Overview of the COST IC1004 white paper on 'Channel measurement and modelling for 5G networks in the frequency bands above 6 GHz

Sana Salous
School of Engineering and Comupting Sciences
Durham University
Sana.salous@durham.ac.uk

Durham University

Contributors

Interdigital LLC

Ofcom

Samsung R&D Institute UK

Durham University UK

Northwestern Polytechnical University, Xi'an, China

University of Technology, Brno, Czech Republic

Austrian Institute of Technology, Vienna, Austria

TU Wien

Rohde and Schwarz GmbH & Co. KG

Huawei Europe

Beijing Jiaotong University

TU Ilmenau

Lund University

Durham University

Primary motivation

- Large available bandwidths in higher frequency bands
- Demand for high data rate services
- WRC15 identified a number of mm wave band between 24-86 GHz
- Need for channel measurements and models for channels in the higher frequency bands

Durham University

WRC15 frequency bands

WRC15 Band (GHz)	Band Designation	Bandwidth (GHz)
24.25-27.5	I	3.25
31.8-33.4	II	1.6
37-43.5	III	6.5
45.5-50.2	IV	4.7
50.4-52.6	V	2.4
66-76	VI	10
81-86	VII	5

Durham University

Main topics

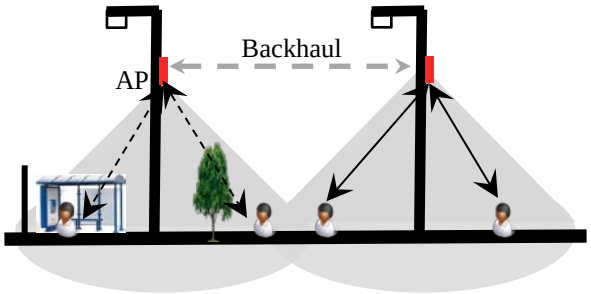
1. Use scenarios of the mm-wave band.
2. An overview of propagation characteristics based on available ITU-R recommendations and recent studies.
3. State of the art channel sounding techniques for mm-wave measurements for the different use scenarios.
4. Channel measurement and ray tracing results.
5. Propagation models.
6. Standardization prospects.
7. Recommendations for further studies.

Durham University

Use Scenarios: outdoor

Street canyon

Open square



Backhaul

Small cells~200 m

Durham University

Use Scenarios: indoor

Shopping mall

Inside Train

Aeroplane

Durham University

ITU-R recommendations

ITU-R P676-10: Gaseous absorption

Model input parameters:

temperature, ambient pressure, and water vapour density.

