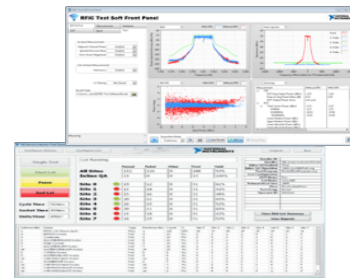
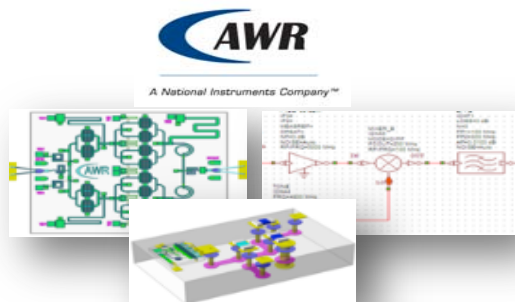




Platform Based Design Accelerates 5G Test

Jim Bains
Vice President | RF and Wireless R&D

NI RF Solutions: Research \leftrightarrow Volume Production



Research

Prototyping

Design & Characterization

Automated Test

Volume Production



Ettus
Research
A National Instruments Company



BEEcube
A National Instruments Company

MP
MICRO
TESTING
YOUR FUTURE
PROSS

Industry Leaders Choose NI for 5G Research

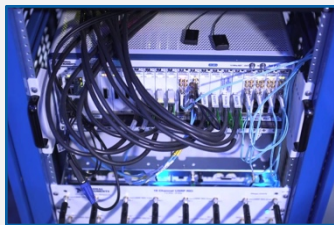
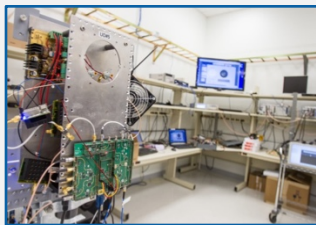
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UNIVERSITÄT
DRESDEN**

KU LEUVEN



University of
BRISTOL



NYU
WIRELESS



**Georgia
Tech**



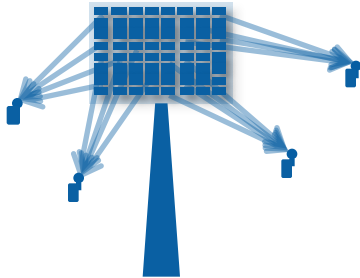
**STANFORD
UNIVERSITY**



Technologies Driving 5G

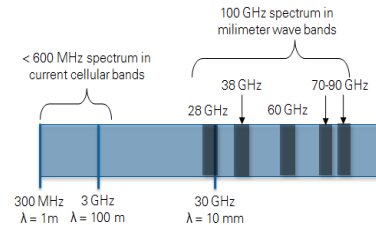
Massive MIMO

Dramatically increased number of antenna elements on base station enabling beamforming.



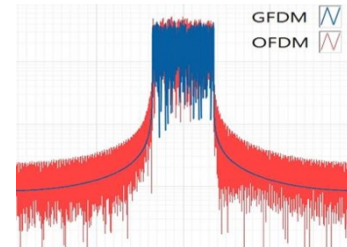
mmWave

Utilize potential of extremely wide bandwidths at frequency ranges once thought impractical for commercial wireless.



Multi Radio Access Technologies (RAT)

