News from FAIR

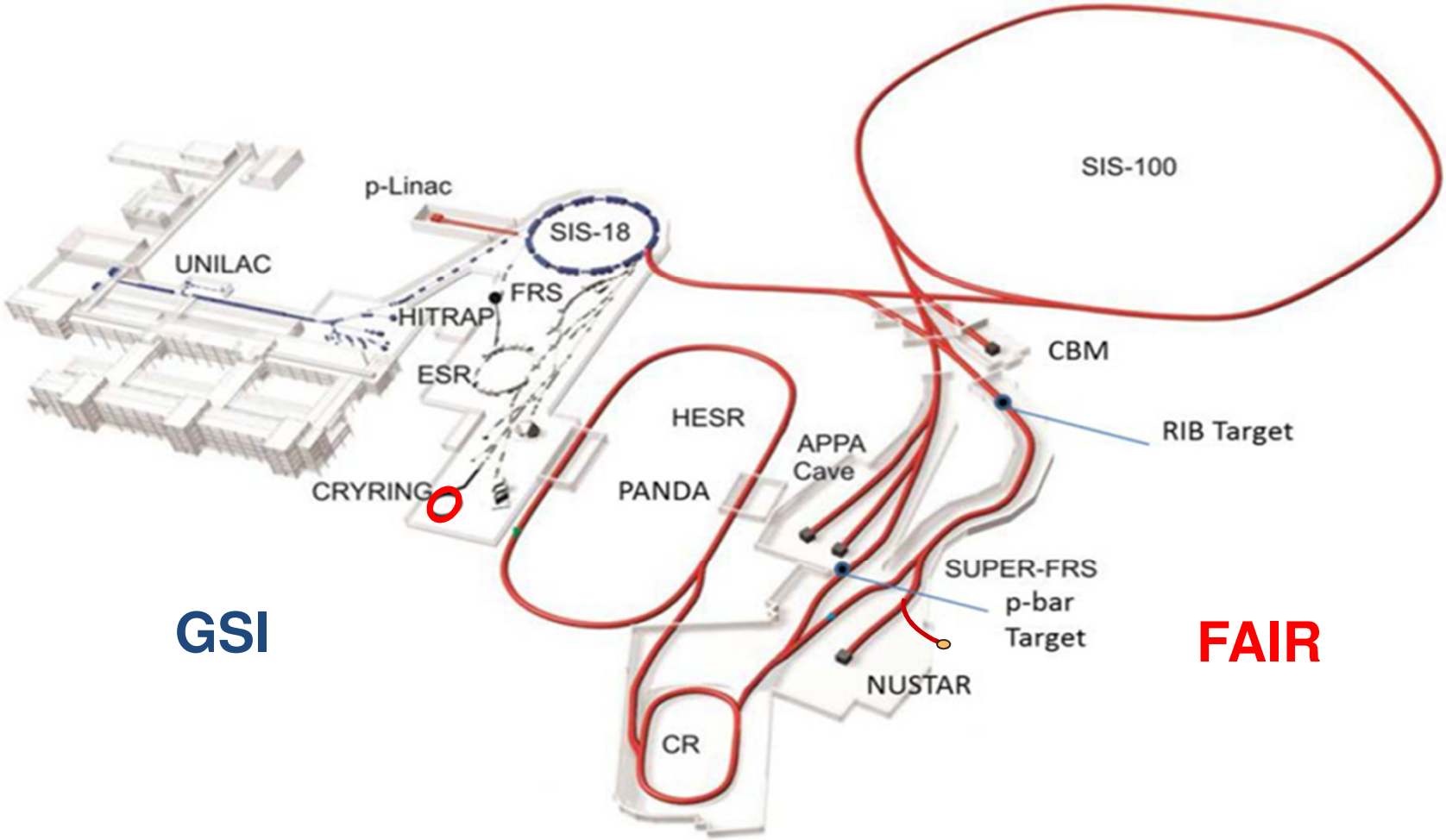
Status and strategy towards completion

Paolo Giubellino

Outline

1. Major events and recent decisions by the FAIR Council
2. Civil construction – realization plan
3. Integrated Project Time Schedule
4. Progress achieved in the Accelerator and Detector Projects
5. Research at GSI continues – beam time 2016
6. Intermediate research program FAIR Phase 0
7. Summary and outlook

FAIR Accelerator Complex



FAIR Accelerator Complex

FAIR

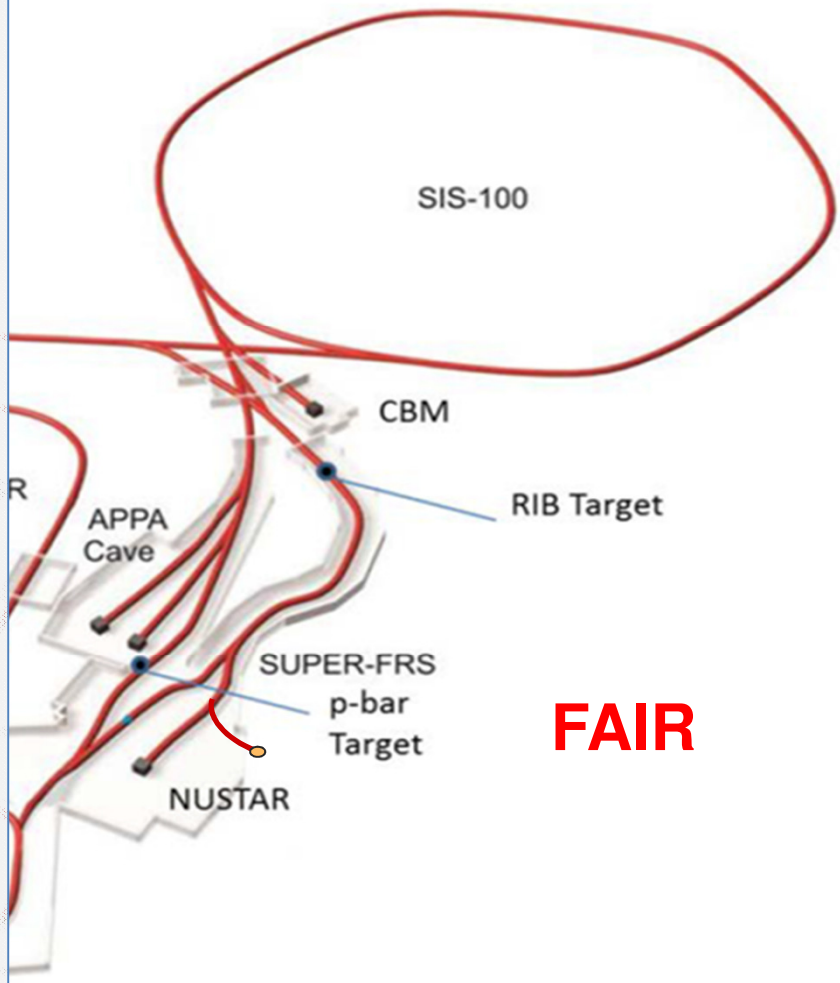
... accelerates particle beams from (anti)protons up to uranium ions with

- 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.



