

Pandora

Big Science with a
SmallSat

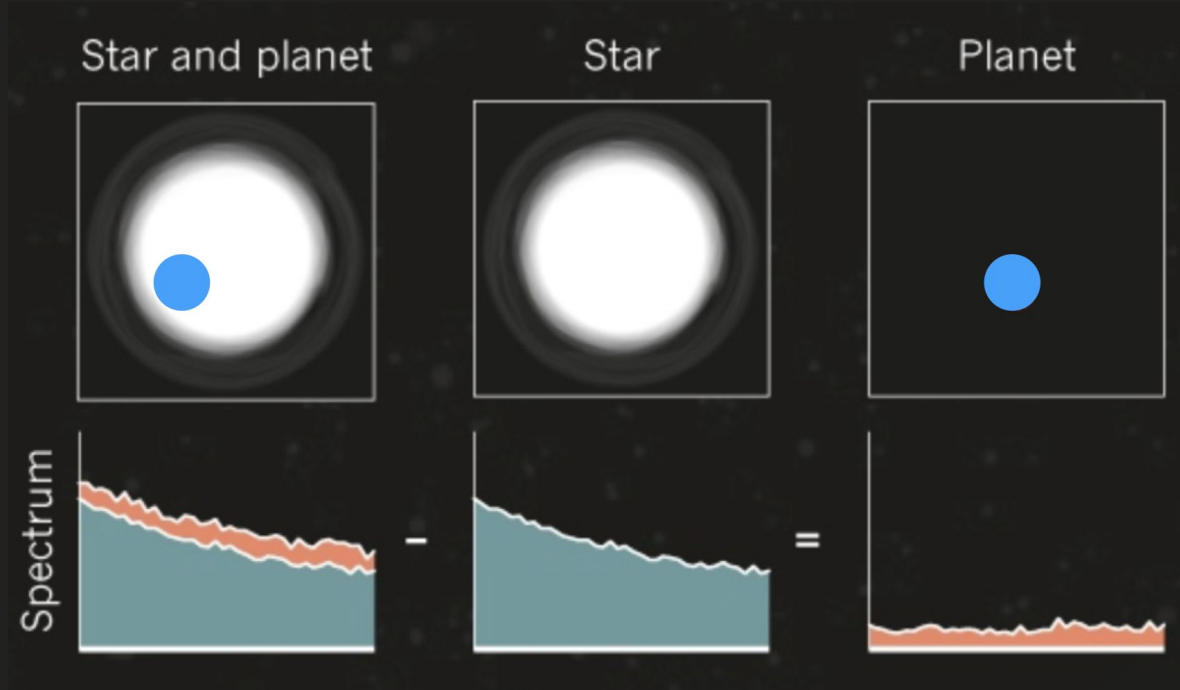
Rae Holcomb
ExSoCal 2023



Transmission Spectroscopy

A **differential measurement** of the planet's atmospheric spectrum by comparing the spectrum in and out of transit.

→ Detect H₂O, CO₂, and other essential ingredients for life?

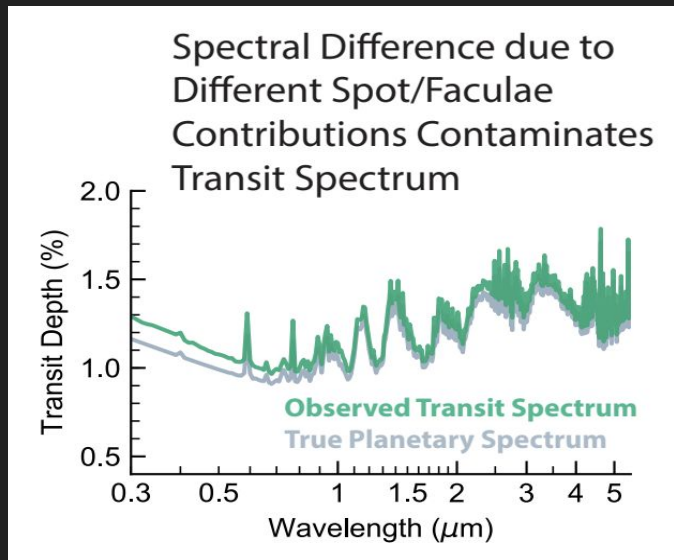
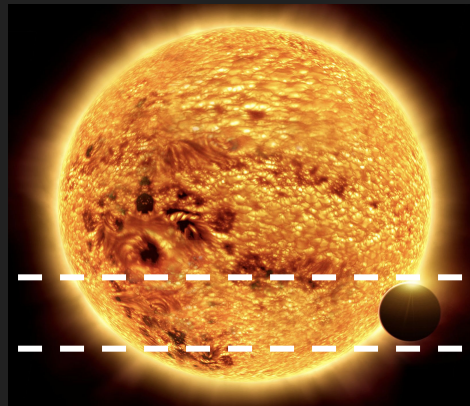


Transit Light Source Effect

We often assume that the light source is homogeneous → not true!

