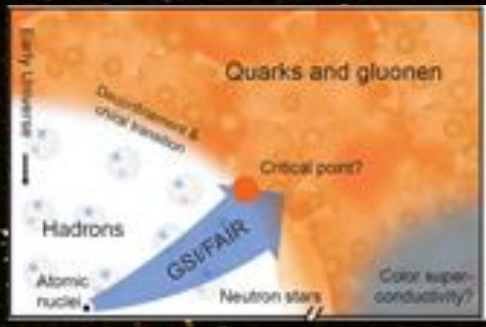
Atomic physics, biophysics, plasma physics, material research



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

CBM

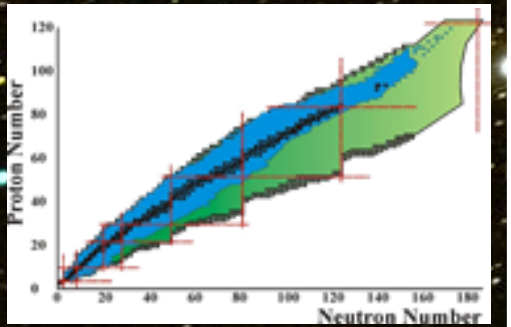
Compressed Baryonic Matter
- Nuclear- and quark-matter



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

NUSTAR

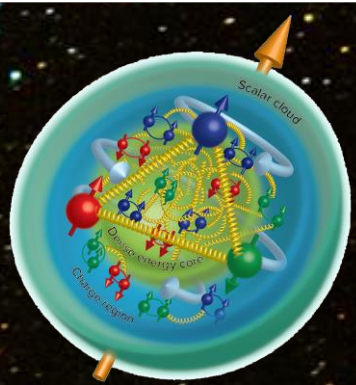
Nuclear structure and nuclear astrophysics



- **Nucleosynthesis of heavy elements**
- **Structure of exotic nuclei (e.g. hyper nuclei)**
- **Neutron matter equaton of state**

panda

antiProton Annihilation in Darmstadt
- Hadron structure and dynamics



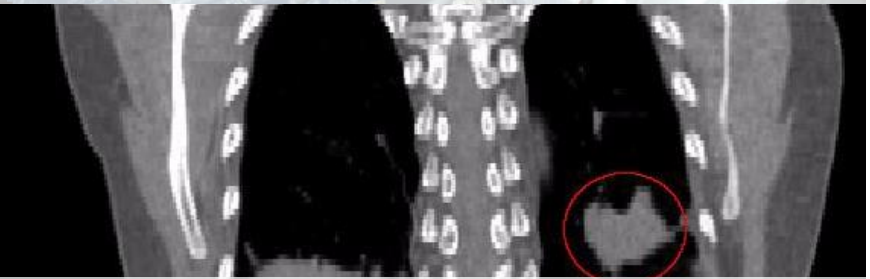
- **Gluonic excitations: Hybrids, Glueballs**
- **Precision spectroscopy of charmonium states**
- **Time-like form factors, nucleon structure**

Direct applications

High-performance and scientific computing, big data, green IT

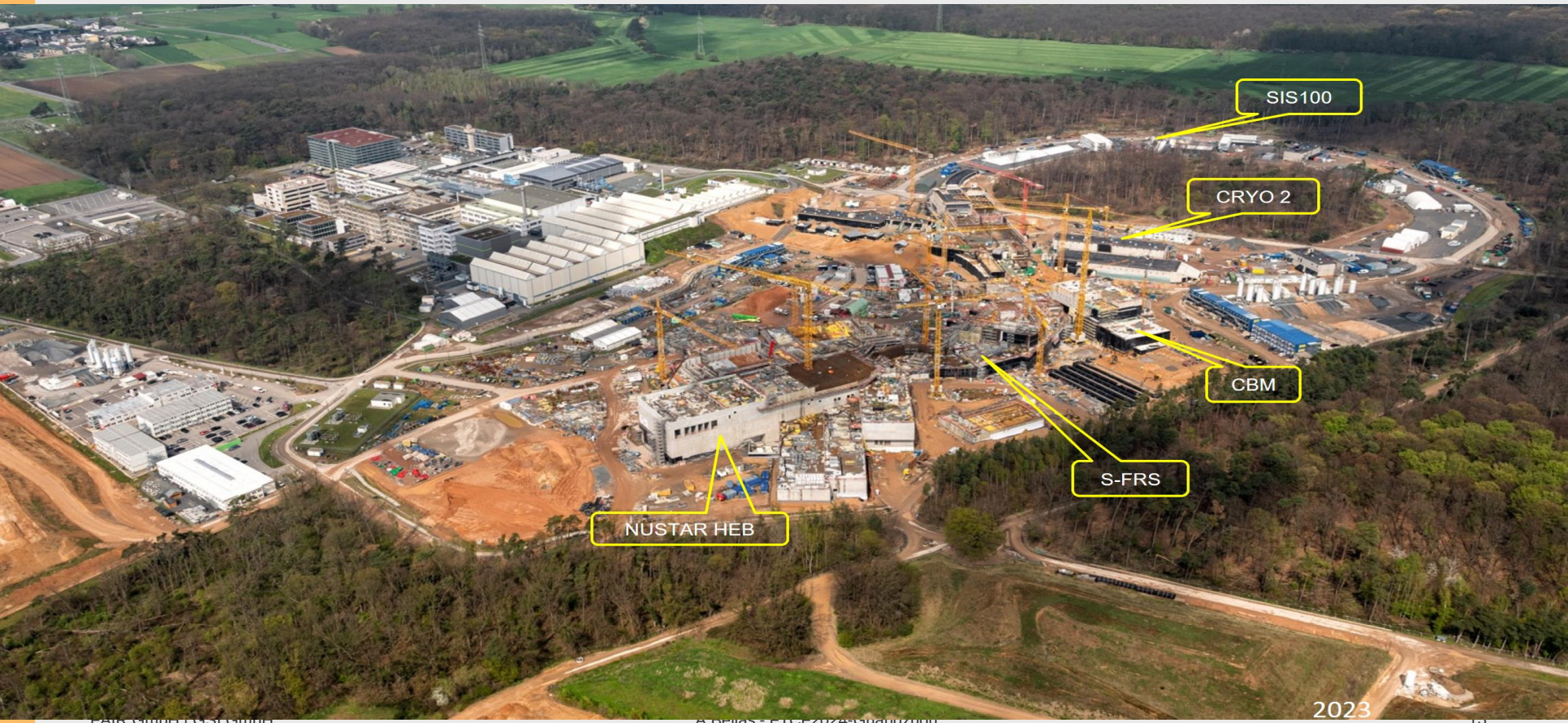
Space radiation protection, unique facility for simulation, collaboration with ESA

