Bringing WiFi Localization to Any WiFi Devices

Tianxiang Li, **Haofan Lu**, Reza Rezvani, Ali Abedi, Omid Abari

Nov. 15, 2022
Austin, Texas, USA

UCLA Samueli Computer Science

UNIVERSITY OF WATERLOO

WiFi Localization

Home automation

Smart industry and warehouse

Smart food delivery

Today's WiFi Localization Systems

Multiple Access Point
Triangulation/Trilateration
[SpotFi: Sigcomm' 15 ,
ToneTrack: MobiCom' 15, TyrLoc: MobiSys' 21]

Single Access Point
Trilateration
[Chronos: NSDI' 16,
MonoLoco: MobiSys' 18]

Unfortunately, not all WiFi devices have multiple transceiver chains

Limitation: coordination among multiple access points

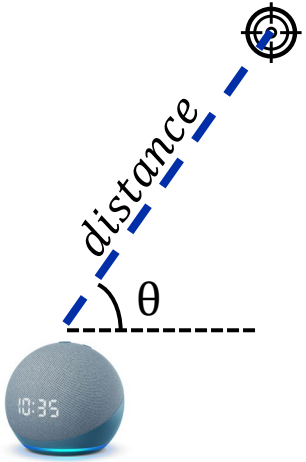
Limitation: multiple transceiver chains

Can we enable localization with a *single* transceiver chain?

WiSight

- A system which brings WiFi localization to any WiFi devices
- Works as a plug-and-play without modification on the WiFi chipset
- Does not require cooperation from other devices

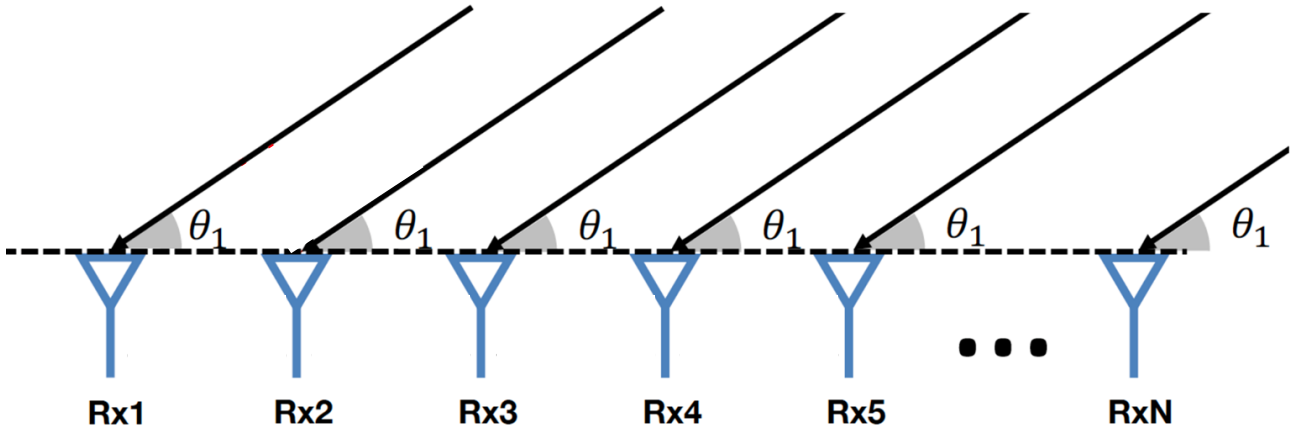
Localization Tasks



Distance

Direction

Traditional approach: Antenna Array



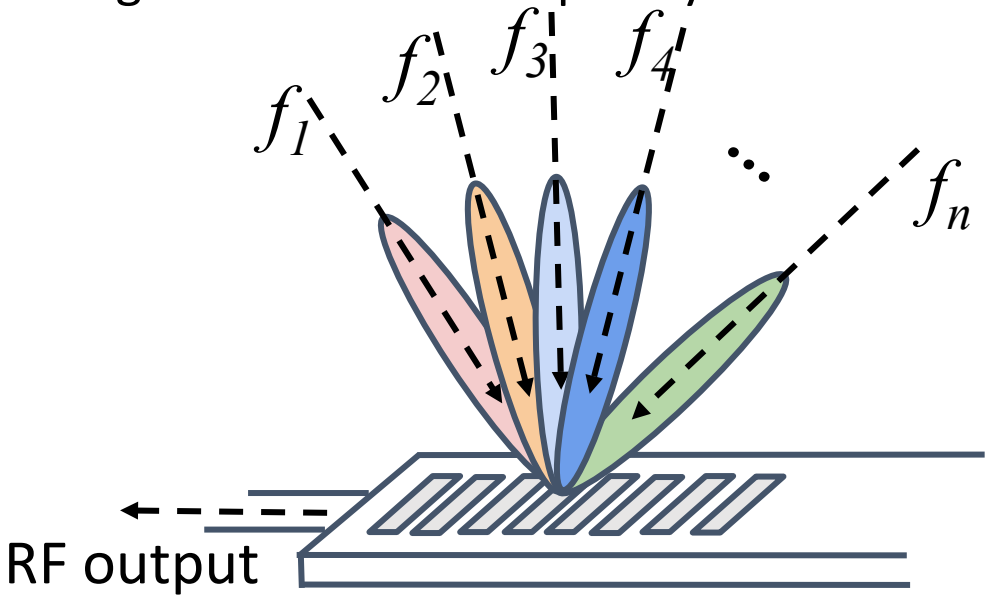
Problem: requires multiple transceiver chains

Can we measure direction using a single transceiver chain?

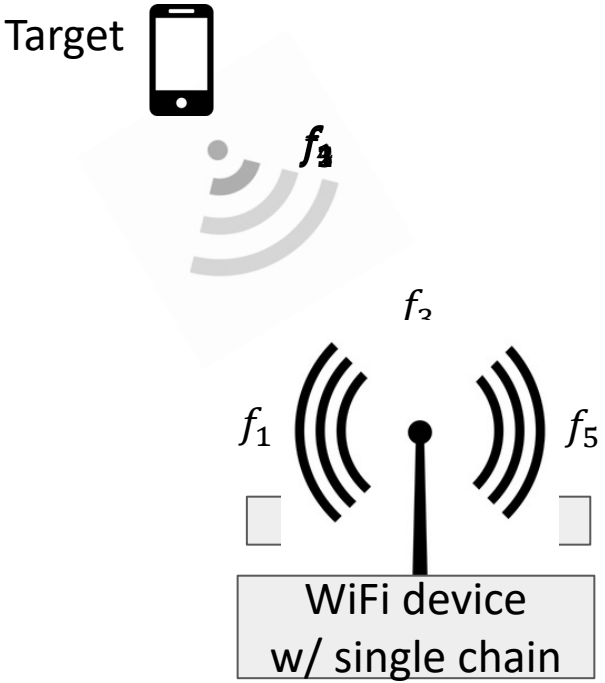
Solution: Use Frequency Scanning Antenna (FSA)

