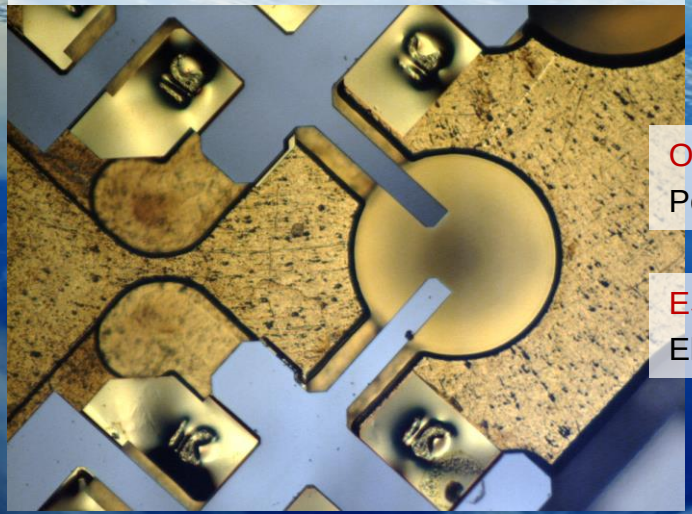
Dual Probe THz Receiver

ESA Contract No. 4000119261/16/NL/GLC



Omnisys Instruments

Peter Sobis, Project Manager/Researcher

ESA/Estec

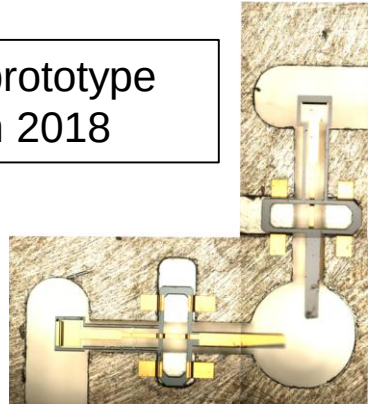
Elena Saenz, Project Officer

GHz CHALMERS UNIVERSITY OF TECHNOLOGY LOW NOISE FACTORY www.lownoisefactory.com OMNISYS INSTRUMENTS esa Met Office VINNOVA Sweden's Innovation Agency RYMDSTYRELSEN Swedish National Space Board

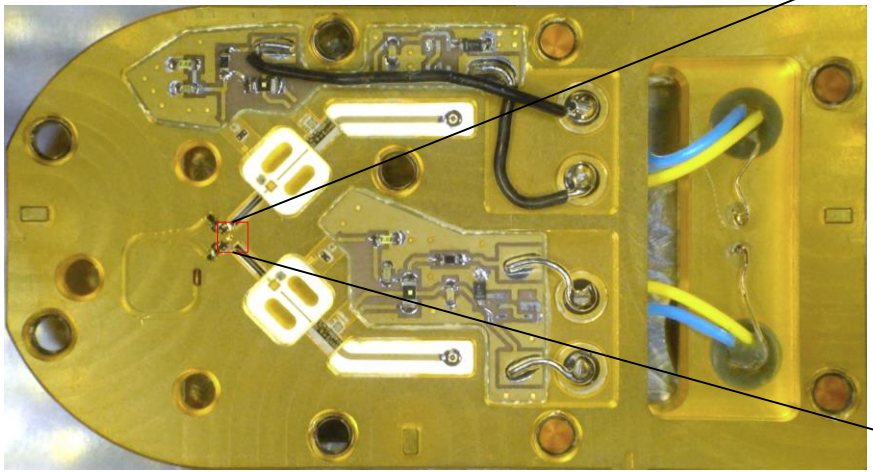
Dual polarization 424 GHz receiver

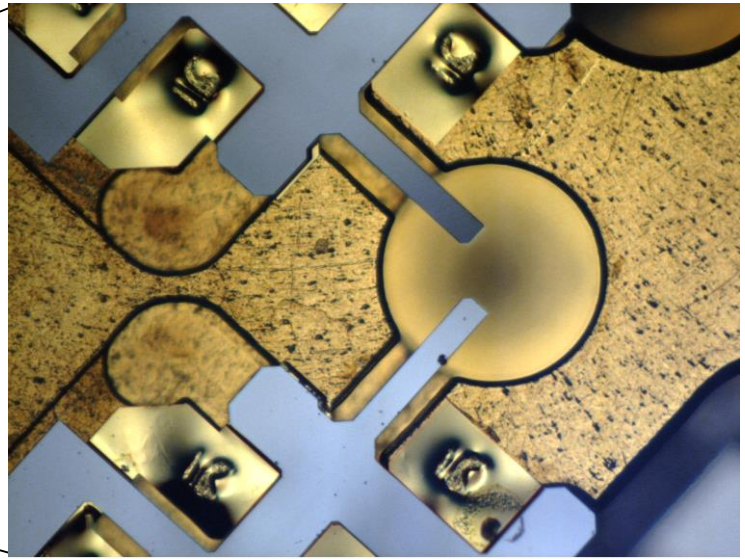
- Integrated SD mixers, spline antenna, InP HEMT LNAs
- No loss penalty for OMT
- Simulated 10% relative bandwidth with better than 15 dB XP
- Can be used for redundancy or improved S/N

OMT prototype from 2018



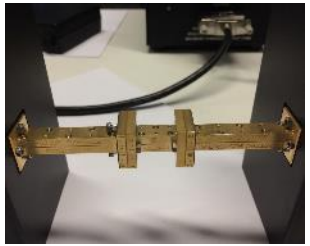
Integrated receiver prototype from 2019



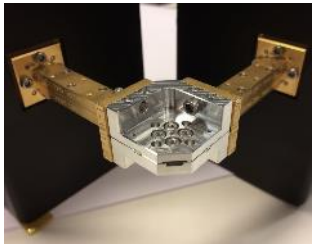


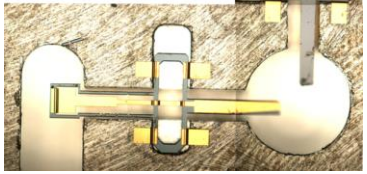
Breadboard test - Integrated dualpolarisation OMT

Line 1” ref.



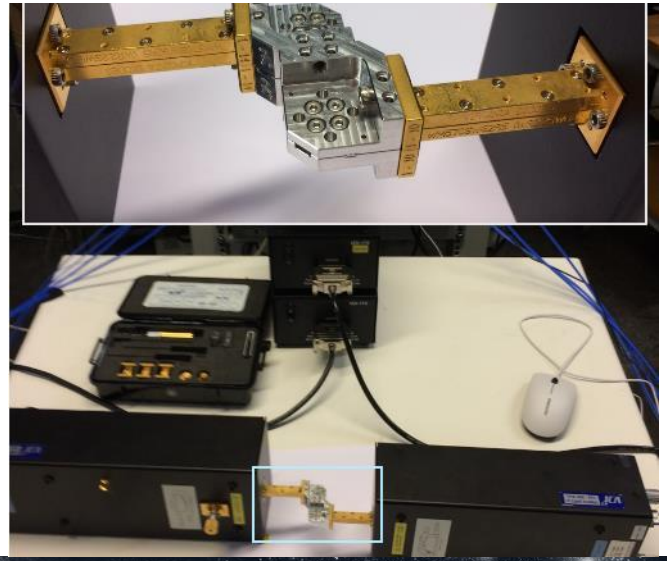
Single ref. WR-2.2 WG



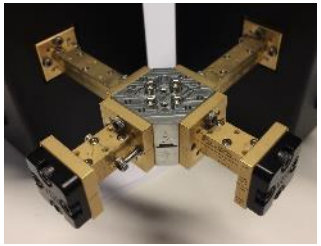


- ✓ Keysight PNAX and VDI WM-570 (WR-2.2) VNAX frequency extenders
- ✓ DUT: Two OMTs back to back

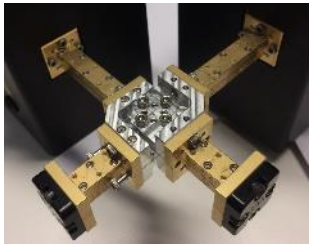
Reference waveguides



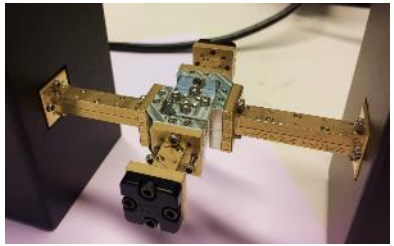
Isolation



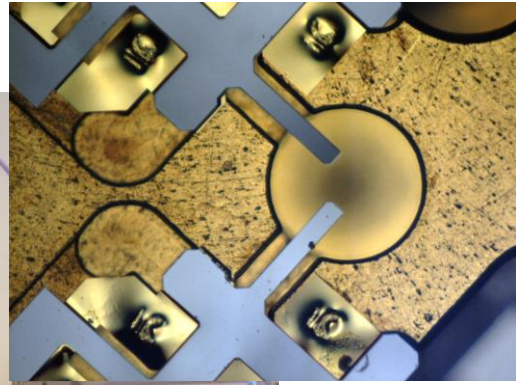
Cross pol.

