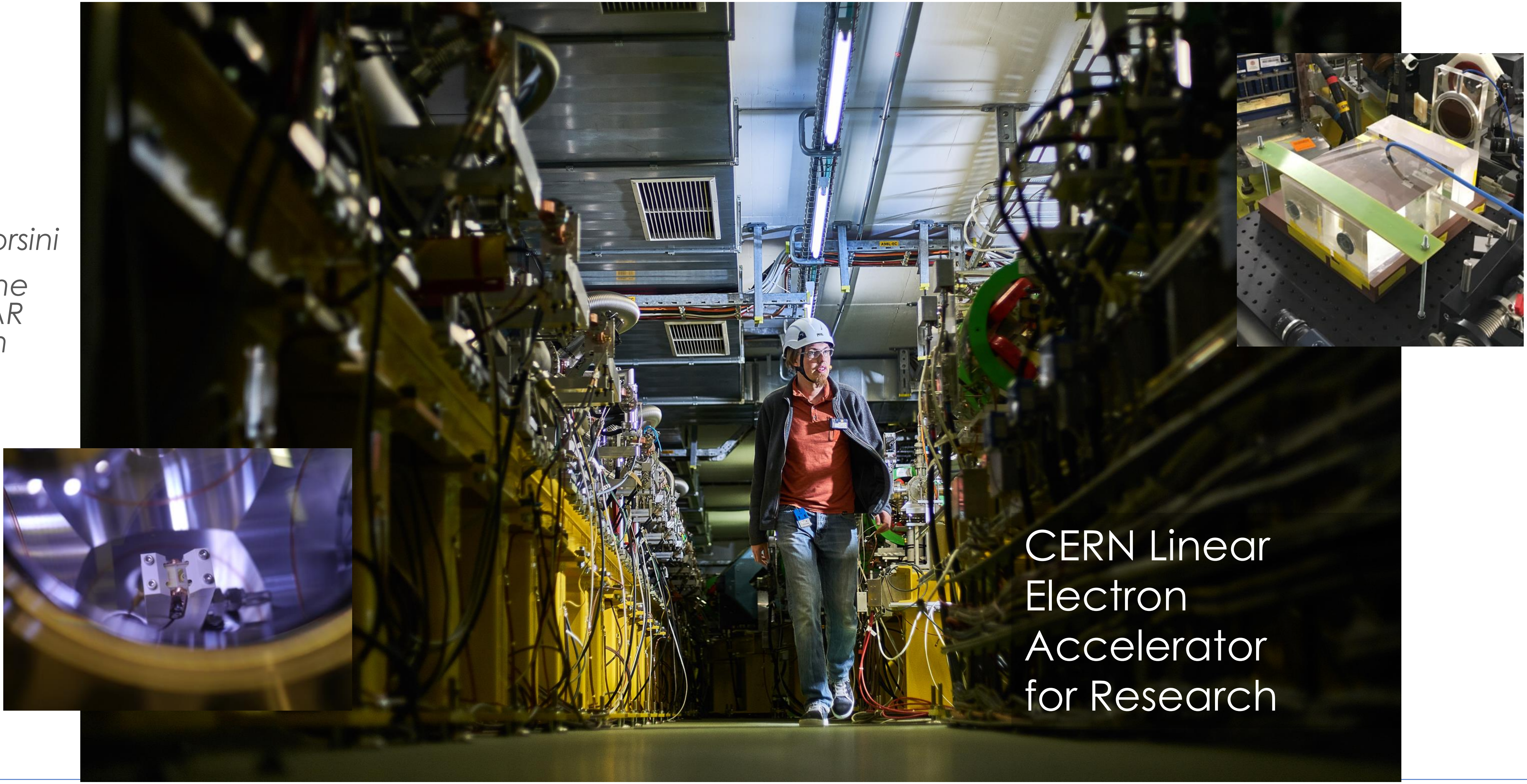
Update on CLEAR and 2024 Scientific Board Meeting outcome

R. Corsini

For the CLEAR team



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CLEAR timeline, operation & resource level

- CLEAR was initially approved as a 2 + 2 years program, operating since August 2017.
- CERN reviews were held in 2019 and 2021 to confirm and further extend its operation.
- CLEAR is a standalone installation, running also during Long Shutdowns. In a typical year 30-40 weeks of beam operation are provided, between March and December.
- The operation team comprises on average 1 staff, 1 fellow and 1 associate, plus contributions of some students and part-time associates. A total of about 3.5 staff FTE/year is allocated to the facility, including technical support.
- The CLEAR material budget is of the order of 800 kCHF/year (including M to P)

- CLEAR operation is currently approved until end 2025.
- A CLEAR budget line (M+P) is present in the current MTP beyond 2025.
- A review is planned in 2024, in order to approve (or not) its operation beyond 2025.

Draft MTP2023

Accelerator technologies and R&D	Total 2023-2028 M+P [MCHF]
RF technologies R&D	55.2
High-field superconducting accelerator magnets R&D	136.3
Proton-driven plasma wakefield acceleration (AWAKE)	33.5
CERN Linear Electron Accelerator for Research (CLEAR)	9.2
Other accelerator R&D	18.9

M. Lamont, 329th IEFC meeting

CLEAR Roadmap

Following previous discussions with the CERN management we will request in spring 2024 a CERN internal review on the potential extension of CLEAR operation beyond 2025.

- Date: April-May 2024.
- Aim: extend operation for a period of about 5 years.
- Format: similar to the last one, held in 2021 (https://indico.cern.ch/event/1015632/)
- In preparation of the review, the 2024 meeting of the CLEAR Scientific Board received the mandate to assess the scientific case for an extension.

A decision in mid 2024 would allow to better organize and possibly anticipate the long-term consolidation of the infrastructure (substitution of obsolete material, restock of spares), as well as to prepare the manpower plan.

CSB 2024 Mandate

The CLEAR Scientific Board (CSB) periodically reviews the progress of the experimental program, steers the experimental program and gives recommendations on proposed experiments and activities on the basis of their scientific interest and the availability of the facility. The Scientific Board members participate to the formal approval process of the beam time requests.

This meeting is focused on the specific charge:

- Review and assess the past CLEAR experimental programme, with particular focus on the one executed last year.
- Review the 2024 experimental program, as defined by the user proposals received so far and the extrapolation of past experiments, and give recommendations on most relevant directions or activities to be followed.
- Assess the present consolidation and upgrade plan of the facility and give indications on the potential contribution of the CLEAR facility to the future accelerator program at CERN, e.g., on its relevance for possible test facilities needed in FCC-ee pre-injector era.

