Task 3.3: Electron and Plasma Beams

Anthony Gleeson (STFC) on behalf of the WP3.3 team

This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No 101057511.

Progress Summary

- **Aim:** To co-ordinate and deliver trans-national access to cutting-edge electron and plasma beam sources. It covers a total of six facilities across four institutions: CEA, INFN, KIT and STFC.

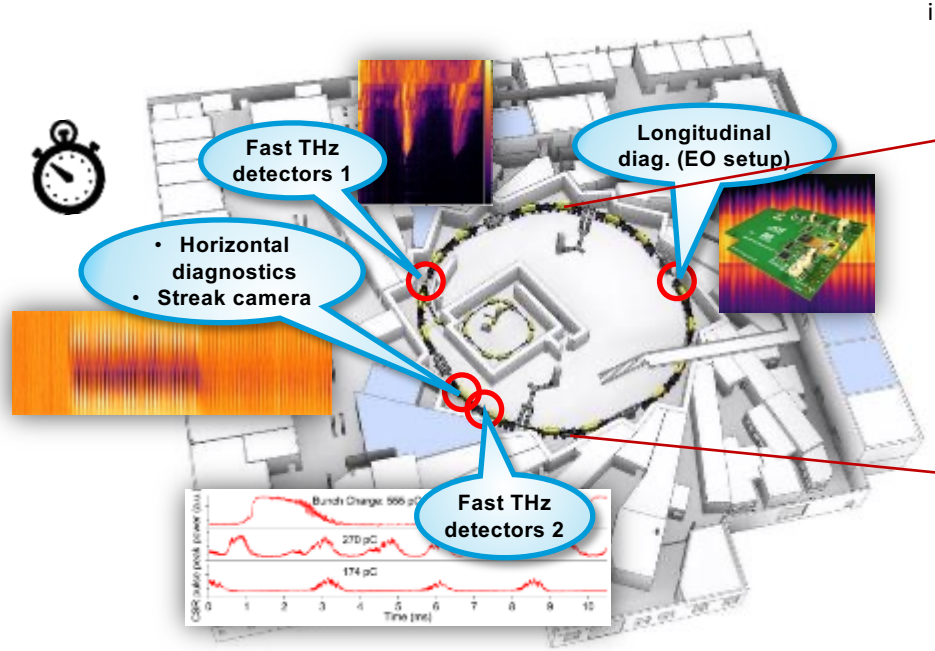
- **Achievements:** The task-level USP has been established, assessed its first TA proposals and the first two TA experiments have been successfully delivered on the KARA facility at KIT.

- **Ongoing challenges:** To fully deliver the programme of agreed TA units tensioned against the impact of disrupted supply chains, approval delays and increased costs on facility availability.

Synchrotron KARA (KArlsruhe Research Accelerator)

KIT Light Source for User Applications & Accelerator Test Facility

with distributed synchronized sensor network: emitted CSR, energy spread, bunch profile, phase space tomography in MBI, in parallel: simulation of MBI by OCELOT, INOVESA



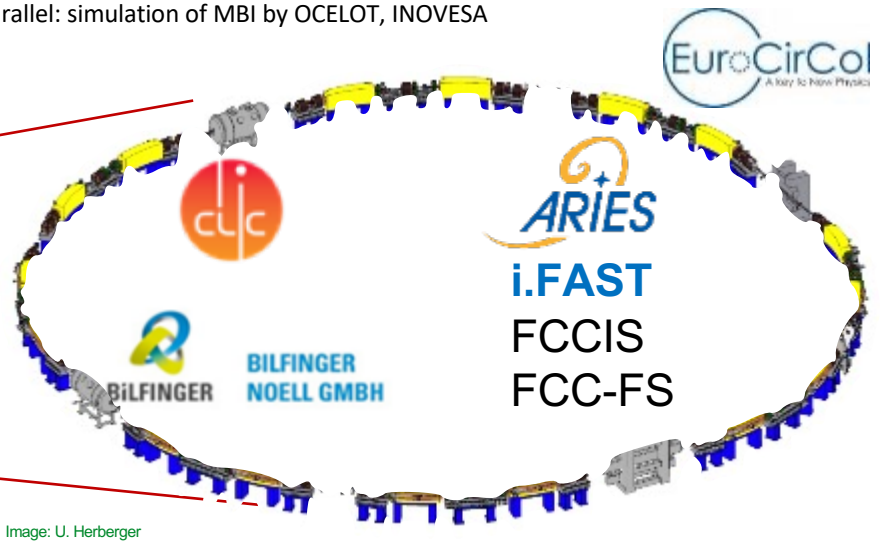


Image: U. Herberger

www.ibpt.kit.edu/kara

- Circumference: 110.4 m
- Energy range: 0.5 - 2.5 GeV
- RF frequency: 500 MHz
- Revolution frequency: 2.71 MHz
- Operation (22-)23h/5d/30w/y
- Single or multi-bunch mode

Short bunch mode

- Lower momentum compaction factor → Bunch length: 45 ps ↘ few ps
- Coherent synchrotron radiation (CSR) in THz range

