Analysis of a Hybrid Broadband Reverberation Chamber Antenna

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Motivation

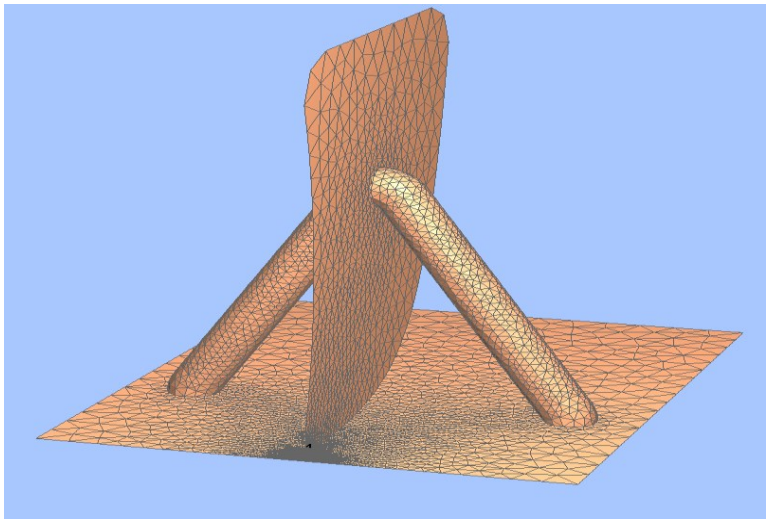
- Our aim was to produce an antenna for use in a reverberation chamber over a wide frequency range.
- Specifically the antenna should be usable in our chamber (4.8m x 3.3m x 2.2m) over the frequency range 200MHz to 20GHz.
- As with any linear structure its frequency range can be adjusted by dimensional scaling

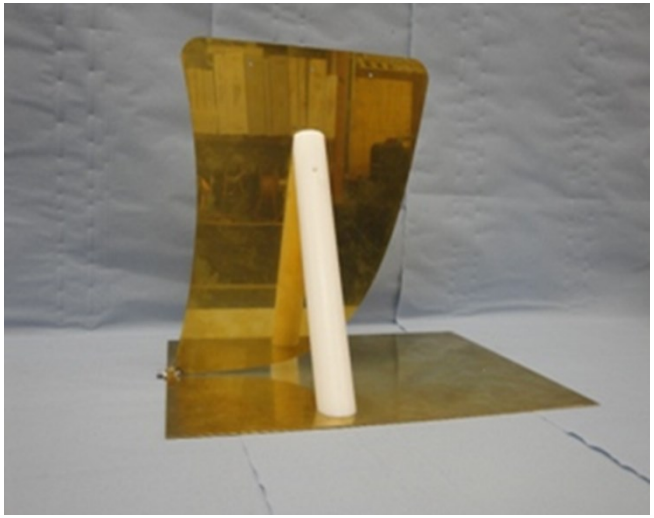
Specification

- Frequency range defined by input reflection coefficient:
  - |S11| < 0.316 (-10dB) 200MHz – 20GHz
- Radiation pattern:
  - Not specified (isotropic in RC)
- Efficiency:
  - Maximised
- Size:
  - Minimised

Solution –Dual Mode Antenna

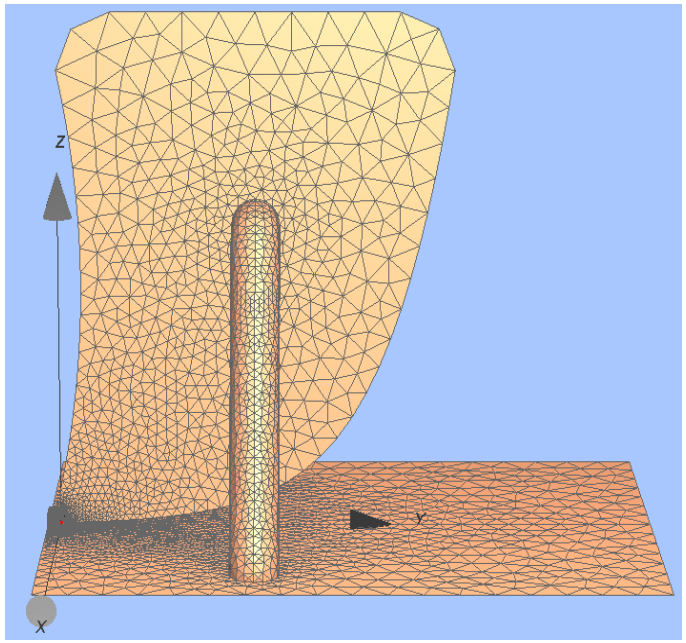
- A hybrid monopole-exponential taper (Vivaldi) structure.
- Height 305mm.
- Ground plane width 300mm.
- Ground plane length 375mm.