CSB Meeting Timetable

09:30	10:00	Coffee	30m
10:00	10:15	**Introduction** **Speaker:** Roberto Corsini (CERN)	15m
10:15	10:35	**CLEAR Facility Status and 2023 Experimental Program** **Speaker:** Avni Aksoy (CERN)	20m
10:35	10:45	**Discussion**	10m
10:45	11:05	**CLEAR Plans and Experimental Program in 2024** **Speaker:** Wilfrid Farabolini (CERN)	20m
11:05	11:15	**Discussion**	10m
11:15	11:45	Coffe Break	30m
11:45	12:05	**Review of Medical Application Studies in CLEAR** **Speaker:** Pierre Korysko (University of Oxford (GB))	20m
12:05	12:15	**Discussion**	10m
12:15	12:35	**CLEAR beyond 2025 and Scenarios for e- Future Test Facilities at CERN** **Speaker:** Roberto Corsini (CERN)	20m
12:35	13:00	**Discussion and Closing of Open Session**	25m
13:00	14:30	Lunch	1h 30m
14:30	15:30	**Scientific Board Closed Session**	
15:30	15:50	Coffee Break	20m
15:50	16:45	**Scientific Board Closed Session**	
16:45	17:45	Visit to CLEAR	1h

2023 CLEAR Operation Summary

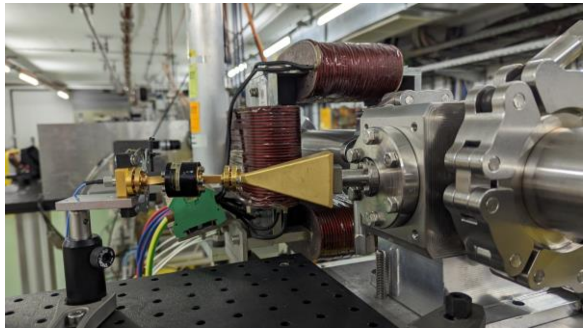
A. Aksoy/W. Farabolini

Week	Type of experiment	Institute	Install (h)	Acces nb.	Beam time (h)
11	MD	ABP	6	1	6
	Neutron monitors	CERN- RP	2	7	22
12	Optic fiber dosimetry	Oxford U.	5	8	20
	Film dosimetry	Oslo U.	5	2	19
13	LUXE BPM	INFN Bol./Pad.	16	5	46
14	Scatterers	Oxford U.	8	5	24
	Real time dosimetry	Oxford U.	2	0	6
	Uniform beam generation	Cern-ABP	0	0	6
15	Wall current transformer	Bergoz	2	2	12
	MD Cavity BPMs	ABP			
16	MD Dispersion free steering	ABP			
	Optic fiber dosimetry	Oxford U.			
	Film dosimetry	Oslo U.			
	MD Flat Beam space charge	ABP			
17	Plasmid irradiations	Manchester			
	Film dosimetry	Oxford U.			
18	Medical irradiation Ch. ZFE Cells	CHUV			
	Optic fiber dosimetry	Oxford U.			
19	Ch DR	CERN-BI			
20	VHEE UHDR	Victoria U.			
	ZFE irrad. And phantom dosimetry	CHUV			
	MD	ABP			
21	Scintillator dosimetry	Victoria U.			
	VHEE UHDR larve irrad.	EPFL	2	6	12
	Spatially fractionated irrad.	Victoria U.	2	2	8
	MD	ABP	0	0	6
22	Ch DR BPMs for Awake	Oxford U.	2	2	20
23	EOS	CERN-BI	4	9	25
	LUXE BPM	INFN Bol./Pad.	0	0	4
24	MD	ABP	1	0	50
25	Quarz fiber Cherenkov	Bologna U.	10	5	32
	LUXE BPM	INFN Bol./Pad.	1	0	3
26	MD	ABP	8	7	36
27	Ch DR EOS	CERN_B	4	4	35
28	MD BBA	ABP	0	0	8
	CHUV preparation	CHUV	3	3	12

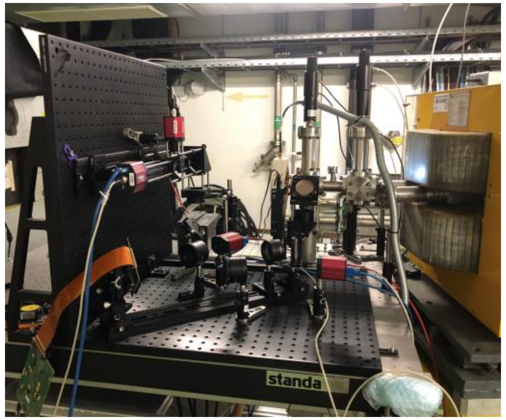
29	Bunch Length Monitor EOS for FCC	KIT	8	3	25
	LUXE BPM	INFN Bol./Pad.	2	1	5
30	Real time dosimetry	Oxford U.	6	7	25
	ZFE irrad	CHUV	1	4	6
	MD uniform beam	ABP	0	0	12
31-33	Summer shut-down PL installation		30	1	
34	Plasma Lens	Oslo U.	6	5	25
35	Dual Scatterers for flat beam	Oxford U.	6	9	30
36	Ch DR BPMs for Awake	Oxford U.	4	6	15
			0.5	2	6
		thclyde U.	1	6	17
			0.5	1	4
		N-BI	1	1	18
		L	16	1	0
		L	16	1	25
		rpool U. / Cockcroft	2	8	36
			0	0	3
		TI-BMI HSE	5	5	50
			0	0	5
			12	7	18
		rd U. and JAI	8	7	15
		N-BI	3	2	4
			0	4	32
44	P-cubed BBP	PSI	5	5	50
	Dual Scatterers for flat beam	ABP	0	2	5
45	P-cubed BBP	PSI	4	3	30
46	microBPMs	CERN-EP-DT	3	7	12
	Detectors	Kansas U.	3	6	20
47	VHEE irradiation of cells	CHUV	2	5	20
48	optic fiber BPM	Oxford U.	8	2	15
	Dual Scatterers for flat beam	Oxford U.	2	1	15
	YAG/film comparison	Oslo U.	1	1	2
	MD dosimetry prediction code	ABP	0	0	5
49	MD BBA	ABP	0	0	50
	Flat beam generation	ABP	0	0	10
total			**279**	**230**	**1209**

- 37 weeks of beam
- 279 hours of set-up installation
- 230 accesses with the radioprotection
- 1209 hours of beam
- 40 hours of fatal failure
- 1.9 experiments per week in average

2023 CLEAR Operation – Highlights

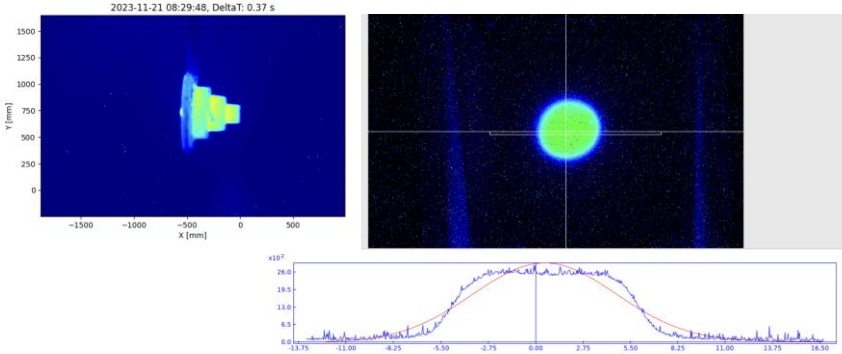


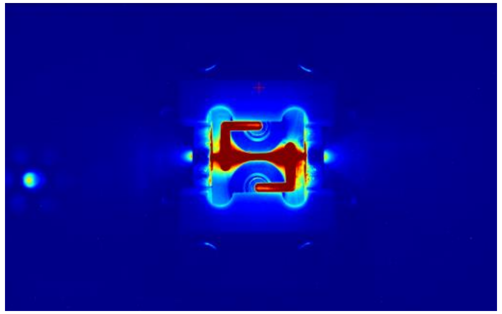
AWAKE Cherenkov Diffraction Radiation BPM



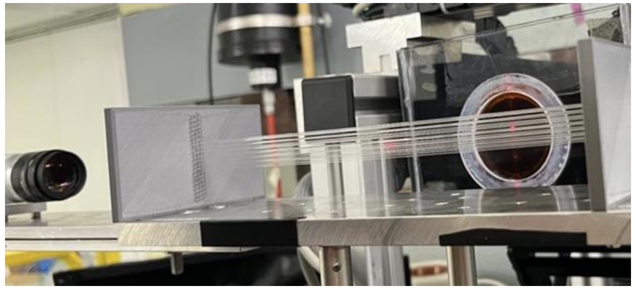
Novel OTR-based emittance meas. system for AWAKE (Liverpool U.)

