



Research Consortium in Speckled Computing

# Channel Modelling for Specknet

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Supervised by

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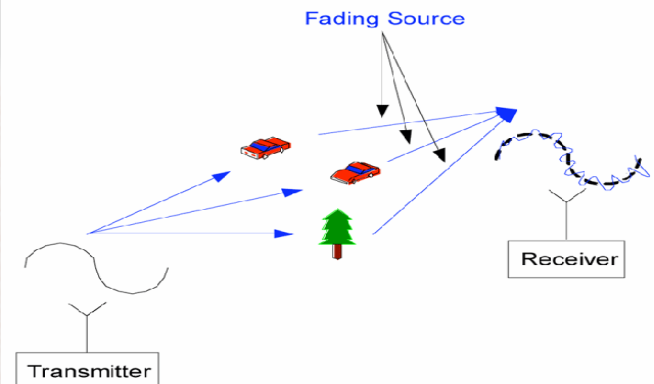
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# Outline (Wireless Channel)

Channel models describes “*what* happens”

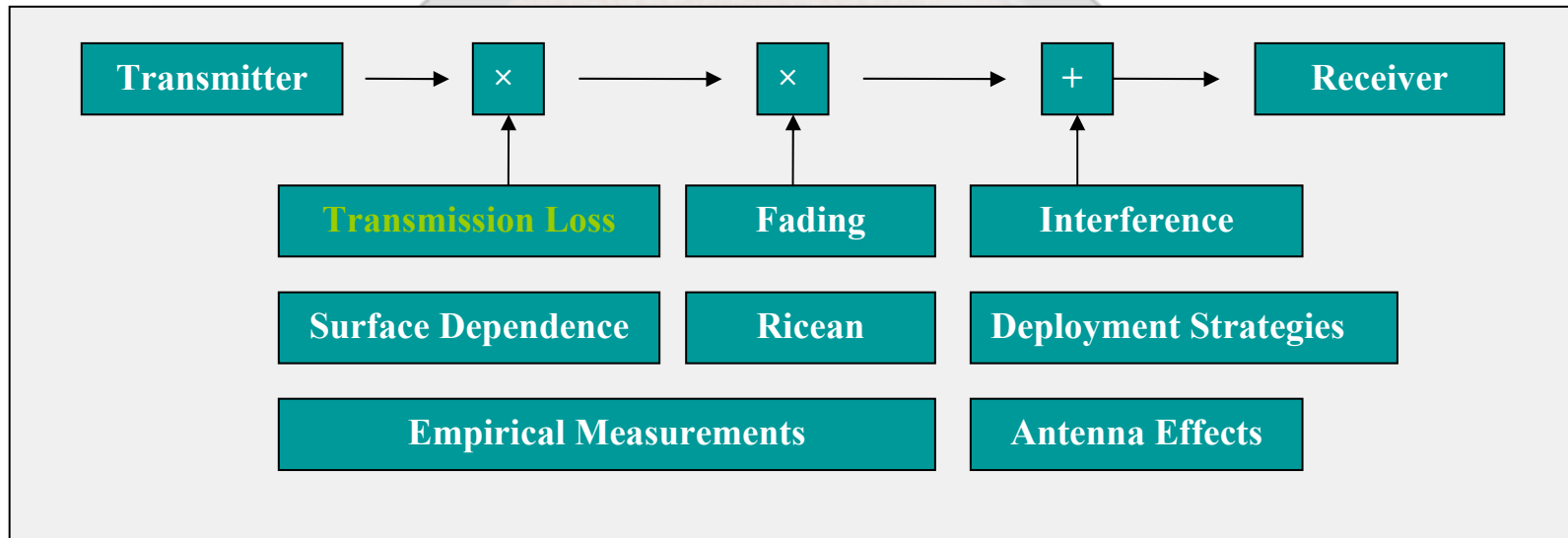
- gives channel output for a particular input
- requires appropriate parameters e.g. loss, fading, dispersion statistics etc



Propagation model describes “*how* it happens”

- how signal gets from transmitter to receiver
- how energy is redistributed in time and frequency
- can be used to obtain the parameters needed by channel models

