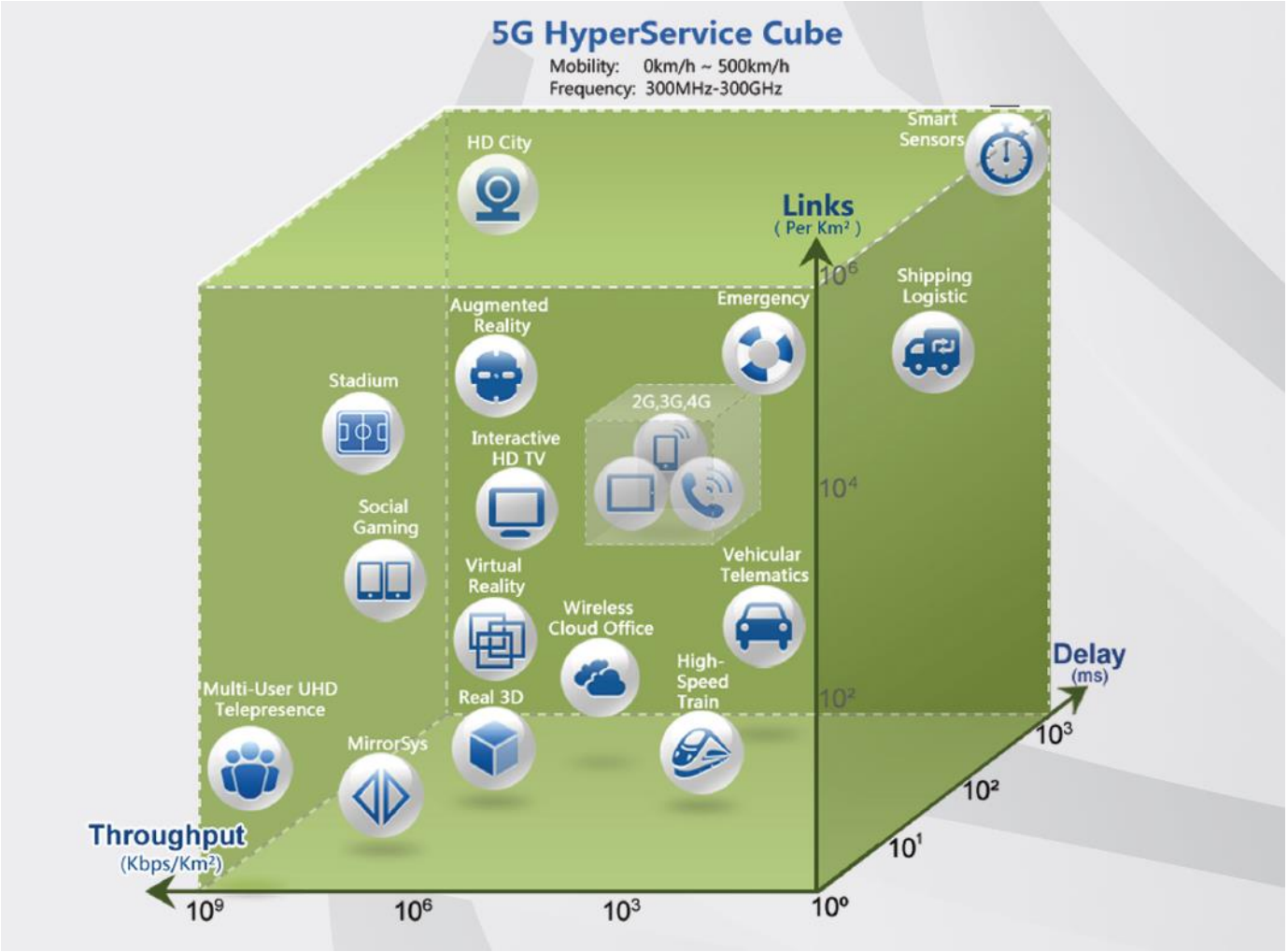
Exploiting TDD Channel Reciprocity in Massive MIMO

