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Wide Band Single Pixel Feed

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Outline

WB+SPF and SKA
HIA WB+SPF
How WB+SPF?
Now WB+SPF?
Building WB+SPF
Testing WB+SPF
Conclusions

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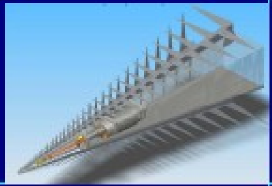
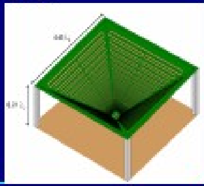
WB+SPF and SKA

Peter Dewdney et al. Proceedings of the IEEE, Aug. 2009:

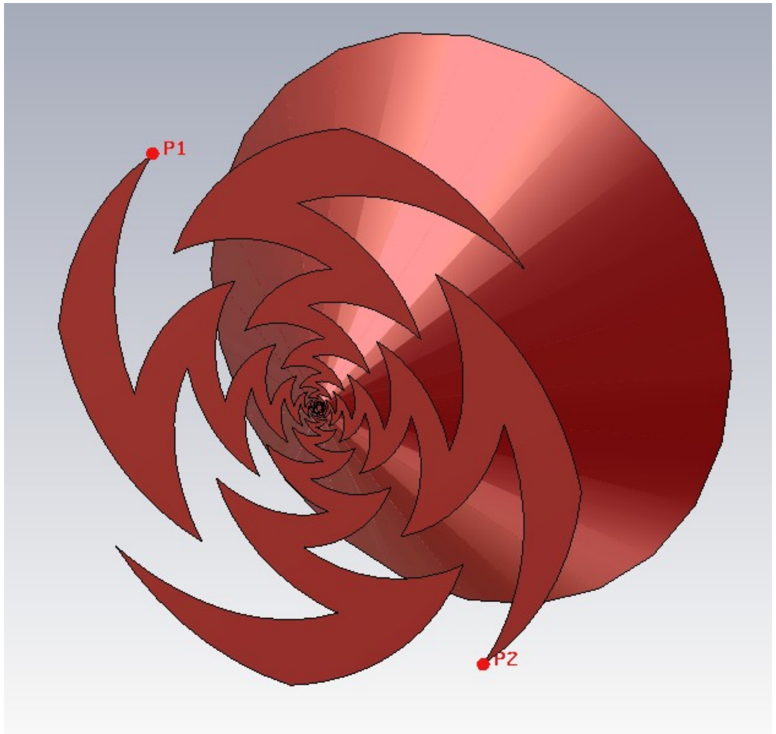
- "It is likely that two different arrays of antennas will be needed to cover the frequency range up to 500 MHz.
- From 500 to 1000 MHz, there are three possibilities: dense AAs, parabolic antennas with PAFs, and parabolic antennas with SPFs.
- From 1000 MHz to 10 GHz, parabolic antennas with SPFs are chosen."

Dewdney, et al., "The Square Kilometre Array," Proceedings of the IEEE , vol.97, no.8, pp.1482-1496, Aug. 2009

	BANDWIDTH	BEAMWIDTH	PHASE CENTER	RETURN LOSS	SIZE
Tecom 	> 20:1	100 deg H > E	Strong Frequency Dependence	> 6 dB	$(0.7\lambda_{max})^2 x\, 1.8\lambda_{max}$
ATA 	23:1	43 deg H = E	Strong Frequency Dependence	> 14 dB	$(0.5\lambda_{max})^2 x\, 2.4\lambda_{max}$
Lindgren 	8:1	> 60 deg freq. dependent E > H	Moderate Frequency Dependence	> 8 dB	$(1.1\lambda_{max})^2 x\, 1.2\lambda_{max}$
Chalmers 	11:1	62 deg ?	Frequency Independent	5 dB	$(0.65\lambda_{max})^2 x\, 2.1\lambda_{max}$
QSC 	> 10:1	65 deg ?	Frequency Independent	10 dB	$(0.75\lambda_{max})^2 x\, 0.2\lambda_{max}$
Conical Sinuous GP 	> 10:1	65 deg, H > E	Frequency Independent	5 dB	$(2.0\lambda_{max})^2 x\, 0.25\lambda_{max}$
FS	> 10:1	100 deg, H = E	Small Dependence	> 16 dB	$(0.5\lambda_{max})^2 x\, 0.25\lambda_{max}$

