# [Propagation measurements and considerations for TGad channel modeling in conference room, living room and cubicle environments]

**Date:** 2009-07-15

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# Abstract

**[This document describes propagation measurement results and considerations for TGad channel modeling in conference room, living room and cubicle environments.]**

**1. Intra cluster propagation parameters by measurement for 3 environments**

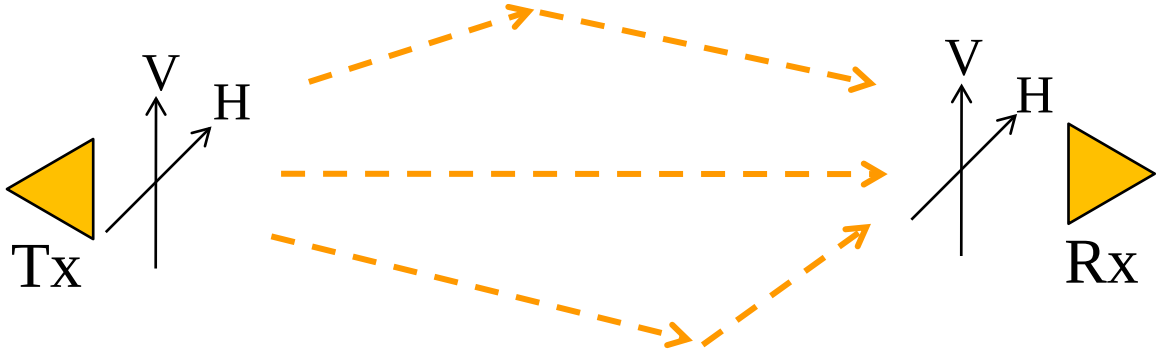
**2. Dual polarization feasibility tested for 3 environments – confirmed feasibility of dual-polarized system in some case**

# Current status of channel models and this contribution

| Environments | | Inter cluster by simulation | Intra cluster by measurement | Dual polarization feasibility |
|---|---|---|---|---|
| Conference | Previous work | Done | Done | Done<br>Conclusion? |
| | This work | | Done<br>Modeling:<br>Further study | Done<br>Linier pol. STA-STA OK<br>AP-STA ?<br>Circular pol.: STA-STA OK<br>AP-STA OK |
| Living | Previous work | Not yet | Not yet | Not yet |
| | This work | | Done<br>Modeling:<br>Further study | Done<br>Linier pol. OK<br>Circular pol. OK |
| Cubicle | Previous work | Not yet | Not yet | Not yet |
| | This work | | Done<br>Modeling:<br>Further study | Done<br>Linier pol. STA-STA OK<br>AP-STA ?<br>Circular pol.: STA-STA OK<br>AP-STA OK |

# Problems in the current channel models (1)

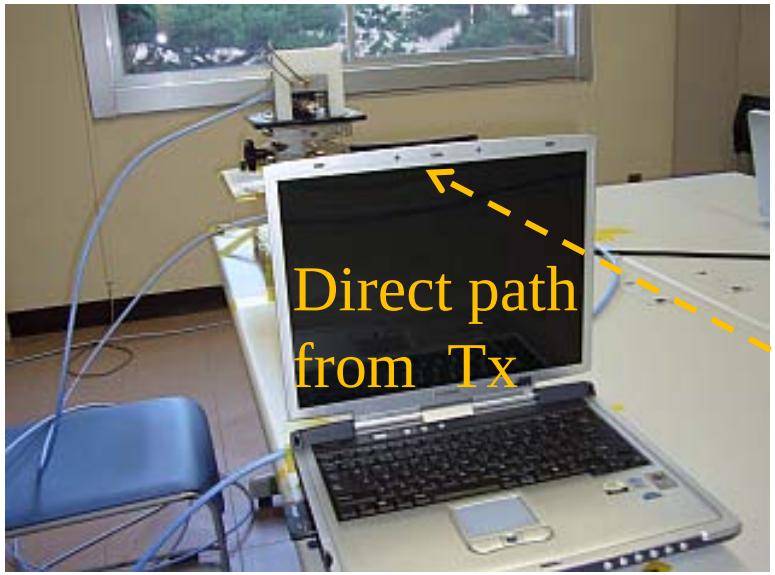
- Polarization concept was shown in Doc.09/431 and 09/552, however, it is not integrated in the current TGad channel model.
- We propose a channel model including $S_{VV}$, $S_{HH}$, $S_{VH}$, $S_{HV}$ matrices by real measurement results.



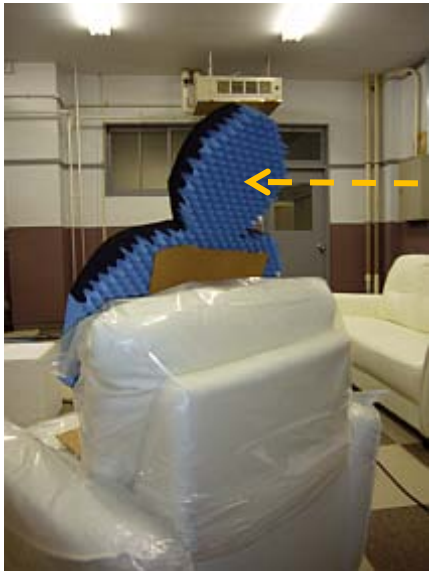

$$\begin{bmatrix} E_{VRx} \\ E_{HRx} \end{bmatrix} = \begin{bmatrix} S_{VV} & S_{VH} \\ S_{HV} & S_{HH} \end{bmatrix} \begin{bmatrix} E_{VTx} \\ E_{HTx} \end{bmatrix}$$

# Problems in the current channel models (2)

- **NLOS scenario is not clearly defined. We propose to define NLOS scenario as shadowing due to PC in conference room and human body in living room.**

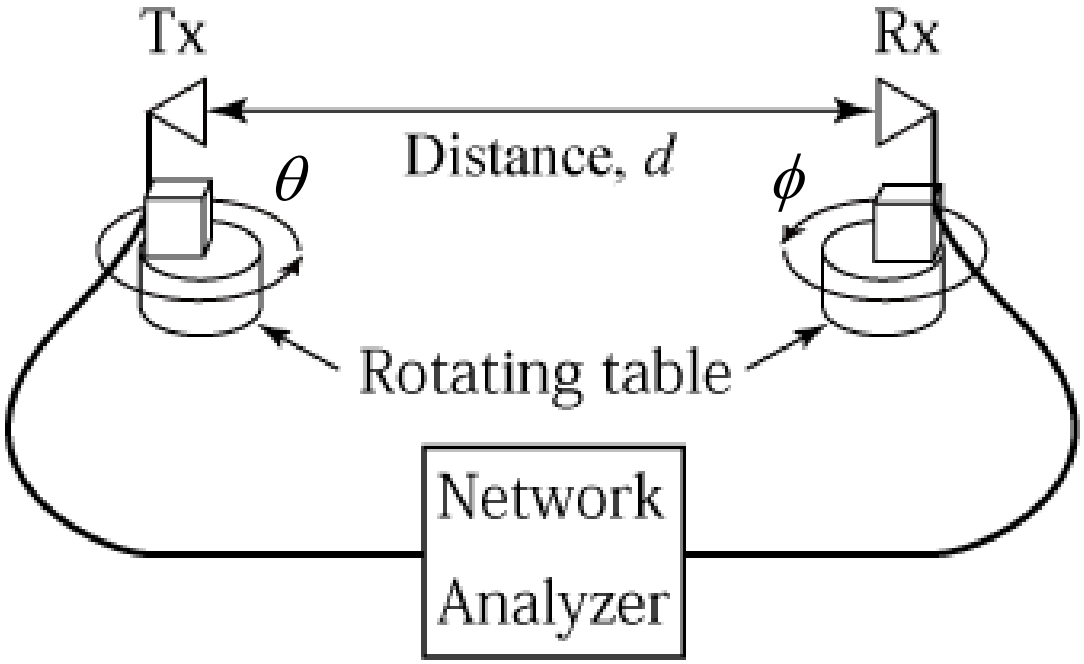



NLOS scenario in conference room




NLOS scenario using human phantom in living room

# Measurement system




- Instrument: Vector network analyzer
- Antenna: Conical horn antenna

# Measurement set up for conference environment

| Parameter | Value |
|---|---|
| Center frequency | 62.5 GHz |
| Band width | 3 GHz |
| Number of frequency points | 801 / 1601 |
| Frequency step | 3.75 MHz / 1.875 MHz |
| HPBW of antenna (Gain) | 60 degree (10dBi)<br>30 degree (16dBi) |
| Polarization | Co-polarized signal:<br>Vertical / Horizontal / Circular<br>Cross-polarized signals:<br>V→H, H→V |
| Calibration | Direct port connection without antennas |