Use can be made of

ITU-R P.836-5 water vapour density

ITU-R P1510 mean annual surface temperature

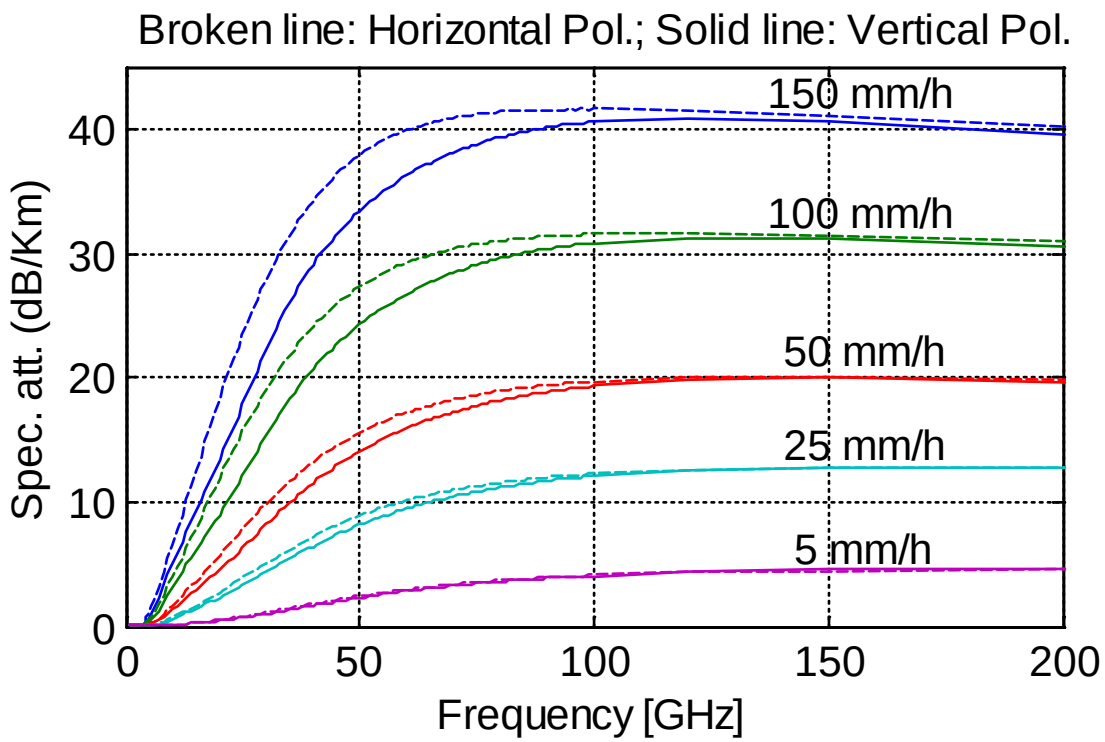
ITU-R P.840-6: Fog absorption

ITU-R P838-3: Rain absorption

ITU-R P 837-6: Rain rates

Durham University

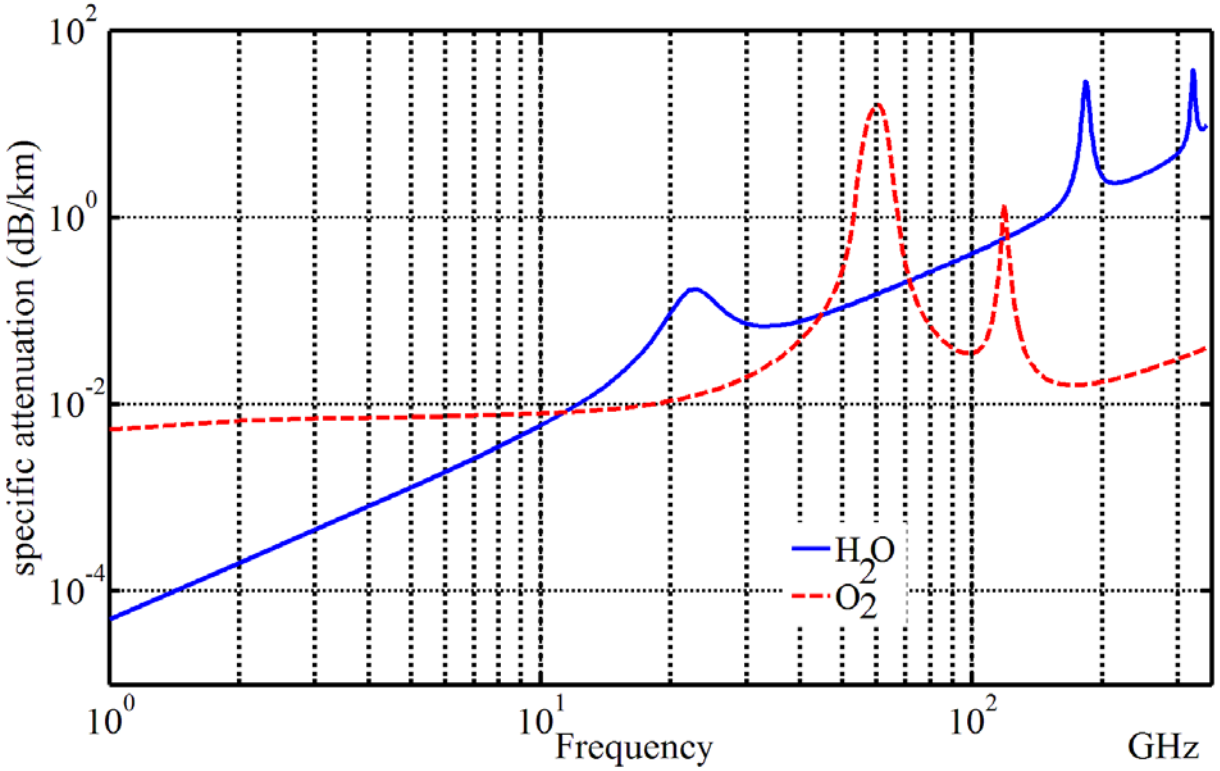
Rain attenuation model ITU-R P838-3



Rain:10 dB/km at 25 mm/hr increasing to 30 dB/km at 100 mm/hr rainfall

Durham University

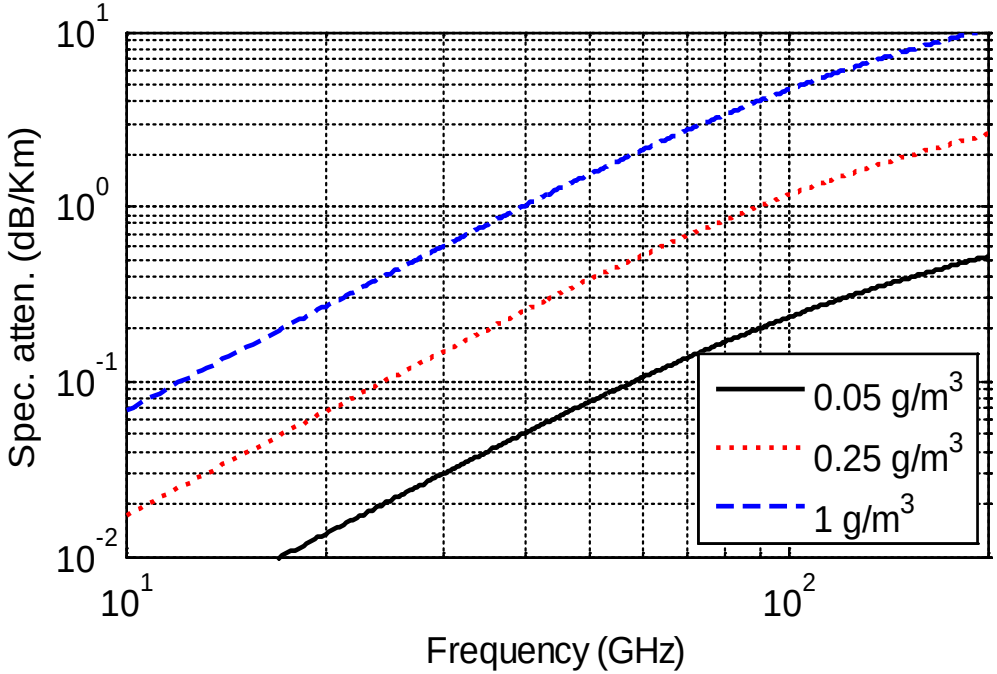
Gaseous absorption



Gaseous: 0.3-0.5 dB/km for frequencies up to 38 GHz and 70-100 GHz maximum at 60 GHz of 15 dB/km

Durham University

Fog absorption



as high as 5dB/km at 100 GHz for 1g/m^3

Durham University

ITU priority areas

To address

ITU-R P-1411-8 Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300MHz-100 GHz

ITU-R 1238- 8 Propagation data and prediction methods for indoor radiocommunication systems and radio local area networks in the frequency range 300MHz-100 GHz

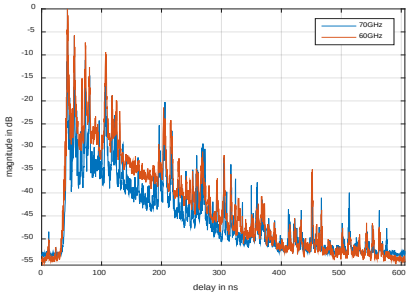
Durham University

State of the art channel sounding techniques for mm-wave measurements

Equipment based channel sounding

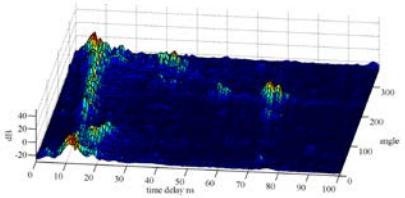
Custom designed multi-band MIMO channel sounders

60, 70 GHz



1. PRBS sounder: Illmenau

2. FMCW sounder: Durham



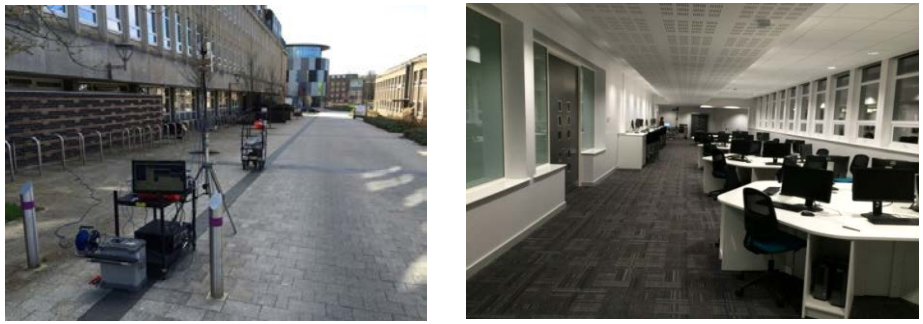
60 GHz

Durham University

Channel measurement: environments

(a) (b)

