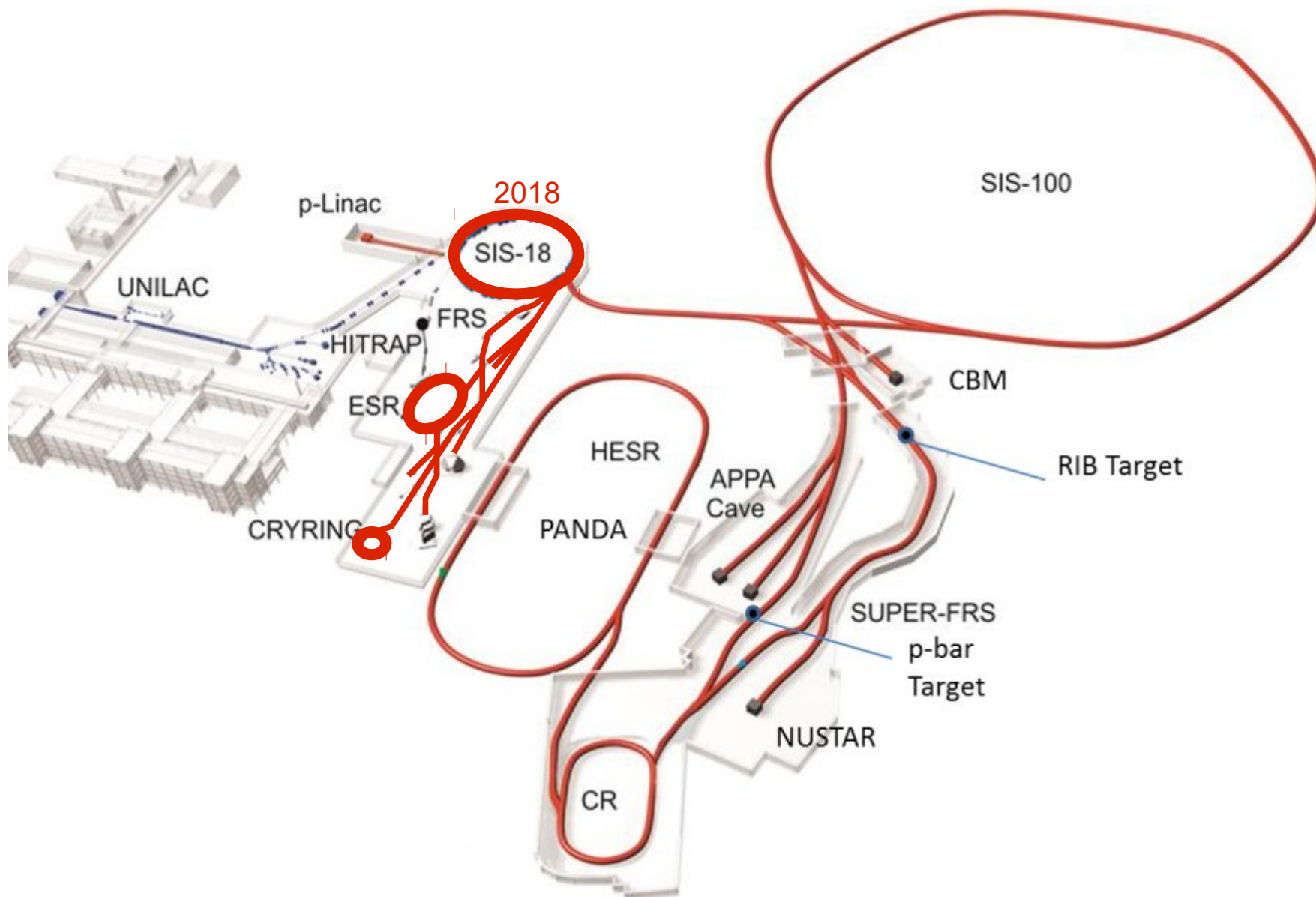


FAIR (Re-)Commissioning (in 2018)

