Octagonal Ring Antenna (ORA) Development for AAMID

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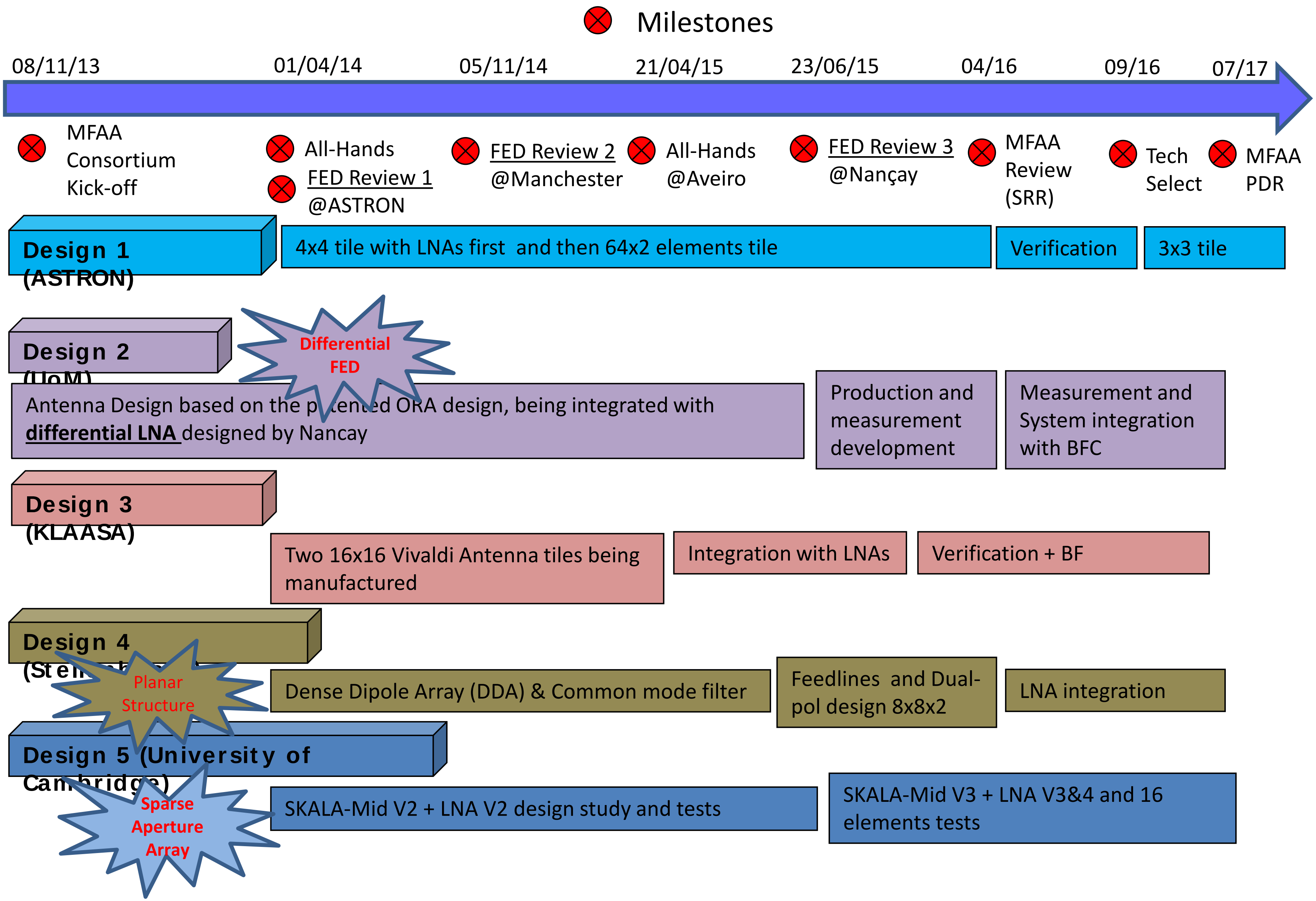
Outline

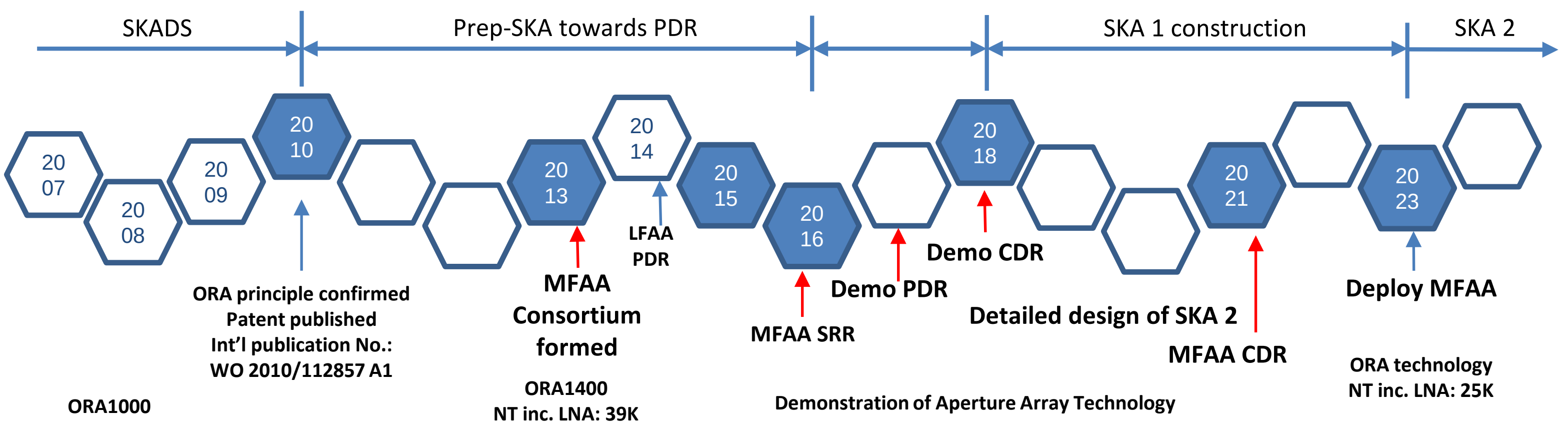
- Review of Front-End Design for SKA AAMID
- Current progress status
- Preliminary Active array measurements
- Forward Looking