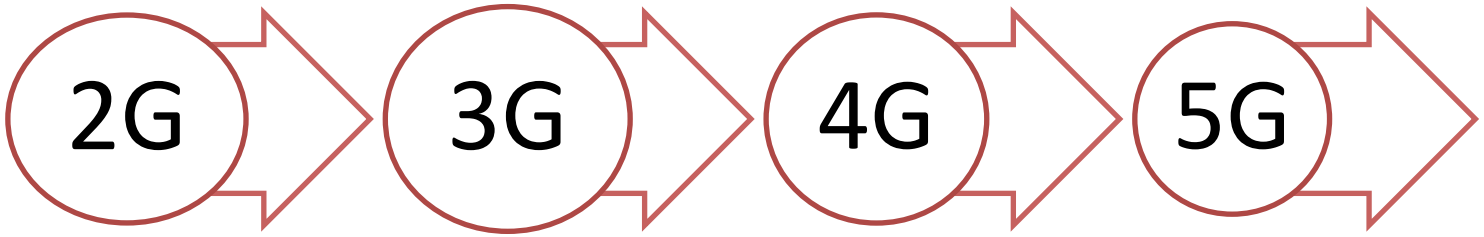
Xiwen JIANG
Supervised by Florian Kaltenberger and Luc Deneire
Labex UCN@Sophia
http://ucnlab.eu

Future Services and Requirements



Source: [5G: A Technology Vision - Huawei]

