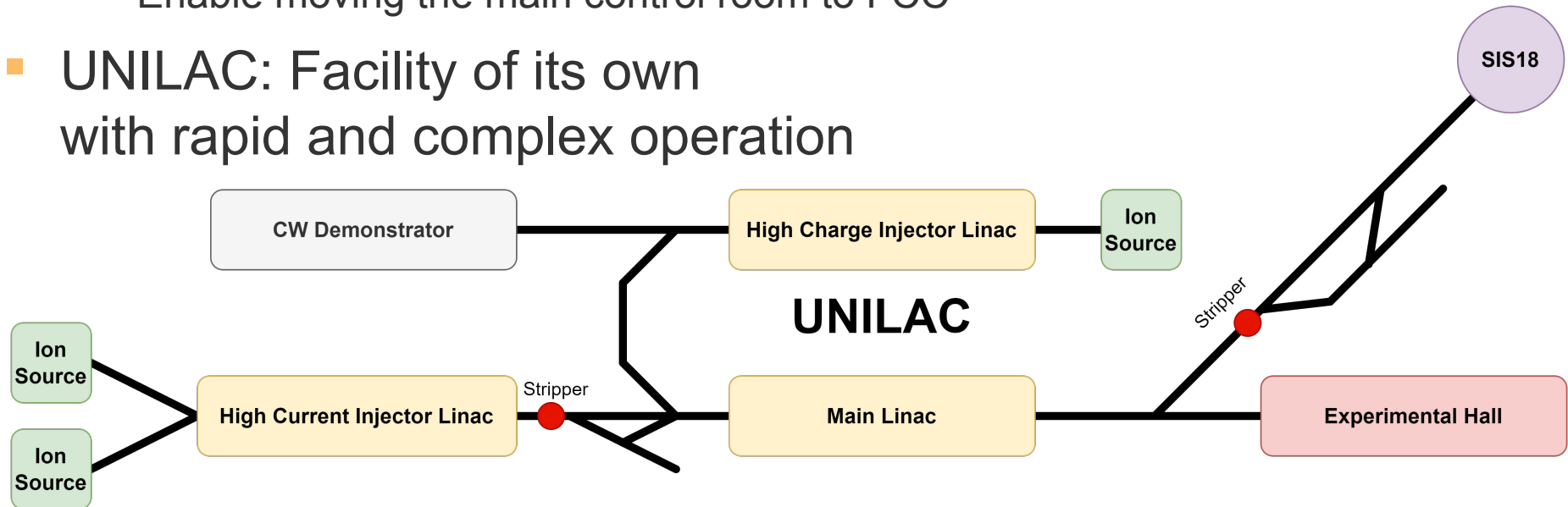# UNILAC Control System Upgrade

Jutta Fitzek, Hanno Hüther
2024-09-19

Agenda

- Introduction and Motivation
- Strategy and Timeline
- Most Relevant Changes for OPE
- Current Developments in APP
- Architecture Comparison
- Project Organization
- Milestones
- Report from the Dry Run in July
- Preparation for the Dry/Wet Run in October/November
- Outlook on the Wet Run in Summer 2025

Introduction

- ## Injector Controls Upgrade (ICU) project
  - Provide modern, sustainable control system for GSI linacs
  - Focus on UNILAC, consolidate with overall system
  - Enable moving the main control room to FCC

- ## UNILAC: Facility of its own with rapid and complex operation

- Hard- and software of existing UNILAC control system from the 1990s

  - Obsolete, outdated, deprecated, not maintainable anymore

  - Stuck with operating system running beyond extended support contract, leading to compatibility issues and security risks

  - Drain of expert knowledge due to retirement

  - Moving the main control room to the FCC requires control system upgrades

  - GSI can not maintain two separate control systems

➔ Adapt the (not so new anymore) control system established at SIS18, ESR and CRYRING and apply to UNILAC

- Functionally, UNILAC would be able to serve ES/FS today
  - Integrate UNILAC into FAIR control system
  - Use existing legacy control system as template
  - Replace analog cables and appliances with digital signals and software

- Several improvements result from introducing new technology
  - Maintainability, transparency, traceability, extensibility, flexibility, usability, …

- Make the transition as painless as possible for operators

- ➜ New concepts and features only where necessary for now (e.g. timing system, LSA) or high benefit at low effort

✔ Step 0 (done):
Secure UNILAC beam operation for beamtime 2025

- Replace existing operating cluster with virtual machines
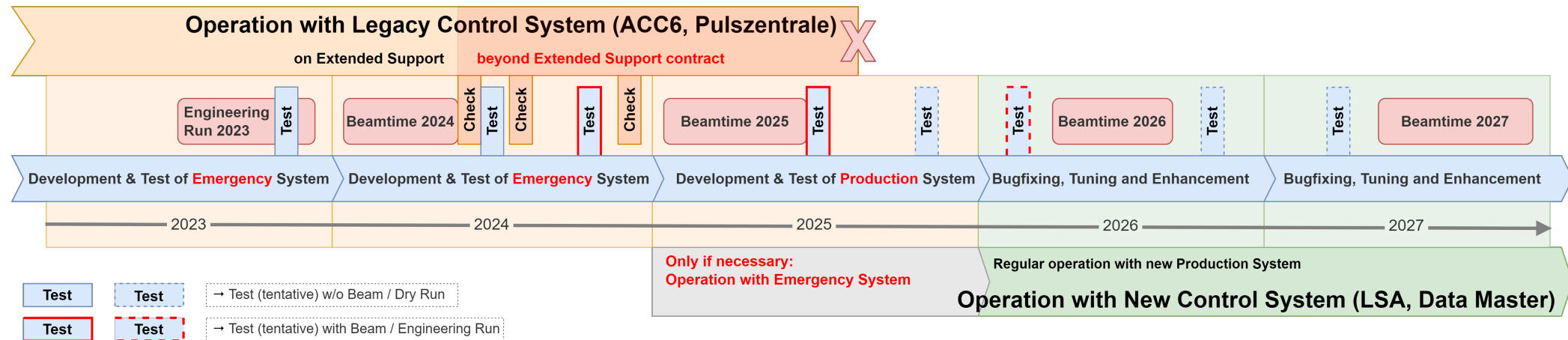- Implement IT security measures

➢ Step 1 (in progress, until beamtime 2025):
Develop „emergency" control system

- Intermediate step towards full system, useful for testing and feedback
- First viable version with reduced and simplified feature set
- Emergency backup for beam time 2025 in case of a (very unlikely) major failure or security breach in the legacy control system

Strategy and Timeline [2/3]

- **Step 2 (until beam time 2026):**
  Develop production control system
  - Based on emergency control system
  - Replace simplifications by full-fledged solutions, implement full feature set
  - Enhance usability and efficiency

- **Step 3 (beam time 2026 and onward):**
  Bug fixing, tuning and enhancements
  - Further development, implement feedback from operators
  - Streamlining and consolidation with the other machines
 - Include other linear accelerators

GSI

- Develop emergency control system as intermediate step until beam time 2025, regular operation with legacy system
- Regular operation with new control system from BT 2026
- Interleave tests with beamtimes and shutdowns

