Overview of the 5G India Test Bed

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5G Test Bed in India, by India

To be at the forefront of 5G developments and deployments

Why

- Digital Connectivity programmes
- Make in India Startup India
- Building 5G ecosystem

How

- Scale and evolve nascent test beds
- Leverage wireless expertise
- Monetise Outcomes of 5G research project

Indigenous 5G Testbed Project

- First proposed by Dr. Paulraj
- Funded by Department of Telecommunications (DOT)
  - **THANK YOU!**
- 240 Crore project
- Three year duration

Build and demonstrate an end-to-end 5G test bed

Major Goals of 5G test bed

- Encourage telecom product startups in India
- New startups
- Multiply R&D capability to develop 5G based solutions for Indian markets
- Demonstrate solutions for India
  - LMLC for Rural network deployments
  - Smart city applications
  - Dense Urban broadband, “wireless fiber” for spurs
- Hugely enhance capacity in 5G technology skills
- Increase India’s participation in global forums (3GPP, ITU, IEEE) - present test results for Indian use cases

5G Test Bed Team

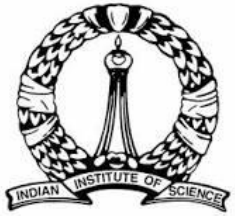
Collaborating Institutes

IITB

IITH

IITM

IITD



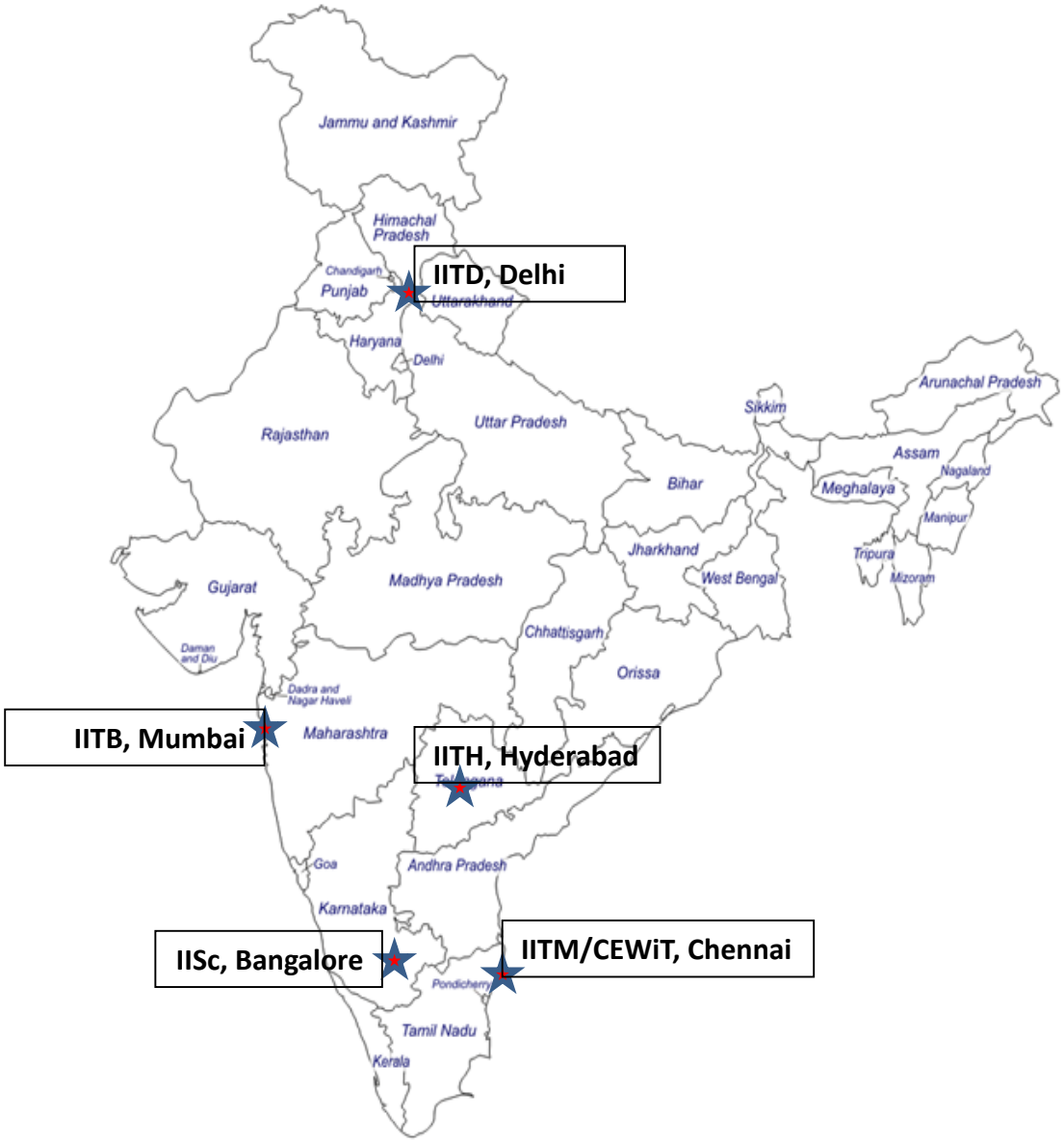
IISc

IITK

CEWiT	Baseband Algorithms, Core Network, Hardware Platforms
IIT Bombay	Core Network
IIT Delhi	Baseband Algorithms, LiFi, Security
IIT Hyderabad	NB-IoT Asic, Algorithms, UE (CPE form factor)
IIT Madras	Hardware Platforms, Core Network, Algorithms
IIT Kanpur	Relay, Hardware Platforms,
IISc Bangalore	Baseband Algorithms, IoT, LiFi
SAMEER	Antennas, RF platforms

- 40 Investigators (faculty members/Senior researchers) from 8 institutes
- **Currently 200 researchers working on the testbed**
- Engaging with Indian telecom startups for various sub-systems

