

THE SPHERE^X* MISSION

An All-sky Survey of 0.75-5.0 μm Spectra

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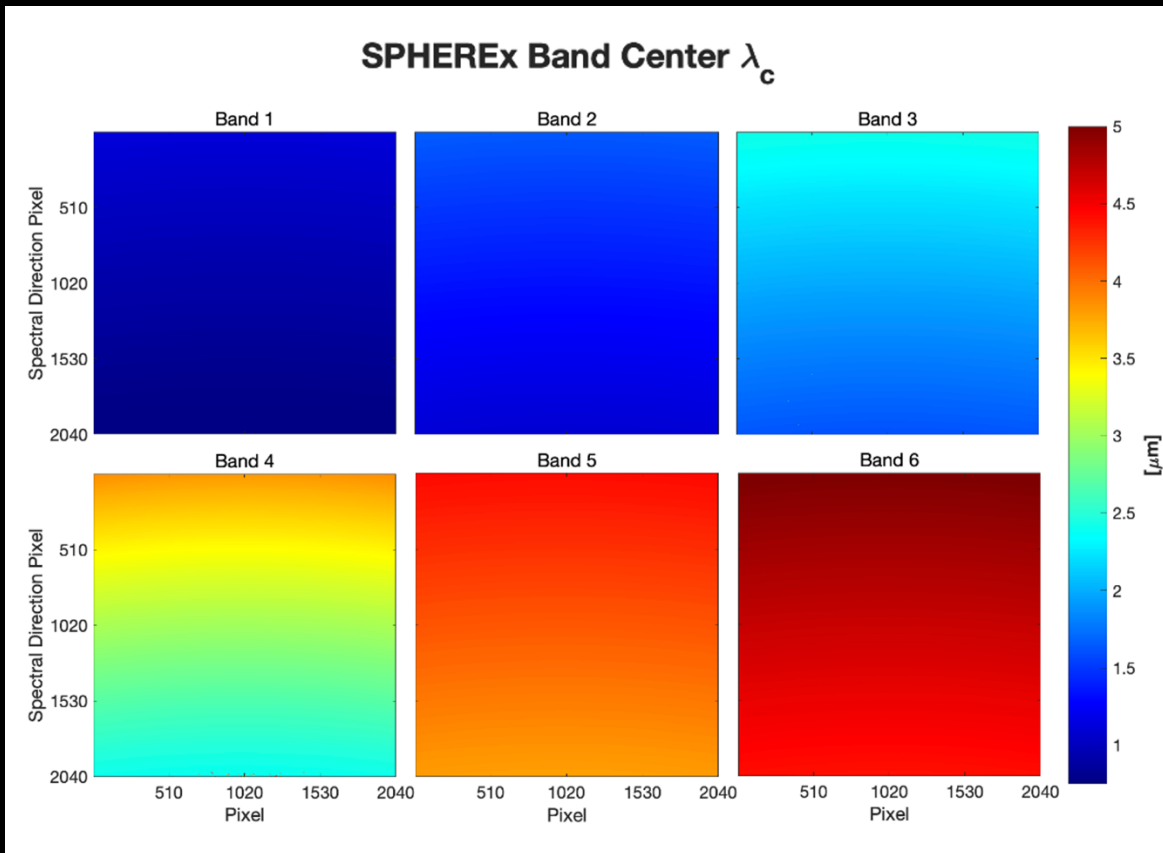
*Spectro-Photometer for the History of the Universe,
Epoch of Reionization, and Ices Explorer

What will SPHEREx do?

It will acquire 0.75 – 5.0 μm spectra at $R \sim 100$ over the entire sky using Linear Variable Filters.

There are six 2k x 2k HgCdTe detectors observing three adjacent fields of view.

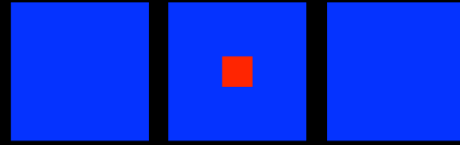
Dichroic beamsplitters allow two wavelengths to be observed simultaneously.



