Dielectric Communications

Polarization Considerations for Mobile TV

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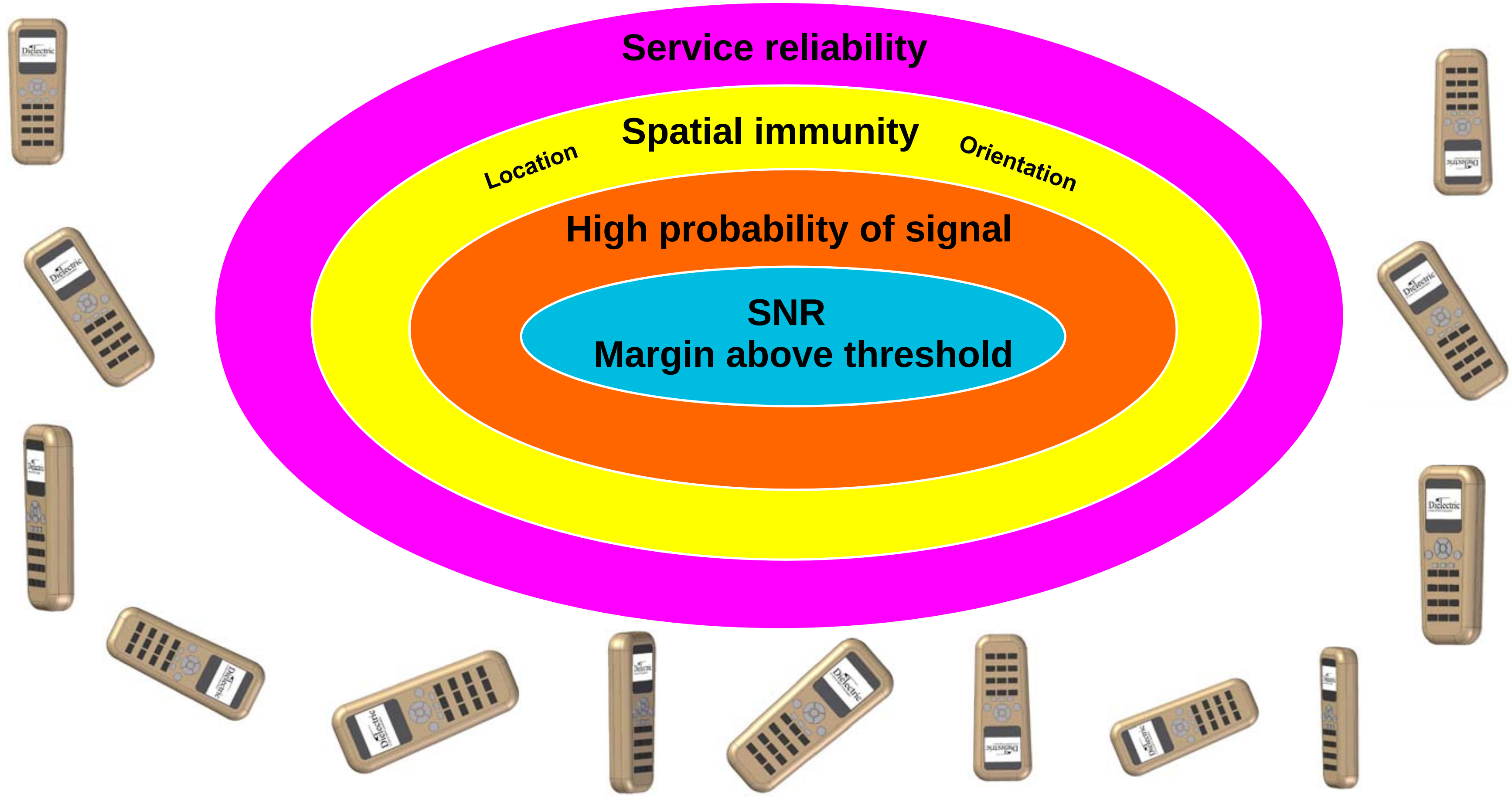
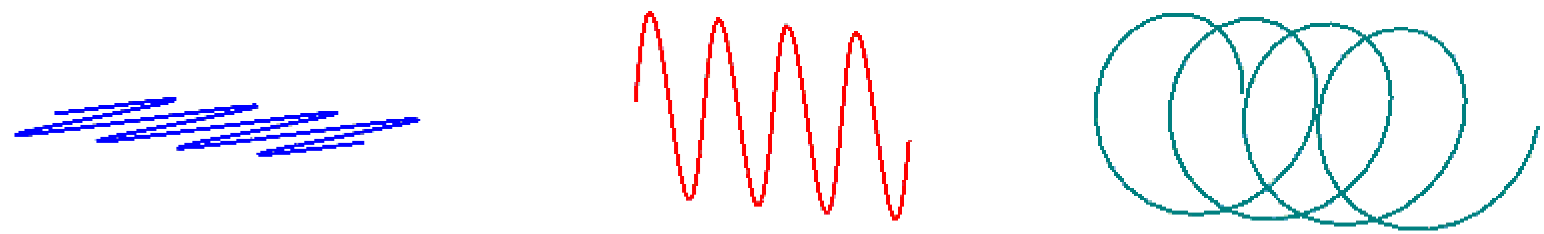
Dielectric Communications

The success of mobile reception depends on…



Service reliability is key

Can the choice of transmit polarization increase the reliability of service?



Horizontal **Vertical** **Circular**

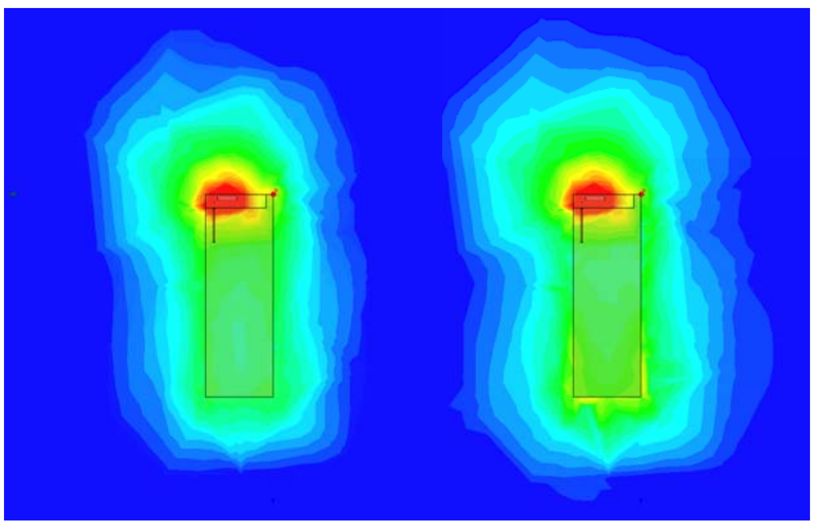
Conditions
- **Polarization Mismatch**
- **Small Scale Fading**

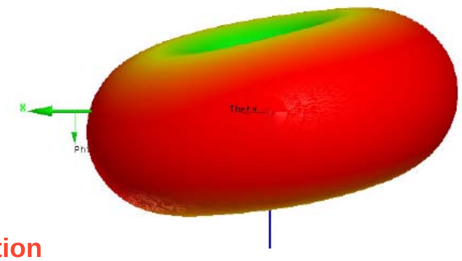
First….we must understand the limitations of a handheld device