Development of nuclear clock:
Promising candidate Thorium-229



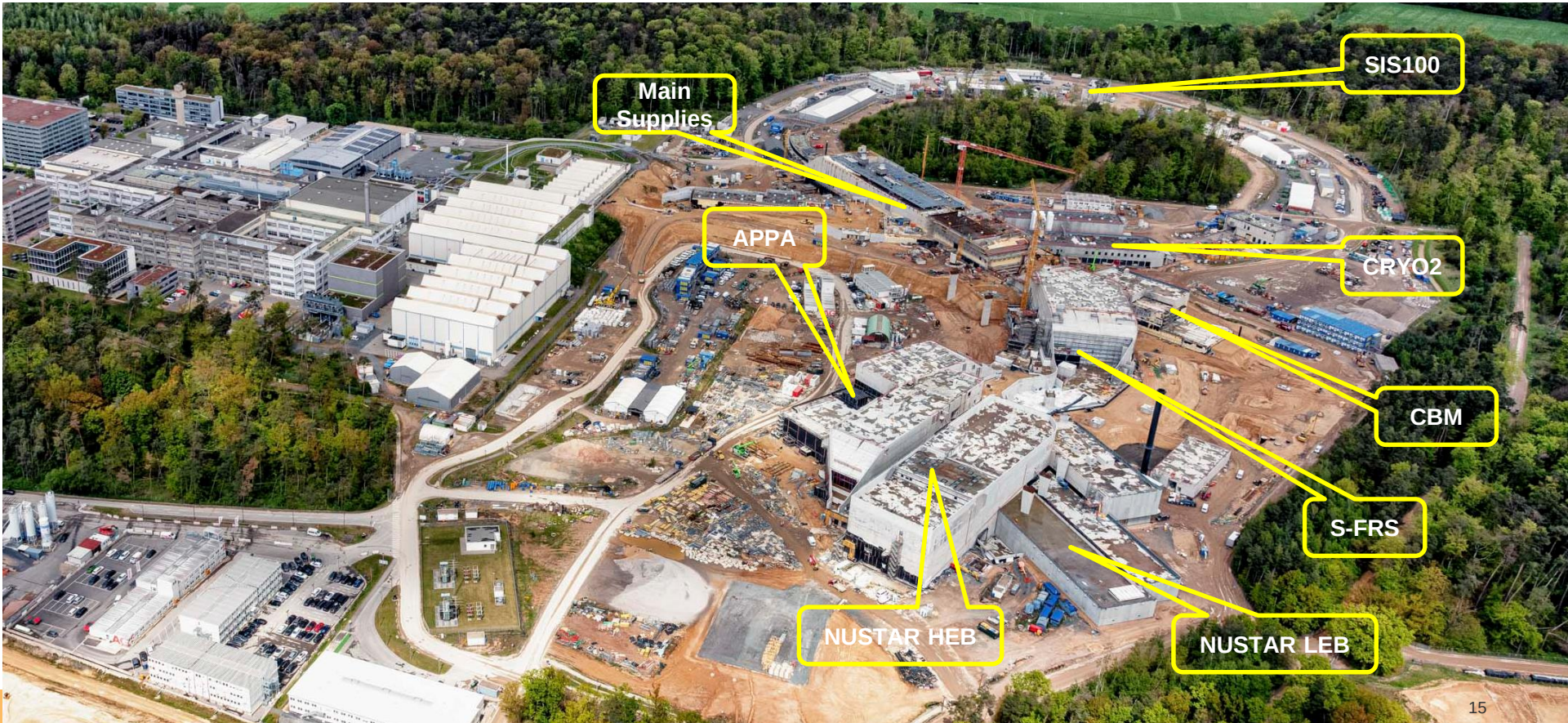
Novel applications for tumor and non-tumor diseases