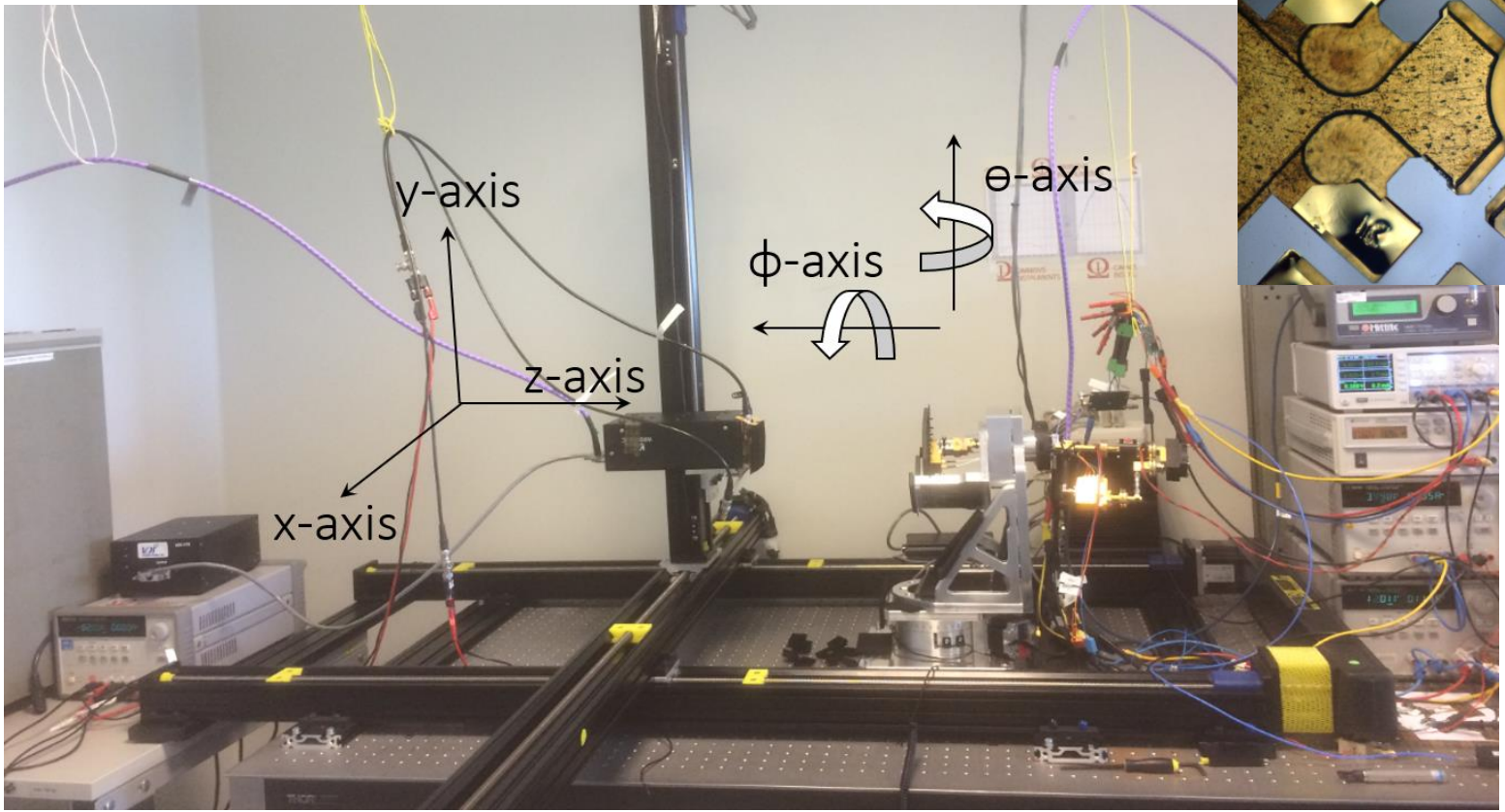


Insertion loss

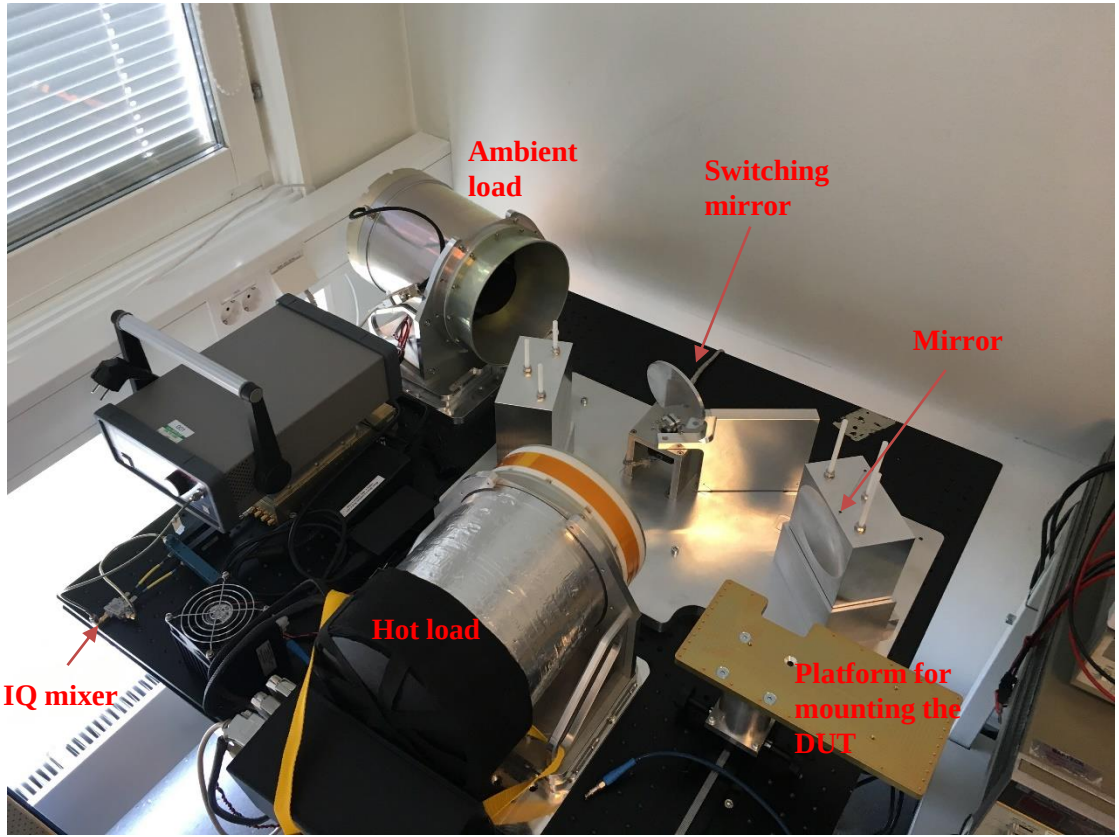


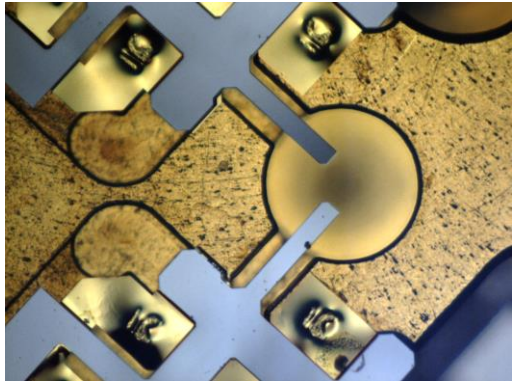
Antenna Far-field measurements





Radiometric Characterization





- ✓ Y-factor setup using high precision loads from Tomas Keating
- ✓ Stability measurements