Operation with Legacy Control System (ACC6, Pulszentrale)

on Extended Support — beyond Extended Support contract

| Engineering Run 2023 | Test | Beamtime 2024 | Check | Test | Check | Test | Check | Beamtime 2025 | Test | Test | Test | Beamtime 2026 | Test | Test | Beamtime 2027 |

Development & Test of **Emergency** System | Development & Test of **Emergency** System | Development & Test of **Production** System | Bugfixing, Tuning and Enhancement | Bugfixing, Tuning and Enhancement

2023 — 2024 — 2025 — 2026 — 2027

Only if necessary: Operation with Emergency System

Regular operation with new Production System

Operation with New Control System (LSA, Data Master)

| Test | | Test | → Test (tentative) w/o Beam / Dry Run |
| Test | | Test | → Test (tentative) with Beam / Engineering Run |

Most Relevant Changes for OPE

- ## UNI-PZ will be replaced by UNILAC Data Master
  - Pre-planned schedules instead of ad-hoc decisions

- ## Settings calculation and storage will be performed by LSA
  - Dedicated settings management system with settings database instead of calculation directly in apps and settings storage in front end computers

- ## Fortran-based programs will be replaced by Java applications
  - Many general purpose applications already known from SIS/ESR/CRYRING operation, but also dedicated apps for UNILAC
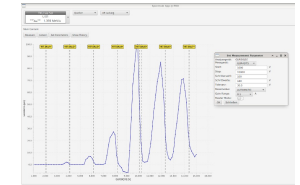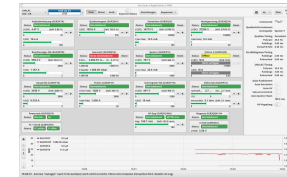
Current Developments in APP
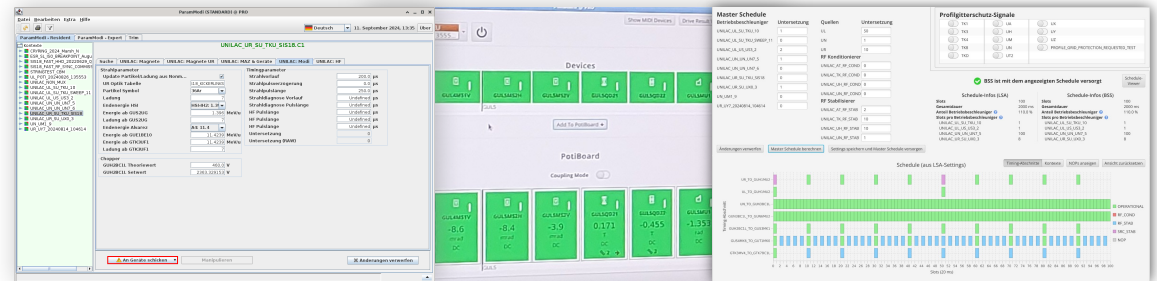
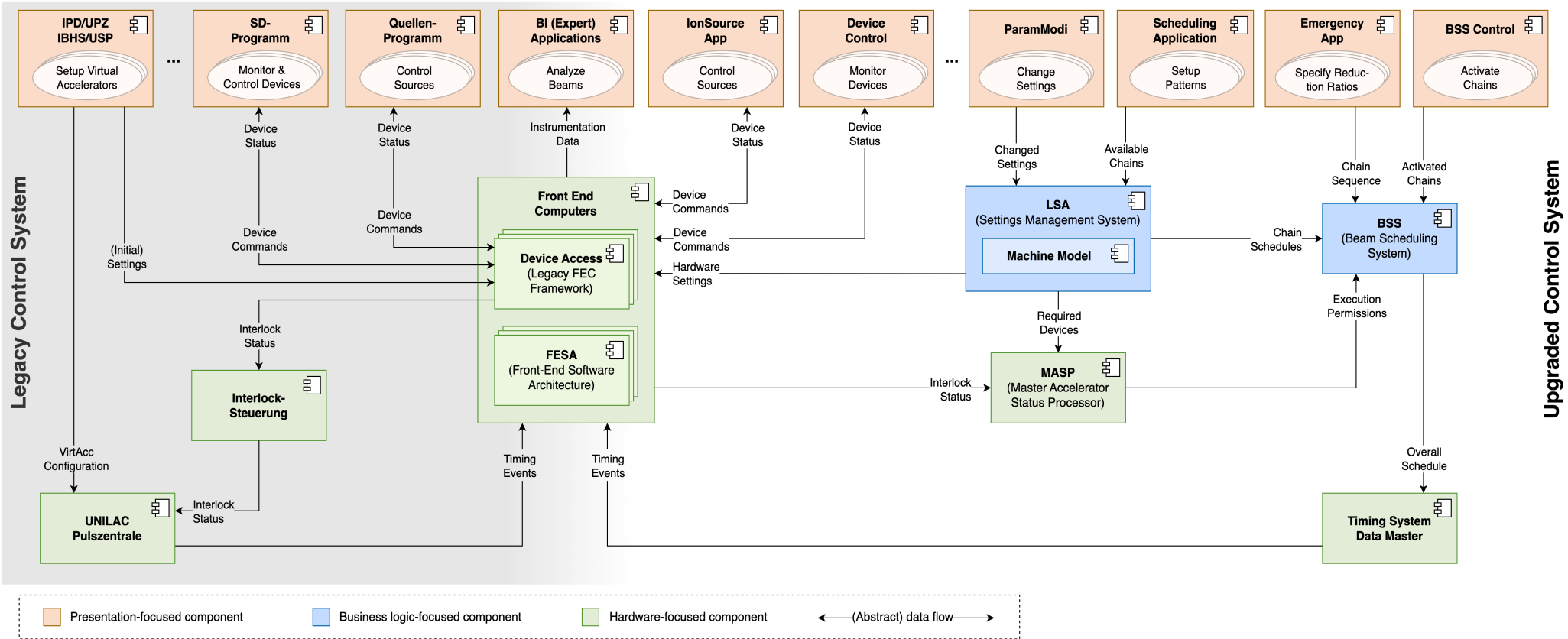- Mapping of functionality as basis for development
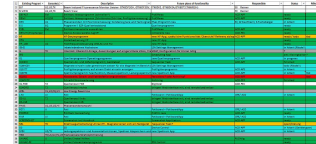
- Implementation – Adaptation of existing Applications

