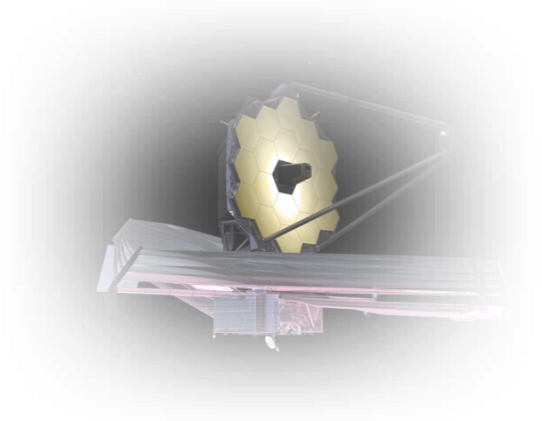
The Transiting Exoplanet Community Early Release Science Program

Nicolas Crouzet

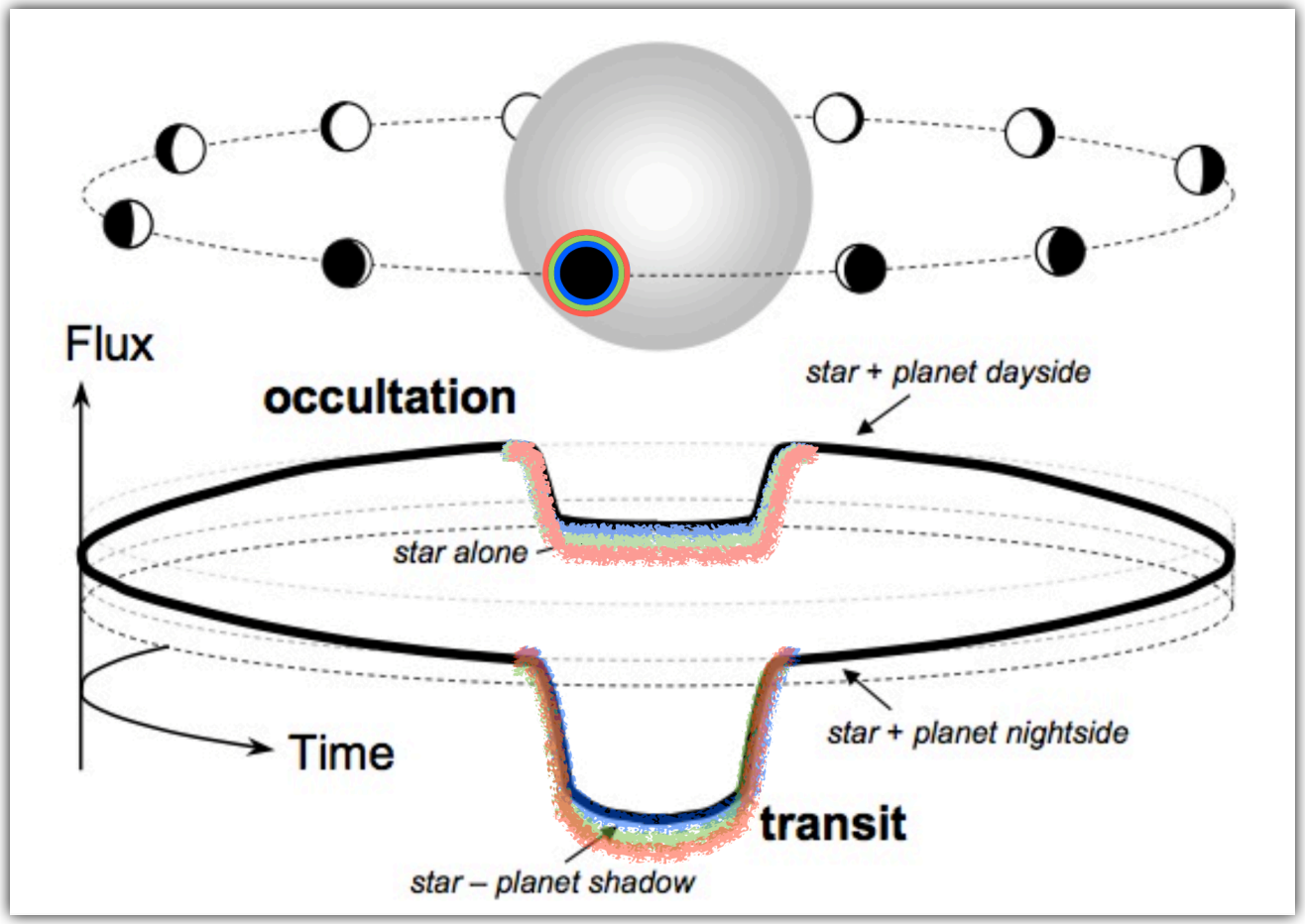
And the Transiting Exoplanet ERS team



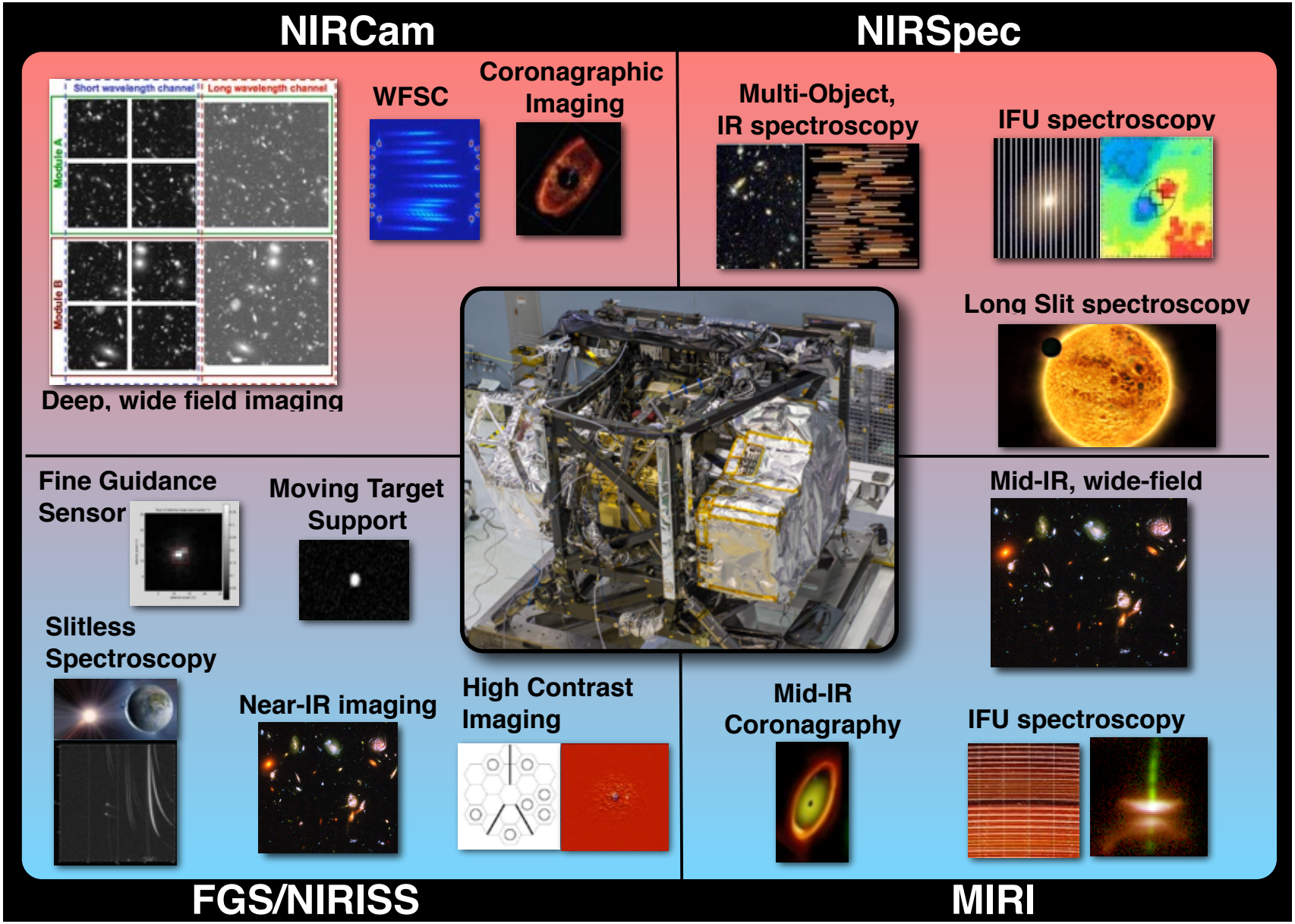
JWST IAC Workshop – 12-13 March 2018

Spectroscopy of transiting exoplanets

