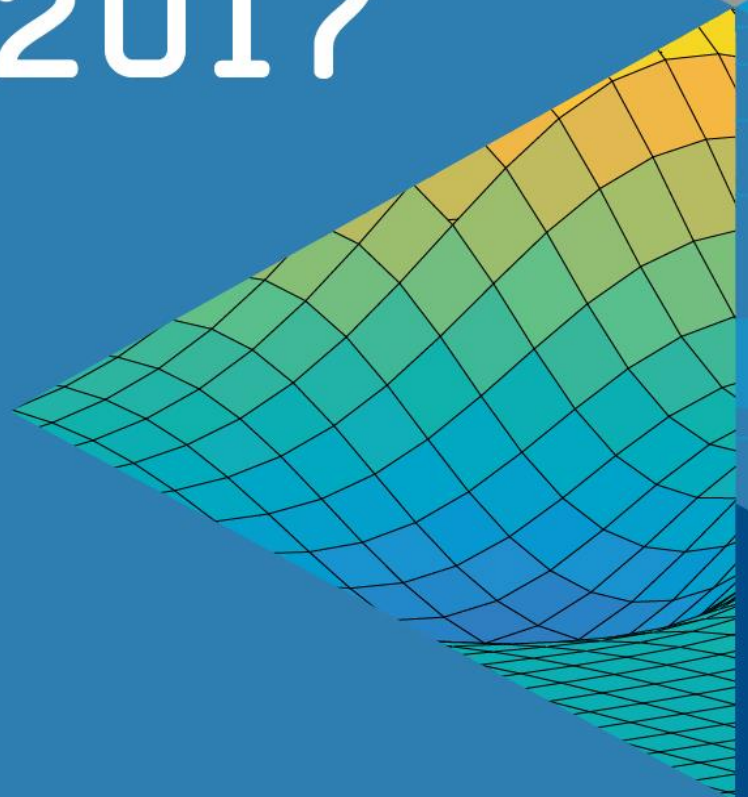
MathWorks

MATLAB EXPO 2017

通往5G之路:
无线系统的仿真和原型实现



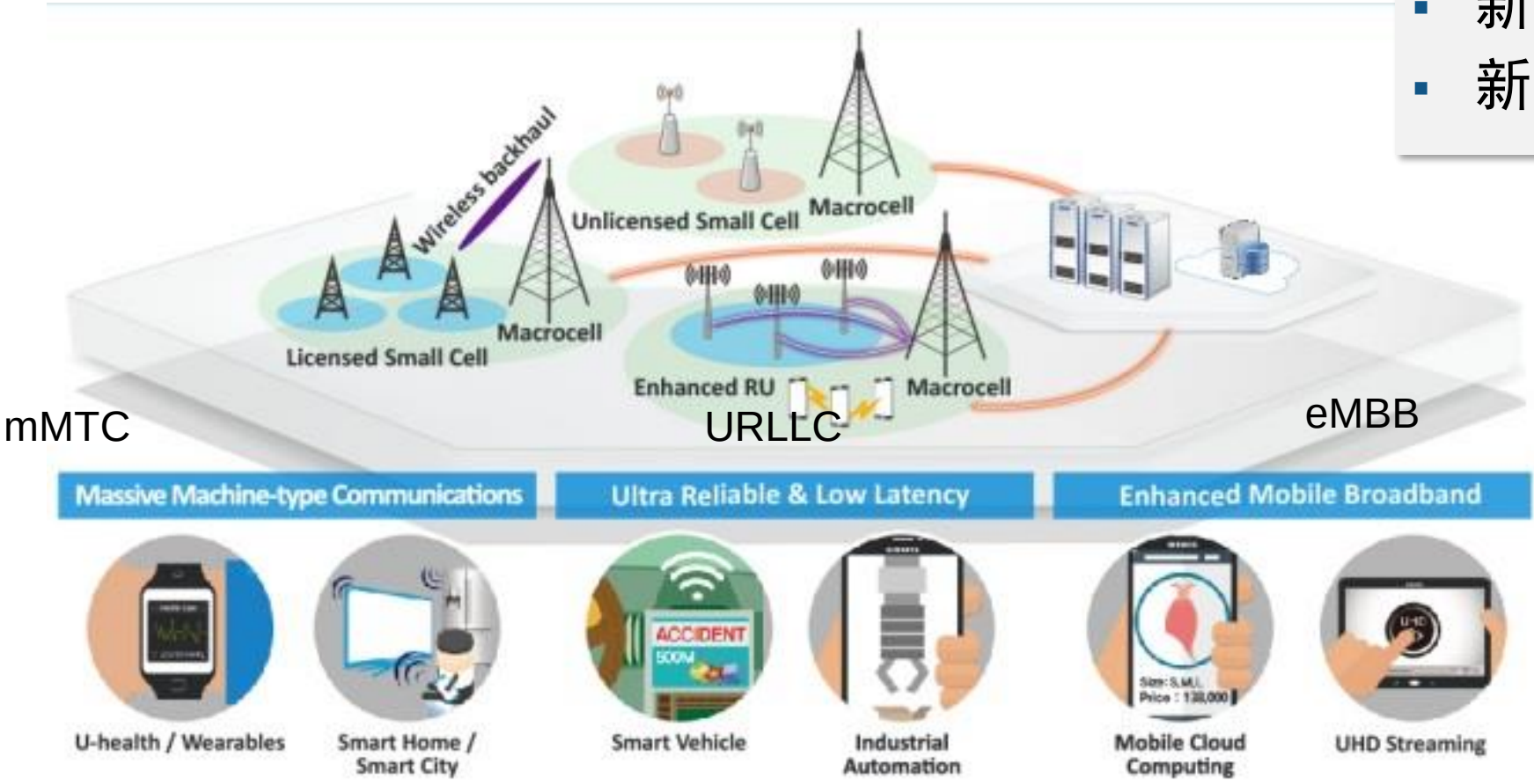
王峥 (John Wang)
通信，电子， 半导体行业经理, MathWorks

目录

5G 展望和应用场景

5G的技术需求

- 新的物理层技术
- 新的RF架构
- 新的网络配置
- 新的设计方法和外场测试



IoT 物联网

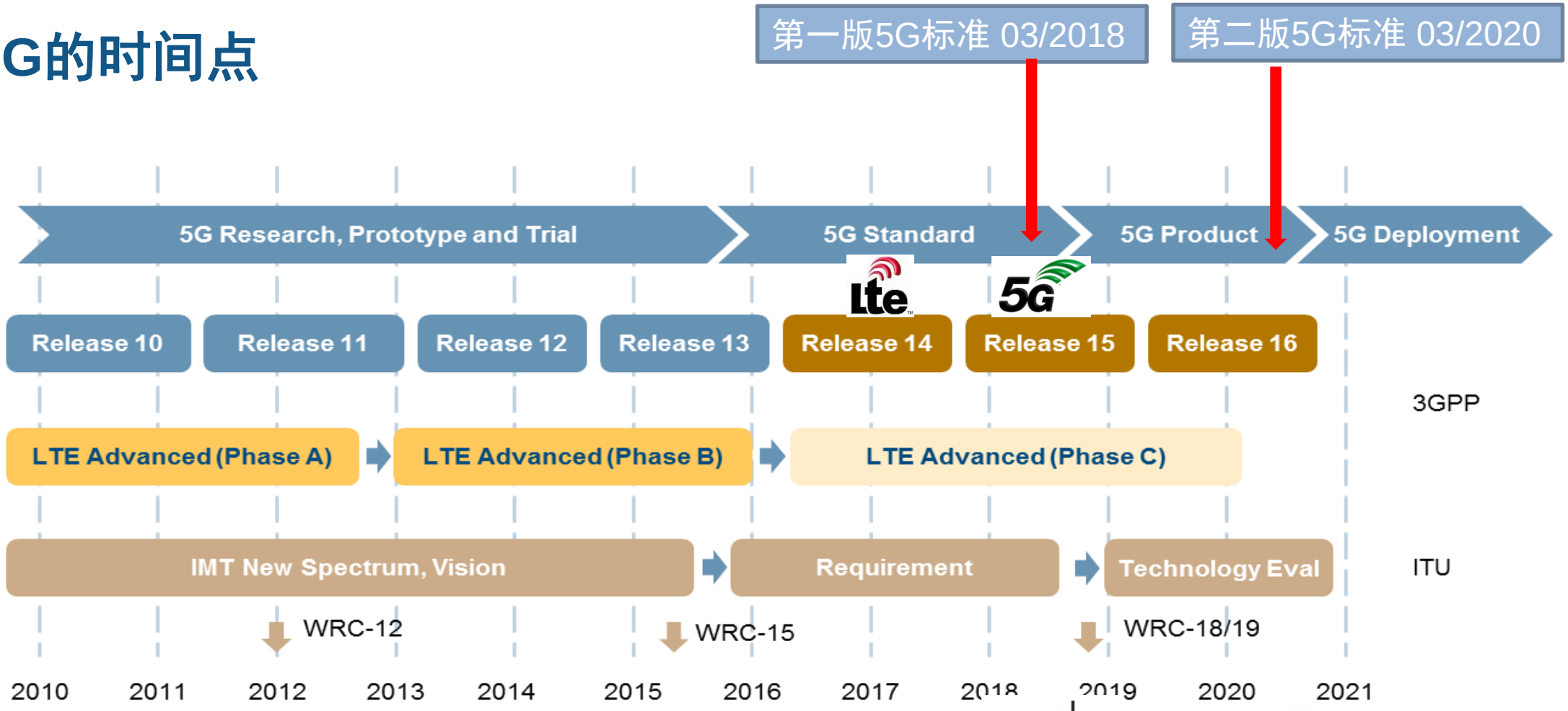
V2X 车联网

Ultra-Fast Mobile 超高速宽带

5G 技术挑战

- **毫米波 (mmWave)**
- **天线和中射频设计**
- **信道模型(>6GHz)**
- **新的信道编码 Polar Code**
- **新的波形 (f-OFDM)**
- **多天线 Massive MIMO**
- **快速原型**
- **外场测试**

5G的时间点



- LTE: Long Term Evolution
  - Long Term Employment
- 5G: NR: New Radio
  - Never Retirement

