

# Handset MIMO antenna measurement using a Spatial Fading Emulator

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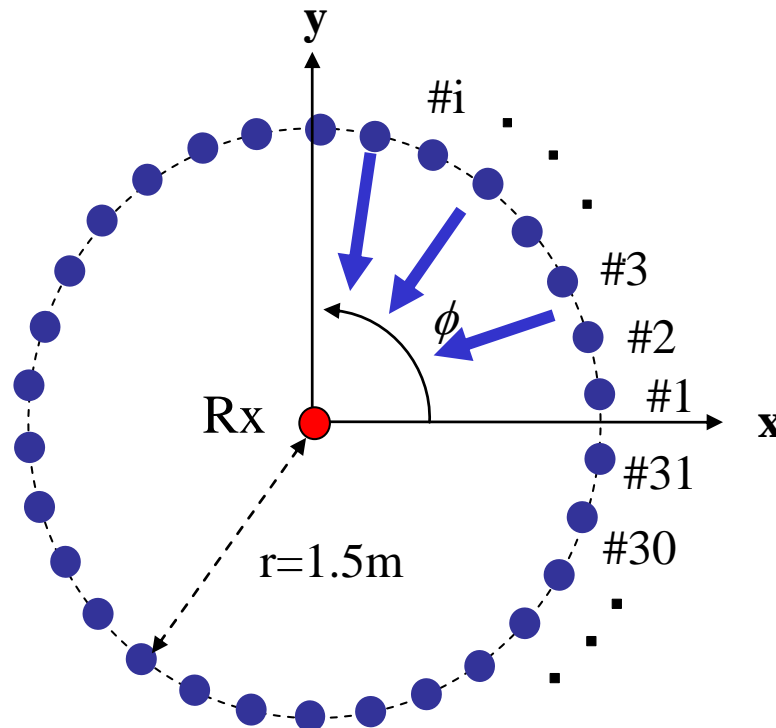
NTT DOCOMO, INC., Japan

Aalborg University, Denmark

Tokyo Institute of Technology, Japan

# Principle of the emulator

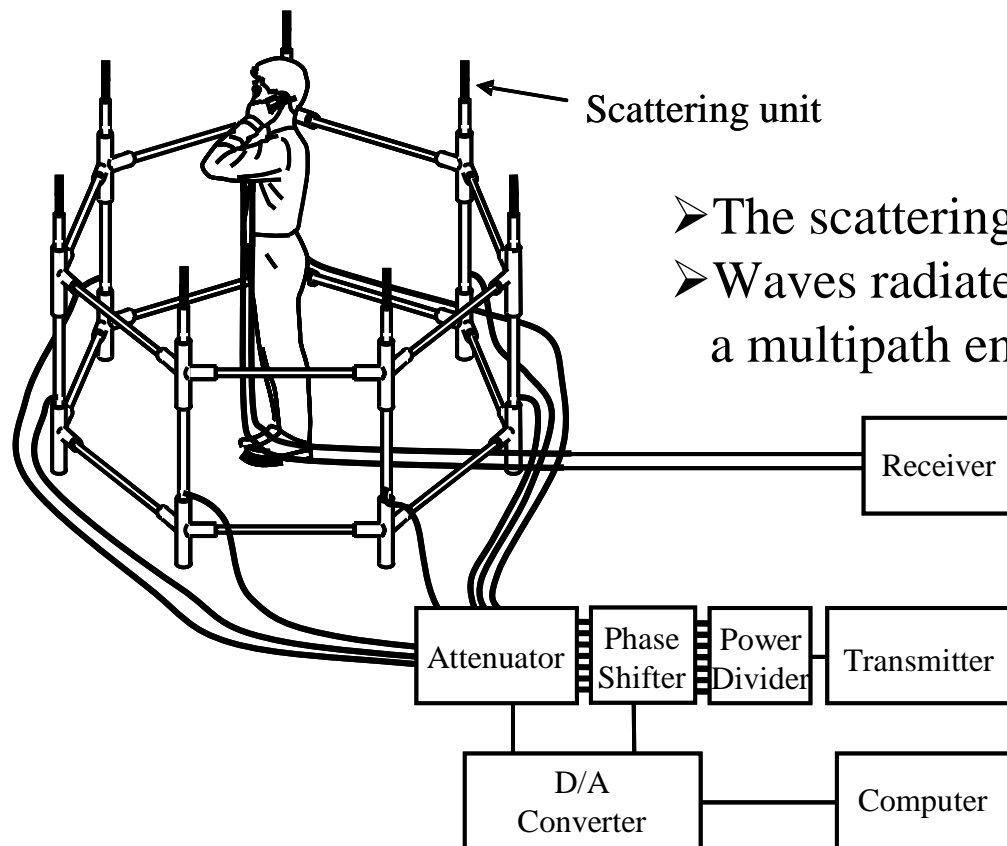
- Waves coming from the same direction are affected by the same Doppler effect, regardless of delay time.
- We can give a Doppler effect to all the waves in the same direction using one phase shifter.
- A phase shifter in the RF band enables us to evaluate antenna performance of a handset array excluding demodulator performance.



