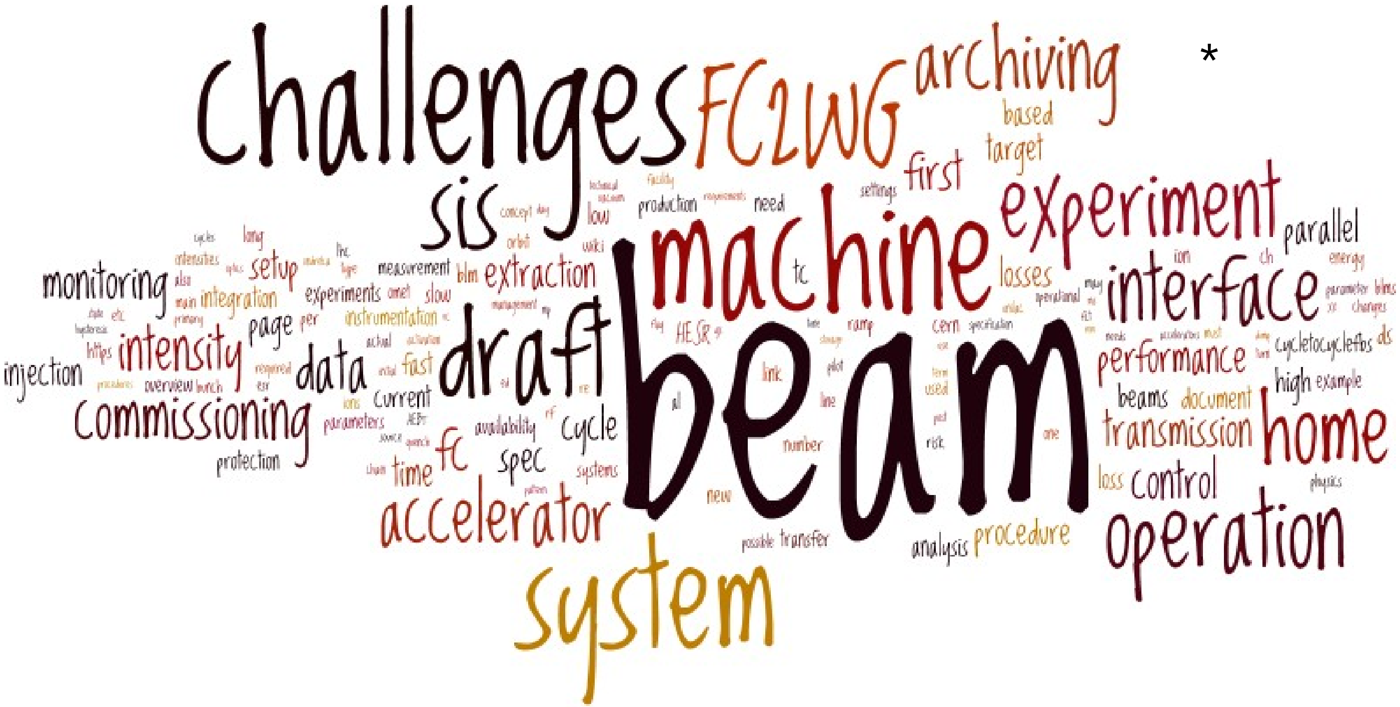
FAIR Commissioning & Control WG

Status, Strategy & Concepts for 2018 and beyond



*

Ralph J. Steinhagen, S. Reimann, D. Severin for the FC²WG

* based on 2015/16 FC2WG presentations & meeting minutes

An attempt on defining a ...

FAIR Figure of Merit

- Integrated Luminosity per experiment

$$\frac{\int \mathscr{L}(t)\ \mathrm{d}t}{\left[\int \mathscr{L}\ \mathrm{d}t\right]_{\mathrm{ref}}} \sim \int_{\mathrm{OP\ year}} \underbrace{\frac{dN_{\mathrm{ions}}/dt}{\epsilon_{\mathrm{x,y,s}}}} \cdot \underbrace{\varepsilon_{\mathrm{FAIR}}}\ \mathrm{d}t$$

Experiment constraints:

- dN_{ions}/dt constant (spill-structure)
- $dN_{ions}/dt|_{max}$ constraints
- ...
- **beam brightness: N_{ions} & $\varepsilon_{x,y,s}$**
  - x 10-100 higher intensities N_{ions}
  - x 10 beam energies
    → **new:**
  - machine protection
  - activation/loss minimisation (ALARA)

FAIR efficiency (simplified):

$$\varepsilon_{\mathrm{FAIR}} \approx \frac{\langle t_{\mathrm{physics}} \rangle}{\langle t_{\mathrm{physics}} \rangle + \langle t_{\mathrm{operation}} \rangle + \langle t_{\mathrm{down\text{-}time}} \rangle}$$

Primary FC²WG goals:

1. efficient operation
2. better & <u>safe</u> beam control

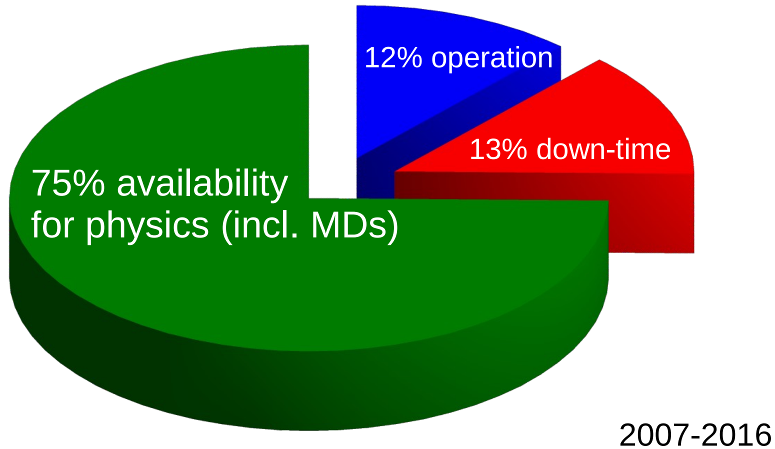
… across the whole accelerator facilitiy

SIS18 Operation Experience & Efficiency

1995-2016: U. Scheeler, S. Reimann, P. Schütt et al.

Statistik Betrieb | **Beginn** 01.01.2014 | 22:00 | **Ende** 31.12.2014

Status		Ereignis	Gesamt	Minuten	Prozent
SAT		Strahl auf Target (inkl. Nachoptimieren)	12000.35 h	720021	50.18
NO		Nachoptimieren	92.63 h	5558	0.39
STDBY		Standby	6782.43 h	406946	28.36
UNTERBR			5039.55 h	302373	21.07
	EINST		2206.85 h	132411	9.23
	QW		520.52 h	31231	2.18
	AUSF		2312.18 h	138731	9.67
GESAMT			**23914.97 h**	**1434898**	**100.00**

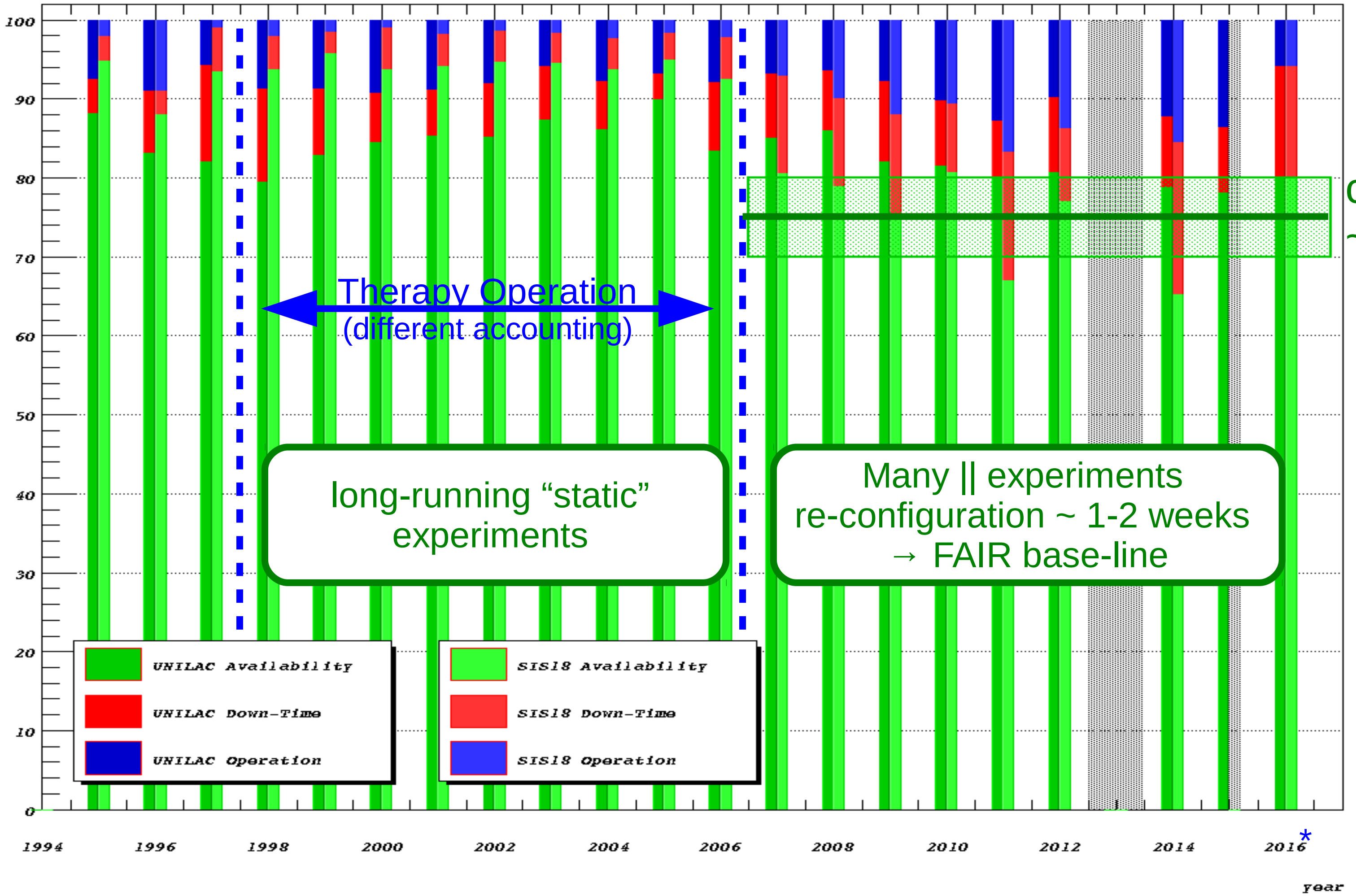


2007-2016

- simple[1,2] estimate, but relates to qualitative control room experience:
  - presently: '~ 1 shift UNILAC' + '1 shift SIS18+TL setup' ↔ 1-2 weeks of experiments
  - potential target after 2-3 years of FAIR operation:
    - simple experiments (e.g. attached to SIS18/SIS100): 1-2 shift setup ↔ 1-2 weeks beam-on-target
    - more complex experiments (e.g. at HESR): ~week setup ↔ months of operation (HESR),
- Need to factor in efficiency evolution: early beam commissioning → reaching final beam parameter
  - N.B. early SIS100-only availability indications (C. Omet et al.): 66 %

