BAN Over-the-Air Testing Using an Arm-Swinging Dynamic Phantom

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FinJap2 Wrap-up Meeting, Dec. 13, 2012

FinJap2 Outcome

(1) Arm-Swinging Dynamic Phantom

ICC2011, Kyoto   Submit to IEEE Trans

Panasonic

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(2) Shadowing-Fading Combined Analysis

EuCAP2012, Prague   APS2012, Chicago

(3) Walking Motion Modeling

ISAP2012, Nagoya (Honda)

FinJap2
Toyama

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(4) BER Characterization Using a Realistic Model

ISMICT2013, Tokyo (Li)

(5) Diversity for BER Reduction

URSI-EMTS2013, Hiroshima (Honda)

FinJap3?

1st Subject

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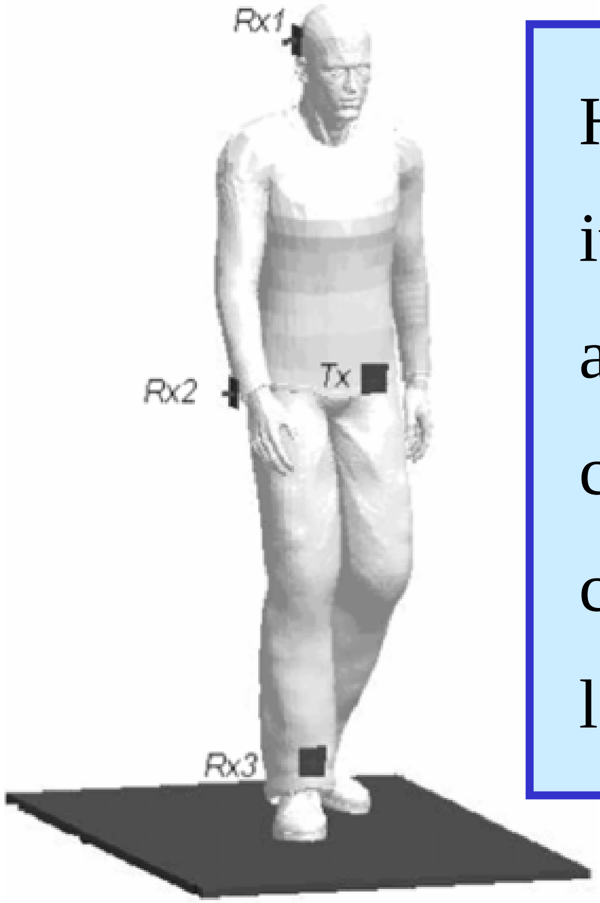
Animation Software is Successfully Used to Simulate Human Walking Motion



However, using a simulation-based approach, it is difficult to evaluate commercially available BAN electronics devices with communication capabilities, including complicated antenna structure, circuit board layout, batteries, and packaging.

Michele Gallo, Peter S. Hall, et al.:
"Use of Animation Software in Simulation of On-Body Communications Channels at 2.45 GHz,"
IEEE Antennas and Wireless Propagation Letters, vol. 7, 2008.

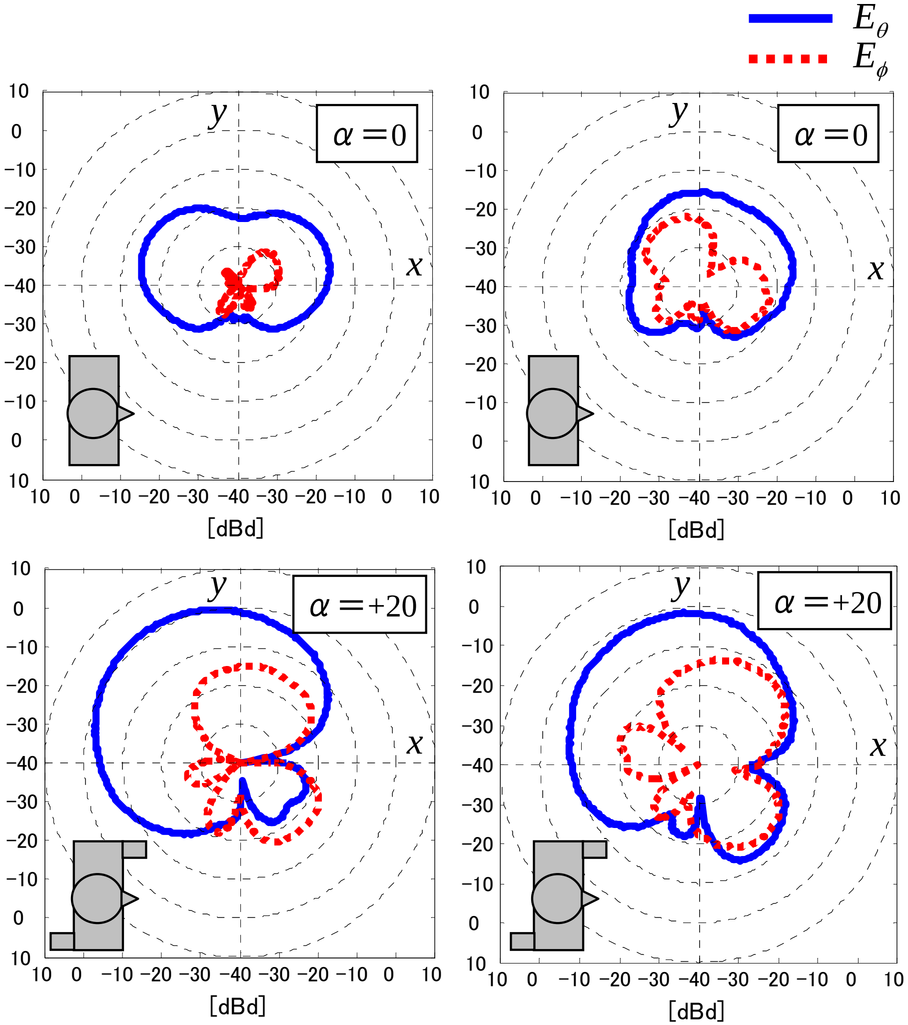
Thus Experimental Tool for Predicting Fading due to Body Movement is Needed

In consideration of previous research work, an arm-swinging dynamic phantom that can simulate human walking and running actions has been developed.

Animation

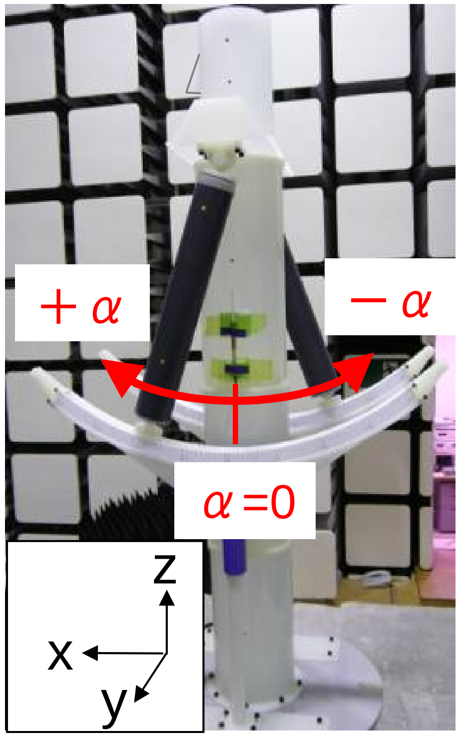
Measured Radiation Patterns

Good agreement confirms the effectiveness of the phantom for the assessments including the movement of the arm in a walking situation.



