NLC
Program Overview

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NLC Machine Advisory Committee
Fermilab
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Mission Need

The need for a linear collider to study particle physics at the TeV energy scale has been firmly stated – ACFA, ECFA, and HEPAP (Snowmass).

There is a clear definition of the mission requirements:

- Start at 500 GeV, but technology must be able to reach a TeV.
- Luminosity in excess of 10^{34} cm^{-2} s^{-1} .
- Physics studies emphasize accumulation of 500 - 1000 fb^{-1} .

(Note: $\pi \times 10^7$ seconds $\times$ 10^{34} cm^{-2} s^{-1} $\approx$ 300 fb^{-1} .)

Global coordination is being put into place:

- International Steering Committee initiated by ICFA to coordinate global LC activities.
- Regional Steering Committees to coordinate regional LC activities.

Project Model

There is a Project Model – HEPAP "On Shore":

International Collaboration

Integration of Existing HEP Resources – Lab and University Infrastructures and People

New Money

Examples (in $B):

TPC	International	Existing	New
5	1.5	1.5	2
6	1.5	1.5	3
7	1.5	1.5	4

… with a project start "sometime around 2005".

A TeV Linear Collider

LC02 (Feb 2002)	Two candidates left for a TeV-scale linear collider --- TESLA and NLC/JLC.
NLC/JLC	Completion of 8-Pack test at NLCTA with high-gradient (1 TeV) structures in 2003 with operations in 2004.
TESLA	Completion of the first high-gradient (800 GeV) cryo-module in 2003 with operations at TTF-II in 2004.

The "8-Pack"

The prototype NLC rf system optimized for 1 TeV cms …

Phase-I. A "Single-Feed" in 2003.

→ Demonstrate rf power suitable for one girder of structures.

→ Test facility for rf power system to run independently of the high-gradient structure testing.

Phase-II. Complete 8-Pack in 2004.

→ Demonstrate full power source with DLDS feeding high-gradient structures.

NLC 1 TeV Main Linac RF System

(Snowmass Baseline)