[1]possibly strong assumption that new machines can be operated with the same routine, ease and efficiency as the present GSI infrastructure, …
[2] complex beam chains (e.g. HESR) with long beam setup times are typically run longer/more static than shorter (SIS18 experiments)

Accelerator Experience & Efficiency
1995-2016: U. Scheeler, S. Reimann, P. Schütt et al.



Based on: U. Scheeler, S. Reimann, P. Schütt et al., “Accelerator Operation Report”, GSI Annual Scientific Reports 1992 – 2015 + 2016 (D. Severin)
https://www.gsi.de/en/work/research/library_documentation/gsi_scientific_reports.htm
N.B. ion source exchanges are factored out from UNILAC & SIS18 data (~ constant overhead)
Availability: *experiments + detector tests + machine development + beam to down-stream accelerators;*
Down-time: *unscheduled down-time + standby;* Operation: *accelerator setup + re-tuning*

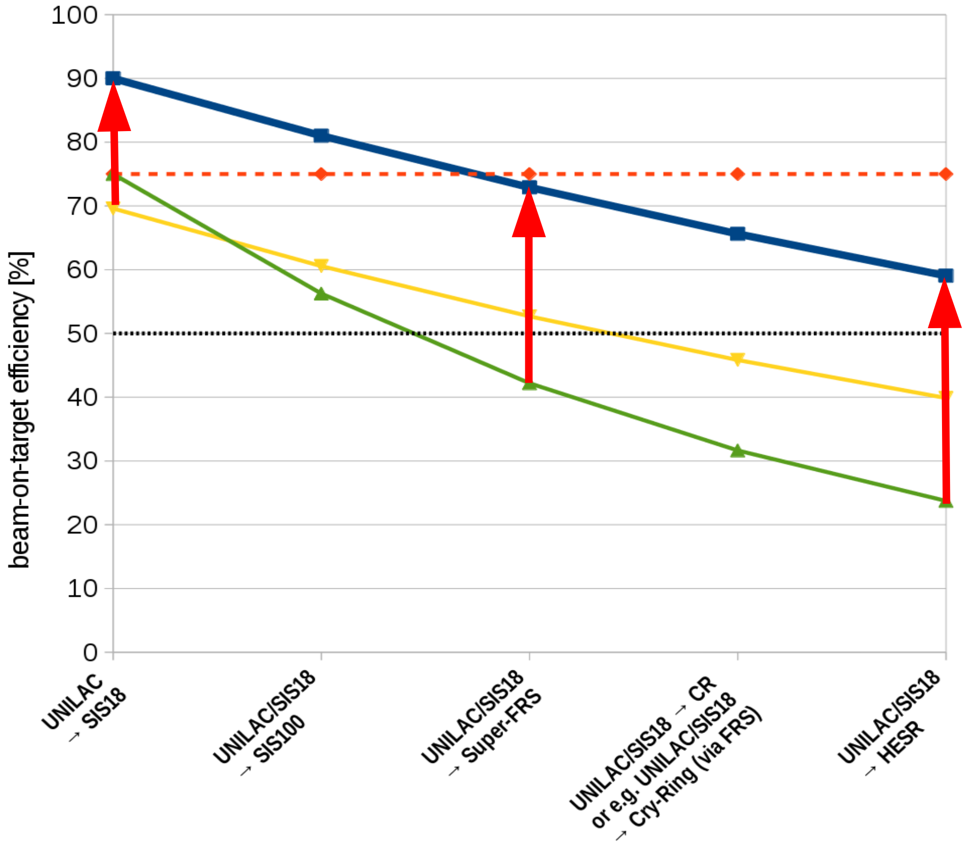
* 2018 operation limitations:
- only ½ UNILAC (w/o A3 & A4)
- only 1 element in SIS18

FAIR Challenges & Constraints

… SIS18 Operation Experience & Efficiency

- Beam-on-Target figure of merit (FoM) of ~75% → FAIR-BoT (efficiency ε_{FAIR}):

$$\varepsilon_{FAIR} := \prod_{i}^{n_{machines}} \varepsilon_i = \varepsilon_{UNILAC} \cdot \varepsilon_{SIS18} \cdot \varepsilon_{SIS100} \cdot \varepsilon_{SuperFRS} \cdot \varepsilon_{CR} \cdot \varepsilon_{HESR} \cdot \ldots$$

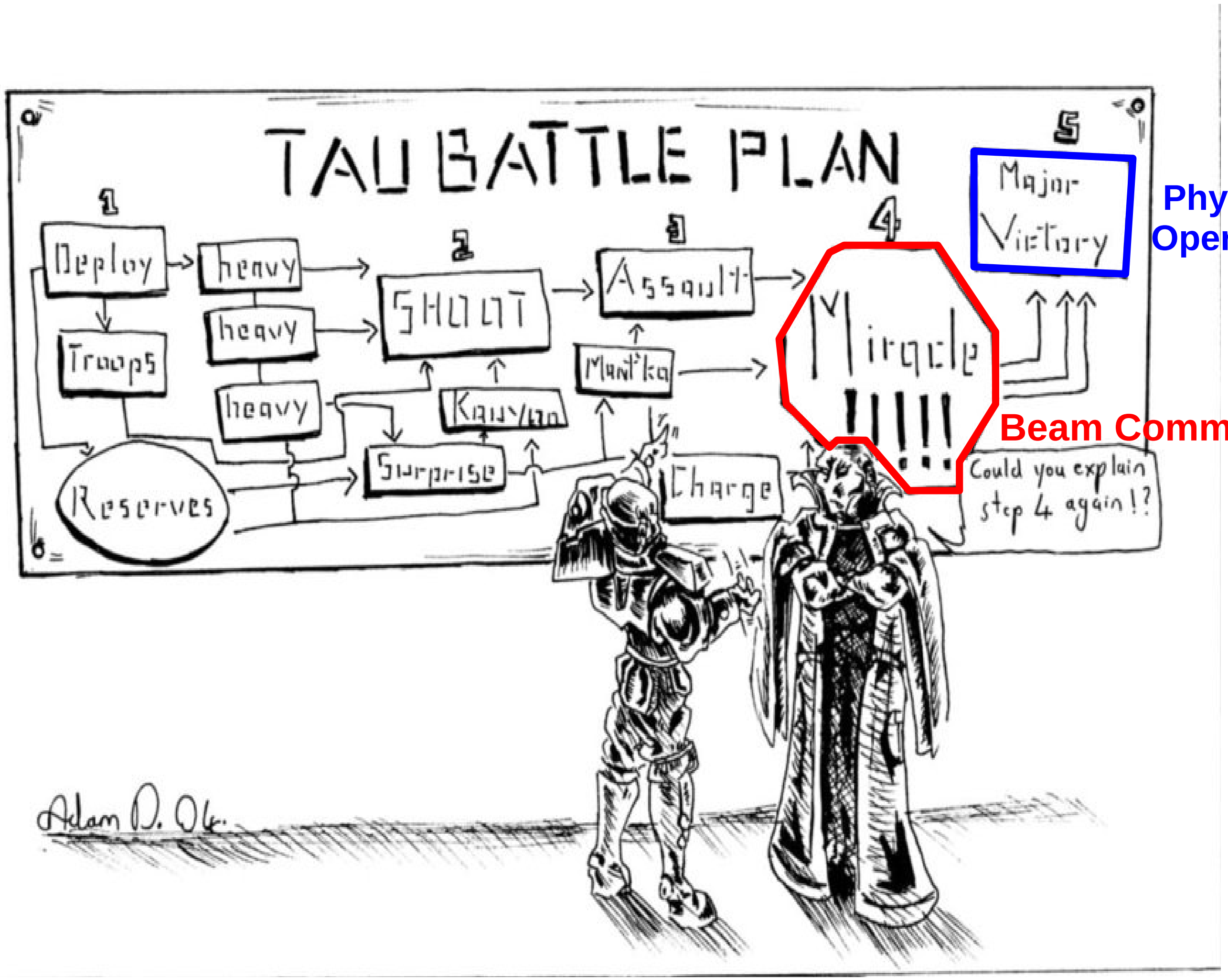


+ new operational challenges:

operating beyond present beam parameter envelope, x10-100 higher intensities, x10 higher energies → machine protection & losses/activation become an issue

"… have to improve!"

Plan of Action



Need to be more explicit w.r.t. 'item 4' for commissioning and operation of FAIR.

