Facility Status GSI/FAIR

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MT ARD ST3 Meeting, 29.9.-01.10.2021

Agenda

1. recent performance of GSI accelerator facility
   - *parallel operation*
   - *availability*
   - *operation modes*
   - *beam parameters FAIR phase 0 – user operation*
   - *status FAIR beam parameters*

2. preparation for FAIR commissioning
   - *goal*
   - *concept & planning strategy*

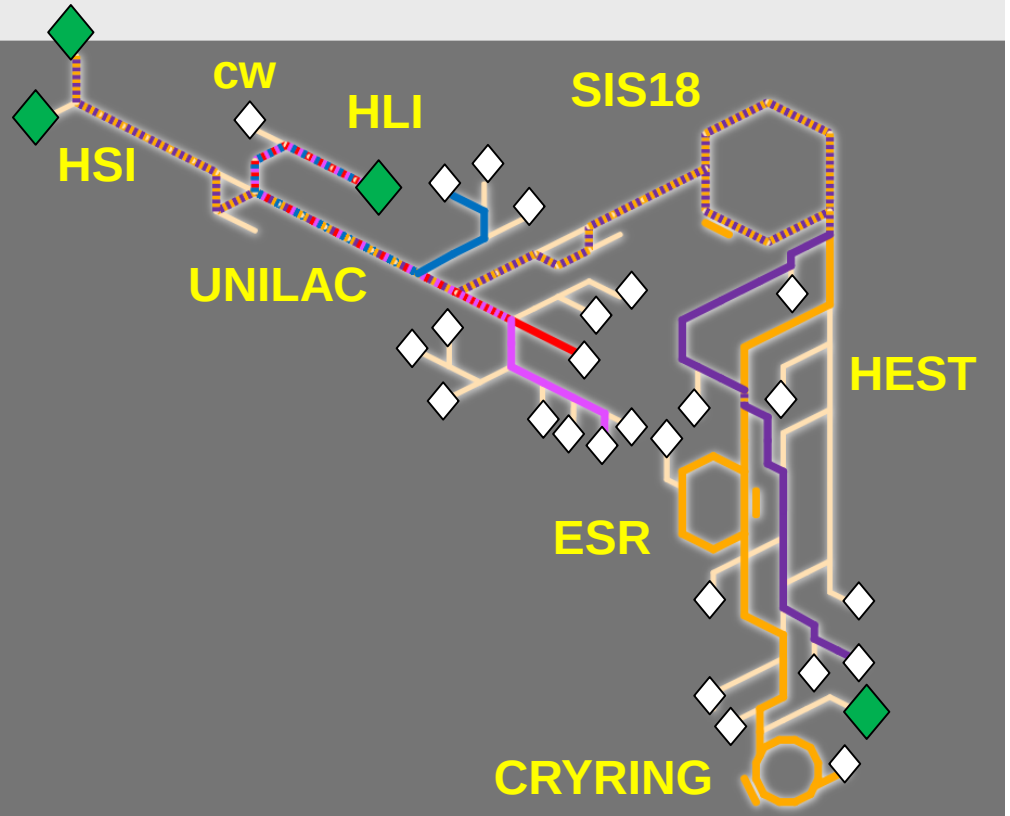
Remark: Input of this slides is from the S.Reimann - Operation Manager and coordinator of FAIR commissioning.

GSI operation performance

parallel operation

Accelerator Status

CRYRING E138	APPA-SPARC	$^{238}U^{92}$		beam on target
E138 The Ground-State Lamb Shift in the Heaviest Hydrogen-like Ion (U91+): High Resolution X-ray Spectroscopy at the CRYRING Electron Cooler				
HTC S455	NUSTAR-R3B	$^{238}U^{72}$	322.59 MeV/u	beam on target
Fission investigated with relativistic-radioactive beams and the advanced SOFIA@R3B setup				
UY7 U321	NUSTAR-SHE-P	$^{48}Ca^{10}$	4.55 MeV/u	beam on target
Laser spectroscopy of fermium, nobelium and lawrencium around N=152				
UX8 U327	NUSTAR-SHE-C	$^{48}Ca^{10}$	4.8 MeV/u	beam on target
Chemical studies of the superheavy element Z=115				
UM3 UMAT	APPA-MAT	$^{48}Ca^{10}$	4.8 MeV/u	beam on target
Materials Research program				



ion sources

target stations

20.04.2021

Parallel factor

experiments, served at the same time

average: 3.3 (in 2021)
average: 2.3 (in 2020)

