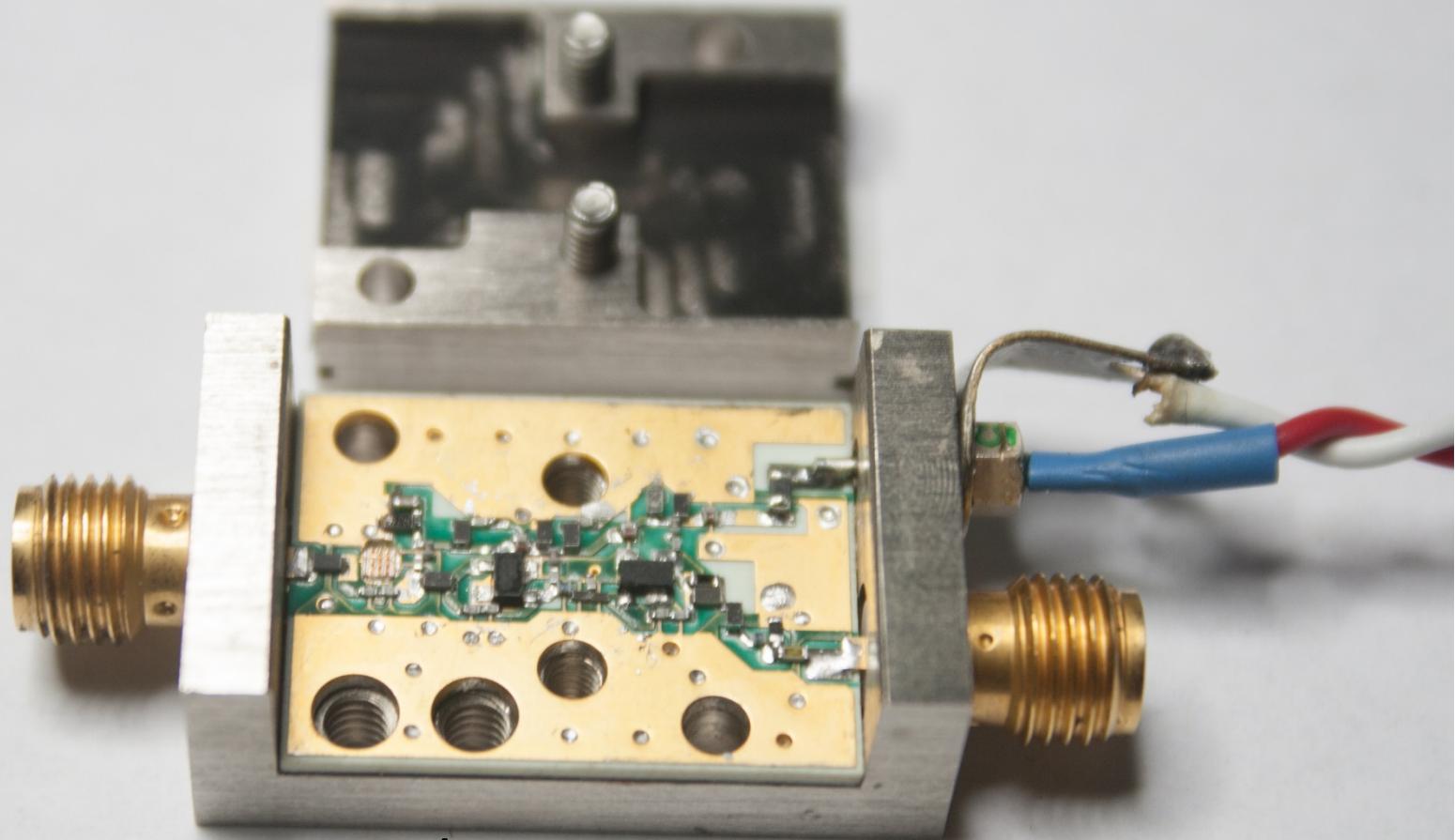


# MANUFACTURABLE CRYOGENIC SIGE LNA FOR RADIO ASTRONOMY AND SPACE COMMUNICATIONS



Andrew Janzen  
California Institute of Technology

# Outline

- Designing the amplifier

- Understanding the transistor
- Designing the circuit

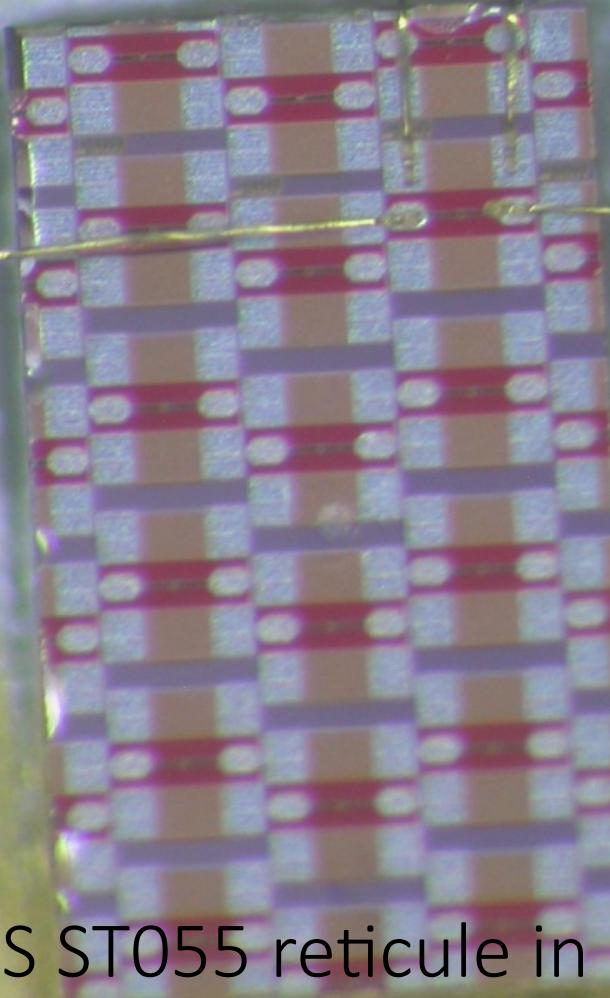
- Amplifier measurements

- Noise measurements
- Modeling comparison

- Current work

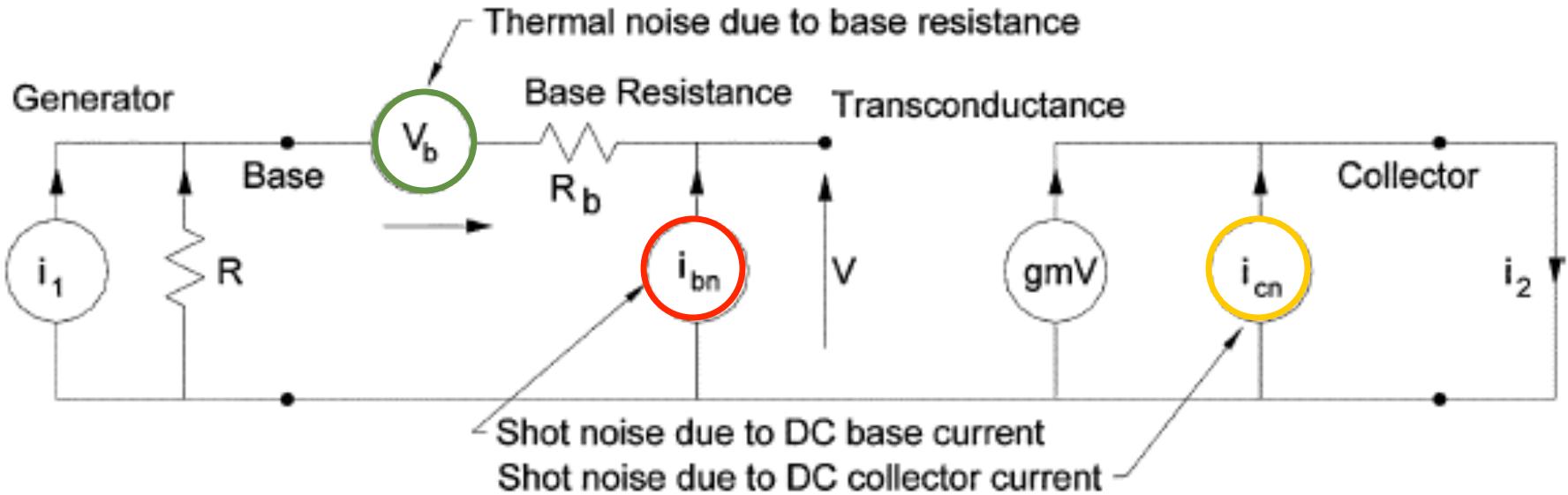
