

How to Make a Large Space Telescope

ASCEND Webinar, 2024-06-25

Kunio M. Sayanagi

NASA Langley Research Center

kunio.m.sayanagi@nasa.gov



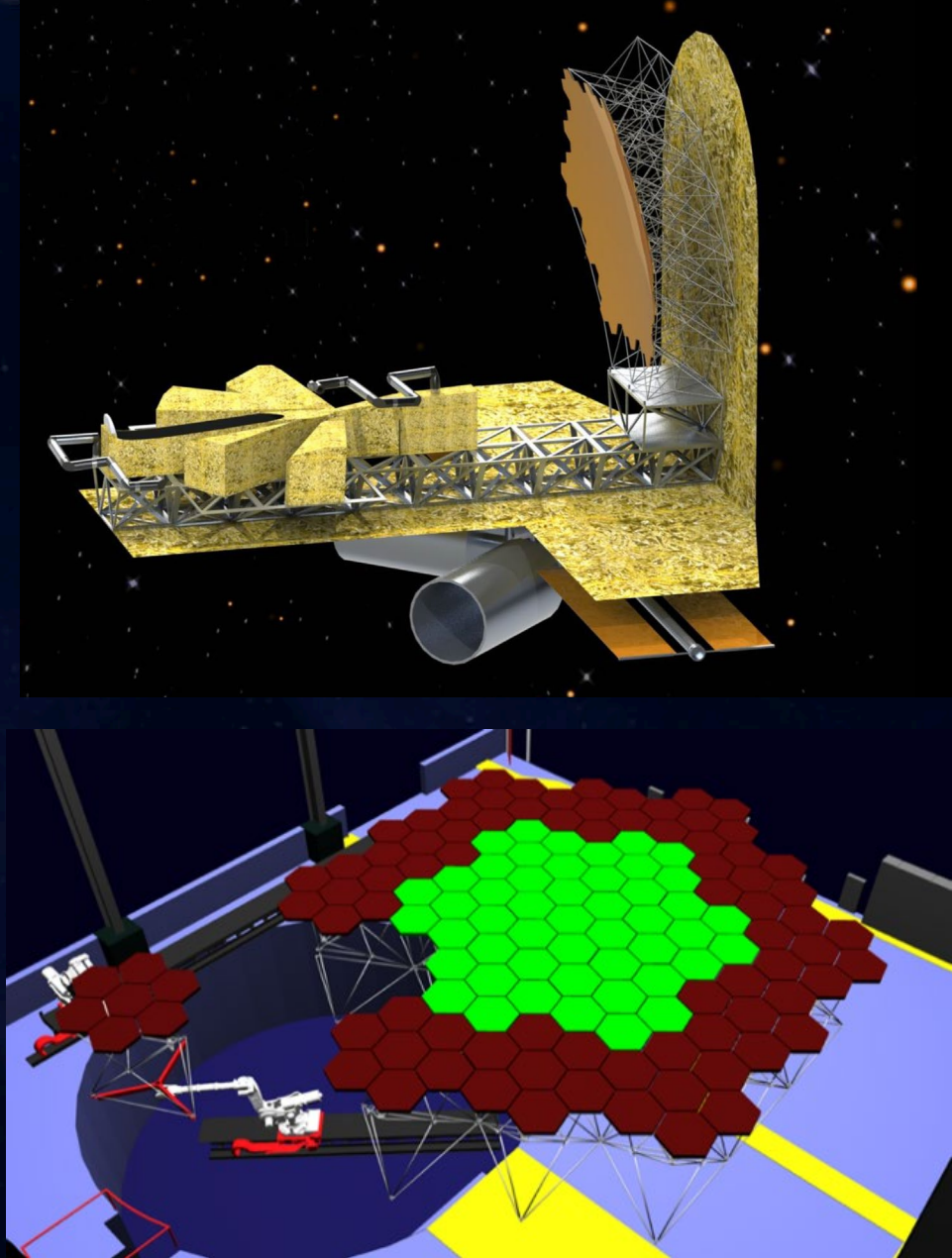
2020 Astrophysics Decadal Survey iSAT Concept Study

Astro2020 in-Space Assembled Telescope (iSAT) study:

- Examined feasibility of a 5, 10, 15 and 20-meter telescope assembled in space
- Optimized for sensitivity: Filled Aperture design
- Optical surfaces: actively controlled to maintain mirror shape

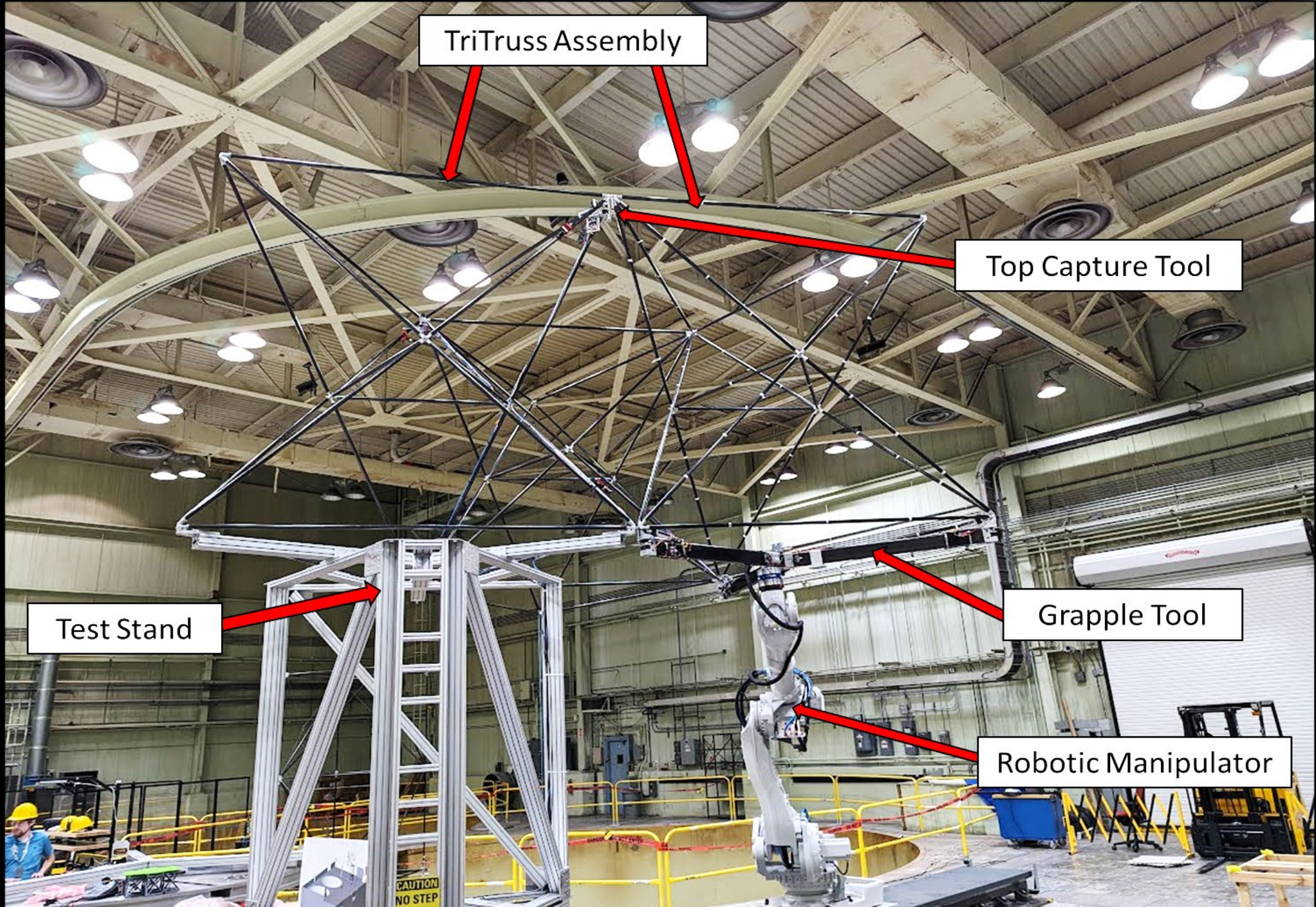
On-going Development:

- Precision Assembled Space Structures (PASS)
 - Laboratory Demonstration of Robotic Autonomous Assembly of a 20-meter aperture backing structure
 - Effort is applicable to future Solar System Telescope