FAIR – four research pillars

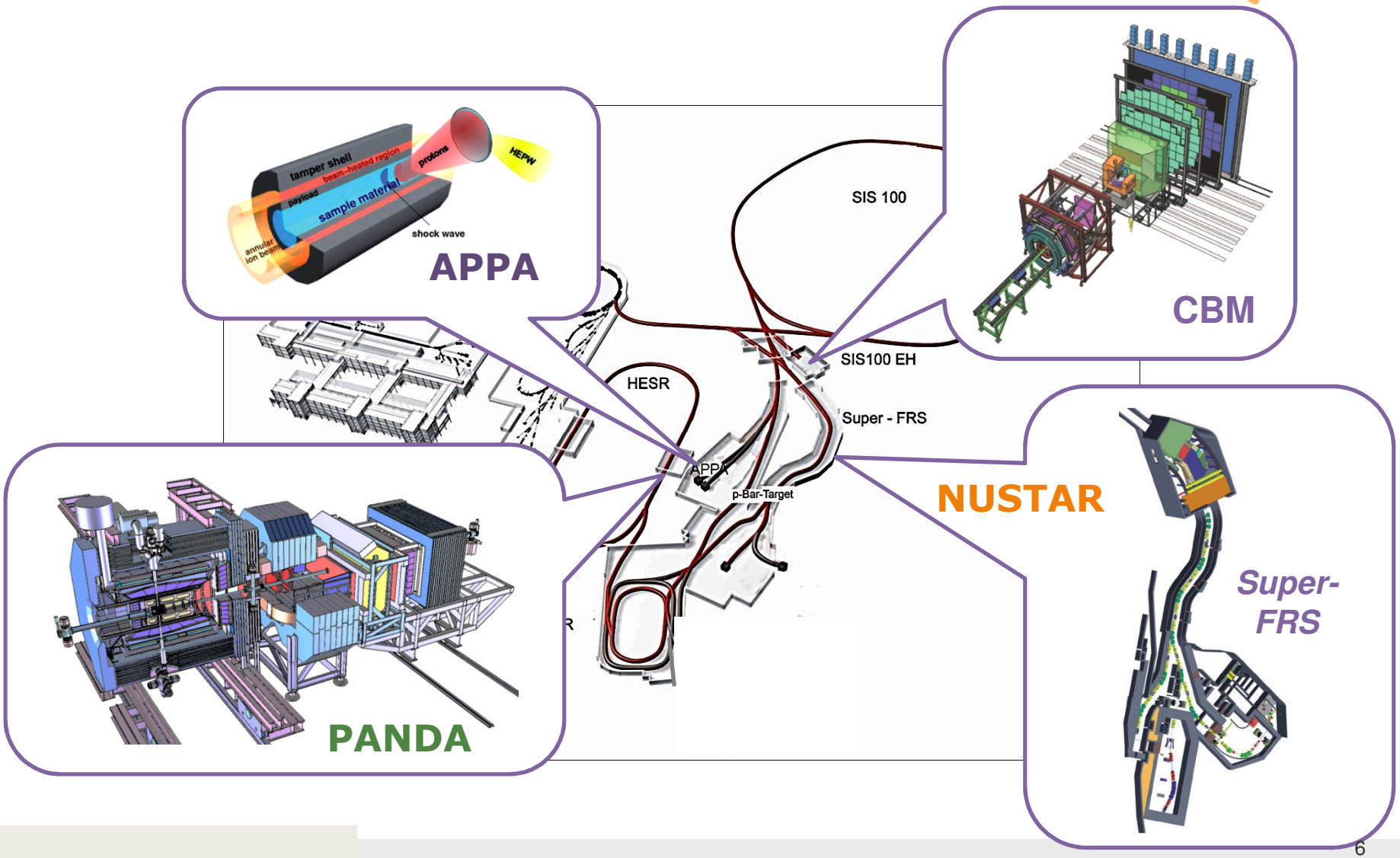
APPA
- Atomic Physics and Fundamental Symmetries,
- Plasma Physics,
- Materials Research,
- Radiation Biology,
- Cancer Therapy with Ion Beams / Space Res.

CBM
- Dense and Hot Nuclear Matter

NUSTAR
- Nuclear Structure far off stability,
- Physics of Explosive Nucleosynthesis (r process)

PANDA
- Hadron Structure & Dynamics with cooled antiproton beams

FAIR – four research pillars



International Participation in FAIR

- FAIR governed by international convention
  - 9 shareholders + 1 assoc. partner (orange)
- Scientists from all over the world are engaged
  - More than 200 institutions from 53 countries are involved with their scientists (orange + blue) → FAIR community growing

Important recent achievements and events

- In the course of 2016: Development of a comprehensive civil construction plan for completing all buildings until 2022
- 13 September 2016: BMBF approved funding for the civil construction of FAIR northern site area
- 26 September and 22 November 2016: Inquiry and contracting of civil construction has started; first calls for tender for ground water lowering, trench sheeting, excavation and building shell for construction have been launched.
- 7 December 2016: Full integrated planning for the FAIR construction and commissioning presented in the Council. Solid resource loaded plan for completion of the full project by 2025.

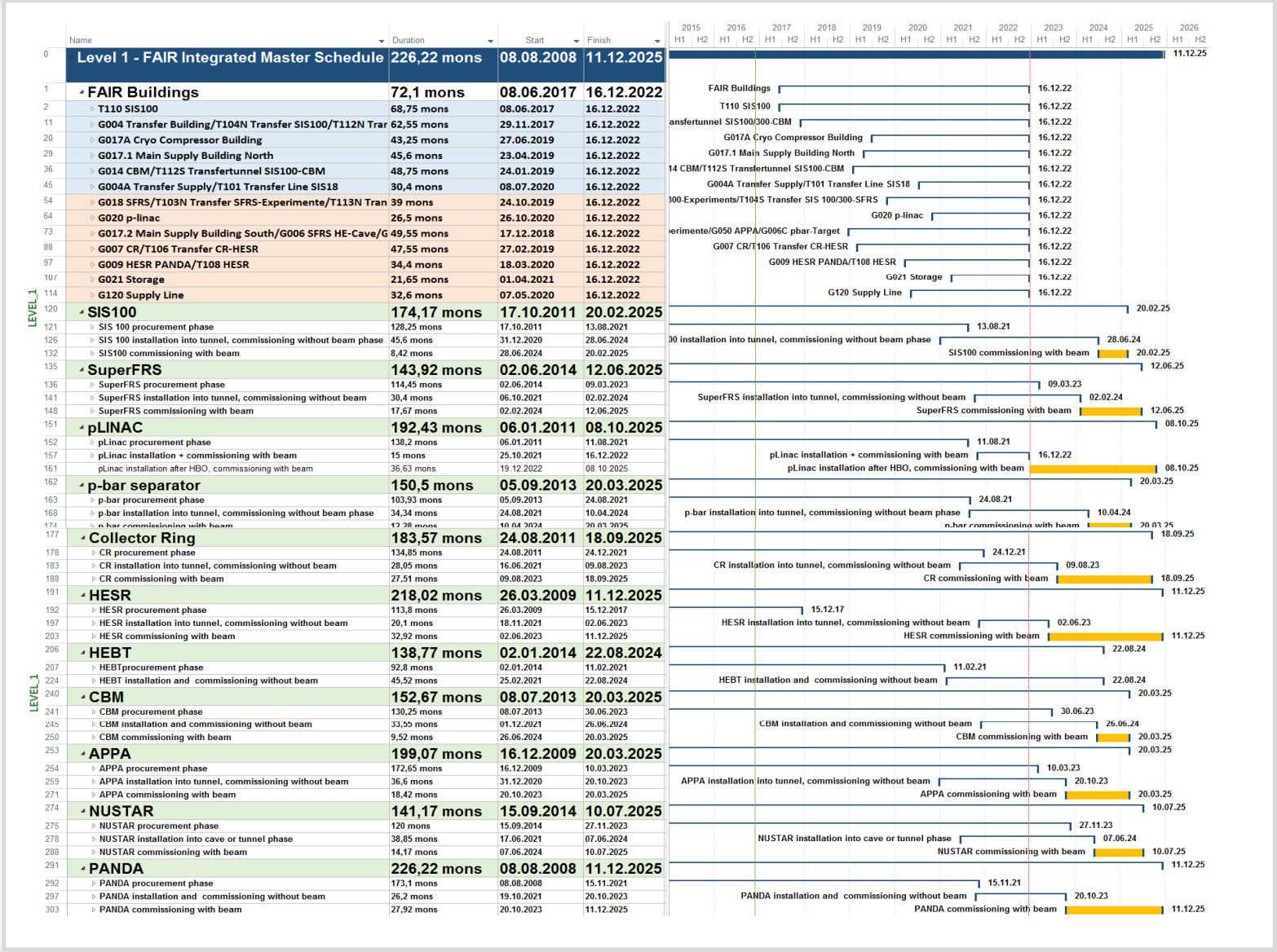
Civil construction – realization plan

FAIR CC animation

Integrated Project Time Schedule: FAIR Buildings, Accelerators & Experiments

- Planning scope is the FAIR MSV
- Completion by 2025
- Full integration in planning of Civil Construction, Machine & Experiments is achieved
- A staged approach is realized (“Along the Beamline” / North & South) to speed up the start of experiments
- Installation windows prior finalization of Civil Construction starting in 2021 until 2024
- Components (Machine & Experiments) for this installation identified & respective dates set
- Continuous progress monitoring is defined and established

