Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

The CLEAR user facility at CERN

D. Gamba [a,*], R. Corsini [a], S. Curt [a], S. Doebert [a], W. Farabolini [a], G. Mcmonagle [a], P.K. Skowronski [a], F. Tecker [a], S. Zeeshan [a], E. Adli [b], C.A. Lindstrøm [b], A. Ross [c], L.M. Wroe [c]

[a] CERN, Geneva 1217, Switzerland

[b] Department of Physics, University of Oslo, Oslo 0316, Norway

[c] Department of Physics, University of Oxford, Oxford OX1 3PJ, United Kingdom

ARTICLE INFO

Keywords:
Test facility
Accelerator R&D
Beam instrumentation
High gradient
Plasma acceleration
Irradiation

ABSTRACT

The conversion of the CALIFES beamline of CTF3 into the "CERN Linear Electron Accelerator for Research" (CLEAR) facility was approved in December 2016. The primary focus for CLEAR is general accelerator R&D and component studies for existing and possible future accelerator applications. This includes studies for high gradient acceleration methods, e.g. for CLIC and plasma technology, and prototyping and validation of accelerator components, e.g. for the HL-LHC upgrade. The facility also provides irradiation test capabilities for characterisation of electronic components and for medical applications. A description of the facility with details on the achievable beam parameters, and the status and plans are presented.

1. Introduction

The CLIC Test Facility (CTF3) [1] has demonstrated the feasibility of the CLIC [2] key concepts, and it ended its operation at the end of 2016. This made available expertise, space and equipment, which triggered the interest of a broad community within and outside CERN. The idea of reusing part of CTF3 for broader scopes was explored in a dedicated workshop that was held at CERN in October 2016 [3]. The CTF3 probe beam injector, called CALIFES [4], was identified as the most interesting and easily maintainable part, also thanks to the its demonstrated versatility [5,6]. A proposal to adapt and reuse CALIFES as an electron injector for a new test beamline was submitted to the CERN management, who quickly supported the project for an initial period of 2 + 2 years, with a review foreseen between the two terms. The resulting "CERN Linear Electron Accelerator for Research" (CLEAR) is a new stand-alone user facility, with the following primary goals:

- provide unique test capabilities to an international user community in key areas of accelerator R&D;
- support the development of high-gradient acceleration concepts, including the continuation of CLIC technology studies, but also to explore the potential of plasma acceleration technology;
- create a test bench for beam instrumentation and components for the consolidation and upgrade of the CERN accelerator complex, including the HL-LHC project;
- boost the collaboration with other science fields that need electron-beam test capability, including X-ray FELs, medical, space and industrial communities;
- maintain training capabilities for the next generation of accelerator scientists and engineers.

Adaptation works started in January, and the first beam was delivered to users at the beginning of September 2017.

In Section 2 the facility is described with references to previous works where more details can be found. Section 3 present the typical beam optics that can be implemented in the machine and finally in Section 4 the present and future experimental planning is discussed.

2. Beamline description

The CLEAR facility is hosted in the previous CLEX experimental area, building 2010, on CERN Meyrin site. The accelerator hall is approximately 42 m long and 7.8 m wide. The CLEAR beamline is installed along the middle of the hall, and it is composed of the CALIFES injector which is approximately 25 m long, followed by a 16 m-long beamline which can be easily adapted to suit the requirements of the users.

