Italian national interuniversity consortium for telecommunications

RadarConf'25
2025 IEEE RADAR CONFERENCE
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National Lab RaSS Radar and Surveillance Systems

IEEE AESS Radar Challenge 2025

Developing a Complete System with the ADALM-PHASER, Signal Processing and

Francesco Mancuso, CNIT RaSS Team – 6th October 2025

Presentation Outline

- Project Highlights and Key Outcomes
- Indoor test & Outdoor test
  - Hardware setup
  - Results

Project Highlights and Key Outcomes

Scope: Full radar pipeline

Hardware

- Tested two different transmitting antennas
- Tested HB100 as an interfering source

Data Interfaces

- Implemented data acquisition over TCP/IP
- Python-based GUI for acquisition, and live visualization
- MATLAB-based GUI for replay, processing, and video

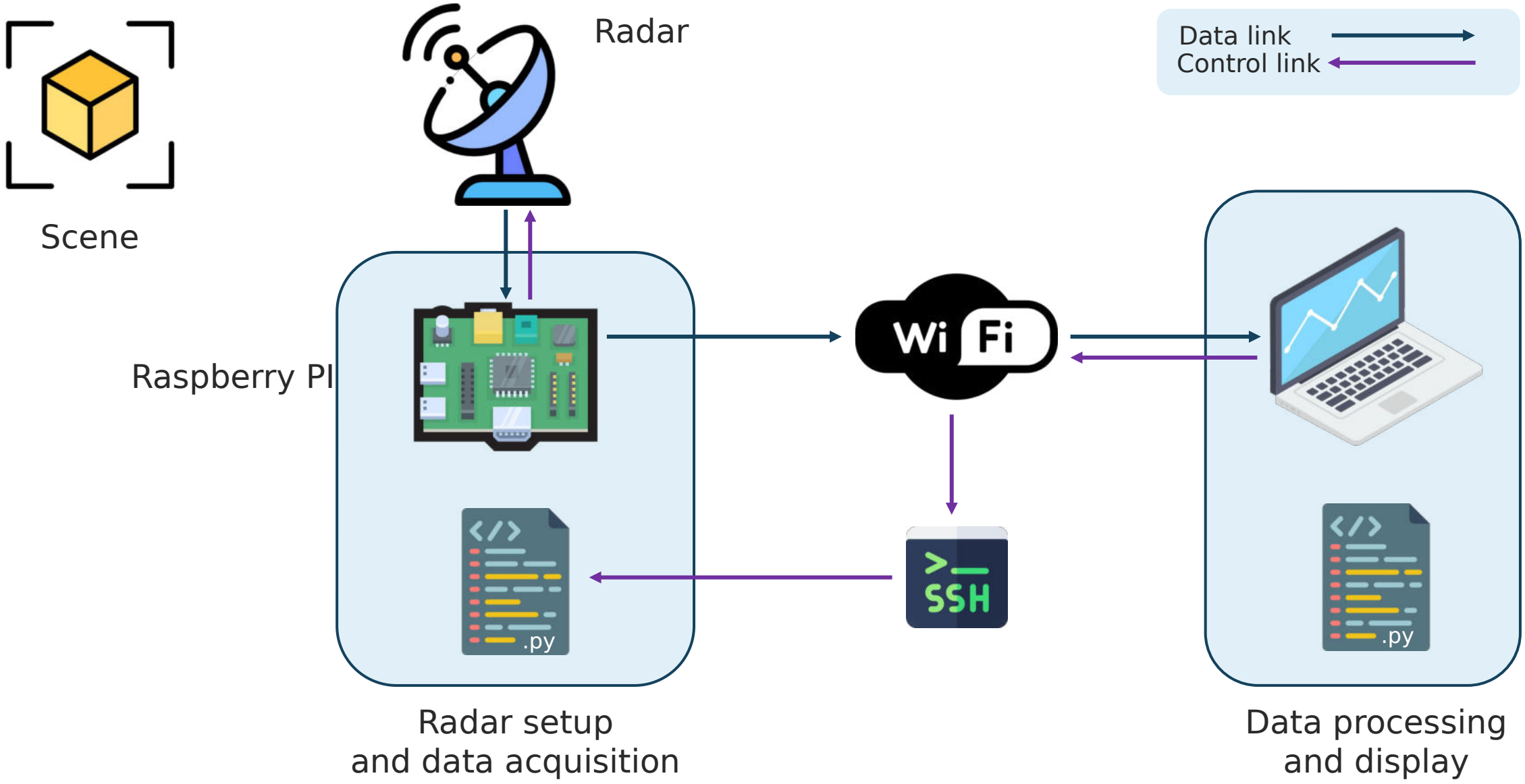
Target Tracking & Estimation

- CFAR detection in the range–Doppler domain
- Direction of Arrival (DoA) estimation
- Track association in range–angle (and time) domain
- Velocity and angle monitoring over time

