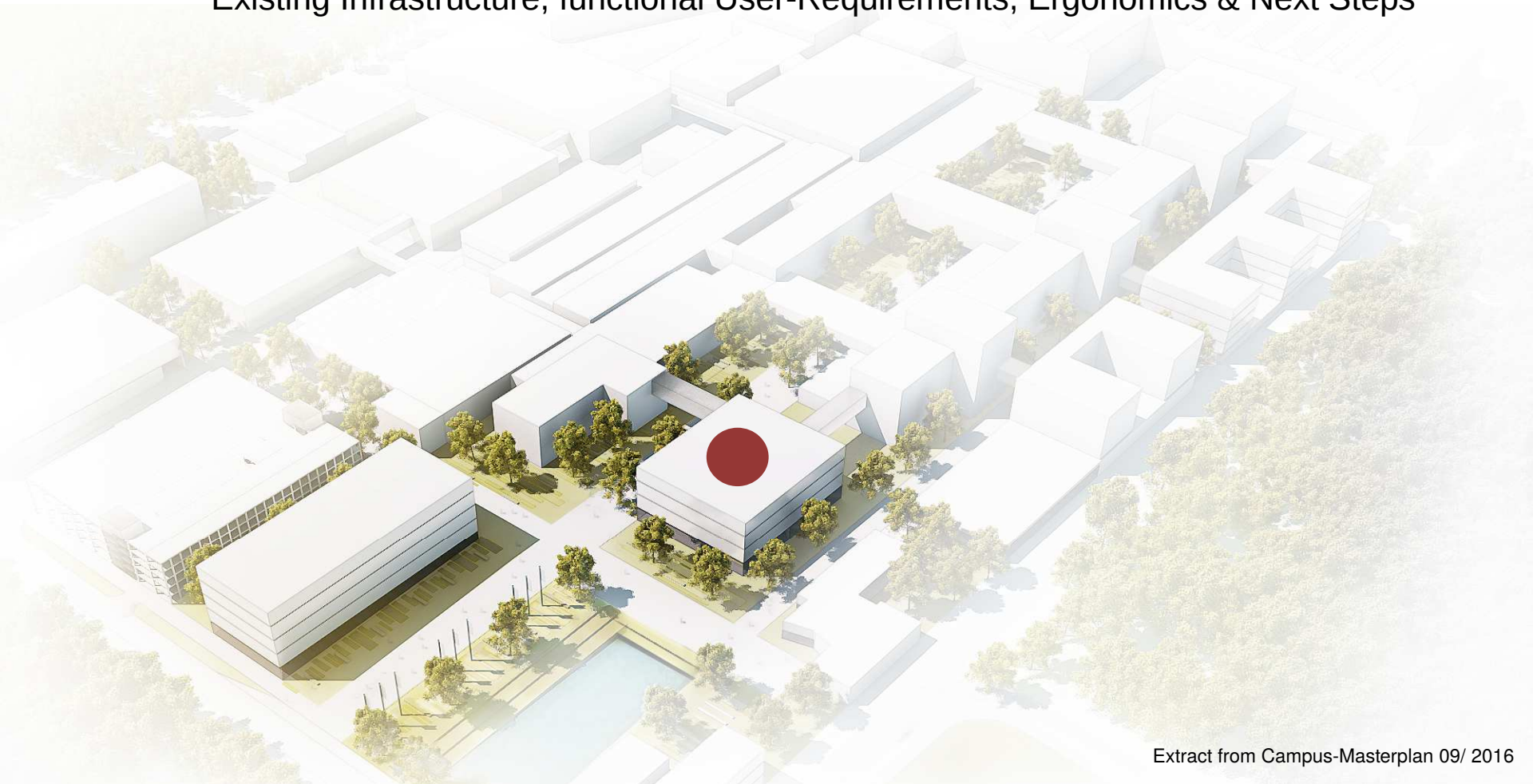
FCC – FAIR Control Centre

Existing Infrastructure, functional User-Requirements, Ergonomics & Next Steps



Extract from Campus-Masterplan 09/ 2016

Ralph J. Steinhagen for the FC^{2}WG & FCC-WG, based on previous work and input from:
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S. Reimann (deputy), U. Scheeler, P. Schütt, G. Stephan (CE), M. Schwickert

special thanks: R. Giachino, M. Lamont, D. Manglunki, R. Steerenberg (CERN)

Outline I/II

- 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

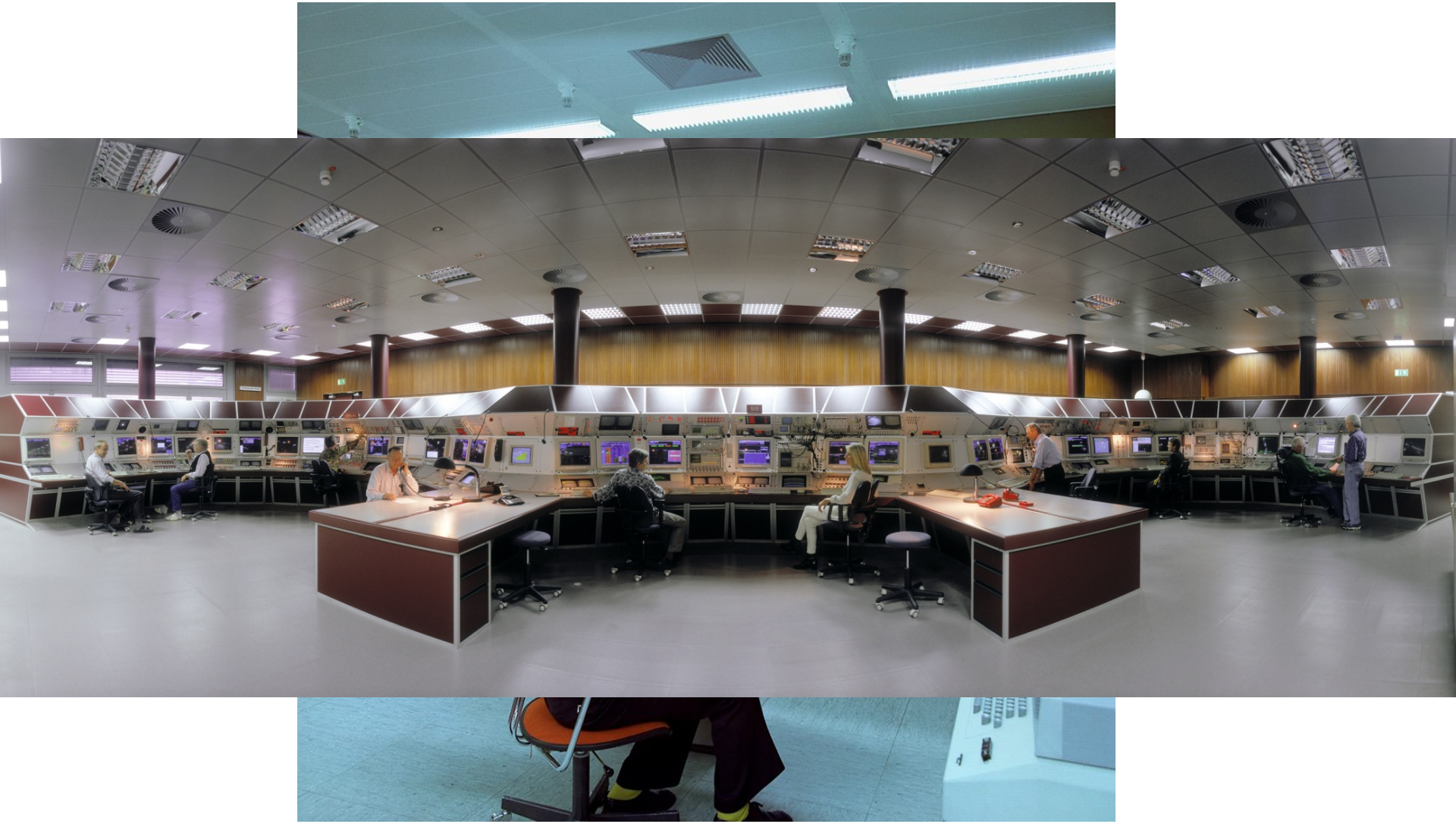
Outline II/II

- **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 FC^{2}WG)
  - basis for further in-depth detailing of user-requirements in view of tendering process

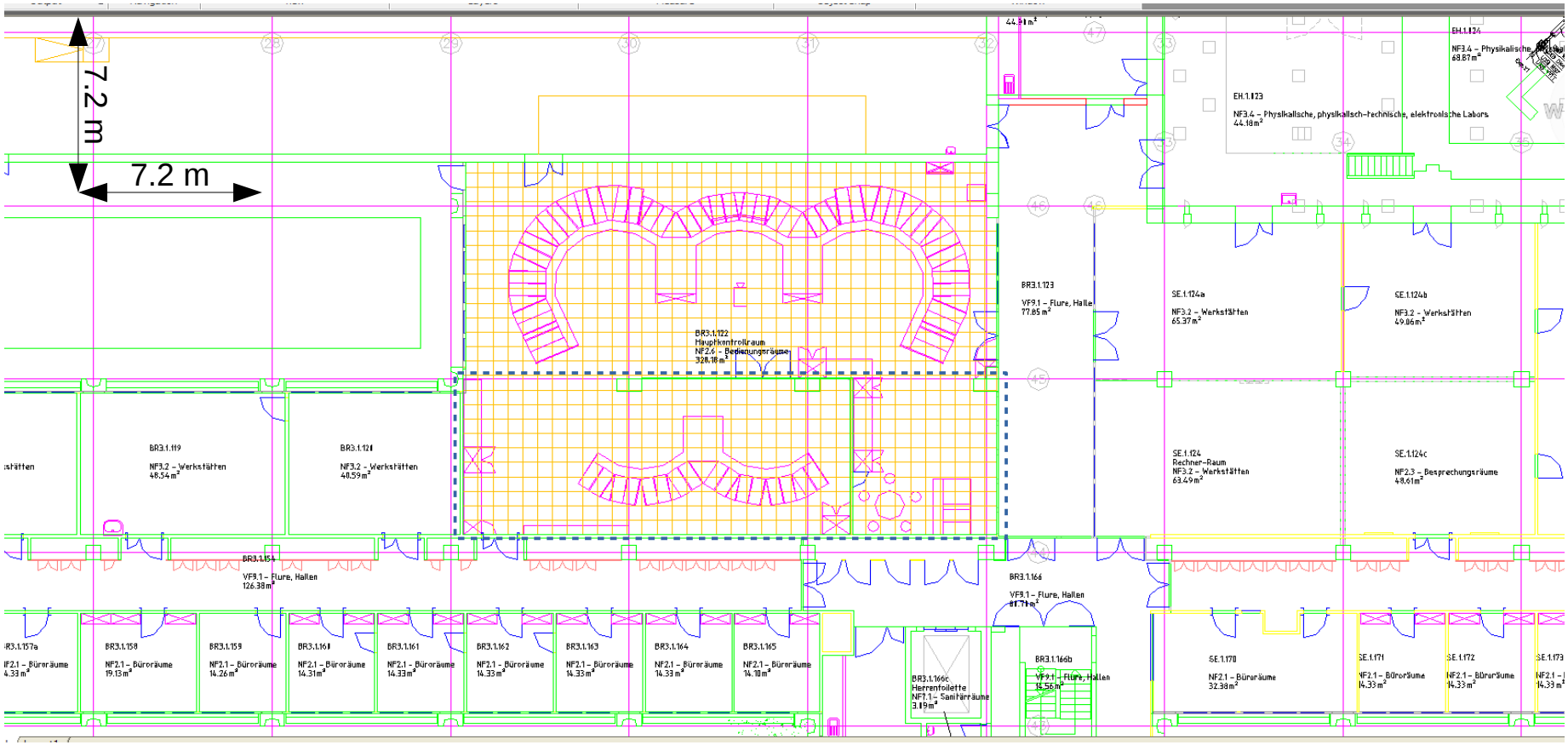
- Next Steps via FCC Project-Group (smaller circle, interest-based representation/mandate)
  - Elaborate missing requirements from other groups tightly intertwined with accelerator: Cryo, TI, (accelerator-kin) experiments, ... → remaining 20% of input to CMP

