J/NLC Progress
on
R1 and R2 Issues

Chris Adolphsen

Charge to the International Linear Collider – Technical Review Committee (ILC-TRC)

- To assess the present technical status of the four LC designs at hand,

  TELSA, NLC/JLC-X, JLC-C and CLIC

  and their potentials for meeting the advertised parameters at 500 GeV c.m. Use common criteria, definitions, computer codes, etc., for the assessments.
- To assess the potential of each design for reaching higher energies above 500 GeV c.m.
- To establish, for each design, the R&D work that remains to be done in the next few years.
- To suggest future areas of collaboration.

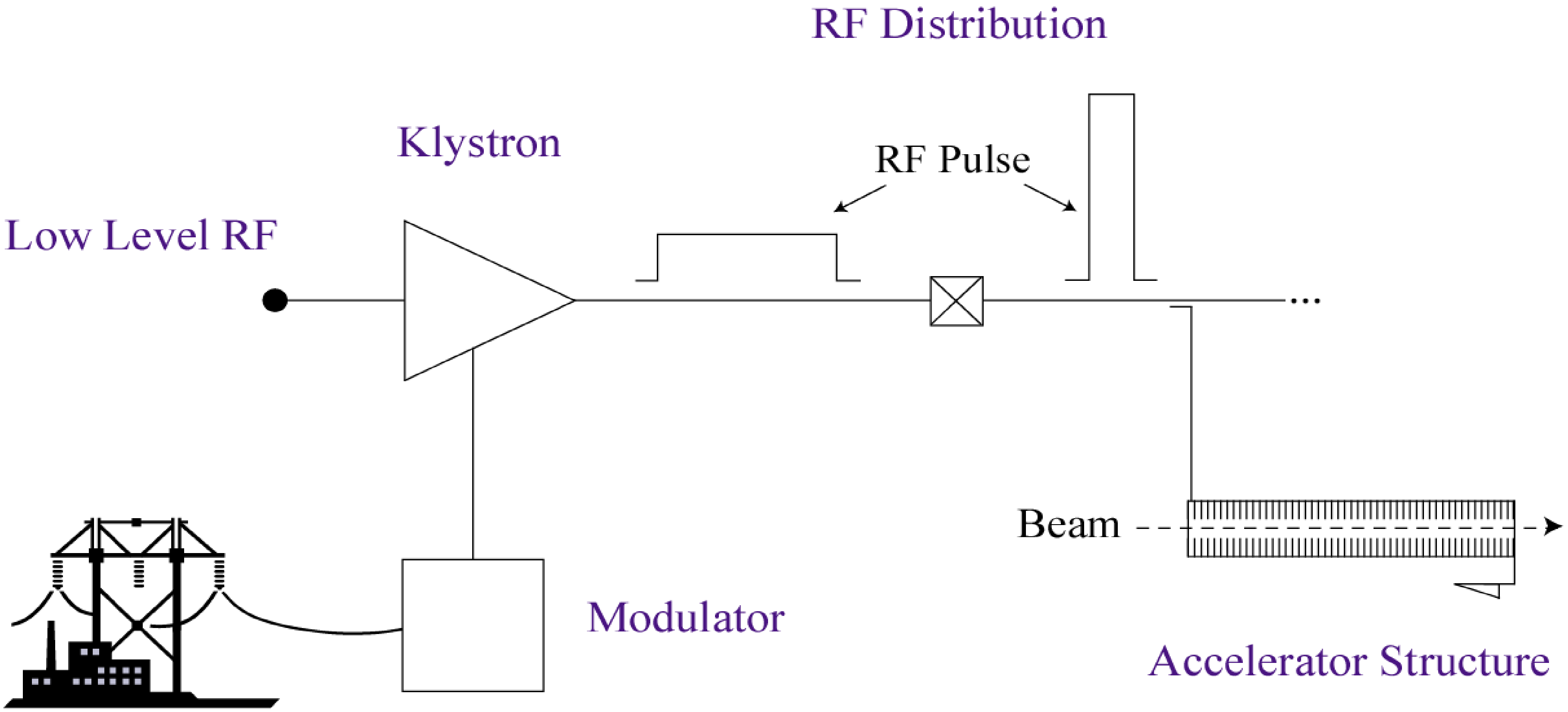
TRC Working Group Methodology

- The groups assessed their respective systems and topics for all machines.
- They examined milestones.
- They summarized their positive reactions as well as their concerns.
- The concerns were translated into R&D they felt is needed to mitigate them.
- A great effort was then made to rank the R&D issues according to certain criteria →

Ranking Criteria

- R1: R&D needed for feasibility demonstration of the machine.
- R2: R&D needed to finalize design choices and ensure reliability of the machine.
- R3: R&D needed before starting production of systems and components.
- R4: R&D desirable for technical or cost optimization.

Simplified RF System Layout



R1: R&D Needed for a Feasibility Demonstration of the Machine

R1 'Score Card': Is a Feasibility Demonstration Required* ?

	Modulators	Klystrons	RF Distribution	Accelerator Structures
TESLA	No	No	No	No (500 GeV) Yes (800 GeV)
NLC/JLC-X	No	No	Yes	Yes
JLC-C	No	No	Yes	Yes
CLIC	Yes	Yes	Yes	Yes

* Unchanged Since Arlington

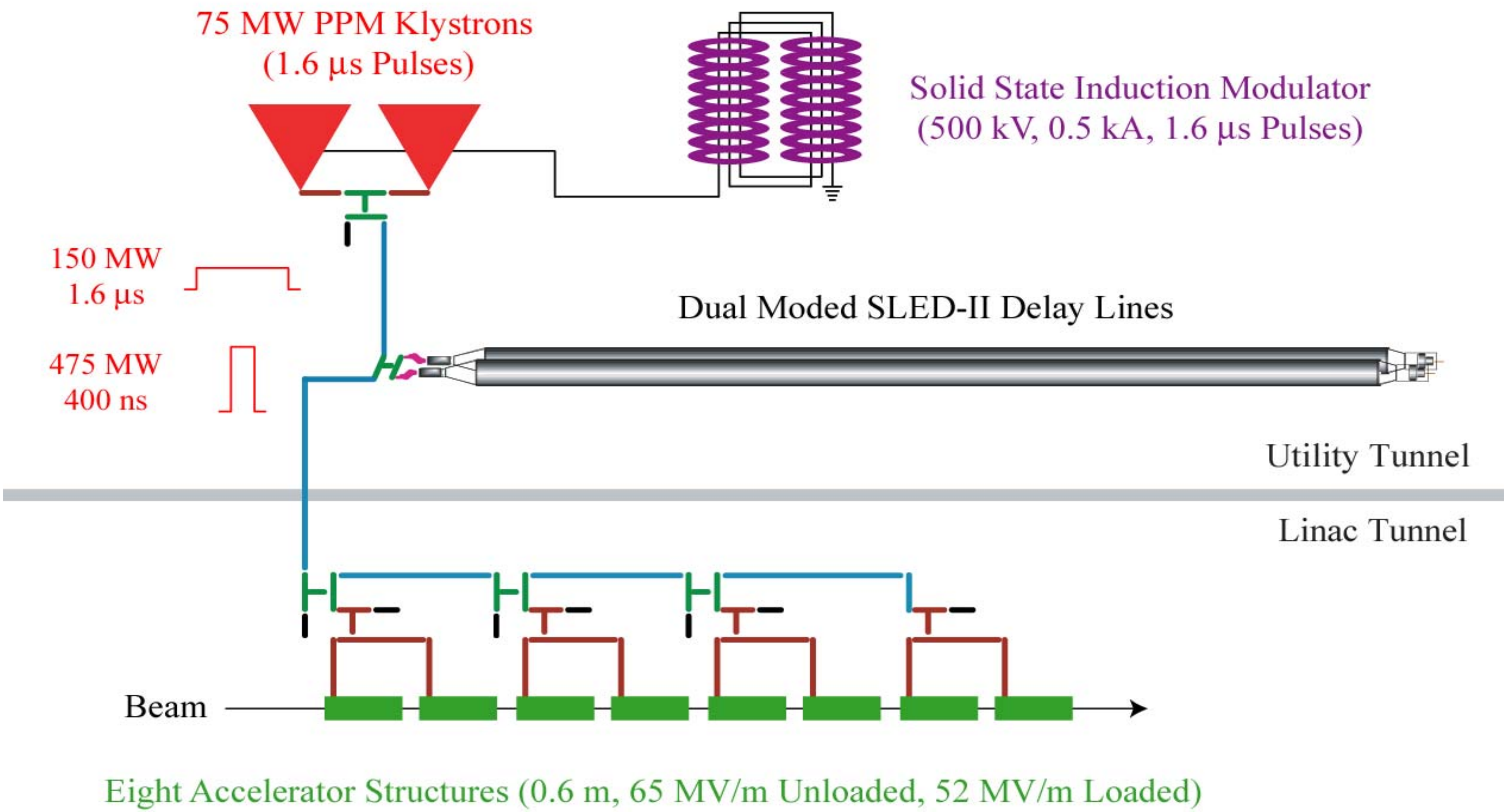
R2: R&D Needed to Finalize Design Choices and Ensure Reliability of the Machine

Requires Test of an RF Unit:

- Assemble essential RF Unit components that at minimum will power a single ‘feed’ of structures:
  - Modulator
  - Klystrons and Low Level RF
  - RF Distribution
  - Accelerator Structures (some with HOM damping).
- Run at nominal power (peak and average) with beam in a machine-like environment.
- Evaluate performance.

