Supplementary Material

Usability of tilted plasmon antenna with structured light

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One important aspect of this work is to visualize the intensity profile near the focal point as well as to maintain the phase structure, this can be aided by the polar plot of the electric field at a specific radial position. The next set of plots were taken at z = 0 nm and ρ = 70, ~80, and 100 nm. At normal incidence, the symmetry makes the plots easy to follow, see figure S1 for ρ = 70 nm, E_z^2 is zero (green dot a 0), and E_x^2 (red line) is the same as E_y^2 (blue line) just rotated 90 degrees and $|E|^2$ (black line) shows the 45 degrees symmetry, theta is used following the usual definition measured from the *x-axis*. Figure S3 shows plots for the norm of the electric field, |E| at ρ = 70 nm (black plot), ~80 nm (red plot) distorted due to the proximity with the metallic antenna at multiples of 45 degrees and 100 nm (blue dots), the missing parts are caused by measuring over the metallic antenna.

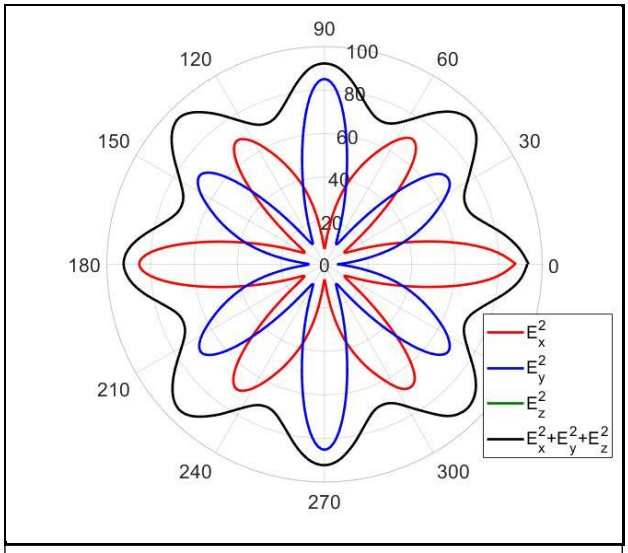

Figure S1. Electric field squared at normal incidence at ρ = 70 nm

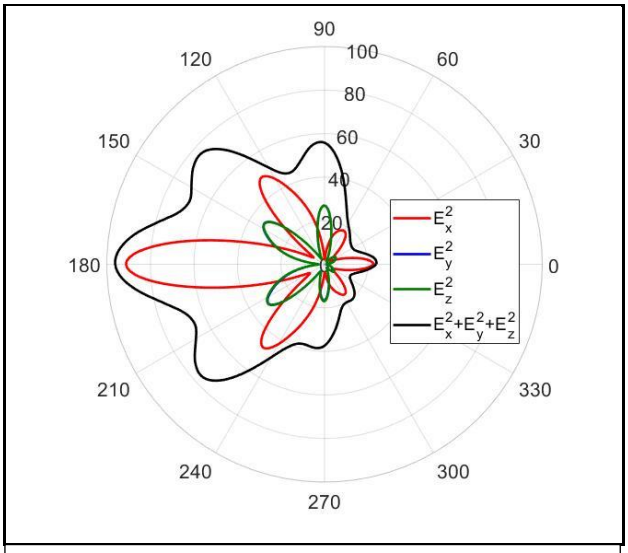

Figure S2. Electric field squared at 45 degrees tilted antenna at ρ = 70 nm

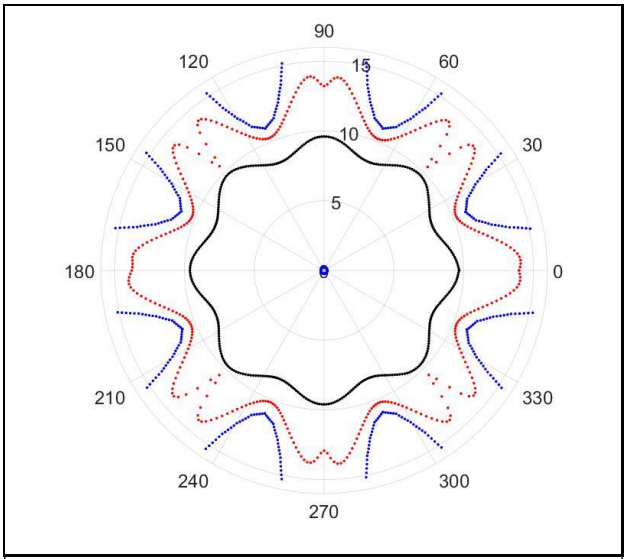

Figure S3. Norm of total electric field at normal incidence at ρ = 70, 80 and 100 nm, black, red, and blue, respectively.

