SSERVI Monthly Report
NESS/PI Burns - June, 2019

Progress Report

- **Papers:** (1) **Hegedus** et al., "Measuring the Earth's Synchrotron Emission from Radiation Belts with a Lunar Near Side Radio Array", submitted to Radio Science; (2) Eastwood, **Anderson**, Monroe, **Hallinan**, et al., "The 21 cm Power Spectrum from the Cosmic Dawn: First Results from the OVRO-LWA", arXiv:1906.08943.
- **News:** (1) Space News: commentary by PI **Burns** -at the May National Space Council meeting, Vice President Pence challenged the nation to begin exploring space again with a human mission to the Moon's south pole by 2024: "America is ready to explore"; (2) The New York Times: NASA officials on Monday evening unveiled an updated budget request to Congress, seeking more than $1 billion in additional funding in what they called a down payment to accelerate the return of astronauts to the Moon by 2024, with quotes by **Burns**: "For Artemis Mission to Moon, NASA Seeks to Add Billions to Budget"; (3) CPR interview to **Burns**: "Colorado Public Radio, Colorado Matters Podcast - CU scientist is shaping the new U.S. plan to go to the Moon"; (4) In addition, the previous podcast referred to "America to the Moon by 2024: NASA's FY2020 Budget Amendment Summary"; the Coloradan Alumni Association magazine features **Burns** on "Heading Back to the Moon (This Time, For Good)".
- **Event/Outreach:** Reuters international news organization interviewed **Burns** and CU graduate student **Tauscher** and master student **Mellinkoff** about the planned return to the Moon; still pictures of **Burns** were also taken for printed press, some of which also included CU graduate student **Bassett** and Assistant Director **Rapetti**.

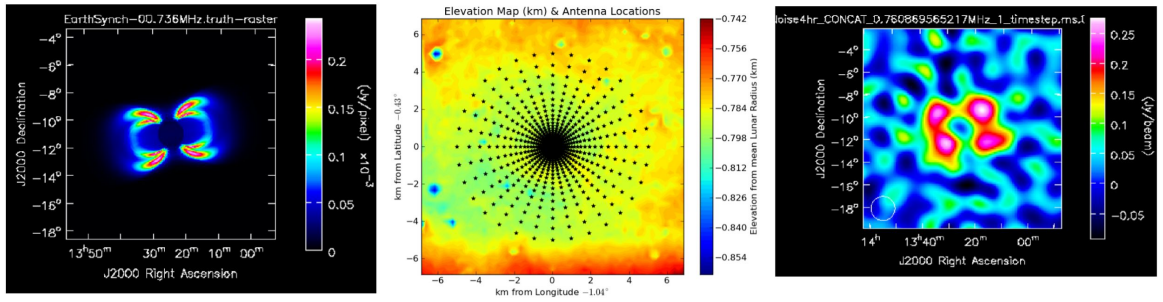
Upcoming Events

- **Meetings:** The **NASA Exploration Science Forum 2019 (NESF)**, July 23-25, 2019 includes the following NESS presentations: (1) talk on "Cosmology from the Moon" by **Burns**; (2) talk on "Insights into the First Stars from Low-Frequency Radio Observations: The Lunar Environment as an Astrophysics Platform" by **Furlanetto**; (3) talk on "The Radio Quiet Environment Above the Lunar FLunar Payload for Radio Wave Observations at the Lunar Surface of the Photoelectron Sheath (ROLSES)" by **MacDowall**; (4) talk on "The Radio Quiet Environment Above the Lunar Farside and its Application to 21-cm Experiments" by **Bassett**; (5) talk on "Virtual Reality Interfaces for Surface Telerobotics from the Lunar Gateway" by **Walker.**

Upcoming Events (cont.)

- **Meetings (cont.):** Poster on "Measuring the Earth's Synchrotron Emission from Radiation Belts with a Lunar Near Side Radio Array" by **Hegedus**; poster on "Searching for exotic physics and investigating the first stars with the 21-cm signal measured from lunar orbit" by **Tauscher**; poster on "Hydrogen Cosmology Data Analysis Pipeline for Lunar-based Observations" by **Rapetti**; poster on "Modeling Planar Dipoles on Lunar Regolith for a Radio Array on the Lunar Far-side" by **Mahesh**; poster on "Low-Latency Telerobotic Assembly of a Low Frequency Radio Telescope on the Moon: Establishing Baselines for User Situation Awareness and Cognitive Load" by **Kumar**, **Bell**, **Mellinkoff**, **Sandoval**. Talks at the **LunGradCon**, July 22, 2019 (before NESF19) by CU graduate students **Tauscher** and **Bassett**.

Moment of Science:



