11.424 GHz High Gradient Testing of a T18 TW Structure Using a Fast Response Protection and Power Recirculating System

Work performed under the auspices of the U.S. Department of Energy SBIR
Grant No. DE-FG02-08ER85197

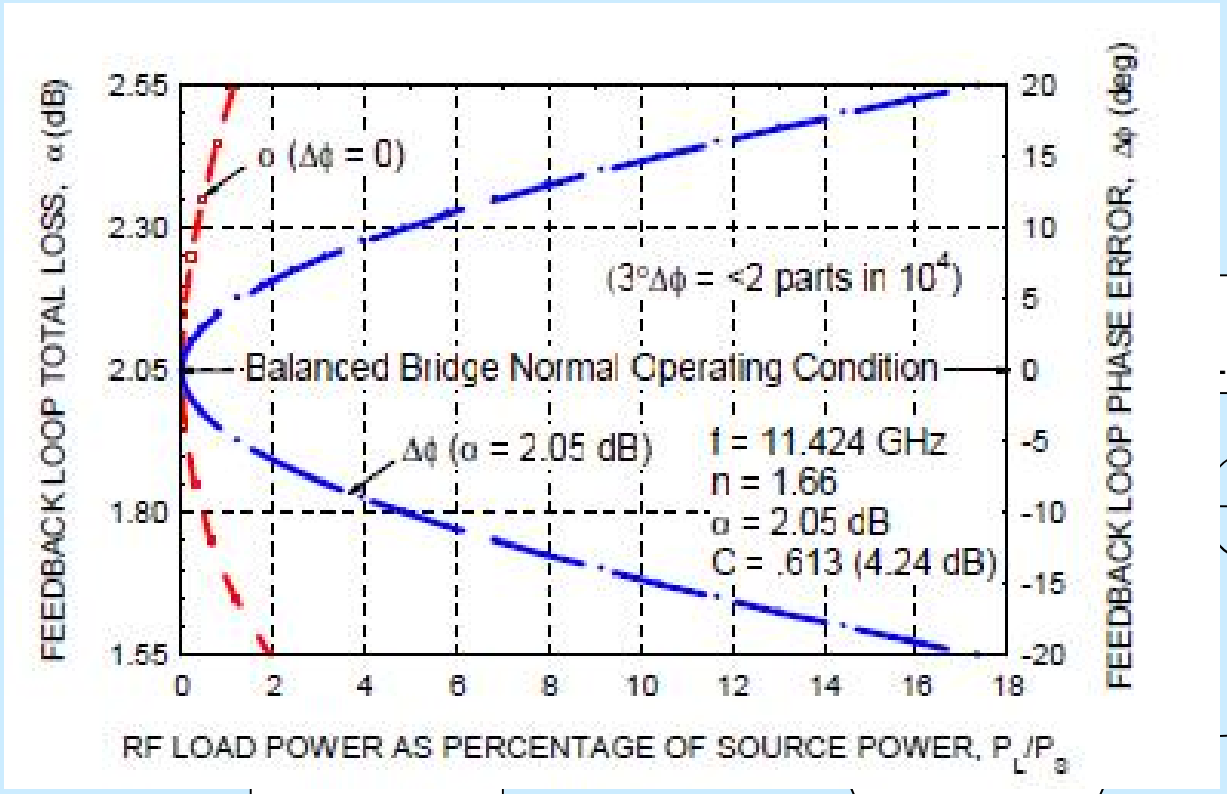
Objective:

To Compare the High Gradient Performance of a Dual Feed T18 TW Linac Structure when Driven by a Resonant Ring Power Amplifier and when Load Terminated and Excited Directly with a High Power Klystron.

Content:

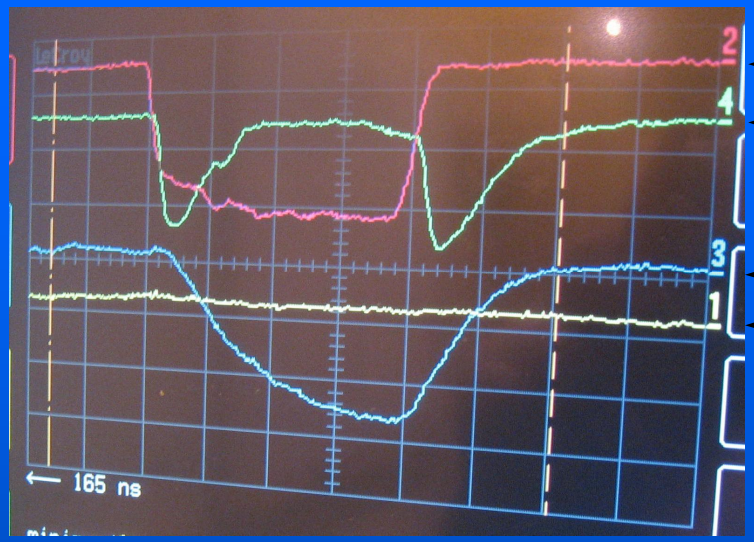
1. Describe Advantageous Operating Characteristics of Resonant Ring Driven TW Linacs.

2. Discuss Design Features of the Planned 11.424 GHz Power Recirculating System


FEEDBACK LOOP TOTAL LOSS, α (dB)
FEEDBACK LOOP PHASE ERROR, Δφ (deg)
RF LOAD POWER AS PERCENTAGE OF SOURCE POWER, P_L/P_S
α (Δφ = 0)
(3°Δφ = <2 parts in 10^4)
Balanced Bridge Normal Operating Condition
Δφ (α = 2.05 dB)
f = 11.424 GHz
n = 1.66
α = 2.05 dB
C = .613 (4.24 dB)
2.55
2.30
2.05
1.80
1.55
20
15
10
5
0
-5
-10
-15
-20
0
2
4
6
8
10
12
14
16
18

