EXPERIMENTAL EVALUATION OF MIMO & PHASED-ARRAY PROTOTYPE DEMONSTRATORS FOR EMERGING 5G APPLICATIONS

Host institution: **DELTA/Force, Hørsholm, DENMARK**
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Personal presentation

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EMC and Space Systems Engineer
ISAE-SUPAERO, Toulouse, France
National University of La Plata (UNLP), Argentina

- Background
  - Flight Segment EMC Engineer
    Argentine Space Agency (CONAE)
    - Radio Frequency Compatibility (RFC)
    - ESD at System and Sub-Assembly Level
    - Radiated and Conducted Emission/Susceptibility
  - EMC Engineer
    EMC Laboratory of UNLP, Buenos Aires, Argentina
    - Conducted EMC on electromedical and industrial devices

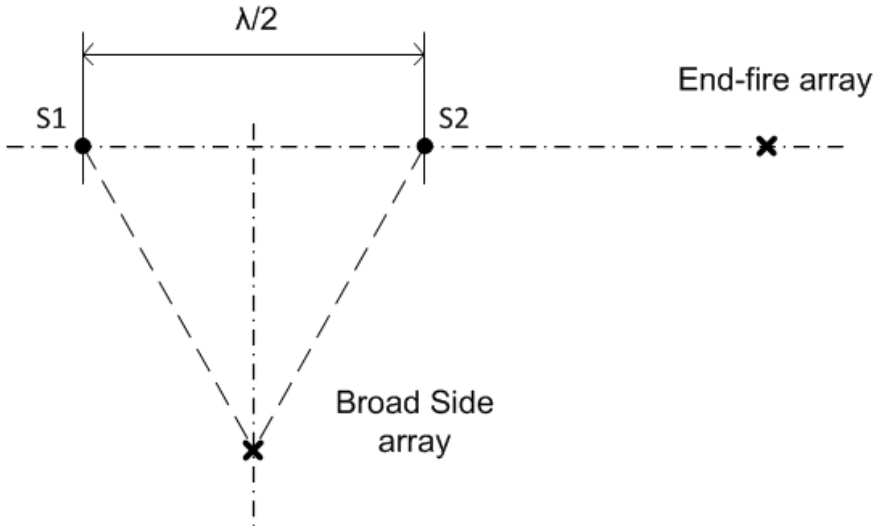
Motivation: MIMO and 5G

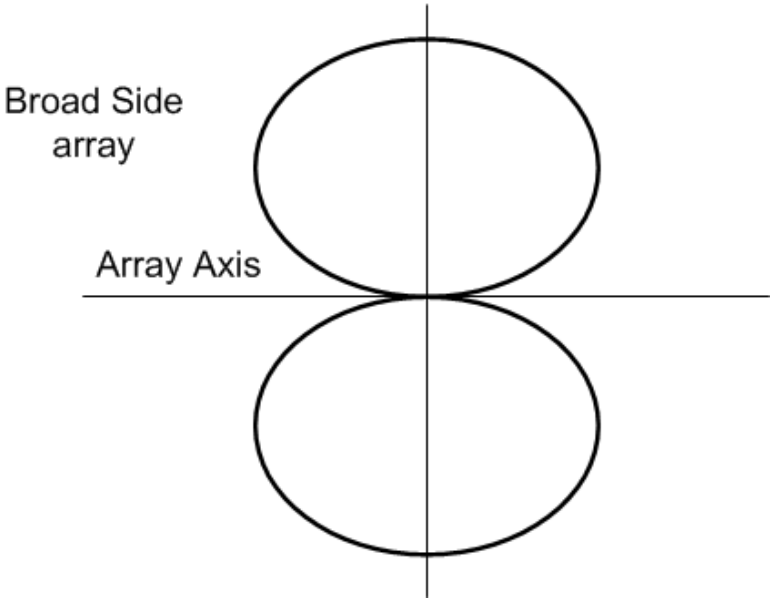
- Higher frequency (26 GHz – 30 GHz)
- Beam steering capability
- Densely integrated RF Modules
  (PA + LNA + SW + Antenna Element, MMIC)
- Production testing becomes challenging (many parameters/scenarios)

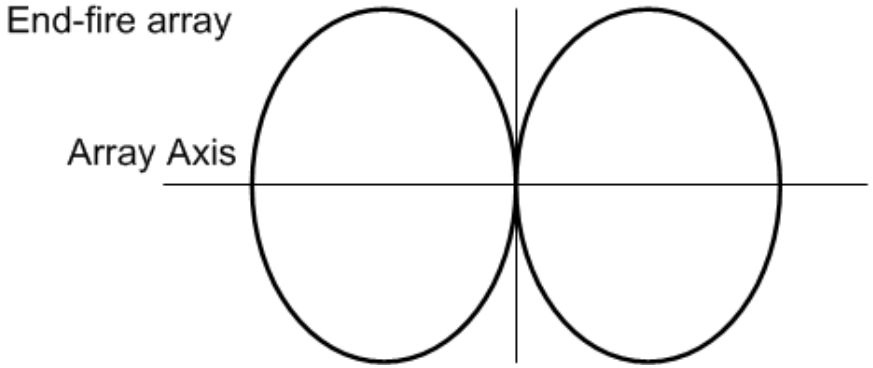
Phased Array Basics

The contribution of each element to the Far Field emission can be modified by changing the Phase Delay (β) between their inputs

- Broadside Array (0)
- End-Fire Array (λ/2)
- Intermediate cases

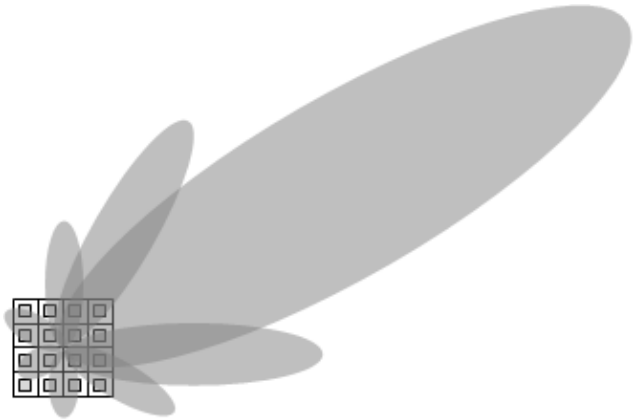




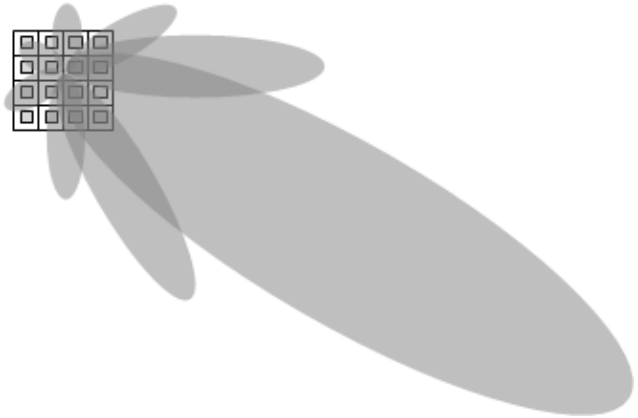


Phased Array Characterization

- Parameters
  - Gain
  - Phase
  - Compensation (LUT)



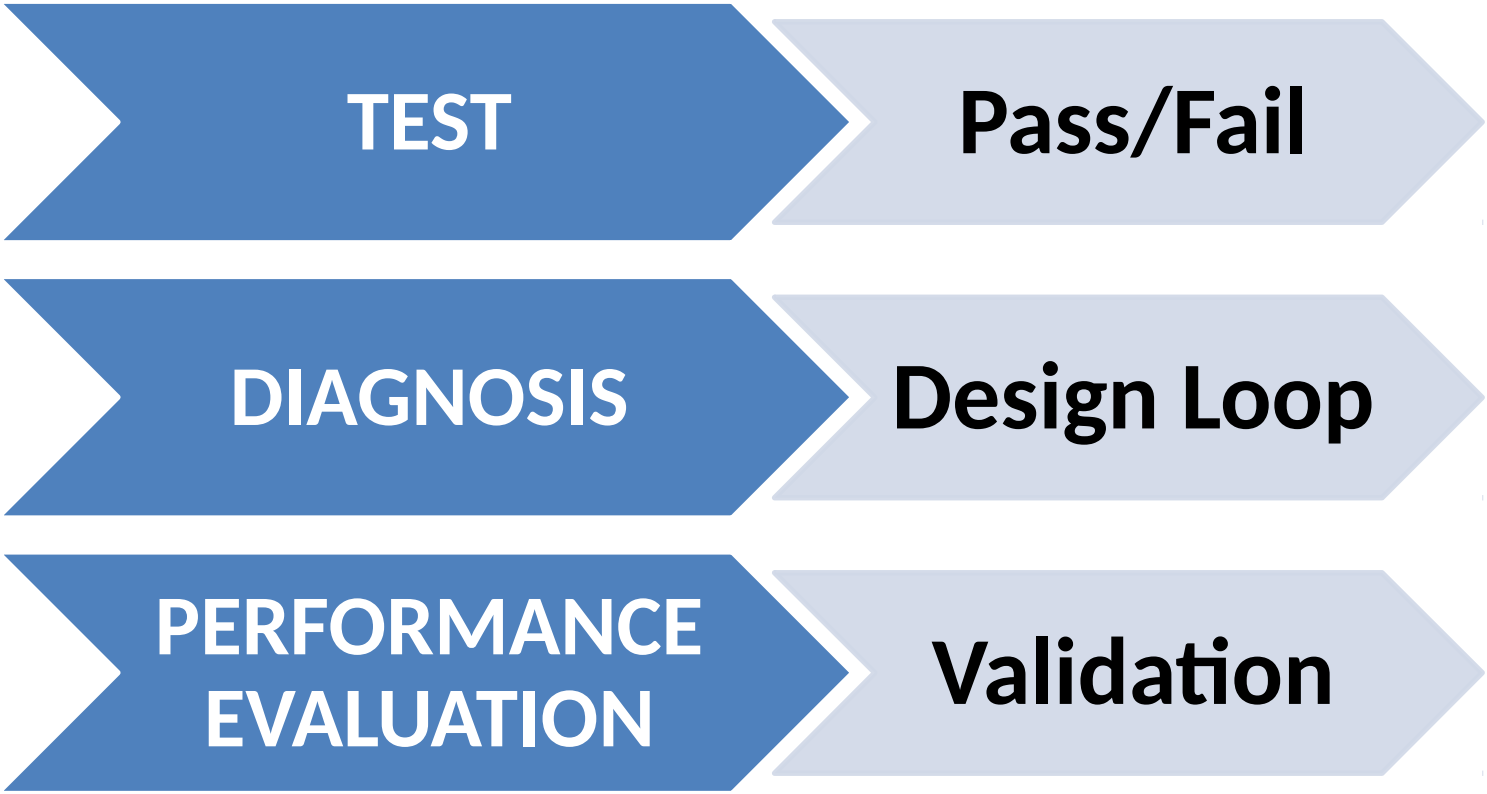
- Constraints
  - Representative operational modes?
  - Worst case scenario?