PyeongChang 2018

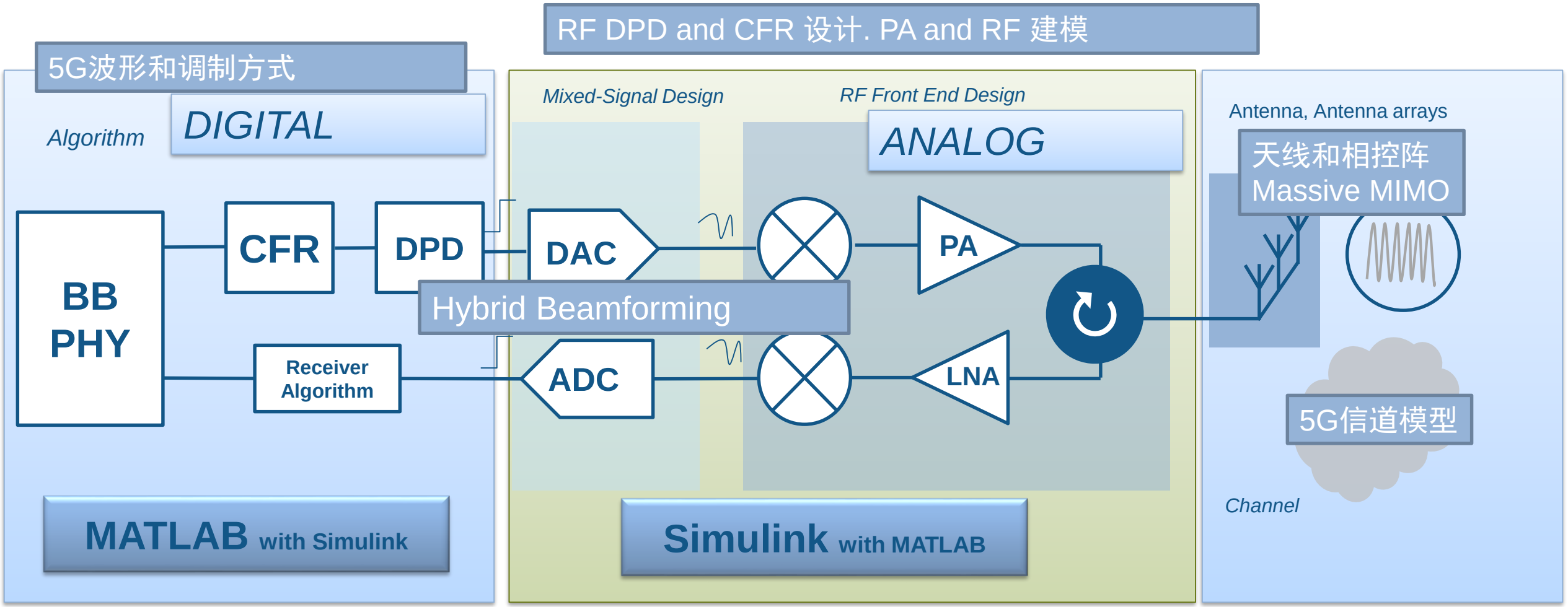
TOKYO 2020

5G Library Support Package

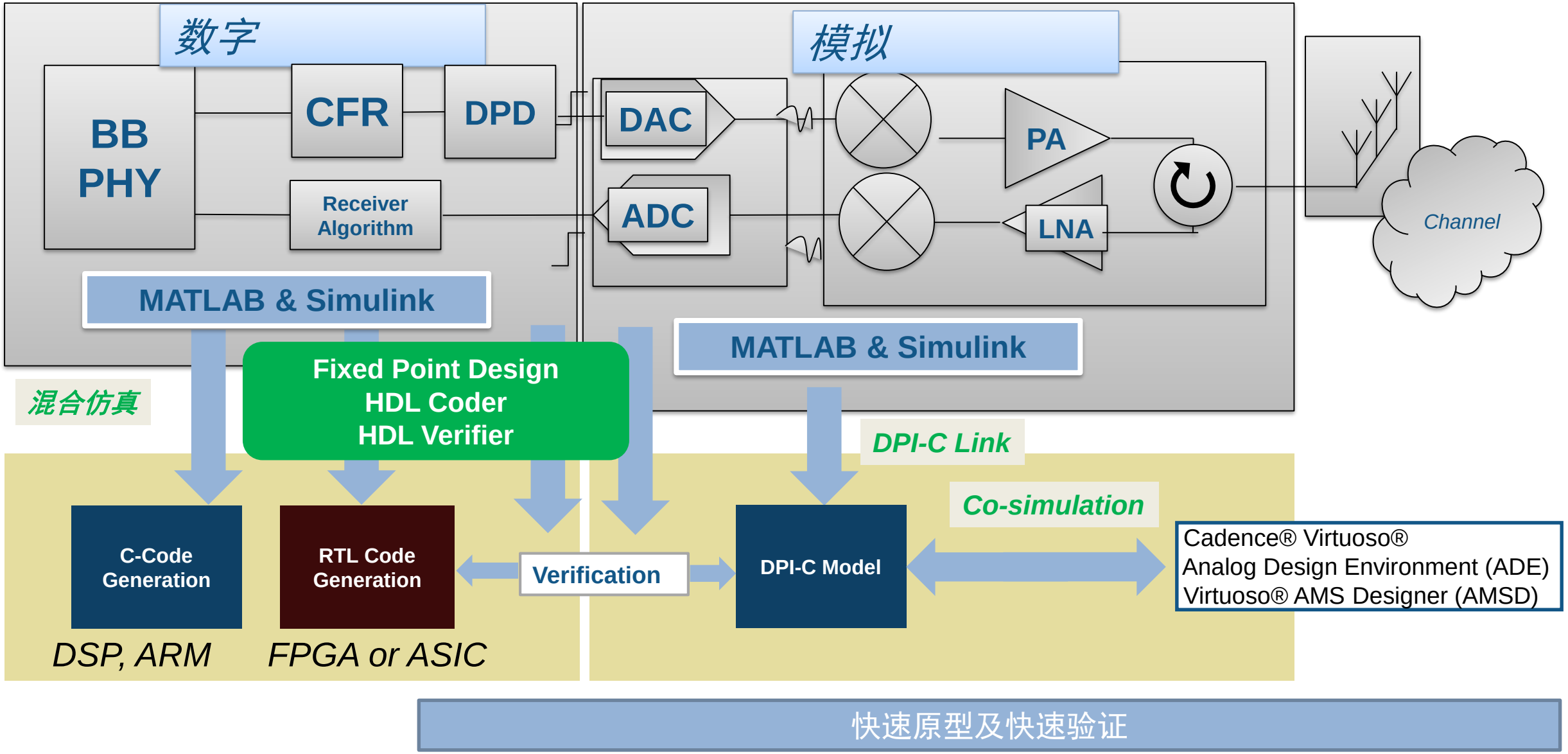
LTE System Toolbox

Source: 3GPP

5G: 从算法到天线

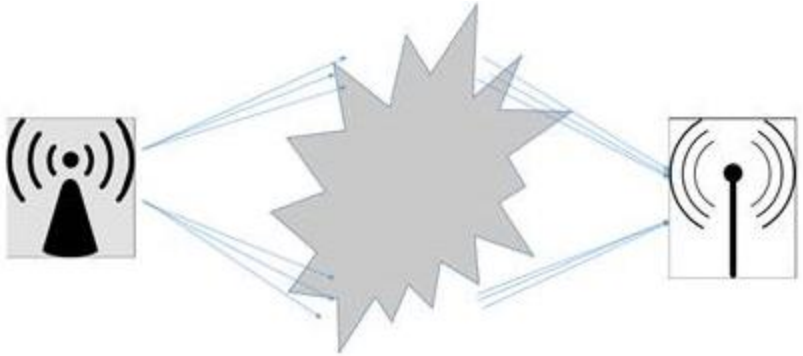

RF DPD and CFR 设计. PA and RF 建模
5G波形和调制方式
Algorithm
DIGITAL
Mixed-Signal Design
RF Front End Design
ANALOG
Antenna, Antenna arrays
天线和相控阵
Massive MIMO
BB
PHY
CFR
DPD
DAC
Hybrid Beamforming
PA
Receiver
Algorithm
ADC
LNA
5G信道模型
Channel
MATLAB with Simulink
Simulink with MATLAB

5G: 从算法到实现

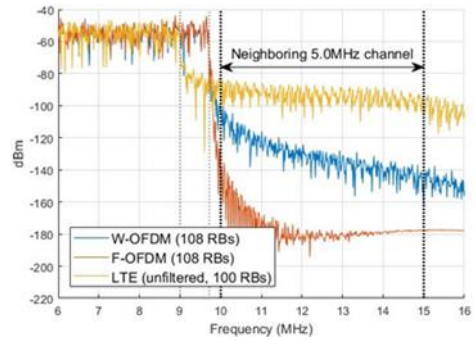

数字
模拟
BB PHY
CFR
DPD
Receiver Algorithm
DAC
ADC
PA
LNA
Channel
MATLAB & Simulink
MATLAB & Simulink
混合仿真
Fixed Point Design
HDL Coder
HDL Verifier
DPI-C Link
Co-simulation
C-Code Generation
RTL Code Generation
Verification
DPI-C Model
Cadence® Virtuoso®
Analog Design Environment (ADE)
Virtuoso® AMS Designer (AMSD)
DSP, ARM
FPGA or ASIC
快速原型及快速验证

5G Support Package

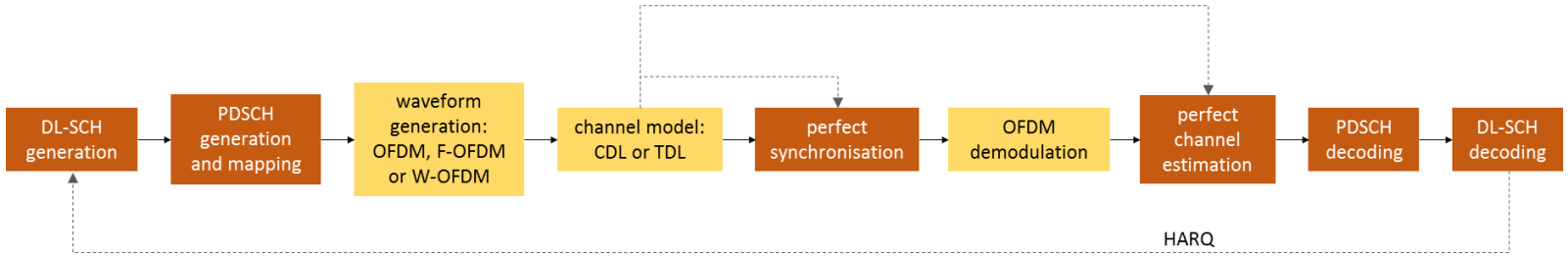
- 5G 信道模型(3GPP TR 38.900)



- 新的波形(F-OFDM, W-OFDM)