Double-scattering system for uniform beam delivery in VHEE radiotherapy (CERN/Oxford U.)

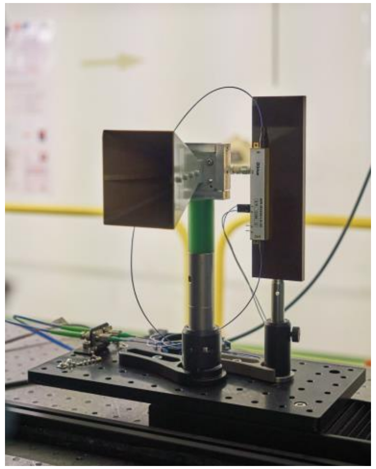




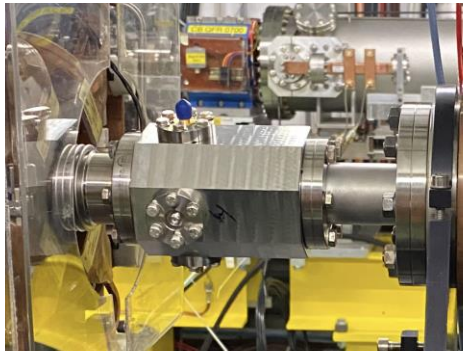
Plasma lens defocusing tests (Oslo U./CERN/Oxford U./DESY)



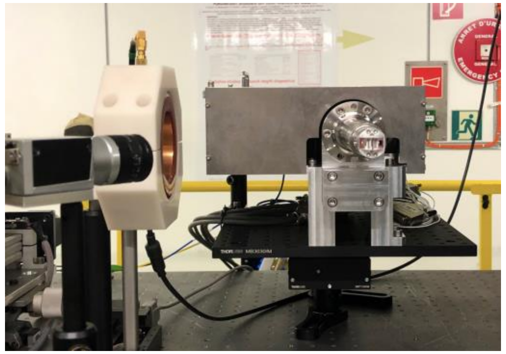
Fibre-optic beam profile and dose monitor for VHEE radiotherapy at ultra-high dose dates(CERN/Oxford U.)



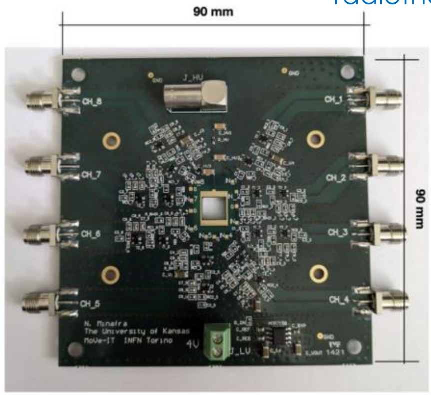
Coherent Cherenkov diffraction radiation dielectric buttons (FCC-ee bunch length monitors)



Broadband Pick-up for the PSI Positron Production Project (FCC-ee collaboration)

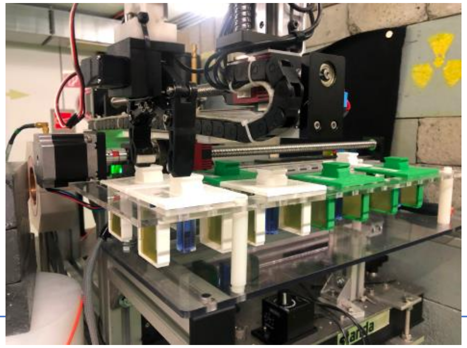


Bunch Profile Monitor for FCC-ee (Karlsruhe)



Beam testing of PCB + detectors using different technologies (Kansas U.)

Real-time dosimetry for VHEE radiotherapy using cuvettes (Strathclyde U.)



2023 CLEAR Operation – User distribution

A. Aksoy/W. Farabolini

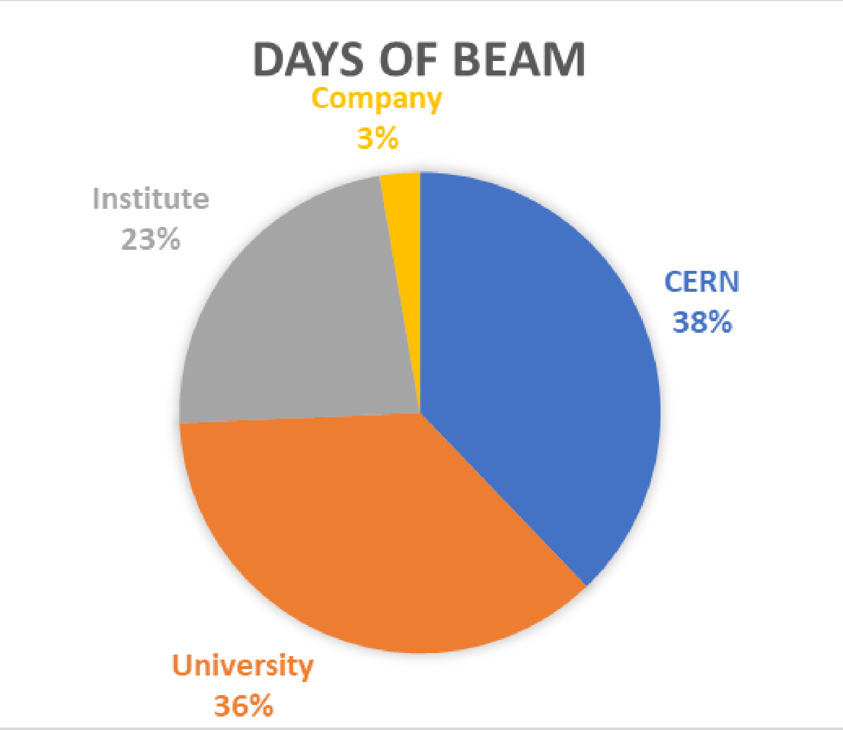
- 27 Experiments
- About 18 User Groups internal/external
- More than 13 external collaborating institutes

- CERN – ABP
- CERN – BI
- CERN – RP
- CERN – EP
- CERN – TE
- CERN – SY

- BERGOZ
- DAES

- Manchester Univ.
- Oxford Univ.
- RHUL
- Liverpool Univ.
- Strathclyde Univ.
- Queen's Univ.
- Oslo Univ.
- Bern Univ.
- Victoria Univ.
- Kansas Univ.

- PSI
- CHUV
- EPFL
- INFN Bologna
- INFN Padova
- KIT
- PTB
- RAL – ENEA
- Cockcroft Inst.
- JAI