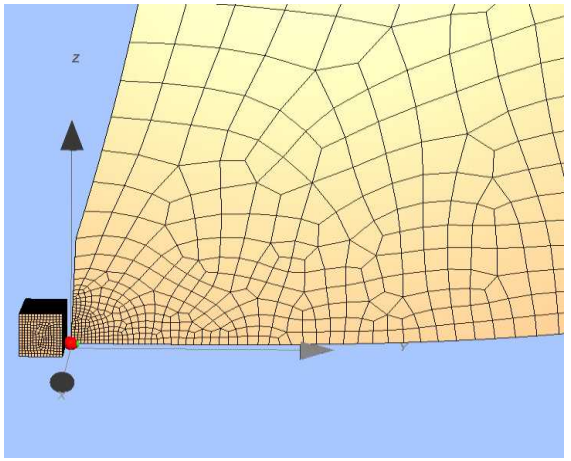




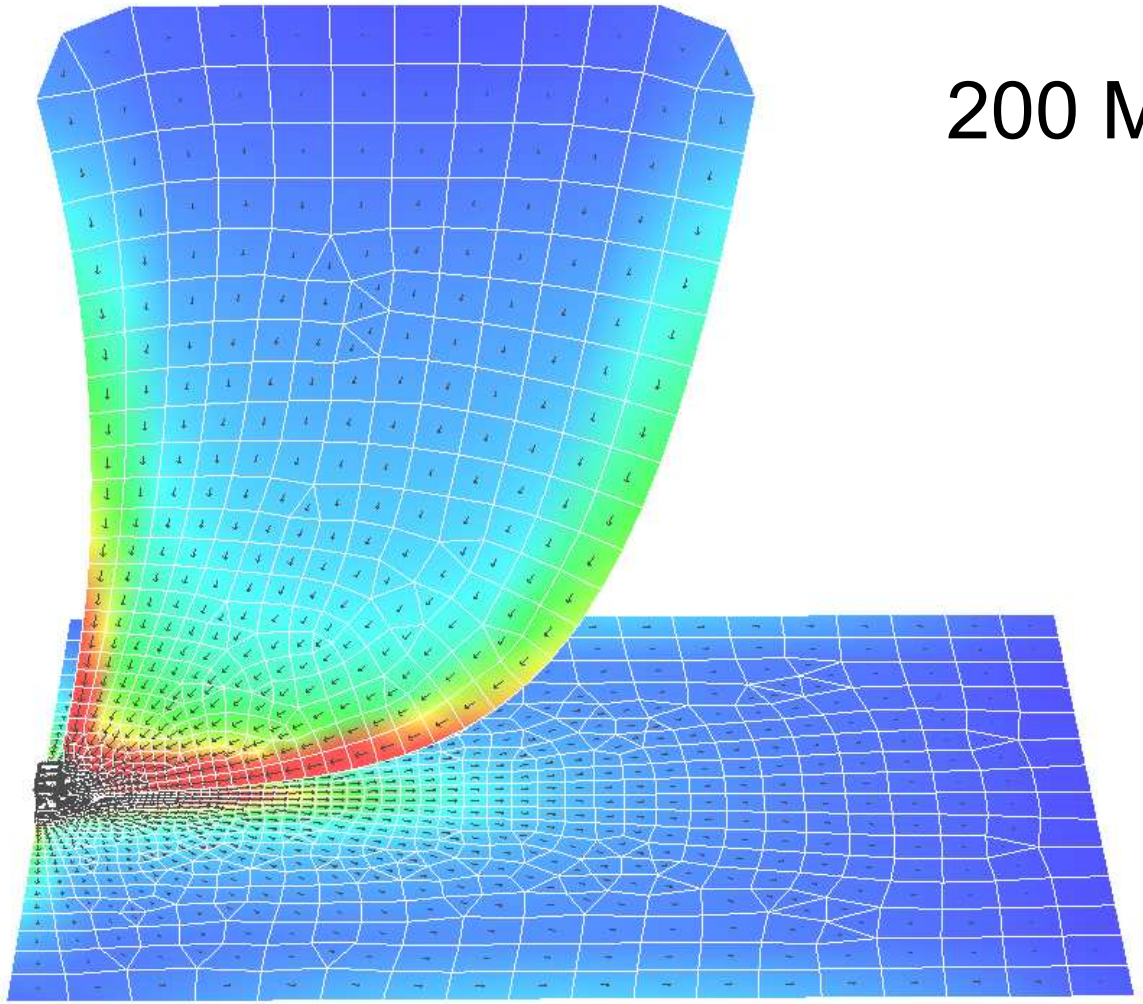
Mode of Operation

- Low frequency monopole resonant at ~250 MHz.
  - Determined by the effective minimum length of the monopole defined by the curved edge above the feed point.
- Simple exponential taper from 400 MHz upwards
- The key is that the taper takes over before the $\lambda/2$ anti-resonance of the monopole at ~ 500 MHz

