Optics and Receiver Design for Sensitivity

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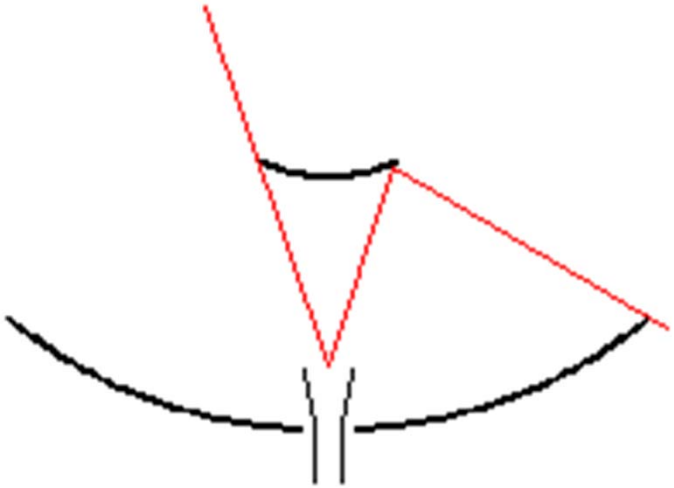
Introduction

- Sensitivity is king
- Effective area is costly
  - Difficult to use “more efficiently”
- Dishes operate in the low sky noise range
- Pays to control system noise temperature
  - “Every K is sacred”
- Modern EM modelling can really help

Introduction

- Understand the mechanisms
  - Cassegrain systems believed to have low noise as the feed points at the sky
  - Main reflector is still illuminated
  - Pattern calculation show sharp drop off