# Transmission characteristics of polarized signal waves

$$S_{ij} = S_{VV}, S_{HV}, S_{VH}, S_{HH}, S_{CC}$$

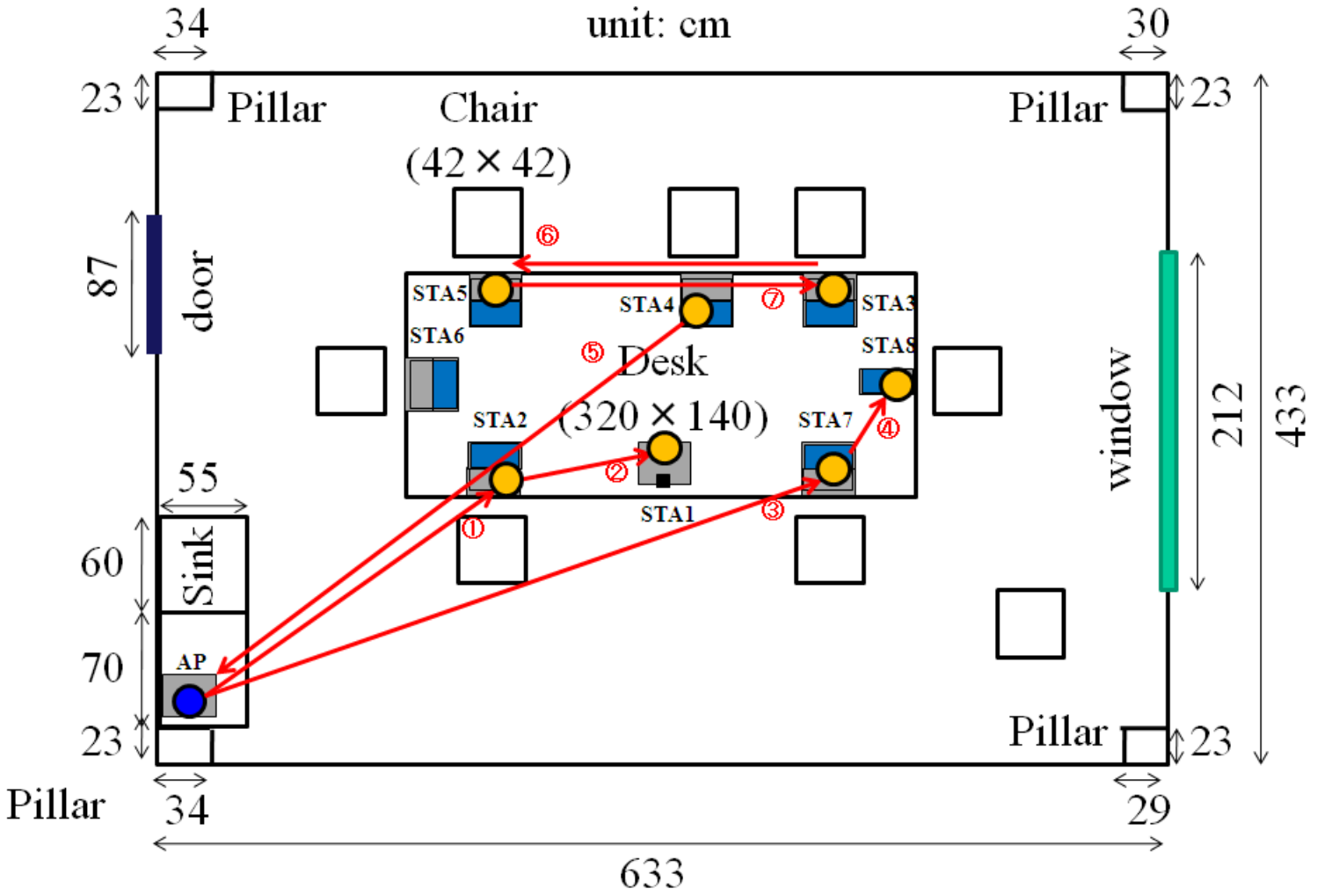
$i$ : Polarization of receiving signal
$j$ : Polarization of transmitting signal

Polarization
V: Vertical
H: Horizontal
C: Circular

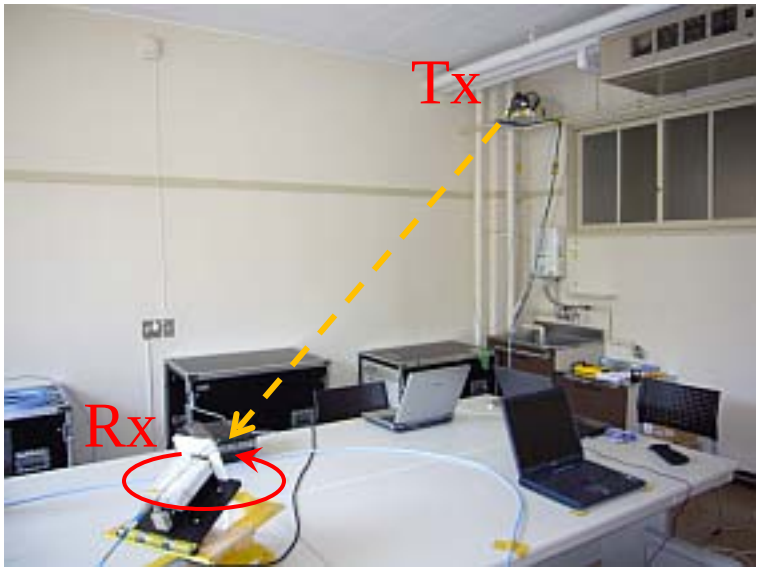
- Measurements were carried using polarized signal waves to investigate the feasibility of dual polarized signal transmission and polarization diversity systems

# Measurement in conference room

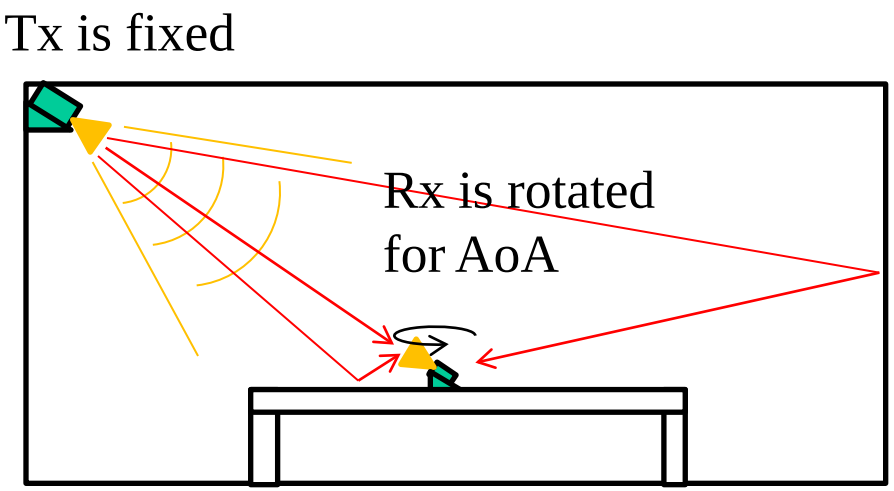
# Floor plan of conference room defined by TGad



# AP-STA communication link



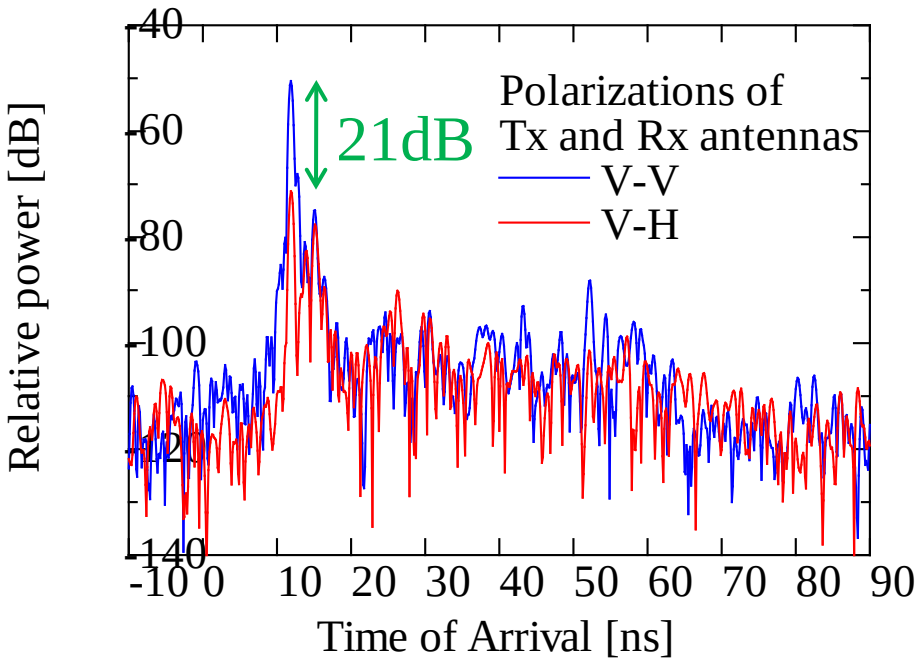

AP-STA link



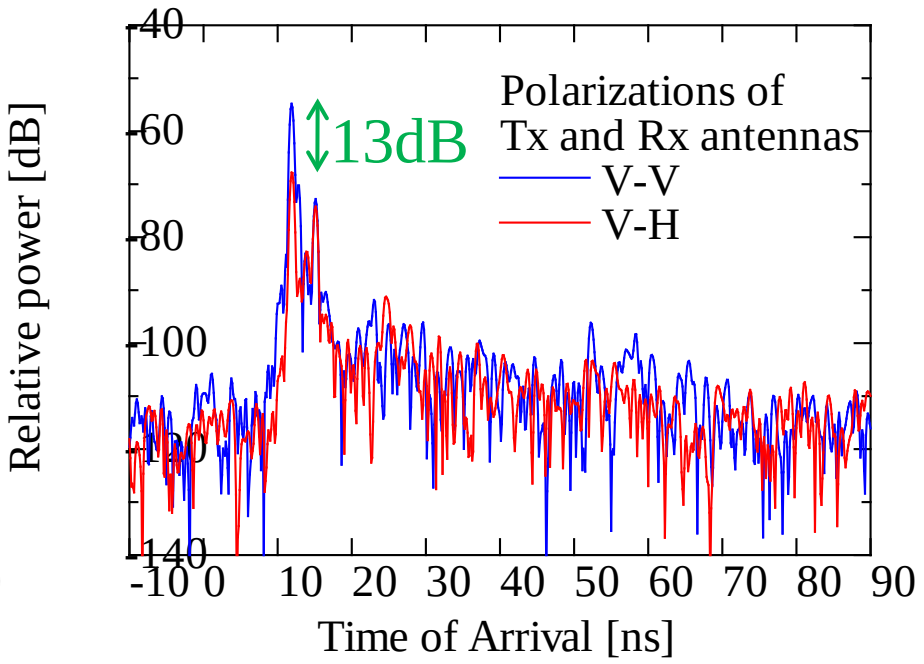

Measurement configuration

- HPBW of Tx antenna(AP) is 60 degrees, it covers all desktop area.
- Single directional propagation channels in which Tx antenna was fixed were measured for all AP-STA communications.