FAIR Project - Civil Construction
Area North and South - Progress 2023

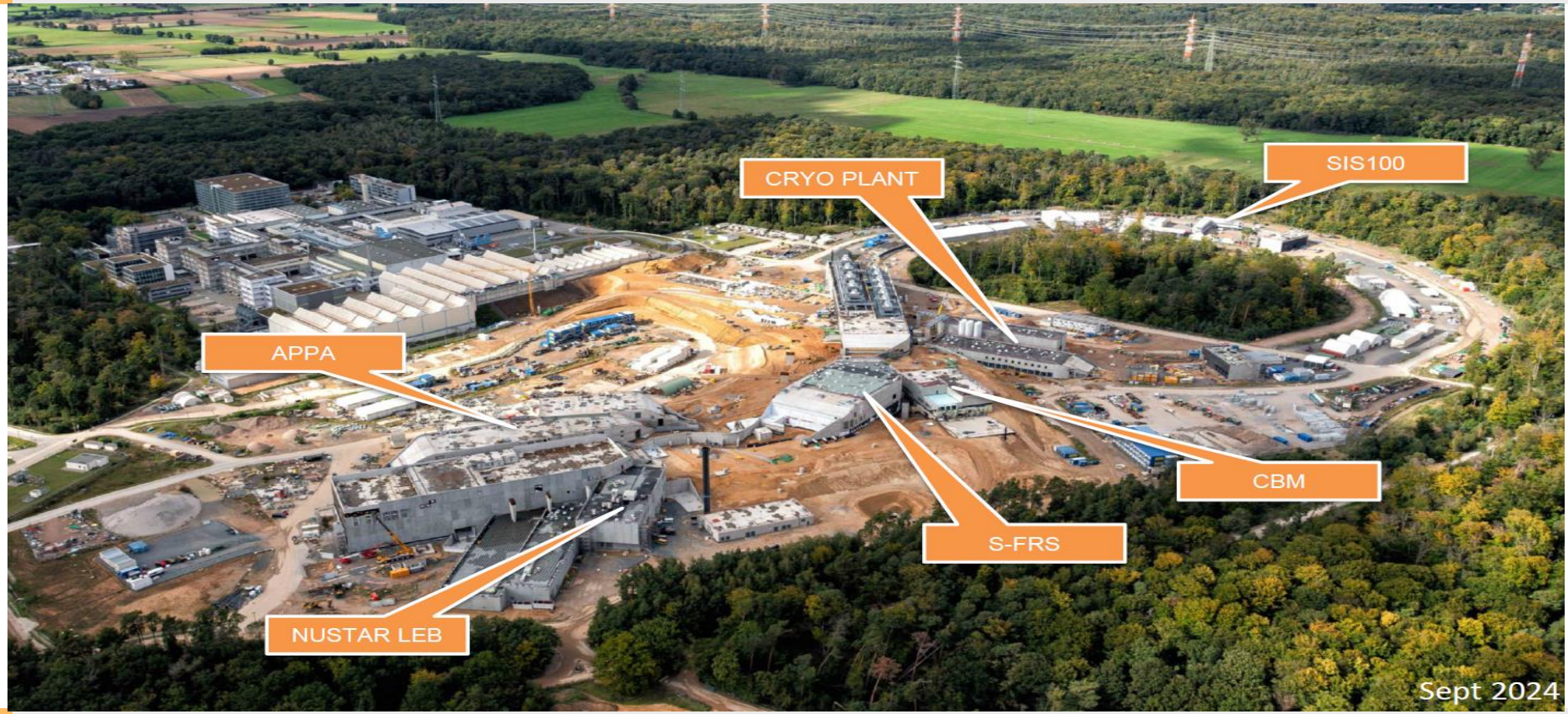


FAIR Project - Civil Construction
Area South - Progress 2023

FAIR Project - Civil Construction
Area North and South - Completed Q4/2023



FAIR Project - Civil Construction
Area North and South - Ready



FAIR SIS100 accelerator tunnel

FAIR SIS 100 supply tunnel

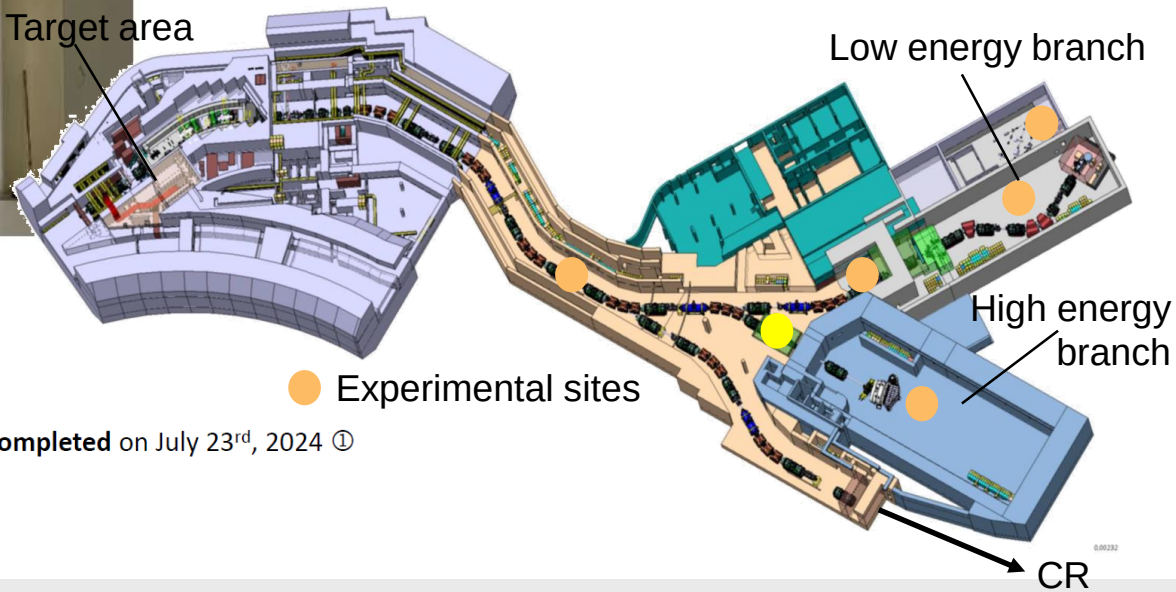
FAIR Project – Installations
Beam Transfers

SIS18/HEBT Beam Dump
Installation completed

Building reach from 17 meters below ground
to 20 meters above and contain up to six floors.

