The next energy-frontier accelerator
a linear $e^+e^-$ collider?

G. Geschonke
CERN, Geneva, Switzerland
### Muon Collider

#### Collider Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C of m Energy</td>
<td>1.5</td>
</tr>
<tr>
<td>Luminosity</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>$10^{34}$ cm$^2$sec$^{-1}$</td>
</tr>
<tr>
<td>Muons/bunch</td>
<td>2</td>
</tr>
<tr>
<td>Ring circumference</td>
<td>3</td>
</tr>
<tr>
<td>Beta at IP = $\sigma_z$</td>
<td>10</td>
</tr>
<tr>
<td>rms momentum spread</td>
<td>0.1</td>
</tr>
<tr>
<td>Required depth for $\nu$ rad</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>135</td>
</tr>
<tr>
<td>Repetition Rate</td>
<td>12</td>
</tr>
<tr>
<td>Proton Driver power</td>
<td>$\approx 4$</td>
</tr>
<tr>
<td>Muon Trans Emittance</td>
<td>25</td>
</tr>
<tr>
<td>Muon Long Emittance</td>
<td>72,000</td>
</tr>
<tr>
<td></td>
<td>72,000</td>
</tr>
</tbody>
</table>

#### Neutrino Factory and Muon Collider Collaboration (NFMCC)

- R. B. Palmer (BNL)
- PAC09
- 5/5/09
- Vancouver

- Very active R&D
- Time line: ➔ 2028

- 8 GeV SC Linac
- Main Injector to 60 GeV
- Hg Target
- 20 T Capture Solenoid
- Phase Rotation to 12 bunches
- Linear Transverse Cooling
- 6 D Cooling
- Merge 12 to One Bunch
- 6 D Cooling
- Transverse Cooling in 50 T
- Linac
- RLA(s)
- Pulsed Synchrotron(s)
- Collider Ring 1.5 / 4 TeV

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**Linear Collider base-line**

**LEP: 209 GeV**

**next Electron-Positron Collider**
- Centre-of-mass-energy: \(0.5 - 3\) TeV
- Luminosity: \(>2 \times 10^{34}\)

**Physics motivation:**
"Physics at the CLIC Multi-TeV Linear Collider: report of the CLIC Physics Working Group,“
CERN report 2004-5

Storage Ring not possible, energy loss \(\Delta E \sim E^4\)

\(\Rightarrow\) two linacs, experiment at centre

- total energy gain in one pass: **high acceleration gradient**
- beam can only be used once: **small beam dimensions at crossing point**

Boundary conditions: site length
Power consumption
In 1999 ICFA issued a statement on Linear Colliders, ..... that there would be compelling and unique scientific opportunities at a linear electron-positron collider in the TeV energy range. Such a facility is a necessary complement to the LHC hadron collider now under construction at CERN.

Two options: ILC - CLIC

Collaboration on common issues
Basic relation

\[ L = \frac{n_b \times N^2 \times f_{\text{rep}}}{A} H_D \quad \rightarrow \quad L = \frac{P_{\text{beam}}}{4 \times \pi \times E_{\text{cm}}} \times \frac{N}{\sigma_x \times \sigma_y} H_D \]

\( n_b \): bunches / train
\( N \): Particles / bunch
\( A \): beam cross section at IP
\( H_D \): beam-beam enhancement factor

⇒ optimization process:

- efficiency
- Mains power consumption
- site length
- cost
Particle acceleration using RF fields in cavity resonators

accelerating voltage \[ U = \sqrt{\frac{R}{Q \omega W}} \]

\[ W = \frac{Q}{\omega} P \]

\( W \): stored RF energy

\( P \): RF power

Very high \( Q \) \(\Rightarrow\) small RF power to obtain accelerating voltage.
only power taken by beam needs to be replaced.

Superconducting cavities: \( Q \) about \(10^{10}\)
Cu cavity: about \(10^4\)
Superconducting RF

\[ R_s = R_{BCS} + R_{Res} \]
\[ R_{BCS} \sim \frac{\omega^2}{T} e^{-\frac{T_c}{T}} \]

losses not zero!
powerful cryogenics system needed.

total operating power for cryogenics: 37 MW
(includes also magnets e.t.c.)