RF
.OAD
RF MONITOR
P_L
2
3
P_A = (1 + n)P_S
P_F = nP_S
ELECTRON SOURCE
TEST LINAC
SPECTROMETER

NORMAL LINAC OPERATION



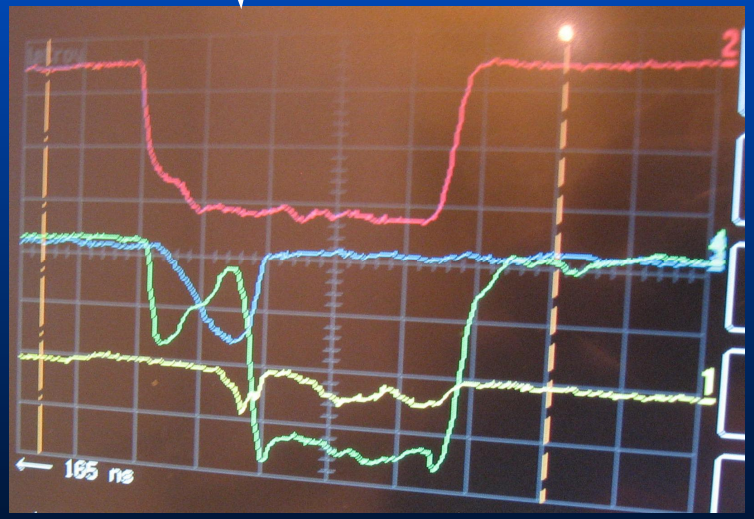
RF Source Power

Bridge Load Power

Linac Input Power

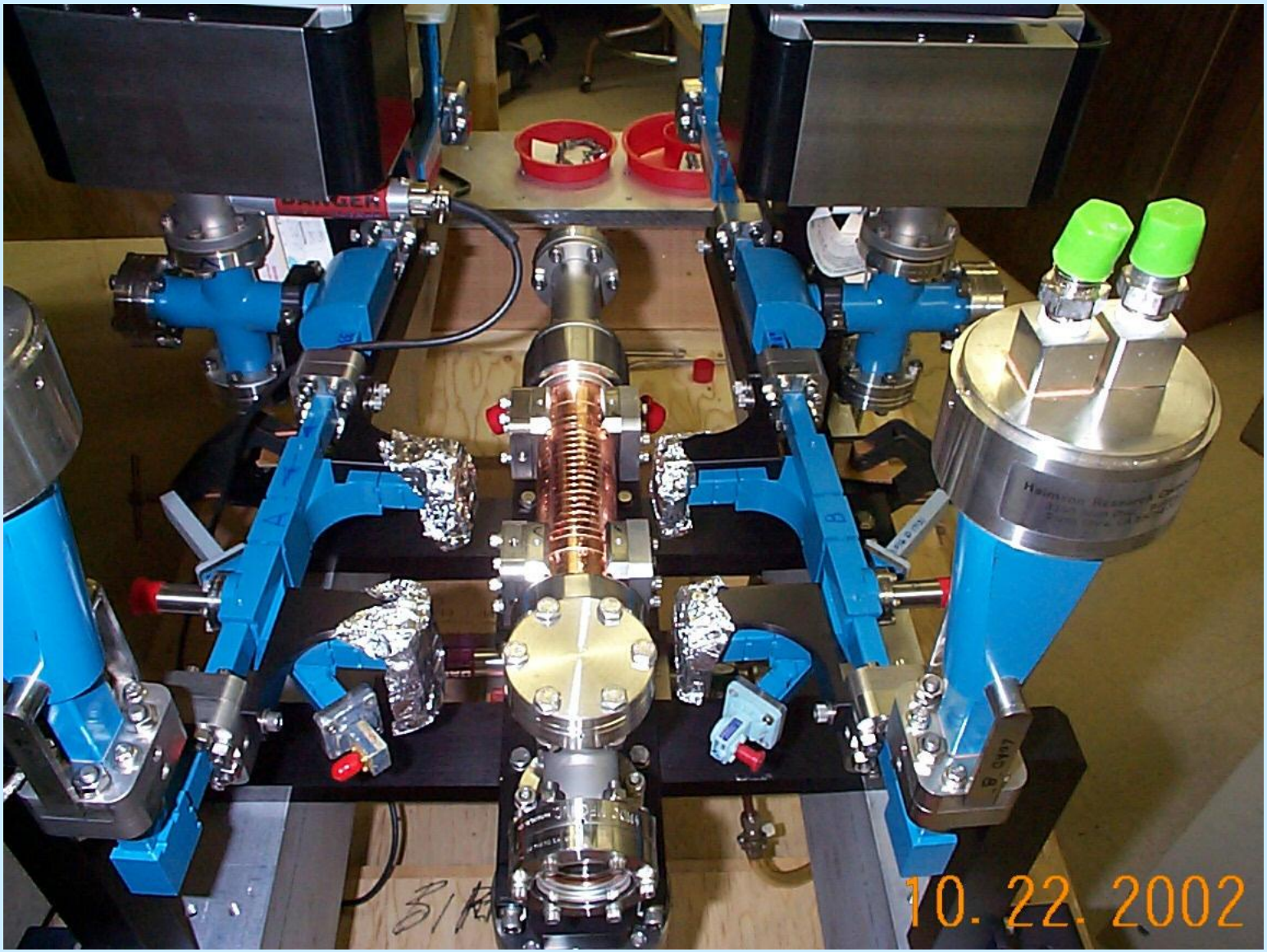
Linac Reflected Power

WITH ARC IN LINAC

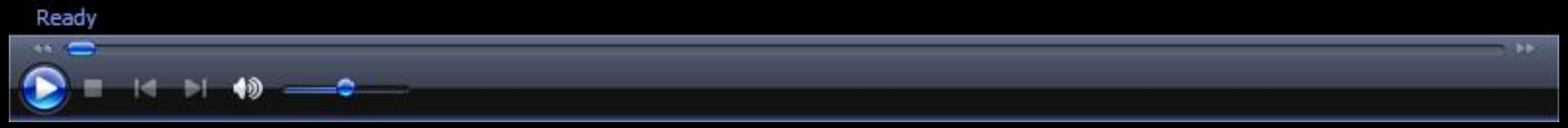


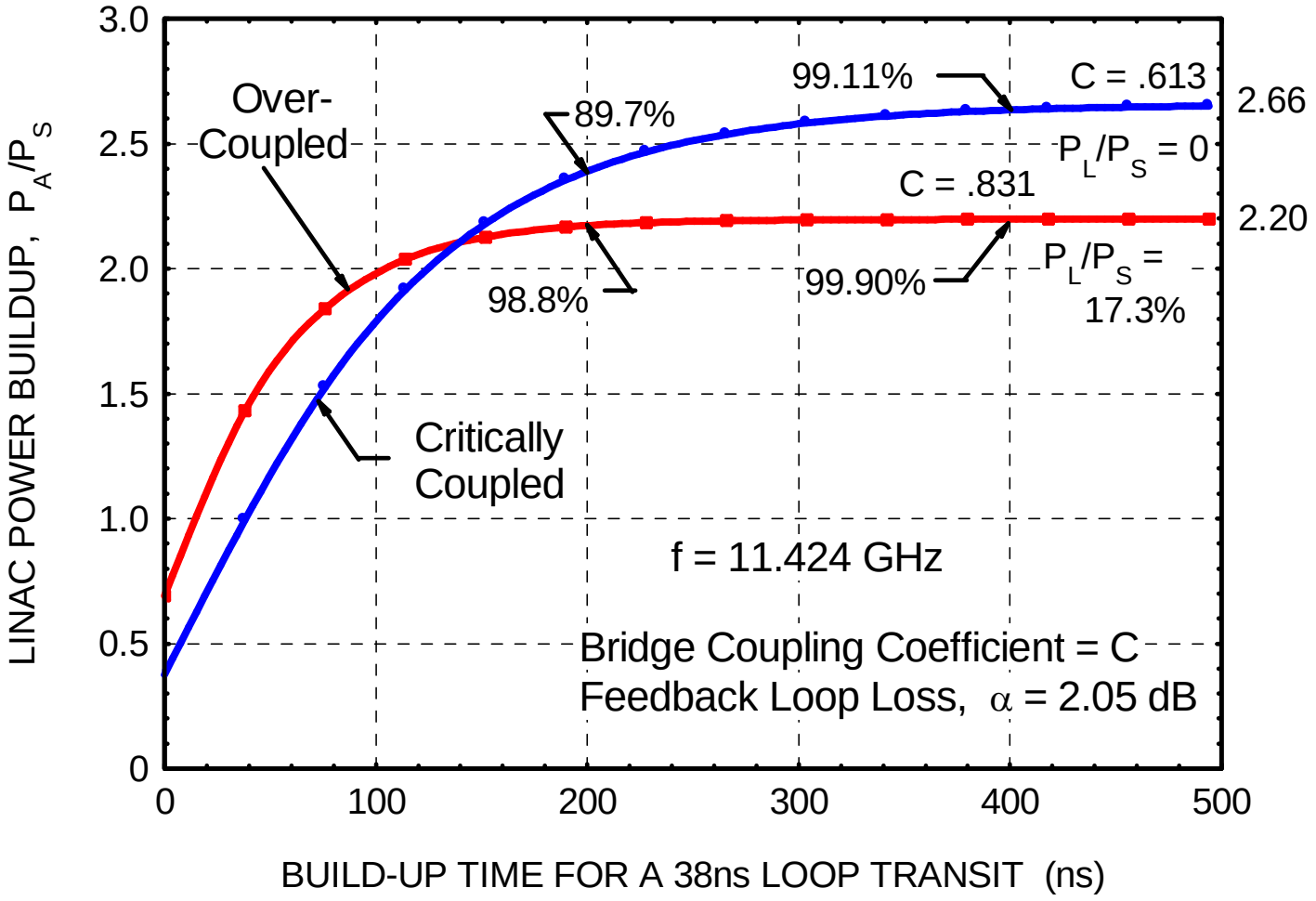
Showing that when an Arc Occurs in the Linac, the Linac Input Power (blue) is Rapidly Truncated and, for