FCC – FAIR Control Centre
Existing Infrastructure, functional User-Requirements, Ergonomics & Next Steps

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special thanks: R. Giachino, M. Lamont, D. Manglunki, R. Steerenberg (CERN)
• Discontinued 17.1 MCR option: issues w.r.t. accessibility, being a controlled area, ... (ECR in 2015)

• New control room and additional support infrastructure needed for FAIR
  - Existing GSI “alt-HKR” is
    A) too small for an effective commissioning & operation, and
      - need long-term ~25 ‘workstations’ (8+ accelerators, ↔ > 600 m²)
    B) not adapted to new FAIR control & OP paradigms
      - analog signals (manual labour-intensive operation), unsafe/unsustainable w.r.t. machine protection and high-intensity operation
  - Single common platform for more efficient accelerator operation, communication across different domains, ... → improved facility performance (i.e. no multitude of local control rooms)
  - Positive public portrayal of GSI & FAIR: core facility/experiments in-accessible to public and most scientific visitors → FCC being the ‘heart’ & ‘brain’ of the facility

• Abstracted previous site-specific concepts → generic FCC user-requirements
  → became input to Campus Master Plan (CMP)
  - mainly site/building parameters/recommendations: location, outer hull and additional infrastructure, also “HKR”
    → “FAIR Control Centre (FCC)”

• FAIR Management reviewed CMP in 2016: confirmed FCC prioritisation within CMP, decided for ‘new building’ option, and to continue detailed & expedient planning targeting a soon-as-reasonable-achievable realisation
Today: presentation of accelerator operation related FCC user-requirements (80% of the input to CMP)
- update involved present and future stake-holders on current state
- link to ‘FAIR Accelerator Control and Operation‘ concept (dealt by FC²WG)
- basis for further in-depth detailing of user-requirements in view of tendering process

Next Steps via FCC Project-Group (smaller circle, interest-based representation/mandate)
- Elaborate missing requirements from other groups tightly intertwined with accelerator: Cryo, TI, (accelerator-kin) experiments, ... → remaining 20% of input to CMP

Two new aspects since 2016:
- office spaces above main control room: collection of user-requirements, development of usage concept, ...
- main control room planning combined/advanced with primary building tranche → FCC user-requirements need to be finalised by March ‘17 to minimise overall planning costs and potential additional post-award contract charges afterwards
Existing Infrastructure: 'GSI Hauptkontrollraum (HKR)'
Existing Infrastructure:
GSI “alt-HKR” floor plan (328 m²)
Existing Infrastructure:
GSI HKR consoles

- 8% LEBT / MEBT / HEBT
- Arbeitsplätze Quellen unzusammenhängend
- Konsolen sehr tief für Oszi + Röhren (teilw. obsolet)
- "Analog Betrieb"...

Farbcodes:
- Quelle
- Beschleuniger
- Speicherring
- Experiment

courtesy C. Omet
Existing Infrastructure: division of ground surface area

328 m² Grundfläche
200 m² Nutzfläche

- 41% für Konsolen, Bedienflächen
- 39% für Wege
- 14% „tote“ Flächen für Wartung
- 6% für Sitzecke, etc.

60% eff. Nutzfläche

courtesy C. Omet
Migration Strategy
GSI 3 → FAIR 8½ (11+) accelerator(-like) machines

existing:
3 Ion-Sources
1 LINAC
1 synchrotron + 1 storage ring
13/7 transfer-lines (MEBT / HEBT)
3 experimental areas

new:
• 1 proton source + linac
• 4 synchrotrons & storage rings
• 18 (26) transfer-lines
• 4 (5) experimental areas
• similar number of accelerators to FAIR, but
• lower complexity (shorter chains)
• quasi-static operation (infrequent ion-type changes per year)
for comparison: FNL Accelerator Complex

- similar complexity/number of accelerators, but
- quasi-static operation & primarily (anti-)protons only
for comparison: CERN Accelerator Complex

