Science and Technology Facilities Council

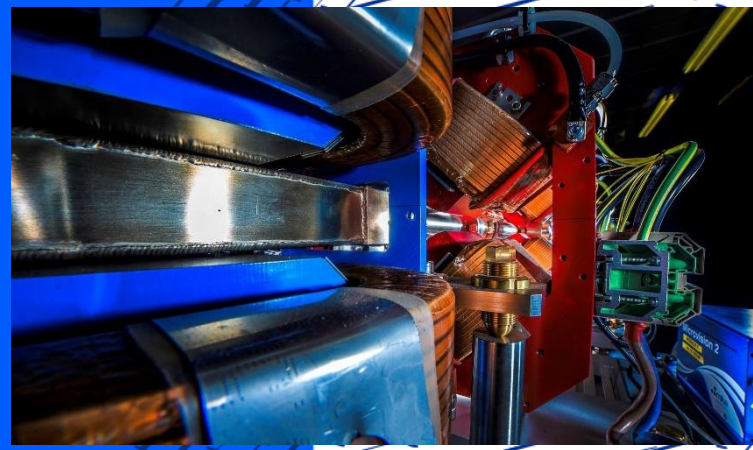
ASTeC

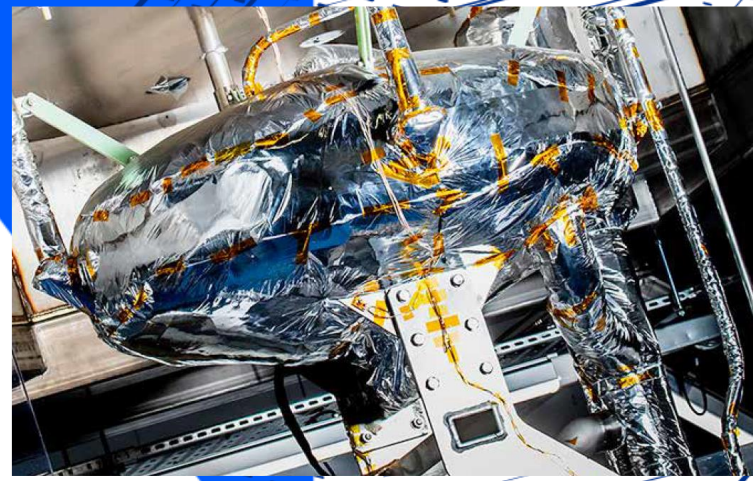
Making a brighter future through advanced accelerators

Status of CLARA Test Facility at Daresbury Laboratory

Deepa Angal-Kalinin on **behalf of the CLARA Team**

ASTeC, STFC Daresbury Laboratory and The Cockcroft Institute





PAB Conference, 11th -12th June 2024, Workington

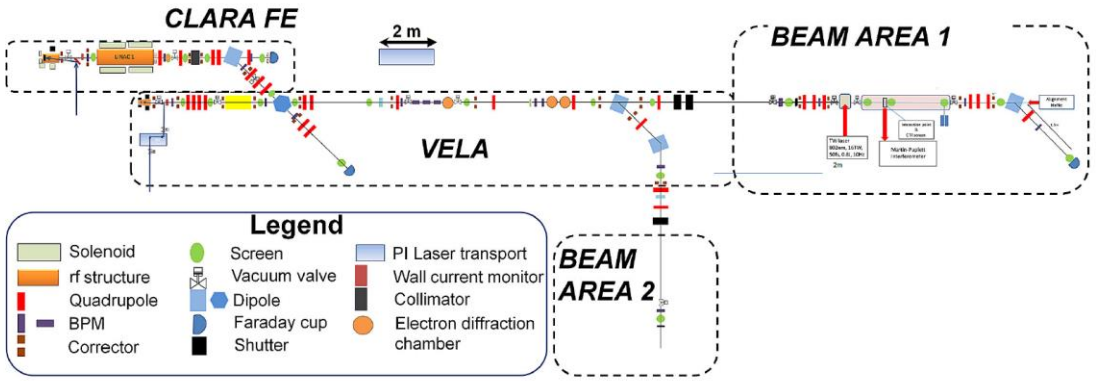
Outline

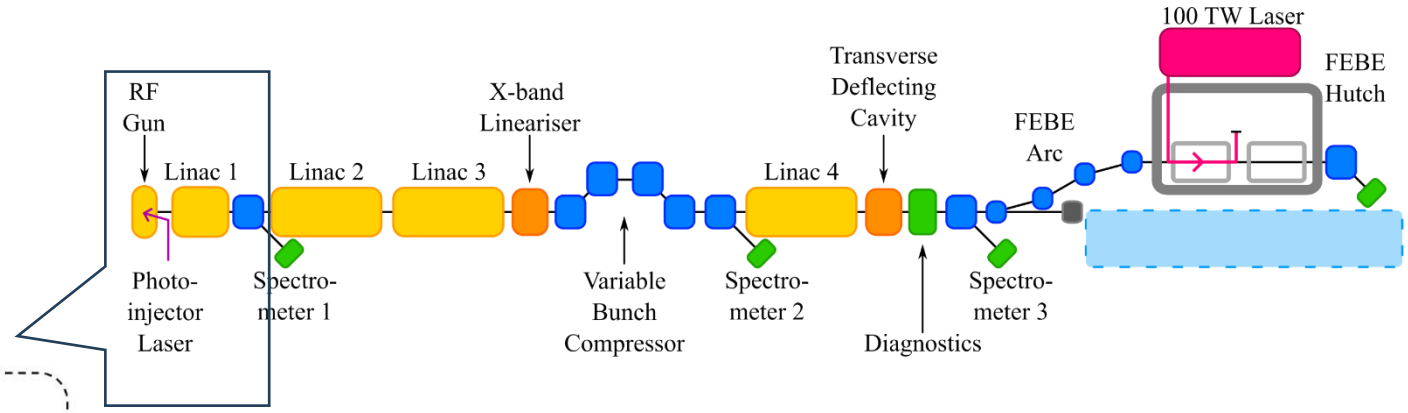
- Introduction
- CLARA Phase 2
- Current Status
- Preparations: CLARA as User Facility

CLARA Introduction

CLARA (Compact Linear Accelerator for Research and Applications) is a 250 MeV ultra-bright electron beam test facility under construction at STFC Daresbury Laboratory.