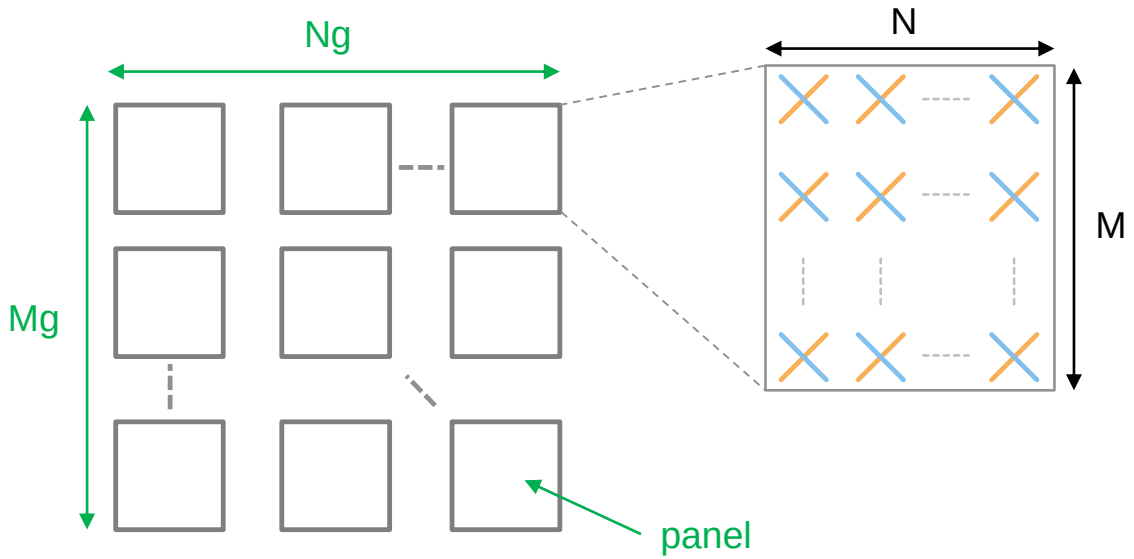


- 链路仿真参考平台



5G 信道模型

- 5G 信道模型 TR 38.900的数学实现
- 包括以下可调参数
  - Delay profile: TDL and CDL profiles: A, B, C, D, E or custom
  - Channel delay spread
  - 多普勒
  - MIMO 相关性
  - CDL: spatial channel model, includes also:
    - Antenna array geometry [M, N, P, Mg, Ng]



新的波形的分析

Demo

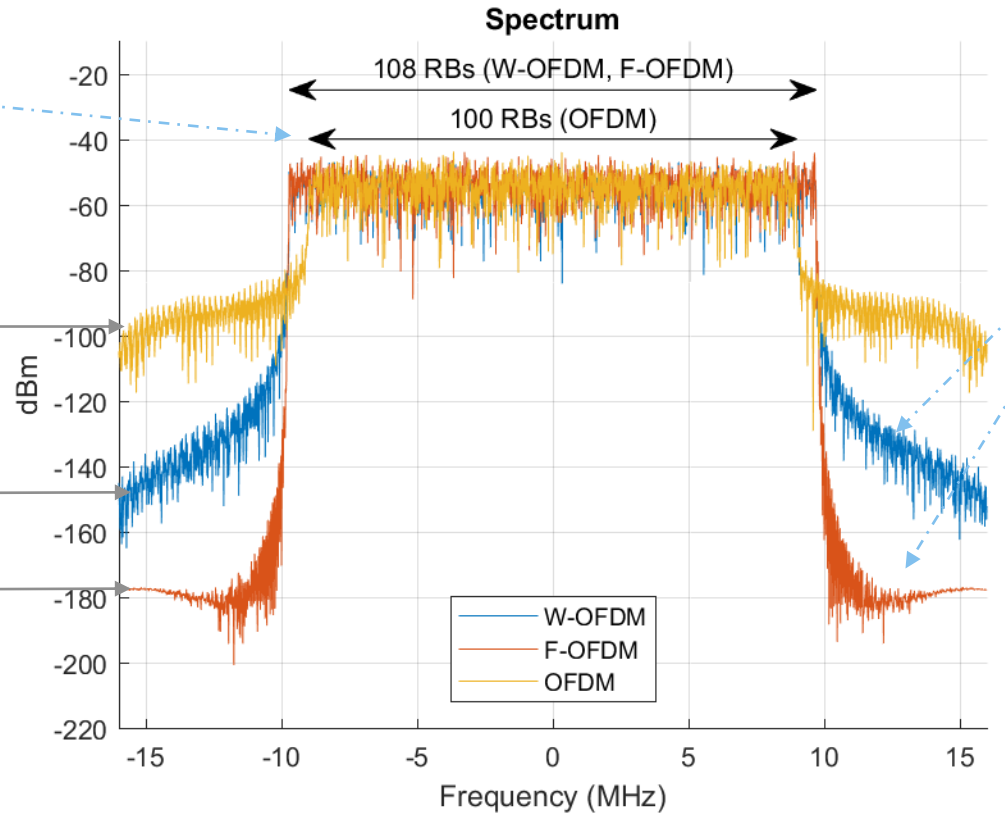
- 5G 增加带宽效率 （超过LTE的90%的限制）

LTE: Max BW occupancy is 90% of allocated BW (100 RBs for 20 MHz ch)

OFDM

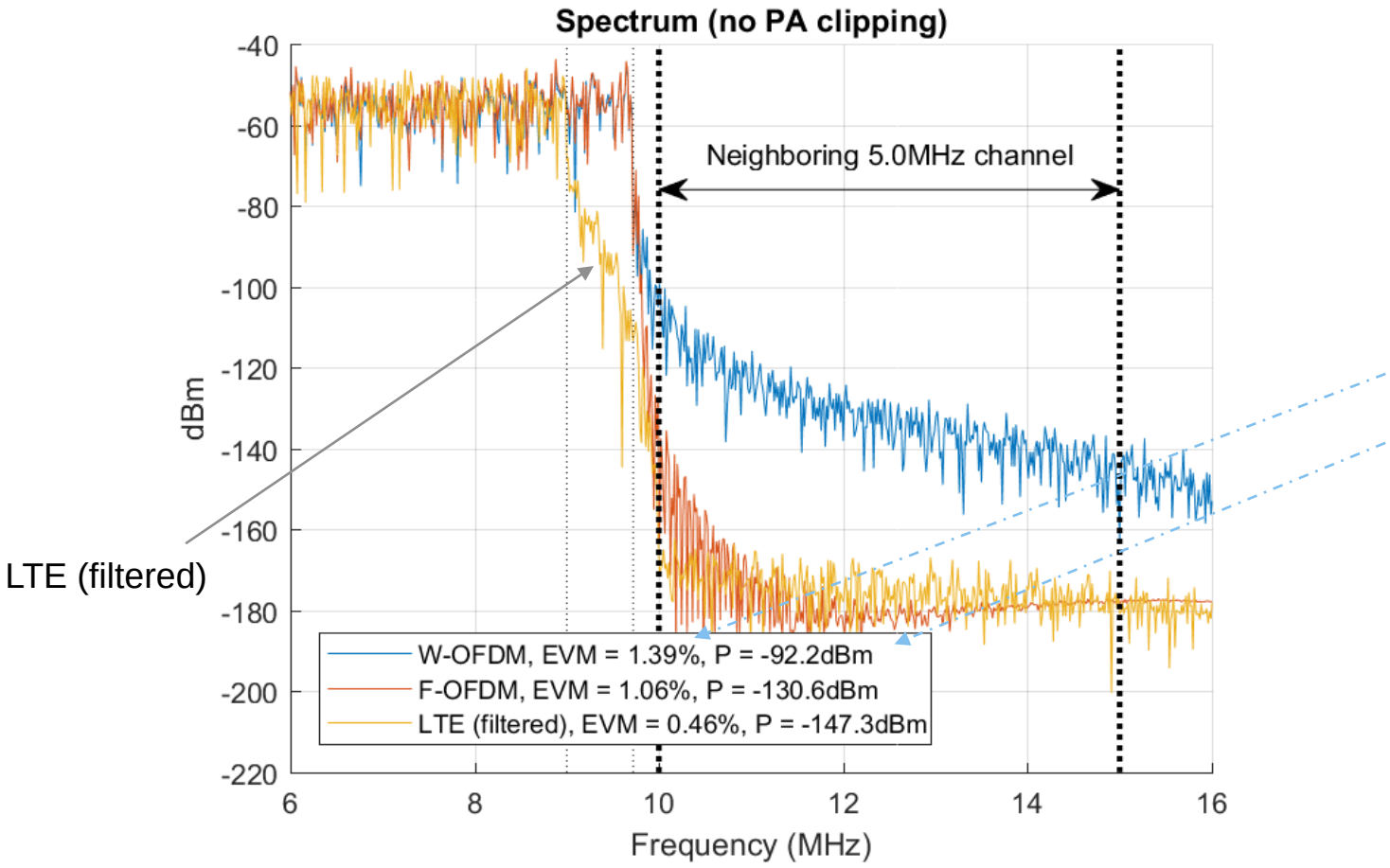
W-OFDM

F-OFDM



In 5G the 90% limit does not apply, we need to design a filter (F-OFDM) or windowing parameters (W-OFDM) to limit out of band emissions

