

Adaptive Beamforming and Diversity Combining Measurements at 2.05 GHz using arrays of four low-profile wire elements backed with an electromagnetic band gap structure.

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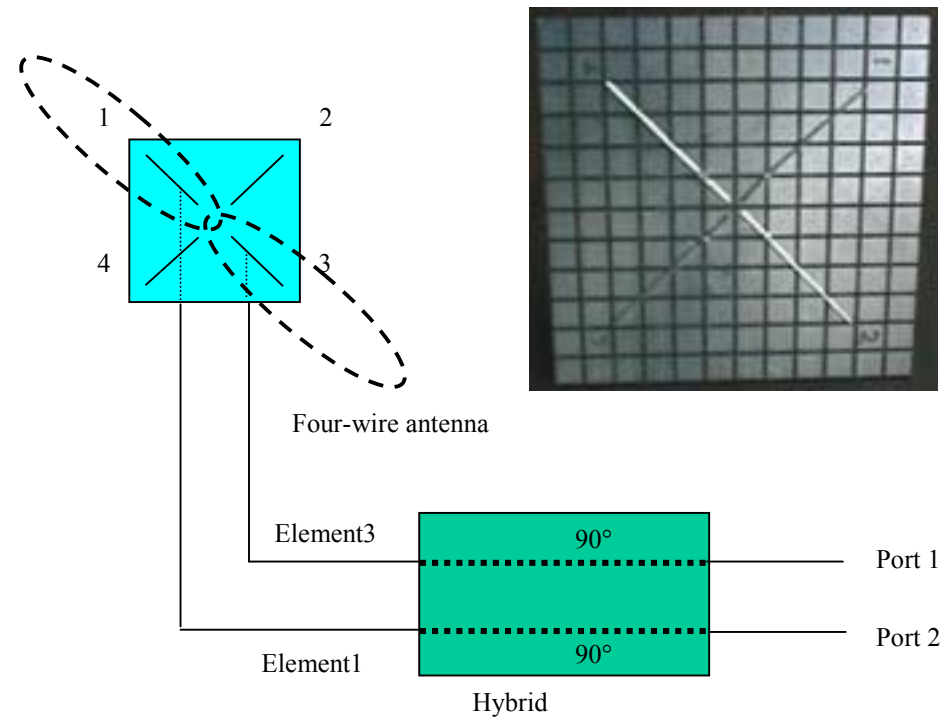
J. H. Schaffner, H. P. Hsu, D. F. Sievenpiper

HRL Laboratories (www.hrl.com)

Low Profile Four-element Array with wire antenna mounted over a high impedance electromagnetic band gap structure



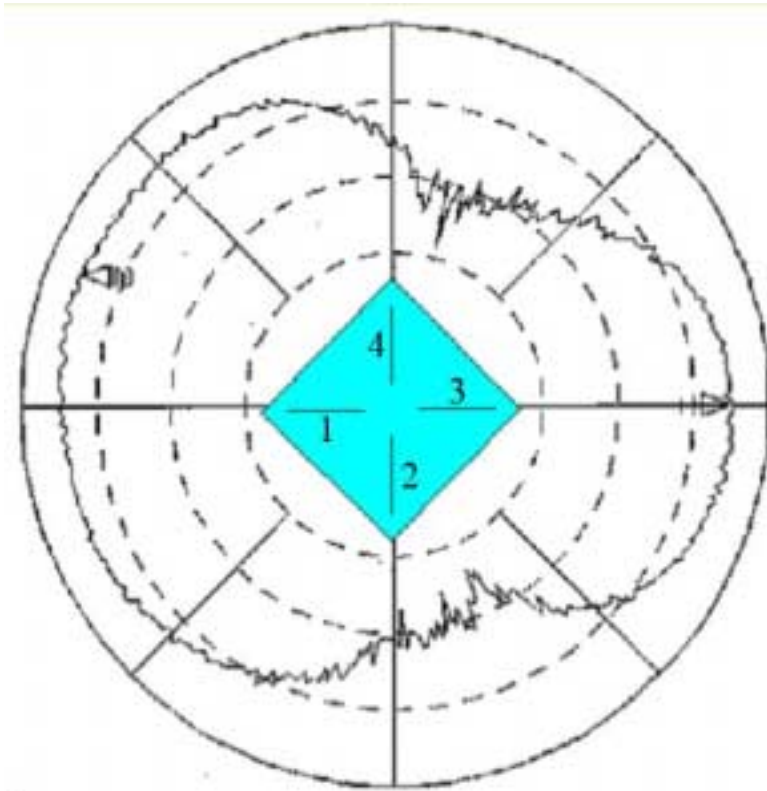
Linear Array of single wire elements with $d = 0.4\lambda - 1.0\lambda$