Negative momentum compaction factor

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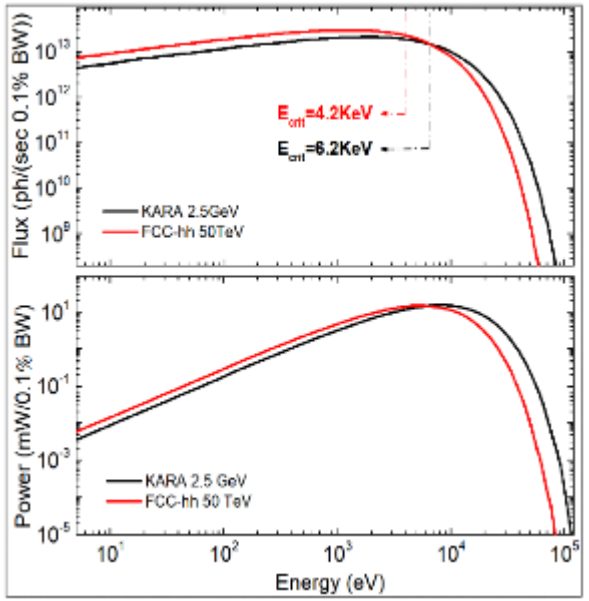
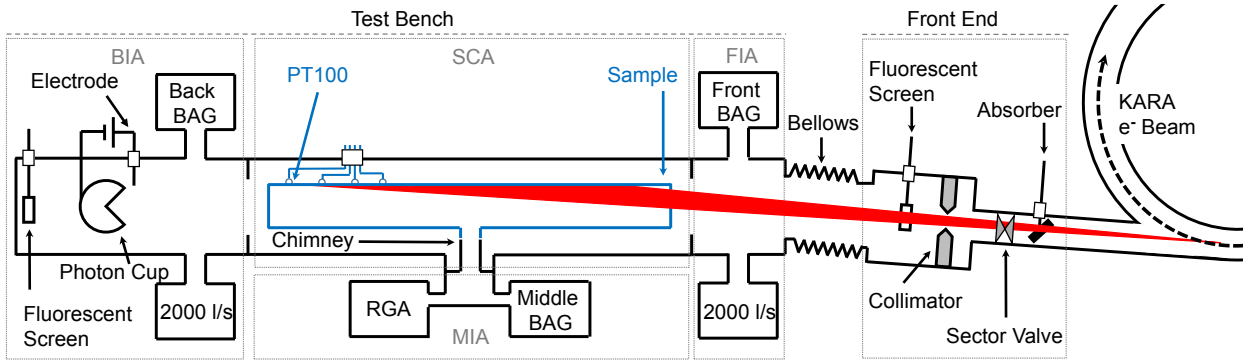
BESTEX beamline at KARA: 1st TNA in EURO-LABS

- The FCC-hh's photon spectrum and linear power are reasonably reproduced in KARA, even at nominal beam energy.
- **Beam Screen prototype No. 5 with sawtooth profile** tested at CERN's BESTEX beamline at KARA
- Heat load and photon-stimulated desorption was measured under cryogenic conditions (liquid N_2 cooling)





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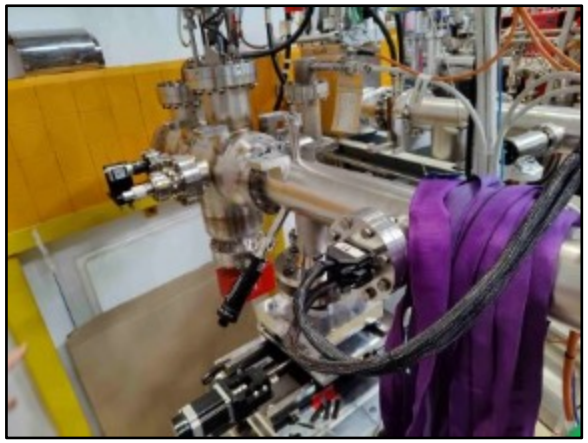
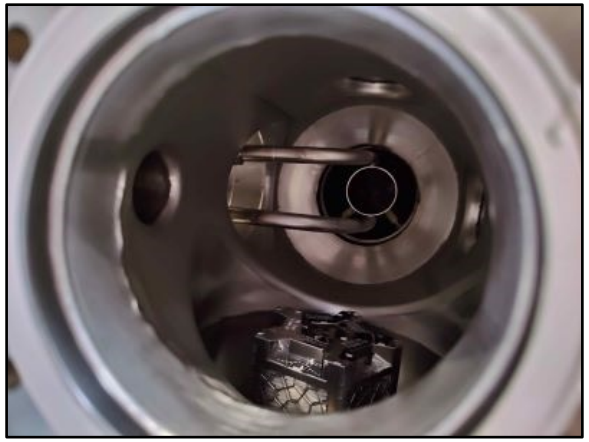




Peter Lindquist Henriksen, Marton Ady, Roberto Kersevan, FCCweek 2023; https://indico.cern.ch/event/1202105/contributions/5380087/