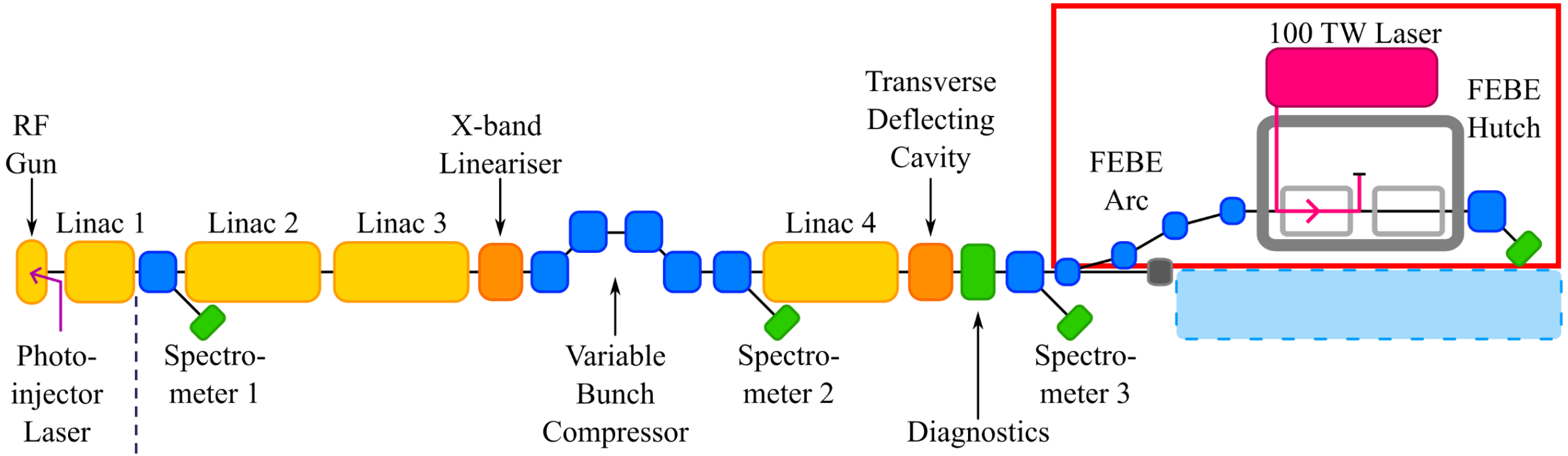
Conceived to test advanced Free Electron laser schemes, front end of CLARA has been used for user-led experiments in a wide range of disciplines.





Installation to complete CLARA to deliver 250 MeV FEL ready beam now nearly complete.

CLARA Overview and Status



PHASE 1:
50 MeV,
250 pC, 10 Hz

Beam exploitation, inc. novel acceleration (2018-2023)

PHASE 2:
250 MeV ASSEMBLED & INSTALLED OFFLINE

Installation in accelerator hall almost complete.

Beam Commissioning to follow later this year.

