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

Submission Title: [Propagation Model Using Circular Polarized Antennas]
Date Submitted: [September 2006]
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Abstract: [Update of activities in the channel modeling sub-group and call for participation]

Purpose: [Contribution to 802.15 TG3c conference call on channel model]

Objective & Motivation

Objective

Develop a channel model for pulse transmission in support of applications in office and residential environments

Motivation

Reduction of multipath simplifies system design for high data rate applications using circular polarized directional antennas

Advantages of Circular Polarization

Summary of Manabe and Sato's Work [2]

A

Estimated RMS Delay Spread

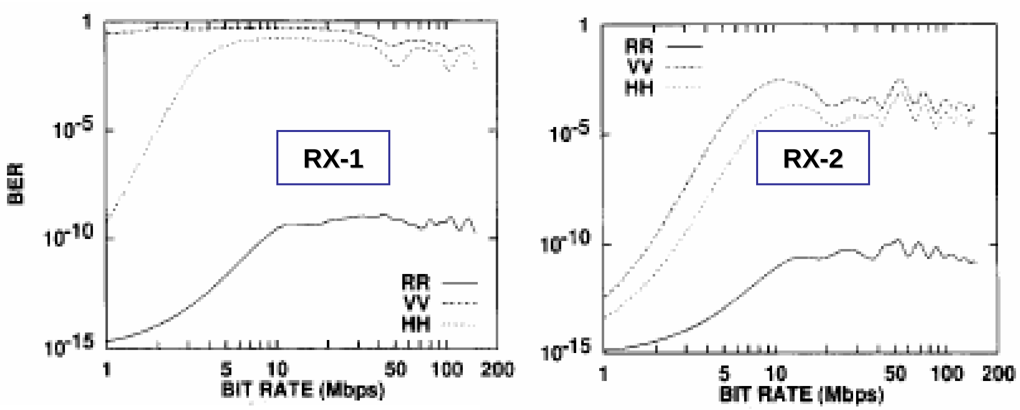
Rx Location	Vertical	Horizontal	Right Hand
RX-1	11.02 ns	9.96 ns	5.66 ns
Rx-2	11.08 ns	10.07 ns	4.68 ns

B

Reported that the circular polarization suppressed multipath up to 30 dB.

