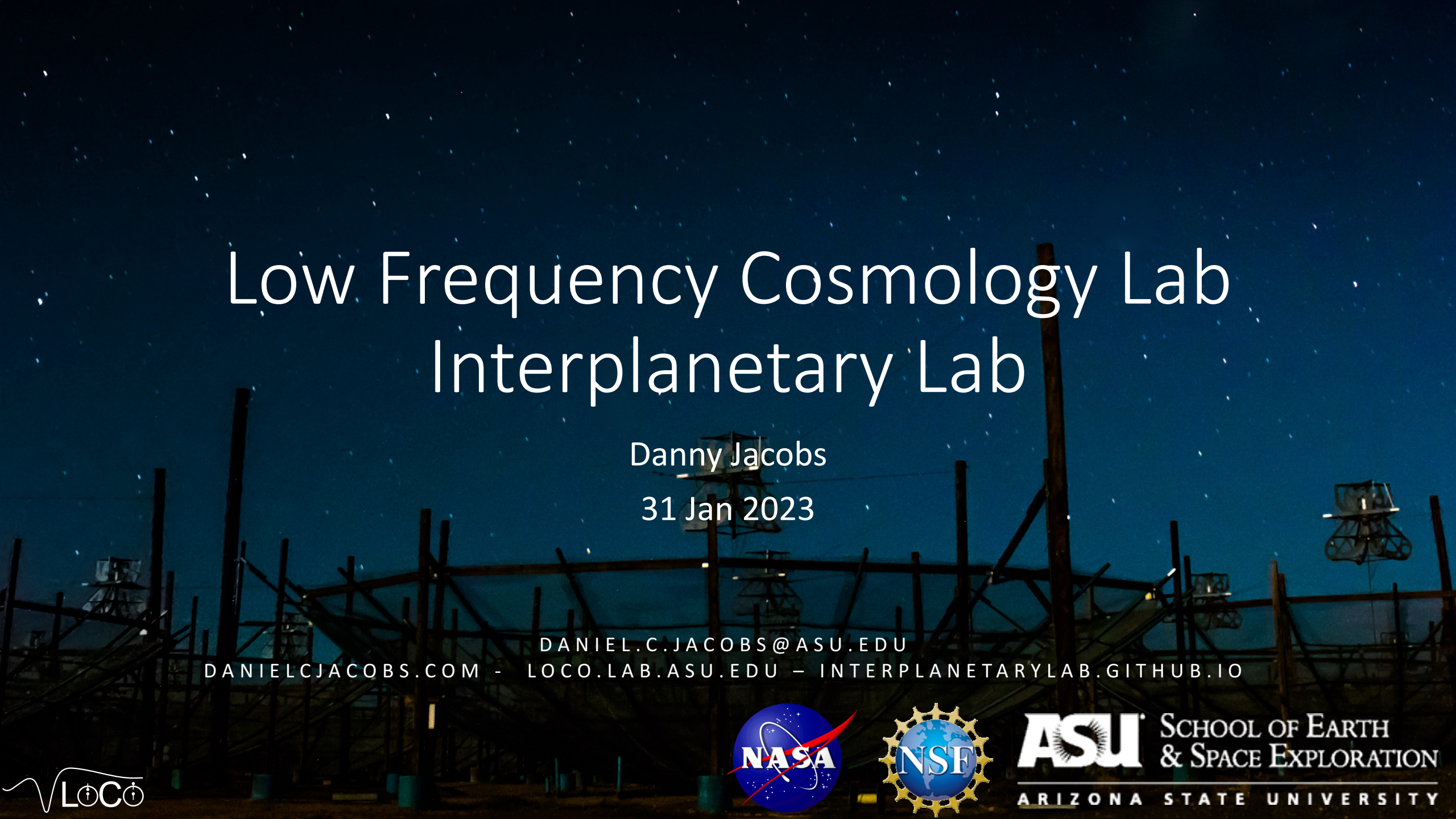


Low Frequency Cosmology Lab
Interplanetary Lab

Danny Jacobs

31 Jan 2023

DANIEL.C.JACOBS@ASU.EDU
DANIELCJACOBS.COM - LOCO.LAB.ASU.EDU – INTERPLANETARYLAB.GITHUB.IO

LoCo

NASA

NSF

ASU School of Earth & Space Exploration
Arizona State University

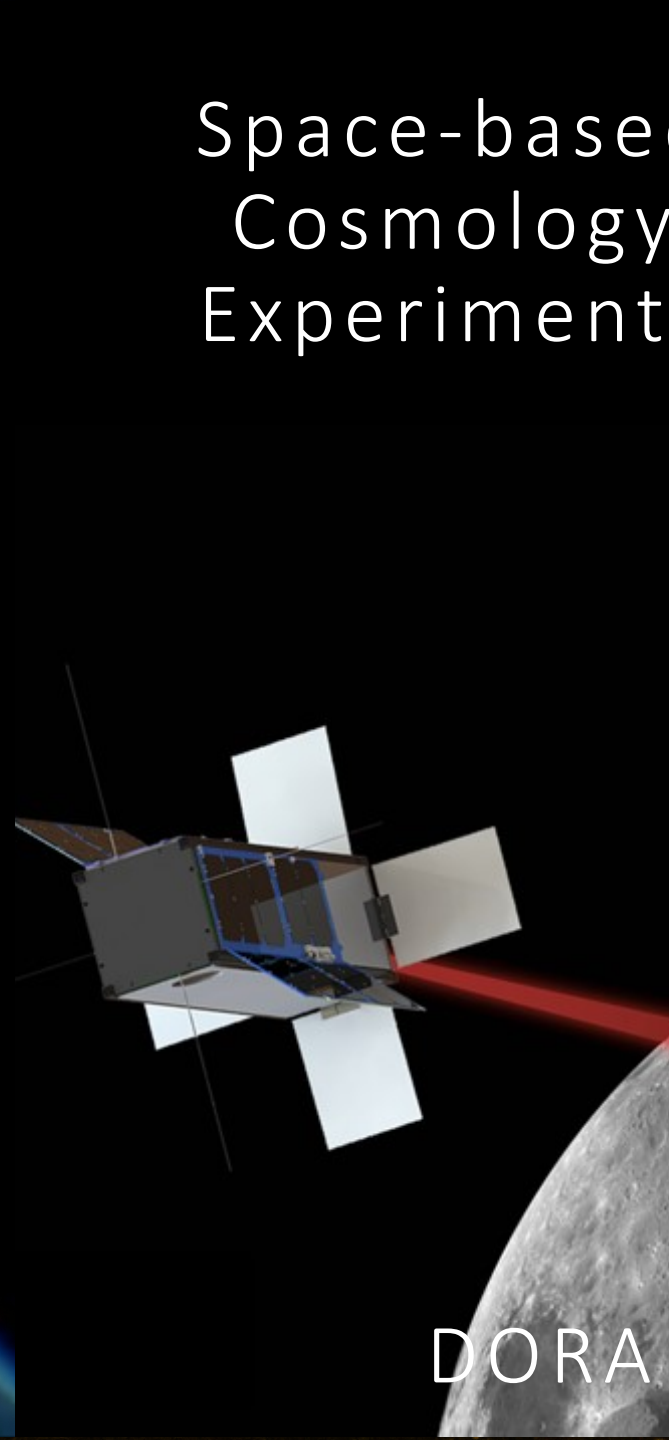
Ground-based Cosmology Experiments

HERA