- 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

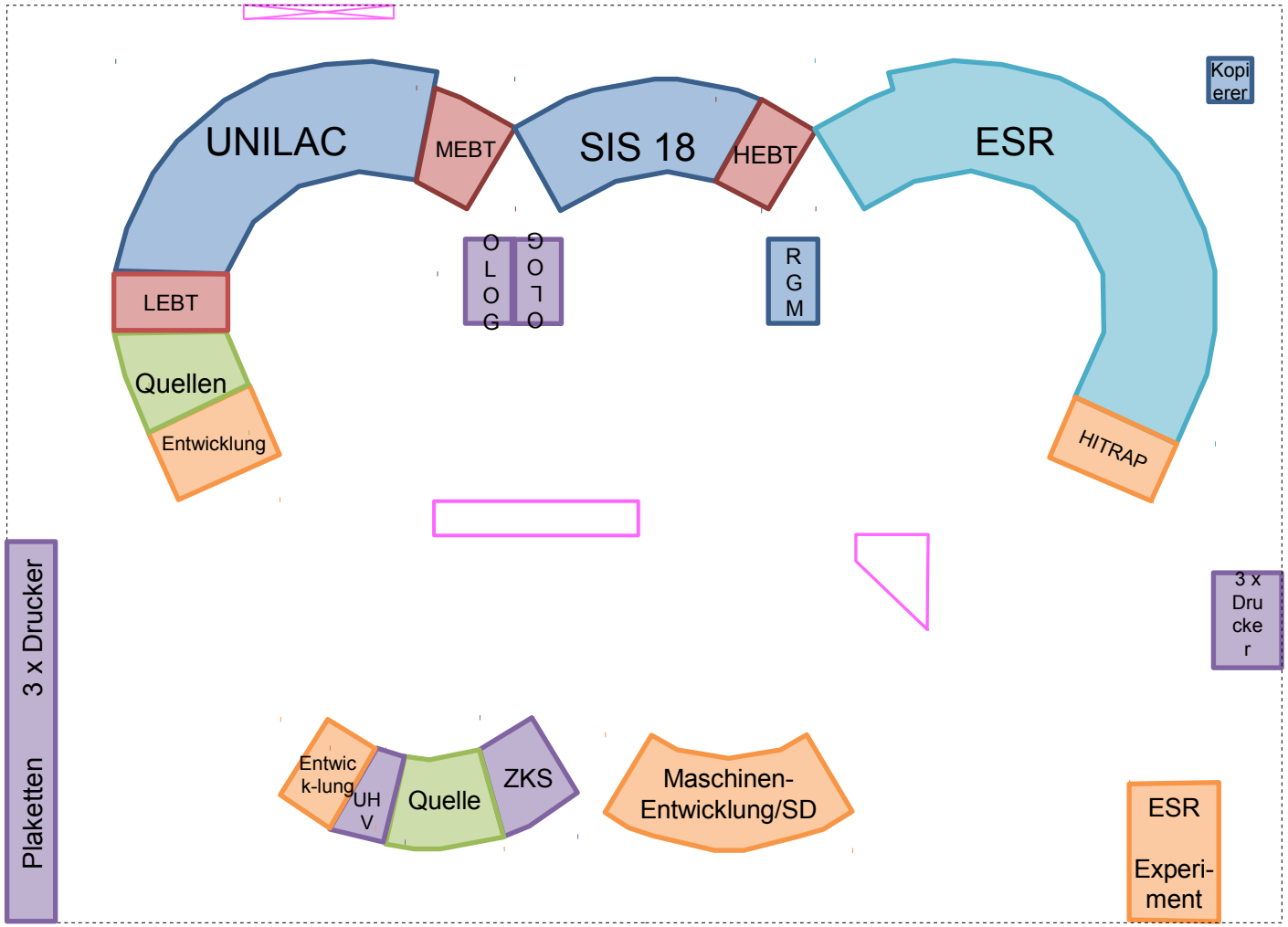
Existing Infrastructure:
'GSI Hauptkontrollraum (HKR)'



Existing Infrastructure:
GSI “alt-HKR” floor plan (328 m²)



Existing Infrastructure:
GSI HKR consoles

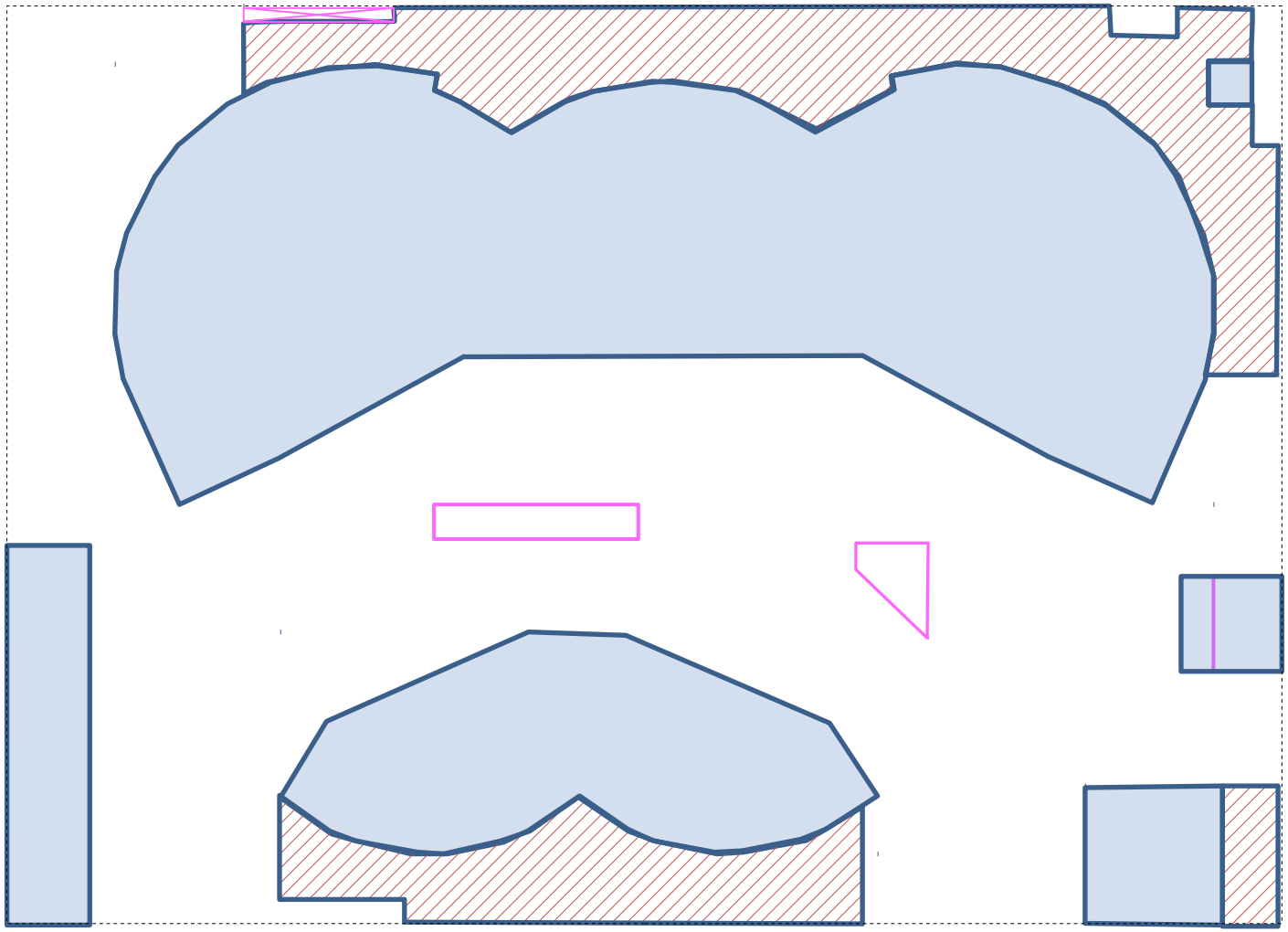


- ➔ 8% LEBT / MEBT / HEBT
- ➔ Arbeitsplätze Quellen unzu-sammenhängend
- ➔ Konsolen sehr tief für Oszi + Röhren (teilw. obsolet)
- ➔ "Analog Betrieb"...

