

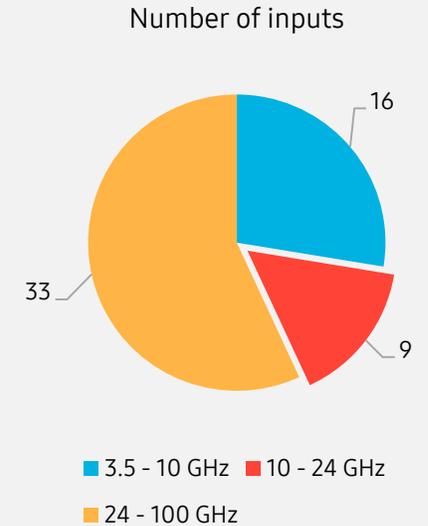
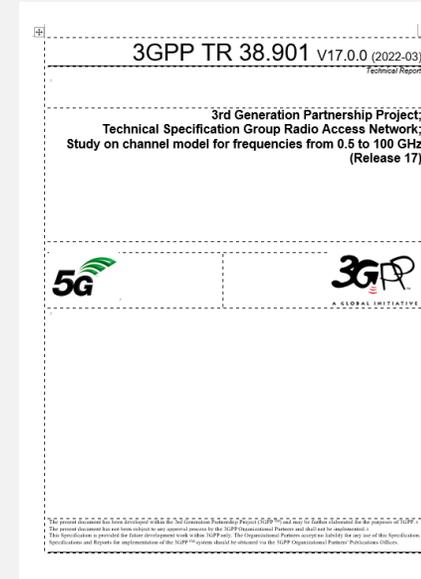
# Motivation and Proposal for FR3 Channel Model Study in Rel-19

# Background

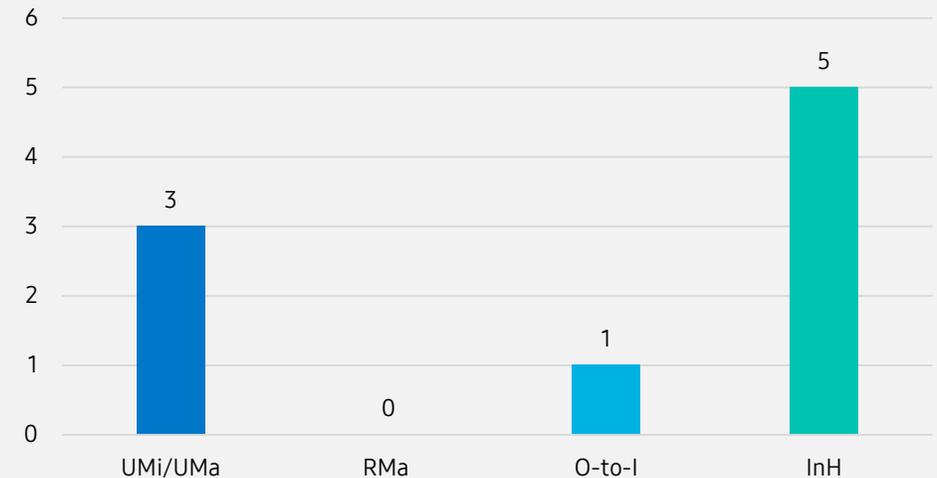
## Frequency spectrum in FR3

- FR3 (7.125 – 24 GHz) is receiving high attention as a candidate spectrum for 6G.
- While the current channel model in 3GPP (e.g., TR38.901) includes from 0.5 to 100 GHz, only a few measurements results were submitted for FR3
  - 3 results for UMa/UMi
  - No result for RMa
  - 1 measurement for O-to-I
- Important to develop proper channel model to evaluate performance especially for MIMO in FR3

**Need to confirm channel model before start working on FR3**



Inputs per scenario in 10 – 24 GHz frequency range



# Review: channel model in TR38.901

In TR38.901, channel model have updated from LTE and for NR covering 0.5 – 100 GHz.

However, there are still missing parts in TR and some models are not confirmed for evaluation for FR3.

- These can be more important in RAN-level performance evaluation and preparation of 6G.

