IRaST and YTHP Update

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Northrop Grumman Corporation and Jet Propulsion Laboratory

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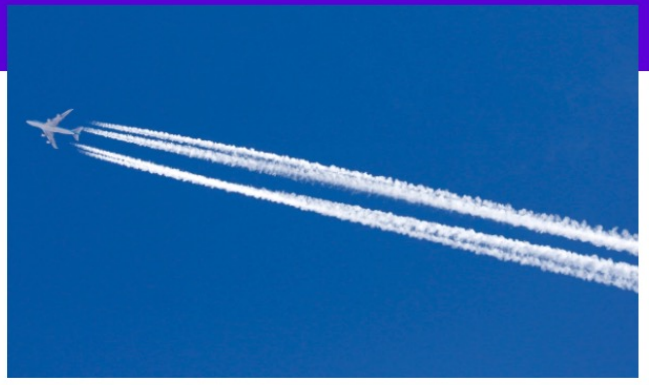
Abstract

- "IRaST": Integrated Receiver and Switch Technology
- "Switch Technology": Focused on switching techniques on mitigating 1/f noise in direct detection receivers
- "Integrated Receiver": A 424/448 GHz receiver intended for temperature and humidity sounding *at aircraft cruising altitudes*
- When combined with aircraft jet engine attributes, temperature and humidity predict when aircraft leave contrails
- Optically thin contrail cirrus clouds have been identified as a contributor to global warming
- IRaST is currently focused on demonstrating the 424/448 receiver can be used to predict contrail formation (YTHP)

Significant Public Awareness

Do airplane contrails add to climate change? Yes, and the problem is about to get worse.

New research suggests the global warming effect will triple by 2050 as air travel increases.



Contrails from a KLM Royal Dutch Airlines Boeing 747 jetliner flying high over Las Vegas on Feb. 27, 2019. Larry MacDougal / AP file

July 28, 2019, 2:07 AM PDT / Updated July 28, 2019, 11:28 AM PDT

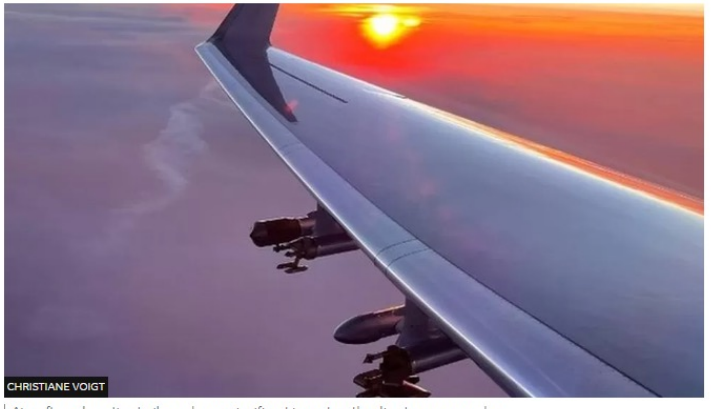
By Jeremy Hsu

Despite conspiracy theories about so-called chemtrails, there's no evidence that the white plumes seen trailing from high-flying airplanes are part of a secret government program to spray toxic

Contrails: How tweaking flight plans can help the climate

22 October 2021

COP26



Aircraft condensation trails can have a significant impact on the climate, say researchers

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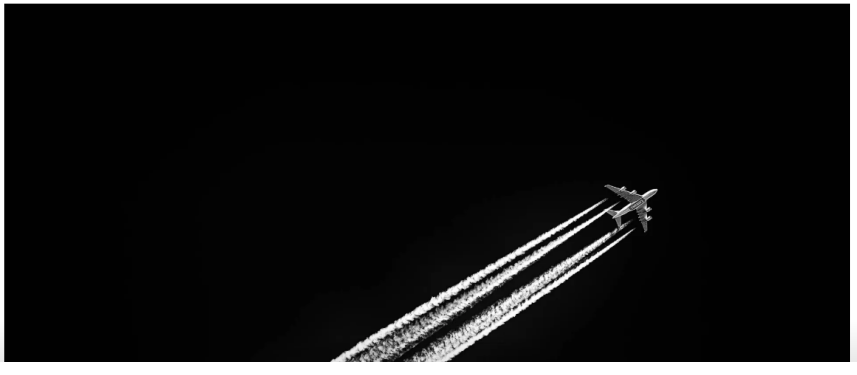
Plane Contrails Have a Surprising Effect on Global Warming

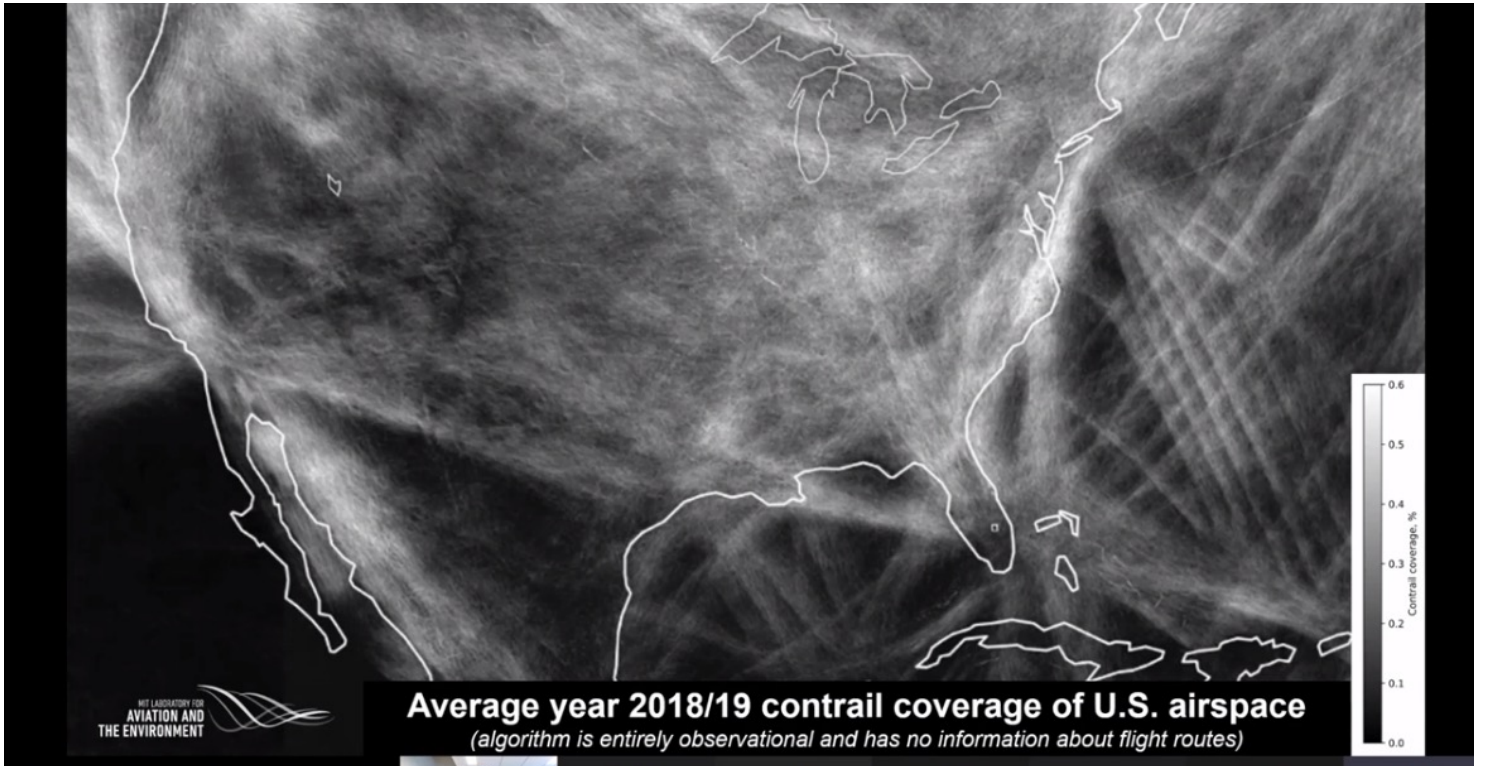
The wispy ice clouds formed by jet exhaust help trap heat near the Earth's surface. But small changes in altitude can dampen the effect, a study says.



