Upgrading the Receiver System and Amplifiers of the Drone and Transmitter System

Éle Donegan
Morse ‘26
Wright Lab Undergraduate Summer Research Symposium
Why is this important?

**Goal:** Better understanding of dark matter, and the role it plays in the expansion rate of the universe.

Requires precise instrumentation, calibrations and measurements.

The signal chain is a small part a much larger picture.
Beam maps to DM distribution pipeline

High precision beam characterization

Detect redshifted 21cm signal

Allows distant galaxies to be traced

Map dark matter distribution in the early universe
Summer Research Objectives

Improve the signal chain at the receiver end of the feed

- Boost signal in desired narrow frequency bandwidth
- Lower noise temperature so it is more sensitive in detecting target signals
What should be order of the amplifiers?

Where should the filters go?

Where should the cable go?
Methods: Experimental

‘Gain’ of each amplifier: Vector Network Analyser (VNA) or the spectrogram

Noise Temperature of each amplifier: Liquid Nitrogen power output comparison test using spectrum analyser
Methods: Theory

Equations needed for the NT tests:

1. \[ P_{\text{milliwatts}} = 10^{(\frac{P_{\text{dBm}}}{10})} \]

2. \[ Y = \frac{P_{\text{hot}}}{P_{\text{cold}}} \]

3. \[ T_{\text{noise}} = \frac{T_{\text{hot}} - Y T_{\text{cold}}}{Y - 1} \]

4. \[ T_{\text{cas}} = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} + \cdots \]

For a lossy element:

5. \[ T_1 = T_{\text{ref}}(L - 1) \quad G = \frac{1}{L} \]
## Amplifier summary

<table>
<thead>
<tr>
<th>Amplifier</th>
<th>Gain Measured (dBm)</th>
<th>Spec sheet Noise Temperature (K)</th>
<th>Measured Noise Temperature (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4MA</td>
<td>41</td>
<td>230</td>
<td>530</td>
</tr>
<tr>
<td>V63</td>
<td>20.5</td>
<td>390</td>
<td>750</td>
</tr>
<tr>
<td>V83</td>
<td>18.7</td>
<td>930</td>
<td>1540</td>
</tr>
</tbody>
</table>
What should be order of the amplifiers?
Where should the filters go?
Where should the cable go?

Old Signal Chain
Results: Improving the Amplification

Comparing Gains of different chains

- Old Chain: V83, 3dB, V63, 3dB, 4MA, SAW + 20dB
- Amp 1st: 4MA, 6dB, SAW, 6dB. H, 6dB, V63, 6dB, V83 + 20dB
- Filter 1st: SAW, 4MA, 3dB, SAW, 3dB, V63, 3dB, V83, LPF + 20dB

Frequency [Hz]

Gain [dBm]
What should be order of the amplifiers?
Where should the filters go?
Where should the cable go?

Coaxial cable will go here

New Signal Chain
Results: Lowering the Noise Temperature
Future Steps

Weatherproofing

- Purchased a waterproof, UV resistant, padlocked enclosure
- Plan: drill two holes, use gasketed connectors, cover with conformant coating

Once the dish is moved....

- 24hr sky surveys comparing old and new signal chain
- Compare the two polarities
- Include new signal chain in drone test flights
Thank you to Professor Laura Newburgh, Dr Pranav Sanghavi, Morgan, Audrey, other Audrey and Andrew. It was such a privilege to work with and get to know you all. And to fly the drone occasionally.