2.1. CALIFES injector

The CLEAR injector is basically unchanged with respect to CALIFES [4], except for major modification of the RF network and klystron

* Corresponding author.
E-mail address: davide.gamba@cern.ch (D. Gamba).

https://doi.org/10.1016/j.nima.2017.11.080
Received 20 November 2017; Accepted 23 November 2017
Available online xxxx
0168-9002/

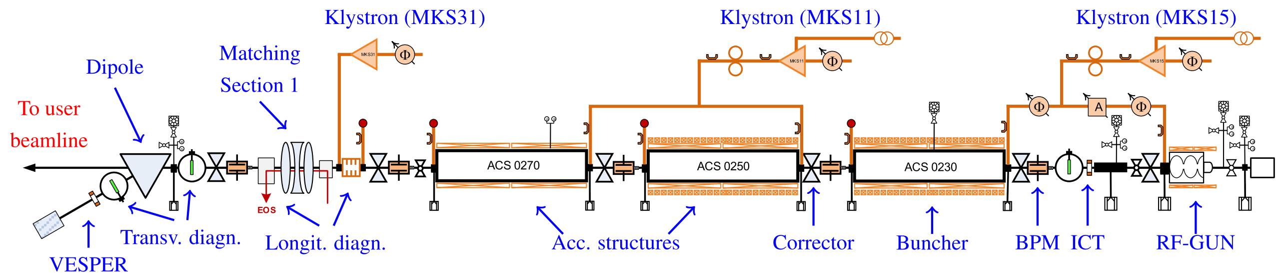

Fig. 1. Layout of the CLEAR injector (CALIFES). The electron beam travels from right to left.

Table 1
Photo-injector laser parameters.

Laser parameter	Value range
Energy onto the cathode [nJ/bunch]	up to 270
Intensity stability rms	< 3%
Spot size onto the cathode FWHM [mm]	1
Pointing stability onto the cathode rms [mm]	< 0.2
Wavelength [nm]	262
Micro bunch length FWHM [ps]	8
Micro bunching frequency [GHz]	1.5
Number of micro bunches [#]	0 to ≈300
Repetition rate [Hz]	0.833 to 5

sources. The layout of the present installation is depicted in Fig. 1, in which the beam travels from right to left.

The electron beam is generated on a Cs_2Te photo-cathode (QE > 0.3%, lifetime 1 year) pulsed by an UV (converted from IR) laser [7,8]. The main laser parameters are summarised in Table 1. A dedicated preparation chamber allows for in-situ regeneration of the photo-cathode by co-evaporation [9]. The RF-gun, developed and built by LAL-Orsay [10], is followed by three LEP Injector Linac (LIL) [11,12] 4.5 m-long accelerating structures [13]. The first structure can be used to tune the bunch length from 300 μm to 1.2 mm r.m.s. by means of velocity bunching. Both the gun, buncher and first accelerating structure are immersed in a tuneable solenoid field for focusing and space charge compensation. A matching section with three tuneable quadrupoles and a spectrometer line complete the injector.

CALIFES is equipped with a rich set of beam diagnostic [14]. An Integrated Current Transformer (ICT) from Bergoz [15] and a ceramic screen are installed right after the RF-gun to allow for the RF-gun characterisation. Along the linac BPMs based on a coaxial re-entrant cavity [16,17] are installed for transport optimisation. Bunch length measurements are possible by means of an Electro-Optical Spectral Decoding (EOSD) system [18], streak camera measurements [19] or by using a dedicated S-BEND RF deflector [20]. A transverse beam profile monitor [21] equipped with Yttrium Aluminium Garnet (YAG) scintillator and Optical Transition Radiation (OTR) screen is installed before the spectrometer. An additional ICT and YAG screen in the spectrometer line complete the longitudinal beam diagnostic capabilities.

The RF network is composed by two independent 3 GHz PLC-controlled [22] modulators/klystrons [23] (MKS11 and MKS15) equipped with LIPS [24] pulse compression system [25]. Each klystron can provide up to 45 MW 5.5 μs-long plateau pulses, at maximum repetition rate of 10 Hz. The pulse compression allows to reach about 60 MW over 1.2 μs-long flat pulses or more than 120 MW peak power with short pulses. A 4.5 dB splitter after the MKS15 pulse compressor is used to send power to the RF-gun and buncher structure. Amplitude and phase of the RF delivered to the RF-gun can be adjusted by an in-waveguide attenuator and phase-shifter. A second in-waveguide phase-shifter allows to independently adjust the buncher phase. The last two accelerating structures are powered by a 3 dB splitter after the MKS11 pulse compressor. A third klystron (MKS31, 25 Hz repetition rate) can be used to power the transverse deflector installed at the end of CALIFES.

