CLIC-CTF3 Collaboration Board #23

1st October 2020

Participation:

Canada	M. Boland (Saskastoon University)
CERN	A. Augier
	R. Corsini
	S. Stapnes
	A. Petry (CLIC dp)
France	A. Faus-Golfe (LAL IN2P3)
Finland	M. Aicheler (HIP)
	K. Huitu (HIP)
	K. Osterberg (HIP)
Greece	E. Gazis (NTUA)
India	P. Shrivastava (RRCAT) – *Remote*
Italy	G. D'Auria (Synchotrone Trieste)
Norway	E. Adli (University of Oslo)
Serbia	V. Zadin (University of Tartu)
Spain	F. Perez (ALBA-CELLS)
	D. Gavela (CIEMAT)
Sweden	T. Ekelöf (Uppsala University)
	R. Ruber (Uppsala University)
Switzerland	T. Garvey (PSI)
UK	P. Burrows (Oxford)
	A. Dexter (Lancaster)
	P. Karatev (RHUL)
	R. Jones (Manchester)

Apologies:

Italy	A. Ghigo (INFN)
Russia	G. Shirkov (JINR)

1. Welcome

R. Ruber thanks everyone for attending the Zoom meeting, reminding that this meeting was initially foreseen on 12.03.2020 during the CLIC workshop but was then postponed due to the COVID19 situation. It comes now after two sessions of a CLIC Project Meeting held on 30.09pm and 01.10am (More information available on indico: https://indico.cern.ch/event/952778)

He reminds that the agenda and corresponding documentation are available on the link below:
https://indico.cern.ch/event/959053/

The agenda is approved without any modification. Minutes of the previous meeting (24.01.2019) are online. There were no pending actions to mention. Minutes are considered as approved by default, knowing that any modification/comments can still be made after the meeting by sending an email to A. Augier.

R. Ruber reminds that institute should send as summary of their activities to A. Augier (so far 6 contributions were received – *Updated after the meeting*)

2. Collaboration Issues and Status

No new collaboration members as of today.
T. Garvey wonders if Compact Light be mentioned in this reporting exercice? > G. D'Auria will sent an update on this topic.

Reports below were sent by email to A. Augier prior to or after the meeting.

Oxford (P. Burrows)

The Oxford University team has contributed to CLIC as follows: P. Burrows continues to serve as Collaboration Spokesperson. Three PhD students have completed their studies, submitted their PhD theses, and graduated:

- Chetan Gohil: Dynamic imperfections in the Compact Linear Collider
- Pierre Korysko: Intensity-dependent effects in the Accelerator Test Facility 2 and extrapolation to future electron-positron linear colliders
- Jan Paszkiewicz: Studies of Breakdown and Pre-Breakdown Phenomena in CLIC Accelerating Structures

Our current student, Luke Dyks, continues to pursue beam dynamics studies and support beam operations at CLEAR. We continue to participate in final-focus studies for CLIC at the KEK/ATF2 facility.

CIEMAT (F. Toral)

The present contribution of CIEMAT to CLIC consists of two items:
- An accelerating structure TD26 type: all the parts are produced, first steps of assembly have been performed. The next step is the bonding of the copper disks at Bodycote, whichs is pending since the beginning of the COVID crisis. We are very interested to follow up the bonding in person but restrictions do not allow it for the time being.
- A dipole with longitudinally variable aperture: the design is finished. All the permanent magnets are procured, and most of the parts, both for the magnet and the assembly tooling, are produced. We are waiting for the production of the magnetic yoke to start the assembly.

University of Tartu (V. Zadin)

CLIC related activities in Institute of Technology can be summarized as follows:

- Initiation of the Horizon 2020 ERA Chair project MATTER. Project started at 1st of january of 2020. The main goal is to establish centre of materials research in extreme environments, about 1/3-1/2 of the project consists of CLIC electric breakdown related activities. The first stage of the project has been hiring of top researchers. So far, Andreas Kyritsakis and Sergei Vlassov have joined the project. Hiring of first postdoc is ending in counted days.
- Plans for electric breakdown related research:
    a. DFT of surface nanodefects, incorporating electric field effects in calculations
    b. In situ SEM experiments inside electron microscopes with applied electric field. Application of electric field is reached by the help of nanomanipulators connected to the voltage source. Nanoscale sharpness of the tip will boost the local electric field up to 100 MV/m-1000MV/m range, allowing to recreate similar conditions to the CLIC surface fields. Option for in situ real time observation is available and will be utilized to understand surface behaviour.
- CLIC MoU addendum no. 2 between Tartu University and CLIC is in process of signing. Focus of research will be placed in DFT calculations + nanoscale in situ SEM experiments inside electron microscopes, allowing real time observation of electric field influence to the surface in presence of applied electric field.