SPX

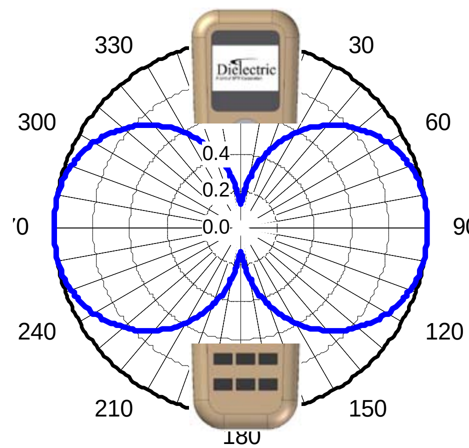
- **Modeled a "phone" using HFSS (High Frequency Simulation Software) to evaluate the radiation characteristic at UHF and VHF frequencies**
- **Conclusions**
  - **At both VHF and UHF frequencies, small antennas in a handheld device do nothing more than excite the long dimension of the phone or the circuit board**
  - **Polarization is along the axis of the phone**
  - **The phone itself acts like a dipole**

VHF **UHF**





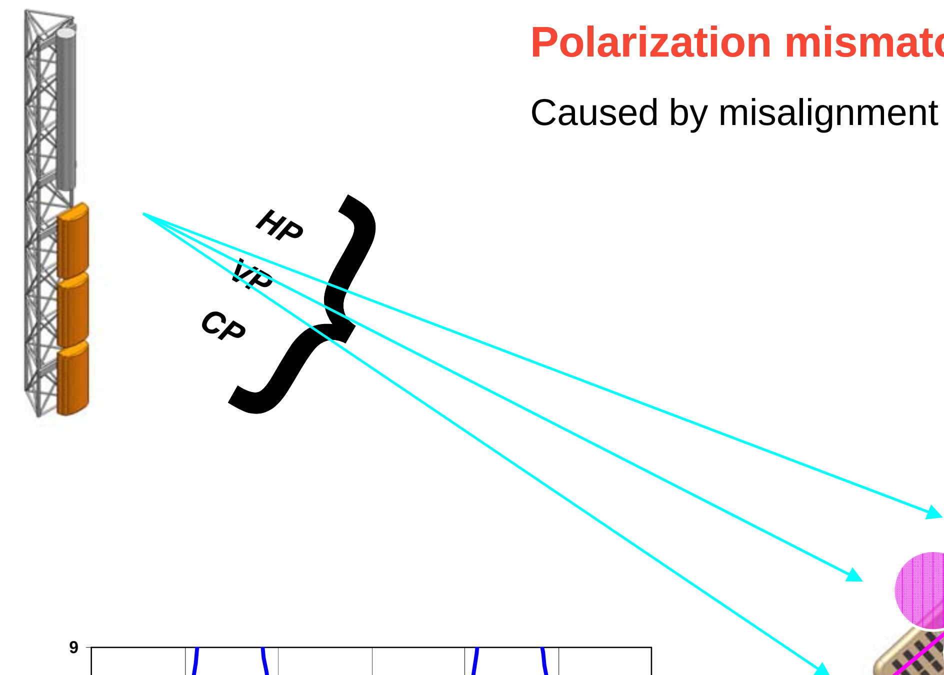
Direction of polarization



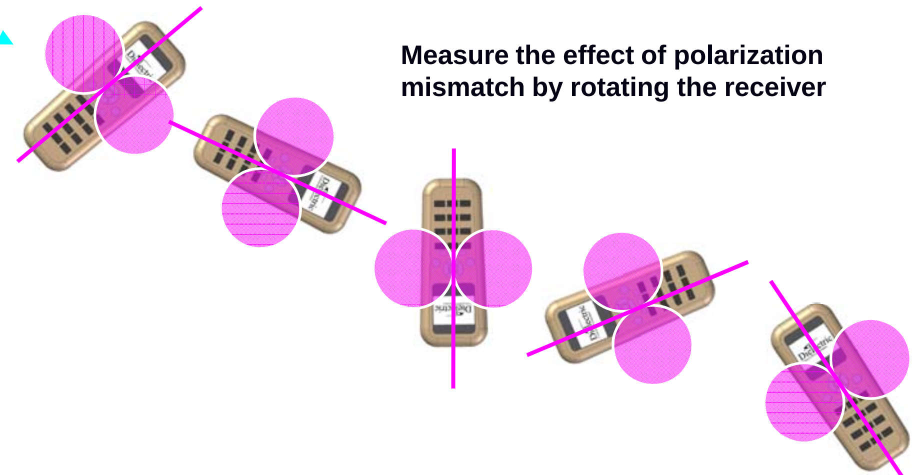
SPX

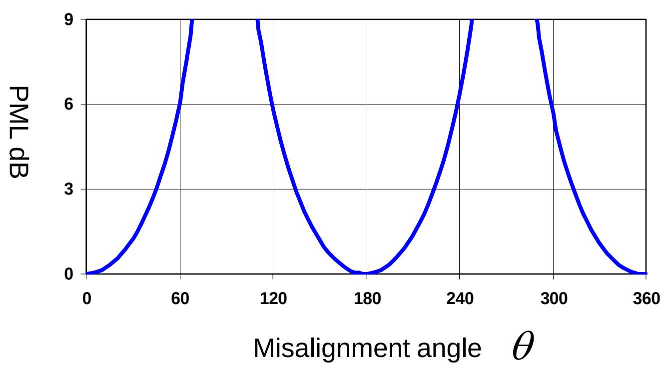
Polarization mismatch loss (depolarization)

Caused by misalignment between the transmit and receive antenna

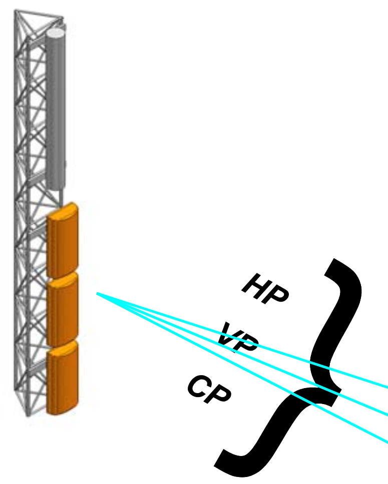


$$PML = 20\log(\cos\theta)$$





Measures the orientation immunity of the receiver

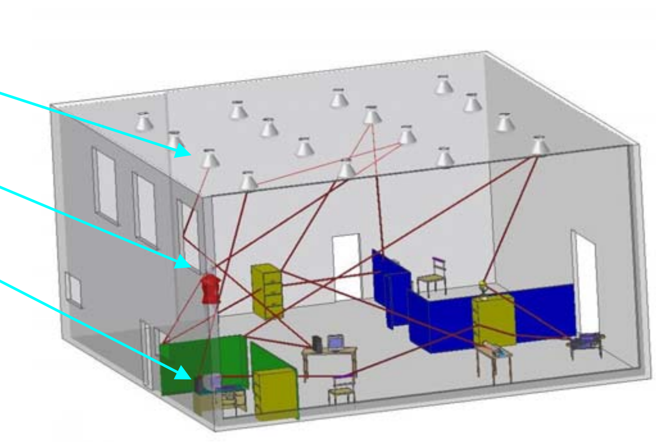


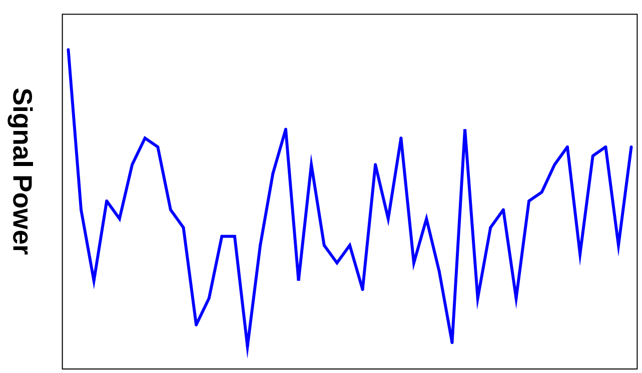
Small scale fading

Occurs when multiple signals arrive at the receiver from nearby reflecting objects