Improve bandwidth utilization through evolving PHY Level and flexible numerology



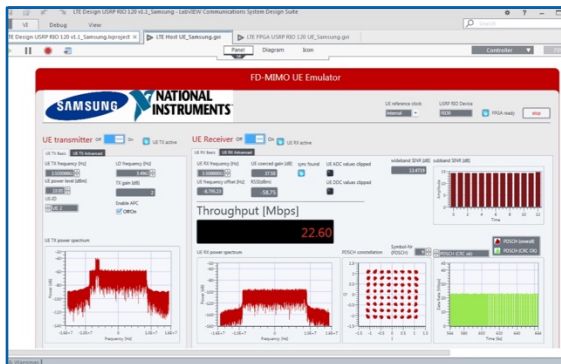
Wireless Networks

Consistent connectivity meeting the 1000x traffic demand for 5G

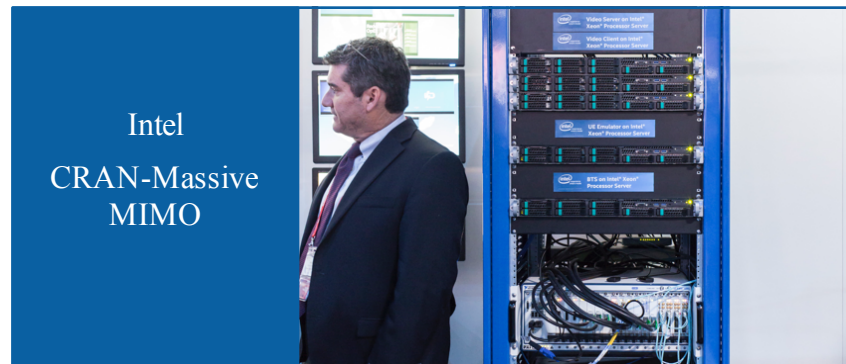
- Densification
- SDN
- NFV
- CRAN



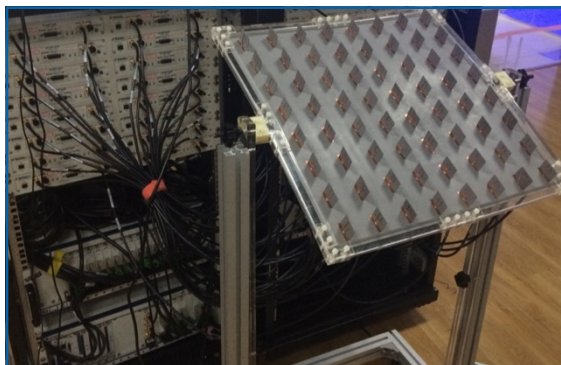
Massive MIMO Demonstrations



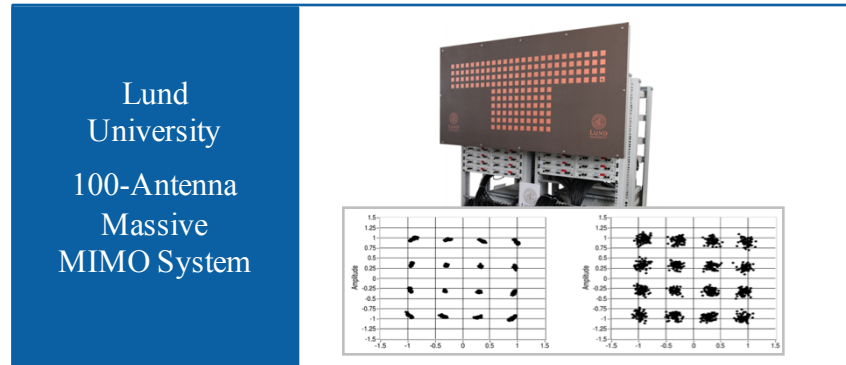
Samsung
Full Dimension
MIMO, LTE UE
Emulation



Intel
CRAN-Massive
MIMO



Southeast
University
100-Antenna
Massive
MIMO System



Lund
University
100-Antenna
Massive
MIMO System

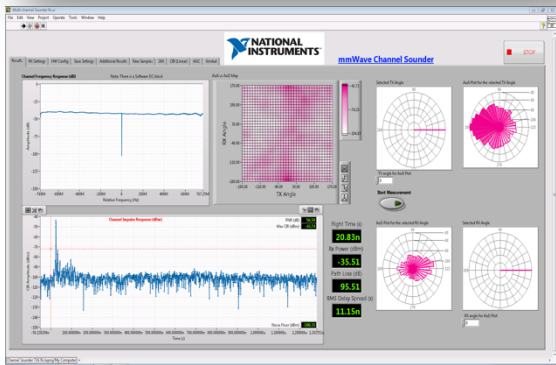
mmWave Demonstrations



Prof. Ted Rappaport

NYU Wireless
mmWave
Channel Sounding

NTT Docomo
73 GHz
BW = 1 GHz



AT&T
Channel Sounding

Nokia
Multiple Prototypes



Nokia Timeline with NI Platform



NOKIA

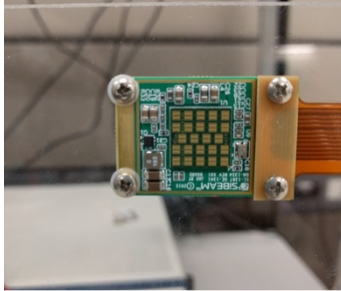


Frequency
Bandwidth
Streams
Modulation
Peak rate

	Brooklyn 5G Summit 2014	NIWeek 2015	MWC 2016
Frequency	73 GHz	73 GHz	73 GHz
Bandwidth	1 GHz	2 GHz	2 GHz
Streams	1x1	2x2	2x2
Modulation	16 QAM	16 QAM	64 QAM
Peak rate	2.3 Gbps	>10 Gbps	>14.5 Gbps

mmWave System Flexibility

RFIC & Phased Array



Integrate 3rd party RFIC

- Hardware integration done by customer
- Ex: SiBeam RFIC

3rd Party RF



Integrate 3rd party RF

- User must develop digital control of RF
- Ex: Virginia Diodes radio head

High Quality RF

28 GHz, 60 GHz, 73 GHz



Complete system from NI

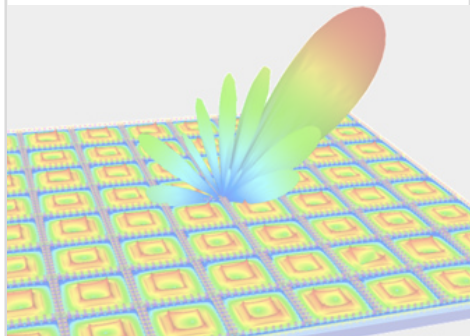
- Tested, proven configuration
- Technical support available



