

Parallel Channel Sounder for MIMO Communications

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www.wico.sh

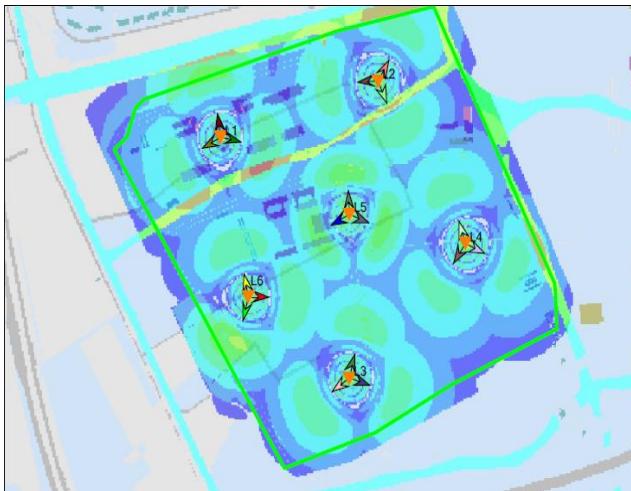
About our our lab



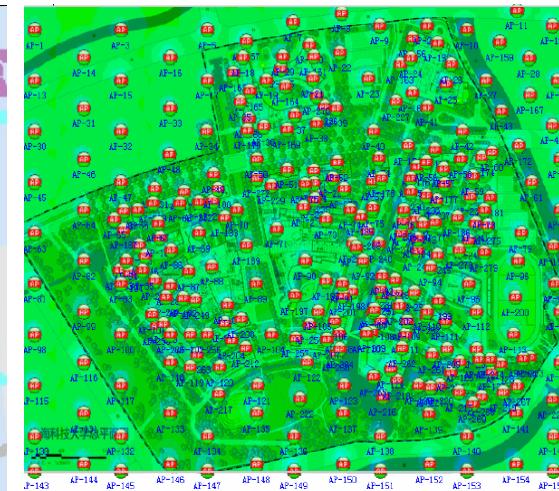
- **WiCO:** R&D on Communication Technology
- **SHIFT:** R&D on Fog Computing (combination of IT and CT)
- **SIMIT:** R&D on Internet of Things



ShanghaiTech University



LTE+5G macro-cell BSs



Outdoor APs

About our our lab



➤ LTE + 5G hierarchical network architecture

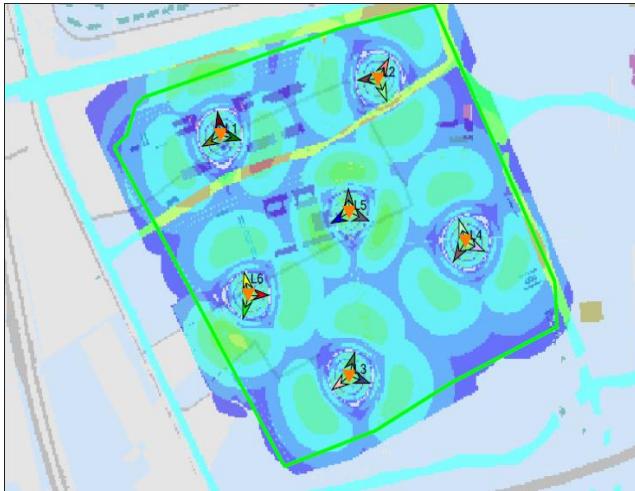
- 6 macro-cell base stations
- 10~20 micro-cell base stations
- 100+ small base stations
- Trial of GPP-based BSs



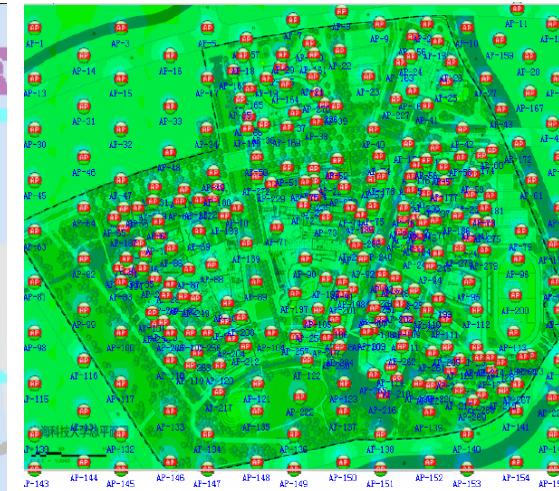
ShanghaiTech University

➤ 802.11ac high speed WLAN

- 100~200 outdoor APs
- 1000~10000 indoor APs
- UDN, multi-carriers
- Trial of GPP-based APs

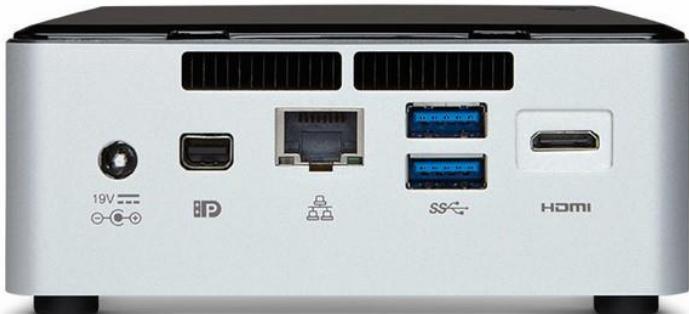


LTE+5G macro-cell BSs



Outdoor APs

About our our lab



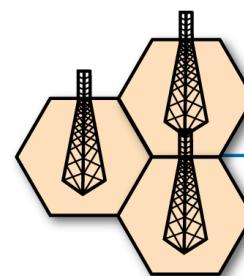
eNodeB



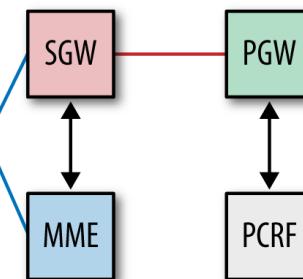
EPC



Radio Access Network (RAN)



