PAFAR2022 – Nov. 15-17, 2022

A combination of PAF and spherical reflector to obtain large FoV

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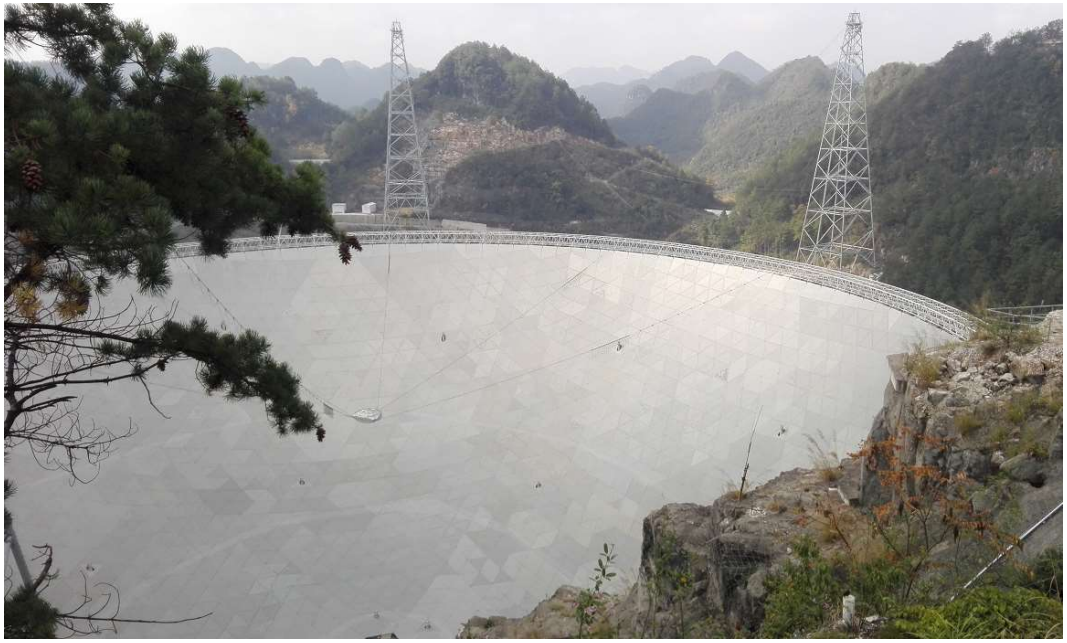
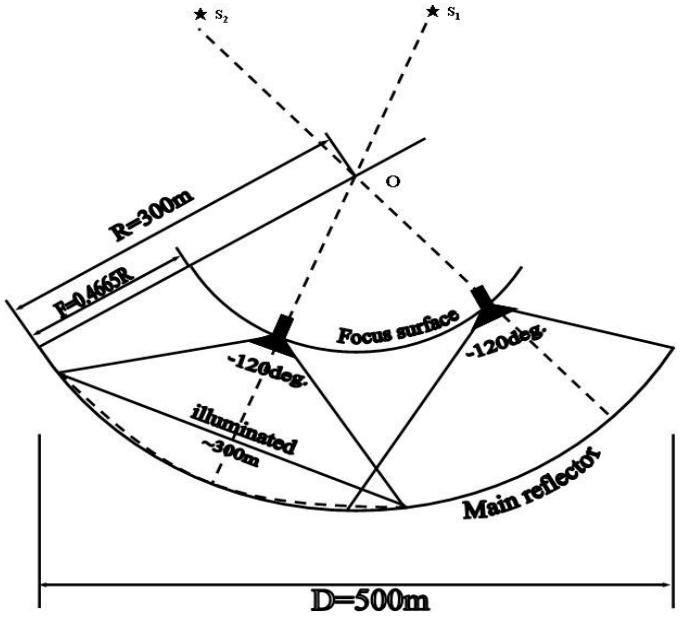
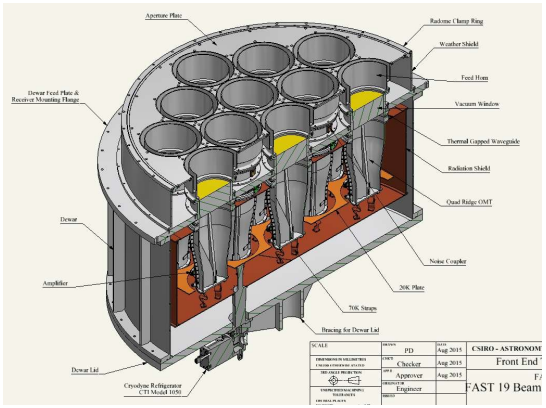
NAOC and MPIfR

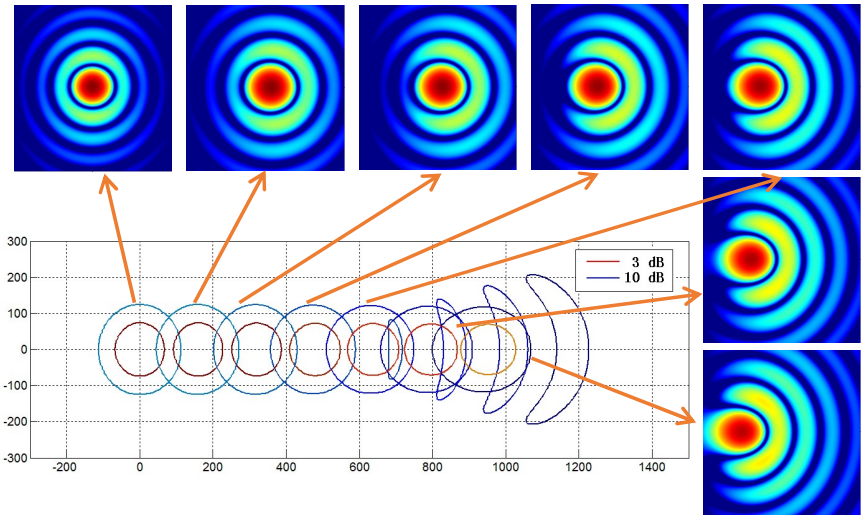
FAST：active surface + light focus suspention

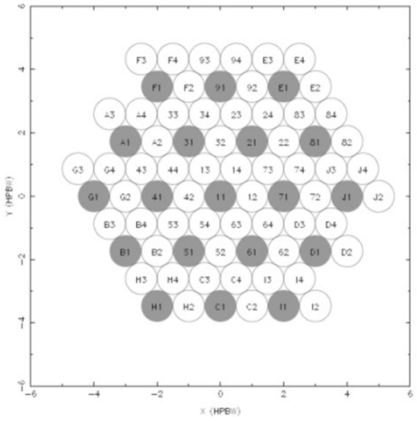


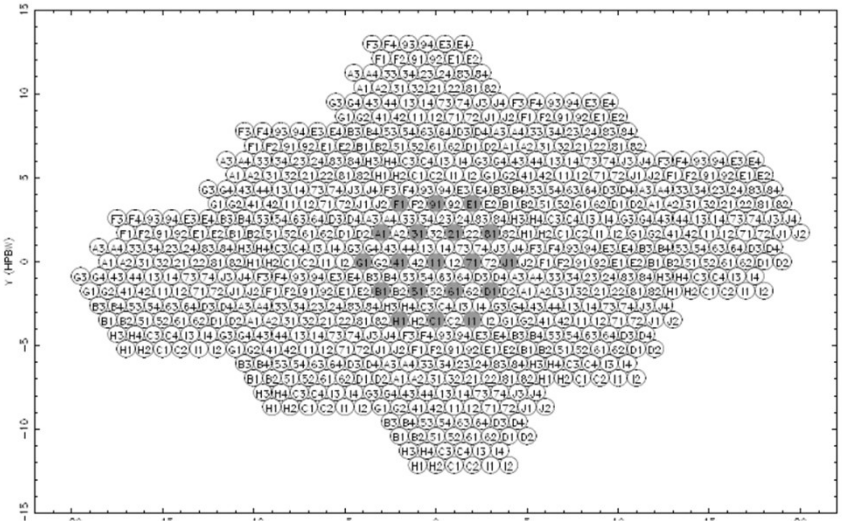


The 19-horn receiver on FAST

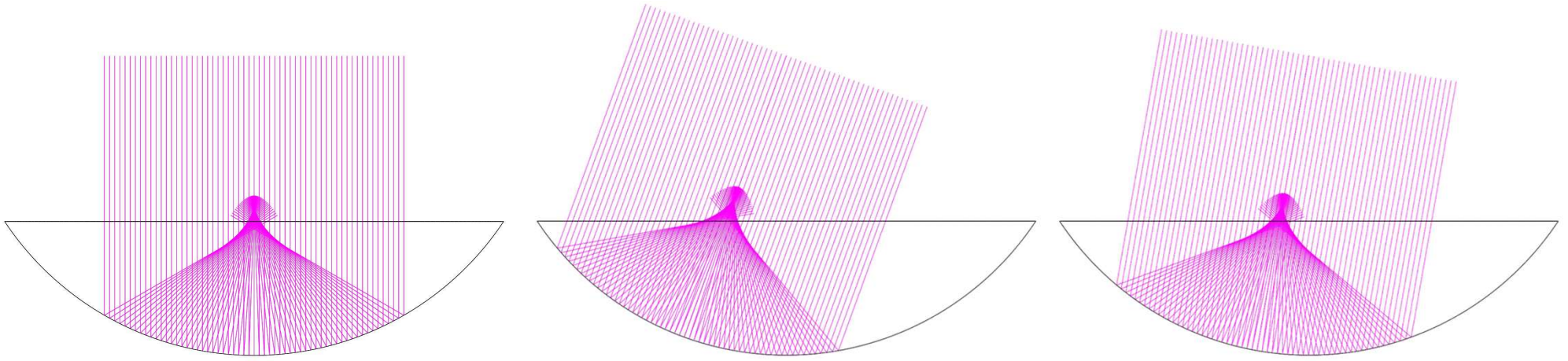








Reflection from a Spherical Reflector

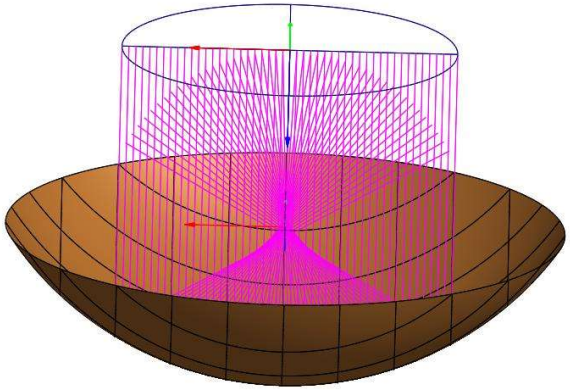


0 deg

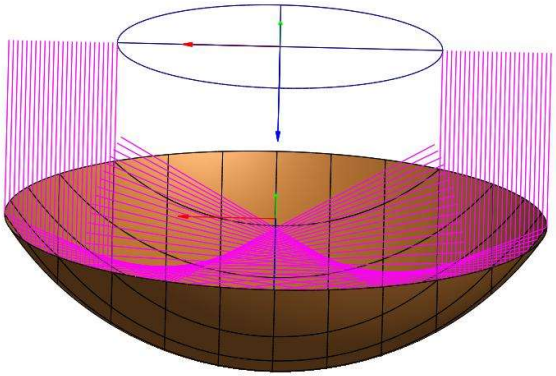
10 deg

20 deg

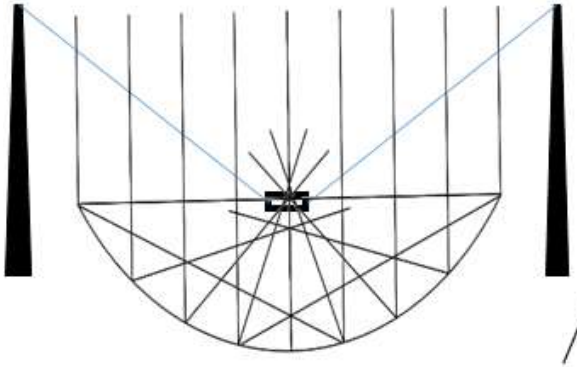
Large Spherical Reflector + PAF receiver



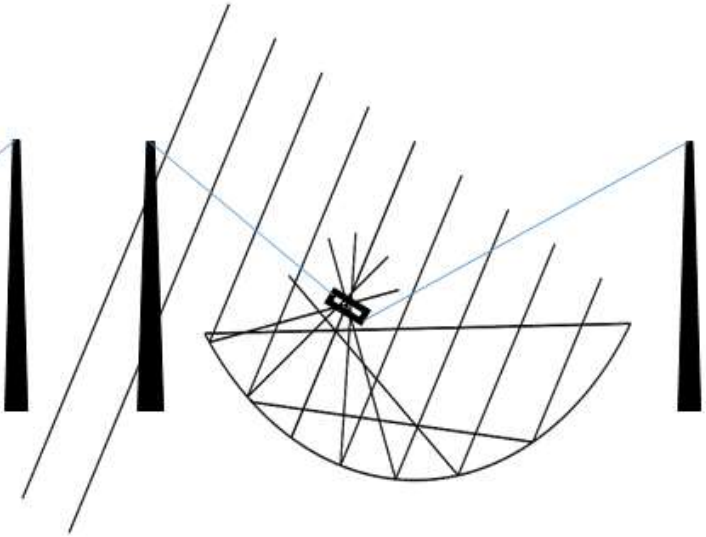
r < 150



150 < r < 250

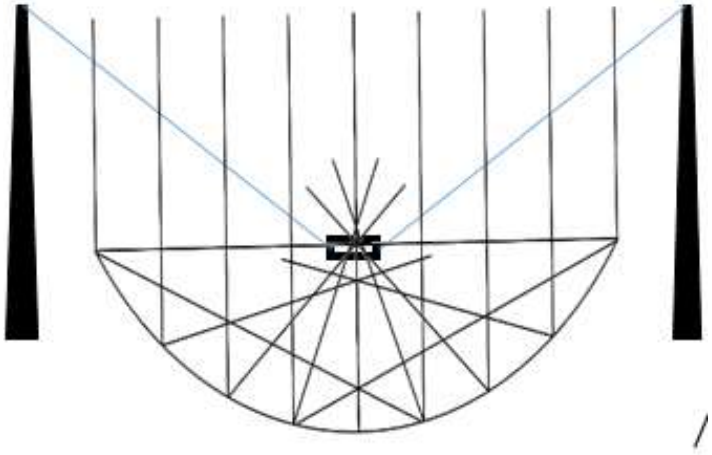


0-deg zenith angle



30-deg zenith angle

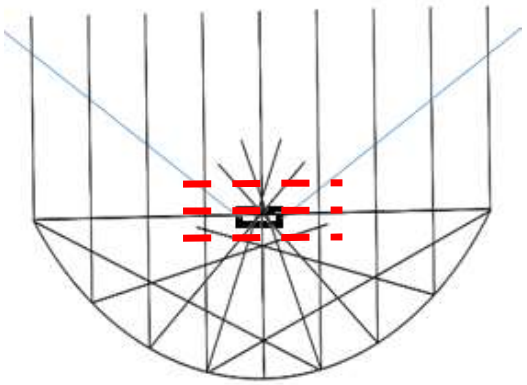
Spherical surface + PAF receiver

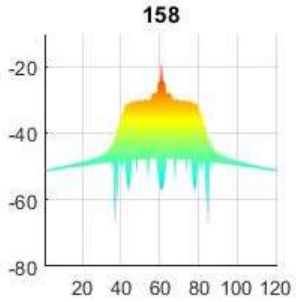


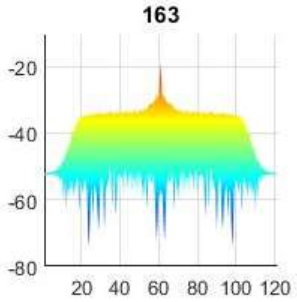
- Efficiency
- System Noise Temperature
- FoV – Field of View

