JLC/NLC X-Band Structure Design

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ISG10

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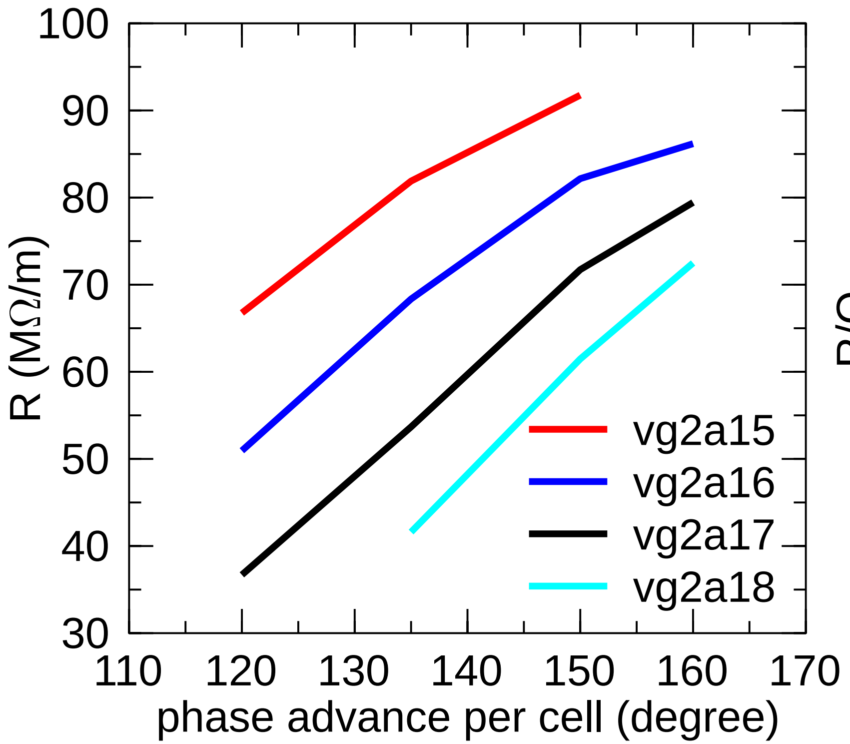
Design Considerations

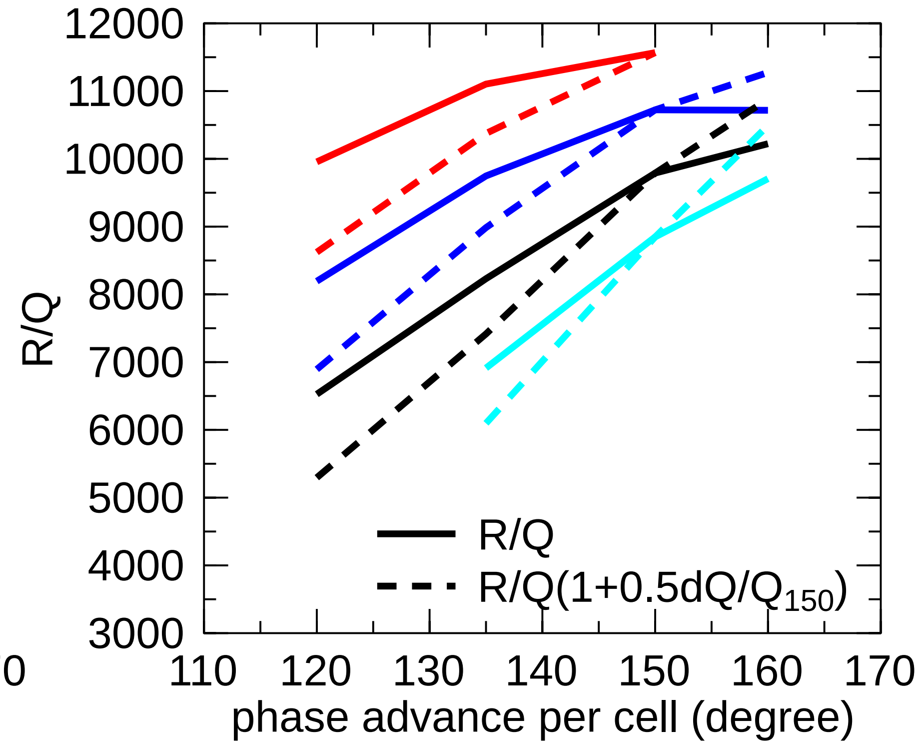
- Minimize input power
  - Using shorter structure length
  - Improving shunt impedance
- Optimize aperture profile to meet long-range (detuning) and short-range (average) wakefield requirements
- Tailor gradient profile to “remove” “hot” breakdown region
- Include beam loading and BNS damping in optimization
- Lower surface fields (E,B)
- Fix length; optimize filling time; “no” constraint on vg profile

Structure Length

- Power and surface field are relevant factors that cause breakdown and damage
- Input power roughly proportional to length
- Shorter length to lower input power
- Present designs stay with 0.60m

Phase Advance and a/λ





- Higher phase advance provides higher *R* and *Q*.
- Power per structure inversely proportional to *R/Q(1+0.5dQ/Q150)*
- 150^0 phase advance provide good efficiency and surface fields.

a/λ: Input Power Comparison

a/λ v.s. Power Requirement Unloaded gradient=65MV/m, ~5% more power for slotted/elliptical		
a/λ	Non-slotted, Circular iris	Slotted, Elliptical iris
0.18	63.0	68.6*
0.17	55.8	58.6
0.165	52.4	55.0
0.16	49.6	52.8
0.15	43.7	45.9

*H60VG3S18

- Iris was changed from circular to elliptical without optimization
- Filling time is shorter, due to elliptical iris, than H60VG3N-6C
- More power needed

Beam Loading v.s. a/λ

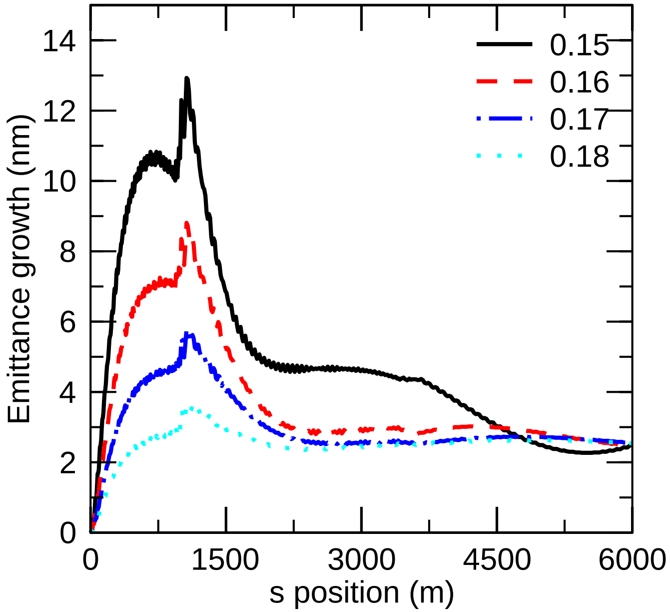
a/λ	Multi bunch (MV/A/m)	Single bunch	
		MV/A/m	ϕ_0,degrees
0.18	14.17	0.83	-10.5
0.17	15.78	0.85	-10.7
0.16	17.67	0.95	-12.6
0.15	19.23	1.05	-15.0

- The multi-bunch beam loading ($\propto R$) more sensitive to a/λ than RF gradient ($\propto R^{1/2}$).
- The single-bunch loading need to be compensated by accelerating the beam off crest and with higher RF gradient.
- Larger loading ratio at smaller a/λ that may reduce the gain in efficiency.

