

LHEC CAVITY DESIGN CONSIDERATIONS

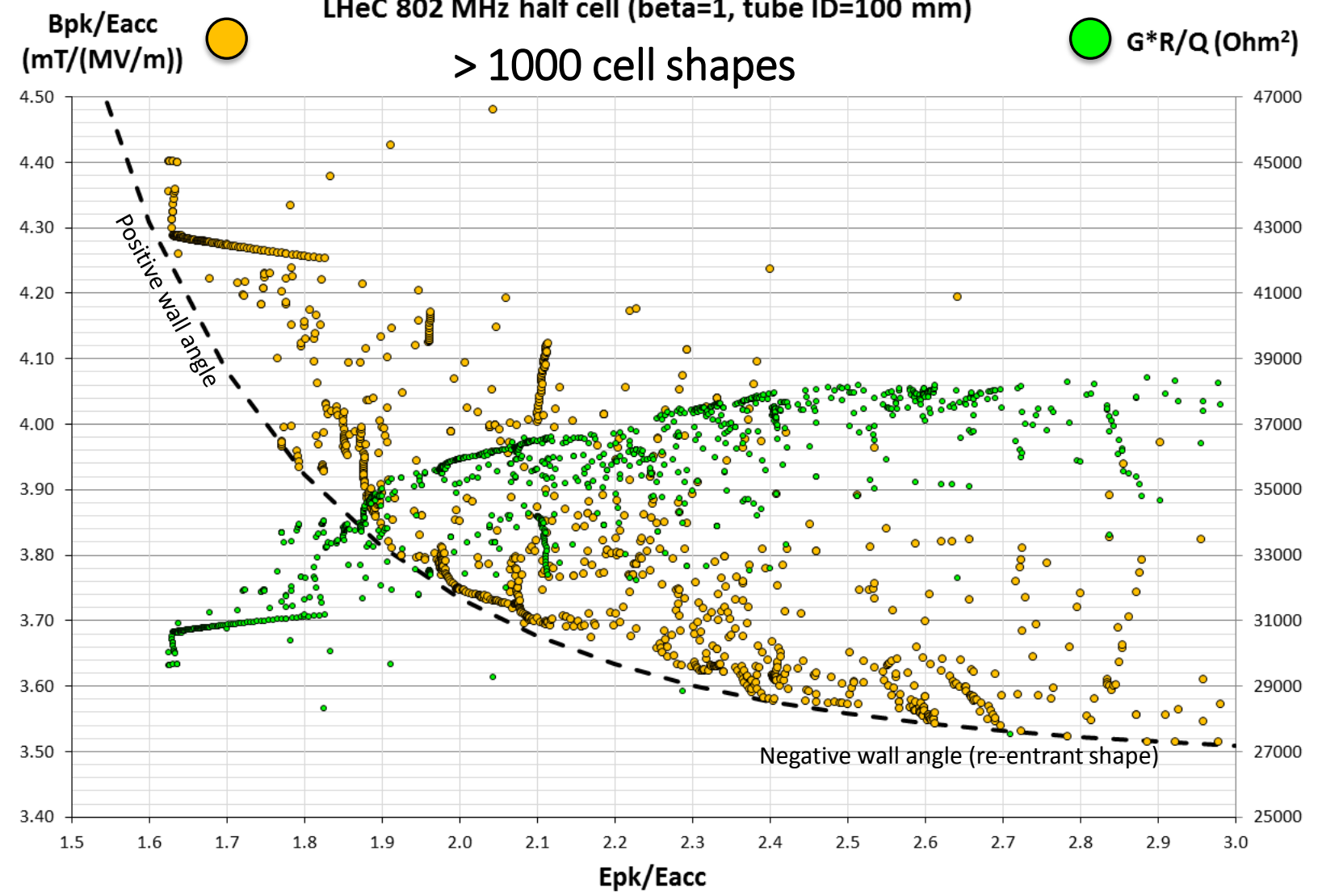
June, 2015

F. Marhauser