FAIR Project – Installations
Shielding S-FRS Target area

SFRS Pre-Target Area placing of lateral shielding blocks and target foundation completed



- **installation** lateral **iron**-shielding in target area **completed** on July 23rd, 2024 ①

FAIR CBM Cave

FAIR Project – Storage and Logistics
Ready to install units for accelerators and experiments

Storage area Weiterstadt: approx. 9.900 m²

4.195 objects (Components, assemblies, boxes)

50% of SIS100 components stored

90% of HESR components stored

FAIR Project – Storage and Logistics
Ready to install units for accelerators and experiments

LHCb / CERN sends gift to PANDA GSI / FAIR
- Straw Tracker Detector arrival 24.Aug.2023

Storage area Weiterstadt: approx. 9.900 m²	50% of SIS100 components stored
4.195 objects (Components, assemblies, boxes)	90% of HESR components stored

FAIR Project – Storage and Logistics
Ready to install units for accelerators and experiments

September 2024

The first partial delivery (Lot-1) of IT and diagnostic cables (80% of these cable types from FAIR) from Siechem Ltd, Chennai/Pondicherry, as part of the Indian In-kind for FAIR was delivered to FAIR. The full delivery will be performed by the end of the year 2024.

FAIR Project – Preparing installations
Tests before installations


Multiplet in testbench@CERN


Long Multiplet

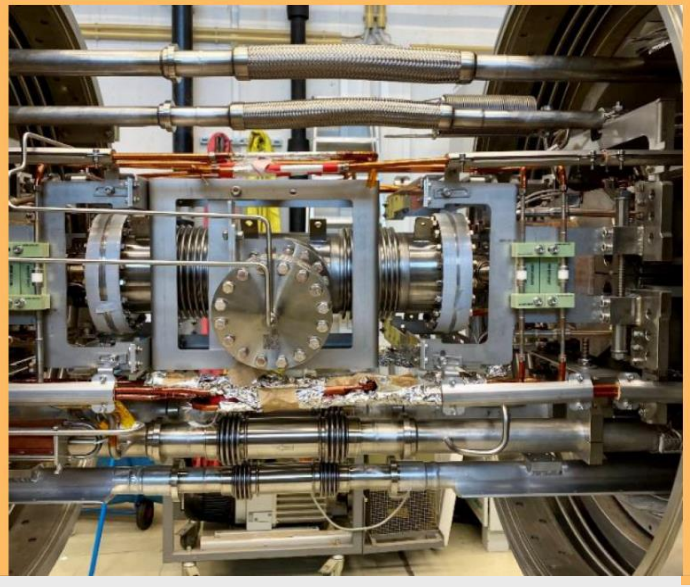

Short Multiplet@ASG

- repaired **sc long multiplet** LM11 **successfully tested** at CERN, delivered to GSI on August 14th, 2024 ②
- repaired **sc dipole** type-3 successfully cooled at CERN, **no leakage**; test magnetic field ongoing
- **Local Cryogenics** (PL-IK) branch T: INOX India, under shipment, arrival FoS for cold test **end-October 2024** ③

FAIR Project – Preparing installations
Tests before installations

SIS100 String Test Facility

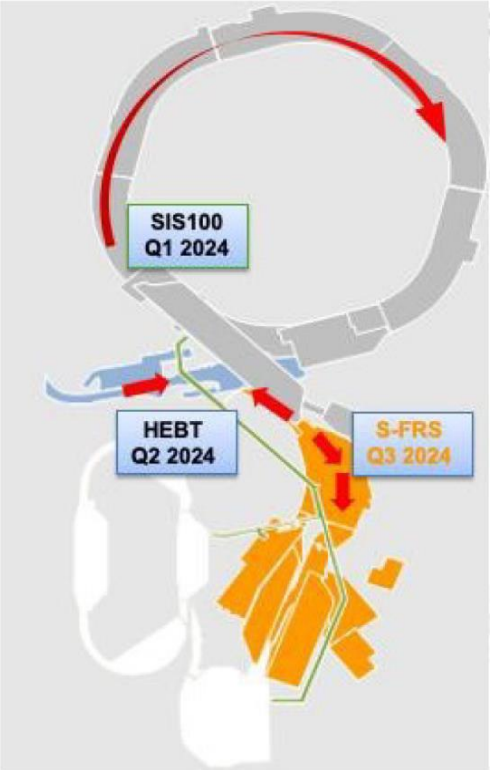
- Pressure test successfully passed in Sep 2023
- Completed cold test in Dec 2023

