Design and Analysis of a Hyperspectral Microwave Receiver Subsystem

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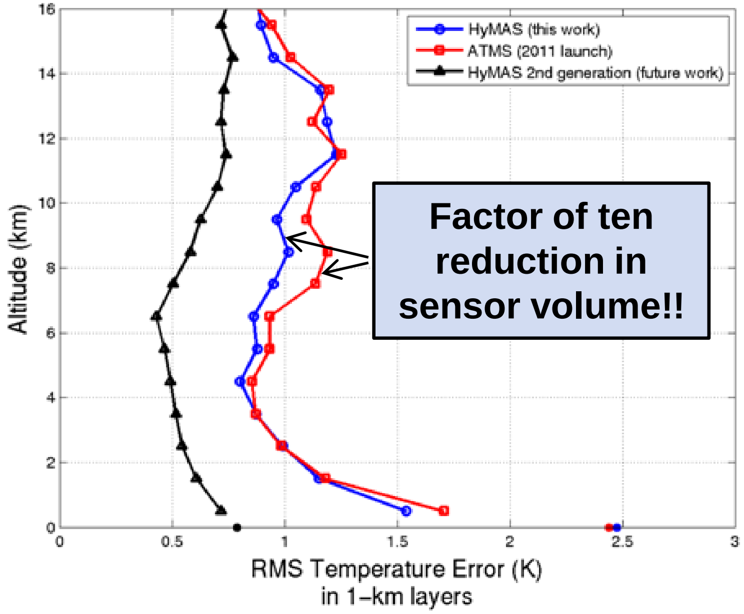
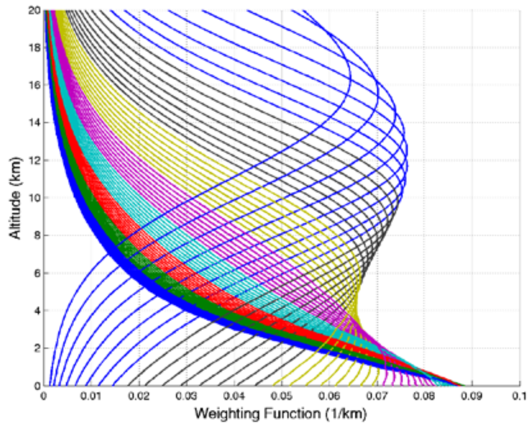
Outline

- Project summary, key objectives, and roles/responsibilities
- RF receiver electronics and scan head
- IF processor module
- Next steps

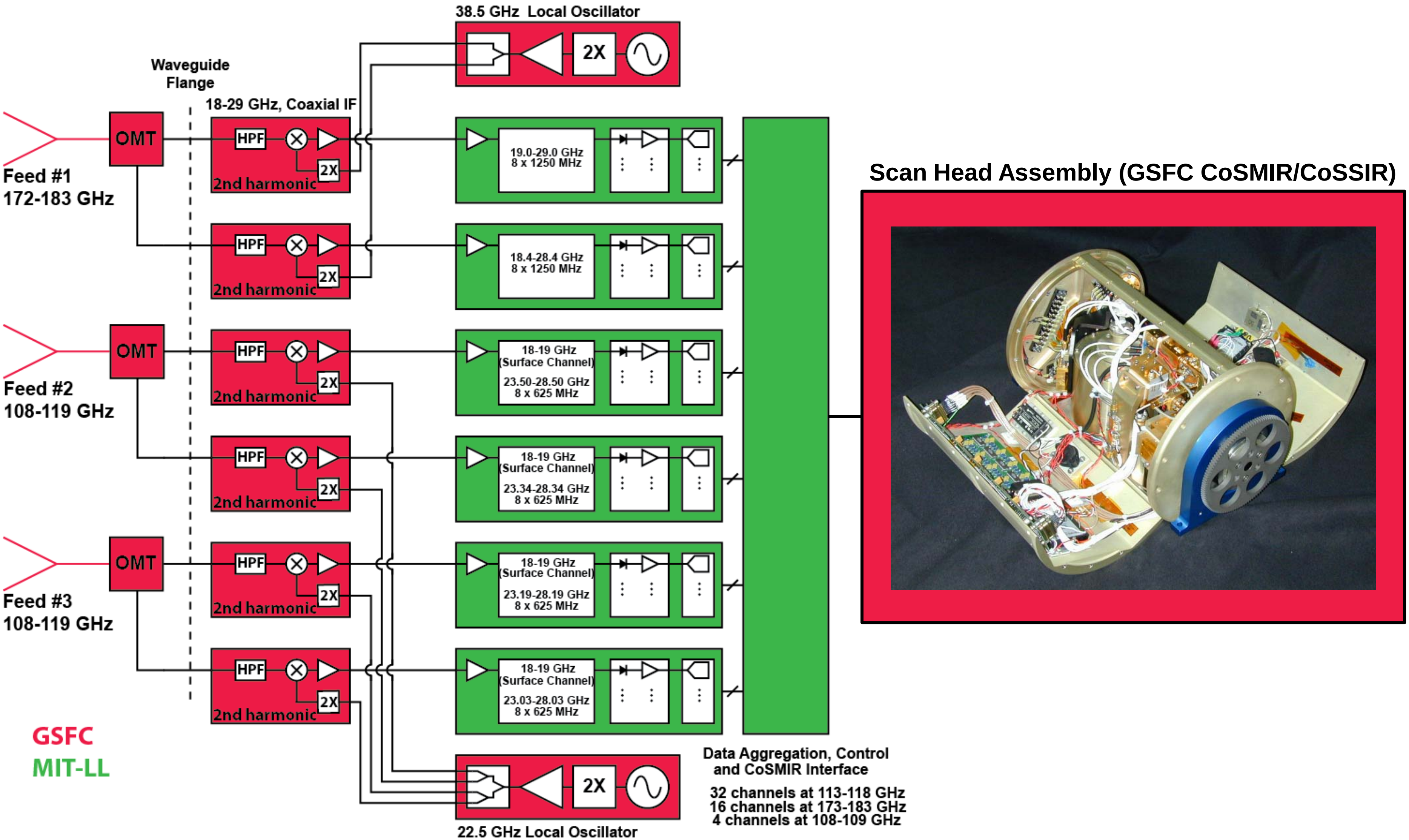
Project Summary and Key Objectives

- **Hyperspectral microwave (HM) sounding has been proposed to achieve unprecedented performance**
- **HM operation is achieved using multiple banks of RF spectrometers with large aggregate bandwidth**
- **A principal challenge is Size/Weight/Power scaling**
- **Objectives of this work:**
  - **Demonstrate ultra-compact (100 cm^3) 52-channel IF processor (enabler)**
  - **Demonstrate a hyperspectral microwave receiver subsystem**
  - **Deliver a flight-ready system to validate HM sounding**

