

External Calibrator for Hydrogen Observatories

Michael Horn

Mentor: Dr. Danny Jacobs

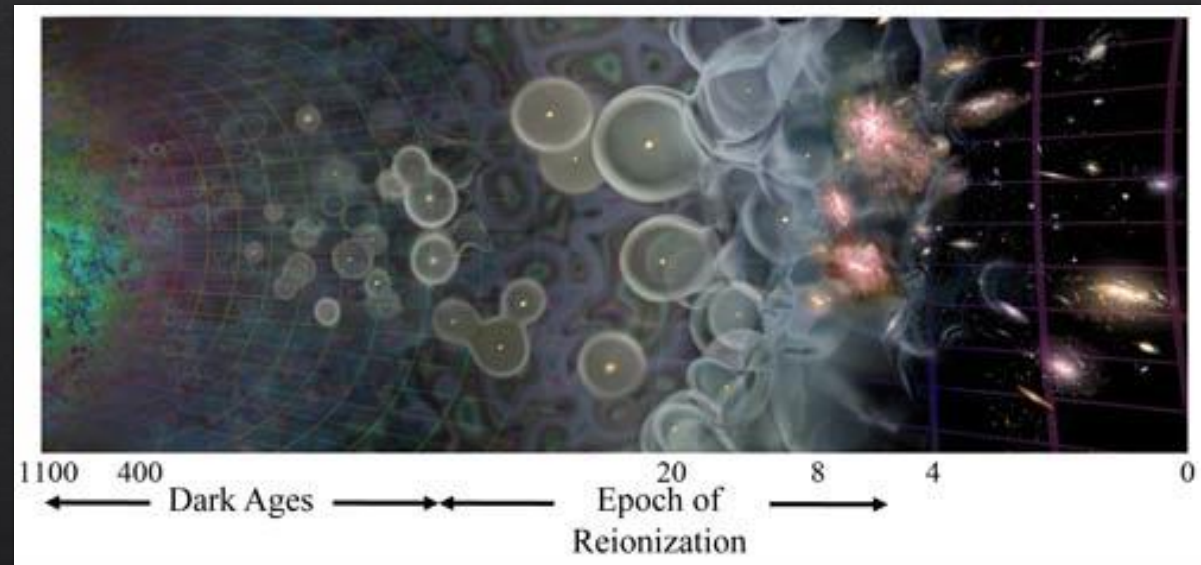
NASA Space Grant Symposium

April 14, 2018



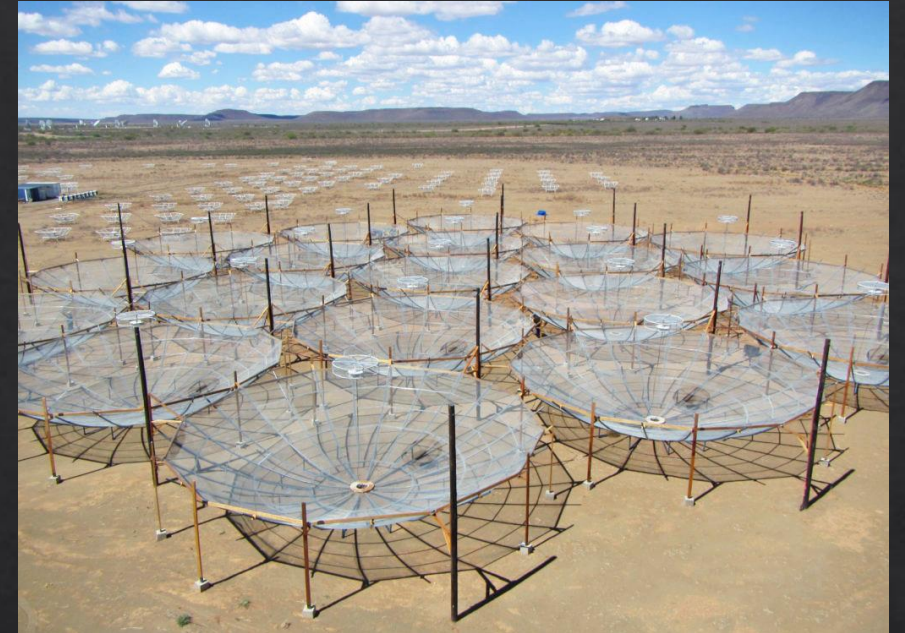
Overview

- ◆ ECHO is a drone-mounted calibrator for radio telescopes
- ◆ Radio telescopes are being used to study the early universe
- ◆ Typically, telescopes use known sources in space for calibration (Sun, nearby stars)
- ◆ ECHO provides a calibration system under full experimental control