Low Level RF System

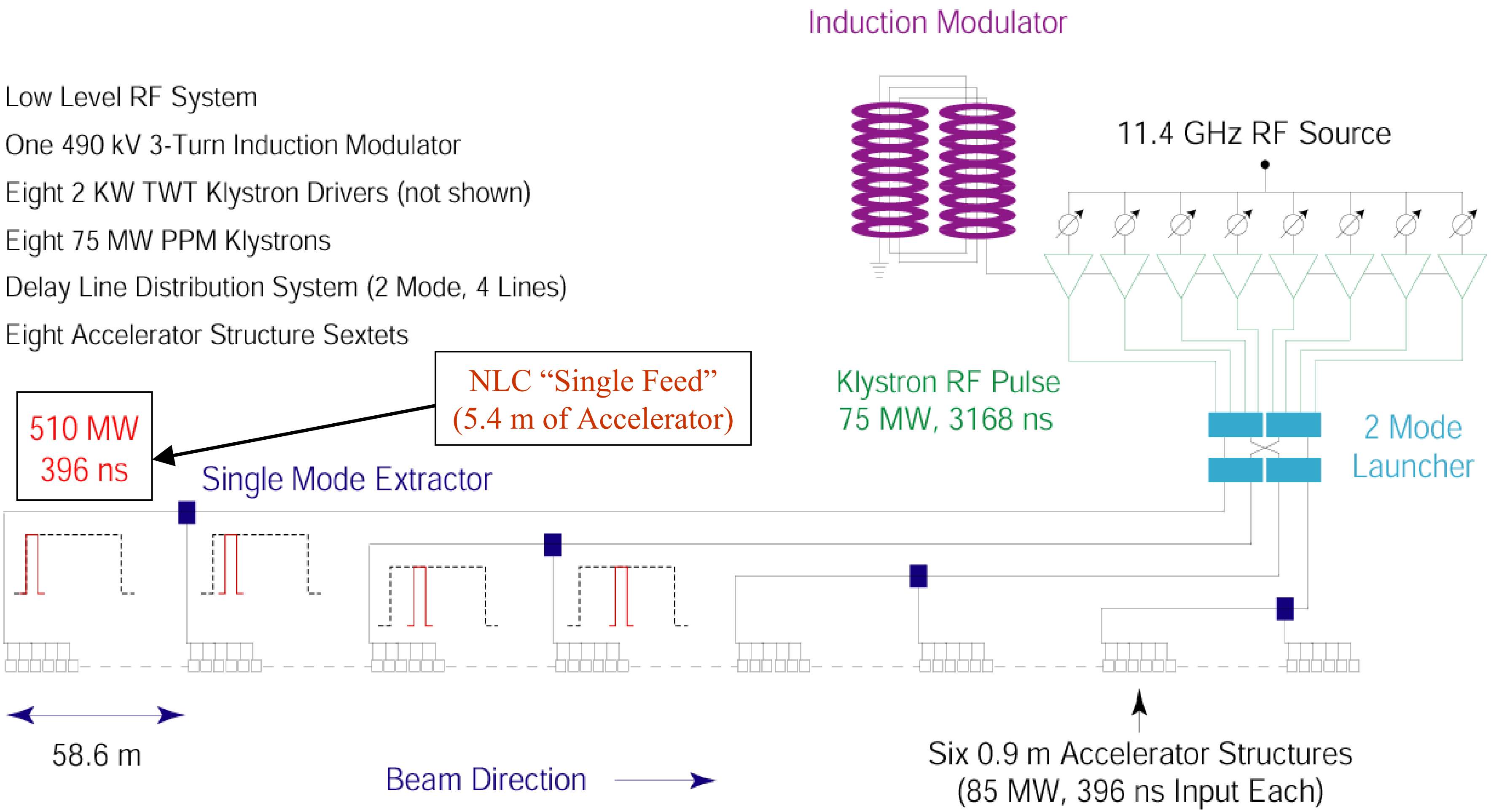
One 490 kV 3-Turn Induction Modulator

Eight 2 KW TWT Klystron Drivers (not shown)