  – All Apps: UNILAC support   development ongoing

  – MASP GUI, UNILAC support   completed

  – Snoop GUI, UNILAC support (BEA)   completed

  – Profile Grid App, UNILAC support   started

Current Developments in APP

- Implementation – New Applications

  - UNILAC Emergency App   used for Emergency System

  - IonSource   first test version in place

  - Spectrum App   development ongoing

  - PotiBoard App   development "phase 1" ongoing with external work

  - UNILAC What's Running   conceptual work done, API design started

  - Faraday-Cup-Panel App   2024/25

  - BTM GUI   2025, external work

  - HF App   2025
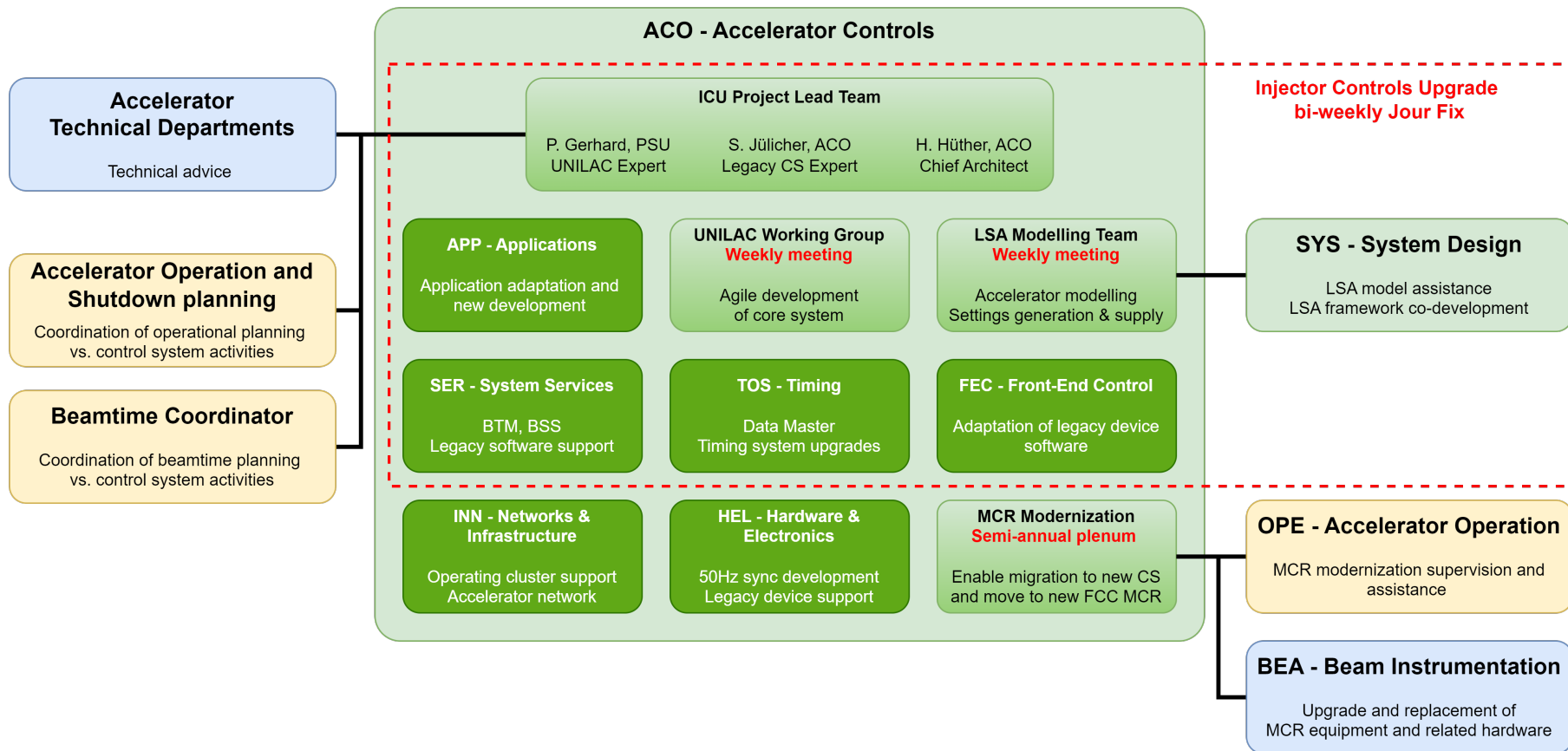
Architecture Comparison

Legacy Control System

Upgraded Control System

Presentation-focused component · Business logic-focused component · Hardware-focused component · ←(Abstract) data flow→

Note: This is a (very) simplified view on the control system's architecture. Several integral components have been omitted for the sake of comprehensibility.
If you would like to gain a more comprehensive understanding or have any questions or comments, please feel free to call Hanno at -3089 or write to h.huether@gsi.de.

Project Organization

GSI

ACO - Accelerator Controls

Accelerator Technical Departments

Technical advice

Accelerator Operation and Shutdown planning

Coordination of operational planning vs. control system activities

Beamtime Coordinator

Coordination of beamtime planning vs. control system activities

Injector Controls Upgrade bi-weekly Jour Fix

ICU Project Lead Team

P. Gerhard, PSU
UNILAC Expert

S. Jülicher, ACO
Legacy CS Expert

H. Hüther, ACO
Chief Architect

APP - Applications

Application adaptation and new development

UNILAC Working Group
Weekly meeting

Agile development of core system

LSA Modelling Team
Weekly meeting

Accelerator modelling
Settings generation & supply

SYS - System Design

LSA model assistance
LSA framework co-development

SER - System Services

BTM, BSS
Legacy software support

TOS - Timing

Data Master
Timing system upgrades

FEC - Front-End Control

Adaptation of legacy device software

INN - Networks & Infrastructure

Operating cluster support
Accelerator network

HEL - Hardware & Electronics

50Hz sync development
Legacy device support

MCR Modernization
Semi-annual plenum

Enable migration to new CS and move to new FCC MCR

OPE - Accelerator Operation

MCR modernization supervision and assistance

BEA - Beam Instrumentation

Upgrade and replacement of MCR equipment and related hardware

Milestones [1/3]

- ✔ **Dry Run 2023**
  - first test of new control system components at UNILAC (settings generation and data supply)

- ✔ **Beamtime 2024**
  - operation of user beam time with legacy control system on extended support

- ✔ **Dry Run 2024**
  - verify main capabilities of emergency control system

- **Wet Run 2024**
  - test emergency control system with beam

Milestones [2/3]

- ## Beamtime 2025
  - Operation of user beam time with legacy control system beyond extended support
  - Only if necessary: operation with emergency control system

- ## Wet Run 2025
  - Test new production control system with beam
  - First test of beam injection into SIS18 with new control system

