Component Testing for ADMX at Washington University

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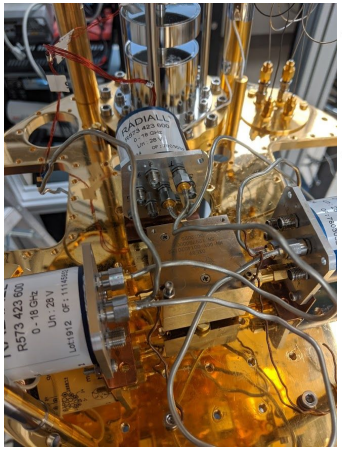
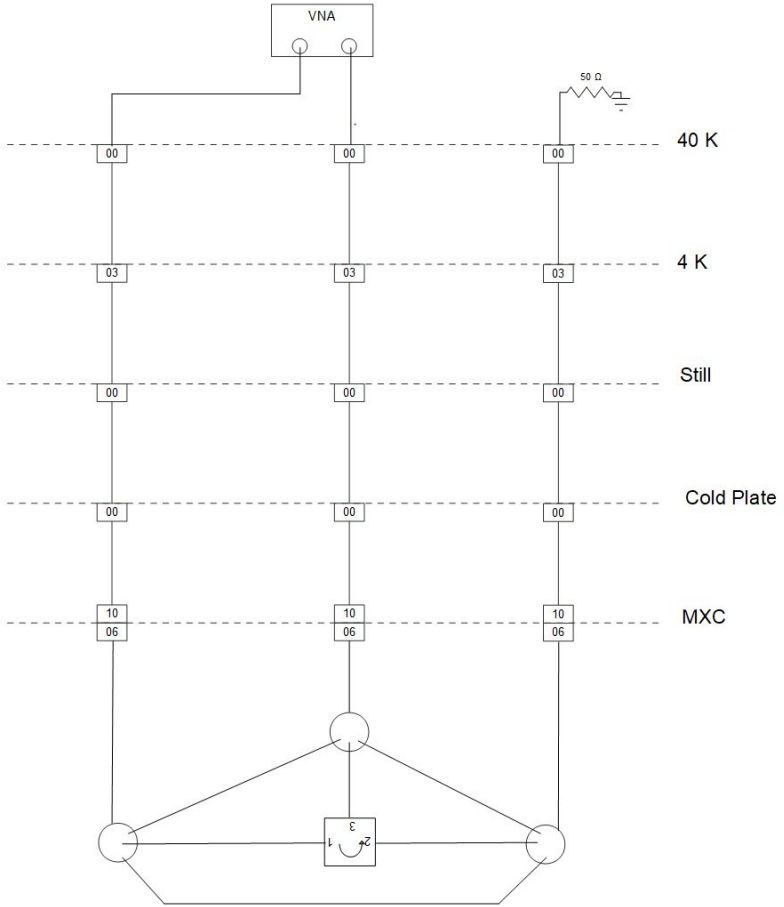
Measurement Infrastructure

- Bluefors DR with extended mixing chamber
- HEMT - LNF 34 dB, 4 K HFET
- VNA - Keysight E5070B ENA
- Spectrum Analyzer - R&S FSV
- Signal Generator - Anritsu MG369XB
- Current Source - Keithley 2450
- Bias & switch equipment
    - Current Source - Keithley 2450
    - Radiall 6-way and bypass switches
    - QDevil breakout box
    - In house switch pulse (one-shot circuit)

Circulator Test Setup

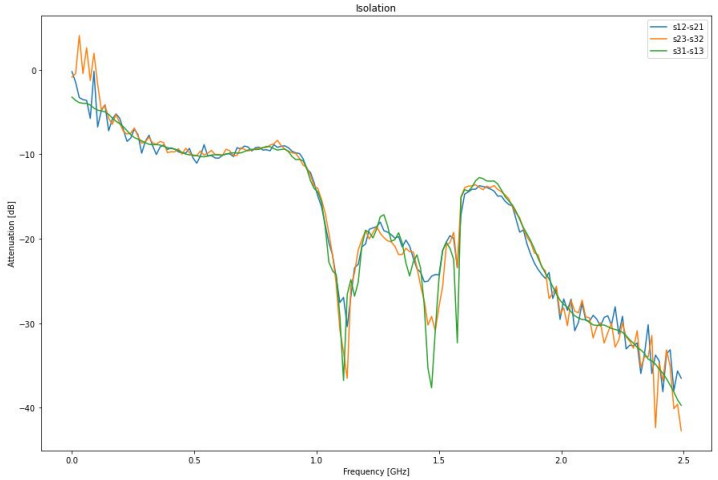
- What we're measuring:
  - Insertion loss
  - Isolation
- 3-port configuration to measure all S-parameters
- Over estimating bypass cable and underestimating through cables gives an upper bound on insertion loss