# Channel Model for Specknet



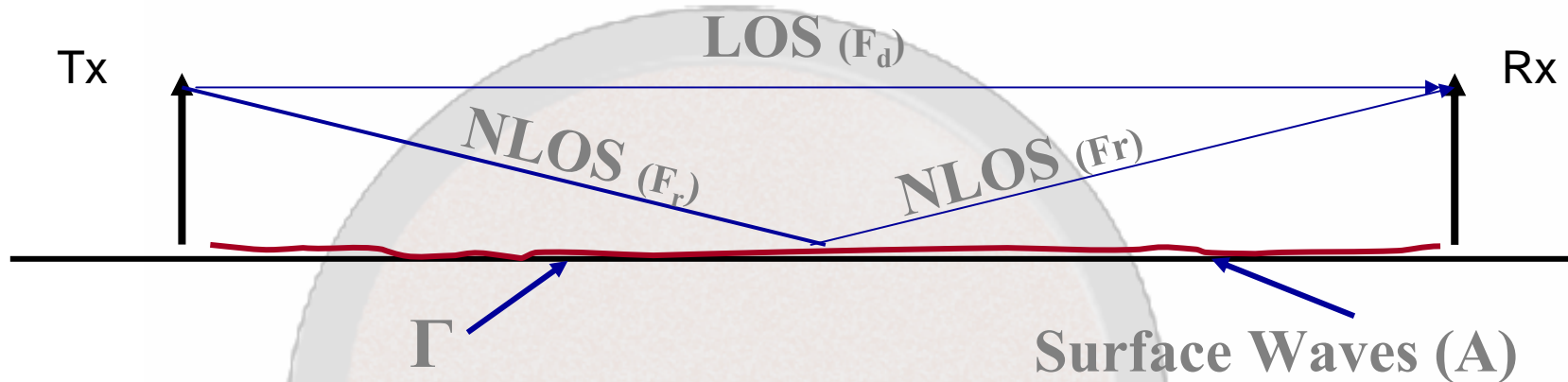
# Outline (Short Wireless Links)

- Because of their small size specks are constrained by the amount of energy they can transmit.
- The presence of the ground has an effect on radio propagation
  - Effect of antenna polarisation
  - Cross polarisation effect due to medium
  - Electrical properties of the ground
  - Existence of ground surface waves
  - Physical size of the device
  - Near field and far field

# Sequence of Presentation

- Radio propagation mechanism
  - LOS, NLOS and surface waves
- Propagation models and path loss
  - Closed form physical models
- Empirical measurements
  - Vertical polarised antennas
  - Horizontal polarised antennas
- Conclusion
- Future work

# Radio Propagation Mechanism



$$P = \left| \frac{e^{-jKd}}{2Kd} \left[ F_d + F_r [\Gamma + (1-\Gamma)A] \right] e^{-j\phi} + \dots \right|^2$$

$$P = \left| \frac{e^{-jKd}}{2Kd} \left[ \cancel{F_d} + \cancel{F_r} [-1 + (1-(-1))A] \right] e^{-j\phi} + \dots \right|^2$$

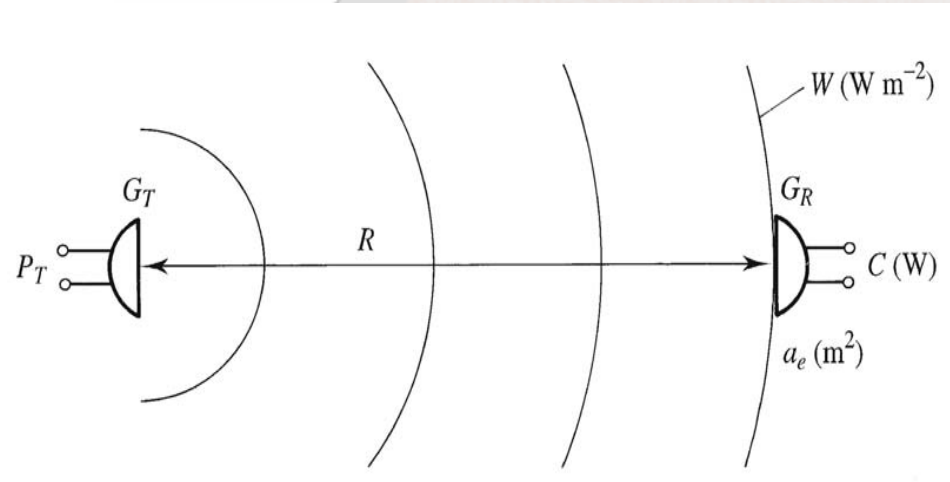
$$A = \frac{-1}{1 + jkd \left( jkd (\Gamma + \sin(\theta)) \right)^2}$$

# Propagation Models

- Closed-form physical models
- Empirical and semi-empirical
- Numerical physical models
  - Ray tracing
  - Others
    - Parabolic equation method (PEM)
    - Finite differences (especially FDTD)
    - Transmission line matrix (TLM) method
    - ...