- similar complexity/number of accelerators, but
- semi-static operation (mode of operation change typically ~ weeks → months)

N.B. CERN-OP crew + support: ~ 90+20 FTEs
Global Requirements & Operational Constraints

A) Much larger facility, cannot reliably extrapolate from present 'UNILAC→SIS18→ESR' operation to requirements for FAIR (3 → 9+ accelerator(-like) structures)

B) Will be in a constant flux of frequent adaptations to new cycles/beam parameters, etc. present estimate:

1) avg. experiment run: ~ 1-2 weeks per exp. + many new storage rings and transfer lines with high(er) complexity → machine setup time-scale
   - increased number of users & parallel operation
   - added complexity: long accelerator daisy chains $O(n^5)$
   - present efficiency for physics $\epsilon_{\text{UNILAC+SIS18}} \sim$ up to 75% → >90% (target, see appendix)

2) high-intensity operation requires more and better fine-tuning
   - dynamic vacuum, machine protection & activation, collective effects

3) limited operator resources: 4-5 (beam operation) + 1 (infrastructure, cryo)

→ need to be smart and develop efficient commissioning procedures, training and tools to facilitate fast turn-around and to maintain/improve present operational performance

→ control and operation aspects are reflected in FCC design/user-requirements
FAIR Control Centre & Operation Concept Development – User Community Organisation

FAIR Management

Experiments
(fixed-target- & accelerator-based)

Equipment Groups
(GSI: ~28 on-call experts → FAIR: ??)

Technical Infrastructure (GA)
(cooling, ventilation, )

FAIR Control Centre
(planned: 25 workstations)

Visitors
(150-200/day)
(I. Peter et al.)

OP Coordinator

Campus Development
(G. Stephan)

Skeleton crew:
5 accelerator operators (& 1 shift leader)
1-2 cryo-operators
1 TI operator (tbc.)
additional:
~5 machine/system experts
~5-10 physicists from accelerator-based experiments

Machine Coordinators
4 on call machine experts
UNILAC, SIS18/100, ESR, FRS
System Design

Equipment Groups

Technical Infrastructure (GA)
(cooling, ventilation, )

FAIR Control Centre
(planned: 25 workstations)
Main Control Room
(25 work stations*, ≥600 m²,
< 35 dB(A) ambient noise, fully digital
open communication lines,
> 3 (5) m ceiling, false floor, ...)

Conference Room
(25 + 25 persons)

Equipment group offices & laboratories/workshops.

new:
Offices
(generic, w/o labs)

< 2 min./100 m

< 5 min.

gross surface: ~ 1000 m²

see Appendix for detailed functional user-requirements that went into the CMP
Open Communication Line of Sight
here: old MCR-in-Canteen proof-of-concept

‘No pillars user-requirement’:  
  - impedes line-of-sight  
    - less efficient eye-to-eye com.  
    - visibility of shared fixed-displays  
    - Non-ideal visitor’s view  
  - limits console layout/future upgrade options

“'room' must not get in the way of the primary purpose of the room”
25 workstations → > 600 m² surface
FCC ceiling design reference height: 5 m

The 5m ceiling height avoids the “parking house effect” and is also beneficial for the acoustics, ventilation system, indirect lighting and fixed-display concept
Control Room as Open Plan Office
Number of Service Personnel I/II

• Existing GSI Facility Operation:
  – 3 operators for 3 accelerators and ~ 300 m² control room surface area

• Possible FAIR Operation – naïve scaling
  (minimal automatisation/tuning, truly independent parallel operation, etc.)
  
