Development of the University of Delaware CubeSat Ground Station

Bennett A. Maruca[†,1];
E. C. Graff, Jr.[1]; J. Neumann[1]; A. Tamimi[1];
D. Sundkvist[2]; and J. C. Martínez-Oliveros[2]

[†] bmaruca@udel.edu
[1] University of Delaware
[2] University of California, Berkeley

Motivation

- Purpose
  - Provide communications (uplink and downlink) for the CURIE spacecraft
  - Establish infrastructure in Delaware for future CubeSat missions
- Goals
  - Provide student with hands-on experience with space hardware design
  - Foster interdisciplinary collaboration at UD (science and engineering)
  - Simulate public engagement with space research

Image credit: Judith Provencal

CubeSat Radio Interferometry Experiment (CURIE)

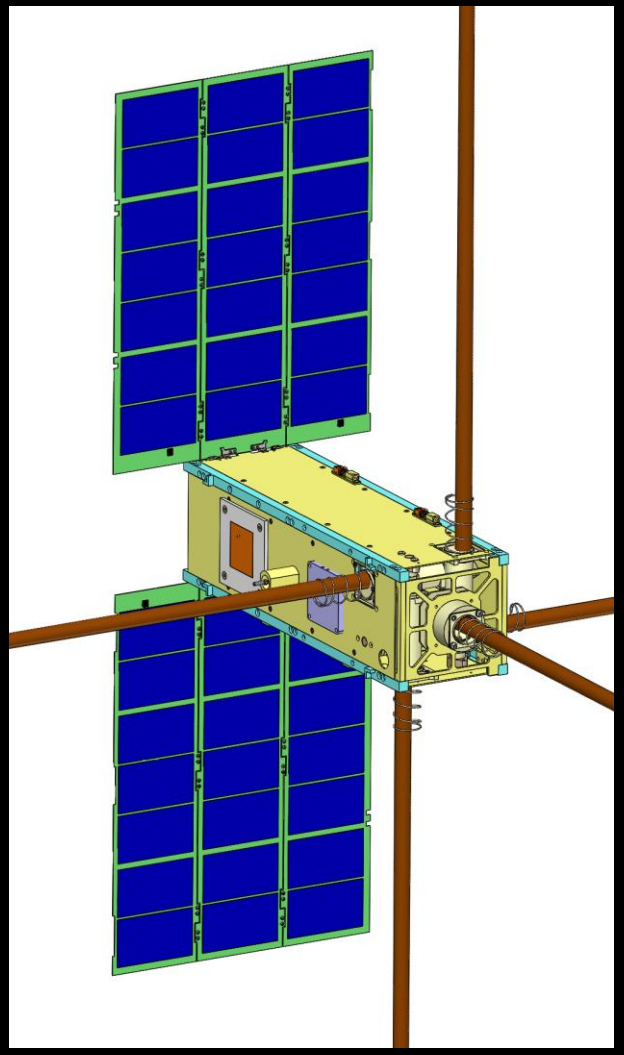
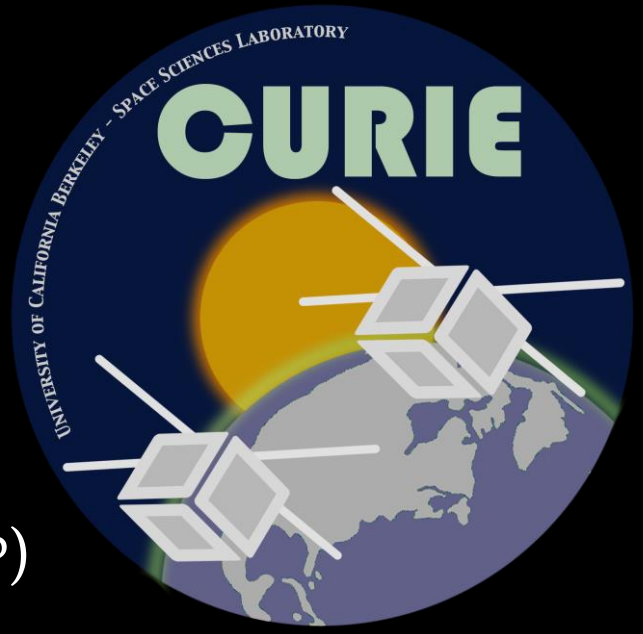


