HIGH-CURRENT SRF CAVITY DESIGN

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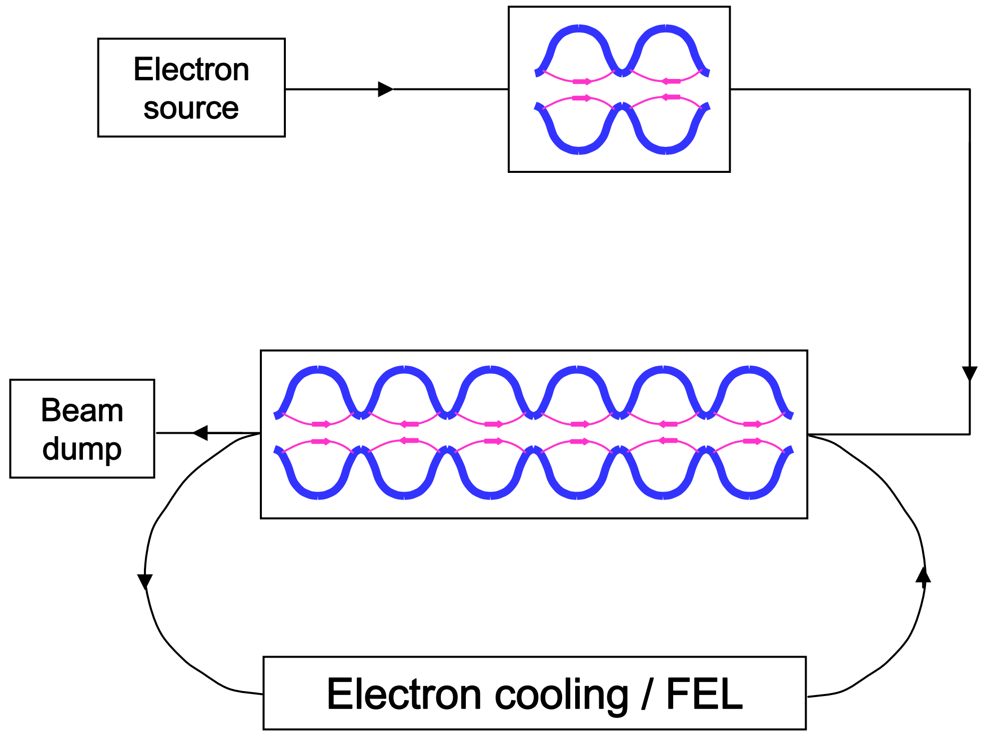
OUTLINE

- Introduction
- Primary Concerns that Direct Cavity Design
- 6-Cell Elliptical Cavity
- 2-Cell Injection Cavity
- TM012 Cavity
- Summary

Objective

- High current ERL (100's mA) (10 MeV-100's MeV)
- Simplified HOM damping
- Simplified cavity and cryomodule
- Lower cost