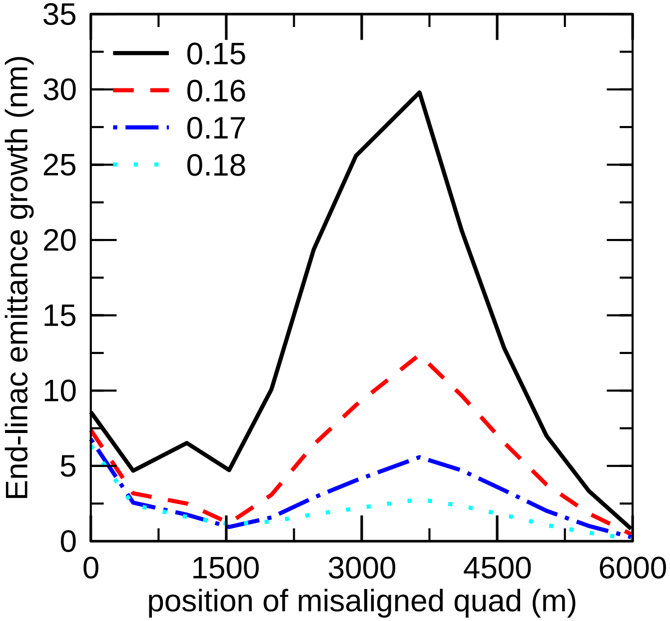
Linac Tolerance v.s. a/λ

a/λ	ϕ_1, degrees	E_1, GeV	ϕ_2, degrees	E_2, GeV	ϕ_3, degrees
0.18	12	30	0	165	-30
0.17	14	30	0	162	-30
0.16	16	30	1	142	-30
0.15	19	30	4	113	-30

It is not possible to achieve an acceptable emittance for a/λ=0.15, despite significant BNS phase offsets utilized.

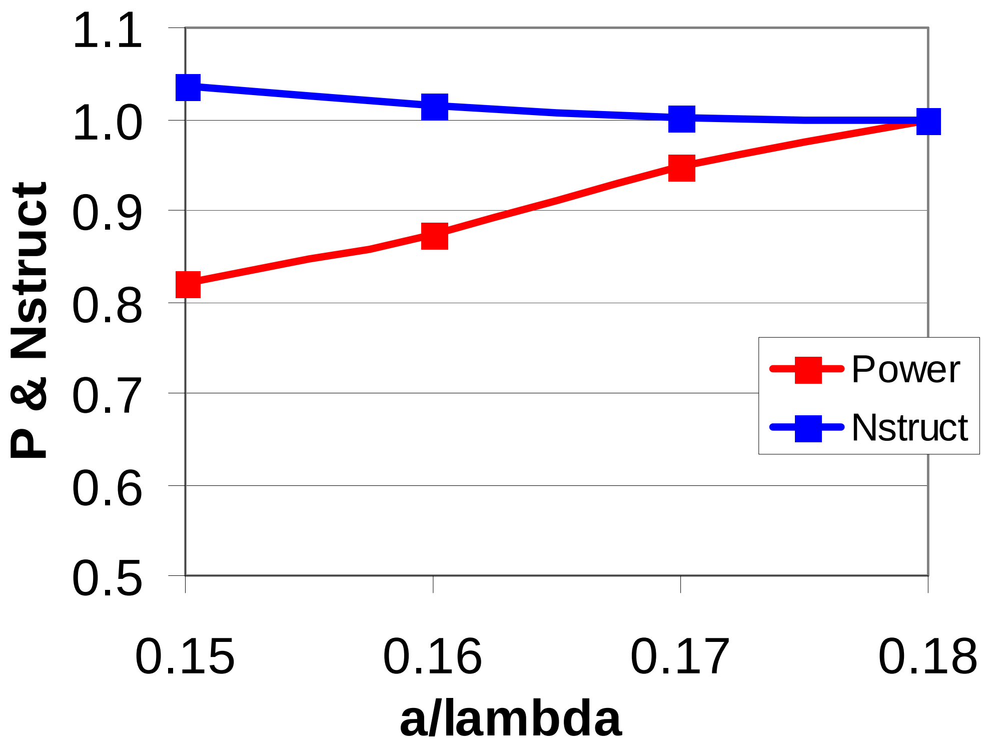


Emittance growth along the linac due to an initial 1σ_y betatron oscillation



Emittance growth in end-linac emittance from a misaligned quad as a function quad position in the linac