Integrated Project Time Schedule – Level 1: FAIR Buildings, Accelerators & Experiments



	Name	Duration	Start	Finish
0	**Level 1 - FAIR Integrated Master Schedule**	**226,22 mons**	**08.08.2008**	**11.12.2025**
1	**FAIR Buildings**	**72,1 mons**	**08.06.2017**	**16.12.2022**
2	T110 SIS100	68,75 mons	08.06.2017	16.12.2022
11	G004 Transfer Building/T104N Transfer SIS100/T112N Trar	62,55 mons	29.11.2017	16.12.2022
20	G017A Cryo Compressor Building	43,25 mons	27.06.2019	16.12.2022
29	G017.1 Main Supply Building North	45,6 mons	23.04.2019	16.12.2022
36	G014 CBM/T112S Transfertunnel SIS100-CBM	48,75 mons	24.01.2019	16.12.2022
45	G004A Transfer Supply/T101 Transfer Line SIS18	30,4 mons	08.07.2020	16.12.2022
54	G018 SFRS/T103N Transfer SFRS-Experimente/T113N Tran	39 mons	24.10.2019	16.12.2022
64	G020 p-linac	26,5 mons	26.10.2020	16.12.2022
73	G017.2 Main Supply Building South/G006 SFRS HE-Cave/G	49,55 mons	17.12.2018	16.12.2022
88	G007 CR/T106 Transfer CR-HESR	47,55 mons	27.02.2019	16.12.2022
97	G009 HESR PANDA/T108 HESR	34,4 mons	18.03.2020	16.12.2022
107	G021 Storage	21,65 mons	01.04.2021	16.12.2022
114	G120 Supply Line	32,6 mons	07.05.2020	16.12.2022
120	**SIS100**	**174,17 mons**	**17.10.2011**	**20.02.2025**
121	SIS 100 procurement phase	128,25 mons	17.10.2011	13.08.2021
126	SIS 100 installation into tunnel, commissioning without beam phase	45,6 mons	31.12.2020	28.06.2024
132	SIS100 commissioning with beam	8,42 mons	28.06.2024	20.02.2025
135	**SuperFRS**	**143,92 mons**	**02.06.2014**	**12.06.2025**
136	SuperFRS procurement phase	114,45 mons	02.06.2014	09.03.2023
141	SuperFRS installation into tunnel, commissioning without beam	30,4 mons	06.10.2021	02.02.2024
148	SuperFRS commissioning with beam	17,67 mons	02.02.2024	12.06.2025
151	**pLINAC**	**192,43 mons**	**06.01.2011**	**08.10.2025**
152	pLinac procurement phase	138,2 mons	06.01.2011	11.08.2021
157	pLinac installation + commissioning with beam	15 mons	25.10.2021	16.12.2022
161	pLinac installation after HBO, commissioning with beam	36,63 mons	19.12.2022	08.10.2025
162	**p-bar separator**	**150,5 mons**	**05.09.2013**	**20.03.2025**
163	p-bar procurement phase	103,93 mons	05.09.2013	24.08.2021
168	p-bar installation into tunnel, commissioning without beam phase	34,34 mons	24.08.2021	10.04.2024
174	p-bar commissioning with beam	12,28 mons	10.04.2024	20.03.2025
177	**Collector Ring**	**183,57 mons**	**24.08.2011**	**18.09.2025**
178	CR procurement phase	134,85 mons	24.08.2011	24.12.2021
183	CR installation into tunnel, commissioning without beam	28,05 mons	16.06.2021	09.08.2023
188	CR commissioning with beam	27,51 mons	09.08.2023	18.09.2025
191	**HESR**	**218,02 mons**	**26.03.2009**	**11.12.2025**
192	HESR procurement phase	113,8 mons	26.03.2009	15.12.2017
197	HESR installation into tunnel, commissioning without beam	20,1 mons	18.11.2021	02.06.2023
203	HESR commissioning with beam	32,92 mons	02.06.2023	11.12.2025
206	**HEBT**	**138,77 mons**	**02.01.2014**	**22.08.2024**
207	HEBTprocurement phase	92,8 mons	02.01.2014	11.02.2021
224	HEBT installation and commissioning without beam	45,52 mons	25.02.2021	22.08.2024
240	**CBM**	**152,67 mons**	**08.07.2013**	**20.03.2025**
241	CBM procurement phase	130,25 mons	08.07.2013	30.06.2023
245	CBM installation and commissioning without beam	33,55 mons	01.12.2021	26.06.2024
250	CBM commissioning with beam	9,52 mons	26.06.2024	20.03.2025
253	**APPA**	**199,07 mons**	**16.12.2009**	**20.03.2025**
254	APPA procurement phase	172,65 mons	16.12.2009	10.03.2023
259	APPA installation into tunnel, commissioning without beam	36,6 mons	31.12.2020	20.10.2023
271	APPA commissioning with beam	18,42 mons	20.10.2023	20.03.2025
274	**NUSTAR**	**141,17 mons**	**15.09.2014**	**10.07.2025**
275	NUSTAR procurement phase	120 mons	15.09.2014	27.11.2023
278	NUSTAR installation into cave or tunnel phase	38,85 mons	17.06.2021	07.06.2024
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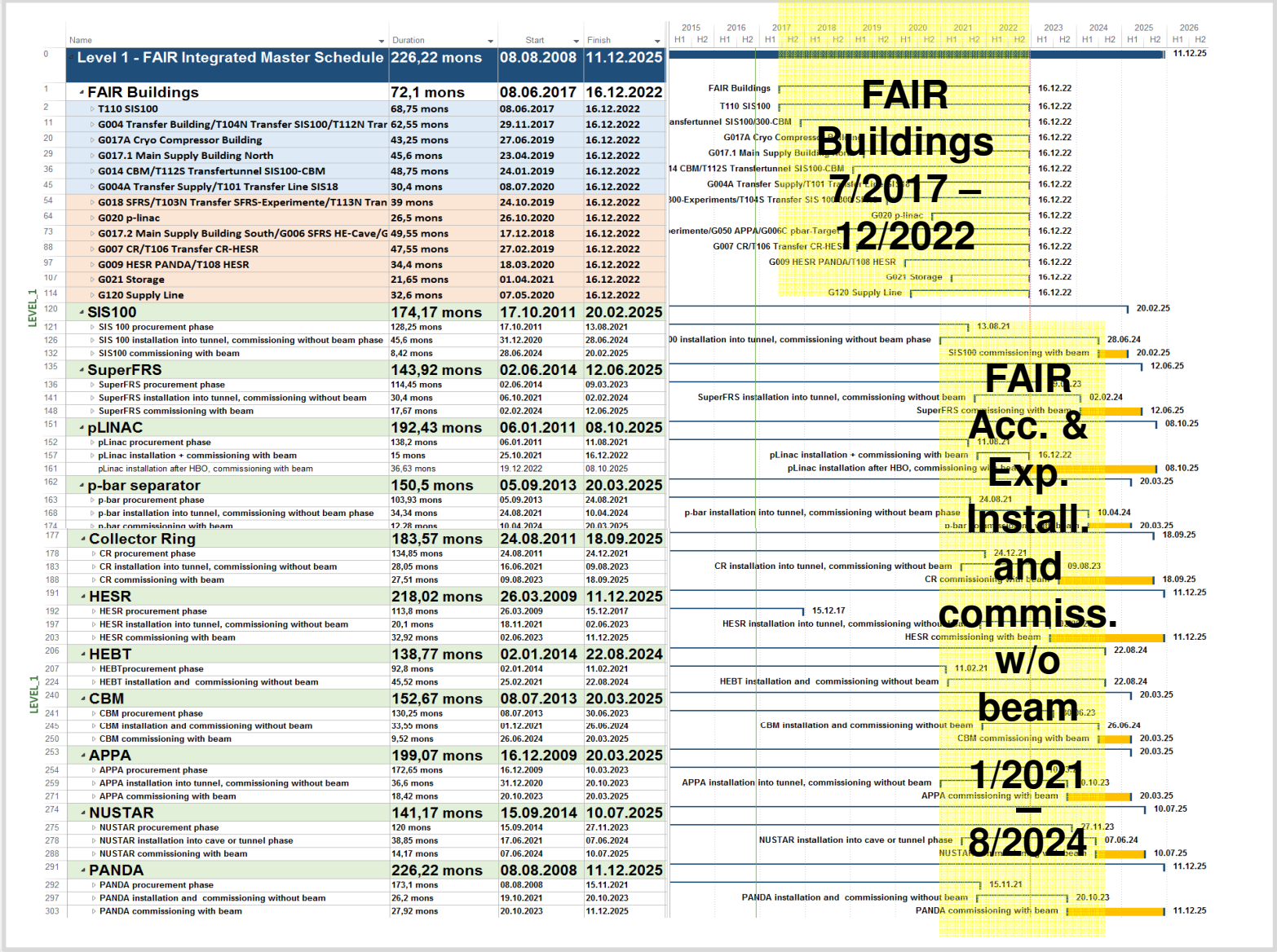
LEVEL 1

