Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [LOS office channel model based on TSV model]
Date Submitted: [September, 2006]
Source: [Hirokazu Sawada, Yozo Shoji, Chang-Soon Choi, Katsuyoshi Sato, Ryuhei Funada, Hiroshi Harada, Shuzo Kato, Masahiro Umehira, and Hiroyo Ogawa]
Company [National Institute of Information and Communications Technology]
Address [3-4, Hikarino-Oka, Yokosuka, Kanagawa, 239-0847, Japan]
Voice:[+81.46.847.5096], FAX: [+81.46.847.5079], E-Mail:[sawahiro@nict.go.jp]
Re: []

Abstract: [This contribution describes update of the generic channel model merging two-path and S-V models.]

Purpose: [Contribution to mmW TG3c meeting.]

Agenda

- Background
- Measurement procedure and results
- Extracted TSV model parameters

Background

- Channel model for LOS office environment is one of the important channel models for TG3c
- However, we did not have LOS office channel model so far. Therefore we were trying to make a LOS office channel model

Measurement conditions

Instrument	HP8510C VNA
Center frequency	62.5 GHz
Bandwidth	3 GHz
Time resolution	0.333 ns
Distance resolution	19.1 cm
# of frequency points	801
Frequency step	3.75MHz
Times of average	128 times

Time resolution and distance resolution were determined by bandwidth

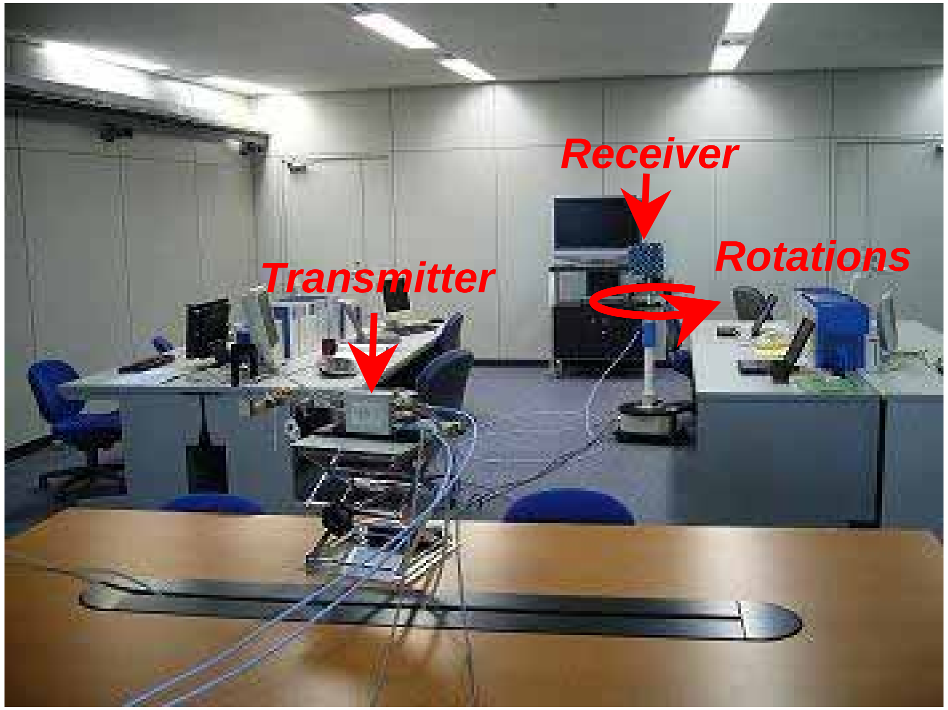
Measurement conditions (cont')

- **Antenna:** Conical horn antenna
- **Polarization:** Vertical
- **Beam-width:** Tx:30 and Rx 30, Tx:60 and Rx60

