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A SUMMARY OF THE ACTIVITIES OF THE CLIC STUDY TEAM FOR THE YEAR 2005

I. Wilson

Abstract

This report describes the progress made by the CLIC Study Team during the year 2005 on the design and development of the various sub-systems of the Compact Linear Collider (CLIC), the results obtained from the CLIC test facilities, the status of the initiatives taken to expand the CLIC collaboration to obtain additional resources for the accelerated CLIC R&D programme, and the CARE and EUROTeV activities within the EU FP6 programme of studies.

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Introduction

This report describes the progress made by the CLIC Study Team during the year 2005 on the design and development of the various sub-systems of the Compact Linear Collider (CLIC), the results obtained from the CLIC test facilities, the status of the initiatives taken to expand the CLIC collaboration to obtain additional resources for the accelerated CLIC R&D programme, and the CARE and EUROTeV activities within the EU FP6 programme of studies.

Parameters

The basic CLIC parameters have been updated during the course of this year to take advantage of (i) a new 30 GHz HDS design resulting from a better understanding of surface-field, power and pulse-length limitations and (ii) improvements in the generation of low emittance beams in the damping rings and emittance preservation during beam transport through the main linac and the beam delivery system. The new HDS design has been optimized to give the highest peak luminosity in a 1% energy bin per MW of mains input power. The resulting structure has excellent long-range damping characteristics allowing the bunches to be spaced at 8 rf cycles, but the reduced aperture ($\langle a \rangle/\lambda = 0.178$) requires the number of particles per bunch to be reduced from 4×10^9 to 2.56×10^9 to limit short-range wakefield effects. The reduced spacing has enabled the pulse length to be reduced from 130 ns to 68 ns whilst still maintaining the same luminosity (in the 1% energy bin) of 3.3×10^{34} cm^{-2}s^{-1} at 3 TeV. The single bunch luminosity could be further increased if the horizontal spot size at the IP could be reduced from the present value of 60 nm to the optimum value which is around 37 nm, but no lattice layout has yet been found to do this. The updated parameters provide a total luminosity of 6.5×10^{34} cm^{-2}s^{-1} at 3 TeV with 220 bunches at a repetition rate of 150 Hz for a total AC site power of 418 MW.

A new drive-beam-generation mode of operation, the so-called ‘double-pulse scheme’, has been adopted for the new parameters with the reduced rf pulse length that maintains both the basic layout, and the good compromise between transverse stability in the decelerator and collective effects (wake-fields and CSR) in the drive-beam-generation complex. Contrary to the previous scheme which had a separate drive-beam generation complex for each linac, the new scheme uses the same one for both linacs and consists of (i) a single 2.4 GeV drive-beam accelerator (ii) a short delay loop (21 m for 70 ns) (iii) two long combiner rings (84 m and 334 m for 70 ns). The new mode of operation is to inject and to combine two pulse trains at the same time, and then to extract a two-pulse couple and separate it sending one to each main linac. With this scheme the number of decelerator sections per linac is 21. The main hardware changes are the reduction of the delay line length and the need of a kicker after extraction from the second combiner ring, to switch every second pulse from the electron to the positron linac.

Damping ring

The basic layout of the damping ring remains essentially the same for the new parameters but the mode of operation has been modified. The ring is composed of (i) two long FODO-cell straight sections containing 76 two-metre long 1.7 T wigglers with a period of 10 cm, (ii) two arcs made up of TME (Theoretical Minimum Emittance) cells with nine families of interlaced sextupoles, and (iii) four dispersion suppressors connecting the arcs and the straights; the whole forming a racetrack shape with a circumference of 360 m. To further enhance the dynamic aperture, two additional families of harmonic sextupoles are installed in the two long dispersion-free wiggler sections. Due to the reduced bunch population (2.6×10^9) which decreases collective effects, the 2.42 GeV damping ring now gives transverse equilibrium emittances in the horizontal and vertical planes for a perfectly aligned machine of $\gamma\varepsilon_x = 550$ nm and $\gamma\varepsilon_y = 3.3$ nm respectively. These values take into account intra-beam scattering, radiation damping, and quantum excitation and correspond to a betatron coupling of 0.6%, an rf voltage of 2.39 MV, and an rf frequency of 1875 MHz. This lower rf frequency corresponds to a bunch spacing in the damping ring of 16 cm and results from the new way that the damping ring will operate for the new parameters. The longitudinal emittance of 4724 eVm is smaller than the design value of 4800 eVm. The ring circumference was made as small as possible, while still maintaining a reasonable ratio of store time over damping time, to keep the RF voltage low and the space-charge tune shift at an acceptable level. To maintain a high degree of polarisation for the electrons, the beam energy of 2.424 GeV corresponds to half an integer spin tune. The dynamic acceptance of the ring at injection is of ±1 %. In view of the flatness of the dynamic aperture, a pre-damping ring appears to be necessary for both electron and positron beams, unless the electron beam can be produced from a flat electron gun. The mode of operation of the damping ring has been modified to match the new parameters in that two trains are now extracted simultaneously and need to be combined using a subsequent delay line and RF deflectors. The advantage of this is that the bunch spacing in the ring (16 RF cycles at 30 GHz) is twice that in the linac (8 RF cycles) which alleviates the impact of electron-cloud and fast-ion instabilities, and allows for a lower (but still higher than usual) RF frequency in the ring, which itself leads to a longer bunch and reduced intra-beam scattering. Limitations from collective effects have been studied and suggest that countermeasures must still be developed for the electron cloud in the positron damping ring and for the fast beam-ion instability in the electron ring.

Although the wiggler period has been reduced from 20 cm to 10 cm, there is every hope that this can be reduced further resulting in even smaller emittances. A novel wiggler design, based on Nb_3Sn technology and developed in collaboration with BINP (Novosibirsk) achieves a 45-mm wiggler period with a 2.5 T peak field. Using these parameters the horizontal and vertical normalized emittances at extraction are reduced from 550 nm to 375 nm, and from 3.3 nm to 2.3 nm respectively. One of the problems associated with the use of wigglers in the straight sections is the large synchrotron radiation heat load that is produced and has to be absorbed, this has not yet been resolved but possible solutions are being studied. The problem has been mitigated by lowering the beam current in the ring to 75 mA (only two bunch trains - equivalent to one linac train - are stored in the ring simultaneously).

A comprehensive study of tolerances, errors and beam-based tuning has been carried out. It was found that in the presence of realistic errors and after tuning, the emittances are still smaller than the target CLIC values although the dynamic aperture is reduced by some 10-20%. Methods of increasing the dynamic aperture of the ring are being investigated. Our BINP collaborators in particular have surveyed the tune and momentum dependence of the dynamic aperture using the BINP code Acceleraticum.