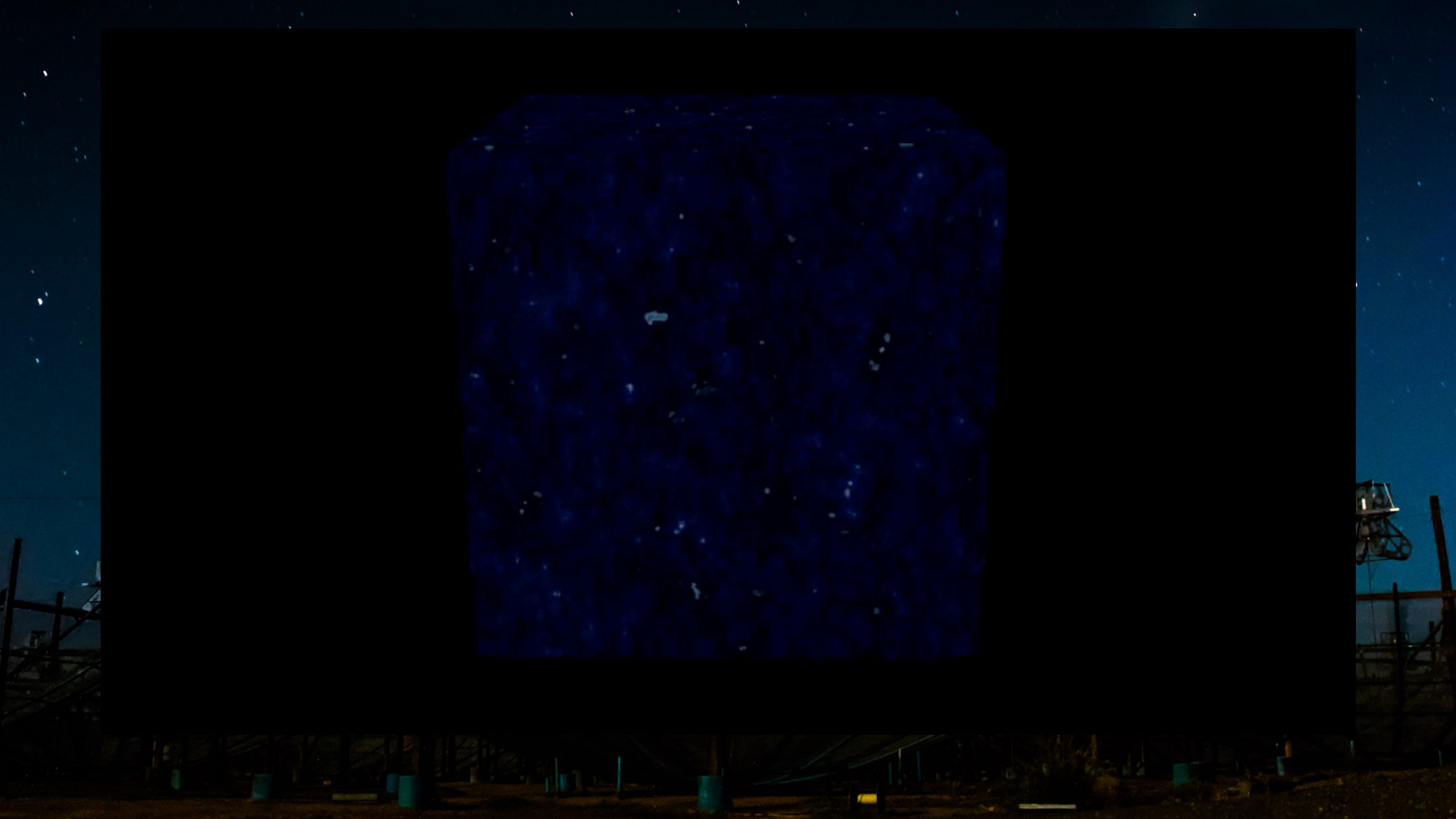
Astronomy Smallsats

SPARCS

Space-based Cosmology Experiment



DORA



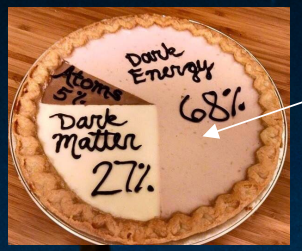
The Dark Ages

Reionization

The Light Ages

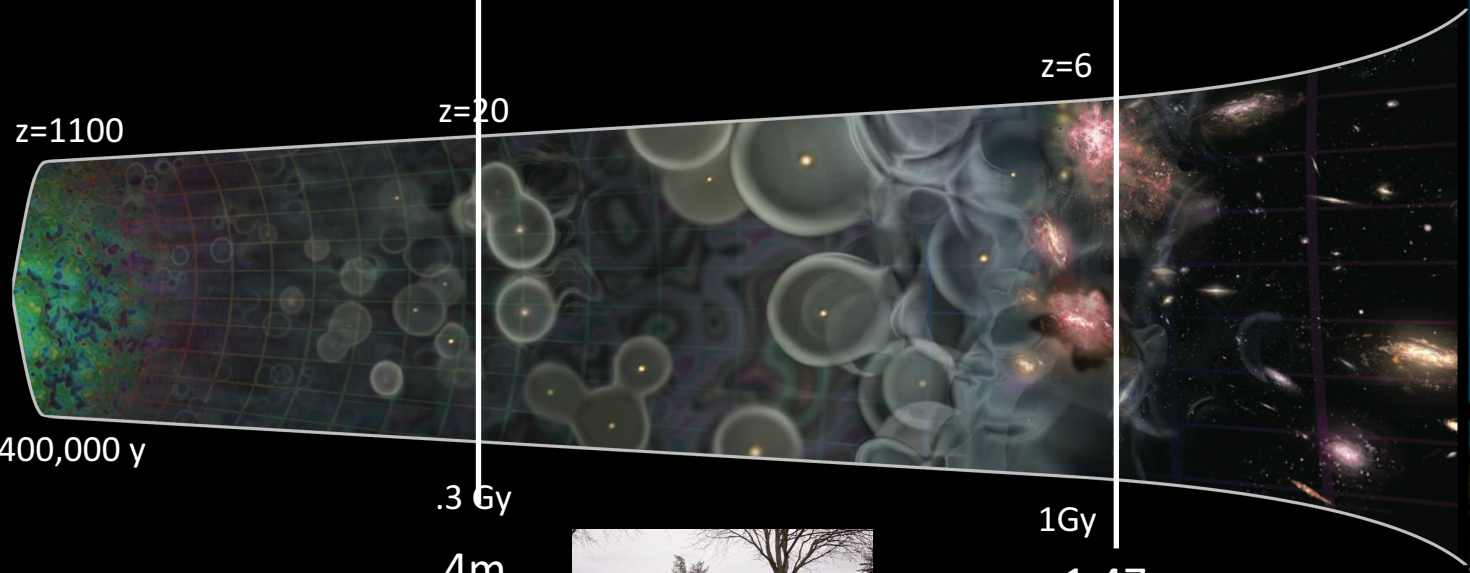
Dark Matter?

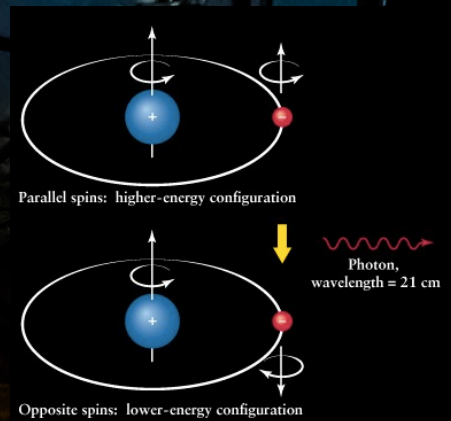
first galaxies, supermassive blackholes
Also: , As, ∑ m_ν,



Dark Energy?