(a) Phantom (b) Human

Freq=950MHz
Dipole antenna



2nd Subject

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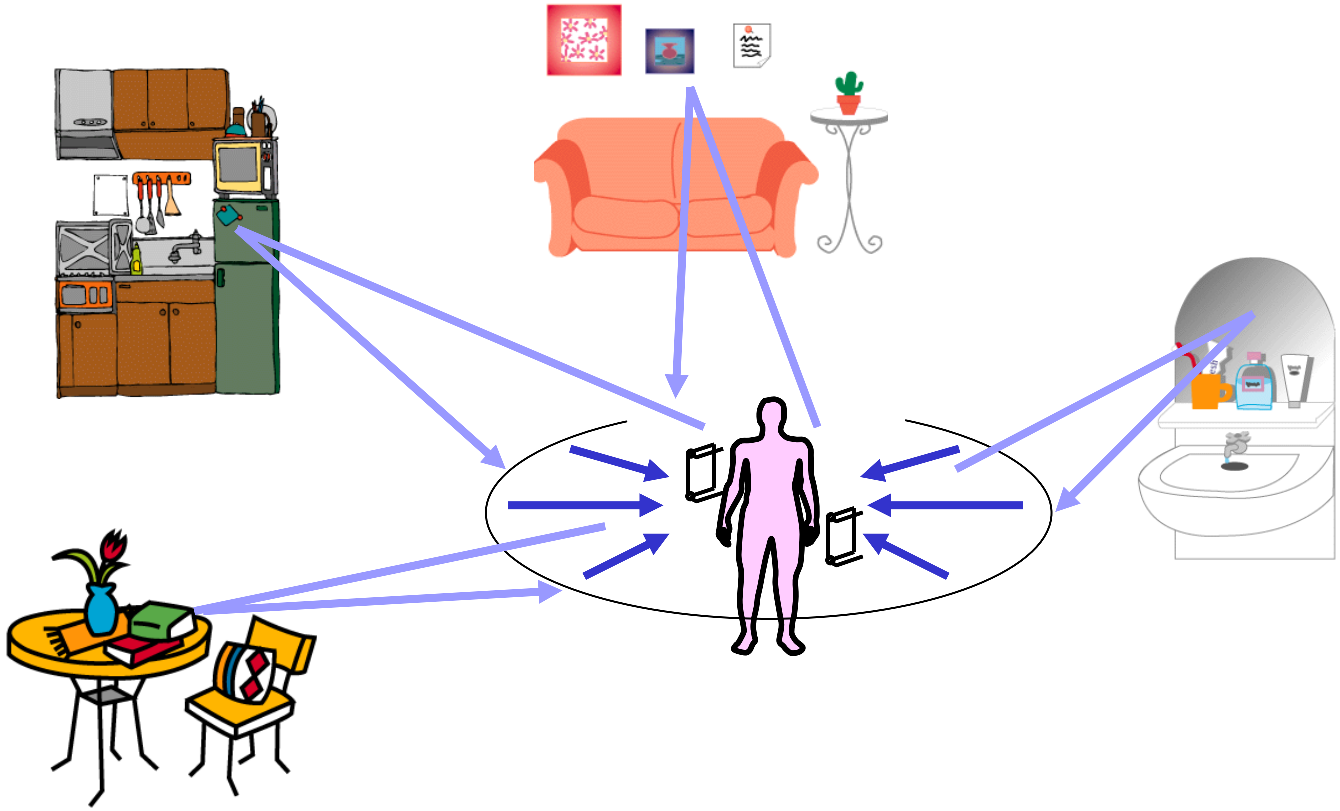
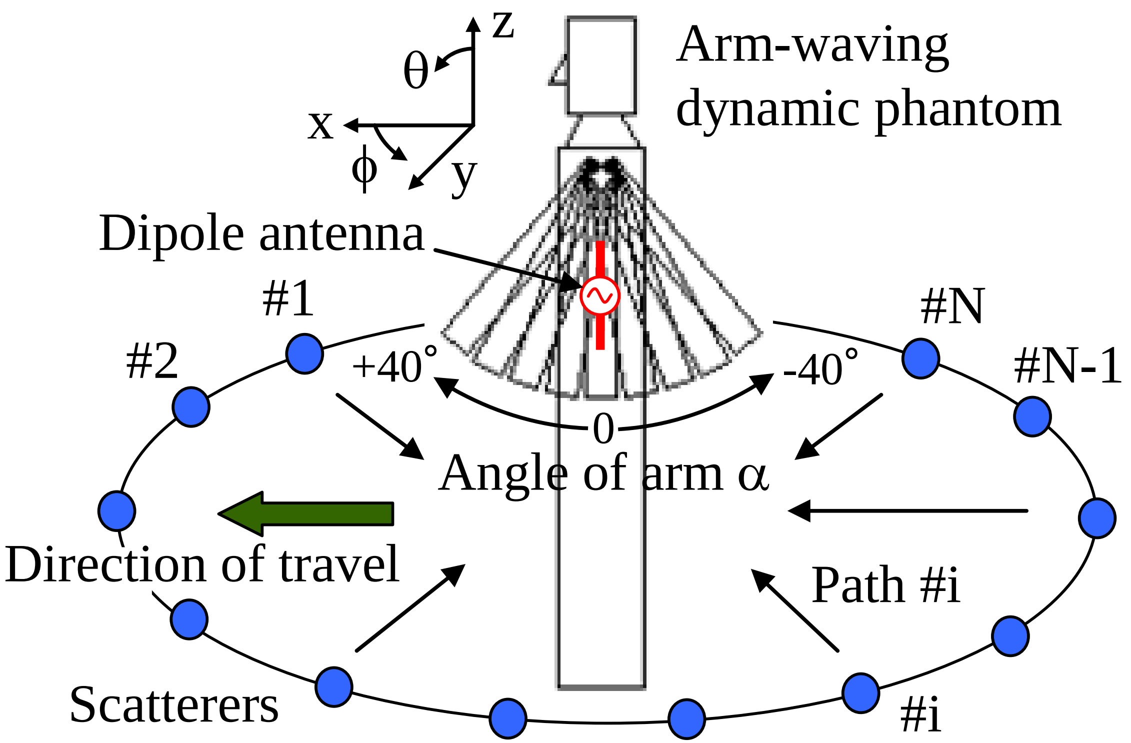
In Previous Studies, Only the Shadowing Effects are Taken Into Consideration

However, in actual-use scenarios in BAN systems, multipath signals arising from surrounding objects, such as household appliances and furniture, must be included in the analysis.



Hence, Combined Analysis of Shadowing and Multipath Effects was Conducted

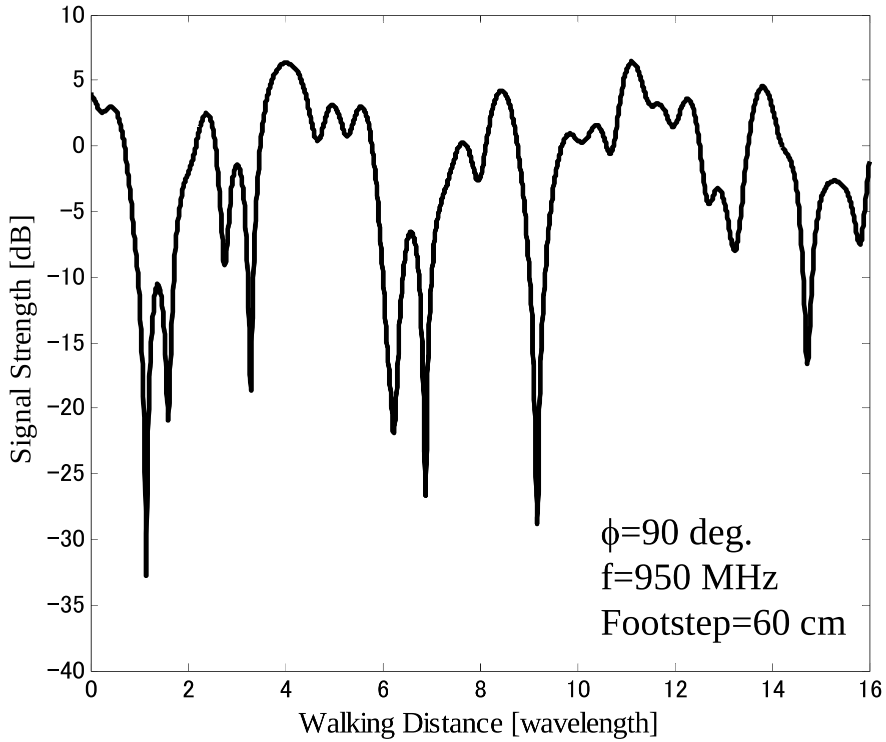
The phantom is surrounded by a uniform distribution of scatterers in the horizontal plane, which simulates a large number of radio waves reflected or diffracted by the surrounding objects. Using this model, a Rayleigh propagation channel can be realized.

