ANTI-JAMMING GNSS ANTENNA FOR TIMING APPLICATIONS

BY

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INTRODUCTION

- Global Navigation Satellite Systems are experiencing substantial expansions.
- New national systems are being installed.
- Expansion of the number frequencies and protocols.
- Greater frequency coverage of terrestrial based receivers.
- Greater RF performances are required.
- GNSS antennas are used for timing applications.
- These antennas at fixed site infrastructures are susceptible to unintentional and intentional interference.
- Strong immunity against interfering signals, especially in-band jammer, is required.

Anti-jamming GNSS Timing Antenna specifications

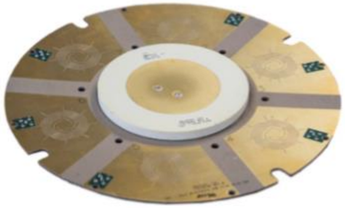
- **Antenna to cover the upper GNSS bands(1.559 to 1.610 GHz).**
- **Good left hand polarized signals rejection.**
- **Timing antennas need less satellites (three is enough)**
- **Most of the interfering signals come from a low elevation angle**
- **Rejection of the in-band signals for an elevation between 0 and 20 deg.**
- **Simple to build.**
- **Light and compact**

EXISTING SOLUTION

Existing solutions

- **Adaptive antennas:**
  - Steer a null in the direction of the interfering signal
  - Military grade
  - Big and expensive solution

7-element Pinwheel Antenna Array



The 7-element Pinwheel antenna array allows gain pattern shapes to be changed in response to interference. Provides 6 independent nulls.

Novatel antenna solution

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Existing solutions

- **Horizon Ring Nulling Quadrifilar Helix Antenna:**
  - Generate a null at low elevation angles
  - Tall solution
  - MITER Patented design

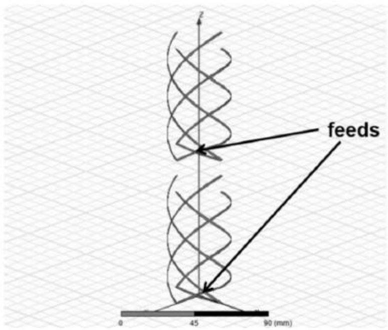
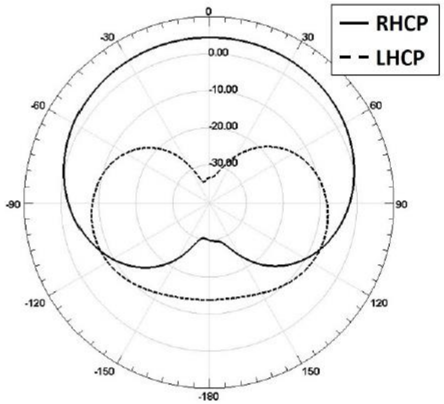
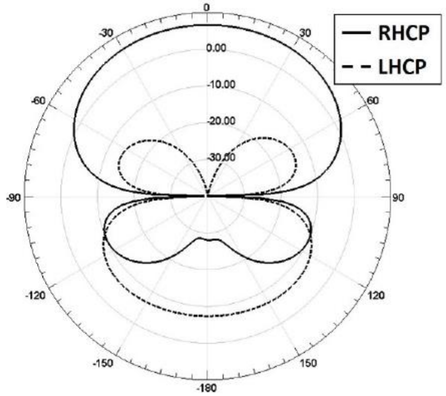


Figure 2. Two element quadrifilar helix array





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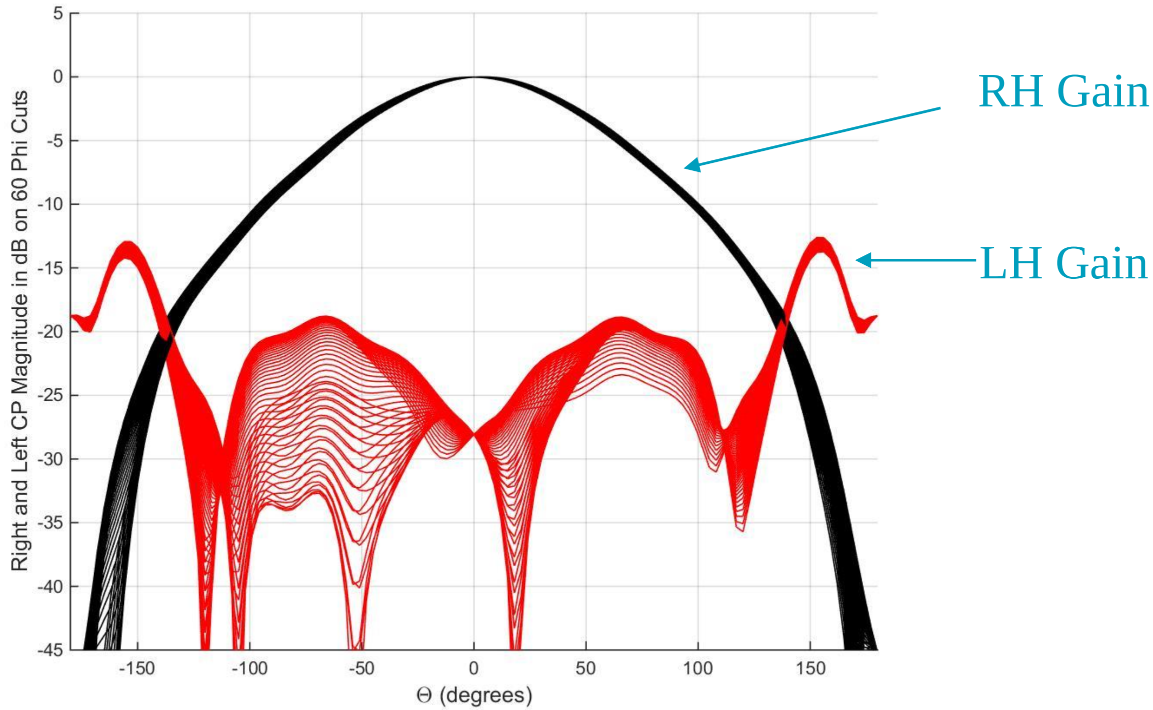
DESIGN OF THE ANTI-JAMMING ANTENNA

DUAL FEED PATCH ANTENNA

- GNSS antennas are right hand circularly polarized
- Tallysman Wireless is expert in dual feed patch antennas
- The dual feed technic insures a good left hand signal (multipath) rejection