dark energy equation of state,
intensity mapping





4m
61MHz

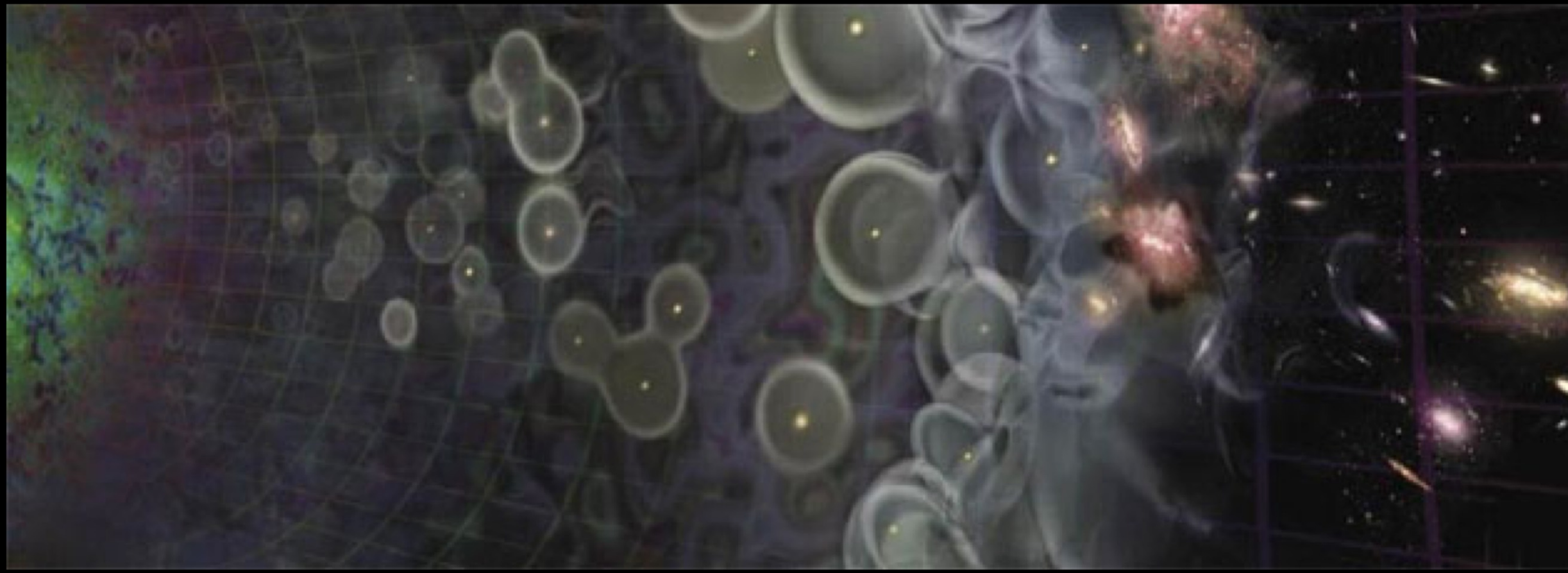
1.47m
203MHz

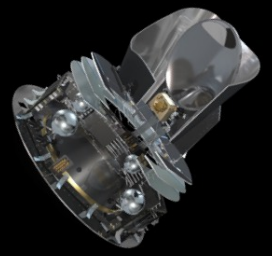
Dark Ages

First stars

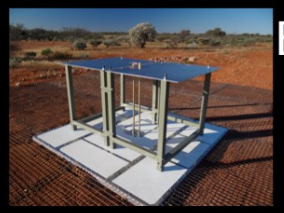
Galaxy evolution

Big Bang



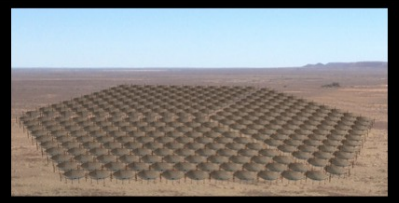


Planck



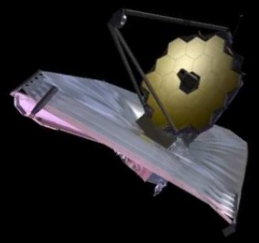
EDGES

Bowman



HERA

Jacobs

