STATUS OF A 3 TEV COMPACT LINEAR COLLIDER (CLIC)

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Abstract

The current progress of the CLIC program will be reviewed. The resent experimental results of the CLIC Test Facility (CTF3) operation will be presented.

INTRODUCTION

It is well recognized that CLIC is the only known viable scheme for a linear collider in the Multi-TeV energy range. The physics for CLIC case is well established [1].

Compared with other linear collider schemes CLIC has three very distinct features:[2]: high frequency (30 GHz) and high accelerating gradient (150 MV/m) in a normal conducting accelerating structure allow for a compact machine. The second CLIC key ingredient is two beam-acceleration which provides high efficiency for the rf power production at a high frequency and a simple tunnel without high power active elements. It should also be mentioned that the central injector complex and modular design make it possible to build CLIC in stages.

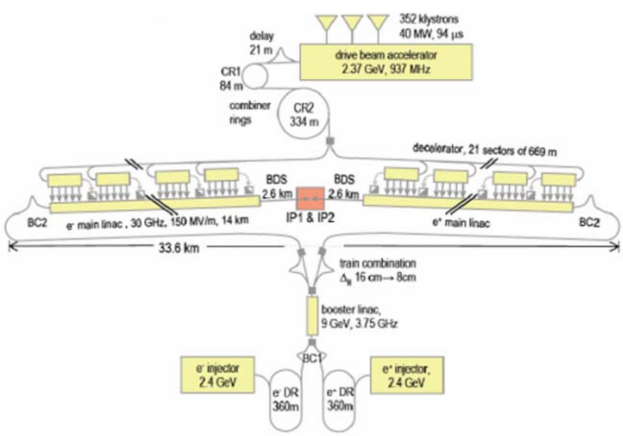

Figure 1: CLIC overall layout.

In 2003 the 2nd ILC Technical Review Committee identified the technological issues specific to each of the existing LC projects of that time [3]. These issues were grouped into four classes following their priorities:

- R1: R&D needed for feasibility demonstration of the machine
- R2: R&D needed to finalize the design choices and insure reliability of the machine
- R3: R&D needed before starting production of systems and components
- R4: R&D desirable for technical or cost optimization

Following this classification, the three R1 and six R2 issues were identified in the TRC report as the CLIC technology related. In 2004 the "CLIC Accelerated R&D program" was established [4] with a mandate to demonstrate all of the key feasibility issues (R1 and R2) of the CLIC scheme before 2010 within the framework of a broad International Collaboration. In order to do that, the CLIC Test Facility (CTF3) is now under construction/commissioning in CERN. The remaining technology-independent feasibility issues are studied in the framework of EUROTeV and in close collaboration with ILC [5].

CTF3 SCIENTIFIC PROGRAM

The three major components of CTF3 will be fully operational in 2009: drive beam generation complex, CLIC experimental area (CLEX) and 30 GHz high gradient test stand, see Fig. 2. In the following we will discuss the experimental program in CTF3.

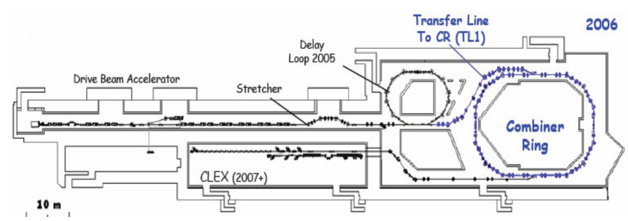

Figure 2: CTF3 general layout.

CLIC accelerating structure program

The following CLIC feasibility issues will be demonstrated within the framework of the CLIC accelerating structure program:

- R1.1: Test of damped accelerating structure at design gradient and pulse length.
- R2.1: Development of structures with hard breaking materials (Mo, W …).

In 2004 a dedicated 30 GHz rf power production station was build in CTF3 to carry out very intense accelerating structure testing program, see Fig 3. The core of this station is a special, 1.5 meter long power extraction structure, which generates tens of MW 30 GHz rf power pulses by interaction with the 3 GHz, 5A drive beam from the CTF3 linac.

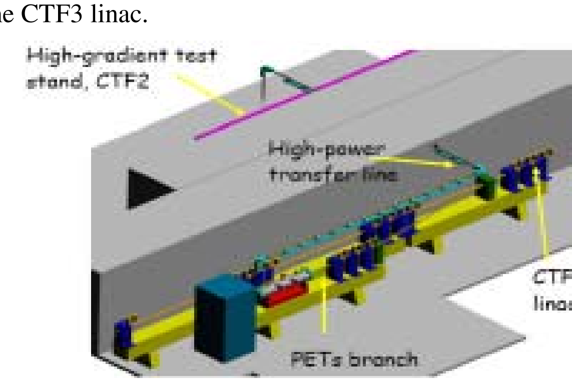

Figure 3: 30 GHz rf power production station.