- ## Beamtime 2026
  - first regular operation with new control system
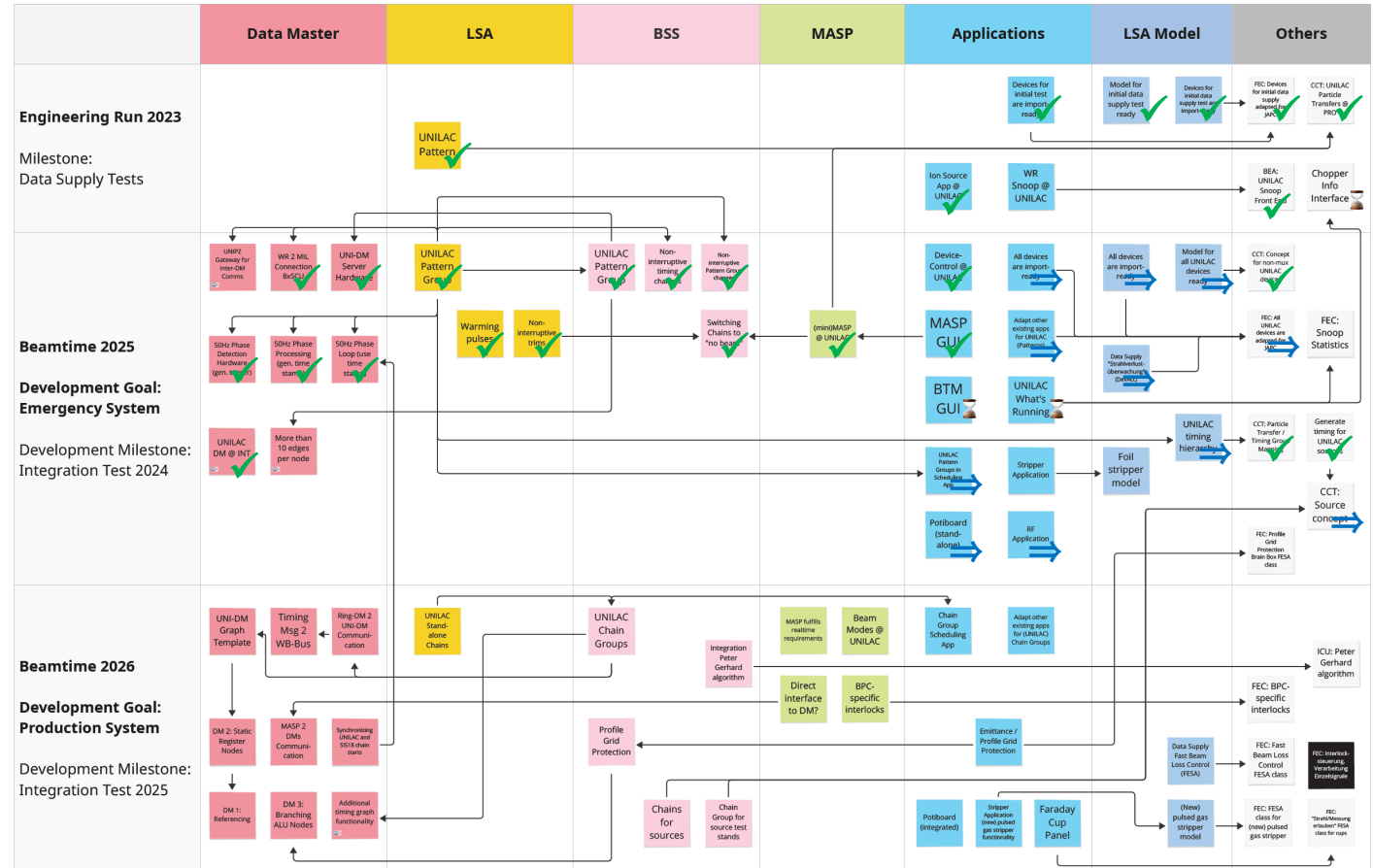
Dry Run 24_2: 2024-07-01 to 2024-07-24
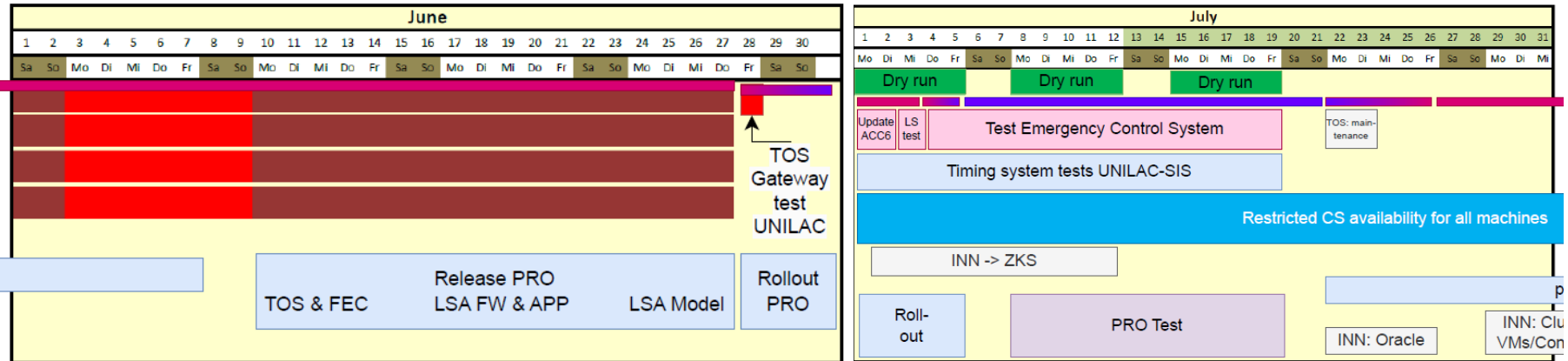
excerpt from ICU Project Test and Release Plan

- Dry run was very successful: Almost all goals achieved, requirements for the milestone even exceeded in some areas

- Thanks to everybody that contributed!

DR 24_2: Excerpt from the results [1/3]

- WR-2-MIL-Gateways provided, connected and successfully tested

- Dedicated Data Master for UNILAC provided, installed and successfully tested

- 50 Hz synchronization of Data Master integrated into timing schedules and successfully tested

- Chains for realistic multiple-beam scenario successfully scheduled using Emergency App prototype

Please refer to the dry run wiki page for the full list

- Settings for various magnet and RF devices
  (including LEBT magnets, MAZ) successfully supplied

- Chain timing (i.e. timing for Virtual Accelerators)
  successfully tested with actual devices

- Pulses on various RF devices verified using BEA's UniMon
  application

- All relevant UNILAC devices integrated into MASP for
 monitoring

Please refer to the dry run wiki page for the full list

- Shortened pulses, no beam and profile grid protection timing schedules successfully tested

- Stabilization and conditioning chains successfully scheduled and tested

- Non-interruptive trims and non-interruptive changes to timing schedules successfully tested

- PotiBoard prototype hardware and software tested and trim response times verified to be adequate

Please refer to the dry run wiki page for the full list

DR 24_2: Postponed work packages

- Phase advance magnets (scheduled for 24_3)

- Solenoids (scheduled for 24_3)

- Transfer channel preparation / MAGN_DOWN (after 24_3)