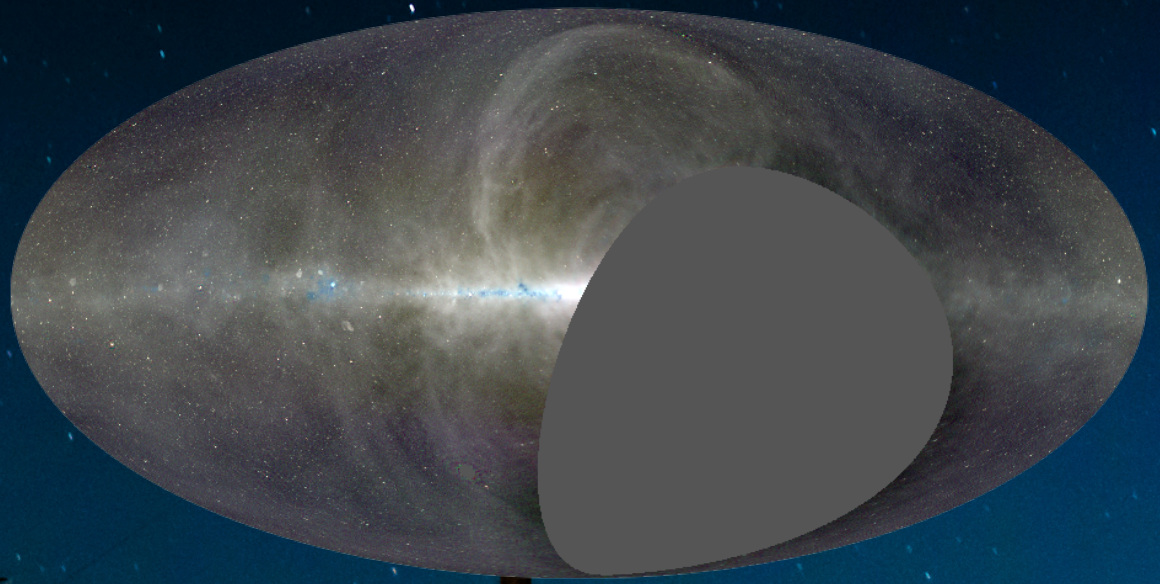


JWST


Google Earth
Data SIO, NOAA, U.S. Navy

Hydrogen Epoch of Reionization Array (HERA)

HERA Vivaldi Feed
ASU Grad Student Libby Berkhout for scale

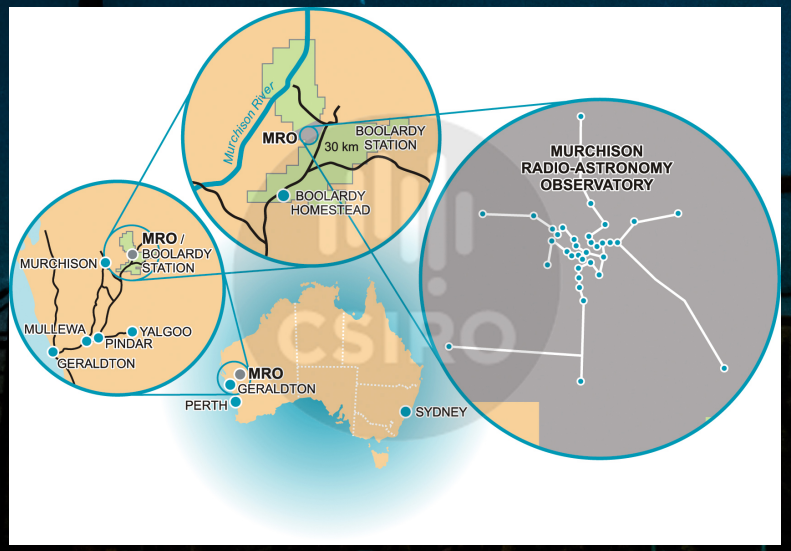


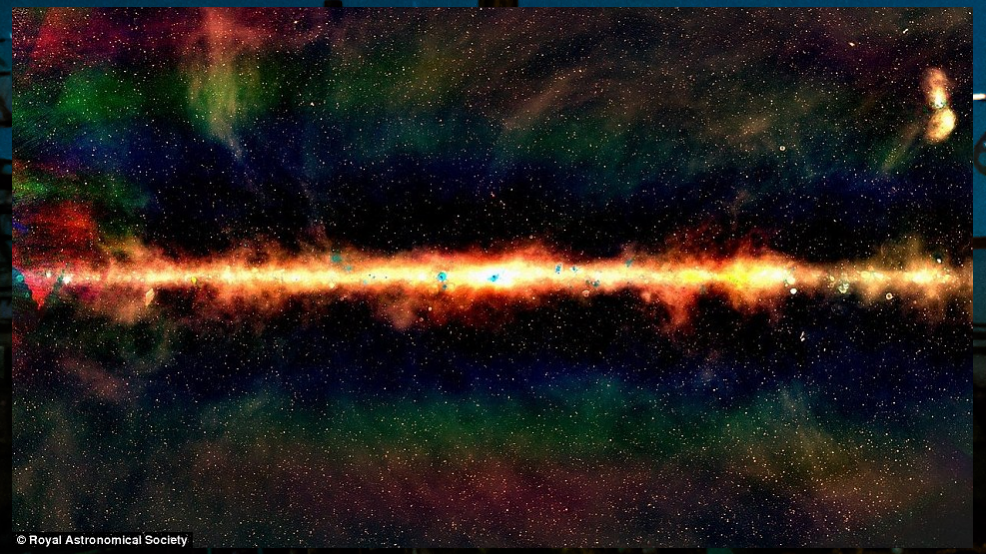
Owens Valley LWA

Caltech

Murchison Widefield Array

Analyze years of cosmology data
Upgrades to receivers
Advances in Instrument Modeling



