Toward Massive-MIMO mmWave ISAC

An Open Framework for Scalable RF Sensing and Communications

Tiami Networks

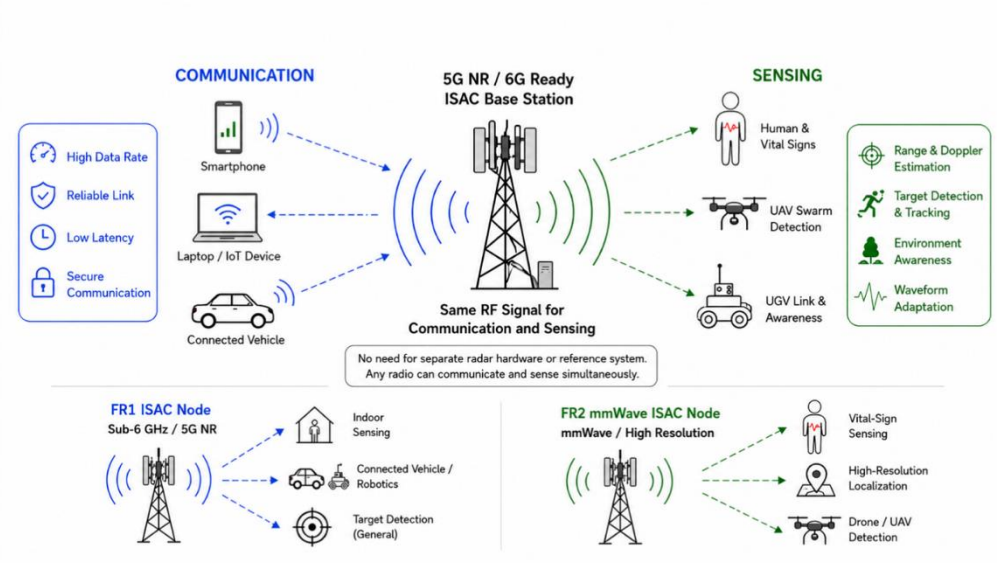
Overview

KEY CONTRIBUTIONS

- **PolyBase**: We present PolyBase, an open SDR-based ISAC framework that provides a practical implementation path for next-generation ISAC systems.

- **mmWave ISAC:** We demonstrate a practical experimental pathway toward massive-multiple-input multiple-output (MIMO) mmWave ISAC using existing 5G NR infrastructure.

- **OTA Validation:** We validate both systems using SDR-based HWIL and OTA testbeds. The captured in-phase and quadrature (I/Q) samples are processed using a real-time radar digital signal processing (DSP) pipeline in both indoor and outdoor environments.



Waveform Configuration: Standard 5G NR

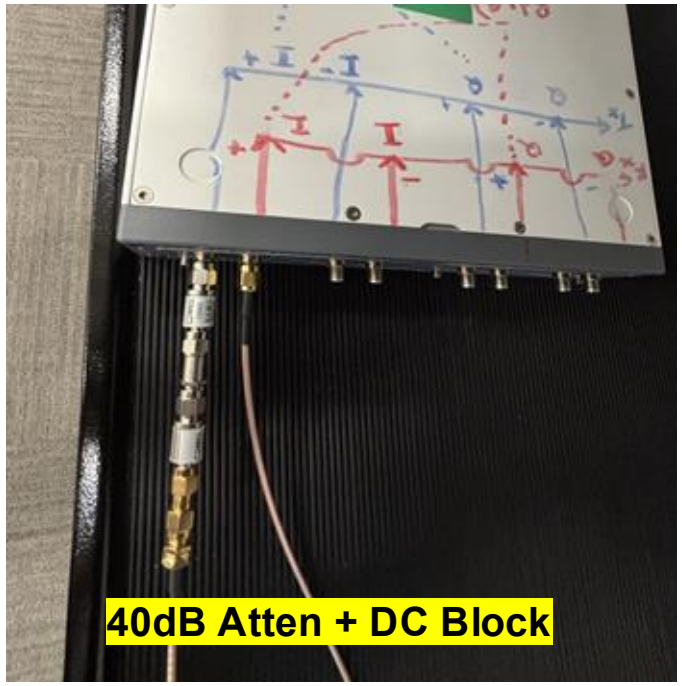
Key Waveform Configuration: 5G NR, 3GPP Compliant