Integrated Project Time Schedule – Level 1: FAIR Buildings, Accelerators & Experiments



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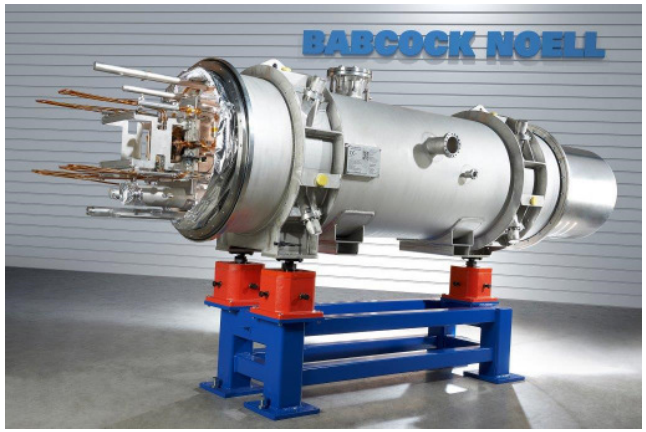
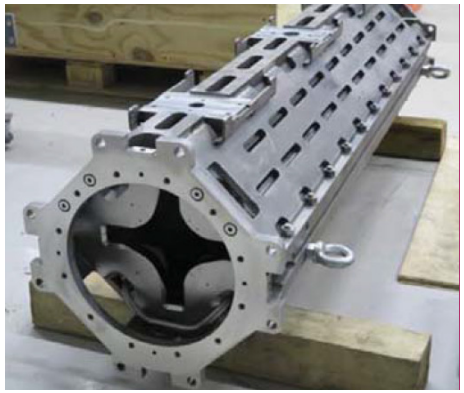
Progress achieved in the FAIR Accelerator and Experimental Projects

Procurement of the FAIR Accelerators - SIS100

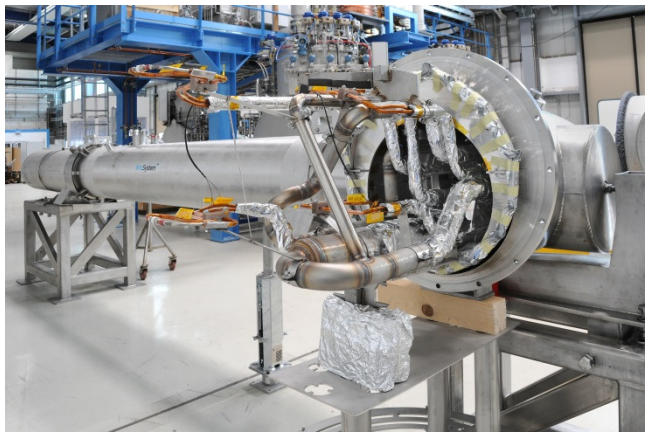


S.c. dipol magnet: Release of series production in July 2016 (Germany)

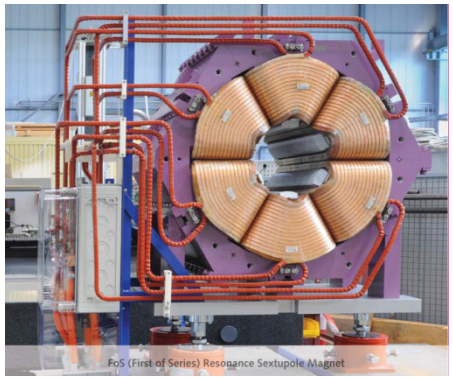


First SIS100 s.c quadrupole yoke and s.c. coil at JINR (Russia/Germany)

First SIS100 bunch compressor cavity: SAT (on-site acceptance test) successful (Germany)



First cryogenic bypass line delivered and under cold testing at GSI (Poland)

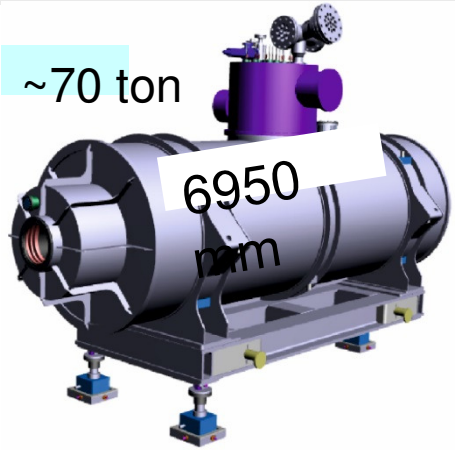


FOS (first of series) sextupole magnet delivered. SAT successful, Series released (Denmark).

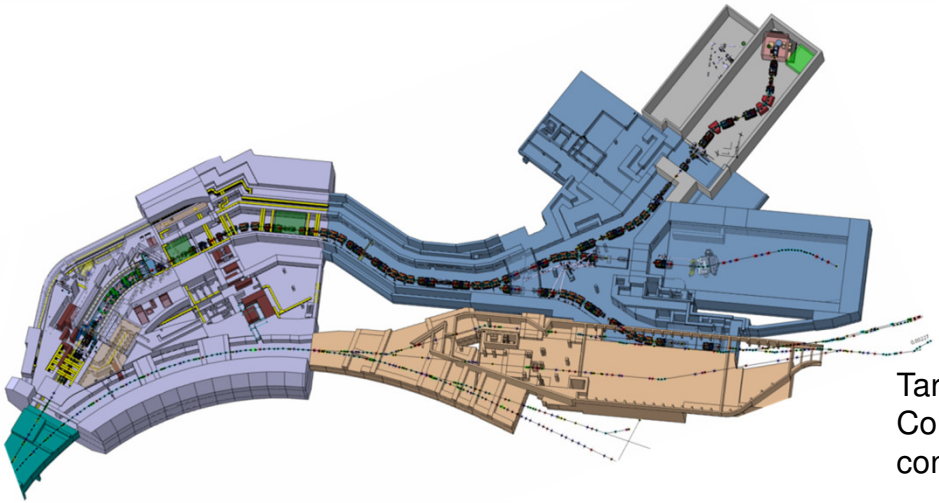
Parts for FOS acceleration cavity produced. Assembly started. FAT (factory acceptance test) in Dec. 2016 (Germany)