Issues Driving Cavity Design

- Transverse multipass/multibunch beam breakup

$$I_{th} \propto \frac{1}{f\;Q\left(\frac{R}{Q}\right)}$$

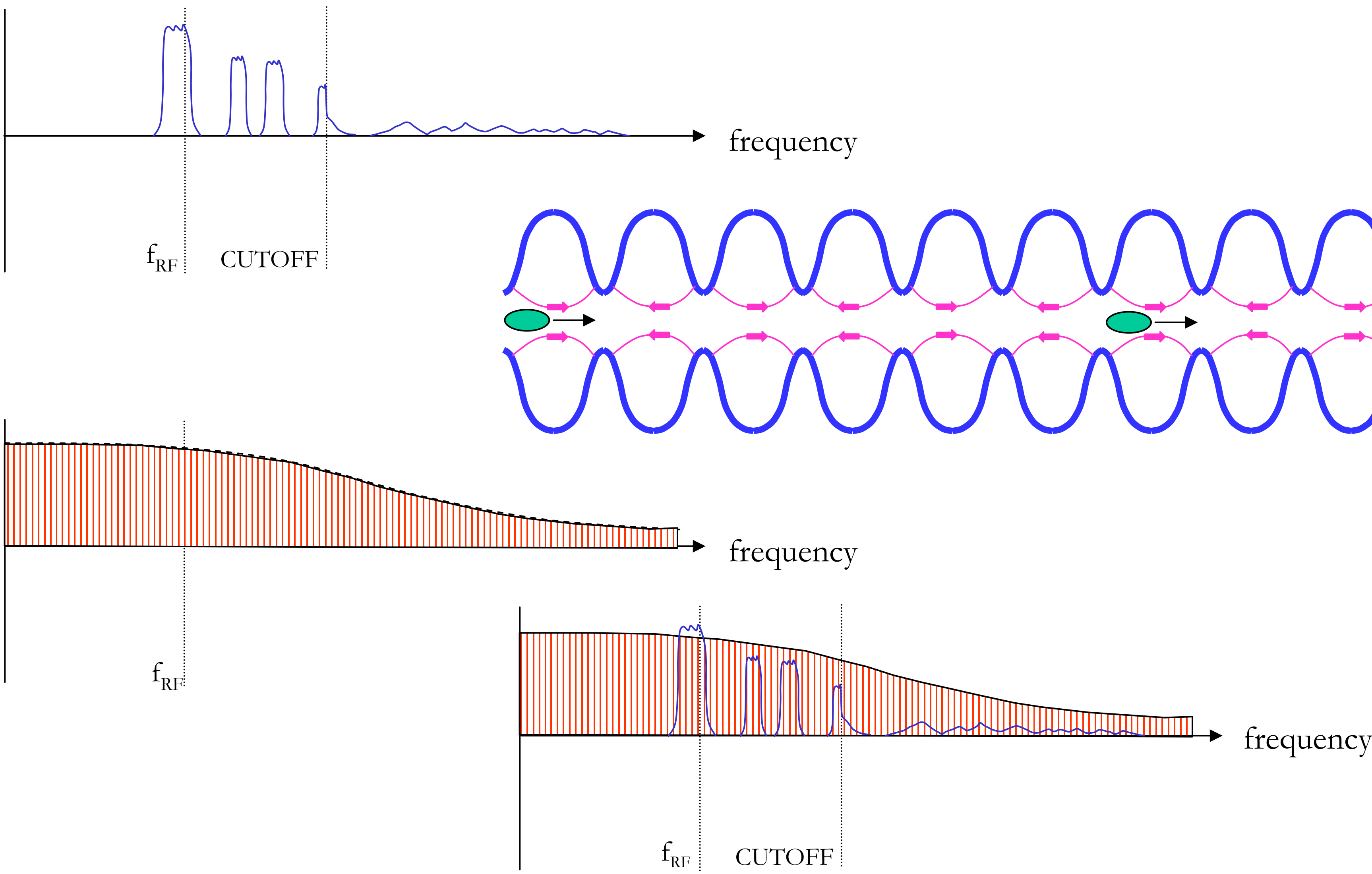
- HOM power dissipation

$$P_{HOM} = k_{loss}\left|q\right|I_{AVG} \qquad k_m = \frac{\pi\ f_m}{2}\left(\frac{R}{Q}\right)_m$$

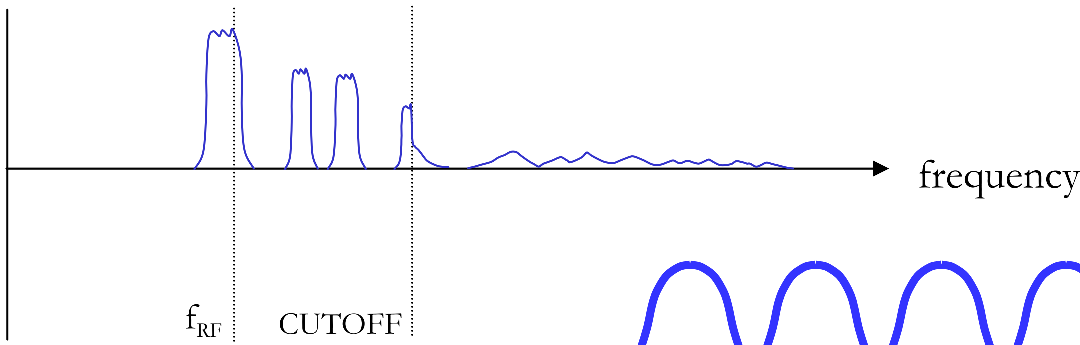
Bunch Frequency

- Setting $f_{bunch} = f_{RF}$
  - Can simplify HOM damping for a large enough diameter beam pipe.
    - i.e. all dangerous HOMs above cutoff (low Qs)
  - Lowers bunch charge for same average current

