

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

Date: 2009-07-15

Authors:

Name	Affiliations	Address	Phone	email
Hirokazu Sawada	Tohoku University	2-1-1 Katahira, Aoba-ku, Sendai 980-8577, JAPAN	+81-22-217-6112	sawahiro@riec.tohoku.ac.jp
Shuzo Kato	NICT/ Tohoku University	3-4, Hikarino-Oka, Yokosuka, Kanagawa 239-0847 Japan		shu.kato@nict.go.jp
Katsuyoshi Sato	NICT	3-4, Hikarino-Oka, Yokosuka, Kanagawa 239-0847 Japan		satox@nict.go.jp

Abstract

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

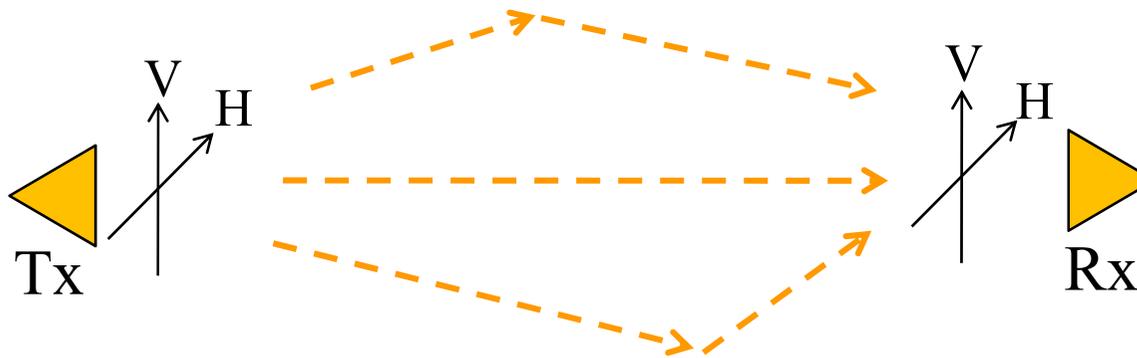
- 1. Intra cluster propagation parameters by measurement for 3 environments**
- 2. Dual polarization feasibility tested for 3 environments – confirmed feasibility of dual-polarized system in some case**

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 Conclusion?
	This work		Done Modeling: Further study	Done Linier pol. STA-STA OK AP-STA ? Circular pol.: STA-STA OK AP-STA OK
Living	Previous work	Not yet	Not yet	Not yet
	This work		Done Modeling: Further study	Done Linier pol. OK Circular pol. OK
Cubicle	Previous work	Not yet	Not yet	Not yet
	This work		Done Modeling: Further study	Done Linier pol. STA-STA OK AP-STA ? Circular pol.: STA-STA OK AP-STA OK

Problems in the current channel models (1)

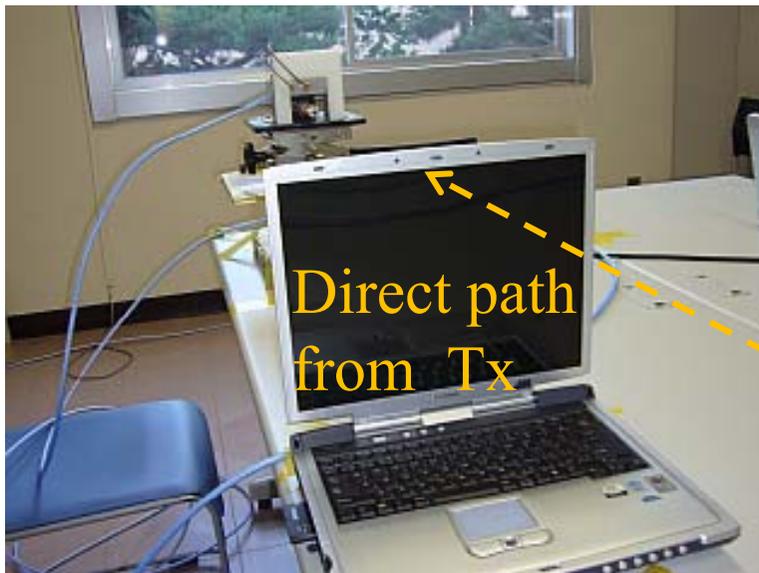
- Polarization concept was shown in Doc.09/431 and 09/552, however, it is not integrated in the current TGad channel model.
- We propose a channel model including S_{VV} , S_{HH} , S_{VH} , S_{HV} matrices by real measurement results.



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

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.**

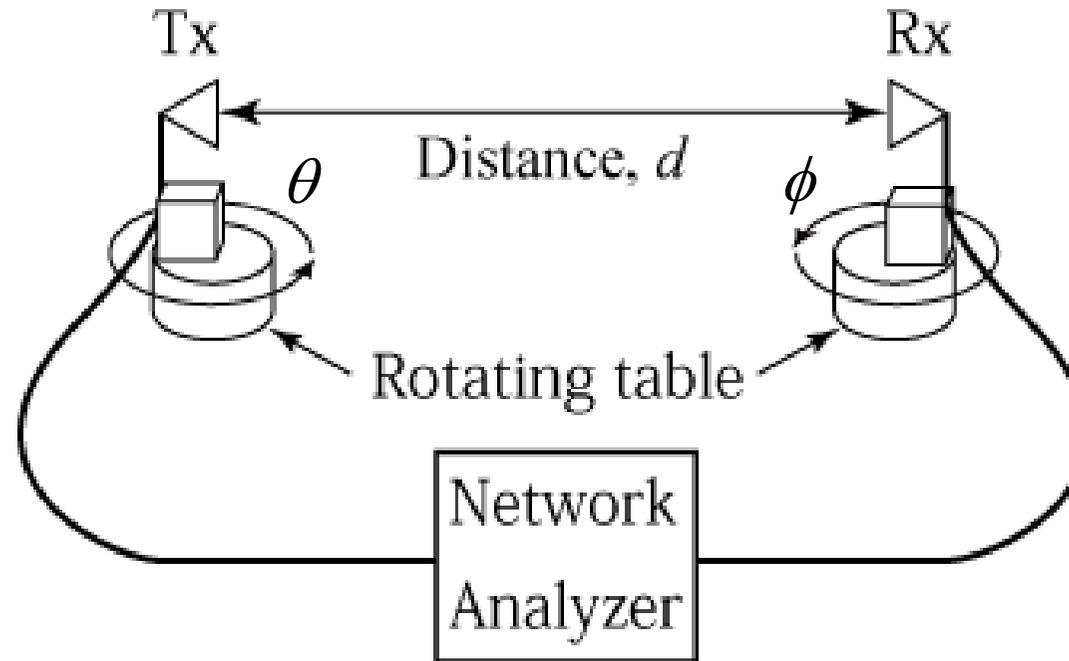


NLOS scenario in conference room



NLOS scenario using human phantom in living room

Measurement system



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

Measurement set up

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) 30 degree (16dBi)
Polarization	Co-polarized signal: Vertical / Horizontal / Circular Cross-polarized signals: 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