- **Interpolate channel correlation parameters from <6 and >28 GHz without enough measurement sampling in FR3**

- The simple first order scaling of the mean and standard deviation of DS, AoD, AoA, ZoA
- Lack of frequency dependency observation for cluster DS, ASD, ASA, and ZSA for UMi
- Lack of measurement for RMa

- **Pathloss models are applicable for some limited scenarios and assumptions which are important for FR3 applications**

- Pathloss model only with the fixed BS height measurement
- RMa pathloss is limited to use up to 7 GHz, since only one measurement was made in 24 GHz as Note 2 in Pathloss Table 7.4.1-1

- **Lack of measurement on the O2I loss and calibration**

- Measurement for O2I was very limited so this cannot verified yet for FR3
- Calibration is only made for 3.5 and 28 GHz

# Paper Survey on FR3 channel

To identify what to develop in FR3, we reviewed for 100+ published papers for FR3 measurements and found the following observations that are not aligned in 3GPP

## Outdoor measurement

- Mostly considered pathloss and DS only with short distance.
- Significant dependency with BS height for pathloss
- DS is independent of frequency (contradict to 3GPP)
- Not enough measurement for angular domain spread

## Indoor measurement

- Majority of measurements in papers is for indoor with short distance
- Pathloss exponents are more like low frequency
- Significant dependency for wall and floor attenuation
- Small frequency dependency of DS
- Observe some elevation spread

## Special conditions

- Diffraction loss at the corner fits not well with the conventional Knife edge diffraction model
- 30 dB loss with a few trees
- O2I mostly follows established models and also 3GPP model

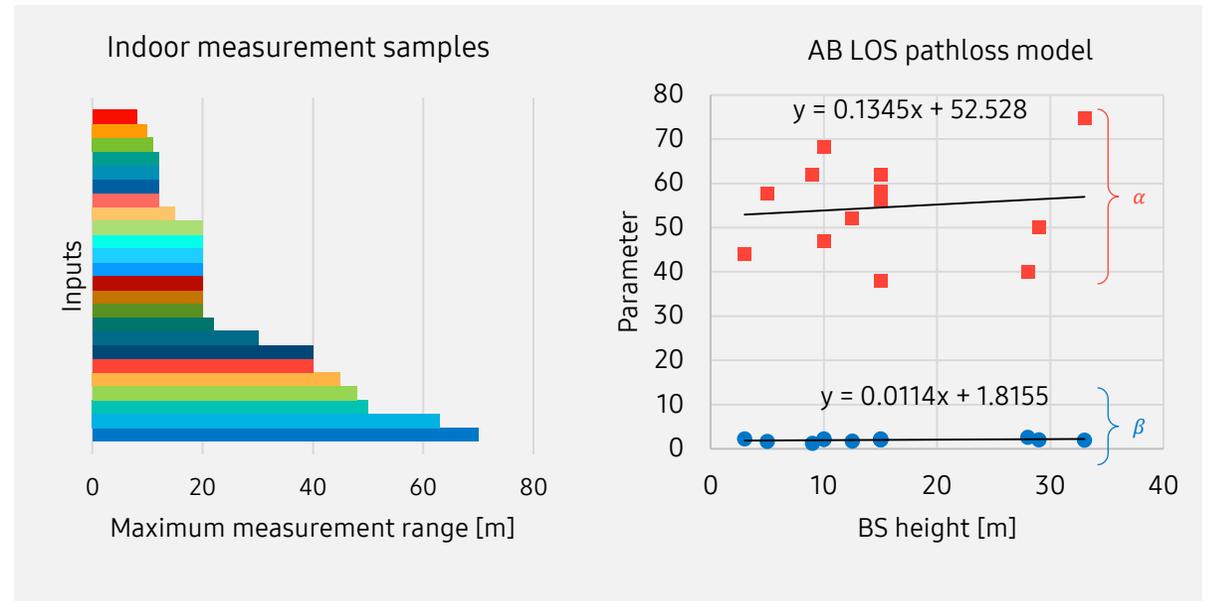
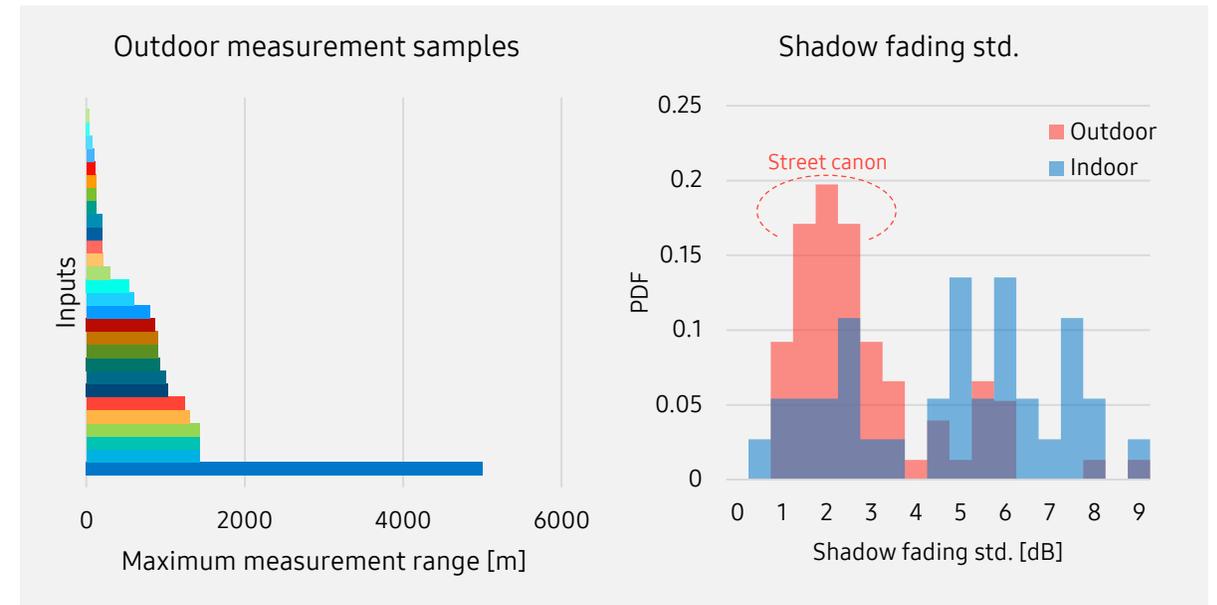
# Pathloss