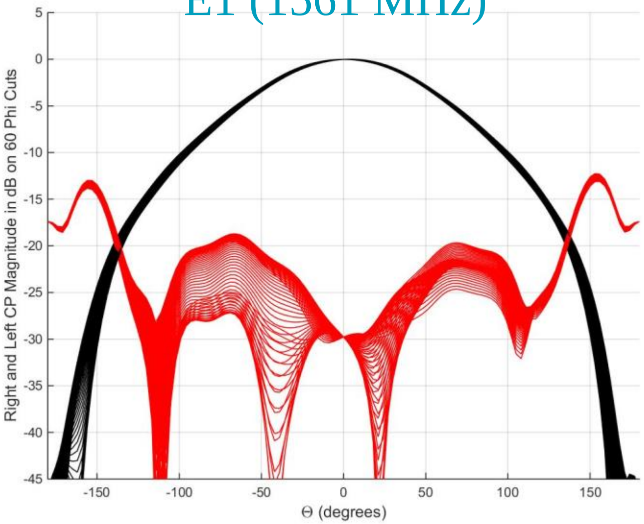


L1 (1575 MHz) measured radiation pattern

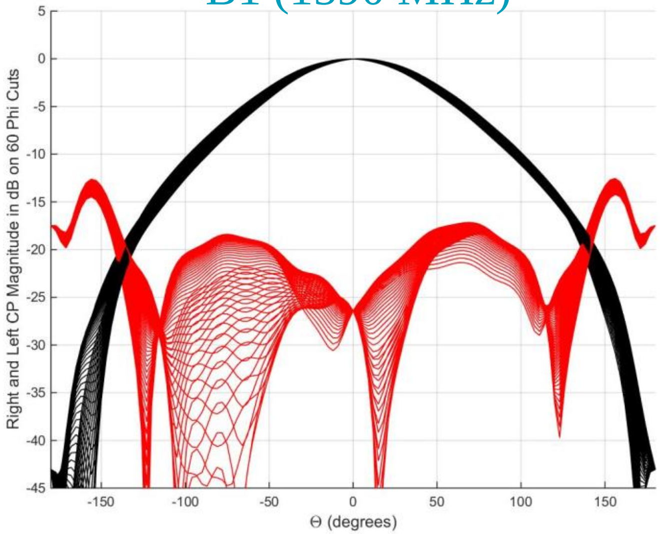
Dual Feed Patch Antenna

- On a wide bandwidth from 1559 MHz to 1610 MHz:

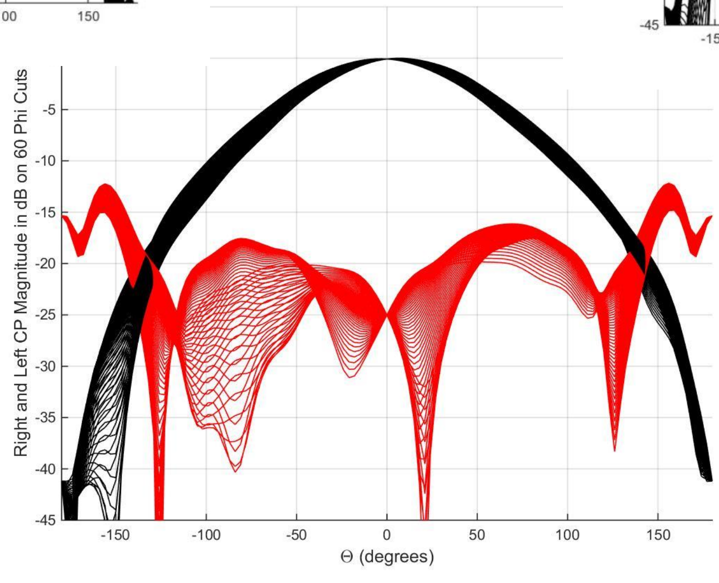
E1 (1561 MHz)



B1 (1590 MHz)

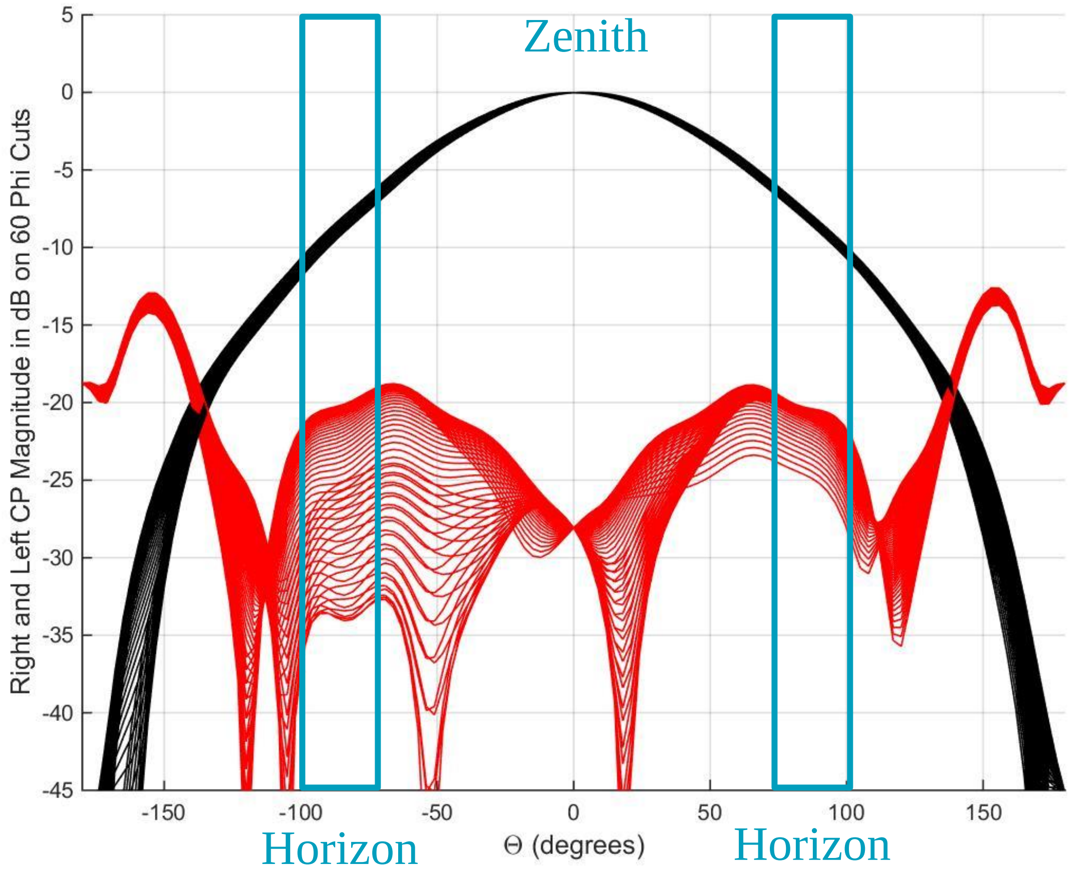


G1 (1602 MHz)