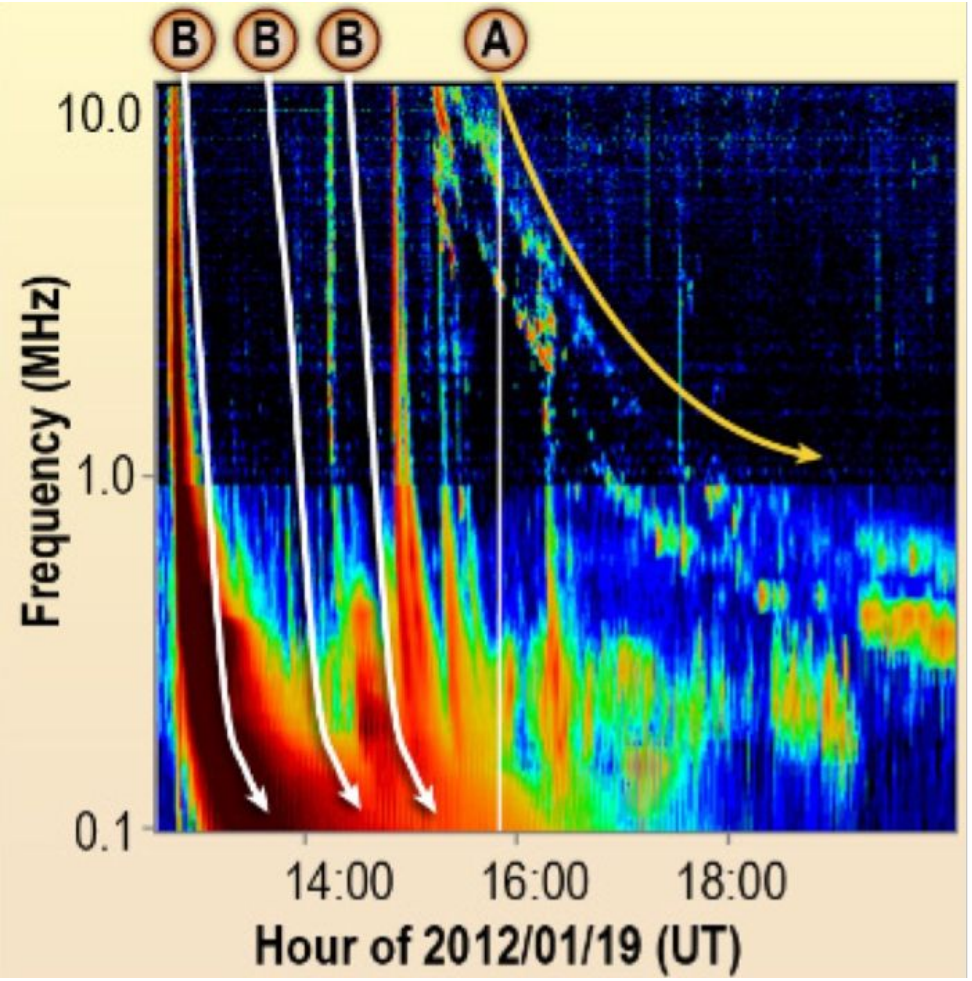
Left: Simulated Synchrotron Emission from Earth's Radiation Belts as seen from the Lunar Surface. *Middle*: 10 km diameter array located at minimum altitude variance site determined with Lunar Reconnaissance Orbiter maps on the Lunar Near Side. *Right:* Recovered image with simulated array after 4 hours of integration time in a moderate noise environment. These figures are taken from Hegedus et al. submitted to Radio Science that outlines the scientific prospects of a large Lunar Near Side Radio Array that could see a range of low frequency radio emission from Earth, including synchrotron emission from its radiation belts.