Core Network (EPC)



External Network

Outline



- 
- Motivations
 - System Design and Implementation
 - Key Technologies
 - Future Work

Channel Modeling is important for Wireless Communications



VANET



High-speed Train



Aircraft



Industry



Residential area



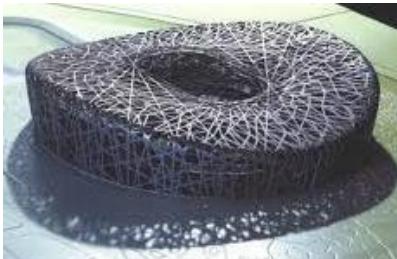
Office



Metro



Large stadium



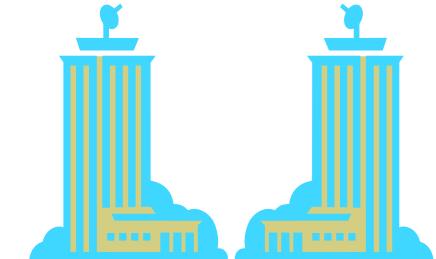
Suburb



Highrise



Backhaul



Channel Emulator to facilitate R&D on Physical Layer Algorithms



What have been done?



Channel Sounder



Data Sharing Platform www.wise.sh

WISE

SIG Datasets Sign in Sign up

A screenshot of the WISE website's data sharing platform. It shows a photograph of a playground with buildings in the background. Overlaid on the image are technical parameters: frequency: 3.5GHz, scene: playground, number of transmitting antenna: 8, and number of receiving antenna: 8.

WHO WE ARE

Shanghai Research Center for Wireless Communications (WICO) is a leading research and evaluation institute focusing on the R&D of the key technologies for next-generation mobile communication network, including integration testing, validation, and standardization. We are a highly skilled team of electronics engineers and researchers performing a full range of quality measurement and research to promote the development of the wireless communications. We have undertaken a great number of scientific research projects funded by the MOST, MIIT, NSFC, National Science and Technology Major Projects, 863 Hi-Tech

WHAT WE DO

WICO has developed a multi-channel based platform for wireless communication system testing and evaluation, which has overcome a series of technical difficulties, such as nonlinear crosstalk of multi-channel RF signals, insufficient precision of multi-channel synchronization. Based on this advanced platform, a large mount of wireless channel measurements has been conducted in many typical scenarios, including beach, stadium, hotel lobby, rural area, campus hot spots, etc.