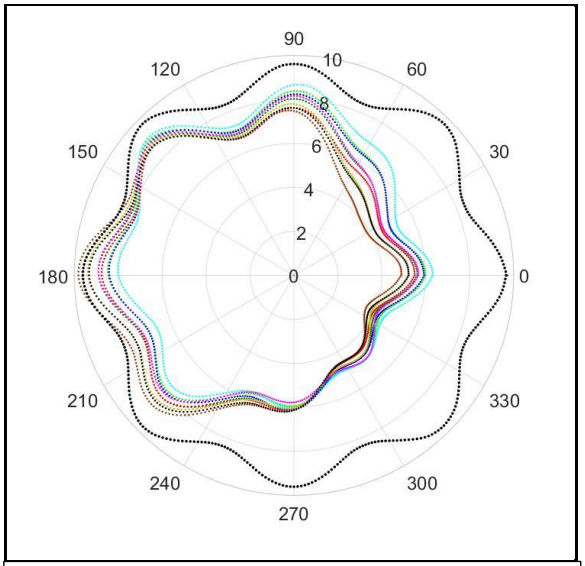

Figure S4. Norm of total electric field at ρ = 70. Black is for normal incidence and other colors are for a tilted antenna.

Figure S2 is like figure S1, just for a 45 degrees tilted antenna, here E_y^2 and E_z^2 have the same result, and the field distortion is evident, one objective is to envision an antenna structure that ameliorates this distortion. Figure S4 presents the norm electric field |E| at ρ = 70 nm, the black dots are for an antenna normal to the z-axis, and all the other plots are for a 45 degrees tilted antenna with different location in the x-y plane as is explained in the next set of figures.

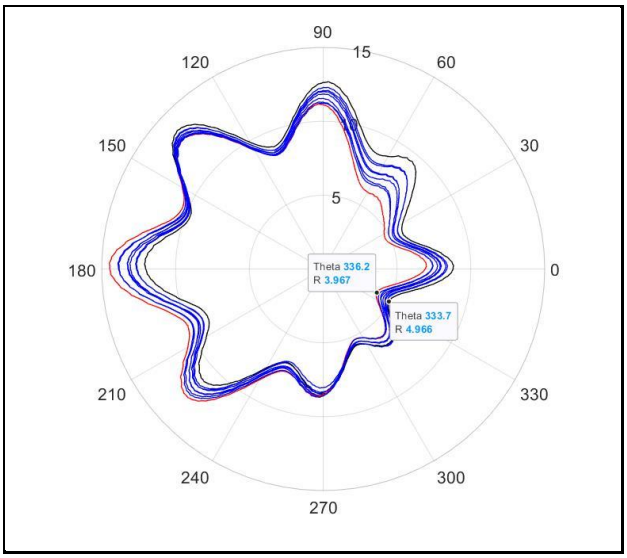

Figure S5. Norm of total electric field at ρ = 80 nm. We want to illustrate the extreme distortion as a function of the antenna center-location as in figure S6. Maximum distortion location #7 (|E| = 3.967), and minimum distortion location #3 (|E| = 4.966).

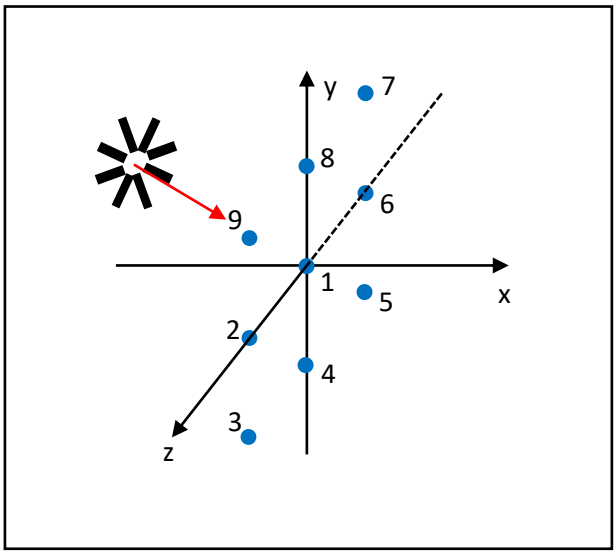

Figure S6. Antenna center location, simulating defocusing and adjustments, each dot is for 25 nm around zero (y and z axes).

Figure S5 Illustrates the distortion with a tilted antenna moving the center according to locations in figure S6. Table TS1 presents the summary for the lower norm of the electric field for ρ = 80 nm.

TABLE TS1			
Antenna location	Z displacement	Y displacement	$\|E\|_{min}$
#1	0	0	4.516
#2	+	0	4.816
#3	+	-	4.966
#4	0	-	4.699
#5	-	-	4.377
#6	-	0	4.156
#7	-	+	3.967
#8	0	+	4.641
#9	+	+	4.156

The next figures illustrate the change in the length of only one arm in the antenna, S7 and S8 are the references, all antenna arms with the same length, only S7 centered at y = - 50 nm and z = + 50 nm and S8 centered at y = - 25 nm and z = +25 nm. All subsequent figures maintain y = - 25 nm and z = +25 nm. As well in each figure the $|E|_{min}$ is labeled at ρ = 70 nm however in the table TS2 and TS3 are for $|E|_{min}$ at ρ = 80 nm. Figures S9 to S15 increase 30 nm one arm at the time from the y-axis clockwise. Figure S16 to S23 decrease 30 nm one arm at the time from the y-axis clockwise.