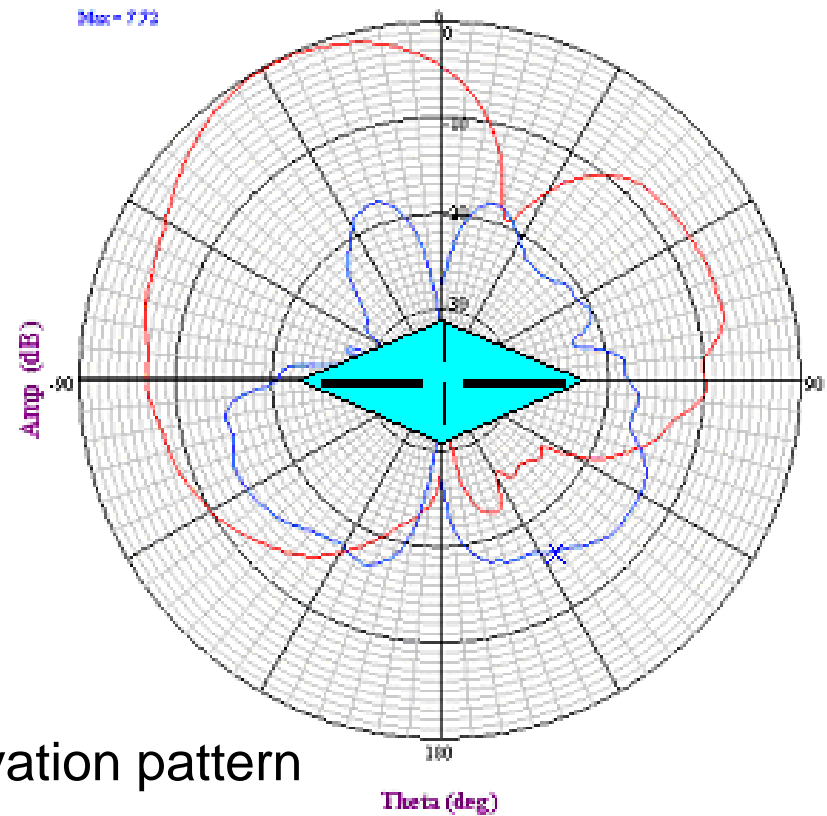
Square Four-wire Antenna

Co-Polarized H-plane Active element patterns at 2.050 GHz

Scale = 10 dB/division



azimuth pattern

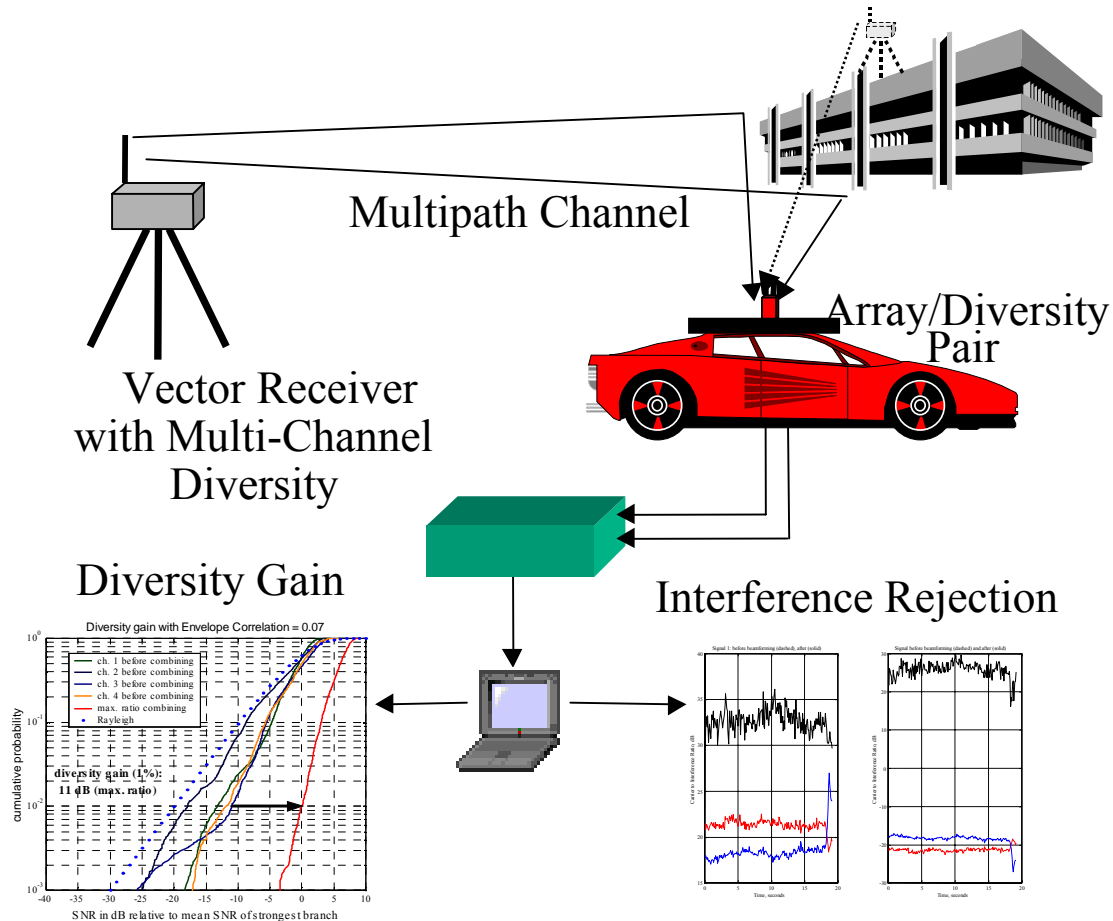


elevation pattern

Square Four Wire Antenna

- Co-polarized
- Cross-polarized

Handheld Antenna Array Testbed (HAAT)



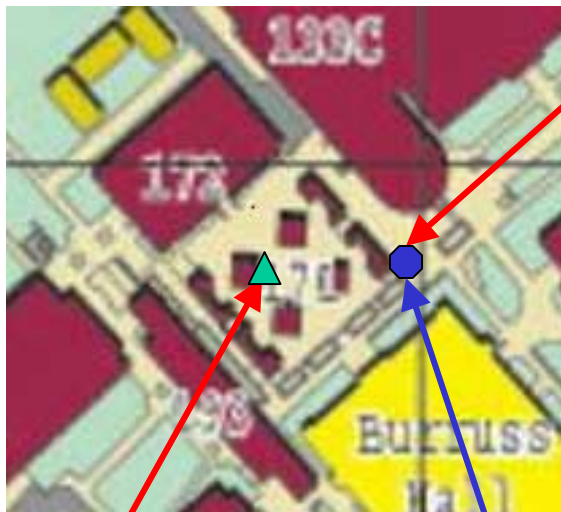
- 4-channel Narrowband Receiver at 2.05 GHz
- Arrays mounted on Linear Positioner/Vehicle Roof-top
- Offline processing of the data collected

