Summary of activities of CLIC Study Team during 2002

Ian Wilson
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Purpose of presentation – to give you a brief overview (just a flavour) of all different subjects studied in 2002 by the CLIC team without giving too much detail

This summary be published as CLIC Note 559

In particular I will :

- Review progress made on design and development of CLIC Machine Studies
- Give results obtained with various test facilities

Given large amount of work accomplished by Team during this 12-month period

– faced with two options

- Either to choose some high-lights and give detailed results with plots and photos
- Or to try to cover all activities with a very brief statement of results

Chosen latter (although it results in much drier presentation) because I believe :

- important that work of every Study Member is acknowledged
- community is made aware of extent and quality of our achievements

CLIC damping ring

Design modified - still based on compact TME arc cells with short-period wigglers in two long straight FODO sections.

Energy increased from 1.98 GeV to 2.42 GeV essentially to reduce IBS effects whilst maintaining option to operate with polarized beams.

Layout based on 2 super-periods and has circumference of 370 m.
Parameters optimized by semi-analytical approach taking into account effects of IBS, quantum excitation, and radiation damping.

Final equilibrium emittances of $\gamma\varepsilon_x$ = 620 nm and $\gamma\varepsilon_y$ = 9 nm respectively for horiz. and vert. emittances now reached after ~ 16000 turns (20 ms) - much less than store time.

Momentum acceptance of ring exceeds $\pm$ 1%.

Reminder : Nom. values $\gamma\varepsilon_x$ = 450 nm and $\gamma\varepsilon_y$ = 3 nm – still some progress to be made.

The longitudinal emittance however has been greatly improved - rms bunch length and energy spread at extraction correspond to ε ~ 4280 eVm – which is compatible with max. value required for the subsequent bunch compressors (4870 eVm).

Improvements were made to dynamic aperture by introducing : 9 families of chromatic correcting sextupoles which because of space limitations have interleaved –I pairs, and by adding two families of harmonic sextupoles in wiggler section.

Dynamic aperture now exceeds 5-6 σ rms at injection.

CLIC combiner ring studies

Transverse stability of beam in 2nd CLIC combiner ring evaluated by tracking simulations. Concern - that injection errors become amplified during combination process because of a coupling of an off-axis beam to fund. longitudinal mode of RF deflectors.

Was shown that by a proper choice of phase advance around ring, and of β-function in RF deflectors, this effect can be minimized to extent that injection angle has only a small influence on beam stability.

Concluded by using scaling arguments that the beam in first ring where RF deflectors operate at 937.5 MHz rather than 3.75 GHz would therefore also be stable.

CLIC main beam turn-around loops for injection into linac

Not much effort was put into this part of the machine in 2002. The semi-analytical tools and new tracking code (with compatible output files for subsequent MAD tracking) developed last year to design isochronous modules for drive-beam-generation complex – however were used to both : optimise transfer lines and turn-around loops, and to investigate effects of coherent synchrotron radiation in the bunch compressors.

CLIC drive-beam accelerator

Each of CLIC drive-beam linacs will be powered by about two hundred 50 MW klystrons operating at 937 MHz with a pulse length of 100 μs. These klystrons will very likely be multi-beam klystrons (MBK) for efficiency reasons. A paper design study of a possible tube is being carried out by Lancaster University as part of a UK/CERN collaboration under the UK-PPARC-PIPSS program.

CLIC study team is closely following this development.

Main linac beam dynamics

Simulated effectiveness of main-linac beam-based alignment system - for different hardware configs. and correction algorithms - using updated version of PLACET.

For this work - assumed (i) quads and near-by BPMs supported independently of main support girders (ii) central cell of RF structures is also used as a BPM (iii) beam-line components are pre-aligned using active the stretched-wire and hydrostatic-levelling systems (iv) beam-based "ballistic" method used to re-align BPMs and quads. and finally (v) emittance is minimised using emittance-bump tuning.

The simulations were made for configurations where 2 consecutive girders were either linked or unlinked putting emphasis on tolerances for different error sources.