The vector addition of all multi-path components create variations in the received signal strength

$$F(x) = \sum \overline{R(x)}$$





Measures the effect of multi-path at the receiver

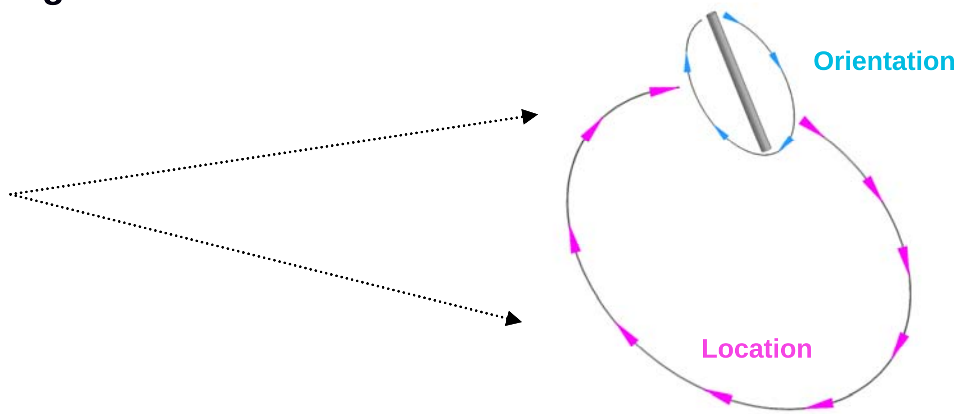
Purpose: To evaluate the reliability of service of horizontal, vertical and circular polarization in a depolarized fading environment

Transmit

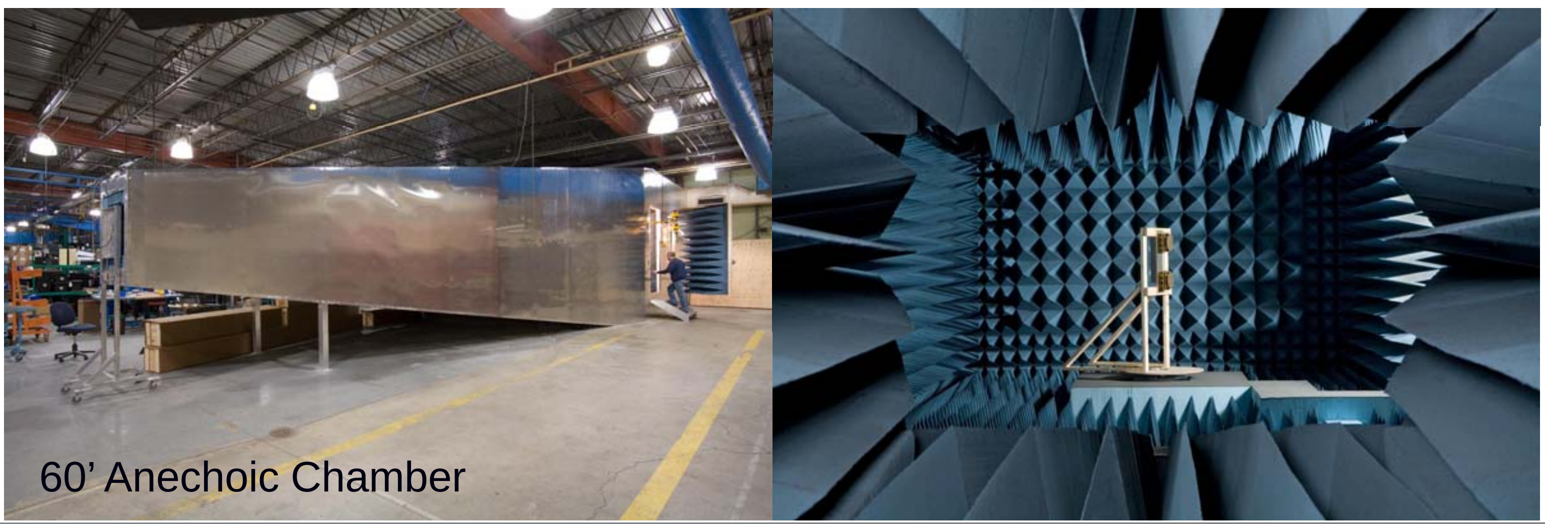
HP

VP

CP



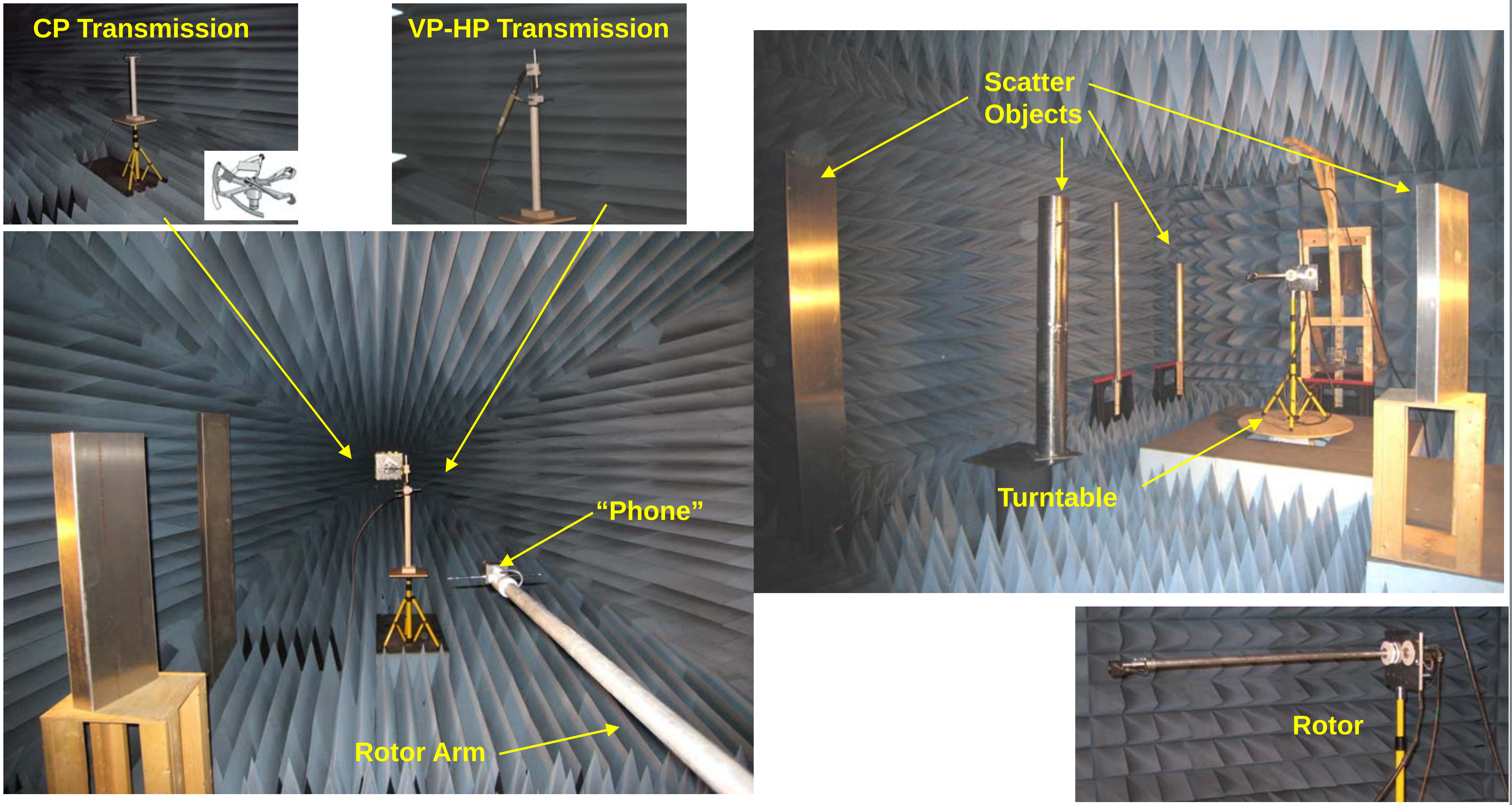
Receive linear polarization at all orientations and 360 degrees of location



