28 GHz mmWave Measurements for Joint Communications and Sensing

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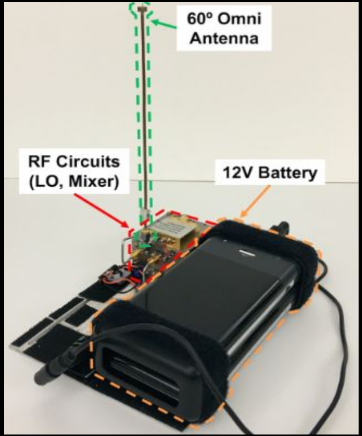
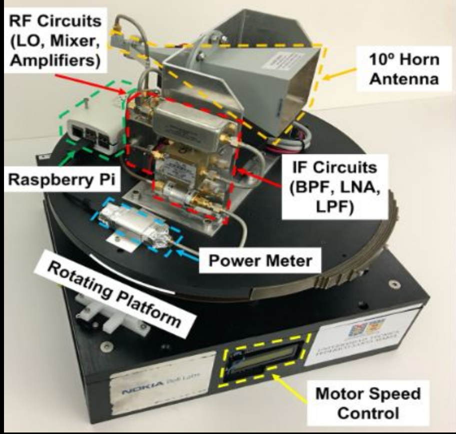
NSF

Motivation

- Expand the traditional use of communication systems to perform sensing.
- Outdoor:
  - Pedestrian and traffic detection for self-driving cars
- Indoor:
  - Warehouse management
  - Fall detection

28 GHz mmWave Channel Sounder



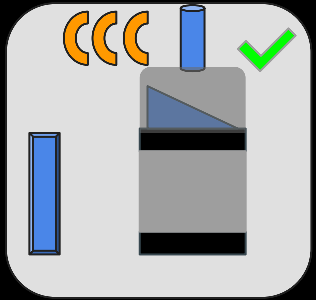


Portable 28 GHz omni antenna transmitter and 10-degree receiver developed by Nokia Bell Labs and Universidad Técnica Federico Santa María for propagation modeling in communication [1-3].

[1] J. Du, D. Chizhik, R. Valenzuela, R. Feick, G. Castro, M. Rodriguez, T. Chen, M. Kohli, and G. Zussman, "Directional Measurements in Urban Street Canyons from Macro Rooftop Sites at 28 GHz for 90% Outdoor Coverage," IEEE Transactions on Antenna and Propagation, Dec. 2020.
[2] M. Kohli, A. Adhikari, G. Avci, S. Brent, J. Moser, S. Hossain, A. Dash, I. Kadota, R. Feick, D. Chizhik, J. Du, R. Valenzuela, and G. Zussman, "Outdoor-to-Indoor 28GHz Wireless Measurements in Manhattan: Path Loss, Location Impacts, and 90% Coverage," in Proc. ACM MobiHoc'22, Seoul, South Korea, Oct. 2022.
[3] D. Chizhik, J. Du, M. Kohli, A. Adhikari, R. Feick, R. Valenzuela, and G. Zussman, "Accurate urban path loss models including diffuse scatter," in Proc. 17th European Conf. on Antennas and Propagation (EuCAP'23), Florence, Italy, Mar. 2023.

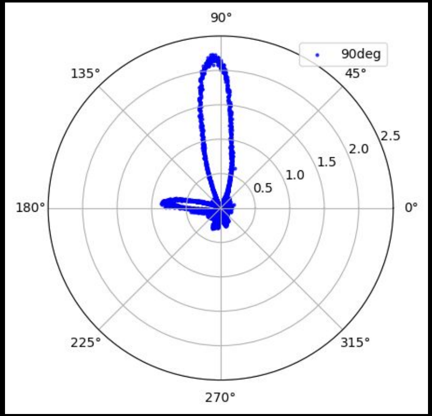
Building a JCAS Platform

- Elevated TX above RX to clear nearby obstacles.
- Aluminum foil below transmitter to avoid self-interference.