Hall, office
Illmenau



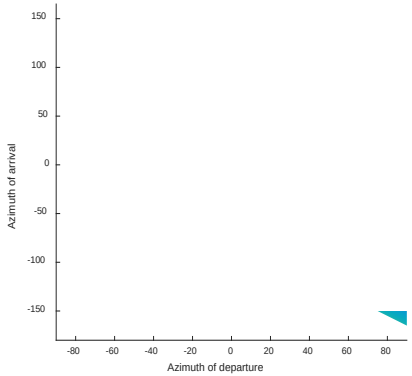
(a) (b)

Outdoor
and indoor

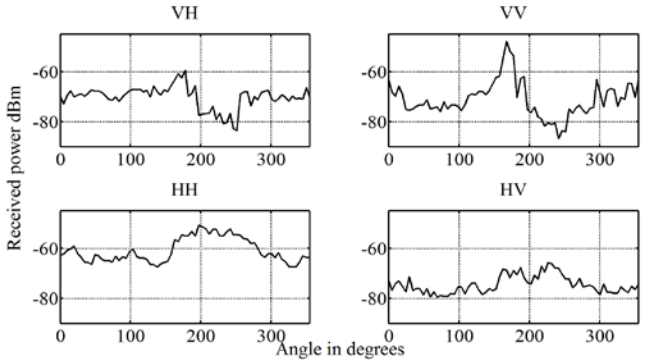
Durham

Durham University

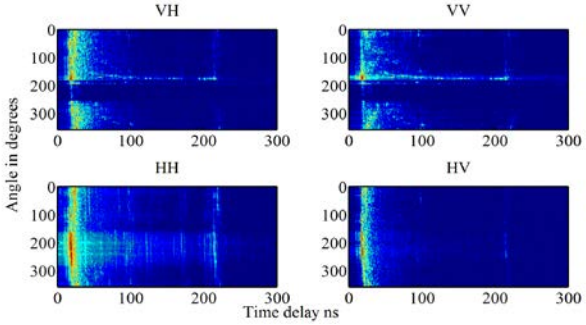
Channel measurement: results



Hall environment,
Illmenau



(a)

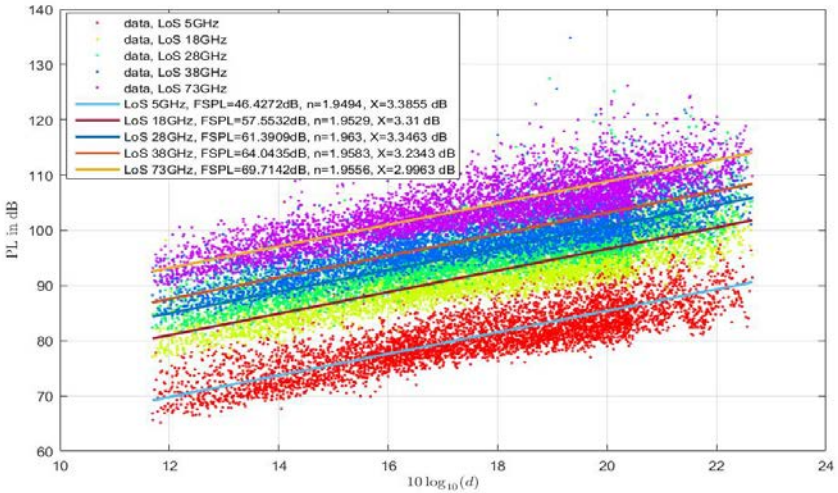


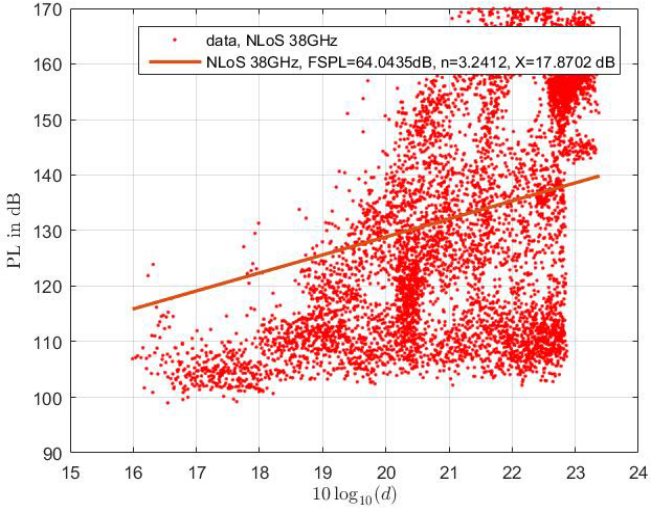
(b)