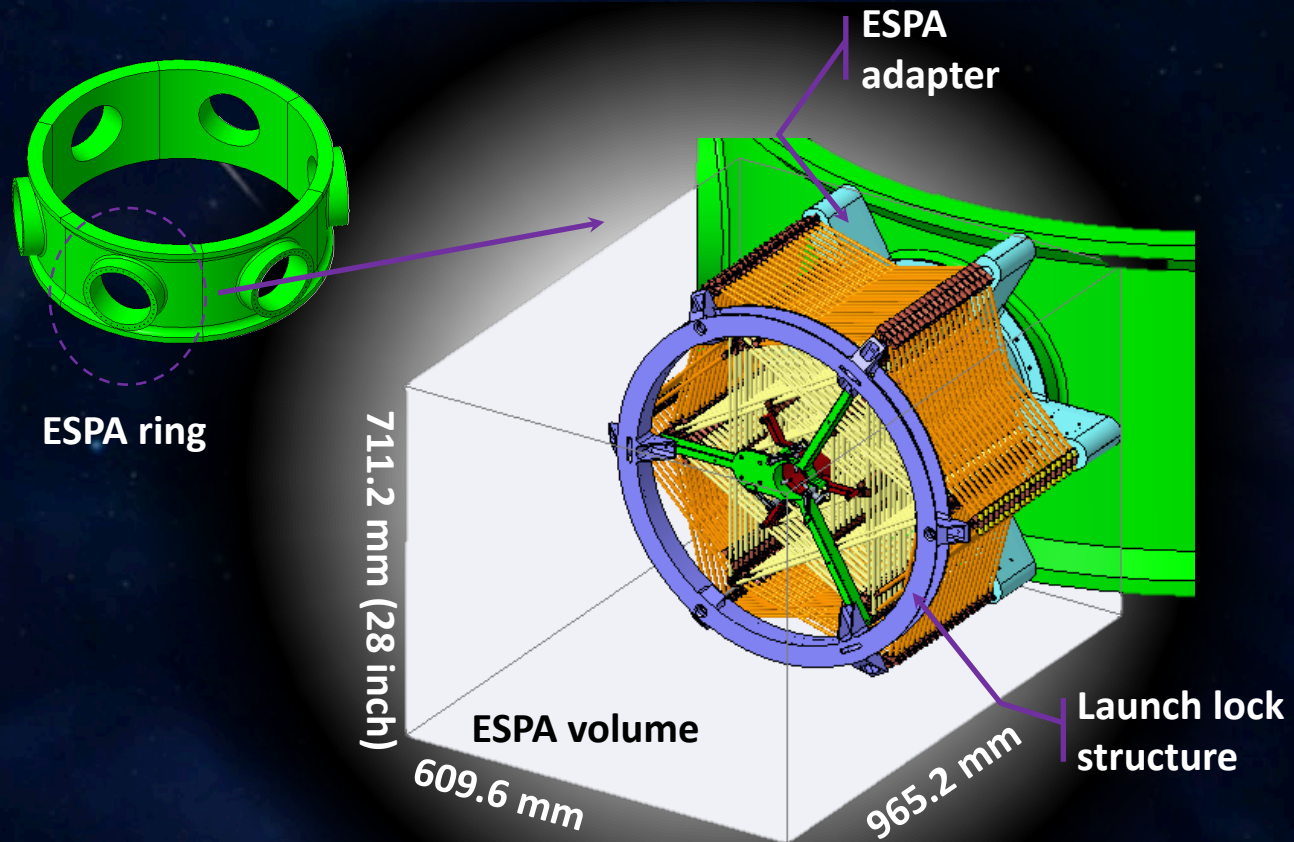


PASS Laboratory Demonstration
Robotic Assembly of Modular Space Exploration Systems