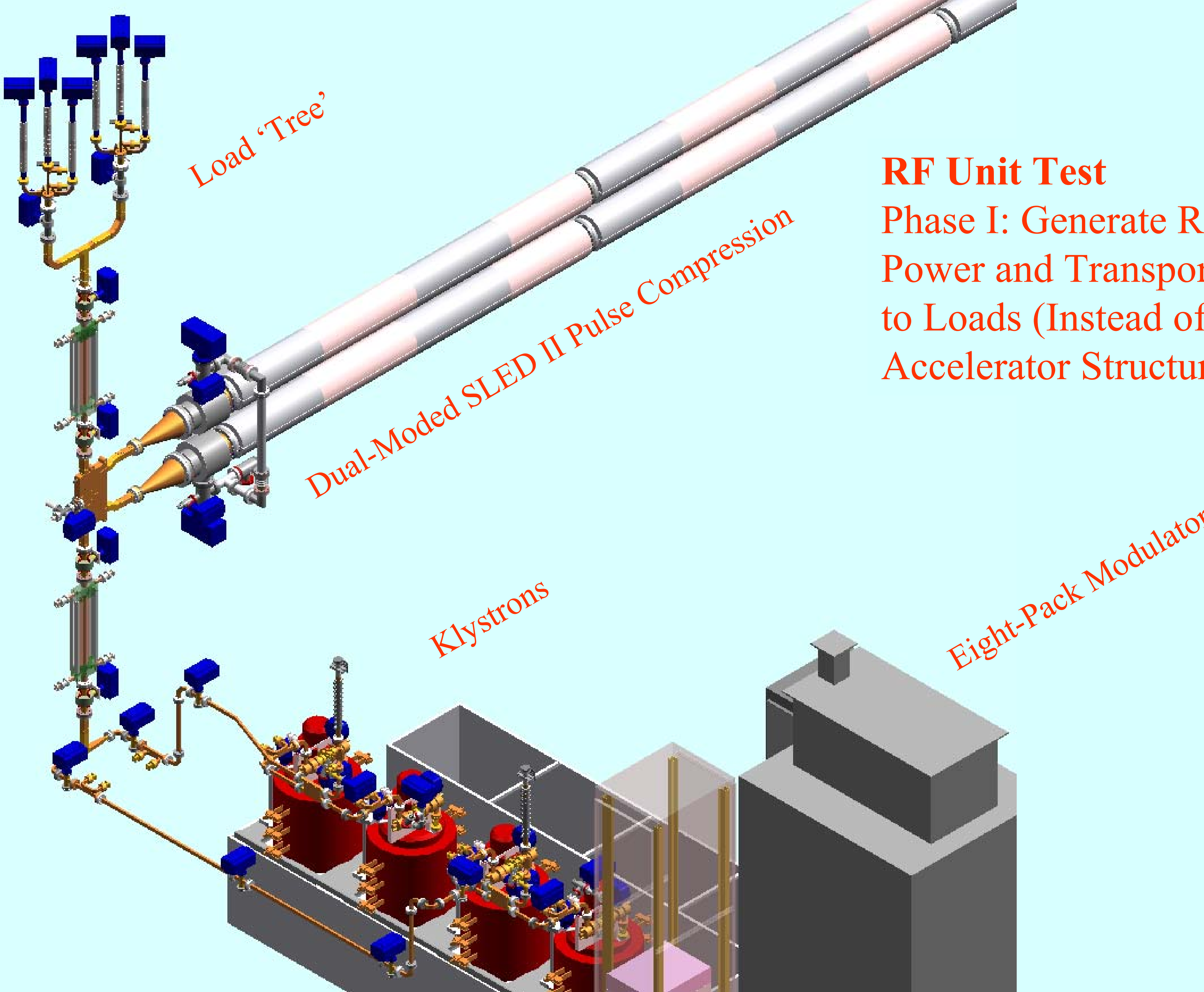
NLC/JLC Linac RF Unit

(One of ~2000 at 500 GeV cm, One of ~4000 at 1 TeV cm)



RF Unit Test

Phase I: Generate RF Power and Transport to Loads (Instead of Accelerator Structures)

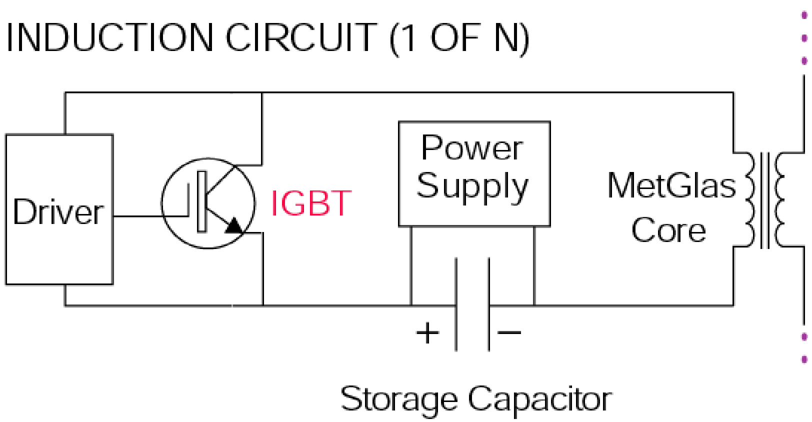


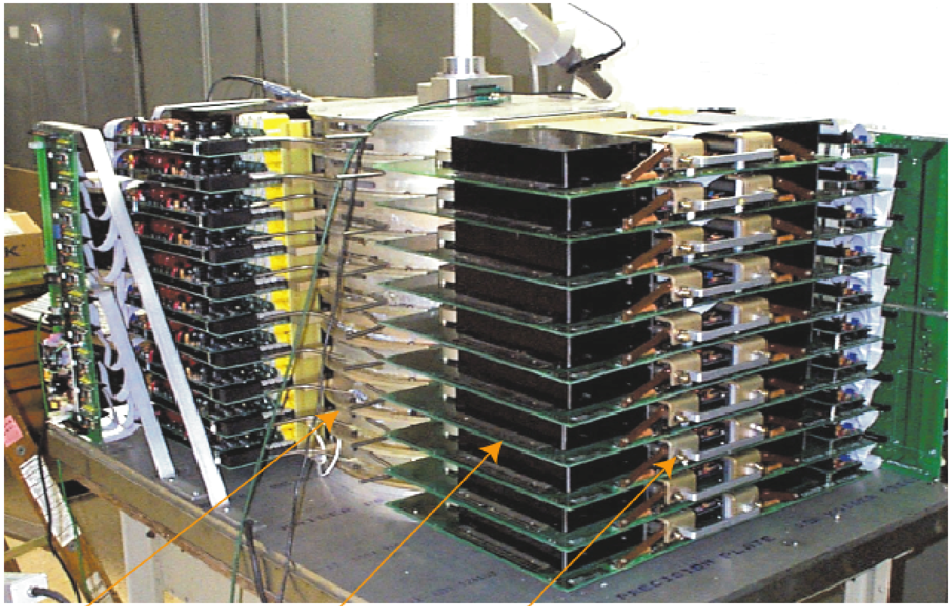
INDUCTION MODULATOR :

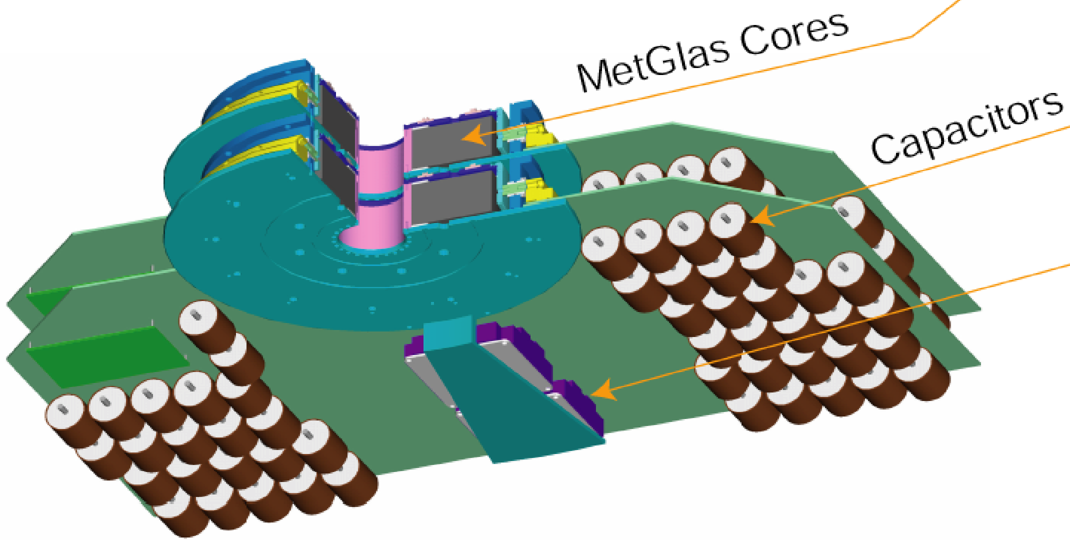
10 Core Test: 22 kV, 6 kA, 3 μs Pulses

SUM MANY LOW VOLTAGE (~ 2 kV) SOURCES INDUCTIVELY

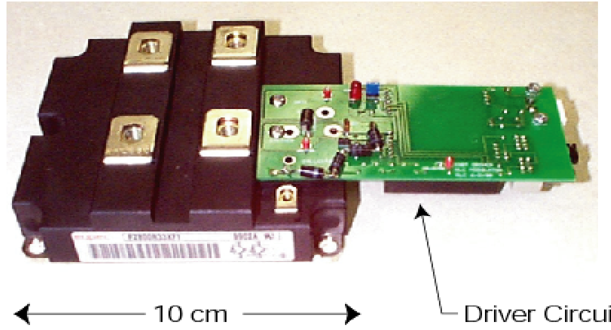
INDUCTION CIRCUIT (1 OF N)