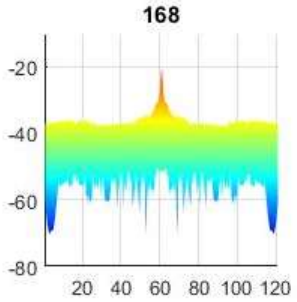
- Technical feasibility

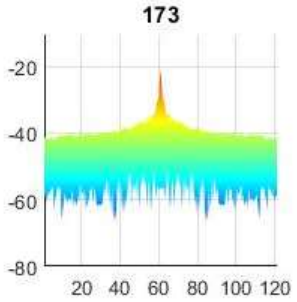
The “focal” field distributions across a 10 X 10m region

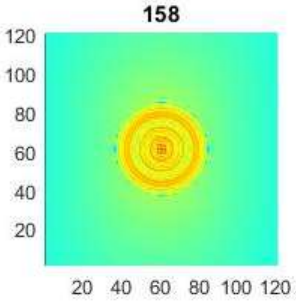


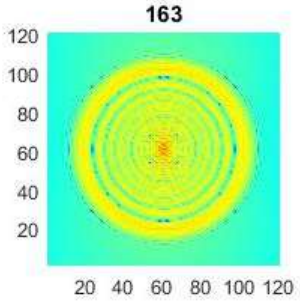


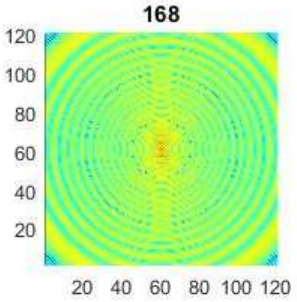


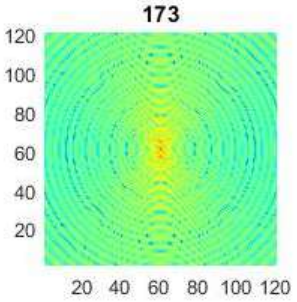




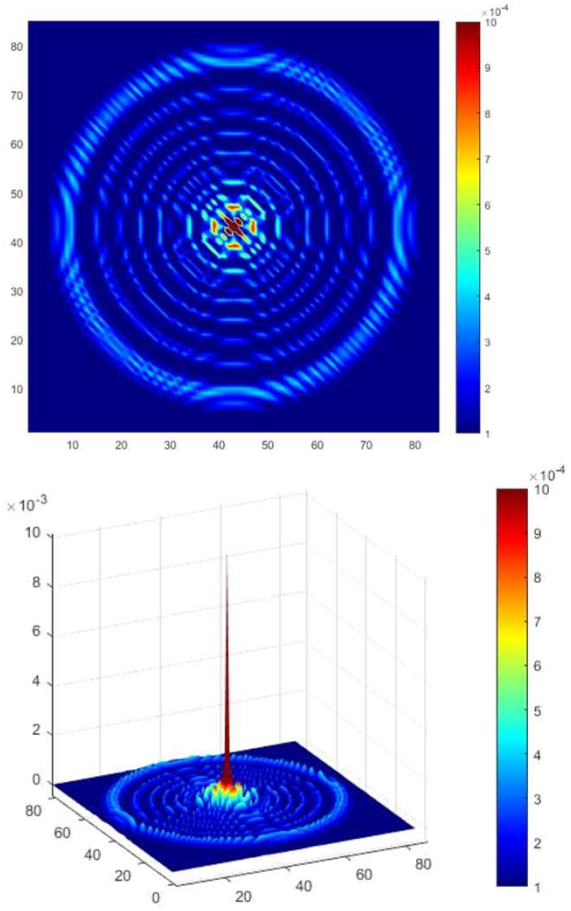








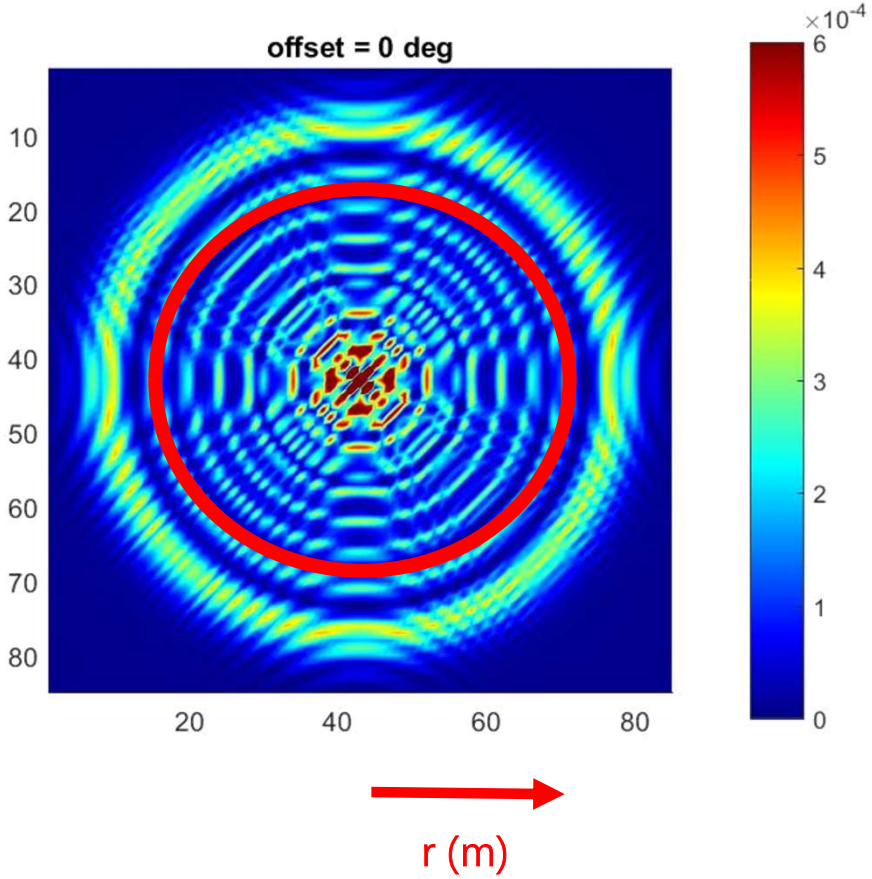
Efficiency of the Spherical reflector + PAF receiver

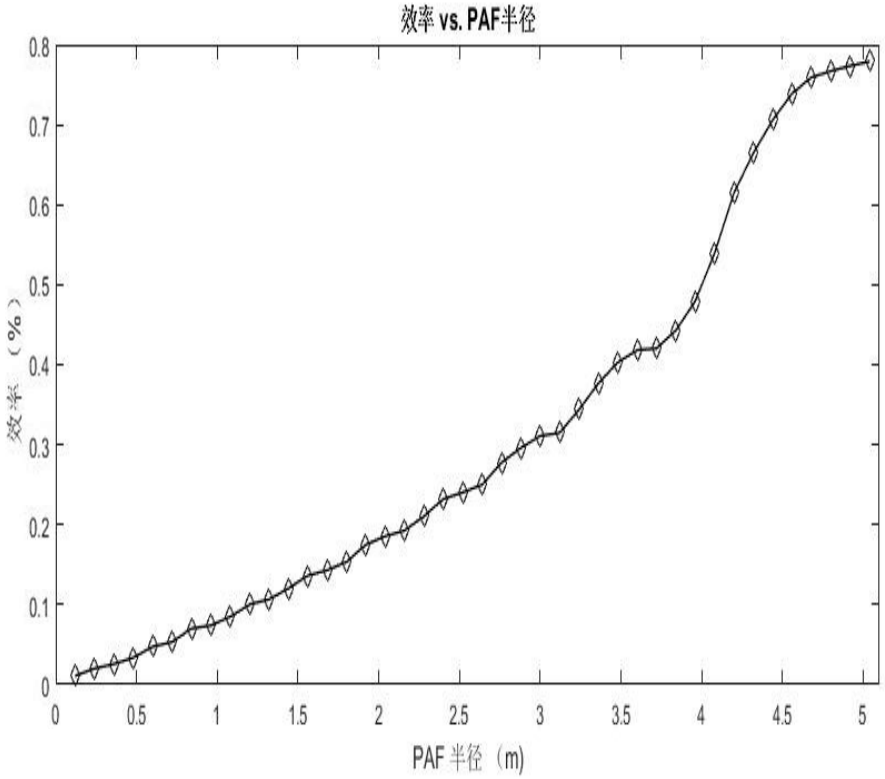


- Zenith angle : 0 degree
- PAF receiver
  - Element size: 12 cm
  - Edge taper： 4.4dB @ 56.4 deg
  - Square array: 85 X 85
- Efficiency： 79.3%

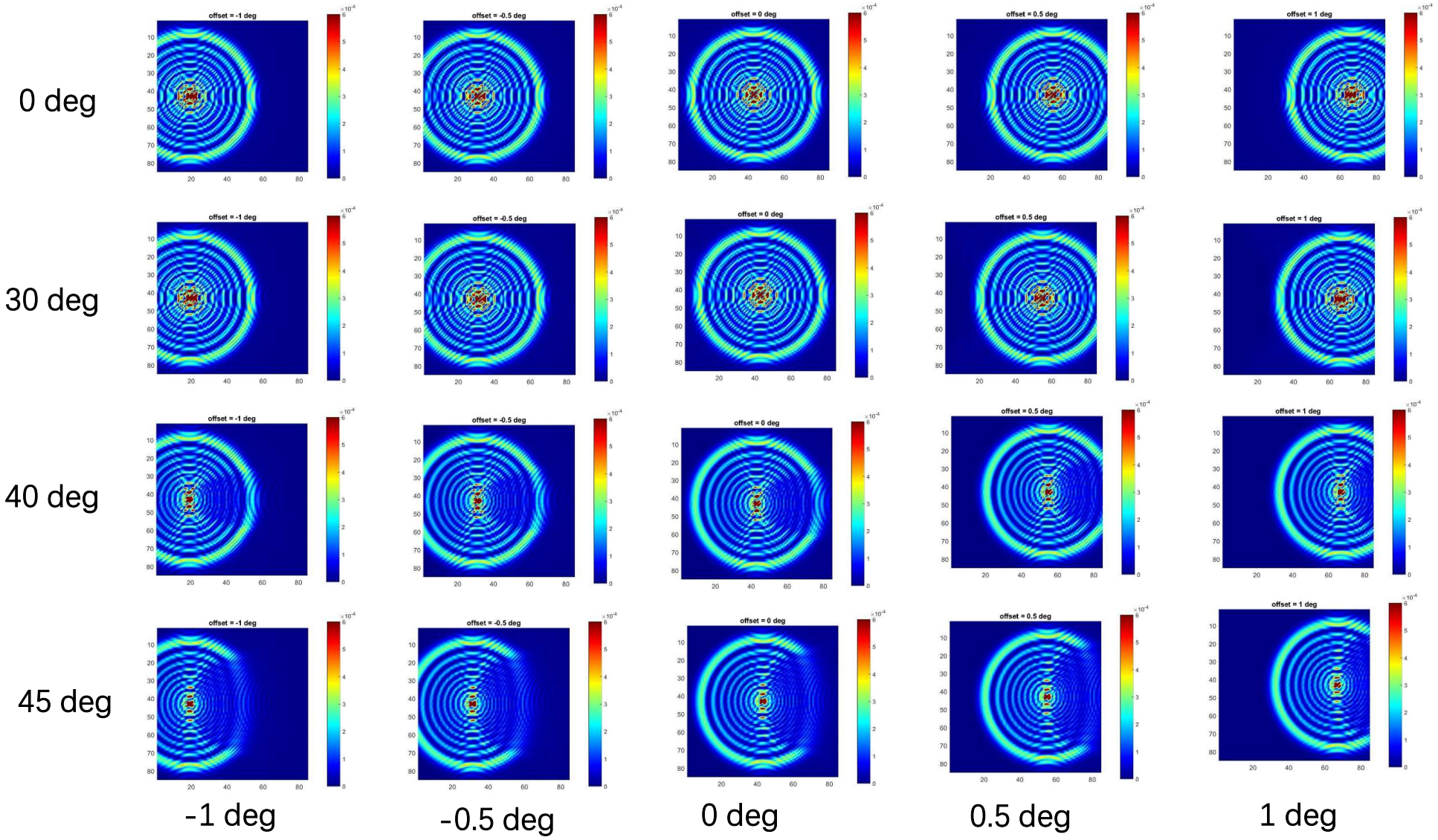
  (normalized to a 300m aperture)

Received Energy vs. Size of PAF(1.4GHz)

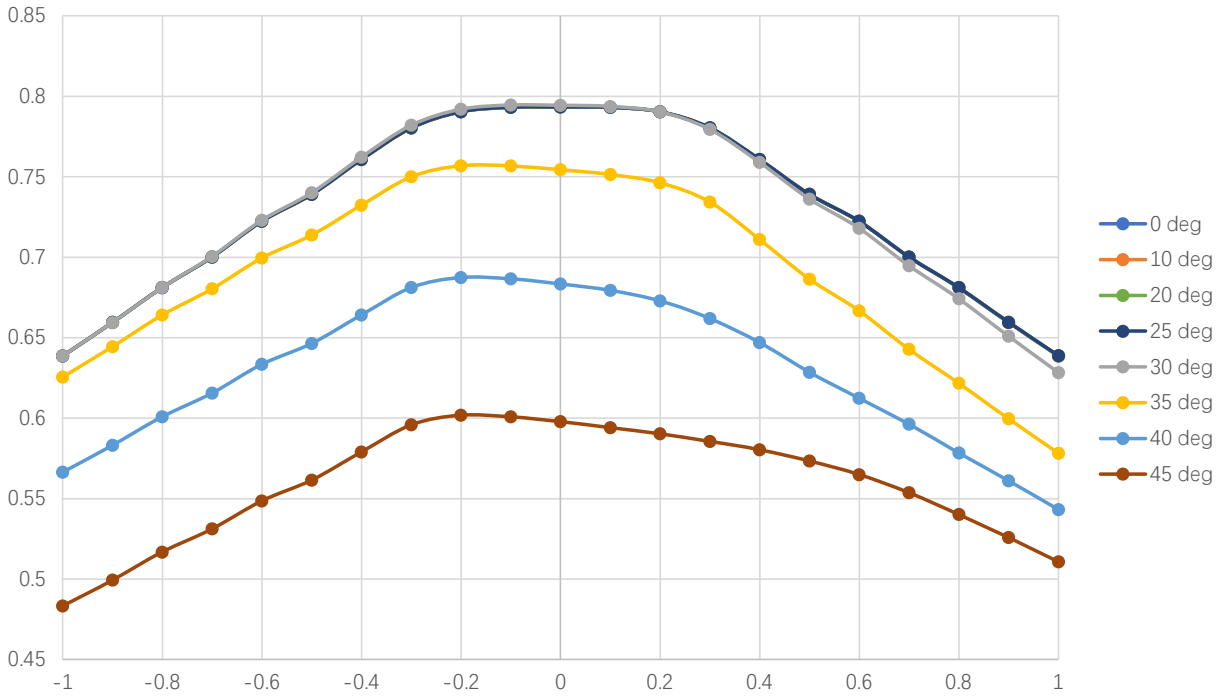




The distribution of received energy across the PAF array

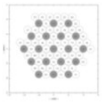


Efficiency of the Spherical surface + PAF at various zenith angle and off-axis angle

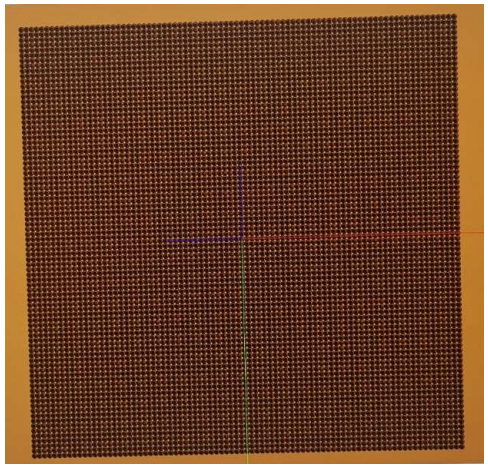


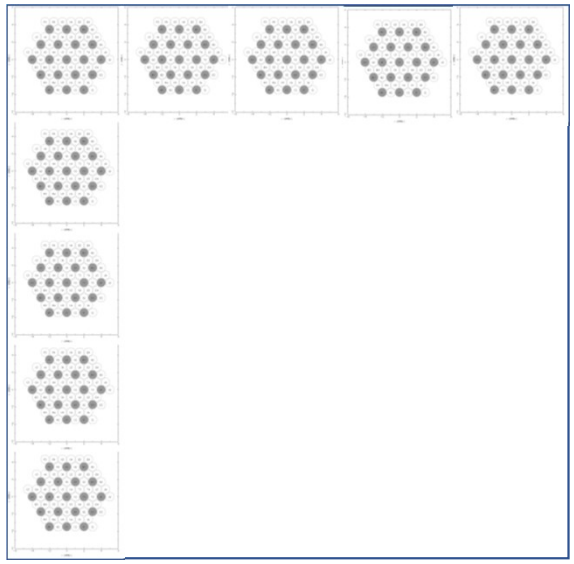
- Zenith angle: 0 – 40 deg
- Off-axis angle: -1 ~ 1 deg
- Efficiency > 50% at 45-deg zenith angle
- The efficiency at 40-deg is 14% lower than that at 0-deg zenith angle.
- In the case of FAST, the corresponding reduction in efficiency is ~ 25%. This imply that this spherical surface + PAF combination may work at higher zenith angle

