INTRODUCTION OF A GROUND BASED KA-BAND RADIOMETER FOR WEATHER OBSERVATIONS

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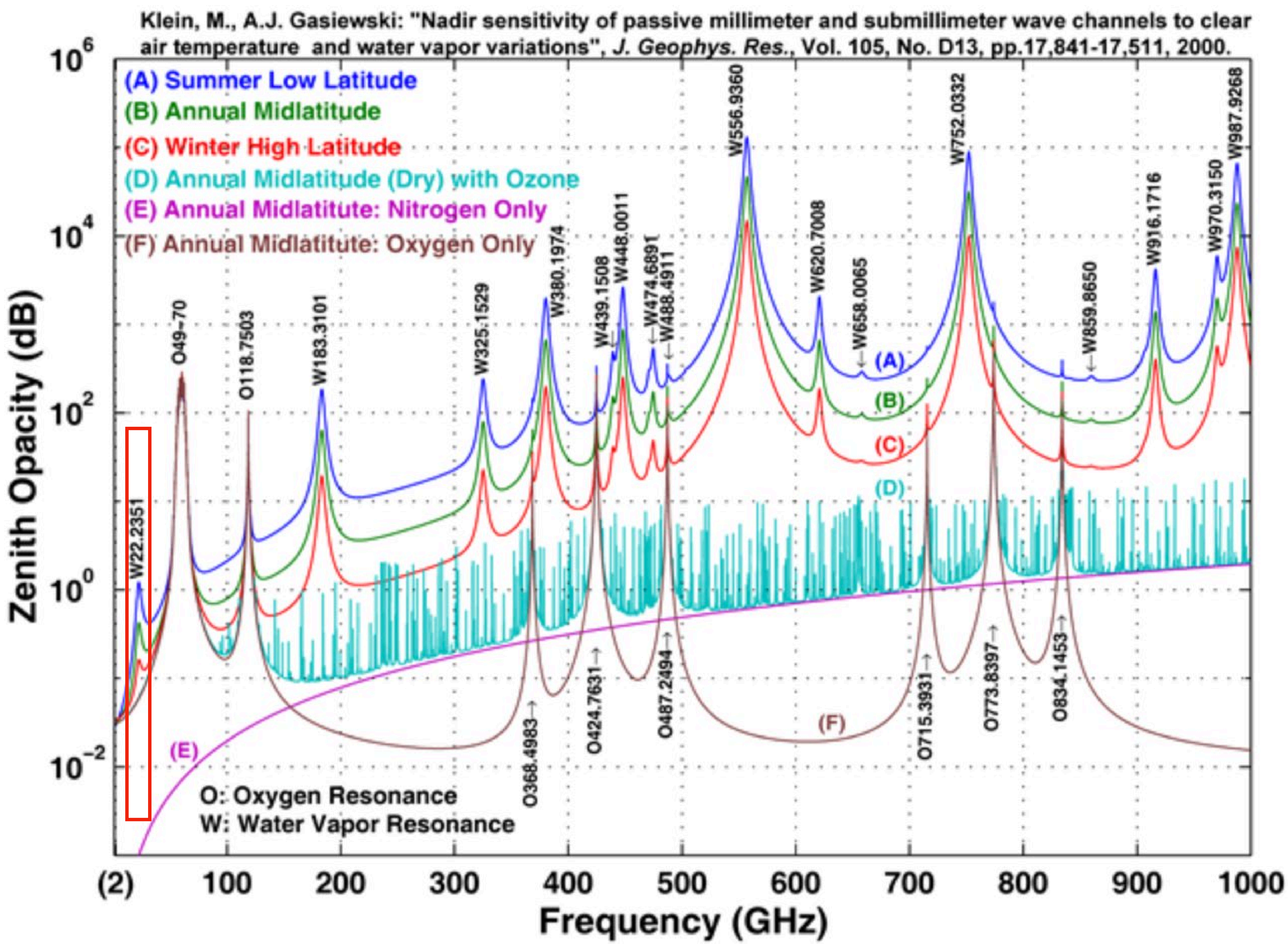
Project Background/Purpose

- To provide end-to-end demonstration and education for remote sensing, from principal of instrument hardware to data applications. Encouraging undergraduate and graduate students with different backgrounds involved in different level of remote sensing, from instrument design and calibration to geophysical retrieval