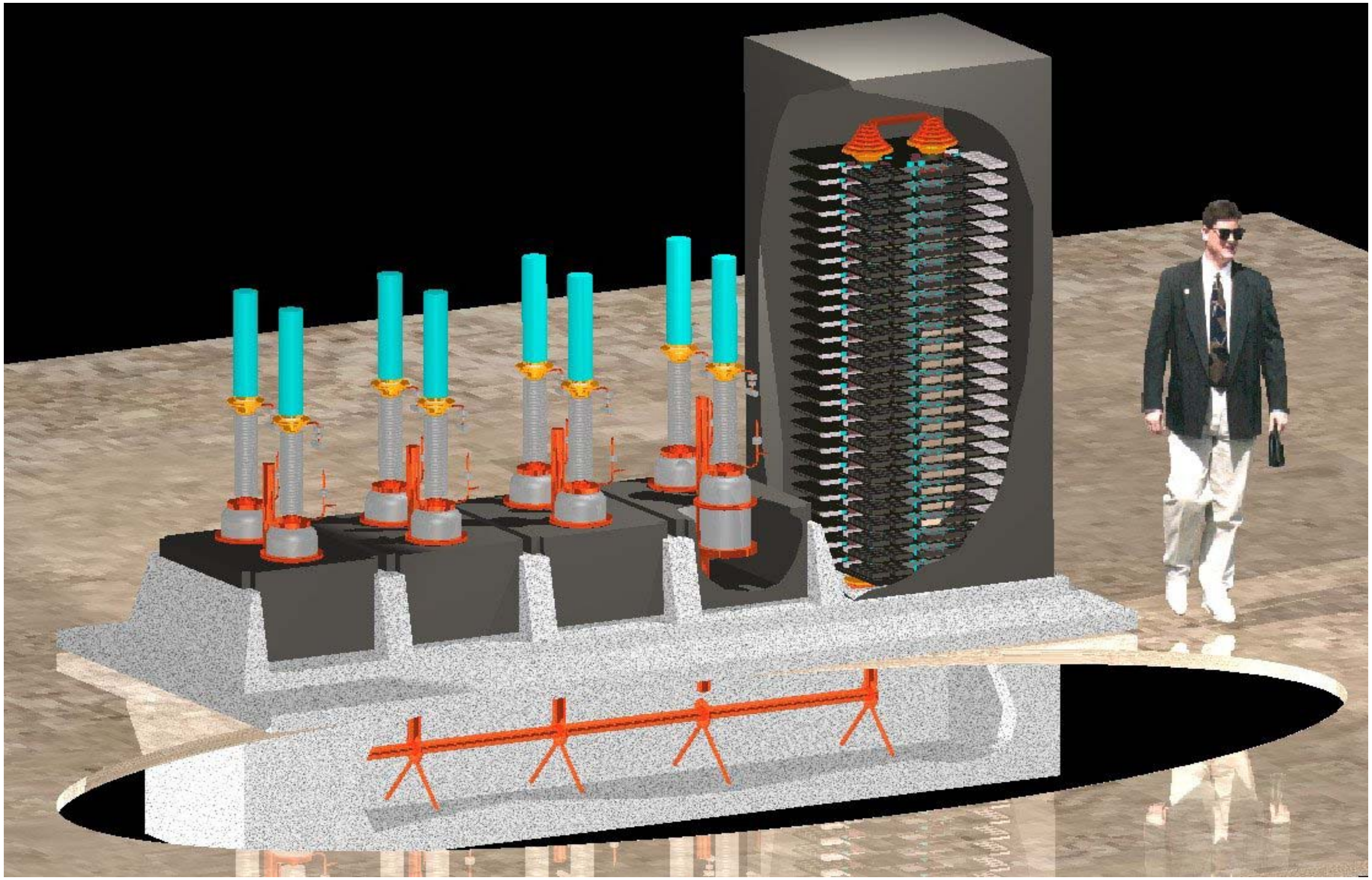
Eight 75 MW PPM Klystrons

Delay Line Distribution System (2 Mode, 4 Lines)

Eight Accelerator Structure Sextets



NLC Solid-State Induction Modulator
Klystron 8-Pack

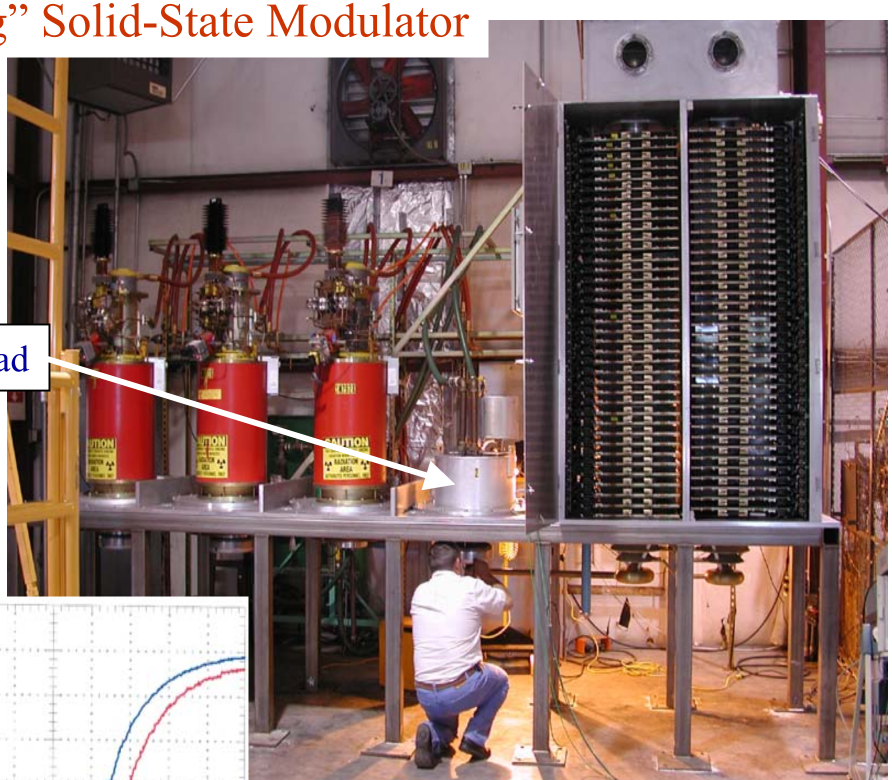


Artist's Rendition

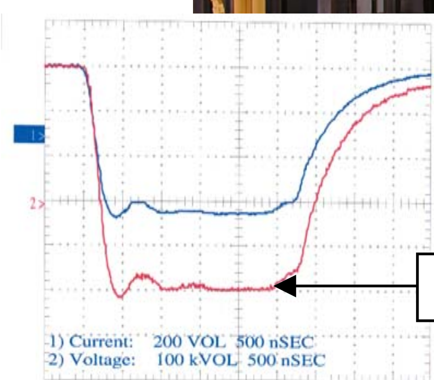
X-Band Power Sources

→ deLamare and Caryotakis.