$$P_{HOM} = k_{loss} |q| I_{AVG} = k_{loss} \frac{I_{AVG}^2}{f_{bunch}}$$



frequency
f_{RF}
CUTOFF
frequency
f_{RF}
frequency
f_{RF}
CUTOFF


frequency
fRF
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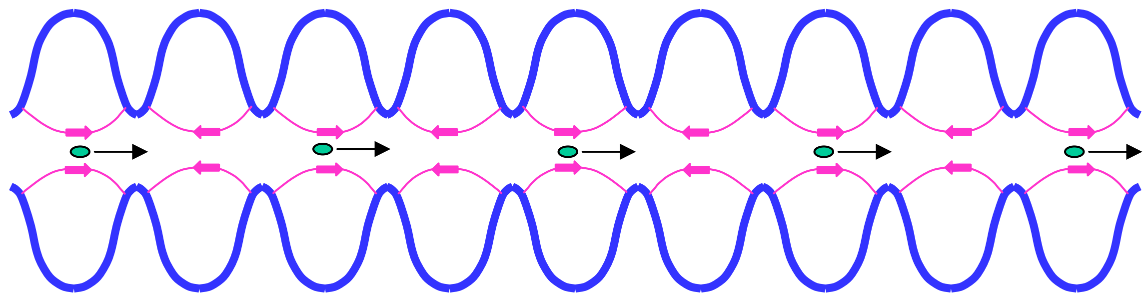
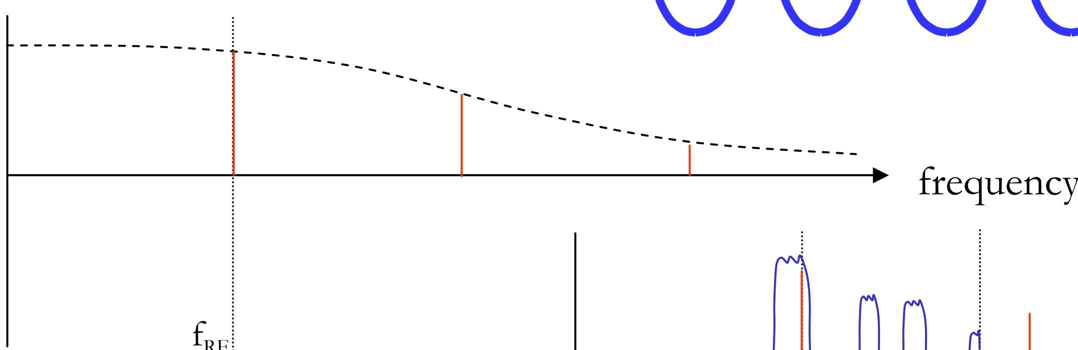
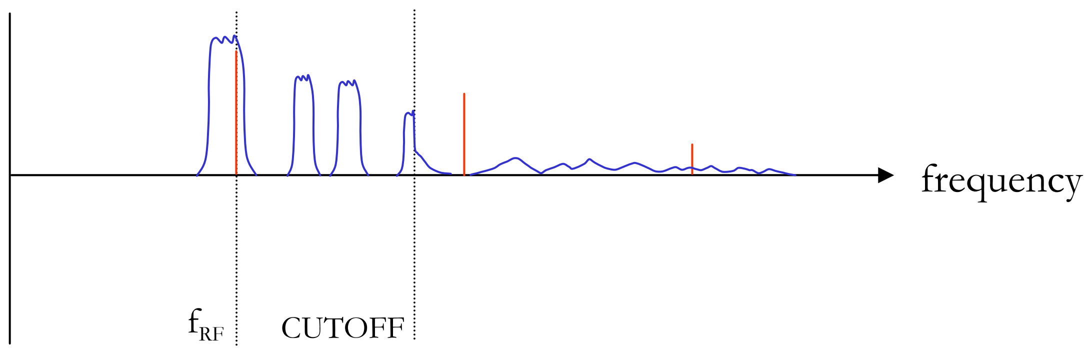
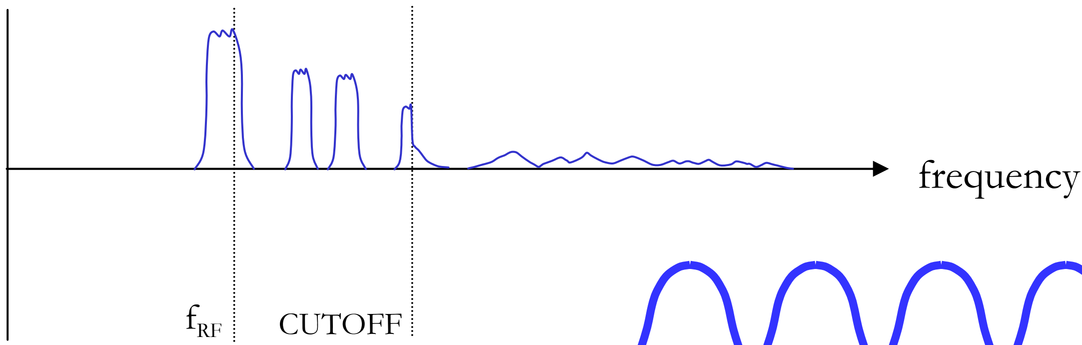
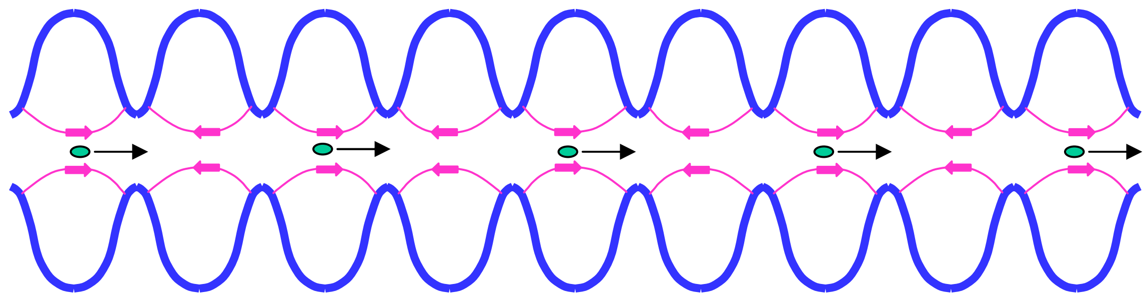
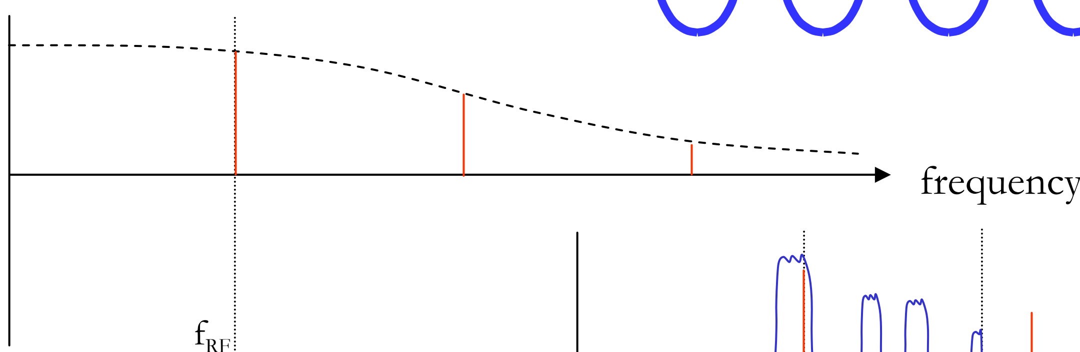