- Improving frequency range
- Improving P1dB

# Why Use Silicon Germanium?



BiCMOS ST055 reticule in module

# Understanding the transistor



$$i_{dn}^2 = 2qI_{dn}$$
$$v_{dn}^2 = 4kT_o R_b$$

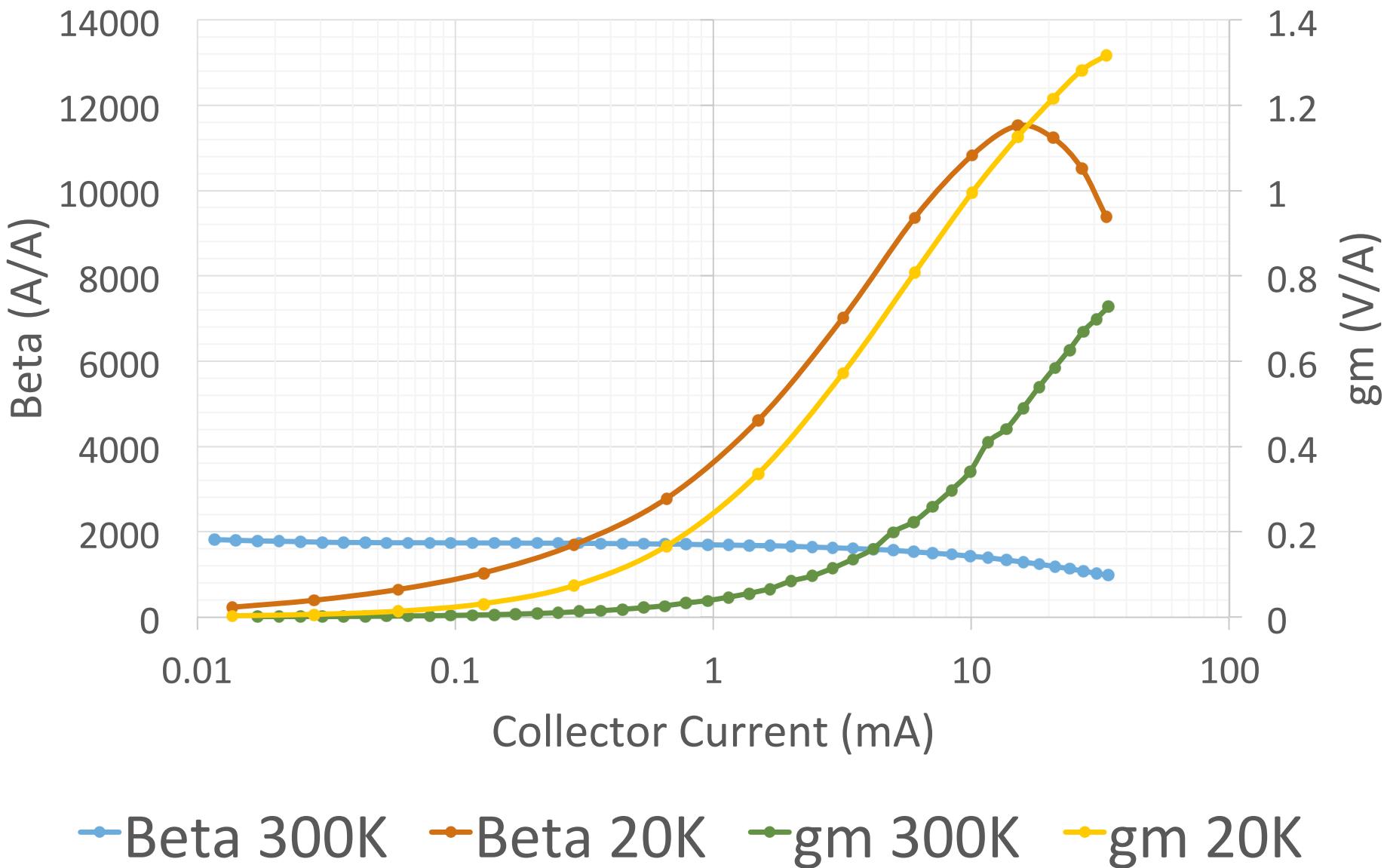
## Understanding $T\downarrow min$

$T\downarrow min$  is the minimum noise temperature achievable. It occurs when the generator impedance  $R\downarrow g = R\downarrow opt$