“4-Dog” Solid-State Modulator



Water Load



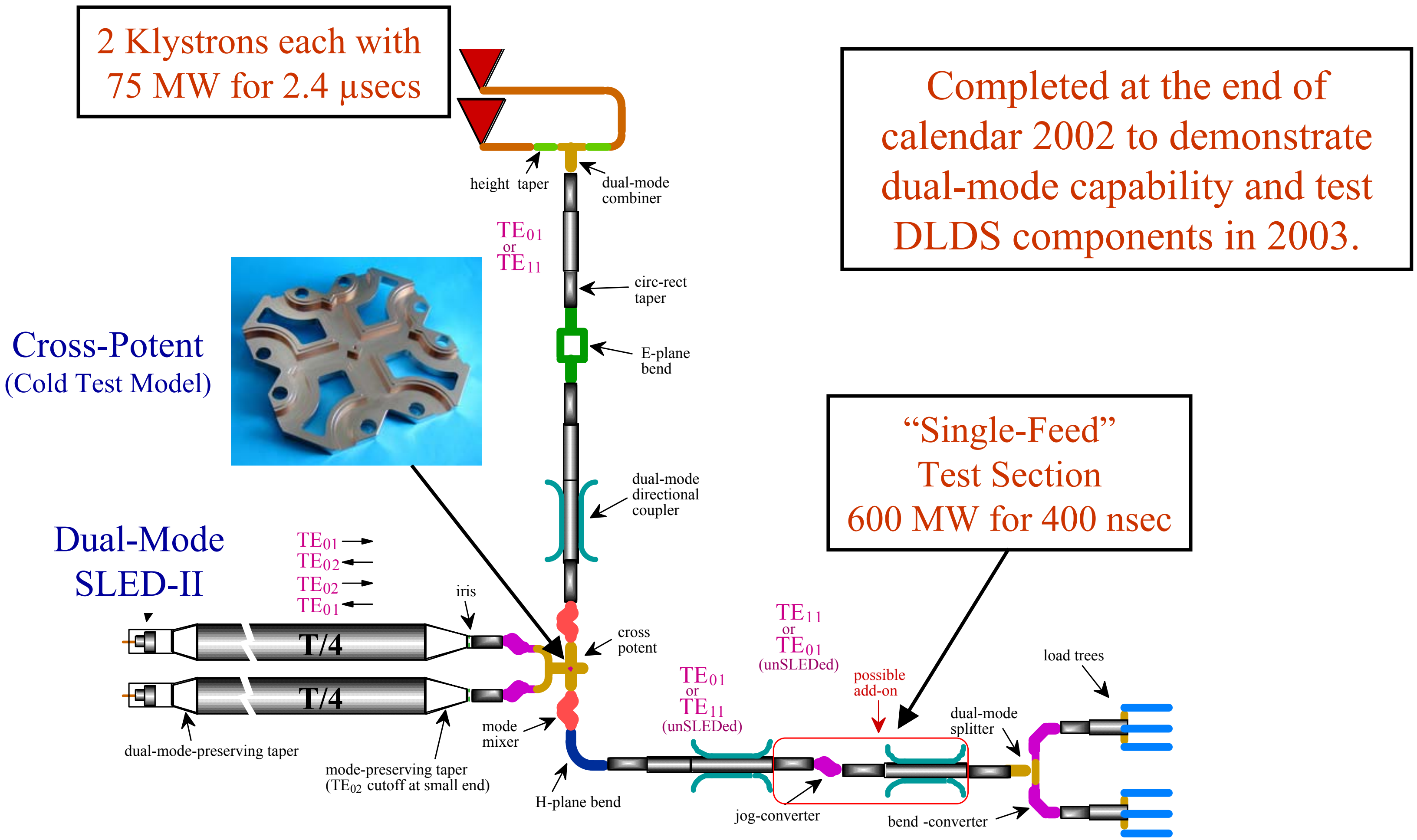
500 kV

75XP3 PPM Klystron

Two tubes under test with parts in hand for a third. Task-force approach to delivery for 8-Pack.

8-Pack Phase-I

→ Schultz, Tantawi, Atkinson



8-Pack Phase-II

Operations in summer 2004.