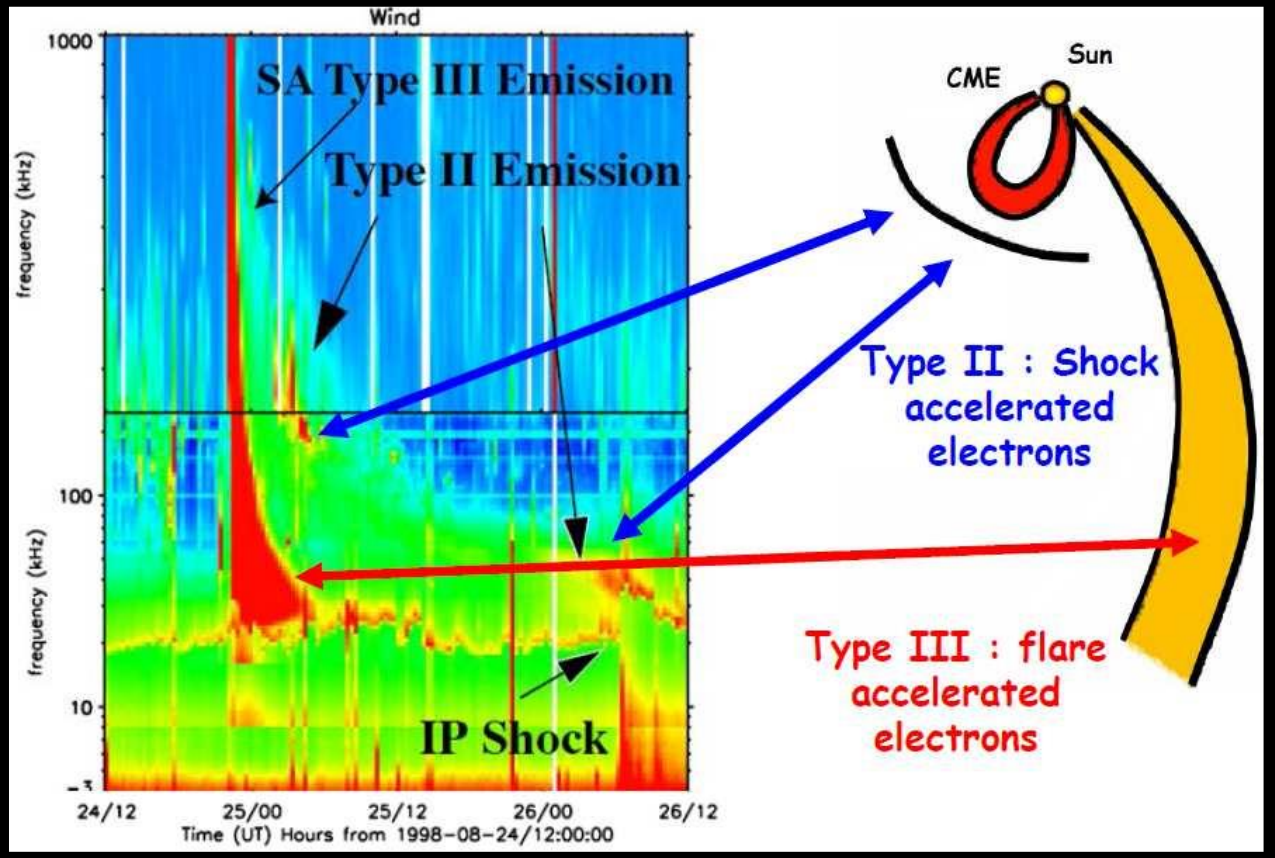
Image credit: UC Berkeley

- Dr. David Sundkvist, UC Berkeley, Space Sci. Lab.
- Funded by NASA Heliophysics Div. (H-TIDeS)
- Launch: late 2020
- Pair of 3U CubeSats; length ≈ 30 cm (12 in)
- Radio antennas (stacers)
  - Length: 2.5 meters (8 feet)
  - Five per spacecraft
  - Heritage: STEREO
- Radio receiver
  - Low-frequency (< 20 MHz)
  - Heritage: Parker Solar Probe (PSP)



