# Reference Level and Average Received Power in RIMP

We generate waves in virmlab. For each realization, the sum of the power densities of these waves will be normalized to one. This can be verified in Matlab with the following command for waves “w”:

N = 1e5;

w = gen\_waves('3D', N, 40, 'LP');

sum(abs(w.Eth).^2+abs(w.Eph).^2, 2)

This should give a column vector with ones.

If we place a 100 % efficient antenna in a RIMP environment (several waves per realization) normalized as described above, the average received power of this antenna will be 0.5 [power unit]. We get half power because of polarization mismatch. This can be verified with the following additional commands:

a = gen\_farfield('inc. electric dipole', 181);

get\_power\_radiated(a)

p = gen\_positions(0);

H = calc\_waves(w, a, p);

mean(abs(H(:)).^2)

If we want, we can assume polarization matching between the incoming waves and the antenna. This is easily accomplished by generating theta-polarized incoming waves like this:

w2 = gen\_waves('3D', N, 40, 'theta');

H2 = calc\_waves(w2, a, p);

mean(abs(H2(:)).^2)

Then the antenna will receive 1 [power unit]. The channel matrices can be plotted also:

figure;

plot\_cdf(H);

plot\_cdf(H2);

legend('Normal antenna', 'Polarization matched antenna', ...

'Location', 'SouthEast');

They follow the Rayleigh distribution.

# Rayleigh Distribution

The received amplitude in RIMP will be Rayleigh distributed. If we instead consider the power, it has a CDF curve according to this formula:

CDF = 1 - exp(-p/r) = 1 – exp(-10^((p\_dB-r\_dB)/10))

where r is the mean received power. We can also write

p\_dB = 10\*log10(p) =

= 10\*log10(r) + 10\*log10(-log(1-CDF)) =

= r\_dB + 10\*log10(-log(1-CDF))

so we see that different mean power levels will shift the Rayleigh curve sideways when plotting in dB. Since exp(x) can be approximated as 1+x when x is close to zero it is also possible to show that the Rayleigh curve approaches a straight line for low dB-values, when plotting with log-scale on the y-axis. For r=1, this curve approaches -20 dB at 1% level, -30 dB at 0.1% level and so on.

# Reference Level in RLOS

In RLOS, the reference level we define is dependent on the intended coverage sector of the antenna. For an antenna intended to be omni-directional, this reference level is 0 dB. This is what an omni-directional, 100 % efficient, polarization-matched antenna would receive.

If the antenna is intended to cover a certain sector, we can define a reference level from an ideal polarization-matched antenna, covering this sector with constant gain and no radiation elsewhere. (And also 100 % efficient.) If the sector is defined in terms of theta and phi angle ranges, the gain can easily be calculated by integration of the unit sphere area:

area = (phi2-phi1) \* (cos(theta1)-cos(theta2))

G\_ref\_dB = 10\*log10(4\*pi/area)