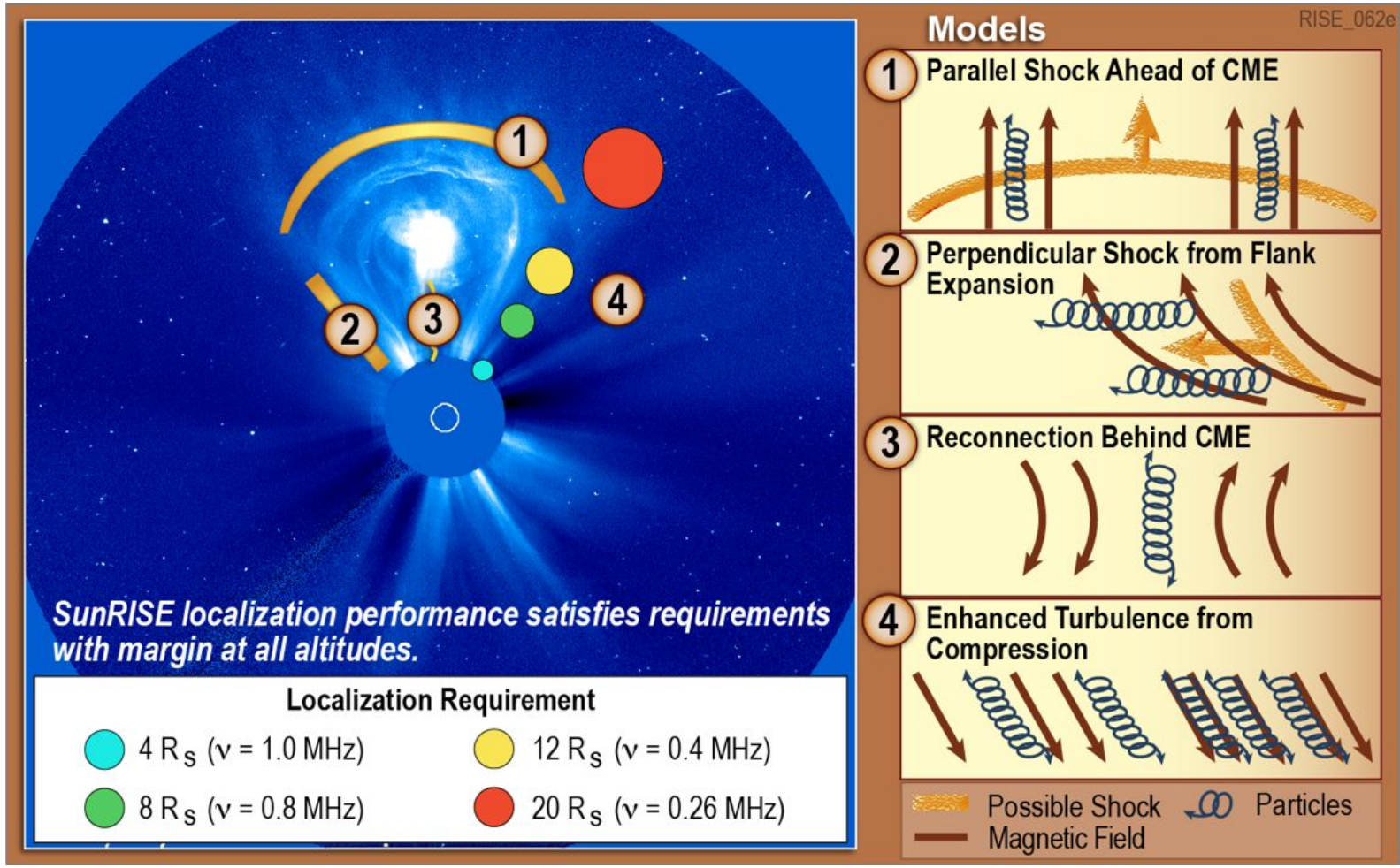
06/28/2019

NESS Approved Missions and Mission Concepts

SunRISE: Localize Radio Bursts that Precede Solar Energetic Particle (SEP) Acceleration