the Remaining Portion of the Klystron RF Pulse the Bridge Input Power (red) is Automatically Directed into the Bridge Load (green). Thus, the Linac Power Amplifying Bridge Assists in Automatically Protecting both the RF Source and the High Gradient Linac Structure.

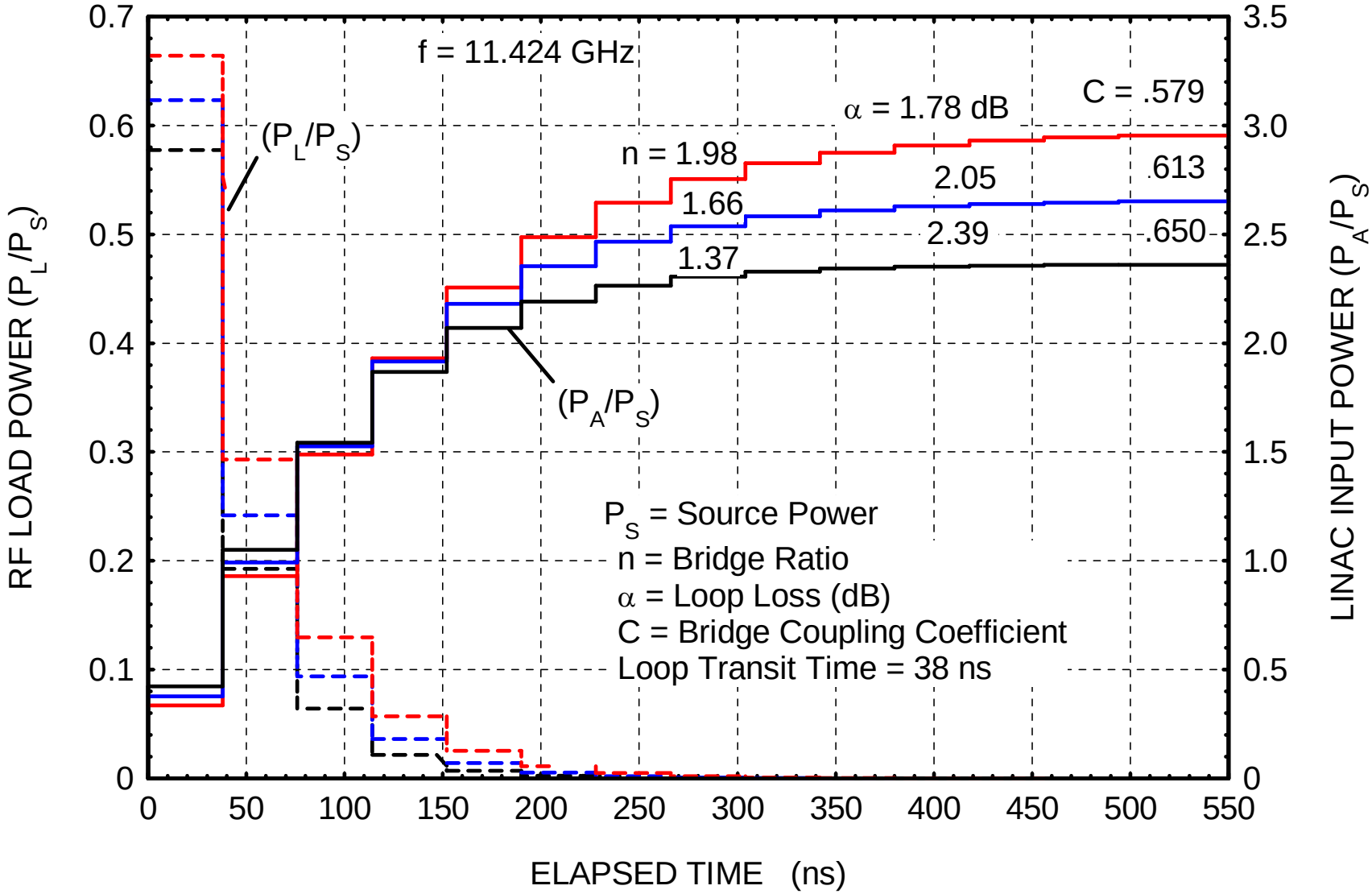
"Design Features and Initial RF Performance of a Gradient Hardened 17 GHz TW Linac Structure," in *Advanced Accelerator Concepts*, AIP Conf. Proc., No. 1086, pp. 464-469, 2008.



