News and Directions

D. Burke

NLC "All Hands"
September 2002

Outline

- Recent Results from R&D Program
- Scientific, Political, and Organizational Activities
- Next Steps

E158 and NLC Injector Beam Parameters

Parameter	E158	NLC-500
Charge/Train	6×10^{11} (*)	14.3×10^{11}
Train Length	300ns	260ns
Bunch spacing	0.3ns	1.4ns
Rep Rate	120Hz	120Hz
Beam Energy	45 GeV	8 GeV
e^- Polarization	80%	80%

*Source has factor 5 overhead in charge.

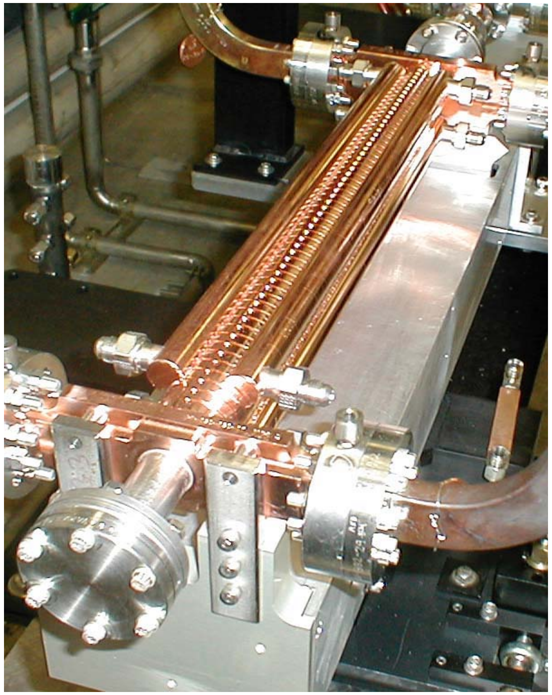
New!!

Gradient-Doped Strained GaAs Photocathode

See *NLC News* article by Mike Woods.

High Gradient Test Structures

1.8 m NLCTA Structure
(DDS3)
v_g from 12% to 3.3% c



53 cm Low v_g Test Structures
v_g from 5% to 3.3% c
and v_g from 3.3% to 1.6% c
(T53VG5 and T53VG3)

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

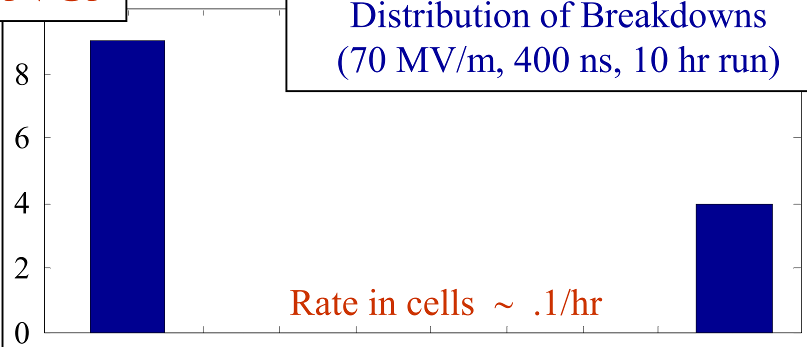
Test Structure	L (m)	V_g (% c)	Maximum Gradient [a]	Operation [b]
DDS3	1.8	12	50	40
T105VG5	1.0	5	70	60
T53VG5	0.5	5	80	65
T53VG3	0.5	3	90	70 (Spec)
T53VG3RA	0.5	3	80	70 (Spec)

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

→ 6000 hours of high-power operation of the NLCTA.

RF Pulse Heating

T53VG3

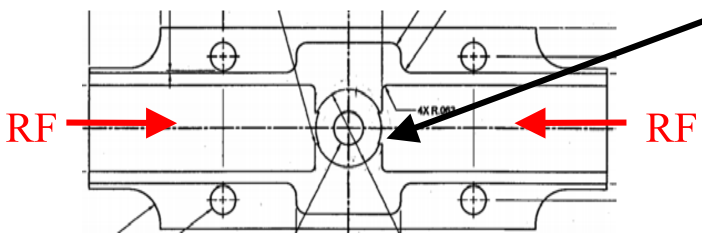


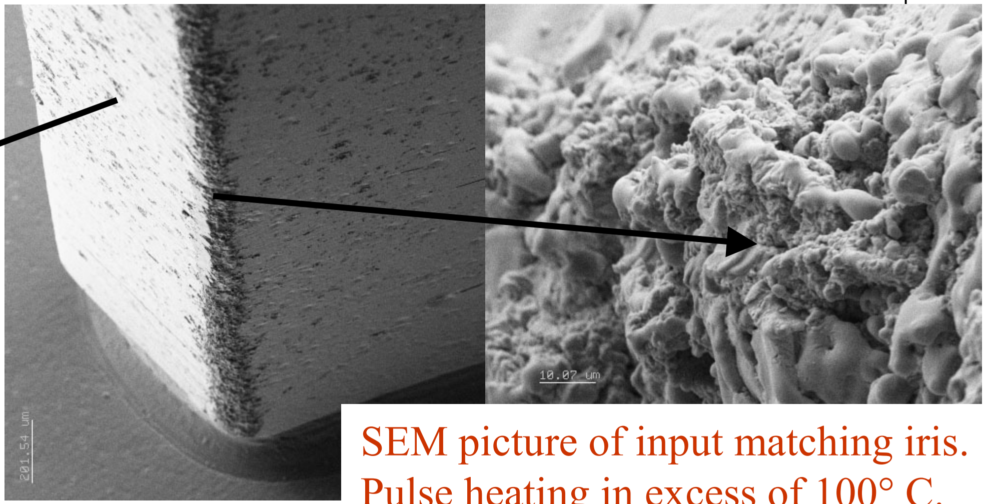
Input coupler ← 58 Cells → Output coupler

Performance limited by pulse heating of coupler matching irises.

Autopsy performed after high-gradient testing.