Diversity Measurement Scenario

Urban Scenario

Suburban Vehicular Scenario

LOS Condition

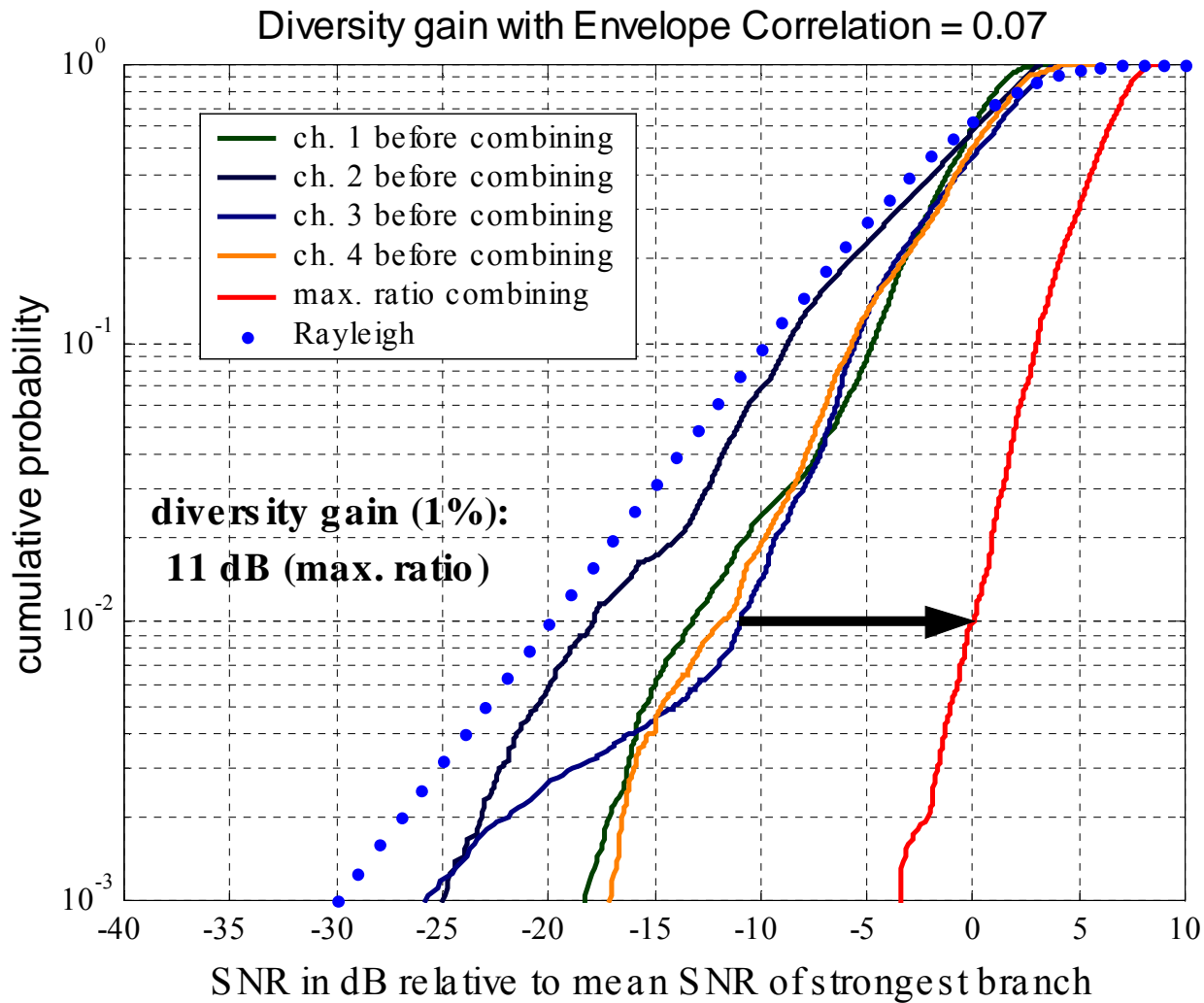


Receiver (fixed)