Review of Front-Ends Design for SKA AAMID

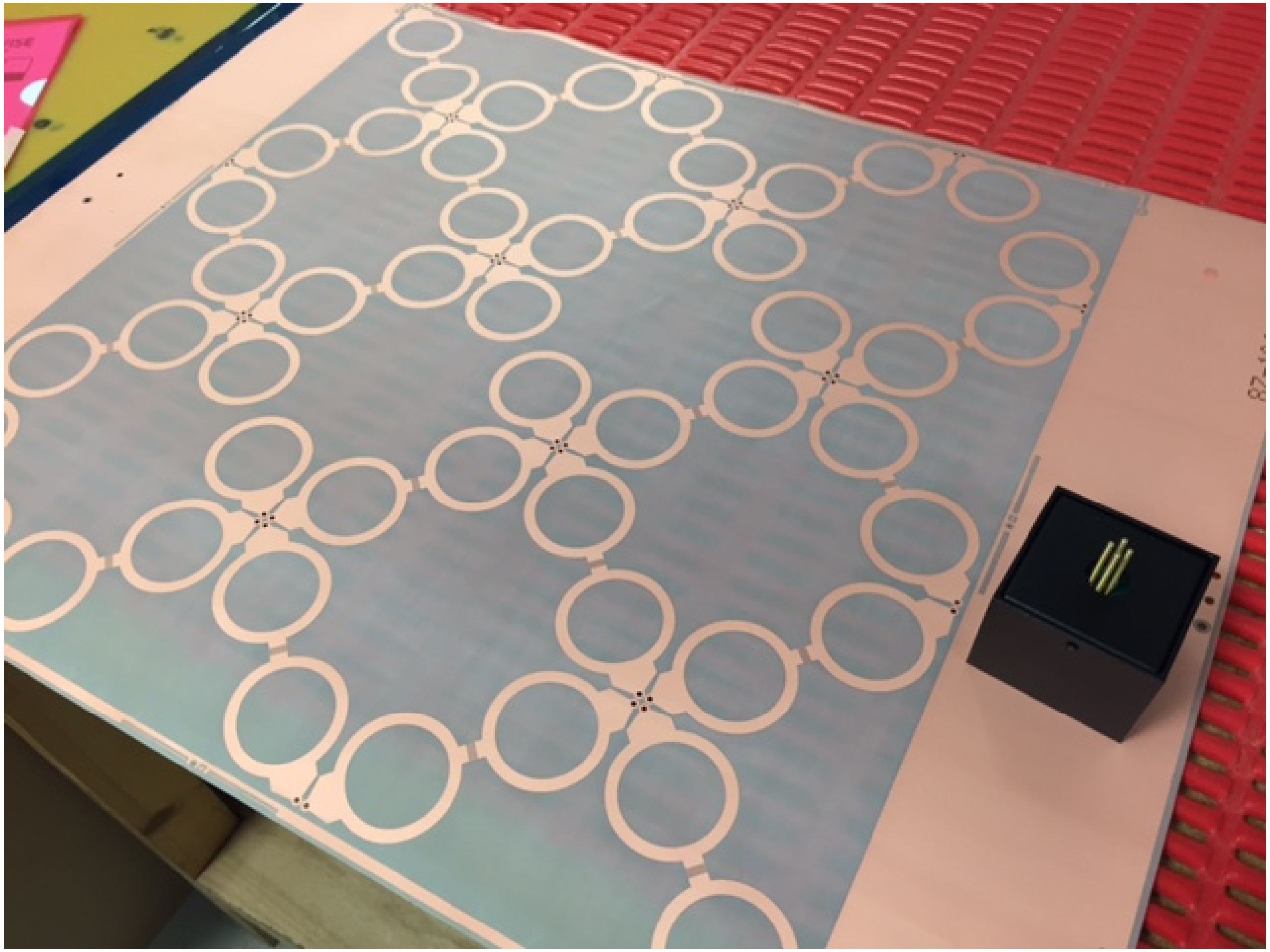
Front-End Design Roadmap



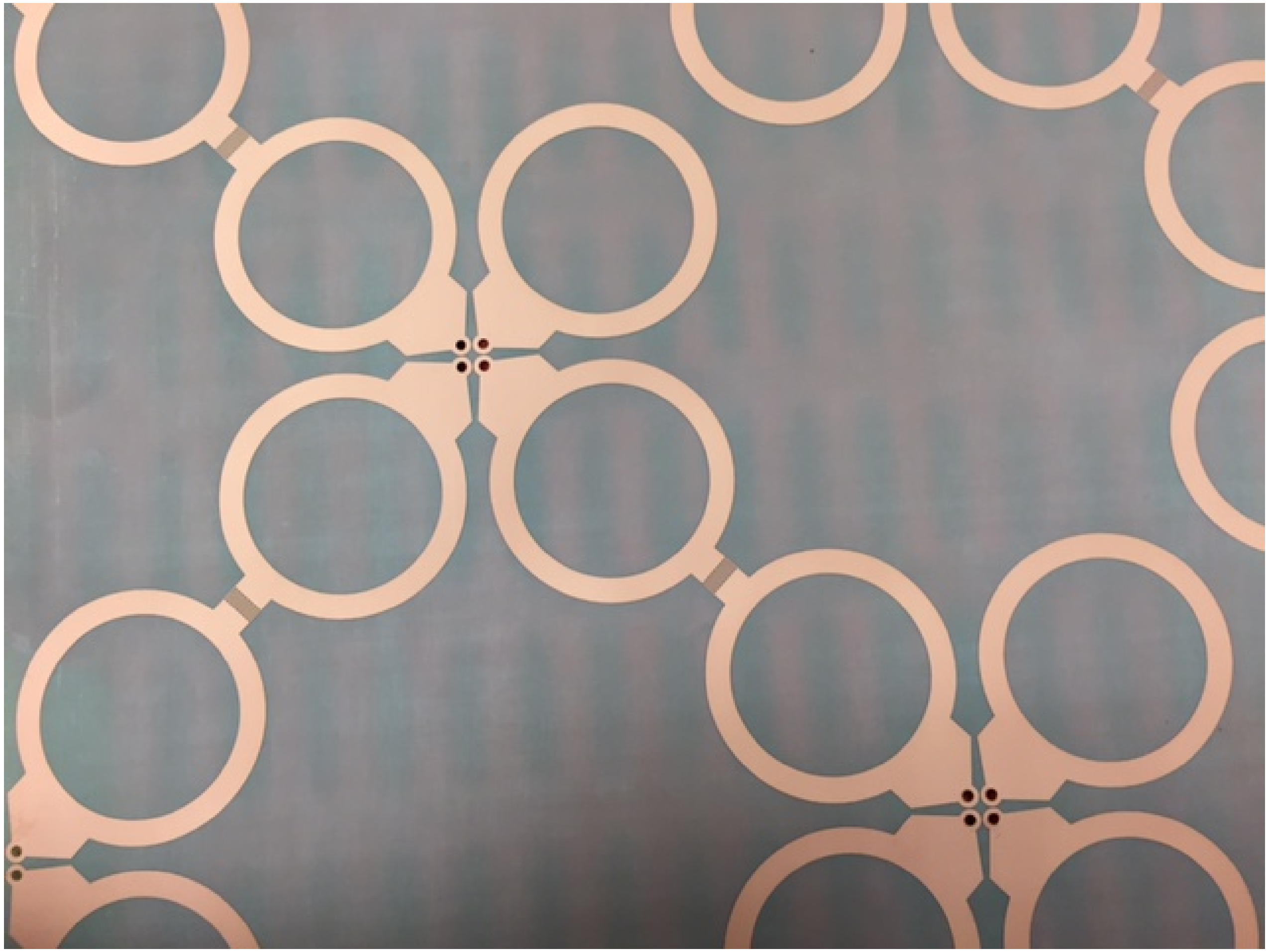
Front-End Design at Manchester aligned with MFAA timeline



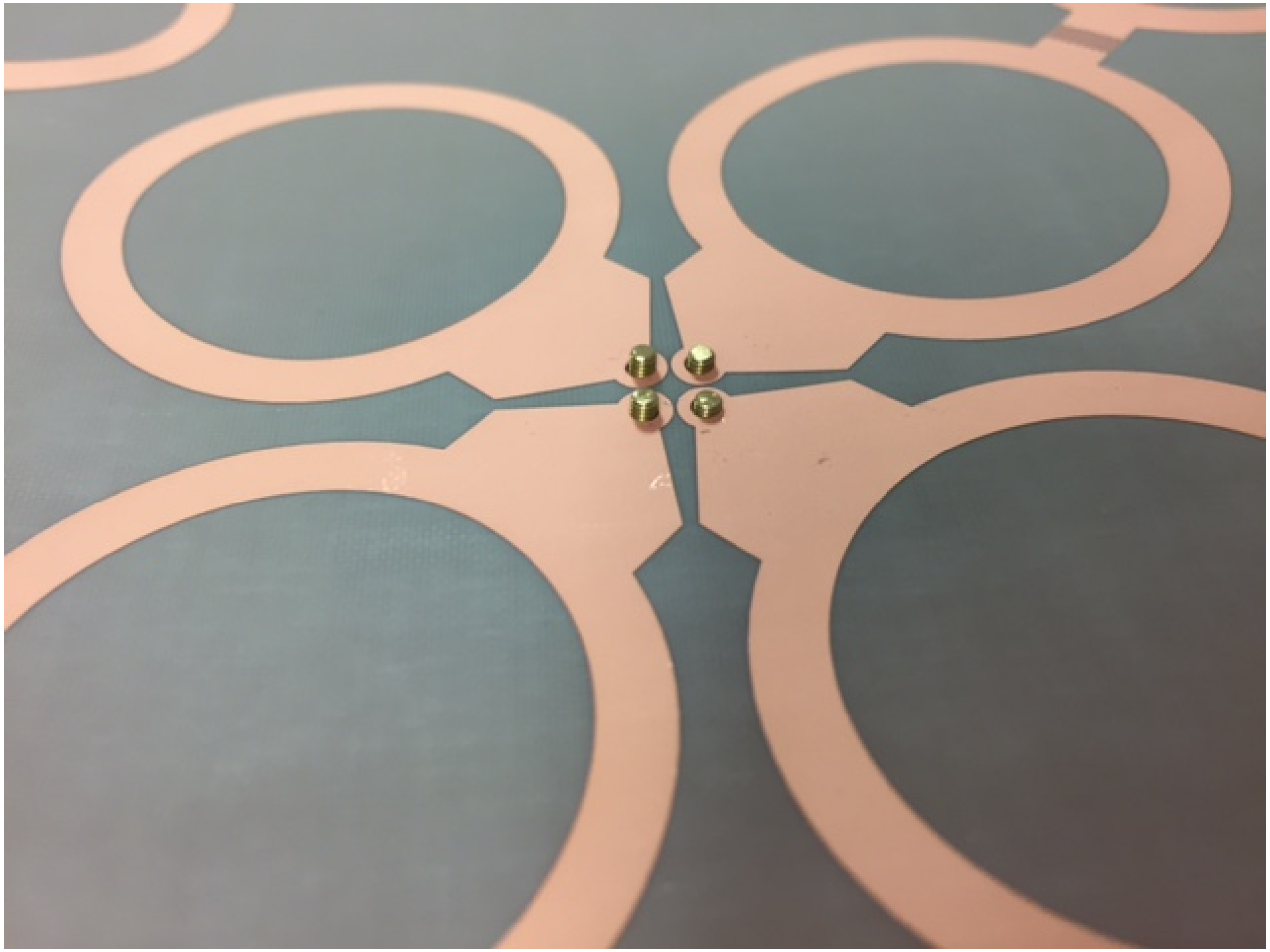
Dual polarised active layer section



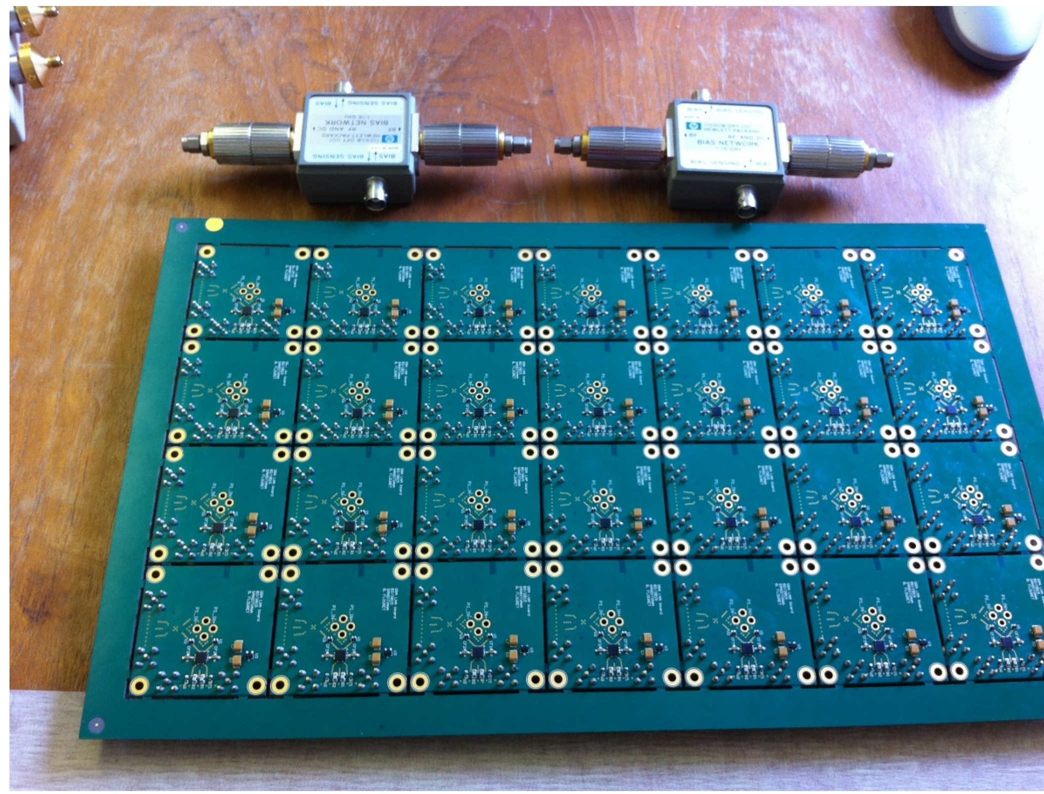
Dual polarised elements coupled together



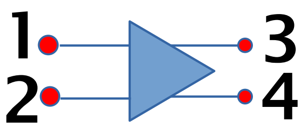
Integrated LNAs with antenna elements



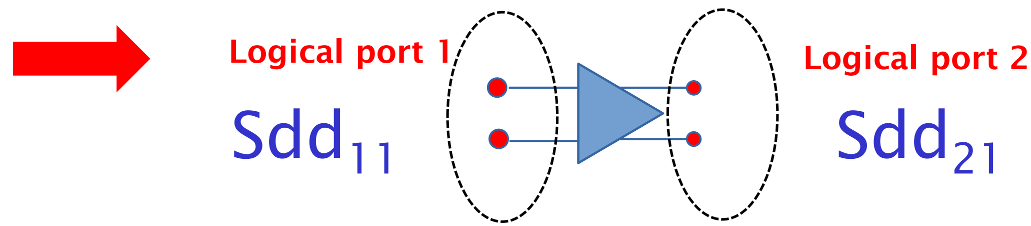
LNAs for dual polarisations in one board (Developed by Nancay)