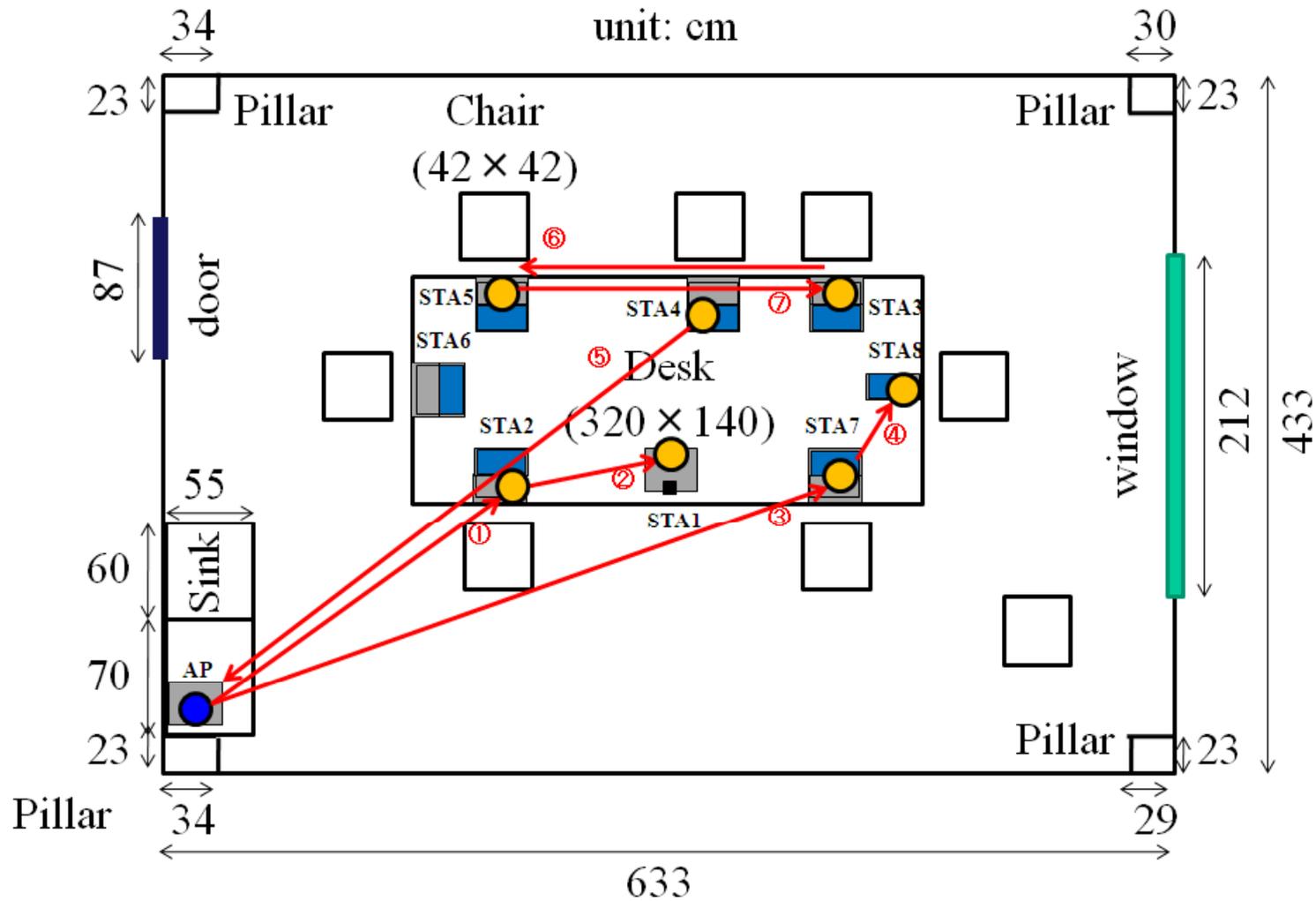
H: Horizontal

C: Circular

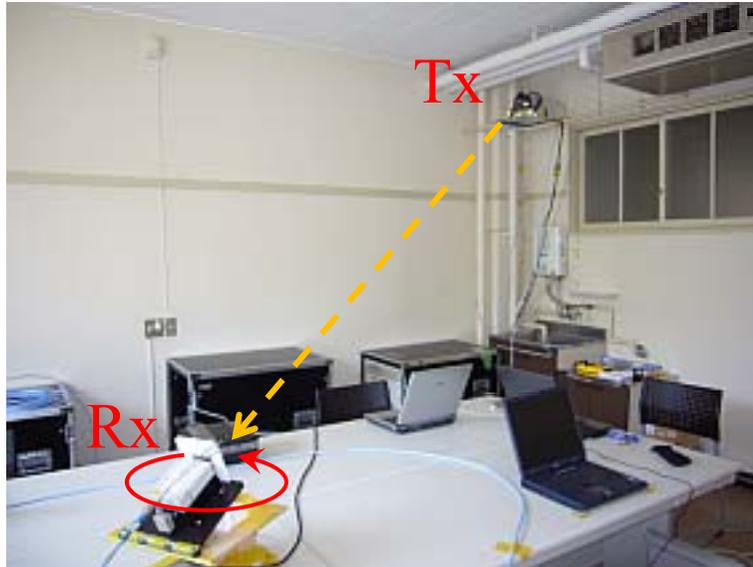
- Measurements were carried using polarized signal waves to investigate the feasibility of dual polarized signal transmission and polarization diversity systems

Measurement in conference room

Floor plan of conference room defined by TGad

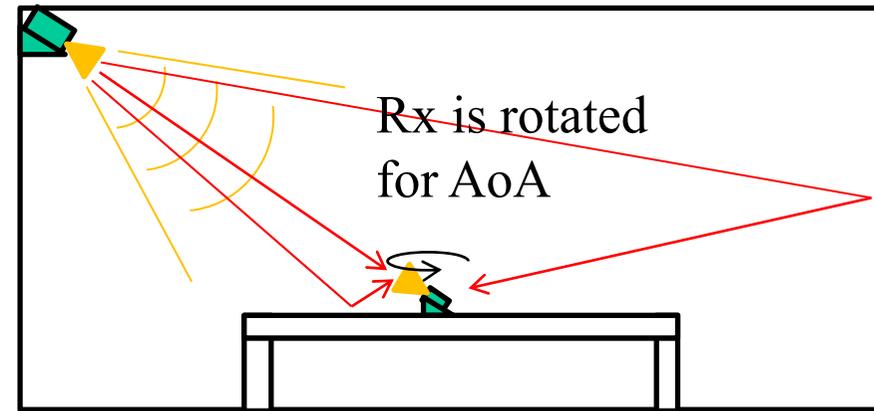


AP-STA communication link



AP-STA link

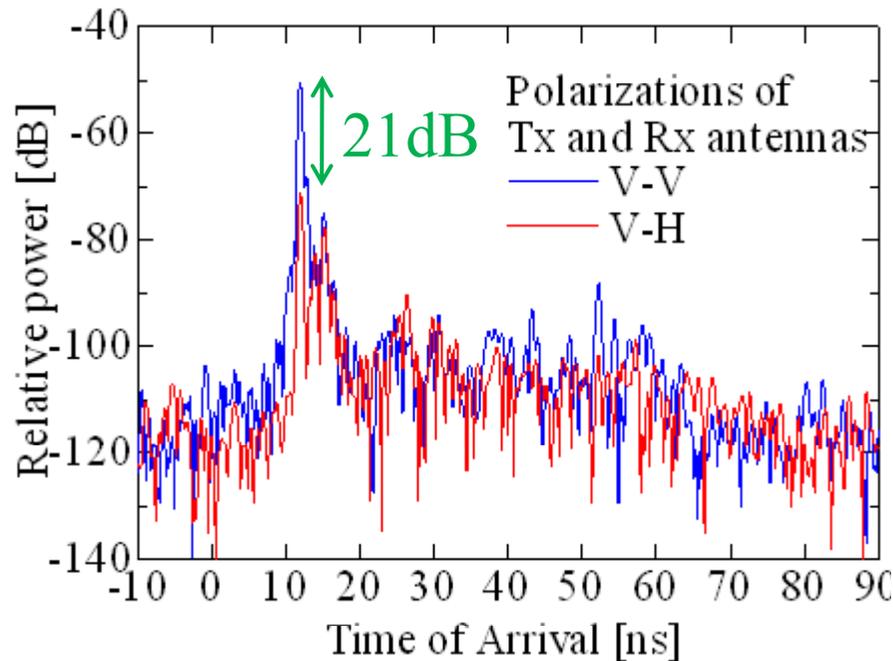
Tx is fixed



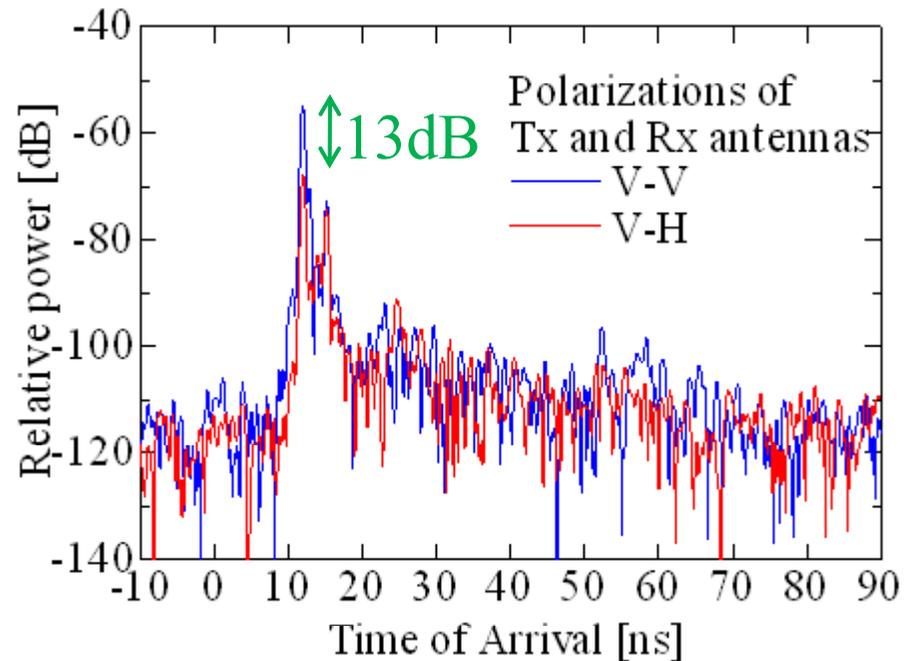
Measurement configuration

- 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)



