CORE+ Telescope

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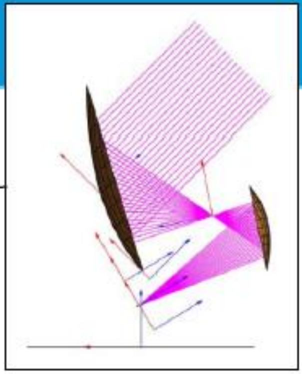
Comments on

- Where we are
- Baffles + Stop
- Focal Surface Shape
  - ARC

Telescope configuration trade-off

Four configurations considered:

- Gregorian option 1

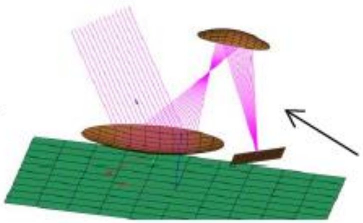


Selected option:

Fits in V-Grooves

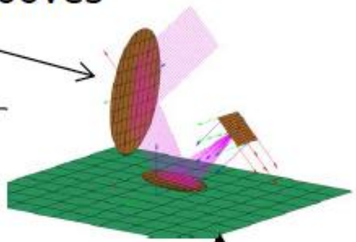
and can easily be mounted

- Gregorian option 2

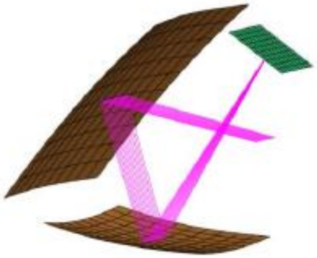


Does not fit in V-Grooves

- Open Dragone



- Cross-Dragone with F~2



Focal plane too high.

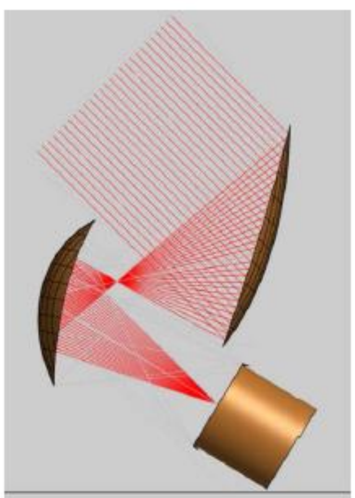
Complex Thermo-Mechanical accommodation

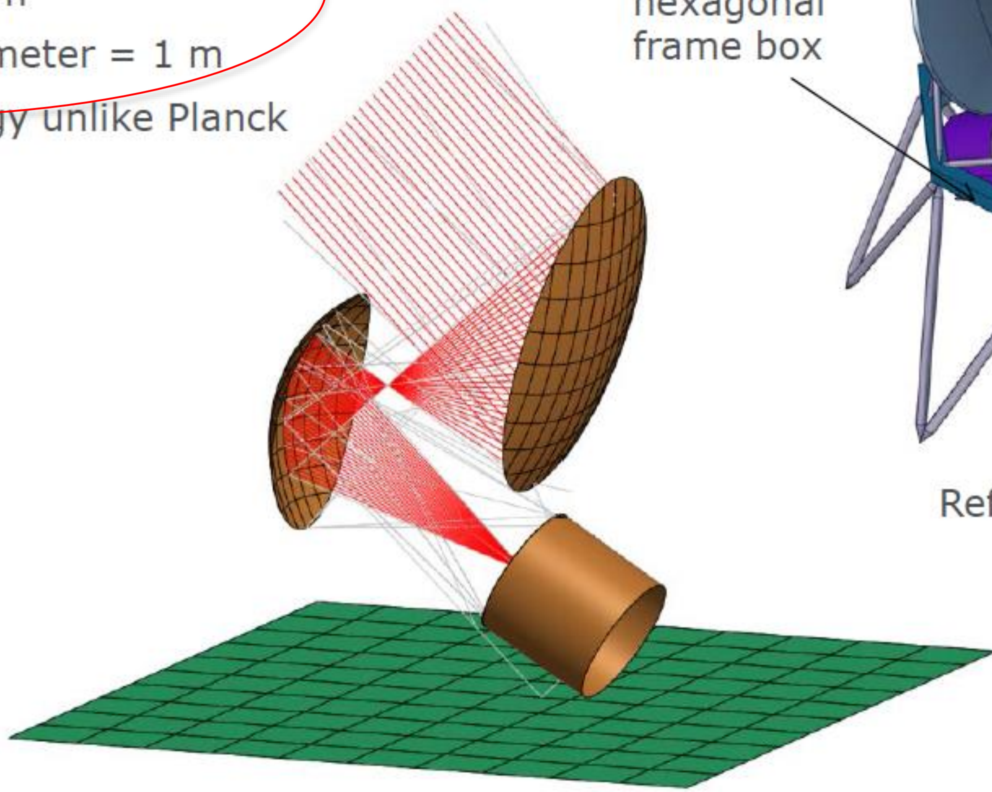
Large secondary mirror

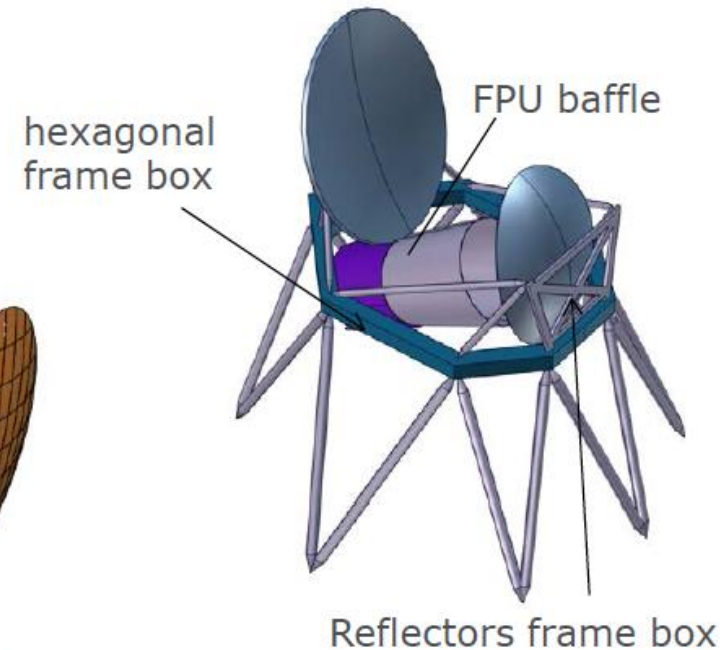
Telescope baseline

Gregorian configuration:

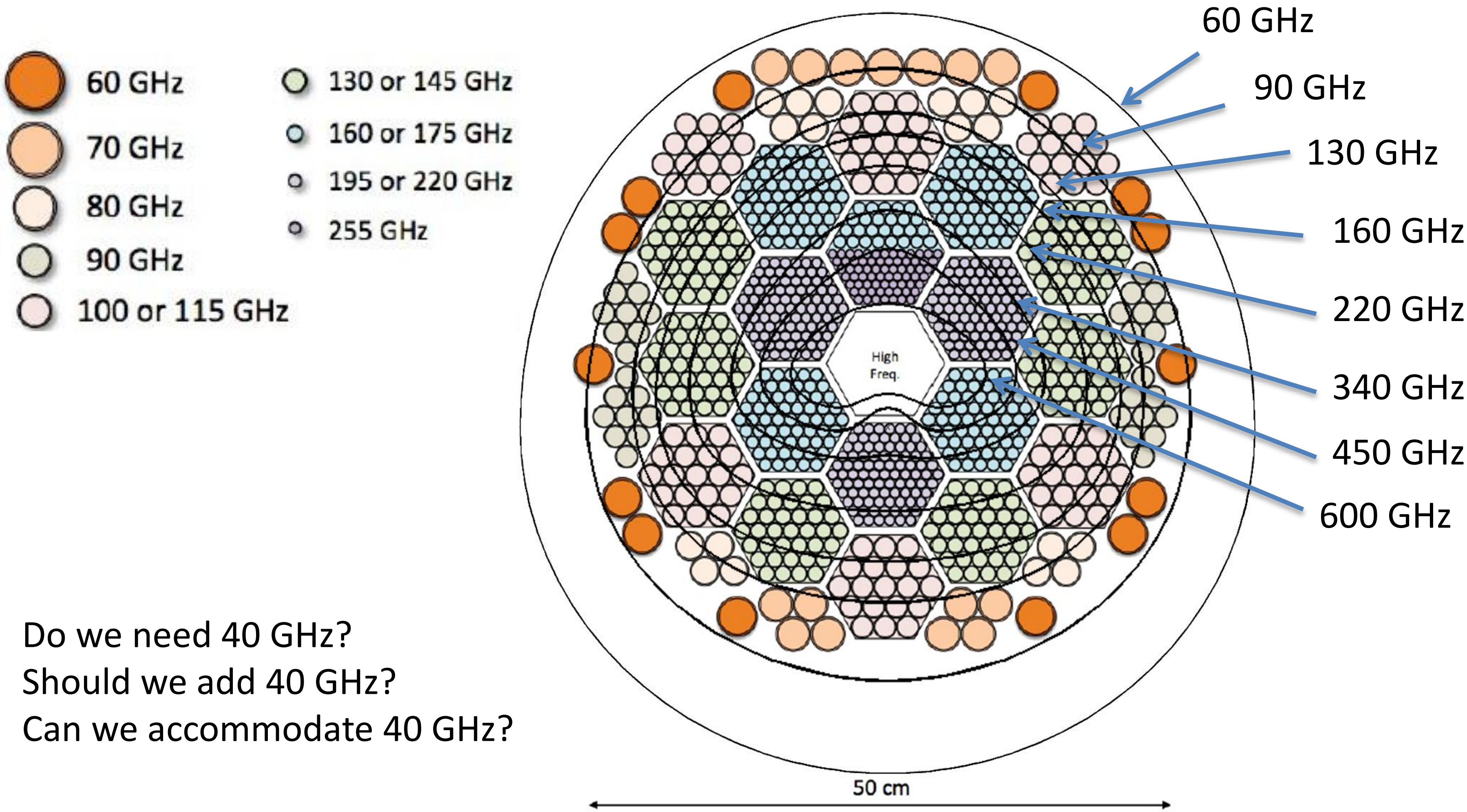
- Aperture =1.2 m - F/D ~ 2.
- Primary Mirror 1.5X1.2 m
- Secondary reflector diameter = 1 m
- Monolithic SiC technology unlike Planck