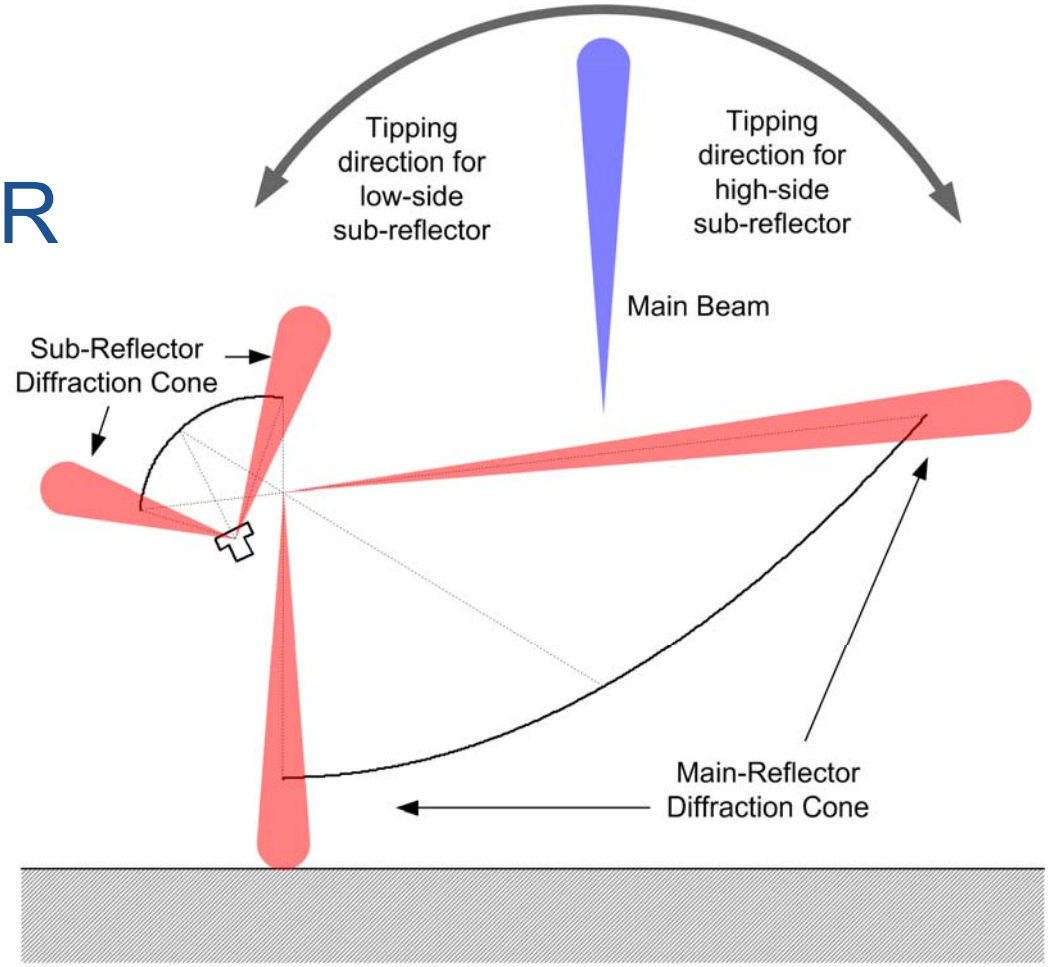


System noise temperature

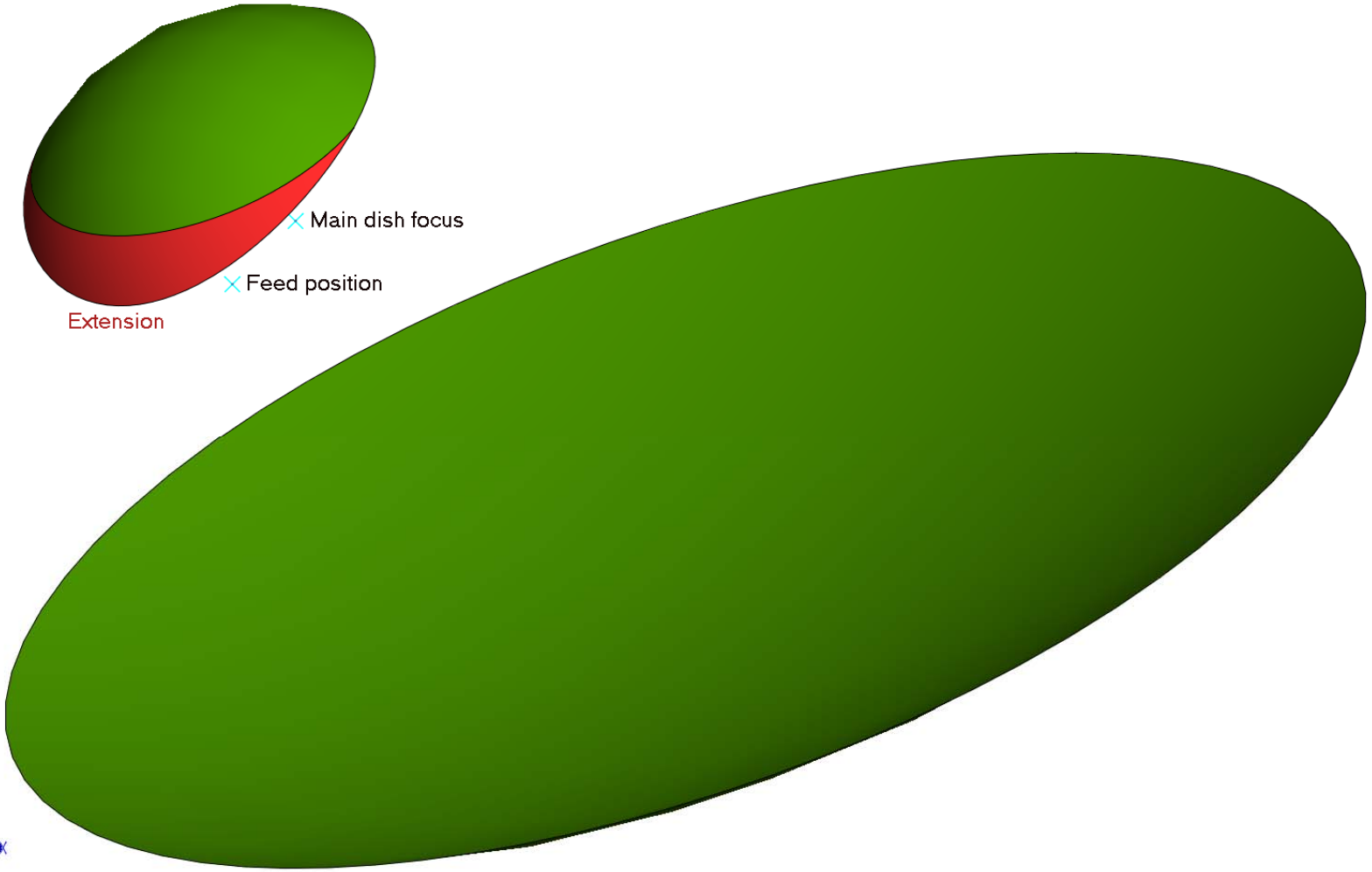
- Spillover noise
  - Optics has significant impact
  - Feed must be optimised for optics
- Signal path loss
  - Under control of feed package designer
  - Most attention to hot parts
- Active component (LNA) contribution

Controlling spillover

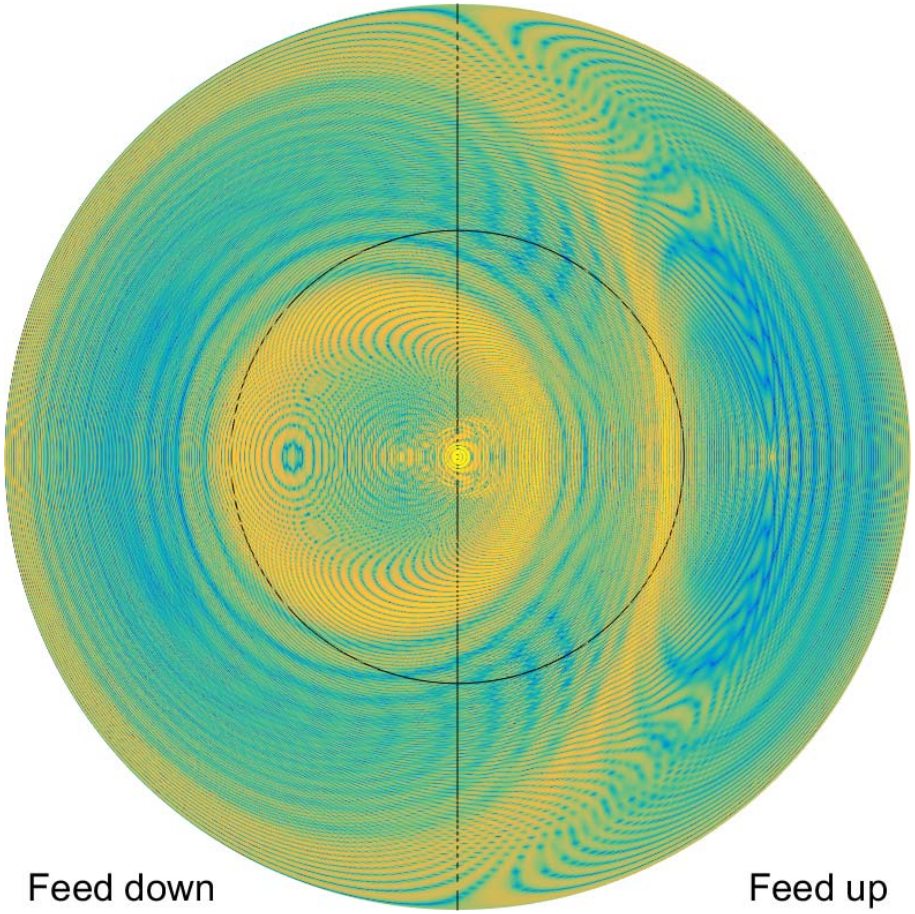
- Offset Gregorian
- Feed up past MR
- Feed down past SR
- Extend reflector to shield



