THE 1.5 GHz RF DEFLECTOR FOR THE CTF3 DELAY LOOP

F. MARCELLINI

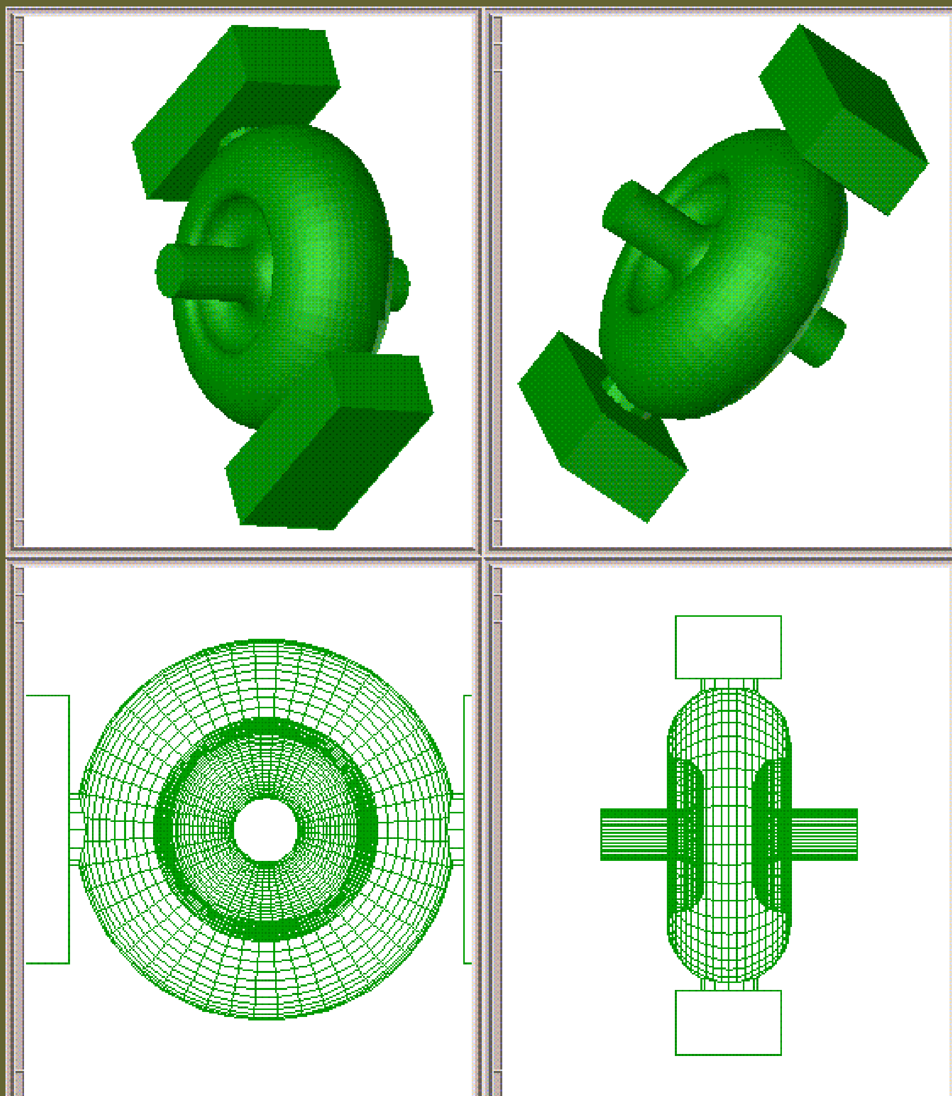
THE RF DEFLECTOR OF THE COMBINER RING HAS BEEN REALIZED WITH A TRAVELING WAVE STRUCTURE. DIFFERENTLY FROM THAT CASE, FOR THE **DELAY LOOP** IT HAS BEEN CHOSEN A **STANDING WAVE** DEVICE, EXCITED IN A DEFLECTING MODE, BECAUSE IT SEEMS **EASIER TO REALIZE**.

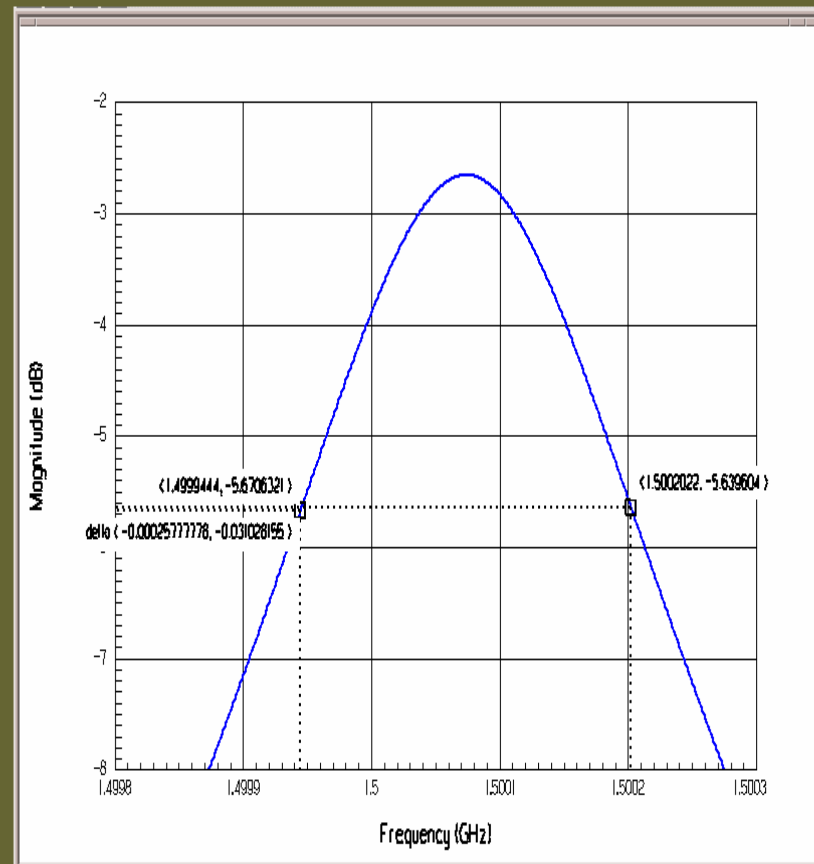
NEVERTHELESS ALSO THIS SOLUTION PRESENTS SOME **DRAWBACKS**.
SINCE THE KLYSTRON FEEDING THE CAVITY IS A PULSED RF SOURCE (PULSE LENGTH 5 μs), THE **CAVITY FILLING TIME HAS TO BE AS SHORT AS POSSIBLE** TO MINIMIZE THE DIFFERENCE OF DEFLECTING VOLTAGE SEEN BY THE HEAD AND THE TAIL OF THE BUNCH. AS A CONSEQUENCE THE Q OF THE CAVITY HAS TO BE OF THE ORDER OF FEW THOUSANDS. THIS IS OBTAINED LOADING THE CAVITY FROM THE INPUT COUPLER (COUPLING COEFFICIENT $\beta > 1$).