Polarized Positron Source

A possible layout and parameters for a polarized positron source have been developed following experimental tests at the ATF which have demonstrated the production of 10^4 polarized e+ per bunch with 77 +/- 10% polarization. The polarized positrons are collected after conversion of polarized X-rays on a metal target. The polarized X-rays are themselves created by Compton scattering of a 1.3-GeV electron beam off a YAG laser in a 42m circumference storage ring with possibly just one optical cavity. The positron yield per turn from the Compton ring has been simulated with a dedicated programme and was found to be close to the ideal maximum value and compatible with the CLIC requirements. It is foreseen to stack the positrons in a dedicated compact pre-damping ring.

BDS studies

The status of CLIC BDS studies was reviewed at a one-day CLIC BDS mini-workshop at CERN in November 2005. Topics covered included (i) beam-beam effects (ii) time-dependent luminosity performance (iii) possible use of very fast intra-train beam feedback (iv) progress on the non-linear collimation system (v) aberrations and spot-size limitations (vi) tuning studies and integrated simulations (vii) halo studies (viii) crab cavity and extraction line design (ix) beam diagnostic issues.

Several simulation codes, namely MAD-X, SAD, PLACET, and PTC, have been bench-marked against each other and used to characterize the performance of the present baseline linear BDS which has a total length of 2.5 km and consists of a particularly compact 0.5 km final focus (FF) section which uses optics derived from the NLC, and a 2 km collimation section for first energy and then betatron collimation. In the energy collimation section, the dispersion at the location of the energy spoiler is chosen such that the spoiler can survive a direct hit of the full beam with nominal emittance provided that the spoiler is made from carbon, diamond, or possibly (but hopefully not) beryllium. Due to beamstrahlung, the IP beam size is highly non-Gaussian, with more than 15% of the population lying outside 3σ in the vertical plane, and about 7% in the horizontal plane. The rms spot sizes widely overestimate the size of the beam core (100 nm rms for 55 nm horizontally and 3.5 nm rms for 0.7 nm vertically). The luminosity (without pinch effect) obtained by particle tracking is 3.6 x 10^{34} $cm^{-2}s^{-1}$ which falls short of the target value of 9.3 x 10^{34} $cm^{-2}s^{-1}$. The largest loss in luminosity can be attributed to the collimation section since with the FF alone the luminosity is 4.85 x 10^{34} $cm^{-2}s^{-1}$. One of the limitations of the present design is the inability to reduce the horizontal spot size below 60 nm due in part to excessive synchrotron radiation in the energy collimation system. At the moment, the collimation system seems to be a bottle-neck for improved performance and new layouts or strategies will have to be found.

Accelerating structure design

The focus of the 30 GHz main-linac accelerating structure studies has once again been on the HDS (Hybrid Damped Structure). The new HDS design of CLIC main-linac accelerating-structure has a new geometry which includes fully-profiled rf surfaces optimized to minimize surface fields, and hybrid damping using both iris slots and radial waveguides. This structure incorporates both iris slots and radial waveguides for long-range wakefield damping, and has fully-profiled rf surfaces to minimize surface fields. The slotted irises allow a simple structure fabrication in quadrants with no rf currents across joints. It is foreseen to construct the structure from two different metals, molybdenum for the tips of the irises and copper zirconium for the cavity walls.

The new structure optimization process which simultaneously optimises surface fields, power flow, short and long-range transverse wakefields, rf-to-beam efficiency and the ratio of luminosity to input power has been extensively used and further developed this year. This procedure is based on the interpolation of structure parameters and allows millions of structures to be analyzed taking into account the full and extremely complex interplay between rf and beam dynamics parameters. The criteria used in this process are continuously being updated to take into account the latest experimental data and the most probable interpretation of both new and old data. Three criteria are currently being used. The first is the maximum surface electric field which for molybdenum has been fixed at 380 MV/m. The second is the pulsed rf surface heating limit which for a lifetime of 10^{10} pulses for copper-zirconium has been fixed at 56C°. The third criterion is the power/pulse-length limitation. It has been observed that above a given limit of power and pulse length, the surface of the structures start to be eroded. At the beginning of the year the limit used in the optimisation process was $P\sqrt{\tau} < 1200$ MW$\sqrt{}$ns and was based essentially on SLAC NLCTA data for X-band structures, and this led to an optimised HDS structure with a phase advance per cell of 60°, a bunch spacing of 8 rf cycles, a pulse length of 68 ns, an rf-to-beam efficiency of 31 %, and an input power of 151 MW for the nominal loaded gradient of 150 MV/m. Later in the year a better fit for the existing data was found using $P\tau^{1/3}$/circum < 21 MW ns $^{1/3}$ / mm instead of $P\sqrt{\tau}$. If this new criterion is shown to be valid, it would mean that the newly-adopted structure for the new CLIC parameters would most likely not work. Using this criterion the figure of merit and the pulse length of the optimised HDS structure are both roughly halved. That means twice the power to keep the same luminosity. It is also not yet clear if such short pulse lengths are compatible with the present CLIC layouts – this needs more study.

For all the above-mentioned optimization work it was assumed that the structures would operate at 30 GHz and at a loaded accelerating gradient of 150 MV/m. Since these two parameters may themselves not be optimised, it was decided to carry out a structure optimization study in which the gradient and frequency were also free parameters. Using the same figure of merit (luminosity per MW) and the new power flow criterion $P\tau^{1/3}$/circum, it was found that (roughly) a 50% improvement could be made by either (i) maintaining the frequency at 30 GHz and reducing the gradient to around 120 MV/m, or (ii) maintaining the gradient at 150 MV/m and reducing the frequency to around 18 GHz. On the other hand, a 100% gain could be achieved by both changing frequency to around 18 GHz and reducing the gradient to around 120 MV/m. For all these studies the pulse length of the optimised structures was about 30 ns – as mentioned above it remains to be seen if this is compatible with the present CLIC layouts for drive-beam generation.

CLIC Power Extraction and Transfer Structures (PETS)

The new CLIC parameters require that the 0.6m long (active length) PETS extracts 642 MW of RF power from the 181 A 15 GHz drive beam which with an extraction and transfer efficiency of 94% provides 151 MW of power to each of four HDS accelerating structures. Eight radial 1.3 mm wide slots cutting the PETS all the way along its length channel out the disruptive higher-order-mode energy to

SiC loads. The main body has an octagonal cross-section (~22.5 mm diameter) composed of 8 identical racks with shallow (~1.3 mm deep) sinus-type corrugations with 140 degrees phase advance per period (3.8885 mm). Eight HOM damping slots are placed symmetrically around the circumference. The power can be turned OFF or just attenuated by inserting thin (~1.6mm) corrugated metal wedges into the PETS through four of the eight damping slots. These wedges detune the synchronous mode frequency and prevent coherent build up of the excited field. A study of the mechanism to insert and extract these wedges has been started in the TS Department. At the end of the year, a first 400 mm long prototype CLIC PETS structure with an active length of 0.23m was rf tested at low power on the bench. This copper structure was assembled using eight racks that were machined by high speed milling to an accuracy of +/-10 µm which is probably adequate for this particular CLIC component.

