

A large, detailed wireframe model of a particle accelerator, likely the FAIR facility, is shown in a perspective view. The model consists of a complex network of circular and linear structures, representing the various components of the accelerator. The central part of the model is a large, oval-shaped ring, which is the main acceleration region. The text "GSI-FAIR" and "The Universe in the Laboratory" is overlaid on this central ring.

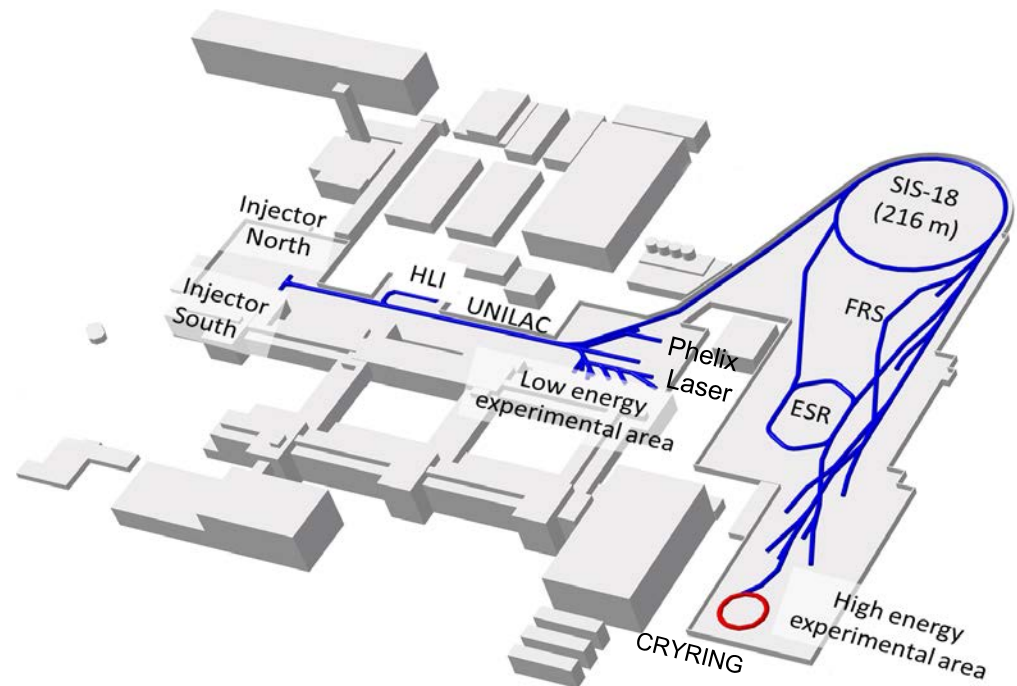
GSI-FAIR

The Universe in the Laboratory

CBM Collaboration Meeting, October 2018

**Paolo Giubellino,
FAIR and GSI**

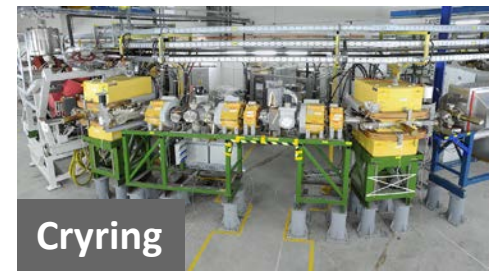
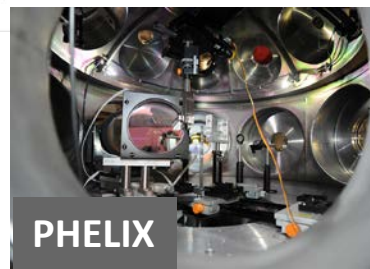
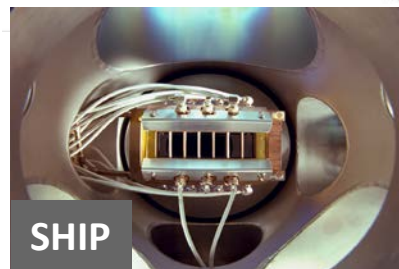
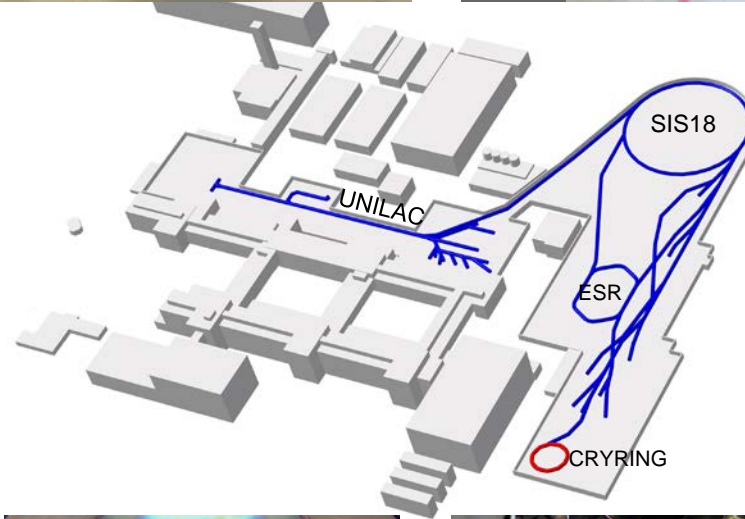
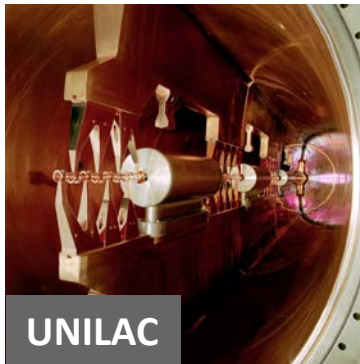
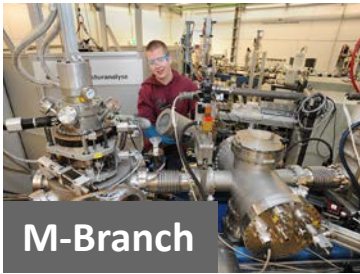
GSI – Almost 50 Years of Scientific and Technical Competence



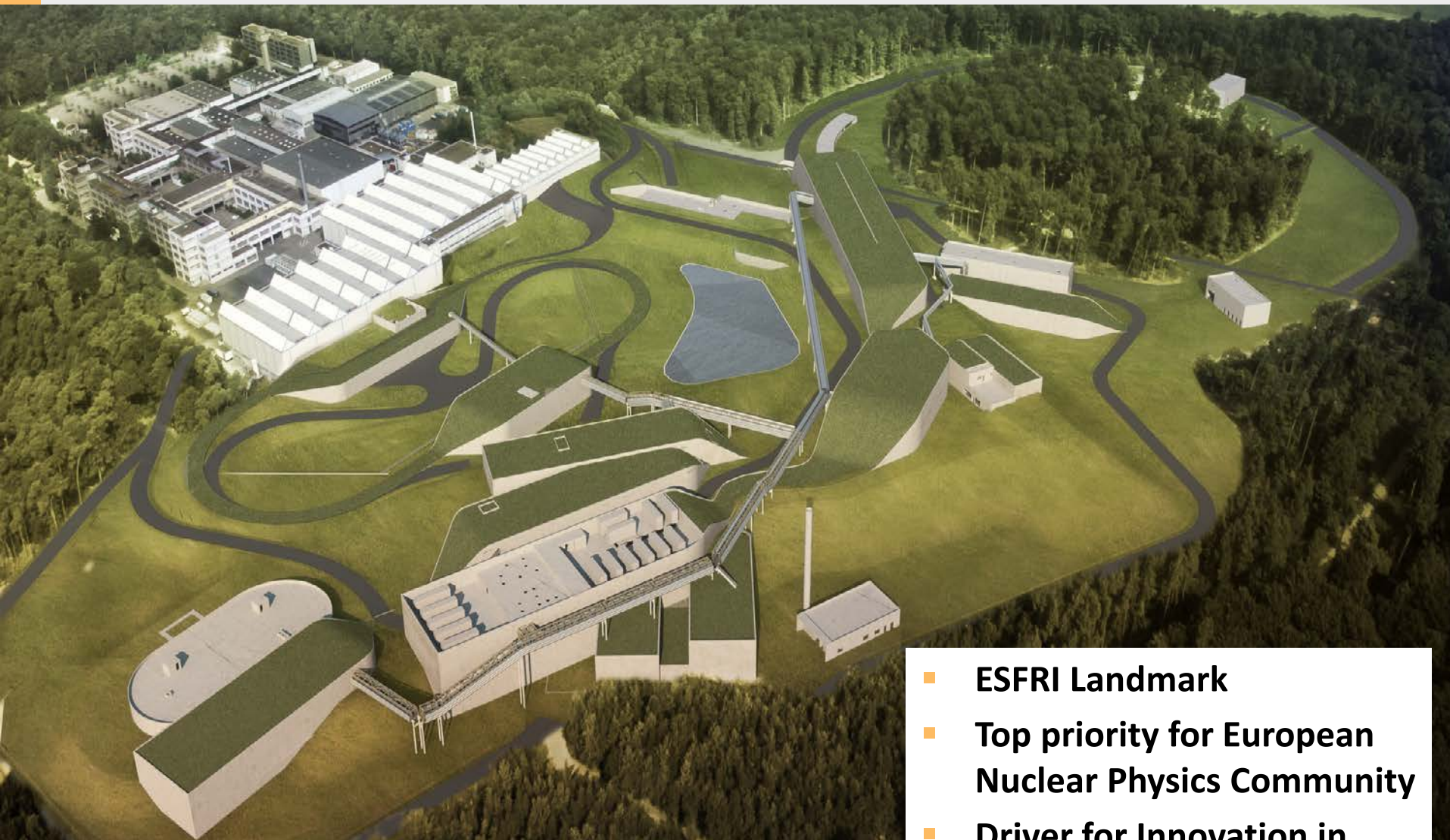
- Existing accelerator facility has been upgraded to serve as injector for FAIR and – in the meantime – for FAIR phase 0

