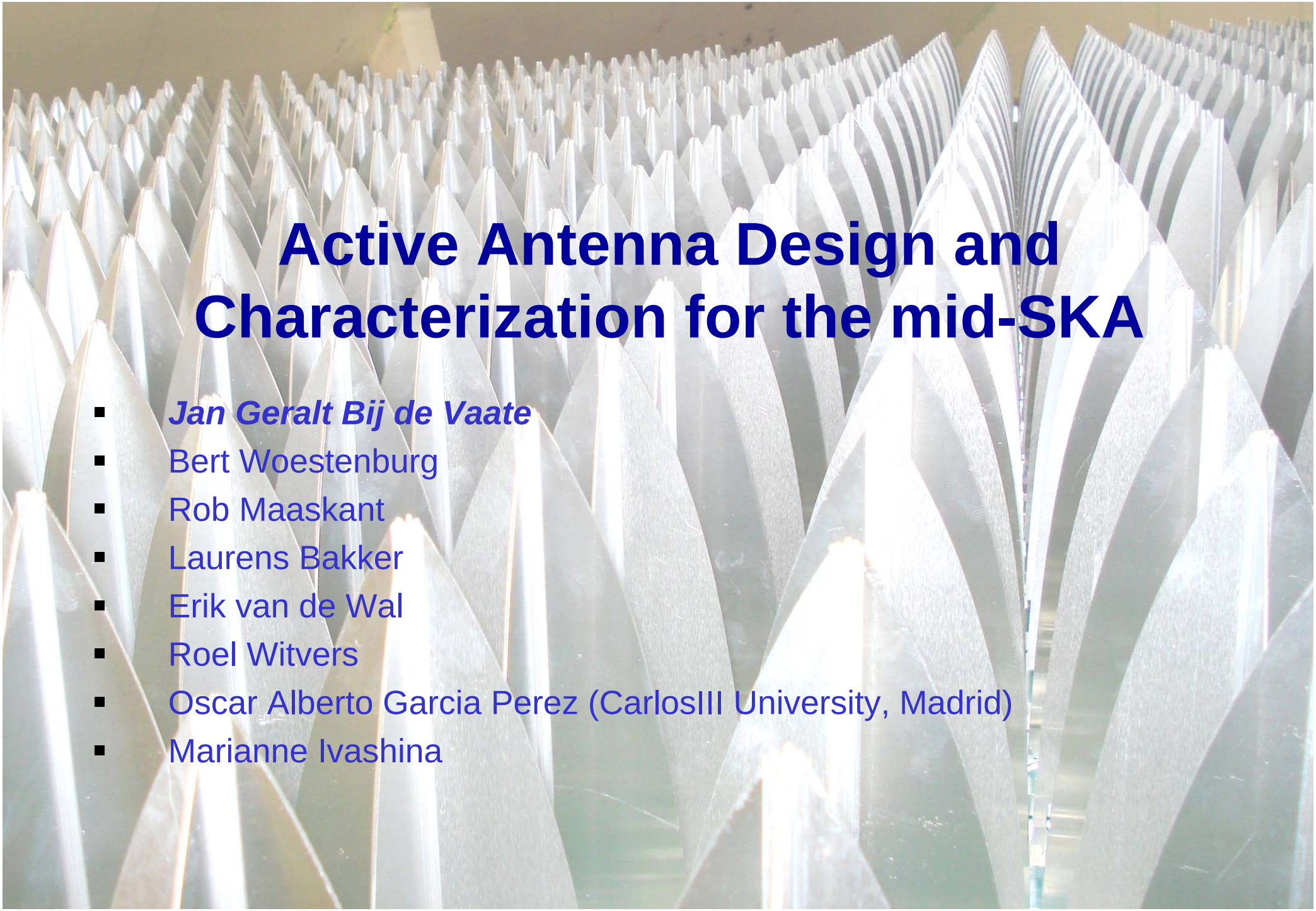


Active Antenna Design and Characterization for the mid-SKA

- ***Jan Geralt Bij de Vaate***
- Bert Woestenburg
- Rob Maaskant
- Laurens Bakker
- Erik van de Wal
- Roel Witvers
- Oscar Alberto Garcia Perez (CarlosIII University, Madrid)
- Marianne Ivashina