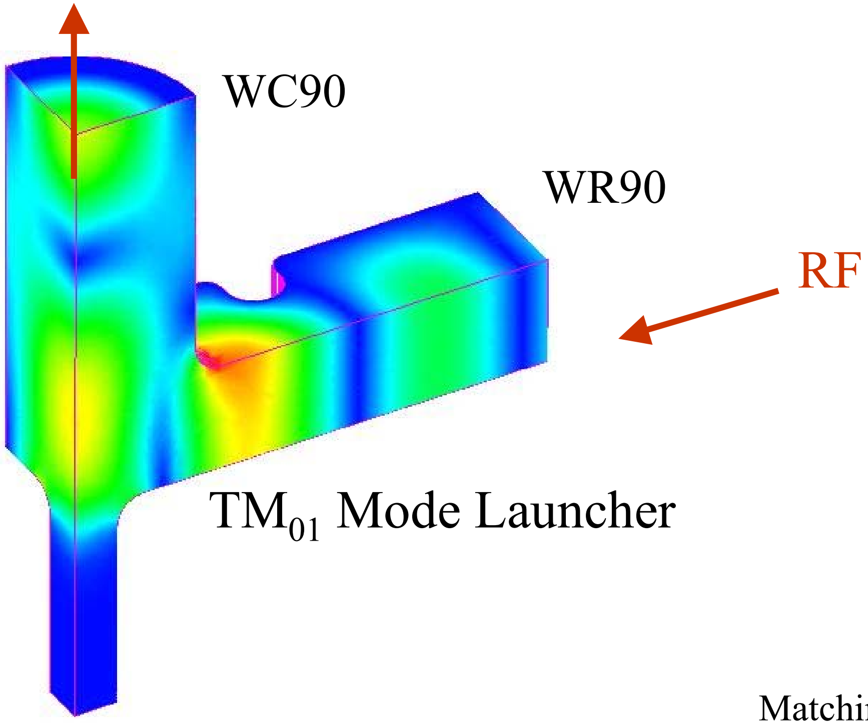
Beam's eye view of input coupler.





SEM picture of input matching iris.
Pulse heating in excess of 100° C.

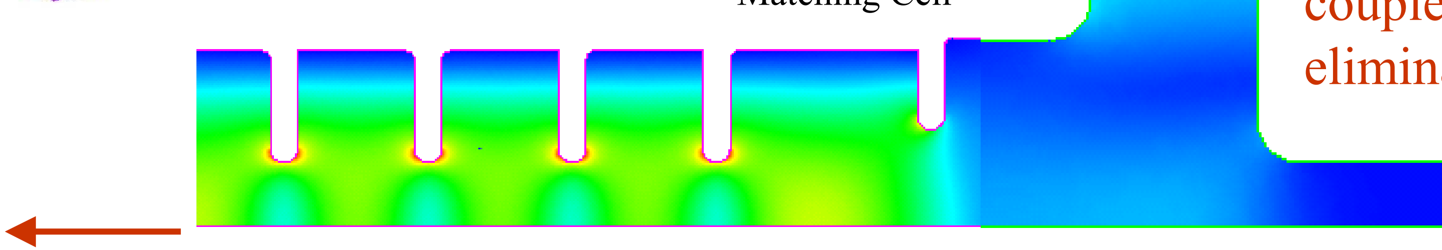
Mode Conversion (MC) Coupler



$|E^s|_{max}$= ~34 MV/m @ 48 MW

$|H^s|_{max}$= ~98.4 kA/m @ 48 MW

→ **Pulse Heating ~ 3° C**



NEW!!

T53VG3MC …
coupler breakdowns
eliminated!

Mode Conversion Coupler

High-Gradient R&D

Summary

- We are close to our goals.
- Test structures 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.
    - Starting to test structures with proper NLC apertures and wakefield detuning and damping, and working on designs to increase structure length. → Slide
    - Changes in manufacturing procedures have been identified to further improve performance. → Slide
    - Starting manufacture (CERN) of structures with irises made from harder materials (tungsten and stainless).

→ Continue to address these issues.

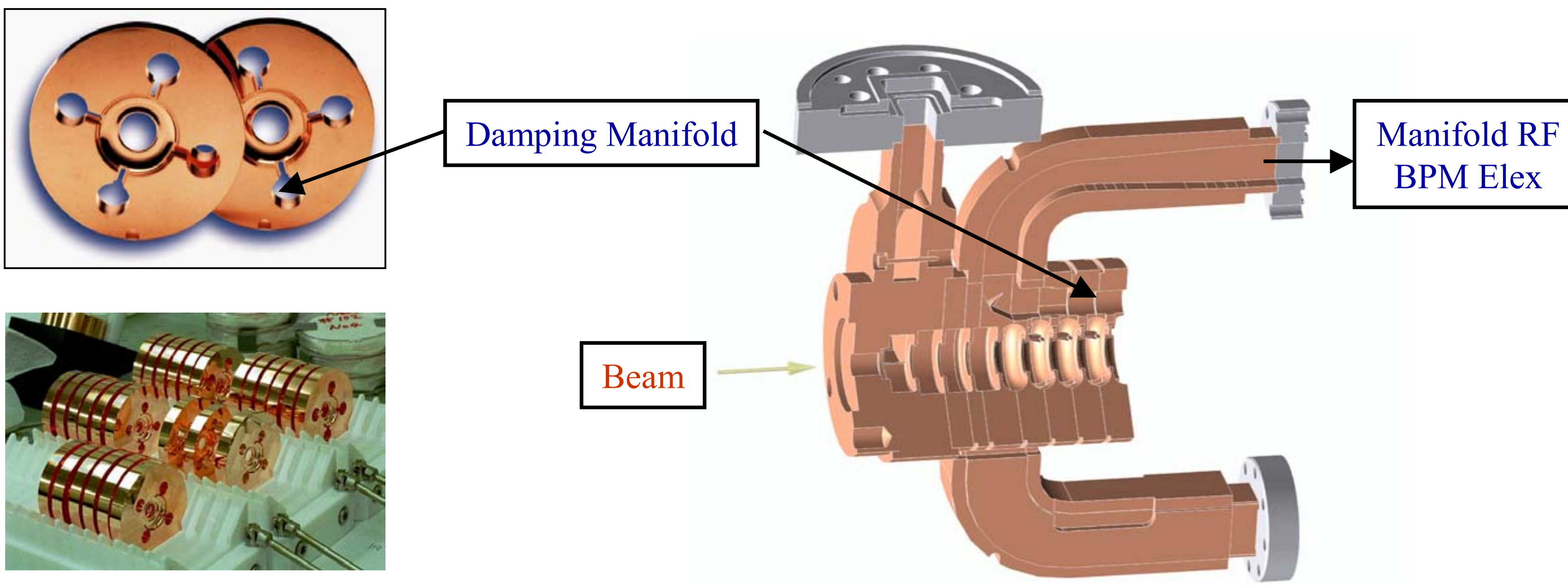
Wakefields and Accelerator Design
(SLAC and KEK)

Wakefields – fields left by beam particles as they pass through the structure.