Goal: Observe and study their atmospheres

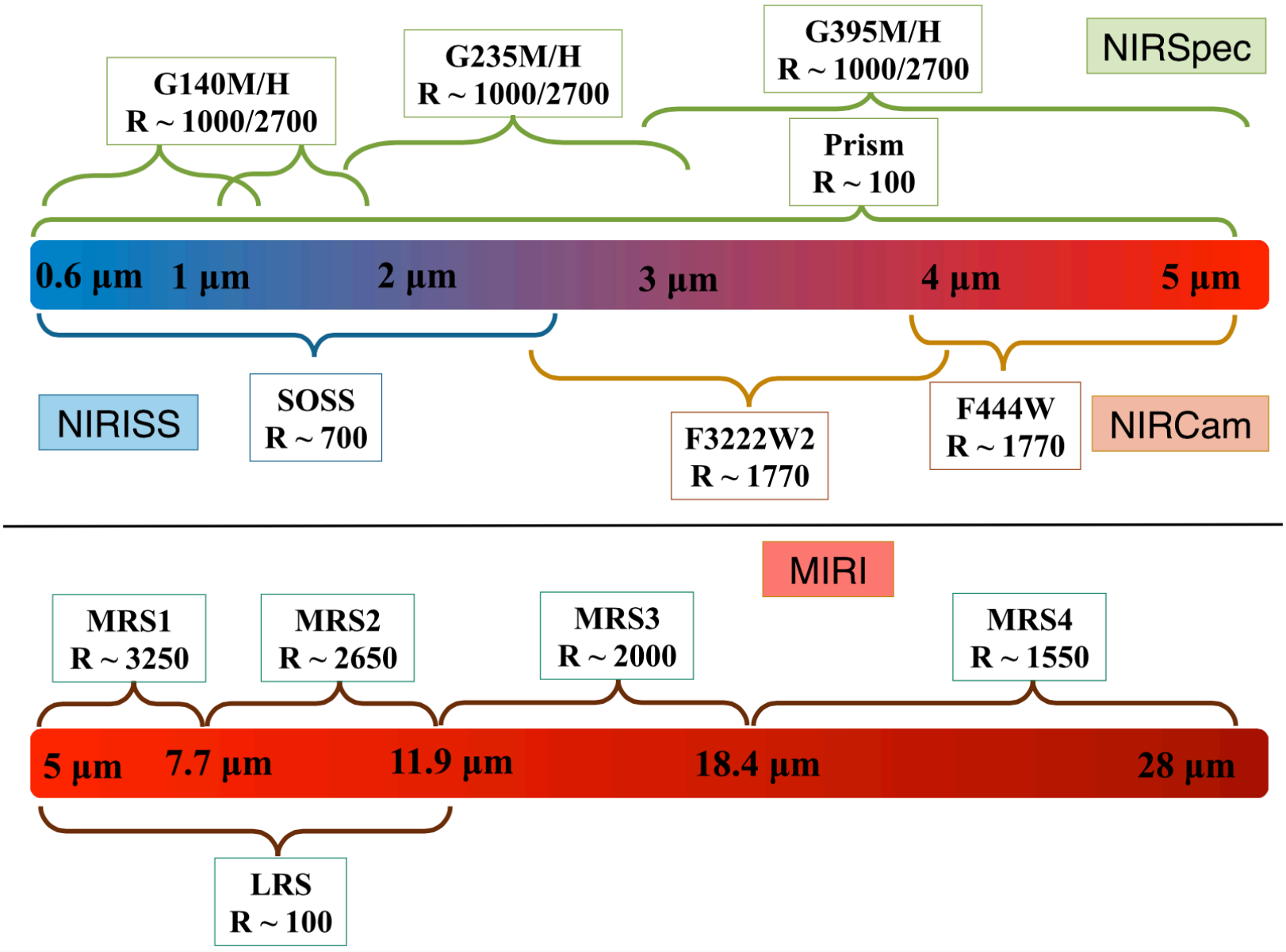


The JWST Instruments



Slide from Mark Clampin (GSFC, JWST Observatory Project Scientist)

Spectroscopic modes for transiting exoplanets



The Transiting Exoplanet ERS program

Overview:

- Spectroscopy of **transiting exoplanet atmospheres**
- A **community program**: ~100 people
- PI: Natalie Batalha, co-PIs: Jacob Bean & Kevin Stevenson,
  Science council: led by David Sing
- First round of ideas: *Stevenson et al. 2016, PASP 128, 4401*
  Program summary: *paper in prep.*
- Divided into **four sub-programs**, all in one proposal
- **78 hours** allocated