# Closed Form Free Space Model

- Free space path loss (FSPL) (GO single-ray) model
- Received power decays with distance at a rate of 20 dB/decades



$$\begin{aligned}
 C &= \frac{P_T}{4\pi R^2} G_T a_e \\
 &= \frac{P_T}{4\pi R^2} G_T \frac{\lambda^2}{4\pi} G_R \\
 &= P_T G_T \left( \frac{\lambda}{4\pi R} \right)^2 G_R \quad [\text{W}]
 \end{aligned}$$

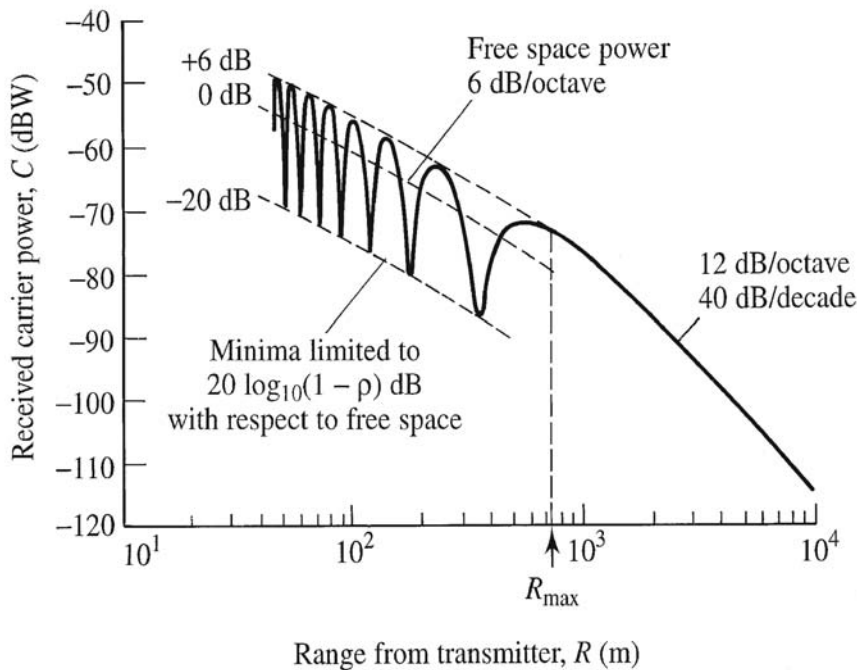
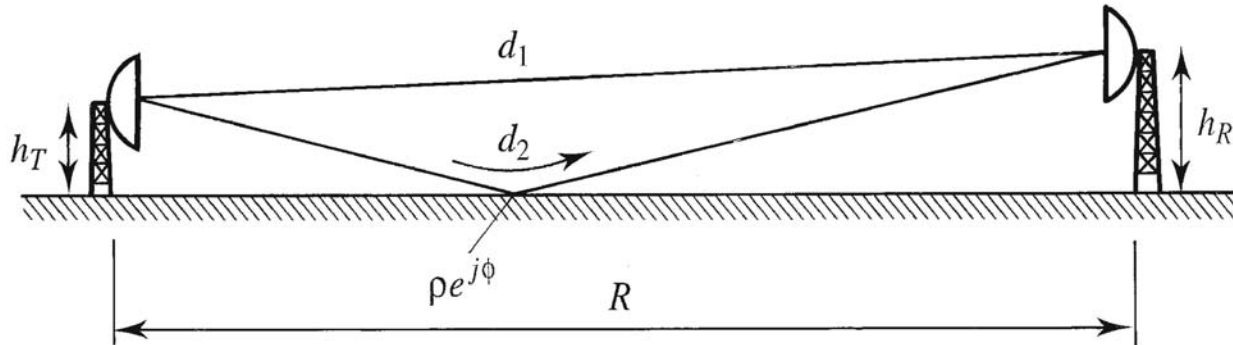
$$K = 20 \log_{10}(4\pi/\lambda)$$

$$L_{fspl} = K + 10n \log_{10} \left( \frac{R}{R_0} \right)$$

$$n = 2$$

$$C = P_T + G_T - \underbrace{20 \log_{10} \left( \frac{4\pi R}{\lambda} \right)}_{L_{FSPL}} + G_R \quad [\text{dBW}]$$

# Closed Form Two Ray Model



For  $R > R_{max}$ :