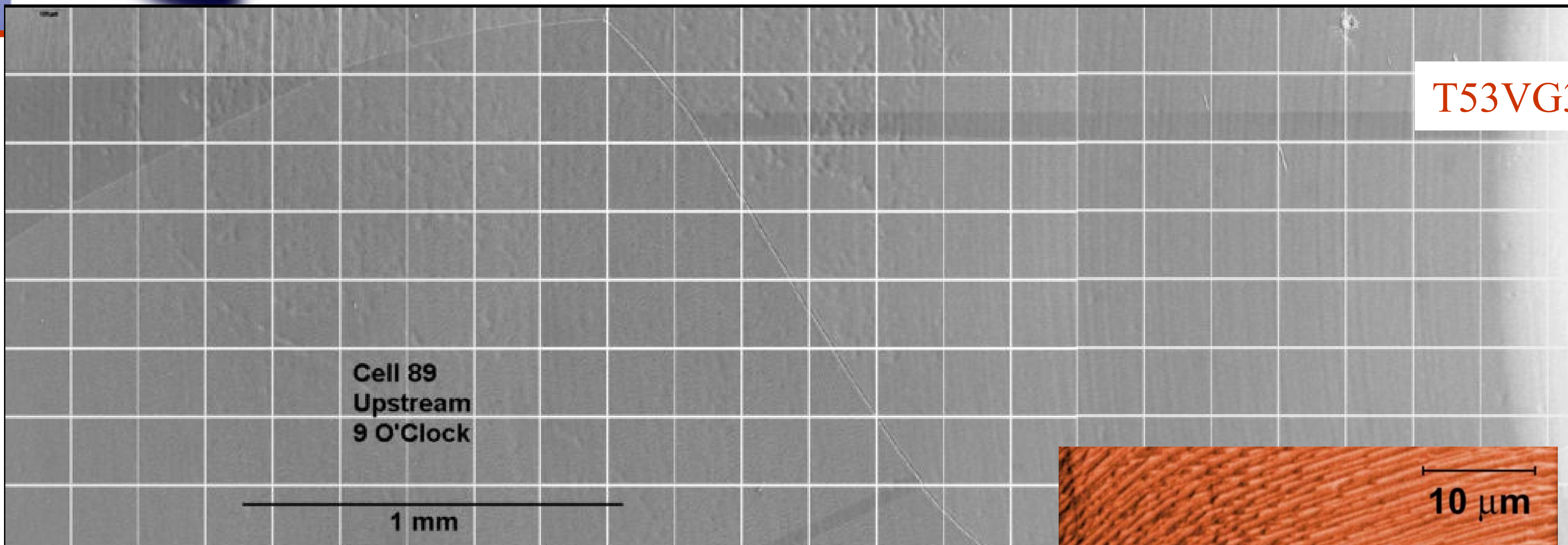
Control of transverse wakes …

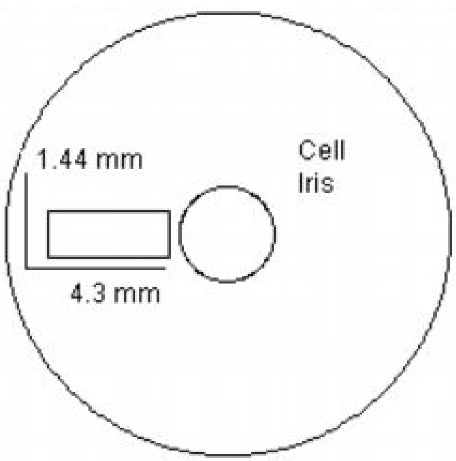
- “Detune” cells by giving each different transverse dimensions.
- “Damp” transverse wakefields by coupling to damping manifold and extracting power at frequencies above 11 GHz.

Structure RF BPMs –power extracted from horizontal and vertical damping manifolds.



SEM Survey of Structure Cells

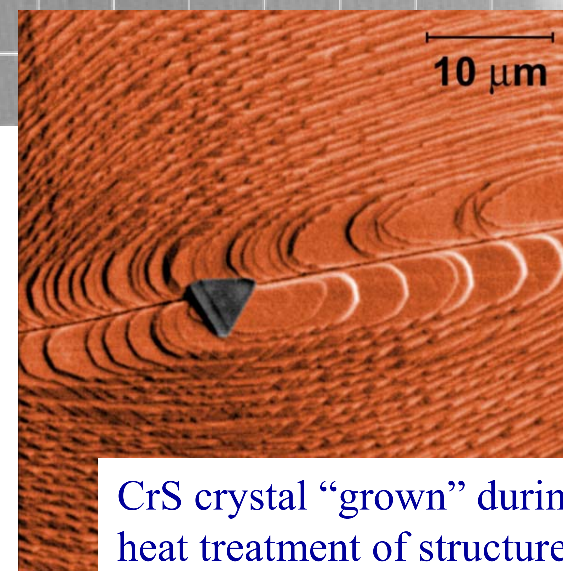




Survey Results

S – Cr	: 17	Cr – Fe	: 3
S – Fe	: 21	Others	: 6
S	: 5		

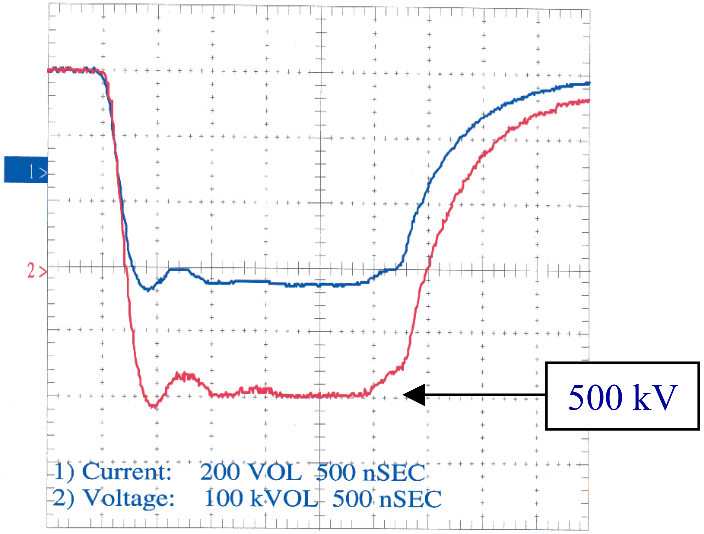
Trace sulpher in copper "getters" metals from stainless steel during heat treatments of manufactured structures.



CrS crystal "grown" during heat treatment of structures.