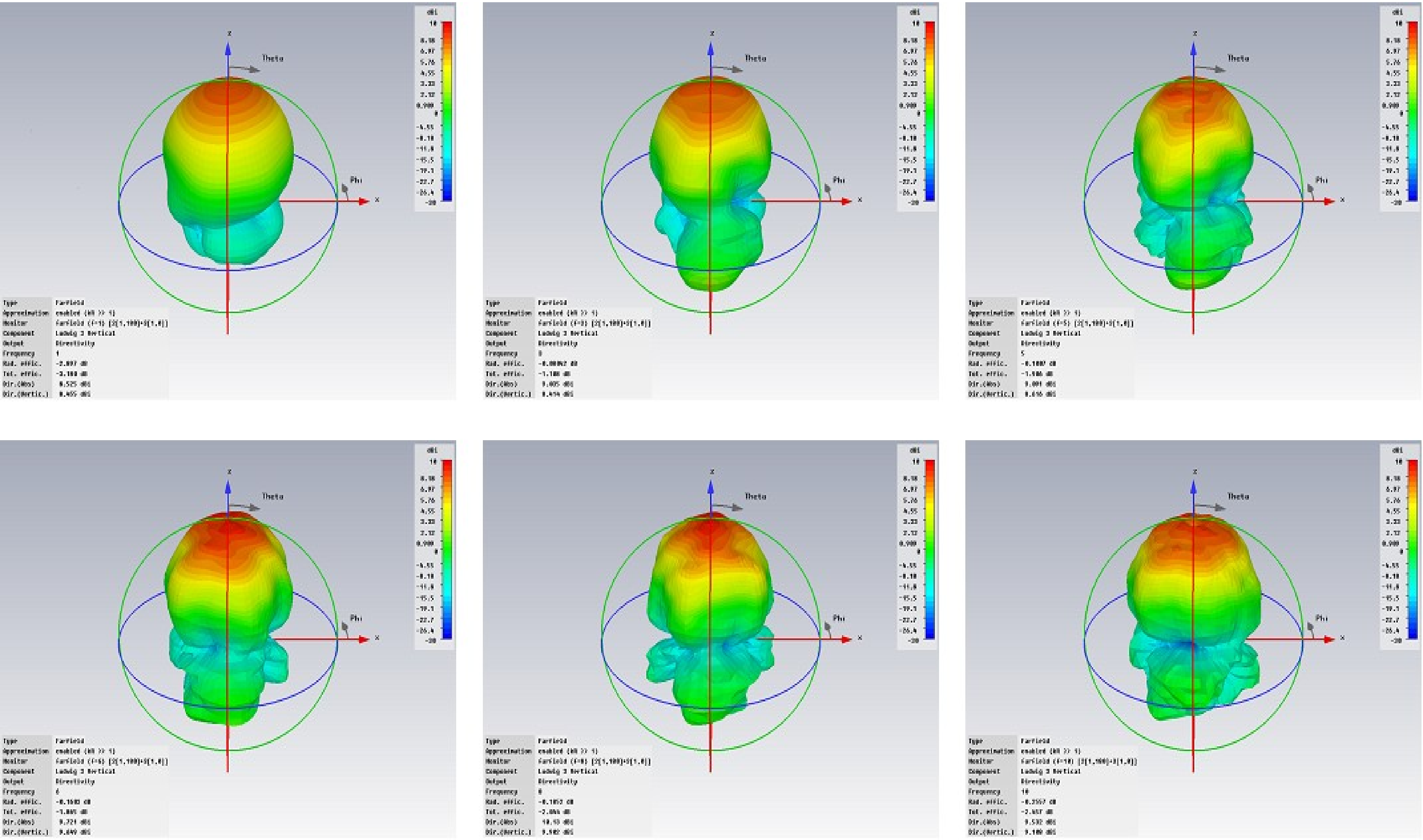
Rich Bradley, Rohit Gawandec, “The Challenges of Broadband Feed Design”, URSI 2009