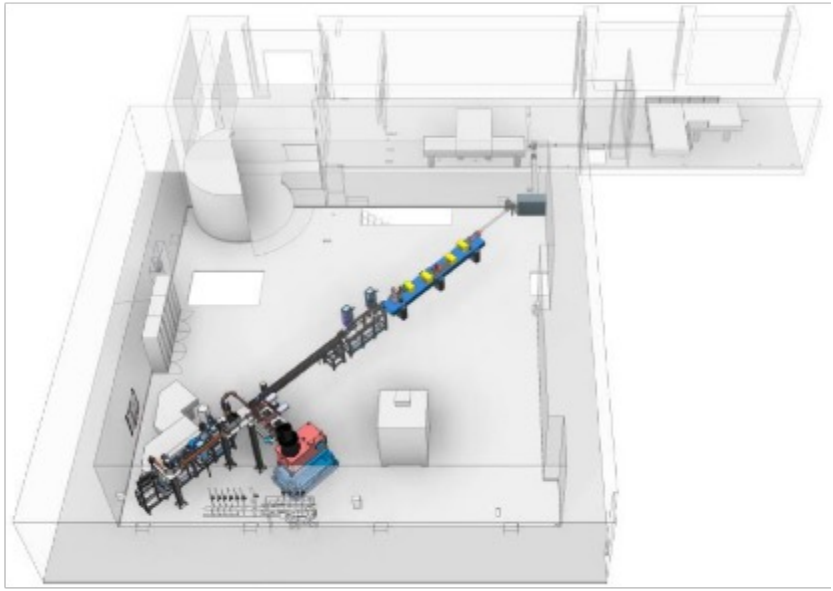
TNA [h]	P1 done	Plan: 4 years
KARA	220	880

Upgrade

www.ibpt.kit.edu/flute

- **FLUTE** (**F**erninfrarot **L**inac- **U**nd **T**est-**E**xperiment)
  - Compact test facility for **accelerator physics within ARD**
  - **Experiments** with e^- & THz radiation, e.g. experiments for FLASH therapy
- R&D topics
  - Systematic bunch compression and THz generation studies
  - Serve as a test bench for new beam diagnostic methods and tools
  - Develop single shot fs diagnostics
  - Synchronization on a femtosecond level

Final electron energy	**5 to 50 (41)**	**MeV**
Electron bunch charge	**0.001 - 1 (3)**	**nC**
Electron bunch length	**1 - 300**	**fs**
Pulse repetition rate	**up to 10**	**Hz**
THz E-Field strength	**up to 1.2**	**GV/m**



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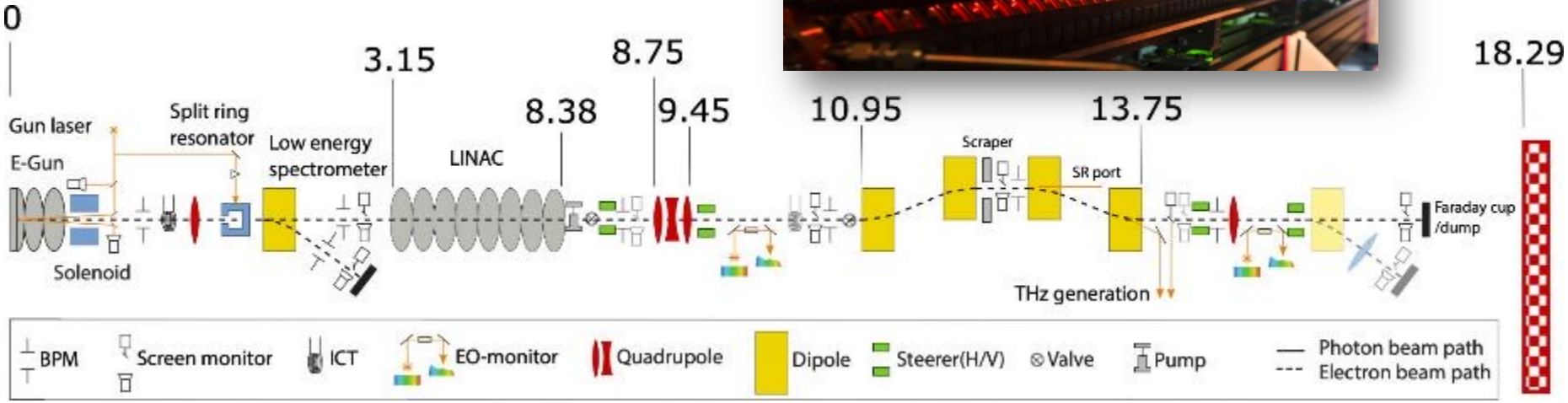
FLUTE Upgrade

Ferninfrarot **L**inac- **U**nd **T**est-**E**xperiment



1st stage

(in commissioning)

- New E- gun
- New RF system
- 1st diagnostics section improved
  after 5 years in operation

2nd stage

(RF commissioning)

- Linac baked out
- 2nd diagnostics section built
- K300 for RF in commissioning

3rd stage

(assembly in finalization)

- Bunch compressor
- e^- diagnostics
- THz diagnostics in manufacturing

TNA [h]	P1 done	Plan: 3 years
FLUTE	0	330

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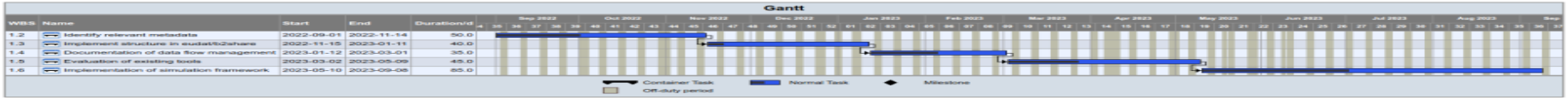
Service Improvements for KARA & FLUTE < ALFA:
Simulation, Measurement and Data Management Framework

Karlsruhe Institute of Technology

Goal: develop & establish meta-database for KARA, FLUTE, & other acc.