# Example of impulse responses of link 5 (AP-STA4)



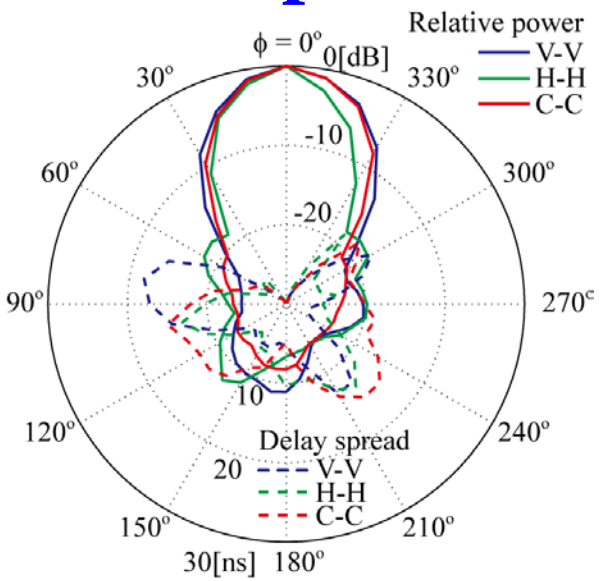

(a) Tx and Rx antenna were aligned



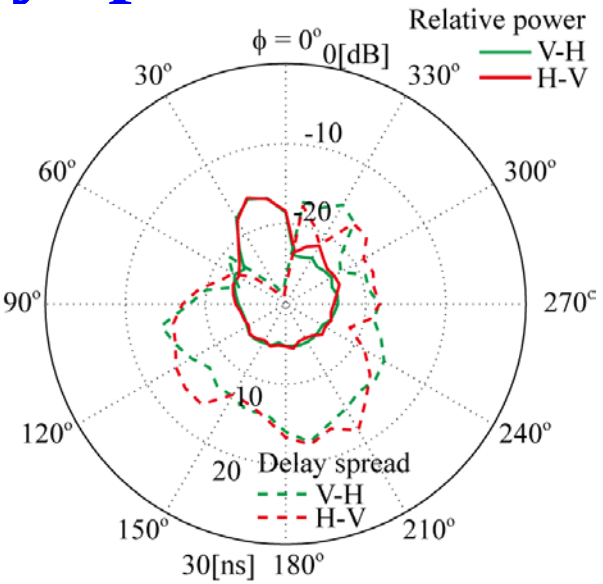

(b) Rx antenna angle offset : 20deg

- Cross polarization discrimination was 21dB at the direct path, and 13 dB at 20 degree Rx offset angle from the direct path.
- Antenna alignment by beam-forming is important to avoid interference of cross-polarized signal.

# Received power and delay spread of the link5




(a)Co-polarized signal waves

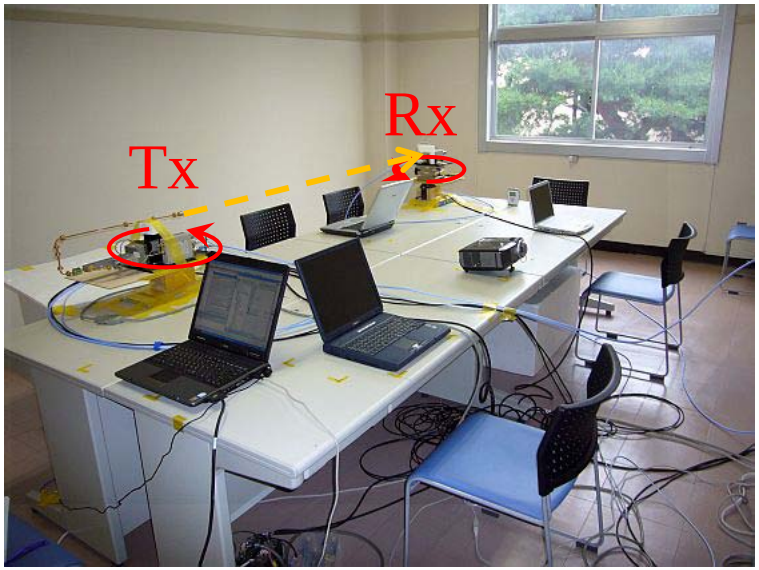



(b)Cross-polarized signal waves

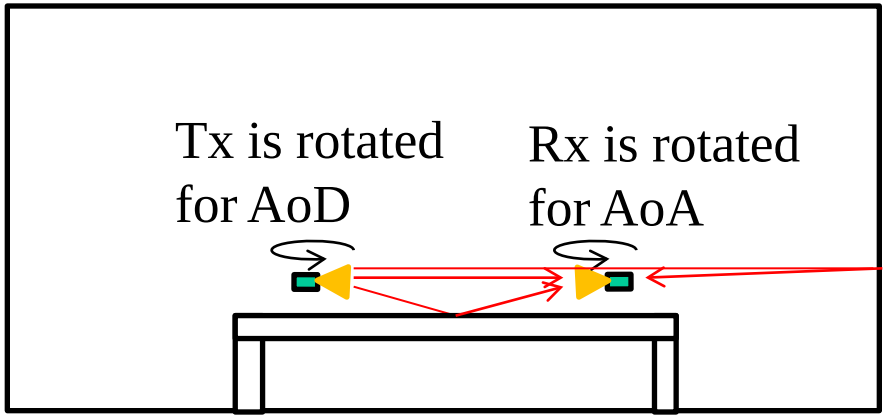
※All relative power were normalized by the maximum power level of V-V.
Threshold level for delay spread calculation is less than 30dB from the peak power.

- The AWGN channel model is acceptable for the evaluation, since AP-STA link can keep LOS situation basically.
- XPD is the minimum when Tx and Rx antennas are aligned.
- About dual signal transmission feasibility is describes in cubicle environment.