FoV of FAST vs. the Spherical surface + PAF



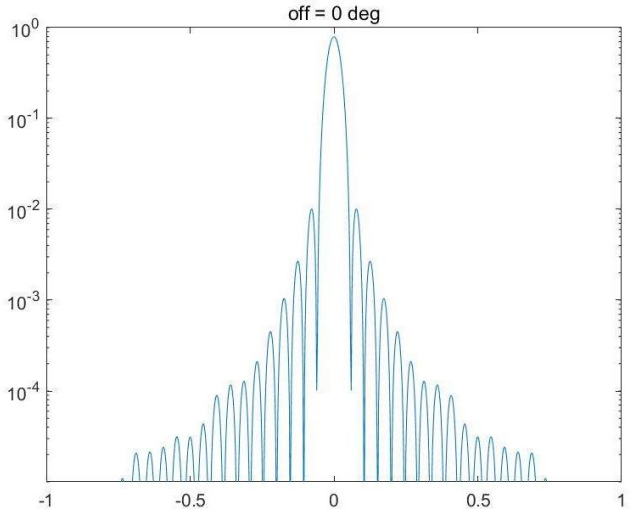
Beam size: ~ 0.05 deg
Number of beams: 19

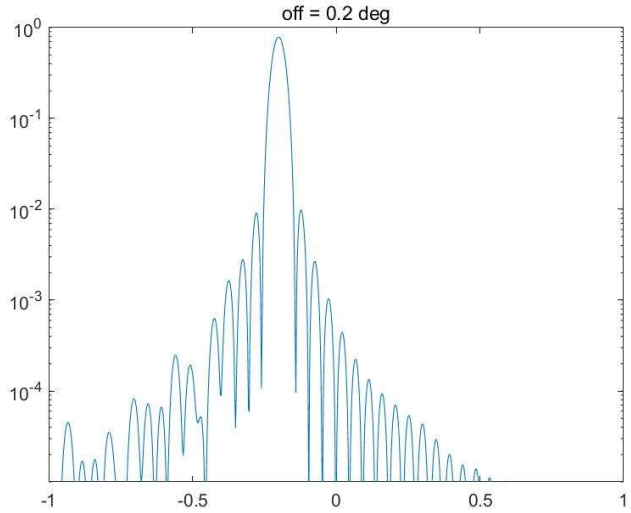


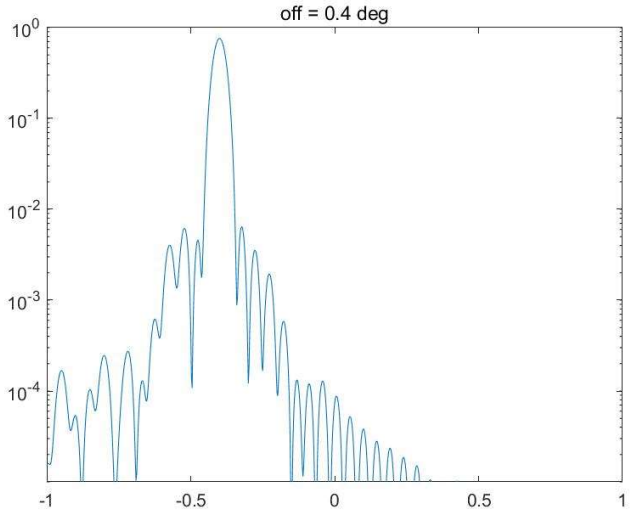


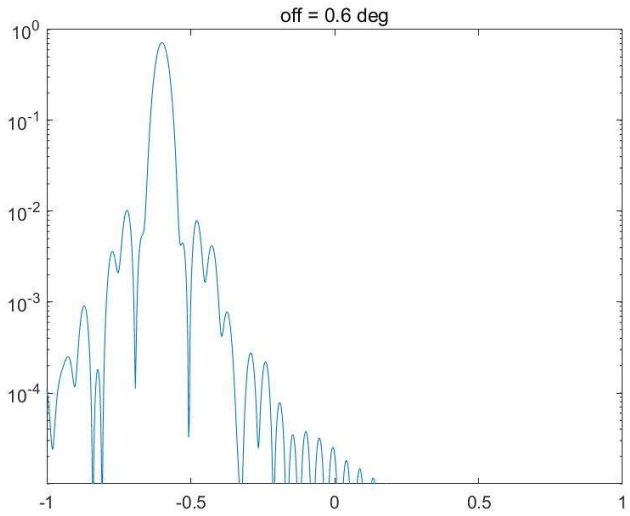
FoV: 2 X 2 = 4 square degree

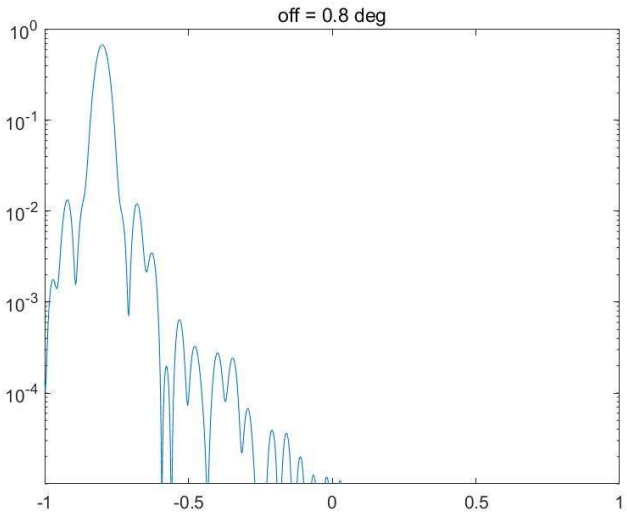
Far-field pattern of spherical surface + PAF under CEM mode

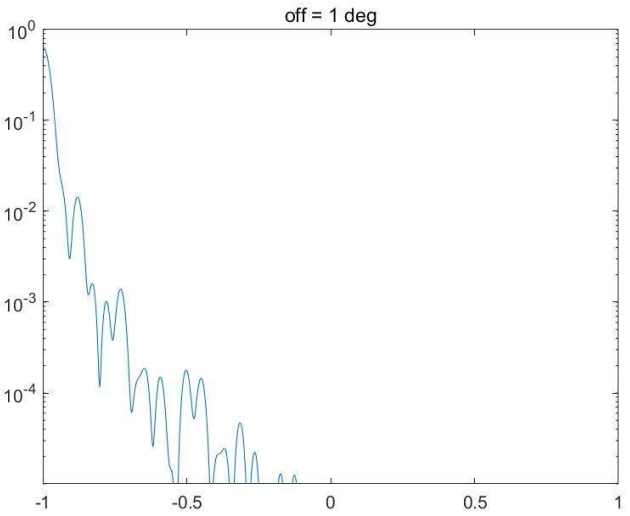




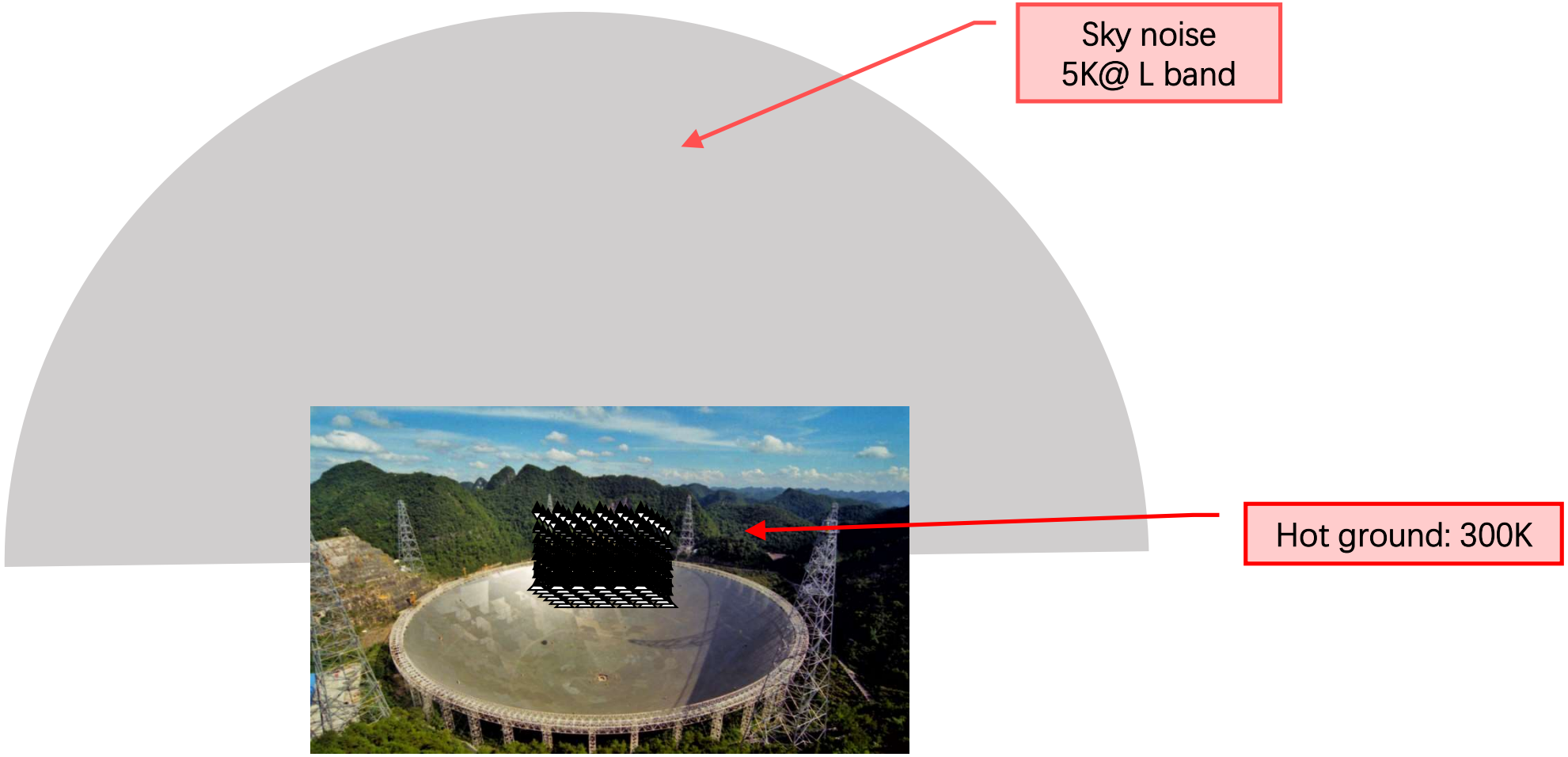






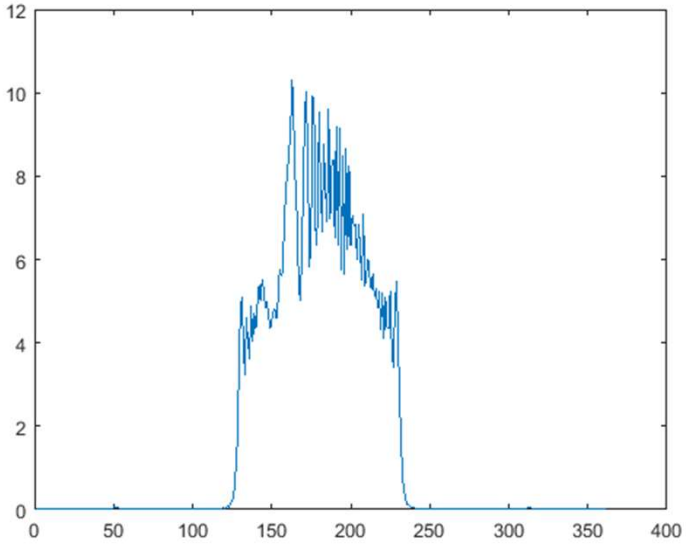


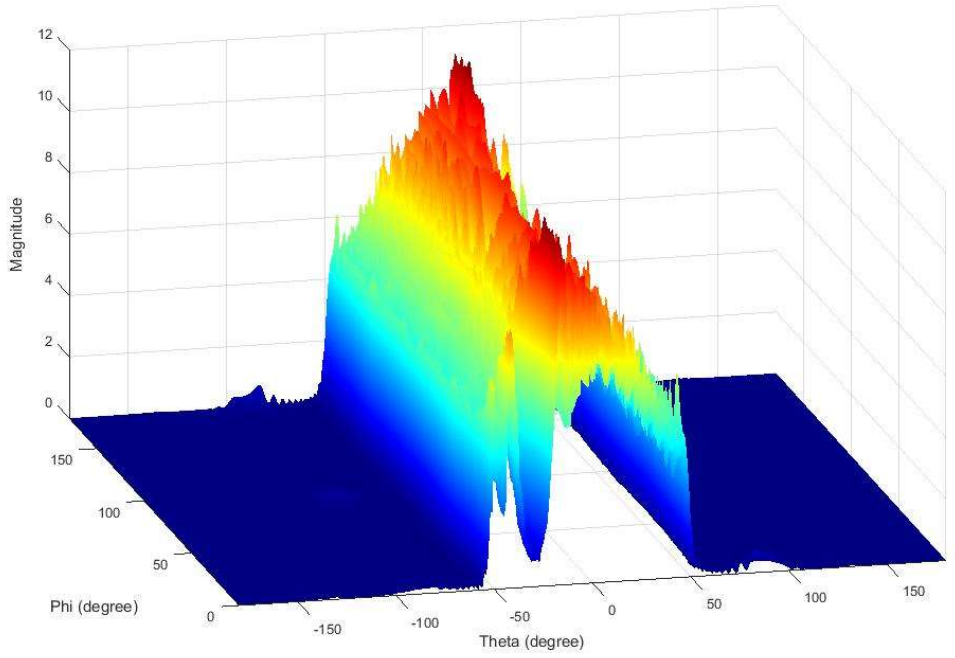
Tsys of the Spherical surface + PAF receiver