Ponderomotive oscillations
(coupling of RF energy to mechanical oscillation)
Solutions have been demonstrated
(Flash FEL at DESY)

maximum fields are limited

9-cell NB cavity

I. Ben-Zvi
Basic differences ILC-CLIC

ILC: Superconducting RF

500 GeV

accelerating gradient: 31.5 MV/m
35 MV/m target

RF Peak power: 0.37 MW/m, 1.6 ms, 5 Hz
RF average power: 2.9 kW/m

total length: 31 km
site power: 230 MW

Beam structure:

particles per bunch: 20 * 10^9
2625 bunches / pulse of 0.96 ms

CLIC: normal conducting copper RF

3 TeV

100 MV/m

RF Peak power: 275 MW/m, 240 ns, 50 Hz
RF average power: 3.7 kW/m

total length: 48.4 km
site power: 392 MW

Beam structure:

particles per bunch: 3.7 * 10^9
312 bunches / pulse of 156 ns

bunch spacing 369 ns 0.5 ns
The ILC Reference Design

- 200-500 GeV centre-of-mass
- Luminosity: $2 \times 10^{34}$ cm$^{-2}$s$^{-1}$
- Based on accelerating gradient of 31.5 MV/m (1.3GHz SCRF)

$N.Walker$
ILC Reference Design

Electrons

Positron source

Detectors

Electron source

150 GeV

Main Linac

Damping Rings

Main Linac

8/9 cavities

SC cavity

N. Walker

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RDR Baseline Tunnel Layout

Two 4.5 to 5.5 m diameter tunnels spaced by ~7 m.

Accelerator Tunnel
Penetrations (every ~12 m)
Service Tunnel

one klystron feeding
26 cavities
KLYSTRON CLUSTER CONCEPT

- RF power “piped” into accelerator tunnel every 2.5 km
- Service tunnel eliminated
- Electrical and cooling systems simplified
- Concerns: power handling, LLRF control coarseness

Same as baseline

2x35 klystrons housed in surface building.
350MW feeds via 0.5m diameter circular waveguide

Each tap-off from the main waveguide feeds 10 MW through a high power window and probably a circulator or switch to a local PDS for a 3 cryomodule, 26 cavity RF unit (RDR baseline).
### SCRF Technology Required

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>C.M. Energy</td>
<td>500 GeV</td>
</tr>
<tr>
<td>Peak luminosity</td>
<td>$2 \times 10^{34}$ cm$^{-2}$s$^{-1}$</td>
</tr>
<tr>
<td>Beam Rep. rate</td>
<td>5 Hz</td>
</tr>
<tr>
<td>Pulse time duration</td>
<td>1 ms</td>
</tr>
<tr>
<td>Average beam current</td>
<td>9 mA (in pulse)</td>
</tr>
<tr>
<td><strong>Av. field gradient</strong></td>
<td><strong>31.5 MV/m</strong></td>
</tr>
<tr>
<td># 9-cell cavity</td>
<td>14,560</td>
</tr>
<tr>
<td># cryomodule</td>
<td>1,680</td>
</tr>
<tr>
<td># RF units</td>
<td>560</td>
</tr>
</tbody>
</table>
SRF Test Facilities

NML facility
Under construction
first beam 2010
ILC RF unit test

TTF/FLASH
~1 GeV
ILC-like beam
ILC RF unit
(* lower gradient)

STF (phase I & II)
Under construction
first beam 2011
ILC RF unit test

A. Yamamoto
latest news:

- 20% improvement required for ILC

Cryomodule Gradient Progress

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B. Barish

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TDP Goals of ILC-SCRF R&D

Field Gradient
- 35 MV/m for cavity performance in vertical test (S0)
- 31.5 MV/m for operational gradient in cryomodule
  - to build two x 11 km SCRF main linacs

Cavity Integration with Cryomodule
- “Plug-compatible” development to:
  - Encourage “improvement” and creative work in R&D phase
  - Motivate practical ‘Project Implementation’ with sharing intellectual work in global effort

Accelerator System Engineering and Tests
- Cavity-string test in one cryomodule (S1, S1-global)
- Cryomodule-string test with Beam Acceleration (S2)
  - With one RF-unit containing 3 cryomodule
ILC R&D ongoing in several test facilities:

Beam tests at Flash
ATF2 at KEK: Fast kicker performance, final focus design tests
CesrTA: e-cloud mitigation
Damping Rings R&D

ILC R&D Board S3 Task Force (Damping Rings) identified 11 *very high priority* R&D items that needed to be addressed for the technical design:

- Lattice design for baseline positron ring
- Lattice design for baseline electron ring
- Demonstrate < 2 pm vertical emittance
- Characterize single bunch impedance-driven instabilities
- Characterize electron cloud build-up
- Develop electron cloud suppression techniques
- Develop modelling tools for electron cloud instabilities
- Determine electron cloud instability thresholds
- Characterize ion effects
- Specify techniques for suppressing ion effects
- Develop a fast high-power pulser

Targeted for CesrTA Effort with Low Emittance e⁺ Beam

Targeted for ATF Effort

Mark Palmer
**LET Summary for the KEK-ATF**

- **2 pm is a TDP R&D plan deliverable for ATF**
  - Recent demonstrations at light sources (eg., Diamond) may reduce the critical need for this demonstration
  - BUT, the lowest possible emittance is still needed for the ILC experimental R&D program (FII, ATF2,…)
- **4 pm achieved in 2004**
  - LET based on Orbit Response Matrix analysis with iterative correction of orbit dispersion and coupling
  - In 2007 the same tuning procedures yielded 20-30 pm
- **Critical Improvements**
  - DR magnet re-alignment in 2008
  - BPM upgrade program is in progress
- **April 2009:**
  - $\varepsilon_y \sim 10$ pm measured by XSR
  - $\varepsilon_y \sim 5$ pm measured by Laser Wire
Summary

• Low Emittance Tuning and Vertical Emittance Demonstration
  – Progress at both ATF and CesrTA towards emittance targets
  – Efforts underway for closer collaboration to achieve ultimate goals at both facilities
  – Low emittance tuning and measurement tools will be of general benefit to the accelerator community

• Beam Dynamics Issues – FII and EC
  – ATF will be in a position for the next series of FII measurements next month
  – CesrTA focus shifting from upgrades to experimental measurements
    • Mitigation studies underway – arrival of chambers with new mitigations from CERN, LBNL, SLAC over the next 2 months
    • Instability and incoherent emittance growth studies will be a principal focus for last half of 2009

• Fast Kickers
  – Beam demonstration effort continues at KEK
  – Development of a reliable fast pulser will continue to be a high priority R&D task

• Integration of R&D Results into the ILC Damping Rings Design
  – Improved projections (based on new measurements) for DR instabilities and emittance growth issues expected during 2010
  – Technical inputs for design (vacuum and feedback systems) available on the same timescale
  – Results applicable to both the 6.5 km baseline design as well as the proposed 3 km ring with fewer bunches
## ILC R&D plan

<table>
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<tr>
<th>Event</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td><strong>Technical Design Phase I</strong></td>
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<td><strong>Technical Design Phase II</strong></td>
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<td><strong>Siting</strong></td>
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<td>Main linac Configuration Alternative studies</td>
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<tr>
<td>Define acceptable site criteria</td>
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<td><strong>Collider Design Work</strong></td>
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<td>Definition of minimum machine</td>
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<td>Minimum machine &amp; cost-reduction studies</td>
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<td>Review TDP-II baseline</td>
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<td>Publish TDP-I interim report</td>
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<td>Prepare technical specifications</td>
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<td>Generate cost &amp; schedule</td>
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<td>Internal cost review</td>
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<td>Design and cost iteration</td>
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<td>Technical Design Report</td>
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<td>Cost &amp; Schedule Report</td>
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<tr>
<td>Project Implementation Plan Report</td>
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<tr>
<td><strong>Publication final GDE documentation &amp; submit for project approval</strong></td>
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</table>
CLIC = Compact Linear Collider
(length < 50 km)

CLIC parameters:
**Accelerating gradient:** 100 MV/m
RF frequency: 12 GHz

**64 MW RF power / accelerating structure**
of 0.233m active length
⇒ 275 MW/m

total active length for 1.5 TeV: **15’000 m**

Pulse length 240 ns, 50 Hz

**Efficient RF power production !!!!!**
Individual RF power sources?

→ Not for the 1.5 TeV linacs

Two Beam Scheme:
Drive Beam supplies RF power

• 12 GHz bunch structure
• low energy (2.4 GeV - 240 MeV)
• high current (100A)
The CLIC Two Beam scheme