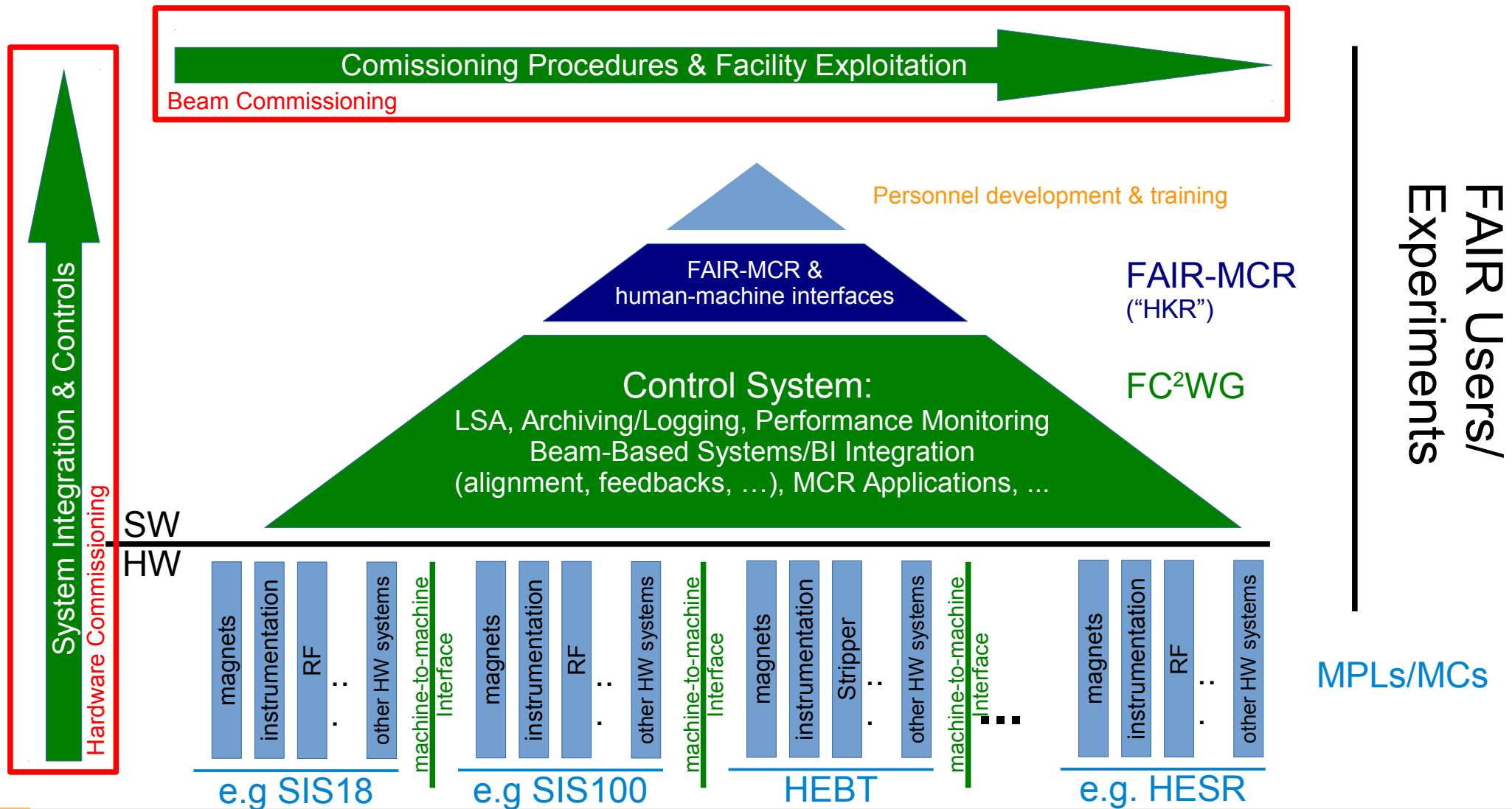
Strategy & Concepts

– Follow-up –

Ralph J. Steinhagen



An accelerator is more than the sum of its parts:



- 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

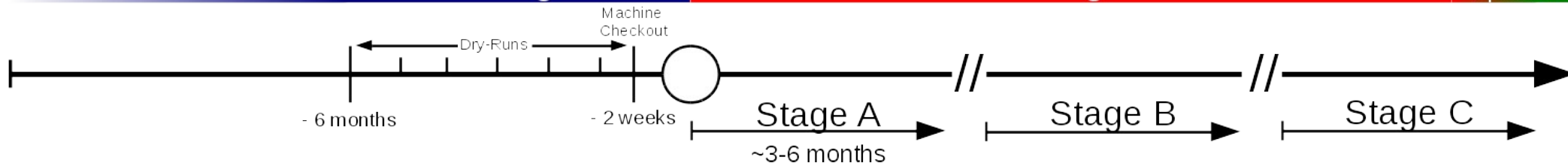
*Procedure aims not only at the initial first but also subsequent re-commissioning e.g. after (long) shut-downs, mode of operation changes and/or regular operation

→ operational procedures

Hardware Commissioning

Commissioning with Beam

Assisted
Operation



'Dry-Runs' & 'Machine Checkout':