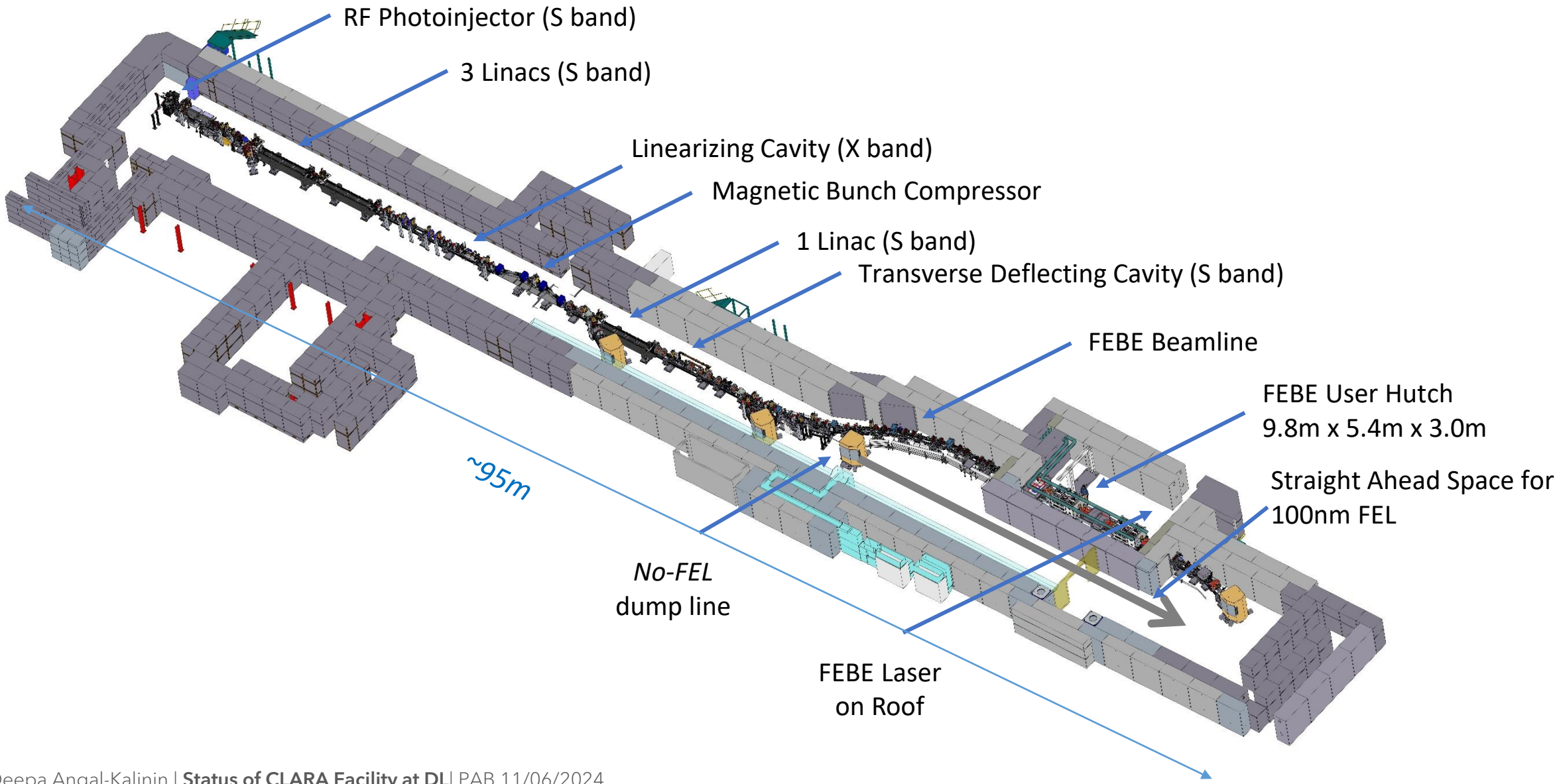
FEBE Hutch
SHIELDED USER AREA

- Flexible user experiment space with FEL quality beam
- 100 TW class laser

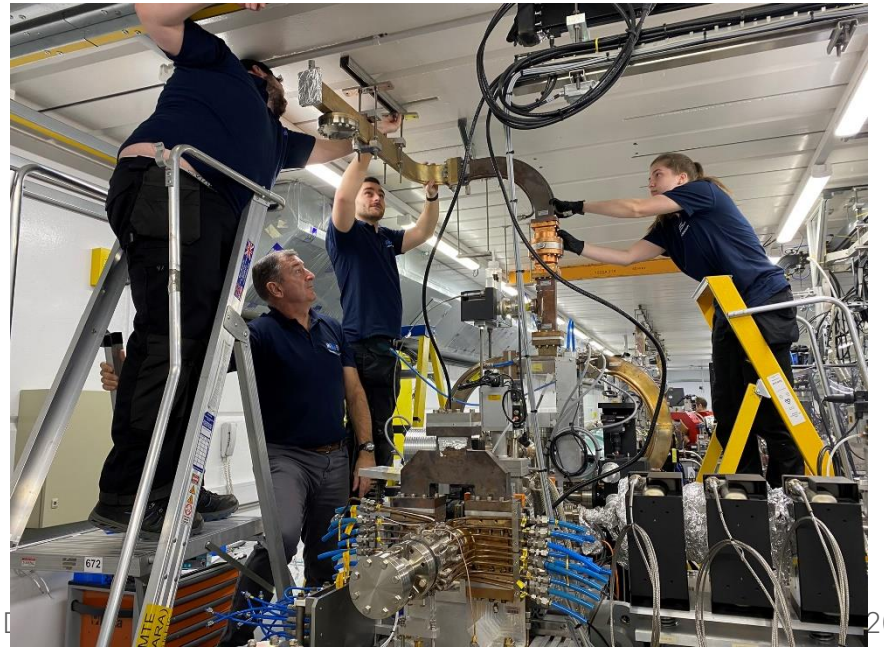
Straight-on:
FEL technology development
NOT YET FUNDED