# Configuration

Phase shifter in the RF band can directly vary phase of the RF signal according to a Doppler frequency to perform a moving test for a handset.

## Proposed spatial fading emulator



- The scattering unit are arranged around the handset antenna.
- Waves radiated from the scattering units can produce a multipath environment.

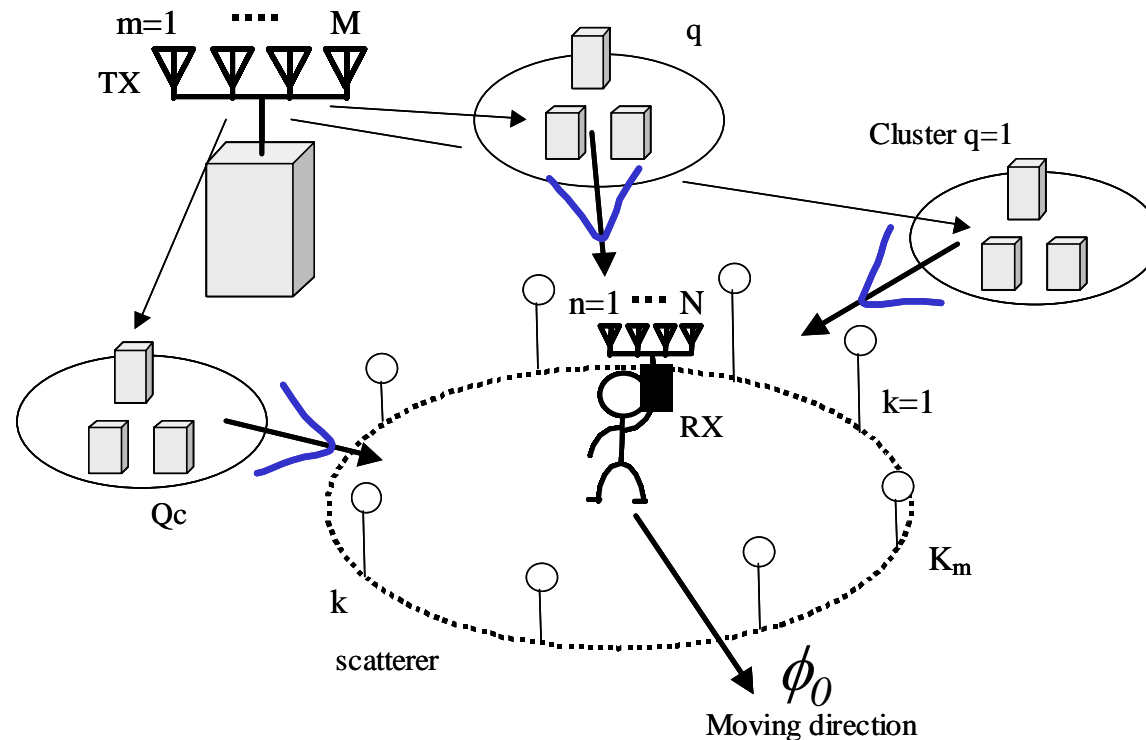
## Multipath environment

- Uniform distribution
- Non-uniform angular power spectrum (APS)

# Scenario for MIMO channel

- ✓  $M$  base station (BS) antennas create a set of  $M$  uncorrelated waves.
- ✓  $M$  uncorrelated waves comprises  $Q_c$  clusters surrounding around  $N$  handset antennas moving toward the azimuth direction,  $\phi_0$ .