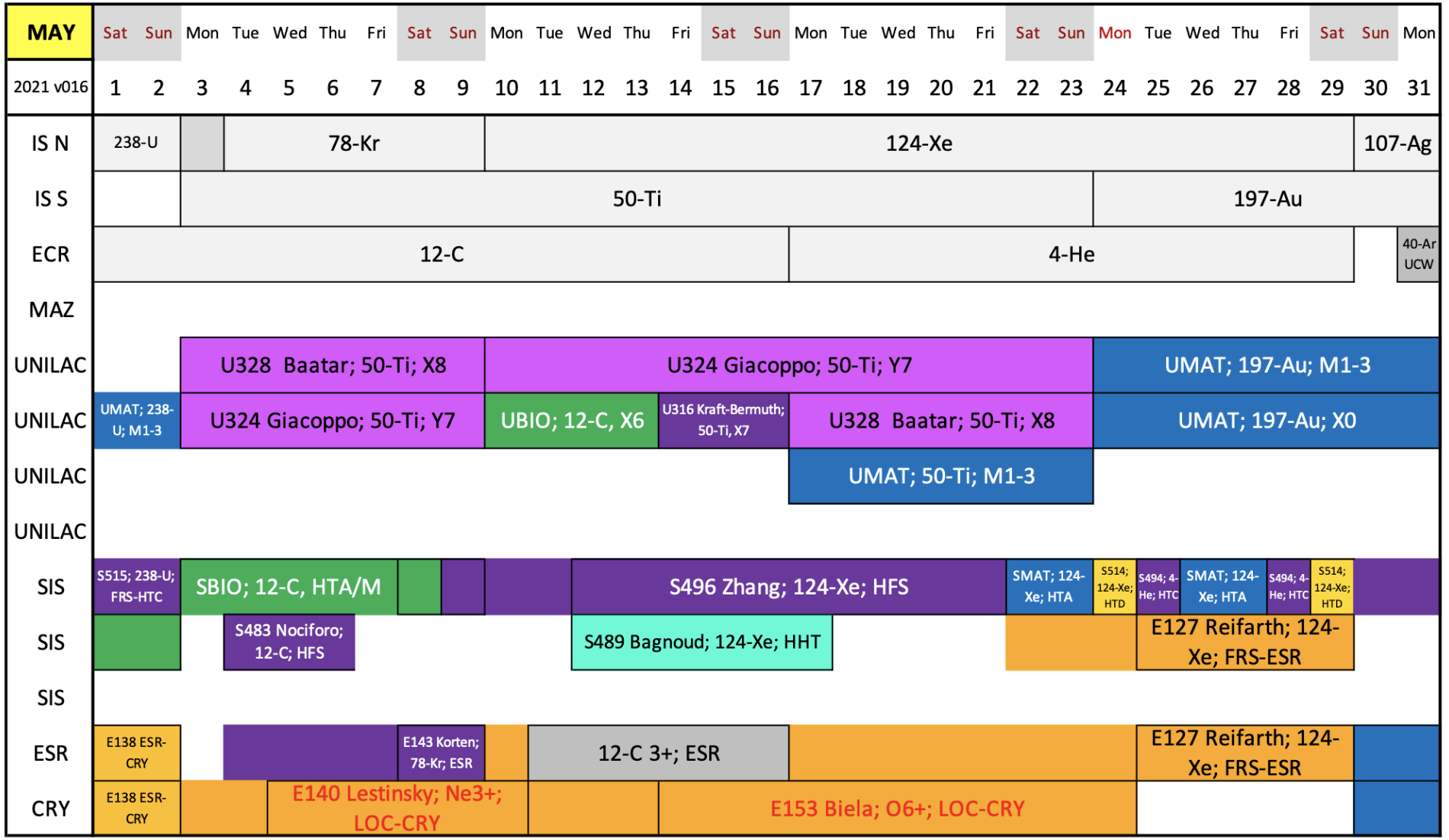
maximum: 6

very efficient use of available beamtime

picture by: Achim bloch-Späth

GSI user beam time

detailed beam time schedule of May 2021

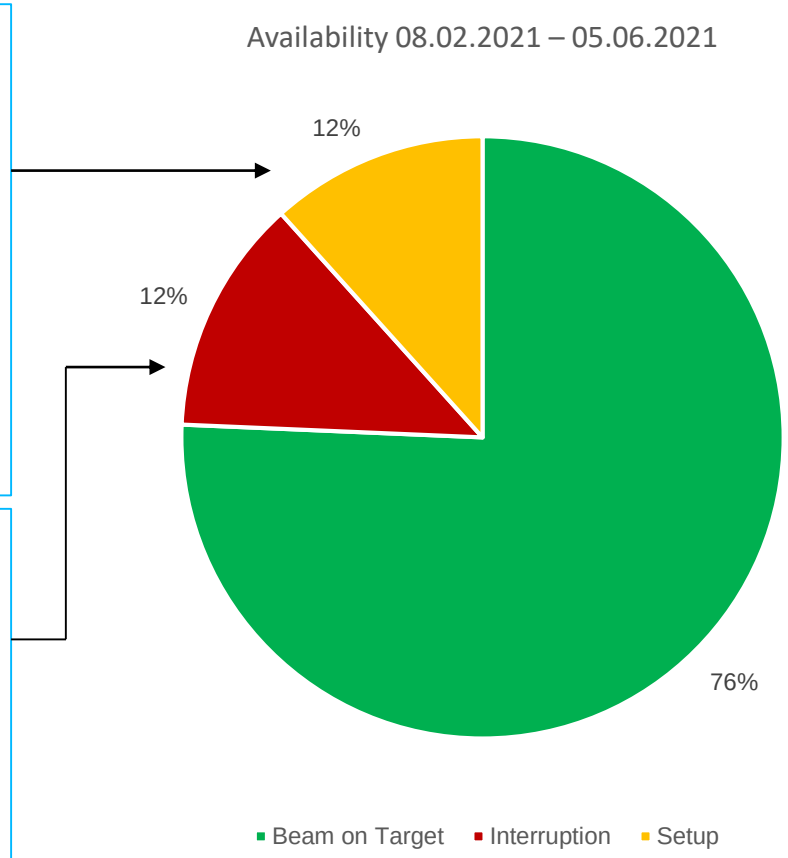


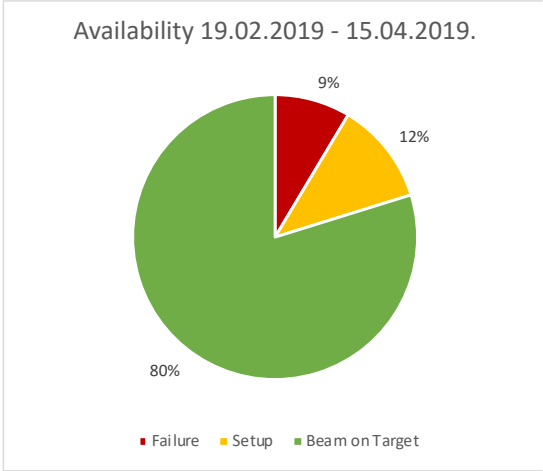
D. Severin

GSI operation performance
availability

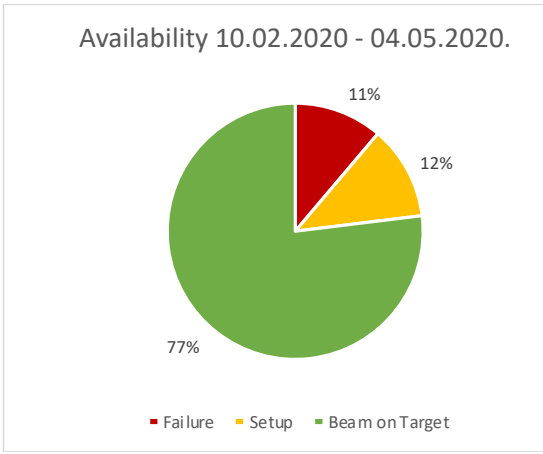
beam setup:
- complexity of beam time schedule & requested beam quality
- parallel factor
- control system response
- instrumentation
- operator skills

interruptions:
- front-end software problems
- device failures (mainly aging & maintenance back lock)





2019:
only 7 weeks,
no ESR,
no FRS,
no Cryring,
no Uranium



2020:
no Uranium
Covid19

statistics by: O. Geithner, M. Klich

GSI accelerator facility – recent performance

operation modes

special achievements

- almost all operation modes are restored – thanks to progress of control system retrofitting to FAIR standard
- full chain user-operation UNILAC-SIS18-ESR-Cryring established for heavy ions (Cryring commissioning well advanced)
- Uranium operation for users re-established after 5 years