6 articles related to CLIC breakdown studies have been published in 2020

Uppsala University (T. Ekelof)

Uppsala activities were mainly focused on the commissioning of the newly constructed cryogenic DC spark system in Uppsala (K-contract with CERN). The commissioning was successful and during 2019, two sets of oxygen-free "hard" copper electrodes were tested in the setup. The cryostat was operating in wide temperature range down to 20K. Preliminary results indicate that lowering temperature of the electrodes to cryogenic temperatures allows sustaining 30% larger surface field with the same probability of vacuum breakdowns.

We also observed that the high field conditioning at cryogenic temperatures affects significantly the field emission properties. After conditioning, the field emission characteristics become extremely regular and very consistent with a standard big metal tip drastically different from spectra collected before conditioning or after conditioning in room temperature.
We are currently restarted the cryogenic DC system with a new set of “soft” copper electrodes to further study the cryogenic effects on metallic surface under high fields.
We started also new activity around the cryo-DC setup that could shed light on the question if movement of dislocations in the crystal structure is indeed the underlying mechanism for breakdown phenomenon. We want to measure the change in resistivity before and after conditioning process as a way to quantify movement of dislocations. We plan to use the electrode system as a resonance cavity and induce a high frequency (GHz) current in the electrodes that will only flow near the surface exposed to high fields and affected by dislocations. Huge advantage of our system is the cryogenic environment since resistivity at low temperature is due only to dislocations, vacancies, impurities and all possible material defects. With this we hope to extend the understanding of high-field physics and material science to low temperatures and make also new and potentially important connections between the high-gradient normal-conducting and superconducting fields.

University of Oslo (E. Adli)

Our main activities have been to investigate CLIC synergy and upgrade possibilities with Novel Acceleration Techniques including instability studies, experimental tests of CLIC wake field monitors in CLEAR and continued our experiment on plasma lensing in CLEAR. The personnel involved has been the team leader (Erik Adli), a researcher (Kyrre Sjøbæk) and a CERN-Oslo PhD student (Ben Chen).

Helsinki Institute of Physics (K. Osterberg)

HIP and UH are interested in various accelerator technology challenges related to the application of X-band technology in CLIC. We heavily contribute to the development of the next generation CLIC module and all its related studies and prototyping. We have also taken responsibilities in CLIC related projects to help fostering further the CLIC technology e.g. editorial duties related to the eSPS CDR and task leader in the heavily CLIC influenced CompactLight Study. We are in addition ramping up an industry activation project in Finland related to some selected technologies used in CLIC

Design of efficient RF accelerating structures for CLIC components rely on good understanding of fundamental mechanisms causing surface modification under high electric and electromagnetic fields. HIP and UH play a leading role in multi-scale modelling of the relevant processes. The current focus of the study is on surface diffusion affected by strong electric fields, which explains self-growth on surface field emitters. Plasma cleaning and conditioning experiments are being performed with the voltage pulsing DC-setup at Helsinki.

The total contribution of HIP and UH to the CLIC study in 2020 will be about 4 FTE.

NTUA (E. Gazis)

NTUA (National Technical University of Athens) in cooperation with members of the IASA (Institute of Accelerating Systems & Applications), AUEB (Athens University of Economics & Business) and ESS (European Spallation Source/Mechanical design) Mechanical design teams activities were mainly focused on the following items:

- Laser/Photocathode design & selection
- e-Gun, TWS, Solenoids design, Injector beam simulations
- Beam dynamic simulations for RF cavities 4.5 and 5.6 cells
- 3D CAD model design of a novel FEL facility
- ANALYSES: Cost, Cost/Benefit - SWOT, Risk, Transfer Technology and Data Management planning

The major results of the above items were implemented to the COMPACTLIGHT project, but a lot of our work was taken from our experience in the previous years from the CLIC collaboration
Our target, in home, is to develop an X-box facility for test measurements and education of our students. A positive reaction from Ministry of Development in Greece is encouraging us to continue our effort.
In addition, we are very much interesting to participate to the new activities by CLIC in relation with the transfer technology applications of the CLIC technology for nano-beams and medical applications for imaging and cancer treatment.

