Operation of
GSI and FAIR

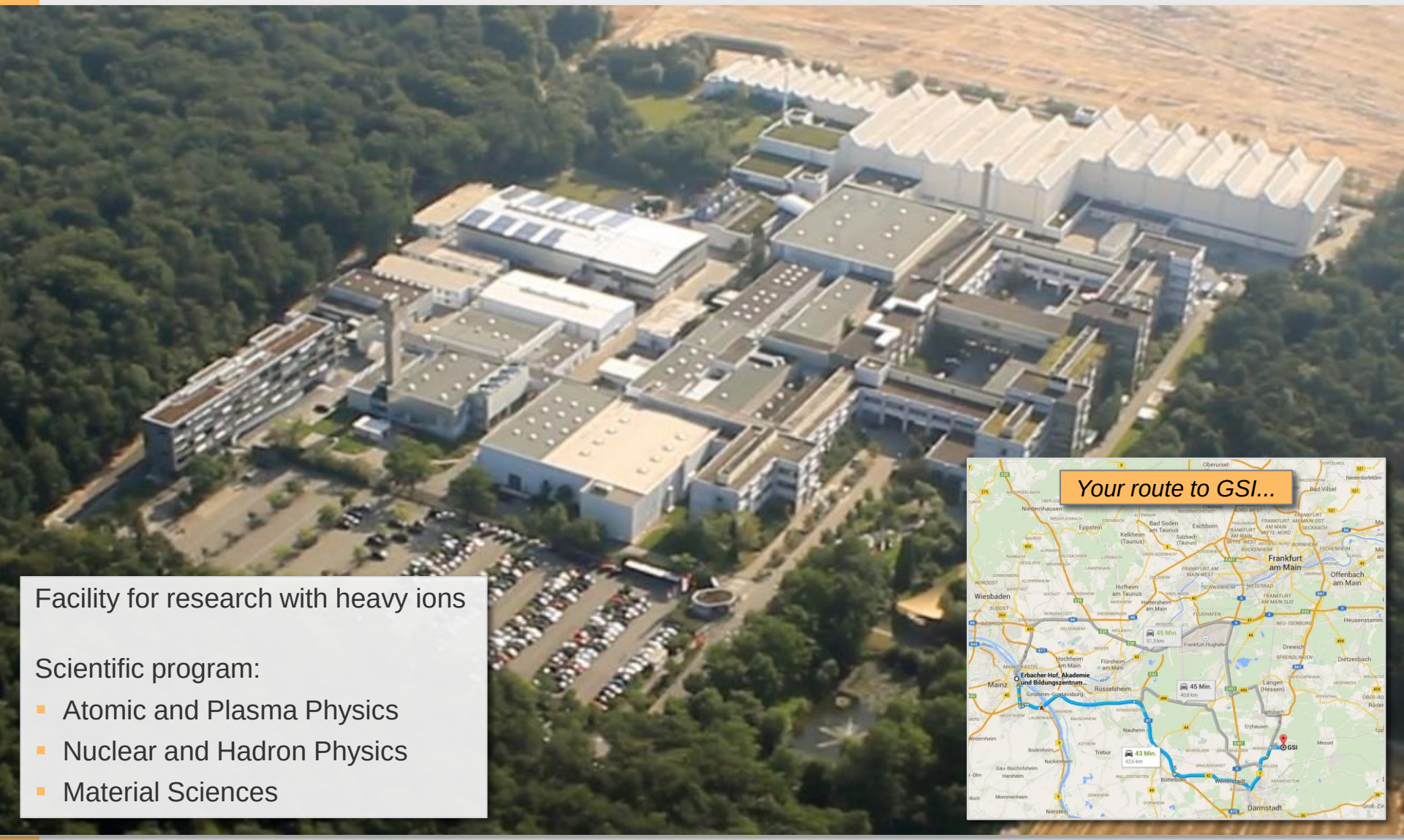
David Ondreka

WAO 2014, Mainz, 31.10.2014

Overview

- GSI
  - Facility
  - Operation
- FAIR
  - Project
  - Facility
  - Operation
- Outlook

GSI Helmholtzzentrum für Schwerionenforschung GmbH



Facility for research with heavy ions

Scientific program:

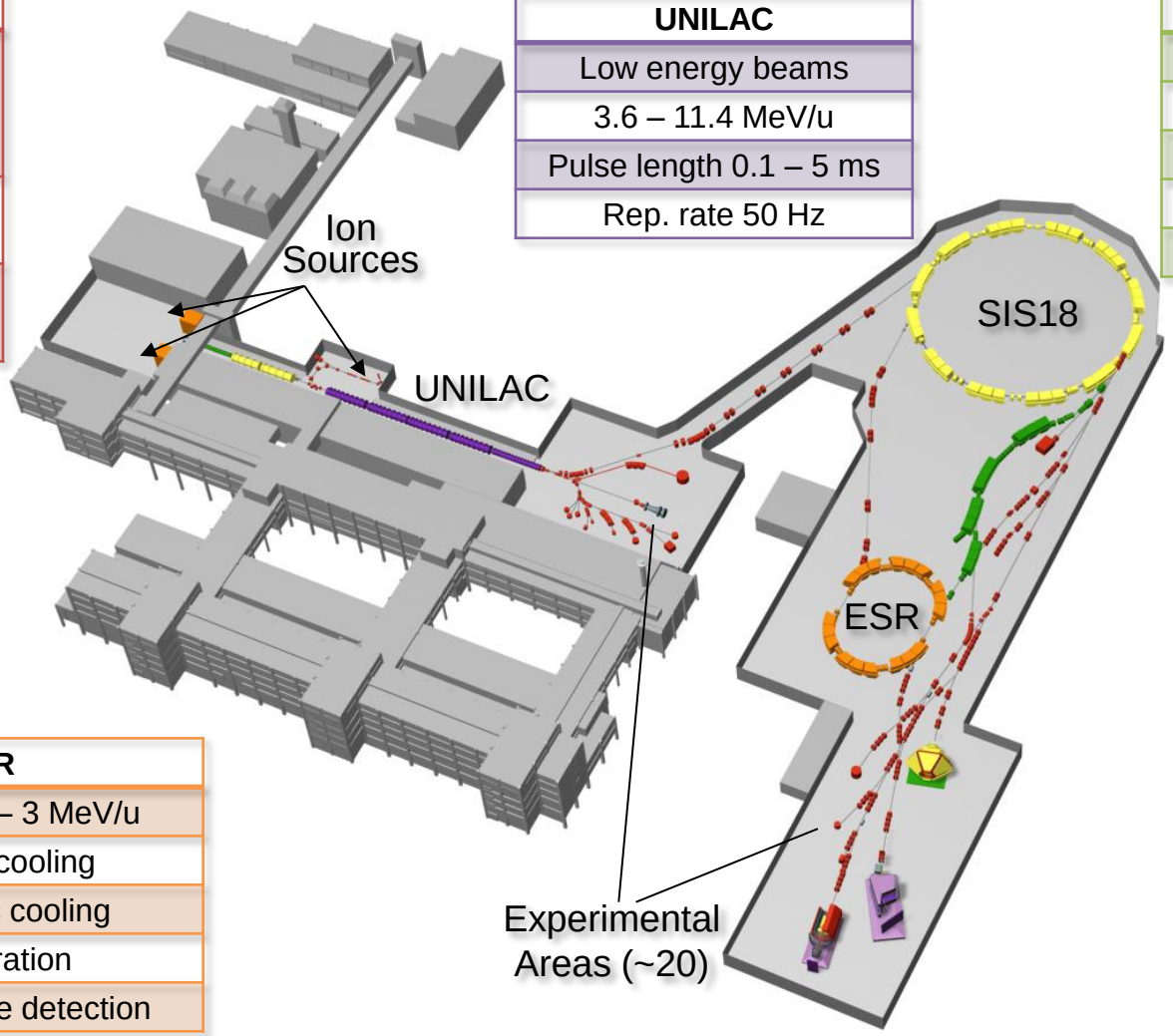
- Atomic and Plasma Physics
- Nuclear and Hadron Physics
- Material Sciences