Scope – Phased Array V&V

- Device/Technology Verification & Validation

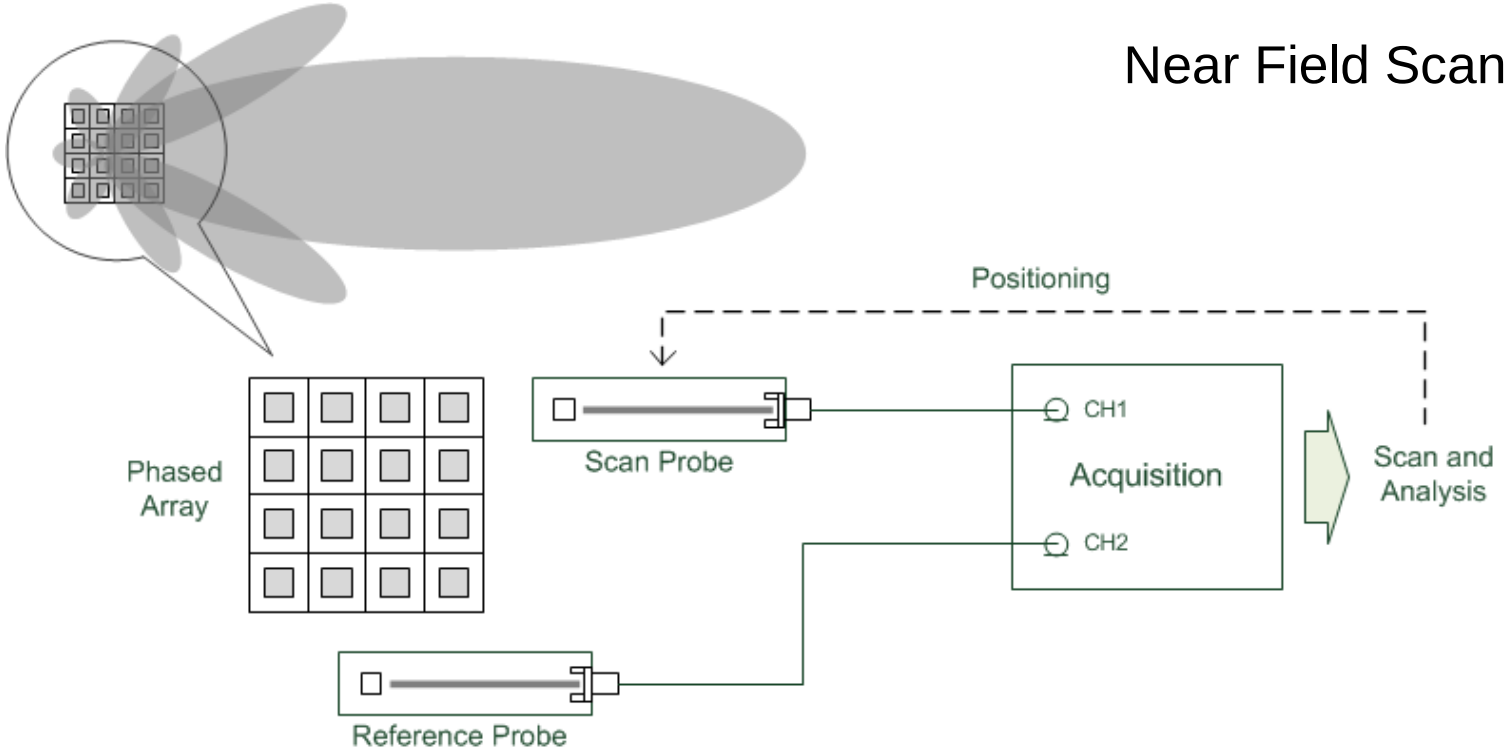
Highly integrated RF Devices – Phased Arrays



Evaluation and proposed method

- Near to far field transformation: necessary?
- Time Domain (Stochastic) / Frequency Domain?
- Measurement of individual element magnitude/phase?
- Alternative methods: Time and costs?

Near Field Scanning

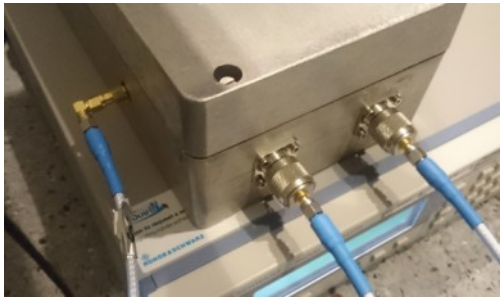


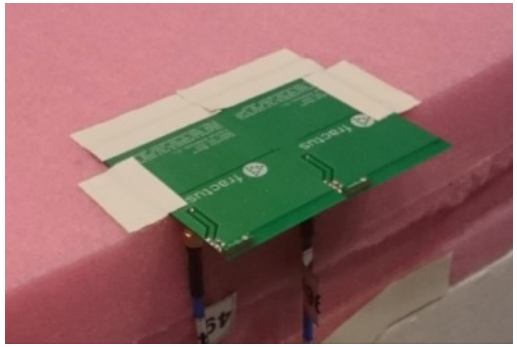
Preliminary Activities

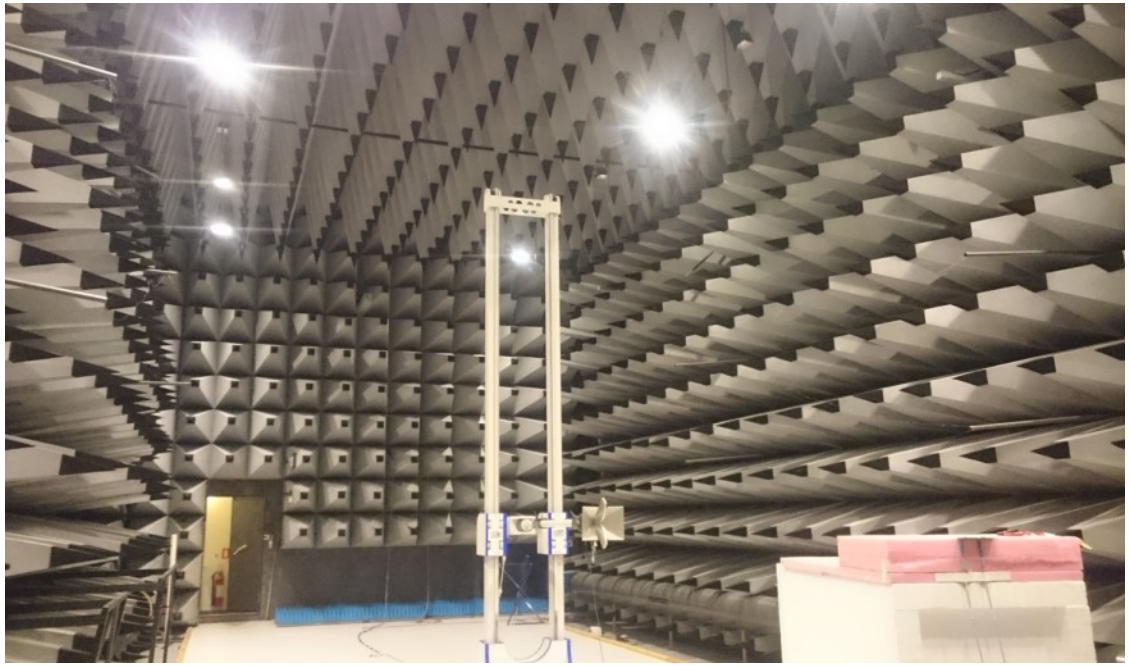
- Splitting and phase delay network characterization
- Individual antenna and array radiation pattern measurements (in Far Field)
- Acquisition + Processing SW evaluation using Stochastic Signal Source
  - Direct Input (Conducted)
  - 2 Probe Measurement (Radiated)
- DUT Setups (2.4 GHz – 5.8 GHz)
- Sensitivity evaluation (reference probe position, and scanning grid)