BUT A REDUCTION OF Q RESULTS IN A PROPORTIONAL **DECREASE OF THE SHUNT IMPEDANCE** AND OF THE DEFLECTING VOLTAGE, UNTIL IT COULD BECOME DIFFICULT TO GET THE REQUIRED ANGLE OF DEFLECTION.

MOREOVER, IN A CLASSICAL SCHEME THE USE OF A **CIRCULATOR IS NECESSARY** TO PROTECT THE KLYSTRON FROM THE POWER REFLECTED AT THE CAVITY INPUT PORT. THE WHOLE COST OF THE SYSTEM IS CONSIDERABLY AFFECTED BY THE CIRCULATOR.

RF STANDING WAVE CAVITY DEFLECTOR

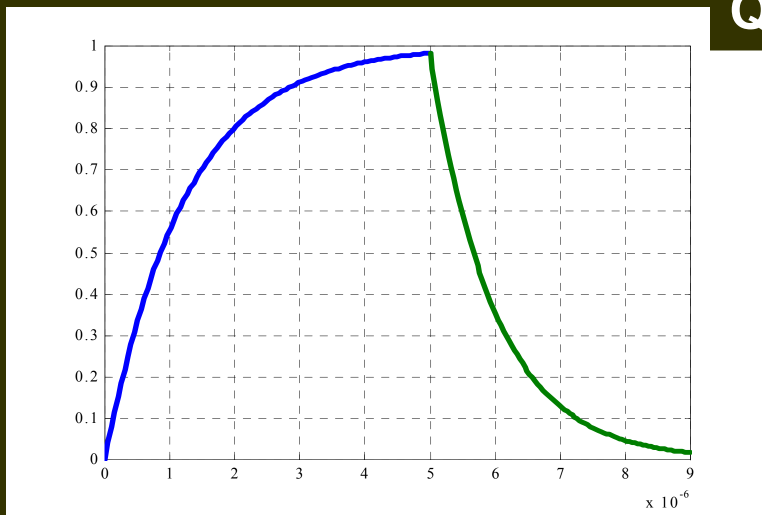


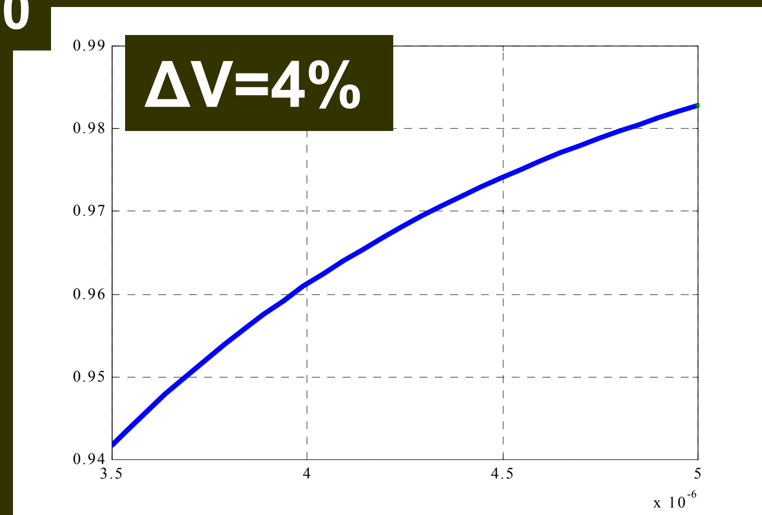


HFSS 3D model and calculated frequency response

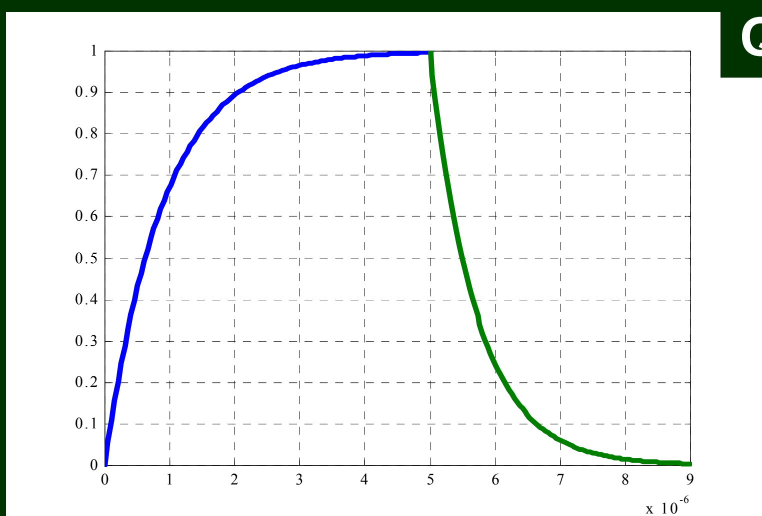
TWO DIFFERENT LOADINGS OF THE CAVITY FROM THE INPUT PORTS HAVE BEEN CONSIDERED. DEFLECTING VOLTAGE VS. TIME FOR BOTH THE OPTIONS ARE SHOWN.

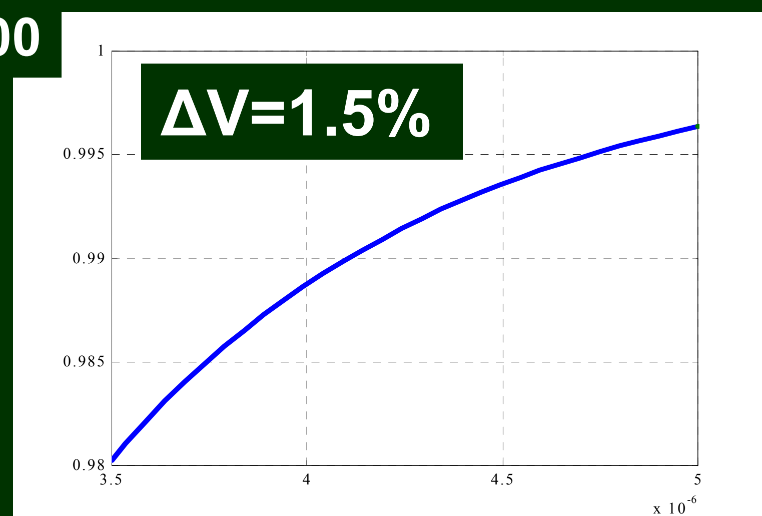
Q=5800





Q=4200





FOR BOTH THE CONSIDERED OPTIONS, THE RF POWER AVAILABLE FROM THE KLYSTRON (20 MW) IS SUFFICIENT TO GET THE REQUIRED ANGLE OF DEFLECTION (15 mrad).