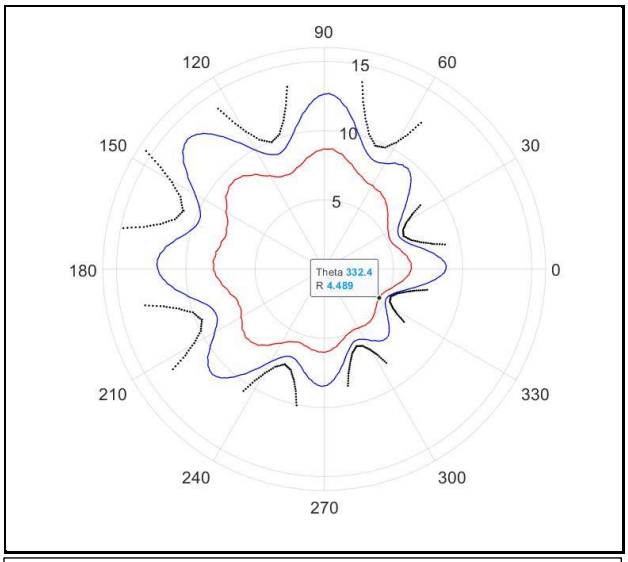

Figure S7. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm, black, red, and blue, respectively. All antenna arms with the same length and centered at y = - 50 nm and z = + 50 nm.

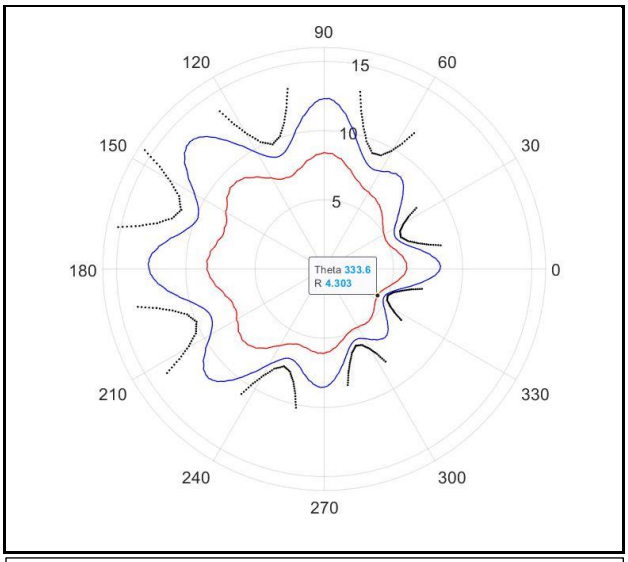

Figure S8. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm, black, red, and blue, respectively. All antenna arms with the same length and centered at y = - 25 nm and z = + 25 nm.

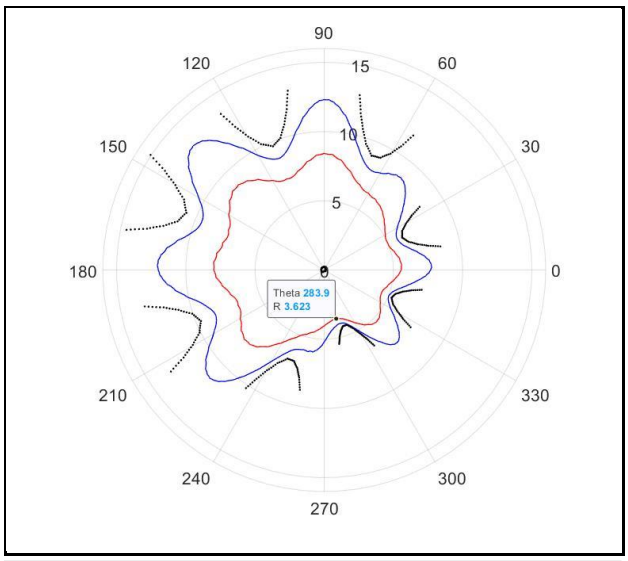

Figure S9. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 90°.