# STA-STA communication link



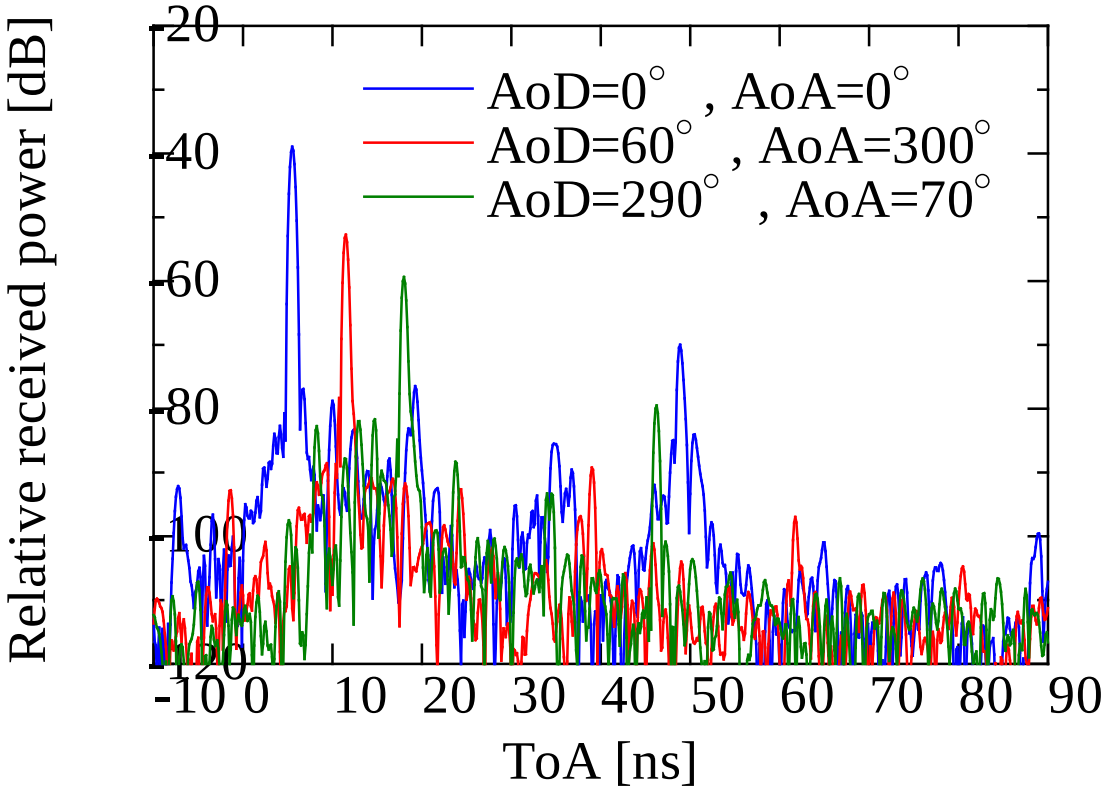

STA-STA link




Measurement configuration

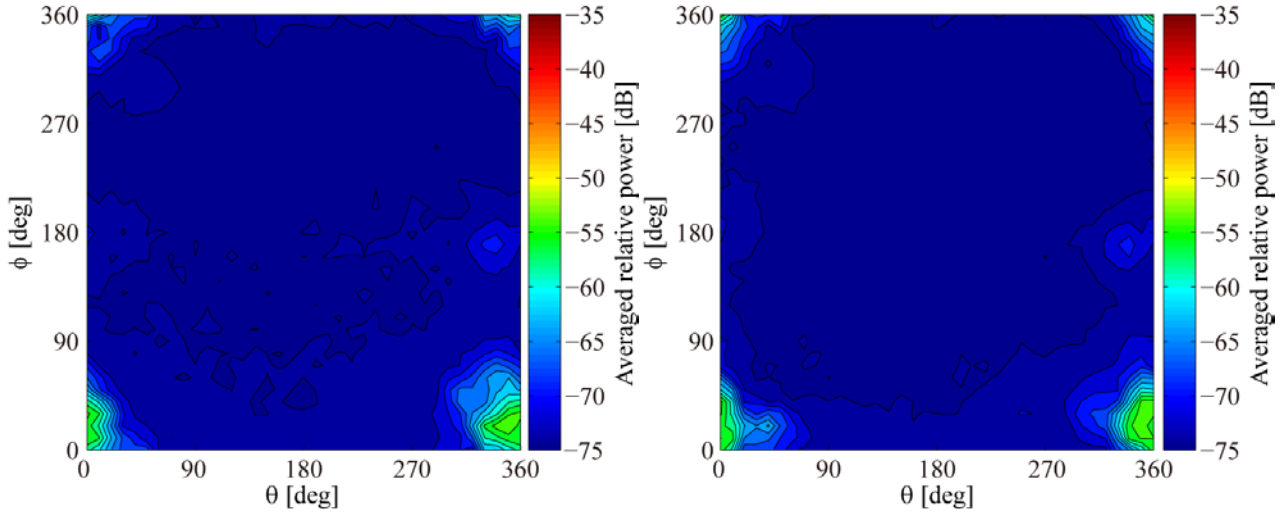
- Double directional propagation channel was measured for all STA-STA communications.

# Impulse response example of link7 (V-V) in conference environment




- Intra cluster parameters in each cluster can be extracted from measurement results

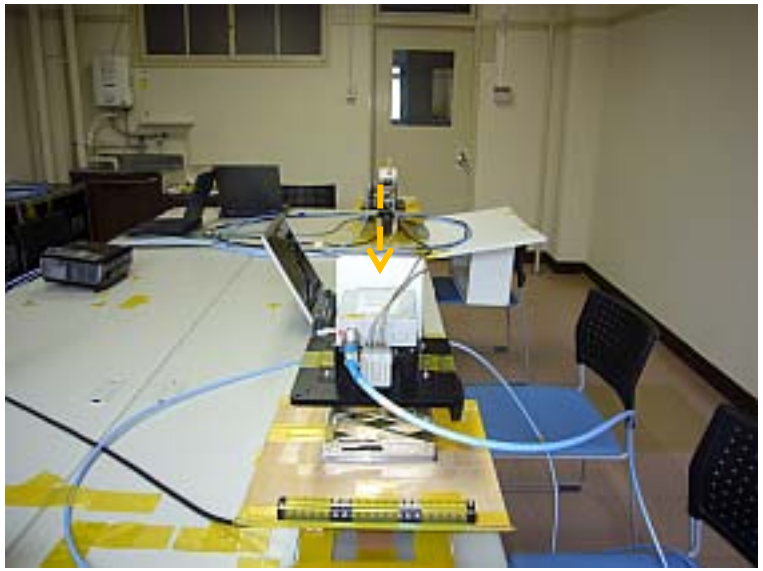
# Relative received power of the link7 LoS scenario for cross-polarized signal waves



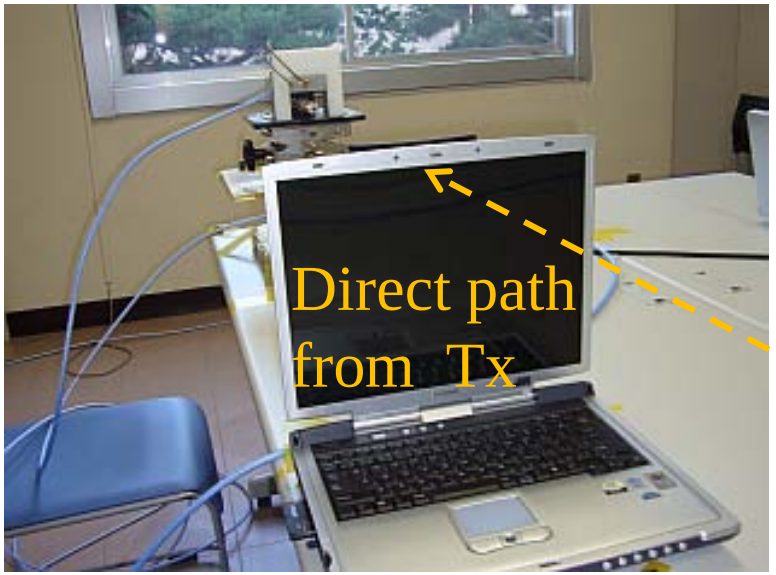

V-H H-V

- Cross-polarized components were not observed on STA-STA link in conference environment.
- Dual polarized signal transmission is feasible.

# LOS/NLOS scenario for STA5→STA3 link



LOS scenario

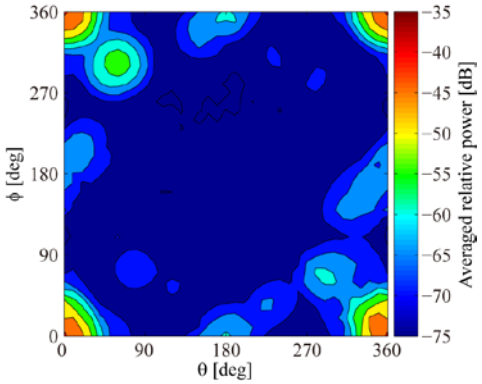


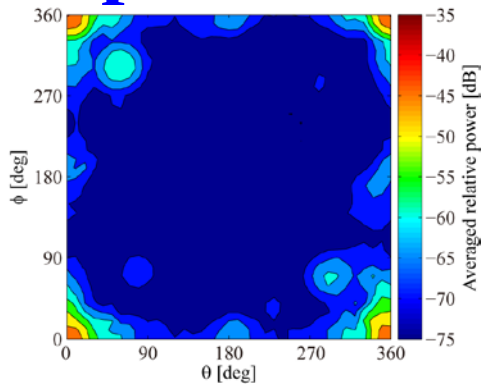

NLOS scenario

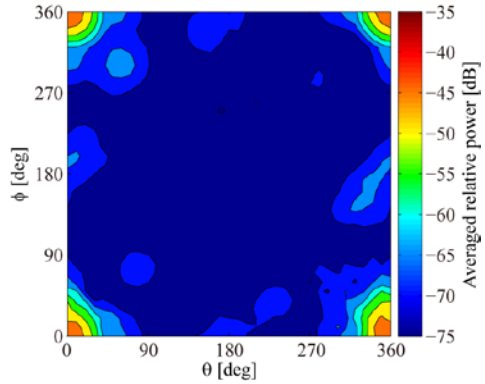
- NLOS scenario was also measured as the direct path component was blocked by notebook PC.