Wireless Network Evolution



SISO

Single Input
Single Output

SU-MIMO MU-MIMO

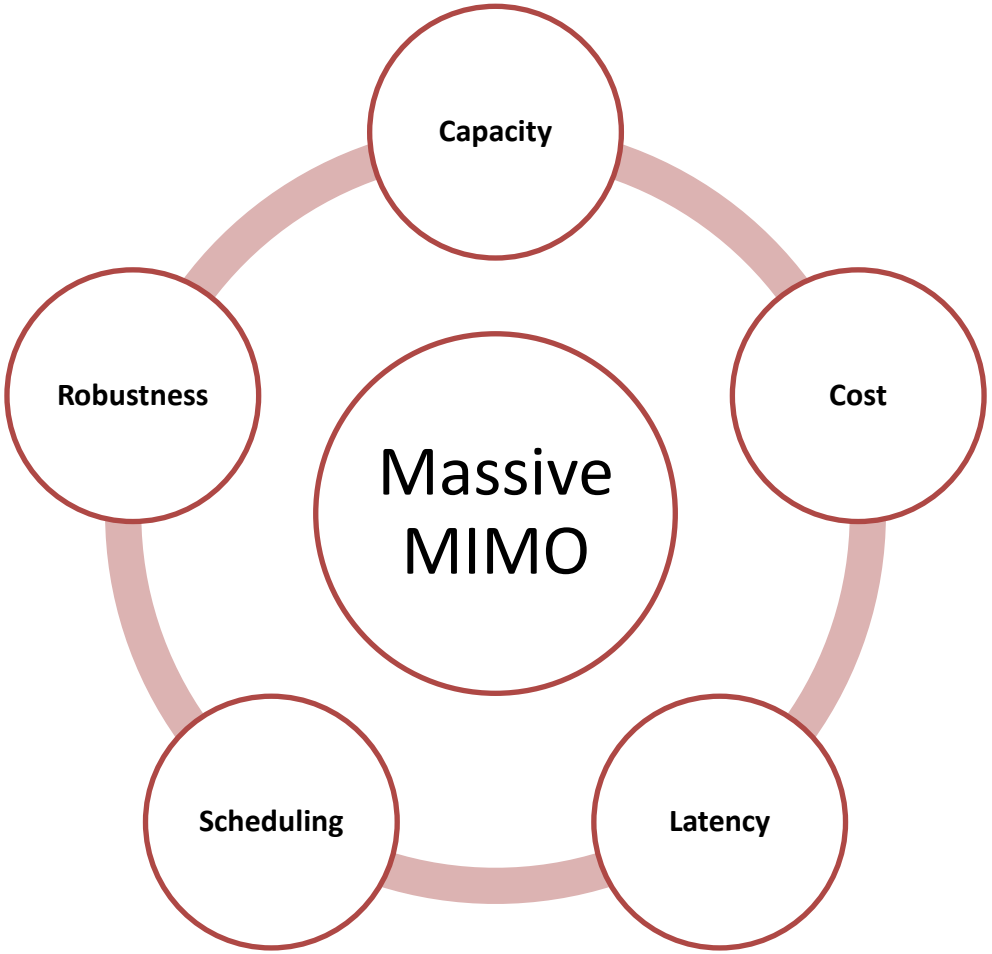
Multiple Input
Multiple Output

Multi-user
MIMO

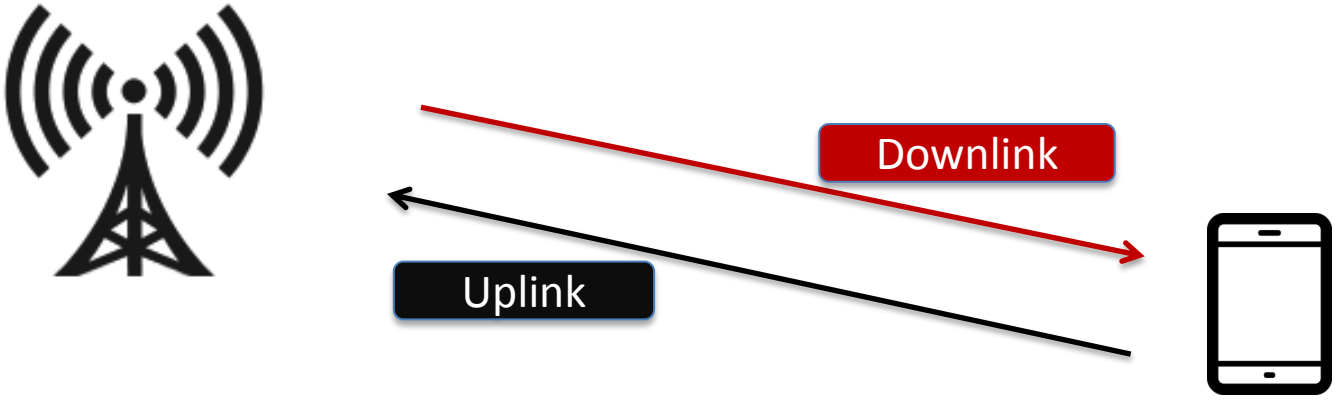
Massive MIMO

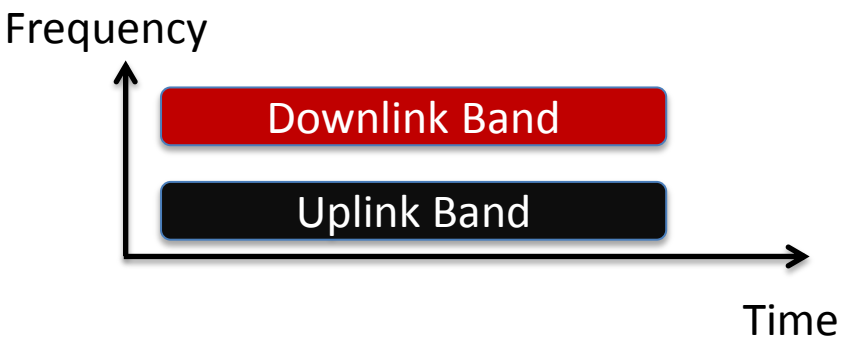
Large number of antennas at the Base Station