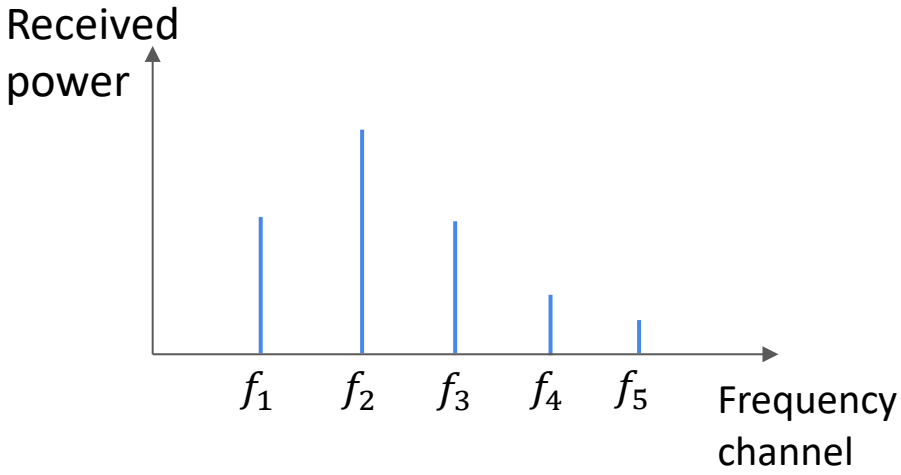
There is a one-to-one mapping between frequency and direction

- Receives signals of certain frequency in each direction



Measuring direction using FSA

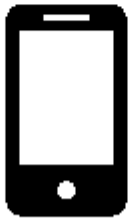




WiFi client devices typically only work on a single channel!

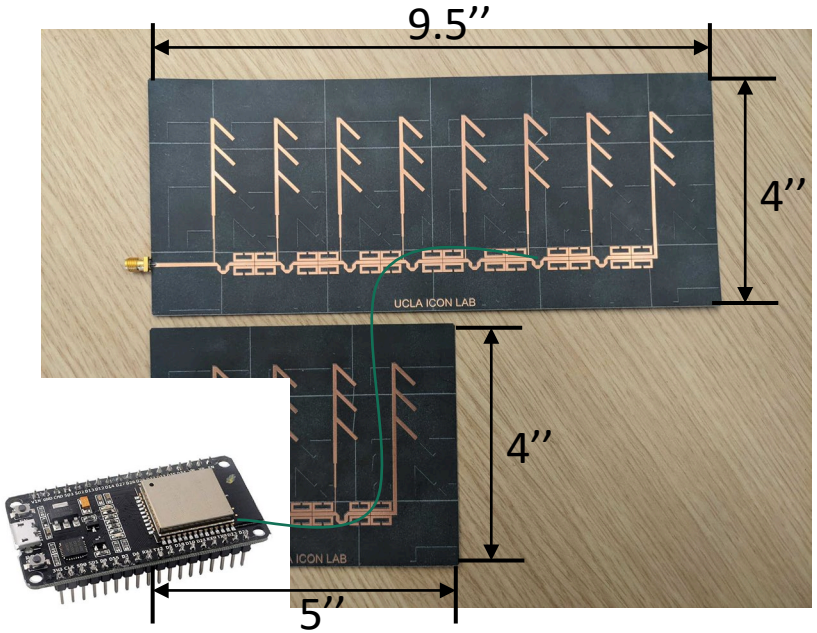
Solution: Probing Mechanism of WiFi

- Probing is an inherent process of WiFi protocol for finding surrounding APs
- WiFi probe request packets are broadcasted by each WiFi device **on each frequency channel periodically**
- Independent of whether the device is connected to a network