Sub-reflector extension

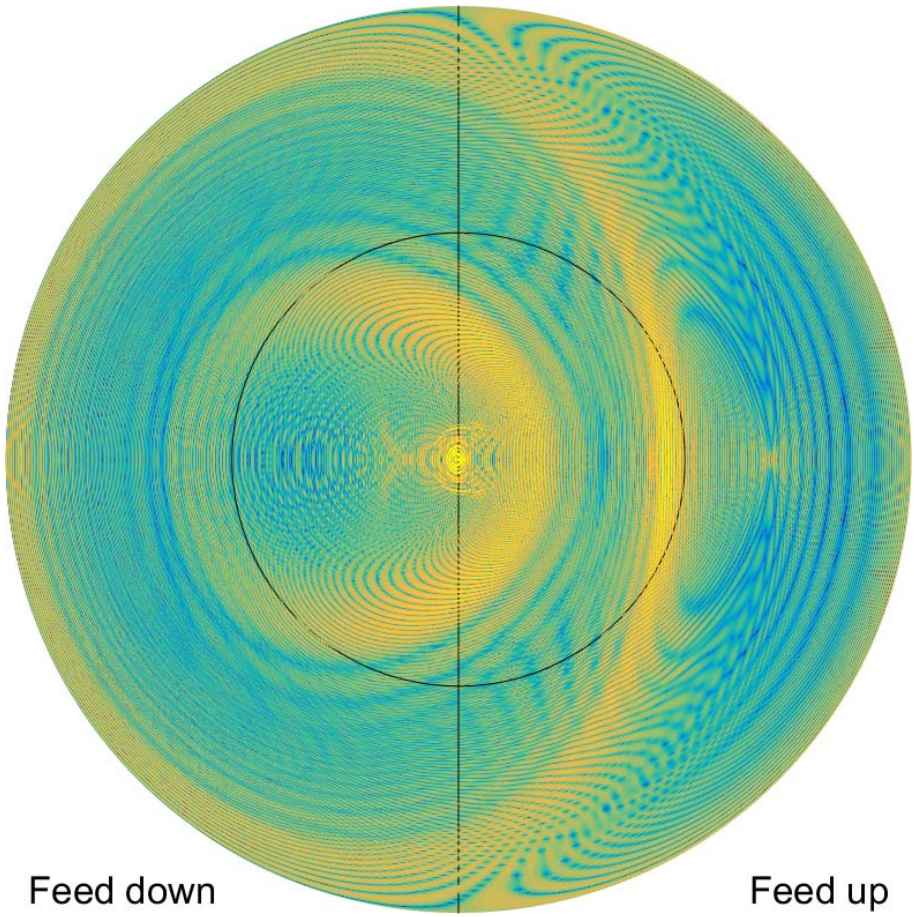


Effect of extension



Feed down

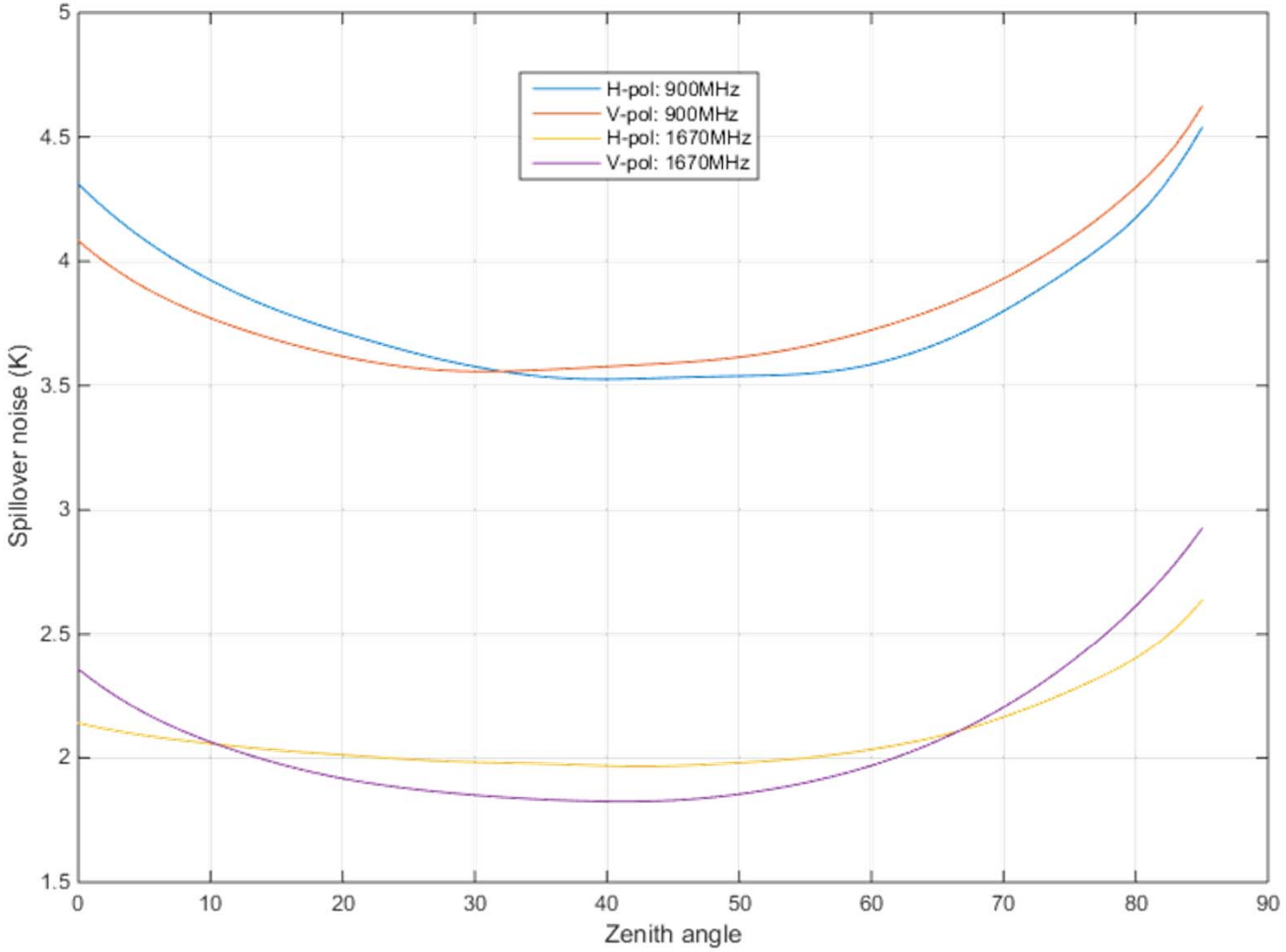
Feed up



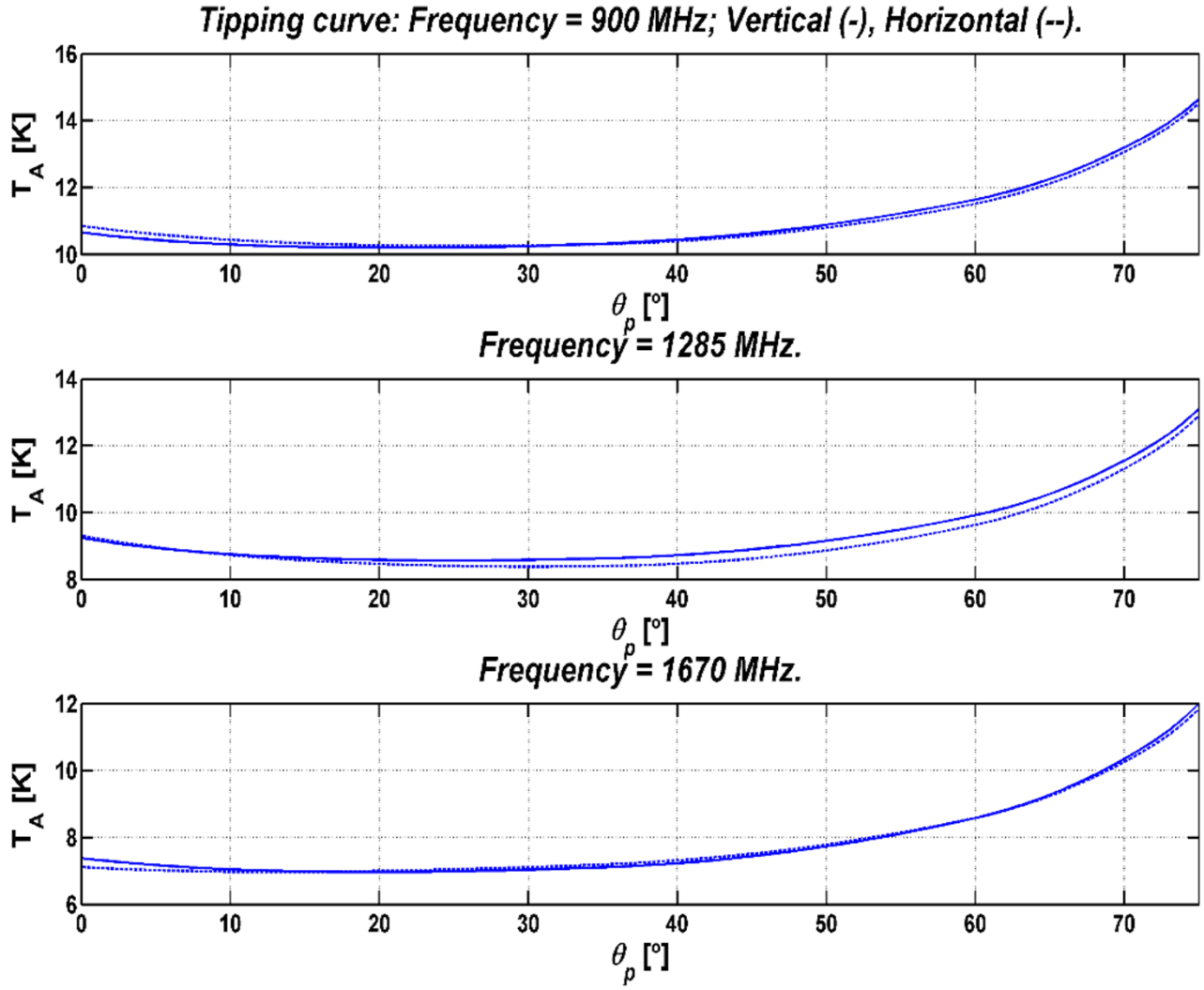
Feed down

Feed up

MeerKAT spillover

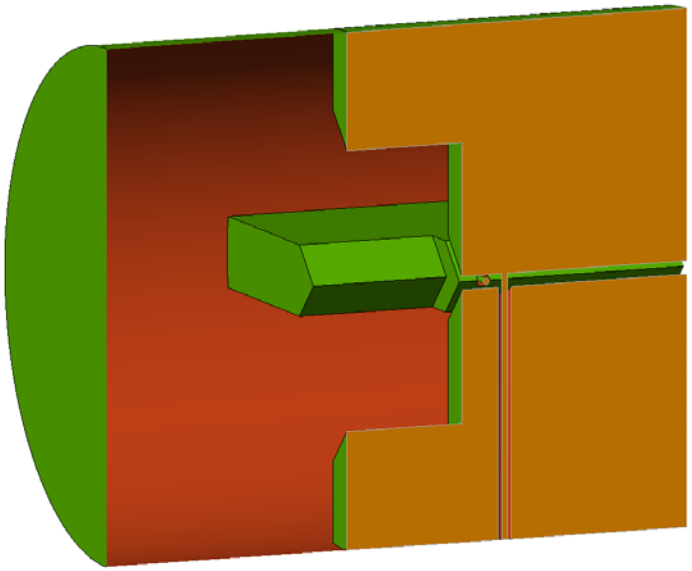


MeerKAT spillover



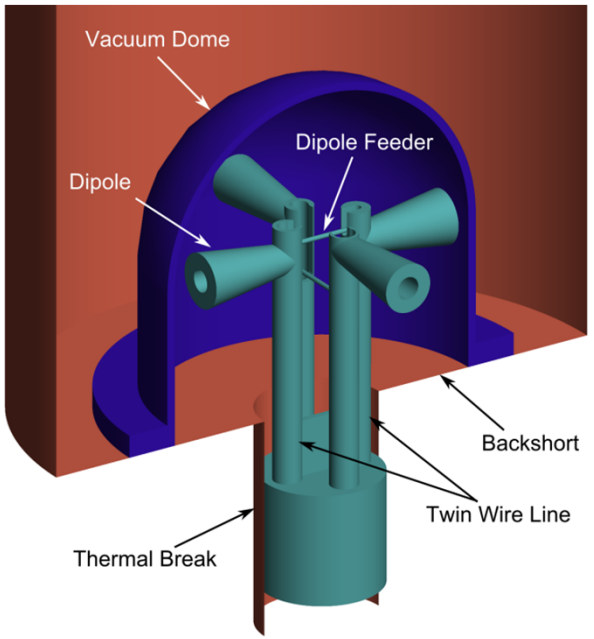
Signal path loss

- Cool loss as early as possible
- Horn low loss