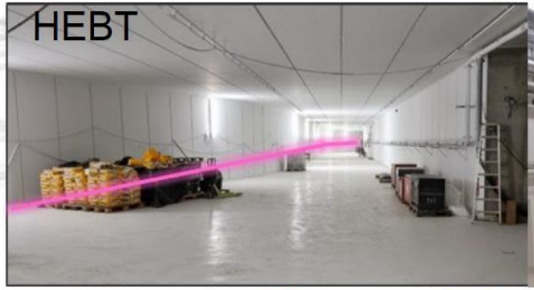


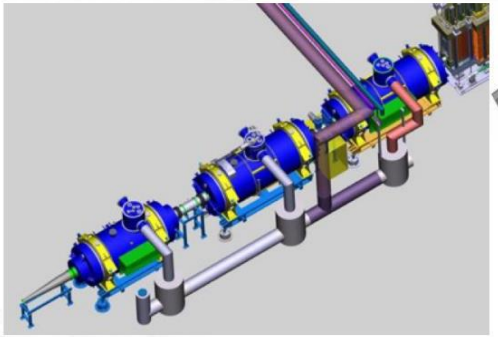
Main Cryo Plant

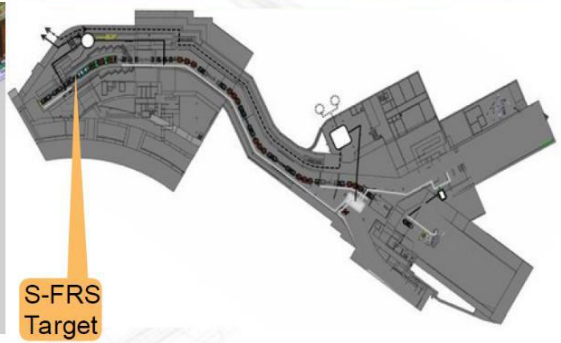
- Linde finished cryo plant assembly Sep 2024
- Start of commissioning beginning 2025

FAIR Project - Installations
Start 2024 at several locations









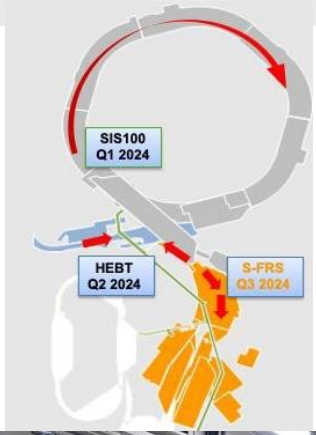
FAIR Project - Installations
Start 2024 at several locations

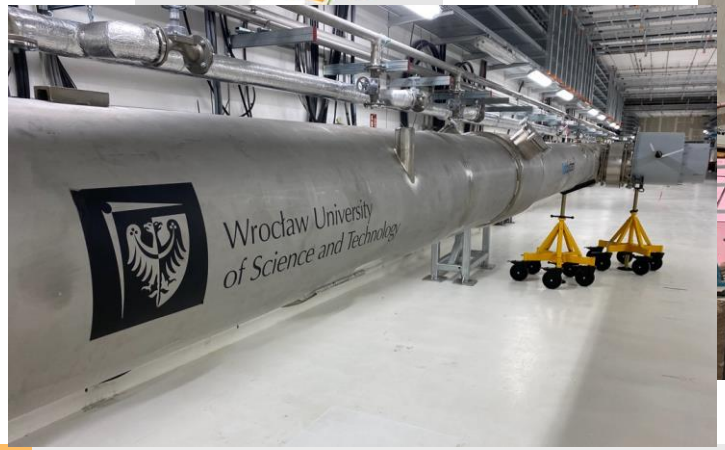
January 2024

Start of Machine Installation

First SIS100 Power Supply Units (PSU) installed in the SIS100 Tunnel

FAIR Project - Installations
Start 2024 at several locatio

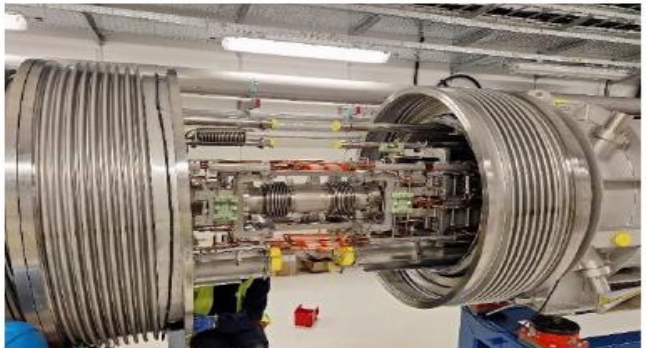




FAIR Project - Installations
Start 2024 at several locations

April 2024:
Dipoles placed in SIS100 tunnel

Installation



First interconnection of a pair of dipole modules in the accelerator tunnel, executed by IFJ PAN Krakow

FAIR Project - Installations
Start 2024 at several locations

SIS100 Sector 3 Arc Dipole Pairs Installation completed

SIS100 Straight 4 – partially completed: to be continued after cable pulling

FAIR Project - Installations Progress and preparations

3rd SIS100 Workshop Procurement and Installation at Eberbach Monastery, 9.-11. Sep. 2024