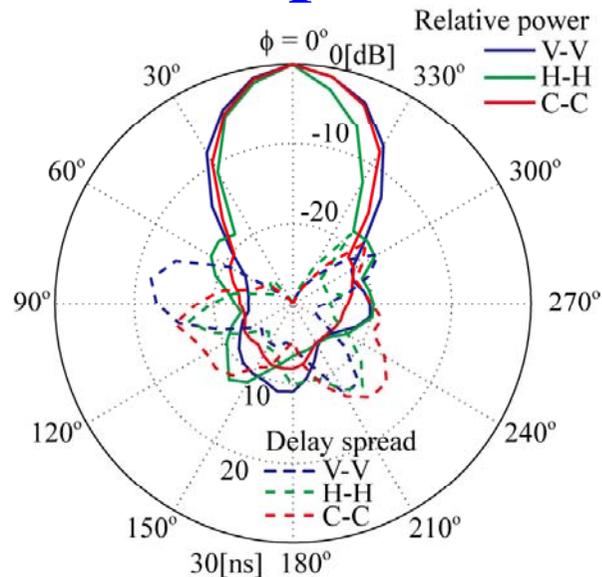
(a) Tx and Rx antenna were aligned



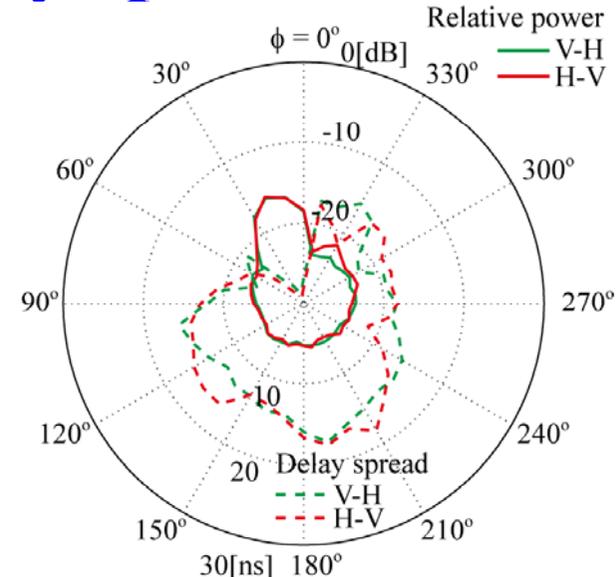
(b) Rx antenna angle offset : 20deg

- 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



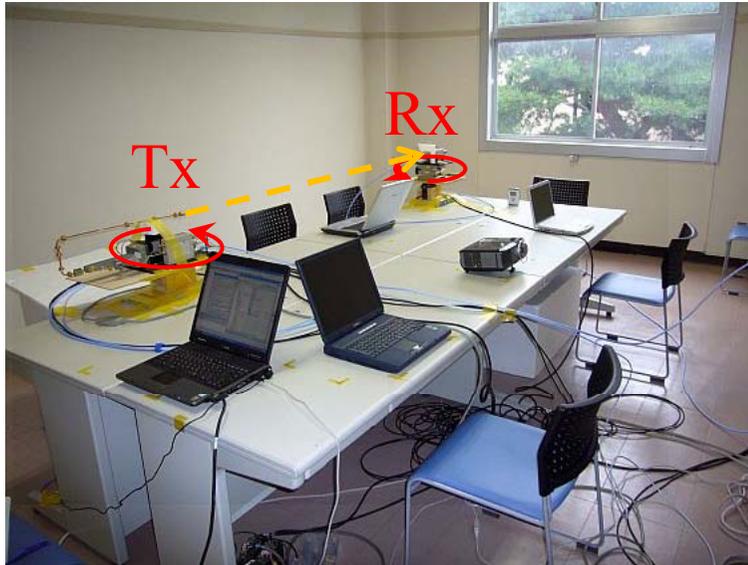
(b) Cross-polarized signal waves

※ All relative power were normalized by the maximum power level of V-V.

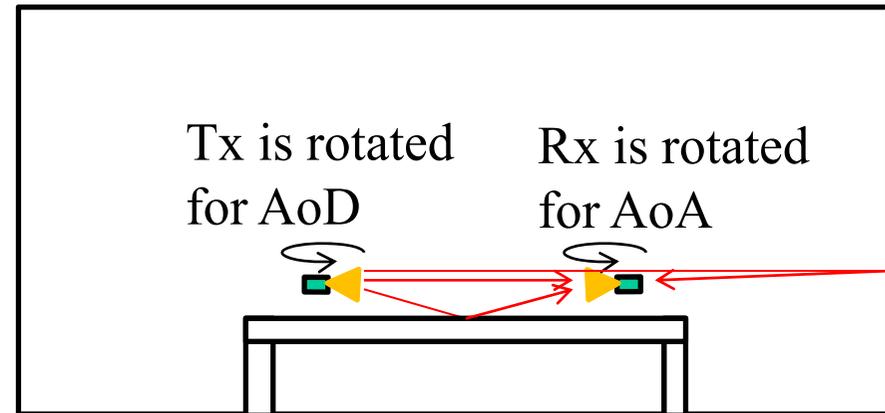
Threshold level for delay spread calculation is less than 30dB from the peak power.