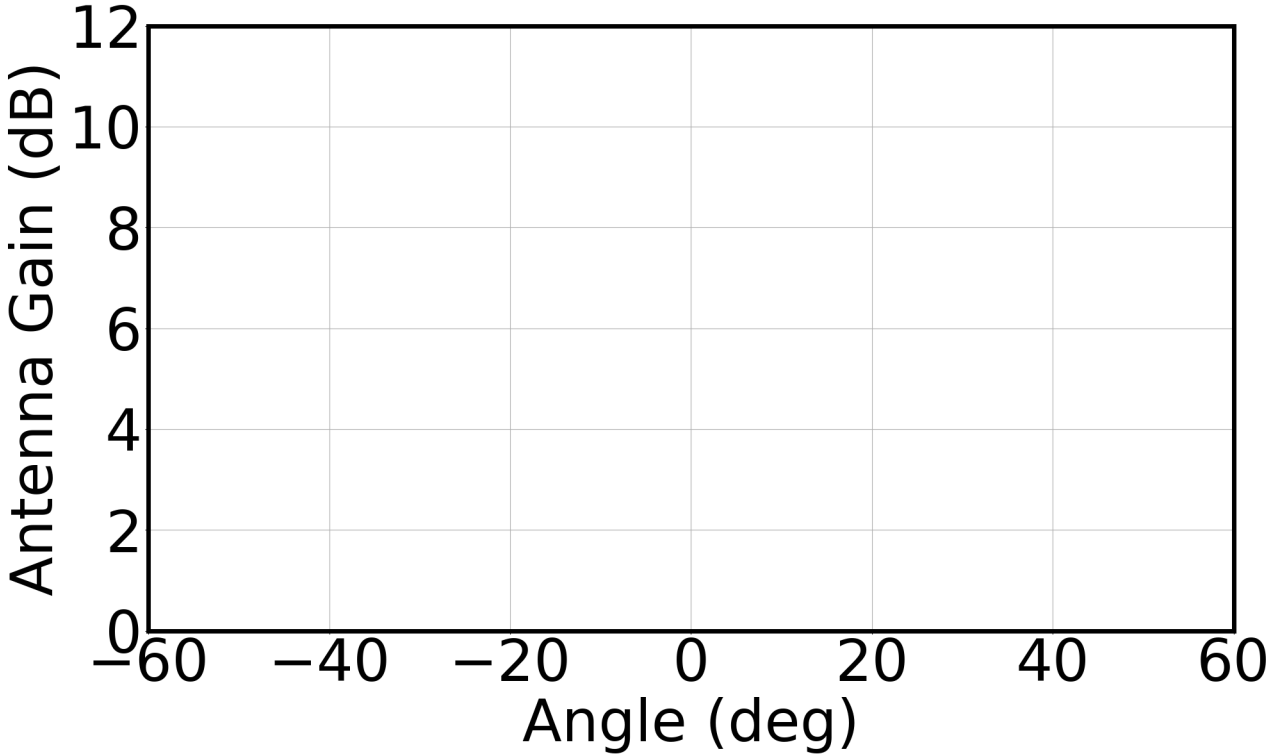


FSA + Probing → finding direction using a single transceiver chain

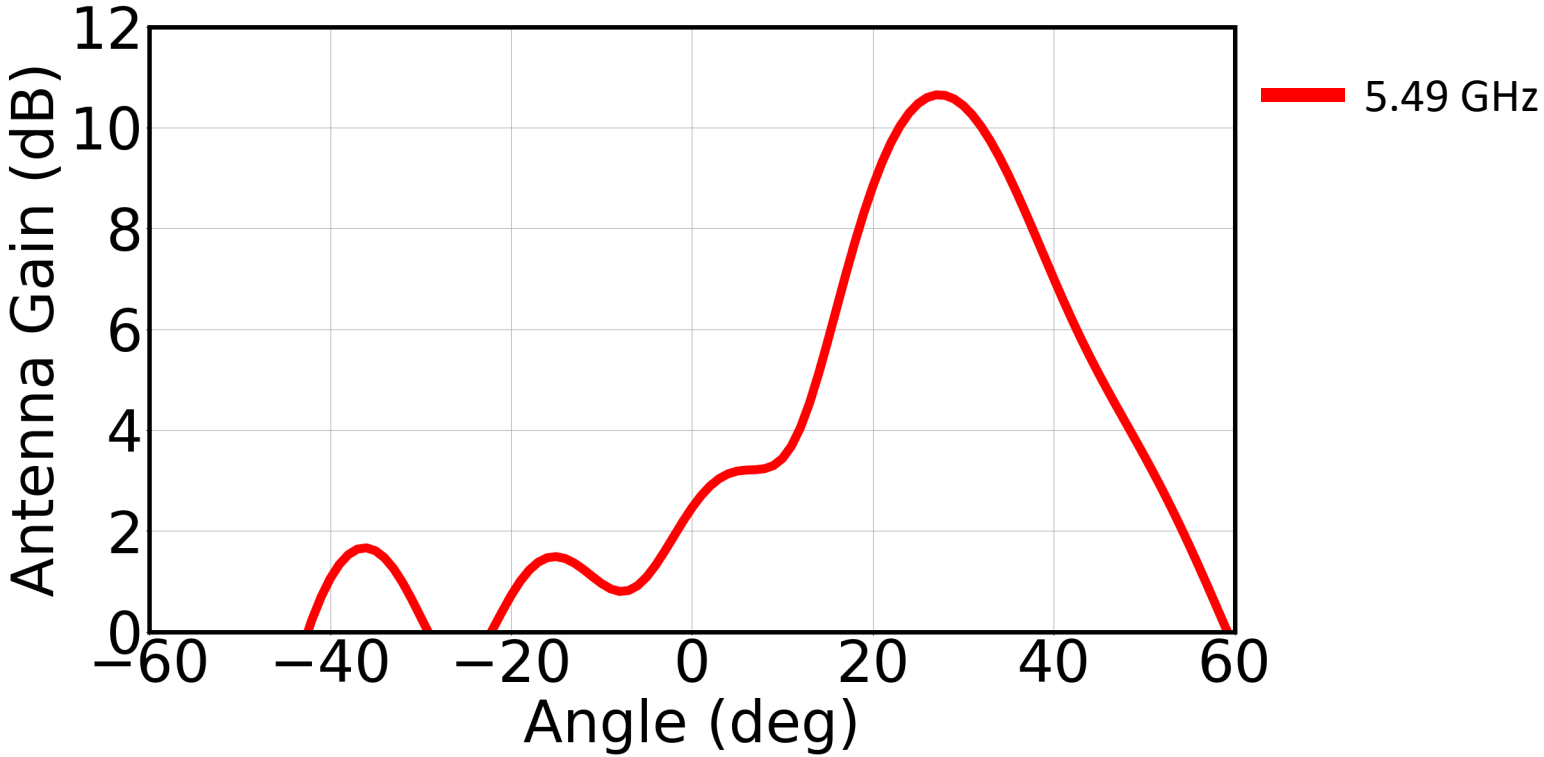
Evaluation



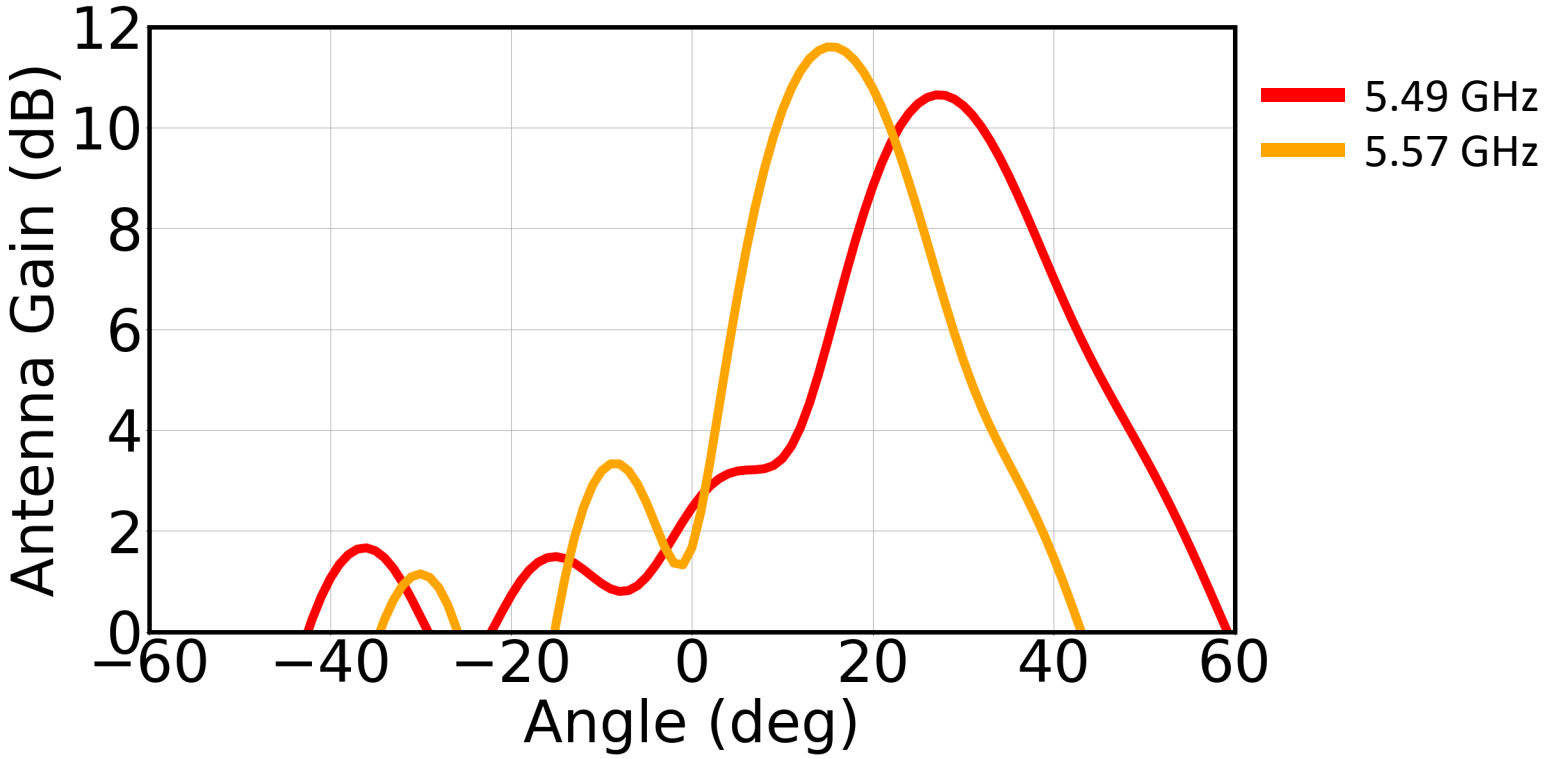