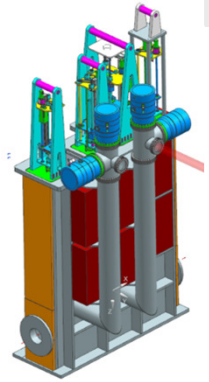
Procurement of the FAIR Accelerators

Super-FRS

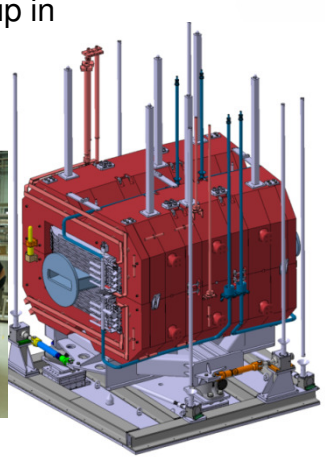


FOS s.c multiplett: PDR approved in July. Steel and wire orderd. Coil mock-up in production (Italy).



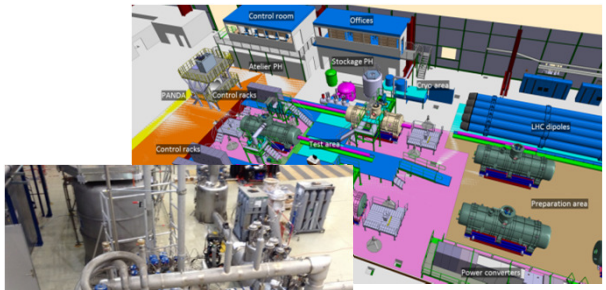


Target chamber with plug ins. Collaboration and R&D contracts with KVI-CART (NL)



Radiation hard dipole. Prototype testing almost completed. Tendering on short term (Russia)

Collaboration agreement signed with CEA, including design and technical follow-up (France)

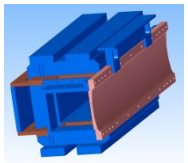


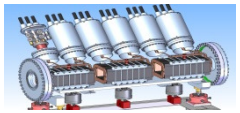
Set-up of test facility started at CERN, Commissioning of cryogenics system in 2016. First magnet end of 2017.

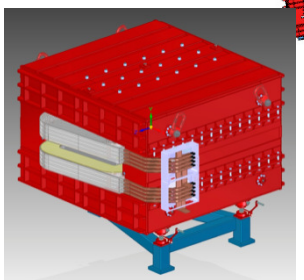
Procurement Highlights of the FAIR Accelerators
Collector Ring

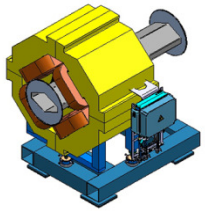
FOS debuncher cavity
SAT ongoing.

Prototype stochastic cooling tank at GSI

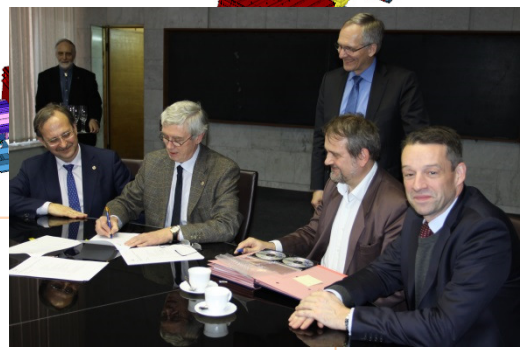








- The update of TDR (Annex) is ready and approved. Several spec. completed
- The full 3D model of CR system is ready (DMU model)
- MA debuncher cavity in SAT at GSI.
- Prototype of Stochastic cooling Pick–up under development.



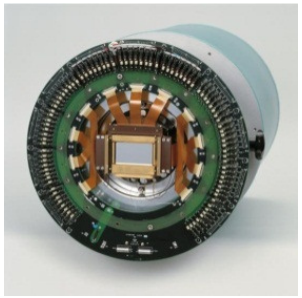
December 2016: Collaboration contract signed for the dipole magnets (production until 2021) and potentially for all other components with BINP, Novosibirsk (Russia)

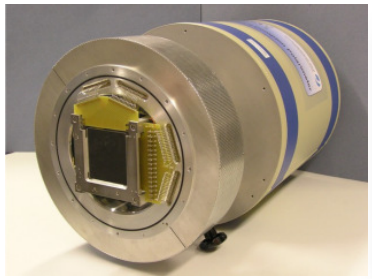
APPA

Sophisticated & Versatile Instrumentation

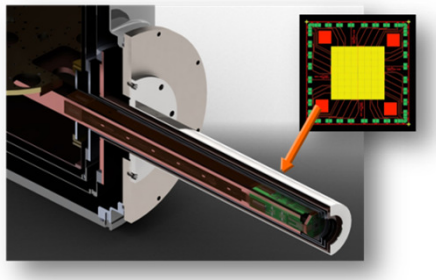
Observables: Photons, electrons, positrons, ions

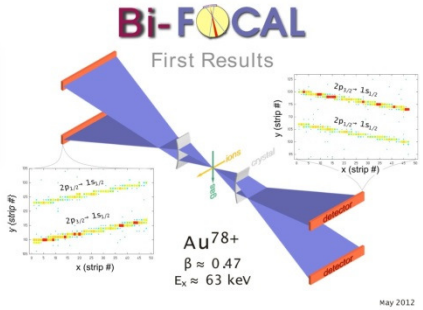
Targets



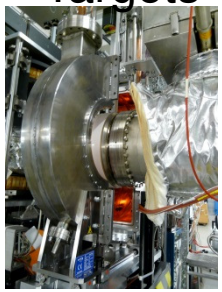


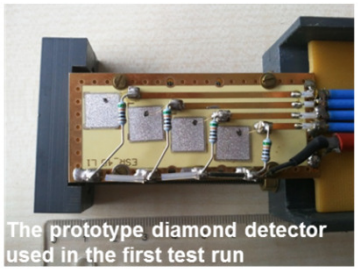
Position-sensitive solid-state detectors