Research Infrastructures available at GSI

- open to external users, in particular from univ.

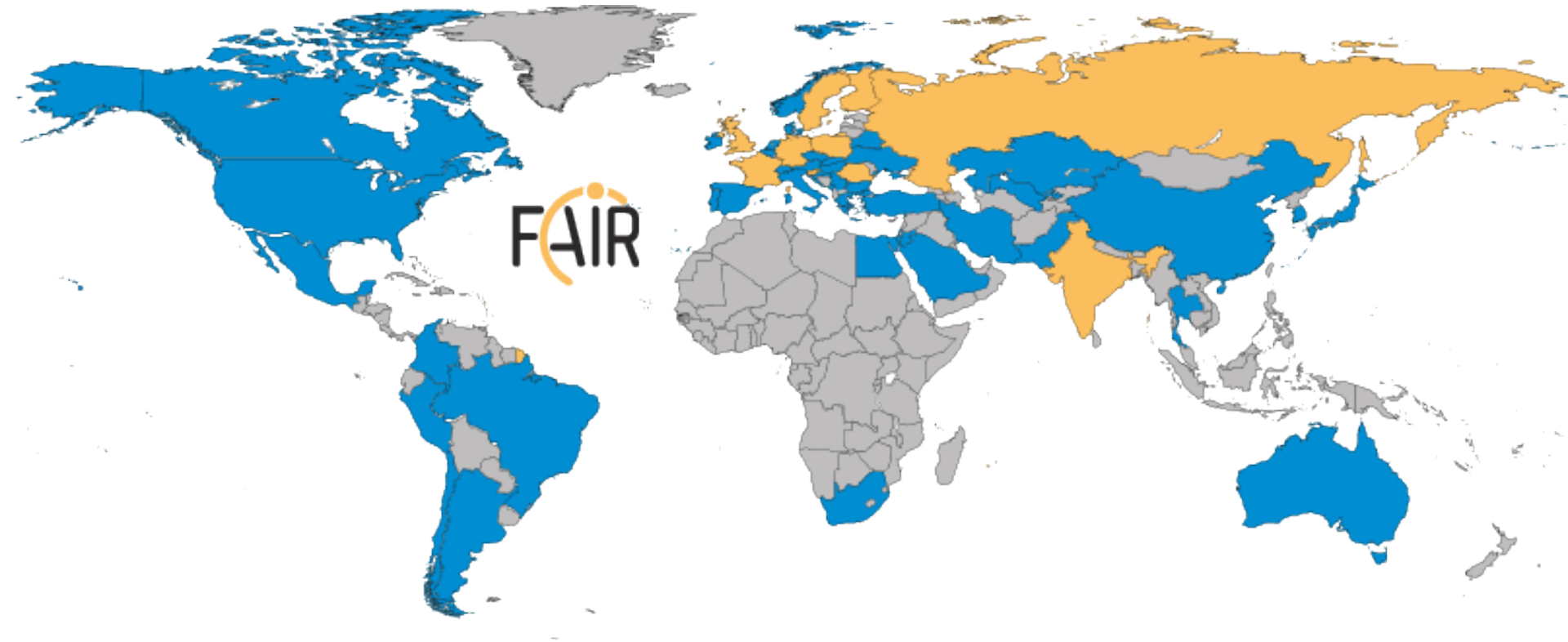


FAIR: Facility for Antiproton and Ion Research – A World-Wide Unique Accelerator Facility

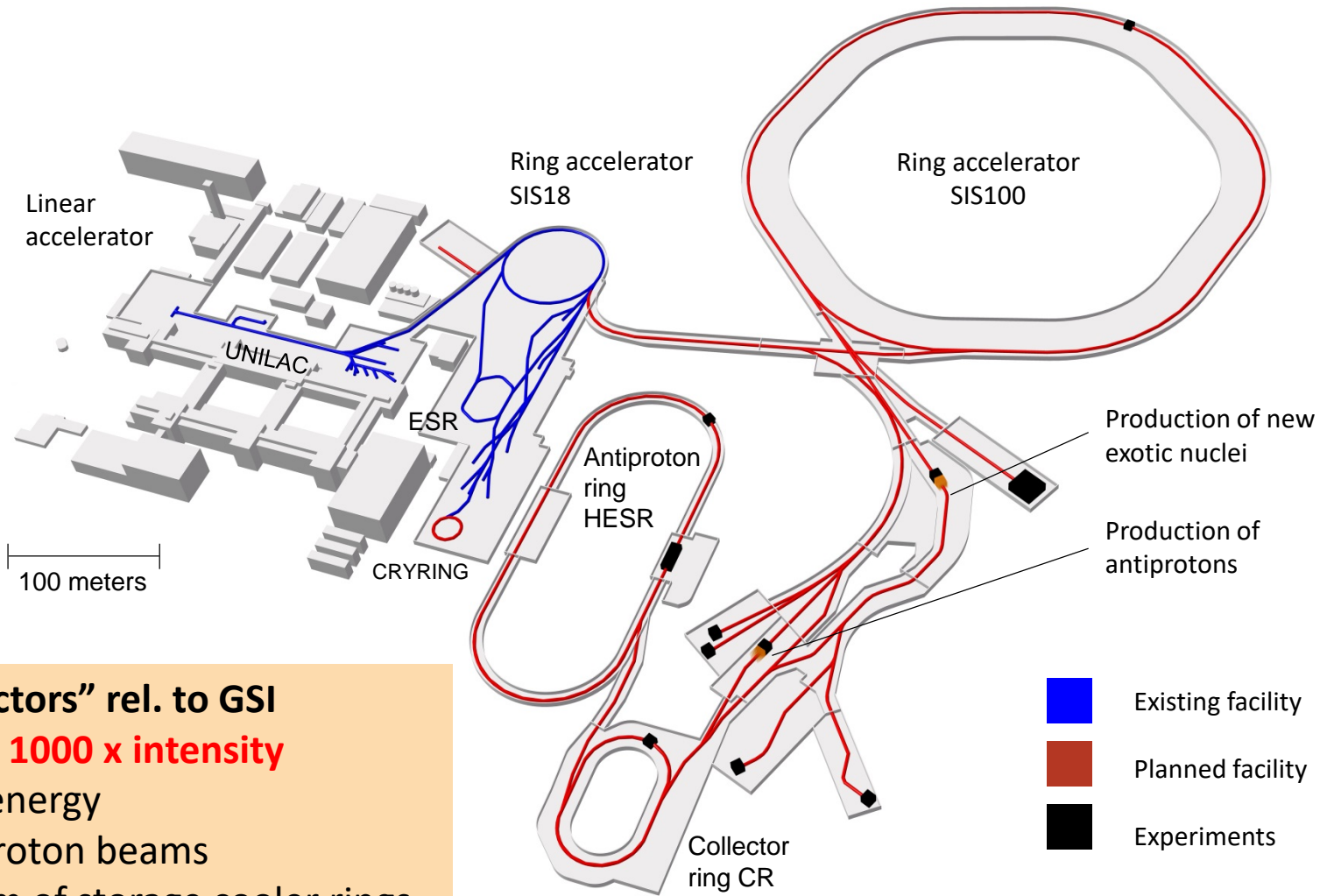


- **ESFRI Landmark**
- **Top priority for European Nuclear Physics Community**
- **Driver for Innovation in Science and Technology**