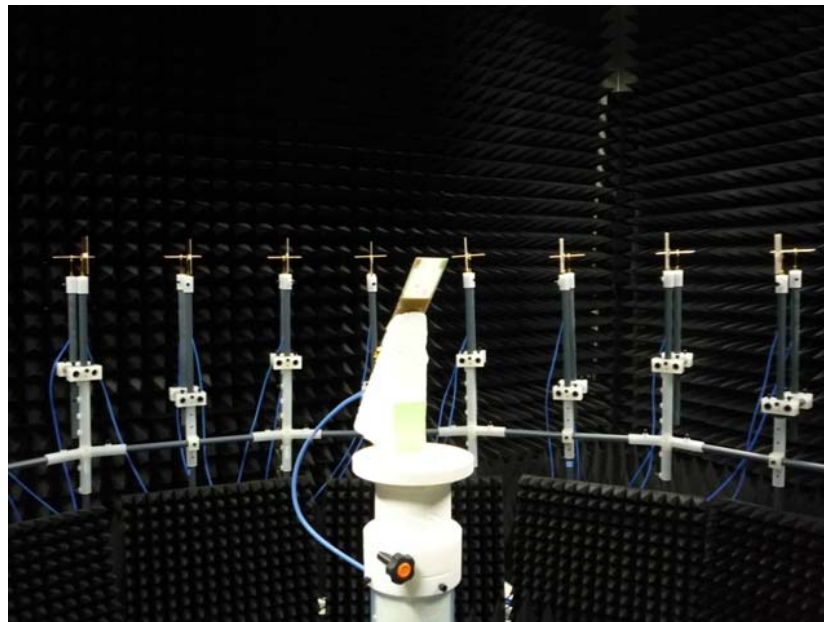
## ● Channel model of M-by-N MIMO system



# Purpose

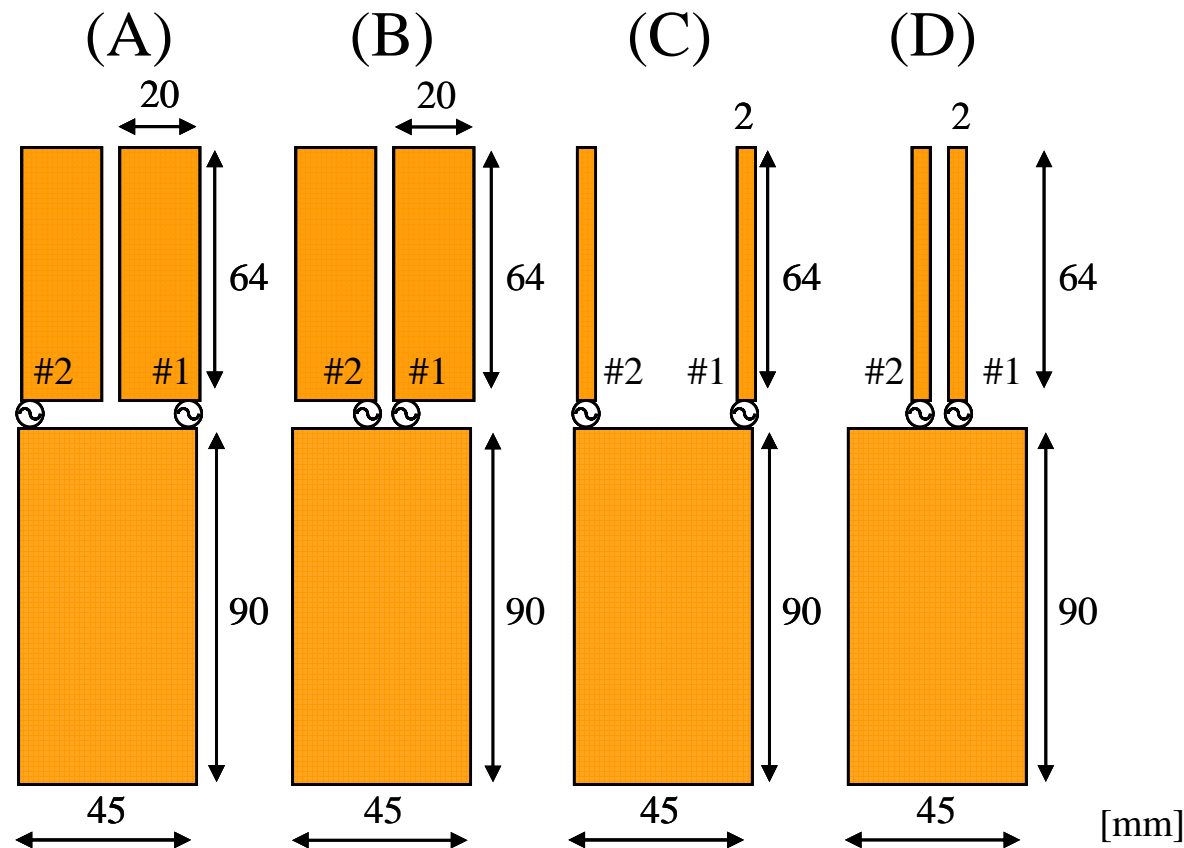
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The purpose is to confirm effectiveness of the RF-controlled spatial fading emulator in MIMO OTA with regard to antenna measurement and handset evaluation.