$Q = 5800$ (Δkick=4%)

$S_{11} = 0.482$

$\beta = 2.857$

15mrad @ 300MeV → 14MW

20MW → 18mrad @ 300MeV

$Q = 4200$ (Δkick=1.5%)

$S_{11} = 0.613$

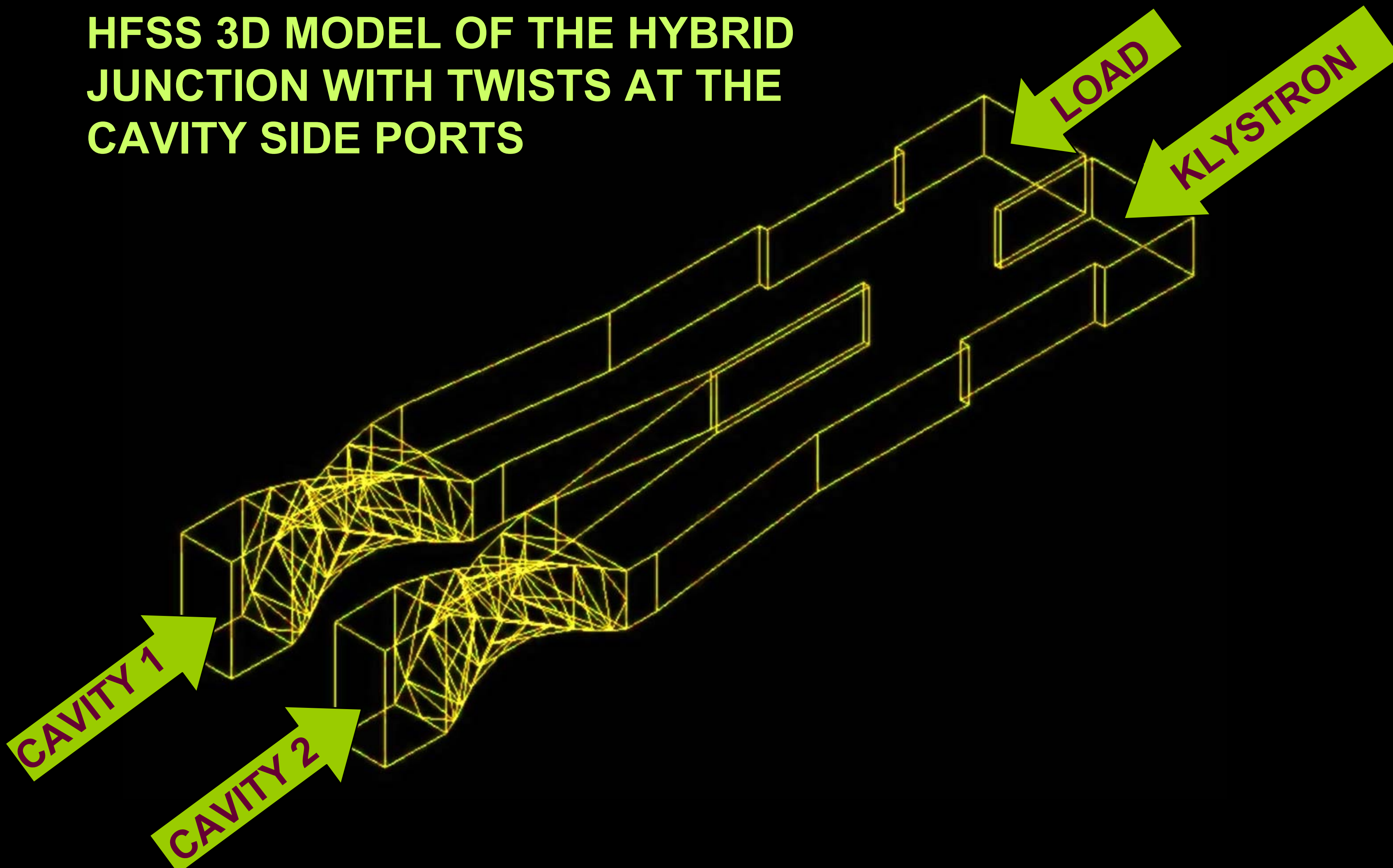
$\beta = 4.168$

15mrad @ 300MeV → 18MW

TO OVERCOME THE PROBLEM RELATED TO THE EXPENSIVENESS OF THE CIRCULATOR, A **SYSTEM COMPOSED BY TWO IDENTICAL CAVITY CONNECTED TO A 90 DEG HYBRID JUNCTION**, HAS BEEN STUDIED.
THIS SCHEME IS BASED ON THE **IDEA OF THE SLED** USED IN THE LINAC TECHNOLOGY.
NOT ONLY THE **CIRCULATOR SEEMS NO MORE ESSENTIAL**, BUT, WITH TWO CAVITIES, THE REQUIRED **DEFLECTING VOLTAGE IS MORE EASILY OBTAINED**.