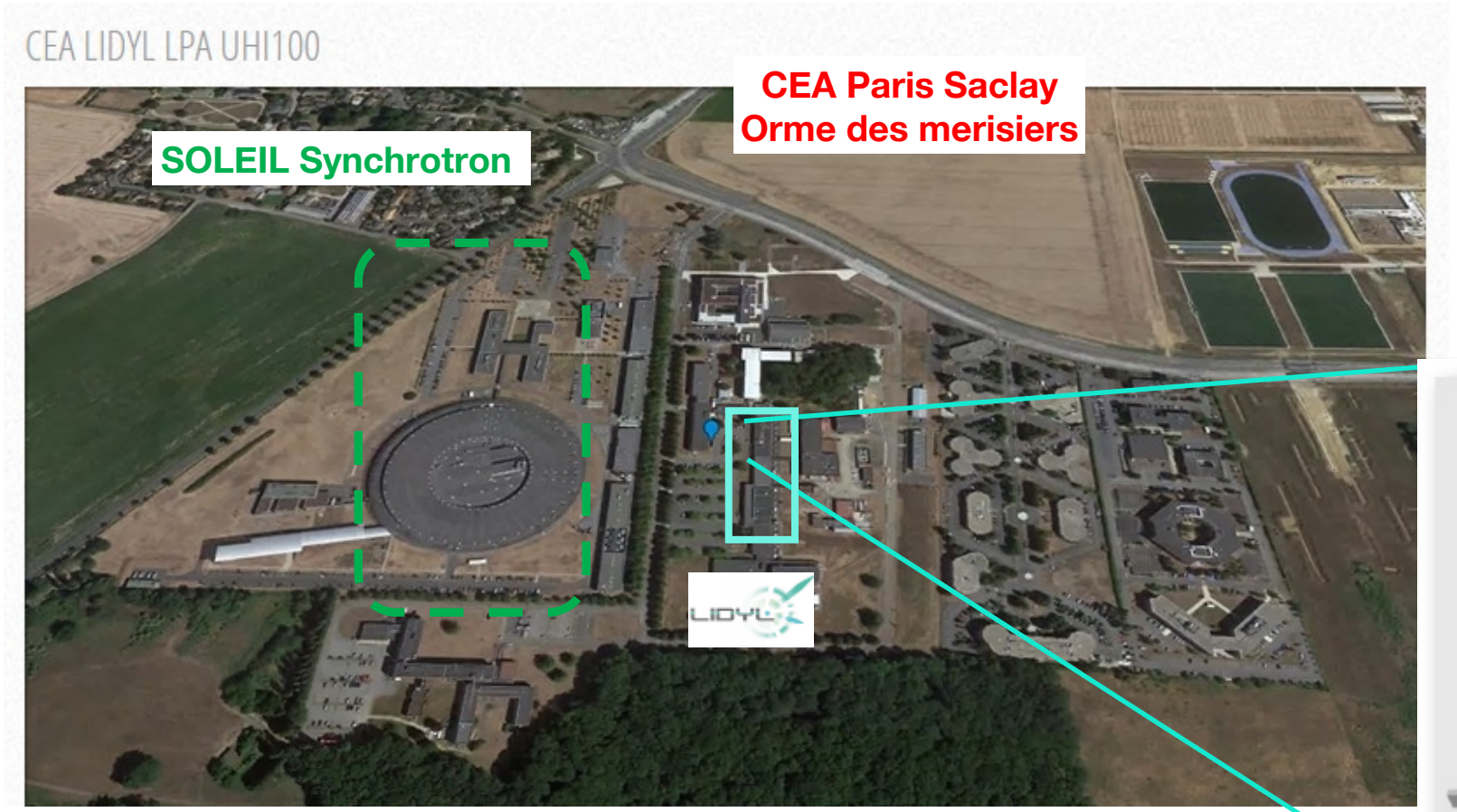
- Identify relevant metadata ✓ Date, Time, System (Detector, DAQ System), Fill Nr, Description, Experimenter, General Beam Parameters / Machine State, Used Optics ("Squeeze State", maybe alpha, quadrupoles, sextupoles etc.), (multiple) filling pattern, Energy, Accelerating Voltage, Insertion device status, maybe Feedback Settings, Excitation Settings (BBB/RF), Scraper Positions, Associated Measurements (How? change ID position?), Comment (What was the goal?),… :✓
- Implement structure in eudat/b2share or RADAR: which system will KIT use?
- Next ToDo: Implementation of the automated data handling
- Next ToDo: data registration in RADAR or EUDAT together with meta data
- Measurement Framework ✓ (rather similar to bluesky) implemented, handles data file creation, grouping naming, bundling, elog creation, abortion, clean up:✓
  (https://ankagit.anka.kit.edu/python-tools/packages/measurement) installed from our own Python package index server
- Framework for Simulations online simulation model for KARA utilizing the multi-physics simulation toolkit OCELOT is in place : https://github.com/ocelot-collab/ocelot ✓
- **Our expert moved to another institute > Open position advertised <**