Tsys under Conjugate Field Matching mode

- Zenith angle： 0 degree
- Off-axis angle： 0.3 dgree





Sky （5K）

-180 ~ -100 deg
0.0088 K

Ground （300K）

-100 ~ -90 deg
0.42 K

Sky （5K）

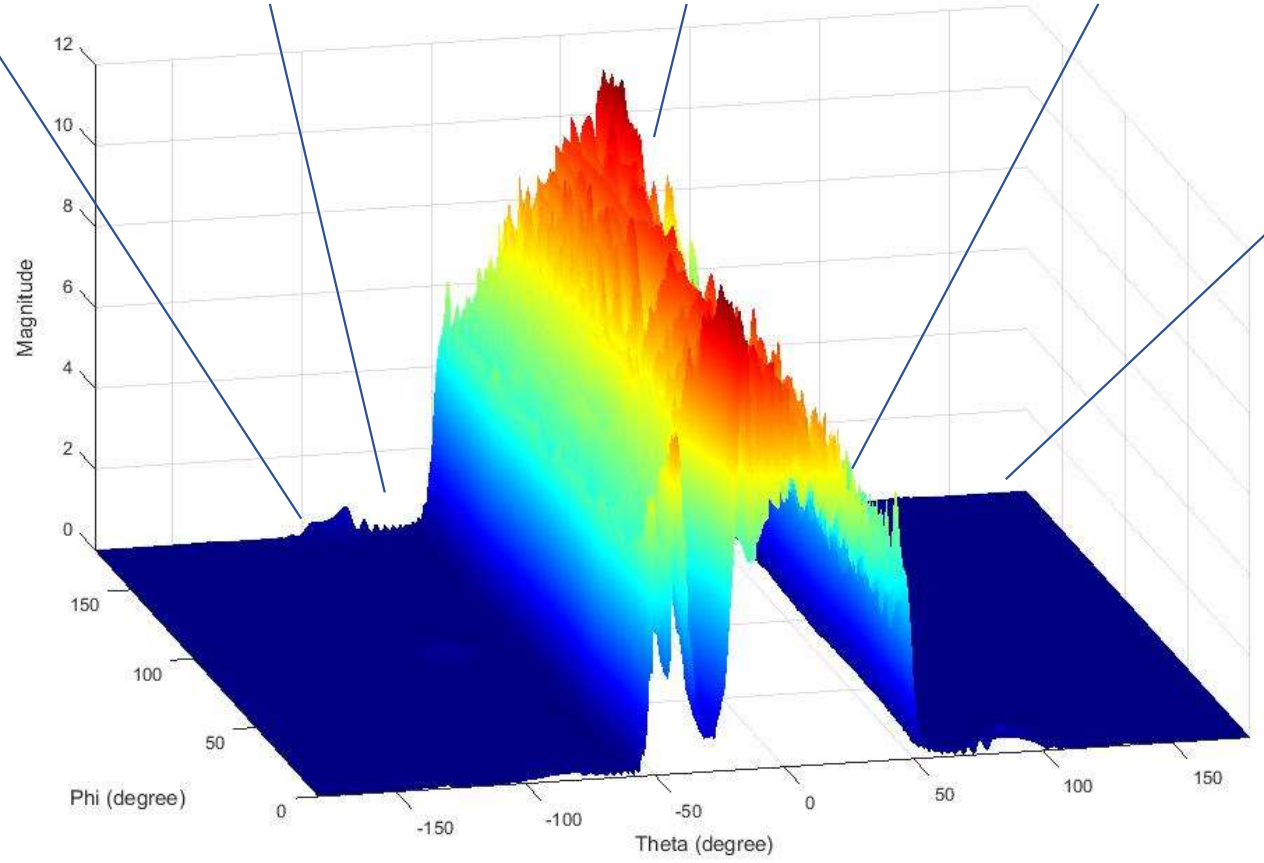
-90 ~ 90 deg
5.13 K

Ground （300K）

90 ~ 100 deg
0.37 K

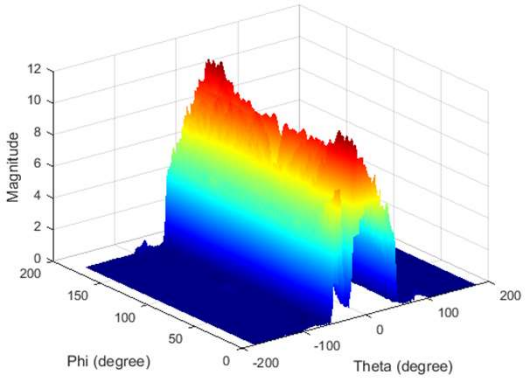
Sky （5K）

100 ~ 180 deg
0.0087 K



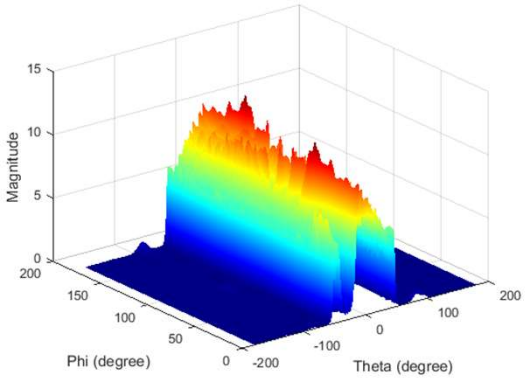
Tsys at various off-axis angle when zenith angle is 0 deg

Off-axis: 0.3 deg



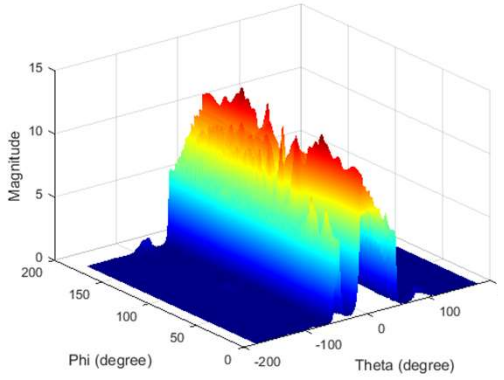
T_an = 5.84 K

Off-axis: 0.5 deg



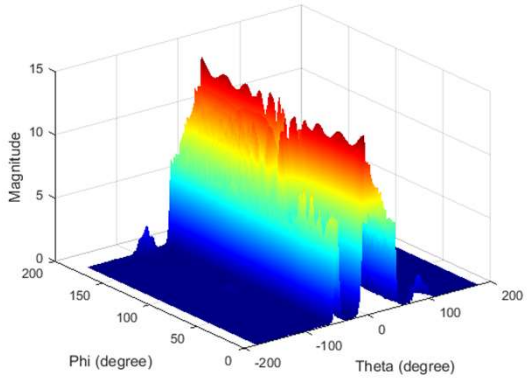
T_an = 5.96 K

Off-axis: 0.7 deg



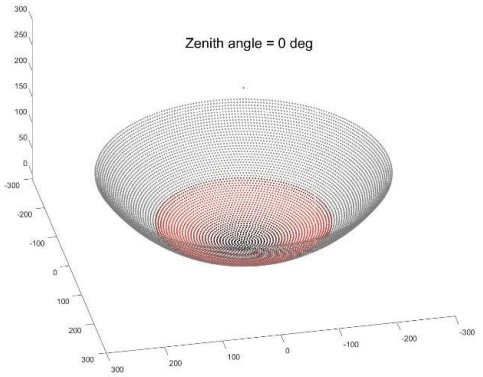
T_an = 6.12 K

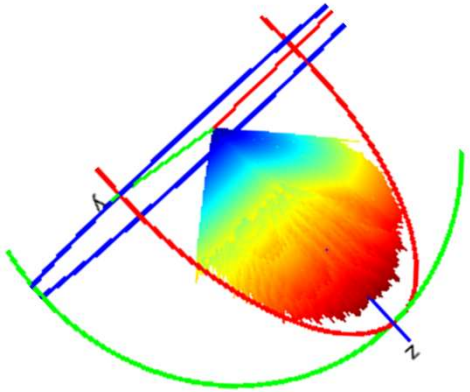
Off-axis: 1 deg

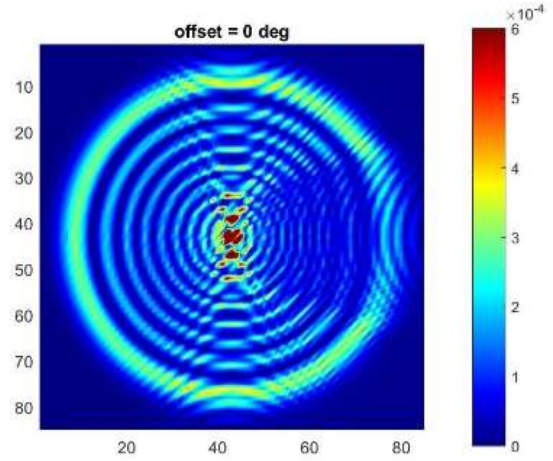


T_an = 6.67 K

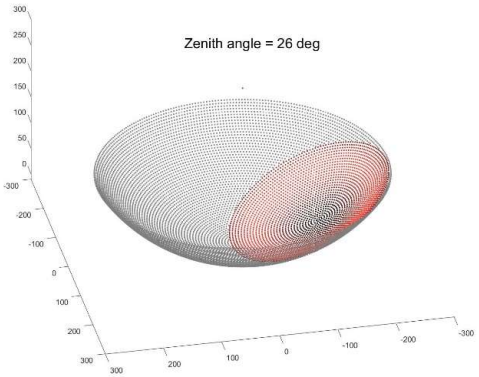
The far-field pattern of PAF under CFM mode (zenith angle = 40 deg)



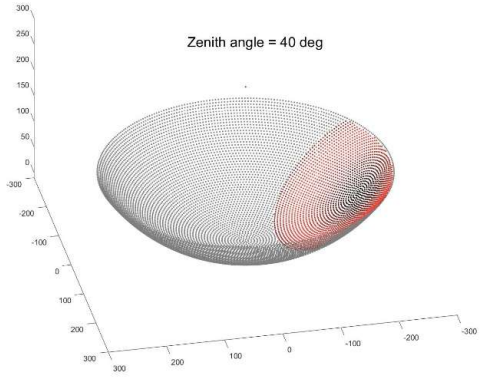




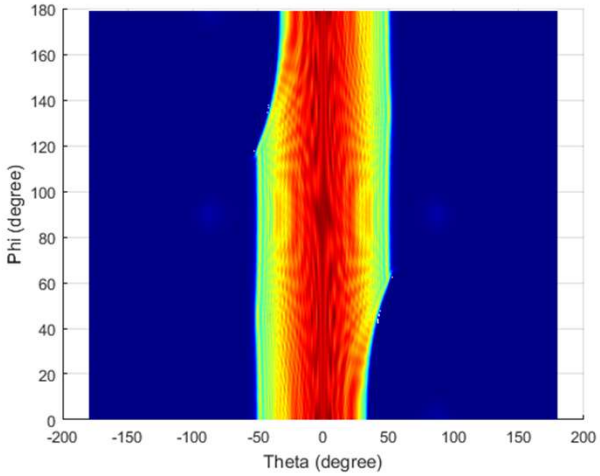
Zenith angle: 0 deg



Zenith angle: 26 deg

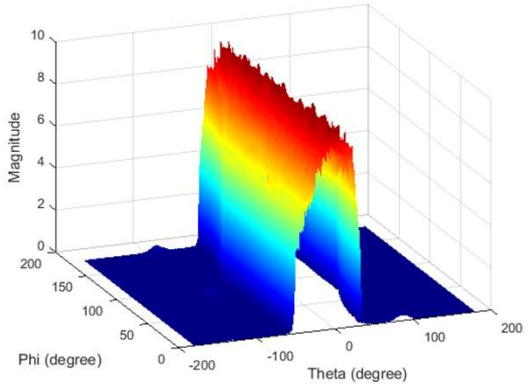


Zenith angle: 40 deg



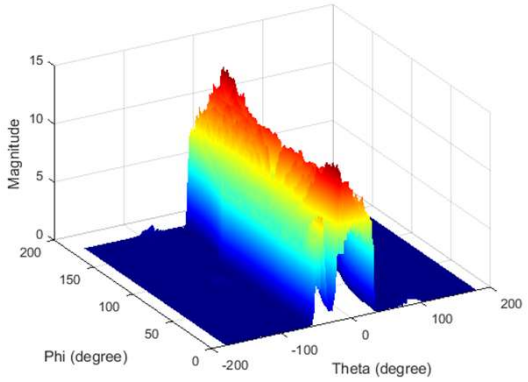
Tsys at various off-axis angle when zenith angle is 40 deg

Off-axis: 0 deg



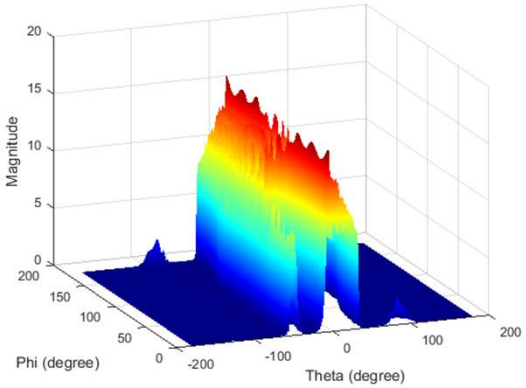
T_an =
5.97 K

Off-axis: 0.3 deg



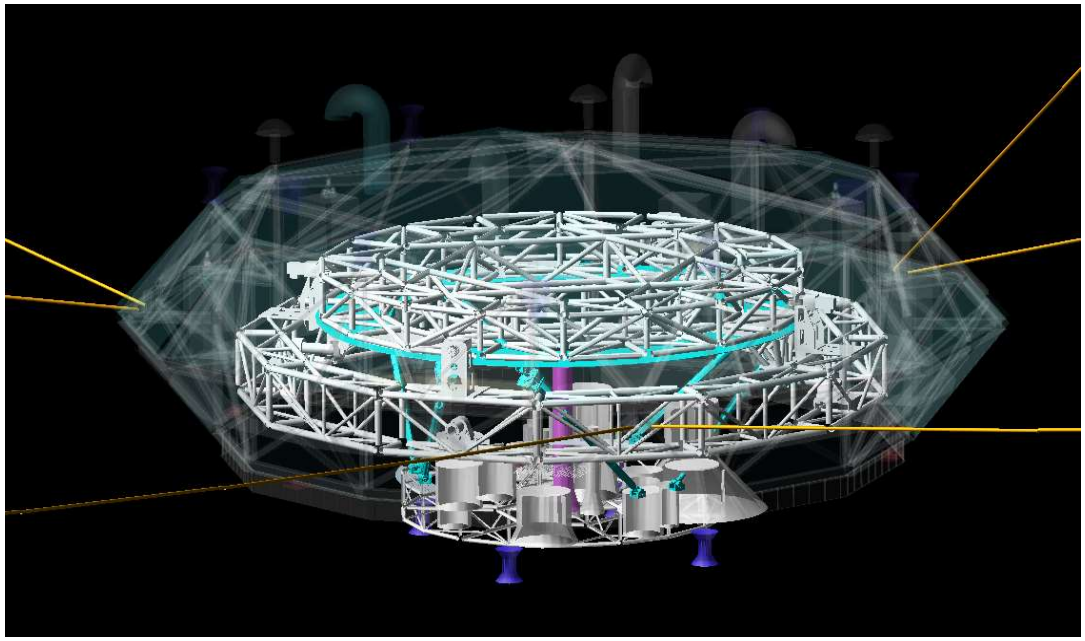
T_an =
6.04 K

Off-axis: 1 deg



T_an =
6.67 K

Focus cabin of the FAST



- **6 cables to the tower**
- **AB axis to set the orientation of the platform**
- **Stewart stabilizer to correct for the residual errors**

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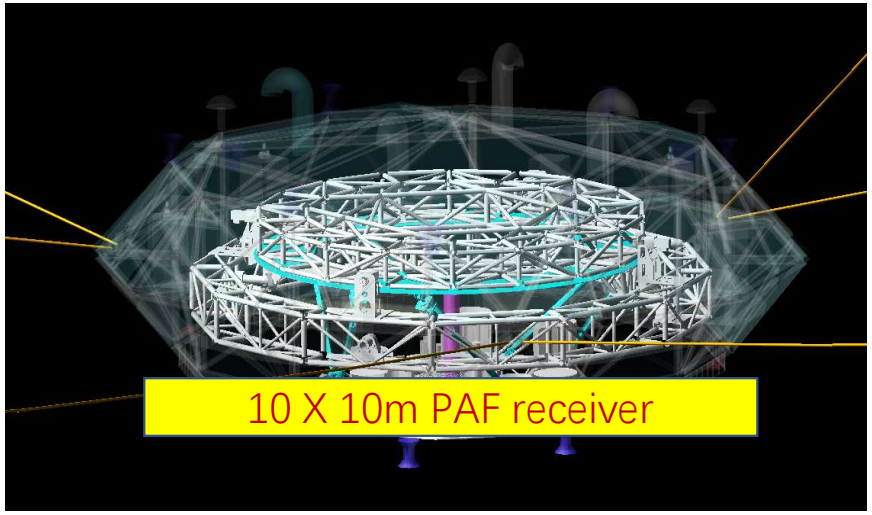
Focus cabin suspension for the spherical surface + PAF