Low Level RF System

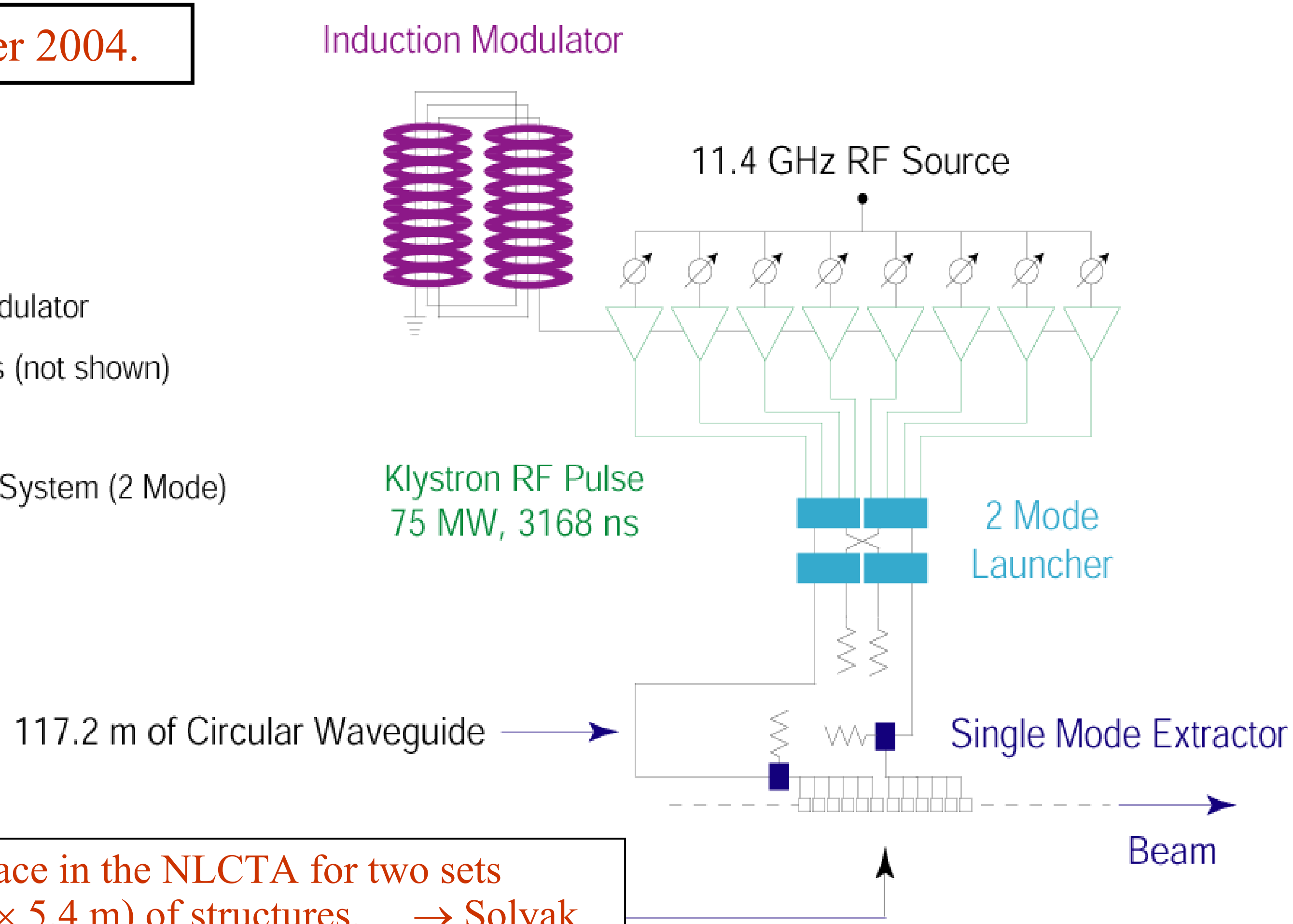
One 490 kV 3-Turn Induction Modulator

Eight 2 KW TWT Klystron Drivers (not shown)

Eight 75 MW PPM Klystrons

Reduced Delay Line Distribution System (2 Mode)

The critical test is to launch power into the longer waveguide with no recovery.



Space in the NLCTA for two sets (2 × 5.4 m) of structures. → Solyak

High Gradient - Observations and Attack

Observations of Gradient Limitations …

150 - 200 MV/m	Historic single-cell tests.
100 - 150 MV/m	Early short high-Q test structures (with low-power sources).
40 - 50 MV/m	Long 1.8 m NLC structures at the NLCTA.

→ Limit realized following extensive 24/7 running of the NLCTA at high gradient.

Aggressive R&D Program …

Focus on completed structures tested at NLCTA with substantial exposures.

Broad attack on the problem –

- Theory and Modeling
- Accelerator Design
- Manufacture and Q/C
- Operations

High Gradient Test Structures
(Partial List for Past 18 Months)

Test Structure	L (m)	V_g (% c)	Maximum Gradient [a]	Operation [b]
DDS3	1.8	12	50	40
T105VG5	1.0	5	70	60
T53VG5	0.5	5	80	65
T53VG3	0.5	3	90	70 (NLC Spec)
T53VG3RA	0.5	3	80	70 (NLC Spec)