# Relative received power of the link 7

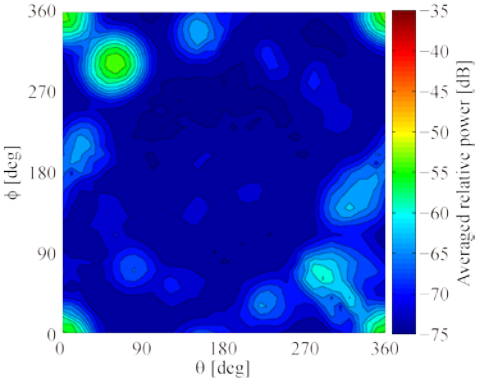
LOS scenario

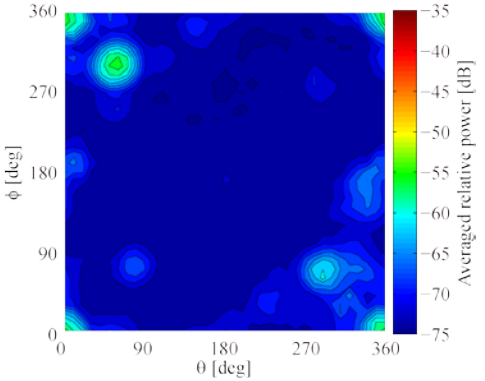


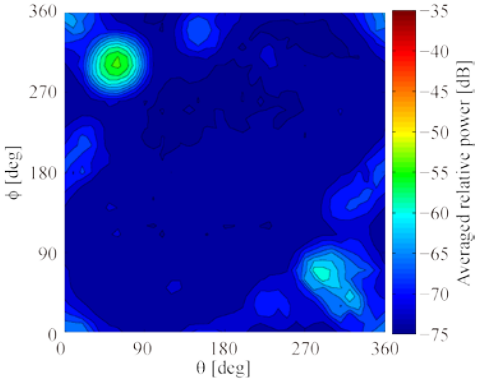




NLOS scenario



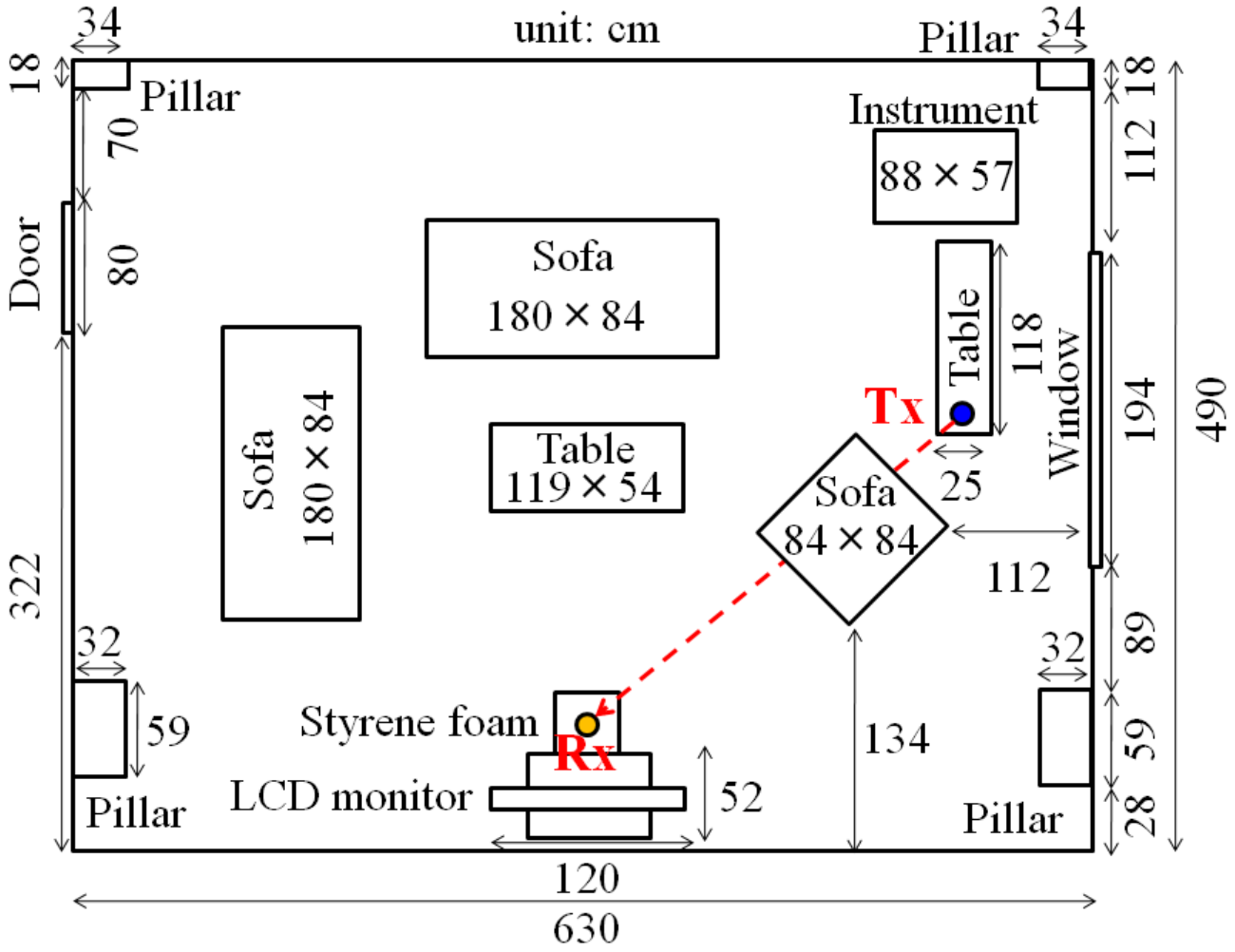

V-V H-H C-C

- NLoS pathloss is larger than LoS pathloss in direct-path by +14.5dB in vertical, +15.5dB in horizontal, +23.5dB in circular
- H pol. reflection path loss :+2.6dB larger than vertical
- V pol.: better for single polarized signal transmission