Preliminary activities

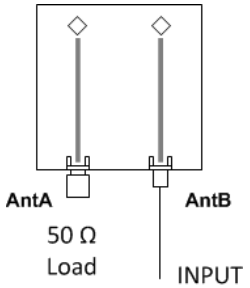
- Setups definition and characterization
  - Splitting and phasing
  - Antenna element and array measurements (radiation pattern)

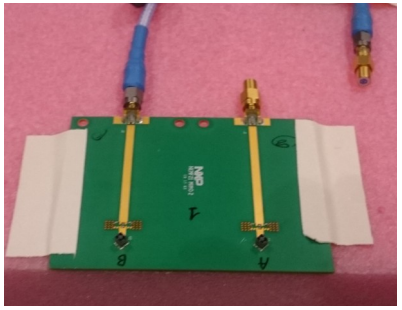




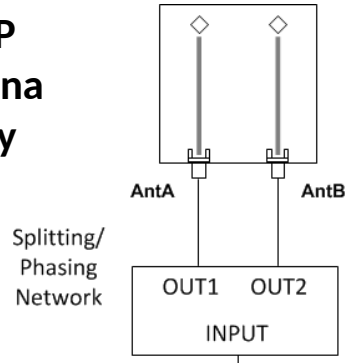


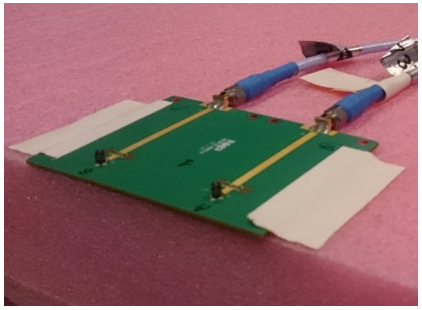
LCP Antenna Array

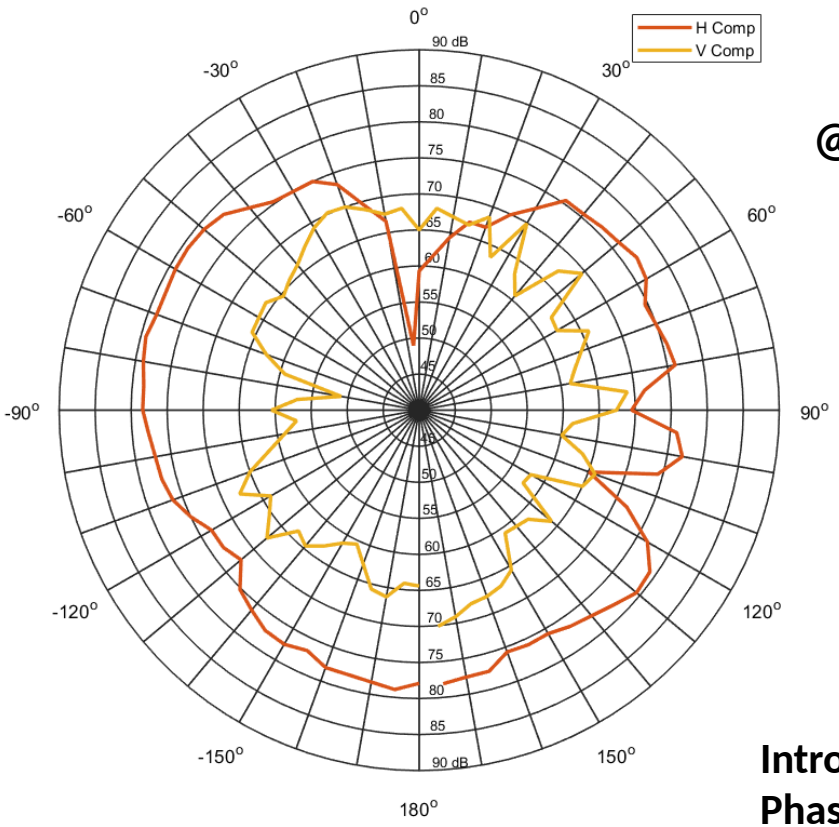




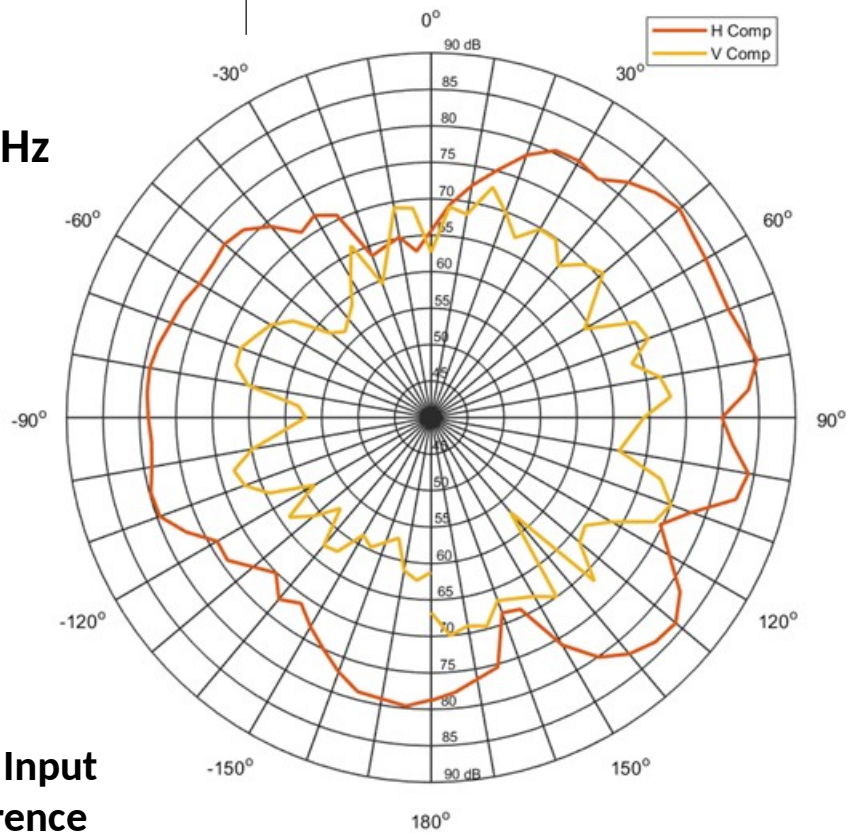
2xLCP Antenna Array







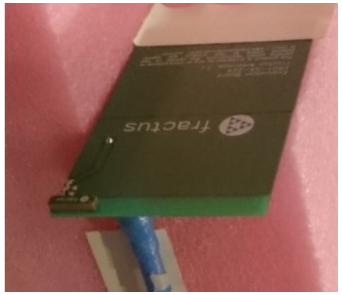
@ 2,4 GHz

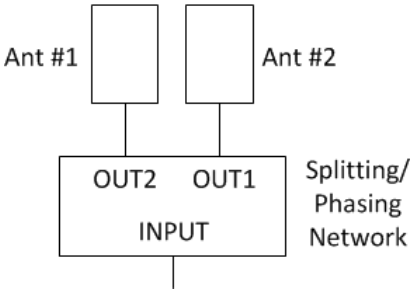