Technology Background

Clean Room: 1240 m^2 clean room

Particles: Class 10-1000

Staff: 22 engineers

Dedicated processing lines:

Microwave and photonic components

Quantum and nanodevices

Clothing: Full body suits

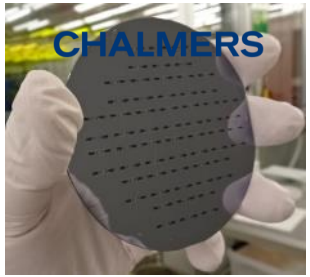
Ventilation: 520 000 m^3/h

Climate control:
± 3% RH,
± 1± 0,1° C (around e-beam)

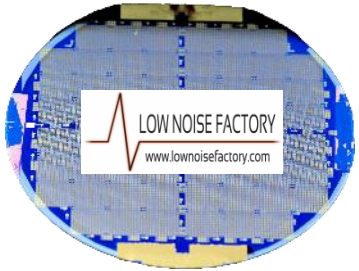
Machine park:

~ 190 tools (broad processing platform specialized in nanolithography)

III/V Semiconductor fabrication

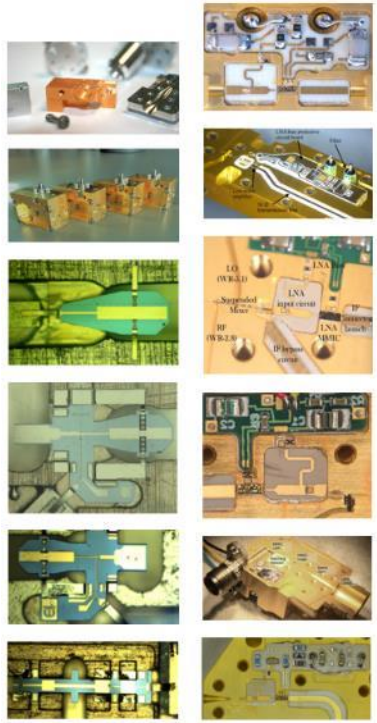


Chalmers: 3” GaAs SD Wafer

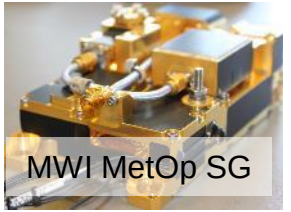


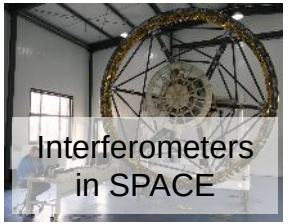
LNF: 4” InP HEMT Wafer

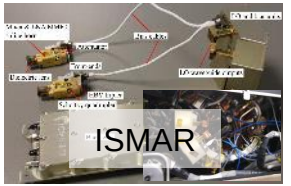
High performance receiver components



Systems & Instruments







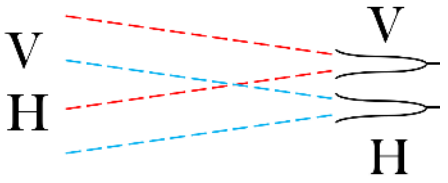
End-users , LSI's, and the scientific community

Motivation

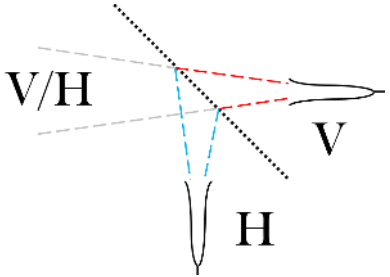
- Polarimetric observations (V&H) are mainly used for estimation of cloud ice properties, e.g. particle size, orientation and mass using window channels at 243 GHz, 664 GHz, and 874 GHz (ISMAR, ICI)
- There is a scientific interest for dual polarisation observations also at Oxygen (118 GHz, 424 GHz) and WaterVapor (325 GHz, 448 GHz) transitions, as such can provide complementary altitude information of the radiometric scene
- For scenes that are polarisation insensitive DP receivers are used mainly for redundancy and for the increase of measurement accuracy

Dual polarisation schemes

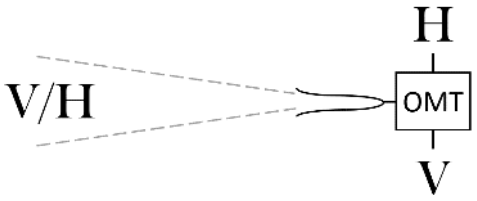
- by the use of separate apertures with opposite polarisation (ISMAR)



- in the optical domain e.g. by the use of polarization grids (SWI, STEAMR)



- by the use of waveguide OMT's (ICI, MWI)



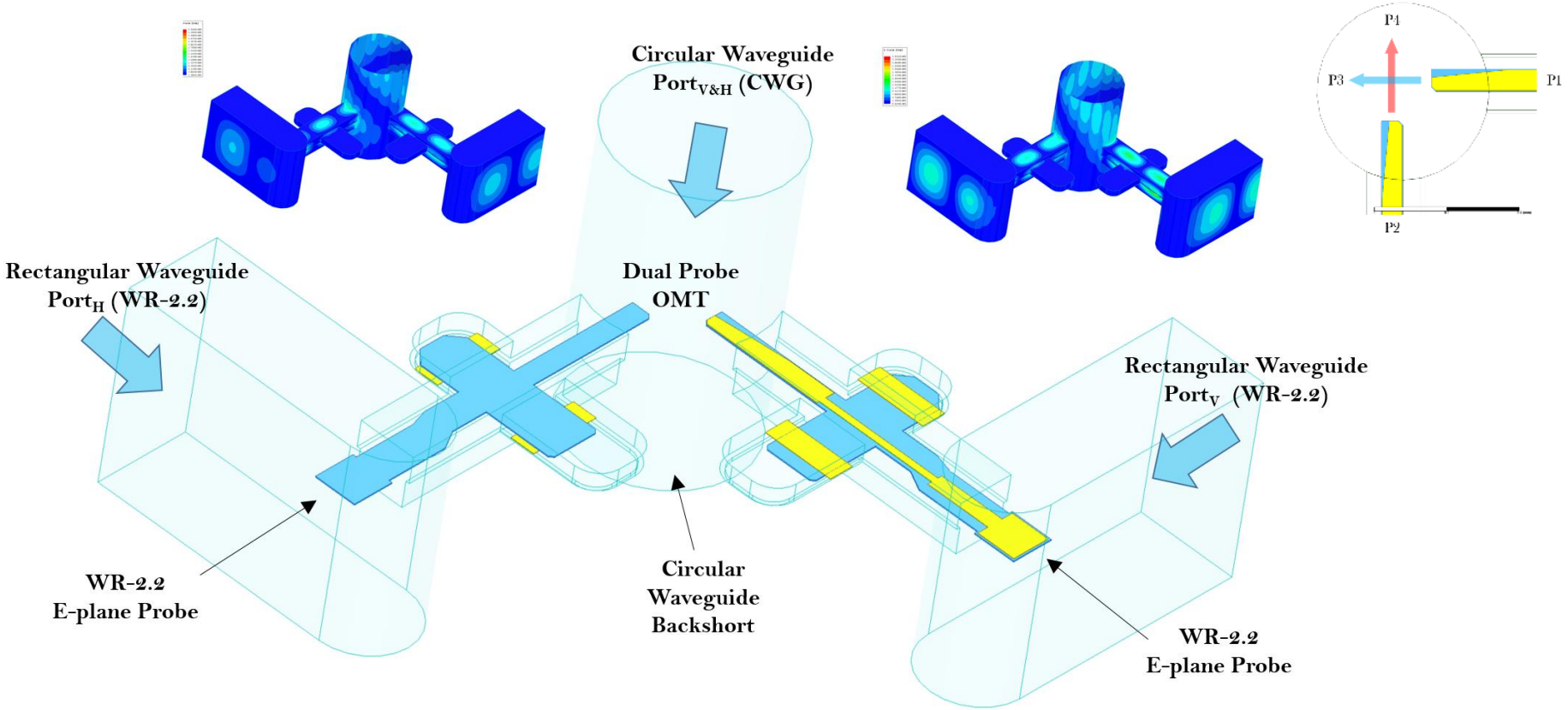
Waveguide OMT’s

- Above 100 GHz waveguide and other types of OMT’s are often found to be
  - bulky
  - lossy
  - sensitive to mechanical tolerances
  - difficult to integrate with feedhorn and receiver

