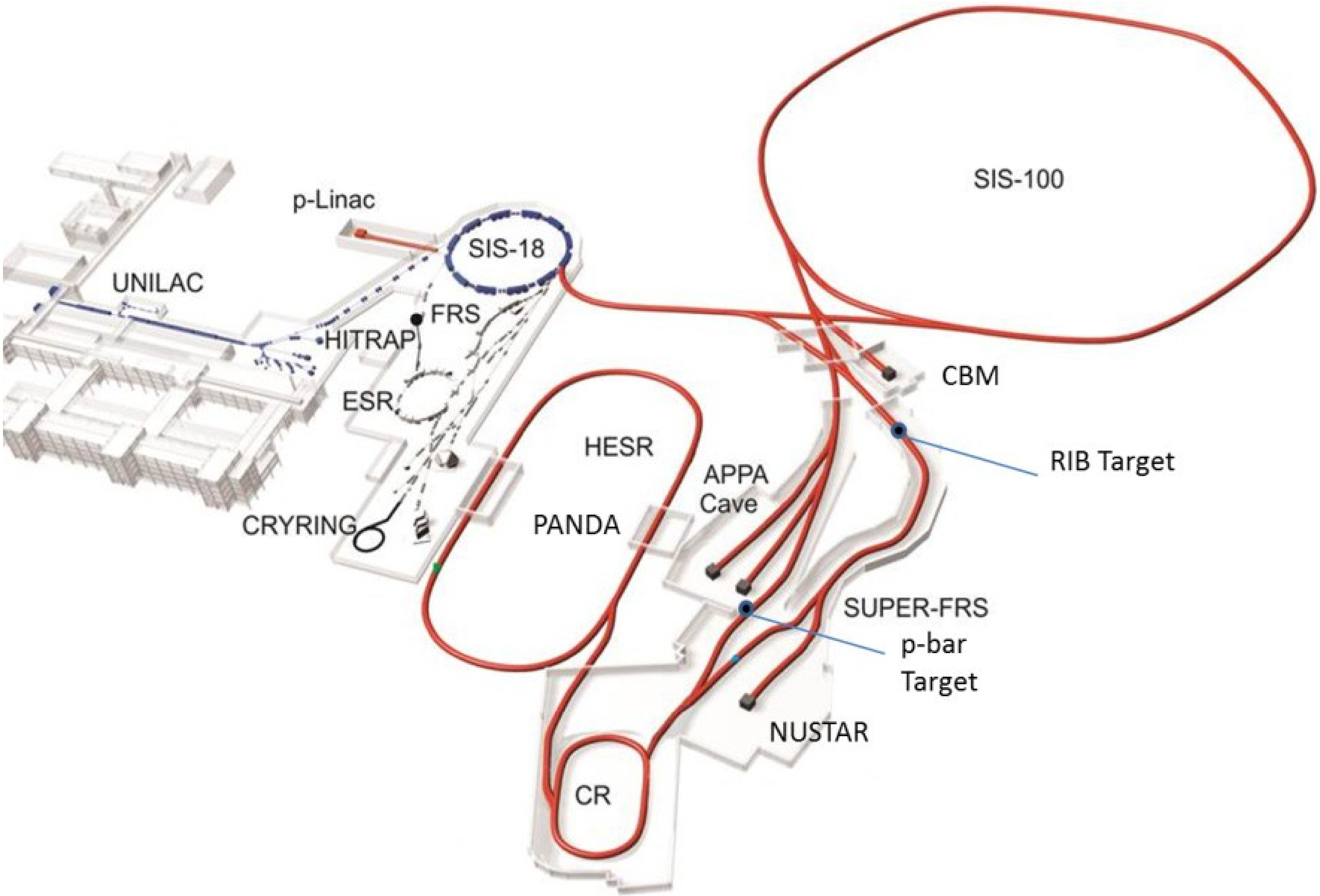
FAIR (Re-)Commissioning (in 2018)