- The design and build process of a ground-based radiometer will provide great help for better understanding of observations from aspect of microwave instrument hardware, therefore provide better scientific support for JPSS program

Microwave Remote Sensing

Center frequency of detection band is selected to be at the 22.235GHz water vapor absorption line

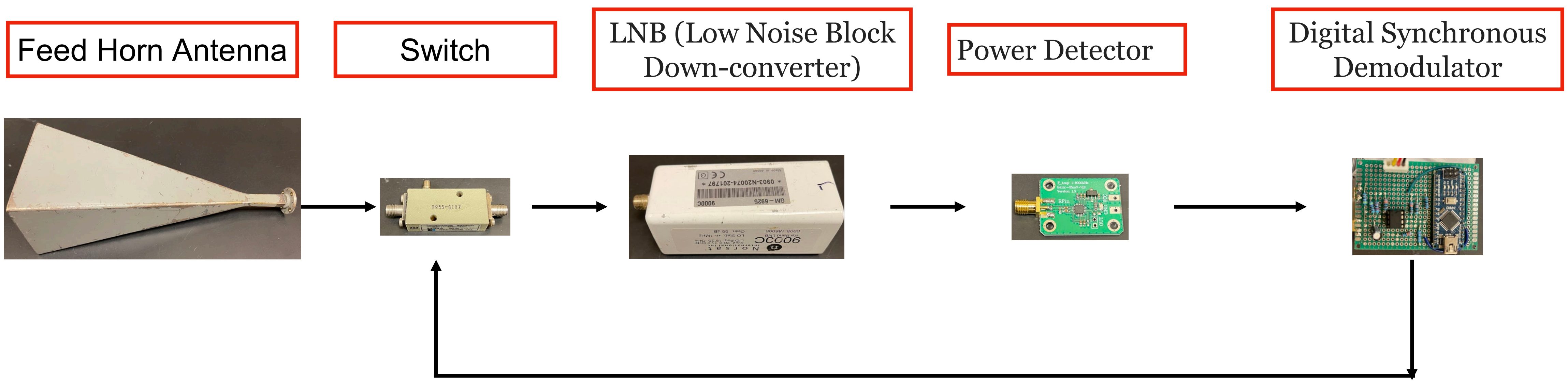


Applications of Microwave Radiometer

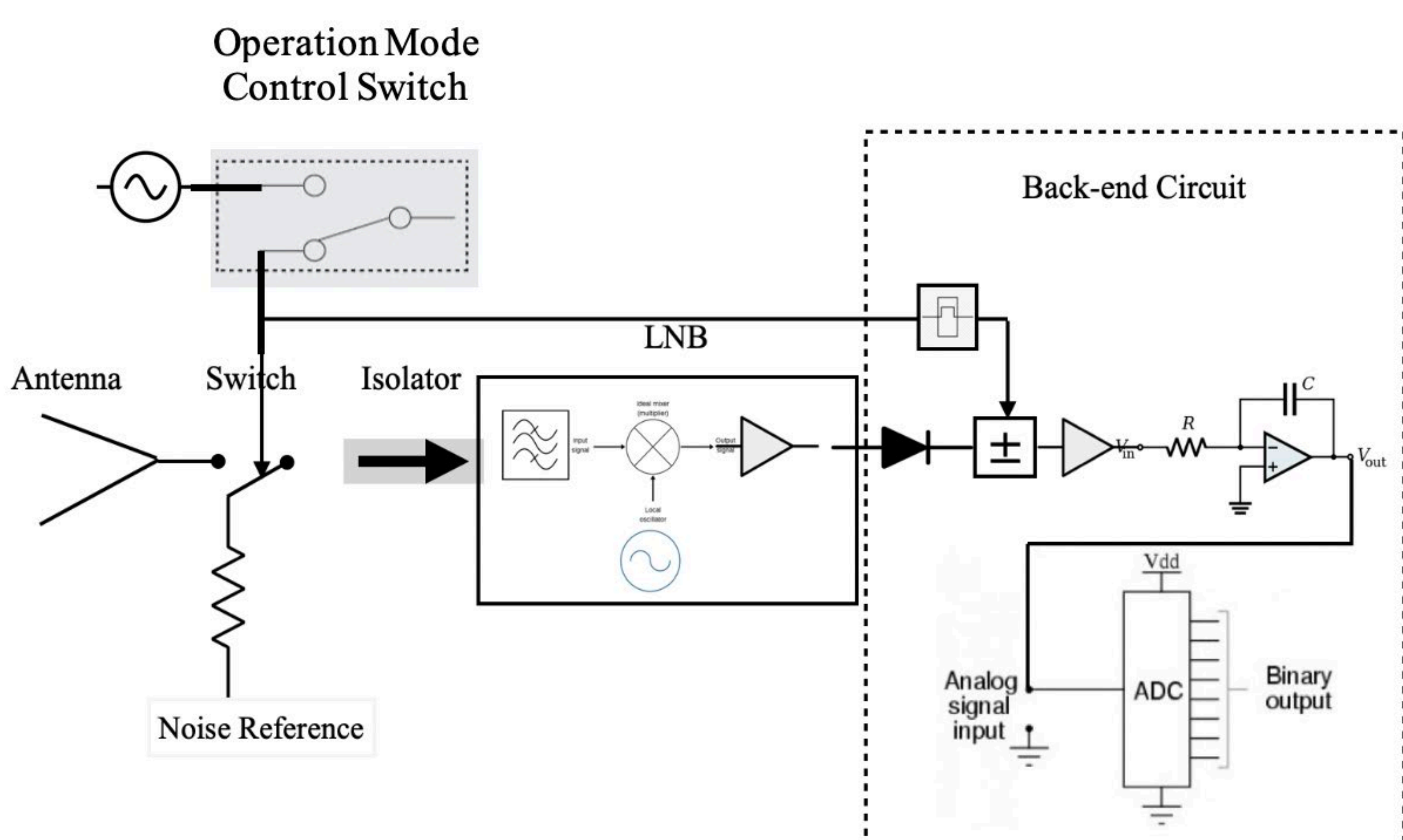
https://www.star.nesdis.noaa.gov/icvs/status_N20_ATMS.php