5G Test Challenges

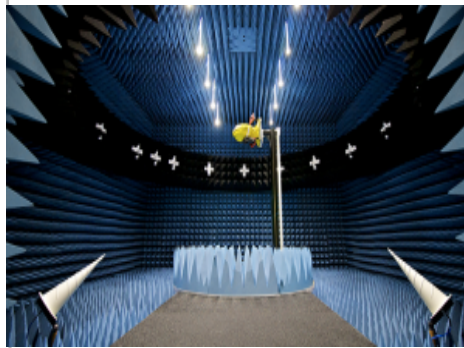
MIMO Systems

- Antenna array validation
- Channel modeling
- Beamforming



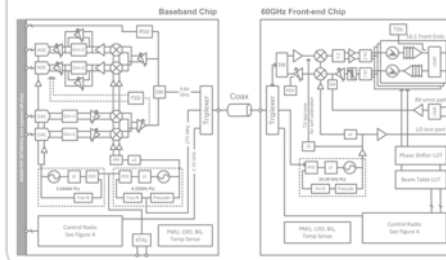
Over-the-Air Testing

- Measurement plane extension
- Air interface de-embedding
- System calibration

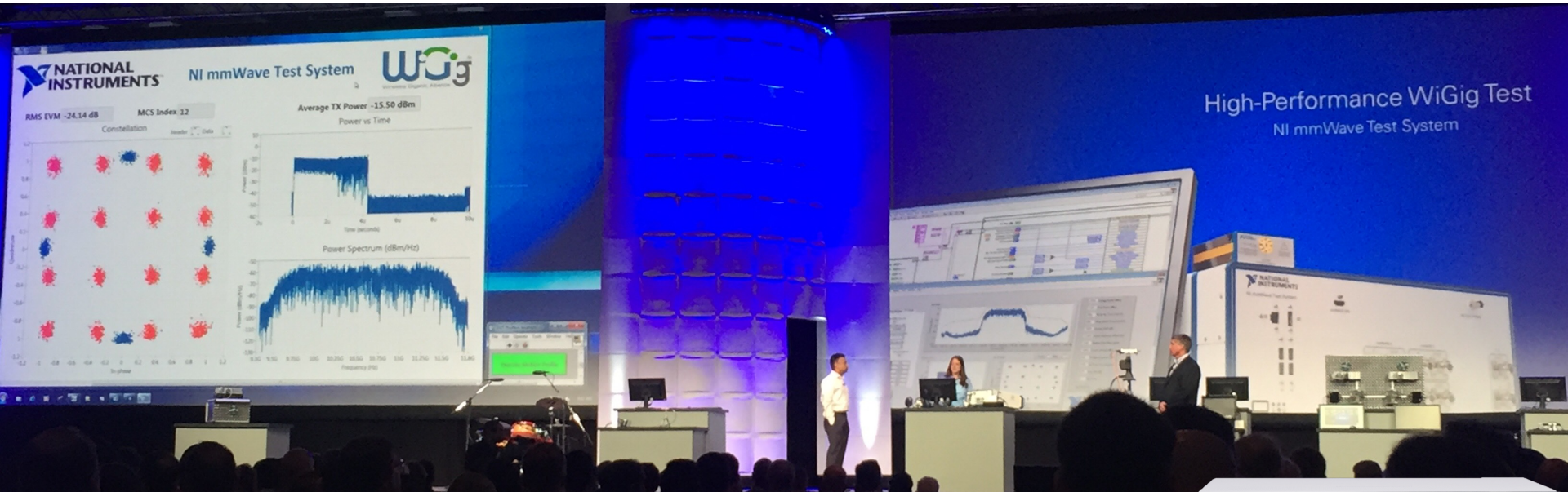


mmWave Architectures

- In-house Expertise
- Scalability for multiple bands
- Fast, high performance measurement



NI Demonstrates mmWave 802.11ad Test at NIWeek 2016



“NI’s developments in mmWave test solutions have allowed us to address various testing challenges like...over-the-air test capabilities.”...said Anand Iyer, director of mmWave product marketing at Broadcom Limited.



Future Opportunities

Visit:


ni.com/rf/5g

Contact:

jin.bains@ni.com

Connect:

[linkedin.com/in/jin-bains-1758471](https://www.linkedin.com/in/jin-bains-1758471)




NI USRP RIO based UE Emulator

UE Emulator Hardware

- USRP-RIO programmable RF with 20MHz BW
- Fully programmable using FPGA
- Portable platform and easy to deploy multi-user test

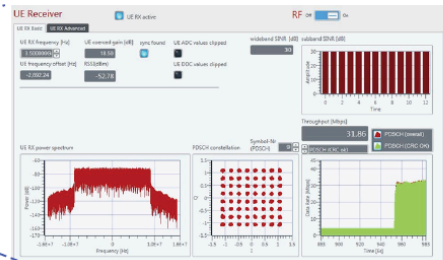
Labview Communications Software

- LTE reference design with pre-release FD-MIMO features
- DSP algorithms that support synchronization and automatic gain control for over-the-air test
- Visibility of the source code and clean GUI interface



Laptop for control & UI

NI USRP RIO UE Emulator



Labview debug display for constellation, throughput, BLER

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*We are looking forward to continued collaboration in both
Design and Test.*