Strategy & Concepts
– Follow-up –

Ralph J. Steinhagen

… a FAIR amount of work ahead



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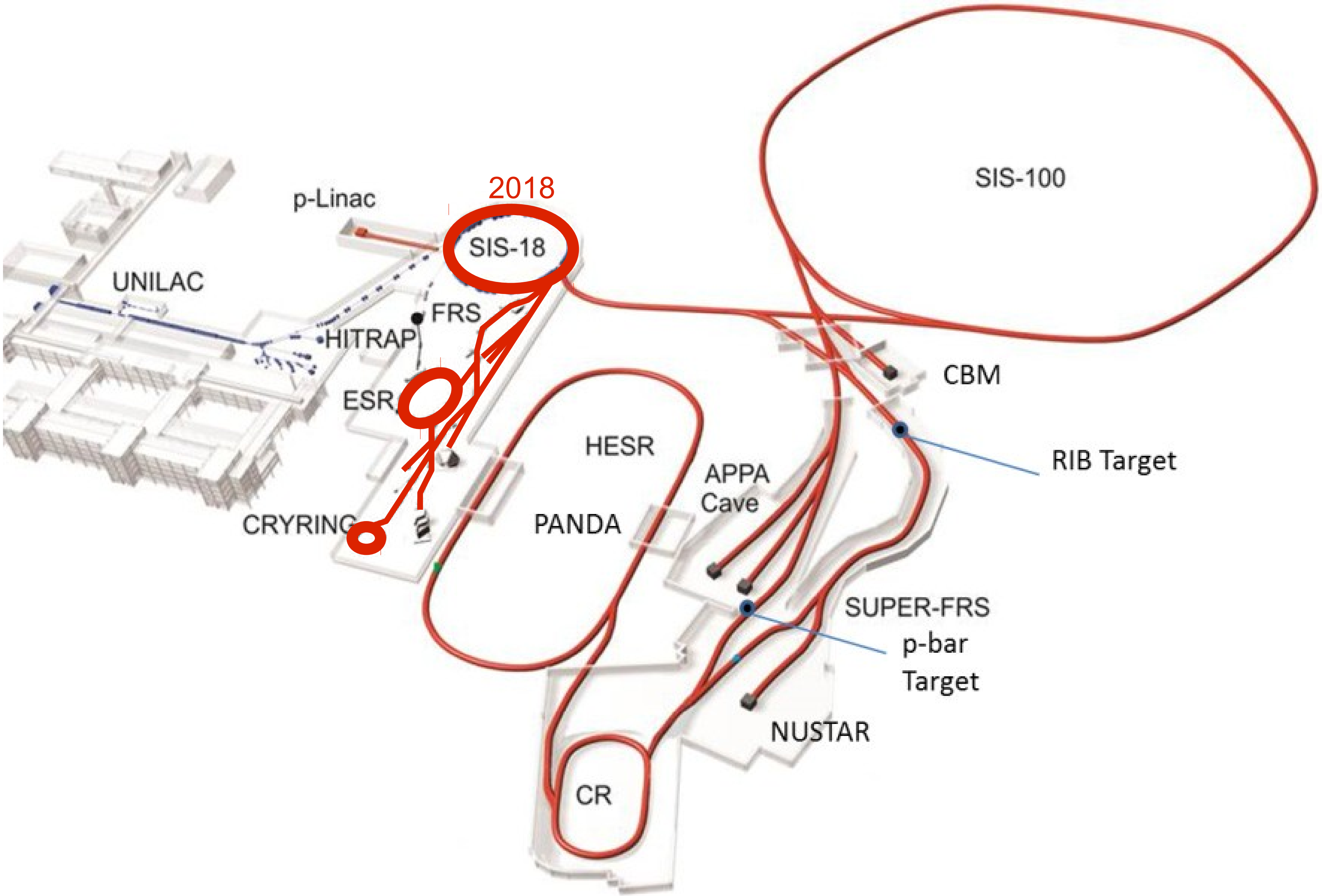
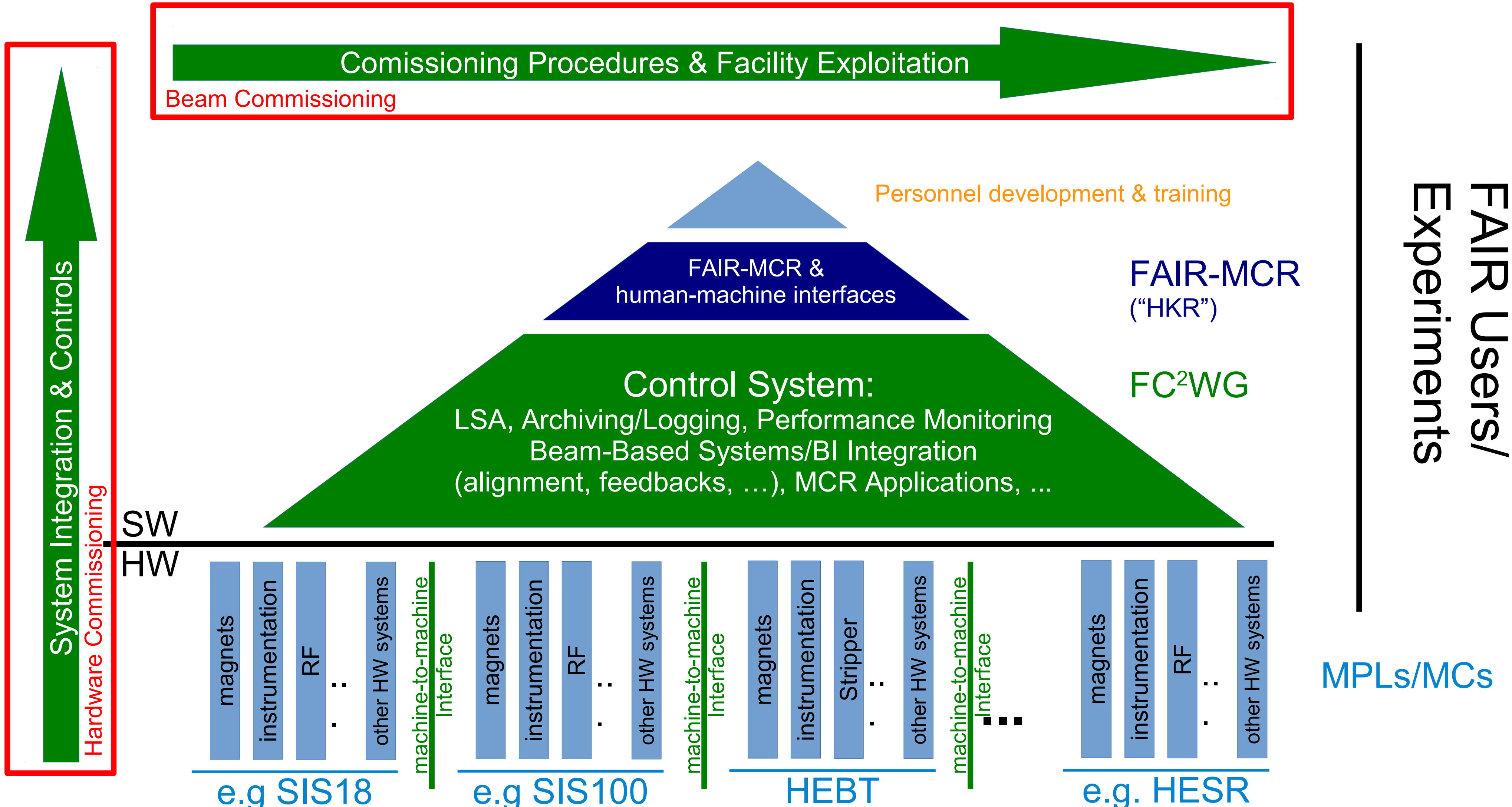


