Shaped Optics and Phased-Array Feeds

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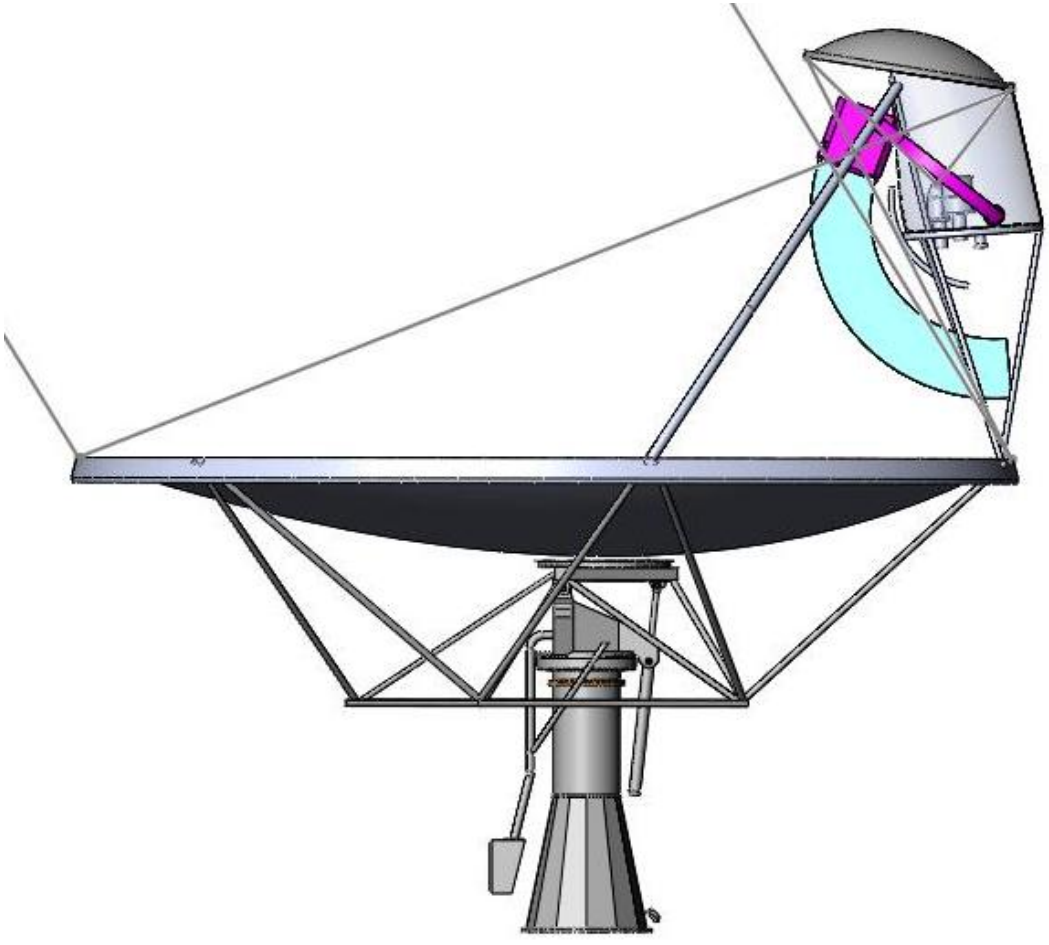
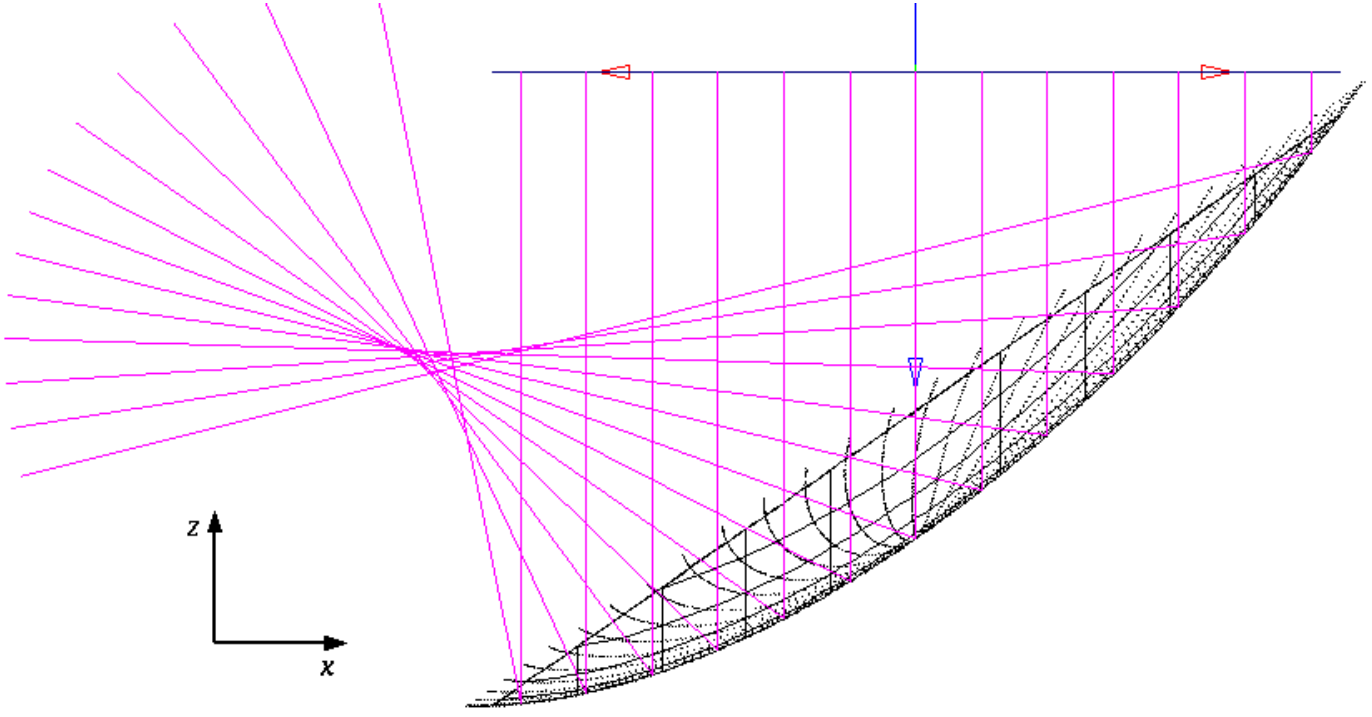
Study Outline