Focal plane layout

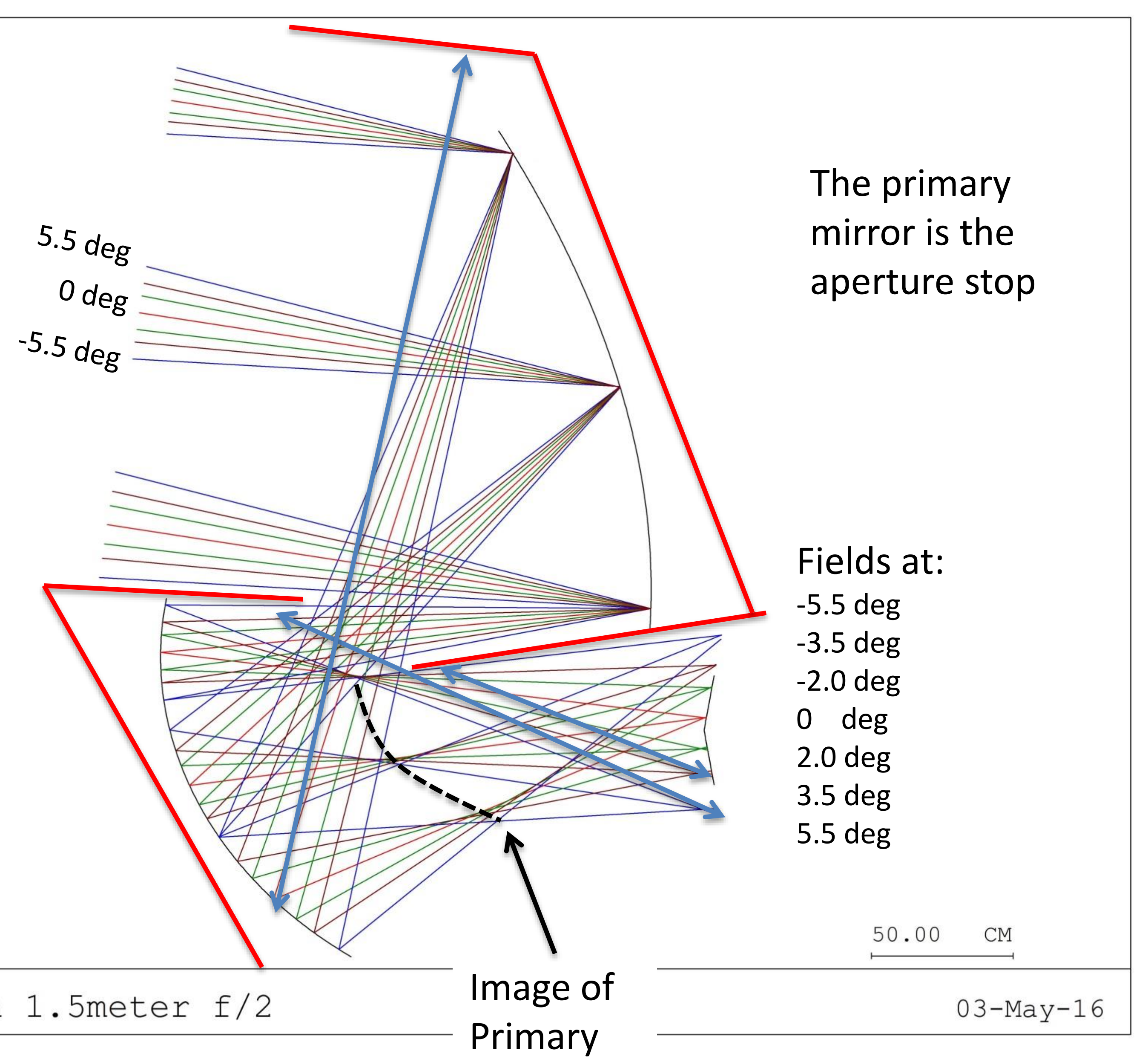


Do we need 40 GHz?
Should we add 40 GHz?
Can we accommodate 40 GHz?

Figure 3: Sketch of the focal plane of COrE+ Light. Contours are Strehl= 0.8 for 60, 90, 130, 160, 220, 340, 450, and 600 GHz.

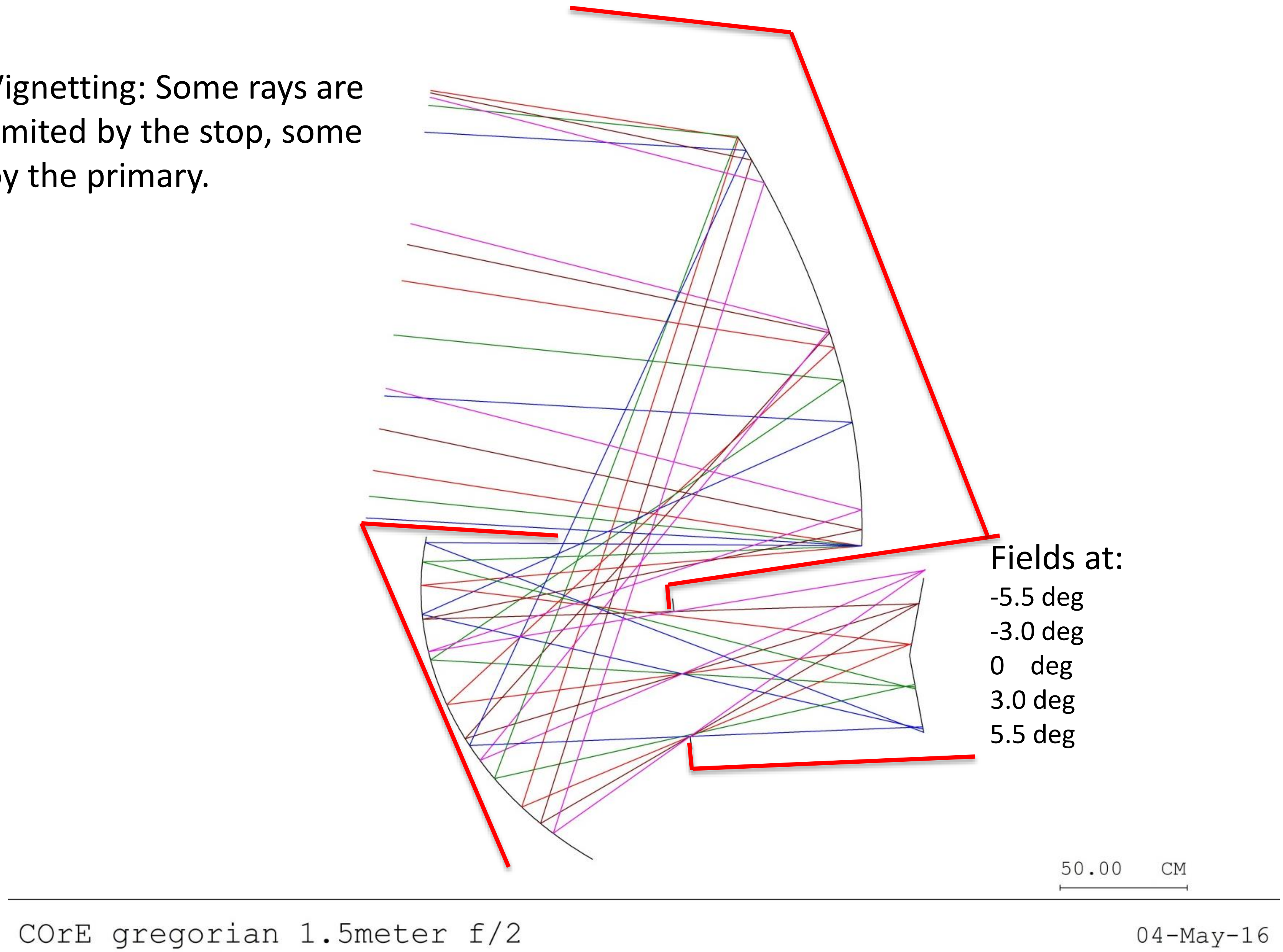
1.5 m Aperture Gregorian, Optimized Dragone, with Aspherics

- Baffles are necessary
- Note compactness of system
- Need GRASP including baffles



Cold Stop Enforced (for most of the rays)

Vignetting: Some rays are limited by the stop, some by the primary.



