

HoRAMA: Automated 3D Wireless Digital Twins for AI-Native 6G

HoRAMA makes the 3D foundation of wireless digital twins easy to build

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1. Motivation

4 weeks

expert time to
hand-build a 3D model

10 min

phone scan, then
13 h processing

36 links

12 per band at 3.7,
6.75, 16.95 GHz

- ❑ **AI-native 6G** needs site-specific channels at scale
- ❑ **Today:** twins are hand-built, judged by path loss only
- ❑ **HoRAMA [1]:** phone scan → twin, validated on channels **and** beams

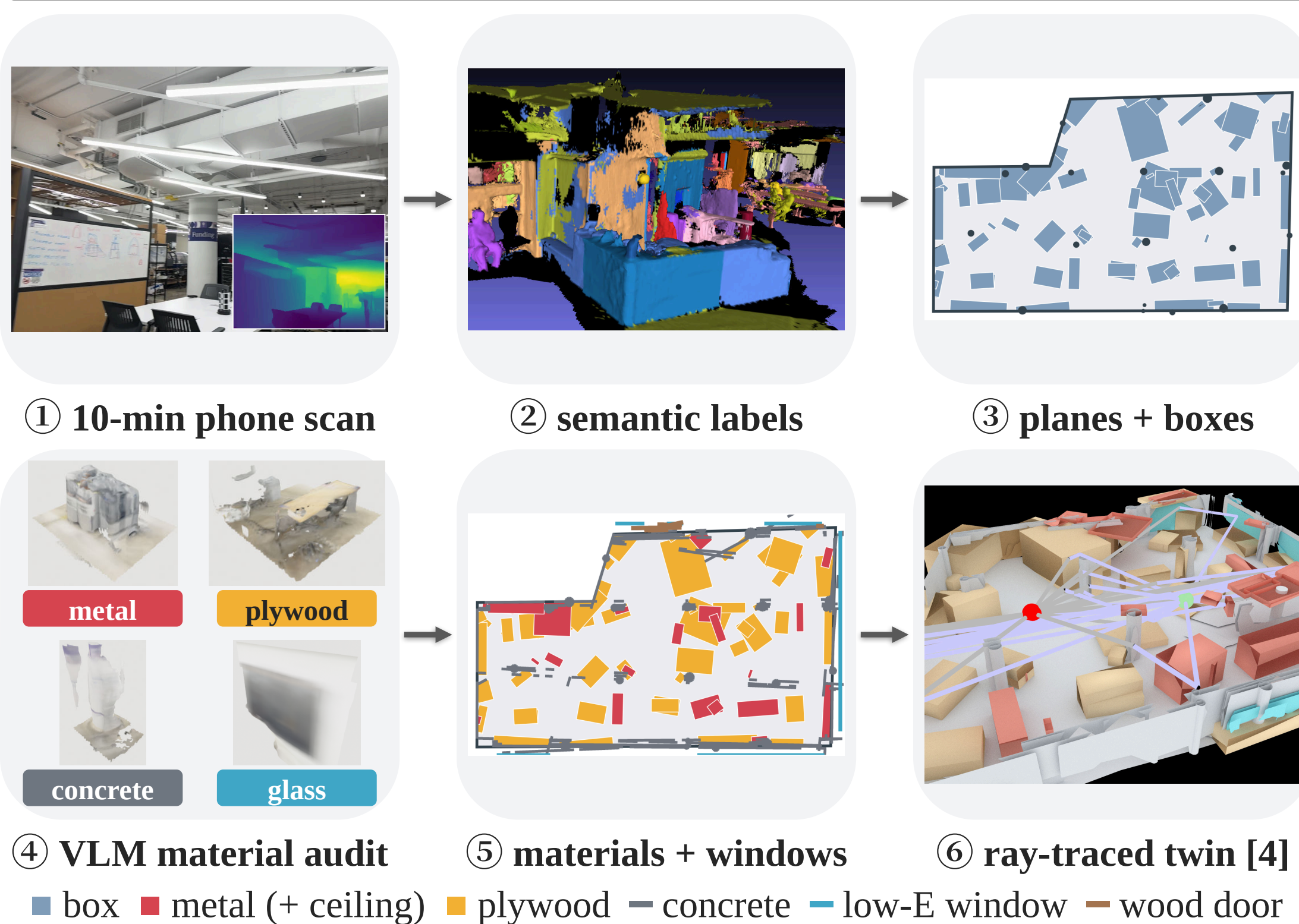
2. Research Gaps and Contributions

Gap in prior work

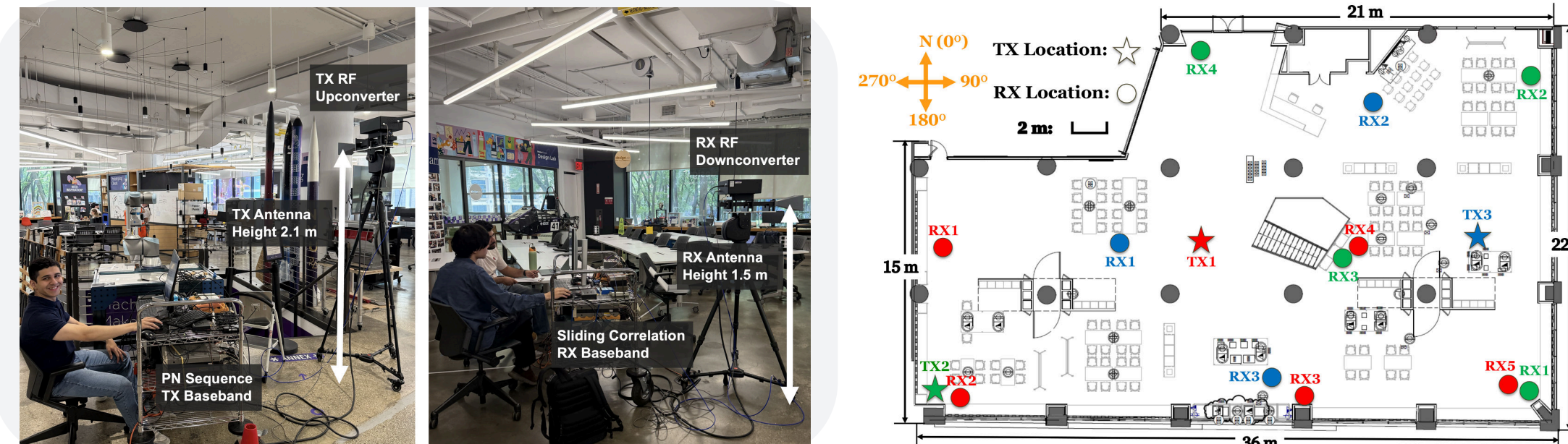
This work

- Twins built by hand: weeks → Automatic twin from a **10-min phone scan**
- Tracer and data never audited → **Audit** ray tracer, data and estimators
- Precise scans assumed best → Phone vs. **LiDAR scanner**, same pipeline
- Judged on path loss only → Also judged on **RMS DS, ASA and beams**