$$T\downarrow min \approx I\downarrow c / (k\downarrow b / q) * gm\sqrt{\beta}$$

# Measured Beta and Gm

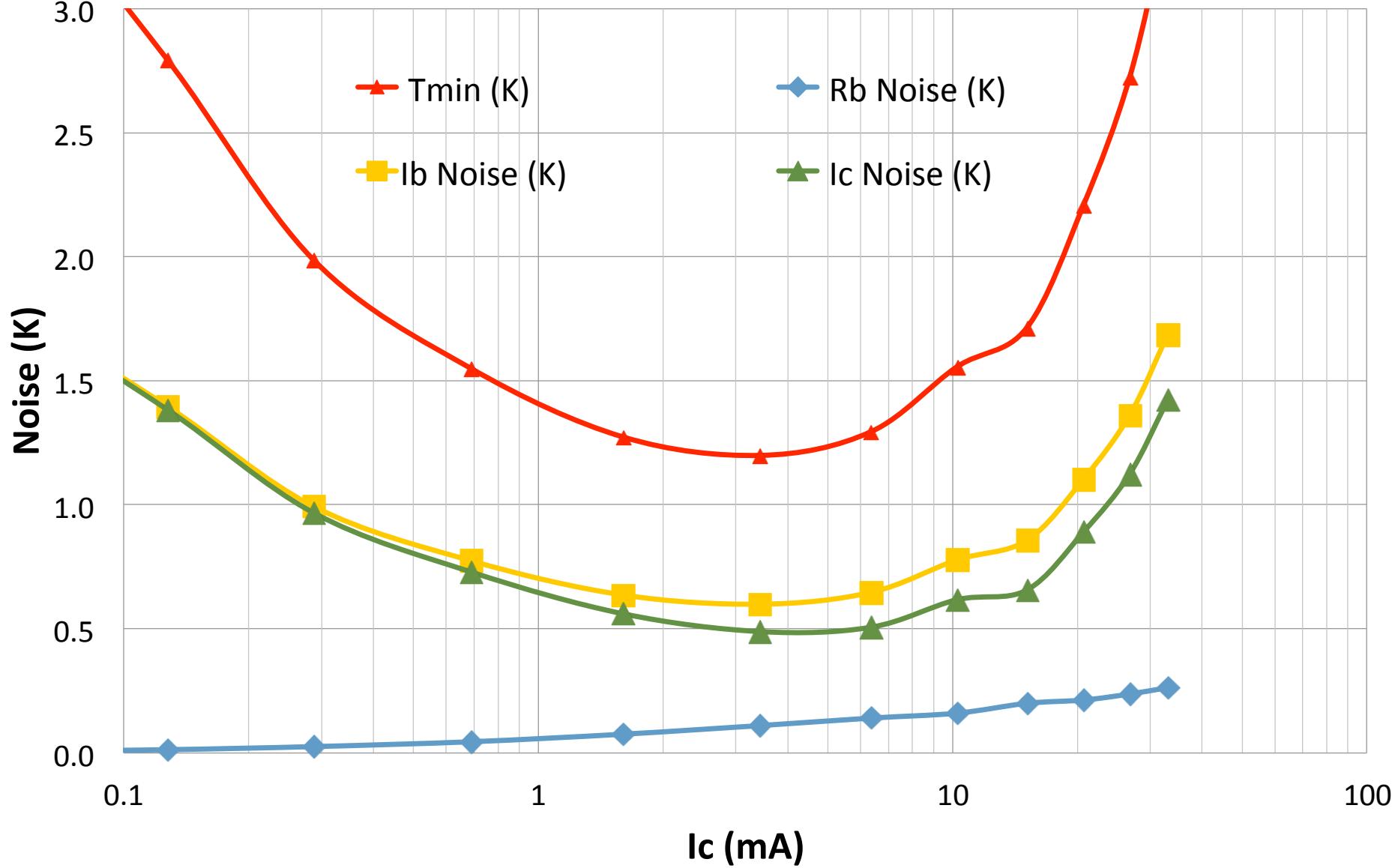
## ST055 HS transistor, 20K ,300K



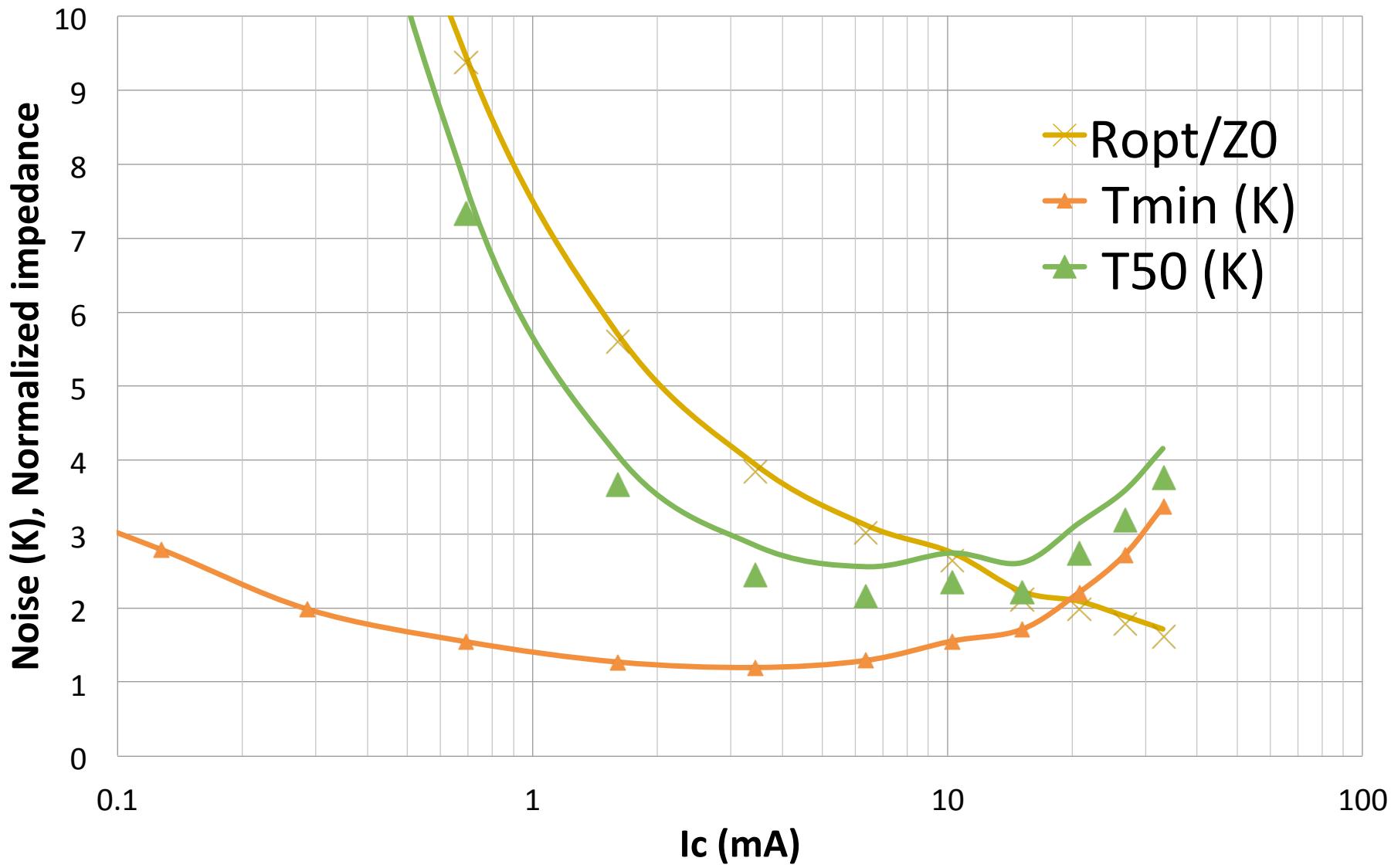
# Components of $T_{min}$

using ST055HF transistor measured gm, DC beta, and