Efficiency Of A 500-*GeV* Machine



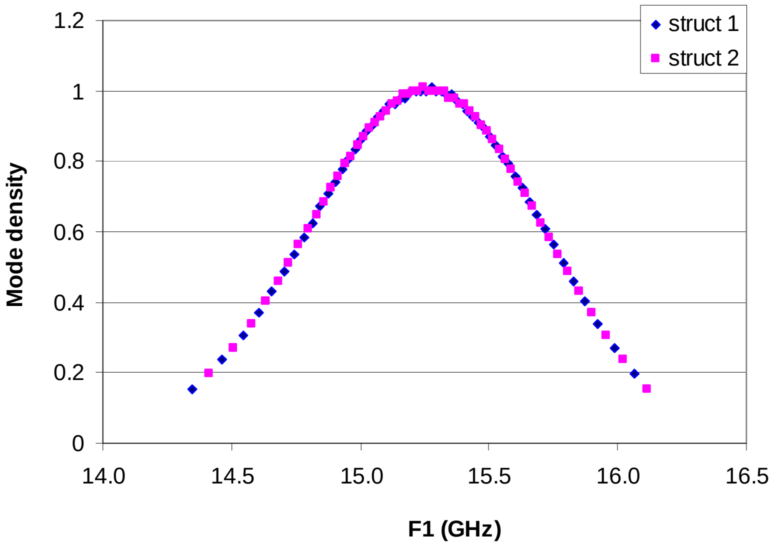
a/λ=0.18 parameter

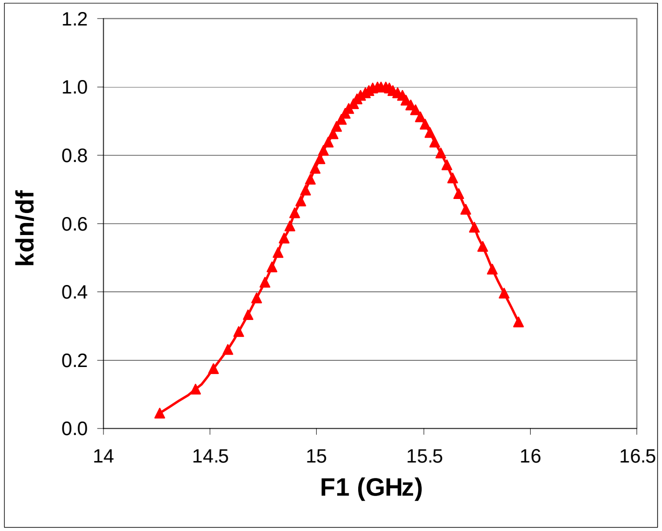
- $P_{a/\lambda=0.18} = 58.6MW$
- $NS_{a/\lambda=0.18} = 8434$

- 50 MV/m loaded gradient assumed
- RF requirements for a 500*GeV* machine, scale to the design of a/λ=0.18.
- Significant gain in RF efficiency with smaller a/λ, though needs larger BNS overhead and beam loading.
- Smaller a/λ can potentially handle high power

Wakefield: Dipole Detuning

- Present design: symmetric Gaussian detuning
- New design: asymmetric Gaussian detuning
- Improving wakefield by interleaving