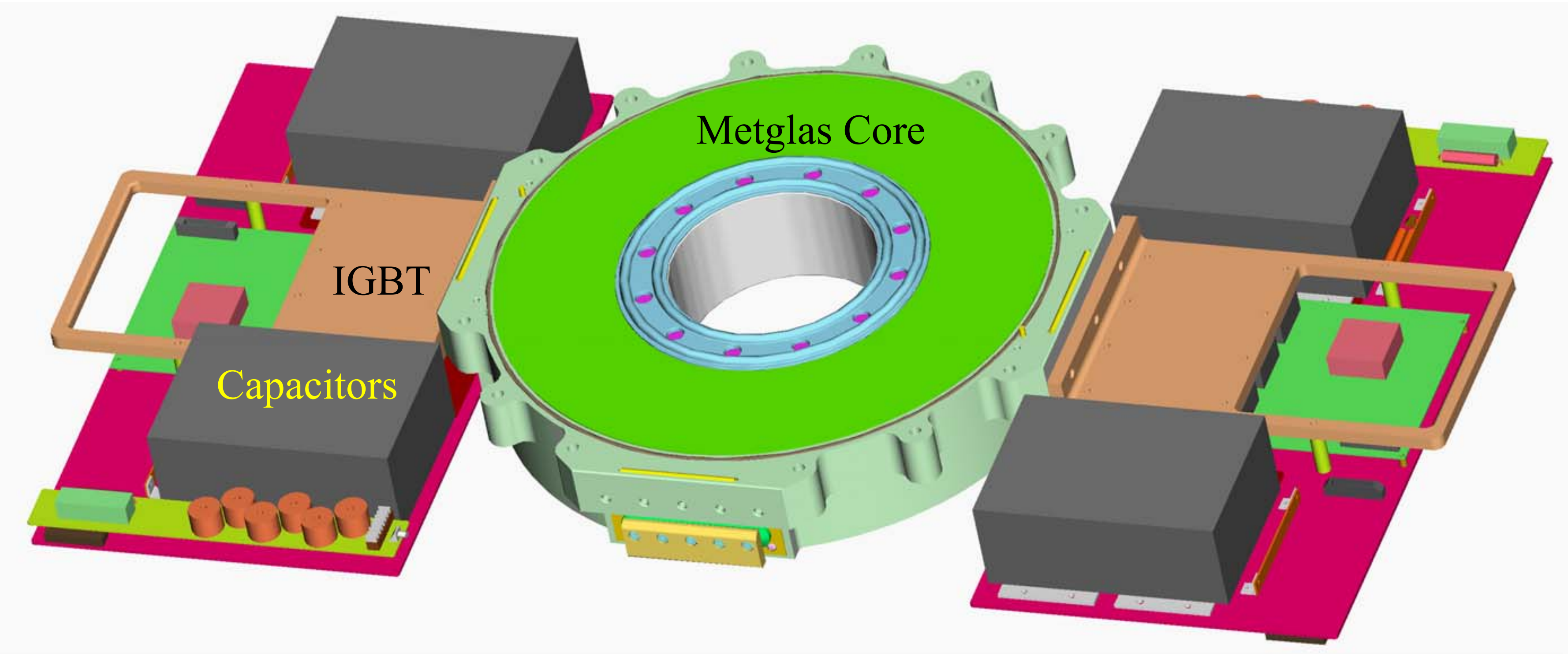


Insulated Gate Bipolar Transistors



SLAC / LLNL / Bechtel NV

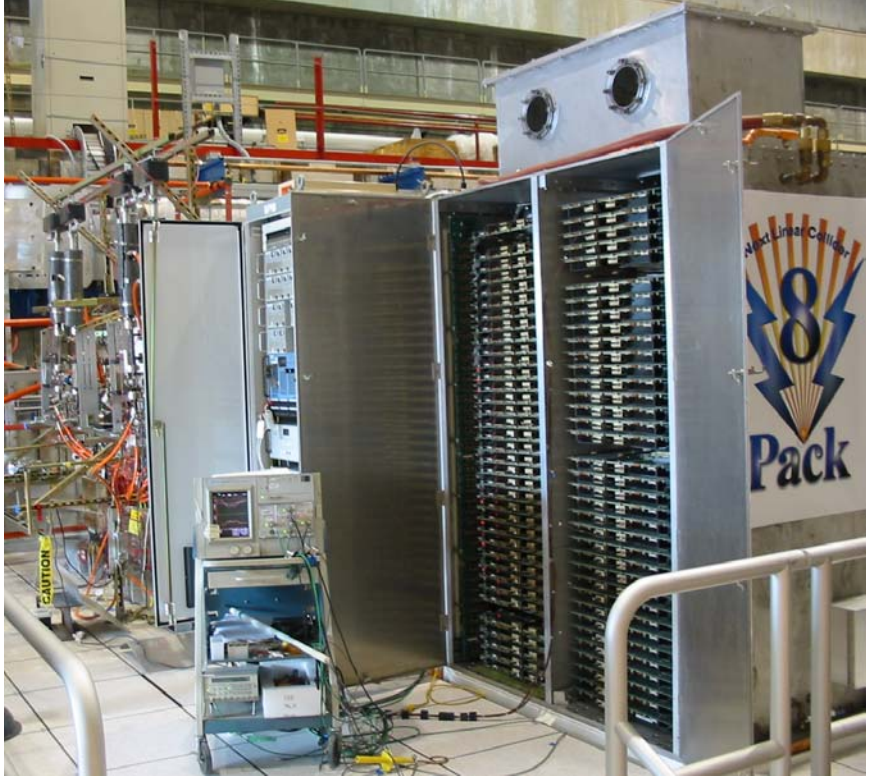
Single Core with Two Drive Boards



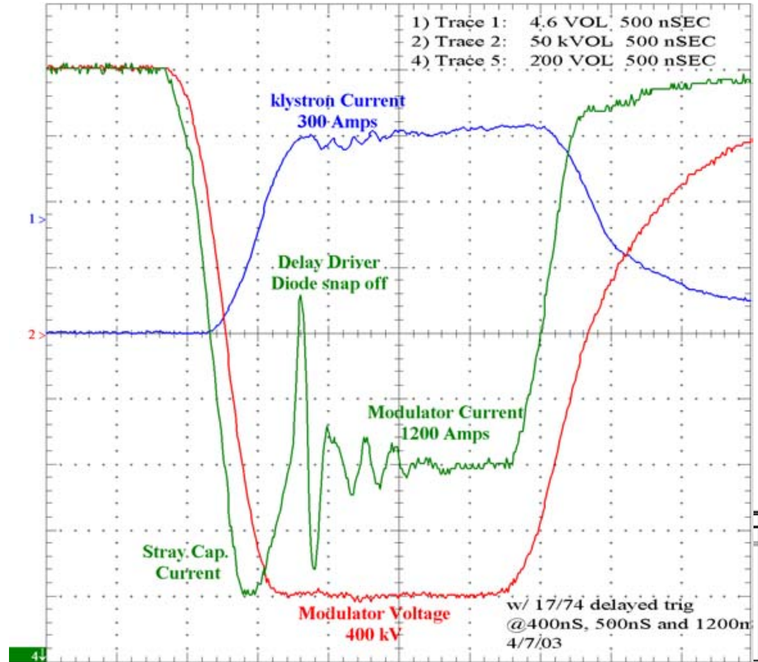
Eight-Pack Modulator

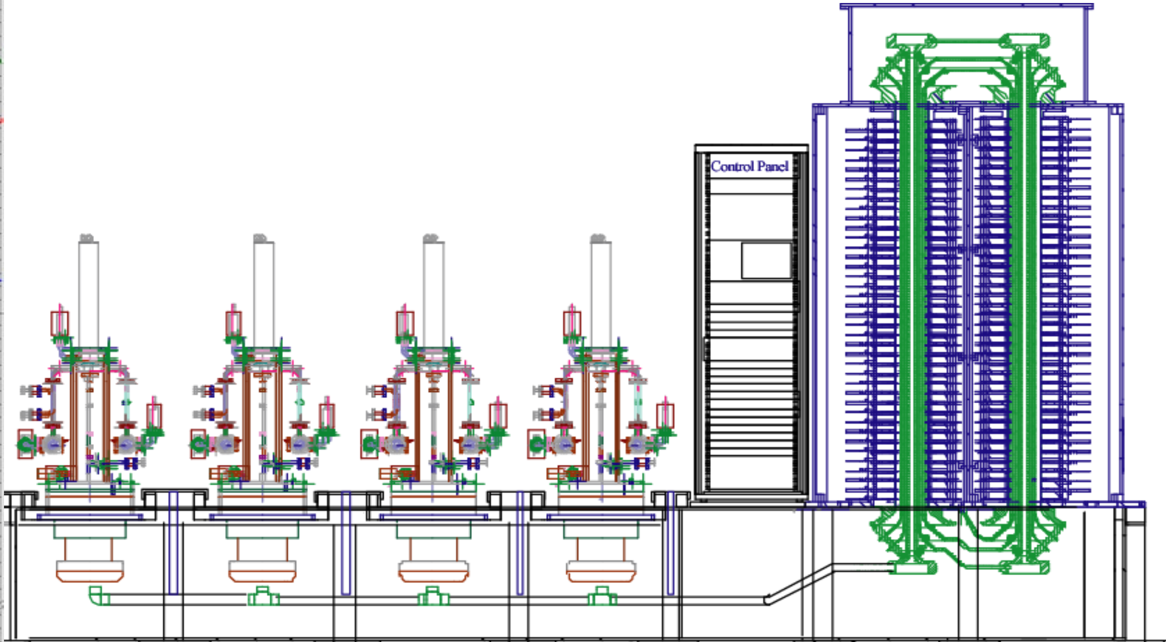
76 Cores

Three-Turn Secondary

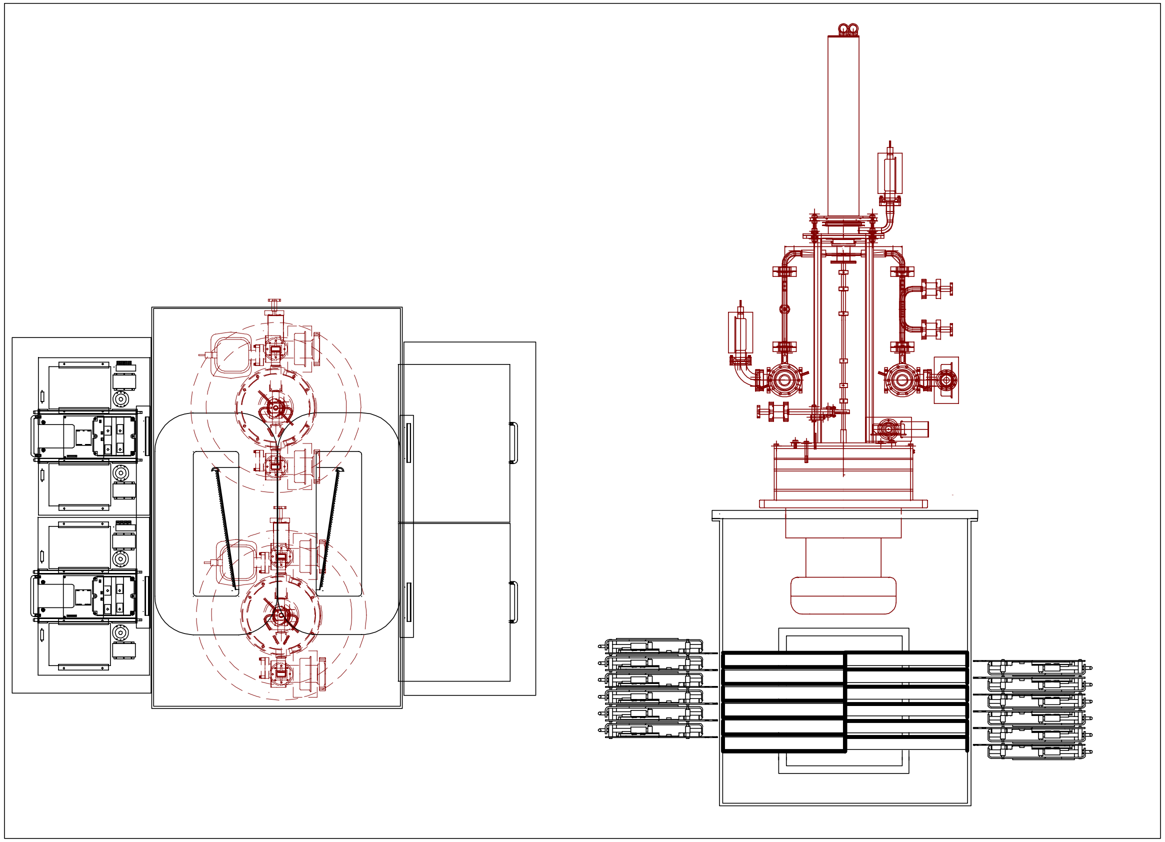


Waveforms When Driving Four 50 MW Klystrons at 400 kV, 300 A Each





Future Development:
2-Pack Design



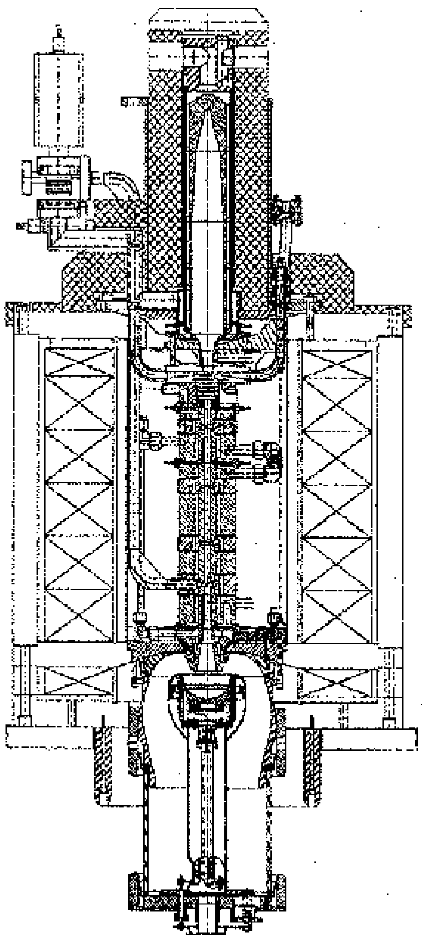
Two Pack Modulator with 40 kV, 6 kA Primary

