Overview of Linear Collider
Test Facilities and Results

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TTF at DESY
NLCTA at SLAC
ATF&GLCTA at KEK
CTF at CERN
TESLA project

- 1.3GHz superconducting cavity main linac
- 23.8MV/m(500GeV), 35MV/m(800GeV)
- Long & sparse bunch train
  (- long damping ring)
TESLA like beam by RF gun. Average 25MV/m.
5 accelerating module (2004)
35MV/m #6 module (2006)
50µm by bunch compressor
27m Undulator
Superconducting Cavity development

Process of cavity:
form 9-cell from high purity Nb sheet, 800deg annealing, 1400deg heat treat (option), chemical etching / electropolishing (EP), High pressure water rinsing.

9-cell cavity

AC72 35MV/m cavity was installed in ACC1 cryomodule

AC70 - Third EP Cavity in High Power Test

- Low power test
- High power test
8 of 9-cell cavities and Quad, BPM are installed in Cryomodule. Super-structure was also tested.
6 ~ 30nm SASE-FEL at TTF2

TTF2 Injector (up to BC2) comm.  
0.8GeV TTF2 commissioning
Saturation 30-120 nm
Operation with full beam current
3rd Harmonic RF & ACC6 installed
1 GeV beam energy
Saturation 6 nm

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**NLC/GLC Project**

- 11.4GHz main linac
- 65MV/m (52MV/m loaded) Dumped Detuned Structure
- RF pulse compression for H.G.
- Short & dense bunch train
**Main Linac Unit**

NLC/GLC Linac RF Unit
(One of ~ 2000 at 500 GeV cms, One of ~ 4000 at 1 TeV cms)

- **75 MW PPM-Focused Klystrons**
- **Solid State Induction Modulator** (500 kV, 0.5 kA, 1.6 µs Pulses)
- **150 MW, 1.6 µs**
- **475 MW, 400 ns**

**Dual-Moded SLED-II**

Utility Tunnel

Linac Tunnel

Eight 0.6 m Accelerator Structures (65 MV/m Unloaded, 52 MV/m Loaded)

- **75 MW, 1.6µs PPM Klystron**
- **500kV IGBT Modulator**
- **475MW, 400ns RF Pulse compression**
- **65MV/m, 400ns Structure**

**Periodic Permanent Magnet focused Klystron**

**75MW, 1.6µs, 120Hz Operational**
RF Power generation
(8-pack system)

Four 50MW Solenoid Klystron run by IGBT modulator,
Dual mode SLED II
NLCTA (NLC Test Accelerator)

Beam supply
by DC gun & buncher
2 SLED II RF station
for structure HG test
1 8-pack system
for high power
& for system integration

RF Unit Test: Phase II
(In Progress)

Power Eight Accelerator
Structures in NLCTA
(TRC R2 Requirement)

Operate Eight, 60 cm Long Structures at 65 MV/m, 400 ns Pulses
X-band Accelerating structure

Cells with Slots for Dipole Mode Damping

Port for Terminating and Extracting Dipole Mode Power

High Power Output Coupler

High Gradient Performance of Five Recent NLC/GLC Structures

Breakdown Rate at 60 Hz (#/hr)

- Average Rate Limit for 99% Availability (2% Overhead and 5 sec Recovery)
- Design Average Rate Limit (~100% Availability)

65MV/m : < 0.1 BD/hour at 60Hz
Accelerating unit integration

NLCTA beam line

Phase 2 8-Pack Layout
Schematic of the power handling to the beamline

From SLED
likely Kazakov hybrid and directional coupler variants with $TE_{210}$-$TE_{020}$ transformers

Mechanical/vacuum system in design

magic-H hybrids
Test Facility of LC low emittance beam

Half scale DR realization

Multibunch Photo-cathode RF gun, Δf-ECS  S-band Linac

E=1.28GeV
Ne=1x10^{10} e-/bunch
1 ~ 20 bunches
Rep=1.5Hz
X emit=2.5E-6 (at 0 int.)
Y emit=2.5E-8 (at 0 int.)
ATF emittance monitors

Tungsten Wire Scanner
OTR, ODR Monitor

Laser Wire Scanner

SR Interference Monitor

X-ray SR Monitor
Laser wire scanner in DR
for X & Y scan, for single/multi-bunch

Two optical cavity chamber
For X-wire and Y-wire

TEM00 wire

TEM01 wire

$\alpha = 4.3 \pm 0.5 \mu m$
Single bunch Transverse Emittance by Laser wire

**Horizontal Emittance**

- x emittance [10^{-3}]
- bunch intensity [electrons/bunch]
- x emittance (run B)
- x emittance (run D)
- simulation (0.4% coupling)

**Vertical Emittance**

- y emittance [10^{-12}]
- bunch intensity [electrons/bunch]
- y emittance (run B)
- y emittance (run D)
- simulation (0.4% coupling)

X emittance determined by Ring Design. Measured data points are fit to simulation.

Y emittance = 6.5 pm at GLC intensity, is below GLC design.
Multibunch Vertical Emittance

Projected Vertical Emittance of Multibunch

GLC Design

Emittance Versus Bunch Number

Blowup at tail bunch is seen.
Multibunch Vertical Emittance after 9.3 A.hours scrubbing

Projected Y emittance is around 1% from X, However, insufficient tuning of Y emittance.
GLCTA (GLC Test Accelerator)

Mission:
1. Structure High Gradient Test
2. High Power Generation Test
3. Main Linac System Integration
   using ATF low emittance beam
   or using GLC intensity beam
   from RFgun

Construction: 2003 ~ 2005
- Two-beam Acceleration
- 30GHz main linac
- 150MV/m Dumped Detuned Structure
- High Intensity Drive Beam
- Short & dense bunch train
CLIC RF component

SICA (Slotted Iris Constant Aperture) Structure for Drive Beam acceleration

937MHz (3GHz at CTF3)

C-PETS: Circular Power ExTraction Structure Ø25mm, 512MW, 30GHz

Mode converter from circular to rectangular

30GHz Main Beam accelerator structure
CTF3 (CLIC Test Facility)

CTF2: Two beam acceleration component demonstration and High Gradient study

CTF3:
Test of Drive Beam Generation, Acceleration & RF Multiplication by a factor 10
Two Beam RF power generation & component tests with nominal fields & pulse length
Drive Beam Generation Test

CTF3 Injector commissioning

First demonstration of full beam loading

Output power from accelerating structure

Beam off
~ 24 MW

Beam on
~ 0 MW

ACS0385 exit

1.6 µs compressed RF pulse
Tungsten Iris Test

Iris after high-gradient testing to about the same field level

Test structure in external vacuum can, with clamped coupler cell

Copper iris replaced by Tungsten iris

Copper - damaged

Tungsten - undamaged
High gradient tests of new structures with molybdenum irises reached 190 MV/m peak accelerating gradient without any damage well above the nominal CLIC accelerating field of 150 MV/m but with RF pulse length of 16 ns only (nominal 100 ns).
Test Facility Plans for 2004-2005

- **TTF2**
  Commissioning of TTF2, 30nm SASE-FEL lasing.

- **NLCTA**
  Complete RF unit demonstration.

- **ATF/GLCTA**
  Multibunch emittance, wiggler,
  Construction of complete RF unit.

- **CTF3**
  Commissioning of Drive beam,
  Construction of Delay Loop & Combiner Ring.
The figures and pictures are borrowed from following web-site:
DESY, SLAC, CERN, ITRP and conference papers(EPAC2004 etc.).

I would like to appreciate to all of presenter.