Signal Processing

- Clutter cancellation
- Angular cancellation

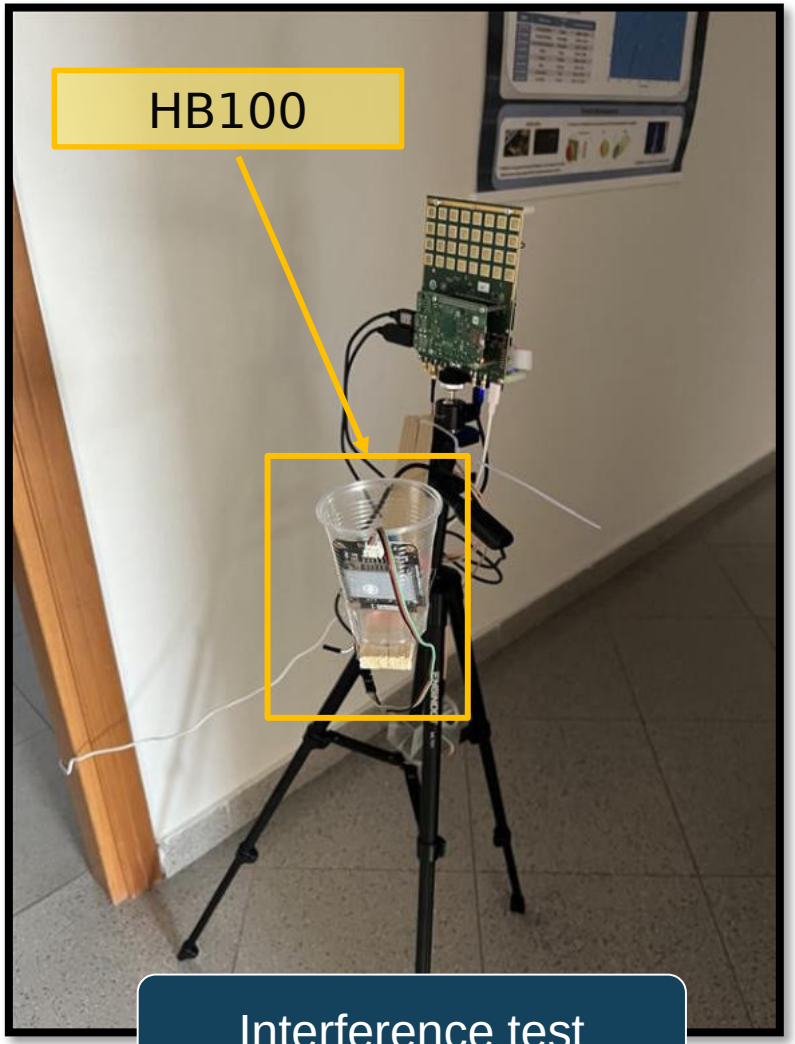
Indoor test hardware setup



Indoor test

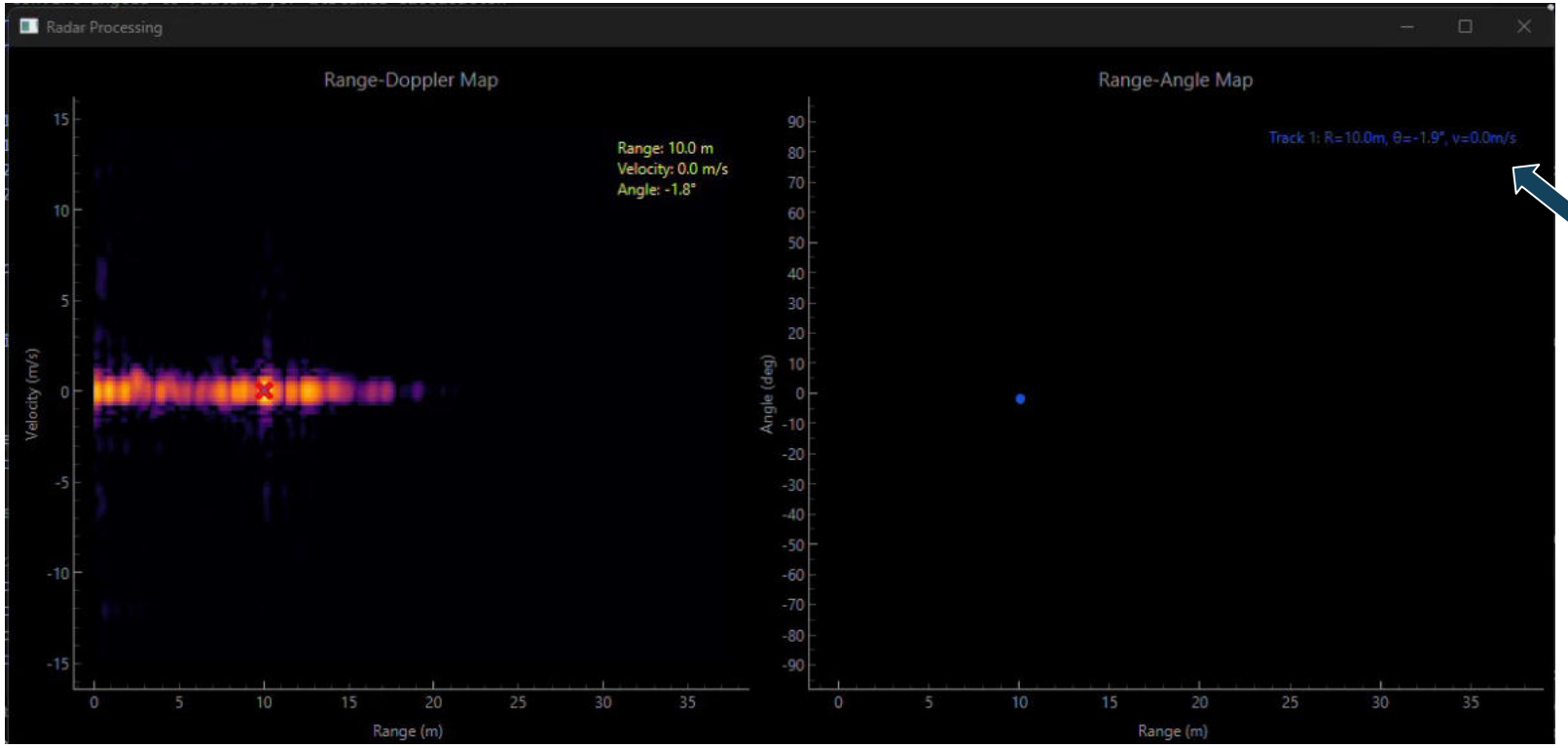
First setup

Turntable test



Interference test

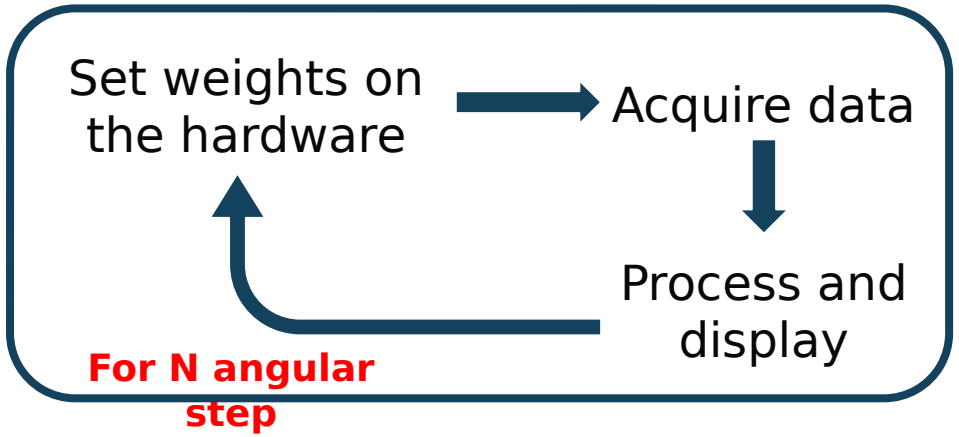
Indoor test (2)

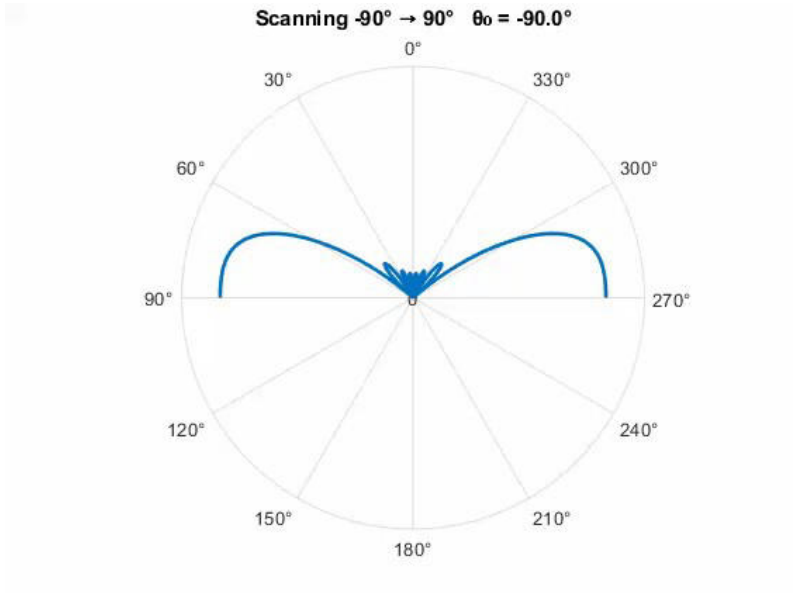


Range, angle and velocity information about the active track

Range-Doppler Map with single target detection and Range-Angle plot
(**live acquisition, processing and plotting**, DOA with two digital channels)