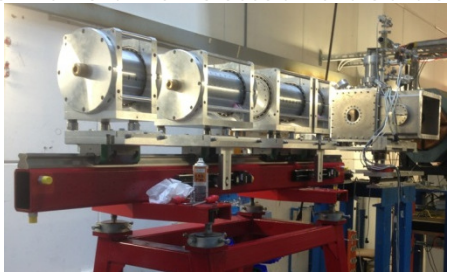


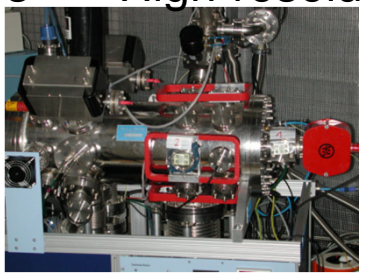
High-resolution spectrometers



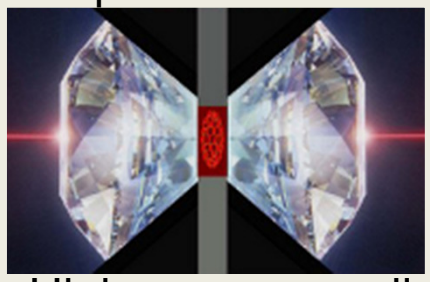


Particle detectors

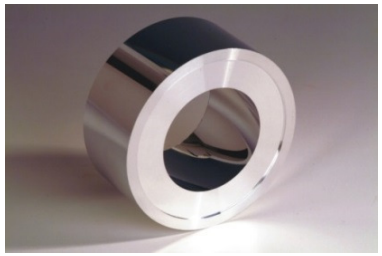


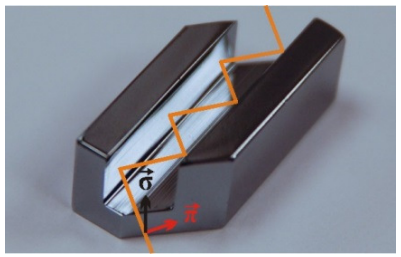


Particle spectrometers



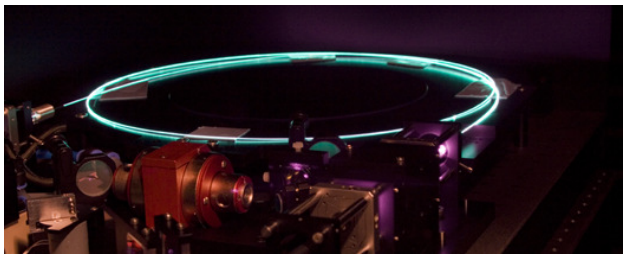
High pressure cell





Traps

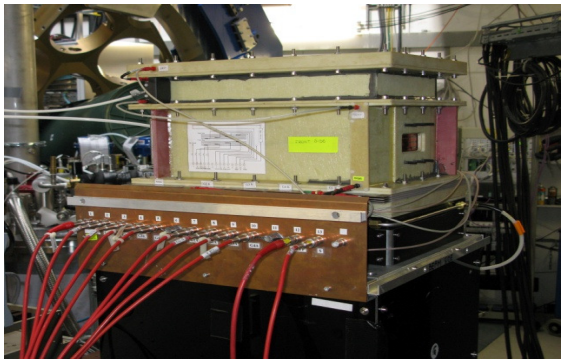
X-ray optics, channel-cut crystals



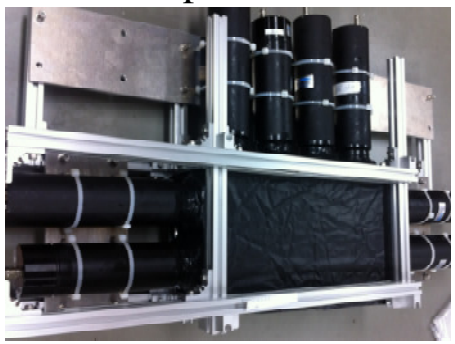
Laser systems

Novel detectors developed for NUSTAR

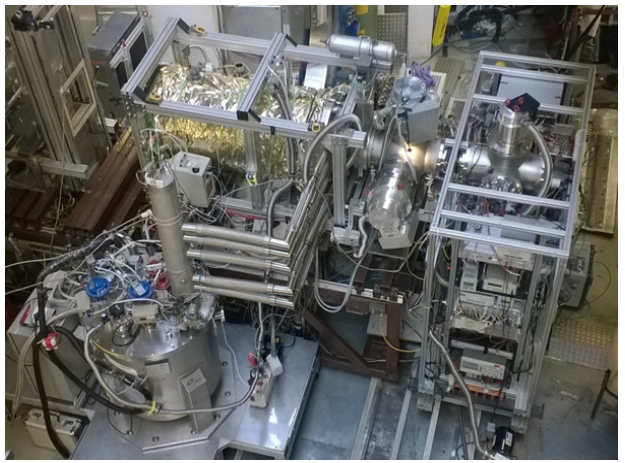
O-TPC: discovered β-delayed 3p-emission of ^{31}Ar



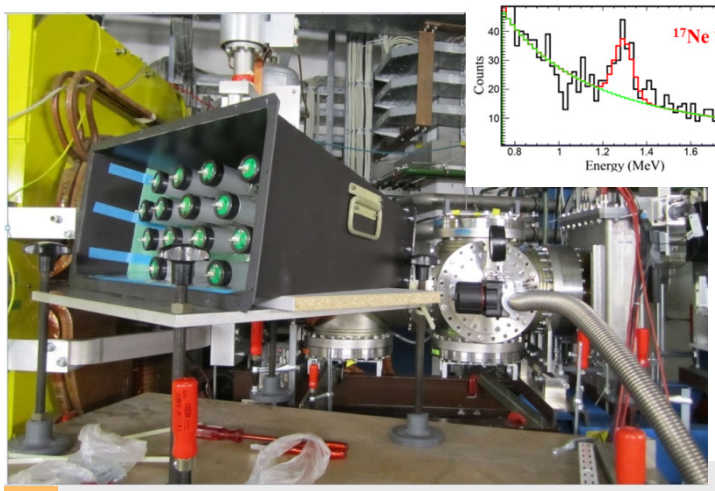
Backward-angle neutron detector for tensor-force experiments