Solid-State IGBT Modulator

Test Lab with "Dog" Loads

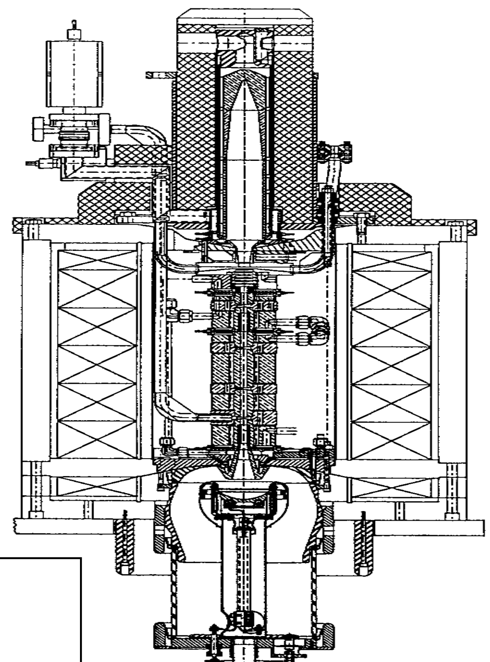


26-October-2001

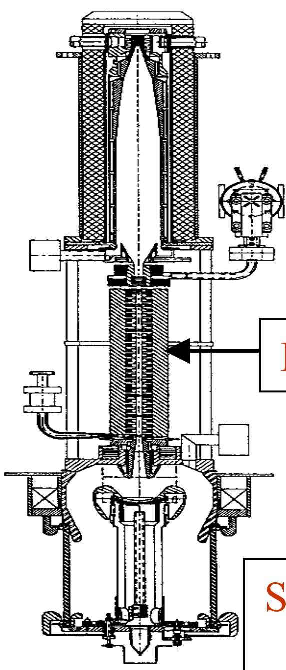
System and Failure-Mode (Spark-Down) Tests Successfully Passed

Periodic Permanent Magnet Focused (PPM) Klystrons

Solenoid-Focused
Workhorse



PPM
Prototypes

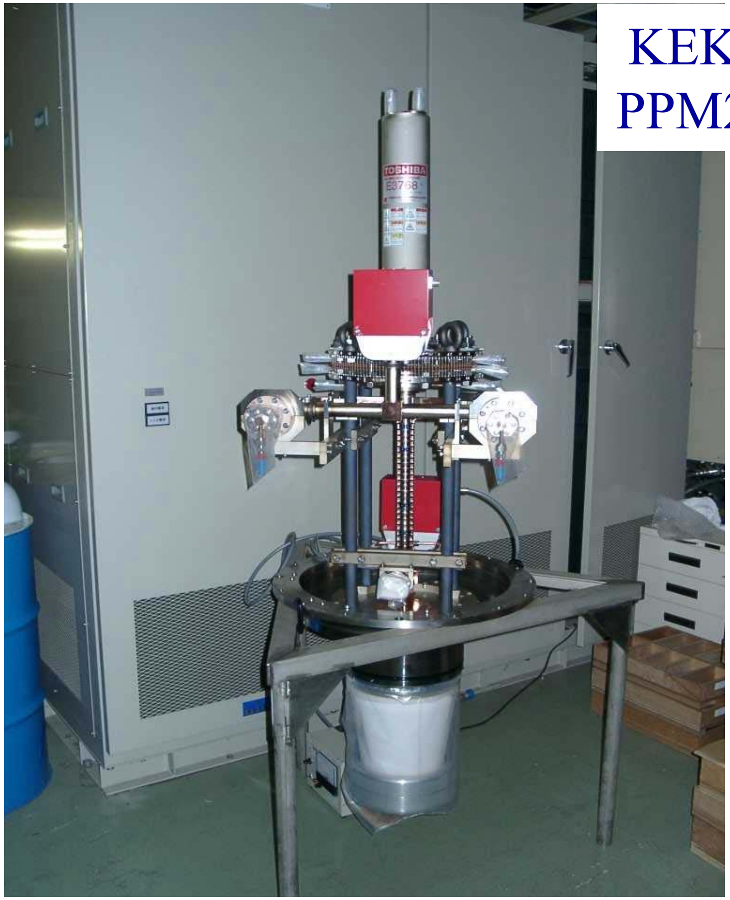


Permanent magnets.

DC power for solenoid coil comparable to average klystron electron beam power.

Specifications:
- 75 MW at 55% efficiency
- 1.6 – 3.2 μsecs

PPM Klystrons



Klystron Performance

Solenoid-Focused XL-4 (Workhorse NLCTA tubes – 10 in operation for 10^4 hrs.)

	75 MW	1.6μs	120 Hz

SLAC Prototype Permanent Magnet Klystrons

50 MW Design	50 MW	2.4 μs	120 Hz
75 MW Design #1 (75XP1)	80 MW	2.8 μs	N/A (No PM cooling)
75 MW Design #2 Serial #1	50 MW	1.6 μs	120 Hz
Serial #2	40 MW	1.6 μs	

Performance limited by gun arcing and unwanted rf oscillation at 11.7 GHz (source now understood).

KEK Prototype Permanent Magnet Klystrons

75 MW PPM2	70 MW	1.5 μs	25 Hz (Modulator limited)
75 MW PPM3*	65 MW	1.5 μs	50 Hz

*PPM3 now in test and performance not yet limited by tube characteristics.

Scientific, Political, and Organizational Activities

- Physics Imperative and Synergy Between Linear Collider and LHC
  - LCWS 2002 and World-Wide Study Group

    → Concurrent LC and LHC Physics!!

- Recent Reviews and Recommendations
  - PCAST and OSTP (President's S&T Policy Arm)
    - Redress underfunding of Physical Sciences. → We hope advice is taken.
  - HEPAP Report (ECFA and ACFA, too) and DOE 20-Year Outlook
    - The Linear Collider is in view. → We hope it's on the agenda.
  - TESLA and German Science Council Recommendations
    - Move aggressively on the FEL as a European project led by DESY.
    - Define a plan for an international collaboration on the linear collider.

- National and International Organization
  - U.S. Linear Collider Steering Group
  - International Linear Collider Steering Group

  → Organization by and of the scientific community.

Strategic View

- Steering Committees are moving to expedite technical decisions (read, "get our house in order") and to facilitate governmental action (read, "lobby").
- The need for "concurrent" running of the Linear Collider and the LHC to achieve the 20-year goal of understanding physics at the TeV energy scale is being recognized.
  - The HEPAP Report asked for start of construction in 2005.
- The NLC/JLC X-Band technology offers the tightest synergy and best match to the LHC energy reach. → Slide