HERA

- ◆ **Hydrogen Epoch of Reionization Array**
- ◆ 350-dish array
- ◆ Each dish is 14m across and 6m tall
- ◆ Based in Karoo, South Africa
- ◆ Studies the early formation of stars and galaxies through Hydrogen emission
- ◆ Still being built, currently up to 65 dishes
- ◆ Layout designed for optimal resolution and high sensitivity



Prescott Test Dish

- ◆ Exact replica of one HERA dish
- ◆ Located right on Embry-Riddle Aeronautical University's campus in Prescott, AZ
- ◆ Built by students from ASU and ERAU
- ◆ Local testing dish for ECHO
- ◆ Made out of common materials
- ◆ Currently developing a software defined radio to examine the spectrum response





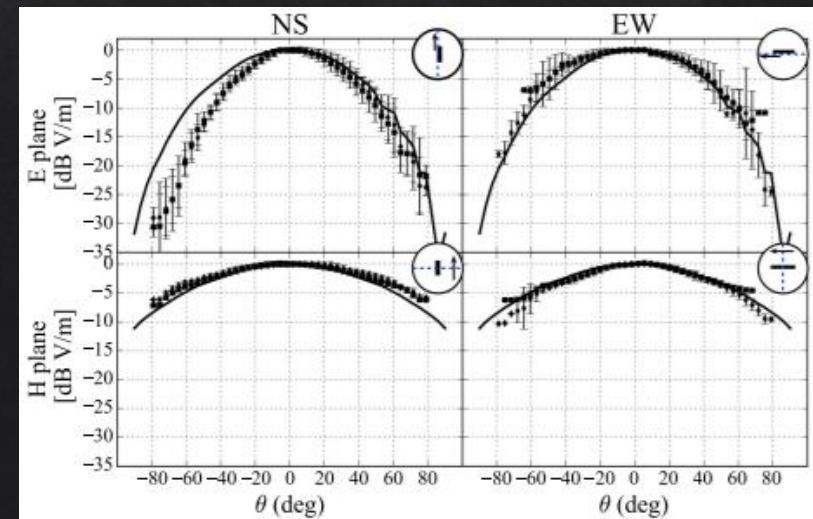
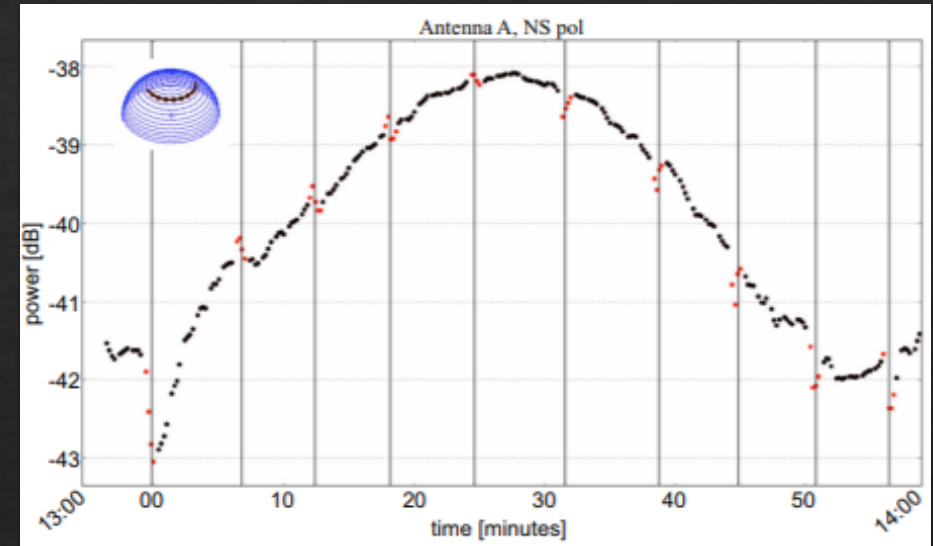
ECHO X8