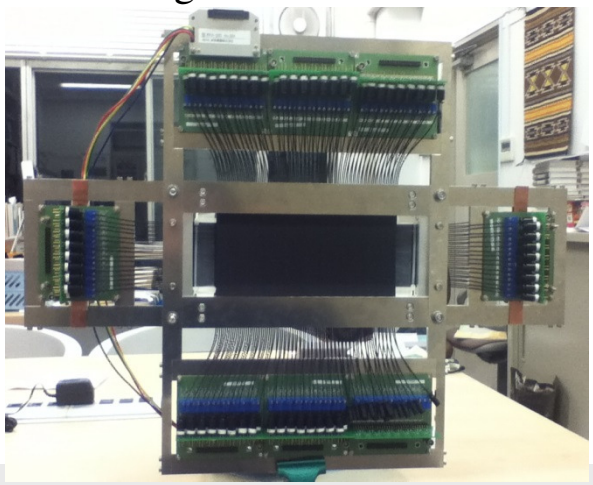
Ion Catcher → LEB-MATS/LASPEC



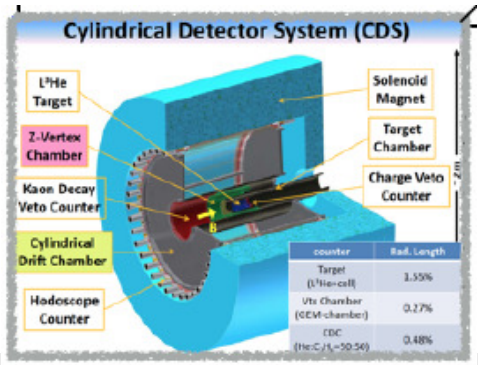
GADAST prototype measurements at S2



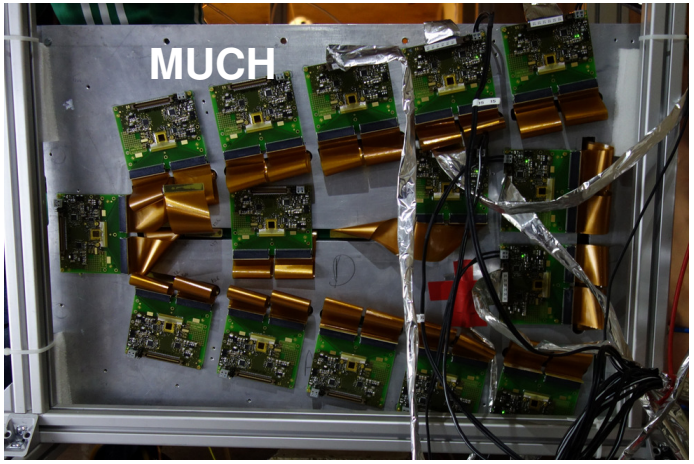
Full integrated S2 fiber tracker

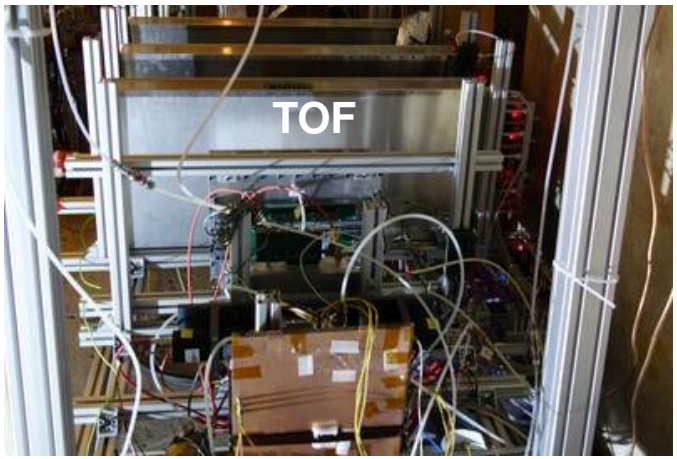


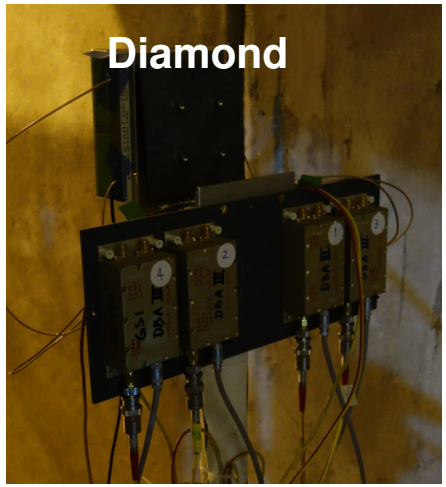
Simulations for a pion detector integrated at S2

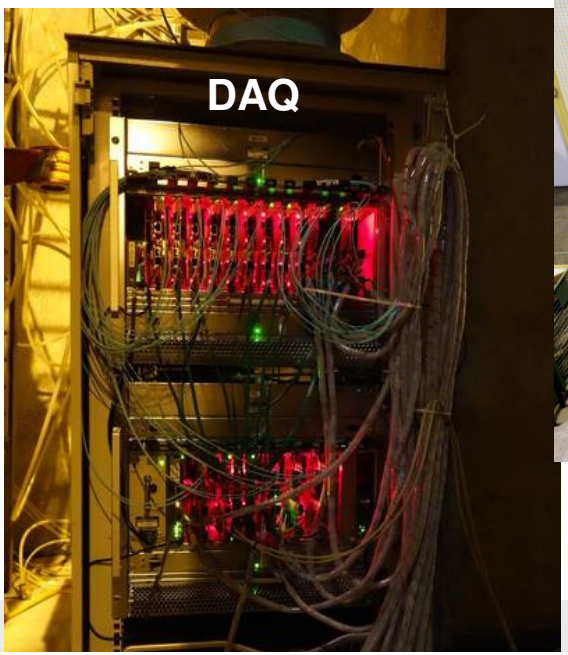


New detectors and DAQ for HADES, CBM and PANDA



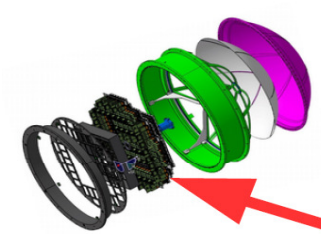




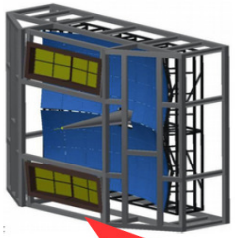


New detectors and DAQ for HADES, CBM and PANDA

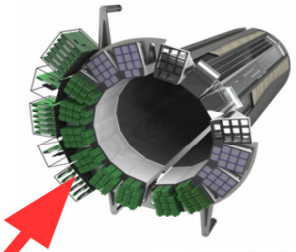
DiRICH MAPMT/MCP readout chain
common development for **HADES**, **CBM** and **PANDA**



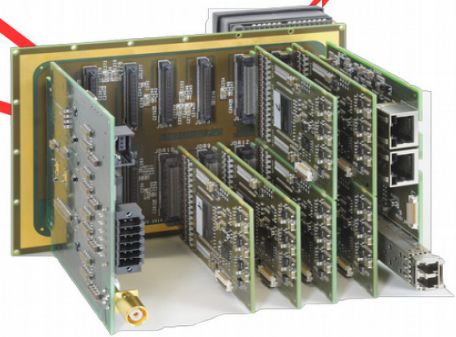
HADES RICH
28k channels
MAPMT readout
First beam 2018
FAIR phase-0 !

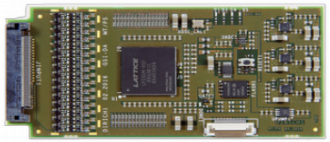


CBM RICH
55k channels
MAPMT readout



PANDA
Barrel-DIRC
11k channels
MCP readout





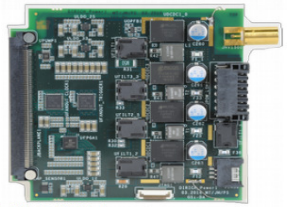
DiRICH 3x2 PMT readout module

- Perfect synergy between FAIR experiments
- **Based on TRB3 project** (GSI development)
- Development funded by BMBF

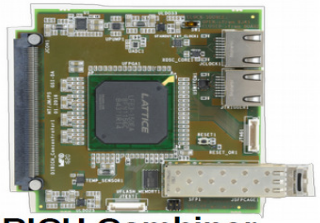
- **prototypes** of all modules **available** and under evaluation (06 / 2016)
- **Very promising first results**

DiRICH Front-end
- **32ch** low-power preamp,
- **discrimination** (FPGA)
- high precision **FPGA-TDC**
- Time+ToT measurement
- **< 50ps RMS precision**

Urgent needs:
- Man-power for FPGA TDC development (FAIR / GSI)
- Additional Funding (~230k€) to equip full HADES RICH (presently 50% funded)



DiRICH Power
- Common LV+HV supply



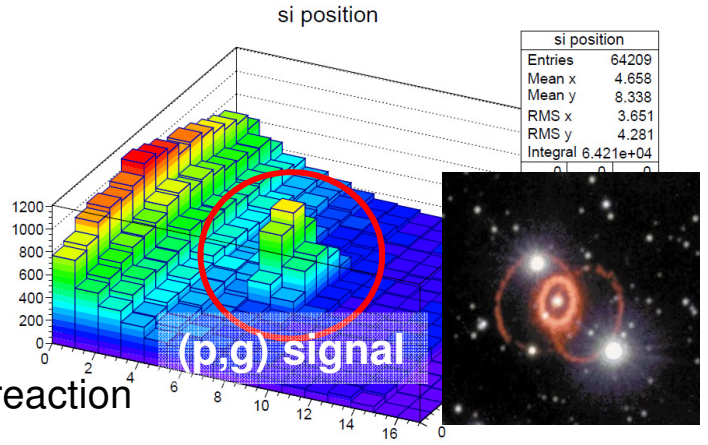
DiRICH Combiner
- 12 DiRICH → single fiber

Research at GSI continues ...

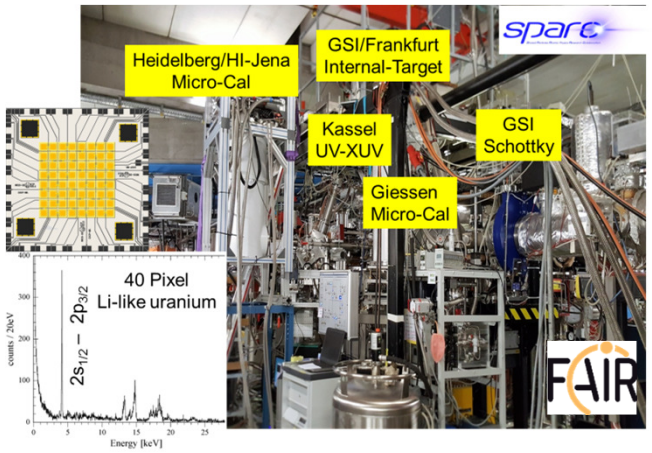
- Beam Time 2016
  - 3 months during the first half year
  - Global machine availability about 75% for parallel operation
  - Very efficient parallel operation at SIS/ESR:
    on average beam delivery to three experiments in pulse-to-pulse operation
  - Instrumental highlight: start of commissioning of the Cryring
  - Physics highlight: pioneering measurements of proton-capture reactions at the internal target of ESR
    → demonstrating the feasibility of precision studies of astrophysical reactions at storage rings.