- Focus on individual systems/devices
- Machine specific, aim at
 - generic system procedures (N.B. specifics part of FATs/SATs
↔ MPLs/equipment group responsibility)
 - specific schedule per acc. sector
- folded with:
 - acc. system availability (↔ equip. groups)
 - machine schedule (MC/MPLs)
- Traceability & Repeatability

Commissioning with Beam (BC):

- Focus on tracking beam progress through the along the beam production chain (BPC)
 - injection, circulating beam, ramp, ..., extraction, target steering
- aim at generic procedures for all ring accelerators
 - supplemented by machine specifics where necessary (e.g. stochastic cooling, ...)
 - transfer-line considered as part of injection/extraction of previous/following accelerator (crucial overlap)

The screenshot shows a web browser window displaying the FAIR Commissioning & Control Working Group (FC2WG) website. The page title is "BeamCommissioning - BeamCommissioning - FC2WG - FAIR Wiki - Google Chrome". The URL in the address bar is <https://fair-wiki.gsi.de/foswiki/bin/view/FC2WG/BeamCommissioning/WebHome>. The page features a navigation menu with tabs for Home, Minutes, Next Agenda, Dry-Runs, Commissioning Procedures (selected), Control Topics, and Admin. The main content area is titled "You are here: FC2WG » BeamCommissioning" and contains a timeline diagram of the commissioning process. The timeline is divided into three main stages: Hardware Commissioning (blue bar), Commissioning with Beam (red bar), and Assisted Operation (green bar). The Hardware Commissioning stage is further divided into Phase A (Pilot Beams) and Phase B (Intensity Ramp-up). The Commissioning with Beam stage is divided into Stage A, Stage B, and Stage C. The Assisted Operation stage is also shown. The timeline indicates a duration of approximately 6 months for Hardware Commissioning, 2 weeks for Machine Checkout, and approximately 3-6 months for Stage A. The Commissioning with Beam stage is also indicated to last approximately 3-6 months. The Assisted Operation stage is shown as a final phase. The page also includes a search bar, a sidebar with a table of contents, and a right-hand sidebar with a search bar, a login/register link, and a toolbox with various utility links.

FAIR Commissioning & Control Working Group (FC²WG)

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

BC Overview

Stage A - Pilot Beams

- Phase A.1 - Injection and First Turn
- Phase A.2 - Circulating Pilot
- Phase A.3 - Injection initial Commissioning
- Phase A.4 - Ramp
- Phase A.5 - Injection & Extraction Optics
- Phase A.6 - Extraction
- Phase A.7 - Final Focus/Target Steering
- Phase A.8 - Preliminary Physics runs
- Phase A.9 - Special aspects

Stage B - Intensity Ramp-up

- Phase B.1

Stage C - Production Operation with nominal Intensities

- Phase C.1

You are here: FC2WG » BeamCommissioning

Hardware Commissioning Commissioning with Beam Assisted Operation

Dry-Runs Machine Checkout

- 6 months - 2 weeks

Stage A ~3-6 months Stage B Stage C

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

Stage A - Pilot Beams

- 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
 - improve the machine model using beam based techniques

Log in or Register

Toolbox

- Create New Topic
- Index
- Search
- Changes
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- RSS Feed
- Statistics
- Preferences

Webs

- FC2WG
- BeamCommissioning
- HardwareCommissioning
- Main
- Sandbox
- System

- Split Beam Commissioning into three stages:

- I. 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

- II. 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

- III. Production operation with nominal intensities

- (N.B. first time counted as 'commissioning' → 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

Phase	Description
A.1	Injection and first turn: transfer lines, injection commissioning; threading, initial commissioning beam instr.
A.2	Circulating pilot: establish circulating beam, closed orbit, tunes, RF capture
A.3	injection initial commissioning: initial commissioning of beam instrumentation cont'd, beam dump
A.4	Ramp: transition crossing (protons), control of orbit, Q/Q', ...
A.5	Injection & Extraction optics: beta beating, dispersion, coupling, non-linear field quality, aperture
A.6	Extraction: fast extraction, slow extraction, ...
A.7	Final Focus/Target Steering: transfer lines, final focus, internal/external target steering, ...
A.8	Preliminary physics runs: "physics" with intermediate safe beam parameter (experiment detector setup etc.)
A.9	Special aspects: special machine functions, e.g. stochastic/e-cooling, transverse FB, special RF manipulation