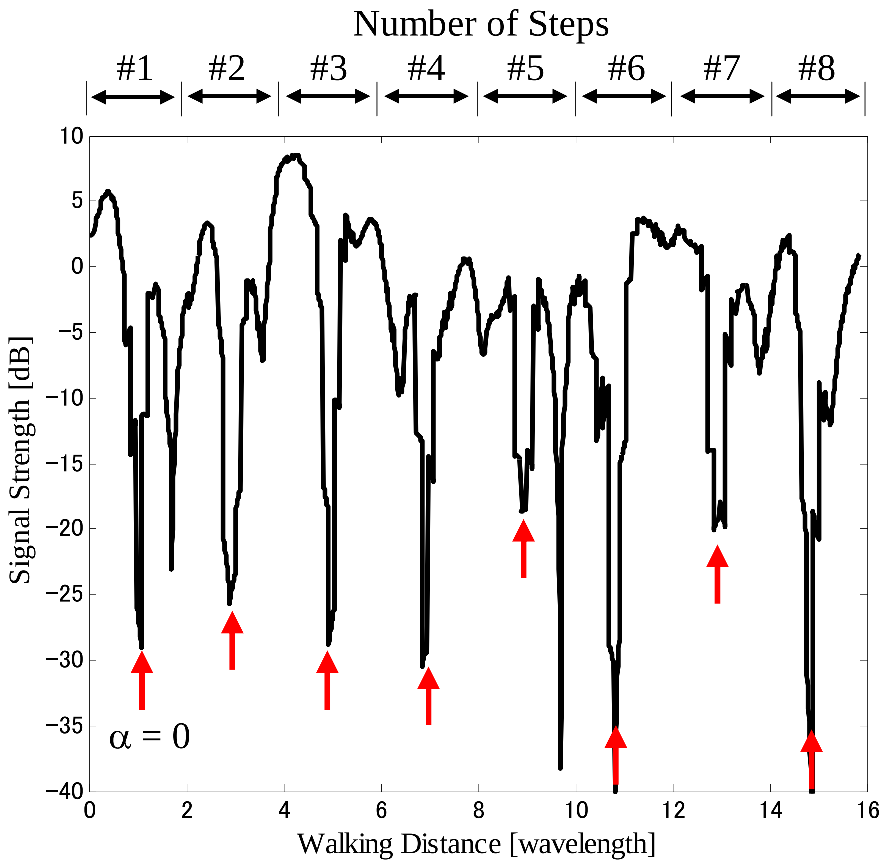


Instantaneous Response While Walking

There are periodic deep nulls in the fading profile, as indicated by the red arrows. The location of each null coincides with the location where the angle of the left arm α is 0 degrees, in which the left arm crosses the immediate vicinity of the dipole antenna.

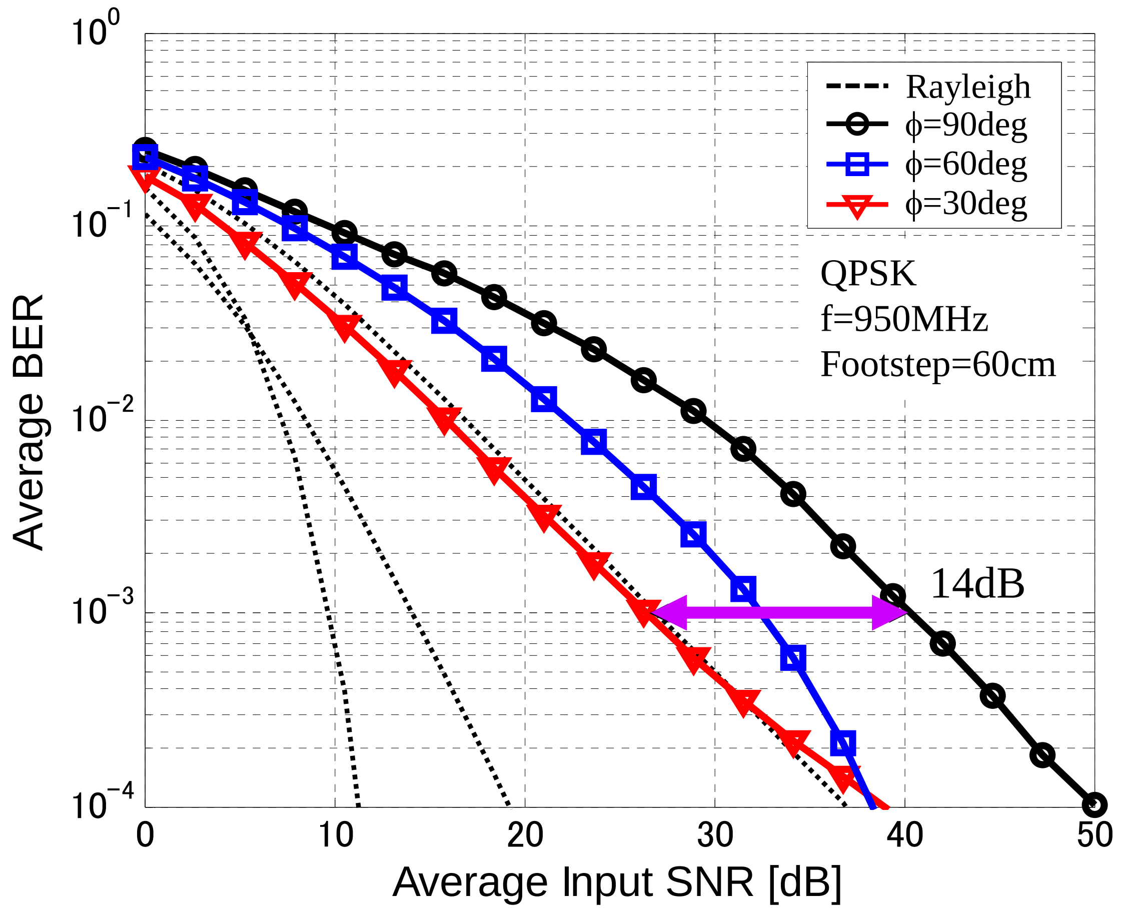
Angle of the left arm is fixed at α=40deg





BER of QPSK Signals

There is a significant impact of the shadowing due to the arms on the BER of QPSK signals. When BER=10^{-3}, a 14-dB increase in SNR is observed, compared with the case when a BAN module is mounted on the front of the body.



3rd Subject

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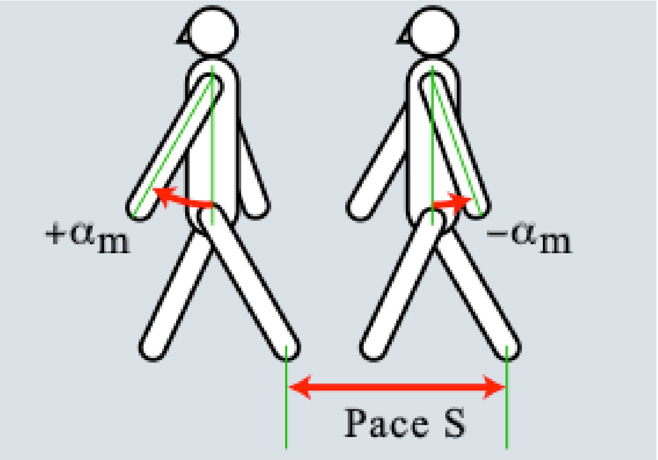
Extensive Video Recording was Made to Gather Statistical Data

Measured video data include

- **Maximum Swing Angle (Forward and Backward)**
- **Instantaneous Swing Angle**
- **Walking Pace**