## Observations in pathloss

3GPP TR38.901	Observations from survey
Outdoor pathloss up to 5Km in UMi/UMa, no model for RMa	Multiple observations for < 100m but a few > 800 m
Outdoor shadow fading std: 4 dB (LOS), 6 dB (NLOS)	Typical value seems 6 dB but less than 4 dB for open space like street canon
Indoor office: 120m x 50m x30 m 300m for big hall	Mostly only measured < 40m
Indoor shadow fading std: 3 (LOS), 8 ~ 8.29 (NLOS)	Observed less than <3 dB
Fixed BS height	Dependency due to BS height

### Recommendation for Pathloss:

- Model verification is required for pathloss of longer range for both indoor and outdoor
- Parameter verification is required for shadow fading values for scenarios
- Consider BS height dependency



# Delay Spread

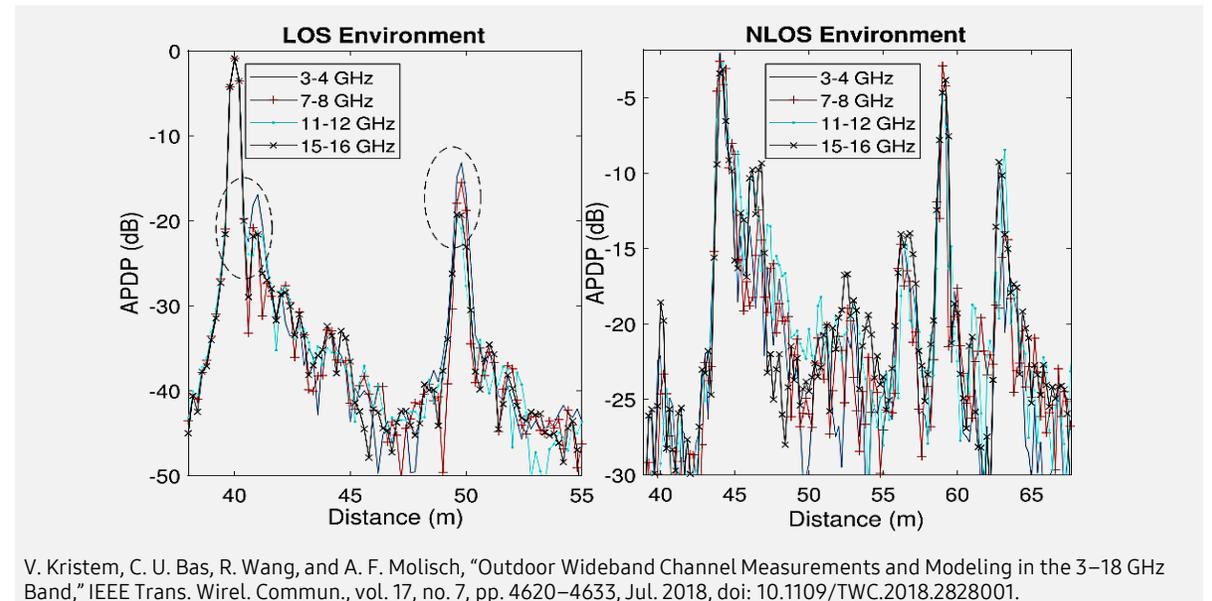
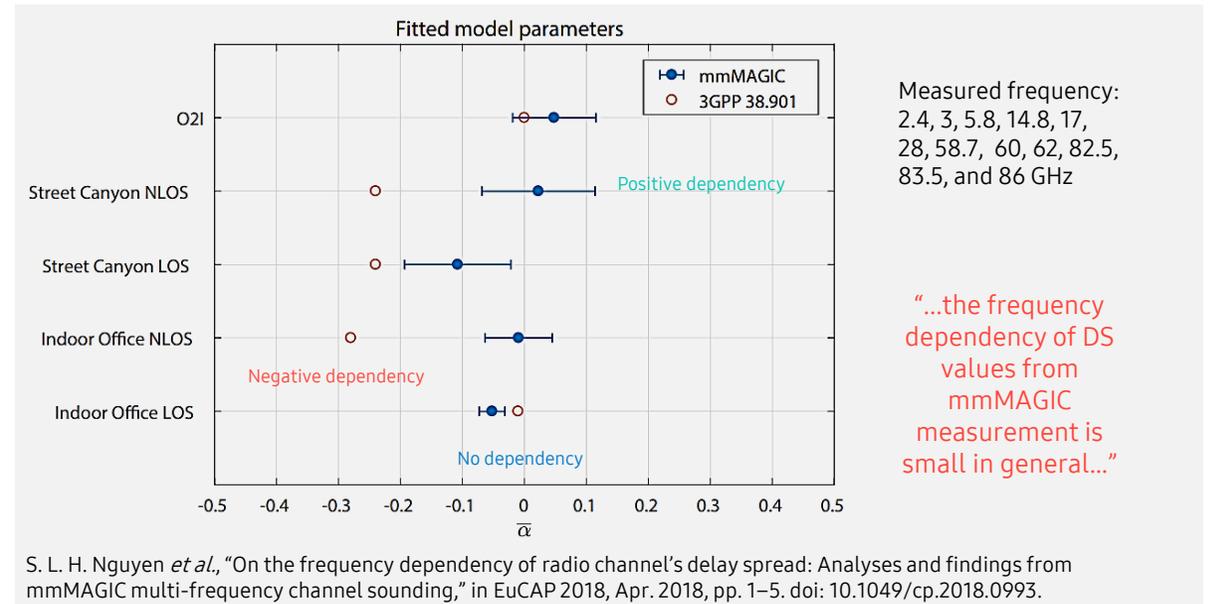
## Observations in DS

3GPP TR38.901	Observations from survey
Frequency-dependent mean and std values of DS: negative dependency with frequency	No dependency can be found
Delay spread scaling factor in Table 7.7.3-2	No dependency can be found

- The 3GPP model has negative dependency, but you can also see a lot of results that do not have dependency or have positive.

## Recommendation for DS:

- Model verification is required for frequency-dependency of DS



V. Kristem, C. U. Bas, R. Wang, and A. F. Molisch, “Outdoor Wideband Channel Measurements and Modeling in the 3–18 GHz Band,” IEEE Trans. Wirel. Commun., vol. 17, no. 7, pp. 4620–4633, Jul. 2018, doi: 10.1109/TWC.2018.2828001.