as configured in the live testbed

Parameter	Testbed value
Frequency band	n257 (26.5 to 29.5 GHz, FR2), TDD
Carrier / SSB frequency	27.53328 GHz (NR ARFCN 2071387)
Subcarrier spacing	120 kHz (numerology μ = 3)
Channel bandwidth	32 PRB = 46.08 MHz occupied (50 MHz channel)
Waveform	CP-OFDM downlink
Frame structure	10 ms frame, 0.125 ms slot, 14 symbols / slot
SSB block pattern	Case D (120 kHz SSB SCS), up to 64 beams
SSB periodicity	20 ms (default assumed for cell search)
Synchronization signals	PSS + SSS, physical cell ID 0
PBCH	Polar coded, QPSK, with PBCH DMRS
UE acquisition	Standard cell search + MIB decode (OAI nrUE)
Sampling / FFT	61.44 MS/s, FFT 512 (implementation choice)

Standard 5G numerology end to end: any 3GPP compliant FR2 receiver can synchronize to this waveform. The same signal carries the communication link and serves as the sensing reference.

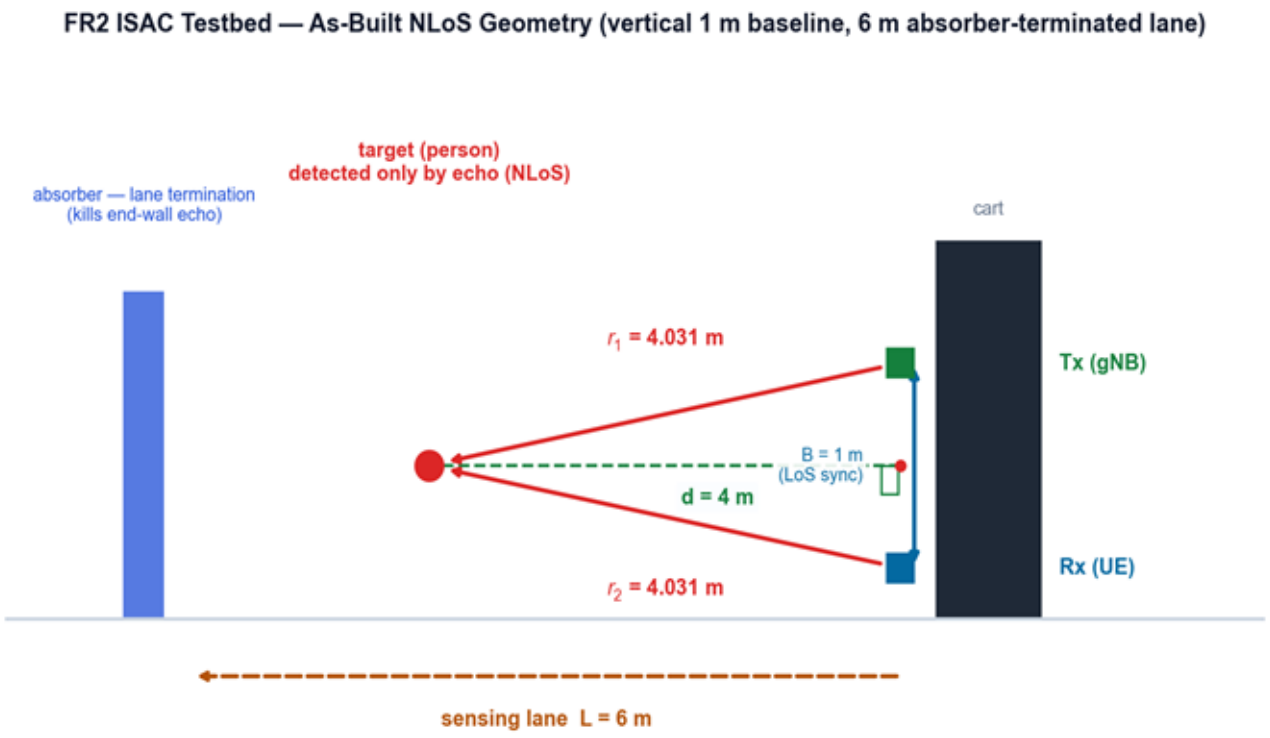
OAI Channel Estimation Testbed

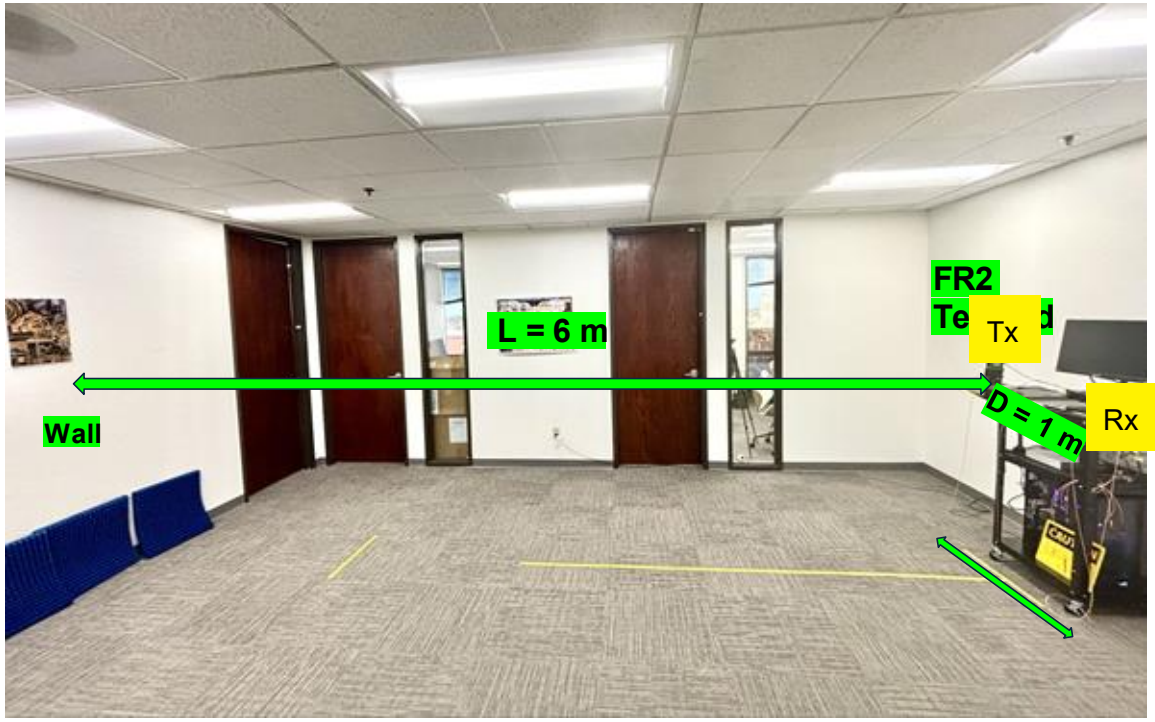


mmWave FR2 OAI Cable Test

- An OctoClock reference keeps its timing disciplined with ten megahertz and pulse per second (pps) signals.
- The X410 works at an intermediate frequency.
- Two Sivers serve as a millimeter wave frontends with integrated antenna arrays.