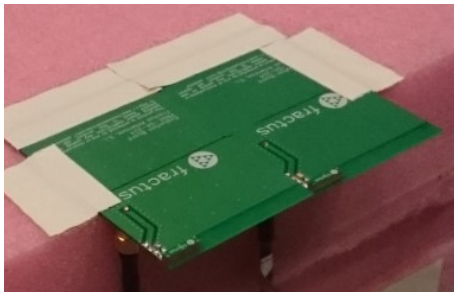
Introducing Input Phase Difference

Fractus Antenna Array

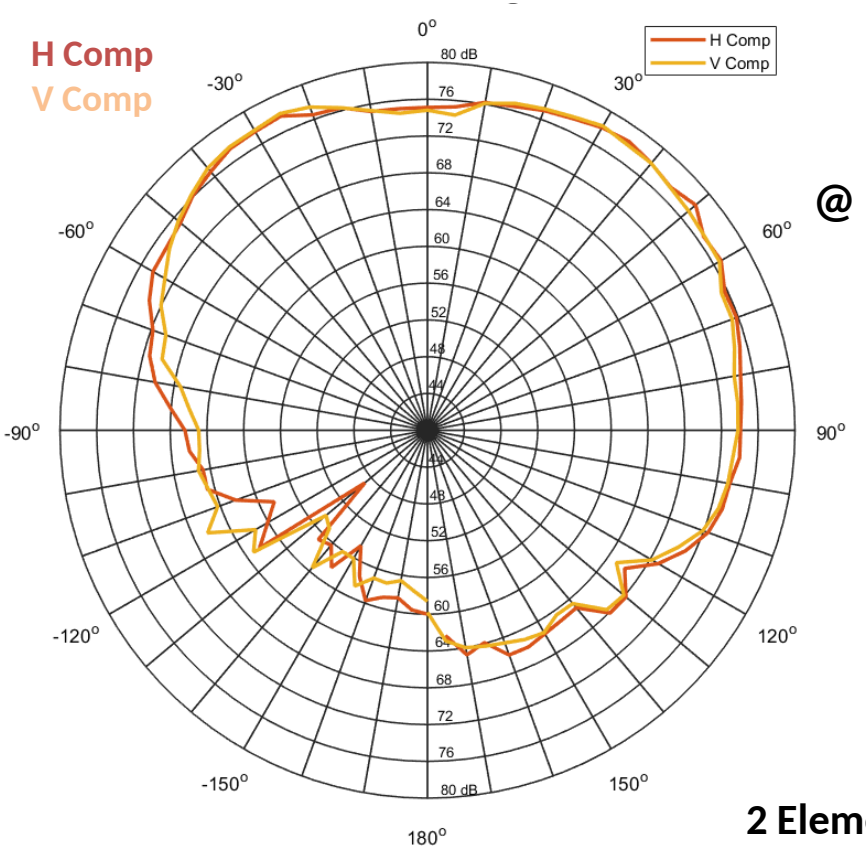
Individual Antenna Element





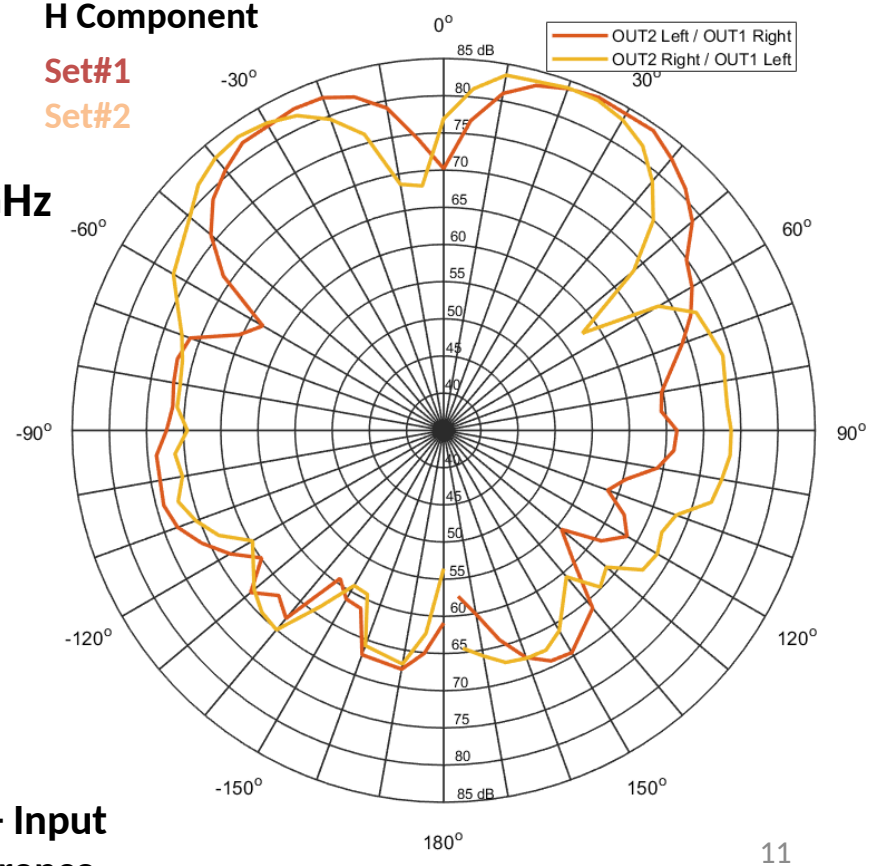


H Comp
V Comp



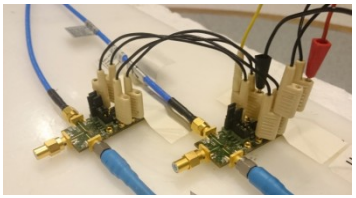
@ 5,8 GHz

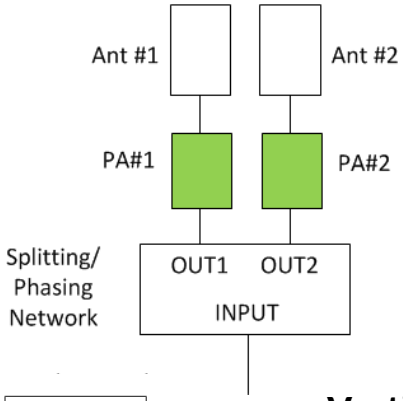
H Component
Set#1
Set#2

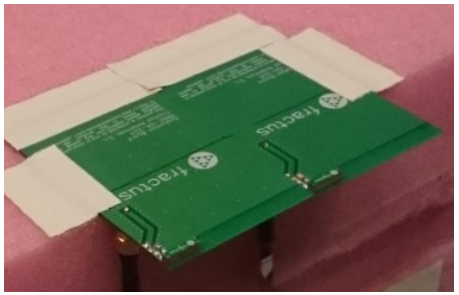


2 Elements + Input Phase Difference

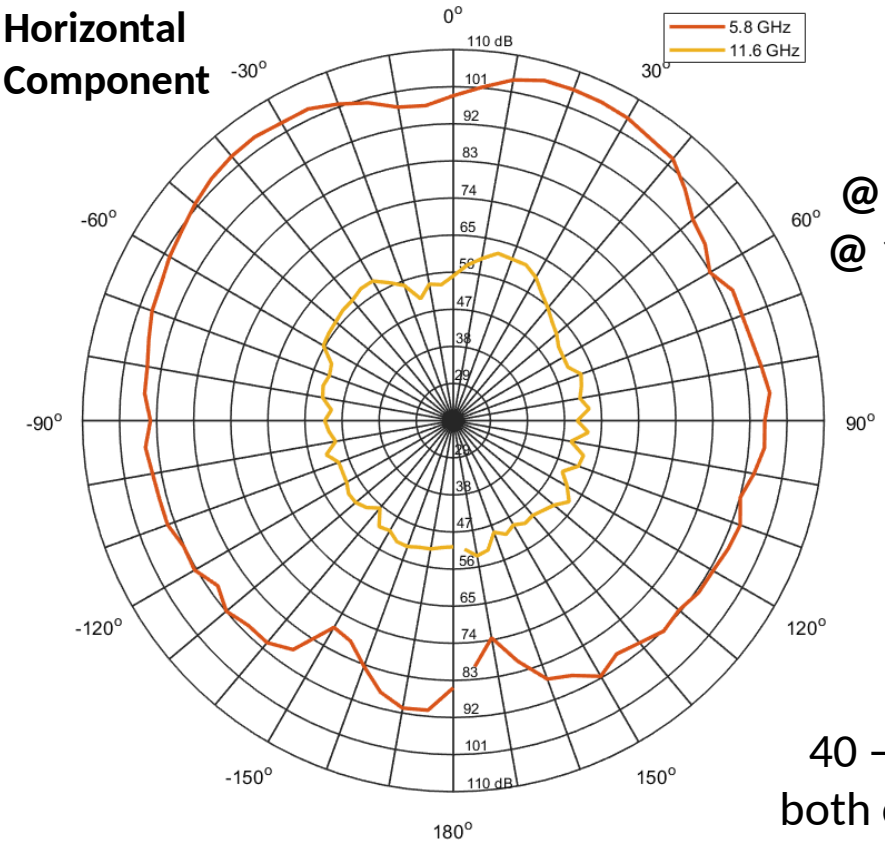
Fractus Antenna Array





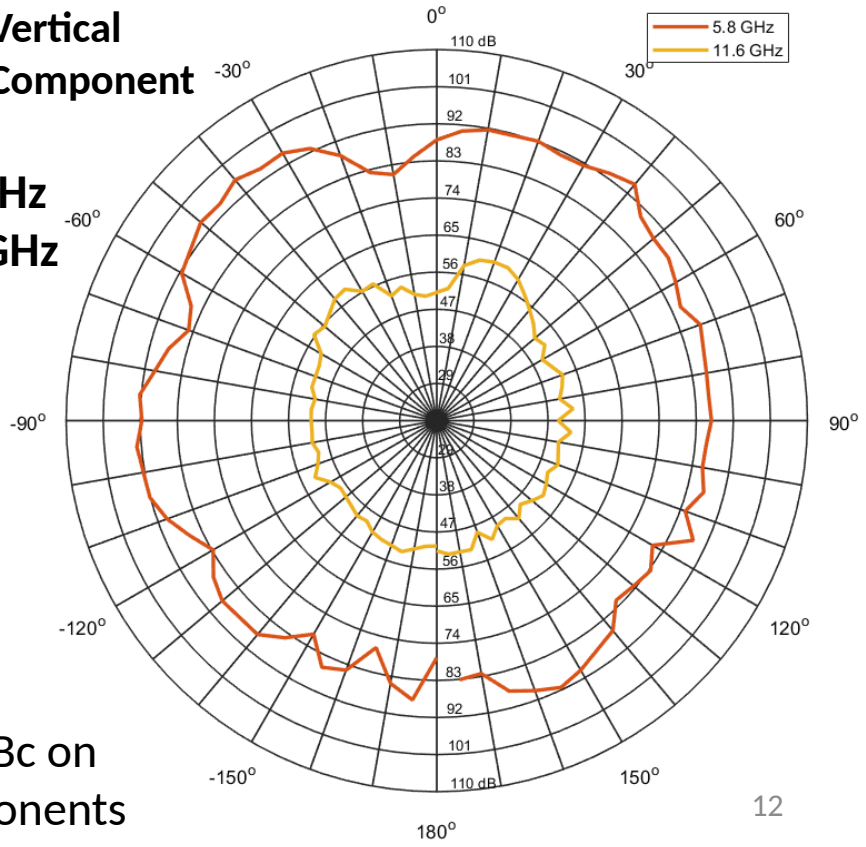


Horizontal Component