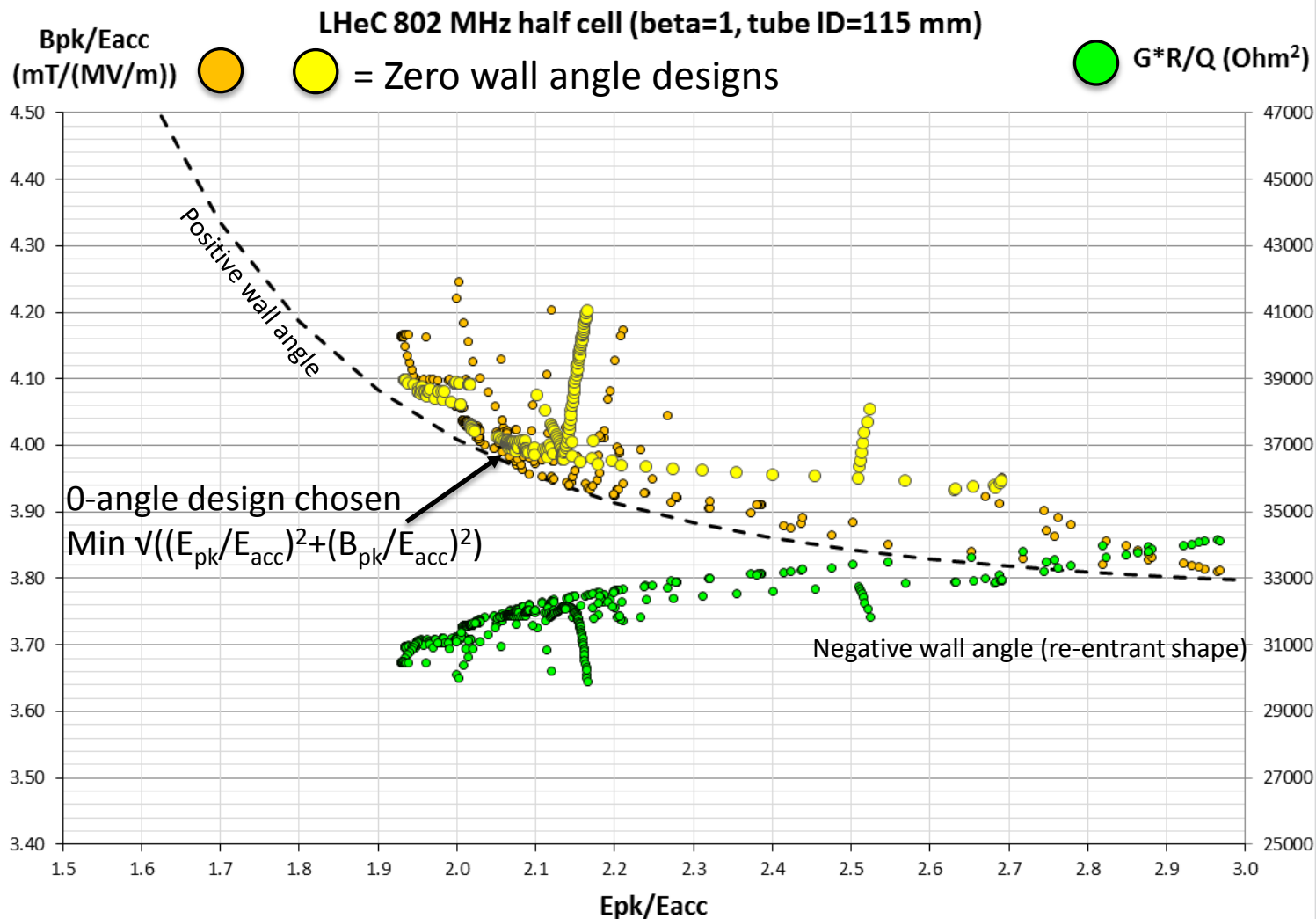
Fixed Parameter: Iris Diameter: 100 mm

LHeC 802 MHz half cell (beta=1, tube ID=100 mm)