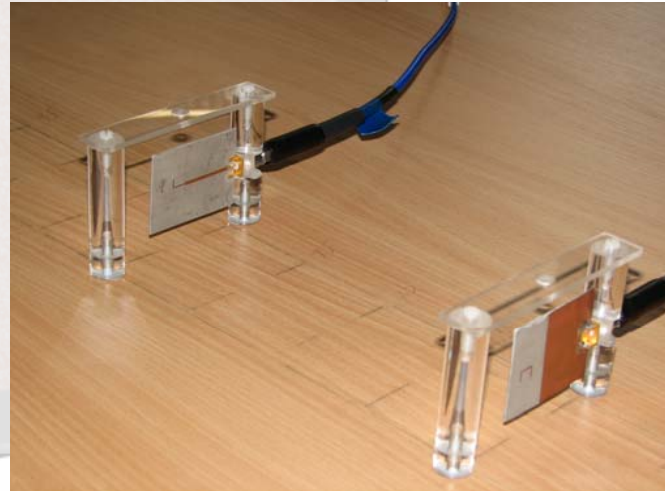
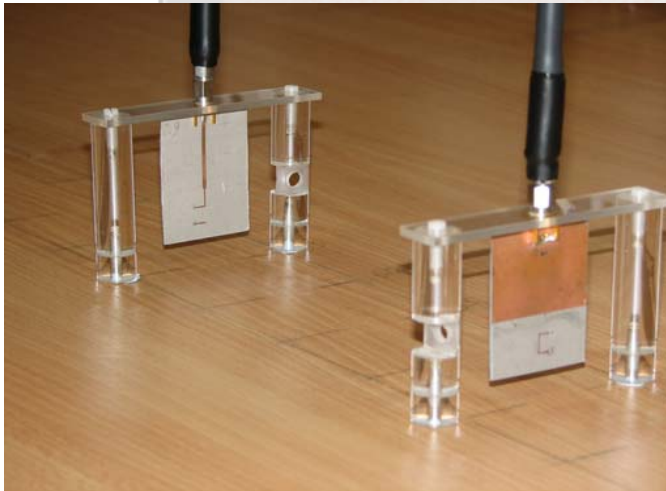
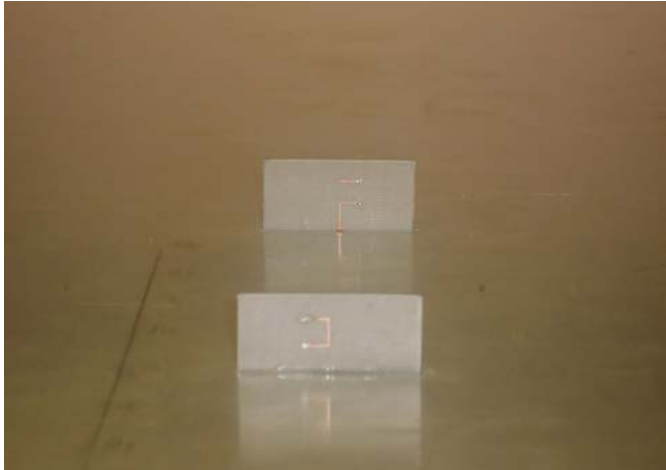
$$C = P_T + G_T - 20 \log_{10} \left( \frac{R^2}{h_T h_R} \right) + G_R$$