2021 operation modes (new or re-established)

- Ion source stability improved → longer lifetime, less interruptions
- Up to 4 ion species in parallel operation established
- Parallel operation of carbon and proton (high current, from one Methane source) established
- SIS18 remanence compensation - function implemented to achieve a better parallel performance for SIS18 users
- SIS18 septum PS changed → voltage increased close to nominal value <=> nominal extraction angle → less losses during extraction @ rigidities > 12Tm
- New RF system allows SIS routine operation with reduced injection energy from UNILAC to highest possible extraction rigidity
- HEST beam-line-optics improved → faster setup, better transmission (e.g. SIS18-HTD, ESR-Cryring)
- New beam path SIS18-FRS-HTM commissioned
- ESR bunch to bucket transfer established
- CRYRING@ESR: deceleration and fast extraction established

GSI nominal intensity

for standard user operation

ion species	ion source	UNILAC max. rep. rate	UNILAC charge state	UNILAC nominal average particle current	SIS18 max. rep. rate (fast ext.)	SIS18 charge state	SIS18 nominal intensity per cycle @ extraction	ESR charge state	ESR energy/u	ESR stored intensity	Cryring charge state	Cryring nominal intensity per cycle @ incjection
U-238	VARIS				0,5 Hz - 1 Hz	73+	2E+09	91+/92+	300-400 MeV	1E+08		
								91+/92+	40 MeV	4E+07		
								91+/92+	10 MeV	5E+06	91+/92+	1E+06
Bi-209	VARIS				0,5 Hz - 1 Hz	68+	2E+09					
Pb-208	VARIS				0,5 Hz	67+	2E+09				78+	5E+06
Au-197	VARIS	25 Hz*	26+	0,1 pµA	0,5 Hz - 1 Hz	65+	2E+09					
Xe-124	MUCIS				0,5 Hz - 1 Hz	48+	3E+09					
Xe-136	MUCIS				0,5 Hz - 1 Hz	48+	5E+08					
Ag-107	VARIS				0,5 Hz - 1 Hz	45+	2E+09				47+	5E+06
Ti-50	PIG	50 Hz	12+	0,8 pµA	0,5 Hz - 1 Hz	22+	2E+08					
Ca-48	ECR	50 Hz	10+	0,8 pµA	0,5 Hz - 1 Hz	20+	5E+08					
Ar-40	MUCIS				0,5 Hz - 1 Hz	18+	3E+10					
Mg-24	Cryring ECR										1+	2E+06
O-18	VARIS		3+		0,5 Hz - 1 Hz	8+	5E+10					
N-14	MUCIS				0,5 Hz - 1 Hz	7+	7E+10					
C-12	ECR	50 Hz	2+	2,4 pµA	0,5 Hz - 1 Hz	6+	4E+09					
	MUCIS (from CH3 molecule***)				0,5 Hz - 1 Hz	6+	4E+09					
	Cryring ECR										1+	2E+06
H-1	MUCIS (from H3 molecule**)				0,5 Hz - 1 Hz	1+	1E+09					
	MUCIS (from CH3 molecule***)				0,5 Hz - 1 Hz	1+	8E+10					