HIA WB+SPF

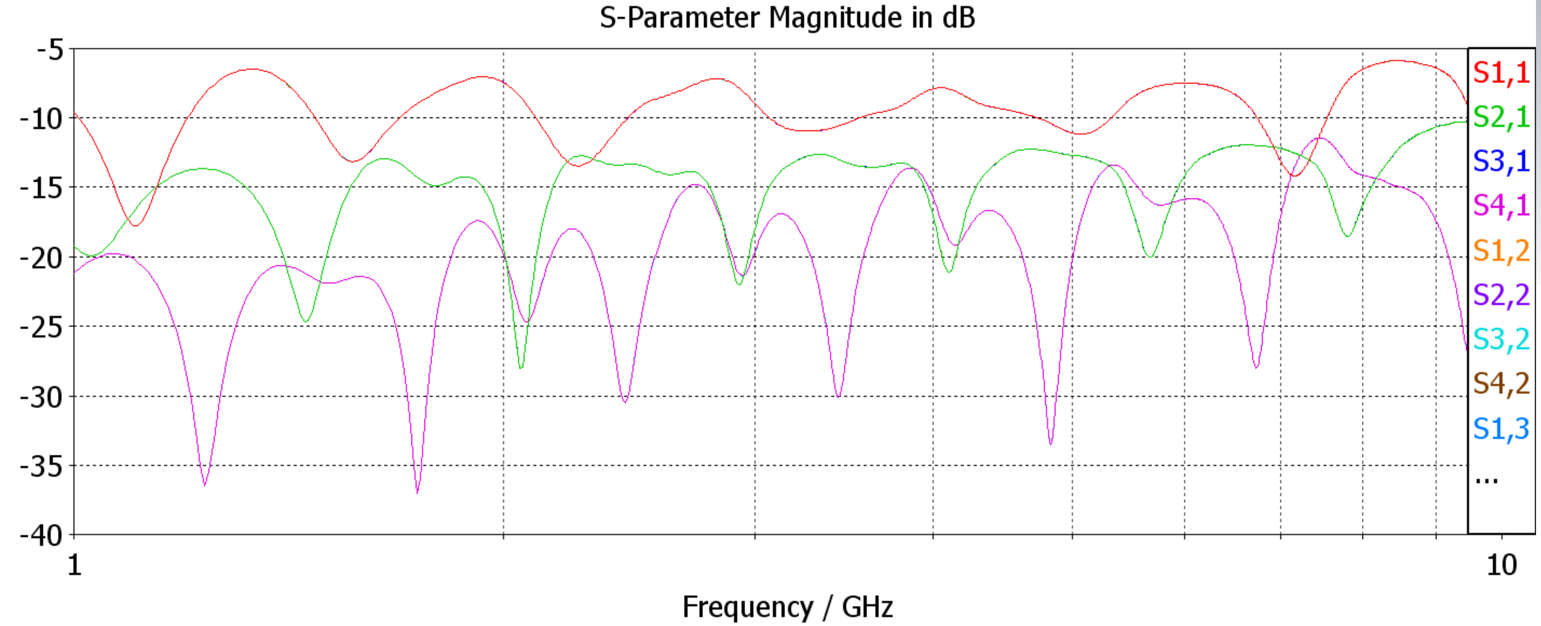


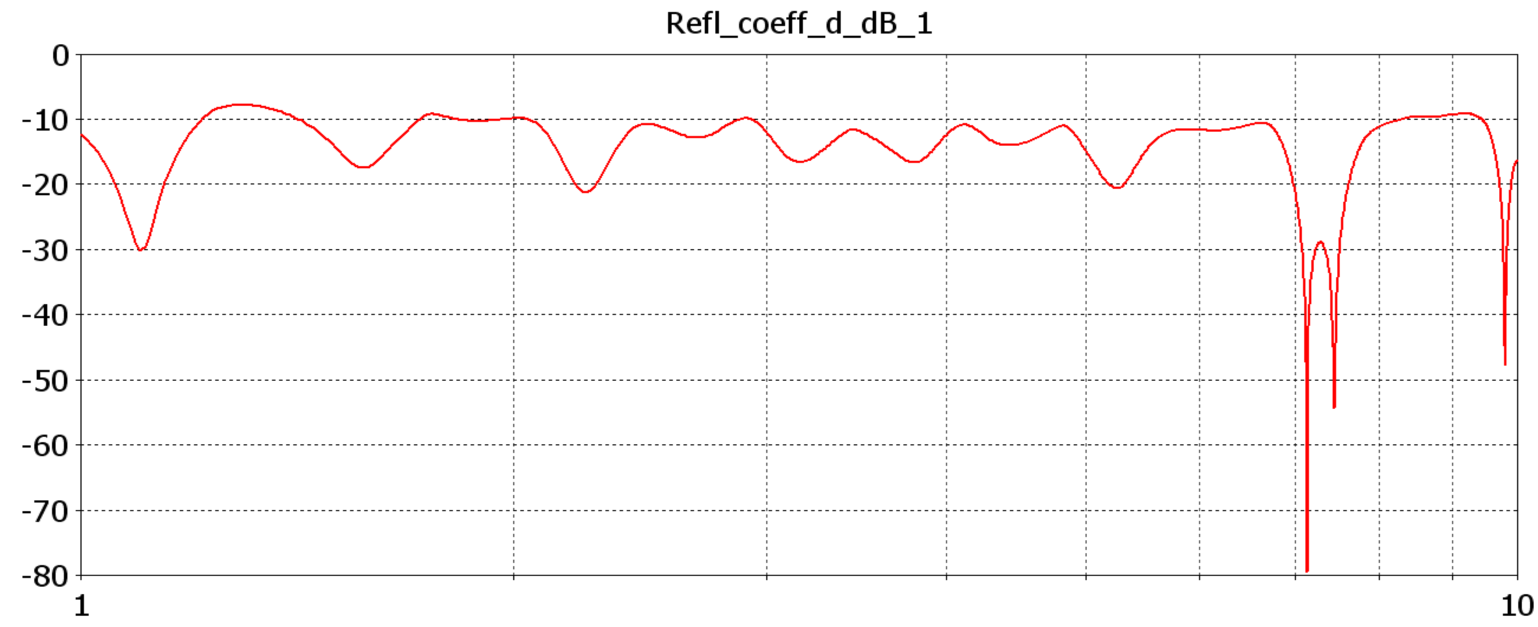
- Bandwidth: >10:1
- Beamwidth: ~60 deg
- Phase center: some dependence
- Return loss: >8 dB
- Size: $(0.57\lambda_{max})^2 \pi \;\; x \;\; .57\lambda_{max}$
- Cross polarization: <-9 dB ?