The Team

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de Wit Julien
Dragomir Diana
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Espinoza Nestor
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Heng Kevin
Henning Thomas K.
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Lahuis Fred
Leconte Jeremy
Lendl Monika
Lillo-Box Jorge
Line Michael R.
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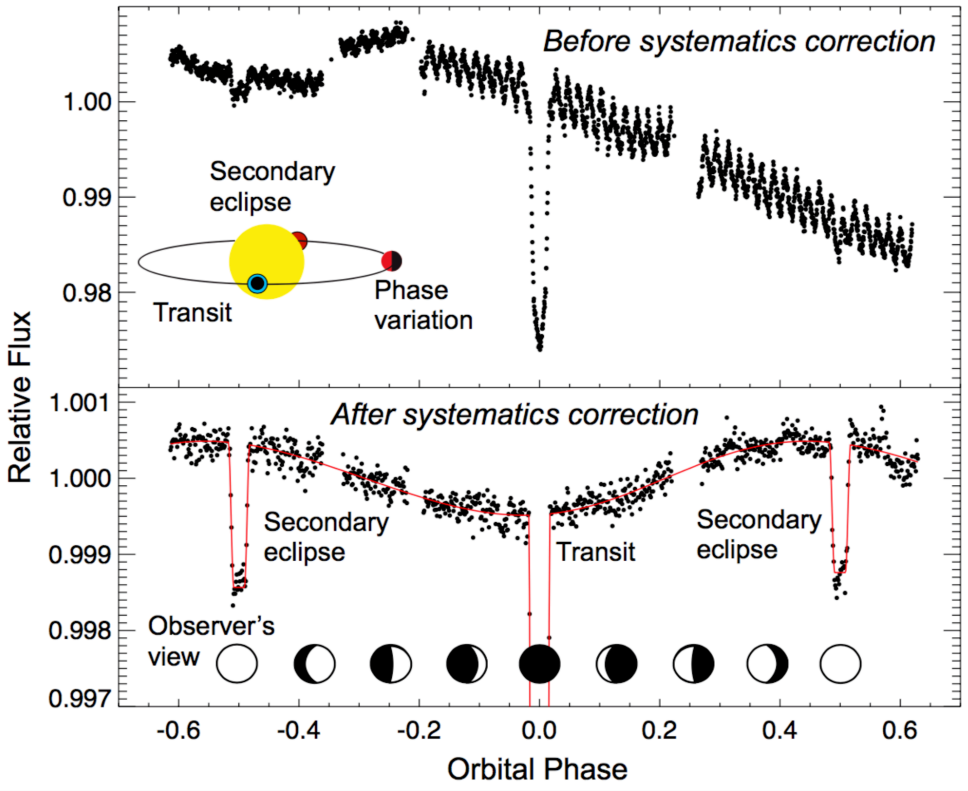
Southworth John
Spake Jessica J.
Stevenson Kevin B.
Swain Mark R.
Teske Johanna C.
Todorov Kamen O.
Tremblin Pascal
Tsiaras Angelos
Tucker Gregory S.
Venot Olivia
Waalkes William C.
Wakeford Hannah R.
Waldmann Ingo P.
Weaver Ian
Wheatley Peter J.
Zellem Robert T.

Context

Spitzer/IRAC 4.5 µm phase curve for the hot Jupiter HD 189733b *(Knutson et al. 2012)*



Evaluating and correcting for systematic effects is essential

Our program will test transits, eclipses, and phase curves

Program 1: “Panchromatic Transmission”

- Chairs: Hannah Wakeford, David Sing, Kevin Stevenson (42 members)