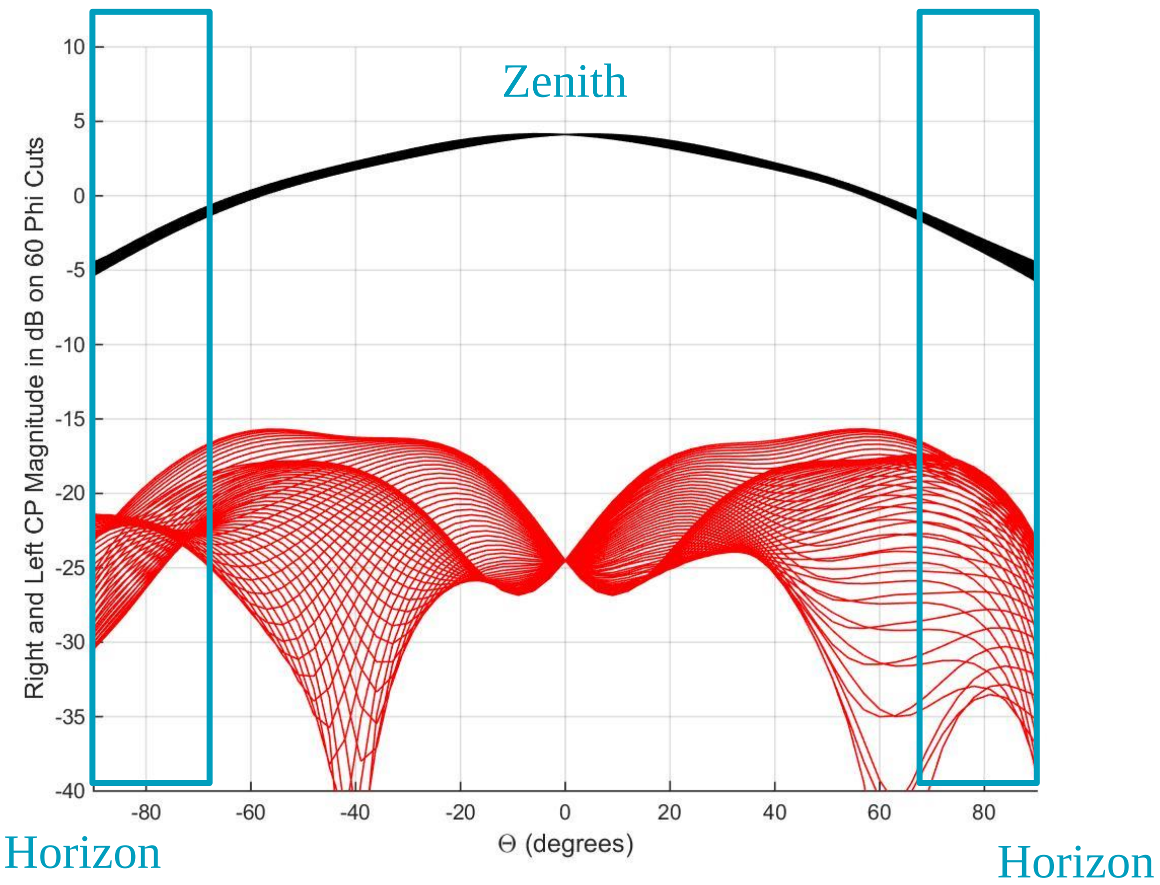
REJECTION SPECIFICATION

- Rejection of the signals between 0 deg and 20 deg of elevations



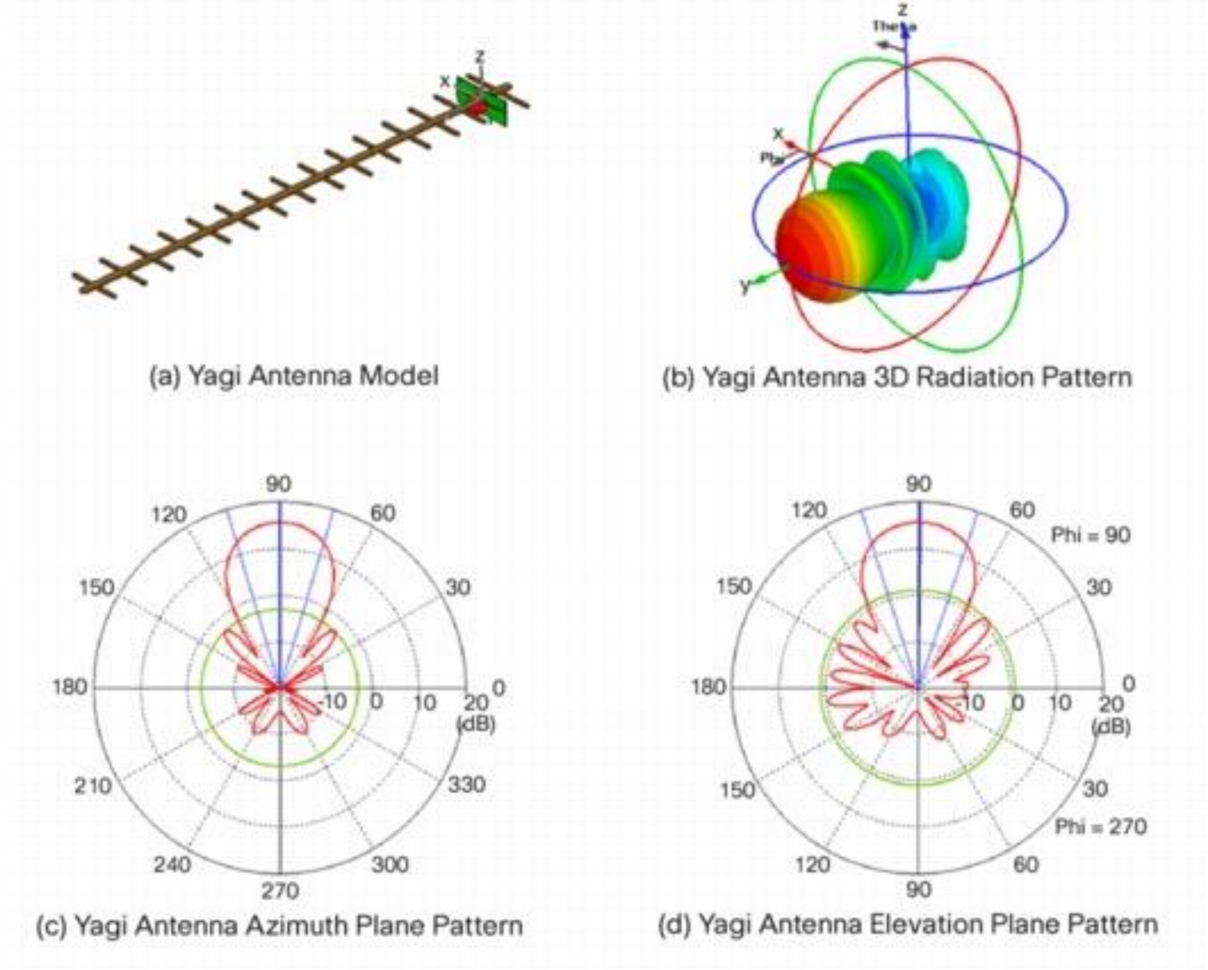
REJECTION SPECIFICATION

- Rejection of the signals between 0 deg and 20 deg of elevations
- 20 dB to 30 dB of rejection at 15 degrees of elevation



The Yagi-Uda antenna

- The Yagi-Uda Antenna increases the directivity
- Reduce the gain at low elevation angles