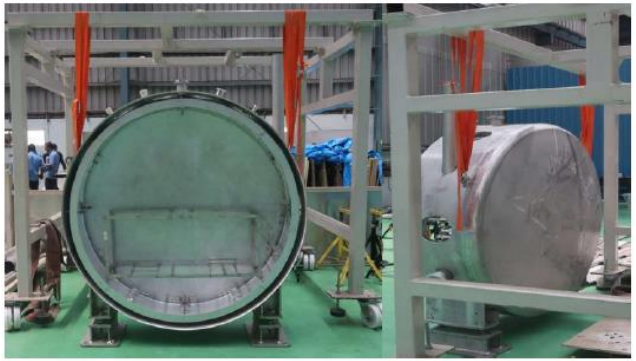
Installation of transformers and switchgears of the main power supply of the Dipole-Quadrupole Magnets completed by GE Vernova, Germany

First 6 x 100 m3 helium gas tanks

First 2 pumping chamber

ium chambers with collimator

Installation of power supplies and electronic cabinets in the supply tunnel is in full swing



Start of manufacturing of the current lead boxes by Inox, India

FAIR Project – Commissioning Plans
Preparations at Multiple Levels of sub-systems

The focus continued to be on preparing the hardware commissioning for the machines needed for Early Science and First Science

The following steps are taken for each system type

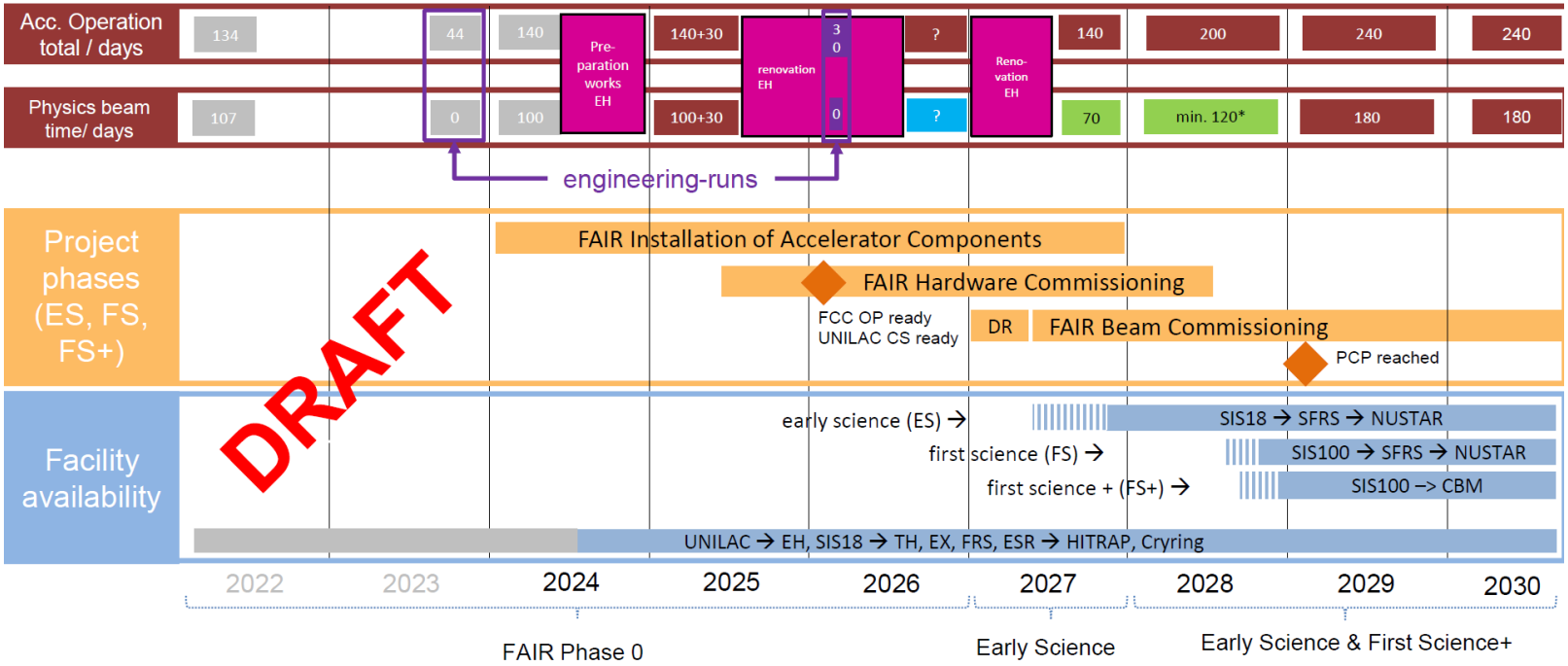
1. Development of the commissioning procedure
2. Collection of preconditions and boundary conditions for each step
3. Review of resource estimation
4. Review of integrated schedule
5. Preparation of written commissioning instructions, if necessary
6. Implementation of sequencer tasks for test automation

- Integrated Project Management – Level 1, Level 2, Sub(sub)Projects, Safety
  - Resource loaded schedules; Lean management
- Regular Progress Monitoring and Risk Evaluation
- Reporting, Assessment, Mitigation