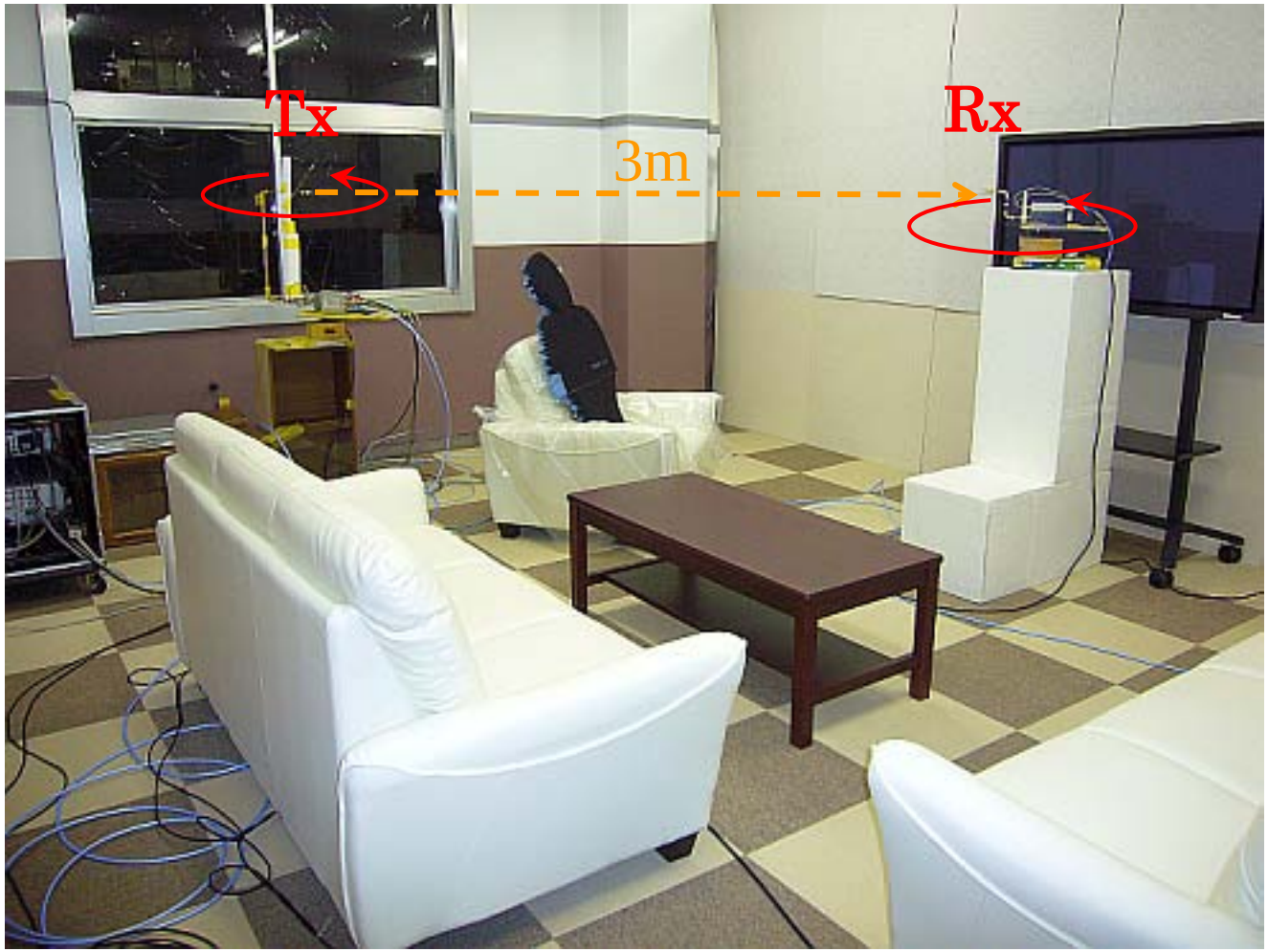
# Measurement in living room

# Floor Plan of Living Room

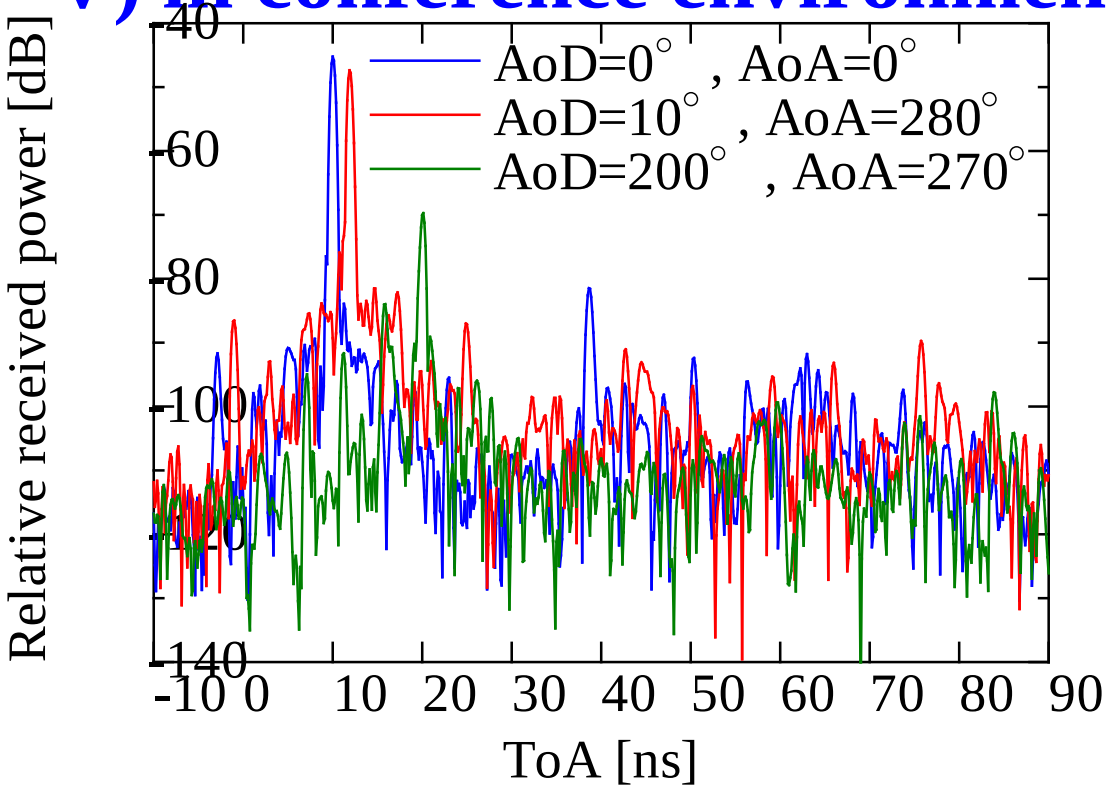
Antenna height is 1.5m
HPBW is 30degree



# Communication link

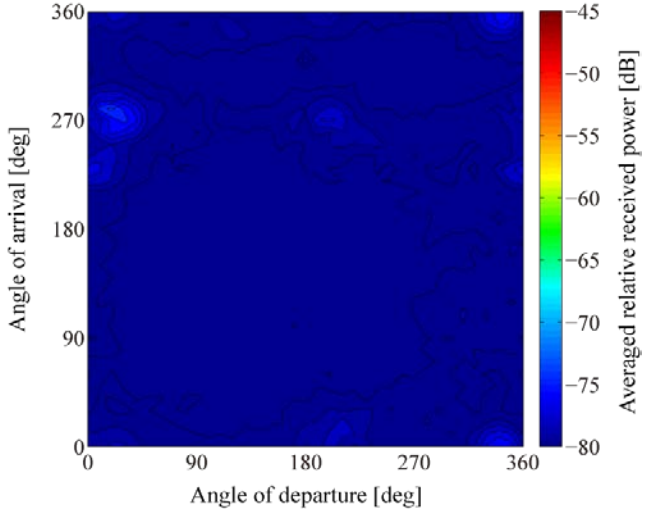


# Impulse response example of LOS scenario (V-V) in conference environment

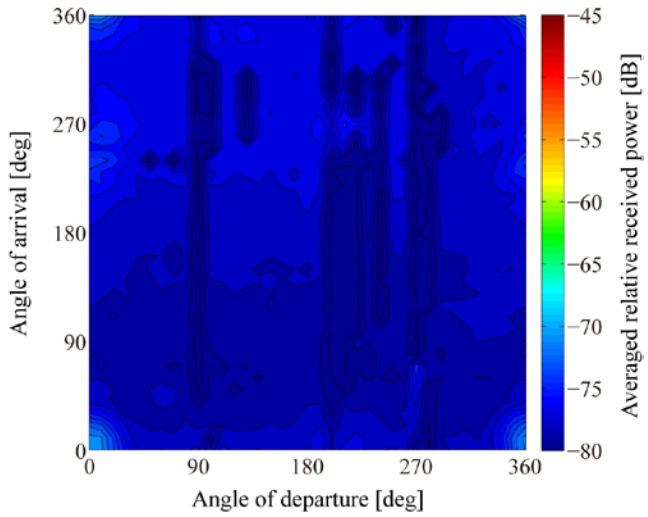



- **Intra cluster parameters in each cluster can be extracted from measurement results**

# Relative received power in LoS scenario for cross-polarized signal waves




V-H




H-V

- Received power of Cross-polarized signal waves is very small.
- Dual polarized signal transmission is feasible.

# Human phantom for NLoS Scenario

(a) Front side

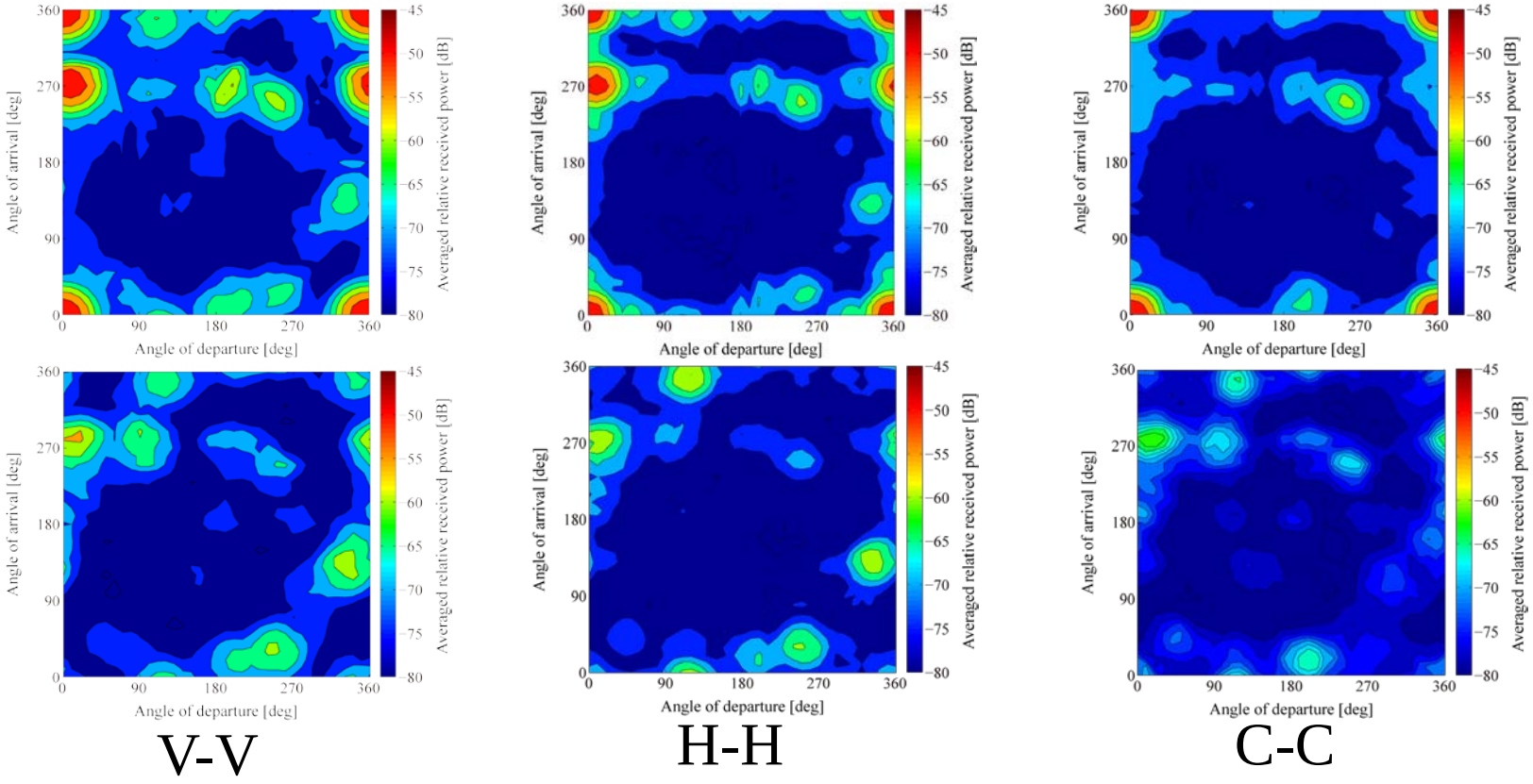
(b) Back side.

To measure the NLOS scenario, a human phantom was made by electromagnetic absorber. Antenna height is changed to 1m.