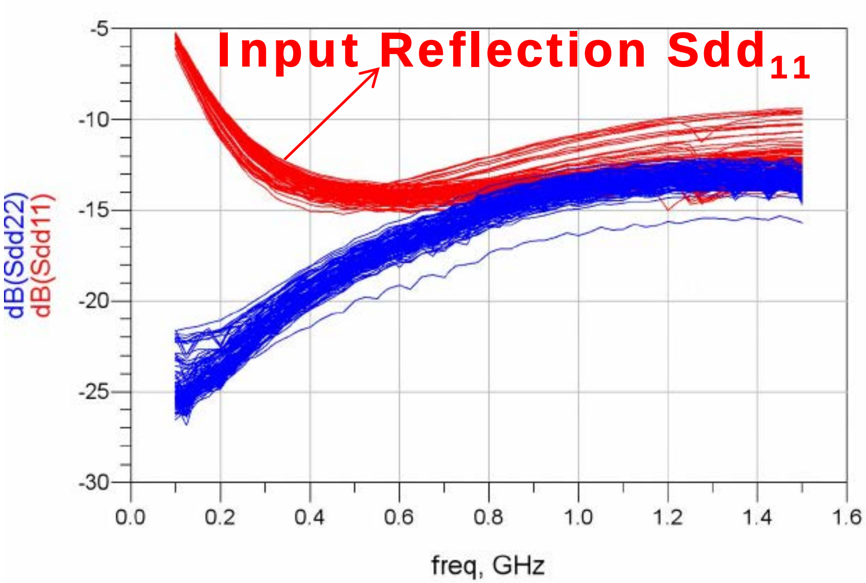


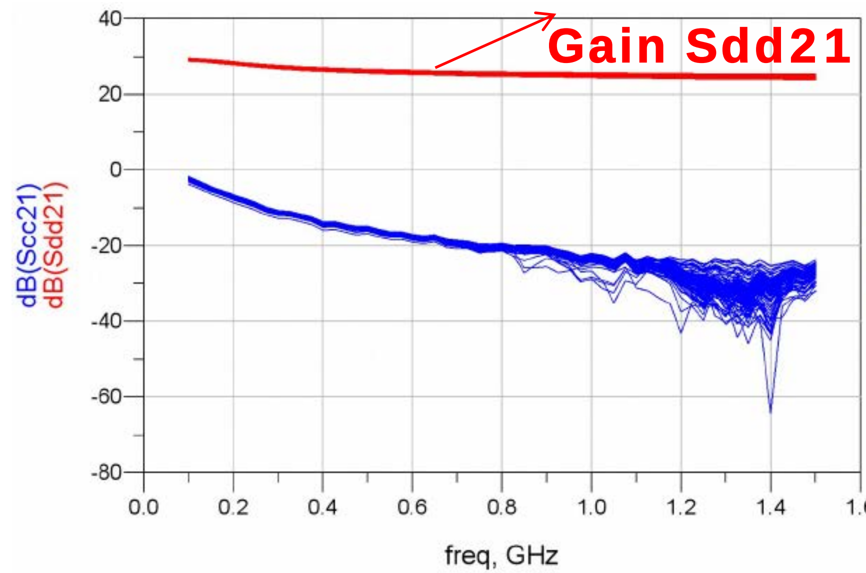
Measured Mixed-Mode S-parameters



$$S = \begin{pmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{pmatrix}$$

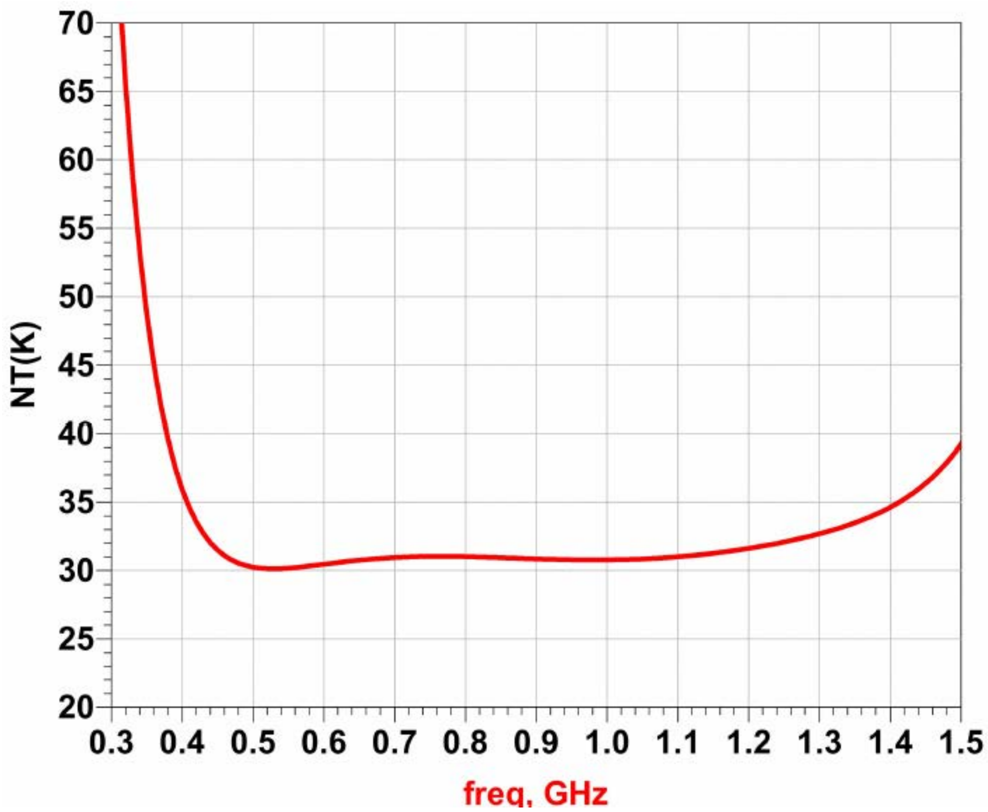






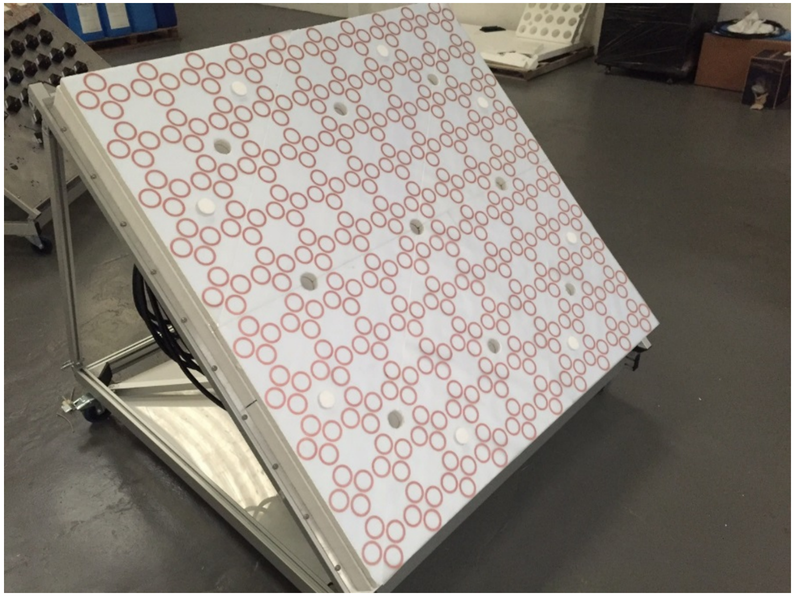
- Mixed-Mode S-Parameter is derived from the Single-Ended S-Parameter measurement of 4 port device

Simulated Noise Temperature of ORA with the integrated LNA

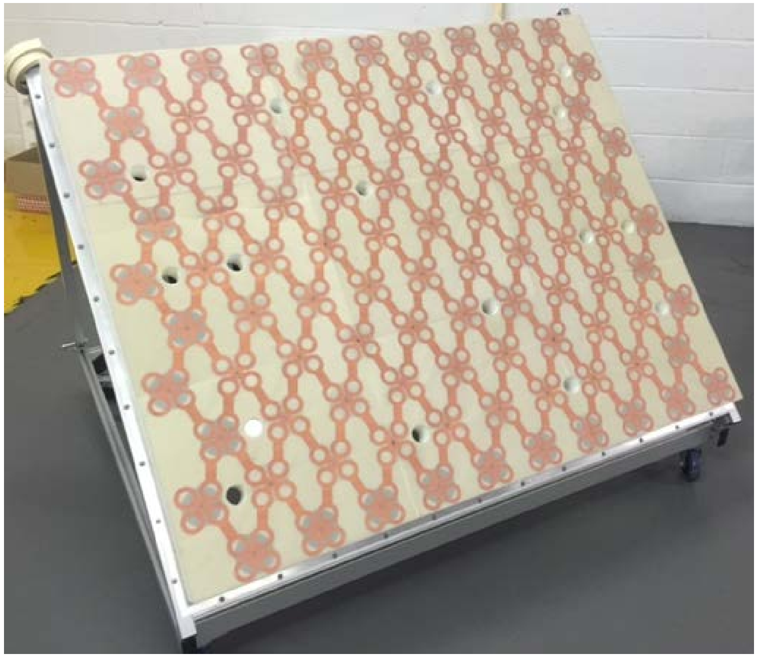


- Simulation shows the low noise temperature performance of ORA with the integrated LNA
- Experimental models are currently under construction

The Prototypes without Cover



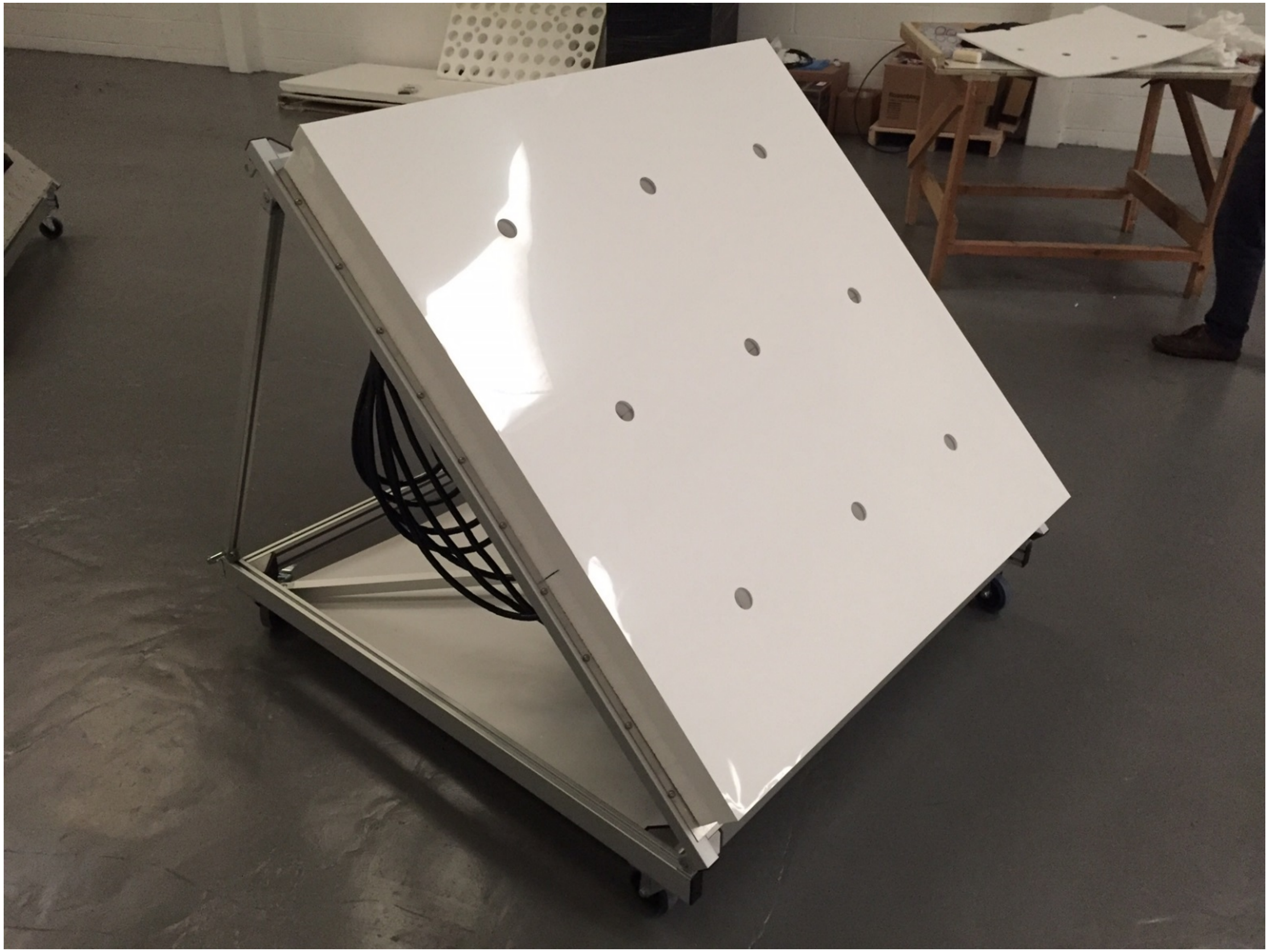
The Square Grid Array (10×10)
1.25m × 1.25m