- TDP shaping study shows 10–15% increase in A_{eff} (0.4 to 0.6 dB)
- Shaping changes prime focus from point to caustic
- Question: how does this affect the performance of a finite-sized array?
- Use GRASP9 to calculate fields in a measurement plane
  - TDP 55° feed half-angle shaped design
  - 1m $\times$ 1m measurement plane (41 $\times$ 41 points)
  - Integrate transverse fields
  - Compare shaped to parabolic (reference)

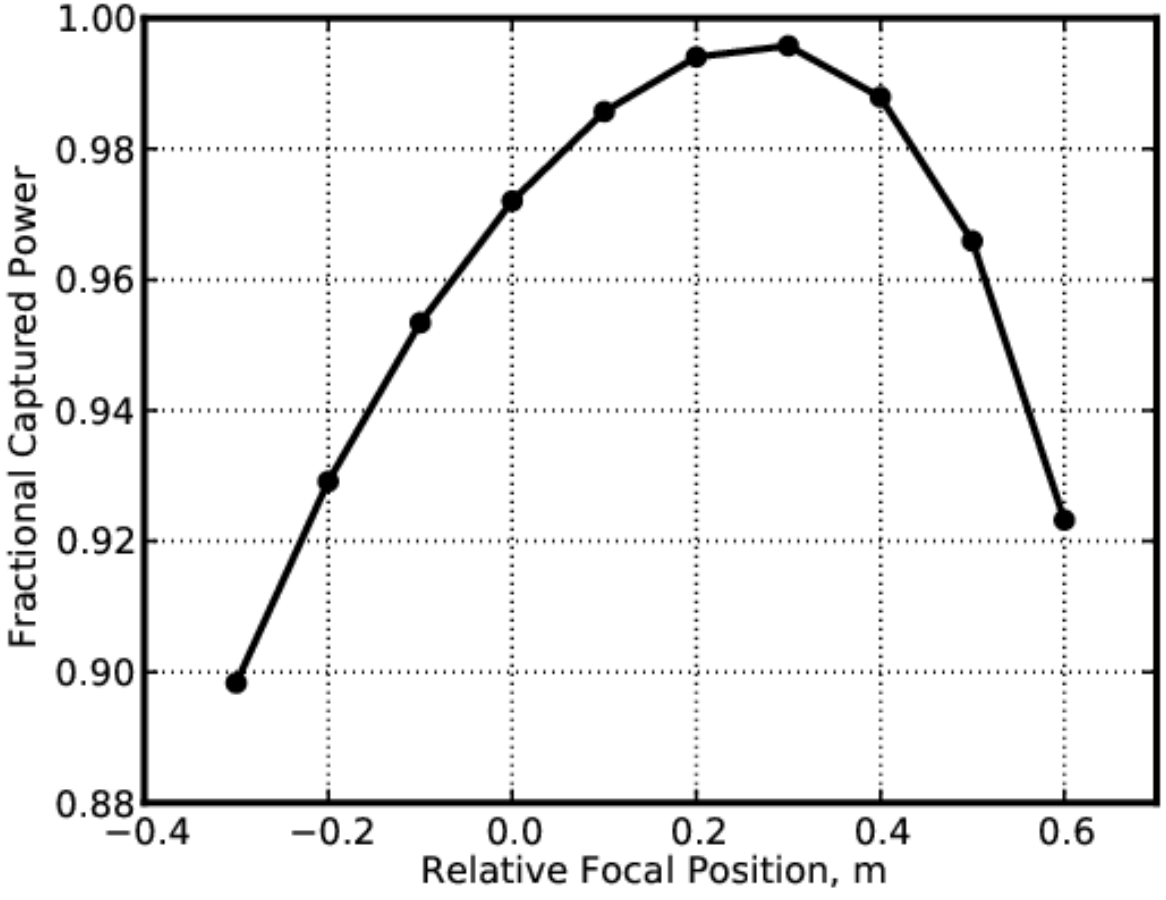
Physical Geometry



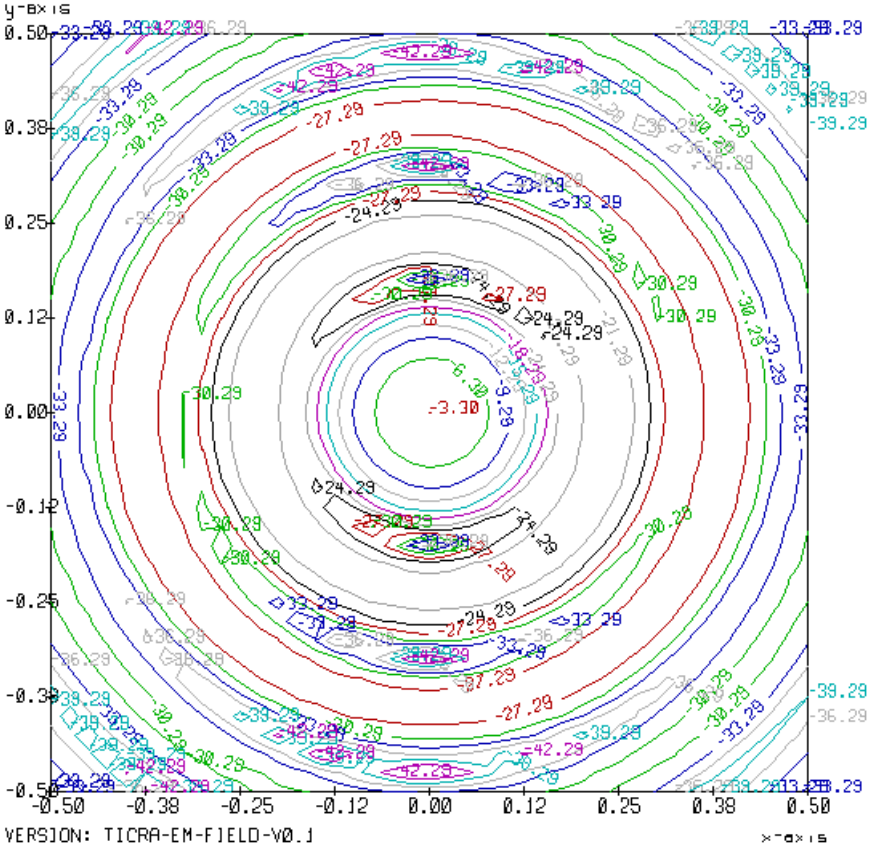
Optical Geometry



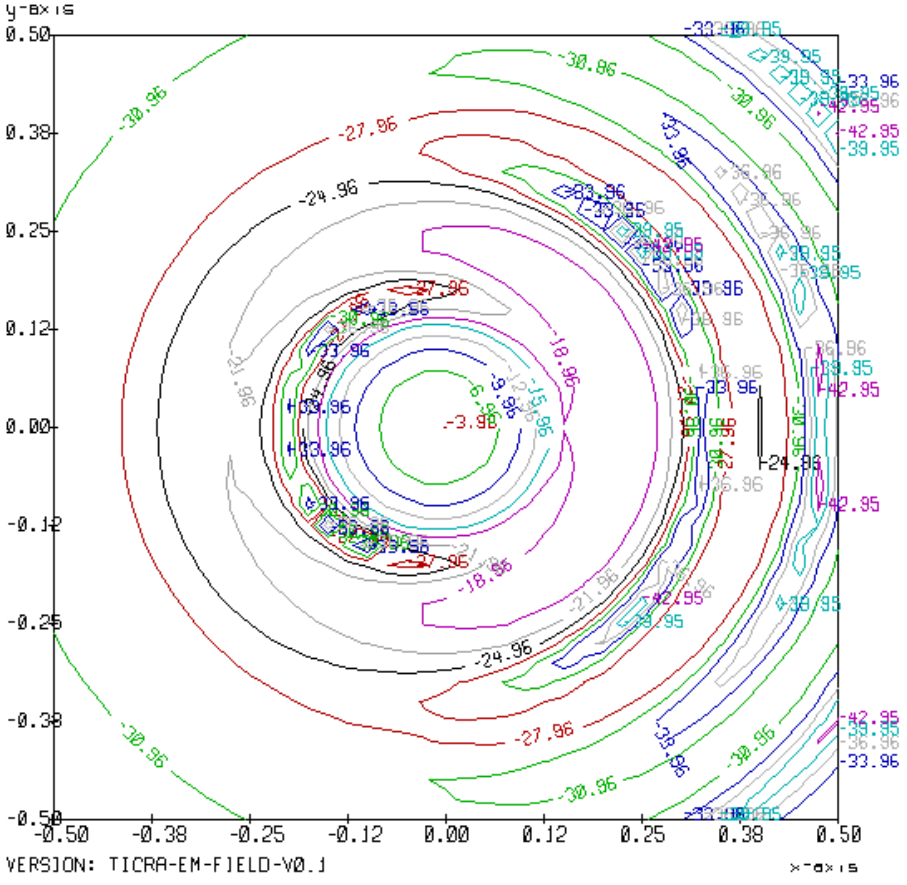
Focus Curve


1.00
0.98
0.96
0.94
0.92
0.90
0.88
Fractional Captured Power
−0.4
−0.2
0.0
0.2
0.4
0.6
Relative Focal Position, m