Change in pupil footprint area due to vignetting

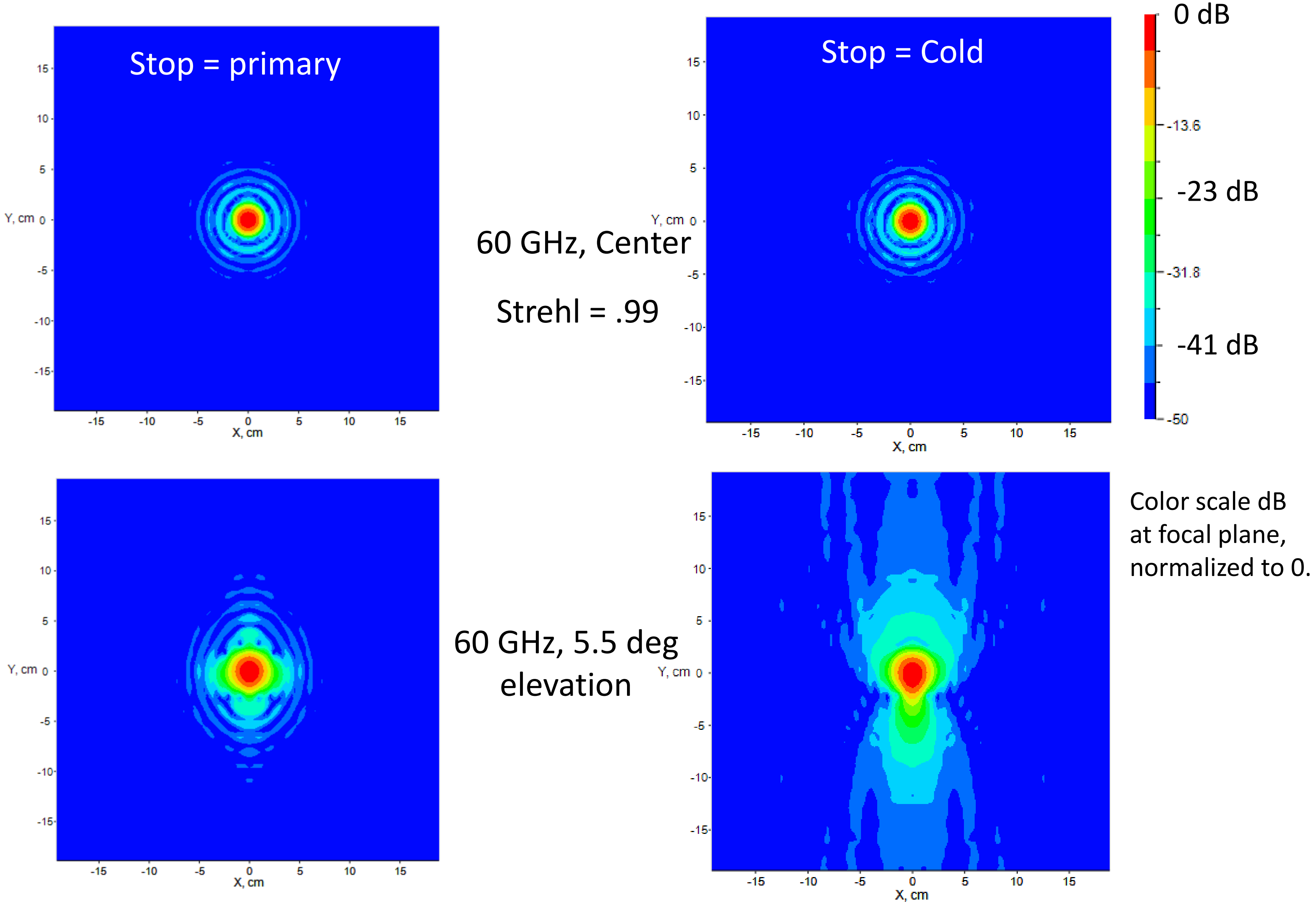
Field Angle (degrees)	Area relative to unvignetted 1.5m pupil
0	1.00
+3 (-3) elevation	1.03; (0.89)
5.5 (-5.5) elevation	1.01; (0.79)
+3.5 in azimuth	0.98
+5.5 in azimuth	0.88

Change in Strehl with Cold Stop; 60 GHz

El. Field angle (degrees)	No stop	Stop 90 cm from focal plane
0	0.99	0.99
5.5	0.81	0.84
-5.5	0.84	0.85
Az. Field angle (degrees)		
5.5	0.79	0.825

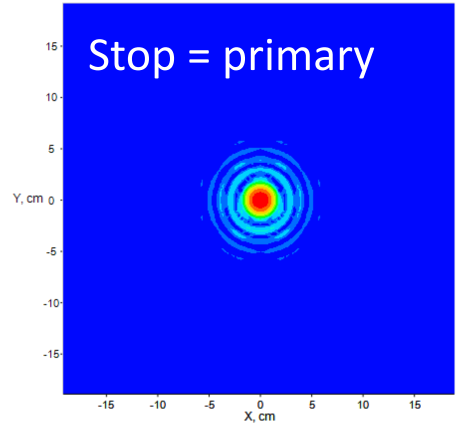
Strehl is the ratio of peak energy to peak energy of diffraction limited system system. It is a single point measure. It gives no information about beam shape.

PSFs

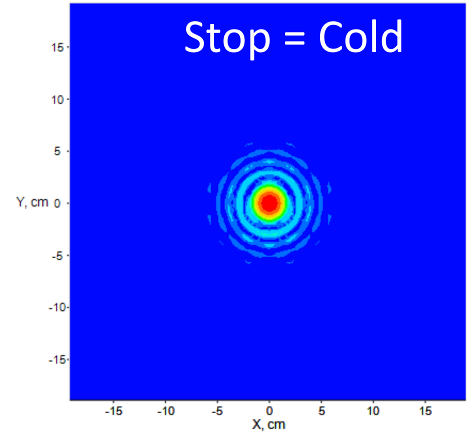


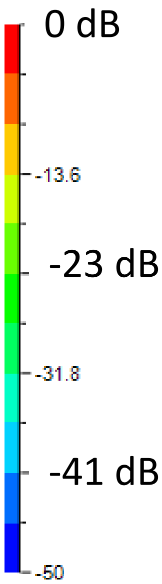
Stop = primary
Stop = Cold
0 dB
-13.6
-23 dB
-31.8
-41 dB
-50
60 GHz, Center
Strehl = .99
60 GHz, 5.5 deg
elevation
Color scale dB
at focal plane,
normalized to 0.
Y, cm
X, cm

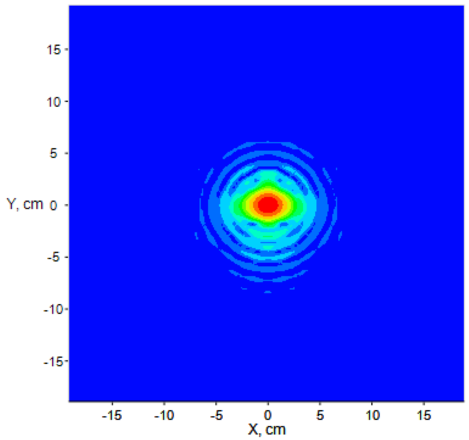
PSFs



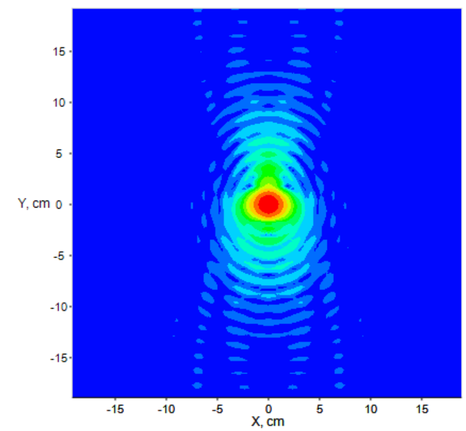
60 GHz, Center



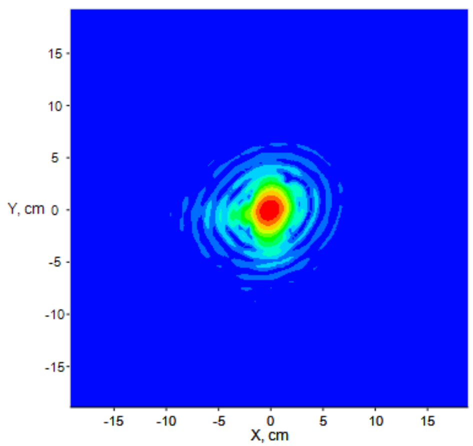




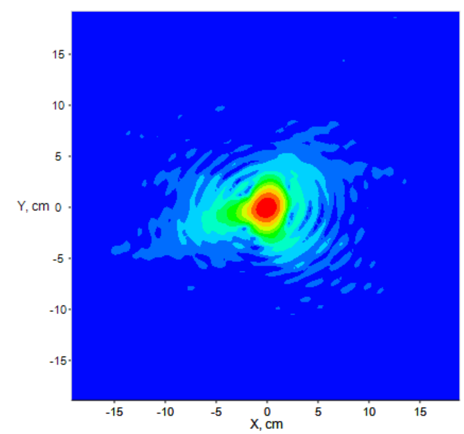
60 GHz, -5.5 deg elevation



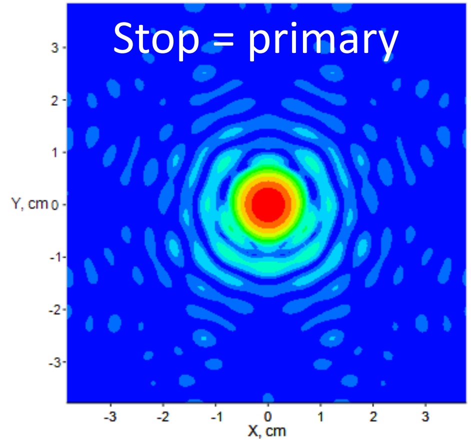
Color scale dB at focal plane, normalized to 0.