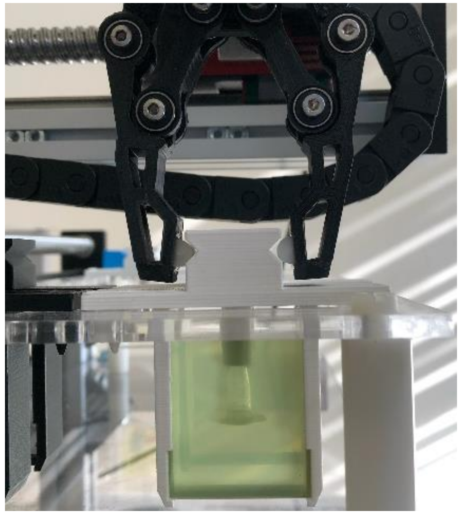


VHEE/FLASH Chemistry Studies

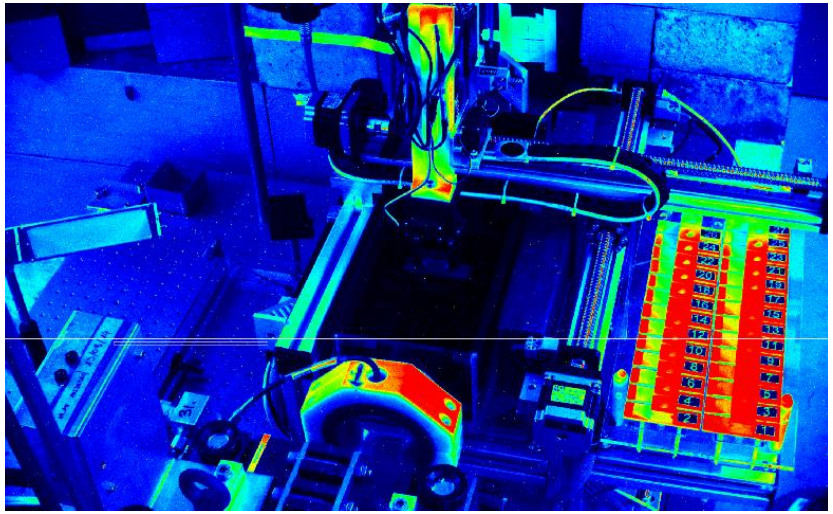
P. Korysko

Experiment:
Measure and compare the production of Reactive Oxygen Species (ROS) in water at Conventional Dose Rate (CDR) and Ultra High Dose Rate (UHDR).

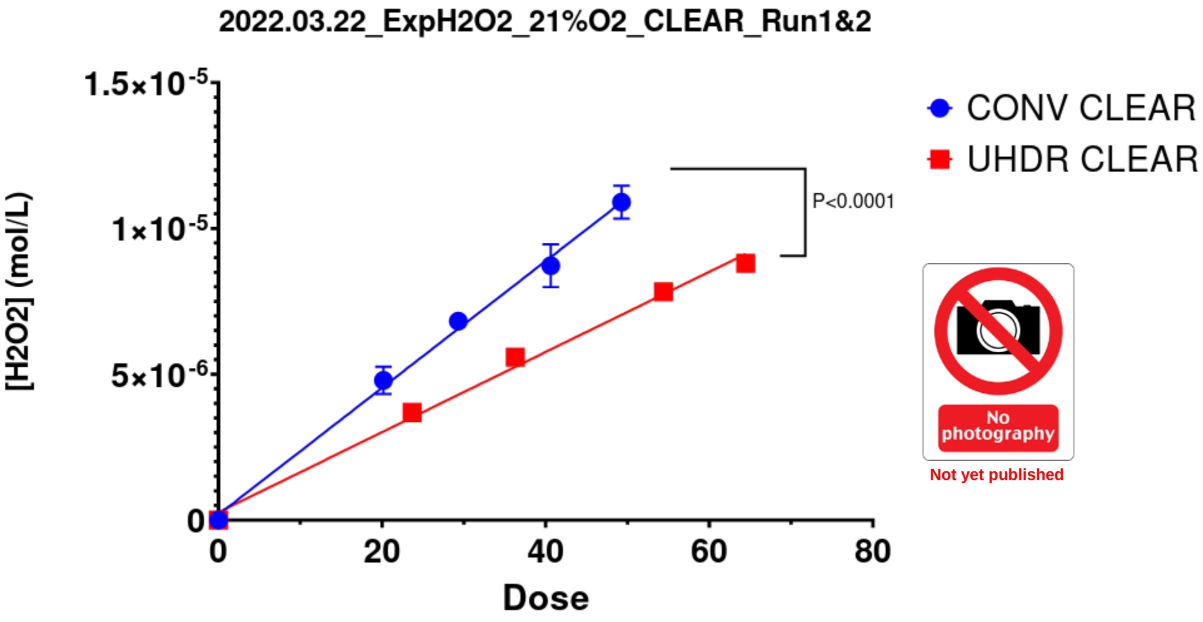
UHDR=1.2 10^9 Gy/s   CONV=0.15-0.41 Gy/s



Holder with films and Eppendorf tube



C-Robot view when performing irradiations for chemistry studies



No photography
Not yet published

Y = 2.175e-007*X + 1.827e-007   Y = 1.375e-007*X + 2.648e-007

M-C. Vozenin & H. Kacem

VHEE/FLASH Biological Effect (Zebra Fish eggs)

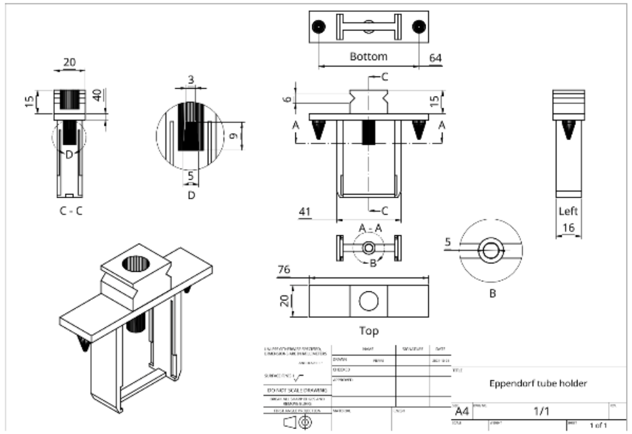
P. Korysko

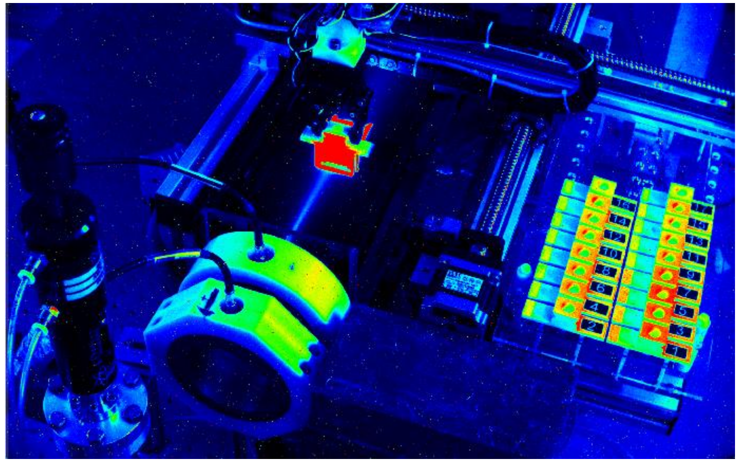
Goal :

Measure the response effect of the dose and the dose rate on biodosimeters (ZFE) with VHEE.