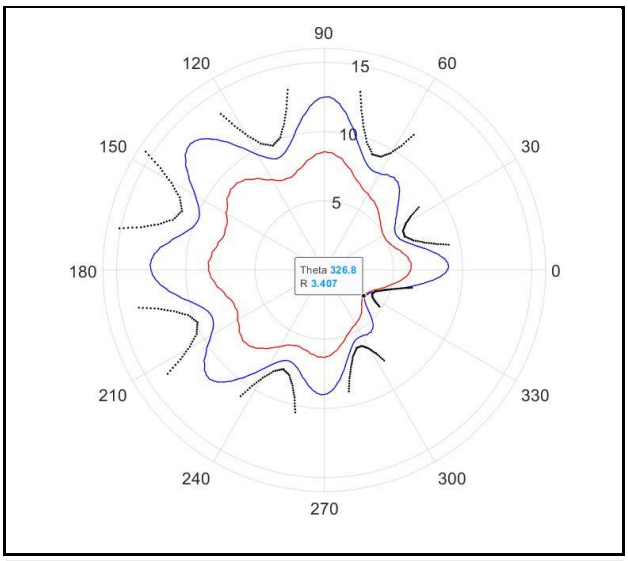

Figure S10. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 135°.

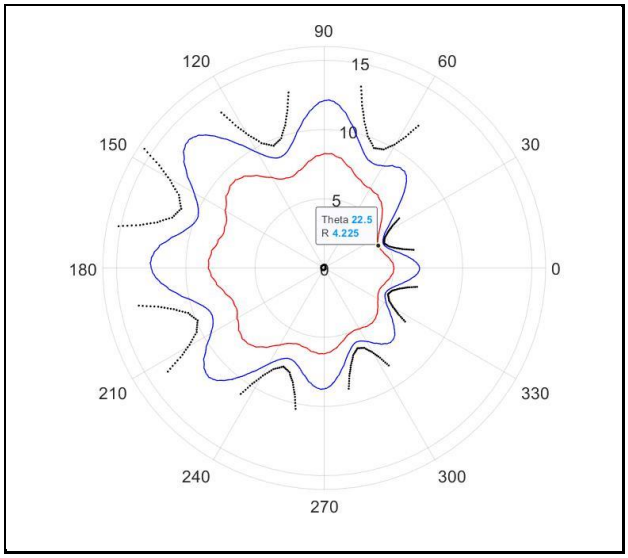

Figure S11. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 180°.

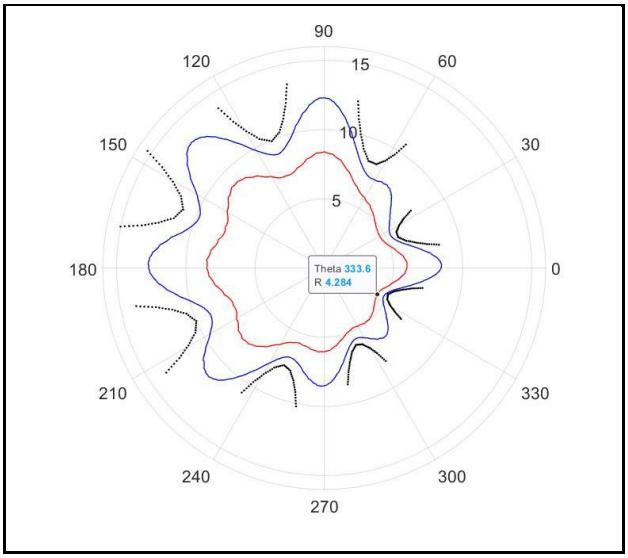

Figure S12. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 225°.

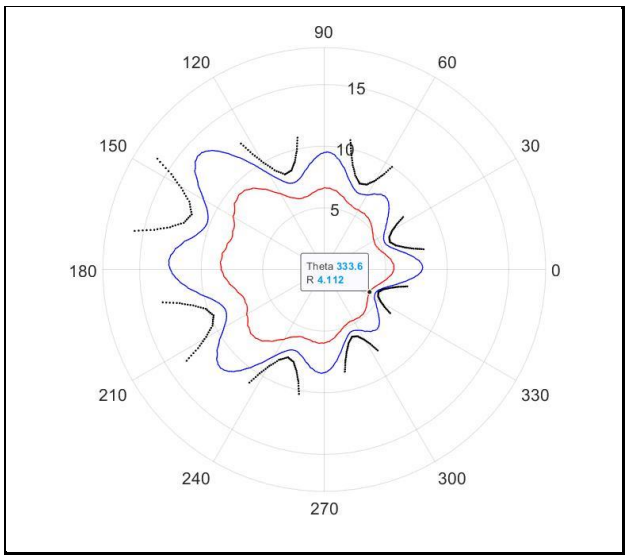

Figure S13. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 270°.