SKA

- Memo100:
  - Sparse aperture array 70-450MHz
    - 4000 m2/K, Tsys~1000: 4 km2
      - 2 million Antennas
  - Dense aperture array 300-1000MHz
    - 10.000 m^2/K, Tsys=50K: 0,9 km2, nearly 1 km^2
      - 45 million Antennas
        - Aperture efficiency 80%, 45 degree scan

Noise budget

Aperture Array	
Spill-over	0 K
Vivaldi feed loss	9 K
Low Noise Amplifier	16 K
Noise mismatch / coupling /2nd stage	7 K
Sky	8 K
Total	40 K

- $T_{LNA} \sim 30\%$ of noise budget only!

300K

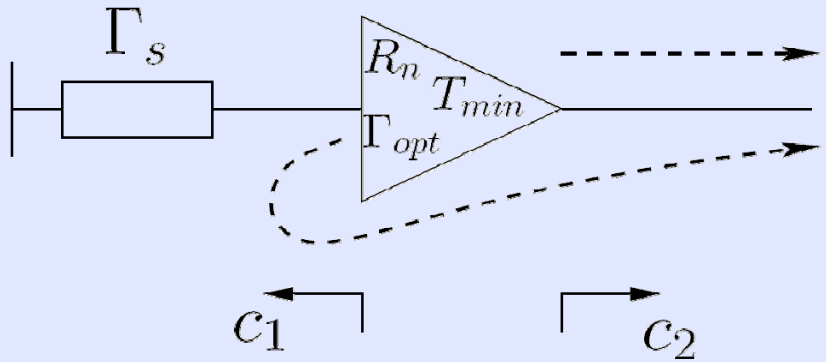
- Cryogenic cooling not possible (€s!)
  - And not needed!?
- Just a wide band matching issue?!
  - Providing $f_T > 100GHz$
- mHEMT GaAs, CMOS

$$F_{MIN} = 1 + \frac{f}{f_T} \times \sqrt{g_m \left(r_g + r_s \right)}$$

$$Tn_{297} = \sqrt{20} Tn_{15}$$

$$T_{\min} = \sqrt{T_{amb} T_{channel}} \frac{f}{f_T}$$

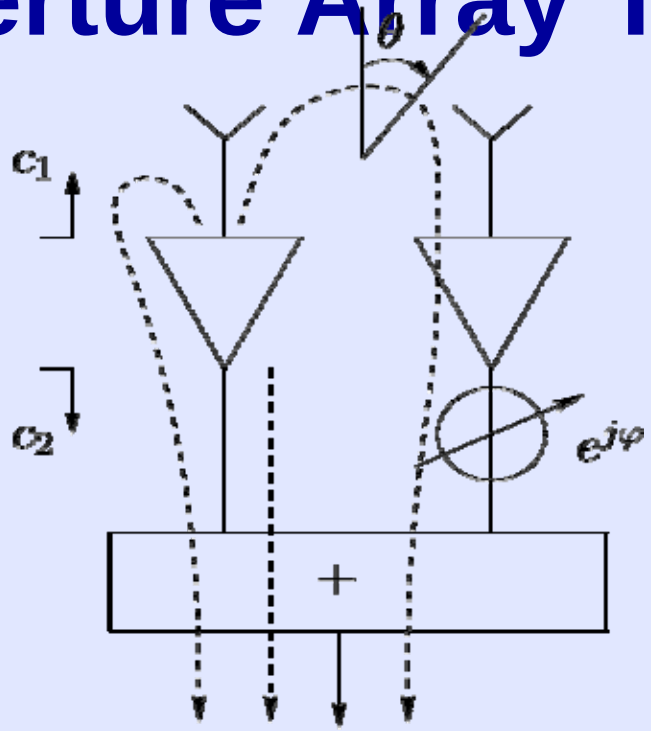
Aperture Array T_{sys}



$$T_{LNA} = T_{\min} + \frac{4T_0 R_n}{Z_0} \frac{\left|\Gamma_s - \Gamma_{opt}\right|^2}{\left|1 + \Gamma_{opt}\right|^2 \left(1 - \left|\Gamma_s\right|^2\right)}$$