CONTACT US

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Outline



Motivations

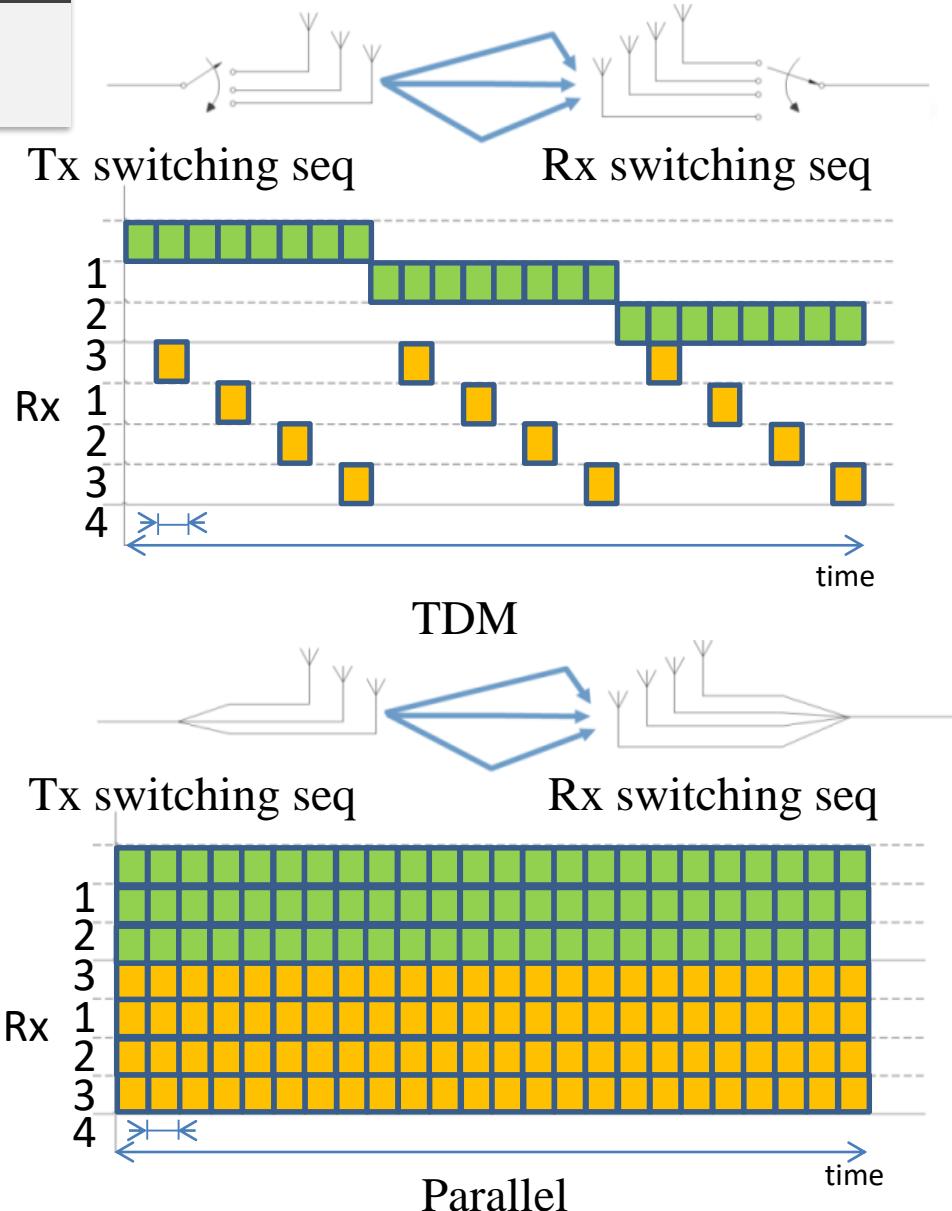
System Design and Implementation

Key Technologies

Future Work

System Design Requirement

- 1. Scenarios:** Distance >500m; **3D channel**; Speed (**350km/h**).
- 2. High-precision synchronization between multiple channels**
- 3. Raw data real-time storage**
- 4. Calibration for MIMO transceiver:** **64 channels** and vector signal transceiver system response
- 5. Post data processing for multichannel:** interference cancellation and parameter estimation

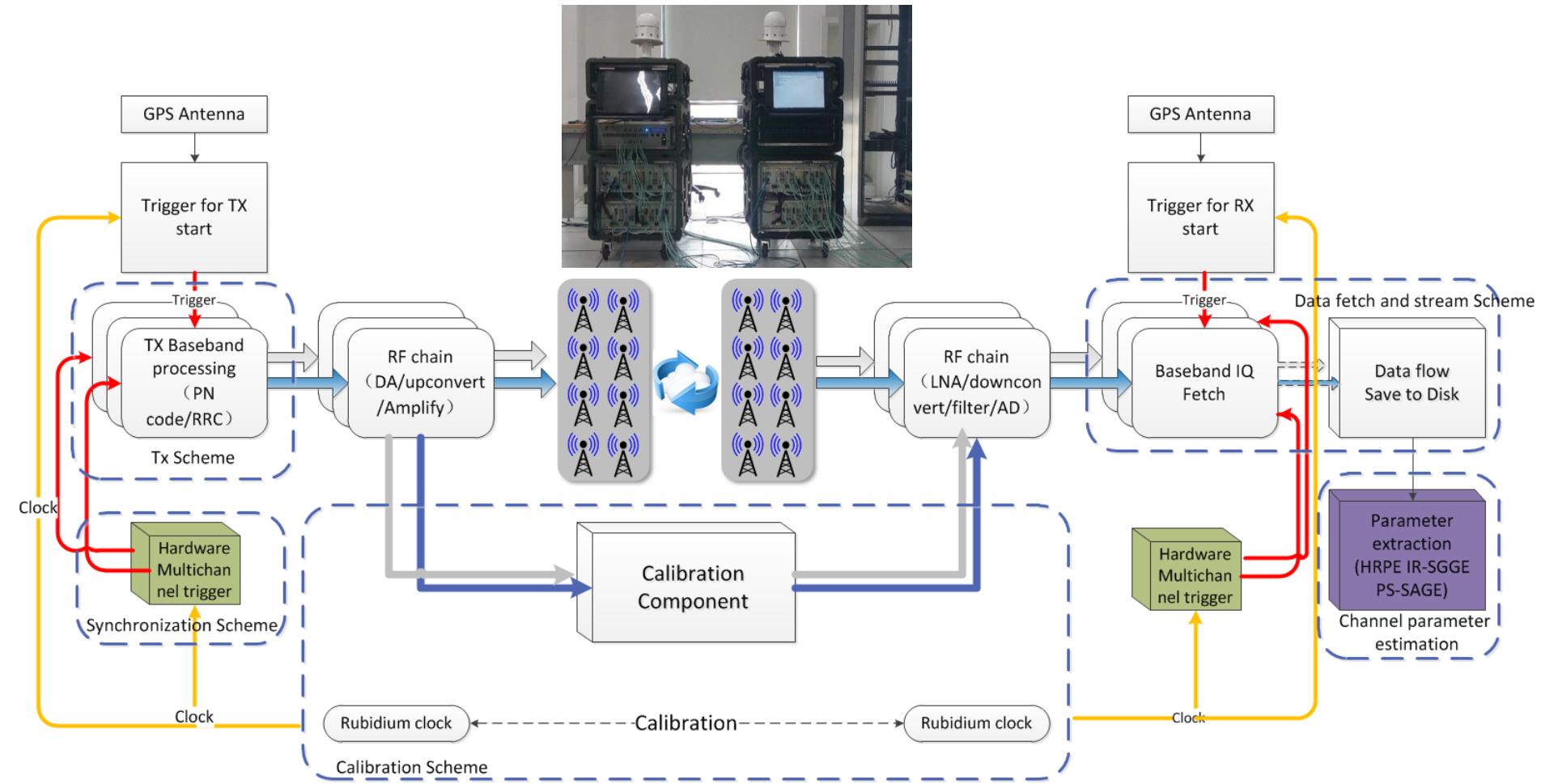


System Design Requirement



ID	Function/Parameter	Value
1	Multi-channel 8×8 bidirection	/
2	Frequency range (without PA)	200MHz-5.9GHz
3	Frequency range (with PA)	2.1GHz-5.9GHz
4	Phase error of time base signal	≤ 5ns
5	Transmit Power (Each Channel)	≤ 8W
6	Overall Power Consumption (Transmitter& Receiver)	≤ 3KW
7	IQ rate of Transmitter (Each Channel)	Max 250MS/s
8	IQ rate of Receiver (Each Channel)	Max 250MS/s
9	System bandwidth	Max 200MHz($\pm 5\text{MHz}$)
10	Phase error of each channel (Transmitter)	≤ 50ps
11	GPS Location Function (Transmitter& Receiver)	/
12	System Calibration Function	/
13	Data transfer rate & storage capacity	≤ 3.2GB/s & 5TB
14	Delay resolving precision	0.4 × 1/Bandwidth
15	Dynamic range of CIR	30dB
16	Max duration of data streaming	≥ 25min
17	Characteristic parameter extraction	/