@ 5,8 GHz
@ 11,6 GHz

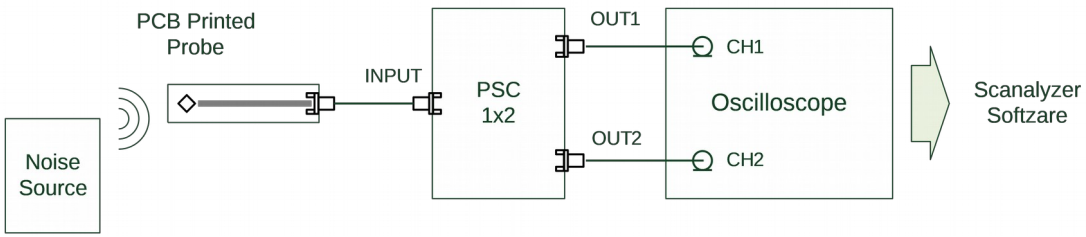
Vertical Component

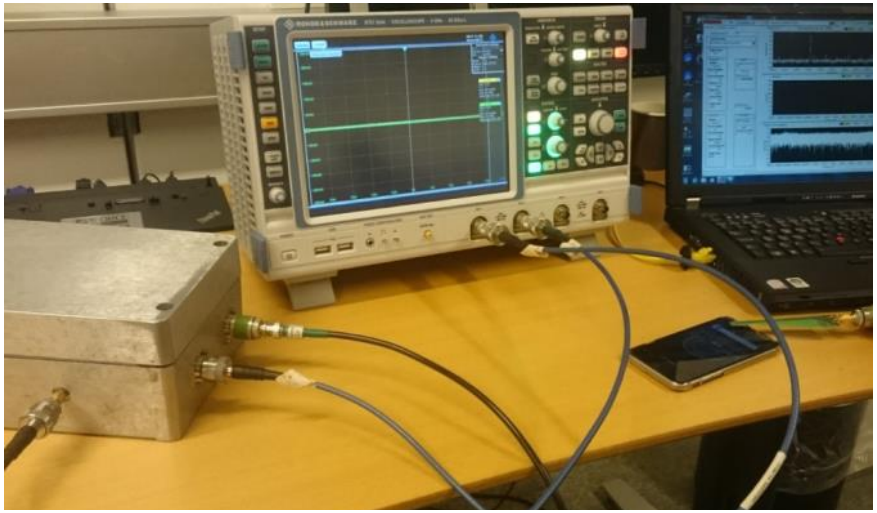


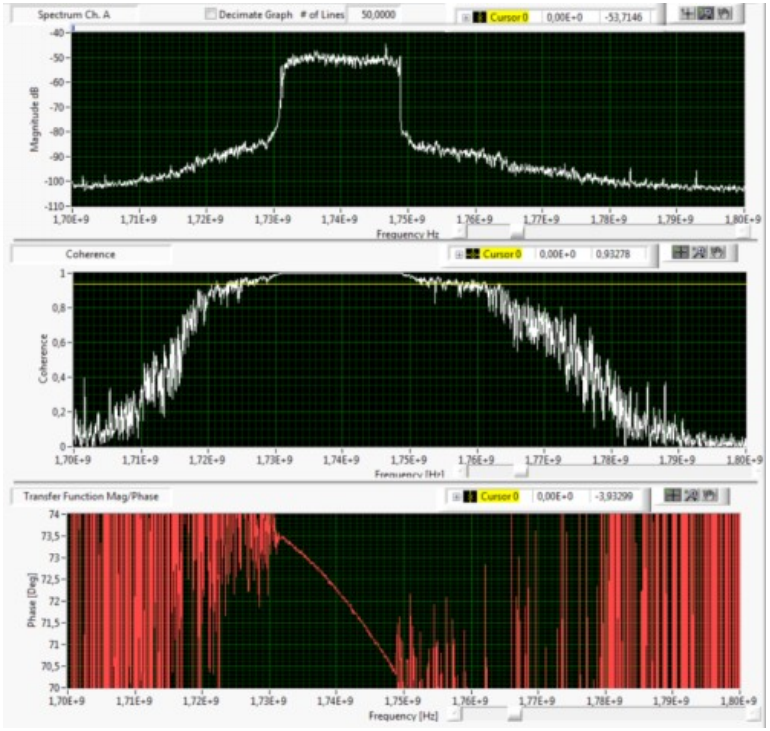
40 – 50 dBc on both components

Preliminary activities

- Acquisition (TD) + Processing SW evaluation
  - Conducted measurements



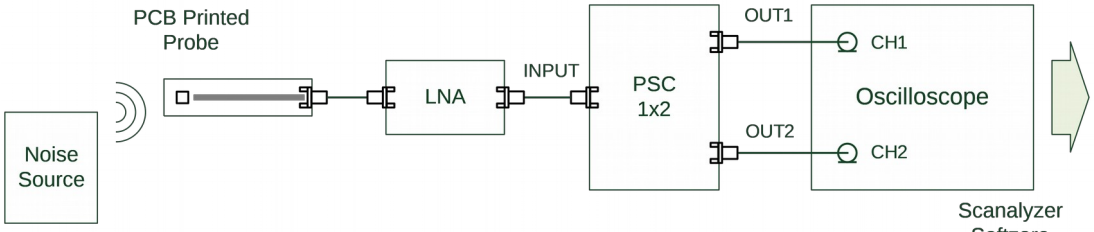


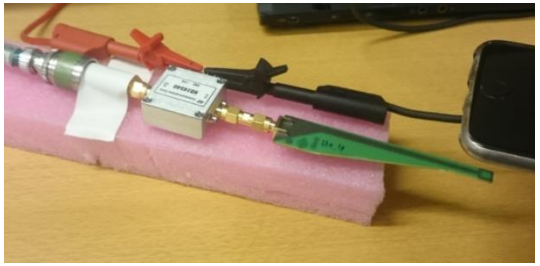


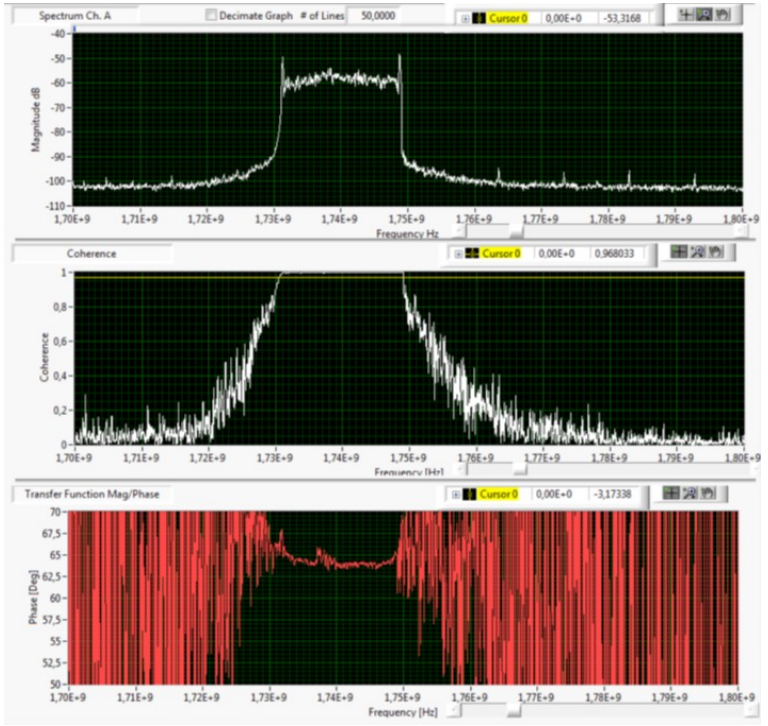
Preliminary activities

- Acquisition (TD) + Processing SW evaluation
  - Conducted measurements

    Setup improvements (LNA)