  A) MSV 0-3: 7 operators for 8 accelerators and 700 m²
  B) MSV 0-6: 12 operators for 12 accelerators and 1200 m²

• Gretchen Frage: ”How many operators will be effectively needed?“
  – Important boundary conditions:
    • 1 operator doing 24h/7 shift-operation = 7.4 “real/gross” operators (FTEs) =
      ~ >0.5 MEUR/year → ’4+1’ vs. ’7-8’ corresponds to ~2 MEUR/Jahr (+ new offices)
    • 7-8 operators probably mainly needed during peak hours (day)
      (recommissioning, setting-up of new experiments/beams, etc.)
    • ‘full utilisation during rush hours’ vs. ‘skeleton crew operation’
• **Beam-Production-Chain:**
  - organisational structure to manage parallel operation and beam transfer through FAIR accelerator facility
  - defines sequence and parameters of beam line from the ion-source up to an experimental cave (e.g. APPA, CBM, SuperFRS, ...)
  - definition of target beam parameters (set values): isotope, energy, charge, peak intensity, slow/fast extraction, ...

• **Beam Pattern:**
  - grouping of beam production-chains that are executed periodically
  - can be changed of pattern within few minutes (target, requires automation for beam-based retuning)
• 'One Operator per Accelerator Domain' vs. 'One Operator per Experiment':

Operator #1

Q1 → UNILAC → SIS18 → SIS100 → SuperFRS → CR

Operator #2

Q2 → pLinac → SIS18 → SIS100 → p-Target → CR → HESR

Operator #3

Q3 → UNILAC → SIS18 → SIS100 → CBM

Operator #4

Q4 → UNILAC → SIS18 → SIS100 → APPA

Qn → UNILAC → SIS18 → ESR etc.
FAIR Operation Paradigm II/II

• Option 1: One Operator per Accelerator Domain:
  - Highly-specialised operators (less accelerator physicists needed)
  - High risk of blocking of single operators/‘congestion’ (notably for UNILAC, SIS18 & SIS100)
  - Poor OP utilisation in case only one of 4+ experiments is in operation
  - Less redundancy → permanently more operators are needed
    • 58 vs. 32 Operators (for comparison CERN OP: 90 total)
    • N.B. on OP shift = 7-8 operators ↔ ~ 0.5 MEUR/year

• Option 2: One Operator per BPC/Experiment
  - More efficient machine-machine / machine-experiment interfaces
    • Less overhead, more efficient handover of beam and adjustments to exp. Requirements
    • Motivational factor of ‘operator BPC ownership’ (i.e. “my experiment“)
  - Possibility of reduced operation crew (e.g. 32-35 for full FAIR acc. OP)
    • Broader Operator training required (not only machine-specifics)
    • … supported by accelerator experts for setting up of new cycles, experiments and peak-times (e.g. recommissioning after technical stops, etc.)
    • Mandatory semi-automation of frequent accelerator processes (also needed for safe high-intensity operation)
  - Better redundancy within OP crew in case of illness, parental leave, holidays, etc.
  - Better value for overall organisational costs (Skeleton Crew + ‘Acc. Support Team’ when needed)
Control Room as Open Plan Office
Number of Service Personnel II/II – Compromise

Proposed FAIR Operation – improved scaling

A) ‘Skeleton Crew’: 4+2+1 people (monitoring, notably during night shift)
   - 4-5 parallel experiments x 1 operator/experiment
   - 1-2 Cryo-Operators (SIS100, SuperFRS)
   - 1 TI Operator (acc. related infrastructure: power network, cooling & ventilation, Leistungsnetze, media supply, ...)
   - Minimum: assumes setup facility and/or (partial) automatisation

B) ‘Normal Operation’: up to 25 people (machine setup, day-time)
   - 4+2+1 ‘Skeleton Crew’ + accelerator experts:
     - accelerator physicists, RF/BI/CO experts, beam-cooling experts, beam-line physicists, experimentalists, etc.
   - Variable scenarios: + 15-20 People with >4h/day occupancy in FCC
     - setup of new (exotic) beam experiments: typ. 3-4 people
     - failure diagnostics and optimisation of the individual machine, accelerator sub-system, or beam production chain: typ. 3-4 people
     - Parallel machine development: typ. 5-8 people
     - Hardware and Beam (Re-)Commissioning: 10-20 people (?)!
     - Experiments tightly intertwined with accelerators (ESR, PANDA, etc.): typ. ~ 8 per experiment
     - ...