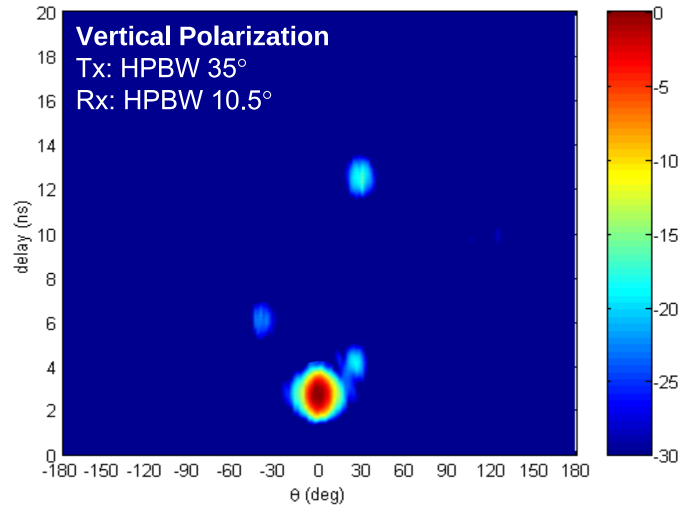
C

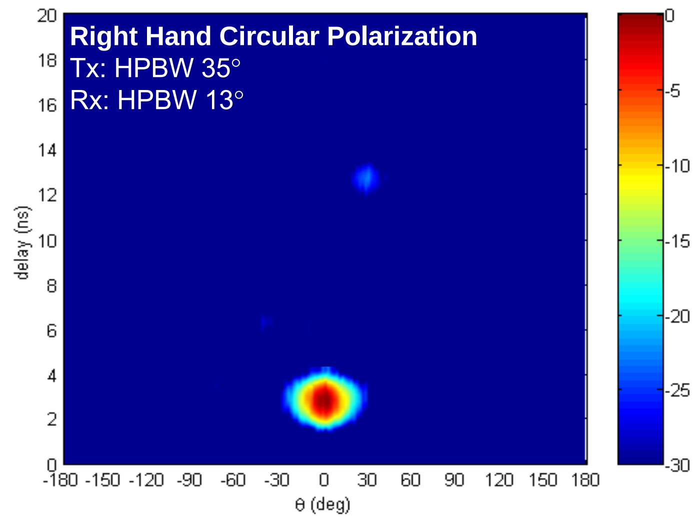
Dependency of BER on Polarization



Estimated for 150 Mbps BPSK transmission with SNR of 15 dB

NewLANS' Office Measurement

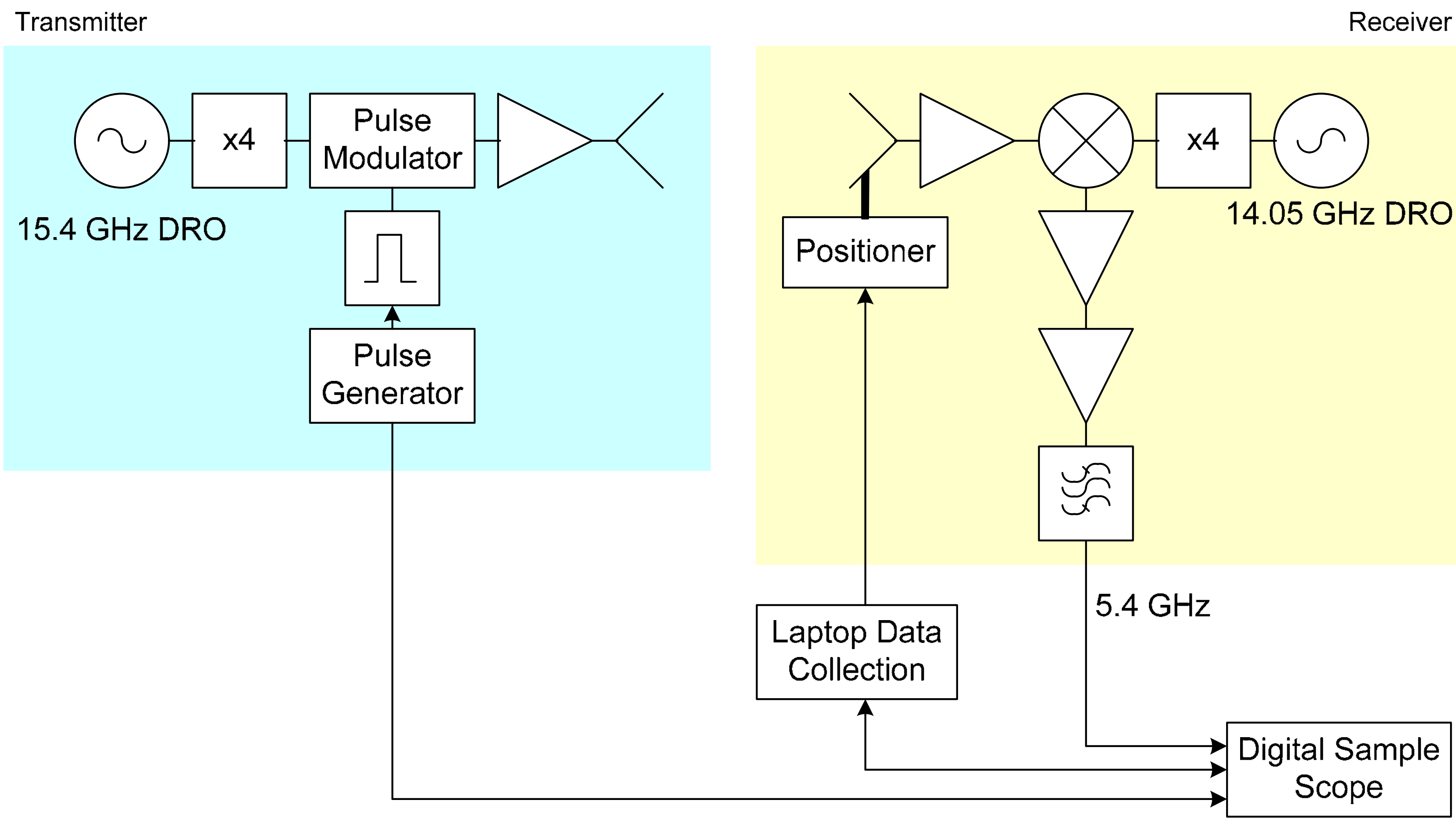




Measurement Information

- Office and residential environments
  - Office → cubicles, conference room and hallway/corridor
  - Residential → Family/living room, dining room and kitchen
- ~60 GHz center frequency
- Pulsed measurement (~1 ns pulse width)
- Tx Antenna
  - Fixed
  - Directional, HPBW of 35°
- Rx antenna
  - Rotated in step of ~2°
  - Directional, HPBW of 13º
- Right hand circular polarization