# Angular Characteristics

## Observations in angular spread

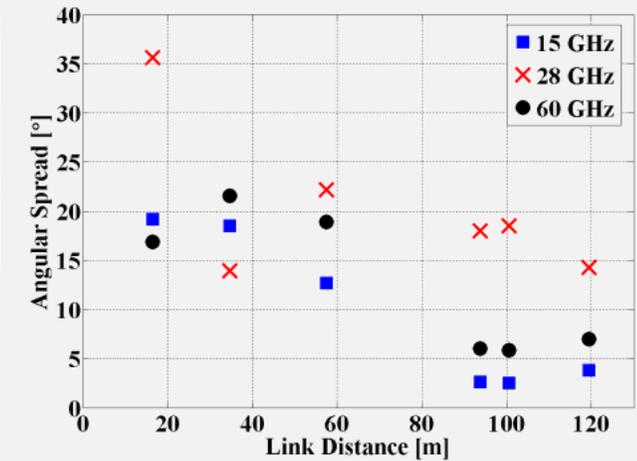
- The number of measurement is quite low for outdoor environment while this is one of the key rule for rank of SU and MU-MIMO
- Some observations found angular spread decreases with distance in “street-canyon” LOS condition
- Some observations found rank distribution is low due to antenna correlation (e.g., 15 GHz) high using one TRP

## Recommendation for AS:

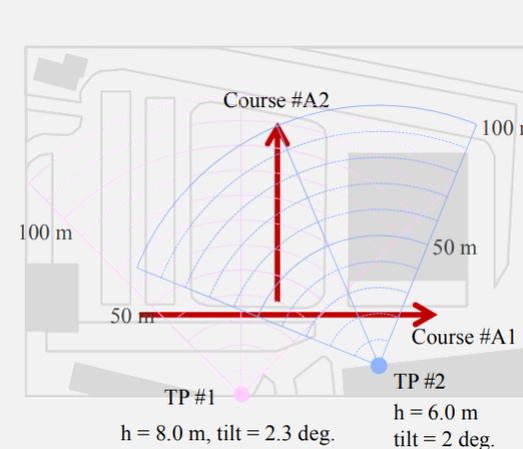
- Angular spread should be carefully measured considering not only correlated but also uncorrelated (MTRP scenarios) scenarios



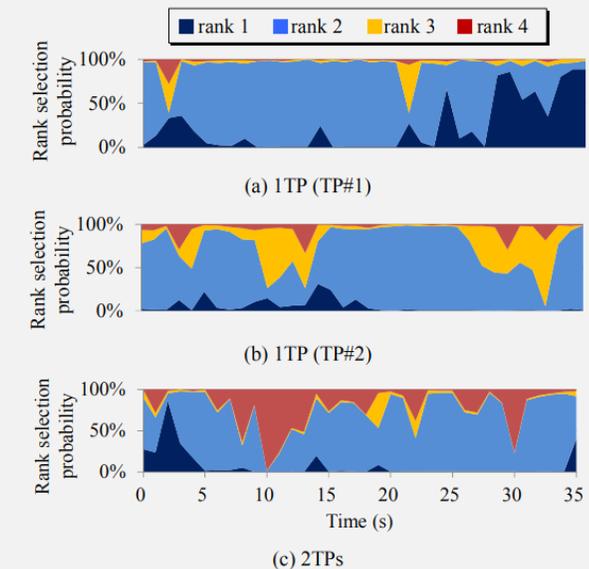
Measurement in a street canyon at 15 GHz



R. Naderpour et al., “Spatio-temporal channel sounding in a street canyon at 15, 28 and 60 GHz,” in PIMRC, Sep. 2016, pp. 1–6. doi: 10.1109/PIMRC.2016.7794730.



“Test in 14.9 GHz S-TRP vs. M-TRP comparison”



D. Kurita et al., “Field Experiments on 5G Radio Access Using Multi-Point Transmission,” in 2015 IEEE Globecom Workshops (GC Wkshps), Dec. 2015, pp. 1–6. doi: 10.1109/GLOCOMW.2015.7414001.