RHUL (P. Karataev)

Cavity Beam Position Monitors : ***Cavity BPM work included two parts: development of a monitor suitable for CLIC and support of the 39-cavity ATF2 system at KEK.***

A 3-monitor X-band installation has been tested at CLEAR. One monitor includes both position and reference cavities for compactness and thus can deliver an independent measurement. The cavities have been demonstrated to be highly sensitive and produced sufficient output for the signals to be processed even at pC bunch charges, while their decay time is short enough to provide several readings along a 150-200 ns bunch train. A suitable system of high linearity analog electronics and high resolution digitisers has now been developed and preliminary tests showed adequate signal to noise ratios for typical CLIC beam parameters. Further beam tests and equipment of all 3 sensors with the new electronics are in the mid-term plans.

At ATF2, the CBPM system has been working reliably for a decade. Some recommendations can be made based on this long term running, such as independent mounting and motorization of the monitors for better alignment and quick calibration, which in longer term offset the cost of the additional hardware. Apart from day-to-day maintenance, work has been concentrating on processing overlapping bunch signals to extract individual bunch positions. This is a requirement for ILC as bunches are separated by 100 ns or more, but is still relevant in the context of CLIC if a system of 2 digitisers with a variable precision trigger delay between them is deployed to minimise the overlap and extract individual excitations. Signal subtraction techniques have been clearly demonstrated, while frequency domain methods are being investigated and a paper prepared for publication.

Polarization radiation as a tool for ultra-relativistic charged particle beam diagnostics.

Sub-micrometer resolution optical transition radiation beam size measurement via analysis of its point spread function: At ATF2 we have demonstrated that the OTR source (point-spread function, PSF) generated by a single electron is not uniform but has a crater-like shape with a zero at the center. The transverse beam sizes can be measured with sub-micrometer resolution. The horizontal beam size was measured to be 132.0 ± 0.3 μm. The minimal vertical beam size was 0.91 ± 0.05 μm. The measurements were cross-checked by simulations performed with SAD code and measured by the laser wire system. From the quadrupole scan the vertical emittance was 59.3 ± 4.2 pm rad. The final paper was published in Journal of Instrumentation [A. Aryshev, et al., JINST 15 (2020)].

Non-invasive optical/UV diffraction radiation micron scale beam size measurement: Optical diffraction radiation (ODR) is a member of polarization radiation family and appears when a fast charged particle moves in the vicinity of a medium (e.g. moves in a hole in a screen). To achieve the best resolution for beam size measurements we have pushed the frequency of the detection technology to near ultra-violet spectral range. The resolution for the beam size measurements was 3 μm. The vertical beam emittance extracted from the quadrupole scan was 32 ± 5 pm rad

Both OTR and ODR technologies can be applied simultaneously to measure low intensity pilot beams using OTR and highly intense beam using ODR. The results were published in [M. Bergamaschi, et al., PR Applied 13, 014041 (2020)]

Cherenkov diffraction radiation as a promising technique for beam diagnostics: Cherenkov radiation is a member of the polarization radiation family and can be generated if the charged particle moves in vacuum in the vicinity of and parallel to a dielectric interface. Due to finite boundaries of a radiator and the lack of direct interaction with the medium the phenomenon was called Cherenkov diffraction radiation (ChDR). On top of non-invasive nature, ChDR has two key advantages in comparison with OTR and ODR: the photon yield is proportional to the length of the radiator and its direction angle is defined by the dielectric properties of the medium and defined as $\cos(\theta) = 1/\beta n$, where n is the refractive index. The ChDR phenomenon has a potential to be applied for transverse beam size, position, bunch length and arrival time diagnostics. Moreover, coherent part of the spectrum can be applied for generation of intense THz radiation beams, drive-witness acceleration scheme and for introducing energy chirp. Despite of the great potential for beam instrumentation a detailed theoretical and experimental investigations are needed. The direct observation of incoherent ChDR in optical wavelength range and its detailed investigation have been performed by our team at Cornell CesrTA facility. The research has clearly demonstrated its basic characteristics. In we have applied coherent ChDR in millimeter wavelength range for longitudinal beam size and profile diagnostics.