Test Bed Locations



Subsystems and Use cases being Developed

Major Subsystems to be developed

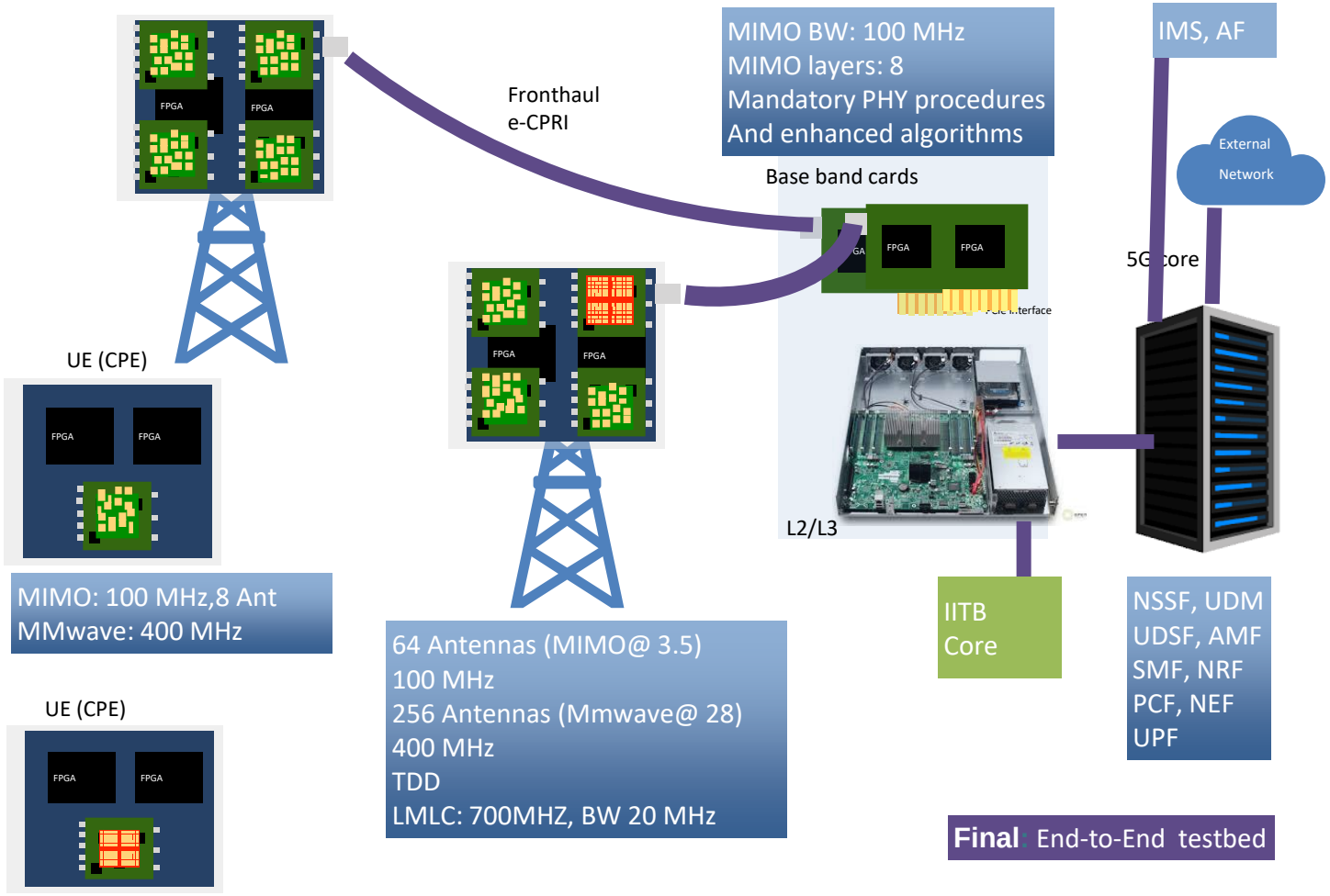
Being developed world over for the first time

- Integrated mmWave Radio Front end
  - Development of hybrid analog/digital architectures
  - 256 Antenna (with 4 streams)
- Massive MIMO subsystem
  - 64 Antenna systems (Sub 6 GHz)
  - Radio, Front end, Baseband
- Full Duplex Radios
- 5G Base band
  - 5G NR (3GPP 38 Series) compliant
  - Supporting lower bands (< 6 GHz) and higher bands (> 6 GHz).
- Edge Computing Subsystem
- CloudRAN
  - Centralized baseband implementation with cooperative schemes

Major Subsystems to be developed [Contd.]

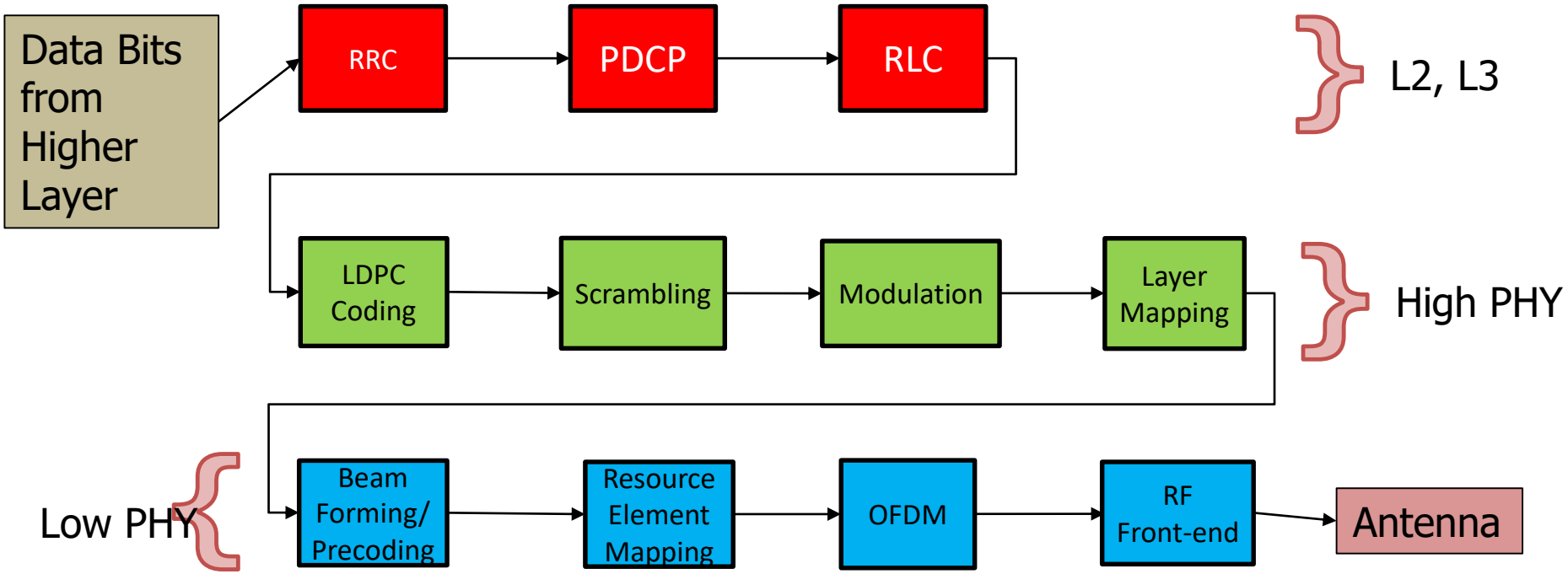
- 5G Core Network
  - SDN based
  - Multi-RAT using WiFi etc
- Management layer for test bed management
- IoT (Internet of Things)
  - An end-to-end IoT network will be developed using a mix of commercial and prototype components
- Security
  - Security for IoT will be a special focus
  - Security for SDN and NFV architectures will be a new challenge to address
- Li-Fi
  - Giga bits range high-speed Li-Fi system
- Devices
  - Mix of devices developed and commercially available