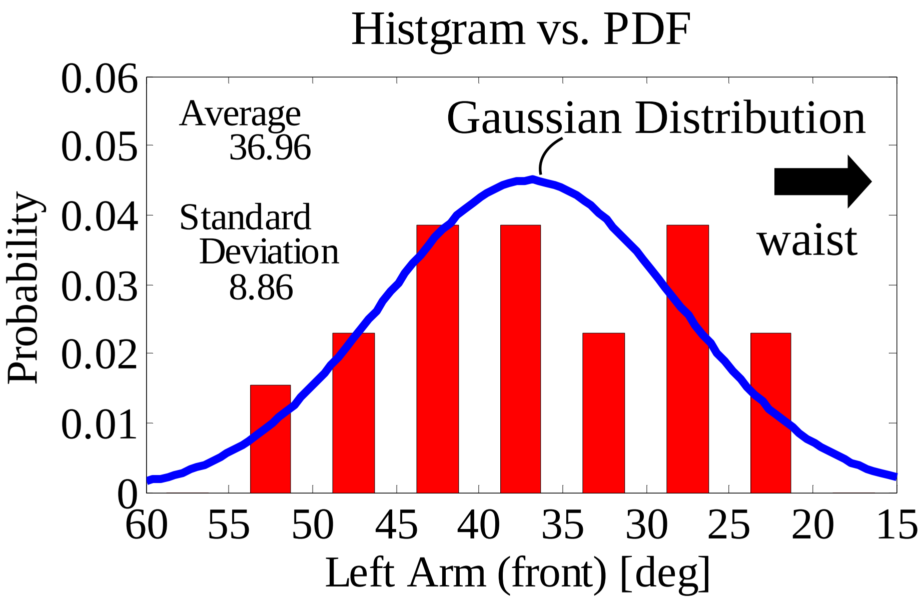
Forward Swing

Backward Swing

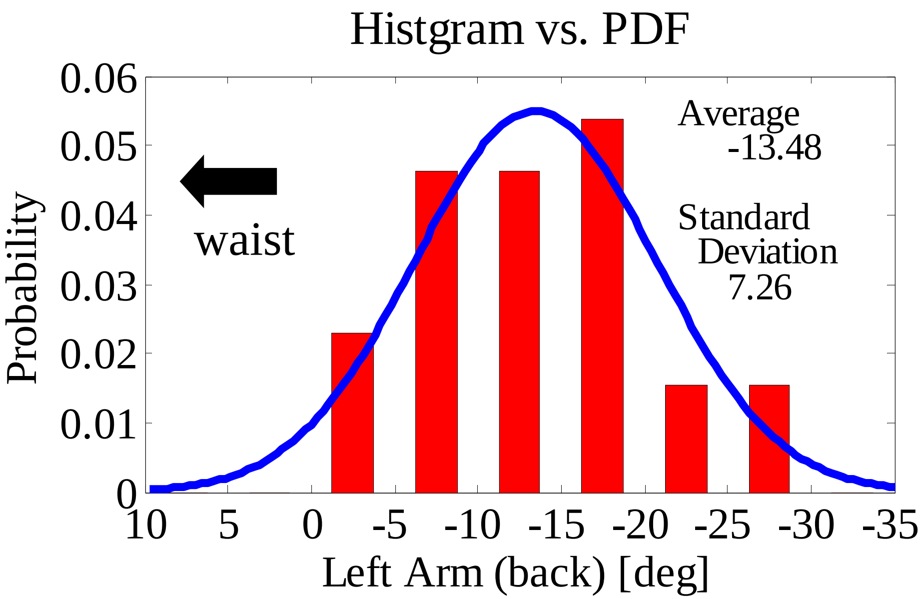
PDF of the Maximum Swing Angle

Swing angle in the forward and backward directions are found to be 40 deg. and -15 deg.

Forward Swing



Backward Swing



Where do we go?

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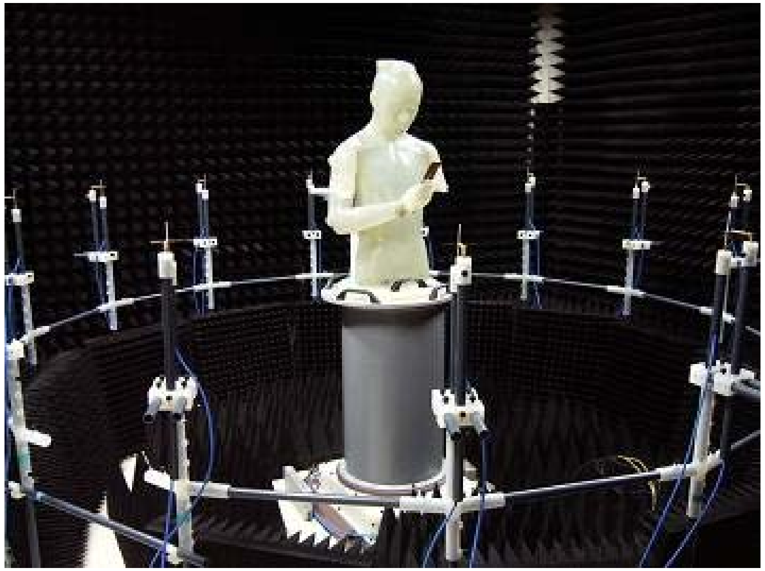
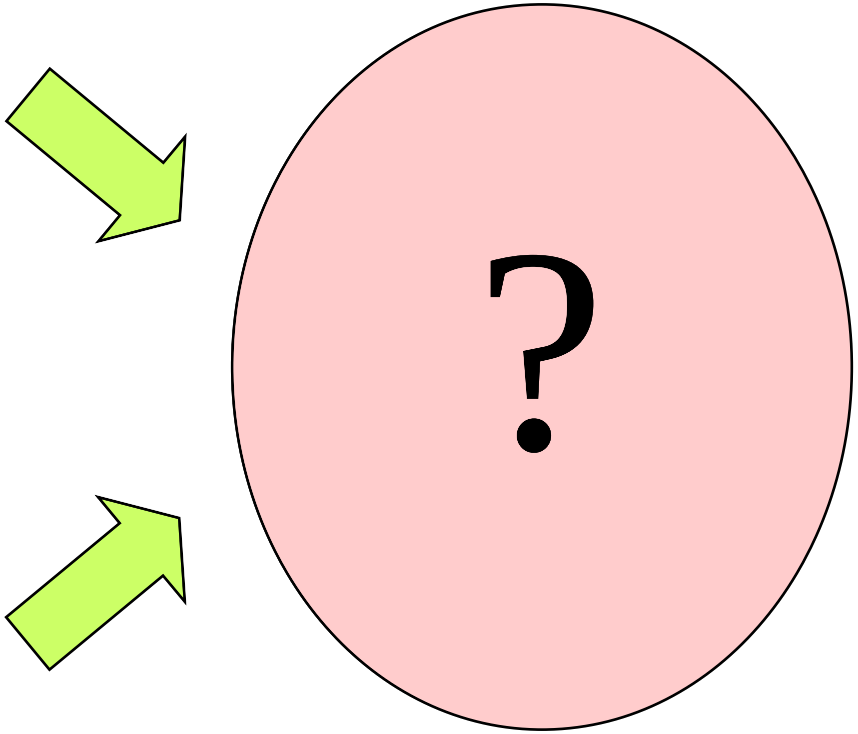
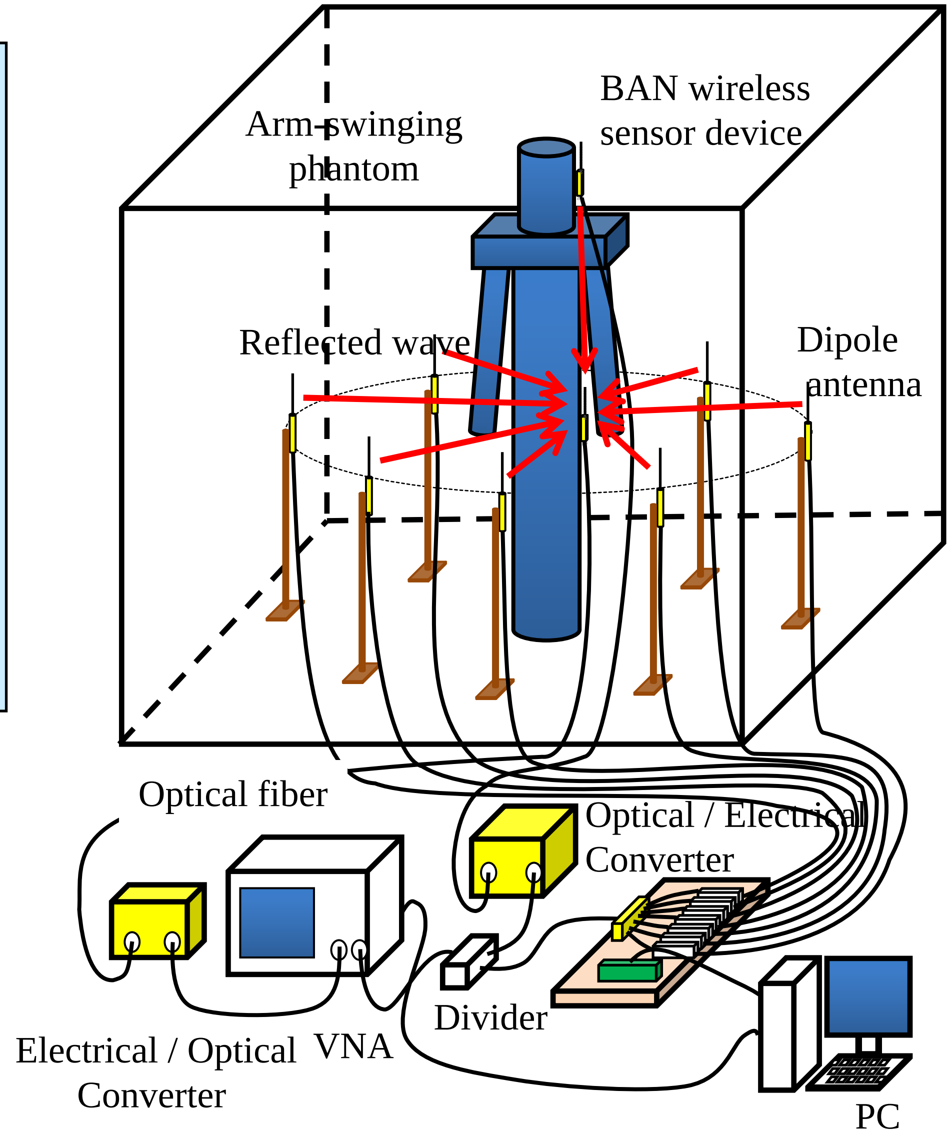