3. HoRAMA: Phone Scan → Ray-Traced Twin

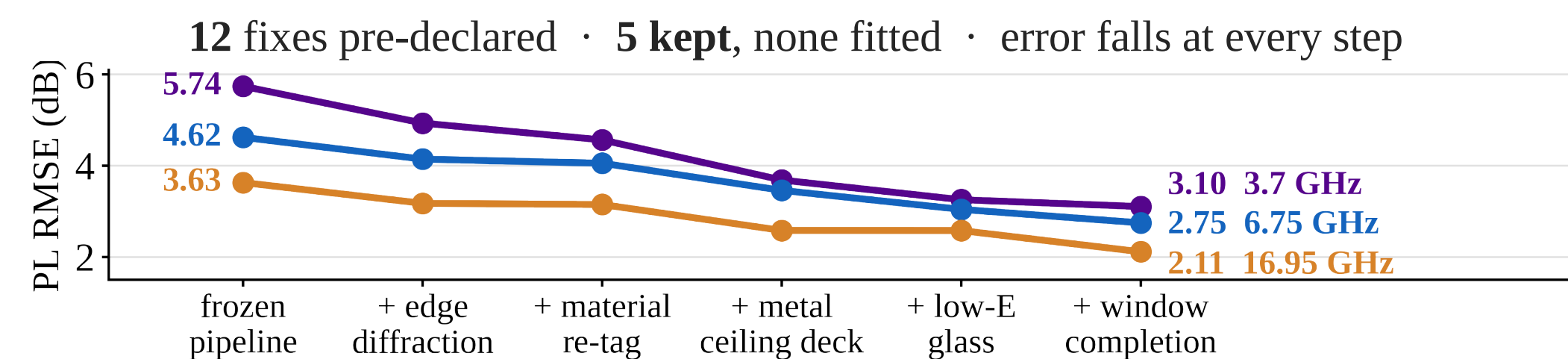


4. Ground Truth: 36 Measured Links

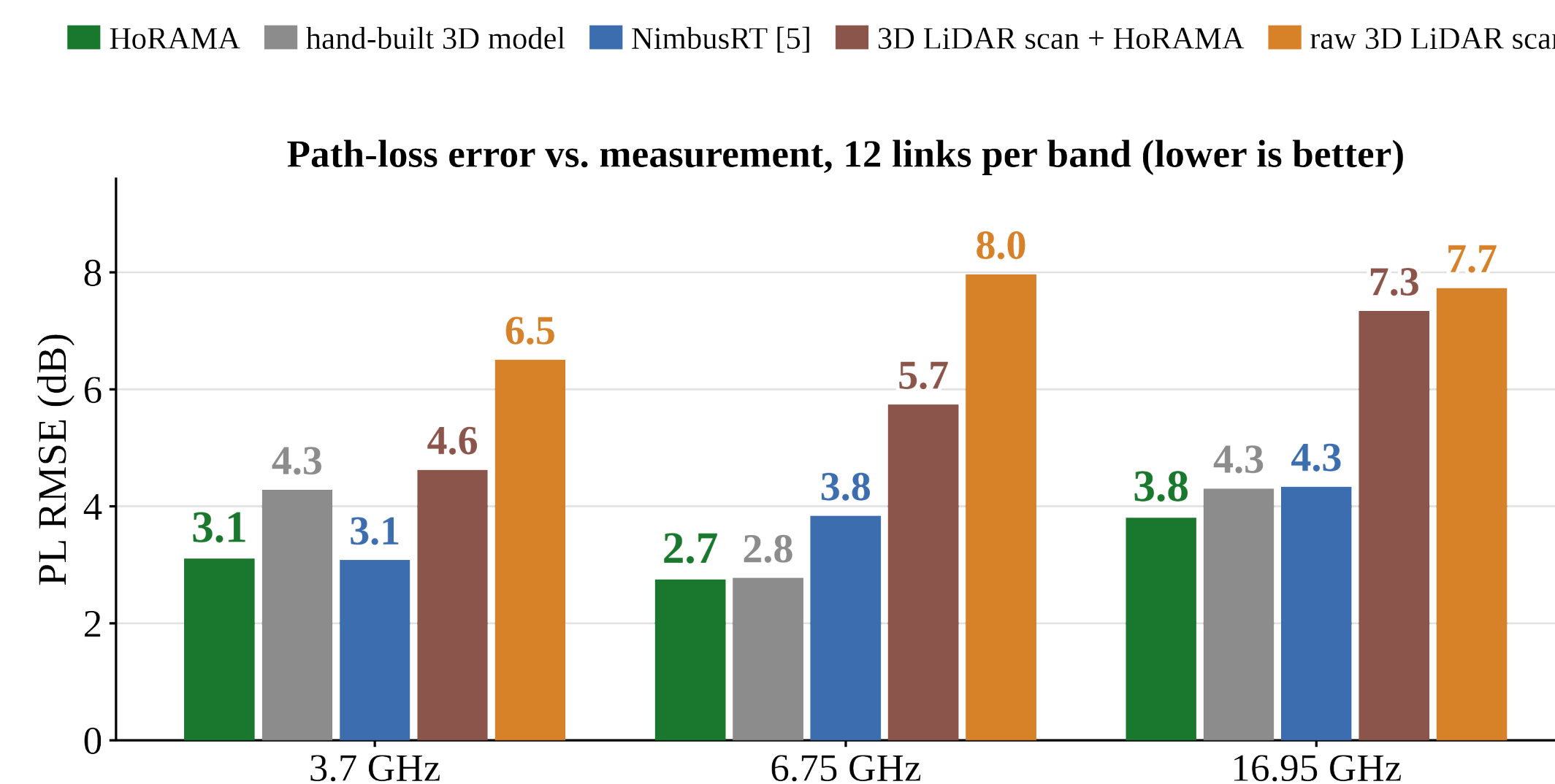


- ❑ **36 m × 22 m × 5 m** factory hall · 3 TX · 3.7, 6.75, 16.95 GHz [2, 3]
- ❑ 500 Mcps sliding-correlator sounder, 1 GHz bandwidth, rotating horns