> 1000 cell shapes

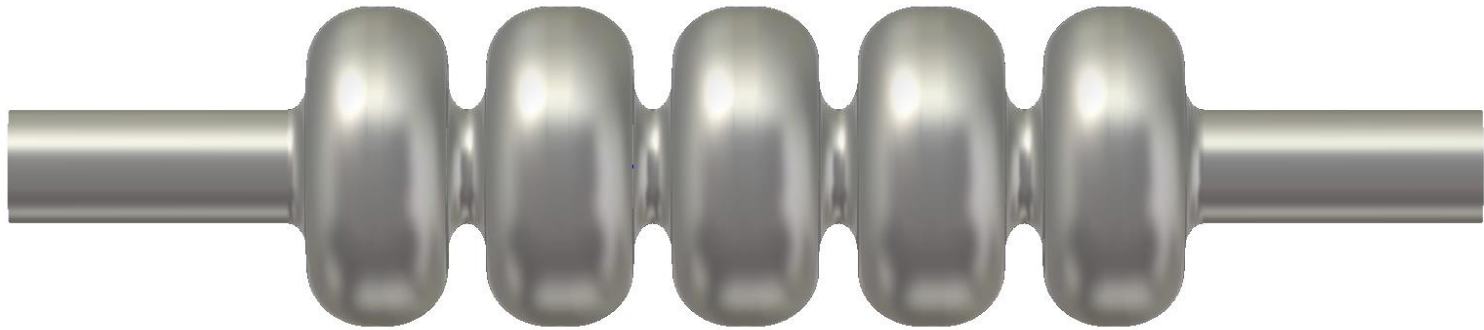


Fixed Parameter: Iris Diameter: 115 mm



Cavity design (single-die, iris ID=tube ID)

802 MHz



Cavity Parameters

Parameter	Unit	Value	Value	Value	Value	Value
cavity type		LHeC study	CEBAF HC	LCLS-II (TESLA)	CEBAF OC	CEBAF LL
frequency	MHz	802	748.5	1300	1497	1497
number of cells		5	5	9	5	7
L_{active}	mm	922.14	1000	1036.02	500	700
$R/Q = V_{\text{eff}}^2/(\omega \cdot W)$	Ω	583.4	518.8	1036.0	482.5	868.9
R/Q/cell	Ω	116.7	103.8	115.1	96.5	124.1
G	Ω	273.2	278.3	270.0	274.0	280.3
R/Q·G/cell		31877	28876	31080	26441	34793
Eq. Diameter	mm	323.12	352.73	206.60	187.03	173.99
Iris Diameter	mm	115	140	70	70	53
Tube Diameter	mm	115	140	78	70	70
Eq./Iris ratio		2.81	2.52	2.95	2.67	3.28
Wall angle (mid-cell)	deg	0	0	13.31		8.10
$E_{\text{peak}}/E_{\text{acc}}$ (mid-cell)		2.07	2.44	1.98	2.56	2.17
$B_{\text{peak}}/E_{\text{acc}}$ (mid-cell)	mT/(MV/m)	4.00	4.24	4.17	4.56	3.74
k_{cc}	%	2.14	3.12	1.89	3.15	1.49
N^2/k_{cc}		11.71	8.01	42.97	7.94	32.89
cutoff TE ₁₁	GHz	1.53	1.25	2.25	2.51	2.51
cutoff TM ₀₁	GHz	1.996	1.64	2.94	3.28	3.28