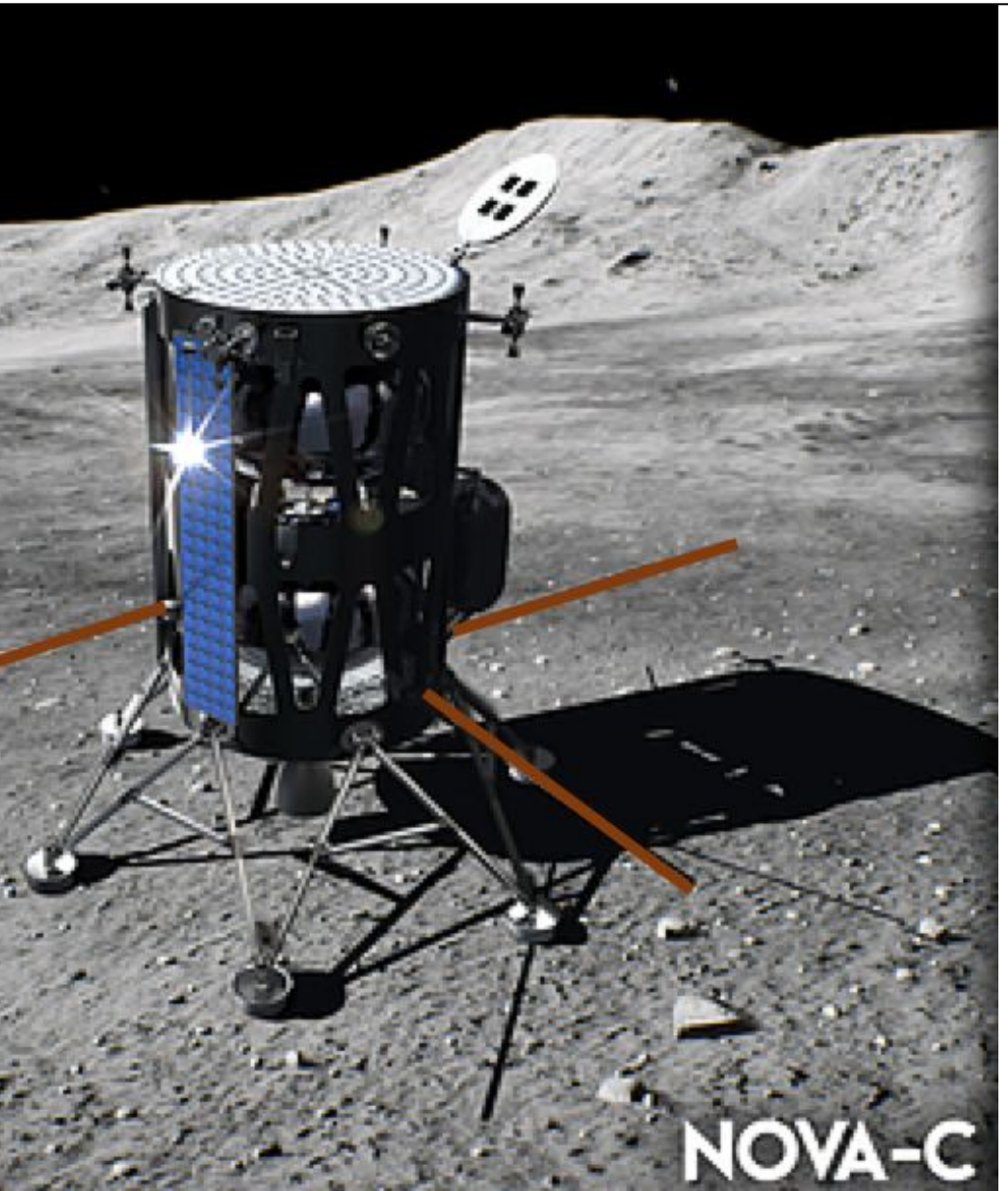
P.I. J. Kasper, U. Michigan





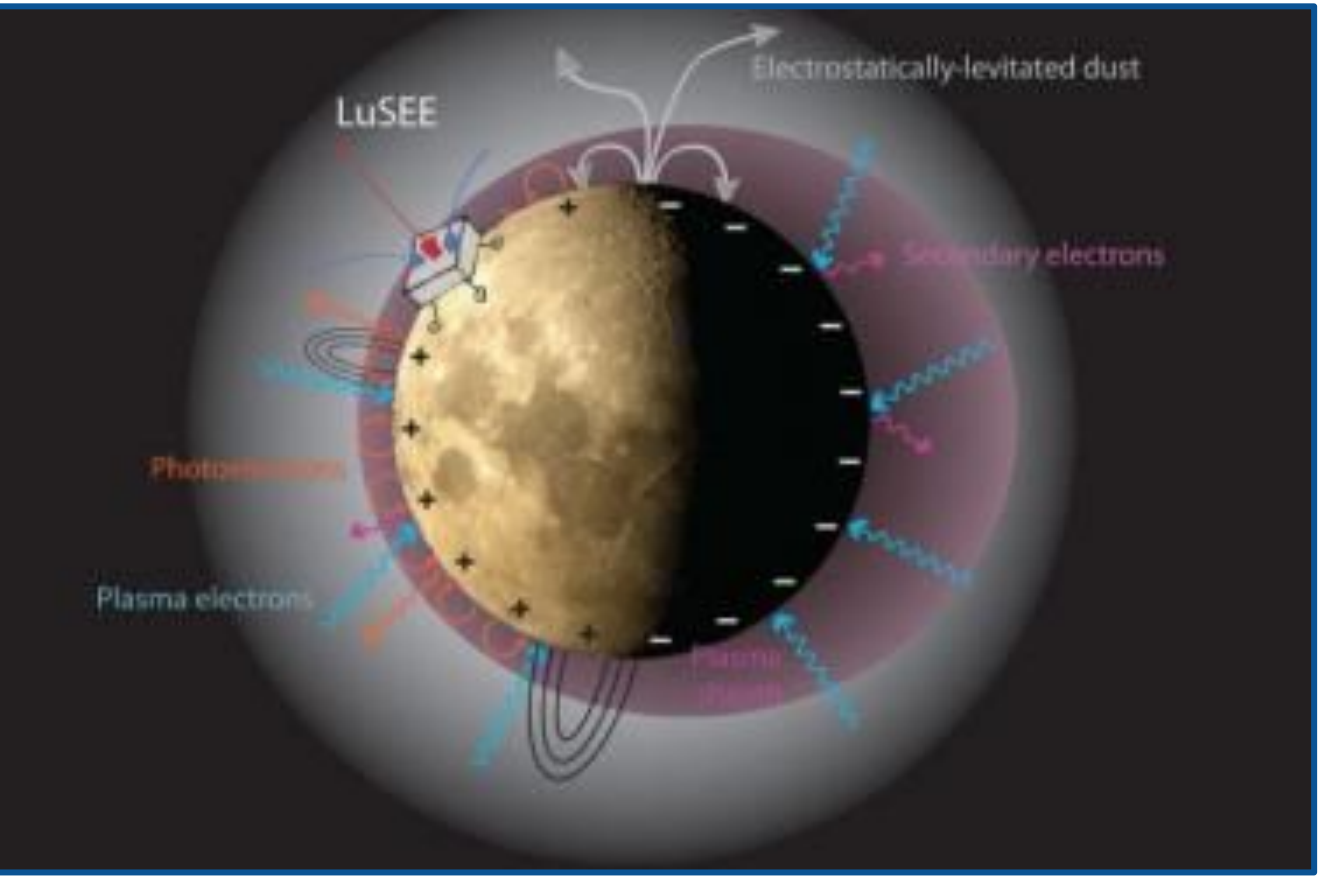
Precursor Low Radio Frequency Space-based Array to observe Solar Coronal Mass Ejections

Radiowave Observations at the Lunar Surface of the photoElectron Sheath (ROLSES)



- ***P.I. Robert MacDowall, Co-I Bill Farrell, Collaborator Jack Burns.***
- Proposal referred to STEREO spacecraft WAVES instrument, but we are building a new digital electronics board, using the design of the GEDI (Global Ecosystem Dynamics Investigation) electronics board.
- Frequency range: 10 kHz to 30 MHz (high frequency in support of other lunar mission proposals).
- Four monopole Stacer antennas, used as dipoles at 1 m and 2-3 m above the lunar surface. Two dipoles are orthogonal, to support some directional measurements.
- The Stacer antennas will be provided by the Heliospace Corporation.
- The commercial lander is the NOVA-C provided by *Intuitive Machines, LLC*, Houston Texas.