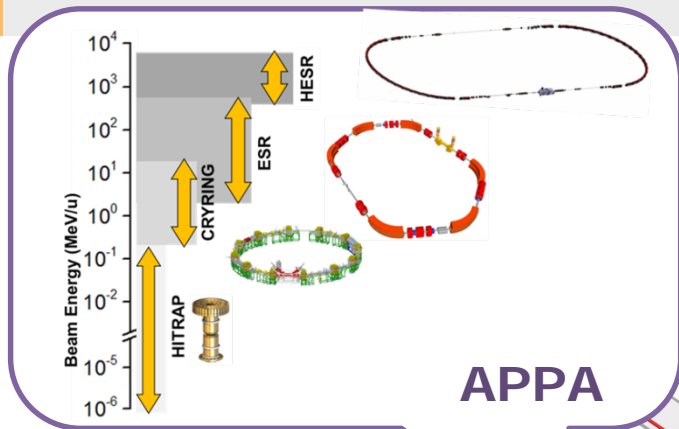
- Realization and operation of FAIR in **international cooperation**
- **Nine international FAIR shareholders**
- Participation of **3.000 scientists from all continents**



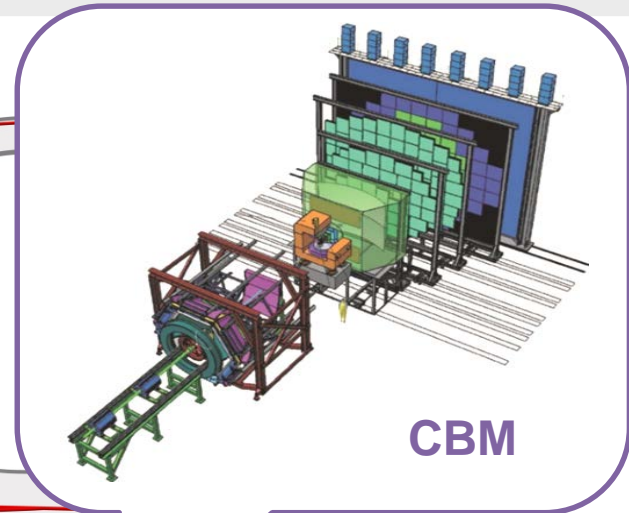
“Gain factors” rel. to GSI

- **100 – 1000 x intensity**
- 10 x energy
- antiproton beams
- system of storage cooler rings

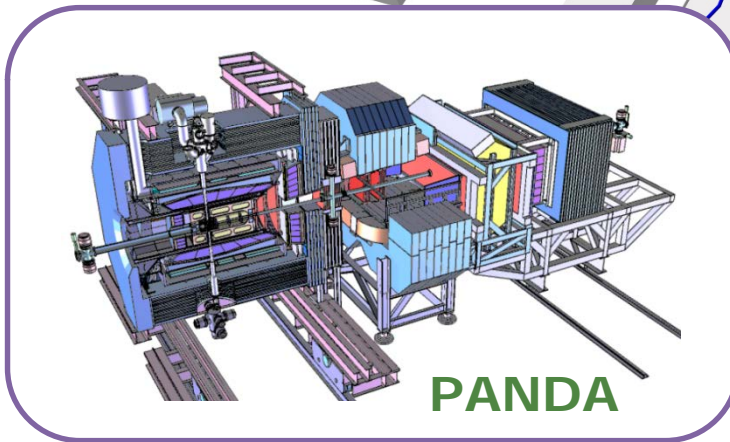
FAIR – four research pillars



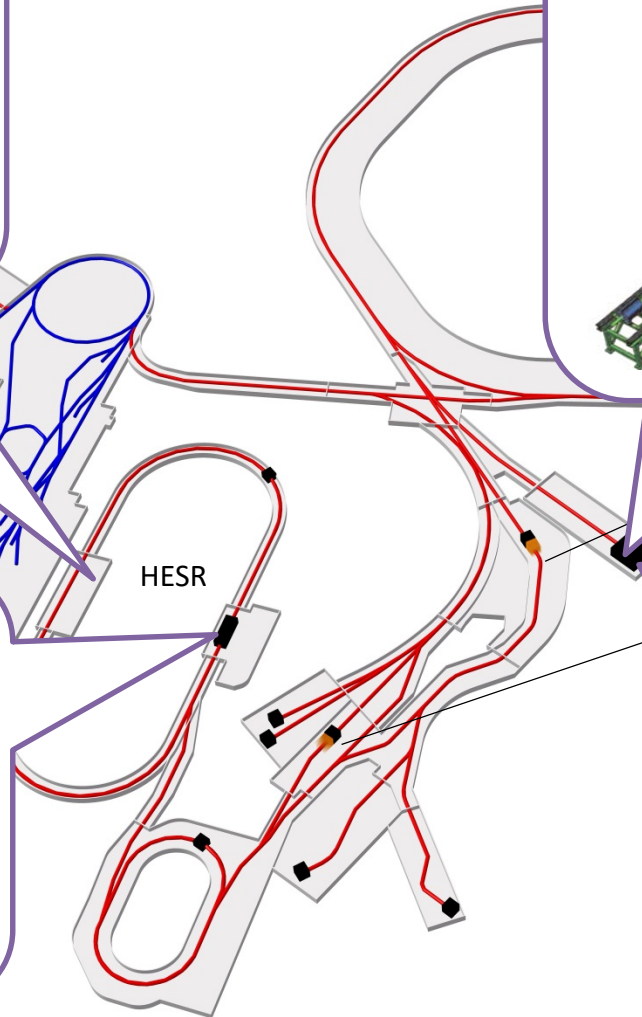
APPA



CBM

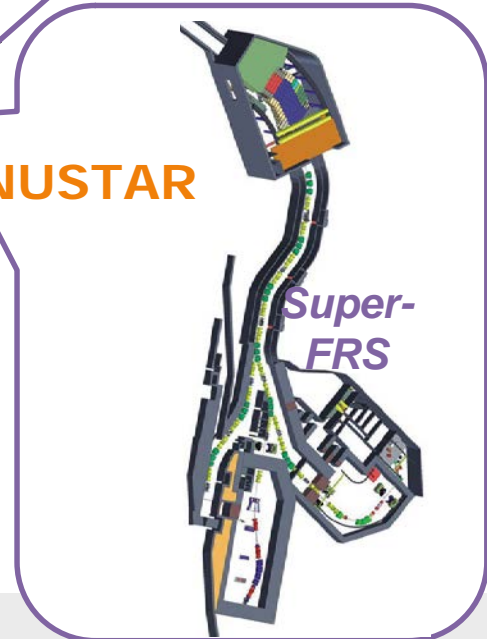


PANDA



HESR

NUSTAR



Super-FRS

FAIR Research Pillars:

- a fore-front scientific program in many areas



APPA

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

CBM

- Dense and Hot Nuclear Matter

NUSTAR

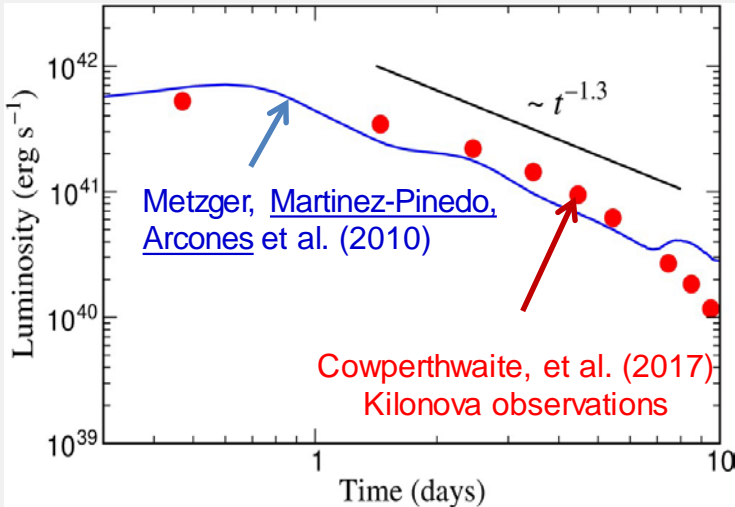
- Nuclear Structure and Reaction Studies with nuclei far off stability,
- Physics of Explosive Nucleosynthesis (r-process)

