FAIR Project & GSI Status November 2021

Jörg Blaurock
Technical Managing Director FAIR GmbH & GSI GmbH

Agenda

FAIR Phase 0

- Beamtime 2021 & 2022

Upgrade of existing accelerators

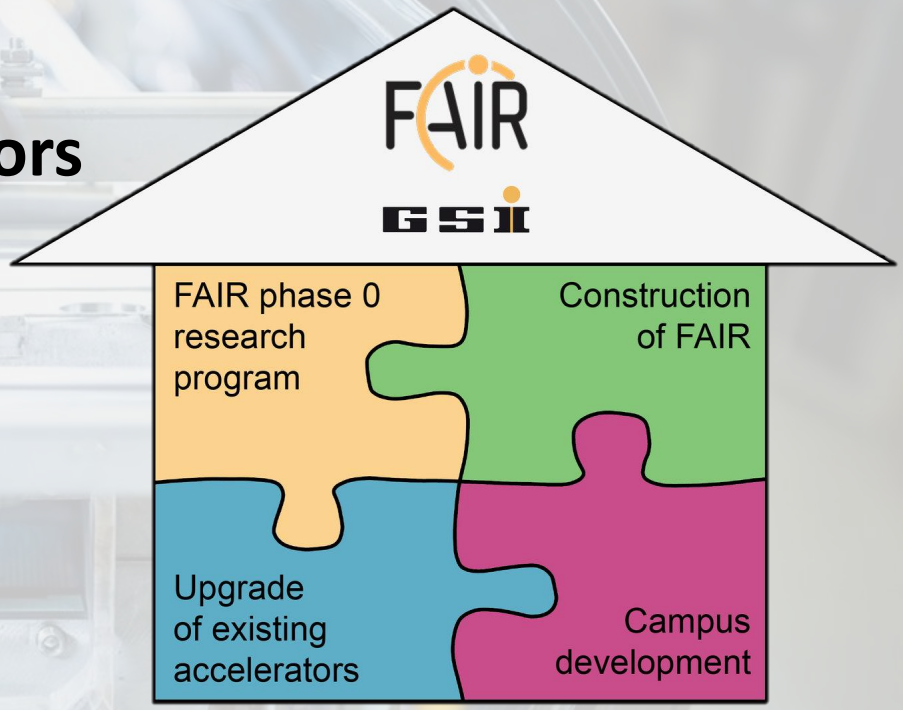
- Integrated Campus Schedule

Development on Campus

- Campus Infrastructure

Construction of FAIR

- Project Time schedule
- Highlights



FAIR Phase 0 - beam time 2021

19 weeks of user beamtime + parallel FOS Unilac -Test from mid May + cw Demonstrator Tests

FAIR Phase 0 - beamtime 2021

- physics run started on February 8th and ended on July 16th as planned
  - Available machines: UNILAC, SIS18, FRS, ESR & Cryring
  - total 3200 hours of user operation
  - integrated availability = 88%, parallel factor = 3.3 → ca. 8000 hours effective beam time
  - plus 2 weeks dedicated to machine studies

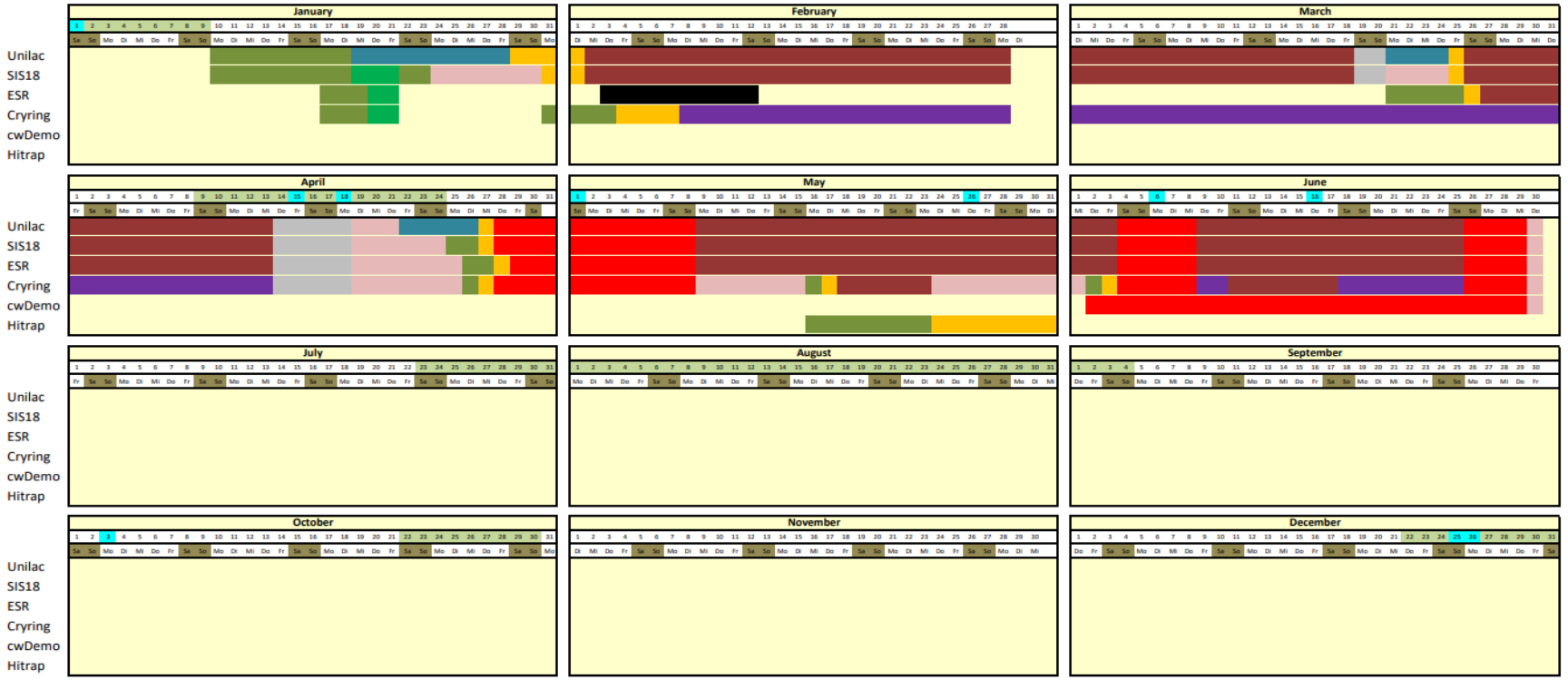
- The beamtime took place under pandemic conditions.
  - general safety measures: distancing, masks, disinfectant, no visitors
  - home office where possible, no in-person meetings
  - additional communication/coordination measure: morning briefing

Under these conditions, the beamtime was an immense challenge for all persons involved. But the run was successfully completed with great effort.