Transmitter

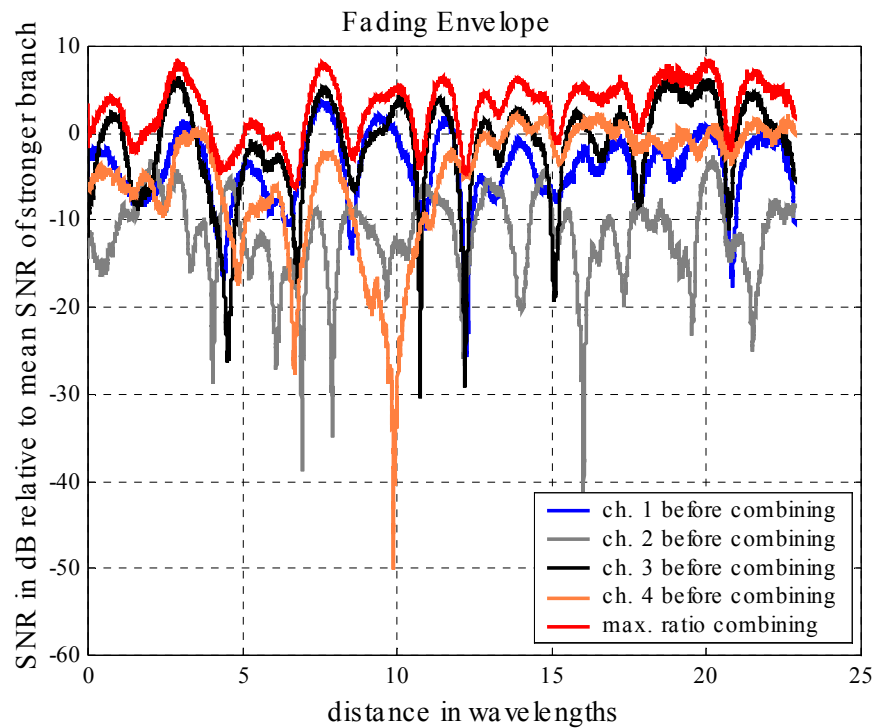
NLOS Condition

Diversity Gain at 1% CDF

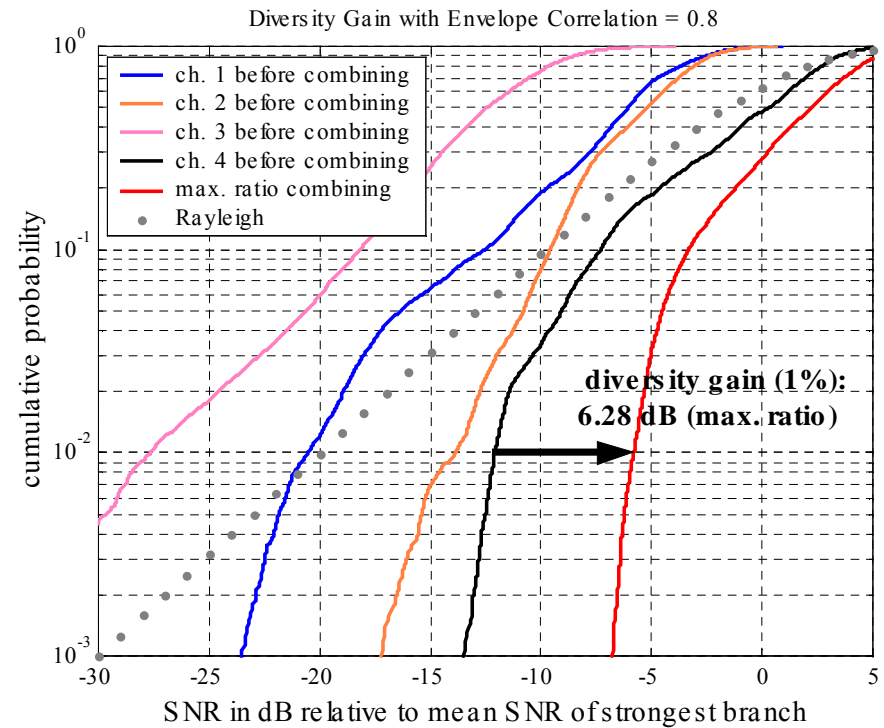


Maximal Ratio Combining

Measured Suburban Line-of-Sight Diversity Results



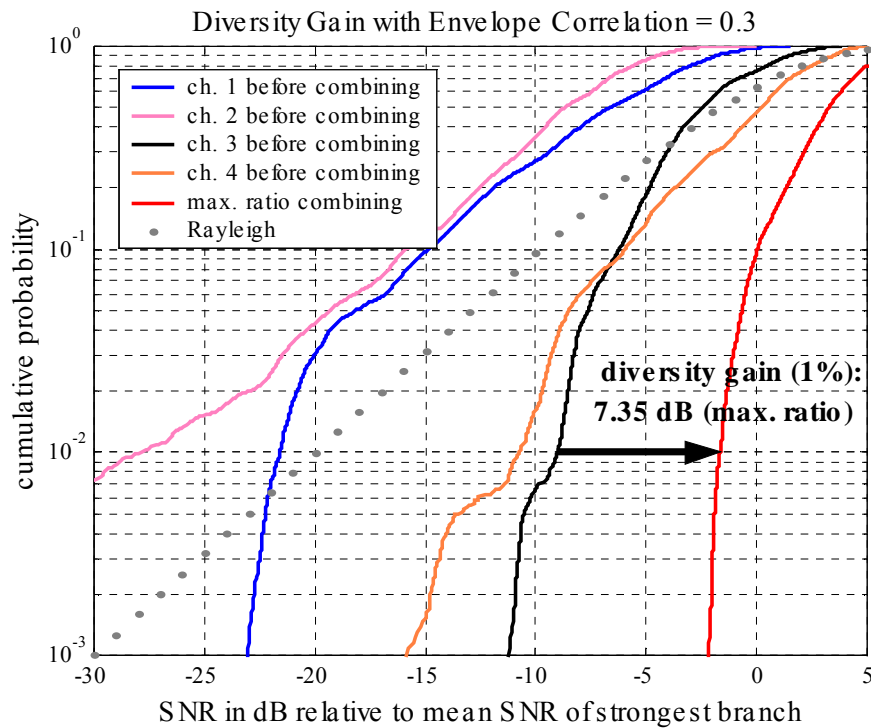
Fading Envelope



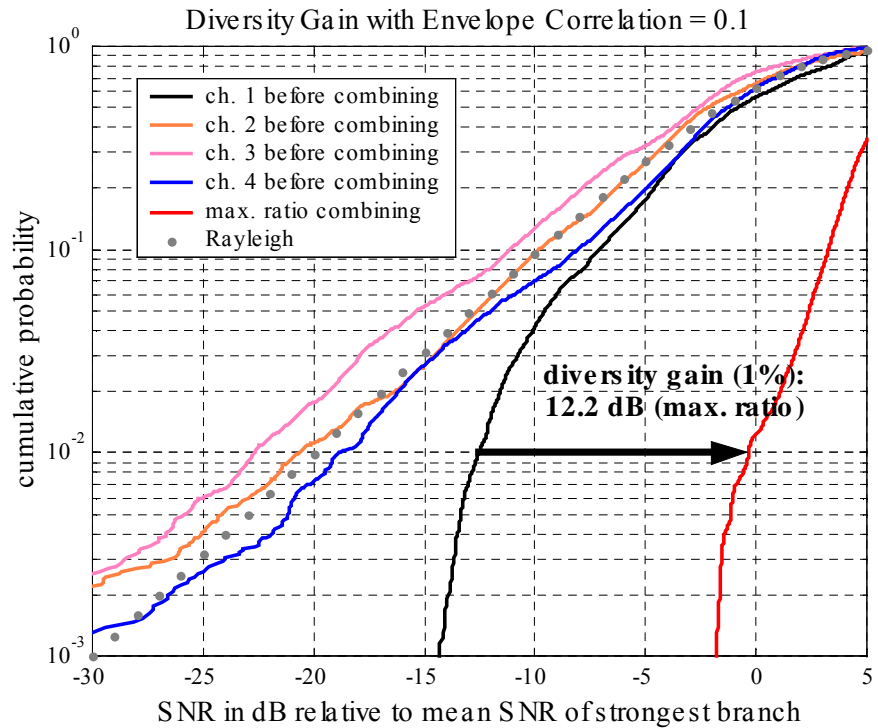
$$G_{\text{div}} [1\%] = 6.3 \text{ dB with MRC}$$

Four-wire antenna with elements mounted on high impedance surface using linear positioner at pedestrian speeds

Measured Urban Non-Line-of-Sight Diversity Results



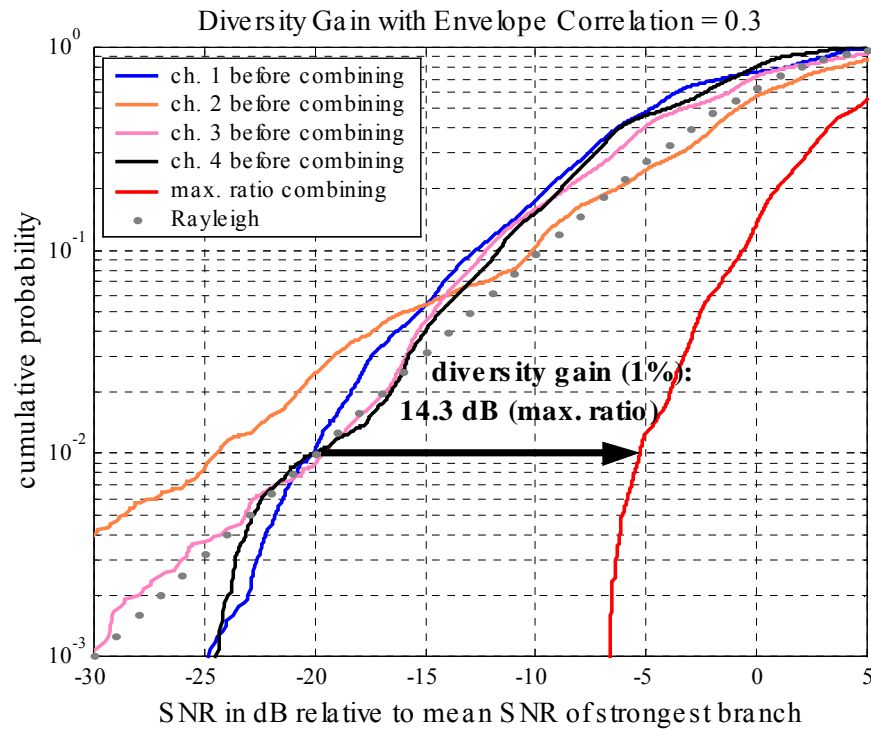
Square Array $G_{\text{div}} [1\%] = 7.4 \text{ dB}$