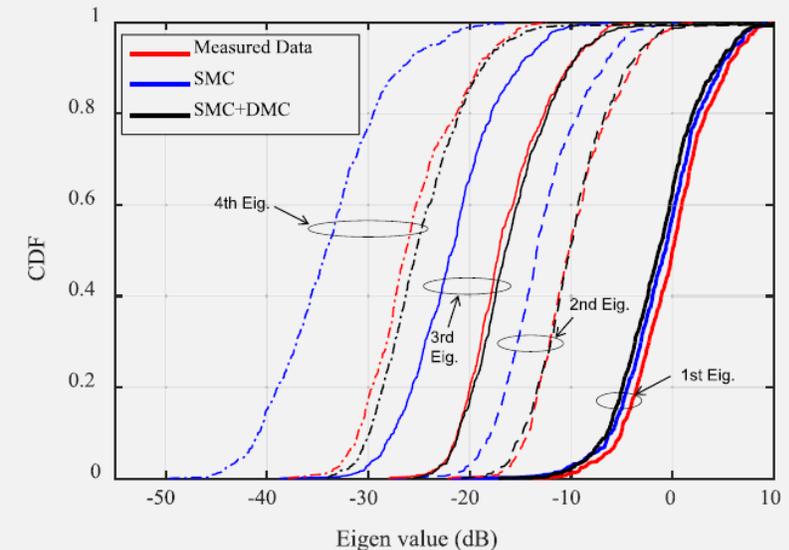
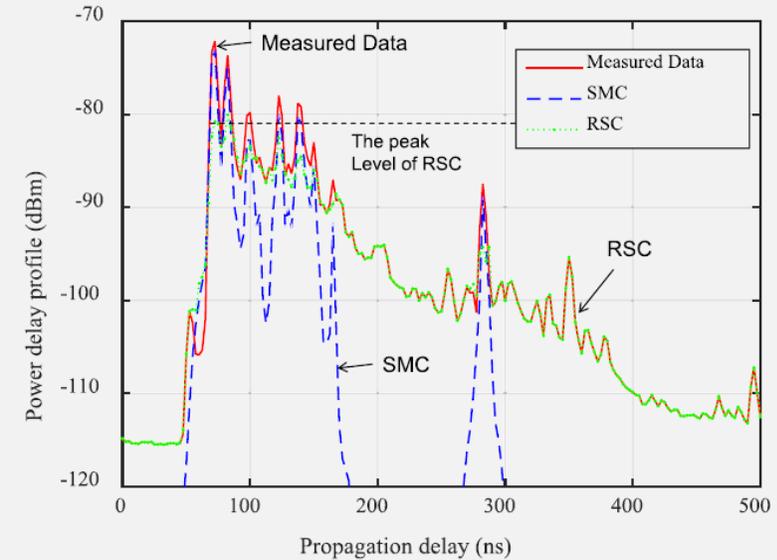
# Channel Profile modeling

## Observation in PDP

- Real channel measurement shows dense diffusion in delay domain esp. indoor channel
- However, for simplicity, current PDP model assumes total channel power only contributes 12 – 20 clusters
- Some measurement found 30 – 50% of channel power can contribute dense multi-path components
- Results found difference of channel rank with and without considering dense multi-path components

## Recommendation for profile modeling:

- Verify current channel modeling to reflect accurate channel rank especially for indoor