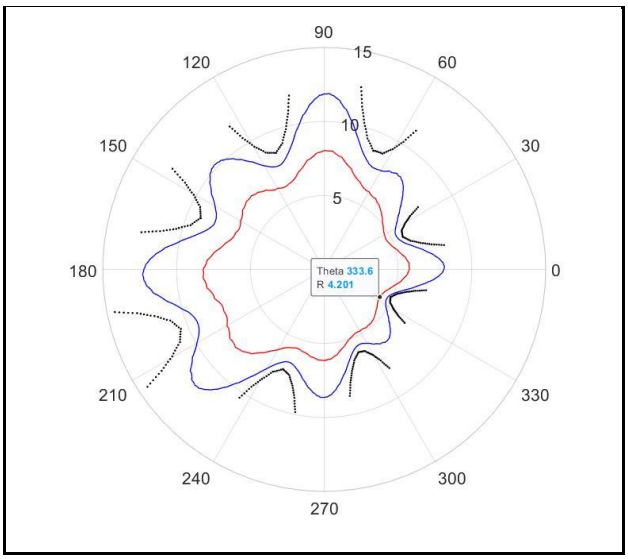

Figure S14. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 315°.

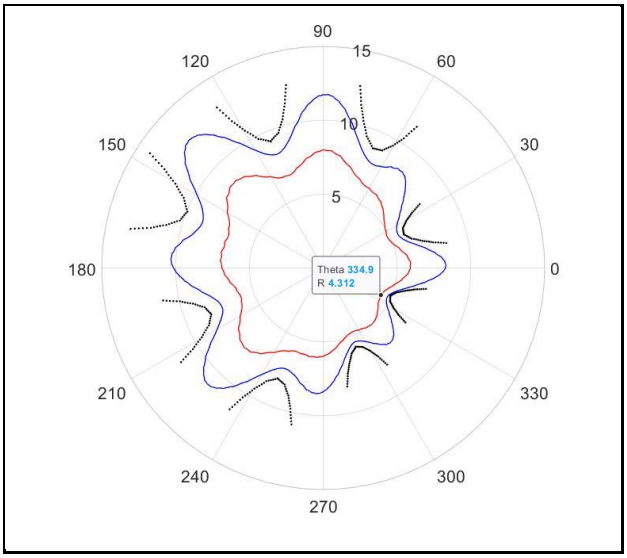

Figure S15. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 0°.

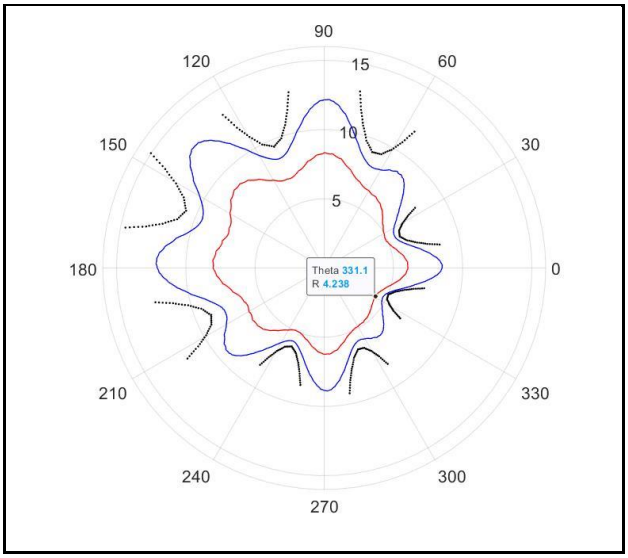

Figure S16. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm longer at 45°.

TABLE TS2		
ρ = 80 nm, center at y = - 25 nm and z = + 25 nm		
Figure	Theta	$\|E\|_{min}$
S7 REF1	333.7	4.966
S8 REF2	334.9	4.774
S9	285.1	4.030
S10	328.2	3.538
S11	22.5	4.606
S12	334.9	4.763
S13	334.9	4.579
S14	334.9	4.668
S15	334.9	4.765
S16	333.7	4.736

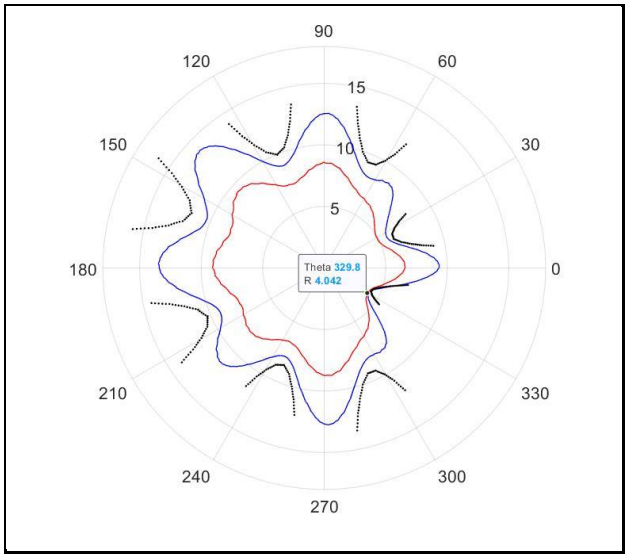

Figure S17. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 90°.