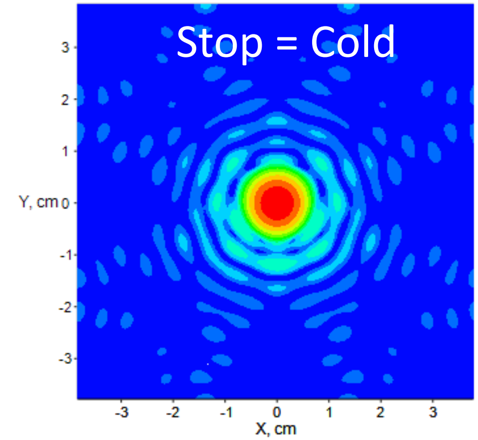


60 GHz, 5.5 deg azimuth

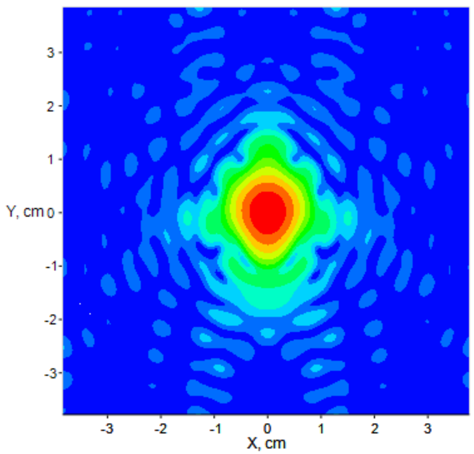


PSFs

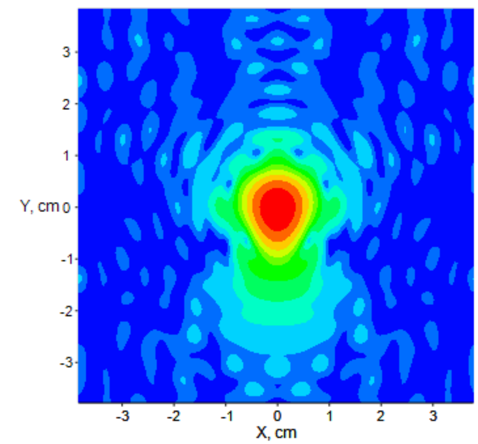


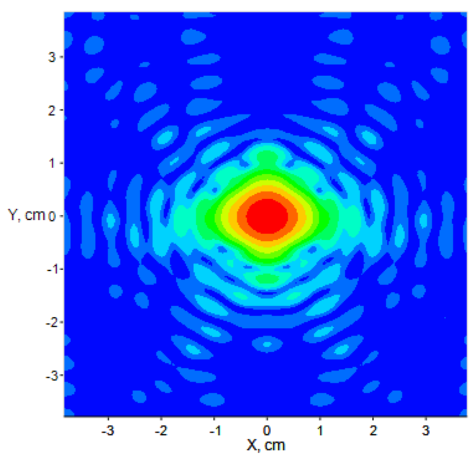


150 GHz, Center

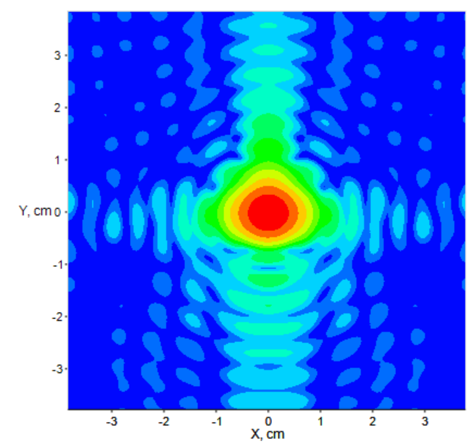


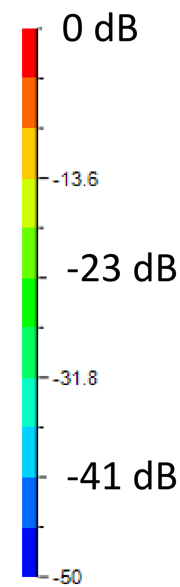
150 GHz, 3 deg elevation





150 GHz, -4 deg elevation





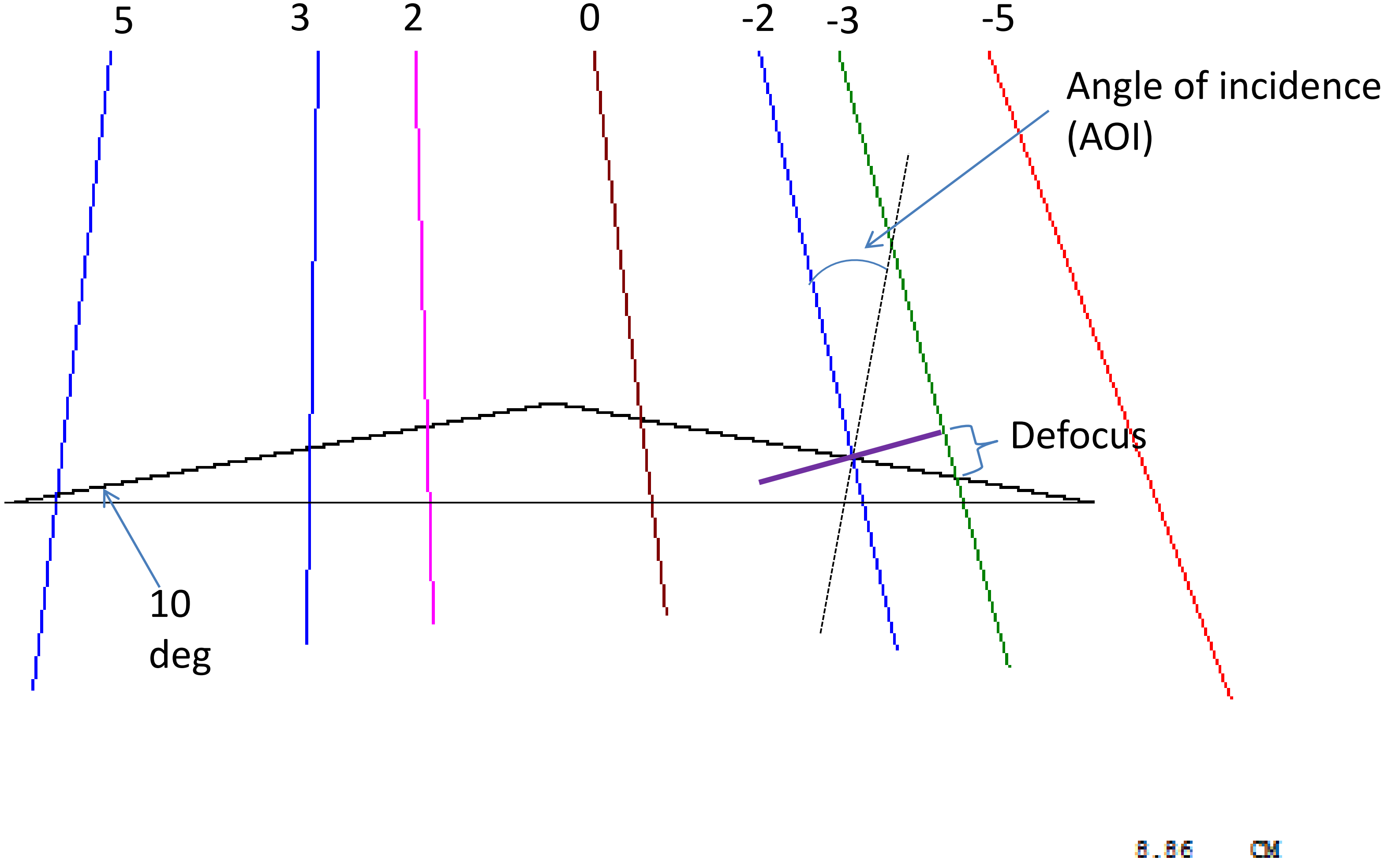
Color scale dB at focal plane, normalized to 0.

Didn’t yet check

- Polarization – should use GRASP
- Higher Frequencies

Conic, Non-telecentric, Focal Surface: What if we tilt the arrays?

Chief rays for 7 field angles.



