CLIC-CTF3 Collaboration Board
Minutes of the 21st meeting
10th March 2017

Participation:

Australia	M. Boland (ANSTO/ACAS)
CERN	A. Augier
	R. Corsini
	L. Linssen
	S. Stapnes
Finland	M. Aicheler (HIP)
	K. Osterberg (HIP)
Germany	A. Bernhard (KIT) *via vidyo*
India	P. Shrivastava (RRCAT)
Italy	A. Ghigo (INFN)
	G. D'Auria (Synchotrone Trieste)
Norway	R. Lillestol (University of Oslo)
Spain	F. Toral (CIEMAT)
	F. Perez (ALBA-CELLS)
Sweden	T. Ekelöf (Uppsala University)
	R. Ruber (Uppsala University)
Switzerland	T. Garvey (PSI)
Russia	G. Shirkov (JINR)
Turkey	M. Dogan (IAT Ankara)
	O. Yavas (IAT Ankara)
UK	P. Burrows (Oxford)
	P. Karataev (RHUL)
US	M. Fazio (SLAC)

Apologies:

France	O. Napoly (CEA)
Norway	E. Adli (University of Oslo)

1. Welcome

R. Ruber welcomes all participants reminding that the agenda and corresponding documentation for this meeting are available on Indico at:
http://indico.cern.ch/event/615300/

The agenda is approved without any modification. Minutes of the previous meeting (22.01.2016) are online. There were no pending actions to mention. Minutes are considered as approved by default but any modification/comments can still be made after the meeting by sending an email to A. Augier.

2. Election of the Spokesperson

(P. Burrows is leaving the room during the discussion and vote)

R. Ruber reminds that, as the mandate of P. Burrows was coming to an end at the beginning of 2017, a Search Committee (consisting of A. Ghigo – INFN, T. Garvey – PSI, and T. Ekelöf - Uppsala) was nominated.

T. Garvey reminds the chronology of events, stressing out that a new mandate was sent to the Collaboration mid-October 2016 and that the Collaboration was also invited to suggest candidates before end of November 2016.

A first (and only) proposal (P. Burrows – Oxford University) was finally received at the end of the deadline (the delay was extended to 9.12.2016), the Collaboration was informed on 25.02.2017.

The Search Committee stresses out that P. Burrows is an excellent Spokesman, however finds disappointing that institutes did not suggest others candidates and wonders why.

S. Stapnes thanks the Search Committee for its works. He confirms that P. Burrows is an excellent choice (Phil replaced Steinar frequently during his sick leave, gave excellent presentations, attended many meetings both on Physics and Accelerator sides). He also informs the Collaboration Board that he has been officially invited as Guest Professor by CERN's DG starting 50% on 01.03.2017 (100% on 01.10.2017).

R. Ruber and the CB congratulate P. Burrows of the extension of his mandate as Spokesperson. He mentions that he is feeling honoured with this role.

3. Collaboration Issues and Status

S. Stapnes informs that the Geological and Geophysical Institute of Hungary joined the CLIC collaboration in 2016 and that new addenda were signed with existing institute (ACAS, Sincrotrone Trieste, IAP NASU). More are also foreseen in 2017 with Tsinghua University, NTUA. It will also be time to renew some contracts: UK, Helsinki, Spain.

S. Stapnes presents the annual report for 2016 reminding the following points:
- a CLIC Rebaselining document (CLIC initial stage defined at 380 GeV) was produced. This yellow report includes updates of the physics for such facility,
- a new stand-alone user facility – CLEAR – will be available for users from 2017 onwards,
- the CTF3 programme was brought to successful conclusion,
- the ATF2 final focus studies continues with promising results,
- the drive-beam front-end and damping ring studies progressed at CERN and in test-programs in light-sources respectively,

- X-band stations have been installed at CERN,
- the CLIC module measurements in the laboratory and CTF3 beam are being completed and evaluated.
- the beam based alignment studies for CLIC have been summarized and published,
- the Collaboration with ILC is continuing,
- the EU Marie-Curie project EJADE (Europe-Japan Accelerator Development Exchange Programme) is operational

S. Stapnes also reminds goals defined for the period 2017-2018*, the main one being to present (by end 2018) a CLIC project that is a “credible” option for CERN beyond LHC (through a Project Implementation Plan).