FSA Performance



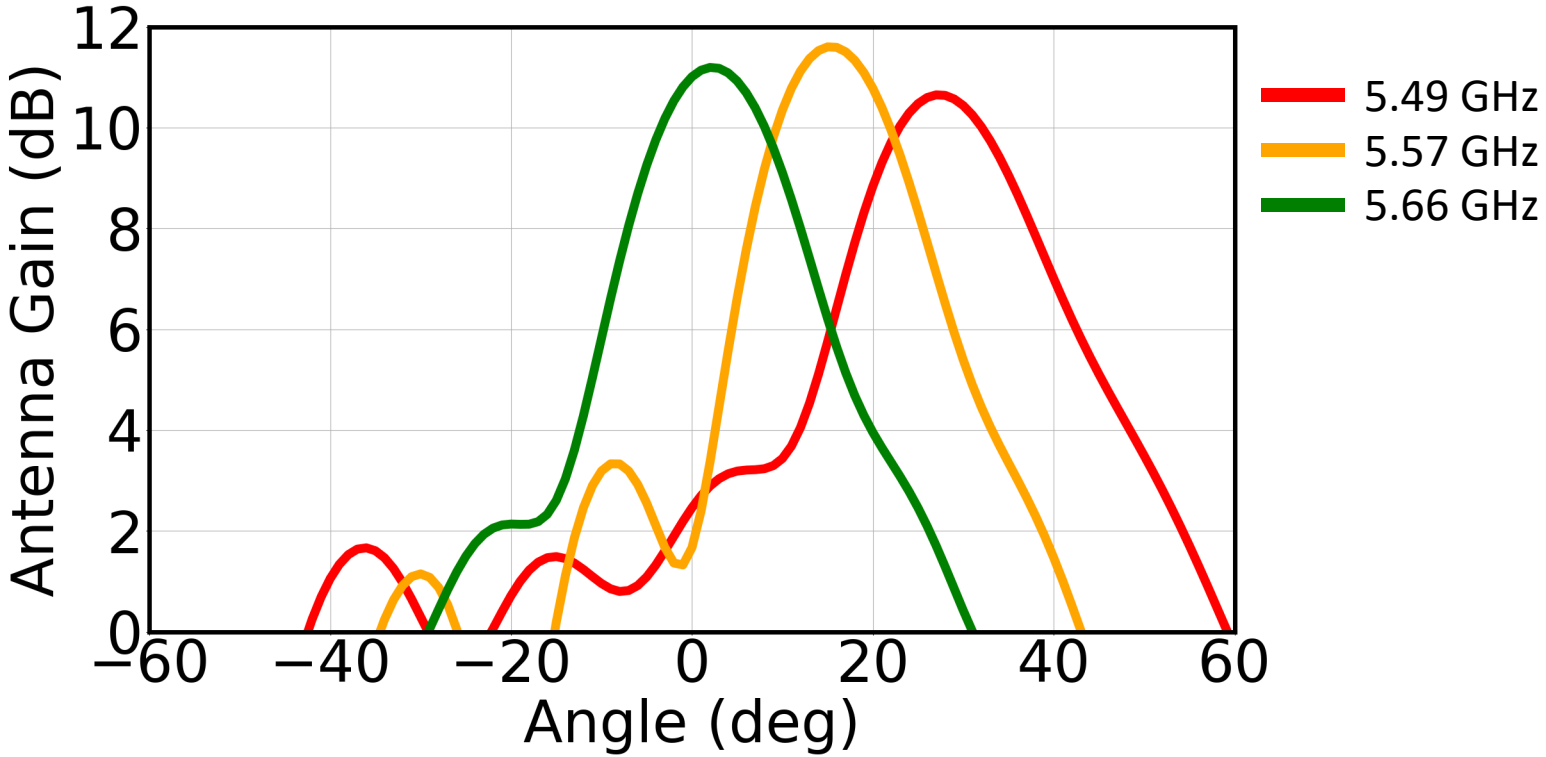
FSA Performance



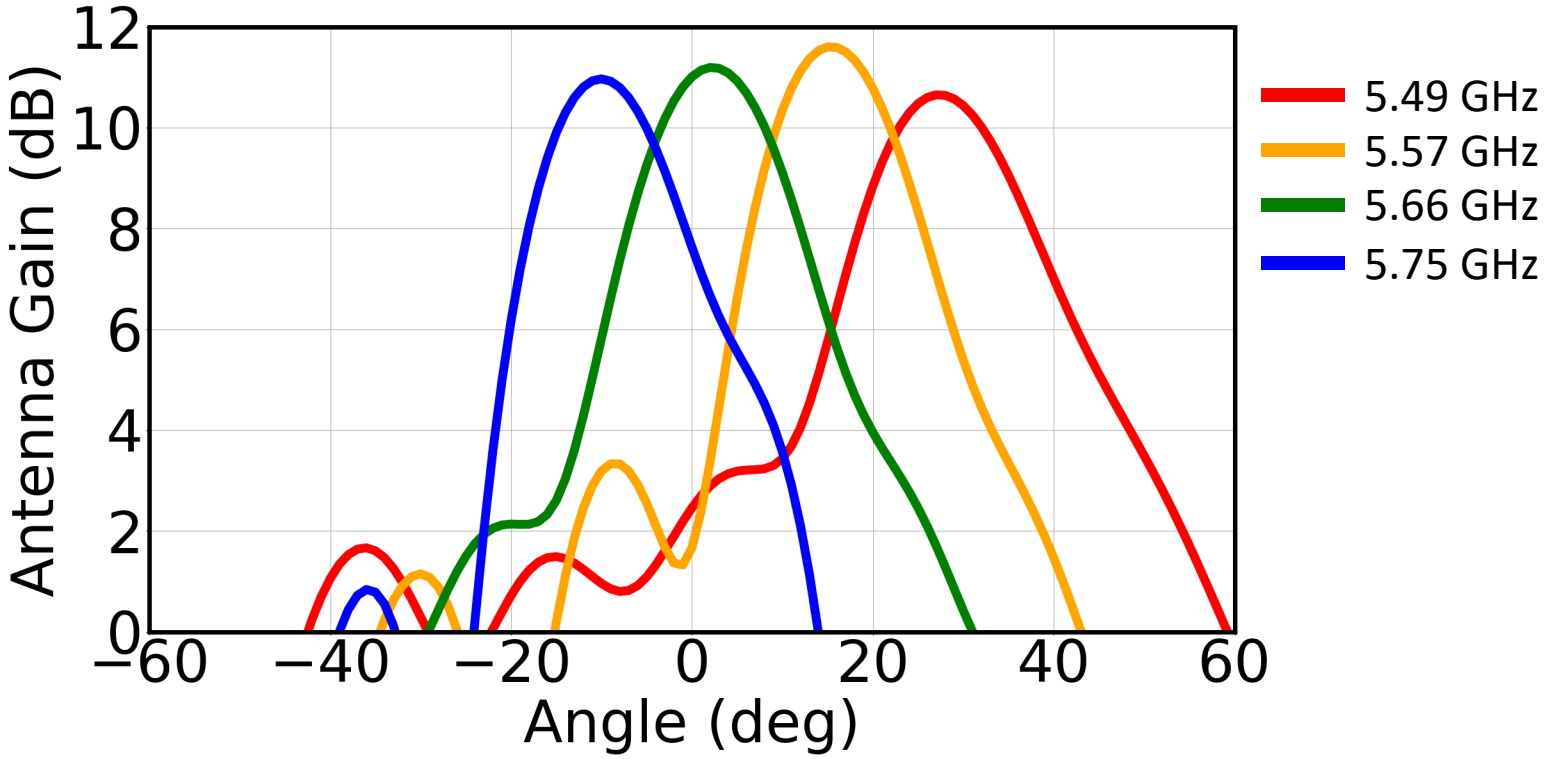
FSA Performance



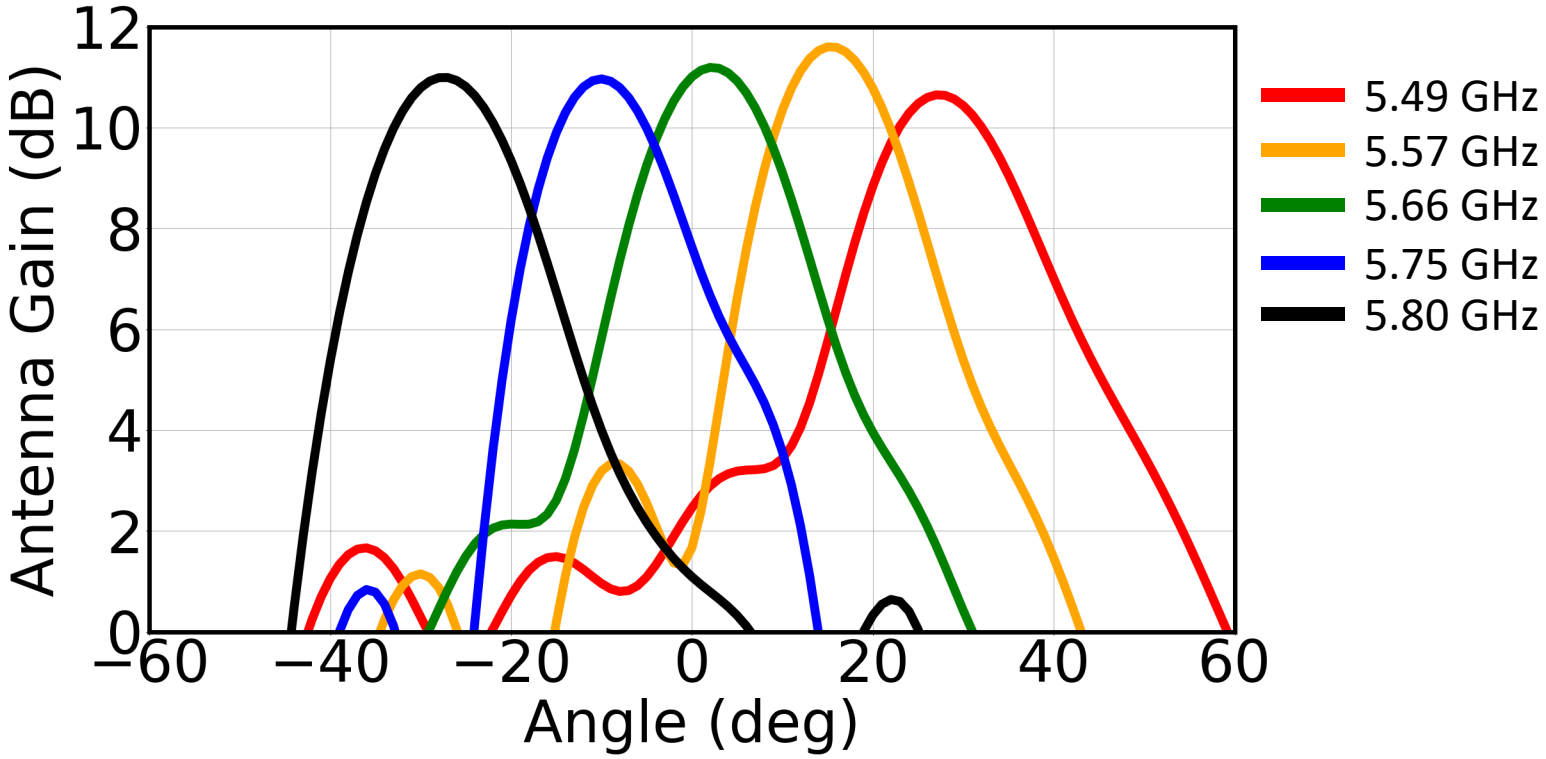
FSA Performance