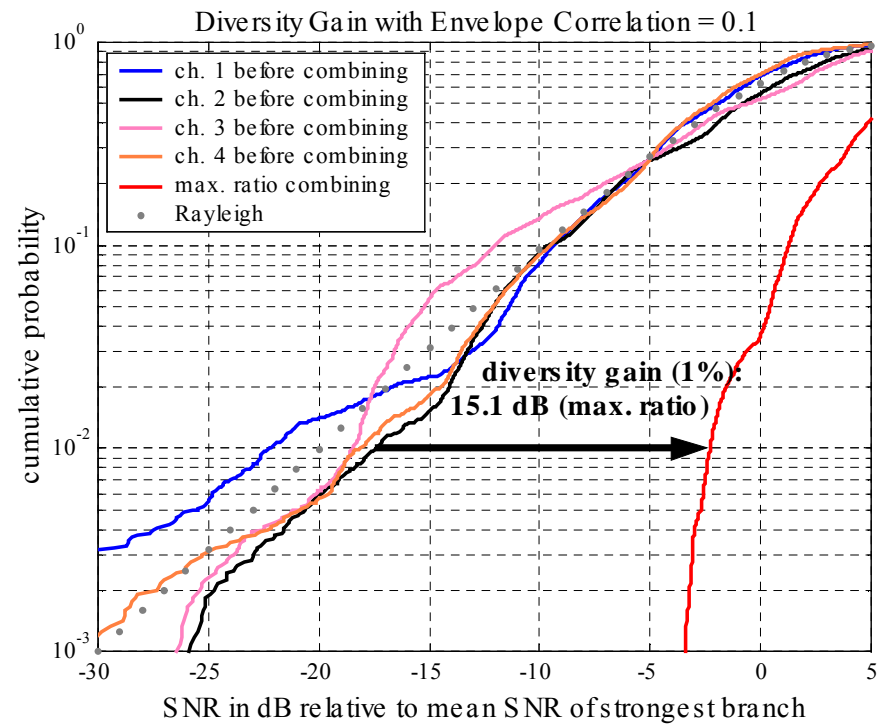
Linear Array with $d = 0.4 \lambda$
 $G_{\text{div}} [1\%] = 12.2 \text{ dB}$

Combining technique: Maximal Ratio Combining (MRC)