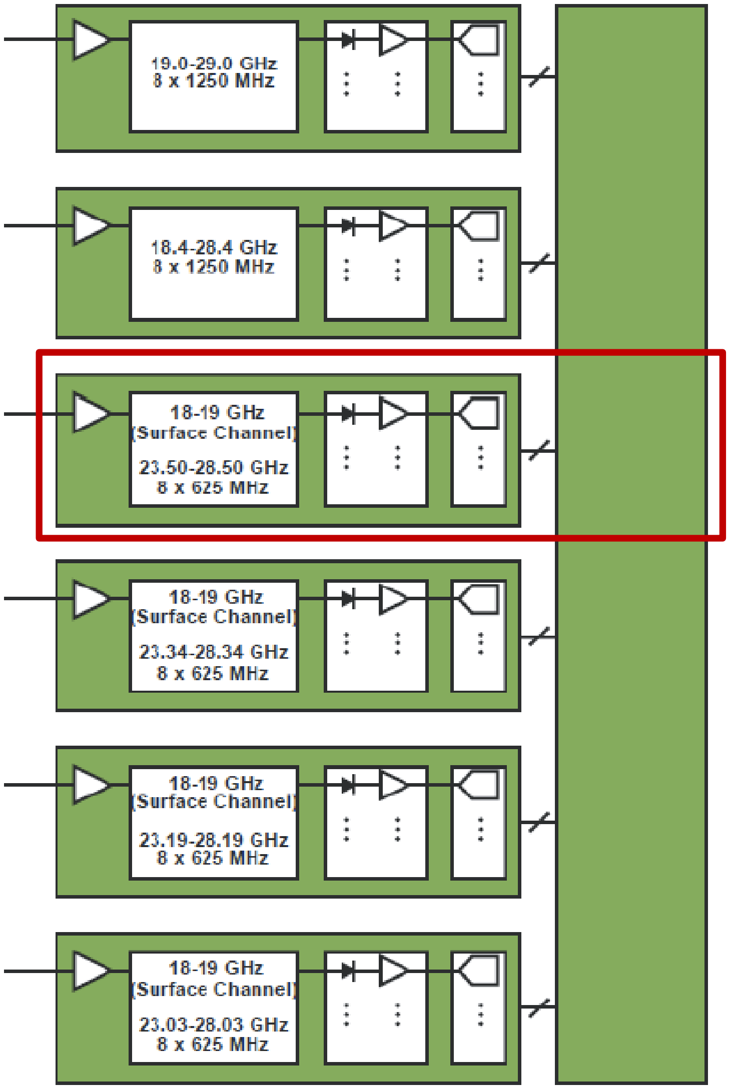




HyMAS System Components Roles and Responsibilities



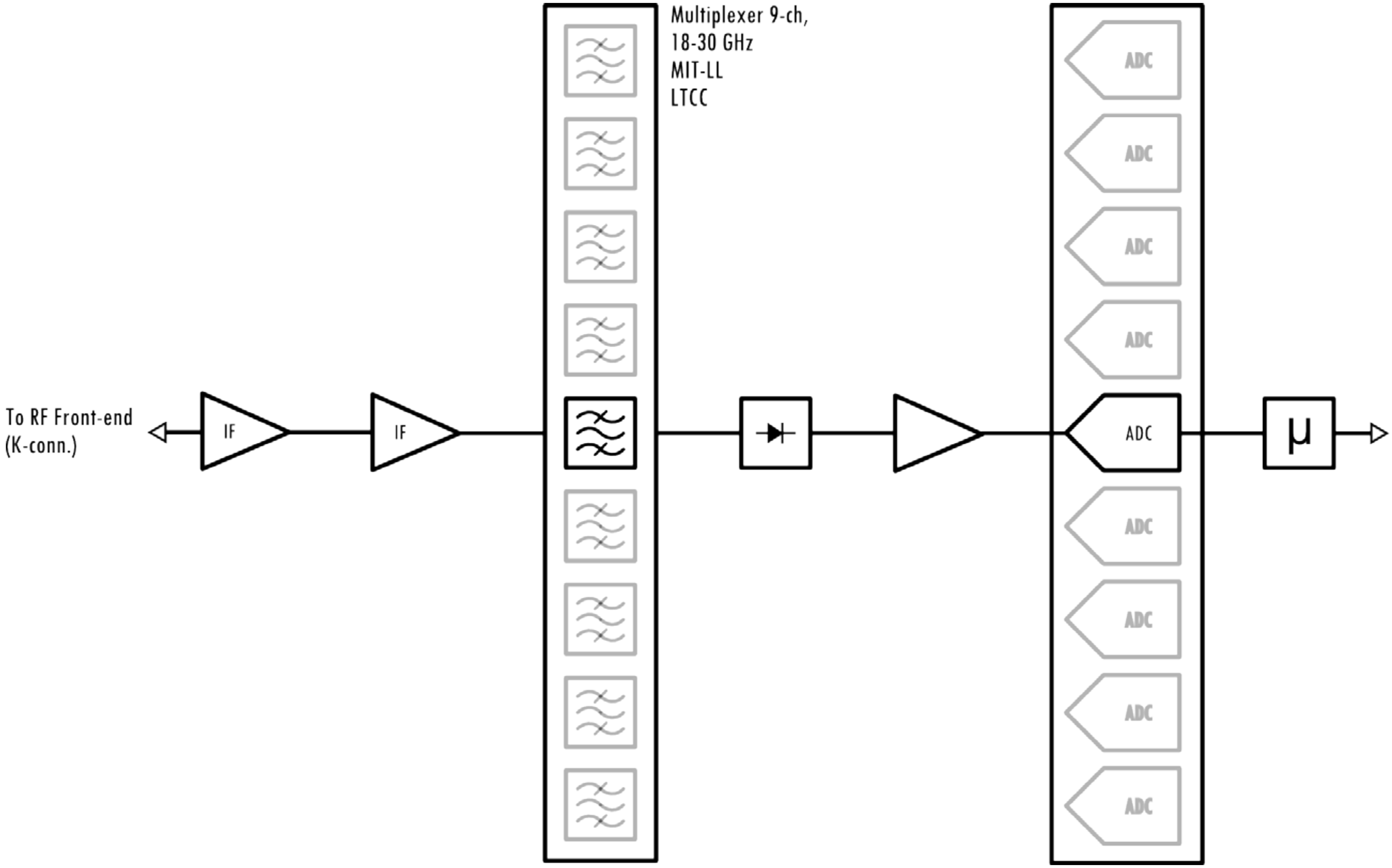
HyMAS (9-channel) IF Frequency Plan



IF Processor Description

- K-connector (18-29 GHz) input from RF front-end
- Two IF amplifiers (18-29 GHz)
  - Buffered with attenuators for gain adjustment and matching at IF input/output
    - Provides termination for RF front-end output and multiplexer input
    - Nominally 3 dB at input/output, “0 dB” in between stages
- Multiplexer channelizes IF band
- Detectors detect power at output of each channel
- Op-amp fed by detectors, drives ADC
- Microcontroller sequences data flow

HyMAS – IF Processor



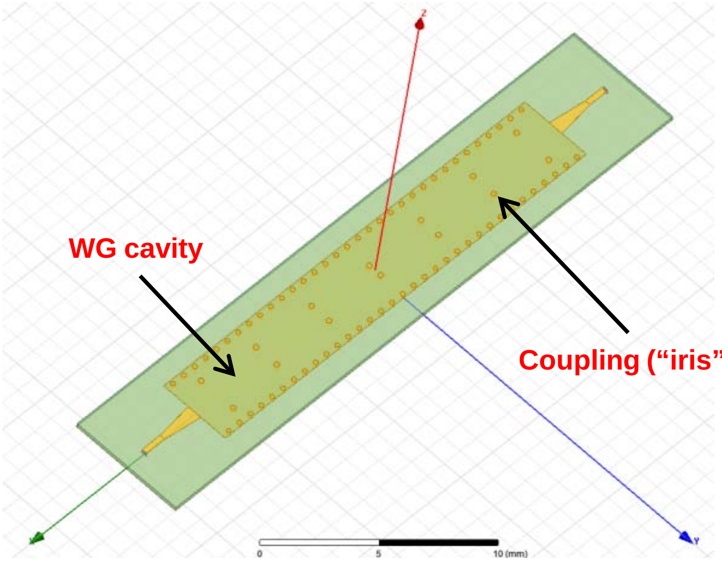
IF Multiplexer

- **Single port feeds 9-channels through a corporate feed power splitting network**
  - **Reduces interaction among contiguous channels**
  - **Low-risk for initial demonstration**
- **IF channel filters are LTCC-based substrate integrated waveguide (SIW) cavity types**
  - **High unloaded *Q* resonators (500+) in small volume for low insertion loss and sharp filter skirts**
  - **Probe/bond pads for S-parameter testing and assembly**
- **First 9-channel design completed and in fabrication**
  - **Omega Micro Technology (DuPont 9K7), expect parts in 9/2012**

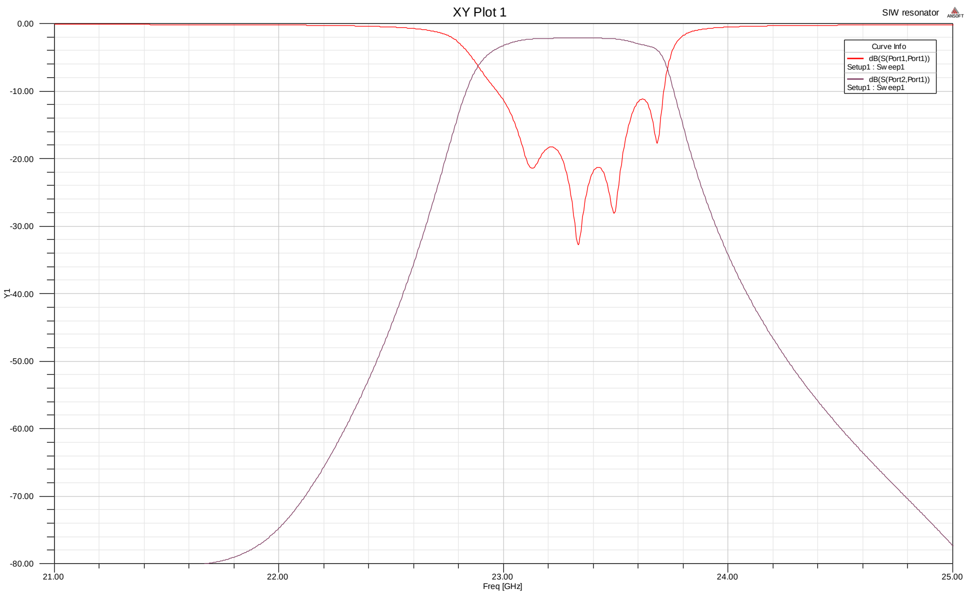
HyMAS LTCC SIW Filters

- **Substrate Integrated Waveguide (SIW) filters offer lower insertion loss and better filter shape factor than stripline interdigital filters due to their higher *Q* (> 500) resonators**
  - **Filters are realized in two-layer LTCC stack with via "fences" creating the waveguide side walls**
  - **Via "posts" control coupling in between resonator cavities**