- Dark/cool spots
- Bright/hot faculae
- ...and they evolve in time!

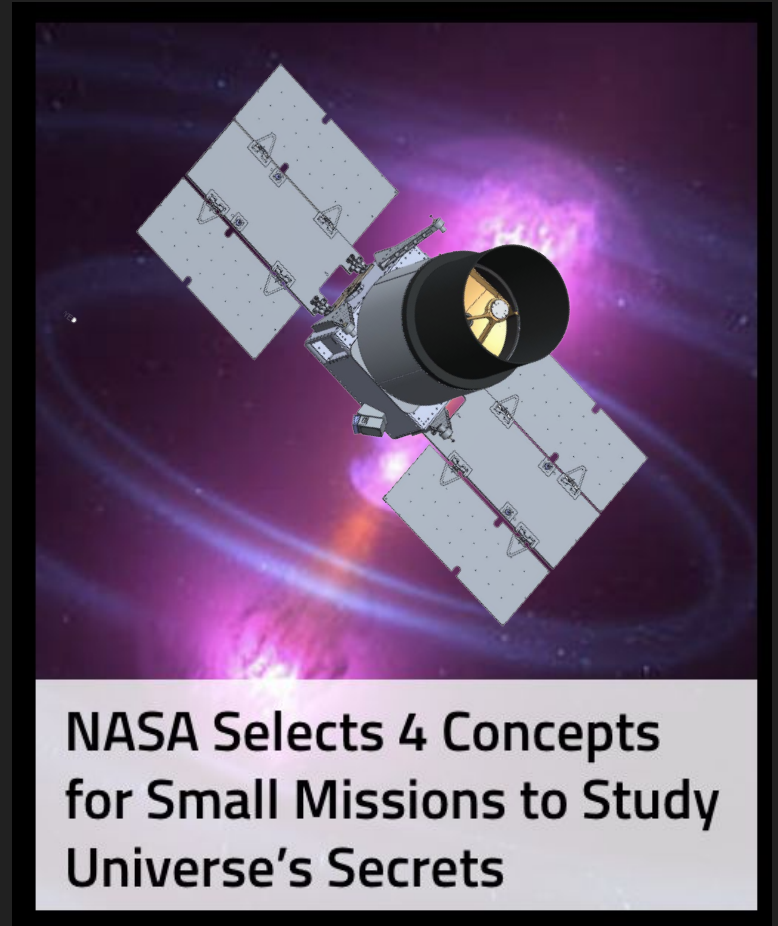
Stellar heterogeneity needs to be well characterized to **avoid false positives**, particularly for late type stars.



What is Pandora?

Pandora is a SmallSat in the NASA Pioneers Program

- Atmospheric transmission spectroscopy for transiting exoplanets
- Simultaneous NIR and visible monitoring
- Launching 2025



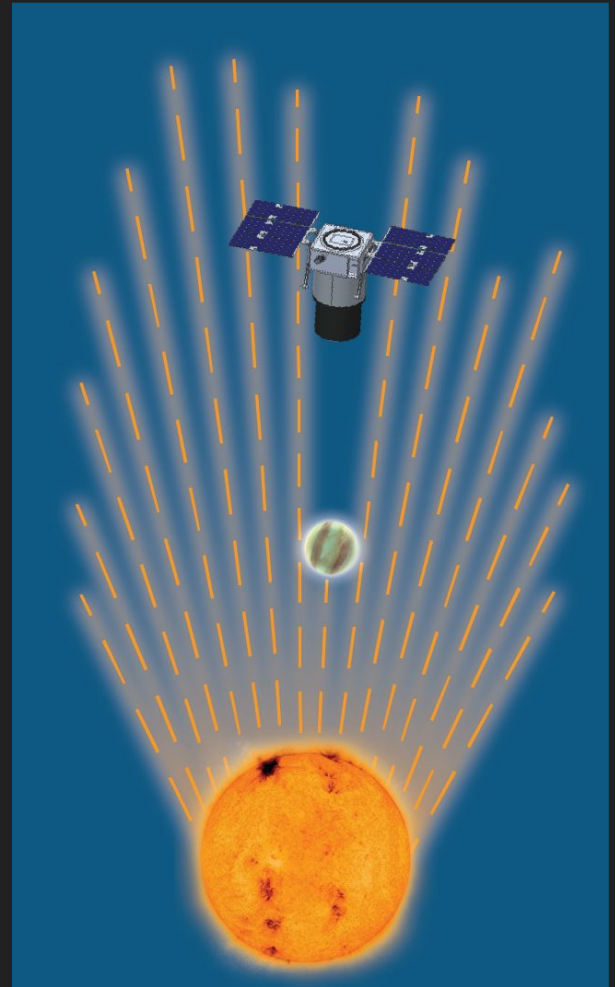
Mission Goal

Objective I:

Determine the **spot and faculae covering fractions** of low-mass exoplanet host stars and their impact on exoplanetary transmission spectra.