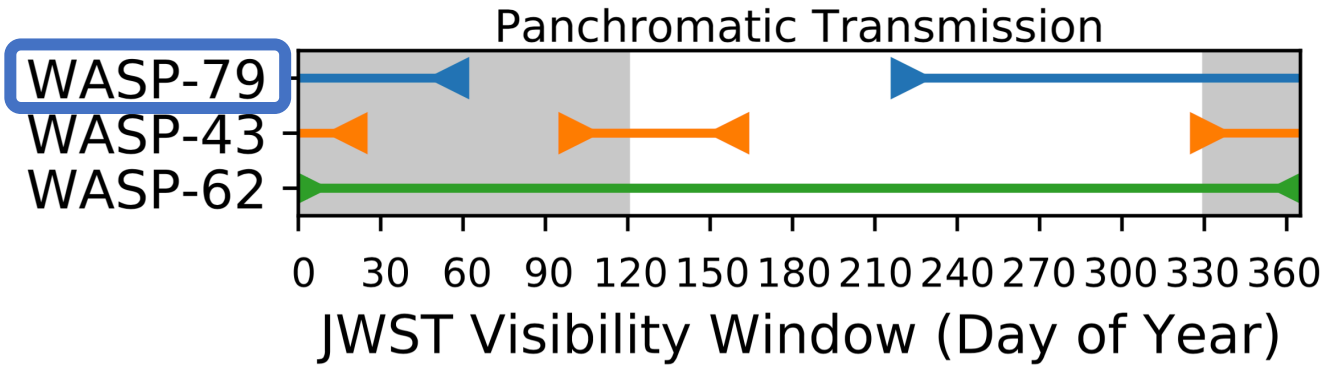
- Goals: - **Compare and validate the observing modes** available for transmission spectroscopy in the 1 – 5 μm range

  - Extract a hot Jupiter transmission spectrum from 1 to 5 μm, measure its **atmospheric composition**, **metallicity**, **C/O ratio**

- Observations: Four transits of one hot Jupiter using different modes

Program 1: “Panchromatic Transmission”

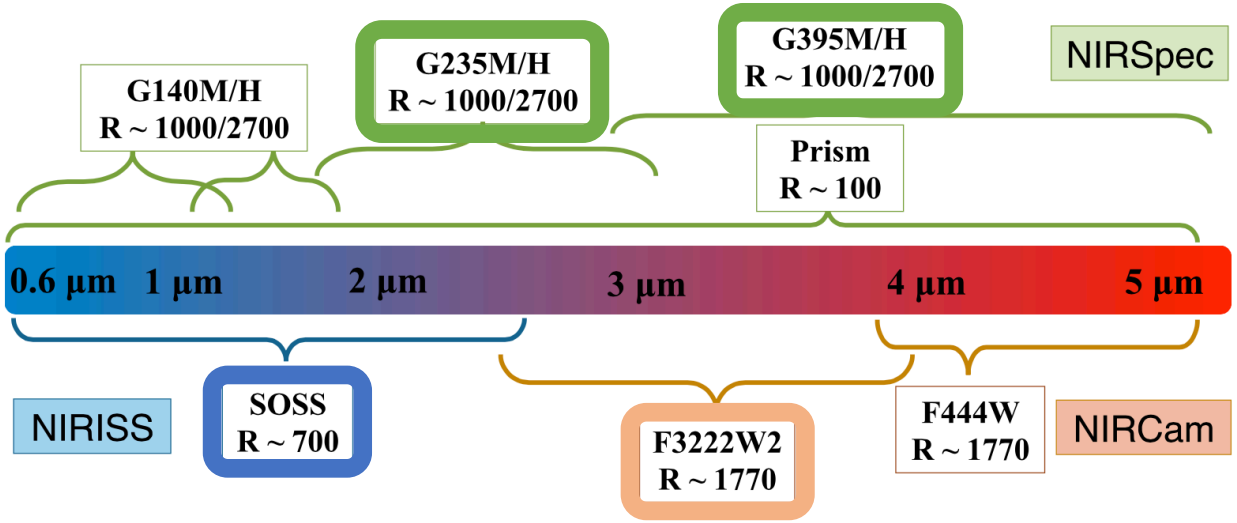
Which target?



➡ WASP-79b: - A highly bloated hot Jupiter (0.9 M_{Jup}, 1.7 R_{Jup})
- Water vapor absorption detected with HST WFC3

Program 1: “Panchromatic Transmission”

Which modes?