- 6 cables to the tower
- AB axis to set the orientation of the platform
- Dynamic Beam-forming
  - Position and Orientation: Measured
  - Beam-forming: Dynamical

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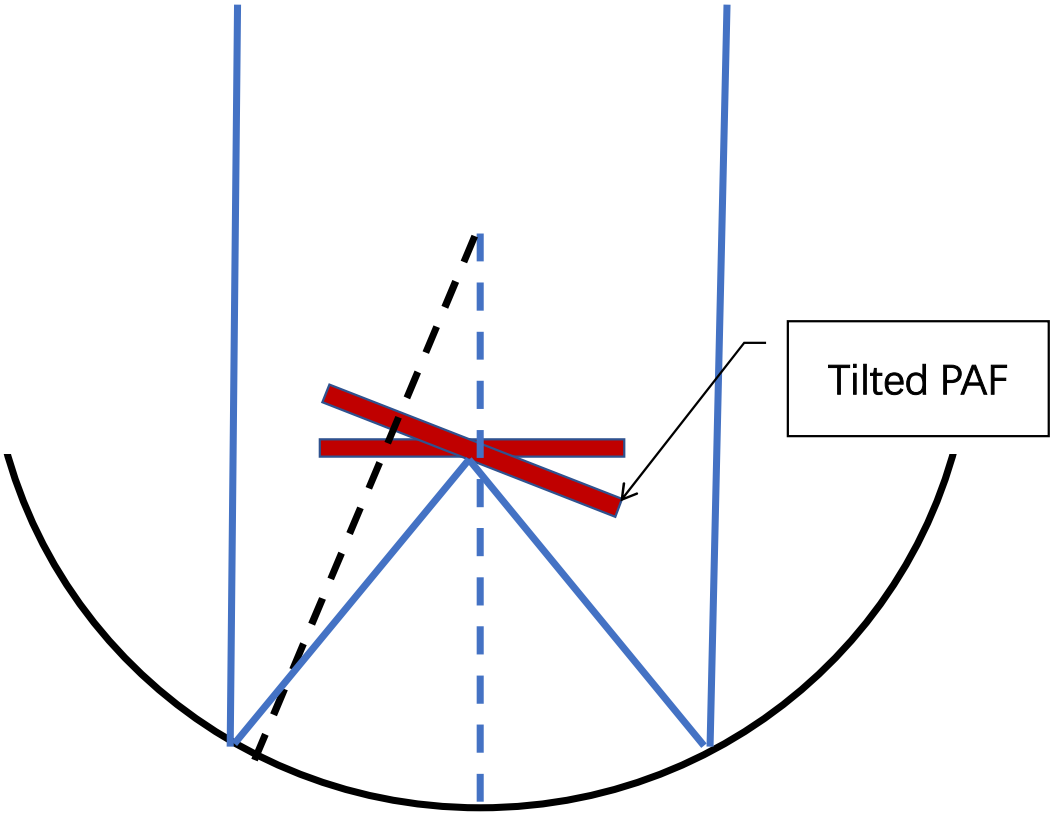
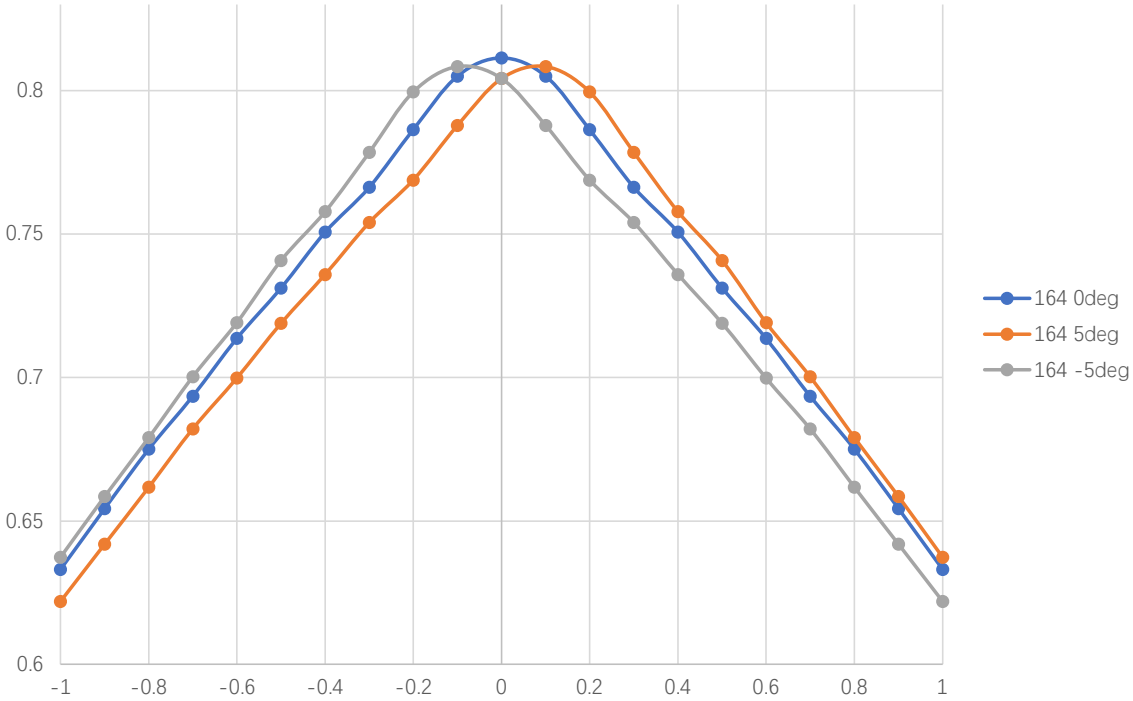
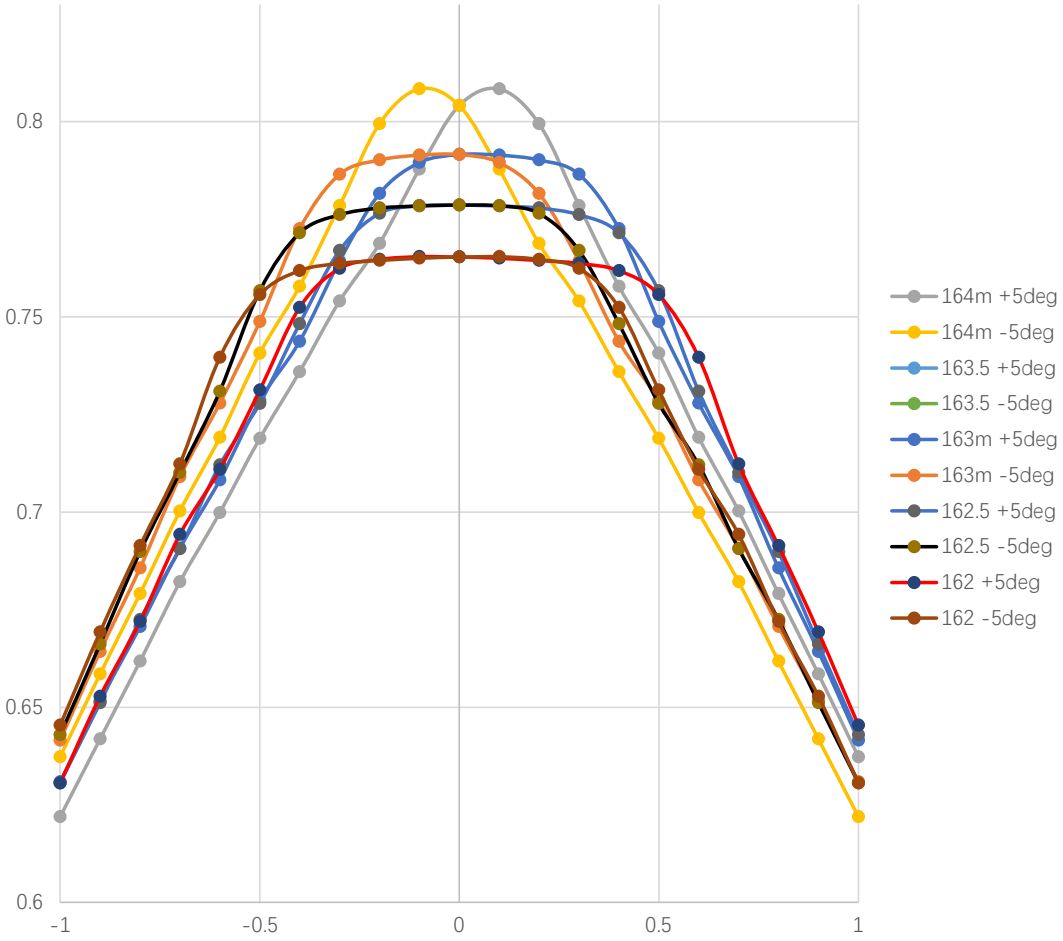
The effect of tilting the PAF receiver

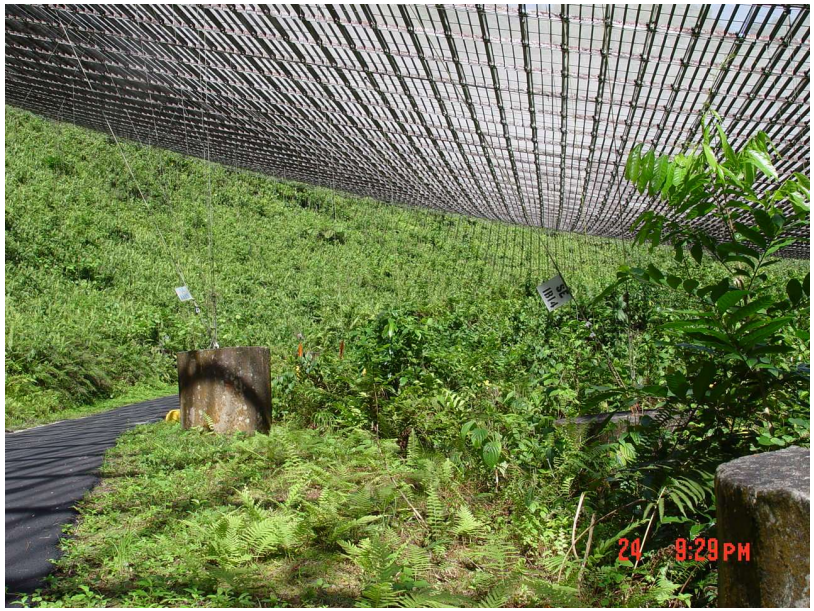




The efficiency as a function of the position and tilting angle of the PAF receiver



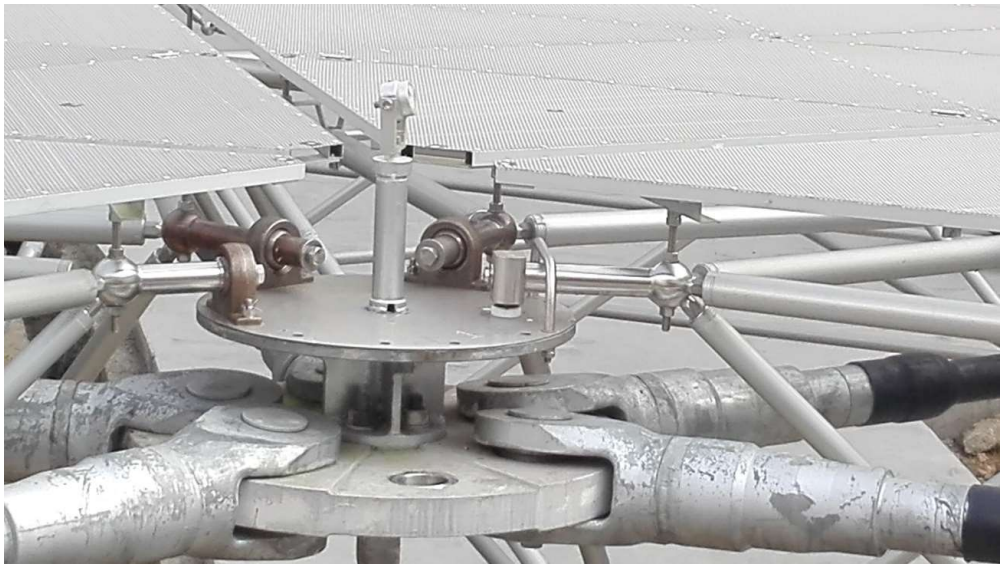
- Efficiency as a function of the position of PAF with tilting angle of +/- 5 degree.
- Within +/- 0.5m and +/- 5 degree tilting angle, the efficiency changes very little.
- Dynamic beam-forming may be feasible. Stewart stabilizer may not be needed.