frequency
fRF

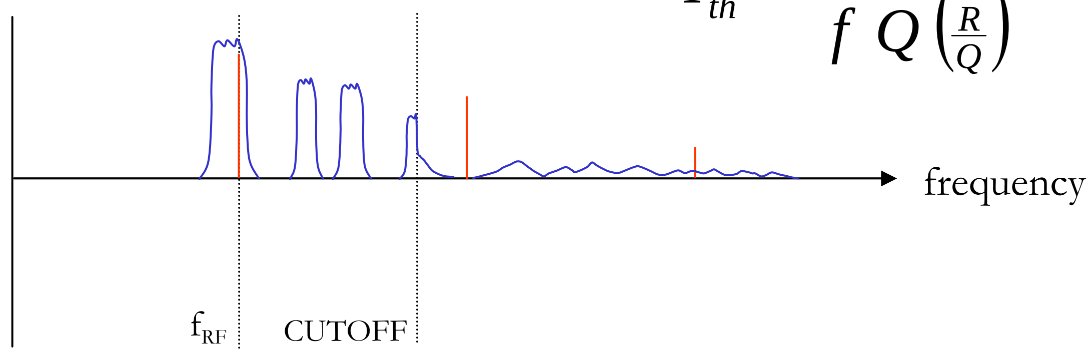

frequency
fRF
CUTOFF







$$I_{th} \propto \frac{1}{f\ Q\left(\frac{R}{Q}\right)}$$



HOM Qs

- Trapped modes and HOM couplers
  - 2100 MHz (JLAB FEL)
  - Q~ 10^6, I_{th} ~ 10 mA

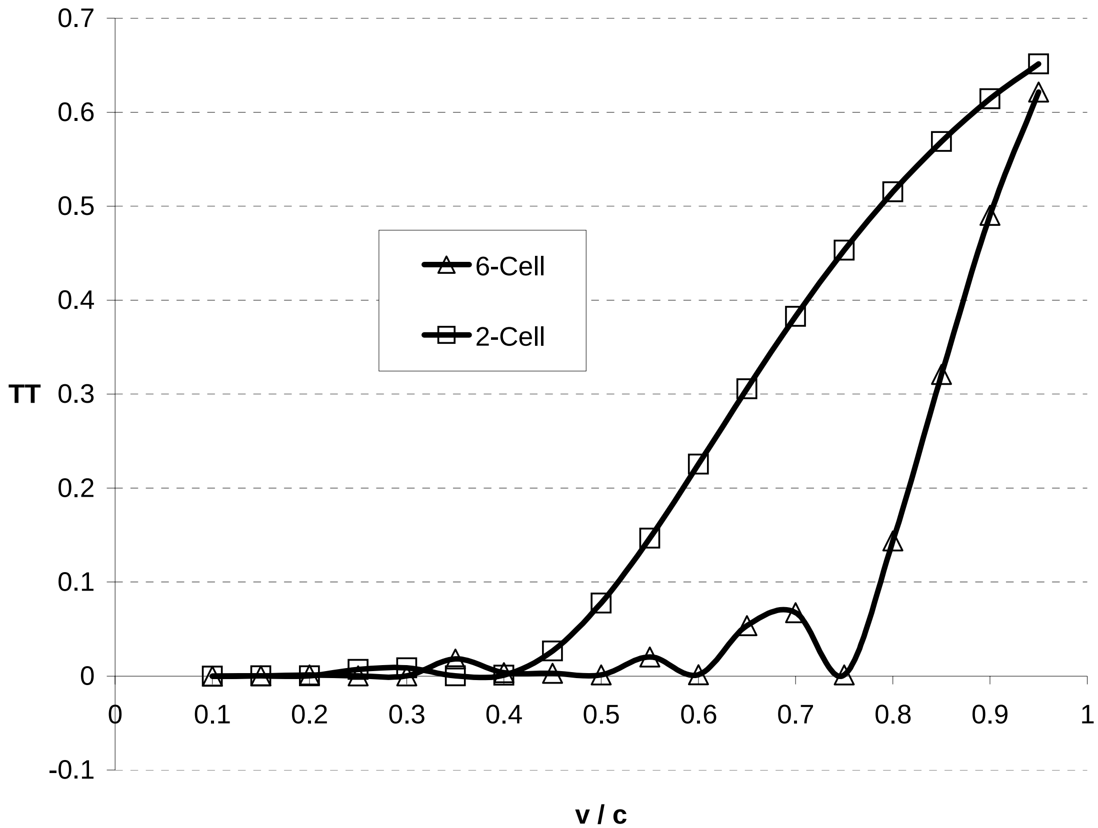
$$I_{th} \propto \frac{1}{f\,Q\left(\frac{R}{Q}\right)}$$

- Above cutoff
  - Damp in beampipe with ferrite, coupler or wall losses
  - Q~ 10^3 , I_{th} ~ 10 A

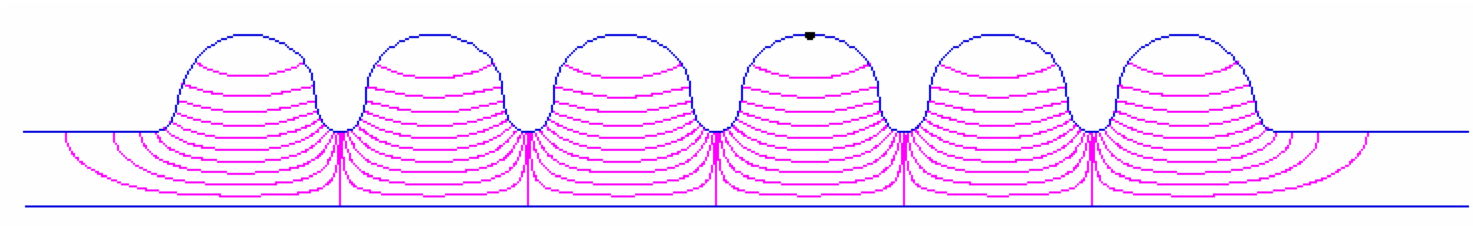
Elliptical Cavity Designs

- 100's mA beam current
- 1.5 GHz
- TM01 cutoff ~1.95f_{RF} and TE11 cutoff ~1.5f_{RF}
- 6^o wall angle
- E_{pk} / B_{pk} equals TeSLA value
- 2 cells $\beta > 0.50$
- 6 cells $\beta = 1.0$