Fundamental Axiom

An accelerator is more than the sum of its parts:



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

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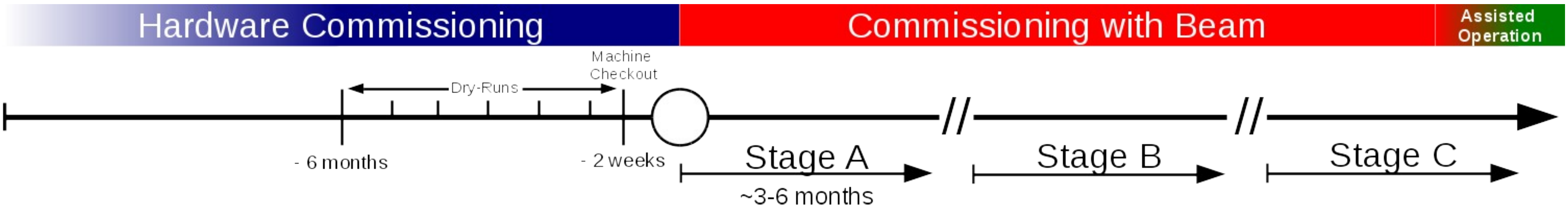
→ operational procedures

FAIR (Accelerator) Commissioning
Terminology & Structure



'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 (cruicial overlap)

Example: FAIR Commissioning Procedures

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

BeamCommissioning - BeamCommissioning - FC2WG - FAIR Wiki - Google Chrome

https://fair-wiki.gsi.de/foswiki/bin/view/FC2WG/BeamCommissioning/WebHome

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Commissioning & Control Working Group (FC²WG)

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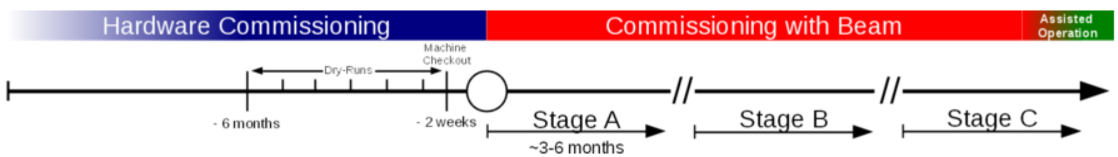
BC Overview
- Stage A - Pilot Beams
  - Phase A.1 - Injection and First Turn
  - Phase A.2 - Circulating Pilot
  - Phase A.3 - Injection initial Commissioning
  - Phase A.4 - Ramp
  - Phase A.5 - Injection & Extraction Optics
  - Phase A.6 - Extraction
  - Phase A.7 - Final Focus/Target Steering
  - 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



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'

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Commissioning with Beam

- 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
     - <u>make fast setup and switch-over between different beam production chains routine</u>

Commissioning Phases*

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

Preliminary Ideas for Dry-Runs I/III

- 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)!

Preliminary Ideas for Dry-Runs II/III
Example: Power Circuits Checks

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 $I_{min}/I_{ref}/I_{nom}$
  - Tracking performance → R_{actual}, L_{actual} → L(I) calibration, I_{DCCT} calibration, ...
  - I_{earth} leakage, FFT(I_{meas}) → 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, ...

Preliminary Ideas for Dry-Runs III/III
Open Questions:

- 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)?

Next Steps

- 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 <u>and</u> 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

Comments? Questions?