60' Anechoic Chamber

SPX

Measure the signal power vs. orientation and location in a heavy scatter environment

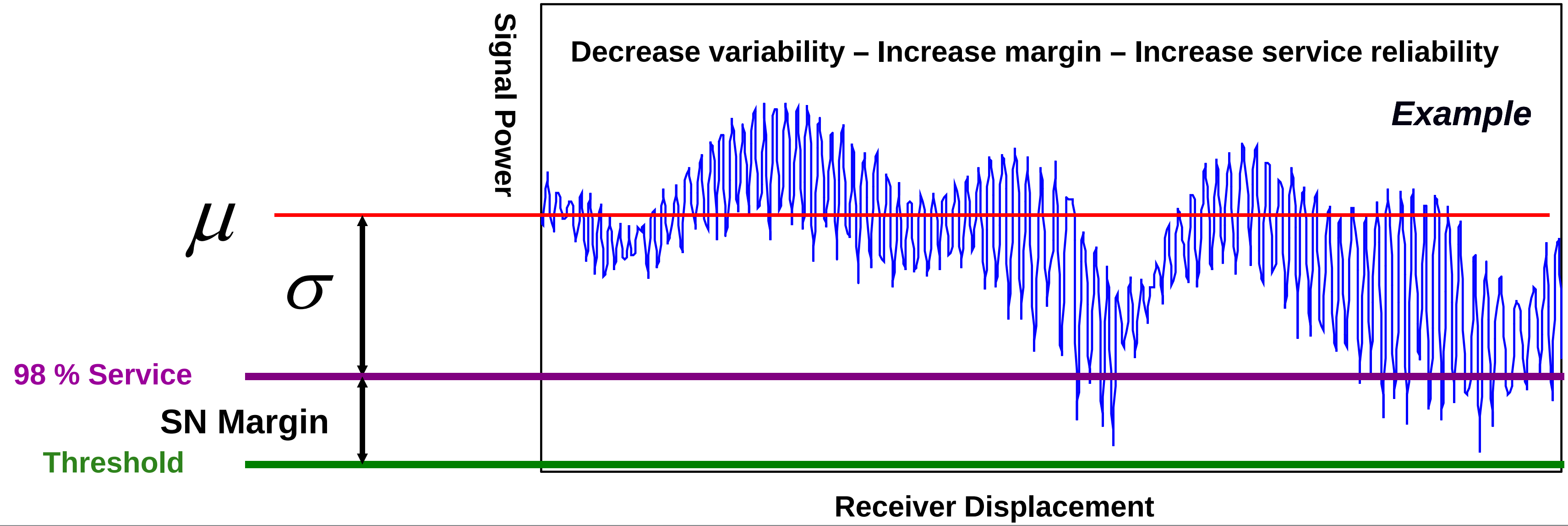


Both polarization mismatch and small scale fading produce variability in the signal as the receiver changes orientation and location

Evaluation of experiment results

3 Step Analysis

1. Measure received signal power versus the antenna orientation and location
2. Calculate the mean value of the data which will represent the signal level that the system was designed for (μ)
3. Calculate the variability spread between the mean and a desired probability of service line (σ)



Decreasing the variability is exactly the same as increasing the SN margin

SPX

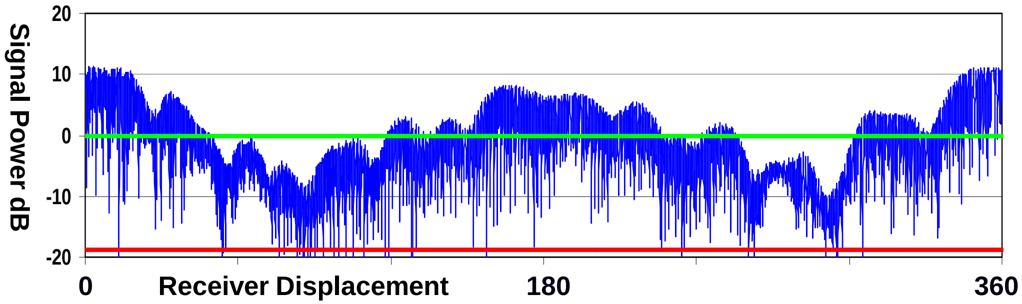
Measured - heavy scatter environment and depolarization