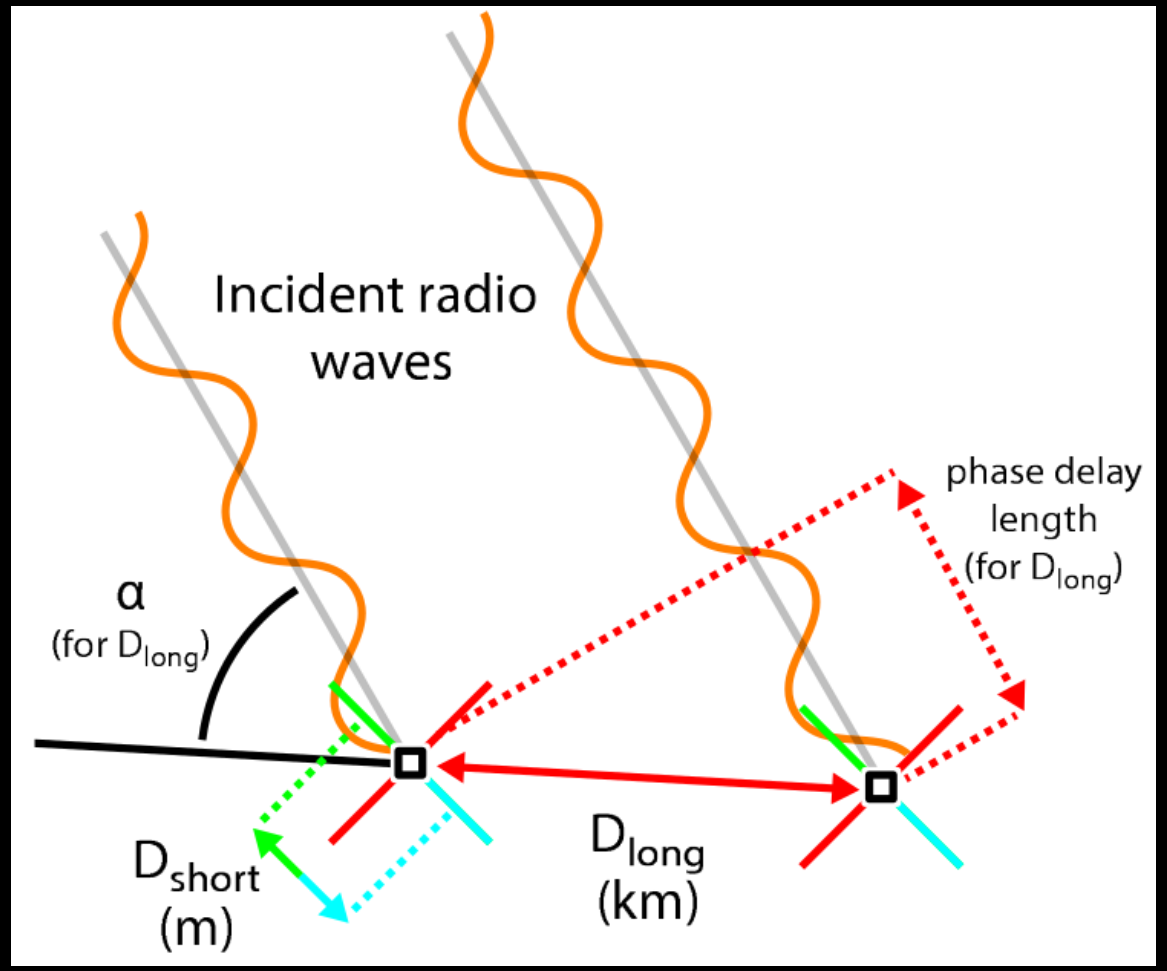
CURIE: Scientific Objectives

- Solar radio bursts
  - Plots: power vs. frequency and time
  - Different “types” of bursts from different regions/processes
  - Unknown: exact mechanisms generating bursts
- Ground observations distorted by Earth’s ionosphere
- CURIE’s goal: determine size and location of source regions
  - Test models of particle acceleration
  - Improve understand of space weather



CURIE: Interferometry

- Multiple (≥ 2) observations from distinct locations
- Slightly different distances from source
  - Phase shift in signals
  - Reconstruction of source direction and structure (imaging)
- Need for precise location and timing data
- Dramatically increased angular resolution



Design Principles for Ground Stations

- Support for CURIE and future missions
  - UHF and S-Band communications
  - Room for expansion:
    new missions, stations, and/or hardware
  - Full separation of ground stations from mission operations centers
- Decentralized network
  - Local control of each ground station
  - Distinct priorities for each ground station
- Remote, autonomous operation
  - Monitoring and scheduling
  - Safety controls (e.g., high winds)