Objective II:

Identify exoplanets with **hydrogen- or water-dominated atmospheres**, and determine which planets are covered by clouds and hazes.





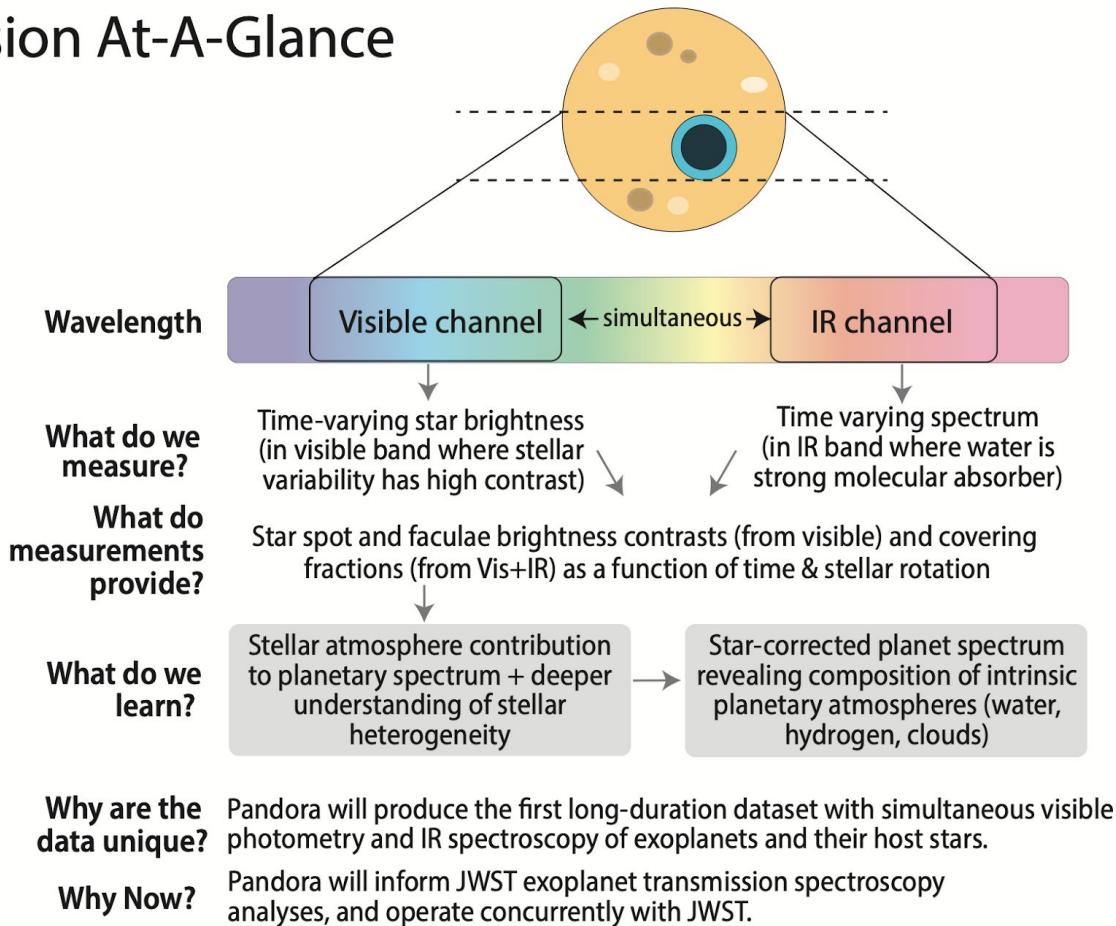
Pandora

Mission At-A-Glance

Pandora provides unique, continuous dual-band data to determine stellar photosphere properties and disentangle star and planetary signals in transmission spectroscopy.

Mission Overview

Launch Date	Mid-2020s
Payload	Telescope (0.45m)
Channels	Visible photometry IR spectroscopy
Orbit	Sun-sync LEO
Science Operations	1+ years