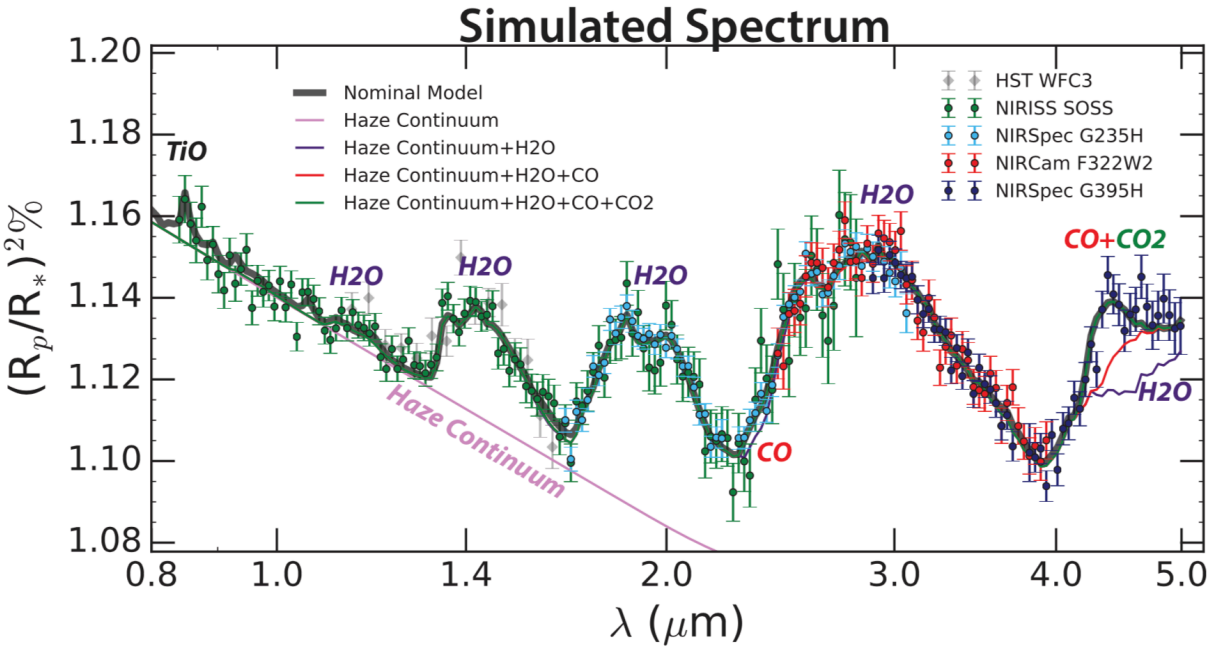


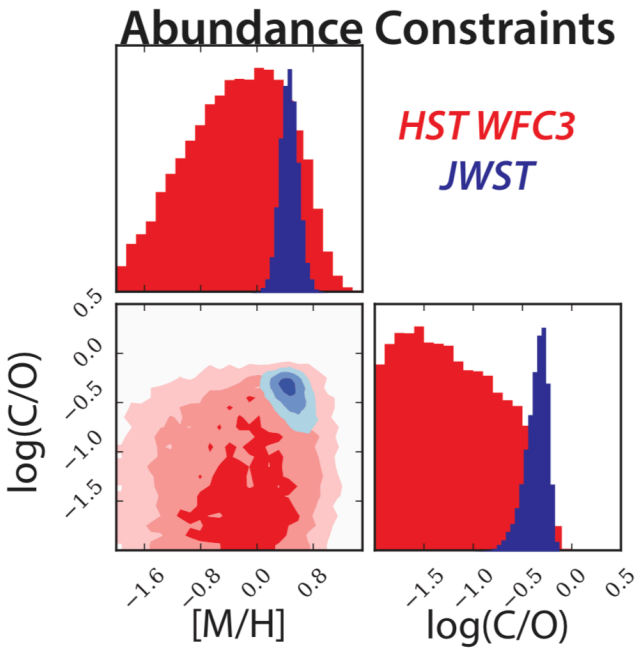
➡ NIRISS/SOSS + NIRSpec/G235H + NIRCam/F322W2 + NIRSpec/G395H

Program 1: “Panchromatic Transmission”

Expected results

- Pandexo simulator *(Batalha et al. 2017)*
- Model transmission spectrum from the CHIMERA code *(Line et al. 2014; Line & Parmentier 2016; Batalha & Line 2017)*
- Based on HST WFC3 measurements *(K. Showalter et al. in prep)*





Program 2: “MIRI Phase Curve”

- Chairs: Laura Kreidberg, Nicolas Crouzet, Julianne Moses (48 members)

- Goals: - Test the **stability of JWST and MIRI/LRS** over **day-long timescales**