- Tied to UKXFEL CDOA and decision on next stages

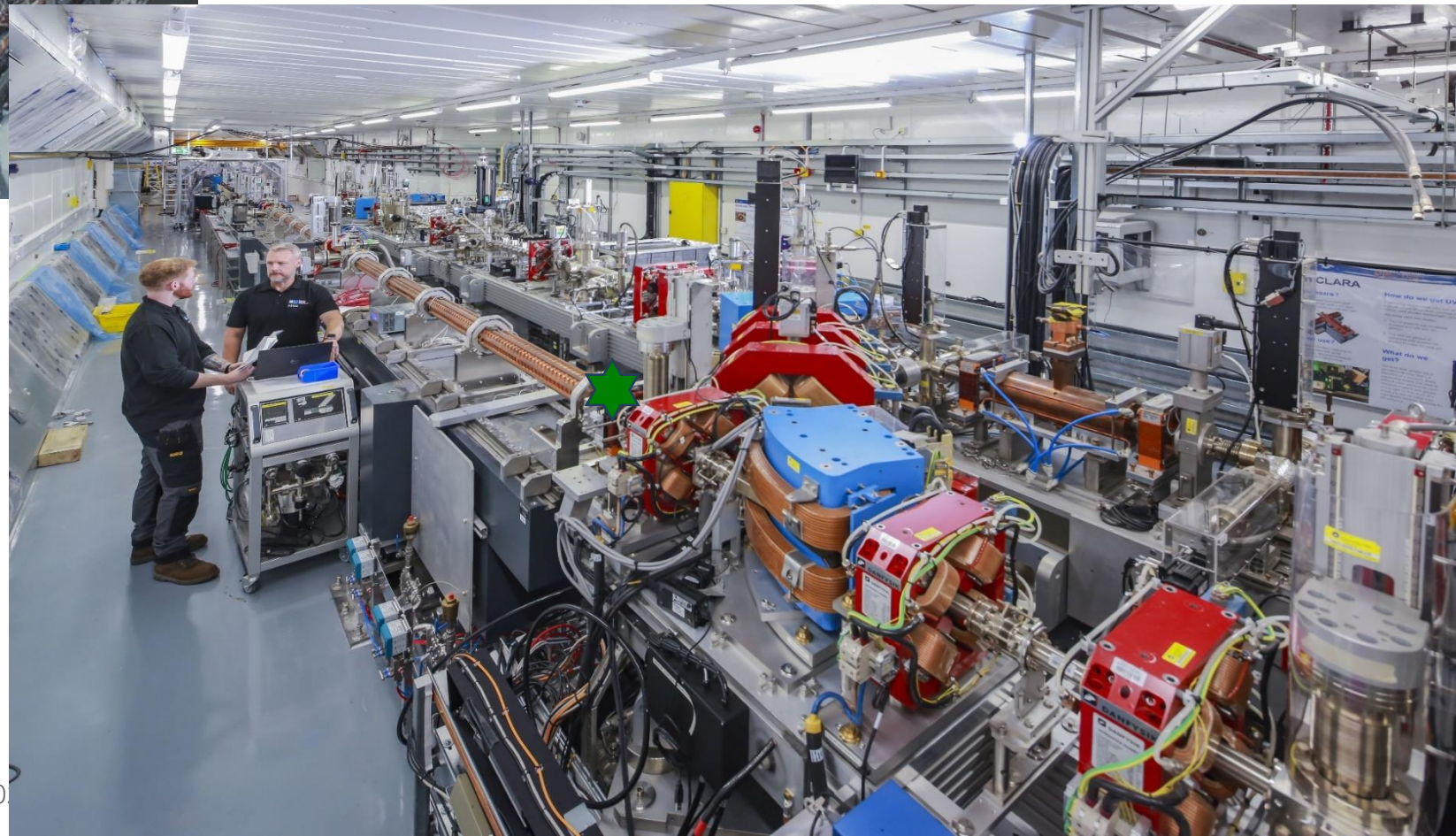
CLARA Overview

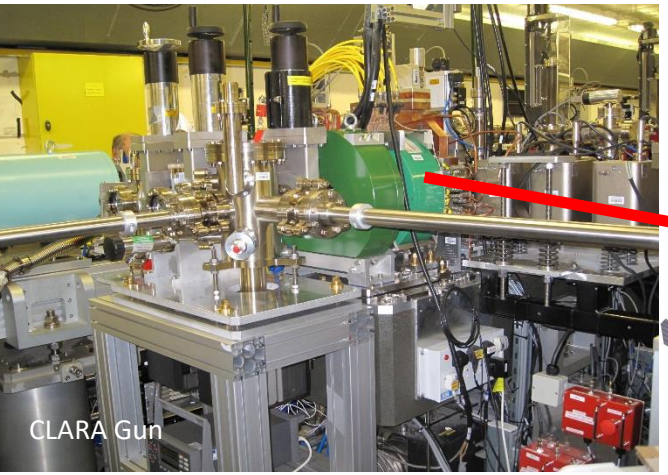


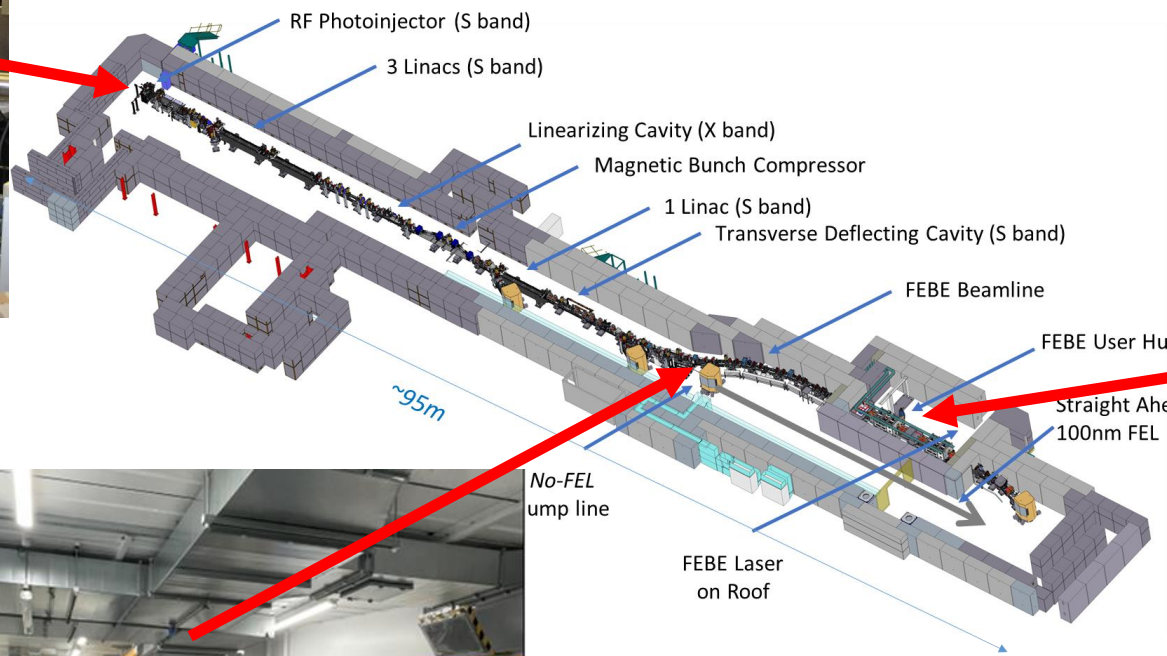
CLARA Front End until April 2023



CLARA installation in FE area - October 2023







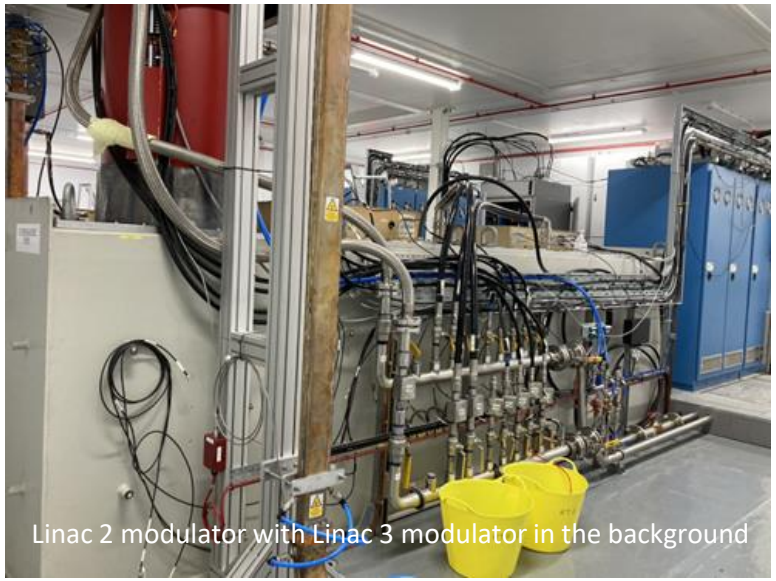

View of CLARA from the other end with shielded beam dumps at the end of spectrometer beamlines.


FEBE hutch – FMBOX1, FEC1, FMBOX2 installed

CLARA Phase 2 Shutdown Status

Phase 2 shutdown is ~95% complete.


Linac 3 modulator with Linac 2 modulator in the background