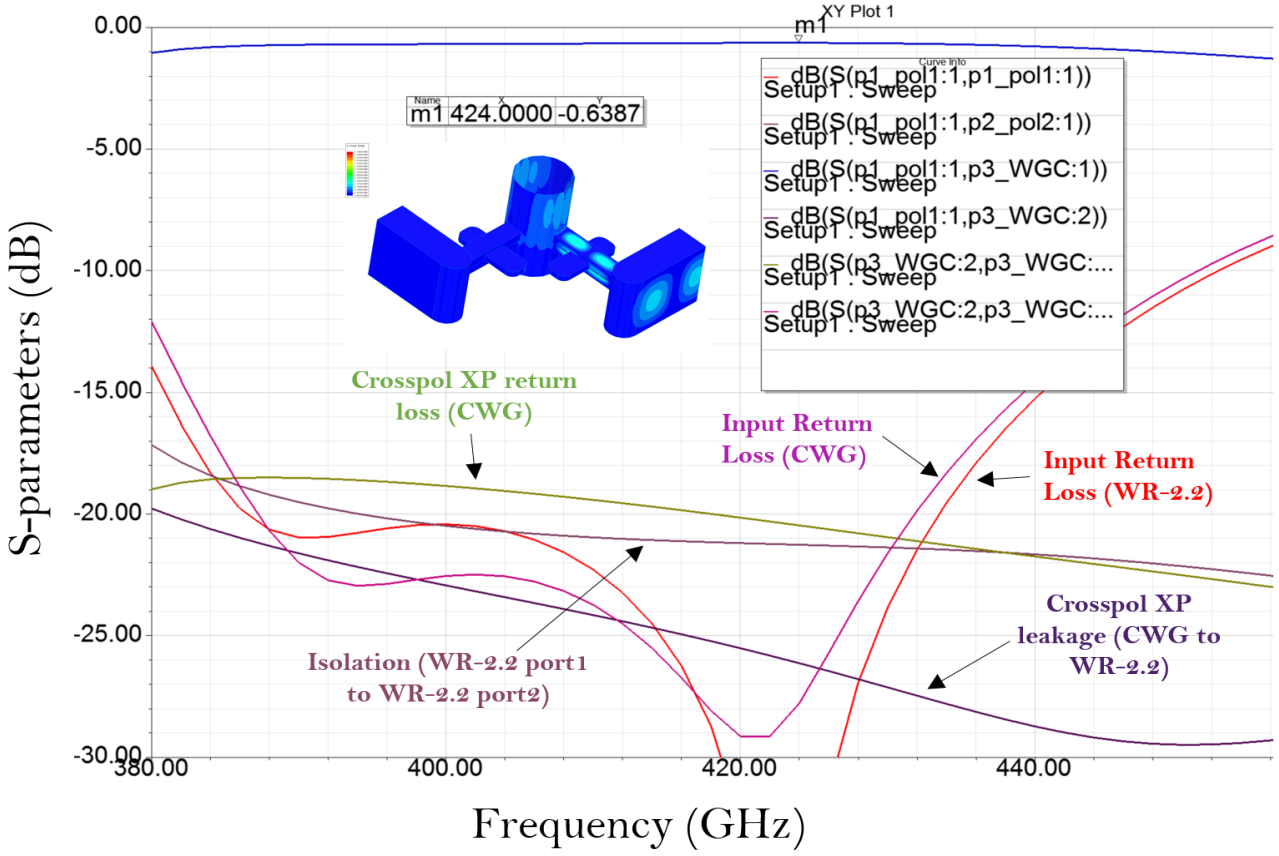
OMT - Integrated dualpolarisation THz receiver

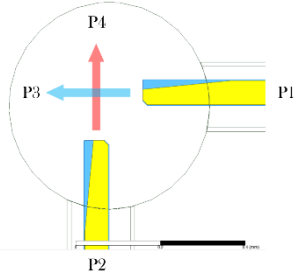
- THz receiver design
  - Removing bulky interfaces in the signal path improves sensitivity and aid flexibility in the package design
    - -> Integration of feedhorn to the receiver module
    - -> Minimizing the RF waveguide transition length
    - -> Integrating the IF amplifier and bias electronics – reduces ripple and improves sensitivity, stability, and susceptibility to EMI
- OMT properties wish list
  - Minimum loss - integral part of the antenna and detector environment
  - Reduced envelope - integral part of the antenna and detector environment
  - Robustness to alignment tolerances

Concept - Integrated dualpolarisation OMT transition



Simulations I - Integrated dualpolarisation OMT transitions

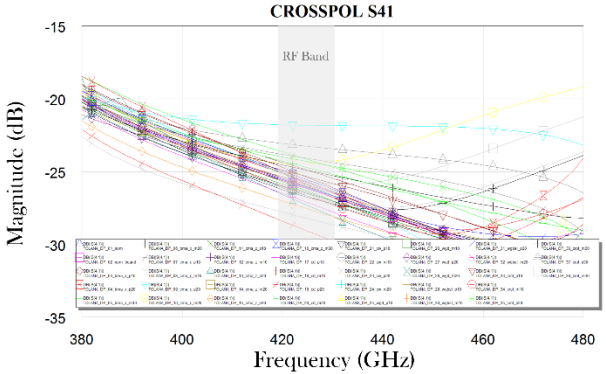


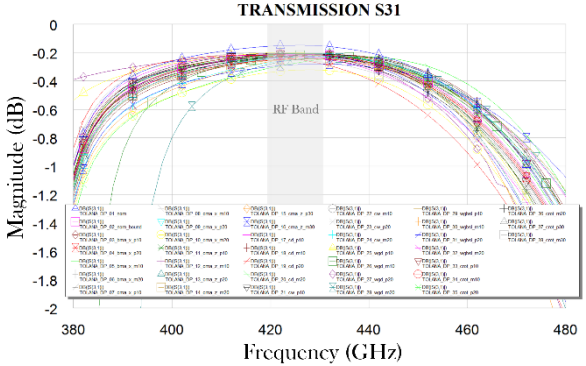


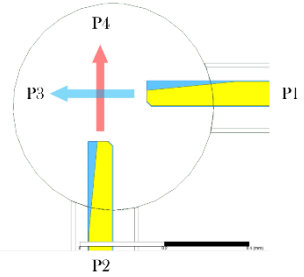
Performance @ 420 GHz

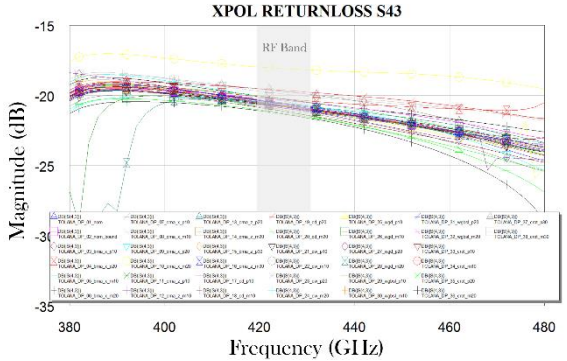
- ✓ 25 dB XP
- ✓ 0.3 dB Loss
- ✓ 25 dB Return Loss
- ✓ 20 dB Isolation
- ✓ 25 dB XP Return Loss

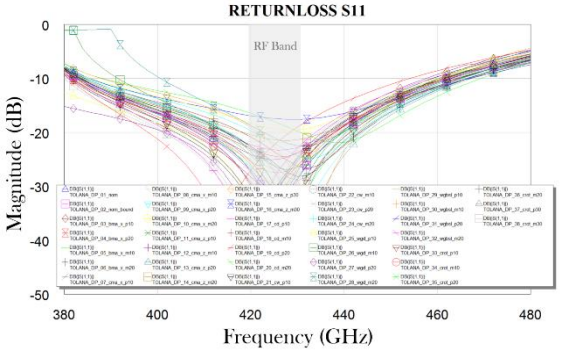
Simulations II - Integrated dualpolarisation OMT transitions