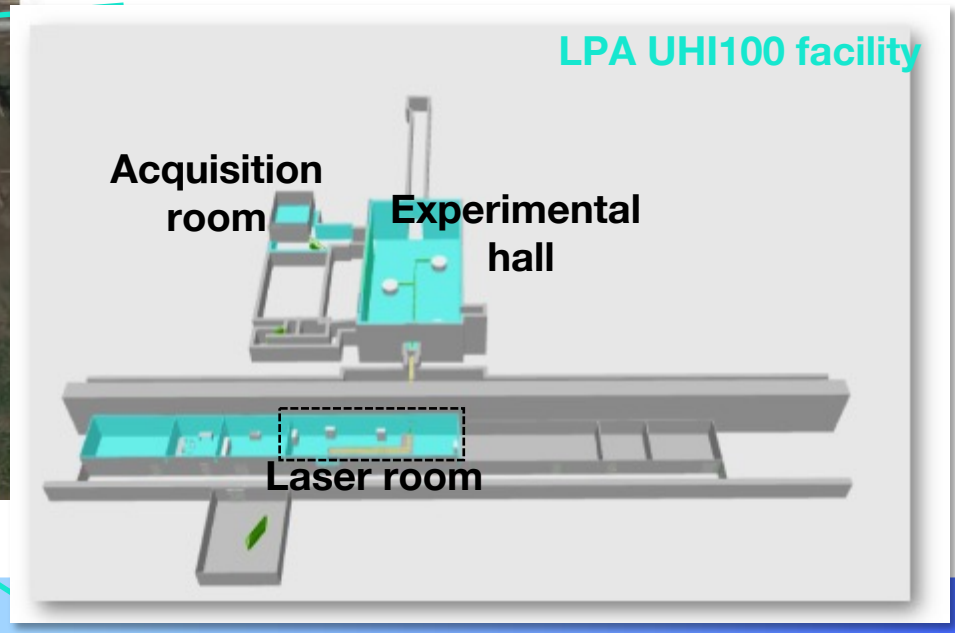


WP3.3 - Electron Beam Facilities LPA-UHI100: a Laser-Driven Electron Source

Contact : S. Dobosz Dufrénoy (CEA-Paris Saclay)

LPA-UHI100 (Laser Plasma Accelerator on UHI100 laser facility) = a platform providing electron beam line and experimental area dedicated to **laser-driven electron acceleration** studies in plasma media, and applications.(FLASH Radiotherapy, secondary particles generation, diagnostic developments ….)