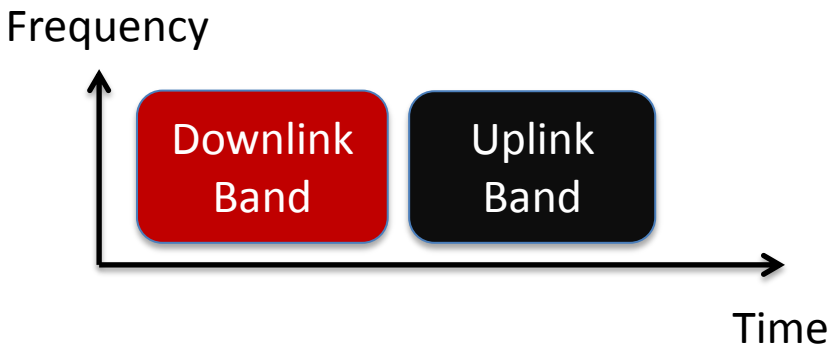
Massive MIMO in 5G



FDD vs. TDD in Massive MIMO



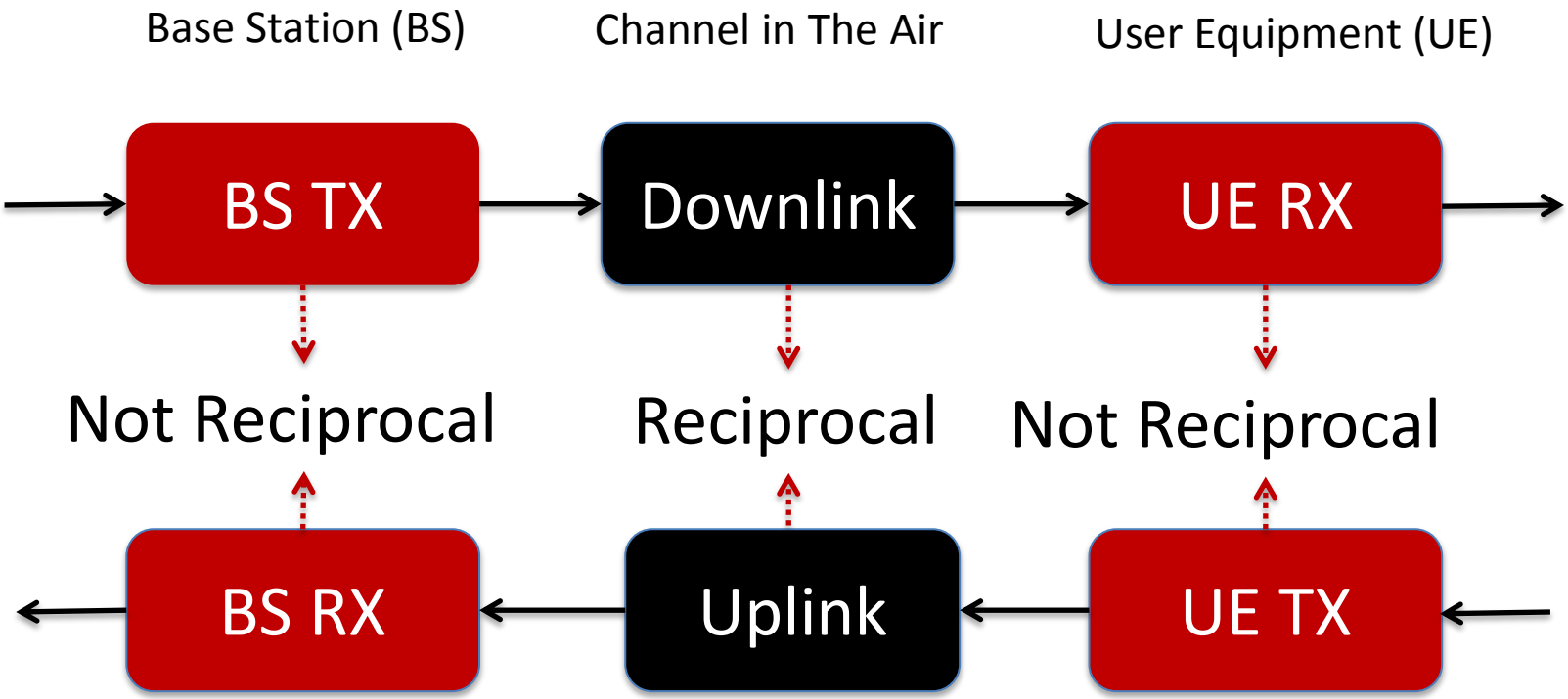




FDD: Heavy feedback for getting channel information at base station in Massive MIMO