Farbcodes:
Quelle
Beschleuniger
Speicherring
Experiment

courtesy C. Omet

Existing Infrastructure:
division of ground surface area



328 m² Grundfläche
200 m² Nutzfläche

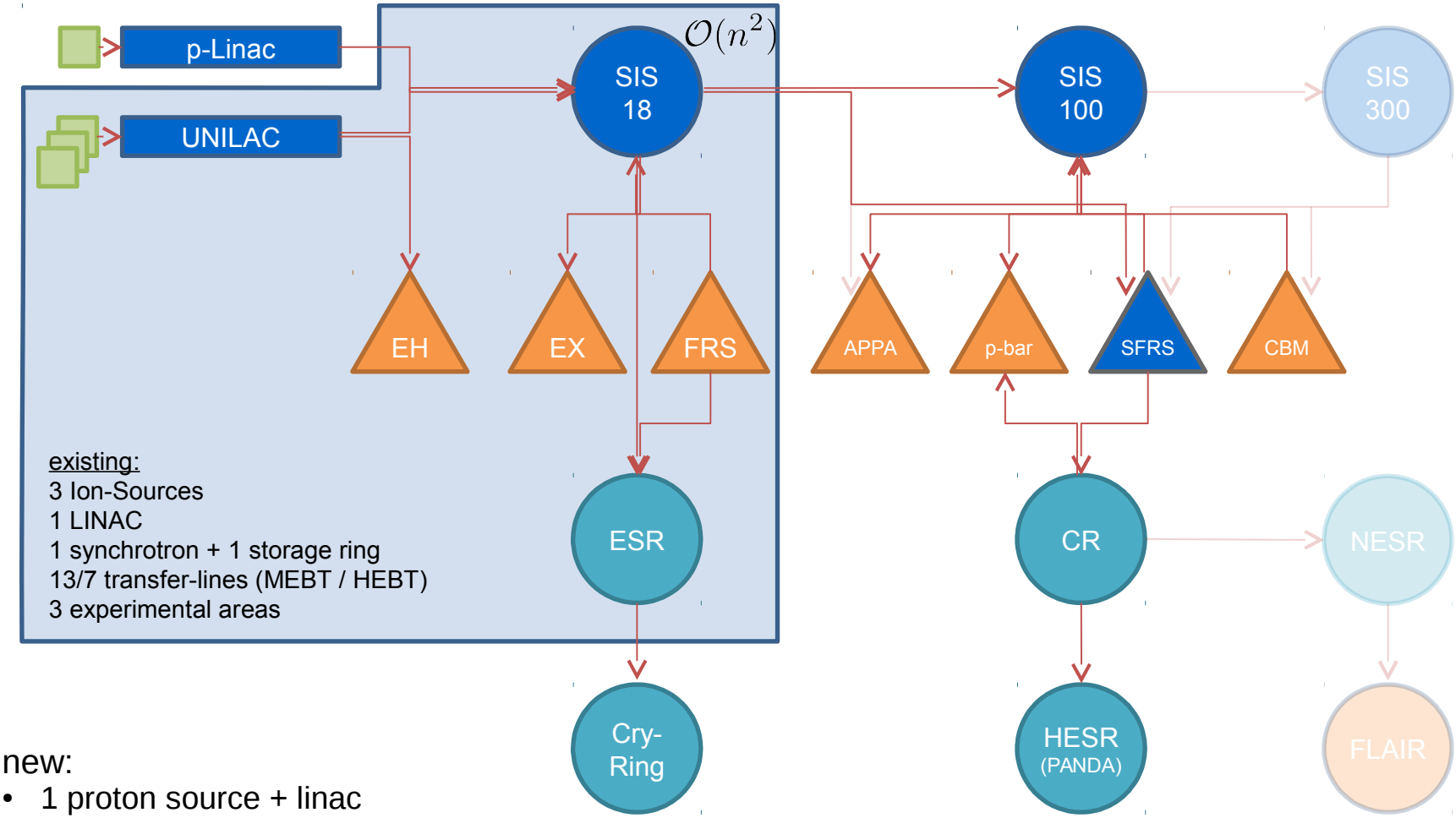
60% eff. Nutzfläche

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

courtesy C. Omet

Migration Strategy

GSI 3 → FAIR 8½ (11+) accelerator(-like) machines



MSV 0-3

MSV

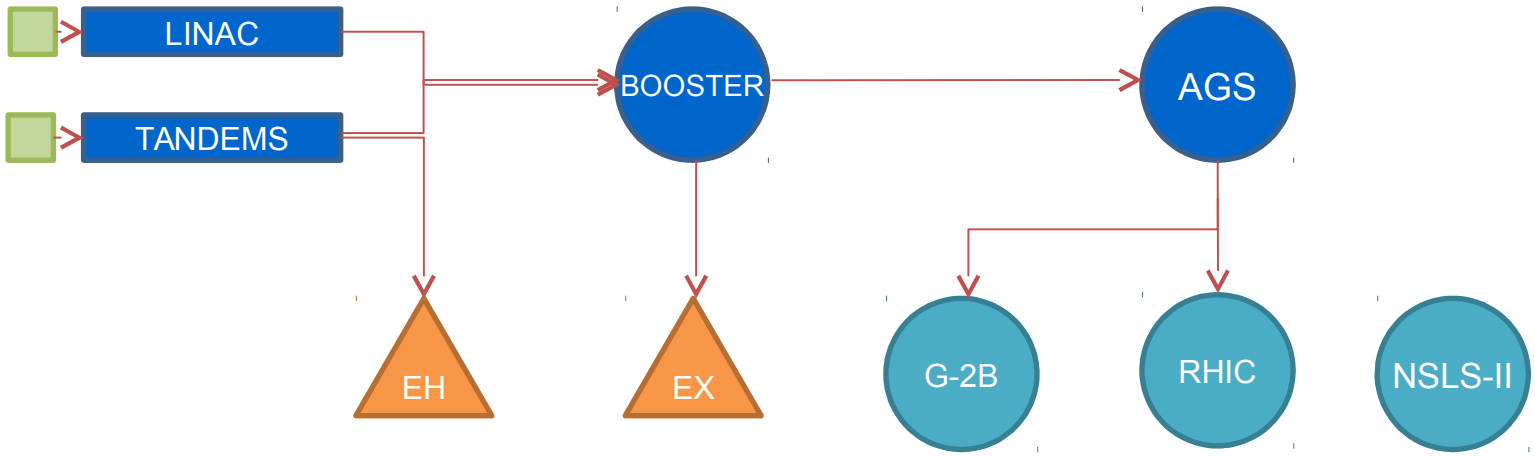
$\mathcal{O}(n^5)$

new:

- 1 proton source + linac
- 4 synchrotrons & storage rings
- 18 (26) transfer-lines
- 4 (5) experimental areas

for comparison: BNL Accelerator Complex

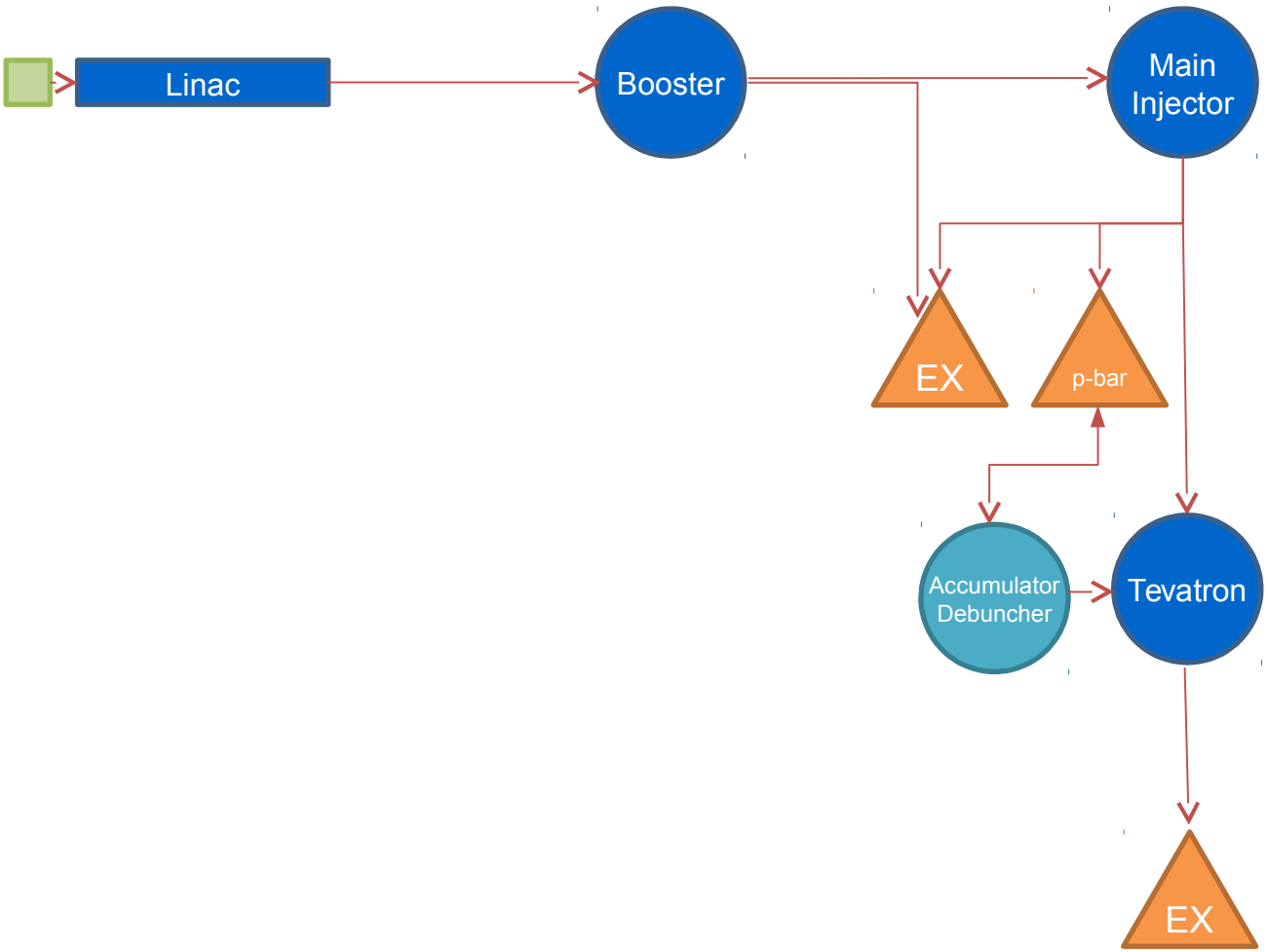
(excluding ATF etc. R&D)



- similar number of accelerators to FAIR, but
- lower complexity (shorter chains)
- quasi-static operation (infrequent ion-type changes per year)