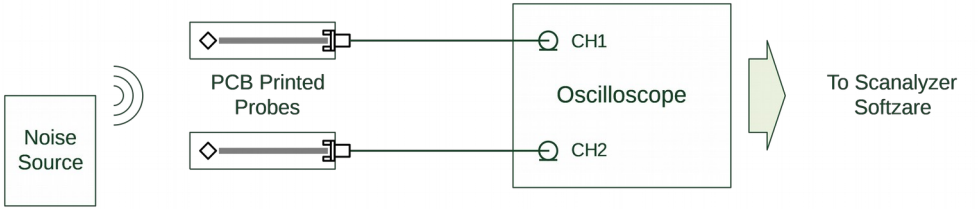


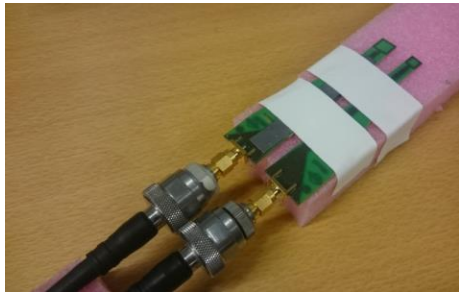




  - Radiated measurements

    Two Near Field probe setup



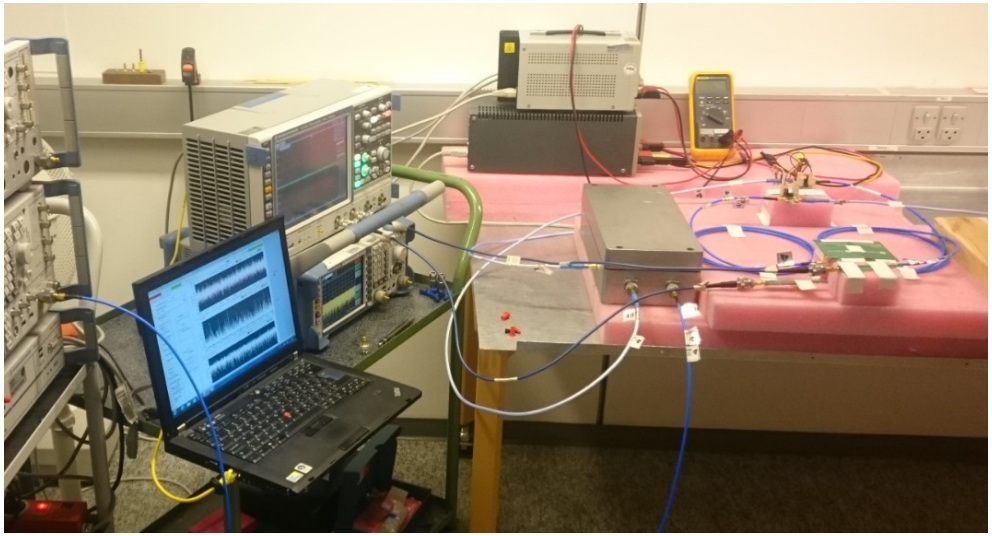


Near Field Scanning

Preliminary System Check

(2,4 GHz and 5,8 GHz Carrier, Digitally Modulated, PRBS)

Sensitivity evaluation

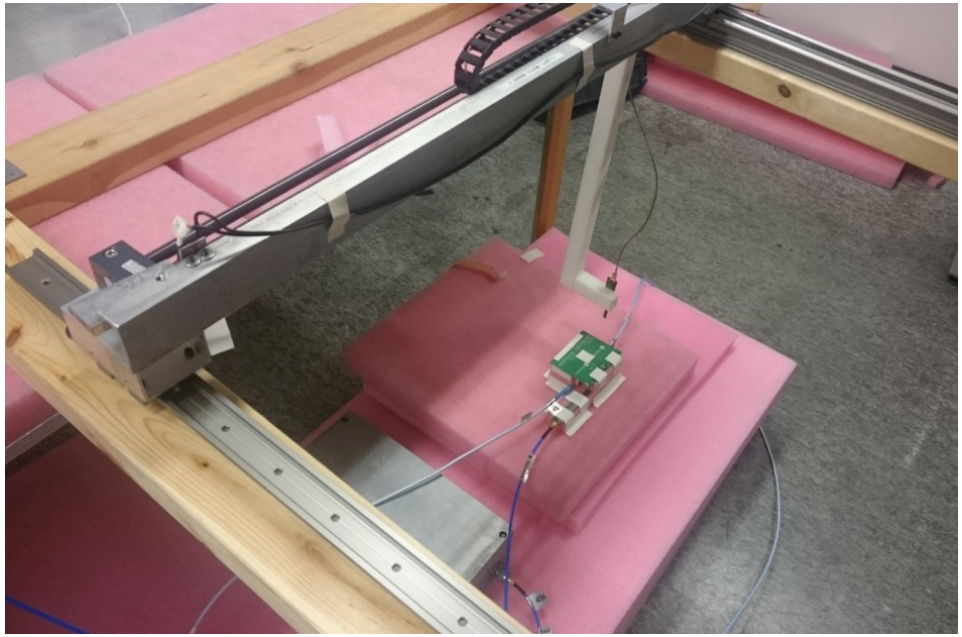


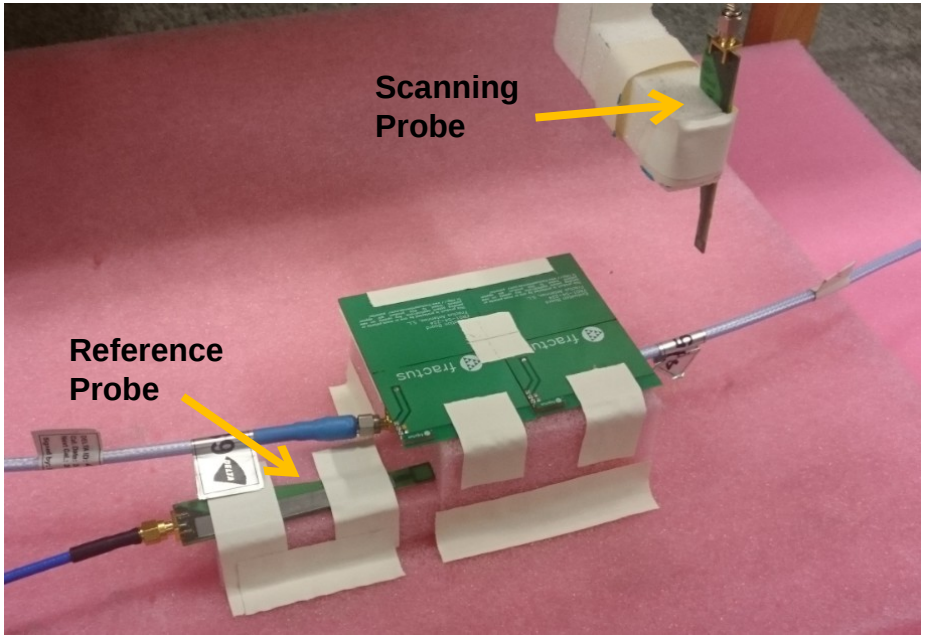
Two selected setups

- 2 x LCP Antenna elements, at 2.4 GHz.
- 2 x Fractus Antenna Evaluation Boards, at 2.4 GHz

Near Field Scanning

- Measurement setup:



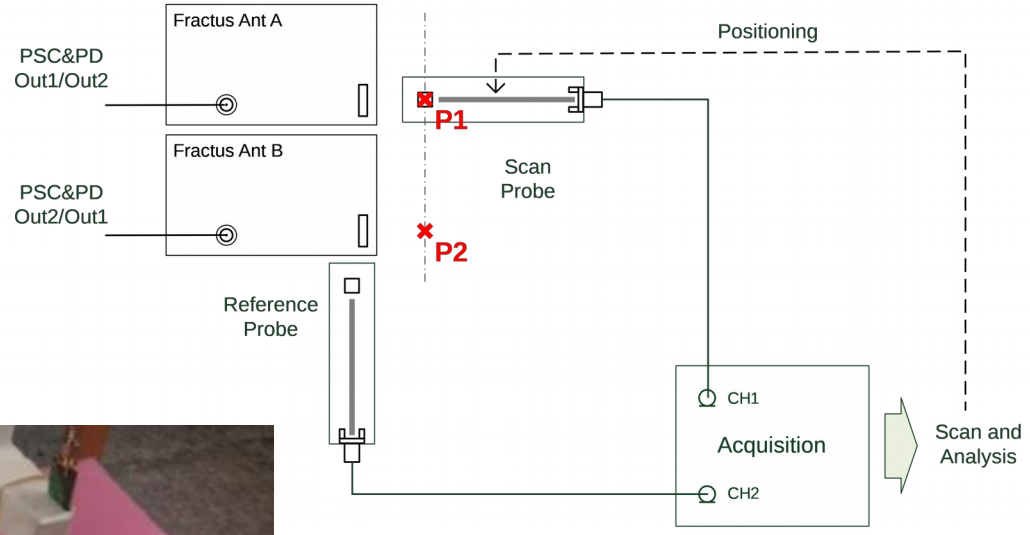


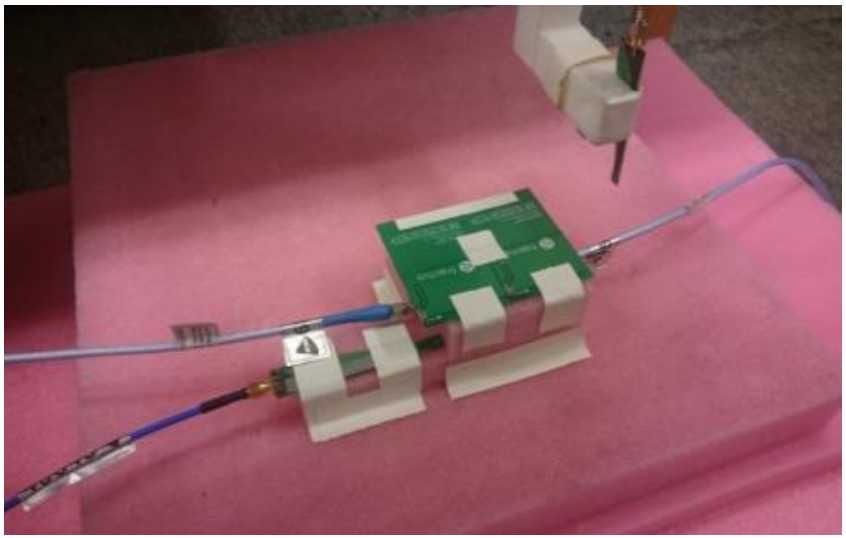
Reference Probe, Scanning Probe, DUT

Near Field Scanning

- 2 x Fractus Antenna Setup

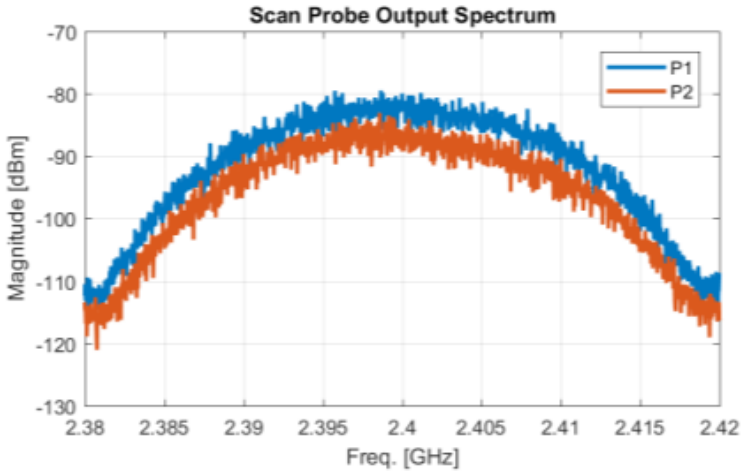
4 measurement points, 2 cm separation from array edge, 2 setups (phase)