Impact of antenna aperture
Lens, open waveguide, Durham

Durham University

Path loss model: ray tracing





LOS: 5, 18, 28, 38, 73 GHz

NLOS: 38 GHz

$$\mathrm{PL[dB]} = \mathrm{FSPL}(f, 1m)[\mathrm{dB}] + 10n\log_{10}d + X$$

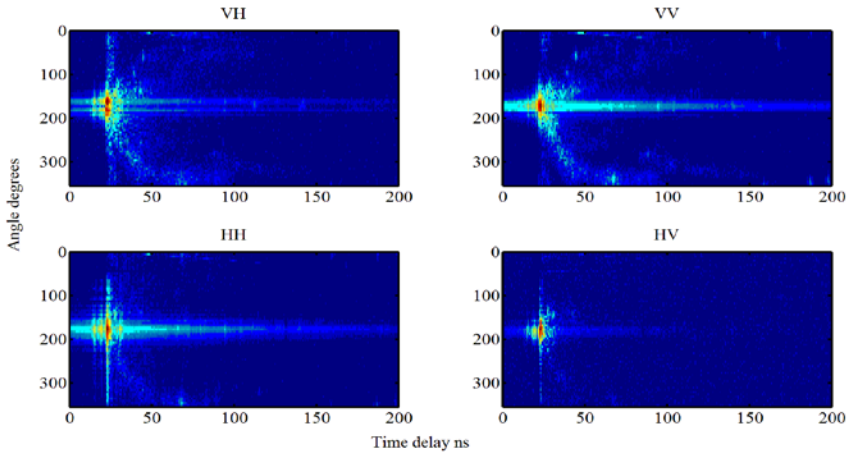
Durham University

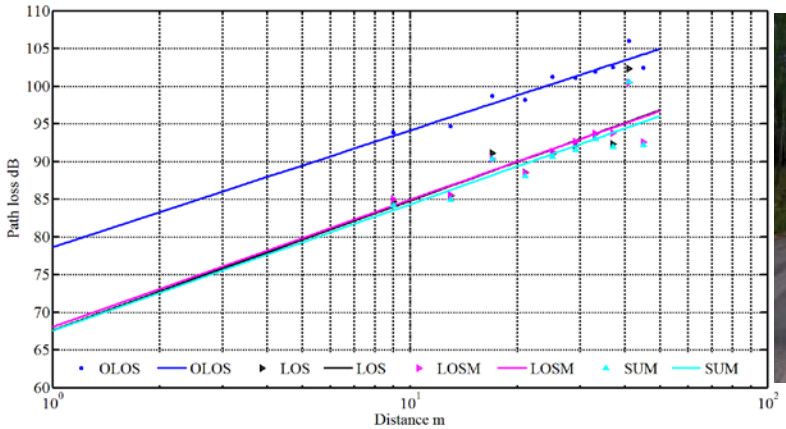
Path loss model: environment

$$\mathrm{PL[dB]} = \alpha + 10n\log_{10}d + X$$

Durham University

Path loss model: measurement based

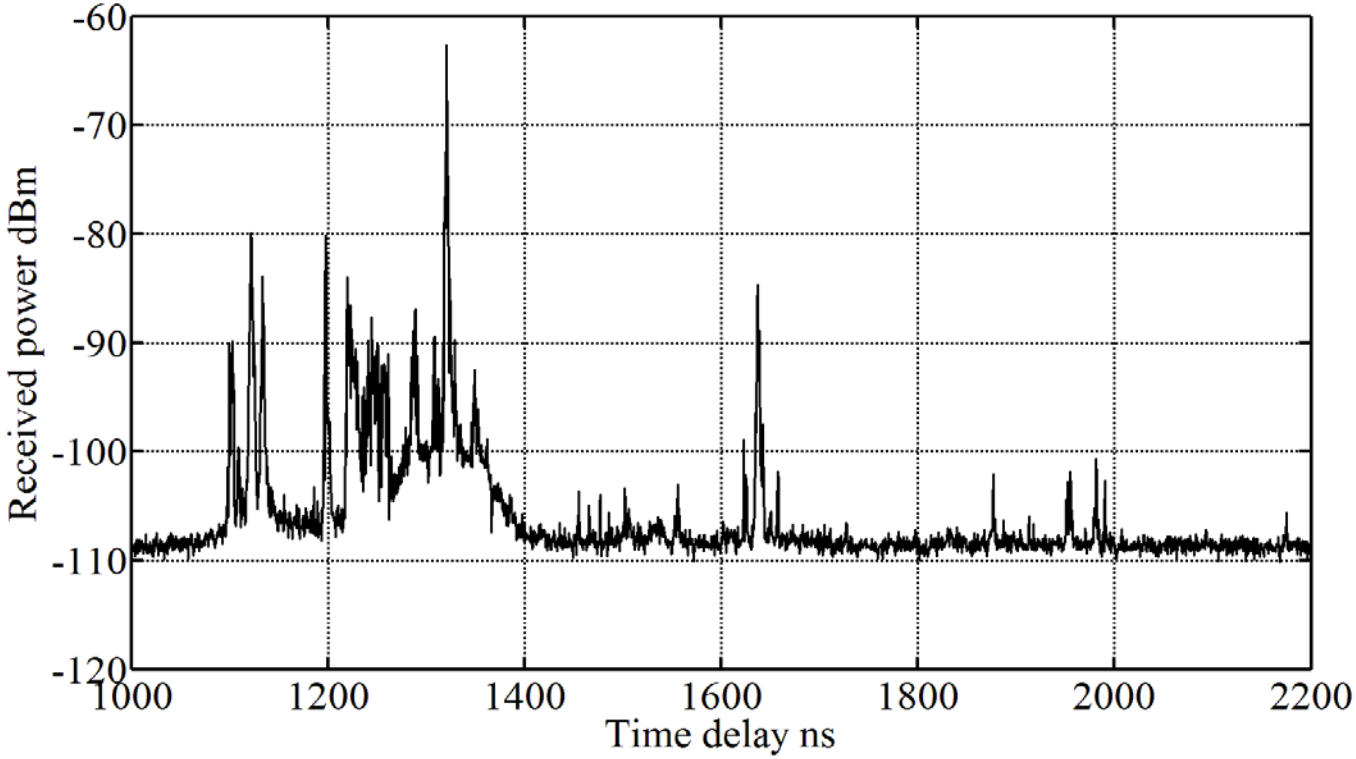




(a) (b)