The range of beam parameters that can be obtained at the end of CALIFES, and therefore available for users, are summarised in Table 2.

2.2. *User beamline*

The present layout of the experimental beamline is depicted in Fig. 2, in which the beam travels from right to left.

After a matching section composed of three adjustable quadrupoles, a two metre-long section is dedicated to beam instrumentation tests. Presently, it host a chamber for Optical (Diffraction) Transition Radiation Interferometry (OTRI/OTDRI) studies [26]. Moreover, a few diagnostic taken from the now discontinued Drive Beam lines have been adapted and installed to fit the CLEAR beam specifications [27–29]; This includes a High Bandwidth Wall Current Monitor (WCM) [30], two Drive Beam Inductive BPMs [31] and a wave guide pickup (BPRW) for non-destructive bunch length measurements [32].

The following CLIC Test Stand consist in part of the existing CLIC Two Beam Module (about 3 m long) on which a CLIC accelerating structure and three CLIC cavity BPM prototypes plus one older BPM prototype are installed to allow for the continuation of Wake Field Monitor (WFM) [33], and BPMs [34,35] studies. The transverse position of the three new prototype CLIC cavity BPMs and of the CLIC structure is remotely adjustable to allow for precise relative positioning.

After the CLIC Module, a matching section allows to adjust the beam before injecting it into a Plasma Test Stand which currently host a plasma lens experiment [36].

Before the final spectrometer, about 1.5 m-long space is available for users, for example for planned impedance studies [37]. The spectrometer line is mounted on a 1.2 m long and 0.9 m wide optical table. The straight line ends about 20 cm after the dipole with a 100 μm thick aluminium window, leaving about 1 m long in-air path for the beam. This area is well suitable for fast installation and test of equipment that does not necessarily need to be operated under vacuum. Presently it host Cherenkov and THz radiation studies [38,39].

The spectrometer line after the CALIFES injector (see Fig. 1) is also used as irradiation test bench under the name of VESPER [40]. Here it is planned to continue the studies on Very High Energy Electron for medical application [41] and Single Event Upset effects on electronics to be used in space missions [42].

3. Beam optics

At the entrance of the first matching section the beam is typically round, with Twiss β equal to 14 m and zero α in both planes. Thanks to the three matching sections installed along the user experimental area, different optics can be implemented to fulfil the users' needs. A MAD-X model of the machine is available on [43]. By assuming an average normalised emittance of 10 μm and energy of 200 MeV, Fig. 3 shows the beam size along the user experimental for three typical optics.

Note that the aperture of the beam pipe is normally 38 mm in diameter. Aperture restrictions are mainly located along the CLIC module, where the minimum aperture is approximately 8 mm in diameter. Other aperture restriction are the CALIFES cavity BPMs (18 mm inner diameter), one of which is installed before and two after the CLIC module. The plasma lens experiment presently installed is made of a 15 mm long, 1 mm diameter capillary, but this can be taken out of the beam path thanks to a mover installed below the vacuum chamber.

Please cite this article in press as: D. Gamba, et al., The CLEAR user facility at CERN, Nuclear Inst. and Methods in Physics Research, A (2017), https://doi.org/10.1016/j.nima.2017.11.080.