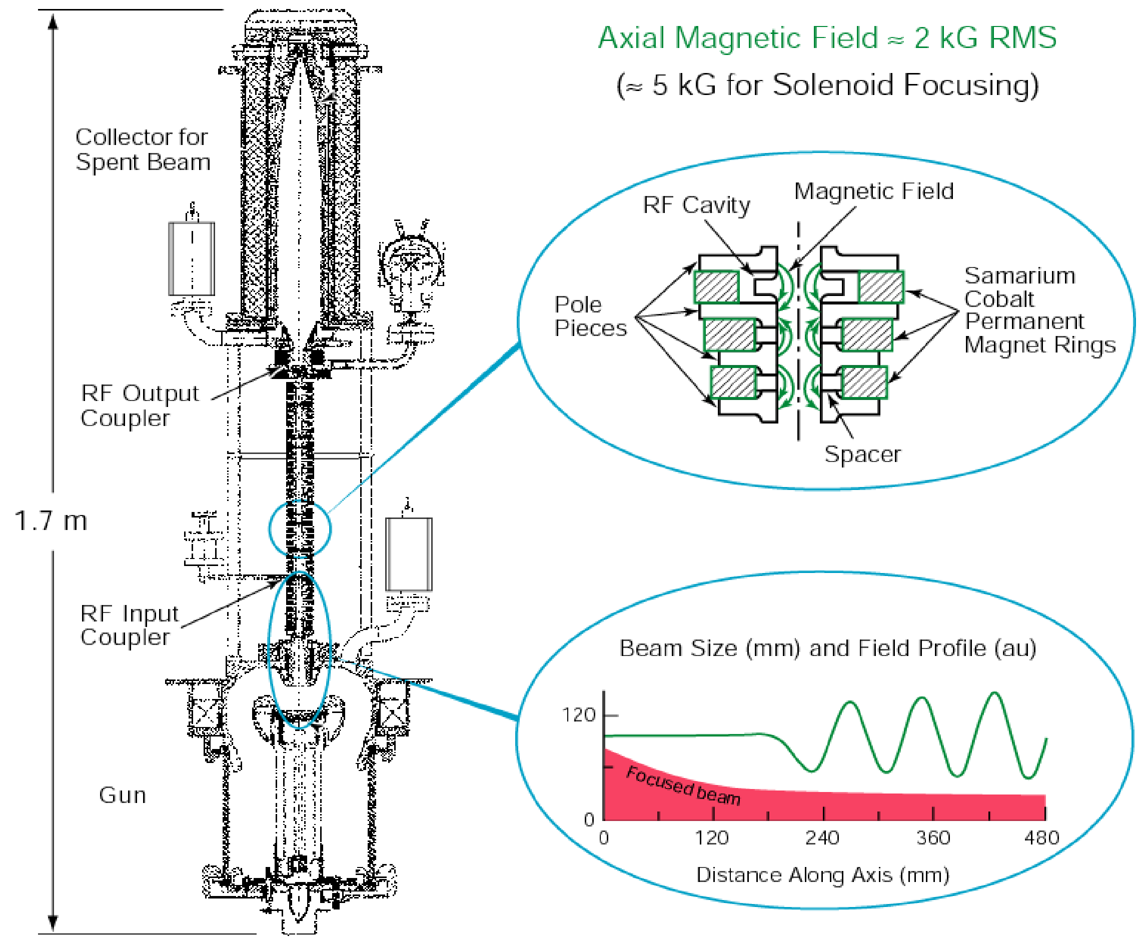
10 Cores @ 4kV, 12/1 Transformer

X-Band (11.4 GHz) KLYSTRONS

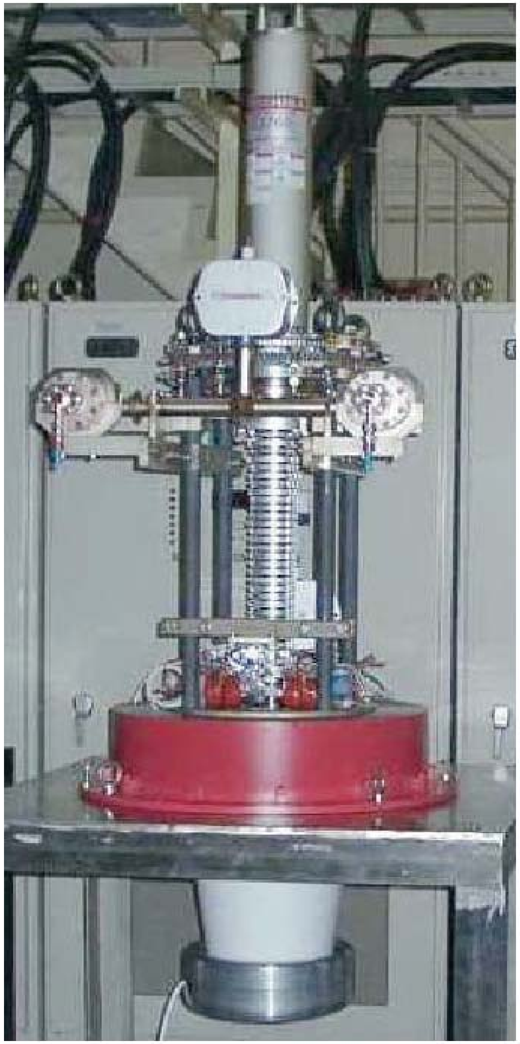
Solenoid Focused Tubes: Have
12, 50 MW Tubes for NLCTA, 8-Pack.
However Solenoid Power = 25 kW.

Developing Periodic Permanent Magnet (PPM)
Focused Tubes to Eliminate the
Power Consuming Solenoid.





PPM Klystron Program



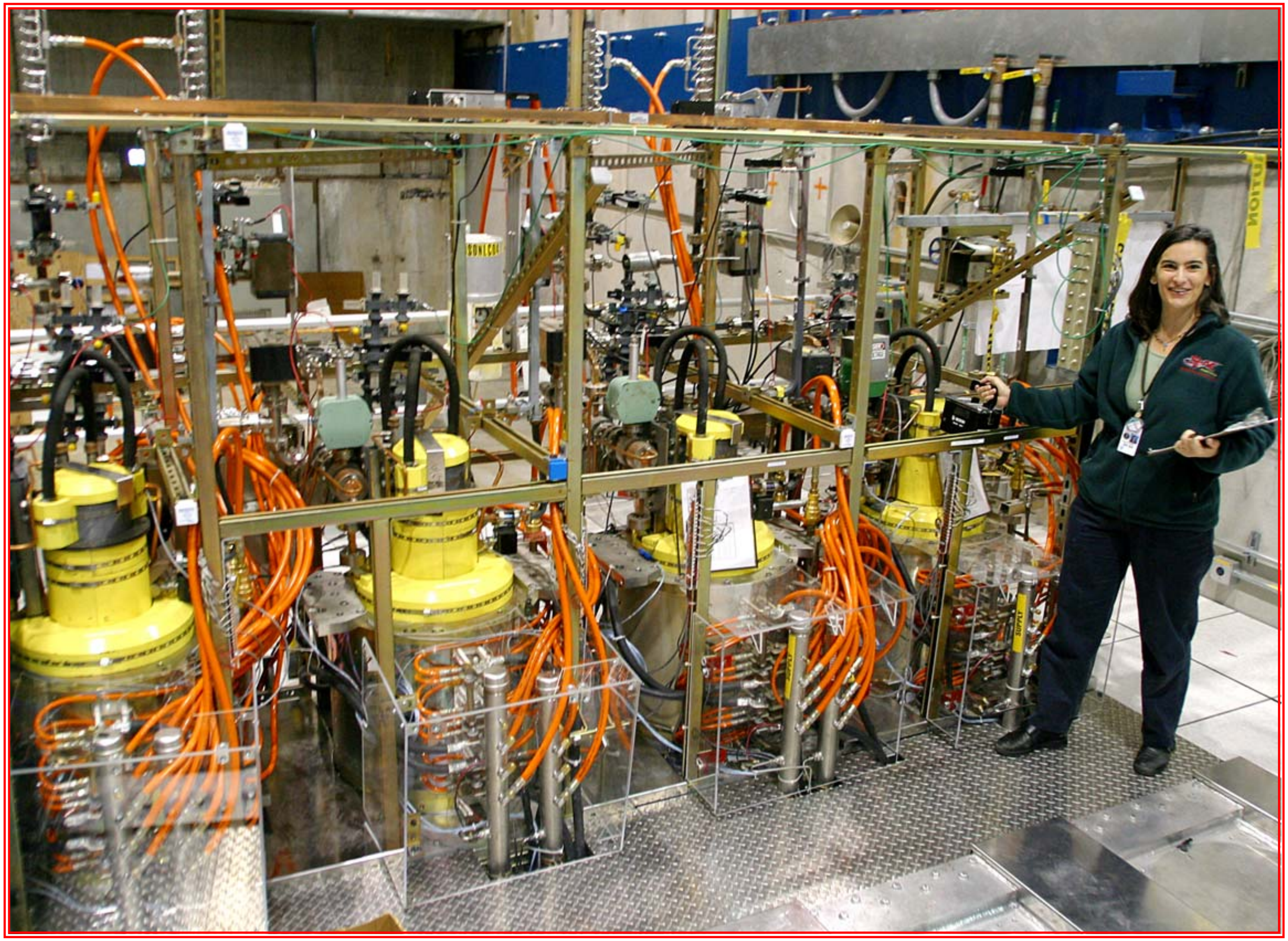
- Both SLAC and KEK (in collaboration with Toshiba) have produced several 75 MW PPM tubes.
- Recent KEK tube (PPM-2) basically met peak power goals (considered an R1 demonstration), but was not run at the design repetition rate due to modulator limitations.

PPM-2:	Design	Achieved
Peak power	75 MW	75.1 MW
Efficiency	55%	56%
Pulse width	1.5 μs	1.4 μs at 74 MW
Repetition rate	150 Hz	25 Hz

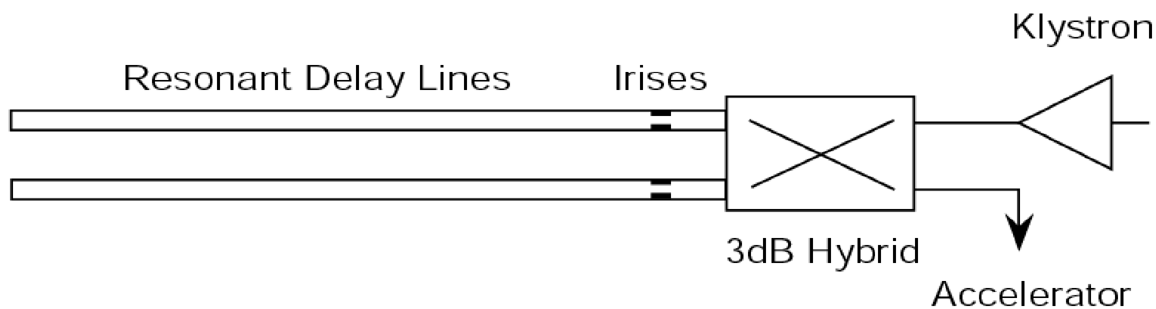
- Currently testing PPM-2 at SLAC and a version with better cooling, PPM-4, at KEK. Goal is to run PPM-4 at 120 Hz at SLAC in September, 2003 to demonstrate average power performance as well (an R2 requirement).
- SLAC is also testing its own PPM designs (XP series), so far with limited success.