Test Bed Setup - Final

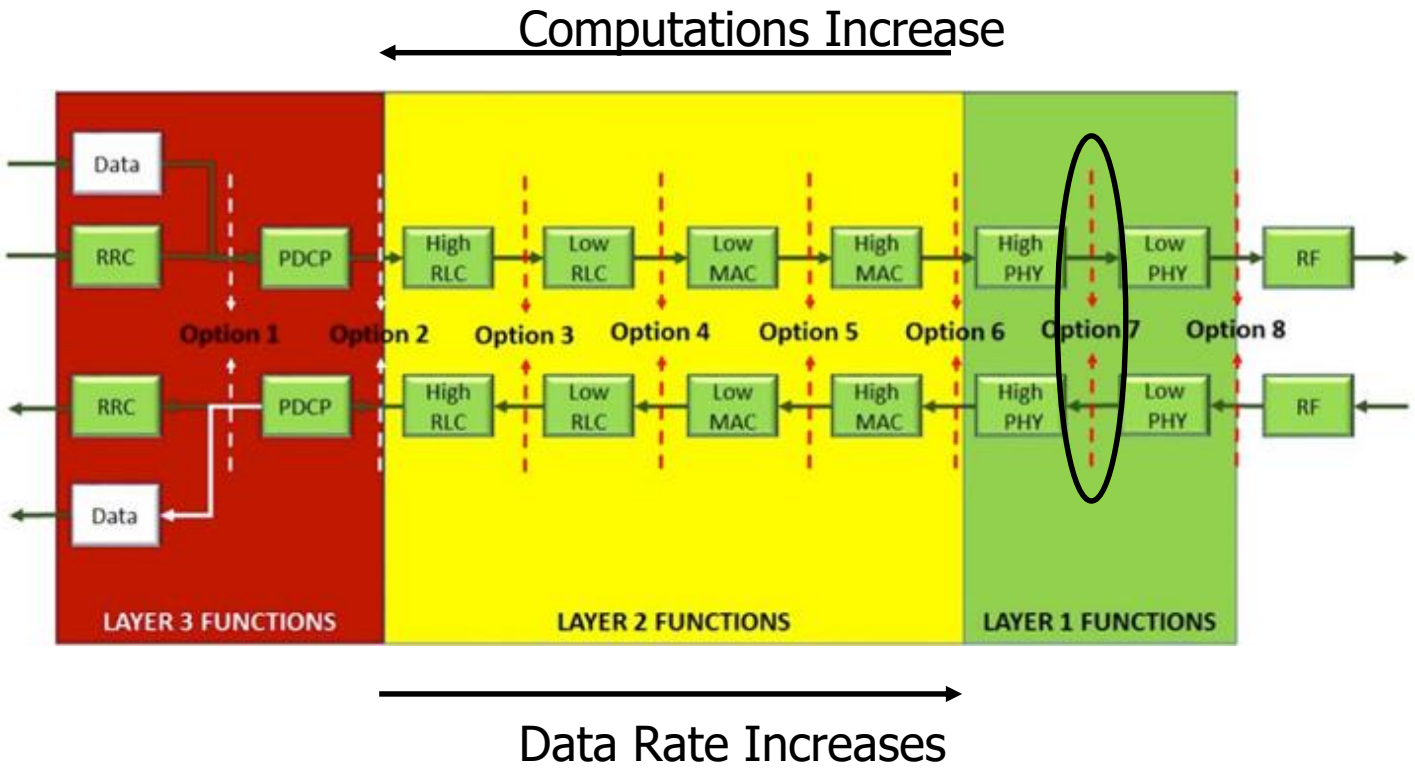


RRH Design

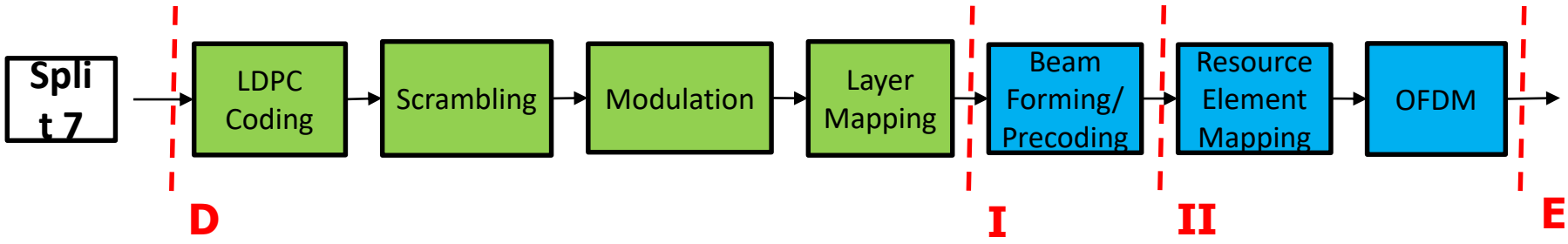
Functions of a Basestation



Functions of a Basestation



Functional Split in the Basestation



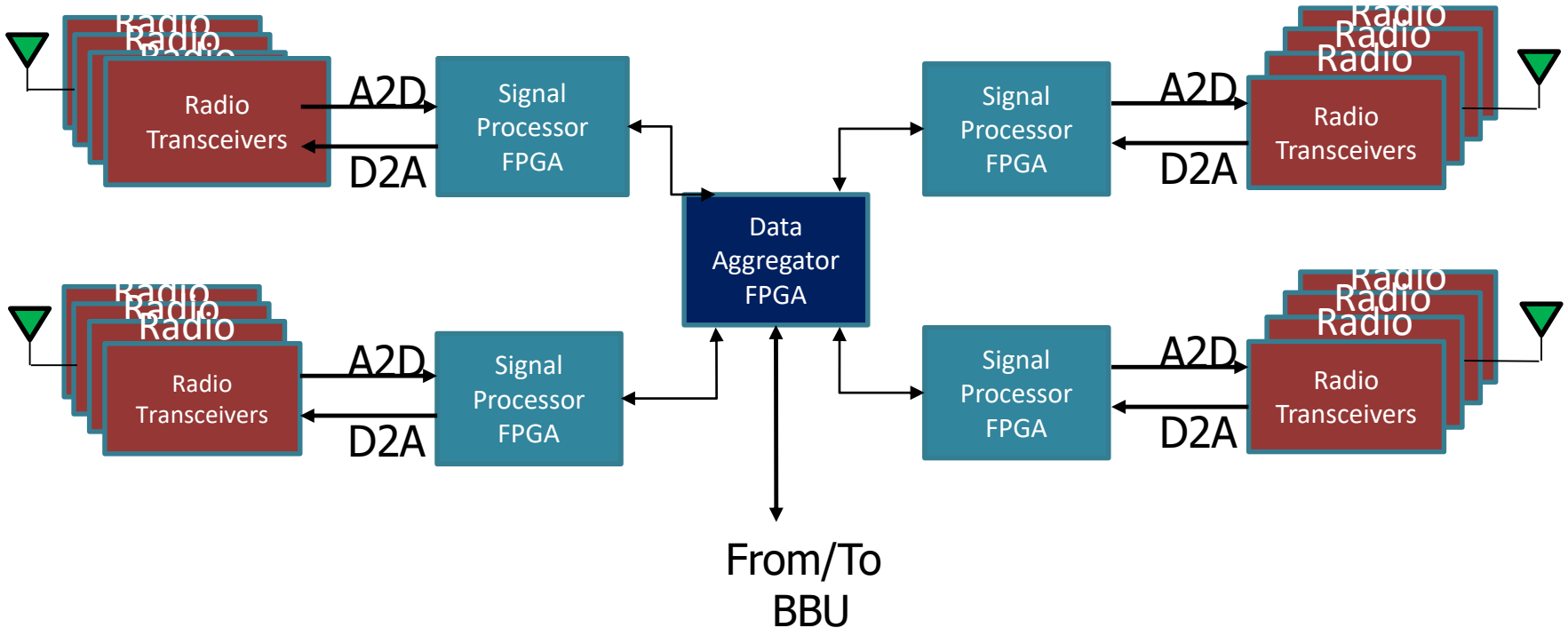
	Split D		Split Iᴅ		Split IIᴅ		Split E
	User Data [Gbps]	Control [Gbps]	User Data [Gbps]	Control [Gbps]	User Data [Gbps]	Control [Gbps]	User Data [Gbps]
eREC→ eRE	3 (assumption)	<< 1	< 4	< 10	~ 20	< 10	236
			Split Iu				
eRE → eREC	1.5 (assumption)	<< 1	~ 20	< 10			236