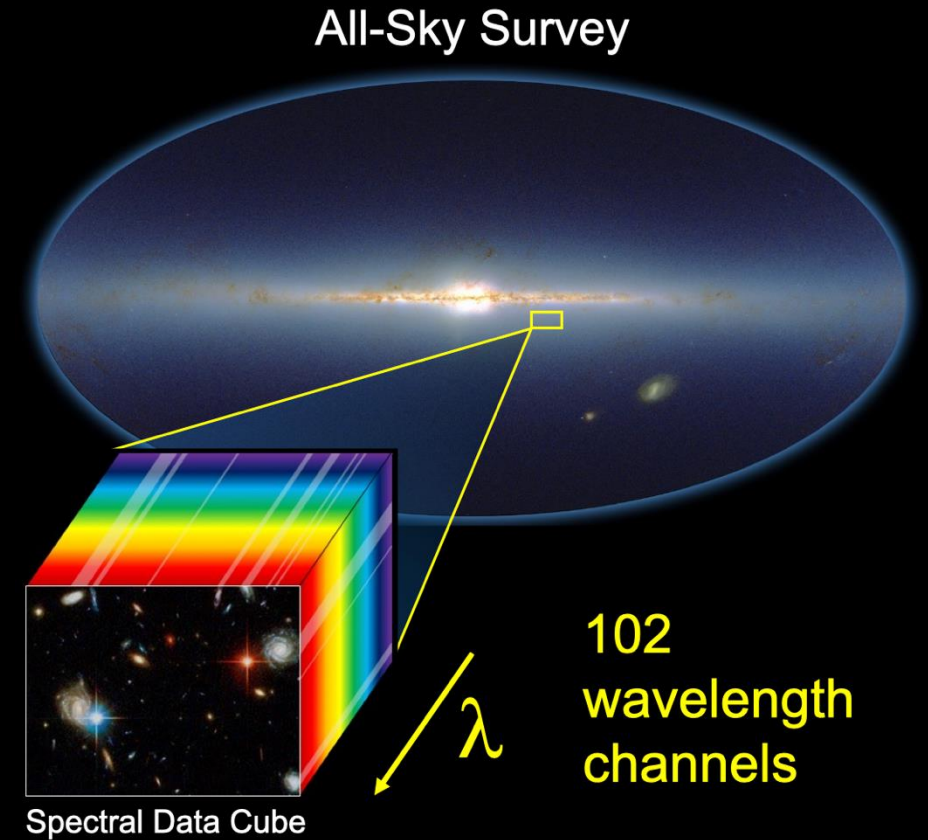
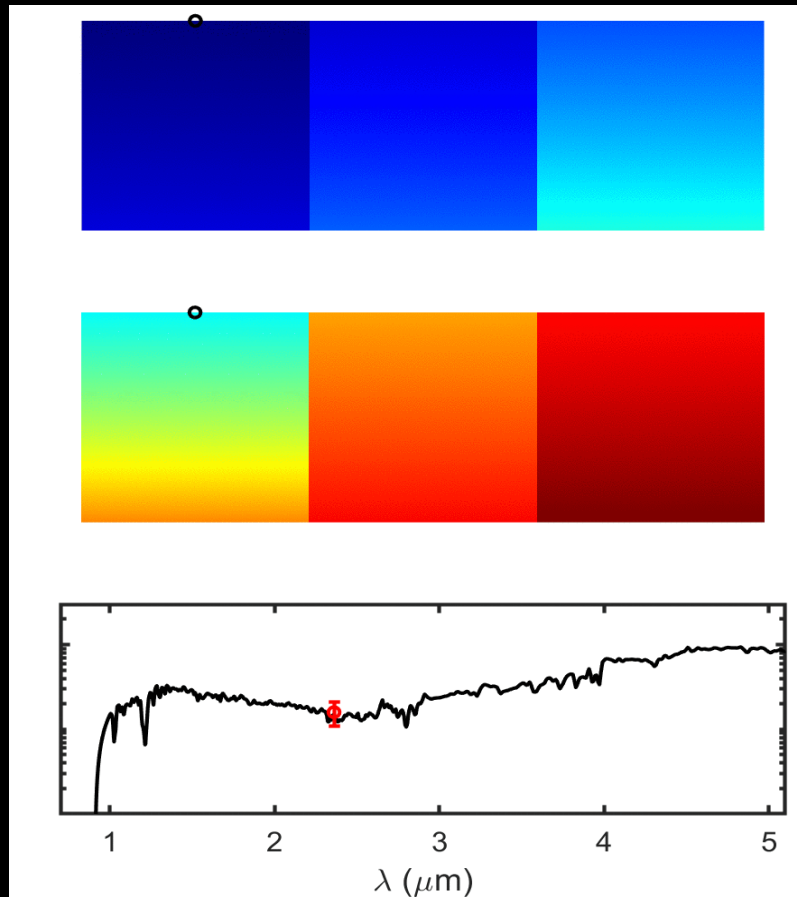
| | Coverage (μm) | $\lambda/\Delta\lambda$ |
|---------|----------------------------|-------------------------|
| Field 1 | | |
| Band 1: | 0.75-1.2 | 41 |
| Band 4: | 2.4 – 3.7 | 35 |
| Field 2 | | |
| Band 2: | 1.2 – 1.7 | 41 |
| Band 5: | 3.7 – 4.4 | 110 |
| Field 3 | | |
| Band 3: | 1.7 – 2.4 | 41 |
| Band 6: | 4.4 – 5.0 | 130 |