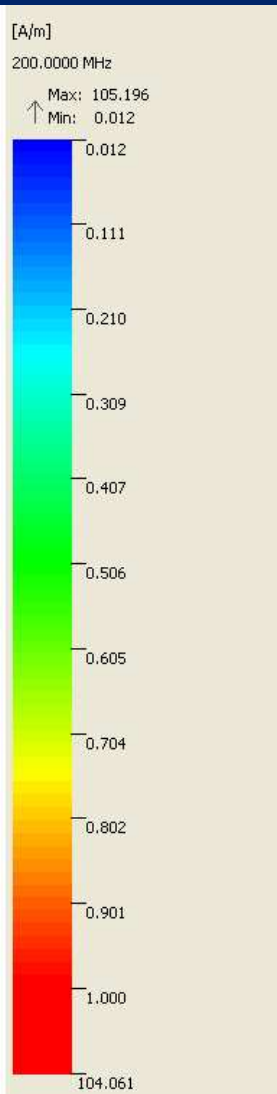




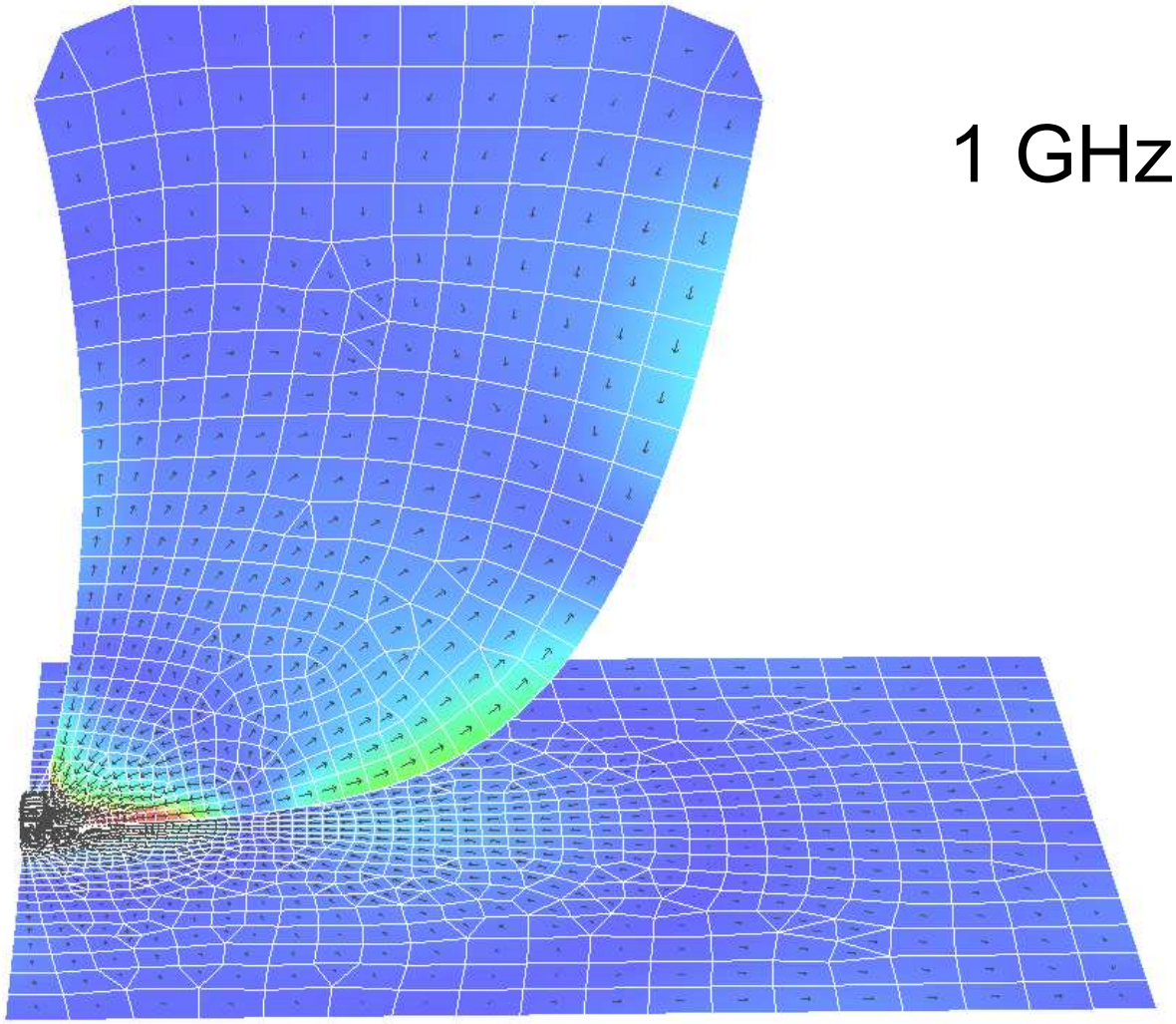
Monopole Mode



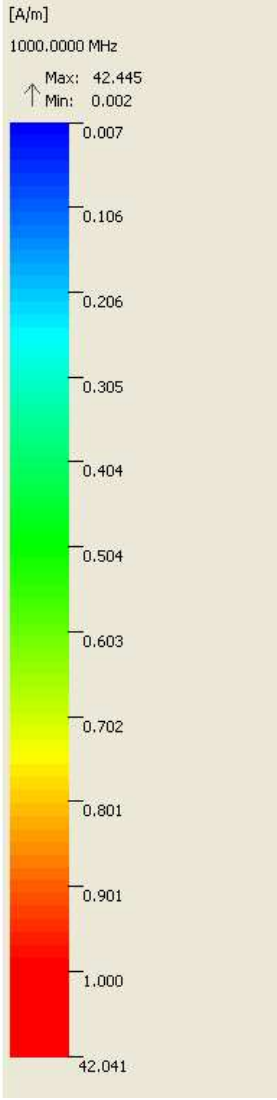
200 MHz



Vivaldi Mode



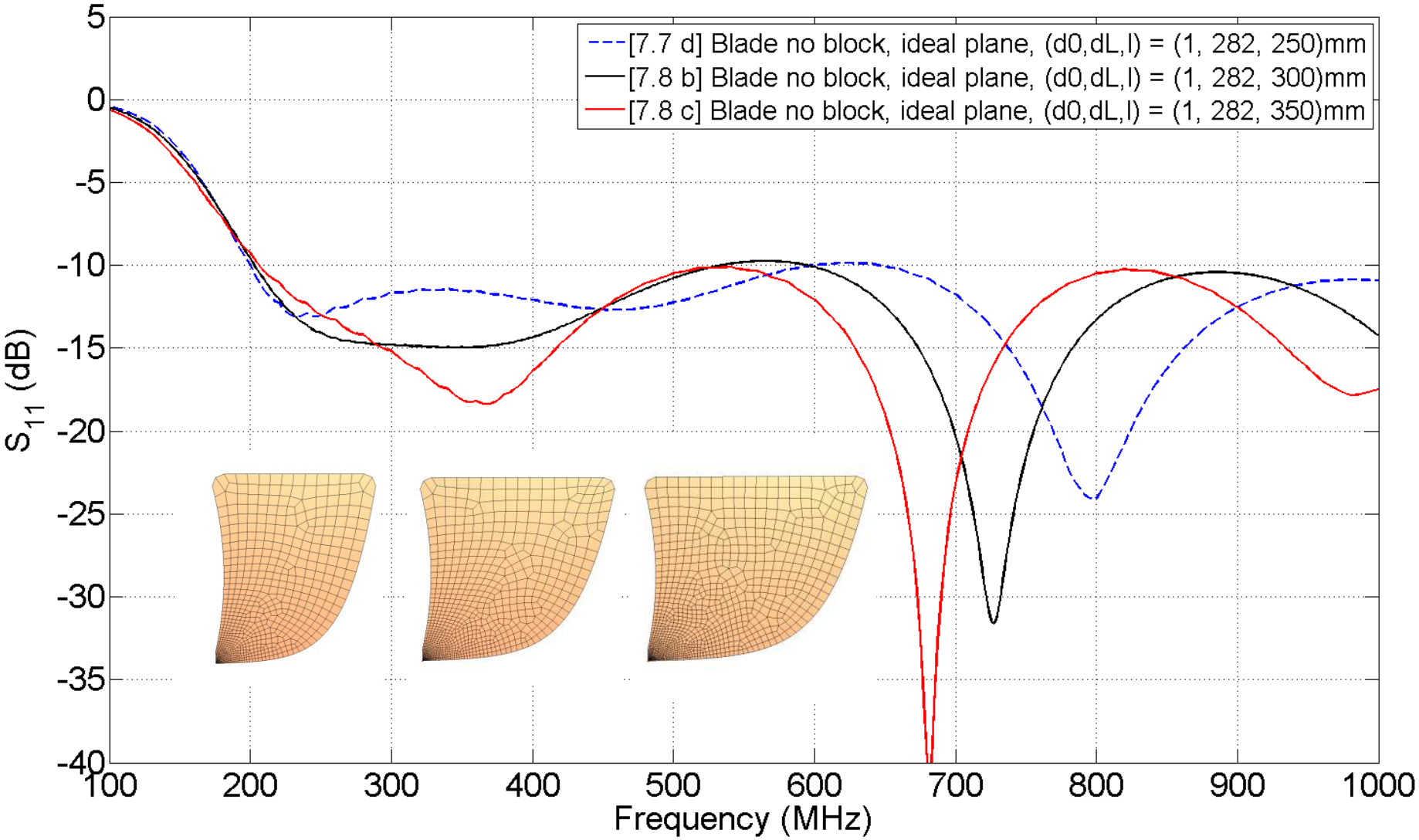
1 GHz



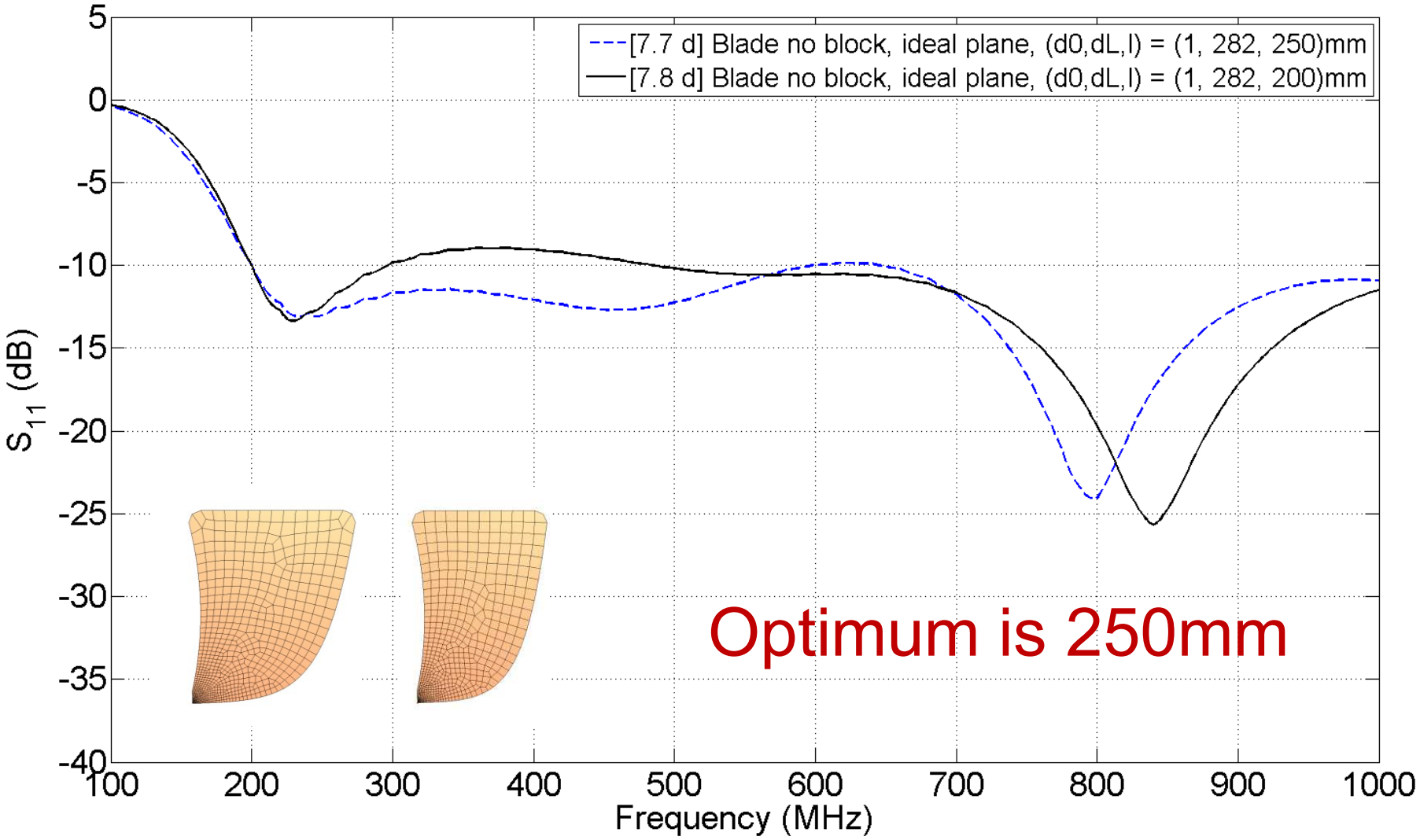
Optimisation

- Modelled with CONCEPT II and Gmsh
- Target: S_{11} < -10dB from 200 – 1000 MHz
- Radiation pattern less important for use in reverberation chamber
- Vary parameters including length and shape of exponential taper, and size of feed block
- Mesh size ~1 cm at edges away from feed and ~0.5mm near feed