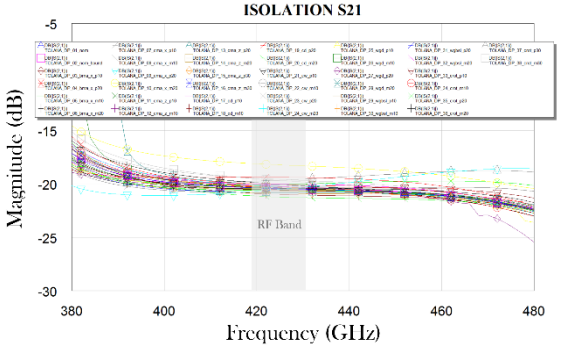




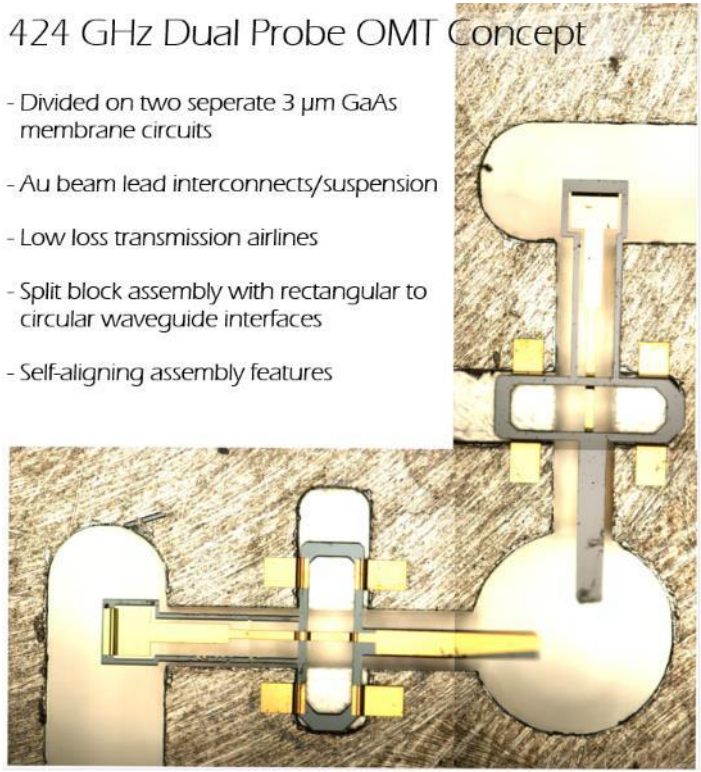








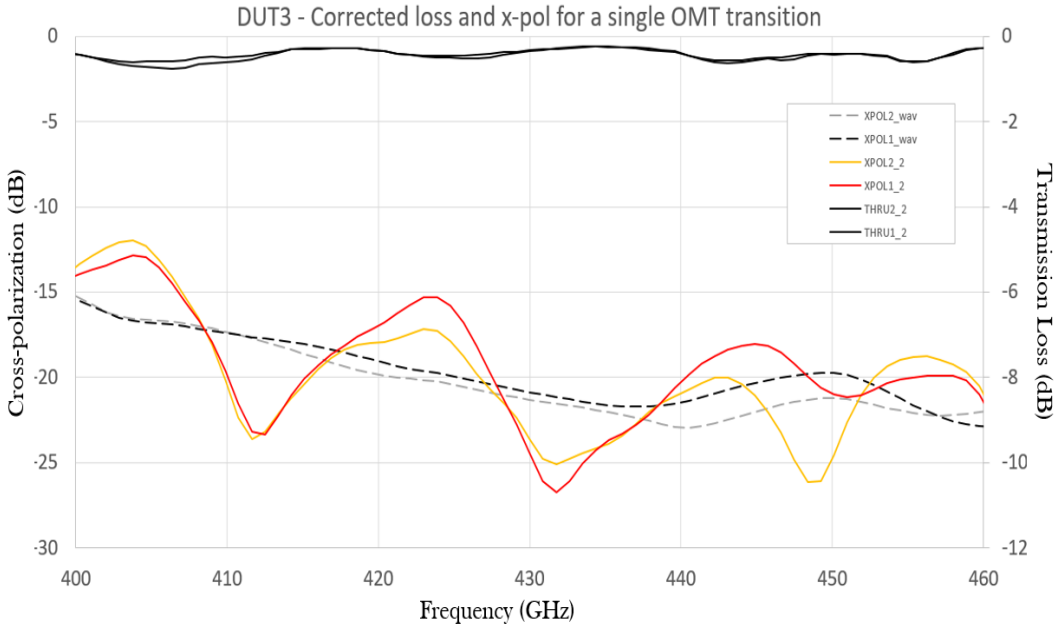
Breadboard manufacturing - Integrated dualpolarisation OMT