- Single LNA case
- Noise Wave analyses
  - Optimum Noise match if $\Gamma_{opt} = \Gamma_s$

Aperture Array T_{sys}



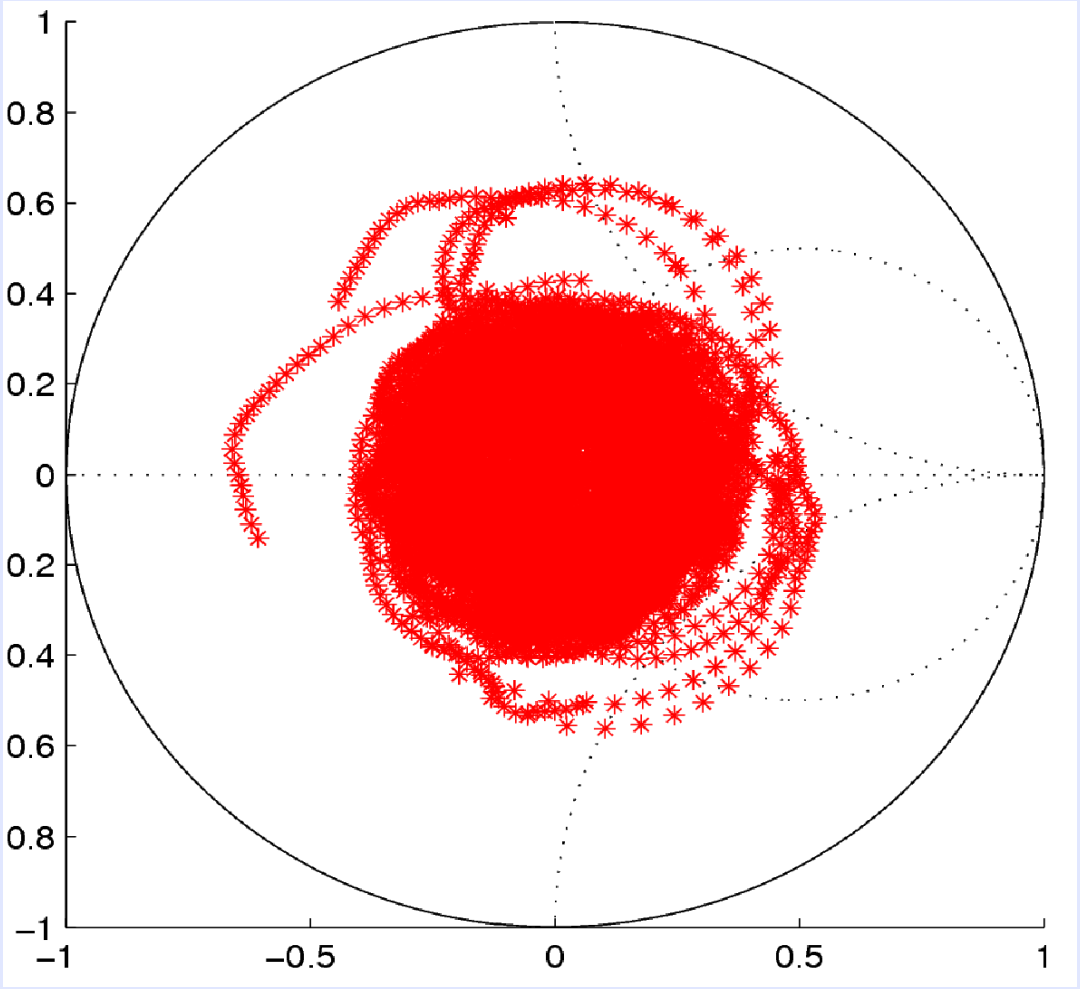
$$T_{LNA} = T_{\min} + \frac{4T_0 R_n}{Z_0} \frac{\left|\Gamma_s - \Gamma_{act}\right|^2}{\left|1+\Gamma_{opt}\right|^2 \left(1-\left|\Gamma_{act}\right|^2\right)}$$

$$\Gamma_i(\theta,\varphi) = \frac{1}{a_i} \sum_{j=1}^{N} S_{ij} a_j$$

$$a_j = e^{-jk_0[(k-1)d_x \sin\theta\cos\varphi + (l-1)d_y \sin\theta\sin\varphi]}$$