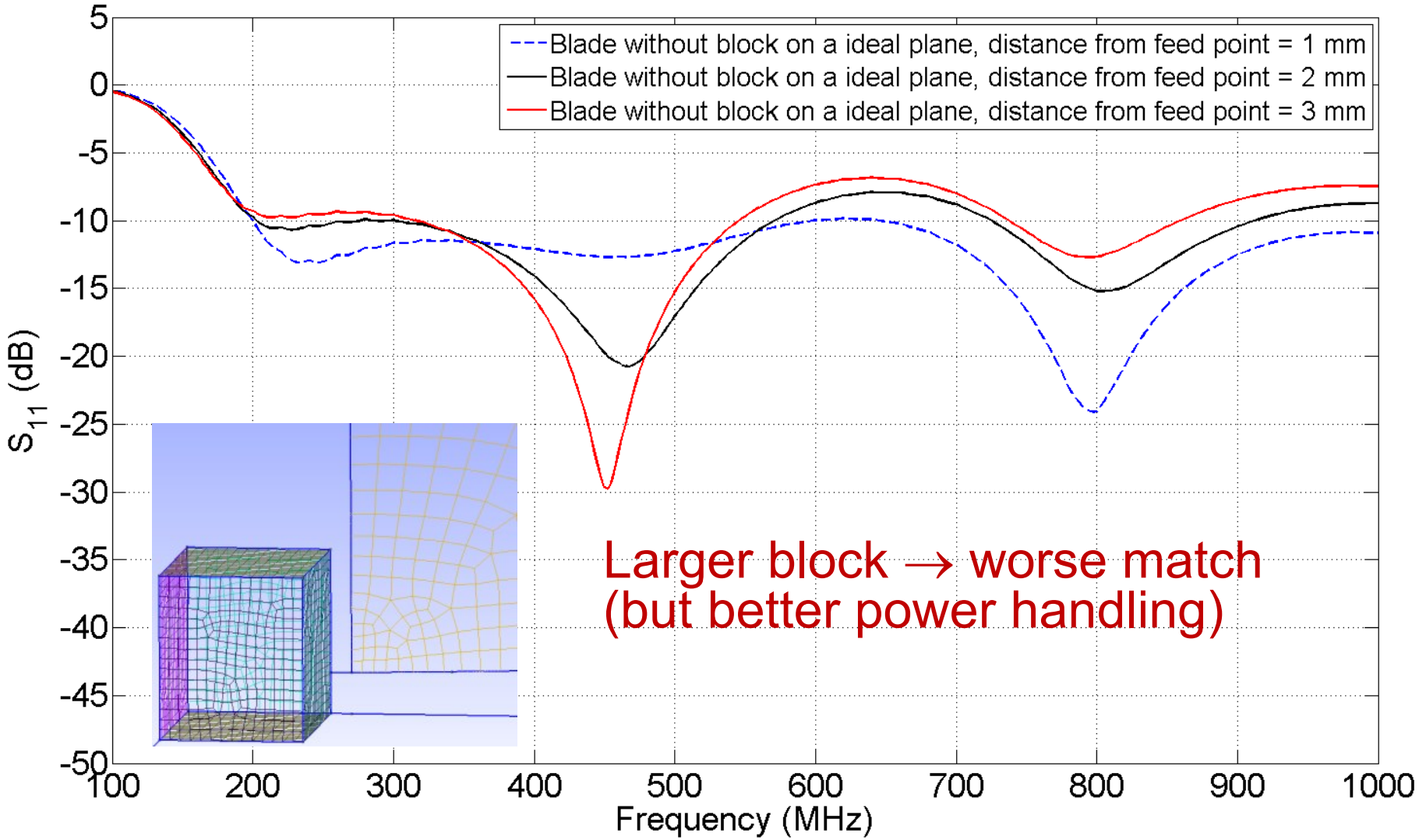
Taper length 250, 300, 350 mm



Taper length 250, 200 mm

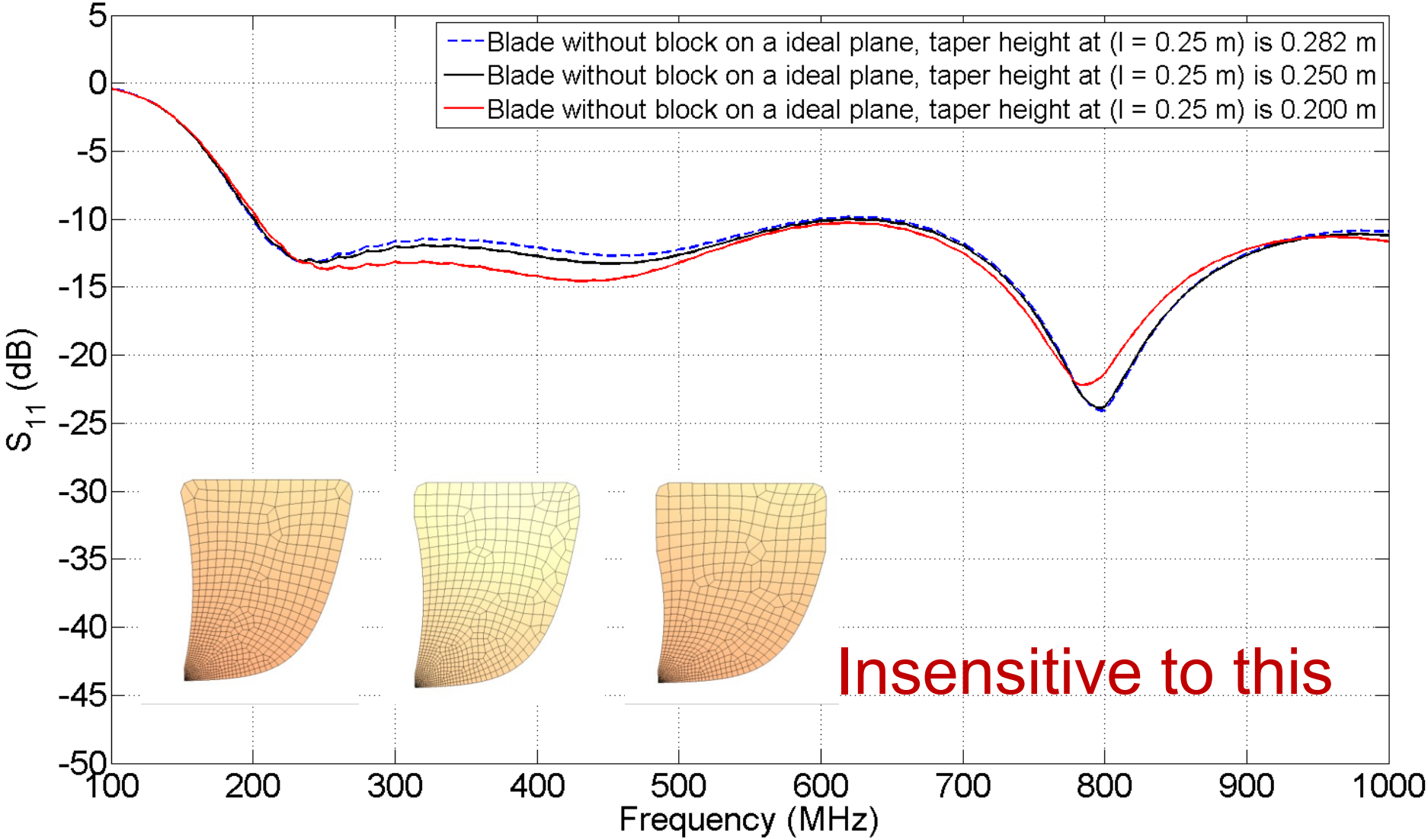


Feed point 1, 2, 3 mm

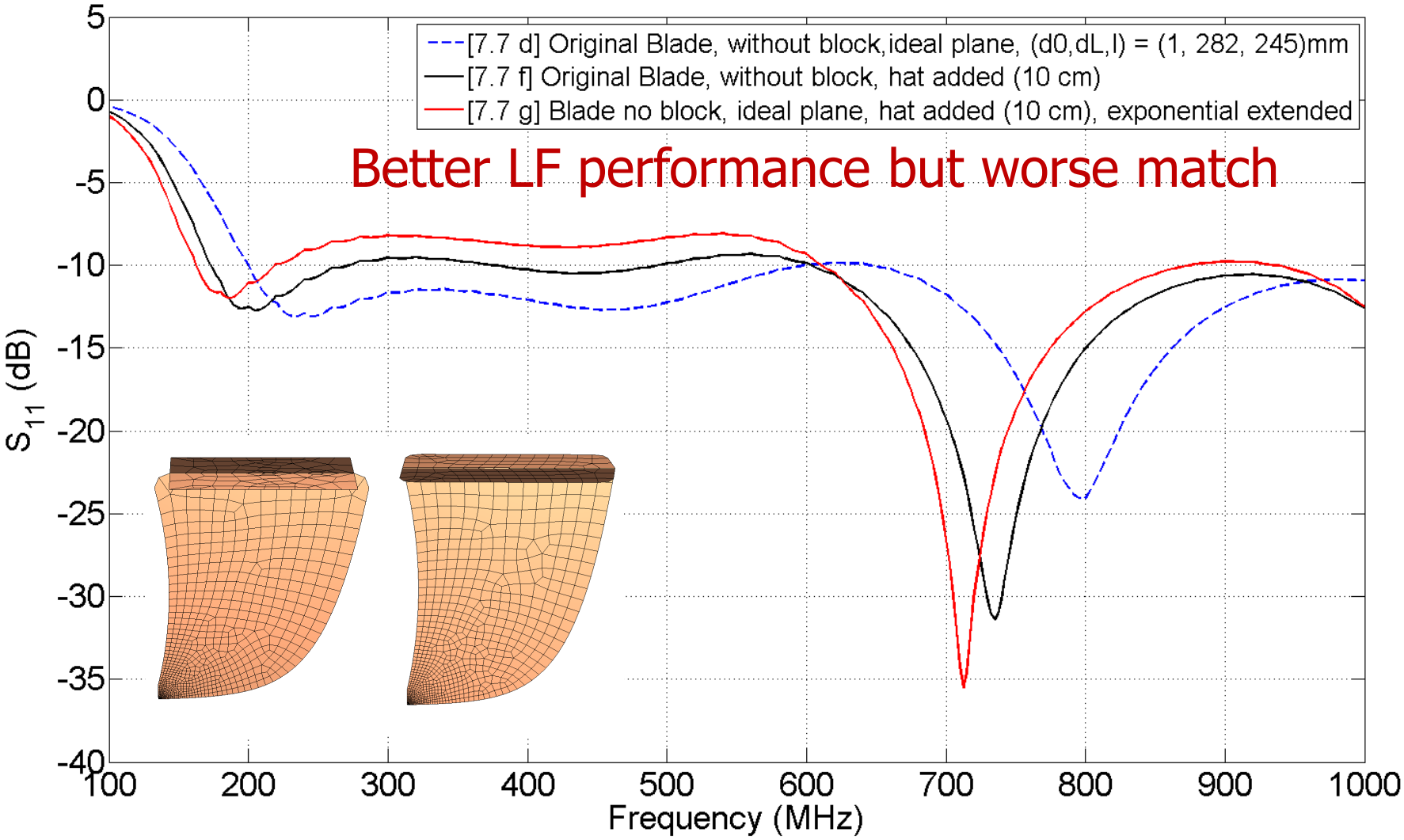


Larger block → worse match
(but better power handling)