- Remaining Device Access LSA compatibility issues
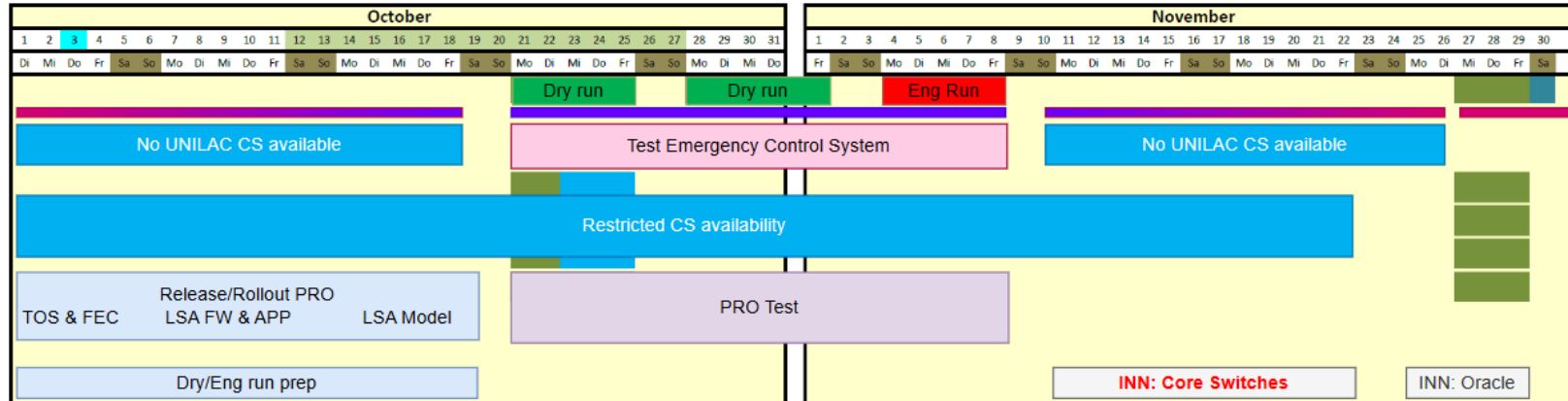 (after 24_3, workarounds in place)
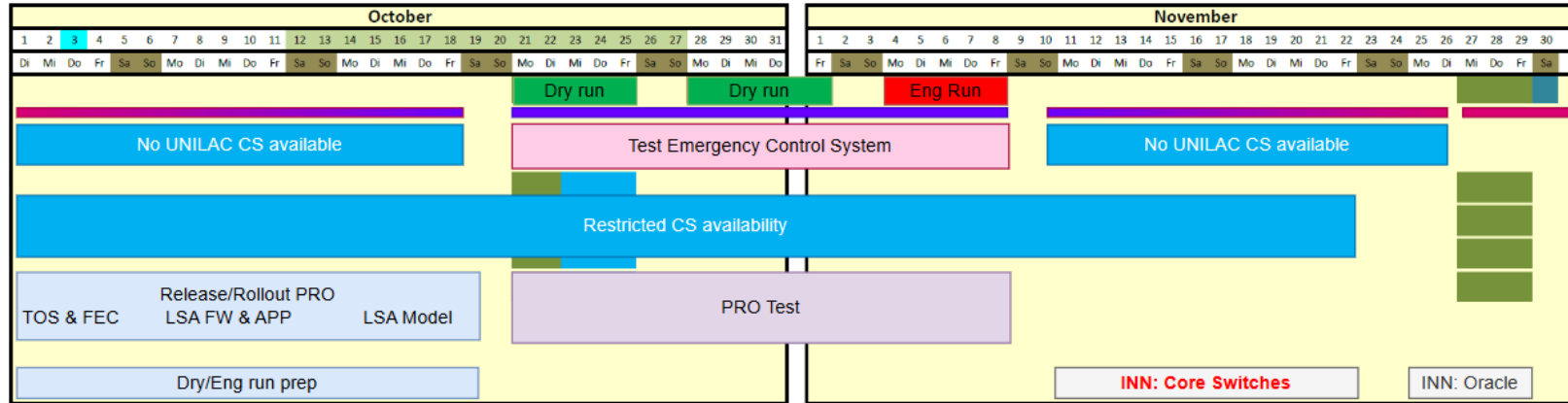
excerpt from ICU Project Test and Release Plan

- Preparation status: Still in rough planning, timeframe for commissioning currently in negotiation

- Proposal for detailed planning to be prepared by Peter & Hanno
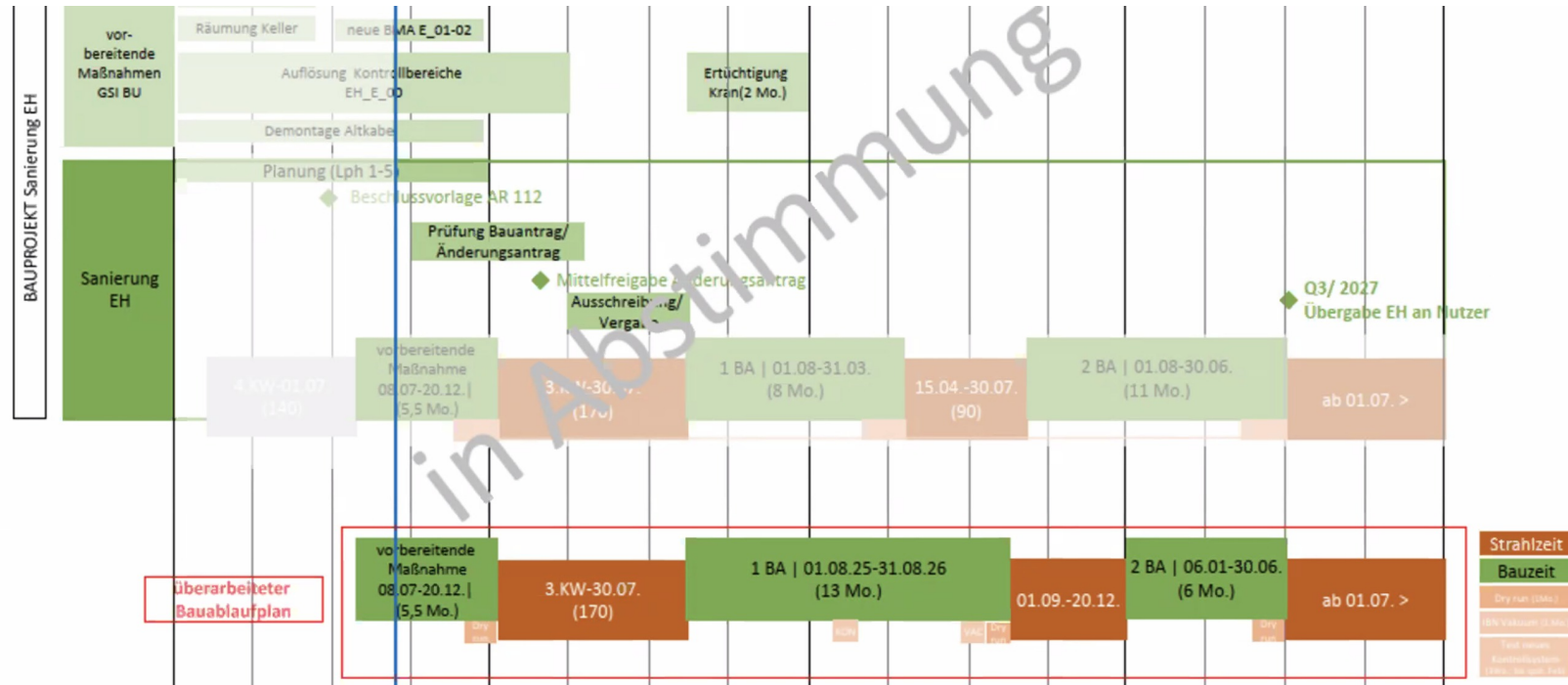
DR/WR 24_3: Major Phases

excerpt from ICU Project Test and Release Plan

- Ensure dry operation of all required devices

- Verify chopper control and machine protection

- Produce beam and use beam diagnostics to analyze

Currently planned as next steps for dry run preparation:

- Detailed planning in preparation,
  to be discussed in ICU JF on 2024-10-02)

- Coordination with equipment specialists regarding requirements for beam production and commissioning

- Follow-up progress on Chopper Control Interface implementation

- Suggestions and issue reports welcome!