- Climate change studies
- Weather forecasting
- Hurricane/Typhoon monitoring
- Precipitation monitoring
- Sea ice monitoring

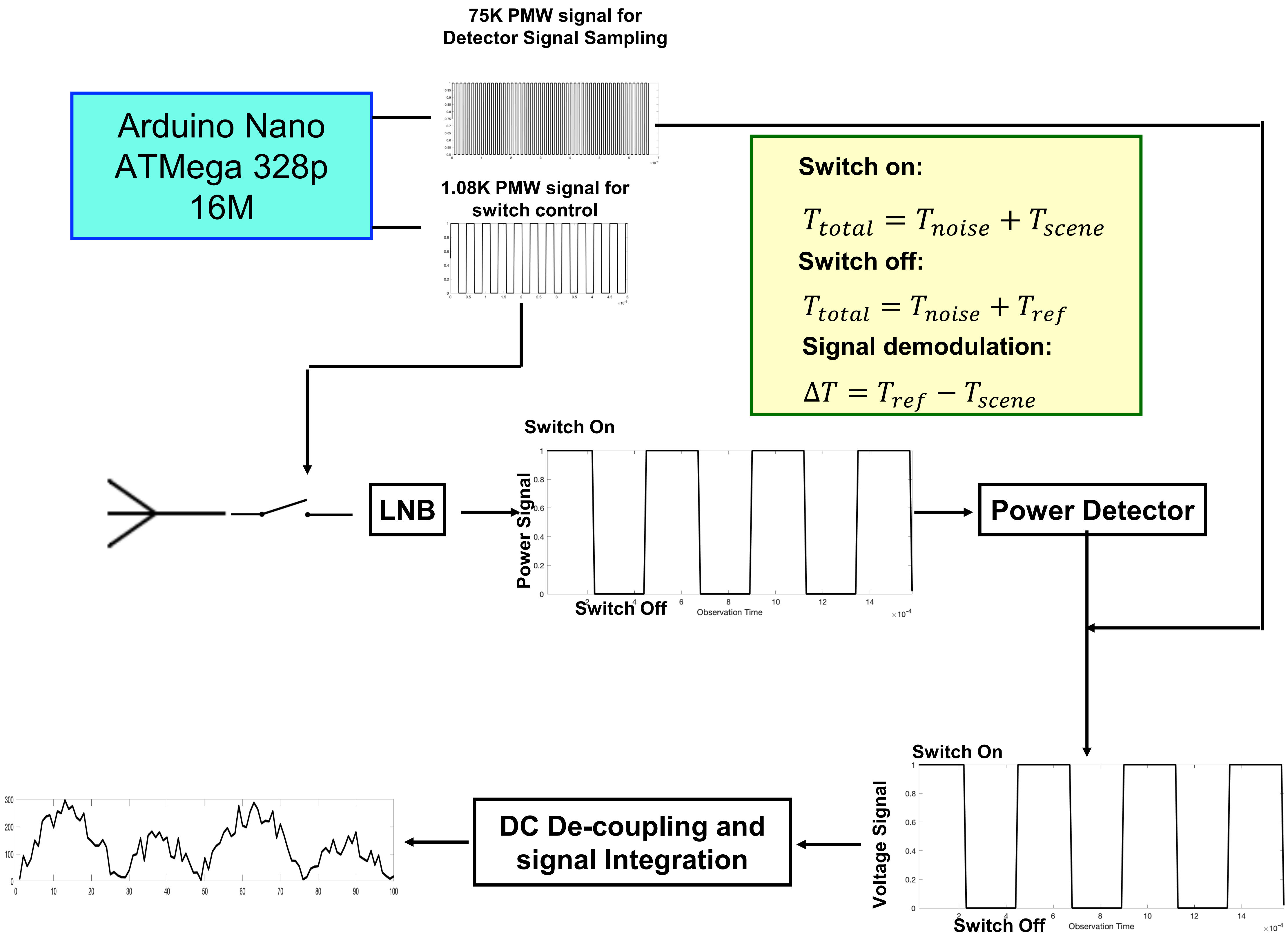
Design of the Ground Based Dual-Mode Ka-band Radiometer