Conical horn antenna
Beam-width 30 deg

Conical horn antenna
Beam-width 60 deg

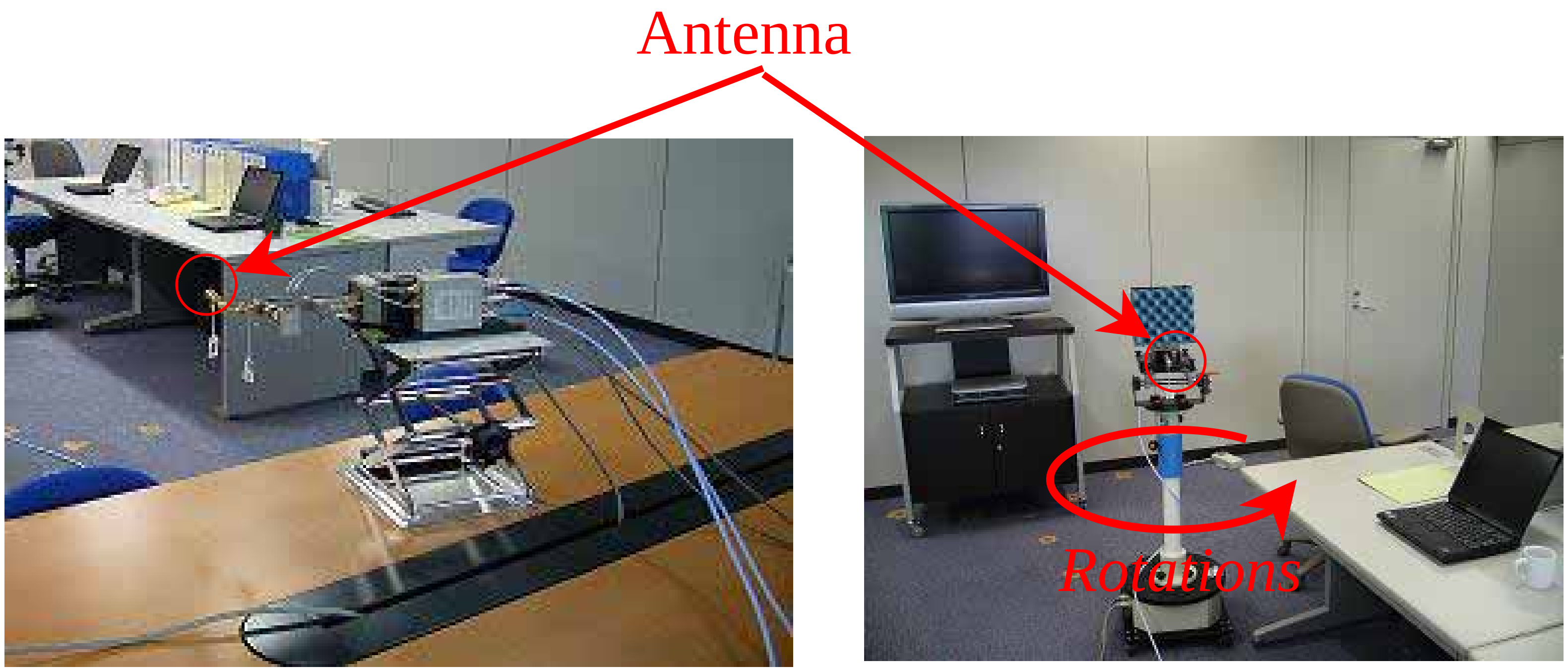
Measurement environment



- Office room: 6.4 m×7.4 m
- Ceiling height: 2.7 m
- Surrounding: metallic wall, glass window
- Floor: Concrete plates covered with carpet
- Furniture: Metal desk, chair, computer, LCD TV, books

Receiver was rotated 0 to 360 in 5 degree step

Measurement environment(cont')



Tx side

Rx side

- Receiver was not put on the desk due to large rotator size
- Calibration was done at 1 m distance

TSV model for LOS office environment

- For LOS desk top environment (06/297)

TSV model = Statistical two-path component + S-V component

$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta\left(t-T_l-\tau_{l,m}\right)\,\delta\left(\varphi-\Psi_l-\psi_{l,m}\right)$$

$$\beta=\left(\frac{\mu_D}{D}\right)^2\left|\sqrt{G_{t1}G_{r1}}+\sqrt{G_{t2}G_{r2}}\,\Gamma_0\exp\left[j\frac{2\pi}{\lambda_f}\frac{2h_1h_2}{D}\right]\right|$$