Ranking



Cavity Parameters

Parameter	Unit	Value	Value	Value	Value	Value
cavity type		LHeC study	CEBAF HC	LCLS-II (TESLA)	CEBAF OC	CEBAF LL
frequency	MHz	802	748.5	1300	1497	1497
cell length	mm	5	5	9	5	7
cell gap	mm	922.14	1000	1036.02	500	700
cell gap	mm	583.4	518.8	1036.0	482.5	868.9
cell gap	mm	116.7	103.8	115.1	96.5	124.1
cell gap	mm	273.2	278.3	270.0	274.0	280.3
cell gap	mm	31877	28876	31080	26441	34793
cell gap	mm	323.12	352.73	206.60	187.03	173.99
cell gap	mm	115	140	70	70	53
cell gap	mm	115	140			
Eq./Iris ratio		2.81	2.52	2.95	2.67	3.28
Wall angle (mid-cell)	deg	0	0	13.31		8.10
E_{peak}/E_{acc} (mid-cell)		2.07	2.44	1.98	2.56	2.17
B_{peak}/E_{acc} (mid-cell)	mT/(MV/m)	4.00	4.24	4.17	4.56	3.74
k_{cc}	%	2.14	3.12	1.89	3.15	1.49
N^2/k_{cc}		11.71	8.01	42.97		
cutoff TE_{11}	GHz	1.53	1.25	2.25		
cutoff TM_{01}	GHz	1.1	1.1	1.4		

Balanced single die design
 (- cryo losses
 -HOM damping
 - FE onset
 - quench field limit)
 - trade-off using flat equators
 to lower MP e- impact energies
 and iris=tube ID