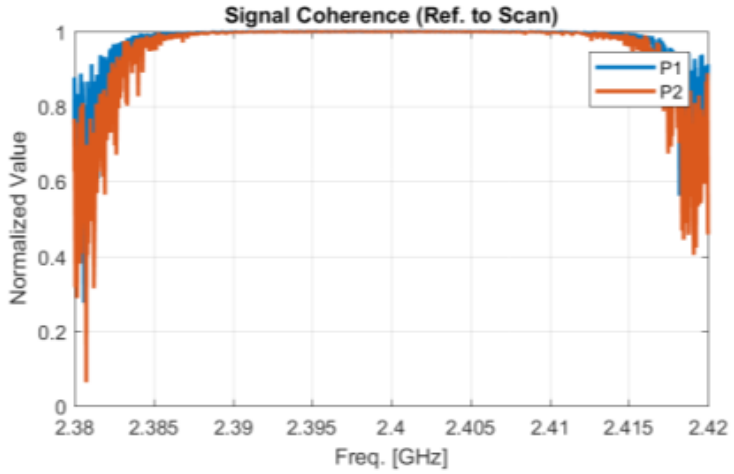


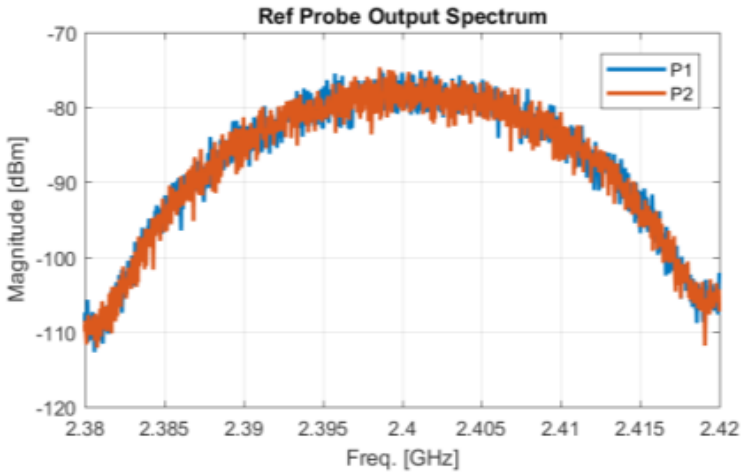


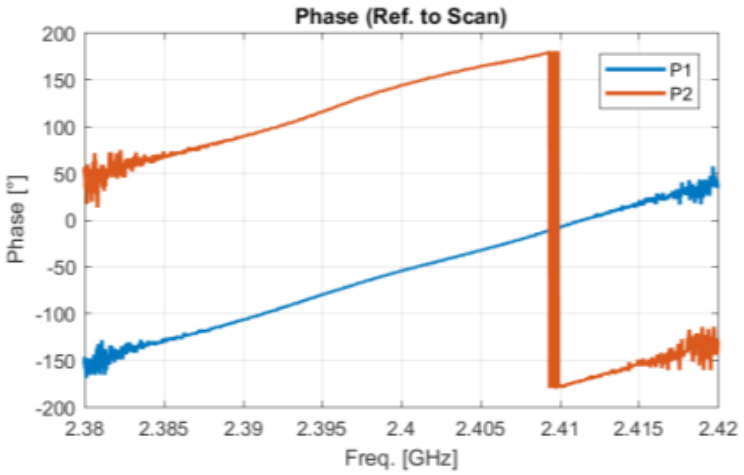
Results: 2 x Fractus Antenna Array

Phase(AntB) – Phase(AntA) = 143°





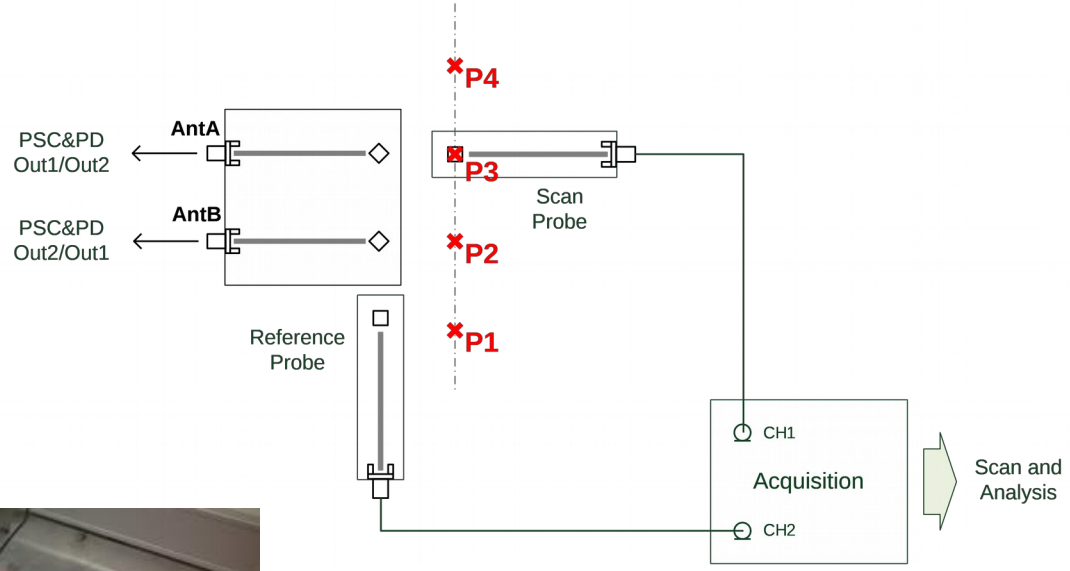


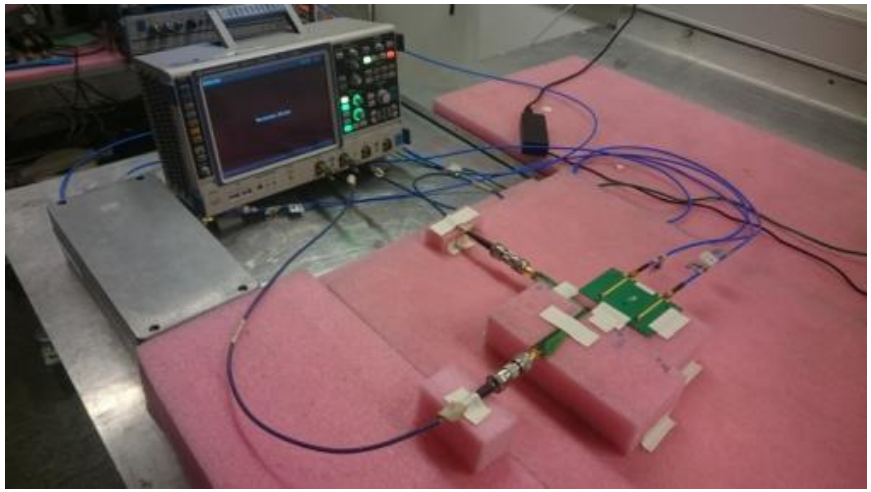


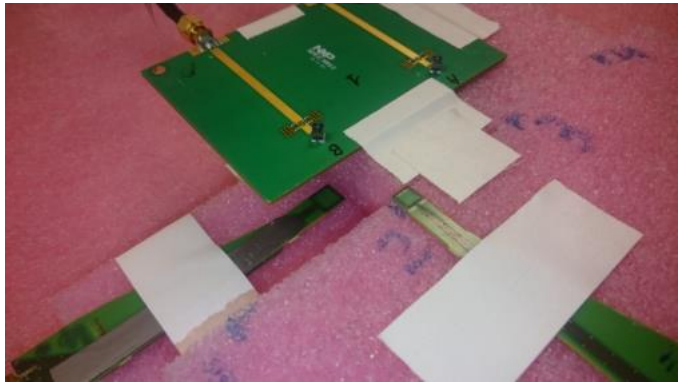
Near Field Scanning

- 2 x LCP Antenna Setup

4 measurement points, 2 cm separation from array edge, 6 setups (phase)