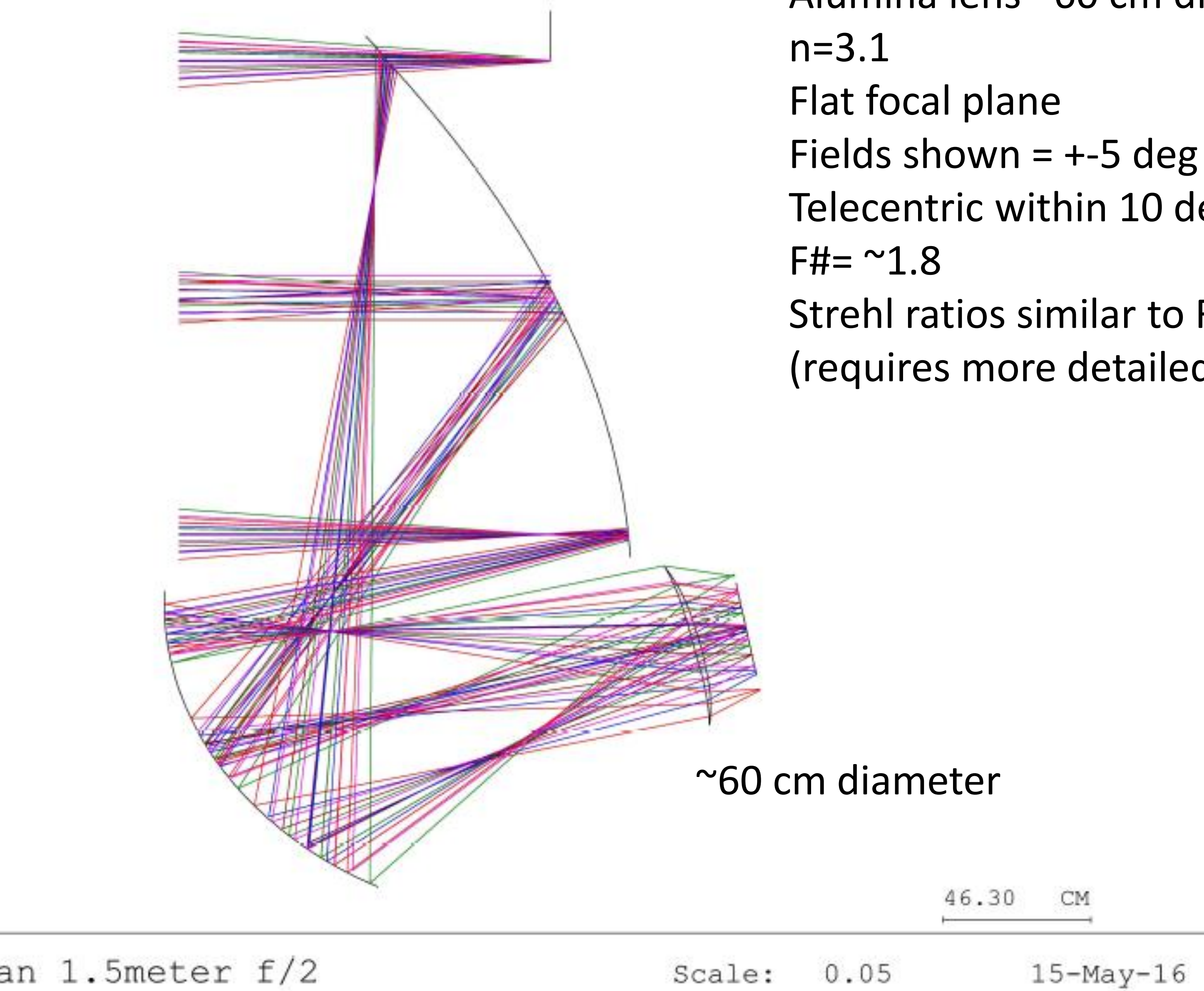
Results

Field (degrees)	Freq. (GHz)	AOI (deg)	Defocus (cm)		Strehl at focus	Strehl				average delta strehl/cm
			4''	3''		4'' outer	4'' inner	3'' outer	3'' inner	
-5	60	30.9	3.150	2.347	0.89	0.81	0.72	0.85	0.78	0.03
-3	150	25.9	2.419	1.803	0.93	0.57	0.60	0.70	0.740	0.13
-2	300	23.3	2.031	1.514	0.90	0.22	0.40	0.35	0.62	0.28
0	600	17.9	1.214	0.904	0.90	0.28	0.23	0.45	0.38	0.53
2	300	8.6	0.216	0.161	0.71	0.70	0.71	0.70	0.71	0.025
3	150	11.5	0.231	0.172	0.81	0.80	0.81	0.81	0.81	0.01
5	60	17.39	1.136	0.846	0.86	0.88	0.83	0.87	0.84	0.02

Need to steer the beams

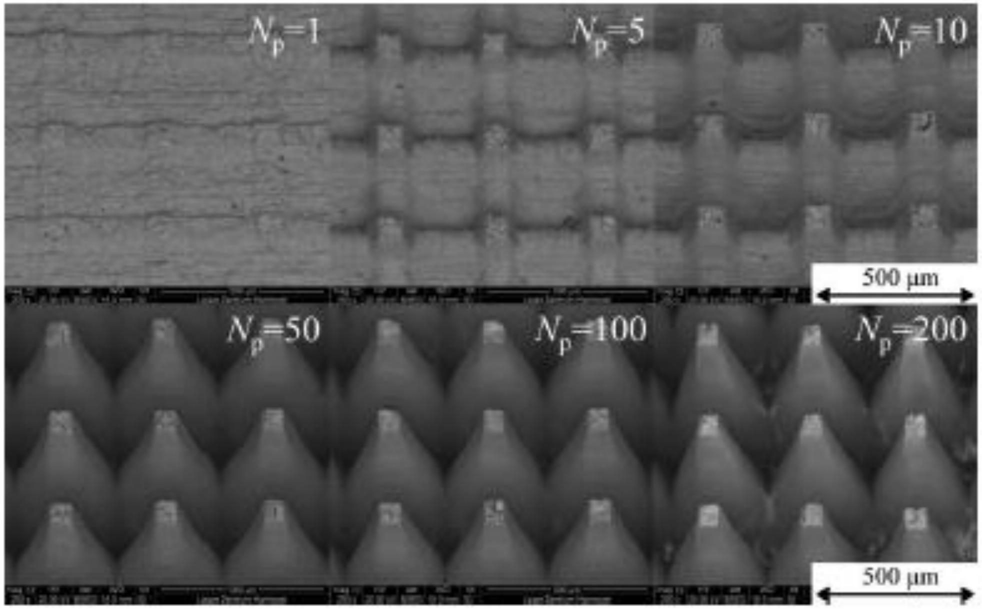
Or – Use a Lens?

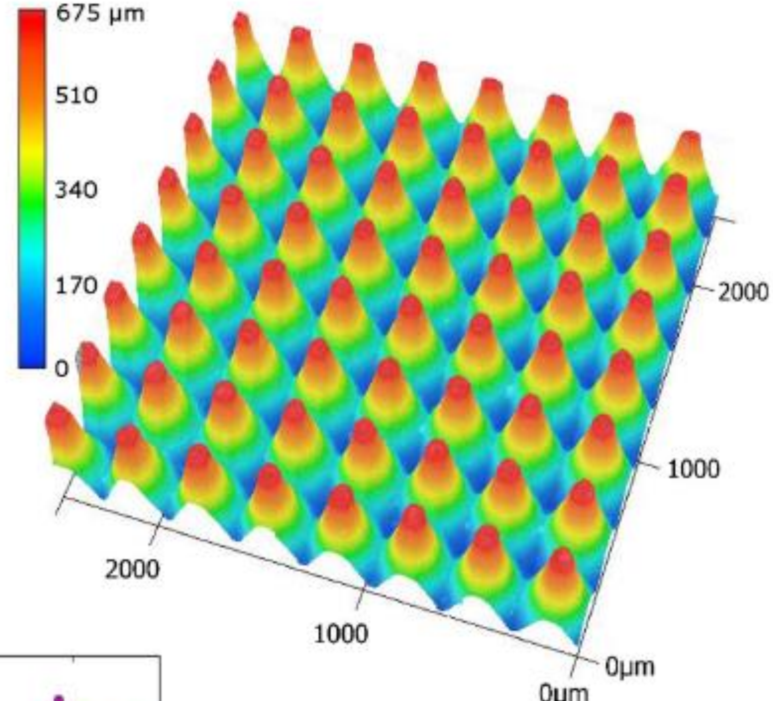
Alumina lens ~60 cm diameter
n=3.1
Flat focal plane
Fields shown = +-5 deg
Telecentric within 10 deg
F#= ~1.8
Strehl ratios similar to F#=2
(requires more detailed study)