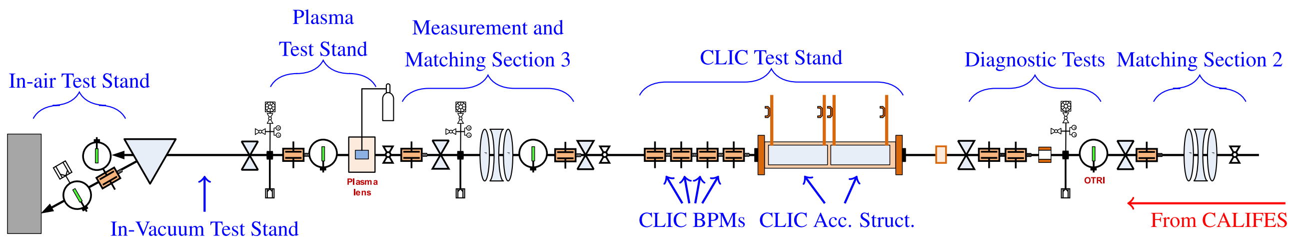

Fig. 2. Layout of the CLEAR experimental beamline. The electron beam, coming from the CALIFES injector, travels from right to left.

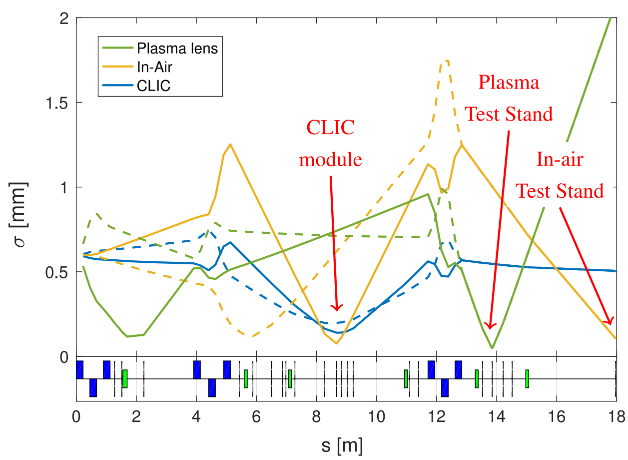

Fig. 3. Modelled horizontal (solid) and vertical (dashed) beam sizes (assuming 200 MeV, 10 μm normalised emittance) along the CLEAR user experimental area for three different optics. In the bottom the locations of matching section quadrupoles (blue), correctors (green) and beam instrumentation (dashed line) are highlighted. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

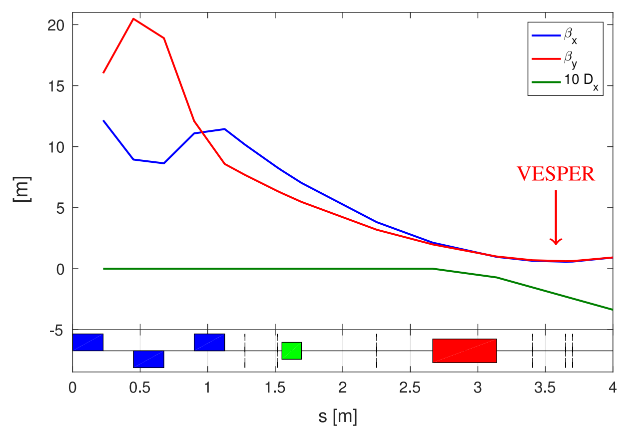

Fig. 4. Modelled horizontal (blue) and vertical (red) Twiss β functions and horizontal dispersion (green) from the entrance of the first matching section to the VESPER spectrometer line. In the bottom the locations of matching section quadrupoles (blue), spectrometer dipole (red), correctors (green) and beam instrumentation (dashed line) are highlighted. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 2
Beam parameters at the end of CALIFES.