GSI Accelerator Complex

Ion Sources	
ECRIS	Gases
MUCIS	
CHORDIS	
PIG	Gases Metals
MEVVA	Metals
VARIS	

UNILAC
Low energy beams
3.6 – 11.4 MeV/u
Pulse length 0.1 – 5 ms
Rep. rate 50 Hz

SIS18
High energy beams
Slow extraction (≤10s)
Fast extraction (1 turn)
Bunch compression
Rep. rate 0.1 – 1 Hz



Max. Energies	
p	4.5 GeV/u
Ne^{10+}	2.0 GeV/u
U^{73+}	1.0 GeV/u
U^{28+}	0.2 GeV/u

Max. Intensities	
p	10^{11}
Ne^{10+}	$5 \cdot 10^{10}$
U^{73+}	$3 \cdot 10^{9}$
U^{28+}	$3 \cdot 10^{10}$

ESR
Energy 800 – 3 MeV/u
Electron cooling
Stochastic cooling
Deceleration
Single particle detection

GSI Scientific Highlights

Super Heavy Elements

$_{107}$Bh $_{108}$Hs $_{109}$Mt

$_{110}$Ds $_{111}$Rg $_{112}$Cp

UNILAC

SHE

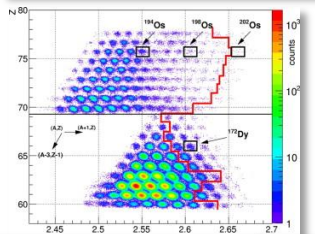
SIS18

FRS

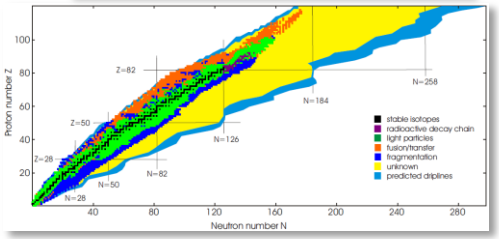
ESR

Cave M

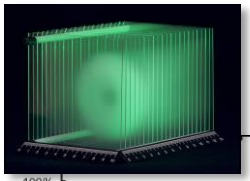
Exotic Nuclei

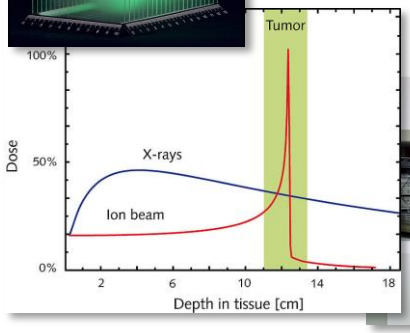


Rank	Laboratory	Country	Number	First year	Recent year
1	Berkeley	USA	635	1928	2010
2	GSI	Germany	435	1977	2013
3	Dubna	Russia	223	1957	2013
4	Cambridge	UK	222	1913	1940
5	CERN	Switzerland	119	1965	2009
6	Argonne	USA	118	1947	2012
7	GANIL	France	85	1985	2005
8	Oak Ridge	USA	77	1946	2006
9	Orsay	France	73	1959	1989
10	Michigan State	USA	72	1967	2013
	RIKEN	Japan	72	1972	2013



Ion Radiotherapy

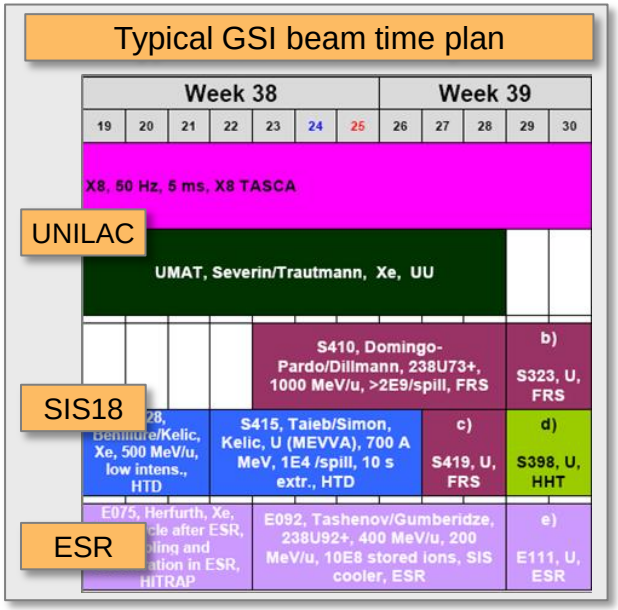


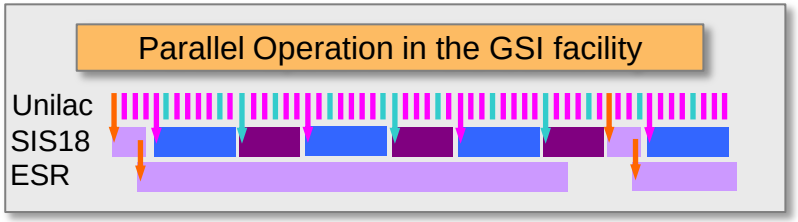


GSI Operation

- GSI operating conditions
  - Operation 24/7
  - 1 shift leader + 2 operators
  - Support by physicists for set-up
  - On-call duty for technical problems
- Parallel operation
  - UNILAC, SIS18, ESR independent
  - 3 different ion species
  - 5 parallel experiments
- Experiments demand high flexibility
  - General beam time coordination
    - Switching of ion species (weekly)
    - Adjustment of schedule (monthly)
  - Daily coordination in noon meeting
    - Variation of beam parameters (E, N, T)
    - Change of beam sharing

Success of GSI as research institute is highly linked to this flexible operation!