Found - major contribution to emit. growth came from misalignment of structure BPMs and that there was little influence whether girders were linked or not.!!

However - if misalignment of structure BPM could be substantially reduced - would be a preference for girders to be unlinked, allowing RF structures on each girder to be independently aligned to beam.

More - Main linac beam dynamics

PLACET was also used to study feedback response in main linac to trans. and long. dynamic imperfections - simulations made for the configuration with 40 local feedbacks distributed along linac and one feedback at IP. For this work – transverse perturbation of 1 nm in range 0-50 Hz - applied to all quads.

One result of this work - for communicating feedbacks - emittance growth could be substantially reduced for excitation frequencies below 1 Hz but further work is needed using real noise spectra before any firm conclusions can be made.

Longitudinally - assumed that RF phase of each of the 22 decelerating sections varied from pulse-to-pulse with rms value of 1° around nominal value - in this case emittance growth found to be 4.7%.

Additionally - shown that for pulse-to-pulse bunch length variations following a normal distribution from 30 to 40 μm - emittance increased by 1.3 %.

Accelerating structures

Major revision of CLIC accelerating structure design - made because old TDS design found to have unacceptably high peak surface electric and magnetic fields for design gradient of 150 MV/m.

Experimental work in CTF2 - shown to avoid surface damage – max surface electric field should not exceed about 350 MV/m.

More factor of 5 improvement in pulsed surface heating level - made by introducing convex outer cavity walls. This - combined with substantially improved knowledge of interplay between max surface electric field, max surface magnetic field, transverse-wakefield suppression and RF-to-beam efficiency - lead to new structure design - comes close to fulfilling design gradient while respecting rf-breakdown and pulsed-heating limits as they are understood today.

For 150 MV/m average accelerating gradient - structure has peak surface electric field of 350 MV/m - peak pulsed surface-heating temp. rise of 128°K - transverse wakefield < 45 V/pC/m/mm at second bunch and rf-to-beam efficiency of ~ 24 %.

In this work - use made of relatively-new simulation code GdfidL - can make time-domain calculations of the wake of full-length heavily damped structures.

A new electrically-coupled power coupler - developed for structure - very compact and has surface fields lower than in the DLWG part of rest of structure.

The collaboration between CERN, JINR (Dubna) and IAP (Nizhny Novgorod) to provide pulsed surface-heating fatigue data progressing well but taking longer than expected.

Present status - 30.7 GHz FEM shown in extended power production - can reliably produce powers of 25-30 MW for 150-200 ns long pulses at rep.rate of 1 Hz with deviations of heating parameter $P\sqrt{\tau}$ within specified 10% range.

This power - transmitted to test cavity with efficiency of ~ 60%.
Initial IAP test cavity design proved to be flawed - been replaced with new CLIC H_{011}-mode cavity design with "hour-glass" shape giving a ΔT of 250°C.

Test set-up - now complete - first fatigue test results expected this year.

Beam position monitors

The work to develop CLIC main-linac BPM's has continued.

An experiment to measure the beam position using signals produced by a heavily damped accelerating structure was made this year using prototype CTF3 3 GHz SICA structure in the CTF2 probe beam.

This 5-cell structure was modified by replacing one of damping waveguide loads with a well matched waveguide-to-coax / vacuum-to-air transition.
And new electronics were developed to detect, and acquire with an absolute phase reference, the very fast (high bandwidth) signal.

First analysis of data indicates resolution from this novel monitor was ~ 50μm.

Drive-beam decelerator

No progress made this year on design of power generating structures - lack of manpower - current design still based on a large aperture (25 mm diameter) circularly symmetric structure with 1 mm shallow corrugations and eight continuous longitudinal damping slots.

Have however updated DB decelerator simulations using characteristics of this structure and obtained two important results :

First - transverse beam stability was good.

Second - maximum power generating efficiency is obtained when RF frequency of structure was ~ 1.5% above frequency of generated power.

This work also reminded us that the max tolerable coherent RF phase error along whole linac must be less than 0.2° !!