*inspired by commissioning and SW analysis efforts for LHC:

http://lhccwg.web.cern.ch/lhccwg/overview_index.htm

<http://lhccwg.web.cern.ch/lhccwg/Bibliography/background-material.htm>

<http://proj-lhc-software-analysis.web.cern.ch/proj-lhc-software-analysis/>

<http://lhc-commissioning.web.cern.ch/lhc-commissioning/machine-checkout.htm>

- Organised per machine and/or group of accelerators/transfer-lines
- Tests per sub-systems, e.g.: **technical services** (controls network, electrical network, cooling and ventilation, access and safety systems), **vacuum systems**, **power circuits** (cryo & QPS (where applicable), powering interlocks, PC currents checked, low-level communication, ...), **high-level controls** (alarms, interlocks, cryo, post-mortem, archiving, equipment monitoring, remote device control, settings generation, ...), **timing system**, **MPS**, **radiation monitoring**, **pre-injector and transfer-lines**, **injection equipment**, **beam instrumentation**, **RF system**, **beam dump & collimation**, **experiments**, ... (list to be agreed upon)
- Within each sub-system: list of actual individual devices
 - link to system description (↔ control room level documentation)
 - tracking w.r.t. machine/system availability...
 - link to generic test procedure (OP view → HW specifics done as part of FAT/SAT)
 - summary of dry-run test results (+ document repetitions if necessary, last test/'good as of')
 - ... not all test results are 'OK'/'not OK'. Need to discuss required level of detail.
 - Problems & issue tracking (↔ impact on beam commissioning)!

*Just a rough 1st-order example
Real-world LOEP input needed*

- Sequence, check (details need to be fleshed out):
 - supply of energy & utilities
 - low-level communication, On/Off
 - Tests with short & actual load (PC vs. circuit tests)
 - Test-ramps to $I_{\min}/I_{\text{ref}}/I_{\text{nom}}$
 - Tracking performance $\rightarrow R_{\text{actual}}, L_{\text{actual}} \rightarrow L(I)$ calibration, I_{DCCT} calibration, ...
 - I_{earth} leakage, $\text{FFT}(I_{\text{meas}}) \rightarrow$ detects EMC issues, PC faults
 - state-machine tests (fault testing): interface to interlocks (FBAS), PC permit, ...
 - SIS100/Super-FRS: quench training, circuit-quench via QPS, fast power abort, ...
 - ...
 - availability of LSA (HWC) settings, ...
 - tests cycles
 - top-level applications, ...

- Traceability: poor-mans-solution acceptable for for small machines/few devices, e.g:
 - single Excel/OpenOffice/Wiki spread sheet for status tracking
 - detailed procedures in Wiki would do its job, how
 - Documentation of individual test results?
 - Screenshots? data blobs (files)?
 - How-to keep track of these results on the long-term? DB? EDMS? ...?
- Repeatability: how-to track tests that were done or need to be redone (e.g. after next technical stop)
- Applications:
 - HWC Tracker (overall status)?!
 - Sequencer in MCR: ~ 20 power converter OK to test by hand, but FAIR > 100!!
 - Equipment monitor (time traces, prior to availability to 'Archiving System')
 - Larger machines would benefit from automation/proper record keeping
 - [what could be done with a reasonable effort for 2017 \(2019\)?](#)

- **Plan & coordinate dry-runs in view of SIS18 re-commissioning in 2018**
 - driven by SIS18 constraints & CSCO milestone plan and availability
 - tentative schedule:
 - start 6 month before scheduled commissioning with beam, frequency ramp-up
 - Dry-Runs: 1-2 days every month, follow-up of issues, increase frequency if necessary
 - Last two weeks 'Machine-Checkout' every morning (afternoon to follow-up bugs)
 - Availability of systems determine what will be tested during each dry-run
- **Start developing beam commissioning procedure → tentative review by Q3/Q4-2016**
 - FAIR commissioning & operation success depends on readiness of systems and people
 - Responsibility shared collectively → not a 'one man show' → active participation & volunteers needed → small activity groups, documentation on wiki
 - **feel free to propose further participants you consider pertinent or whom it may concern**
 - **requirement for dissemination and impact on real-world FAIR operation**