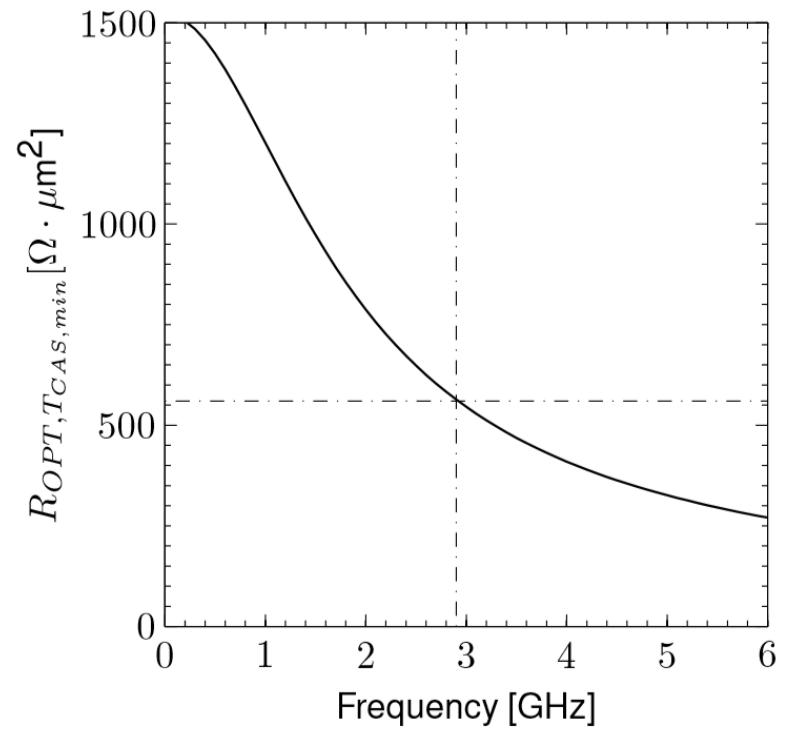
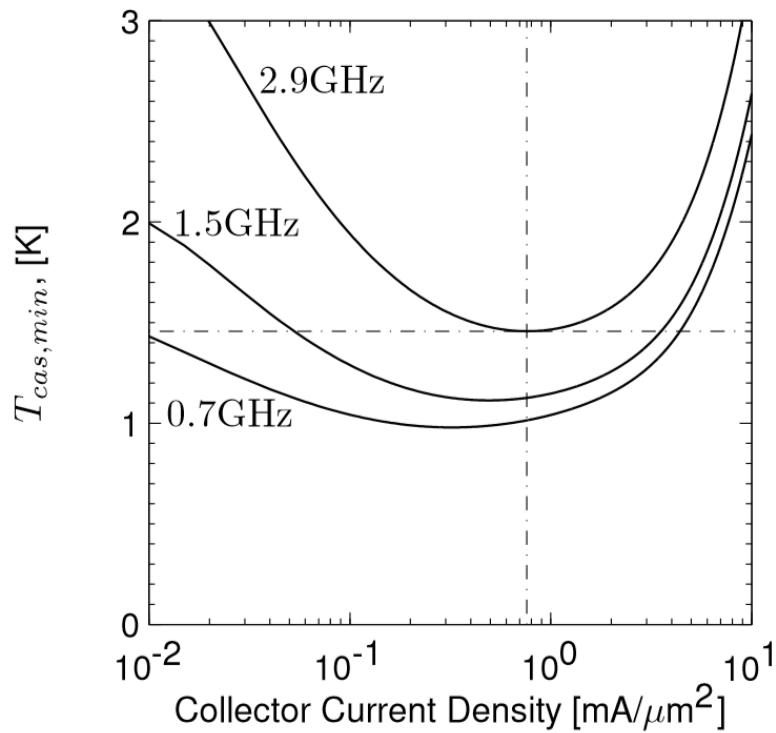
$R \downarrow B$



# Noise Model predictions for $R_{opt}$ , $T_{50}$ , and $T_{min}$ using measured $gm$ , $\beta_{DC}$ , and $R_b$ from ST055HF transistor