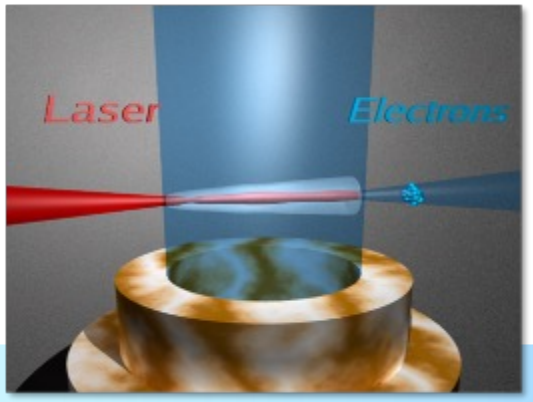
LPA UHI100 Facility

Commercial 100TW laser system

Radioprotected experimental hall

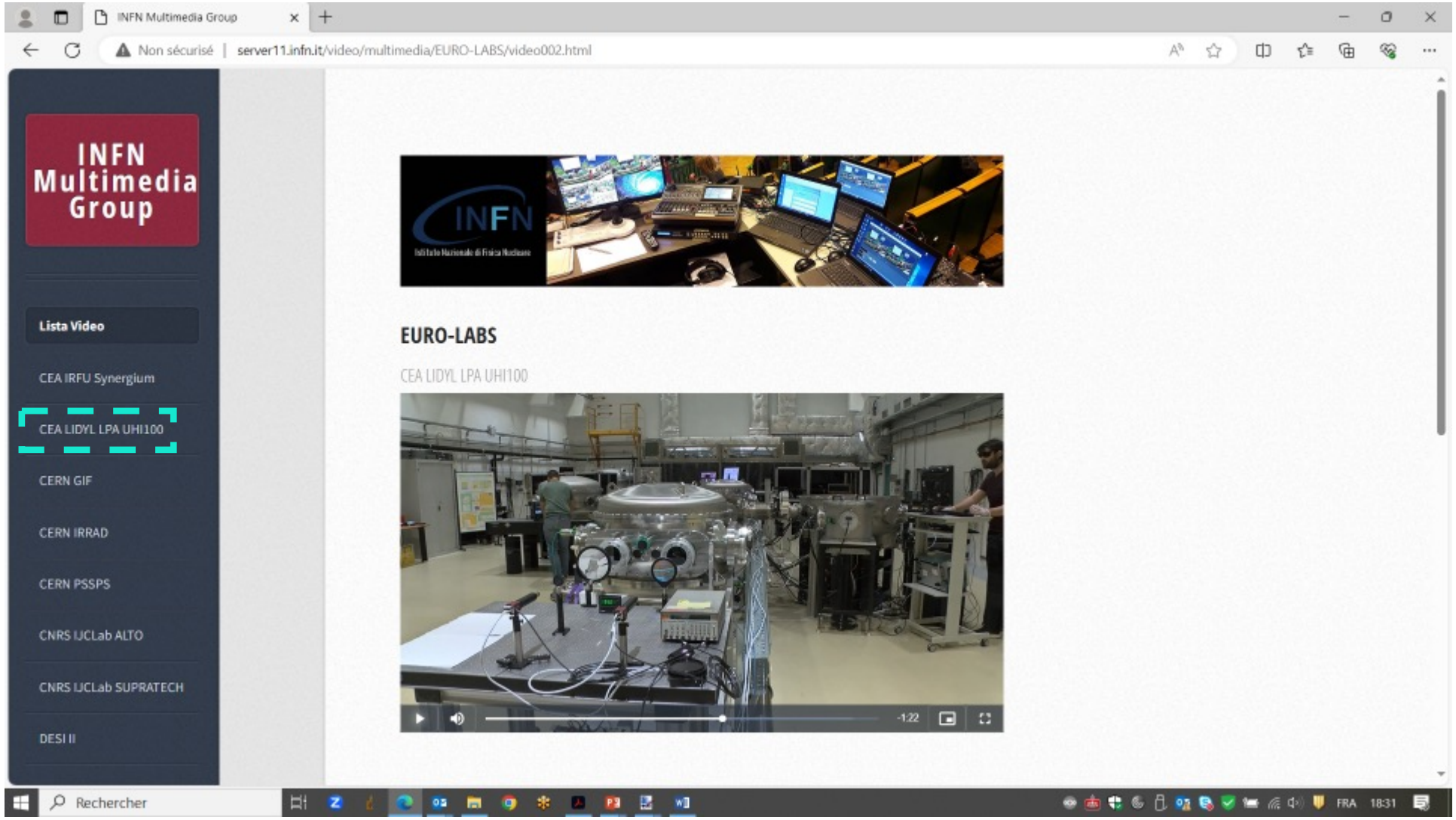
Acquisition room

Laser-plasma Accelerator



- Up to **150MeV** over few mm length
- **10's pC up to 100's pC/ shot** depending on the acceleration mechanism
- **fs** range duration
- **few mrad** divergence

Advertisement of the facility through EURO LABS website

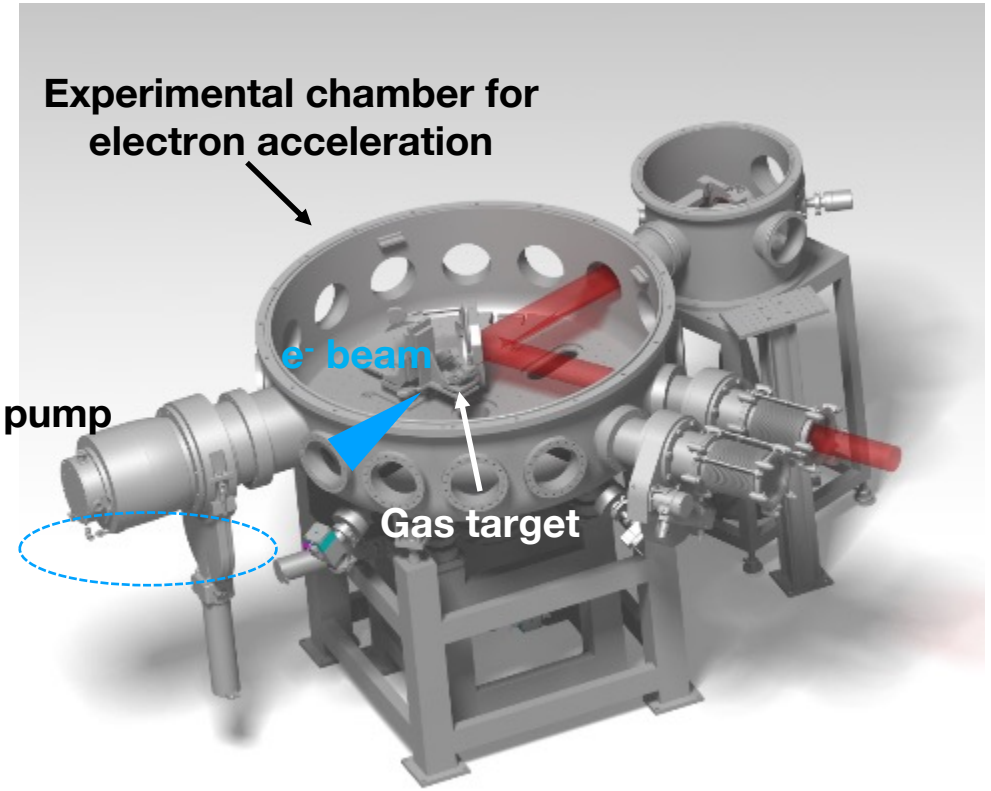


Videos recorded in July (5th) 2023 by INFN multimedia group

Service Improvements

Objective: increase the repetition rate of the laser-driven electron source (around 0,05Hz initially on the platform)

- ✓ **Pumping capacity increased by 140%** by additional turbo molecular pump connected to the experimental chamber
- ✓ **New gas regulator system** to control the backing pressure and suitable to repetition rate up to 10Hz
- ✓ **Development of automatic data saving system**
  - Software completed at 90%
  - Server implemented for data saving
  - Tests to validate the full system planned in Oct-Dec (2023)



Planning for the next period

UPDATE: **Nuclear Safety Authority** has given a temporary authorization to shoot with the laser on target with reduced electron beam characteristics (50MeV, 16pC, 1shot/min) in August 2023.
We wait for the CEA authorization to operate the facility now.

no beam time delivered yet!