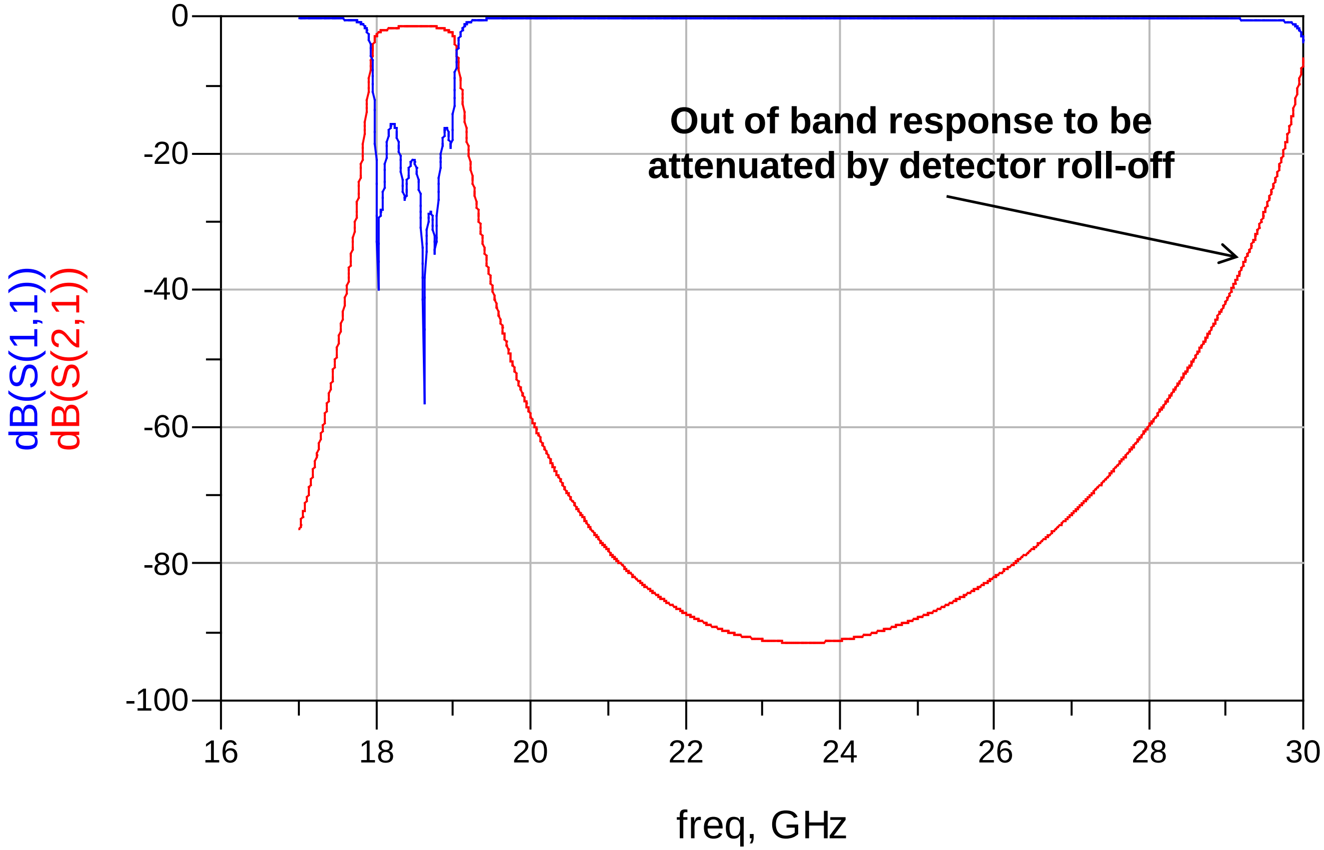
HFSS Model



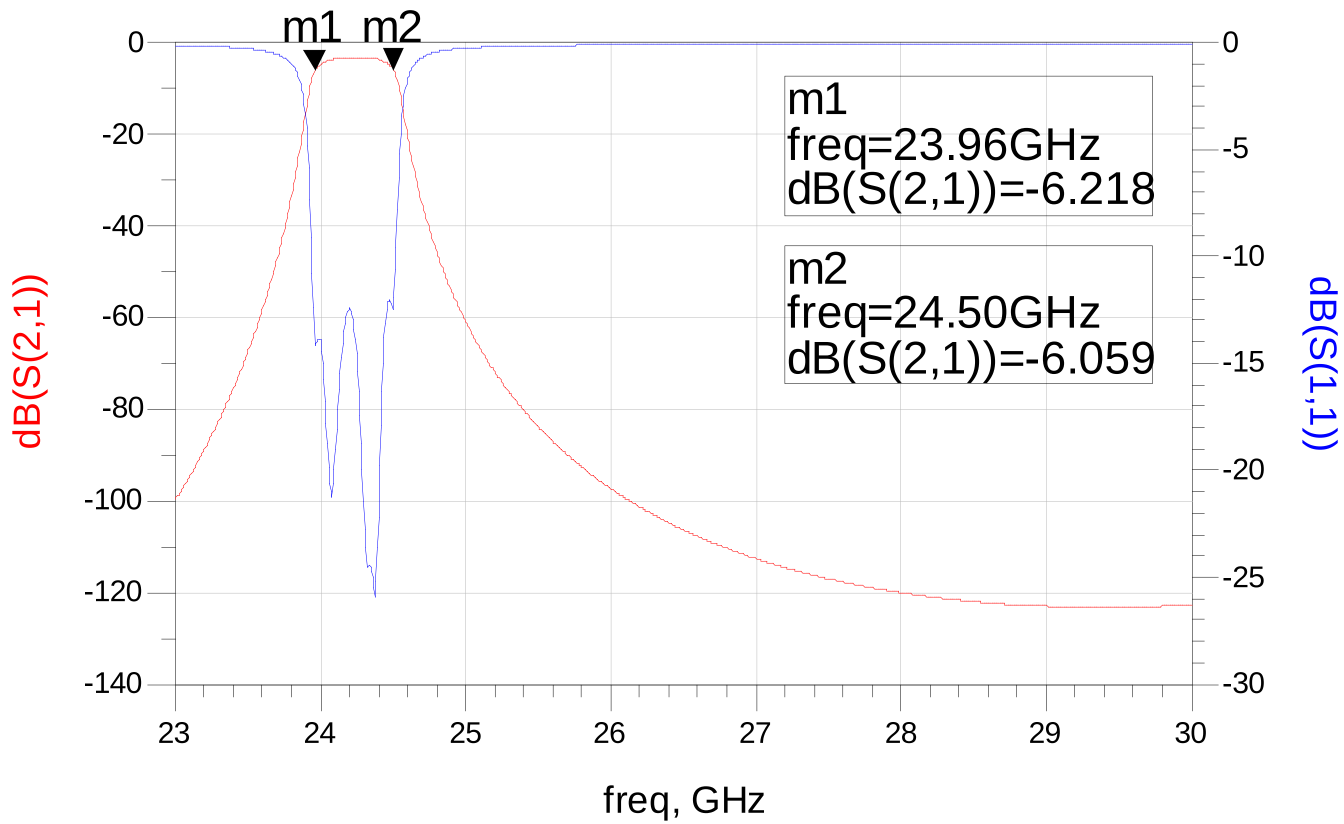
HFSS Simulation



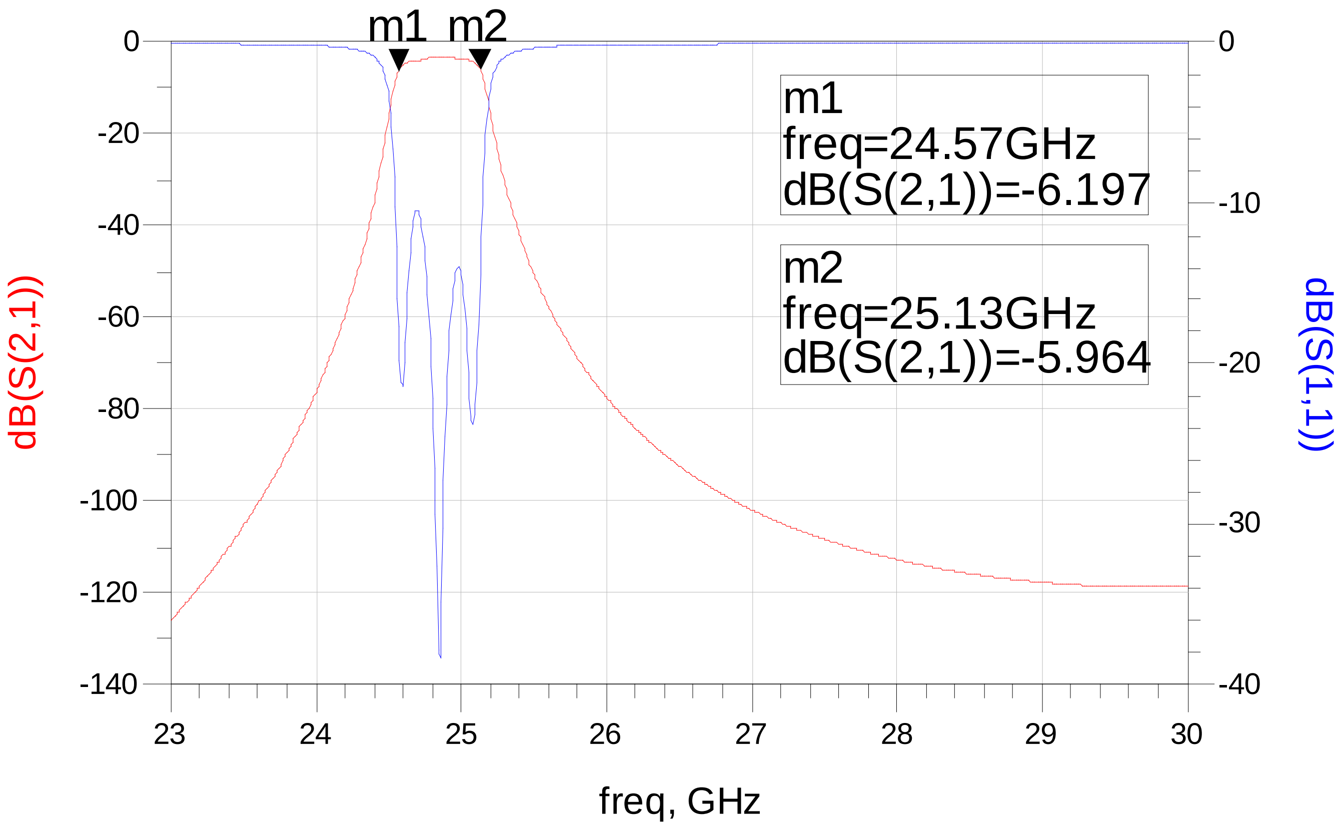