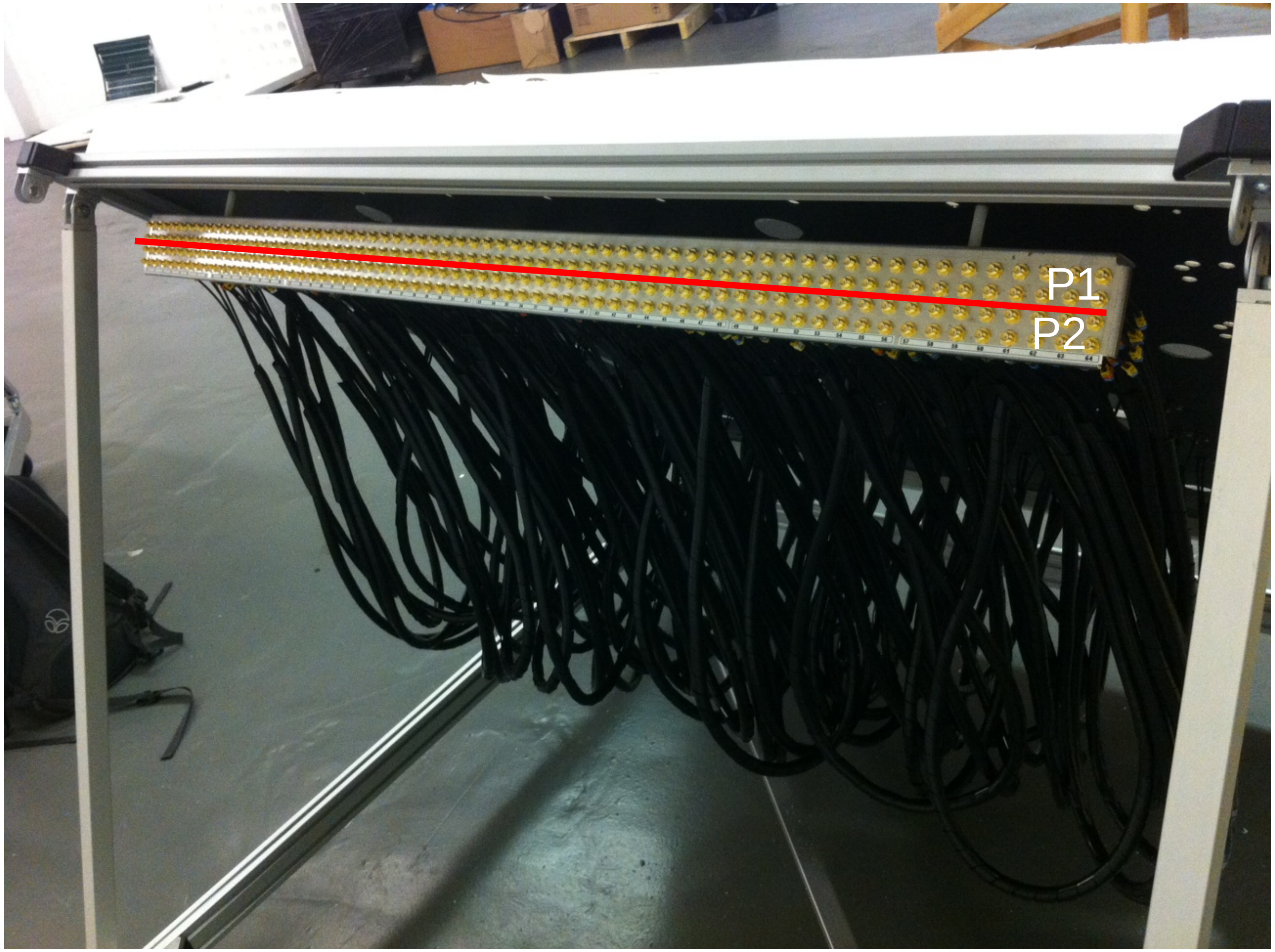
The Triangular Grid Array (10×10)
1.5m × 1.3m

Fully differential front-end design

The Square grid prototype with cover (polypropylene)

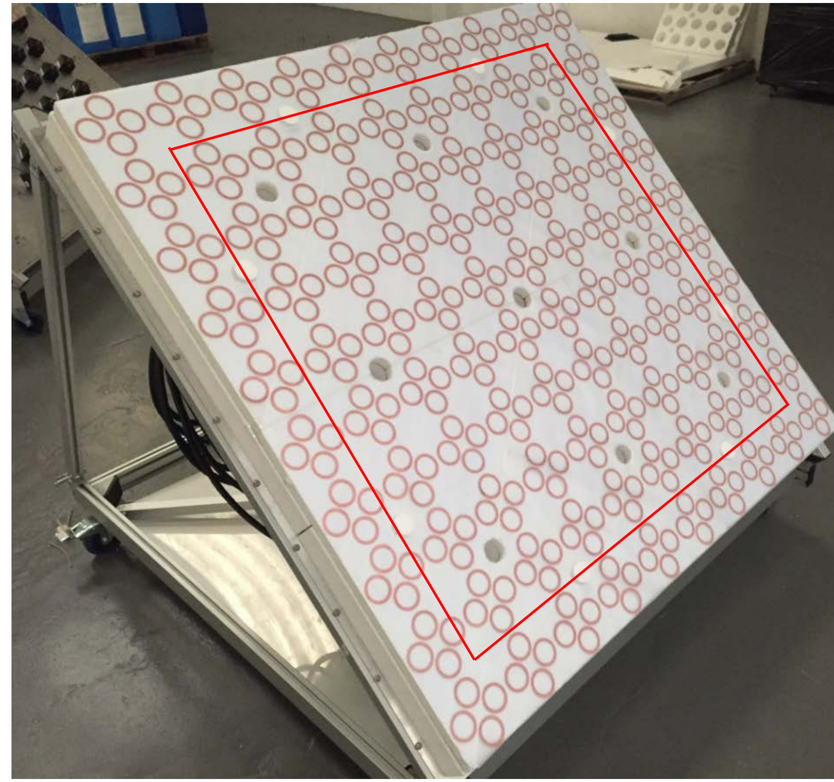


The dual-pol differential outputs



The 1 m^2 ORA prototype facts

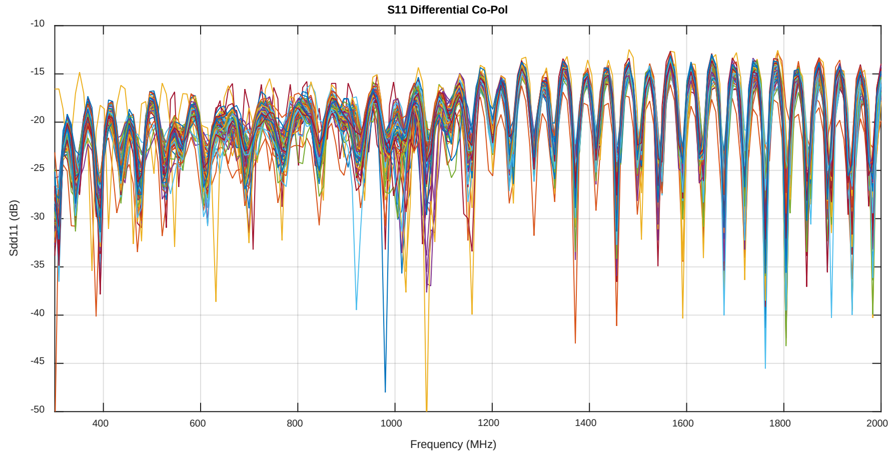
- 10x10 elements(1.25m x 1.25m)
- Dual-polarised for each element
- Frequency 400MHz to 1450MHz
- Element separation: 125mm
- Low profile (array thickness <10cm)
- 64 (8x8) central elements excited (within the red box)
- 36 edge elements terminated with the matched load
- 128 LNAs integrated (64 for each polarisation)



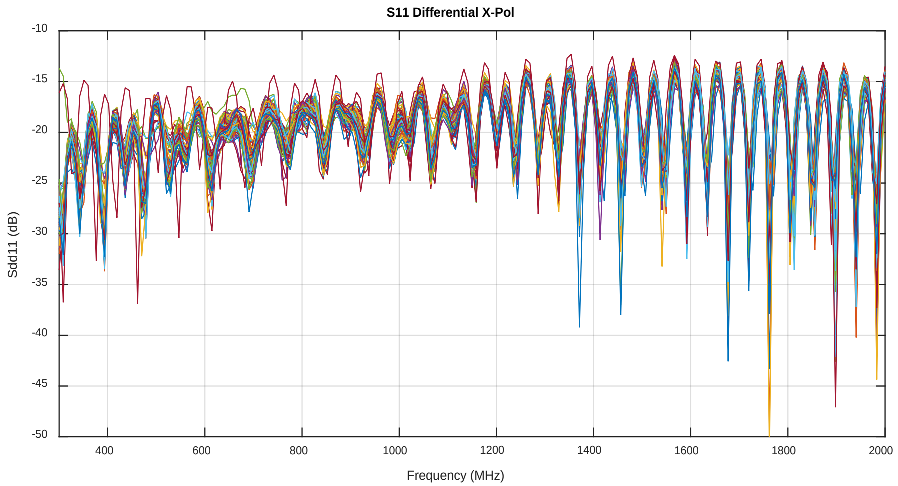
Active ORA Array Measurements

(Only preliminary measurements have been performed on the square grid array tile)