60 GHz Pulsed Measurement Set-Up



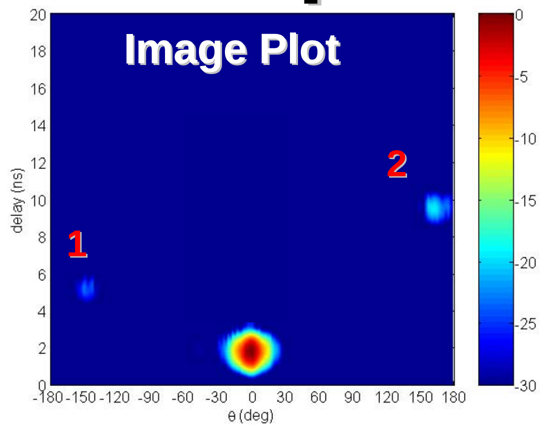
Environment

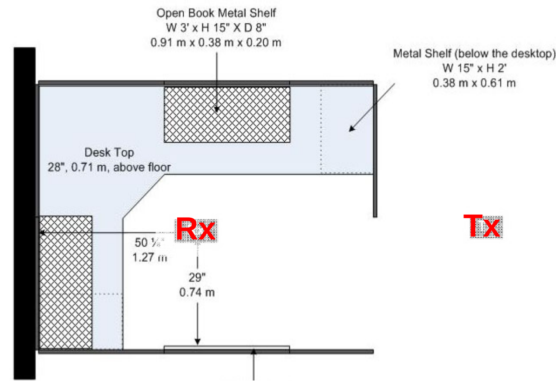
Environment	Number of Locations	Number of Measurements
Office	34	6,188
Residential	31	5,642
Total	**65**	**11,830**

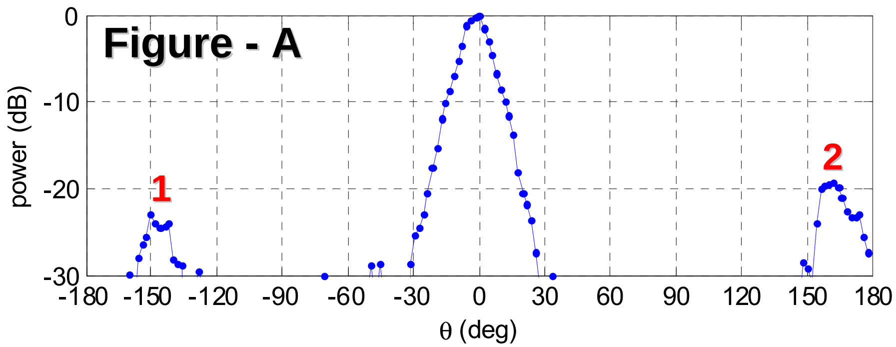
Data Processing & Analysis

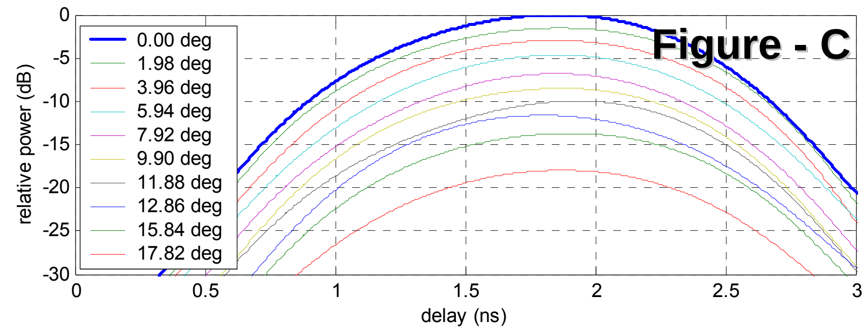
- Time domain impulse response measured as Rx rotated through 360° (in step size of ~2°)
- Envelope detector digitally implemented in Matlab to recover baseband pulses
- Multipath information collected from processed data and layout of each environment