IF Channel 1 (HFSS)



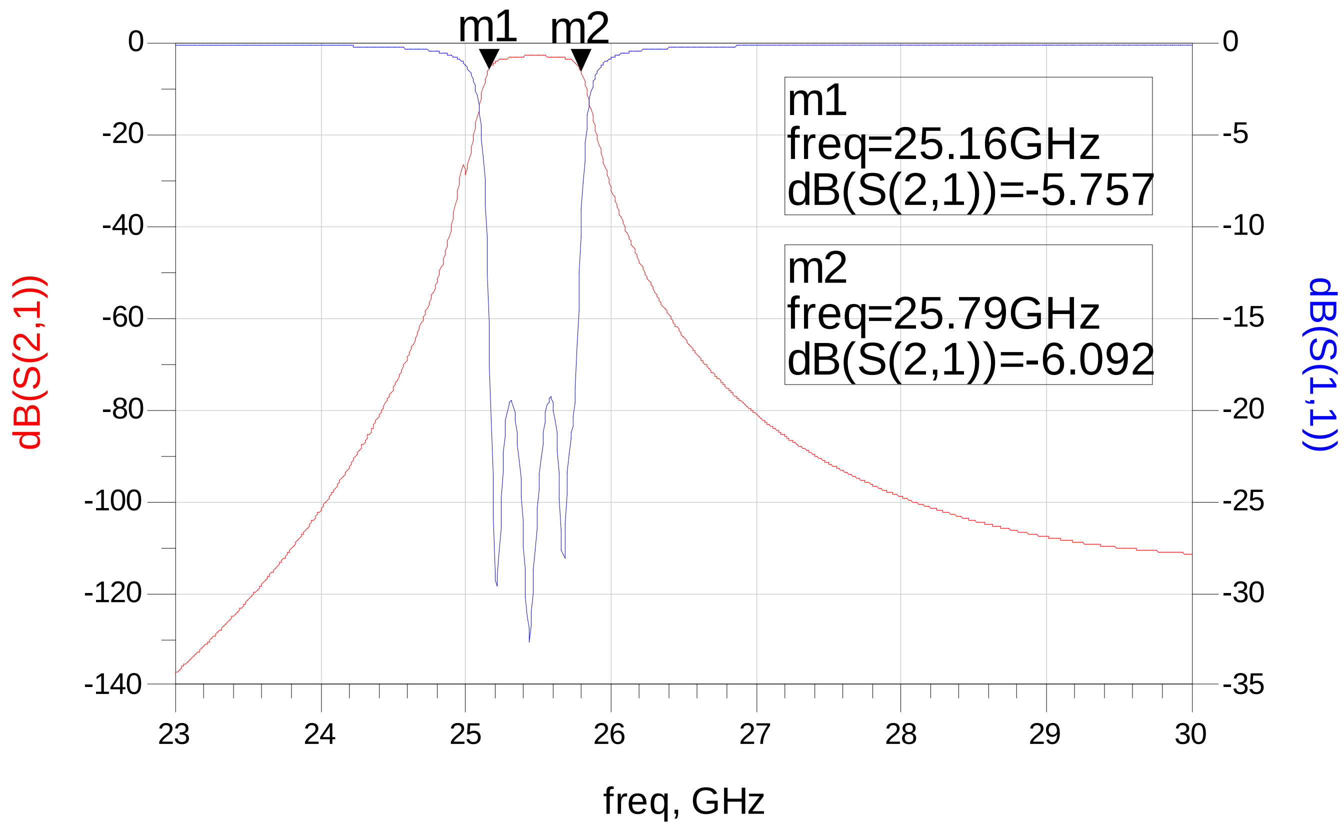
IF Channel 2 (HFSS)



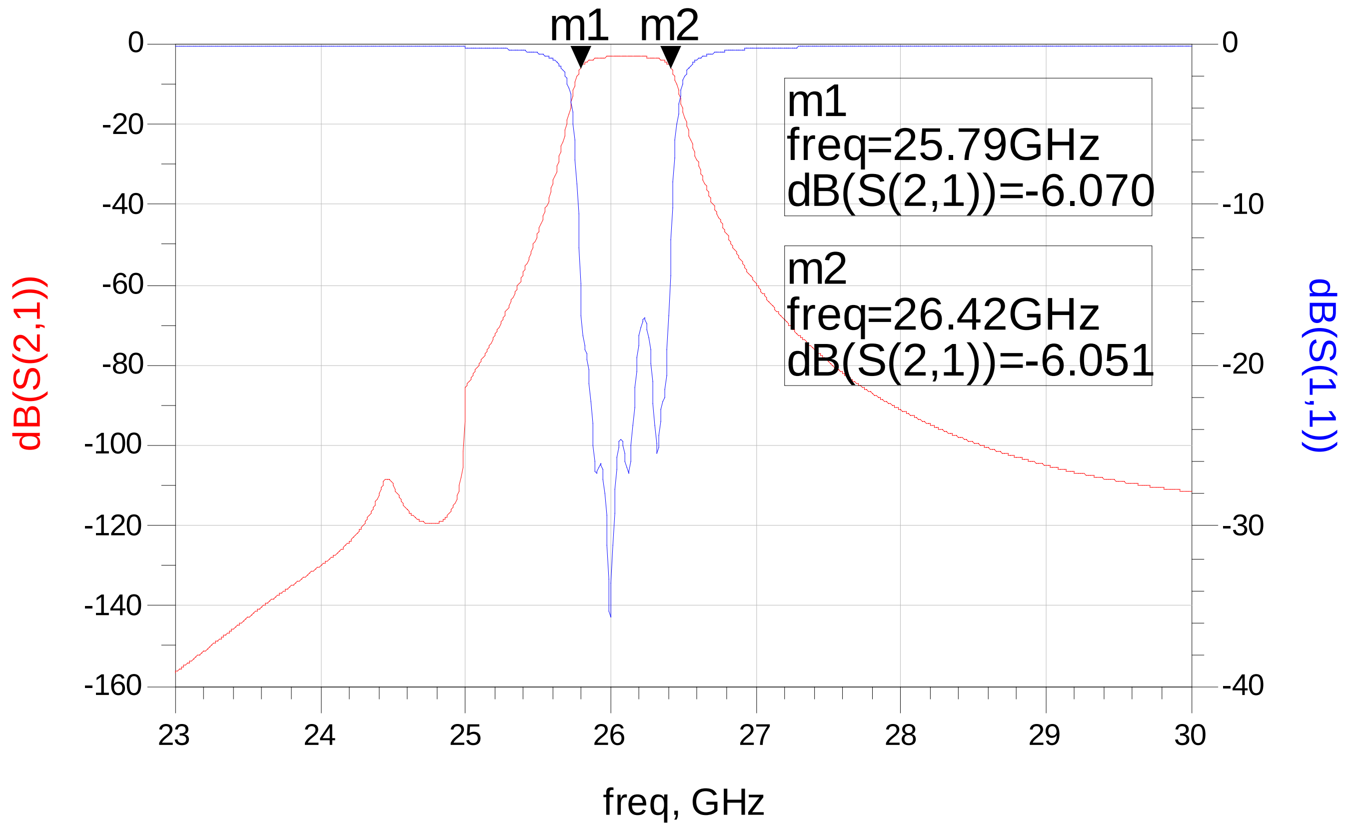
IF Channel 3 (HFSS)