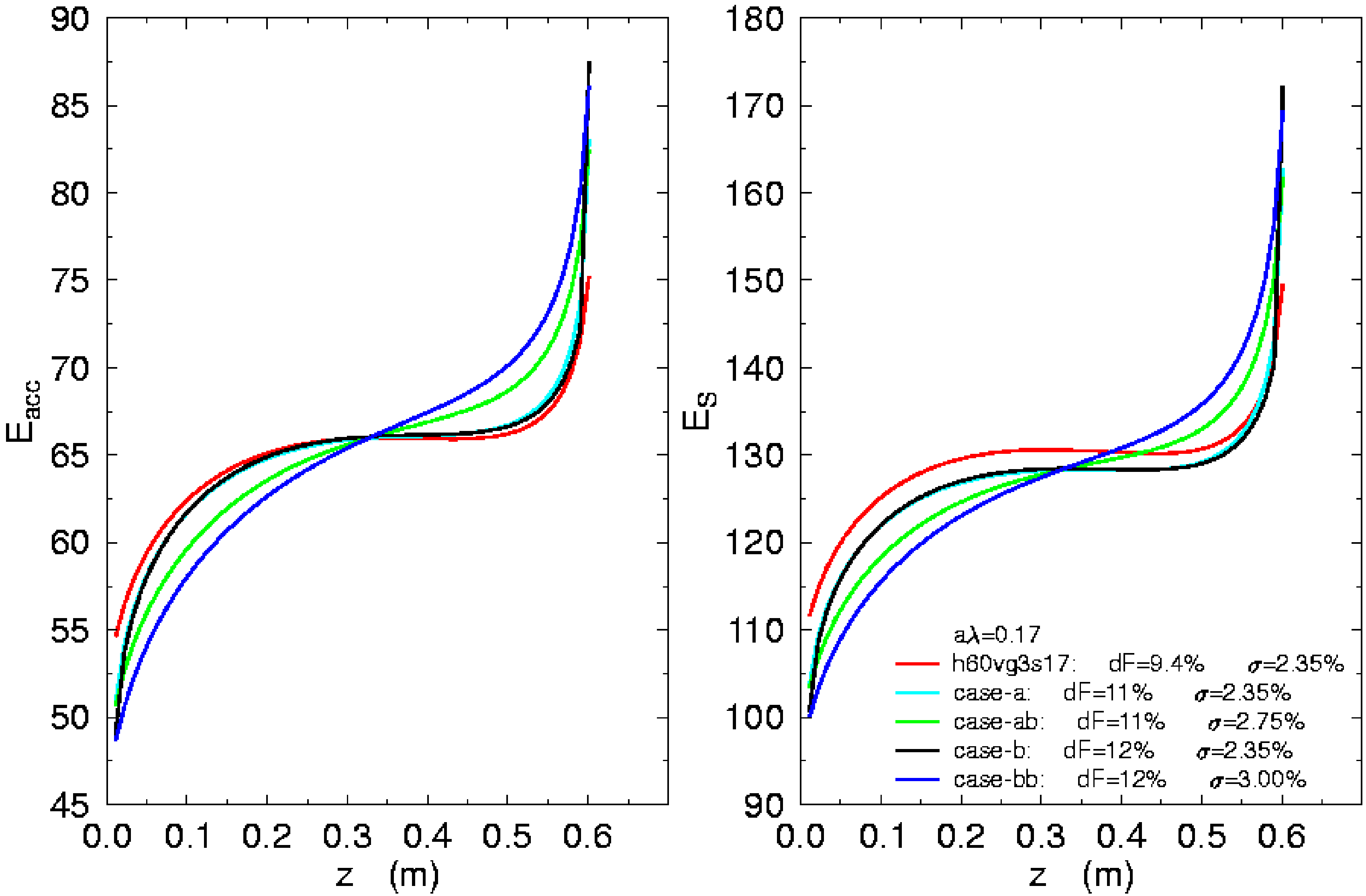
Gradient Improvement

Hope to gain more gradient margin for the next structure

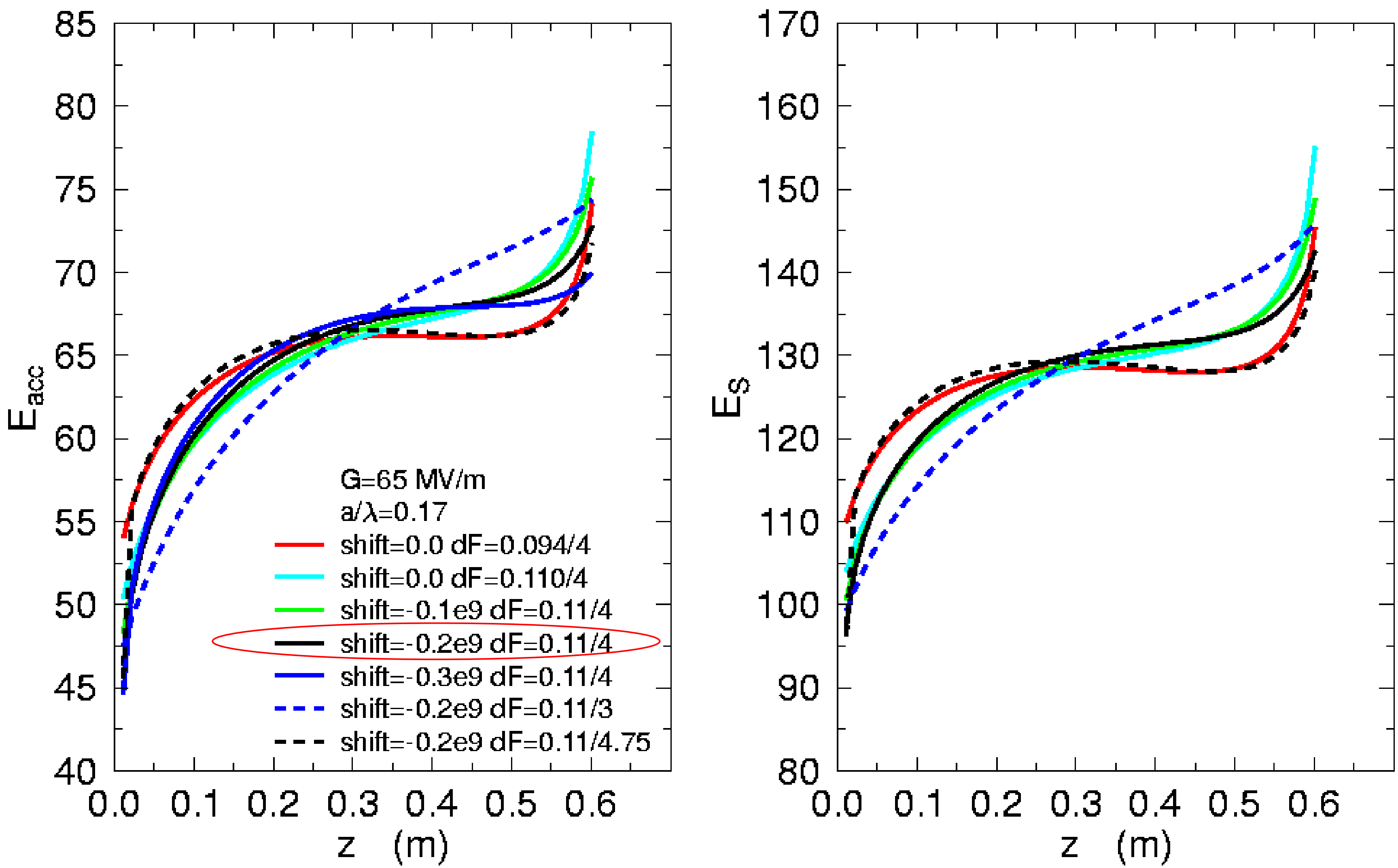
- Introduce stronger gradient tapering in front by
  - Larger detuning
  - Asymmetric spectrum, more cells at low dipole frequency end