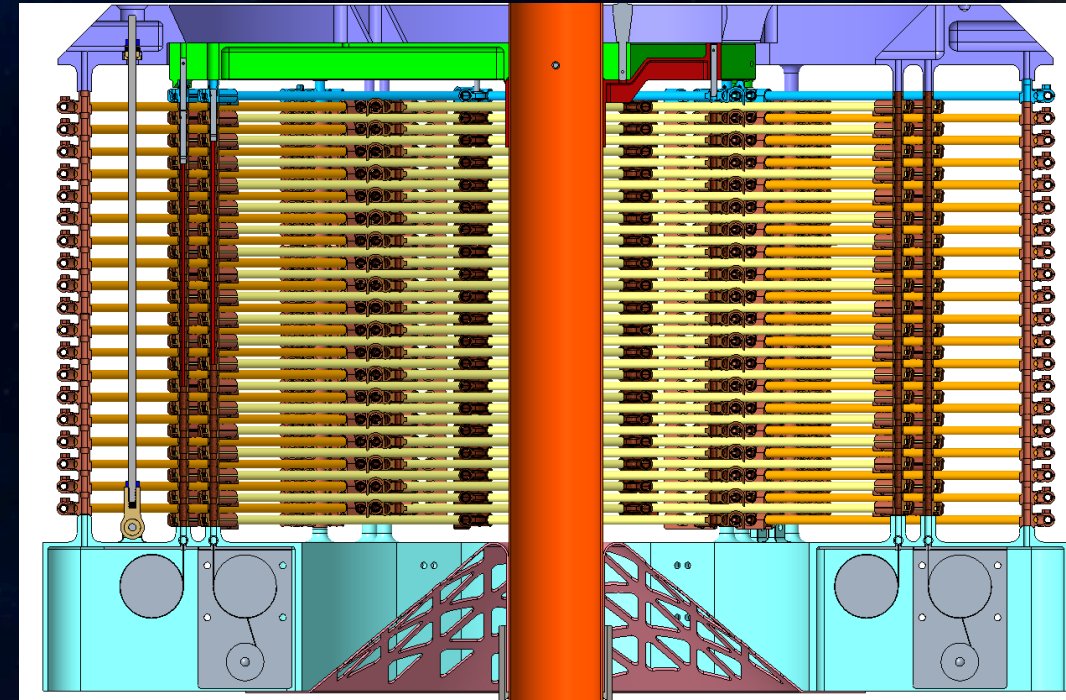
PASS Project Current Status



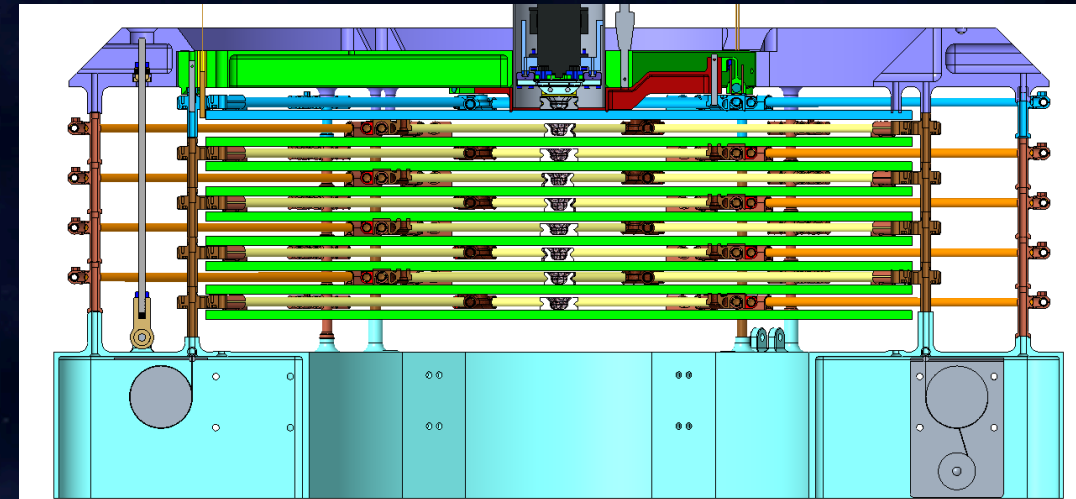
ESPA Packaging Study



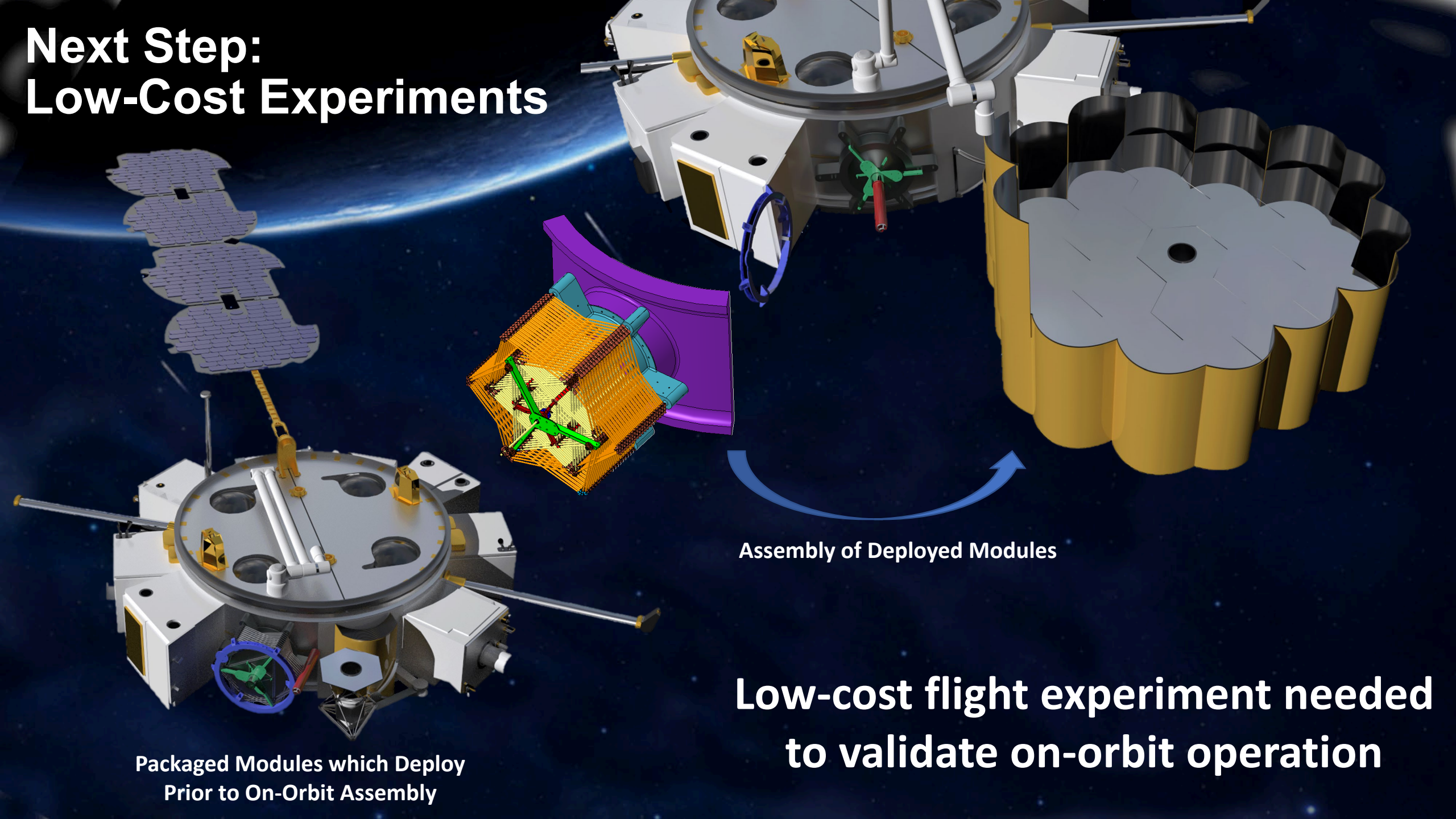
Packaging of Structure Only