$\mathcal{O}(n^4)$

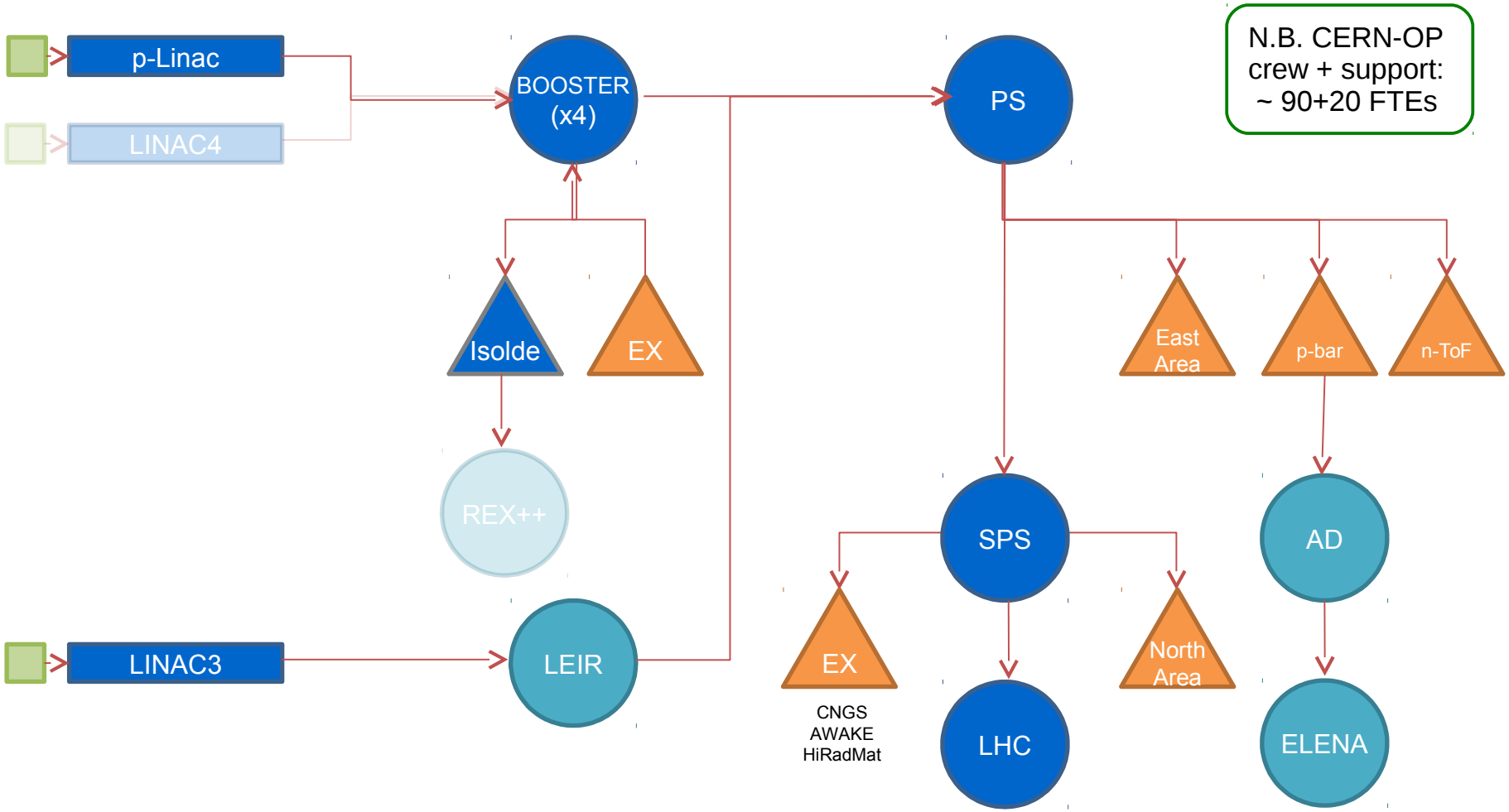
for comparison: FNL Accelerator Complex



- similar complexity/number of accelerators, but
- quasi-static operation & primarily (anti-)protons only

$\mathcal{O}(n^5)$

for comparison: CERN Accelerator Complex



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

$\mathcal{O}(n^5)$

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)

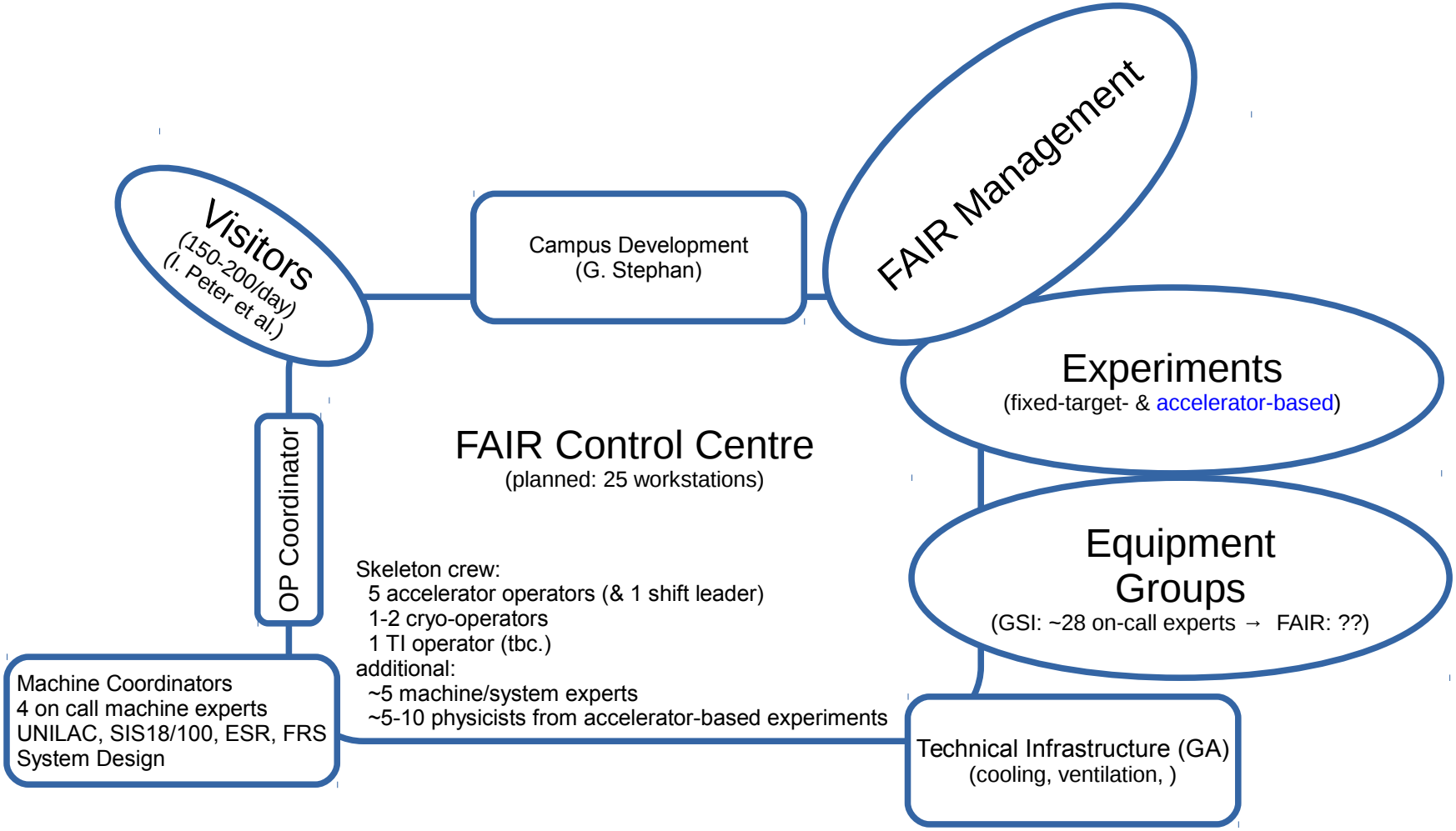
B) Will be in a constant flux of frequent adaptations to new cycles/beam parameters, etc. present estimate:

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 $\varepsilon_{UNILAC+SIS18}$ ~ 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)

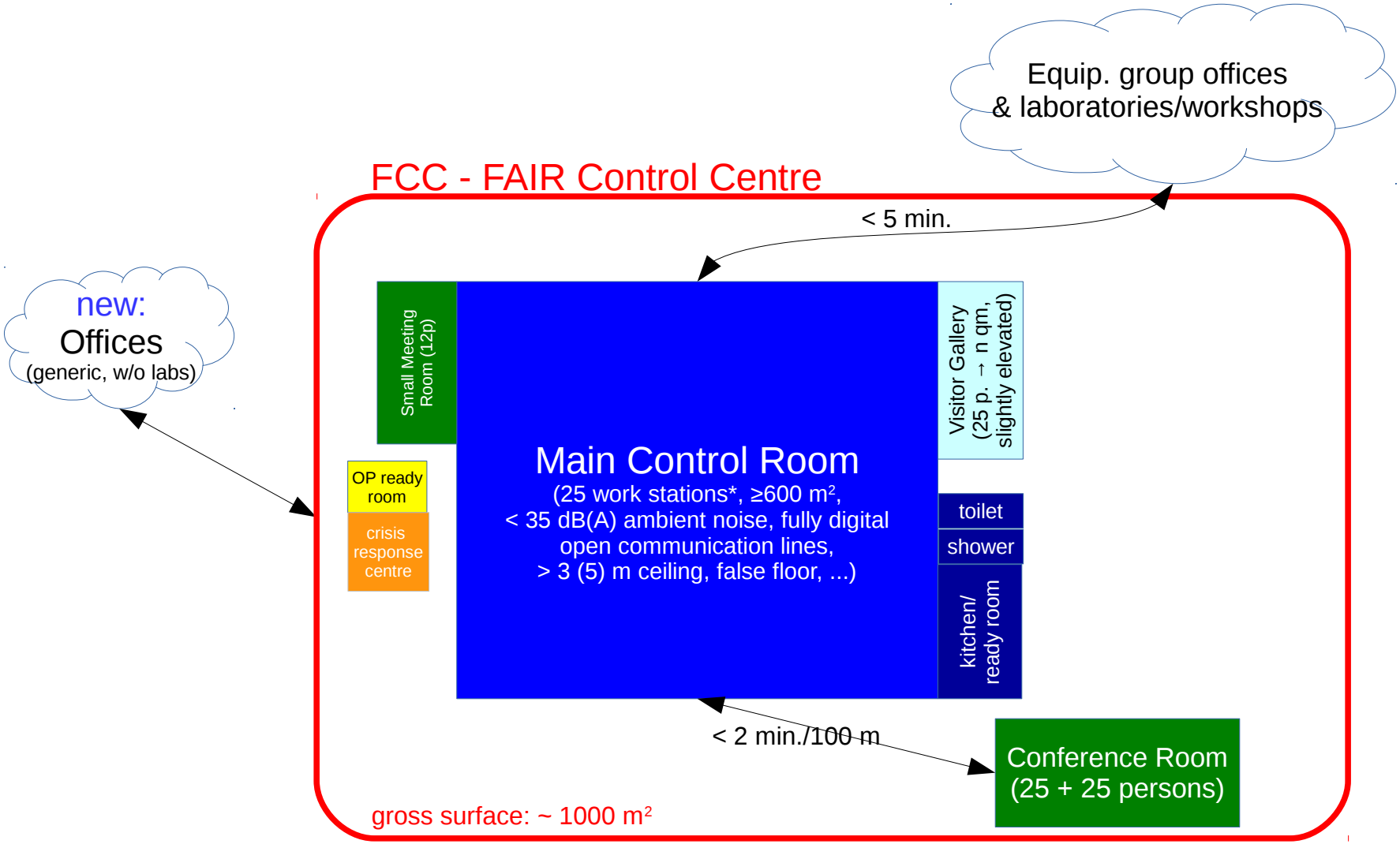
→ need to be smart and develop efficient commissioning procedures, training and tools to facilitate fast turn-around and to maintain/improve present operational performance

→ control and operation aspects are reflected in FCC design/user-requirements

FAIR Control Centre & Operation Concept Development
– User Community Organisation



FCC ... more than a 'Main Control-Room'
additional required facilities



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

Courtesy D. Manglu

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.)