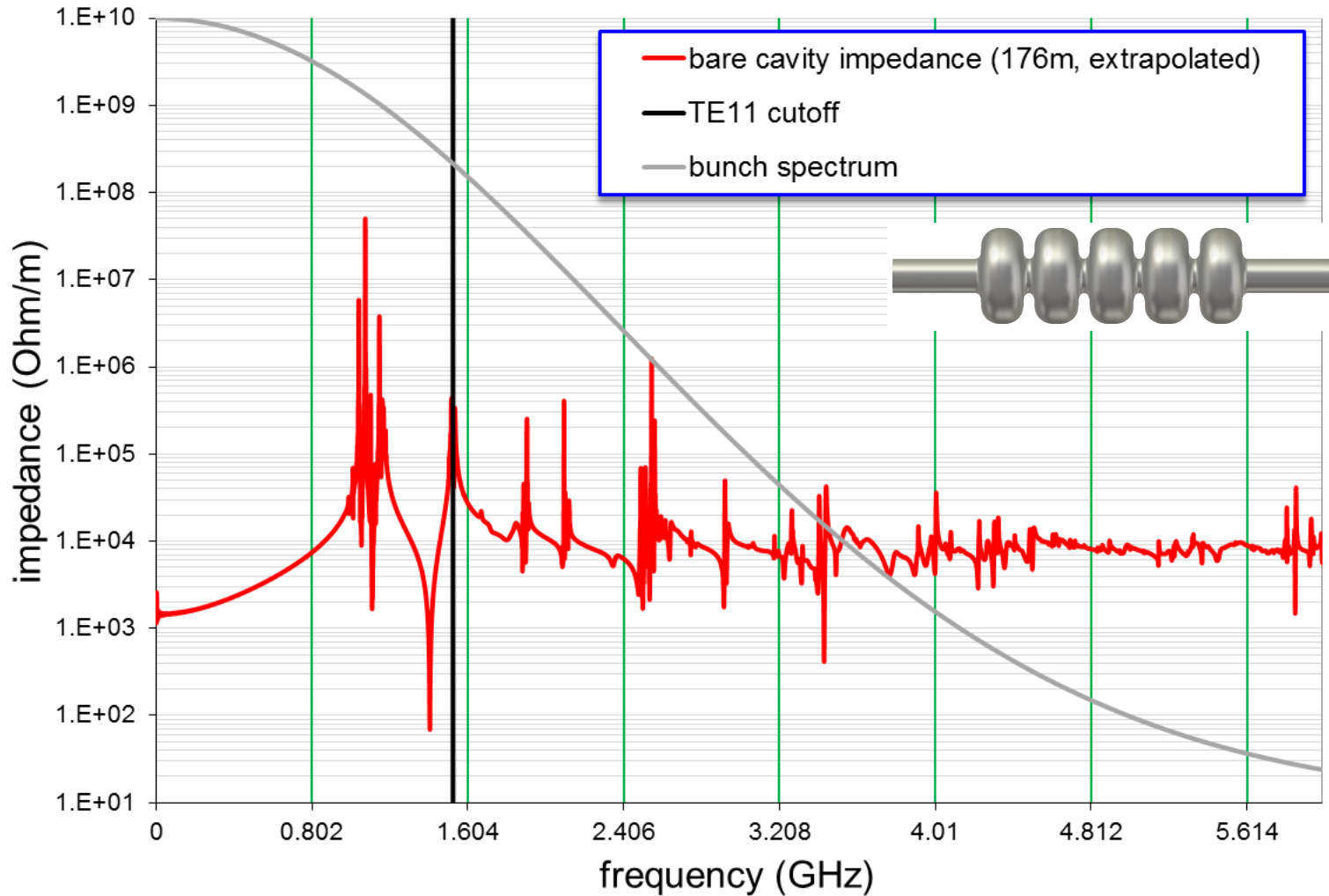
Cryo losses a problem

Early field emission
 and quenches

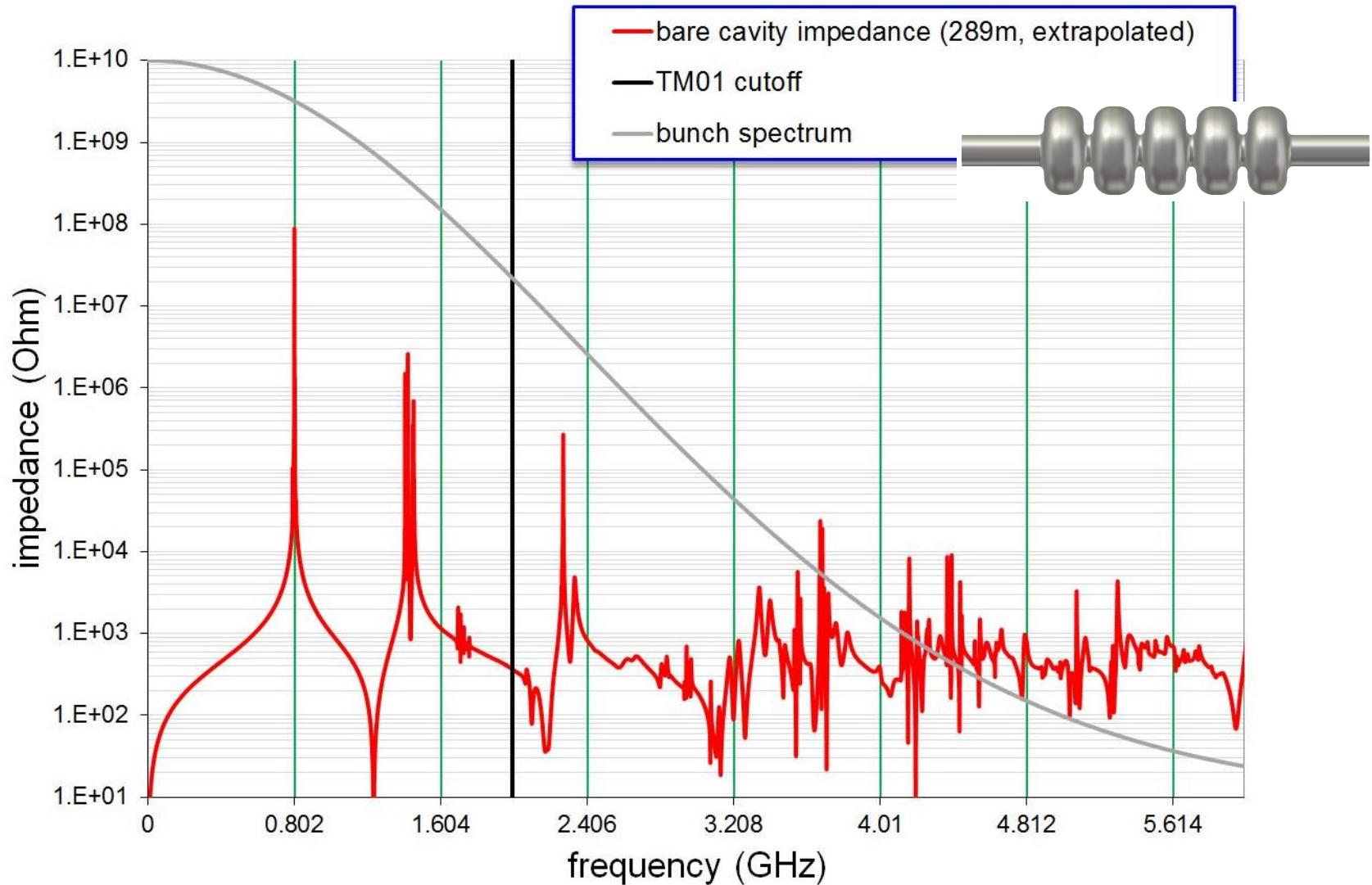
Ranking **1** (strong HOM damping) **5** HOM damping issues