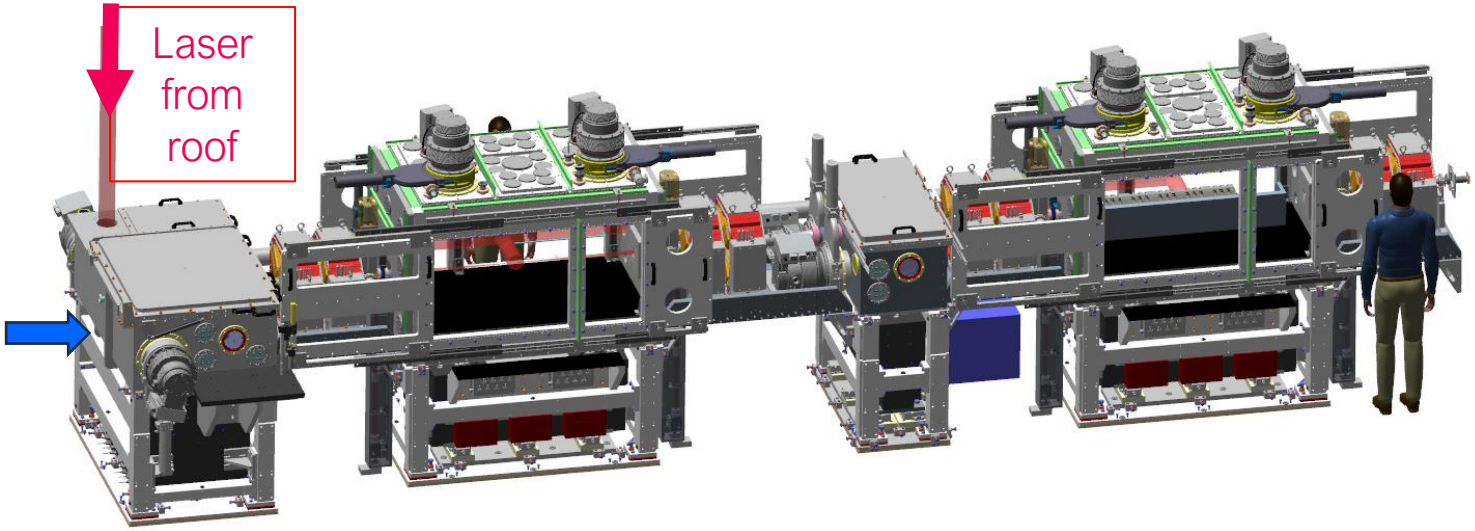

Linac 2 modulator with Linac 3 modulator in the background


4HC modulator

- Delay in completing shutdown due to some technical issues.
- Commissioning of technical systems carried out as and when systems were ready, even if shutdown was not fully completed.
- Have started RF conditioning (using in-house developed automated script) of Linac 2 and Linac 3 from last week of March 24.
- The focus is to complete all work in the accelerator hall to start Gun conditioning followed by beam commissioning whilst beamline and services installation in the FEBE hutch will be progressed.