Material test facilities

The two experimental facilities which have been developed by the TS Department for CLIC studies, the dc-spark test stand and the laser pulsed-surface-heating test stand, were fully exploited in 2005. These facilities are very important for CLIC since they speed-up technical developments in areas such as materials studies and material preparation techniques.

The dc-spark system has been equipped with a pressure measurement system to enable the amount and type of gas released during breakdown in the conditioning phase to be estimated. DC breakdown studies on molybdenum, tungsten and titanium have been made. For molybdenum, it was found that thermal treatments accelerate the conditioning process, and exposure to CO and dry air up to the 10^{-5} mbar range during conditioning can reduce the breakdown field by as much as 50%, and extra conditioning time is needed to re-establish the previously higher level (this is contrary to the behaviour of copper which shows no change in levels). Tests on titanium produced even higher fields than molybdenum but with a large scattering in the values from one breakdown to the next, and more importantly, with substantial erosion of the material.

For the CLIC main-linac structures the amplitude of the thermal cycling due to rf surface heating is about fifty degrees and the estimated lifetime of the linac is ~ 10^{11} pulses. The laser-surface-heating test stand simulates this thermo-mechanical fatigue behaviour. During the course of the year, the test stand was relocated in building 101 and all instrumentation had to be checked out after the move. Fatigue data was obtained for CuZr in the aged and cold worked (40%) state, and for Glidcop and CuZr after a thermal simulation of the HIP (Hot Isostatic Pressing) process. The criterion for fatigue damage was surface break-up (characterized by average surface roughness). The Glidcop sample showed a better resistance to fatigue than the published data for properly-aged CuZr. The experiment needs to be repeated to confirm reproducibility. At the end of the year a new laser enabling a higher repetition rate (200 Hz instead of 25 Hz) was installed and is now ready for operation. This will hopefully speed-up the data acquisition process.

The new ultrasonic fatigue test stand became fully operational in 2005 and towards the end of the year was working 24 hours a day and seven days a week. Since this device works at 24 kHz data can be acquired very rapidly. The major challenge in getting this set-up working was the design of the mechanically resonant sonotrodes (the test pieces) using the FEM program ANSYS, the precise determination of the material properties, and the development of an accurate (few percent) LED strain calibration system. Using this set-up, fatigue data up to 7x10^10 cycles (the estimated lifetime of CLIC) has been obtained for pure copper and zirconium copper in different states of hardness.

Collaboration with the Japanese metal industry is proving to be very fruitful. Hitachi Cables has provided free of charge various copper zirconium alloys in different states to evaluate their fatigue properties, and a new technique to improve the fatigue resistance of materials called 'cavitation shot-less peening' is being studied in collaboration with Tohoku University, Japan.

The collaboration between CERN, JINR (Dubna) and IAP (Nizhny Novgorod) to provide pulsed-surface-heating fatigue data has again been delayed this year by the need to replace and improve many parts of the JINR FEM. The FEM is currently producing around 15-20 MW but breakdown problems at the output window have again slowed the progress. This experiment is now running more than four years late but the latest schedule foresees results by early-2006. It is worth persevering with this experiment since it will provide essential data from an rf test set-up to cross-check the validity of the results from the other high-repetition-rate fatigue set-ups.

Material, machining and metrology studies

The TS Department has continued their studies concerning the fabrication and machining of HDS and PETS structures. Three bimetallic bars of CuZr with a Mo core have been tested at CERN. Two came from by the Finnish firm METSO and was made by HIP (Hot Isostatic Pressing) to achieve a diffusion bond between the materials. The second was supplied by the Lutch Institute in Russia and was made by co-extrusion. Only the second bar from METSO showed satisfactory mechanical properties. Explosion bonding is being considered as an alternative technique for a bimetallic assembly. Preliminary samples of explosion-bonding in Mo-Cu have been investigated and larger samples of CuZr-Mo are being prepared.

Two techniques are currently being investigated for the machining of the HDS and PETS structures; these are high-speed 3D milling and 3D electro-discharge machining (EDM). Ten 400mm long PETS racks were successfully machined by high speed milling to an accuracy of +/-10 µm by the Finnish firm IMTEC, and eight of these racks have been assembled to form the first CLIC PETS prototype structure. PETS racks ordered from the German firm DAHMEN were found to be less precise with form errors of up to 50 µm. Prototype copper quadrants have been supplied by IMTEC and DAHMEN for HDS60 (60 cells) structures. The accuracy of the pieces which were made by high-speed milling was ± 20µm for IMTEC and was ± 40µm for DAHMEN. In addition orders were placed for enough quadrants to make one HDS11 (11 cells) from each of the following materials : copper, aluminium, titanium, molybdenum and stainless steel.

Interfaces between CATIA and HFSS now exist for the accurate exchange of dimensional data for rf analysis and the subsequent CNC machining of complex 3D shapes.

The accuracy of the HDS and PETS pieces is checked at CERN by the TS metrology laboratory using a contact profilometer (+/- 3µm). At the level of accuracy which is presently obtained on such pieces the existing facilities at CERN are still good enough to pick up machining errors but new equipment will be required for the next generation of parts which will hopefully have a ± 1µm accuracy. Photogrammetry has been considered as a non-contact alternative. The advantage of this technique is that a global view of the part is obtained, the disadvantage however is that the accuracy in present commercial instruments is limited to 10 µm.

Alignment studies

The CERN Survey Group, who is now responsible for CLIC alignment studies has decided to follow two directions of studies concerning the active pre-alignment system : first to validate the already-proposed stretched-wire solution and to find solutions to remaining problems, and second to define together with the NIKHEF Institute in Holland an alternative laser-alignment solution based on the very successful RASNIK sensors. In order to evaluate the relative performances of these two systems, it is proposed to build a new 100 m long pre-alignment test stand (RASCLIC) in the underground transfer tunnel TT1 that incorporates both solutions. This facility will be used to make detailed studies of the effects that could possibly perturb the two alignment systems, and to identify items that need further investigation. For the WPS this includes (i) wire protection issues (ii) effects of wire length on the modelization of the catenary and the quality of the measurements achieved (iii) other influences such as temperature or gravity perturbations. For the optical system this includes (i) diffraction due to air fluctuations (ii) optical alignment (iii) loss of coherence of the laser (iv) the choice of targets or patterns (v) reflection in the tube (vi) laser instabilities (vii) thermal and other effects. This new test facility is expected to become operational during the course of 2006.