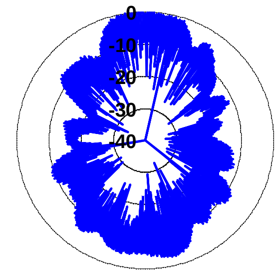
Horizontal polarization

Mean

$\sigma = -18.7dB$

98 %



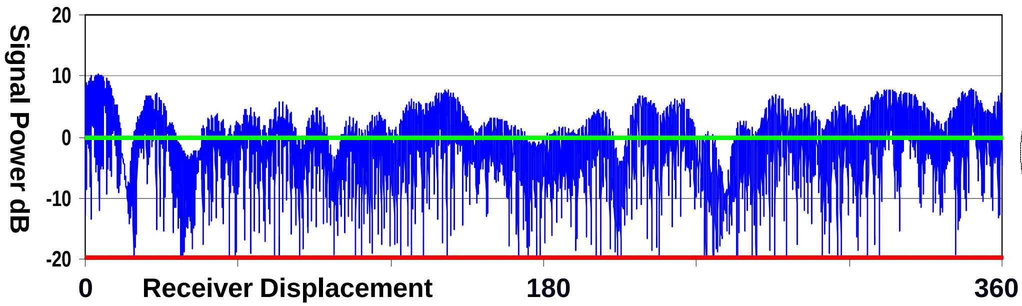


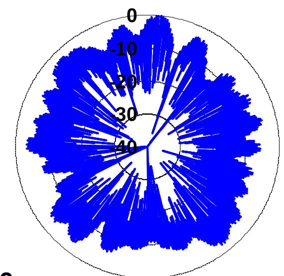
Vertical polarization

Mean

$\sigma = -19.7dB$

98 %



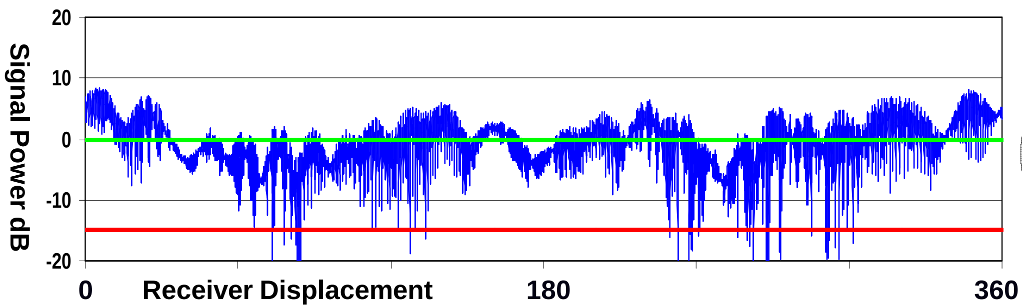


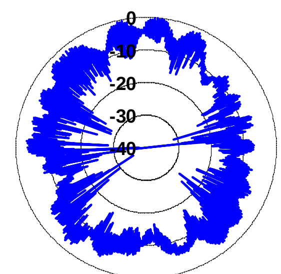
Circular polarization

Mean

$\sigma = -14.8dB$

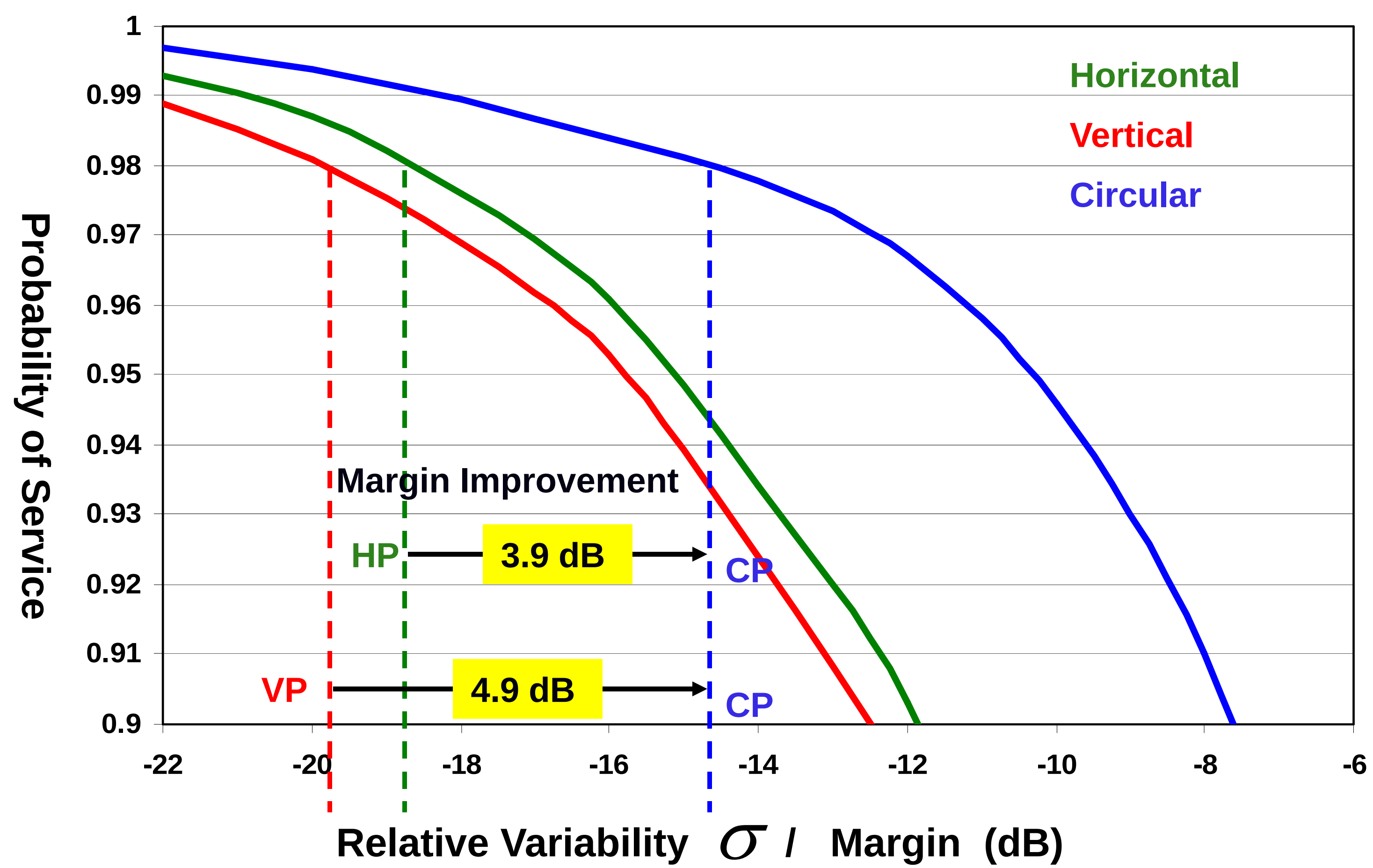
98 %





CP provides 4 to 5 dB improvement in signal variability

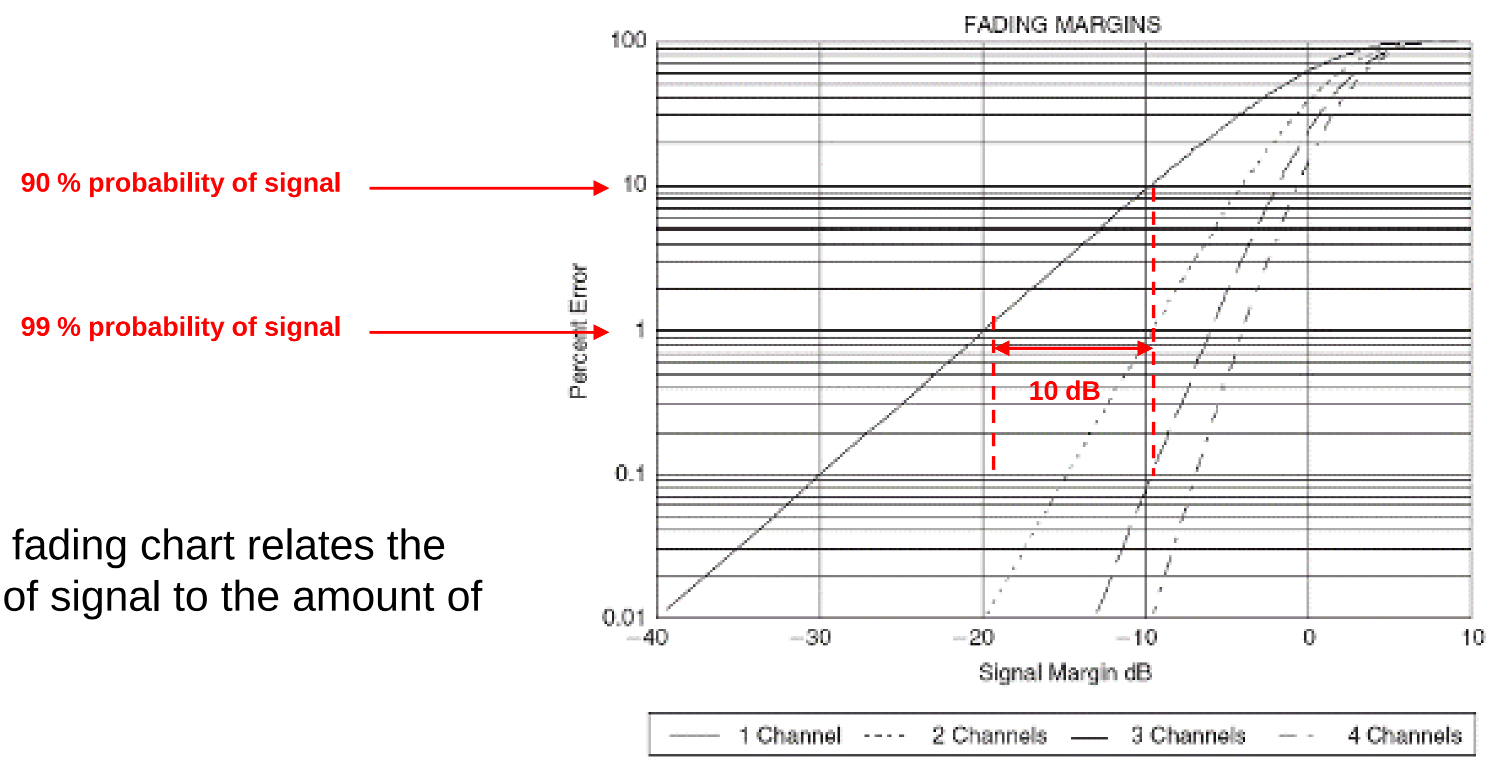
Signal Variability versus Probability of Service



CP provides margin improvement at all probabilities of service

Does the data make sense?