Asymmetric cavity design encountered
 copes with HOMs

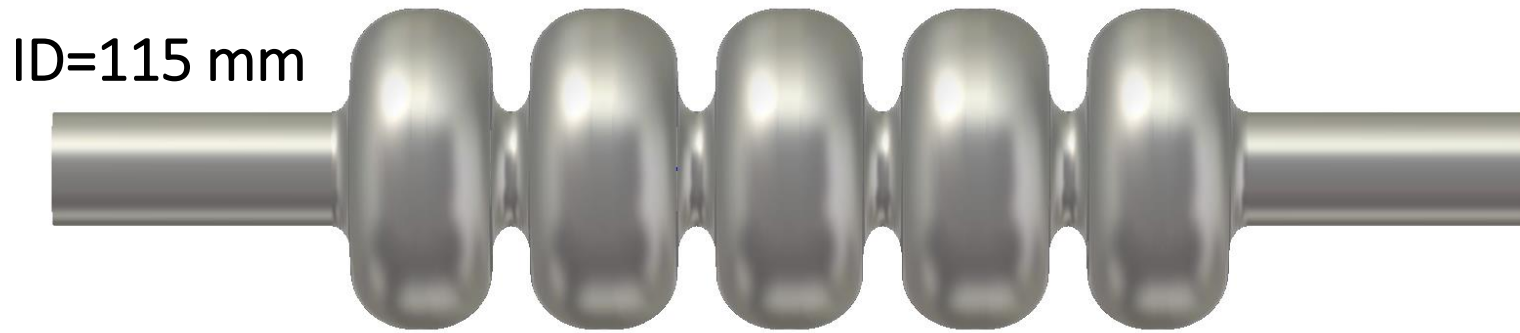
Dipole HOMs (Bare Cavity)