can

Contrails Contribute to Global Warming

- Contrail Cirrus passes light and traps infrared
- Significant research is on-going to better understand impact on global warming
- Government organizations are looking at methods for mitigating
  - NASA ESTO (IRaST)
  - ARPA-E (Pre-Trails)



Screenshot from: "Overview of the State-of-the-Art of Satellite Image Identification of Contrails", Steven Barrett, MIT

Potential Solutions for Contrail Cirrus

- Proposed solutions tend to focus on modifications to jet fuels and altered flight paths

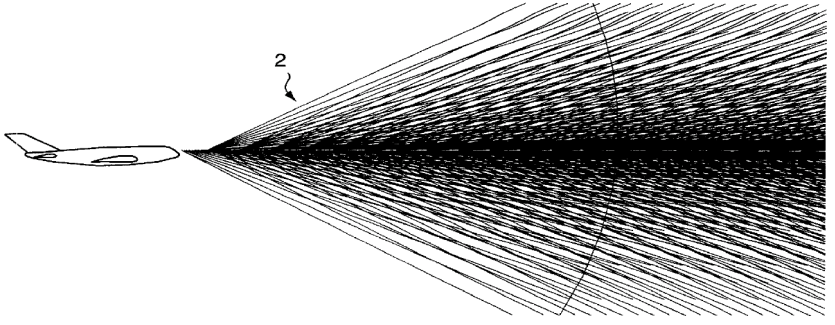
- Jet Fuel Solutions: eliminate/change soot particulate that ice crystals form on
  - Benefit: modest impact on commercial aviation if successfully implemented
  - Disadvantage: Unproven, could require replacement of jet engines, decades to implement

- Modified Flight Paths: Research shows changing altitude by several 1,000 feet can eliminate most contrail cirrus
  - Benefit: relatively simple solution if techniques to do it can be developed
  - Disadvantages: Lack of models and instruments to predict required changes in altitude!

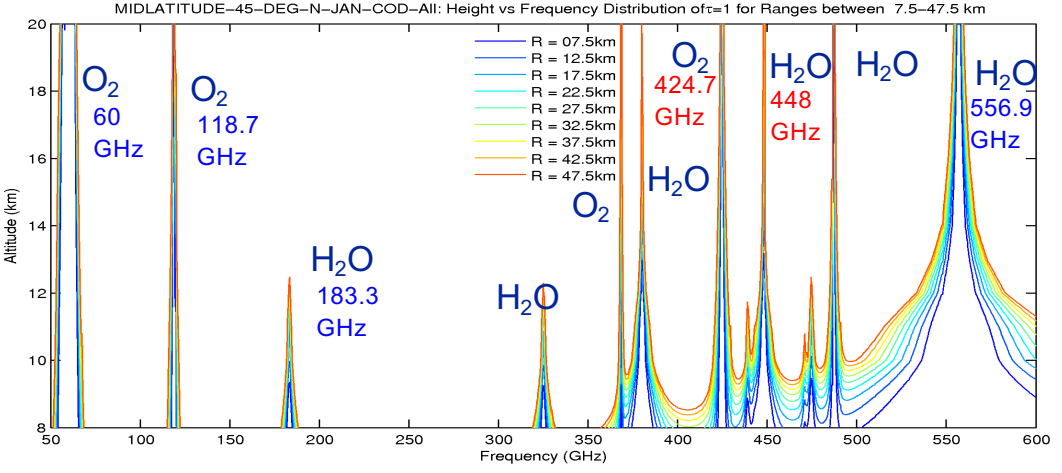
YTHP Overview

- Y-Band Temperature and Humidity Profiler (YTHP) is a forward scanning passive sounder in GHz frequencies to measure mixing ratios of oxygen and water vapor.
- Will be integrated into Northrop Grumman's G-II aircraft
- G-II aircraft is outfitted for contrail formation sensing
- Multiple flights for data gathering in different conditions
- Data will be analyzed