Outlook: Wet Run in Summer 2025

excerpt from ICU Project Test and Release Plan

- Goal: Test of production system prototype for 2026 beam time including beam transfer to SIS18

- Preparation status: Time frame and machine availability confirmed by OPE

- Preparation status: Time frame and machine availability confirmed by OPE & considered by CAM

PotiBoard?

→ Martin's presentation
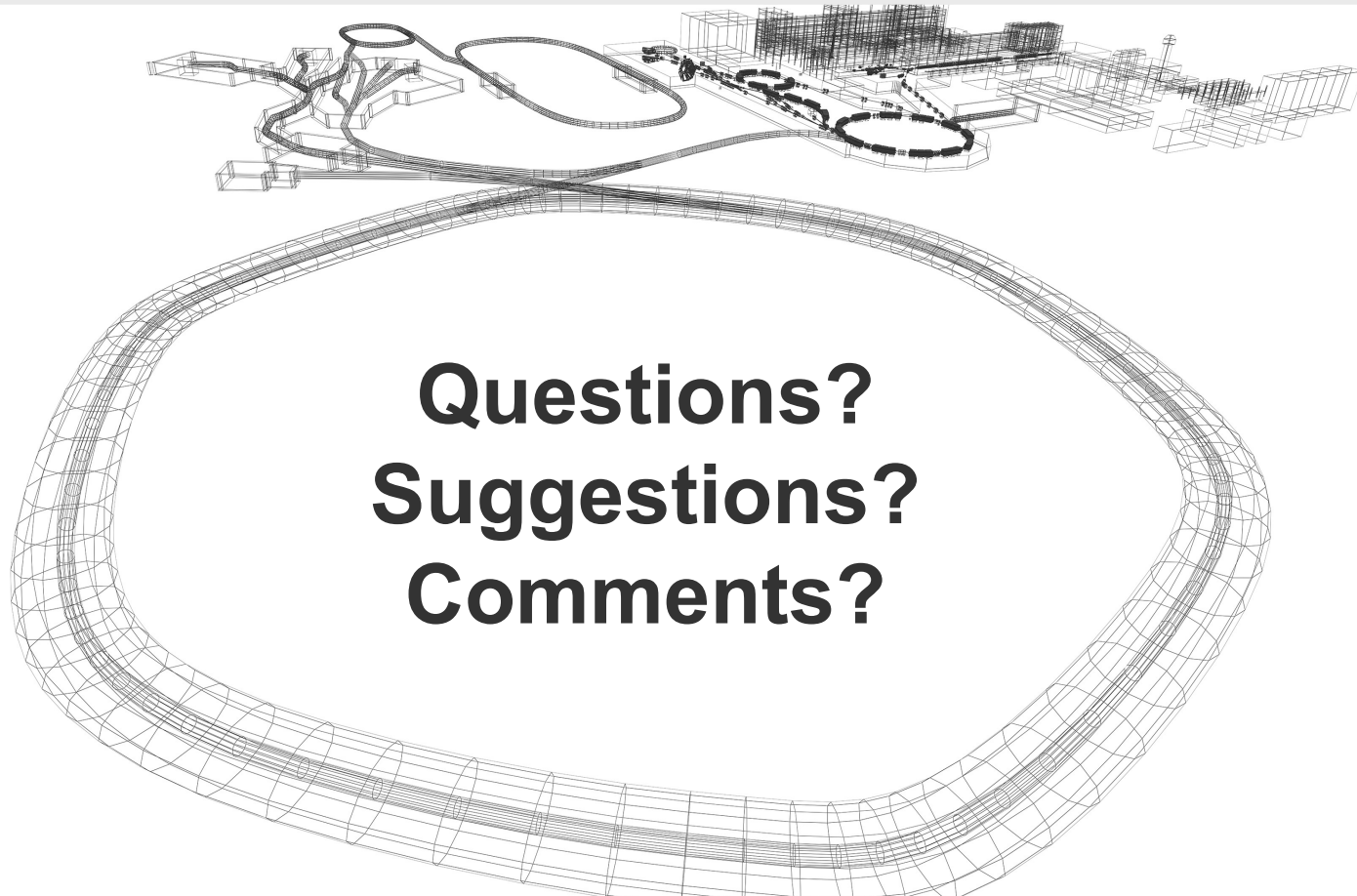
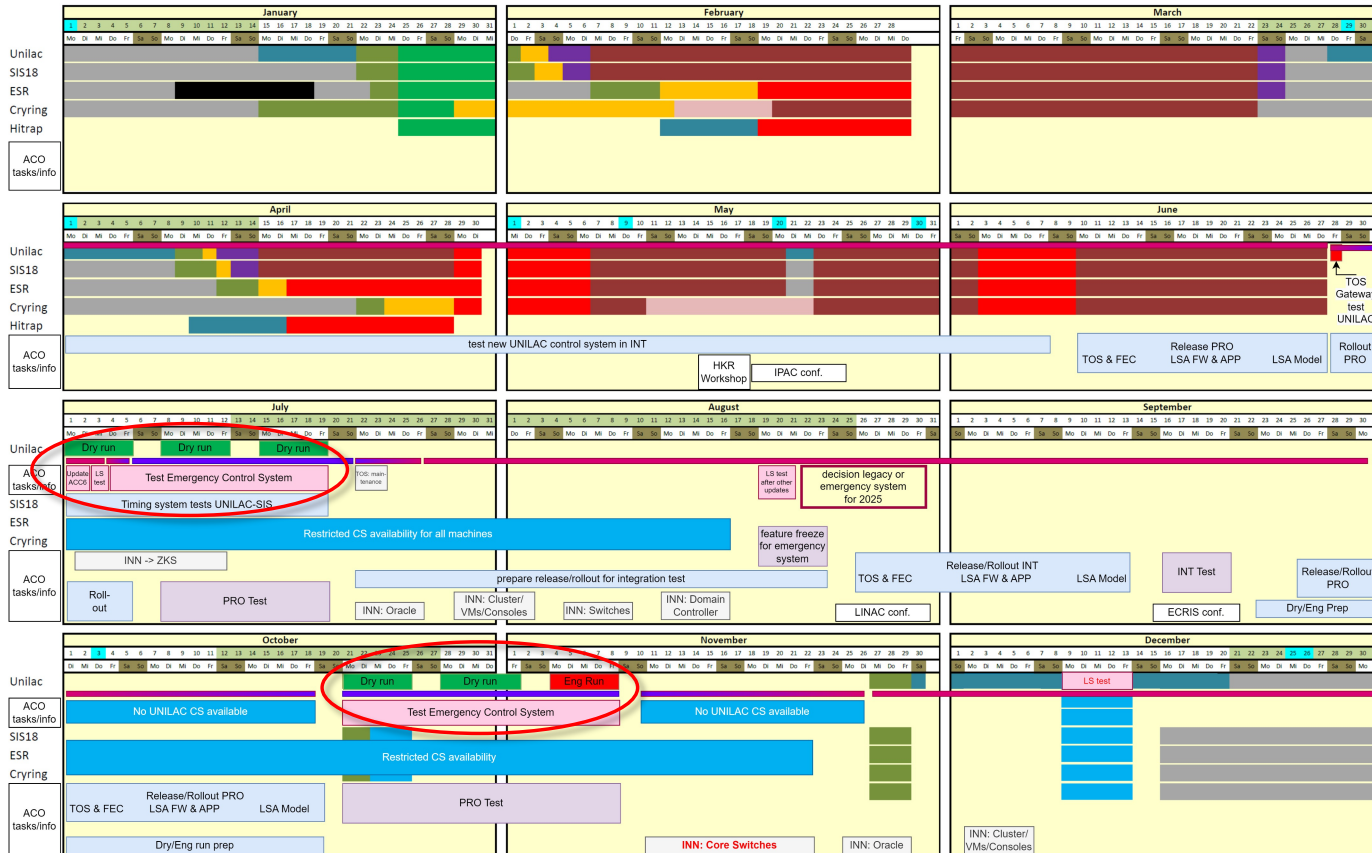# Questions?
Suggestions?
Comments?
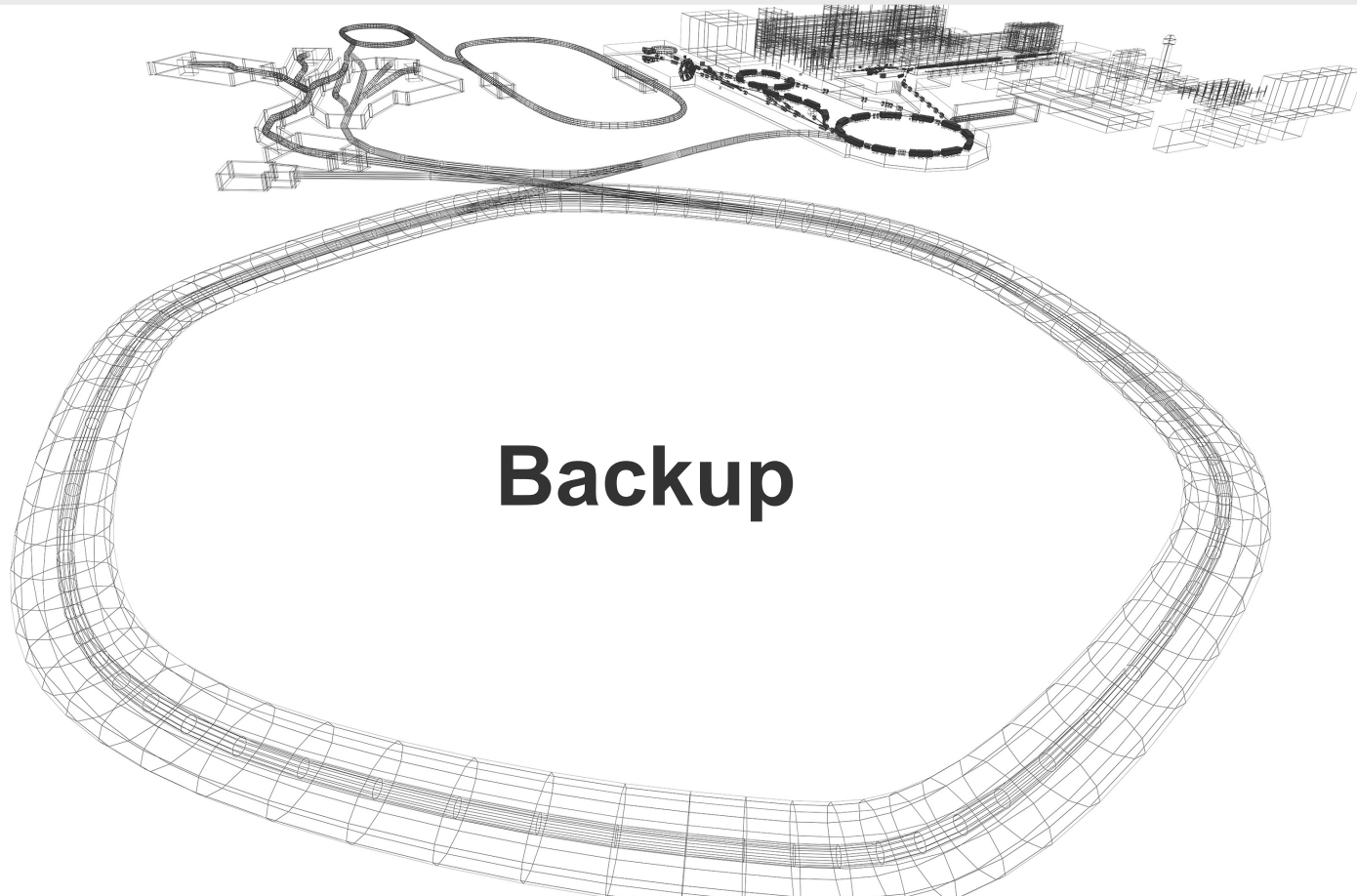
Backup
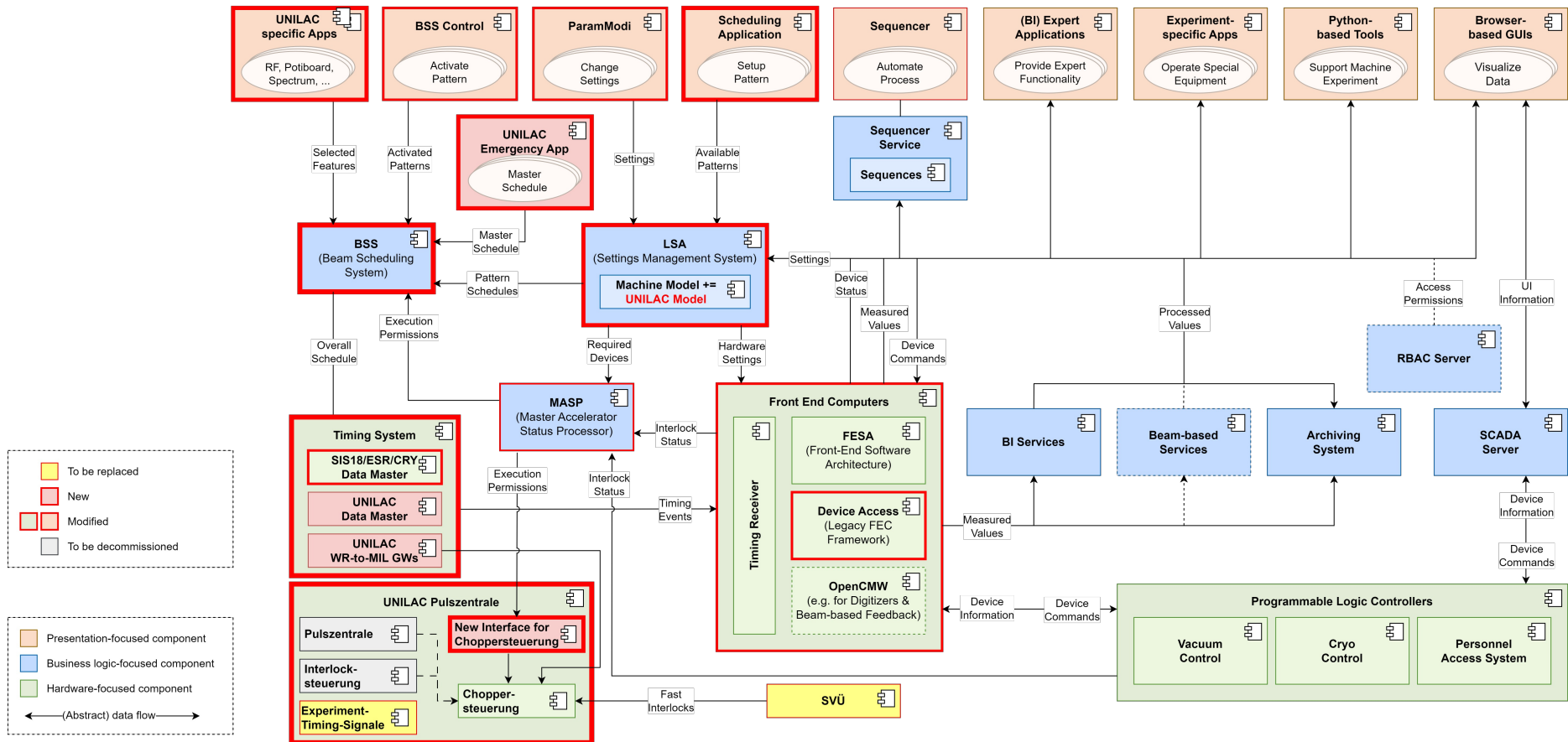
General Plan of Accelerator Operations 2024