System Framework



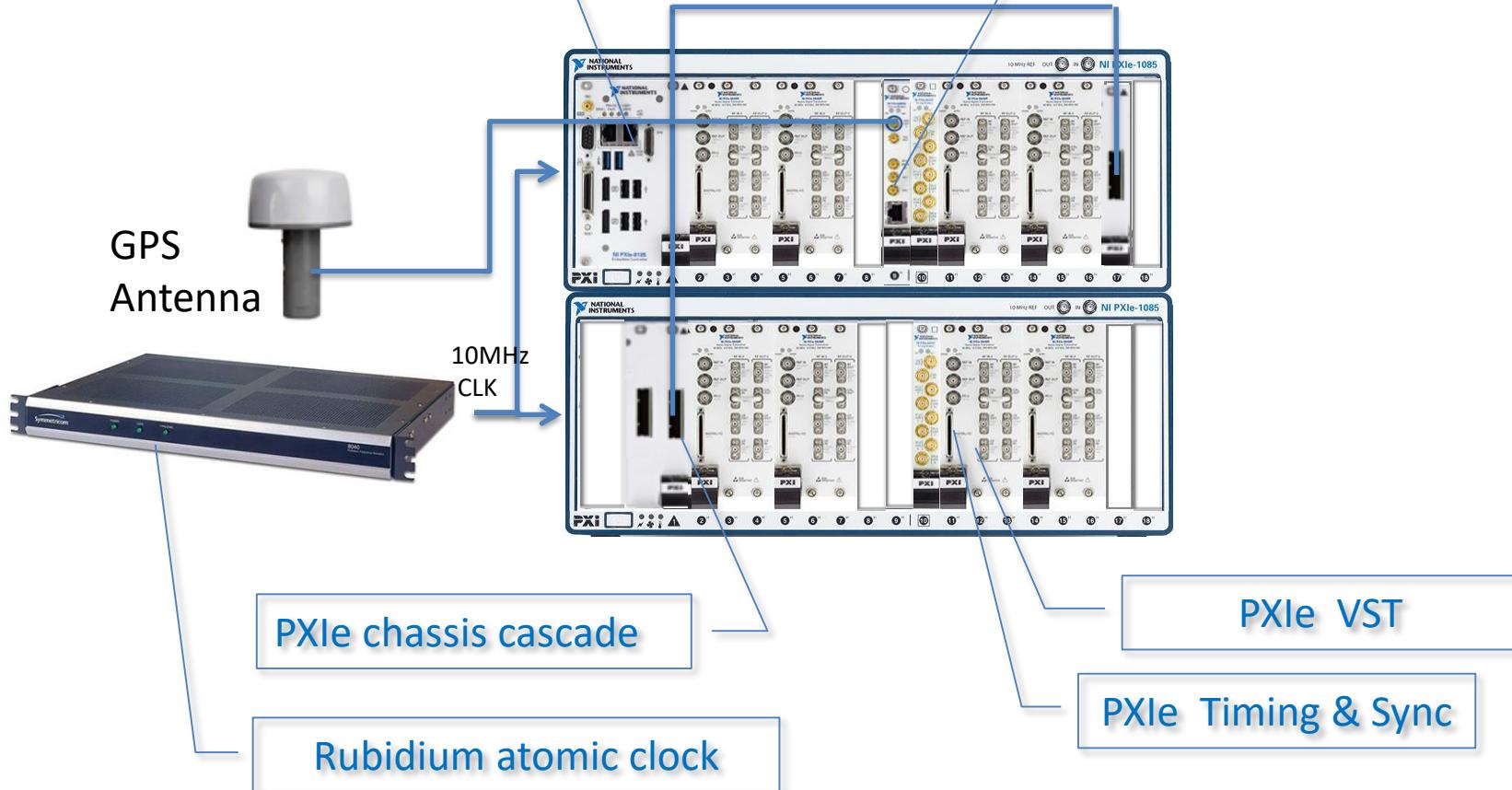
Transmitting Unit



Tx: 8*8 MIMO TX Part

PXIe PC controller

PXI GPS Receiver



Receiving Unit



Rx: 8*8 MIMO RX Disk
Streaming

PXIe PC controller

PXI GPS Receiver

PXIe cascade + Disk Array (SSD)