- For LOS office environment

Reflection coefficient: Γ_0 0

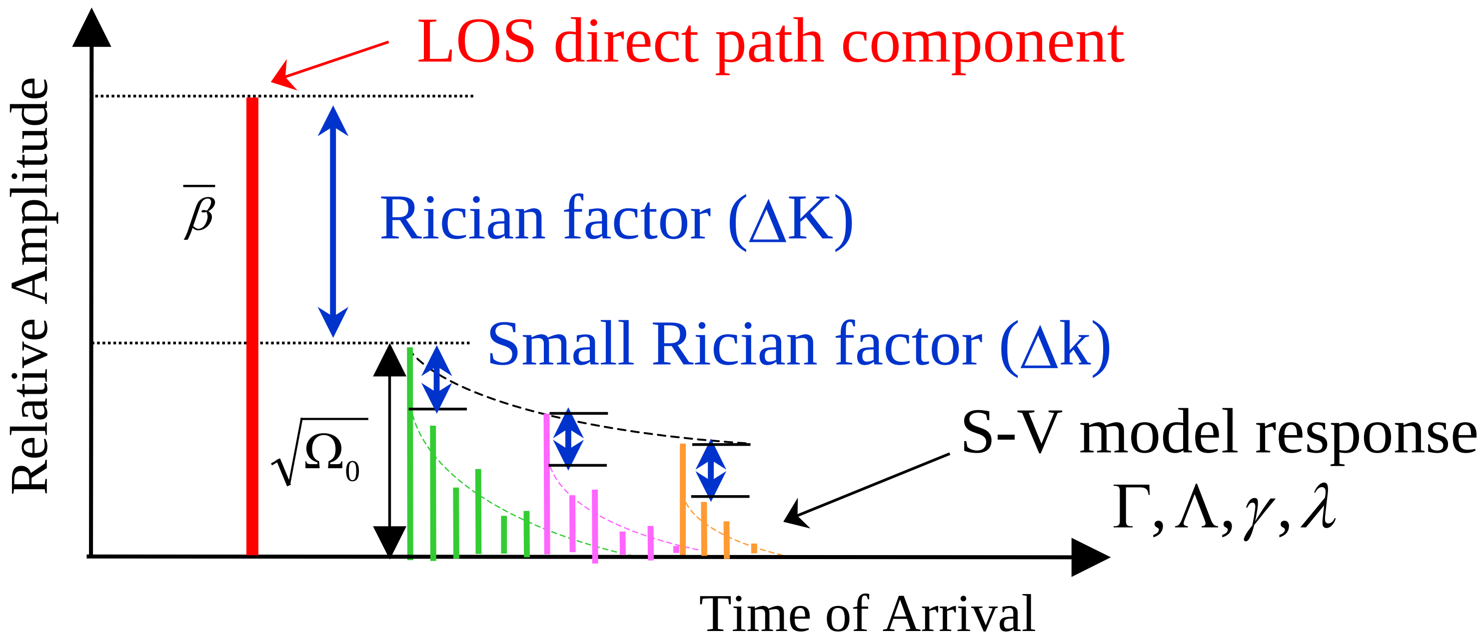
Modified TSV model = Direct-path component + S-V component

$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta\left(t-T_l-\tau_{l,m}\right)\,\delta\left(\varphi-\Psi_l-\psi_{l,m}\right)$$