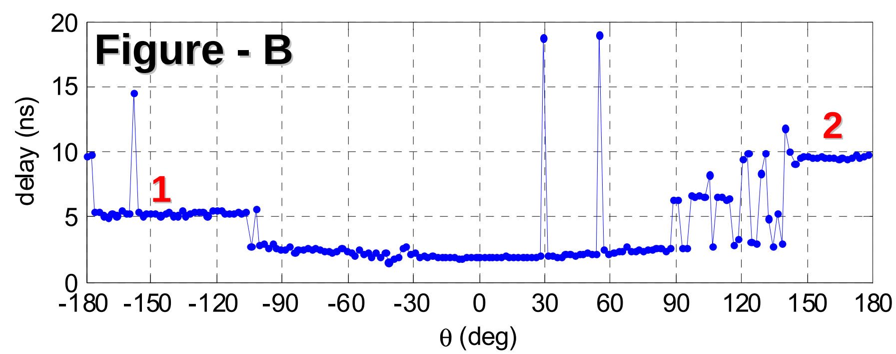
Example – Office Environment

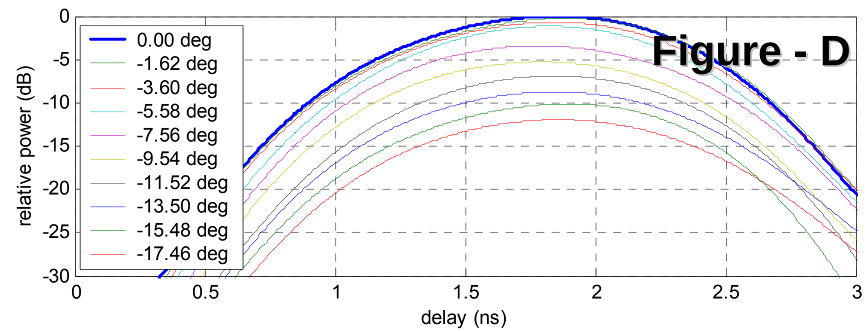












Proposed Channel Model

Modified Single-Cluster Saleh-Valenzuela (SCSV) Model

LOS   Multipath (SCSV)

$$h(t,\theta) = \beta\left[\underbrace{\delta(t - t_{\mathrm{LOS}}, \theta)}_{\text{LOS}} + \underbrace{\sum_{l=1}^{L} \alpha_l \delta\left(t - t_{\mathrm{LOS}} - t_l, \theta - \theta_l\right)}_{\text{Multipath (SCSV)}}\right]$$

where :

h = channel impulse response

β = a deterministic factor *

t_{LOS} = delay for line-of-sight signal

L = number of arrivals (or rays)