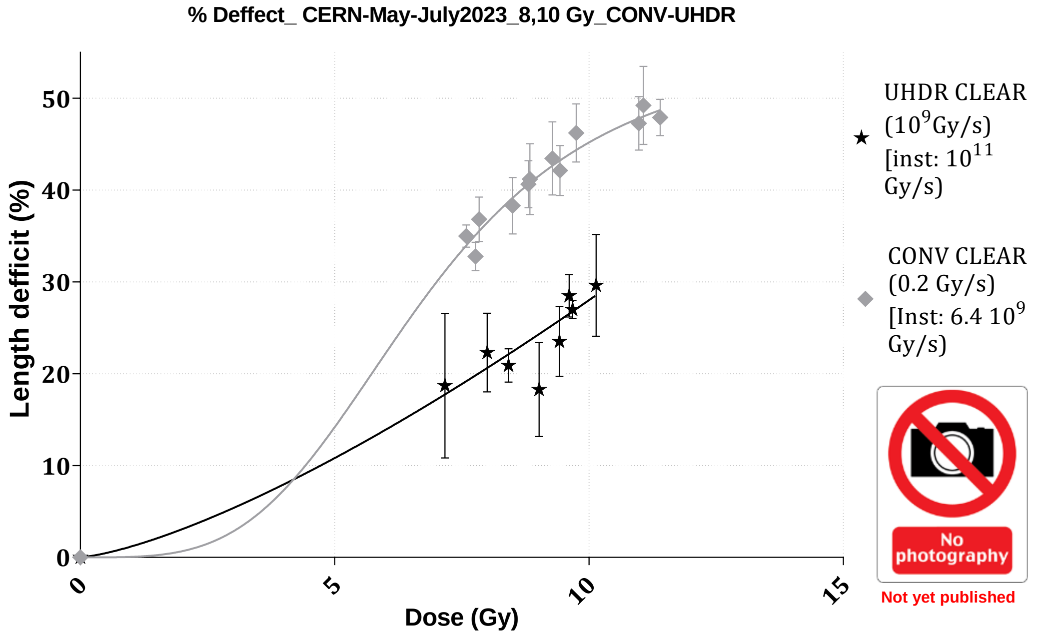
Experiment :

Irradiate biodosimeters with numerous doses and dose rates: UHDR (Ultra High Dose Rate) and CDR (Conventional Dose Rate) and measure the length deficit.





Preliminary results



Not yet published

M-C Vozenin & J. Ollivier

CSB Report – 2023 Program

Scientific accomplishments of 2023 beam operations

- In 2023 27 user experiments were performed during 37 weeks of operation, amounting to 153 days of beamtime (including machine development); the beam uptime was an impressive 97%. Scientists from 18 user groups from 13 institutes, in addition to CERN, benefitted from beamtime. The scientific output included 10 conference papers, 8 journal papers, experimental data for 13 PhD theses, and numerous presentations. It should also be noted that CLEAR is an important facility for training and outreach. In 2023 31 CERN tours and visits (including 'VIP's as well as journalists, companies, and artists) were hosted; CLEAR was mentioned in 2 international press articles as well as 3 internal CERN articles. As in previous years students attending the Joint Universities Accelerator School (JUAS) spent a training week operating the facility.

- **Finding 1:** We commend the CLEAR team for achievement of both excellent operational efficiency and outstanding support for user experiments in 2023. The resulting scientific papers, PhD theses, training sessions, and facility visits are testament to the impressive output and impact of CLEAR. That this was achieved with very modest resources is all the more commendable. CLEAR is a great asset to CERN.

CSB Report – 2023 Program

- ***Beam diagnostics experiments***

- In 2023 ten experiments on beam diagnostics were performed using 62 beam days in total, representing a doubling of the activities in this area compared with the five experiments in 2022. The table below lists the experiments, together with the lead institutes and, where applicable, the target of the activity.

Experiment	Institute or Company	Target of activity
AWAKE scintillation screen	University College London	AWAKE
3D Diamond Detectors	University of Kansas	
MicroBPM	CERN	CERN IIRAD
Broad Band pickups	PSI	P3 experiment, FCC-ee e+ prod.
FCC Cerenkov bunch length monitor	CERN	FCC
CLIC Cavity Beam Position Monitors	Royal Holloway, University of London	CLIC
EO Bunch Profile Monitor for FCC-ee	KIT	FCC-ee
Emittance measurement with OTR light	Liverpool University	
Beam Profile Monitor for LUXE	INFN Bologna	LUXE experiment DESY/Eu-XFEL
High frequency Wall Current Monitor	Bergoz	

- **Finding 2**: It is striking that the majority of the beam diagnostic experiments have clear target applications, thus emphasizing the importance of CLEAR as a test-bed for critical beam instrumentation for both existing and future accelerator facilities and/or experiments.

CSB Report – 2023 Program

Medical-application experiments

- The medical-application experiments were one of the main activities at CLEAR, with growing demand and representing a total of roughly 14 weeks of beamtime. The ‘C-Robot’, which allows the precise control of samples for multiple irradiations, was used in most of the experiments. In addition, a new C-Robot v2.0 was built for the new CLEAR beamline (see below) which is particularly adapted for medical applications with very flexible optics. (This development is so successful that the robot will be replicated at the PITZ facility at DESY-Zeuthen).

- Experiments in 2023 were mainly focused on Very High Energy electron (VHEE) beams targeted at understanding better the ‘FLASH’ effect, aimed at minimizing the dose and the damage to healthy tissue, including investigations of new dosimetry methods. Experiments can be broadly classified as:

1. Dosimetry studies with various methods: real-time dosimetry with thin scintillating screen, Ultra High Dose Rate (UHDR) using radio-chromic films, optical fiber dosimetry (Oxford Univ.) and combination of real-time and high spatial resolution by using scintillators and optical fibers.

2. Irradiation methods and dose delivery modalities, where the experiments planned were on minimizing the damage on healthy tissues by improving strong focusing, minimizing dose and damage by reducing scattering, and studying dose values using GRID collimators. Irradiation methods: VHEE focusing (Manchester Univ.), impact of scatterers (Oxford Univ.) or collimators (spatial fractionation) (UVic), and

3. FLASH effect studies via: chemical, plasmid irradiation, in vivo radiobiology (UVic, EPFL) or bio dosimeters (CHUV).

- **Finding 3:** CLEAR is a unique facility for addressing the FLASH effect in radiotherapy with VHEE, which has brought an increase in requests in this field. The selection of experiments in 2023 (and those proposed for 2024) are strategically chosen to help progress studies of the FLASH effect towards clinical use. The new tools, C-Robot v2 and the new beamline with flexible optics, which will become available in 2025, demonstrate the degree of effort put into the facility to better serve the medical user community.

CSB Report – 2023 Program

Advanced accelerator technology experiments

- Several experiments relevant to the field of advanced accelerator technology, including beam manipulation and beam diagnostics (see above), were performed during the 2023 CLEAR operation. Of particular note are:
    1. A plasma lens test has been performed, in the framework of the fruitful collaboration with Oslo University, investigating the “double-plane optical beam enlargement without scattering” and tests of “non-linear plasma lens device concept”.
    2. Advanced beam manipulation and diagnostics tests have been performed with possible application to advanced accelerators, in particular uniform beam generation and novel emittance measurement.
    3. A scintillation screen in support of the AWAKE facility program has been tested.

- **Finding 4:** CLEAR is an ideal machine for implementing and testing advanced accelerator components. Strengthening the collaboration with AWAKE will certainly be of mutual interest, in particular concerning the foreseen new AWAKE photoinjector.

- **Recommendation 1:** More visibility should be given to the CLEAR capabilities for tests of advanced acceleration concepts in order to attract more users from other broad international collaborations such as EuPRAXIA.

Irradiation experiments

- During 2023, a test setup at the THz station was used for the first time for the irradiation of cables in the scope of the CARE project at CERN. A high-intensity beam (30 nC/train) was directed on a 15 cm long Al target, previously characterized by the R2E team during 2021 and 2022. The beam was optimized to obtain the highest possible energy, and the lowest possible energy spread, while keeping the high intensity (achieving energies in the range between 170 and 205 MeV). In total, 3 cables were irradiated, reaching approximately 100 kGy, 200 kGy, and 400 kGy. The first irradiation lasted around a half-day, the second lasted one day, and the third lasted two days. The level of dose that was reached during the campaign is remarkably high considering the short duration of the test (around 200 kGy/day).

- **Finding 5:** This experience suggests that the CLEAR accelerator may be productively used in future to perform similar irradiations. One aspect to be considered is Radiation Protection (RP): when operating at high beam intensities and for several hours, the activation of the area is non-negligible, requiring ideally at least one night of cooldown before access.