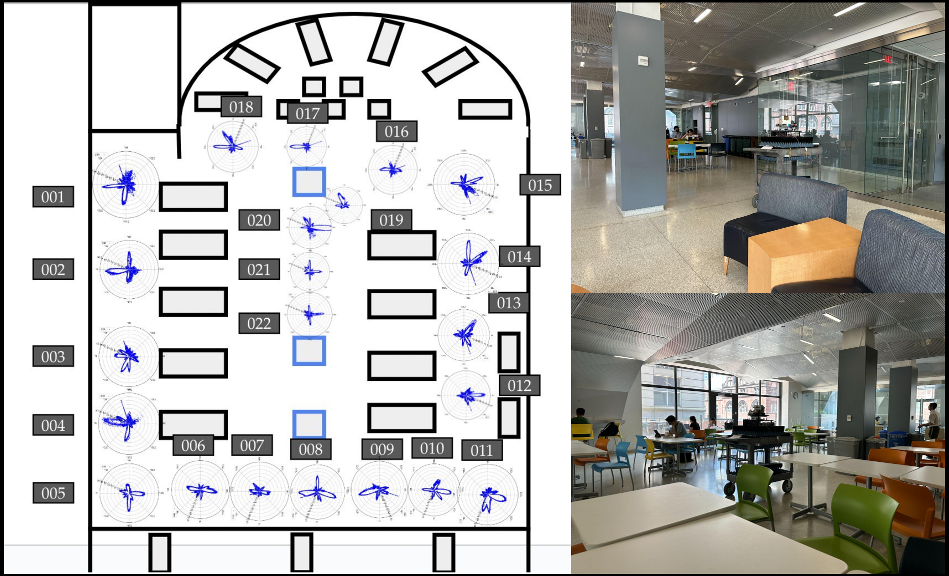
Height Adjustment

Outdoor Calibration



Peak in direction of wall (90°)

Indoor measurements



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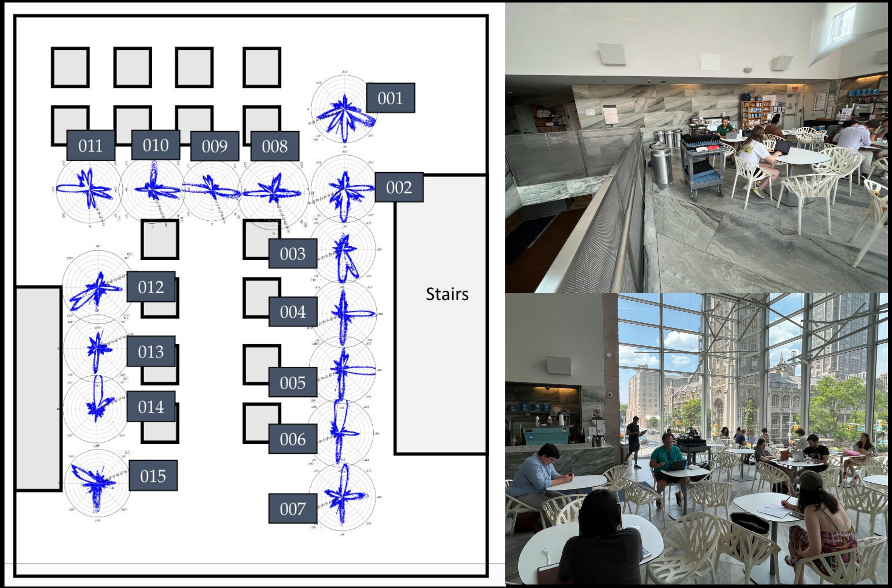
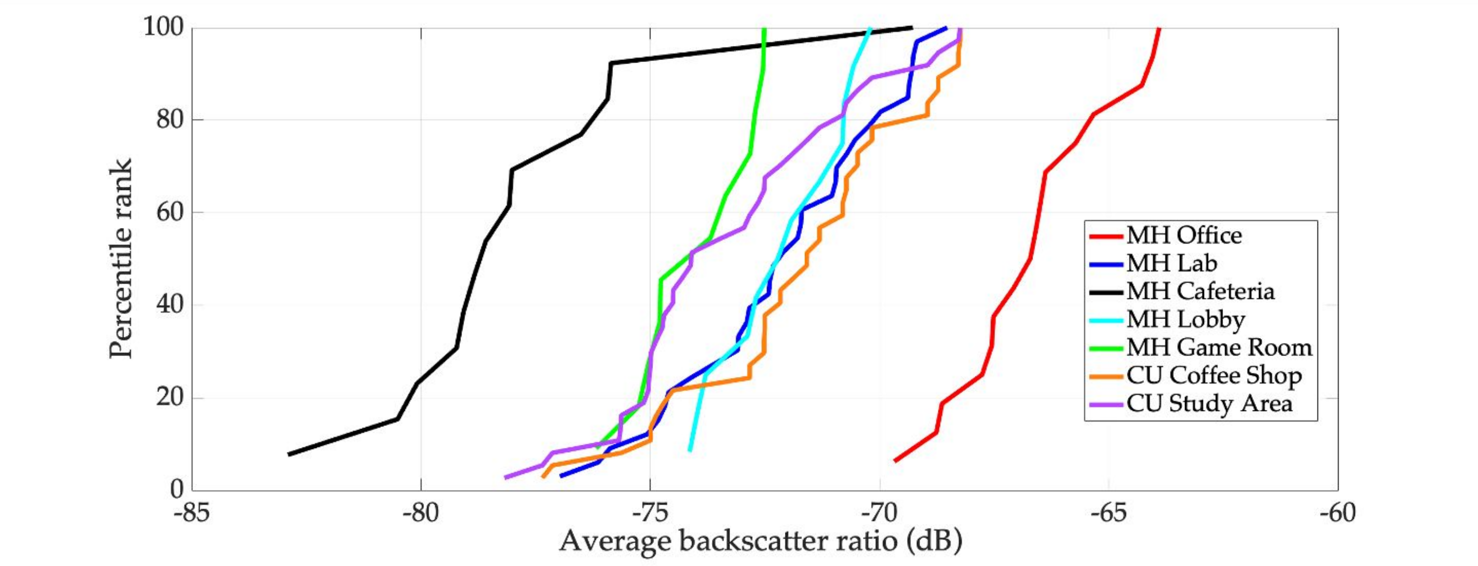