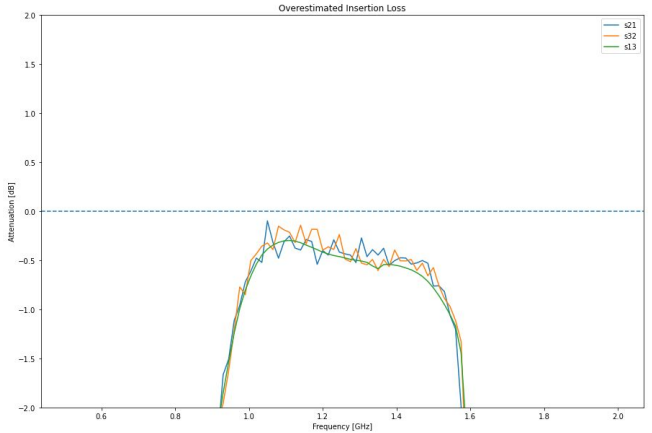




Circulator Test Results

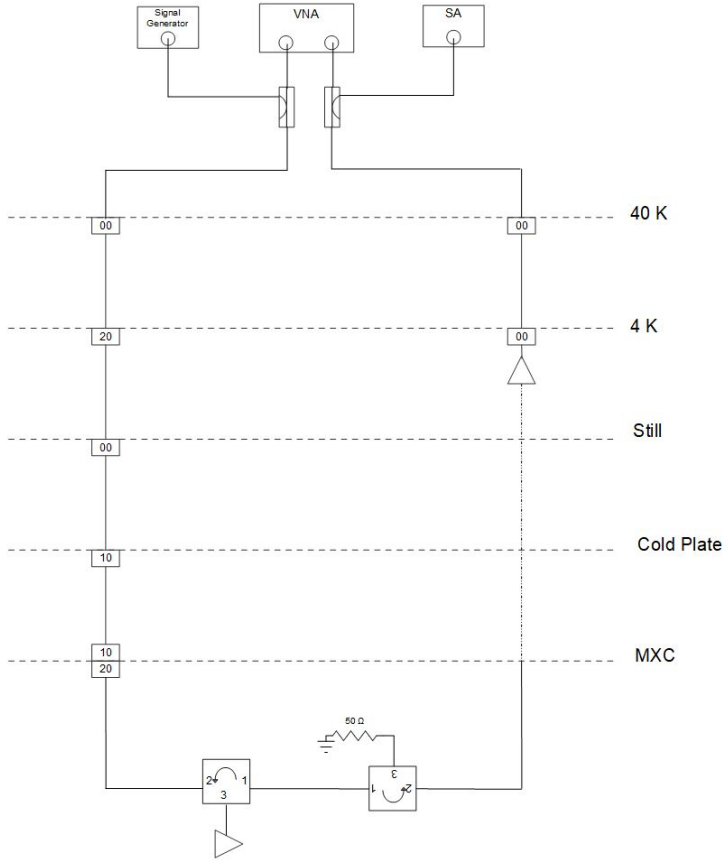
- We looked at a 1 - 1.5 GHz circulator and an incorrectly packaged 2A circulator
- 1 - 1.5 GHz circulator
  - Shown on the right
  - >15 dB isolation
    - Enough to account for a 30 dB gain JPA
  - Overestimated insertion loss shows <4 dB at peak around 1.1 GHz and <6 dB out to 1.5 GHz
- 2A circulator
  - Exhibited good qualities (>18 dB isolation and <0.7 dB insertion loss) from from ~ 1.3 - 1.8 GHz
- Planned cable attenuation measurements for more precision in insertion loss
- Waiting on properly packaged devices