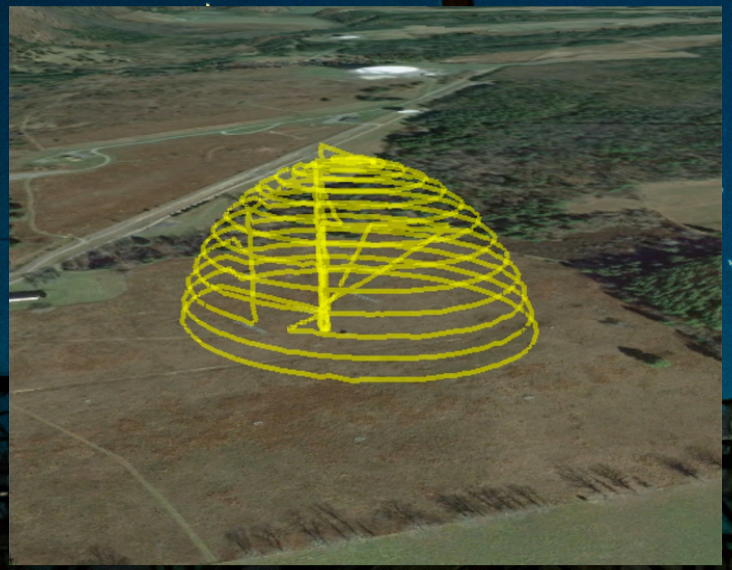


External Calibrator for Hydrogen Observatories

Transmits known Calibration signal

record amplitude as a function of GPS position

Complete spatial coverage



What Goes into the ECHO Project

Field Experiments

Sevilleta NM

Custom Drone Systems

Lab Testing

Advanced Electromagnetic Simulation

Owens Valley California

ASU Undergrads, a Grad student and one postdoc

21cm in Space:
Development Plan

Lunar Far Side
Science mission

Low Earth
Orbit
TRL Raising

Balloon Near-space testing

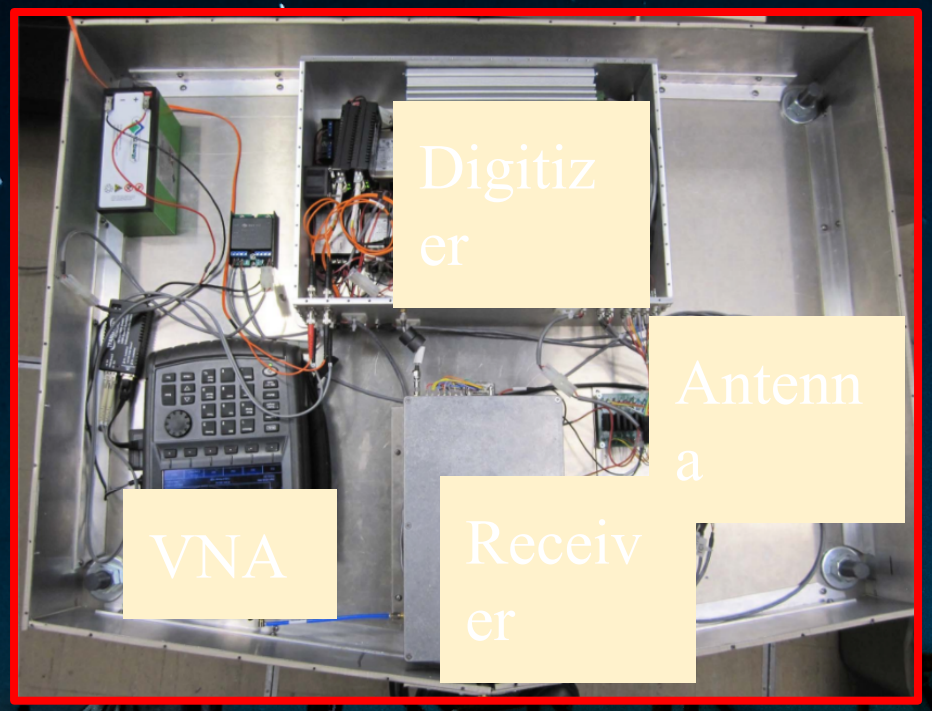
We are here!

1. Raise TRL of receivers
2. Rapid access to space for experimenters
3. Environmental Tests

Terrestrial
EDGES 3

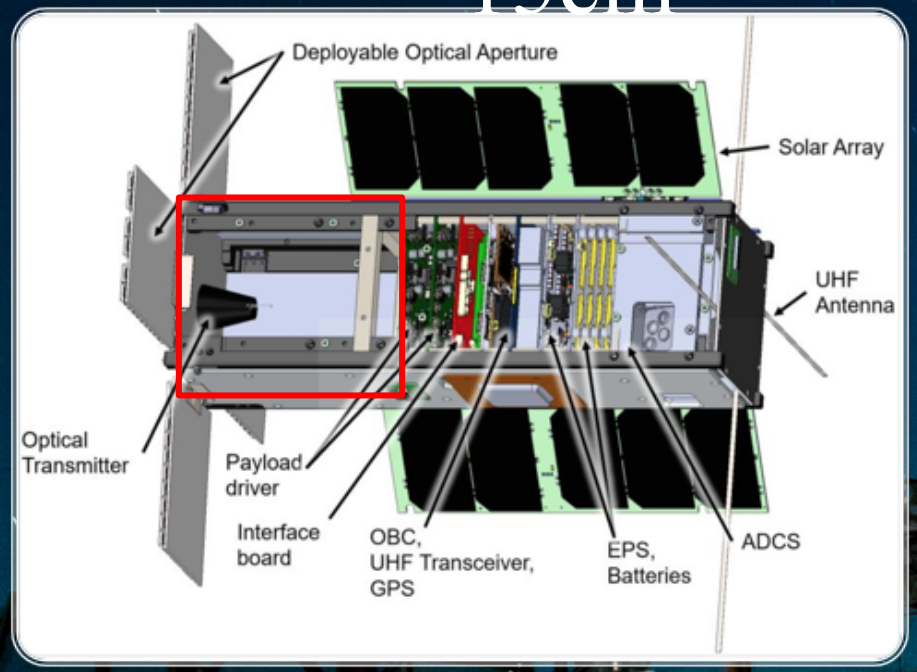
Miniaturization for Space (SWaP)

~1m



EDGES3 Prototype 2020

~15cm

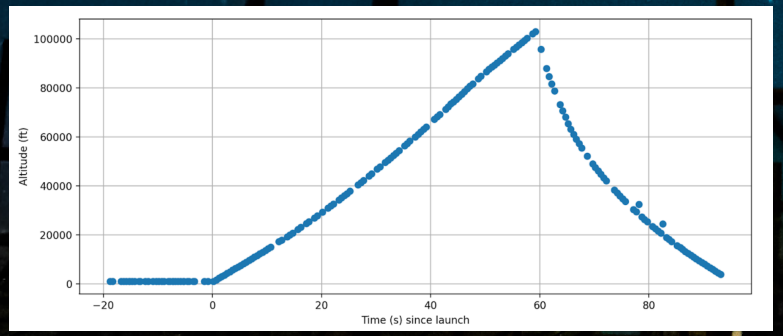


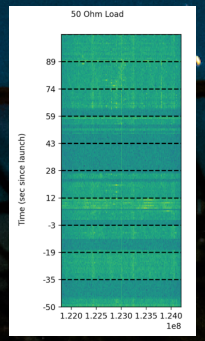
3U Cubesat

Flight Test #1

- Pretesting: thermal vac, EMI
- Lead: Grad student Amy Zhao
- Flight goals:
  - Space time for receiver board
  - Systems integration experience