...
3 fixed displays split between 2 workspaces
3 flat screens per workspace
1 keyboard
1 mouse
1 additional admin PC

CERN experience → FAIR: independent fixed displays for each workspace

Courtesy D. Manglunki (CERN)
Fixed-Display & Workstation Layout
Information Density Hierarchy

- I: semi-fixed displays – monitoring context, rare interactions (slightly overhead)
  - beam-transmission/beam-loss monitoring, primary experiment performance index, ...
- II: active user-interaction – automatically adapted to commissioning step (see FC²WG)
- III: non-multiplexed information:
  - Zugangskontrollsystem' (ZKS, access system), machine interlocks, ...

- UNILAC Status
- SIS18 Status
- SIS100 Status
- Super-FRS Status
- CR Status
- HESR Status

- FAIR Facility Overview
- BPC Overview #1
- BPC Overview #2
- BPC Overview #7
- BPC Overview #8
- FAIR Facility Overview

- Fixed-Displays (on wall)

- Workstation multiplexed on BPC
- shared workstation non-multiplexed

- 100x313
- 60/65" Fixed-Displays
- (on wall)

- I: semi-fixed displays – monitoring context, rare interactions (slightly overhead)
- II: active user-interaction – automatically adapted to commissioning step (see FC²WG)
- III: non-multiplexed information:
  - Zugangskontrollsystem' (ZKS, access system), machine interlocks, ...

- 2.5 ... 3 m
- Information Density/Level of Detail
Example: FAIR Facility Overview
Proof-of-Concept Prototype

courtesy Achim Bloch-Spaeth

Beam stored for the CRYRING users
FAIR Beam Production Chain Overview
Proof-of-Concept Prototype

courtesy Achim Bloch-Spaeth
FCC Workstation Layout
General Concept

Central meeting table:
- shift hand-over
- small ad-hoc meetings (→ + small meeting room)
- social functions

Fixed Displays (on wall)

Primary Accelerator, Cryo- & TI-Operation

Island/Bay #1

Island/Bay #2

12 Workspaces for short-notice stand-by personnel (|| R&D, acc. exp. Students, ..) (table with data / power connections)

permanent usage 24h/7 during OP year (includes all accelerators, technical infrastructure needed for acc. operation)

reconfigurable usage
- storage ring experiments
- machine developments
- experiments tightly intertwined with acc.
- Hardware and Beam (Re-) Commissioning
Proposed BPC-Paradigm Scheme:

- **12 – Skeleton-crew (24h/7 OP)**
  - 6 parallel BPCs/operators
  - 3 – Cryogenics (non-multiplexed)
  - 3 – Technical Infrastructure (non-m.)

- **5 – Island/Bay #1 – reconfigurable usage**
  - storage ring/accelerator-kin experiments
  - machine developments
  - Hardware (HWC) & Beam (Re-)Commissioning (BC)

- **5 – Island/Bay #2 – reconfigurable usage**
  - as above

- **2 – generic short-term consoles**
  (debugging & shift leaders)

Classic scheme (deprecated):

- **5 – primary beam accelerators**
  (UNILAC → SIS18 → SIS100)

- **3 – ESR, CRYRING, CR**

- **2 – HESR**

- **2 – SuperFRS**

- **3 – Cryogenics**

- **3 – Technical Infrastructure**

- **5 – accelerator-kin experiments**

- **2 – generic short-term debugging consoles (+ shift leaders)**
Several options have been studied by the consultants (GTD, CCD), the CCC-WG and the IDOC. A one-day workshop gathered the IDOC and the CCC-WG, moderated by M. Clark (CCD), and chaired by S. Baird, AB/OP group leader, allowed to develop a model satisfactory for all parties.

