TU3H-4

Study of Coexistence between 5G Small-Cell Systems and Systems of the Fixed Service at 39 GHz Band

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Outline

- Introduction
- Coexistence Study between 5G Cellular Systems and Fixed Service Stations Operating in the 39 GHz
- Simulation Results
- Conclusions and Future Work

Introduction

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Introduction

- One key requirement for next-generation cellular systems (5G)
  - Achieving multi-Gigabit/s data rates
  - Millimeter-wave wireless technologies have been mainly considered to achieve this goal: 28GHz, 38/39GHz, 60 GHz or 73 GHz
- The use of millimeter-wave bands for 5G could offer
  - Ultra-wide-band spectrum availability, increased channel capacity, and greater potential for spatial densification while reducing the need for high spectral efficiencies.
  - All these benefits come at the expense of potentially greater system complexity particularly in terms of radio frequency (RF) front end and antenna design, but the recent advancements around millimeter-wave wireless systems development have produced cost effective solutions that can be leveraged to overcome these challenges.

Introduction

- 39GHz frequency is considered
  - But the methodology could be applied to many other bands.
  - The 39 GHz band is being globally allocated to the Fixed Service (FS) and being used for point-to-point (PP) applications including backhaul of cellular system in several countries including the United States.
  - As such, successful coexistence of 5G small cells and stations of the FS in same or adjacent areas is of significant interest, specially in terms of opportunities it could create through finding synergies between the two systems.

Introduction

- Analyze interference between 39GHz millimeter-wave small cell networks and stations in the fixed service
  - To numerically identify
    - How much potentially harmful interference will be generated into fixed service stations
    - How much interference should be suppressed to enable co-existence.

39 GHz Sharing Study

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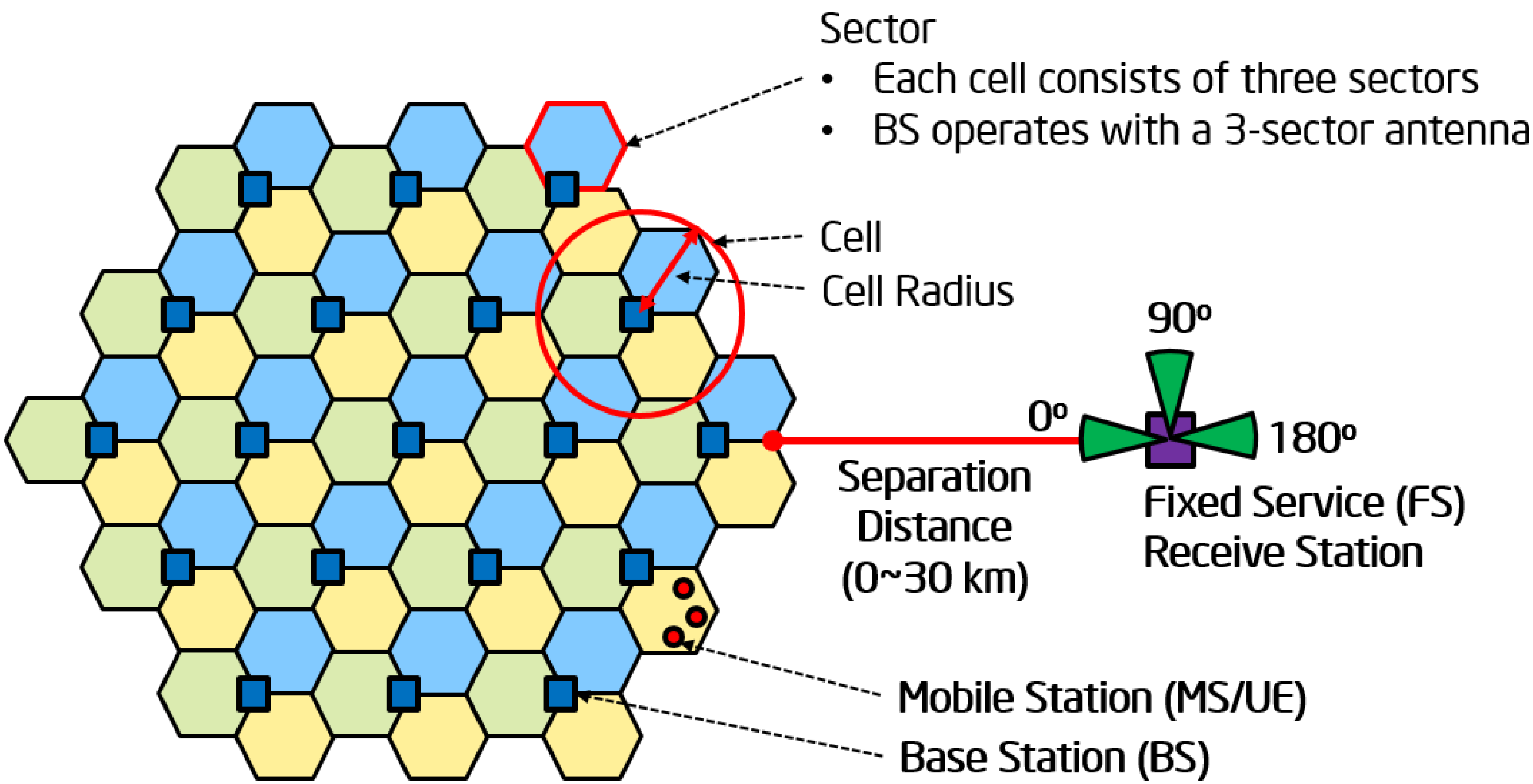
39 GHz Sharing Study