Chosen Split = 7.1

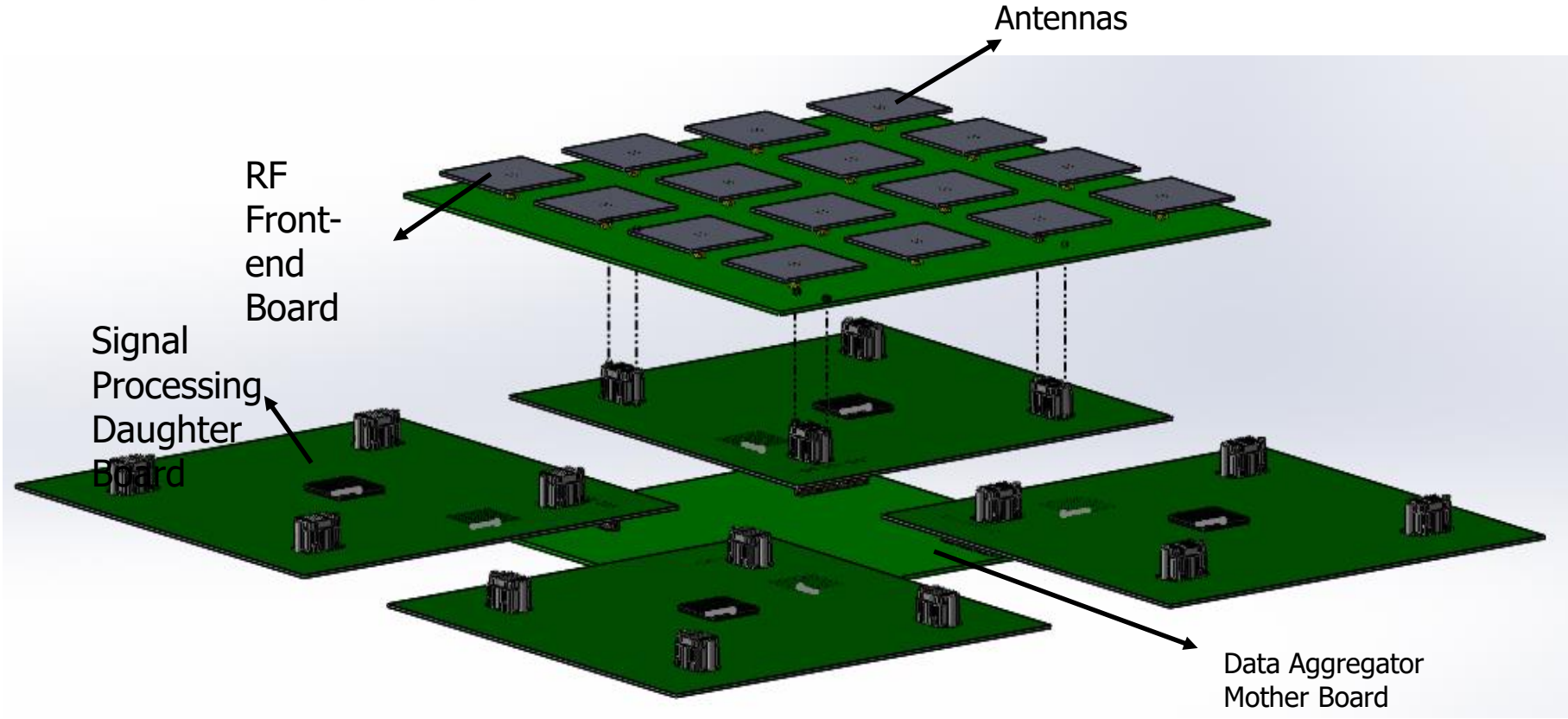
RRH Design Requirements

- RF front-end – PA, LNA, Antennas, etc.
  - RF operation at 3.5GHz - 100 MHz bandwidth
  - And at 28 GHz – 400 MHz bandwidth.
- ADC, DAC interfacing.
- eCPRI interface with BBU.
- Low PHY processing.
- Clock Synchronization.
- **Support for Massive MIMO and mmWave.**
  - **64 antennas for sub-6 GHz, 256 antennas for mmWave.**