Beam parameters

Our basic 3 TeV parameters remained unchanged during 2002 but an interesting analysis of the ultimate quantum mechanical limits on emittances, spot sizes, and luminosity were investigated and compared to the parameters proposed for TESLA, NLC and CLIC.

As an example - quantum mechanical limit for normalized emittance found to be 0.2 pm. (would be nice if we were limited by this value !!)

Not surprisingly - found - present parameters are in general well above these ultimate limitations - one exception is Oide effect which limits the achievable spot size at IP due to energy loss resulting from synchrotron radiation emitted in final quadrupole.

Luminosity at IP

Shown last year - vertical profile of individual bunches arriving at IP are banana-shaped due to single-bunch wakefield effects in linac and BDS - luminosity as a consequence reduced due to induced beam-beam instability when vertical disruption parameter is large.

Studies of this effect - continued this year - interfaces created to allow beam profiles to be passed from one simulation tool to next - done for MAD, PLACET, MERLIN and GUINEA-PIG.

Through PLACET / GUINEA-PIG interface – shown for “static” misalignments - luminosity loss can be almost completely compensated by optimizing both collision angle and the beam offset at IP – this of course requires some sort of luminosity monitor.

To correct for fast “dynamic” effects such as ground motion - the fast inter-pulse IP feedbacks have to be included in optimization process - in this case a luminosity loss of only 0.1 % was found for CLIC using LEP ground motion spectra.

Similar simulations have been made by the CLIC team for TESLA and NLC.

Beam delivery system

Present BDS layout consists of a 2-km long betatron ($\pm$ 12σx and $\pm$ 80σy) and energy ($\pm$ 1.5%) collimation system - followed by a Raimondi-type 600-m long compact FF.

Total length (5.2 km or 2.6 km per side) is same for the 3 TeV and 500 GeV machines - only relatively minor optics modifications required to transform one system to other.

Performance of present design - simulated using variety of different programs - all simulations show - if vertical beta functions squeezed down to 50-70 μm - target lum. is almost reached at 3 TeV - and is exceeded by factor of 1.5 or 2 at 500 GeV.

Several potential luminosity degrading effects – studied - in particular relative vertical motion and beam-size increase induced by : crab cavity, solenoid, crossing angle, gas scattering, wake-fields, and non-linear field errors.

None of these proved a serious obstacle.

More - Beam delivery system

The integrated simulations including BDS and beam-beam interaction - showed – present design produces luminosity of about 8 10^{34} $cm^{-2}s^{-1}$.

Found - beam did not have very Gaussian charge distribution at IP and so effective transv. beam sizes had to be calculated from beam-beam simulation program. Compared to target sizes of σ_x = 43 nm , σ_y = 1 nm - effective sizes $\sigma_x \approx$ 60 nm, $\sigma_y \approx$ 0.7 nm. Result - luminosity is slightly below target value but spectrum is somewhat better.

An alternative nonlinear collimation system occupying same length but using skew sextupoles to blow up beam size at the spoiler - investigated. At present - chromatic properties of this alternative system - inferior to conventional design - appear to be holes in phase space where particles may even escape collimation.

Significant progress made in developing a generic design procedure for compact FF systems which optimizes layout and minimizes third order aberrations – illustration : scaled-down 10-m long system designed for possible future operation with CTF3 beam. Has been proposed - this prototype system could form central piece of new advanced accelerator test facility with emphasis on beam-delivery issues in CTF3 (more later).

Background studies

Backgrounds in IR - estimated using new Geant4-based BDSIM simulation code. BDSIM simulates scattering and secondary generation (including muons) in components both inside and outside the vacuum pipe and tracks these particles all the way to IP.

Generation and tracking of SR is taken into account - enabling an overall accounting for total energy to be obtained with ability to identify local areas of excess heating.

Code used to simulate BDS to get first estimates of collimation efficiency for different halo distributions - found that every particle hitting collimator creates a background of $2x10^{-5}$ muons in detector.

This means - for halo level of 10^{-3} of nominal bunch charge - would be about $1.24x10^{4}$ muons in detector for a train of 154 bunches.