PLANNING: :

1/ test shots on the facility / Upgrade of the command control of the laser system **nov-dec 2023**

2/ implementation of the Machine Learning Toolkit Prototype GeOff developed by GSI (see Sabrina Appel's talk - WP5) and adjustments to the Laser- plasma accelerator specificities **spring 2024**

3/ **1st campaign** : tests of a double compartments gas cell as new target to **generate low dispersion energy electron beams around 150 MeV** **summer 2024**

EUROLABS Task 3.3 - ELECTRON BEAMS at INFN Frascati

- INFN Frascati Labs have a long-established tradition in production and operation of e^+/e^- beams;
- Presently there are two major accelerator complexes:
  - ✓ The DAFNE e^+/e^- collider (including a e^+/e^- Linac, a two-lines **BTF**, a Damping ring + Transfer Lines)
  - ✓ The e^- multi-disciplinary test facility **SPARC_Lab** (including a high brightness photo-injector, the high power laser system FLAME + various lines for FEL, THz radiation, beam diagnostics, …)
- Within the EURO-LABS project the beams of two facilities are offered to transnational users, namely:

Beam Test Facility (lines #1 and #2, e^+/e^-)

SPARC_Lab (high brightness e^-)

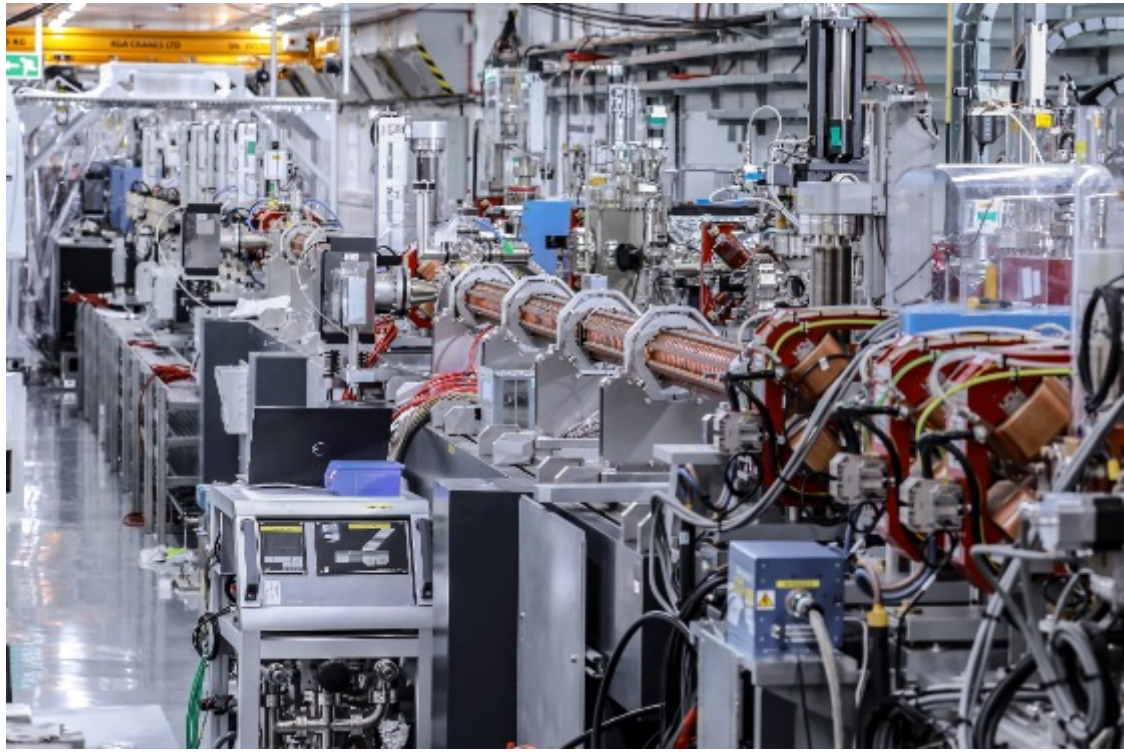
EUROLABS Task 3.3 - INFN Frascati ELECTRON BEAMS Facilities BTF and SPARC_LAB – PRESENT STATUS