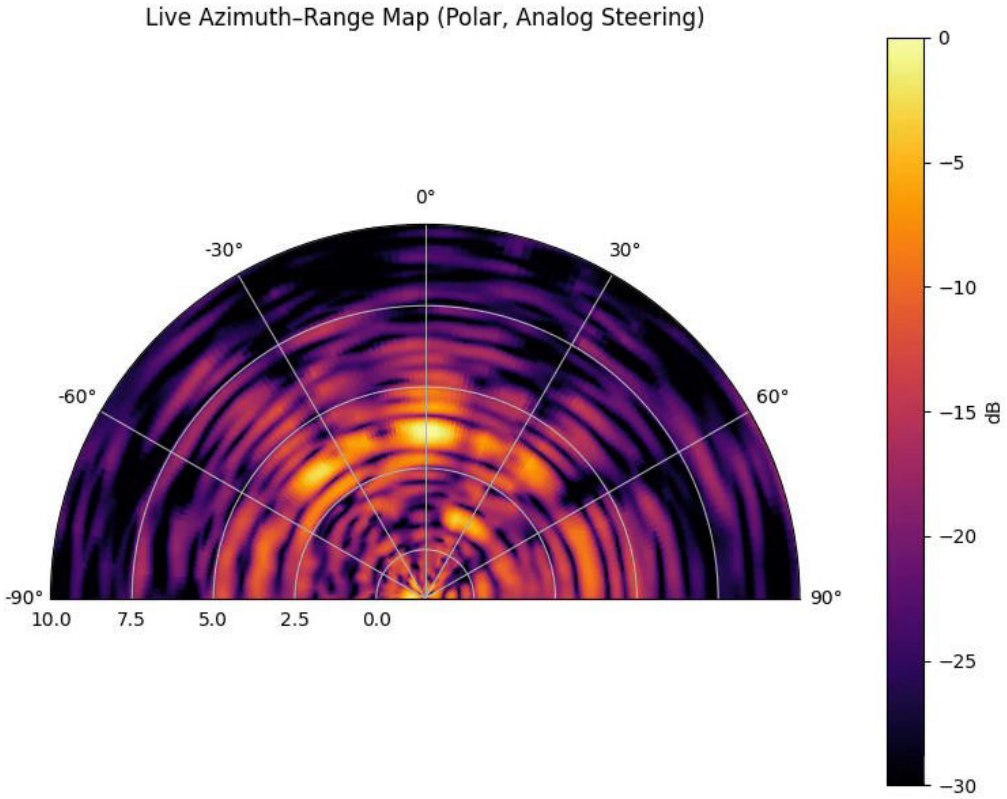
Indoor test (3)





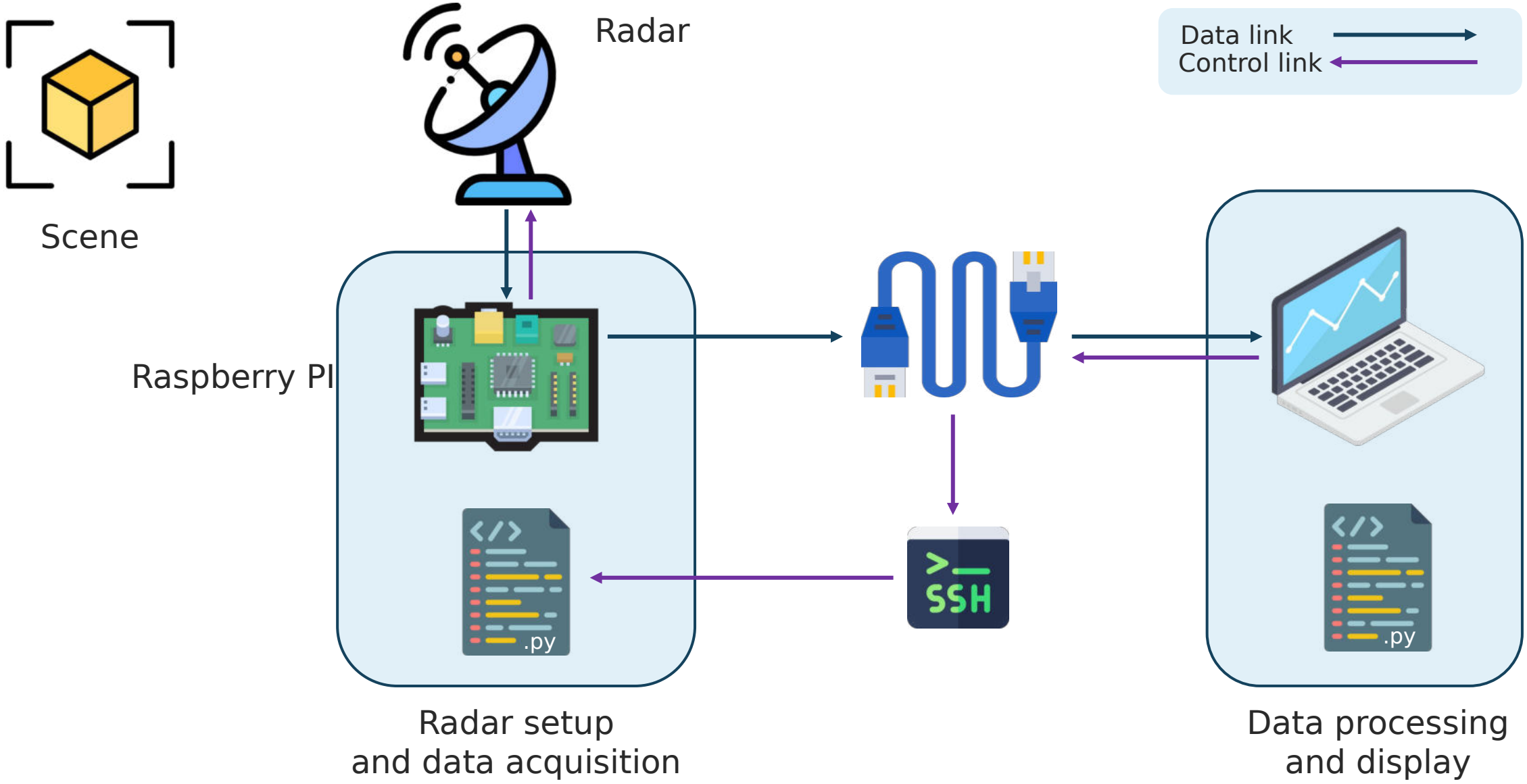
Beam steering MATLAB animation

Range-Azimuth Polar Plot
(Beam steering using eight elements, **requires writing back the weights on the Phaser**)