Main Beam

Drive Beam
decelerator, 24 sectors of 876 m

2904 bunches
83 ps (12 GHz)

Time structure of Drive Beam

Bunch charge: 8.4 nC, Current in train: 100 A
CLIC Drive Beam generation

Accelerate long bunch train with low bunch rep rate (500 MHz) with low frequency RF (1 GHz) (klystrons)

interleave bunches between each other to generate short (280 ns) trains with high bunch rep rate (12 GHz)
The full CLIC scheme

CLIC 3 TeV

Not to scale!
Why 100 MV/m and 12 GHz?

**Optimisation: (A.Grudiev)**

**Structure limits:**
- RF breakdown – scaling
- RF pulse heating

**Beam dynamics:**
- Emittance preservation – wake fields
- Luminosity, bunch population, bunch spacing
- Efficiency – total power

**Figure of merit:**
- Luminosity per linac input power

**take into account cost model**

*after > 60 * 10^6 structures:*
**100 MV/m 12 GHz chosen,**
**previously 150 MV/m, 30 GHz**

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reference to conference contribution
CLIC Accelerating Module

Main Beam

Drive Beam

Transfer lines

ref: Germana Riddone
Accelerating structures

Objective:
- Withstand of 100 MV/m without damage
- Breakdown rate < 10^{-7}
- Strong damping of HOMs

Technologies:
Brazed disks - milled quadrants

Collaboration: CERN, KEK, SLAC

(W. Wünsch this conference)
Nominal performance of Accelerating Structures
Design@CERN, Built/Tested @KEK, SLAC

BDR(ACC)

\[ y = 3.0827 \times 10^{-19} \times e^{0.28174x} \]

BDR\_252nsec

Eacc are a little shifted artificially to show error bars clearly

BKD Rate for 230ns

SLAC

500hrs

250hrs

900hrs

1200hrs

KEK

CLIC target

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Power Extraction: PETS

Special development for CLIC

- Travelling wave structures
- Small R/Q: 2.2 kΩ/m
- 100 A beam current
- 136 MW RF @ 240 ns per PETS
- (accelerating structure: 15-18 kΩ/m) 0.21 m active length
- total number: 35’703 per linac

Status:
CTF3: up to 45 MW peak (3 A beam, recirculation)
SLAC: 125 MW @ 266 ns

ref: Igor Syratchev

8 Sectors
damped
on-off possibility
Getting the Luminosity ($>2 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$)

Beam size at Interaction Point (rms): $\sigma_x = 40 \text{ nm}$, $\sigma_y = 1 \text{ nm}$

Total site AC power: 392 MW

Issues:
- generating small emittance beams
- emittance preservation
- alignment and vibration control
- final focus (Beam Delivery System)

<table>
<thead>
<tr>
<th>jitter tolerances</th>
<th>Final Focus quadrupoles</th>
<th>Main beam quadrupoles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>$\sim 0.1 \text{ nm} &gt; 4 \text{ Hz}$</td>
<td>$\sim 1 \text{ nm} &gt; 1 \text{ Hz}$</td>
</tr>
<tr>
<td>Horizontal</td>
<td>$2 \text{ nm} &gt; 4 \text{ Hz}$</td>
<td>$5 \text{ nm} &gt; 1 \text{ Hz}$</td>
</tr>
</tbody>
</table>

Work ongoing,
Proof-of-principle:
 quadrupole stabilized to < 0.5 nm in vertical plane
CLIC has two damping rings each for $e^+$ and $e^-$
output DR: $\gamma \varepsilon_x = 381 / \gamma \varepsilon_y = 4.1 \text{ nm rad}$
for $4.1 \times 10^9$ particles at 2.4 GeV

DR design exists
Wigglers being developed, superconducting and normal conducting versions considered
1st phase: Initial operation
500 GeV conservative parameters