At ATF2 facility we have proposed to reuse the equipment used for OTR/ODR studies and investigate ChDR characteristics as a tool for transverse beam size, emittance and position diagnostics. An extremely low emittance beam of ATF2 can challenge any diagnostics equipment and demonstrate its strengths and weaknesses. The experimental work will be performed in frame of international collaboration spanning KEK, CERN (Switzerland), RHUL, Daresbury Laboratory and Diamond LS (UK), TPU and Belgorod University (Russia). The results were published in [R. Kieffer, et al., PRL 121, 054802 (2018); R. Kieffer, PR-AB 23, 042803 (2020); A. Curcio, et al., PR-AB 23, 022802 (2020)]

Lancaster University (A. Dexter)

Lancaster University's primary activity has been supporting the operation of the XBOX test stands and DC SPARC through a PhD programme. Students have managed the tests stands collecting and analysing data. Recently considerable effort has been directed to analysing dark current data and creating models to predict conditioning. With academic and CERN technical support, they have designed and developed a new LLRF system for XBOX1. An experiment is being designed to demonstrate the stabilisation of a long waveguide distribution system so it delivers accurately phased RF power. The Lancaster academics have facilitated collaboration between the Daresbury laboratory and the CLIC X-band activities so that CLIC technology might be utilised on the Free Electron Laser test stand CLARA. Lancaster has been supporting a researcher working with Igor on high efficiency klystrons.

3. CLIC report

Steinar presents a report focusing on the CLIC activities for the period 2021-2025 (https://indico.cern.ch/event/959053/contributions/4031507/attachments/2113807/3556735/lc21-25-cb.pdf)

P. Burrows stresses out few numbers for 2021

- LC 4-5 MCHF (M&P)
- Muons 2 MCHF
- CLEAR 1.5 MCHF
- HEK 1.5 MCHF
- FCC 15-20 MCHF (industrial contracts, 1/3 for accelerator activities)
- HEM 10 MCHF

T. Ekelof wonders is the Drive Beam activities are included in the plan. This is indeed the case.

R. Ruber wonders about the Drive Beam gun future. There is no guarantee that it can be part of the programme anymore.

Kenneth wonders about the collaboration with ILC. Steinar mentions the set up of a development team for the preparation phase of ILC (lead by Tatsuya Nakada). Steinar will be representing the European region.

4. Upcoming Activities

No CLIC workshop in the Spring but foreseen during the Autumn.

5. Near future outlook and strategy

Point covered under point 3.

6. Election of Spokesperson and CB Chairperson

R. Ruber reminds that both P. Burrows and himself were elected 4 years ago with normally a 3 years mandate. A one year extension given to the specific context (PIP preparation, European Strategy decision, final ILC decision expected from Japan, etc.) was exceptionally approved. Time has come for new elections.

A draft mandate for the spokesperson is available from Indico. R. Ruber mentions that the amount of time spent at CERN can be reduced from 50 to 20%. CB members are requested to comment this mandate ASAP.

R. Ruber then suggests setting up a Search Committee with the following members:
Steinar, Angeles, Phil and Roger (Mark as back-up1, Roger Jones as Back-up2 for Phil/Roger). The Search Committtee will send possible names (spokesperson and Chairman) end of October.

It is suggested that the Election process is done by email.

The vote took place electronically (Indico form - https://indico.cern.ch/event/1009849/) over the period 19.02.2021 – 07.03. 2021.
18 voting participants
*Spokesperson**: A. Faus-Golfe** (10), T. Garvey (7), Abstention (1)*
*Chairman: **G. D'auria** (17), Abstention (1)*

7. Next CB
To be defined at a later stage.

8. AOB
S. Stapnes warmly thanks R. Ruber and P. Burrows for the time spent during their mandate. He is looking forward working with the new elected persons in the coming years.

The Board gives a special thanks to A. Augier for her excellent help organizing the CB and CLIC Project meetings.