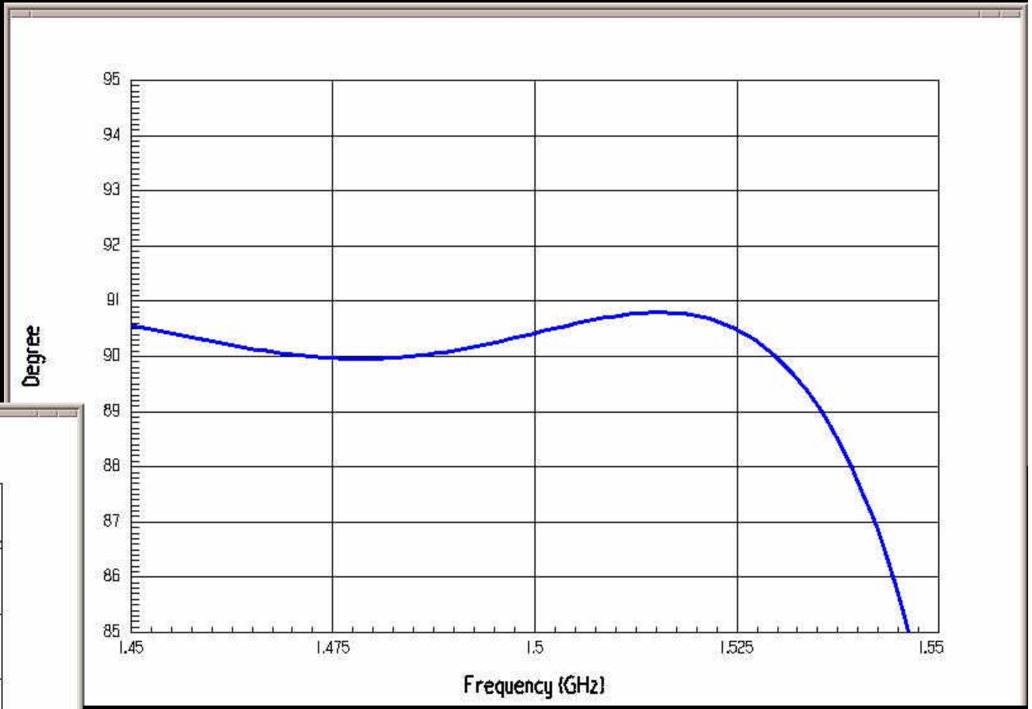
D.ALESINI, R.CLEMENTI, A.GALLO, A.GHIGO, L.THORNDAHL AND R.ZARLENGA HAVE CONTRIBUTED TO DEVELOP THE DESIGN AND TO CARRY OUT MEASUREMENTS ON A SPARE SLED OF THE DAFNE LINAC. THAT HAS BEEN VERY HELPFUL TO BETTER UNDERSTAND HOW THE DEVICE WORKS.

HFSS 3D MODEL OF THE HYBRID JUNCTION WITH TWISTS AT THE CAVITY SIDE PORTS

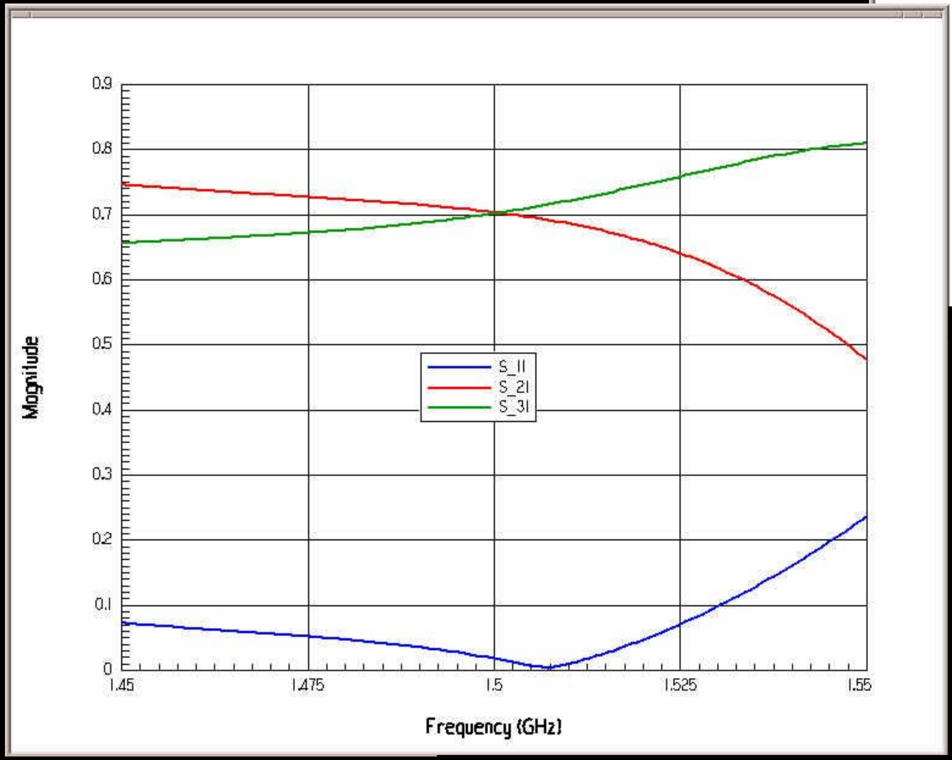


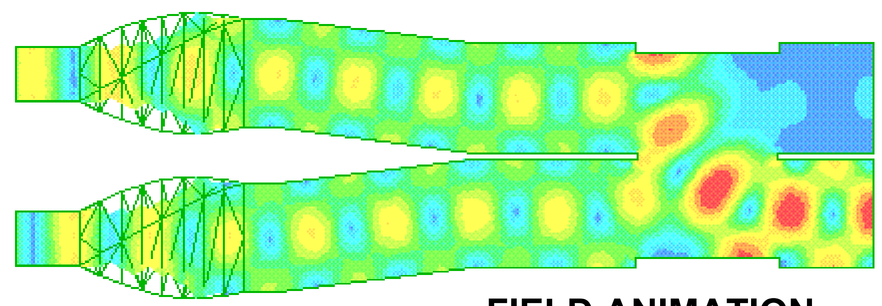
HFSS SIMULATION RESULTS

PHASE DIFFERENCE BETWEEN SIGNALS OF THE CAVITY SIDE PORTS WHEN THE DEVICE IS FED FROM KLYSTRON PORT.



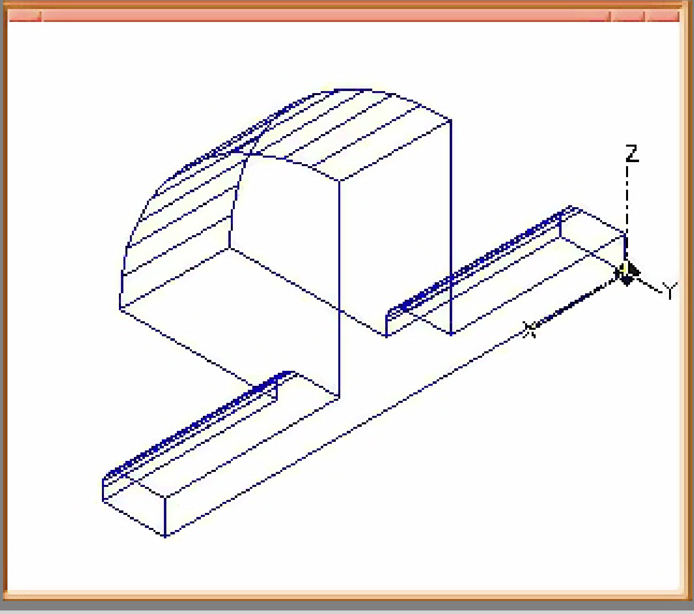
MAGNITUDE OF CAVITY SIDE PORT SIGNALS (GREEN AND RED), AND REFLECTED SIGNAL AT KLYSTRON PORT (BLUE). LEVEL OF OUTPUT SIGNALS ARE BALANCED AT 1.5 GHz.