FSA Performance

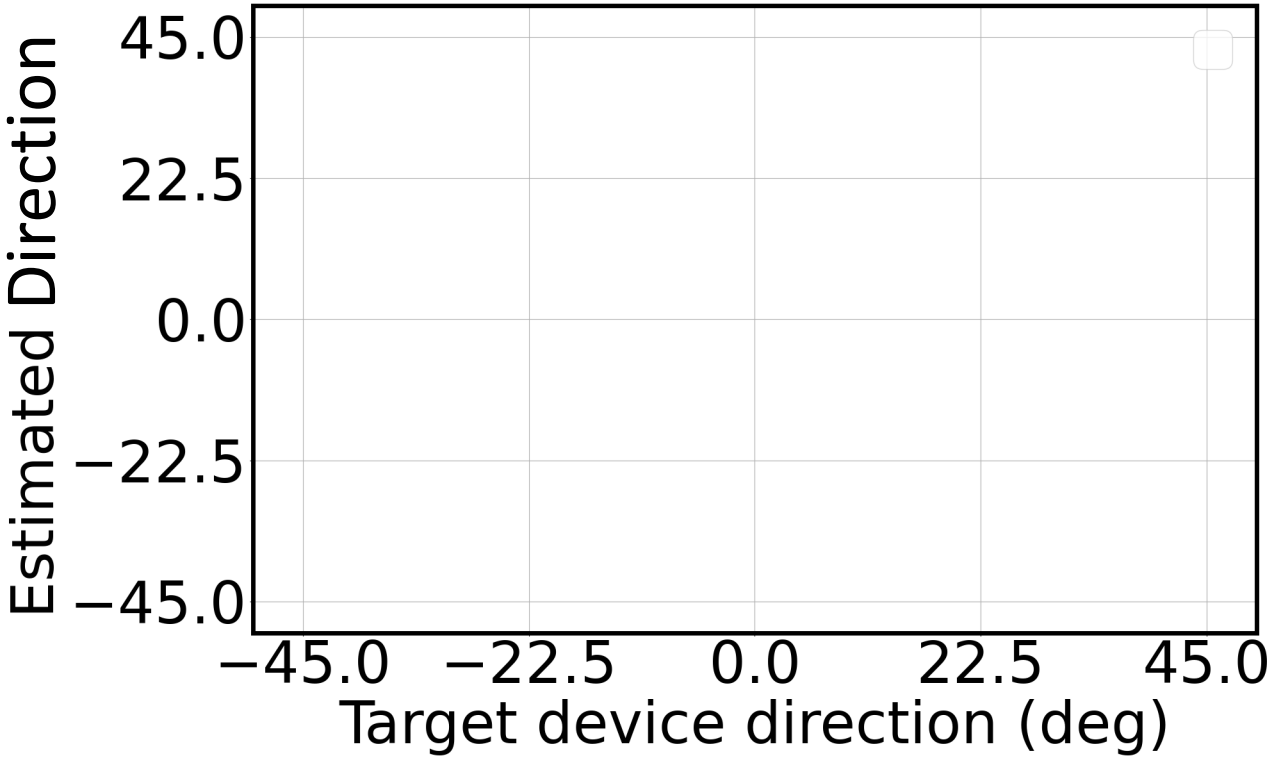


FSA Performance

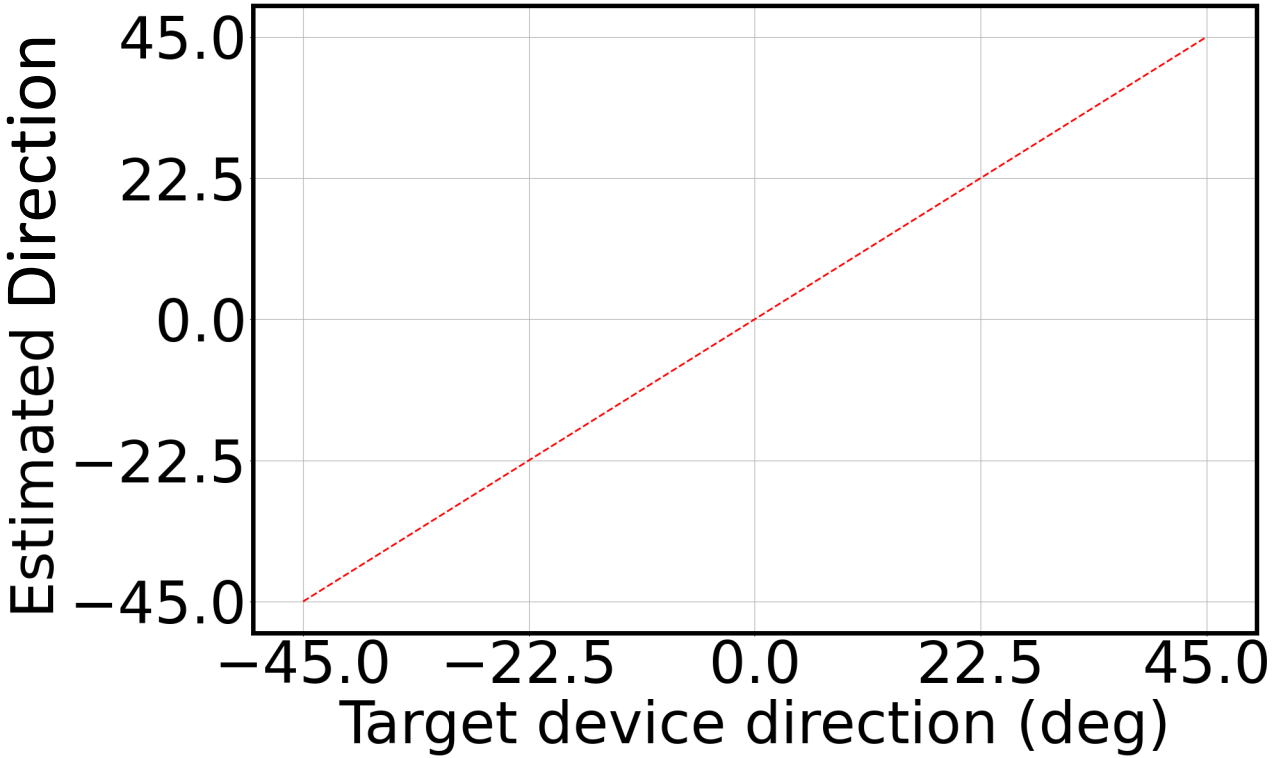


FSA can be used to find the direction

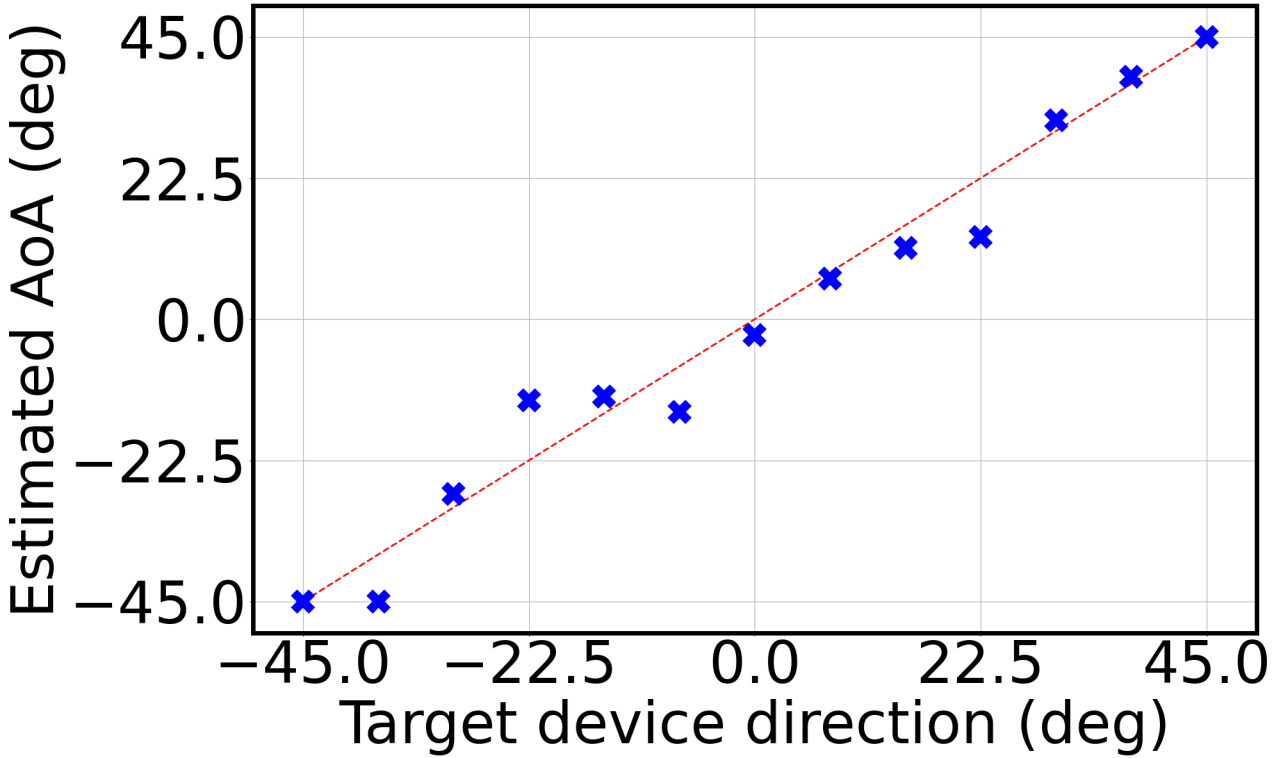