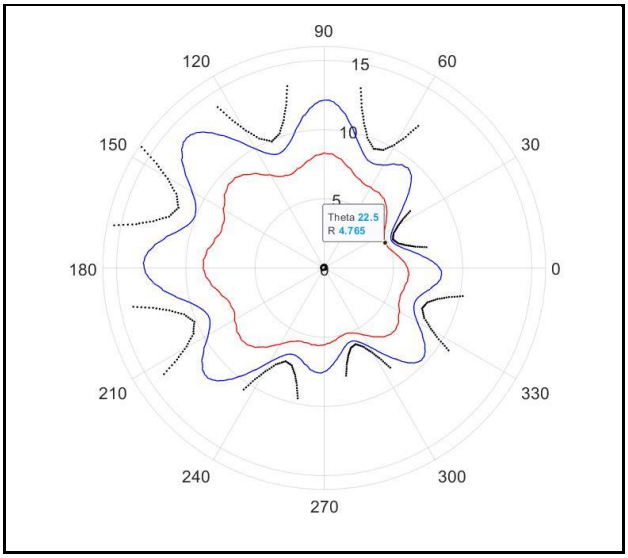

Figure S18. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 135°.

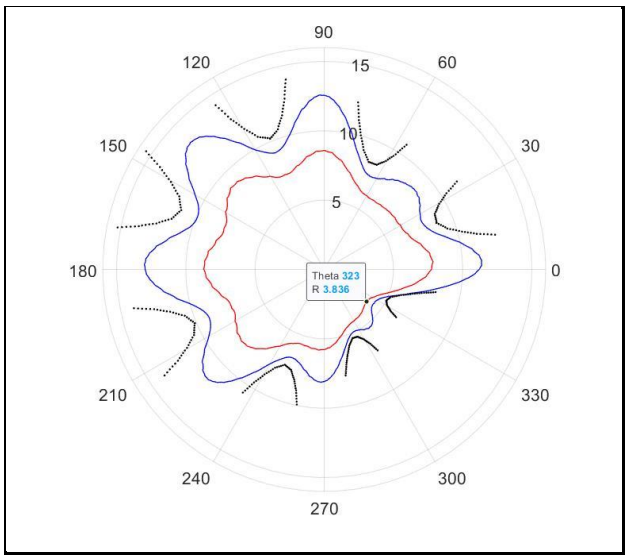

Figure S19. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 180°.

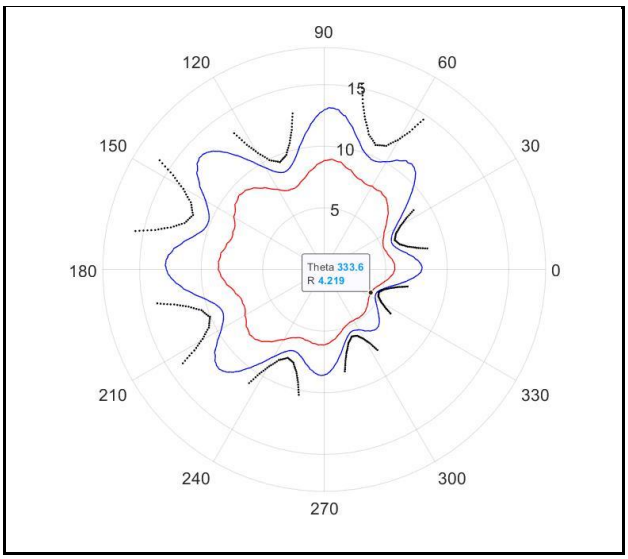

Figure S20. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 225°.

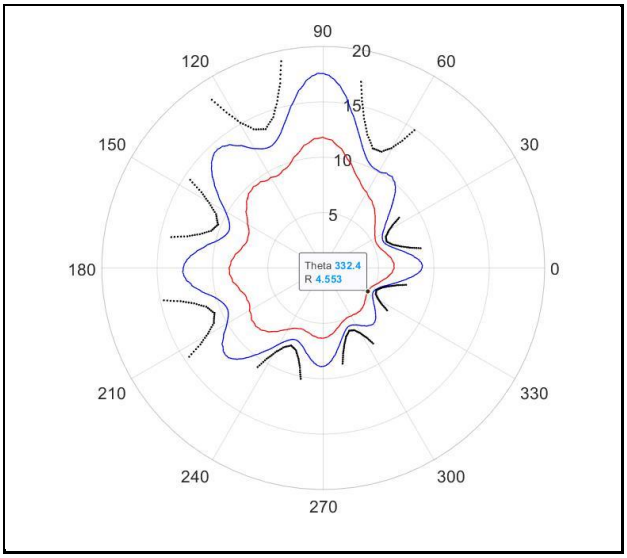

Figure S21. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 270°.