- Network Topology



39 GHz Sharing Study

- **Objective and Methodologies**
  - To determine the **required frequency rejection** as a function of **separation distance** that would allow compatible operation of 5G small cell systems and stations of the fixed service (FS).
  - Two interference scenarios
    - Aggregation of interference to an FS receiver station occurred by transmissions from cellular base stations (BS) to their associated mobile stations (MSs), i.e. **downlink interference**.
    - Aggregation of interference to an FS receiver station occurred by transmissions from MSs to their associated BS, i.e. **uplink interference**.
  - Only Line-of-Sight (LOS) conditions are analyzed here.

39 GHz Sharing Study

- **Objective and Methodologies**
  - After calculating accumulated interferences in each downlink interference and uplink interference scenarios, the required frequency rejection needed to meet protection requirement (denoted as R) can be calculated as follows:

$$R = I - N - \alpha$$

where

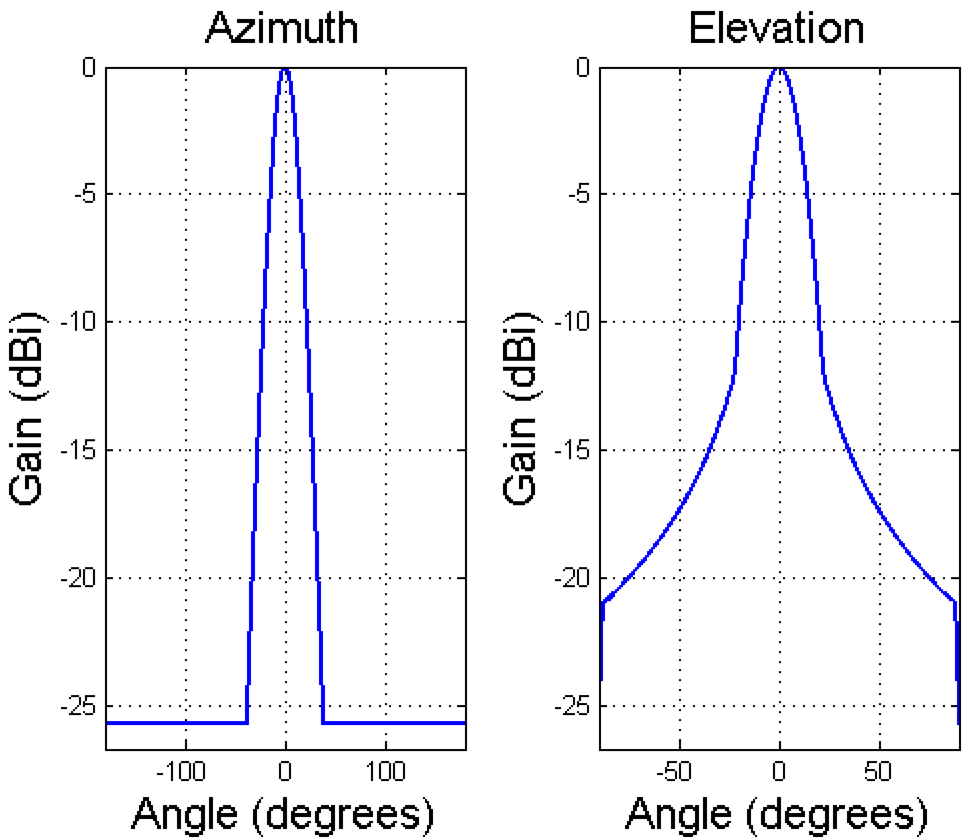
I: accumulated interference,

N: FS receiver antenna thermal noise density (-107.7dB/MHz, ITU-R F.758)

α: required interference-per-noise for protect of FS (-6dB , ITU-R F.758)

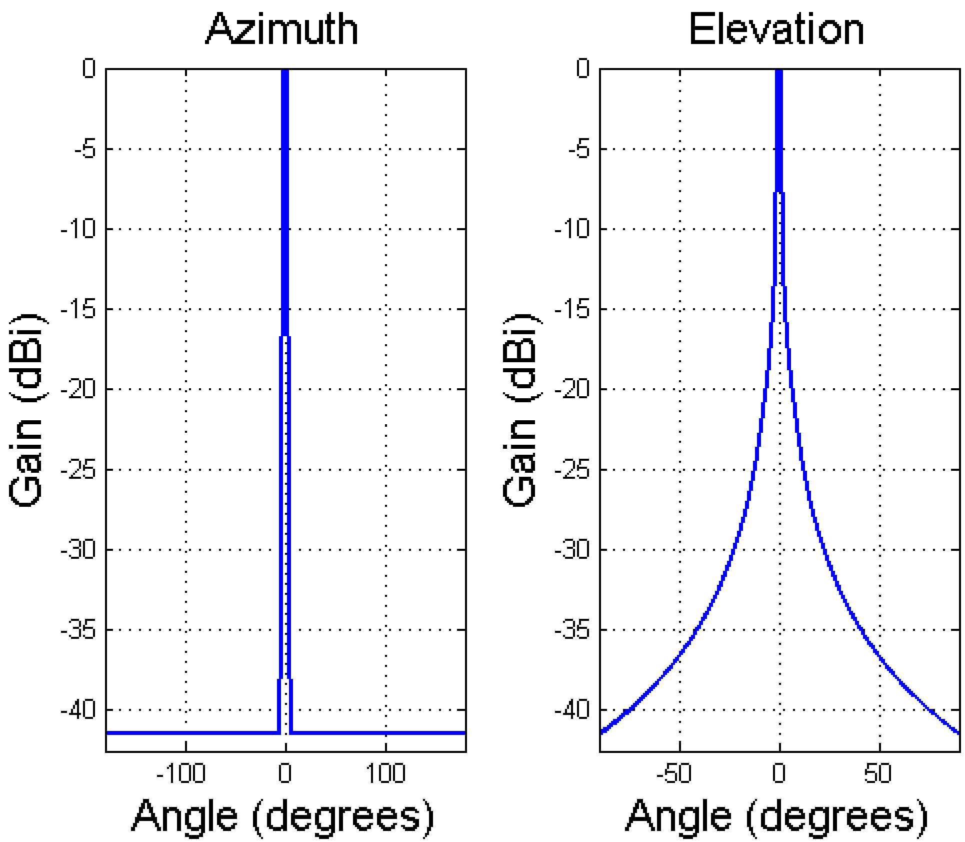
39 GHz Sharing Study

- **Interference Calculation**
  - Antenna radiation pattern (@ BS, max gain: 18 dBi), ITU F.1336-4



39 GHz Sharing Study

- **Interference Calculation**
  - Antenna radiation pattern (@ FS, max gain: 39.2 dBi), ITU F.1336-4