- Maintain a/λ=0.17
- Maintain the same efficiency – same input power

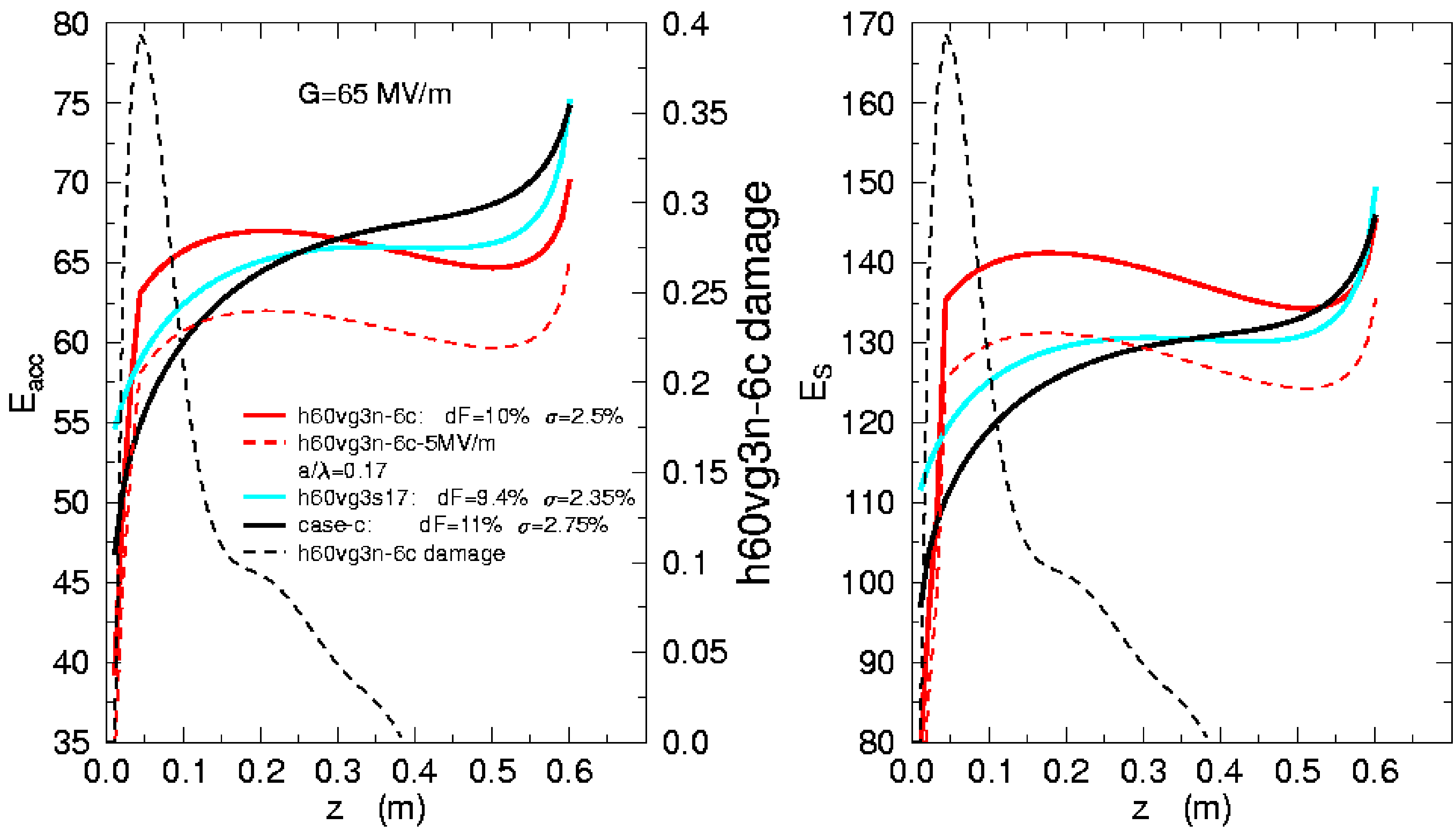
H60 E_s, E_{acc} v.s. Detuning



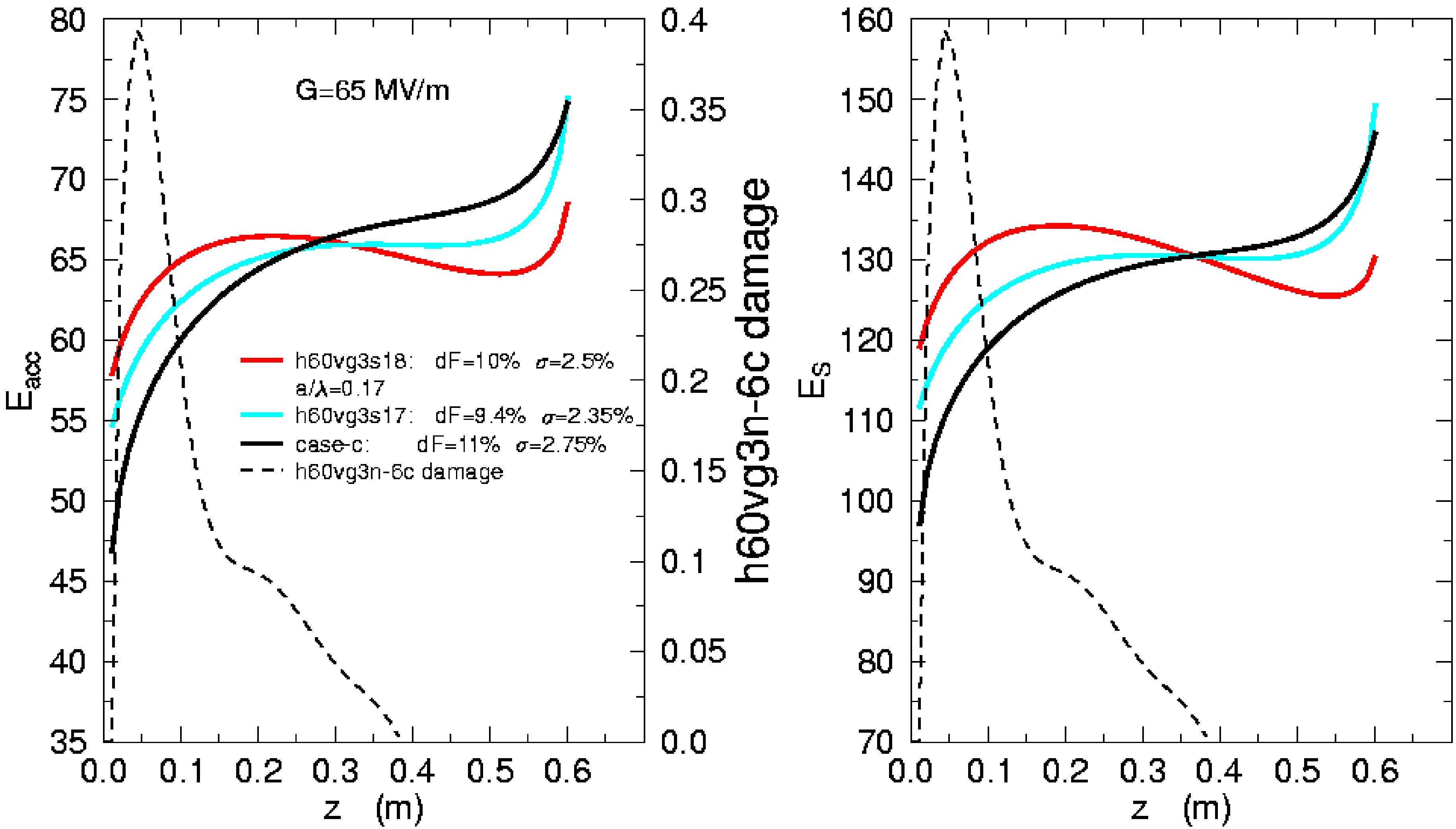
E_{acc}, E_s v.s. Detuning+Shifting



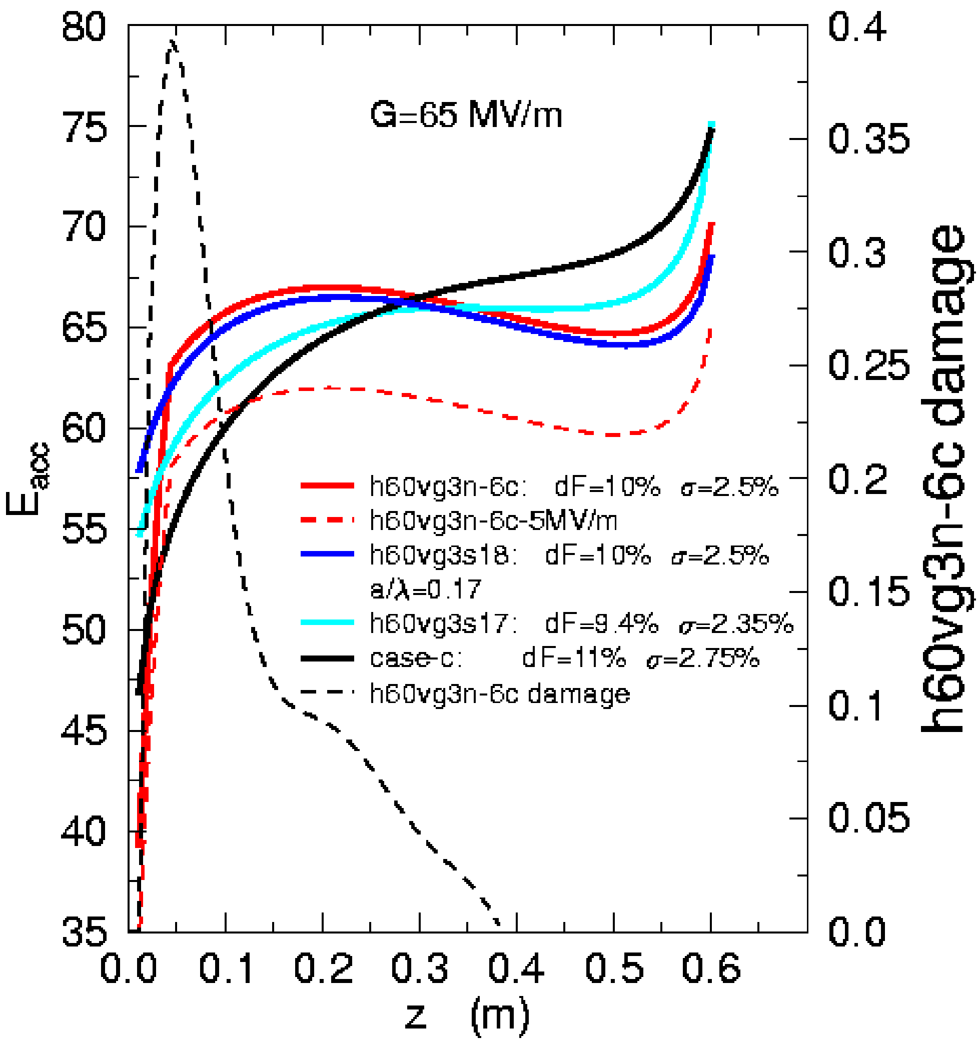
Improving E_{acc}/E_s With New Dipole Detuning