HIA WB+SPF's: Beamwidth: ~60 deg



HIA WB+SPF Return loss: >8 dB





- Differential-mode reflection coefficient:

$$1/2(s_{11} - s_{14} - s_{41} + s_{44})$$

- For port 1 and 4 in same polarization

How WB+SPF?

Far field pattern

- Two similar antennas (scaled in spatial dimensions) have same radiation properties at the inversely scaled frequency.
- A self-similar antenna has scaled structures embedded
  - Equiangular, aka., logarithmic spirals
    - Entire structure scales with Φ
  - Log-periodic antennas
    - “Cells” scale by “tau”
- Aperture size scales
  - Low pass filter behaviour
- For finite structures:
  - Eliminate “end-effect”
    - Traveling waves

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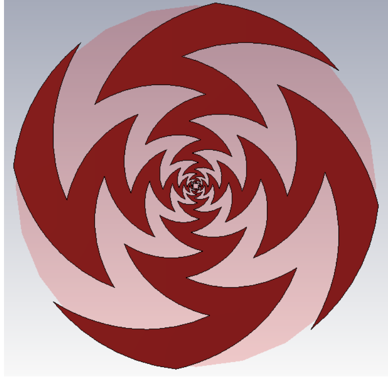
How WB+SPF?
Impedance



- Complementary structures
  - Babinet's principle

$$Z_{metal} Z_{air} = Z^2_{freespace} / 4$$

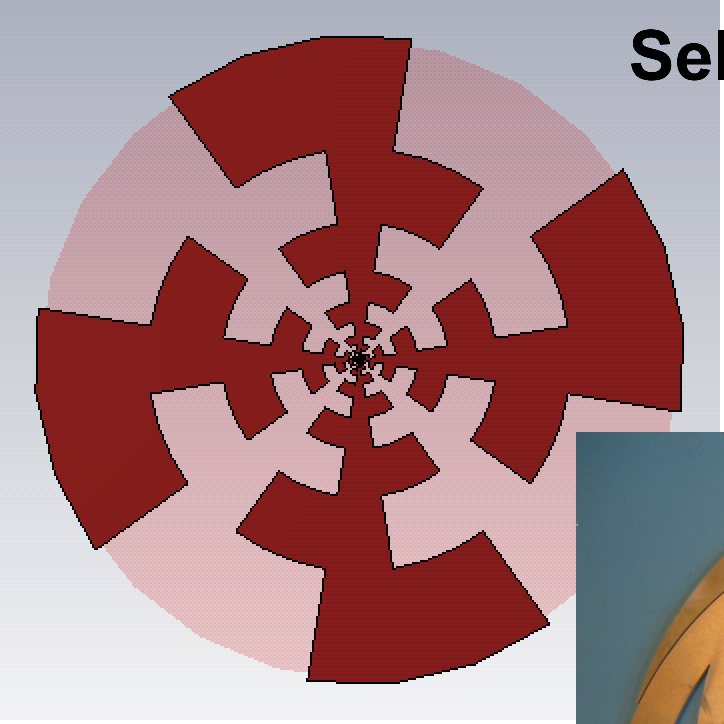
$$Z_{slot} = Z^2_{freespace} / (4 Z_{dipole})$$