CLIC Test Facility (CTF3) Studies

A large fraction of CLIC resources once again this year has been devoted to CTF3. This facility is being built in collaboration with Ankara and Gazi Universities (Turkey), BINP (Novosibirsk), CEA (Saclay), CIEMAT (Spain), Finnish industry, Helsinki Institute of Physics, IAP (Nizhny Novgorod), JINR (Dubna), LAL (Orsay), LAPP (Annecy), LNF (Frascati), RAL (Oxford), SLAC (Stanford), North Western University (Illinois) and Uppsala University. The following chapters summarize the various CTF3 activities this year.

Installation - CTF3 linac

During the winter shut-down two more SICA (Slotted Iris Constant Aperture) structures were installed in the linac before the PETS 30 GHz power line and a collimator was added in the PETS line. This brings the total to 14 in the linac and two in the injector. After many problems with the manufacturer of the HV power supply for the 1.5 GHz travelling-wave tubes for the sub-harmonic bunching system, one power unit was finally installed and one cavity successfully operated at the end of the year. The 3 GHz RF power distribution system was rearranged to enable all accelerating structures in the linac before the PETS line to be operated at a repetition rate of 50 Hz. Some progress has been made with the on-going problem of finding someone to repair the existing Valvo klystrons – E2V have now got permission from Phillips to make the klystron drawings available to both CERN and the eventual repairer for a small nominal fee. A new cooling water station and temperature stabilization system for the RF pulse compressors was installed during the shut-down and successfully commissioned at the start of the second run. In contrast to the old system which required about an hour to reach equilibrium after a step increase of RF power, the new system which has a working range of 24 -35ºC with a temperature stability of ± 0.01ºC, enables stable conditions to be re-established in only a few minutes. The dramatic improvement of the stability of CTF3 during the second run can be almost entirely attributed to the successful implementation of this TS department project.

Installation - CTF3 delay loop

The installation of the delay loop which is fully under the responsibility of INFN (Frascati) was successfully completed during the year except for a few beam position monitors. INFN equipment included sextupoles, wigglers, corrector magnets, the vacuum system, the 1.5 GHz RF deflector, waveguides and some beam diagnostics. CERN provided the dipoles, quadrupoles, some correctors, power converters, the septa, controls, the 1.5 GHz RF power system, vacuum pumps, and all infrastructure (cabling, alignment, water, installation support). It was very fitting that after all the effort by both the Frascati and CERN teams to complete the installation of all this equipment in the very tight schedule, a first test of beam combination was achieved at the very end of the year.

Installation - CTF3 beam diagnostic equipment

The development and updating of beam diagnostic equipment for the special requirements of CTF3 beams continued during 2005. New materials have been found to replace the carbon and aluminium foils that are presently used as OTR (optical transition radiation) screens in the linac and spectrometer lines. The basic problem here is to produce a homogeneous and flat reflective surface. Excellent results have been obtained with polished CVD silicon carbide and polished aluminium-coated silicon wafers. All the associated lens and mirror supports for this system have also been replaced so that the exact positioning of all elements should now be ensured.

In the spectrometer lines, where the beam size is larger, the amount of light collected by the optical line (optical acceptance) was found to depend on the position of the beam on the screen, the intensity dropping rapidly as the beam goes off-centre. This is due to the small angular distribution ($\sim 1/\gamma$) of OTR light and the limited angular aperture of the optical system. Two possible ways of improving this have been studied and prototypes tested in the laboratory. The first idea is to use a diffusive screen and the second to use a parabolic screen to provide a focusing effect exactly where the OTR light is created.

The best results were obtained with the parabolic screen and this solution will be tested in CTF3 during the first run of 2006. Another problem that has been degrading the performance of the OTR system in the spectrometer lines stems from the fact that above 80 MeV the synchrotron radiation yield emitted in the visible range by electrons in a 30° bend is equivalent to the OTR yield. This unwanted radiation has been suppressed by introducing an additional thin carbon foil in front of the OTR foil. This was tested successfully in the spectrometer line located in the transfer line from the linac to the delay loop.

The development of time-resolved measurements of position/energy variations within the bunch train in the spectrometer lines has progressed well and the results are now very encouraging. A new slit dump was constructed and installed in the spectrometer line on girder 10. Tests with beam currents ranging from 1-5 A demonstrated a very good signal-to-noise ratio and a 50 MHz time resolution.

Encouraging results were also obtained from a 32-channel segmented photomultiplier (PMT) which was installed in parallel to the existing gated CCD cameras on two CTF3 girders to view the light produced by the OTR screens. The PMT showed a better time resolution than the slit dump with a good signal-to-noise ratio. Unfortunately PMTs are sensitive to beam losses which degrade the signal-to-noise ratio.

Design work on a sub-picosecond bunch-length monitor similar to the one used in CTF2 (the Cesar monitor) has started in collaboration with North-Western University. The CTF2 monitor measured bunches as short as 0.7 ps and was limited by a maximum mixing frequency of 90 GHz. The intention is to improve the performance by (i) increasing the maximum mixing frequency to 170 GHz to be able to measure bunch lengths of 0.3 ps, (ii) possibly using a diamond RF window (a CVD sample has been donated to NW for tests), and (iii) using a large-bandwidth waveform digitizer to make online single shot FFT spectral analysis. This work is progressing well and a preliminary test of the electronics has already been done in CTF3 using the signal from a BPR beam position monitor in the CT line.

A new system for the control and acquisition of images of the MTVs was implemented. It is based on recently developed VME cards which are now the CERN standard for TV systems in CERN accelerators. A total number of 13 cards have already been installed, 8 replacing the previously used devices and 5 for the new installations in the delay loop and the transfer line to the combiner ring.

Several beam diagnostic systems were installed in collaboration with INFN in time for the successful commissioning of the delay loop at the end of the year. These included (i) 6 beam position monitors (BPI) (ii) one button pick-up for bunch length and phase measurements (BPR) and one beam position monitor (BPM) (iii) 5 MTVs and one optical line to the streak camera laboratory. All systems worked well with no major problems.

Work on the CTF3 machine protection system was started this year using wall current monitors (4 in total) to detect beam loss and to trigger the gun interlock.

On the CTF2 side, two faraday cups and a set of 5 X-ray monitors were installed in the 30GHz accelerating structures test stand to monitor breakdown.