Implementation of production of muons in Geant4 as standard electromagnetic process - made by CLIC/DESY-Zeuthen collaboration.

Emittance monitor studies

Laser wire scanners (LWS) - proposed as possible accurate non-destructive way of measuring very small emittances of main beams - expected performance of such scanners in collimation section of BDS where beam sizes are ~ 10 μm - been simulated using BDSIM which has a special LASERWIRE module.

Main LWS requirement - large signal and good resolution –for TeV beam energies - best achieved by measuring either Compton up-shifted photons or degraded electrons. Photons offer greater flux intensity but detection of TeV-range photons is a challenge.

The degraded electrons can be extracted by, for example, a low (100 gauss) dipole field, and detected by a simple gas detector.
A signal to noise ratio of 10:1 predicted for realistic parameters using a 400nm laser.

Simulation results used to reconstruct emittances with accuracies of 5-10%, with measurement times of order 0.1 s. - reconstructions however require measurements at 3 points, 2 of which are separated by 90 degree phase advance.

Beam profile studies

Have a lot of experience at CERN of OTR measurements of beam profiles.

Very little is however known about the possible use of diffraction radiation in the visible range where image detectors are available for beam diagnostic purposes.

Some work on this subject was made in 2002 for a possible monitoring of CLIC beams.

Shown vert. component of angular distribution of diffracted radiation can be used to :

- center beam
- to measure beam divergence

- but horizontal component provides no practical diagnostic information.

More studies are required to determine if there is a future for such monitors.

Stability studies

The vertical position jitter tolerances on main linac and FF quadrupoles are very tight - typically 1-2 nm and 0.2 nm above 4 Hz respectively for 2% luminosity loss.

Stabilization SG that is investigating feasibility of stabilising these elements to these levels - set up experimental test stand in fairly noisy location on CERN Meyrin site. Test stand is equipped with 3-axis motion sensors with sub-nm resolution (4-250 Hz), a honeycomb support table and state-of-the-art industrial stabilization equipment.

Have stabilized CLIC prototype quadrupoles vertically to 0.9 nm rms above 4 Hz, and to 1.3 nm with nominal flow of cooling water.

In horiz and long directions values were 0.4 nm and 3.2 nm respectively without cooling water.

These measured vibration levels meet CLIC requirements for the 2600 linac quads.

More -Stability studies

More detailed study of effect of water flow in quads revealed main source of vibration up to 60 Hz comes from onset of turbulence in pipes feeding quads rather than in quads themselves.

The ~0.4 nm rms (integrated displacement above 4 Hz) increase in level measured with and without cooling water for a flow of 30l/h - consistent with approximate formulae derived last year.

Concerning seismic vibration studies :
Study team - collaborating with ESRF, PSI, SLAC and DESY on sensor comparisons and on-site measurements.

Nanobeam 02 – members of the CLIC study team proposed and participated in organization of 26th Advanced ICFA Beam Dynamics Workshop on Nanometer-Size Colliding Beams which took place in Lausanne in September 2002.
Required a lot of hard work - was a great success – thanks to efforts of all concerned.

Alignment studies

The successful CTF2 demonstration last year of ability of active-alignment system to maintain positions of components within a window of 1-2 microns during routine operation concluded an important phase of the CLIC team's alignment studies.

To make sure that acquired expertise in this field isn't lost – especially with impending retirements of two of the key participants to these studies - decided to summarize all development work carried out over last ten years or so in a single report.

This important report has now been published (CLIC Note 553)

With the closure and dismounting of CTF2 – we no-longer have a representative module of the CLIC two-beam scheme available for alignment tests or to show our many visitors – so we have decided to re-build a two-module unit on the wooden base in the basement of building 169 – this work is presently underway.

ILC-TRC activities

Lot of effort this year used to prepare information, to update designs, and to make comparative simulations for ILC-TRC - since main focus was a 500 GeV collider - many of CLIC sub-systems had to be revisited to ensure both parameters and hardware were downwards compatible with nominal 3 TeV design.