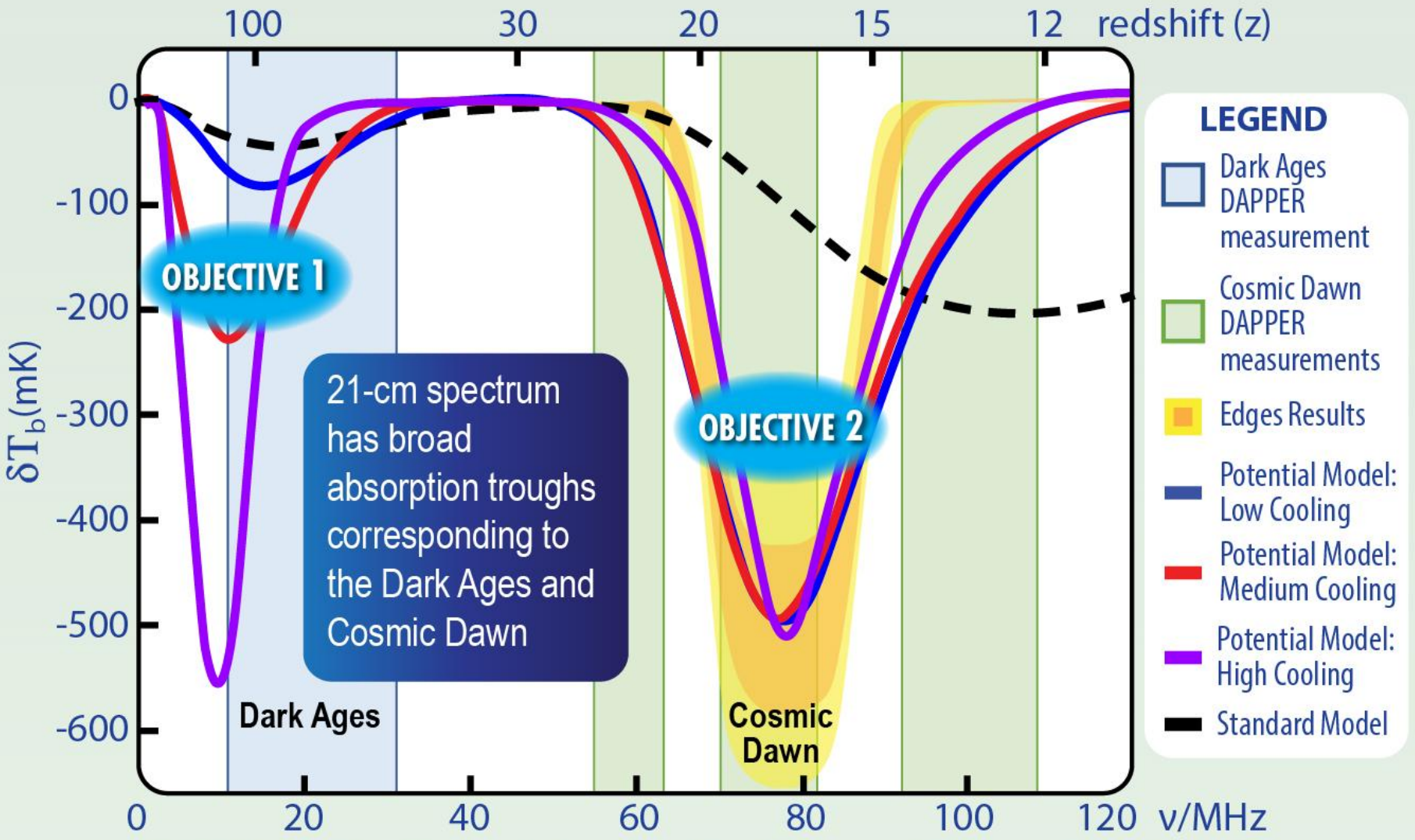
Lunar Surface Electromagnetics Experiment (LuSEE)



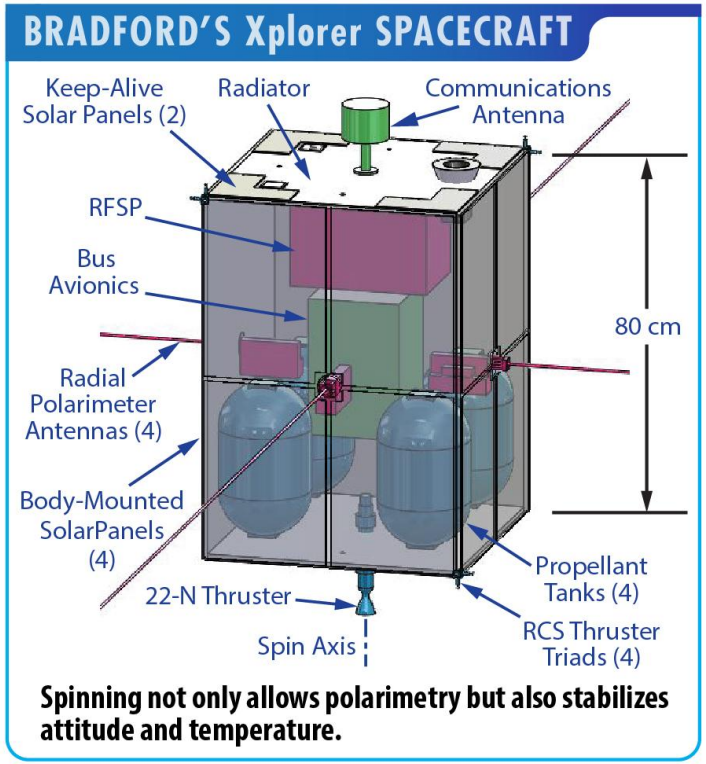
LuSEE will be built by the UC-Berkeley Space Science Laboratory to study the magnetic and electric fields on the Moon's surface and how they interact with fine dust particles.

- ***P.I. Stuart Bale (Berkeley), Co-Is R. MacDowall, J. Burns.***
- LuSEE will integrate flight-spare and repurposed hardware from the NASA Parker Solar Probe FIELDS experiment, the STEREO/Waves instrument, and the MAVEN mission to make comprehensive measurements of electromagnetic phenomena on the surface of the Moon.

Dark Ages Polarimeter Pathfinder (DAPPER)



DAPPER uses the 21-cm all-sky signal to observe redshifts z = 83-12, associated with the Dark Ages and the Cosmic Dawn.