PANDA

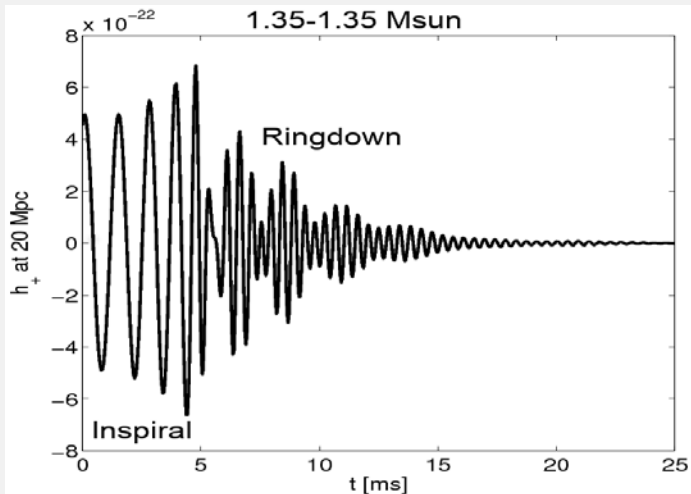
- Hadron Structure & Dynamics with cooled antiproton beams

Further push of FAIR science motivation

... by multimessenger study of a neutron-star merger
last summer combined with theory & simulations



Electromagnetic “Kilonova” Signal



Gravitational Wave Signal

Theoretical prediction by GSI researchers (2010):

Neutron star mergers are the astrophysical site of the r-process producing the very heavy elements like Pt, Au and beyond, *thereby exhibiting a characteristic electromagnetic “Kilonova” signal.*

Confirmation by Ligo, Virgo and other astronomer groups (2017)

via detection of both *gravitational and electromagnetic waves emerging from such an event.*

FAIR was designed to study the properties of neutron star matter and to trace back the production paths of the heavy elements!

Neutron Star Mergers



FAIR Research Pillars

- Equation of State (**Hades, CBM**)
 - Gravitational wave signal
 - Amount of ejecta
- Baryon-Baryon interaction (**PANDA**)
- Exotic neutron-rich nuclei (**NUSTAR**)
 - r-process nucleosynthesis and abundancies of the heaviest elements gold, platinum and beyond
- Plasma and atomic opacities (**APPA**)
 - Kilonova electromagnetic transient

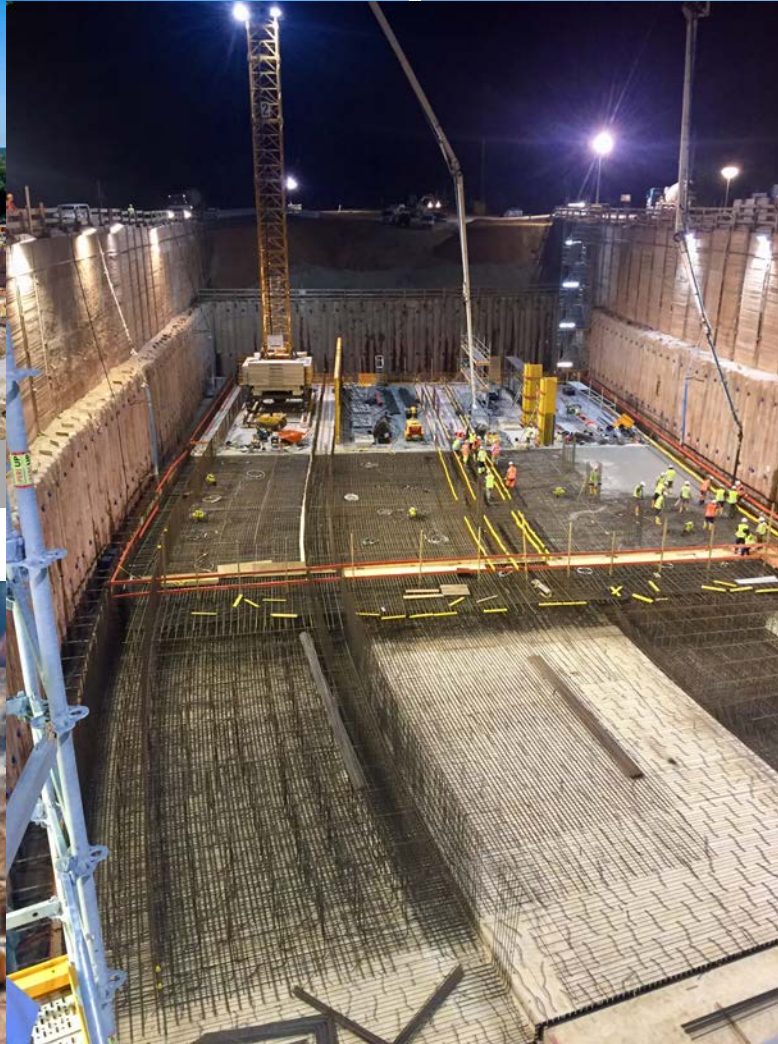
The FAIR experiments offer unique opportunities for studying and solving these fundamental questions!

Status of FAIR: Civil Construction

rapid progress since official start on 4th of July 2017



Excavation SIS100 tunnel



Completed ready for FAIR and FAIR phase 0



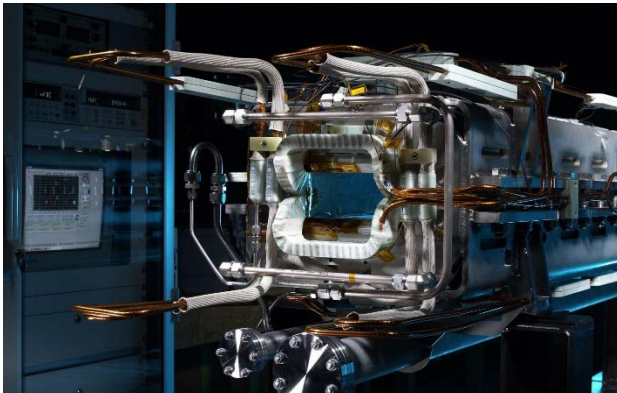
Excavation transfer building & CBM cave



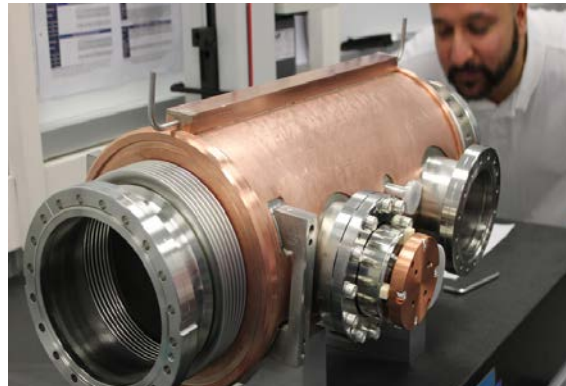
Start of concrete shell works for SIS100

Status of FAIR: accelerators: construction / procurement progresses well

- Serial production for major components for SIS 100 is progressing with one quarter of the dipole magnets already manufactured.



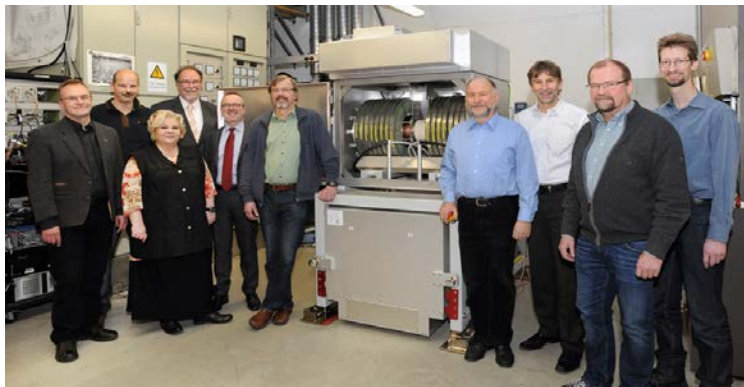
SIS100 Dipole Magnets



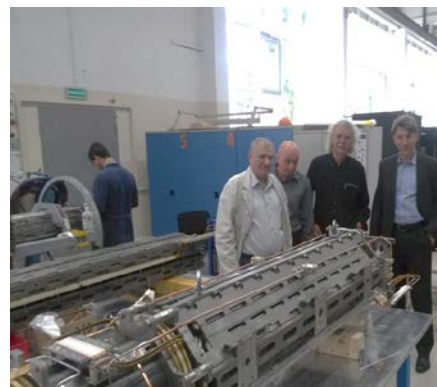
Cryo Catcher



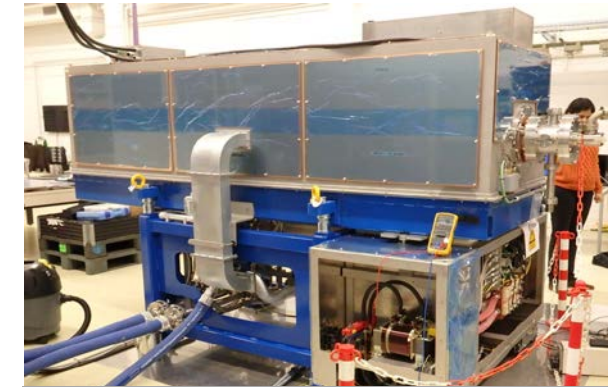
Cryo-Bypass Line



Bunch Compressor



Quadrupole Unit



RF Cavity System

First of Series of SIS100 Quadrupole Magnets successfully cold-tested at JINR...