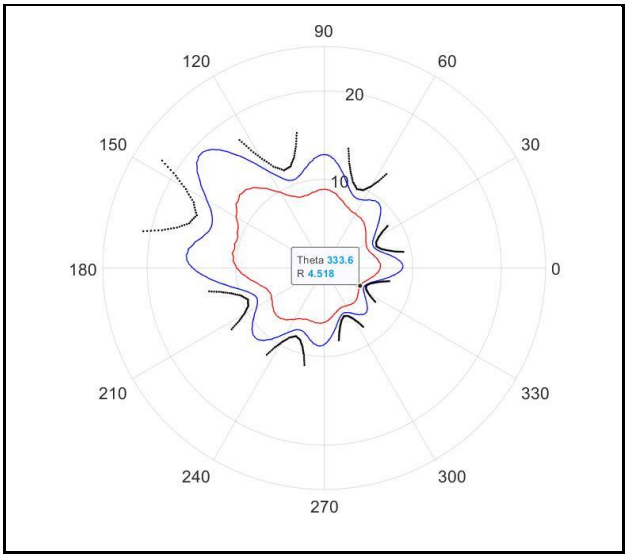

Figure S22. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 315°.

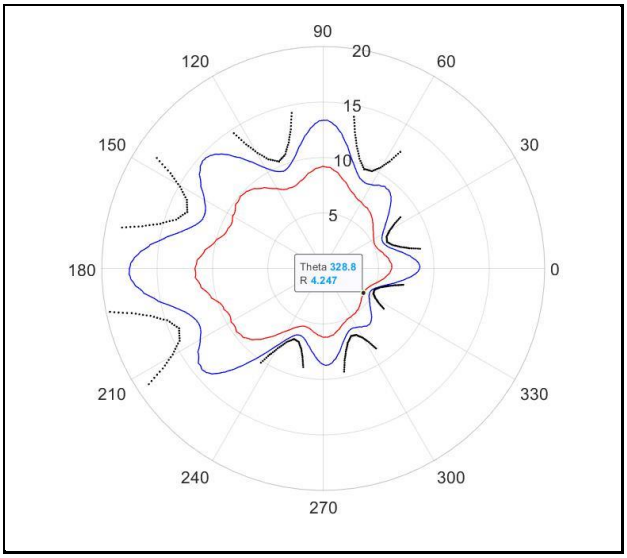

Figure S23. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 0°.

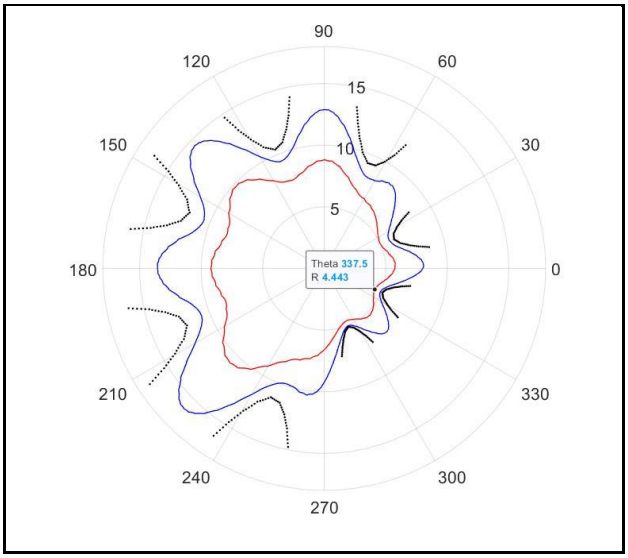

Figure S24. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. One arm 30 nm shorter at 45°.

TABLE TS3		
ρ = 80 nm, center at y = - 25 nm and z = + 25 nm		
Figure	Theta	$\|E\|_{min}$
S7 REF1	333.7	4.966
S8 REF2	334.9	4.774
S17	331.1	4.152
S18	22.5	5.241
S19	327.2	4.346
S20	334.9	4.643
S21	333.7	5.017
S22	334.9	4.978
S23	333.7	4.729
S24	337.5	4.934

From table TS2 it is possible to observe the null advantage of increasing the arm's length in the scheme of increasing the length of one antenna's arm at a time and in table TS3 it is clear the advantage of decreasing the arm at 135°.

From the previews results, it is possible to imagine that more antenna arms could synergically improve the electric field symmetry. Figures S25 and S27 are for the same antenna, four arms 30 nm short at 90°, 135°, 180°, and 225°, S25 is for a 45° tilted antenna and S27 is for normal incidence. The $|E|_{min}$ value changes from 5.79 to 9.83. Figures S26 and S28 are for the same antenna, three arms at 90°, 135° and 180°, 30 nm shorter, S26 is for a 45° tilted antenna and S28 is for normal incidence. The $|E|_{min}$ value changes from 6.04 to 9.69.