# Received power in LOS/NLoS scenario for co-pol. signal waves

LOS scenario

NLOS scenario

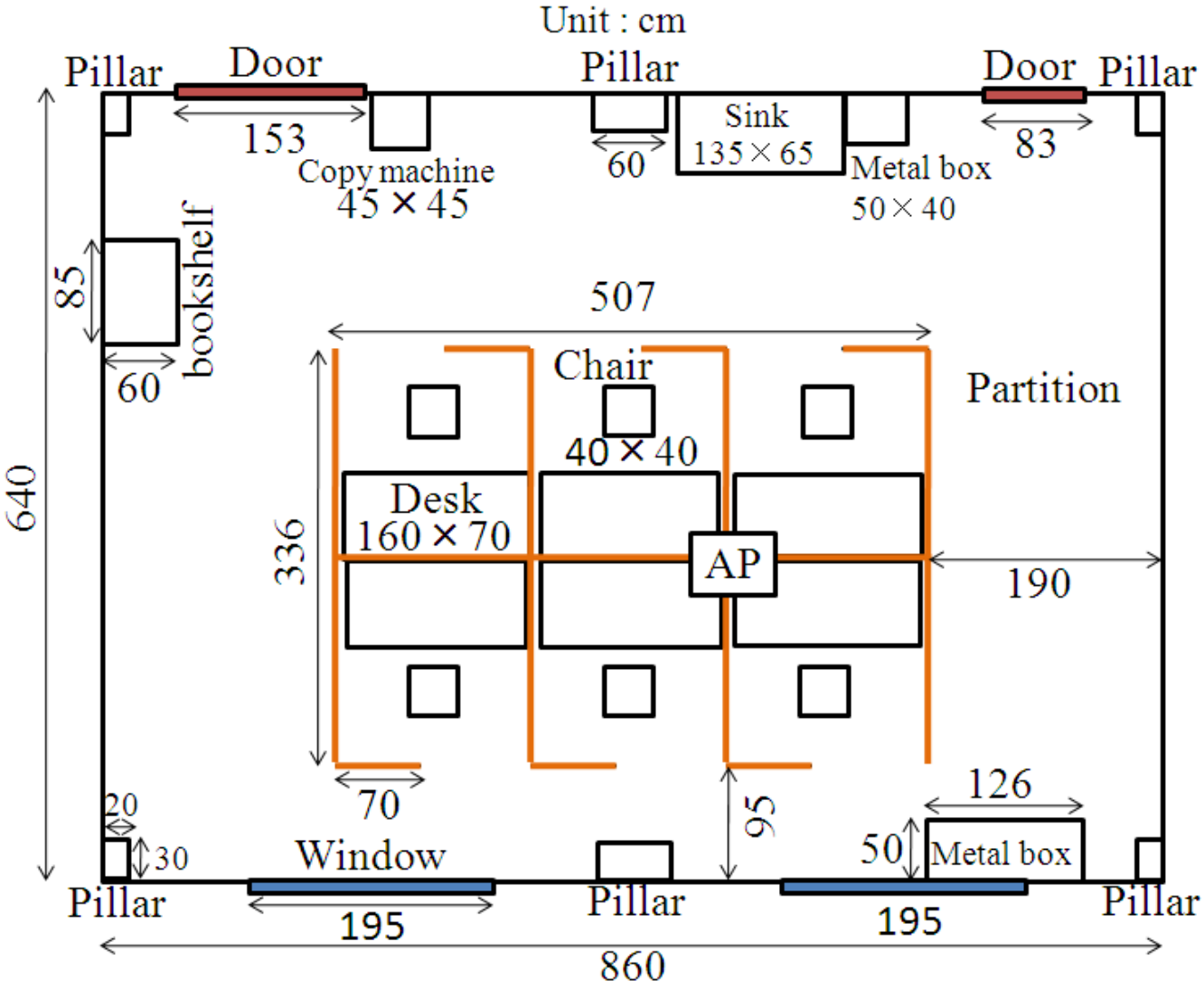



V-V H-H C-C

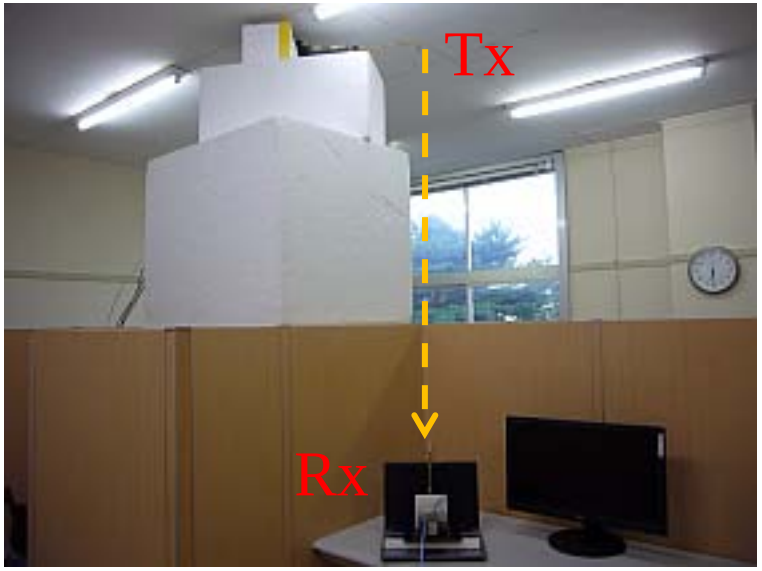
- NLOS scenario: Attenuated LOS component by human absorber
- NLoS path loss is larger than LoS path loss in direct-path by +26dB in vertical, +23dB in horizontal, +26dB in circular
- Loss measurement of actual human body with mobility is future work

# Measurement in cubicle office

# Floor Plan of Cubicle Office



# AP-STA link

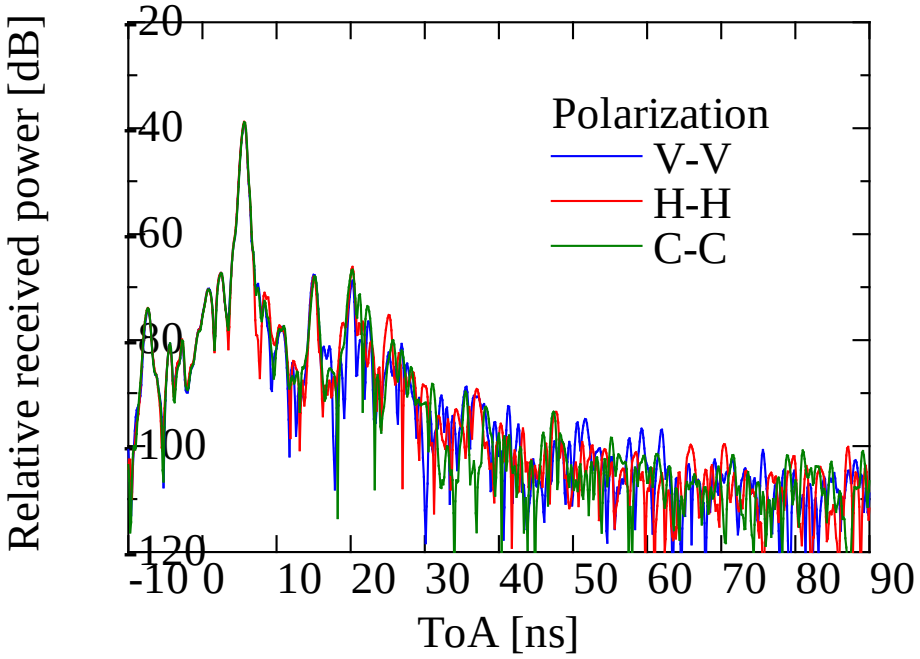



AP-STA Link

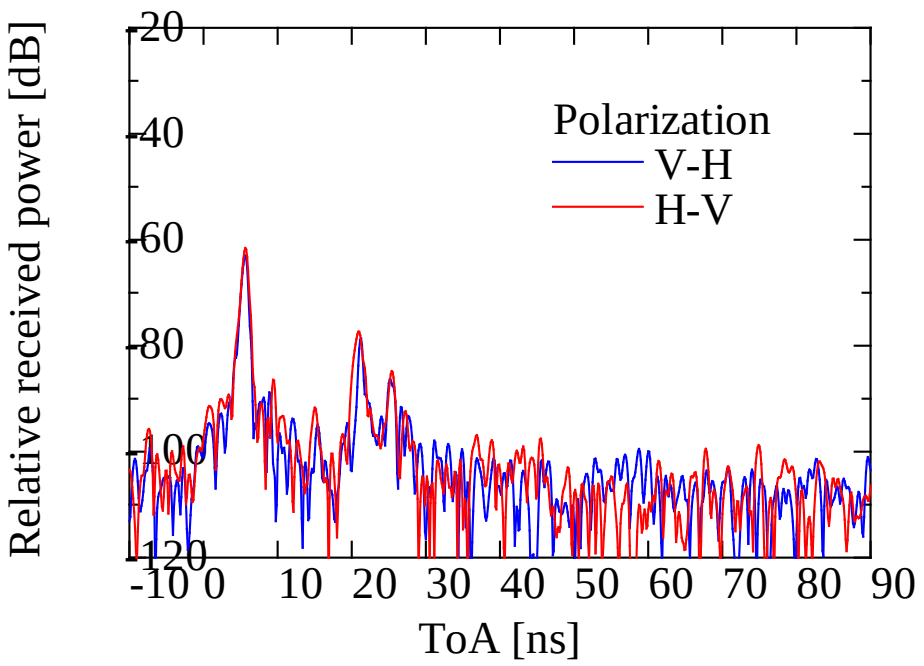
Inside of a cubicle

This is a vertical transmission link scenario.