CSB Report – KT and TA

KT aspects

- CLEAR is also an interesting facility for industrial partners. In 2023 some tests were conducted by the company Bergoz Instrumentation on an improved beam current transformer. Another important knowledge transfer aspect of CLEAR comes from the scientific results (publications, presentations at conferences, PhD theses) and from the use of CLEAR as a training facility for students, including the Joint Universities Accelerator School. In 2024 the company Bergoz Instrumentation will continue tests on the beam current transformer. Another test will be done by the company DAES SA for the VULCAN project, which aims at developing a compact accelerator-driven neutron source for neutron diffraction applications. The project will be carried out by a consortium of Swiss and Danish SMEs: DAES, DTI, and Xnovo and is partially funded by the Eureka Eurostars program. A key component of the VULCAN instrument is the Target-Moderator-Reflector (TMR) system, where photoneutrons are produced by electron beam interaction with a high-Z target and are moderated using a combination of a room temperature pre-moderator and a cryogenic moderator. Experimental characterization of the TMR will be the main objective of the measurement campaign at CLEAR facility. One of the most interesting applications of VULCAN will be for material analysis of batteries and fast fuel cell development.

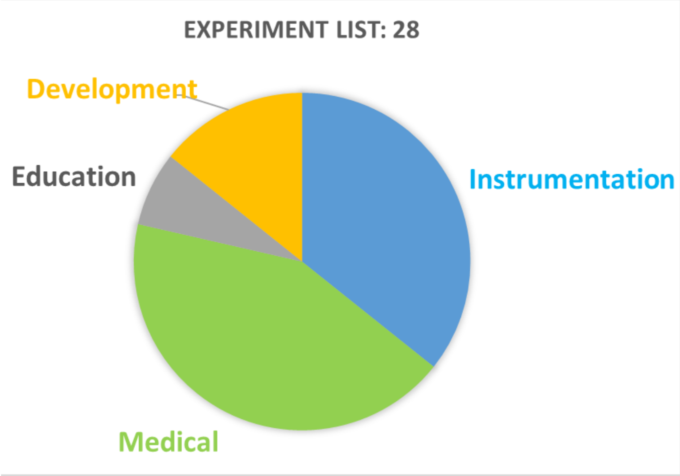
Transnational access aspects

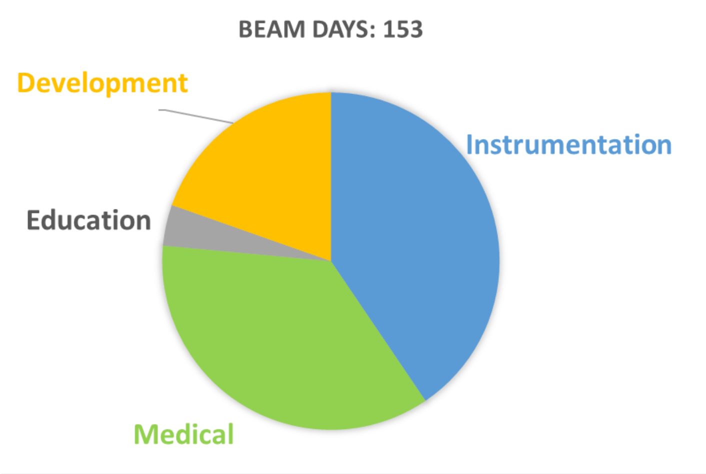
- CLEAR is an active participant in the EURO-LABS project, providing Transnational Access (TA) support to its users. Additionally, EURO-LABS allocates funds to CLEAR for targeted facility improvements aimed at benefiting its users, and CLEAR will be one of the three CERN facilities to offer hands-on training courses. In 2023, the inaugural year of the project, the CLEAR team actively promoted the TA opportunities within the user community; as a result, a total of 6 TA project requests were satisfied in 2023 and 250 access units were delivered out of the 1200 committed total over 4 years. While the startup was gradual, there are promising indications for improvement in the coming years. Regarding the service enhancements, progress has been made in utilizing project funds for the design work of the new C-robot and the development of the new beamline design.
- CLEAR will continue the TA program for EURO-LABS in 2024 with the aim of catching up based on the progress from 2023. The facility is set to host an advanced hands-on training school in June.
- **Finding 6:** Although the TA projects started gradually, the rate improved significantly towards the end of the year.
- **Recommendation 2:** The CLEAR team should continue to further increase the publicity of the TA possibilities within EURO-LABS to the user community. At the end of 2024, more than 50% of the declared access units for the facility need be delivered, leaving the remaining ones for 2025 and possibly 2026 the last year of the EURO-LABS project should the operation of CLEAR be extended.

Beam time requests (so far)

W. Farabolini

- 28 experiments in the list: 23 beam requests officially received, 5 in preliminary discussions
- 14 of them are continuation of last year experiments
- Already a total of 153 days of beam time requested by the users (before optimization). Last year: 185 days of beam delivered, including MD.
- 12 exp. related to Medical Applications (55 beam days)
- 10 exp. for Beam Instrumentation (62 beam days)
- 4 exp. for Accelerator Development and Physics (30 days)
- 2 cessions for Education (6 days): JUAS and Eurolabs
- Growing interest in FCC-ee (instrumentation and physics)





CSB Report – 2024 Program

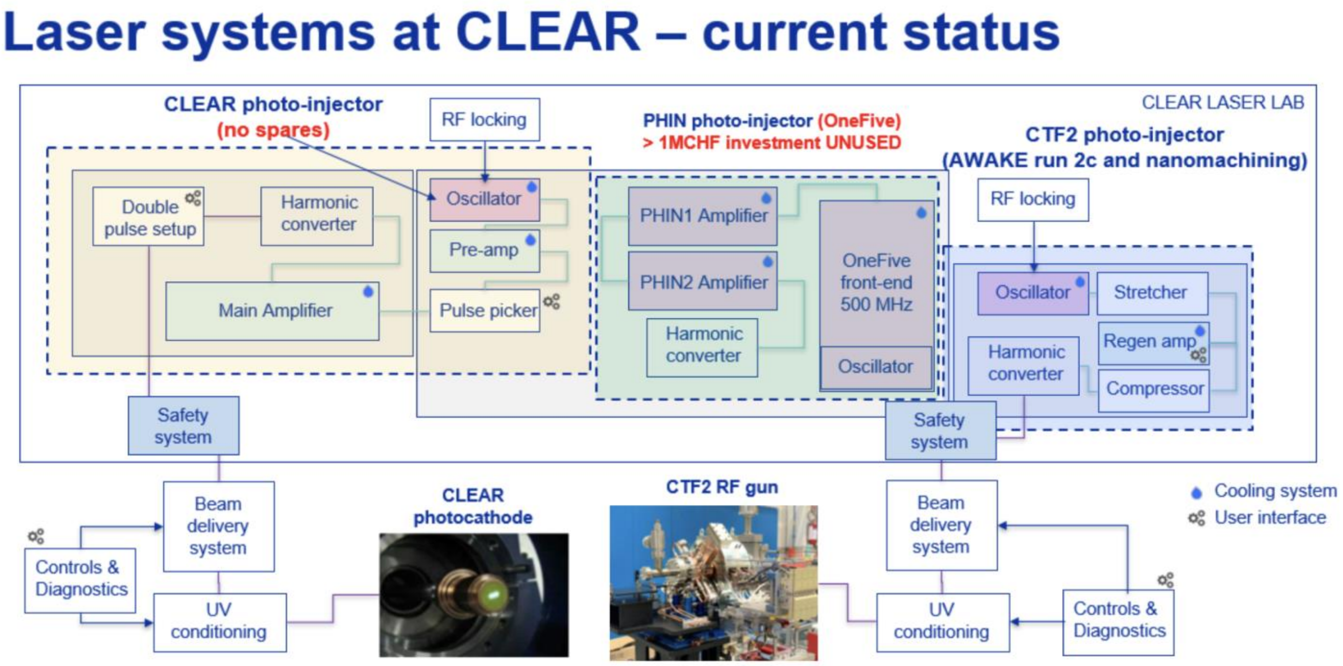
Scope of beamtime requests for 2024 operations