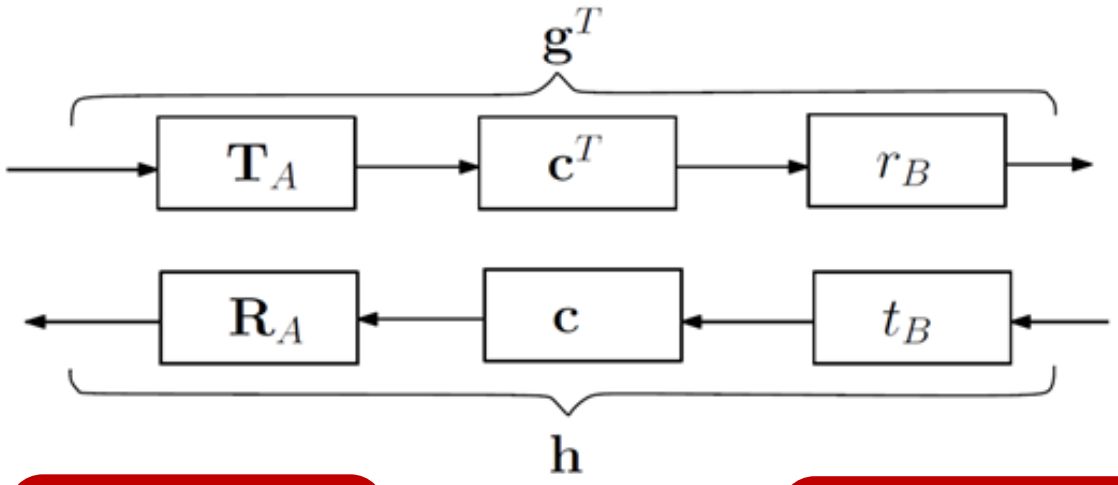
TDD: channel information at base station can be obtained from channel reciprocity