A careful comparison of tracking codes LIAR, MERLIN and PLACET made in collaboration with DESY and SLAC - found for error free lattices - all 3 codes gave similar results for TESLA, NLC and CLIC machines.

A similar comparative study made specifically for CLIC BDS by CERN, DESY and SLAC teams using codes MAD, DIMAD, MERLIN, PLACET and BDSIM - found codes agreed for perfect machines without synchrotron radiation - but minor differences appeared when energy spread was taken into account.

More - ILC-TRC activities

As well as comparing codes - considerable effort invested in checking published results of various LC designs.

In particular CLIC team used CLIC codes to check :

beam-beam interaction
energy band-width of various BDS systems
kink instability due to parasitic collisions in multi-bunch mode
minimization of effects of bunch distortions
performance of trajectory and IP feedback systems.

To carry out these checks and comparisons - necessary in many cases to modify codes.

PLACET for example - modified to enable correlated ground motion model of A. Seryi to be used for evaluation of static luminosity performance of TESLA, NLC, JLC-X and CLIC.

CTF2

In 2002 CTF2 operated very reliably with no major component failures.

Used mainly as high-gradient test stand for testing of 30 GHz accel. structures.

Some time however found on probe-beam line to carry out variety of experiments related to development of beam diagnostic equipment – these included :

- CTF3 beam position and beam current monitors
- a number of different transition radiation targets
- RF monitor to measure beam position in accel. structure with HOM damping
- a laser wire monitor

The latter (as explained earlier) measures beam size by detecting Compton photons produced by collision of a sharply focused laser beam with electrons – to be able to do this experiment - optical set-up of CTF2 laser had to be radical changed to produce a single, intense infra-red pulse instead of UV train – worked out well - operated reliably

More - CTF2

Improvements to CTF2 laser made during 2002 - conversion efficiency from green to UV increased to more than 27%. This improved efficiency, combined with modifications to pulse-train generating system which increased transm. by 30%, and improvements to cooling system - enabled laser to be operated reliably and with greater stability at high output levels over long periods of time and with reduced risk of optical damage.

CTF2 probe beam operated all year using the Cs_2Te photo-cathode prepared in situ in December 2001 using preparation chamber connected to RF gun - clearly demonstrated technical feasibility of in-situ preparations of Cs_2Te photo-cathodes with QE's of 0.5% at 262 nm, and lifetimes of several months operating in electric fields of ~ 70 MV/m.

Development studies to improve QE of photocathodes - continued in PC lab.
16 new Cs_2Te PC's produced using new co-evaporation method using different sub stratum materials - average QE measured in DC gun was ~ 15%.

More - CTF2

11 of these PC's tested in CTF2 DB gun - best sub stratum material found to be Cu.

With gun operating at 100 MV/m - average QE's and lifetimes found to be high.

QE as usual decreased following two exponentials; 1st starting from 8 % was very fast (average of 8.4 h) whereas 2nd starting from ~ 4.4 % much slower (average of 302 h).

Used mainly as high-gradient test stand for testing of 30 GHz accel. structures.

In 2002 - instrumentation and measurement techniques for RF breakdown identification and location improved by refining light spectrum and ultrasonic measurements.

However 10-20% discrepancy in average accel. gradient when derived from measured RF power and measured energy gain has not been either identified or resolved.

More - CTF2

Following four accelerating structures tested :

1. An all Cu, diamond turned, brazed, $2\pi/3$ phase advance, 3.5 mm aperture, v_g/c = 4.6%, 30 cell (100 mm long) structure.

2. A W-iris, Cu-cell wall, clamped, v_g/c = 4.6%, $2\pi/3$ phase advance, 3.5 mm aperture, 30 cell structure with geometry very close to Cu structure.

3. A Mo-iris, Cu-cell wall, clamped, $2\pi/3$ phase advance, 3.5 mm aperture, v_g/c = 4.6%, 30 cell structure with geometry identical to W-iris structure

4. A W-iris, Cu-cell wall, clamped, $\pi/2$ phase advance, 4.0 mm aperture, v_g/c = 7.5%, 36 cell (90 mm long) structure.