CTF3 operation

There were only two runs in 2005, the first from 17 May–10 June, and the second from 3 Oct–16 Dec. with a total of 13 weeks of beam operation during not only the normal working days but also night and week-end working. Although only four or five specialists were able to tune the machine, many hours of extra high-gradient test work were made possible by the presence of non-machine-experts from both CERN and Ankara University during PETS running. A long summer shut-down period and two weeks during the second run were used for further installation work. The beginning of the first run was used to debug and consolidate the machine set-up for 30 GHz power generation. This proved to be problematic due to stability problems (slow drifts and beam jitter), reliability and availability problems due in the main to inadequate cooling water temperature regulation, and lack of time for beam measurements and re-matching. Reliability and availability was much better in the second run, thanks to the newly-installed stabilized water cooling system for the RF pulse compressors, the reduction of power supply ripple on key units, improved diagnostics and more time spent on setting-up the beam. The two runs were dedicated to the testing of the molybdenum-iris accelerating structure and the commissioning of the delay loop. After 20 hours of running at 50 Hz with a current of 3.5A, a leak appeared in a flange in the 30 GHz power line at a place of high beam loss and although the leak was sealed by simply tightening the flange, the repetition rate was reduced to 10 Hz as a precaution for the rest of the run. The radiation measured at this flange on contact after 3 days was 5 mSv. The last part of the 30 GHz power generating activity was dedicated to long-pulse running with a view to using the 30 GHz RF pulse compressor. Although very little time was available for the commissioning of the delay loop, a circulating beam of about 1 A (300 ns) was obtained in a very short time with nonisochronous optics first of all using magnetic deflection into the ring (3 GHz beam), and at the very end of the run using an RF deflector and one unit of the 1.5 GHz sub-harmonic bunching system combined with an 180 degree phase flip to provide the bunch coding (1.5 GHz beam).

30 GHz power generation

The special PETS line that has been built alongside the CTF3 linac in a by-pass configuration is still regrettably the only source of 30 GHz high RF power for high-gradient development work. The 400-cell copper PETS structure is made from three segments with 9, 6.7 and 9 mm diameter apertures which follow the waist of the drive beam. Powers of 30 MW, 77 MW and 100 MW were obtained from the PETS using beam currents of 3.5 A, 4.5 A, and 5 A respectively and were consistent with a bunch form factor F=0.9. Maximum transmission through the PETS was around 80-85%. The 30 GHz rf power generated by the PETS structure is transferred to the CTF2 building via a low-loss (<5%) line. During the shut-down the clamping of the molybdenum-iris structure was increased to make sure that the contacts were not limiting the performance. Conditioning of this structure was at first very slow because the process was interlocked with the Faraday-cup signal and was stopped after every breakdown. Later this restriction was removed and the rate of conditioning increased dramatically. Obviously molybdenum reacts favourably to an aggressive approach. By the end of the run, the CLIC nominal gradient (150 MV/m) and pulse length (70 ns) had been achieved albeit with a very high breakdown rate and at the limit of the available power (55 MW). Some long-pulse running was made in preparation for an eventual use in CTF2 of the SLEDII-like RF pulse compressor that has been installed and configured for 70 ns pulses but not yet connected. For these tests a power of about 15 MW was achieved with 300 ns pulses with evidence that several components in the system were limiting the performance and needing to be conditioned. To get to 100 MW in CTF2 the requirement is for 25-30 MW and 400 ns.

The calorimetric power measurement set-up has been completed and is ready for use when the right conditions are available – this system requires reasonably high average powers to give accurate readings.

Preparation for the next CTF3 stages

Good progress has been made in parallel with this year's installation and test programme, to design, build and order equipment in preparation for the next CTF3 installation phases. The following chapters summarize this preparatory work.

Preparation – miscellaneous magnets

The AT magnet group at CERN is involved in one way or another with all the magnets for the future CTF3 phases, either as supplier, technical coordinator or collaborating partner. The magnets concerned are (i) 8T/m Slim Quadrupoles QG for TL1, CR and TL2 being manufactured by BINP Novosibirsk – delivery foreseen beginning 2006 (ii) 33 H/V Corrector Magnets for TL1, CR and TL2 – based on a design of delay loop correctors by Frascati – being manufactured by ANTEC (Spain) as part of CIEMAT contribution – delivery foreseen beginning 2006 (iii) 32 Recuperated Quadrupoles (8T/m) from LURE for CR – shipment of first batch of 16 not foreseen before end of March 2006 – will however receive a prototype in near future to study necessary modifications (iv) 26 Sextupoles XC (180 T/m^2) for CR – being manufactured by BINP/Novosibirsk – based on design of delay loop sextupoles by Frascati – delivery foreseen beginning 2006 (v) 6 Bending Magnets BF (1.3T) for TL2 – design based on EPA bending magnets – drawings are in preparation – needed for 2007 (vi) 16 Quadrupoles for TL2 (CELSIUS) – already delivered – need modification of water and electrical connections and measurement before installation in 2006 (vii) 18 Quadrupoles and moving tables for TBL – preliminary magnetic design finished – to be provided by CIEMAT – required for 2008 (viii) 12-16 Quadrupoles for Two-Beam test stand – beam line design not yet done – however required for 2007 (ix) 4 Wigglers for DL and CR - 2 units delivered to CERN by Sigmaphi/France

Preparation – sub harmonic bunching system

The 1.5 GHz sub-harmonic bunching system is almost complete. This wide-band (10%) bunching system will allow the phase of the bunching voltage to be changed very quickly (typically 10-20 ns) so that the bunches of 140 ns-long bunch trains can be placed alternatively in even and odd RF buckets.

The three 6-cell large-aperture travelling wave structures are installed, and two of the three 40 kW travelling wave tubes and power supplies have been delivered and installed.

Preparation – septa

The conceptual design of two types of septa for injection and extraction in the CR ring has been made by ELYTT Energy S.L. on behalf of CIEMAT and manufacturing drawings are being prepared. For the thin septum, the septum plate is made out of a 1.5mm thick Glidcop sheet and has two cooling tubes brazed at the top and the bottom and is insulated by 2 layers of 0.1 mm thick polyimide. It is not foreseen to reinforce the copper sheet with a steel plate as is often done. The thick septum design is based on a 4-turn magnet divided into two coils. The 4 turns are in 4 independent water circuits. A horizontally-split yoke allows the magnet to be insertion around the vacuum chamber. The circulating beam is shielded from the stray field by a 1 mm mu-metal sheet. Iron plates at the ends shield the stray field as well as controlling the magnetic length.

Preparation – extraction kicker magnet

The conceptual design of the kicker strip-line magnet for the combiner ring has been made by CIEMAT following detailed discussions with INFN concerning specifications, geometries, simulations and fabrication. A copy of HFSS has been purchased and installed and first calculations and simulations of a real magnet have been made. Although behind schedule by about 4 months, it is planned to complete the kicker by the end of 2006. Following discussions in the US, the original idea to collaborate with LLNL on the kicker pulser now looks very improbable. A decision on how to proceed with this development has to be decided soon since Spain does not have the expertise to go it alone.

Preparation – TBL magnet movers

The conceptual design and drawings for the fabrication of a prototype quadrupole magnet mover for the TBL has been made by CIEMAT. A first prototype based on a sliding inclined plane is expected for early 2006.