- T=Direct part + Reflected part + coupled part
  - Optimum Noise match if $\Gamma_{opt} = \Gamma_{act}$

Active reflection coefficient while scanning



Measured

8×8 array

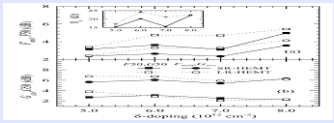
Γ_{act} of centre element

$500 < f < 1500$ MHz

$\theta < 45$ deg

Aperture Array T_{sys}

- Clearly low T_{min} and R_N or N required
- Limited work on N (process) optimization

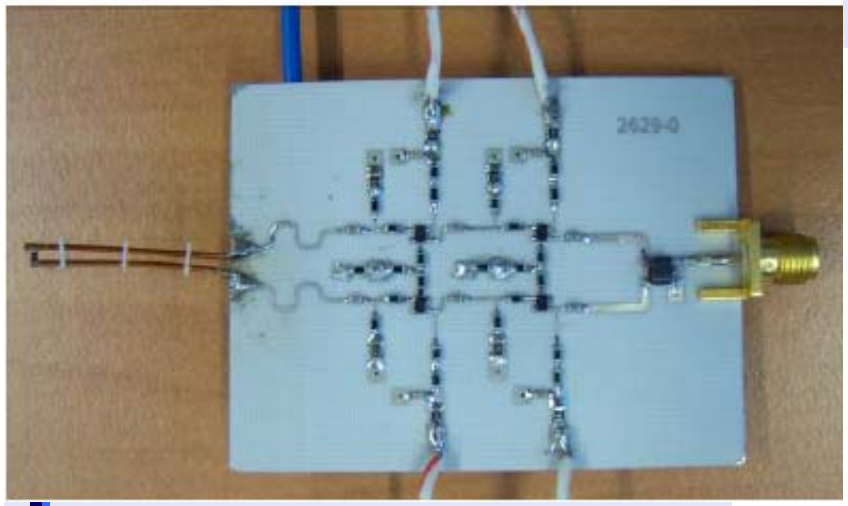


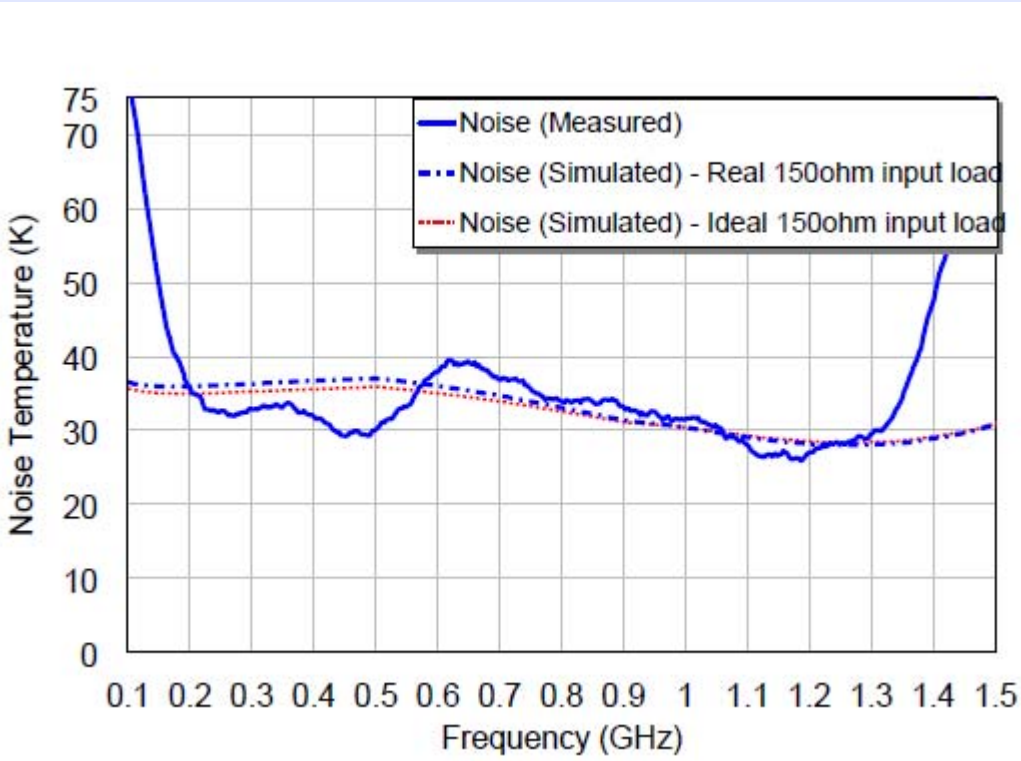
Simulations Ref. Mateos et.al., 2004/2008