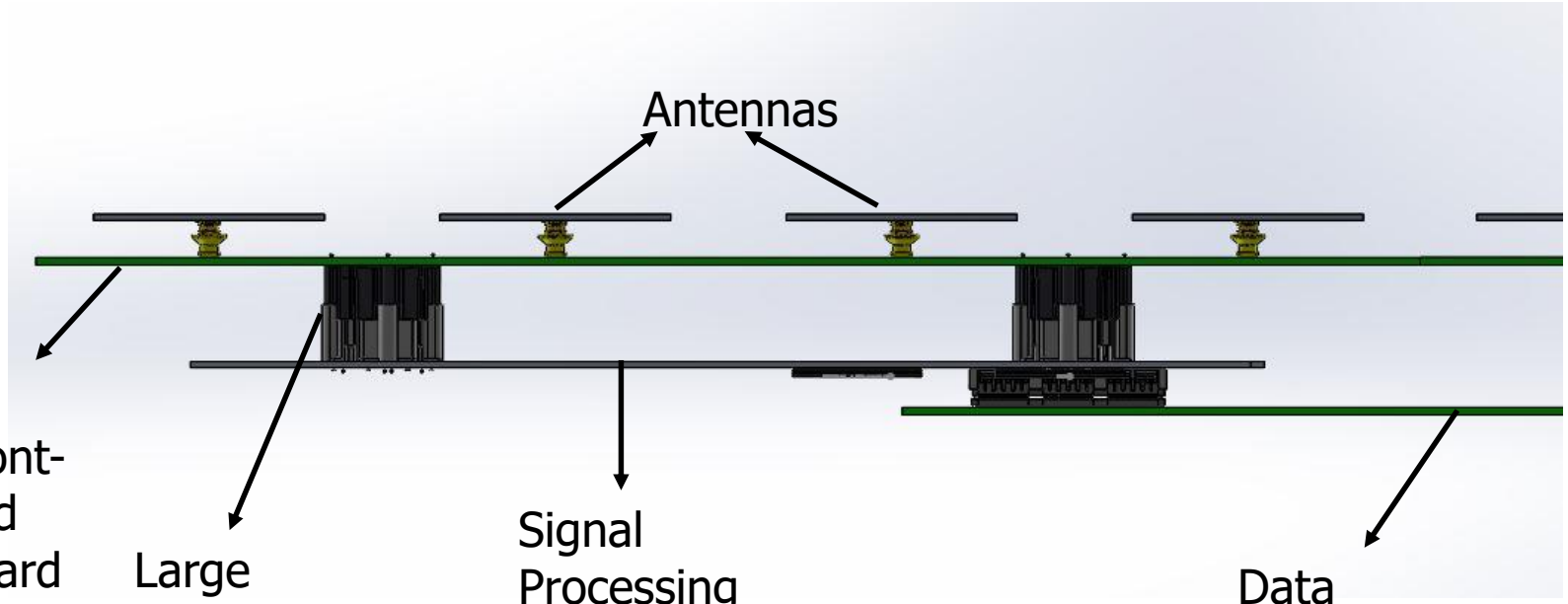
RRH Block Diagram



RRH Boards

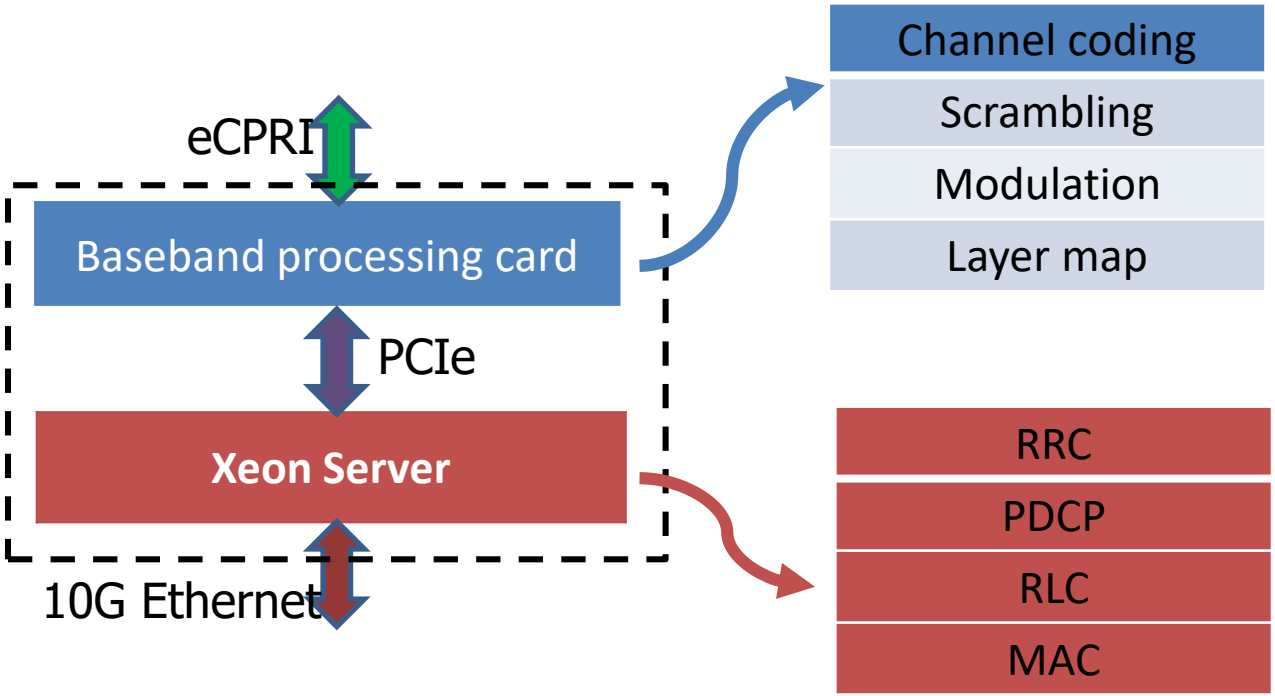

Antennas
RF
Front-
end
Board
Signal
Processing
Daughter
Board
Data Aggregator
Mother Board

RRH Boards Side-View



Base Band Unit

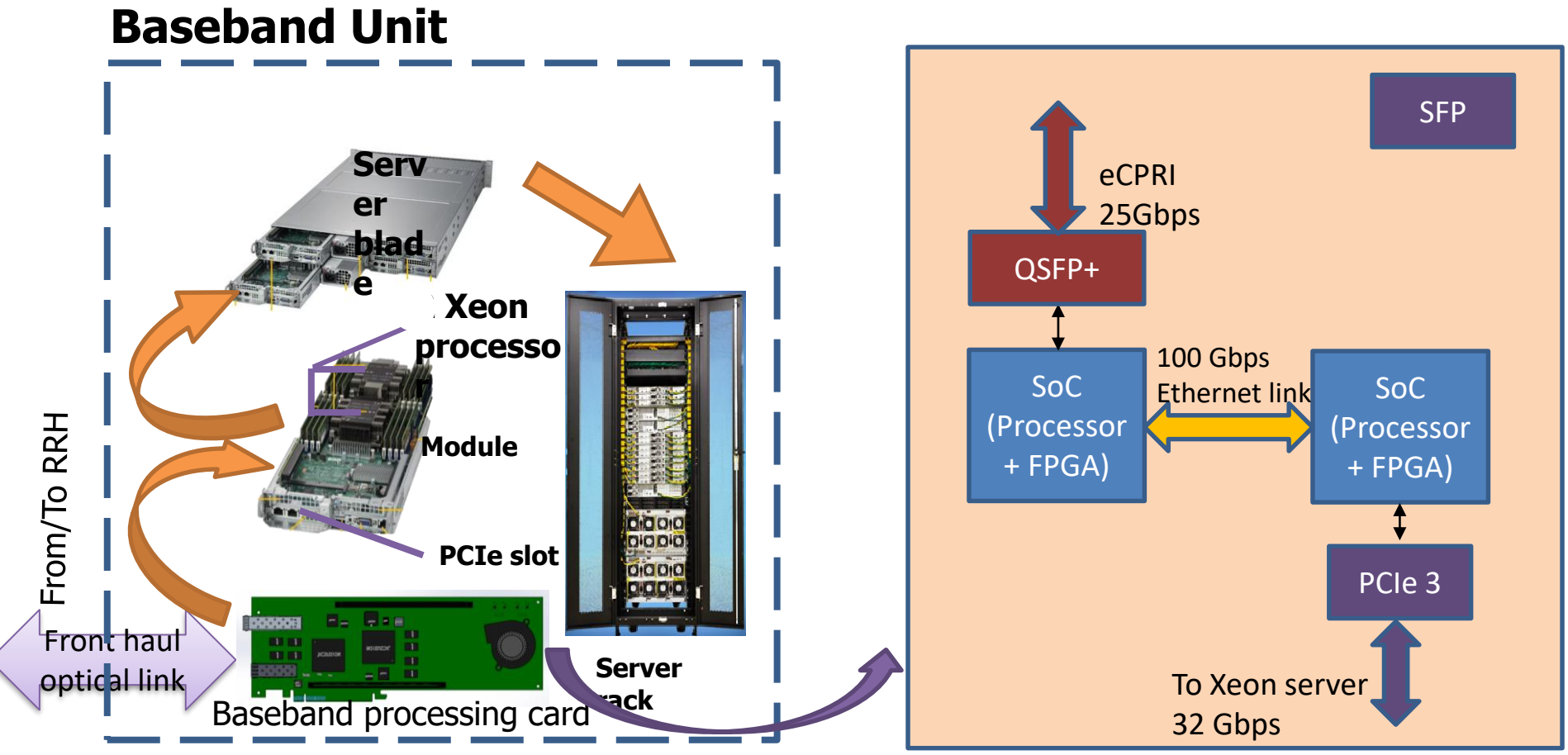
BBU : Requirements & Architecture



Proposed architectu re

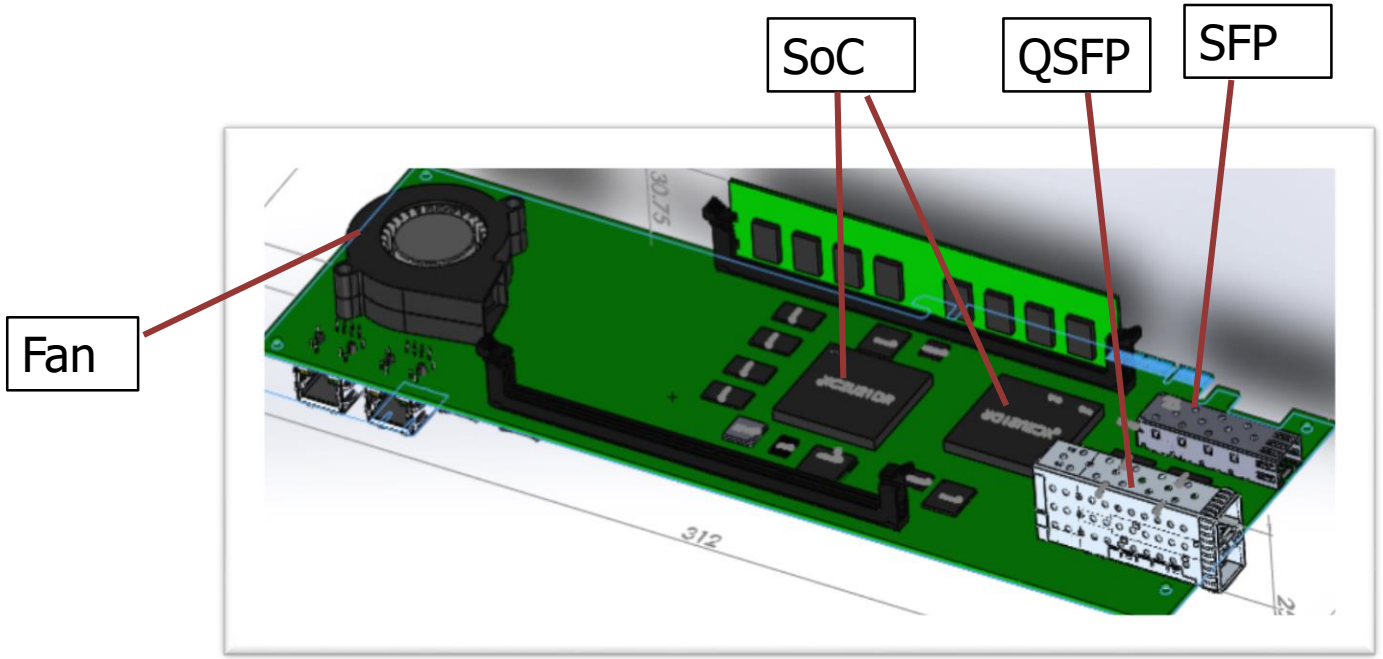
- **H/w features:**
  - Scalable
  - Processing power
  - High bandwidth interfaces
  - Low latency
  - Power efficient