Hardware impairment -- Calibration



Calibration: Compensate Hardware Impairment

System Model



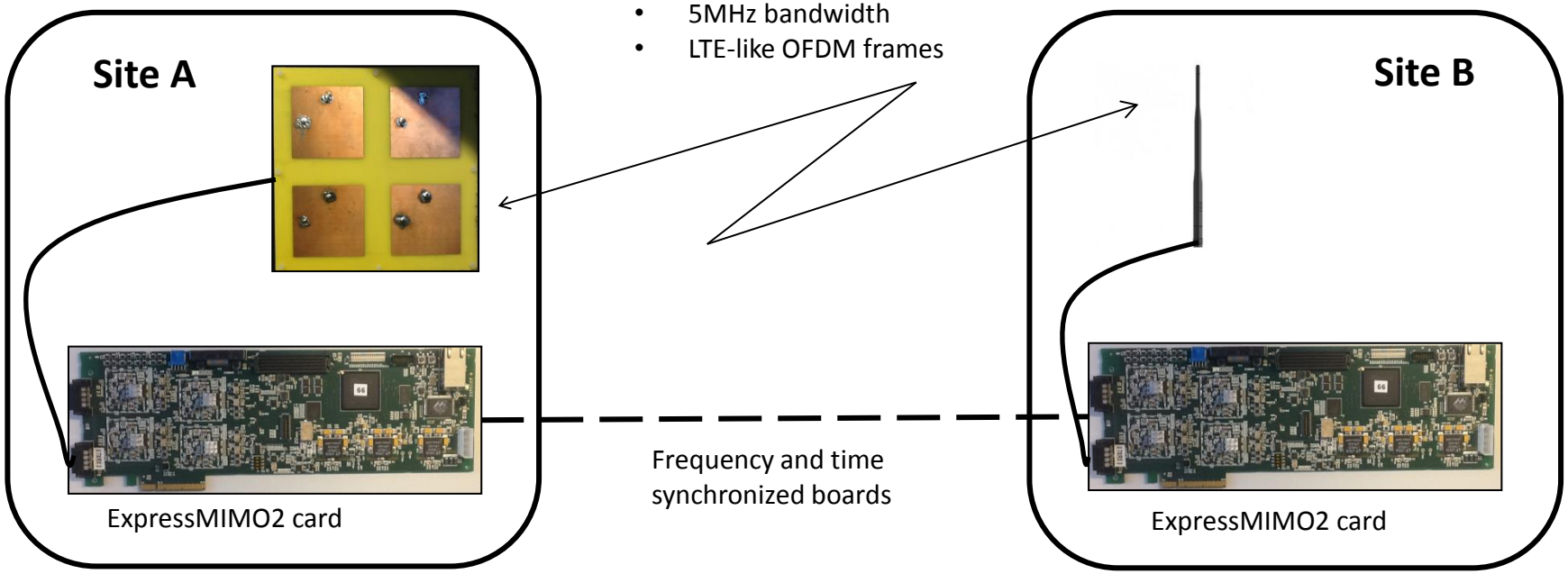
Site A (BS)
N Antennas

Site B (UE)
Single Antenna

$$\left.\begin{aligned}\mathbf{g}^T &= r_B \mathbf{c}^T \mathbf{T}_A \\ \mathbf{h} &= \mathbf{R}_A \mathbf{c} t_B\end{aligned}\right\} \Rightarrow \mathbf{g}^T = \mathbf{h}^T \underbrace{\frac{r_B}{t_B} \mathbf{R}_A^{-T} \mathbf{T}_A}_{\mathbf{F}} = \mathbf{h}^T \mathbf{F}$$