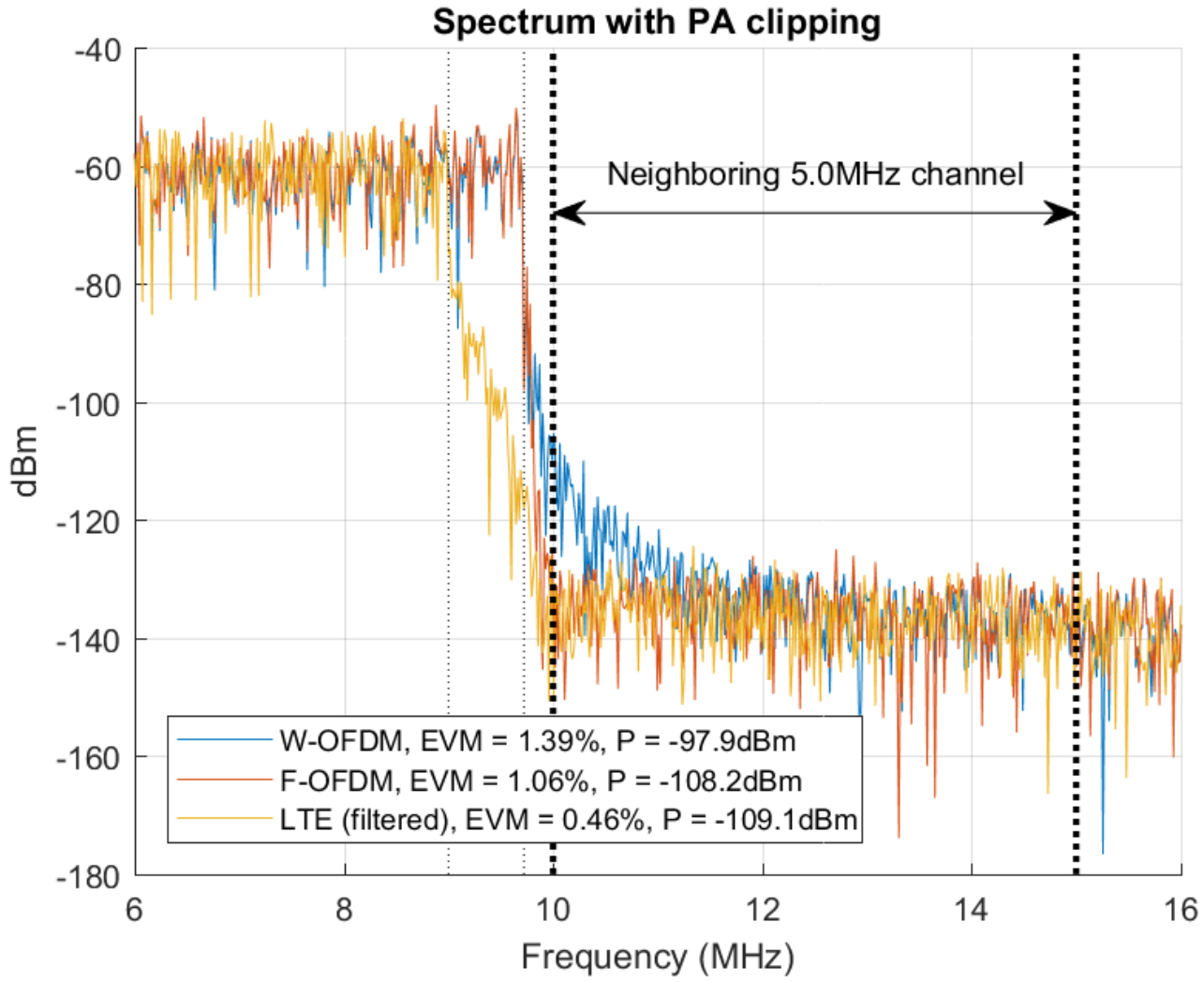
仿真带外特性



Filter和Window如何应先带外特性

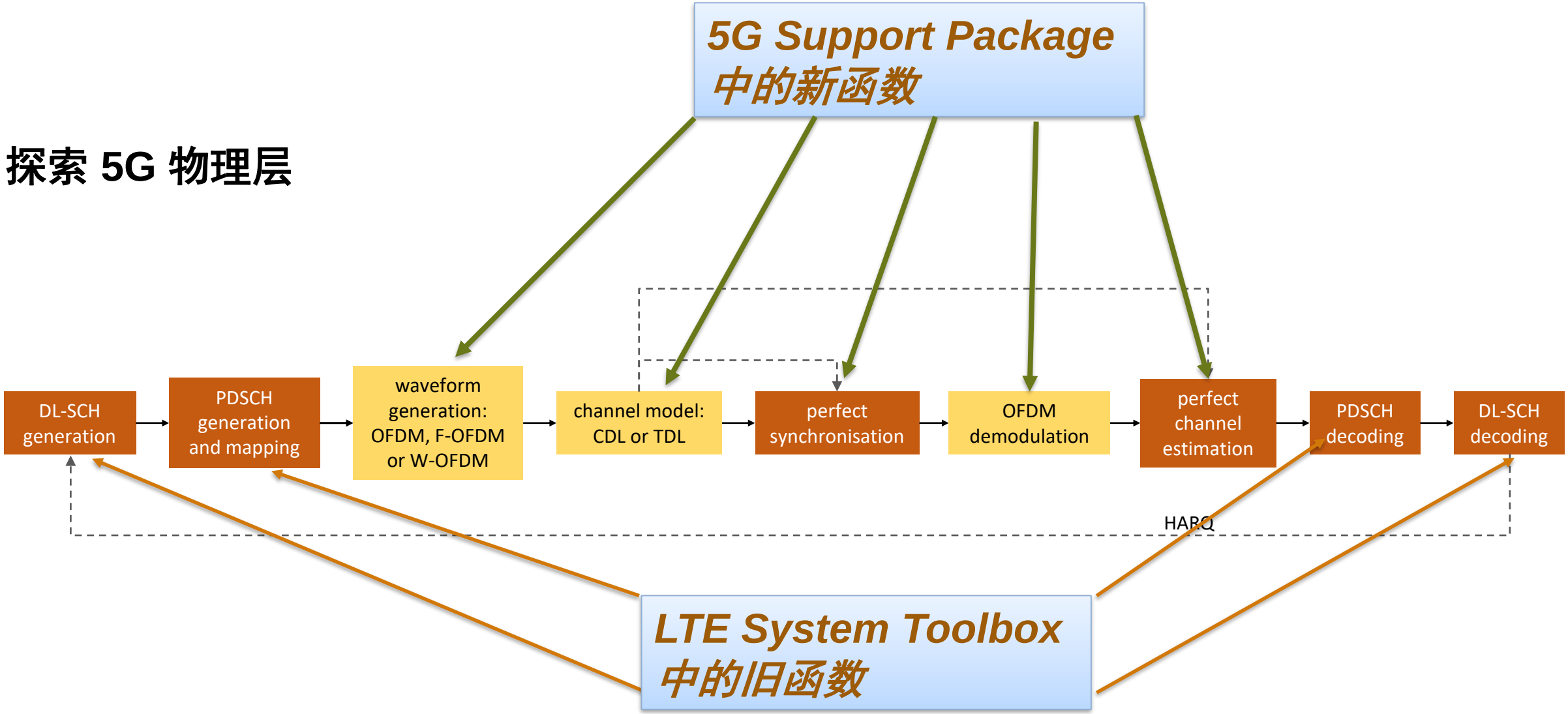
- Distortion: EVM
- Energy leakage to neighbouring bands