Scan forward zenith-to-nadir to measure water and T profile

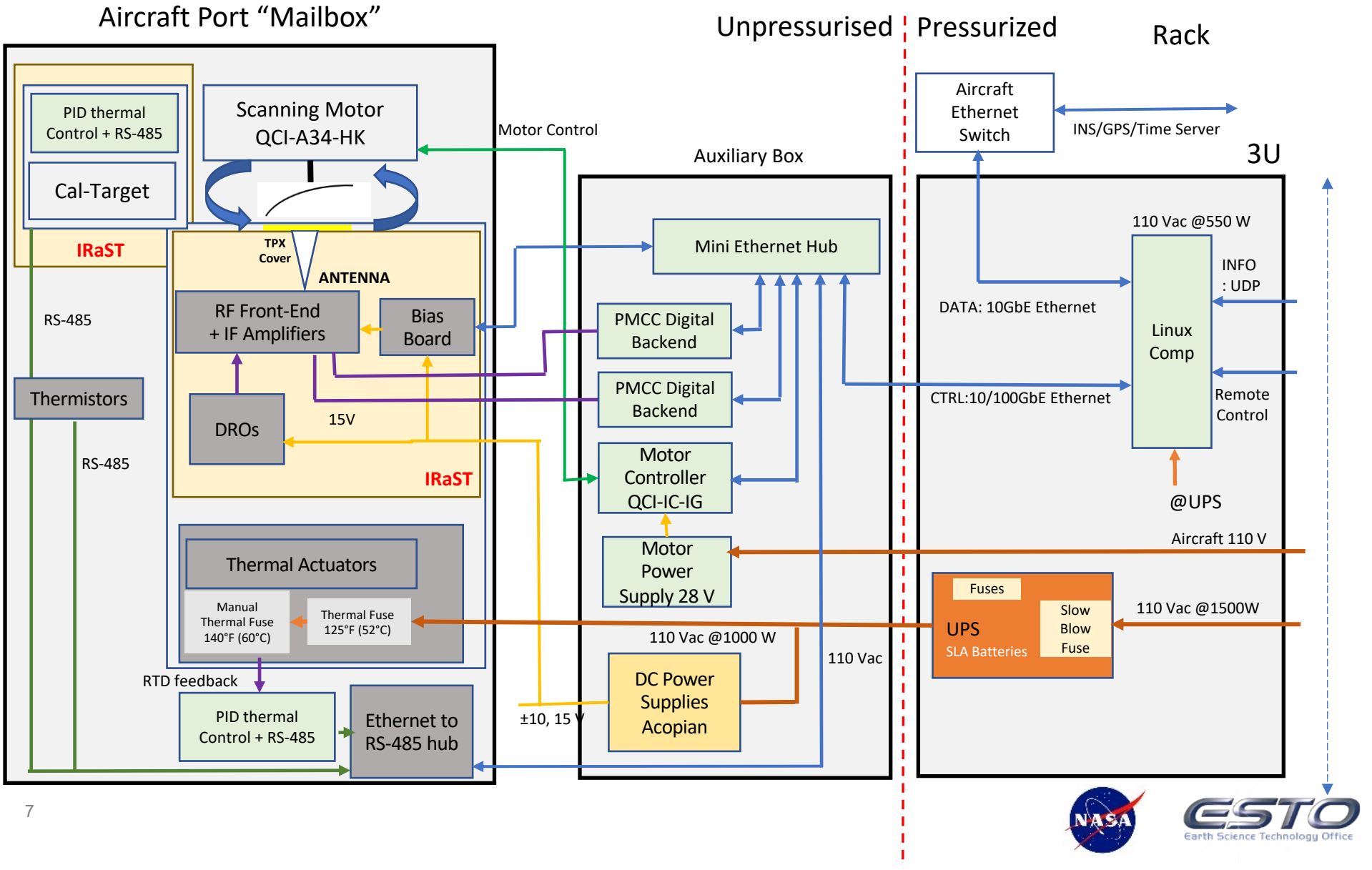


The band centers labeled in red were selected as candidate bands



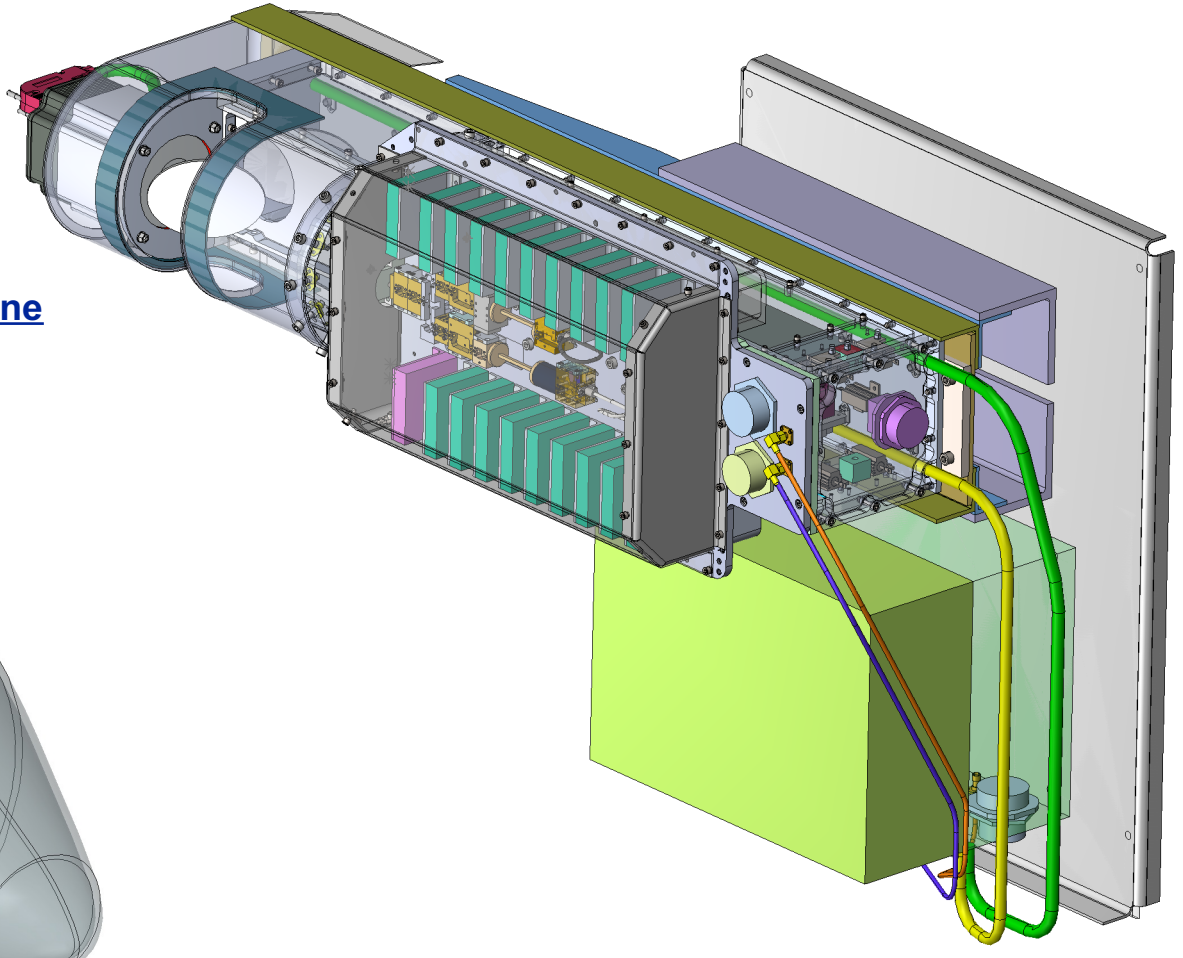
YTHP Block Diagram

System Funded by Space Act Agreement (SAA) except for the receivers and calibration target (funded by IRaST)