Launch: Maricona AZ 29 Oct 2022

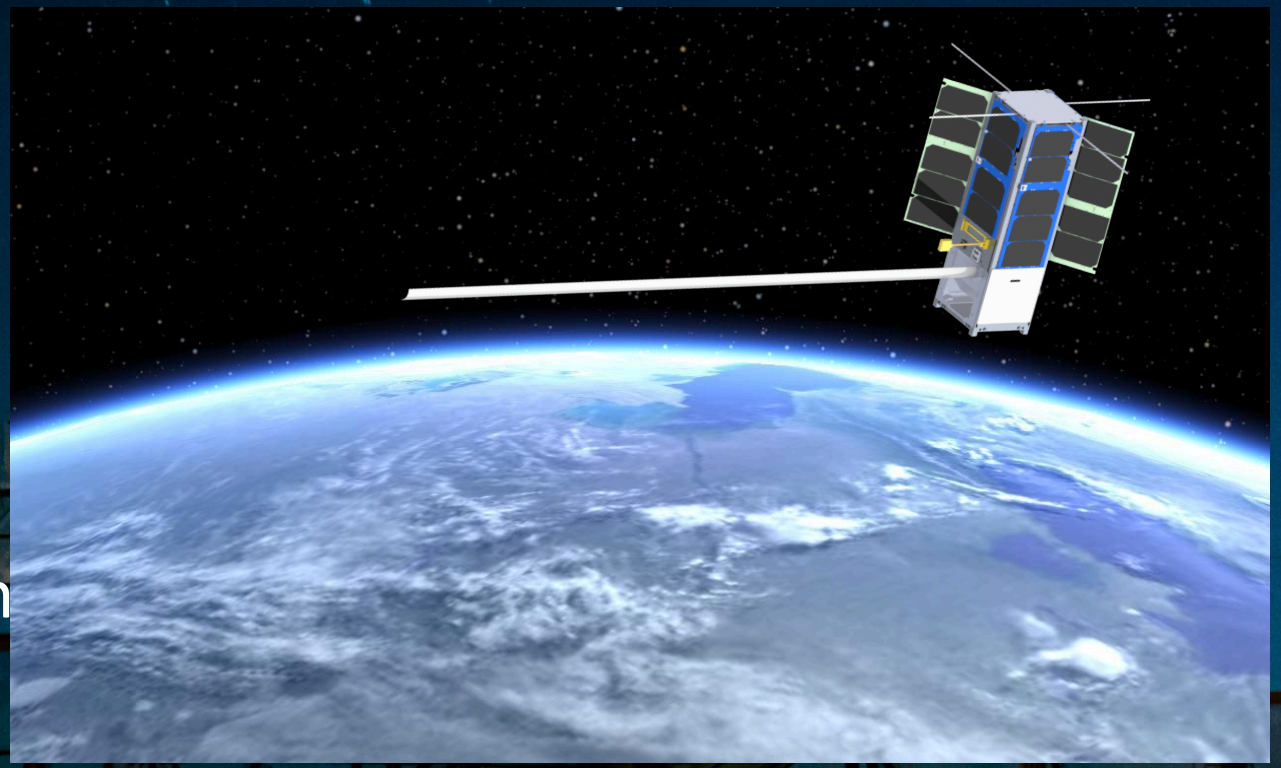




Flight Test A: DORA

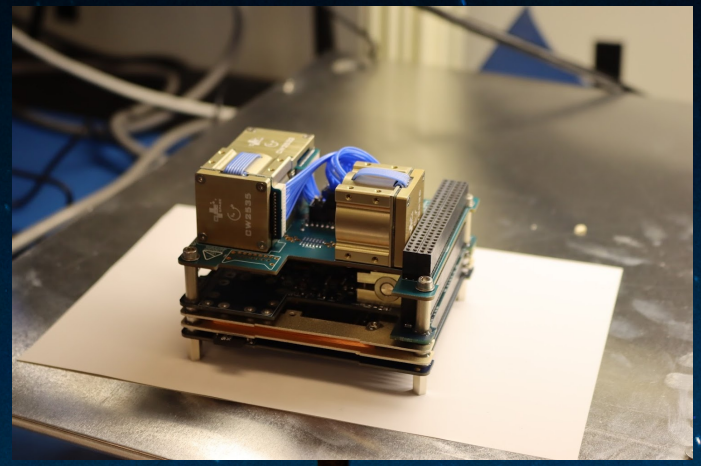
Deployable Optical Receiver Array

- Raise TRL of 21cm instruments
- Measure backgrounds
- SDR Spectrometer
- Analog filterbank:
  - 160MHz in 20MHz chans
- Silicon Photomultiplier at 850nm

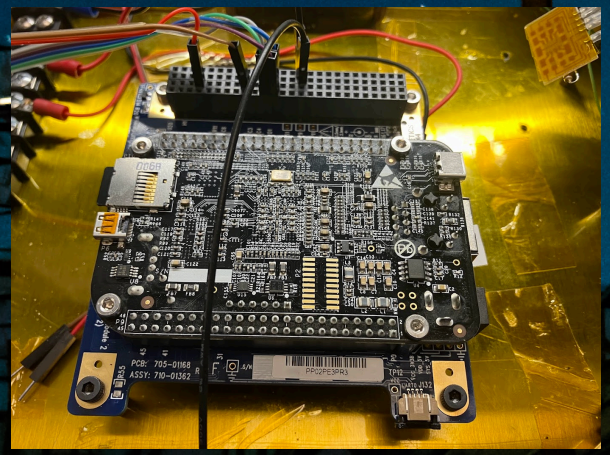


Flight Test A: DORA

- 3U Cubesat
- NASA Ames
  - Smallsat Technology Partnerships
- Selected for NASA CSLI
- Expected Launch Jan 2025