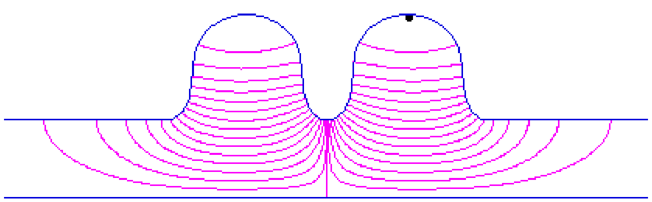
Transit Time Factors



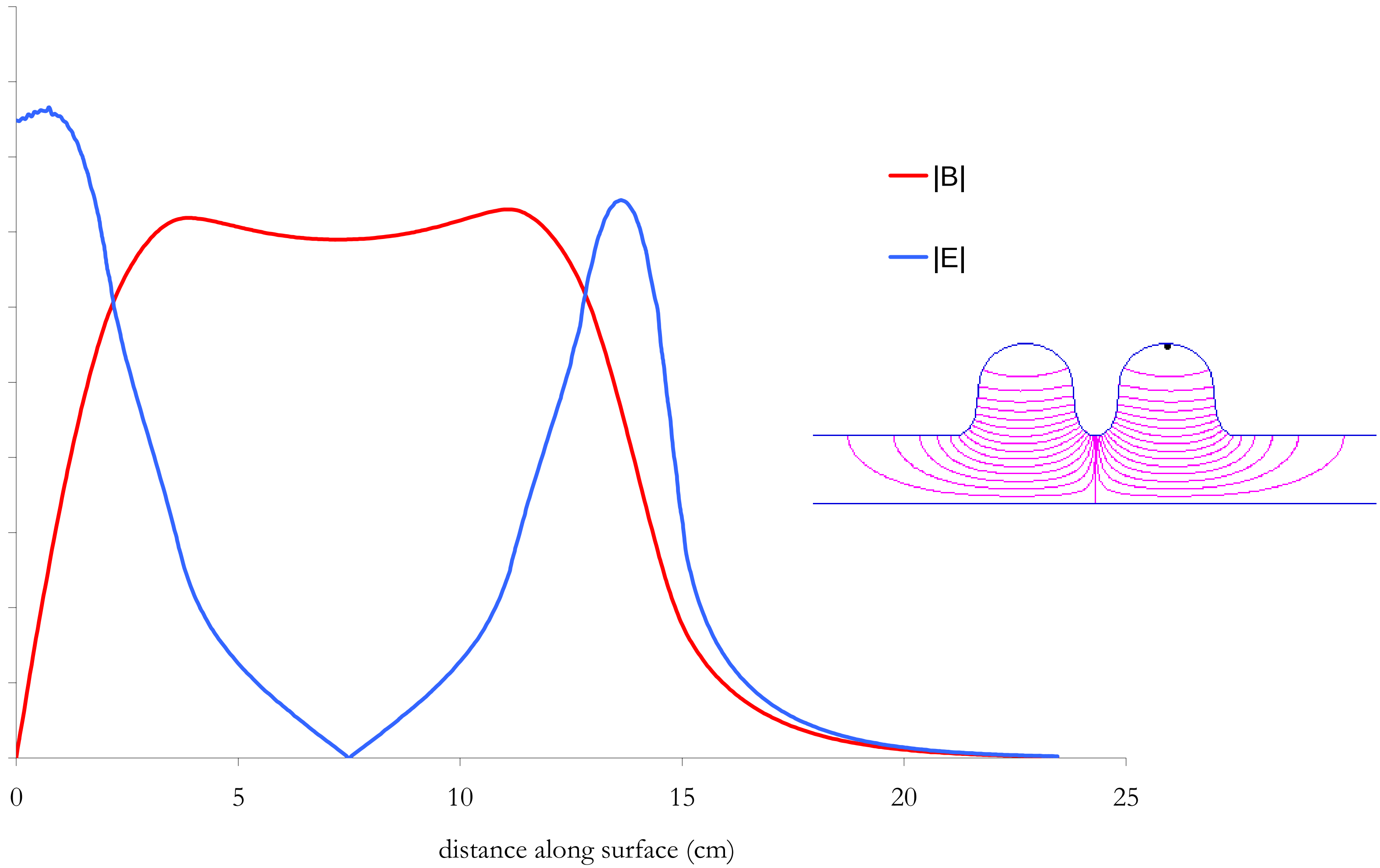
Cavity Figures of Merit



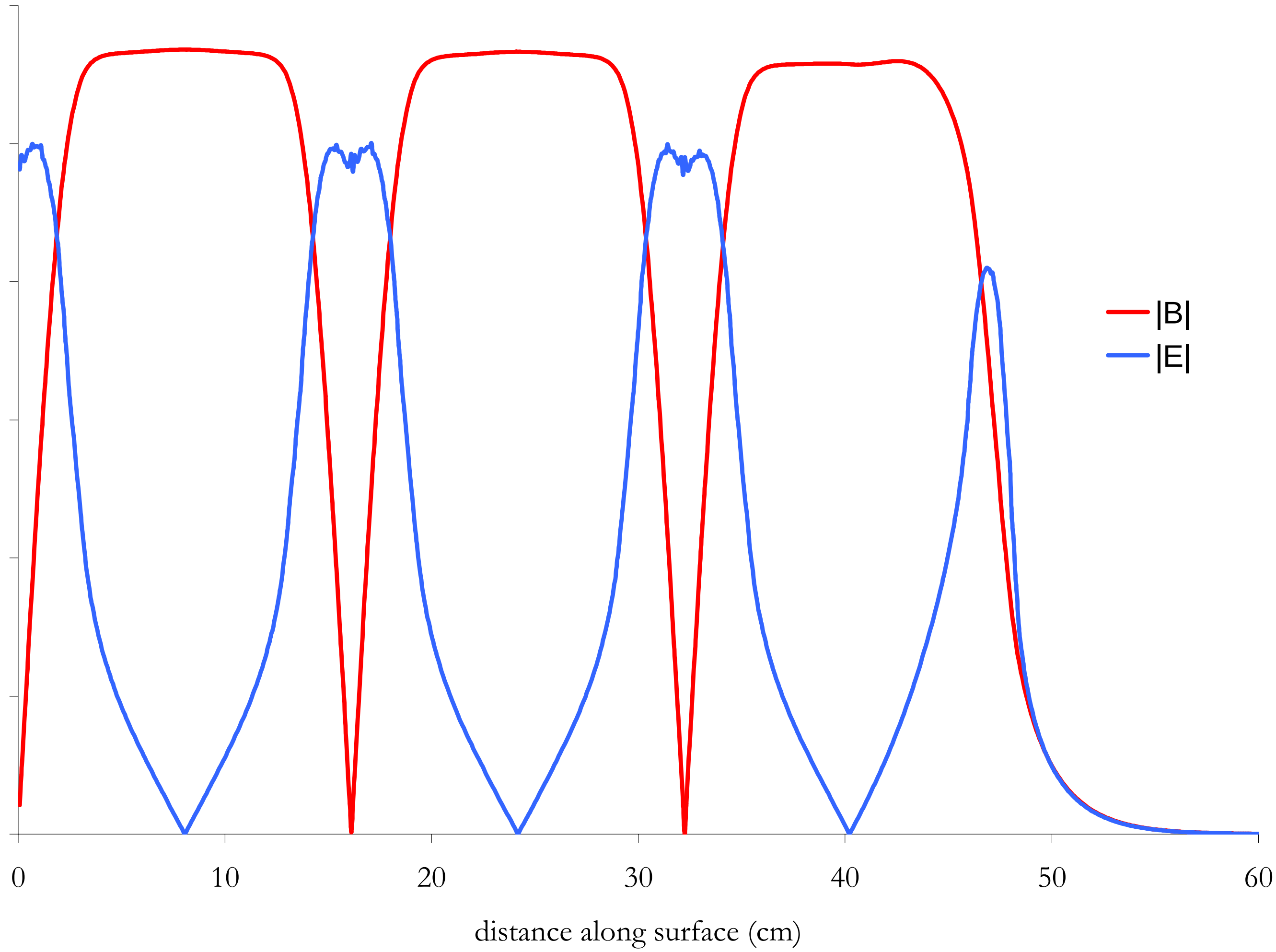
		2-Cell	6-Cell
E_p / E_A	-	2.16	2.19
B_p / E_A	mT / (MV/m)	4.59	4.68
R / Q	Ω	165	535
Geometrical Factor	Ω	228	275
Cell-to-cell Coupling	%	2.8	3.9
Number of Cells	-	2	6
Geometric β	-	0.81	1.0