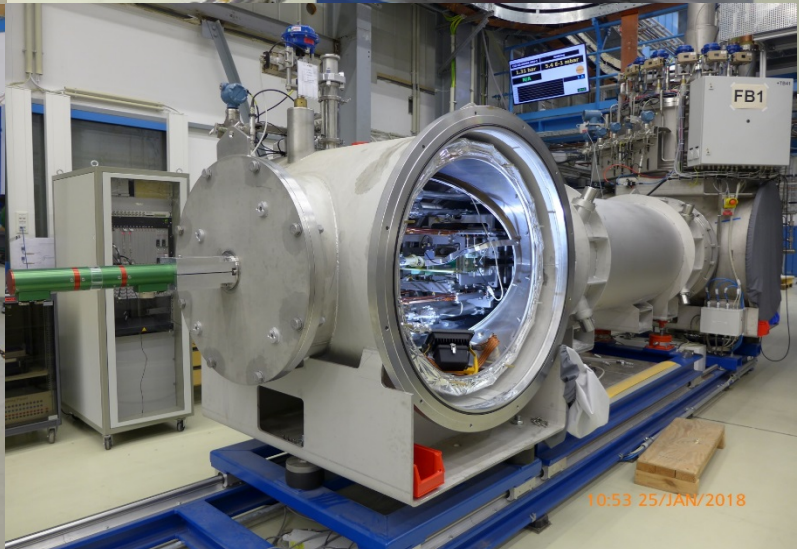


SIS100 quadrupole unit mounted in the test cryostat (blue) at JINR, Dubna

Cold-Test Facility at JINR, Dubna



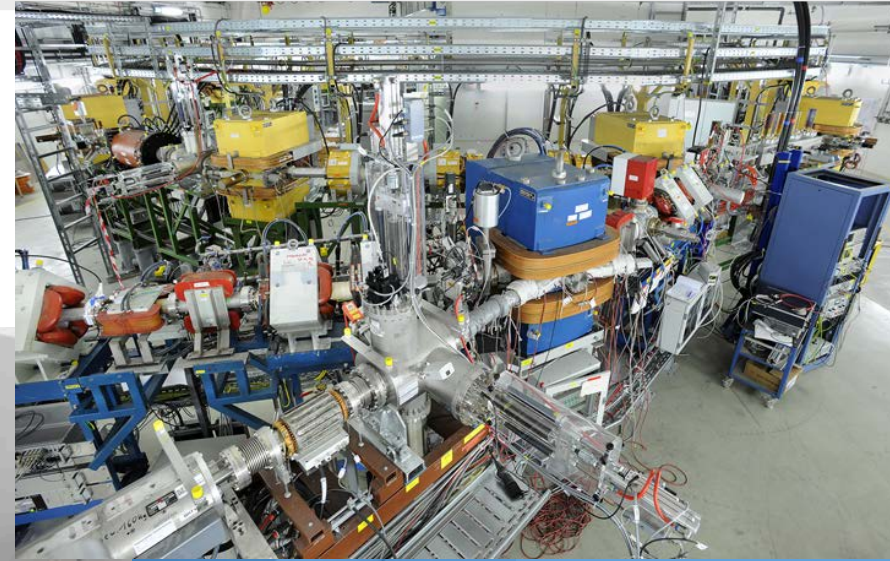
24 SIS100 (of 120) dipole magnets have been delivered and are being cold-tested ...



New CRYRING@GSI/FAIR



- ready for experiments and tests



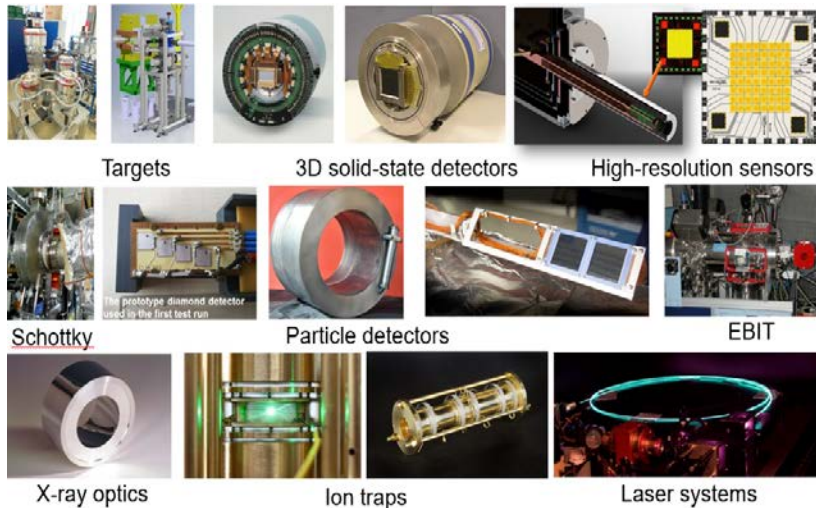
View from local injector to the ring



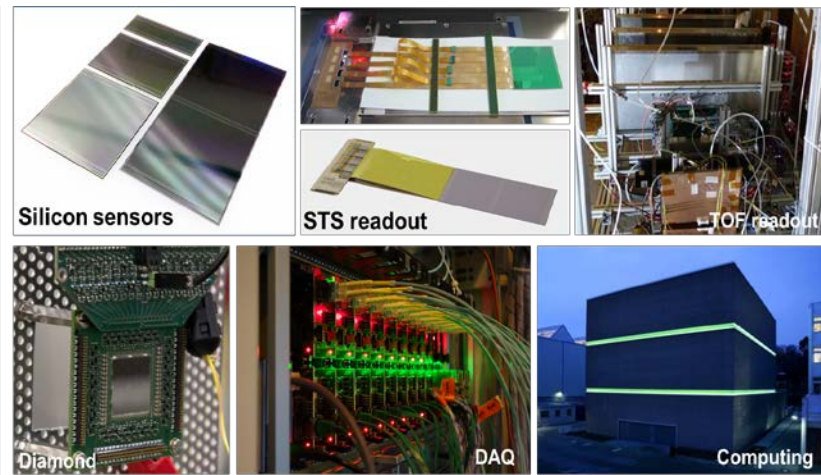
Status of FAIR: experiments detector R&D and construction well on track ...



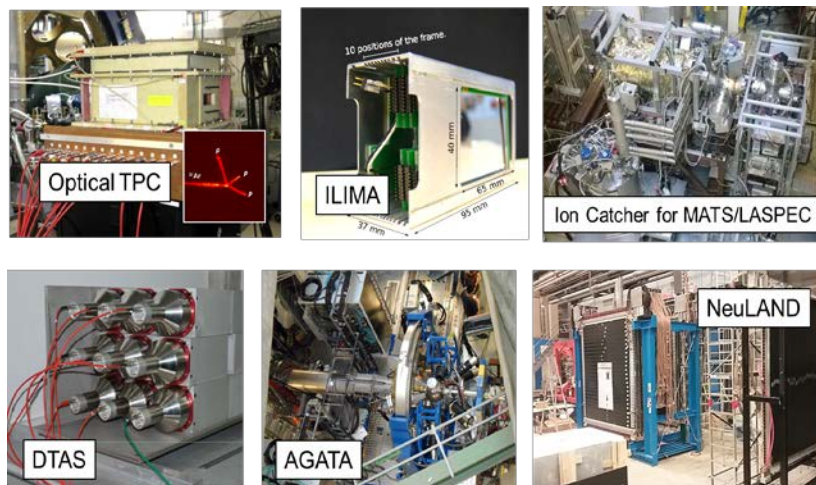
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- Working towards the completion of FAIR by 2025
- ➔ Major thrust is on construction of FAIR accelerators and experiments
- ➔ But at the same time we pursue a staged approach to FAIR science and to the progressive commissioning of accelerators and detectors:
 - ***FAIR phase 0 : start in 2018/2019***
 - FAIR day 1/ phase 1 with FAIR accelerators progressively approaching design parameters
 - Full FAIR operation