- OMT condense currents
- Quad-ridge OMT
  - Large, so not easy to cool
  - High field between ridges
    - High loss
  - Coaxial lines add loss



Signal path loss

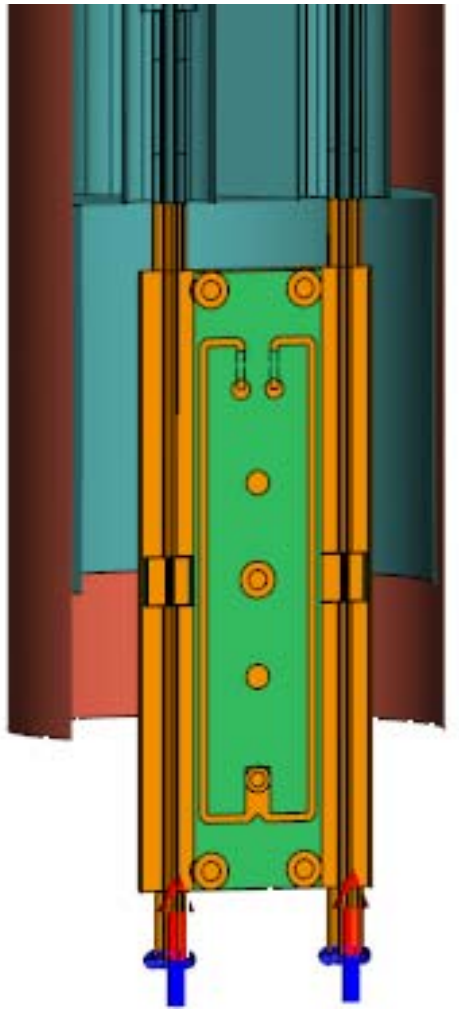
- Dipole OMT
  - Less bandwidth than quad-ridge type
  - Waveguide increase bandwidth – 60%
- Modified Marchand balun
- Loss in feed lines
  - Small so cold
  - Optimised to be short (Single λ/4 section)