In preparation of this phase, the LC study has changed its organisation to put more emphasis on implementation studies related to the entire CLIC machine. In addition of the five usual main activities (Beam Dynamic and Design, Xband including Klystron studies, LINAC systems, Technical systems and studies and General), four new implementation working groups preparing the European Strategy Update have started:

- Civil Engineering & Infrastructure and Siting WG (CEIS), lead by J.Osborne
- Cost, Power and Schedule, lead S. Stapnes
- Main Linac Hardware Baselining, lead C.Rossi
- Baseline parameters and design, lead D.Schulte
- Novel Accelerator methods for future stages of CLIC, lead E.Adli

*Detailed list of Goals 2017-2018 are in Steinar’s slides available on Indico https://indico.cern.ch/event/615300/contributions/2482029/attachments/1425606/2186909/clic-CB-March17.pdf),

Reports from the Collaboration (these reports were sent by email to A. Augier prior to the meeting)

University of Oslo

The group has two post.doc. researchers (Jurgen Pfingstner and Reidar Lillestøl), one Oslo student (Carl A. Lindstrøm) and one CERN PhD student (Lukas Malina) contributing to the CLIC project, in addition to Oslo accelerator group leader (Assoc. Prof. Erik Adli). Our main activities include further experimental tests of CLIC wake field monitors in CTF3/CALIFES (now CLEAR), emittance preservation schemes (numerical studies as well as experimental tests) and contributions to the X-band FEL studies, especially on the topic of photon generation. This year we have proposed, and will implement, a new experiment on plasma lensing in CLEAR, and will also help in commissioning and operate the CLEAR beam line (one Oslo student will come full time to CERN from May 1st). Oslo is also chairing the new CLIC working group on Novel Acceleration Techniques.

Ankara University, Institute of Accelerator Technologies, TURKEY

Updated Baseline for a Staged Compact Linear Collider
CERN-2016-004, doi: 10.5170/CERN-2016-004, arXiv: 1608.07537
Co-authors: A. Aksoy, O. Yavas, Z. Nergiz, I. Tapan, E. Pilicer

A. Aksoy: He took responsibility on desing on CLIC drive beam linac. He studied different bunch compressor scheme on DB layout and different type of injectors including thermionic gun based and photo gun based. He also took responsibility on design of X-Band based FEL. Start to end beam dynamics, integrated simulations were performed by him.
M. Doğan: He is studying on power electronics, high power RF and control with LLRF. In frame of CLIC studies, he deal with X-band klystron preamplifier development and he is also working on RF sources and pulse compressor system as well.
Z. Nergiz: He is studied on X-Band XFEL proposal. GENESIS simulation program is used to investigate FEL properties. Magnetic lattice for undulator region is designed. It is shown that 1 A high power (1 GW) FEL can be produced from x-band linac at 30 m saturation length.
H. Denizli, A. Yılmaz, U. Keskin: Study on redesign of the CLIC main beam injector complex (design and optimization of primary 5 GeV e-linac). Contact: Andrea Latina and Daniel Schulte

Visits:
Avni Aksoy, January 17-21, 2016 / June 19-22, 2016
Zafer Nergiz, January 17-21, 2016 / June 19-22, 2016
Mustafa Doğan, January 17-23, 2016
Haluk Denizli, June 22-July 01, 2016
Ali Yılmaz, June 22-August 31, 2016
Umut Keskin, June 22-Sept. 15, 2016
Total expenditure for the year (2016): Reserved budget for the next year (2017): ~ 20.000 CHF
~ 17.000 CHF Team Leader: Prof. Dr. Omer Yavas, IAT, Ankara University, Turkey

CIEMAT
CIEMAT is presently working on two devices: a dipole with longitudinally variable field for CLIC damping rings and an accelerating structure. The magnetic design of the dipole is well advanced, although another iteration will be made to try to improve even further its efficiency to decrease the beam emittance. Next steps are the mechanical design and the fabrication drawings.
The accelerating structure under development is the so-called TD26R1CC. DMP is in charge of the machining of the precision copper parts. All the disks are roughly machined and now fine machining is starting. Two disks will be completely measured to guarantee the accuracy.

Karlsruhe Institute of Technology (KIT)

Brief Activity Report: Superconducting Wiggler Development and Tests at ANKA

In November 2012 CERN and KIT have signed a collaboration agreement (k-contract) on the procurement, installation and test of a CLIC damping wiggler prototype at ANKA.