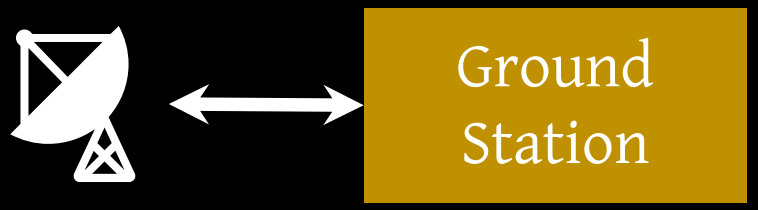
Ground Station Network

Berkeley

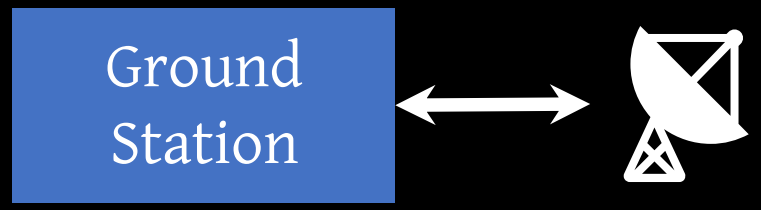
Delaware

Ground Station Network

Berkeley



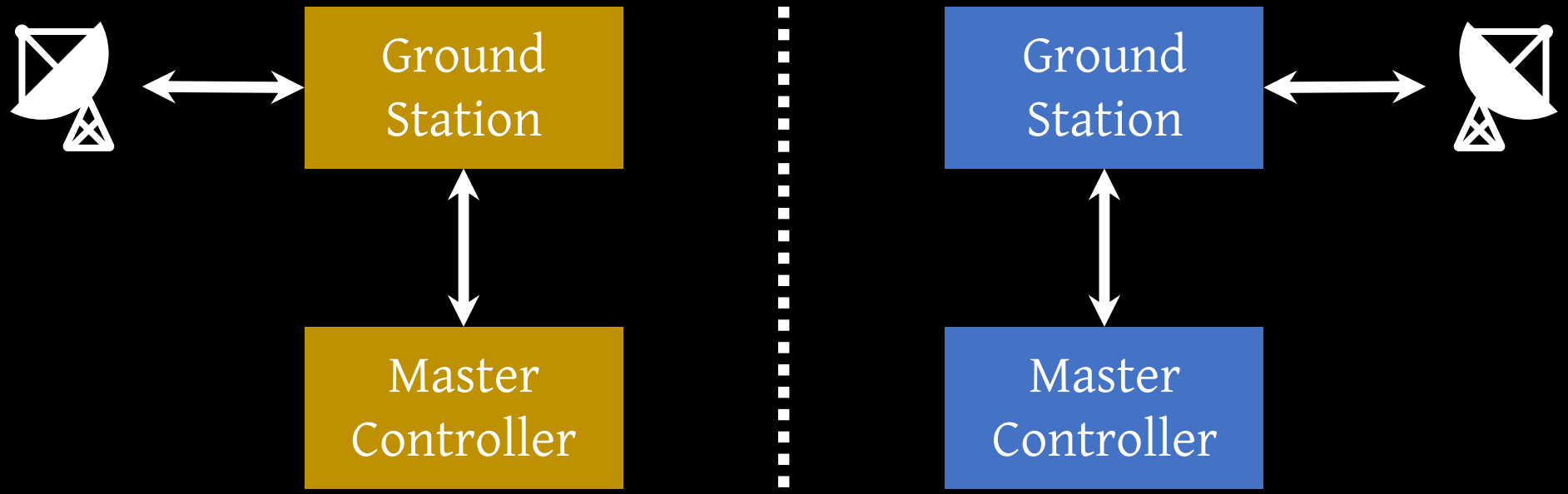
Delaware



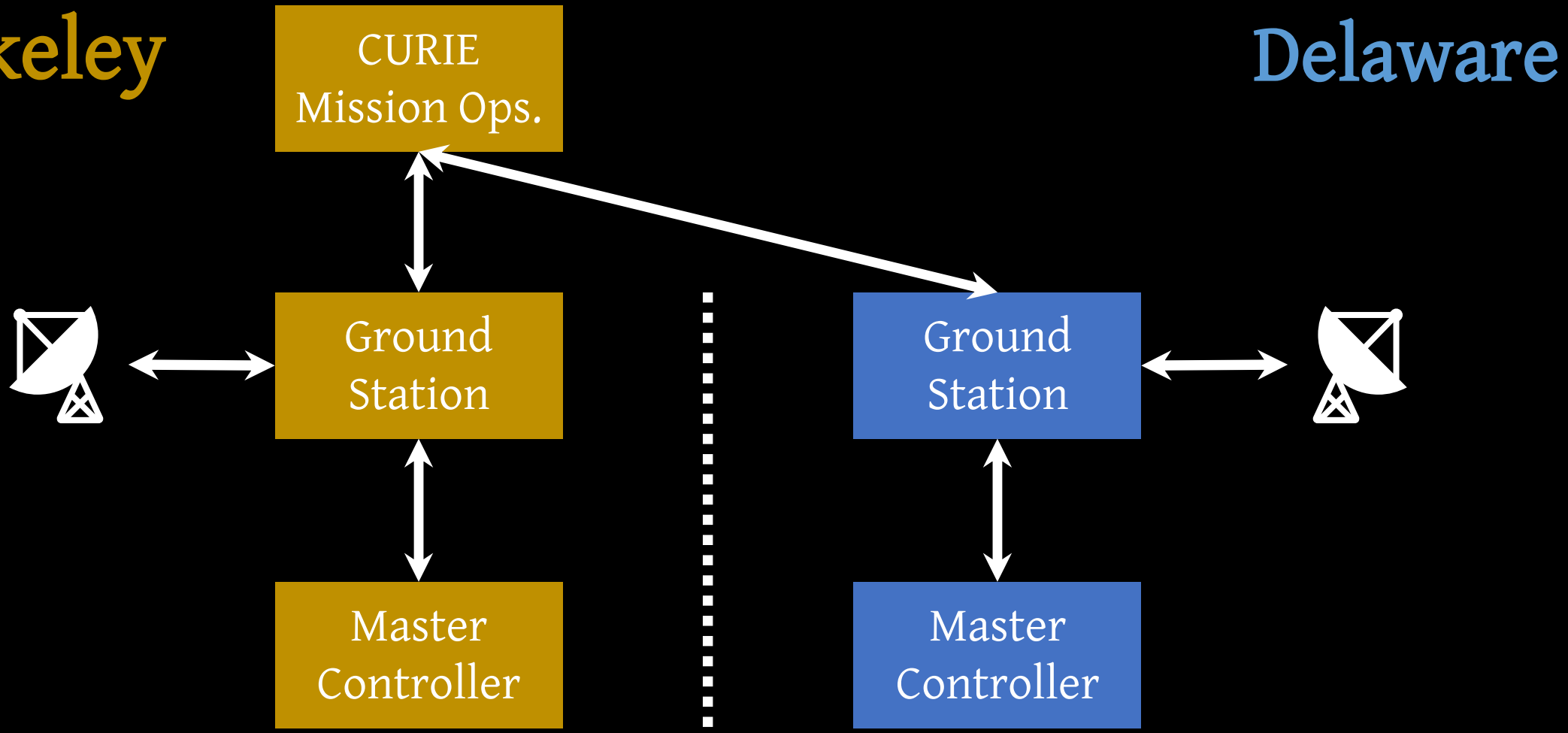
Ground Station Network

Berkeley

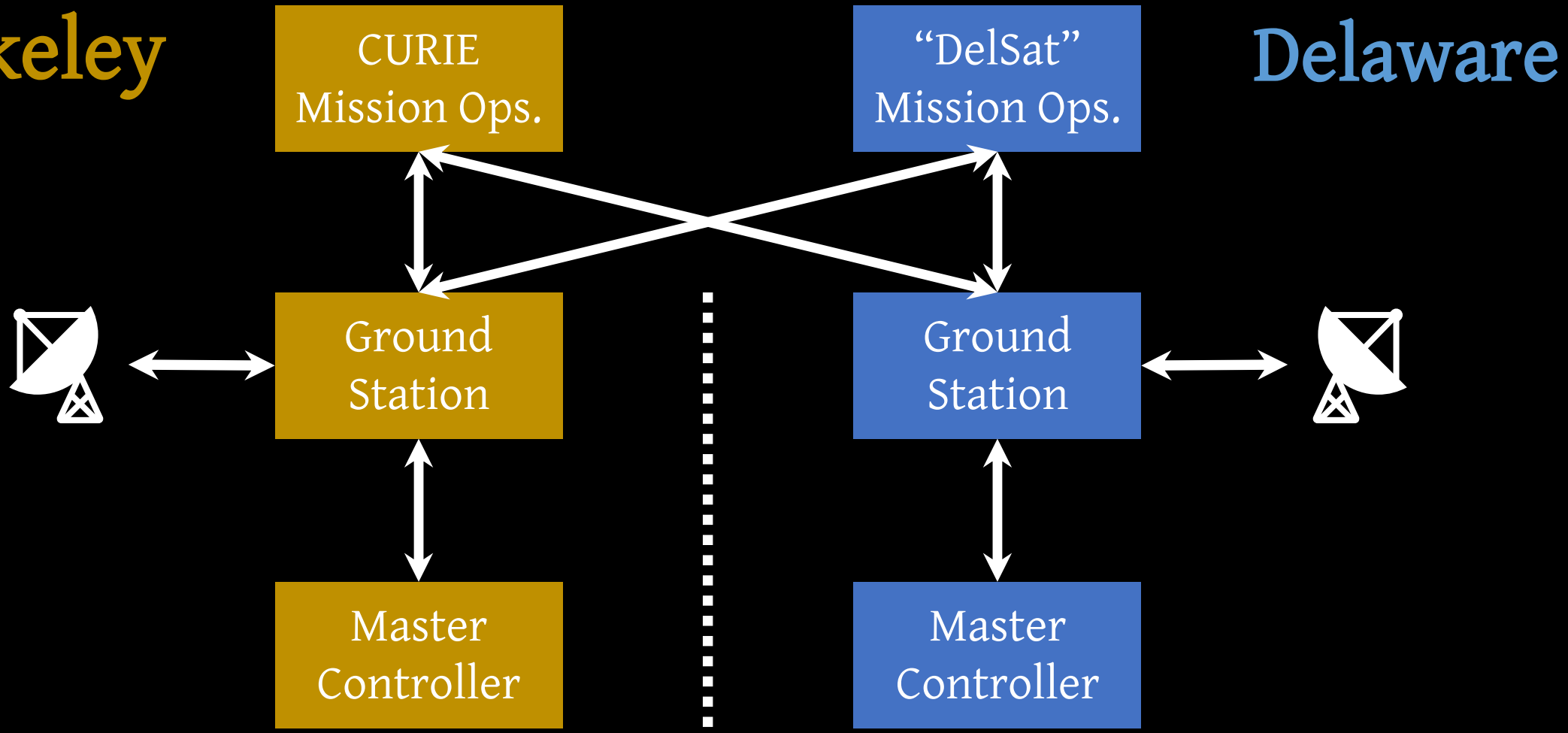