Measured Urban Non-Line-of-Sight Diversity Results

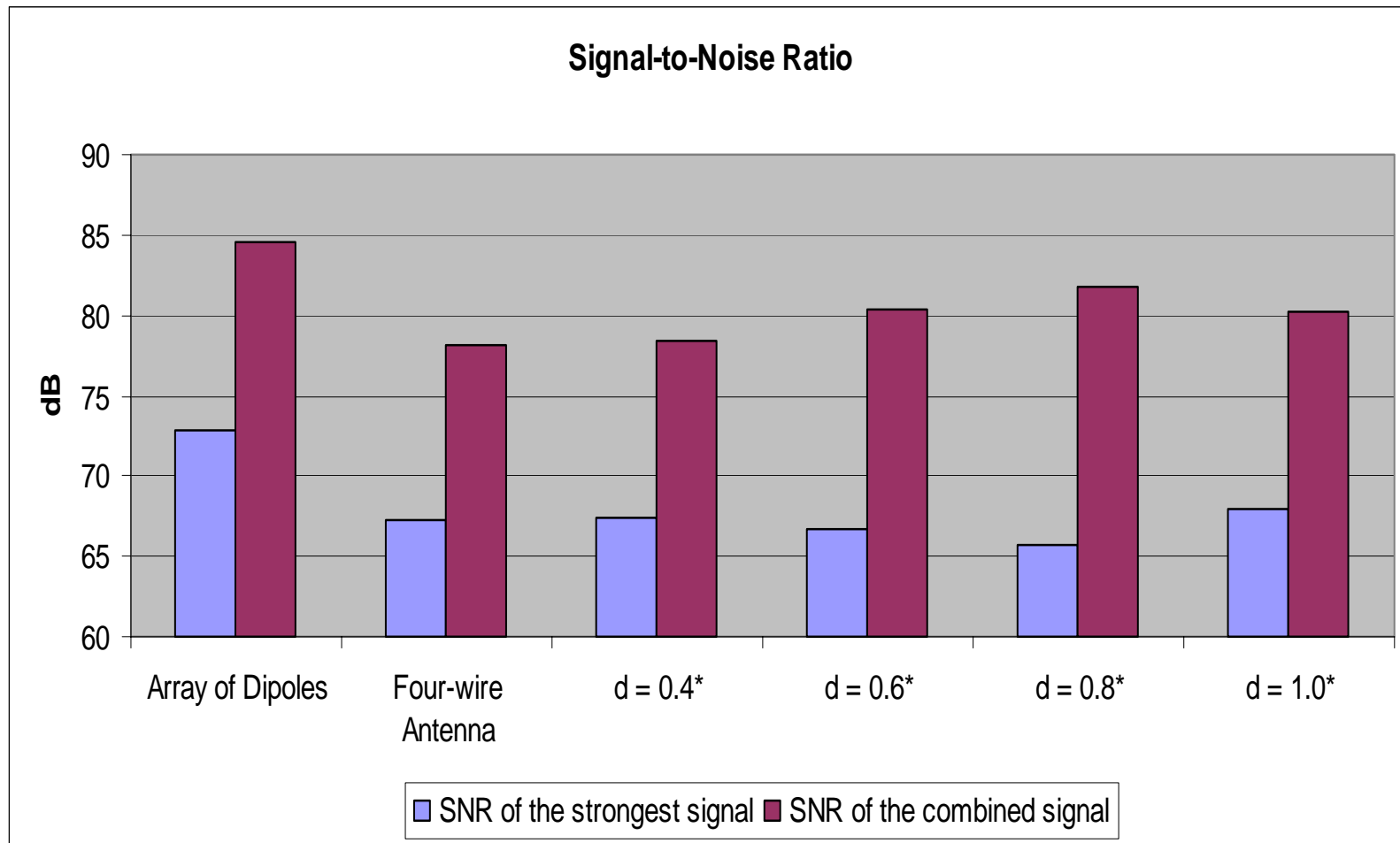


Linear Array with $d = 0.6 \lambda$
 $G_{\text{div}} [1\%] = 14.3 \text{ dB}$



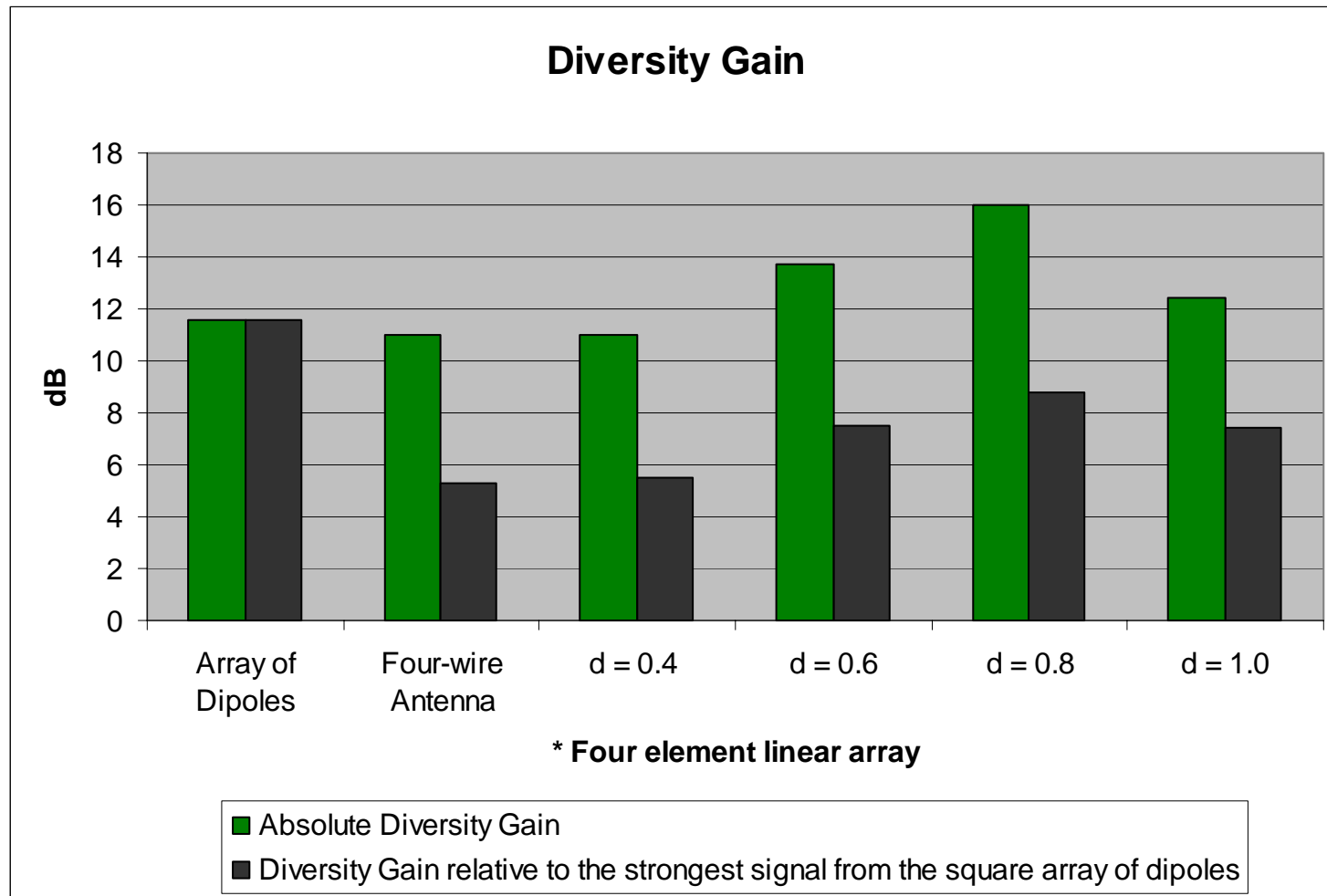
Linear Array with $d = 0.8 \lambda$
 $G_{\text{div}} [1\%] = 15.1 \text{ dB}$

Diversity Performance in Suburban LOS for Arrays mounted on a vehicle roof-top

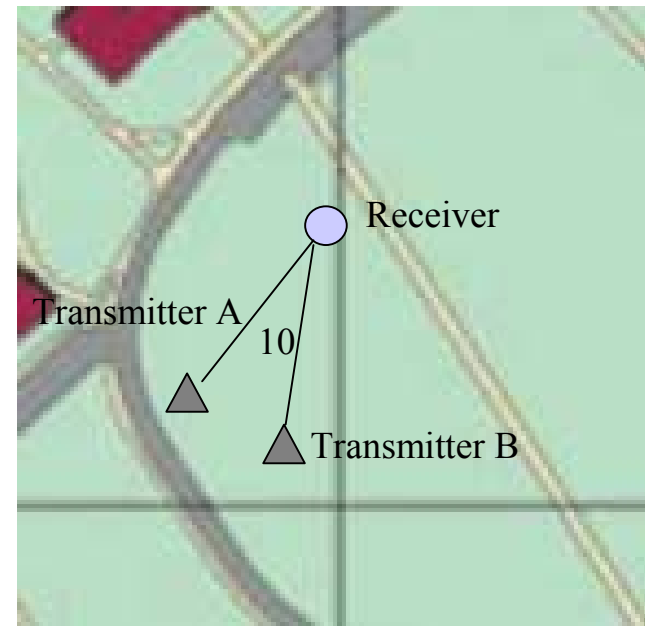
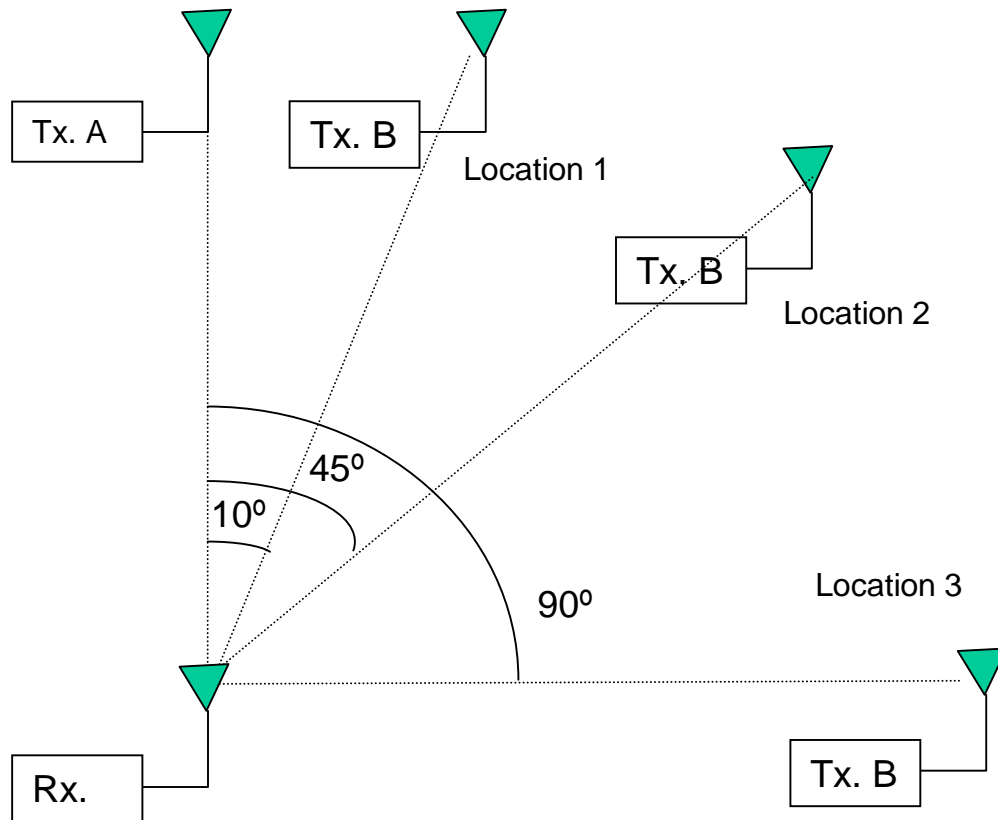