The Yagi-Uda antenna

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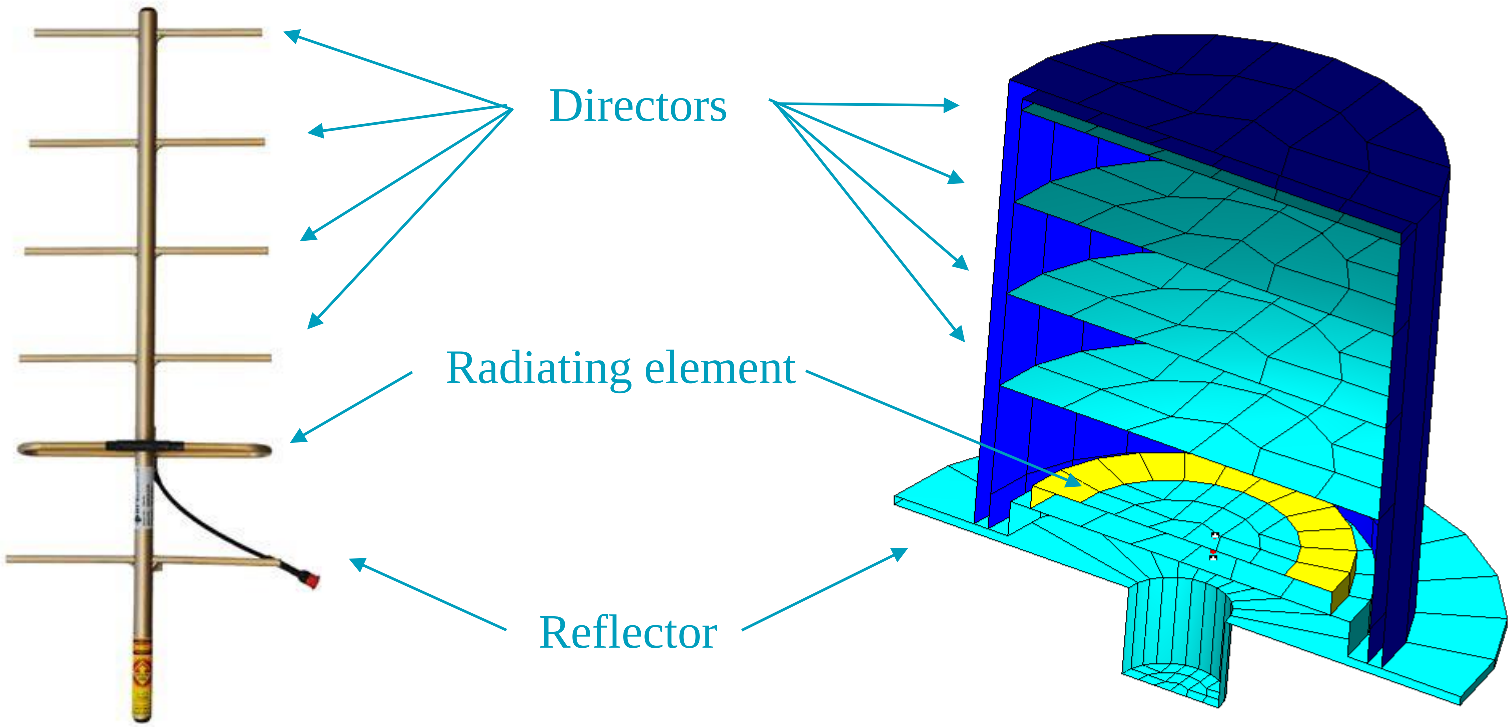
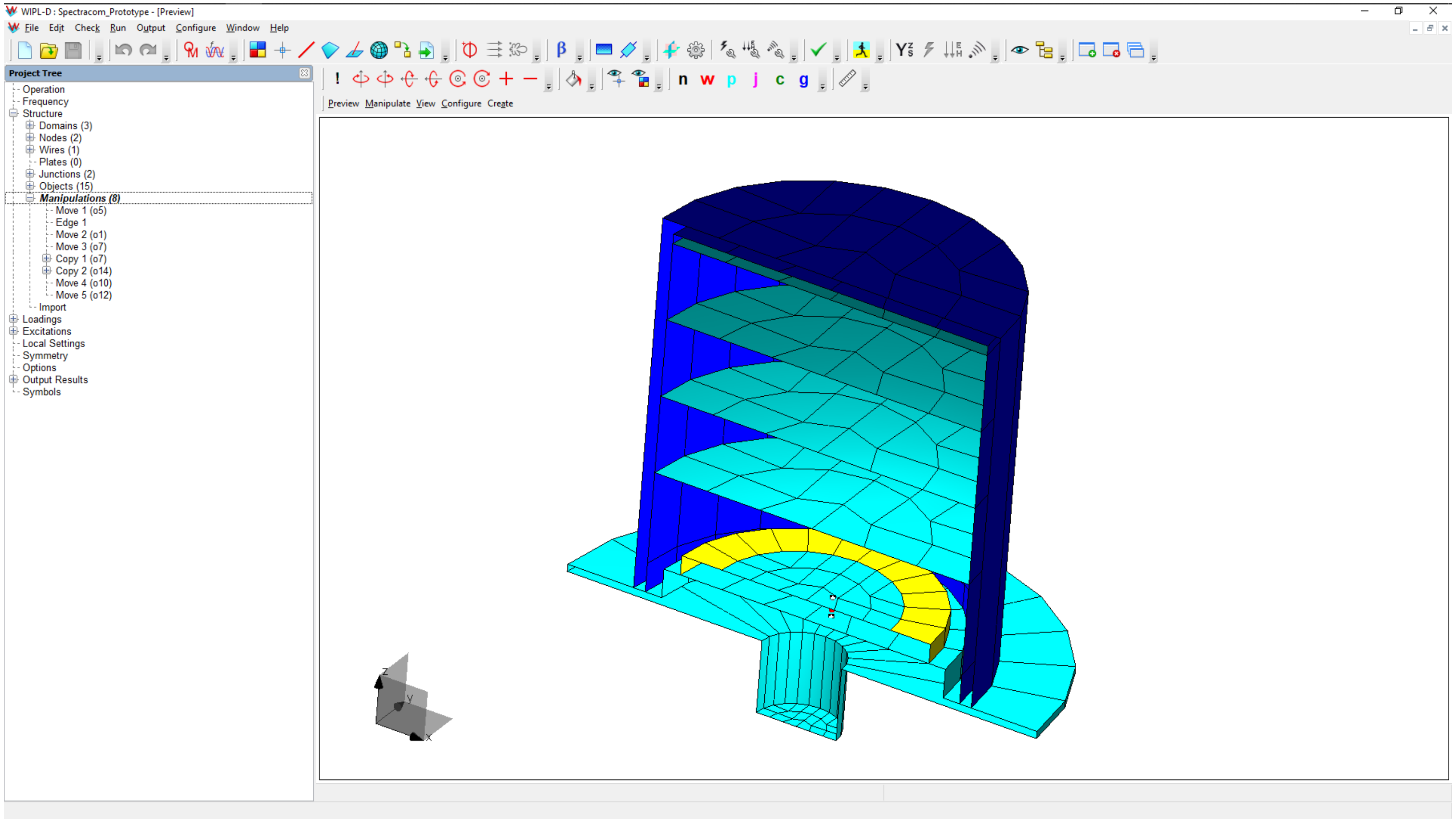