OMT's back to back

Reference WG's

Breadboard result - Integrated dualpolarisation THz receiver

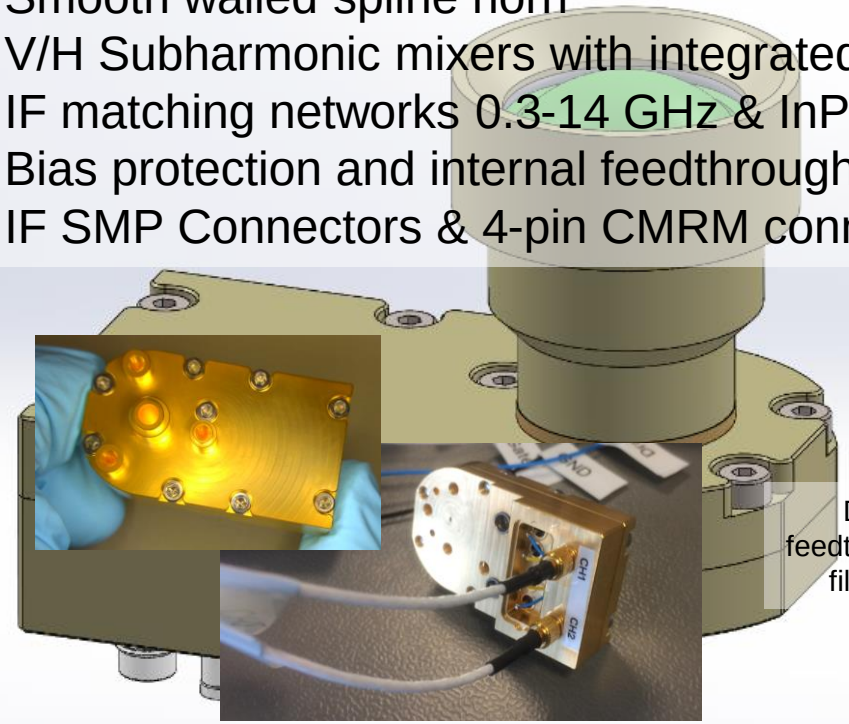


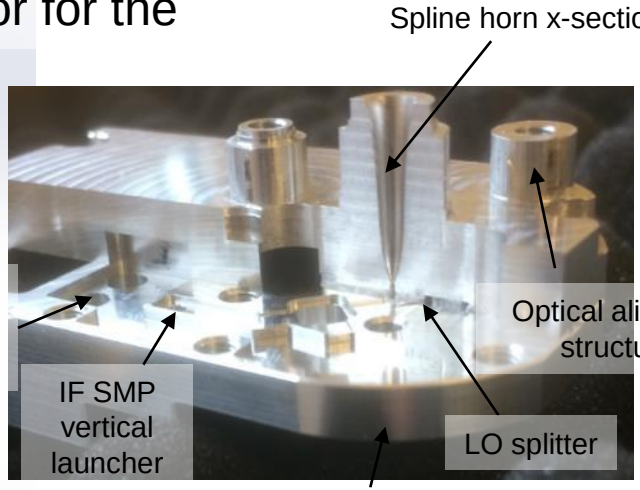
Results @ 420 GHz

- ✓ 18 dB XP
- ✓ 0.4 dB loss
- ✓ <17 dB Return Loss
- ✓ 15 dB Isolation

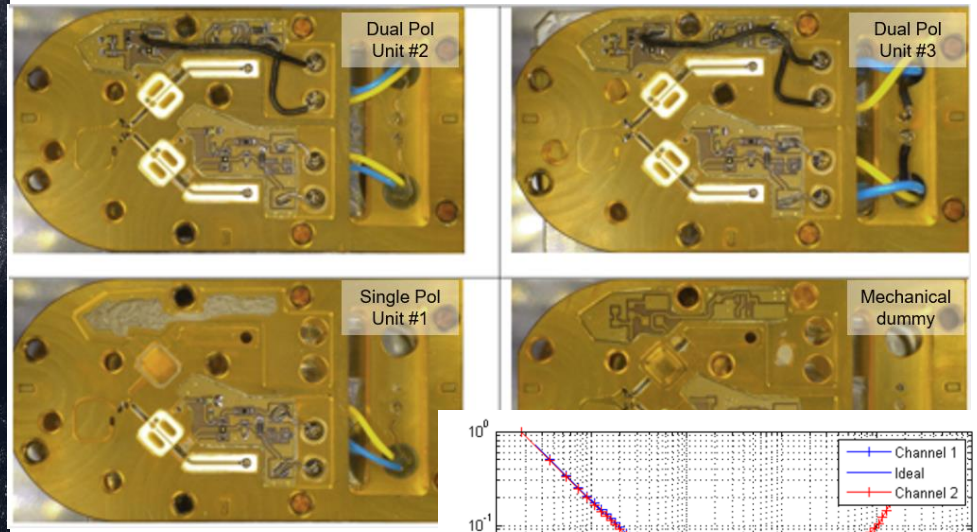
DP 424/448 GHz Receiver Design – Tr,dsb=800 K @ RT

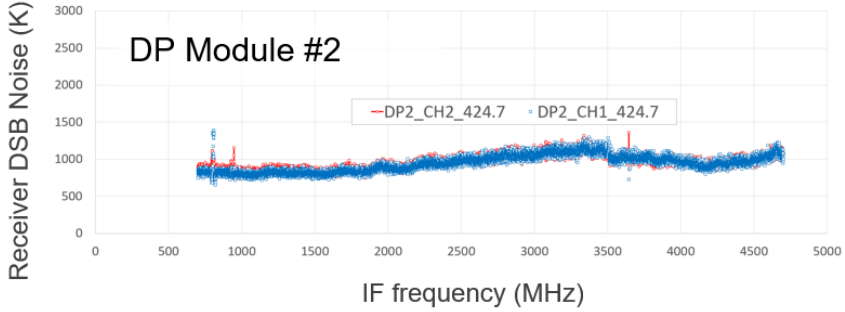
- ✓ Dielectric lense
- ✓ Smooth walled spline horn
- ✓ V/H Subharmonic mixers with integrated OMT probe transitions
- ✓ IF matching networks 0.3-14 GHz & InP HEMT MMICs from LNF
- ✓ Bias protection and internal feedthrough filters
- ✓ IF SMP Connectors & 4-pin CMRM connector for the