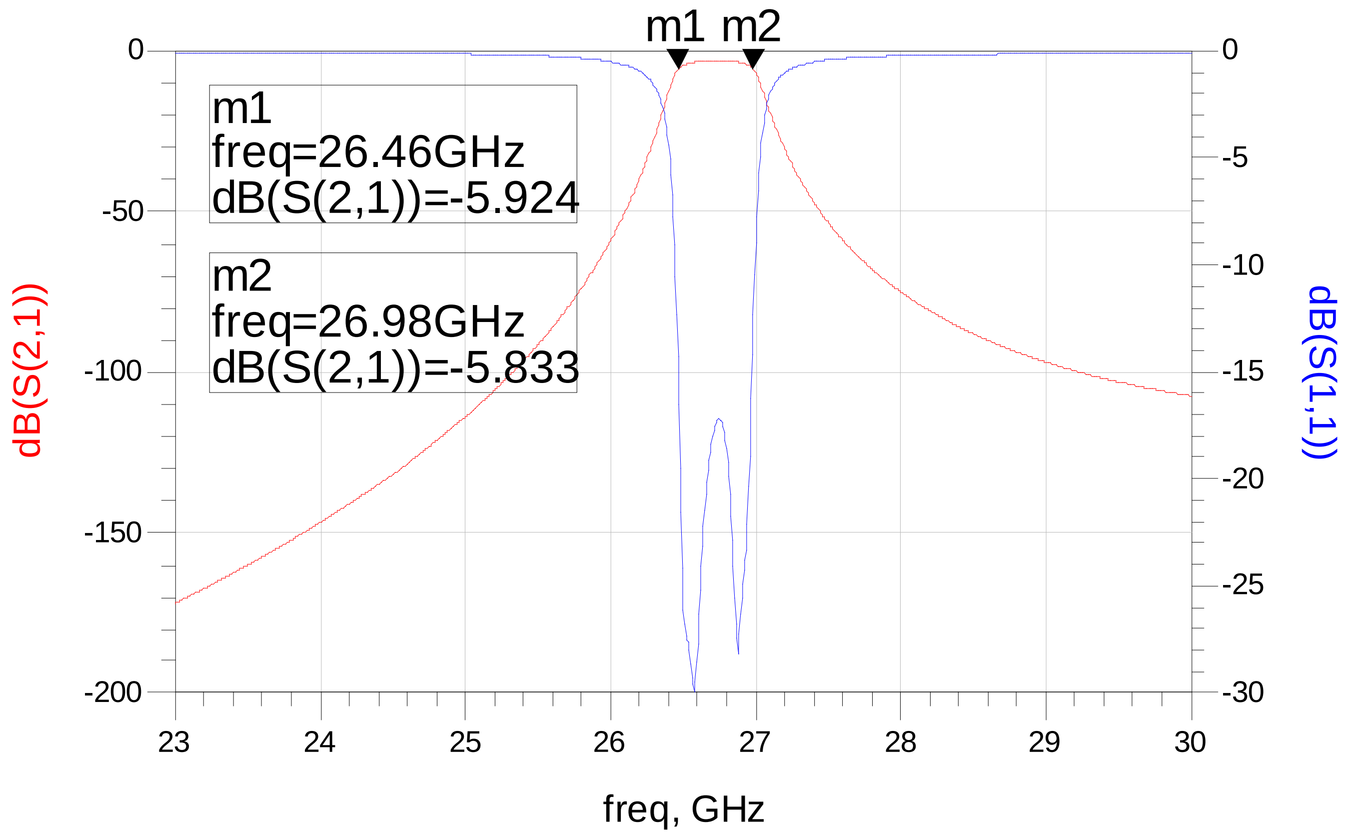
IF Channel 4 (HFSS)



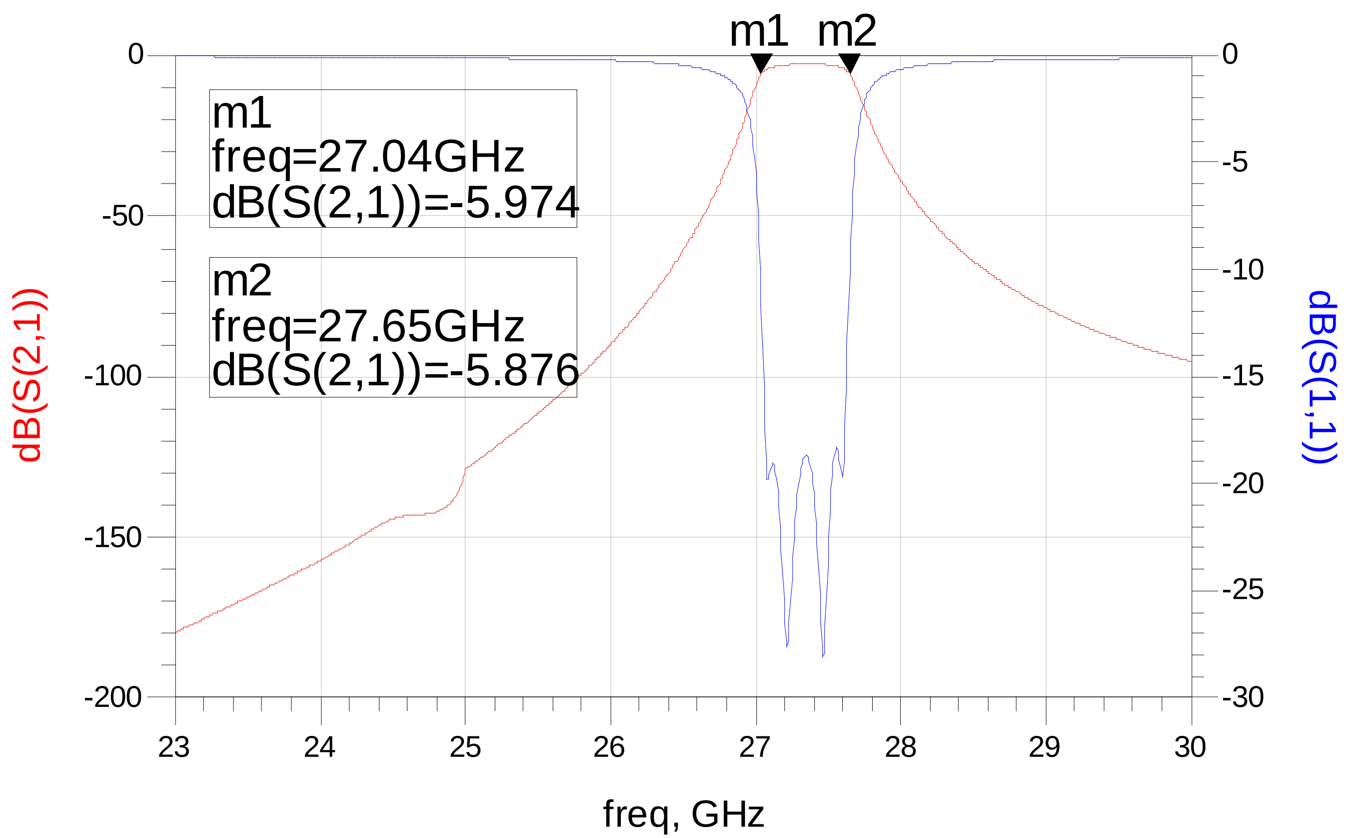
IF Channel 5 (HFSS)