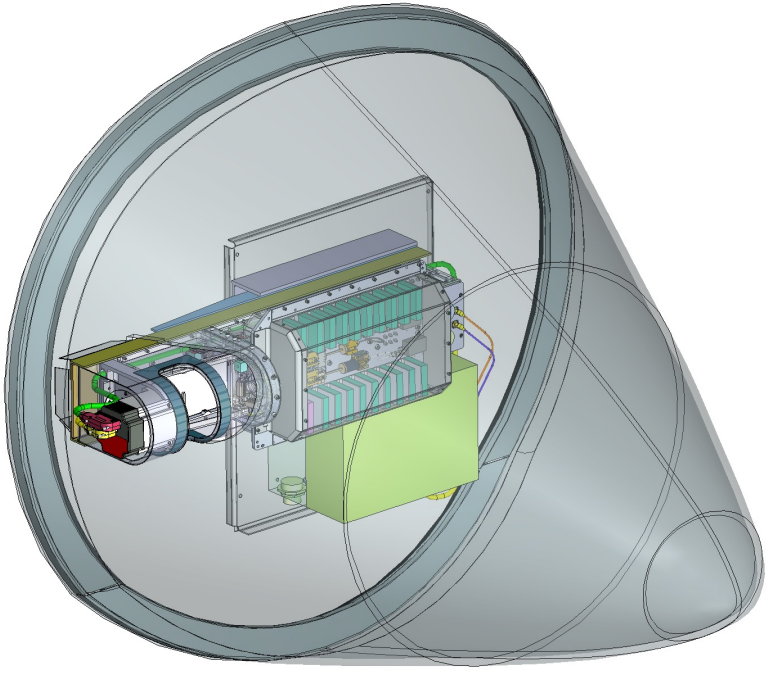


YTHP Full Cad Model

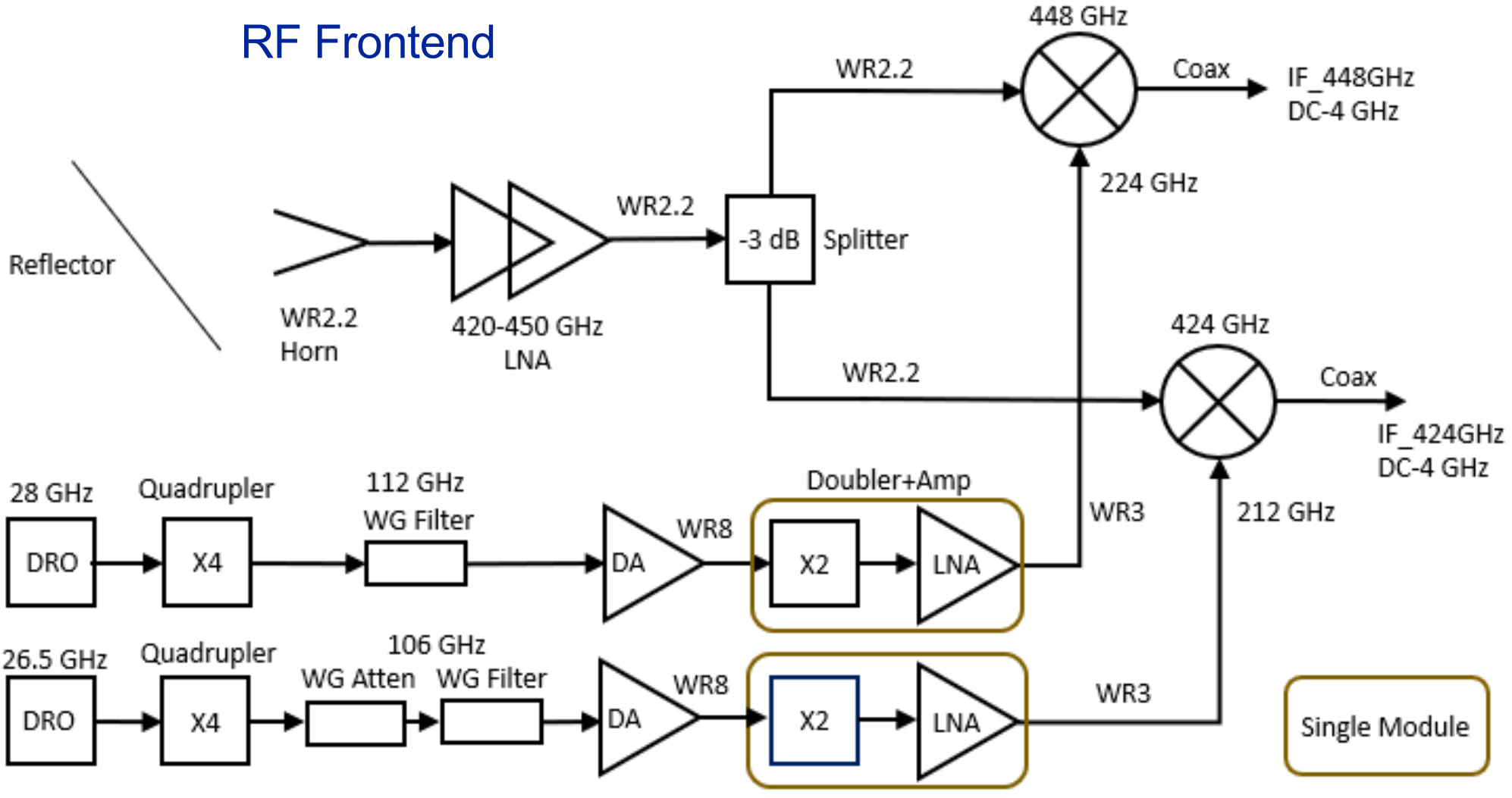
- Most components/assemblies received
- Instrument integration continuing