Delaware



Ground Station Network

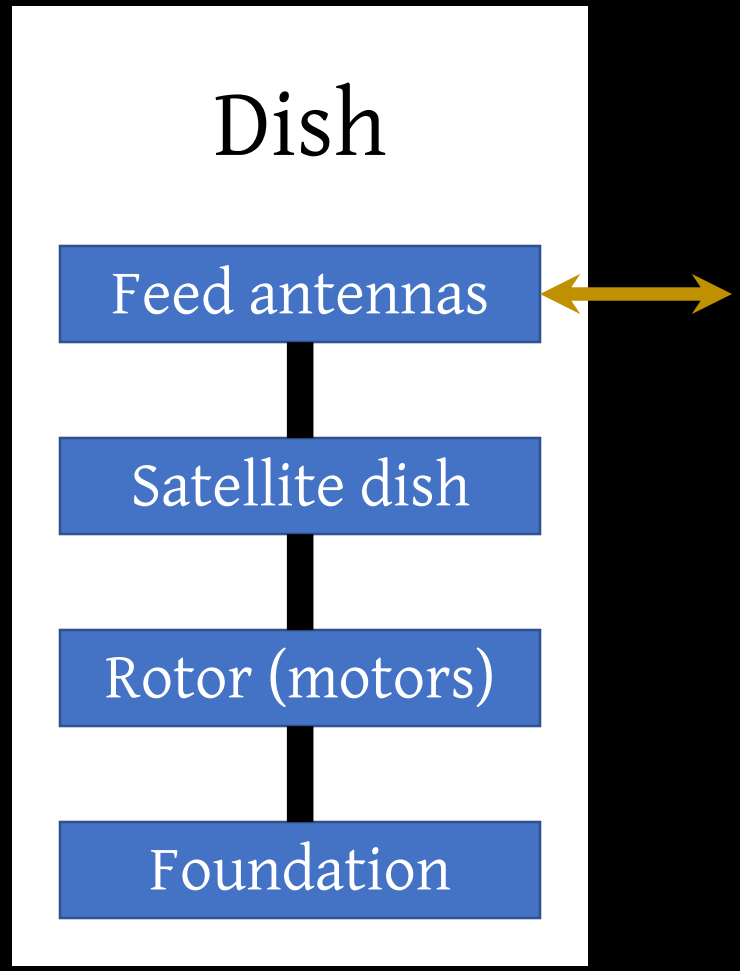


Ground Station Network

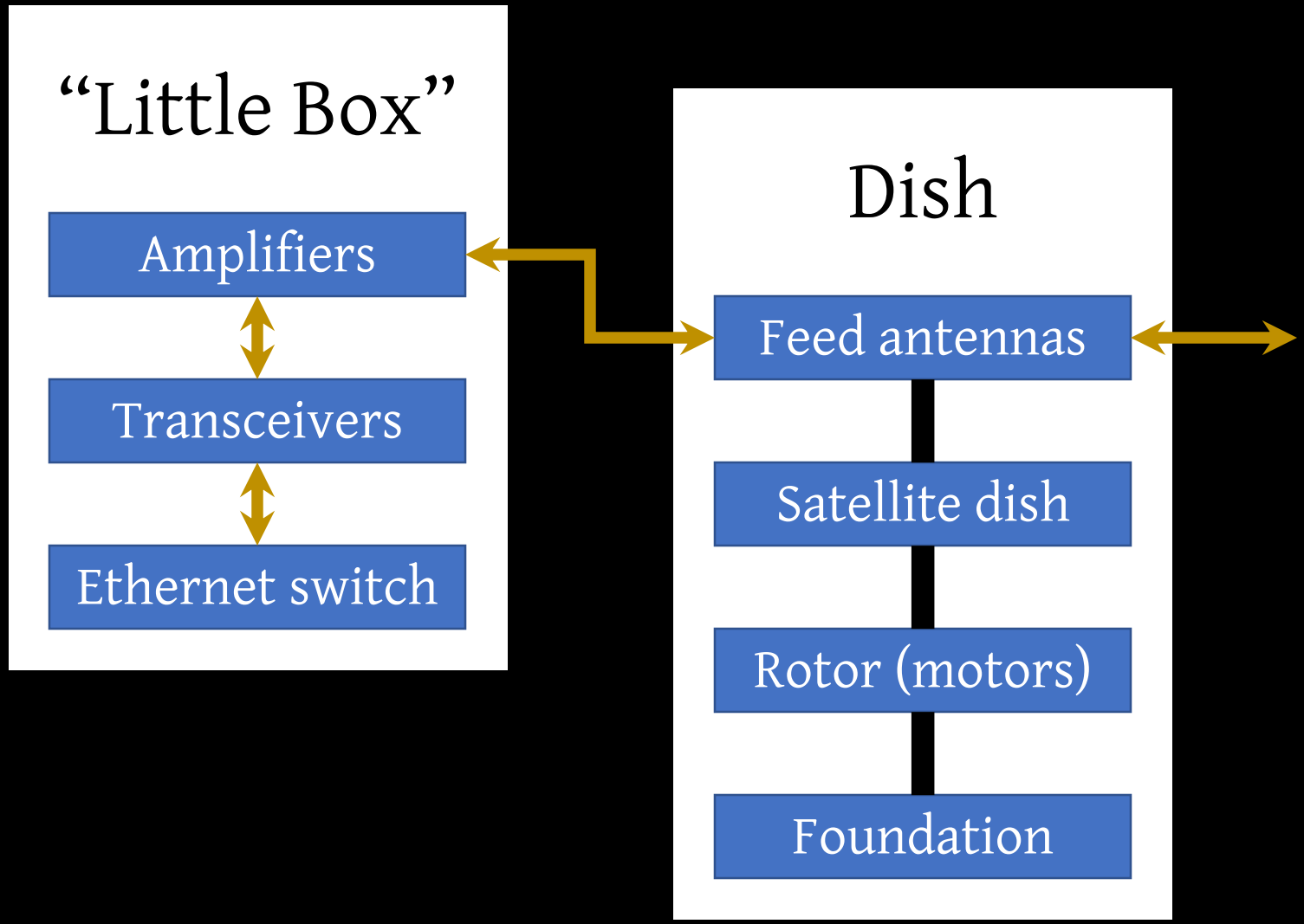


Ground Station Design: 3 Subsystems

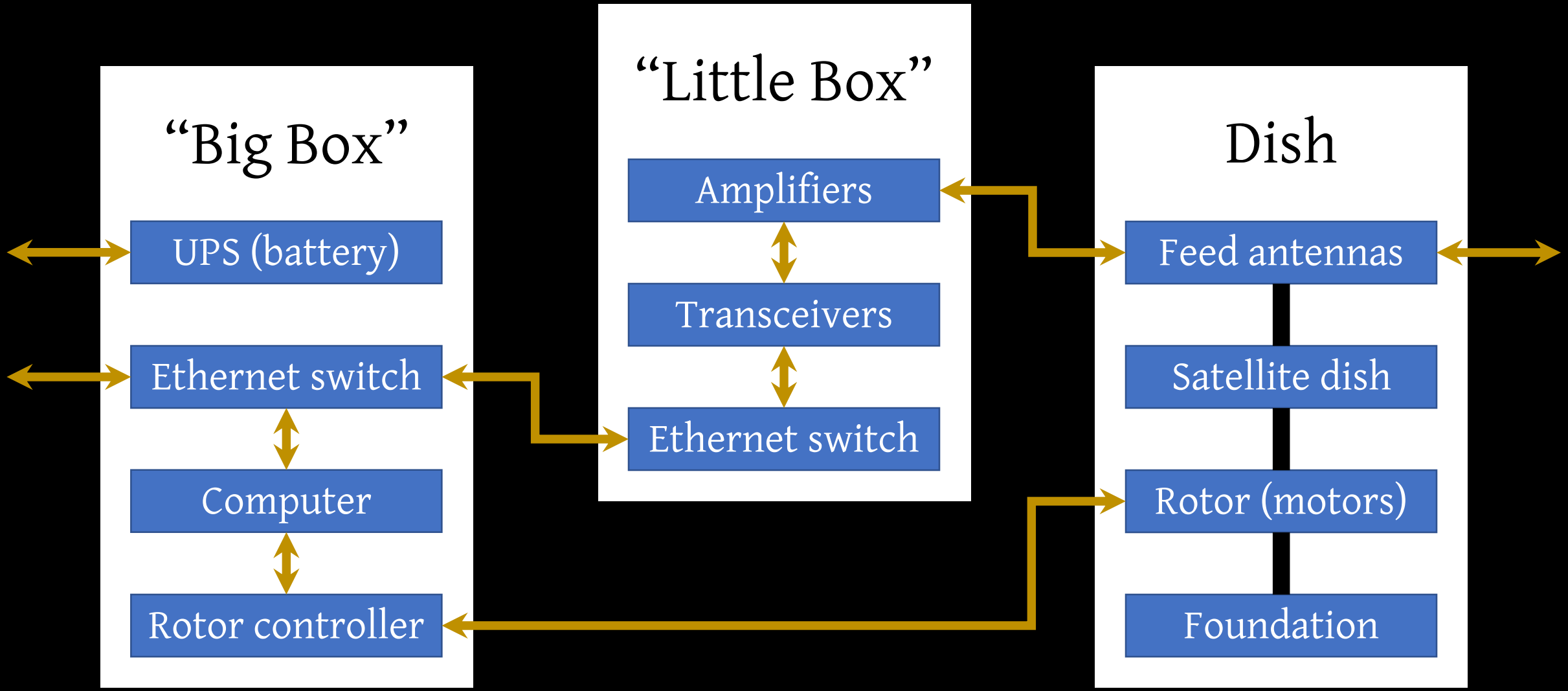
Ground Station Design: 3 Subsystems



Ground Station Design: 3 Subsystems



Ground Station Design: 3 Subsystems



Components: Dish

- Manufacturer: RF HamDesign
- Diameter: 3 meters (10 feet)
- Mass: 27 kilograms (60 pounds)
- Materials: aluminum
  (tube and 6-millimeter mesh)
- F/D = 0.45
- Not shown: supports for feed antenna

Image credit: RF HamDesign

Components: Rotor

- Hardware
  - SPID BIG-RAS HR
  - Dual motors (elev. and azimuth)
  - Not shown: rack-mount controller and power supply (“Big Box”)
- Software
  - Free and open source
    - Hardware interface: Hamlib
    - Satellite tracking: Gpredict
  - Custom system under development
    - Scheduler and monitor system
    - Command and data protocol