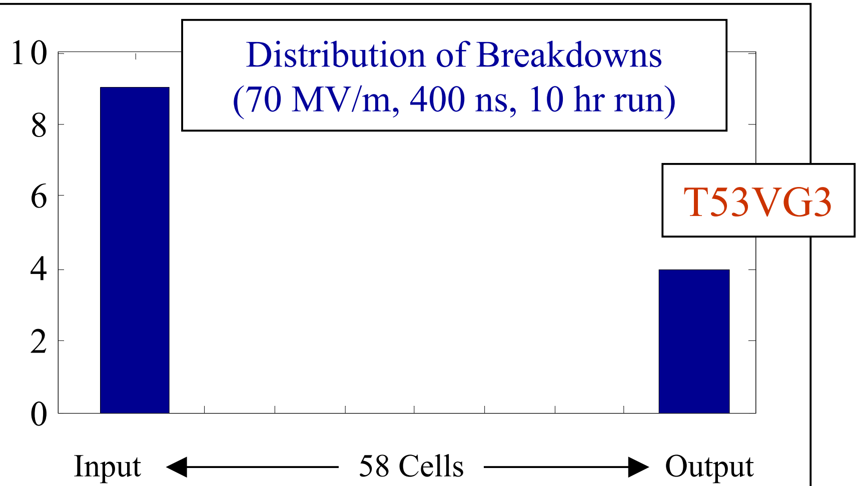
(a) Unloaded gradient (MV/m) used during processing.
(b) Unloaded gradient (MV/m) at which cells operate satisfactorily.

→ 5000 hours of high-power operation of the NLCTA.

Work Left To Do

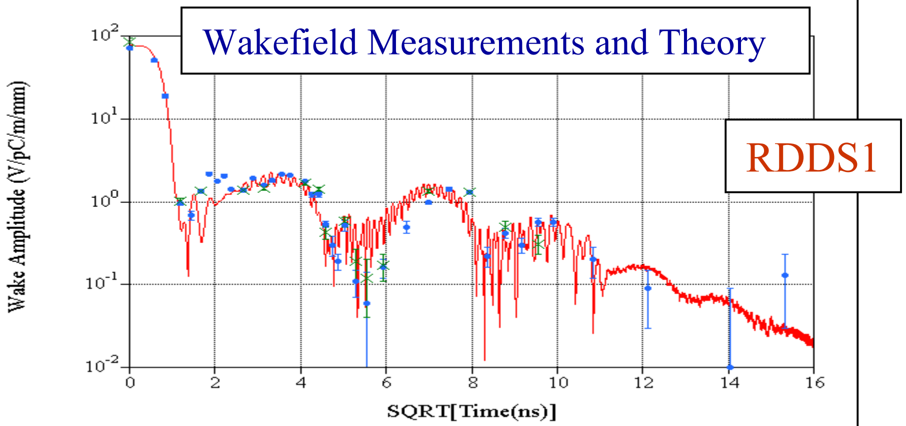
Performance still dominated by input and output rf couplers …

→ Structure T53VG3RA with adaptive input waveguide did not solve this problem, and it processed more slowly than T53VG3 – (etch-cleaning and vacuum firing were different).