FR2 Quasi-Monostatic ISAC Testbed



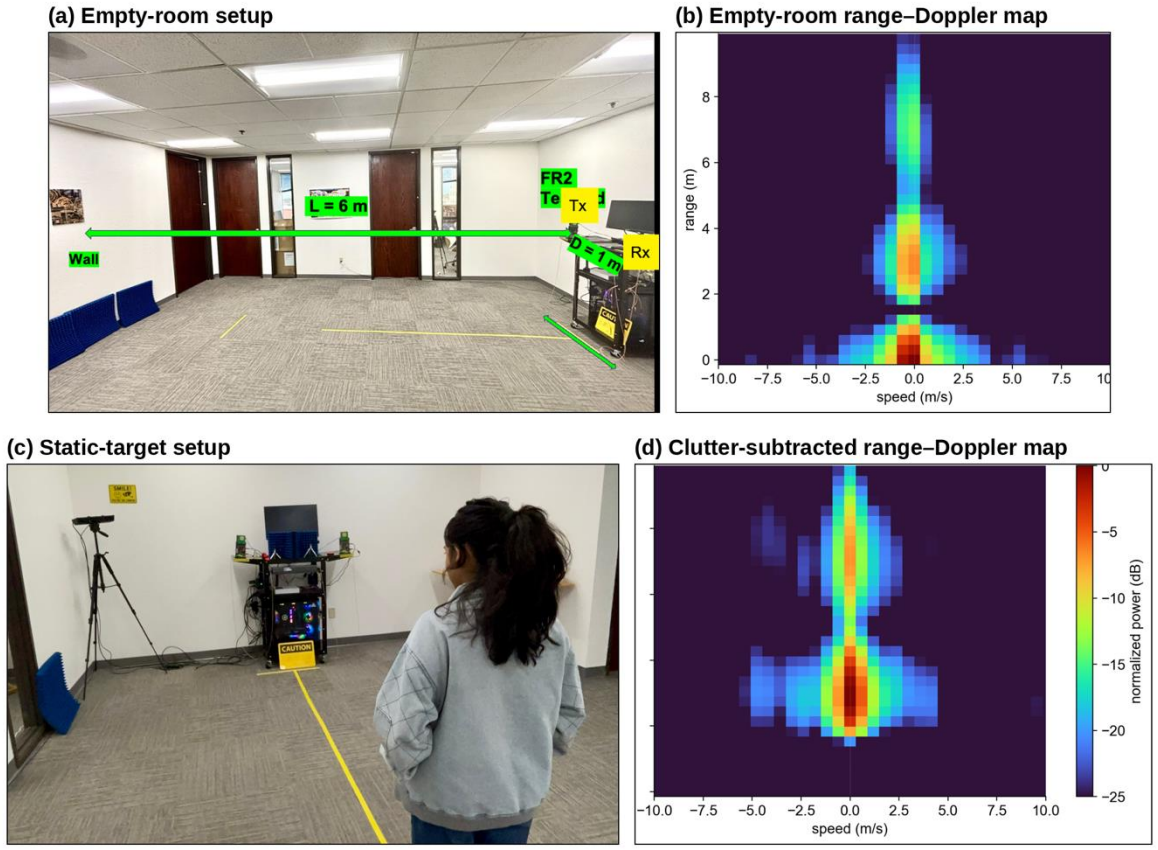


Pythagoras per arm: $r = \sqrt{d^2 + (B/2)^2} = \sqrt{4^2 + 0.5^2} = 4.031$ m

Echo path $r_1 + r_2 = 8.06$ m → excess $\Delta = 7.06$ m → delay $\tau = 23.6$ ns

Invert: $d = \sqrt{((B+\Delta)/2)^2 - (B/2)^2}$ Motion: Doppler ≠ 0, static room cancels

