Status of a 3 TeV Compact LInear Collider (CLIC)

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Basic features of CLIC

Present mandate: To demonstrate all key CLIC feasibility issues by 2010

- High acceleration gradient (150 MV/m)

- “Compact” collider - overall length < 40 km
- Normal conducting accelerating structures
- High RF frequency (30 GHz)

Two-Beam Acceleration Scheme

- Capable to reach high frequency
- Cost-effective & efficient (~ 10% overall)
- Simple tunnel, no active elements

Central injector complex

- “Modular” design, can be built in stages

Common to Multi-TeV Linear Colliders
- Generation and preservation of ultra-low emittance beams
- Beam delivery and IP issues
- Alignment and stability

Specific to the CLIC technology
- 30 GHz components
- Efficient RF power production by Two Beam Acceleration

CLIC aim: Develop technology for e+/e- Linear Collider with ECM from 1 to 5 TeV

I. Syratchev, RUPAC 2006, Novosibirsk, September 11
In 2003 the ILC Technical Review Committee identified the technological issues specific to each of the existing LC project of that time. 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 designchoices 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 the CLIC mandate up to 2010, the CLIC technology related issues listed in ranking groups R1 and R2 are the subjects that should be demonstrated in the CLIC Test Facility (CTF3).
**CLIC technology issues**

**Accelerating beam related issues**
R2.5 Effect of coherent synchrotron radiation in bunch compressor.
R2.6 Design of an extraction line for 3 TeV c.m.

**L-Band High power RF source:**
R2.4 Validation of drive beam 40 MW, 937 MHz, 100 μs Multi-Beam Klystron.
Feasibility study done - need development by industry

**RF power production and acceleration**
R1.3 Design and test of damped ON/OFF power extraction structure.
R2.3 Test of relevant linac sub-unit with beam.

**Drive beam generation:**
R 1.2 Validation of drive beam generation scheme with fully loaded linac operation.

**Drive beam accelerator Delay Loop Combining ring**

**30 GHz RF power production and RF components test area**

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

**Machine reliability issues:**
R 2.2 Validation of stability and losses of DB decelerator; Design of machine protection system.

The CTF3 program covers all CLIC technology related issues
High gradient test stand is equipped with RF/vacuum valve and high power RF attenuator.

The special low-losses Transfer Line provides high power transport with efficiency ~ 87% at a distance of 17 meters.

Special power extraction structure can routinely produce and deliver to the high gradient test area 70 MW, 70 ns 30 GHz RF pulses.
**Geometry**

The CLIC Hybrid Damped Structure provides strong attenuation of the transverse wakes ($Q_{ext} \approx 6$) and optimized to reduced, for the given gradient, surface electric and magnetic fields. This approach enables a new production technology – precision high speed milling, which allows to avoid brazing procedures.

**Materials and technology.**

To reach very high gradient it is proposed to use spark resistant refractory metals (W, Mo...) in the area of the strong electric field and special Cu alloys (CuZr) in the area of the strong magnetic field to increase fatigue resistance due to the pulsed heating.

**Complimentary experimental programs in CERN**

- DC spark tests
- Ultrasonic testing for high cycling ($10^{11}$) fatigue data

**Surface modification of the iris tip after RF processing for the two different materials**

- Mo
- Cu

**Remaining issues:**

- Surface preparation
- Surface treatment (laser, ion implantation and etc.)
Drive beam generation (R1.2)

Major results of CTF3 operation up to date

- Fully loaded operation in CTF3 Linac
- Bunch stretching chicane
- Bunch frequency/current multiplication x2 in a delay loop
- Streak camera image before and after delay loop
- Transfer Line#1 and Combiner Ring will be commissioned in 2006

Full Beam Lading demonstrated: > 95% Efficiency. Beam is very stable.
In interaction with drive beam, the CLIC PETS should produce and efficiently extract few hundred of MW RF pulsed power. In itself PETS is a periodically corrugated structure with low impedance (big a/\lambda).

To provide stable, without losses, drive beam transport through the whole decelerator, very strong damping of the transverse wakes is absolutely necessary. This is done via longitudinal slots terminated with broadband loads.
The construction of the CLEX building will be finished in 2006.

In 2007 the 35 A, 15 GHz, 150 MeV drive beam will be available in a CLEX area. There will be three major experimental stands installed:

- **Drive beam**
- **Probe beam injector**
- **Two-beam test stand (R2.3)**

Test Beam Line (R2.2)

Here the 150 MeV, 35 A drive beam should be decelerated by ~ 55%. The total amount of RF power to be produced ~ 2.6 GW!

Probe beam injector

0.5nC/bunch, ~200 MeV

All experiments in CLEX should be fully operational in 2009!
CTF3 scientific program

SCHEDULE WITH EXTRA RESOURCES

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In 2006 more than 20 scientific labs and industrial companies in 13 countries were participating in CLIC/CTF3 collaboration. And we believe this number will grow...
There is a long standing collaboration between CLIC/CTF3 and three Russian laboratories:
- BINP, Novosibirsk
- JINR, Dubna
- IAP/Gycom, Nizhniy Novgorod
Superconducting wiggler for the CLIC damping ring

Quadrupoles and sextupoles for CTF3 combining ring and transfer lines
CTF3-CTF2 low-losses RF transfer line (17m)

Various high power waveguide components

Laser driven high power RF phase switch (to be tested in 2006)

30 GHz resonant delay line pulse compressor

IAP/Gycom, Nizhniy Novgorod
Experimental study of copper surface fatigue due to the cycling RF pulsed heating (together with IAP)

Automatic control for conditioning of the 3 GHz and 30 GHz high power structures and components.
CONCLUSIONS

- CLIC is the only possible scheme to extend the Linear Collider energy into the Multi-TeV range
- CLIC technology is not mature yet, requires challenging R&D
- Very promising results were already obtained in CTF II and in the first stages of CTF3
- Remaining key issues clearly identified (ILC-TRC)
- Technology independent key issues studied within EuroTeV and in close collaboration with ILC
- CLIC-related key issues addressed in CTF3 by 2010

Aim to provide the High Energy Physics community with the feasibility of CLIC technology for Linear Collider in due time, when physics needs will be fully determined following LHC results

Safety net to the SC technology in case sub-TeV energy range is not considered attractive enough for physics