These particular structures chosen to gather as much information as possible during last year of CTF2 op. concerning HG properties of different geometries and materials.

More - CTF2

All structures had 0.85 mm thick irises (compared to 0.55 mm in past tests) with ratios of peak surface electric field to peak accelerating gradient of 2.2.

All structures had identical 'mode launcher' couplers with surface electric fields at least 20% lower than anywhere in rest of structure - guaranteed that couplers neither limited nor complicated testing - structures tested in vacuum can for best vacuum and minimum experimental turn-round time.

All structures conditioned with 15 ns RF pulses by maintaining nearly continuous, but controlled, level of breakdown - breakdowns were identified by measurements of emitted currents, vacuum activity and missing RF energy.

Cu structure conditioning saturated at peak accel. gradient of 120 MV/m (110 MV/m average, 260 MV/m peak surface) - W $2\pi/3$ structure conditioning stopped (due to limited testing time) at peak accel. gradient of 150 MV/m (125 MV/m average, 340 MV/m peak surface) - Mo structure conditioning stopped (due to limited testing time) at peak accel. gradient of 193 MV/m (153 MV/m av - 426 MV/m peak surface).

More - CTF2

Preliminary inspection of interior of structures using an endoscope - only allows descriptive surface and geometrical analysis - showed copper structure slightly eroded. W and Mo structures - undamaged (no removal of material) but surface finish clearly modified by multiple breakdowns.

W $\pi/2$ structure conditioned quickly to 130 MV/m average accel. gradient - performance then quickly deteriorated - explanation for counter-performance - W irises of this structure - made from rolled sheet – cheaper - but strongly layered structure - outer layers separated when thermally shocked by repeated breakdown.
Irises of $2\pi/3$ structure made from forged bars - more homogeneous and stronger.

Although these HG results - very encouraging - stressed gradients achieved with 15 ns pulses - for CLIC pulse length of 150 ns achievable gradient may be somewhat lower. 15 ns pulse length corresponds to maximum electron bunch train that CTF2 can produce.

More - CTF2

In attempt to obtain some indication of pulse length dependence on max achievable gradient before CTF2 closure at end of year - novel RF ‘pulse stretcher’ to double pulse length - conceived, designed and built in record time

Stretcher used to condition Cu structure with one million 30 ns pulses - already conditioned with one million 15 ns pulses – the encouraging result - same 120 MV/m gradient was achieved for both pulse lengths.

Unfortunately not enough power available to use stretcher with W and Mo structures.

Finally - structure tests with probe beam - revealed mode-launcher longitudinal mode at ~ 34 GHz - coupled strongly to beam.

Mode was of no consequence for high-power testing but might be a problem for CLIC.

EST contributions to high-gradient test and development program

Very fruitful collaboration between CLIC Structures Group and Surface and Material Technologies Group of the EST Division.

- Surface analysis/high-resolution imaging of irises before and after HG testing (Cu, W and Mo structures)
- Investigation of properties of alternative materials to copper (procurement of a large single-crystal W disc)
- DC spark-gap tests to investigate factors affecting breakdown, arc resistance and surface damage, and alternative materials
- Cleaning and brazing

- First look at equipment and feasibility of making some laser induced pulse surface heating tests

CTF3

A large fraction of CLIC resources again this year devoted to CTF3.
This facility being built in collaboration with Frascati, LAL, SLAC and Uppsala.

Preliminary Phase

In 2002 - major milestone reached with successful completion of Preliminary Phase.

Main goal - demonstrate scheme of electron pulse compression and bunch frequency multiplication by factors 4 and 5 at low bunch charge, using injection by RF deflectors into an isochronous ring - for this purpose - former-LPI complex modified in 2001 – 1st commissioning period ended with circulating beam in ring for 1st time on 7th Dec 2001.

Beam experiments resumed again in April -with total of 17 operating weeks in 2002.