24 9:29PM

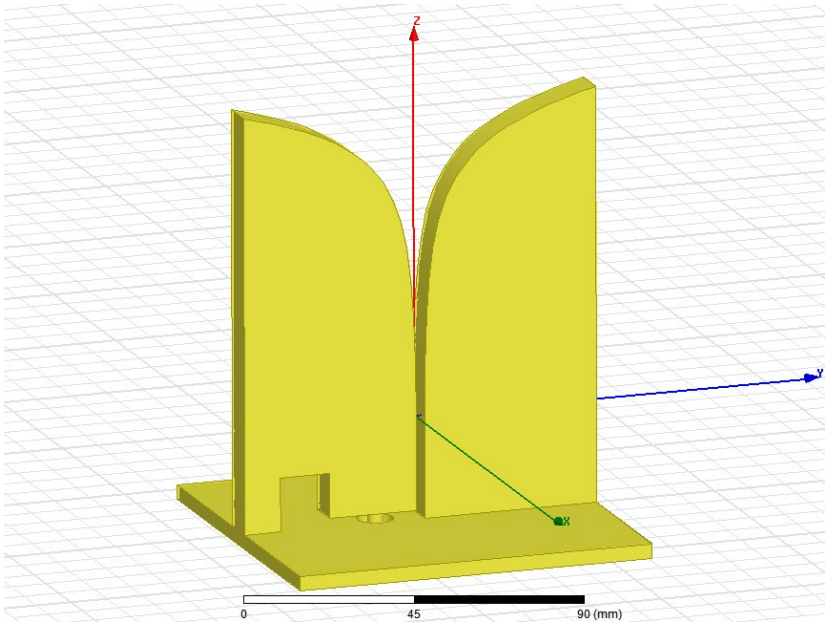

24 9:01PM

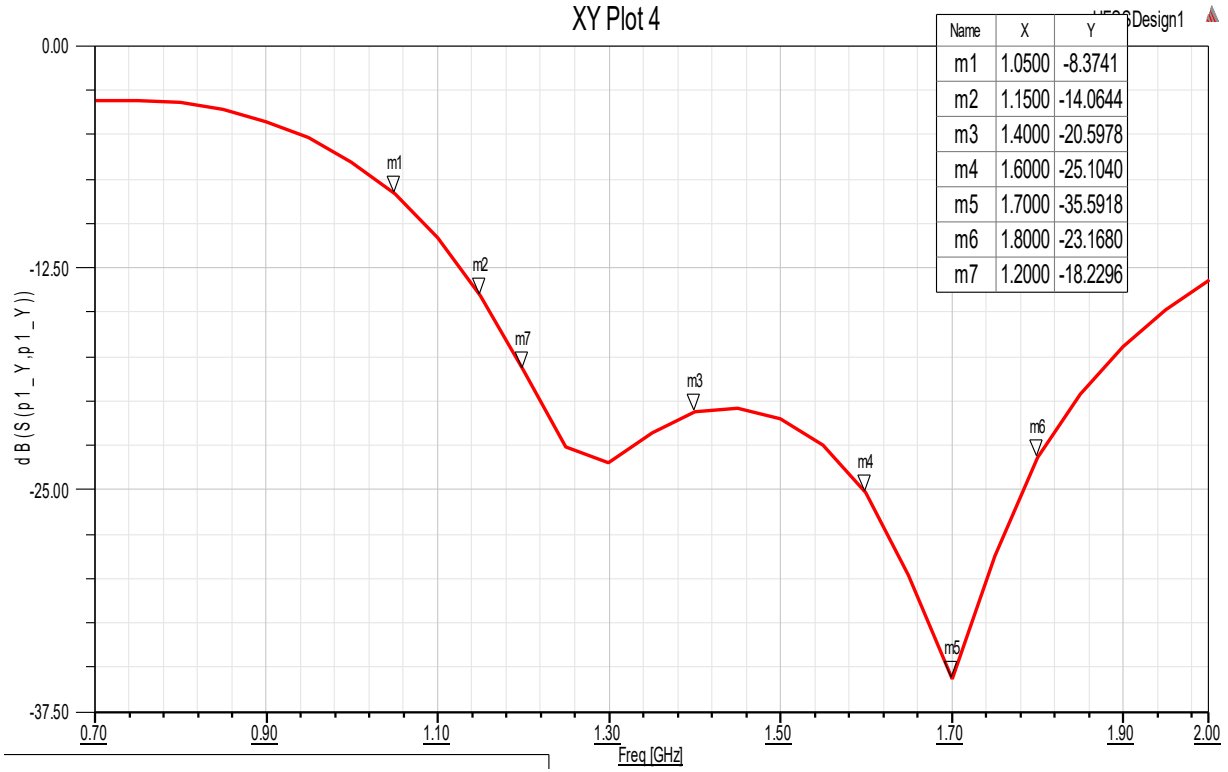

24 10:11PM


24 10:23PM



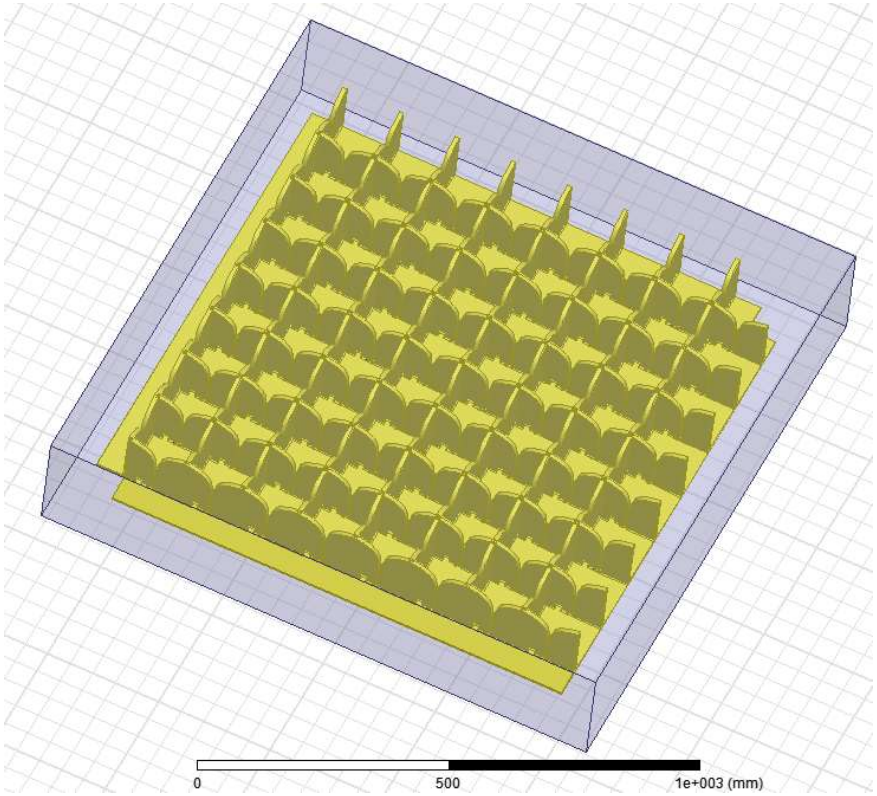
All-metal Vivaldi element





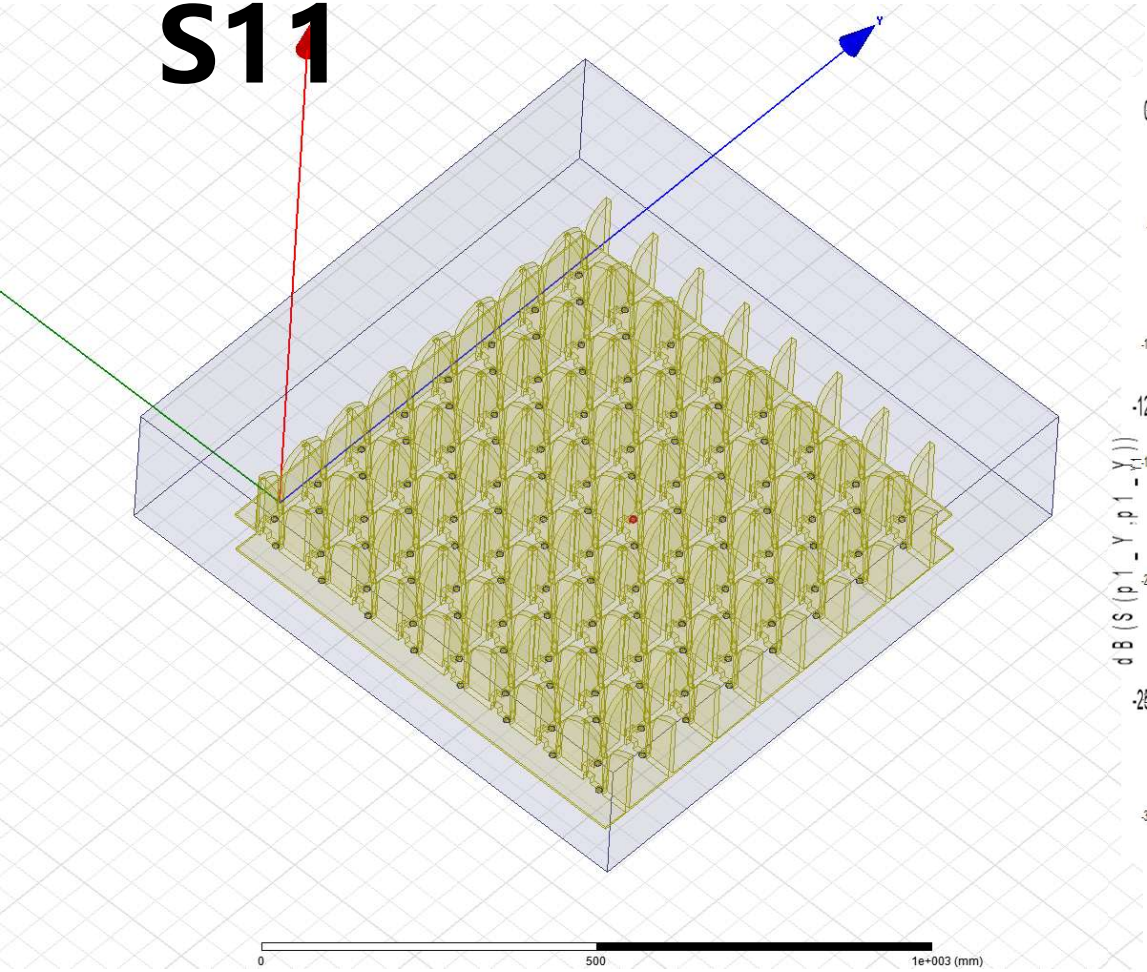
- 3D model
- S11

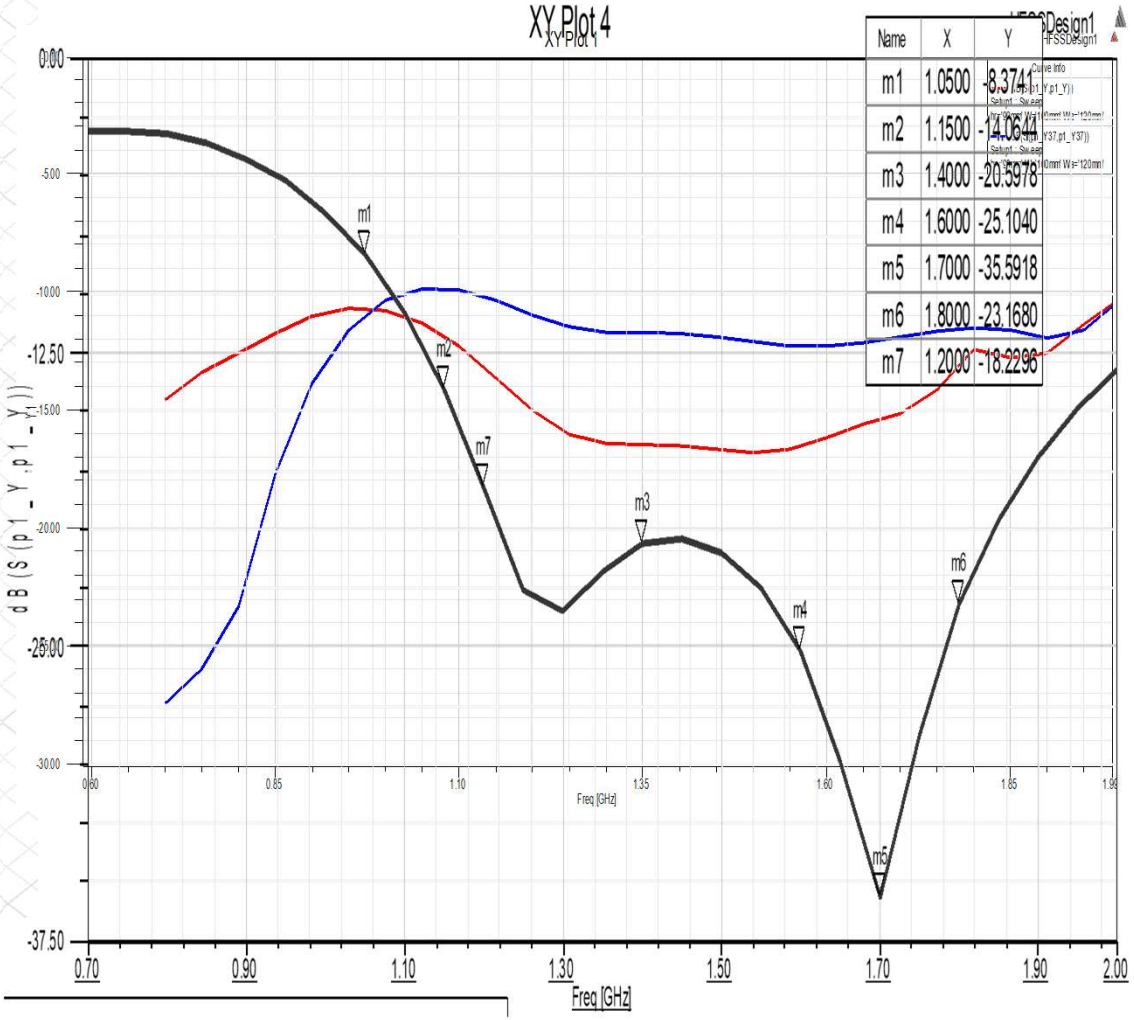
8 X 8 Vivaldi array



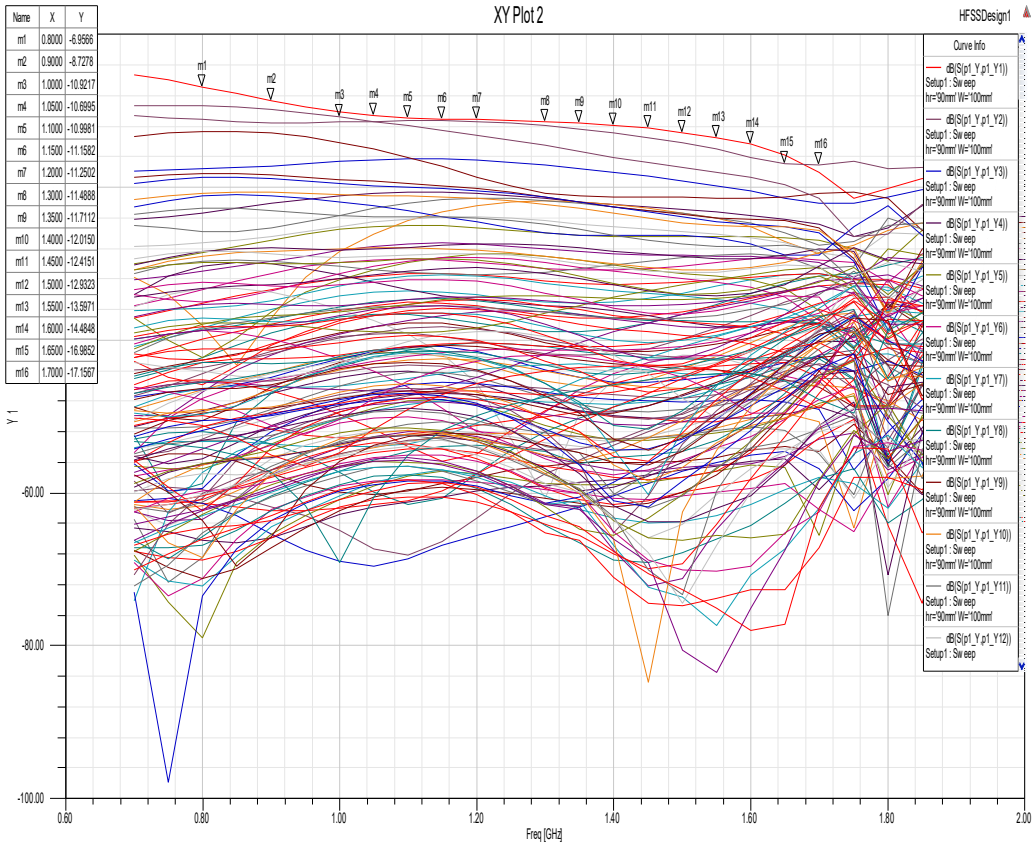
- Vivaldi size: 96mm
- Height： ~130mm

The Vivaldi array and the embedded S11

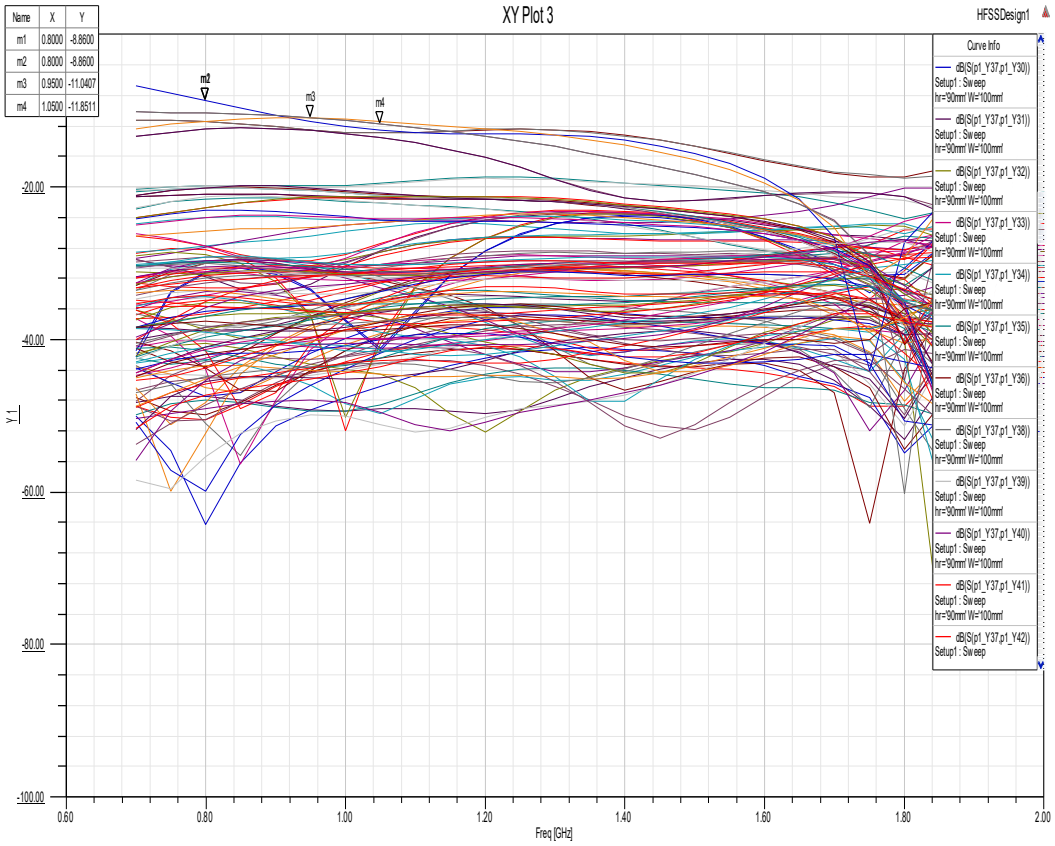




Mutual coupling among the feeding ports

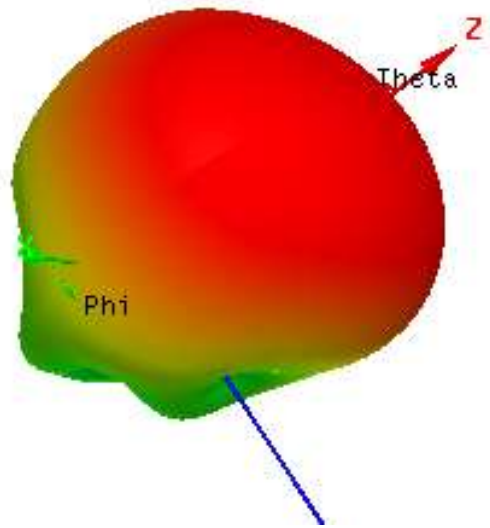


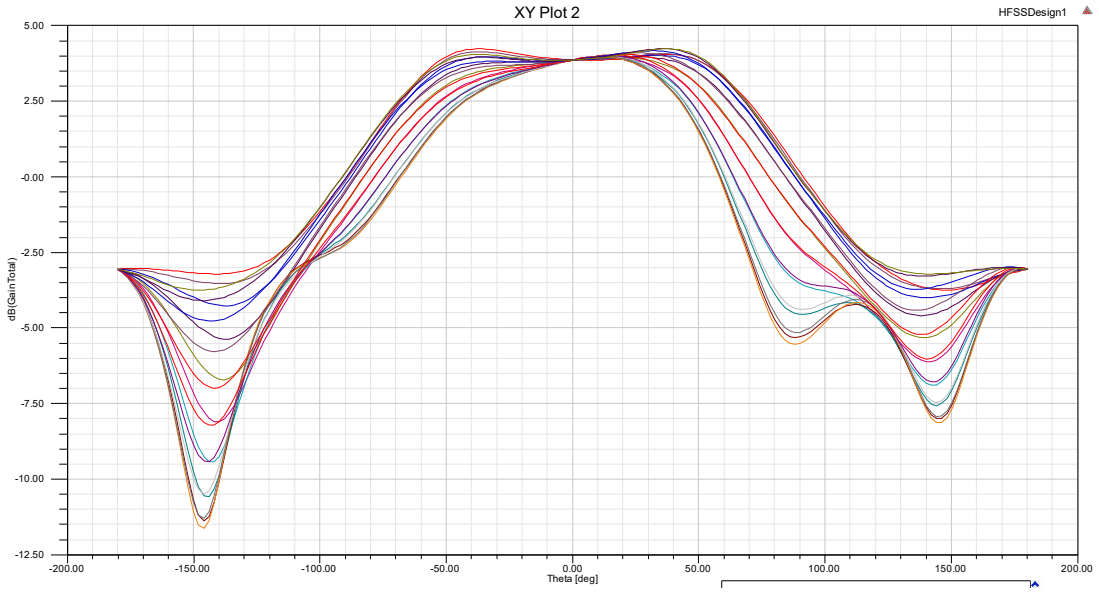
Edge – Other elements



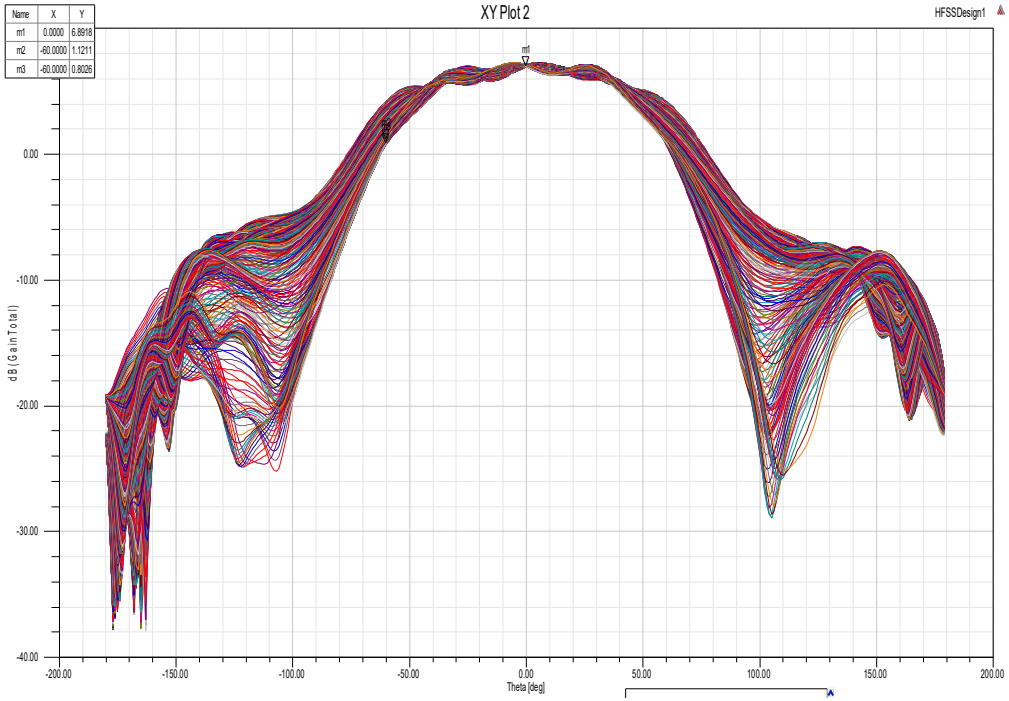
Central – Others elements

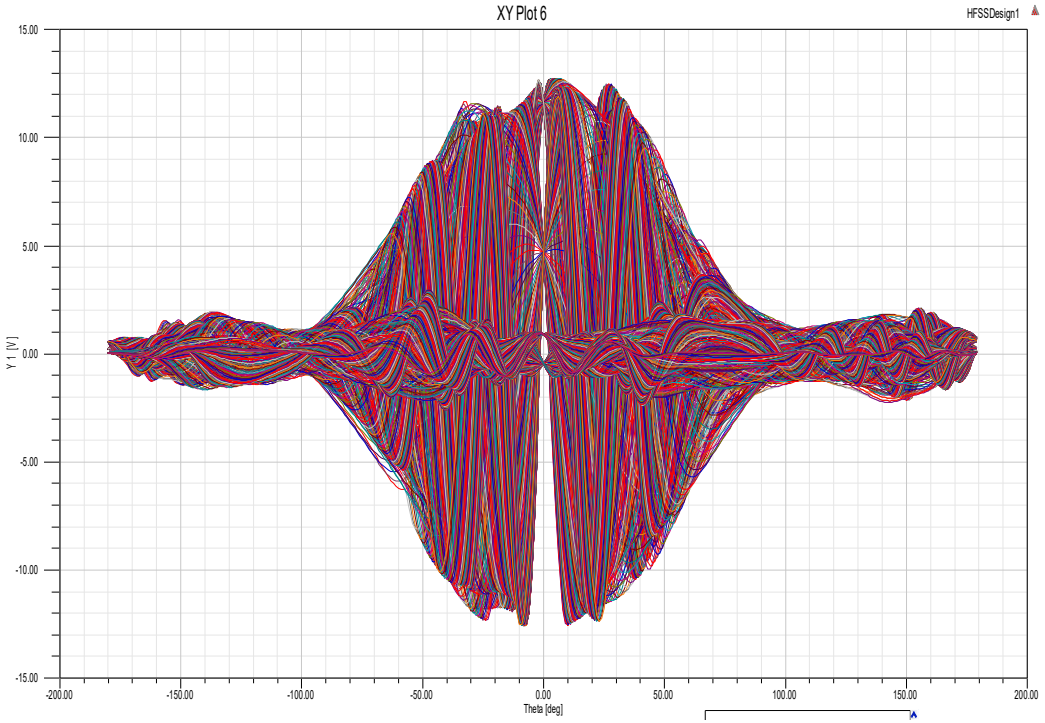
Far-field patter of a single element



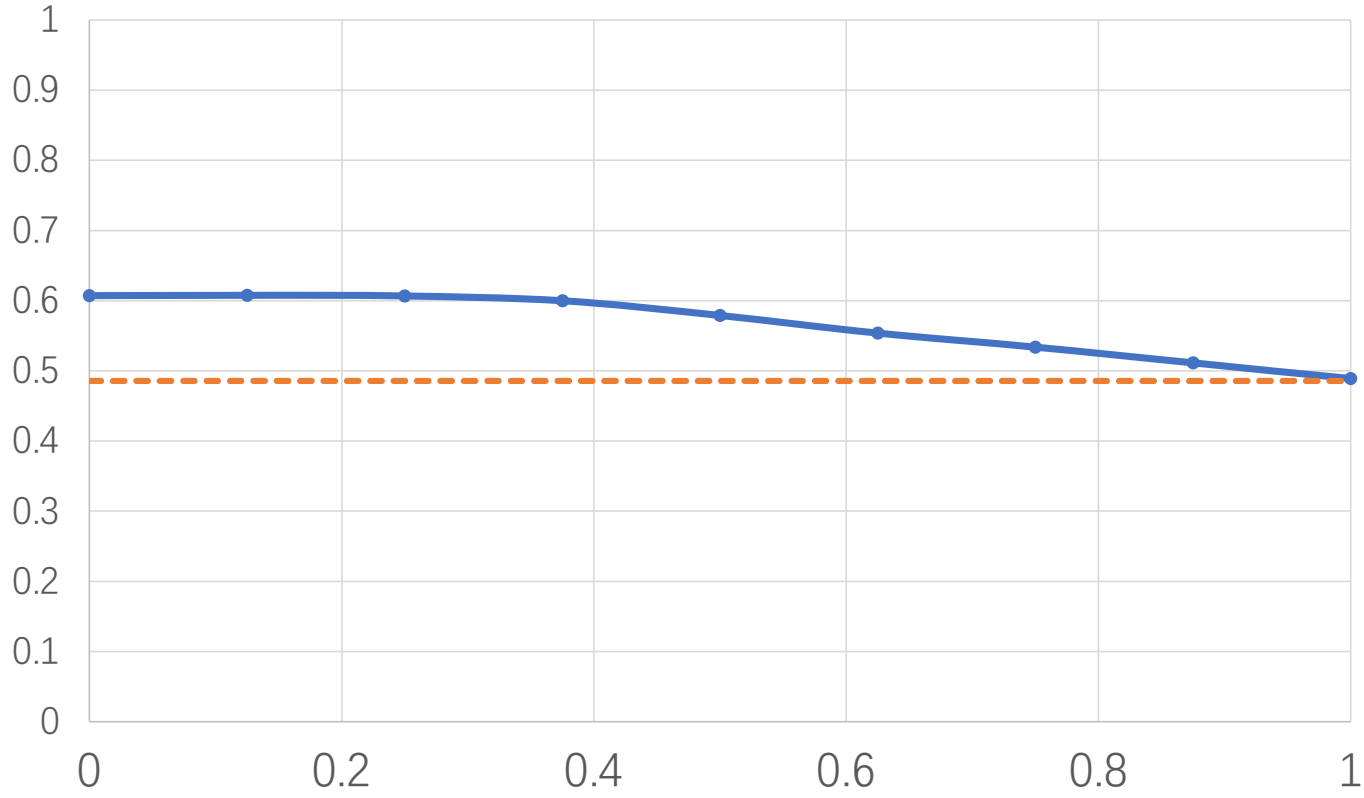


Embedded far field pattern of the Vivaldi element





Simulated efficiency vs. offset angle (deg)