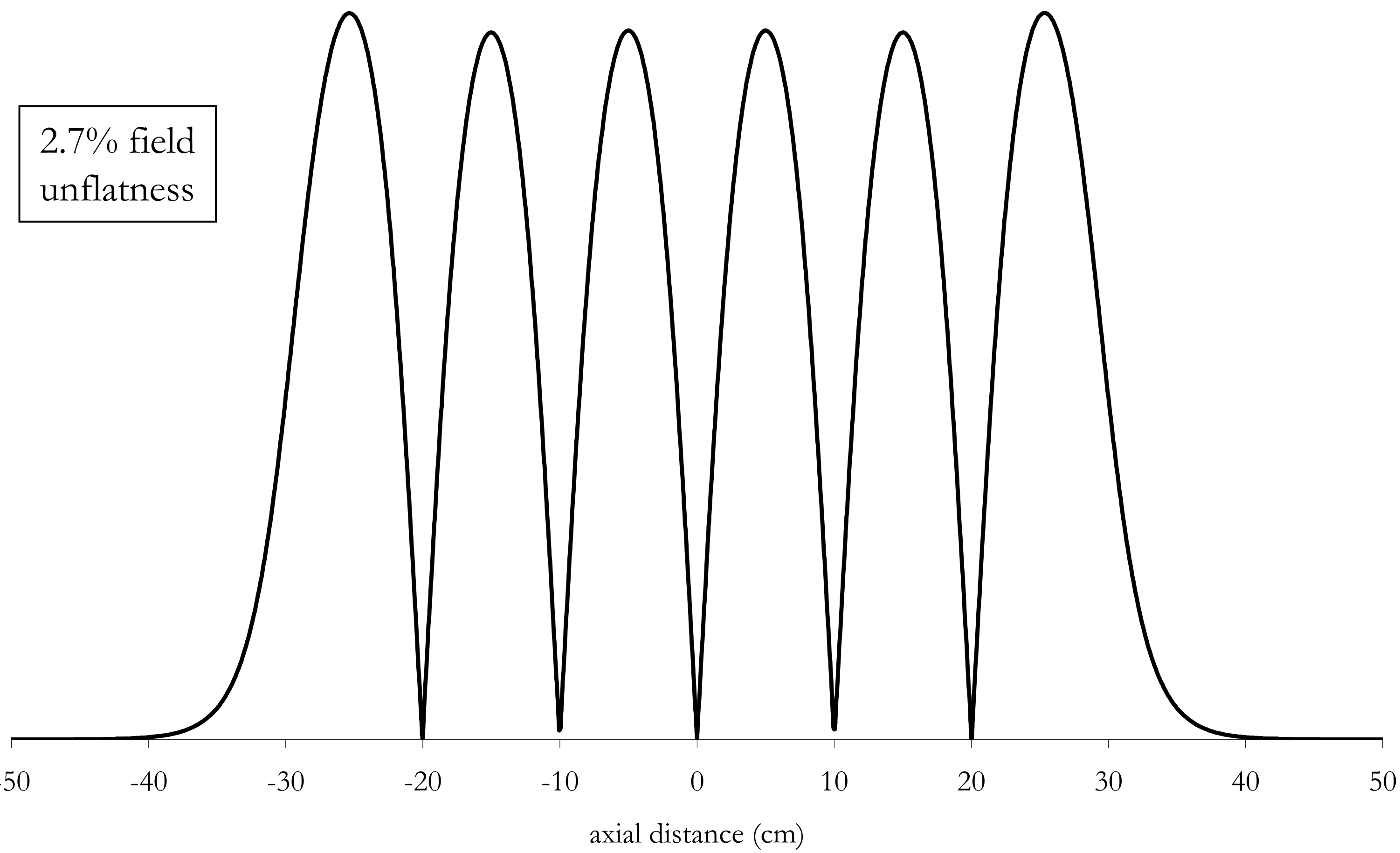
2-Cell Surface Fields



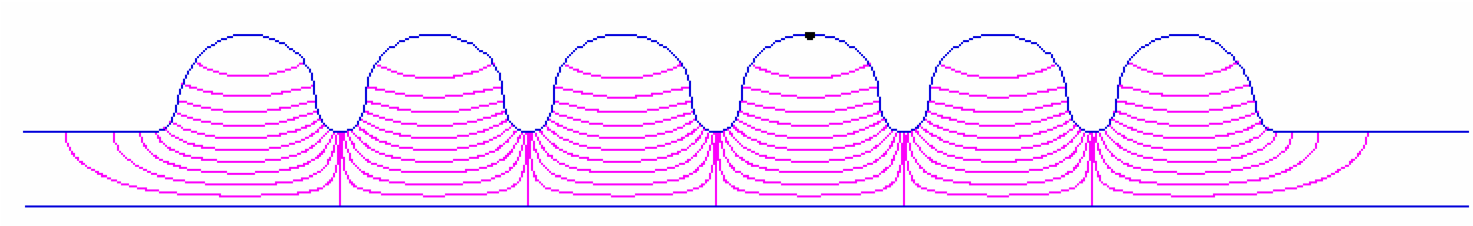
6-Cell Surface Fields



Electric Field Profile

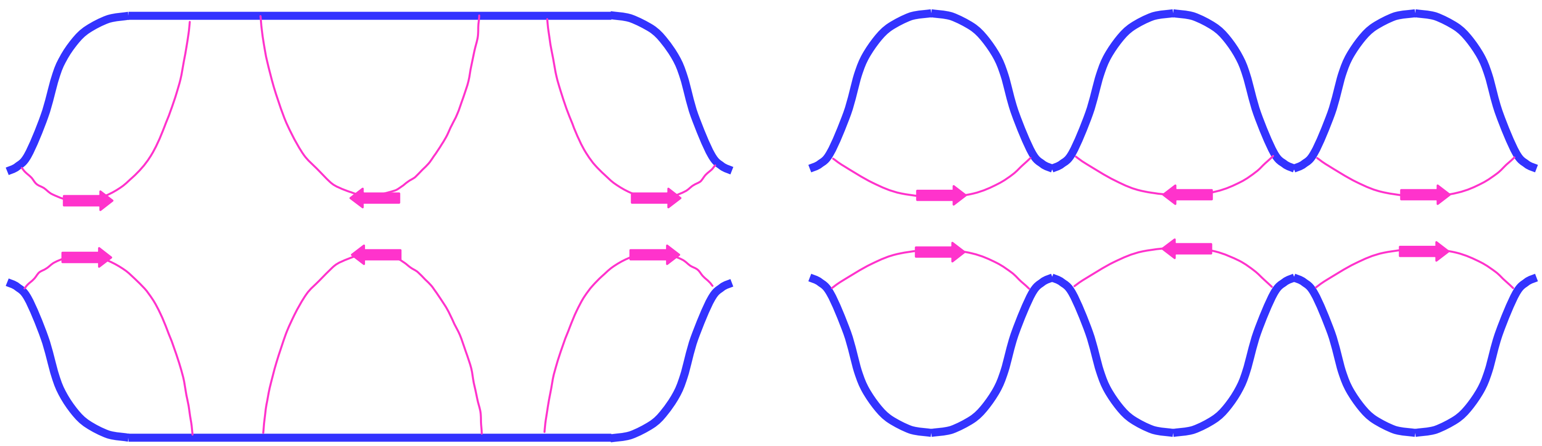


6-Cell Elliptical



		6-Cell	BNL Ampere Class	TeSLA	CEBAF
E_p / E_A	-	2.19	2.0	2.00	2.56
B_p / E_A	mT / (MV/m)	4.68	5.8	4.26	4.56
R / Q	Ω	535	404	1036	482.5
Geometrical Factor	Ω	275	225	270	273.8
Cell-to-cell Coupling	%	3.9	3	1.9	3.29
Number of Cells	-	6	5	9	5