Statistik Betrieb Beginn Ende

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

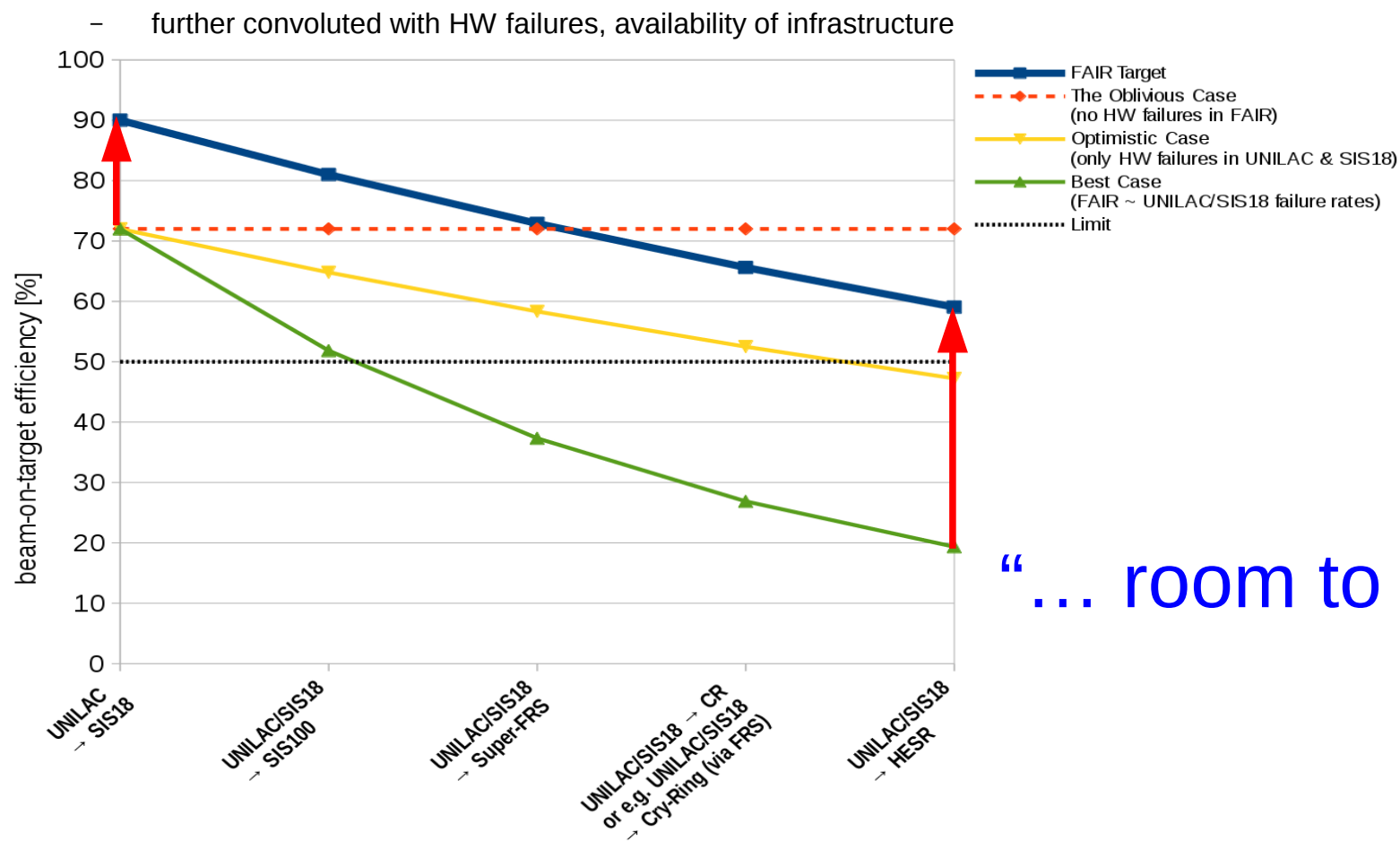
- possibly pessimistic/simplistic^{1,2} estimate, control room experience:
 - presently: '~ 1 shift UNILAC setup + 1 shift SIS18+TL setup' → 1-2 weeks of experiments
- **2014: Beam-on-Target (BoT) figure of merit (FoM) of ~70%**
 - sufficient for present mode of operation (~20% HW failures, ~13% setup)
 - **however: high losses/activation & FoM does not scale for FAIR**

¹possibly strong assumption that new machines can be operated with the same routine, ease and efficiency as the present GSI infrastructure, ...

²complex beam chains (e.g. HESR) with long beam setup times are typically run longer/more static than shorter (SIS18 experiments)

- FAIR-BoT (efficiency ϵ_{FAIR}):

$$\epsilon_{\text{FAIR}} := \prod_i^{n_{\text{machines}}} \epsilon_i = \epsilon_{\text{ESR/SIS18}} \cdot \epsilon_{\text{SIS100}} \cdot \epsilon_{\text{SuperFRS}} \cdot \epsilon_{\text{CR}} \cdot \epsilon_{\text{HESR}} \cdot \dots$$



“ ... room to improve!”