Beam parameter	Value range
Energy [MeV]	50 to 220
Bunch charge [nC]	0.001 to 1.5
Norm. emittance [μm]	≈3 for 0.05 nC/bunch
	≈20 for 0.4 nC/bunch
Bunch length rms [mm]	0.3 to 1.2
Energy spread rms [$\Delta p/p_0$]	<0.2%
Repetition rate [Hz]	0.833 to 5
	up to 10 for dark current
Number of bunches [#]	Selectable: 0 to > 200
	up to ≈4 μs for dark current
Micro-bunch spacing [GHz]	1.5
	3 for dark current

All optics in Fig. 3 allow for a comfortable transport of the beam along the beam line. The blue-coloured optics is suitable for general purpose and for CLIC WFM and BPM studies. The orange-coloured optics allows to get a minimum β function of 0.5 m in the middle of the in-air test stand, while the green one yields 0.1 m at the entrance of the plasma lens experiment. query[no = 27,change = Figs. 3 and 4]

The VESPER experimental area sits in a spectrometer line, therefore the beam size is also affected by dispersion. Fig. 4 shows a typical optics. The derivative of the dispersion (DPX) after the spectrometer dipole is −0.31, therefore, depending on the location along the 1.8 m-long line, one should expect a dispersion up to about 0.5 m. Typical minimum Twiss β functions achievable in the area are below 1 m as shown in Fig. 4.

4. Present planning and outlook

After 6 months of renovation works, the CLEAR facility delivered its first beam in mid-August 2017, and experiments were resumed in September. A campaign of measurements is ongoing with the aim of exploit the full capabilities of the present installation. For example, studies for injector optimisation are ongoing [44] with the aim to crosscheck the ASTRA [45] model of the RF-gun, and possibly to allow for reaching sub-ps bunch lengths. At the same time CLIC-related studies have been resumed, as well as irradiation campaigns in collaboration with the European Space Agency (ESA) and the TRAD Tests & Radiations company. First beams were also delivered to the novel plasma-lens experiment which is now fully installed and ready for measurements [36]. Among the previously mentioned experiments for 2017/2018, there is the development for a new Electro Optical BPM for HL-LHC and impedance measurements of a wire scanner for the Super Proton Synchrotron (SPS).

The proposal and selection of the experiment to be performed at CLEAR is managed by a scientific and a technical board which are presently being set up. For the time being, a generic form for experiment proposal is available on the CLEAR official website [43].

On the longer time scale, additional hardware consolidation and improvement are being evaluated, for example:

- Move the laser source closer to the gun. Presently the laser is transported through a 70 m long light transfer line, with consequent degradation of intensity and position stability. Double pulse and/or pulse shaping capability might also be added.
- Introduce additional user beamlines branching off at the end or in the middle of the CALIFES linac.
- Add a second independent beam source for running more experiments in parallel and for impedance studies. This could be in synergy with AWAKE for the development of its advanced source for its planned Run 2 starting in 2021.
- Connect the presently un-powered CLIC structure to the XBOX1 [46] 12 GHz klystron. This would allow to resume high-gradient studies and to boost the beam energy.

Please cite this article in press as: D. Gamba, et al., The CLEAR user facility at CERN, Nuclear Inst. and Methods in Physics Research, A (2017), https://doi.org/10.1016/j.nima.2017.11.080.

The implementation of such or other upgrades will depend mainly on the users' needs, and on the judgement of the scientific and technical boards.

Acknowledgements

The authors would like to acknowledge the CLEAR user community and CERN for their invaluable support in the upgrade and put in operation of the CLEAR facility.

References

[1] G. Geschonke, A. Ghigo, CTF3 Design Report, in: Tech. Rep. CERN-PS-2002-008-RF, CERN, Geneva, 2002.

[2] M. Aicheler, P. Burrows, M. Draper, T. Garvey, P. Lebrun, K. Peach, N. Phinney, H. Schmickler, D. Schulte, N. Toge, A Multi-TeV Linear Collider Based on CLIC Technology: CLIC Conceptual Design Report, in: Tech. Rep. CERN-2012-007, CERN, Geneva, 2012.

[3] Califes workshop 2016, Geneva, 2016. https://indico.cern.ch/event/533052/.

[4] A. Mosnier, et al., The probe beam linac in CTF3, in: Proceedings of the 10th European Particle accelerator Conference, EPAC2006, vol. C060626, 2006, pp. 679–681, Edinburgh, UK.