Preparation – CLEX building

It is foreseen to construct the CLEX building in 2006 so that equipment can start to be installed in 2007. The building has been specified to have inside dimensions of 40 x 8 x 2.75 m with no support pillars. An equipment gallery of dimensions 20 x 8 x 3.55 m is foreseen above the test facility with an installed electrical power of about 700 kW to house all CLEX power supplies, vacuum controls and beam diagnostic racks plus two more S-band modulators and klystrons for the probe beam linac. The present CTF2 gallery will be used for one or two more modulators and klystrons and for more electronic racks for the two-beam test stand and the Test Beam Line. The CLEX floor will be 50 cm lower than the floor of the combiner ring building and drive-beam linac building. Since the beam height of the linac, delay loop, and combiner ring is 135 cm, the beam height in CLEX will be 185 cm requiring vertical bends in TL2.

Preparation – radiation protection wall between linac and delay loop

A radiation protection wall between the linac and the delay loop is being prepared which will allow the high-gradient test stand to be operated during installation of the combiner ring in 2006. This will significantly increase the number of test hours for high-gradient development work. For security reasons this will mean the construction of a new emergency exit door at the end of the linac and a beam stopper in the straight-through line of the INFN chicane. For delay loop running this means that the beam will have to go via the chicane at all times. Construction of the wall will entail non-negligible modifications of cabling and other technical services in this area.

CTF3 TBL beam dynamics studies

Work has started on possible layouts for the test beam line (TBL) for CTF3. This beam line will be used to bench-mark the behaviour of the CTF3 drive-beam against simulation programs so that the stability of the CLIC drive beam can be predicted with convincing certainty. The design is complicated by the fact that the CTF3 beam current will be much lower than that of CLIC and the beam energy at the entrance of the line will be lower than at the end of a CLIC decelerator. The problem is not simple. It would be preferable to use prototype CLIC PETS structures in this line so that later there are no surprises with spurious modes which could possibly lead to a large loss in CLIC. Unfortunately the space available in CLEX excludes this solution. It is therefore necessary to consider a non-CLIC PETS structure with a smaller aperture to achieve a stronger coupling to the beam. Since the beam energy is lower than in CLIC this however makes it difficult to pass the beam through the apertures. No satisfactory way of designing and testing this line has yet been found but the discussions are on-going. A general way of detecting harmful transverse wakefield modes would be to add a kicker that excites the beam at different transverse frequencies before the TBL and monitoring the beam profile at the same frequency after the TBL.

CLIC accelerated R&D programme

Substantial progress has been made this year with the setting-up and consolidation of the multi-lateral collaboration to complete the construction of CTF3 and to carry out the necessary feasibility experiments to demonstrate the key issues of the CLIC scheme. A draft MoU was circulated to all interested parties and after several iterations was finalised in March. During the course of the year, the following laboratories or industrial partners officially committed themselves to the collaboration by signing an Addendum to the MoU describing their specific contributions : CERN, Ankara University Group, BINP (Novosibirsk), DAPNIA (CEA), HIP (Helsinki), IAP (Nizhny Novgorod), JINR (Dubna), North Western University (Illinois), SLAC, and Uppsala University. A further 4 draft addenda from other laboratories are being discussed. These contributions cover a large part of the project costs but 6.9 MCHF and 40 man-years of effort are still missing to complete the programme.

CERN's contribution covers (i) existing buildings, equipment and facilities (ii) magnet power supplies, vacuum equipment, controls and cabling for the CR and TL1 (iii) the CLEX building (iv) magnets for the CR with BINP (v) accelerating structure and PETS development (vi) CTF3 commissioning, operation and testing (vii) a substantial contribution to the probe beam together with DAPNIA and IN2P3.

The Ankara University group contribution is for 1 man-year per year for CTF3 operations for 2005-9.

BINP has agreed to manufacture 11 quadrupoles and 26 sextupoles for 50% of the manpower cost.

DAPNIA (CEA) and CERN have taken commitments for the design and construction of a large part of the probe-beam linac.

HIP has committed itself to providing 3 man-years of specialist effort in micro-machining technologies for CLIC structure development.

IAP has joined the collaboration based on its ISTC-sponsored development work on 30 MW 30 GHz gyro-klystrons which in an intermediate stage will produce a tube with an output power of about 10 MW (compatible with GYCOM technology) which can be used as a prototype for the possible industrial fabrication by GYCOM of four tubes for a stand-alone power source for the longer-term CLIC research programme. A MoU for this work was signed by CERN and ISTC in 2005.

JINR is contributing 50% of the manpower for the development of specialised software for the computer-controlled operation of the CTF3 high-gradient test stands.

The North Western University undertakes to provide beam-loss monitors and a bunch-length monitor.

SLAC has joined the collaboration on the strength of its past contributions to the CTF3 drive-beam injector linac (loan of the triode gun and optics design).

In addition to the 16 quads, 3 bending magnets and 5 steering magnets from the ex-CELSIUS facility Uppsala University will provide (i) phase monitor (ii) design and construction of the two-beam test stand including optics, magnets, vacuum, beam diagnostic equipment, RF diagnostics and data handling.

INFN Frascati is waiting for approval of a proposal to continue its contribution beyond the delay loop to include (i) the optics design for the Combiner Ring (CR) and Transfer Line (TL1) and (ii) the vacuum chambers and beam diagnostic equipment (without electronics) for the CR and TL1.

Spain is building (i) corrector magnets and waiting for approval of a proposal for (ii) two double septum magnets and an ejection kicker (iii) quadrupole magnets with precision movers for the Test Beam Line (TBL) (iv) RF structure work with the aim of building one PETS for the TBL.

IN2P3 (LAL and LAPP) plans to contribute to the design and construction of the probe-beam linac together with DAPNIA and CERN.

The Adams Institute in the UK would are interested in building and exploiting a general purpose beam instrumentation line in the CLEX test area but for the moment no funds are available for this initiative.

The first meeting of the CTF3 Coordination Committee took place on 30th November at which the following collaborators officially signed the MoU: Ankara University Group, CERN, CEA (DAPNIA), NW University of Illinois and SLAC.

The tenth CTF3 technical collaboration meeting was held at CERN from 29-30th November 2005. All collaborating institutes participated. The CTF3 status, results obtained in 2005 and plans for the coming year 2006 were presented. For details see: http://ctf3.home.cern.ch/ctf3/New_collab_meet.htm

CARE activities

In addition to their current activities, several members of the CLIC study team now have additional commitments within the so-called CARE project (Coordination in Accelerator Research in Europe) which is part of the Sixth Framework Program (FP6) of the European Commission. In particular, for CLIC, it means participation in a European-wide network on linear accelerators (ELAN), and in a joint research activity (PHIN) together with LAL and RAL to construct a photo injector for the CTF3 drive beam. During the year ELAN was associated with the WIGGLE2005 workshop at Frascati, LCWS05 at SLAC, the Metrology workshop at Annecy, the Positron sources workshop at Daresbury, the ILC meetings at London and Snowmass, and the CTF3 collaboration meeting at CERN.