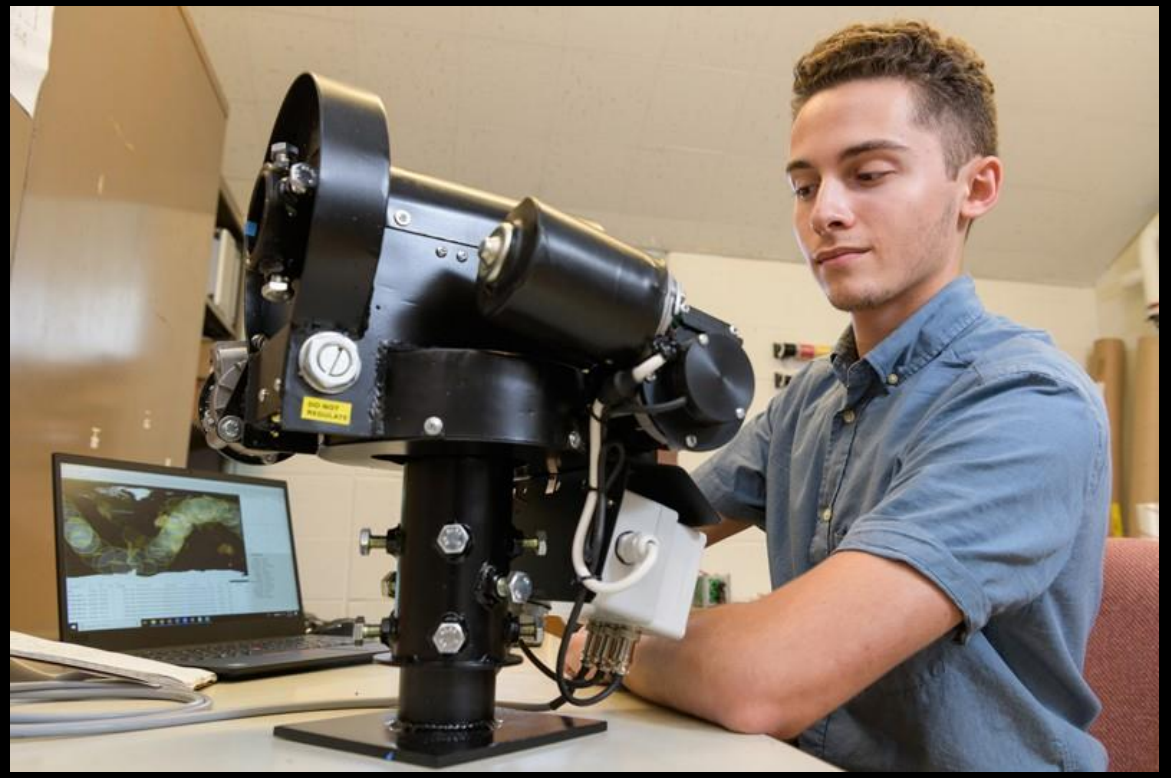


Image credit: UD/Evan Krape

Components: Feed Antennas

- Dual frequency: 430 MHz and 2.4 GHz
- Nested, wire helices with secondary reflector
- Support structure
  - Protects wire's shape from wind, snow, ice, etc.
  - Custom designed (by E. Campbell Graff, Jr.)
  - 3-D printed from PETG plastic
  - Design revisions ongoing
- Testing in anechoic chamber at National University of Colombia

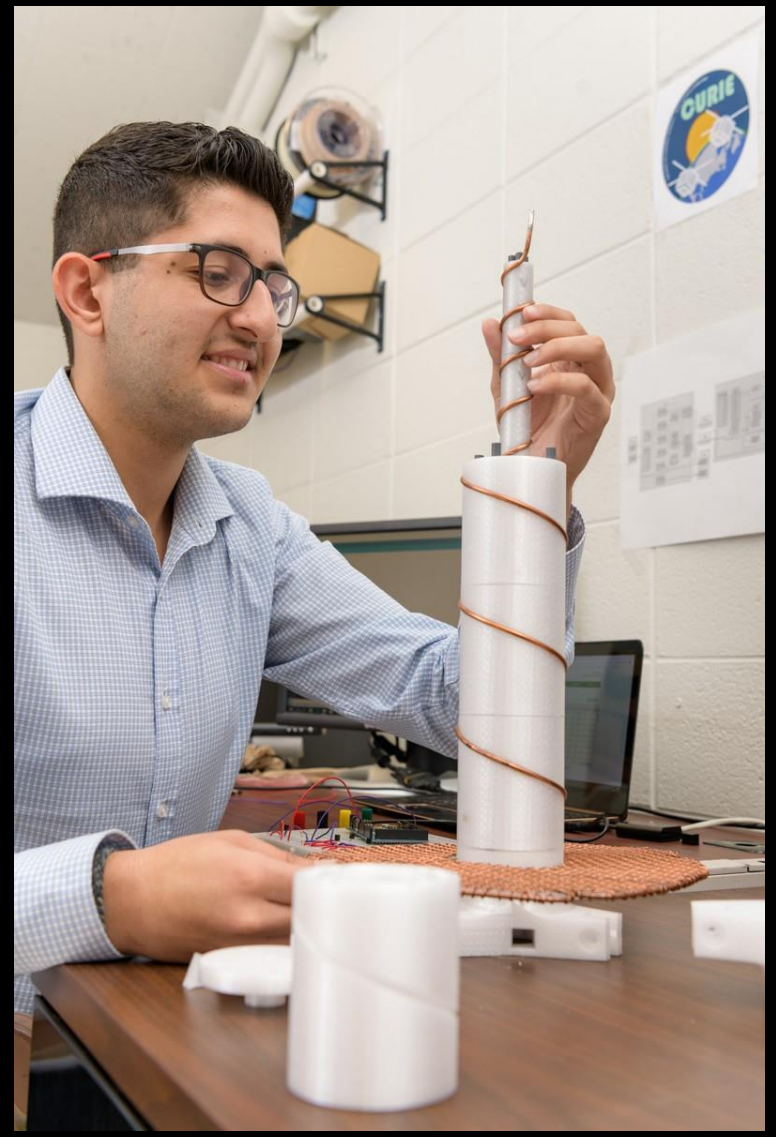


Image credit: UD/Evan Krape

Delaware Site: Mt. Cuba Astronomical Observatory

- Location: Greenville, DE
- Elevation: 90 meter
  (near DE high point)
- Advantages
  - Long partnership with University of Delaware
  - Accessibility: 30 min. from UD
  - Low population: limited RFI
  - Existing infrastructure: building and personnel
  - Center for research (e.g., astroseismology)

Image credit: MCAO

Delaware Site: Mt. Cuba Astronomical Observatory

Image credit:
Jeffrey Neumann

Delaware Site: Mt. Cuba Astronomical Observatory

Image credit:
Jeffrey Neumann

Delaware Site: Mt. Cuba Astronomical Observatory

Image credit:
Jeffrey Neumann

Delaware Site: Mt. Cuba Astronomical Observatory

Image credit:
Jeffrey Neumann

Delaware Site: Mt. Cuba Astronomical Observatory

Image credit:
Jeffrey Neumann

Project Timeline

- Current status
  - Electrical conduit laid
  - Foundation for dish poured
  - “Big Box” installed
  - Rotor and dish delivered
- Future work
  - Sept. 2019: Remove trees
Install rotor and dish
  - Fall 2019: Complete feed antenna
Build and install “Little Box” (transceivers)
  - Winter 2020: Write software for “Big Box” computer
  - Spring 2020: Write software for “Master” controller
  - Late 2020: Launch CURIE