# Handset antennas

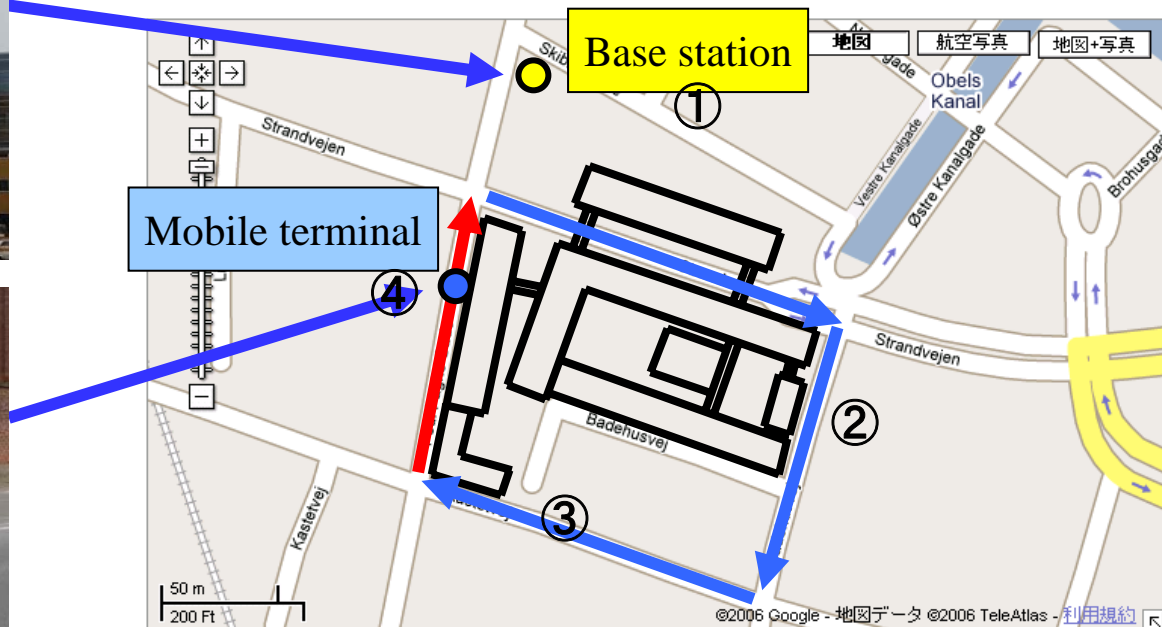
For antenna evaluation, we made a comparison between MIMO channel capacities of a radio propagation test and OTA testing using the emulator. we used four types of handset antennas.



# Radio propagation test

- ✓ The MIMO propagation test was conducted in a central area of a downtown in Aalborg city in Denmark.
- ✓ The handset antenna was set on a car trailer to be moved along the test route.
- ✓ Radio frequency was 2.35 GHz.

We used the experimental data along the route 4.