The magnet technology (Nb-Ti, horizontal racetrack coil geometry, 51mm period length, 3T field amplitude) is today's state of the art, whereas the cryogenic design (conduction cooling by LHe-flow, beam vacuum chamber at relatively high temperature level, 20K to 80K) is advanced. The wiggler has been designed manufactured at the Budker Institute for Nuclear Physics (BINP), Novosibirsk.

The CLIC damping wiggler prototype has been installed in the ANKA storage ring in December 2015 and successfully commissioned in February 2016 and is in regular operation since then. The system test with beam, particularly at elevated heat load (up to 50W, the maximum heat load expected for the operation conditions in the CLIC damping rings) were successful. The final acceptance of the wiggler was approved in January 2017 after delivery of the full technical documentation.

A collaborative experimental program on the wiggler's influence on the beam dy- namics is ongoing.

R&D on a magnetic design based on Nb3Sn is continuing at CERN. The test of a short prototype is expected for summer this year.

Uppsala University

A spectrometer for detection of the dark and breakdown currents during conditioning of new accelerating structures for CLIC, is now routinely operated at the XBox2 12 GHz stand-alone test-stand. In combination with the regular RF diagnostics we are able to obtain the location of the breakdown inside the structure both in the transversal and longitudinal direction. During summer 2016 two summer students worked on improvement of data analysis tools and on the increase of the sensitivity of the setup to dark currents.

The spectrometer is now providing energy information for electrons emitted during normal RF pulses (field emitted currents) as well as during RF pulses with discharges (breakdown currents) thus giving a more complete picture of the vacuum breakdown phenomenon.

CLIC uses normal-conducting accelerating structures that are sensitive to wakefield effects and therefore the alignment of the beam relative is extremely important. Due to the four-fold symmetry of the structures, they allow for an octupole component of the rf fields. By scanning the beam transversely we can determine the center of the structures from the shifts in beam position due to the kicks from the octupole field. We tested this method at CTF3 during fall 2016.

Anton Tropp "Studies of vacuum discharges in the CLIC accelerating structure."
Master Thesis, 2016
http://lup.lub.lu.se/student-papers/record/8895078/file/8895085.pdf

J. Ögren, S. H. M. Jafri, K. Leifer, V. Ziemann
"Surface characterization and field emission measurements of copper samples inside a scanning electron microscope", Proceedings of IPAC2016, Busan, Korea
http://accelconf.web.cern.ch/AccelConf/ipac2016/papers/mopmr023.pdf

M. Jacewicz, V. Ziemann, T. Ekelöf, A. Dubrovskiy, R. Ruber
"Spectrometers for RF breakdown studies for CLIC"
Nucl. Instrum. Methods, A828 (2016), p. 63
http://dx.doi.org/10.1016/j.nima.2016.05.031

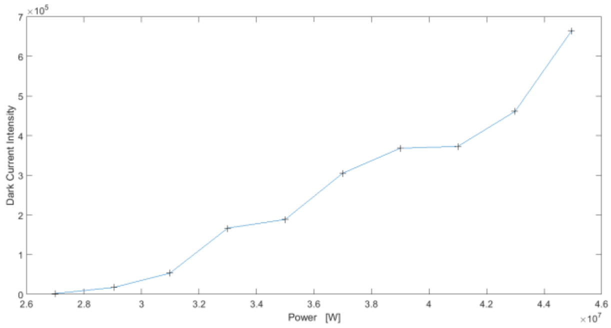

Figure showing the increase in the measured dark current with incident power during conditioning process

Oxford University

Major contributions in 2016 include successful completion (with INFN and CERN) of the CLIC Drive Beam phase feed-forward prototype at CTF3. Phase correction to the CLIC design specification of 0.2 degrees stability (12 GHz) was achieved and is reported in the PhD thesis of Jack Roberts. Beam orbit studies were also performed in several regions of CTF3, using a generic linear feedback tool, with significant improvements in beam orbit control and beam properties; these are reported in the PhD thesis of Davide Gamba. We continue to participate (Colin Perry) in CLIC MDI studies and track the proposed changes in the CLIC L* and its implications for the IP feedback system. We are also contributing (postdoc Ryan Bodenstein) to single- and two-beam BDS low-emittance beam tuning studies with the beam dynamics group. Three new PhD students started their studies on CLIC in 2016: Jan Paszkiewicz (RF studies), Chetan Gohil (impact of stray magnetic fields on beam properties) and Pierre Korysko (wakefield effects on low-emittance beams). We are working towards the CLIC Project Plan to be submitted as input in late 2018 to the European Strategy Update.