BBU: Architecture



Baseband processing card: PCB

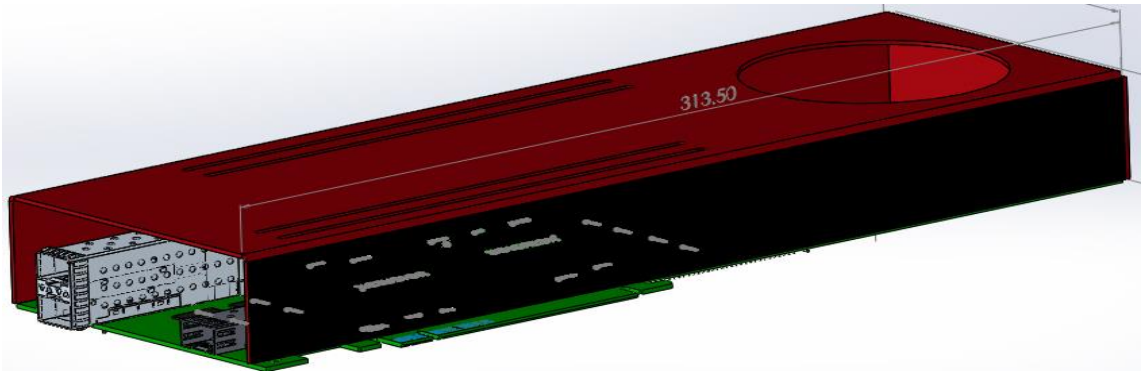
PCB size: 312x111.5x1.6 (mm)



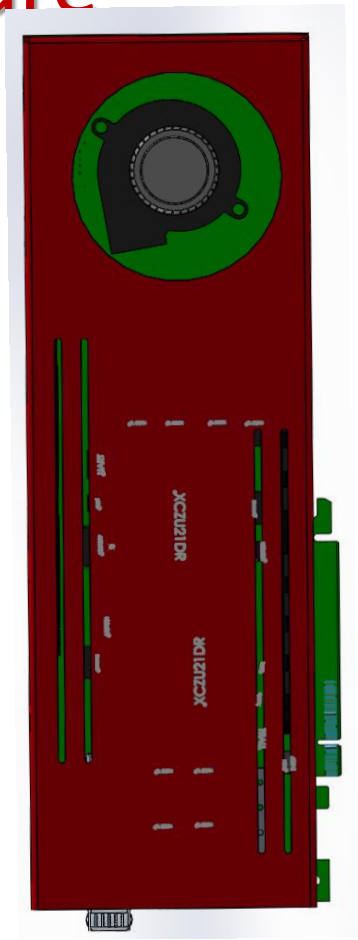
Side view

Top view

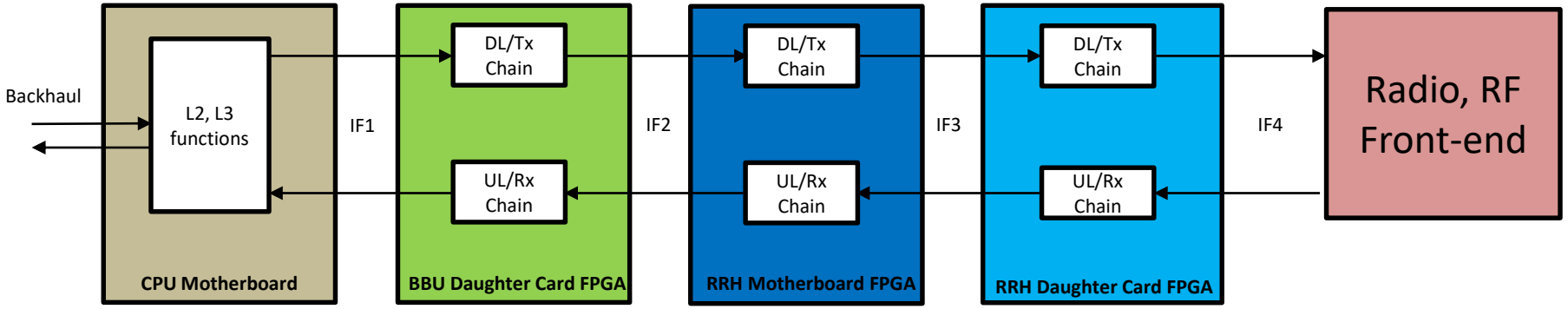
Baseband processing card: Enclosure



Dual width, Full length, PCIe compliant

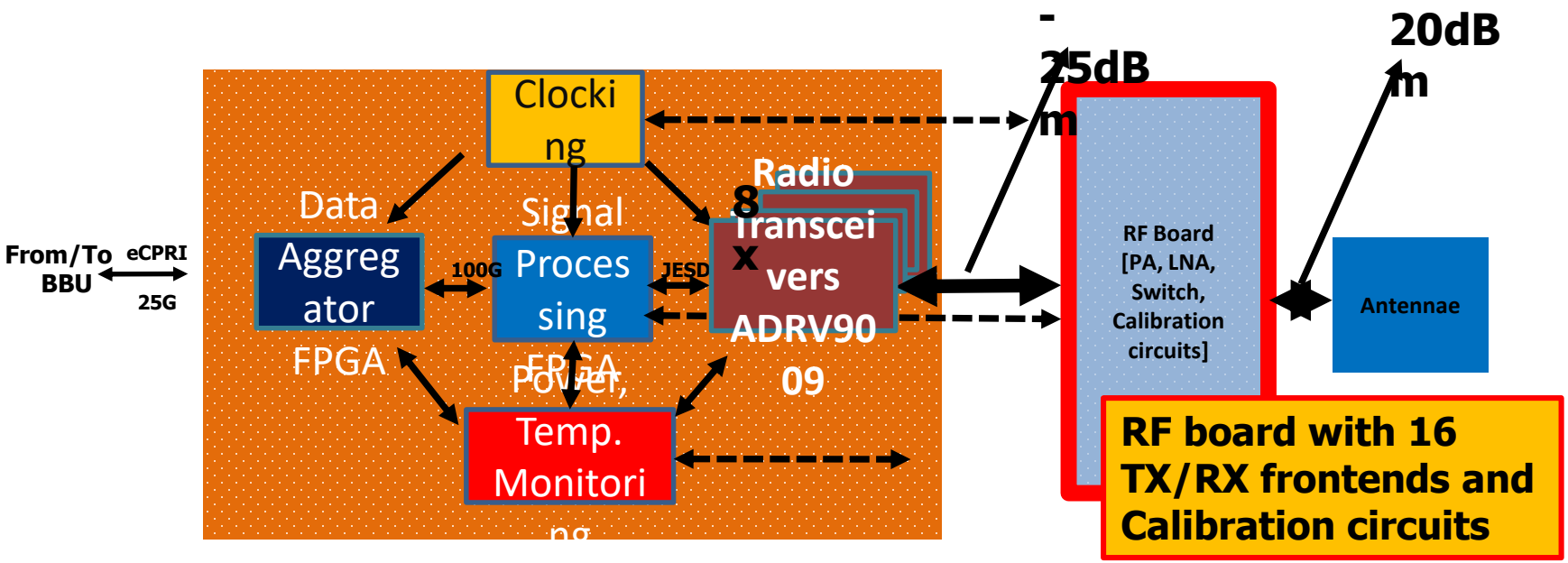


Overall Data Flow



Massive MIMO

Version 0



- **Output power : 20dBm**
- **Bandwidth : 100MHz**
- **Frequency : 3500MHz**
- **Receiver Sensitivity : -94dBm**