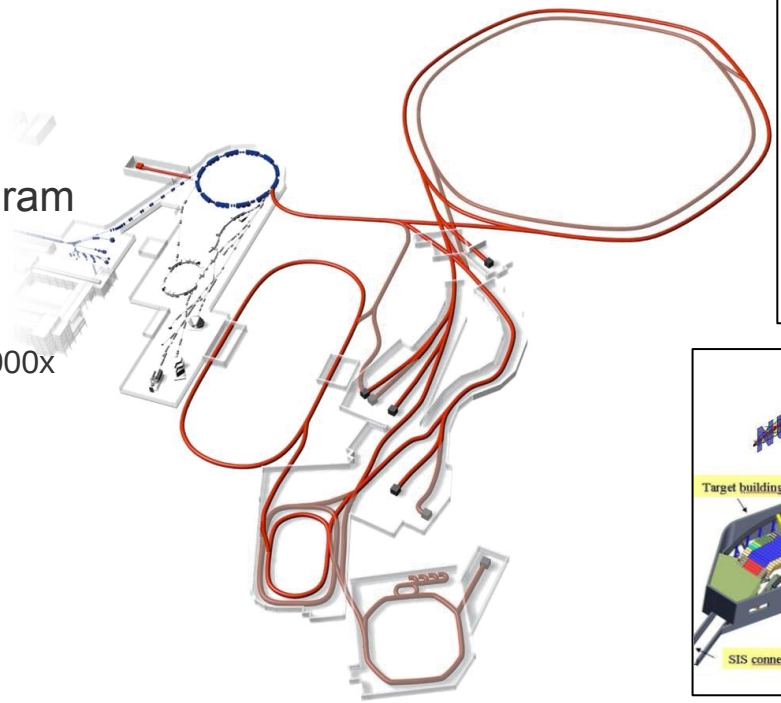


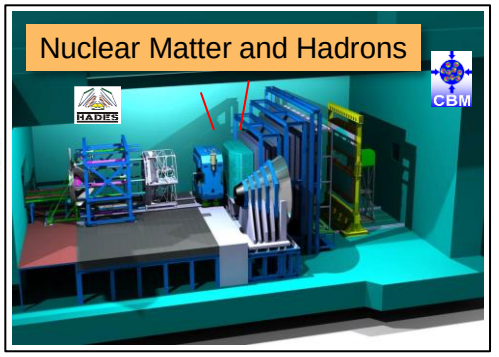
Facility for Antiproton and Ion Research

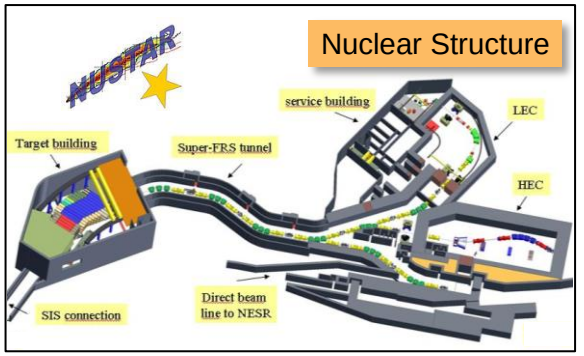
Scientific Motivation:

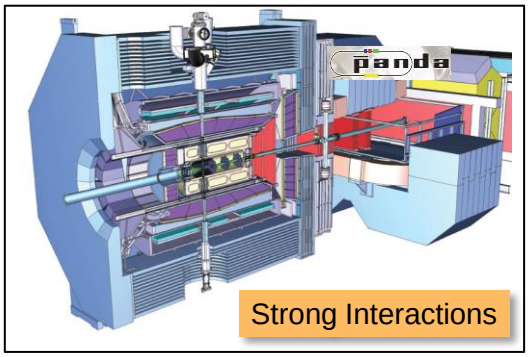
- Continuation and extension of GSI's heavy ion research program
- Breaking limits of GSI
  - Primary beam intensities: 100x
  - Secondary beam intensities: 10000x
  - Primary beam energies: 10x
  - Production of Antiprotons
  - High brilliance through cooling
- Scientific questions
  - Properties of 'cosmic matter'
  - Matter in the early universe
  - Origin of hadron masses
  - Origin of the chemical elements
  - Matter under extreme conditions

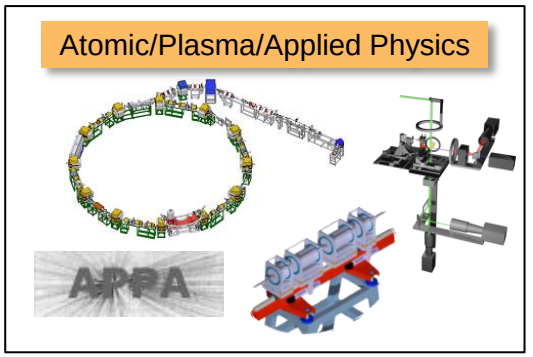
More information:
www.fair-center.eu











FAIR Project Milestones

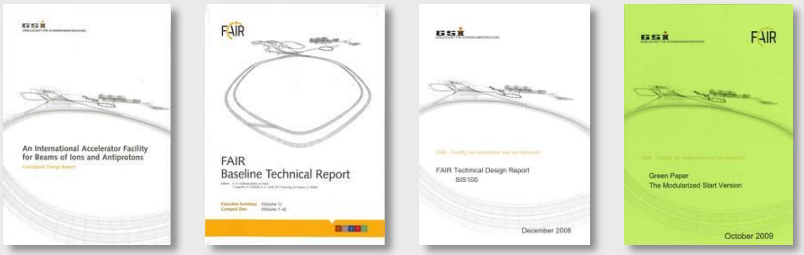
2001

FAIR Conceptual Design Report	11 / 2001
BMBF approval of FAIR	02 / 2003
Baseline Technical Report	03 / 2006
Official start of FAIR project	7.11.2007
Technical Design Report	12 / 2008
Signing of FAIR convention	**4.10.2010**
Foundation of FAIR GmbH	4.10.2010
Granting of project funds	6.11.2011
Start site clearance	12 / 2011
Start Procurement Accelerator	01 / 2012
Radiation protection permit	12.06.2012
Construction permit	29.10.2012
Start pile construction work	03 / 2013
End pile construction work	05 / 2014