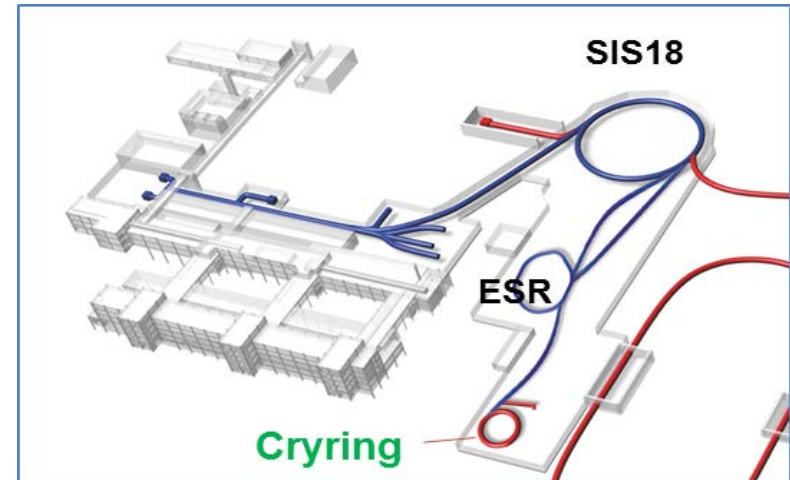
FAIR Phase-0

intermediate research program



Objectives:

- Commissioning of accelerators and detectors
- Forefront research by employing and testing new FAIR detectors
- Exploiting upgraded GSI accelerator facilities incl. the **newly installed CRYRING**
- Education of young scientists
- Maintain and extend skills and expertise
- Serve national and international user community



- requires careful techn. preparation:
 - **full re-commissioning of the UNILAC/SIS18/ESR complex incl. new controls**
 - gradual implementation

- Scientific programme and beam parameters defined, taking into account scientific and technical priorities of the FAIR Collaborations
- 110 days of beam time in 2018 planned, similar amount of beam time envisaged for 2019
- ‘Call for Proposals’ opened 2017
- **Nearly 150 submitted experiment proposals by well over 1000 scientists “overbook” available beam time by a factor of 2-3**
- High-profile international Program Advisory Committees, Overall PAC chaired by Prof. Sydney Galès evaluated proposals (G-PAC meeting held on 19.-21. Sept. 2017)

Evaluation of proposals for first FAIR Phase-0 Campaign 2018/19




Results G-PAC (overall): beamtime recommendations in 8 h-shifts

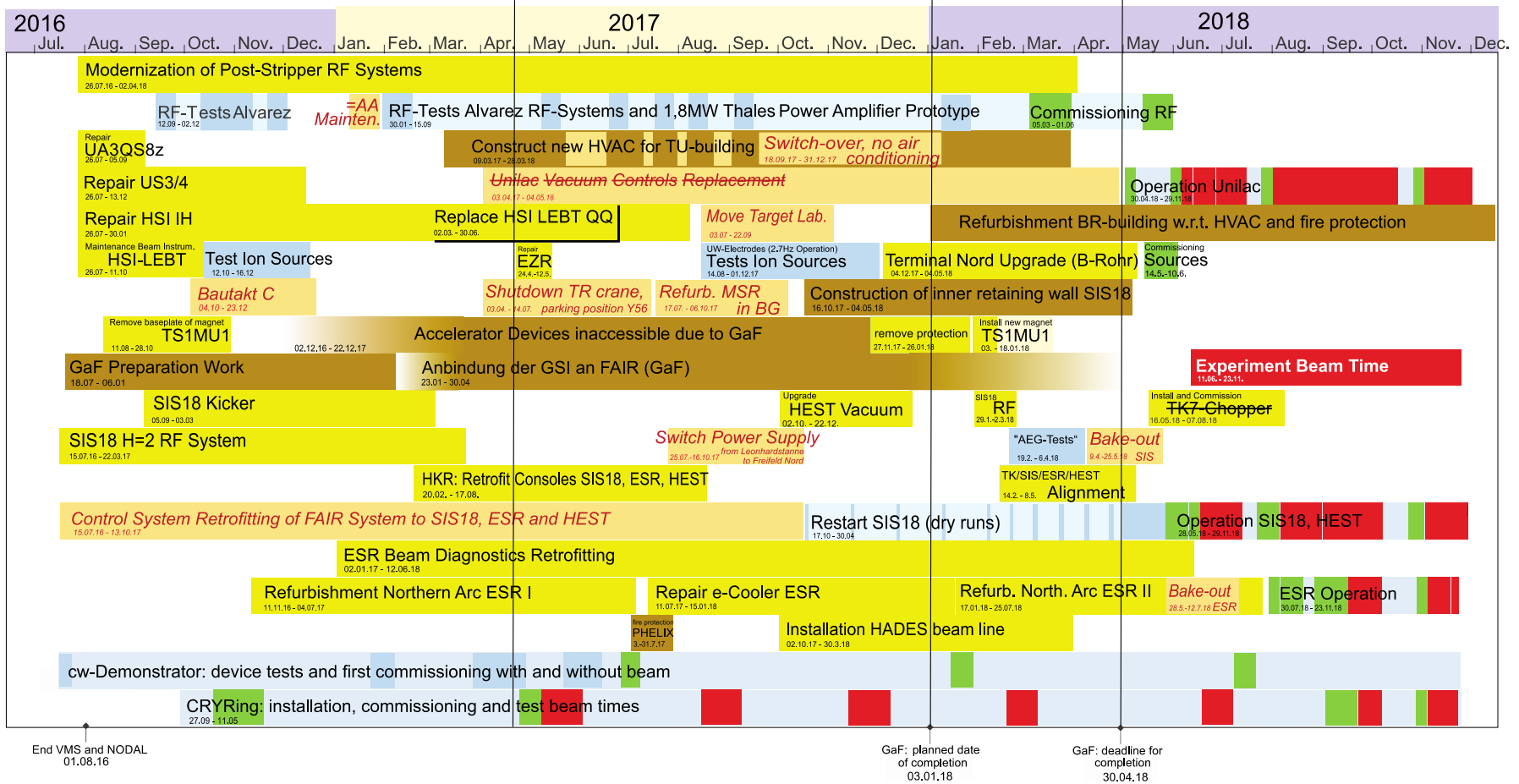
Session	Shifts requested			Shifts recommended (A)			Shifts extended (A and A-)		
	Sum main	Sum para.	Total	Sum main	Sum para.	Total	Sum main	Sum para.	Total
ESR / CRYRING	555	0	555	188	0	188	278	0	278
SIS18: HADES / CBM	183	81	191	94	81	102	134	81	142
SIS18: NUSTAR - R3B	264	20	266	85	34	88	120	34	123
SIS18: NUSTAR - S-FRS	185	69	192	62	38	66	102	59	108
SIS18: NUSTAR - DESPEC	221	40	225	58	22	60	58	40	62
UNILAC / SHE	570	261	596	294	174	311	327	174	344
Σ	1978	471	2025	781	349	816	1019	388	1058