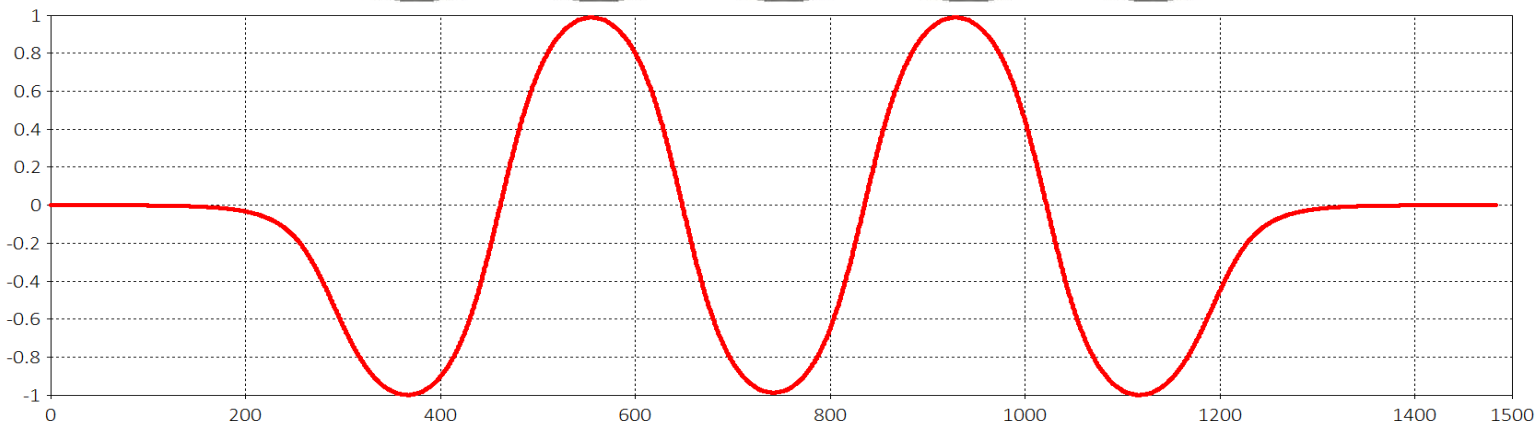
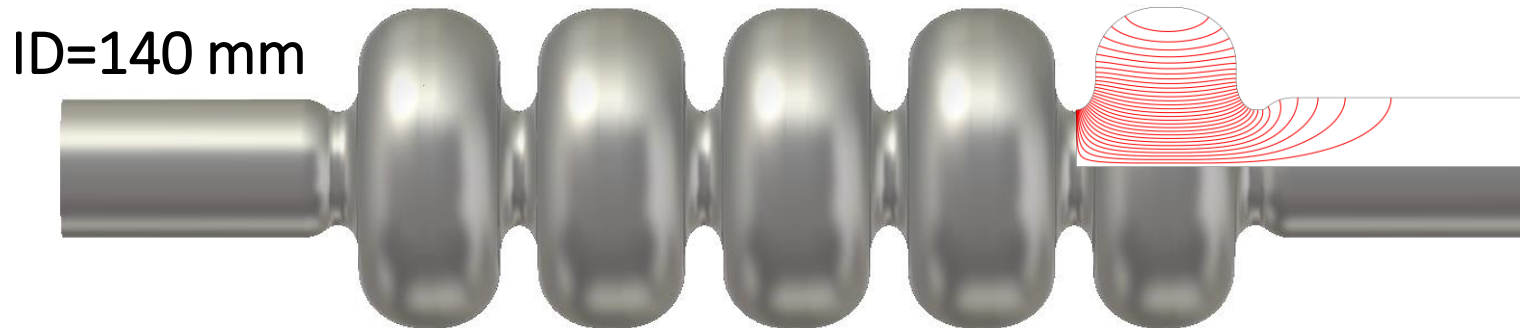
Monopole Modes (Bare Cavity)



Cavity design (single-die, iris ID = tube ID)



Cavity design (single-die, iris ID < tube ID)