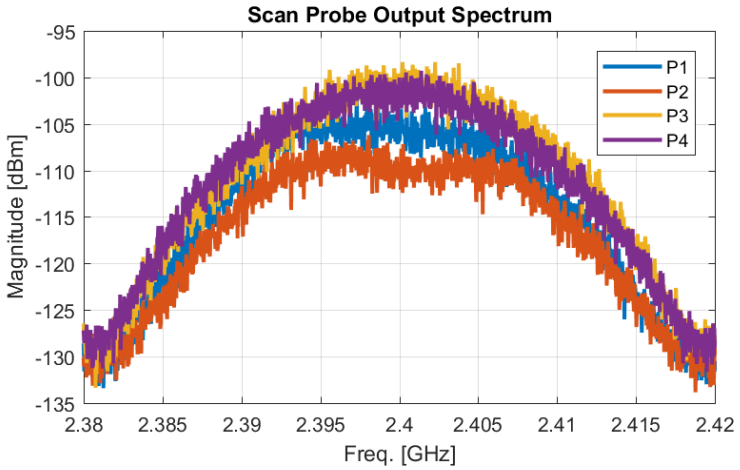


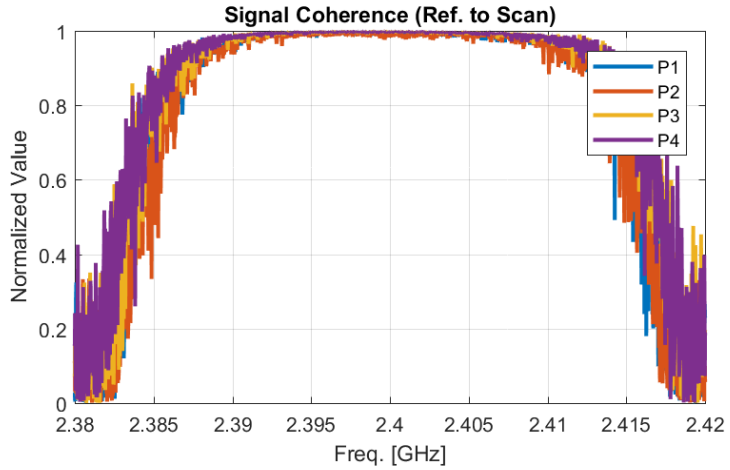


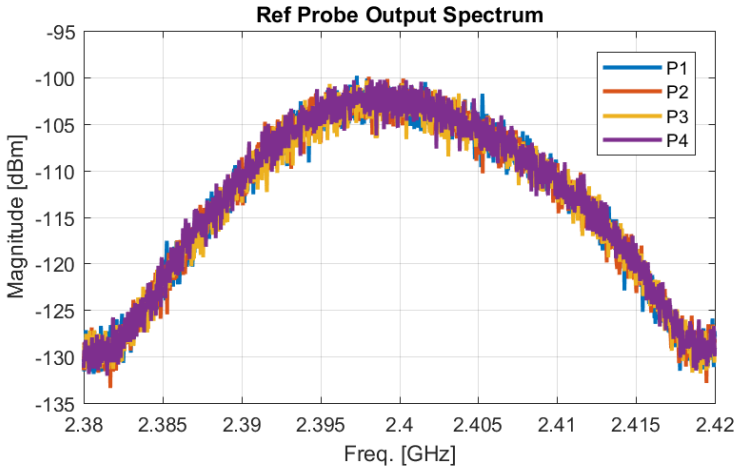


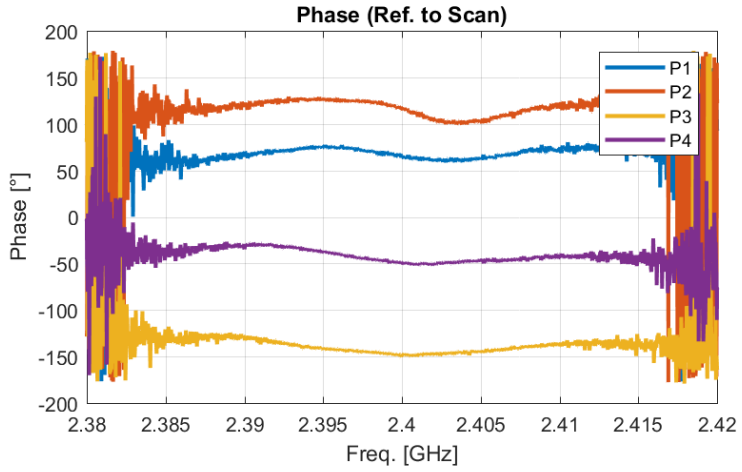
Results: 2 x LCP Antenna Array

Phase Diff = **-227°** (Phase Ant B – Phase Ant A)



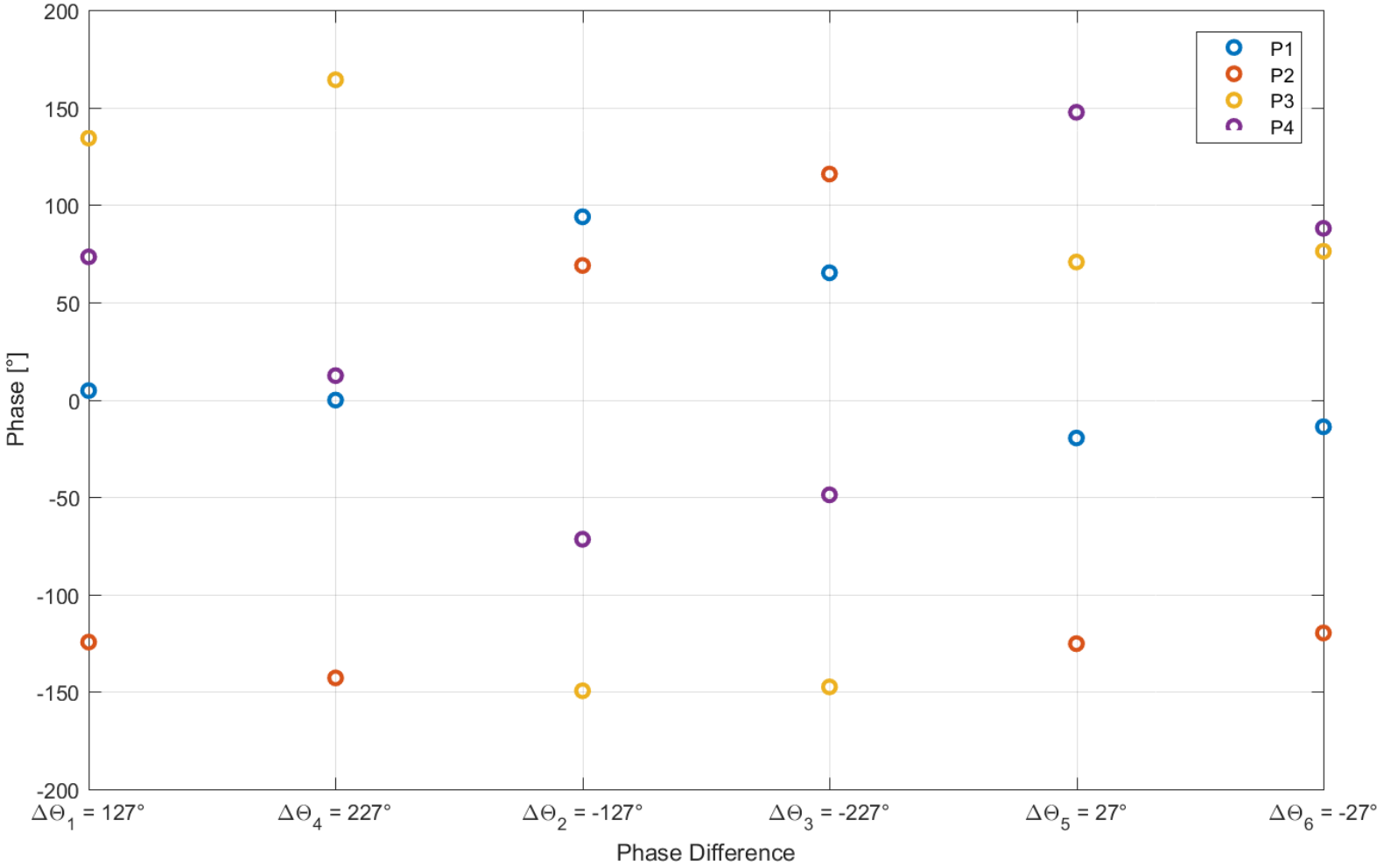






Summary of results (LCP Array)

Summary of results for LCP Antenna Array, at 2,4 GHz



Conclusions

- A reduced phased array of 2 antenna elements was achieved and characterized (conducted and radiated)
- The measurement system (Acquisition + Processing) was verified to be suitable
- It was possible to detect the input phase variation in a contactless manner, by means of a random digitally modulated signal

  (errors are to be evaluated)
- Sensitivity and spatial resolution will be **drivers** when moving to higher frequencies.

Next Steps and Future Actions

- Immediate next steps:
  - Measurement & Modelling
    - A simplified model using geometric optics is considered to initialize iterative process to obtain antenna input phase
    - EM Simulation /Measurement building probe de-embedding
  - Full characterization of the development array

  (Next level of integration)
  - Scanner improvements

  (RF Front End, probes, LNAs)

- Future actions:
  - Joint development of higher frequency scanner
  - Fully functional configurable phased array
  - Measurement scenarios evaluation (beam steering)

Thank you for your attention

Measurement System

- Near Field Scanner (DELTA)
  - 3 Axis Positioner

    (X axis: 1/100 mm, Y axis: 1/1000 mm)
  - 2 Channel Time Domain Acquisition (Oscilloscope)
  - Near Field Probes: Reference and scanning
    - E-Field (monopole)
    - B-Field (square loop)
  - Scan and Analysis Software (DELTA Scanalyzer)