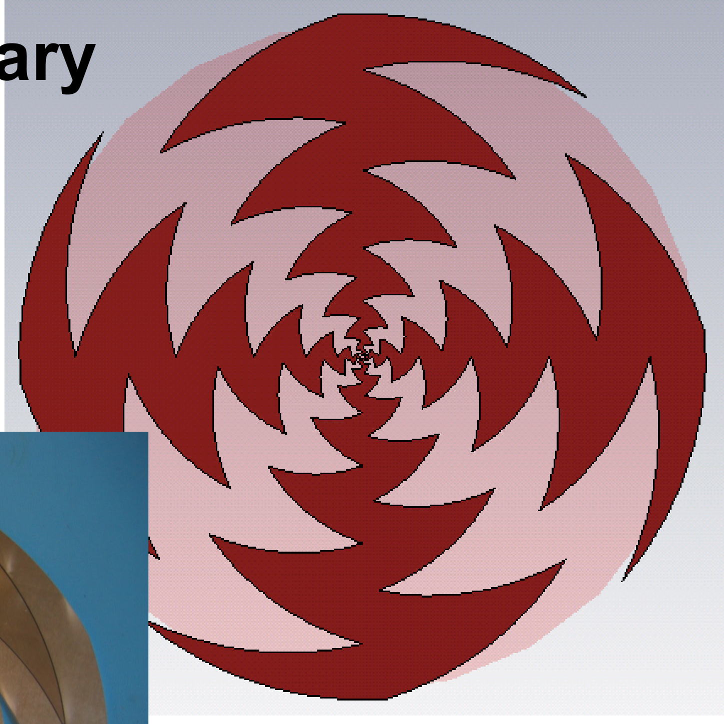
- Self-complementary structures
  - Mushiake's relation