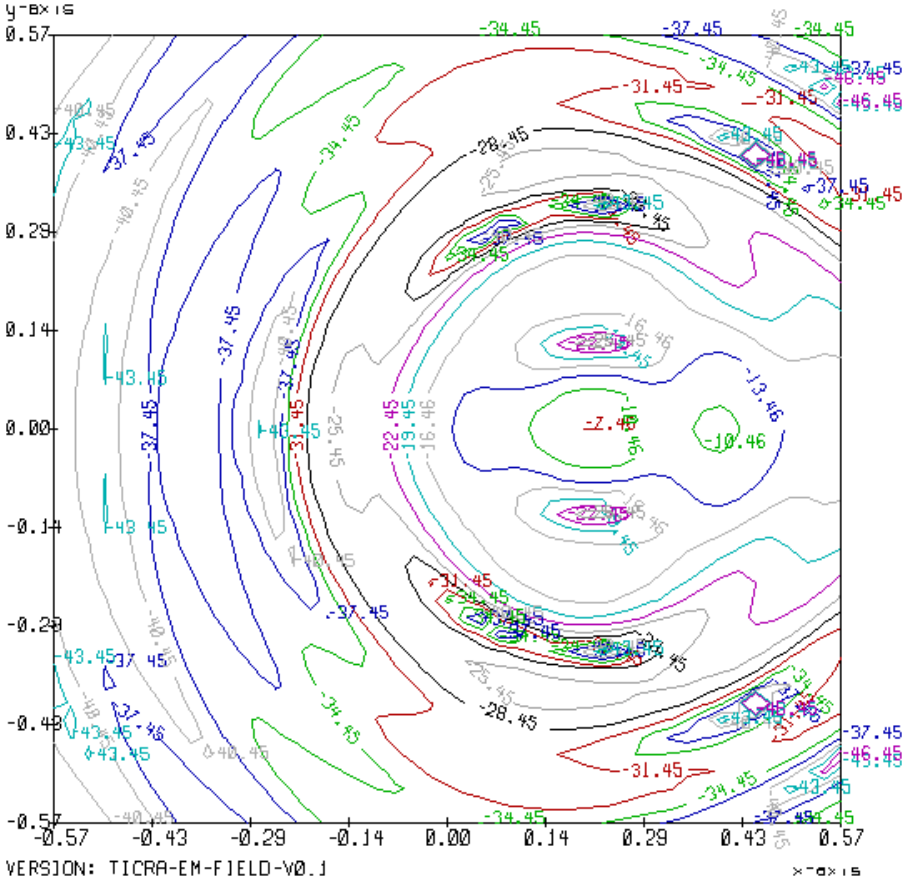
Focal Spot for Parabolic Reflector



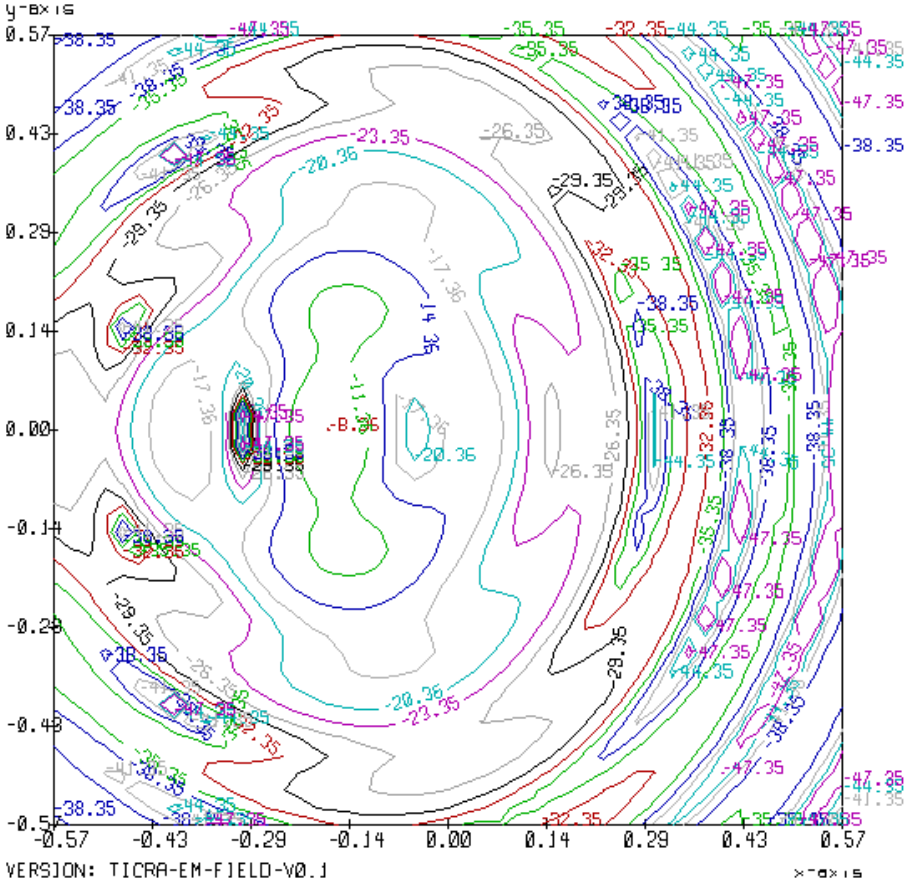