功率放大器的非线性特性的影响



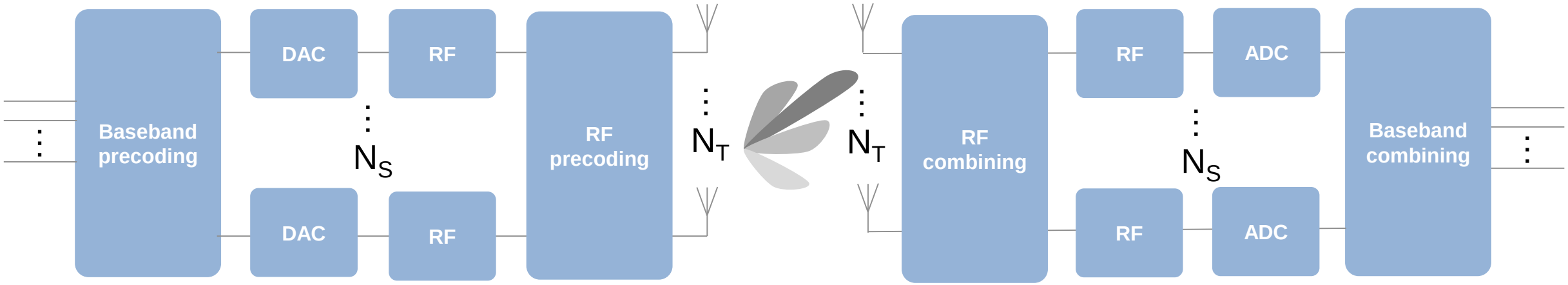
5G 链路仿真平台

探索 5G 物理层



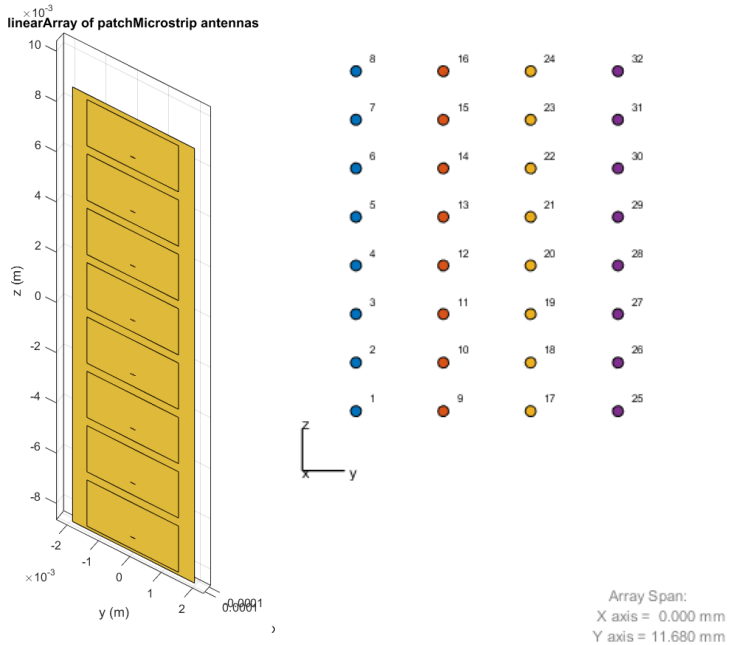
Hybrid Beamforming

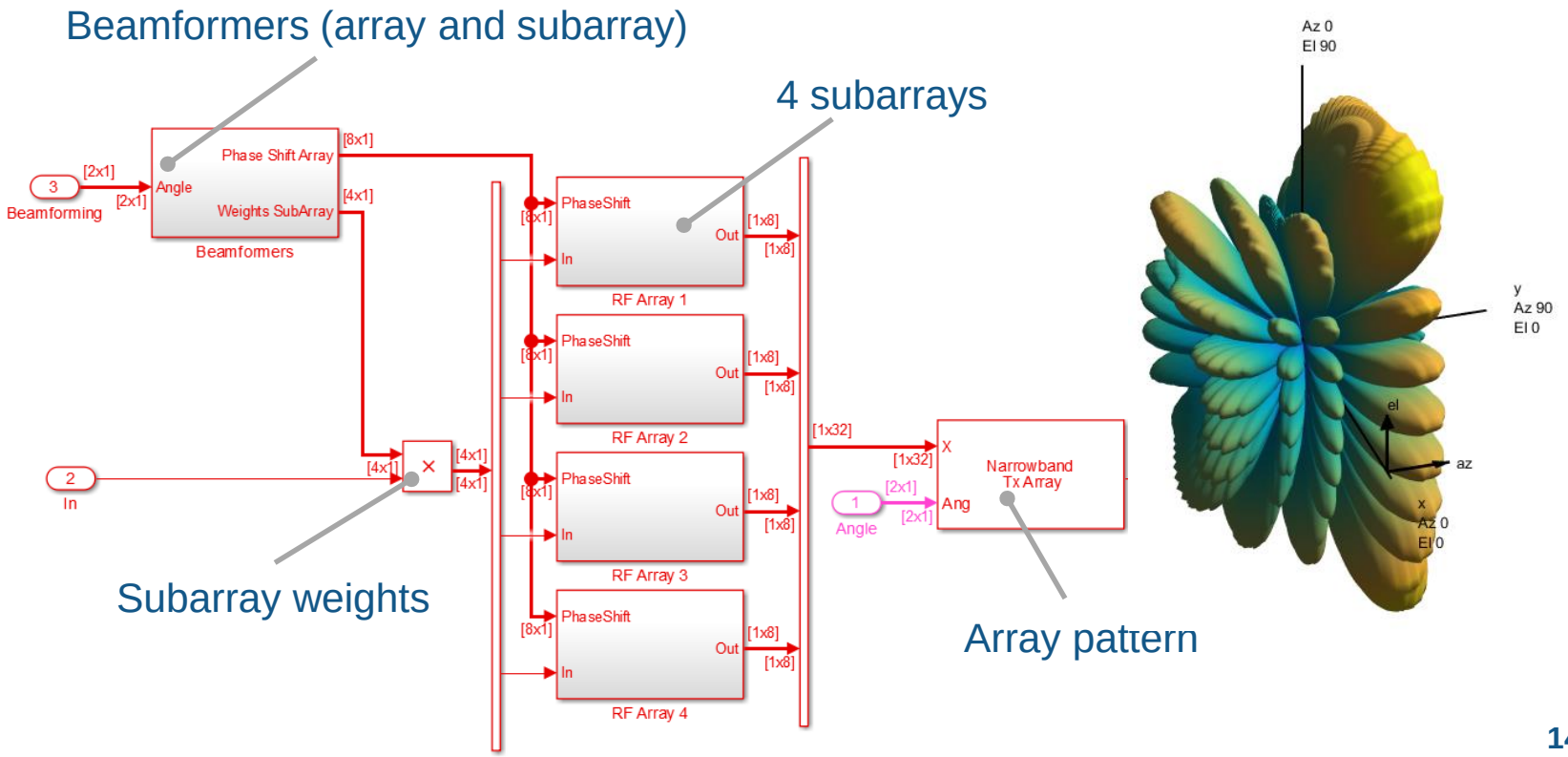
- Beamforming 在基带和RF中的混合设计
  - 性能的Trade-off, power dissipation, 实现复杂度的考量
- 不同的模拟器件的实现方式
  - Phase shifters vs. Switching networks
- 不同模拟器件的结构
  - RF chains 和每条天线相连还是和每个子天线阵相连



举例: Hybrid Beamforming 发送端相控阵

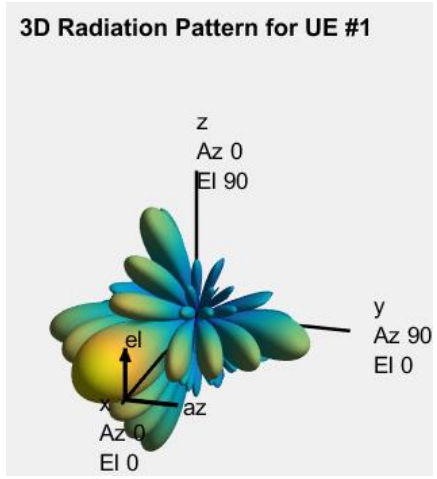
- 4 subarrays of 8 patch antennas operating at 66GHz → 8x4 = 32 antennas
- 数字beamforming 到 4 个子天线阵 (azimuth steering)
- RF beamforming (phase shifters) 到 8 个天线阵 (elevation steering)

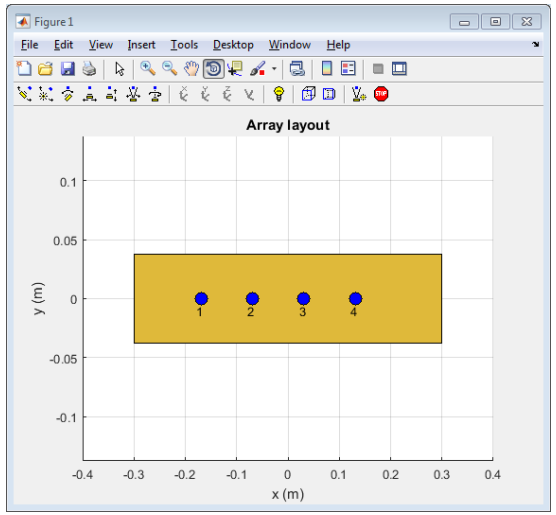


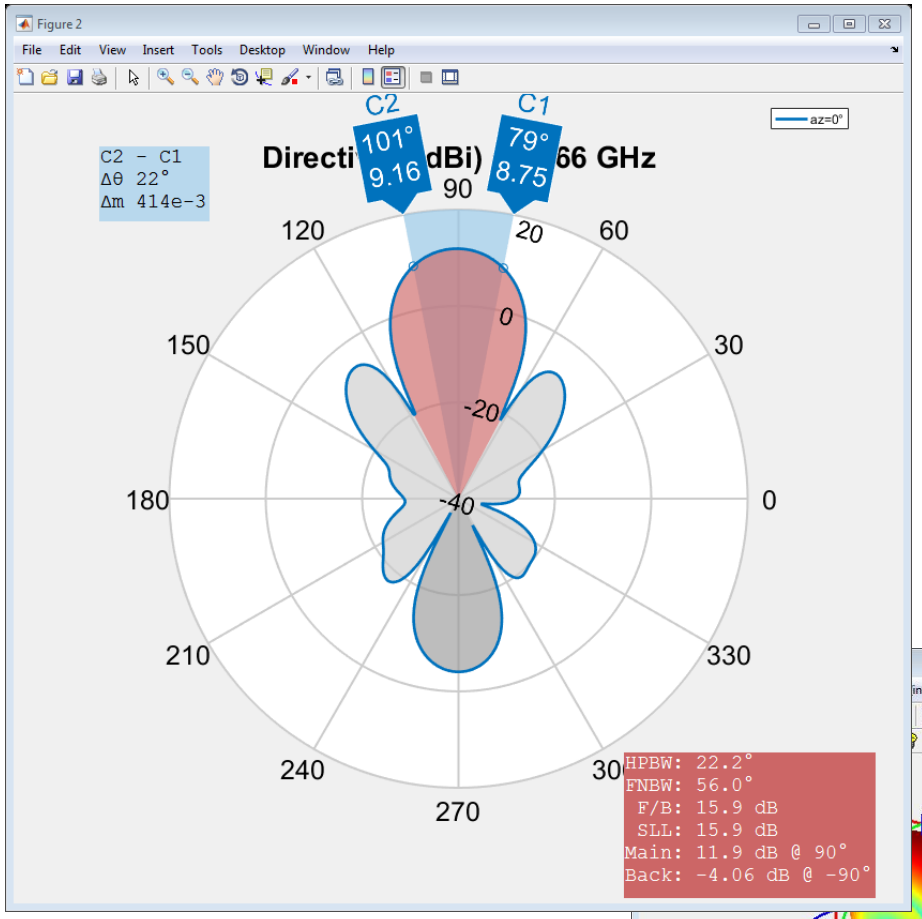


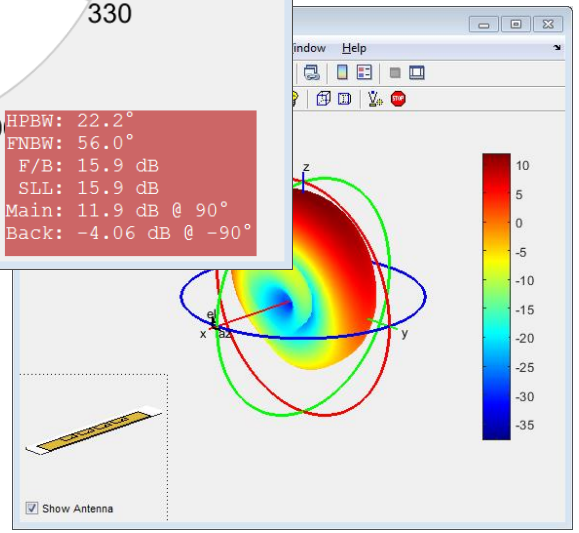
例子：你的第一个自行设计的天线

```
>> a = linearArray
>> a.Element = p;
>> a.ElementSpacing = 0.1;
>> a.NumElements = 4;
>> layout(a);
>> pattern(a, 1.66e9);
```