Direction Measurement



Direction Measurement

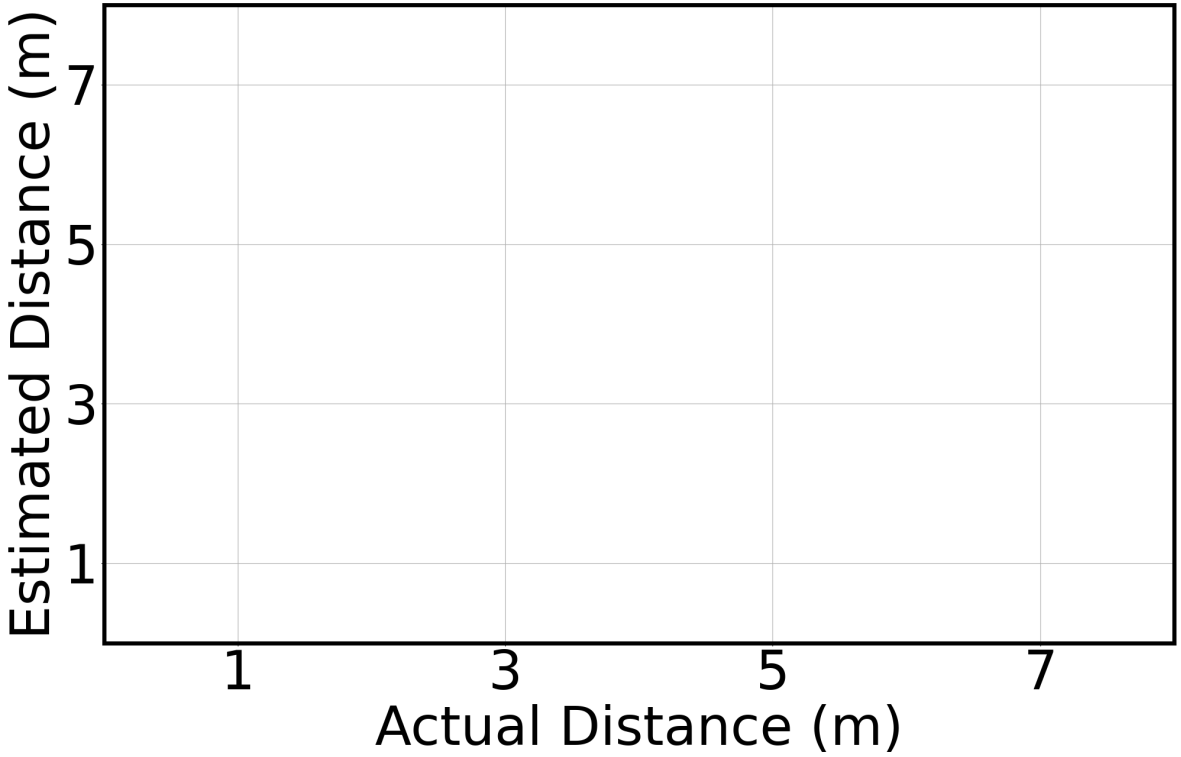


Direction Measurement

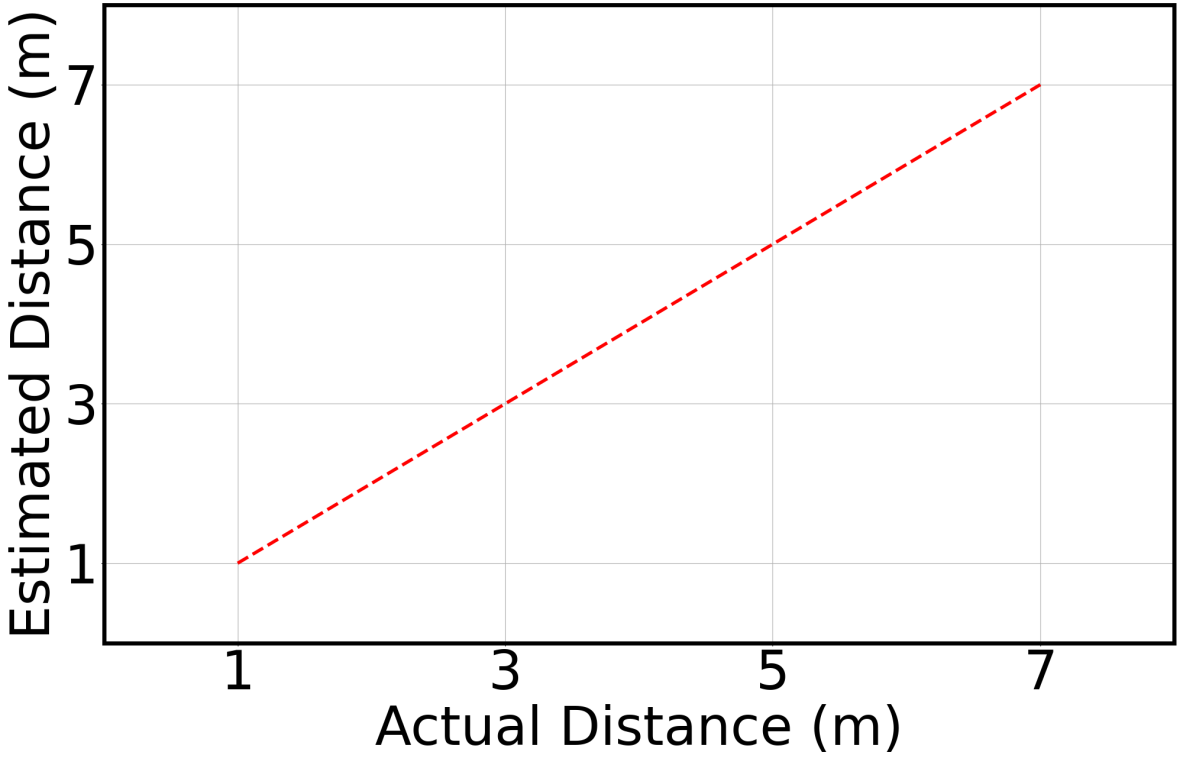


Direction estimation achieves high accuracy