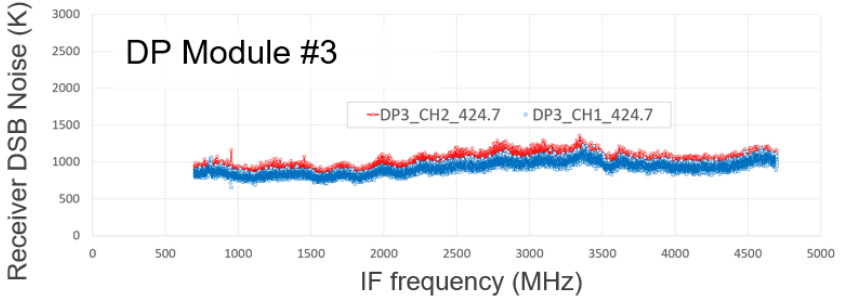


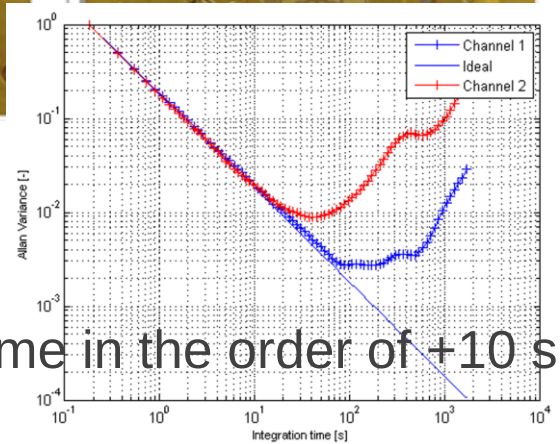


Dual Polarisation Receiver Units





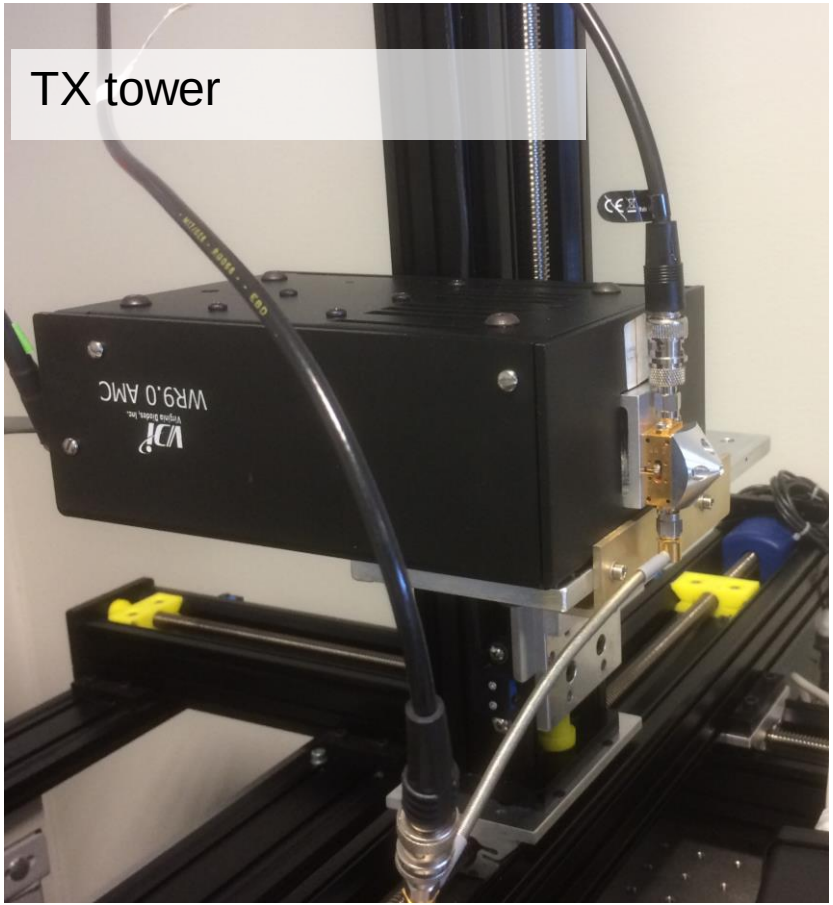


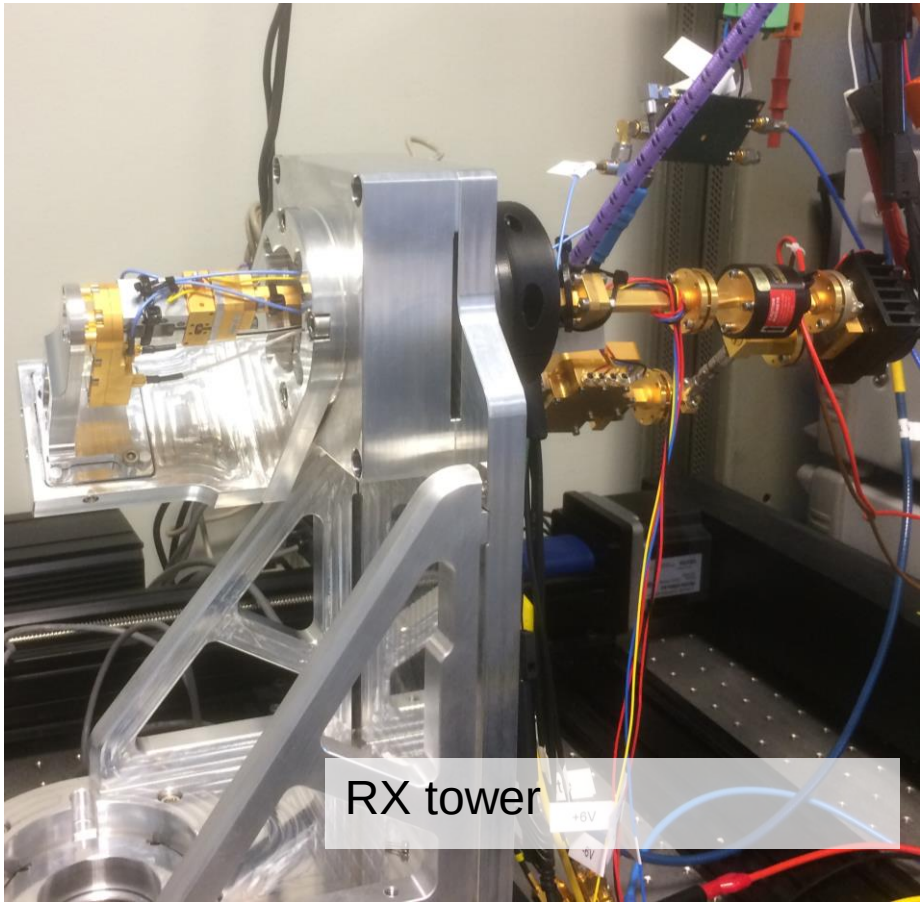


Allan time in the order of +10 seconds!