Focal Spot for Shaped Primary



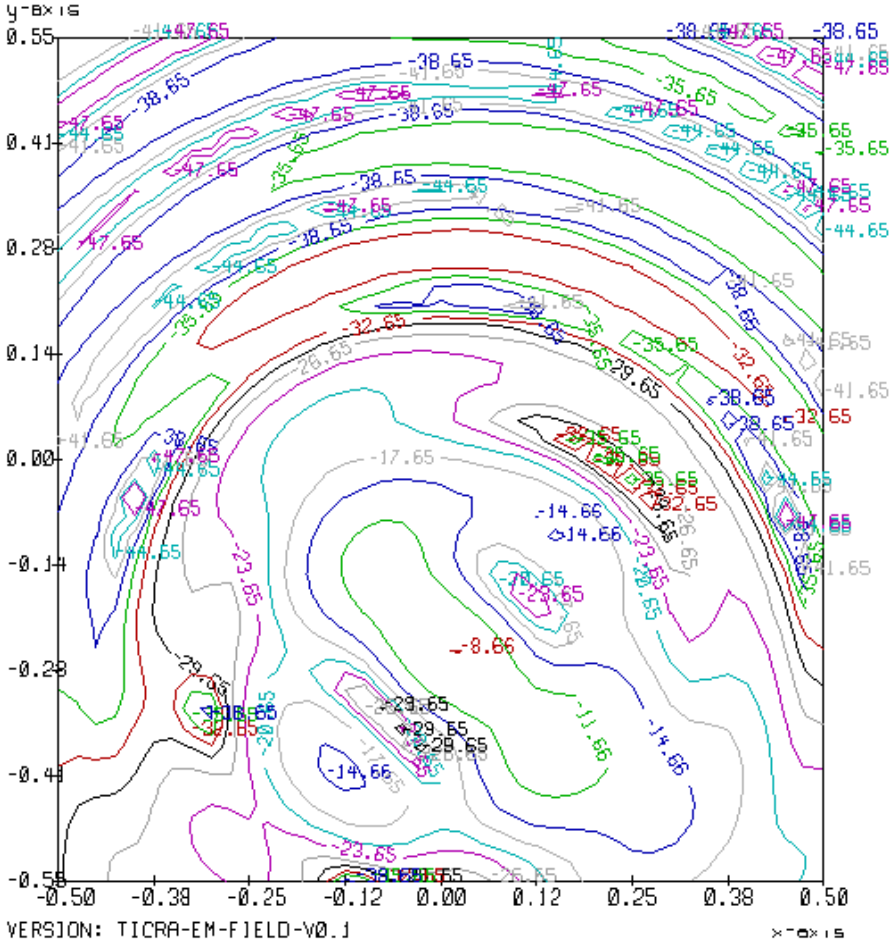
Focal Spot -1.5°(x-z plane)



Focal Spot +1.5°(x-z plane)