Measured Reflection Coefficients of the active array elements – The Square Grid Array

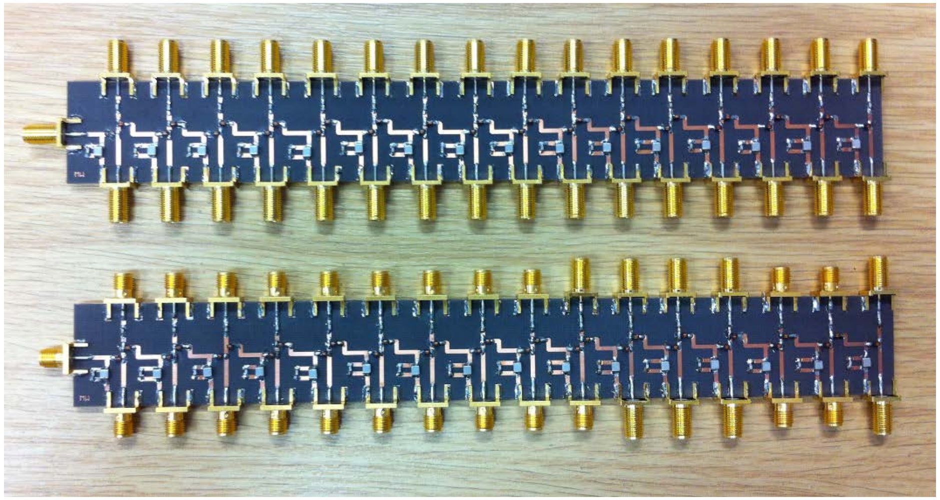


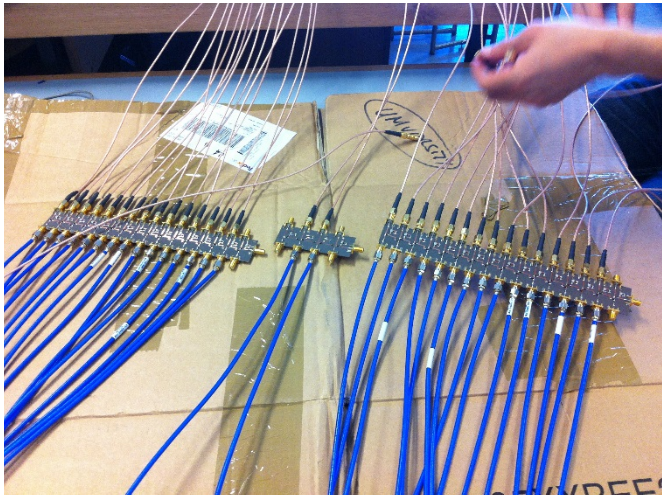
Pol 1



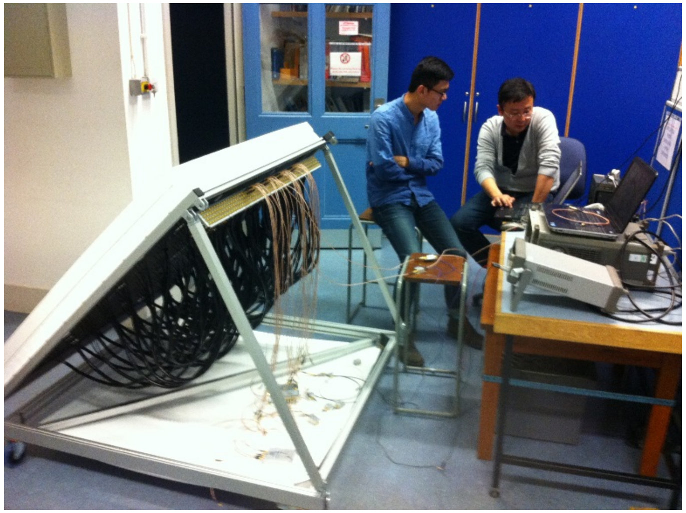
Pol 2

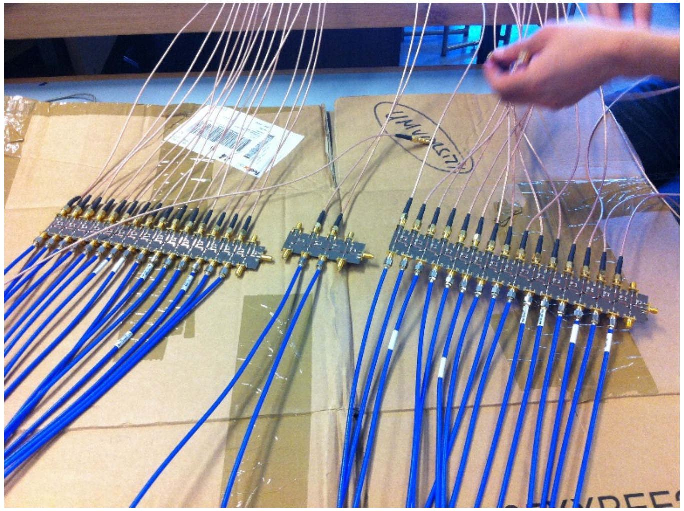
The temporary bias/interface board for the active array measurements