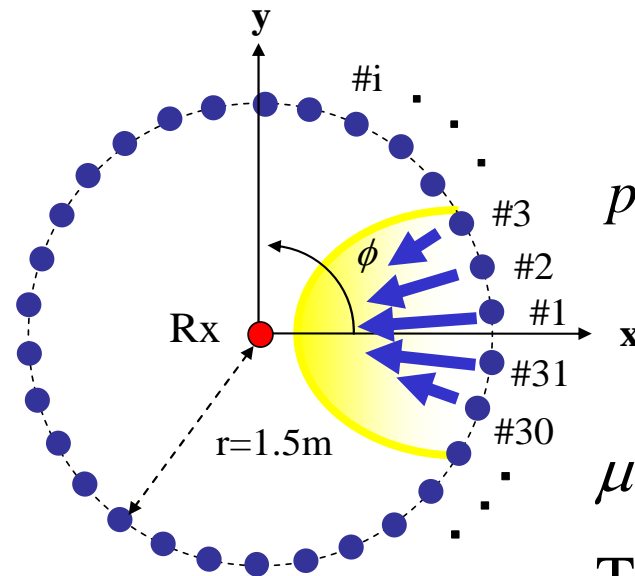
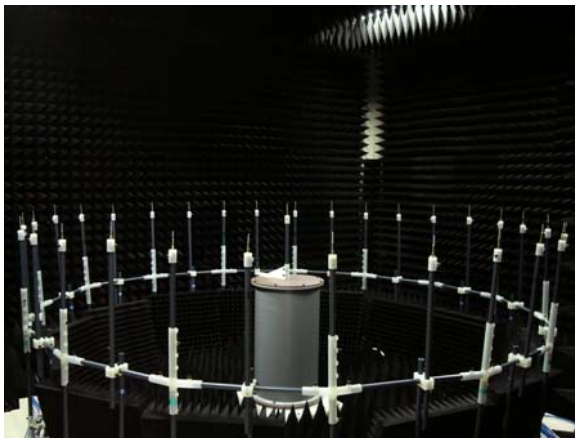


# Channel model for the emulator

We used angular power spectrum (APS) of incoming waves with a Laplacian distribution in the same manner as the spatial channel model (SCM) of 3GPP.

- Number of scattering unit: 31

- Model for spatial cluster



$$p_\theta(\theta, \phi) = \delta(\theta) \frac{1}{2\sigma} \exp\left\{-\frac{|\phi - \mu_\phi|}{\sigma}\right\}$$

$\mu_\phi$  and  $\sigma$  are 0 and 35 degrees.

The XPR is set at 9 dB.

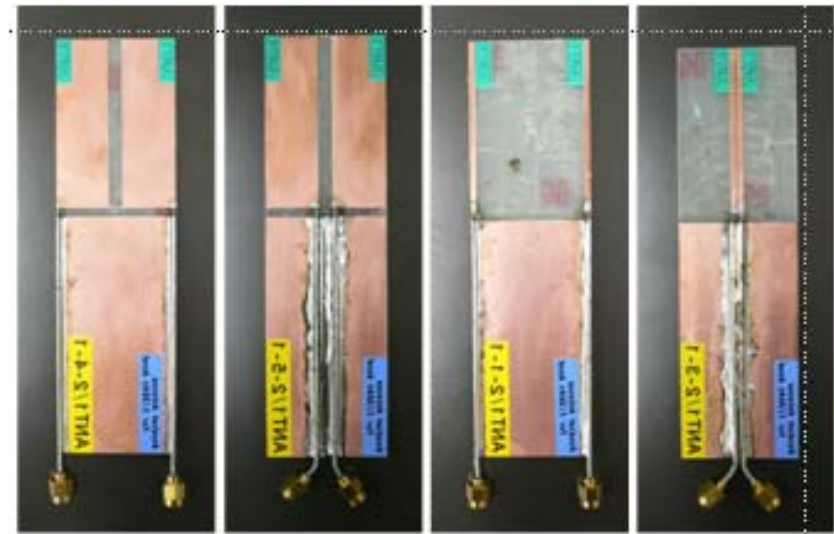
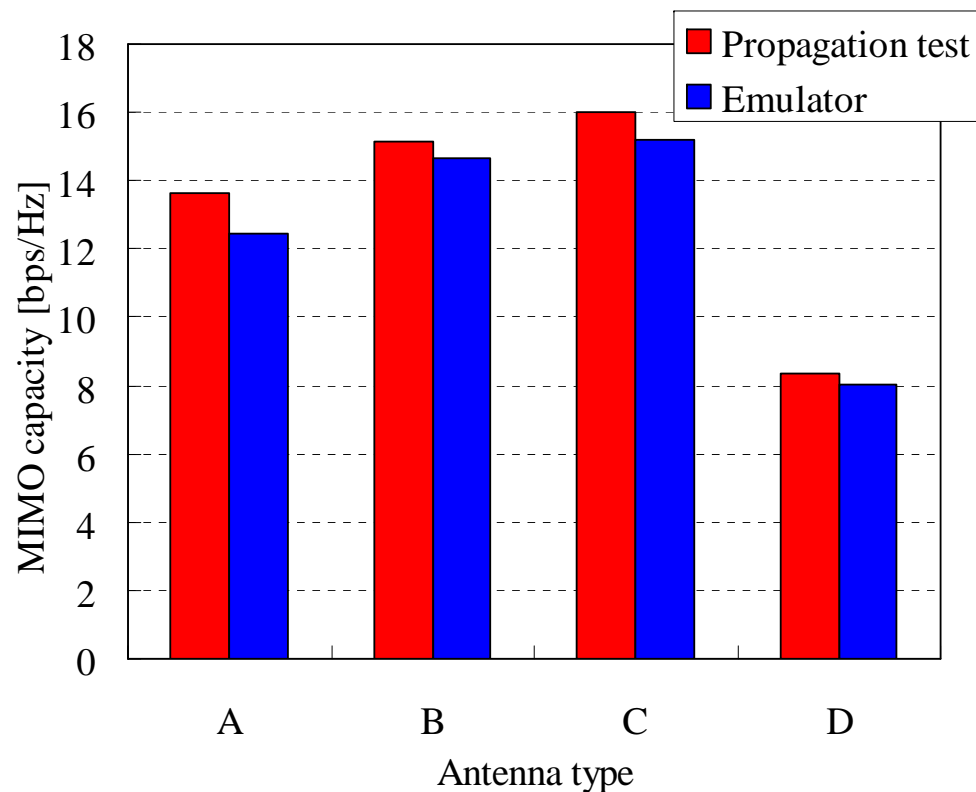