FAIR Phase 0 - beam time 2022

General Plan of Accelerator Operations 2022

release 20.10.2021



Legend

- Bake Out
- Dry-Run
- Commisioning without Beam
- Beam Commisioning
- Physics Run
- Engineering Run / Beam Studies
- Operator Training
- RF-Conditioning
- Physics Run-Cryring standalone
- Maintenance break / Exp. Installation
- Device Testblock

User Beamtime

	Days:	Shifts:
Unilac	107	321
SIS18	107	321
ESR	61	183
Cryring@ESR	13	39
Cryring (standalone)	75	225
HKR besetzt	168	504

Information

- Final acceptance Dry-Run in January
- Feb. 2nd - Mar. 18th - UNILAC low RF-level, low A/Q (e.g. C+p from CH4-source and Lithium operation)
- Mar. 26th - Apr. 13th - heavy ion operation (incl. Uranium)
- Maintenance break starting April 19th (only repair & standard maintenance, no general access)
- Apr. 28th - May 8th - machine study (mainly Uranium)
- May 9th - June 29th - heavy ion operation (no Uranium) - incl. 2 machine study blocks
- On June 30th, all accelerator components will be switched off (except vacuum systems)

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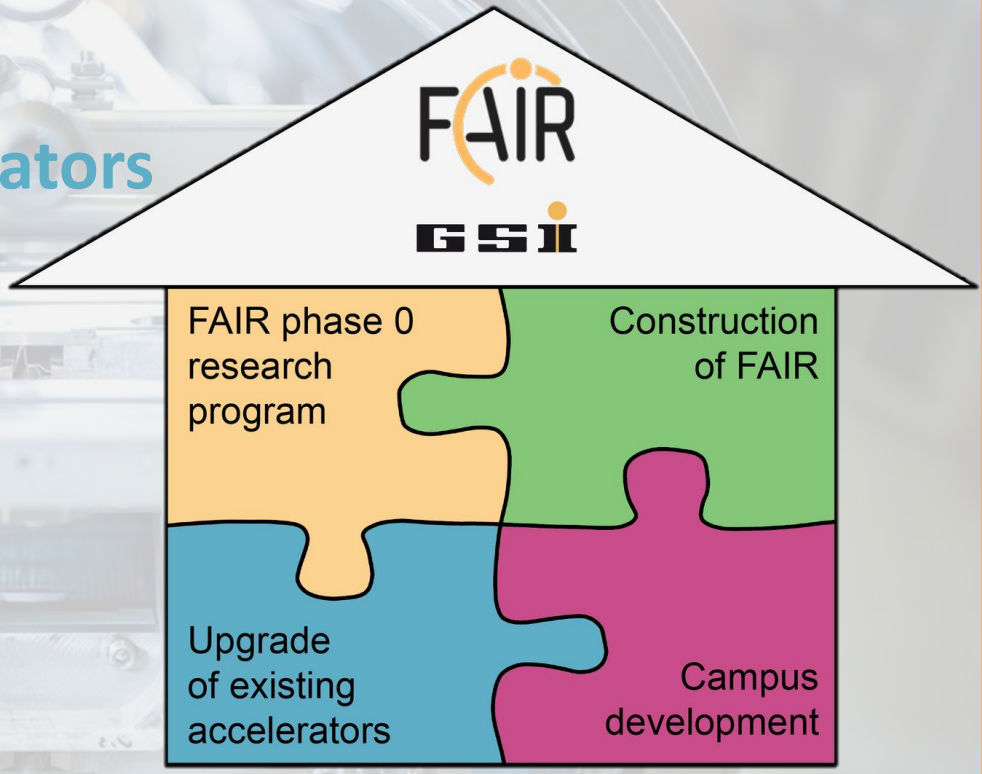
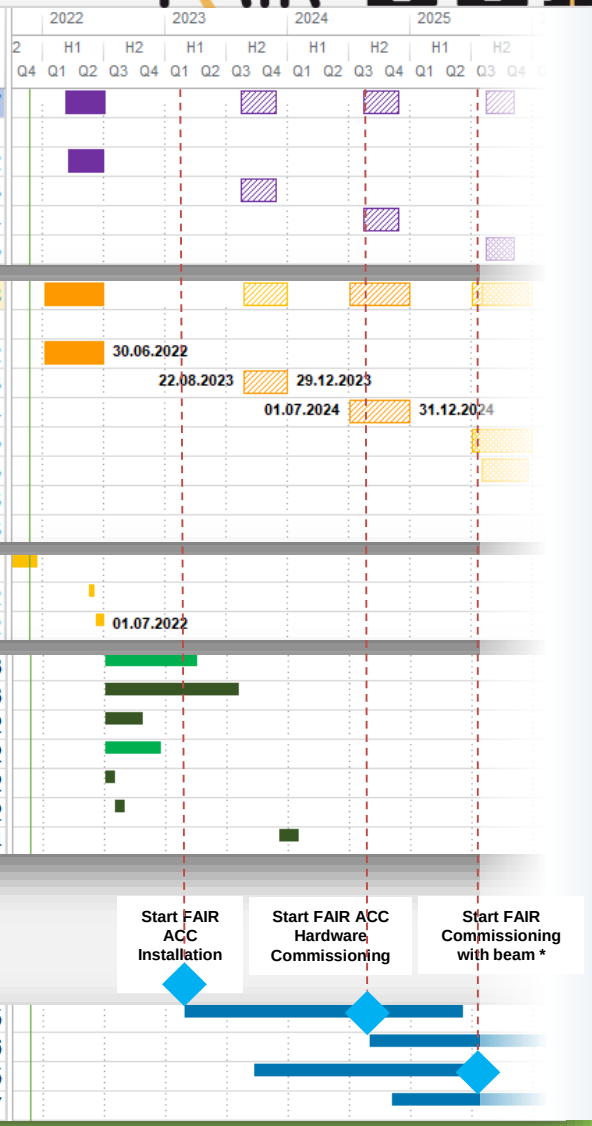


Integrated Campus schedule 2022 (ICS)

Status Q3/ 2021

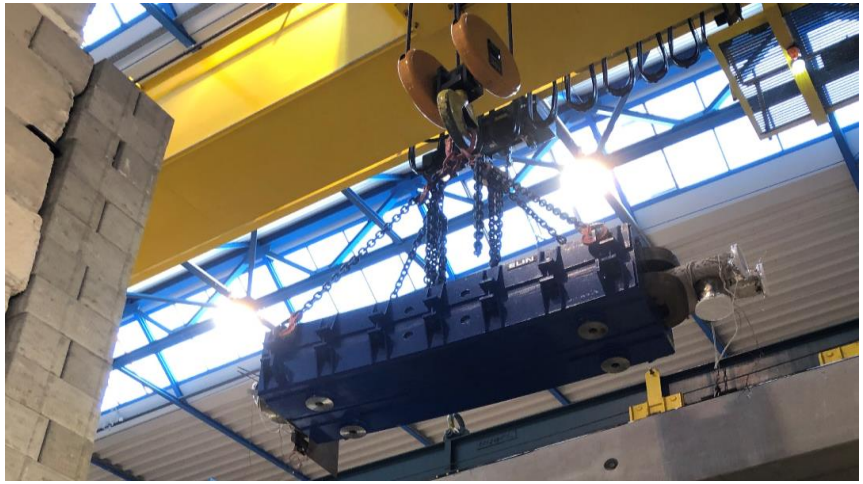
	Responsibility	Description	Anfang	Ende
74	Research	**Beamtime 2019-2024 / 3 Months per year**	**01.02.21**	**21.12.27**
75	Research	ACC Operation / beamtime 2021	01.02.21	16.07.21
76	Research	Physics Run 2022	14.03.22	30.06.22
77	Research	Physics Run 2023	12.08.23	29.11.23
78	Research	Physics Run 2024	10.08.24	27.11.24
79	Research	Physics Run 2025 (restricted)	10.08.25	07.11.25
193	ACC	**Accelerator Operation 2019-2028**	**10.02.20**	**30.12.28**
195	ACC	ACC Operation / beamtime 2021	01.02.21	16.07.21
196	ACC	Accelerator Operation incl. Commissioning & Conditioning 2022	03.01.22	30.06.22
197	ACC	Accelerator Operation incl. Commissioning & Conditioning 2023	22.08.23	29.12.23
198	ACC	Accelerator Operation incl. Commissioning & Conditioning 2024	01.07.24	31.12.24
199	ACC	Accelerator Operation incl. Commissioning & Conditioning 2025	01.07.25	31.12.25
200	ACC	FAIR Beam-Commissioning	29.07.25	15.12.25
201	ACC	Accelerator Operation for FAIR Beam-Commissioning & early physics 2026-1	01.03.26	31.07.26
202	ACC	Accelerator Operation for FAIR Beam-Commissioning & early physics 2026-2	01.09.26	31.12.26
310	ACC	Alvarez 2.0 - FoS High power rf test (coppered, empty DT) | Shutdown Ac. 2021 !	23.07.21	14.12.21
362	ACC	CW Advanded Demonstrator HF-Test ohne Strahl	17.05.22	03.06.22
363	ACC	CW Advanced Demonstrator CM1 Test mit Strahl	06.06.22	01.07.22
458	CAM	Renovation roof VR east -->dependent on HF + LA16	01.07.22	31.03.23
529	GAT	BS-TGA subsequently renewal LA16	01.07.22	02.08.23
528	GAT	LA14 renewal inside RF gallery	01.07.22	20.10.22
441	CAM	SE renovation - room SE1.124a in shutdown time	01.07.22	15.12.22
514	GAT	Renewal of MV switchgear =AA Step 1	01.07.22	30.07.22
515	GAT	Renewal of MV switchgear =AA Step 2	31.07.22	29.08.22
516	GAT	Renewal of MV switchgear =AA Step 3	04.12.23	30.01.24
10	FAIR	Area North FAIR ACC - installation IO	22.02.23	30.05.25
13	FAIR	Area North FAIR ACC - commissioning IO	29.08.24	25.08.26
11	FAIR	Area South FAIR ACC - installation IO	18.09.23	28.07.25
14	FAIR	Area South FAIR ACC - commissioning IO	04.11.24	09.02.27