$$\beta\Big|_{\mu_D<<D}=\sqrt{G_{t1}G_{r1}}$$

Refer to Appendix A for each parameter

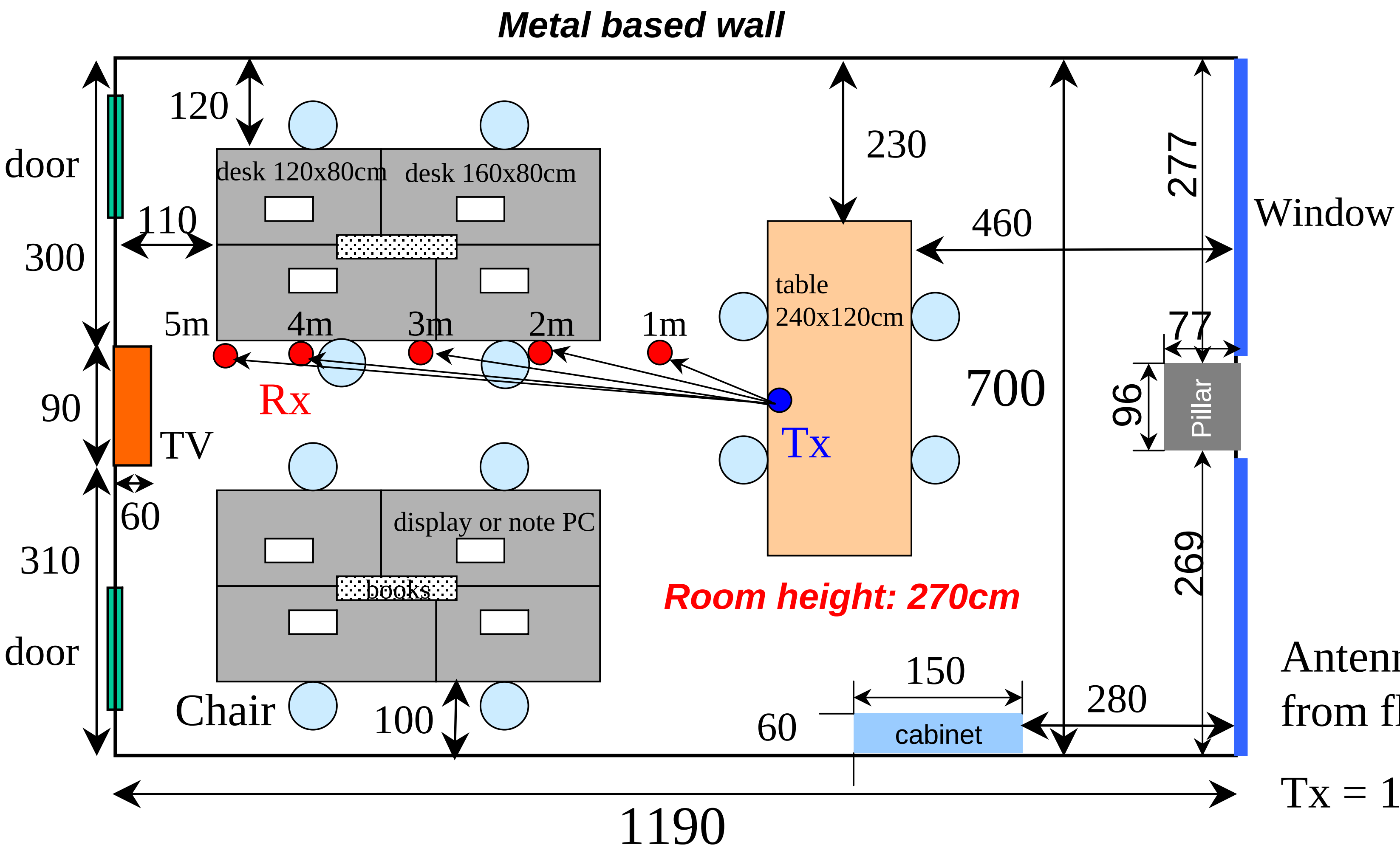
Impulse response



This response can be also obtained in TSV model by setting $\Gamma_0 = 0$

Therefore we do not need any modification from this model

AoA measurement environment



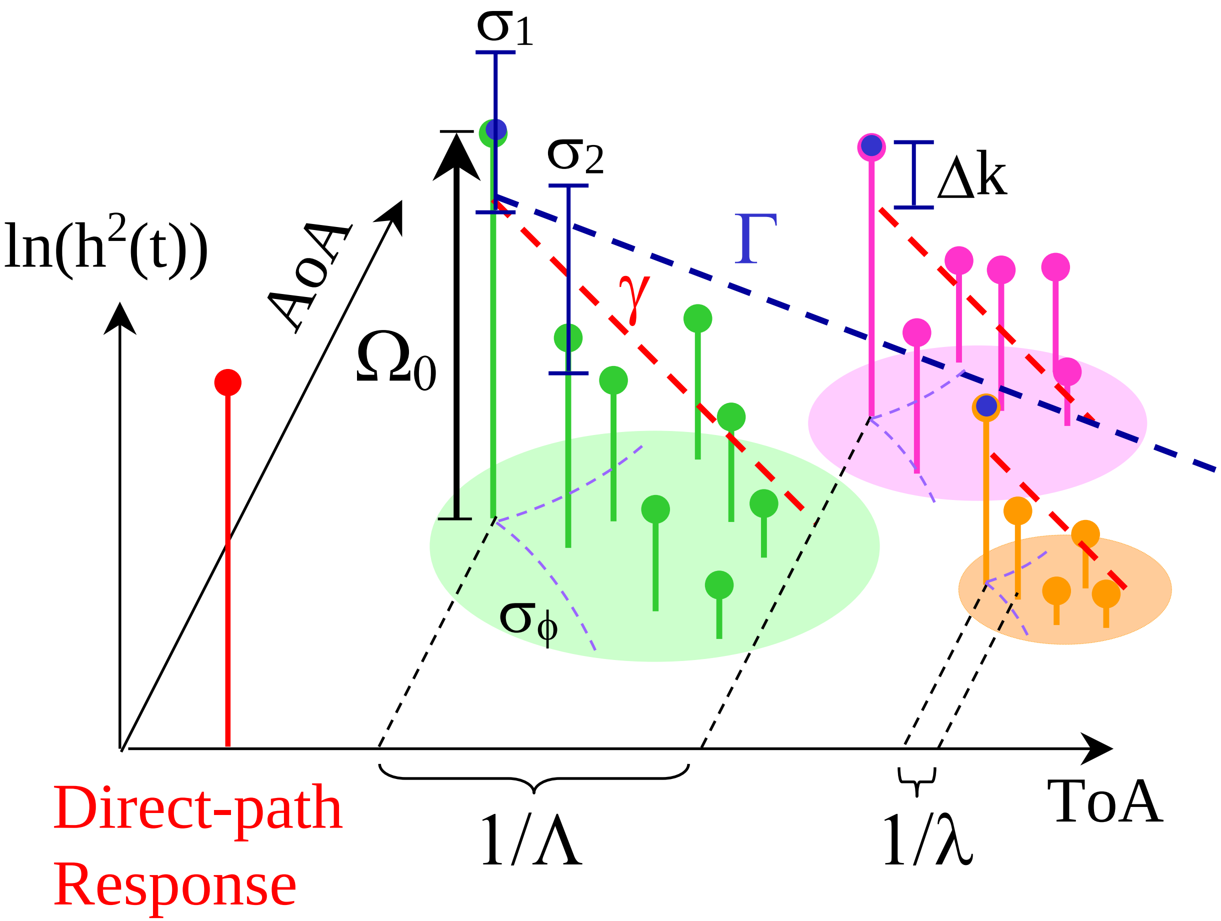
Unit: cm

Antenna height from floor

Tx = 110 cm

Rx = 110 cm

TSV model parameters to be extracted



Γ : *cluster* decay factor

$1/\Lambda$: *cluster* arrival rate

γ : *ray* decay factor

$1/\lambda$: *ray* arrival rate

σ_1 : *cluster* lognormal standard deviation

σ_2 : *ray* lognormal standard deviation

σ_ϕ : Angle spread of ray within cluster (Laplace distribution)

Ω_0 : Average power of the first ray of the first cluster

S-V parameter and Ω_0 are required for TSV model

Extracted TSV model parameters

	TSV Model	S-V model oriented parameter							Rician effect @3m	Small Rician effect
Parameter	$\Omega_0(D)$ [dB]	Γ [ns]	$1/\Lambda$ [ns]	γ [ns]	$1/\lambda$ [ns]	σ_1 cluster	σ_2 ray	σ_ϕ [deg]	ΔK [dB]	Δk
Tx:30 Rx:30	-3.27 D-85.4	49.8	24.6	45.2	1.03	6.60	12.8	102	27.2	5.04
Tx:60 Rx:60	-0.303 D-89.9	38.8	37.6	64.9	3.41	8.04	18.8	66.4	22.8	2.63