Block Diagram



Digital Synchronous Detector and De-modulator Back-end Processing Module based on Microcontroller



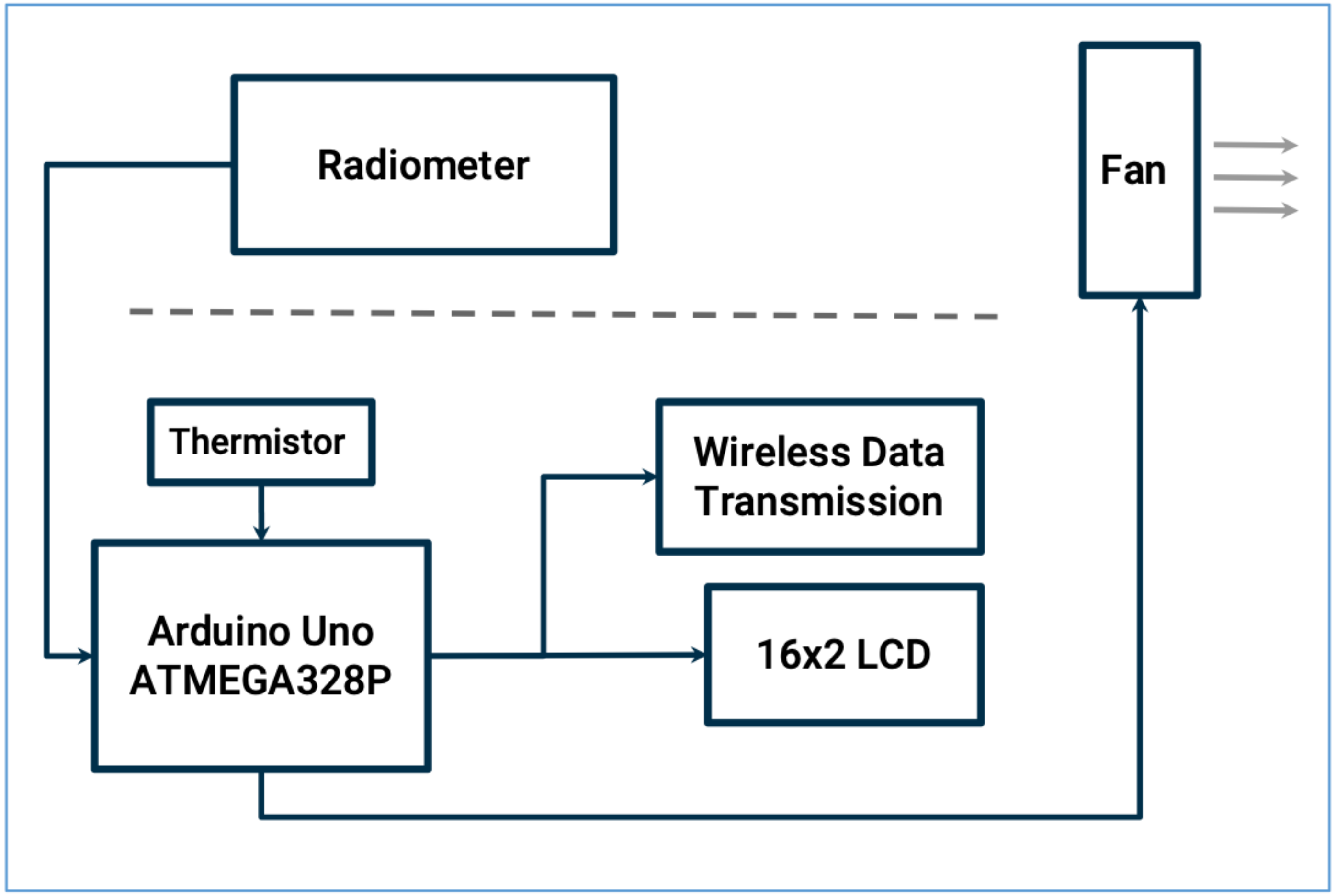
Data Collection and Temperature Control

Objectives

- Receive and display demodulated data from radiometer
- Monitor and control temperature within the system

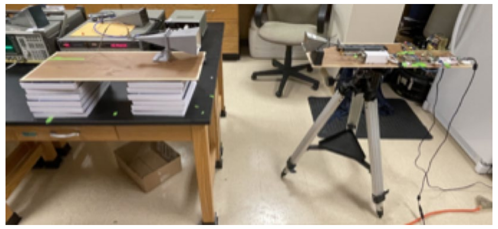
Method

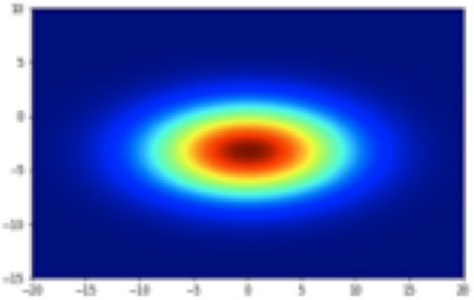
- I2C serial communication for collection of demodulated data
- Send data to LCD + another computer for more convenient display

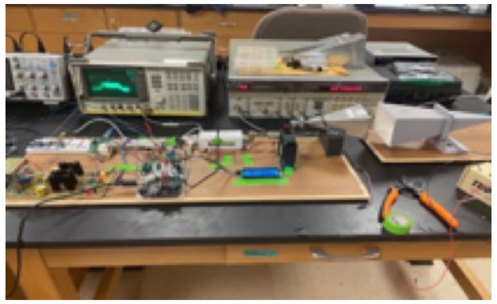


System Integration and Function Testing

- The prototype of the Ka-band radiometer was build based on the different function modules introduced in previous section. To test the performance of the instrument, an indoor experiment was designed to evaluate the instrument under ambient temperature. As shown in the Figure, the microwave radiometer was mounted on a telescope tripod, so it points directly towards a fixed signal source from the signal generator. A 2D image of the signal source was obtained with an azimuth range of 40 degrees with a 1-degree increment and an elevation range of 25 degrees with a 2.5-degree increment. The azimuth angle and elevation angle was adjusted manually, and the device output was recorded for 5 seconds for each angle. Figure 11 shows the scan results for the signal source.