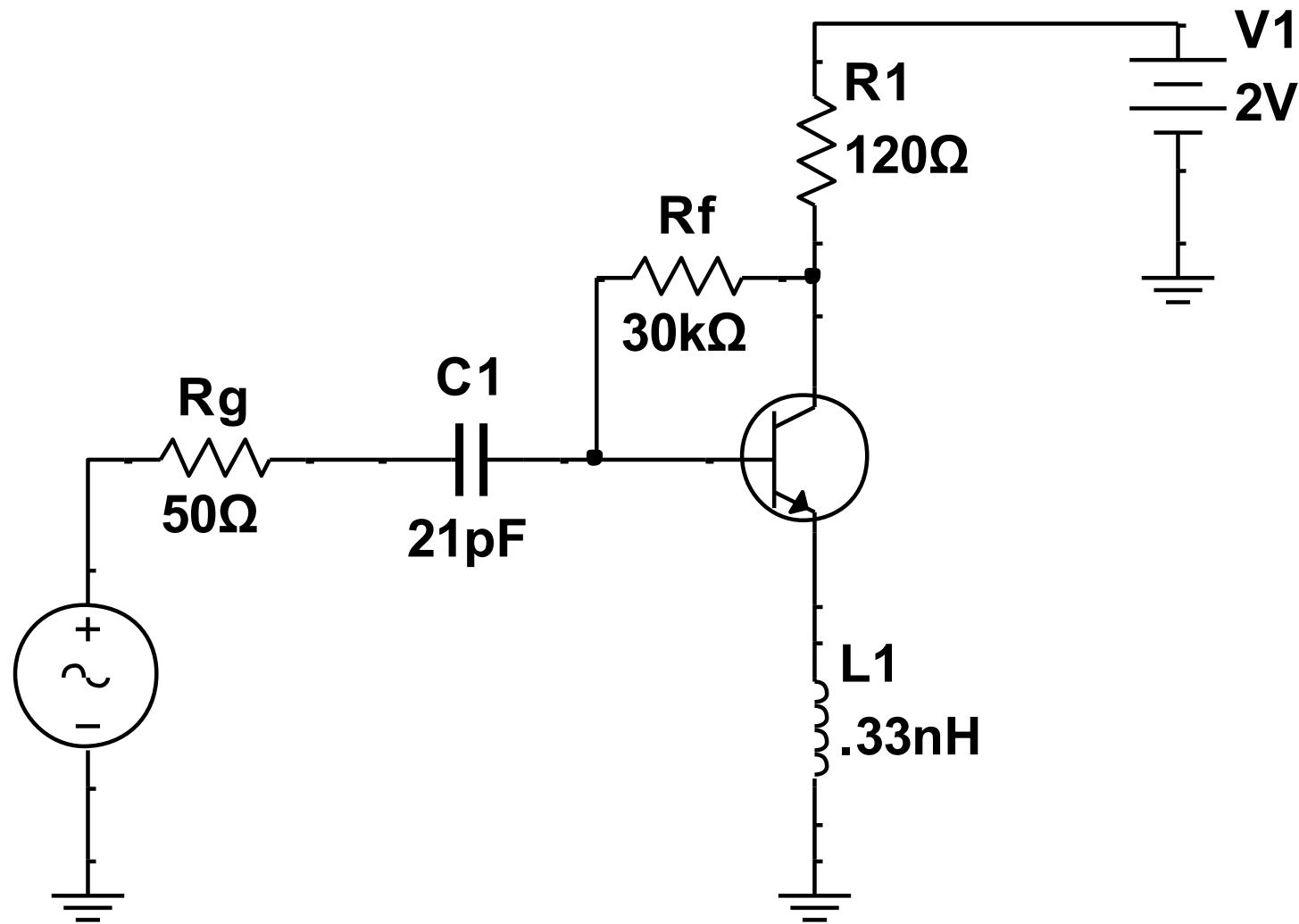


# Selecting Area and Bias for minimum noise

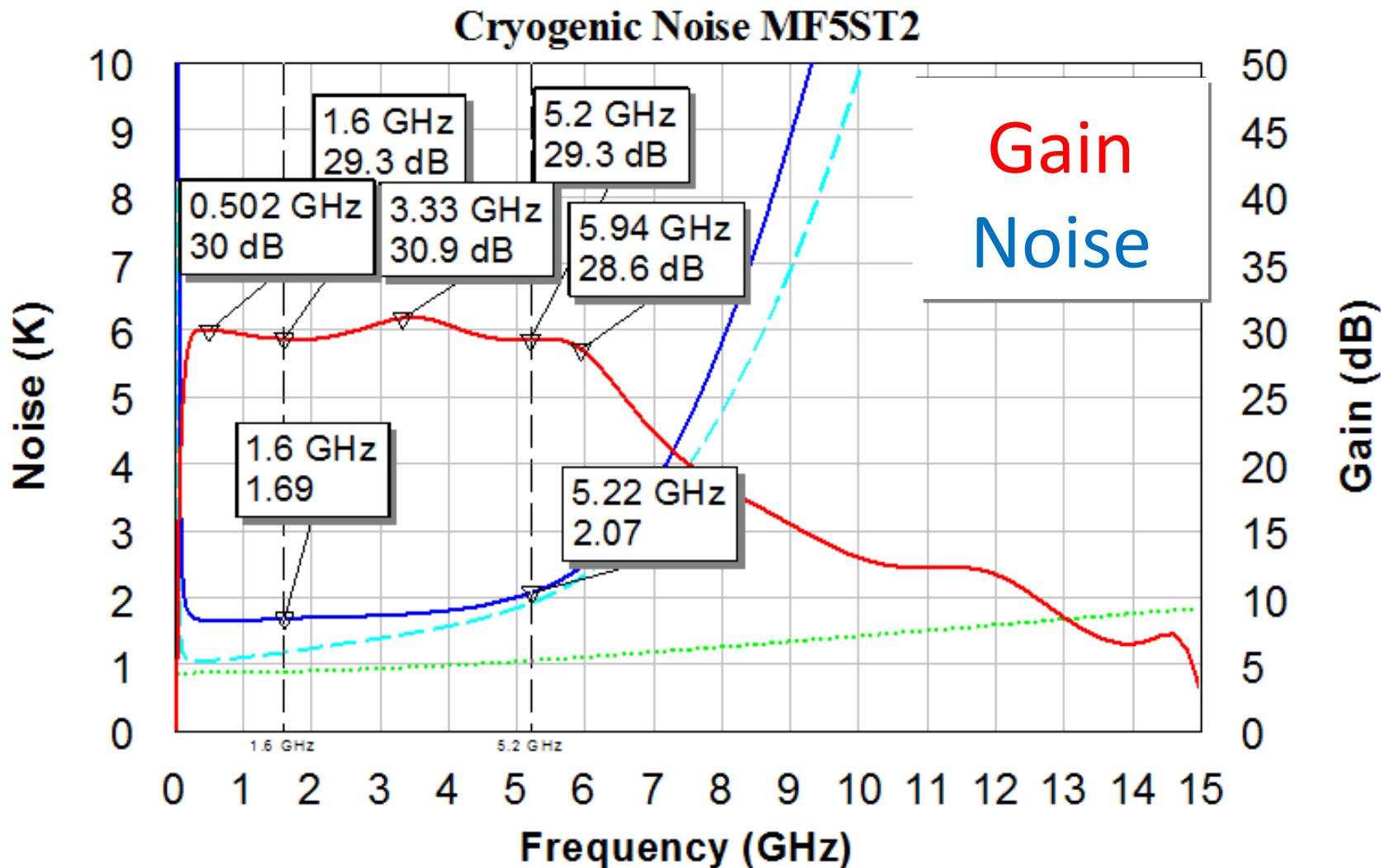


Silicon-Germanium Heterojunction Bipolar Transistors for  
Extremely Low-Noise Applications. J. Bardin Thesis. 2009.