- And analyses based on a normalization of Γ_{act} to S_{11} of the LNA: reasonable power match required!

Avago 35143 differential LNA

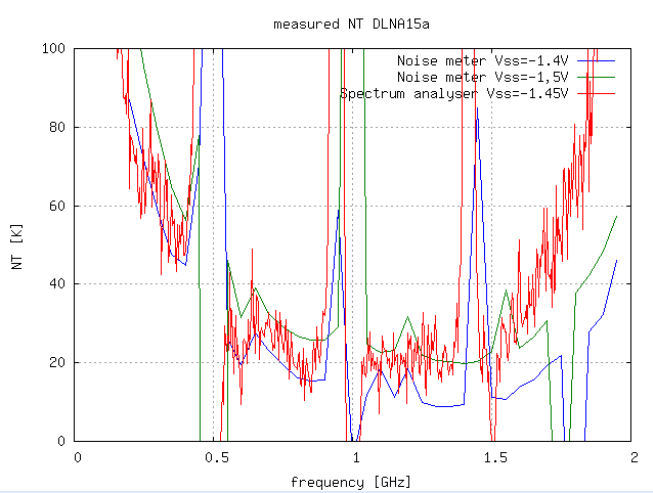
- 150 Ohm input impedance

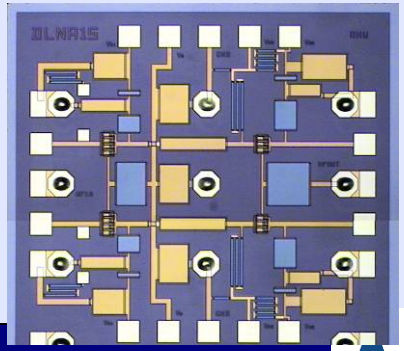




MMIC LNA

- mHEMT OMMIC LNAs
  - differential
  - Low Rn, Low Noise @300K
    - f_T~250GHz
  - Measurement ~20K
    - Oscillations issues