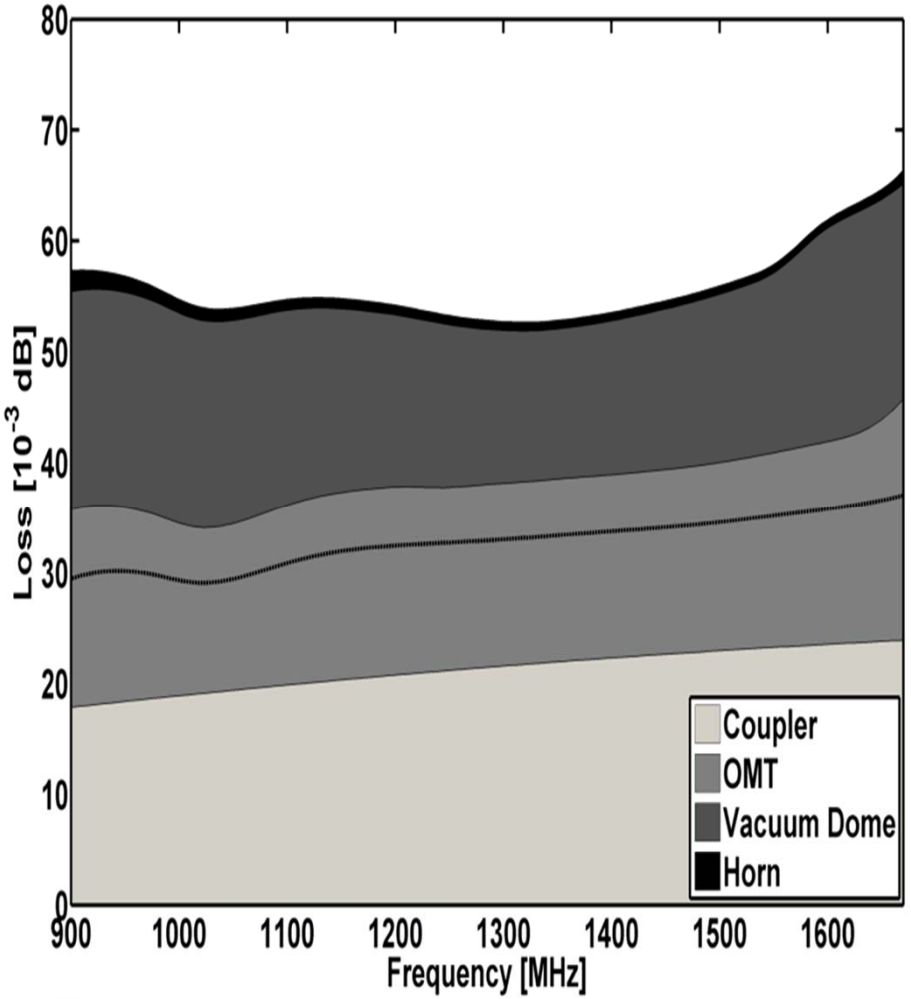
Signal path loss

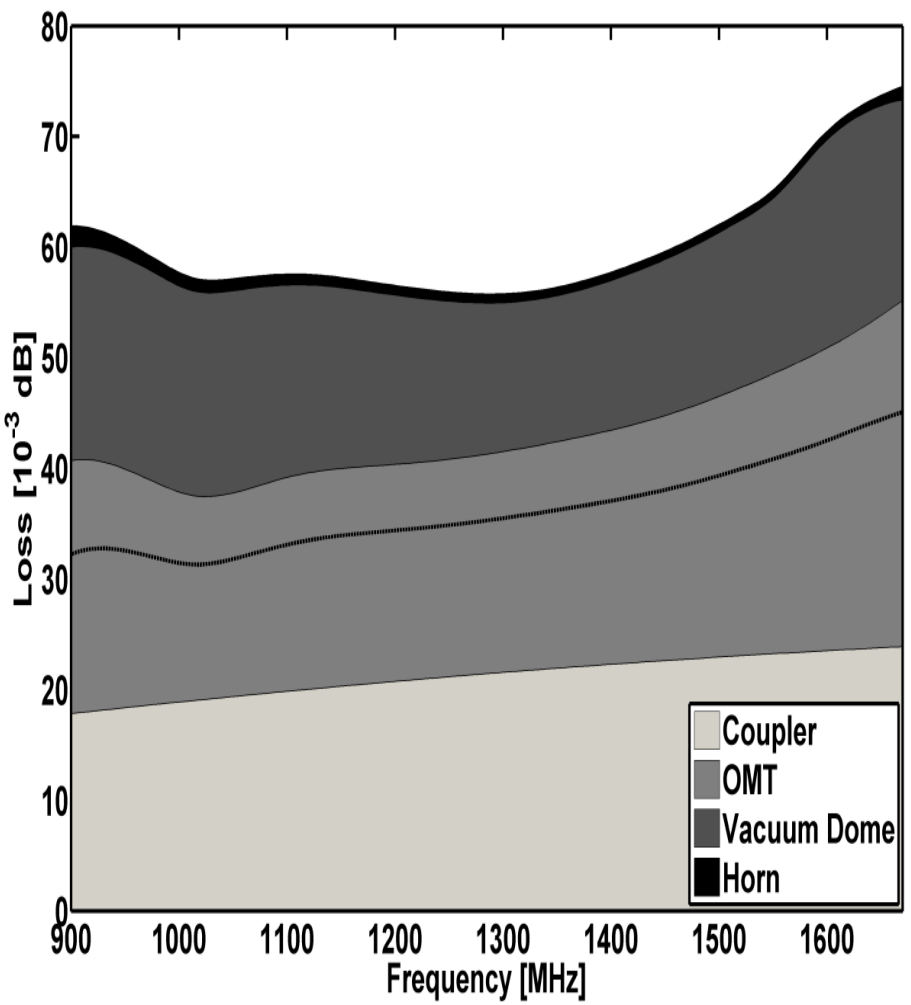
- Integrate noise coupler
- Air coax lines
- Part of thermal break