This power is then delivered to the high gradient test area via a 17 meter long, low loss rf transfer line. In 2006 the rf power station was routinely producing and delivering 30 GHz RF pulses to the high gradient test area of up to 70 MW, 70 ns [6]. The test area is equipped with a special high power attenuator, to manipulate the rf power level without changing the drive beam settings and unique rf/vacuum valve, to replace DUT without breaking the vacuum in the rest of the system.

The new CLIC Hybrid Damped Structure (HDS) design [2] provides strong damping of the transverse wakes and is optimized to reduce, at given gradient, surface electric and magnetic fields. The new structure geometry, see Fig 4 (right), enables new production technology – precision high speed milling, and avoids brazing procedures. Another innovation used in HDS is a bi-metallic technology; see Fig 4 (left). To reach a very high gradient it is proposed to use spark resistant refractory metals (tungsten, molybdenum…) in the area of the strong electric field and a special copper alloy (CuZr) in the area of the strong magnetic field to increase fatigue resistance due to the pulsed heating .

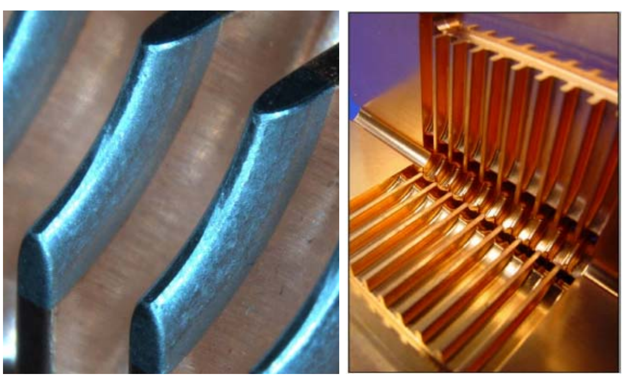

Figure 4: The first bi-metallic HDS machining prototype (left). The new HDS geometry (right). Three quadrants of four are mounted together.

Drive beam generation program

The two-beam acceleration is the other key issue of the CLIC scheme. In this scheme the high intensity, low energy drive beam produces rf power to accelerate the main beam. The CLIC drive beam is prepared in a drive beam generation complex using current/frequency multiplication technique with rf deflectors and combiner rings [2]. The CTF3 drive beam generation complex should demonstrate the validity of this technique following another R1 CLIC feasibility issue:

- R1.2: Validation of drive beam generation scheme with fully loaded linac operation.

There are five components comprising the CTF3 drive beam generation circuit: drive beam accelerator, stretching chicane, delay loop, transfer line and combiner ring. Next we will present the most important results achieved during CTF3 operation to-date.

1) The drive beam accelerator operation in a fully beam loaded regime was first demonstrated in 2003 [7], see Fig. 5. The efficiency of acceleration is above 95 %. Considering refrigerator power this is more efficient than acceleration in a superconducting cavity. The beam is kept very stable despite of the high current long pulse length operation.

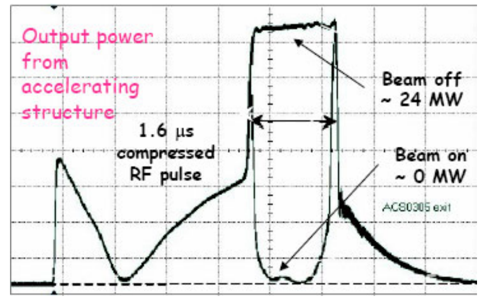

Figure 5: The rf pulse envelopes at the output of the drive beam accelerating structure with and without beam.

2) The stretcher chicane is needed to increase the bunch length in order to reduce the effects of CSR in the subsequent delay loop. The first test were successfully performed in 2004 [8], see Fig. 6.

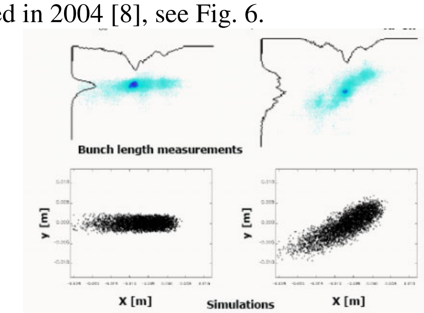

Figure 6: The beam streak camera images before (left) and after (right) chicane.

3) The first drive beam current/frequency multiplication by a factor two was done with the delay loop early 2006 [9], see Fig. 7.