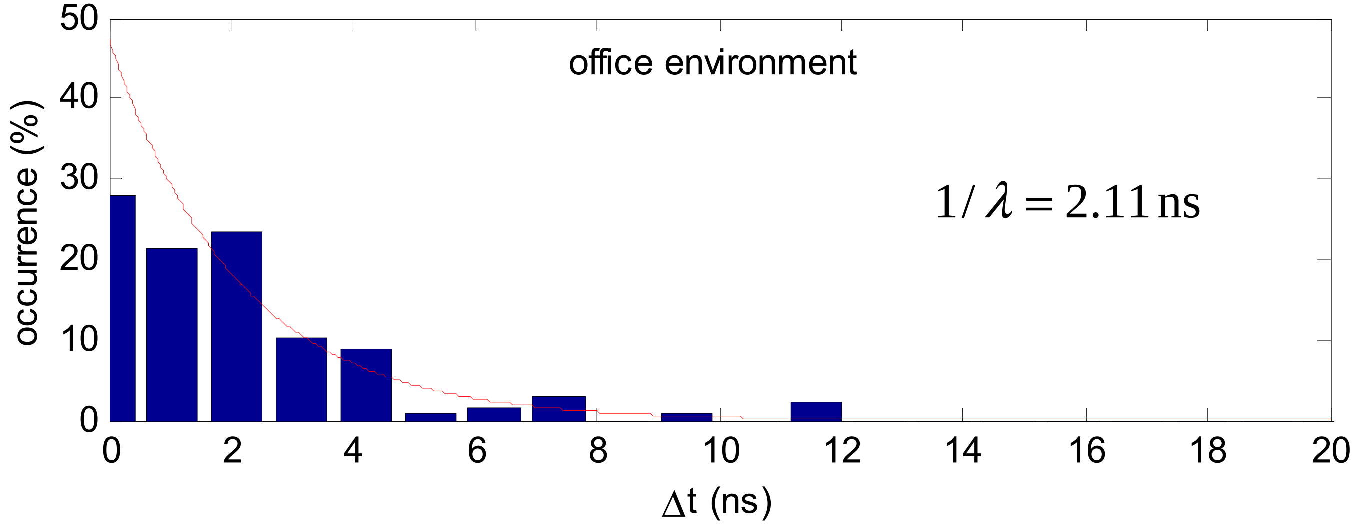
α_l = multipath gain of the l^{th} ray

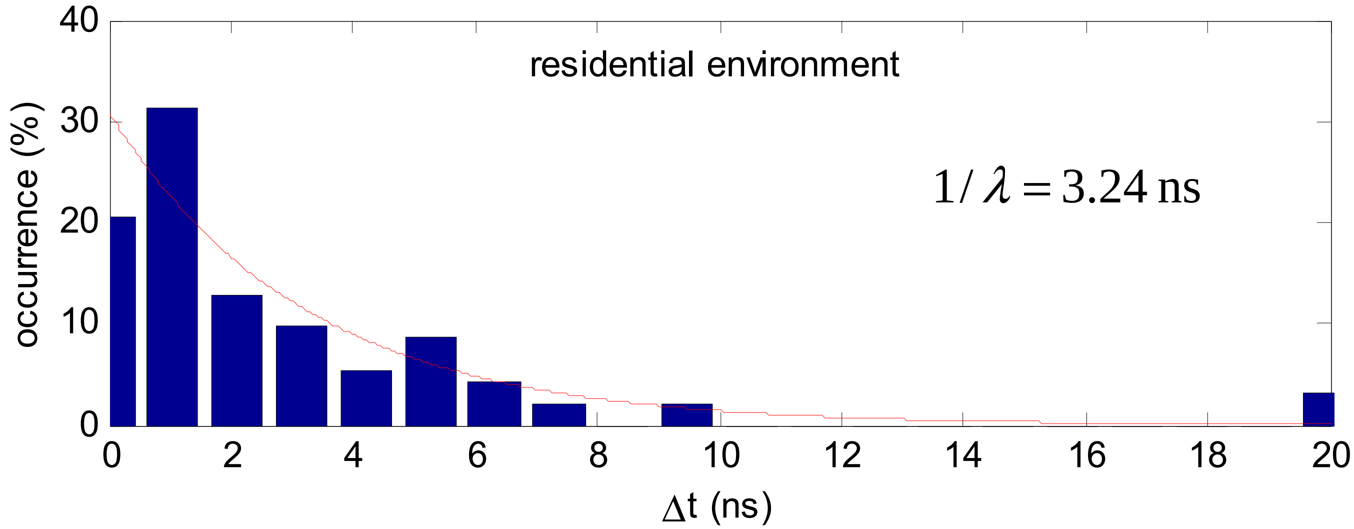
t_l = arrival time of the l^{th} ray