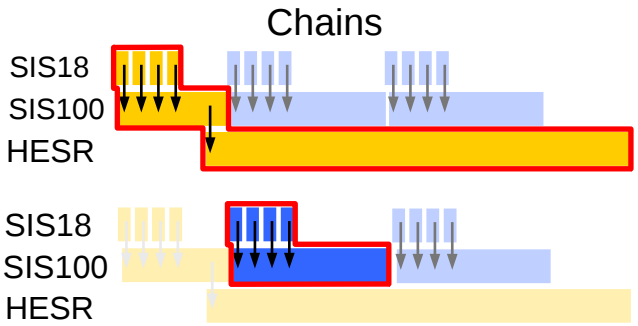
  A) MSV 0-3: 7 operators for 8 accelerators and 700 m²

  B) MSV 0-6: 12 operators for 12 accelerators and 1200 m²

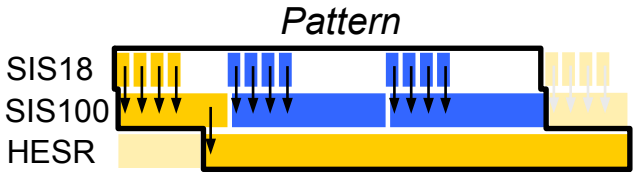
- Gretchen Frage: ”How many operators will be effectively needed?“
  - Important boundary conditions:
    - 1 operator doing 24h/7 shift-operation = 7.4 “real/gross” operators (FTEs) = ~ >0.5 MEUR/year → '4+1' vs. '7-8' corresponds to ~2 MEUR/Jahr (+ new offices)
    - 7-8 operators probably mainly needed during peak hours (day) (recommissioning, setting-up of new experiments/beams, etc.)
    - ‘full utilisation during rush hours’ vs. ‘skeleton crew operation’

Beam Production Chains & Patterns

- *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, …

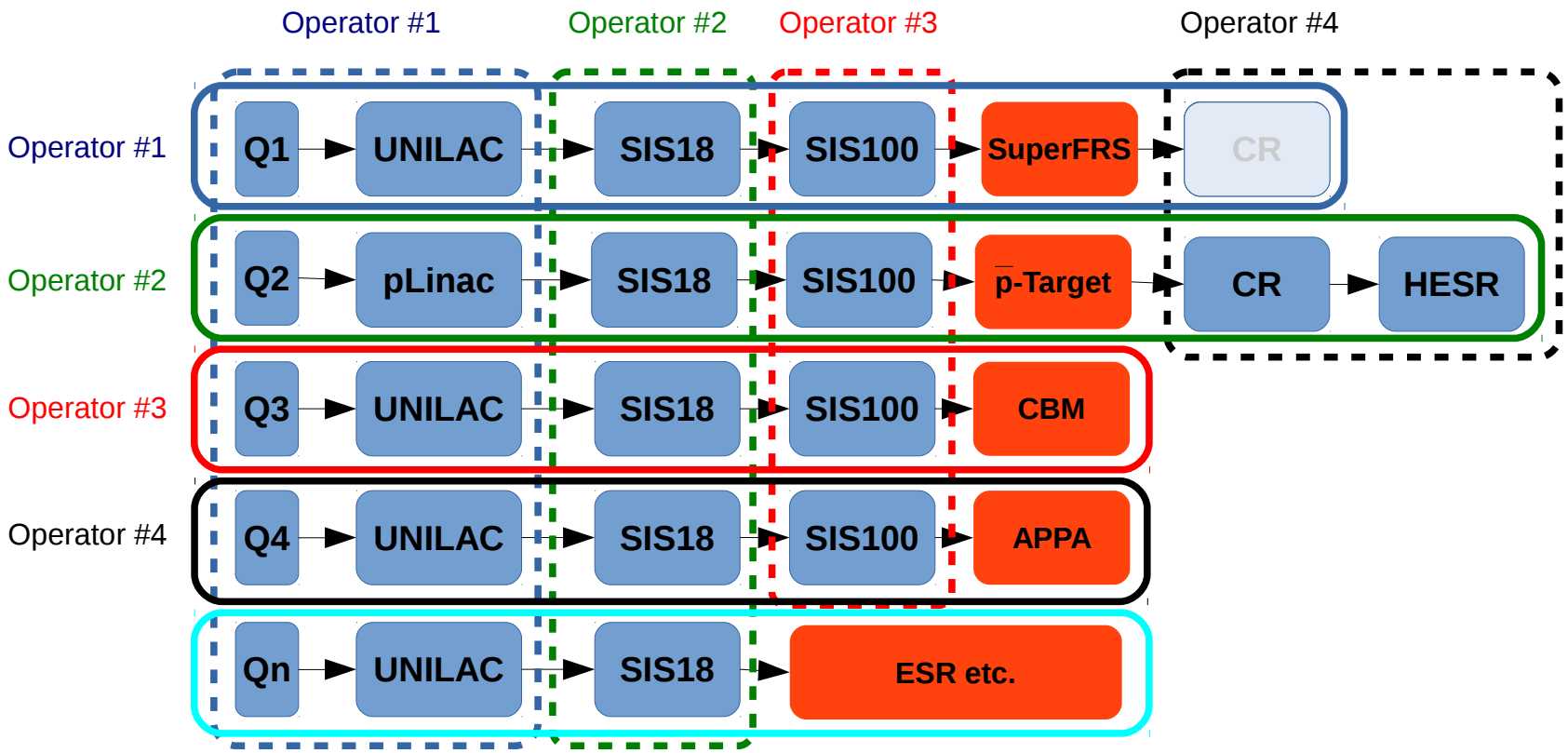


- *Beam Pattern*:
  - grouping of beam production-chains that are executed periodically
  - can be changed of pattern within few minutes (target, requires automation for beam-based retuning)



FAIR Operation Paradigm I/II

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



FAIR Operation Paradigm II/II

- Option 1: One Operator per Accelerator Domain:
  - Highly-specialised operators (less accellerator 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 → <u>permanently</u> 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 adjustemtns 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 withnin OP crew in case of illness, parental leave, holidays, etc.
  - Better value for overall oranisational 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 & ventialtion, Leistungsnetze, media supply, ...)
- Minimun: assumes setup facility and/or (partial) automatisation

B) 'Normal Operation': up to 25 people (machine setup, day-time)

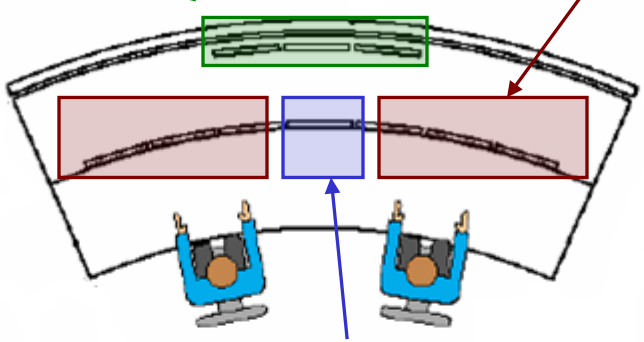
- 4+2+1 'Skeleton Crew' + accelerator experts:
  - accelerator physicists, RF/BI/CO experts, beam-cooling experts, beam-line physicists, experimentalists, etc.
- Variable scenarios: + 15-20 People with >4h/day occupancy in FCC
  - setup of new (exotic) beam experiments: typ. 3-4 people
  - failure diagnostics 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
  - ...

Workstation Layout
CERN reference concept

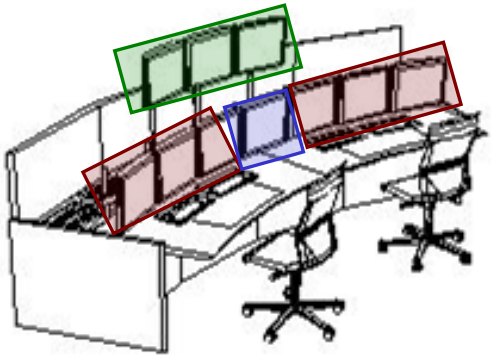
3 fixed displays split between 2 workspaces

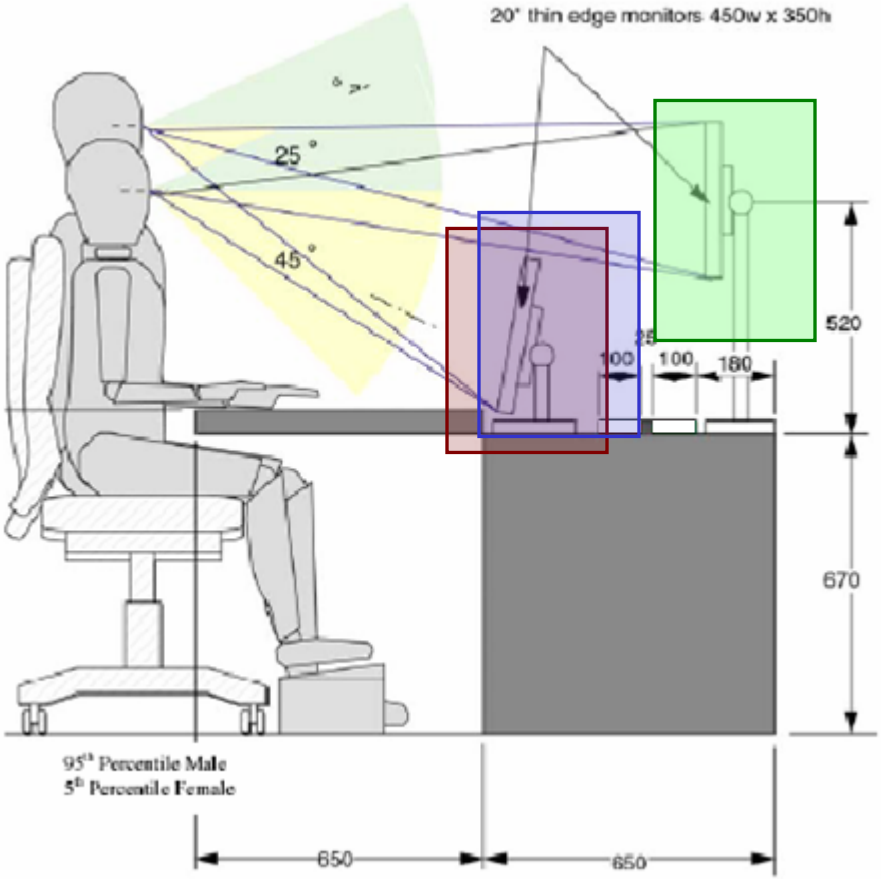
CERN experience→ FAIR:
independent fixed displays for each workspace