Four 50 MW Solenoid-Focused Klystrons Installed in the Eight-Pack Modulator for RF Unit Test

(In Place of Two 75 MW PPM Klystrons)

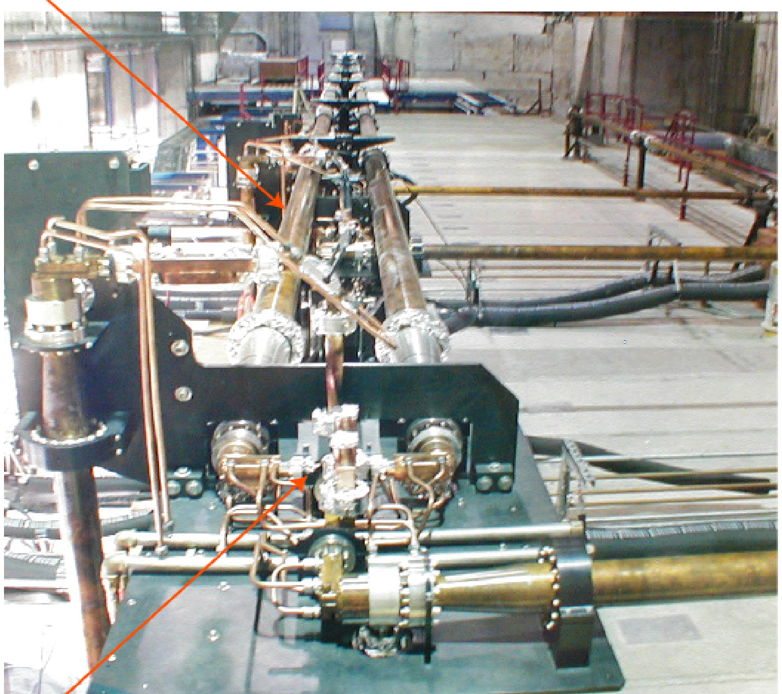


NLC/JLC-X RF Pulse Compression (SLED II)

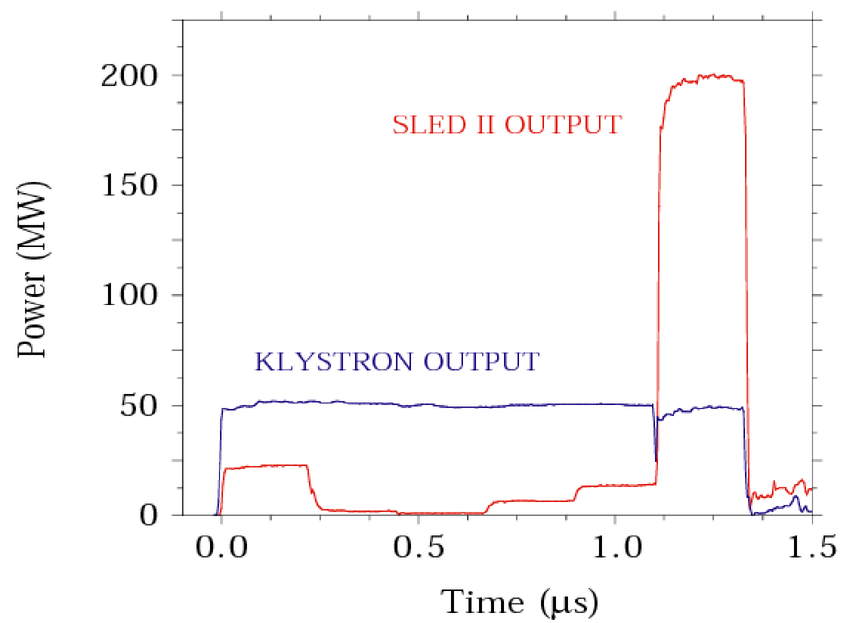


At NLCTA:

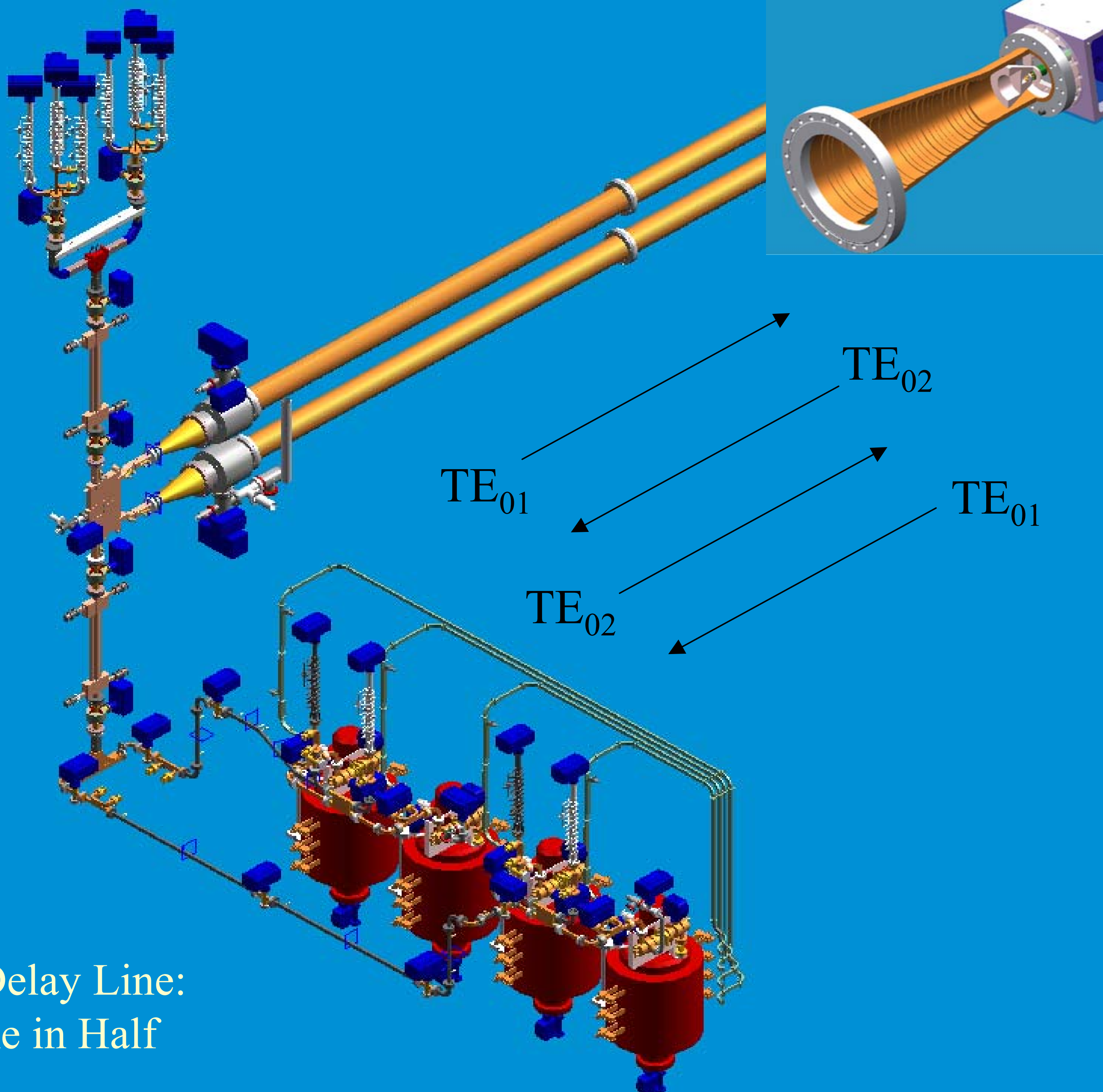
40 m Long, 12 cm Dia. Circular Waveguide



3 dB Hybrid Using a 'Magic Tee'



Have Generated 240 ns, 250 MW Pulses at NLCTA and 150 ns, 485 MW Pulses in an Experimental Test Facilty

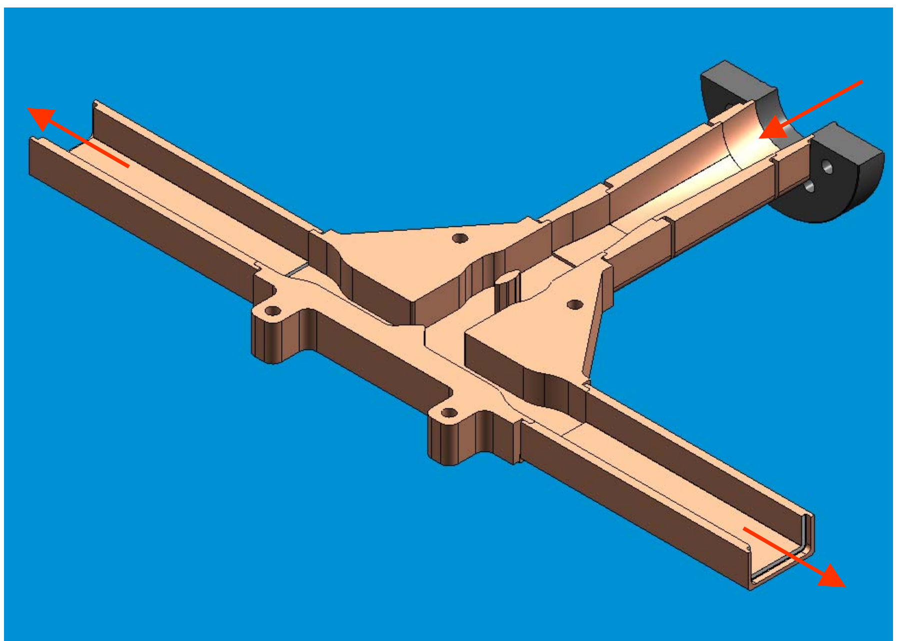


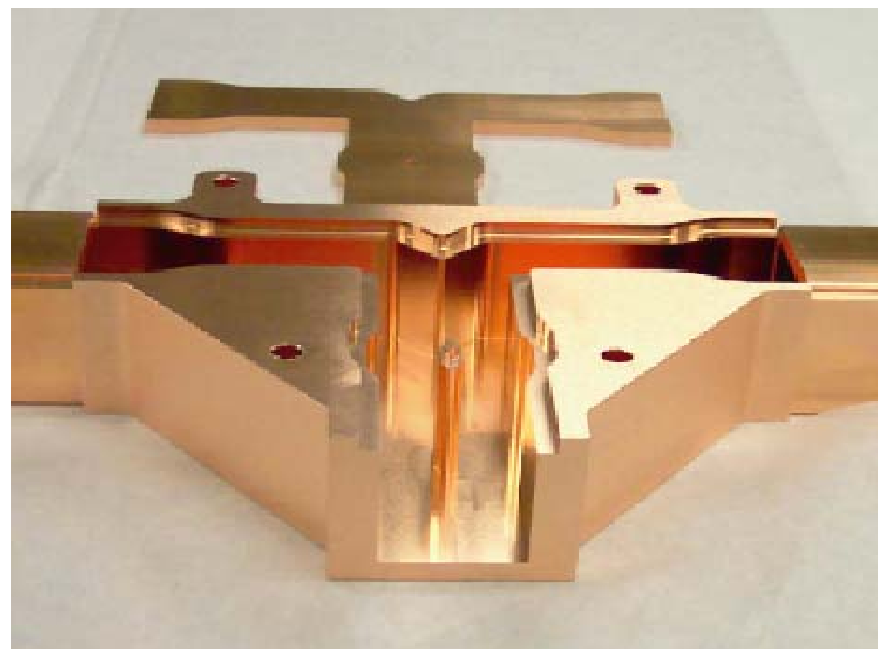
Use Dual Moded Delay Line:
Reduces Delay Line in Half

Use Over-Height Planer Waveguide to Lower Surface Fields and Thus Increase Power Handling Capability

(400 ns, 475 MW Pulses Required)

Example: Power Splitter





Phase 1 Project Schedule

Delay Lines

Finish conditioning loads 7/15

SLED lines in cold testing now

Cross potent hybrid ready 7/14

Cold testing / assembly in July & Aug.