FAST (Active surface) vs. Fixed surface + PAF

	Active Surface + Single Pixel Feed	Fixed Spherical surface + Large PAF receiver
Reflector	Complicated structure High construction cost High operation and maintenance cost Limitation of highest frequency	Simple structure Low construction cost Low operation and maintenance cost
Receiver	Simple (SPF, horn array) Small scale PAF	Complicated Large scale PAF
Sensitivity and FoV	Sensitivity: Good FoV: suffered from coma effect	Sensitivity: Good FoV: no obvious coma effect, limited mainly by the size of PAF

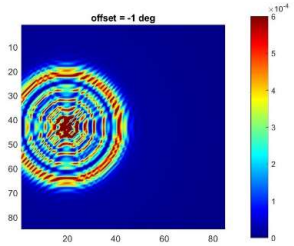
Future Plan

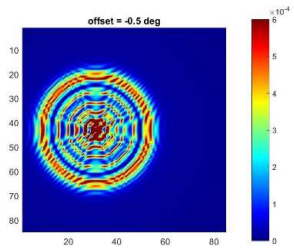
- Site selection
- Investigation on the feasibility study of the large PAF
  - Modular PAF array
  - Ambient temperature receiver vs. cooled receiver
  - Data transmission
  - Calibration, beam-forming, data storage, etc.

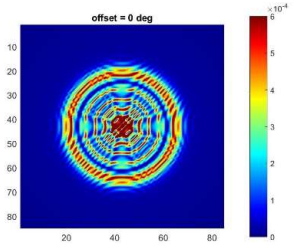
Thank you for your attention!