11 dB – 14 dB improvement in SNR was recorded for arrays mounted on a vehicle roof-top in suburban line-of-sight measurement scenario

Diversity Performance in Suburban LOS for Arrays mounted on a vehicle roof-top

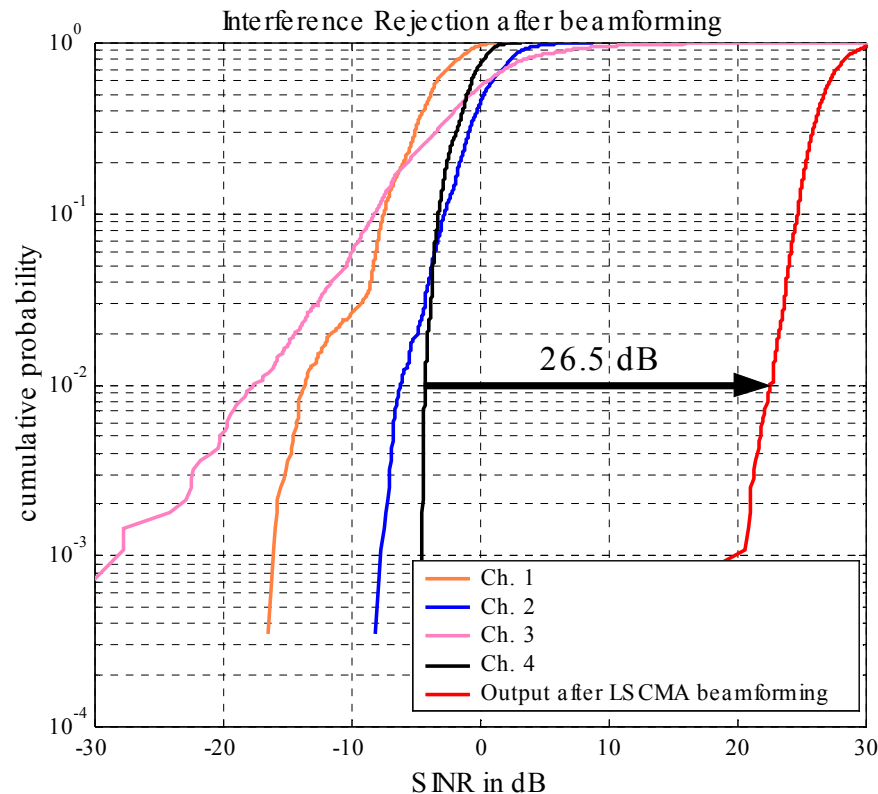


Suburban Interference Rejection Measurement Scenario

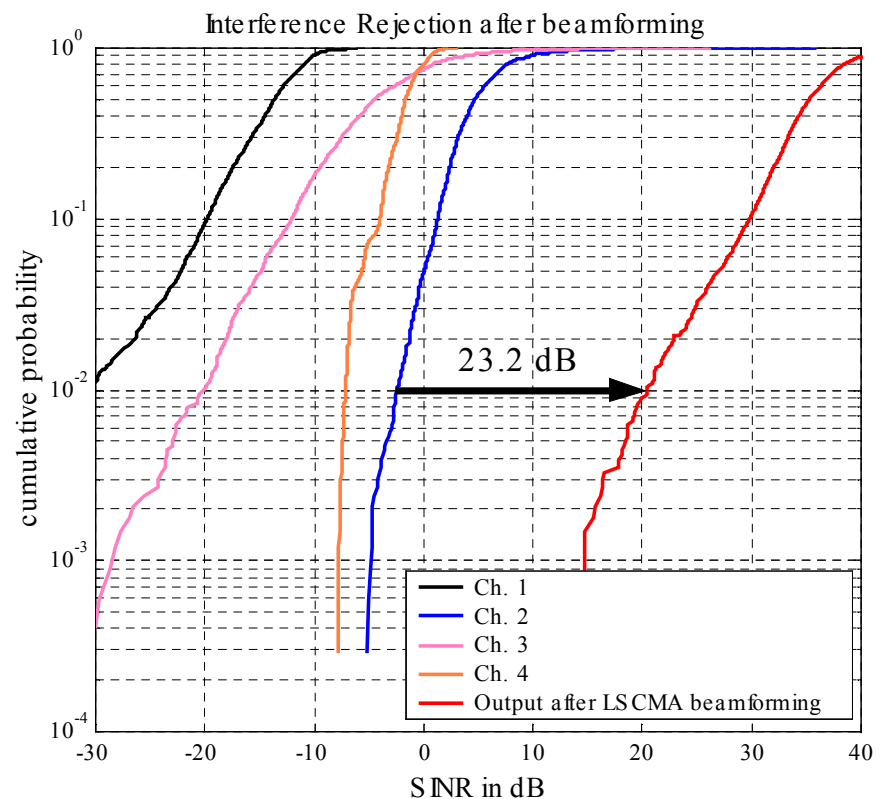


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Interference Rejection in Azimuth Plane with Four-wire Antenna - I