- 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



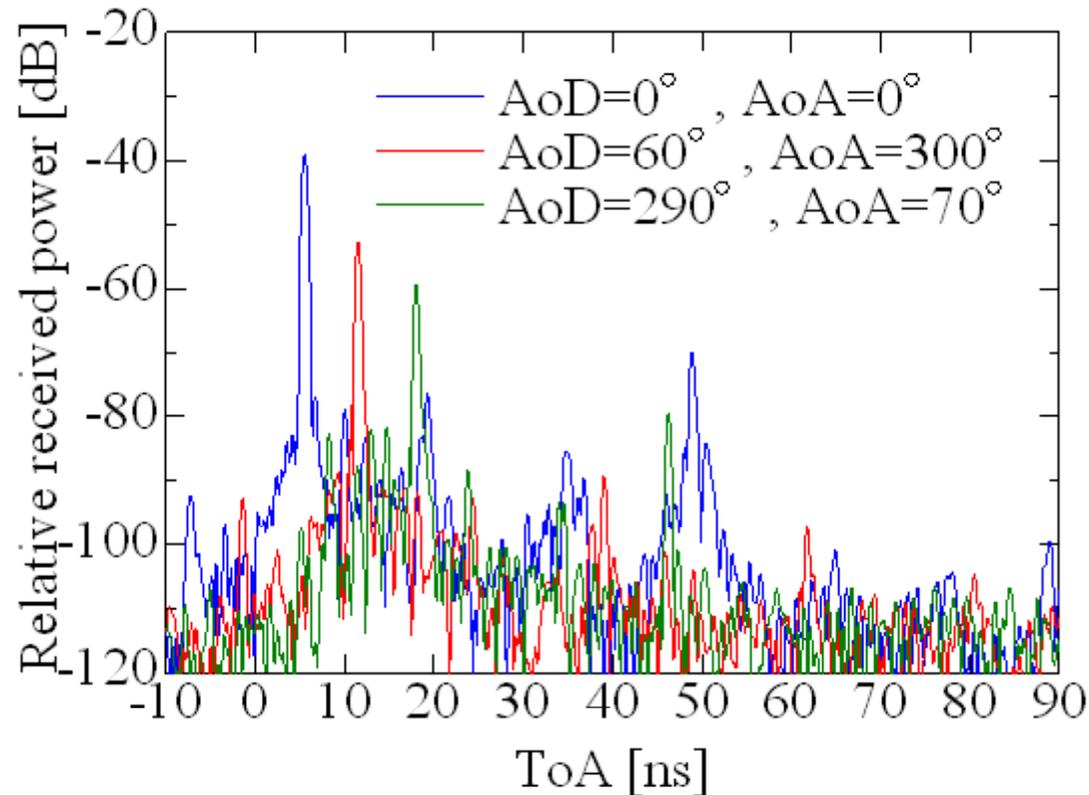
STA-STA link



Measurement configuration

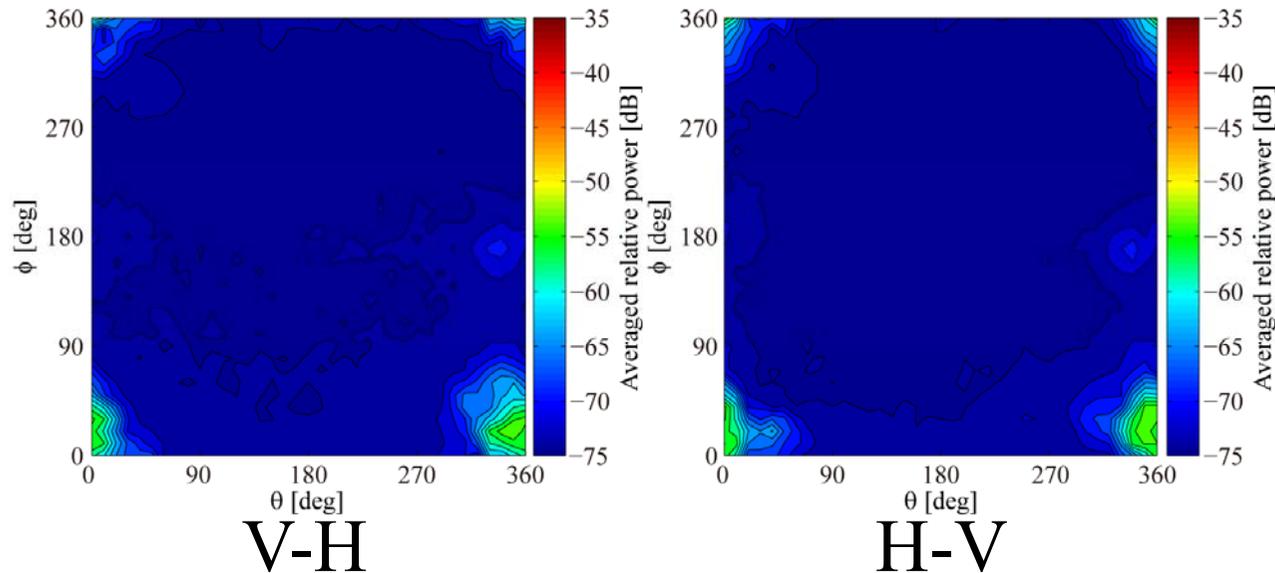
- Double directional propagation channel was measured for all STA-STA communications.

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

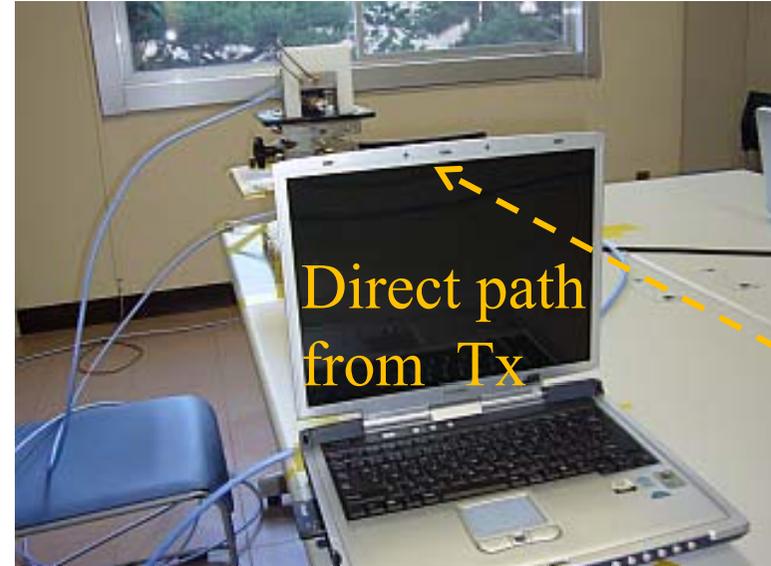


- Cross-polarized components were not observed on STA-STA link in conference environment.
- Dual polarized signal transmission is feasible.

LOS/NLOS scenario for STA5→STA3 link



LOS scenario

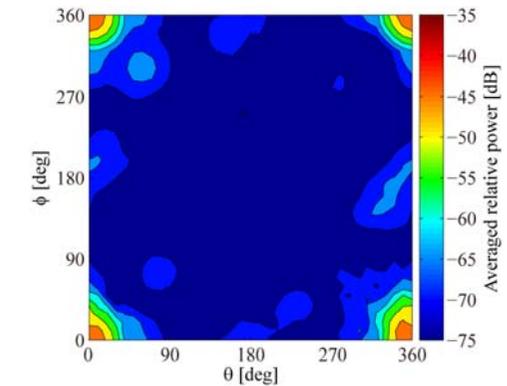
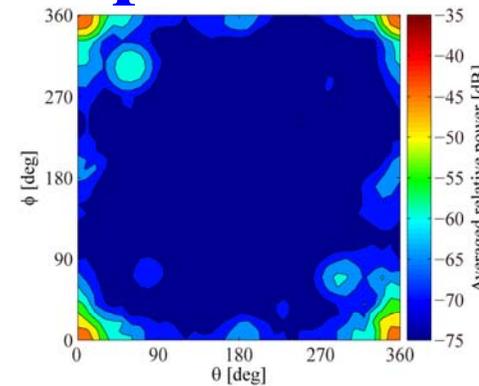
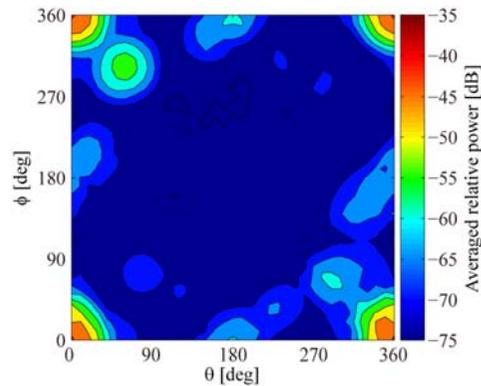


NLOS scenario

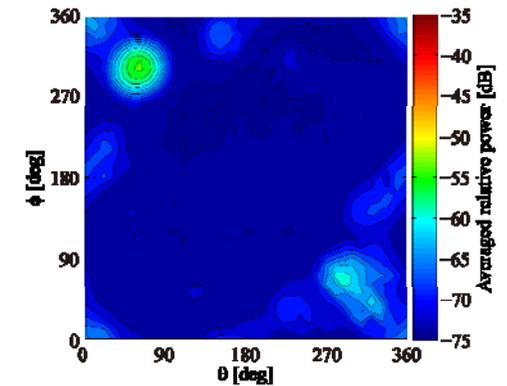
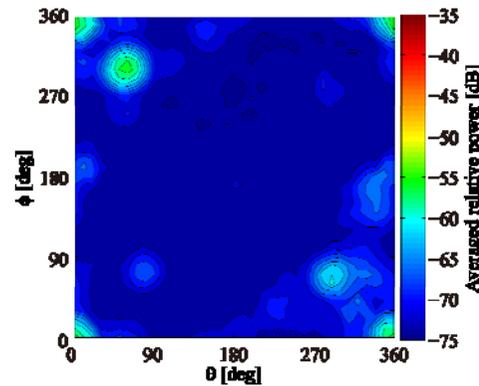
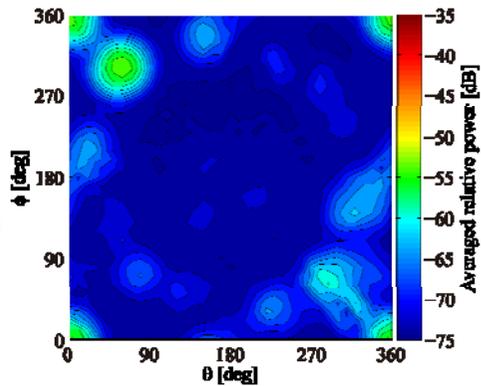
- NLOS scenario was also measured as the direct path component was blocked by notebook PC.