Energy Reach of X-Band

Beam Loading

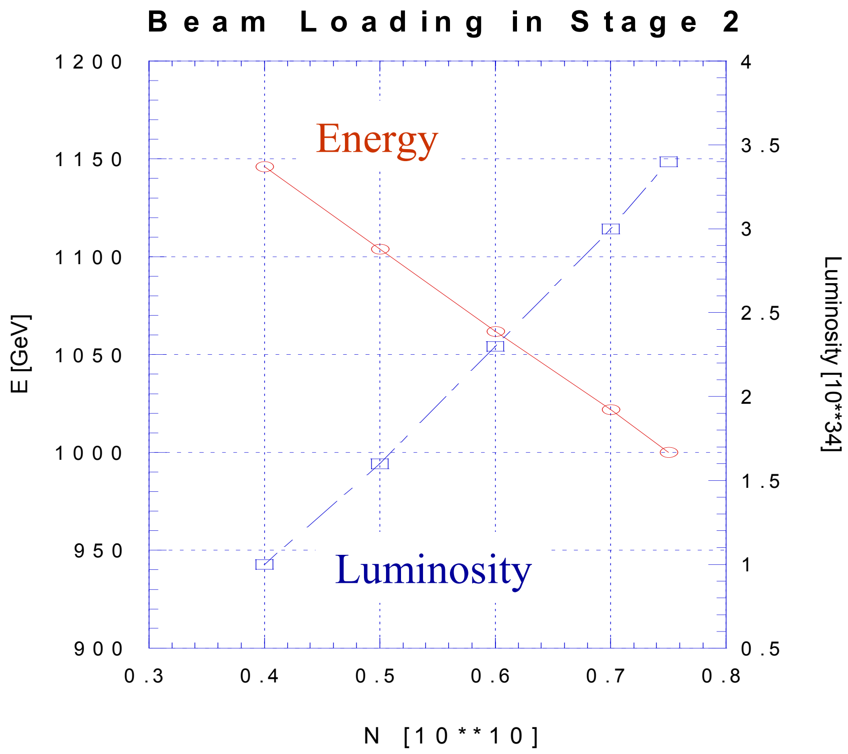
Beam loading is about 30% in the linac.

As the number of bunches is reduced the loaded gradient goes toward the unloaded gradient and the energy of the remaining bunches increases.

We are qualifying the **unloaded** accelerator gradient, so NLC/JLC can trade energy and luminosity over a wide range.

At 1.3 TeV cms the design luminosity of NLC/JLC is 5×10^{33} cm^{-2} s^{-1}.

HEIR



Next Steps

- There is compelling reason to establish the credibility of X-Band technology soon.
  - The DOE submits its FY06 budget request to OMB in April of 2004.
  - The German Science Ministry is expected to respond to the Science Council's recommendations at the end of next year (2003).

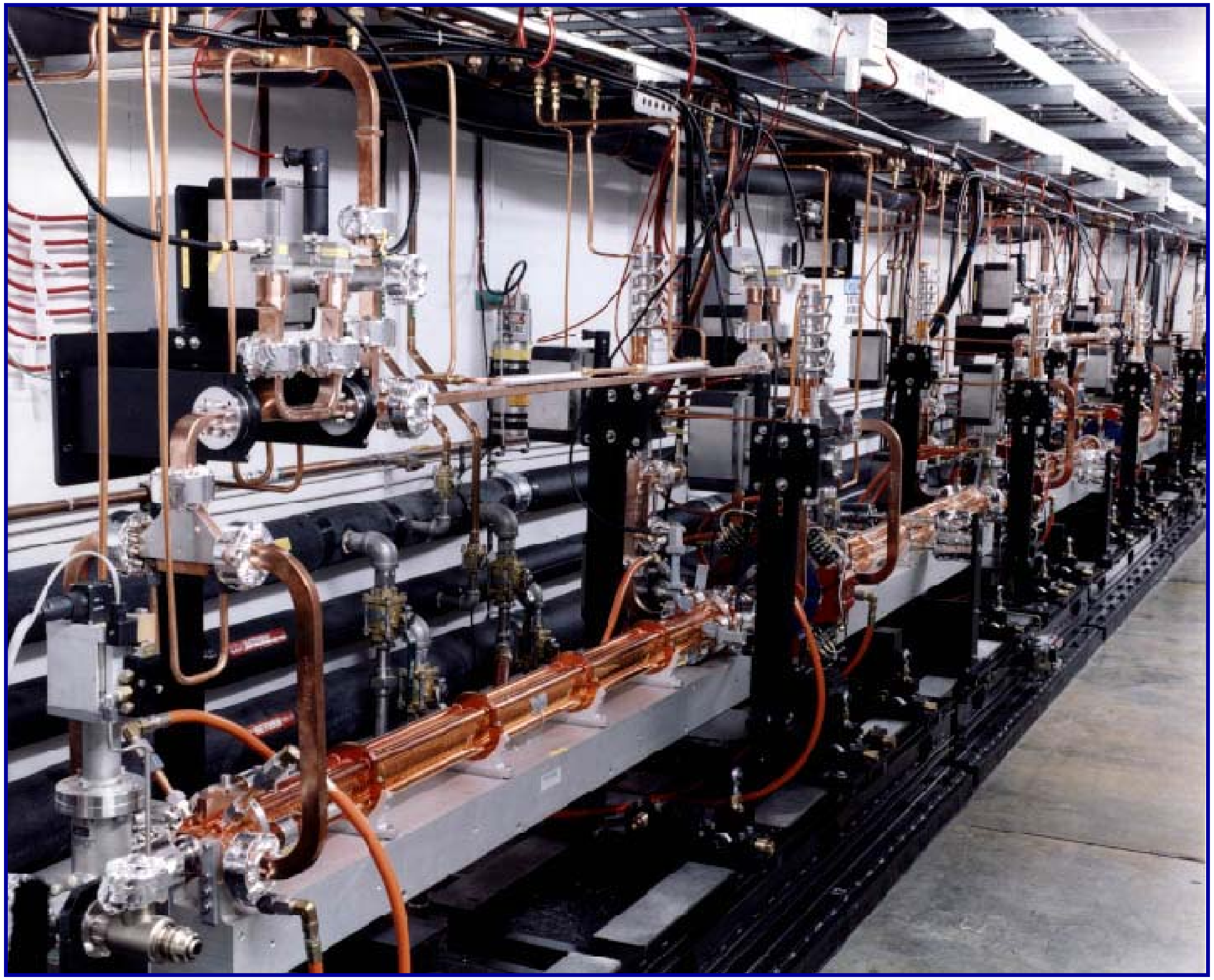
- Our R&D plan has been based on a 2-phased demonstration of

  (i) Generation of a "Single-Feed" rf pulse with SLED-II compression powered by two klystrons in 2003.

  (ii) Acceleration of beam in 5.4 – 10.8 meters of structures with DLDS pulse compression powered by an 8-Pack of klystrons in 2004.

- We must accelerate the demonstration of a complete X-Band rf system … and we must do it with no increase in level of funding.