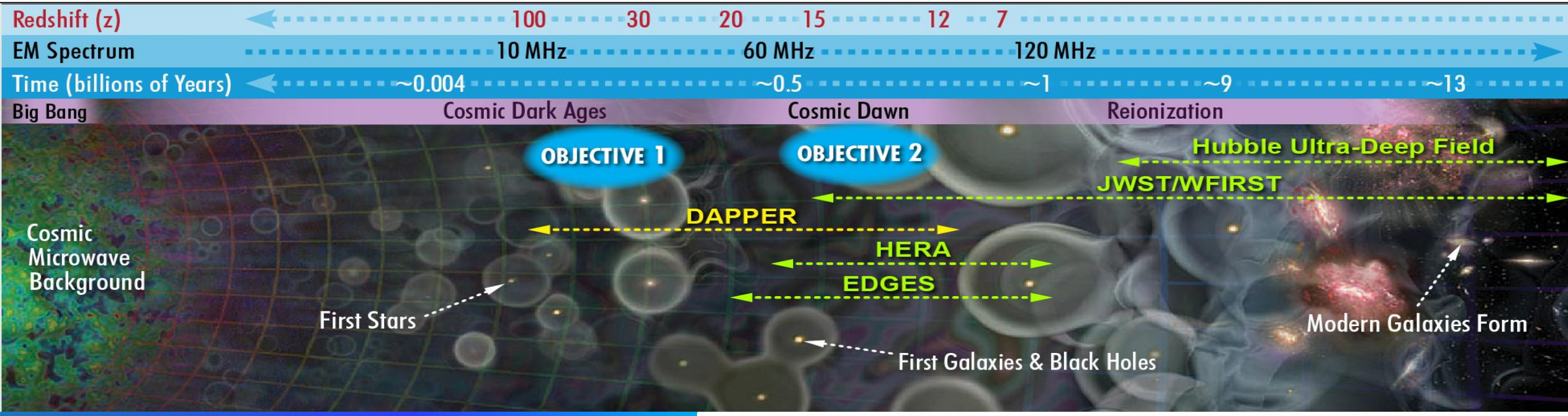


Spinning not only allows polarimetry but also stabilizes attitude and temperature.

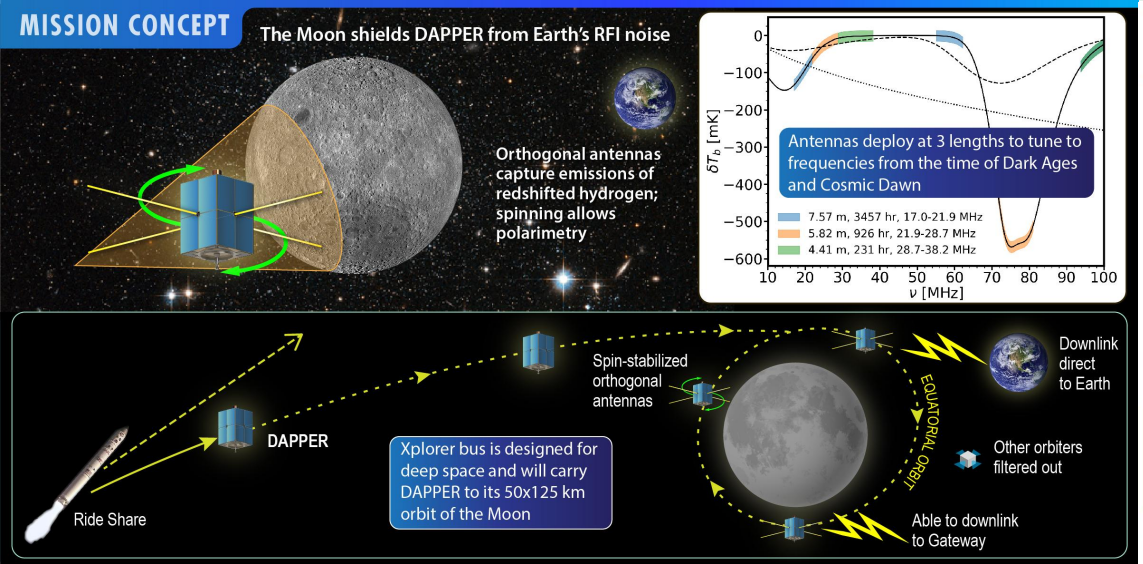
P.I. Jack Burns

The early Universe's Dark Ages, probed by the highly redshifted 21-cm neutral hydrogen signal, is the ideal epoch for a new rigorous test of standard cosmological model. DAPPER operates in a low lunar orbit above the radio-quiet farside.

Dark Ages Polarimeter Pathfinder (DAPPER)