39 GHz Sharing Study

- **Interference Calculation**
  - LOS path loss model, ITU-R P.2001-1

$$PL = 92.44 + 20\ \log_{10} f_c + 10 \cdot n \cdot \log_{10} d$$

where

f_c: carrier frequency in a GHz scale

n: path-loss coefficient ($n = 2.2$)

d: distance in a meter scale

39 GHz Sharing Study

- **Interference to FS receive antenna from BS (Downlink)**
  By the transmission from each BS i to its associated UE j (interference to FS k)

$$I_{i\to j} = P_i + G_i(\varphi^+, \theta^+) - PL(d_{i\to k}) + G_k(\varphi^*, \theta^*)$$

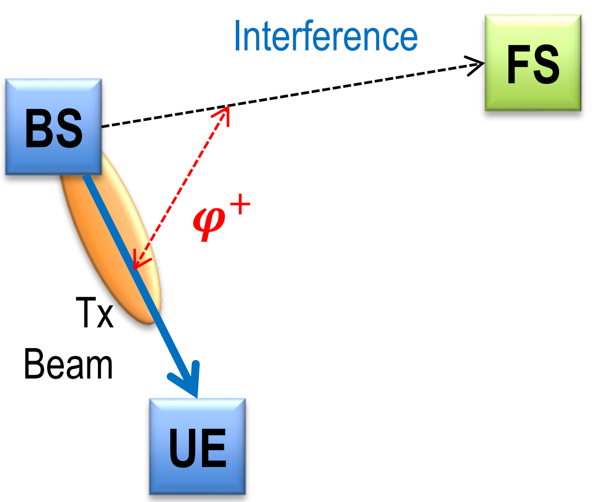
where $I_{i\to j}$ stands for the generated interference to FS k by the transmission from BS i to MS/UE j

- P_i: transmit power at BS i
- $G_i(\varphi^+, \theta^+)$: refer to next page
- $PL(d_{i\to k})$: path-loss from BS i to FS k
- $G_k(\varphi^*, \theta^*)$: refer to next page

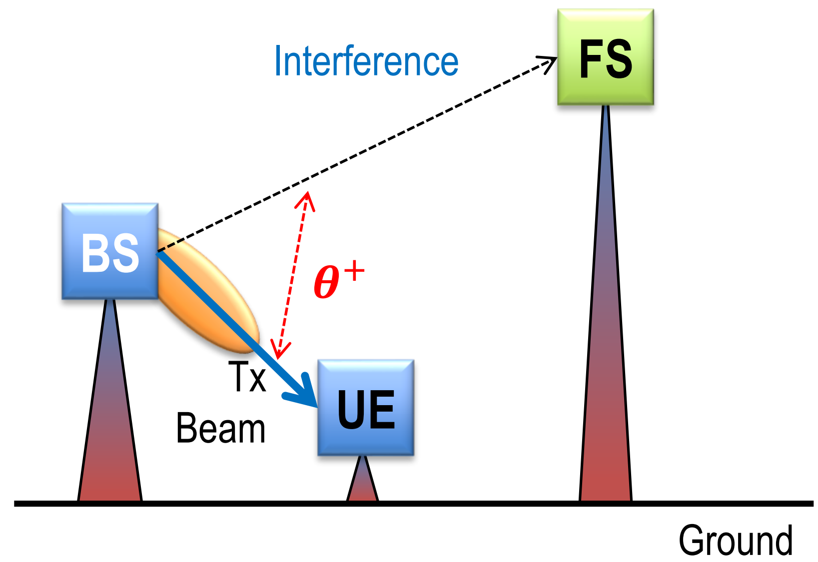
39 GHz Sharing Study

- **Interference to FS receive antenna from BS**
  $G_i(\varphi^+, \theta^+)$: gain to FS due to the transmission from BS to UE