Construction of a CTF3 drive-beam photo-injector

In the CERN/LAL/RAL collaboration on PHIN, the laser is being developed and built by RAL, the RF gun by LAL, and the photocathodes, installation and commissioning by CERN.
The specification for the 3 GHz RF gun is for an electron beam of 2300 pulses of 2.3 nC with an emittance of 20.π.mm.mrad and a vacuum at the photocathode of 10^{-10} mbar. The design of the gun started from the CTF2 gun IV but ended up being substantially different. Notable design features include (i) a reduced cathode wall angle (ii) two symmetric couplers to reduce transverse kicks (iii) racetrack shaped cells (iv) elliptical-shaped irises (v) full beam loading compensation by delayed filling (vi) 3 coils close to the cathode to reduce emittance growth from space charge (vii) over-coupling (β=2.9) to match the beam (3.51 A – 1.5μs) (viii) 42 vacuum pumping holes (Φ=4mm) in cells plus NEG-coated surfaces (ix) high temperature bake-out of copper (3 days 550ºC) to reduce the out-gassing rate by at least one order of magnitude. Measurement and re-machining of a cold model of the gun is now in progress but there have been problems and the plan to order the gun before the end of 2005 didn't work out.

The design of the main parts of the laser has been completed but several design features are at the edge of technology and require components not previously existing on the market including the high frequency oscillator, the fast switching electronics for the Pockelscells and the ultra stable drives for the pumping diodes. The specifications on amplitude stability (<0.25% rms) and time jitter from pulse to pulse (<1ps rms) are particularly tight. The oscillator and the preamplifier which are capable of delivering a CW train of 10 W at 1.5 GHz have been made by the Austrian firm HighQLaser. Preliminary tests at the firm showed full agreement with the specifications and these two elements have been delivered, installed and commissioned. The optical pumping of the amplifiers will be made with laser diodes with a total power greater than 35 kW QCW. The mechanical design of the amplifier has been completed, orders for the diode stacks have been placed and many of them have been delivered. A suitable driver (5 kV in 333 ps) remains to be found for the Pockelscells. Studies on stabilization feedback and phase coding have started at RAL. The stabilisation control architecture has still to be decided. On the CERN side, the rejuvenation and realignment of the preparation chamber and the transport carrier has been completed, and the co-evaporation setup for the production of the standard caesium telluride photo-cathodes has been modified. This included the installation of new evaporators, using a new VME-based control system, improving the thickness calibration and the control of the stochïometric ratio, and by using an improved vacuum pressure measurement and new rest gas analysis system. A new informal collaboration has been set-up up with the CEA-SP2A (CEA Bruyères-le-Châtel F) to study and to exchange new photocathodes of the Secondary Emission Enhanced (SEE) type proposed by BNL (Upton NY - USA).

Construction of a CTF3 probe-beam photo-injector

The same collaboration group is also responsible for the CTF3 probe-beam photo-injector. For cost reasons, the specification of the probe beam linac has been revised (down-sized) enabling the probe-beam laser pulse to be derived from the unused part of the drive-beam laser pulse, and enabling the use of the former-CTF2 in-situ photo-cathode preparation chamber to produce up to 105 electron bunches with a charge of 0.2 nC at a repetition rate of 5 Hz.

EUROTeV activities

The new Eurotev design study which was approved in 2004 at the level of nine million Euros and which runs for three years from 1st January 2005 until 31st December 2007 has further increased the commitments of the CLIC study team members to FP6. It is foreseen that Eurotev will concentrate on the issues which are common to all linear collider proposals. In particular it will address some of the high ranking issues identified by the Technical Review Committee with the aim of delivering significant input to the ILC Conceptual Design Report (CDR) and thereafter to the ILC Technical Design Report (TDR), but it will also investigate upgrade paths into the multi-TeV energy regime (CLIC). The design study is structured around seven scientific work-packages and CLIC study members are participating in a number of areas that are considered of critical importance. These include

1) the study of the electron cloud build-up in the damping ring
2) the potential to provide timing stability at the level of fifteen fs
3) development of a wide band beam current monitor
4) high precision BPMs with reduced sensitivity to beam losses
5) provision of beam time for instrumentation tests at CTF3
6) study of beam halo generation
7) study of failure modes and their impact on machine design
8) study of the integrated luminosity performance including the relevant dynamic and static effects
9) study and improvement of the beam delivery and collimation system and the spent beam lines

As well as contributing to the study itself CERN is contributing to the management of the study by participating in the overall scientific coordination and by coordinating the work-package on integrated luminosity performance studies.

For more general information see http://www.eurotev.org.

In the damping ring work-package CERN is focusing on the development of a new code to simulate the electron cloud build-up. This build up of primary electrons from collisional and/or field ionization of the residual gas which become trapped near the centre of the chamber by the beam field and rf fields near to the beam can drive beam instabilities, change the single-particle optics, and cause particle losses by scattering. The code is able to simulate arbitrary beam pipe shapes and to track electrons and ions. Machine experiments made in the SPS in 2004 have been used to benchmark the HEADTAIL code which calculates beam stability in the presence of an electron cloud – this code is being updated to handle more realistic models of both the machine and the electron cloud distribution.

Ion effects have been estimated analytically for three different ILC damping rings. In particular, the trapping conditions were considered, the exponential rise time of the fast ion instability, and the incoherent tune shift at the end of the train, for arcs, wigglers, and straight sections. The ion effects were found to be significant even for an extremely low CO pressure of 0.01 nTorr.

In the TPMON activity, a major task is to build the electronics for a high precision RF-based bunch timing measurement system. The scheme requires the measurement of the phase of a bunch train at 30 GHz with an accuracy of 10 fs using a single-shot wideband system. An essential part of this work will be to test the system on a working accelerator and it is planned to do this in CTF3. Phase detection will be done at an intermediate frequency (IF) somewhere in the range of several hundred MHz. The choice of an optimum (or even acceptable) IF phase detector is not evident and so the first task is to evaluate the characteristics of available devices and the effort is at present concentrating on this. A test setup to do this has been built and tested, and the support software has been written. First test results are expected by the beginning of 2006.

The work on a precision transformer BPM and a wide-band current monitor have started at the end of the year and the design phase is progressing well.

In the beam halo generation work package a list of all known halo and tail generation processes is being compiled, codes when missing are being written to simulate their behaviour, and proposals of how to benchmark them are being formulated.

In the integrated luminosity performance work package, studies at CERN have focused this year on the effects of static and dynamic imperfections on the luminosity, and proposals for correction, feedback and tuning strategies. The performance of a beam-based dispersion-free-steering alignment procedure has been simulated allowing optimum gain factors to be established and a better understanding of which imperfections are most relevant. It was found that these alignment procedures alone are not sufficient to ensure the preservation of the beam quality. A study of the performance of the main-linac emittance-tuning bumps for static machines has shown that the newly-proposed system of five bumps not only gives a better performance than the previous ten-bump system but the performance achieved is significantly better than required. A novel, faster method has been proposed for the beam-size measurements required for the emittance-bump technique and first indications are that this is a viable option.