Fundamental FC^2-Principles: Reworking, re-optimisation is inefficient and costly

Proposal to follow a long-term strategy and 'lean principles':

- Continuous improvement
  - Right processes to produce right results and for getting it right the first time
    - *commissioning procedures as evolving operation standard*
    - system integration: definition of what, how and when (prioritisation) is needed
  - Prevention of inefficiencies, inconsistencies & waste by design
    - 'poka-yoke' or 'error proofing' principle – culture of stopping and fixing
      1. early, when and where they occur (at the source)
      2. with low-intensity beam rather than with high-intensity beam
      3. addressing first basic parameters before complex higher-order effects
    - Examples:
      - first fix injection, trajectory, orbit, Q/Q' before addressing space-charge or slow-extraction problems
      - important losses for low-intensity beam have larger impact for high-intensity beam (↔ activation)
        - pilot-beam concept: always verify machine safety with low-intensities before moving on to high-intensity beams

- Respect for people – “develop people, then build products”
  - optimise operation ↔ smart tools & procedures, e.g. beam-based feedbacks, sequencer, …
    - automate routine task so that operator talents are utilised and focused on more important tasks
  - training, investment in and development of people – minimise overburden/strain of personnel
  - FAIR is a large facility and needs wider support: communicate concepts and strategy to broader base → FC^2WG

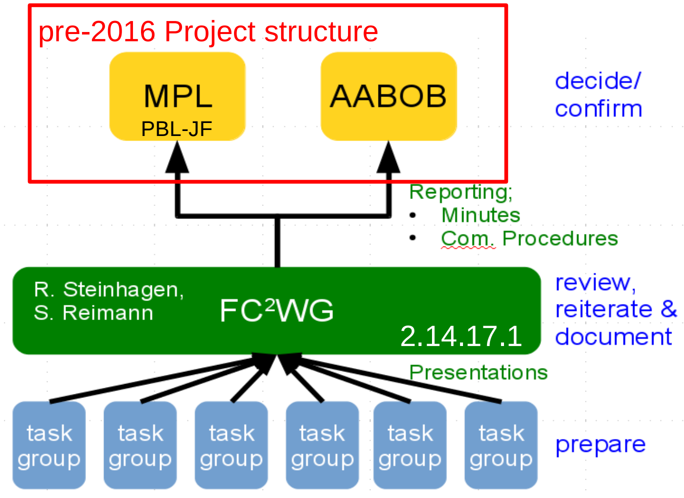
FAIR Commissioning & Control Project

project lead: R. Steinhagen (deputy: S. Reimann), since PBL-JF 21.03.2015, project ID: 2.14.17

Scope: coordination, development and follow-up of a coherent and sustainable concept, strategy and technical guide-lines/specifications for

1. Commissioning[1],
2. Control[2], and
3. Operation

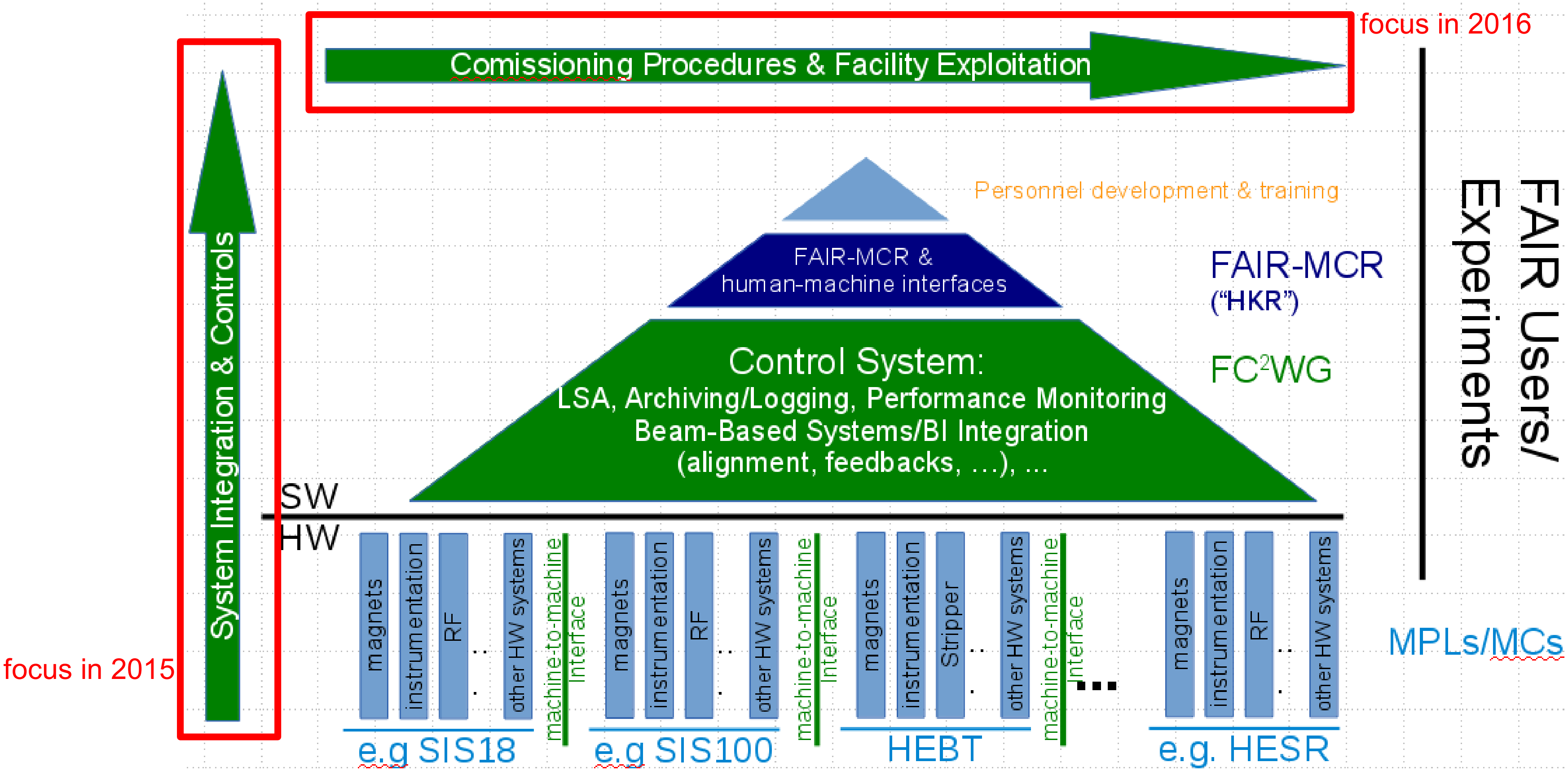
of the whole[3] FAIR Accelerator Complex



- Broken down into 2 Work Packages:
  - 2.14.17.1 FC²WG -- FAIR Commissioning & Control WG (link to: 2.14.10.1, 2.x.[3,4,6,7 & 12])
    - development, engineering check of the concepts and functional guidelines (acc. tech-experts, equip-GL)
    - EDMS signatory process:: MPL, MKs, main equip.-GL, head FC²WG (as approval leader)
  - 2.14.17.2 FCC-WG – FAIR Control Centre WG (link to: 2.14.10.10)
    - technical control room infrastructure: consoles, furniture, IT infrastructure, etc. (mainly CO-IN, OP, Exp-reps.)
    - Machine-Civil-Construction Interface (↔ 'Campus Master Plan')

[1] commissioning covering the initial commissioning, subsequent re-commissioning & assisted operation phases (prior to 'regular operation')
[2] N.B. 'control' here dt. “Anlagenkontrolle”
[3] including all existing GSI and future FAIR accelerators as well as machine-experiment specific CO interfaces (e.g. target steering, spill control, data exchange)

An accelerator is more than the sum of its parts:



- FAIR Commissioning & Control Working Group
  - platform to discuss, coordinate and work-out FAIR commissioning and operation
  - open to all who can participate and contribute to this subject!

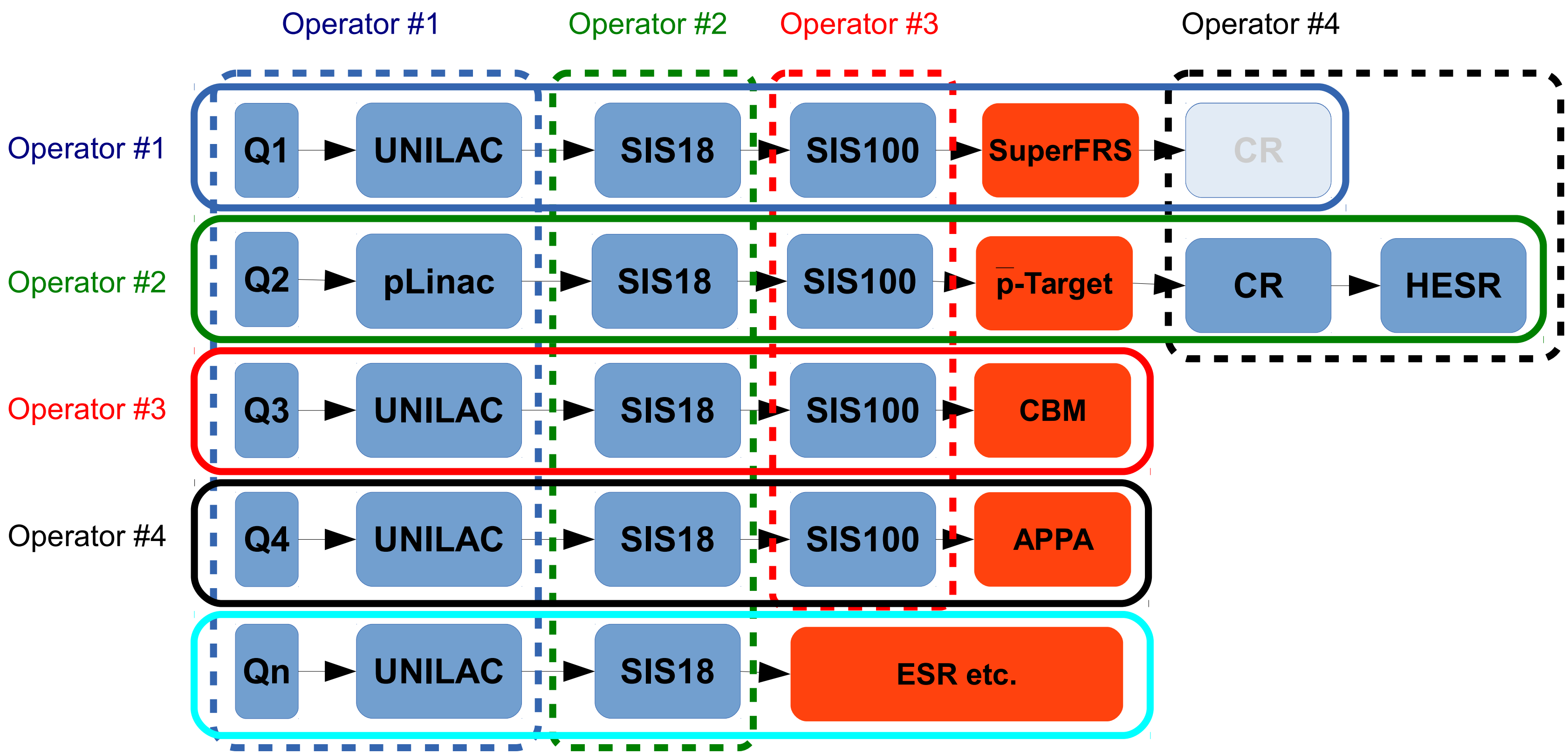
FC²WG Control Topics – more than “Control System” & Data Supply