From an organisational point of view - "operation" and "shut-down" periods alternated to give time to analyse data and prepare new measurements.

More -Preliminary Phase

First weeks used to make more precise measurements of optics of linac, injection line and ring prior to installation of RF kickers - new measurements showed very good agreement with MAD model.

New way of measuring tune of ring also implemented - as opposed to more standard method - based on spectral analysis of BPM signal of accumulated beam - new one based on FFT of beam trajectory after injection - enables direct tune measurement to be made of an isochronous ring - in which beam accumulation is impossible.

CERN small-aperture RF deflectors installed in ring in May - and after a re-optimization of injection process – 1^{st} combination of 4 pulses demonstrated on 18^{th} June - the RF frequency in linac and deflector then increased by 120 kHz, as required for combination by a factor 5 - this obtained on June 21^{st}.

Two CERN deflectors then replaced by new ones - designed and built by Frascati for CTF3 nominal phase, which have larger aperture (40 mm dia instead of 21 mm), and are better adapted to high-beam-current operation. These deflectors performed very well.

More -Preliminary Phase

A systematic set-up procedure for combination process - devised and tested.

Application of this procedure and larger acceptance enabled bunches to be combined very efficiently with no beam losses - measurements of time structure of combined bunch train with 3ps-resolution streak camera showed - bunch phases after combination fell within CTF3 specification.

New RF phase monitor - developed by University of Uppsala for CTF3 nominal phase - installed in ring and tested - full study of collected data is in progress, but preliminary analysis shows qualitative agreement with expectations and indicated such a device can be useful for future operation.

Nominal phase injector system

Commissioning of thermionic injector - foreseen for Spring 2003 - consists of electron gun working at 140 kV - followed by bunching system - cleaning chicane for removal of low energy particles and 2 TW accelerating structures.

Complex beam diagnostics system required - consisting of WCM's, a capacitive current monitor, BPM's, a SEM grid and a TCM monitor.

Work at LAL on HV equipment for gun - advancing well - all components ordered. Triode assembly provided by SLAC - mounted on test stand at LAL and preliminary tests with beam are underway to demonstrate newly developed HV pulser circuit working correctly.

Design of 2 pre-bunchers at LAL - finished and fabrication under way.

17-cell TW buncher been designed and built at CERN and extensively tested with low power RF - after final adjustments and addition of an asymmetrical coupler cell to avoid transverse deflections of beam - structure now ready for brazing.

More - Nominal phase injector system

2 accelerating structures already available - one is of TDS type - other SICA type. Both constructed at CERN as prototypes for Drive Beam Accelerator.

Wherever possible equipment and components from former-CTF2 and former-LPI will be used in CTF3 – the procurement and fabrication of all other items on schedule.

CTF3 beam characteristics such that new designs, or substantial mods to existing beam diagnostic equipment – required - work progressed well and fabrication started.

After evaluating prototype cards - decided to use modern fast digital data acquisition systems lately become available for beam diagnostic equipment - same system will be used for other applications including low power RF system.

In parallel with all this work - been necessary to make mods and additions to : controls system, to reconfigure many of power converters, to build a new 3 GHz RF distribution system, and to fabricate several large water-cooled focusing solenoids.

Photo-injector studies

Studies by RAL of laser-driven PI as alternative to thermionic injector - shown this option is technically feasible with technology available today at reasonable cost.

Initial laser power estimates revised due to : new developments in preparation of PC's leading to significant increases in QE - and to improved IR/UV conversion efficiency. This enabled power of pumping diodes of last amplifier to be reduced from 60 kW to 30 kW for CLIC - and from 33 kW to 15 kW for CTF3.

Validation test for some parts of this system - planned on CTF2 DB line in May 2003.

Aim of this PILOT (Photo Injector Long Train) test - demonstrate reliable production of long electron pulse train with intensity and shot-to-shot variation of ~ 1%.

Due to : limited power from laser amplifier (5 kW), beam-loading effects in RF gun, and limitations of beam diagnostic equipment - will only possible to produce 250 MHz, 0.2 nC/bunch, 1.4 μs train of 350 bunches.