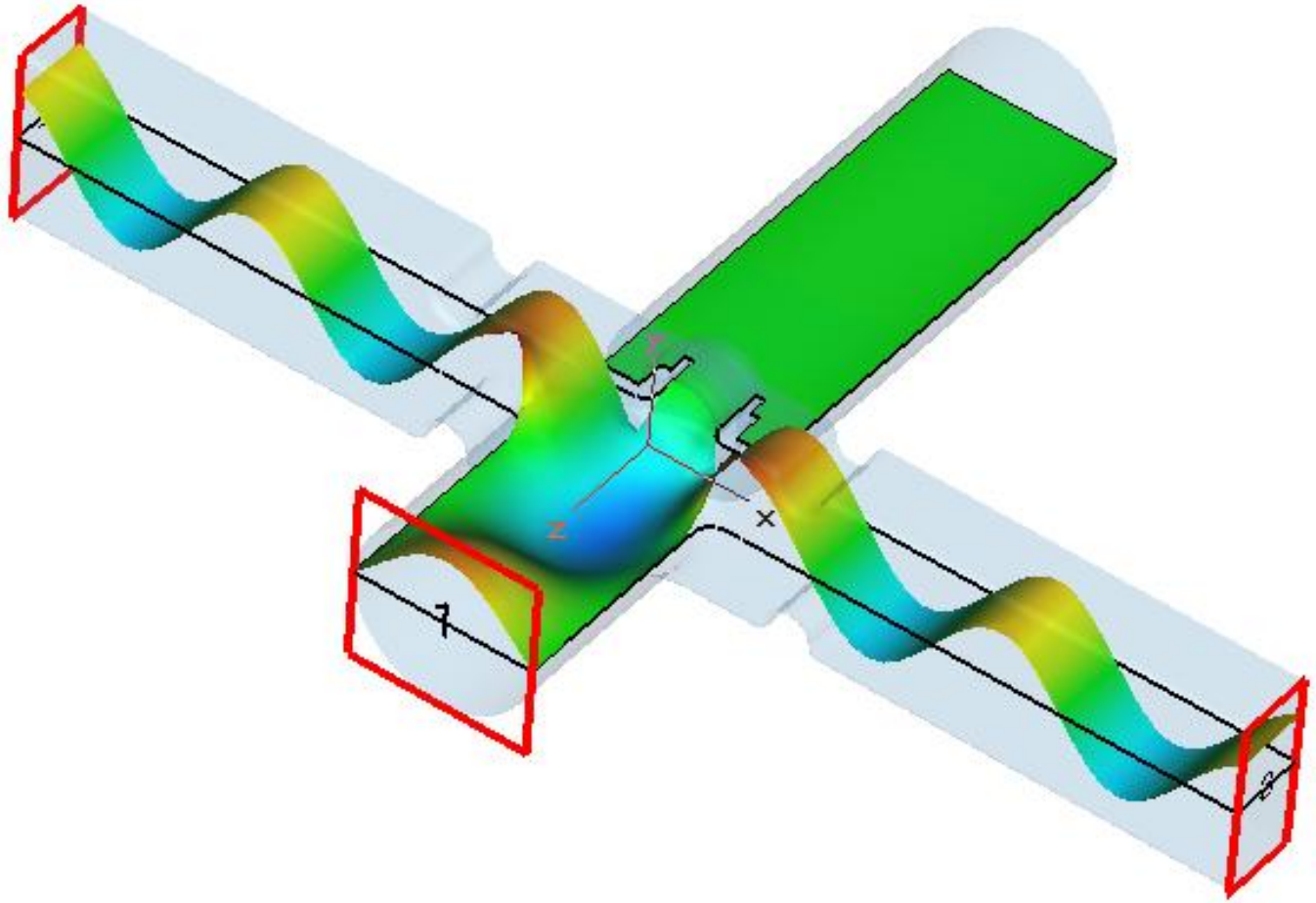
View of All-Copper 17 GHz Linac Structure and 4X Peak Power Amplifier System.


Ready


LINAC POWER BUILDUP, P_A/P_S
3.0
2.5
2.0
1.5
1.0
0.5
0
0
100
200
300
400
500
BUILD-UP TIME FOR A 38ns LOOP TRANSIT (ns)
Over-
Coupled
Critically
Coupled
89.7%
98.8%
99.11%
99.90%
C = .613
C = .831
P_L/P_S = 0
P_L/P_S =
17.3%
2.66
2.20
f = 11.424 GHz
Bridge Coupling Coefficient = C
Feedback Loop Loss, α = 2.05 dB


f = 11.424 GHz
α = 1.78 dB
C = .579
n = 1.98
2.05
.613
1.66
2.39
.650
1.37
(P_L/P_S)
(P_A/P_S)
P_S = Source Power
n = Bridge Ratio
α = Loop Loss (dB)
C = Bridge Coupling Coefficient
Loop Transit Time = 38 ns
RF LOAD POWER (P_L/P_S)
LINAC INPUT POWER (P_A/P_S)
ELAPSED TIME (ns)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
300
350
400
450
500
550

