RF DESIGN OF A SINGLE CELL SUPERCONDUCTING ELLIPTICAL CAVITY WITH INPUT COUPLER

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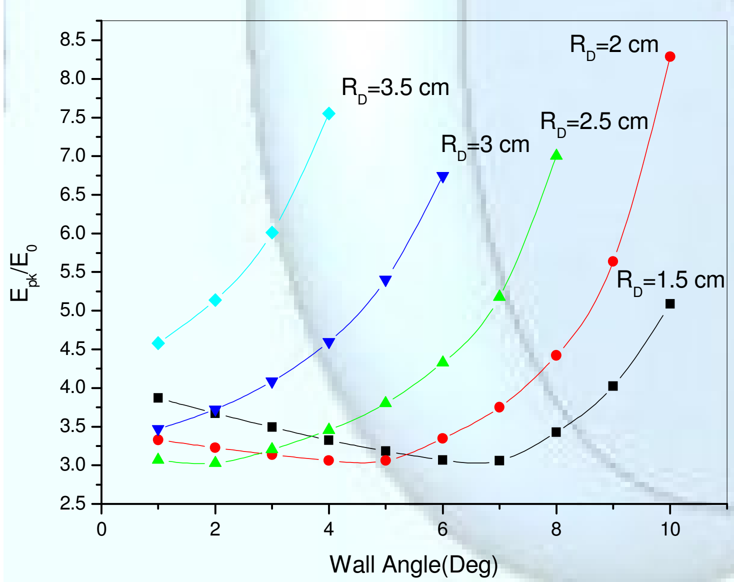
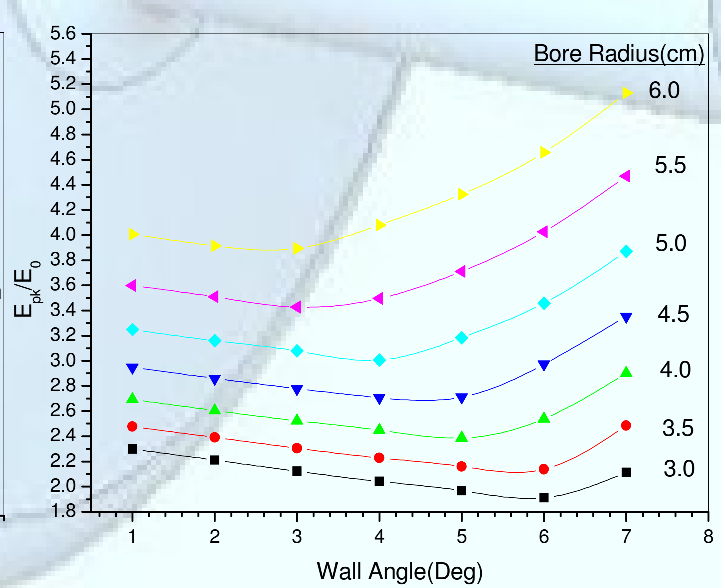
INTRODUCTION

- **RF superconducting elliptical cavities will be used to accelerate protons up to 1 GeV.**
- **A prototype single cell elliptical cavity has been designed with input power coupler.**
- **Cavity shape optimization has been done by means of 2D simulation code SUPERFISH.**
- **Trapped higher order modes in the cavity are analyzed with the conventional eigenmode analysis as well as with the time domain analysis using CST Microwave Studio.**

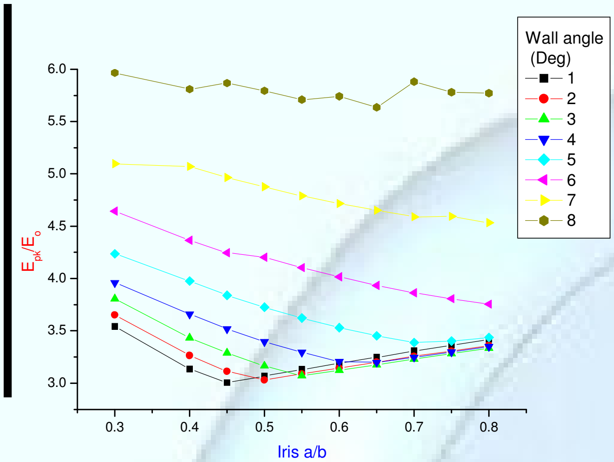
OPTIMISATION OF CAVITY SHAPE VARIABLES



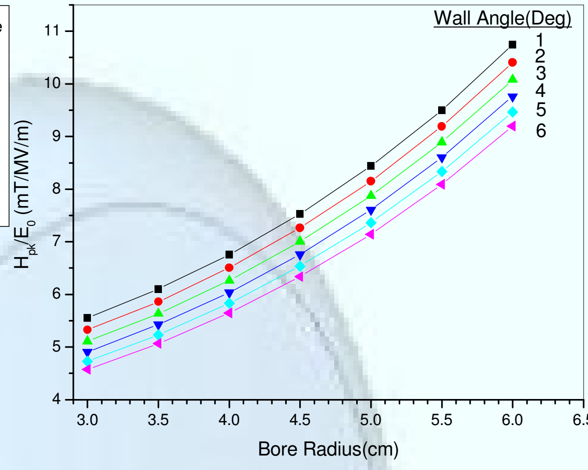
Variation of E_{pk}/E_0 with α_w varying R_D