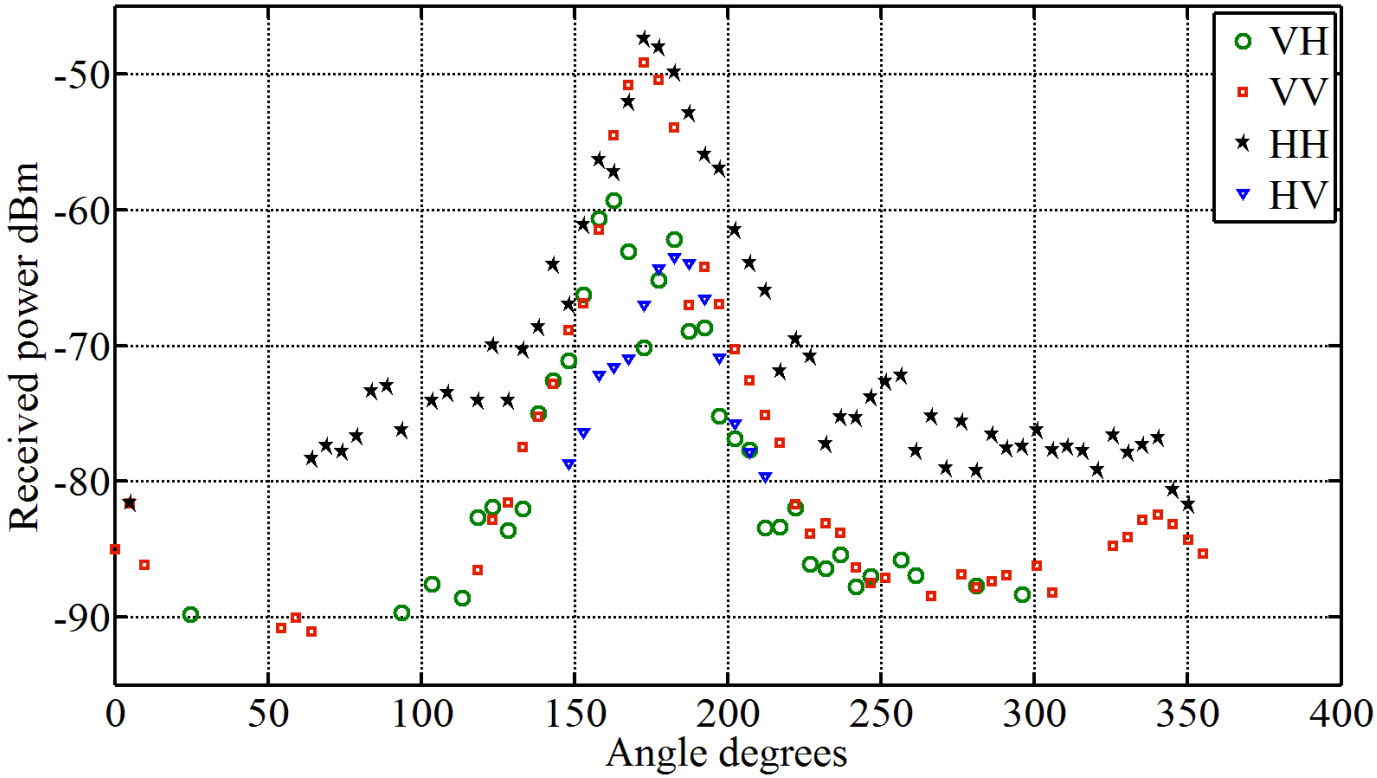
Durham University

Example of PDP



Durham University

Power versus angle



Durham University

Estimation of path loss:possible approaches

Filter data for:

(a) Strongest received signal

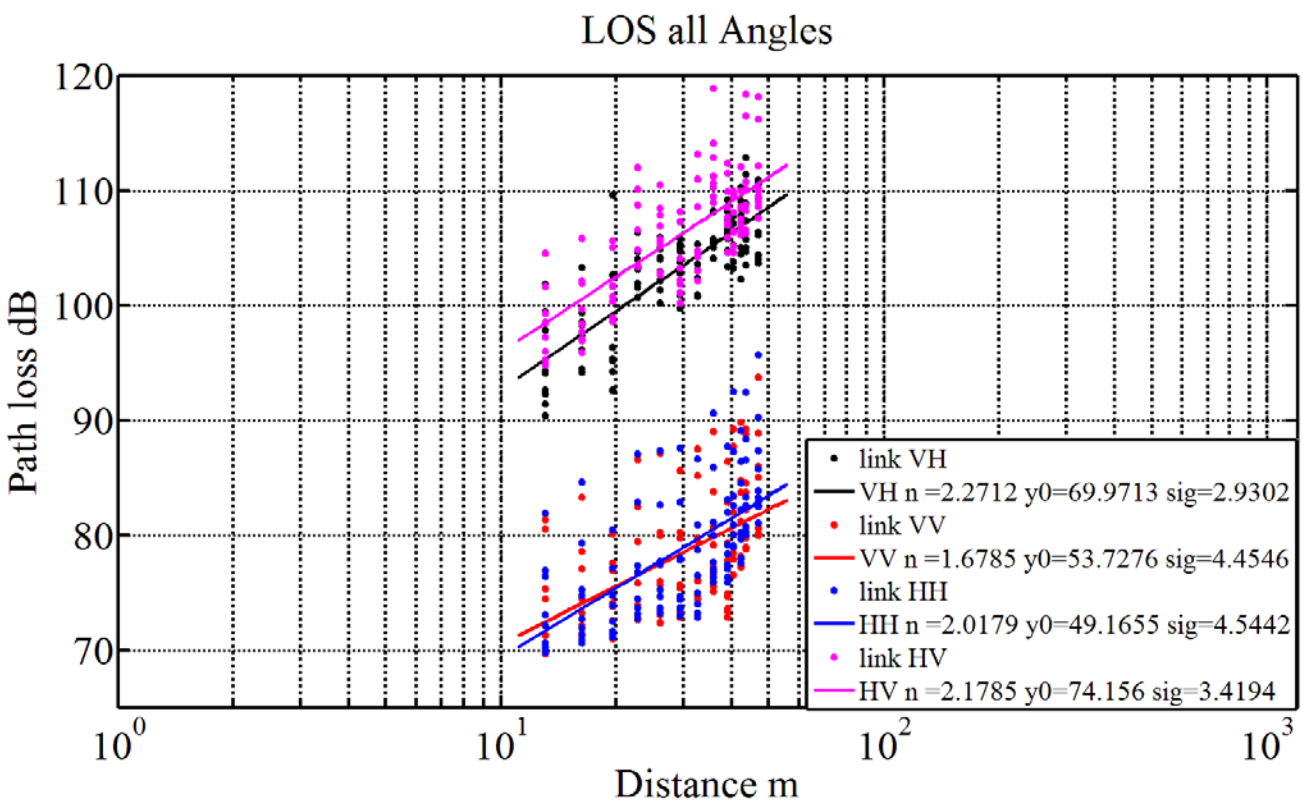
(b) sum of received power from main lobe of antenna