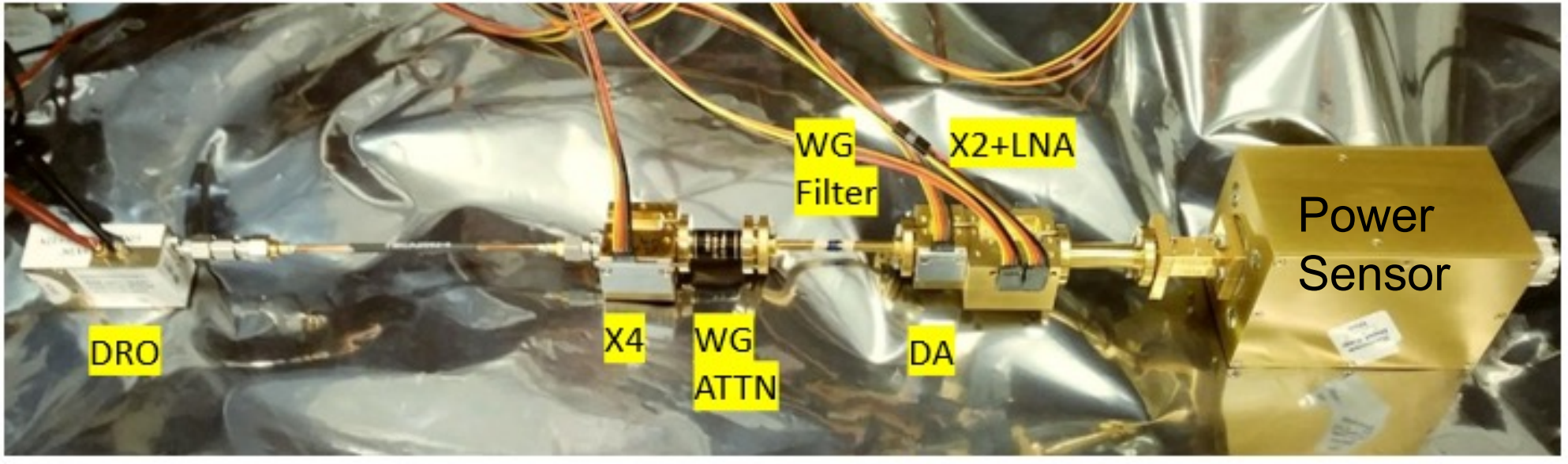
YTHP Instrument Shown in Nose Cone



Final Receiver Block Diagram



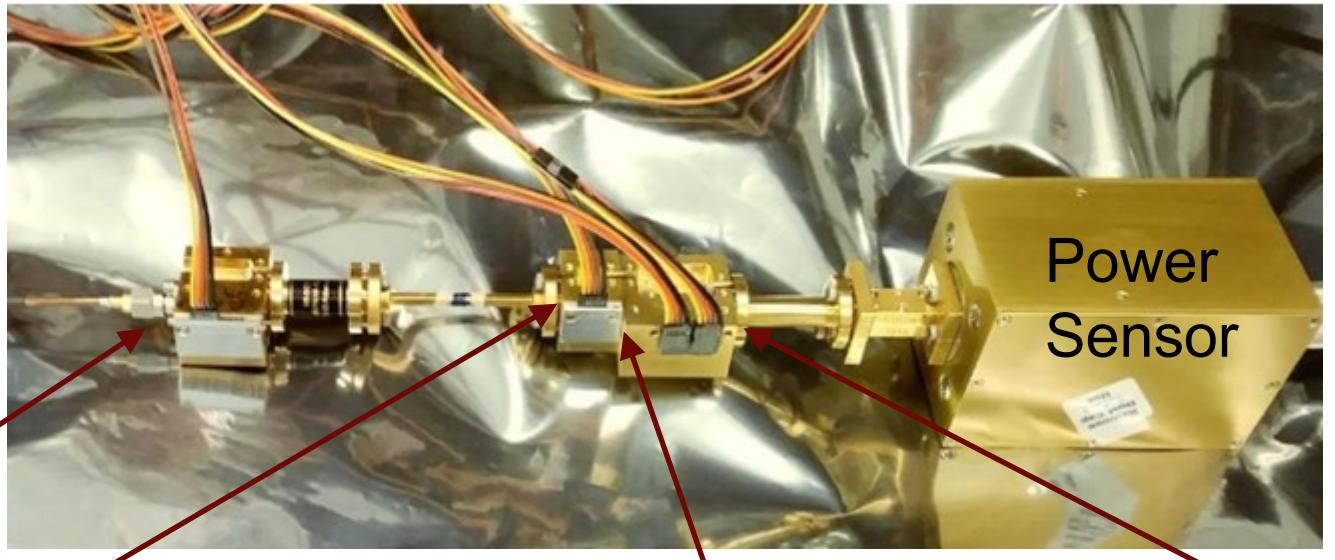
LO Chain Modification

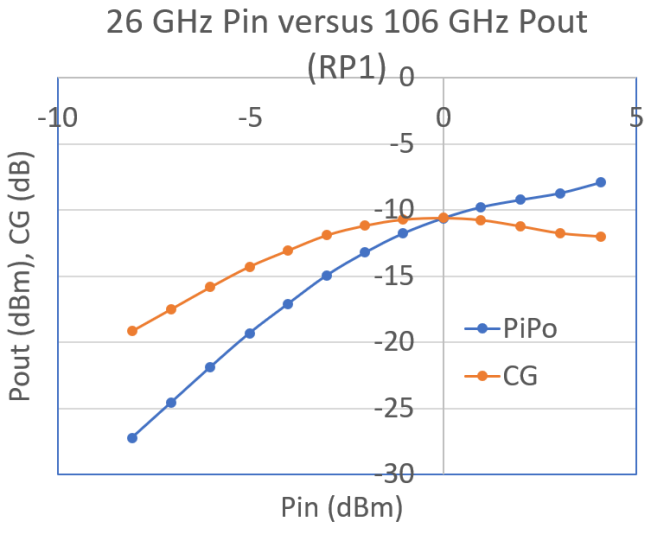


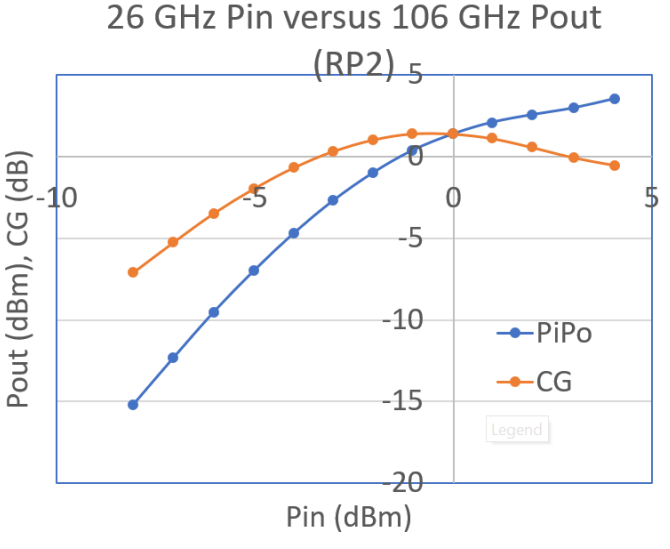
LO testing replaced DRO with PNA synthesizer and measure Pin vs Pout at reference planes