FIELD ANIMATION

RESULTS FROM THE EIGENMODE SOLUTION OF THE SINGLE CELL



	Frequency (GHz)	Q
Mode 1	(1.50796e+00, 3.36823e-05)	2.23850e+04
Mode 2	(2.51411e+00, 5.88202e-05)	2.13711e+04
Mode 3	(2.53341e+00, 4.23812e-05)	2.98884e+04
Mode 4	(2.77952e+00, 4.64036e-05)	2.99494e+04
Mode 5	(2.84405e+00, 8.10564e-05)	1.75437e+04

MODES WITH IMPEDANCE IN HORIZONTAL PLANE

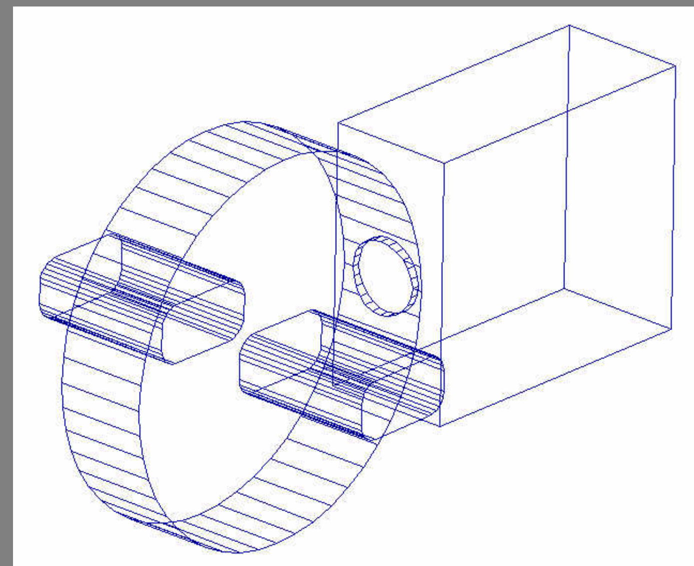
	Frequency (GHz)	Q
Mode 1	(1.46853e+00, 3.55166e-05)	2.06739e+04
Mode 2	(2.10358e+00, 7.02623e-05)	1.49695e+04
Mode 3	(2.37256e+00, 7.37548e-05)	1.60841e+04
Mode 4	(2.53395e+00, 4.24586e-05)	2.98403e+04
Mode 5	(2.65239e+00, 6.62414e-05)	2.00206e+04

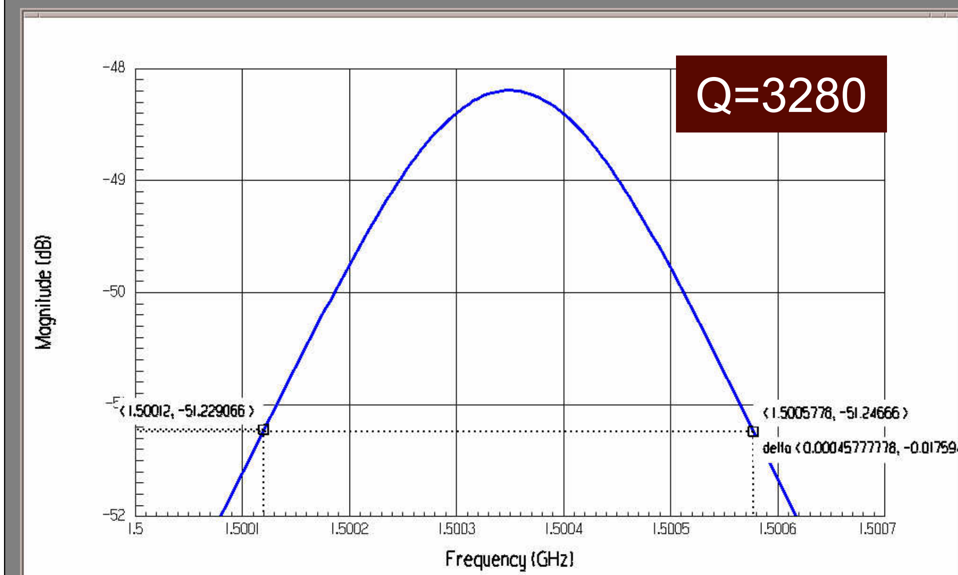
MODES WITH IMPEDANCE IN VERTICAL PLANE

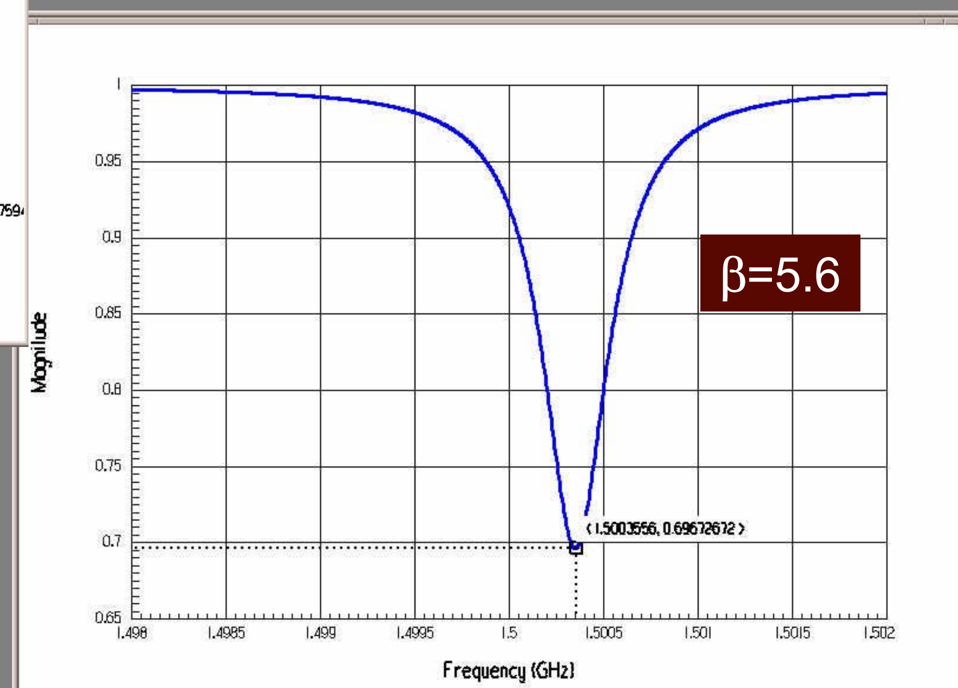
	Frequency (GHz)	Q
Mode 1	(9.67509e-01, 2.63453e-05)	1.83621e+04
Mode 2	(2.03428e+00, 3.84650e-05)	2.64432e+04
Mode 3	(2.23390e+00, 3.90771e-05)	2.85833e+04
Mode 4	(2.67978e+00, 7.25079e-05)	1.84793e+04
Mode 5	(2.70794e+00, 1.07915e-04)	1.25466e+04