# MIMO channel capacity

The MIMO channel capacities of the OTA testing are in good agreement with those of the propagation test.



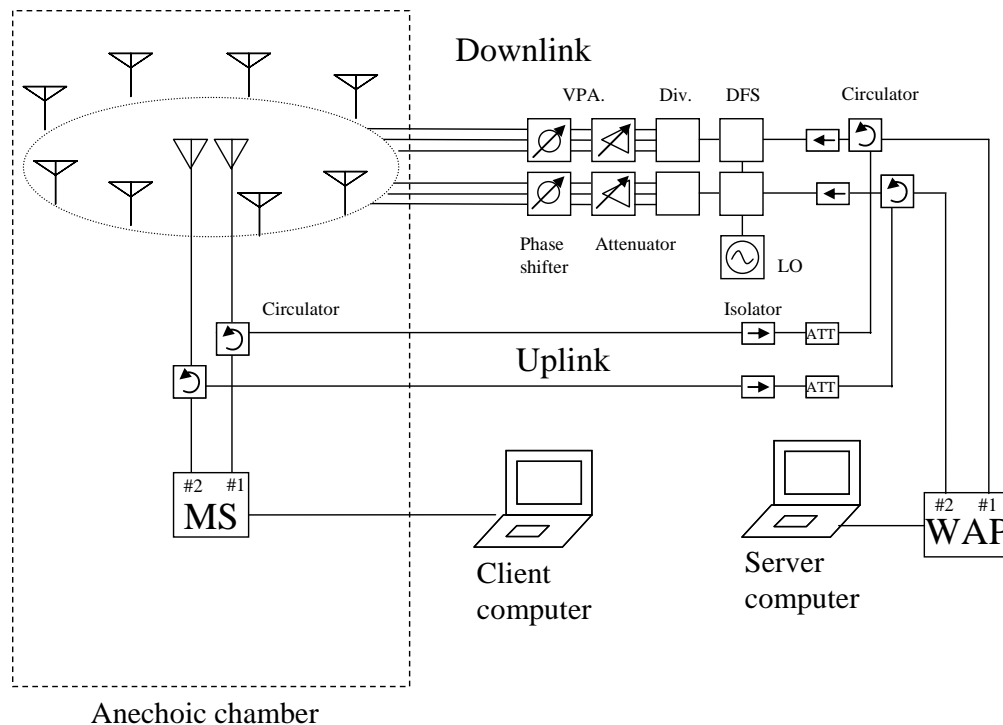
The emulator is effective in evaluating the MIMO antenna by the agreement between the data obtained from the emulator and the propagation test.