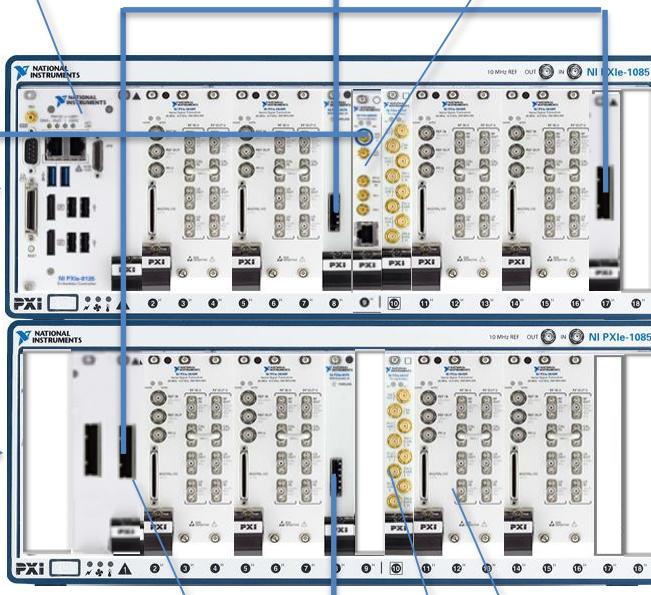


10MHz CLK



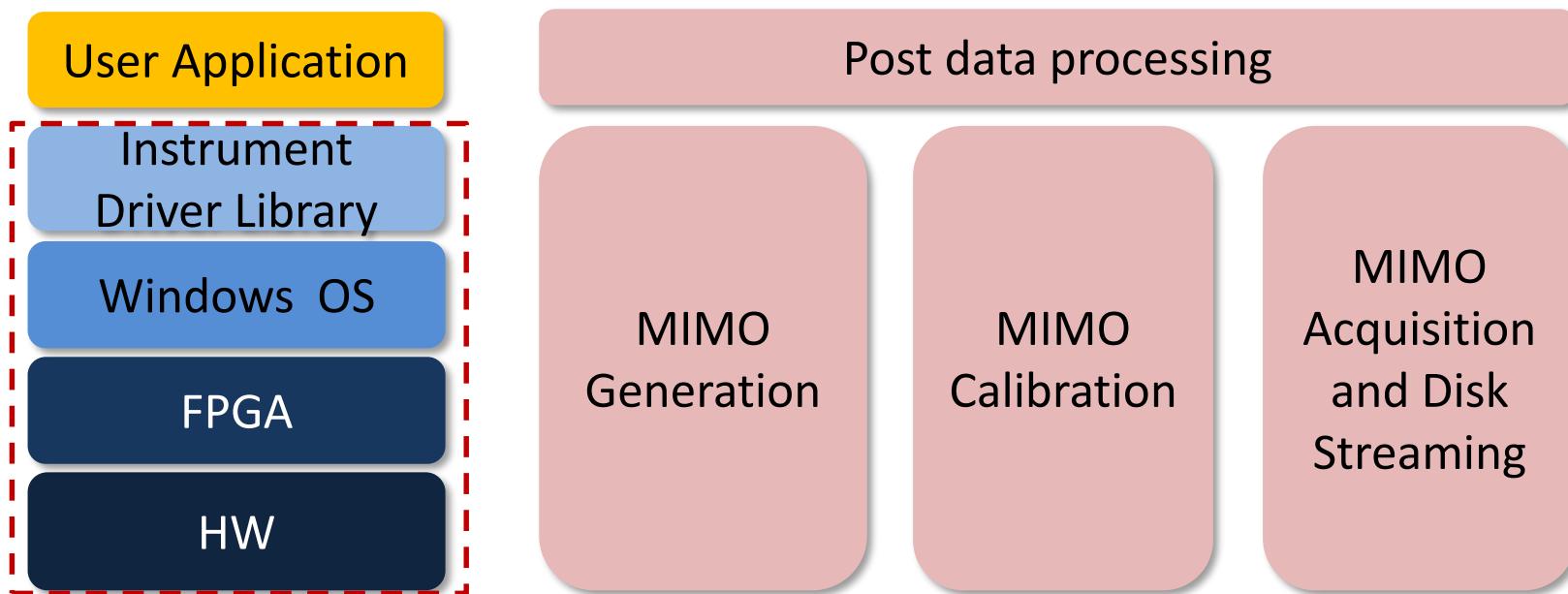
PXIe chassis cascade

Rubidium atomic clock



PXIe VST

PXIe Timing & Sync



Content

Motivation

system design and implementation

Key technology

Future work

Channel synchronization



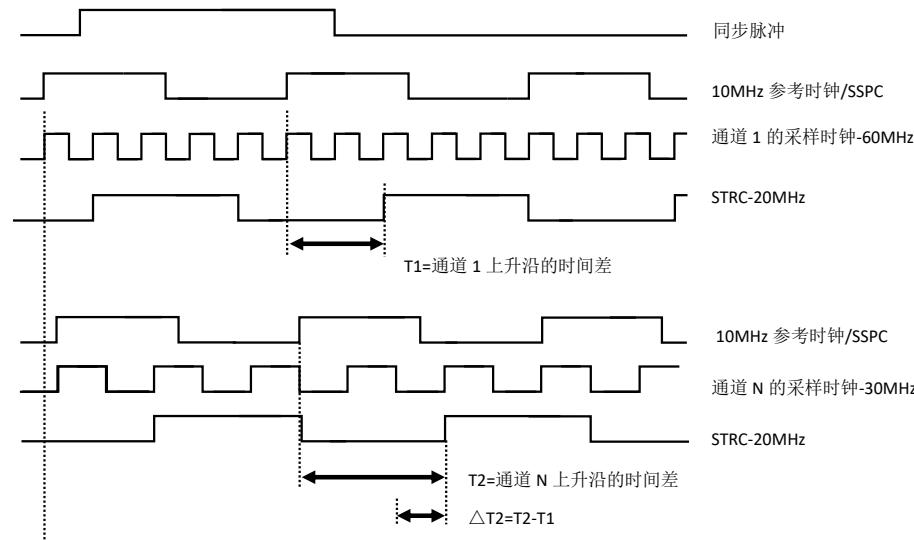
Challenge :

- Crosstalk , non-orthogonal error, path difference raise the phase difference
- Pico second level synchronization precision for accurate estimation
- Phase coherent Signal generation & Acquisition