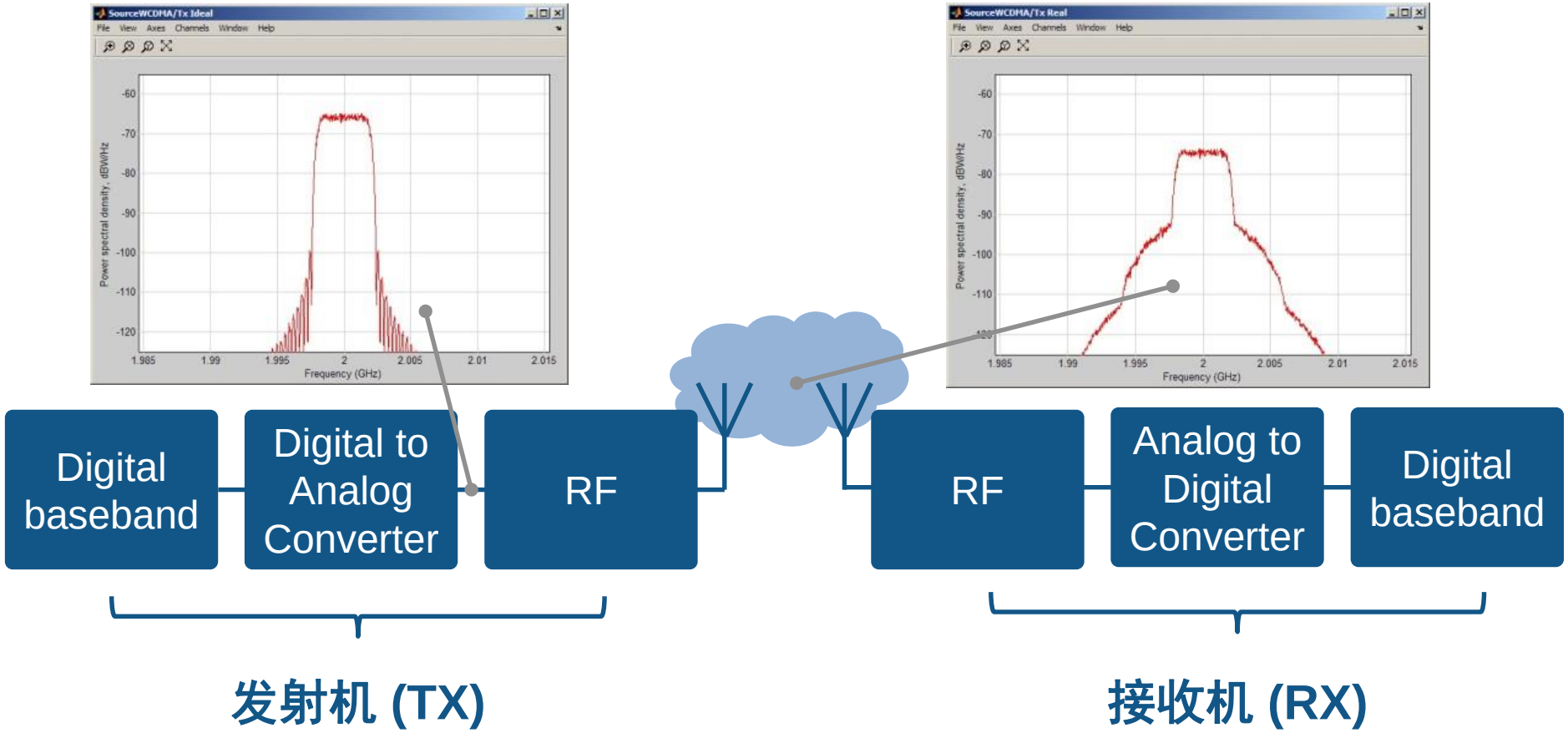




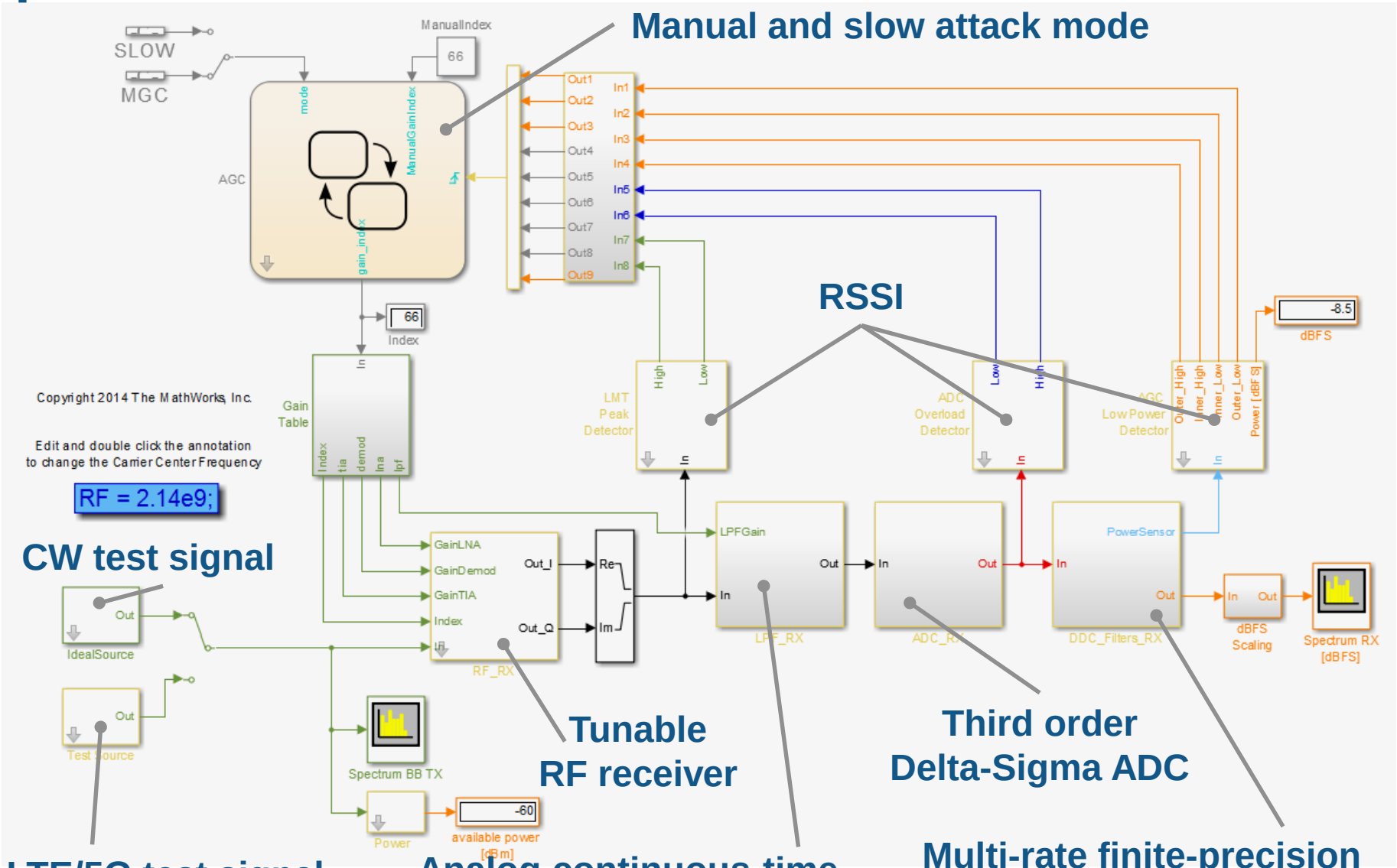


为什么要在5G链路级仿真中考虑RF

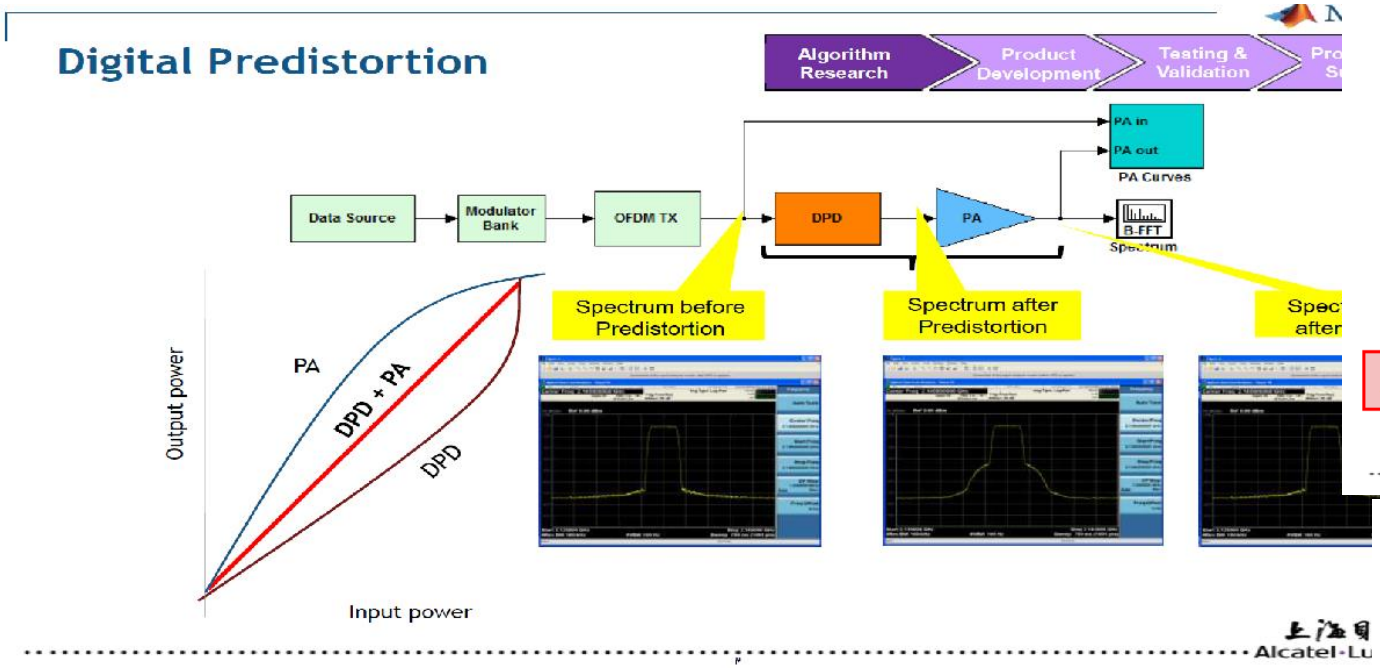
- 5G的mmWave高频设计需要考虑RF
- RF和基带在5G设计中需要统一考虑