Channel model for LOS office environment is available

Conclusion

- Channel model for LOS office environment is available

Appendix A: Definition of TSV model (modified)

CIR: $$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta(t-T_l-\tau_{l,m})\,\delta(\varphi-\Psi_l-\psi_{l,m})$$

(Complex impulse response)

$$\overline{|\alpha_{l,m}|^2}=\Omega_0 e^{-T_l/\Gamma} e^{-\tau_{l,m}/\gamma-\Delta k[1-\delta(m)]}\sqrt{G_r(0,\Psi_l+\psi_{l,m})},\ \angle\alpha_{l,m}\propto \mathrm{Uniform}[0,2\pi)$$

t: time[ns]
$\delta(\cdot)$: *Delta function*
l = cluster number,
m = ray number in l-th cluster,
L = total number of clusters;
M_l = total number of rays in the l-th cluster;
T_l = arrival time of the first ray of the l-th cluster;
$\tau_{l,m}$ = delay of the m-th ray within the l-th cluster relative to the firs path arrival time, T_l;
Ω_0 = Average power of the first ray of the first cluster
$\Psi_l \propto$ Uniform[0,2π); arrival angle of the first ray within the l-th cluster
$\psi_{l,m}$ = arrival angle of the m-th ray within the l-th cluster relative to the first path arrival angle, Ψ_l

Two-path response

$$\beta=\left(\frac{\mu_D}{D}\right)^2\left|\sqrt{G_{t1}G_{r1}}+\sqrt{G_{t2}G_{r2}}\,\Gamma_0\exp\left[j\frac{2\pi}{\lambda_f}\frac{2h_1h_2}{D}\right]\right|$$

Path number of G_{ti} and G_{ri} (1: direct, 2: refrect)

Arrival rate: Poisson process

$$p(T_l\,|\,T_{l-1})=\Lambda\exp[-\Lambda(T_l-T_{l-1})],\quad l>0$$
$$p(\tau_l\,|\,\tau_{l,(m-1)})=\lambda\exp[-\lambda(\tau_l-\tau_{l,(m-1)})],\quad m>0$$

Two-path parameters (4)

$D\propto$ Uniform: Distance between Tx and Rx
$h_1\propto$ Uniform: Height of Tx
$h_2\propto$ Uniform: Height of Rx
$|\Gamma_0|\cong 1$: Reflection coefficient (incident angle $\cong \pi/2$)

S-V parameters (7)

Γ: *cluster* decay factor
$1/\Lambda$: *cluster* arrival rate
γ: *ray* decay factor
$1/\lambda$: *ray* arrival rate
σ_1: *cluster* lognormal standard deviation
σ_2: *ray* lognormal standard deviation
σ_ϕ: Angle spread of ray within cluster (Laplace distribution)

Antenna parameters (2)

$Gt(\theta,\phi)$: Antenna gain of Tx
$Gr(\theta,\iota)$: Antenna gain of Rx

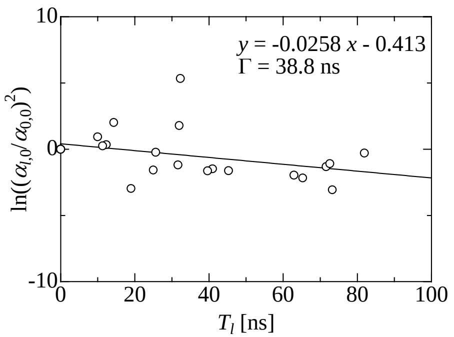
Rician factor (2)