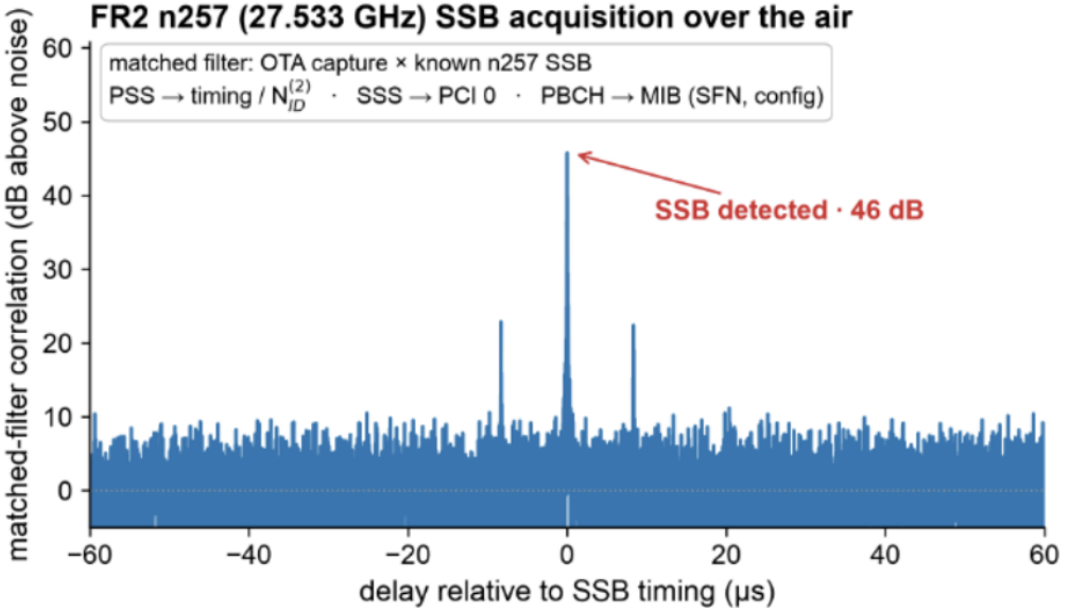
OAI-Enabled FR2 Live HWIL-OTA Test Setup