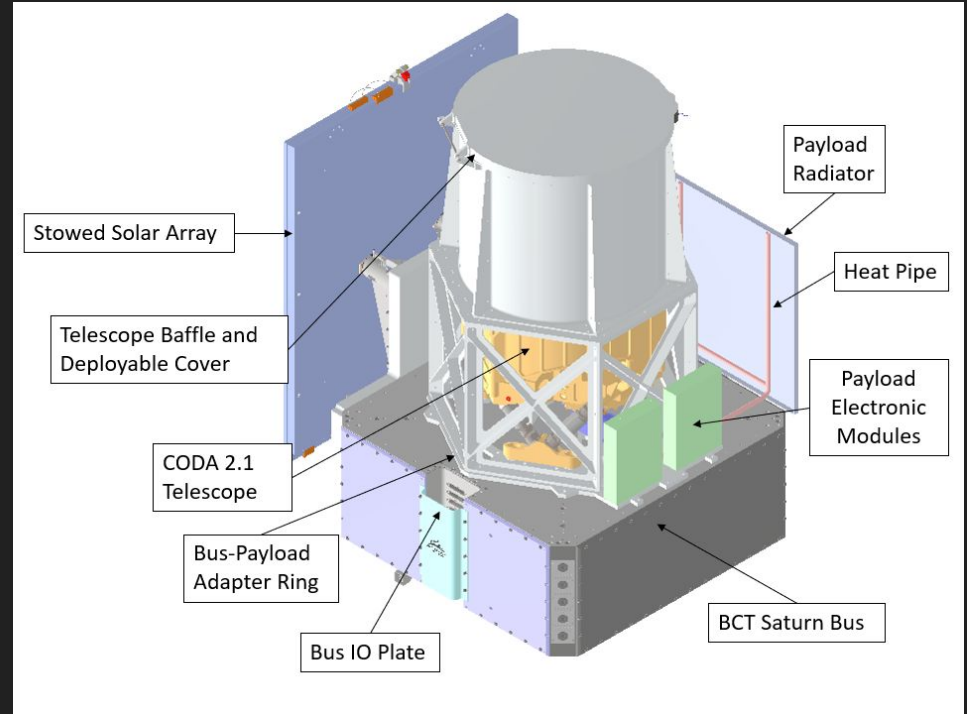


The Spacecraft

Technical development led by Lawrence Livermore National Laboratory (LLNL).

CODA telescope

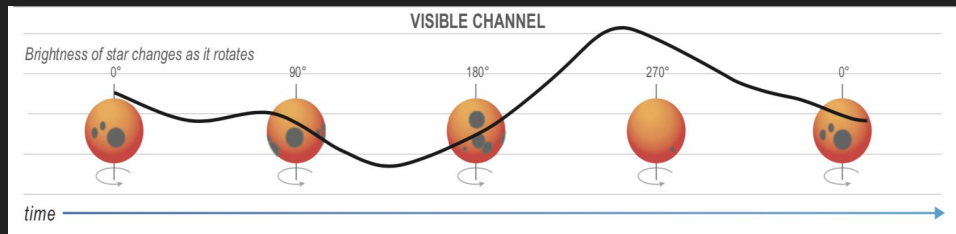
- 45-cm-aperture Cassegrain telescope
- Design for versatile design easy instrument integration
- Enables **low mission cost and fast timeline** – and still do cutting-edge science!



The Instrument

Visible photometry

Region with high spot contrast.