Antenna Measurements

TX tower



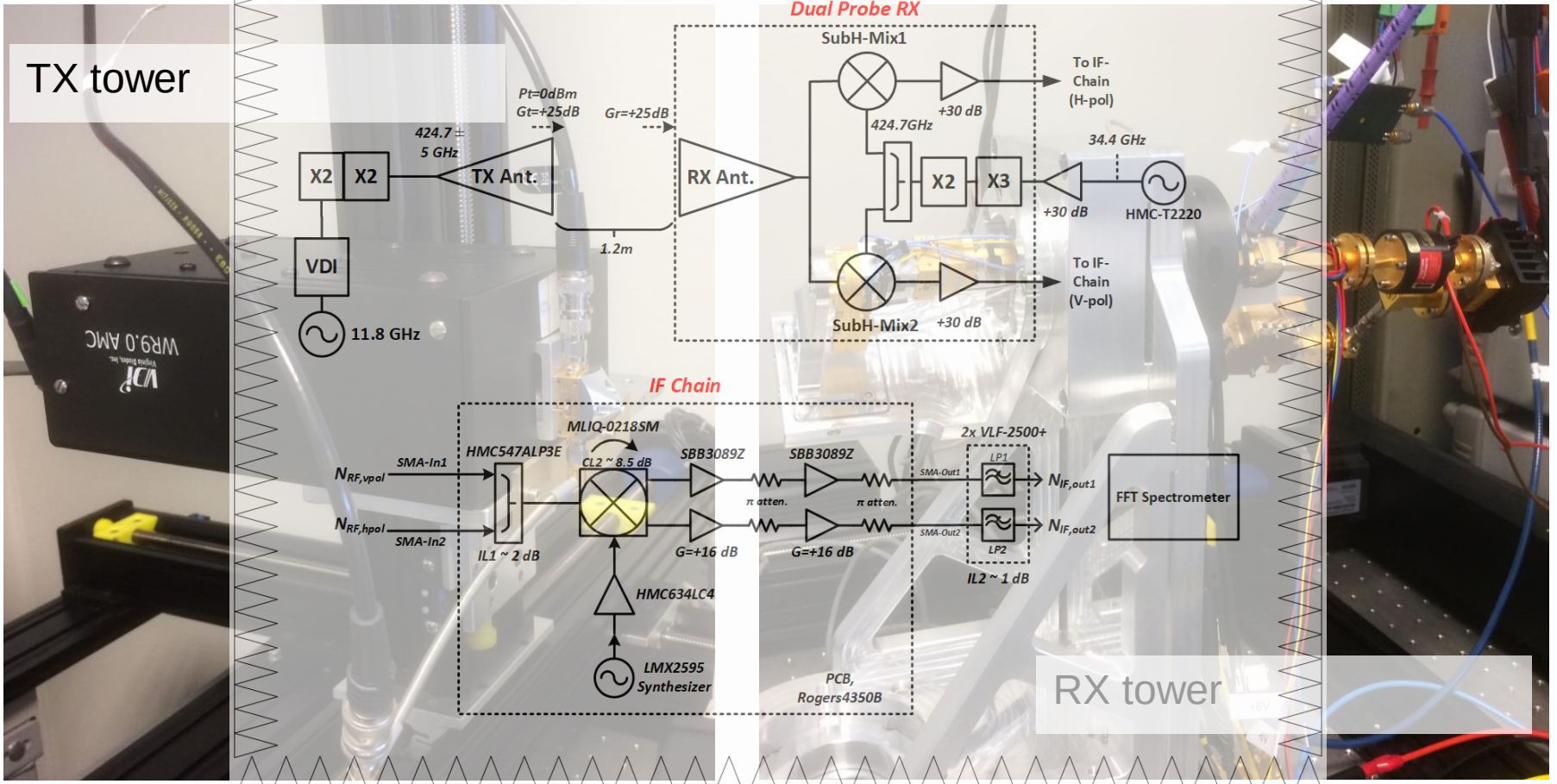


RX tower

OMNISYS INSTRUMENTS

Antenna Measurements

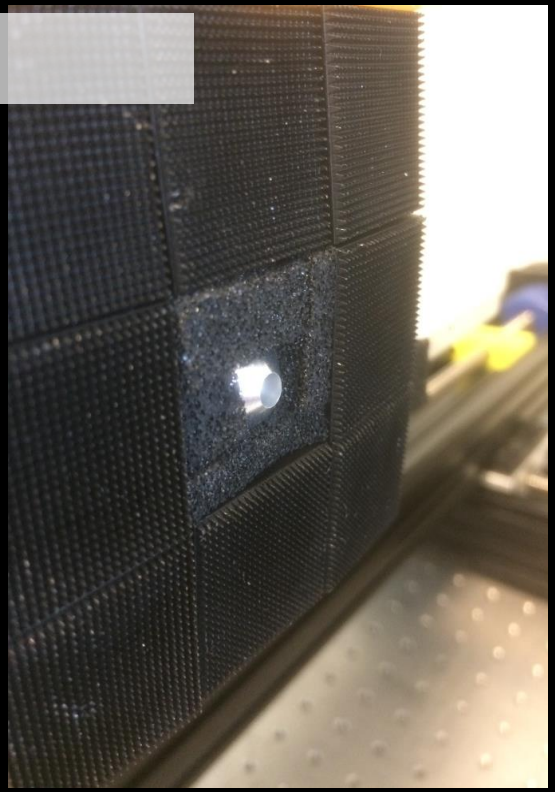
TX tower

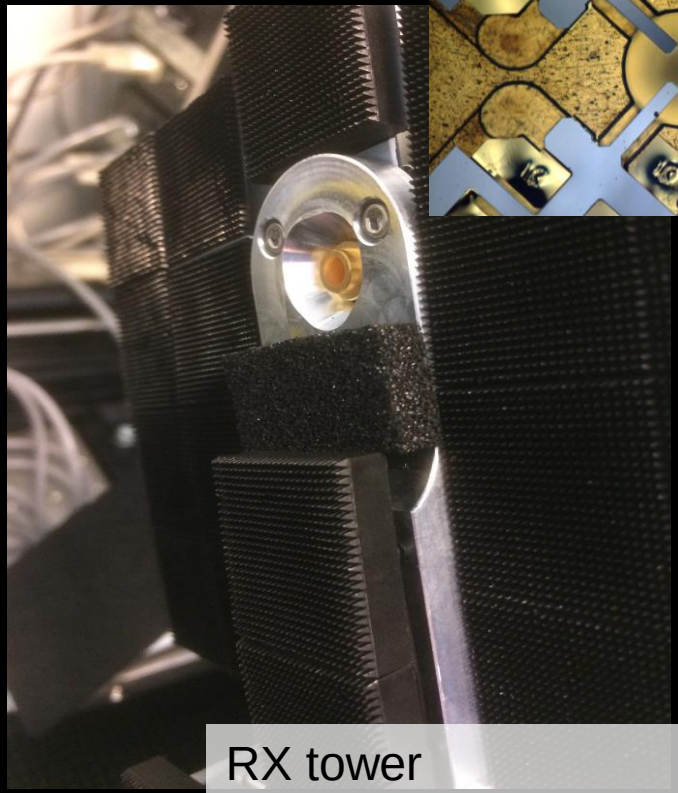


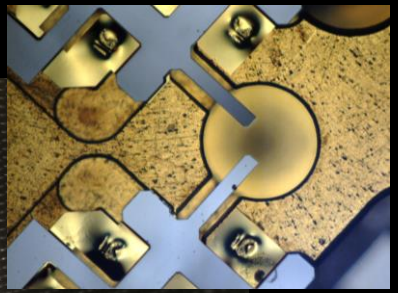
RX tower

Near-/Far-field antenna measurement setup

TX tower

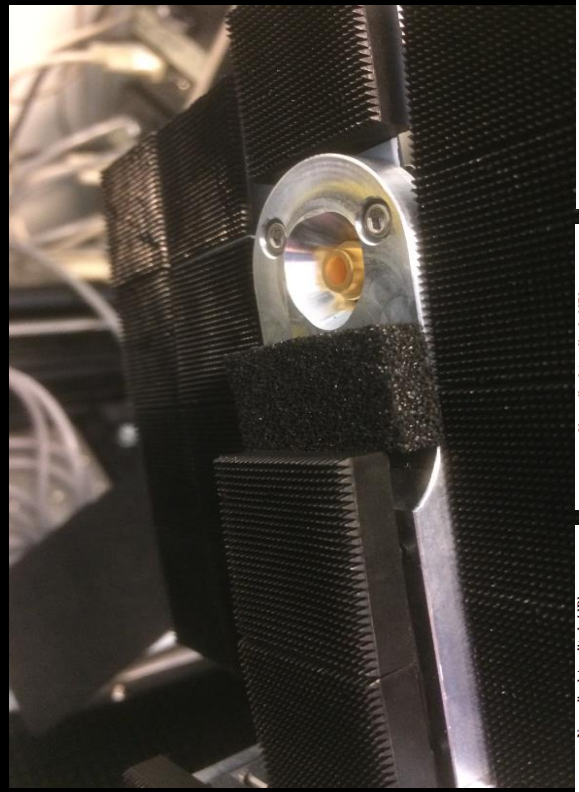


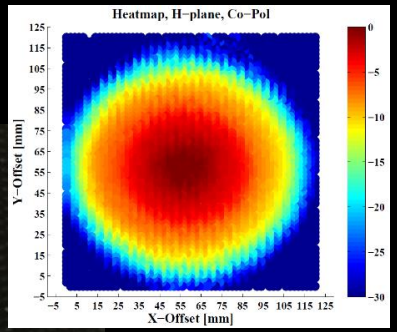


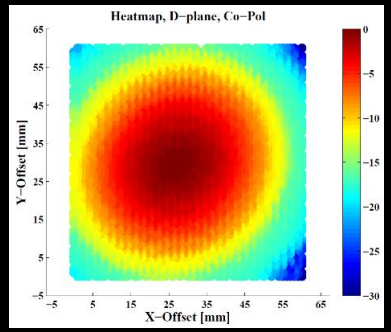


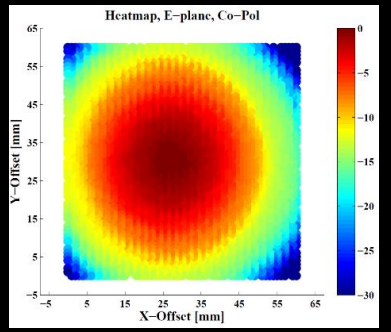
RX tower

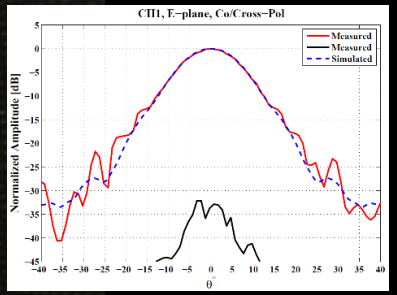
Heatmaps & Beampatterns Co-/Cross-Pol E/H/D-planes

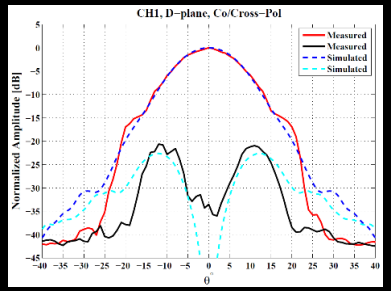


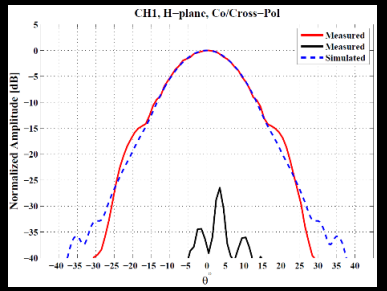


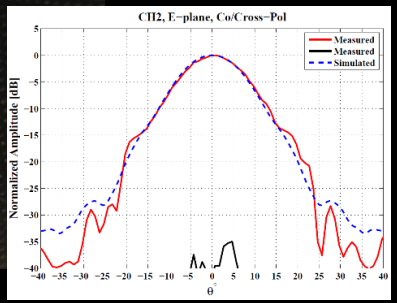


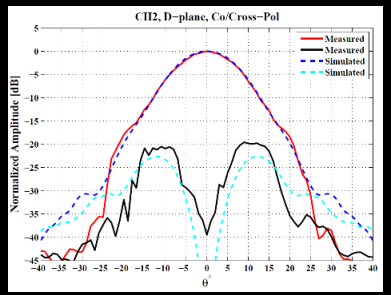


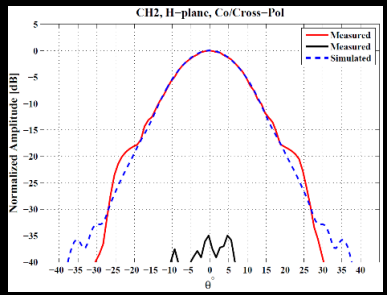




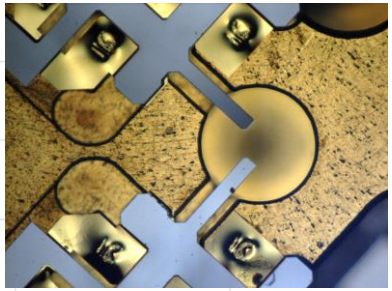








Dual polarization 424 GHz receiver – Cross-Polar Discrimination XPD



Conclusions

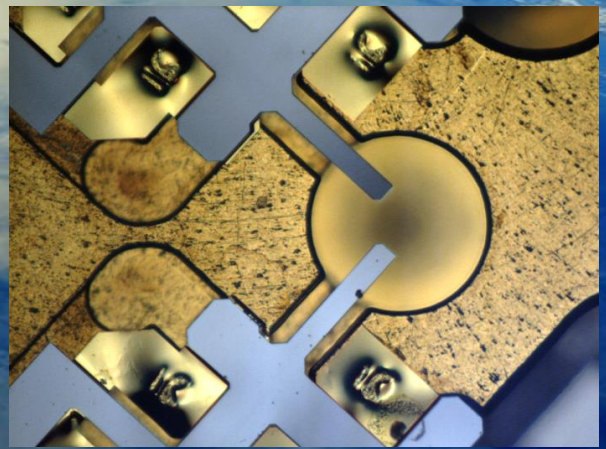
- An integrated dual polarisation scheme for THz receivers has been developed with minimum penalty in terms of loss, size, and mass
- Cross-pol levels in the order of 20 dB seem feasable with a bandwidth useful for most atmospheric sensing applications
- The concept has been evaluated in a 424/448 GHz receiver demonstrator for the airborn ISMAR instrument as part of this ESA GSTP 6.2 activity
- Integration into future instruments will be the next step, a number of candidates exist!

OMNISYS INSTRUMENTS

Dual Probe THz Receiver

2020-01-22 Final Presentation Days, ESA/Estec, Noordwijk, The Netherlands

ESA Contract No. 4000119261/16/NL/GLC



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Martin Pettersson (Assembly)