Every plot update correspond to a full angular sweep

Outdoor test hardware setup

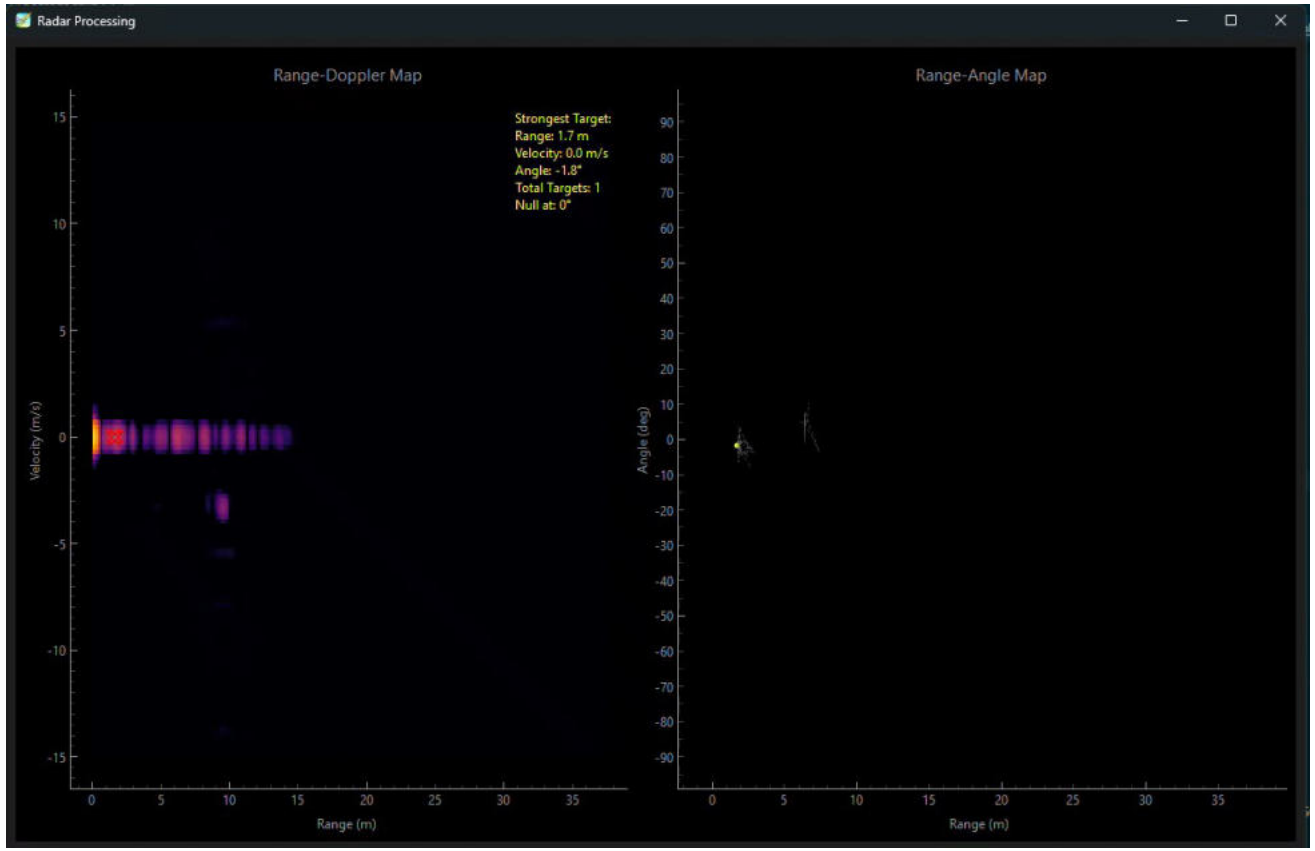


Outdoor data acquisition – Session 1

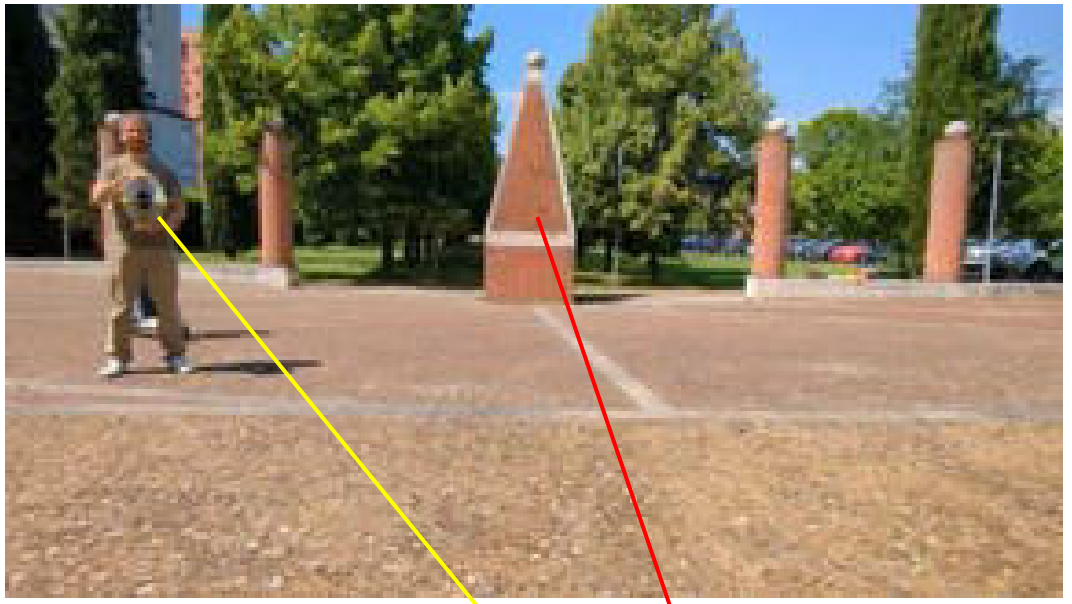
Using a horn antenna* on the transmitting side

* The enhanced directivity of the current antenna decreased power leakage onto the RX antenna

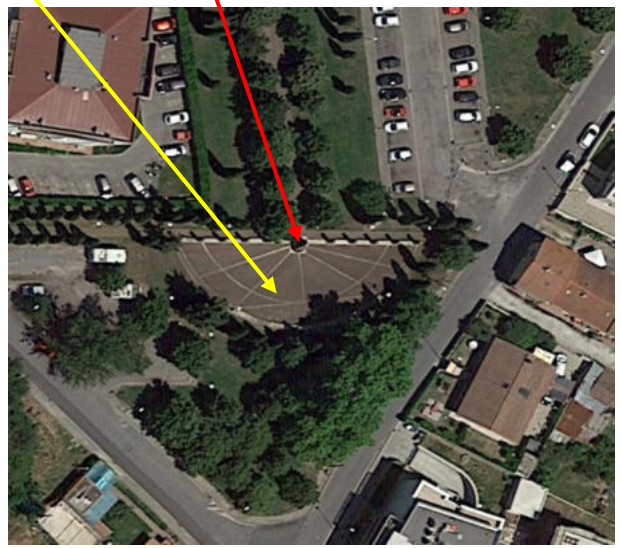
Outdoor data acquisition – Session 1 (2)



The corner reflector is not visible in the Range-Doppler map because clutter suppression has been applied.

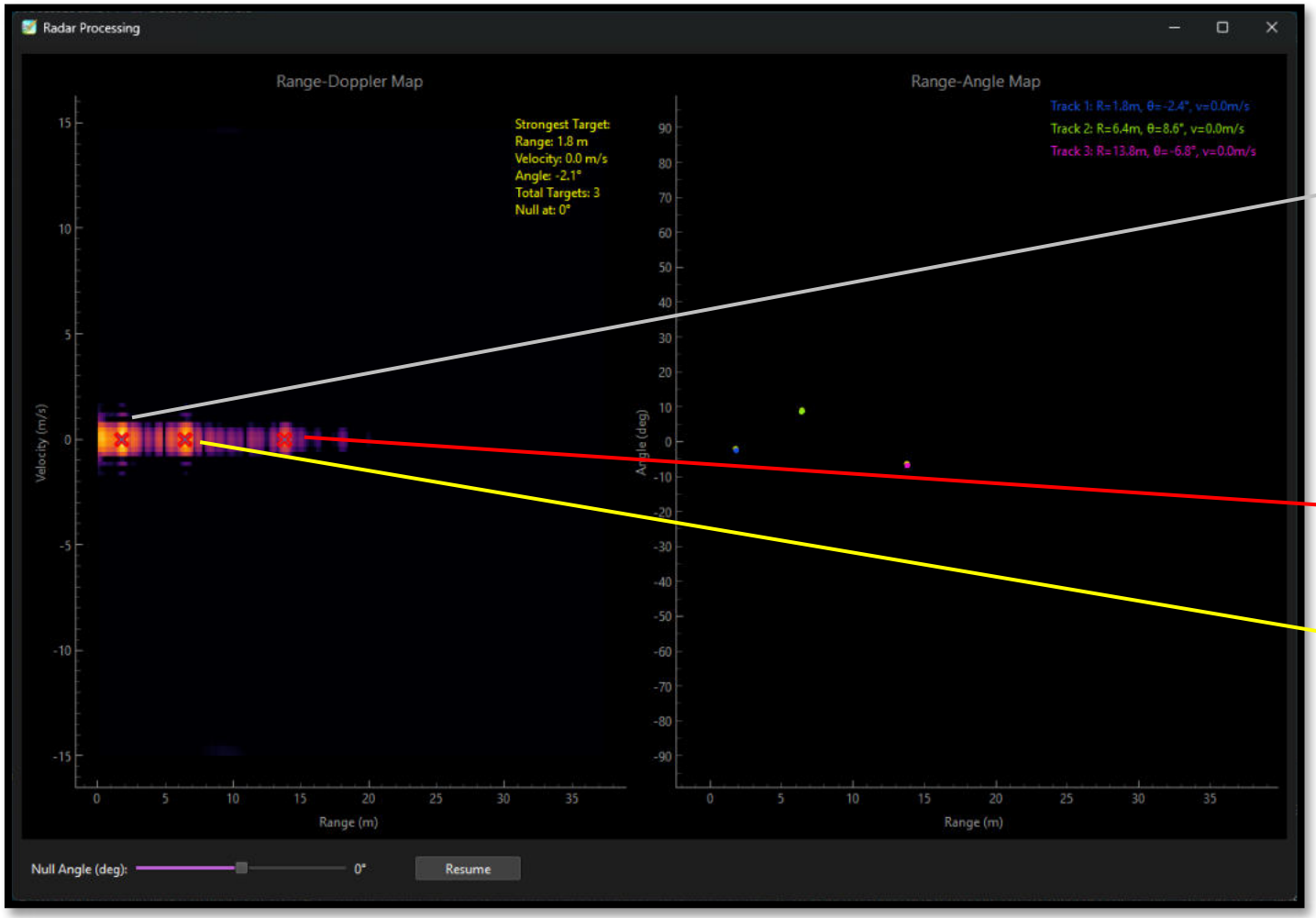


Francesco is holding a corner reflector, while Bhaskar is driving the scooter in front of the radar.