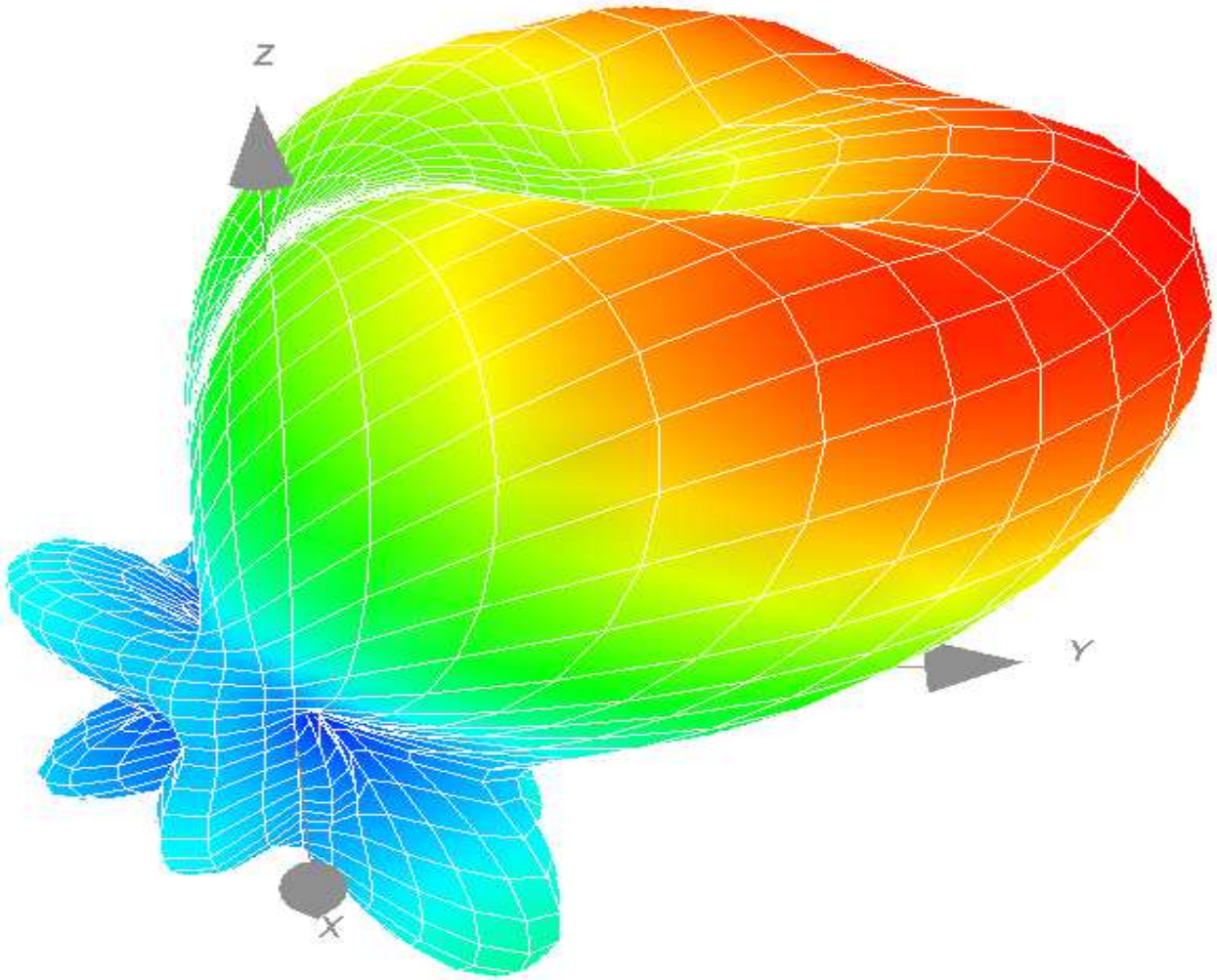
Shape of taper



Top loading

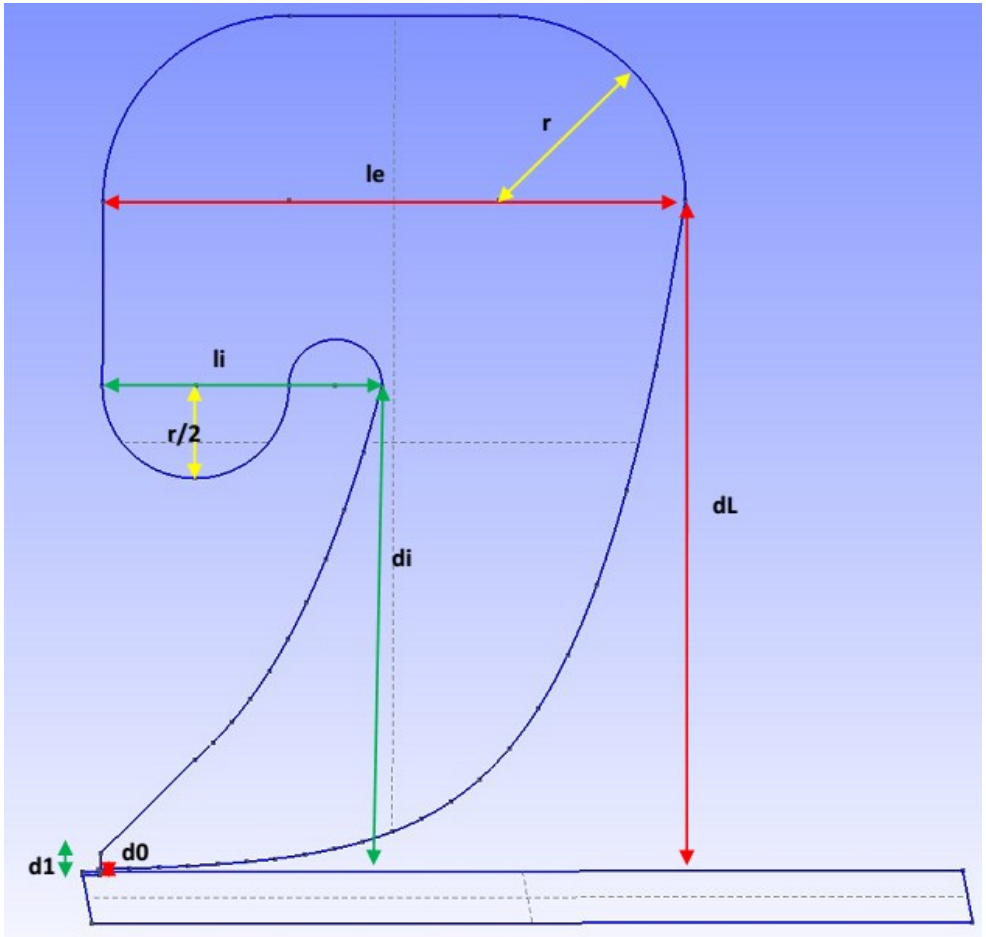

[7.7 d] Original Blade, without block,ideal plane, (d0,dL,l) = (1, 282, 245)mm
[7.7 f] Original Blade, without block, hat added (10 cm)
[7.7 g] Blade no block, ideal plane, hat added (10 cm), exponential extended
Better LF performance but worse match
S11 (dB)
Frequency (MHz)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
100
200
300
400
500
600
700
800
900
1000