Start Date: July 2018

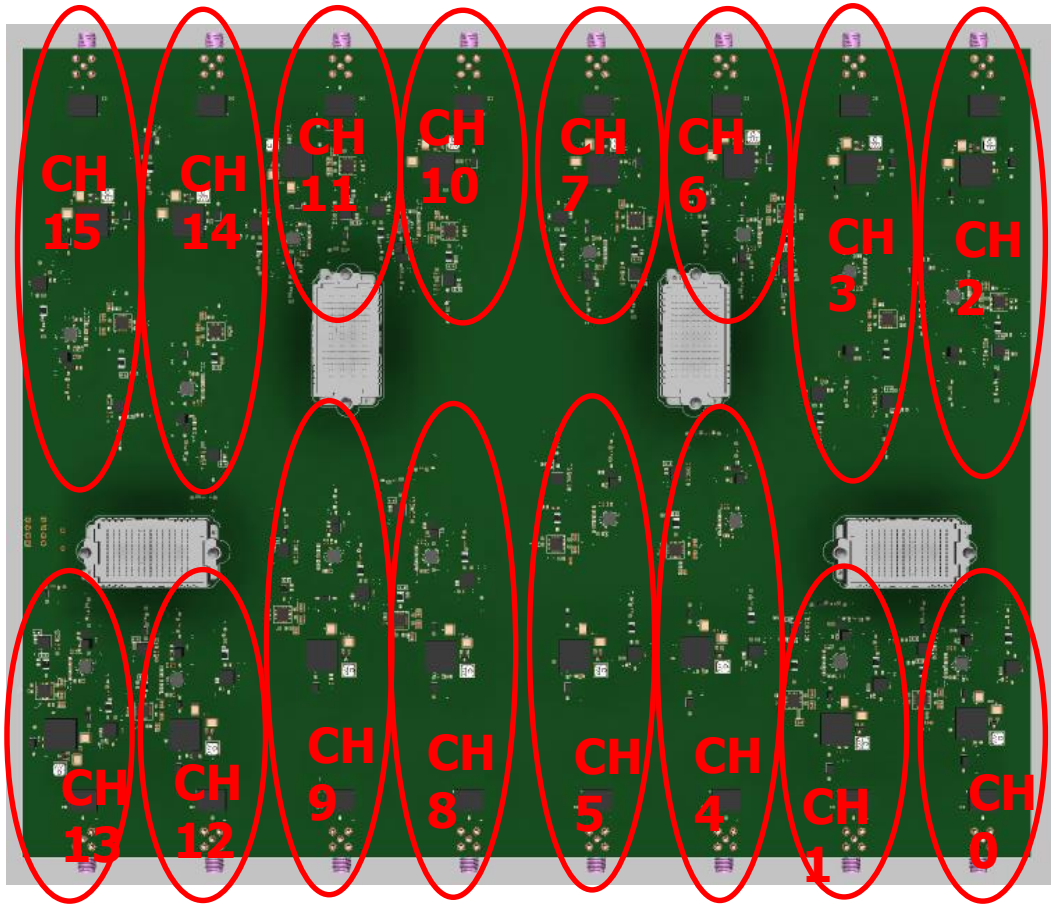
Current status: Layout completed

Completion Date: Jan 2019

Specifications

Operating Mode	**TDD**
TDD switching speed	**10 us**
Rx Noise figure of Radio Transceiver	**13 dB**
Tx output power from Radio Transceiver	**-25 dBm**
Tx gain required to get 20 dBm output	**45 dB**
Rx gain Required	**-**
Reciprocity and Linearity Maintenance	**TDD Calibration Path and ORx Path to do DPD**
To Attenuate Out of band Interferers and Reduce Out of band radiation	**Saw Filters**