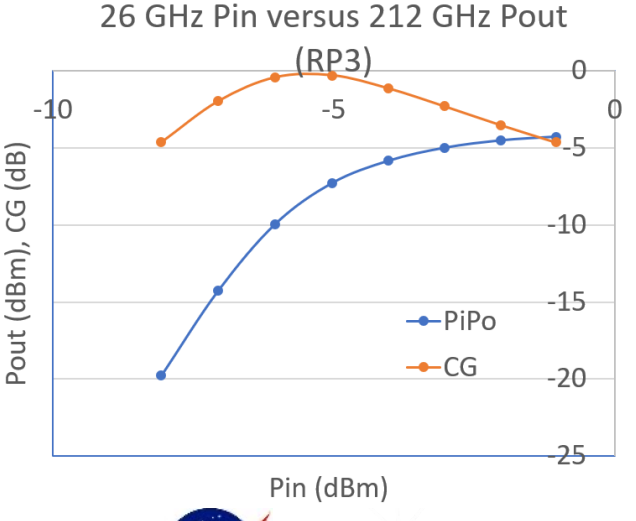
- Reference Plane 1 (RP1) Output of WG filter without WG attenuator
- RP2 Output of WR8 DA (LNA)
- RP3 Output of WR3 X2 + LNA

LO Chain Modification

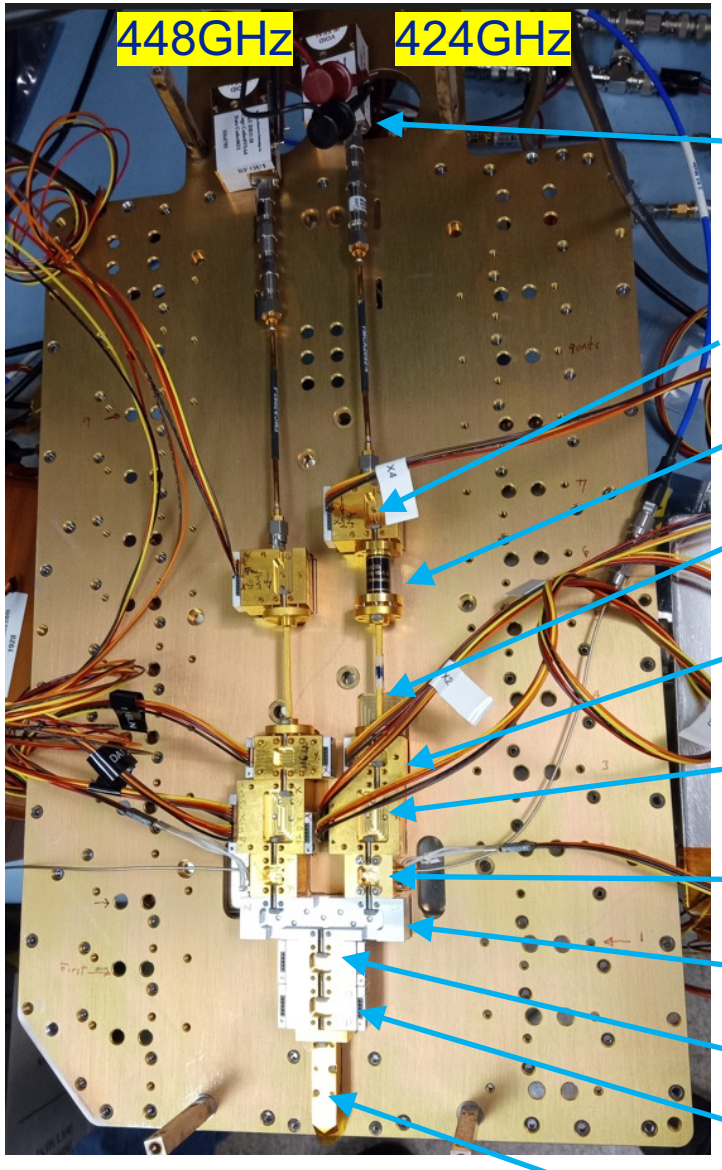








Receiver Noise Temperature



- Measured receiver noise temperatures are similar to noise temperatures of previously tested WR2.2 LNAs
- 448 GHz receiver:

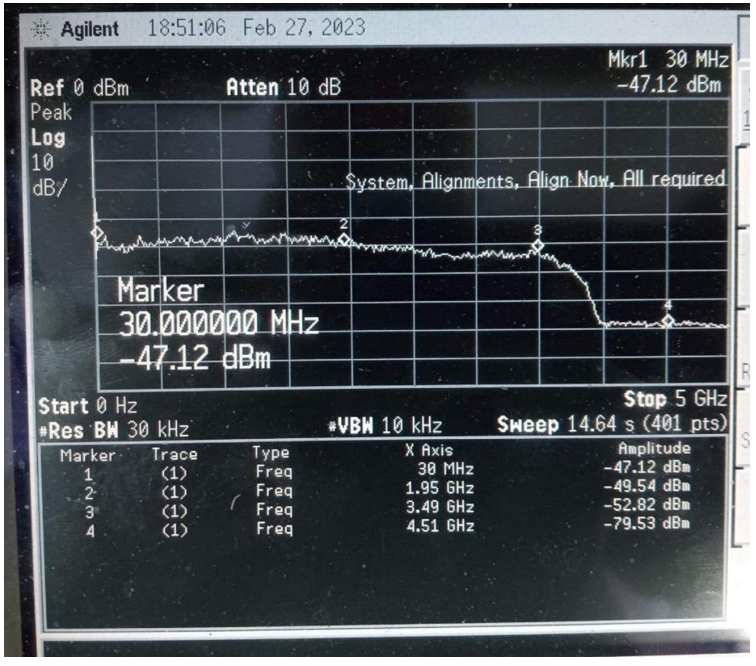
  Noise temperature = 2070K
- 424 GHz receiver:

  Noise temperature = 1920K
- 424 and 448 GHz receivers tested while simultaneously powered ON using bench top power supplies (not flight bias boards)