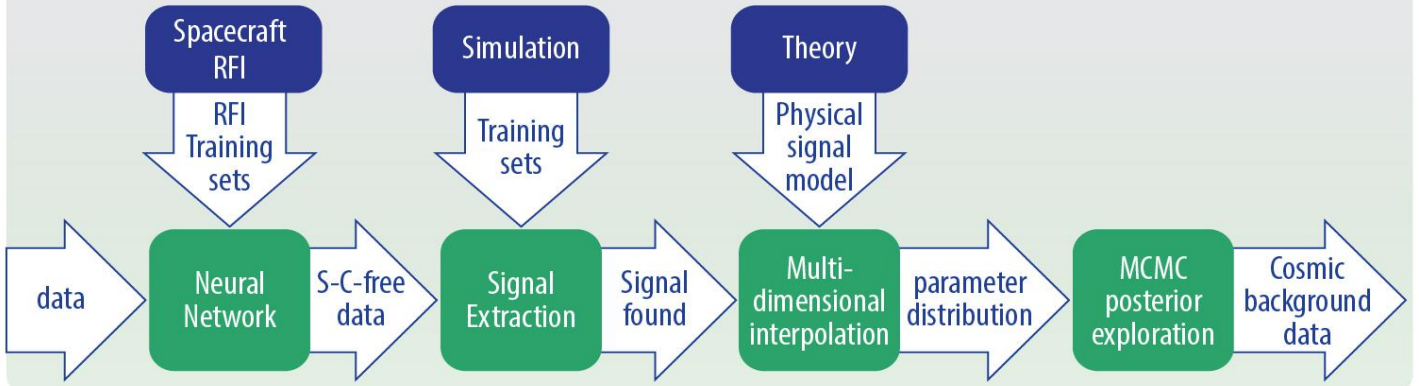


MISSION CONCEPT

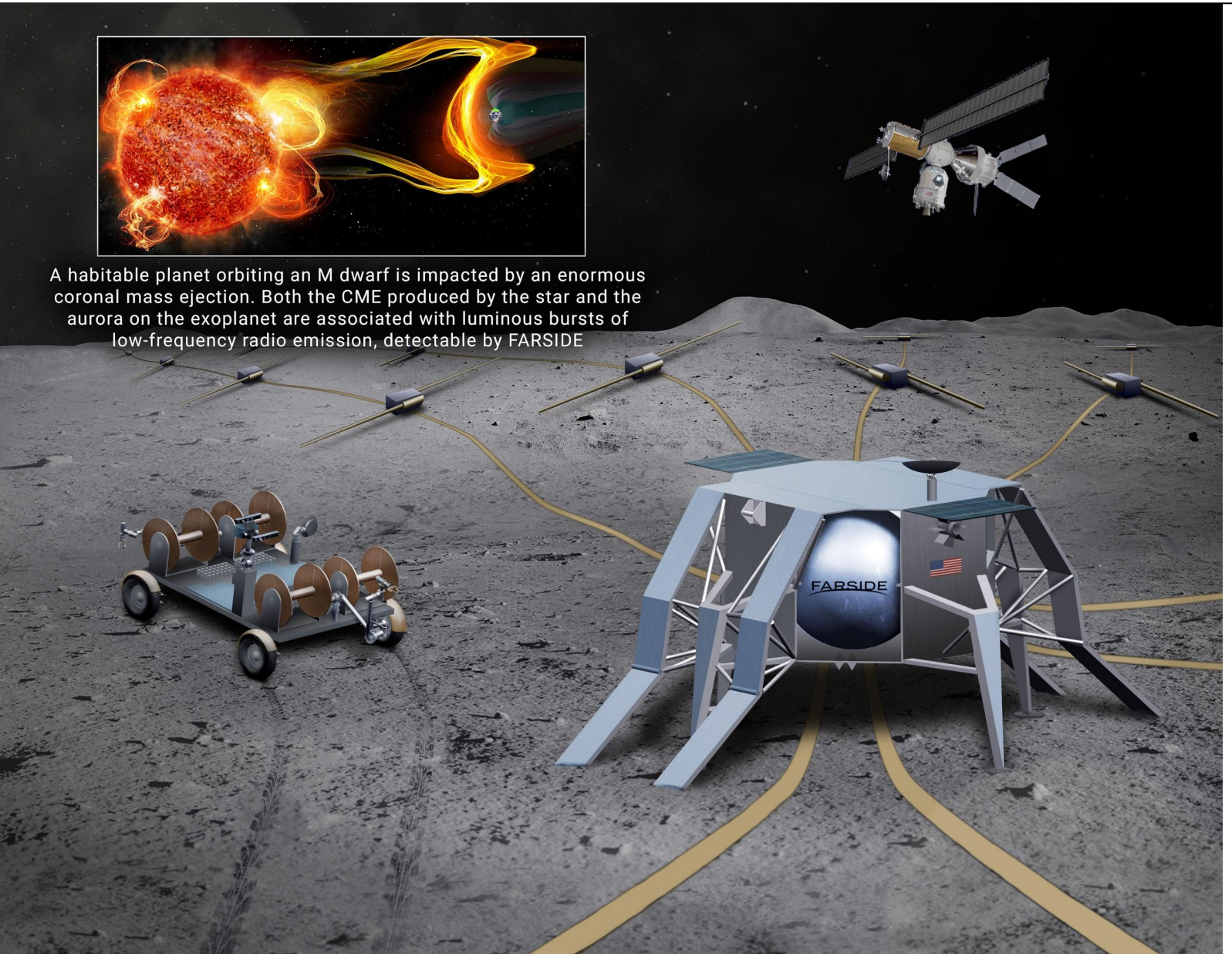


DATA PROCESSING PIPELINE

Pipeline uses pattern recognition and training sets to separate signal from known S/C, foreground, and systemic effects, and then fits cosmological models to the data.



FARSIDE



A habitable planet orbiting an M dwarf is impacted by an enormous coronal mass ejection. Both the CME produced by the star and the aurora on the exoplanet are associated with luminous bursts of low-frequency radio emission, detectable by FARSIDE

- ***P.I.s Jack Burns, Gregg Hallinan.***
- **FARSIDE (Farside Array for Radio Science Investigations of the Dark ages and Exoplanets)** is a Probe-class concept to place a low radio frequency interferometric array on the farside of the Moon.
- A NASA-funded design study, focused on the instrument, a deployment rover, the lander and base station.
- This notional architecture consists of 128 dual polarization antennas deployed across a 10 km area by a rover, and tethered to a base station for central processing, power and data transmission to the Lunar Gateway.

Public Outreach by the NESS Team

Apollo Anniversary Celebration

ANNIVERSARY CELEBRATION & FUTURE EXPLORATION

SHOWS, TALKS, CONCERTS & MORE

WEDNESDAY, JULY 3
12:30pm Dream to Fly
2:30pm Incoming!

SUNDAY, JULY 7
1pm Max Goes to the Moon & Laser Galactic Odyssey
2:30pm Stars and Moons
4pm Incoming!

