Cornell Laboratory for
Accelerator-based Sciences and Education (CLASSE)

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Baseline Main Linac Cavity Design for Cornell's ERL

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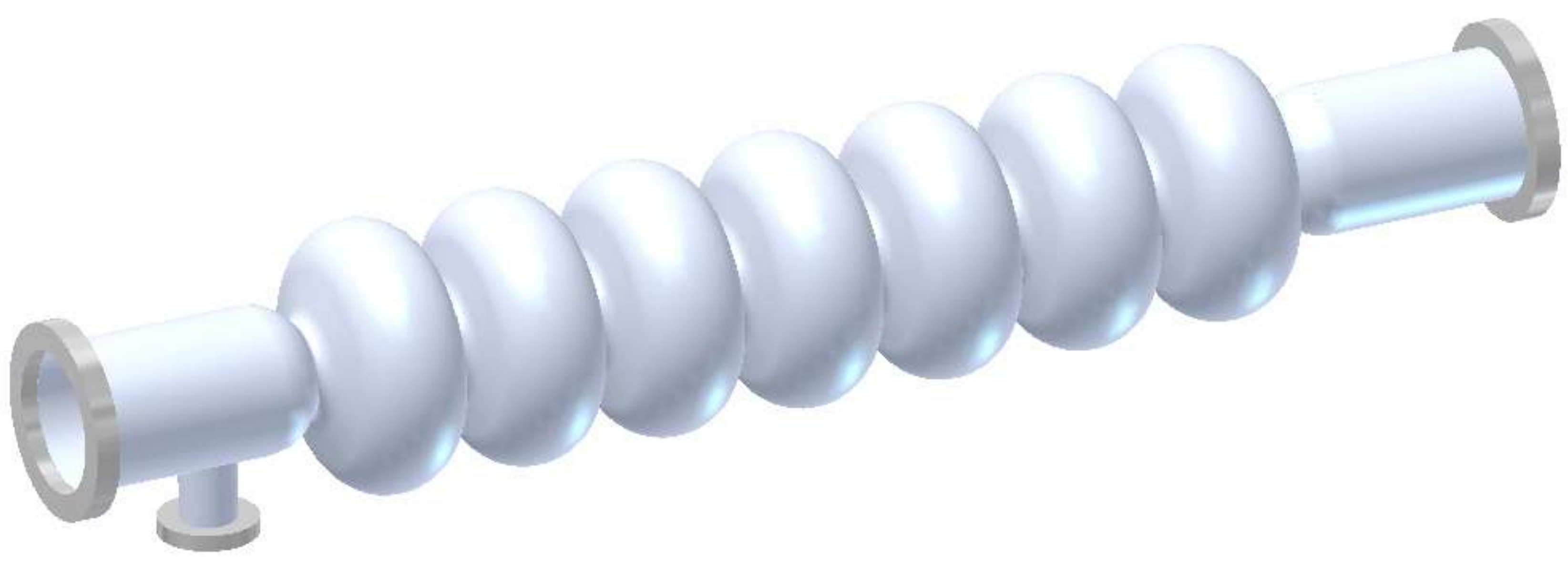
Introduction

Cornell is designing a high-current Energy Recovery Linac. Maximum current through the linac is limited by higher-order-modes (HOMs) in the accelerating cavities. Our optimized cavity serves as the baseline design and prototyping has begun



Design Process:

- Construct center cells that are stable under unavoidable fabrication perturbations
- Optimize End Cells to minimize dangerous HOMs
- Create center cell cavity designs with maximal relative frequency spread to maximize threshold current through the linac.