- Aluminium cable from OMT to LNA
  - 1 to 1.5 K contribution

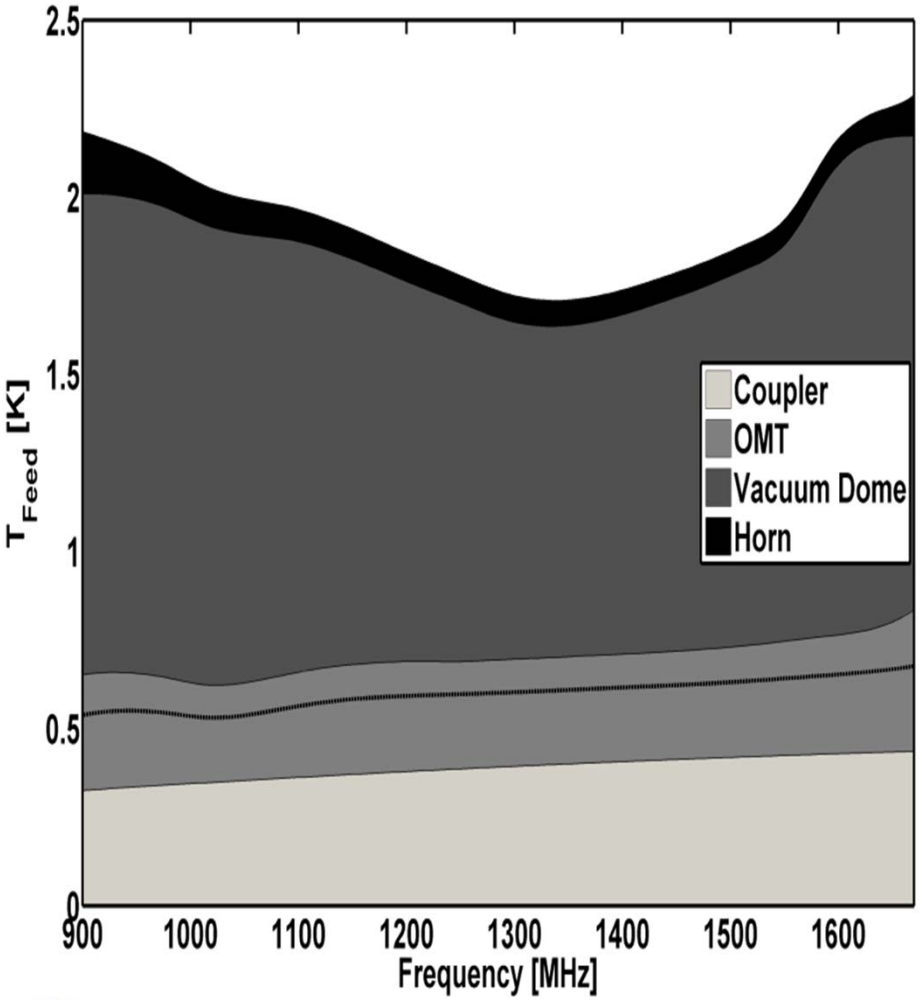


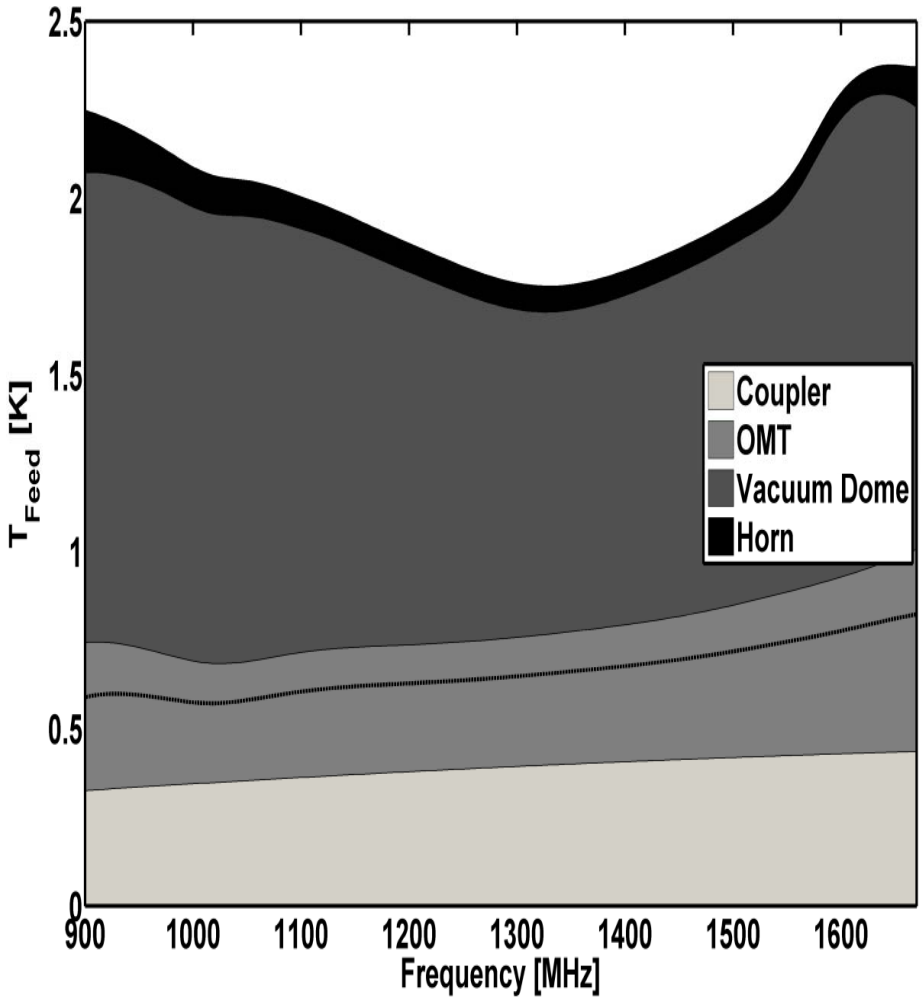
Total signal path loss





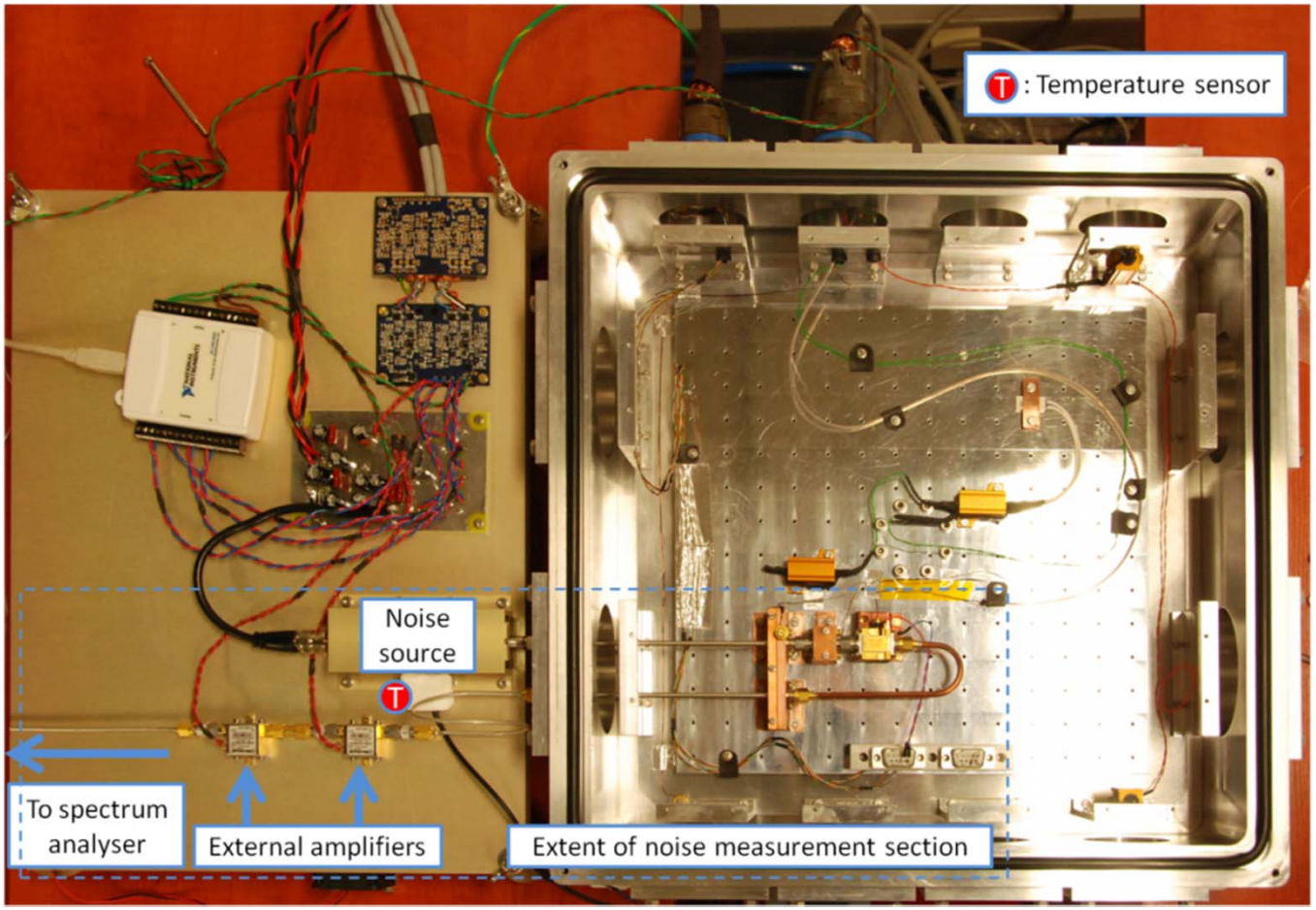
Noise contribution