Raja Ramanna Centre for Advanced Technology

India is proud to become the Associate Member of CERN council. RRCAT has contributed to the design, development, testing and installation of a 20kW solid state power amplifier for the harmonic buncher for the CLIC injector linac R & D. The amplifier was constructed in India tested and supplied to CERN. The amplifier has met all the specifications desired by CERN. Young engineers from India participated in the testing and commissioning trials at CERN.

Tartu University

Activities of Tartu University are aimed to understand the mechanisms behind electrical breakdowns taking place on the accelerating structures. Currently, the research group consists of 1 researcher, 2 PhD students (1 of them shared with Helsinki University), 3 master's students and 2 bachelor's students. Current studies aim to improve the emission current models with state of the art methods, including combined thermos-emission models and Nottingham effect. DFT studies are conducted to investigate the work function dependence from electric field and surface defects, MD simulations of polycrystalline copper under applied field is in progress. In addition, collaboration with Helsinki University focuses on kinetic monte carlo analyses and multiscale simulations of material deformation under applied field.

During 2016, additional funding for following 4 years was obtained, 3 research papers, connected to CLIC related activities were published, complemented with several oral presentations at international conferences. Next to the scientific result, 2 bachelor's theses were defended. At the moment, two master's theses are prepared for defense at the spring. Currently, 3 manuscripts, covering the mechanical behavior of material defects, possible mechanisms of surface protrusion formation and Cu self-sputtering effects are in preparation.

The studies were conducted in close collaboration with Helsinki University (prof. Kai Nordlund and Flyura Djurabekova group).

Helsinki Institute of Physics

HIP is interested in various challenges in accelerator technology related to the application of X-band technology in CLIC. Together with UH, HIP plays a leading role in the development of a physics model for the electrical breakdown phenomena in CLIC Accelerating Structures (AS) limiting their performance. Multiple numerical methods have been developed and applied to treat the problem as a whole in a multi-scale approach.

HIP is also co-responsible for the development, design, assembly and integration of the CLIC two beam modules including all necessary components and auxiliary systems. In addition, UH is developing ultrasound based methods to measure hardness and structural properties of Cu. Furthermore, UH develops a method to measure the internal shape of the AS disk stack with λm precision based on Fourier Domain Short Coherence Interferometry (FDSCI). After calibration, the method was validated on a CLIC high precision machined AS disk.

The total contribution of UH is about 10 FTE to the CLIC study.

Paul Scherrer Institute
The SNF funded activities of PSI have been centered on the development of high-gradient X-band (12 GHz) accelerating structures. Such structures are at the heart of the CLIC accelerator concept. A 3 TeV collider would require typically ~ 120'000 structures according to the present baseline design. The structure would have to exhibit several features crucial for the design and performance of the collider. It has to be able to provide an accelerating field of 100 MV/m under beam loaded conditions. Its design should mitigate the detrimental effects of wake-fields excited by the passage of the train of bunches through the structure. Furthermore, the frequency of RF breakdown should be below $3x10^{-7}$ /m/pulse (240 ns pulses) in order to avoid loss of luminosity during operation.
In the period 2014 – 2016 (period covered by the current FLARE funding) our activities have continued to be centered on the development of high gradient structures. In agreement with the CERN group the FLARE 2013 funding is being used to finance the construction of prototypes following a procedure which has been developed at PSI for the C-band (5.7 GHz) structures of PSI's X-ray free electron laser project, *SwissFEL*. In the current procedure used by CERN for the production of CLIC structures, the metallic "disks" of the structure are bonded in an atmosphere of hydrogen gas. Before the structure can be conditioned with RF it is necessary to 'out-gas' them in a vacuum oven for up to two weeks. This is an extremely expensive stage in the production of CLIC structures as they are foreseen today. The SwissFEL structures are brazed under vacuum and demonstrate high gradient performance with low breakdown rates after a relatively short period of conditioning.
For this reason the CERN group are very interested in testing a prototype structure using the CERN geometry at X-band but employing the PSI fabrication protocol. During the first year of this project activities centered on RF simulations and mechanical engineering design studies in order to allow the CERN disk types to be brazed following the PSI procedure. At the time of our status report to SNF in 2015, we had completed the mechanical design of the new disks and engineering drawings had been prepared in order to request quotations from industry for their manufacture. A schematic of the structure is shown in Fig. 1. A single precision-machined disk is shown in Fig.2.