Azimuth angle: φ^+



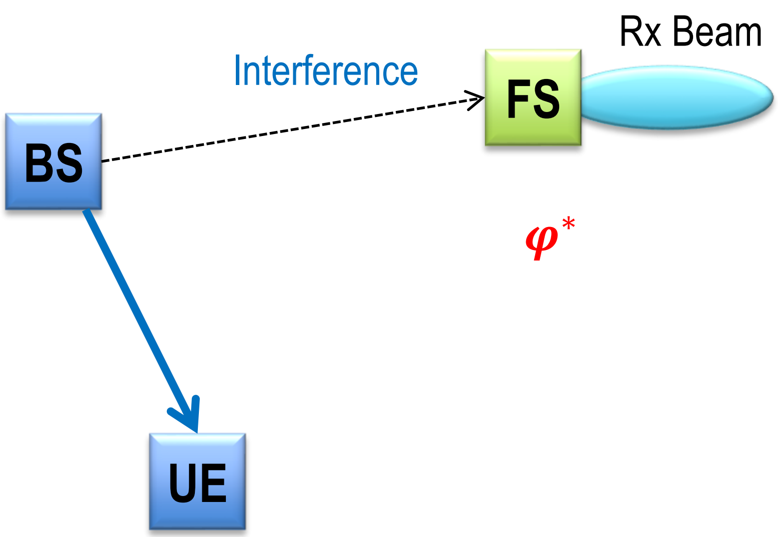
Elevation angle: θ^+



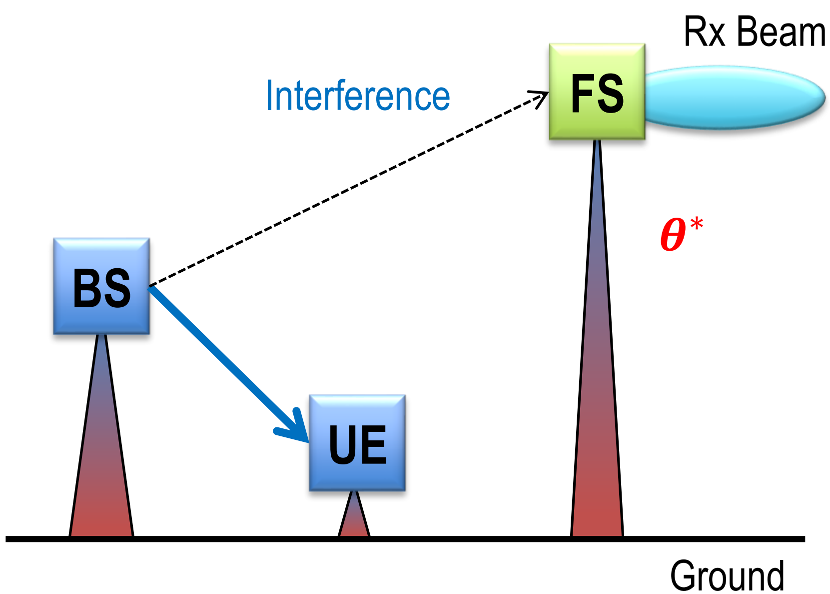
39 GHz Sharing Study

- **Interference to FS receive antenna from BS**
  $G_k(\varphi^*, \theta^*)$: gain at FS due to the transmission from BS to UE

Azimuth angle: φ^*



Elevation angle: θ^*



39 GHz Sharing Study

- **Interference to FS receive antenna from UE (Uplink)**
  By the transmission from each UE *j* to its associated BS *i* (interference to FS k)

$$I_{j\to i} = P_j^* + G_j(0,0) - PL\left(d_{j\to k}\right) + G_k(\varphi^*, \theta^*)$$

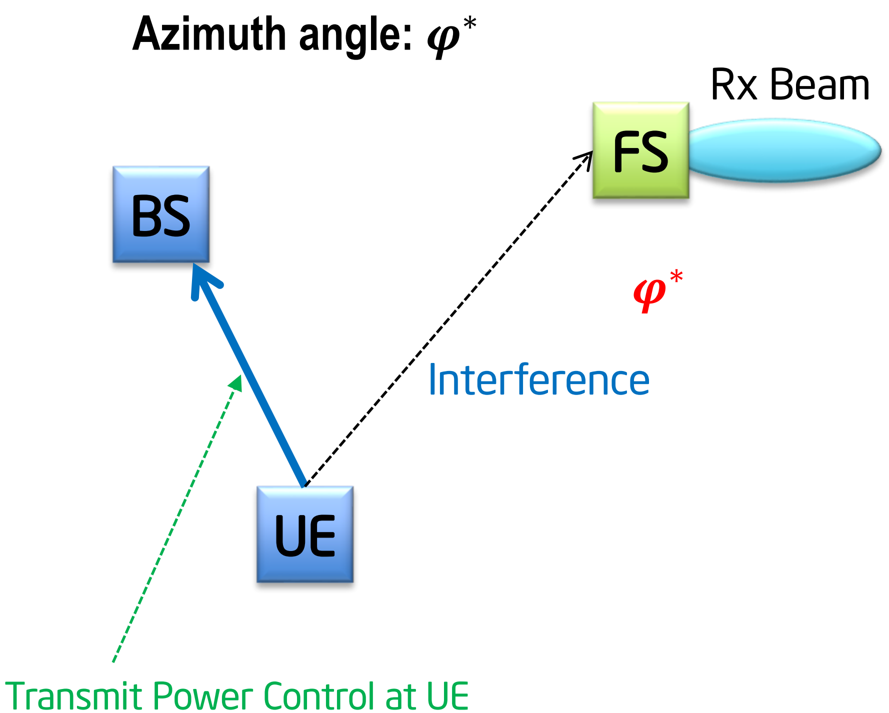
where $I_{j\to i}$ stands for the generated interference to FS k by the transmission from MS/UE j to BS i