The NLC Test Accelerator



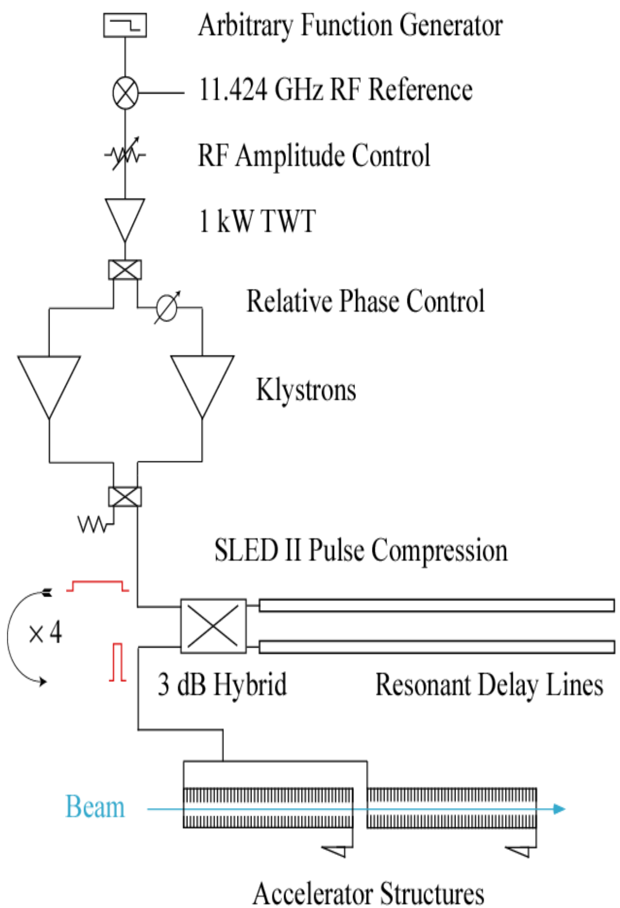
The NLCTA with 1.8 meter long accelerator structures (ca 1998).

Demonstrated capability to reach 500 GeV cms.

SLED RF Baseline

NLCTA SLED-II System (ZDR 1996)

- Conventional PFN modulator
- 50 MW/1.6μs solenoid-focused klystrons
- SLED-II pulse compression
- 2 x 1.8m DDS structures at 50 MV/m



X-Band TeV SLED-II System

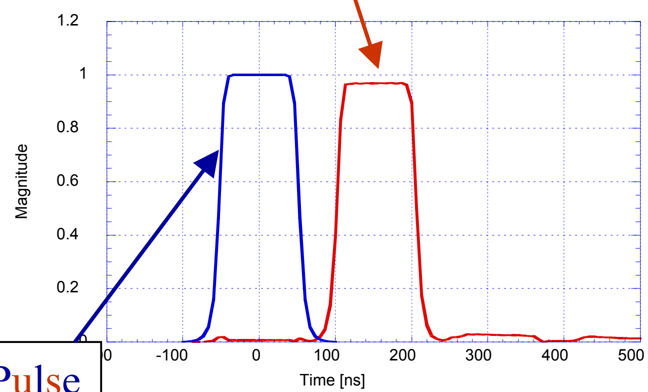
- Solid-state modulator
- 75 MW/1.6μs PPM klystrons
- Dual mode SLED-II pulse compression
- 6 x 0.9m DDS structures at 70 MV/m

Dual-Mode SLED II

Low-Power (Cold) Tests

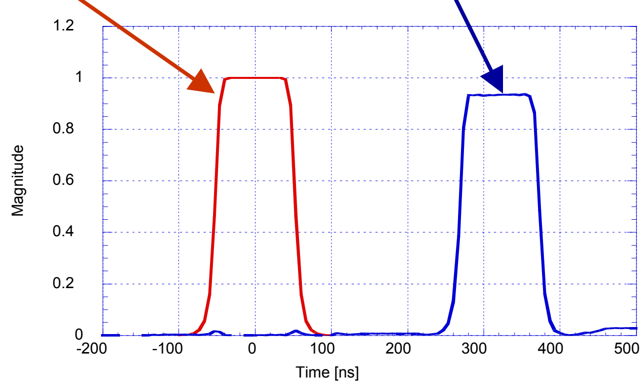
Dual-Mode SLED II with 2 × 75 feet of Waveguide

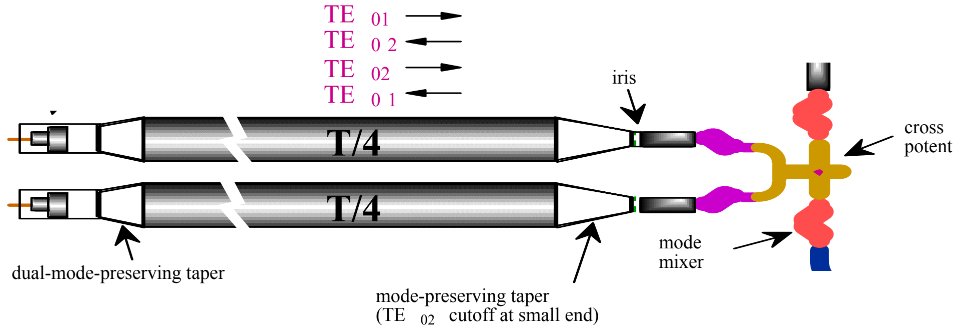
First Reflection (TE02)

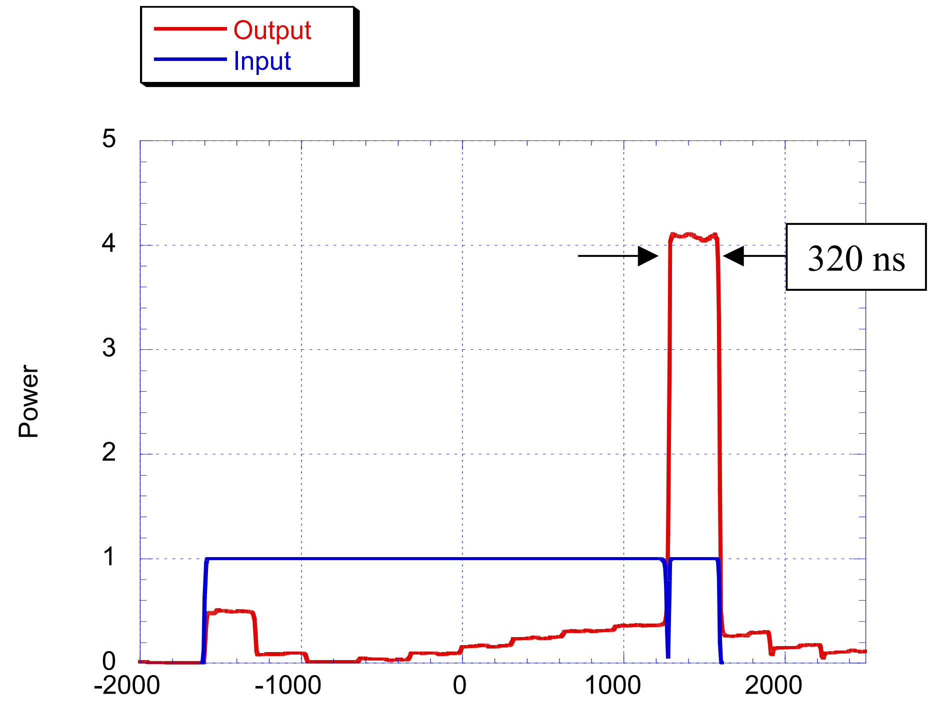


Input Pulse (TE01)