Optimization Methods

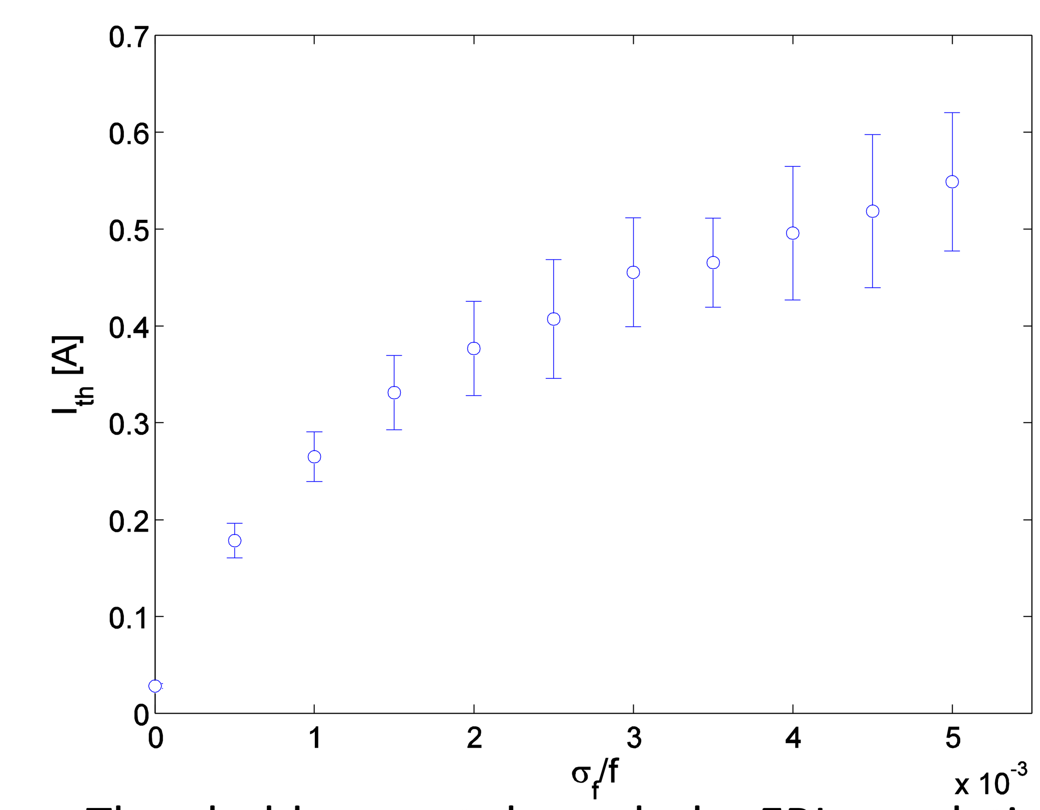
End cell optimization utilized an empirical relationship between each HOM's properties, λ, and beam-break up current through the linac:

$$\zeta_\lambda = \left(\frac{R}{Q}\right)_\lambda \frac{\sqrt{Q_\lambda}}{f_\lambda}$$

Minimizing the maximum of these parameters effectively increases the threshold current through the linac.

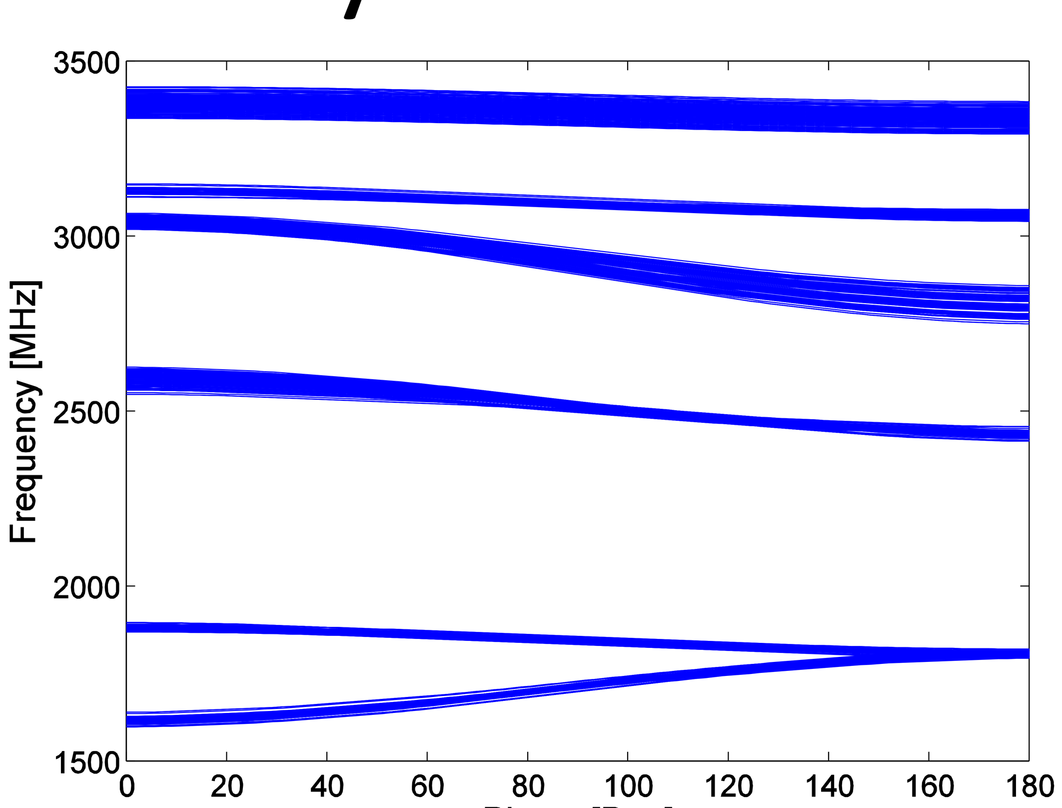
Threshold current through the linac is further increased by having relative frequency spread between cavities.