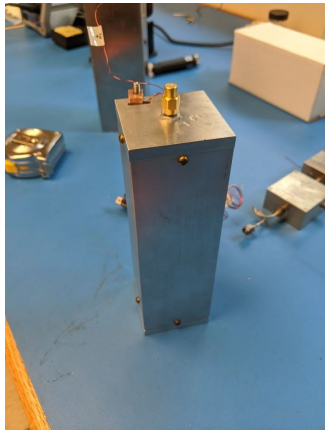




JPA Test Setup

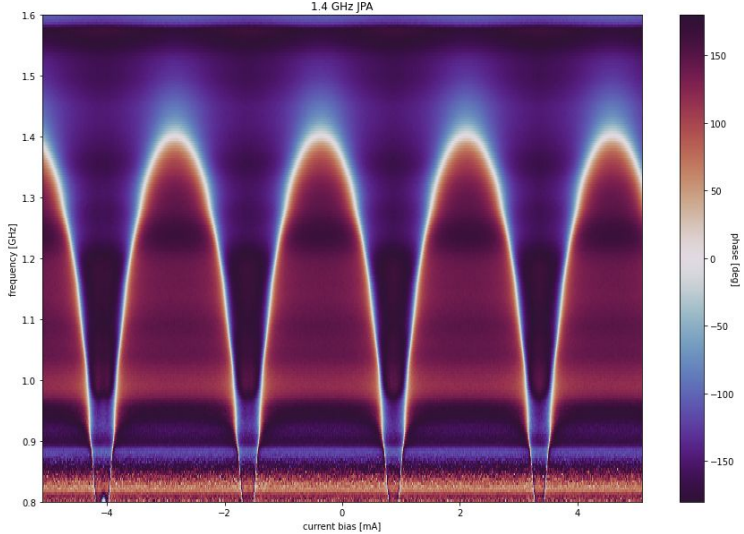
- What we're looking for:
  - Gain
  - SNRI
  - Frequency tunability
  - Noise temperature
- Shielding
  - Mu-metal shield
  - Aluminum Box
- Flux / current bias stability
  - 1 kHz low pass filter
  - 1 kΩ series resister