Second Reflection (TE01)







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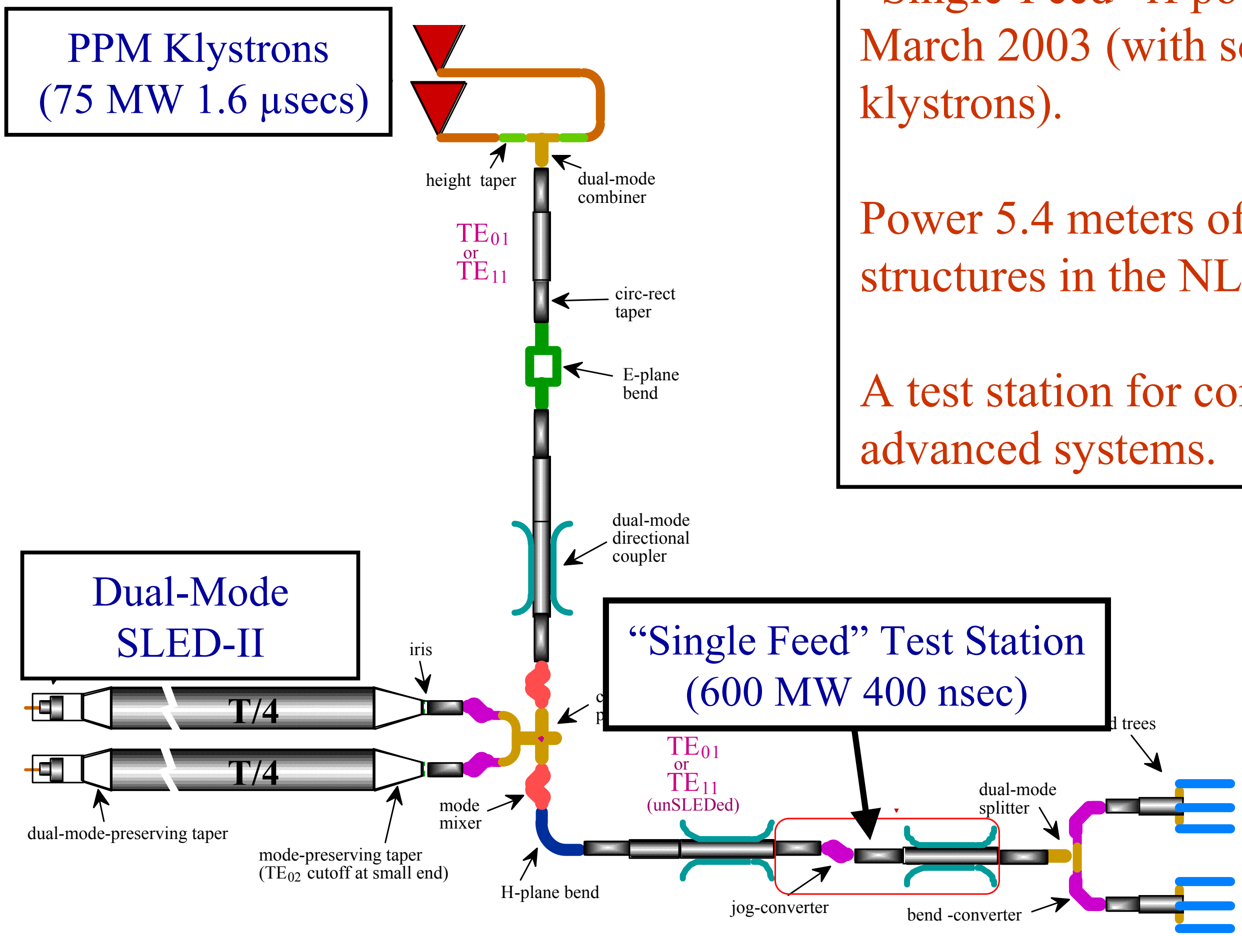
Comparison with Snowmass 2001

- Klystron Pulse Length Halved
  - Twice as many klystrons and modulator sockets per unit energy.
- SLED-II vs DLDS Efficiency
  - Approximately 15% loss in power efficiency.
    - Site power increases.
    - Main Linac becomes 7-8 % longer.
  - Factor 4 reduction in the length of rf pipe.
- Guestimate is the cost for the machine increases 10% or so.

→ A competitive machine with a core technology that can be demonstrated soon, and that we would be prepared to build if the opportunity is there to do so.

SLED-II Baseline Test



"Single-Feed" rf power to loads in March 2003 (with solenoid-focused klystrons).

Power 5.4 meters of high-gradient structures in the NLCTA in Fall.