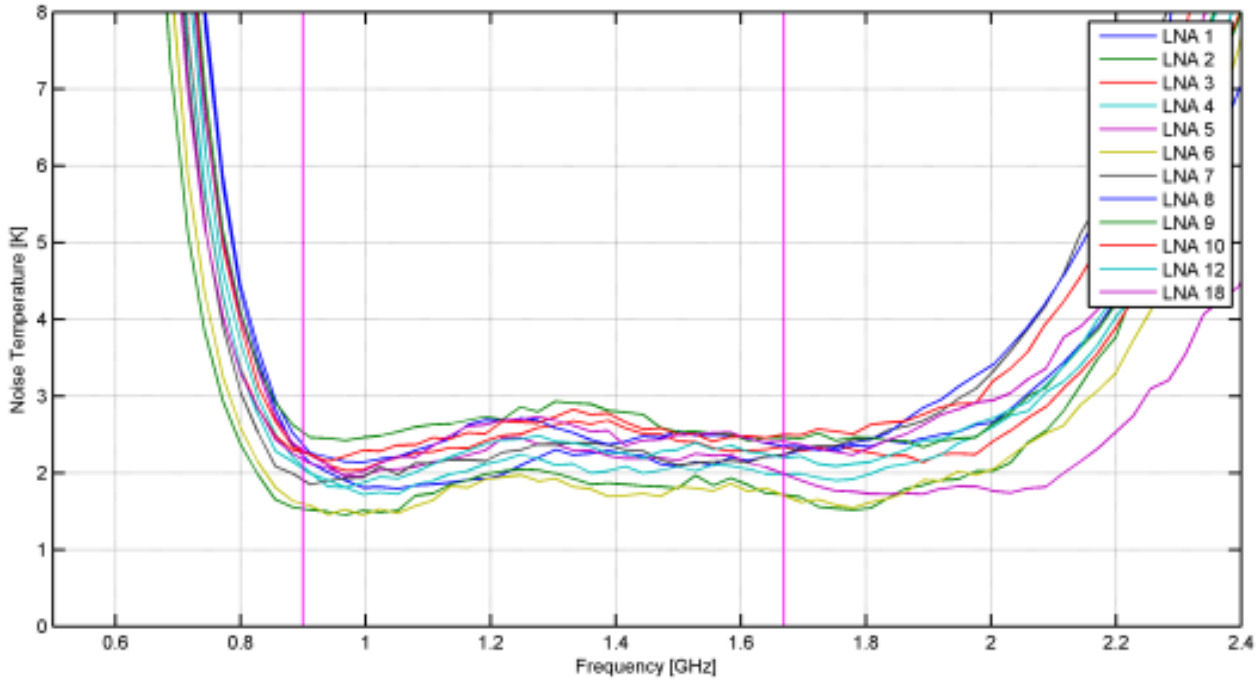
Active component noise

- Evaluate a number of options



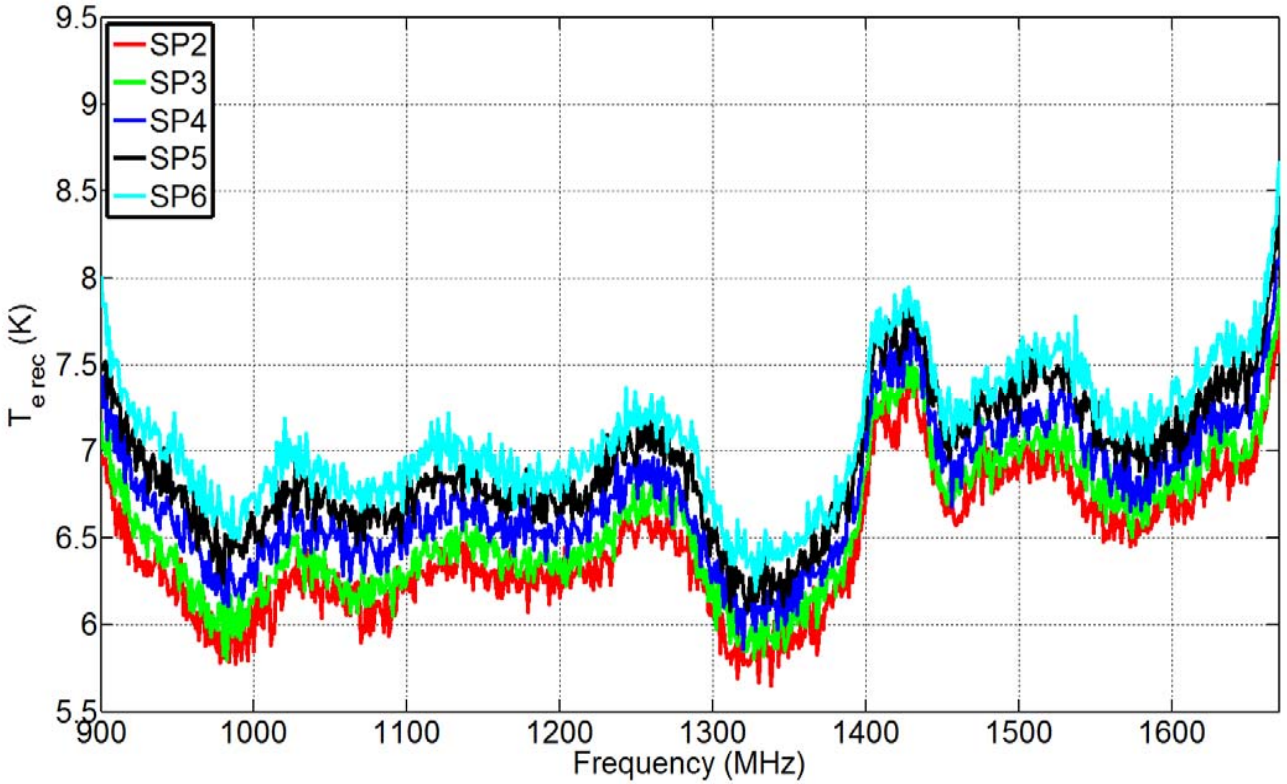
Active component noise

- LNA from Herzberg Institute of Astrophysics (NRC)
- InP technology with wire bonding