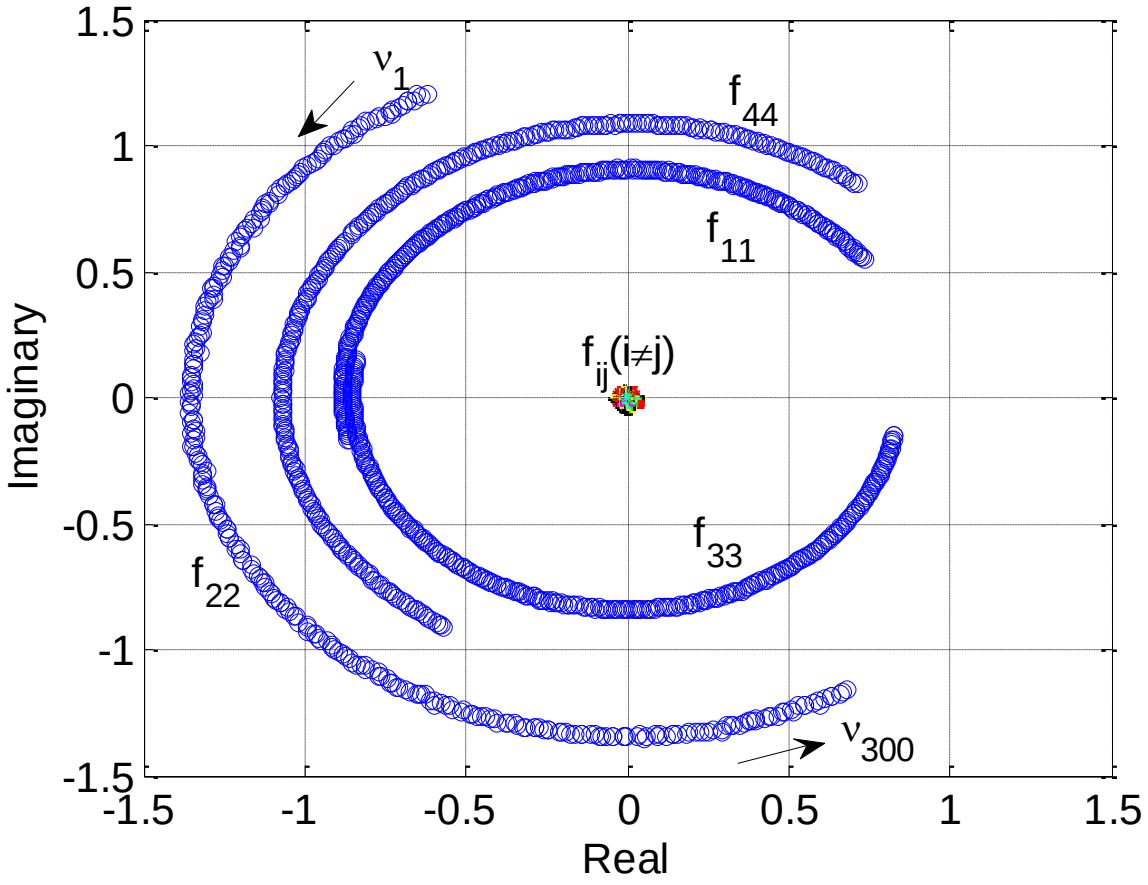
Experiment Setup

- 1,9GHz
- 5MHz bandwidth
- LTE-like OFDM frames



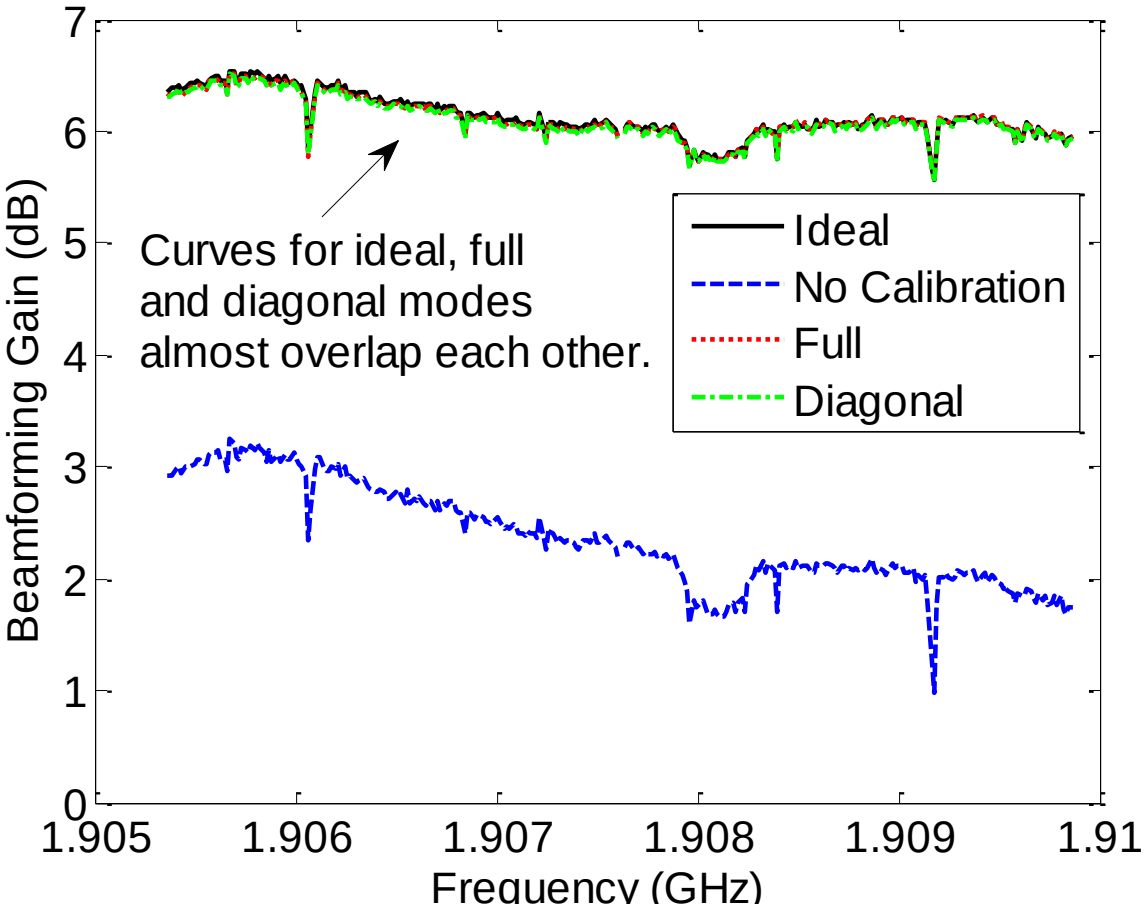
OpenAir4G software modem

Experiment Results 1



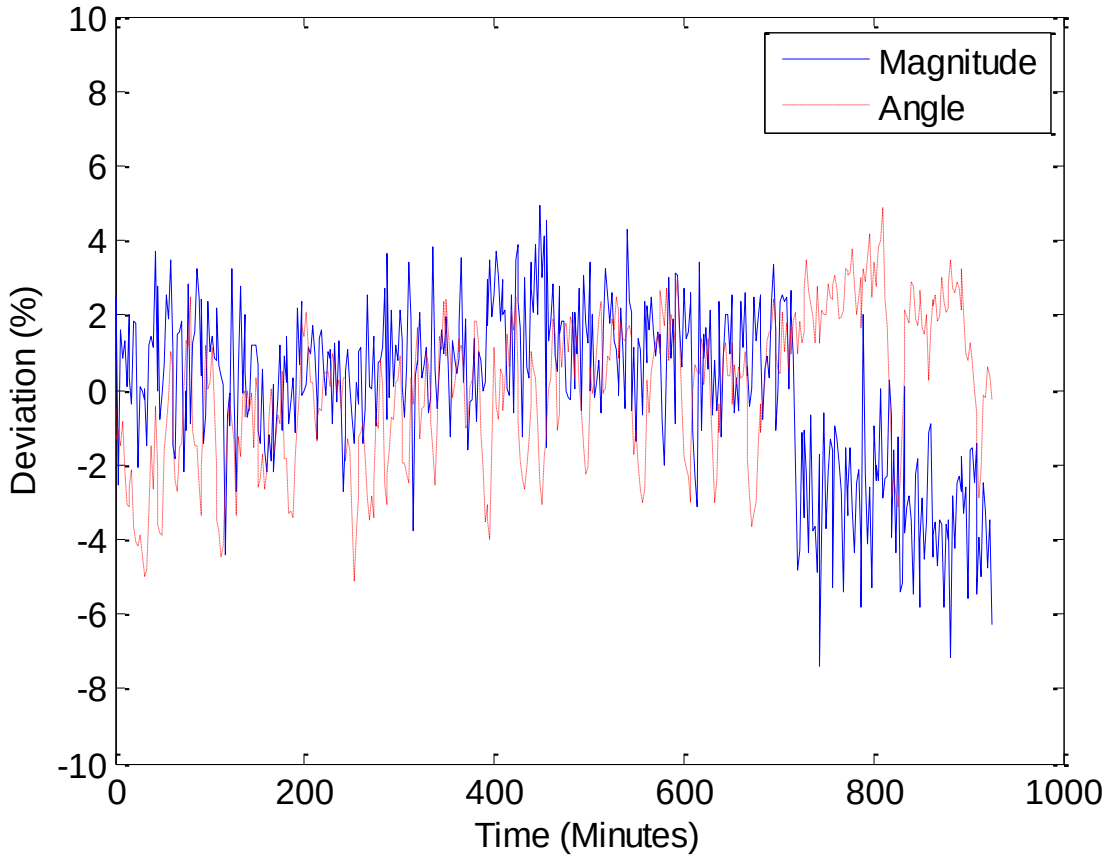
Measured 4x1 MISO System Calibration Matrix

Experiment Results 2



4x1 Beamforming Gain based on TDD calibration

Experiment Results 3



Variation of Calibration parameter during the time

Conclusions and Future work

- Conclusions
  - Relative Calibration is feasible in real TDD system
  - Near perfect beamforming performance in small MISO system
  - Calibration parameter relatively stable during the time
- Future work
  - Scale up the MISO system
  - Real time calibration
  - Massive MIMO prototype