Variation of E_{pk}/E_0 with α_w varying R_b



Variation of E_{pk}/E_0 with α_w varying Iris a_i/b_i



Variation of H_{pk}/E_0 with R_b varying α_w

DESIGN PARAMETERS OF THE SINGLE CELL CAVITY

Accelerating Gradient	**5** ***MV/m***
Bore Radius	**5** ***cm***
Cell Length L	**8.994** ***cm***
Cavity Diameter	**37.384** ***cm***
Wall Angle	4^o
a_I / b_I	**0.65**
a_D / b_D	**1**
Dome Radius r_D	**2.5** ***cm***
E_{pk} / E_{acc}	**3.6**
H_{pk} / E_{acc}	**8.3** ***mT/MV/m***
Q	**0.61×10^9 @ 4.2*K***
r/Q	**8.069** Ω

BASICS OF TRAPPED MODES

- **One quadrant of the cavity cross-section has been simulated with proper boundary conditions.**
- **Only odd azimuthal numbered modes (i.e. dipole, sextupole ….etc) are excited.**
- **Total Q value is determined as**

$$1/QTOT = 1/QRAD + 1/QMAT$$

- **Cavity modes with high QRAD factors are identified as trapped modes.**
- **In superconducting cavities material loss is small and we have neglected QMAT.**

EIGEN MODE ANALYSIS

Influence of boundary conditions on the eigenmodes

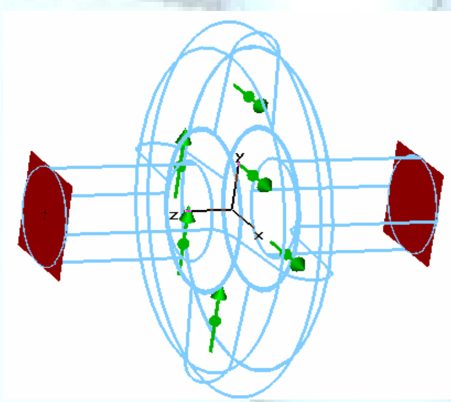
NO	f_E	no	f_M	f_{mid}	K=Δf/f
5	2.84271	5	2.84271	2.84271	0
6	2.94567	7	2.94705	2.94636	0.00047
8	2.21259	8	3.21259	2.71259	0.36865
9	3.30792	10	3.30792	3.30792	0
11	3.36781	11	3.36777	3.36779	1.19E-05
12	3.37565	12	3.37565	3.37565	0
14	3.6781	14	3.67808	3.67809	5.44E-06
15	3.70969	15	3.70951	3.7096	4.85E-05
16	3.7414	17	3.74141	3.74141	2.67E-06
19	3.85274	19	3.85264	3.85269	2.6E-05
		20	3.89901	3.89901	
20	3.90357	21	3.90506	3.90432	0.00038
24	4.12039	24	4.12039	4.12039	0
25	4.19012			4.19012	