Mobile RF channels in a fast fading environment are usually modeled as a Rayleigh p.d.f



Rayleigh fading chart

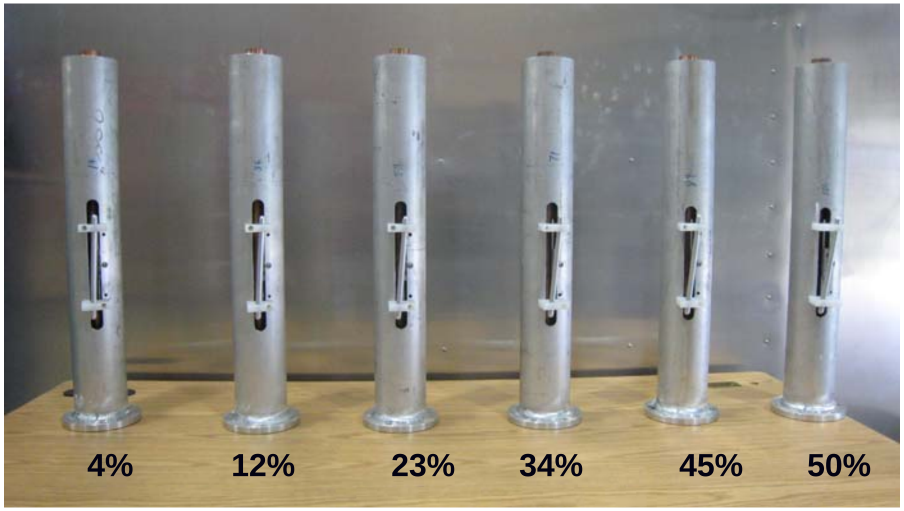
A Rayleigh fading chart relates the probability of signal to the amount of margin

Reduction of variability is equivalent to margin improvement

What about elliptical polarization?

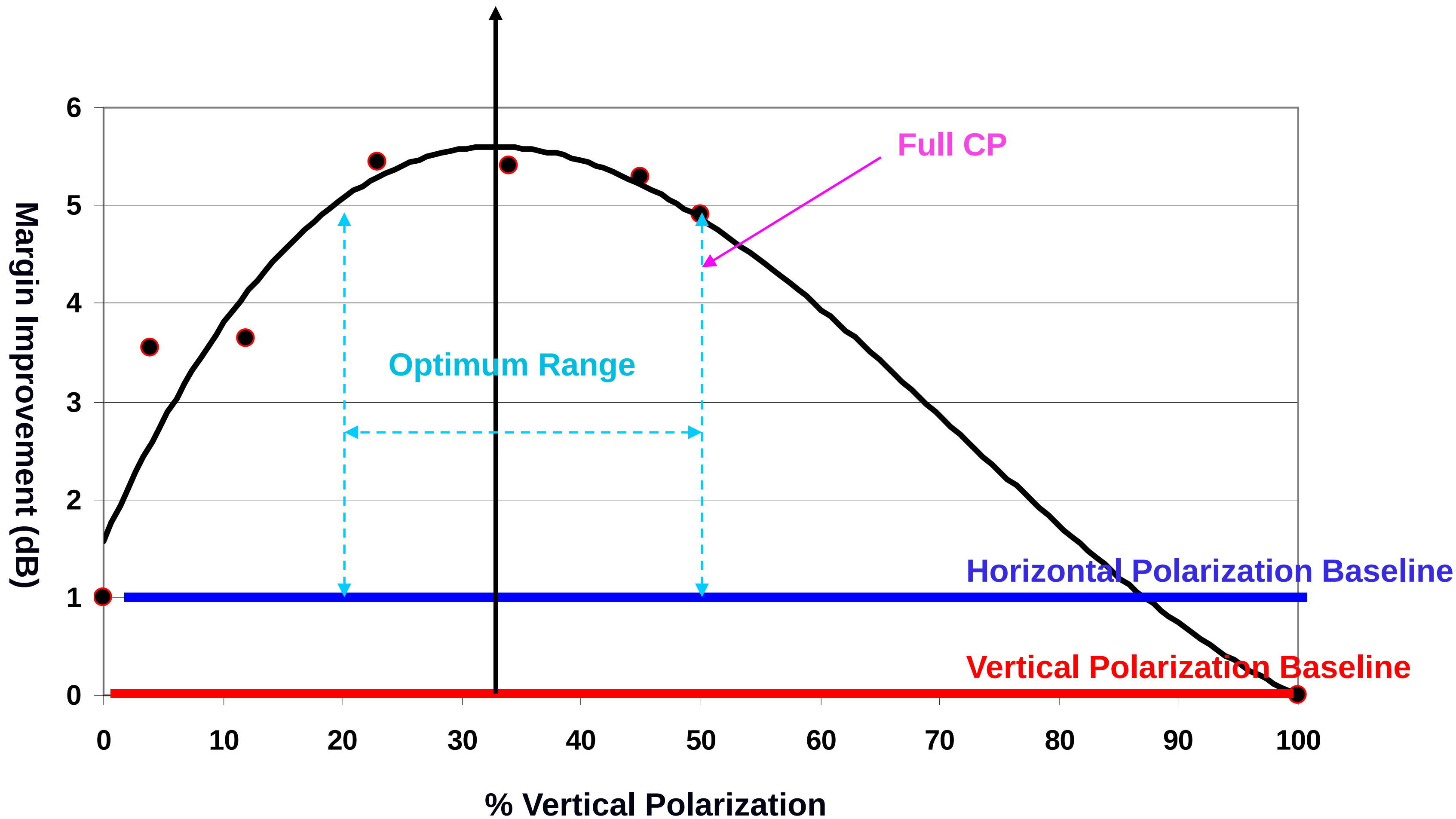
Is there an optimum amount of vertical component for reliable mobile service to a linearly polarized receiver in a heavy scatter environment?

Elliptically polarized transmit antenna



Amount of vertical component

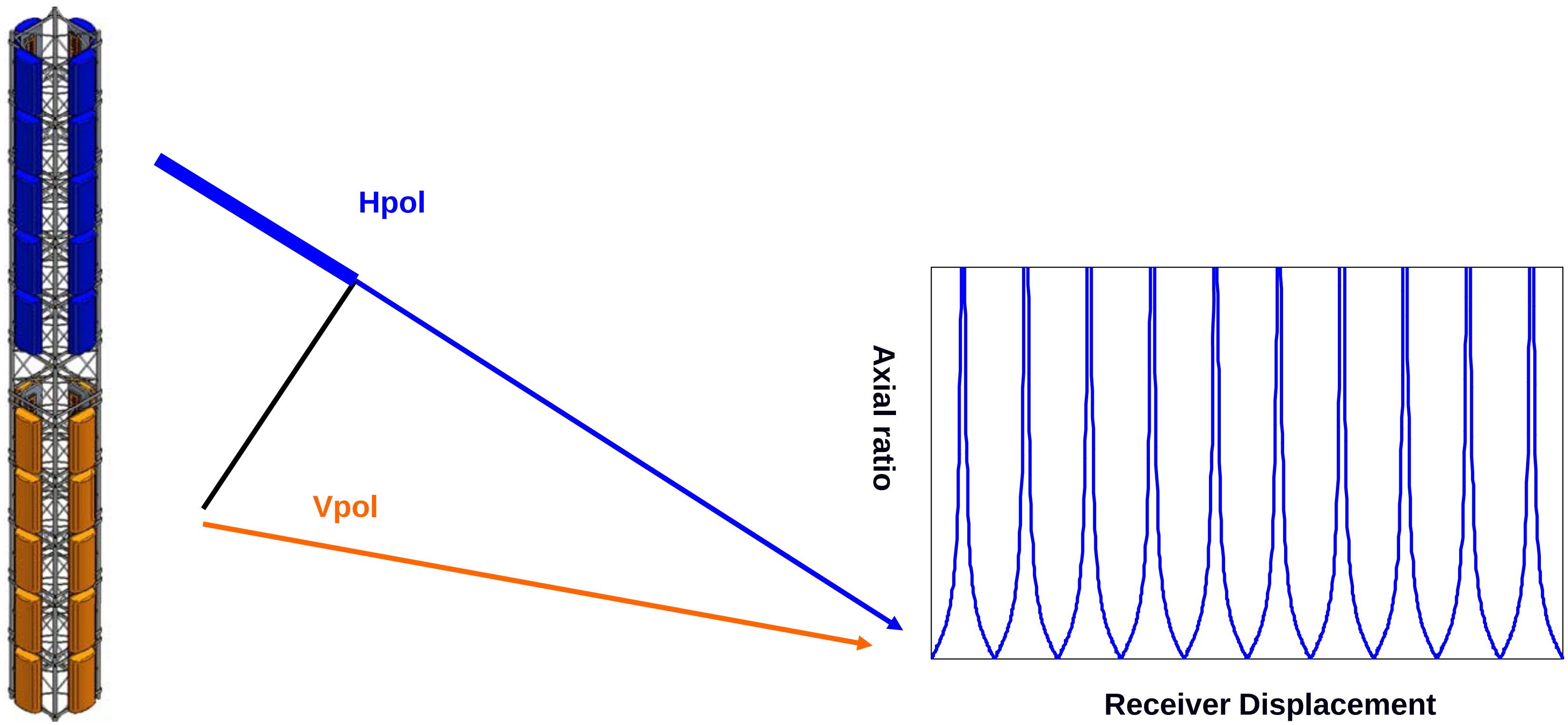
Greatest Margin Occurs at 33% Vertical Component