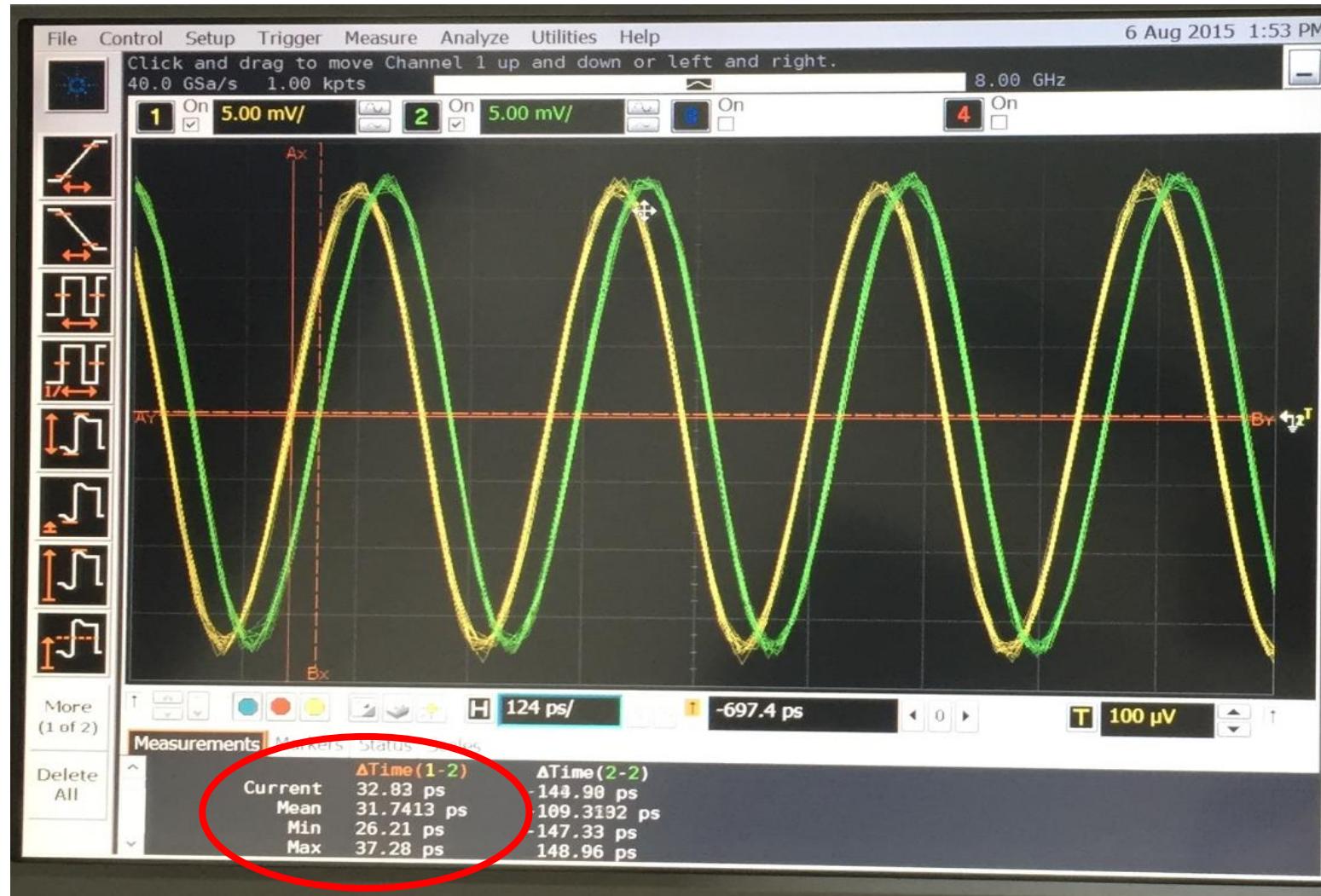
Implementation:

Timing jitter can be reduced to 30ps among 8 channels of MIMO parallel Channel sounder

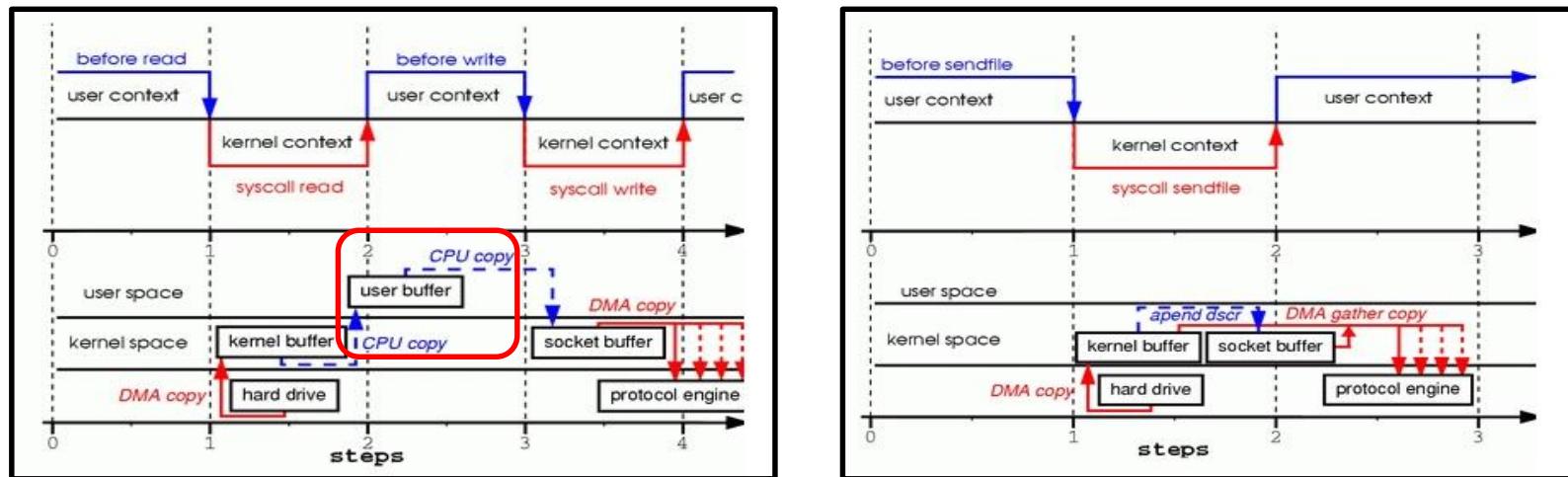
The synchronization accuracy is less 1ns of Keysight M9391A (PXIeVSA) and M9381A (PXIe VSG)