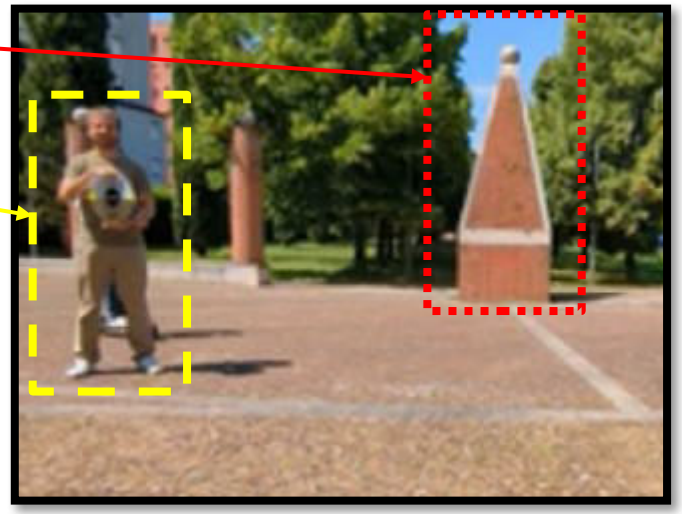


Note: The radar processing visualization is not synchronized with the video!

Outdoor data acquisition – Session 1 (3)

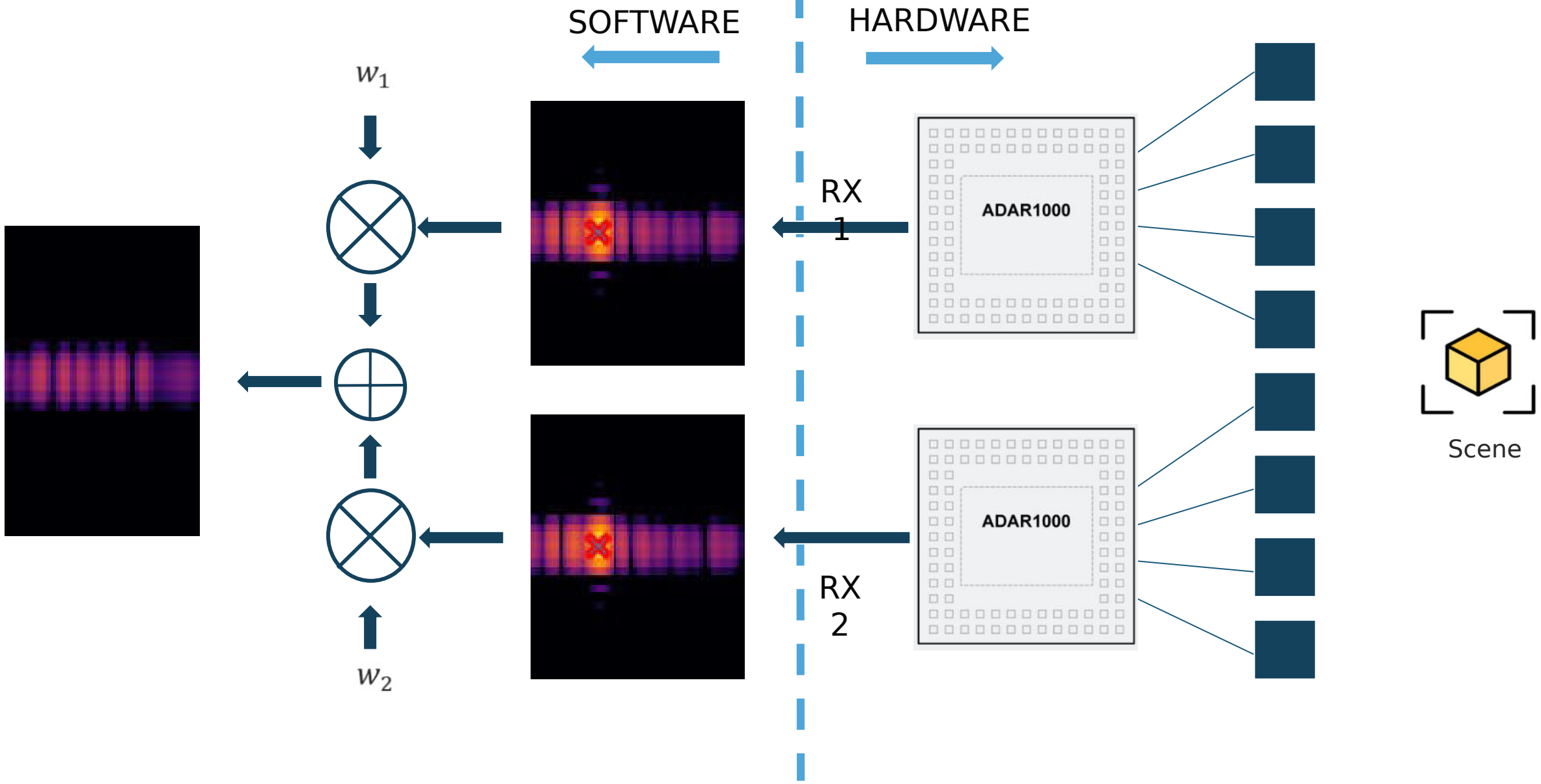


Most likely reflection from the ground in front of the radar.



No clutter suppression applied.

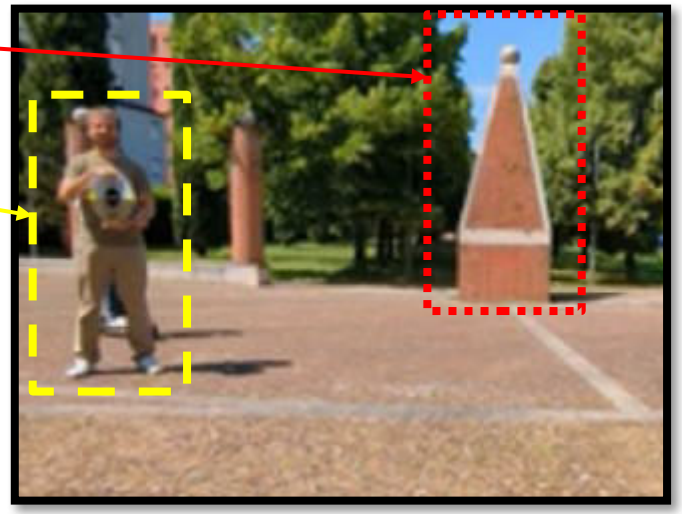
Outdoor data acquisition – Session 1 (3.5)



Outdoor data acquisition – Session 1 (4)

Most likely reflection from the ground in front of the radar.

The corner reflector is not visible anymore!