From fabrication variation, we expect $\sigma/f=0.5\times10^{-3}$, ~200 mA threshold current.



Threshold current through the ERL vs relative frequency spread of the HOM pass bands.

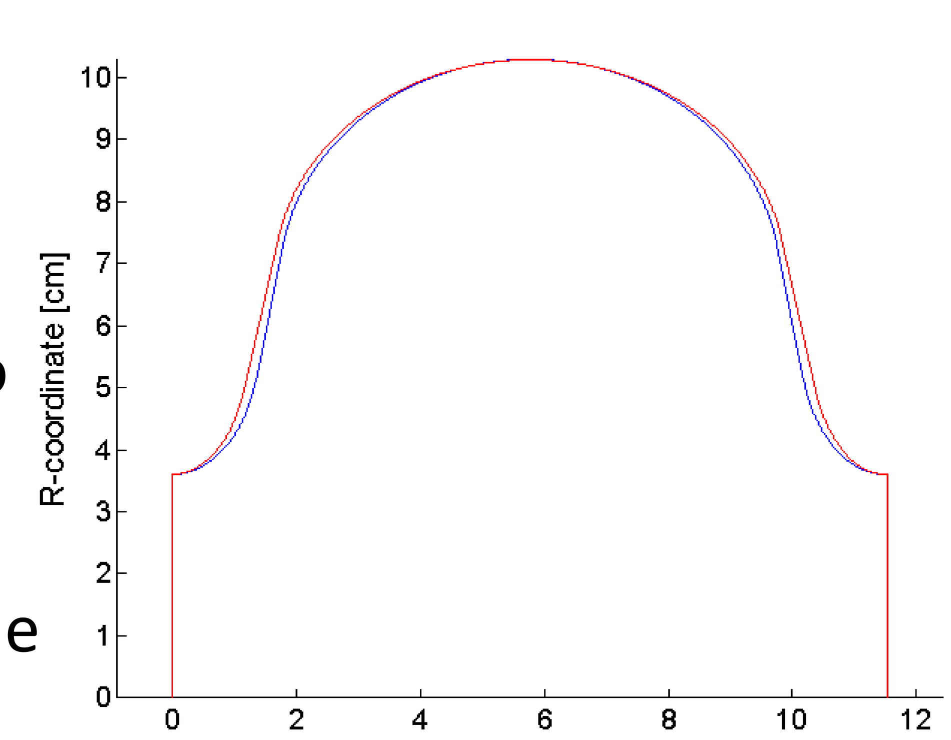
Cavity Classes



Dispersion curve of dipole pass bands

Small variations to the baseline center cell design does not significantly change fundamental mode properties, but introduces relative frequency spread of the HOM passbands.

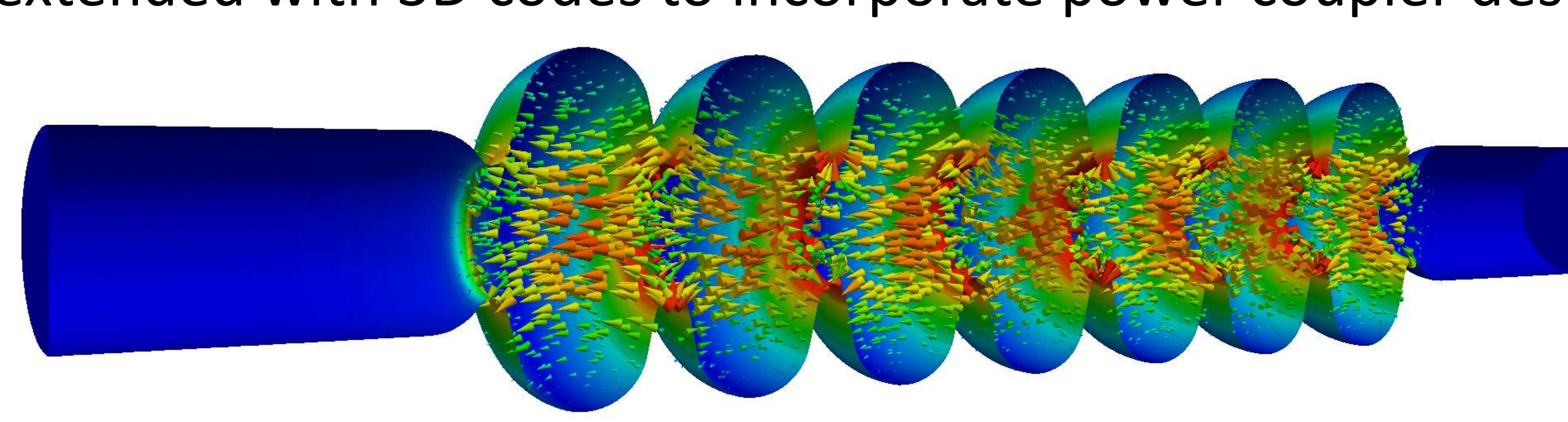
By including several cavity classes with different center cell shapes, $\sigma/f>3.5\times10^{-3}$, is achievable, corresponding to 450 mA threshold current. This more than doubles the threshold current through the linac from previous designs.