Need similar user iteration at FAIR: Accelerator operations, machine experts (& SPLs), GA/TI, experiments, … tbd.
Appendix
• mind. 600 m² Nutzfläche
  – Mindestens 5 bis 25 Arbeitsplätze (Vorgaben ASR A1.2 – Abs. 5.4: 12 - 15 m²/Person, 60% effective Nutzfläche → siehe Appendix)
  – klare Kommunikationslinien → offene unbehinderte Sicht (→ frei von Säulen)
• Deckenhöhe: > 3 m (optim. 5 m)
• Doppelboden: mind. 15 cm bzw. 50 cm falls Ent-/Belüftung benötigt
  – N.B. getrennte Lüftung für Raum und Unterboden
• Raumklima: (20-24) ± 1° C, 30-70 % Luftfeuchte, max. 0.1 m/s Luftgeschw.
• Beleuchtung: ≥ 500 lx (regelbar, DIN EN 12464-1, E DIN 5035-7)
  – Gesetzlicher Tageslichtanteil & direkte indirekte Beleuchtung (ggf. Vollspektrumlicht)
• Akustik  (Einfluss auf: Bodenbeläge, Wandverkleidungen, Abtrennwände, etc.)
  – Lärmpegel: <35 dB(A) (Hintergrund) bzw. <35-45 dB(A) (10+ Personen, BildscharbV & BAuA)
    • Nachhall-Zeit: 0.4 (best) bzw. max. 0.6 s (DIN EN ISO 9241 – part 6)
    • N.B. Schließt Klimaanlage, PCs, Drucker, usw. ein!
  – Geringerer Rauschhintergrund → geringere Gesprächslautstärken → geringere Störfaktoren
    für andere HKR Nutzer → bessere Konzentration → ...
• N.B. Elektrische Leistung: ~40 kW
Kein Einzelobjekt sondern:

- **Eigentliche Hauptkontrollraum: ~ 600 m²**
- **Zusätzliche Flächen**
  - Gesetz. 'Pausenraum' bzw. Küche (ArbStättV §6): > 25 m² (optimal: ~ 60 m²)
  - Aufstellflächen für IT/CO Infrastruktur: ~ 200-300 m² ??
  - **Kleiner Besprechungsraum (~ 10-15 Personen): ~ 60 m²**
    - Unmittelbar an HKR angrenzend
  - **Großer Konferenrraum (~ 25 + 25 Personen): ~ 60-100 m²**
    - bisher nicht existent bzw. mangelhaft: „Beschleunigerbesprechungszimmer“
    - Kurze Laufdistanz (< 100 m) zum HKR
  - **Besuchergalerie für 25 Besucher + Ausstellung (100-200 Besucher/Tag)**
  - Abgetrennter Arbeitsplatz für Betriebsleitung: ~ 15 m²
  - **Versorgungsflächen & Technische Gebäudeausrüstung: ~ ?? m²**
  - **Druckerraum (~ 5 m², tbc.)**
    - Gesetzlich (BAuA) nicht zwingend für >25 m³ + keine Dauernutzung von Druckern im HKR! (N.B. Meisten Laserdrucker/Kopierer erfüllen Feinstaubpartikel Norm)
- **Rezeption?**
“alt-HKR” & Accelerator Controls Retrofitting
GSI → FAIR Transition in 2018
Periodic beam patterns, dominated by one main experiment:

**AP** + RIB ext. target ($^{28+}_U$) + Biomat

**CBM** + RIB ext. target ($^{73+}_U$) + AP (LE)

**RIB ext. target ($^{28+}_U$) + ESR

courtesy D. Ondreka
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

Therapy Operation (different accounting)

constant ~ 75 ± 5 %

long-running “static” experiments

Many || experiments re-configuration ~ 1-2 weeks → FAIR base-line

https://www.gsi.de/en/work/research/library_documentation/gsi_scientific_reports.htm

* 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 $\varepsilon_{\text{FAIR}}$):

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

  + 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!”