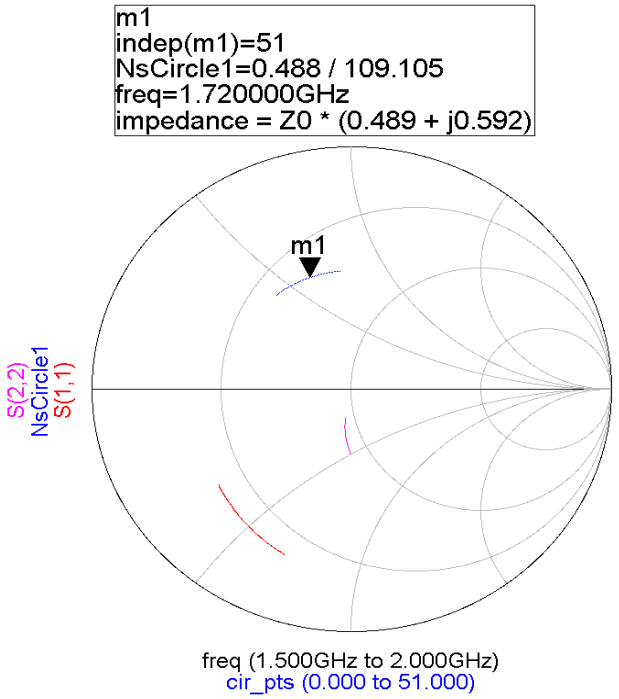




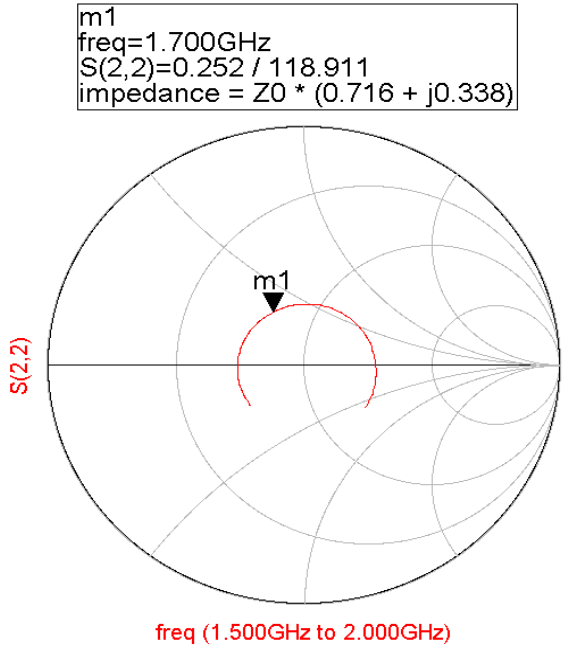
70nm mHEMT process validation

To validate the noise modelling of the mHEMT,

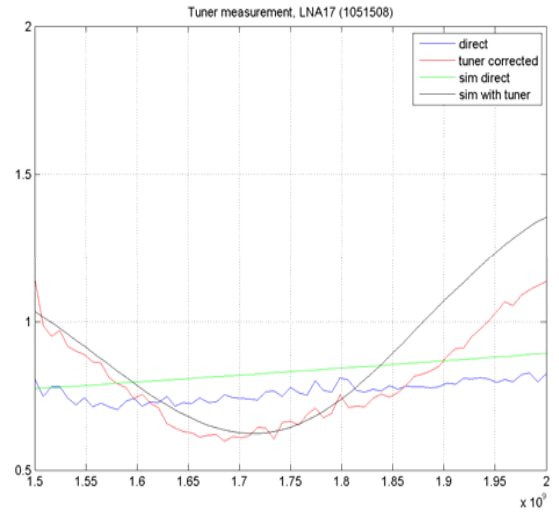
the Γ_{opt} and the Rn have been measured: models not correct