# 2-by-2 MIMO measurement system

- ✓ For handset evaluation, we have constructed measurement system with a delay wave using a set of WLAN radio transceivers.
- ✓ The two digital fading simulators are used only for producing delay profile of the incoming waves.

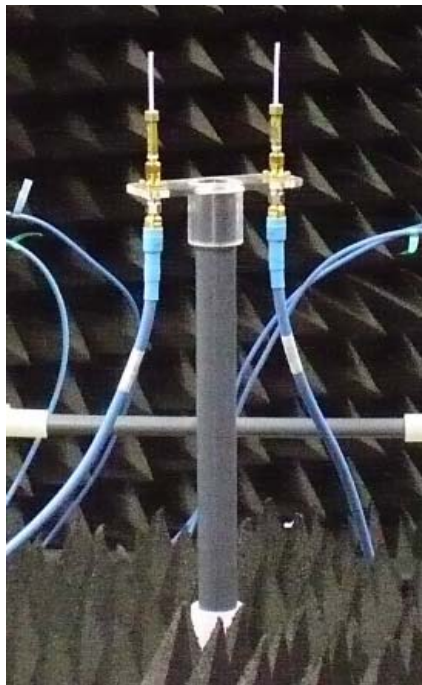
Spatial fading emulator for a 2-by-2 MIMO wireless LAN system



# Measured throughput vs. delay time ( $f_d=6\text{Hz}$ )

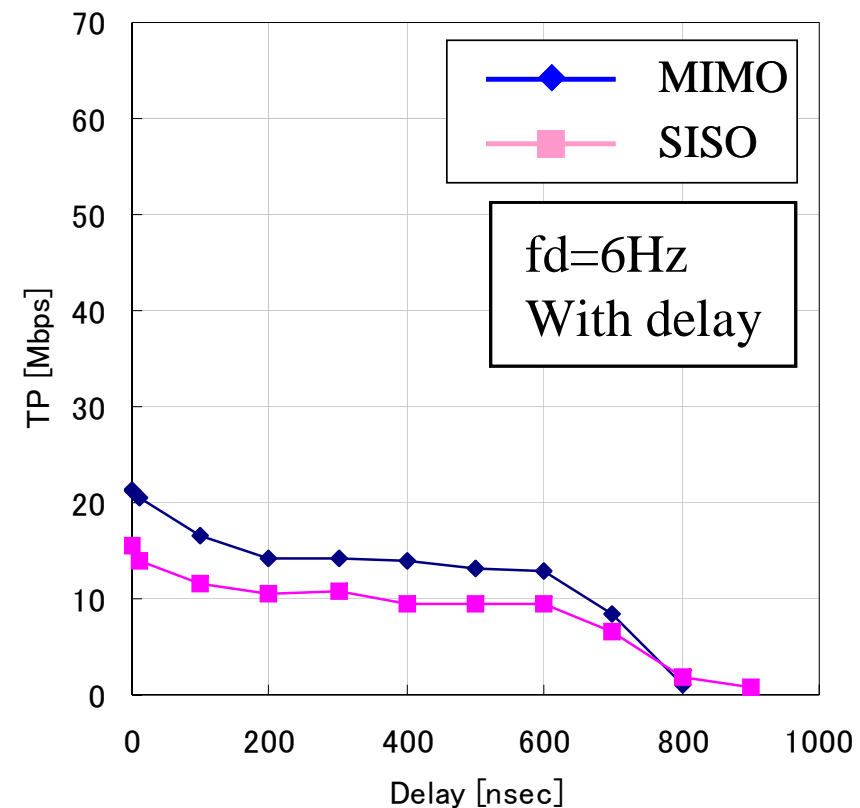
- The MIMO throughput is almost similar to SISO in the case of  $f_d = 6\text{Hz}$  because the low throughput causes a change of the transmission method from MIMO to SISO.
- The advantage of the MIMO configuration is obtained by only the maximum ratio combining (MRC) diversity effect.

Dipole array



Radio frequency: 2.412 GHz.

One delay wave with the same power as the direct wave.



# Conclusion

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I presented an effectiveness of the RF-controlled spatial fading emulator with regard to both antenna measurement and handset evaluation.

For antenna evaluation, the agreement between MIMO characteristics in the propagation test and OTA testing reveals that the emulator is effective in evaluating handset antennas.

With respect to handset evaluation, we have made a start of the MIMO throughput measurement using the emulator.