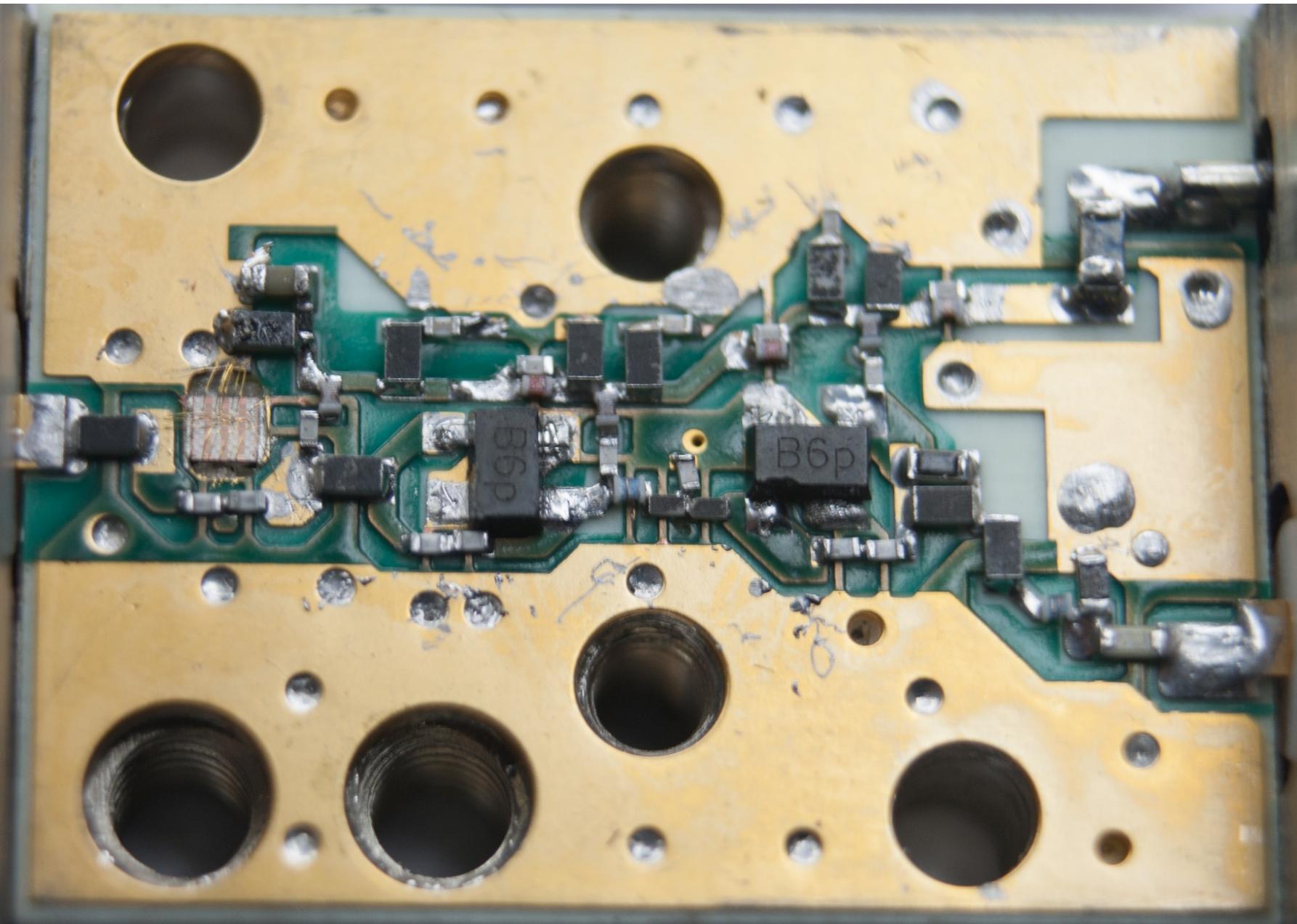
Common Emitter amplifier employing base feedback



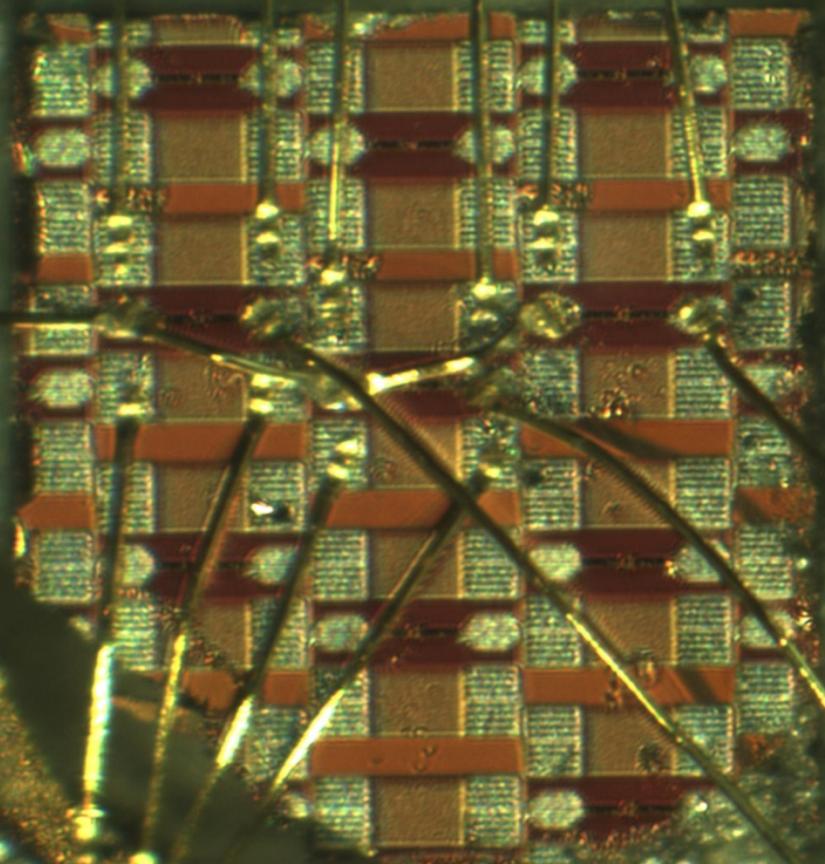
# Simulation noise prediction ST2 transistor, MF5 amplifier