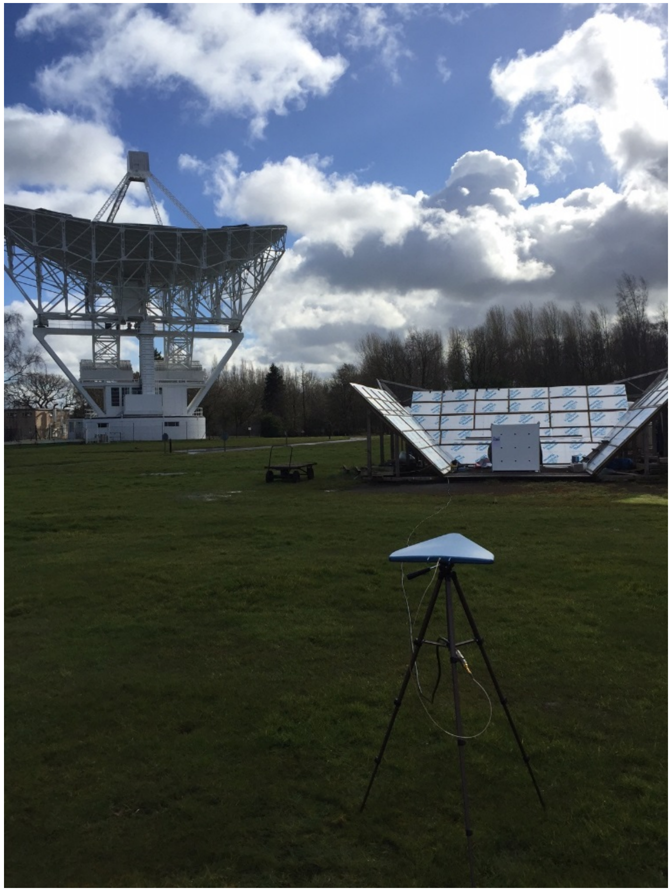


Initial Measurements in the Lab

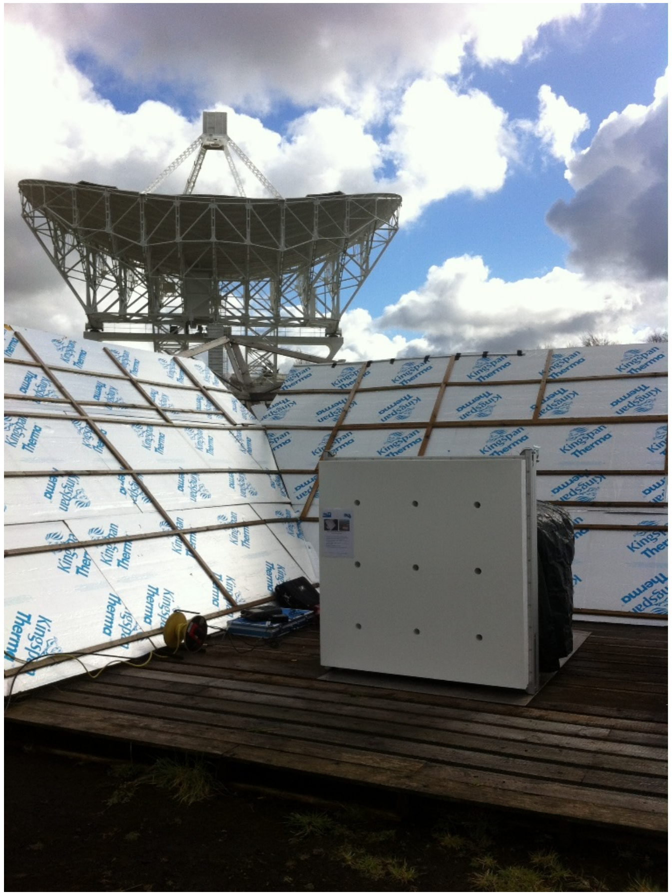


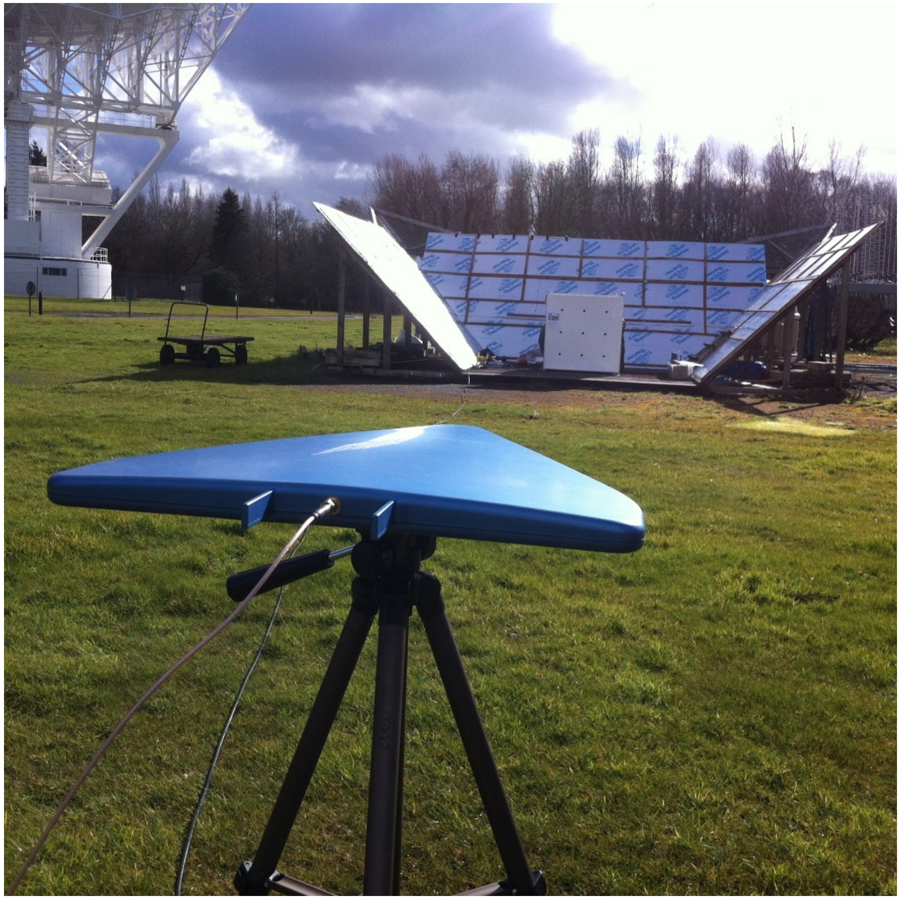


Lineality Test at JBO

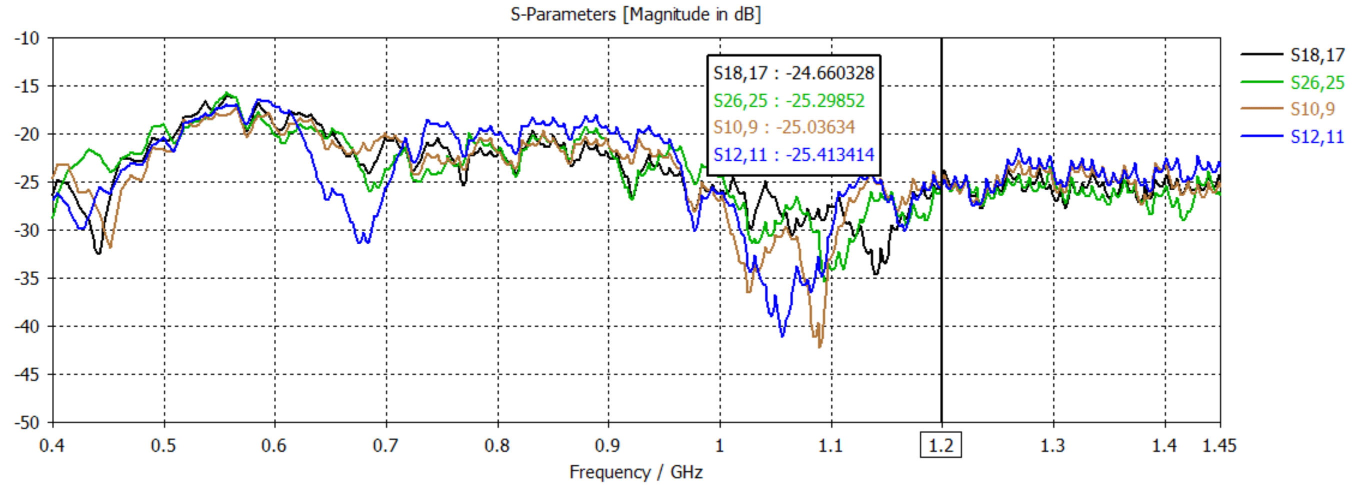


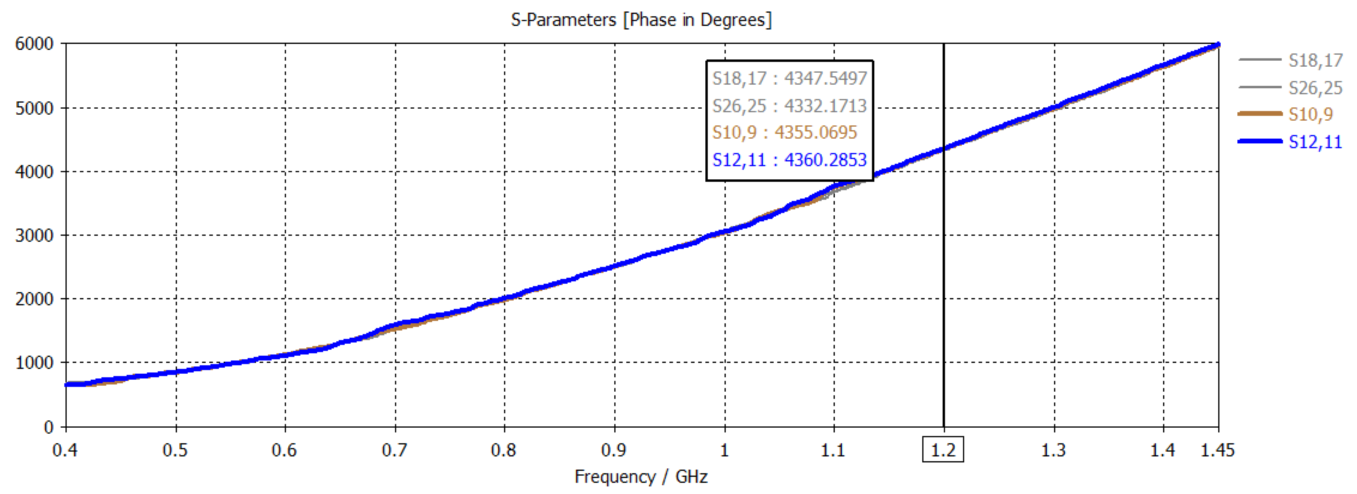
Lineality Test at JBO



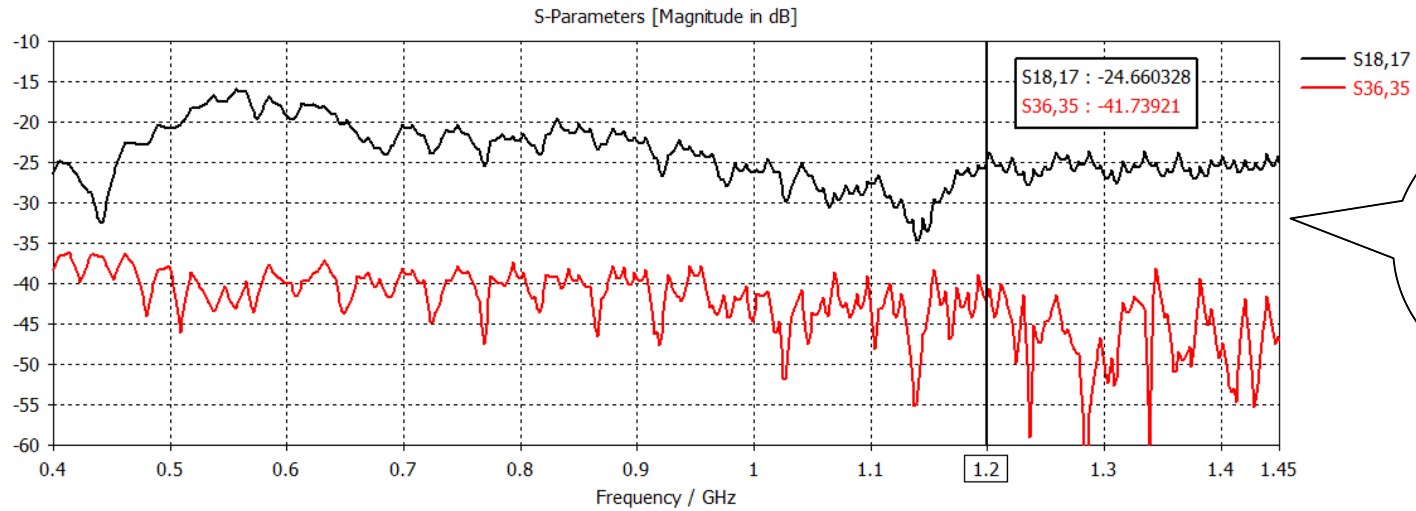


Preliminary results- Amplitude and Phase Response

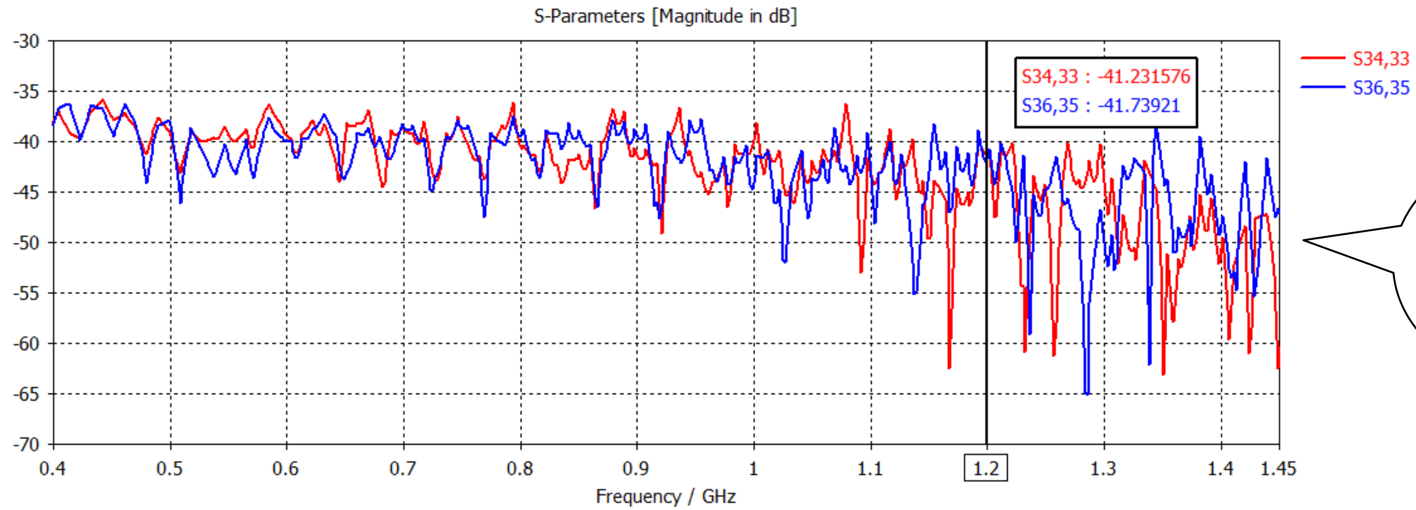