- Facility & Interface Analysis
  - Procedures: HWC, HWC-'Machine Check Out', BeamCommissioning, BC-Stage A (pilot beams), BC-Stage B (intensity ramp-up), BC-Stage C (nominal/production operation) Beam parameters, FAIR performance model, optimisation, Accelerator & Beam Modes
- Beam Instrumentation & Diagnostics – System Integration
  - Intensity (DCCTs) & beam loss (BLMs) → Beam Transmission Monitoring System (BTM), trajectory & orbit (BPMs), Q/Q', optics (LOCO & phase-advance), longitudinal & transverse emittance (FCTs. WCM, screens, IPM, etc.), Δp/p, long. bunch shape (FCTs, Tomography), abort gap monitoring, ...
- Accelerator Hardware – System Integration
  - Power converter, magnets, magnet model, RF, injection/extraction kicker, tune kicker/AC-dipole, beam dump, collimation/absorbers, cryogenics, vacuum, radiation monitoring, k-modulation, machine-experiment interfaces
- Control System
  - Archiving system, analog signal acquisition, test-beds, timing, bunch-to-bucket transfer, cyber security, role-based-access, middleware, RT & Feedbacks, daemons
- Components
  - post-mortem, management of critical settings (safe-beam settings), machine protection, interlocks, beam quality checks, daemons, 'Page One', aperture model, ...
- Applications
  - Sequencer (semi-automated procedures), fixed-displays, ...
  - Beam-Based Applications, Cycle-to-Cycle Feedbacks & GUIs → second talk

FAIR Operation/Control Paradigm

- Some important OP boundary conditions:
  A) Compared to GSI, FAIR facility size and complexity increases roughly by a factor 4
  B) Expect some improvement but 'Operator' & 'System Expert' will likely remain a scarce resource

- One strategy item: 'One Operator per Accelerator Domain' vs. 'One Operator per Experiment':



Accelerator and Beam Modes

Accelerator & Beam Modes

- Purpose:
  - Communication of intended accelerator operation to experiments, FAIR and wider community
    - what to expect and when, beam time performance tracking & analysis
  - Conditioning of control sub-system responses
    - e.g. logging, interlocks, management of critical settings (MCS & RBAC), machine sequencer, access system, …
    - associated rules of what is allowed, when, where etc. e.g.:
      - Limit parameter changes during data taking – aka. 'Stable Beams'/'Production Runs'
      - No high-intensity beam injected into an 'empty' machine
      - Block certain operation during unsafe mode of operation

- Main modes:
  1) Accelerator (Machine) Modes
     - covering rule sets outside of beam operation
     - defined per accelerator/transfer-line segment
  2) Beam Modes
     - covering rule sets during beam operation
     - defined per accelerator/transfer-line segment <u>and</u> beam-production-chain

- proposal: extend this concepts also to experiment targets
  - required for safe primary-beam intensity ramp-up & OP-Exp. Ha
  - more fine-grained options for facility availability, performance tra

Quality Management	Document Type:	Document Number: F-TC-C-07	Date: 02.10.2015
FAIR @ GSI	**Technical Concept**	Template Number:	Page 1 of 15

Document Title:	**Accelerator and Beam Modes**
Description:	Technical Concept for definition and integration of Accelerator Modes and Beam Modes in the accelerator control system
Division/Organization:	CSCO, PBSP
Field of application:	Project FAIR@GSI, existing GSI accelerator facility
Version	V 0.2

Abstract

This technical concept proposes two fundamental modes: the *'accelerator mode'* covering rule sets and operational sequence outside of beam operation and that are defined per accelerator or beam-line section (e.g. shutdown, setup, physics run, etc.); and the *'beam mode'* covering rule sets during beam operation and that are defined per accelerator or beam-line section <u>and</u> Beam-Production-Chain (e.g. no beam, pilot beam, stable beam, etc.).

The purpose of these modes is to communicate the intended accelerator operation, and to condition the various control sub-system responses (e.g. archiving, interlock and fast-beam-abort systems, management of critical settings, etc.). The accelerator control system will distribute this information to the accelerator devices, experiments and wider FAIR community.

Prepared by:	**Checked by:**	**Approved by MPLs + Mks:**
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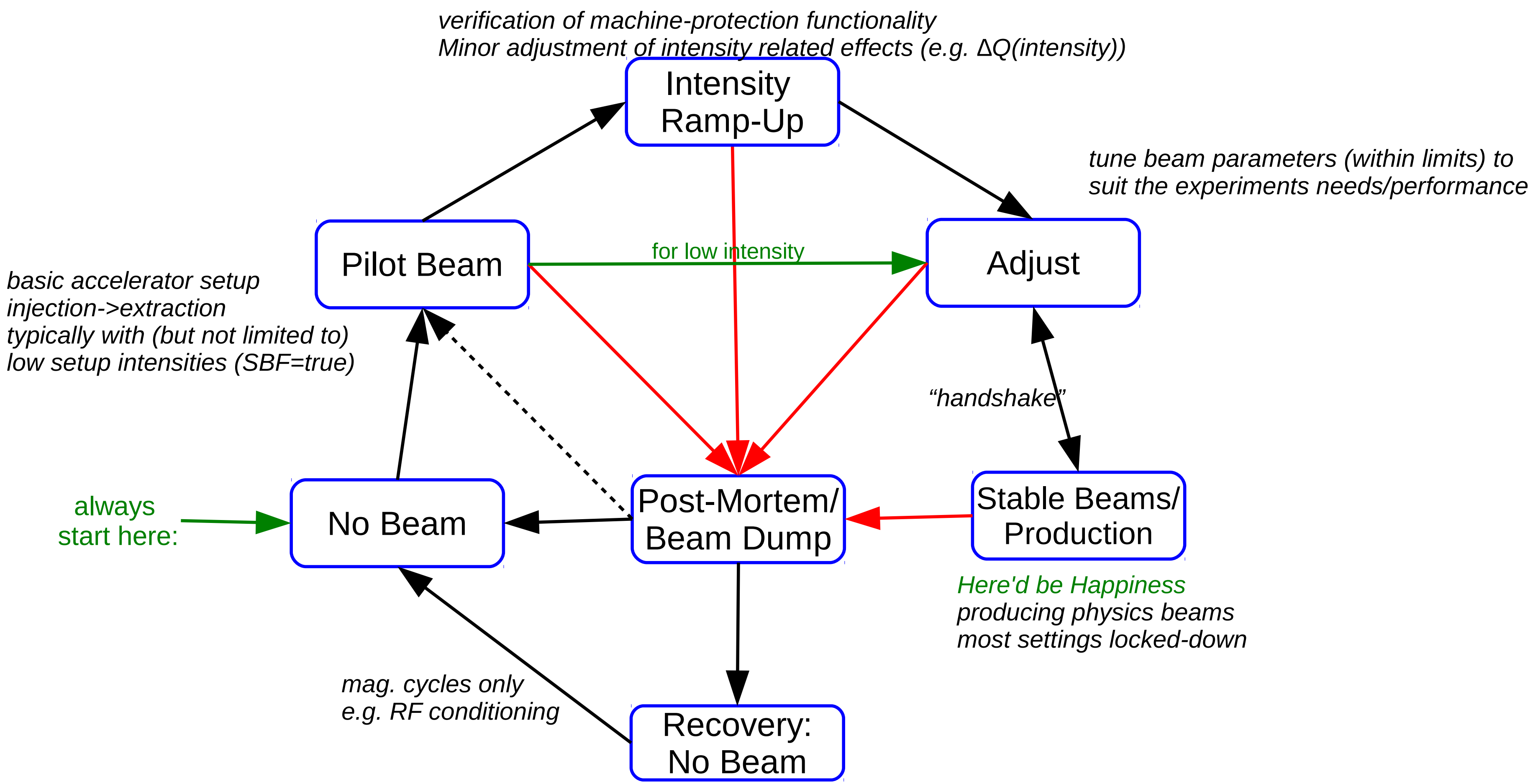
FAIR Beam Modes – State Diagram



normal operational path
error/fault case
low-intensity

cool down + cycling after
magnet quench or main PS failure
N.B. beam mode = machine mode

N.B.:
1) omitted arrows to 'No Beam'/'Pilot Beam' for better visibility (always possible)
2) modes follow existing normal setup routine, initial transition acknowledged by operator, subsequent driven automatically by sequencer

FAIR Archiving System I/II

- *… collect and store all pertinent accelerator data centrally to facilitate the analysis and tracking of the accelerator performance as well as its proper function.*