Pump down system 8/8

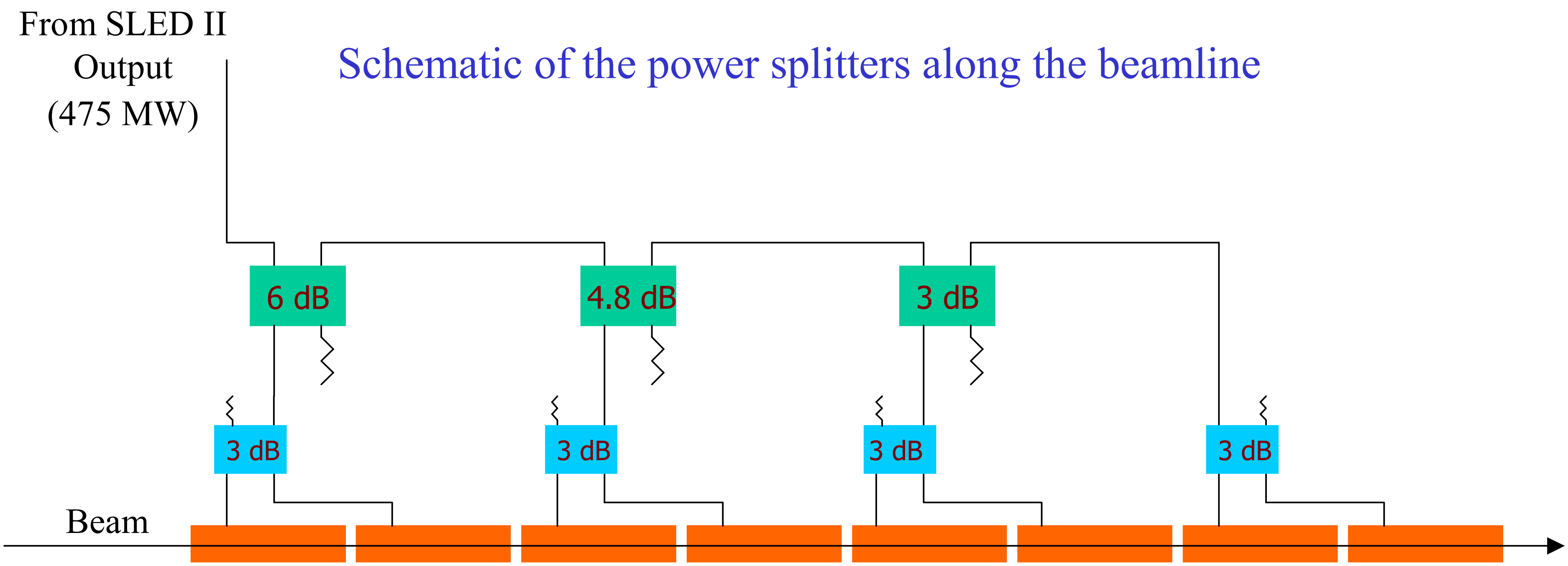
Bake-out finished 9/4

475 MW 400 ns milestone 9/03

Phase 2 of RF Unit Test

Power Eight Accelerator Structures in NLCTA

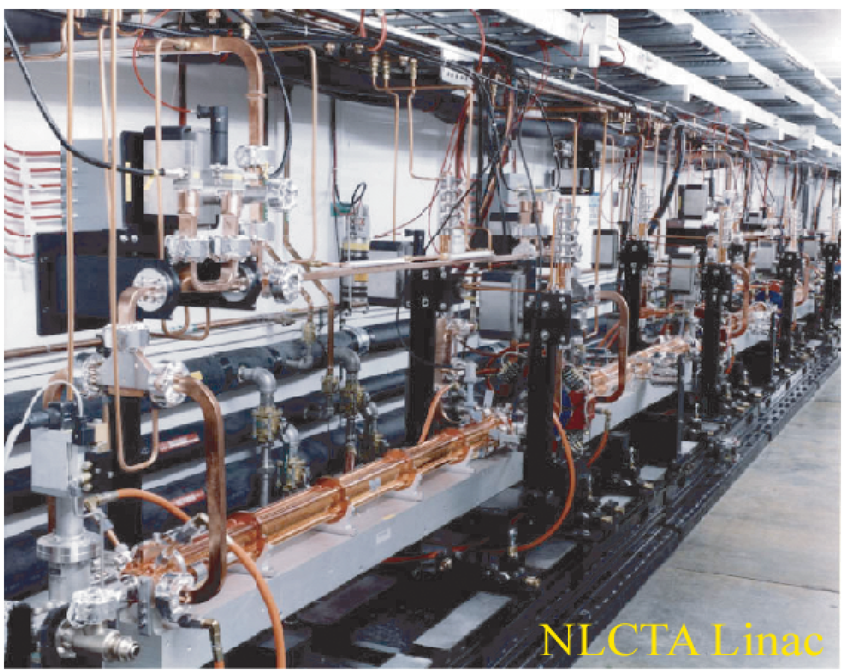
Schematic of the power splitters along the beamline

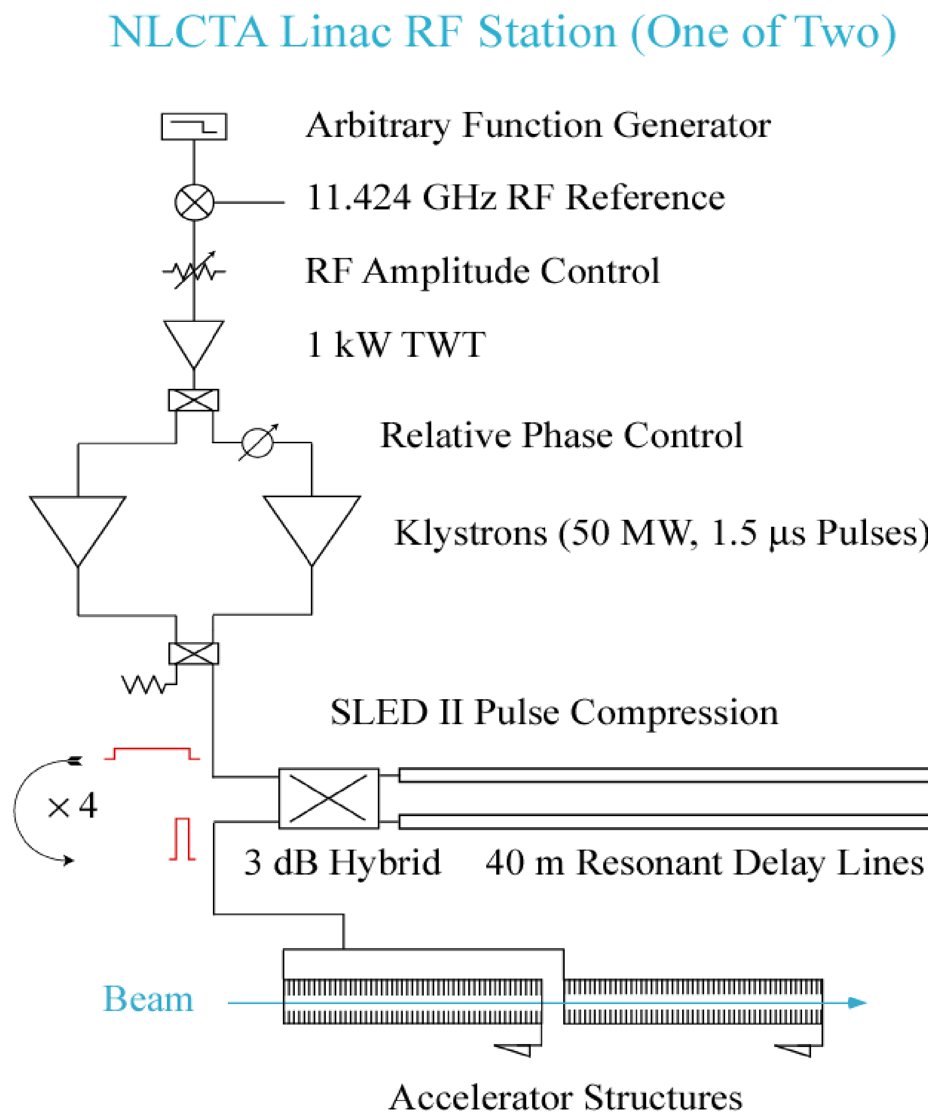


Eight, 0.6 m Long Structures: Run at 65 MV/m, 400 ns Pulses

Next Linear Collider Test Accelerator (NLCTA)

- In 1993, construction started using first generation NLC RF component designs.
- In 1997, demonstrate 17% beam loading compensation in four, 1.8 m structures at a ≈ 40 MV/m gradient.
- In 1998-99, added second klystron to each linac RF station.
- In 2000-03, use four linac structure slots for high gradient studies.