FEBE Experimental Hutch

Two chambers: possible route to ‘interaction’ and ‘characterisation’ experiments with novel components.



250 MeV FEL ready e- beam

FEC1
Primary IP
~1.5m length

FEC2
Flexible array of diagnostics

FEBE design details: E Sneddon et al, PRAB, 27, 041602 (2024)

Offered parameters to evolve
‘Day 1’ → Nominal → R&D

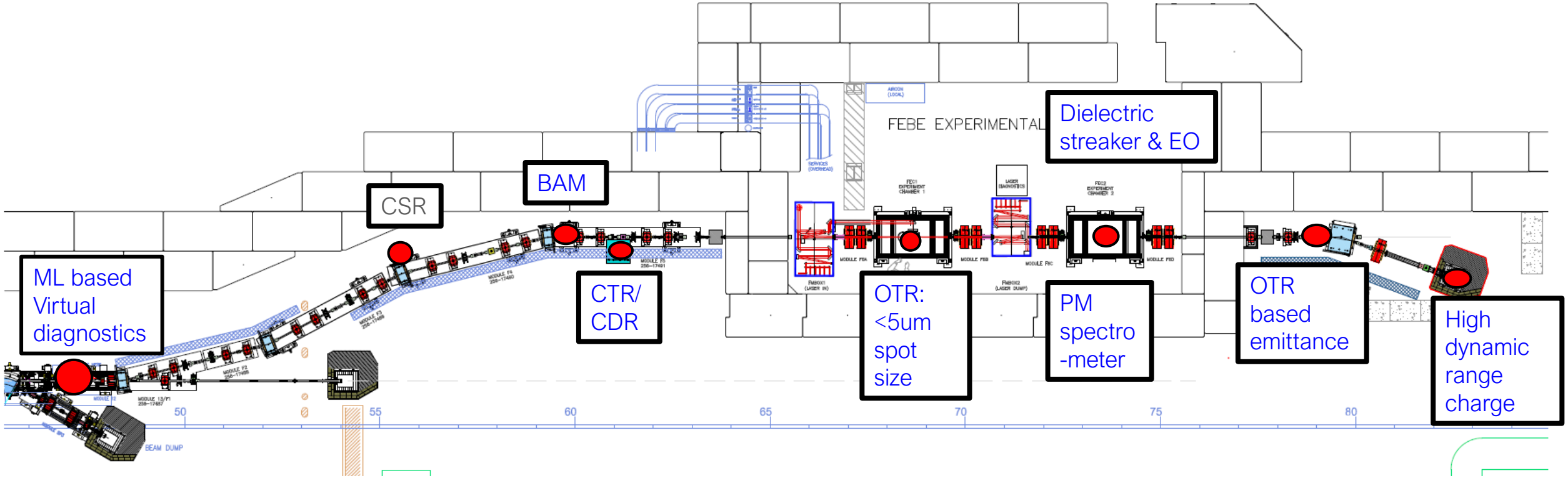
Parameter	High charge	Low charge
Energy [MeV]	250	250
Charge [pC]	250	5
RMS t [fs]	100 (50)	50 (≤50)
σ_E/E [%]	<5 (1)	<1 (<1)
RMS x [μm]	100 (50)	20 (1)
RMS y [μm]	100 (50)	20 (1)
ε_N x @ 250 MeV [μm]	5 (<5)	2 (1)
ε_N y @ 250 MeV [μm]	5 (<1)	2 (<1)

To be confirmed through measurement using appropriate diagnostics (and R&D)