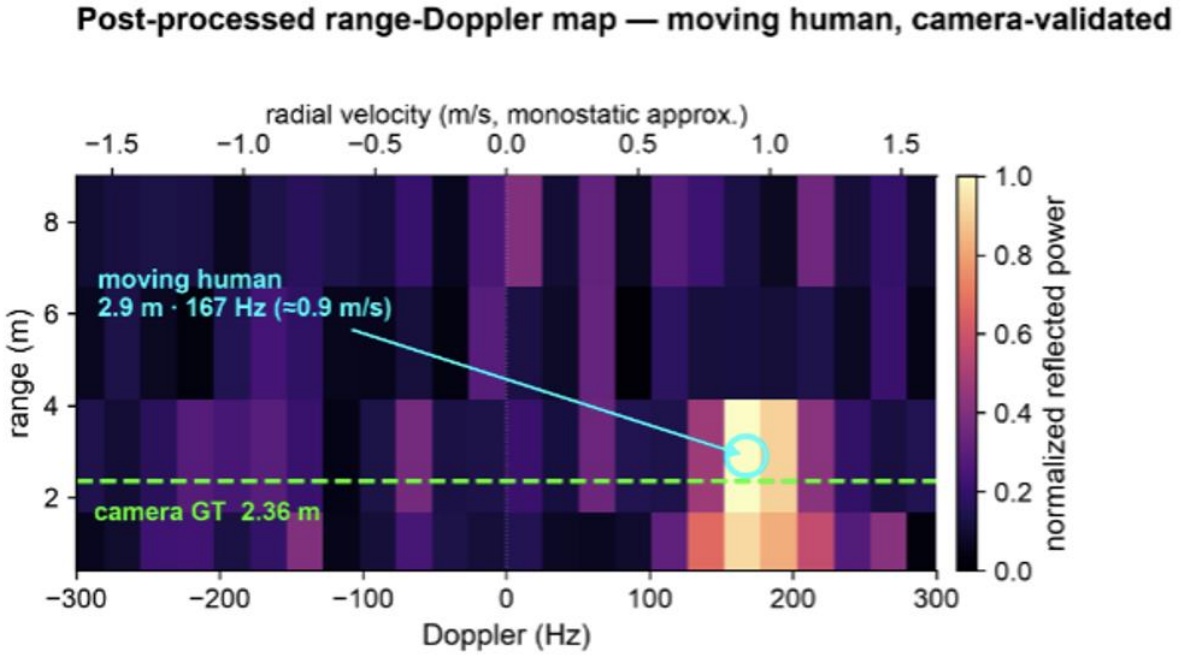


Range–Doppler comparison for the indoor FR2 sensing experiment.

- **Empty-room baseline showing static reflections from the wall, furniture, and surrounding indoor environment.**
- **Clutter-subtracted response after introducing a static human target at approximately 3 m**

OAI-Enabled FR2- ISAC Live HWIL-OTA Test Setup





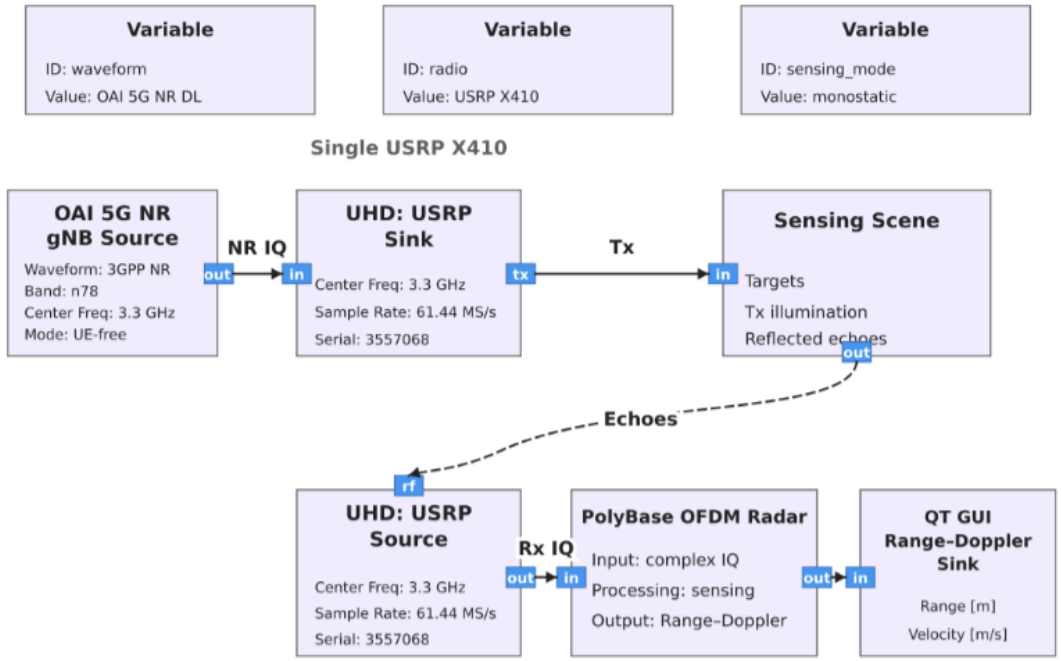
(b) Walking target at 2.9 m, +167 Hz.

OAI FR2 downlink acquisition at 27.53 GHz. Matched-filter correlation with the known SSB produces a dominant detection peak approximately 46 dB above the noise floor, confirming successful synchronization and PBCH acquisition prior to CSI-RS-based channel measurements.