Gain of the individual active element

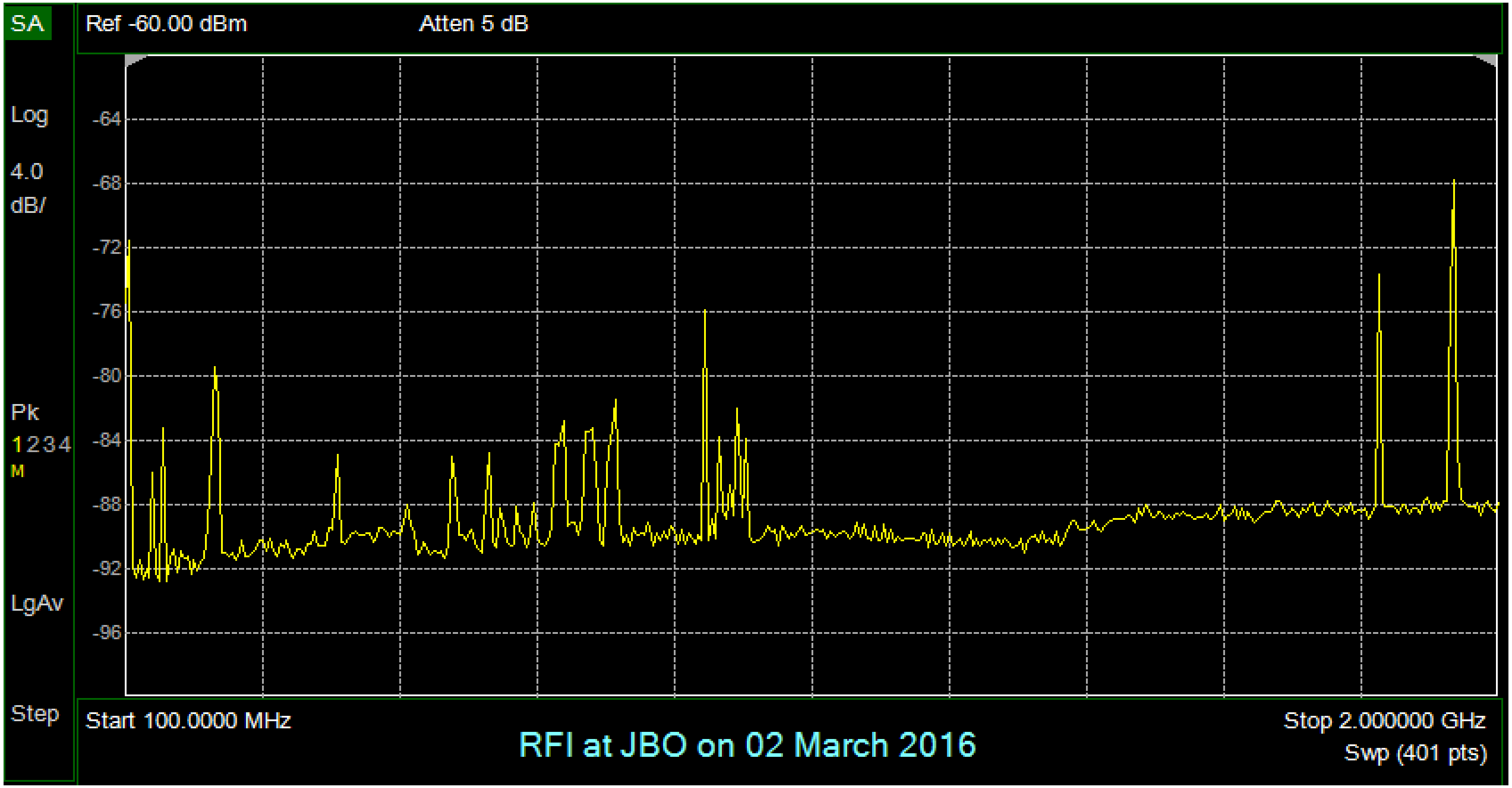


Array Individual element compared with the reference antenna



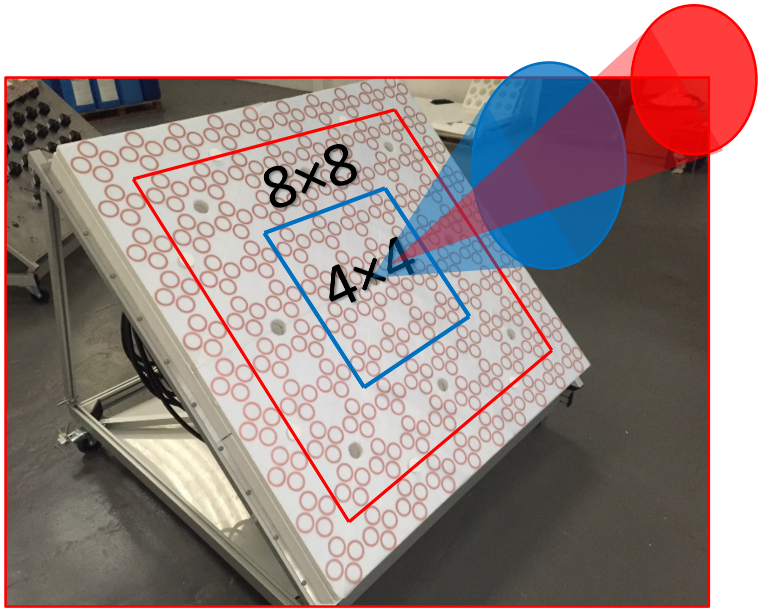
Reference antenna response at different time

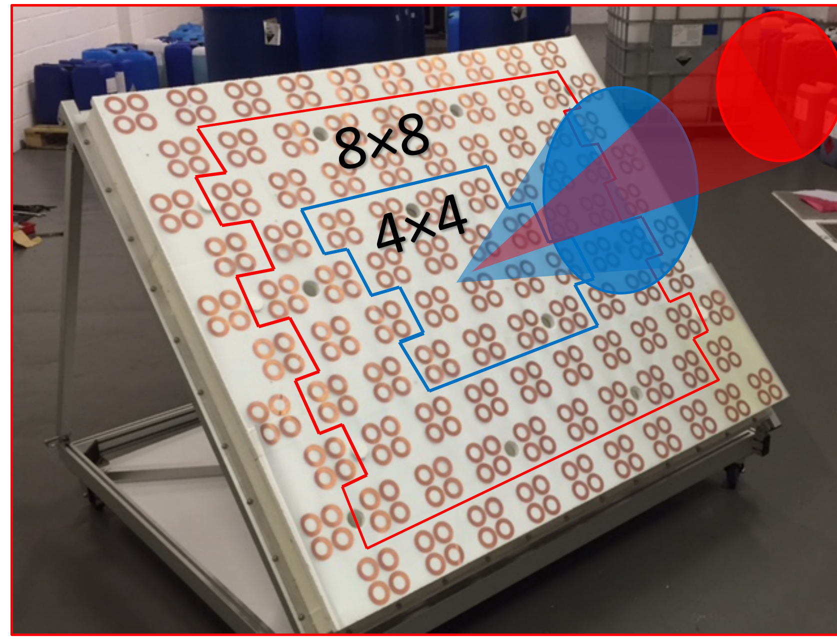
RFI@JBO


SA
Ref -60.00 dBm
Atten 5 dB
Log
4.0
dB/
Pk
1234
M
LgAv
Step
-64
-68
-72
-76
-80
-84
-88
-92
-96
Start 100.0000 MHz
Stop 2.000000 GHz
Swp (401 pts)
RFI at JBO on 02 March 2016