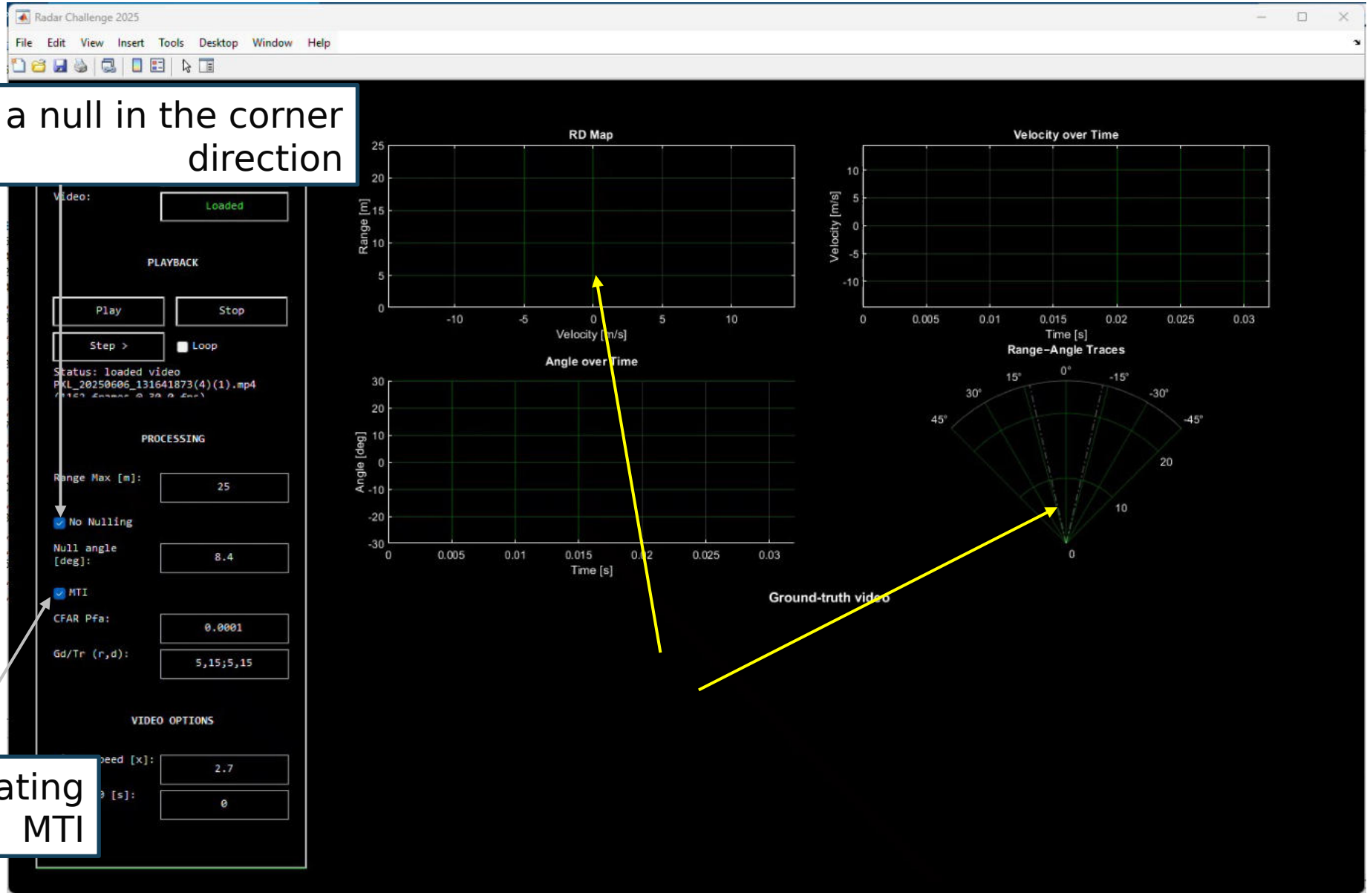
Null steering in the corner reflector direction.

Outdoor data acquisition – Session 1 (5)