θ_l = arrival angle of the l^{th} ray

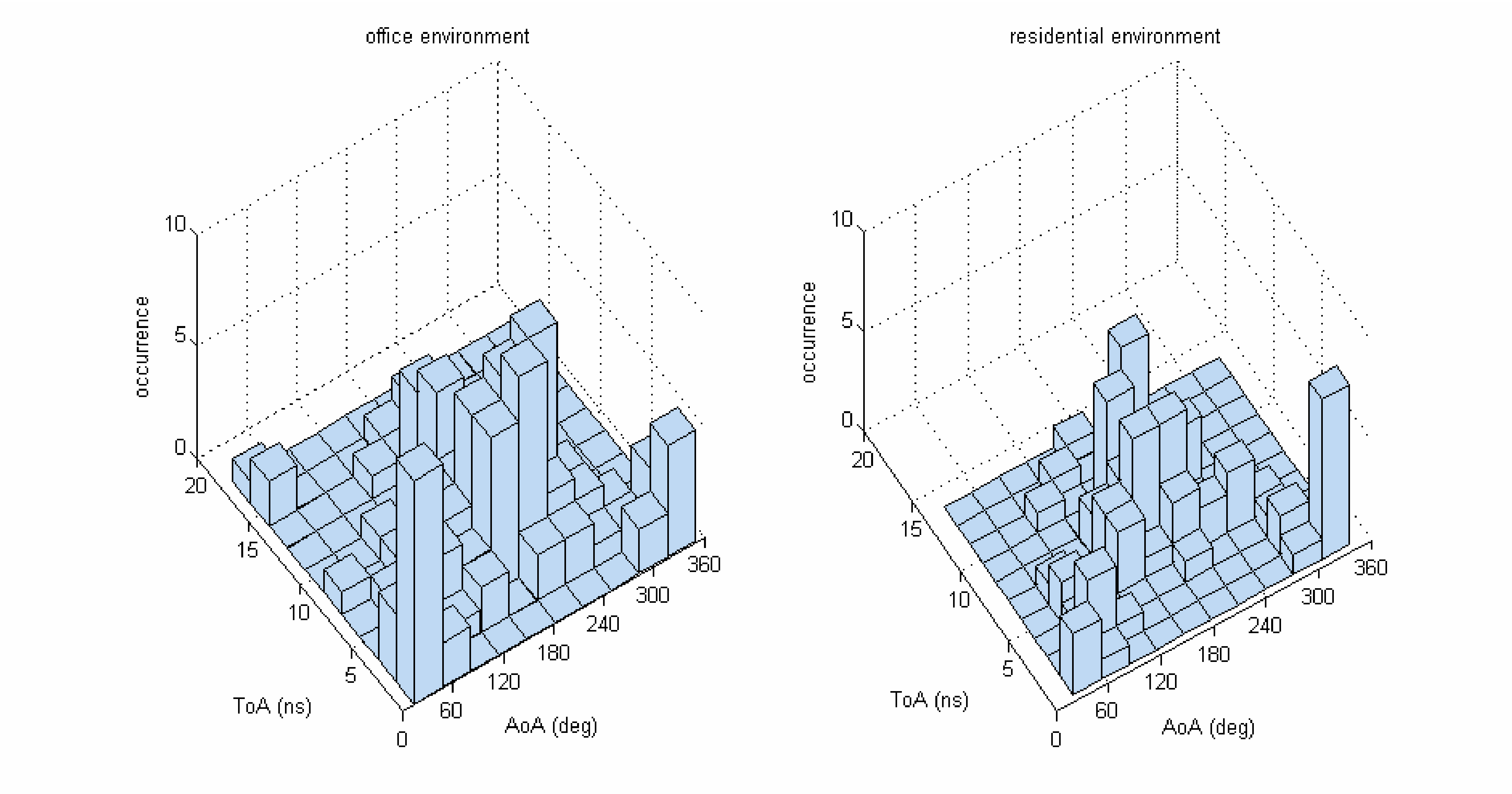
***Determined by the free-space pathloss and gains of Tx and Rx.**