3 flat screens per workspace
1 keyboard 1 mouse



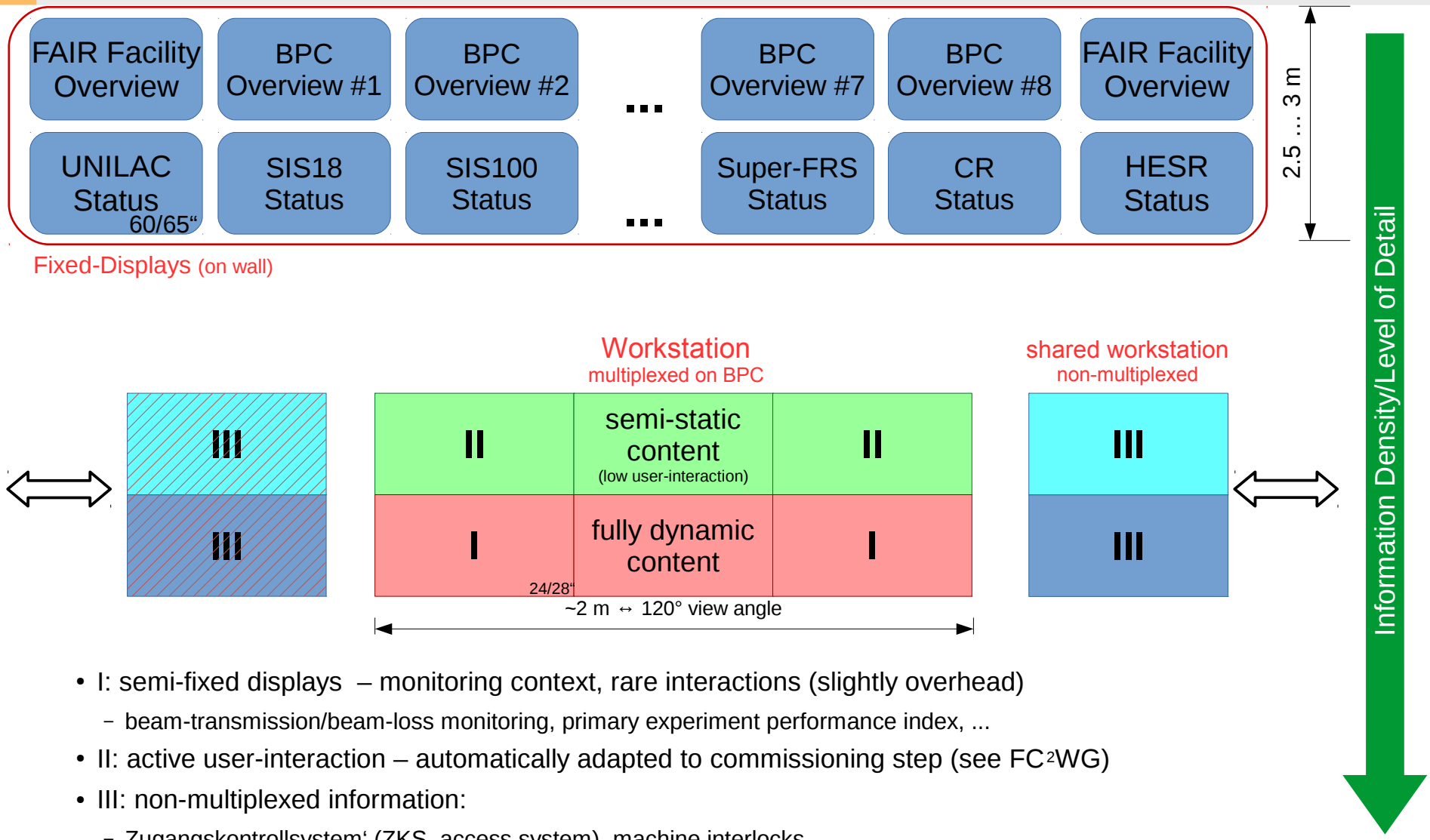
1 additional admin PC





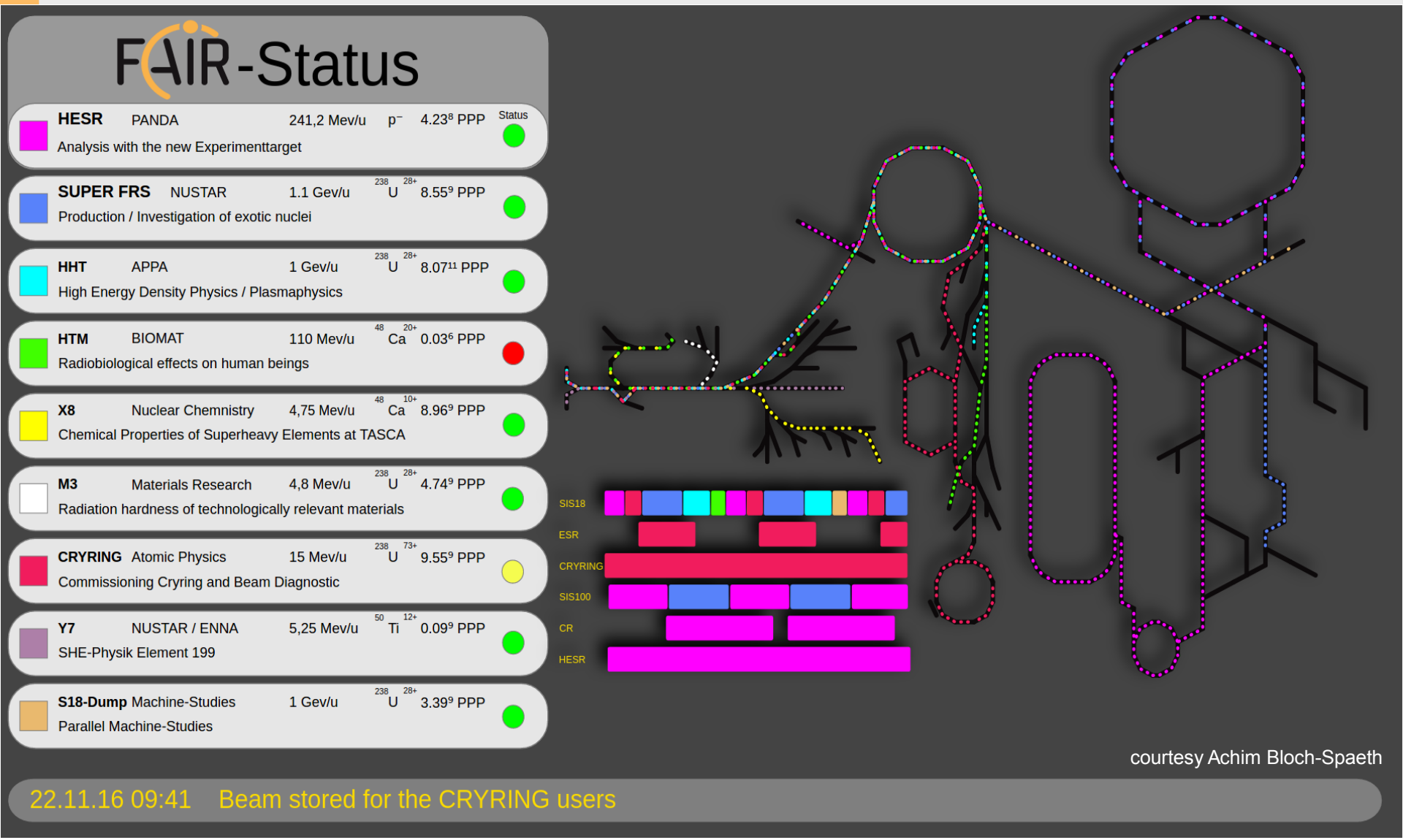
Courtesy D. Manglunki (CERN)

Fixed-Display & Workstation Layout
Information Density Hierarchy



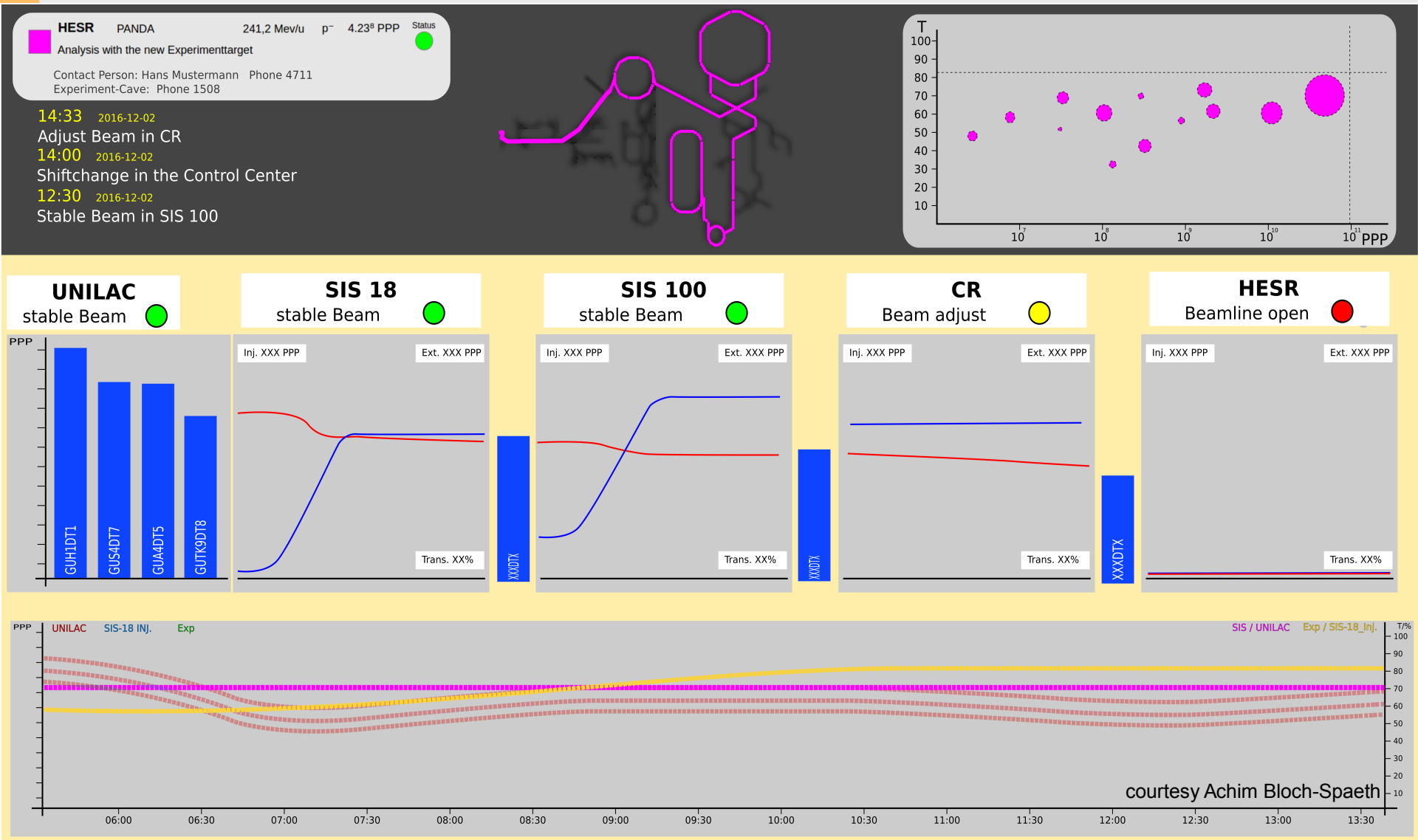
- I: semi-fixed displays – monitoring context, rare interactions (slightly overhead)
  - beam-transmission/beam-loss monitoring, primary experiment performance index, ...
- II: active user-interaction – automatically adapted to commissioning step (see FC²WG)
- III: non-multiplexed information:
  - Zugangskontrollsystem‘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