Diagnostics and Instrumentation

Diagnostics undergoing active R&D

Access to well-developed diagnostics (not shown): BPMs, YAGs, ICTs

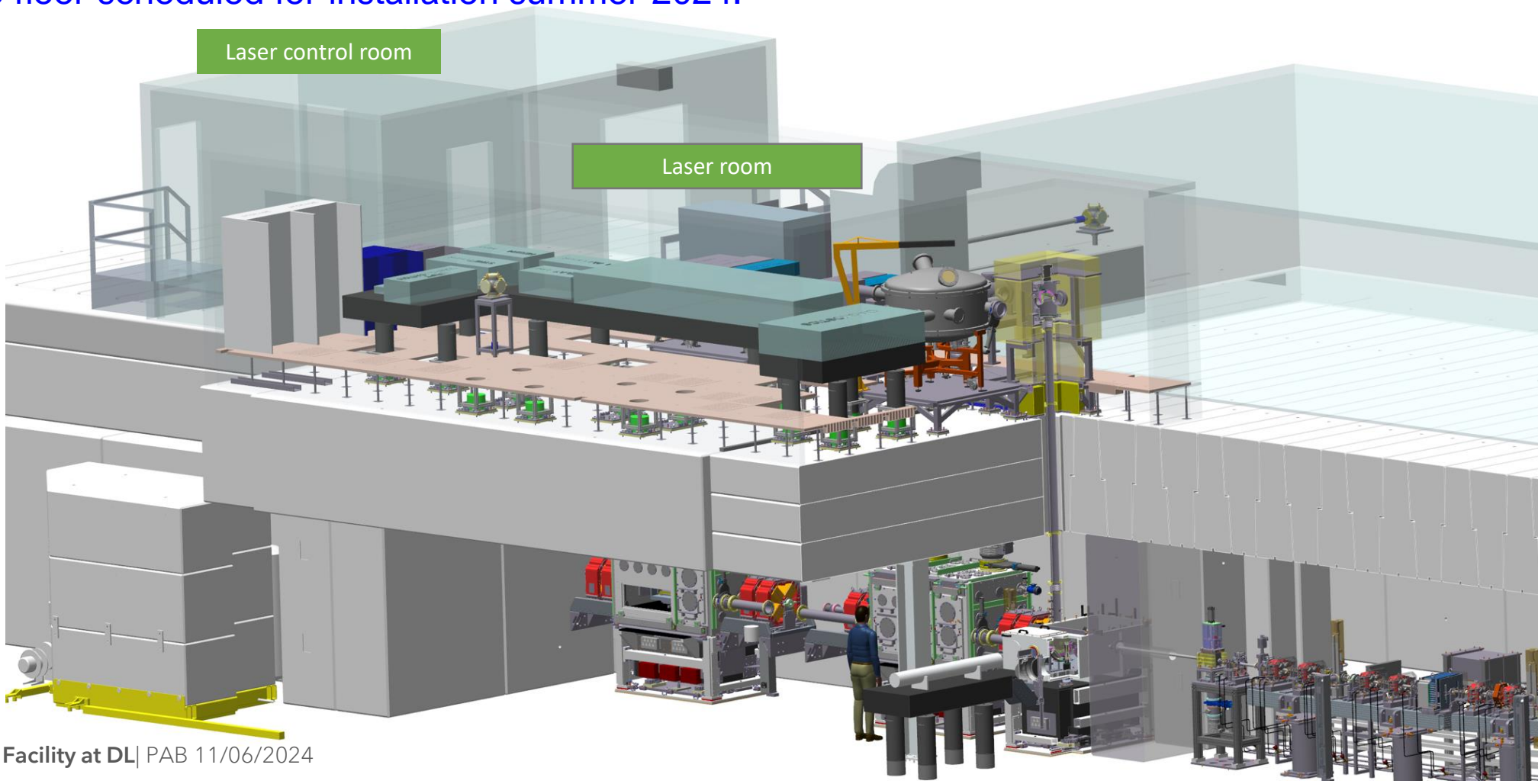


FEBE Laser

FEBE laser contract signed with Amplitude April 2023 to provide 122 TW laser (upgradable to 220 TW) in room above FEBE hutch for combined high-power laser and electron beam experiments.
Mechanical design of laser room has been finalised. HVAC and electrical install currently underway with support frames and false floor scheduled for installation summer 2024.

FEBE laser project timeline:

- July 2024 – FAT
- Nov 2024 – SAT
- Q1 2025 – laser transport to FEBE and electron beam synchronisation



CLARA Commissioning Plans

- Detailed beam commissioning plans are being developed by **Core CLARA commissioning team**; with focus on detailed jitter simulations, High Level Apps and Digital Twin (Next slide) – which allows to develop Apps ahead of beam commissioning.
- Technical systems commissioning with beam threading is expected to begin late summer after completion of RF conditioning of 7 RF systems.
- Goal is to confirm “Day 1” parameters experimentally.
- Plan is to develop number of standard setups as a starting point to deliver beams to wide range of ambitious experiments.

Characterised
- Identify control knobs for changing the beam parameters,
- Have enough measurements of each control to validate the integrated model,
- Have measurements to qualify the specifications,
- Define setup(s) for standard measurements

Flexible
- Identify and build common procedures that can be used for a range of measurements,
- Identify redundancy paths for the most high-risk systems and parameters,
- Be able to operate the machine with an interchangeable team,
- Identify and minimise "single points of failure" among staff,

Repeatable
- Identify the minimum requirements for operators to run the machine,
- Define robust procedures for reaching (one or more) baseline machine setups,

Reliable
- Define a set of standard measurements to diagnose technical systems repeatability

Tools - Current Work ('23/'24)
- Virtual EPICS PVs
  - Majority of RF system PVs extended for Phase 2
  - Magnet PVs extended for Phase 2
- Virtual Accelerator
  - Main framework in-place, users can extend 'scenarios' for hardware
- Integrated Model
  - First stage complete (change magnet, get image)
  - Working on server-based deployment
- CLARA Software Tools
  - In-house python-package for common procedures and processes on CLARA
- CATAP
  - Upgraded to Python 3.10
  - Configuration and Connection to EPICS separated

Apps - Current Work ('23/'24)
- Conversion of EDM panels to Phoebus
  - Phase 1 apps converted
- Operator-focused Phoebus apps
  - Cameras, BPMs, Magnets, Overview