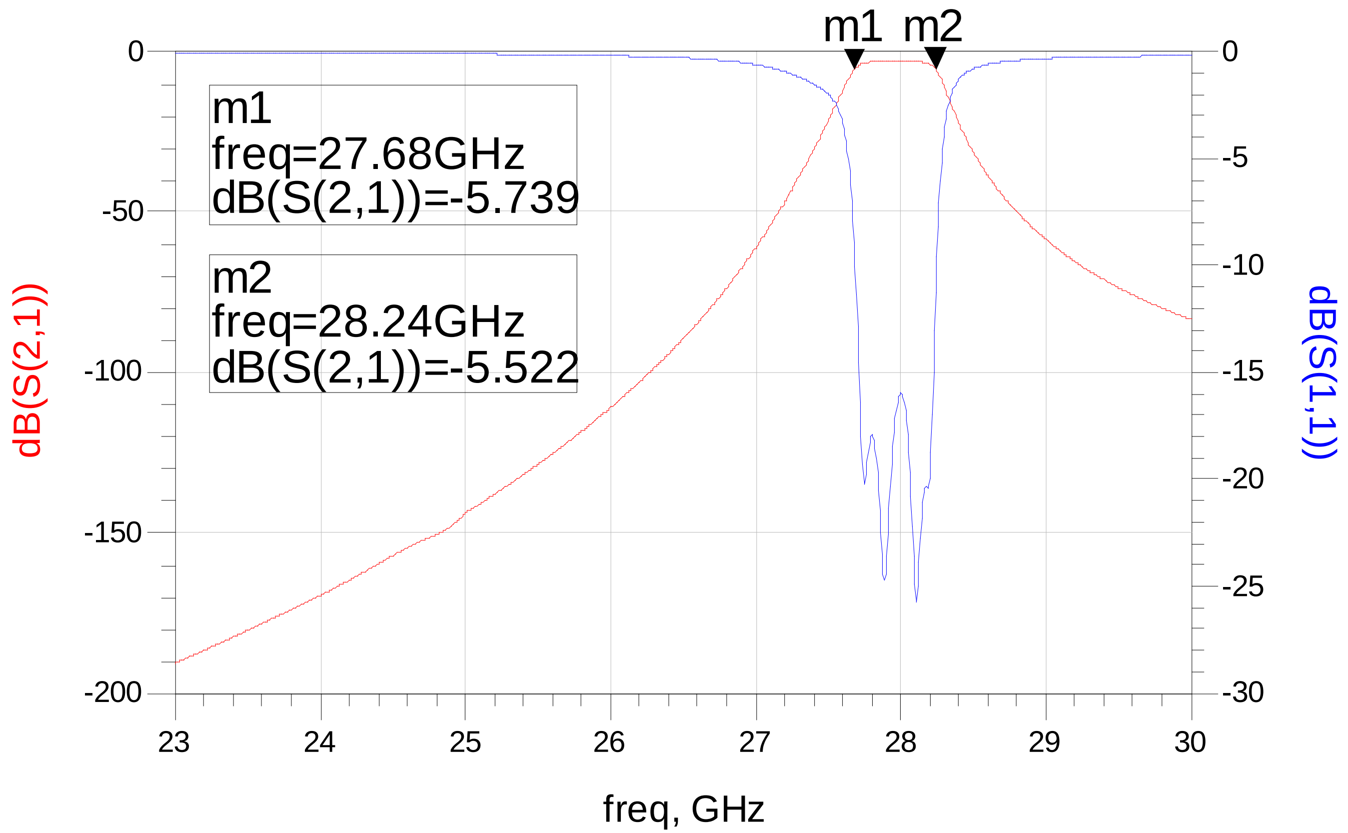
IF Channel 6 (HFSS)



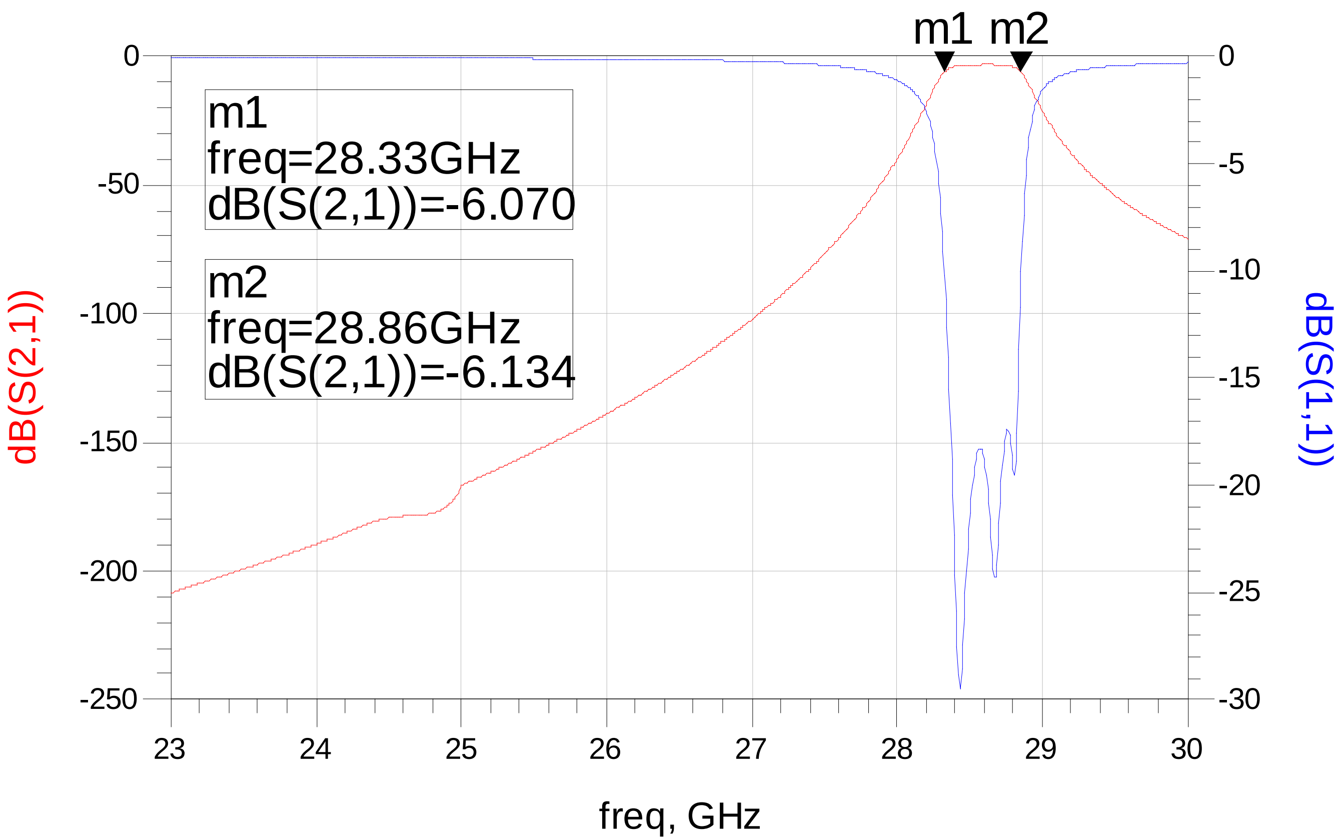
IF Channel 7 (HFSS)