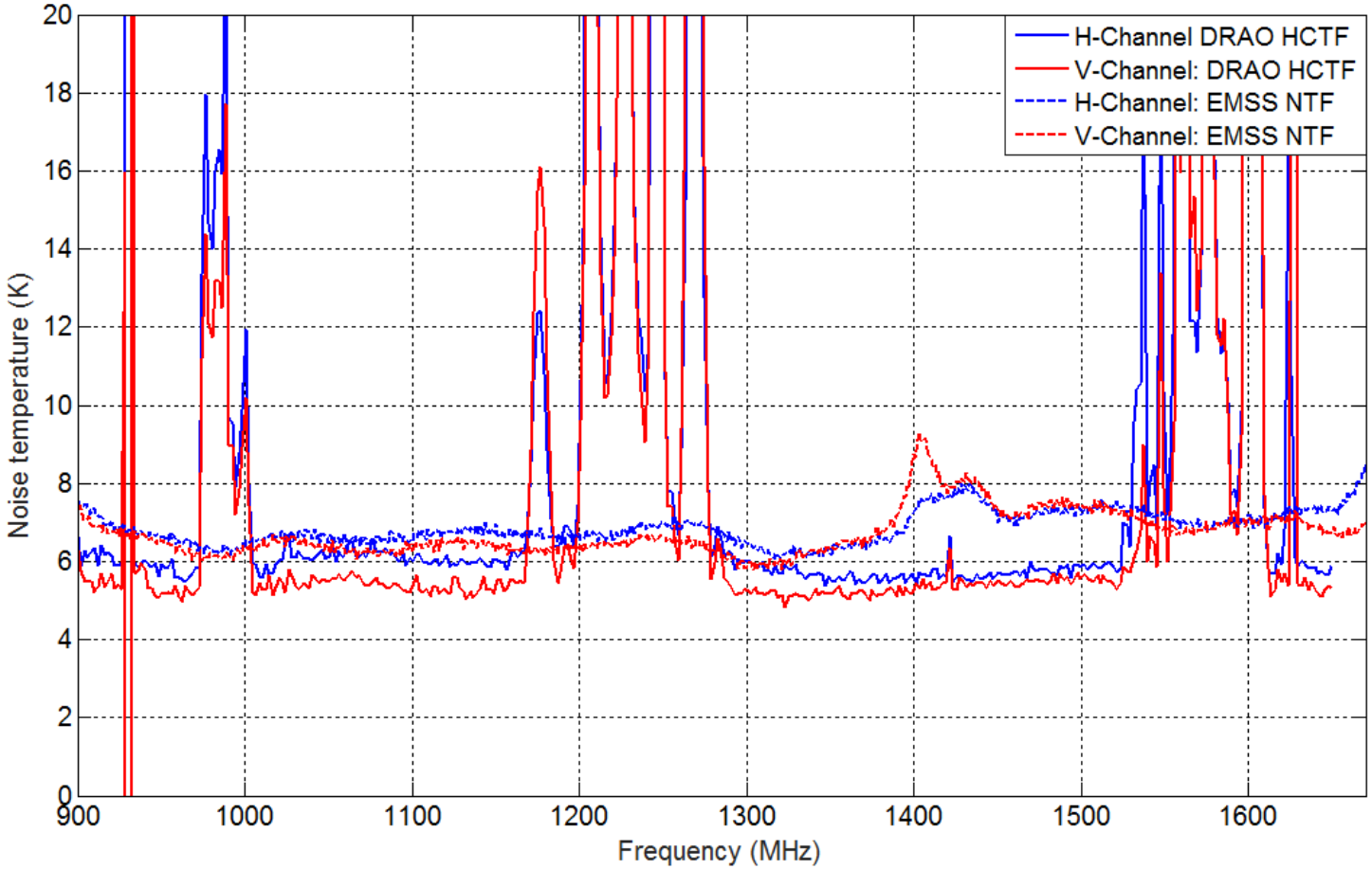
Receiver noise

- LNA temperature important
  - Physical 15.7, 17.7, 19.6, 21.6, 23.4 K



Receiver noise

- Hot cold load test facility in Penticton



Thank you

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