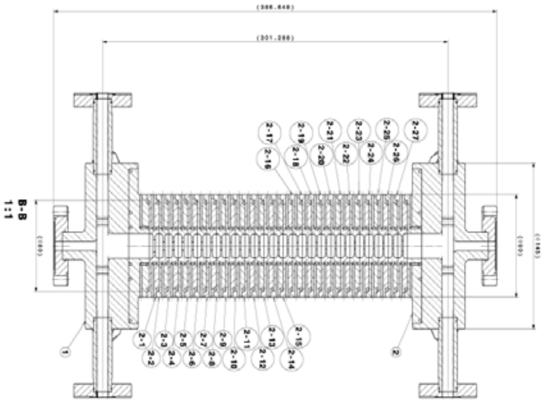

Figure 1. Engineering drawing of the proto-type.

Figure 2. Precision machined disk as delivered by VDL-ET.

After seeking price offers, the company retained for disk production was VDL Enabling Technologies, a highly experienced company in the field of precision manufacturing, frequently contracted to machine disks for CERN. The estimated time to deliver was foreseen to be November 2015. Although this was a little later than we had planned it was still compatible with our objectives. VDL undertook the work of machining the discs in respect of the schedule (a single disk is seen in the attached photograph). However, on making a visual inspection of the parts they observed traces of contamination on the surface of the discs. It was clear that these parts would not be compatible with high gradient operation in an accelerator. The problem was later identified to be due to a high temperature (500 °C) annealing step which VDL had sub-contracted to a third party as they were not equipped to do this themselves. This high temperature annealing is a standard part of the procedure for producing structures for SwissFEL. The CERN process asks for a 200 °C annealing which VDL do in-house. VDL have accepted responsibility for this incident and have provided a complete new set of discs at no additional cost to PSI. These new disks have since arrived at PSI and the structure was brazed in our oven on 8th November 2016. Pressure and leak tests show that the brazing was successful. It will now be shipped to CERN for low power measurements and high power tests on an X-box. CERN have given high priority to this new prototype in the scheduling of the X-box stations. The structure was installed in March of this year and is currently under test.

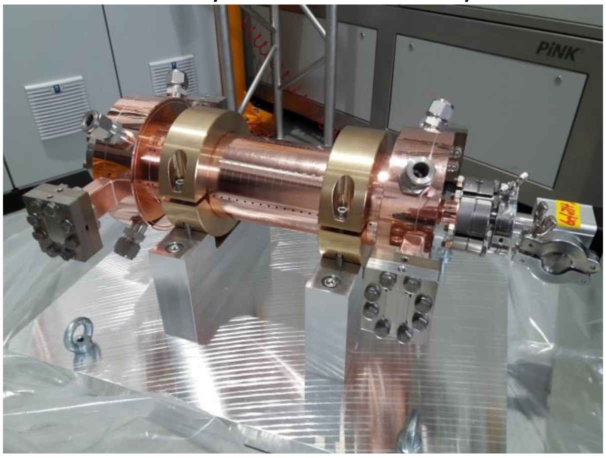

Figure 3. The PSI X-band prototype structure after brazing.

The test of an X-band structure, aiming at accelerating gradients of ~ 100 MV/m and built according to the PSI protocol, remains an important element in the CERN program of high-gradient acceleration. Our structure will allow us to provide information on this topic.

In addition to tests with high power RF sources complementary information may be obtained by studying breakdown using pulsed DC high voltage sources. Presently the CLIC project uses a DC test stand with a Marx generator which produces short DC pulses across a vacuum gap. This allows one to test different materials under high- voltage switching, to obtain information on conditioning effects and to investigate the influence of secondary parameters such as voltage pulse-length on breakdown rate. To support this part of the program, we have purchased a second Marx generator from Energy Pulse Systems. Apart from offering an enhanced performance compared to the existing one at CERN, this offers the attractive option of combining both generators in an enhanced setup. One generator will be used to provide a voltage pulse across the anode-cathode gap, while the other is generating a current pulse across the cathode, thus giving an intense magnetic field in the breakdown region, which is what we have typically during an RF breakdown. The generator will be on loan to CERN for the duration of these studies.