(c) Sum of received power from all angles except main lobe

(d) Sum from all angles to synthesise omni-directional antenna

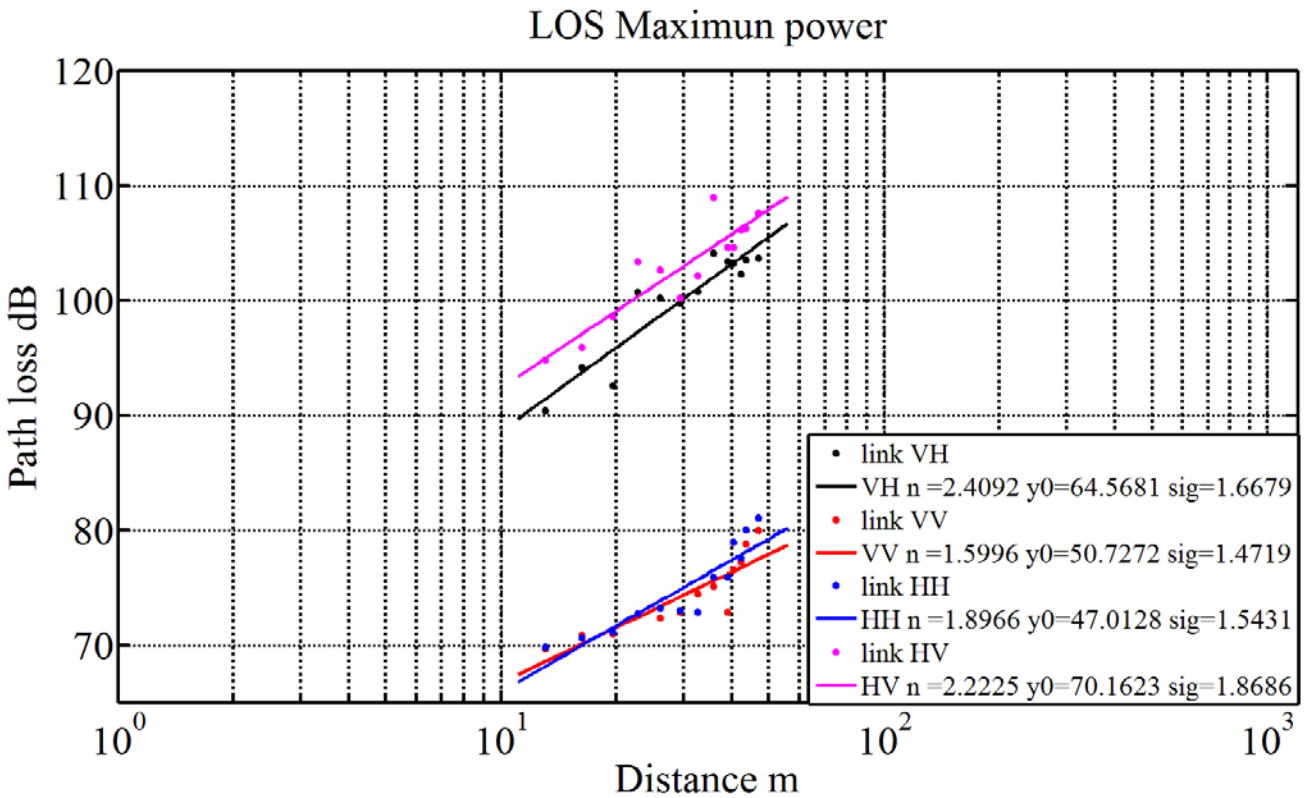
Durham University

Power in the main beam



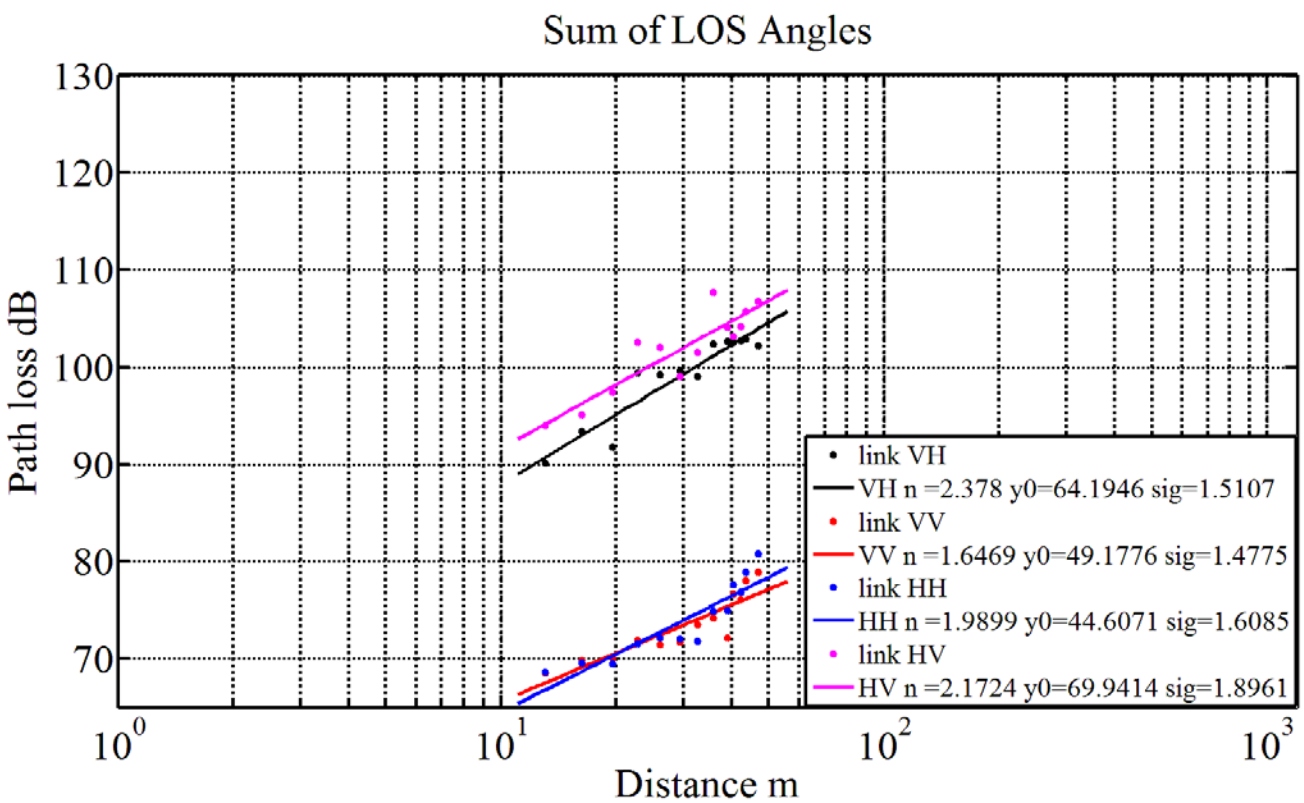
Durham University

Maximum power



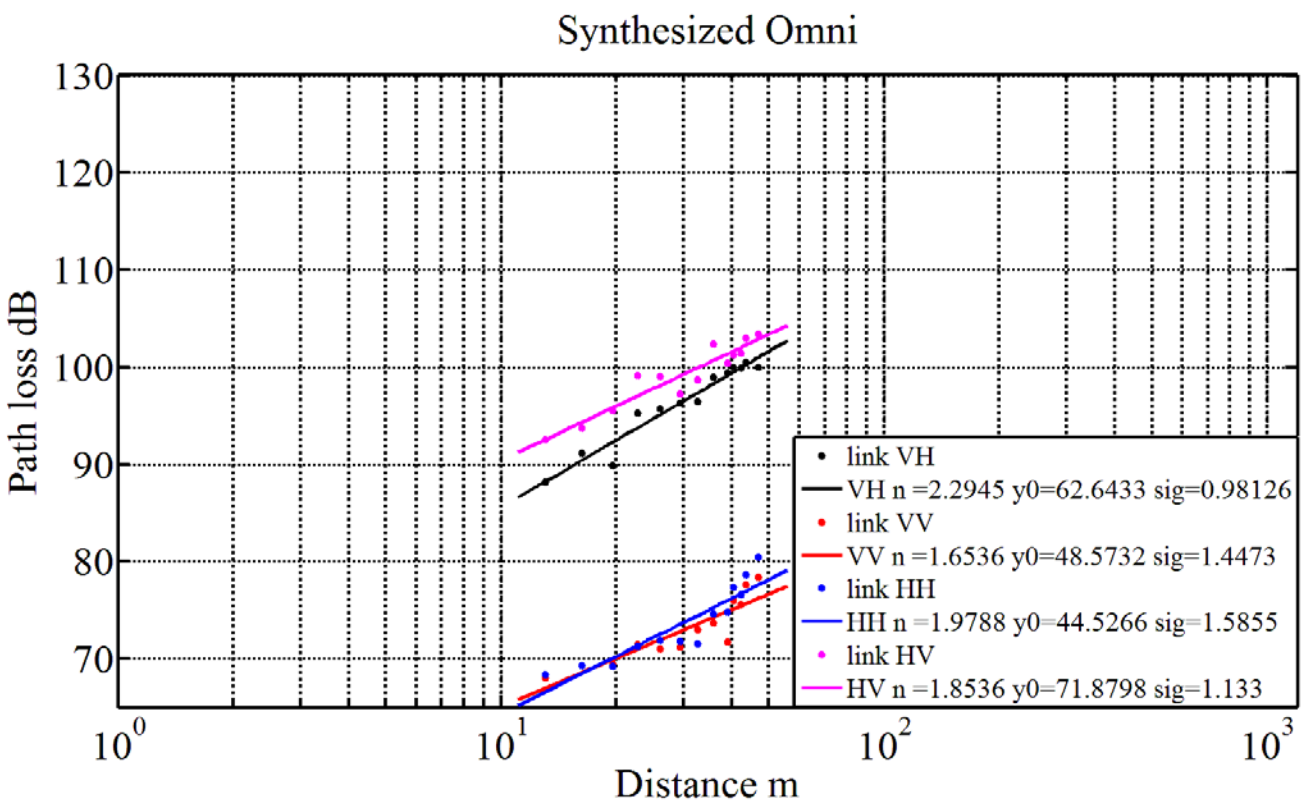
Durham University

Sum of power over main beam



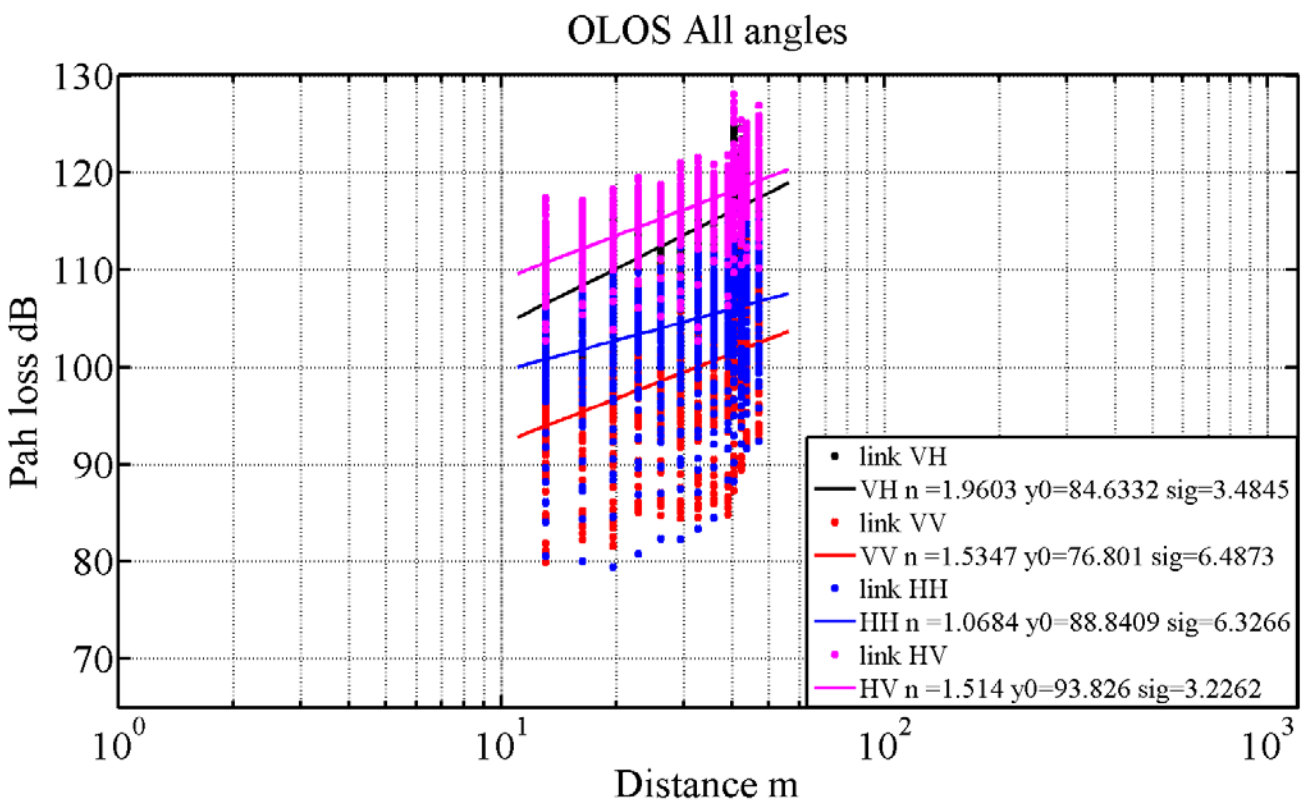
Durham University

Synthesised omni



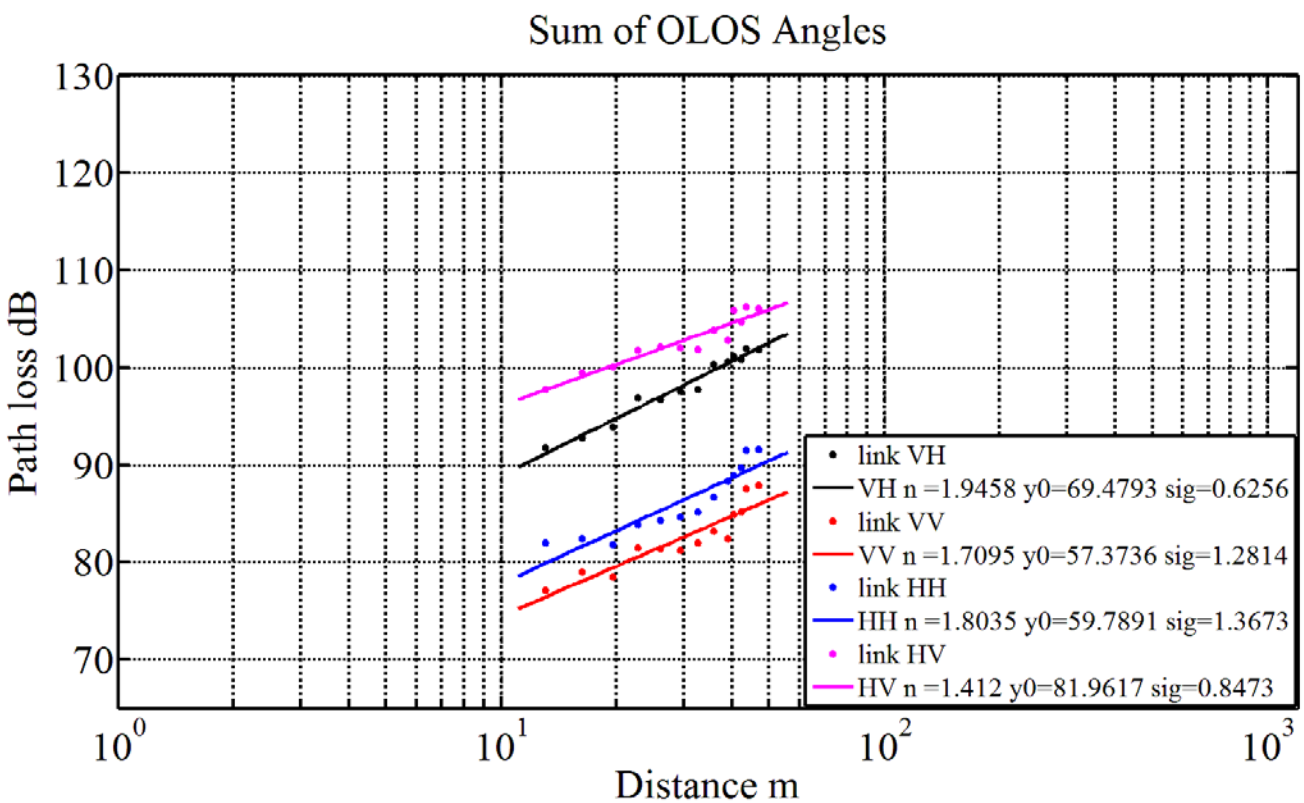
Durham University

OLOS: all angles



Durham University

Sum of power from all OLOS