General Plan of Accelerator Operations   2025
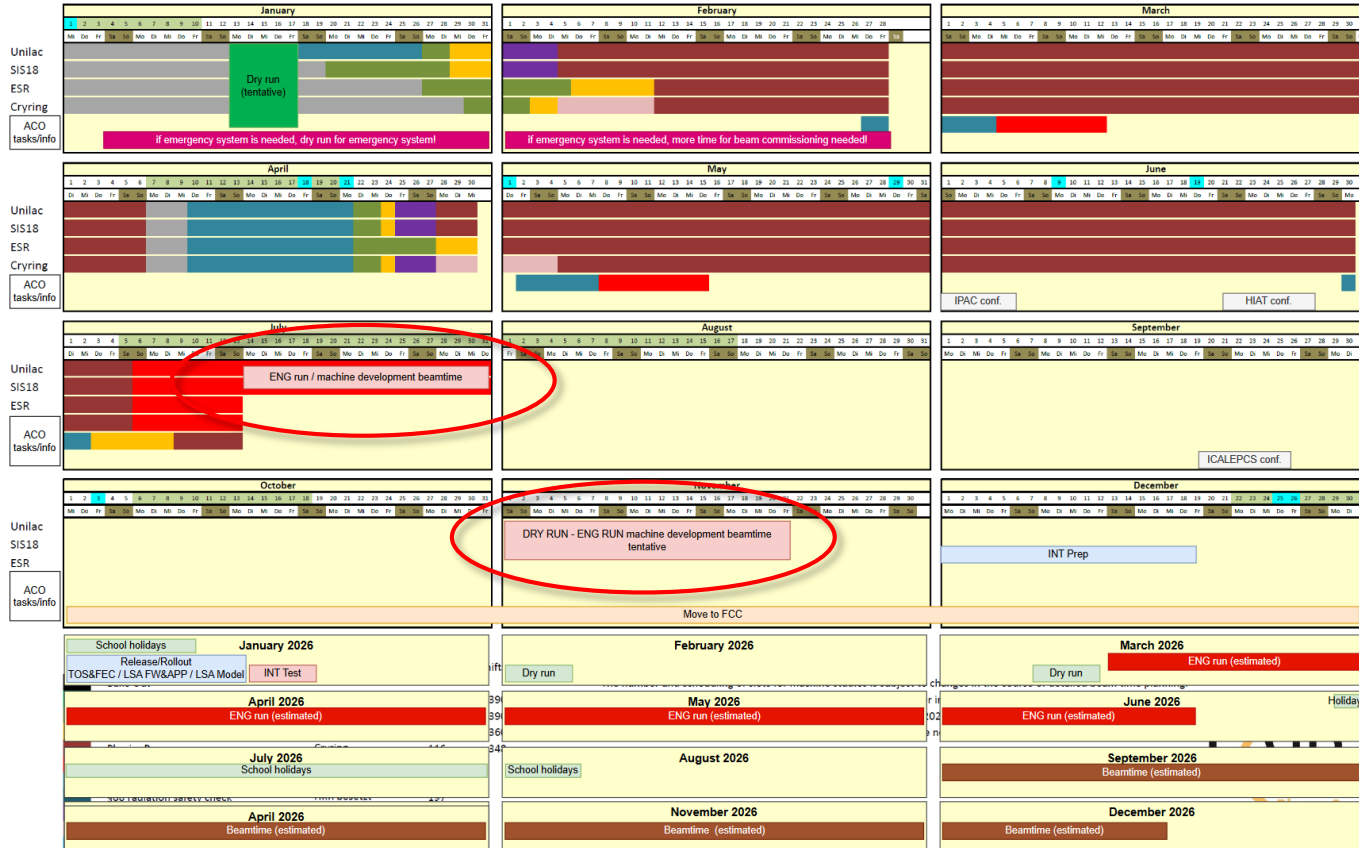
Herausforderungen im ICU-Projekt

Neue Anforderungen für Linac-Betrieb

- Hohe Eventrate
- Kurze Zyklen, hohe Wiederholrate
- Komplexe Sequenz von Kontexten
- Synchronisation mit schwankender Netzfrequenz

- Unterbrechungsfreier Betrieb
- Häufige Wiederholung von Kontexten

- Grenzen der Vorausplanbarkeit
- Umschalten zwischen mehreren Patterns
- Anforderung und Kopplung zwischen Chains
- Ein "Beam" besteht aus mehreren "Chains"

Erkenntnisse aus Synchrotron- und Speicherring-Betrieb

Organisatorische Herausforderungen

- Knappes Zeit- und Personalbudget
- Bisher wenig Erfahrung mit Linacs
- Komplexes Gesamtprojekt
- Ablöse eines hoch-optimierten Altsystems

Bisherige Konzepte nicht auf Linacs zugeschnitten

Anpassungsbedarf am ursprünglichen Pattern/Chain-Konzept

Ressourcen reichen nicht aus, um ein separates Linac-Kontrollsystem zu betreiben

Überarbeiten der Konzepte mit dem Ziel:
Ein Kontrollsystem für die gesamte Anlage

ENTWURF