WEDNESDAY, JULY 10
12:30pm Max Goes to the Moon & Our Moon and You
2:30pm Max Goes to the Moon & Craterology

THURSDAY, JULY 11
12:30pm Max Goes to the Moon & Craterology
2:30pm Max Goes to the Moon & Our Moon and You
7pm A New View of the Moon from NASA's Ongoing Lunar Exploration Program with Dr. Paul Hayne, CU Astrophysical & Planetary Sciences
8:30pm Laser Show Pink Floyd The Dark Side of the Moon

FRIDAY, JULY 12
7pm Our Future in Space: The Moon & Beyond with Dr. Jack Burns, CU Astrophysical & Planetary Sciences & Director of NASA'S NESS Team
8:30pm PREMIERE of CAPCOM Go! The Apollo Story
9pm Apollo 11 Landing Site Public Open House at Sommers-Bausch Observatory
10:30pm Liquid Sky The Age of Aquarius

SATURDAY, JULY 13
1pm Max Goes to the Moon & Laser Galactic Odyssey
2:30pm CAPCOM Go! The Apollo Story
10pm Liquid Sky Kid Cudi Man on the Moon

SUNDAY, JULY 14
1pm Max Goes to the Moon & Our Moon and You
2:30pm CAPCOM Go! The Apollo Story
4pm Nuestra Luna Especial (Our Special Moon) with Francisco Salas, CU Manager of Fiske Planetarium

WEDNESDAY, JULY 17
12:30pm Max Goes to the Moon & Our Moon and You
2:30pm CAPCOM Go! The Apollo Story

THURSDAY, JULY 18
12:30pm Max Goes to the Moon & Craterology
2:30pm CAPCOM Go! The Apollo Story
7pm The Space Environment of Our Moon with Dr. Mihály Horányi, CU Physics & Principal Investigator at LASP
8:30pm Liquid Sky The Age of Aquarius

FRIDAY, JULY 19
7pm Apollo 11 - From Launch to Landing with Dr. John Keller, CU Director of Fiske Planetarium and Warren Keller, Saturn V Test Engineer
8:30pm CAPCOM Go! The Apollo Story
10pm Liquid Sky The Age of Aquarius

SATURDAY, JULY 20
9:30am-5pm ONGOING ACTIVITIES – Creating Crater Station, Science on a Sphere Lunar Exploration Talks, Kinesthetic Moon Phases, Hide & Seek Moon, Scale Model Solar System Tours, Countdown Clock, Astronaut Selfie Stations, Color the Moon, and MORE!
10am Max Goes to the Moon & Our Moon and You
11:30am CAPCOM Go! The Apollo Story
11:30am STEM LAB: Touchdown: Design a Lunar Lander (ages 5-14, 1 hour, space is limited)
1pm Live Concert The Bluegrastronauts – A Family Space Adventure
2:30pm The Summer of 69: The Lasting Impression of the Apollo Program with Dennis Ebbets, Ball Aerospace
2:30pm STEM LAB: Stomp Rockets (ages 5-14, 1 hour, space is limited)
4pm Space Force! The Fictions and Realities of the Military's Final Frontier with William Holsclaw, CU Alumni History/Space Minor
4pm STEM LAB: Touchdown: Design a Lunar Lander (ages 5-14, 1 hour, space is limited)
5:30pm Five Decades of Lunar Sample Science: How the Apollo Missions Continue to Revolutionize our Understanding of the Solar System with Dr. Carolyn Crow, CU Geological Sciences
7:30pm Apollo 11: Celebrating the First Step on the Moon with Dr. John Keller, CU Director of Fiske Planetarium
9:30pm Live Concert The Bluegrastronauts
11pm Liquid Sky The Age of Aquarius

SUNDAY, JULY 21
1pm CAPCOM Go! The Apollo Story
2:30pm Max Goes to the Moon & Craterology
4pm Spacy Crazy! Kids' Letters to Astronauts in the Early Space Age with Dr. Roshanna Sylvester, CU Scholar-in-Residence CMCI

WEDNESDAY, JULY 24
12:30pm Incoming!
2:30pm Max Goes to the Moon & Our Moon and You

THURSDAY, JULY 25
12:30pm CAPCOM Go! The Apollo Story
2:30pm Incoming!
7pm CAPCOM Go! The Apollo Story
8:30pm Laser Show Pink Floyd The Dark Side of the Moon

FRIDAY, JULY 26
8pm CAPCOM Go! The Apollo Story
9:30pm Liquid Sky The Age of Aquarius
11pm Liquid Sky Kid Cudi Man on the Moon

SATURDAY, JULY 27
1pm Max Goes to the Moon & Laser Galactic Odyssey
2:30pm CAPCOM Go! The Apollo Story
7pm CAPCOM Go! The Apollo Story
8:30pm Black Holes: The Other Side of Infinity
10pm Laser Show Pink Floyd The Dark Side of the Moon

SUNDAY, JULY 28
1pm Dream to Fly
2:30pm Stars and Moons
4pm CAPCOM Go! The Apollo Story

WEDNESDAY, JULY 31
12:30pm CAPCOM Go! The Apollo Story
2:30pm Incoming!

Outreach: Fiske Planetarium at the University of Colorado Boulder celebrates the **50th anniversary of Apollo 11** with multiple events during July 2019.

Apollo Anniversary Celebration

Wings over the Rockies (Denver): Apollo-Palloza

NESS Outreach: Keynote presentation (July 13): Dr. Jack Burns, *Our Future in Space: To the Moon and Beyond*.

Apollopalooza event featured Apollo 17 astronaut Dr. Harrison H. Schmitt, astronaut Joe Engel, Apollo 11 flight director Gene Krantz.