Mode Converter Used with the T18 Structure
E_z Field Pattern at f = 11424 MHz



HRC 7131 Resonant Ring Phase Study 03/13/09

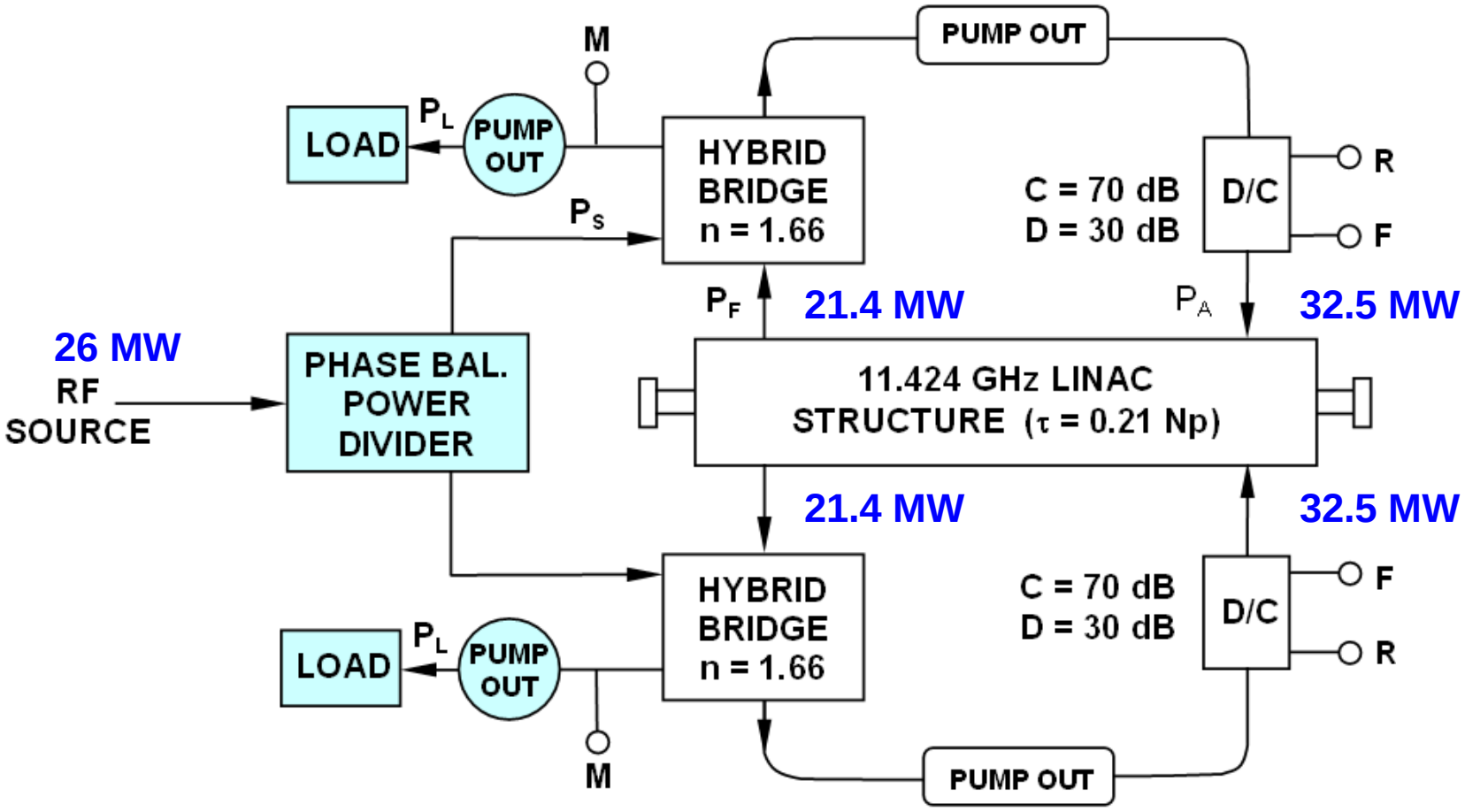
Design Parameters of an 11.4GHz Dual Resonant Ring System Configured for High Gradient Testing of the CLIC/KEK/SLAC (T18) Linac Structure

System Operating Frequency	11.424	GHz
Test Linac Attenuation Parameter (τ)	0.21	Np
Test Linac Harmonic Mean Group Velocity $(v_g)_{hm}$	0.016	c
Total Loss in Feedback Loop (α)	2.05	dB
Resonant Ring Transit Time	38	ns
Resonant Ring Total Phase Length	17280	deg
Resonant Ring Phase Dispersion	15	deg/MHz
WR90 Rectangular Waveguide Phase/Length Relationship	11.2	deg/mm
WR90 Rectangular Waveguide Length/Phase Relationship	.089	mm/deg

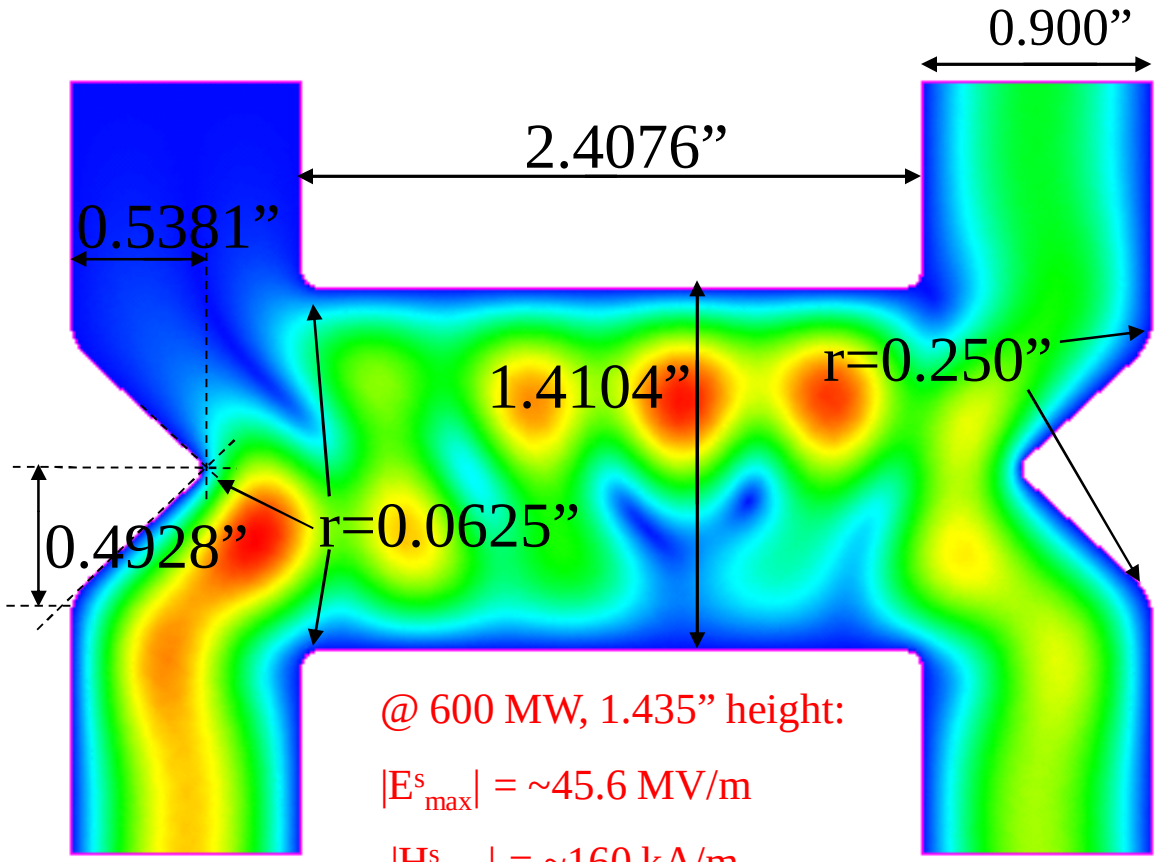
RF Bridge Ratio [$n=(T_C/C)^2$]	1.66	
RF Power Buildup (n+1)	2.66	
RF Bridge Transmission Coefficient $\{T_C= [n(n+1)]^{1/2}\}$	0.790	
RF Bridge Coupling Coefficient $[C=(n+1)^{-1/2}]$	0.613	
Linac Steady-State Input Power (P_A)	65	MW
Unloaded Average Accelerating Gradient . . .	108	MV/m
Klystron Power	26	MW