All the activities converge to something



We are now aiming at making BAN-OTA

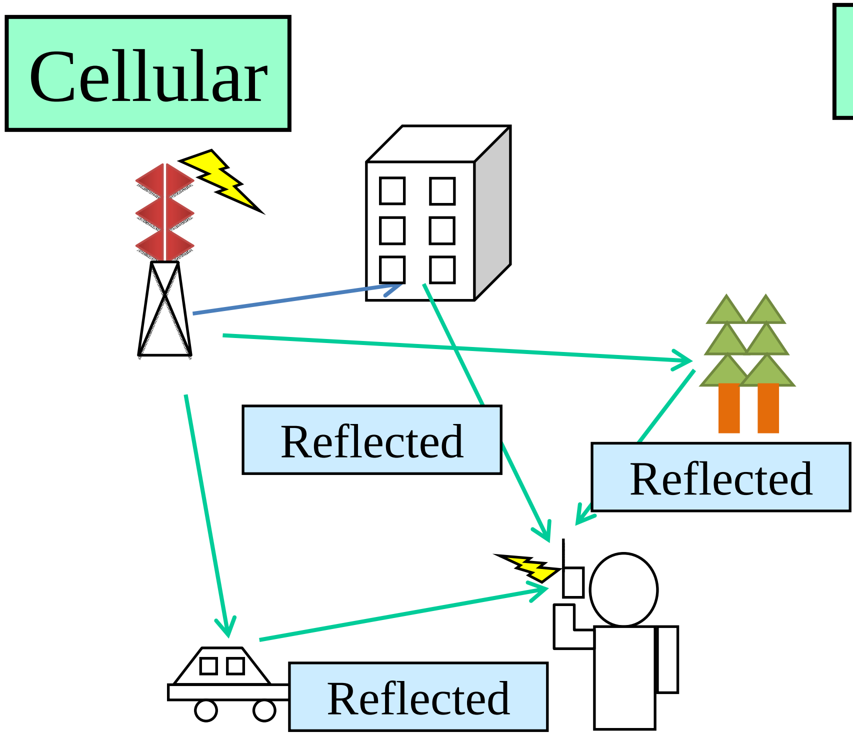
The final target is an experimental evaluation of a BAN antenna including the shadowing due to the movement of the arms in a multipath environment.



Difficulties in BAN-OTA

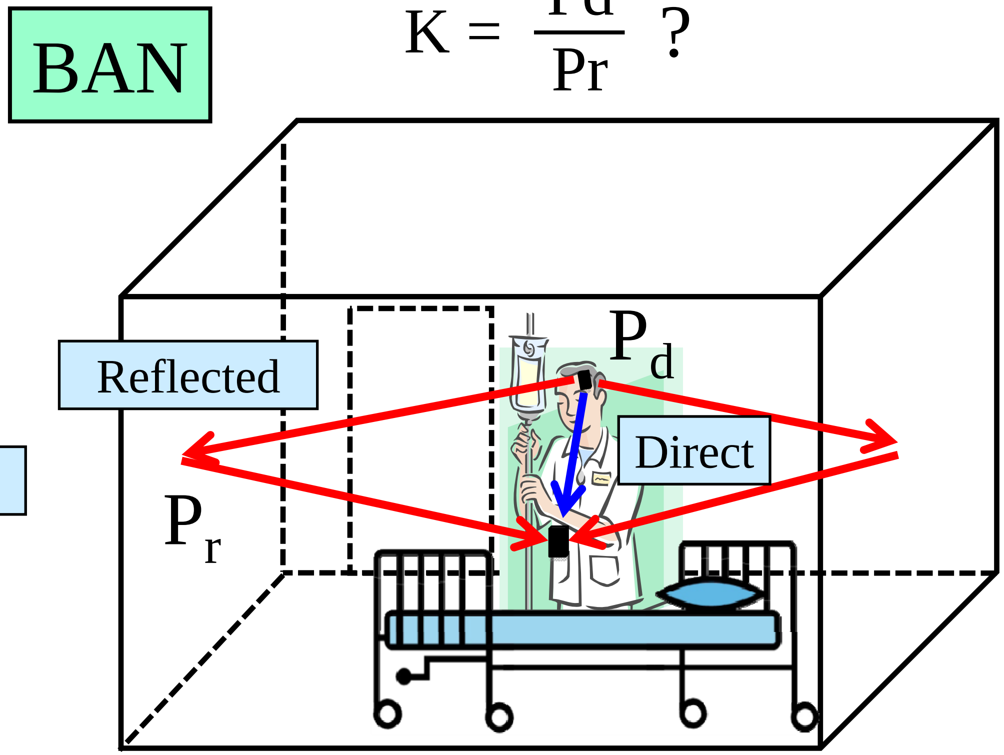
We have to know the Rice Factor to determine Pd/Pr

No Direct Path
Uniform Distribution



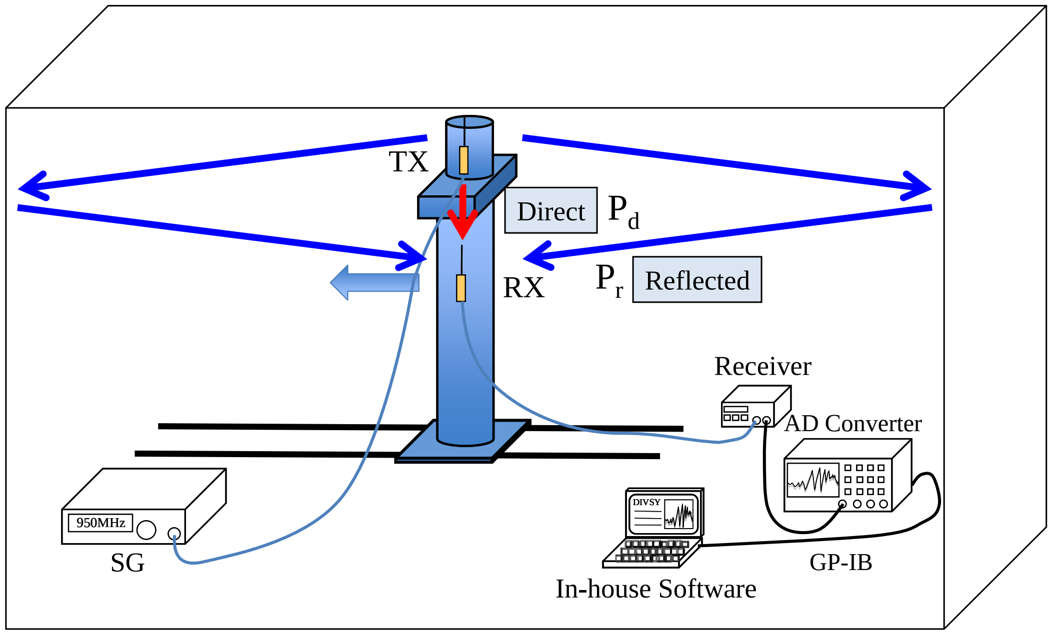
Presence of Direct Path
Non-Uniform Distribution

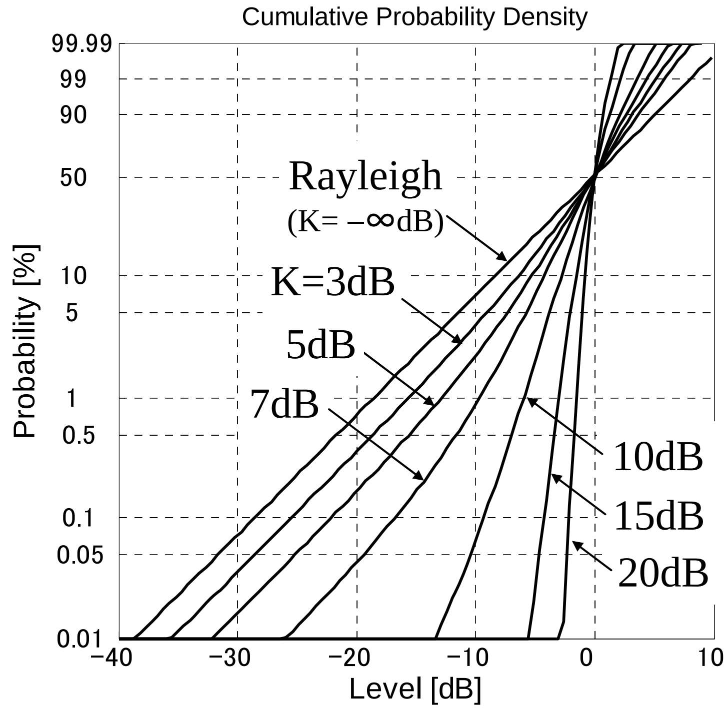
$$K = \frac{Pd}{Pr} \ ?$$



A possible solution is to extract Pd/Pr from the Measured CDF

Knowing the K-factor, we can set attenuators in the fading emulator to adjust the power ratio, Pd/Pr.