Ray Arrival Rate



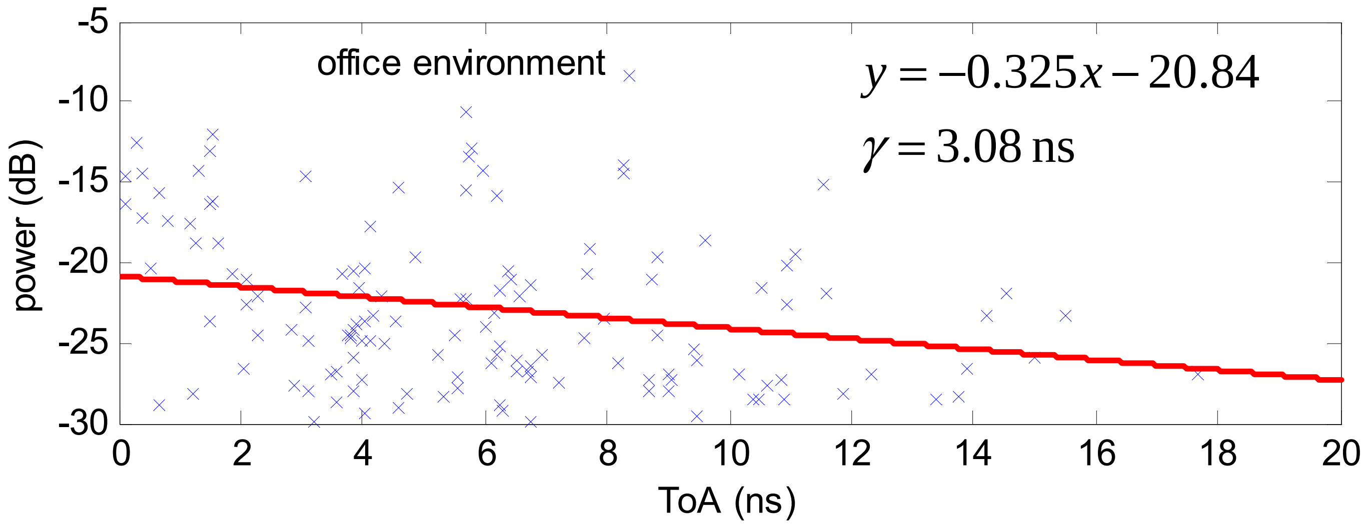


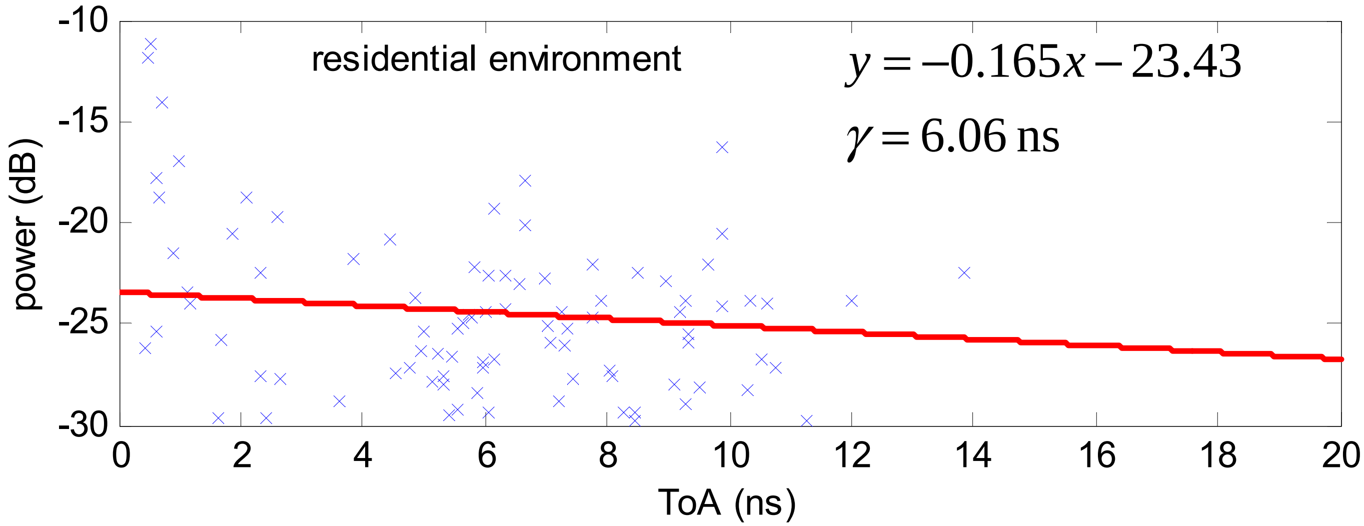
Time-of-Arrival vs Angle-of-Arrival



Modified Joint Gaussian Distribution

Power Delay Profile





Extracted Parameters

$$h(t,\theta) = \beta\left[\delta(t - t_{\mathrm{LOS}}, \theta) + \sum_{l=1}^{L} \alpha_l \delta\left(t - t_{\mathrm{LOS}} - t_l, \theta - \theta_l\right)\right]$$

		Values: Office	Values: Residential	Unit
Ray arrival rate (1/λ)		2.11	3.24	ns
Ray decay factor (γ)		3.08	6.06	ns
Joint PDF between ToA & AoA	Correlation coefficient	0.0427	0.1256	-
	Mean ToA	6.09	7.29	ns
	ToA standard deviation	3.82	6.77	ns
	Mean AoA	172	183	deg
	AoA standard deviation	80	74	deg
Mean delay		5.4	7.1	ns
RMS delay spread		2.8	3.4	ns