Example: FAIR Facility Overview
Proof-of-Concept Prototype



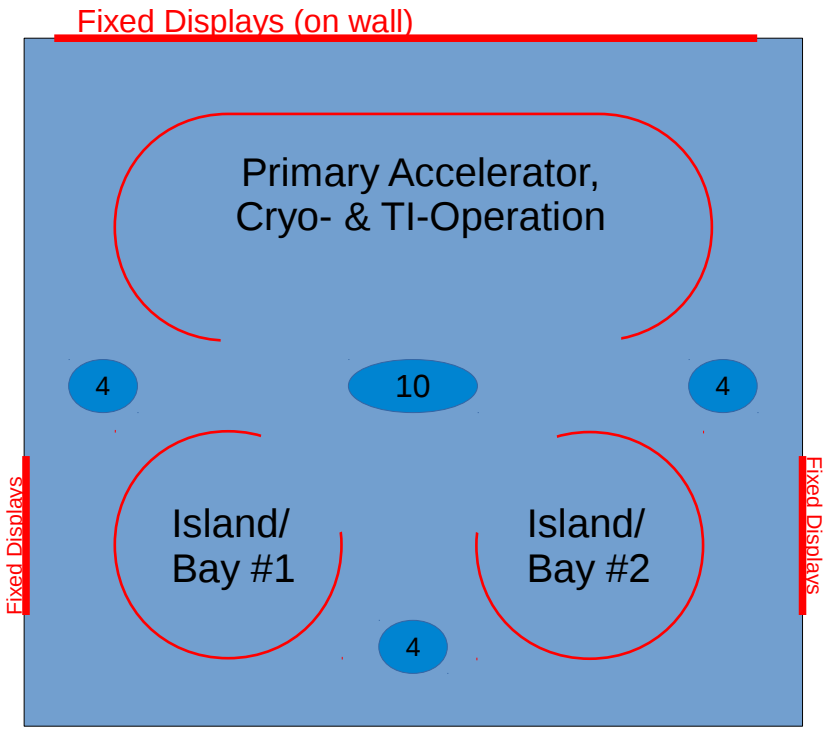
FAIR Beam Production Chain Overview

Proof-of-Concept Prototype



FCC Workstation Layout
General Concept

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



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

Fixed-Display & Workstation Layout

tentative distribution of ~25 consoles...

Proposed BPC-Paradigm Sceme:

- 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)

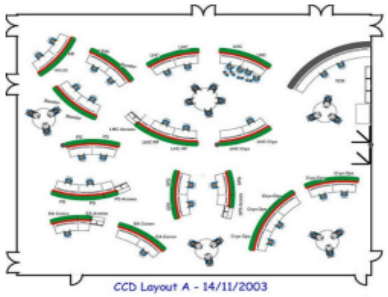
Classic scheme (deprecated):

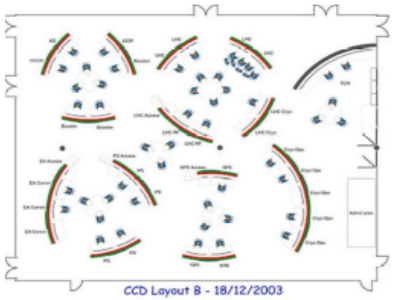
- 5 – primary beam accelerators (UNILAC → SIS18 → SIS100)
- 3 – ESR, CRYRING, CR
- 2 – HESR
- 2 – SuperFRS
- 3 – Cryogenics
- 3 – Technical Infrastructure
- 5 – accelerator-kin experiments
- 2 – generic short-term debugging consoles (+ shift leaders)

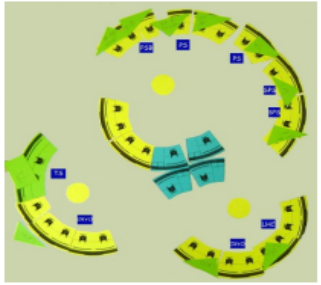
FCC Workstation Layout
Specific Concept

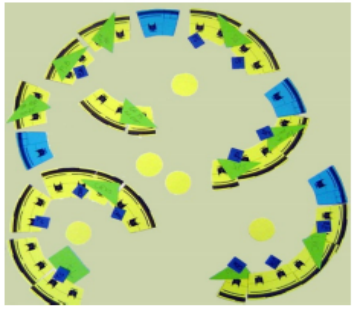
Workstation distribution

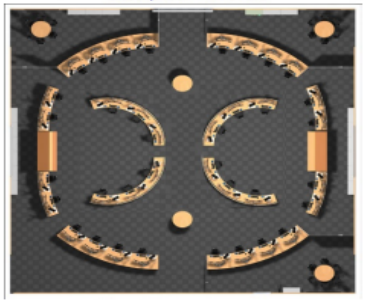
Several options have been studied by the consultants (GTD, CCD), the CCC-WG and the IDOC. A one-day workshop gathered the IDOC and the CCC-WG, moderated by M.Clark (CCD), and chaired by S.Baird, AB/OP group leader, allowed to develop a model satisfactory for all parties.

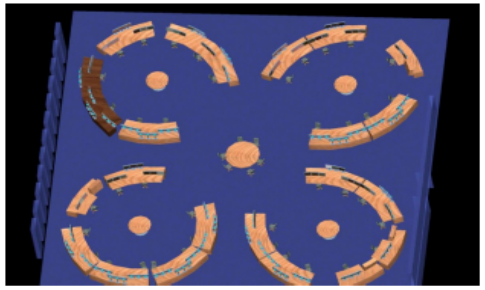












CCC Ergonomics 20 D.Manglunki - AB/OP

Need similar user iteration at FAIR:
Accelerator operations, machine experts (& SPLs), GA/TI, experiments, … tbd.

Appendix

FCC – Executive Summary I/II
primary functional requirements → input to CMP

- 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

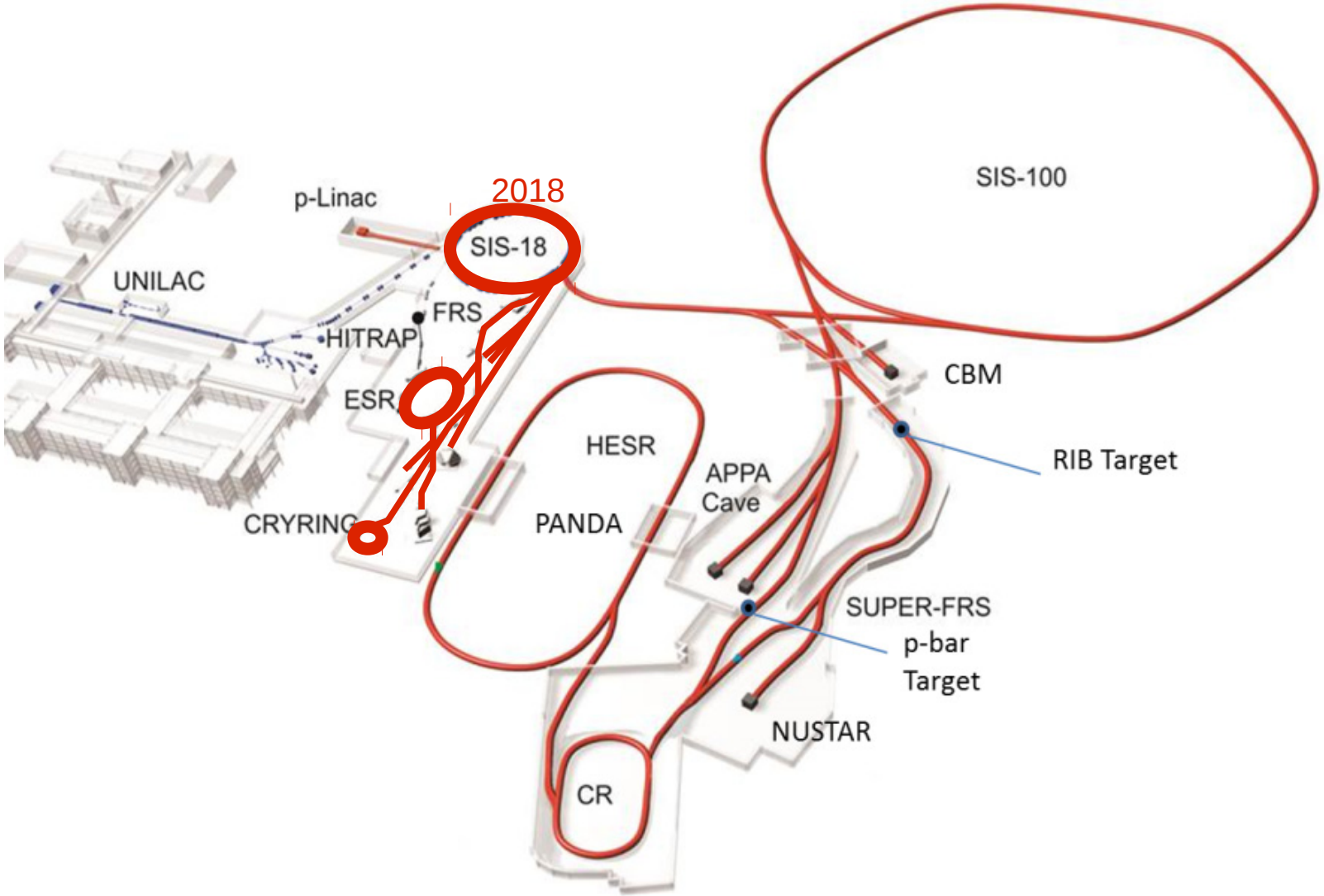
FCC – Executive Summary II/II
secondary functional requirements → input to CMP

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 Konferenzraum (~ 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

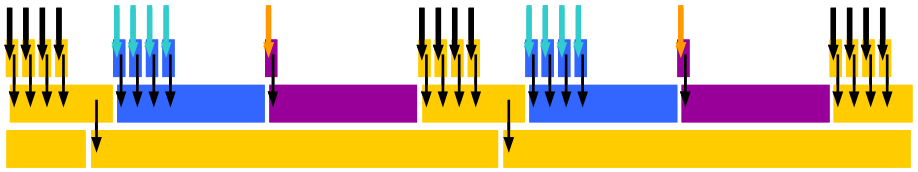
GSI → FAIR Transition in 2018



Beam Production Chains & Patterns
Example II/II

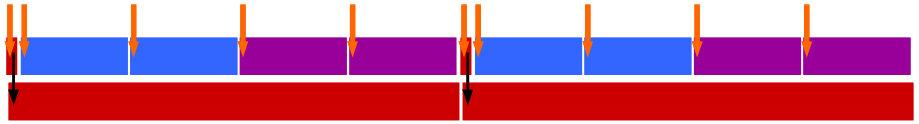
Periodic beam patterns, dominated by one ***main*** experiment:

Unilac
SIS18
SIS100
HESR



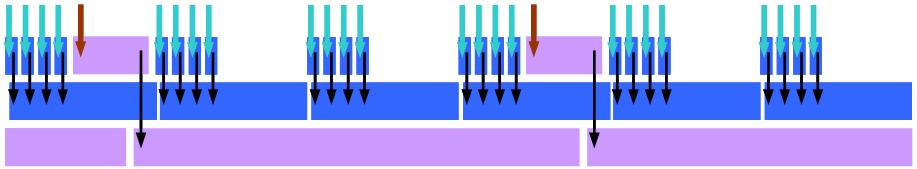
AP *+ RIB ext. target (U^{28+}) + Biomat*

Unilac
SIS18
SIS100

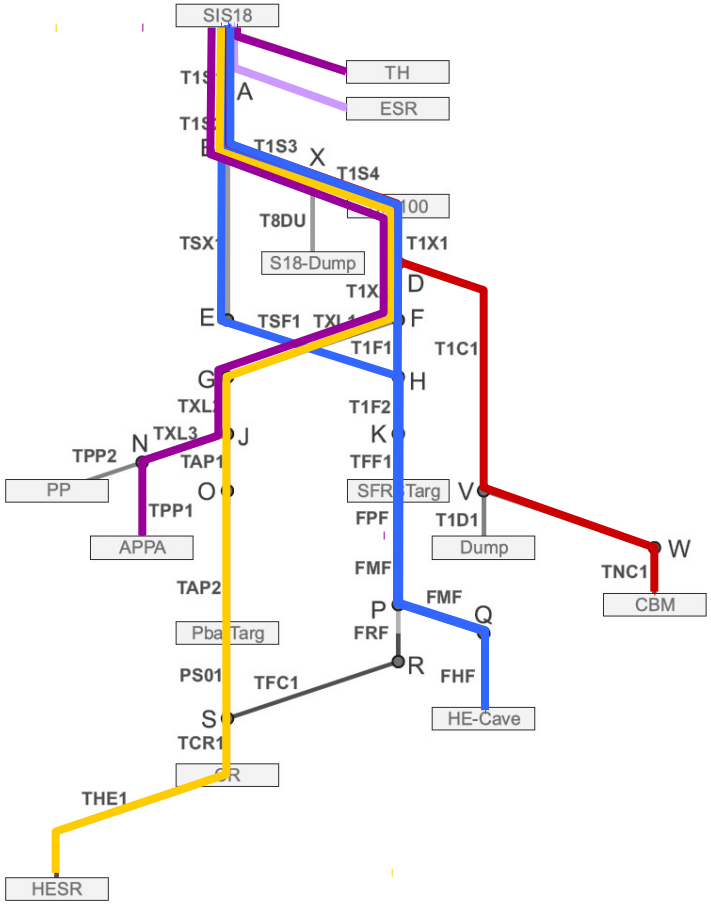


CBM *+ RIB ext. target (U^{73+}) + AP (LE)*

Unilac
SIS18
SIS100
ESR



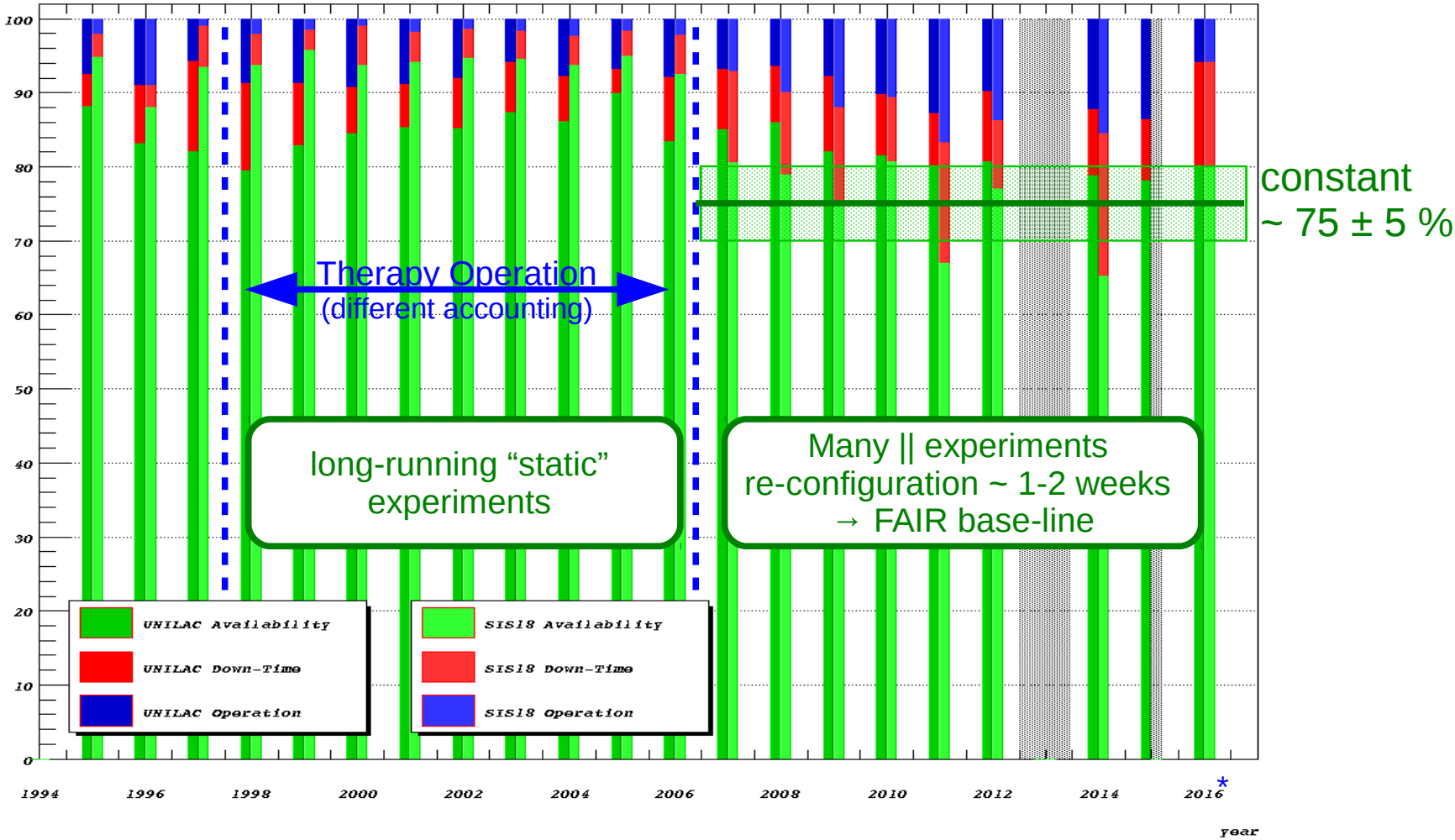
RIB ext. target (U^{28+}) *+ ESR*



courtesy D. Ondreka

Accelerator Experience & Efficiency

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



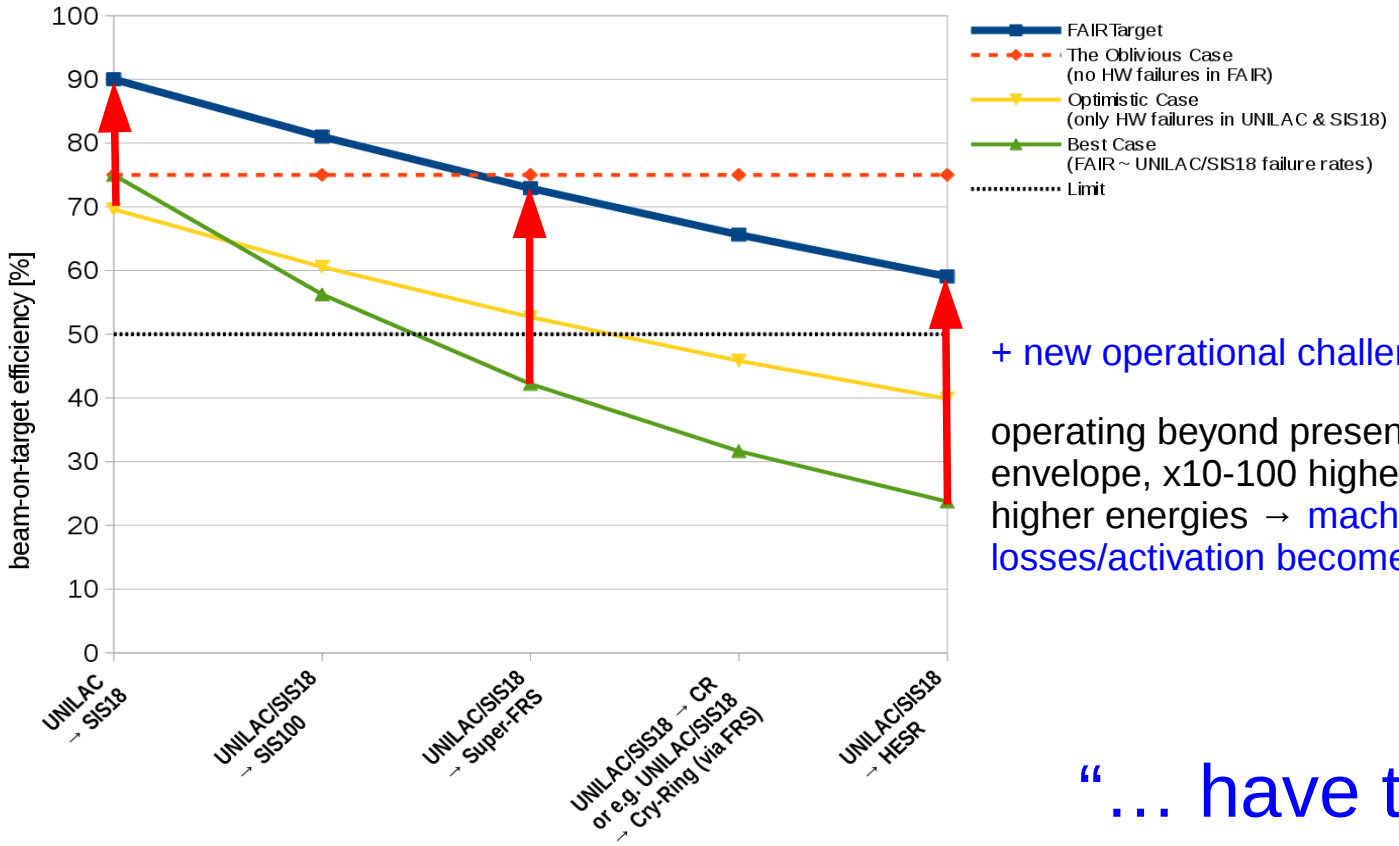
Based on: U. Scheeler, S. Reimann, P. Schütt et al., "Accelerator Operation Report", GSI Annual Scientific Reports 1992 – 2015 + 2016 (D. Severin)
https://www.gsi.de/en/work/research/library_documentation/gsi_scientific_reports.htm
N.B. ion source exchanges are factored out from UNILAC & SIS18 data (~ 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!"