More than 4 dB of margin improvement with 20% < Vpol < 50%

What about adding a separate vertically polarized antenna?

What benefit can be expected from adding a separate vertically polarized antenna to an existing horizontally polarized system?



Separate Hpol and Vpol Antennas

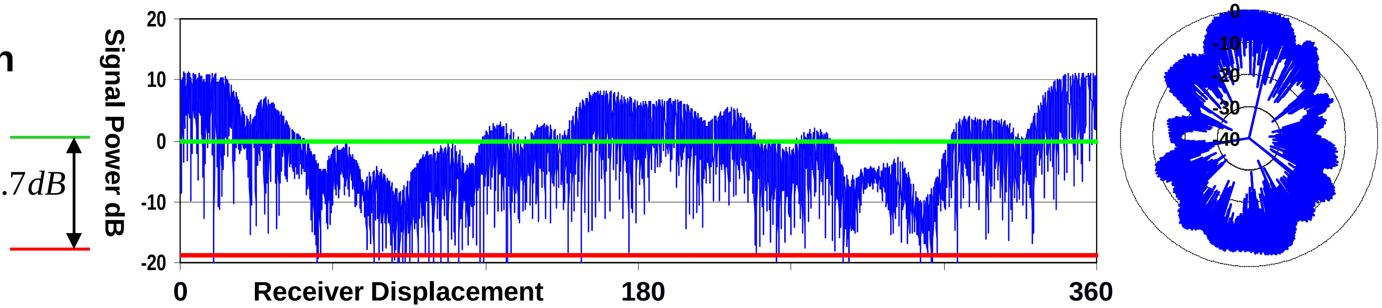
Measured - heavy scatter environment and depolarization