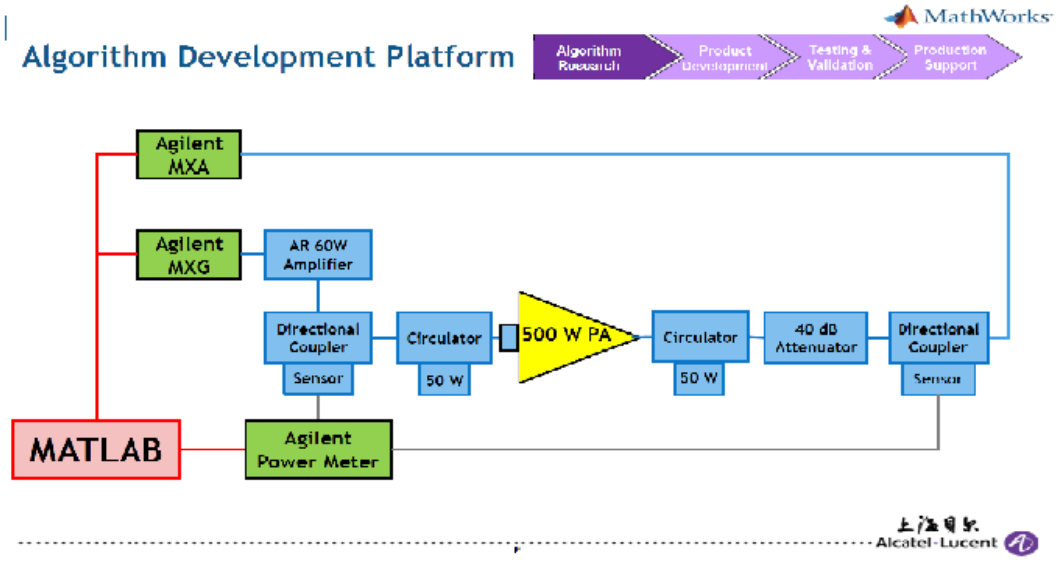


Example: AD9361 RF 首发机的设计 AGC

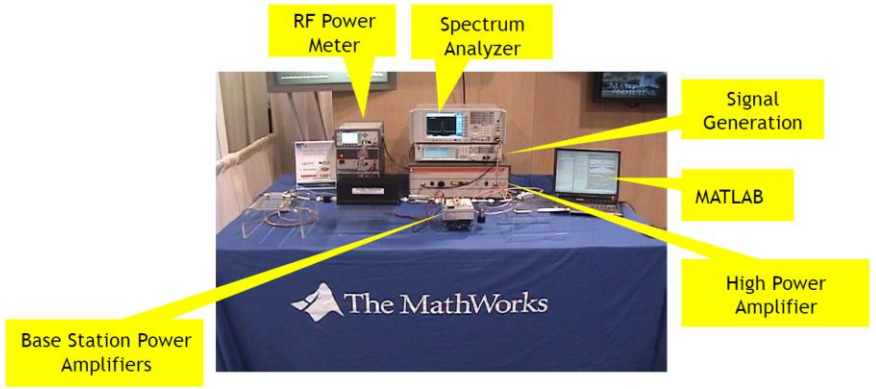


DPD: 基站中的RF with MATLAB

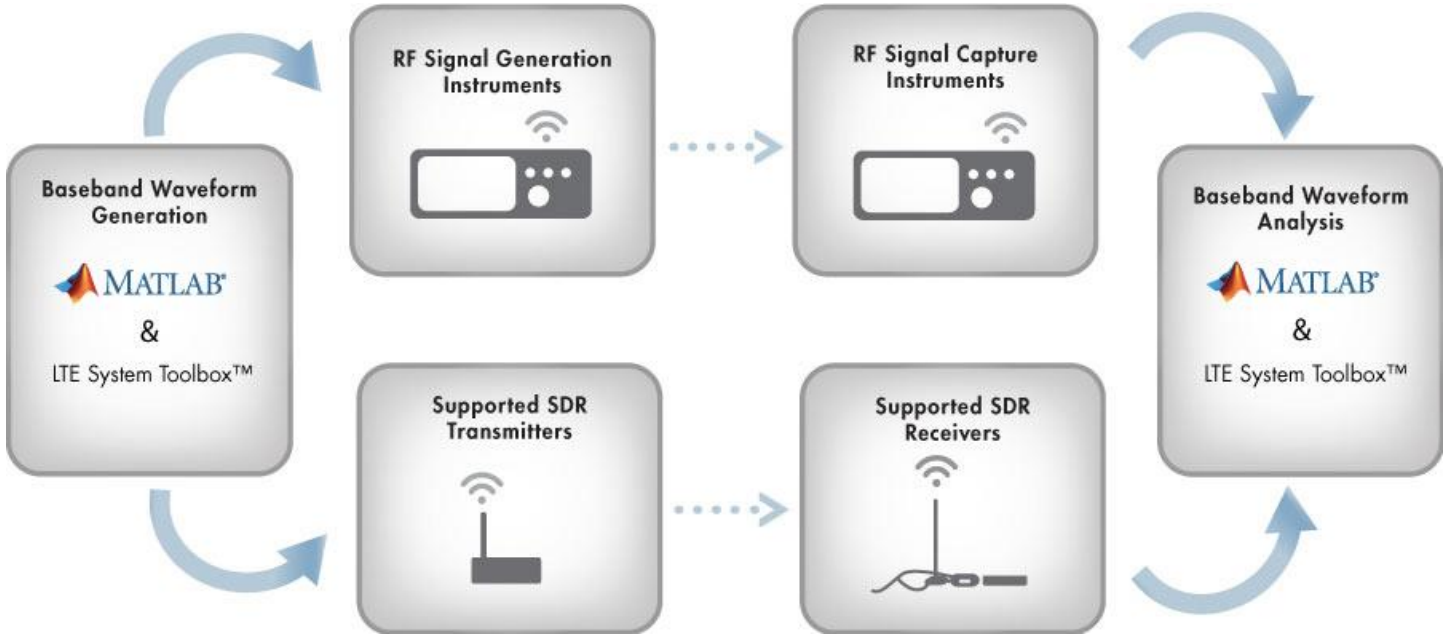




上海贝尔的实例 [The Base Station RF Development with MATLAB]