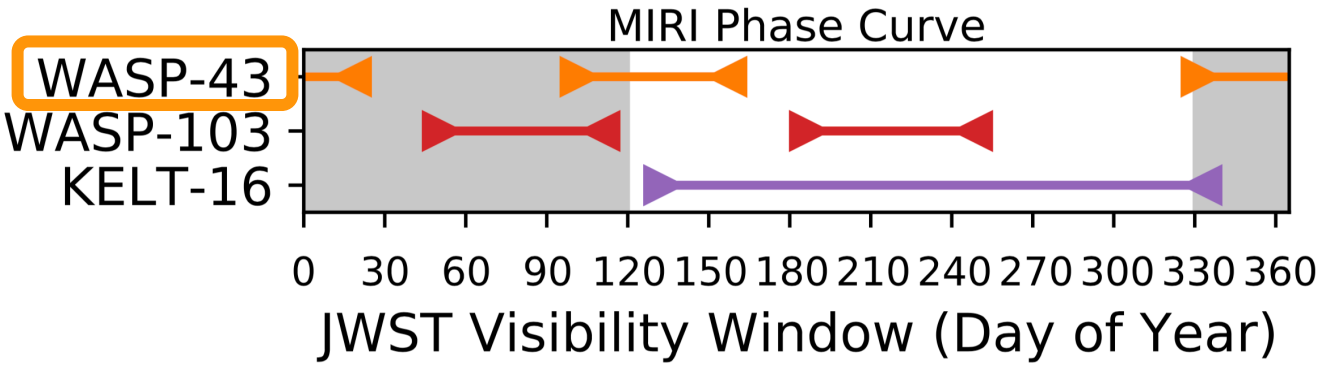
  - Extract **spectroscopic phase curves** of a hot Jupiter in the 5 – 12 μm range

  - Determine its 3-D **atmospheric composition, temperature structure**, **heat transport**, **chemistry**, **cloud properties**

- Observations: **Full-orbit phase curve** (including 2 eclipses and 1 transit) of a short period hot Jupiter with **MIRI/LRS**

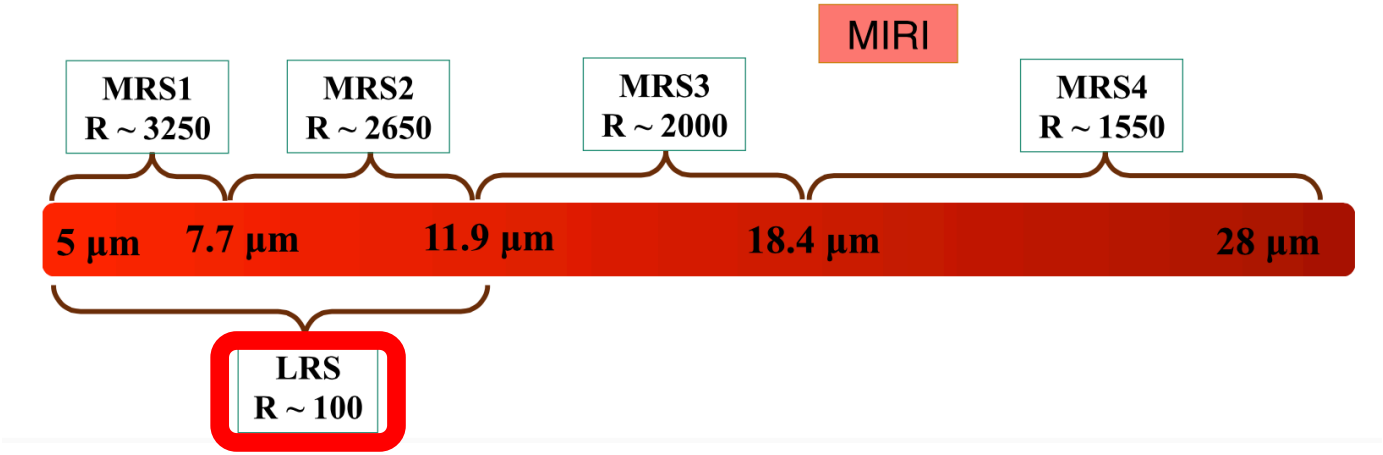
Program 2: “MIRI Phase Curve”

Which target?