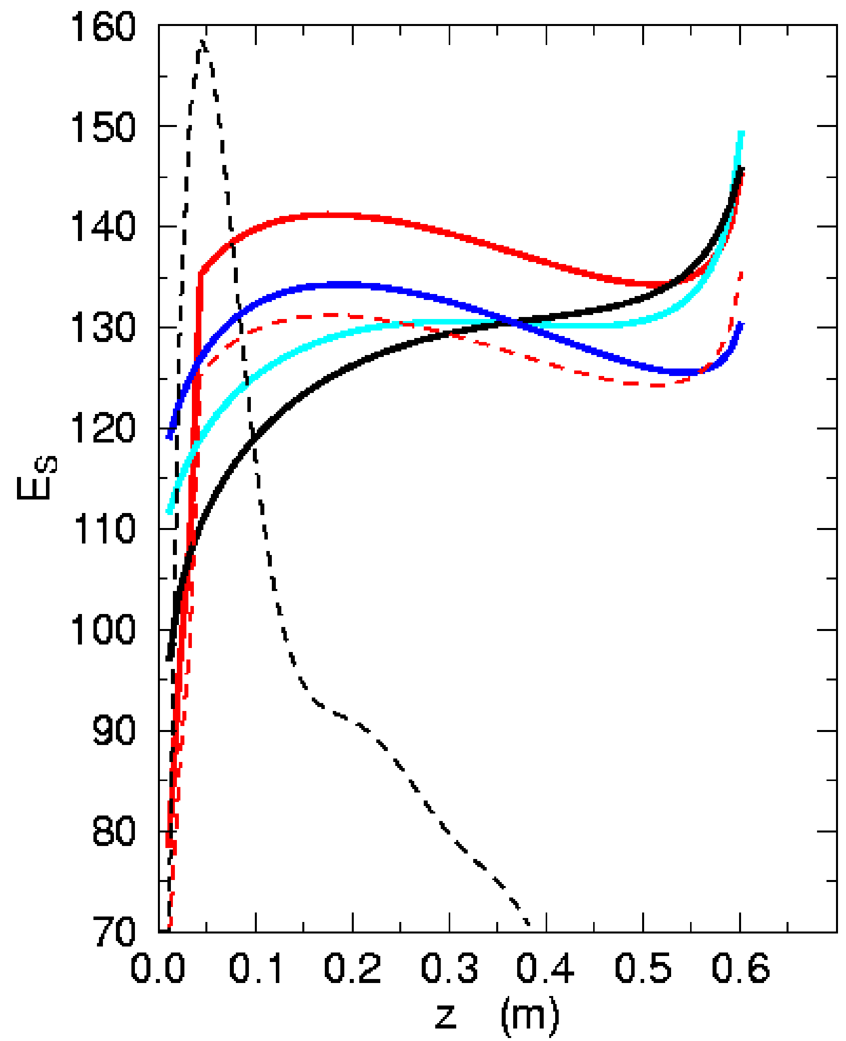


E_{acc}/E_s Compared With H60VG3S18 (2)