17 exp/array, 112s each
17x6 = 102 exposures total
From LEO, 1 full spectrum
every six months
2 yr mission = 4 full spectra
Pixel size = 6.2 arcsec

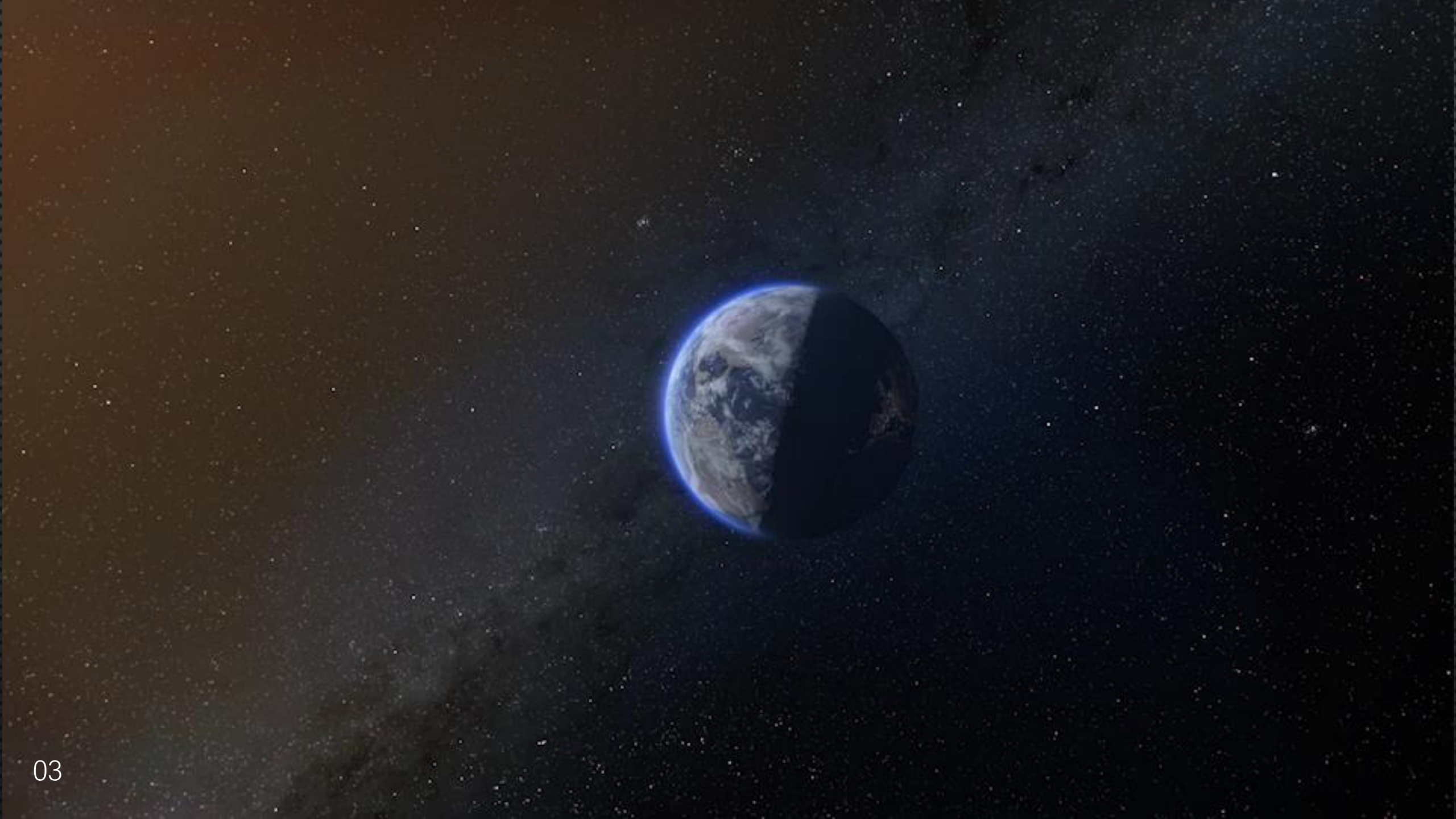