[5] W. Farabolini, CTF3 probe beam LINAC commissioning and operations, in: Proceedings, 25th International Linear Accelerator Conference, LINAC2010: Tsukuba, Japan, September 12-17, 2010, 2011, p. MOP001.

[6] J.L. Navarr Quirante, et al., CALIFES: A multi-purpose electron beam for accelerator technology tests, in: Proceedings of the 27th Linear Accelerator Conference, LINAC2014, Geneva, 2014, paper MOPP030.

[7] I.N. Ross, Feasibility Study for the CERN CLIC Photo-Injector Laser System, in: Tech. Rep. CLIC-Note-462, CERN, Geneva, Switzerland, 2000.

[8] M. Petrarca, H.H. Braun, E. Chevallay, S. Doebert, K. Elsener, V. Fedosseev, G. Geschonke, R. Losito, A. Masi, O. Mete, L. Rinolfi, A. Dabrowski, M. Divall, N. Champault, G. Bienvenu, M. Jore, B.M. Mercier, C. Prevost, R. Roux, C. Vicario, First results from commissioning of the phin photo injector for CTF3, in: Proceedings of the 23rd Particle Accelerator Conference, PAC2009, no. CLIC-Note-802, Vancouver, Canada, 2009 p. MO6RFP063.

[9] E. Chevallay, Experimental Results at the CERN Photoemission Laboratory with Co-deposition Photocathodes in the Frame of the CLIC Studies, in: Tech. Rep. EDMS n. 1215630. CTF3-Note-104, CERN, Geneva, 2013.

[10] J. Brossard, M. Desmons, B.M. Mercier, C.P. Prevost, R. Roux, Construction of the probe beam photo-injector of CTF3, in: Proceedings of the 10th European Particle Accelerator Conference, EPAC 2006, vol. C060626, 2006, pp. 828–830, Edinburgh, UK.

[11] R. Bossart, J.P. Delahaye, J.C. Godot, J.H.B. Madsen, P. Pearce, A.J. Riche, L. Rinolfi, The LEP Injector Linac, in: Tech. Rep. CERN-PS-90-56-LP, CERN, Geneva, 1990.

[12] LEP design report, vol I. The LEP Injector Chain, CERN, Geneva, Switzerland, 1983, by the LEP Injector Study Group.

[13] G. Bienvenu, J.C. Bourdon, P. Brunet, J. Rodier, Accelerating Structure Developments for the LEP Injector Linacs (LIL), in: Proceedings of the 1984 Linear Accelerator Conference, Seeheim, Germany, 1985, p. FRQ0003.

[14] W. Farabolini, D. Bogard, A. Brabant, A. Curtoni, P. Girardot, F. Gobin, R. Granelli, F. Harrault, C. Lahonde, T. Lerch, M. Luong, A. Mosnier, F. Orsini, F. Peauger, C. Simon, Diagnostics for the CTF3 probe beam linac CALIFES, in: Proceedings of the 8th European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators, DIPAC2007, Venice, Italy, 2007, p. TUPB17.

[15] Bergoz Instrumenation. http://www.bergoz.com.

[16] C. Simon, S. Chel, P. Contrepois, M. Luong, N. Baboi, N. Rouviere, Beam position monitors using a re-entrant cavity, in: Proceedings of the 8th European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators, DIPAC2007, Venice, Italy, 2007, p. TUPB15.

[17] C. Simon, M. Luong, S. Chel, O. Napoly, J. Novo, D. Roudier, N. Rouviere, N. Baboi, N. Mildner, D. Nolle, Performance of a reentrant cavity beam position monitor, Phys. Rev. ST Accel. Beams 11 (2008) 082802. http://dx.doi.org/10.1103/PhysRevSTAB.11.082802.