Highlights from 2016 Beam Time at GSI

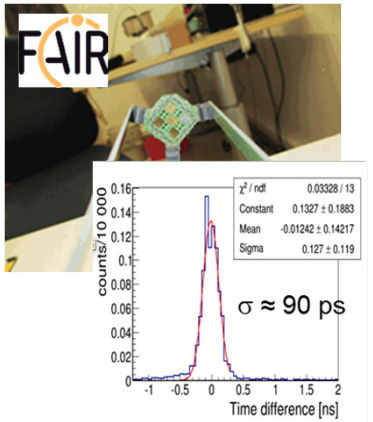
- Successful start of commissioning of the Cryring@ESR (first turn achieved)



- Successful proof-of-concept of nuclear astrophysics studies in storage rings using the 124Xe (p,γ) nucleosynthesis reaction



- Successful test of novel APPA / SPARC instrumentation



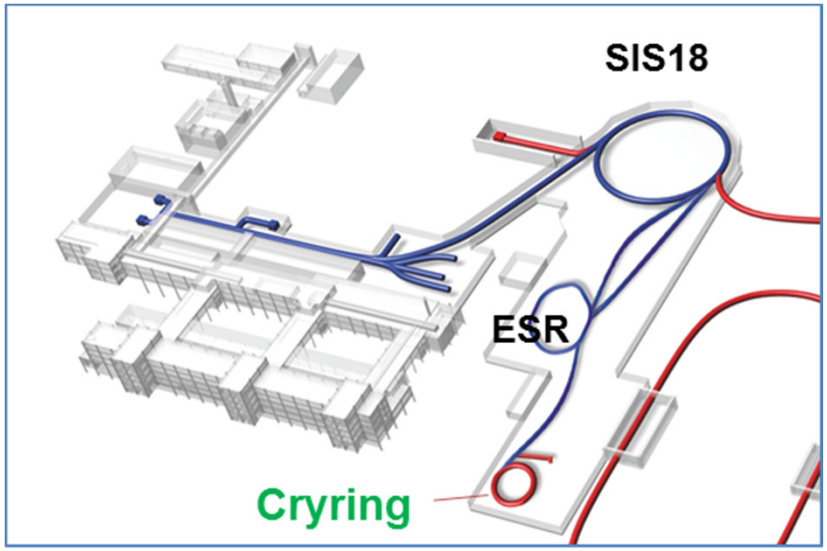
- Tests of CVD diamond detector
  - In vacuum operation without cooling
  - Rate capability up to 10^7 MIPs/s/mm2
  - Timing resolution (sigma) 90ps
  - Radiation hard material CVD diamond

Intermediate Research Program FAIR Phase 0

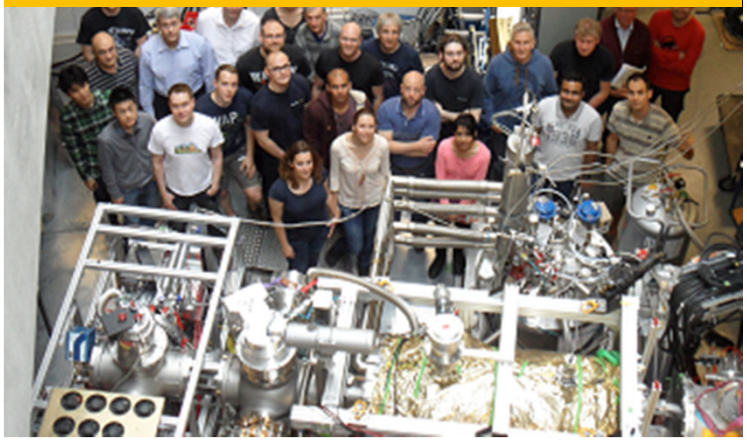
- Goals
  - Forefront research by employing and testing new FAIR detectors
  - Exploiting upgraded GSI accelerator facilities
    - ongoing upgrade of SIS18 completed by mid 2018
  - Education of young scientists
  - Maintain and extend skills and expertise
  - Serve national and international user community
- Plan
  - Establish an international Program Advisory Committee
  - 1st call for proposals for beam time slot 2018/19 in spring 2017

FAIR Phase 0 Program

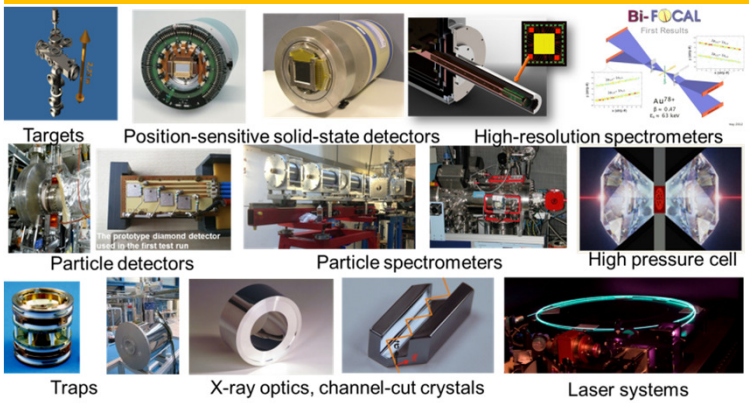
- Benefit from UNILAC and SIS18 upgrade
- Make use of Cryring, R3B magnet and other novel FAIR instrumentation



LEB Stopping Cell



SPARC instrumentation



FAIR Phase 0 – scientific opportunities for the four research pillars of FAIR

APPA	Facility	Research Activity
SPARC	ESR-HITRAP-	Strong field QED, atomic collisions, fundamental
SPARC	CRYRING	symmetries, border to nuclear physics
BIOMAT	M Branch, Z0/ A	Biophysics, heavy ion therapy, Material Science
WDM/HEDgeHOB	HHT/PRIOR	Equation-of-state studies; phase transitions in matter
WDM/HEDgeHOB	PHELIX	Laser plasma interaction and acceleration
CBM		
CBM/HADES	HADES@SIS18	Di-lepton production in pion-induced and HI reactions
miniCBM	miniCBM@SIS18	Test of subsystem plus data acquisition of CBM
CBM	External	Beam energy scan at STAR/RHIC (tests/ physics at NICA)
NUSTAR		
NUSTAR	FRS	Separator-/spectrometer expt.'s with exotic nuclei
NUSTAR	FRS-ESR	Nuclear physics with exotic beams in storage rings
NUSTAR	HISPEC/DESPEC	In-beam and stopped-beam spectroscopy experiments
NUSTAR	R3B@SIS18	Reactions with relativistic radioactive beams
NUSTAR	SHIP, TASCA	Physics and chemistry of SHE
PANDA		
PANDA	HADES	Hyperon Dalitz decays with HADES (use of PANDA F-TRK)
PANDA	External	Search for exotic states, charmonium and time-like form factors at BESIII/Beijing/IHEP. Magnetic moment of $\Delta(1232)$, e-m universality, multi pi0 prod. at MAMI

Summary and Outlook

FAIR is in good shape for full completion by 2025.

Installation incl. commissioning of the experiments is planned during 2021-2024

GSI/FAIR Research Strategy towards 2025:

- **R&D for and construction of the FAIR experiments**
- **FAIR phase 0 – intermediate research program** bridging the construction phase from 2018 until commissioning of the FAIR accelerators and experiments.

FAIR 2025