Horizontal polarization

Mean

$\sigma = -18.7dB$

98 %

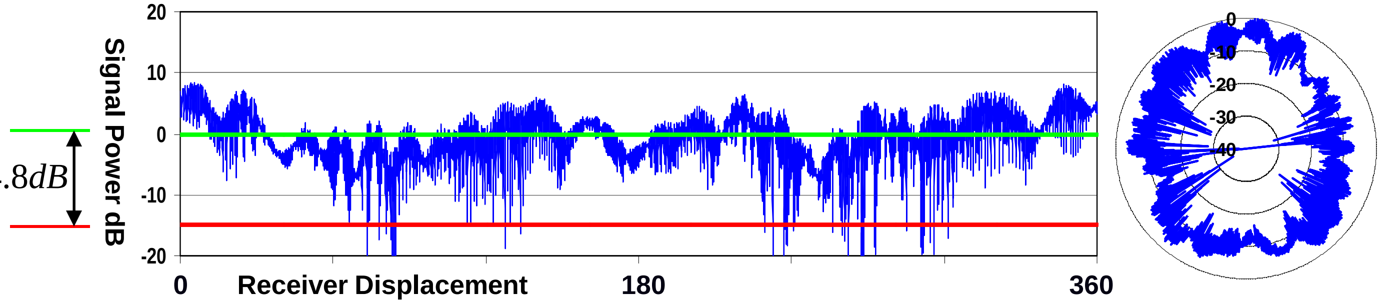


Circular polarization

Mean

$\sigma = -14.8dB$

98 %

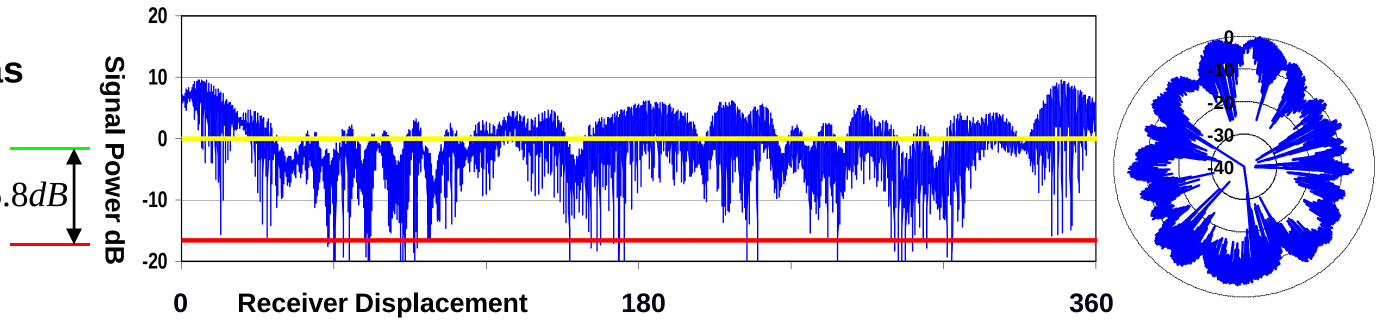


Separate H-V Antennas

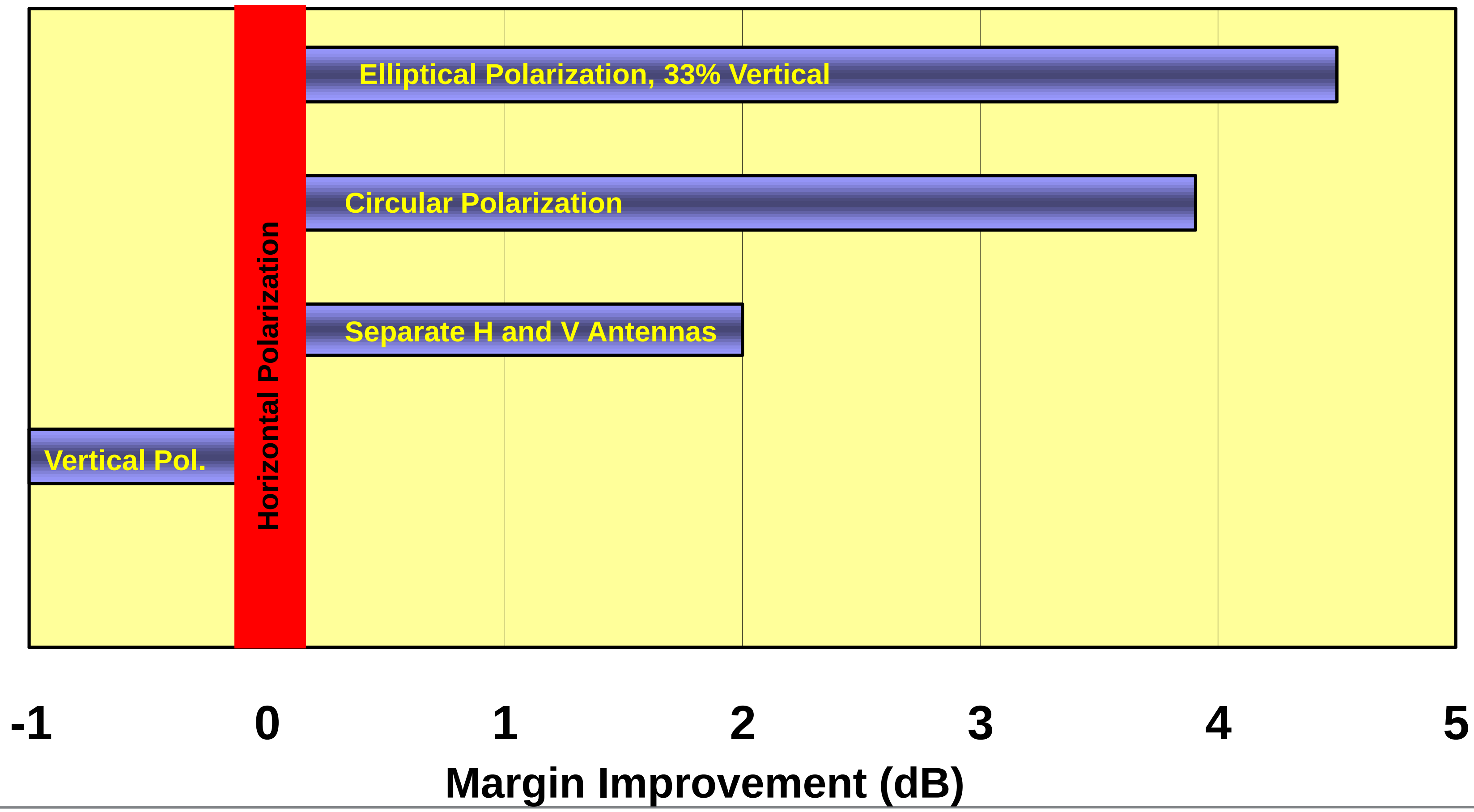
Mean

$\sigma = -16.8dB$

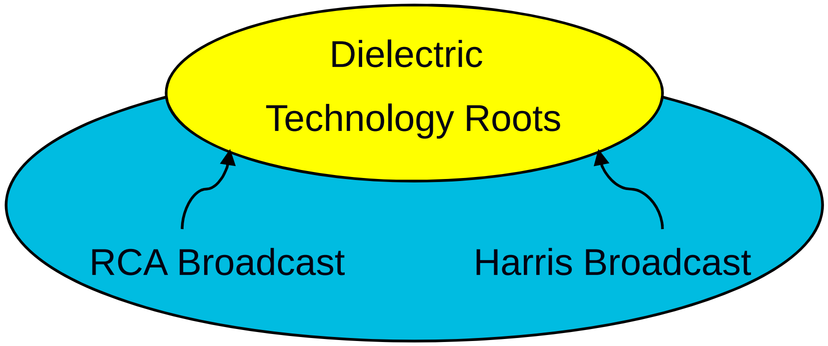
98 %

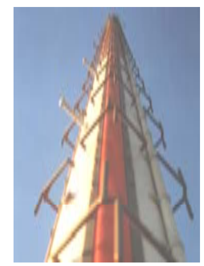


Expected margin improvement over horizontal polarization in a heavy scatter, depolarized environment when transmitting to a linearly polarized receiver

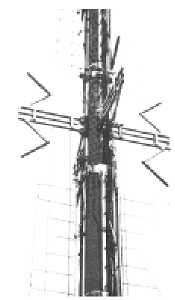


Dielectric is no stranger to circular polarization





- **1965 - RCA introduces dual polarization from a single element**
- **1973 - RCA provides the first commercial circularly polarized TV broadcast antenna**
- **1984 - RCA awarded Emmy for work in circular polarization**
- **1986 - Dielectric develops the concept of parasitically fed dipoles**
- **Dielectric's circularly polarized television broadcast antenna infrastructure**
  - **Over 300 CP TV Broadcast antennas**
  - **Over 1300 CP FM antennas**
  - **Over 500 CP MobileMedia antennas**
- **Over 30 patents related to circular / elliptical polarization**

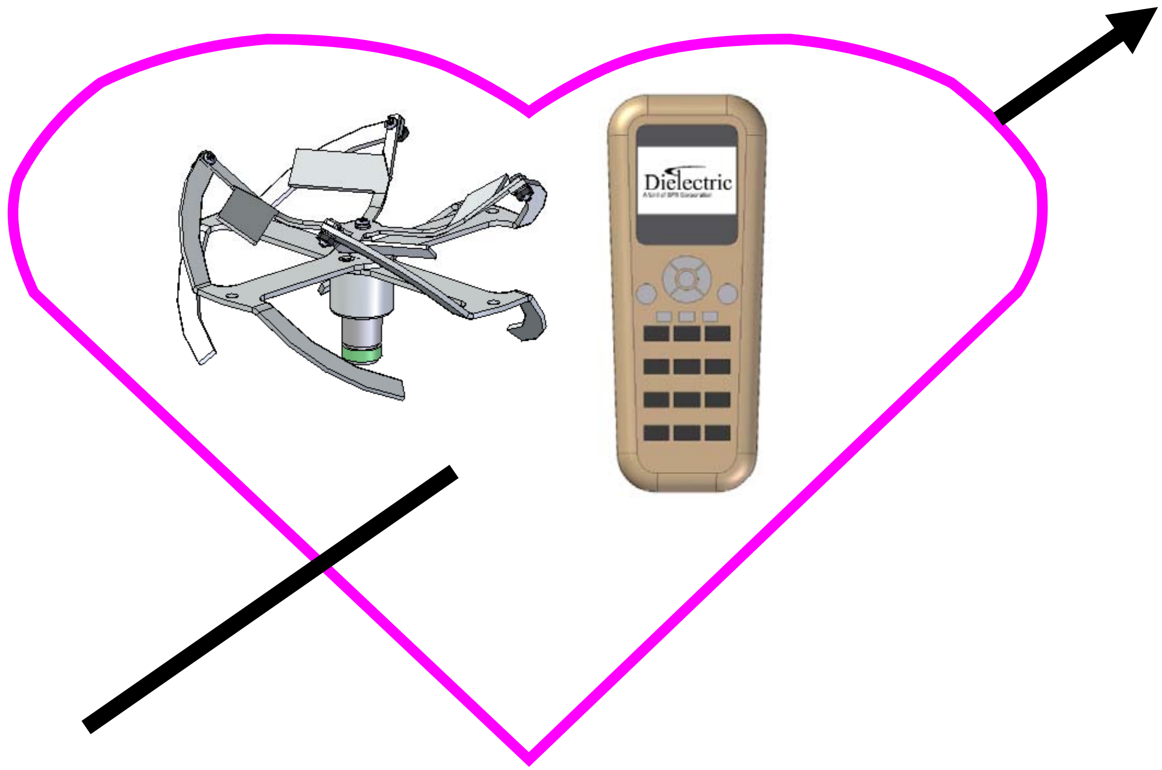


Conclusion

- **Spatial immunity is necessary to maintain a high probability of signal in mobile applications**
- **A high probability of signal can only be achieved by a large SNR margin**
- **Reducing the variability is equivalent to increasing the SNR margin which provides reliable service in a mobile channel**
- **Tests show that transmitting circular polarization to a linearly polarized receiver provided an extra 4 to 5 dB of margin in a depolarized, fading environment**
- **The same tests show that the optimum range of vertical component is 20 to 50% with the greatest margin occurring at 33%**
- **Adding a separate vertically polarized antenna provided an extra 2 dB of margin in a depolarized fading environment**

Bottom Line……20 to 50% of vertical component will be essential for reliable service of mobile TV

One day a circularly polarized antenna met a linearly polarized antenna and fell in love…..



The wedding wasn't much but…the reception was great!