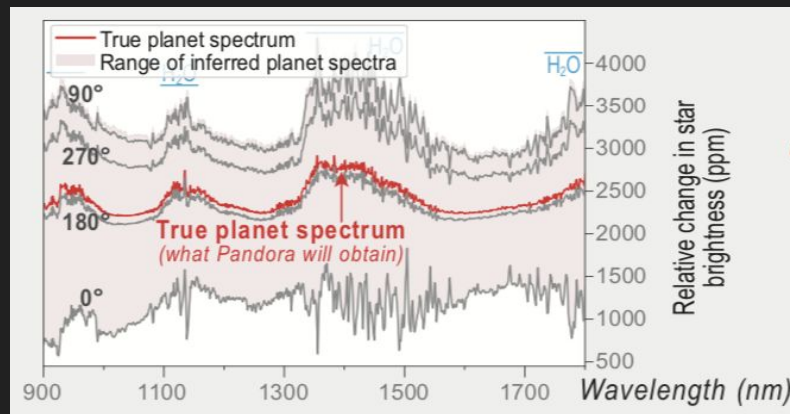
Visible channel

Bandpass:
420–650 nm

Simultaneous IR spectroscopy

Captures variations in spectra over time

- Sensitive to H₂O
- Comparable to HST WFC3



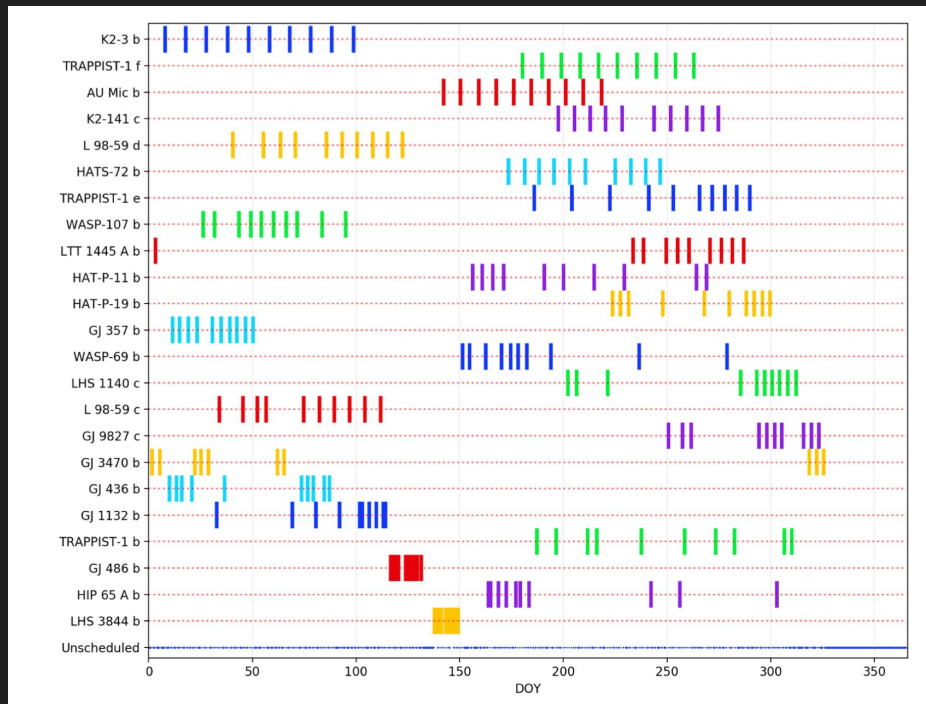
NIR channel

Bandpass:
800–1720 nm

Spectral resolution:
 $R \geq 62$

Target List + Observing Strategy

Example Strategy



Target List

- 20 exoplanet host stars
- Includes planets from Earth-to-Jupiter-size, and K and M dwarfs
- Overlap with JWST GTO and GO lists
- Flexible list to allow for new discoveries

Observing Strategy

- 1 year prime mission
- ~10 transits for each planet
- ~ 24 hour observation for each transit

Mission Scope

Key Dates:

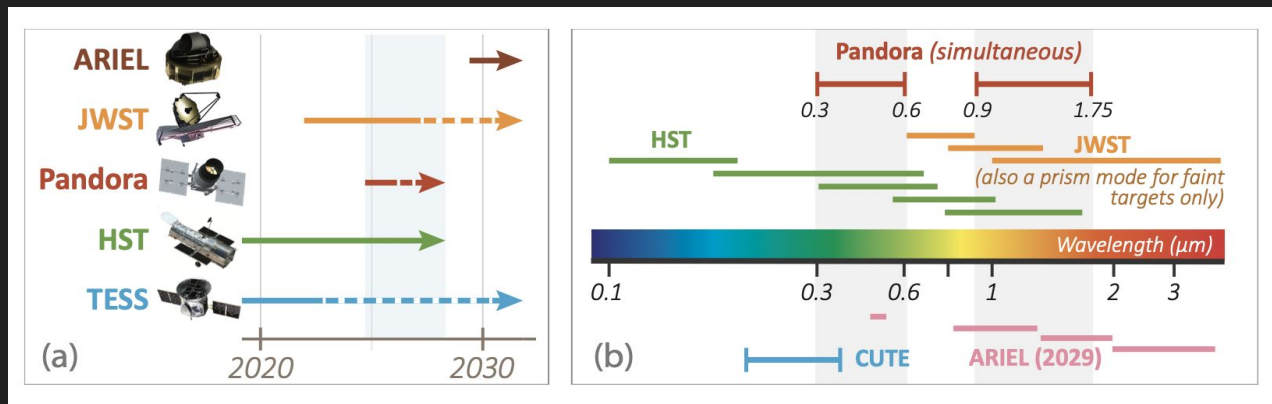
- Commissioning: mid 2024
- Launch: 2025
- Prime mission: 2025-2026



A Companion to JWST

Many JWST targets are around **smaller, cooler stars**

...where disentangling stellar signals is key!