* *50 Hz is possible only with exclusive operation mode*

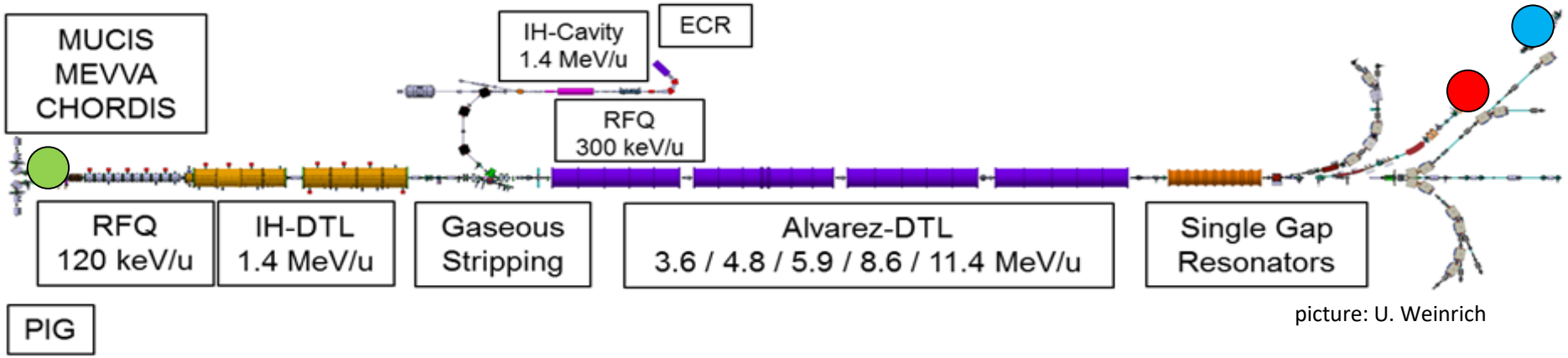
** *in parallel operation mode with high MAZ and adopted synchronous phase (higher intensity possible only during exclusive proton operation)*

*** *C + H parallel high-current operation from molecule source*

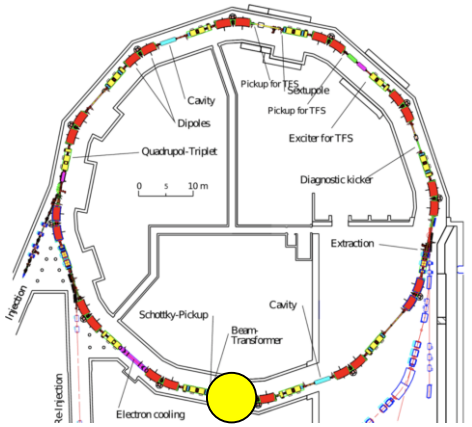
green: changes compared to the 2021 table