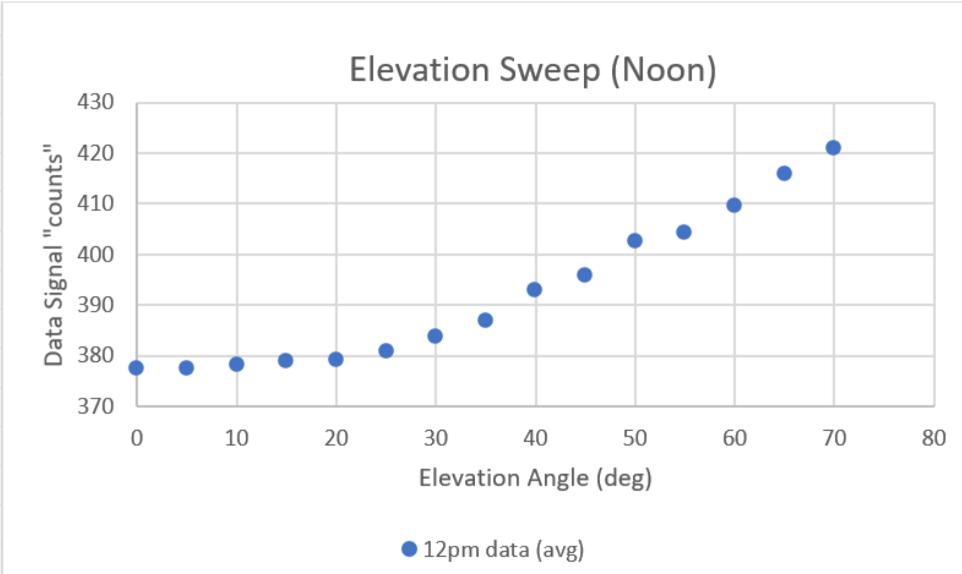




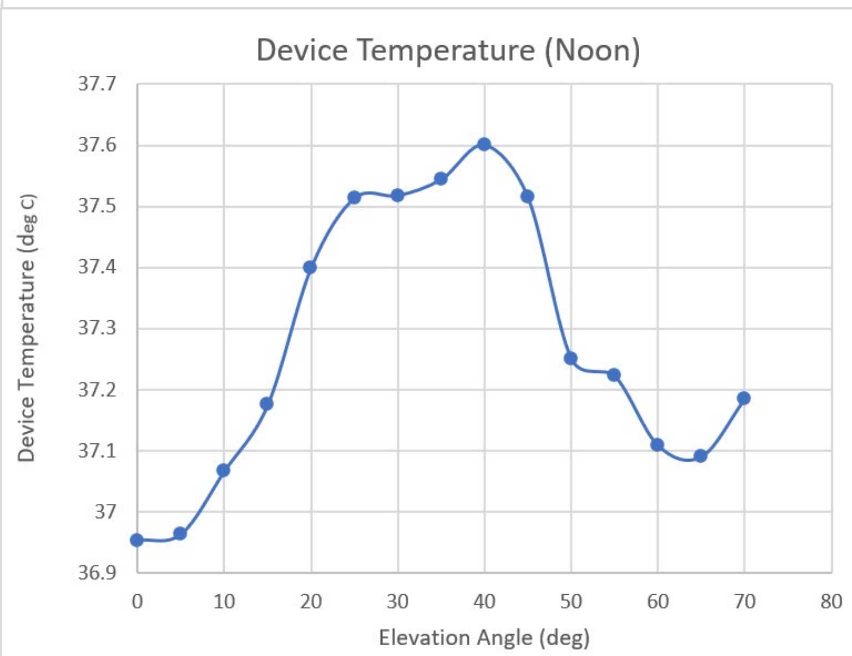


Instrument Parameter	Designed Value
Center frequency	22.148 GHz
Band width	200MHz
sensitivity	Total-Power Mode: 0.43K Dicke Mode: 0.86K
Beam width	15.7^{o}
Dynamic Range	3 K ~ 313 K