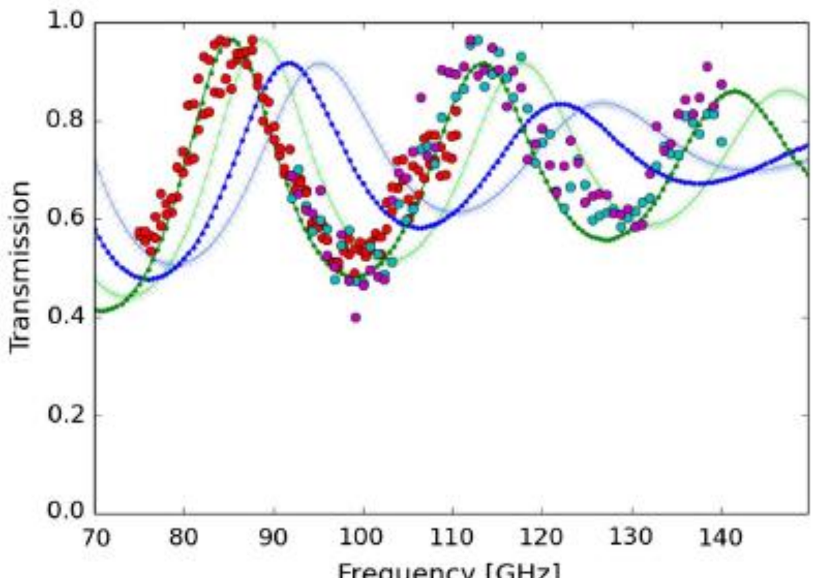


~60 cm diameter

Broadband ARC – Laser Ablation







Matsumura et al. 2016

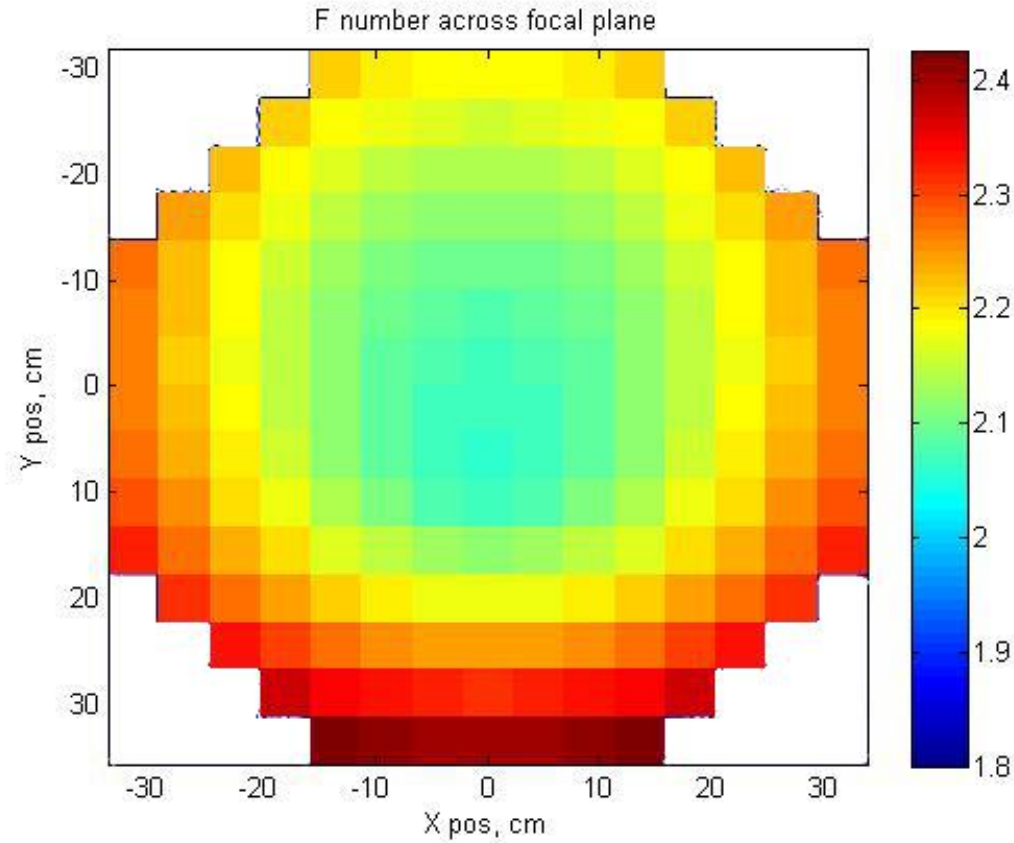
Summary

- So far: 1.5 m; Should we look at 1.2 m?
- Low T baffles/stop
  - Baffles: OK
  - Stop: questionable
  - Do more detailed GRASP for polarization and far sidelobes
- Focal Plane:
  - Steer the beam
  - Use lens?