Placing a null in the corner direction

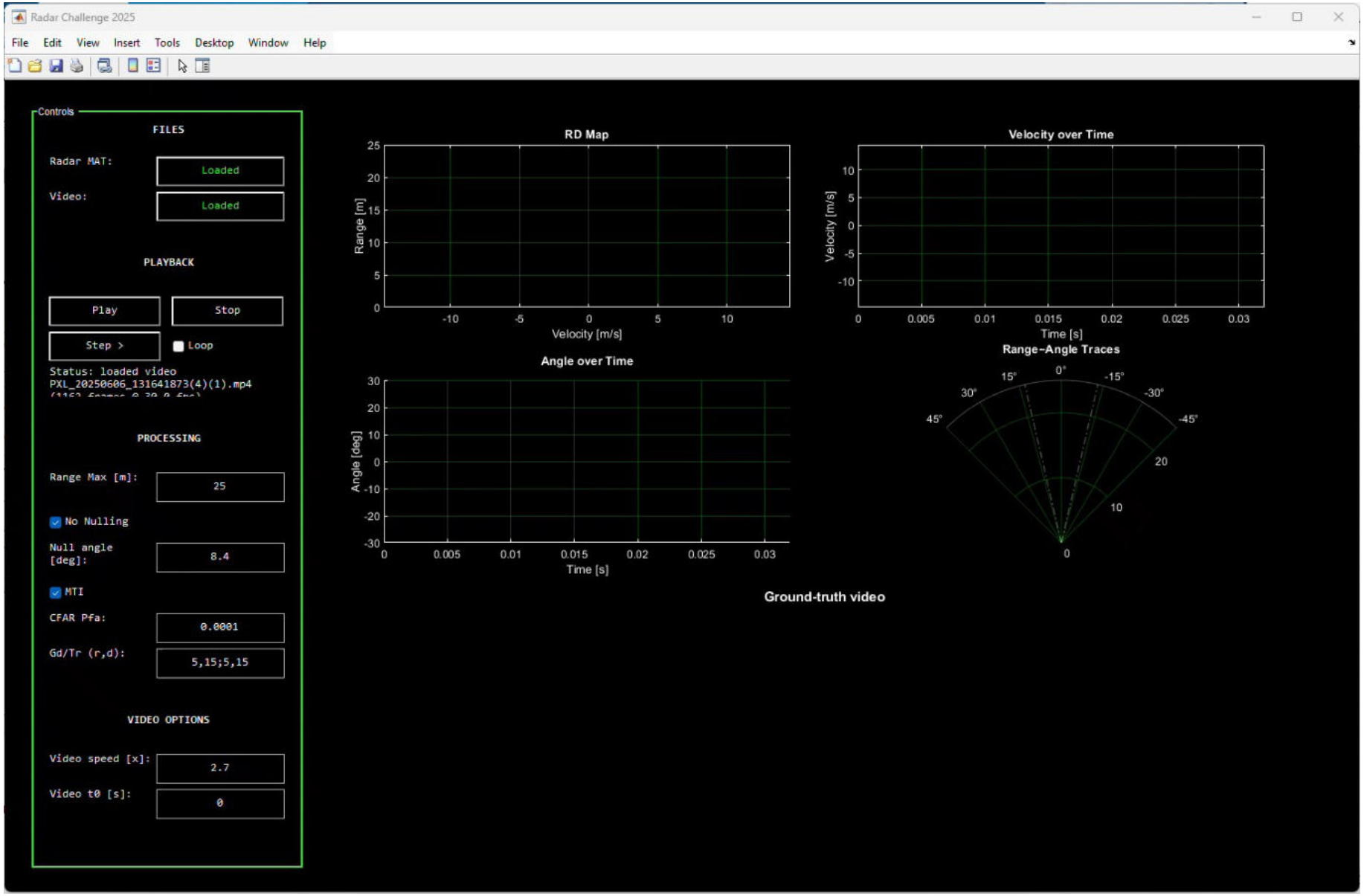
Removing nulling, activating MTI

Deactivating MTI



The RD Map is scaled on a frame-by-frame basis using the current maximum value

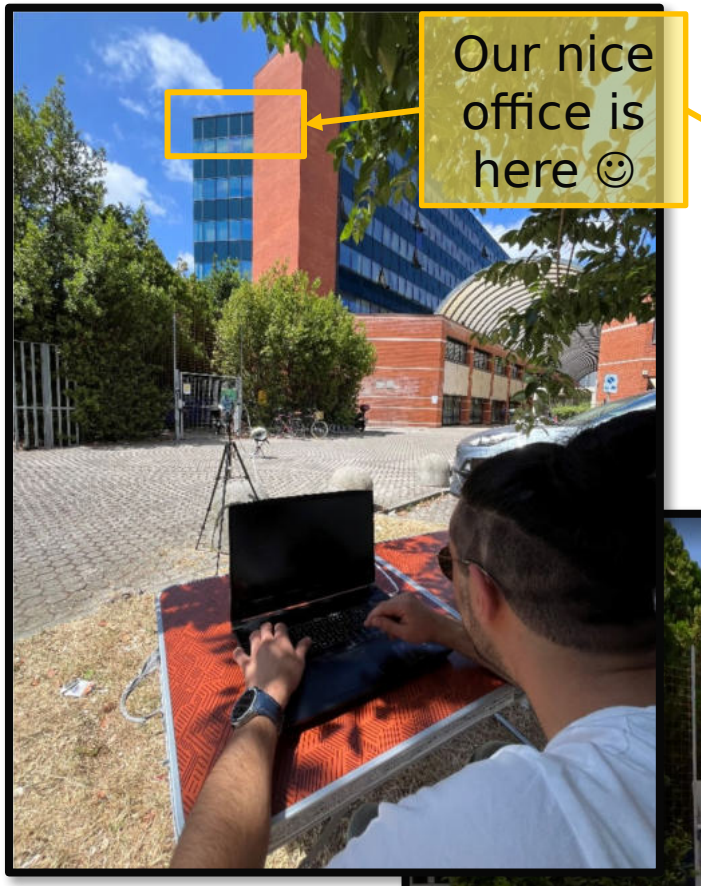
Outdoor data acquisition – Session 1 (6)

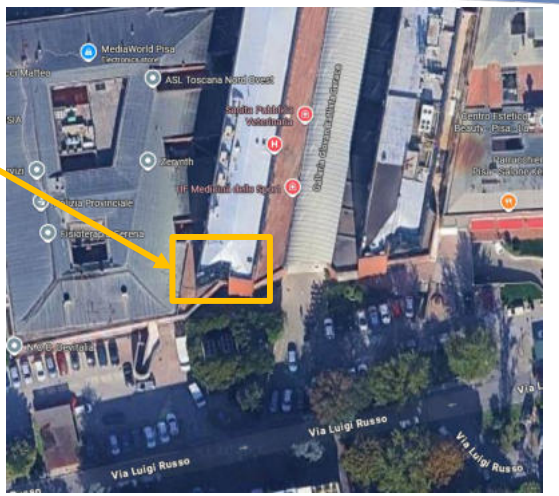


The RD Map is scaled on a frame-by-frame basis using the current maximum value

Outdoor data acquisition – Session 2

Going back to the Vivaldi antenna



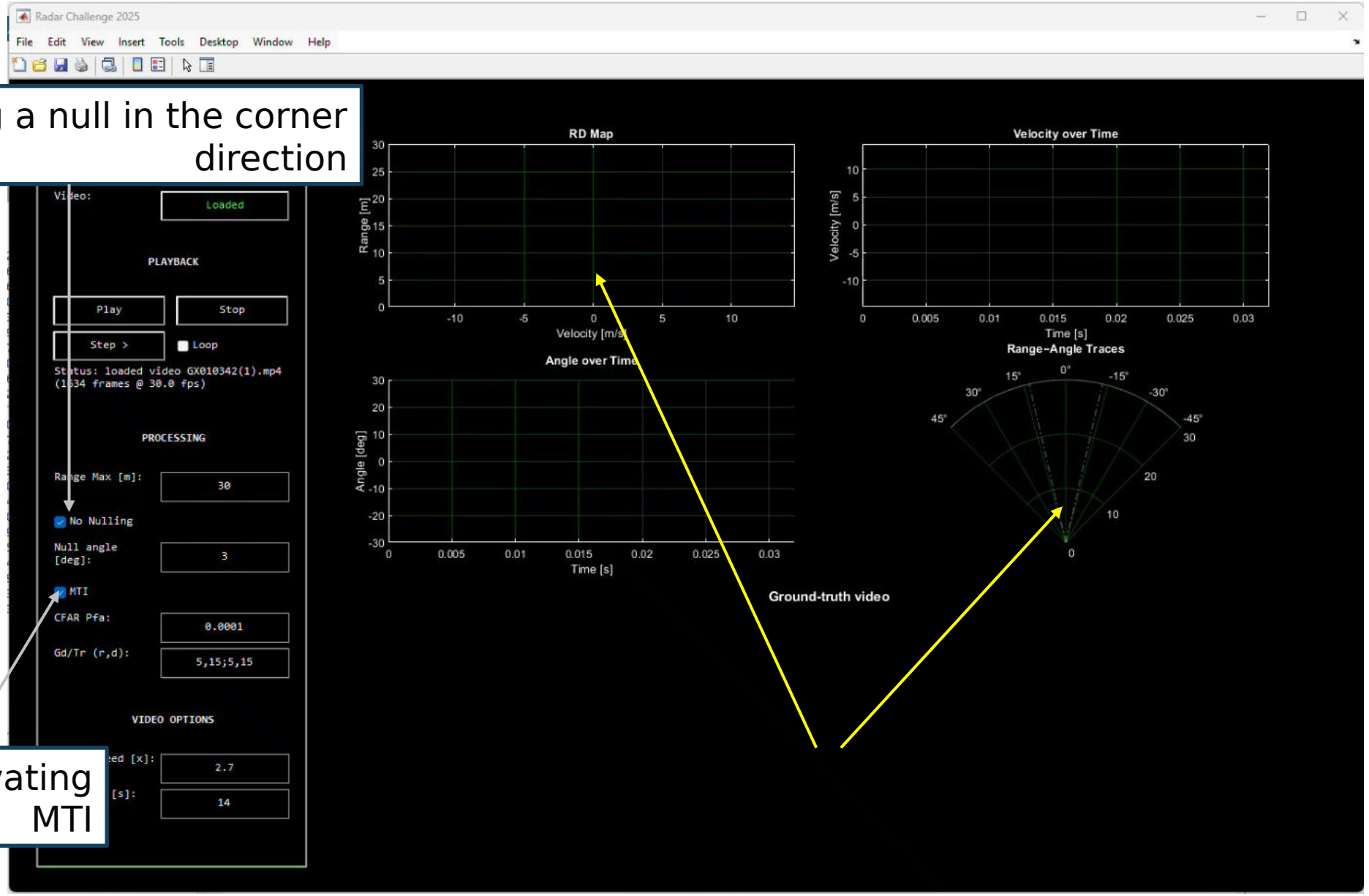


Outdoor data acquisition – Session 2 (2)