Cavity Parameters

Parameter	Unit	Value	Value	Value	Value	Value	Value
cavity type		LHeC study	LHeC study	CEBAF HC	LCLS-II (TESLA)	CEBAF OC	CEBAF LL
frequency	MHz	802	802	748.5	1300	1497	1497
number of cells		5	5	5	9	5	7
L_{active}	mm	922.31	922.14	1000	1036.02	500	700
$R/Q = V_{\text{eff}}^2/(\omega*W)$	Ω	580.1	583.4	518.8	1036.0	482.5	868.9
R/Q/cell	Ω	116.0	116.7	103.8	115.1	96.5	124.1
G	Ω	273.2	273.2	278.3	270.0	274.0	280.3
R/Q·G/cell		31702	31877	28876	31080	26441	34793
Eq. Diameter	mm	323.12	323.12	352.73	206.60	187.03	173.99
Iris Diameter	mm	115	115	140	70	70	53
Tube Diameter	mm	140	115	140	78	70	70
Eq./Iris ratio		2.81	2.81	2.52	2.95	2.67	3.28
Wall angle (mid-cell)	deg	0	0	0	13.31		8.10
$E_{\text{peak}}/E_{\text{acc}}$ (mid-cell)		2.07	2.07	2.44	1.98	2.56	2.17
$B_{\text{peak}}/E_{\text{acc}}$ (mid-cell)	mT/(MV/m)	4.00	4.00	4.24	4.17	4.56	3.74
k_{cc}	%	2.14	2.14	3.12	1.89	3.15	1.49
N^2/k_{cc}		11.71	11.71	8.01	42.97	7.94	32.89
cutoff TE ₁₁	GHz	1.26	1.53	1.25	2.25	2.51	2.51
cutoff TM ₀₁	GHz	1.64	2.00	1.64	2.94	3.28	3.28

Cavity Parameters

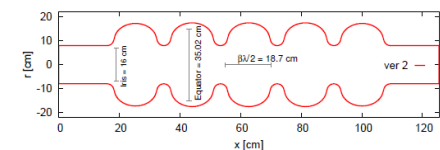


Fig. 6: Envelope of the second version of the five-cell ERL cavity at 802 MHz with 16 cm aperture.

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Parameter	Unit	Value	Value		Value	
cavity type		LHeC study	LHeC study		LHeC Ver. 1	LHeC Ver. 2
frequency	MHz	802	802		801.58	801.58
number of cells		5	5		5	5
L_{active}	mm	922.31	922.14		935	935
$R/Q = V_{\text{eff}}^2 / (\omega * W)$	Ω	580.1	583.4		430	393
R/Q/cell	Ω	116.0	116.7		86.0	78.6
G	Ω	273.2	273.2		276	283
R/Q·G/cell		31702	31877	~-25%	23736	22244
Eq. Diameter	mm	323.12	323.12		350.2	350.2
Iris Diameter	mm	115	115		150	160
Tube Diameter	mm	140	115		150	160
Eq./Iris ratio		2.81	2.81		2.19	2.19
Wall angle (mid-cell)	deg	0	0		12.5	12.5
$E_{\text{peak}}/E_{\text{acc}}$ (mid-cell)		2.07	2.07		2.26	2.40
$B_{\text{peak}}/E_{\text{acc}}$ (mid-cell)	mT/(MV/m)	4.00	4.00		4.77	4.92
k_{cc}	%	2.14	2.14		4.47	5.75
N^2/k_{cc}		11.71	11.71		5.59	4.35
cutoff TE_{11}	GHz	1.26	1.53		1.17	1.10
cutoff TM_{01}	GHz	1.64	2.00		1.53	1.43

Operating Conditions

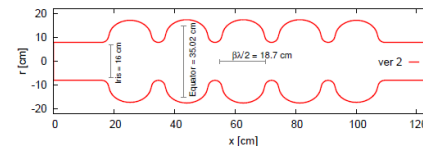


Fig. 6: Envelope of the second version of the five-cell ERL cavity at 802 MHz with 16 cm aperture.

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Parameter	Unit	Value	Value	Value	Value
cavity type		LHeC study	LHeC study	LHeC Version 1	LHeC Version 2
frequency	MHz	802	802	801.58	801.58
number of cells		5	5	5	5
L_{active}	mm	922.31	922.14	935	935
Eff. Voltage	MV	18.7	18.7	18.7	18.7
E_{acc}	MV/m	20.3	20.3	20.0	20.0
E_{pk}	MV/m	41.8	42.0	45.1	48.0
B_{pk}	mT	81.9	81.1	95.4	98.3
R/Q·G/cell		31702	31877	23736	22244
Assume Q_0		2e10	2e10	2e10	2e10
R_s	n Ω	13.7	13.7	13.8	14.2
P_{wall} (18.7 MV peak) W		30.2	30.0	40.7	44.5