**Total
requested**


**Total
recommended**


**Total
recomm. plus
“flexible reserve”**

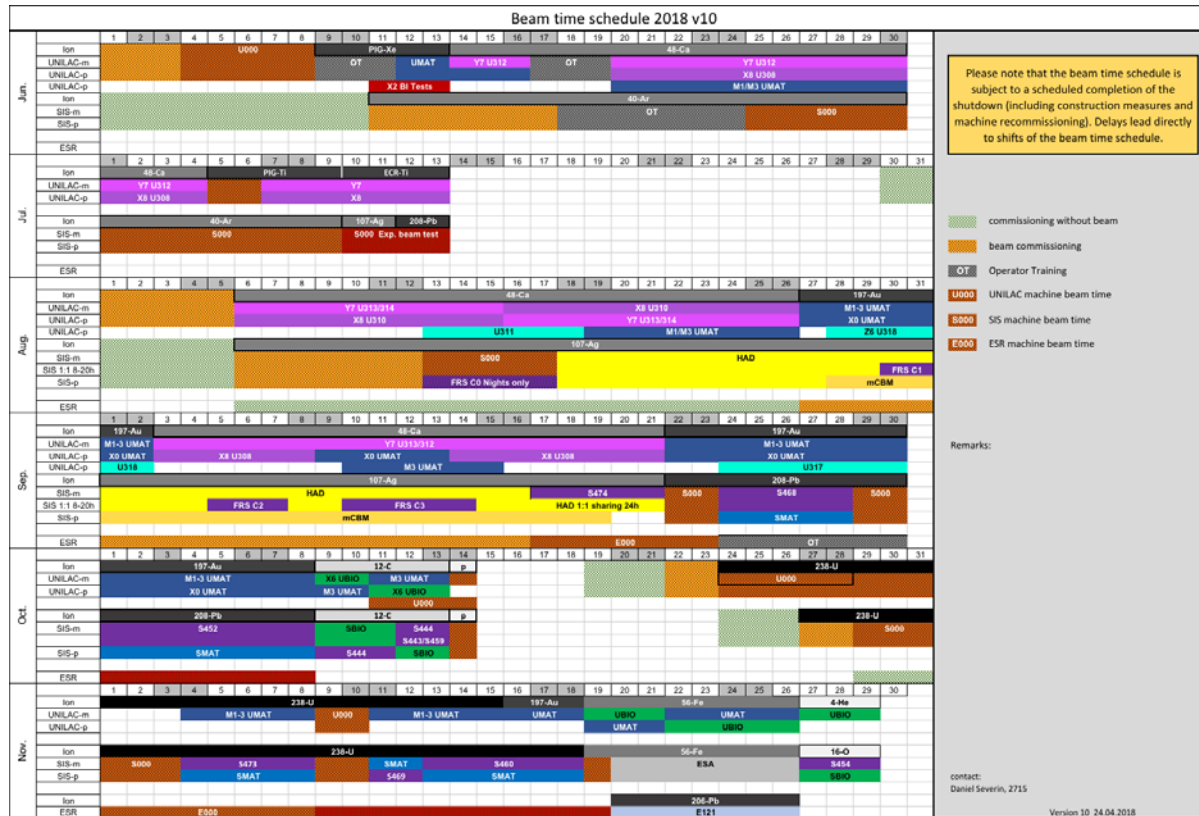
Shutdown 2016-2018



- brown: Civil Construction (GaF, Fire Protection, etc.)
- italic, red type: Process interferes with other work*
- yellow: Accelerator maintenance and repair
- blue: Device tests
- green: Commissioning
- red: Beam Time

21.04.2017 Petra Schütt, Shutdown Koordination, eMail: shutdown@gsi.de

Beam time schedule foreseen for 2018



Accident: ER1 fire and RF ventilation contamination

- Fire in the ER1 transformer
- Power-off in the entire rf gallery

- Separation of the ER1 system
 - No single gap resonators

- Cleaning of all amplifiers AND all transformers
 - No rf operation until mid. Oct.

→ No more physics beam time 2018



Example: A3 transformer (weight about 3.6 t)

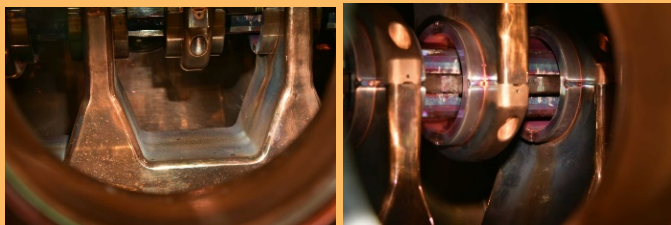


A3 transformer air box detail – contamination with metal pieces
images: B. Schlitt

RFQ

Limited amplitude causes limitation of m/q

⇒ **Very heavy ions: No high intensity yet**



images: P. Gerhard

New control system

FAIR control system not completed

⇒ **Complex operating**

⇒ **ESR not in operation**

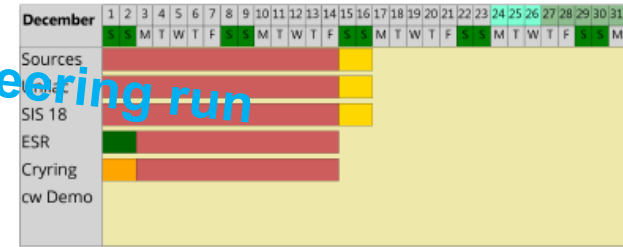
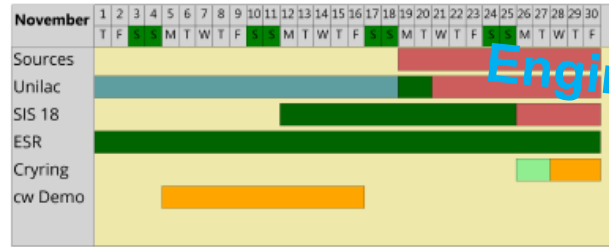
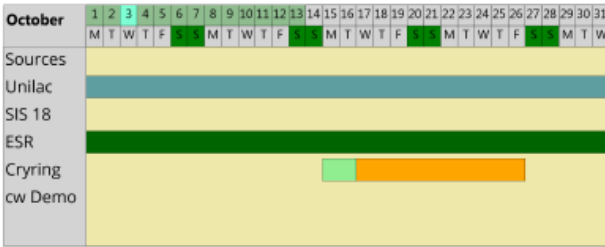
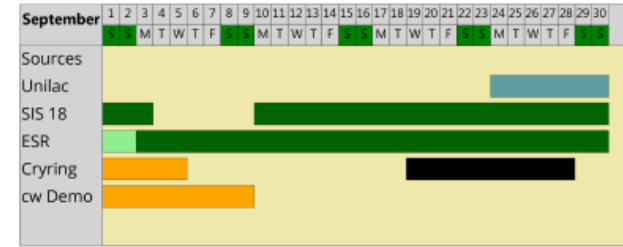
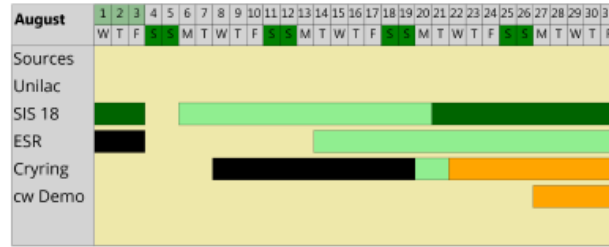
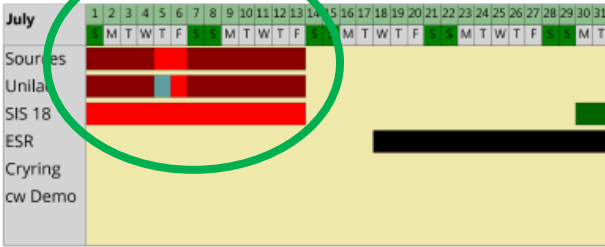
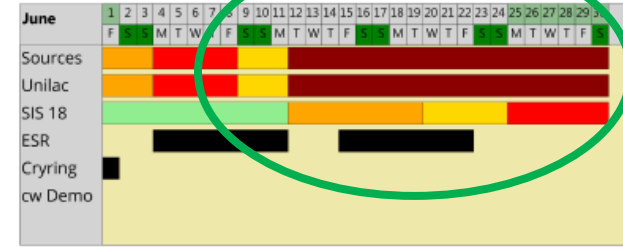
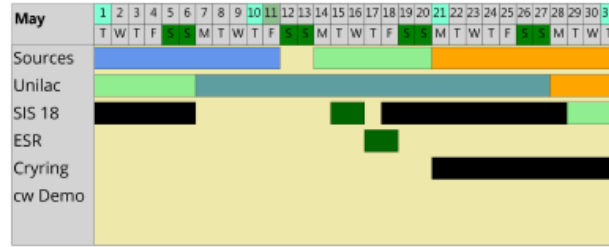
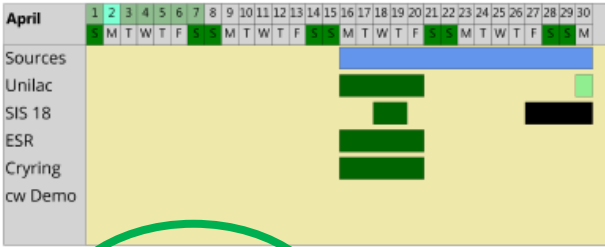
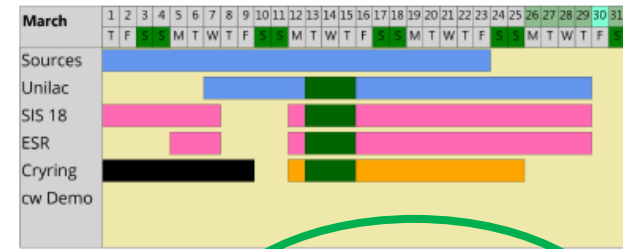
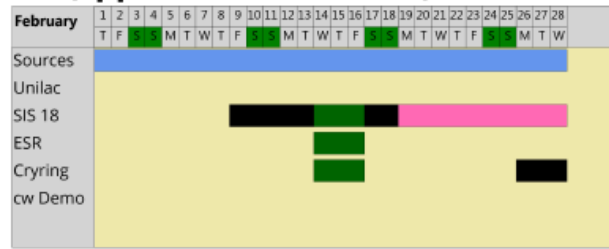
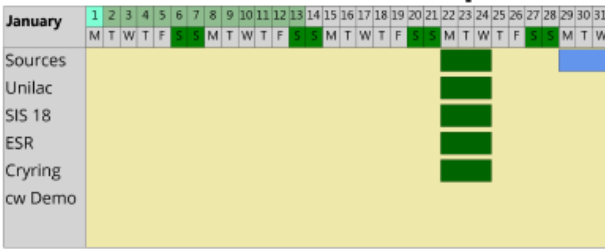
⇒ **Still a lot commissioning needed**