Relative received power of the link 7

LOS
scenario



NLOS
scenario



V-V

H-H

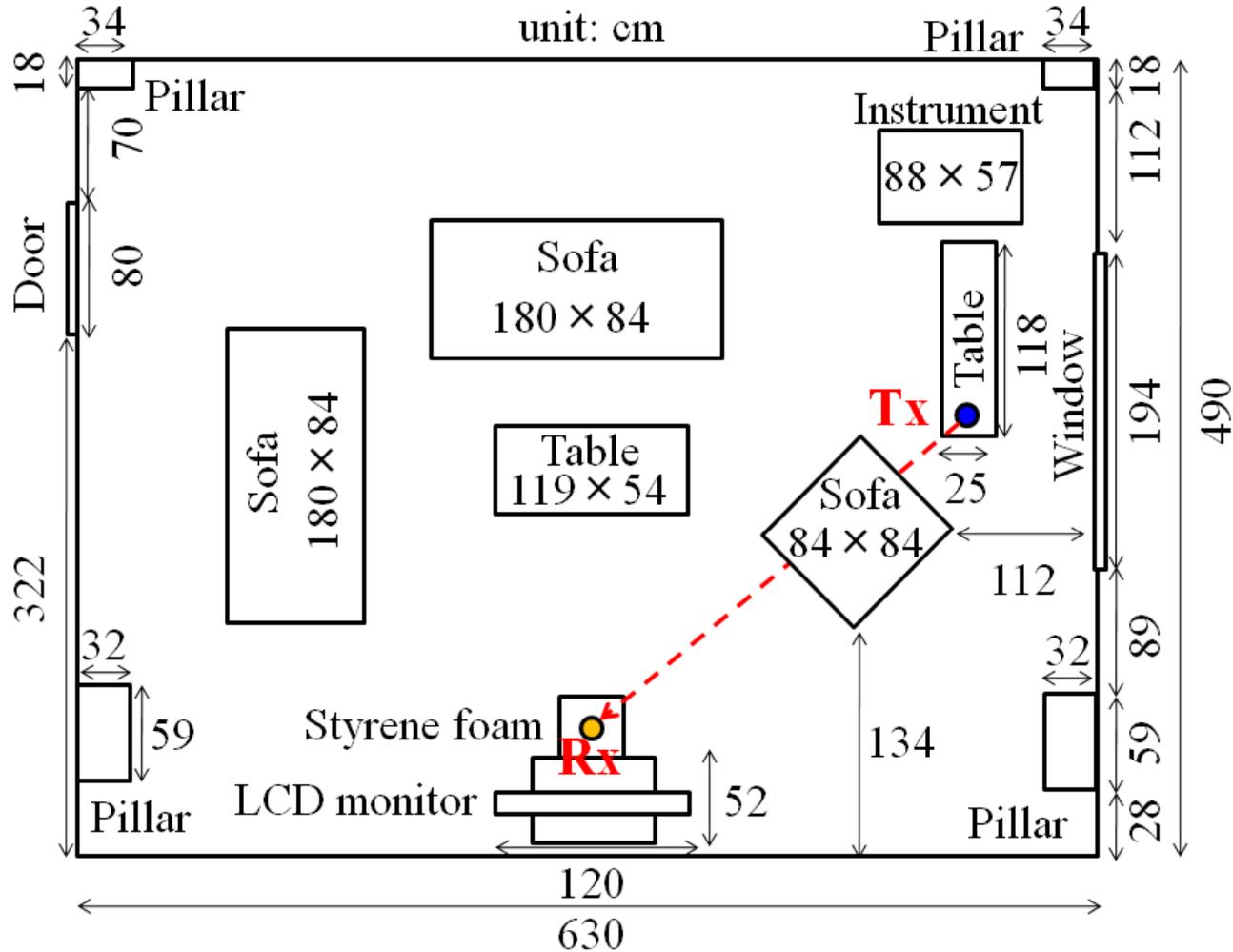
C-C

- 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

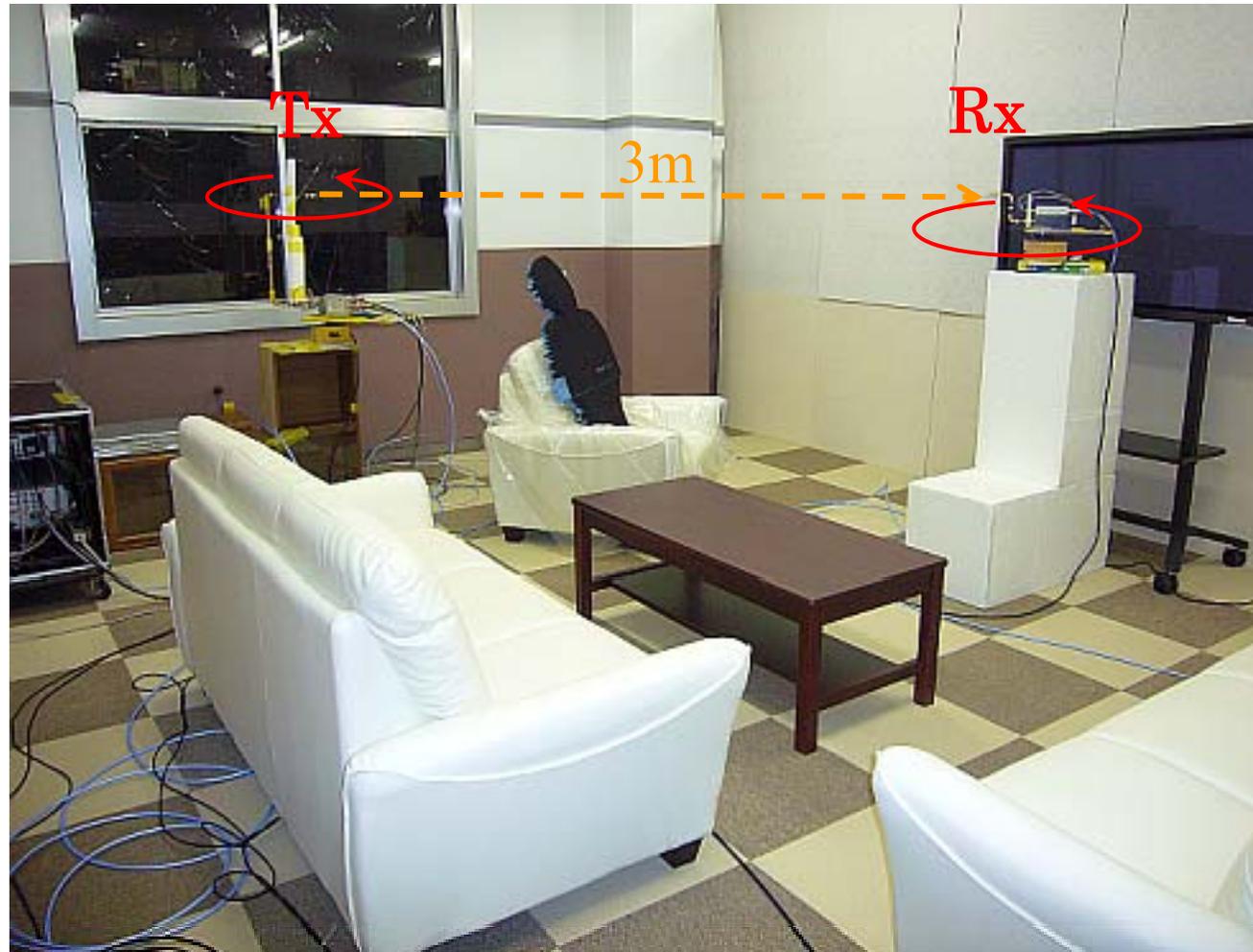
Measurement in living room

Floor plan of living room defined by TGad

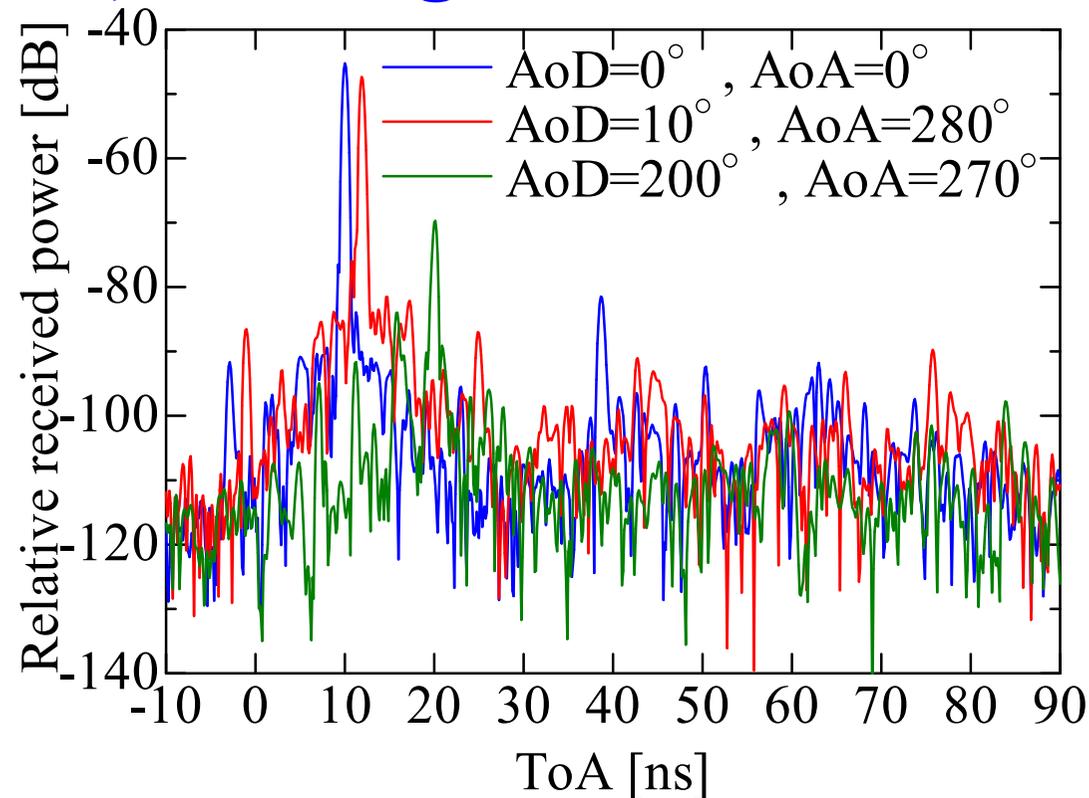
Antenna height is 1.5m
HPBW is 30degree



Communication link

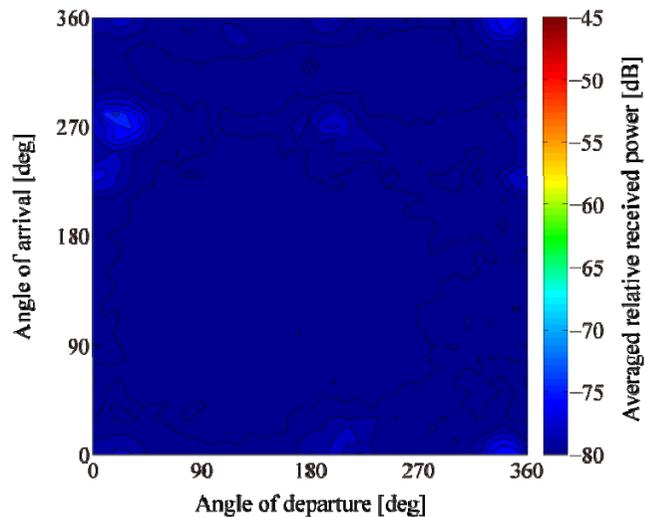


Impulse response example of LOS scenario (V-V) in living room environment

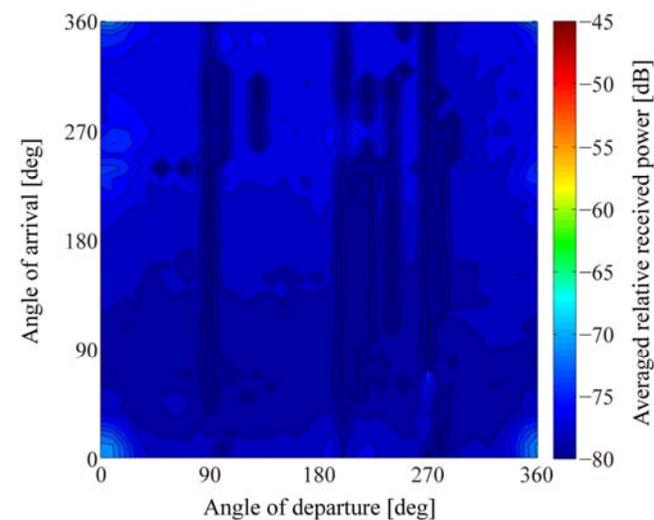