*At the time of FAIR commissioning possible beam time durations will be assessed.

SIS18 – Connection to FAIR

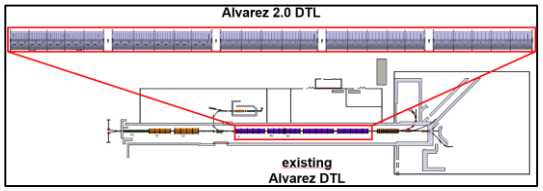
Removed TS1MU1 on the way out of the SIS18. It is used as a branching dipole behind the SIS18 extraction (beam from the left), at the beginning of the high-energy beam guidance.

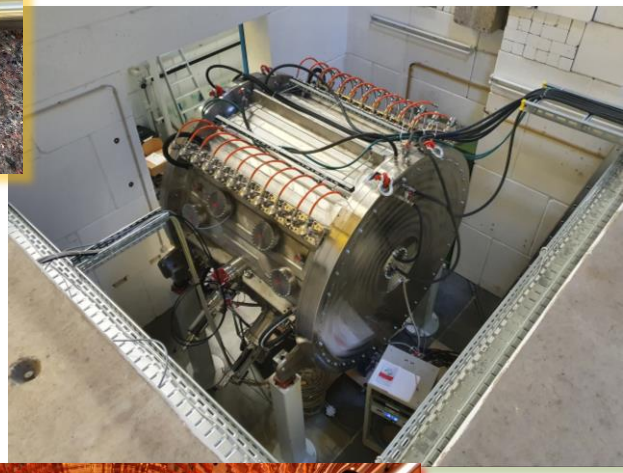


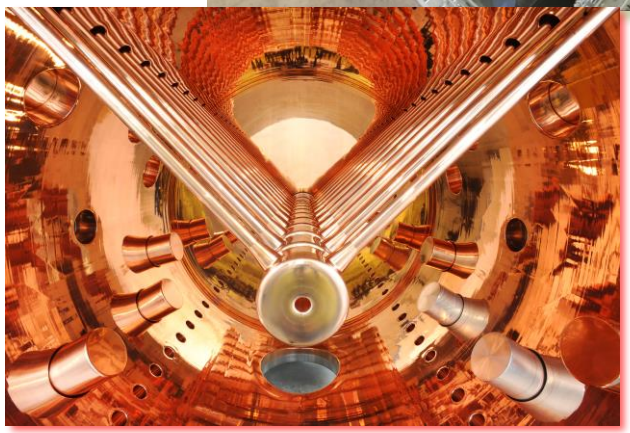
The new bipolar branching magnet GTS1MU1. Looking against the beam direction. The sealed vacuum chamber on the right will steering the SIS18 beam to FAIR in future. The magnet was installed during shutdown in 2021.

UNILAC post stripper upgrade - status

- first of series tank assembled and evacuated, drift tubes aligned
- high-freq. performance rf tests with FAIR parameters completed
- first drift tube with internal quadrupole built and successfully tested







target RF-parameters for FAIR ($^{238}U^{28+}$) are reached

- rf-flat top for beam: 1.0 ms ✓
- repetition rate: (3Hz) 10 Hz ✓
- rf-amplitude: P ~290 kW ✓

S. Mickat, L. Groening

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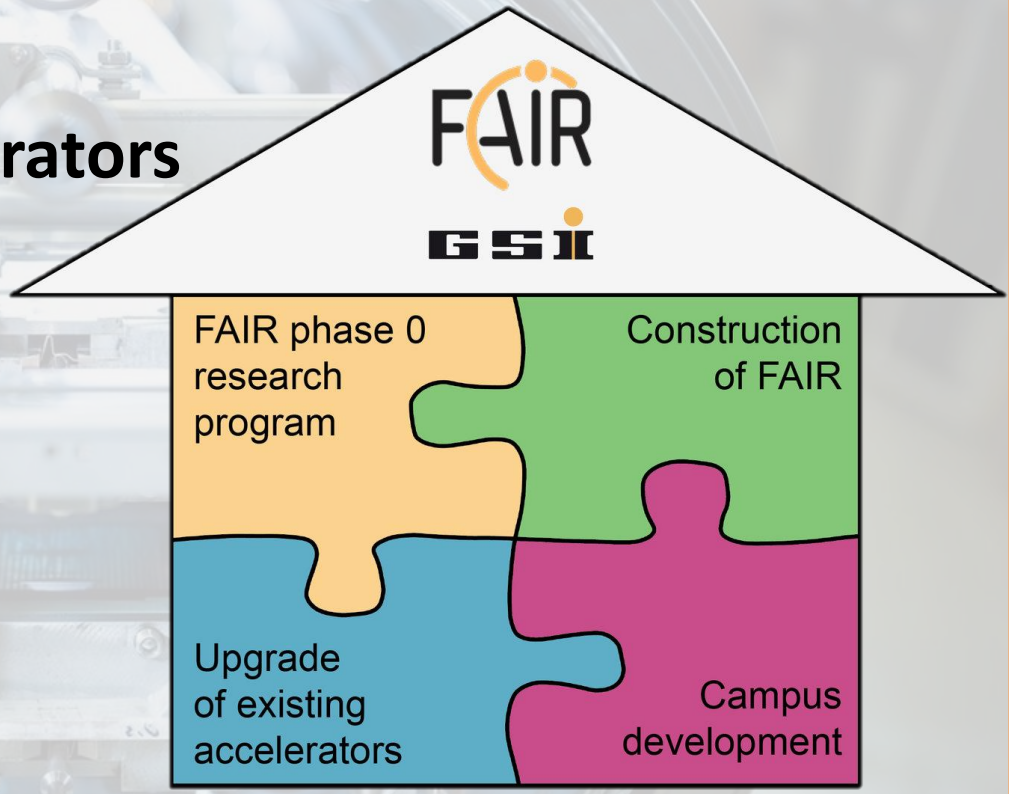
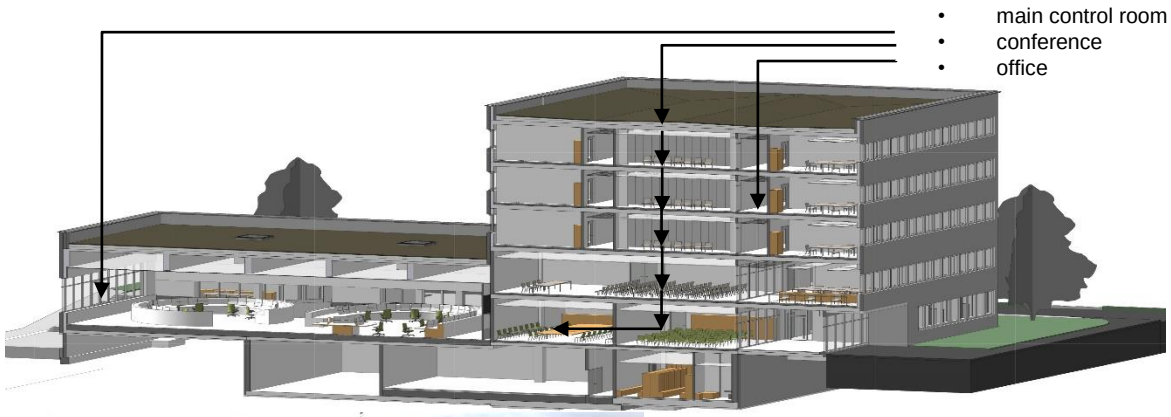