FAIR Challenges & Constraints
… SIS18 Operation Experience & Efficiency I/II

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

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**

[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)

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- 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

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- FAIR-BoT (efficiency ε_{FAIR}):

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

  - further convoluted with HW failures, availability of infrastructure

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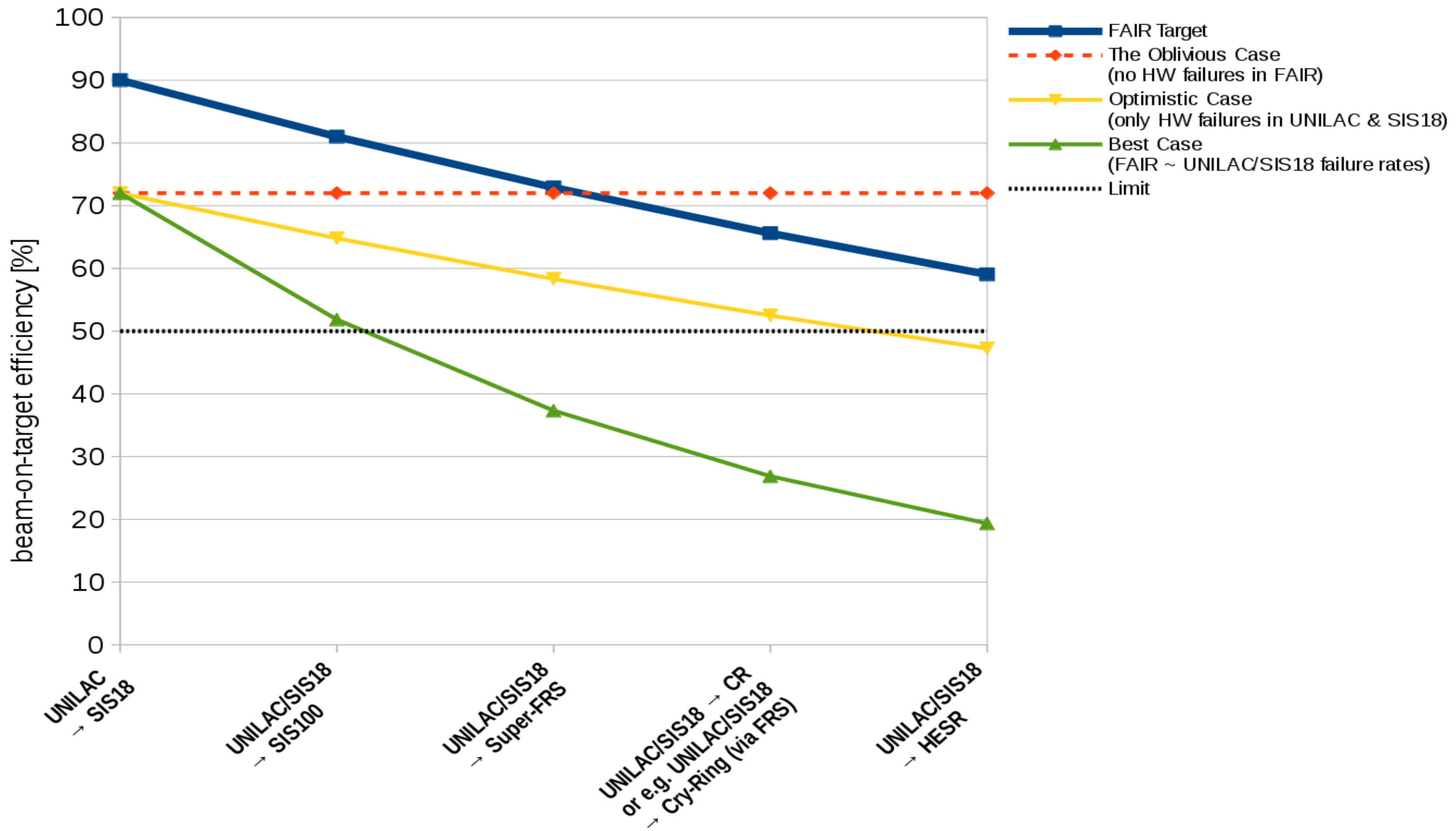