5. Lock the Physics, One Tested Step at a Time

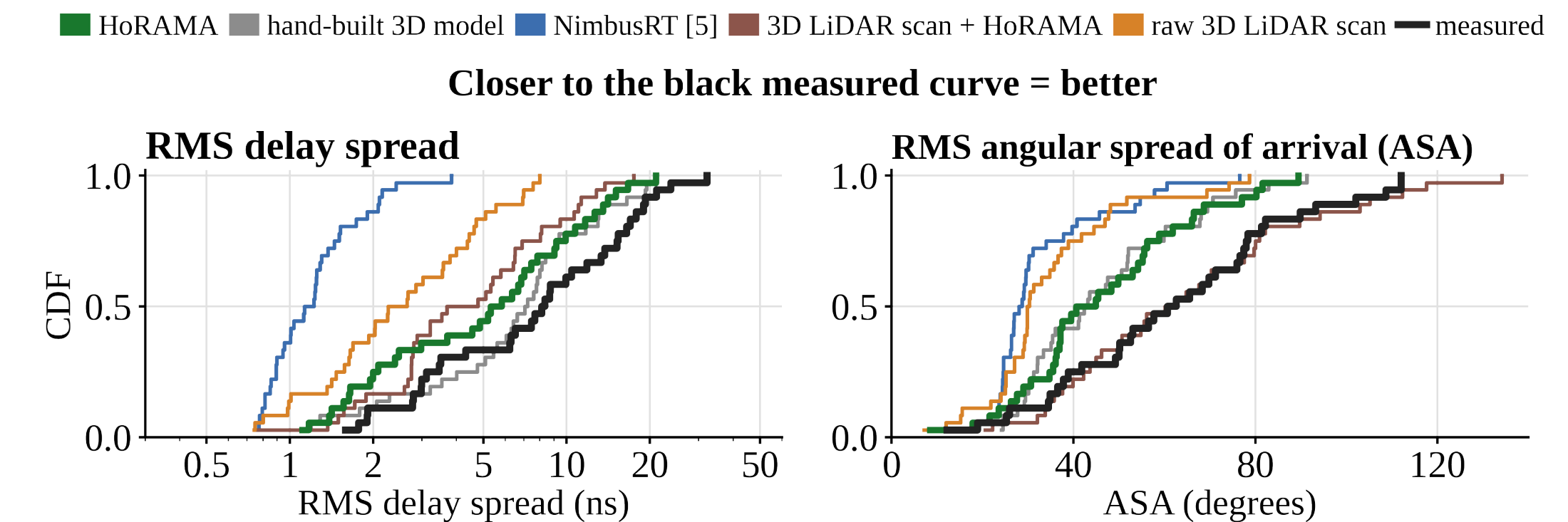


6. Result 1: HoRAMA Has the Lowest PL Error



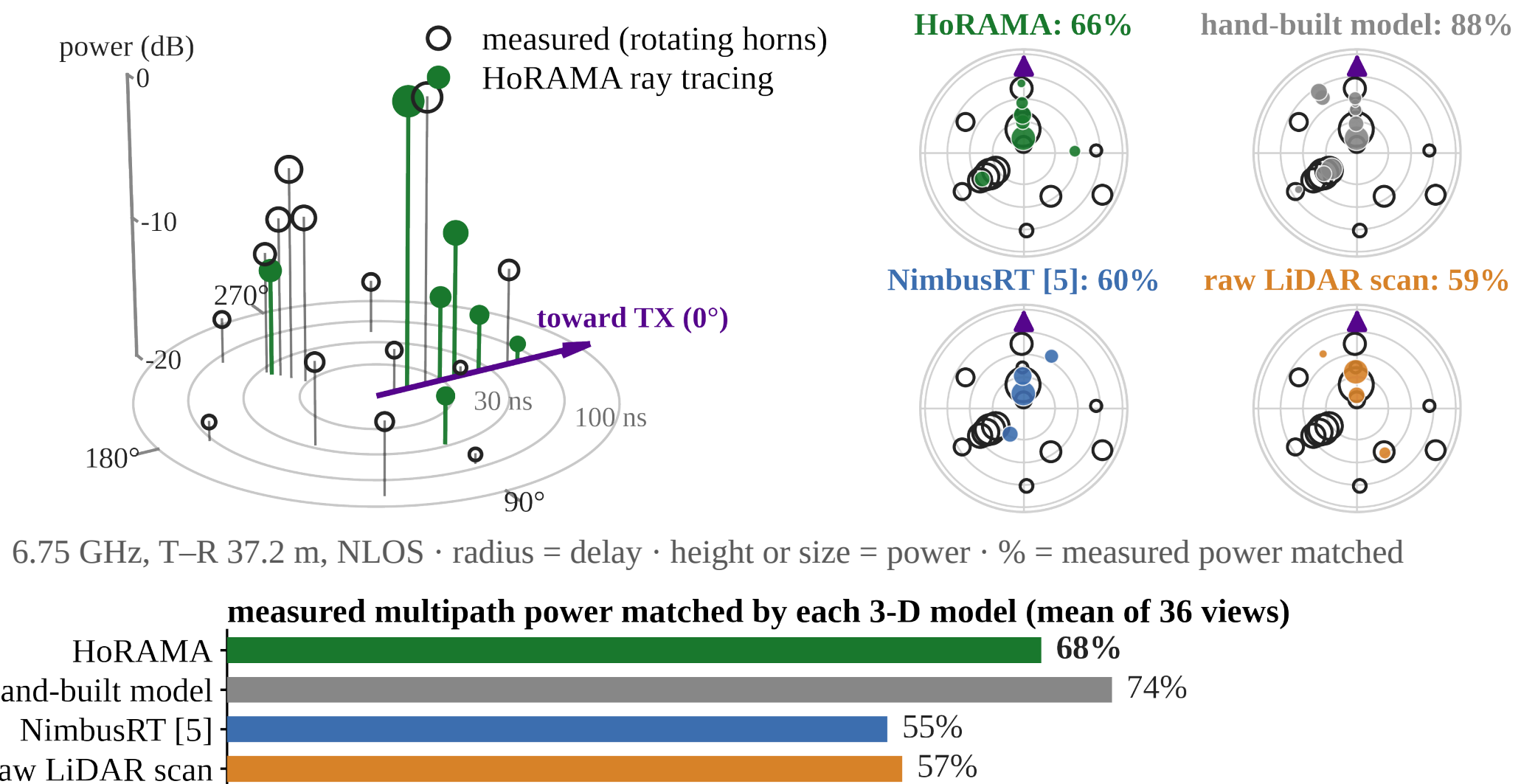
- ❑ **HoRAMA 3.2 dB** PL RMSE (36 links): lowest of five 3-D models
- ❑ **Raw 3D LiDAR scan (Leica):** 7.4 dB, worse than free space (4.9 dB)
- ❑ **Denser 86-setup LiDAR scan:** 11.7 dB, even worse
- ❑ **Why:** the LiDAR scan keeps real clutter on grazing LOS lines

7. Result 2: RMS Delay & Angular Spread



- ❑ **RMS DS using HoRAMA:** closer than NimbusRT [5] and the raw LiDAR scan
- ❑ **ASA using HoRAMA:** closer than these and the hand-built 3D model

8. Result 3: Twin Reproduces Real Multipath



- ❑ **Multipath:** HoRAMA matches 68% of measured cluster power (hand-built 74%)
- ❑ **Beams:** HoRAMA picks a beam within 3 dB of the best in 32/36 (hand-built 33)

9. Conclusion and Future Work

Conclusion

- ❑ A 10-min phone scan matches a 4-week hand-built 3D model: **3.2** vs 3.9 dB
- ❑ A precise LiDAR scan is not a better twin: model and audit the scene
- ❑ Judge twins beyond path loss: DS, ASA, multipath and beams

Future work

- ❑ Extend to outdoor environments
- ❑ Accelerate the pipeline (now 13 h of processing)
- ❑ More accurate material labels

This work was supported by the NYU WIRELESS Industrial Affiliates Program, NYU Technology Opportunities & Ventures, the NYU Tandon ECE Ph.D. Fellowship, and NSF Grants 2216332, 2234123, and 2403287.
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