To Get a Basic Knowledge We are Making a Preliminary Experiment

Without the shoulder

With the shoulder

We examined three subjects

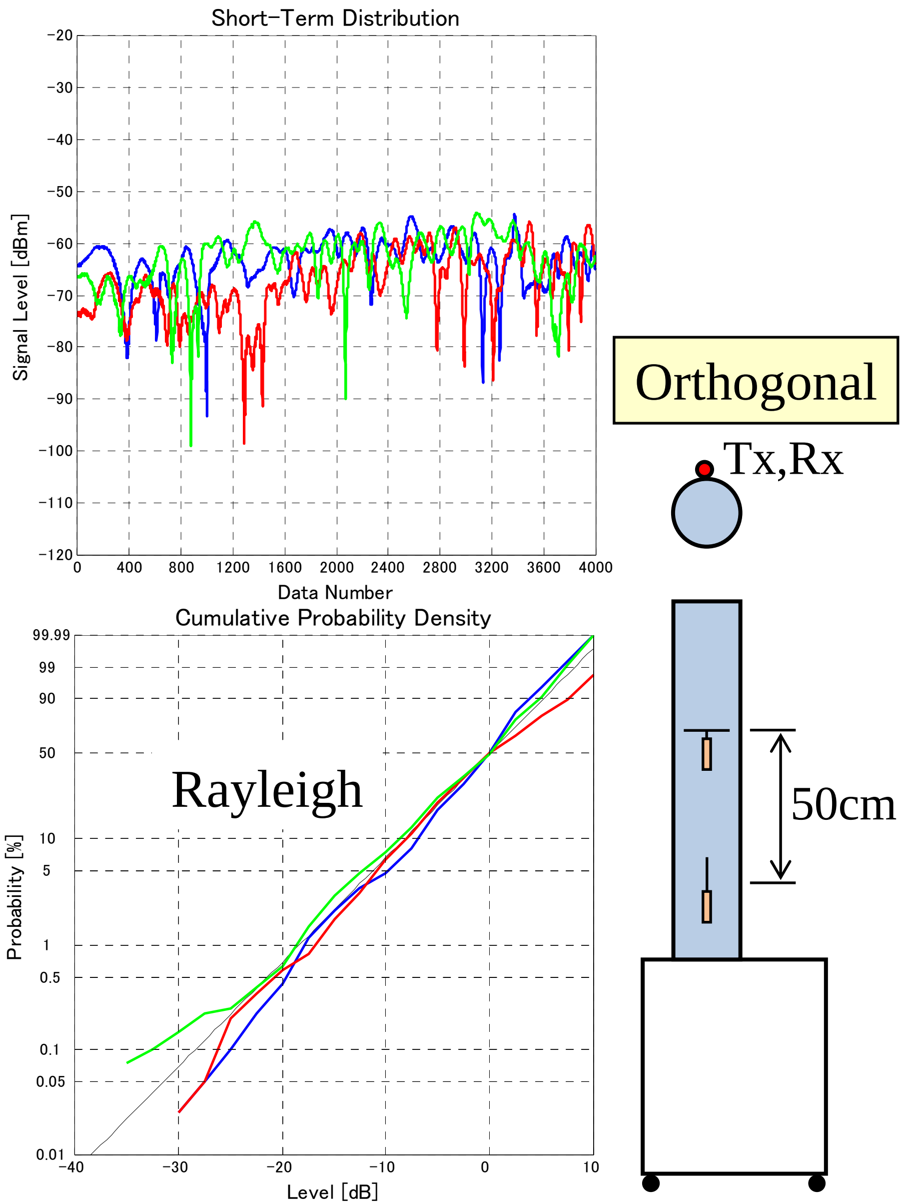
1. Effects of Polarization
2. Effects of Shoulder
3. Effects of Body

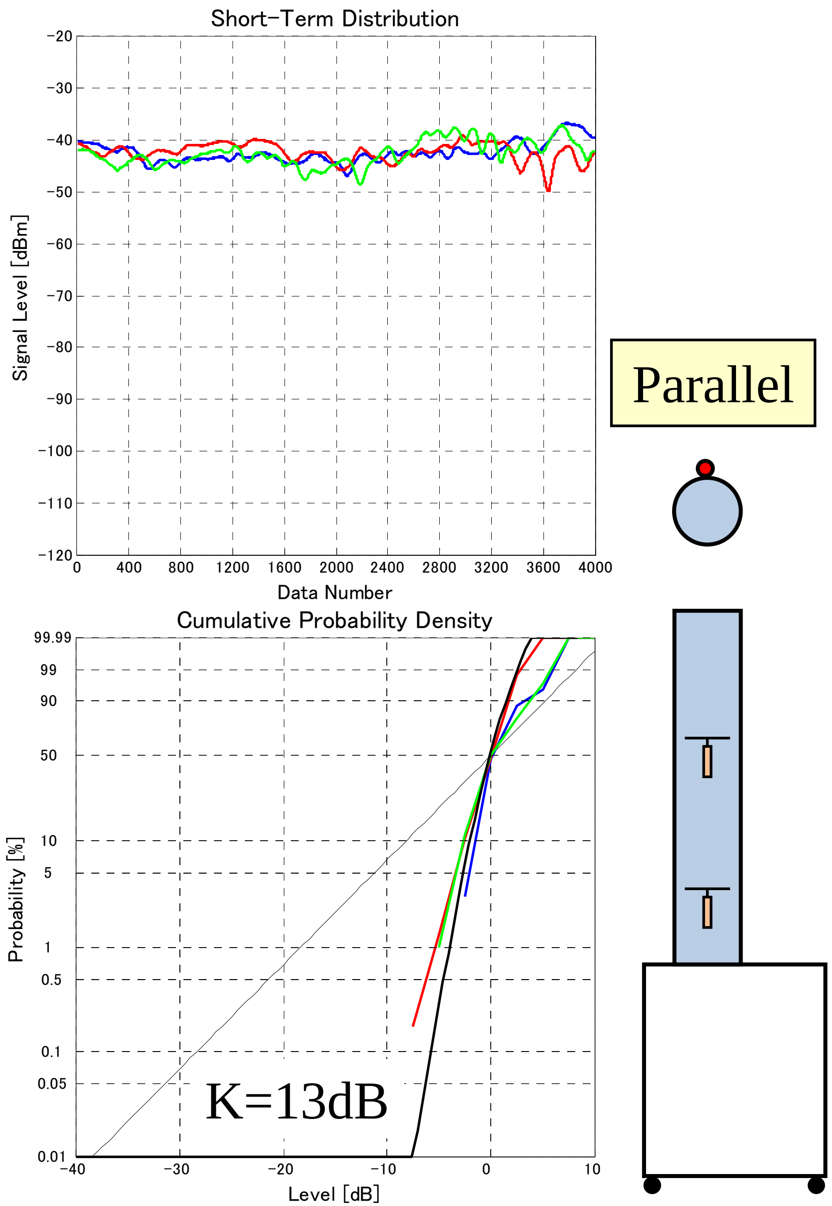
f=950MHz

6m traveling distance / 4000 samplings
1.5 mm / sample (0.005 λ / sample)