FAIR Challenges & Constraints
… SIS18 Operation Experience & Efficiency II/II

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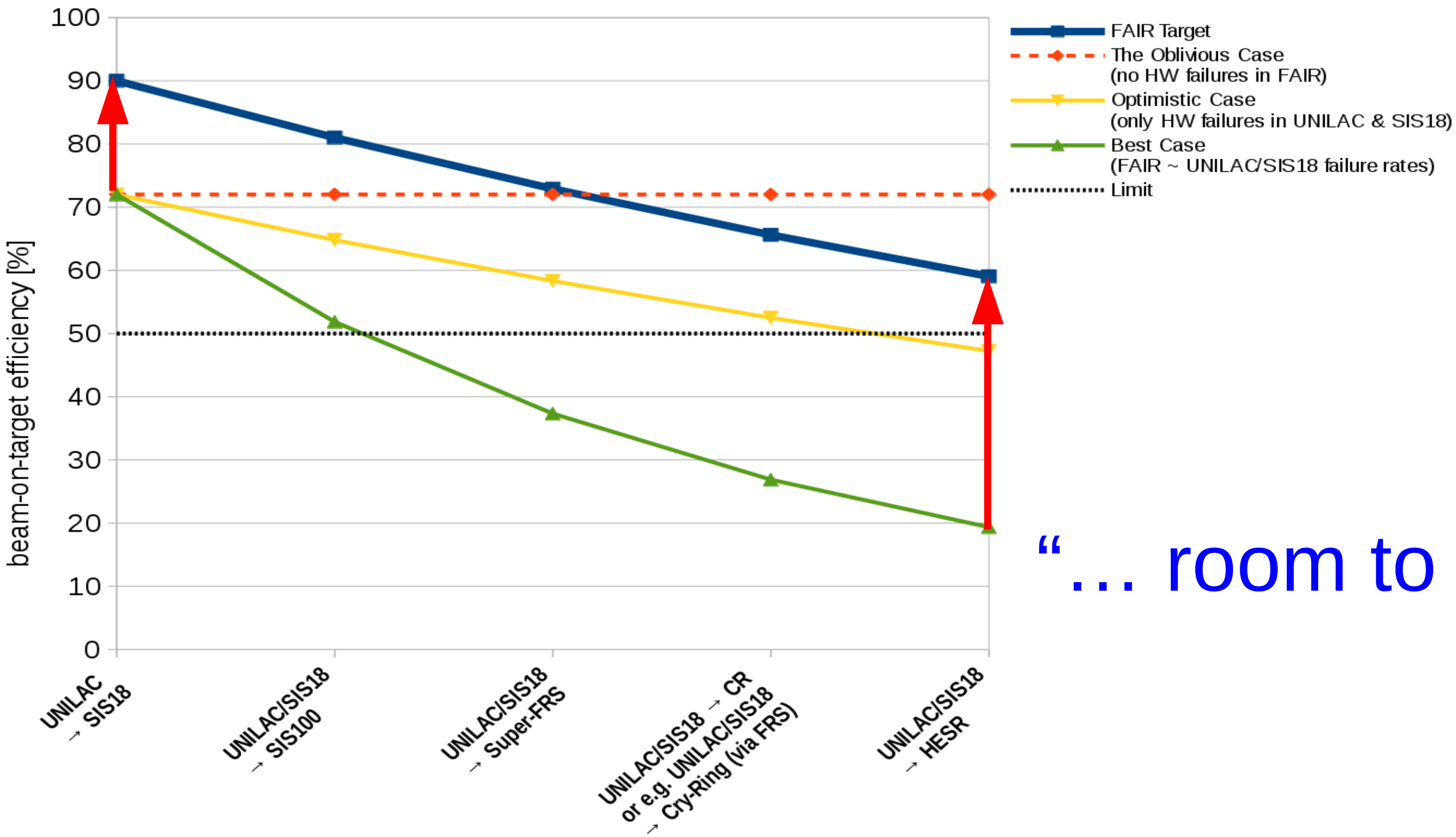

"… room to improve!"