Packaging of Structure with Preattached Mirror Modules



Next Step: Low-Cost Experiments



Packaged Modules which Deploy
Prior to On-Orbit Assembly

Assembly of Deployed Modules

Low-cost flight experiment needed
to validate on-orbit operation

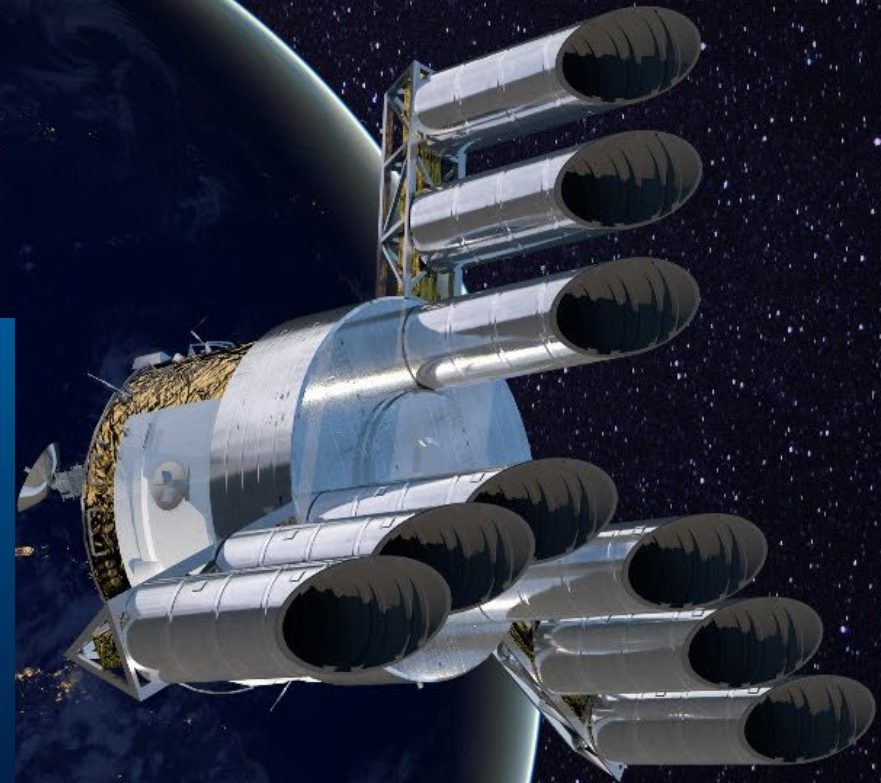
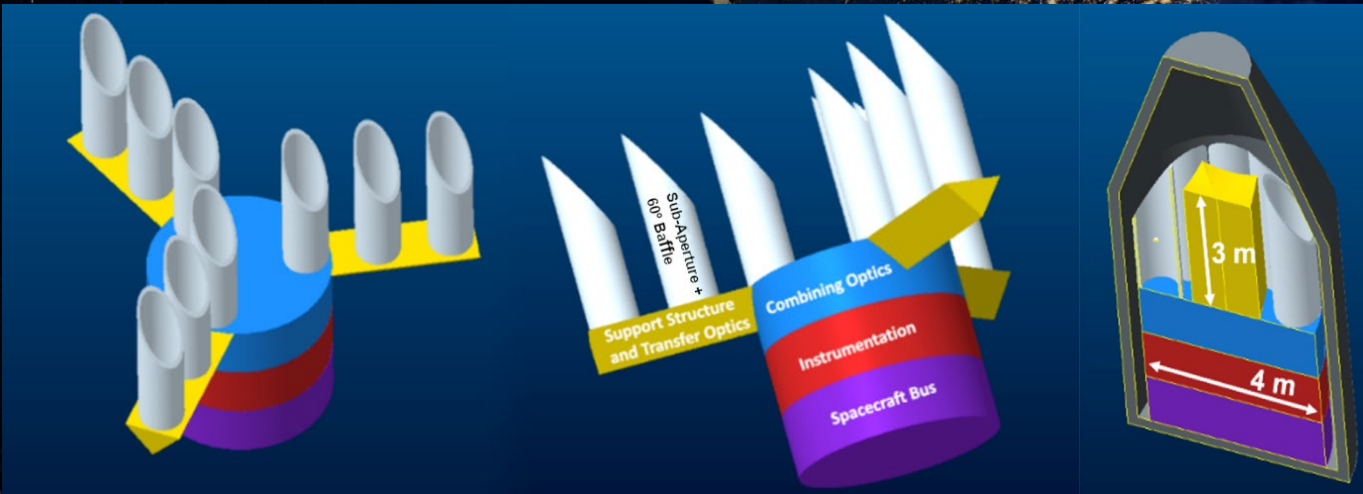
CHARISMA: Caroline Herschel high-Angular Resolution Imaging & Spectroscopy Multi-Aperture Telescope