Test should enable accurate definition of equipment needed for CTF3.

Nominal phase drive-beam accelerator

This is going well - optical layout of DBA been frozen - design layout completed - detailed mechanical design and fabrication of components started.

A CERN-built full-size prototype SICA structure successfully tested with input powers of 32 MW and 65 MW respectively at pulse lengths of 2 μs and 500 ns - shorter pulse foreseen for production of estimated 100 MW of peak power at 30 GHz.

(reminder : nominal power 30 MW for 1.5 μs).

Inner surface of SICA inspected after testing - found to be completely undamaged.

Prototype of series production of 18 SICA structures by German firm ACCEL - delivered - and tested with input powers of 35 MW and 70 MW respectively at pulse lengths of 2 μs and 500 ns.

CERN-built TDS structure - modified to remove one cell which had vacuum leak. After re-brazing - structure quickly conditioned back up to nominal power of 35 MW, and up to 71 MW at pulse length of 500 ns.

More - Nominal phase drive-beam accelerator

DBA will be powered by former LIL klystrons and will use most of former LIPS pulse compression systems - these systems have to produce 1.5 μs long flat top in both amplitude and phase – a scheme to achieve this using a pre-programmed RF phase ramp to klystron - developed - and tested to nominal RF power level.

A new single Barrel Open Cavity (BOC) pulse compression system been developed to complement and partly replace existing two coupled cavity LIPS systems.

A prototype - built - and successfully tested to nominal power - and series fabrication of five of these systems is underway at CERN.

INFN (Frascati) activities

Full technical responsibility for delay loop, transfer lines and bunch compressors been given to INFN/Frascati - responsibility includes basic design and associated hardware.

Design of optics is very well advanced - and on hardware side - prototype components being fabricated.

Two 3 GHz RF deflectors for Combiner Ring already at CERN - were successfully used during operation of Preliminary Phase.

Design of vacuum components and BPM's that take into account the very small impedance budget of the ring ($Z/n \sim 0.4\ \Omega$) been completed and fabrication of prototypes is underway.

The CERN/INFN Collaboration MoU for CTF3 has to date NOT been signed – advancing well in spite of this.

New CTF3 RF power sources

Two new 1.5 GHz RF power sources required for CTF3.

1^{st} is large bandwidth (about 150 MHz) 500 kW device to drive sub-harmonic buncher
2^{nd} is 20 MW narrow-bandwidth device to drive RF deflectors in delay loop.

Design by industry of narrow-band klystron completed and fabrication underway.
No action on large-bandwidth device has yet been taken.

CTF3 timing studies

As far as timing is concerned - old LIL/EPA system found to be unsuitable for CTF3 (different operational constraints, need for more versatility, and because of its age).

New timing system therefore proposed - and development of both new architecture and new equipment completed, and fabrication of remaining hardware is underway.

CTF3 30 GHz power generation

A careful beam dynamics simulation of size and stability of a 7A 50 MeV beam at an intermediate position in CTF3 linac allowed definition of aperture, and in consequence, final RF design of 30 GHz power-generating PETS structure.

A limit of 150 MV/m for max peak surface field imposed to reduce risk of breakdown. An output power of 100 MW targeted for this structure.

CTF3 Collaboration meeting

In 2002, was only one CTF3 collaboration meeting.
Took place in June at CERN and attended by all collaborating institutions.

Very impressive progress was reported by all concerned.

Possible future uses of the CTF3 beam

Proposals to use CTF3 as general-purpose test beam facility beyond present goals of drive beam generation and 30 GHz power testing made in context of ICFA Nanobeam workshop which took place in Lausanne in September.

Ideas included :

(i) a final focus test stand
(ii) plasma applications and high-gradient studies
(iii) feedback studies
(iv) an X-ray source
(v) testing of beam diagnostic equipment
(vi) wakefield studies
(vii) even more advanced topics

After discussion in CSC - decided that although very interesting, no decision would be taken on these proposals for the time being.

As you can see – there is no shortage of new ideas.

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