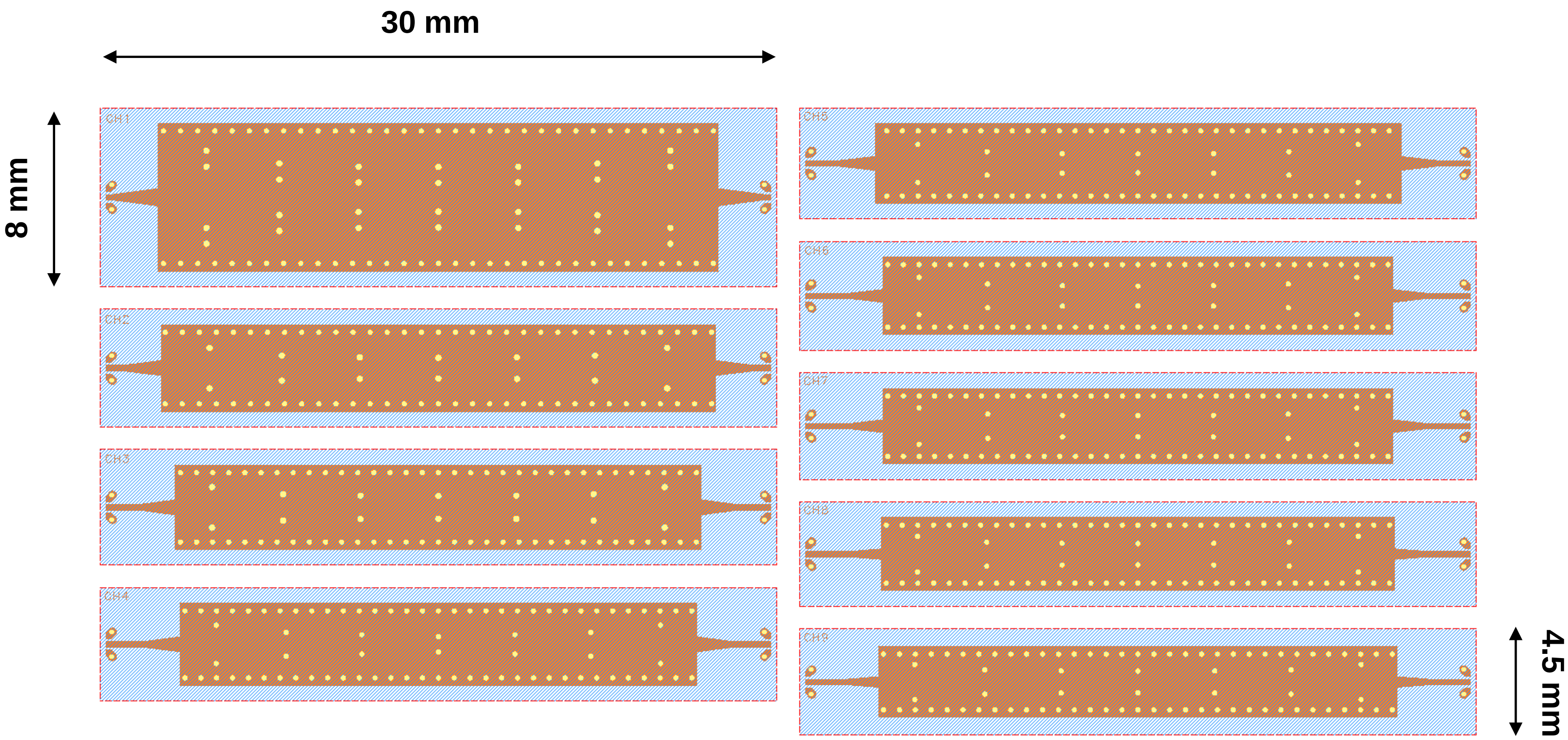
IF Channel 8 (HFSS)



IF Channel 9 (HFSS)

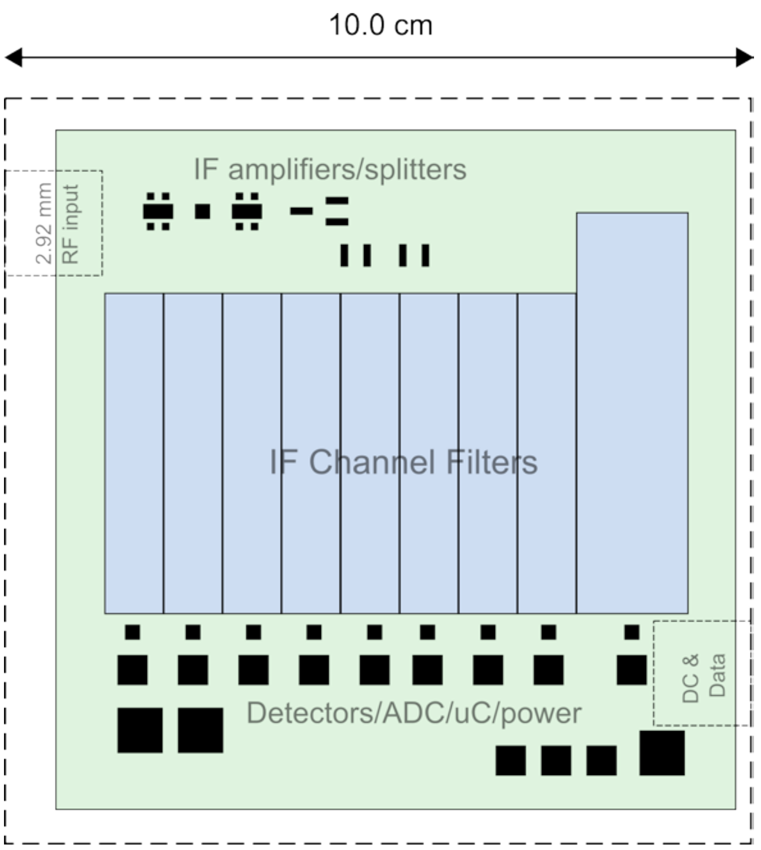


IF Filter Layout (LTCC)