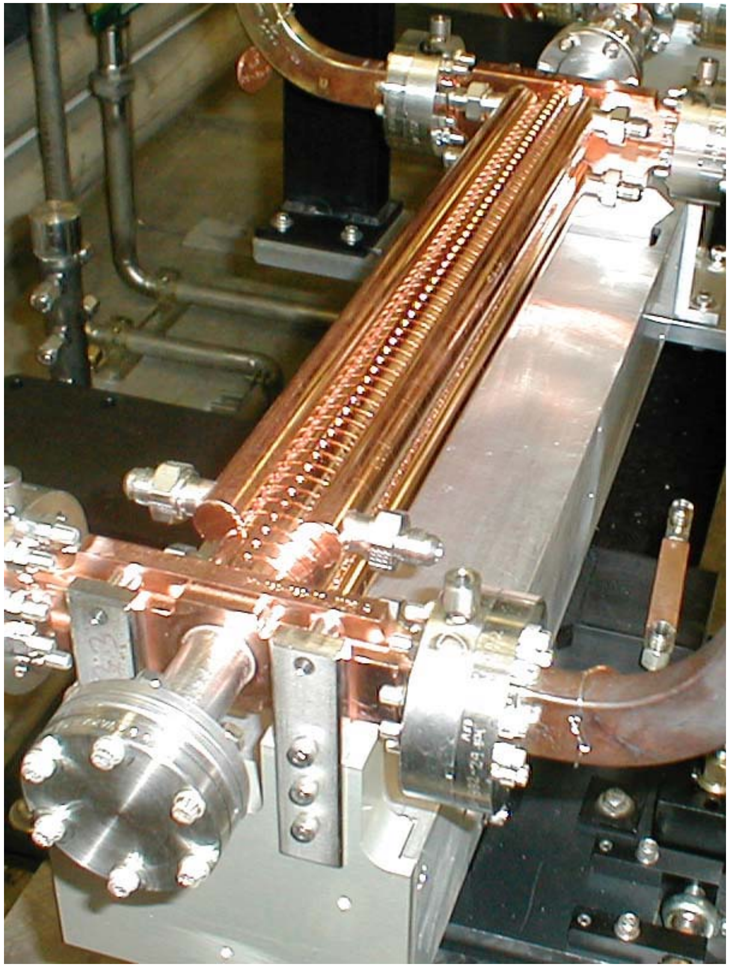
NLC/JLC Structure Development

(65 MV/m Unloaded Gradient Goal for 0.5 & 1 TeV Collider)

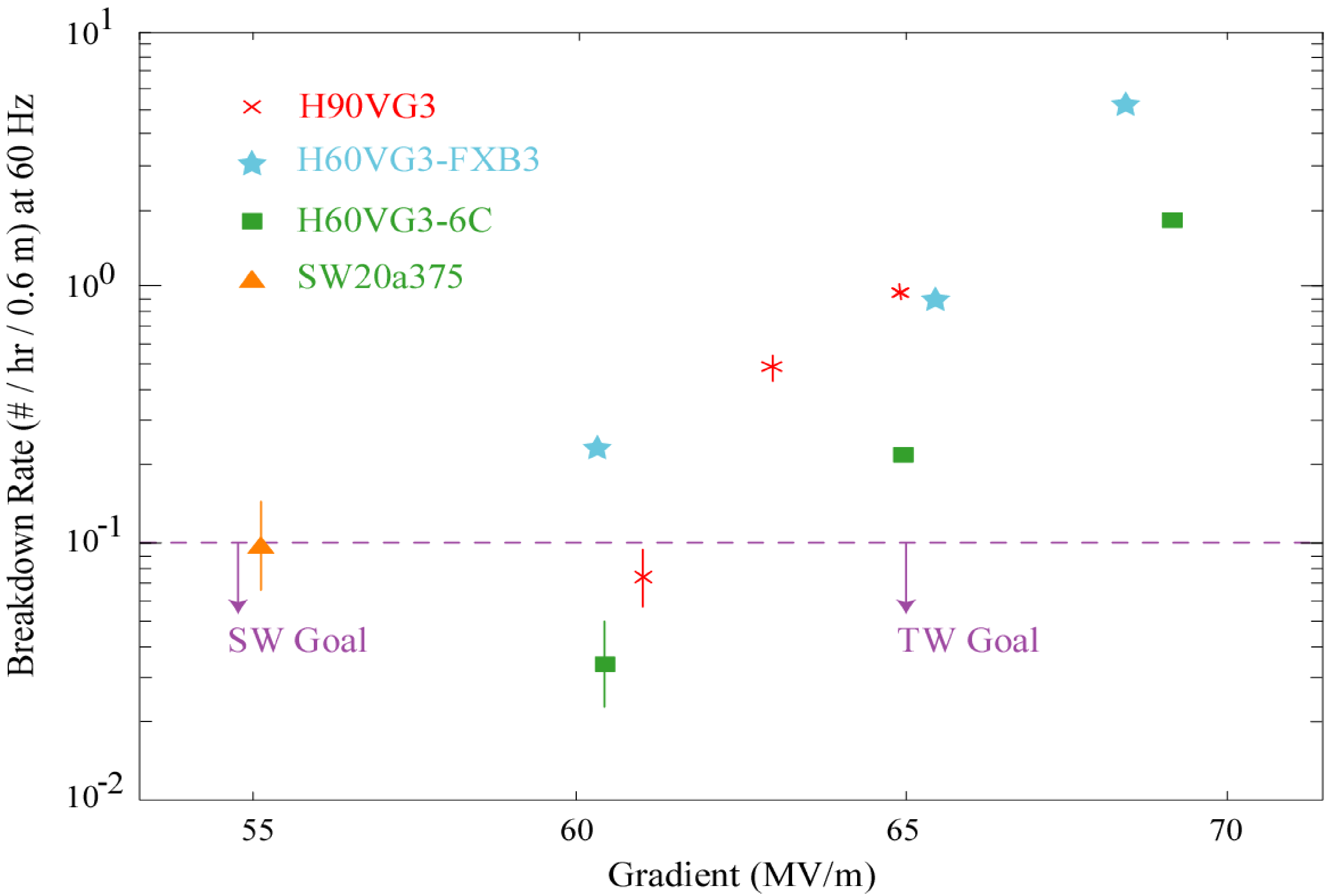
Making Steady Process Toward an 'NLC/JLC – Ready' Structure

- During Past Year Operated a Structure at 90 MV/m with an Acceptable Trip Rate (< 0.1/hr).
- Currently Developing Structures with Suitable Average Iris Radii from a Wakefield Perspective.
- Recent Structures Include Slots for Wakefield Damping.