$$K = -20 \log_{10}(h_T h_R)$$

$$L_{PEPL} = K + 10n \log_{10} \left( \frac{R}{R_0} \right)$$

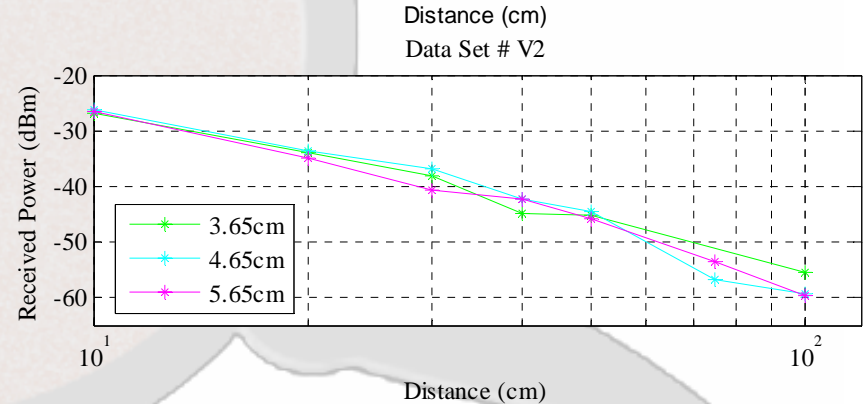
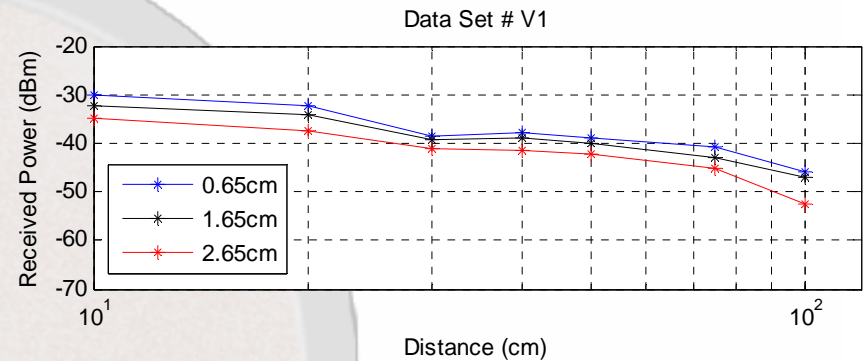
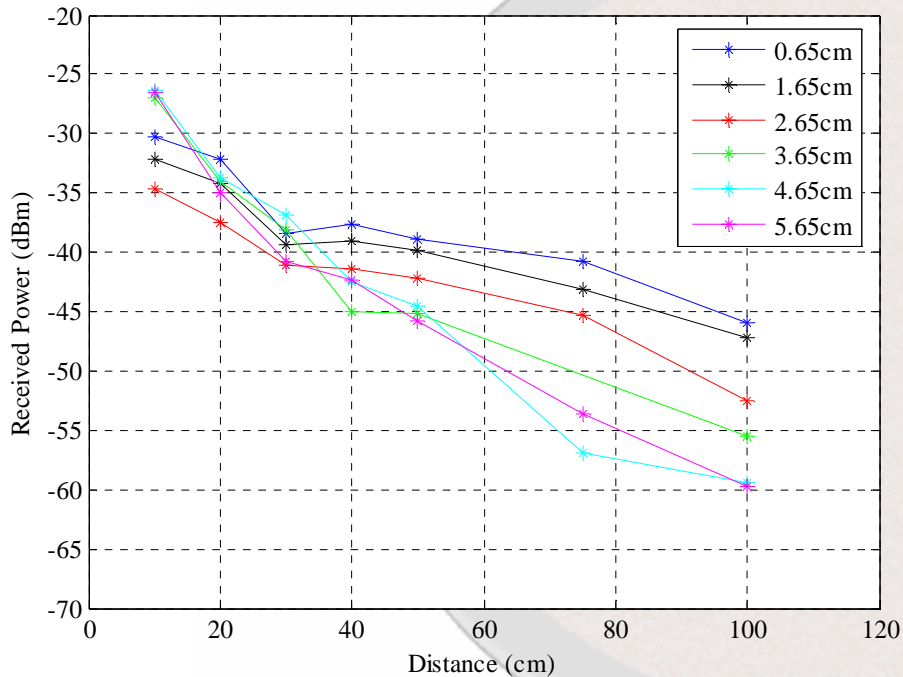
$$n = 4$$