An 11.424 MHz Dual Resonant Ring System for High Gradient Testing CLIC/KEK/SLAC T18 Structures

Power Distribution to Achieve an Unloaded Accelerating Gradient of 108 MV/m



-4.77 dB (1/3) Directional Coupler

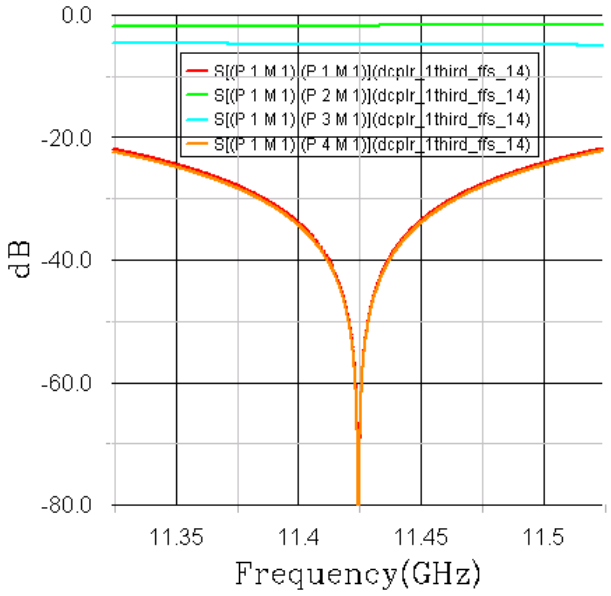


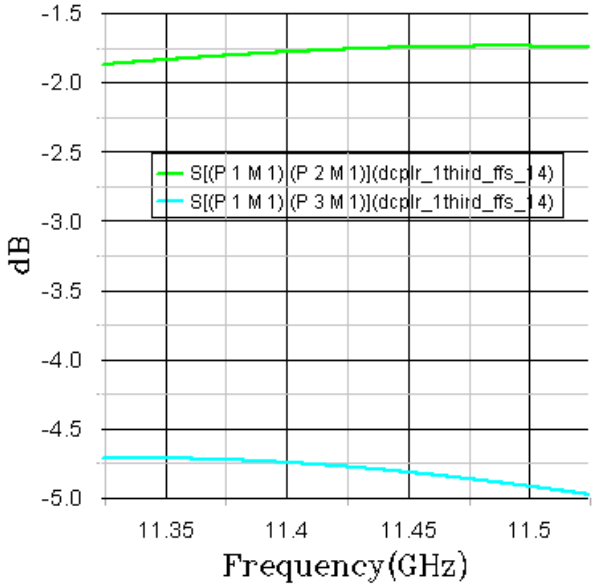
@ 600 MW, 1.435” height:

$|E^s_{max}|$ = ~45.6 MV/m

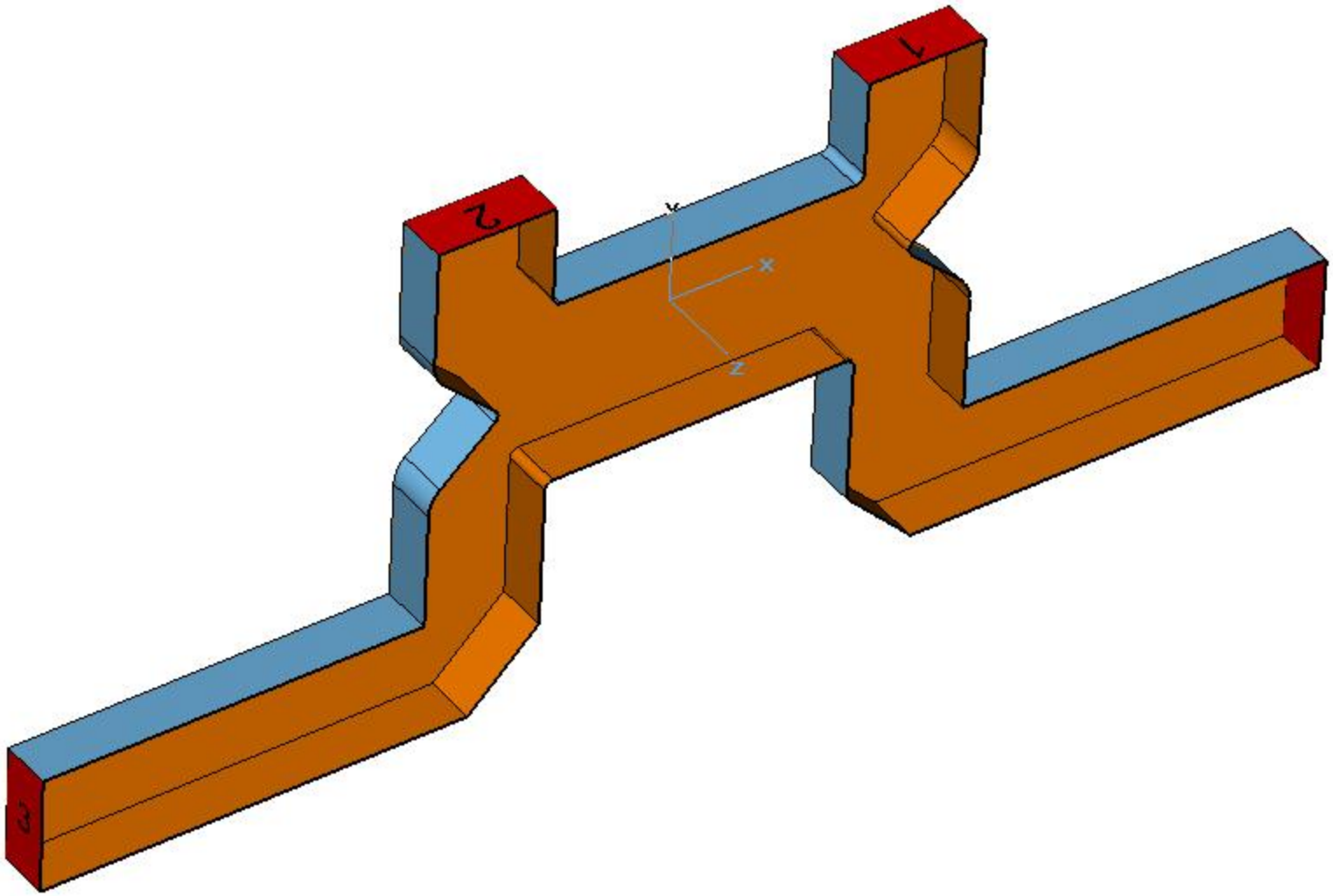
$|H^s_{max}|$ = ~160 kA/m

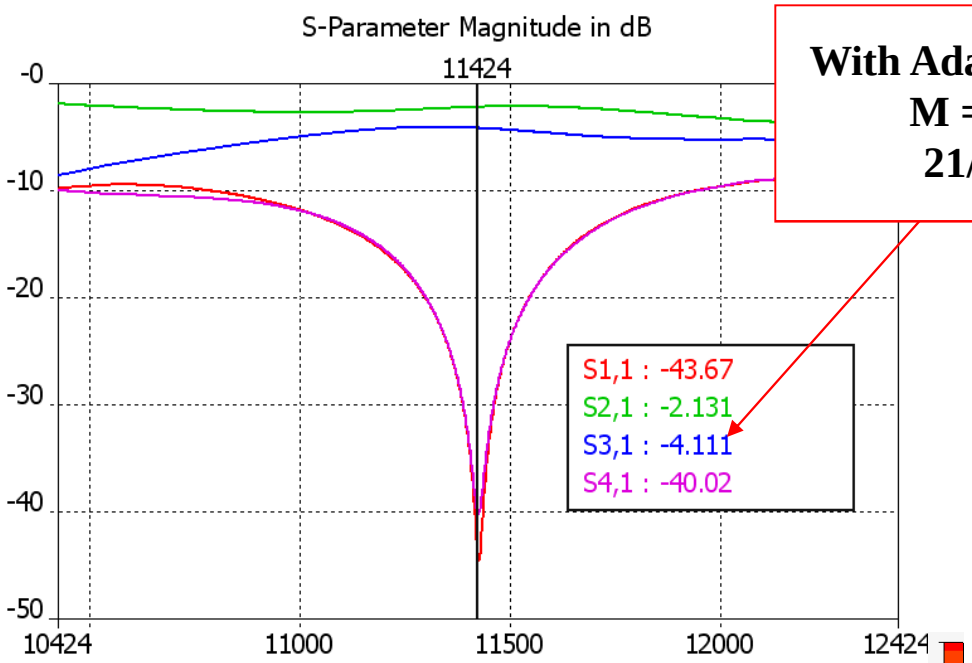
	(P 1 M 1)	(P 2 M 1)	(P 3 M 1)	(P 4 M 1)
(P 1 M 1)	0.0005	0.8166	0.5772	0.0004
(P 2 M 1)	0.8166	0.0005	0.0004	0.5772
(P 3 M 1)	0.5772	0.0004	0.0005	0.8166
(P 4 M 1)	0.0004	0.5772	0.8166	0.0005