Durham University

Standardisation:

1. SG3 and SG5 of the ITU with various correspondence groups : target end of March 2017 in preparation for WRC19

2. 3GPP

3. ETSI

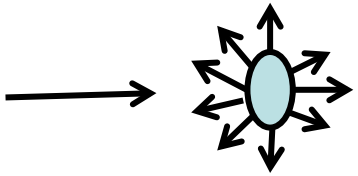
Durham University

Further studies

Dynamic simulations and channel measurements of moving transceivers and scatterers with variations of speed and motion direction.

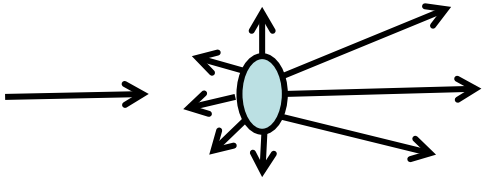
Interference between fixed links. While it is presumed that directional antennas facilitate point to point link communication, the impact of Rayleigh and Mie scattering from rain and precipitation need to be addressed over multiple links.

$\pi D/\lambda << 1$



Rayleigh scattering

$\pi D/\lambda > 1$



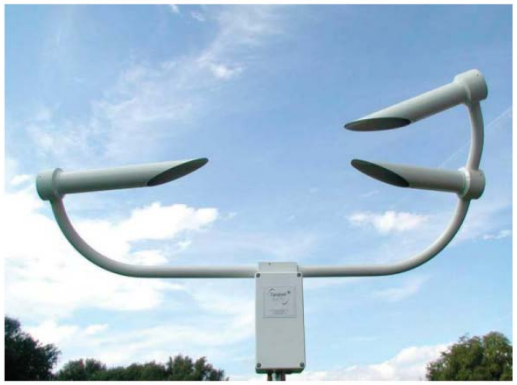
Mie scattering

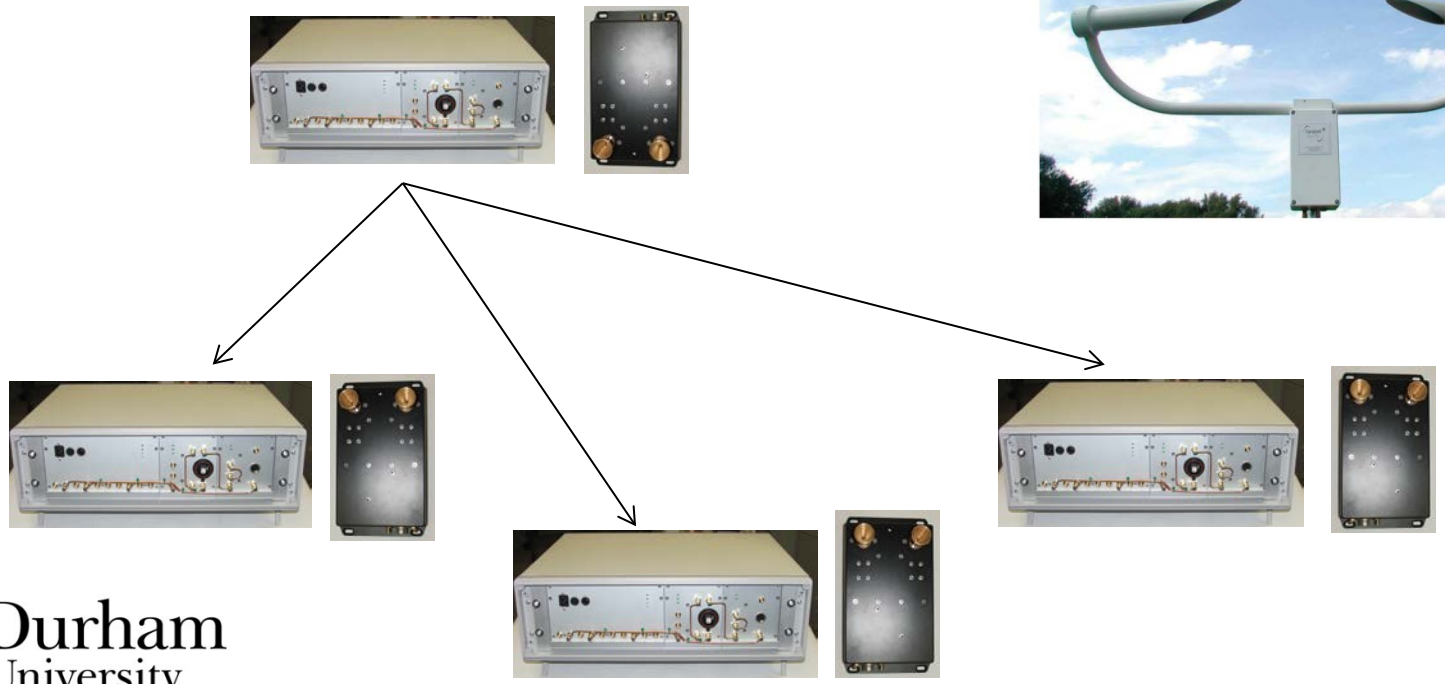
Durham University

Future activity for backhaul

Higher frequency band ~50-90 GHz

Multiple distributed links for interference study





Durham University

Conclusions

Review of ITU Recommendations

State of the art channel sounders and measurements

Proposed path loss estimation

Review of channel models

Directions for future work

Durham University