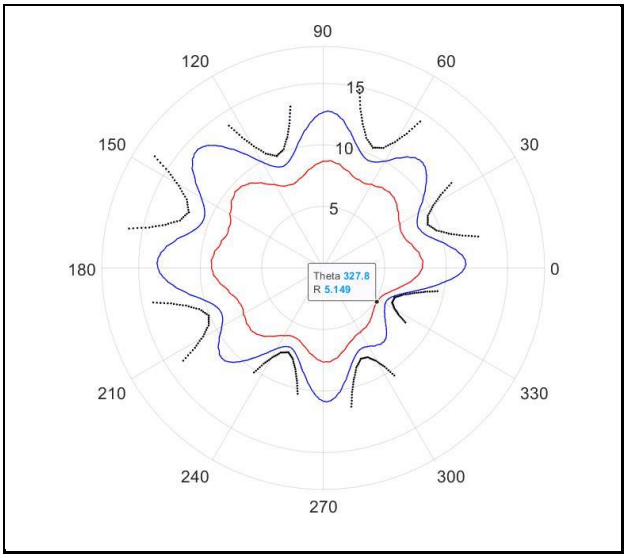

Figure S25. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. Four arms at 90°, 135°, 180° and 225°, 30 nm shorter.

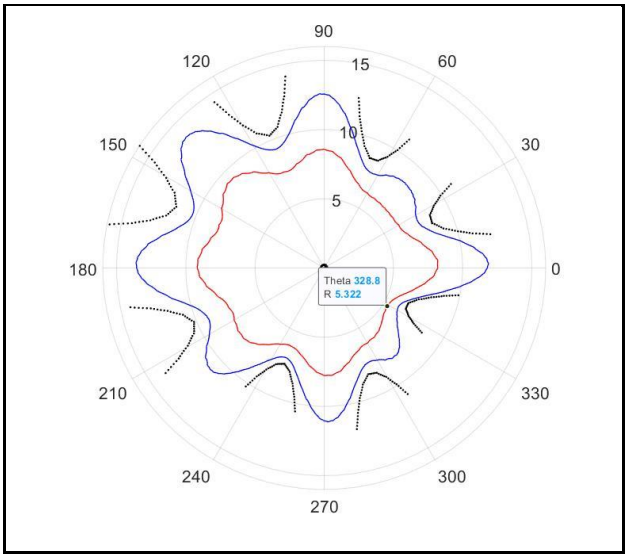

Figure S26. Norm electric field for a 45° tilted antenna at ρ = 70, 80 and 100 nm. Three arms at 90°, 135° and 180°, 30 nm shorter.

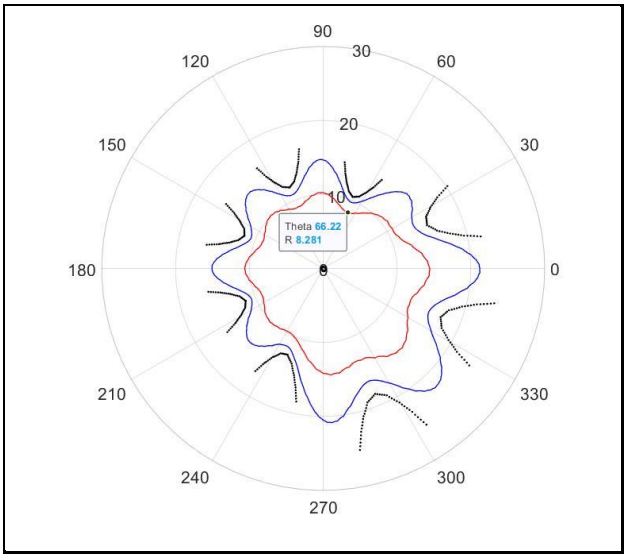

Figure S27. Norm electric field for an antenna normal to z axis and at ρ = 70, 80 and 100 nm. Four arms at 90°, 135°, 180° and 225°, 30 nm shorter.

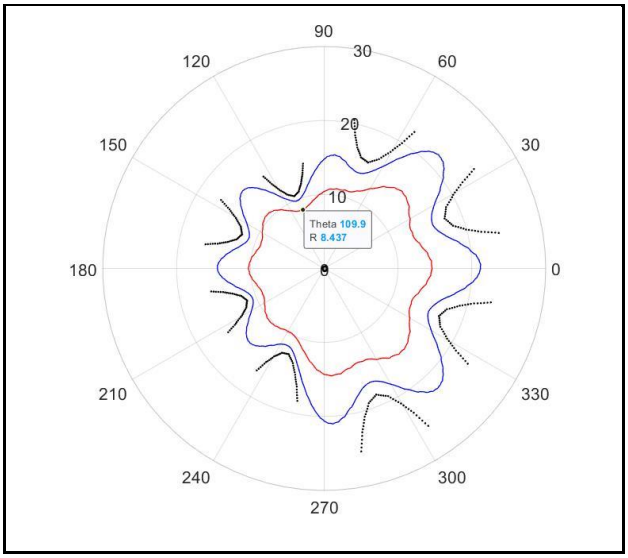

Figure S28. Norm electric field for an antenna normal to z axis and at ρ = 70, 80 and 100 nm. Three arms at 90°, 135° and 180°, 30 nm shorter.