1. Effects of Polarization

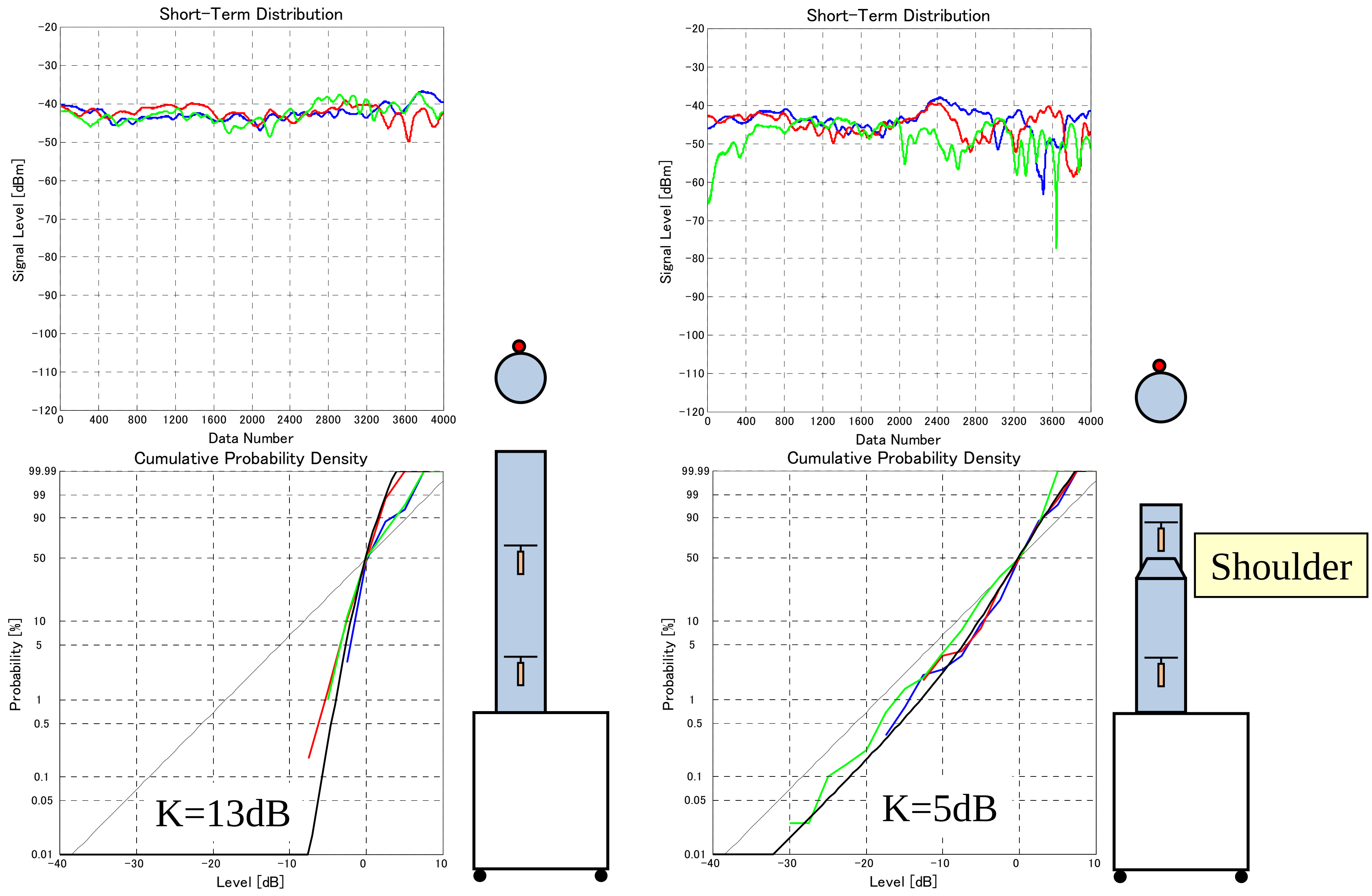
Rayleigh response appears when orthogonal alignment
But, a large K-factor emerges when parallel alignment





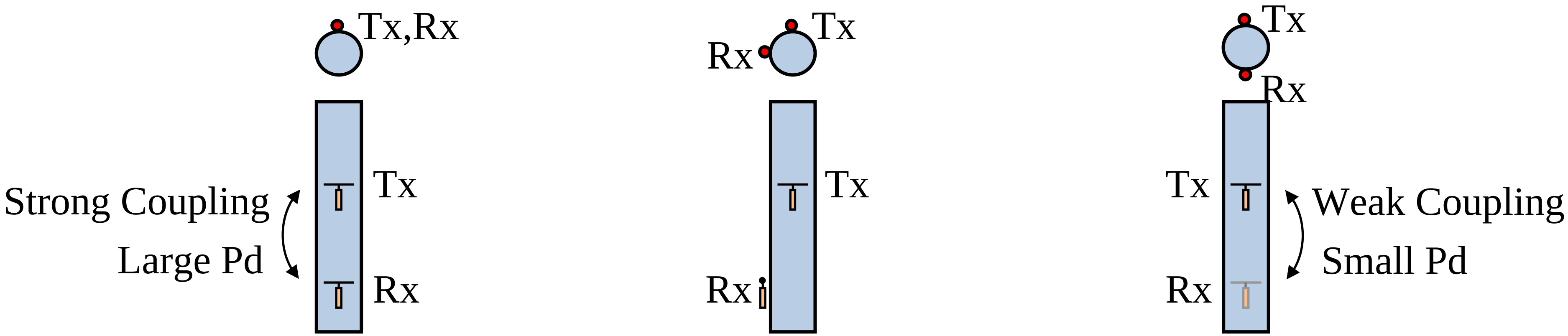
2. Effects of Shoulder

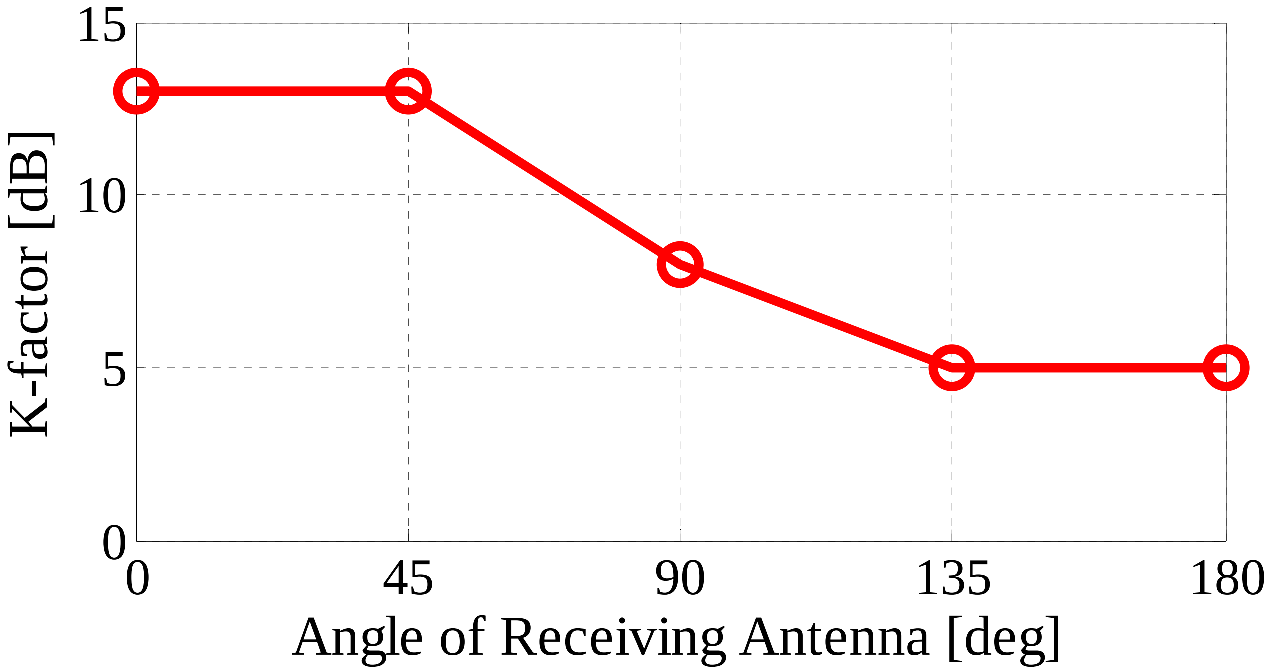
K-factor becomes small due to the shadowing caused by the presence of the shoulder