Simulation Study

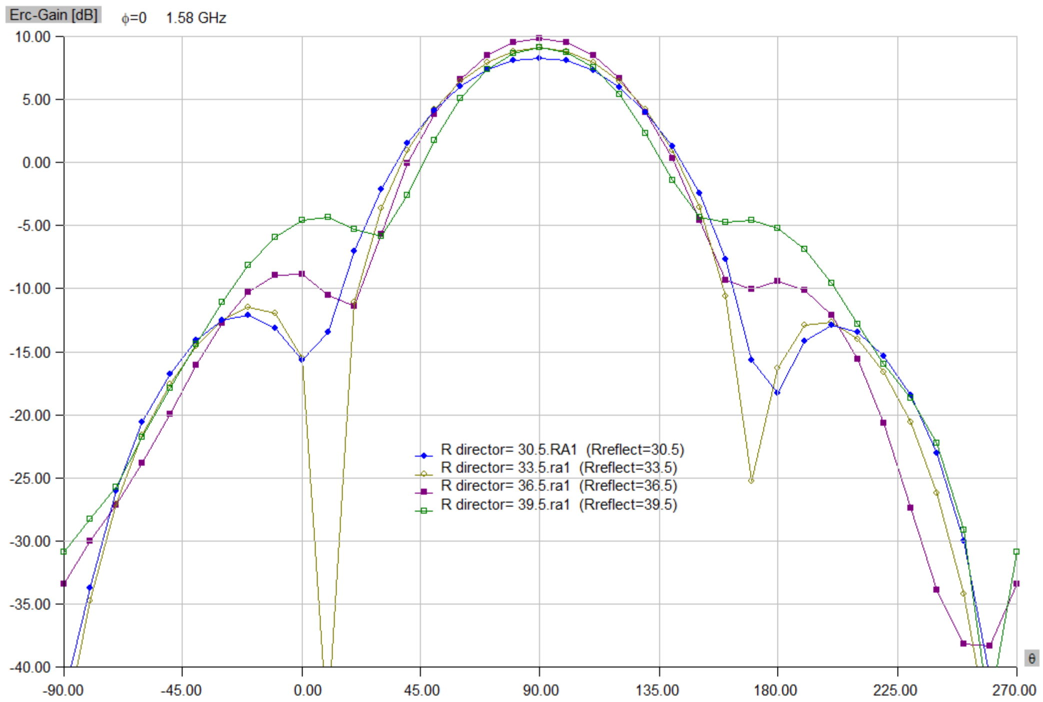
SIMULATION STUDY

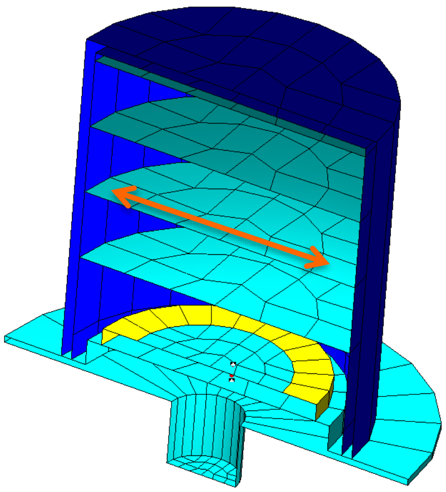


- Simulated and optimized in 3D RF simulator WIPL-D

Simulation Study

- Impact of the radius of the directors
- Radius varies between 30.5 mm and 39.5 mm

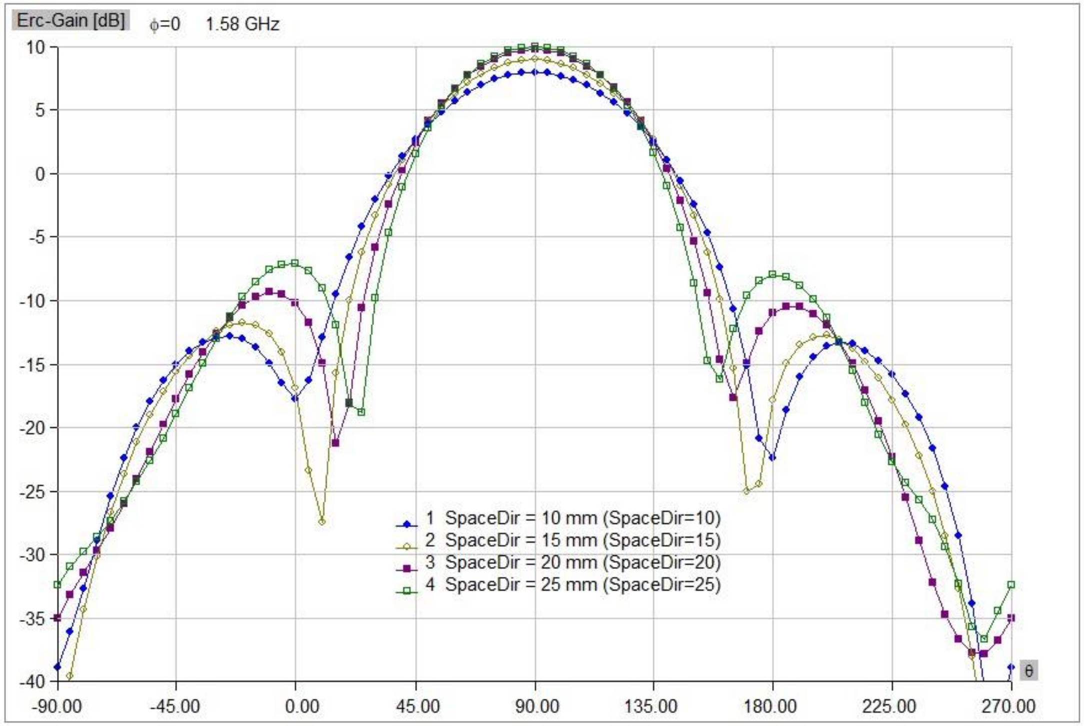


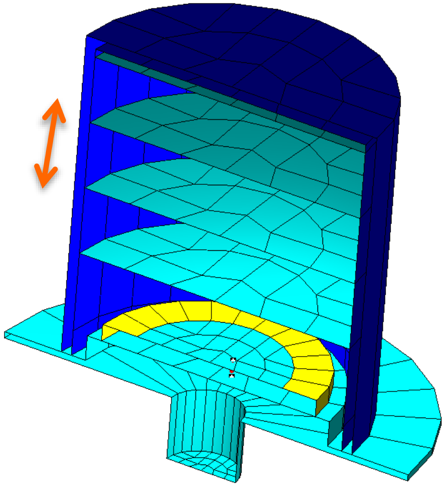


- Impact the directivity and the gain pattern
- Tuning of the null in the radiation pattern

Simulation Study

- Impact of the space between the directors
- Space varies between 10 mm and 25 mm

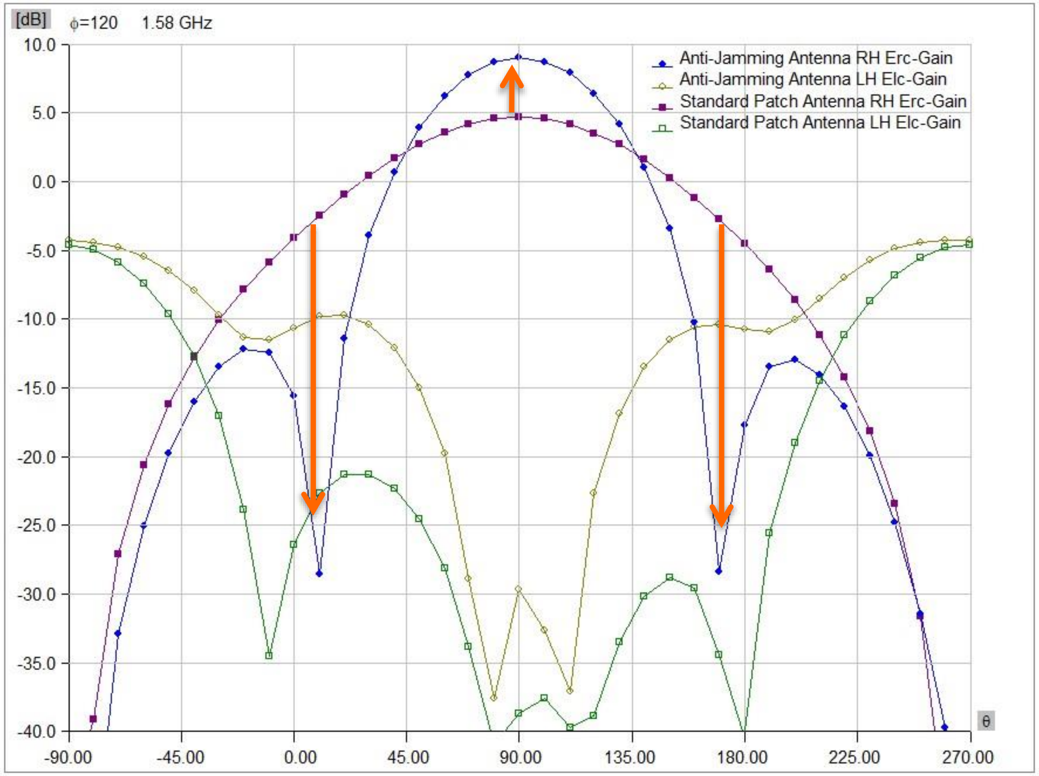




- Impact the directivity and the gain pattern
- Tuning of the null in the radiation pattern