# Assembled PCB



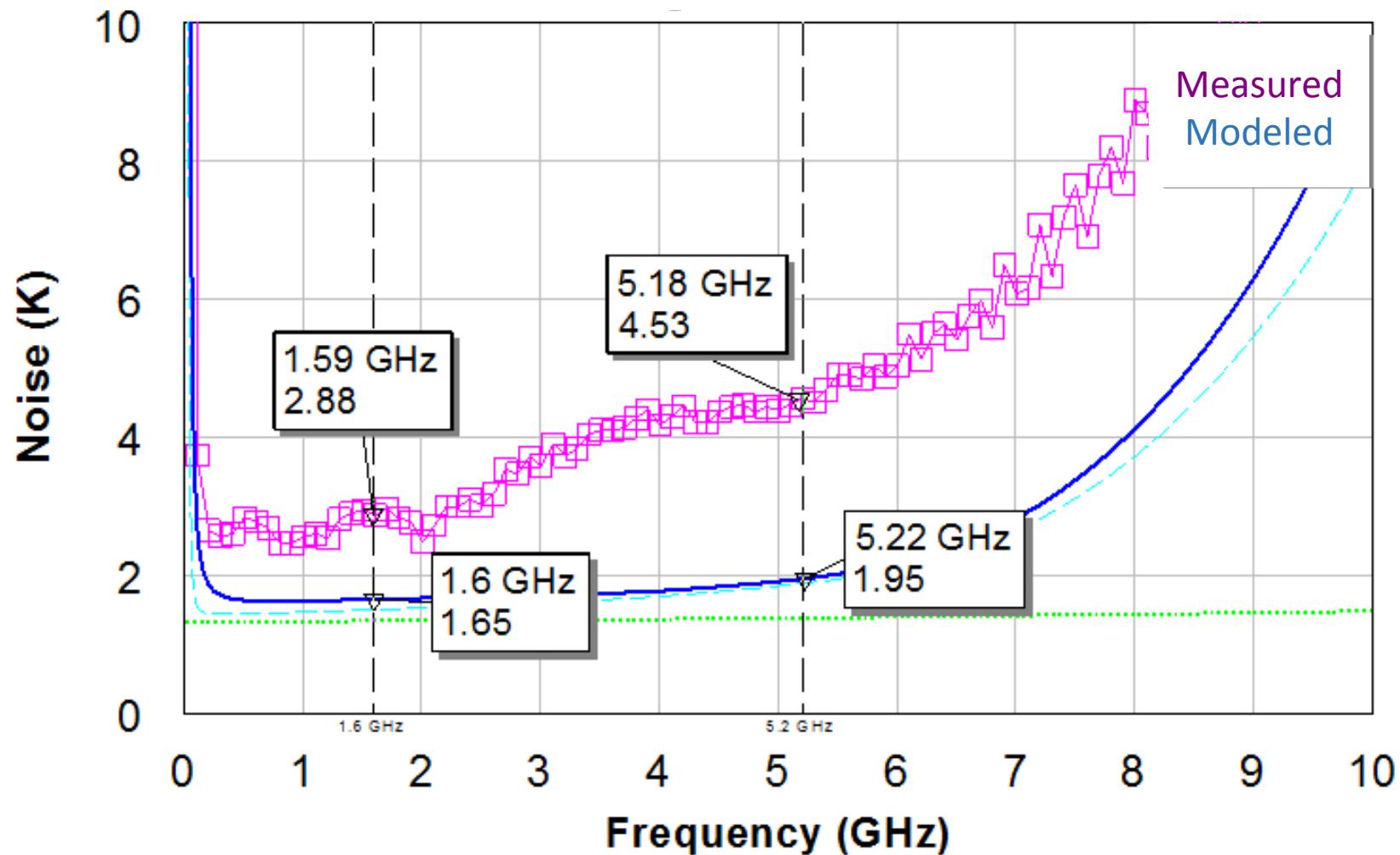
3 ST055HF transistors in parallel



# Measurement vs AWR noise models:

MF5 ST055HF transistor x3

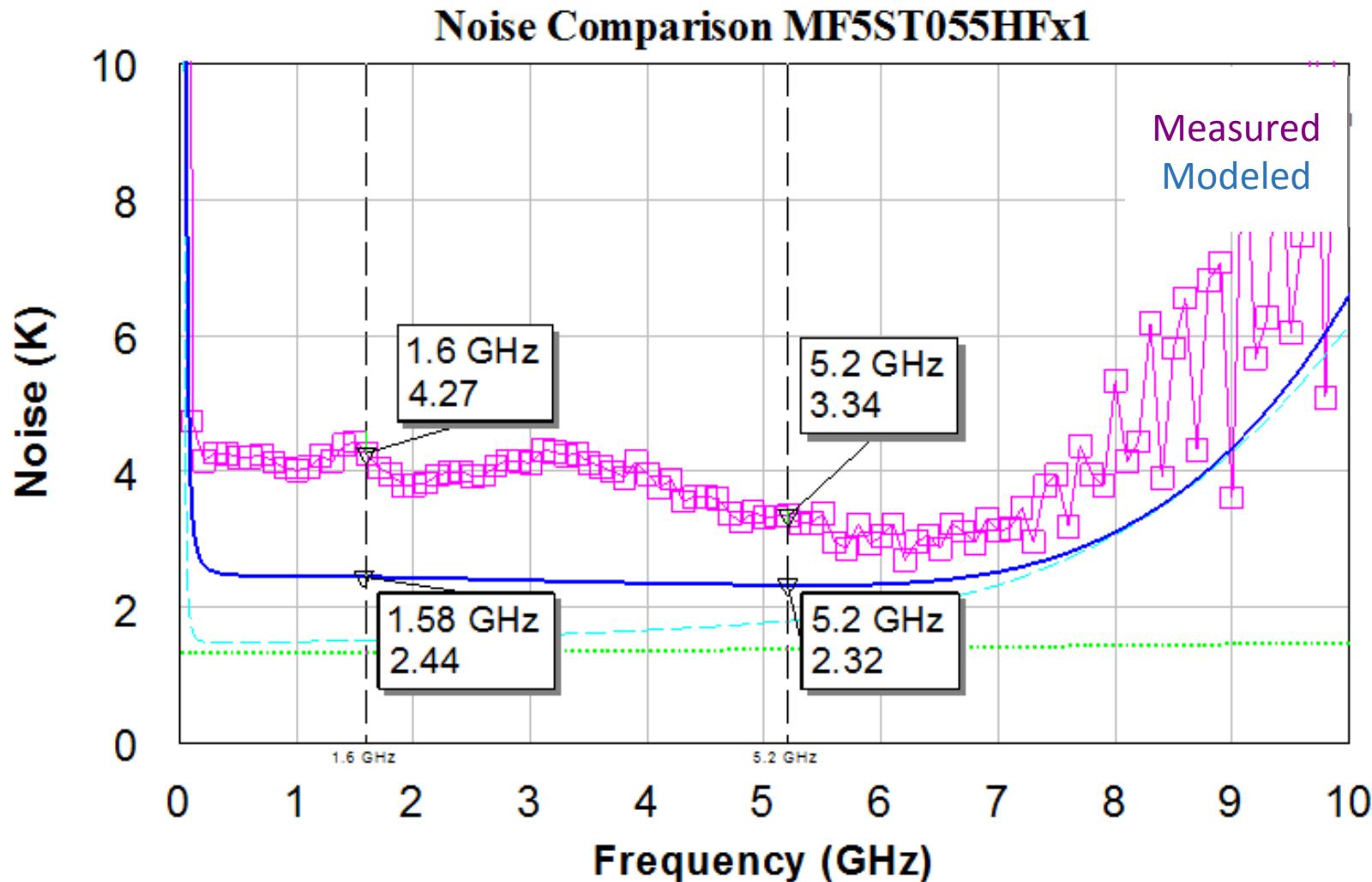
SN366, 19-21K, 8-24-2015 to 8-28-2015, Vcc = 2.5V, Icc = 20.3 mA, Ic Sim = 7 mA