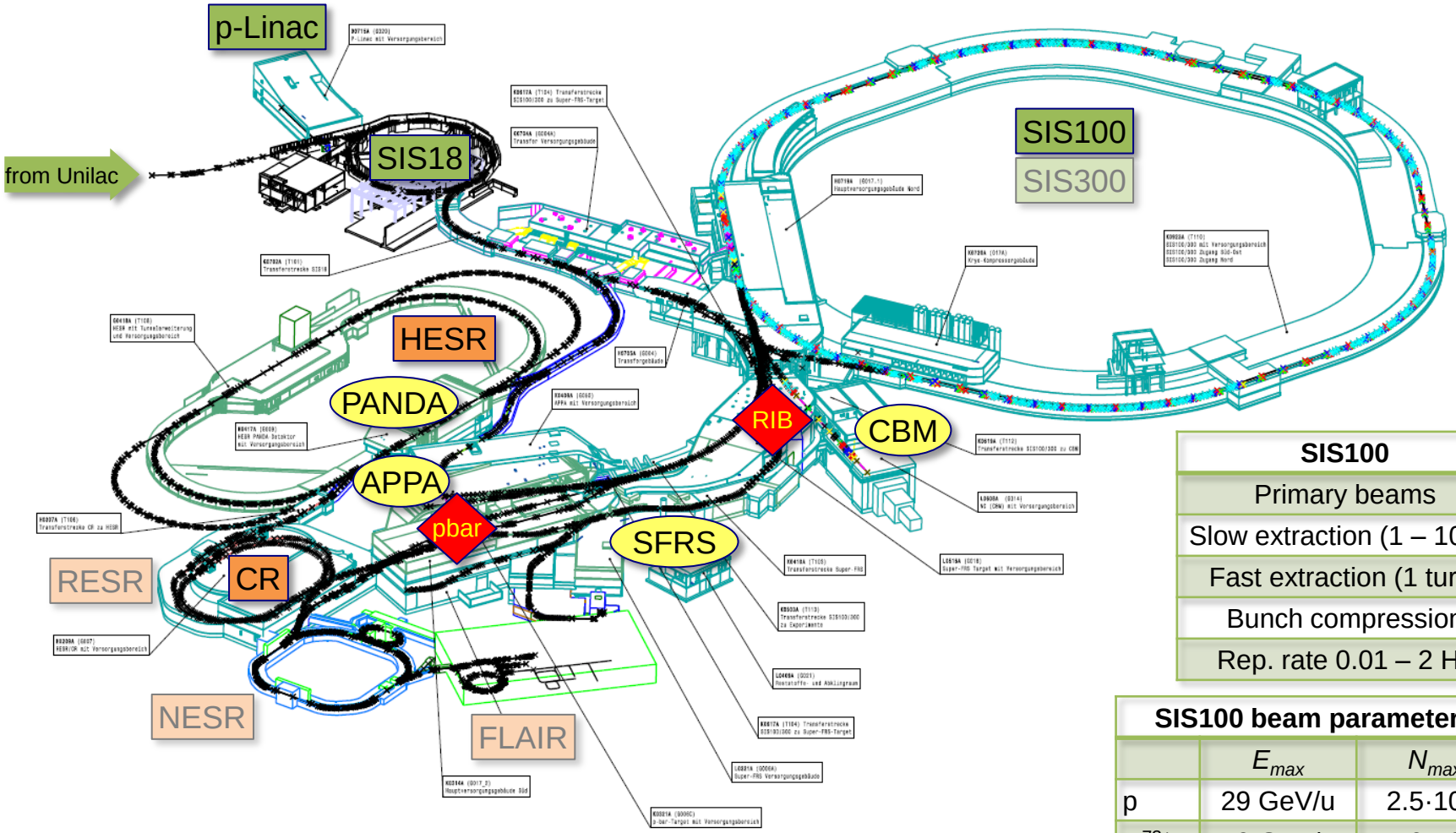
2014

Start SIS18 upgrade	11 / 2014
Start construction work	2016
SIS18 re-commissioning	2017
FAIR buildings completed	2019
FAIR accelerators installed	2019
FAIR facility operational	2020

2020



FAIR Facility



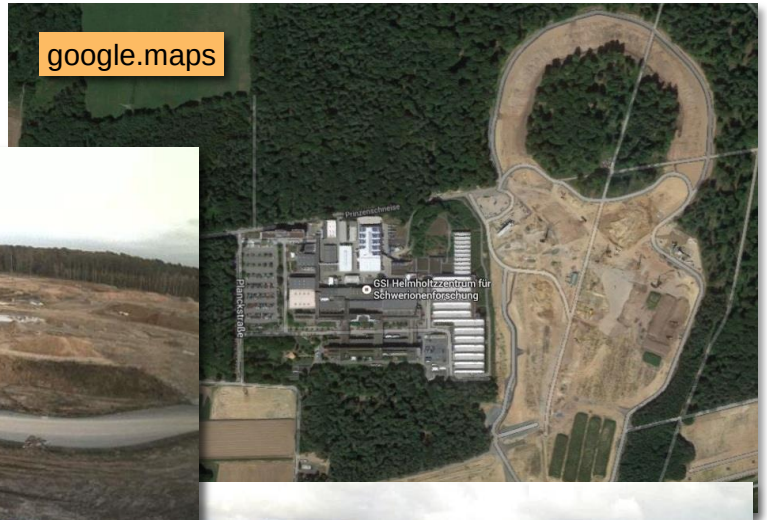
SIS100
Primary beams
Slow extraction (1 – 100s)
Fast extraction (1 turn)
Bunch compression
Rep. rate 0.01 – 2 Hz

SIS100 beam parameters

	E_{max}	N_{max}
p	29 GeV/u	$2.5 \cdot 10^{13}$
U^{73+}	10 GeV/u	$1.0 \cdot 10^{10}$
U^{28+}	2.7 GeV/u	$5.0 \cdot 10^{11}$

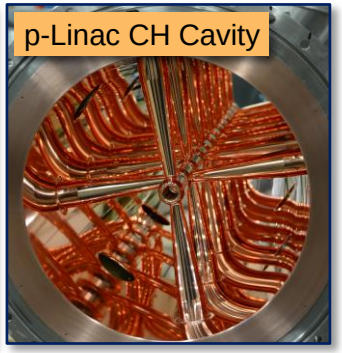
FAIR Site: Construction Work

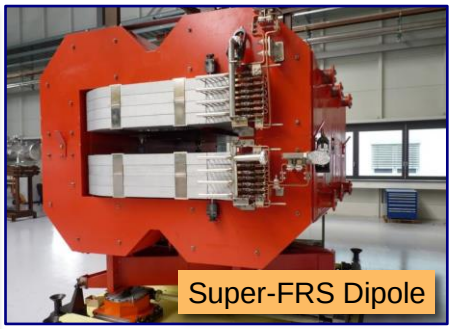
- Construction site cleared
- Access road constructed
- 1400 concrete piles implanted
  - Stabilization of ground
  - Minimization of settlement