GSI performance as FAIR injector

Uranium operation



picture: U. Weinrich



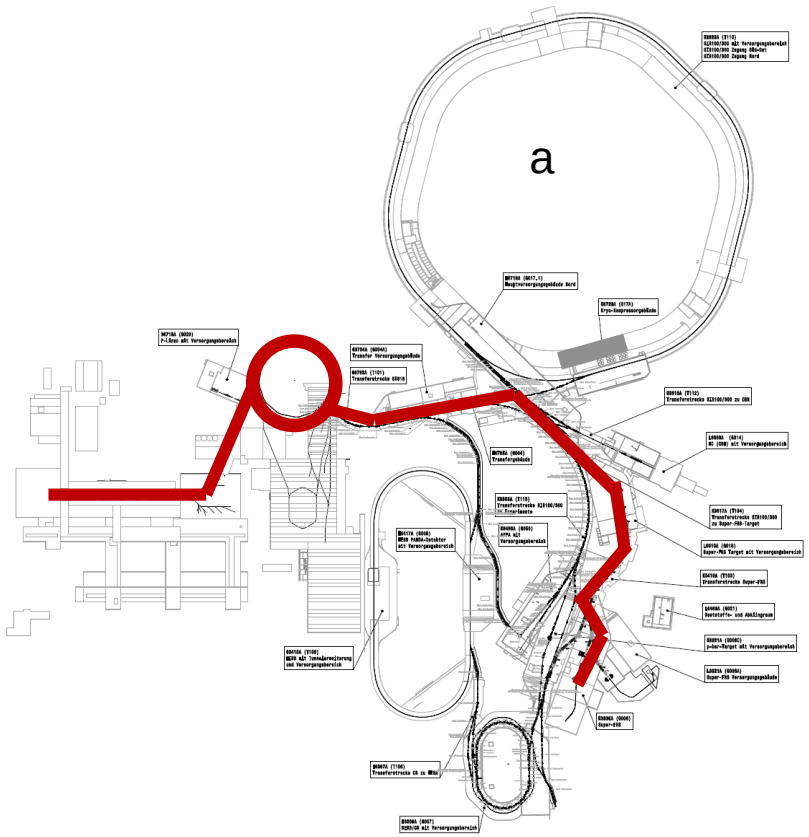
picture: M. Alhumaidi

Current Transformer	Position	charge state	Current in user operation (or recent machine studies)	All time high	FAIR requirement [mA]
UL5DT8	after ion source before RFQ	4+	12 ± 2 mA	15 mA (with 7-hole-ext.-system)	30mA (20 with pulsed gas stripper)
TK2DT4	before TK foil stripper	28+	2.8 ± 0.3 mA	3.2 mA (est. 2012) [2]	10 mA (30 SIS18 turns) 16 mA (16 SIS18 turns)
TK3DT4	after TK foil stripper	73+	1.4 ± 0.1 mA	2.7 mA (2007 TK-end) 1.3 mA (est. 2010)[1]	1 mA (early physics) 2 mA (SIS18 => SFRS)
S09DT1ML_inj S09DT1ML_flattop	SIS18 at injection SIS18 after acceleration	73+	3.0 ± 0.1 E9 particles 2.2 ± 0.1 E9 particles	5.9 E9 (est. 2010) [1] 4.5 E9 (est. 2010) [1]	5 E9 ppc (early physics) 1 E10 ppc (SIS18 => SFRS)
S09DT1ML_inj S09DT1ML_flattop	SIS18 at injection SIS18 after acceleration	28+	1.7 E10 particles 0.6 E10 particles	4.2 E10 (est. 2012) [2] 3.0 E10 (est. 2012) [2]	5 E11 ppc (MSV)