# Measurement vs AWR noise models: MF5 ST055HF transistor x1

SN369, 19-21K, 8-24-2015 to 8-28-2015,

V<sub>cc</sub> = 2.5V, I<sub>cc</sub> = 14.5 mA, I<sub>c Sim</sub> = 7 mA

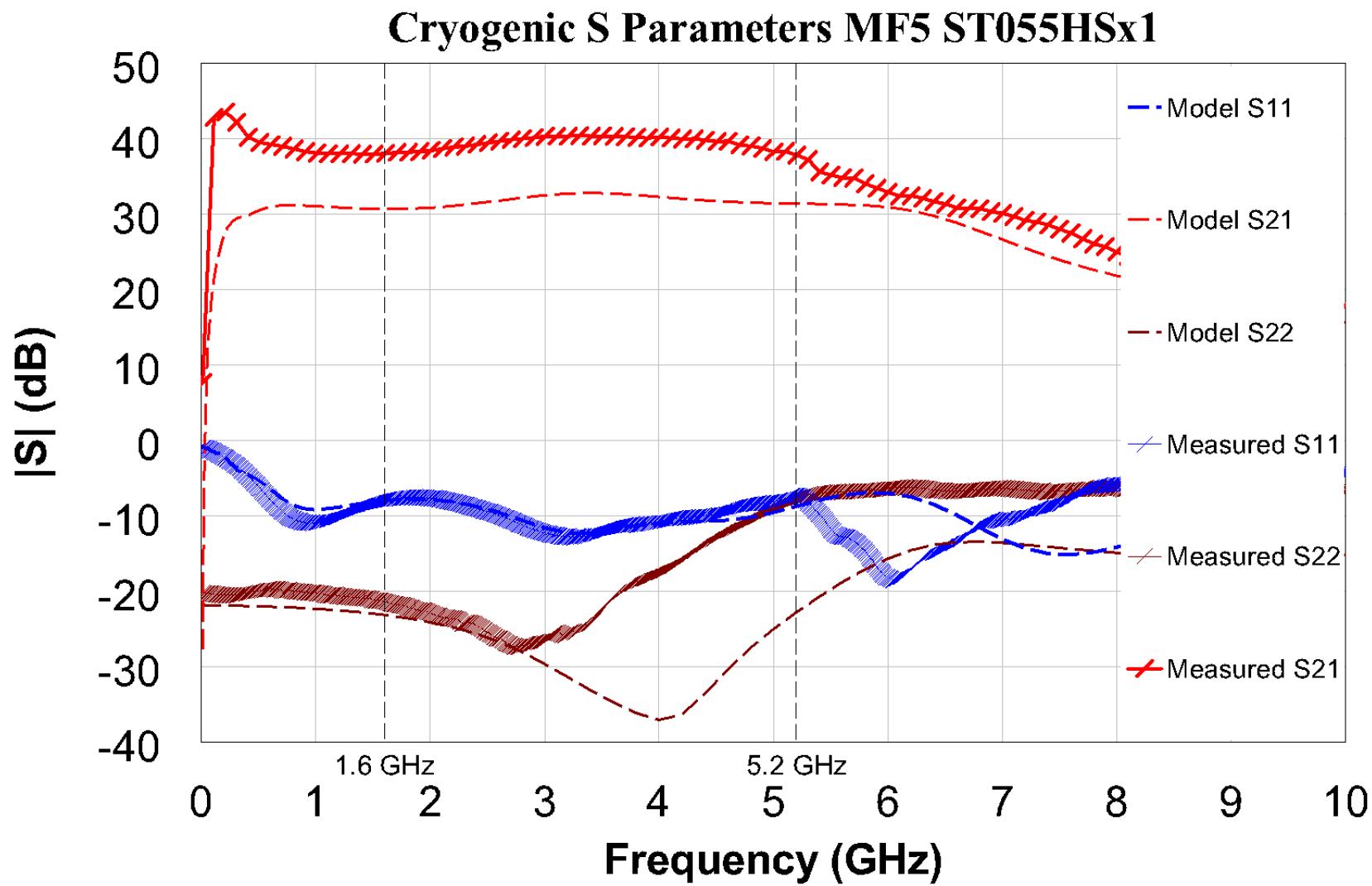


# AWR model and measured S parameters

## MF5 ST055HF transistor 1x

MF5 ST055HF transistor x1 SN369, 19-21K, 8-24-2015 to 8-28-2015

Vcc = 2.5V, Icc = 14.5 mA, Ic Sim = 7 mA



## Future work

- Increasing P1dB to reduce harmonic mixing from strong out of band RFI
- Working on a 1 - 8 GHz and 1 - 12 GHz LNAs
- Improving noise models

A wide-angle photograph of a natural landscape at sunset. The sky is filled with dramatic, wispy clouds colored in shades of orange, yellow, and blue. Below the sky, a range of mountains is visible, their peaks partially obscured by the low-hanging clouds. In the foreground, there is a calm body of water, likely a lake or a large pond, which perfectly reflects the colors of the sky and the surrounding environment. The shoreline is lined with various trees and shrubs, some of which appear to have autumn foliage. The overall scene is peaceful and captures the beauty of a natural sunset.

Questions