Sayanagi et al., 2020 Planetary Decadal Survey White Paper

Designed to balance sensitivity and resolution

Notional Architecture

- ~10-meter Effective Aperture
- Equivalent of 2-meter circular aperture area
- Sparse-Aperture Design
- Assembled and/or Deployed in Space
- 30-deg Solar Exclusion Zone
- Create tech heritage for future astrophysics telescopes



References

- In-Space Assembled Telescope Project
https://exoplanets.nasa.gov/exep/technology/in-space-assembly/iSAT_study/
- Young et al. "The science enabled by a dedicated solar system space telescope"
<https://baas.aas.org/pub/2021n4i232/release/1>
- Sayanagi et al. "Architectures and Technologies for a Space Telescope for Solar System Science"
<https://baas.aas.org/pub/2021n4i363/release/1>
- Dorsey et al. "NASA Langley Research Center Capabilities/Technologies for Autonomous In-Space Assembly and Modular Persistent Assets"
<https://baas.aas.org/pub/2020n7i281/release/1>

Summary

- Unique science only enabled by UV observation
 - Time-domain science (high frequency, long-duration)
 - New, wide-ranging small bodies surveys
- Urgent need: preserve UV observation capabilities
- Mission targets
 - A focused space telescope mission is viable
 - Can potentially serve broad planetary science community
- Telescope Architecture options; optimized for:
 - Spatial resolution
 - Photometric sensitivity
 - Balance of both
- Concept study objectives
 - Survey of technology options
 - Point design to demonstrate viable options for the next decade
- We advocate to add a solar system space telescope to the NF6 list

The time for a solar system space telescope is NOW!



BACKUP MATERIALS



Space Telescope Architecture

Architectures: Resolution & Sensitivity

Measurement Requirements

- Imaging Resolution
- Sensitivity
- Spectral Range
- Solar Exclusion Zone

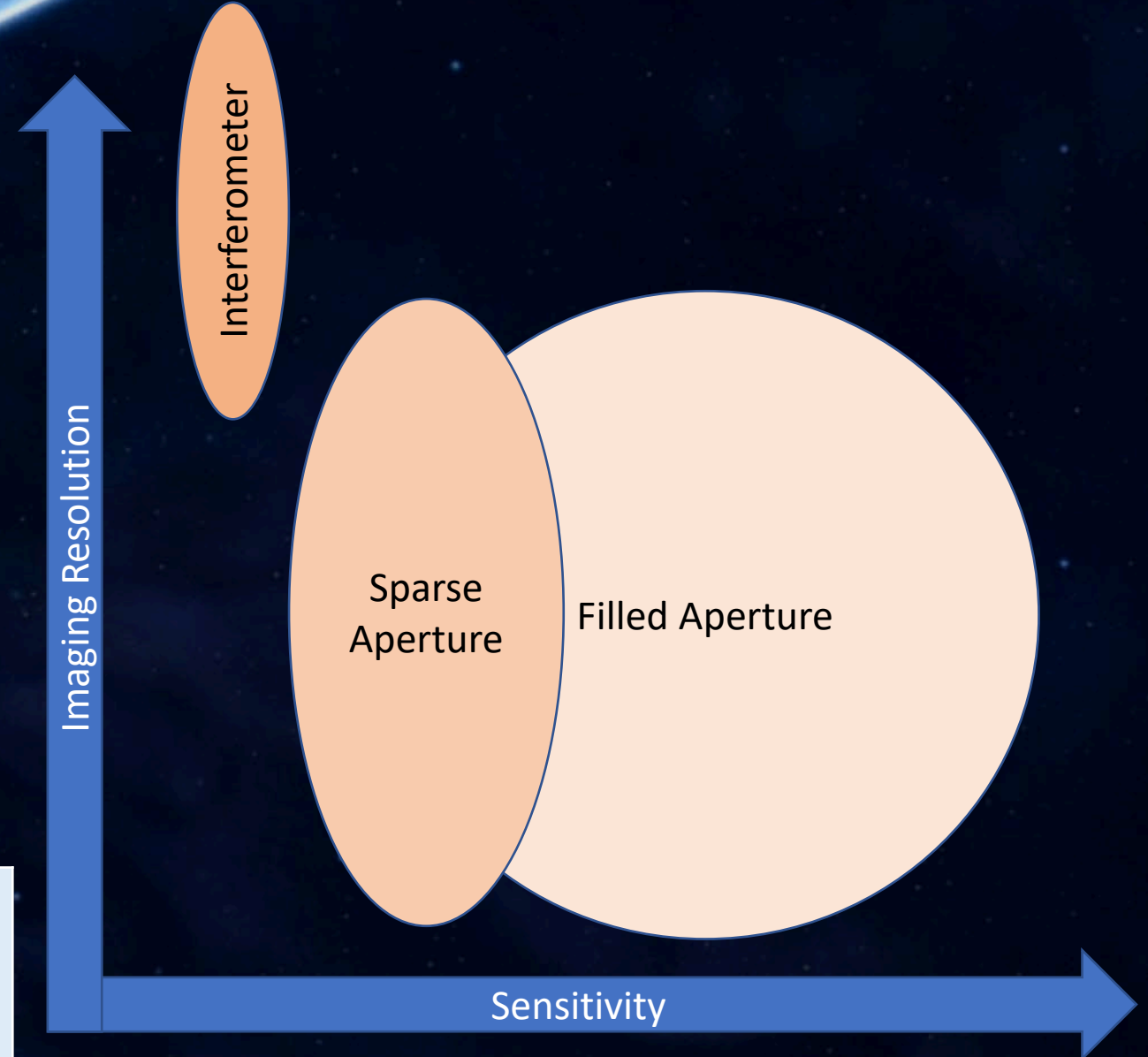
Note: Spectral Resolution is an instrument parameter, not OTA