Backup Slides

To Do

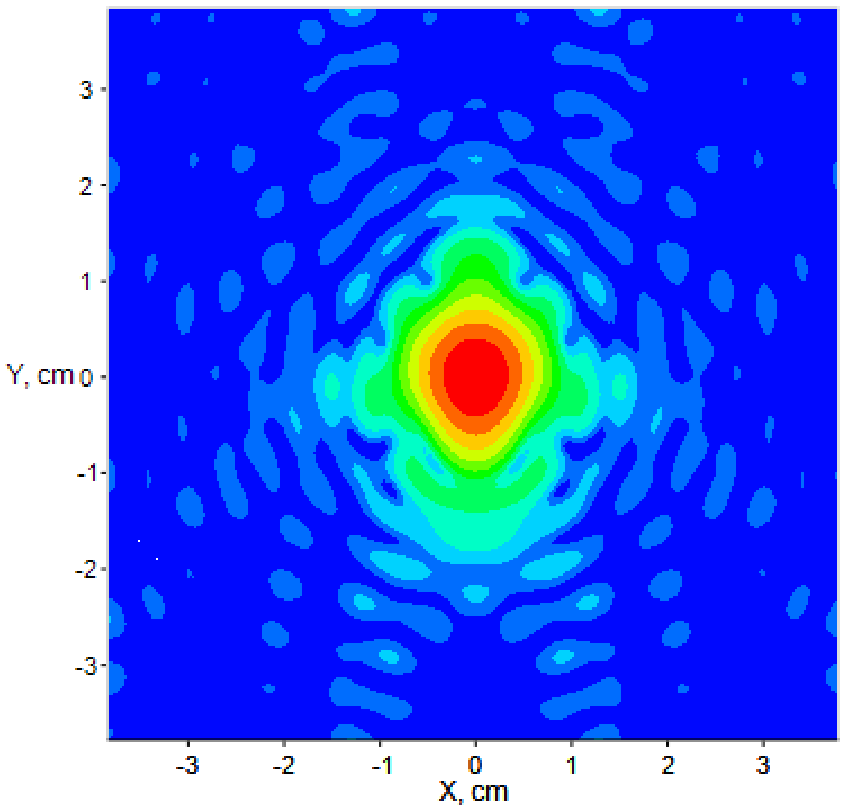
F-number across focal plane



For comparison EBEX2013 had f/# from 1.86 – 2.04

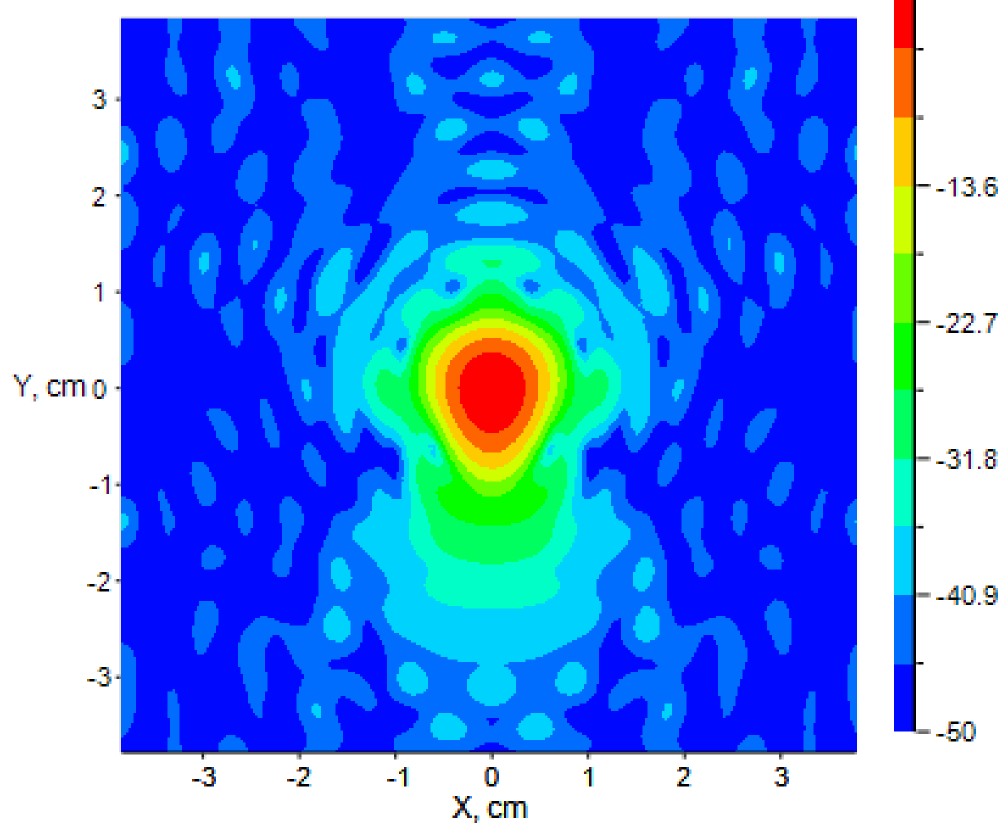
PSFs, at 150 GHz, 3 degrees elevation

Stop = primary



Strehl = 0.81

Stop = Cold

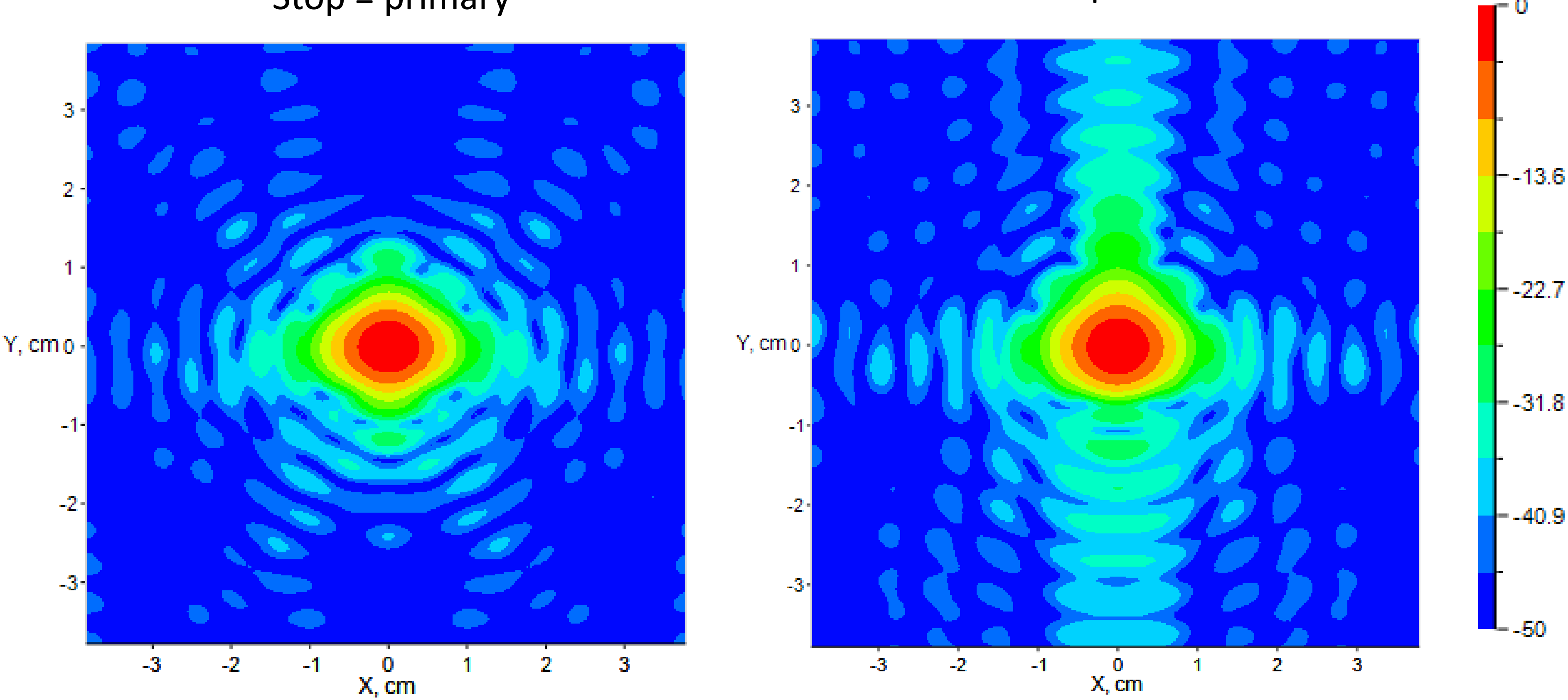


Strehl = 0.83

PSFs, at 150 GHz, -4 degrees elevation

Stop = primary

Stop = Cold

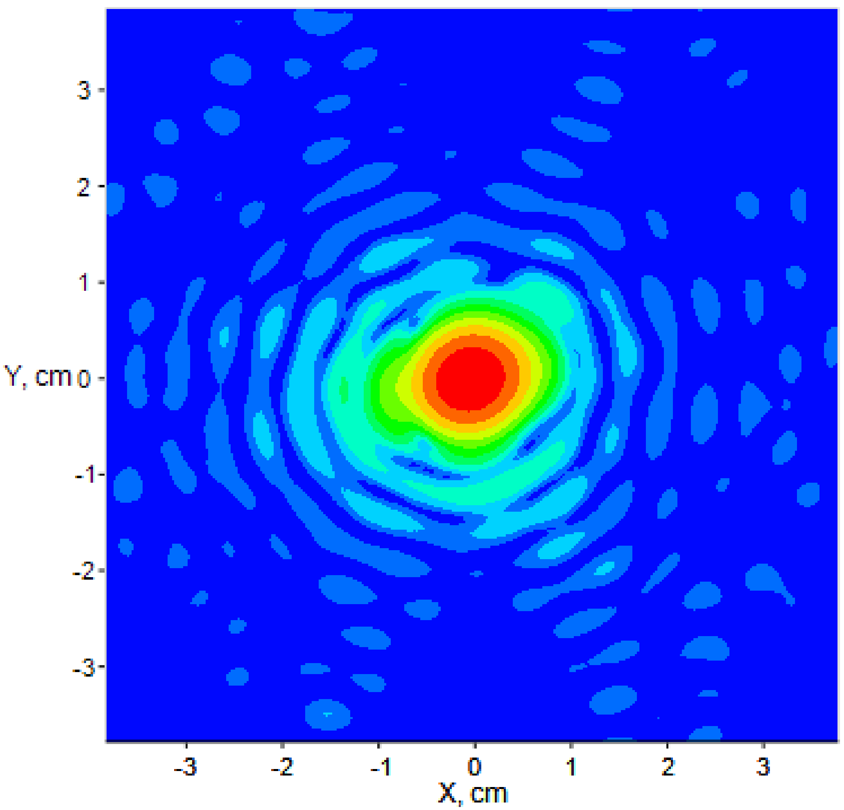


Strehl = 0.80

Strehl = 0.81

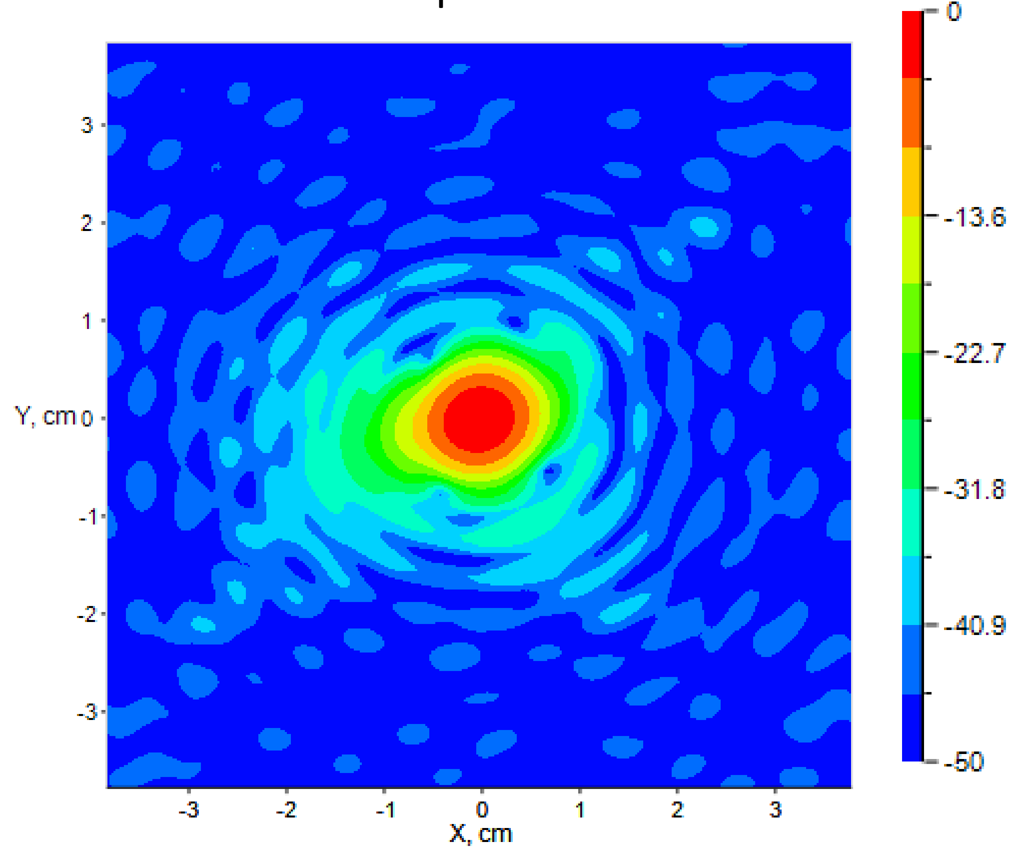
PSFs, at 150 GHz, 3 degrees azimuth