[18] R. Pan, A. Andersson, W. Farabolini, A. Goldblatt, T. Lefèvre, M. Martyanov, S. Mazzoni, L. Timeo, S. Rey, S. Jamison, W. Gillespie, D. Walsh, Electro-optical bunch profile measurement at CTF3, in: Proceedings of the 4th International Particle Accelerator Conference, IPAC2013, no. CLIC-Note-1015, Shanghai, China, 2013, p. MOPME077.

[19] C.P. Welsch, H.H. Braun, E. Bravin, R. Corsini, S. Döbert, T. Lefèvre, F.A. Tecker, P. Urschütz, B. Buonomo, O. Coiro, A. Ghigo, B. Preger, Longitudinal beam profile measurements at CTF3 using a streak camera, JINST 1 (2006) P09002. http://dx.doi.org/10.1088/1748-0221/1/09/P09002.

[20] W. Farabolini, Califes probe beam status, in: International Workshop on Linear Colliders 2010, ECFA-CLIC-ILC Joint Meeting, Geneva, 2010.

[21] W. Farabolini, G. Adroit, P. Girardot, R. Granelli, F. Harrault, C.L.H. Lahonde-Hamdoun, T. Lerch, F. Orsini, Video profile monitors development for the CTF3 Probe Beam Linac, in: Proceedings of the 11th European Particle Accelerator Conference, EPAC 2008, vol. C0806233, 2008, p. TUPC024, Genoa, Italy.

[22] B. Bartholome, Development of the new CTF3 klystron-modulator controls interface system, in: Proceedings of the 5th Modulator-Klystron Workshop for Future Linear Colliders, CERN, Geneva, Switzerland, 2001.

[23] G. McMonagle, Operational performance and improvements to the RF power sources for the Compact Linear Collider Test Facility (CTF3) at CERN, in: Proceedings of the 7th IEEE International Vacuum Electronics Conference and 6th IEEE International Vacuum Electron Sources Conference, Monterey, CA, USA, 2006.

[24] A. Fiebig, R. Hohbach, P. Marchand, J.O. Pearce, Design considerations, construction and performance of a SLED type radiofrequency pulse compressor using very high Q cylindrical cavities, in: Proceedings of the 1987 IEEE Particle Accelerator Conference, PAC1987: Accelerator Engineering and Technology, vol. C870316, 1987, p. 1931, Washington, DC, USA.

[25] R. Bossart, P. Brown, J. Mourier, I.V. Syratchev, L. Tanner, High-Power Microwave Pulse Compression of Klystrons By Phase-Modulation of High-Q Storage Cavities, Tech. Rep., CERN, Geneva, Switzerland, 2004.

[26] M. Bergamaschi, E. Bravin, W. Farabolini, R. Kieffer, T. Lefèvre, S. Mazzoni, P. Karataev, Optical Transition Radiation Interferometry (OTRI) experiment in CALIFES, in: CALIFES Workshop 2016, Geneva, 2016.

[27] M. Krupa, Private Communication.

[28] G.-V. Franck Guy, Private Communication.

[29] T. Lefèvre, Private Communication.

[30] A. D'Elia, R. Fandos, L. Søby, High Bandwidth Wall Current Monitor, in: Tech. Rep. CERN-OPEN-2010-012. CLIC-Note-775. EUROTEV-Report-2008-054, CERN, Geneva, 2009.

[31] M. Gasior, An inductive pick-up for beam position and current measurements, in: Proceedings of the 6th European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators, DIPAC2003, Mainz, Germany, 2003, p. CT01.

[32] A. Dabrowski, H. Braun, R. Corsini, S. Doebert, T. Lefèvre, F. Tecker, P. Urschütz, M. Velasco, Non-destructive single shot bunch length measurements for the CLIC test facility 3, in: Proceedings of the 22nd Particle Accelerator Conference, PAC2007, Albuquerque, NM, USA, 2007, p. 4069.