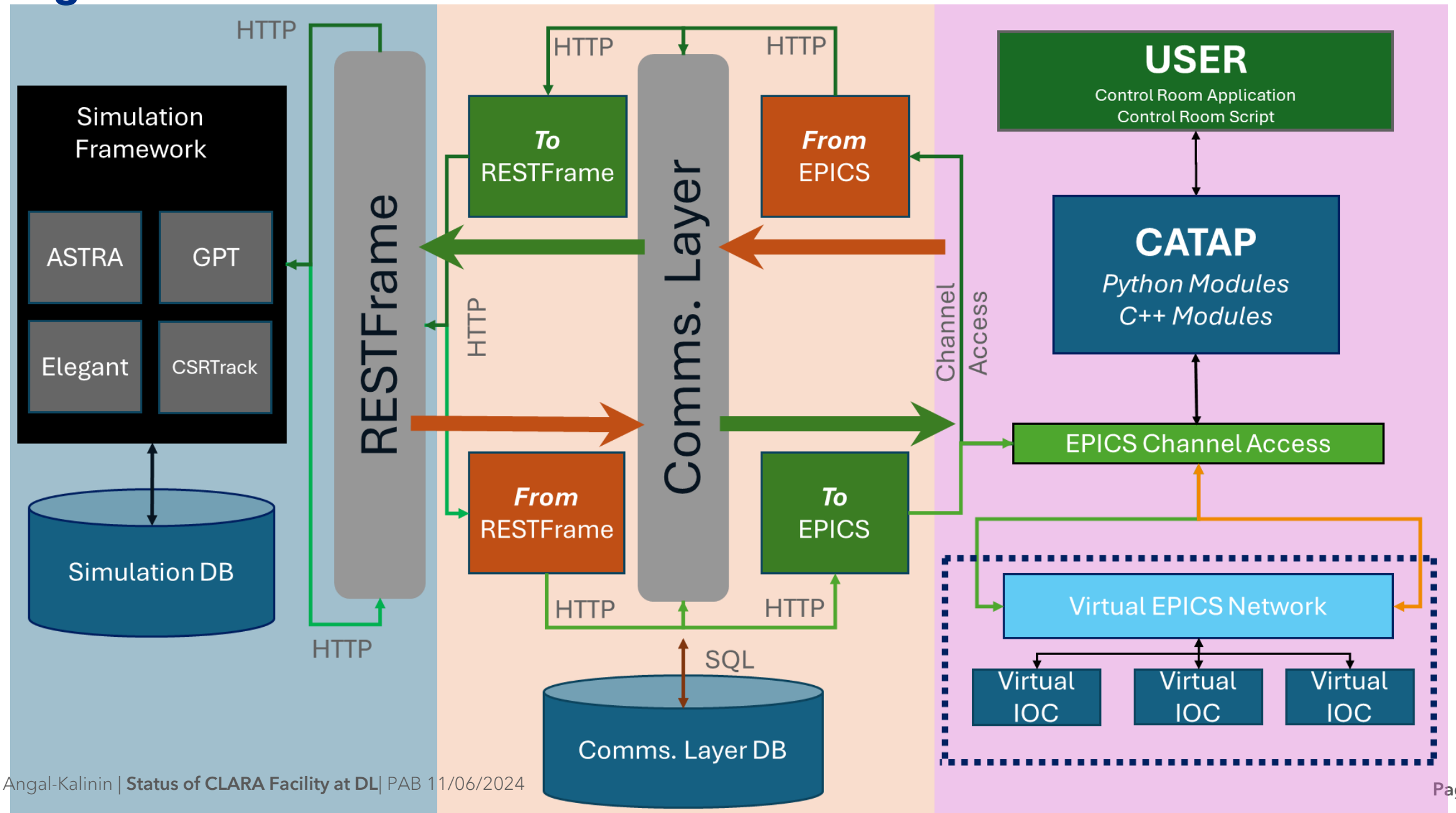
Developers

Anthony Gilfellon, Bradley Wilson, **James Jones**, **Mark Johnson**, **Matt King**, **Matt Shaw**, Nasiq Ziyan, **Rory Clarke**

Tools – Commissioning ('24/'25)
- Virtual EPICS PVs
  - Add PVs via approval pipeline
  - Prototype 'Physics' structures in EPICS7 (rmats, phase space parameters)
  - Migrate simulation in Virtual Accelerator to EPICS
- Virtual Accelerator
  - Create 'normal operation' scenarios for most systems
  - Develop 'PV Playback' with output from Archiver
  - Potentially develop user interface
- Integrated Model
  - Input: Cavity parameters, Laser profile
  - Output: BPM, Twiss, Rmats
  - Triggered Mode
  - Settings database to reduce compute-time
- CLARA Software Tools
  - All procedures and processes to create an optics-matching application
  - Should provide functionality that other applications require
- CATAP
  - Extended to Phase 2/FEBE systems
  - Physical machine testing

Apps – Commissioning ('24/'25)
- Apps and Tasks List
  - Completed and ready for testing
- Phoebus panels
  - Extended for Phase 2/FEBE
  - Ready for machine testing
- Operator Focused GUIs
  - Functionality completed
  - Potentially tweak look/feel when we can use them on real machine
- Control-level Applications (Phoebus)
  - Cameras (operator/expert)
  - BPMs (operator/expert)
  - RF Cavities (operator/expert)
  - Magnets (operator/expert)
  - Charge (operator/expert?)
  - Virtual Cathode (operator/expert?)
  - BAM (operator/expert?)
- High-Level Applications (Python)
  - Correlation Application
  - Emittance Measurement
    - Optics Matching
    - Trajectory Correction
    - Diagnostic Alignment (Screen/BPM)
  - TDC
  - Momentum Measurement
  - AutoCrester (all cavities)
  - More to be confirmed.

Digital Twin of CLARA



Preparations for CLARA as User Facility

- Current plan is to have User Kick-off meeting early December 2024 to update users about the status, beam time request call details and timeline.
- We are currently revising the beamtime access policy and updating the paperwork for beam time request proposals.
- At the start, CLARA facility time will be divided as follows:
  - 6 months for user experiments
  - 3 months for machine development
  - 3 months for maintenance + shutdown

  This will be reviewed in future as the facility will be established for users.
- Machine development will focus on achieving the 'Future' beam parameters, and improved repeatability/reliability of beam delivery.
- Plan is to operate on long day (10-12 hour shifts) on weekdays to allow users to have access to beam at start of their shift at 9 am and allowing few hours after 5 pm for data taking etc.

If you are interested in using CLARA beam for the first time; do get in touch with me.

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Thank you

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