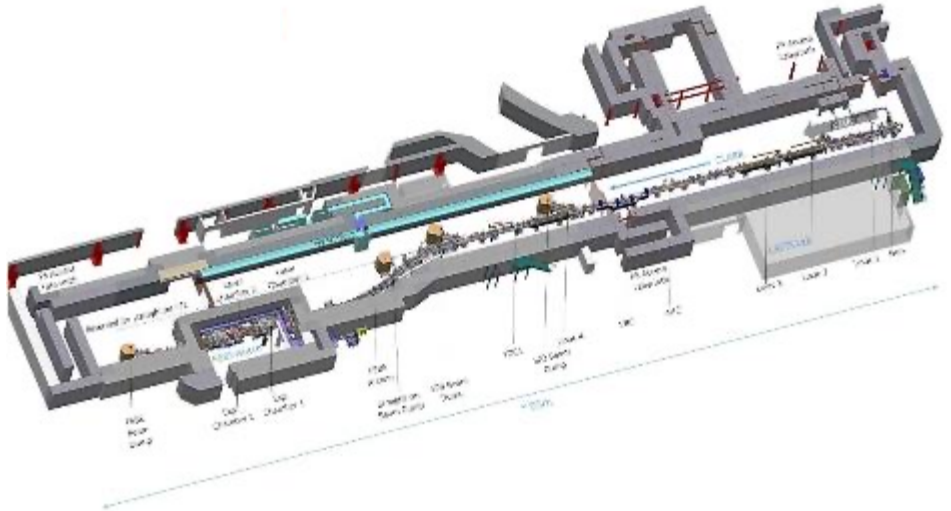
- Started collecting interest from possible EURO-LABS users:
  - We are planning access for BTF before the end of the year with an identified user group;
  - Also SPARC_Lab has potentially eligible users, but a plan is not yet available.
- EUROLABS has been widely advertised by INFN
- Discussions continuing to progress between INFN-LNF and the EUROLABS project office around financial considerations.

CLARA status update

- **CLARA** is a high brightness electron test facility addressing many scientific and technology challenges for future large scale facilities
- Flexible test facility to demonstrate novel concepts
- Straight-on space (Phase 3) is retained for accelerator technology R&D in support of UK XFEL
- 1.5-cell S-band 400Hz High Repetition Rate Gun (HRRG) designed by STFC/CI/INR collaboration
- Using machine learning to deliver an efficient, automated accelerator with rapidly customisable beam properties

TA units delivered to date: **0**





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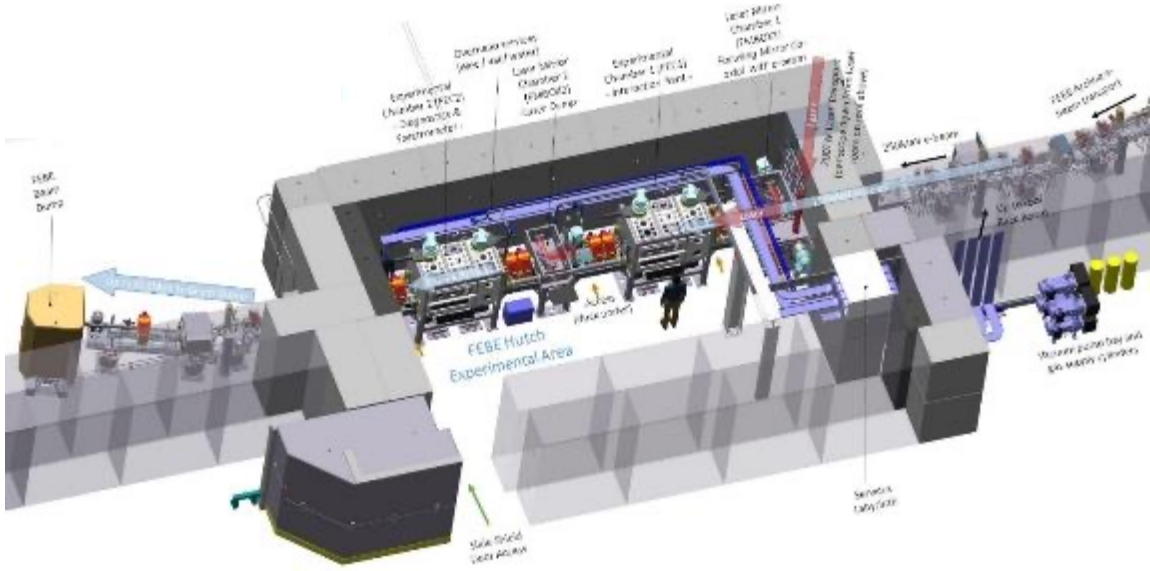
FEBE facility on CLARA

- **Full Energy Beam Exploitation** (FEBE): 250 MeV, 250 pC FEL-ready bunches at 100 Hz
- Two identical chambers interaction chambers provide flexibility and a route towards ambitious interaction/transport/applications
- FEBE Laser: Commercial 100 TW laser at 5 Hz, ‘upgrade ready’ to 250 TW, with femtosecond synchronization to CLARA Optical Timing Network
- All Phase 2 arc modules are installed and all RF modulators have been tested. FEBE hutch accelerator modules are completing their off-line testing

TA initial usage expected: **Q4 2024/ Q1 2025**



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Contact: anthony.gleeson@stfc.ac.uk

Thank you. Any questions?

With thanks to: Robert Ruprecht, Sandrine Dobosz Dufrenoy, Alessandro Gallo