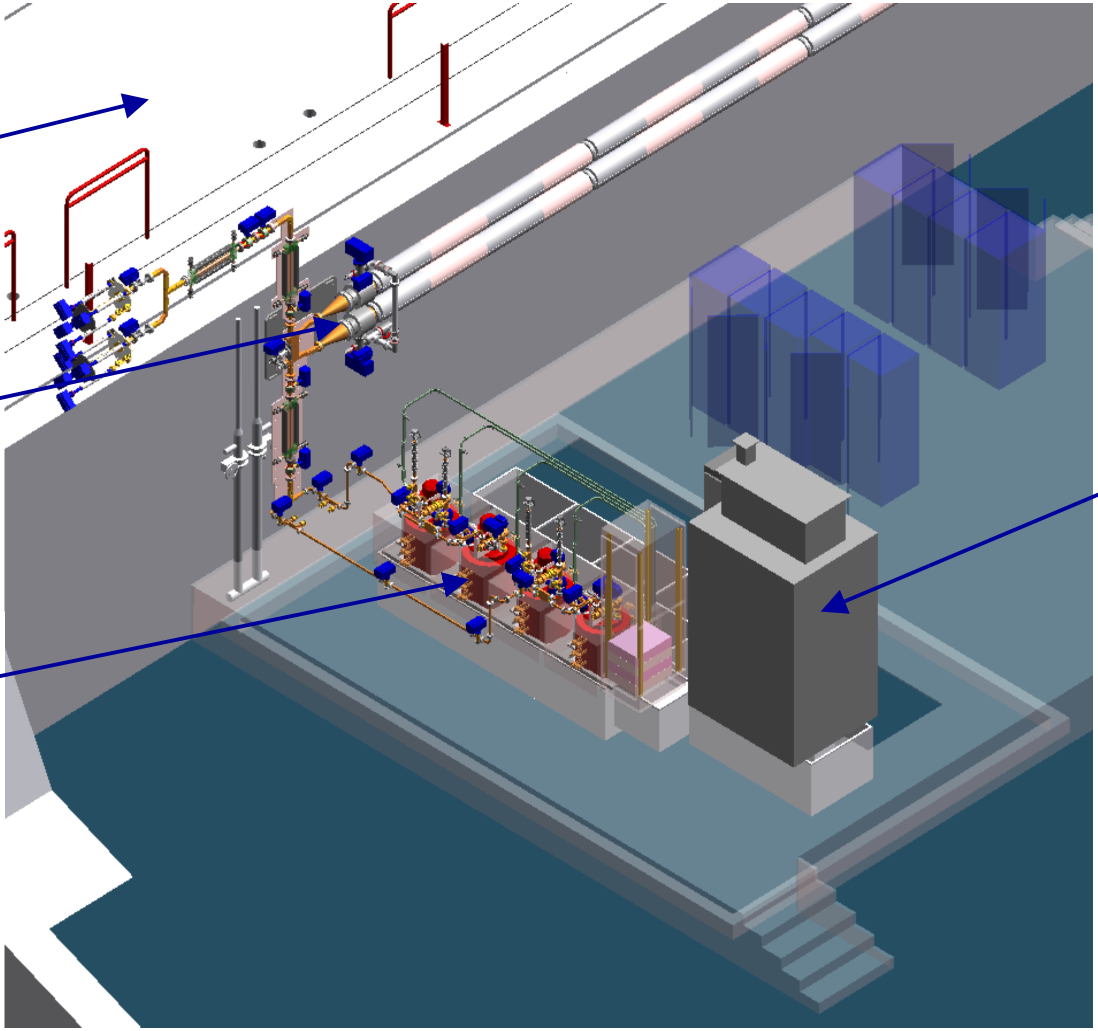
A test station for components of advanced systems.

SLED-II Baseline Test

NLCTA Housing

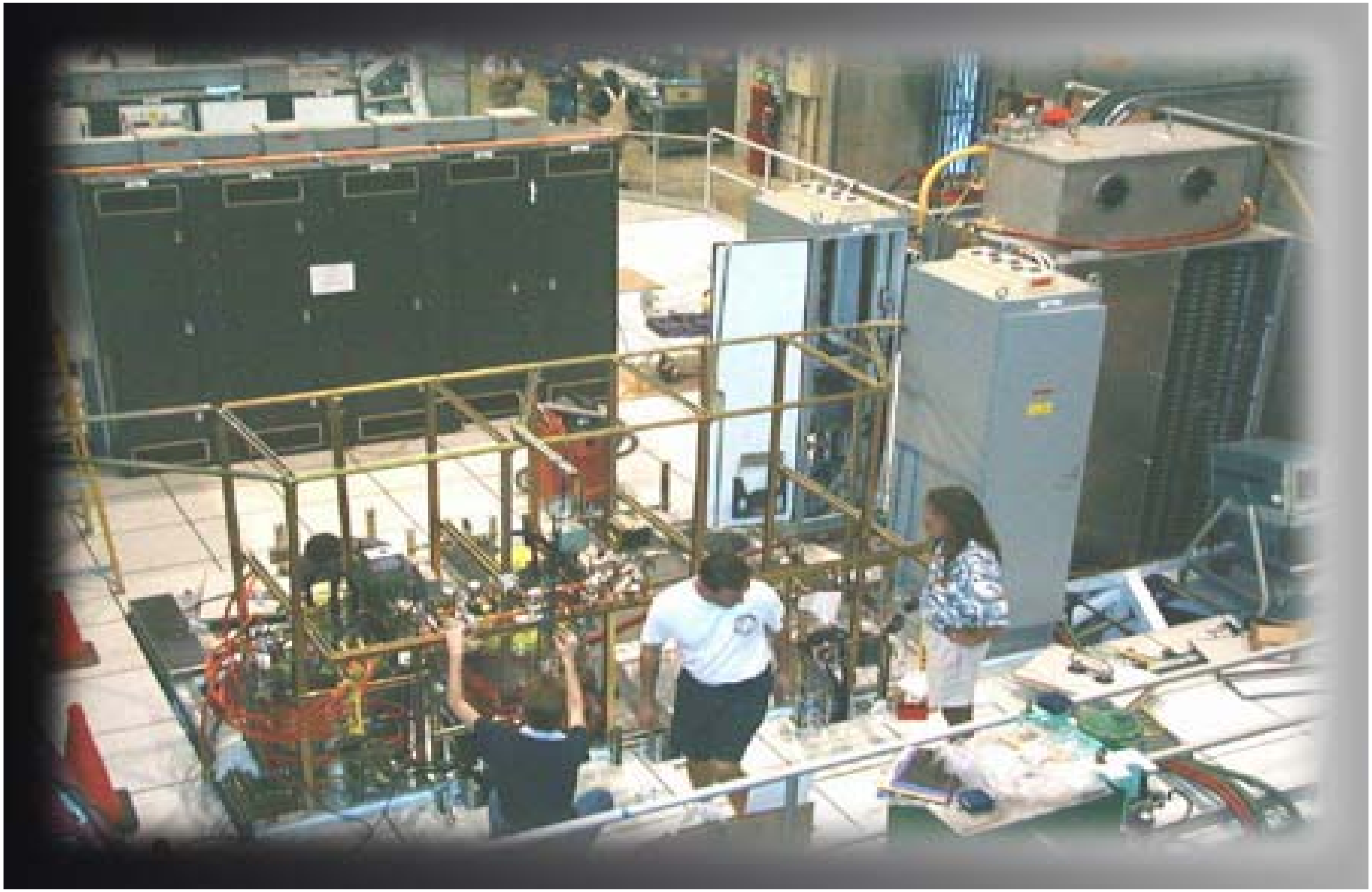
Dual-Mode SLED-II

Solenoid-Focused Klystrons (to be replaced with PPM tubes).



Solid-State Modulator

How It Looks Today



Strength of Collaboration

- Our Japanese colleagues are fully a part of this plan.
  - SLAC and KEK physicists on the ILC-TRC have together presented this common SLED-II Baseline design to the international community (this week in Hamburg).
  - KEK will provide klystrons and accelerator structures and participate in the SLED-II testing program.

- U.S. Collaborators working hard:
  - Bechtel-Nevada/LLNL work on modulators.
  - FNAL building accelerator structures.
  - LBNL and LLNL engineering and fabrication support.

Stay tuned.

Read the *NLC News*.

We will keep you up to date.