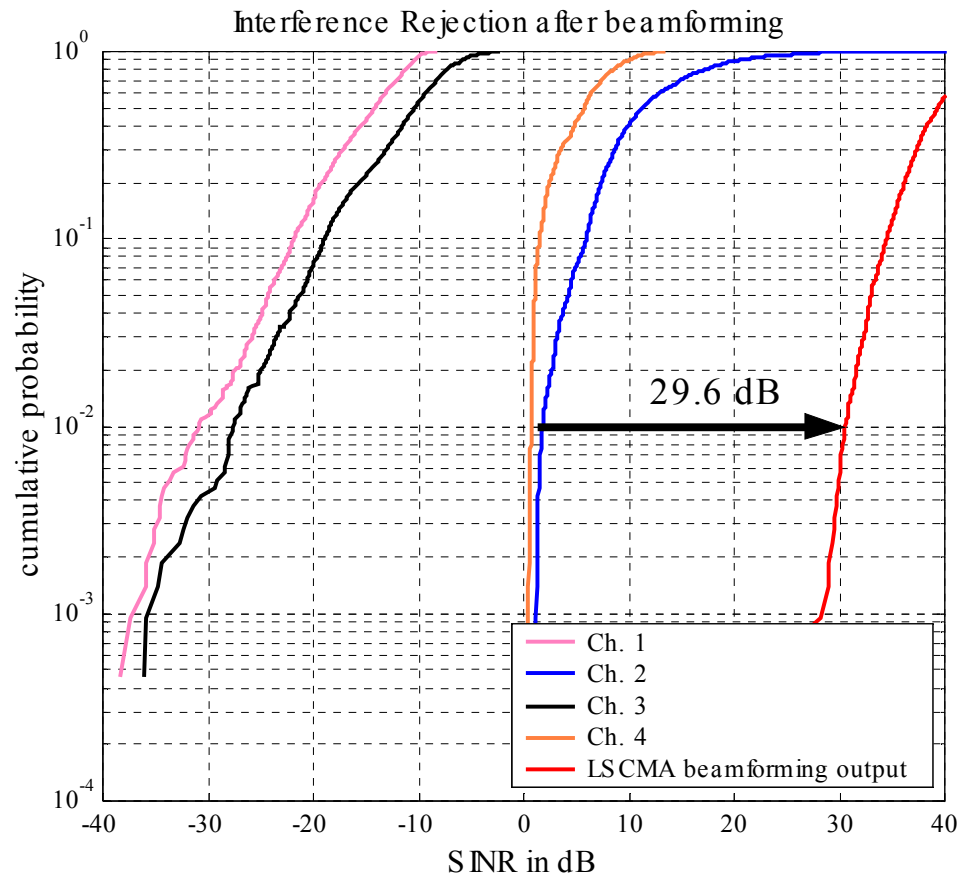


Separation in Azimuth = 10°
 Δ SINR = 26.5 dB
 Mean Output SINR = 22.6 dB



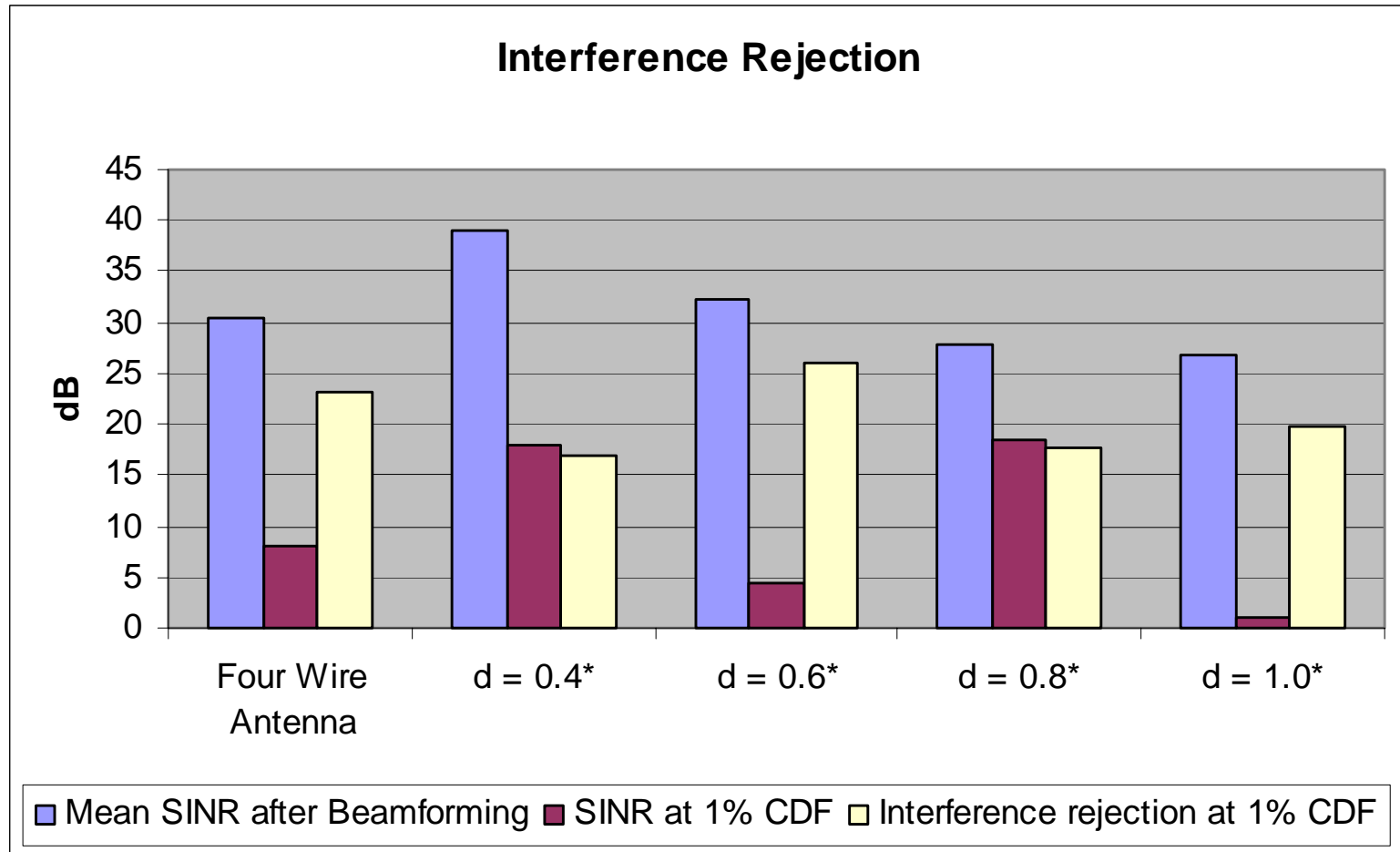
Separation in Azimuth = 45°
 Δ SINR = 23.2 dB
 Mean Output
 SINR = 35.0 dB

Interference Rejection in Azimuth Plane with Four-wire Antenna - II



Separation in Azimuth = 90°
 $\Delta\text{SINR} = 29.6 \text{ dB}$
Mean Output SINR = 39.4 dB

Vehicle-mount array performance comparison in Suburban LOS Scenario



*four-element linear array with distance as fraction of wavelength

Summary and Conclusion - I

- For diversity combining measurement taken in non-line-of-sight (NLOS) obstructed urban channel, Diversity gain values of up to 15 dB were calculated using MRC at 99% reliability
- As the separation between the single elements in a linear array was increased, increased diversity gain was recorded.
- Diversity gain values of 11 – 14 dB were recorded for arrays mounted on a vehicle roof-top in suburban environment

Summary and Conclusion - II

- The four element antenna with square configuration recorded same SINR improvement due to interference rejection for every separation in azimuth.
- With increase in the separation of wire elements the SINR at 1% CDF was seen to drop. We think it is because of the grating lobes of the array.
- Interference rejection of 27 – 38 dB on linear positioner and 12 – 17 dB with arrays mounted on a vehicle roof-top was recorded in Suburban LOS measurement scenario at 99% reliability was recorded.