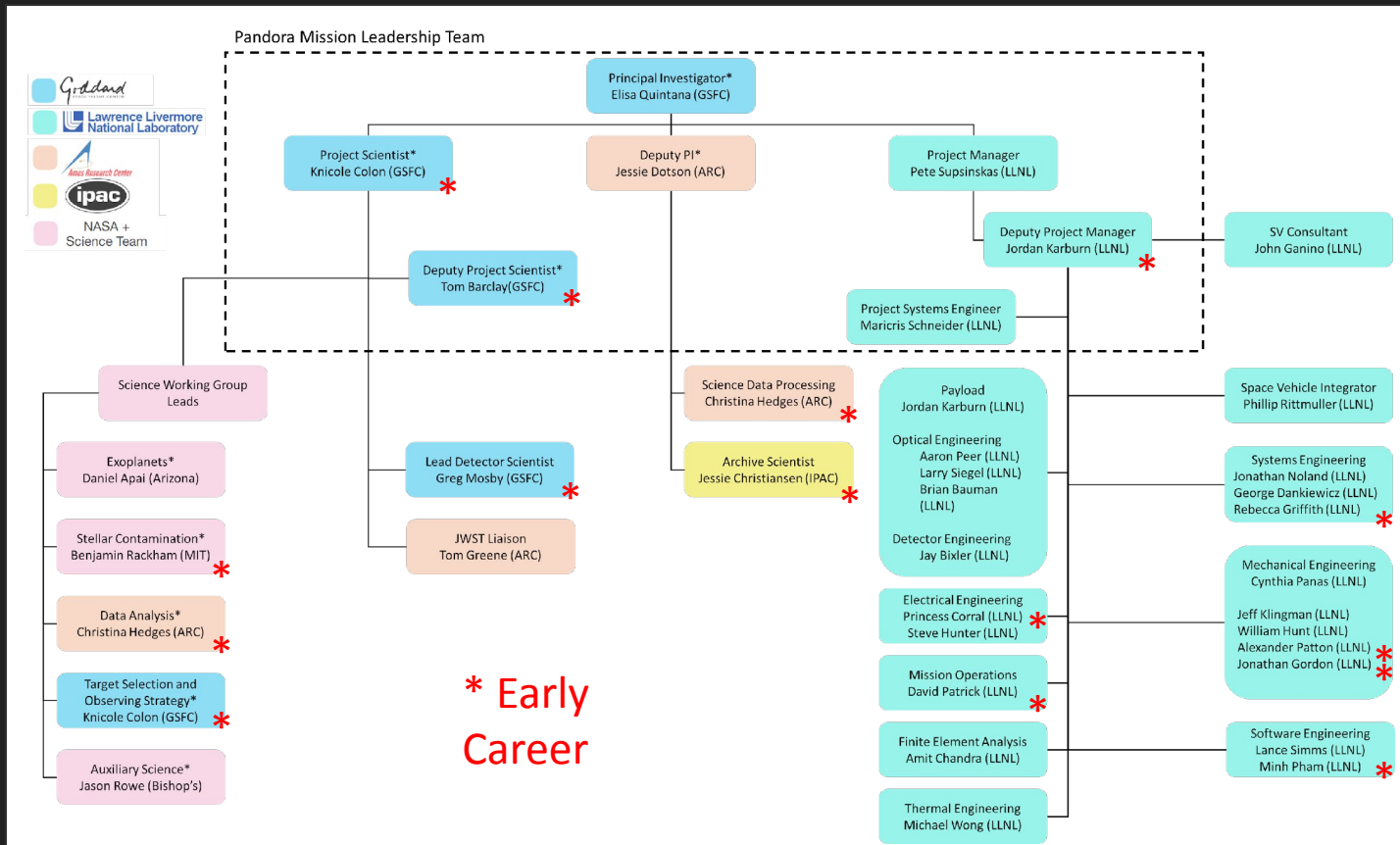


	Long Time Baseline	IR Observations	Visible Observations	Simultaneous IR/Vis	Available in mid-2020s
TESS	✓	✗	✓	✗	?
HST	✗	✓	✓	✗	?
JWST	✗	✓	✗	✗	✓
ARIEL	✗	✓	✓	✓	✗
Ground	✗	~	✓	~	✓
Pandora	✓	✓	✓	✓	✓

The Pandora Team

The Pandora team is **diverse** and prioritizes opportunities and mentorship for **Early Career Researchers (ECRs)**

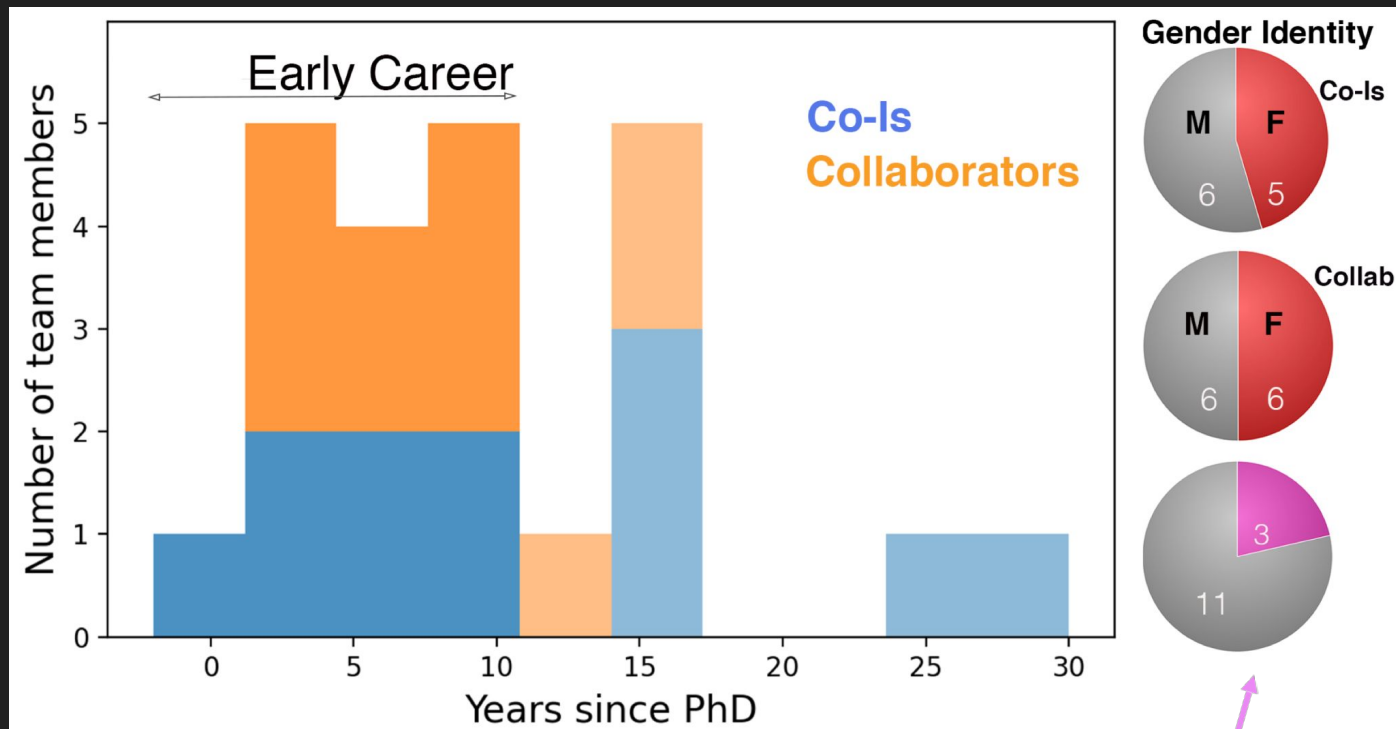
(this is a little out of date!)