- A similar number of weeks of beamtime operation are planned in 2024. At the time of the meeting 28 requests had been identified, amounting to roughly 153 days of beamtime (before schedule optimisation). 12 requests (55 beam days) are for medical experiments, 10 requests (62 beam days) are for beam instrumentation experiments, and 4 requests (30 beam days) are for accelerator development/physics experiments; 6 beam days are planned for education/training for JUAS and EURO-LABS. Of the total of 28 requests, 14 are for follow-on experiments to those performed in 2023. The planned medical application in 2024 are mainly focusing in exploring dose and dose rate parameters for both healthy and cancerous cells, using VHEE beams

- **Finding 7:** A detailed run schedule will be prepared but it already seems clear that the in-hand requests can be expected largely to fill the available beamtime in 2024. If user demand continues to increase, a tighter selection of experiments may be required in the future.

- The CSB affirms its readiness to provide, where desirable, rapid feedback on beamtime requests.

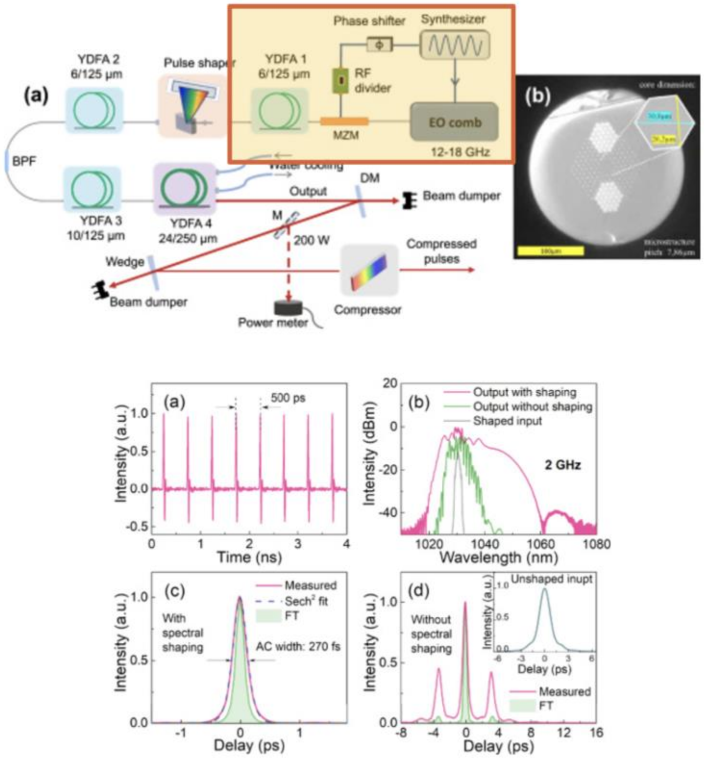
Short-term improvements - laser



E. Granados, B. Marsh

CLEAR laser points of failure:

- Ageing oscillator – could be replaced by OneFive system but operating at 500 MHz
- Laser sub-systems often fail and require replacements and spares (chillers, pulse-picker power supplies, laser diodes, laser power supplies, optical elements and motors)



New EO comb front-end

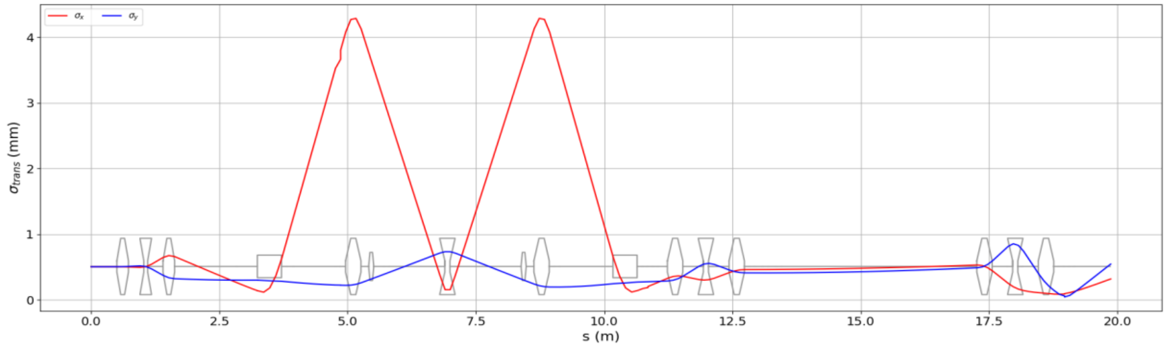
- Enhance significantly CLEAR performances (stability, time structure flexibility, high rep-rate)

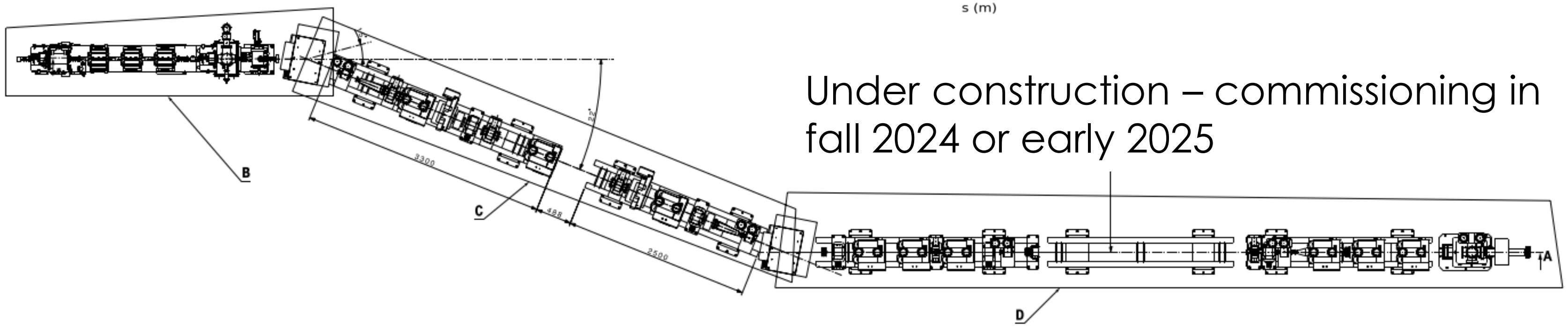
- ~ 100 kCHF program over 2 years
- System may be ready at end 2024

CLEAR improvements – new beam line

Motivations

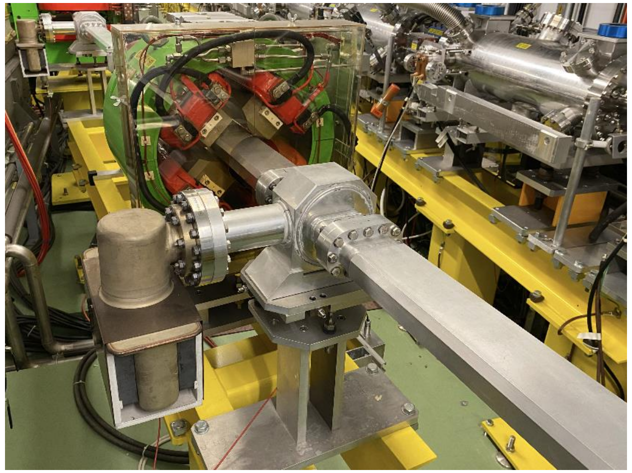
- Create more in-air and in-vacuum test areas for experiments – avoid repeated mounting/dismounting of experiments and diagnostics equipment, hence more beam time
- Added operational flexibility – allow for "non compatible" experiments to be performed in the same week or day, with fast turnaround time
- Expand beam parameter space, e.g., large beam sizes and strong focusing