Placing a null in the corner direction

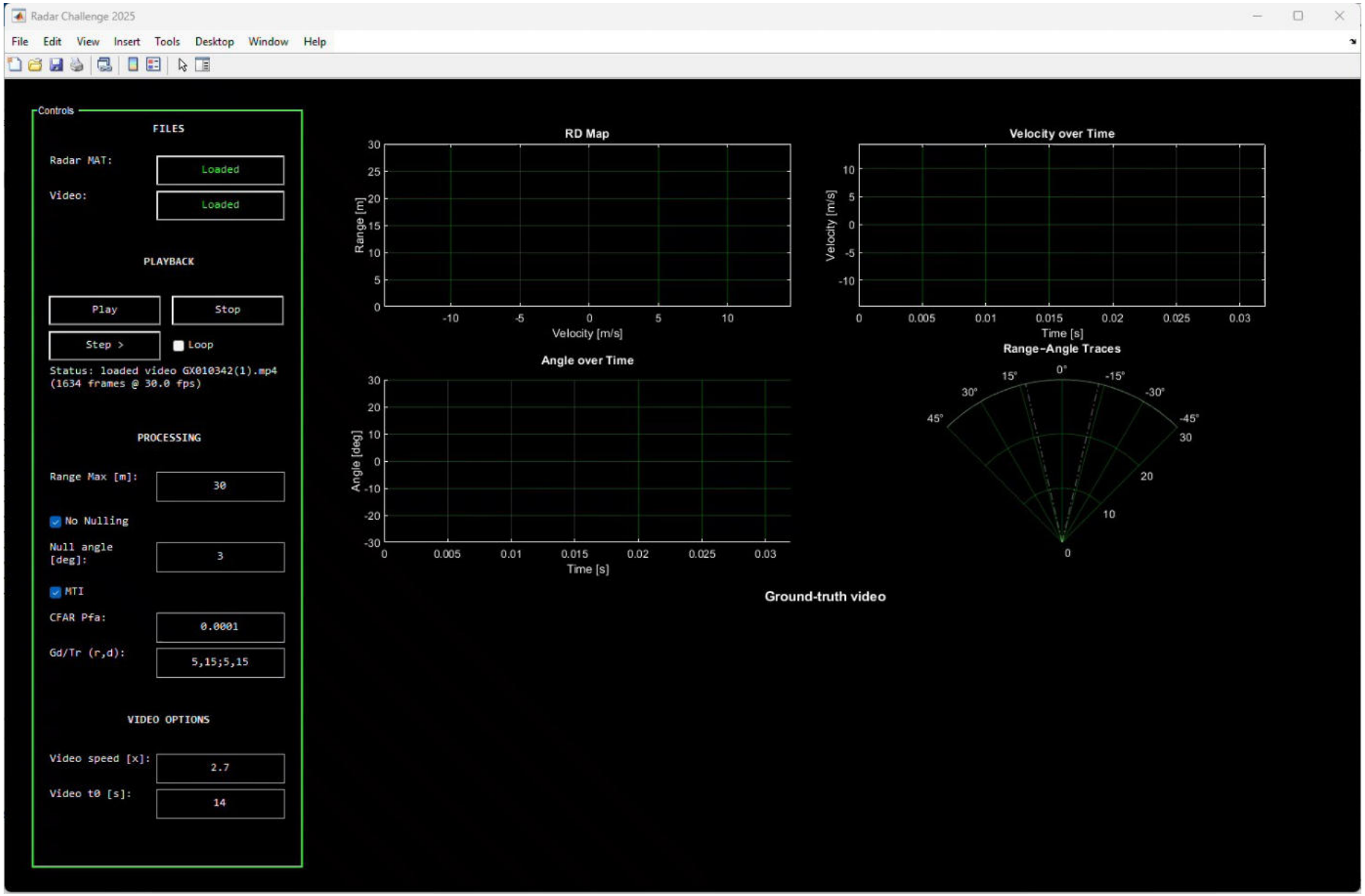
Removing nulling, activating MTI

Deactivating MTI



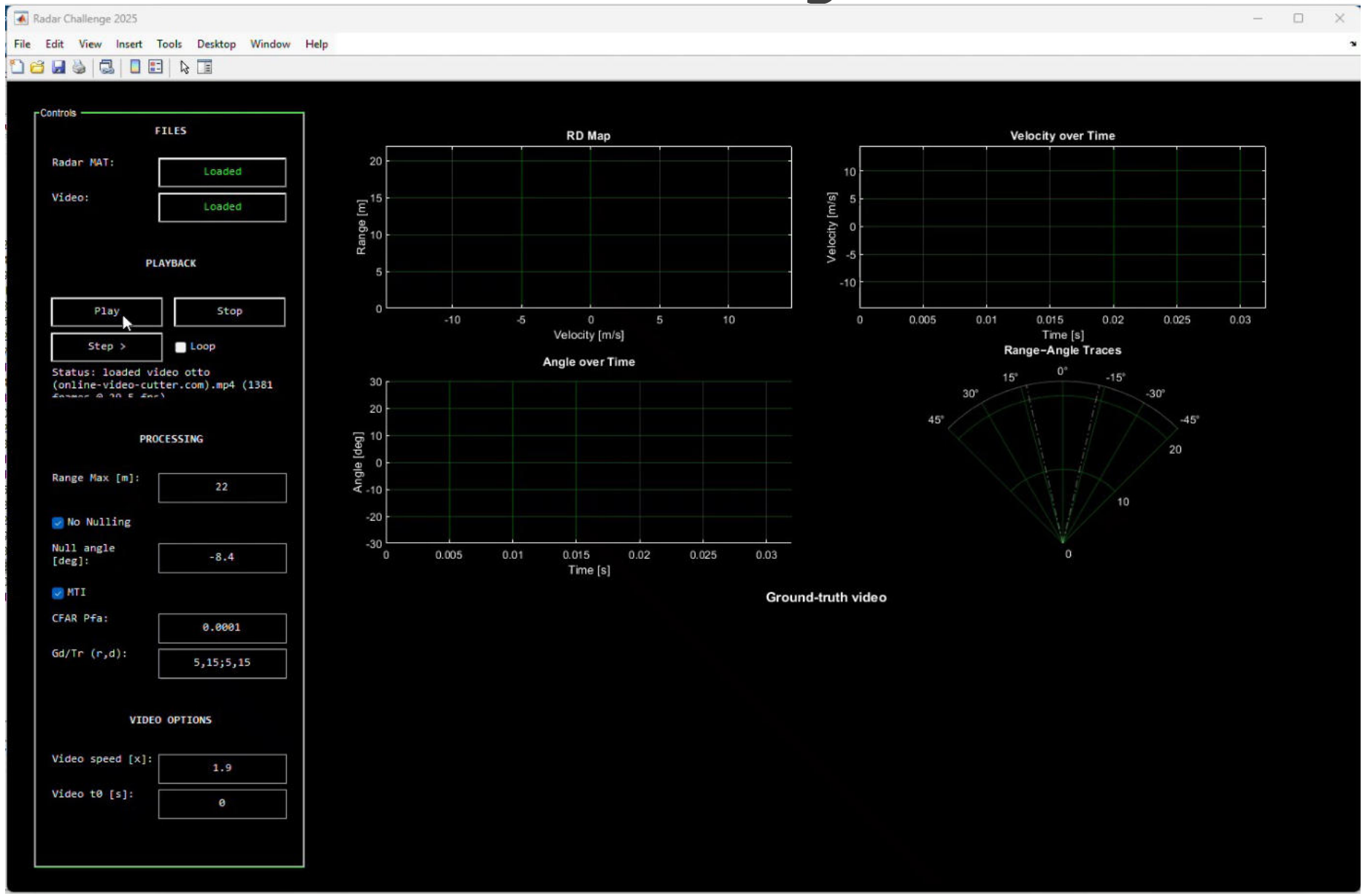
The RD Map is scaled on a frame-by-frame basis using the current maximum value

Outdoor data acquisition – Session 2 (3)



The RD Map is scaled on a frame-by-frame basis using the current maximum value

Outdoor data acquisition – Bonus recordings



The RD Map is scaled on a frame-by-frame basis using the current maximum value

Conclusions & Lessons Learned

- **Hardware in Action:** demonstrated that the provided radar setup can cover a full pipeline (from acquisition to tracking), including remote data acquisition.
- **Hands-On Learning:** gained experience in integration, debugging, and tool-building (Python & MATLAB GUIs).
- **Radar Know-How:** strengthened understanding of radar signal processing (CFAR, DoA, clutter cancellation).
- **Broader Takeaway:** the challenge was both practically productive and educationally rewarding, bridging theory with real-world radar experimentation.

This challenge provided a unique opportunity to experiment directly, which is crucial for building true expertise.

➡Training Future Experts: Affordable, hands-on access to radar hardware is essential. Unlike simulations or pre-recorded datasets, this experience let us work with real signals and face practical, real-world challenges.

…and we had fun driving the scooter

Thank you!

GitHub Repo

ps://github.com/mandugo/IEEE-AESS-Radar-Challenge-2025-RaSS-Team

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CNIT RaSS Lab
Radar and Surveillance Systems National Laboratory

Galleria G.B Gerace 14,
56124, Pisa
Telephone: +39 050 080 1551
Email: rass@cnit.it

Speaker
Francesco Mancuso
francesco.mancuso@cnit.it
+39 050 080 1558

Italian national interuniversity consortium for telecommunications