# others

## Polarization

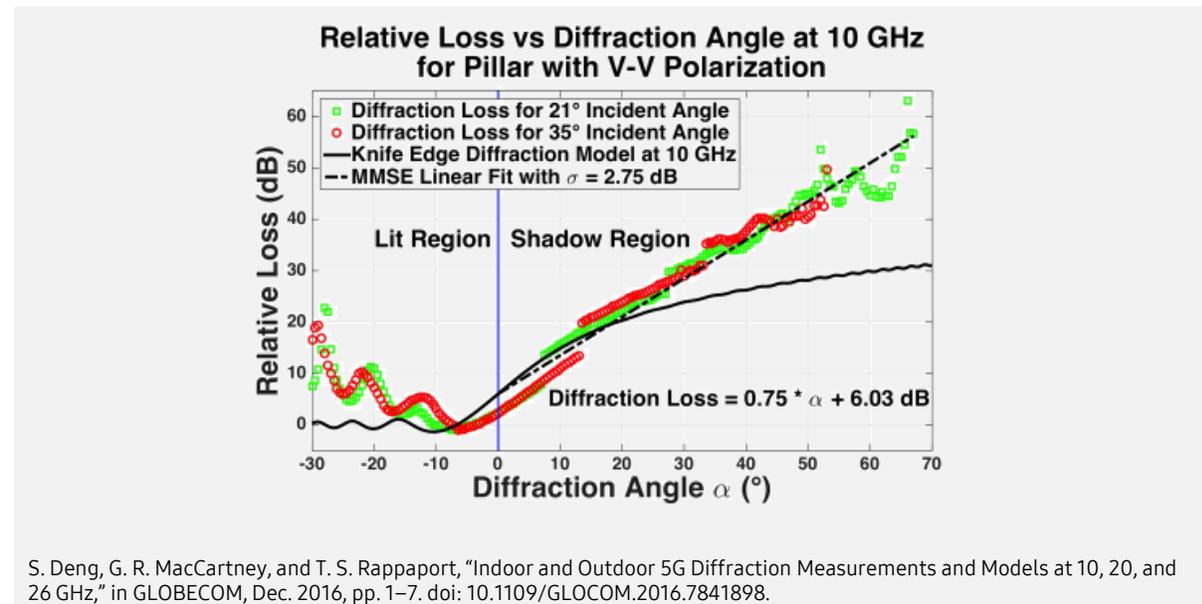
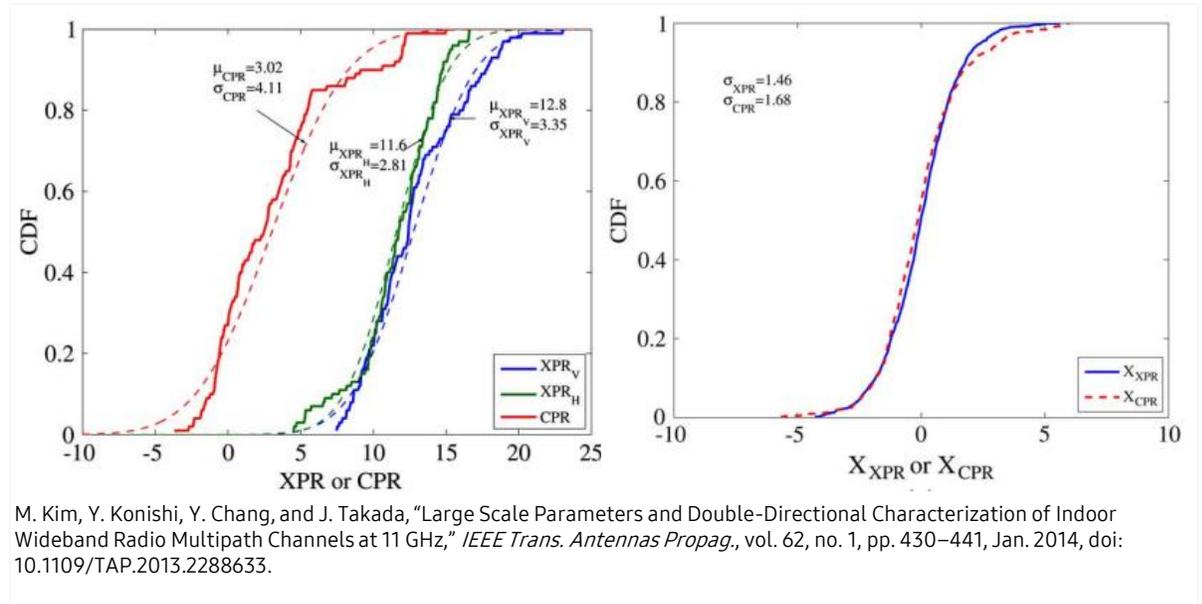
- No big difference for XPR between LOS and NLOS but significant difference was found but only a few sources are available
- Also, large variations over the environments (from 3 to 30 dB) even in LS

## Diffraction

- Knife edge diffraction model may not work with some materials

## Foliage

- Need to check whether foliage loss is more like mmWave or low frequency



# Conclusion: Scope for FR3 channel mode Study

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**Start channel model study for FR3 in Rel-19**

**Update 3GPP Channel Model TR38.901 taking into account additional measurement for both indoor and outdoor, if necessary,**

- Develop pathloss model for longer distance, BS height, and verification of shadow fading (including RMa and O-to-I, if necessary)
- Verification of frequency-dependent parameters such as delay spread
- Develop model of angular characteristic considering antenna correlation and deployments
- Verification of polarization aspect for LOS and NLOS condition and foliage loss in FR3
- Develop model for specific condition including diffraction and multi-diffraction scenario such as cross road or corridor hall
- Develop dense multi-path component model

**To prepare for a study item related on FR3 in Rel-20, a channel model on SI would need to start in Q3/Q4 of 2024**