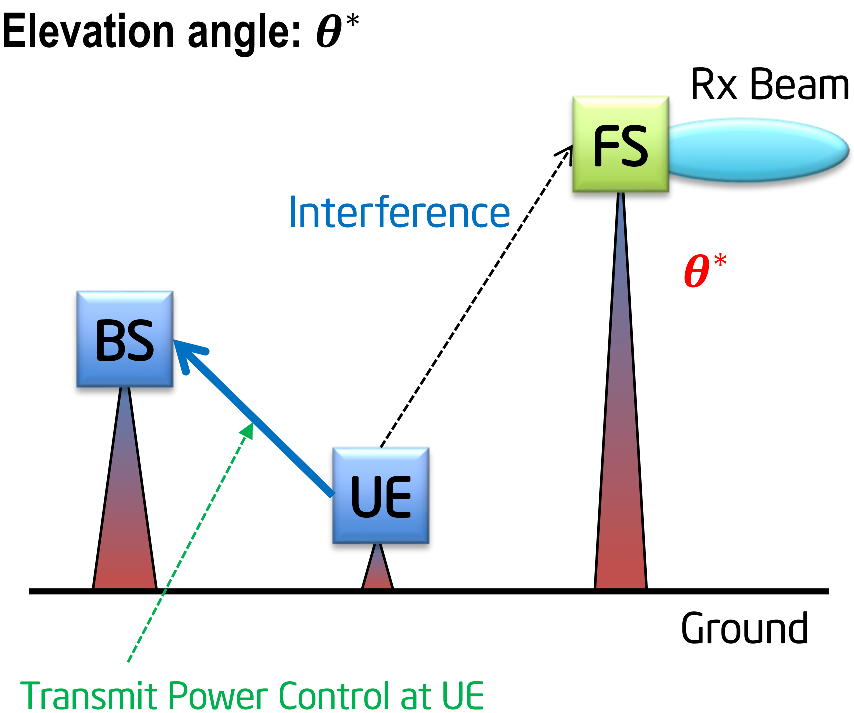
- P_i^*: transmit power at UE *j* with power control (LTE-like operation)
- $G_j(0,0)$: omni-directional antenna at UE, i.e., G_0
- $PL\left(d_{j\to k}\right)$: path-loss from UE *j* to FS k
- $G_k(\varphi^*, \theta^*)$: refer to next page