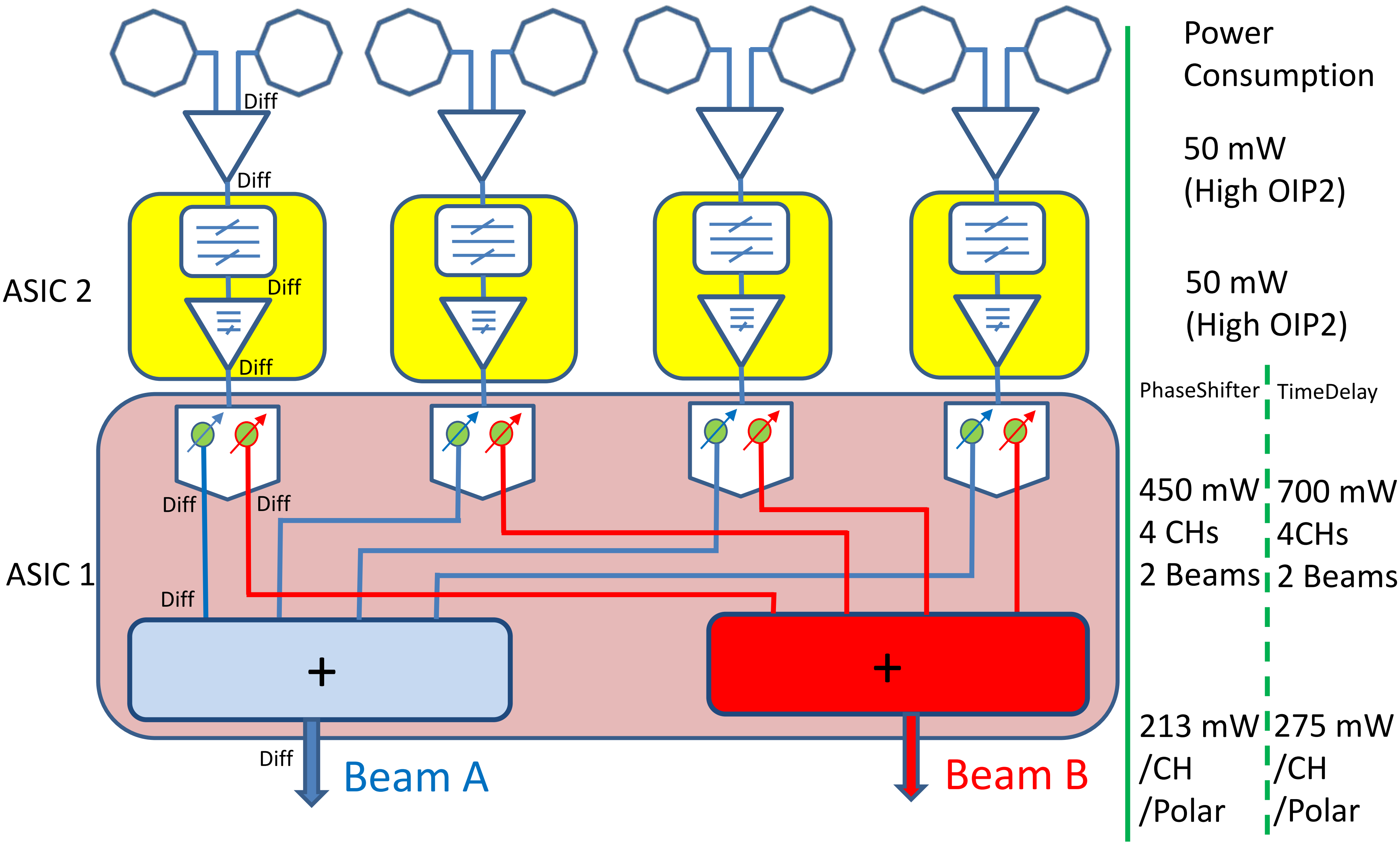
The Forward Planning

Planned Field Measurements



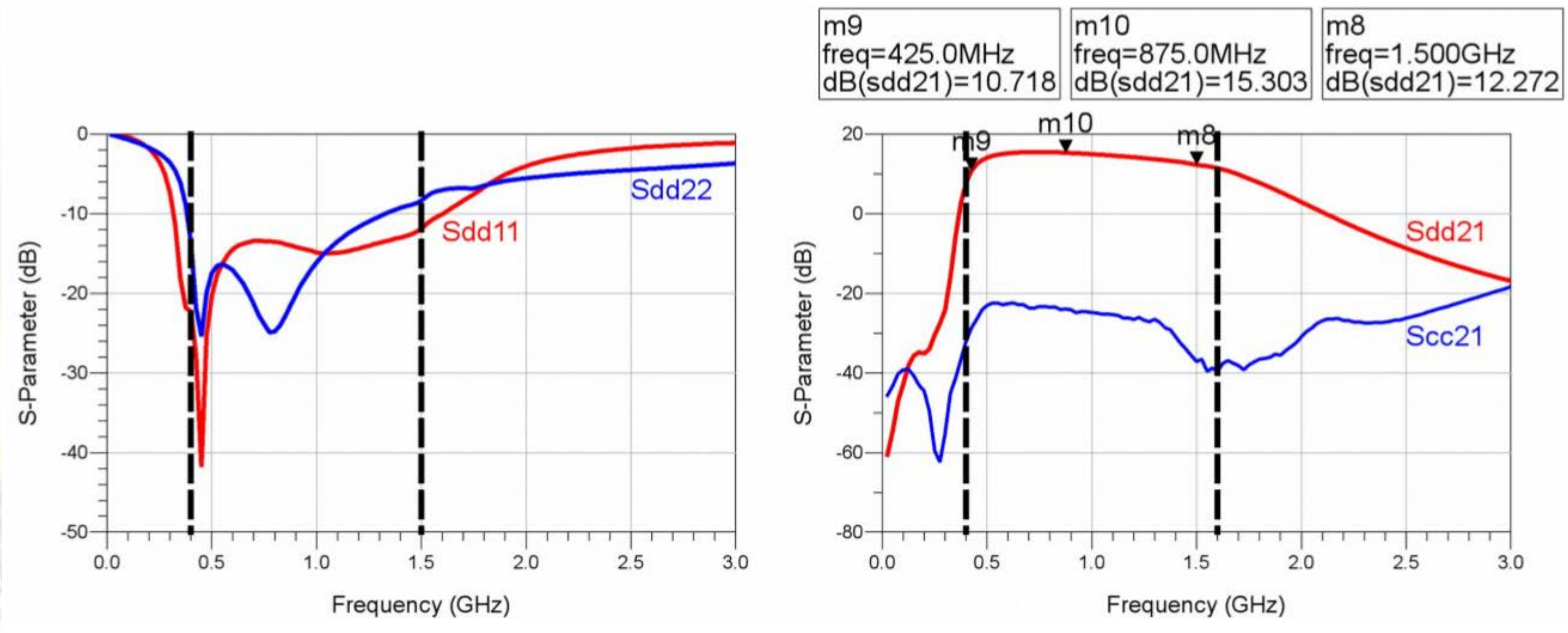


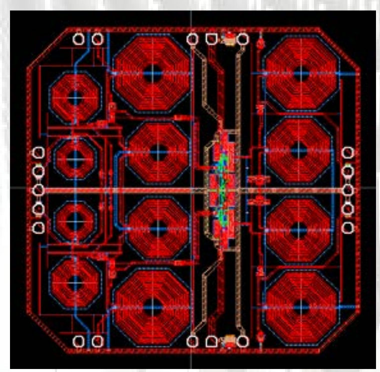
Differential Front-End Design based on ORA



Institution	Year	Gain	Noise Temp.	Frequency	Input impedance	Power	Technologies
Calgary	2007	17 dB	14K	0.7-1.4GHz		43mW Typical	90 nm Bulk CMOS
CIT	2009	27dB	90-120K	0.5-1.5GHz	50ohms	76mW	MMIC SiGe HBT
ASTRON (APERTIF)	2009	40 dB	40K	1.0-1.75GHz	75ohms		pHEMT (ATF54143)
CIT	2011	30dB	20-30K (22K at 1.4GHz)	0.6-1.7GHz	50ohms		GaAs HEMT from OMMIC
ASTRON	2015	40dB	35K	1.0-1.75GHz	75ohms		Skyworks
Cambridge	2015	17dB	15-35K	0.3-1.5GHz	50ohms	180mW	E-PHEMT
				Differential Input			
ASTRON (Diff LNA)	2007	17 dB	35-55K	0.5-1.5GHz	150ohms		pHEMT 0.18µm (CGY2109HV)
ASTRON (Diff LNA)	2007	20-25dB	30-40K	0.5-1.5GHz	200ohms		GaAs 0.18µm (ED02AH)
Calgary (Diff LNA)	2008	14-18dB	29K	0.7-1.4GHz	100ohms	106mW	90 nm Bulk CMOS
Xlim-Nancay-NXP (Diff LNA)	2008	19dB	68-75K	0.35-1.5GHz	Converted diff	32mW (Noise Canceling) or 80mW (Negative feedback)	SiGe BiCMOS
CSIRO (Diff input, SE output)	2009	28dB	30-35K	0.7-1.8GHz	300ohms		GaAs pHEMTs (ATF-35143)
OPAR (Diff LNA)	2009	27dB	65K	0.3-1.9GHz	100ohms	72.6mW	MMIC 250nm SiGe HBT
IGN (Diff LNA)	2010	26-36dB	43-55K	0.3-1.0GHz	150ohms		GaAs pHEMT (ATF34143)
CSIRO (Diff-SE)	2014	25-45dB	23K	0.7-3.0GHz	300ohms		BeRex BCL016B (GaAs pHEMT), and ATF-35143 pHEMTs
Nancay-NXP (Diff)	2015	25dB	30K	0.5-1.5GHz	120ohms	150mW (50mW with new topology)	SiGeC HBT
NWU	2015	30dB	20-25K	0.35-1.5GHz	120Ohms	400mW	GaAs pHEMTs (ATF-35143)

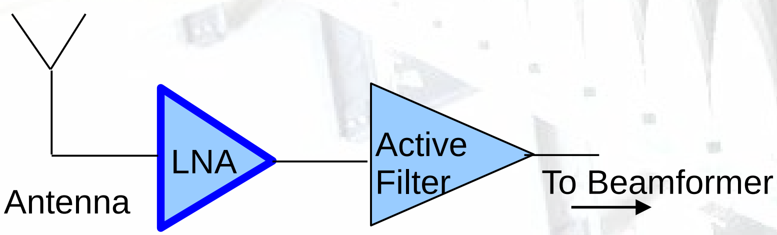
Active Filter measurement



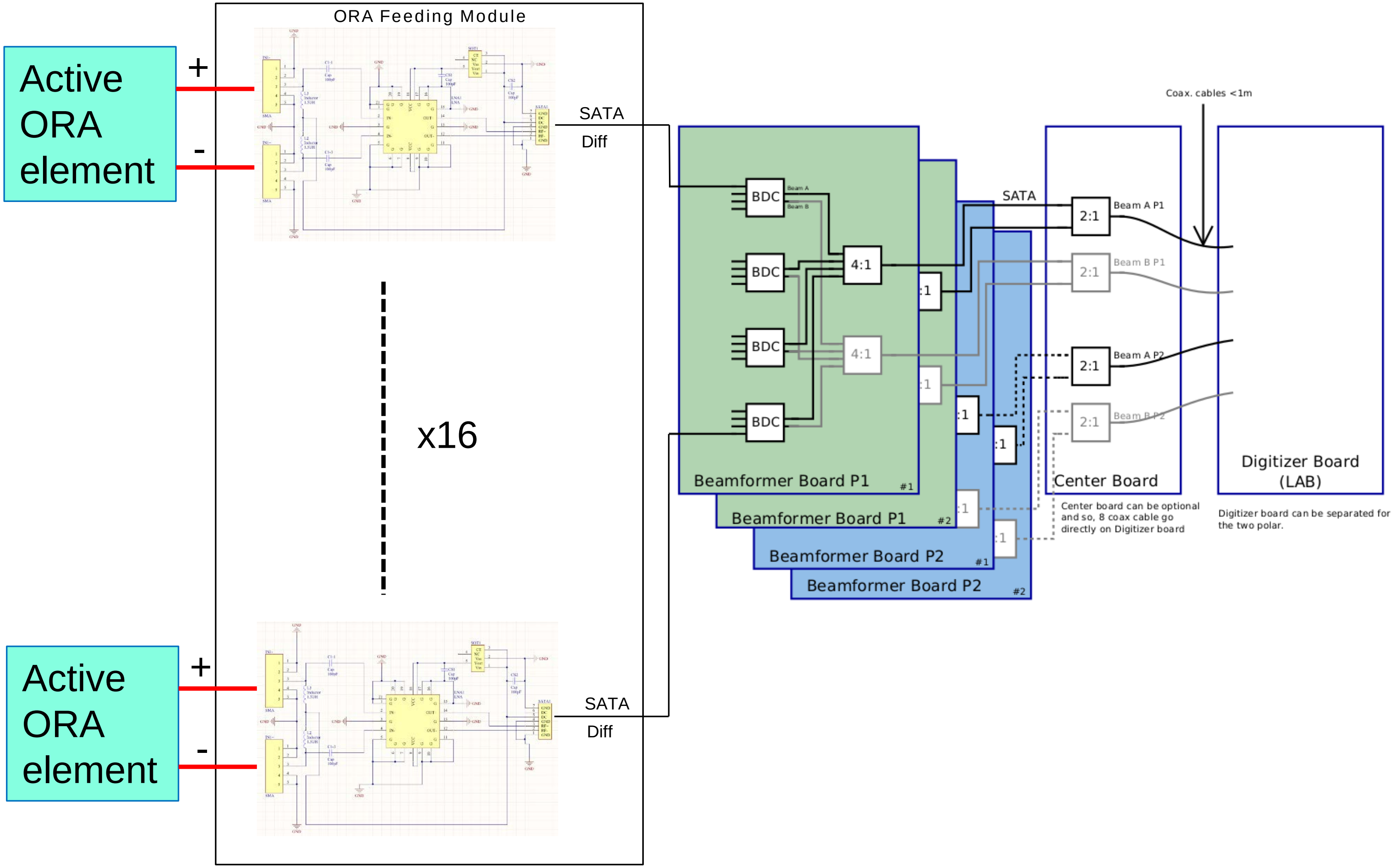


$\approx 5\ mm^2$

	Measure	
Impedance	**Input**	**100 Ω**
	Output	**150 Ω**
P1dB$_{min}$	**-**	
Pdc	**39 mW @ 3,3 V**	



The ORA Feeding Module



MFAA Verification 0.5 in the short term

- Amplitude and Phase Initial calibration
- 4 × 4 analogue beamforming
- Scattering matrix measurement/prediction
- Radiation patterns measurement/prediction
- Dual polarisation characterisation
- Noise temperature measurement for integrated finite array

MFAA Verification 1.0 for PDR

- 8 × 8 Analogue beamforming
- Form Dual polarised beams
- 8 × 8 Digital beamforming
- Twin beams per polarisation
- 16 × 16 tile, the tile design is linked to signal processing
- Demonstration the strength of the aperture array technology

Forward looking

- A whole AAMID system based on different front-end will be ready in due course together with the single-end AAMID system
- 30K receiver noise temperature in room temperature
- The power consumption of the LNA so far is still high, over 100mW, the aim is to be less than 50mW
- Closer link will be established between the front-end design and the back-end development for better integration of the system