5G - Over-the-air testing with SDRs & RF instruments



Generate custom waveforms

Transmit with SDR devices or RF instruments

Capture signals with SDR or instruments

Recover original data

Range of supported hardware

RF Signal Generator

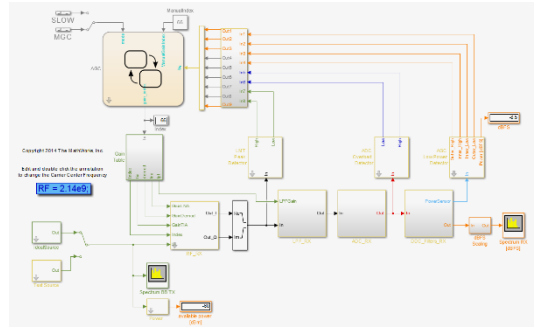
Spectrum Analyzer

Zynq Radio SDR

USRP SDR

Example: MATLAB 连接 SDR and AD9361/9371 进行验证

AD9361 RF Transceiver



Baseband Waveform Generation

MATLAB
&
LTE System Toolbox™

RF Signal Generation

HW Support package

SDR platform

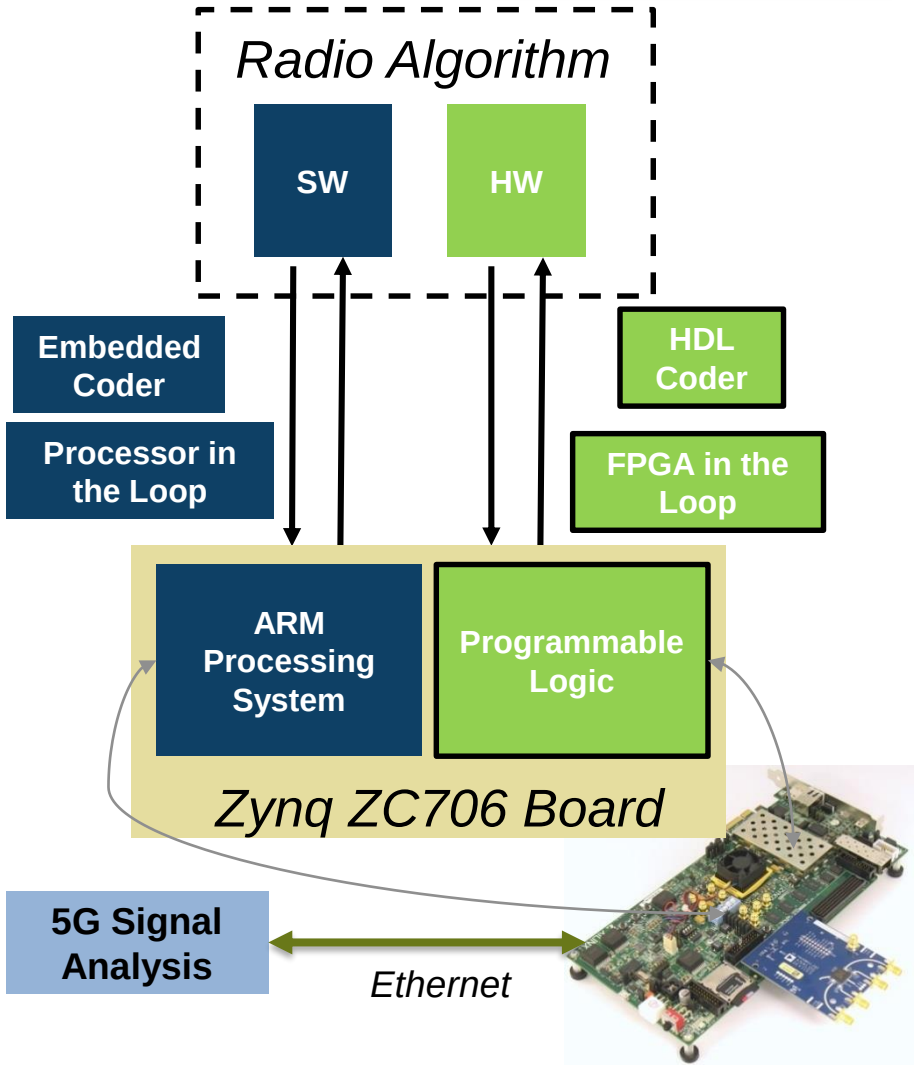
Over-the-Air

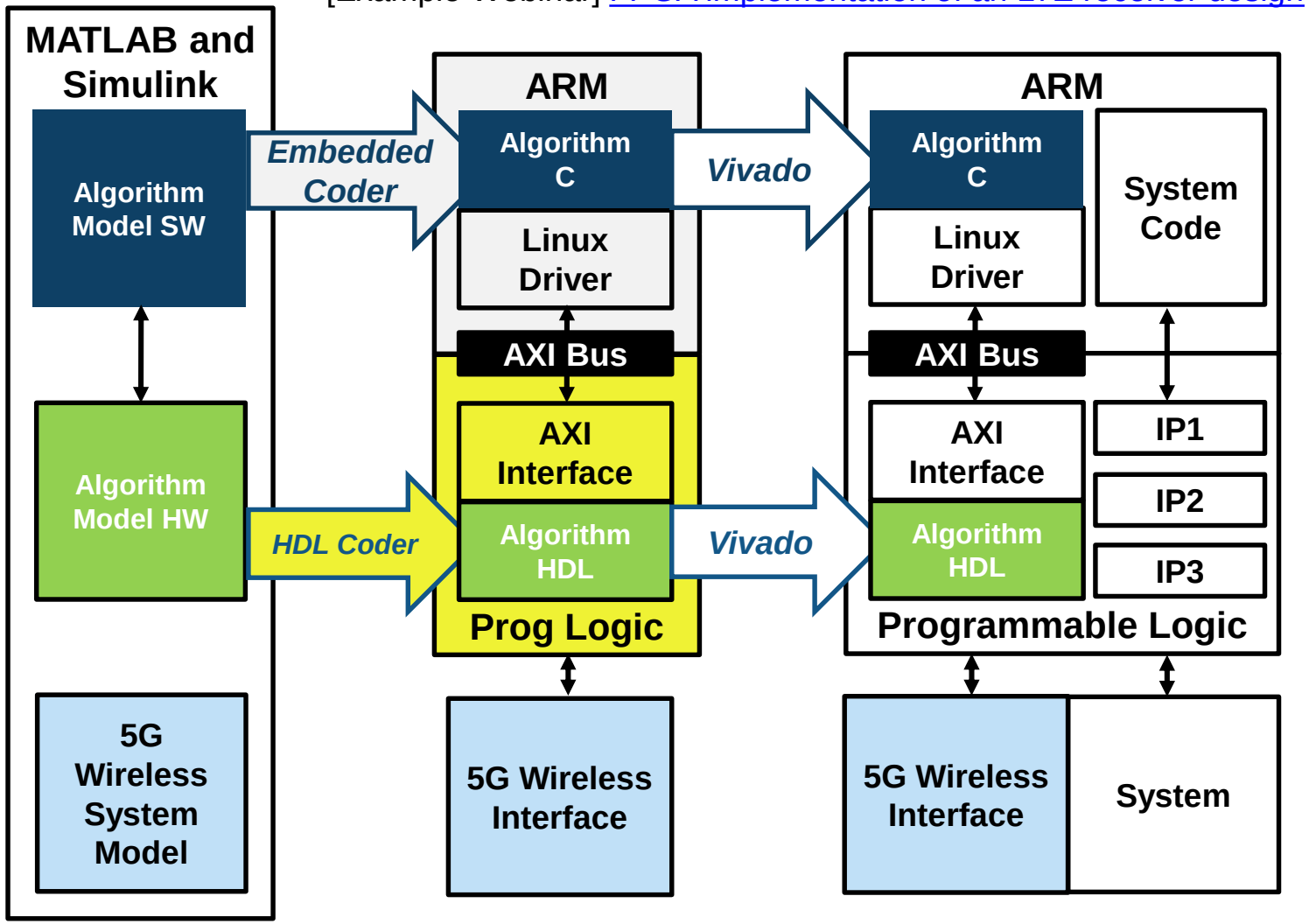
Zynq ZC706 Board

从仿真到实现: Xilinx Zynq + AD9361 SDR

MATLAB code (.m) | Simulink Model

[Example Webinar] FPGA implementation of an LTE receiver design





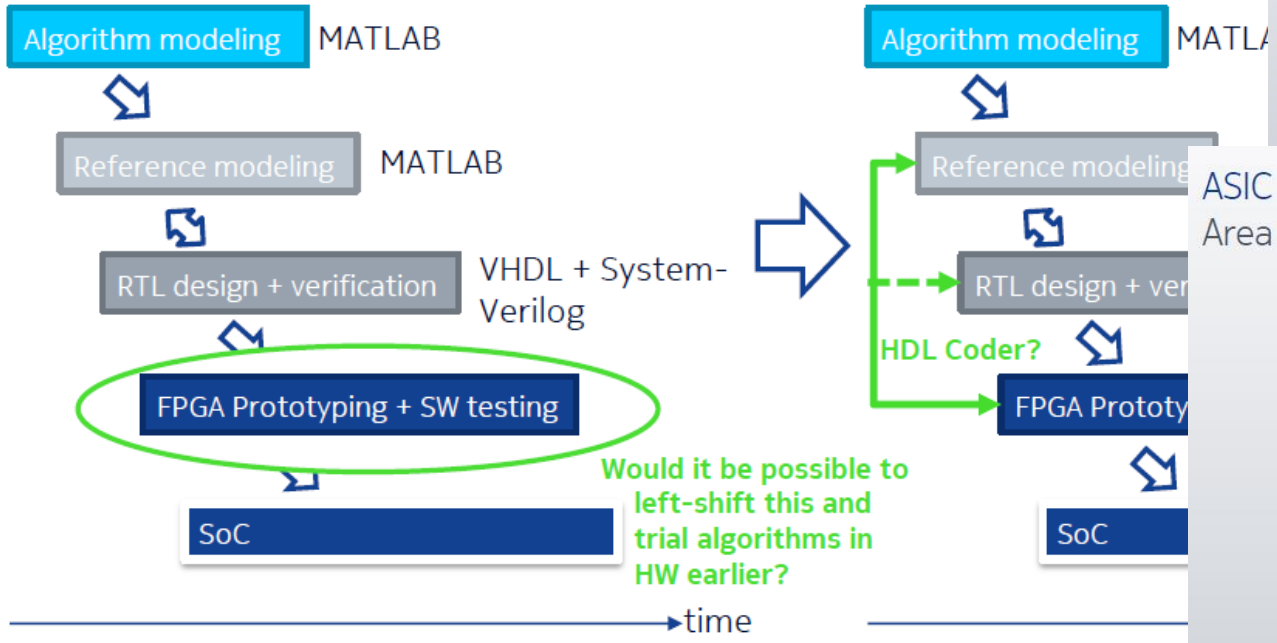
Ericsson – 射频验证板的设计 Using HDL Coder

Systems & Technology (S&T) is the department at Ericsson responsible for securing technology leadership for Development Unit Radio. S&T is involved in standardization, concept development, and pre-pre-studies of new features, standards, and concepts, and acts as a driver for radio technology strategic work. An important part of this work is the development of test beds to validate and demonstrate new technology. In this session, Tomas shares his experiences incorporating HDL Coder™ into the design workflow of a new test bed radio. He highlights how it has been a key factor in managing the rapid development of a complex FPGA application and how it has enabled the design to quickly adapt to changes in specifications.

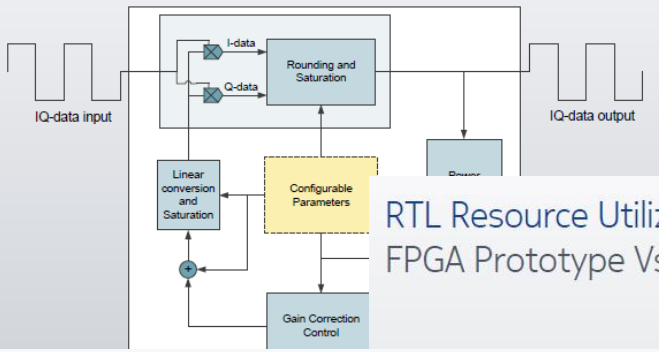
View video online at:
http://www.mathworks.co.uk/videos/radio-testbed-design-using-hdl-coder-92636.html

Nokia: 快速原型实现 Using HDL Coder

Challenge

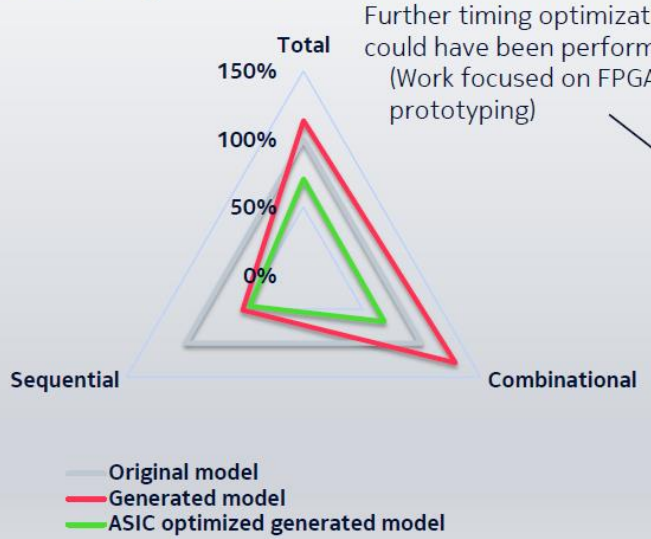


Example Design for HDL Coder Flow
Scaling and Power Limitation Block



RTL Resource Utilization Comparison
FPGA Prototype Vs. Original ASIC Targeted Model

ASIC Optimization
Area and Timing Results



Further timing optimization could have been performed (Work focused on FPGA prototyping)

系统级 ASIC 算法平台 using MATLAB and Simulink

Security Level:

System-Level ASIC Algorithm Simulation Platform using Simulink

Dr. Sun, Defu
Huawei Technologies Co., LTD.
2015/11/03

www.huawei.com

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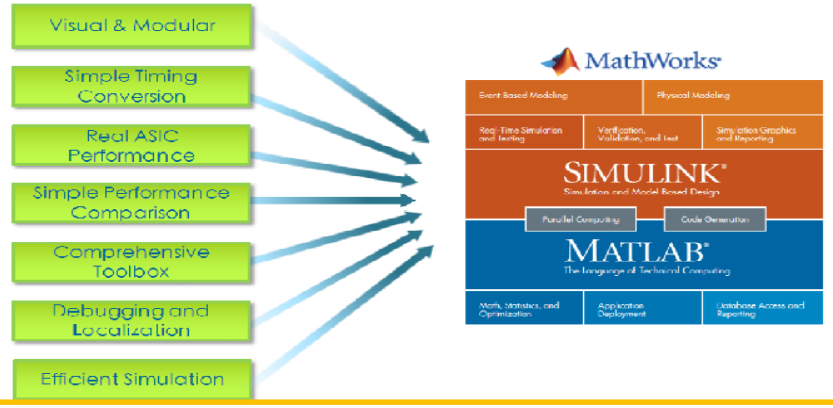
ASIC Algorithm Simulation Platform Requirements



MathWorks MATLAB & Simulink is great for algorithm simulation in ASIC
Huawei consider it as important ASIC algorithm verification tool

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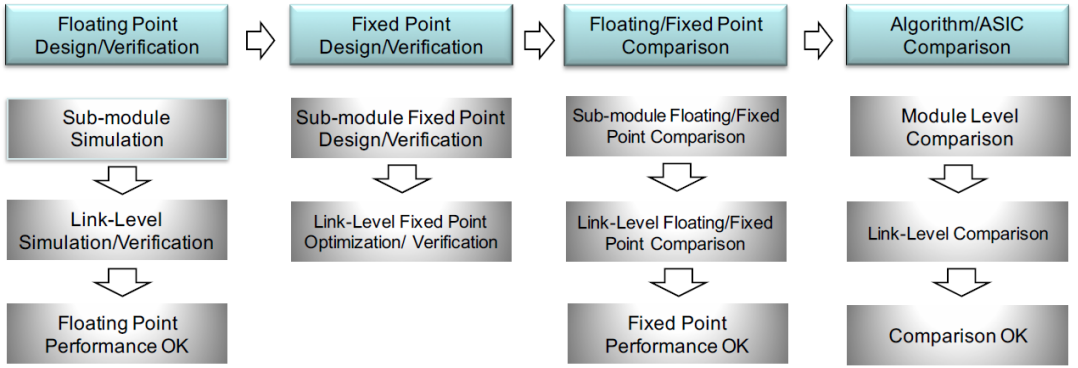
Algorithm Simulation/Verification Workflow in ASIC



Characteristics of ASIC Algorithm Simulation/Verification

1. System Level Design and Verification of Floating Point Arithmetic
2. Accurate Fixed Point design and Performance Comparison with Floating Point
3. Performance Comparison between Fixed Point Algorithm and RTL in ASIC

Compared to conventional floating point algorithm simulation, for ASIC algorithm verification is more extensive to verify accuracy with high degree of confidence

HUAWEI TECHNOLOGIES CO., LTD. HUAWEI

- Huawei: System Level ASIC Algorithm Simulation Platform using Simulink

小结与展望

- 5G系统的挑战
  - 多天线，mmWave，信道模型， 快速原型
- 从算法到天线的设计
  - MATLAB 统一算法开发平台，天线，RF，基带
- 空口的测试
  - 符合5G/LTE行业标准的信号， SDR
- 原型实现
  - 自动C和HDL代码生成，缩短开发时间

更多信息

- Website
  - https://www.mathworks.com/discovery/5g-wireless-technology.html