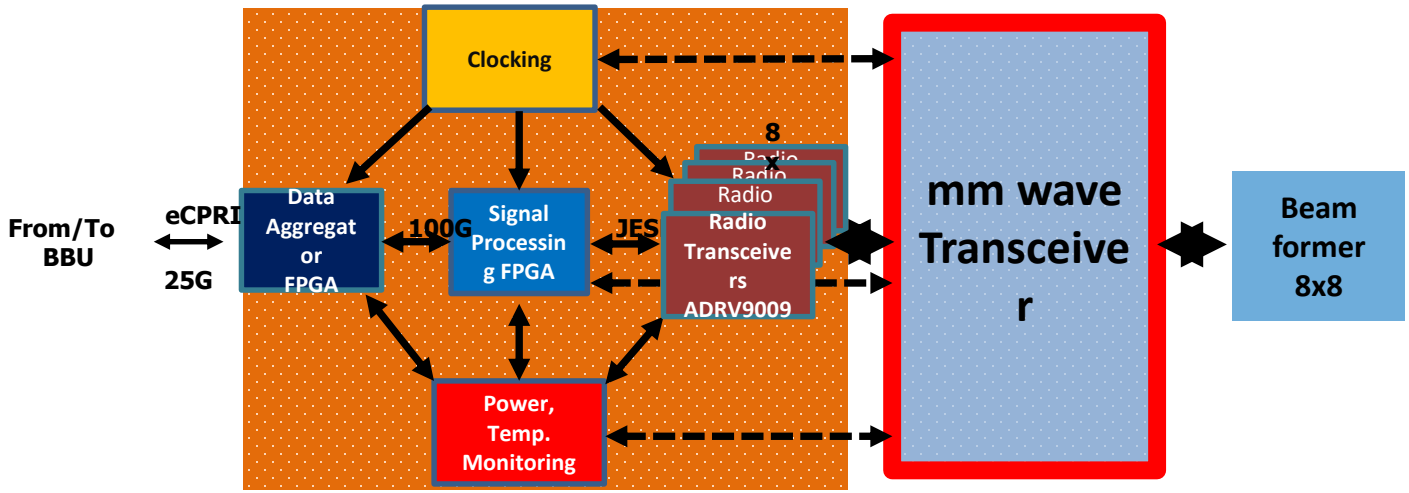
PCB – 3D view – Bottom side



Size:
350mm X 250mm X 2mm
Number of layers: 6

MMWave

Version 0



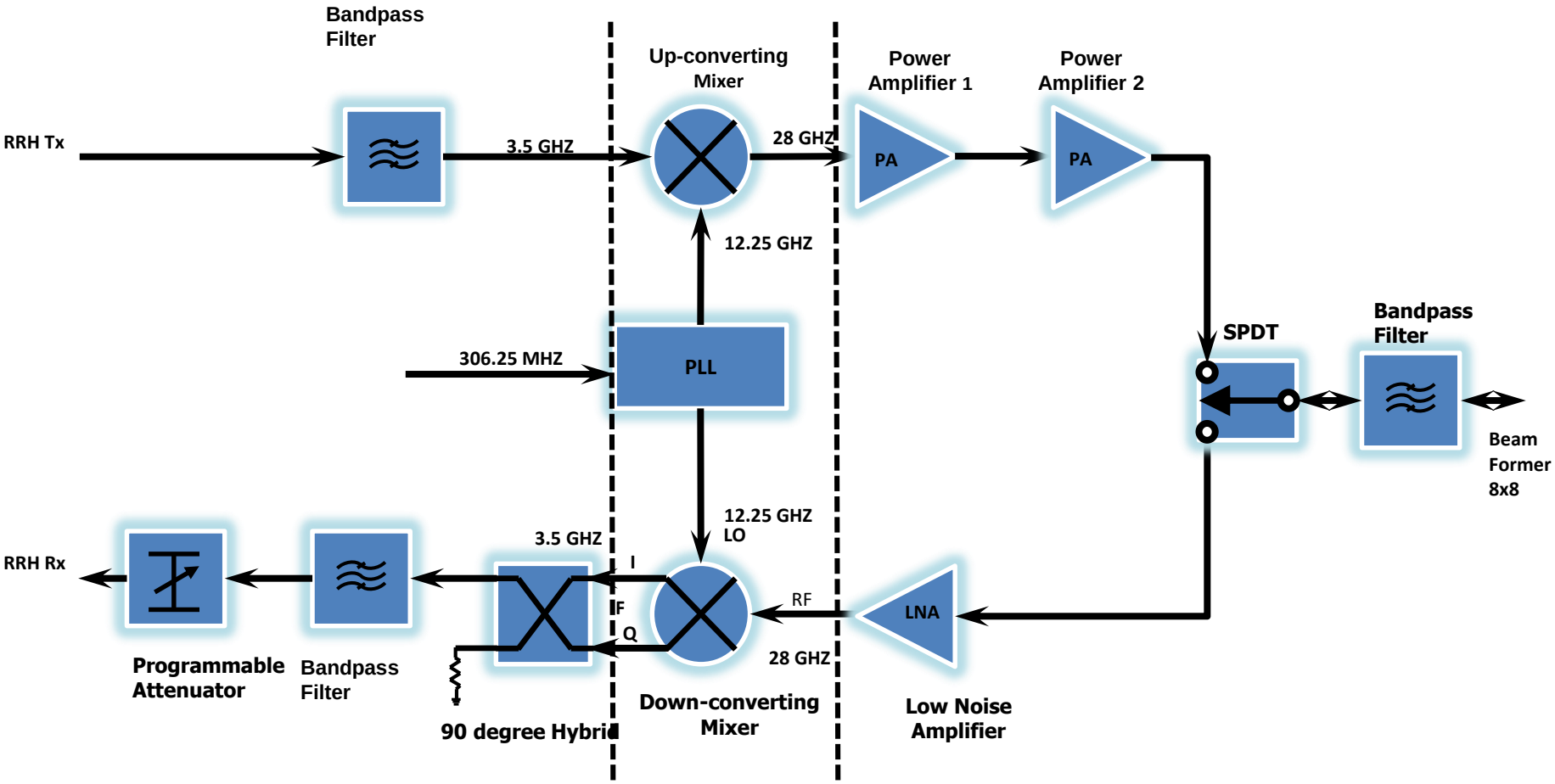
- Output power : +11 dBm
- Bandwidth : 100MHz
- Frequency : 28GHz

Start Date: June 2018

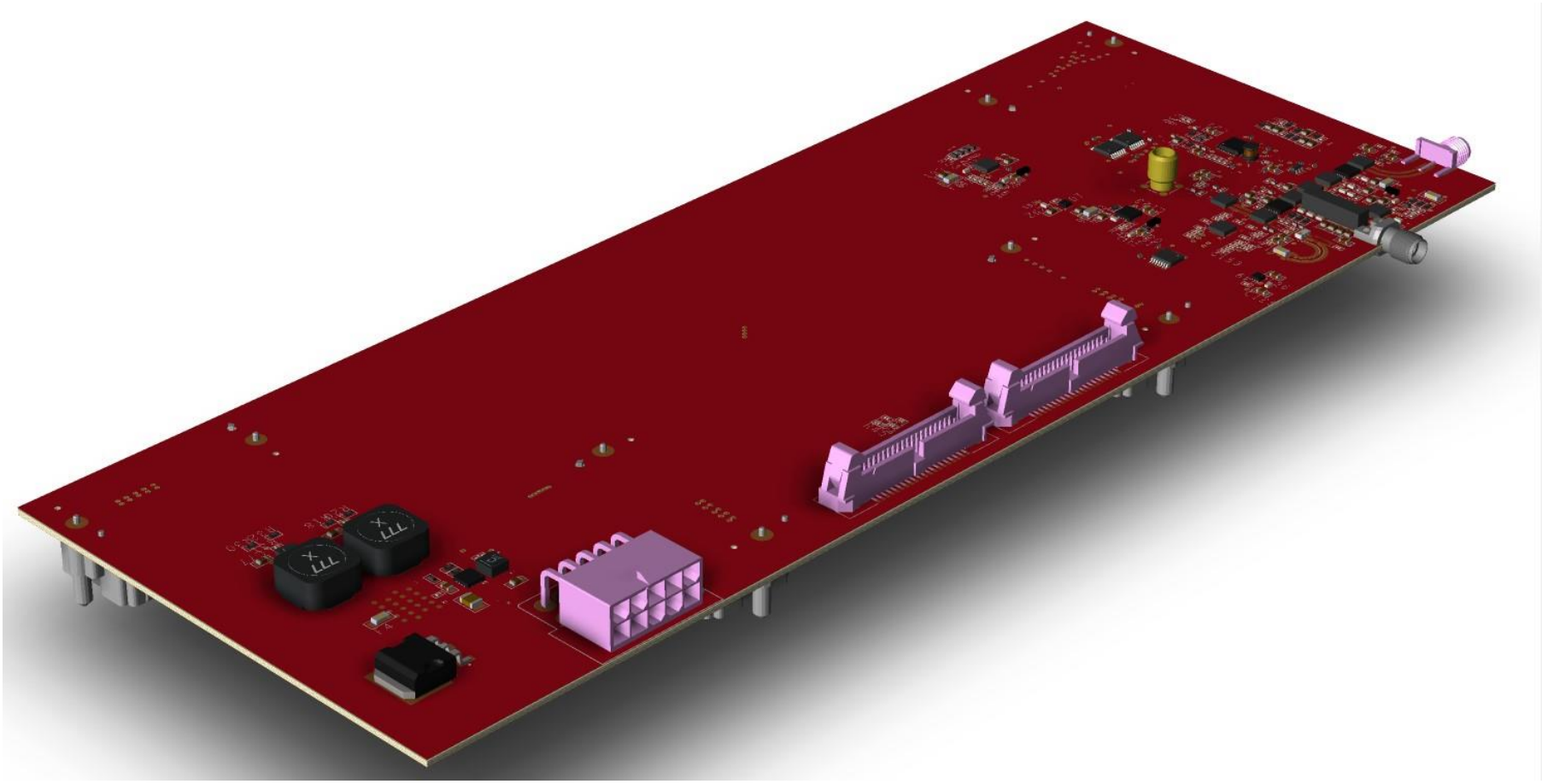
Current status: Layout completed

Completion Date: Jan 2019

Block Diagram



PCB – 3D view



INTEGRATED TEST BED SUMMARY 1/2

Version	Summary Features Available
Version 0 **May 1, 2019**	• Individual RF, RRH, BB subsystems ready for demo to users. • Platform/Tool providers get technical feedback.
Version 1 **January 1, 2020**	• Integrated end to end basic functionality ready for demo for users. • Users can understand the 5G aspects by seeing demo related to massive MIMO, mmWave etc. • Experiential learning tool for 5G technology. • Users can plug in their own modules and check for those features which are within the scope of Ver1. • Partners get an initial version of working hardware and software for internal use.

INTEGRATED TEST BED SUMMARY 2/2

Version	Summary Features Available
Version 2 **September 1, 2020**	• Integrated end to end functionality ready for demo for users. • Users can run end to end applications. • Users can plug in their own modules in RAN or Core and run them in the end to end functionality within the functionality of Ver2. • Researcher can put in their algorithms and check performance. • Software and Hardware ready for initial licensing.
Version 3 **April 1, 2021**	• Integrated end to end functionality ready for use case demos like LMLC, Dense Urban, IOT scenarios. • Users can run end to end applications including IOT. • Users can plug in their own modules in RAN or Core and run them in the end to end functionality. • Users can use slicing techniques to understand its effectiveness. • Users can bring in a network element and integrate with the test bed. • Users can license parts of the test bed Software and Hardware.

An exciting opportunity for academia, industry collaboration

Let us do something different!

Thank You