WISE FoV: 0.61 deg²



SPHEREx FoV: 39.6 deg²

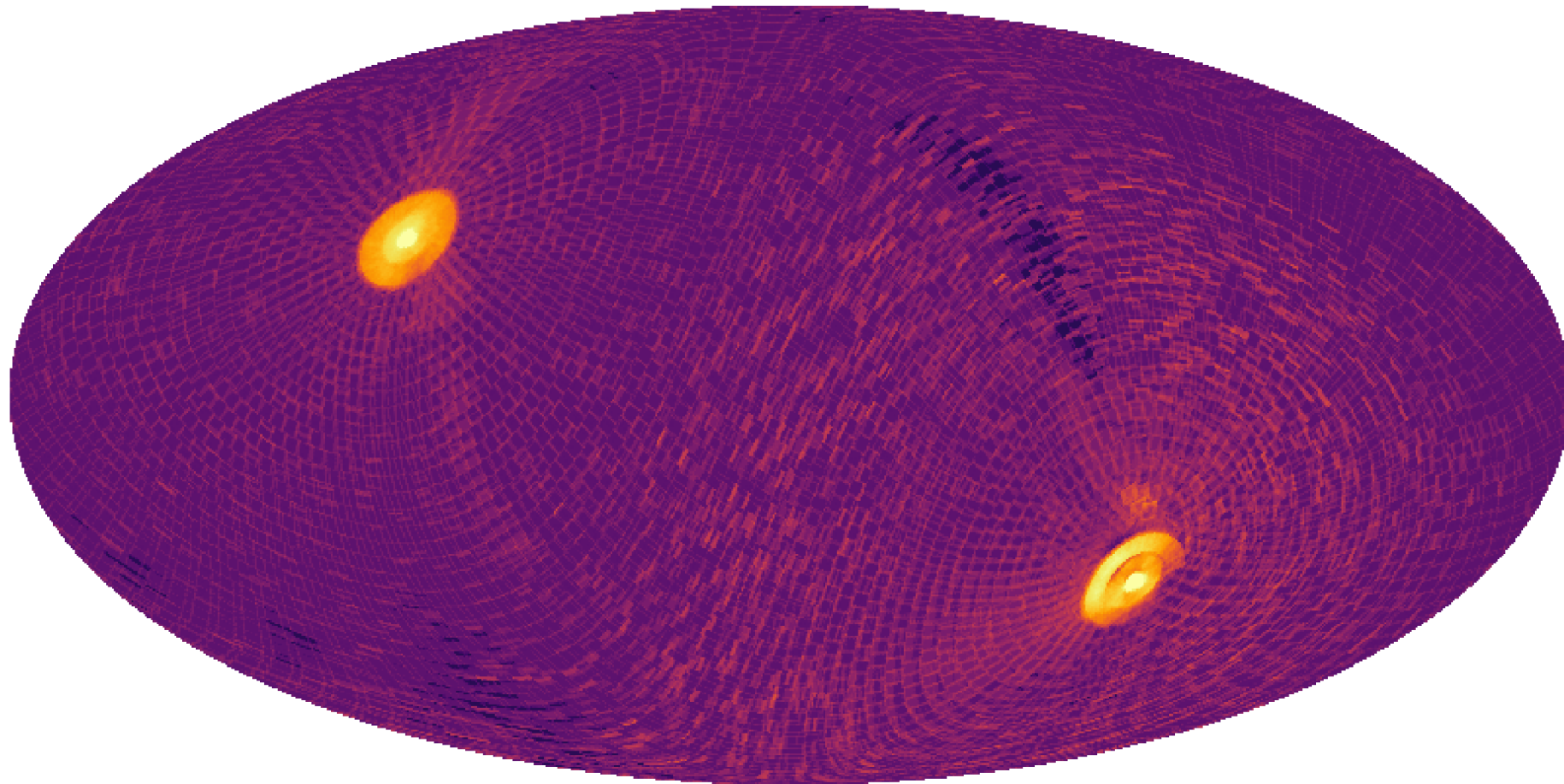


SPHEREx provides a new and unique dataset
a complete near-infrared spectrum
for every 6" pixel on the sky