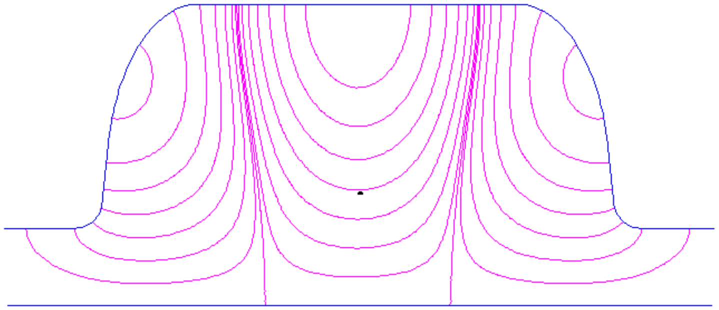
TM012 Cavity



TM012 Cavity

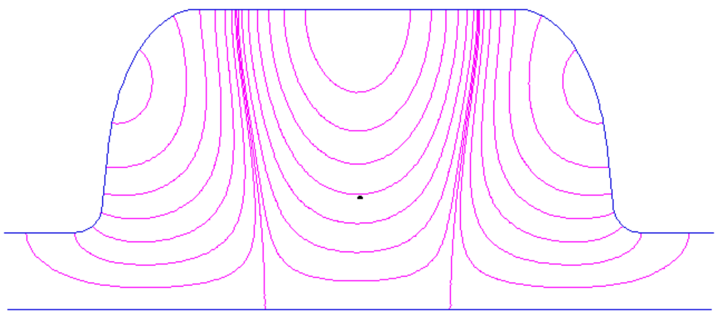
- Advantages
  - Simple shape
    - Easier fabrication
    - Better film deposition
    - Low loss factor
  - Single cell
    - Easier tuning
- Disadvantages
  - High peak magnetic fields
  - Damping parasitic modes below the accelerating mode
  - Low shunt impedance

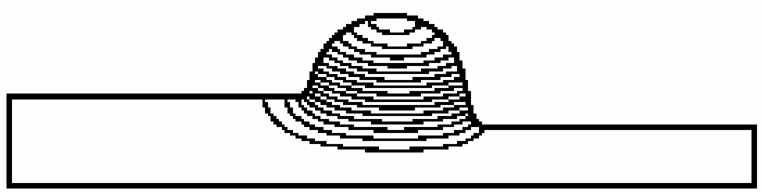
TM012 Cavity



		TM012
E_p / E_A	-	3.06
B_p / E_A	mT / (MV/m)	8.40
Voltage Gain	MV	2
E_p	MV / m	4.8
B_p	mT / (MV/m)	13.19
R / Q	Ω	55
Geometrical Factor	Ω	476
$k_{||}$	V / pC	0.37
beam pipe radius	cm	17
Frequency	MHz	353

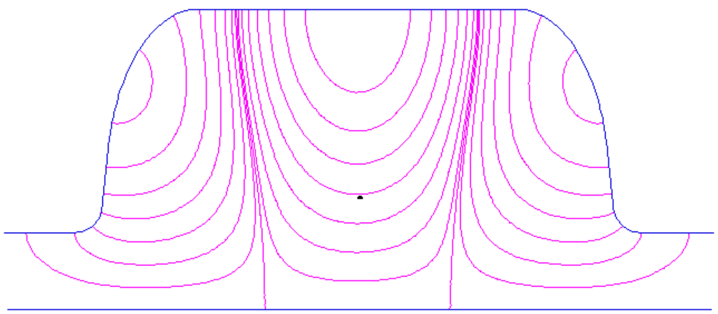
TM012 Cavity

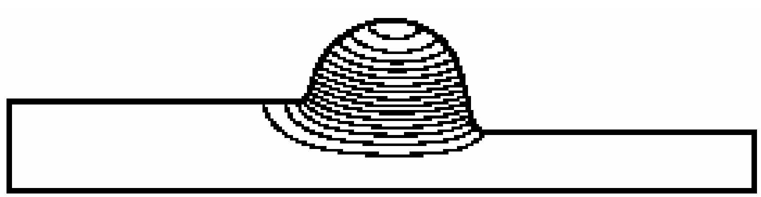




		TM012	SOLEIL
E_p / E_A	-	3.06	2
B_p / E_A	mT / (MV/m)	8.40	4.5
Voltage Gain	MV	2	2
E_p	MV / m	4.8	9.42
B_p	mT / (MV/m)	13.19	21.2
R / Q	Ω	55	90
Geometrical Factor	Ω	476	
$k_{\|\|}$	V / pC	0.37	0.75
beam pipe radius	cm	17	13
Frequency	MHz	353	353

TM012 Cavity





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beam pipe radius	cm	17	13
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Summary

- Objective: 100's mA of beam current with a simplified design
- Concept: Fill every RF bucket so that all dangerous HOMs are above cutoff.
- 2-Cell injection cavity and 6-Cell cavity designed for this purpose.
- Fabrication of 2-cell prototype to be completed by end of 2005.

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