MODES WITH IMPEDANCE IN LONGITUDINAL PLANE

CAVITY HFSS MODEL. THE CAVITY IS COUPLED THROUGH A HOLE TO THE RECTANGULAR WG (WR650).

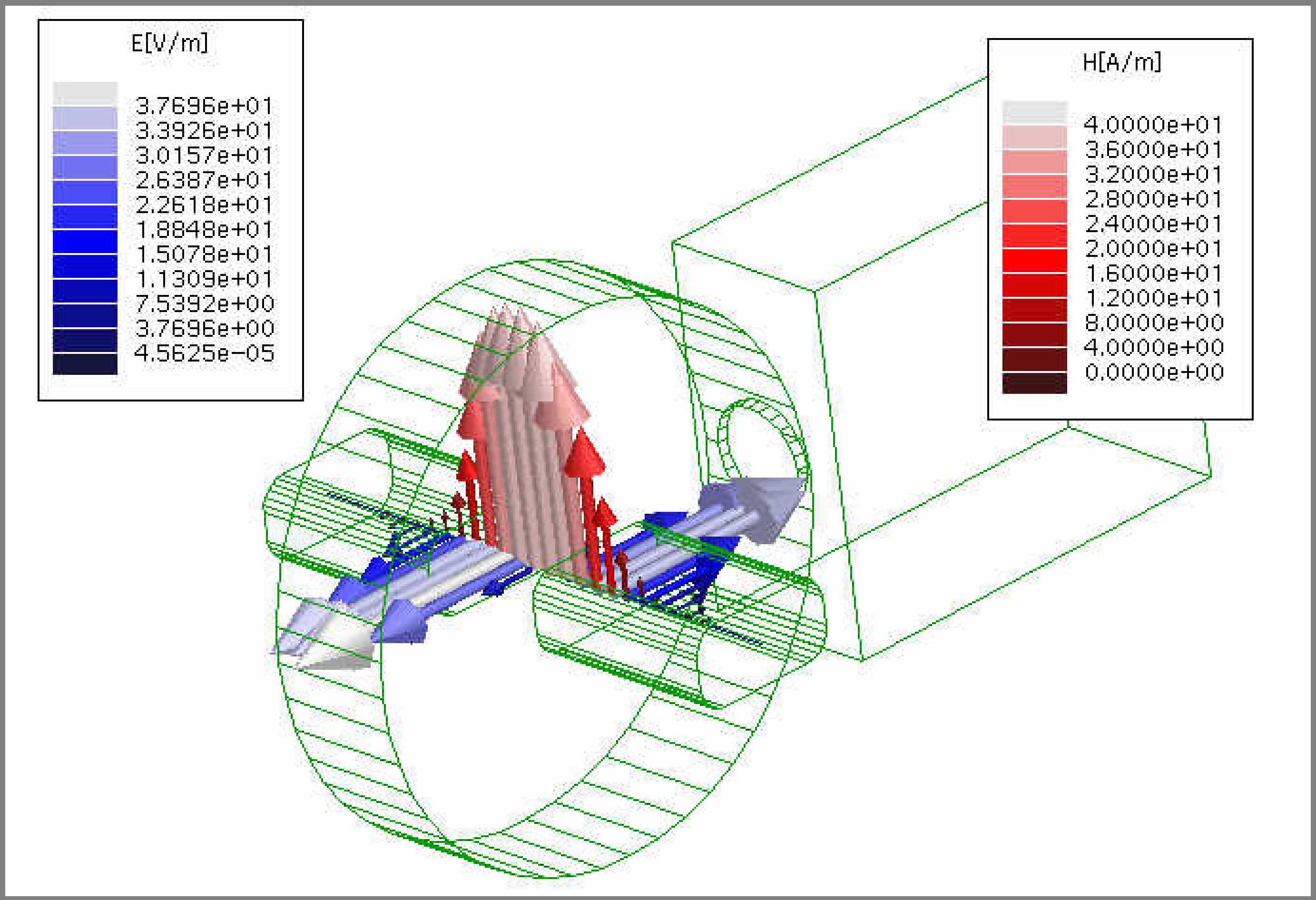




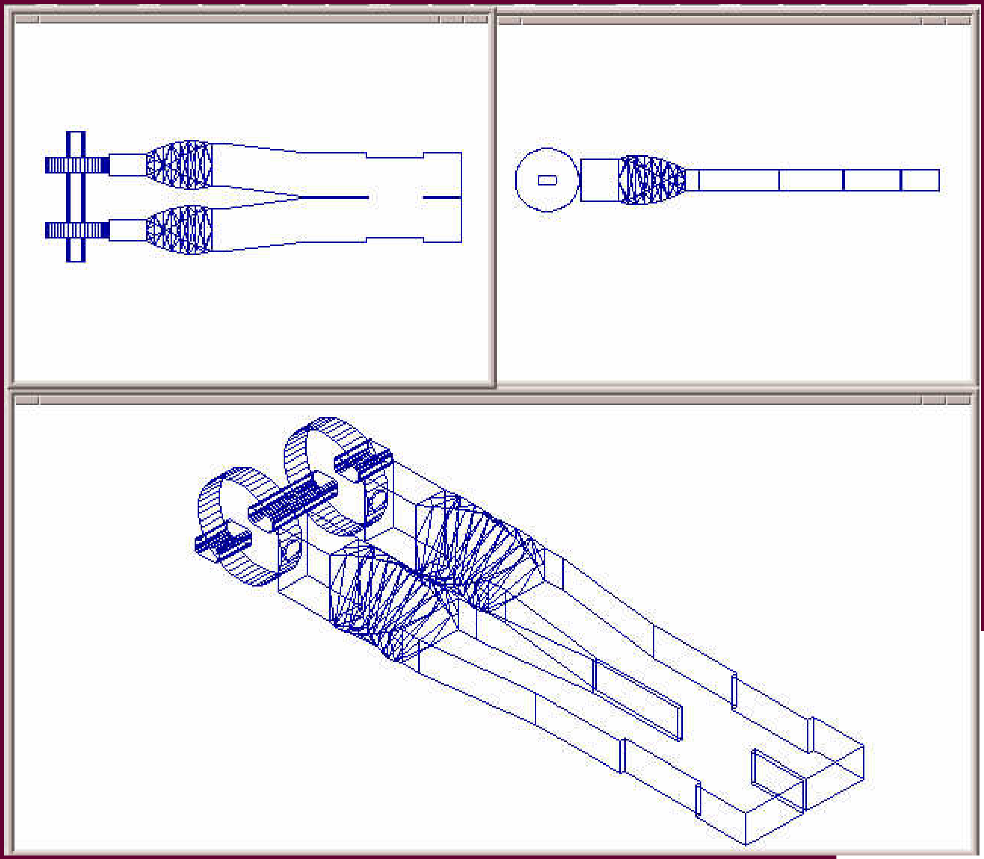


FREQUENCY RESPONSE OF THE CAVITY AND CALCULATED COUPLING COEFFICIENT AND LOADED Q.

REPRESENTATION OF ELECTRIC (BLUE) AND MAGNETIC (RED) DEFLECTING FIELDS ALONG THE CAVITY AXIS.

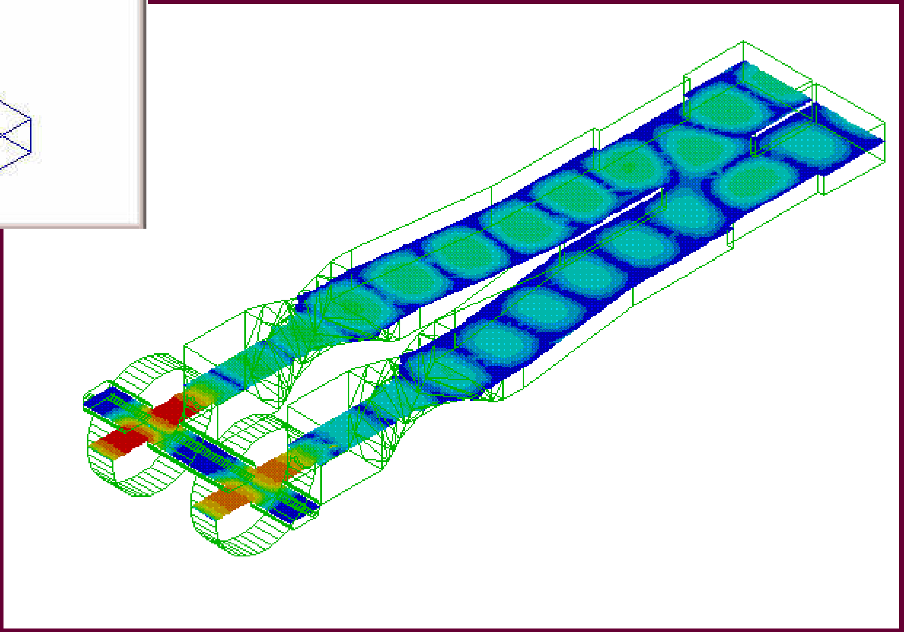


PUTTING ALL TOGETHER...