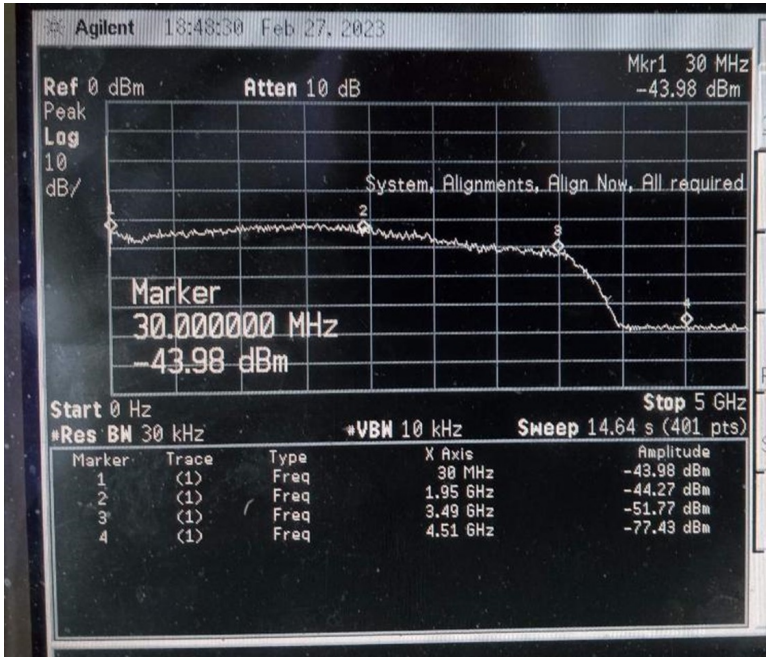
Receiver Spectral Output at the IF

- Broadband performance validated on spectrum analyzer
- Flat bandwidth observed over 3.5 GHz

424 GHz Receiver

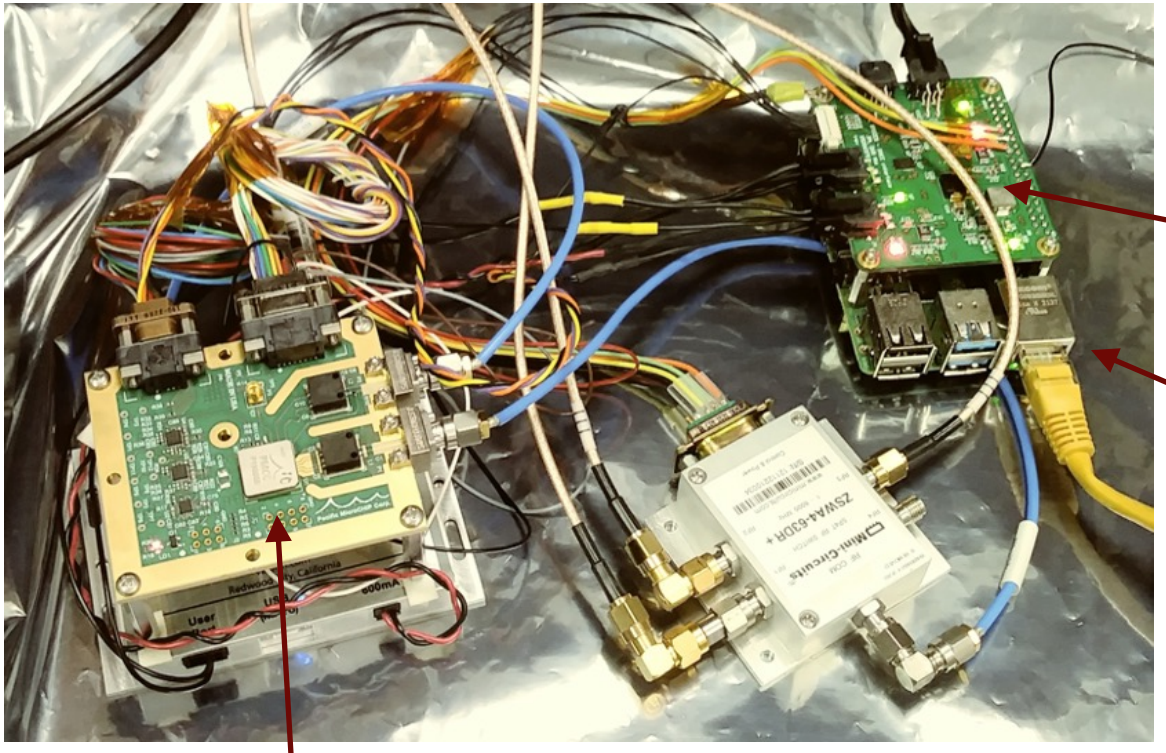


448 GHz Receiver



Backend Spectrometer Status

- 1 of 2 Spectrometers have been assembled and tested



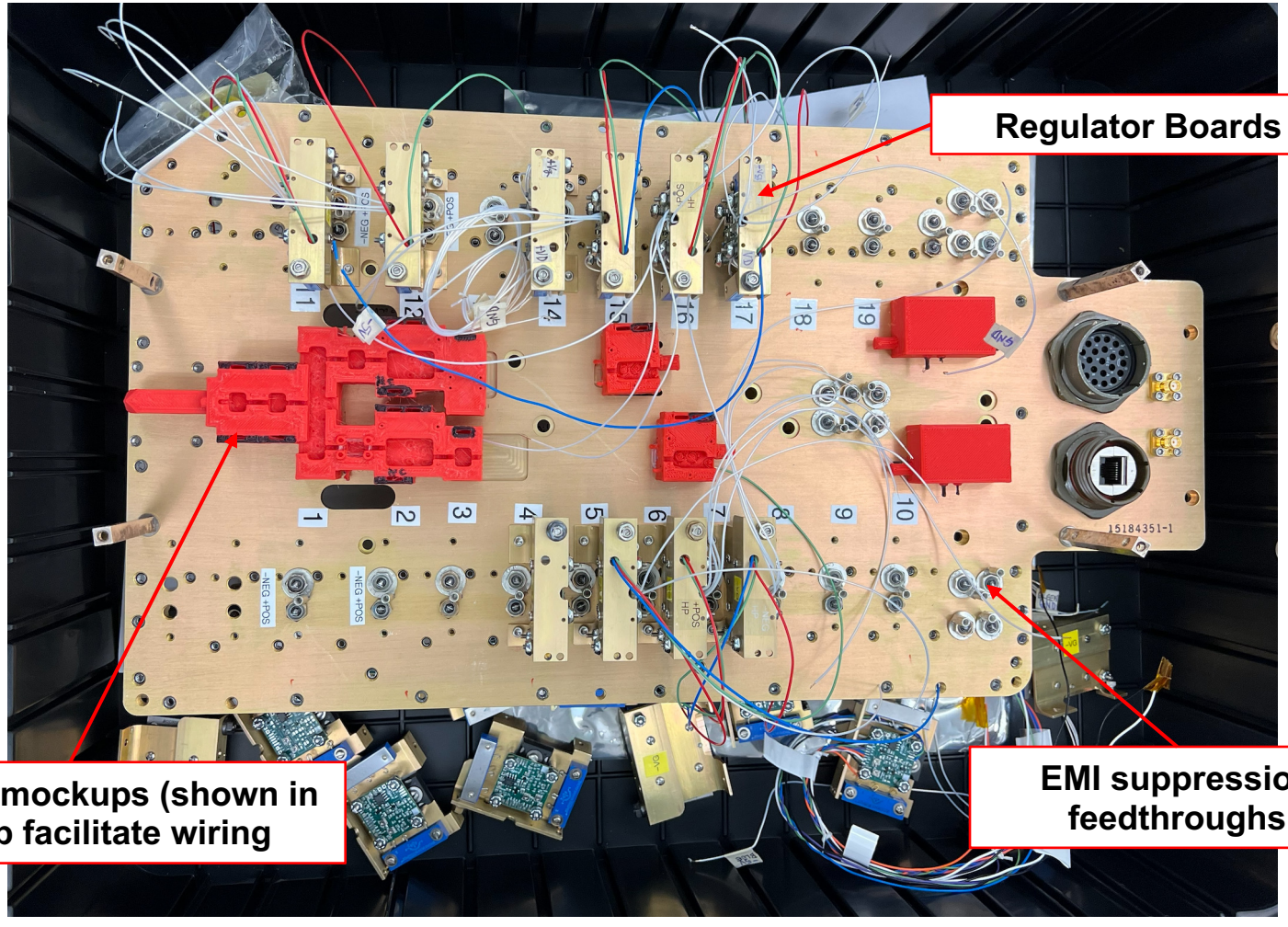
Spectrometer to Raspberry Pi interface board