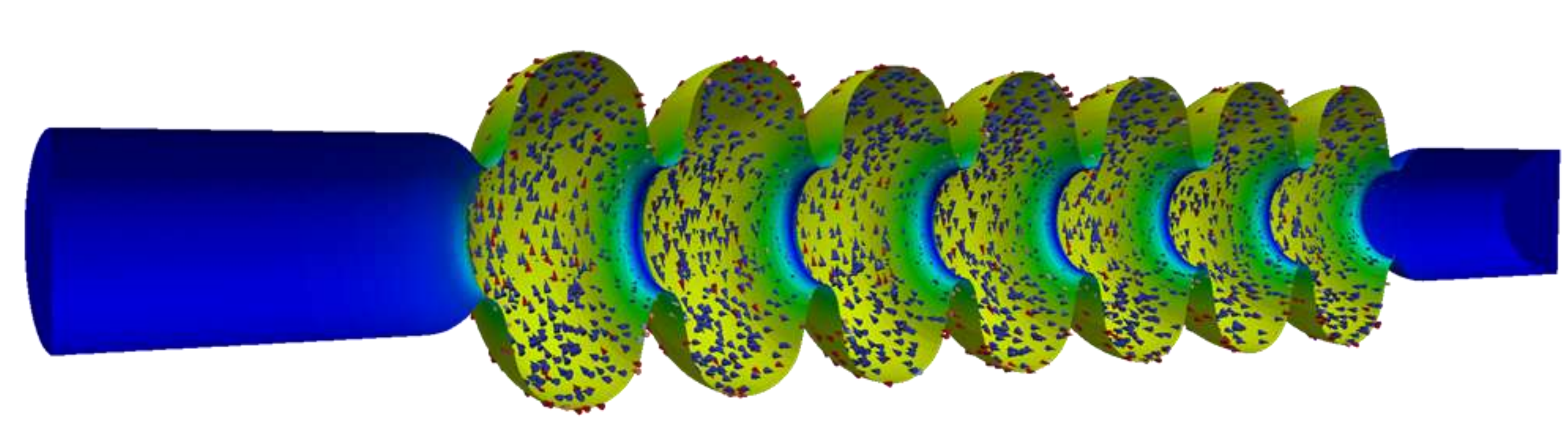


Two center cell shapes with 10 MHz relative frequency spread

Baseline Cavity Results

Prototyping our baseline cavity design has begun with the production of 6 cavities. Our 2D calculations are being extended with 3D codes to incorporate power coupler design.





Figures of Merit for Baseline Design

Parameter	Value	Parameter	Value
Type of accelerating structure	Standing wave	Fundamental Frequency	1300 MHz
Accelerating Mode	TM010 π mode	Cell-to-cell coupling	2.2%
Design Gradient	16.2 MV/m	Geometry factor	270.7 Ω
Intrinsic quality factor, Q_0	$> 2\times10^{10}$	R/Q	387 Ω
Loaded quality factor, Q_L	6.5×10^{7}	E_{peak}/E_{acc}	2.06
Cavity half bandwidth	10 Hz	H_{peak}/E_{acc}	42.0 Oe/(MV/m)
Cell Iris diameter	36 mm	Total longitudinal loss factor*	14.7 V/pc
Beam tube diameter	110 mm	Longitudinal loss factor,	
Number of cells	7	from non-fundamental*	13.1 V/pc
Active length	0.81 m	Transverse loss factor*	13.7 V/pc/m

*Loss factor assuming σ_z/c=2 ps

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, has joined with CHESS to become the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE). LEPP's primary source of support is the National Science Foundation.
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