Radiation pattern at 1 GHz



GA Driven Optimisation

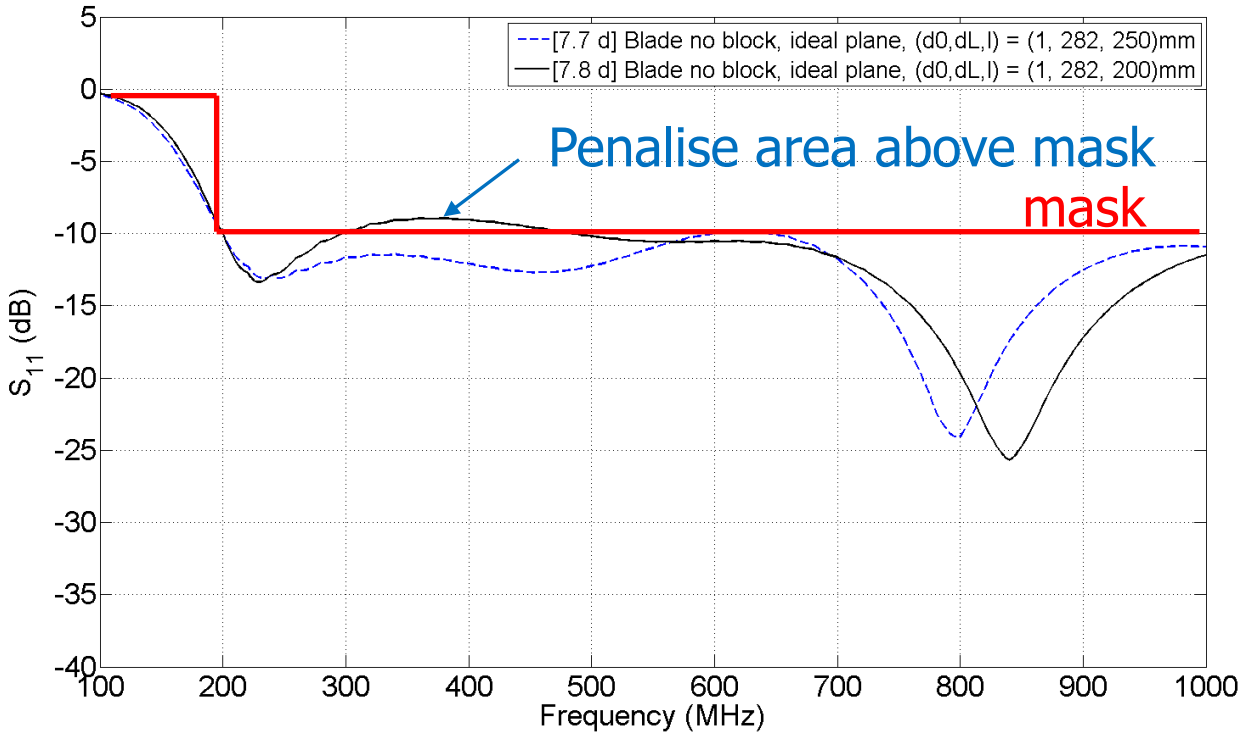
- Automatic optimisation
- Octave/MATLAB program
- Parametric CAD – Gmsh
- MATLAB GA toolbox or in-house Octave GA
- MATLAB/Octave functions to write CONCEPT input files



GA Cost Function

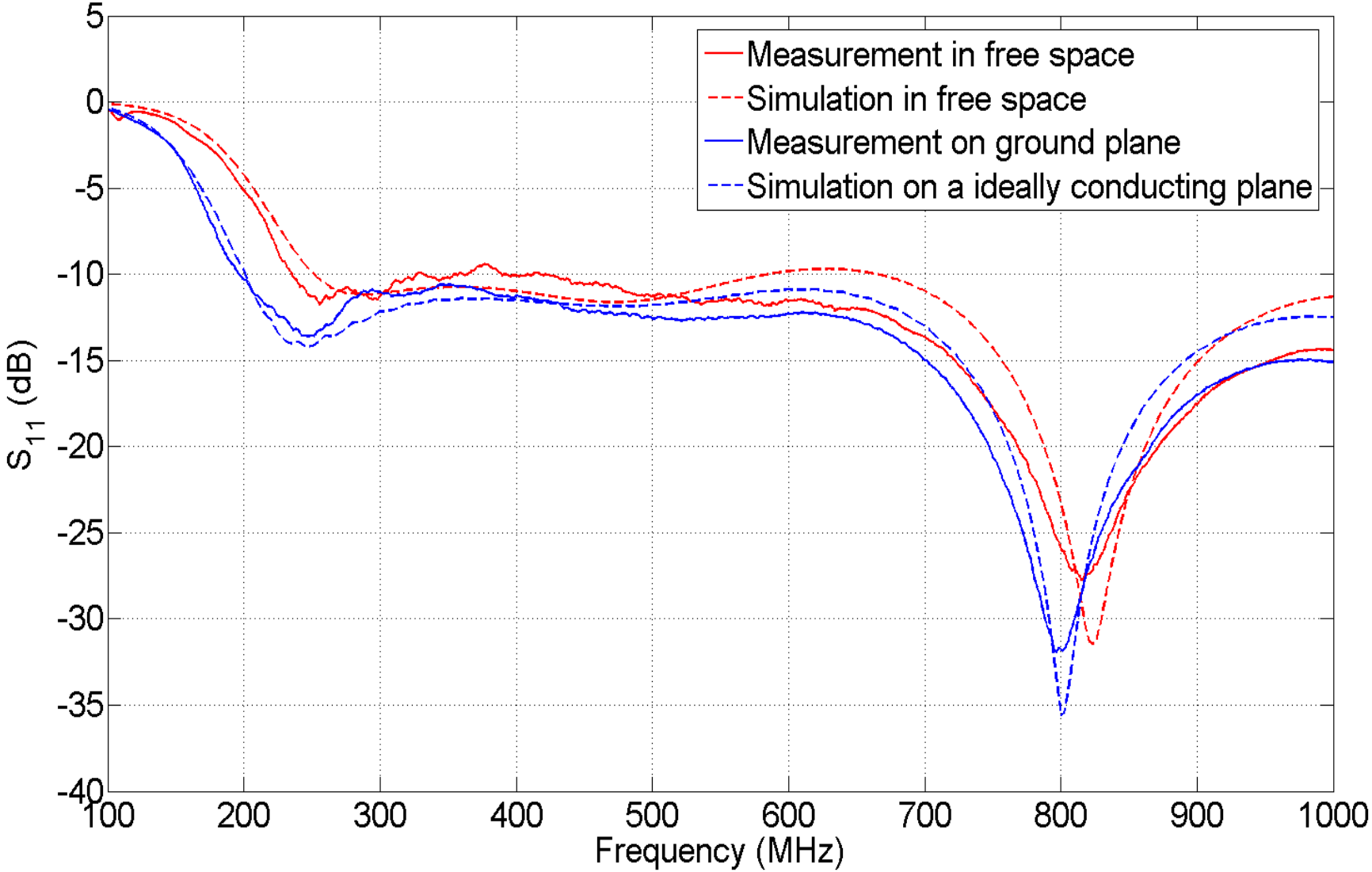
- Decode genotype -> parameters
- Create Gmsh (.geo) file with required parameters
- Create mesh using Gmsh
- Create CONCEPT input files from templates
- Run CONCEPT
- Post- process to get input impedance
- Evaluate cost function as area between |S11| and upper mask