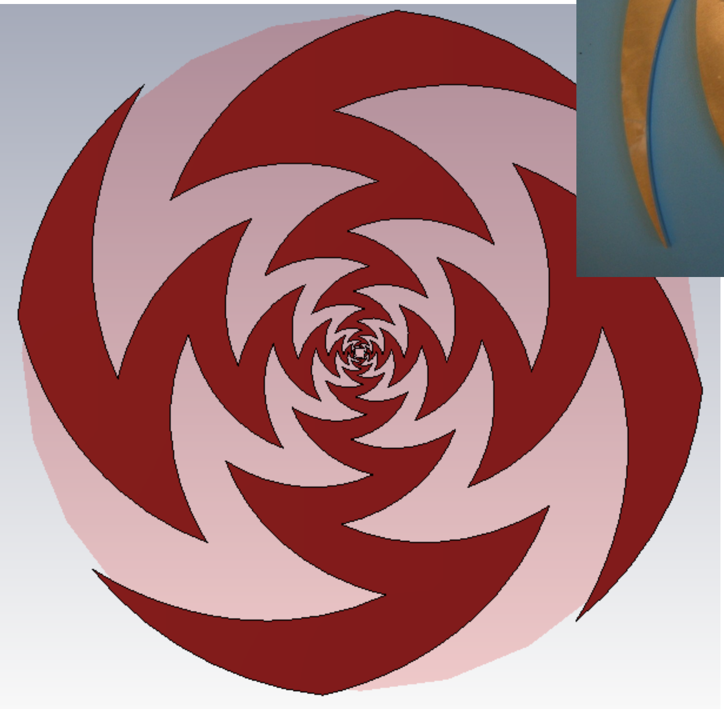
$$Z_{metal} = Z_{air}$$

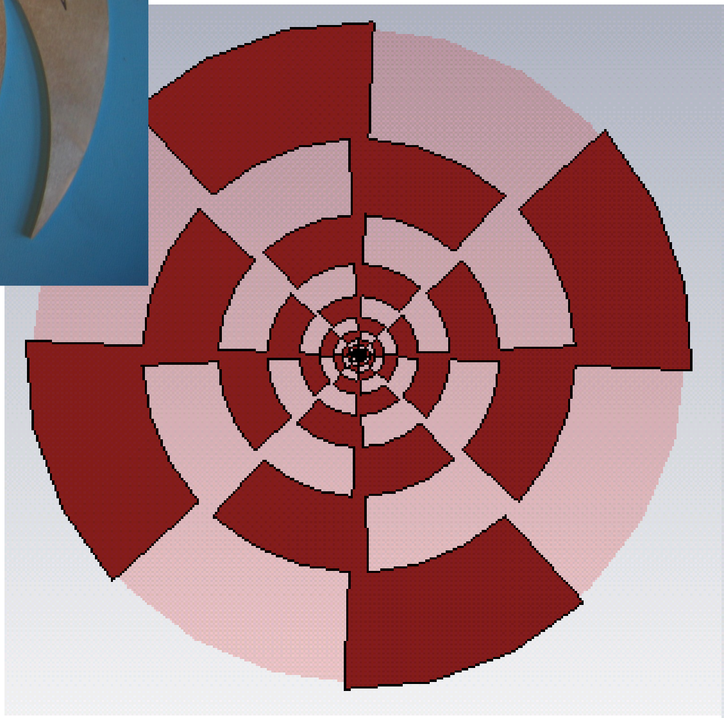
$$Z_{metal} = Z_{freespace} / 2 = 188.5 [ohms]$$