Simulated coverage map of the sky, for one of the 102 spectral channels

Array 1, Subchannel 1

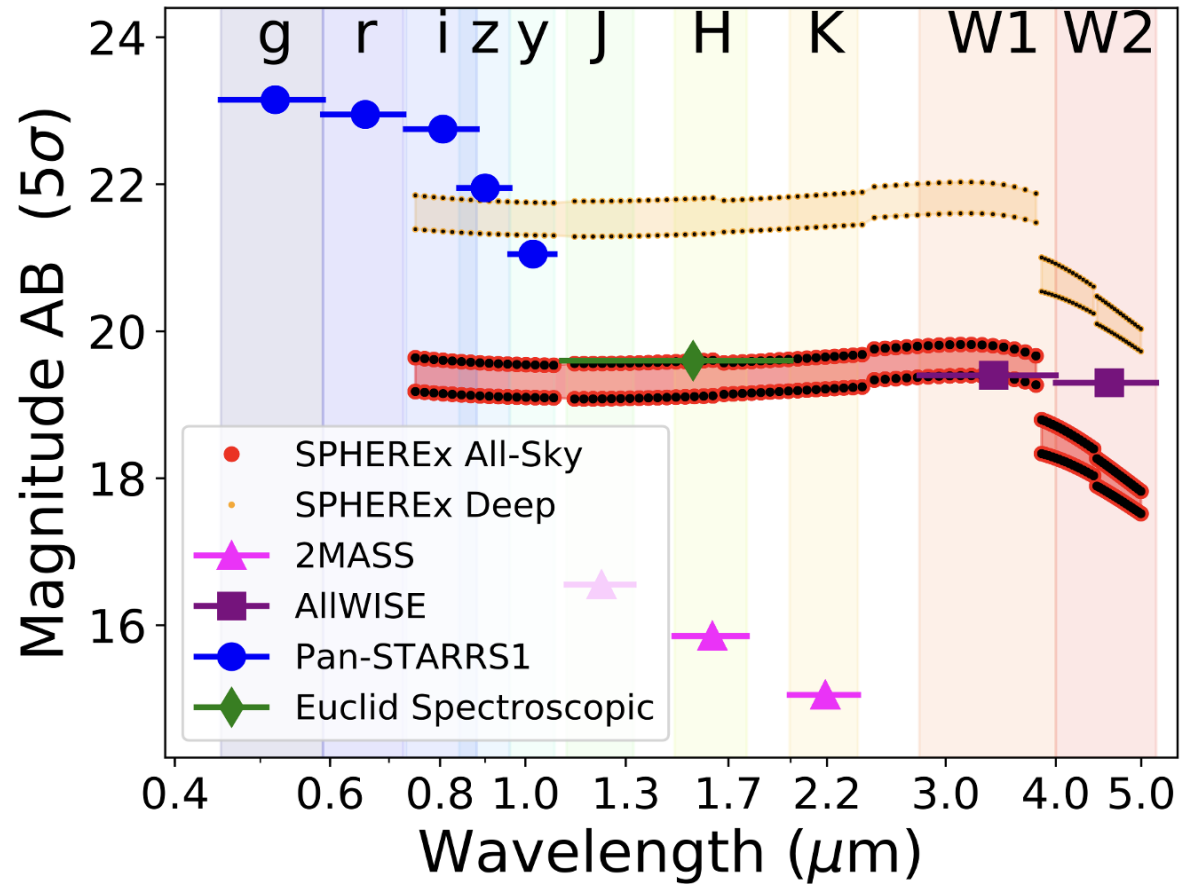


Plot by Giulia Murgia (Caltech undergrad) using the sky simulator and survey sequence