FAIR Procurement Status

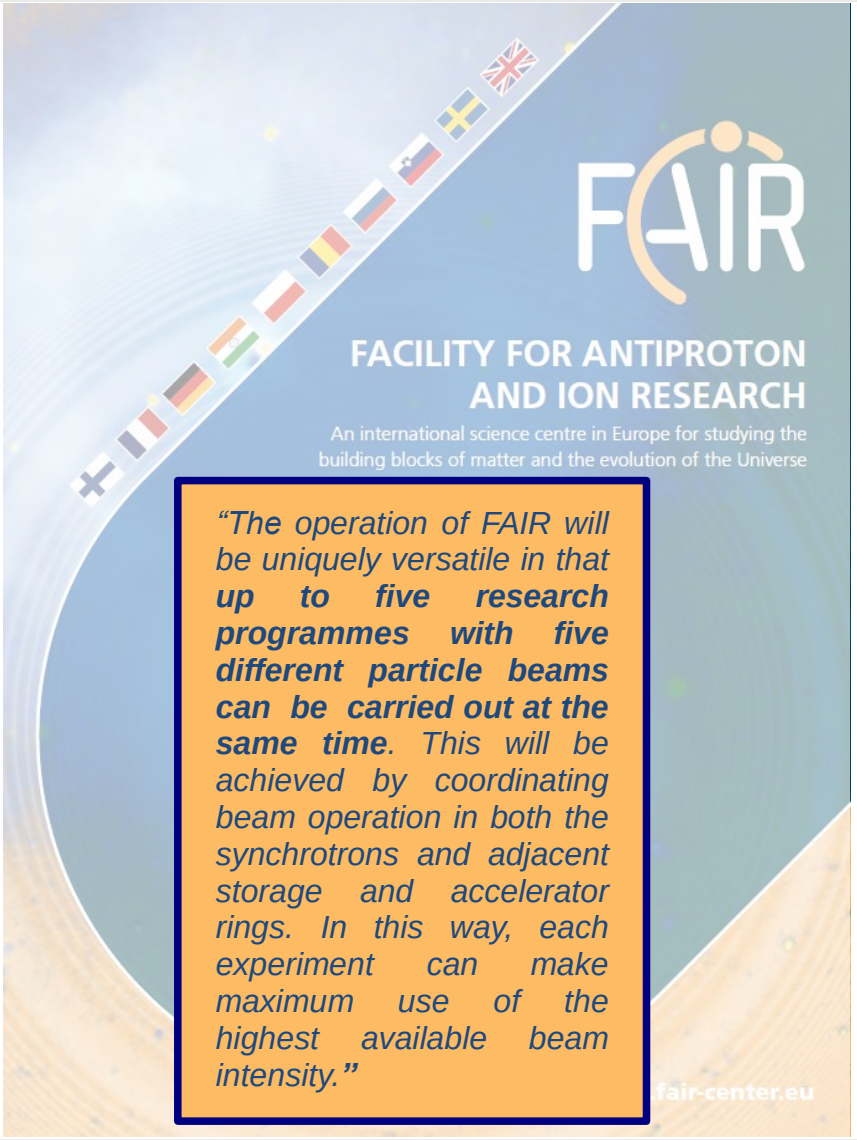
- Procurement of FAIR components
  - Several large series started
    - SIS100 dipoles and RF cavities
    - HEBT dipoles and quadrupoles
  - Many pre-series components under testing
  - Many components to be ordered next year
  - Bulk will arrive from 2016 on
  - Consistent with project schedule
- Upgrade program for GSI accelerators
  - SIS18 and UNILAC upgrade programs for FAIR injector mode
  - Upgrades started, to be completed in 2017
- GSI campus infrastructure
  - Testing areas for site acceptance tests
  - Cryogenic magnet testing facilities
    - Prototype test facility for SIS100 dipoles
    - Serial test facility for SIS100 dipoles and string tests





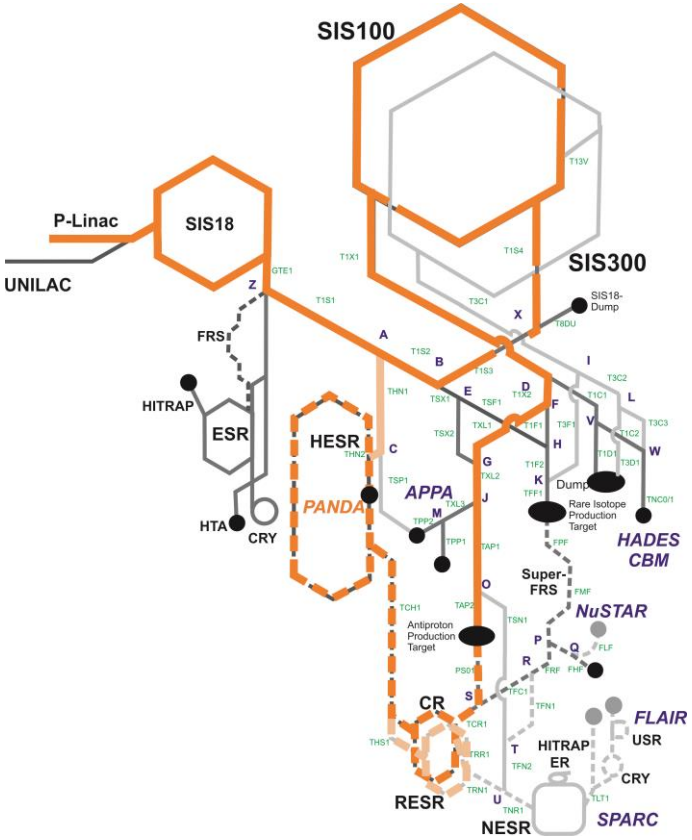
FAIR Operation

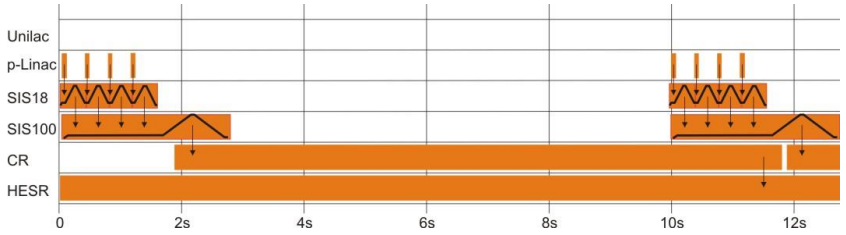
- Goal: Maximal scientific use
  - Maximization of beam on target through parallel execution of experiments in FAIR
  - Requires sophisticated coordination of the various accelerators and transfer lines
- Boundary conditions
  - Similar flexibility requirements as for GSI
    - Longer beam times for main experiments (statistics, polarity changes)
    - Still shorter beam times for tests
    - GSI operation will continue
  - Operation of GSI/FAIR by 5 operators
    - 4 beam operators, 1 cryo operator
    - Basis for operating cost estimates
    - Only two additional operators for FAIR
    - Requires very good support from the operating environment
- Details specified in operating concept
  - Presently being worked out