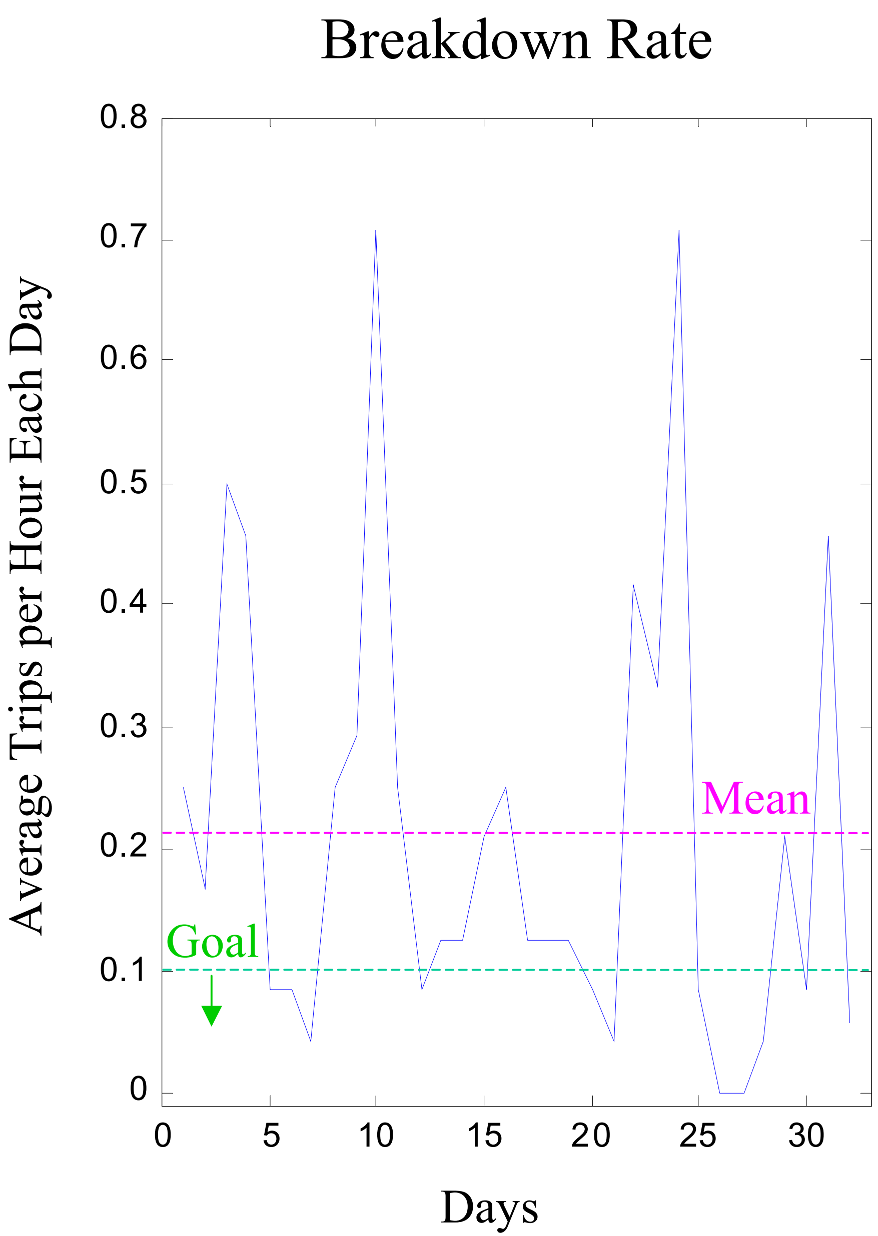
53 cm Traveling-Wave Structure

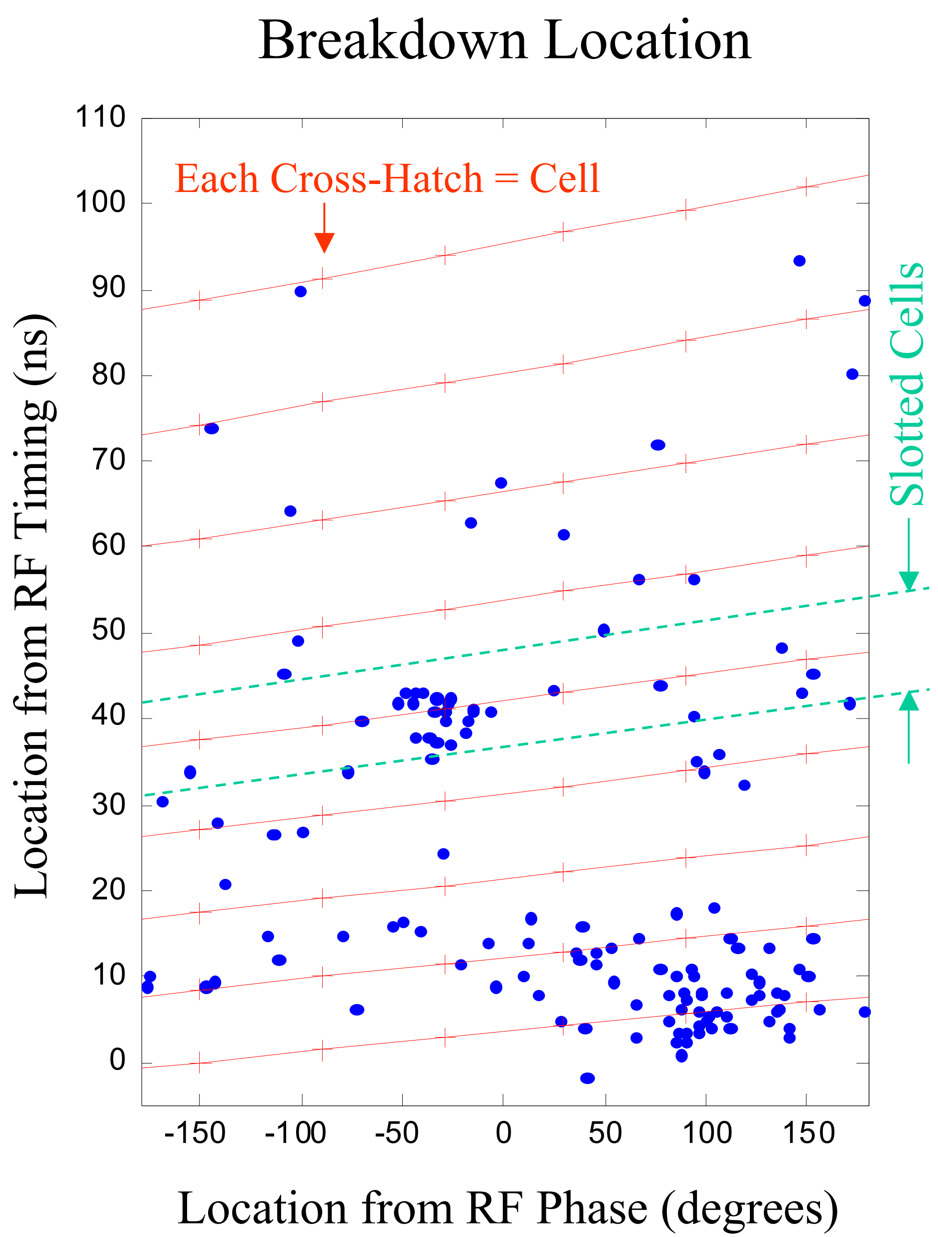


Breakdown Rates at 400 ns Pulse Width

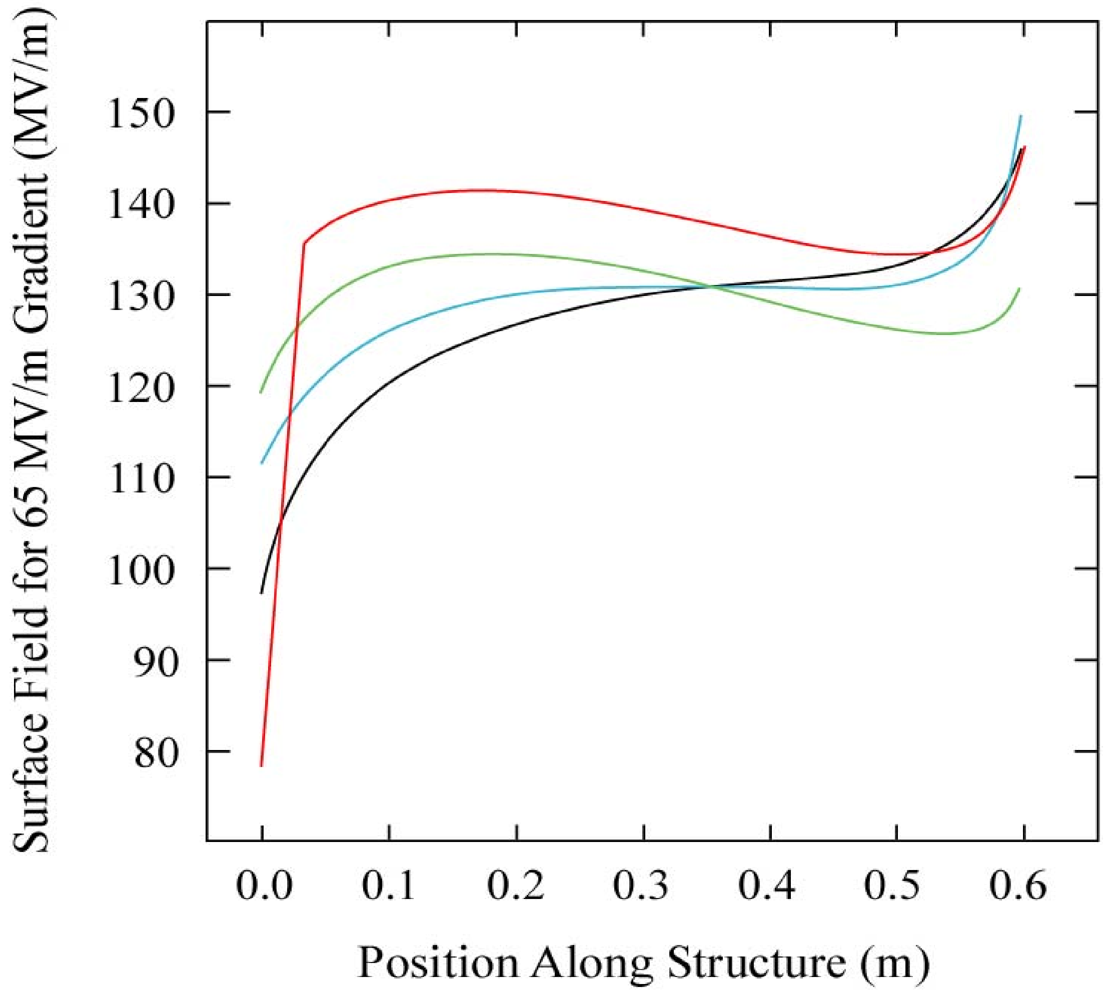


Breakdown Statistics for H60VG3(6C) at 65 MV/m, 400 ns





Peak Surface Field Profile -vs- Structure Type



H60VG3 (a/λ = 0.18, Rounded Irises, Inline Taper, Already Tested)

H60VG3S18 (Elliptical Irises - Reduces Peak Fields by 5% but Requires + 5% Power, Currently Under Test)

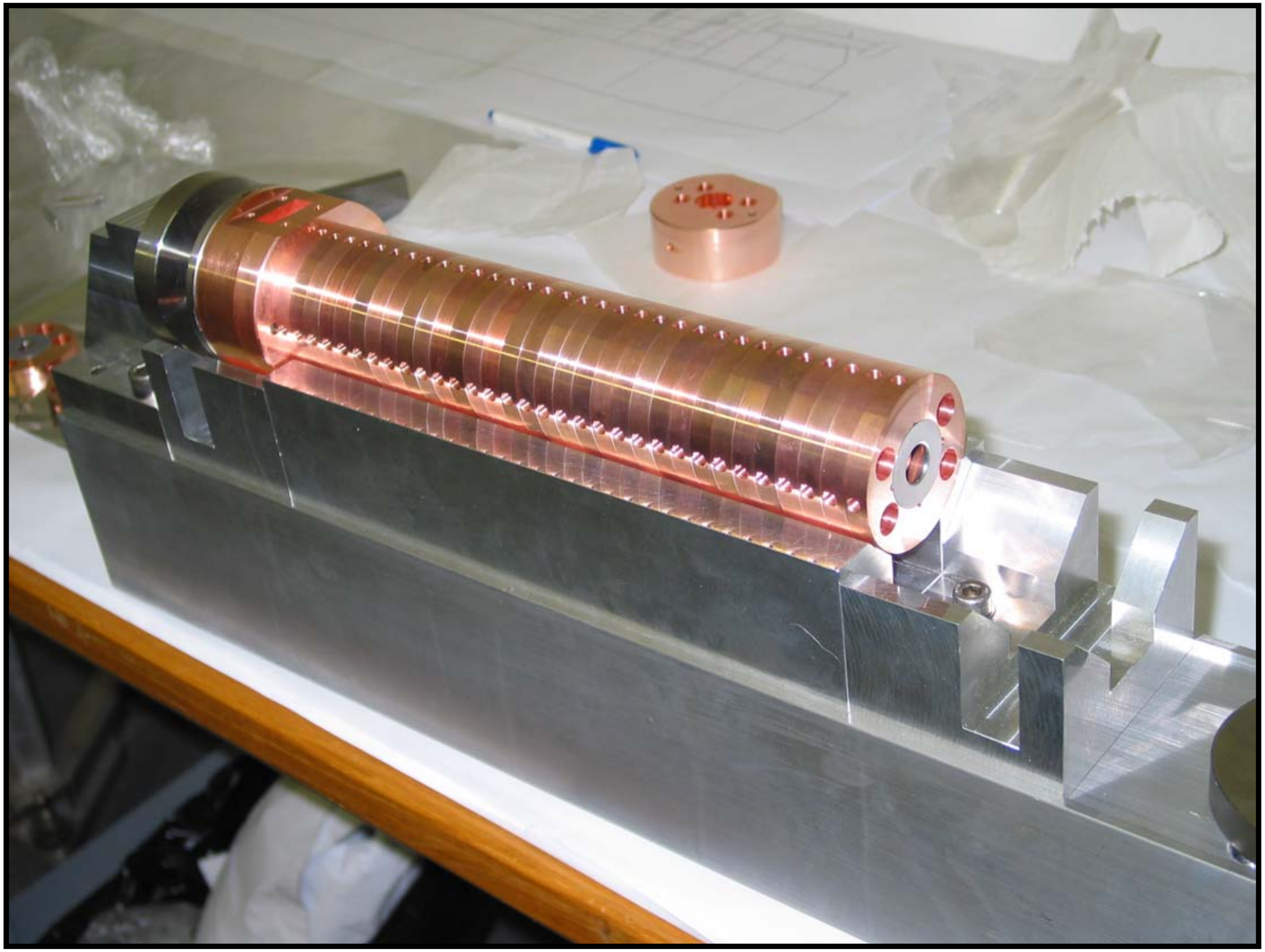
NLC/JLC Candidates:

H60VG3S17 (Elliptical Irises, Lower a/λ, Different v_g and Thickness Profile, Requires 10% Less Input Power Than H60VG3)

H60VG4S17 (Same as Above but Wider, Asymmetric Dipole Spectrum)

CERN X-Band 'Clamped' Structure with Mo/W Irises

(CI, 30 cm, 5% c v_g, $a/\lambda = .175$, 90 MW Input for 65 MV/m Average)



2003-04 Structure Test Schedule

June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June

SW20a375 x 2 20 MW/pair — KEK/SLAC

H60VG3S18 (0.18, 150°, slots, no HOM loads) 69 MW — KEK/SLAC
FXB4 – H60VG3 (0.18, 150°, no slots) 63 MW — FNAL

CERNW (W & Mo irises) 86 MW — CERN

H75VG4S18 (0.18, 150°, slots) 73 MW — KEK/SLAC
FXB5, 6 – H60VG3 (0.18, 150°, no slots) 63 MW — FNAL

H60VG3R17 (0.17, 150°, no slots) 57 MW — SLAC

H60VG4R17 (0.17, 150°, no slots) 57 MW — SLAC

4 X FXC - H60VG3S17 (0.17, 150°, slots) 59 MW — FNAL

Cup Fabrication

Final Assembly

HOM Design, Test and Fabrication

2 X H60VG4S17 (0.17, 150°, slots) 59 MW — KEK/SLAC

H60VG4S17 (one of above)
(0.17, 150°, slots, with HOM) 59 MW

Structures for RF Unit Test

Summary

On Track to Meet Essential R1 and R2 Requirements by Next Summer.

- Induction modulator has driven four klystrons – need to run at higher repetition rate.
- Likewise, need to run a 75 MW PPM klystron at full rate.
- Peak SLED II power (485 MW) has been generated, but with shorter pulses (150 ns).
  - New over-height components should be more robust.
  - Full power and pulse width testing to begin in September.
- Have tested structure with essential NLC/JLC features that basically meets performance requirements (two times higher breakdown rate than desired).
  - Adopted a lower a/λ design to improve efficiency and performance at the cost of somewhat larger wakefields.
- Will operate eight NLC/JLC-like structures at NLCTA to improve performance statistics and demonstrate larger-scale accelerator operation.