39 GHz Sharing Study

- **Interference to FS receive antenna from UE**

  $G_k(\varphi^*, \theta^*)$: gain at FS due to the transmission from UE to BS





Simulation Results

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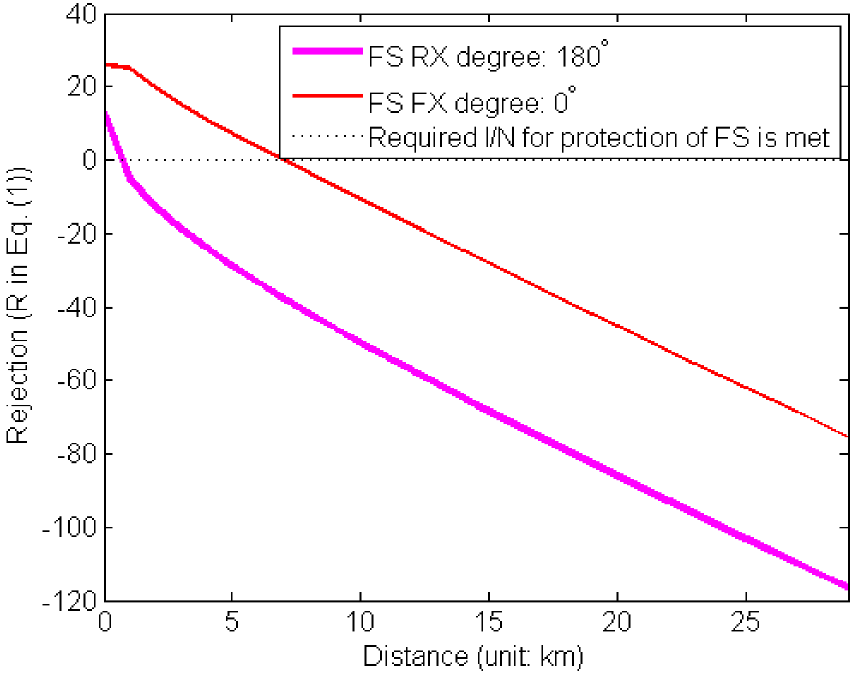
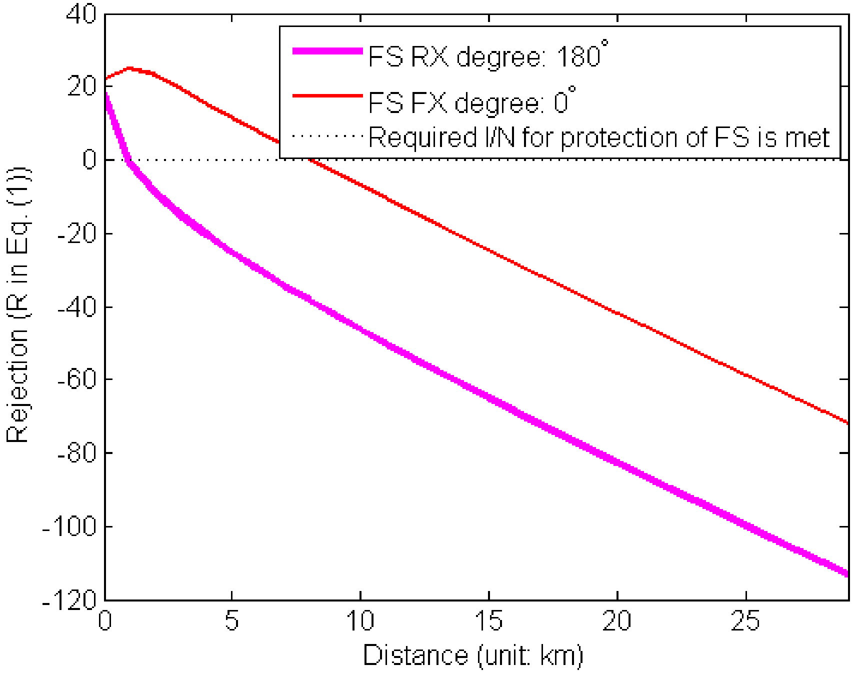
Simulation Results (Downlink)



- For the case of orientation of an FS receive station of 180 degree, a separation distance of 1km is at least needed to satisfy the required I/N for protection of the operation of FS.
- For the case of the 0 degree orientation, however, the required I/N for projection of FS could be met with separation distances of larger than 7km.

Simulation Results (Uplink)



- For the case of orientation of the FS receive station of 180 degree, a separation distance of 1.5km is at least needed to satisfy the required I/N for protection of the operation of FS.
- For the case of the 0 degree orientation, however, the required I/N for projection of FS could be met with separation distances of larger than 8km.

Conclusions and Future Work

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Conclusions and Future Work

- **Conclusions**
  - 39 GHz millimeter-wave sharing study results between small cells and FS stations in terms of required frequency rejection
  - We calculate the amount of downlink and uplink interferences accumulated in an FS receive antenna and determine how much interference should be suppressed to prevent from harmful interference.
- **Future Work**
  - Sharing study for the other millimeter-wave bands

Q&A