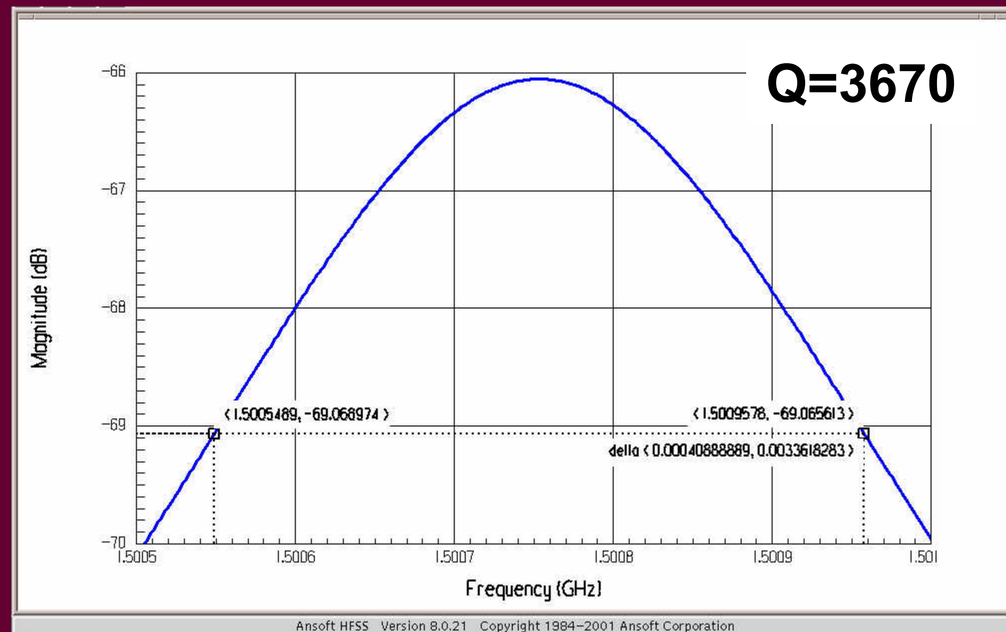


INPUT MODEL FOR SIMULATION

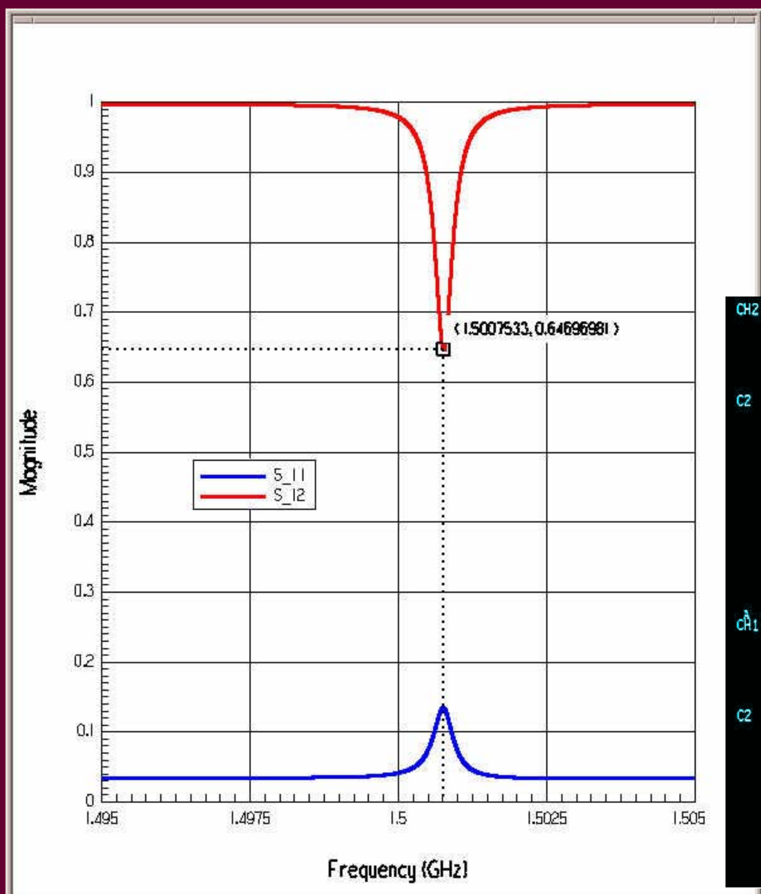
FIELD ANIMATION

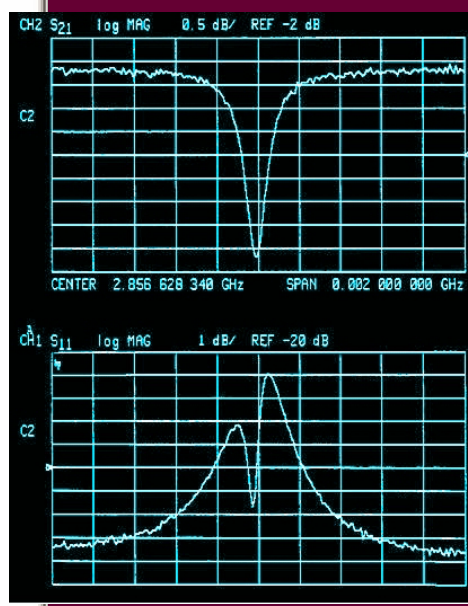


SIMULATED FREQUENCY RESPONSES...



TRANSMISSION BETWEEN INPUT AND OUTPUT PORT (RED) AND REFLECTION AT THE INPUT PORT (BLUE)

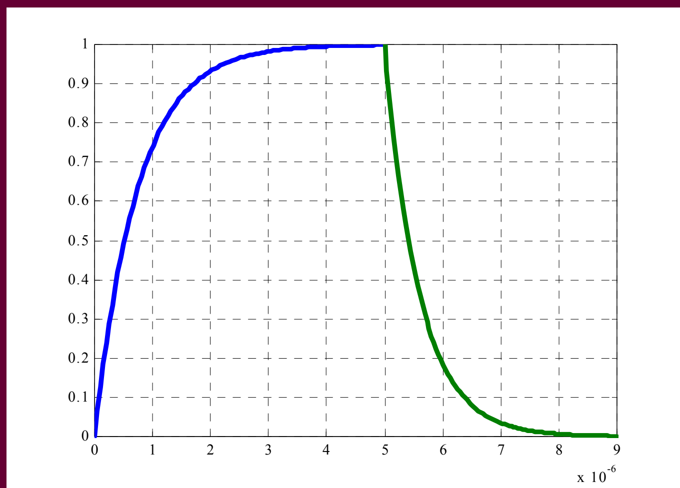




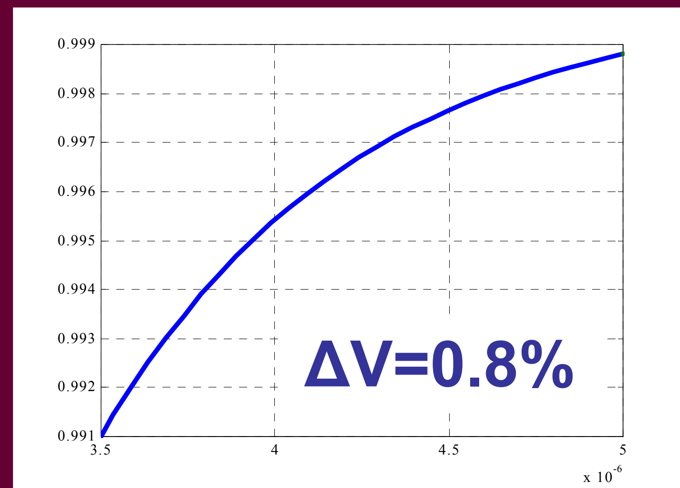
BANDWIDTH OF THE SYSTEM

... AND THEIR COMPARISON WITH MEASUREMENTS PERFORMED ON A DAFNE SLED.

TOTAL DEFLECTING VOLTAGE VS. TIME.



ΔKICK RESULTS ONLY 0.8%.



FROM FIELD INTEGRATION ALONG THE BEAM PATH:

20MW (KLYSTRON OUTPUT POWER) → **5 MV (DEFLECTING VOLTAGE)**

@ 150 MeV (BEAM ENERGY) → **33 mrad** (ANGLE OF DEFLECTION)

CONCLUSIONS

- ACCORDING TO THE RESULTS OBTAINED FROM HFSS SIMULATIONS, A **STANDING WAVE RF STRUCTURE** IS CAPABLE TO PROVIDE THE ANGLE OF DEFLECTION REQUIRED BY THE CTF3 DELAY LOOP.

- BESIDES A DESIGN BASED ON A SINGLE CELL CAVITY, A NEW IDEA HAS BEEN STUDIED AND DEVELOPED FOR THE DEFLECTOR REALIZATION. IT PRESENTS SOME ADVANTAGES:

  1. A **LOWER FILLING TIME**, THAT MEANS A LOWER SPREAD OF DEFLECTION ANGLE ALONG A SINGLE TRAIN OF BUNCHES;
  2. THE **POINTLESSNESS OF THE CIRCULATOR** (EXPENSIVE);
  3. **LOWER FIELD INTENSITY** INSIDE THE CAVITY, THEREFORE REDUCED RISKS OF DISCHARGES.