FAIR Operation: pbar Chain

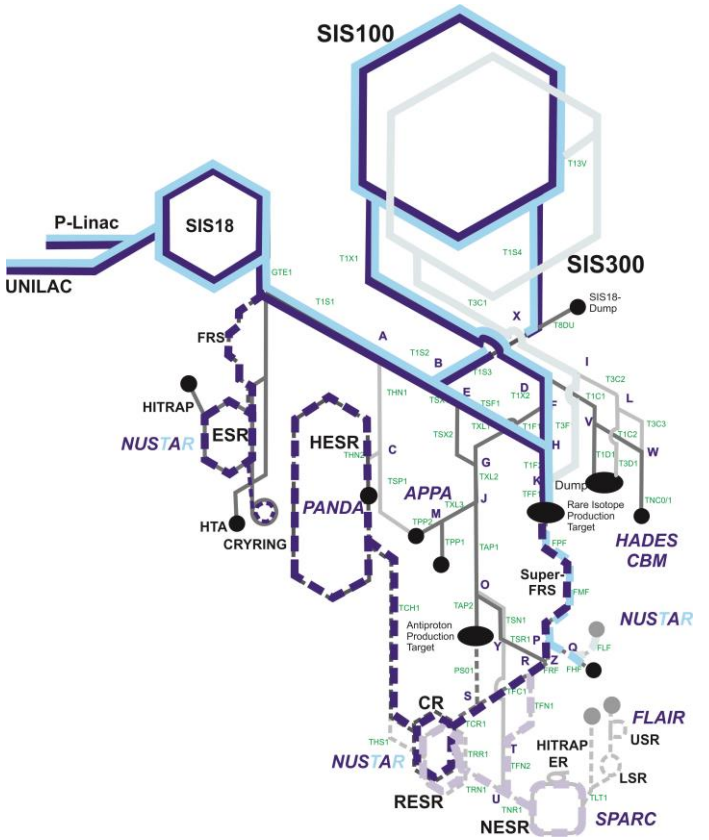
- Beam production
  - p-Linac: 10^{13} p, 70 MeV/u
  - SIS18: $6 \cdot 10^{12}$ p, 4 GeV/u, 2.7 Hz
  - SIS100
    - 4 Injections from SIS18: $2 \cdot 10^{13}$ p
    - Acceleration to 29 GeV/u
  - pbar-Target
    - Production of pbar
    - Conversion efficiency ~10^{-5}
  - CR
    - Stochastic cooling of pbar ~10s
  - HESR
    - Accumulation (~10^{10} pbar, ~15 min)
    - Acceleration to 14 GeV/u
    - Physics experiments ~15 min
- Natural gaps to be filled
  - 10 s cooling time in CR
  - 15 min physics time in HESR

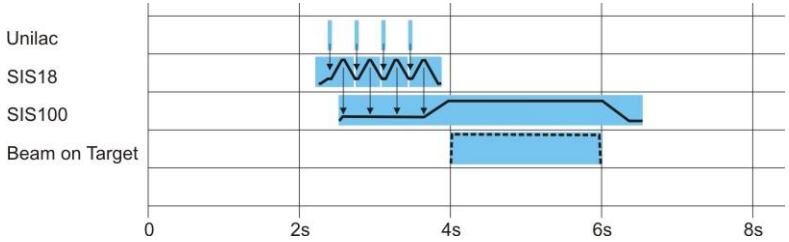




FAIR Operation: RIB Chain (fixed target)

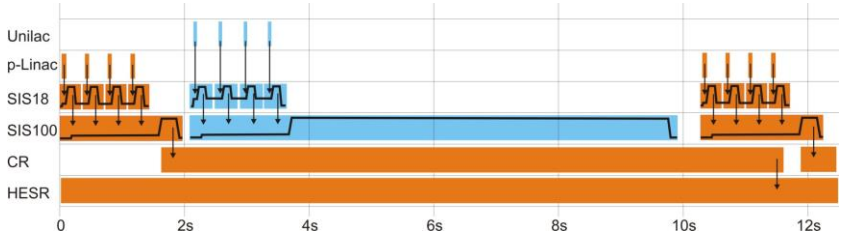
- Beam production
  - Unilac: $2.5 \cdot 10^{11}$ U^{28+}, 11.4 MeV/u
  - SIS18: $1.5 \cdot 10^{11}$ U^{28+}, 200 MeV/u, 2.7 Hz
  - SIS100
    - 4 Injections from SIS18: $5 \cdot 10^{12}$ U^{28+}
    - Acceleration to 1.5 GeV/u
    - Slow extraction
  - SFRS
    - Target: Production of secondaries
    - Separator: Selection of goal RIB
    - Caves: Physics experiments
- Leaves gaps for SIS18
  - Duration depending on extraction time
  - May be used for beam in GSI TH or ESR

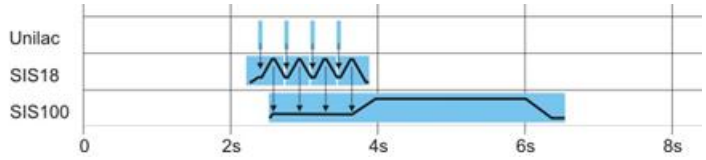


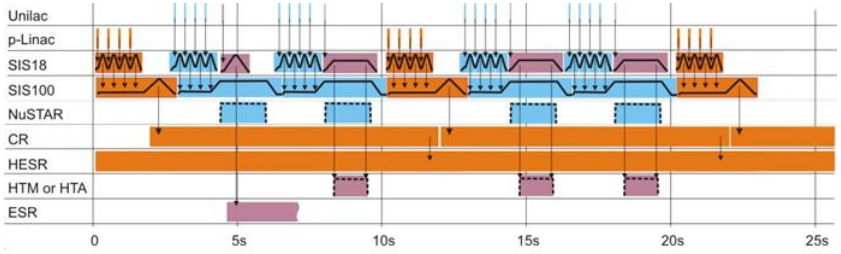


FAIR Operation: pbar/RIB and RIB

- pbar production will run over long times due to small conversion efficiency
- In MSV, 15 min accumulation followed by 15 min physics
- Possible szenario
  - HESR accumulation:
    Run RIB during CR cooling time
  - HESR physics:
    Run RIB stand-alone
- Gaps in SIS18 may also be filled
  - Short gaps: beam for ESR/CRYRING
  - Long gaps: slow extraction to GSI TH
- Control system requirements
  - Patterns integral concept of the FAIR CS
  - Automatic switching between two patterns based on beam request by HESR
  - FAIR CS must allow simultaneous tuning
    - Control room architecture
    - Control system design