2nd phase: 500 GeV luminosity upgrade
500 GeV nominal parameters

3rd phase: 0.5 to 3 TeV energy upgrade
3 TeV conservative parameters

4th phase: 3 TeV luminosity upgrade
3 TeV nominal parameters

ILC
CLIC Nominal
CLIC Conserv

Luminosity (cm^{-2} sec^{-1})

Energy (TeV)
Beam emittances at Damping Rings

Horizontal Emittance ($\mu$rad-m)

- 0.1
- 1
- 10
- 100

Vertical Emittance ($\mu$rad-m)

- 0.001
- 0.010
- 0.100
- 1.000
- 10.000
- 100.000

- CLIC DR design
- CLIC 3 TeV
- CLIC 500 GeV
- NSLS II scaled
- ATF achieved
- ILC
- ATF Design
- SLS
- SLC

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Beam sizes at Collisions

R.M.S. Beam Sizes at Collision in Linear Colliders

Vertical Beam Size (nm)

Horizontal Beam Size (nm)

1000
100
10
1
0.1
10
100
1000

SLC
FFT
ATF2
CLIC 3 TeV
CLIC 500 GeV
ILC GeV 500

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## CLIC main parameters


<table>
<thead>
<tr>
<th>Center-of-mass energy</th>
<th>CLIC 500 G</th>
<th>CLIC 3 TeV</th>
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<tbody>
<tr>
<td><strong>Beam parameters</strong></td>
<td></td>
<td></td>
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<tr>
<td>Accelerating structure</td>
<td>502</td>
<td>G</td>
</tr>
<tr>
<td>Total (Peak 1%) luminosity</td>
<td>0.9(0.6)·10(^34)</td>
<td>2.3(1.4)·10(^34)</td>
</tr>
<tr>
<td>Repetition rate (Hz)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Loaded accel. gradient MV/m</td>
<td>80</td>
<td>100</td>
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<tr>
<td>Main linac RF frequency GHz</td>
<td>12</td>
<td></td>
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<tr>
<td>Bunch charge10(^9)</td>
<td>6.8</td>
<td>3.72</td>
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<tr>
<td>Bunch separation (ns)</td>
<td>0.5</td>
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<tr>
<td>Beam pulse duration (ns)</td>
<td>177</td>
<td>156</td>
</tr>
<tr>
<td>Beam power/beam (MWatts)</td>
<td>4.9</td>
<td>14</td>
</tr>
<tr>
<td>Hor./vert. norm. emit (10(^{-6})/10(^{-9}))</td>
<td>3/40</td>
<td>2.4/25</td>
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<tr>
<td>Hor/Vert FF focusing (mm)</td>
<td>10/0.4</td>
<td>8 / 0.1</td>
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<tr>
<td>Hor./vert. IP beam size (nm)</td>
<td>248 / 5.7</td>
<td>202 / 2.3</td>
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<tr>
<td>Hadronic events/crossing at IP</td>
<td>0.07</td>
<td>0.19</td>
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<tr>
<td>Coherent pairs at IP</td>
<td>10</td>
<td>100</td>
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<tr>
<td>BDS length (km)</td>
<td>1.87</td>
<td>2.75</td>
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<tr>
<td>Total site length km</td>
<td>13.0</td>
<td>48.3</td>
</tr>
<tr>
<td>Wall plug to beam transfert eff</td>
<td>7.5%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Total power consumption MW</td>
<td>129.4</td>
<td>415</td>
</tr>
</tbody>
</table>

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CLIC Test Facility CTF3

Provide answers for CLIC specific issues

⇒ Write CDR in 2010

Two main missions:

Prove CLIC RF power source scheme:
• bunch manipulations, beam stability,
• Drive Beam generation
• 12 GHz extraction

Demonstration of “relevant” linac sub-unit:
• acceleration of test beam

Provide RF power for validation of CLIC components:
accelerating structures,
RF distribution,
PETS (Power extraction and Transfer Structure)
CTF3 building blocks

Infrastructure from LEP

- 150 MeV e-linac
- 3.5 A - 1.4 μs
- 28 A - 140 ns
- 30 GHz test stand
- Delay Loop
- Combiner Ring
- CLEX (CLIC Experimental Area)
- TWO BEAM TEST STAND
- PROBE BEAM
- Test Beam Line
- Photo injector tests, laser
- magnetic chicane
- 10 m
- total length about 140 m