The coupling factor K is defined as,

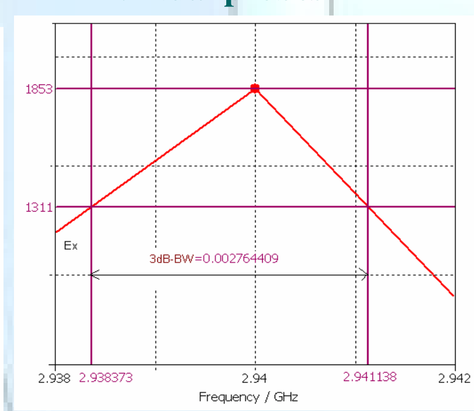
$$K = 2\frac{|f_M - f_E|}{f_M + f_E}$$

TIME DOMAIN ANALYSIS

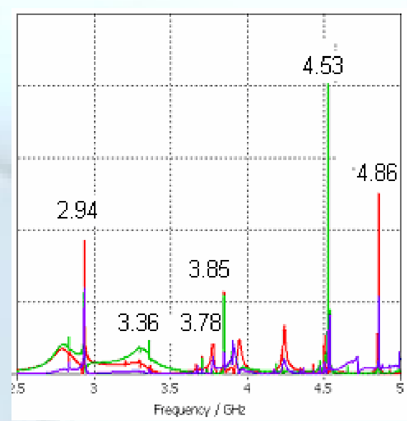
Virtual probes in the cavity



A typical amplitude signal of one of the virtual probes



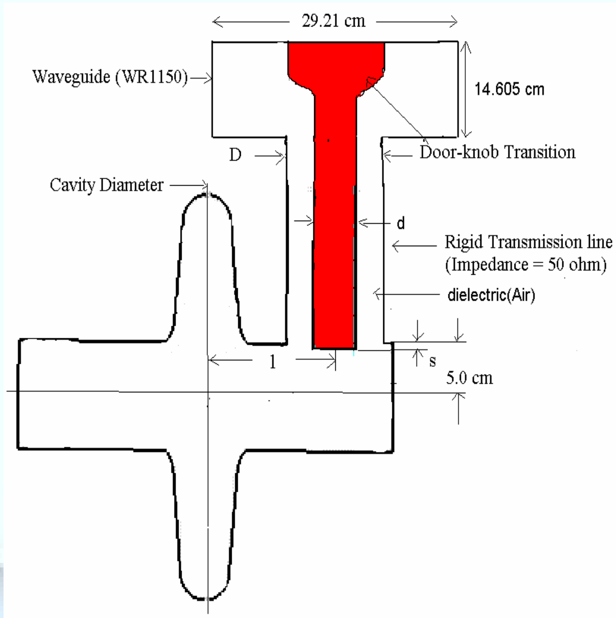
Discrete Fourier Transform of the amplitude signal



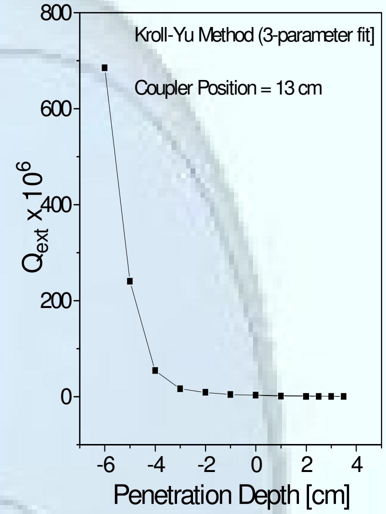
Eigen mode with magnetic BC		Time domain analysis	
No.	f_{res}	f_{peak}	Q value
7	2.95	2.94	1062
11	3.3678	3.3625	919
17	3.741	3.776	491
19	3.85	3.85	2092
×	×	4.528	2551
×	×	4.86	2283

Comparison of eigen mode analysis and time domain analysis.

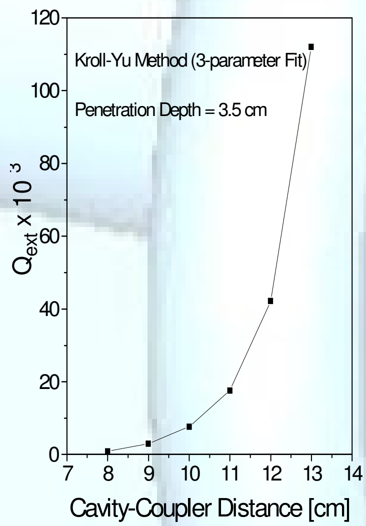
DESIGN OF POWER COUPLER



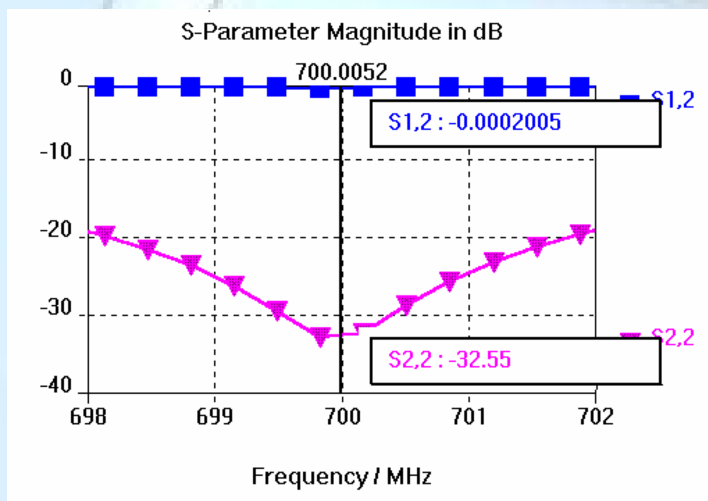
Effect of Penetration Depth



Effect of Coupler Position



S-parameter response at Door-knob Transition



CONCLUSATIONS

- Cavity shape optimization of a prototype single cell superconducting elliptical cavity has been done using SUPERFISH code
- Trapped higher order modes inside the cavity are analyzed using CST MSW code.
- An input power coupler has been designed taking advantages of both waveguide and coaxial coupler.