SPHEREx bands: 1 2 3 4 5 6

SPHEREx^x Point Source Sensitivity

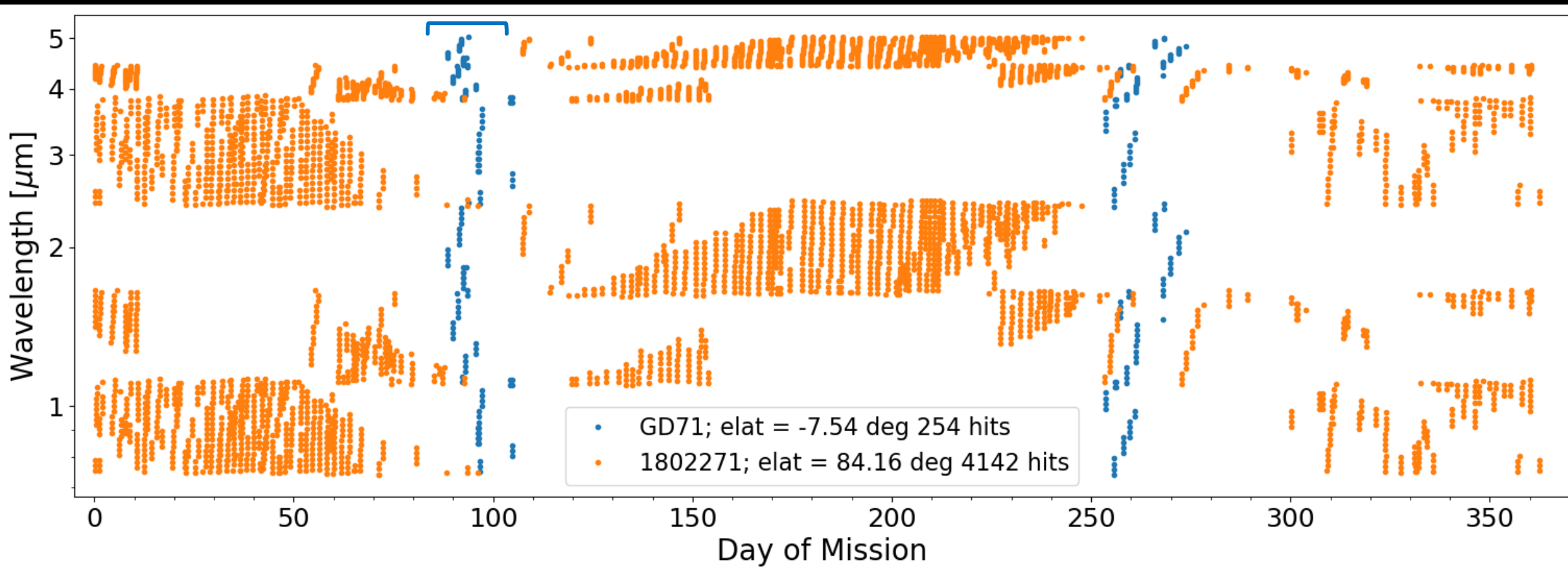


Expected sensitivity in each SPHEREx band

Example of spectral sampling timing over 1 year for two sources:

- (1) Near one of the deep fields (orange)
- (2) In the all-sky survey (blue)

16 days



Data processing and data products

Algorithms developed in collaboration with the SPHEREx Science Team

Level 1

Input: Science and instrument telemetry

Main processing steps

- Assemble data into FITS files
- Coarse astrometry
- Apply reference pixel corrections

Output: Photocurrent Images in Engineering Units

Level 2

Main processing steps

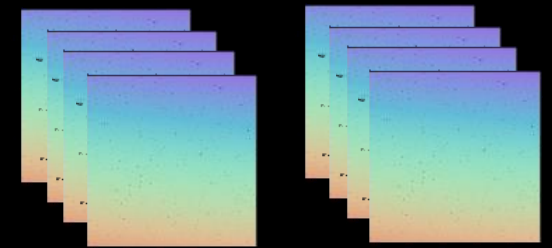
- Nonlinearity correction
- Flagging for persistence, bad/hot pixels, known optical effects
- Apply gain calibrations
- Fine astrometry
- Per-exposure PSF
- Find matching catalog and Solar System sources

Output: Calibrated LVF Images; sent to archive



Calibrated Spectral Image Data

- Output of Pipeline Level 2
- Available in archive within 60 days



Data processing and data products (continued)

Level 3

Main processing steps

- Correct dark current
- Estimate diffuse background
- Measure forced photometry using Tractor algorithm
- Collect spectral measurements

Output: Spectral measurements

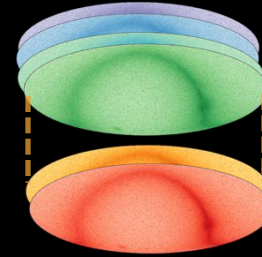


Calibrations

- Dark Current
- Distortion
- Average Point Spread Function
- Absolute Gain Matrix
(combination of flat-field and spectral response)

102 All-sky Data Cubes

- Part of Year 1 and 2 Data Release



High Reliability Source Catalog

- Sources selected from input catalog
- Photometry measurements at native wavelengths and binned over 102 spectral channels
- Created after 3 sky surveys and again after 4

Legacy Data Products

- Legacy Deep Field Mosaics
- Legacy Galaxy Catalog
- Legacy Stellar Type/Ice Column Density Catalog
- Released at end of mission

The Precision Stellar Properties Legacy Catalog

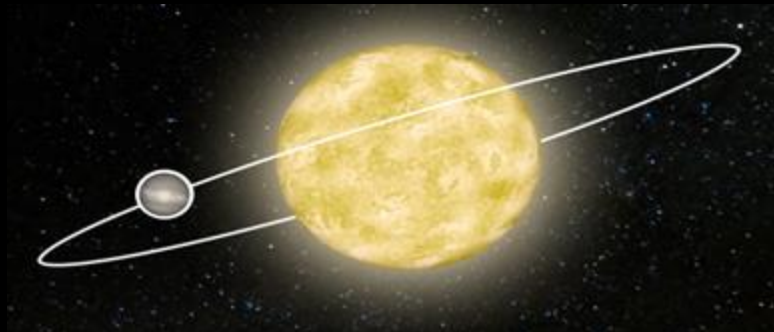
being led by Rachel Akeson, myself, Mike Werner, and a postdoc to be named very soon

Science goal: Enable critical increase in precision of stellar parameters for low-mass stars and brown dwarfs

Exoplanet Characterization

By analyzing SPHEREx spectra of planet-bearing stars and combining with information from Gaia, we can improve the uncertainty of the measured planet radius by a factor of ~ 10 for many known planets.

- These precise planetary parameters will increase the scientific impact of exoplanet missions including Kepler (K2), TESS, Roman, Plato, ARIEL, Cheops



Complete 20pc Sample

A well studied sample for distances and multiplicity, providing touchstones for other studies.

For “planet-like” brown dwarfs specifically, SPHEREx...