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underrepresented minorities in leadership positions (PI, PS, Lead Detector Scientist)

Thank you!

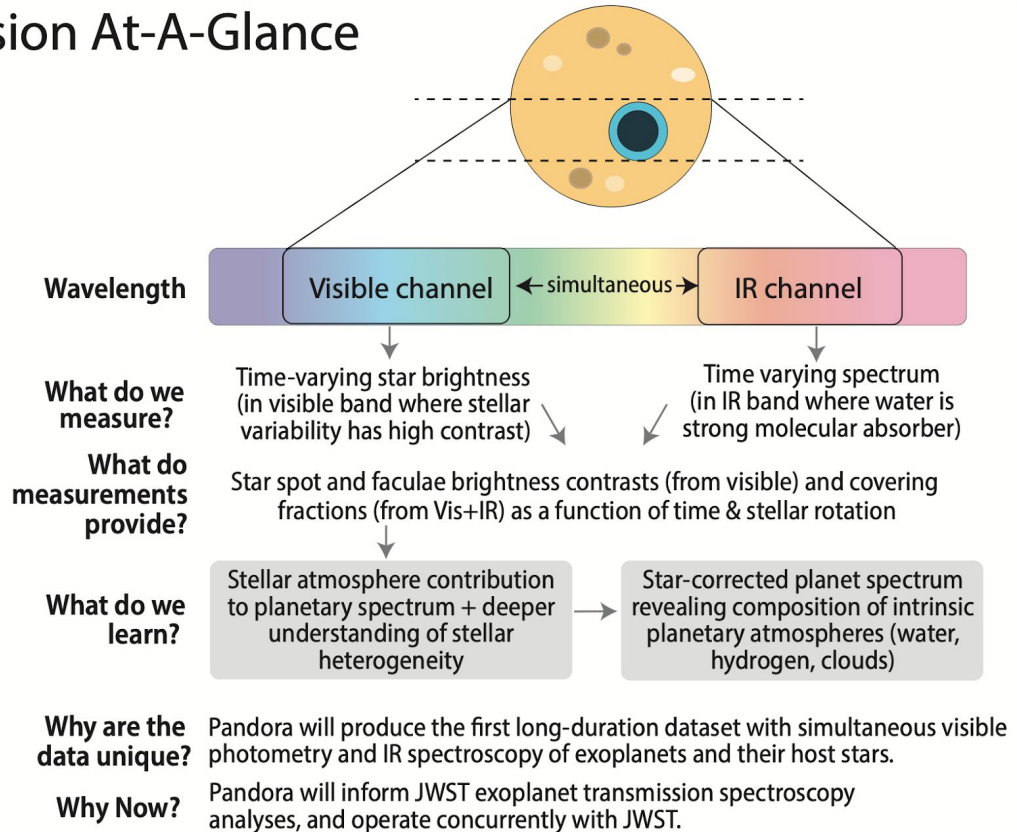


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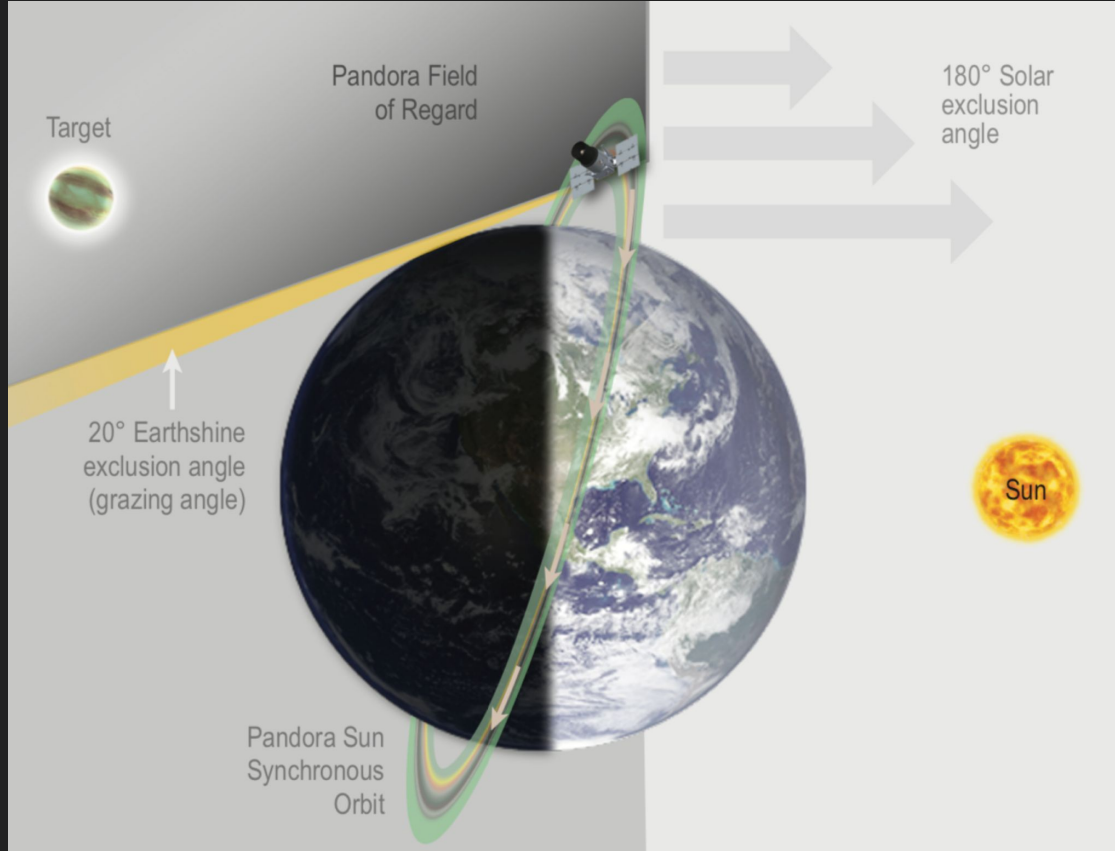
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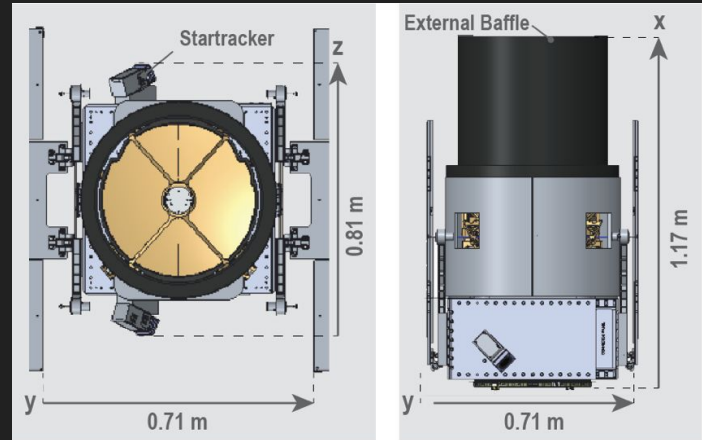


Backup Slides

The Pandora Orbit



Orbit: 450-600km Dusk-Dawn orbit
Bus: BCT Saturn ESPA Grande
Payload: 45cm CODA 2.1 Design
Ground Stations: KSAT Lite
Constraints: Boresight 90deg from Sun & 20deg from Earth limb



ESPA-grande payload

Astrophysics Mission Classes

DECADAL SURVEY		EXPLORER AO		SALMON AO		ROSES			
>\$1B	\$1B	\$450M	\$225M	\$80M	\$40M	\$20M	\$0		
<p>>\$1B</p> <p>LARGE CLASS</p> <p>Great Observatory or Flagship</p>		<p>~450M</p> <p>SMALL CLASS</p> <p>Medium Explorer (MIDEX) PICC \$290M*</p>		<p>\$80M</p> <p>SMALL CLASS</p> <p>Standard Mission of Opportunity **</p>		<p>\$20M</p> <p>SMALL CLASS</p> <p>Pioneers SmallSat **</p>		<p>\$20M</p> <p>SUBORBITAL</p> <p>Pioneers Balloon</p>	
<p>~\$1B</p> <p>MEDIUM CLASS</p> <p>Probe</p>		<p>~225M</p> <p>SMALL CLASS</p> <p>Small Explorer (SMEX) PICC \$145M*</p>		<p>\$40M</p> <p>SMALL CLASS</p> <p>SmallSat Mission of Opportunity **</p>		<p>\$5M</p> <p>SMALL CLASS</p> <p>APRA CubeSat</p>		<p>\$10M</p> <p>SUBORBITAL</p> <p>APRA Balloon</p>	
						<p>\$5M</p> <p>SUBORBITAL</p> <p>APRA Sounding Rocket</p>			