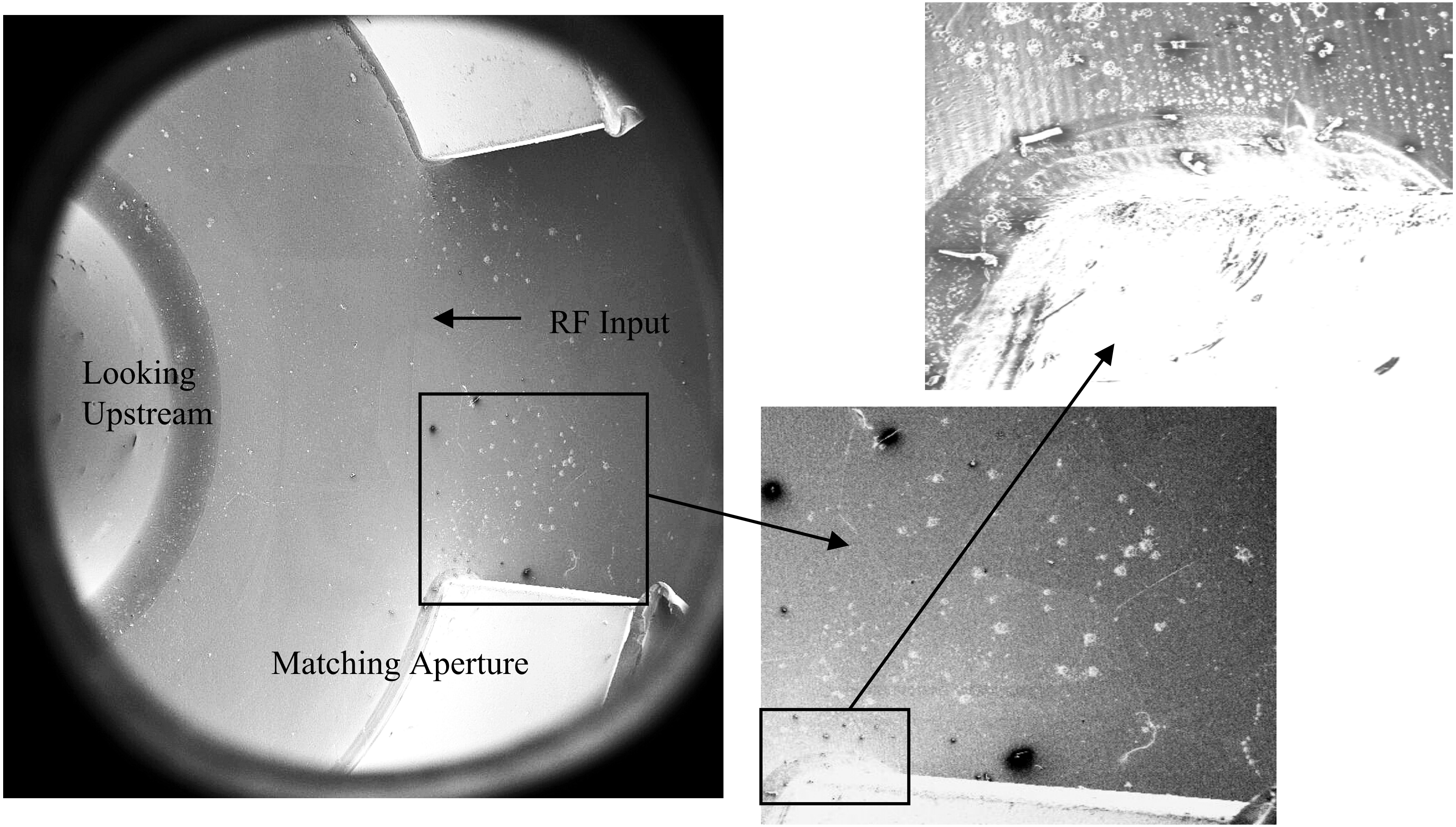
Incorporate proven wake-field control … the "H" series.

- Iris size
- Detuning, then damping



Autopsy of T53VG3 Input Coupler

SEM Photographs



Structure R&D Table

Structures	Features	May-Aug	Sept-Dec	Jan-April	Status
H60VG3	NLC Apertures	xxxxxxxx			Installation
H90VG5	and Detuning	xxxxxxxx			
SW565 (pair)	Standing Wave	xxxxxxxx			Installation
T53VG3MC	Mode-Coupler	xxx			Fabrication
H60VG3ILT	In-Line-Taper		xxxxxxxx		Fabrication (KEK)
H90VG3ILT	Coupler		xxxxxxxx		- ILT in Design
FXB-001	Fermilab "H60VG3"		xxxxxxxx		Fabrication
H60DDSa	NLC Damped-Detuned Pair			xxxxxxxx	Design
H60DDSb	with MC or ILT Coupler			xxxxxxxx	Design
FXB-002/003	Fermilab with MC or ILT			xxxxxxxx	Design

High-Gradient R&D

Summary

→ Adolphsen

- We are not "home" with this problem.
- We have manufactured test structures with cells that reach the design goal of 70 MV/m for a TeV collider … but there are still issues to resolve in their manufacture and final design.
  - Structures with NLC apertures and wakefield detuning are being installed.
  - Excessive pulsed-heating has been identified as a potential source of breakdowns and damage in couplers - designs with substantially reduced fields and heating – "Mode Converter" and "In-Line Taper".
  - Sources of variation in manufacture that need better control have been identified.
- An aggressive program of design, fabrication, and testing of structures will continue with the highest priority.

High Gradient 8-Pack

Calendar	2002	2003	2004

Structures

"H" Test Series ….

Produce 5.4 m of "H" Structures

"HDDS" Test Series

Produce 5.4 m of "HDDS" Structures

8-Pack Phase-I

Civil and Infrastructure

Commission 4-Dog Modulator

Produce 2 Klystrons …….

SLED-II and DLDS Component Tests

Phase-II

Construct 8-Pack Modulator

Produce 8 Klystrons …………..