Channel synchronization



Real-time data streaming

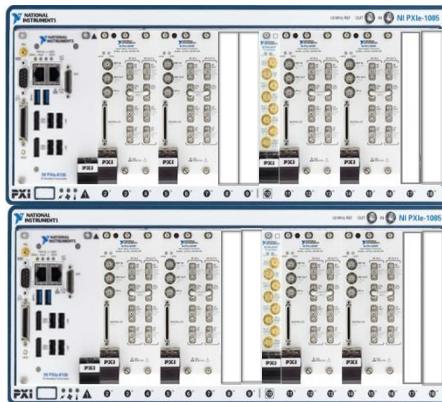
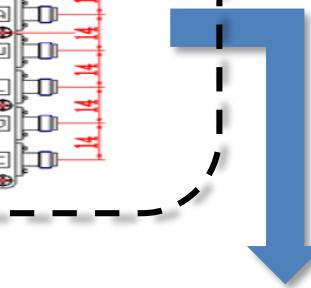
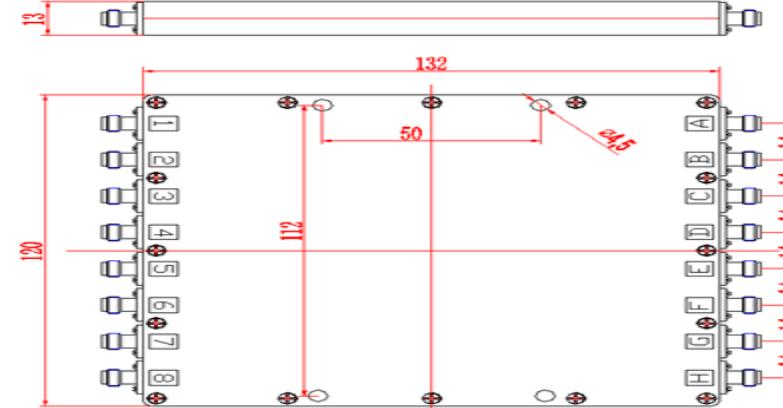
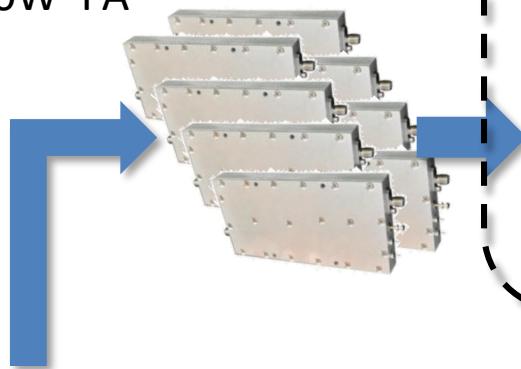


- P2P link between FPGA and SSD
- Zero-copy technology to reduce delay
- TDMS (Technical Document Management System) method for storage and data organization

Parallel channel calibration



10W PA



$$Y = RSTX$$

$$Y^{\circ} = RHTX + N^{\circ}$$

- Using VNA to get S (cali component)
- Using calibration data to get R (receiver) and T (transmitter)
- Using R and T to reconstruction signal

$$\text{MAX}_{chanPara}(P(Y^{\circ}| RH(chanPara)TX))$$

- Using ML to estimation channel parameter



Post data processing



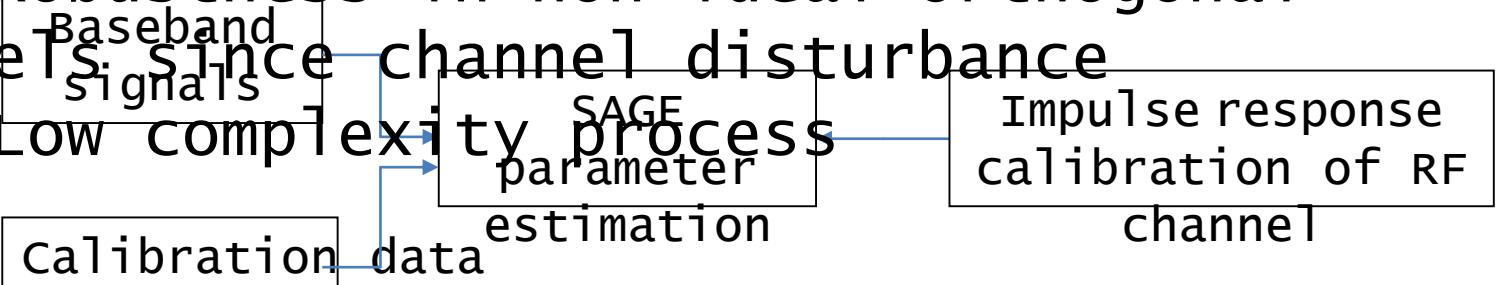
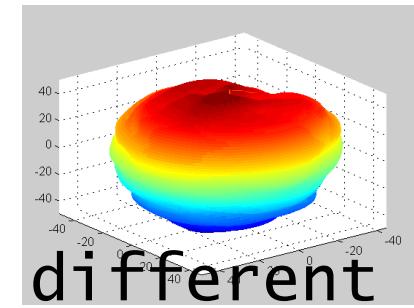
HRPE : PS-SAGE

Parallel Sounder-SAGE(PS-SAGE)

- Considering coherence among the different channel
- Antenna pattern measurement using N paths transmitter and one path receiver

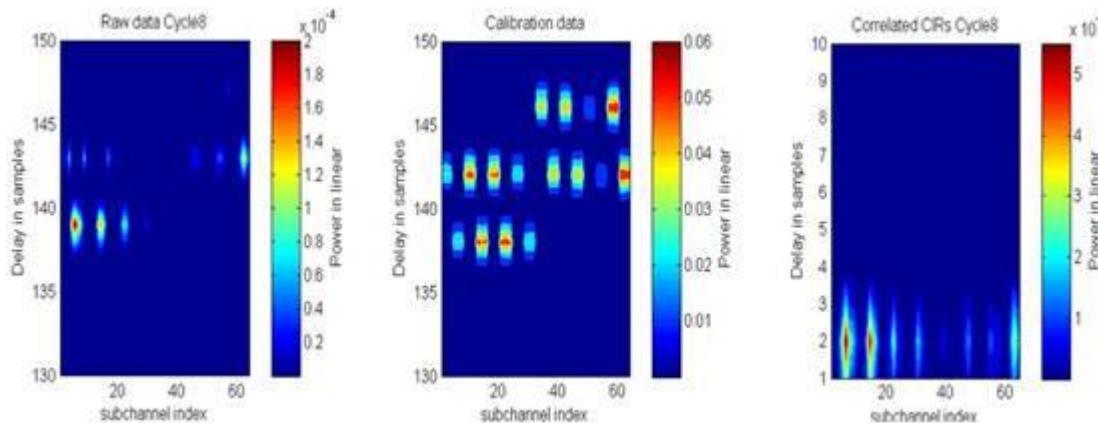
• Robustness in non-ideal orthogonal channels since channel disturbance