# Empirical Measurements

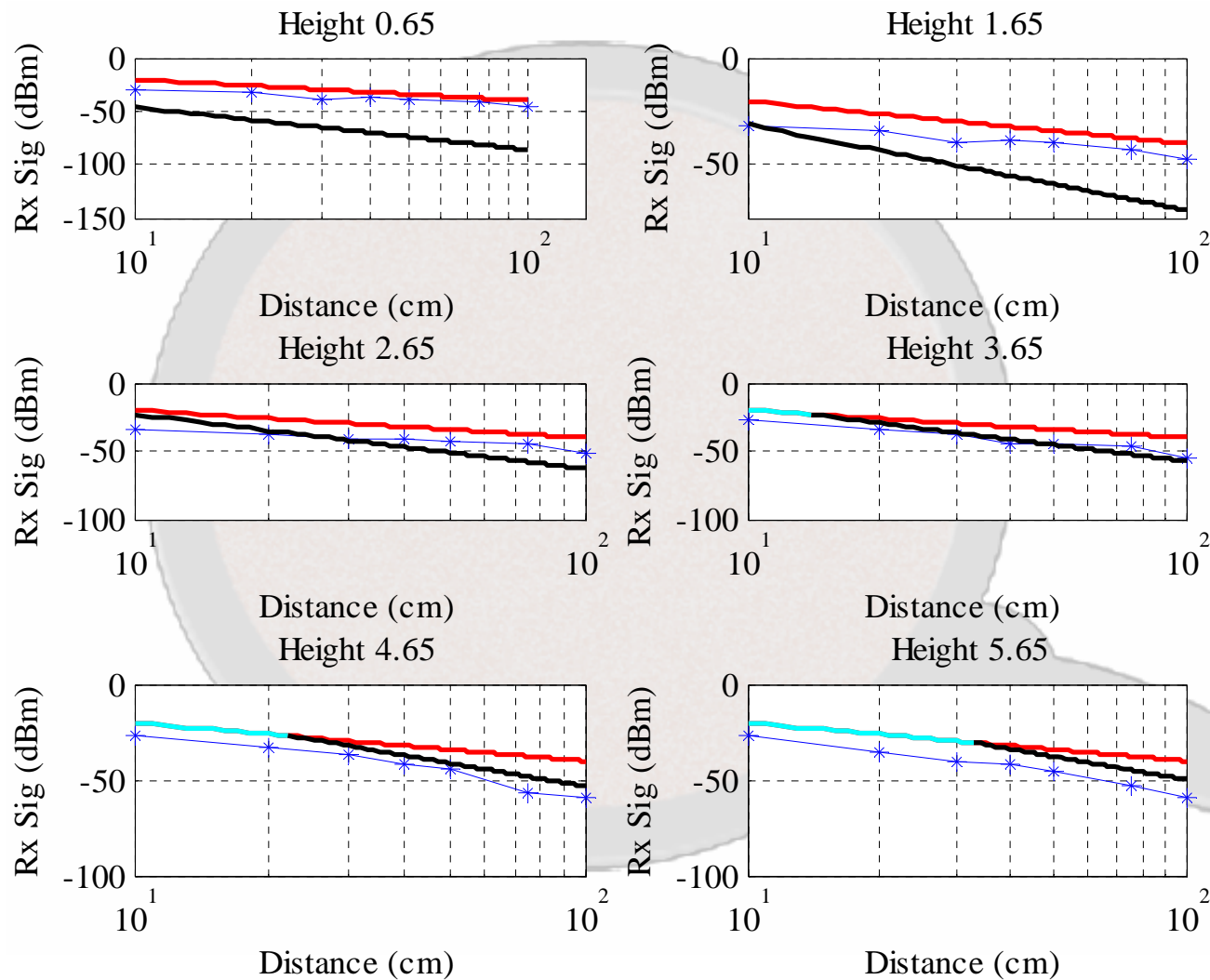


# Effect of Antenna Height on V-POL Waves

Received Power with Different Antenna Heights  
Vertical Polarisation  
Data Set # V1 & V2