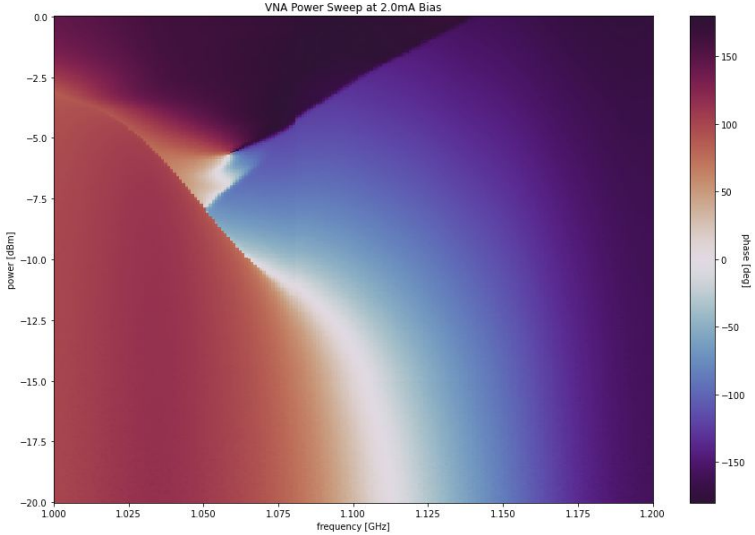




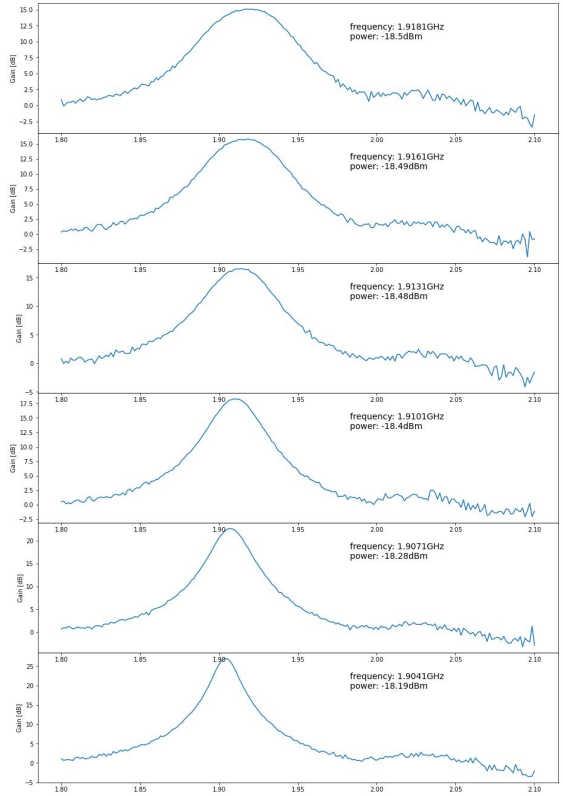
JPA Biasing

- ‘1.4 GHz’ JPA is tunable up to ~ 1.3 GHz
  - As seen in the plot on the right, resonance is higher when under pumping for bias curves
- 1.9 GHz is tunable up to 1.9 GHz

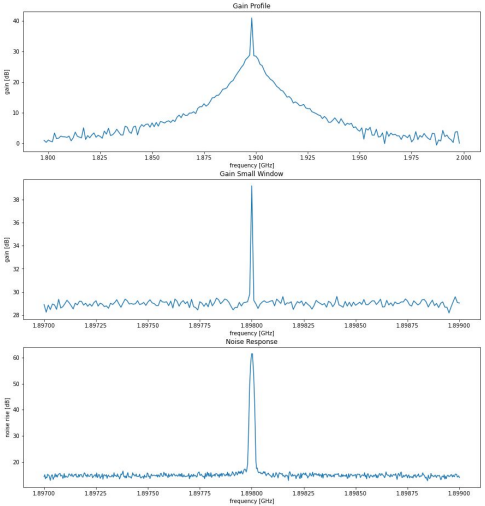




JPA Gain and Noise Measurements



$$SNRI = \frac{G_{JPA}}{P_{on}/P_{off}}$$

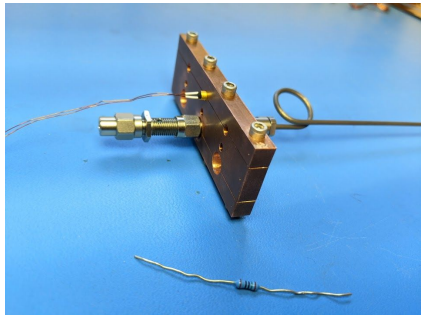


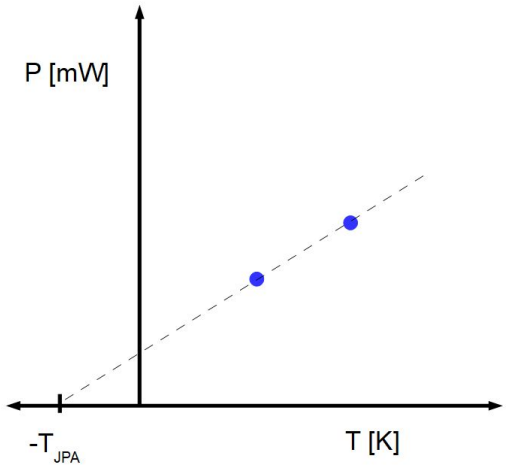
- 1.9 GHz JPA
  - > 25 dB gain at 1.9 GHz with 17 dB SNRI
  - > 15 dB gain down to 1.35 GHz with 12 dB SNRI
- 1.4 GHz JPA
  - > 20 dB gain at 1.34 GHz with 15 dB SNRI
  - ~ 10 dB gain at 1 GHz with 8 dB SNRI

Noise Temperature Measurements

- To make a precise measurement of temperature we want to use y-factor method
  - Still is on the order of saturation level for typical JPA, so unsuitable as a noise source
- We need a calibratable, broadband noise source that is thermally isolated from the device under test.
- Need to calibrate Lakeshore temperature sensor.

$$P_1 = G_{JPA}(T_1 + T_{JPA})k_b B$$





Coming Up

- Temperature sensor calibrations for hot load
- More JPA tests (including noise temperature measurements)
- Characterization of new circulators when they arrive
- Squidadel tests