Campus Infrastructure

- Developing the buildings and facilities in view of the future operation of FAIR is one of the strategic goals of both FAIR and GSI.
- Measures to develop the Campus as a host lab and to provide a state of the art workplace and accompanying infrastructure are:

FAIR Control Center (FCC)



Campus Masterplan

Car Parking

Office extensions

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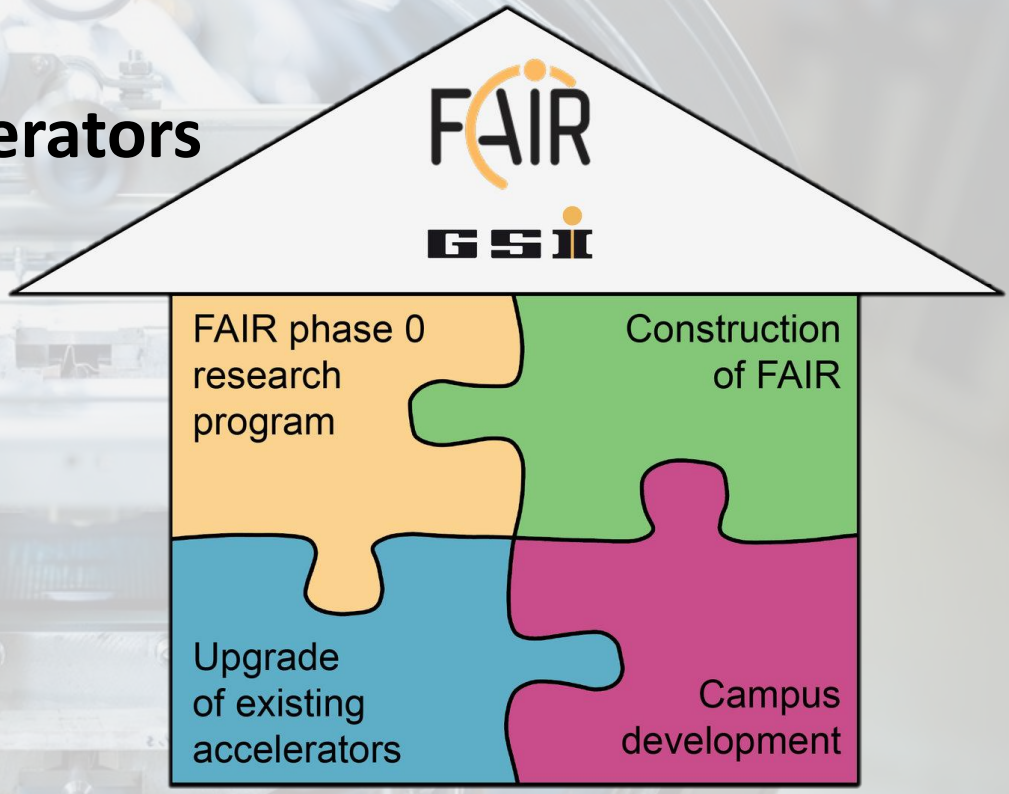
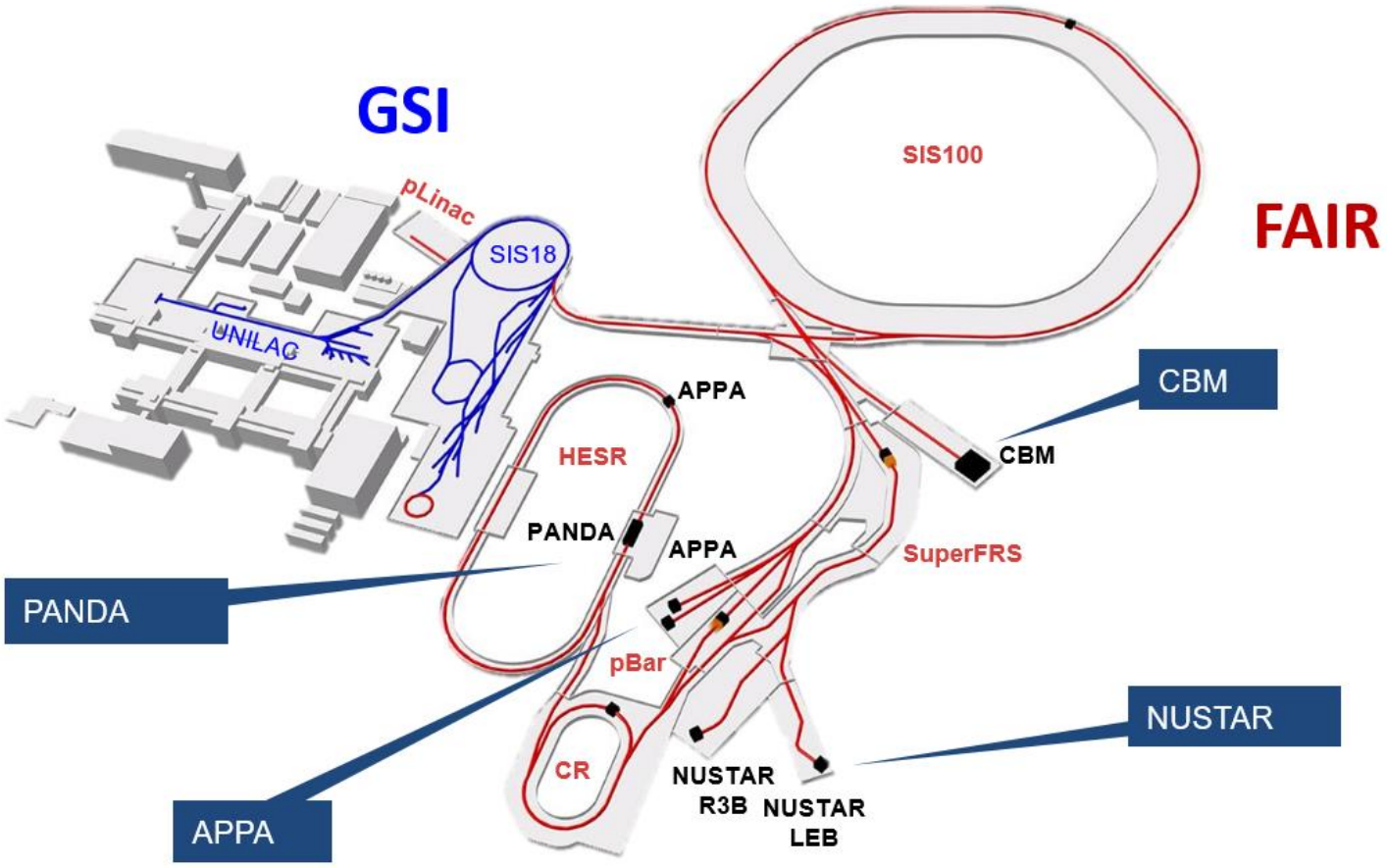


FAIR – The Facility



FAIR Project Time schedule

FAIR Council decided in February 2020 the Intermediate Objective (IO) (marked dark green) as an interim step towards full MSV.
The IO comprises