- Intra cluster parameters in each cluster can be extracted from measurement results

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

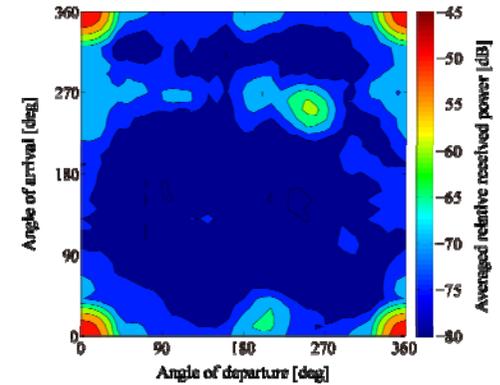
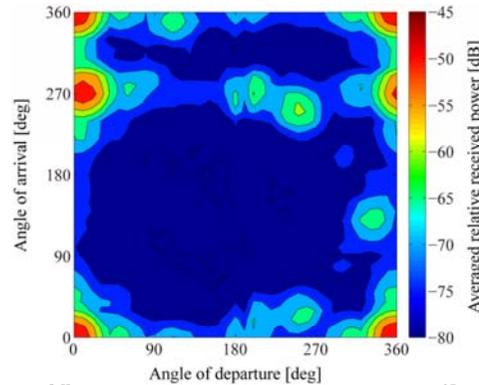
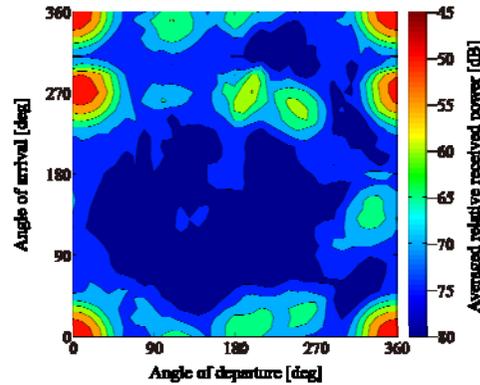


(b) Back side.

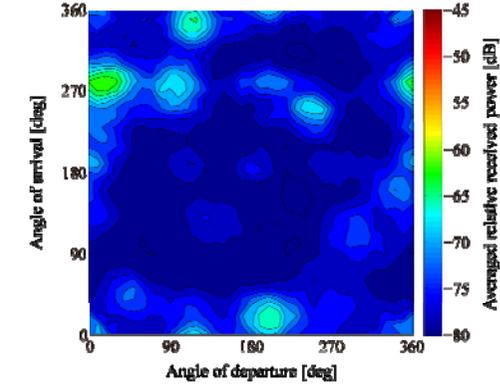
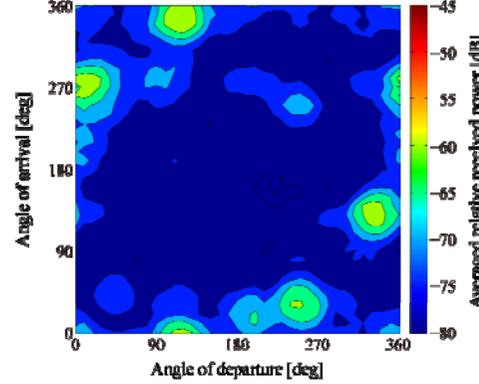
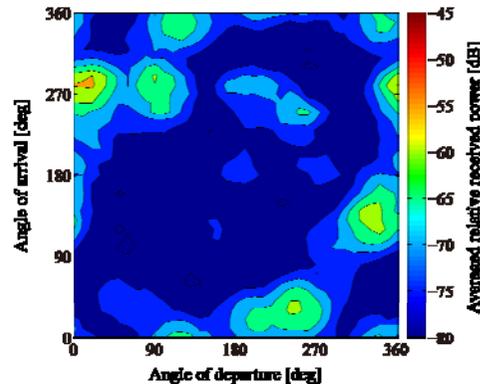
To measure the NLOS scenario, a human phantom was made by electromagnetic absorber. Antenna height is changed to 1m.