Joe Coffee

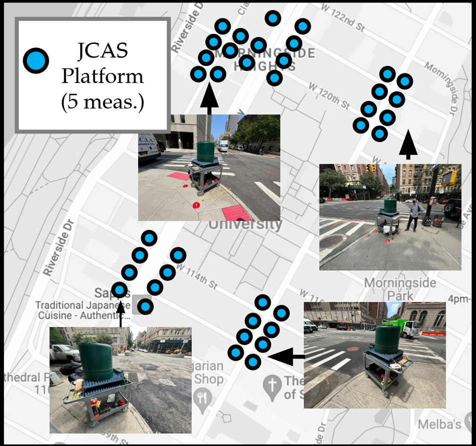
Indoor Backscatter Measurements

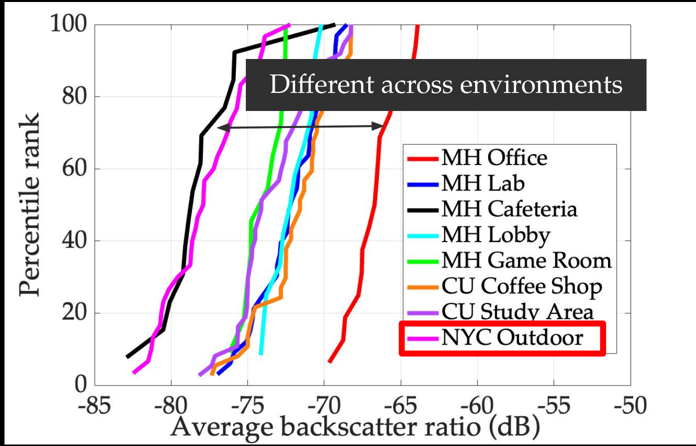
- CDF statistical model confirms that smaller rooms have higher average backscatter, and larger rooms exhibit lower backscatter.

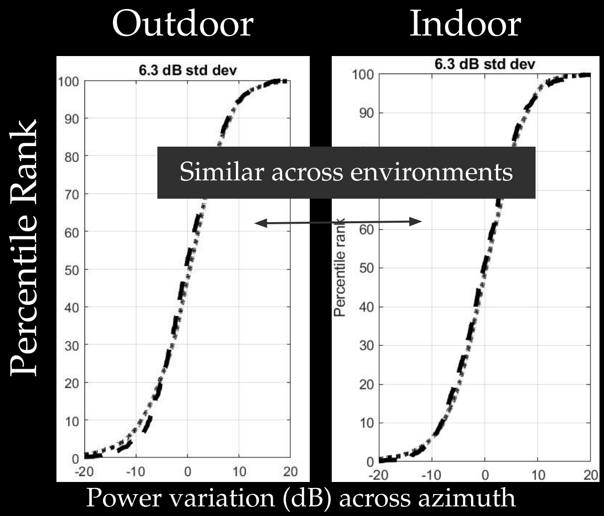


Outdoor Backscatter Measurements

- Using the COSMOS FCC Innovation Zone [4], we collected 2,872,800 individual backscatter measurements in 190 locations spanning 10 intersections in NYC.
- We obtain a static clutter statistical model for avg. backscatter and power variation across azimuth.