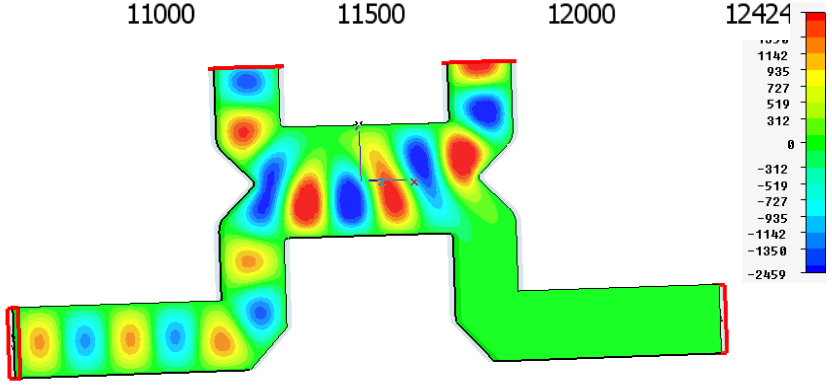


C. Nantista ’03


1
2
3
Y
X
Z

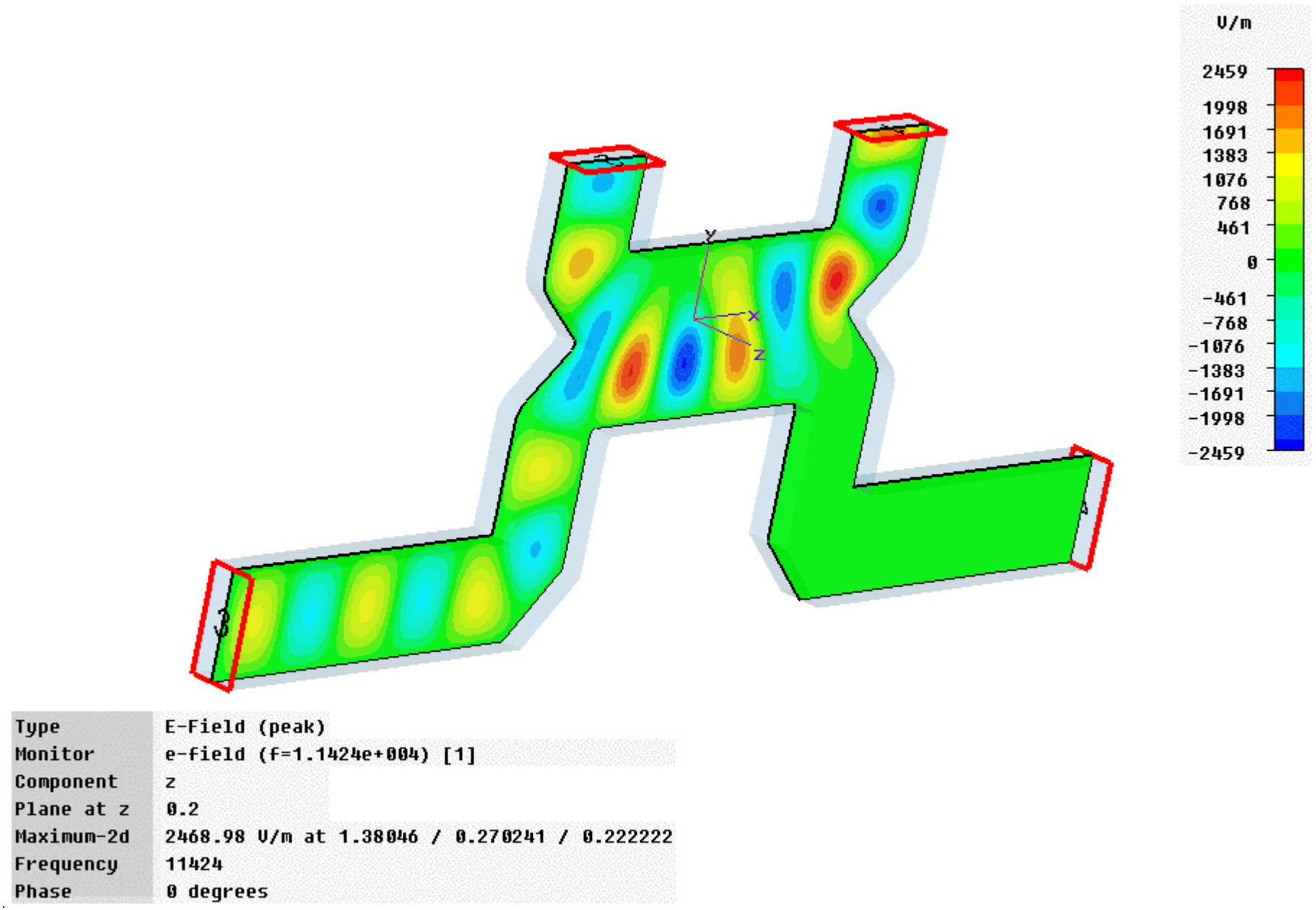


With Adaptive Meshing
M = 1177344
21/15/10R6



Type	E-Field (peak)
Monitor	e-field (f=1.1424e+004) [1]
Component	z
Plane at z	0.2
Maximum-2d	2468.98 V/m at 1.38046 / 0.270241 / 0.222222
Frequency	11424

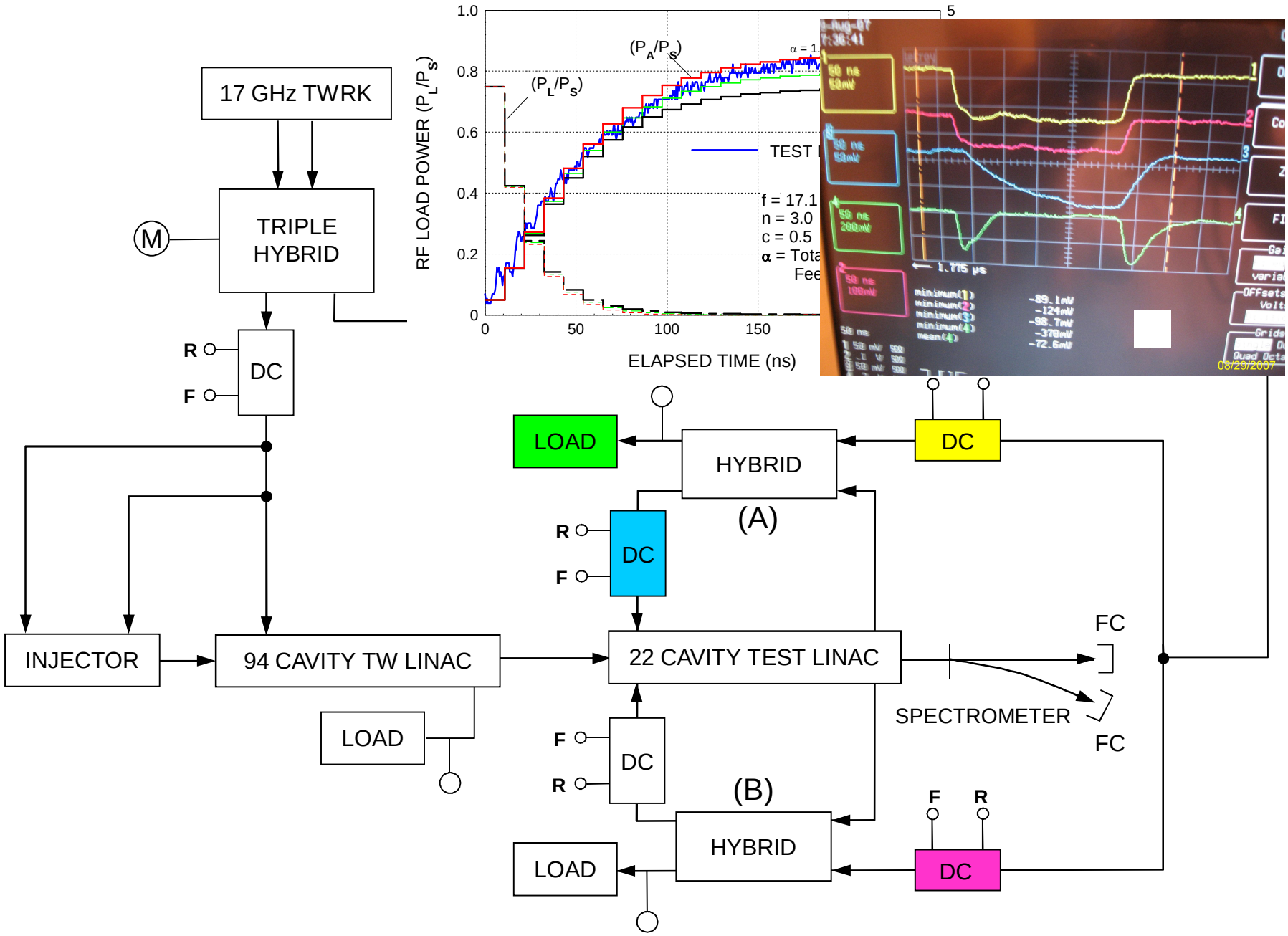
x=-0.854 y=-4.2 z=0.2
Ex=0 Ey=0 Ez=0 Eabs=0



Type	E-Field (peak)
Monitor	e-field (f=1.1424e+004) [1]
Component	z
Plane at z	0.2
Maximum-2d	2468.98 V/m at 1.38046 / 0.270241 / 0.222222
Frequency	11424
Phase	0 degrees

11.424 GHz High Gradient Testing of a T18 TW Structure Using a Fast Response Protection and Power Recirculating System

Work performed under the auspices of the U.S. Department of Energy SBIR
Grant No. DE-FG02-08ER85197


17 GHz TWRK
M
TRIPLE HYBRID
R
F
DC
INJECTOR
94 CAVITY TW LINAC
LOAD
LOAD
HYBRID
(A)
R
F
DC
22 CAVITY TEST LINAC
FC
SPECTROMETER
FC
F
R
DC
(B)
LOAD
HYBRID
F
R
DC
DC
RF LOAD POWER (P_L/P_S)
ELAPSED TIME (ns)
(P_A/P_S)
(P_L/P_S)
TEST
f = 17.1
n = 3.0
c = 0.5
α = Tota
Fee
08/29/2007