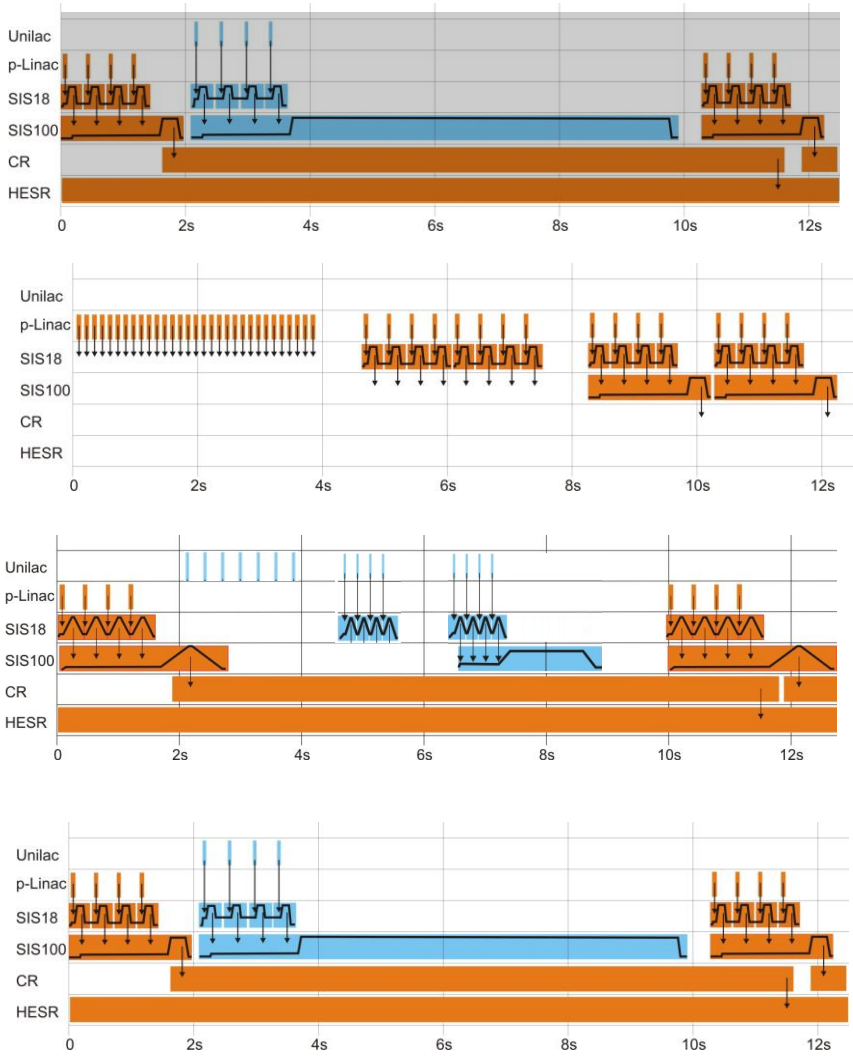






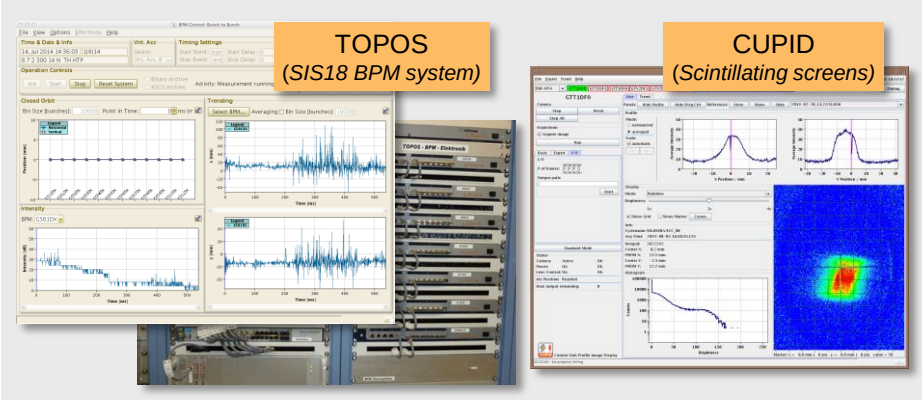
FAIR Operation: Beam Set-up Procedures

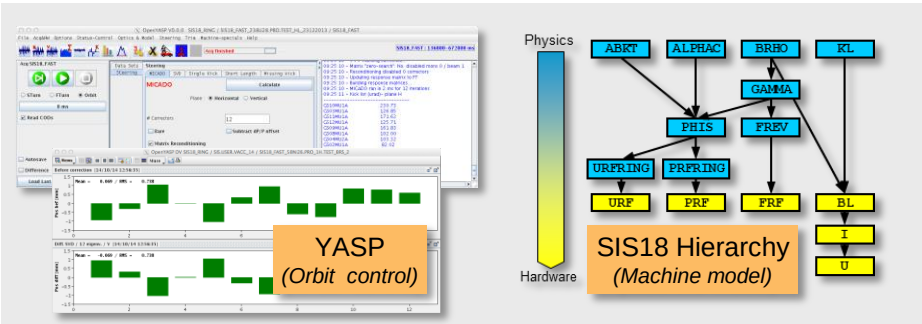
- Set-up of the pbar/RIB pattern
  - Initialize complete pattern (no beam)
  - Switch to set-up pattern for main proton beam
  - Tune proton beam successively on set-up dumps up to highest intensity
  - Tune beamlines to target
  - Add RIB chain, tune similarly
  - In parallel, set-up CR and HESR
- Challenges
  - Possible influence of RIB on pbar (hysteresis)
  - Destructive BI for tuning RIB extraction
  - Parallel exp. may change frequently:
    How to avoid disruption of pbar chain?
- Requirements on CS for patterns:
  - Creation of patterns from beam time plan
  - Creation of set-up patterns from real pattern
  - Execution of set-up procedures

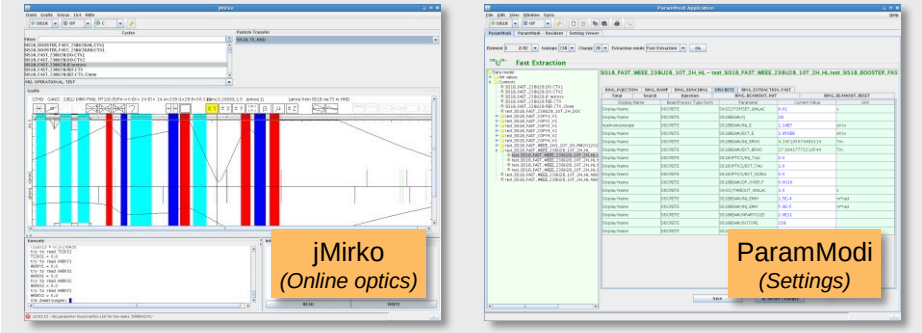


FAIR Control System: Developments

- Control system for FAIR
  - Completely new design
  - Collaboration with CERN
    - FESA framework for front-ends
    - LSA framework for settings management
    - Timing system (White Rabbit)
    - User Interfaces
- Prototype systems at SIS18
  - BI: BPMs, Screens
    - Routine use for orbit correction and steering
  - Settings: machine model, applications
    - Commissioning H=2 cavity
    - Resonance compensation
- Operational at CRYRING (2015)
  - Prototype of FAIR control system
  - FESA front-ends for
    - Magnet PCs, RF, HV, RFQ
    - BPMs, Trafos, Screens, Cups, Grids
  - Operating applications
  - Test bench for FAIR operation concepts