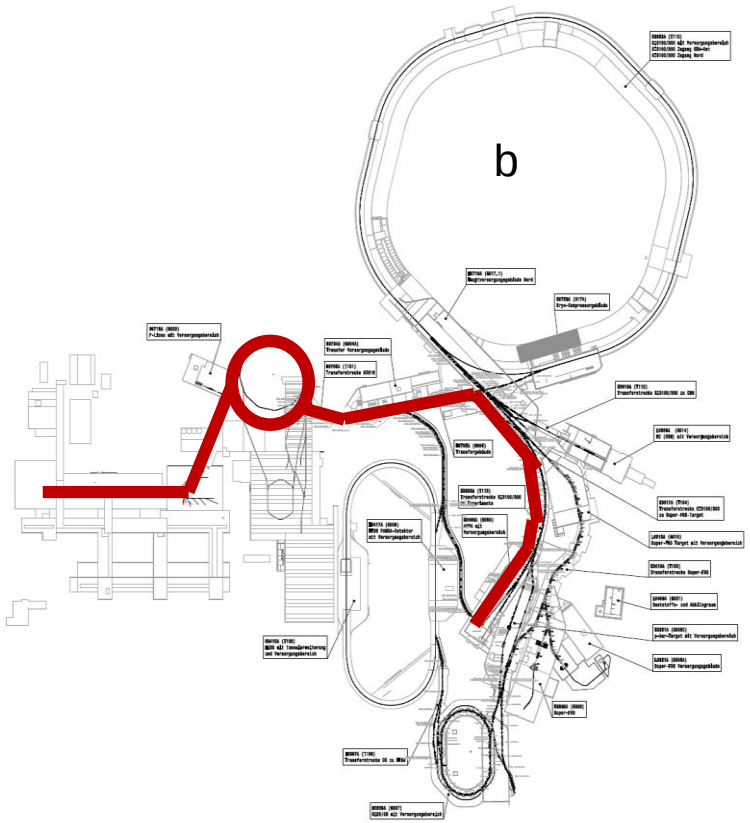
FAIR commissioning concept for intermediate objective