Self-complementary

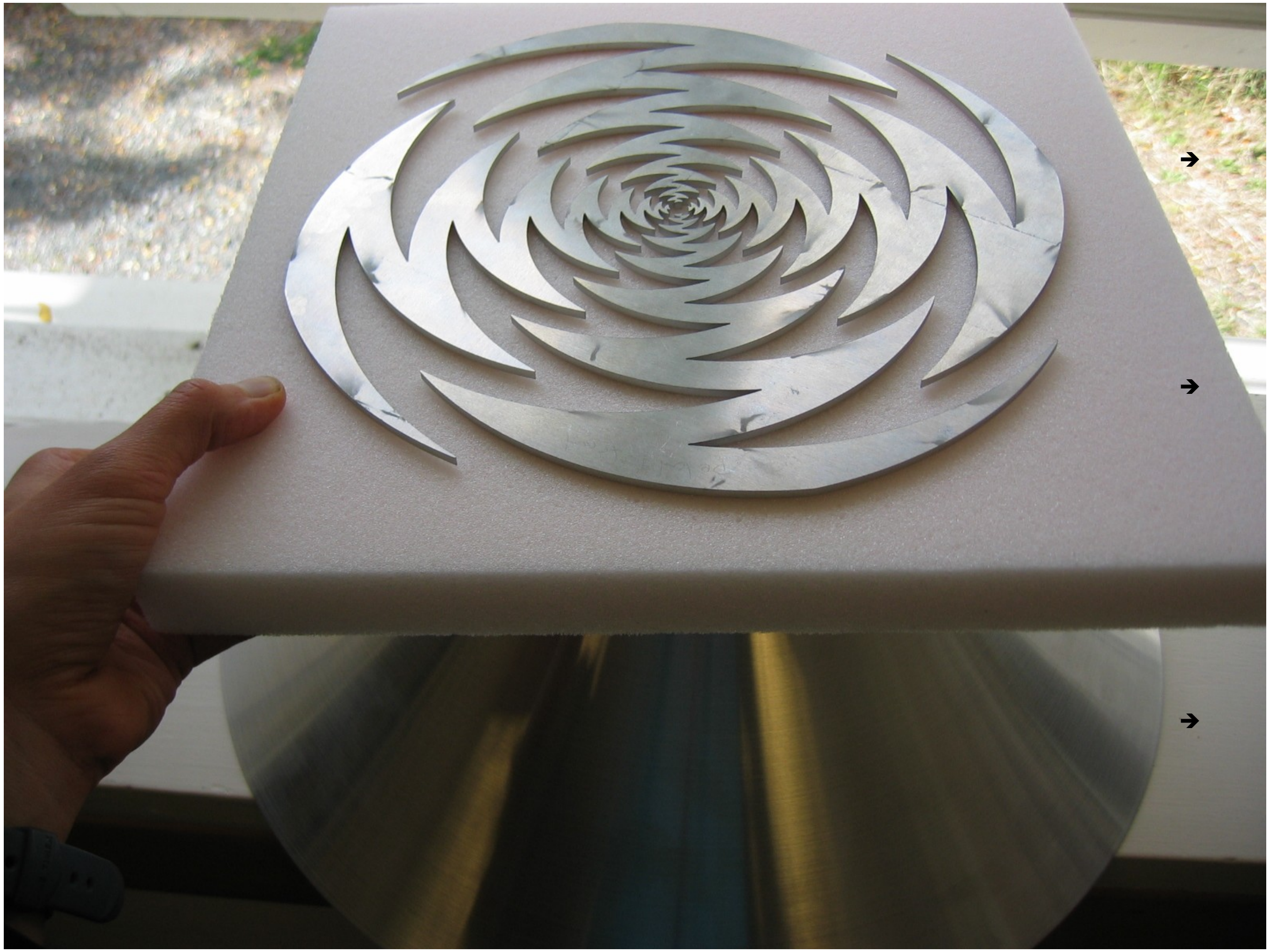








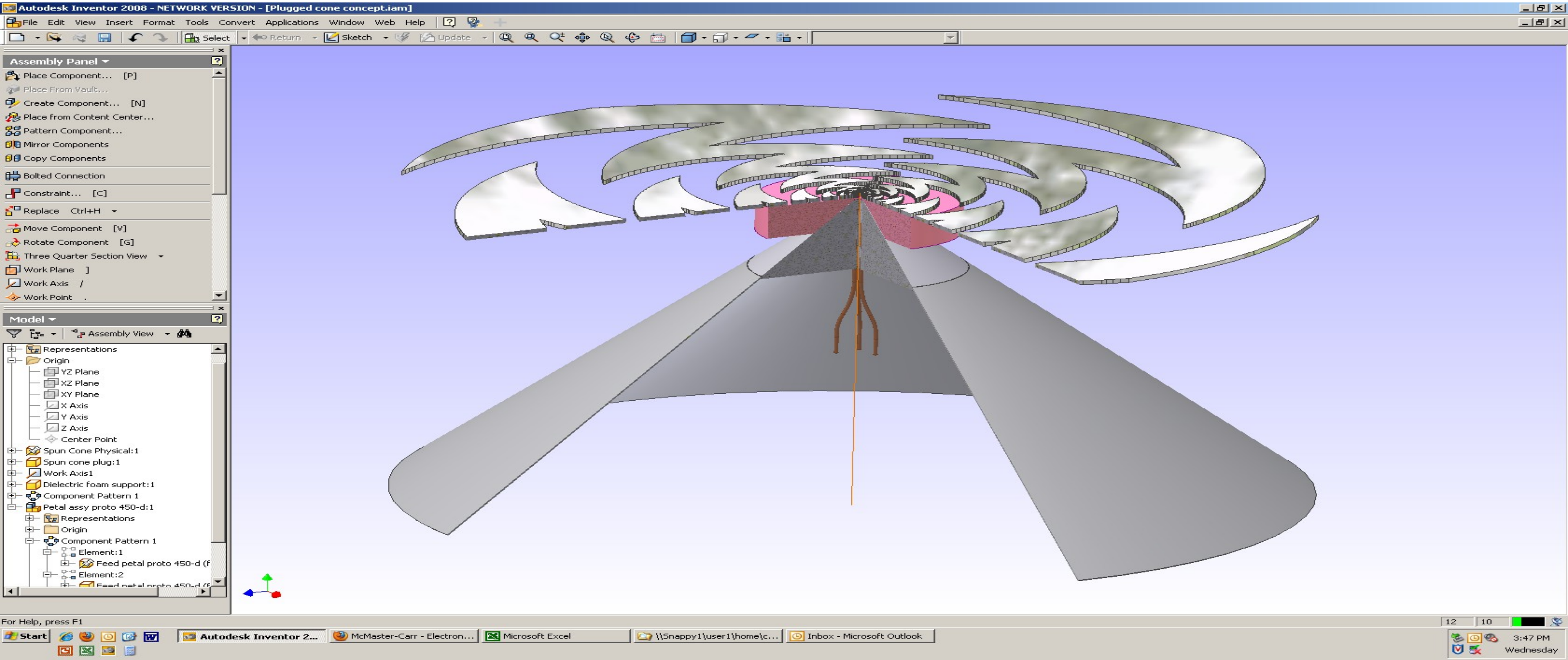
Now WB+SPF?



- Aluminum 1100 cone and antenna "petals"
- Eccostock SH-8 foam
- Eccosorb 268E paint along edge of cone?