Assembly Approach

- Assembled on Ground
- Deployable Structure
- In-Space Assembly
- Any Combination of Above

Orbit Affects temporal cadence

- Low-Earth Orbit
- High-Earth Orbit
- Earth-Trailing
- L2



Solar System Space Telescope Team

¹K.M. Sayanagi, ¹C.L. Young, ¹L. Bowman, ²J. Pitman, ³B. Naasz, ⁴B. Meinke,
⁵T. Becker, ⁶J. Bell, ⁷R. Cartwright, ⁸N. Chanover, ⁹J. Clarke, ¹⁰J. Colwell, ¹¹S. Curry,
¹¹I. de Pater, ⁴G. Delory, ¹²L. Feaga, ¹³L.N. Fletcher, ⁵T. Greathouse, ¹⁴A. Hendrix,
¹⁵B.J. Holler, ¹⁶G. Holsclaw, ¹⁷K.L. Jessup, ¹²M.S.P. Kelley, ¹¹R. Lillis, ¹⁸R.M.C. Lopes,
¹¹J. Luhmann, ¹D. MacDonnell, ⁷F. Marchis, ⁶M. McGrath, ³S. Milam, ¹⁹J. Peralta,
⁵M.J. Poston, ⁵K. Retherford, ²⁰N. Schneider, ¹¹O. Siegmund, ¹⁷J. Spencer,
²¹R.J. Vervack Jr., ¹⁴F. Vilas, ¹¹E. Wishnow, ^{11,7}M.H. Wong

¹NASA Langley Research Center, Hampton, VA

²Heliospace Corporation, Berkeley, CA

³NASA Goddard Space Flight Center, Greenbelt, MD

⁴Ball Aerospace, Boulder, CO

⁵Southwest Research Institute, San Antonio, TX

⁶Arizona State University, Tempe, AZ

⁷SETI Institute, Mountain View, CA

⁸New Mexico State University, Las Cruces, NM

⁹Boston University, Boston, MA

¹⁰University of Central Florida, Orlando, CA

¹¹University of California, Berkeley, CA

¹²University of Maryland, College Park, MD

¹³University of Leicester, Leicester, UK

¹⁴Planetary Science Institute, Tucson, AZ

¹⁵Space Telescope Science Institute, Baltimore, MD

¹⁶University of Colorado, Boulder, CO

¹⁷Southwest Research Institute, Boulder, CO

¹⁸Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

¹⁹Japan Aerospace Exploration Agency, Sagami-hara, Japan

²⁰University of Colorado Laboratory for Atmospheric and Space Physics, Boulder, CO

²¹Johns Hopkins Applied Physics Laboratory, Laurel, MD