⇒ **Limited parallel operation**

- Following the interruption of the physics run due to the accident and the resulting extended downtime, new plans had to be developed. After a careful analysis of the damage and the situation, the machine operation strategy is to shift the two data taking periods foreseen for fall 2018 and fall 2019 by a few months. They now will be performed in early 2019 and early 2020 respectively, and commissioning time has been added for the accelerators in order to address some of the technical issues in an optimised way.

- **Engineering run: Nov. 2018 – Dec. 2018**
 - Goal: to establish basic operation conditions that are required for the Physics program in 2019
 - boundary conditions:
 - limited capabilities of new FAIR controls
 - Not yet comprehensive tools including up to date lattice layouts for beamline tuning
 - no storage mode capabilities available for comprehensive ESR commissioning
- **Physics run: March 2019 – April 2019**
 - Goal: to provide reliable operation for the scheduled Physics programs
 - boundary conditions
 - limited choice of heavy ions due to HSI RFQ technical limitation
 - No single gap resonators at the end of post striper
 - No parallel operation in planning to ensure reliability
- **Engineering run: Nov. 2019 – Dec. 2019**
 - Goal: 1) to establish ESR storage mode 2) to establish deceleration in ESR 3) to complete the commissioning of CRYRING with ESR beam
 - newly introduced FAIR controls for ESR must allow storage mode
 - Expect to be available for commissioning no earlier than Sept. 2019

General Plan of Accelerator Operations 2018 (approved: 2018-09-12)



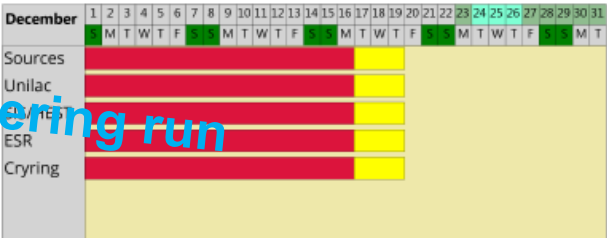
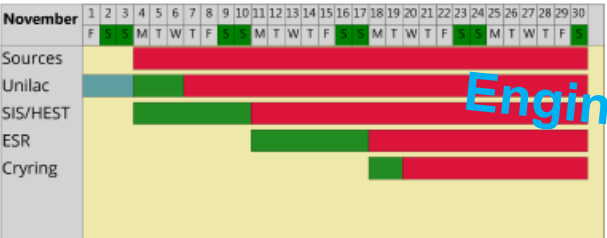
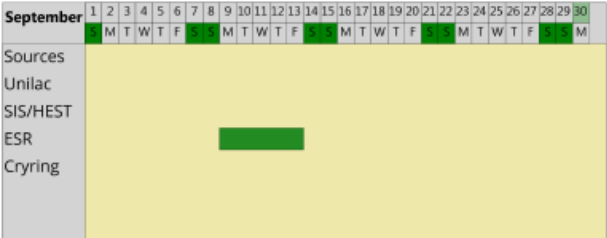
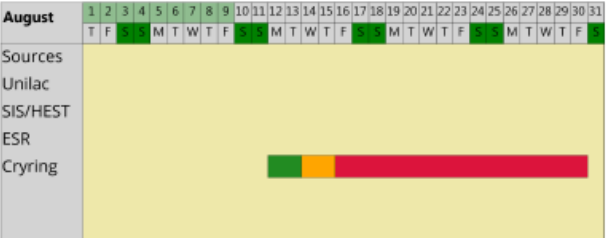
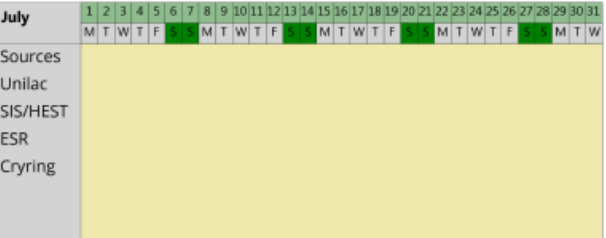
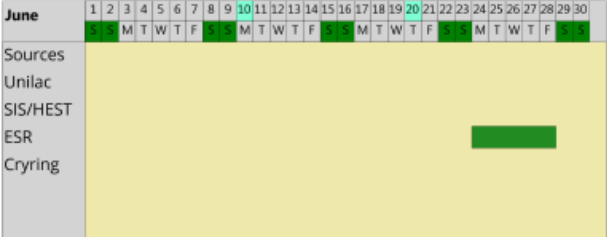
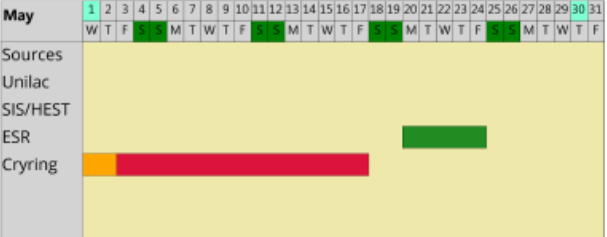
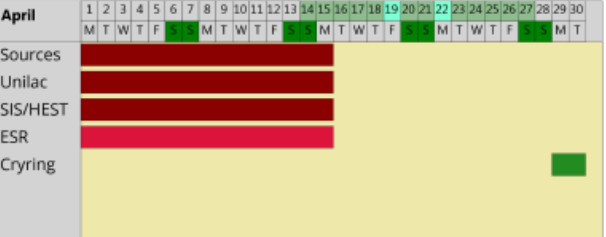
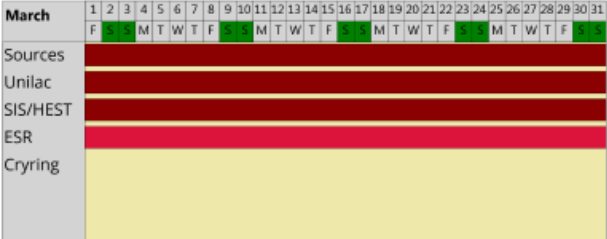
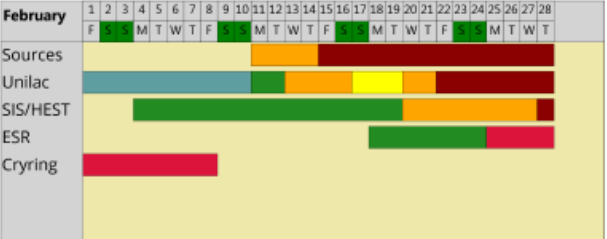
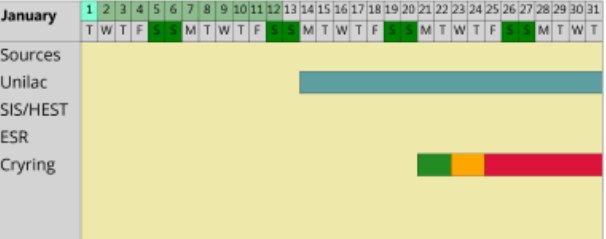
Information

Date of last update: 2018-09-13
Stephan Reimann, Head of Operations,

Main focus of the engineering run

- establish slow extraction beam to HADES
- start ESR commission controls
- FRS commissioning, mCBM detector setup

General Plan of Accelerator Operations 2019 (approved: 2018-09-20)



Legend

- RF Conditioning
- Dry-Run
- Beam Setup
- Physics Run
- Operator Training
- Engineering Run

Holidays

Weekends

Public Holidays

Information

Engineering run

Planned shutdown major activities

- UNILAC HSI RFQ new electrodes
 - in progress. Expect installation ~mid 2019
- UNILAC UHV upgrade: full scale: **8 month**
- TGA fire protection renovation



Thank You!