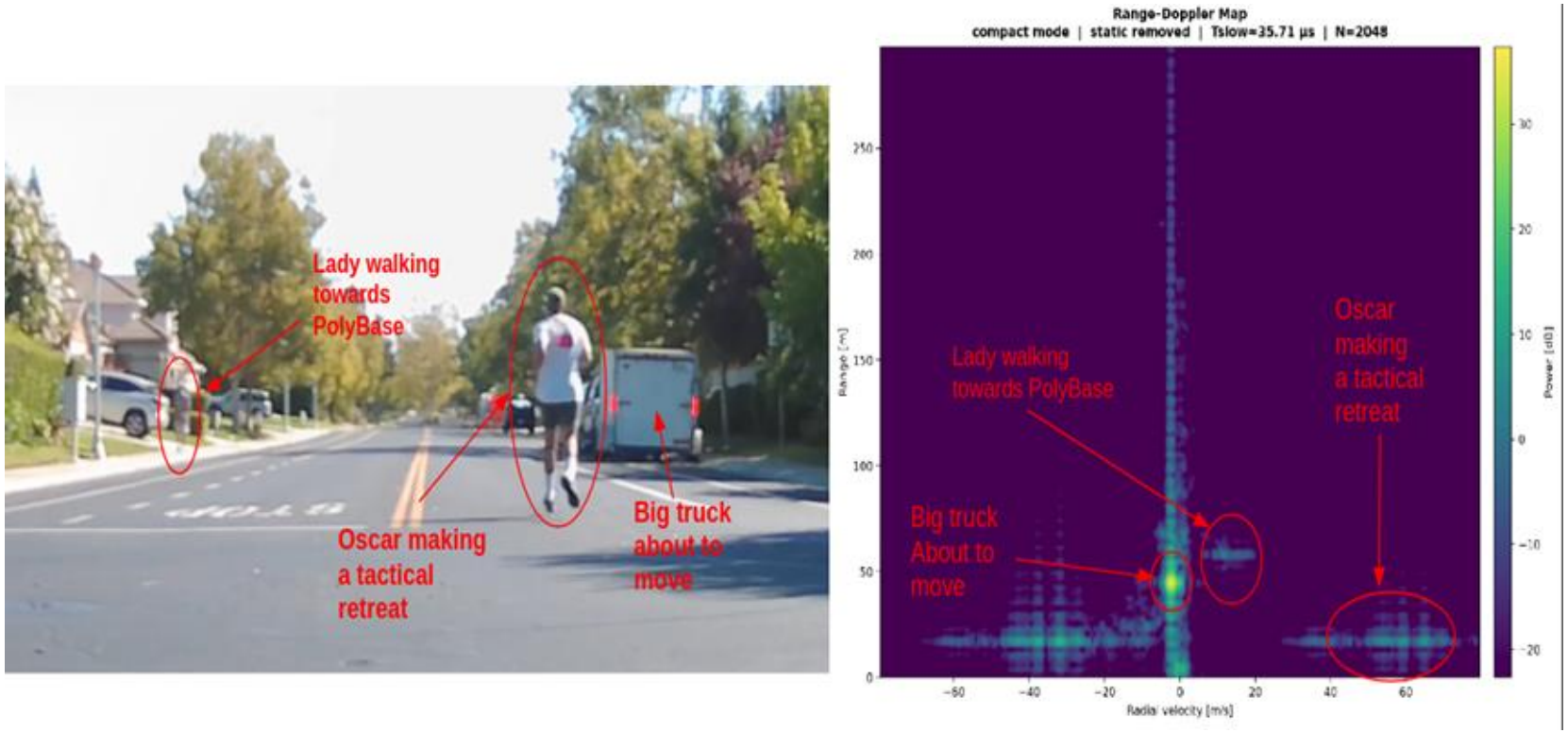
PolyBase gNB - ISAC Monostatic Sensing

Setup - USRP x410 + oai5G (gNB+Core)

- The sensing was performed using a 5G-NR waveform generated by oai5G (40 MHz bandwidth, 30 kHz SCS, 3.3 GHz, Band n78 and 1Tx1Rx).



PolyBase - Multi Target Detection



Multi-target detection using PolyBase with a live 3GPP-compliant 5G NR downlink waveform. The experimental scene and its corresponding range–Doppler map illustrate the simultaneous detection of multiple targets at different ranges and radial velocities.

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