FAIR Project – Commissioning Plans
Beamtime modes

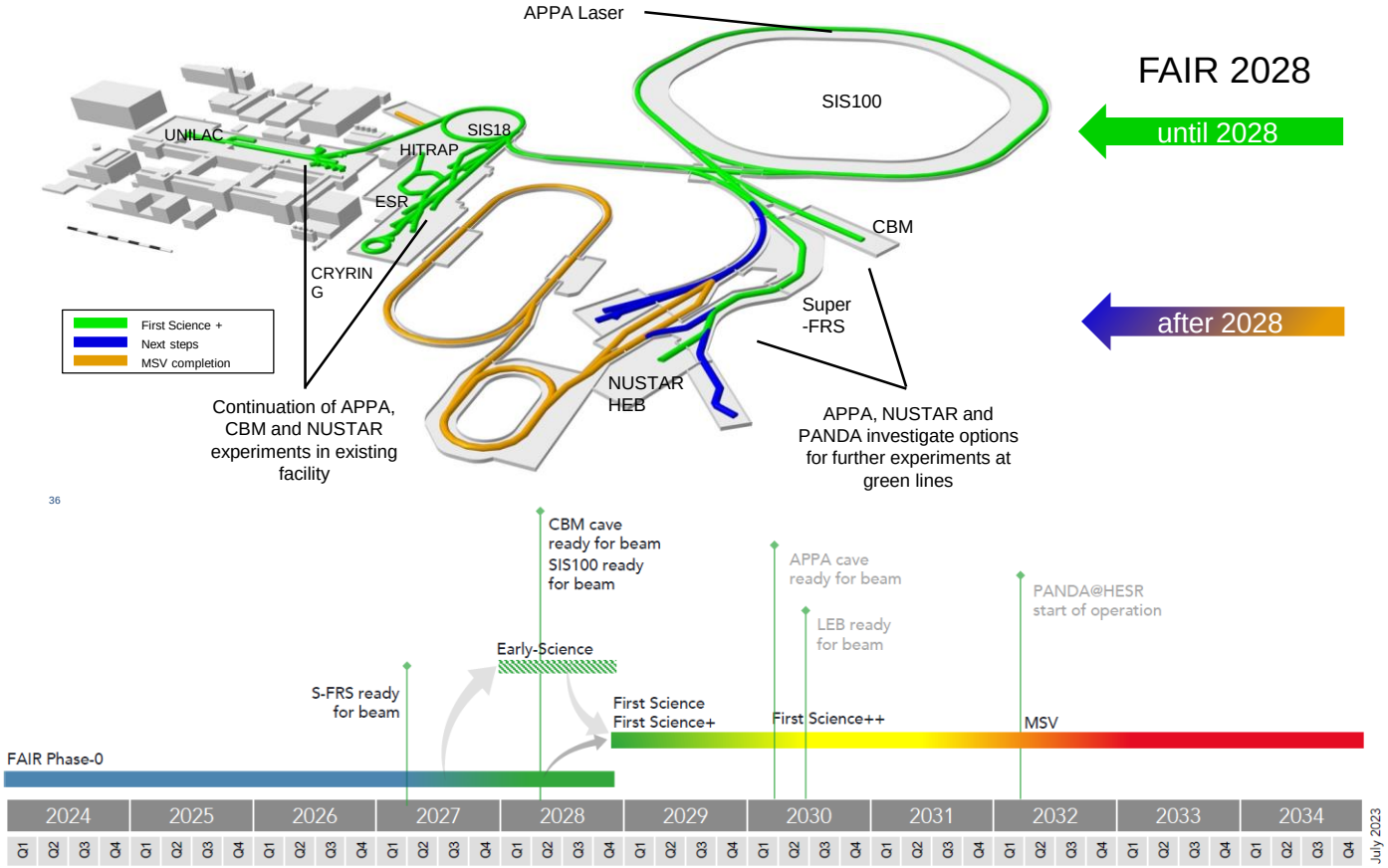
Mode A	Physics beamtime	- highest priority on physics - full parallel operation - full on-call service at any time
Mode B	Best effort operation (BEO)	- priority on physics - limited parallel operation - on-call service by arrangement
Mode C	Second priority	- priority on FAIR commissioning - limited parallel operation - on-call service by arrangement

FAIR Project – Commissioning Plans
Beamtime modes for engineering and science



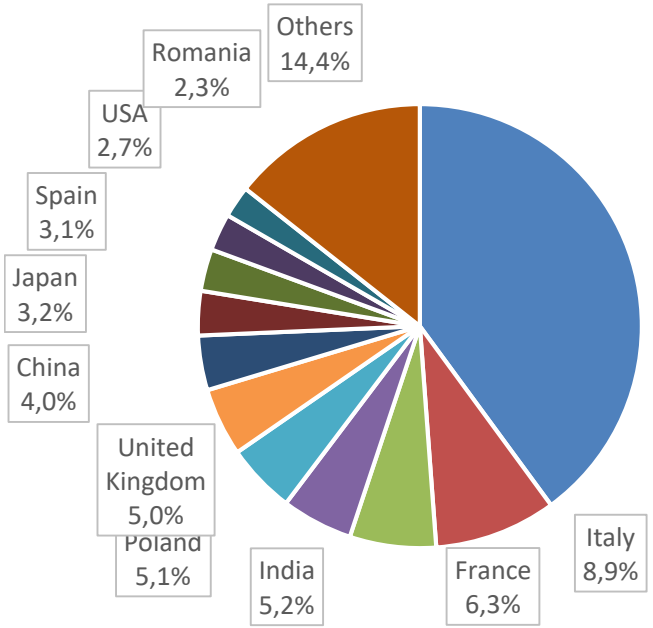
- Engineering run 2023: Priority on preparation for experiment beamtime in 2024/25
  - Highlights: Dual beams; Pion-beam preparation; Intensity record
- Experiments granted in 2022 will run in 2024 and 2025