4 levels of planning

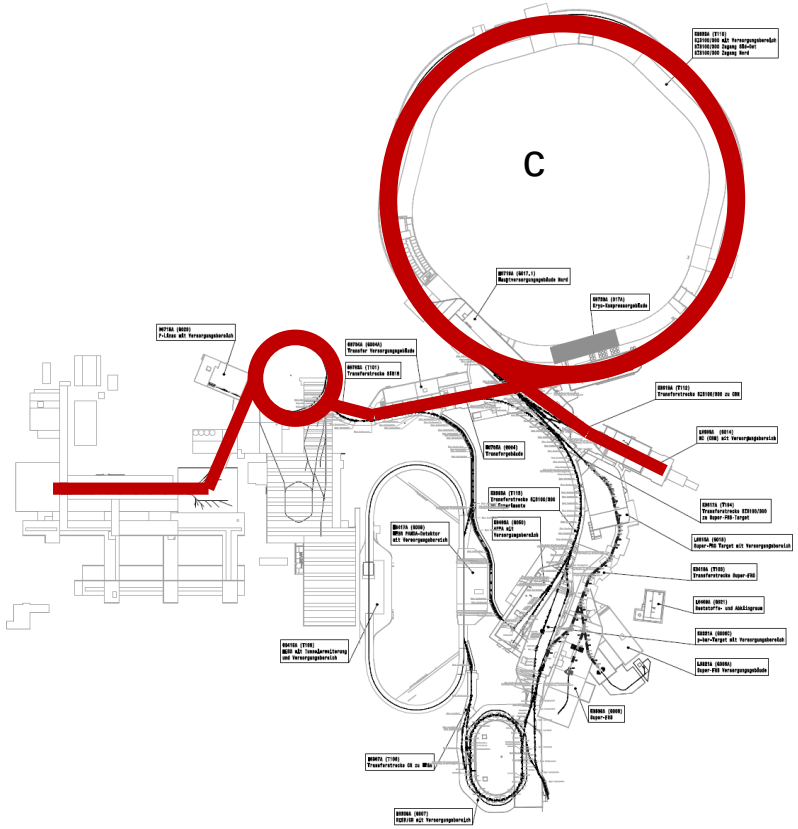
UNILAC → SIS18 → SFRS → NUSTAR



UNILAC → SIS18 → APPA

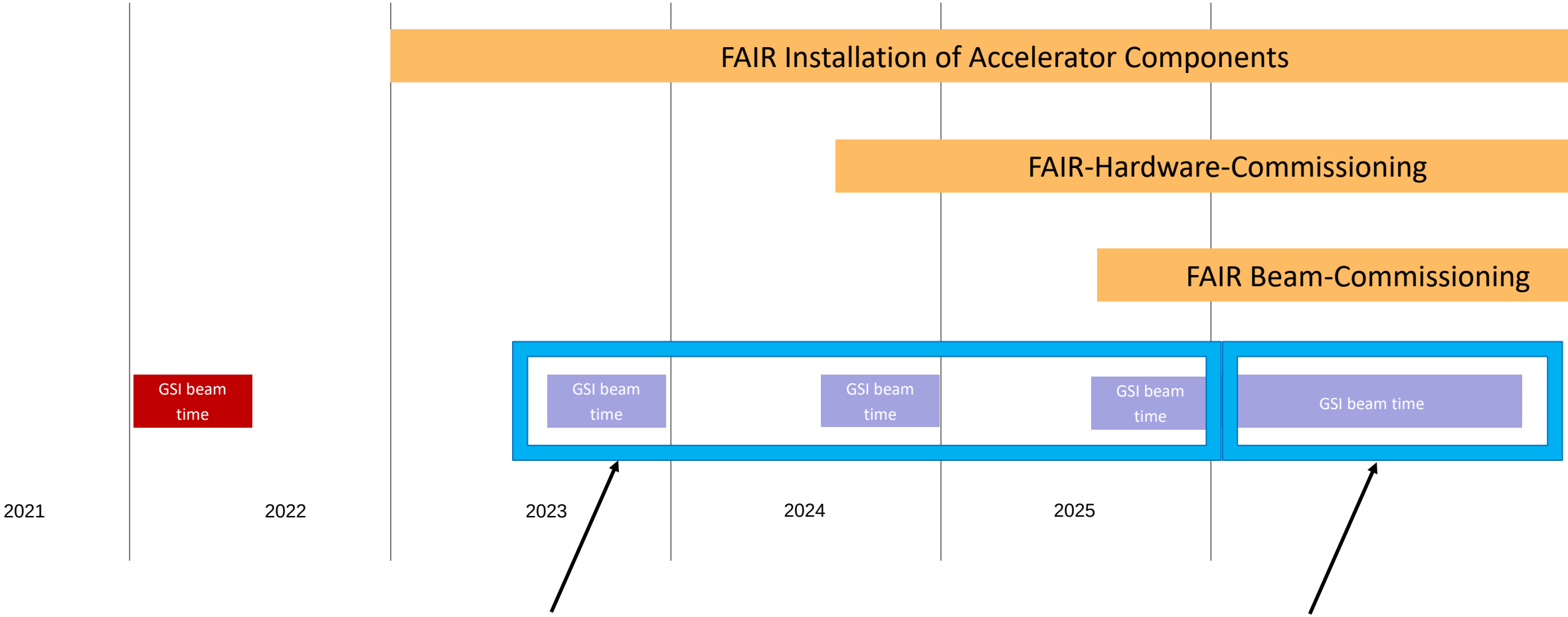


UNILAC → SIS18 → SIS100 → CBM



FAIR commissioning

integrated campus schedule



restricted operation modes,
less parallel operation
more machine related research

major restrictions for user operation
(FAIR beam will have priority)
no long shutdown periods desired

FAIR commissioning concept

4 commissioning phases

inst.

Commissioning without Beam

Beam Commissioning

#	commissioning stage	accelerators & transfer lines	detectors
1 (M??)	local HW-commissioning	• local system tests in tunnel and supply areas • control system not needed (only in limited aspects) • media needed – temporary supply is sufficient	• single detector tests • tests of individual components • install. service & controls
2 (M??)	remote & system commissioning	• single system test (vertical system integration test) • remote testing from MCR (sequences, checklists) • control system integration of the system and timing is needed, TBI & media fully available from here	• system tests (with HV, gas, ...) • pre-test of DAQ system • local control
3 (M11)	integration	• (3.1) multi system tests & (3.2) full Dry-Runs • control system and accelerator models for pilot beam scenarios fully available	• full detector test and DAQ using cosmics
4 (M12)	pilot beam commissioning	• commissioning with pilot beam, PAS available	• commissioning with pilot beam

handover to operations

	beam commission & early science	• operation with PCP-beam respectively status quo beam • commissioning of advanced systems and complex operation modes / intensity ramp-up