GA Cost Function

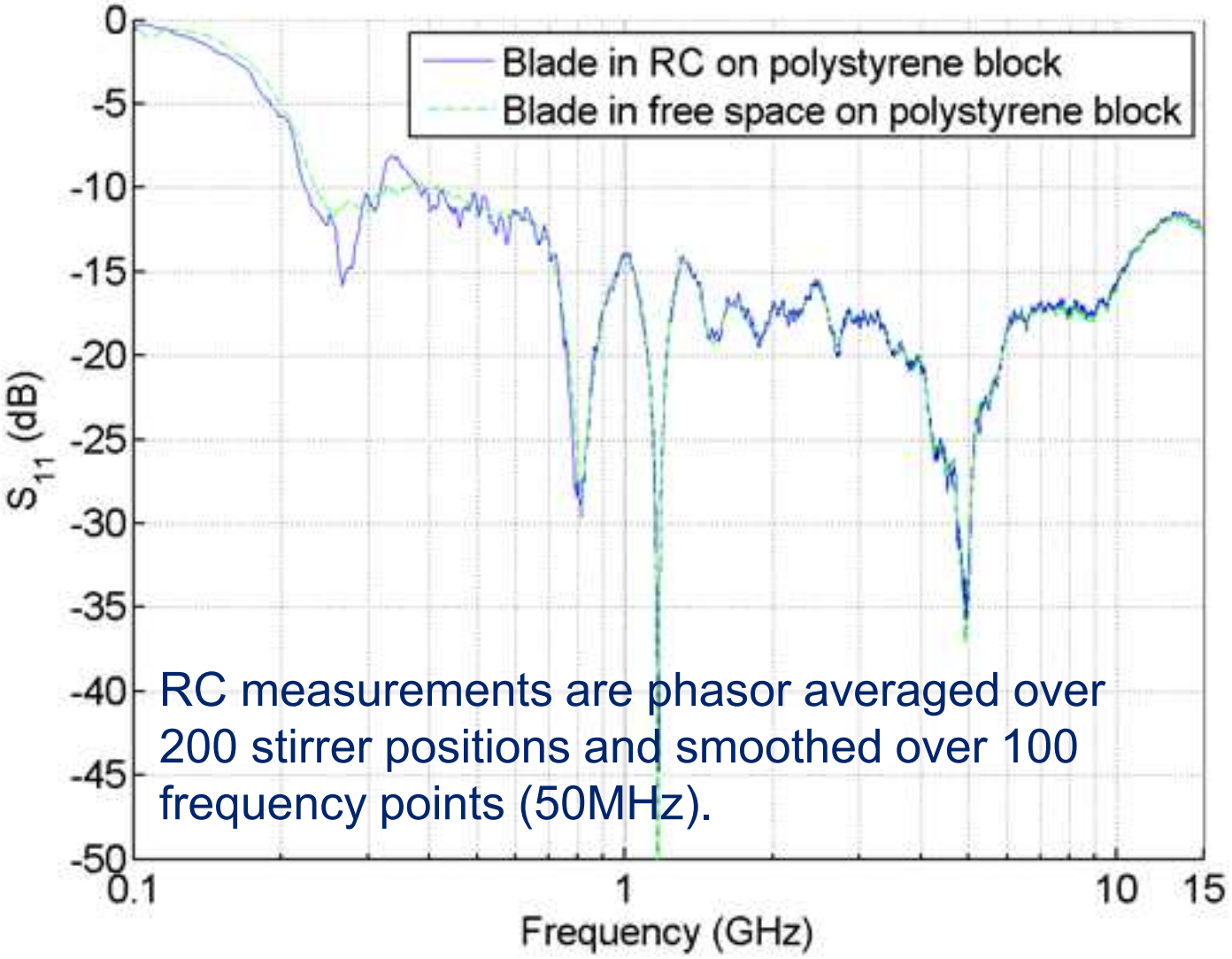


- Optimise cross-over region (monopole-> taper)
- Cost function is area between S11 amplitude mask and simulated |S11|.

Validation of model

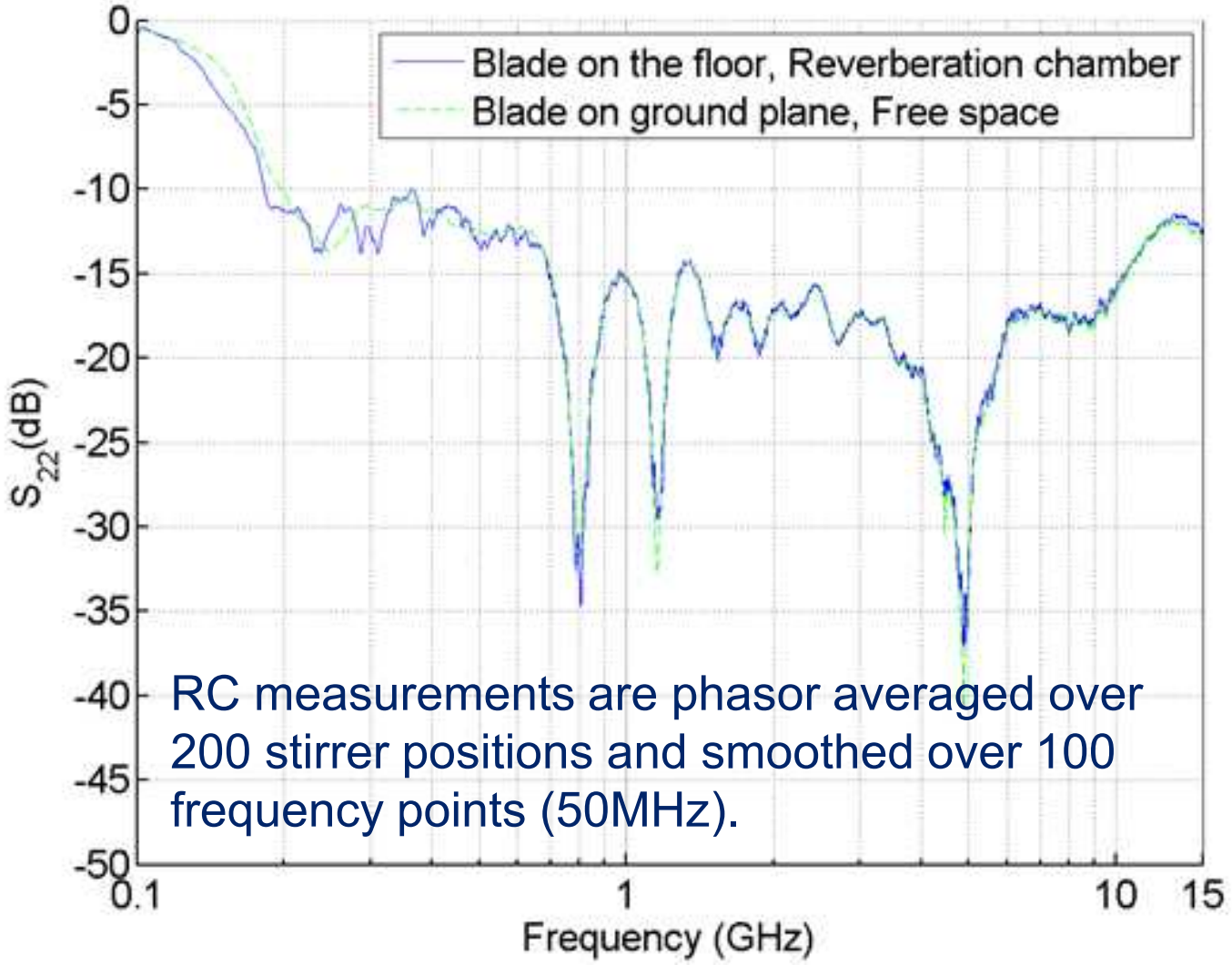


High frequency behaviour in RC



RC measurements are phasor averaged over 200 stirrer positions and smoothed over 100 frequency points (50MHz).

High frequency behaviour in RC



RC measurements are phasor averaged over 200 stirrer positions and smoothed over 100 frequency points (50MHz).

Conclusions

- Successful transition between antenna modes
- Initial design was close to optimal!
- Trade-offs:
  - Feed point: S_{11} against power handling
  - Top loading: S_{11} against LF performance
- Final antennas have acceptable performance from 200 MHz to 25 GHz (maybe higher)