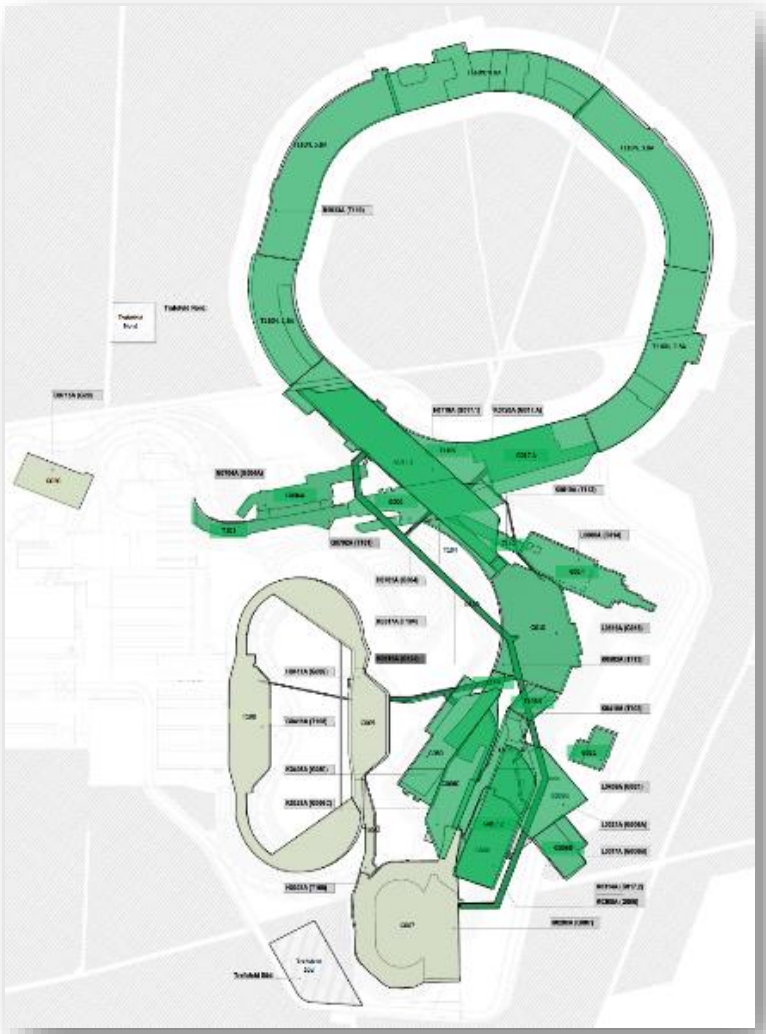
- the full scope of accelerator and experiments for the MSV
- the realization of the buildings for MSV except the buildings for CR, HESR and pLinac.

The engineering for the buildings HESR, CR and pLinac (marked light green) is continuing, while these buildings will be realized when funding is approved by FAIR Council.

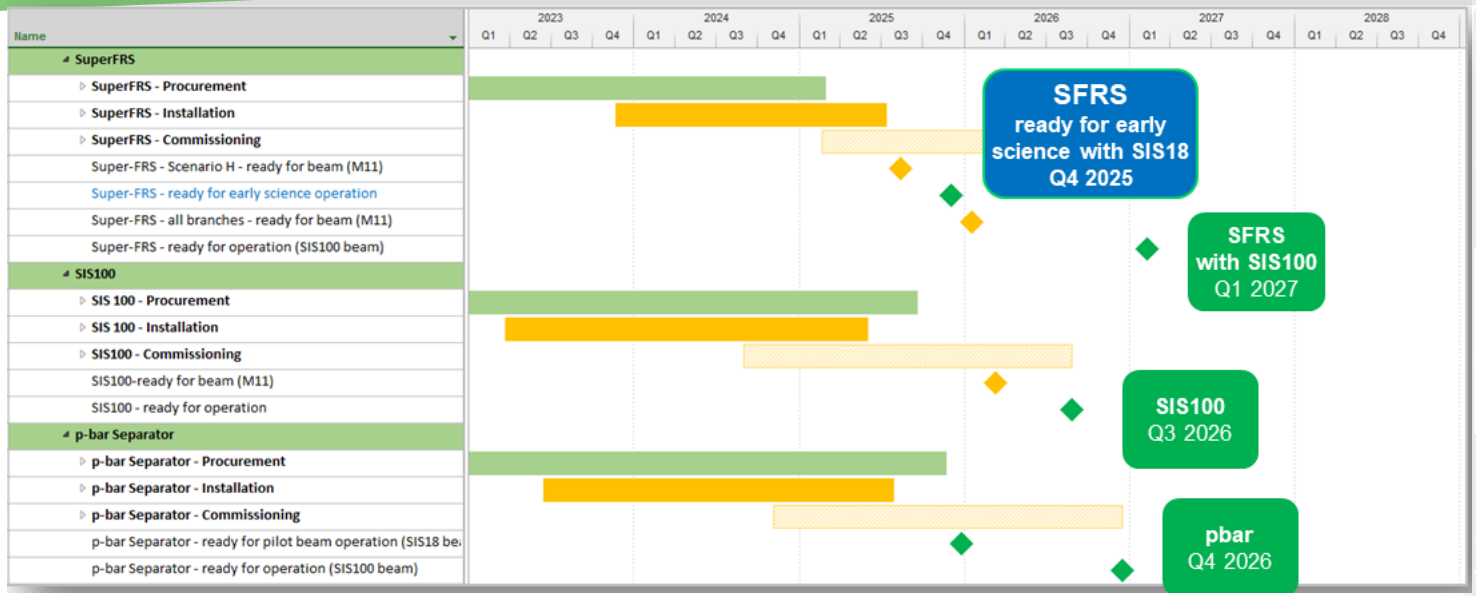
Start of Early science IO is planned for end 2025 with parts of NUSTAR and APPA Cave.

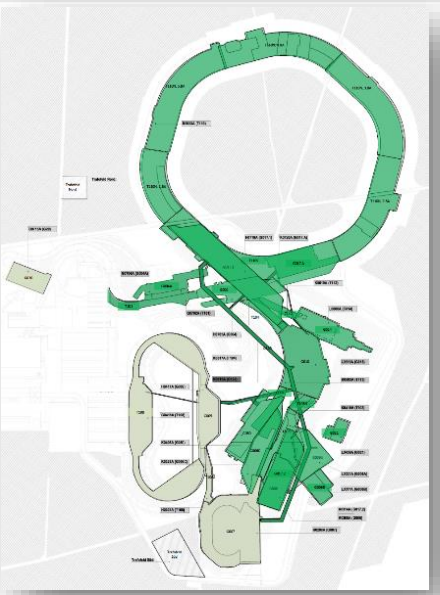
The completion of IO is foreseen in 2027.

