#### **3D** Printing Antennas and Other Dark Arts



Karen Rucker

#### Yes You Probably Know More Than Me

- B.S in Electrical Engineering, 2019
- Antenna Design Engineer in Aerospace, May 2019 present
- HAM licensed since 2015

KAREN REALLY IS AN ENGINEER
KAREN RUCKER A REAL ENGINEER
LEANIN' TREE.

# Designing Stuff

#### What's an Antenna, Anyway?

"a means for radiating or receiving radio waves" - IEEE Standard Definitions of Terms for Antennas



The "I Totally Didn't Forget" 6 m receiver antenna

#### Bad Antenna, Bad!

Frequency&

Gain&

Polarization&

Pattern&

Bandwidth&

Impedance Match



# What Kind of Idiot Recommends Tutorials for a Software You Don't Have?



#### Design Resources That Have Helped Me







# Cool\* Project I

# How Would You 3D Print an Antenna in Space? A Look at My Terrible No Good Undergrad Research





#### What if I Did What They Did... But Worse?



# **3D Printing Your Own Antennas**

"dichloromethane is especially poisonous. It has historically been the key ingredient in common paint stripper, but is being phased out due to its toxicity when used for DIY home projects."

#### It Works, and You Can Do It!

3D printable model

15 dBi standard gain horn

Print Technology: FDM

Infill: 10%

Pattern: standard diamond fill



#### The Simulation



3D Model, E Field magnitude

Return Loss





# Cool\* Project II

#### How to Talk to Aliens

#### Breakthrough Listen / SETI Institute RF Hackathon

Breakthrough Listen, UC Berkeley SETI Research Center, & the SETI Institute invited applications from

- RF professionals
- machine learning experts
- GNU Radio open source community

to participate in a three-day community gathering & technical hackathon at the Allen Telescope Array (ATA).



#### Hackathon Goals/Topics

- Detection and characterization of radio signals, including deep learning approaches.
- Data capture, management, and quality assessment for radio systems.
- RF front-end and antenna status and health management & assessment.
- GNU Radio-based tools for real-time and offline processing at the ATA and other radio astronomy facilities.
- Tools & standards development for open source signal data formats (e.g., SigMF), and transitioning to those formats from existing bespoke formats.
- Enabling citizen science and collaboration with the broader open source community.

#### ATA Background

- 42 offset Gregorian telescopes at Hat Creek Radio Observatory in California
  - plans to grow to 350+
- First of a new class of LNSD (large number of antennas, small diameter) cm-wave interferometers
- Began operation in October 2007



# Totally Not a Death Ray

## Triangular pyramidal log-periodic antenna (PLPA)

- Frequency-independent behaviour -> ideal for broadband
- 2 antennas -> dual polarisation
- Original design:
  - Performs from 0.5 to 11.2 GHz
- Improved design:
  - Shortened feed structure fully contained in a vacuum radome, cooled to ~65K
  - Reduced noise factor by 12
  - Performs from 0.9 to 18 GHz
    - difficult to find LNA w/ similar range.

#### Issues

- Mostly mechanical
  - Cryo breaking
  - Circuit boards/soldering breaking
- Hot and cold loading difficulties
- Have had to splice new SC ends on a few antennas due to high signal loss.
- Only about half of ATA is the new feed style

#### Antenna Health working group

Team:

- Michelle Thompson, Open Research Institute
- Derek Kozel GNU Radio, Cardiff University
- Katie Frey- Harvard & Smithsonian Library of the Center for Astrophysics
- Karen Rucker

Tasks:

- Multi-sensor data fusion
- Data collection code clean-up
- GNU Radio processing block

#### Antenna Health example

```
"cryotemp": {
160
                 "resourceT": "Attribute",
161
162
                 "dataT": "float",
                 "unitT": "K",
163
164
                 "thresholdT": {
               "type": "floatrange",
165
               "RANGE" : [[0.0,59.99],
166
167
                                 [60.0,65.0],
168
                                 [65.01,75.0],
169
                                 [75.01,150.0],
                                 [150.01,400.0]]
170
171
           },
172
                 "parentT": "ant"
173
174
             },
```

# Almost The End

#### **Resources/Links**

- DIY 137 MHz WX SAT V-dipole antenna
- Leap Australia <u>Rectangular Waveguide ANSYS HFSS</u>
- Radio Mobile Freeware by VE2DBE
- Antenna Test Lab, <u>3D Printing Your Own Antennas</u>
- SETI <u>Allen Telescope Array Overview</u>
- Hacking SETI by Steve Croft
- <u>Primary Beam and Dish Surface Characterization at the Allen Telescope Array</u> by Radio Holography

## Summary

- Antennas can be hard
  - There's no shaming in buying one!
  - Be patient, not intimidated
- The connector is always\* the problem
  - \*not always
- Even professionals have to tune, tune, tune
- Antennas can be fun!



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