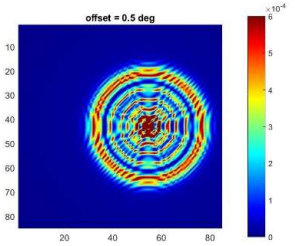
PAF is put at different positions

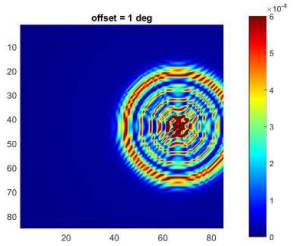
160m



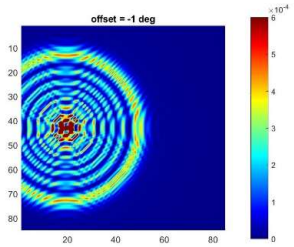


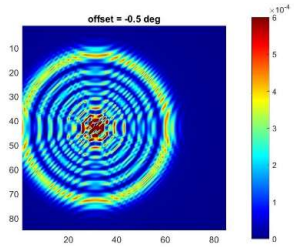


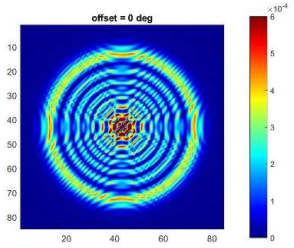


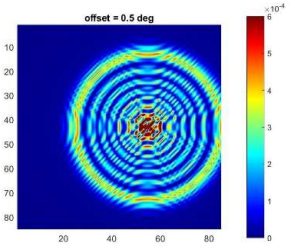


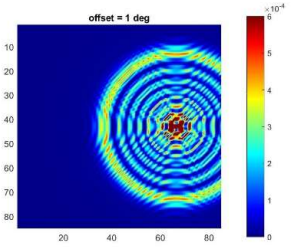
162m



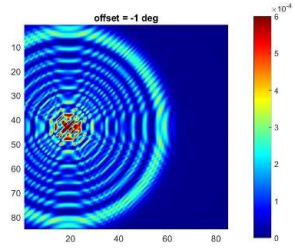


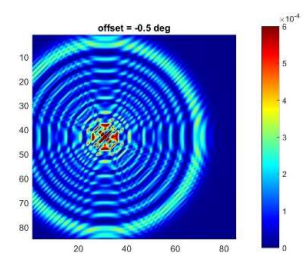


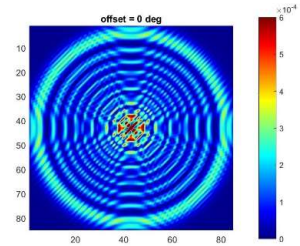


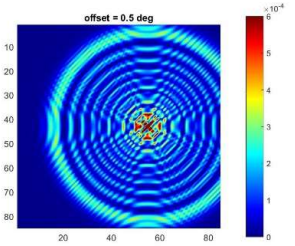


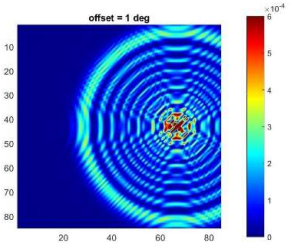
164m



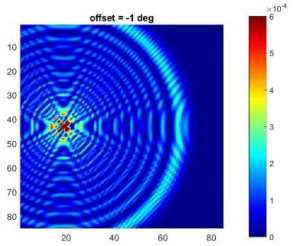


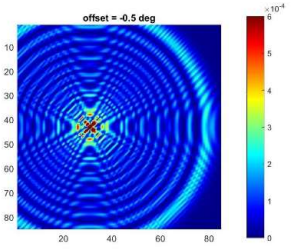


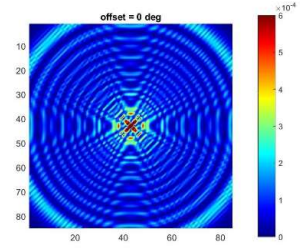


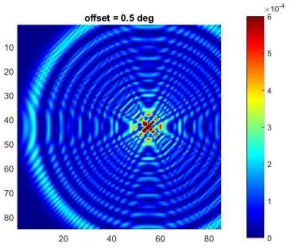


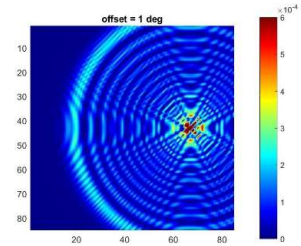
166m





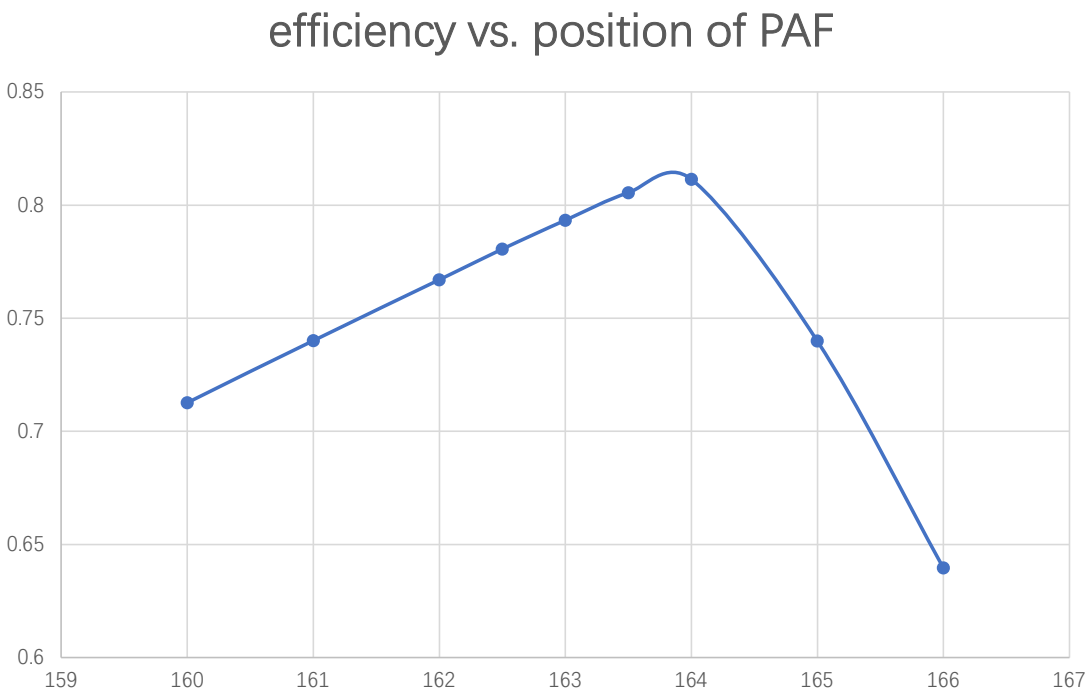






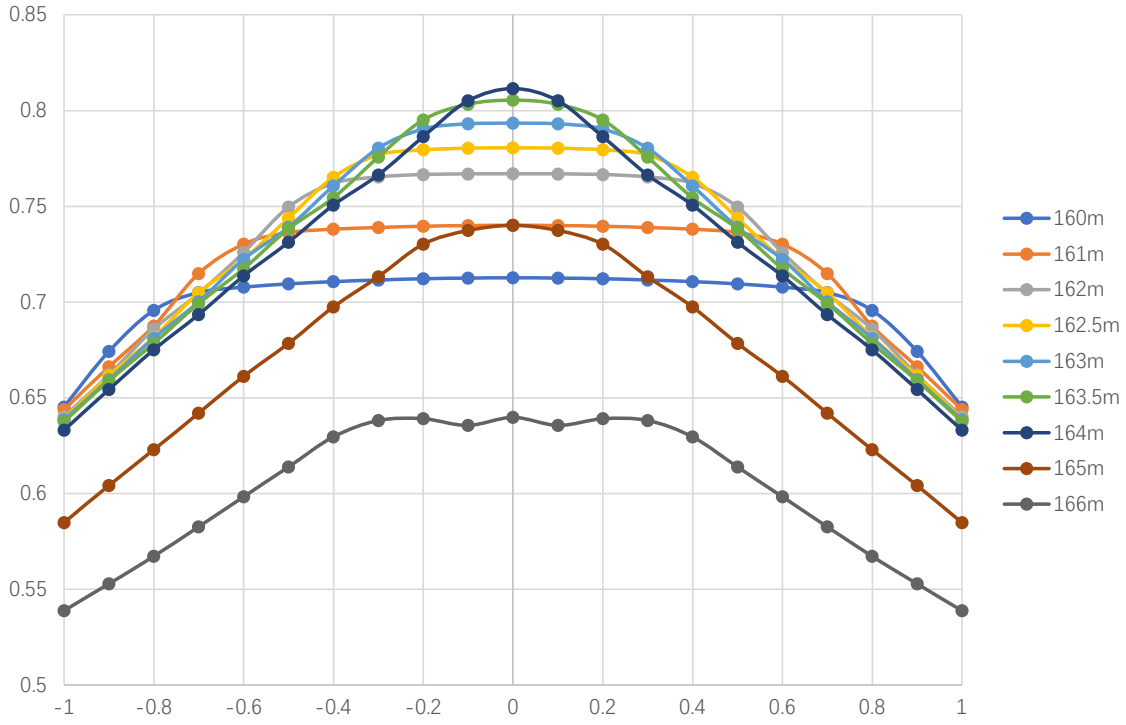
-1 deg -0.5 deg 0 deg 0.5 deg 1 deg

The on-axis efficiency vs. the position of PAF



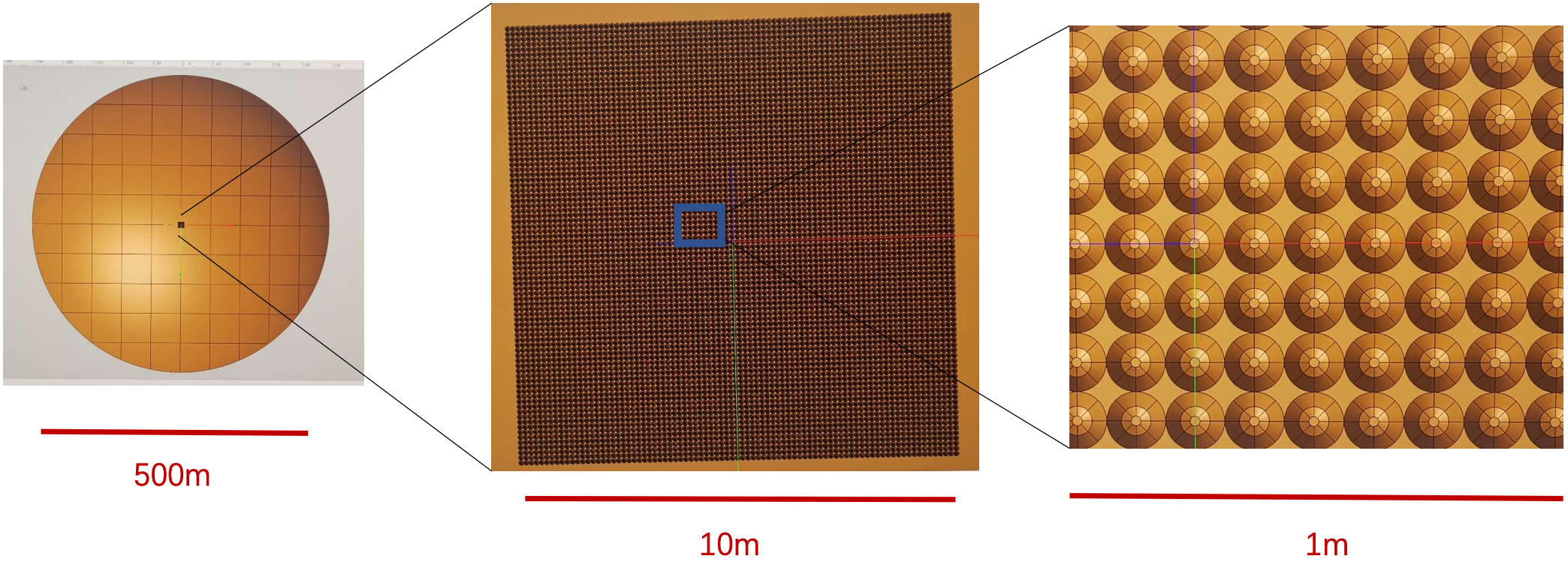
- The efficiency increases gradually when the PAF moves from 160-164m below the center of the spherical surface.
- Beyond 164m, the efficiency decreases more rapidly.

The efficiency as a function of the position of the PAF and off-axis angle

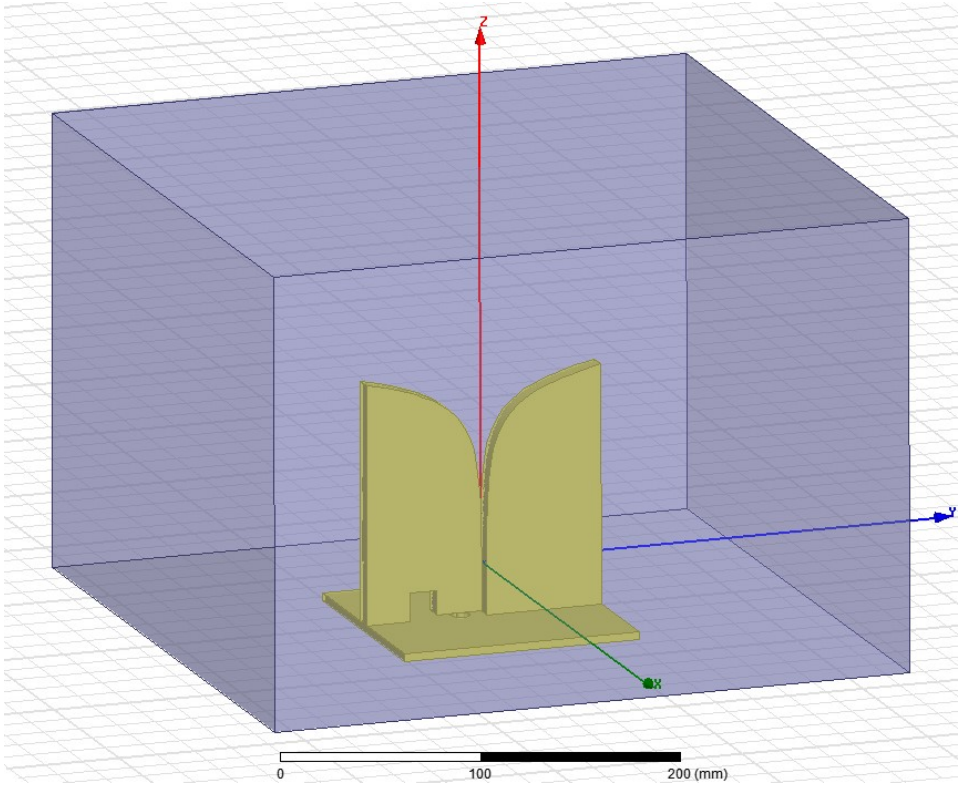


- As the PAF moves from 160-164m below the center of the spherical surface， the on-axis gain increases, but the gain at the edge of FoV doesn't change very much.
- When the PAF is put 163m below the center of the sphere, the gain at the edge is 22% lower than that at the center of the FoV.
- Dynamic beam-forming may be preferred.

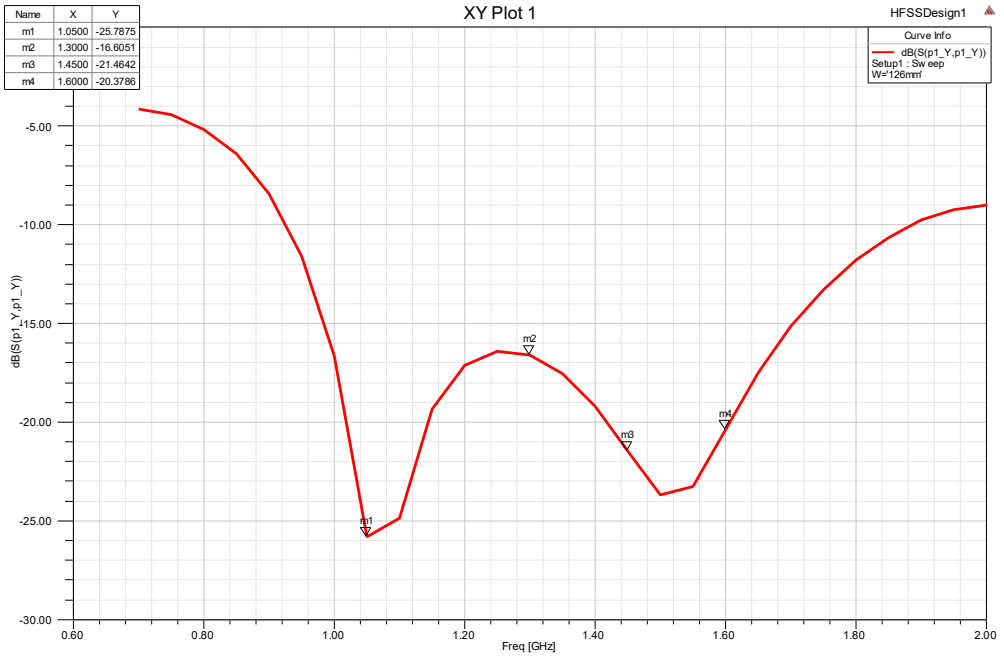
Relative size of the reflector and PAF receiver



单个Vivaldi馈源反射损耗的优化

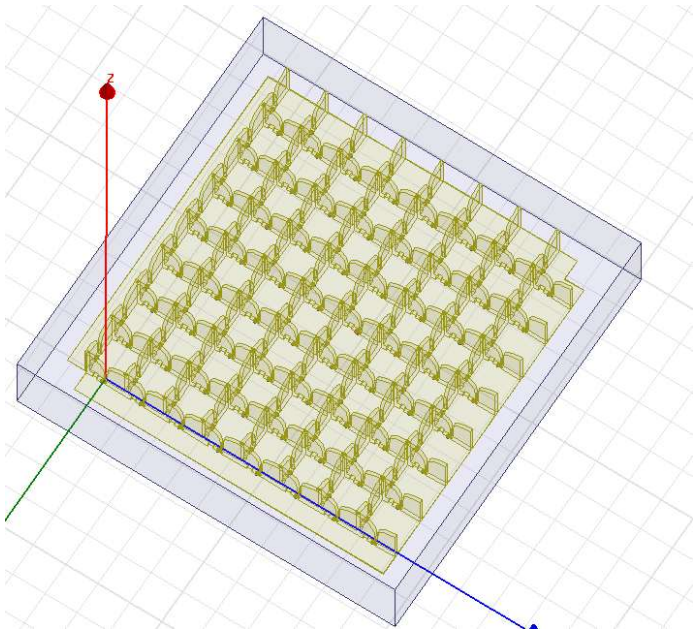


- 3D模型



- 反射损耗

Vivaldi阵列中的馈电单元的S11



- VV