- ◇ ECHO v2 used a 3D Robotics X8 octocopter
- ◇ 11" propellers
- ◇ 4S 25C 10,000mAh battery
- ◇ 15 minute flight-time
- ◇ Pixhawk autopilot for waypoint-based flight to follow a set path
- ◇ GPS, communications radios, and ECHO blackbox (digital oscillator)
- ◇ BicoLOG antenna outputs signal



ECHO X8 Results

- ◇ Tested at National Radio Astronomy Observatory in Green Bank, WV
- ◇ Results mostly match the expected beam patterns as measured by another system (ORBCOMM) and simulations
- ◇ Drone wiggled as it passed through waypoints (top figure)
- ◇ Flexible antenna mount caused about 10° undesired tilt (top left panel, bottom figure)
- ◇ Goal to reduce unwanted movement and increase flight time



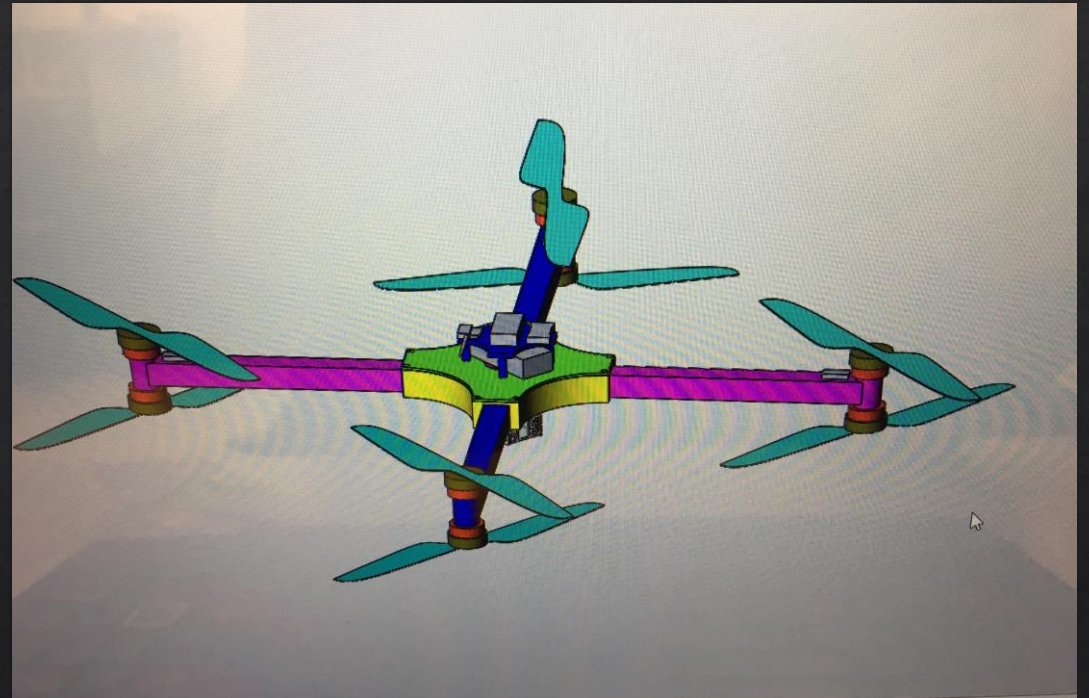
ECHO Vader

- ◇ ECHO v3 will utilize a SteadiDrone Vader octocopter
- ◇ 28" propellers
- ◇ 5S 40C 10,000mAH batteries (4)
- ◇ 30+ minute flight-time
- ◇ Pixhawk autopilot
- ◇ First flights this summer!



ECHO Chiropter

- ◇ Custom designed drone for ECHO
- ◇ Current plans attempt to mimic key Vader design choices
 - ◇ Similar propellers, motors, batteries
- ◇ Accessible mounting area for transmitter
- ◇ Focus on minimizing cost to produce while upholding quality
- ◇ Currently in the design phase
 - ◇ Selecting components
 - ◇ 3D modeling



Acknowledgements

I would like to thank the following people for their help and support throughout this project:

- ◇ Dr. Danny Jacobs
- ◇ ASU/NASA Space Grant
- ◇ Members of ECHO past and present
- ◇ Prescott Test Dish team and ERAU
- ◇ Low-Frequency Cosmology Lab (LoCo) at ASU

None of this would have been possible without each of your individual contributions!

Questions?