# Example of impulse responses for co-and cross-polarized signal waves



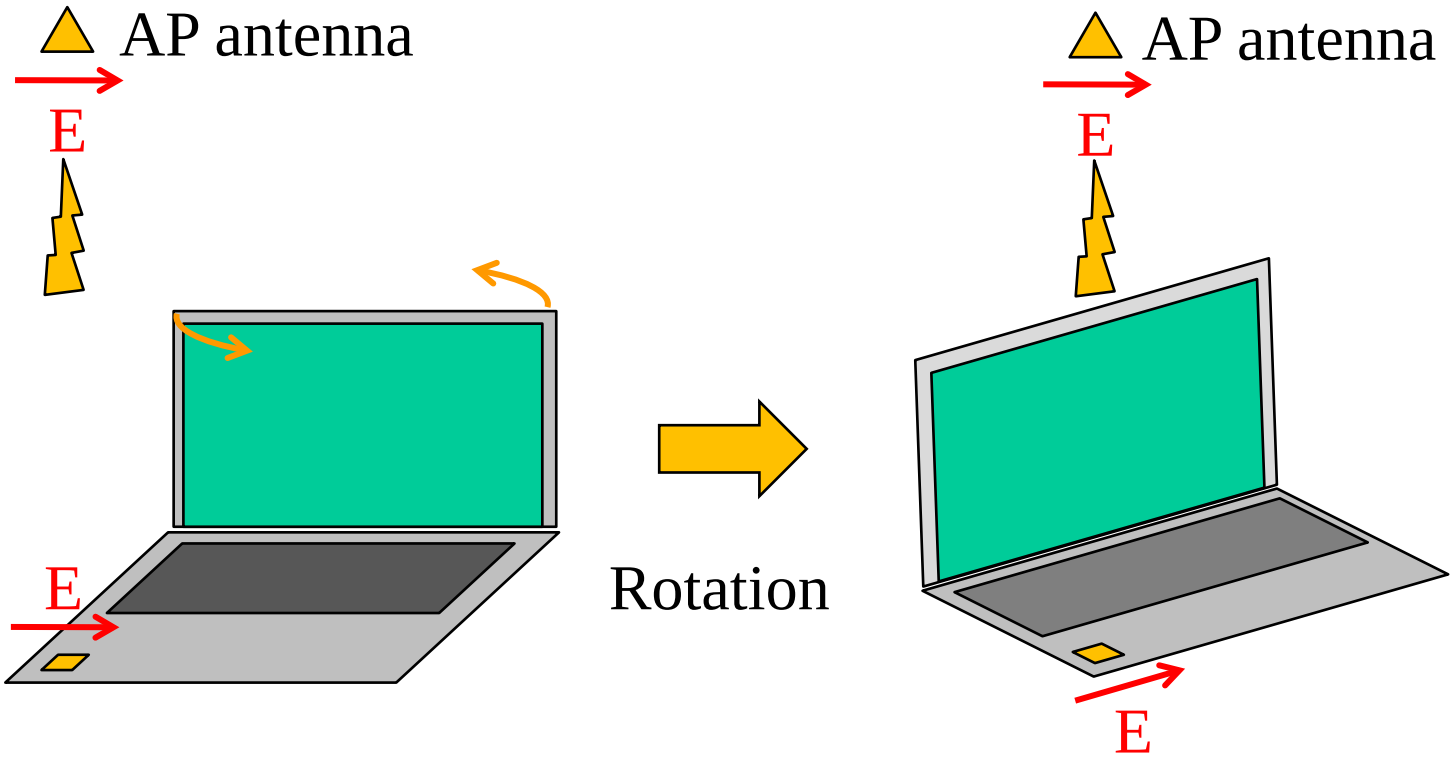

Co-polarized signal waves




Cross-polarized signal waves

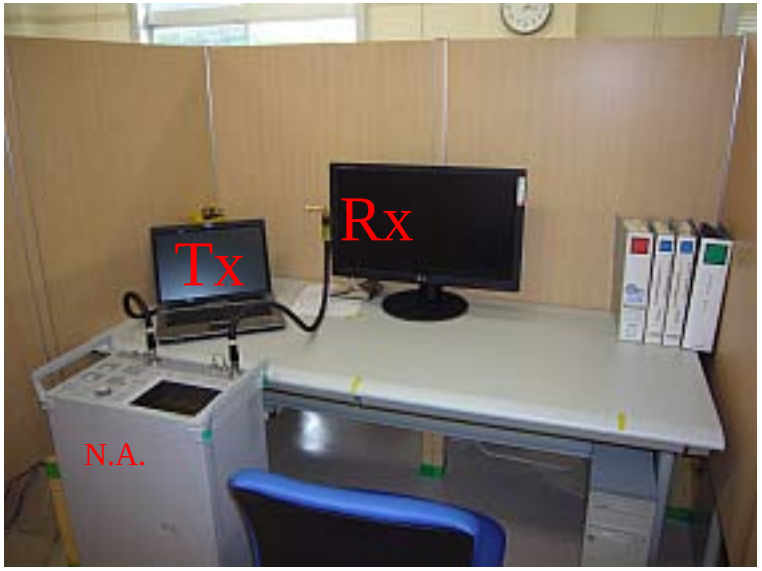
In this vertical link between AP to STA need attention for polarization mismatch.

# Polarization mismatch in vertical link

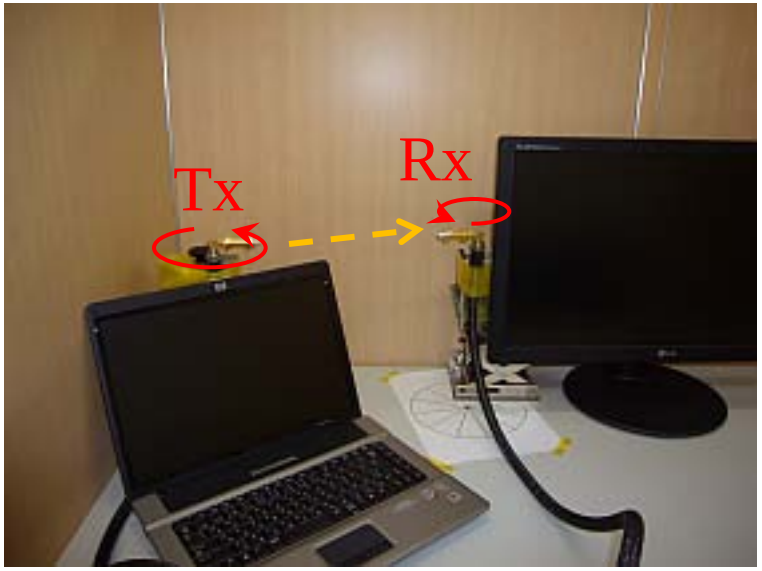



- Polarization mismatch is generated by rotation of PC
- Antenna model should have polarization information
- Circular polarized signal wave has advantage for this link

# STA-STA link



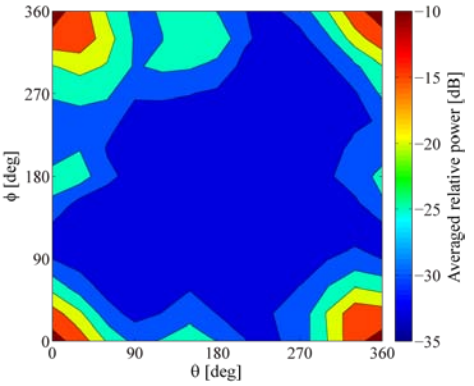

Measurement set up



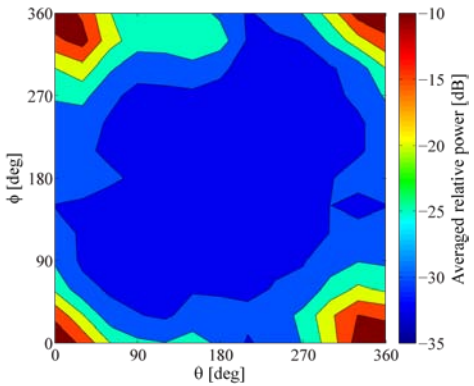

Manually rotation (30deg step)

This is a very short transmission scenario.

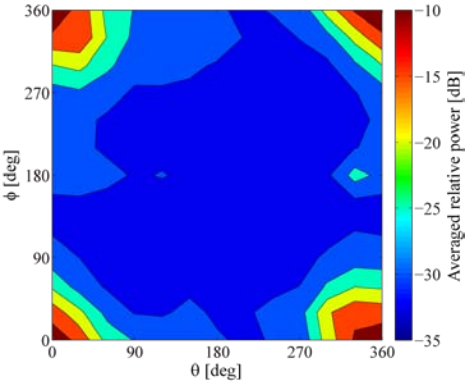
# Laptop PC to LCD monitor link



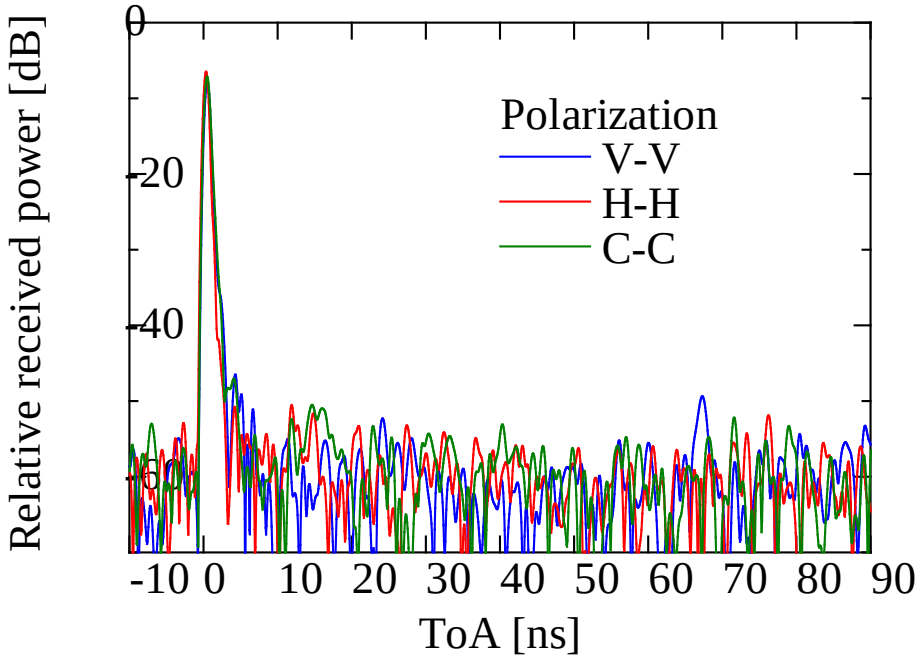

V-V




H-H




C-C




- Direct wave is dominant, significant reflection wave was not observed.
- Channel characteristics is almost AWGN.

# Summary

- The double directional propagation characteristics for all three environments were measured.
- Defined NLOS (by TGad) environments have been evaluated
  - "NLOS path loss addition" varies from 14+ to 25+ dB (depending on obstacles and polarizations): "+10dB for link budget" (in Doc.09/296) may need to be re-evaluated.
- Dual polarized signal waves communications has some feasibility for a fixed wireless link, however, the interference level ($S_{VH}$, $S_{HV}$) depends on the antenna's XPD characteristics and Tx/Rx antenna positioning a lot. → Antenna models with polarization will be required, if we consider such a system for our functional requirement.
- The path-loss and impulse response models including co- and cross-polarization characteristics will be available pretty soon.
- Some channel models can be approximated by AWGN channels if beam-forming technology is properly employed.