Will increase the number of complete brown dwarf infrared spectra by ~ 100 times

Will determine their temperatures by combining SPHEREx spectra with Gaia & Spitzer parallaxes

Will provide constraints on composition and model atmosphere predictions

The Precision Stellar Properties Legacy Catalog

being led by Rachel Akeson, myself, Mike Werner, and a postdoc to be named very soon

Target catalogs:

Exoplanet surveys

- Kepler DR25: 200,038 stars
- K2 (Zink et al 2021): 222,053 stars
- Plato:
 - More complete than TESS sample
 - ~2.4 million FGK dwarfs/subgiants
 - ~300,000 M dwarfs

Total unique count = 2.99 million stars

20-pc sample (Kirkpatrick et al. 2024)

- “Stars” (types \leq M9.5): 3,000
- “Brown Dwarfs” (types \geq L0): 582

Legacy products:

- Computed bolometric luminosities for all.
- Radii for stars; T_{eff} for brown dwarfs.

IRSA tools and simulated data

IRSA SPHEREx Landing Page

- <https://irsa.ipac.caltech.edu/Missions/spherex.html>

Custom Tools

- **Spectrophotometry:** Measure spectra at user-supplied positions using same algorithm as data processing pipeline > Available with first spectral image release
- **LVF Image Cutout:** Collect LVF data meeting user-supplied criteria > Available when ~4 months of data released
- **Source Discovery:** Identify significant signal without position prior > Available when ~4 months of data released
- **Custom Mosaic:** Create single-wavelength images from LVF data > Available when ~4 months of data released
- **Spectral Cube Cutout:** Extract subset from all-sky data cubes > Available with Year 1 data release

Simulated SPHEREx data available now at
<https://irsa.ipac.caltech.edu/data/SPHEREx/AASJan2025/>

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SPHEREx: An All-Sky Spectral Survey

Mission Characteristics

| | |
|-----------------------------------|--|
| Lifetime: | 2025 - 2027 (planned) |
| Wavelength: | 0.75-1.1 microns, R=41 1.1-1.6 microns, R=41 1.6-2.4 microns, R=41 2.4-3.8 microns, R=35 3.8-4.4 microns, R=110 4.4-5.1 microns, R=130 |
| Area Coverage: | 100% of sky |
| Instruments: | Wide Field Linear Variable Filter (LVF) Imaging Spectrograph |
| Funding Agency: | NASA |
| Contributing Institutions: | JPL, Caltech, RIT, Carnegie Mellon, Harvard/CFA, Arizona State, University of Arizona, Ohio State University, KASI |
| Canonical Papers: | SPHEREx Overview: Bock et al. (2018) SPHEREx Instrument: Kongut et al. (2018) Cosmology: Dore et al. (2018) Ices: Meinick et al. (2018) Legacy Science: Cooray et al. (2018) |

IRSA Services - SPHEREx Releases

[SPHEREx Target List of Ice Sources \(SPLICES\)](#) [Access SPLICES catalog](#)

Other Resources

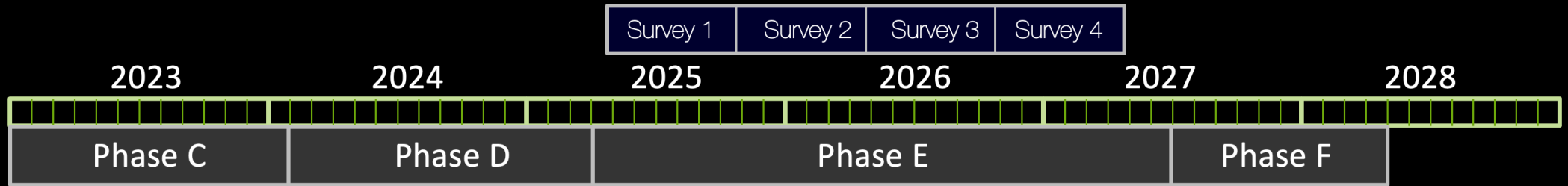
[SPHEREx website](#) [SPHEREx Home Page](#)

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Review of data products and schedule



Data Releases



Launch: February 27, 2025!

Thank you!