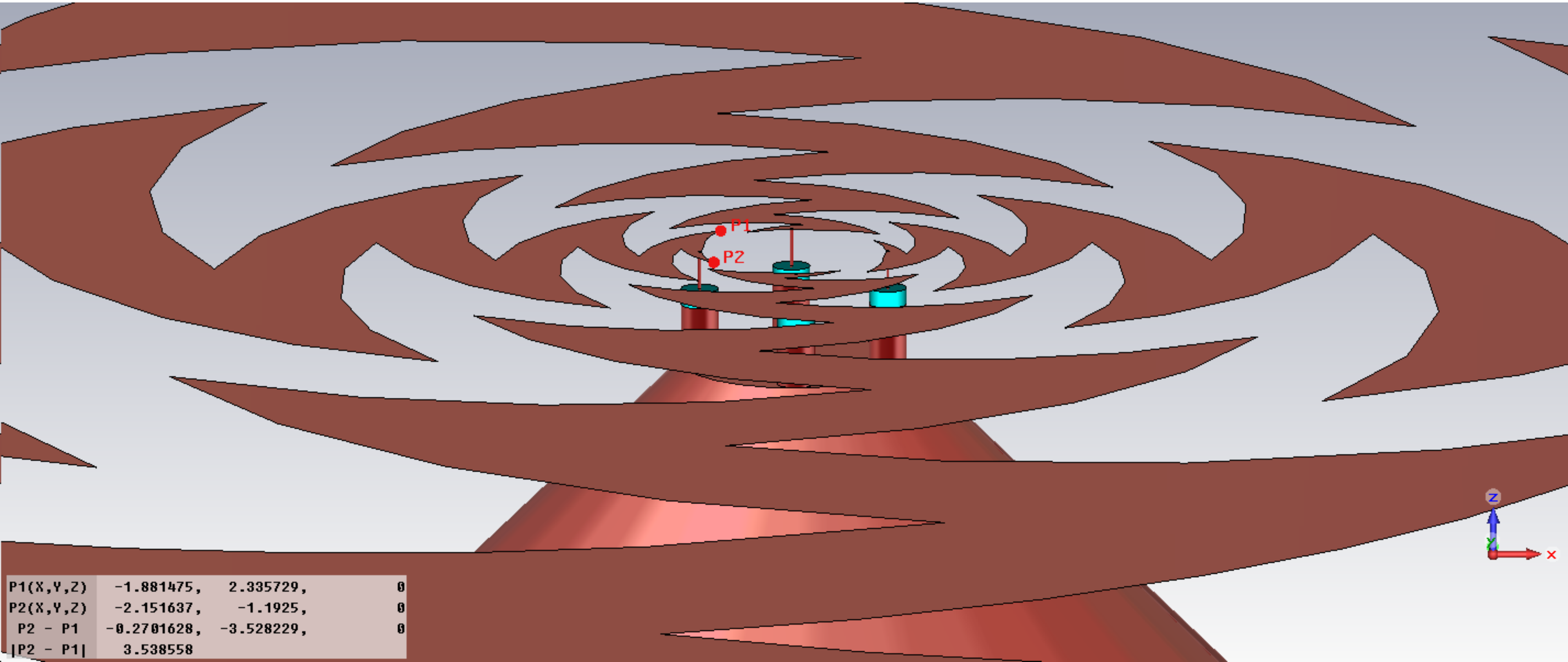
Building WB+SPF

- Low dielectric constant epoxy
- Low dielectric constant and low dissipation factor foam
- Conductive epoxy (large fraction of colloidal silver)
- Complete this month

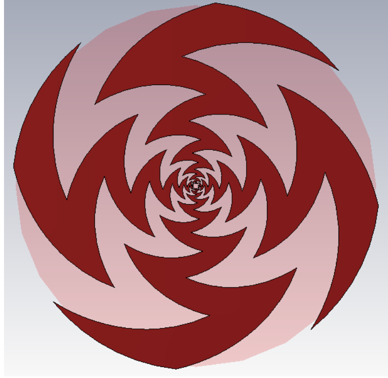


Testing WB+SPF

- Near field range and/or far field anechoic chamber
- Two petals per polarization
- Exciting one petal with three others terminated in 50 ohms
- Complete end of next month



Conclusions



- Comparable bandwidth and beamwidth
- Some phase-center frequency dependence
  - Can be minimized, at cost of return loss
- Poor return loss (though comparable to some)
- Size is smaller than most
- Cross polarization is not as easily comparable, but likely a little worse than average
- Cost is lower, we think:
  - "all the complicated parts in one plane"
  - PCB or milling technology
- Ground plane size is maximized
- Room for improvement with many free variables

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Thank you for your attention.

Questions or comments?