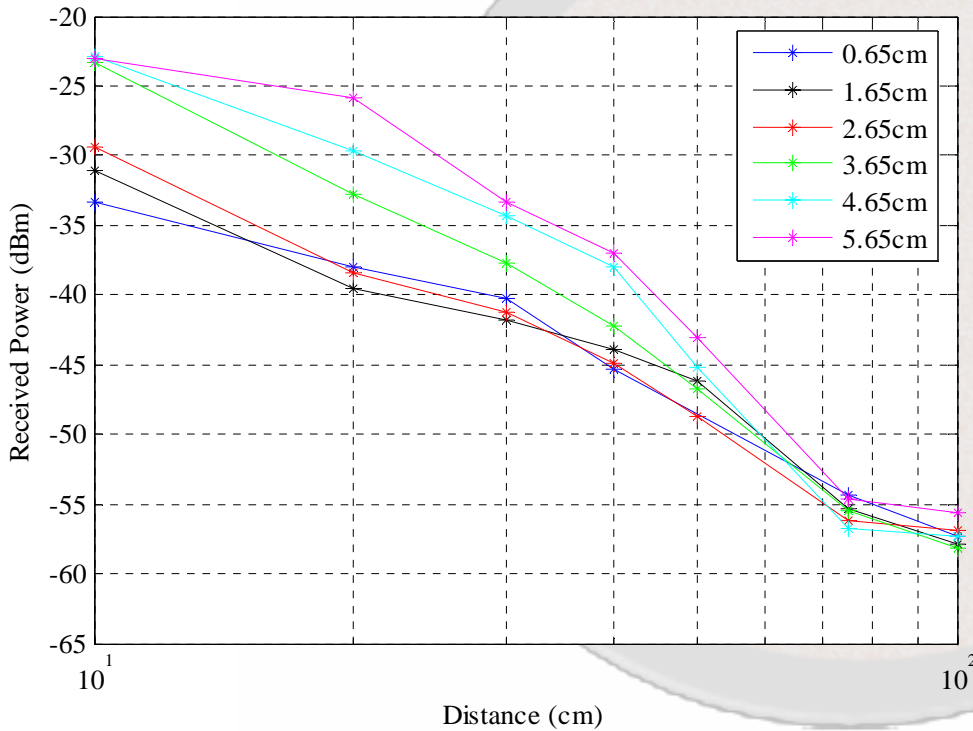


# Effect of Antenna Height on V-POL Waves

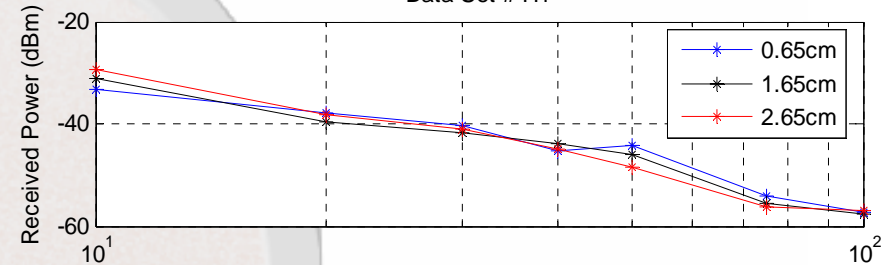


# Effect of Antenna Height on H-POL Waves

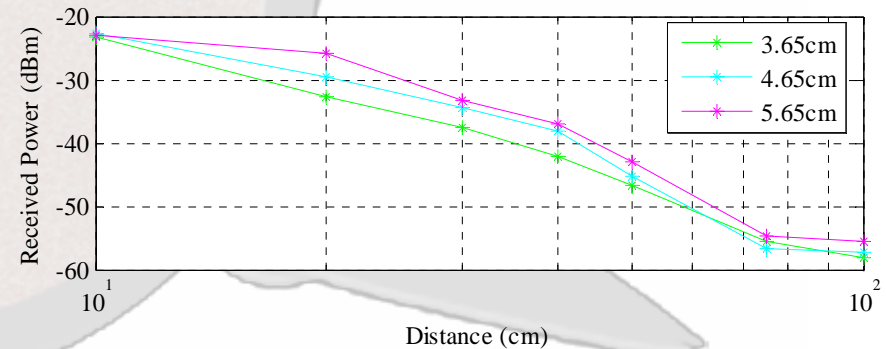
Received Power with Different Antenna Heights  
Horizontal Polarisation  
Data Set # H1 & H2



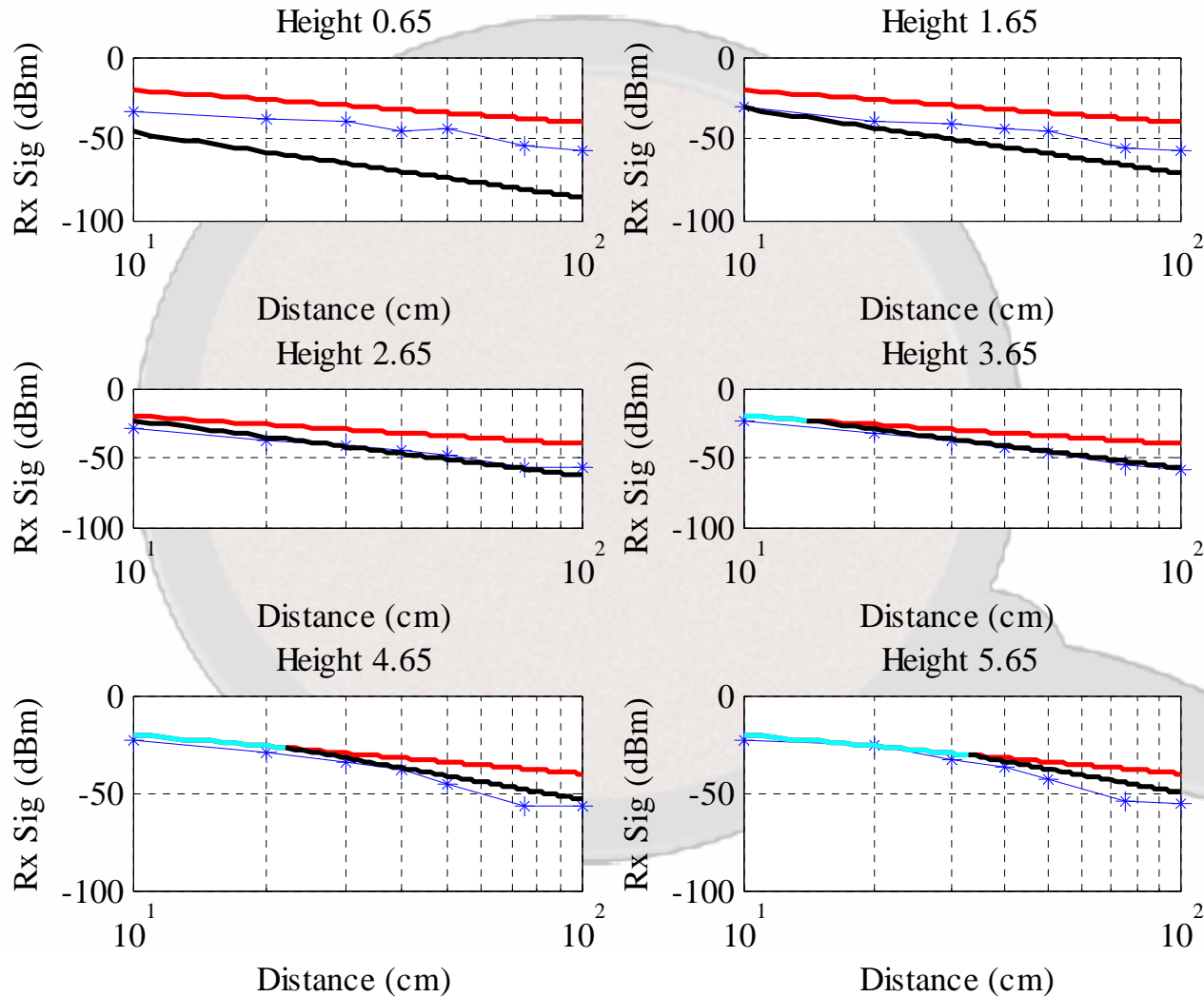
Received Power with Different Antenna Heights  
Horizontal Polarisation  
Data Set # H1