SIMULATION STUDY

- Optimized design compared to standard patch



- 25 dB min of attenuation at 15 deg of elevation
- 4 dB of increased RHCP gain at zenith

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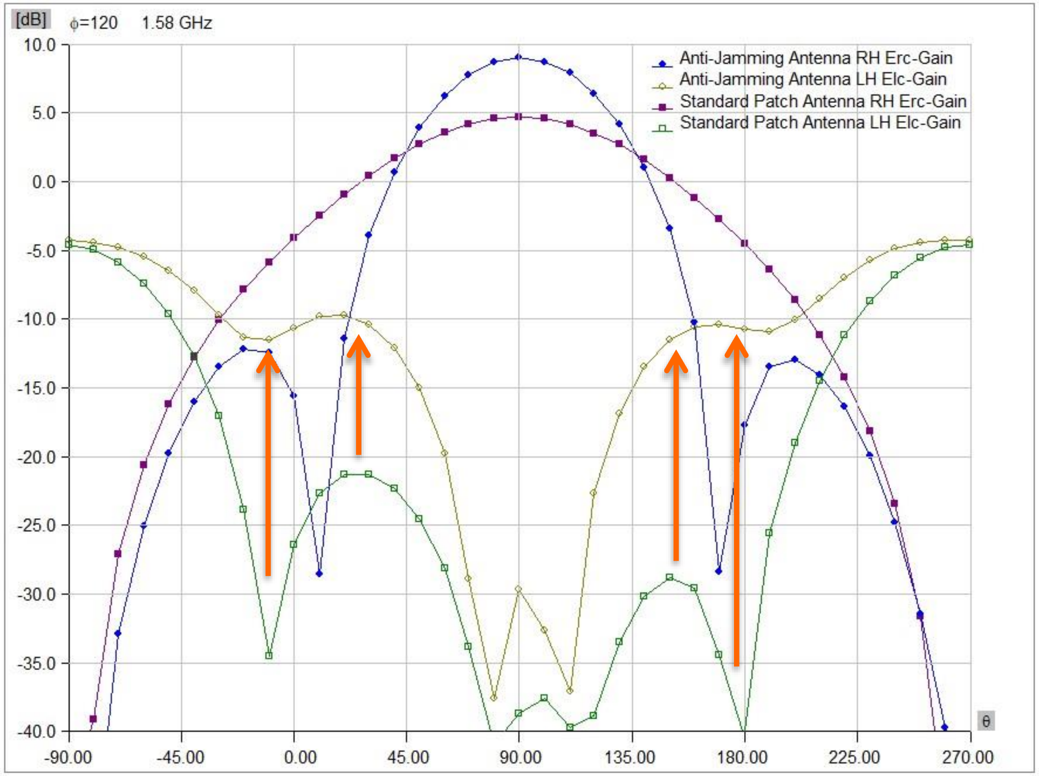
SIMULATION STUDY

- Optimized design compared to standard patch

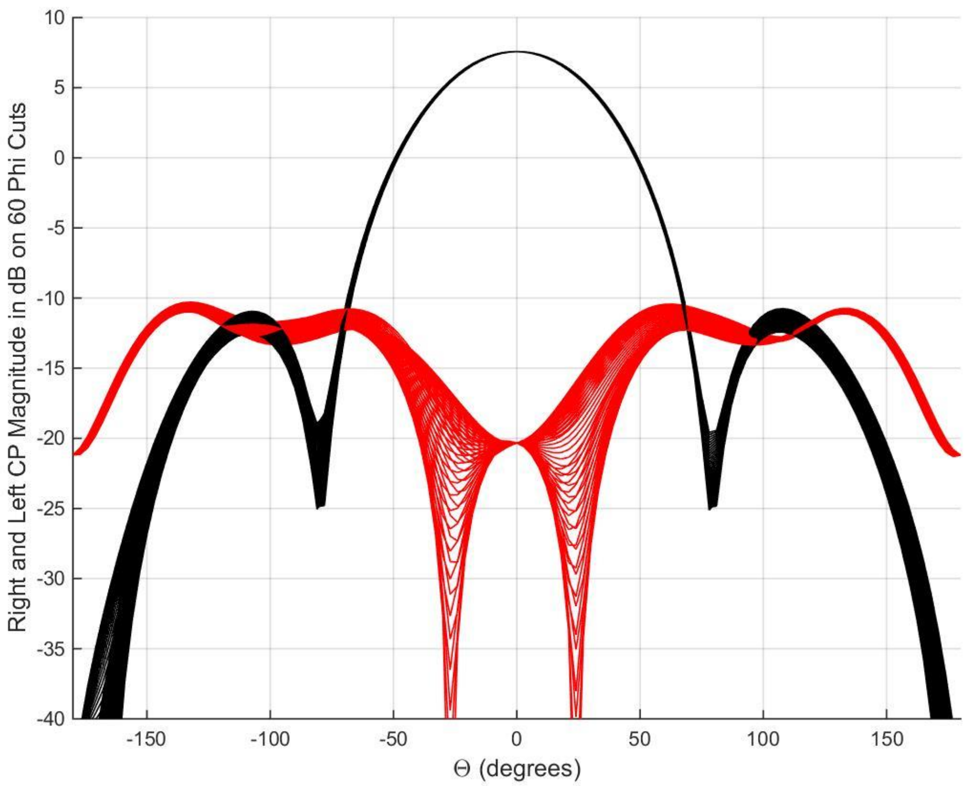


- Increased LHCP gain → Trade-off

RADIATING PERFORMANCES

RADIATION PERFORMANCES

- Radiation pattern at 1575 MHz (MVG SG64)

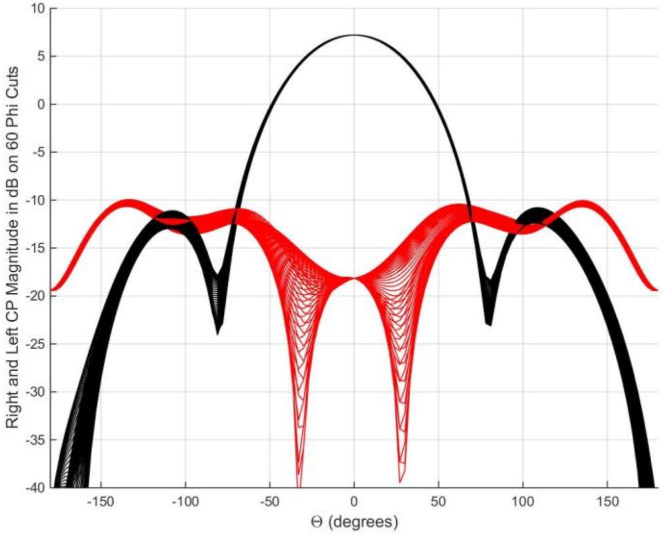


- Gain of 7.5 dBic at zenith
- 22 dB to 27 dB of RCHP gain roll-off at 15 deg

Radiation Performances

- On a wide bandwidth from 1559 MHz to 1610 MHz:

E1 (1561 MHz)



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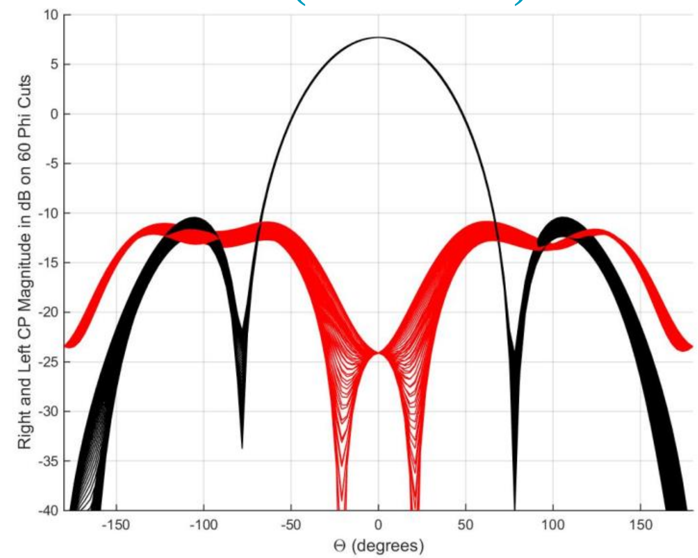

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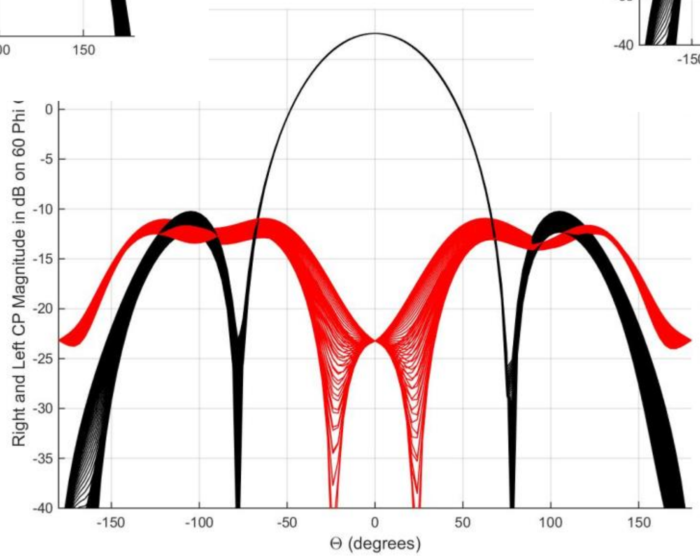

Realized gain:
7.2 to 7.8 dBic

Axial ratio at zenith:
better than 0.9 dB

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Radiation Performances

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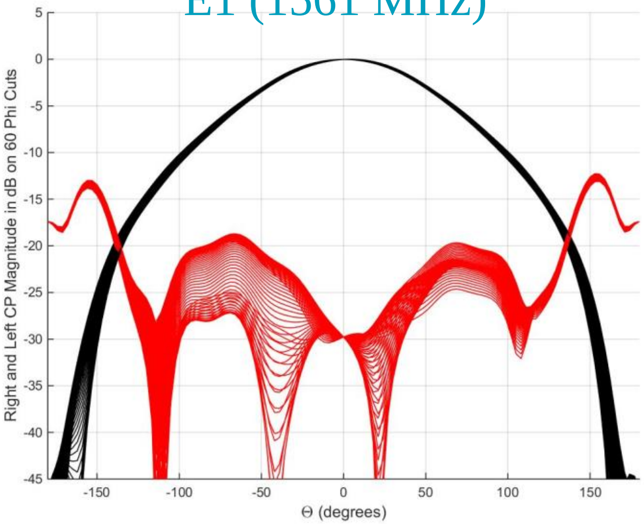

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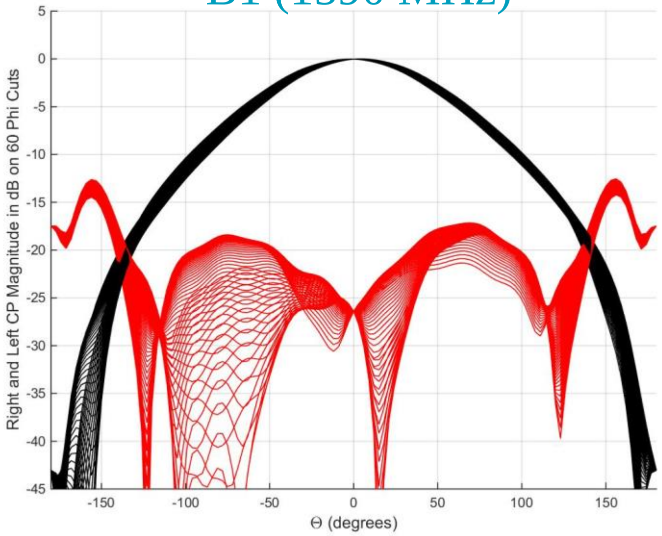

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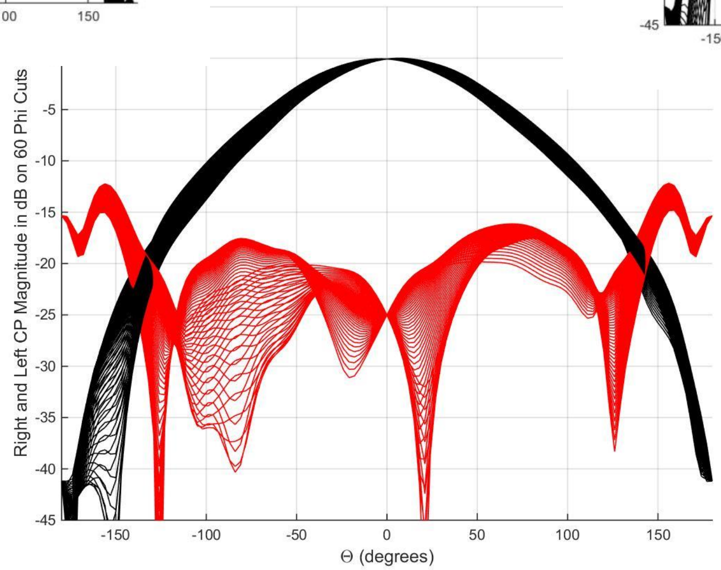
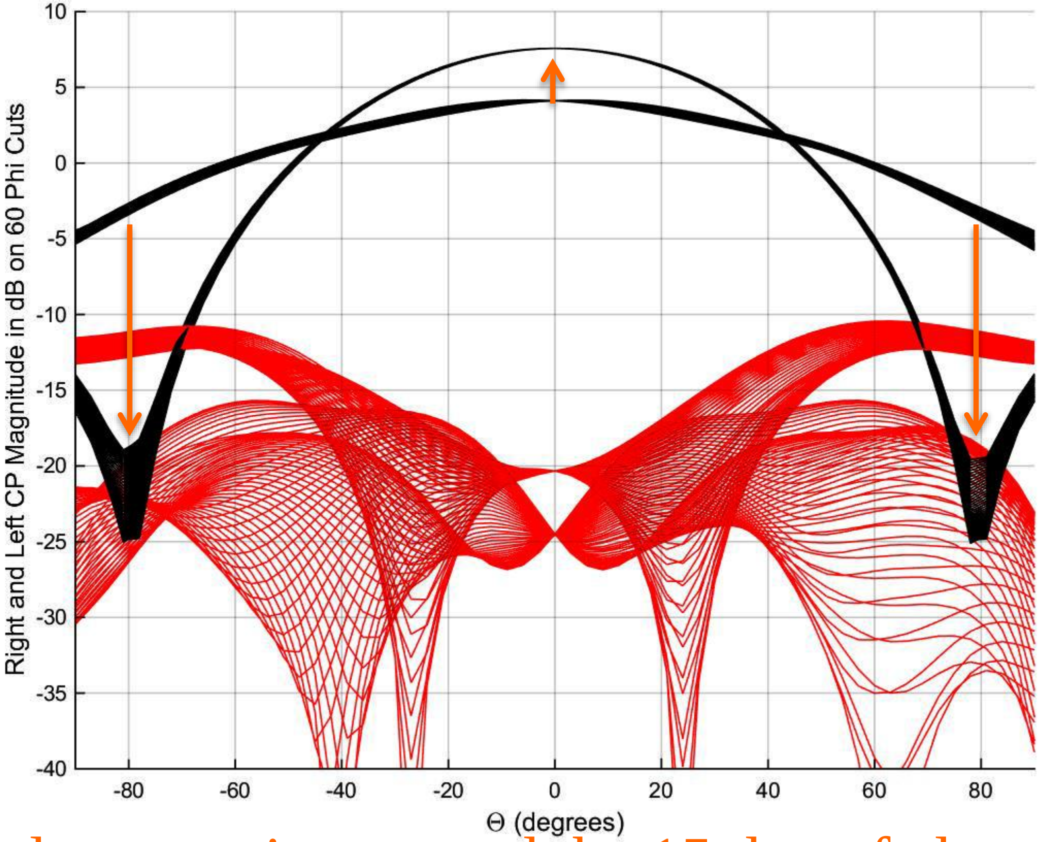