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

LOS
scenario



NLOS
scenario



V-V

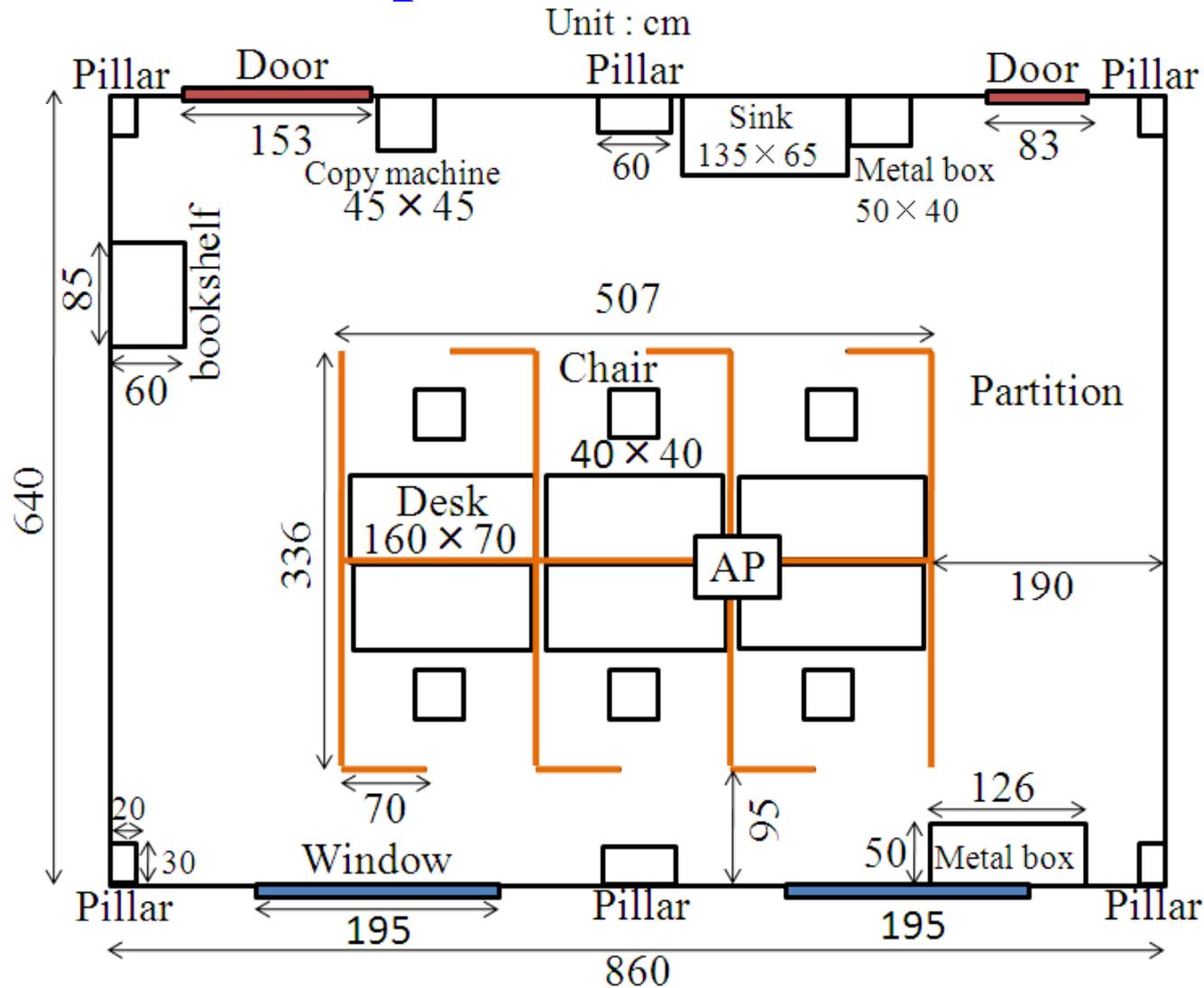
H-H

C-C

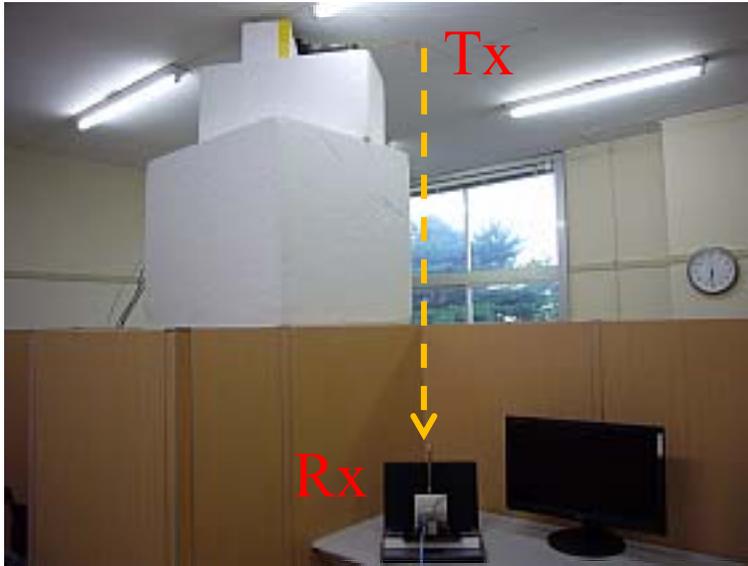
- NLOS scenario: Attenuated LOS component by human absorber
- NLoS path loss is larger than LoS path loss in direct-path by +26dB in vertical, +23dB in horizontal, +26dB in circular
- Loss measurement of actual human body with mobility is future work

Measurement in cubicle office

Floor plan of cubicle office



AP-STA link



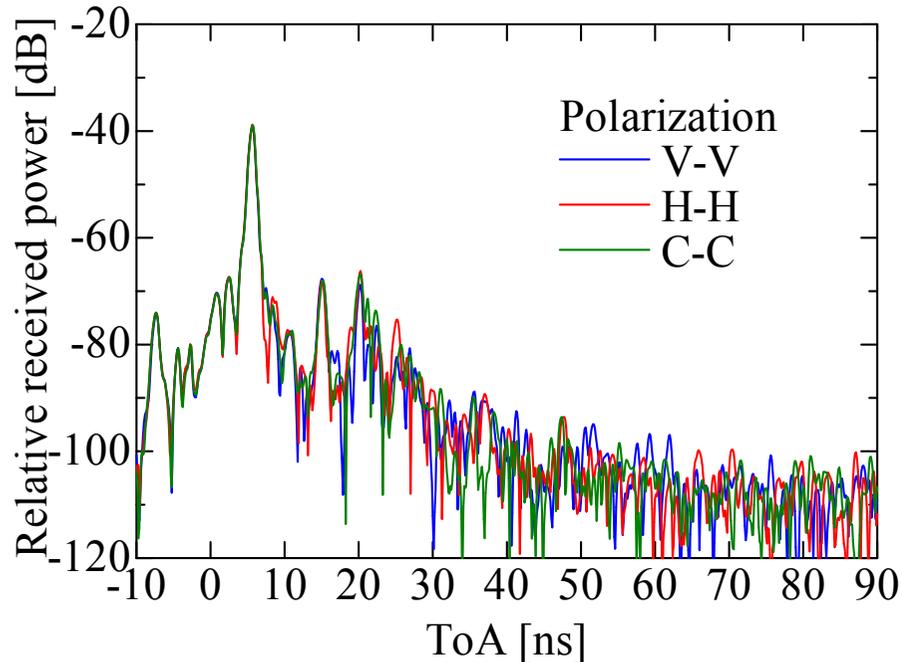
AP-STA Link



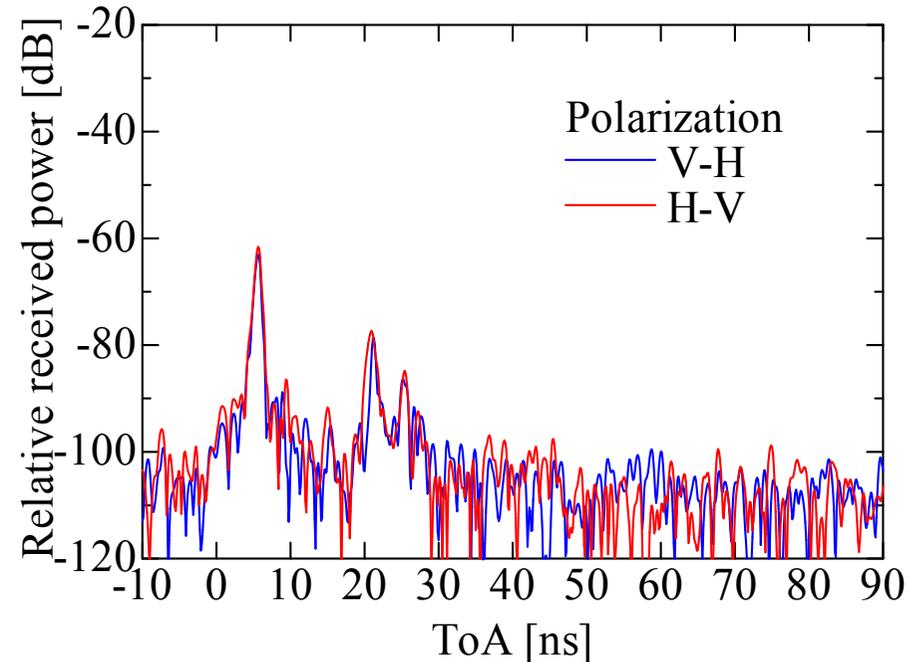
Inside of a cubicle

This is a vertical transmission link scenario.