- Combined Archiving and Post-Mortem storage concepts
- Aim at storing maximum reasonable amount of data
  - facilitates data mining (performance trends, rare failures, …)
  - key to understanding and improving accelerator performance
- Milestones:
  - Conceptual prototype for 2016/17 (in-kind)
  - Aim at testing this for > 2018

Quality Management	Document Type:	Document Number: F-DS-C-11e	Date: 2016-07-11
FAIR	Detailed Specification	Template Number: Q-FO-QM-0005	Page 1 of 24

Document Title:	Detailed Specification of the FAIR Accelerator Control System Component "Archiving System"
Description:	This document is the Detailed Specification of the accelerator control system component 'Archiving System'. Its task is to collect and store all pertinent accelerator data centrally to facilitate the analysis and tracking of the accelerator performance as well as its proper function.
Division/Organization:	CSCO
Field of application:	FAIR Project, existing GSI accelerator facility
Version	V 4.5

Prepared by:	Checked by:	Approved by:
V. Rapp R. Steinhagen	**FAIR-C2WG-ALL** A. Reiter (BI) M. Schwickert (BI) S. Jülicher (CO) J. Fitzek (CO) S. Reimann (OP) P. Schütt (OP) C. Omet (SIS-100 MP) D. Ondreka (System Planning) I. Lehmann (Machine-Exp.) D. Severin (Machine-Exp.) **MPLs & MCs***	R. Bär (Controls) R. Steinhagen(FAIR Comm. & Control)

Archiving

Post-Mortem

Final Engineering Check!
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https://fair-wiki.gsi.de/FC2WG/

Beam Transmission Monitoring (BTM)
– Problem Definition –

Ion-Source

$$I_{source}(t)=\frac{dN_{source}(t)}{dt}$$

transmission

un-controlled losses

controlled losses

Fast current transfomer (FCT)
DC current transformer (DCCT)

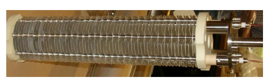
Experiment

primary (secondary)
ions-on-target/s

$$I_{target}(t)=\frac{dN_{target}(t)}{dt}$$

DCCT
/FCT
counter

$$\frac{dN_{collimator}(t)}{dt}$$



dynamic vacuum, ε-blow-up/tails, slow-extraction, ...
→
cryo- & beam-halo collimators, rad-hard magnets, extra shielding, ...

less-avoidable losses
(may need to accept a given amount)

$$\frac{dN_{loss}(t)}{dt}$$

beam instabilities, aperture constraints, slow beam drifts across e-septa
→
activation & machine protection

avoidable losses
(ALARA: should minimise before MP & Activation limits kick in)

online dosimetry (abs. reference)

§§ Radiation Permit – limits on total dose per year (facility & external)

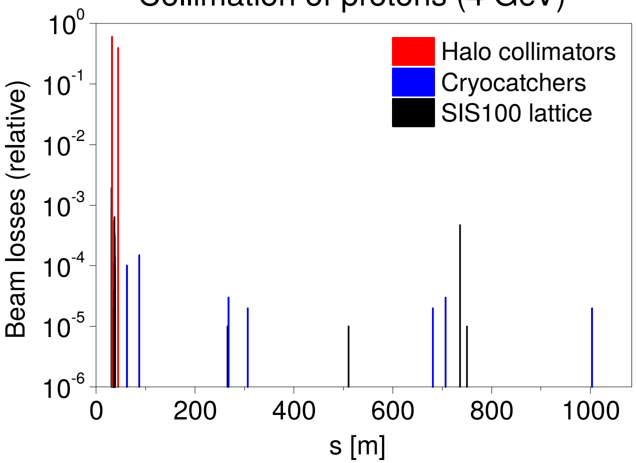
Ivan Strasik @ HIC4FAIR'2015: Tolerable Beam Losses in SIS100

- SIS100 beam parameters and equivalent to 1 W/m (number of particles)

Beam	Injection energy	Extraction energy	1 W/m equivalent (injection)	1 W/m equivalent (extraction)	Beam intensity
Protons	4 GeV	29 GeV	1.5×10^{9}	2.1×10^{8}	2×10^{13}
$^{40}Ar^{18+}$ ions	1.6 GeV/u	12 GeV/u	1×10^{8}	1.3×10^{7}	1×10^{11}
$^{238}U^{92+}$ ions	1.3 GeV/u	10 GeV/u	2×10^{7}	2.5×10^{6}	1.5×10^{10}

- From the beam loss maps tolerable beam losses* (% of the beam) can be identified.

Collimation of protons (4 GeV)



*assumes 10s proton cycle & activation limit only

Beam	Loss criteria (injection)	Loss criteria (extraction)	Tolerable losses (injection)	Tolerable losses (extraction) *
Protons	1 W/m	1 W/m	10 %	5 %
$^{40}Ar^{18+}$ ions	2 W/m	1 W/m	30 %	6 %
$^{238}U^{92+}$ ions	4 W/m	2 W/m	20 %	10 %

Caution: '1 W/m' is only indicative!
existing operation, shielding and radiation permit limits proton losses to <3% @ 29 GeV and nominal intensities!
→ should aim to be significantly below that limit (ALARA)

*for comparison: CERN-PS: 4-8% losses achieved (data courtesy R. Steerenberg, 19th March 2012)
Caution: for protons this implies near-perfect two-stage collimation system

Beam Transmission & ALARA

- Importance of Beam Transmission Monitoring:
  1.) Performance: key accelerator tuning parameter & *"Every ion lost in the accelerator is an ion lost for physics"*
  2.) Machine-Protection: minimising risk of combined failures & reducing stress on MP system, before losses become an operational issue
  3.) ALARA: minimisation of activation and radiation permit compliance

- Gretchen Frage: What are 'As-Low-As-Reasonably-Achievable' Losses?
  - 'golden standard': should exhaust reasonable common operation practices of controlling beam parameter known to induce particle loss ("KISS in mind" – 'actual risk mitigation' vs. 'operational availability'):
    - A) **low-intensity beams**: extraction/injection matching + closed-orbit cycle-to-cycle feedbacks control + tune & chromaticity control + emittance blow-up monitoring
    - B) **high-intensity beams**: <the above> + optics correction + detailed collimation + quantitative slow-extraction optimisation + …
  - → 'acceptable losses' := losses remaining after having performed above pre-defined steps

- Real-World Challenge:
  - May not achieve required BTM performance using beam current transformers alone, or would need to impose unrealistic BI design parameters
    - ‰-level resolutions for stable beam conditions achievable but accuracy typically only 1-3% abs.
  - → Include BLMs and RadMons as complementary input to BTM system
    - single BLM resolution: 0.1%@injection down to 10^{-6}@extr. for $1.5\cdot10^{11}$ U^{28+}/s lost on septa wires

Specification to be completed by Q4-2016
Presentations & draft copies on:
https://fair-wiki.gsi.de/FC2WG/

≠

FAIR one-of-a-kind prototype,
pushing the ion intensity & other limit

↓

Should maintain realistic goals
& strategy how-to reach them

FAIR Commissioning Procedure I/II

- Develop a (initial/re-)commissioning and operation strategy:
  - MoU between various stake-holders (AP, BI, CO, RF, ...)
    - define when, where and how the individual accelerator systems should fit in
  - Identify and define missing procedures, equipment and tools, e.g.:
    - define, check the need or priority of applications vs. 'use cases'
    - define, check integration and interface between specific equipment and CO/OP environment
  - Focus first on commonalities across then specifics within individual accelerators
    - MPLs/MCs define pace & resources of how fast to achieve the above
  - Dissemination/knowledge transfer from groups that constructed and performed the initial HW commissioning to the long-term operation
    - training of operational crews (physics, operation, tools, ...)
  - Scheduling tool for technical stops to follow-up possible issues found

*Procedure aims not only at the initial first but also subsequent re-commissioning e.g. after (long) shut-downs, mode of operation changes and/or regular operation

FAIR Commissioning Procedure II/II

https://fair-wiki.gsi.de/FC2WG/HardwareCommissioning/

- Distinguish two forms of 'commissioning':

  A) Hardware Commissioning (HWC → SAT A)

  - conformity checks of the physical with contractual design targets,
  - || commissioning of individual systems & tasks ↔ MPLs/equipment group responsibility

  B) Commissioning with Beam (BC → “SAT B” …)

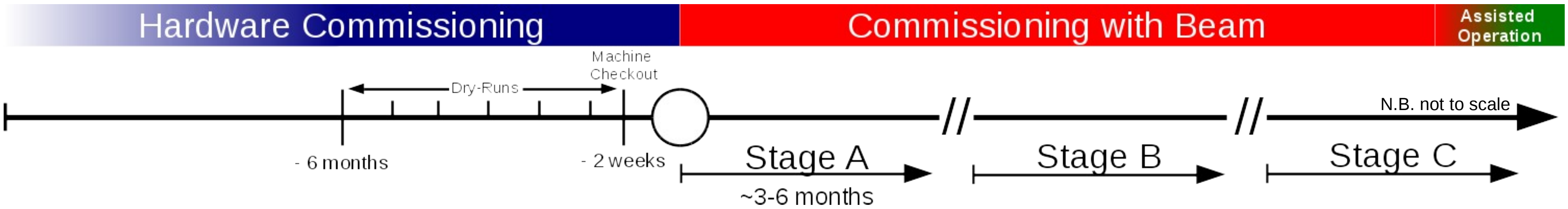
  - Commissioning of beam-dependent equipment
  - Focus on tracking beam progress through the along the beam production chain (BPC)
    - threading, injection, capture, acceleration and extraction
  - + 'Dry-Runs': pre-checks at the end of HWC in view of beam operation:
    - Checks conformity of system's controls integration and readiness for Commissioning with Beam
    - check as much control/system functionality without beam as possible
    - Machine ist put into a state assuming that beam could be injected into the ring/segment
      - unavailable devices/systems are at first ignored, noted down, and followed-up at a defined later stage

Terminology:

- **Dry-runs**: a rehearsal of the accelerator performance/function, starting typically six month before the targeted real BC
  - needs to (partially) repeated after shut-down or longer technical stop with substantial modifications
  - initial frequency: 1-2 days every month
  - frequency increased depending on the outcome of the initial dry-run tests
- **Machine-Checkout**: intense accelerator performance tests (e.g. machine patrols, magnet/PC heat runs, etc.), typically two weeks before BC
  - needs to repeated after every shut-down or longer technical stop
  - repeated also on the long-term during routine operation of existing accelerators (already existing procedures/usus for existing machines)

Commissioning with Beam

https://fair-wiki.gsi.de/FC2WG/BeamCommissioning



- Split Beam Commissioning into three stages:

A) Pilot beams/"easily available" ions (e.g. U28+, Ar)

- basic checks: threading, injection, capture, cool, convert, acceleration/decelerate, stripping & extraction
- always done with 'safe' ie. low-intensity/brightness beam
  - Ions: simpler optics, beam dynamics → Protons: transition crossing

B) Intensity ramp-up & special systems

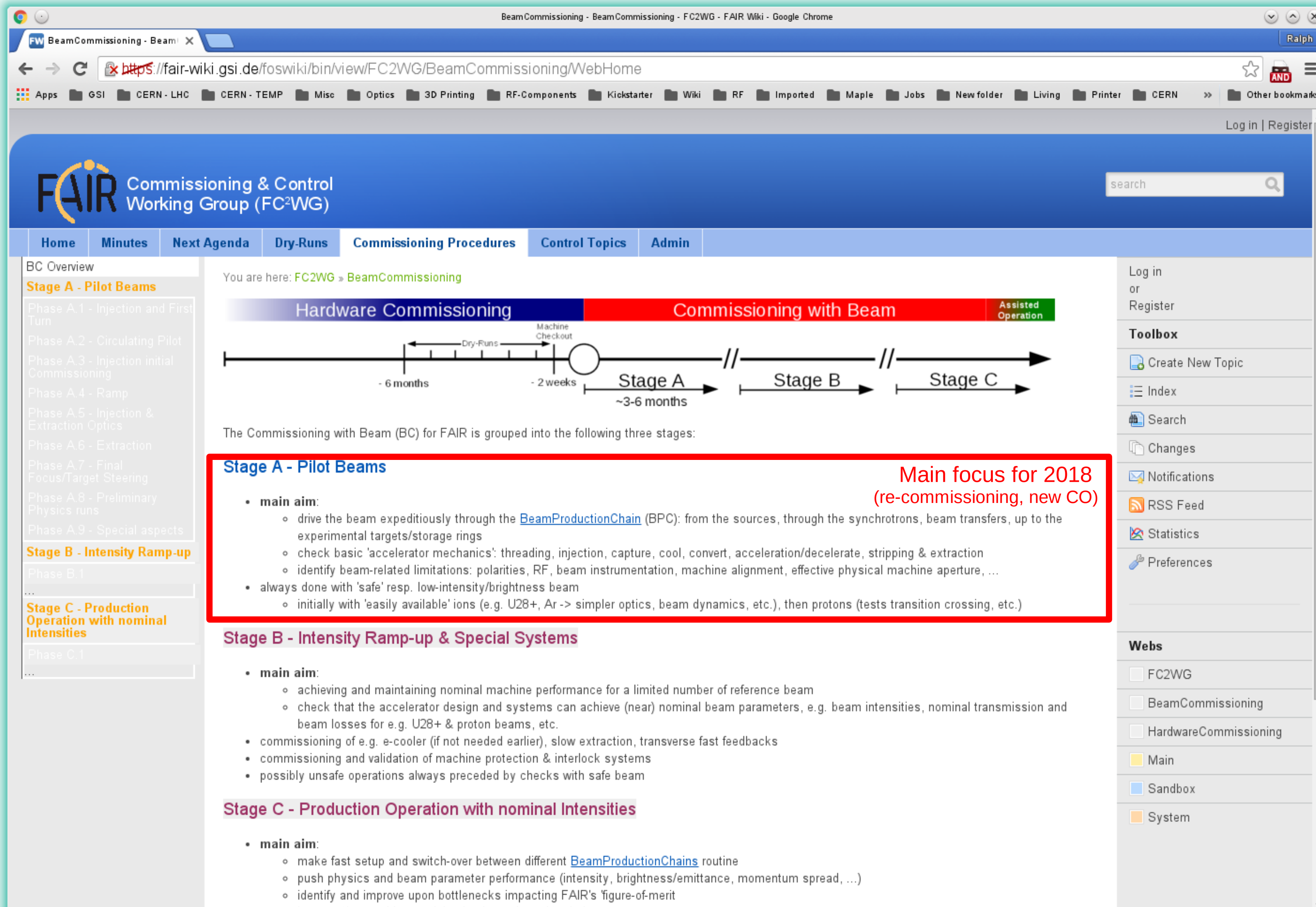
- achieving and maintaining of nominal transmission and beam losses
- commissioning of e.g. e-cooler, slow extraction, transverse fast feedbacks
- commissioning and validation of machine protection & interlock systems
- Possibly unsafe operations always preceded by checks with safe beam

C) Production operation with nominal intensities
(N.B. first time counted as 'commissioning' or 'assisted operation' → later: 'regular operation')

- push physics and beam parameter performance (emittance, momentum spread, ...)
- identify and improve upon bottlenecks impacting FAIR's 'figure-of-merit'
- make fast setup and switch-over between different beam production chains routine

Example: FAIR Commissioning Procedures

https://fair-wiki.gsi.de/FC2WG/BeamCommissioning



The Commissioning with Beam (BC) for FAIR is grouped into the following three stages:

Stage A - Pilot Beams

Main focus for 2018 (re-commissioning, new CO)

- **main aim**:
  - drive the beam expeditiously through the BeamProductionChain (BPC): from the sources, through the synchrotrons, beam transfers, up to the experimental targets/storage rings
  - check basic 'accelerator mechanics': threading, injection, capture, cool, convert, acceleration/decelerate, stripping & extraction
  - identify beam-related limitations: polarities, RF, beam instrumentation, machine alignment, effective physical machine aperture, ...
- always done with 'safe' resp. low-intensity/brightness beam
  - initially with 'easily available' ions (e.g. U28+, Ar -> simpler optics, beam dynamics, etc.), then protons (tests transition crossing, etc.)

Stage B - Intensity Ramp-up & Special Systems

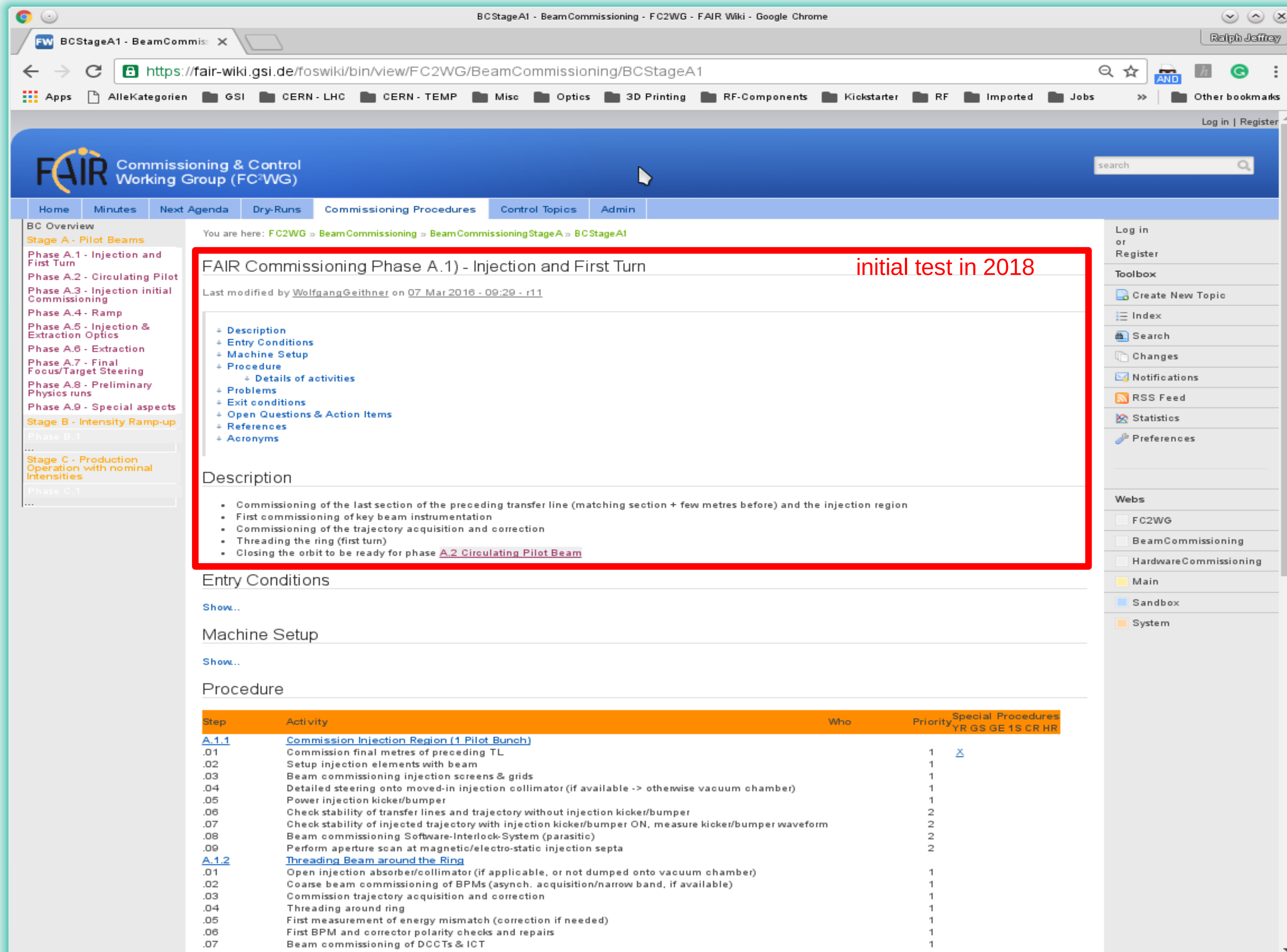
- **main aim**:
  - achieving and maintaining nominal machine performance for a limited number of reference beam
  - check that the accelerator design and systems can achieve (near) nominal beam parameters, e.g. beam intensities, nominal transmission and beam losses for e.g. U28+ & proton beams, etc.
- commissioning of e.g. e-cooler (if not needed earlier), slow extraction, transverse fast feedbacks
- commissioning and validation of machine protection & interlock systems
- possibly unsafe operations always preceded by checks with safe beam