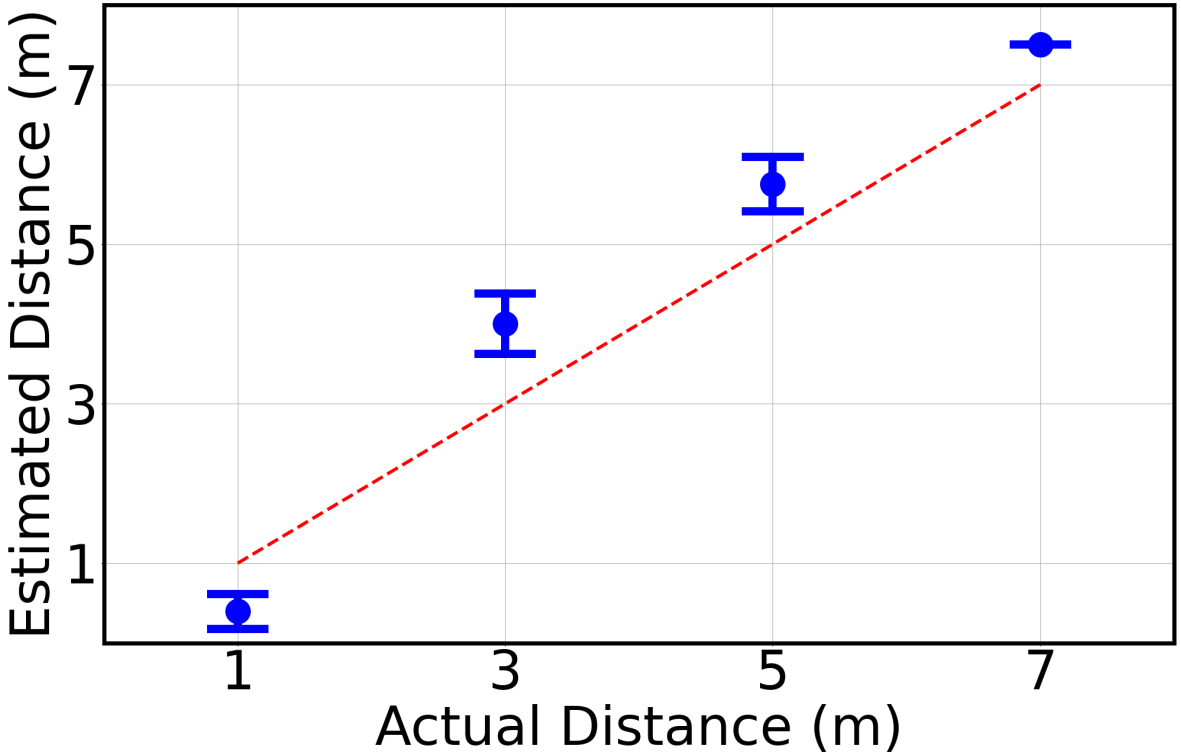
Distance Measurement



Distance Measurement



Distance Measurement



Distance measurement achieves a median error within one meter

Conclusion & Discussion

WiSight brings localization on any WiFi devices, even with a ***single*** transceiver chain.

Future research directions

- Multipath effect
- FSA scanning range
- Integration into applications