simulation



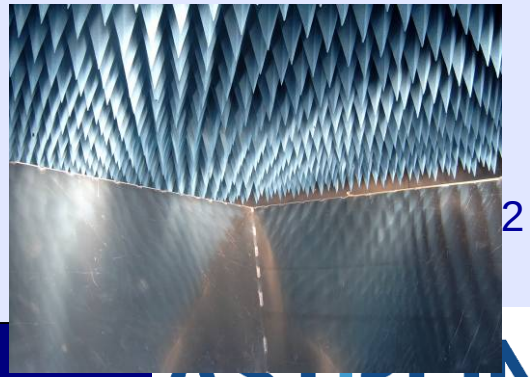
measured



Rn=0.17

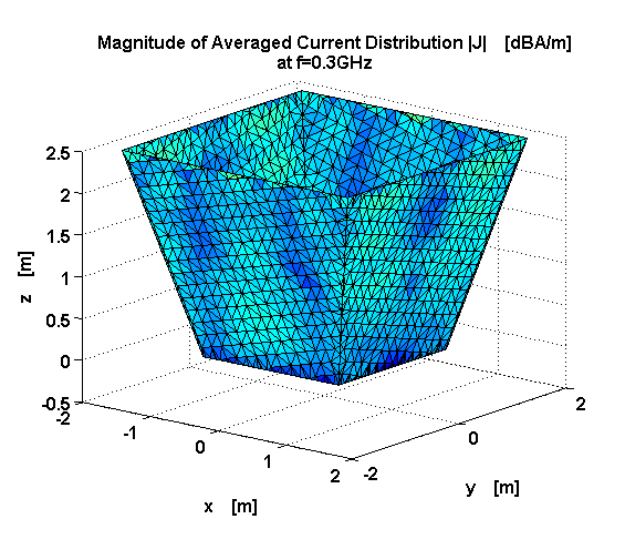
Rn=0.19 @1.6GHz

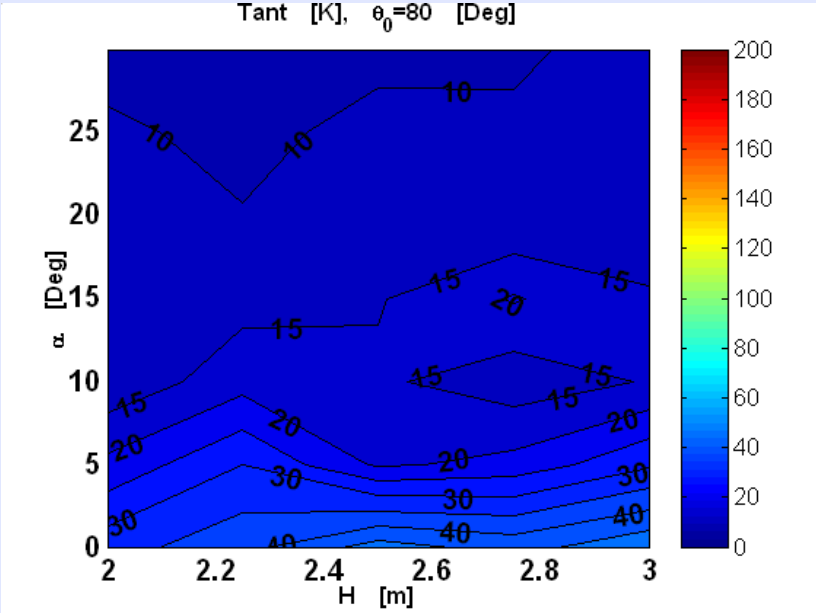
Hot cold test facilitv: THACO



THACO analyses

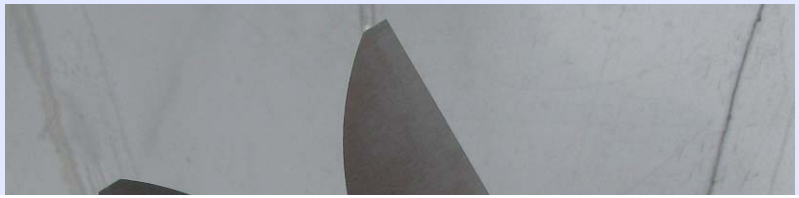
- Spill over simulations

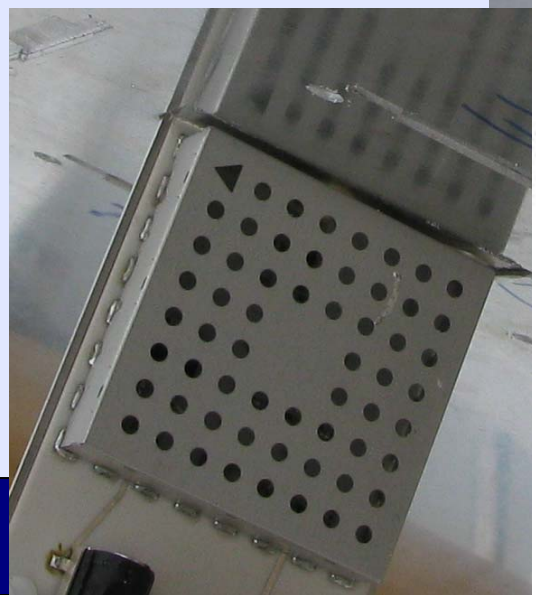


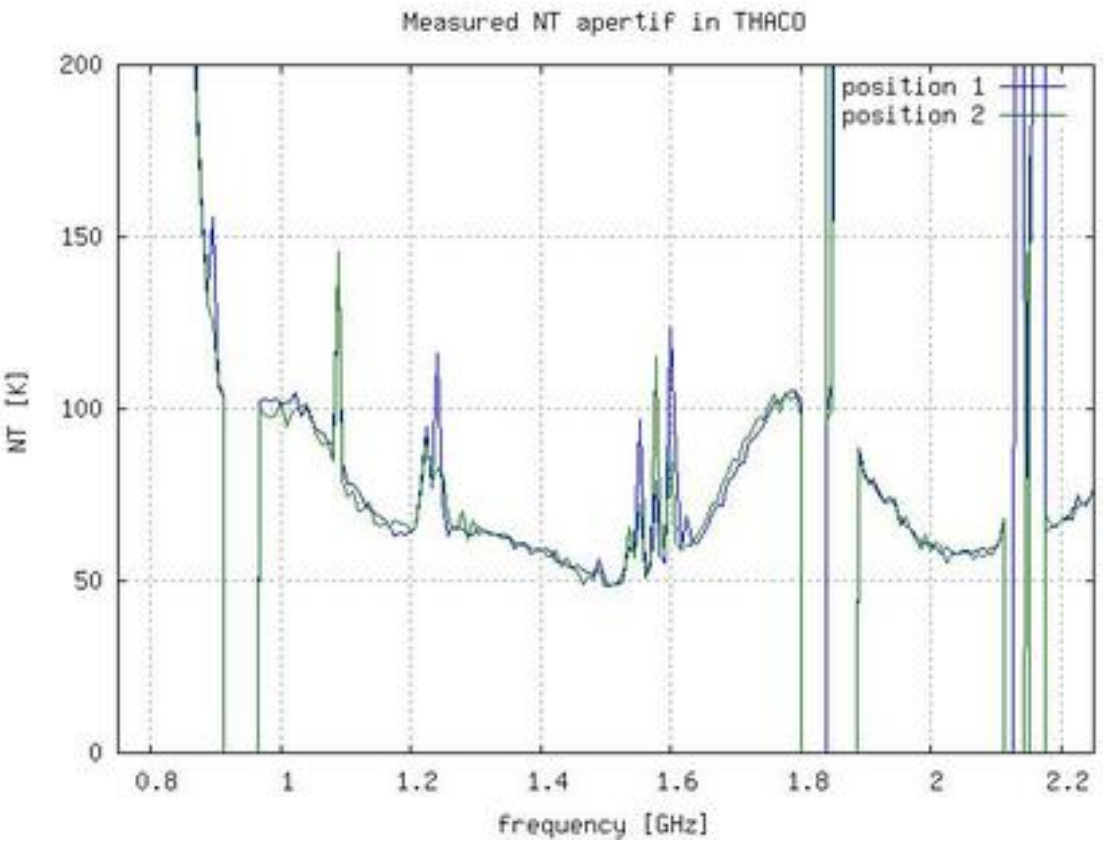


Antenna: Al Vivaldi radiator PAFs; APERTIF

- Feed board and LNA integrated on one board: Avago based APERTIF Vivaldi+LNA
  - Measured 52K Trec







Pitfalls

- Unwanted visitors

✓More RFI

✓Animal Interference

AA T_{sys} characterization

- Action plan..
  - Establish available equipment list
  - Including noise parameter test sets, tuner set-up / F50 method
  - Select AA relevant LNA for cross testing: ***Transfer LNA***
  - Including approach for differential LNAs
  - Set-up small working group →frequent cross test of new designs
- Involvement off all partners working on low noise
  - UoM, OPAR, FG-IGN, Chalmers, Calgery, ASTRON…..and?
  - Start with SKADS soon evolving in ***Aperture Array Verification Plan***

Conclusion

- More effort required on room temperature LNAs
- Low frequency transistor modeling:
  - Pospieszalski, many unphysical models
- Low frequency array T_{sys} characterization

- Design of a 1500m^2 prototype array starts soon
  - 100.000 LNAs