References

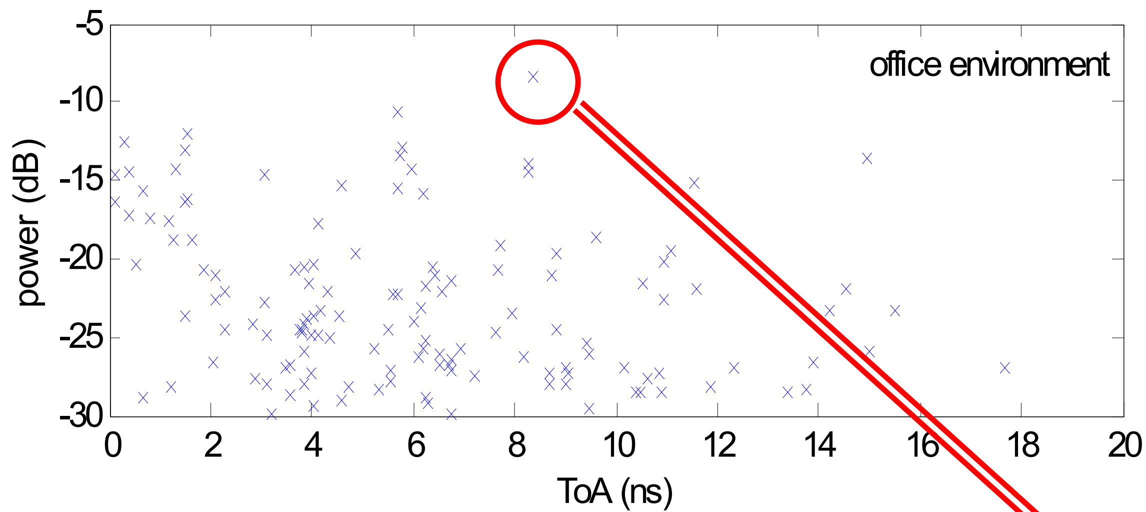
1. T. Manabe, *et*. *al*., Multipath measurement at 60 GHz for indoor wireless communication systems, *IEEE 44th Vehicular Technology Conference*, 905-909, June 1994.

2. T. Manabe, *et*. *al*., Polarization dependence of multipath propagation and high speed transmission characteristics of indoor millimeter channel at 60 GHz, *IEEE Transaction on Vehicular Technology*, **Vol**. 44, **No**. 2, 268-274, May 1995.

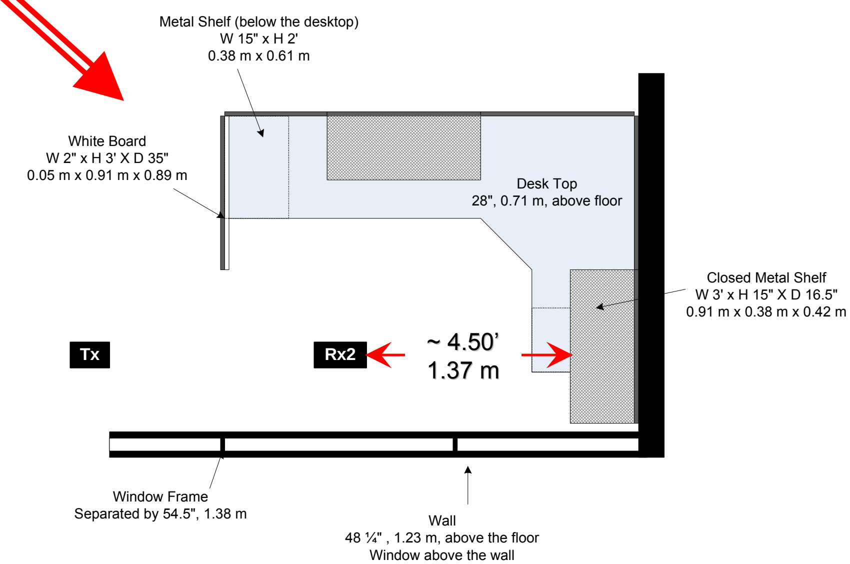
3. K. Sato, *et*. *al*., Measurements of reflection and transmission of office building in the 60 GHz band, *IEEE Transaction on Antennas and Propagation*, **Vol**. 45, **No**. 12, 1783-1792, December 1997.

Backup Slide

Power Delay Profile & Layout



Measurement 22A2
ToA: 8.36 ns
AoA: -169.9°
Power: -8.39 dB



TX-RX LOS Distance: 5.46', 1.66 m