Critical Path of the FAIR project is the on-time delivery of ACC components as per Baseline 2021

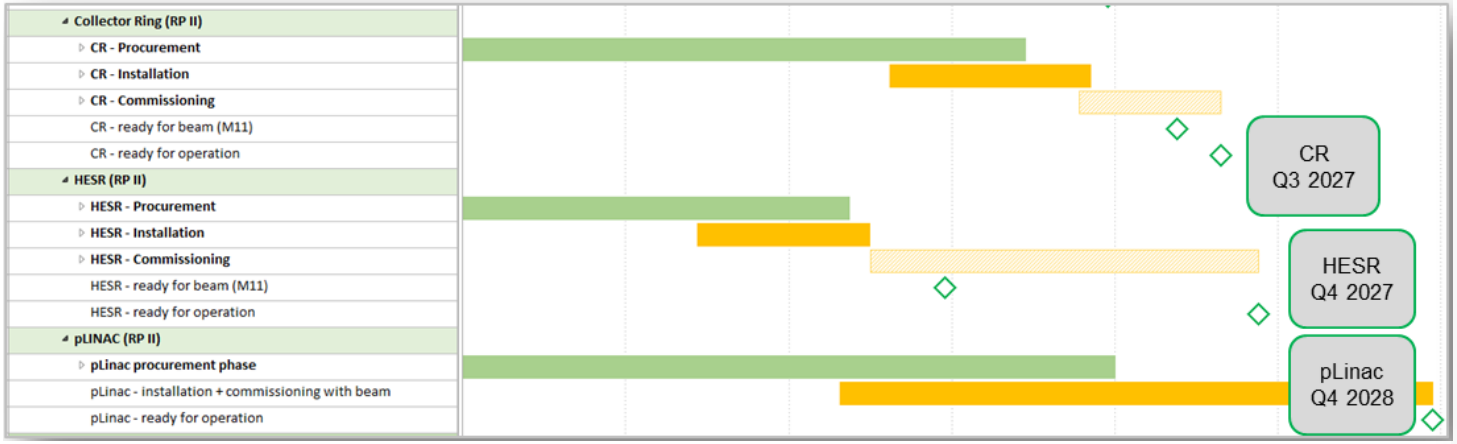


FAIR Baseline schedule 2021





Critical Path of the FAIR project is the on-time delivery of ACC components as per Baseline 2021



Realization timeline of the buildings for CR, HESR and pLinac currently not secured - awaiting the funding approval by FAIR Council

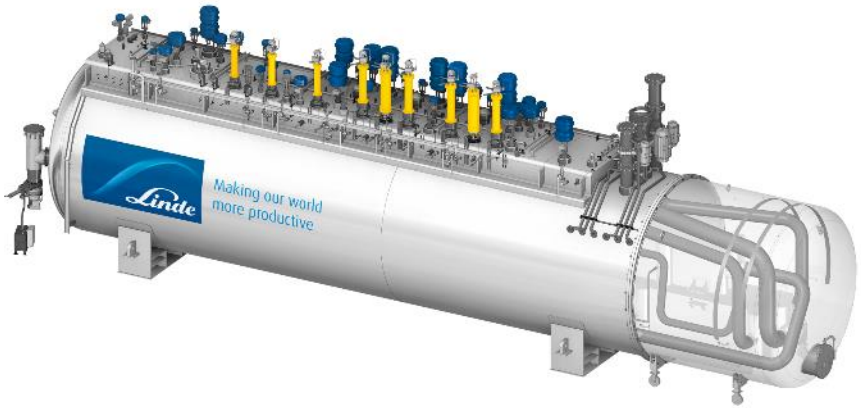
FAIR Highlights (Part 1)

July 2021

Production and Testing of the SIS100 Dipoles was completed

July 2021

Successful FDR for the Cryo 2- Cold Box took place with the company Linde



FAIR Highlights (Part 2)

July 2021

Last successful FDR and start of production for SIS100 distribution system at company Demaco

August 2021

SuperFRS multiplet on a test bench in the test facility designed and constructed in CERN's Building #180

FAIR Highlights (Part 3)

August 2021

Production of bypass lines at company Kriosystem (Poland) progressing.

8 bypass lines delivered to GSI/ FAIR

August 2021

Successful FAT of SFRS FoS Dipole Type 3 & FoS Type 2 performed. FoS Type 3 for testing at CERN. Series production is ongoing at company Elytt (Spain)

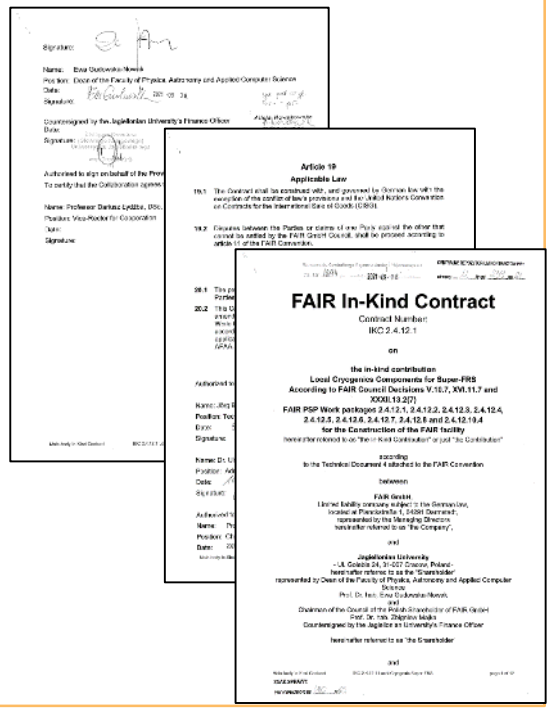
FAIR Highlights (Part 4)

September 2021

Series production of quadrupole units is established at JINR (Russia). 18 units have passed the FAT & SAT and are shipped for integration to company BNG (Germany)

September 2021

Signature of SuperFRS Local Cryogenic contract with JU (Poland)



FAIR Highlights (Part 5)

Storage Warehouse Weiterstadt … filling in progress!

FAIR Project Progress – ACC
SIS100

- Further eight quadrupole units manufactured at JINR, have been accepted (10 % of total)
- First of series module completed at Bilfinger Noell and ready for delivery. Further three cold masses are integrated. Efficiency of work flow enhanced for series production
- The CDR for the current lead boxes (WUST) has been completed successfully. Tendering will be launched by WUST on short term
- Complete series of dipole chambers (110) manufactured at PINK. 50% of dipole chambers have been integrated into dipole modules at GSI

Series integration and production of quadrupole modules at Bilfinger Noell

Cryogenic bypass lines (WUST) in storage area

FAIR Project Progress – ACC
SuperFRS

superconducting magnets production and testing @CERN

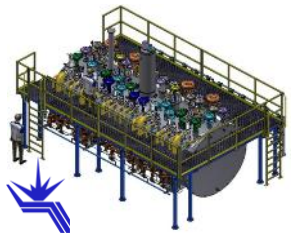
- sc multiplets series production ongoing
- Actual status FAT: 6 short multiplets; 1 long multiplet
- Actual status SAT: FOS short multiplet tested; sc long multiplet test ongoing
- sc dipoles: entering series production
- Actual status FAT: 2 standard dipoles (Type2, 3)
- Kick-off (31/03/21) for EB dipole magnets design with CEA, IK request for assignment sent by CEA

local cryogenics

- Progress in design at WUST/Pl and BINP/Ru
- IK-contracts signed: BINP (21/06/21) and WUST(06/09/21)

normal conducting radiation-hard multipoles

- nc multipoles tender awarded to Buckley Systems Ltd., NZ (06/08/21)
- radiation-hard wires (Hitachi) will be supplied 04/22



special installations in target area

- Target chamber design finished (KVI, FDR, 05/2021)
- Lateral iron shielding blocks: series production, 50% delivered

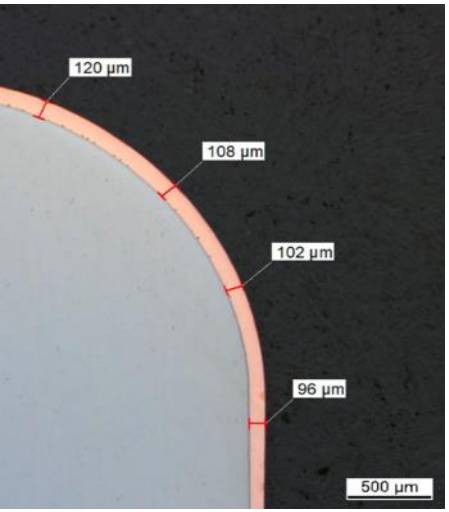
power converters:

- Quench Detection: Tender awarded to company Semicon, Warszawa, Poland

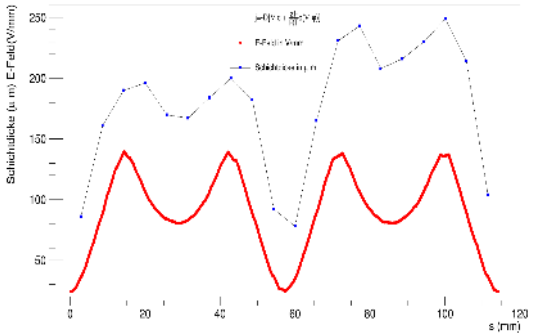
special vacuum: Several IK components (AFAA9) contracted with BINP (09/21)

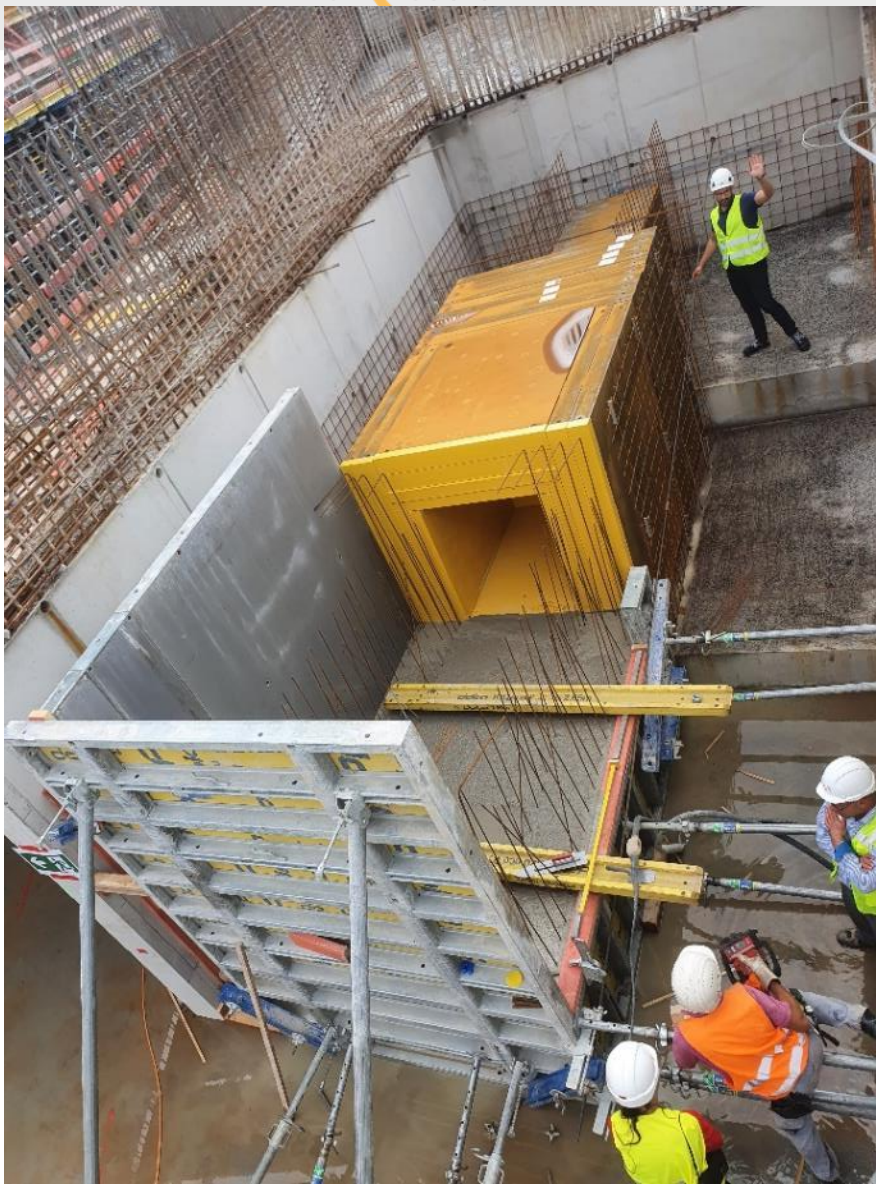
FAIR Project Progress – ACC
pLinac/ pbar Target

- pLinac CH-cavities: CDR accepted, test with 3d printed drift tubes and stems progressing
- Successful copper plating tests and simulations for CH dummy-cavities at GSI
- pbar shielding flask; CDR accepted
- Iron of pbar beamdump installed in building 6c



Section through a drift tube


Thickness of copper layer:
Measurement and simulation


pbar beamdump

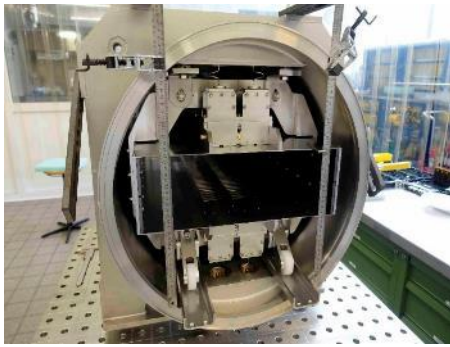
FAIR Project Progress – ACC
Collector Ring

- **FoS CR dipole**
  - Reached specified field quality ($<10^{-4}$) at BINP
  - FAT performed in Nov. 2021
  - Delivery to FAIR expected in Dec. 2021 / Jan. 2022
  - Technical infrastructure for SAT at GSI Target Hall has been prepared

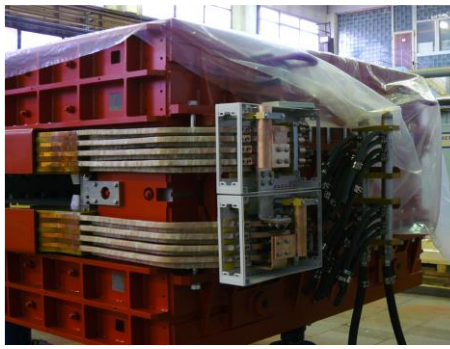
- **CR Stochastic Cooling**
  - SAT of all series power amplifiers finished. 20 of 34 passed SAT
  - Contract on SC kickers is under preparation with FZJ

- **CR Schottky pick-up**
  - CDR review passed (ITEP Moscow)


Power amplifiers for Stochastic Cooling


Palmer Pick-Up for stochastic cooling

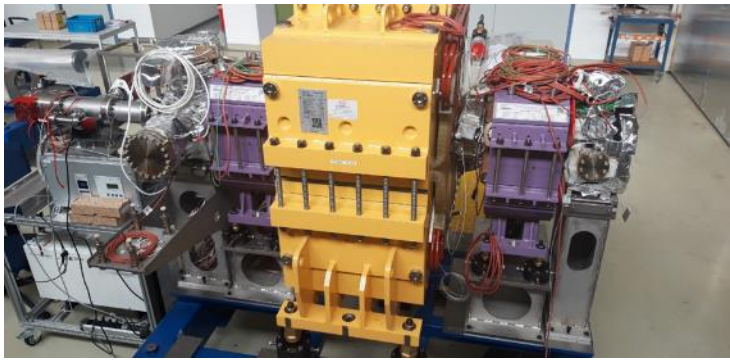

CR temporary storage facility


CR dipole magnet

FAIR Project Progress – ACC
HESR

- All 46 Dipoles are delivered. 4 (SPARC) in Jülich, 42 are in Weiterstadt
- All 84 Quadrupoles are in Jülich. Assembly on girders in progress. Delivery of Girder #1 in Q3 /2021. Continuous delivery of BPMs and ion clearing chambers
- Romania: Delivery of sextupoles and steerers finished. Delivery of power converters to Jülich continuing. EMC measurements finished for 22 power converters.
- All power converters except for main dipoles are in Jülich. Spec of main dipole PC ready for ordering. Waiting for timeline of the buildings for just-in-time delivery (no test load!)
- Production of RF cavity 1 completed, cavity 2 in progress
- Injection kickers and pulsers: 2 Systems delivered to Darmstadt. Systems 3-5 is in production
- All stochastic cooling tanks installed in COSY for tests with beam