Stage C - Production Operation with nominal Intensities

- **main aim**:
  - make fast setup and switch-over between different BeamProductionChains routine
  - push physics and beam parameter performance (intensity, brightness/emittance, momentum spread, ...)
  - identify and improve upon bottlenecks impacting FAIR's 'figure-of-merit'

Example: FAIR Commissioning Procedures

https://fair-wiki.gsi.de/FC2WG/BeamCommissioning



Commissioning & Control Working Group (FC²WG)

Home | Minutes | Next Agenda | Dry-Runs | Commissioning Procedures | Control Topics | Admin

You are here: FC2WG » BeamCommissioning » BeamCommissioningStageA » BCStageA1

FAIR Commissioning Phase A.1) - Injection and First Turn

initial test in 2018

Last modified by WolfgangGeithner on 07 Mar 2016 - 09:29 - r11

- Description
- Entry Conditions
- Machine Setup
- Procedure
  - Details of activities
- Problems
- Exit conditions
- Open Questions & Action Items
- References
- Acronyms

Description

- Commissioning of the last section of the preceding transfer line (matching section + few metres before) and the injection region
- First commissioning of key beam instrumentation
- Commissioning of the trajectory acquisition and correction
- Threading the ring (first turn)
- Closing the orbit to be ready for phase A.2 Circulating Pilot Beam

Entry Conditions

Show...

Machine Setup

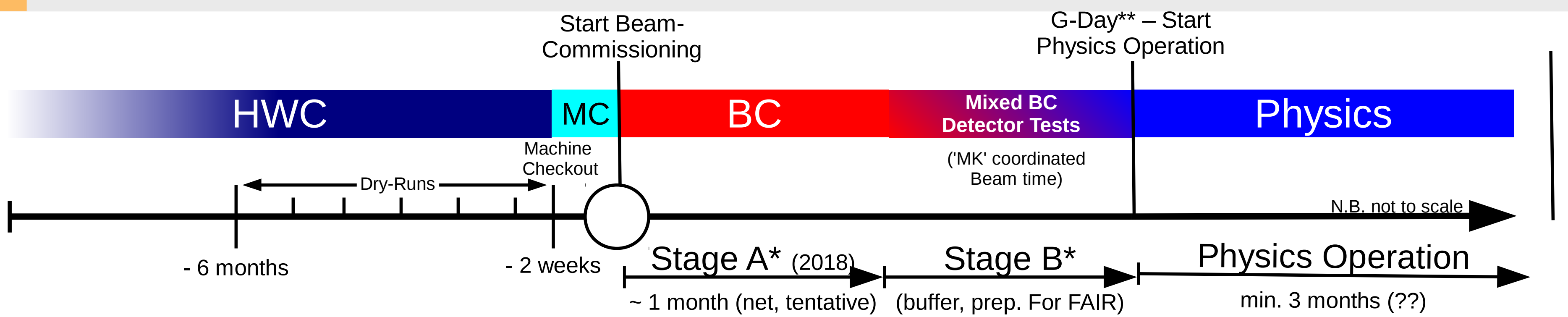
Show...

Procedure

Step	Activity	Who	Priority	Special Procedures YR GS GE 1S CR HR
A.1.1	Commission Injection Region (1 Pilot Bunch)			
.01	Commission final metres of preceding TL		1	X
.02	Setup injection elements with beam		1	
.03	Beam commissioning injection screens & grids		1	
.04	Detailed steering onto moved-in injection collimator (if available -> otherwise vacuum chamber)		1	
.05	Power injection kicker/bumper		1	
.06	Check stability of transfer lines and trajectory without injection kicker/bumper		2	
.07	Check stability of injected trajectory with injection kicker/bumper ON, measure kicker/bumper waveform		2	
.08	Beam commissioning Software-Interlock-System (parasitic)		2	
.09	Perform aperture scan at magnetic/electro-static injection septa		2	
A.1.2	Threading Beam around the Ring			
.01	Open injection absorber/collimator (if applicable, or not dumped onto vacuum chamber)		1	
.02	Coarse beam commissioning of BPMs (asynch. acquisition/narrow band, if available)		1	
.03	Commission trajectory acquisition and correction		1	
.04	Threading around ring		1	
.05	First measurement of energy mismatch (correction if needed)		1	
.06	First BPM and corrector polarity checks and repairs		1	
.07	Beam commissioning of DCCTs & ICT		1	

Recommissioning & Operation in 2018 I/II

https://fair-wiki.gsi.de/FC2WG/HardwareCommissioning/

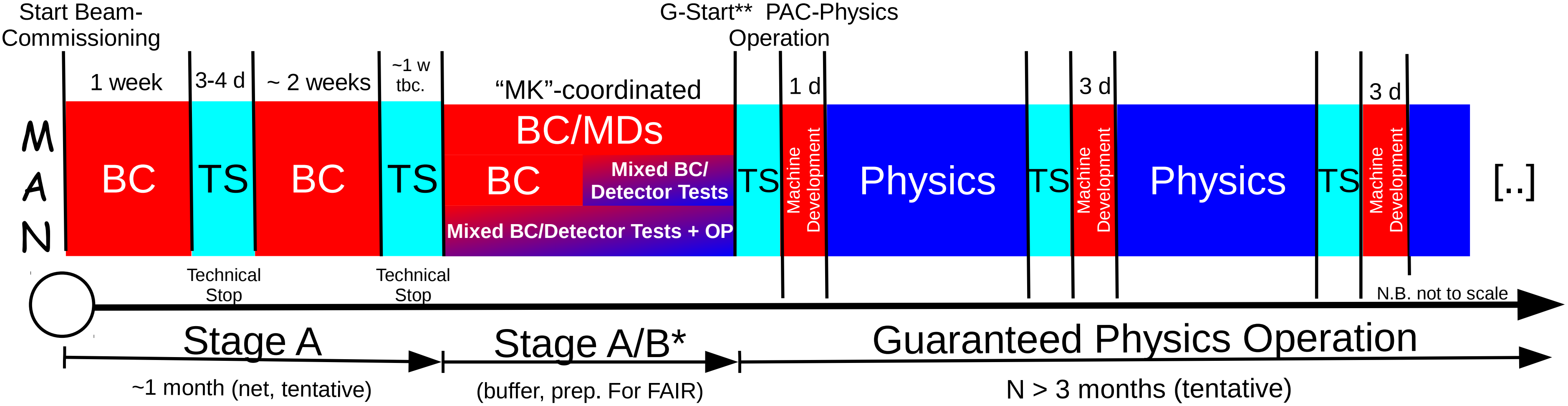


- Hardware Commissioning → coordinated by Sub-Project-Leaders & Machine Coordinators
  - link-existing facilities (GAF), upgrades, machine re-alignment, “SATs”, HW systems (equip. groups),
- Dry-Runs – for all machines post (possibly also UNILAC), each two days, fixed dates (↔ experts availability), starting:
  - Dry-Run #1 – 17.10.2017: CO-core: LSA, Timing System, Archiving System, SCUs, CO core application, …
  - Dry-Run #2 – 14.11.2017: as before + tbd.
  - Dry-Run #3 – 12.12.2017: as before + tbd.
  - Dry-Run #4 – 09.01.2018: as before + BI + related applications
  - Dry-Run #5 – 06.02.2018: as before + Experiments (proposal) + Machine-Experiment Interfaces
  - Dry-Run #6 – 20.02.2018: as before + AEG + “last-minute” checks
  - Dry-Run #7 – 06.03.2018: buffer
- Machine-Checkout – intensive “last minute checks” (N.B closed tunnel/machine):
  - UNILAC: -1 month → BC- 'day 0'
    - patrols, heat runs: RF & power supply conditioning, ...
  - SIS, ESR, CRY: -3 weeks → BC- 'day 0'
    - patrols, heat runs: RF & power supply/AEG conditioning, safety systems: personnel safety, access system, legal ZKS & RP checks (§66 Abs. 2 StrlSchV), “very last-minute” checks/bug fixes: vacuum, power, BI, CO, ...