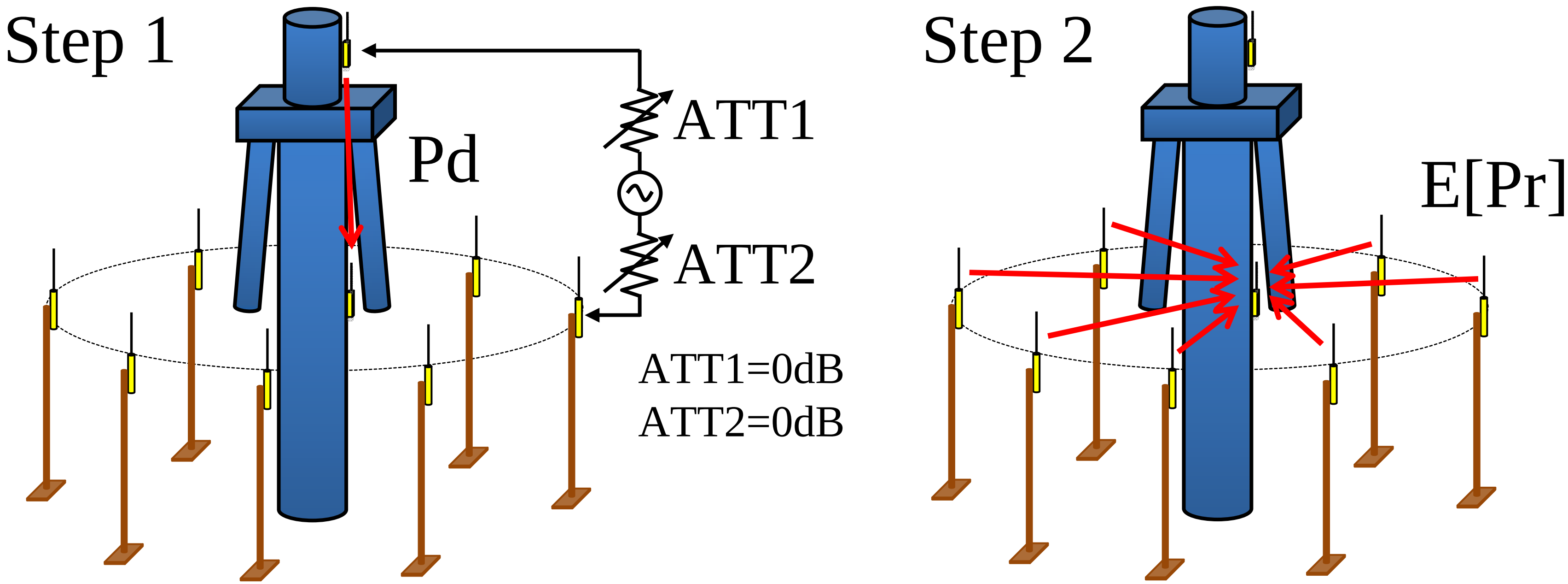
3. Effects of Body

K-factor also changes depending on the location of the antenna around the phantom





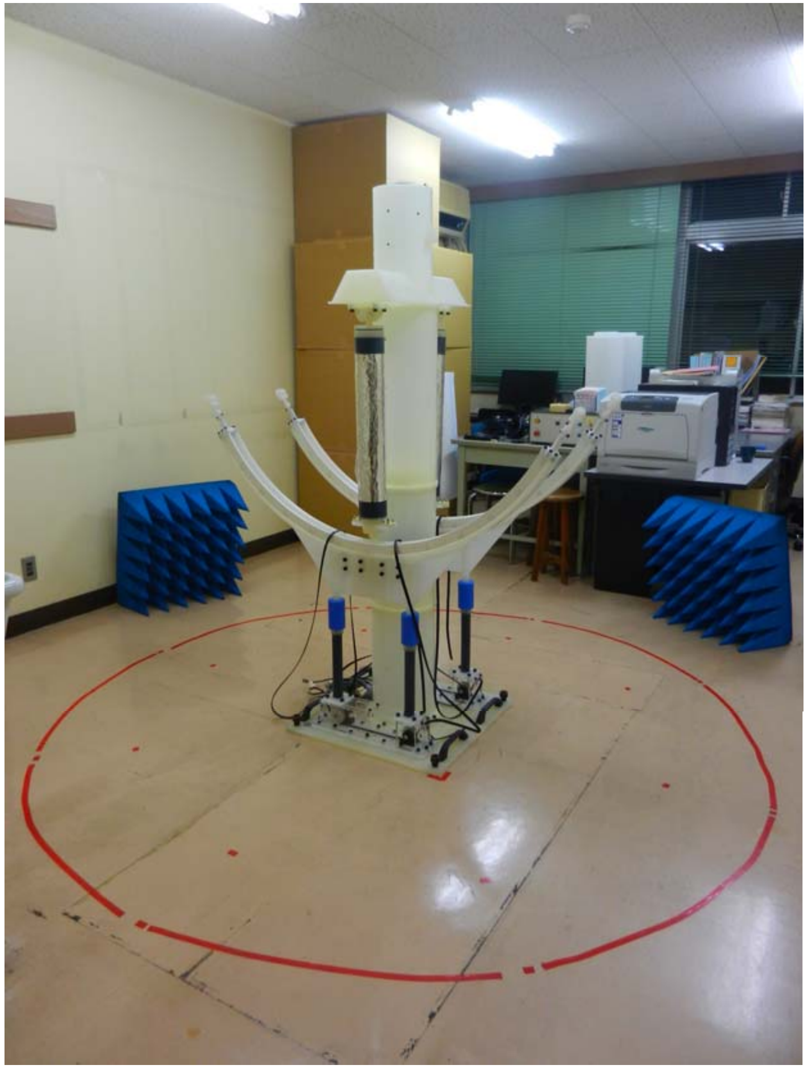
Once K-factor is Known, We can Calibrate the Fading Emulator with K Embedded in it

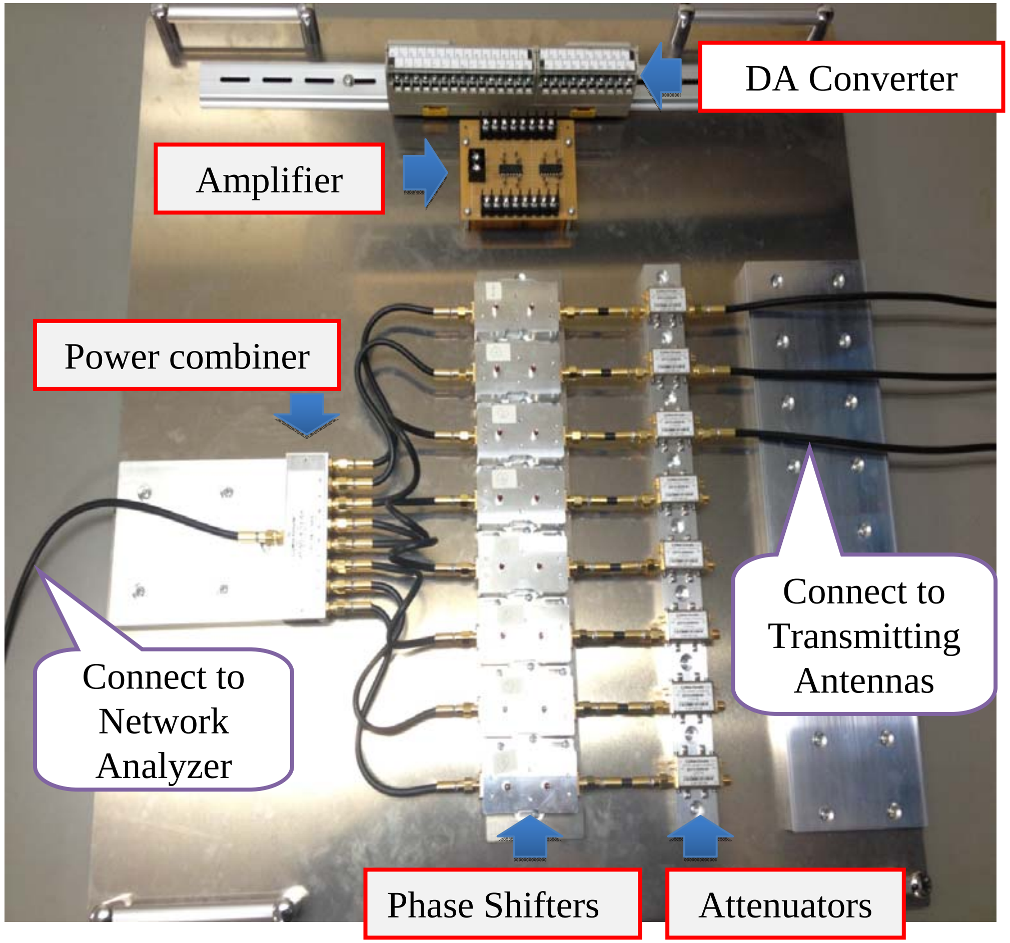


if Pr > Pd then
ATT1 = 0 (dB), ATT2 = E[Pr] (dBm) – Pd (dBm) + K(dB)

if Pr < Pd then
ATT1 = Pd (dBm) – E[Pr] (dBm), ATT2 = K (dB)

Now, we are constructing…





Conclusions

The realization of BAN-OTA includes numerous unknowns to be solved, particularly in indoor propagation characterization.

Today, our current status of the BAN-OTA Project was introduced. The project is still in an initial stage.
So we would like to continue the study in the next FinJap3 Project with you!

Thank You for Your Kind Attention