Δk: Small Rician effect in each cluster

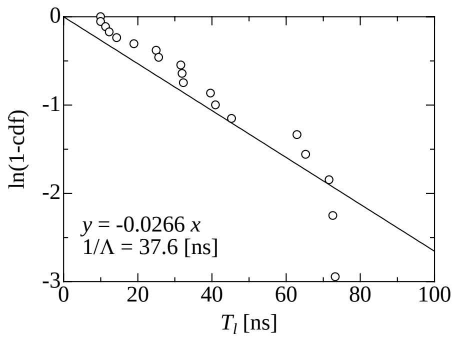
$$K=\frac{\beta^2}{\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}|\alpha_{l,m}^2|\,\delta(t-T_l-\tau_{l,m})\,\delta(\varphi-\Psi_l-\psi_{l,m})\,G_r(0,\Psi_l+\psi_{l,m})}$$

Appendix B: Results of data analysis

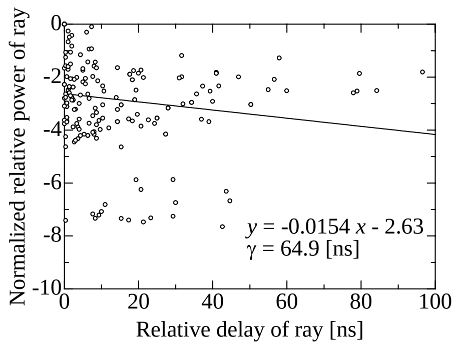
Antenna beamwidth
Tx: 60 deg, Rx: 60 deg



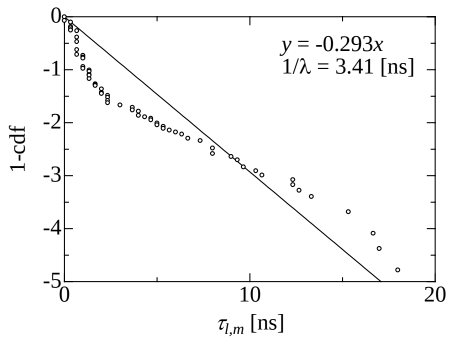
Cluster decay factor (Γ)



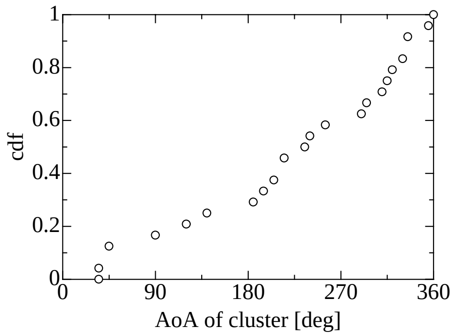
Cluster arrival rate (1/Λ)



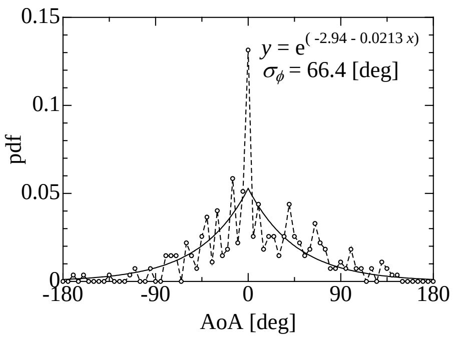
Ray decay factor (γ)



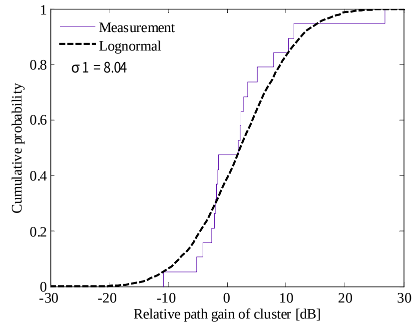
Ray arrival rate (1/λ)



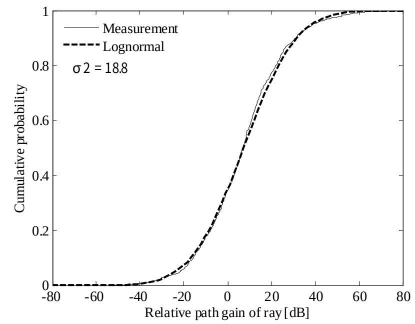
Angle of arrival in cluster (∝Uniform)



Angle spread of ray (σ_ϕ)



Standard deviation of cluster (σ_1)



Standard deviation of ray (σ_2)