Radiation Performances

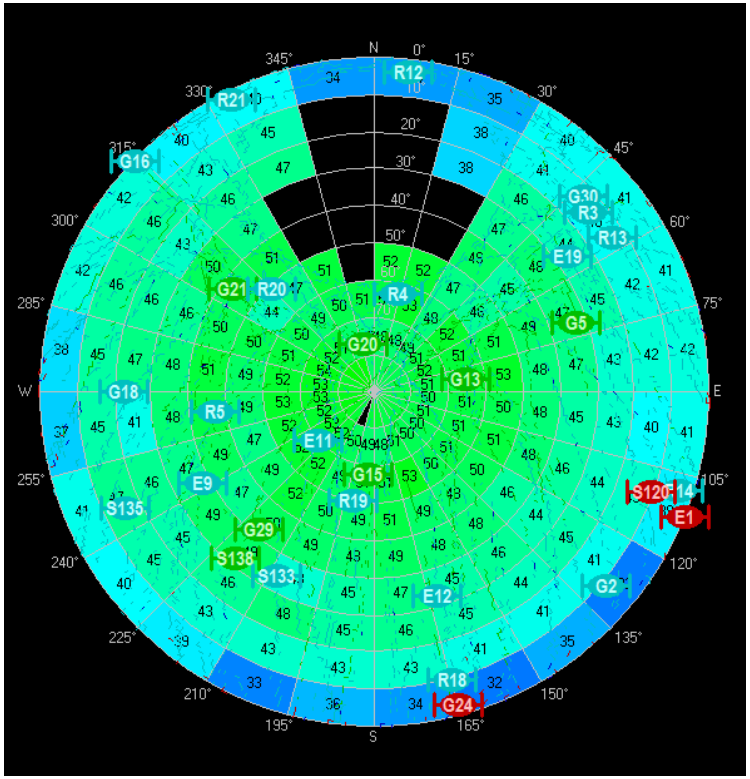
- Direct comparison:

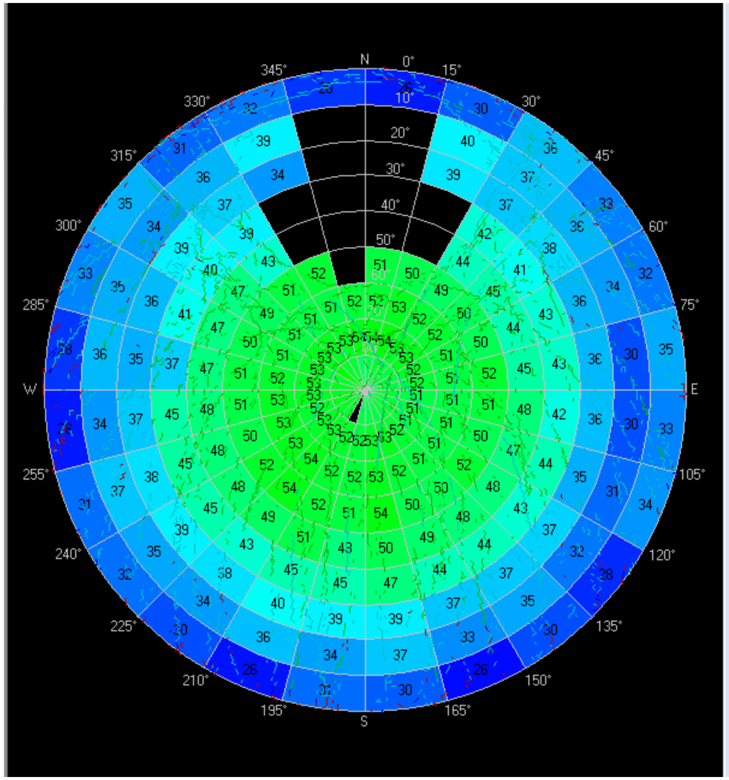


- Good attenuation around the 15 deg of elevation
- Increase of the LHCP gain at that elevation angle

FIELD TEST

- Carrier to noise ratio of the GNSS signal
- Comparison test with a standard dual feed patch





- Decrease of the signal coverage low elevation angles

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FIELD TEST

- Antenna located close to a trucking company
- Comparison test with a standard dual feed patch
- Eight days of measurement

- Loss of GNSS signal:
  - Standard antenna: 1h30 minutes
  - Anti-jamming antenna: < 1min

	Standard Antenna	AJ Conical Antenna
Holdover events	40	4
Total time in Holdover	1 hour 32 minutes	41 seconds
Longest holdover event	14 minutes 26 seconds	17 seconds
Average holdover event	2 minutes 18 seconds	10 seconds
Satellite alarms	31	2

CONCLUSIONS

- Gain reduction at low elevations angles:
  - ➔ Yagi-Uda design was adapted to the patch antenna:

    - Increase of the gain at zenith to 7.5 dB
    - Decrease of the RHCP gain around 15 deg of elevation
    - Great behavior on the full upper GNSS band
    - Trade of with the LHCP gain

  - ➔ Clear impact during the field test

- Future work:
  - ➔ Develop a dual band solution to also cover the L2 frequency

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References

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- I. Mcmichael, S. Best, D. Hanna, E. Lundberg “Horizon Ring Nulling Quadrifilar Helix Antennas for GPS Timing Applications,” MITER, 2016.
- H. Yagi, “Beam transmission of the ultra short waves,” Proc. IRE, vol. 16, pp. 715–741, Jun. 1928.

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