Produce DLDS Long Arm …………

Full System Tests

……. Produce DLDS Short-Arm

The Past Three Years

We laid out a three-year plan in 1999 for DOE review. That plan was strongly endorsed by a Lehman Committee, and we have largely followed that plan on a schedule limited by funding:

- Focus has been kept on critical issues identified in 1999.
- The 8-Pack is underway, and is aimed at an important milestone (the "Single-Feed Test") in 2003, and full tests in 2004.
- Limits on gradients in accelerator structures were unanticipated in 1999.

We have resolved many of the critical issues identified in 1999.

We understand the plans and needs of the 8-Pack.

We have demonstrated that TeV NLC-spec gradients can be achieved, but have work left to do to build TeV NLC-spec accelerator structures.

For the MAC

We are reviewing the overall NLC R&D plan in light of the President's FY03 budget proposal.

From the last MAC Report …

"… the NLC Collaboration is in a serious dilemma because of funding (in FY02) … the question of how to proceed in R&D is reduced to prioritizing existing programs, a rescoping of these programs, and a redefinition of what is needed …"

The President's FY03 budget for NLC R&D is the same as FY02.

We are once again rescoping our programs and seek your advice.

NLC Program Planning

Goal: Complete conceptual design in 2004 with R&D that is needed to support a technology choice and start of project engineering.

The process of forming an international project is not clear, so we are not including effort needed to write a CDR. But evaluations of cost and schedule are important.

Budget Assumptions:

- FY03 will be the same as FY02.
- There will be growth in FY04 and beyond.

First Priorities

The 8-Pack is our highest priority. Even without increased resources in FY03, we will carry out aggressive R&D on structure gradients and complete the 8-Pack. The remaining program will be squeezed to fit this goal.

The 8-Pack is an R&D project with substantial technical risk. The schedule is "success-oriented" and the critical path has little or no "float".

We are working to identify where contingency resources could help assure the timely completion of Phase-I and Phase-II.

Assigning contingency dollars to the 8-Pack will require further reduction in other efforts, but it is our first priority for remaining funds.

Priorities for Remaining R&D

→ Raubenheimer and other speakers.

R&D Aimed at Demonstrating Capability to Produce Luminosity

IP Girder Prototype	Stabilization of nm beams. Goal is a full-sized, but not full-function, prototype in 2004. We can do this, and it is our highest priority after the 8-Pack.
Damping Ring R&D	ATF and ALS experiments and continued analytical evaluation. Very important and does not use much discretionary cash.
Linac Girder Studies	Limit to studies of "cultural" drift and vibration – *e.g.* water flow. Would like to build a full-function prototype, but will delay.

Other Topics with Lower Priority (Effort will depend on offsets from elsewhere.)

Site Investigations	California and Illinois. Ground motion and cost analysis. Opportunistic use of data created elsewhere – *e.g.* NUMI.
Sources	Electron polarization achieved but continue to study cathodes. Study undulator and laser based e^+ sources. TESLA collab?
X-Band RF at Fermilab	Non-NLC uses, structure tests, and prep for ETF. Generic R&D?

Halted or Not Started

- Hardware Development
  - Source Laser, RF Deflectors, and Target Prototypes (Baseline Design)
    - Except Completion of Liquid-Metal Studies at BINP.
  - Damping Ring RF, Vacuum, Magnets, and Kickers
  - Component Supports – Stability and Control
    - Except IP Girder and Machine-Environment Studies
  - Beam Instrumentation
    - Except to support NLCTA, 8-Pack, and ATF.
  - Alternate X-Band RF Components and Systems
  - LINX and Beam Collimation
    - Except Keep-Alive for SLC Arcs and Final Focus
- Engineering and Design
  - Systems and Value Engineering
  - Reliability and Operations
  - Active Site and Environmental Studies

Increasing Effort

- MOU with Brookhaven National Laboratory
  - A very welcomed addition.
- Strengthening Collaboration with KEK
  - RF Technology.
  - ATF.
  - Site Requirements and Options.
  - Cost Information.
- Cornell Initiative and Outreach to Universities

  → Himel
- International Focus
  - ILC-TRC → Phinney

Outlook

- We have pursued a broad range of work over the past three years to bring the design and technologies of the entire machine under control.
- We are putting together the "8-Pack" prototype of the rf system capable of reaching 1 TeV cms energy. Our goal had been operations in FY03.
- We are severely limited by available resources.
  - Budgets in FY00, FY01, and FY02 fell below our hopes in 1999.
  - We could have spent 30 M$ (combined U.S. labs) in FY02.
    - Completion of the 8-Pack will slip into FY04.
  - The 8-Pack is squeezing the remainder of the NLC R&D program … only the most essential pieces will move ahead.