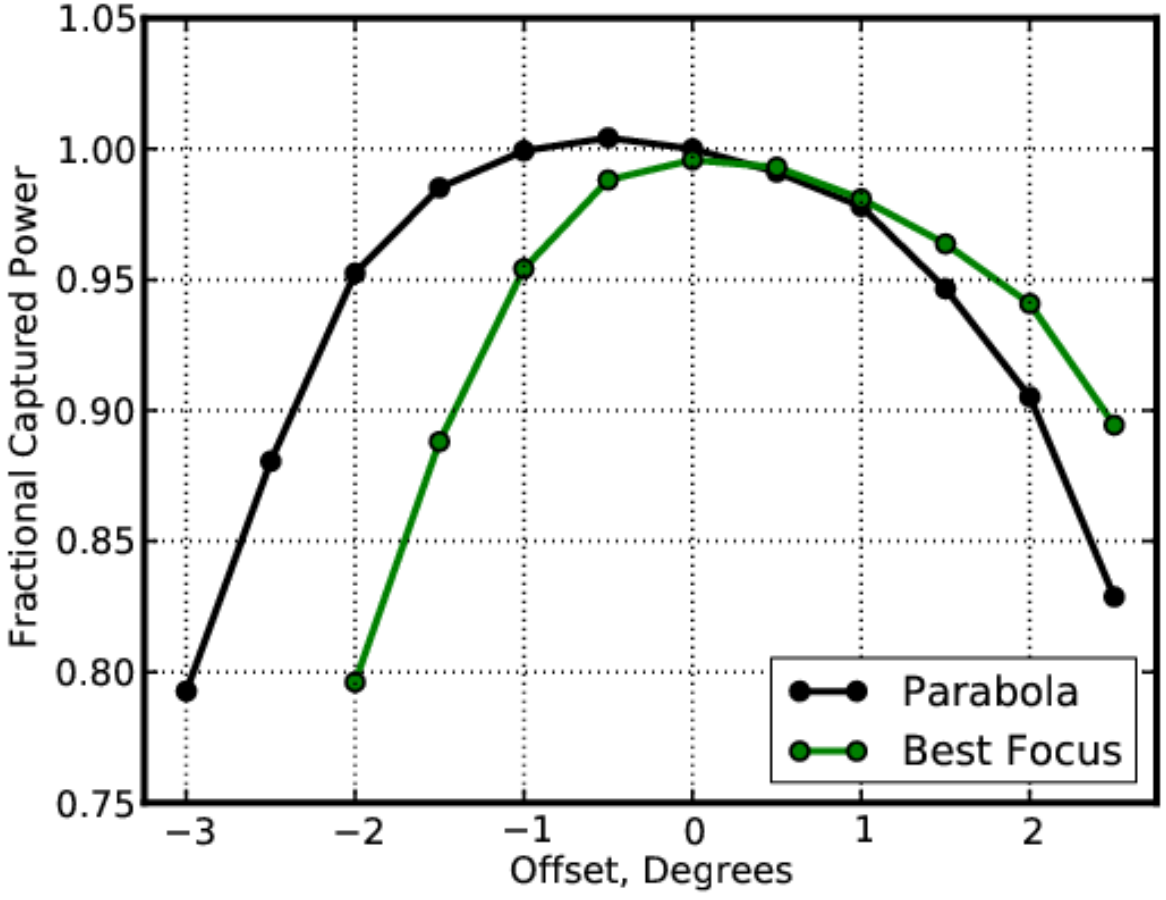
Focal Spot +2°(y-z plane)