Attitude Control from CubeSpace



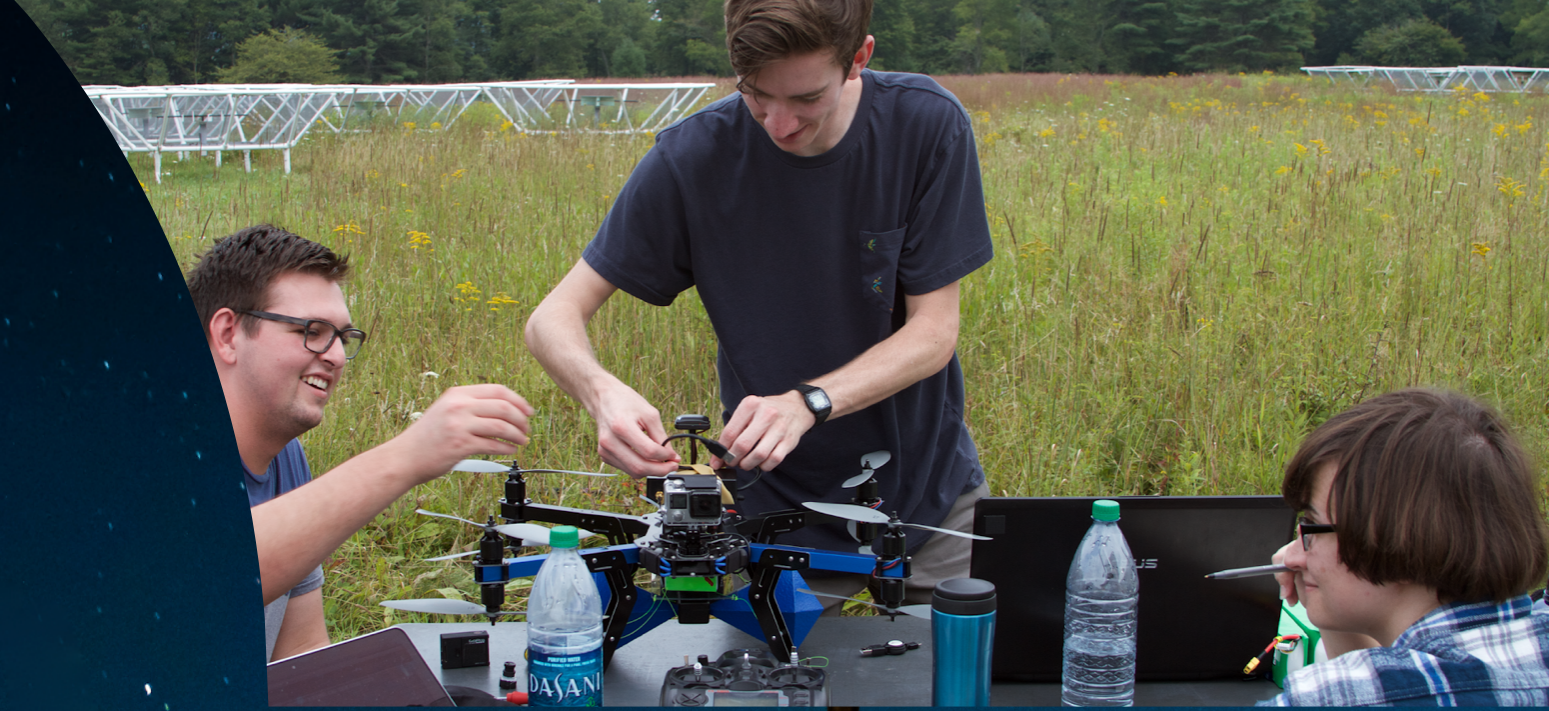
Custom embedded linux system with applications in Rust

Mechanical Mockup for cable design

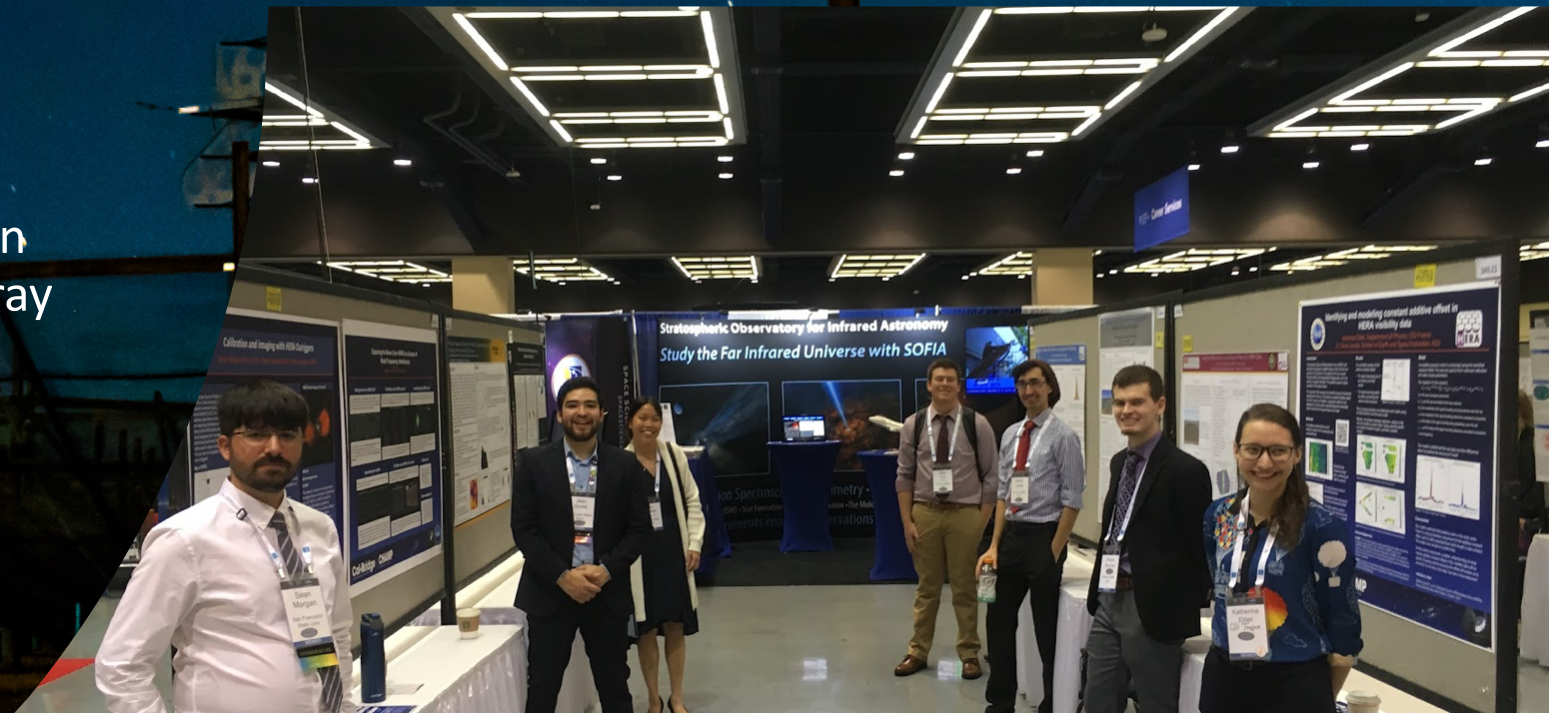
https://github.com/ASU-cubesat/loco-linux

Undergrads can do research

- **Example Top:**
  ASU students field testing my radio calibrator drone in West Virginia



- **Example Bottom:**
  Seven students presenting their work on the Hydrogen Epoch of Reionization Array at the American Astronomical Society meeting in Seattle.