Under construction – commissioning in fall 2024 or early 2025

Magnets, power supplies and most components and vacuum chambers from former drive beam chicane and TBL in CLEX, including pumping ports, bellows, pumps, vacuum valves, …

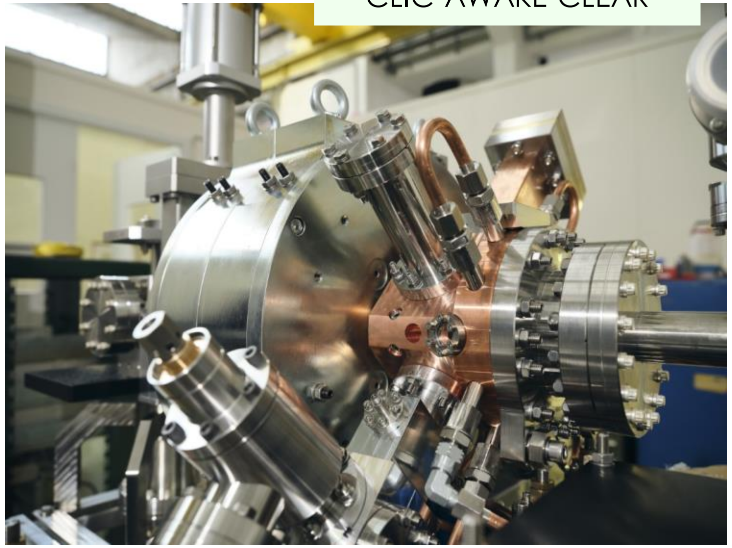


Longer-term improvement – new electron source

- A new electron source (photoinjector + X-band accelerating structure) is presently being commissioned in stages in the former CTF2 area, adjacent to the CLEAR hall.
- Joint effort between CLIC, AWAKE and CLEAR.
    - The initial aim was to develop a front-end for AWAKE Run 2, and to use it before final installation in AWAKE as an additional source in the CLEAR hall.
    - Present plans favors its use after commissioning and before installation in AWAKE as an independent beam line in the present location (CTF2), and as a part of the CLEAR user facility.
    - This solution will have the advantage of being less costly and time consuming, and will better fit present user demand for more beam time and for low-energy beams, rather than two-beam experiments
- This option depends on the actual timeline for AWAKE, the eventual CLEAR extended operation, and on the potential user interest. Main user operation beyond 2025, but some limited use is possible before.
- It will also require some additional resources, particularly in manpower.

Common development of novel electron source

CLIC-AWAKE-CLEAR



CSB Report VIII – Future Operations, near term

Near-term improvements to the CLEAR facility include the introduction of a second beamline. This addition enables the creation of more areas for in-air and in-vacuum testing, reducing the need for frequent mounting and dismounting of experiments and diagnostics equipment. Consequently, it increases the available beam time and operational flexibility, allowing for the parallel execution of 'non-compatible' experiments within the same week or day, with a quick turnaround. This modification also broadens the beam parameter space, for example allowing for larger beam sizes and stronger focusing. Commissioning is scheduled for late 2024 or early 2025.

The CLEAR laser systems have been identified as a potential source of failure and downtime. A new EO comb front-end is foreseen to increase the time structure flexibility, increase the repetition rate, and generally improve the reliability.

- **Finding 8:** The second beamline and laser-system improvements will enhance reliability and flexibility for operations in 2024/25 and can be executed within the existing planned resource envelope. A new electron source (comprising a photoinjector and an X-band accelerating structure) is currently being commissioned in stages in the former CTF2 area, adjacent to the CLEAR hall. This initiative is a collaborative effort involving CLIC, AWAKE, and CLEAR. Current plans favour its use after commissioning and before its installation in AWAKE as an independent beamline in the existing location (CTF2), and as an integral part of the CLEAR user facility.
- **Finding 9:** While the timeline for AWAKE and any potential conflicts requires clarification, it is feasible to duplicate parts of the source with limited investment to avoid such conflicts.
- **Recommendation 3:** CSB recommends that CERN support this approach towards upgrades, including CTF2. The committee encourages the CLEAR team to investigate the possibilities for utilisation of CTF2, define the necessary resources, and evaluate the user interest in CTF2 beyond the planned Inverse Compton Scattering (ICS) studies.
- **Finding 10:** The CLEAR programme has yielded important scientific results, has a growing user community, and an exciting future programme in various key areas. The aforementioned improvements and consolidations will enable CLEAR to accommodate a modest increase in user experiments, aligning with the growth of its user community demand.

CSB Report IX – Future Operations, beyond 2025

- **Finding 11:** Considering a programme of user experiments beyond 2025, future priorities would likely include:

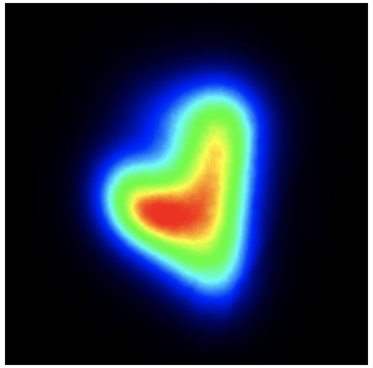
1. Beam diagnostics R&D, which currently accounts for about 30% of total experiments and is roughly evenly divided between CERN and external users. It is reasonable to expect that demand for this will remain at least stable, or more likely increase due to demand from FCCee (see below).
2. Priority for novel acceleration techniques (including plasma, THz, and X-band high-gradient technologies) will be maintained through long-term programmes supported as part of the LDG roadmap. This includes support for the plasma lens, ongoing assistance to AWAKE, and potentially a comprehensive ICS experiment.
3. Medical applications are notably important and prominent. The next four to five years are crucial for fully establishing VHEE/FLASH therapy techniques, covering fundamental studies, time structure dependence, and optimization of parameters, as well as its supporting technologies, including beam delivery, dosimetry, and beam control. If extended, CLEAR will uniquely serve the VHEE/FLASH community for a number of years, playing a pivotal role in the field, including facilitating knowledge transfer to other laboratories equipped for animal testing.
4. There is likely to be an overall increase in activities in other areas, such as irradiation, neutron production, beam testing of particle detectors and detector components, which will provide further demand.
5. The role of training and EU projects, with CLEAR being recognized as a valuable infrastructure in projects such as EURO-LABS.

Completion of the construction and commissioning of the new beamline will be crucial to support an extended programme beyond 2025. This will provide more flexibility to cope with the increasing beamtime demands and will enlarge the technical portfolio of the CLEAR facility. Moreover, as preparations progress towards a future Higgs factory at CERN, there is growing consensus on the need for relevant electron-beam test facilities including, for example, prototypes of key system elements of the FCCee injector complex. If such future electron facilities are designed for versatile use, they could continue and expand the CLEAR programme, attracting a broad user community, in addition to serving as a foundational step towards a Higgs factory.

- **Finding 12:** A CLEAR programme beyond 2025 could serve as a crucial step and bridge towards an electron-beam test facility based around developing key components required for a Higgs factory.
- **Recommendation 4:** CSB recommends that the CLEAR team be centrally involved in discussion of electron test facilities for a future Higgs factory at CERN.

Thanks for your attention!

And many thanks to the CLEAR Scientific Board members:



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