* in 2018: light-version w.r.t. commissioning of new machines
** “guaranteed” start physics operation (Plan A), no hick-ups, sacrificial buffer being activities related to 'Stage B'

Recommissioning & Operation in 2018 II/II

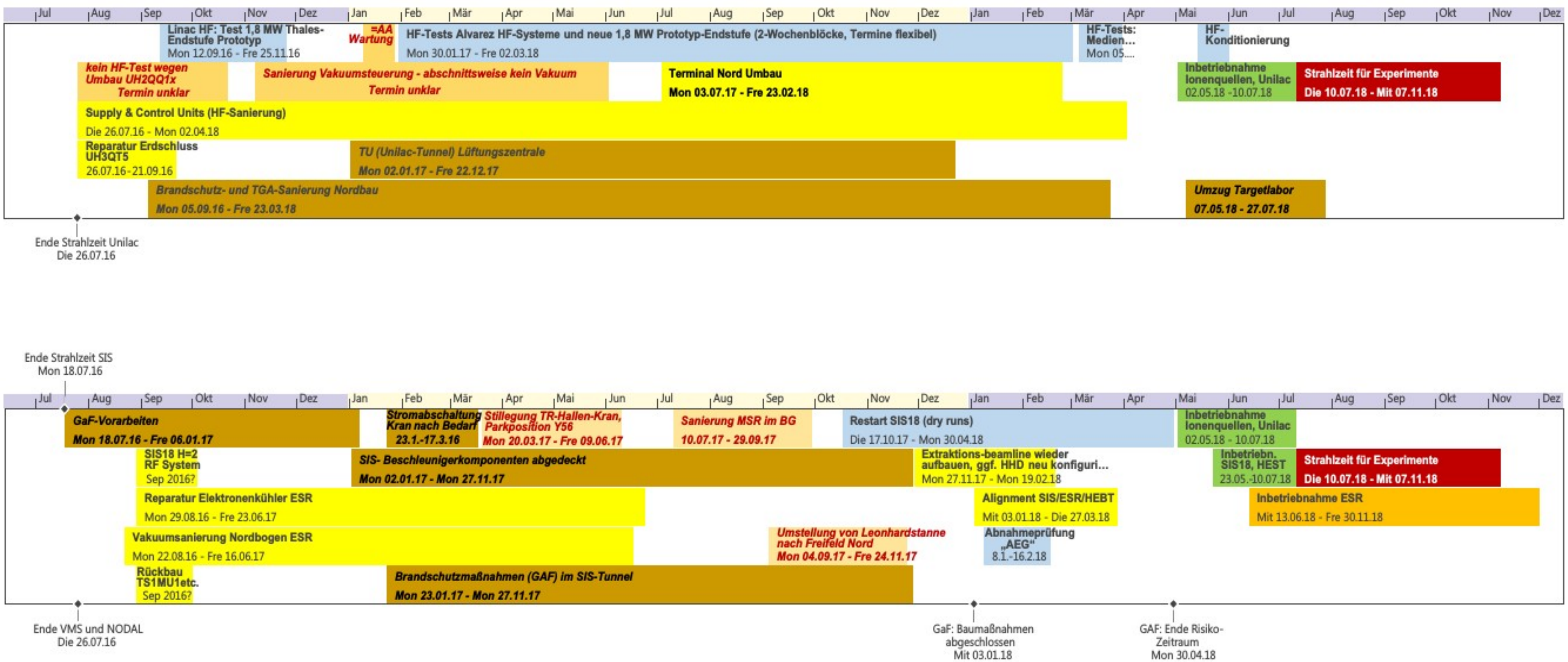
https://fair-wiki.gsi.de/FC2WG/BeamCommissioning



- Stage-A: Initial Beam Commissioning (BC): 2 dedicated 3 week@24h/7 BC blocks, main aim:
  - drive beam expeditiously through the Beam Production Chain: sources → synchrotrons & beam transfers → exp. targets & storage rings
  - check basic 'accelerator mechanics': threading, injection, capture, cool, convert, acceleration/decelerate, stripping & extraction
  - identify beam-related limitations: polarities, RF, beam instrumentation, machine alignment, effective physical machine aperture, ...
- Immediately followed by dedicated, scheduled Technical Stop (TS)
  - needed for follow-up of HW (tunnel) and SW issues (CO, …)
- Stage-A/B*: Mixed-BC, Machine-Development, Detector Tests (aka. "splash events" for experiments) & Operator Training
  - N.B. "old machine" but completely new CO, substantial modifications
- Physics operation: as promised/targeted nett 3 months (to be confirmed), grouped into 2-3 blocks interleaved with
  - TS: routine maintenance → increases overall availability, follow-up of OP/CO/equipment issues + major ion species/source changes
  - MDs: follow-up of beam physics issues, CO improvements (e.g. beam-based FBs), improve facility to reach nominal FAIR parameters
    - N.B. also better for guaranteeing smooth restart/picking-up of physics operation after technical stops (experts availability)

Shut-down Planning → 2018

P. Schütt et al.



- **hellgrün: Inbetriebnahme**
- **hellblau: Gerätetest**
- **orange: Strahlzeit flexibel, ohne PAC-Vergabe**
- **gelb: Shutdownarbeit am Beschleuniger**
- ***kursiv, brauner Grund: Vorgabe von Bauprojekten (GAF, Brandschutz, etc.)***
- ***kursiv, rote Schrift: Vorgang behindert andere Arbeiten***

Detailed discussion in U. Weinrich's presentation

FAIR Accelerator Operation in 2018 – DRAFT – GSI

2018 Version vom 06.07.2016 (S.Reimann)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Einschränkungen für Experimentbetrieb
							FERIEN						
IQ	Shutdown				MC	BC MK	MK	BT	MK	TS	MK	Shutdown	keine
UNILAC	Shutdown		HF-Test		MC HC	BC MK	MK	BT	MK		MK		im Langpulsbetrieb nur A3 Energie
SIS18	SIS18 upgrade inkl. periodische Dry Runs				MC	BC MK	MK	BT	MK		MK		für 2-3 Monate max. 2 Experimente gleichzeitig
HEST	Periodische Dry Runs (3-4Tage am Stück)				MC	BC MK	MK	BT	MK		MK		keine
ESR	Periodische Dry Runs (3-4 Tage am Stück)					MC		BC	MK		MK		nur Speicherbetrieb mit interem Target
CRYRING	Periodischer Teststrahlbetrieb local (2x4 Wochen am Stück)						MC	BC					kein Experimentbetrieb möglich

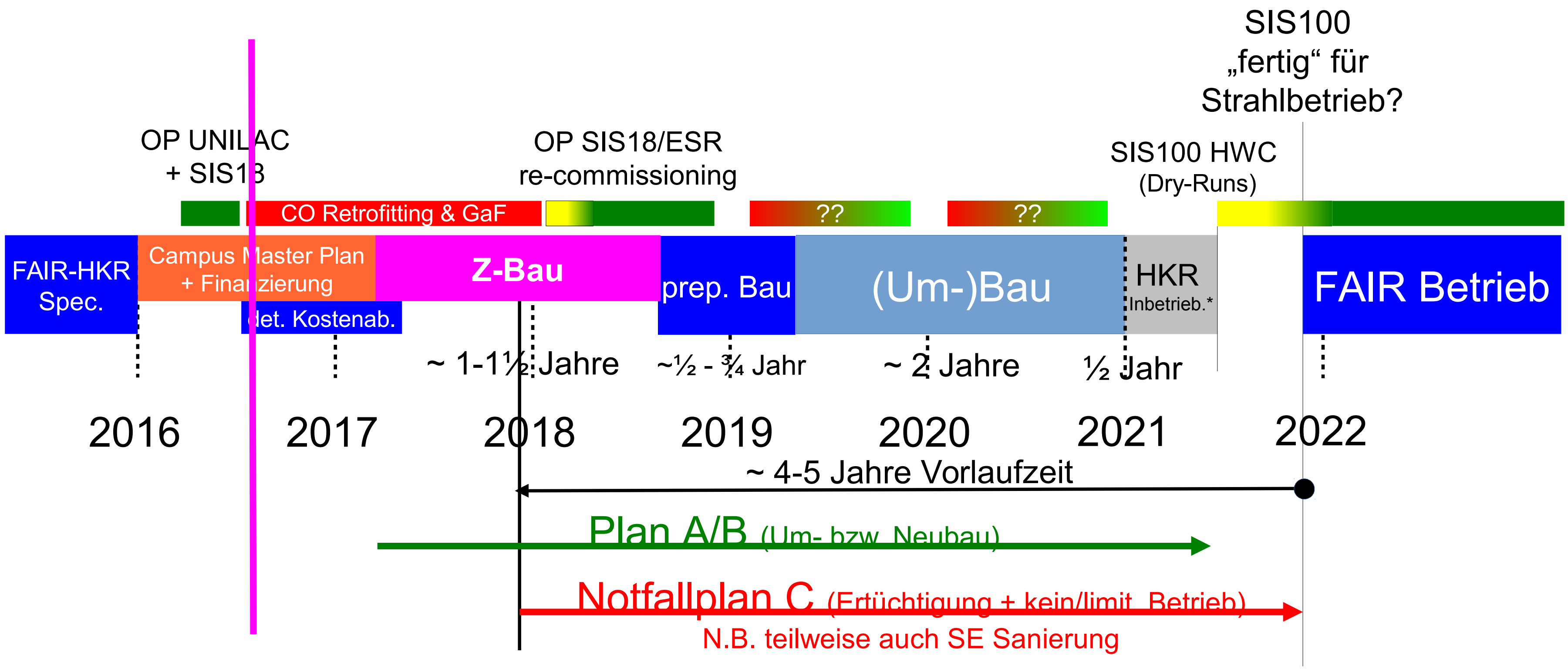
MC	Machine Checkout = Trockeninbetriebnahme incl. Kontrollsystem-/Betriebssoftware Inbetriebnahme
BC	Beam Commissioning = Inbetriebnahme mit Strahl / Inbetriebnahme Strahlwege (Primärstrahl) mit Pilotstrahl, timing System etc.
MK	flex. MK-Beamtime (Maschinenexperimente, Maschinenentwicklung, Geräteinbetriebnahmen, Operateursausbildung, FAIR-Detektorentwicklung, Qualifizierung+Referenzmessungen)
BT	Beamtime = Strahlzeit für PAC-Vergabe vorgesehen
TS	Flexible technische Strahlunterbrechung für Reparaturen, Softwareupdates usw. (als Block oder verteilt)
HC	HF-Konditionierung

First kick-off!
recurring workshop theme, summary, next steps by D. Severin, U. Weinrich et al. at the end

FAIR, can we do it?

Yes, we can!

FAIR Control Centre
HKR Upgrade – Update Q1-2016



2015-Q3: Spezifikation – OK? → GF Bericht?
2016-Q2: Meilenstein GSI Beschluss & Vorfinanzierung ??
2016-Q2/3: detaillierte Kostenabschätzung & Machbarkeitsstudie
2016-Q3/4: Bau-Vorplanung?

2017-Q1: Meilenstein Finanzierung (Vorbedingung Z-Bau)
2017-Q1: UNILAC/SIS18/ESR Migrationsstrategie (digitalisierung analoge Signale)

* HKR Inbetriebnahme == Arbeiten zur Bezugsfertigkeit (Einbau Konsolen, etc.)