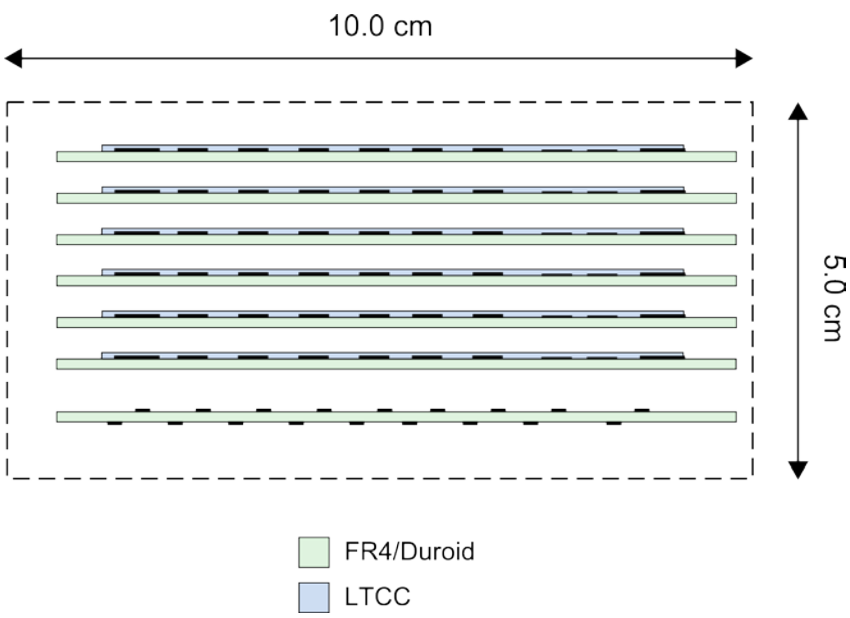


IF Processor Form Factor 1
Horizontal Resonators

Top View: 8/9-channel Panel

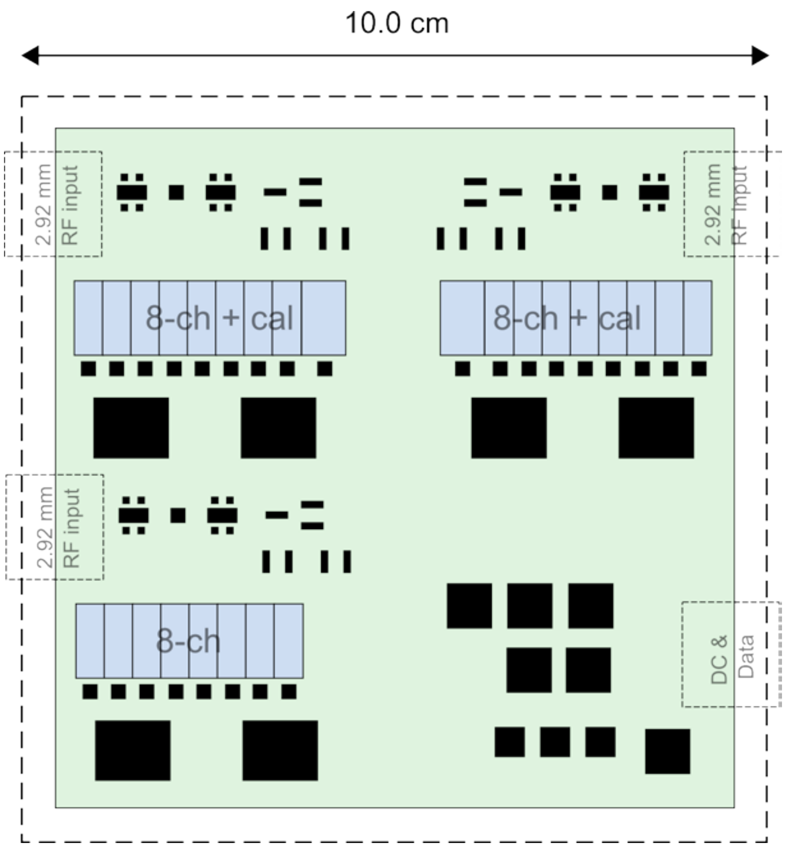


Side View: 52-ch IF Processor

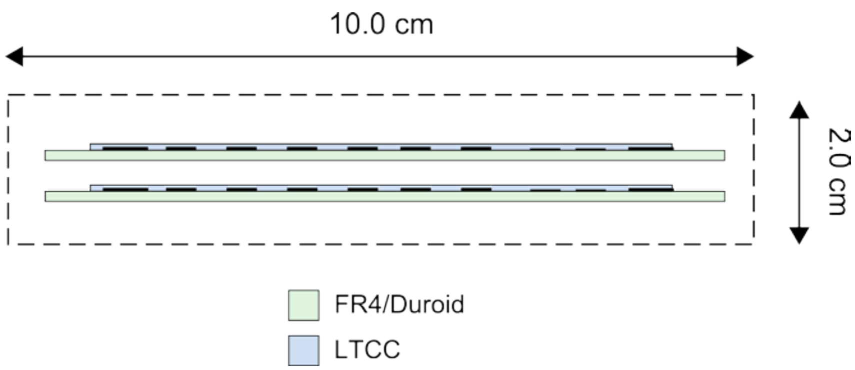


IF Processor Form Factor 2
Horizontal+Vertical (Stacked) Resonators

Top View: 26-channel Panel

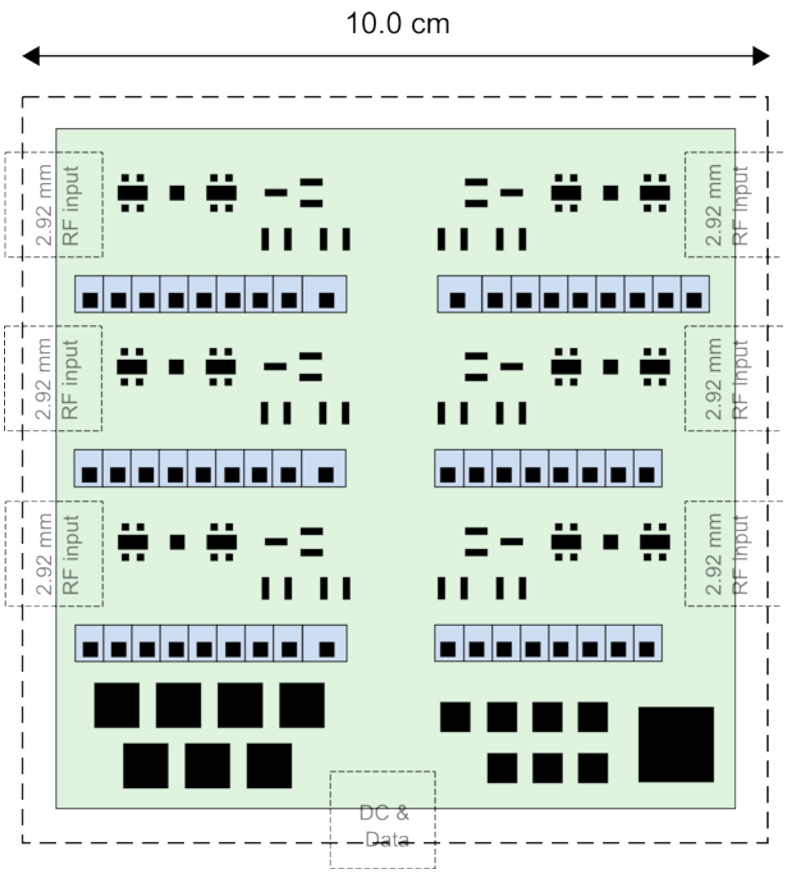


Side View: 52-ch IF Processor

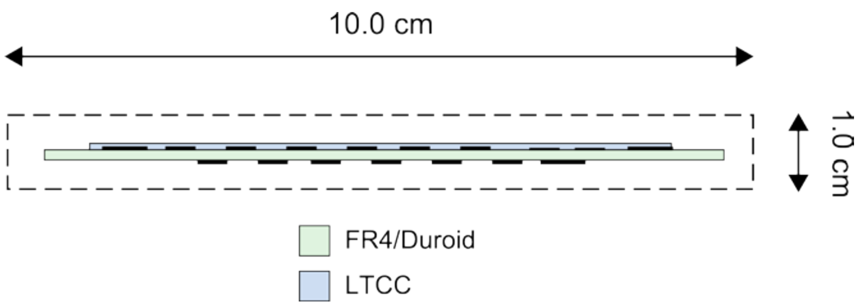


IF Processor Form Factor 3 (Project Goal) Vertical (Stacked) Resonators

Top View: 52-channel Panel



Side View: 52-ch IF Processor

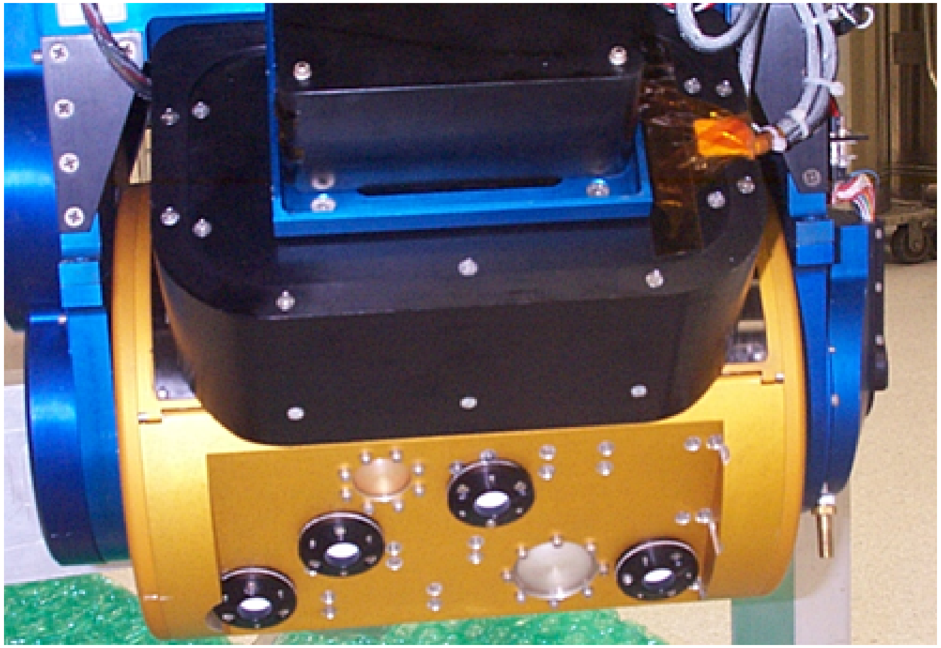


Summary

- **Hyperspectral microwave sensors could change the landscape of atmospheric sounding for both LEO and GEO systems.**
- **An intermediate frequency processor fabricated in LTCC technology is a key innovation enabling ultracompact microwave radiometry in a variety of applications with severe constraints on size, weight, and power.**
- **Fabrication and testing of the hyperspectral microwave receiver subsystem will occur in 2012/2013 with airborne validation in 2014/2015.**

Backup

CoSMIR/CoSSIR Scan Head



The scan head provides calibration and control infrastructure and rotates in azimuth and elevation. CoSSIR is shown in the photo at left.

A compact drum houses the radiometer electronics and rotates relative to the scan head

Flights on the ER-2 have produced many hours of high-quality radiometric data

Frequency Plan

Example: 36 Channels near the 118.75-GHz oxygen line

Channel #	Left edge	Center	Right edge	Bandwidth
1	108.0000	108.5000	109.0000	1.0000
2	113.9135	114.2260	114.5385	0.625
3	114.5375	114.8500	115.1625	0.625
4	115.1615	115.4740	115.7865	0.625
5	115.7855	116.0980	116.4105	0.625
6	116.4095	116.7220	117.0345	0.625
7	117.0335	117.3460	117.6585	0.625
8	117.6575	117.9700	118.2825	0.625
9	118.2815	118.5940	118.9065	0.625

Channels 2-9 above are shifted by 156.25 MHz per band