[33] R. Lillestøl, E. Adli, N. Aftab, R. Corsini, S. Doebert, W. Farabolini, A. Grudiev, S. Javeed, J. Pfingstner, W. Wuensch, Status of wakefield monitor experiments at the CLIC test facility, in: Proceedings of the 7th International Particle Accelerator Conference, IPAC2016, Busan, Korea, 2016, p. WEOBB02. http://dx.doi.org/10.18429/JACoW-IPAC2016-WEOBB02.

[34] F.J. Cullinan, S.T. Boogert, W. Farabolini, T. Lefèvre, A. Lunin, A. Lyapin, L. Søby, J. Towler, M. Wendt, Long bunch trains measured using a prototype cavity beam position monitor for the compact linear collider, Phys. Rev. Spec. Top. Accel. Beams 18 (2015) 112802.

[35] J.R. Towler, S. Boogert, B. Fellenz, T. Lefèvre, A. Lyapin, M. Wendt, Development and test of high resolution cavity BPMS for the CLIC main beam linac, in: Proceedings of the 4th International Beam Instrumentation Conference, IBIC2015, Melbourne, Australia, 2016, p. TUPB060. http://dx.doi.org/10.18429/JACoW-IBIC2015-TUPB060.

[36] C.A. Lindstrøm, K.N. Sjøbæk, E. Adli, J.-H. Röckemann, L. Schaper, J. Osterhoff, A.E. Dyson, S.M. Hooker, W. Farabolini, D. Gamba, R. Corsini, Overview of the CLEAR plasma lens experiment, in: Proceedings of the 3rd European Advanced Accelerator Concepts Workshop, EAAC2017, La Biodola, Italy, 2017.

[37] L.R. Carver, CALIFES for impedance measurements, in: CALIFES Workshop 2016, Geneva, 2016.

[38] T. Lefèvre, THz radiation using Diffraction Cherenkov radiation, in: CALIFES Workshop 2016, Geneva, 2016.

[39] A. Curcio, THz shaping, in: CALIFES Workshop 2016, Geneva, 2016.

[40] VESPER Official Website. http://vesper.web.cern.ch.

[41] A. Lagzda, D. Angal-Kalinin, J. Jones, R. Jones, K. Kirkby, W. Farabolini, Relative insensitivity to inhomogeneities on very high energy electron dose distributions, in: Proceedings of the 8th International Particle Accelerator Conference, IPAC2017, Copenhagen, Denmark, 2017, p. THPVA139. http://dx.doi.org/10.18429/JACoW-IPAC2017-THPVA139.

[42] M. Tali, R.G. Alía, M. Brugger, V. Ferlet-Cavrois, R. Corsini, W. Farabolini, G. Santin, A. Virtainen, Mono-energetic electron induced single-event effects at the vesper facility, in: Proceedings of the 16th European Conference on Radiation and Its Effects on Components and Systems, RADECS2016, Geneva, Switzerland, 2016 http://dx.doi.org/10.1109/RADECS20168093166.

[43] CLEAR Official Website. http://clear.web.cern.ch.

[44] C. Bruni, Private Communication.

[45] Klaus Floettmann, Sascha Meykopff, A Space charge Tracking Algorithm (ASTRA) http://tesla.desy.de/meykopff/.

[46] N. Catalan-Lasheras, A. Degiovanni, S. Doebert, W. Farabolini, J. Kovermann, G. McMonagle, S. Rey, I. Syratchev, L. Timeo, W. Wuensch, B. Woolley, J. Tagg, Experience operating an X-band high-power test stand at CERN, in: Proceedings of the 5th International Particle Accelerator Conference, IPAC2017, no. CERN-ACC-2014-0166, Dresden, Germany, 2014, p. WEPME016.

Please cite this article in press as: D. Gamba, et al., The CLEAR user facility at CERN, Nuclear Inst. and Methods in Physics Research, A (2017), https://doi.org/10.1016/j.nima.2017.11.080.