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



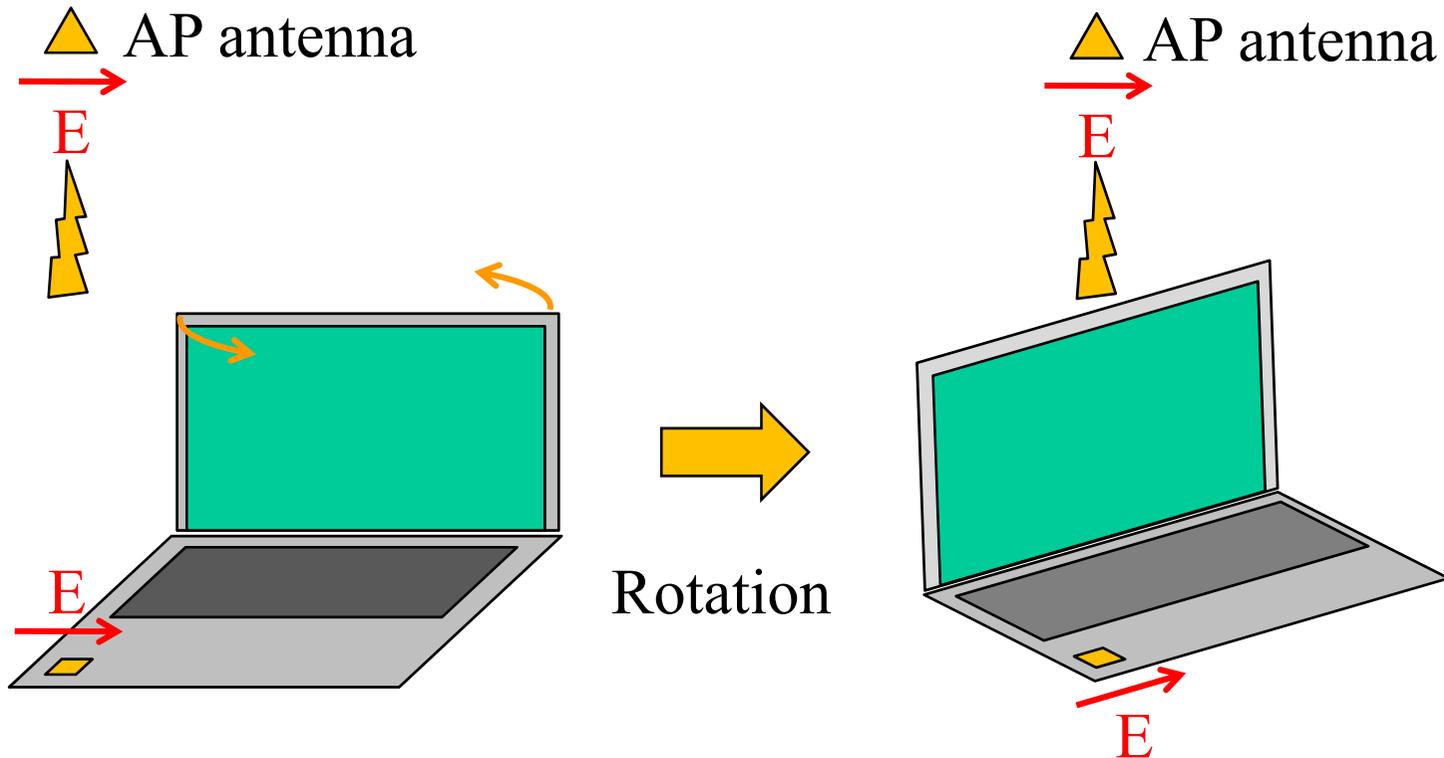
Co-polarized signal waves



Cross-polarized signal waves

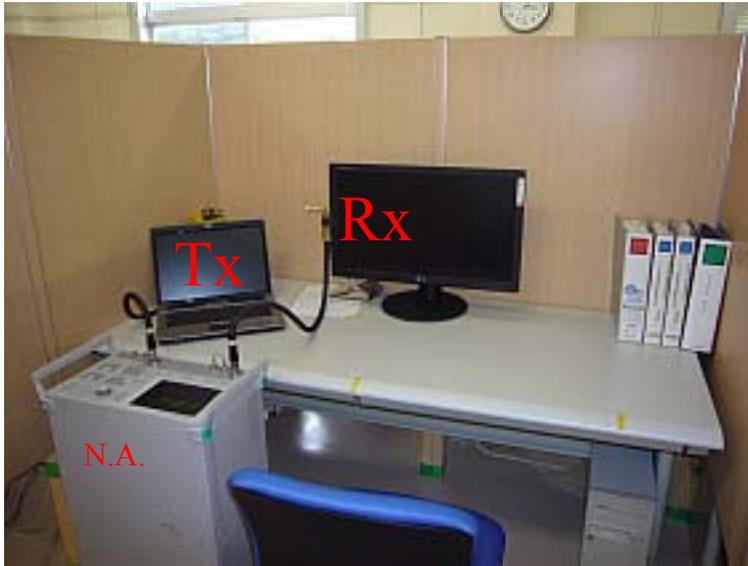
In this vertical link between AP to STA need attention for polarization mismatch.

Polarization mismatch in vertical link

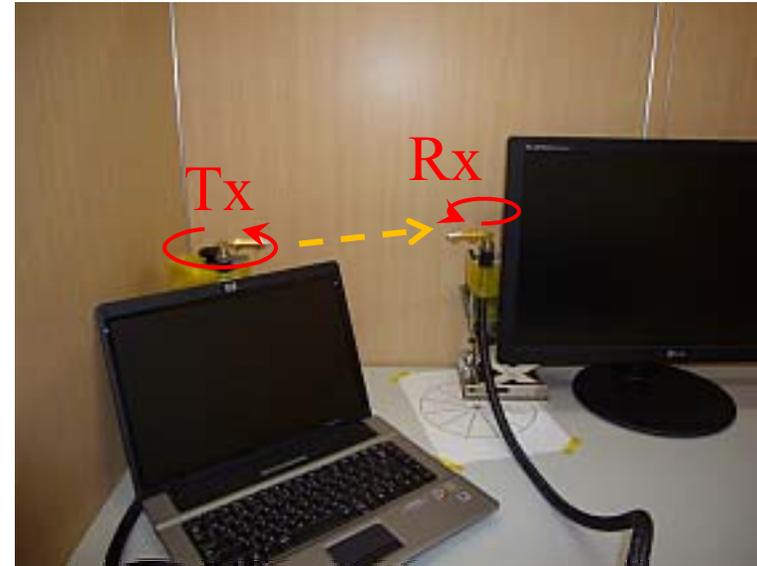


- Polarization mismatch is generated by rotation of PC
- Antenna model should have polarization information
- Circular polarized signal wave has advantage for this link

STA-STA link



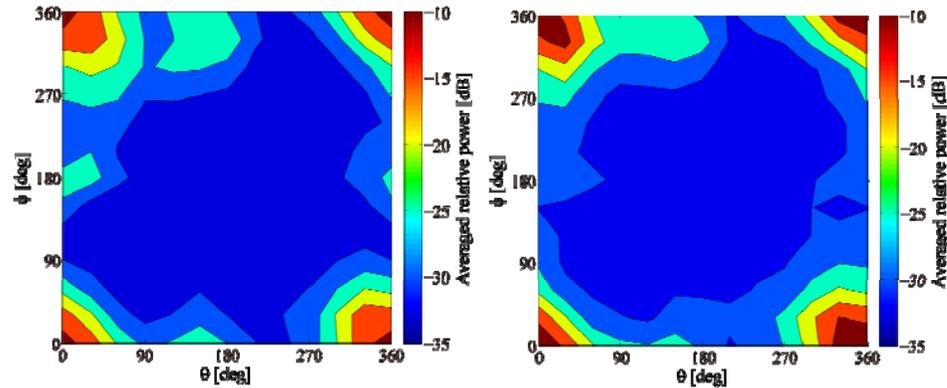
Measurement set up



Manually rotation (30deg step)

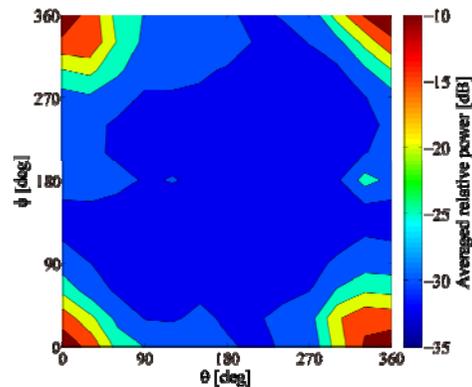
This is a very short transmission scenario.

Laptop PC to LCD monitor link

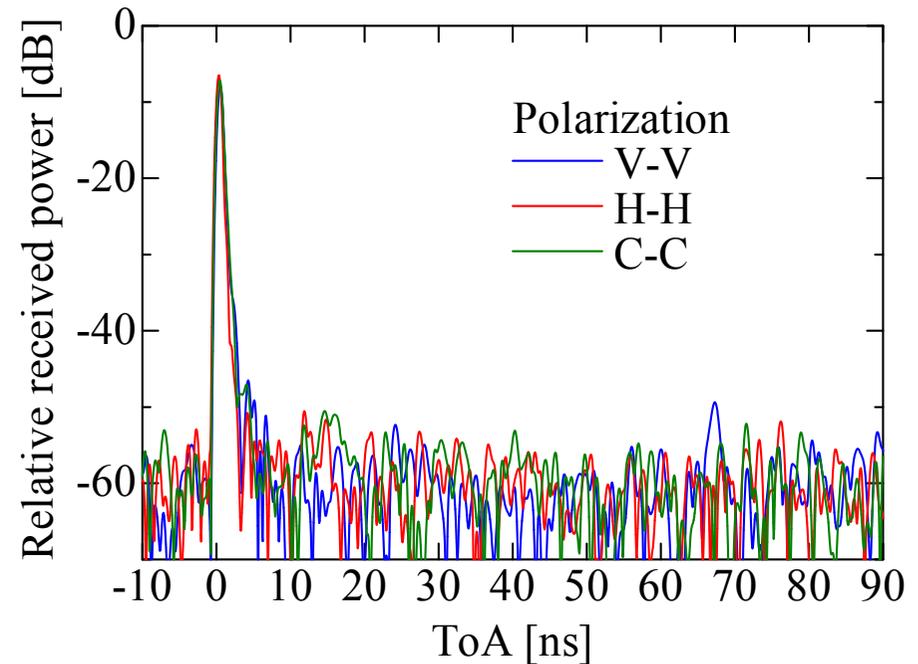


V-V

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.