The CLIC collision parameters, such as collision offset, collision angle and longitudinal position of the beam waists, need to be carefully tuned in order to maximize luminosity. In order to optimize these parameters a fast luminosity signal is needed. Unfortunately there is no signal available which is directly proportional to luminosity and therefore a different strategy has to be found. The proposal is to find and use a signal that will allow an optimum choice of a number of beam parameters to be made during systematic scans. Possible fast signals for this purpose include signals coming from incoherent pair creation, the beamstrahlung of each beam and the coherent pair creation. First simulations using the beamstrahlung signal to optimize the beam parameters look promising.

In the beam delivery and collimation work package studies have focused on optimizing and getting a better understanding of nonlinear collimation systems with the aim of either improving performance or reducing the length. A first attempt was made to implement octupole tail folding by placing an octupole doublet at the entrance of the CLIC final focus. The octupoles efficiently folded the beam tails inside the final quadrupoles, but they unfortunately also resulted in a 30% luminosity loss.

The best non-linear design that has been found to date uses skew sextupoles to blow up the vertical beam size at the spoiler so as to guarantee collimator survival in the case of beam impact but has only been implemented in the energy collimation section. Although the collimation efficiency has been improved, it does not quite achieve the same luminosity as the linear system. More work on this is clearly needed.

A comprehensive survey of wake field effects in the CLIC beam delivery was performed, which addressed, among other topics, the balance of geometric and resistive-wall wake field, the optimization of the CLIC collimator taper angle, and the various regimes of resistive wall wake fields which may be relevant for the short bunches of CLIC.

Simulations tools were set up for modelling beam loss in the 3-TeV CLIC extraction line. The performance of the nominal ILC exit-line design for CLIC parameters was found (not surprisingly) to be inadequate and an optimized optical design for 3 TeV is clearly required.

The CERN tracking code PLACET has been extended to simulate the effect of collimator wakefields, and linacs that follow the curvature of the earth. Further PLACET updates are being developed including a module that implements the different analytical wakefield calculations, a module that enables more sophisticated feedback and tuning to be simulated including the possibility to input real data, and modules to simulate bunch compressors, beam-gas scattering, and bremsstrahlung. An interface is being created to allow PLACET to use a new precise and very fast synchrotron radiation spectrum generator that has been developed to speed-up GEANT calculations. Finally it is also foreseen to adapt PLACET so that it can be run on parallel computer systems which should enlarge the scope of problems that can be handled and reduce the computing time.

Technical publications of the CLIC Study Group

A list of all CLIC Notes and CTF3 Technical Notes published in 2005 is given below.

CLIC Notes 2005

http://clic-study.web.cern.ch/CLIC-Study/Publications/2005.html

620 CLIC Accelerated R&D
CERN-AB-2005-003, I. Wilson (for CLIC Study Team)

621 High Gradient Test of a Clamped, Molybdenum Iris, X-Band Accelerator Structure at NLCTA
CERN-AB-2005-005, C. Achard, S. Döbert, A. Grudiev, S. Heikkinen, I. Syratchev, M. Taborelli, I. Wilson, W. Wünsch

622 Status of CTF3 at the End 2004, Beam Commissioning Results and Plans for the Future
R. Corsini, G. Geschonke, L. Rinolfi, F. Tecker

623 Results from the ELAN-BDYN Workpackage in 2004
D. Schulte

624 Experimental Results on Electron Beam Combination and Bunch Frequency Multiplication
CERN-AB-2005-018, R. Corsini, A. Ferrari, L. Rinolfi, P. Royer, F. Tecker

625 A Summary of the Activities of the CLIC Study Team for the year 2004
I. Wilson

626 Design Study of the CLIC Main Beam Injector Linac
A. Ferrari, L. Rinolfi, F. Tecker

628 CLIC progress towards Multi-TeV Linear Colliders
CERN-AB-2005-045, H. Braun

629 Luminosity Tuning Bumps in the CLIC Main Linac
CERN-AB-2005-046, P. Eliasson, D Schulte

630 CLIC Damping Ring Optics Design Studies
CERN-AB-2005-047, M. Korostelev, F. Zimmermann

631 Automatic Steering for the CTF3 Linear Accelerator
CERN-AB-2005-048, R. Lifshitz, D. Schulte

632 Collective Effects in the CLIC Damping Rings
CERN-AB-2005-049, T. Agoh, M. Korostelev, D. Schulte, K. Yokoya, F. Zimmermann

633 Different Options for Dispersion Free Steering in the CLIC Main Linac
CERN-AB-2005-044, D. Schulte

634 Considerations on the Design of the Decelerator of the CLIC Test Facility (CTF3)
CERN-AB-2005-050, D. chulte, I. Syratchev

635 30 GHz Power Production in CTF3
CERN-AB-2005-030, W. Wünsch, C. Achard, H.-H. Braun, G. Carron, R. Corsini, A. Grudiev, S. Heikkinen, D. Schulte, J. Sladen, I. Syratchev, F. Tecker, I. Wilson, W. Wünsch

636 ATF2 Proposal
CERN-AB-2005-035, H. Braun, D. Schulte, F. Zimmermann

637 Characterization and Performance of CLIC Beam Delivery System with SAD, MAD and Placet
T. Asaka, J. Resta Lopez

638 CLIC Drive Beam and LHC Based FEL-Nucleus Collider . - rev. version
H. Braun, S. Sultansoy, O. Yavas

639 Design of a Polarised Positron Source Based on Laser Compton Scattering
S. Araki, Y. Higashi, Y. Honda, Y. Kurihara, M. Kuriki, T. Okugi, T. Omori, T. Taniguchi, N. Terunuma, J. Urakawa, X. Artru, M. Chevallier, V. Strakhovenko, E. Bulyak, P. Gladkikh, K. Mönig, R. Chehab, A. Variola, F. Zomer, S. Guiducci, P. Raimondi, F. Zimmermann, K. Sakaue, T. Hirose, M. Washio, N. Sasao, H. Yokoyama, M. Fukuda, K. Hirano, M. Takano, T. Takahashi, H. Sato, A. Tsunemi, J. Gao, V. Soskov

640 CLIC 50 MW L-Band Multi-Bam Klystron
CERN-AB-2005-057, E. Jensen, I. Syratchev

641 Normal Conducting CLIC Technology
CERN-AB-2005-056, E. Jensen

645 Optically Controlled 30 GHz High Power Active RF Phase Switch for the CTF3 RF Pulse Compressor
I. Syratchev, G. Denisov, V. Kocharovsky, S. Kuzukov, A. Stepanov

CTF3 Technical Notes

http://clic-study.web.cern.ch/CLIC-Study/CTF3/Lists/2000.html#2005

068 The Automatic Steering System in CTF3
R. Lifshitz, D. Schulte

070 Fast Beam-Ion Instability in CTF3
S. Döbert