SPARC dipole with laser beam pipe



Pre-assembled 1st quadrupole girder in Jülich

Barrier bucket and acceleration cavity on the test bench

FAIR Project Progress – ACC
COMMONS

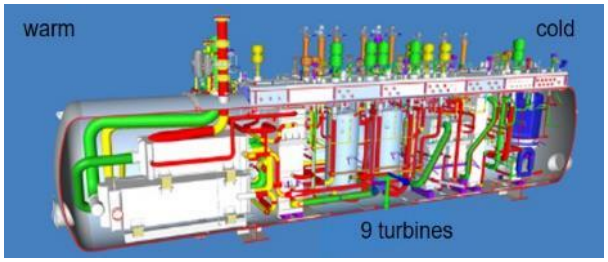
Cryogenic Plant and Distribution Systems (in-kind GSI)
FDR DB4 SIS100 distribution system (Demaco) and FDRs for CRYO2, DB3 and CWU (Linde KT) successfully performed within schedule and without any rework.
Cold Box CRYO2 (Linde): length 18 m, diameter 3.8 m, power 14 kW@4 K, 50 kW@50 K

Electric power system, User Cables (FAIR)
Call for tender of user cables (LV1) published (17.09.2021)

HEBT Power Converters (in-kind India)
FAT of First-of-Series power converter HB.C2 performed successfully at the manufacturer ECIL (July 21)

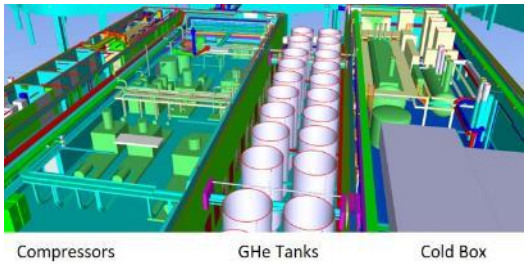
HEBT Magnets Batch 2&3 (in-kind Russia)
Next on-site FAT in October 2021 at BINP premises with at least 1x Dipole and 7x Steerer Magnets

SEM Grid (in-Kind Poland)
2 FoS FT-DG 2010 SEM-Grid, in the mean time serial production started and planned to be finalized in Q4/ 2021 (Prevac)



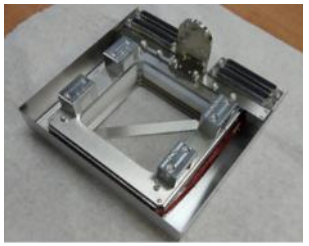
Cold Box Cryo2 (Linde)

Cryo2 Plant




Cable reel

Power Converter



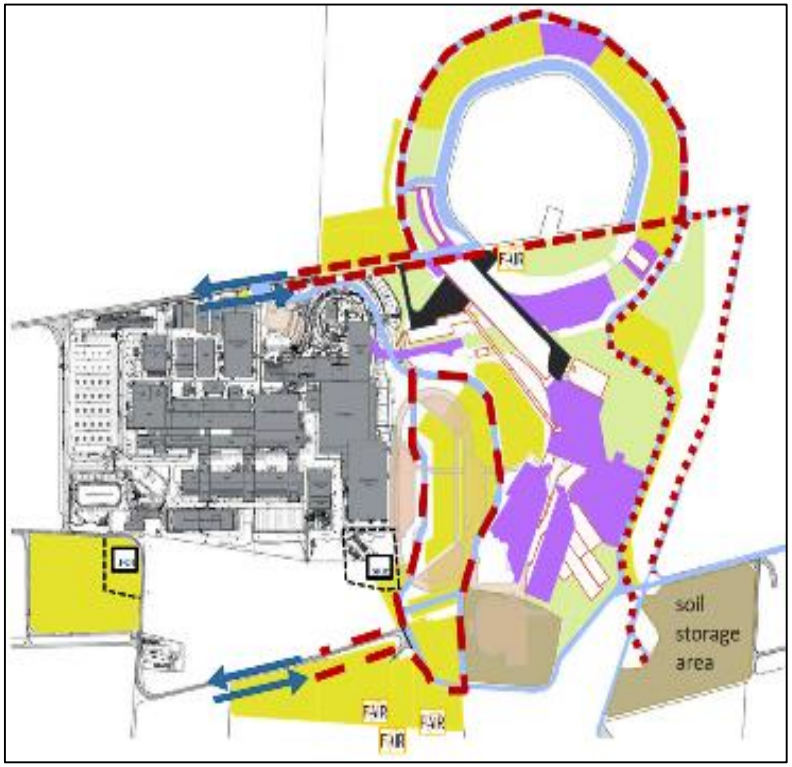

SEM Grid

FAIR Project Progress
Site Management

- Site development and modification as a result of construction progress by end 2021.
- Three main traffic loops divided in Northern and Southern sections.
- Both Gates modified to increase throughput for incoming and outgoing traffic.

Modified gates to increase throughput for incoming and outgoing traffic

- **Northern** section predominantly for TBI contractors.
  - Refill of soil above SIS100 tunnel and preparation of new storage areas by Q1-2022.
  - Allocation of storage areas to contractors already done
- **Southern** section predominantly civil construction for Phase I.
  - Very little storage area for TBI contractors
  - Gate West will remain in operation until end of Phase II in 2027.
  - Soil transports and refill will continue until end 2027



FAIR Project Progress – Civil

FAIR Project Progress – Civil
Area North – SIS100

FAIR Project Progress – Civil

FAIR Project Progress – Civil

FAIR Project Progress – Civil

FAIR Project Progress – Civil

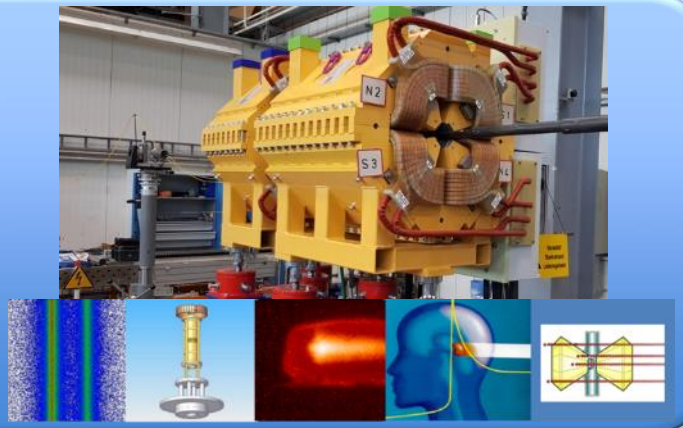
FAIR Project Progress – Experiments

Progress

- Completion of the design - reflected in approved TDRs— is up by 1% over 6 months
- Construction of experimental components, is up by 2.2% over 6 months.

Recent Highlights

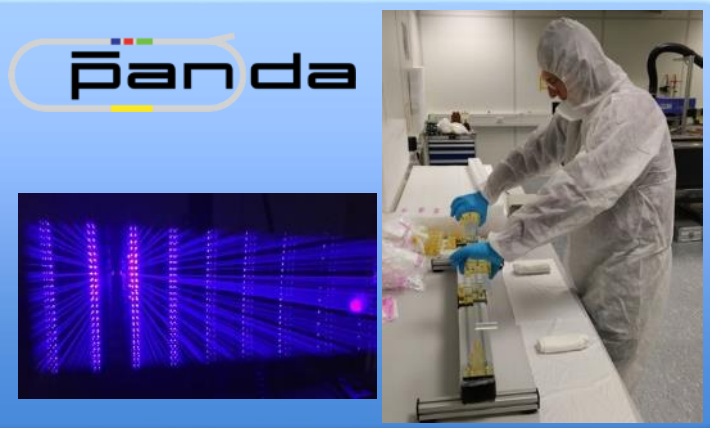
APPA



CBM

NUSTAR

PANDA




Thank you for your attention !