Instrument Performance Evaluation during 2023 Summer Field Campaign

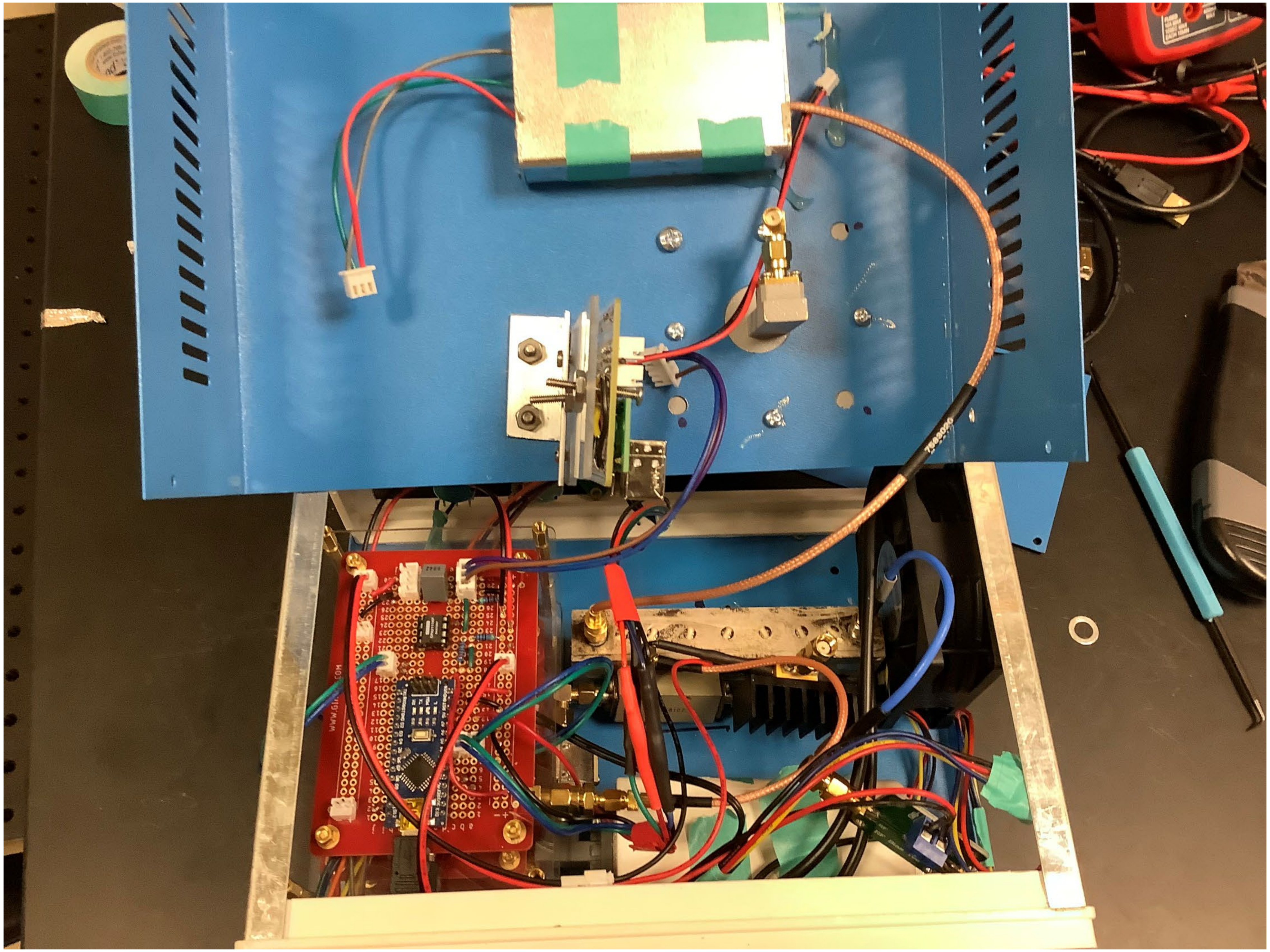


- Counts from demodulator increase as elevation angle increases, starting from 0 degrees (directly above test location) to 30 degrees below horizon (5 deg intervals)



- Device temperature remained fairly stable around 37 degrees Celsius during this test, although in the future we would like to see temperature not deviate by more than .2 degrees Celsius over the course of the test

Instrument Packaging



Conclusion and Future Work

- On instrument hardware development, currently, an operational product of dual-mode Ka-band microwave radiometer has been developed and tested in the Lab and during 2023 summer field campaign. The instrument is designed with center frequency of 22GHz and can be used for atmosphere water vapor observations. It can be operated under two different modes: Total-Power mode (with higher sensitivity) and Dicke mode (with higher stability).

- On student training, from 2021 to 2023, we have a total of 7 students that have worked in our Lab, which include five undergraduates and two high school students. We have average of 2.5 faculty/year from our Lab involved in the CISESS summer intern program. Courses were designed to guide the students learning the basic knowledge of microwave remote sensing and being trained with skills required for microwave instrument development, which include but not limited to hands-on skills of electronic circuit design and development, software and hardware programing, as well as the instrument performance evaluation and testing.

- In future, we will extend the radiometer observation capability by include more lower frequency channels with different polarization for surface observation, demonstrate the benefits of the ground based measurements for the calibration and validation of satellite products.