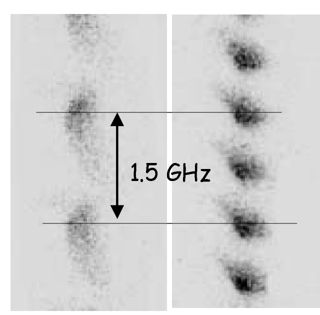

Figure 7: The beam streak camera images before (left) and after (right) delay loop.

The construction and commissioning of the transfer line and combiner ring and the first full scale multiplication by a factor 10 will be done in 2006.

CLIC experimental area (CLEX)

In 2007, the 15 GHz 35 A drive beam will be available for the newly constructed CLEX area. The remaining R1-2 CLIC technology issues will be the subjects of the experimental program in CLEX:

- R1.3: Design and test of damped ON/OF power extraction structure.
- R2.2: Validation of stability and losses of drive beam decelerator.
- R2.3: Test of relevant linac sub-unit with beam.

The CLEX will be equipped with a number of test stands: probe beam injector [10], Two Beam Test Stand (TBTS) and Test Beam Line (TBL) [11].

Together with the probe beam injector, the TBTS will be the full scale experiment to demonstrate two-beam acceleration with CLIC nominal parameters.

The CLIC Power Extraction and Transfer Structure (PETS) will be one of the most important rf components to be tested in CLEX. The CLIC PETS; see Fig. 8, is designed to produce a few hundred MW of rf power, interacting with a CLIC drive beam. It has to provide strong damping of the transverse wakes and be able to cancel rf power production locally in the case of an rf breakdown [12].

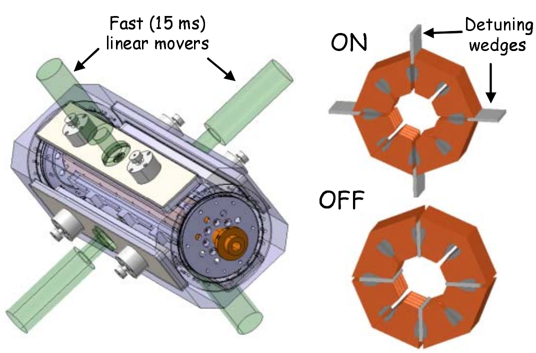

Figure 8: The CLIC PETS with damping features and with ON/OF mechanism equipment.

The TBL aims at demonstrating the stable deceleration of the CTF3 drive beam. It will allow to benchmark computer codes used for the CLIC decelerator design. The most challenging parameter there is the drive beam energy, which even initially is lower than the final energy of the CLIC drive beam. During nominal operation, 2.6 GW rf power will be generated along the decelerator.

CLIC/CTF3 International collaboration

Following the plans to complete the CLIC feasibility study by 2010, the first CLIC Collaboration Meeting was held in CERN on the 19 May 2004. The aim of this collaboration was clearly identified [13]:

"An accelerated R&D programme of CLIC was approved by the CERN Council in March 2004…Extra resources are required to complete the programme which is presently not available at CERN, and laboratories are invited to participate in the programme by taking full technical responsibility for part, complete or several work packages and/or providing voluntary contributions "a la carte", in cash, in kind and/or in man-power… ".

In 2006, more than 20 laboratories, institutes and industrial companies were already participating in the CLIC/CTF3 collaboration. CLIC R&D activity is also a part of EU funded EUROTeV and ESGARD programs.

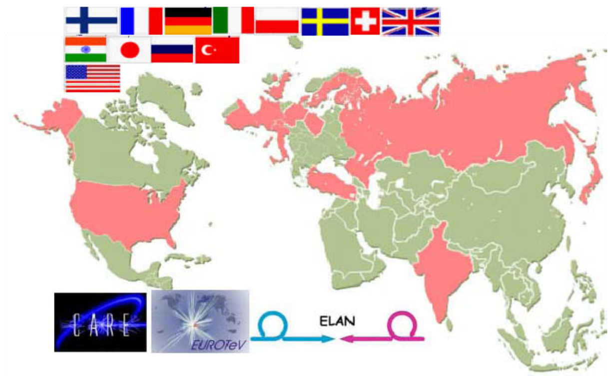

Figure 9: CLIC/CTF3 worldwide collaboration.

CONCLUSION

CLIC is the only viable scheme to extend Linear Collider energy into Multi-TeV range. However the CLIC technology is not matured yet and requires challenging R&D. The experimental program of the CTF3 international collaboration has been realigned to demonstrate all CLIC key feasibility issues by 2010. A number of very promising results has been already achieved in CTF3 to-date.

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