Raspberry Pi Computer

PMCC spectrometer chip and board

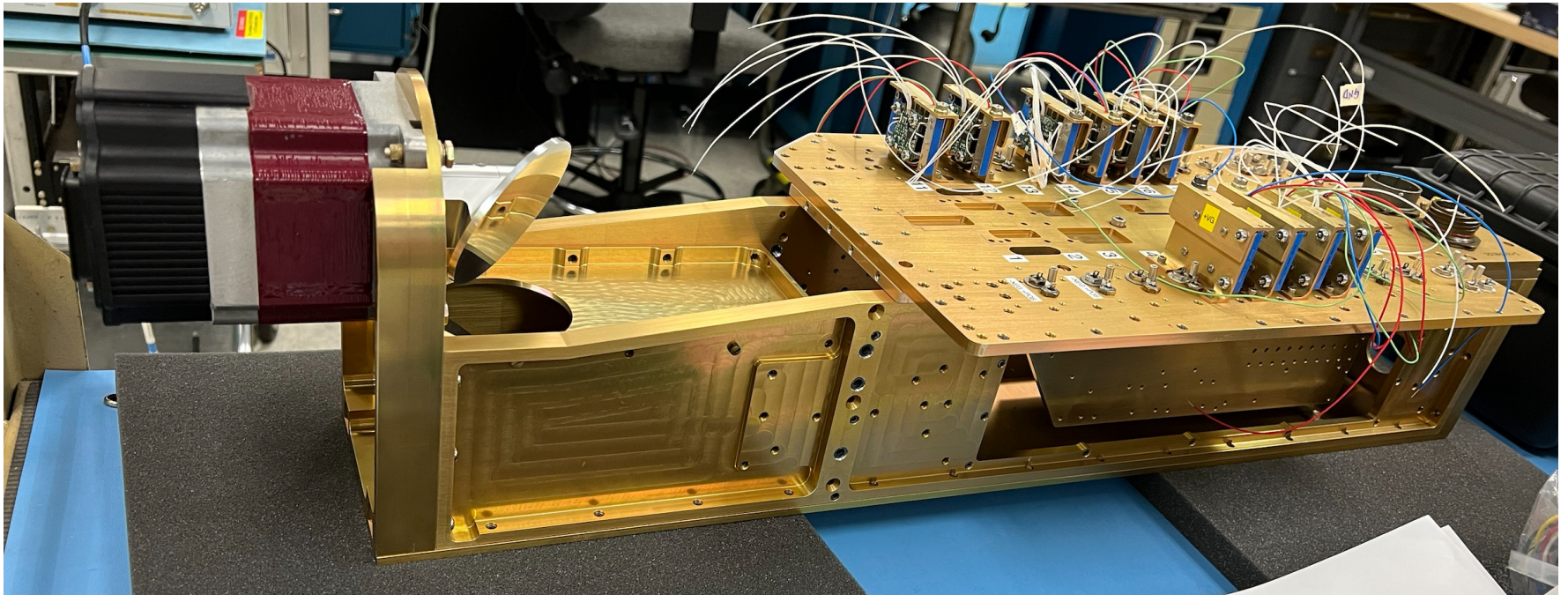
Receiver Integration

Blocks to Regulator Wiring



Bias boards 80% complete

YTHP Integration Progress



View of YTHP in the JPL Lab

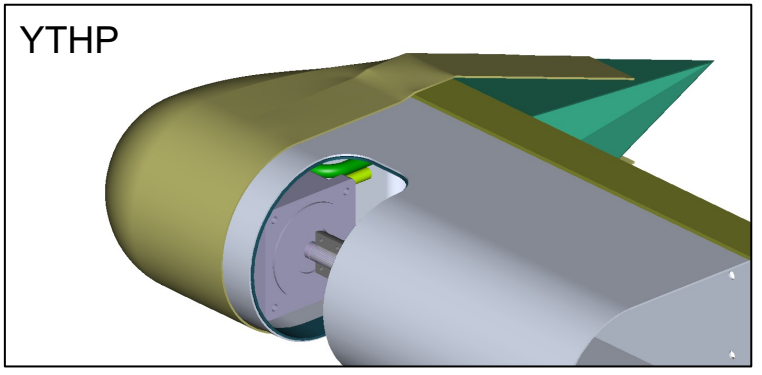
Final assembly shown here in work.

Fit-check for most structural components, motor, mirrors, and connector complete.

Electronic and RF components will be integrated next on Carrier Plate and IF L-Brackets.

Conclusion

- Contrail Cirrus has been shown to be a significant contributor to global warming
- Flight Altitude adjustments have been proposed as an effective technique to mitigate contrail cirrus
- But there are currently a lack of models and instruments to guide altitude adjustments
- YTHP proposes to measure a vertical temperature and humidity profile to help fill this gap.
- YTHP expected to start collecting data in Q3 of 2023

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