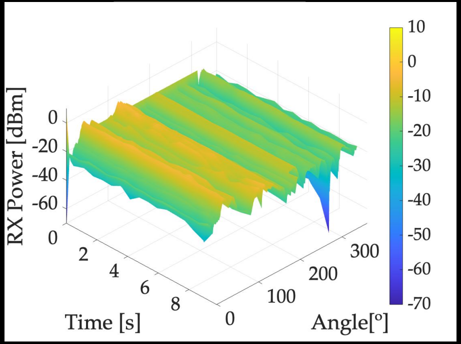


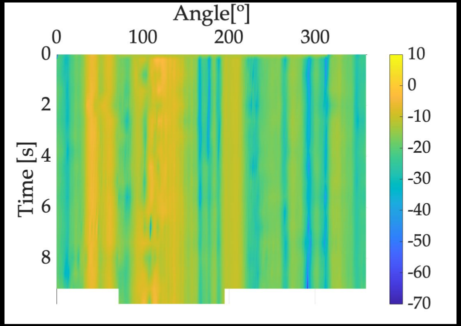
[4] D. Raychaudhuri, I. Seskar, G. Zussman, T. Korakis, D. Kilper, T. Chen, J. Kolodziejski, M. Sherman, Z. Kostic, X. Gu, H. Krishnaswamy, S. Maheshwari, P. Skrimponis, and C. Gutterman, "Challenge: COSMOS: A city-scale programmable testbed for experimentation with advanced wireless," in Proc. ACM MobiCom'20, 2020.

Vehicle Detection

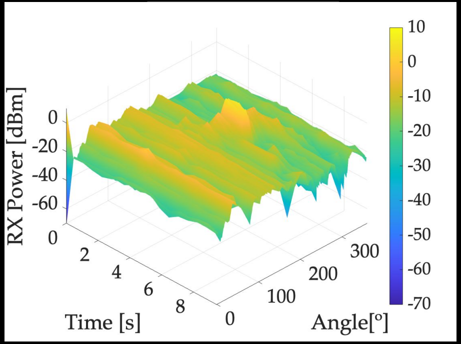
- We observe that the presence of a bus ~3m away from the JCAS Platform causes a 32.7 dB increase in backscattered power.

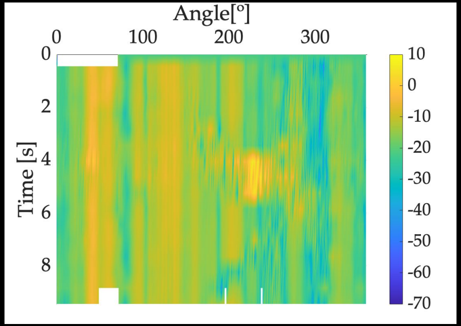
Empty Measurement



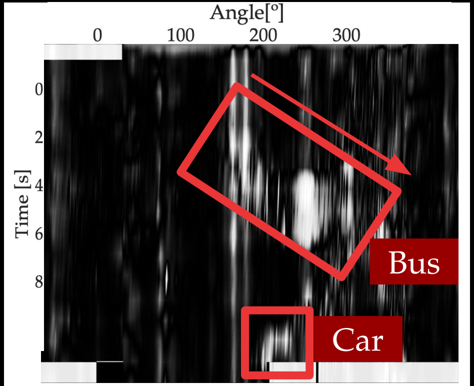


Vehicle Measurement



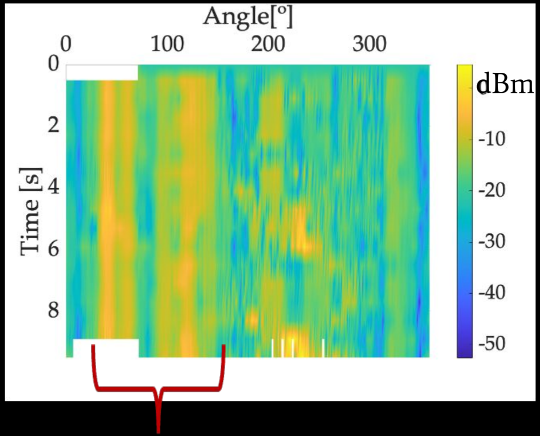


Difference



Vehicle Detection

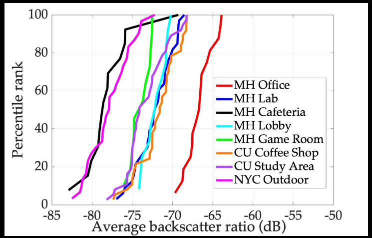
- Shown below is a real-time illustration of the 2D angular spectrum, with red boxes manually labeling nearby vehicles and red arrows manually visualizing the progression in time and arrival angle.

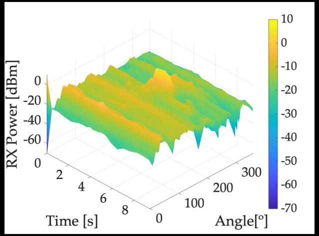


- Greater backscattered power from angles corresponding to nearest building, versus relatively open areas between 150-360 degrees.

Summary

- Street clutter backscatter model provided based on 2,872,800 measurements in 190 locations spanning 10 intersections in NYC
- Both outdoor and indoor environments show examples of deterministic backscatter, useful for detecting people or vehicles





Next steps:

Pedestrian Detection

Traffic Density Modeling

Lidar-Informed Modelling