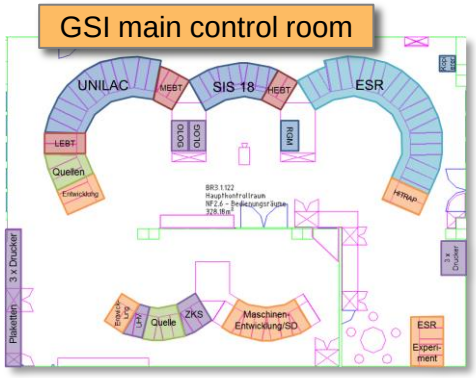
Operation of FAIR: New Main Control Room

- New main control room required
  - More space needed for additional machines and infrastructure (e.g. cryo)
  - Central console for survey, monitoring, and administrative purposes
  - Console arrangement to support parallel tuning of independent beams
  - Acoustic separation of areas
  - Daylight conditions
  - Modern, ergonomic equipment
- Additional requirements
  - Integration of meeting room
  - Representative architecture

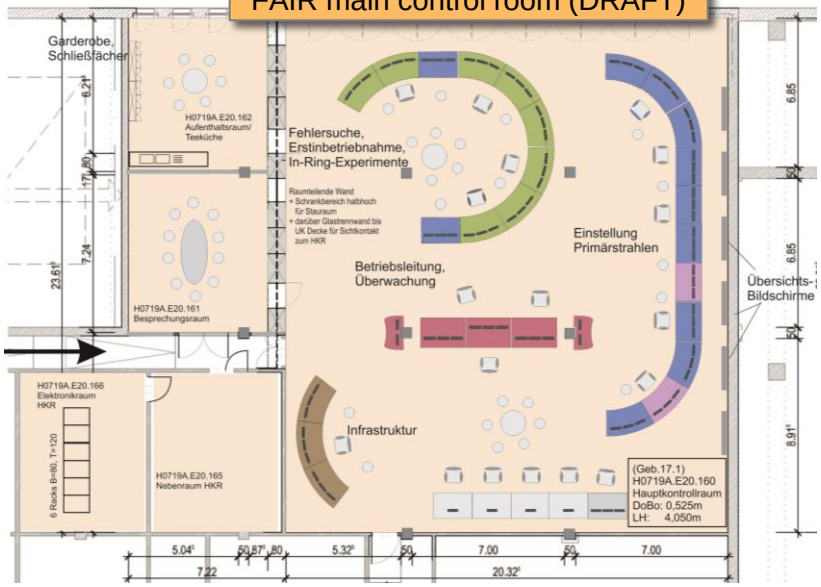
Details will be worked out by project group "FAIR main control room" based on operating concept

Test console

GSI main control room

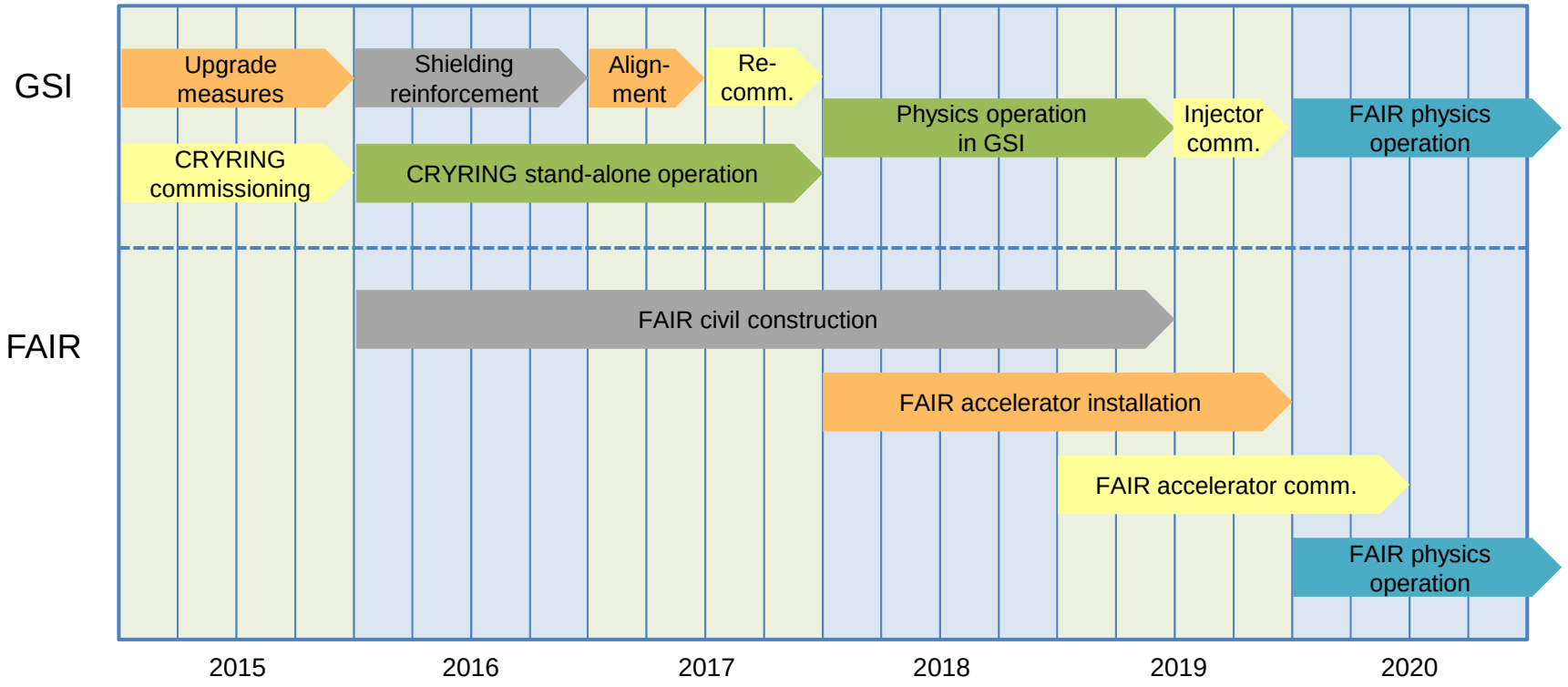


FAIR main control room (DRAFT)



Outlook

Roadmap for operation of GSI and FAIR



These are exciting times, so stay tuned!

Acknowledgments

Thanks to the colleagues providing material:

P. Kowina, C. Omet, B. Schlei, P. Schütt, P. Schwab, P. Spiller
C. Sturm, D. Varentsov, B. Walasek-Höhne, W. Vinzenz

Thanks to all colleagues of FAIR@GSI sharing the big work load
of converting the FAIR idea into reality!

Thank you for your attention!