Stop = primary



Strehl = 0.92

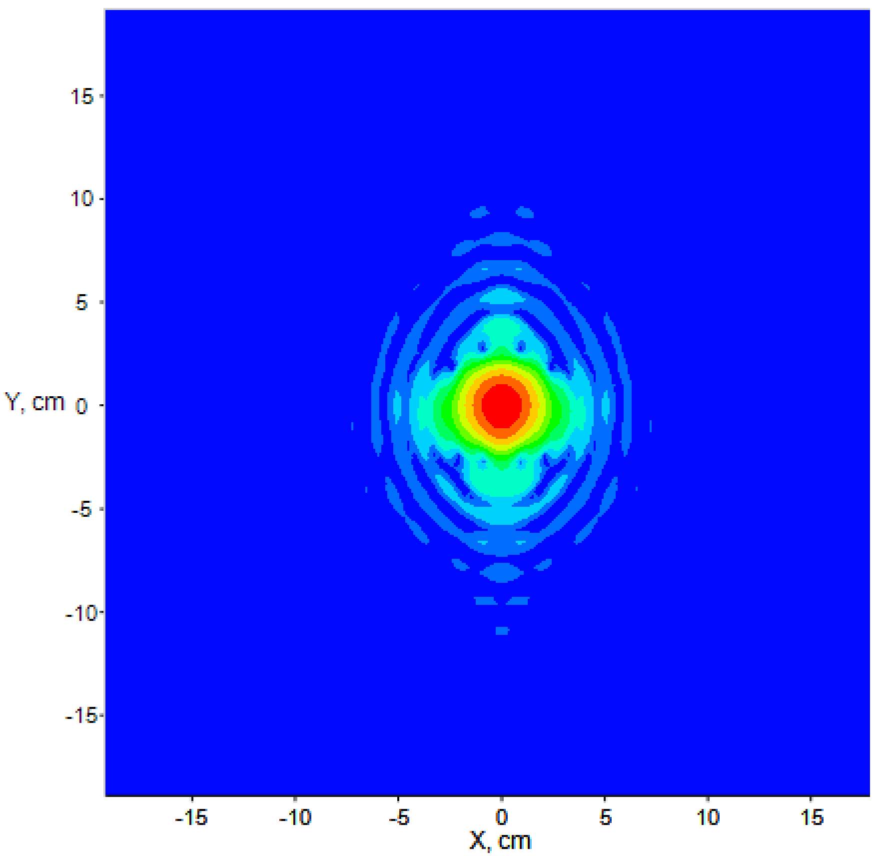
Stop = Cold



Strehl = 0.91

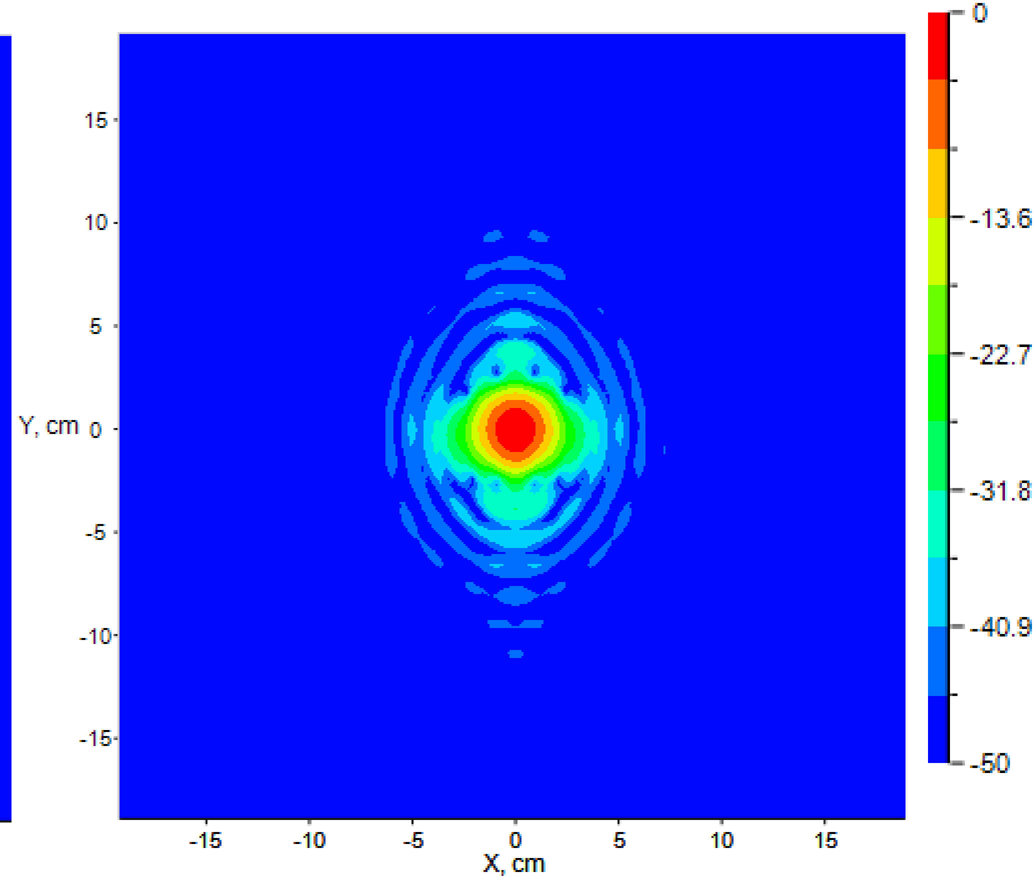
PSFs, at 60 GHz, 5.5 degrees elevation
Polarized input, primary is stop.

Vertical polarization,
E | | to Y axis



Strehl = 0.813

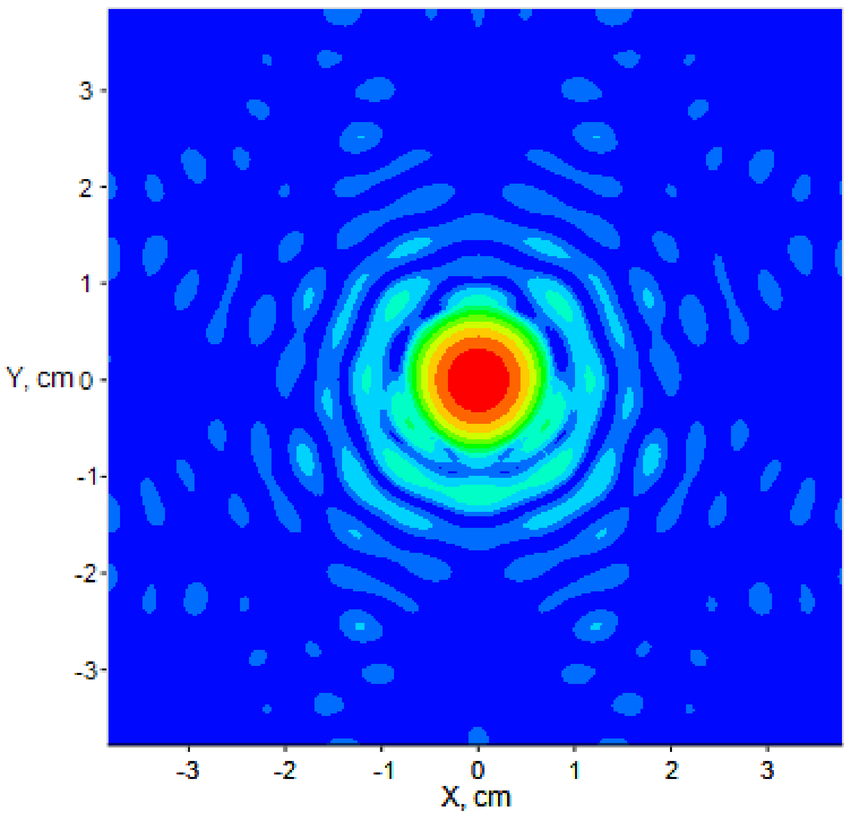
Horizontal polarization



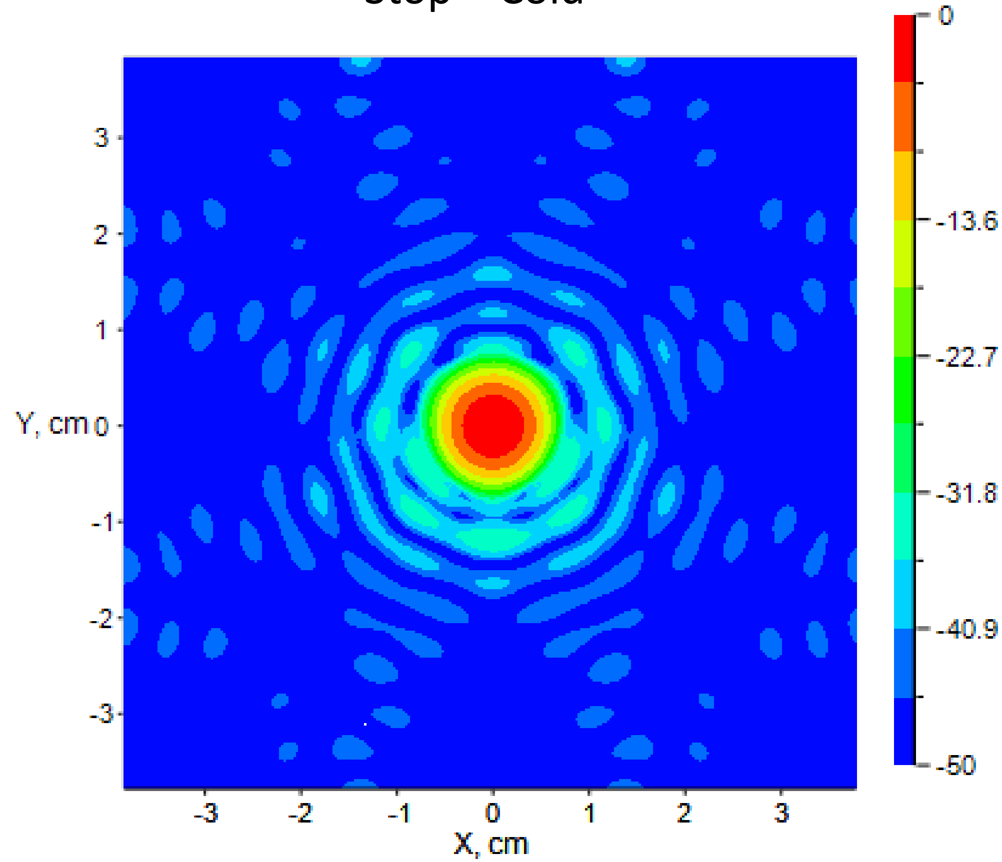
Strehl = 0.812

PSFs at 150 GHz, 0 degrees

Stop = primary



Stop = Cold



Strehl = .99 for both

Color scale dB at focal plane, normalized to 0.