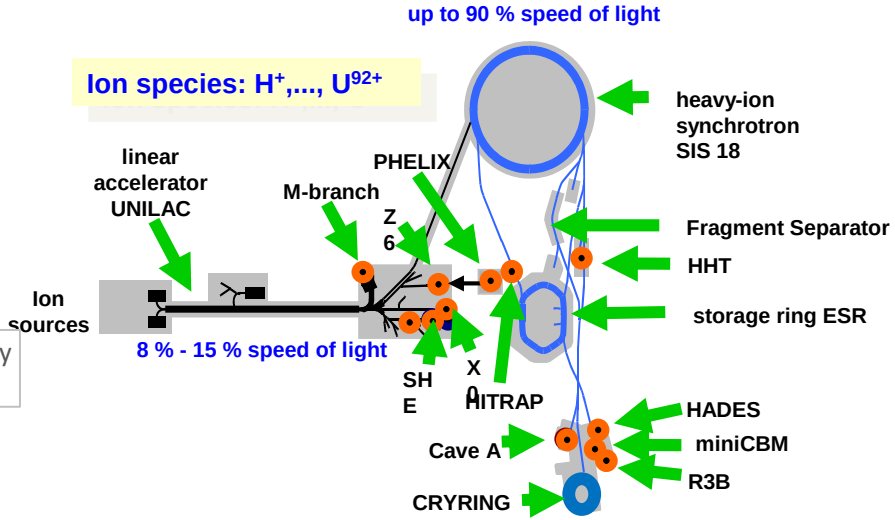
Current prospects and timeline



Ongoing early science program: FAIR Phase-0

- Started in 2019, annual runs of ~110 days until FAIR operation in 2027



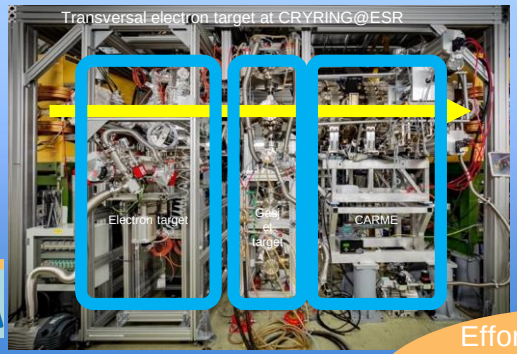


124 proposals with more than 1700 participants from 45 countries received in 2022

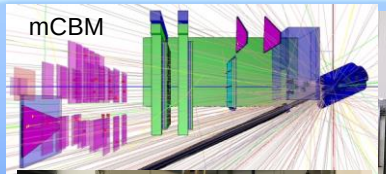
Beam time started, very successful to date

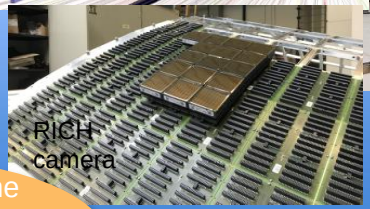
Experimental efforts & progress

APPA



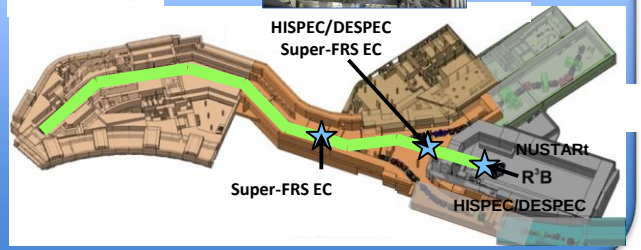
CBM





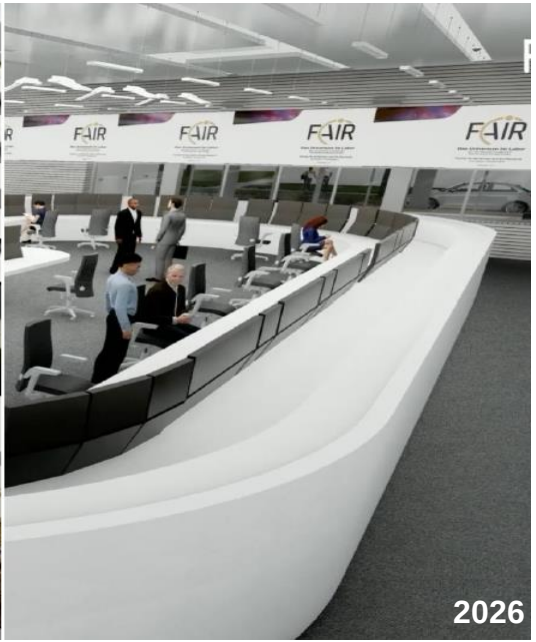
Effort to best use the part of FAIR which will be available by 2028

NUSTAR



PANDA

FAIR Control Center on the GSI Campus



FAIR Control Center – Completion planned end of 2026

FAIR Summary and Next Steps

- FAIR is based on multiple ring accelerators and beam lines to provide high-intensity and brilliant particle and heavy ion beams to many experiment sites.
- **Civil construction completed, in current scope as defined by FAIR council.**
  - **Concrete works complete**
- **Technical infrastructure installation in tunnels, caves and buildings is in progress.**
  - **Aiming at completion and commissioning in 2026**
- **Installations of accelerator components started in January 2024.**
  - **Continuous delivery of magnets and components is**

➔ FAIR Science starts in 2028 ➔


Looking forward for new science from 2028 onwards!
FAIR
GSI
Thank you for your attention!