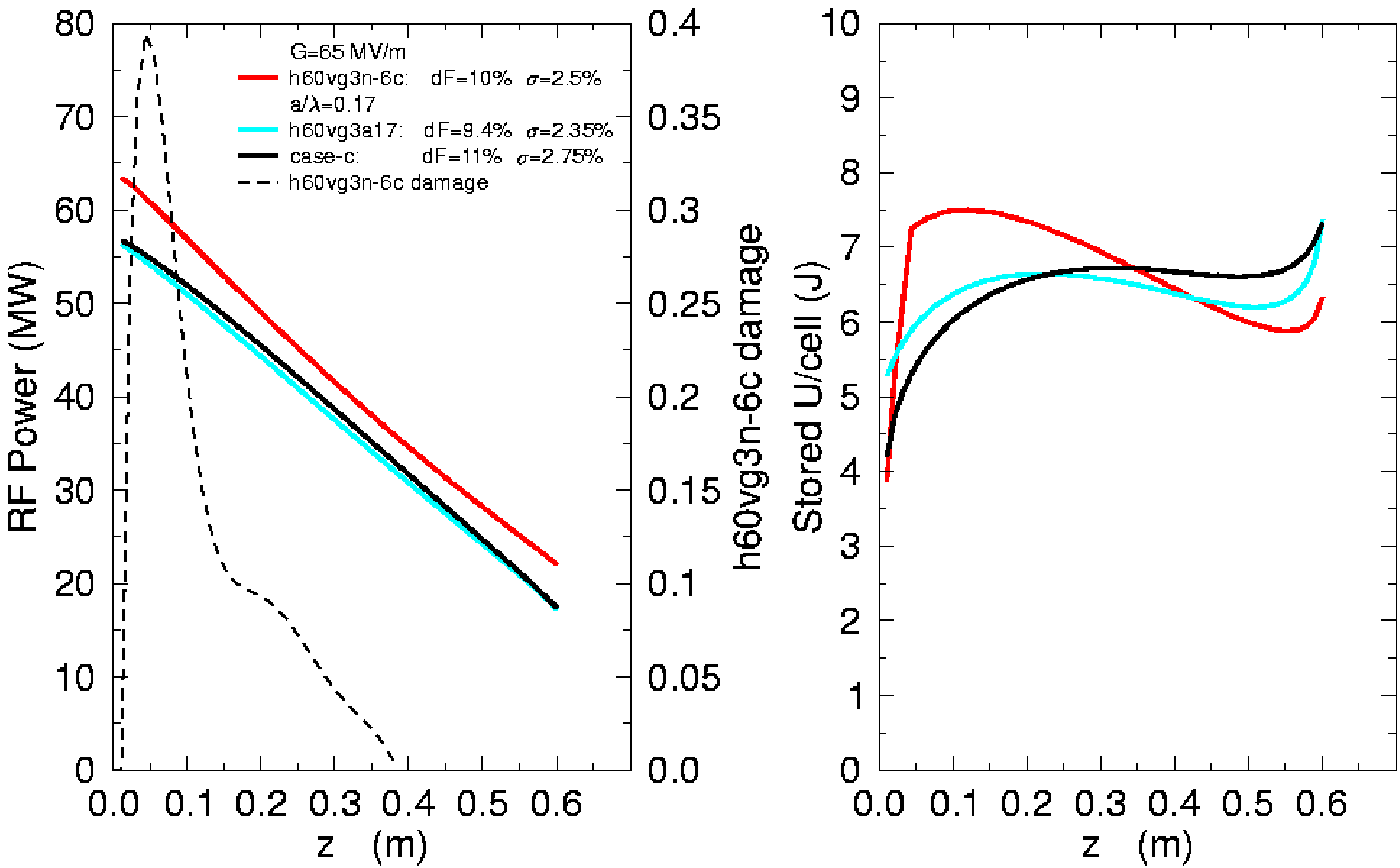


E_{acc}/E_s Compared With
H60VG3N-6C &H60VG3S18 (3)