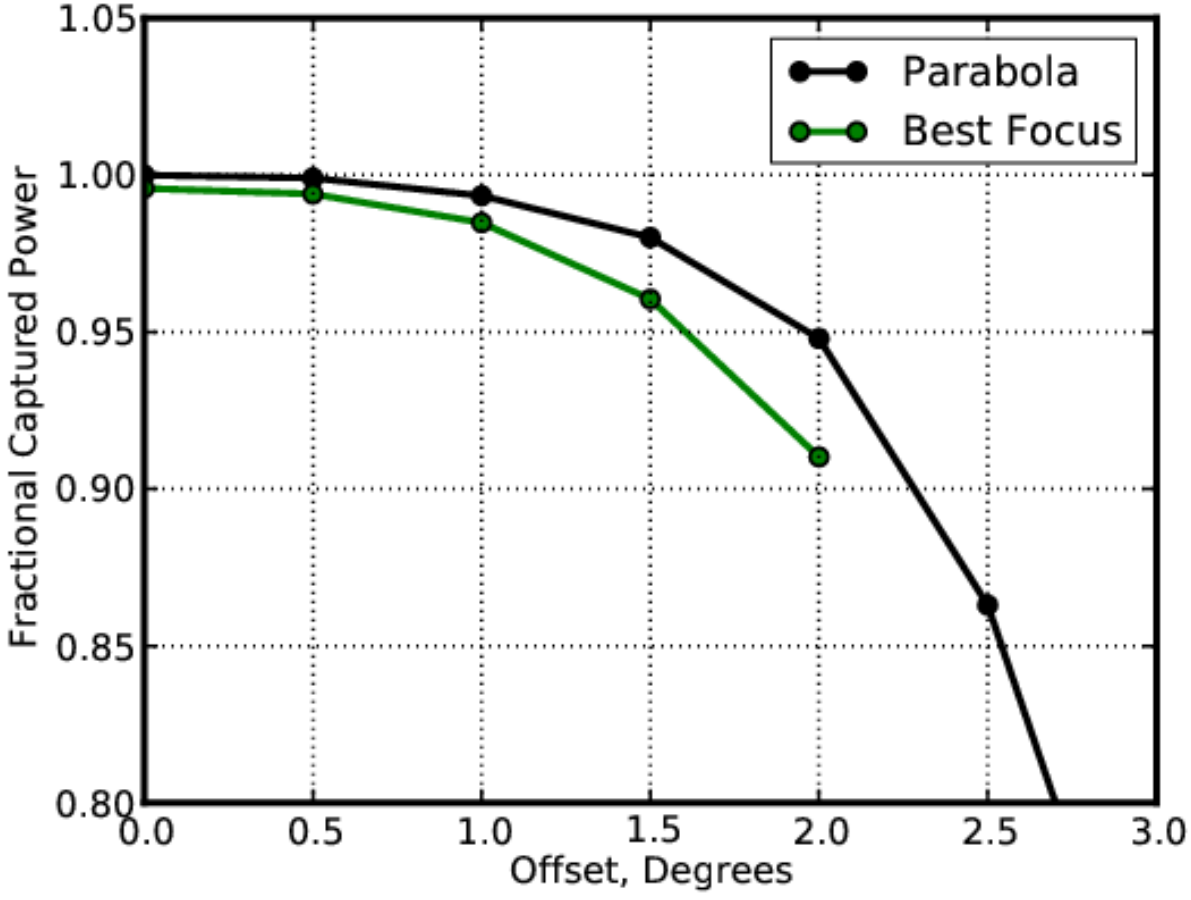
Comments

- Ray tracing plots are a poor indicator of focal fields
  - no amplitude/phase information
- For central beam, measurement plane area has to be expanded by $\sim 10\%$ to equal captured power of parabolic case
- Off-axis focal spots are severely distorted
  - in principle can be corrected with PAF if most of the beam is intercepted by array
  - need to determine size increase necessary to match performance of parabolic case

FoV x-z Plane


1.05
1.00
0.95
0.90
0.85
0.80
0.75
Fractional Captured Power
−3
−2
−1
0
1
2
Offset, Degrees
Parabola
Best Focus

FoV y-z Plane


Parabola
Best Focus
Fractional Captured Power
1.05
1.00
0.95
0.90
0.85
0.80
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Offset, Degrees

Array Size

- Want "shaped, best focus" curves to match parabola at the 95% level
- Measurement plane needs to be expanded by 10% in each dimension or 20% in area
- This increase also applies to the number of receivers, data transmission links, and beamformer inputs

Concerns

- This work needs to be verified
- Starting to work on physically combining PAFs with WBSPFs
- Current optical designs do not leave much room for PAFs
- Examination of secondary focus is next