Distance (cm)  
Data Set # H2



# Effect of Antenna Height on H-POL Waves

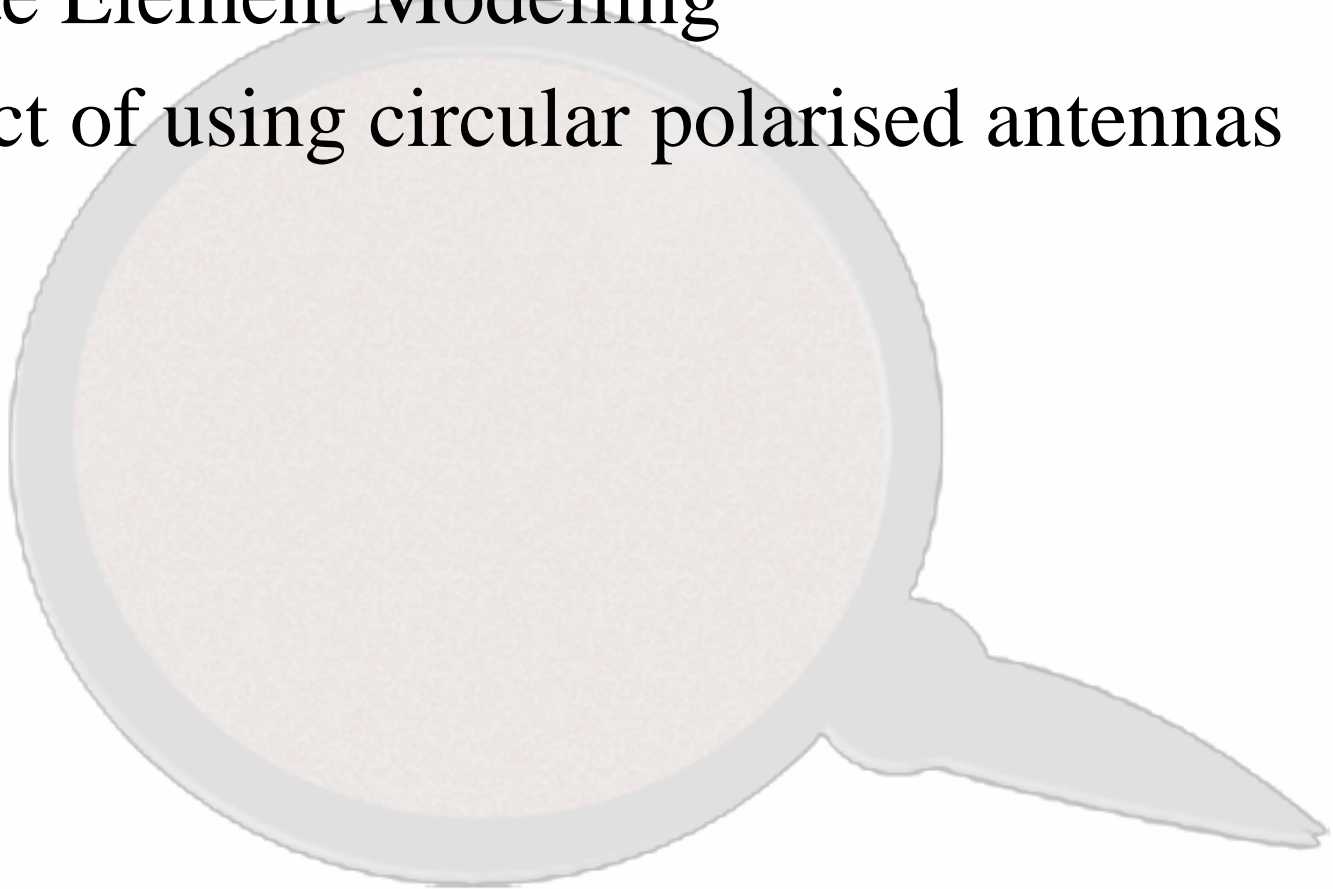


# Conclusion

- Propagation is effected by the electrical properties of the medium
  - Existence of surface waves
  - Dependence on distance and frequency.
- Antenna height
  - For vertical polarisation antenna should be placed close to the ground.
  - For horizontal polarised waves lower antenna heights results in higher propagation loss.

# Future Work

- Finite Element Modelling
- Effect of using circular polarised antennas





# Question and Answer Session