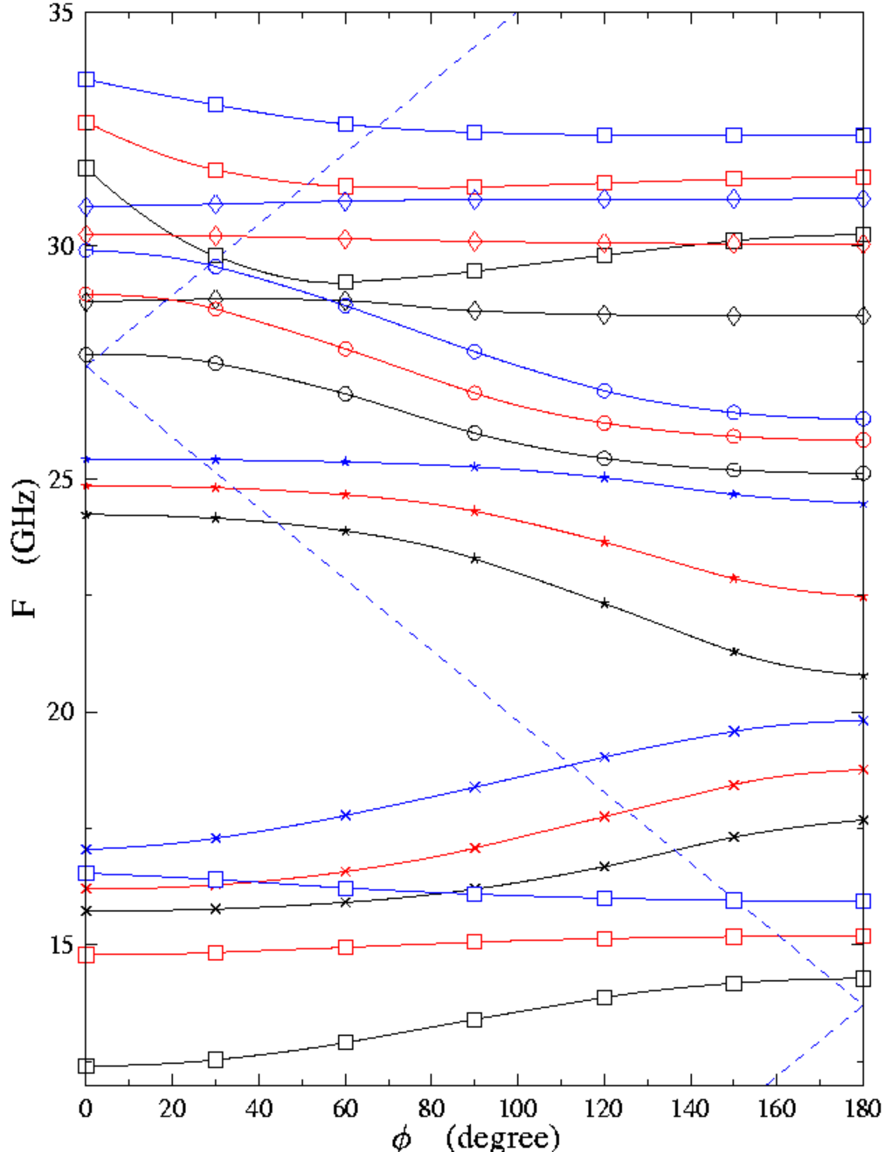




RF Power & Energy Along Structure

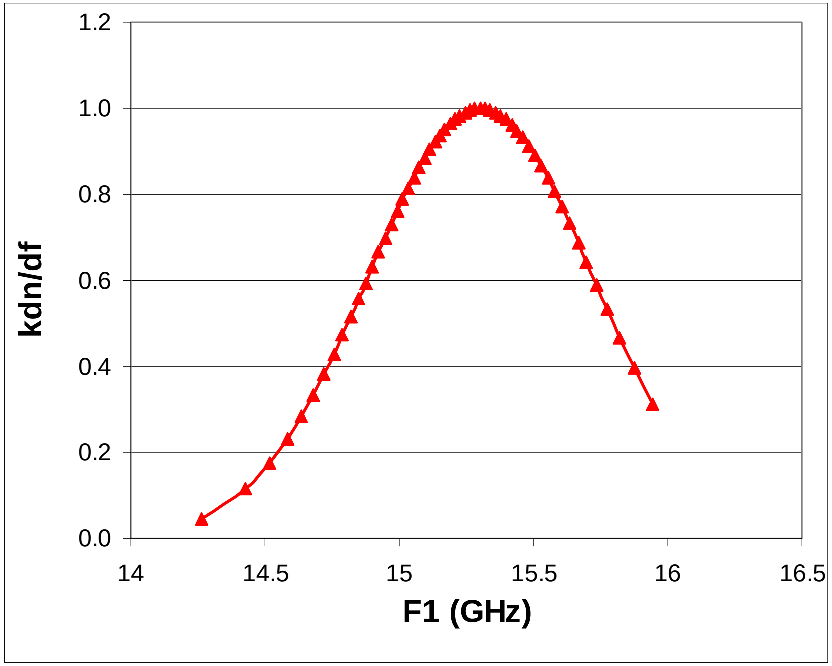


Dipole Dispersion Of Case-c



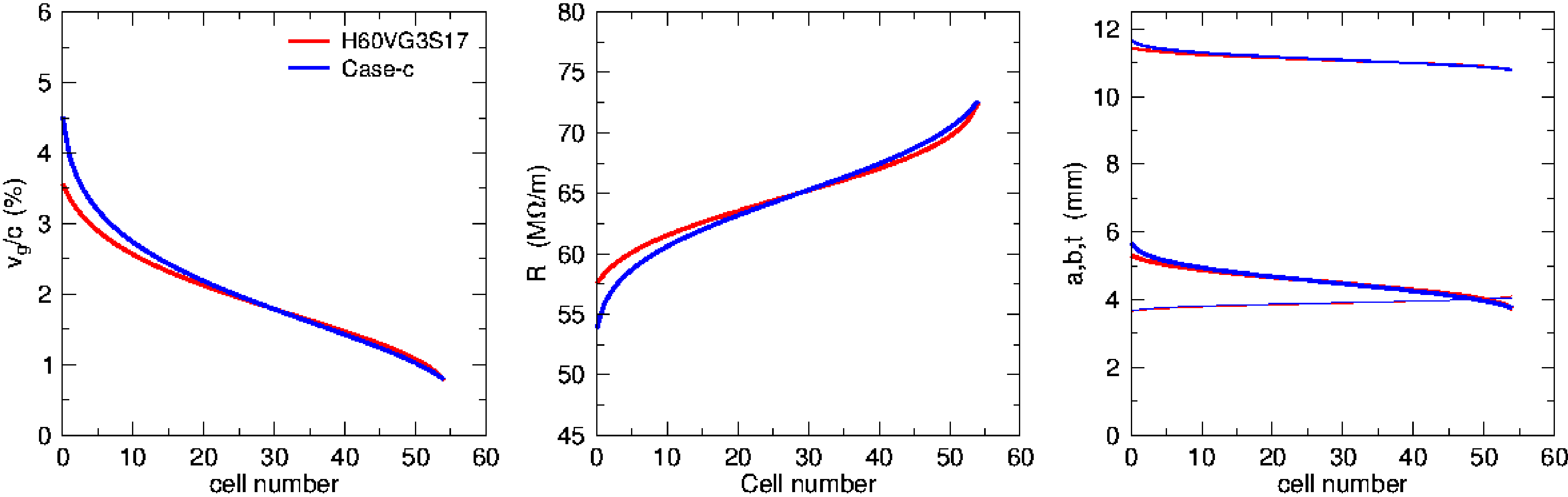
Case-c:

- F_{center}=15.303 GHz
- dF/F=11%
- N_{sigma}=4
- F_{shift}=-0.2 GHz



Structure Parameter Comparison

H60VG3S17 v.s. Case-C



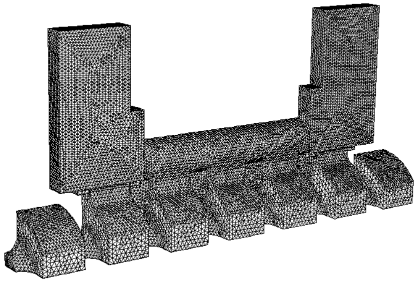
Couplers

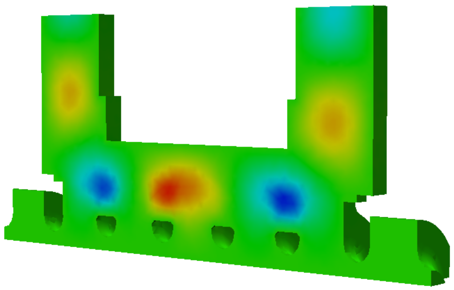
Fundamental Power Coupler – one of the following

- Mode launcher
- Waveguide
- Compact fat-lip

HOM coupler

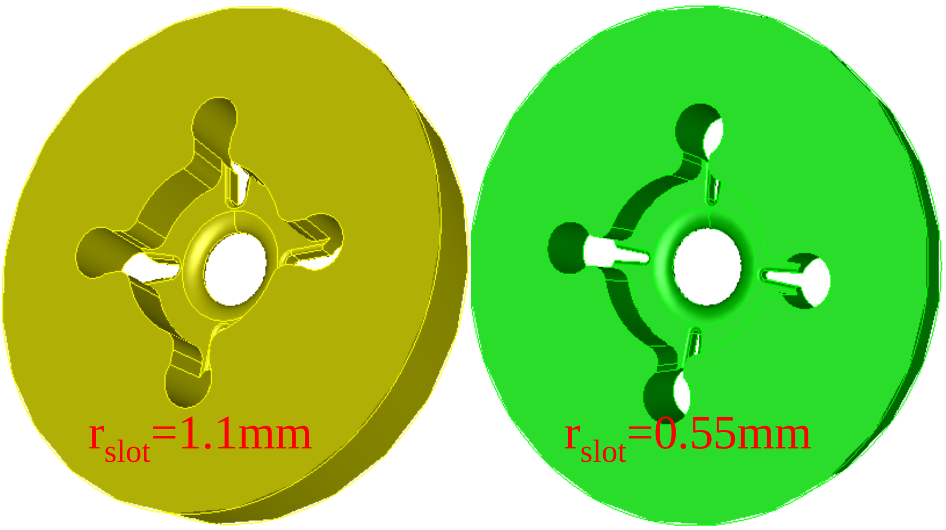
- Improve the compact design
- Cold-test



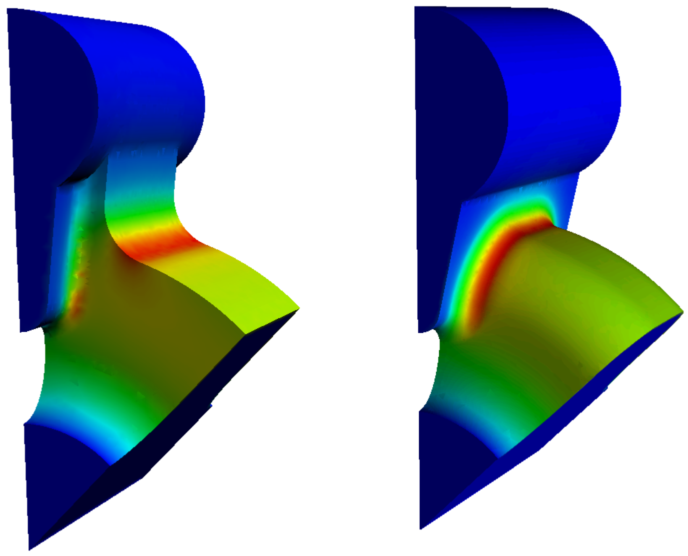


Minimize Q Reduction

Present slot design results in a Q reduction of about 6%
Require 3% more power



Using narrower slots



Round cell to eliminate wide slot

What is the impact on machining?