- Low complexity process



HRPE : High Resolution Parameter Estimation

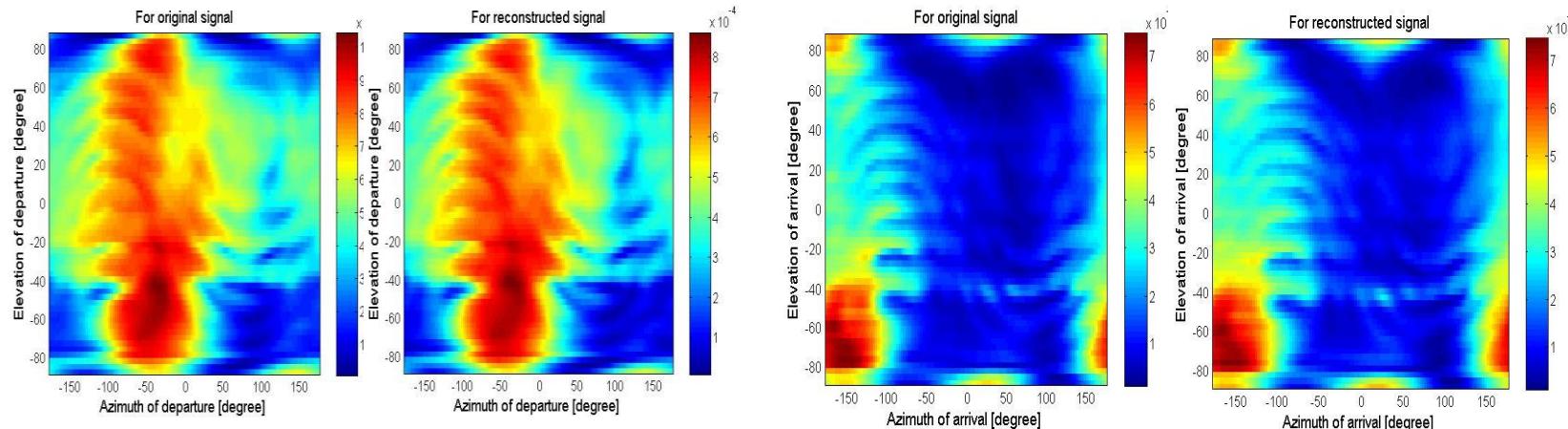
Parameters estimation



Using calibration data to correct different delay among multichannel

Parameter estimation is accurate

Reconstruction signal spectrum is highly similar to original signal spectrum



Key parameters



Parameter	PropSound	SHIFT
Center frequency / bandwidth	<6GHz	<6GHz
RF Channel /Tx (Rx)	1	8
Channel sounder method	TDM MIMO	Parallel
RF bandwidth	120Mhz	200Mhz
Transmitted power per antenna	27dBm~40dBm	15dBm~40dBm
dynamic range	40dB	30dB
multipath time resolution	8.33ns	5ns
maximum Doppler shift	30~60Hz	2kHz
maximum detectable speed of an object	<30kmh	>350kmh
Maximum impulse response	20.48us	20.48us
Data stored	CIR	Raw Data/CIR
Parameter method	SAGE	Parallel SAGE
Implement platform	customized	SDR

Advantages



- Advanced 8x8 parallel channel sounder
- Suitable for dynamic MIMO channel with high velocity
- Dynamic range comparable to TDM sounder
- Flexible and adaptive with SDR platform
- Interference cancellation by PS-SAGE
- Transferable to MIMO channel emulator

Outline



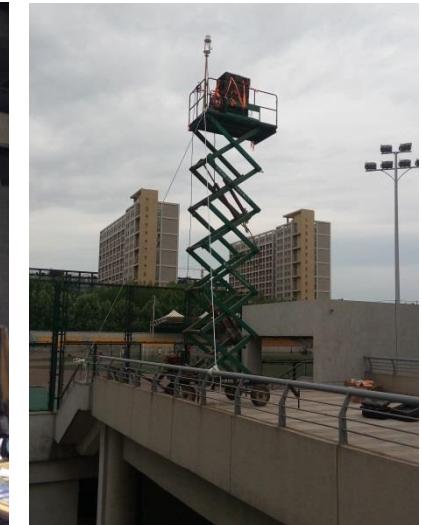
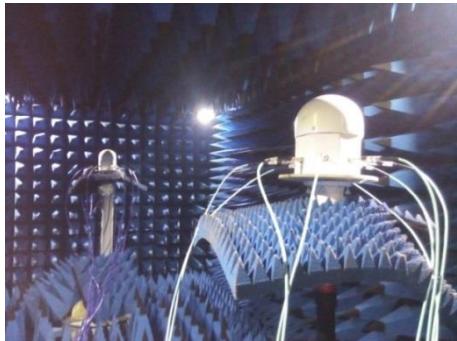
Motivations

System Design and Implementation

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Future Work

Measurement campaign



Channel measurement Databank

1. Verification and Comparison
With ray tracing software
With channel emulator

2. Extend to
64*64
Parallel & Serial

3. mmWave Channel measurement
2GHz bandwidth
60–110GHz





Thank you !

Contact:

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