Research Experience for Non-Traditional Students (RENTU)

- ASU program
- Summer research opportunities for those that **can't travel**
- **New in 2022:** online opportunities through Brown and University of Washington
- Wide definition of "non-traditional".
- danielcjacobs.com/teaching-students/rentu/
- Announcement of 2022 application in ~April

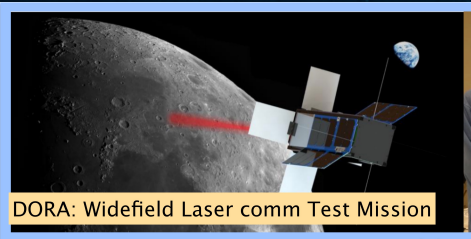
ASU School of Earth and Space Exploration
Arizona State University

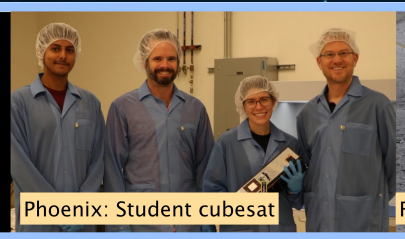
LoCo

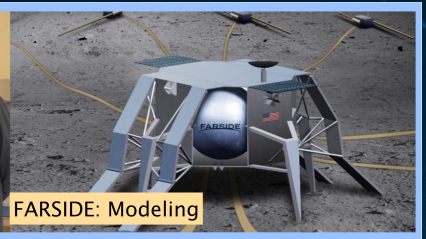
Danny Jacobs
HERA Project Scientist
Assistant Professor, School of Earth and Space Exploration
Associate Director, ASU Interplanetary Initiative

Judd Bowman
Associate Professor, School of Earth and Space Exploration
Co-Director Cosmology Initiative

ASU Low Frequency Cosmology Portfolio


DORA: Widefield Laser comm Test Mission


Phoenix: Student cubesat



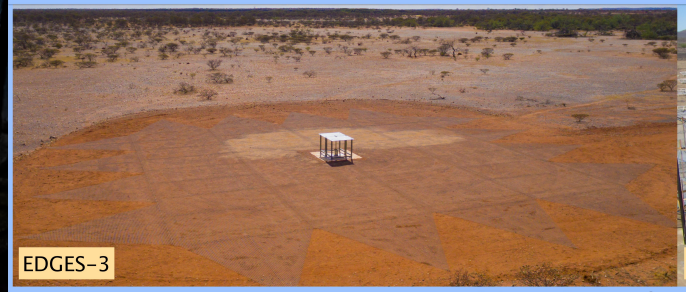
FARSIDE: Modeling

Building space-based Instrument Capability


EPIC: Direct Imaging Correlator


ECHO: Drone-based calibration

Instrument Development


EDGES-3


HERA

21cm Cosmology Experiments

21cm cosmoloyg Research:

- Instrument Operations and Data analysis
- Mitigating Systematics in Analysis
- Next generation instrumentation

Techniques:

- Applied EM simulation
- Lab-based integration testing
- Beam mapping
- Bayesian synthesis

Space-based developments

- Interplanetary Lab (testing and engineering)
- Smallsat cosmology technology

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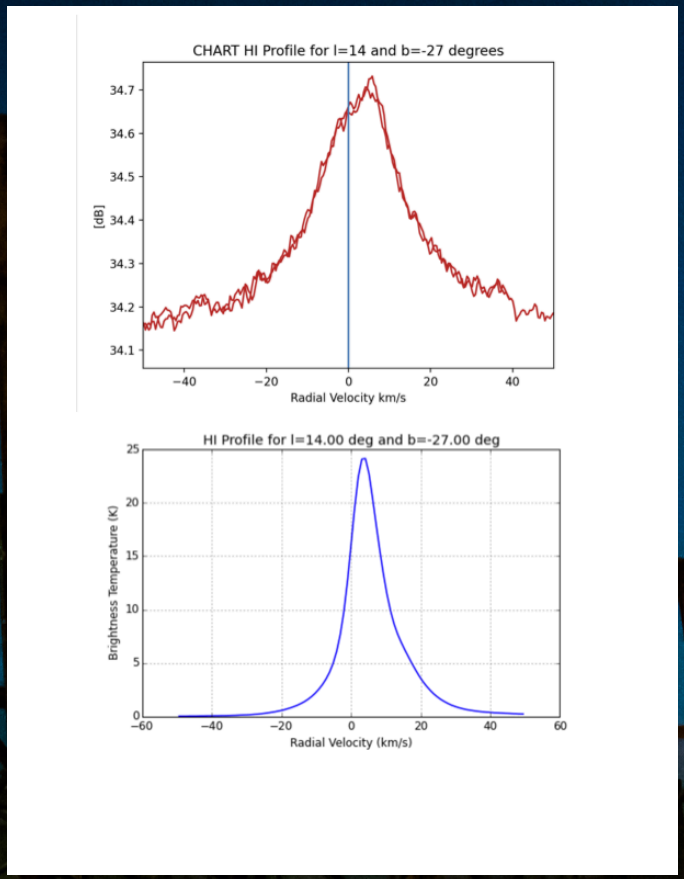
ASU

Completely Hackable Amateur Radio Telescope (CHART)

- We have an open door policy
- Starter projects with CHART
- Observe the Milky Way for <$200
- LoCo Students work the development



Lab Profiles

Low Frequency Cosmology Lab

- Instrumentation Development and Analysis
- 4 grad students, 1 postdoc, 2 research scientists, 1 engineer,
- 1-10 undergrads (RENTU + grant-funded work)

Interplanetary Initiative Lab

- 6000sq ft cubesat lab
- “space maker space”,
- Supporting ASU + Small Industry Smallsat Projects
- Projects: Lightcube, DORA, SPARCS, ++
  - Most work by students!!

LoCo

ASU Interplanetary Initiative
Arizona State University