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CTF3 is scaled down from CLIC:

<table>
<thead>
<tr>
<th></th>
<th>CLIC</th>
<th>CTF3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Beam energy</td>
<td>2.4 GeV</td>
<td>150 MeV</td>
</tr>
<tr>
<td>compression /</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>frequency multiplication</td>
<td>(Delay Loop + 2 Combiner Rings)</td>
<td>(Delay Loop + 1 Combiner Ring)</td>
</tr>
<tr>
<td>Drive Beam current</td>
<td>4.2 A*24 ➞ 101 A</td>
<td>3.5 A*8 ➞ 28 A</td>
</tr>
<tr>
<td>RF Frequency</td>
<td>1 GHz</td>
<td>3 GHz</td>
</tr>
<tr>
<td>train length in linac</td>
<td>139 µs</td>
<td>1.5 µs</td>
</tr>
<tr>
<td>energy extraction</td>
<td>90 %</td>
<td>~ 50 %</td>
</tr>
</tbody>
</table>

CTF3 uses existing infrastructure from LEP injector:
- Building, infrastructure,
- 3 GHz RF power plant,
Delay Loop

Design and built by INFN Frascati

circumference 42 m (140 ns)
isochronous optics
wiggler to tune path length
(9 mm range)

1.5 GHz RF deflector
CTF3 Achievements

- DRIVE BEAM
- LINAC

- DELAY LOOP

- COMBINER RING

- 4 A – 1.2 μs
- 120 Mev

- RF pulse at structure input
- 1.5 μs beam pulse
- RF pulse at output

- 6 A

- 12 A
<table>
<thead>
<tr>
<th>SYSTEMS</th>
<th>Critical parameters</th>
<th>Relevant Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Beam Acceleration Structures:</strong></td>
<td>Average loaded gradient 100 MV/m total/flat-top pulse length 240/160 ns &lt; 3-10^-7 BR/(pulse*m) minimum average a/L 0.11 Long range wake ≤ 6 V/pC/m/mm</td>
<td>CTF2&amp;3 (2005-2010) Test Stand (2009-10) SLAC/NLTA SLAC/ASTA KEK/NEXT TF</td>
</tr>
<tr>
<td>Two Beam Acceleration and module integration:</td>
<td>Two Beam Acceleration at nominal parameters as given above for individual components Pulse shape accuracy 0.1%</td>
<td>CTF2&amp;3/TBTS (2004-10)</td>
</tr>
<tr>
<td><strong>Drive Beam Production</strong></td>
<td>100 Amp peak current 12 GHz bunch repetition frequency 0.2 degrees phase stability at 12 GHz 7.5 x 10^-4 intensity stability</td>
<td>CTF3 (2005-2010) CTF3/TBL (2009-10) X-FEL LCLS</td>
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<tr>
<td>- Beam generation and combination</td>
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<tr>
<td>- phase and energy matching</td>
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<tr>
<td>- Potential feedbacks</td>
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<tr>
<td><strong>RF power generation by Drive Beam</strong></td>
<td>90% extraction efficiency Large momentum spread</td>
<td>CTF3/TBL</td>
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<tr>
<td>- RF power extraction</td>
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<tr>
<td>- Beam stability</td>
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<tr>
<td><strong>Generation and Preservation of Low Emittances</strong></td>
<td>Emittances{nm}: H = 600, V = 5 Absolute blow-up{nm}: H = 160, V = 15</td>
<td>ATM, SLS, NSLSII Simulations LCLS, SCSS</td>
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<tr>
<td>Damping Rings, RTML and Main Linacs</td>
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<tr>
<td><strong>Main Linac and BDS Stabilization</strong></td>
<td>Main Linac : 1 nm vert. above 1 Hz; BDS: 0.15 to 1 nm above 4 Hz depending on final doublet girder implementation</td>
<td>CESRTA ATF2</td>
</tr>
<tr>
<td><strong>Operation and Machine Protection</strong></td>
<td>drive beam power of 72 MW @ 2.4 GeV main beam power of 13 MW @ 1.5 TeV</td>
<td>CTF3</td>
</tr>
<tr>
<td><strong>Beam-Beam Background</strong></td>
<td>3.8 x 10^9 coherent pairs</td>
<td>43</td>
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<tr>
<td>Detector</td>
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</tbody>
</table>
33 Institutes involving 21 funding agencies and 18 countries
### Beam structure:

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<tr>
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<th>ILC</th>
<th>CLIC</th>
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<tbody>
<tr>
<td>particles per bunch:</td>
<td>$20 \times 10^9$</td>
<td>$3.7 \times 10^9$</td>
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<tr>
<td>bunch spacing</td>
<td>369 ns</td>
<td>0.5 ns</td>
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<tr>
<td>2625 bunches / pulse of 0.96 ms</td>
<td>312 bunches / pulse of 156 ns</td>
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Luminosity Spectrum Reconstruction

- Luminosity Spectrum reconstruction is a challenging task
- One proposed method is to measure Bhabha angles
  \[ p_{\perp 1} = -p_{\perp 2} \Rightarrow \frac{p_1}{p_2} = \frac{\sin \theta_2}{\sin \theta_1} \]
- Initial transverse momenta could be different
  - is noticeable in ILC
  \[ \Rightarrow \text{needs to be studied for CLIC} \]
- Need model to separate the beams
- Simple test remix colliding beam particle energies
  \[ \Rightarrow \text{different spectrum} \]
  \[ \Rightarrow \text{correlations are important} \]
  \[ \Rightarrow \text{Further study needed} \]

Daniel Schulte
Electron positron pairs

Pair Spectrum

- ILC, CLIC at 3 TeV and CLIC at 0.5 TeV nominal parameters used
- Spectrum per bunch crossing shown

Daniel Schulte
ILC: IDAG (International Detector Advisory Group
Physics and Experiments Board

LOI’s

CLIC: Physics and detectors working group established
# ILC – CLIC collaboration

<table>
<thead>
<tr>
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<th><strong>CLIC</strong></th>
<th><strong>ILC</strong></th>
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<tbody>
<tr>
<td><strong>Physics &amp; Detectors</strong></td>
<td>L. Linssen, D. Schlatter</td>
<td>F. Richard, S. Yamada</td>
</tr>
<tr>
<td><strong>Beam Delivery System (BDS) &amp; Machine Detector Interface (MDI)</strong></td>
<td>D. Schulte, R. Tomas Garcia, E. Tsesmelis</td>
<td>B. Parker, A. Seriy</td>
</tr>
<tr>
<td><strong>Civil Engineering &amp; Conventional Facilities</strong></td>
<td>C. Hauviller, J. Osborne.</td>
<td>J. Osborne, V. Kuchler</td>
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<tr>
<td><strong>Positron Generation (new)</strong></td>
<td>L. Rinolfi</td>
<td>J. Clarke</td>
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<tr>
<td><strong>Damping Rings (new)</strong></td>
<td>Y. Papaphilipou</td>
<td>M. Palmer</td>
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<tr>
<td><strong>Beam Dynamics</strong></td>
<td>D. Schulte</td>
<td>A. Latina, K. Kubo, N. Walker</td>
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<tr>
<td><strong>Cost &amp; Schedule</strong></td>
<td>P. Lebrun, K. Foraz, G. Riddone</td>
<td>J. Carwardine, P. Garbincius, T. Shidara</td>
</tr>
</tbody>
</table>

EPS 2009 G. Geschenke, CERN
**Tentative long-term CLIC scenario**

*Shortest, Success Oriented, Technically Limited Schedule*

Technology evaluation and Physics assessment based on LHC results for a possible decision on Linear Collider with staged construction starting with the lowest energy required by Physics

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<td>Engineering Optimisation &amp; Industrialisation</td>
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<td>Construction (in stages)</td>
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**Conceptual Design Report (CDR)**

**Technical Design Report (TDR)**

**Project approval ?**

**First Beam?**

---

EPS 2009 G. Geschonke, CERN

50
ILC: 500 GeV, upgradable to 1 TeV
Technology quite advanced. Project could be proposed in 2012

CLIC: reach up to 3 TeV
still in R&D phase, TDR expected end 2015.
Some parameters are more challenging than ILC.
500 GeV parameters however, more relaxed, close to state of the art