Another topic of interest is the measurement of breakdown signals in the high gradient structures during high power conditioning. Currently this is done by analyzing the 12 GHz signals of reflected and transmitted power through the structure. Information on timing and phase help to determine the location of the breakdown within the structure. For enhanced information, it would be also interesting to look at the second and third harmonics at 24/36 GHz, which are generated by the interaction of the breakdown plasma with the fundamental mode, or to look at the transient broadband signals of the breakdown process via signals obtained from higher order mode couplers. To transport these signals from the radiation shielded environment of the structures into the technical area, electro-optical methods are ideal. To setup a flexible modular system we will install a laser with built in modulator together with separate electro-optical modulators with a bandwidth of 36 GHz. Together with an available electro-optical receiver, this will allow us to measure signals up to the third harmonic of the X band power. Using a double modulation, with a LO signal at the source and the breakdown signal at the modulator allows one to down-convert the signal in the optical domain and use more conventional RF equipment for read out and post processing.

4. CTF3 and CLEAR reports

R. Corsini presents the CTF3 results stressing out that CTF3 has addressed and solved the vast majority of CLIC issues related to drive beam generation, power production and two-beam acceleration. The test facility successfully completed its planned experimental program in December 2016 and has stopped operation.

The start-up of the CLEAR program was officially announced by the CERN's DG early January. Roberto reminds the 2017 program status of this 2+2 years program and its tentative schedule (operation should be possible from the beginning of May 2017). R. Corsini also mentions some organizational matters (the idea being that CLEAR is registered as an official CERN experiment).

Last but not least, R. Corsini reminds that a CTF3 decommissioning memo was written and that institutes were asked to send their requests to him if any. Request for re-use of CTF3 equipement were received from AWAKE Collaboration, INFN, IFIC, Uppsala, IPN-Orsay, Trieste, CANDLE Inst., Armenia, Cockroft Institutes, IPM, CERN. Requestors will be asked further details.
A full list of requests should be made available during the next CLIC Collaboration Board **(Action: R. Corsini).**
To be noted: no requests for building space has been received so far. Thus, the corresponding equipment (linac, combiner ring area, klystron gallery) will be kept in place and maintained "ready for re-use), unless needed for CLEAR or requested by collaborators.

F. Toral wonders about the property of the equipment and if the Collaboration Board can decide on where to put the material?

R. Corsini indicates that the first step should be to define CLEAR needs, then make a list of requests and give feedback to institutes that have sent requests. The CLIC MoU (and the document "General Rules for Experiment at CERN") should also be checked versus the procedure that apply in case of stop of CTF3 activity.

5. FEL Application Collaboration

G. D'Auria presents the Compact Light proposal which aims to demonstrate, through a conceptual design, the feasibility of an innovative, compact and cost effective FEL facility suited for user demands identified in the science case.

The grant from the EU could be 3 Million EUR, duration 3-4 years with a starting date early January 2018. The Consortium of some 20 partners is led by Elettra. Seven workpackages have been defined.

More information available on the link below:
https://indico.cern.ch/event/615300/contributions/2510993/attachments/1425727/2187146/GdA_CompactLight_CLIC_WS_09-03-2017_new.pdf

6. Next CLIC and LC related meetings

The Collaboration Board is reminded of the following meetings in 2017:

- High Gradient Workshop, Valencia (Spain), 13-16 June
- AWLC2017, SLAC (USA), 26-30 June
- LCWS17, Strasbourg (France), 23-27 October
- CLIC Project Meeting will be held on 3 October and 8 December (with CLIC Christmas Drink)

An ATF2 collaboration meeting will also be held at CERN on March 14 & 15.

7. Next CB meeting

The next meeting will be connected to the CLIC workshop 2018 (week of 22 January or of 5th February unless of emergency. If possible, it is requested to have the meeting sometime on Thursday rather than Friday afternoon to allow participant travelling back home.