➡ WASP-43b: - A highly irradiated hot Jupiter ($T_{eq} \sim 2100$ K, $\delta_e \sim 0.5$ %)
- Spectroscopic phase curves obtained with HST WFC3
(Stevenson et al. 2014)

Program 2: “MIRI Phase Curve”



MIRI:

- *Only instrument at $\lambda > 5$ µm*
- *Si:As detectors, different systematics*

LRS:

- *Only MIRI mode available for time-series observations*

Program 2: “MIRI Phase Curve”

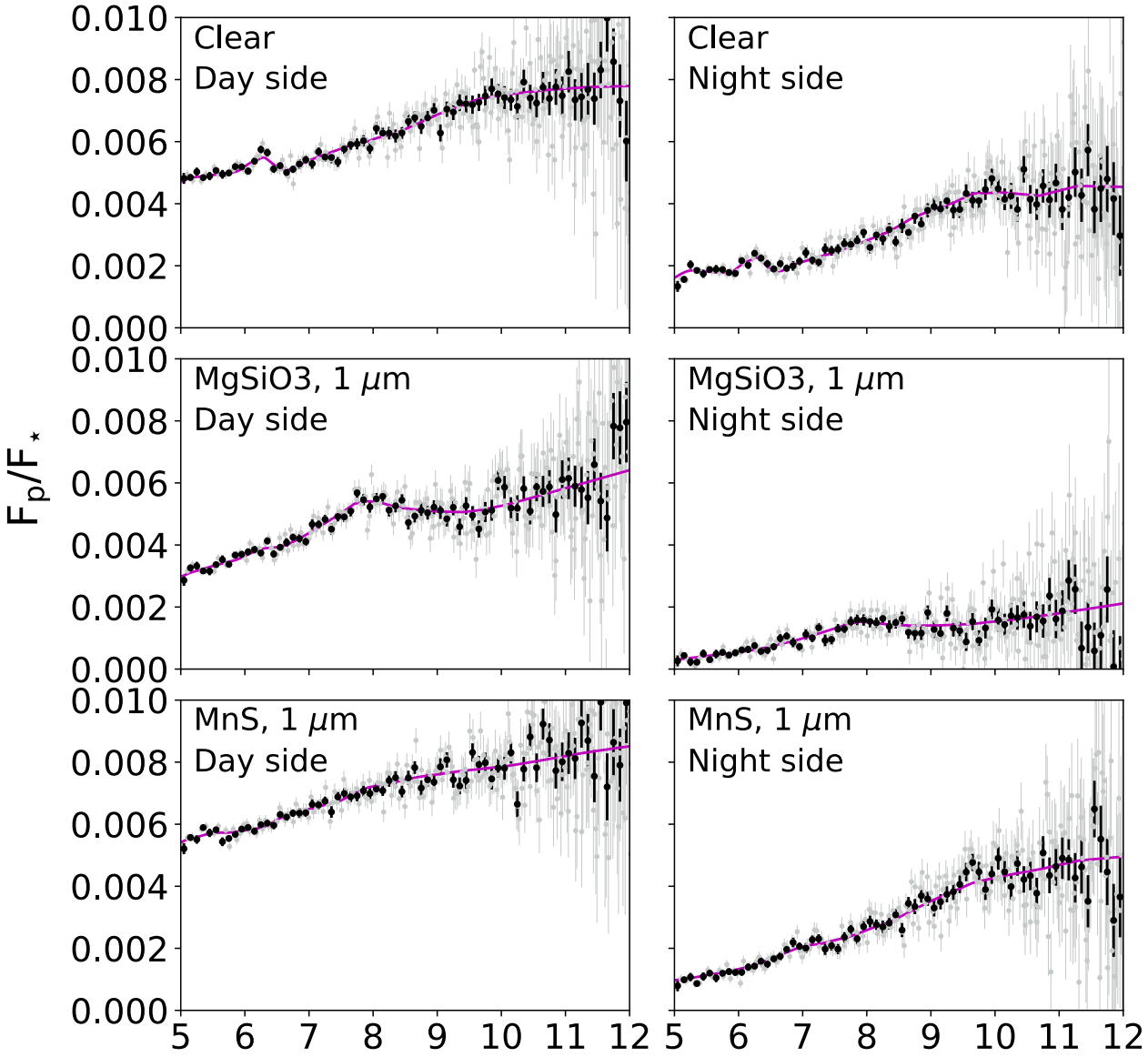
Simulations

System: WASP-43

GCM models
(Vivien Parmentier)

Clear or cloudy atmospheres
(Al_2O_3, $CaTiO_3$, Cr, Fe, $MgSiO_3$, MnS)

Pandexo simulations, MIRI LRS



(Olivia Venot et al. in prep.)

Program 2: “MIRI Phase Curve”

Simulations

System: WASP-43

GCM models
(Vivien Parmentier)

Clear or cloudy atmospheres
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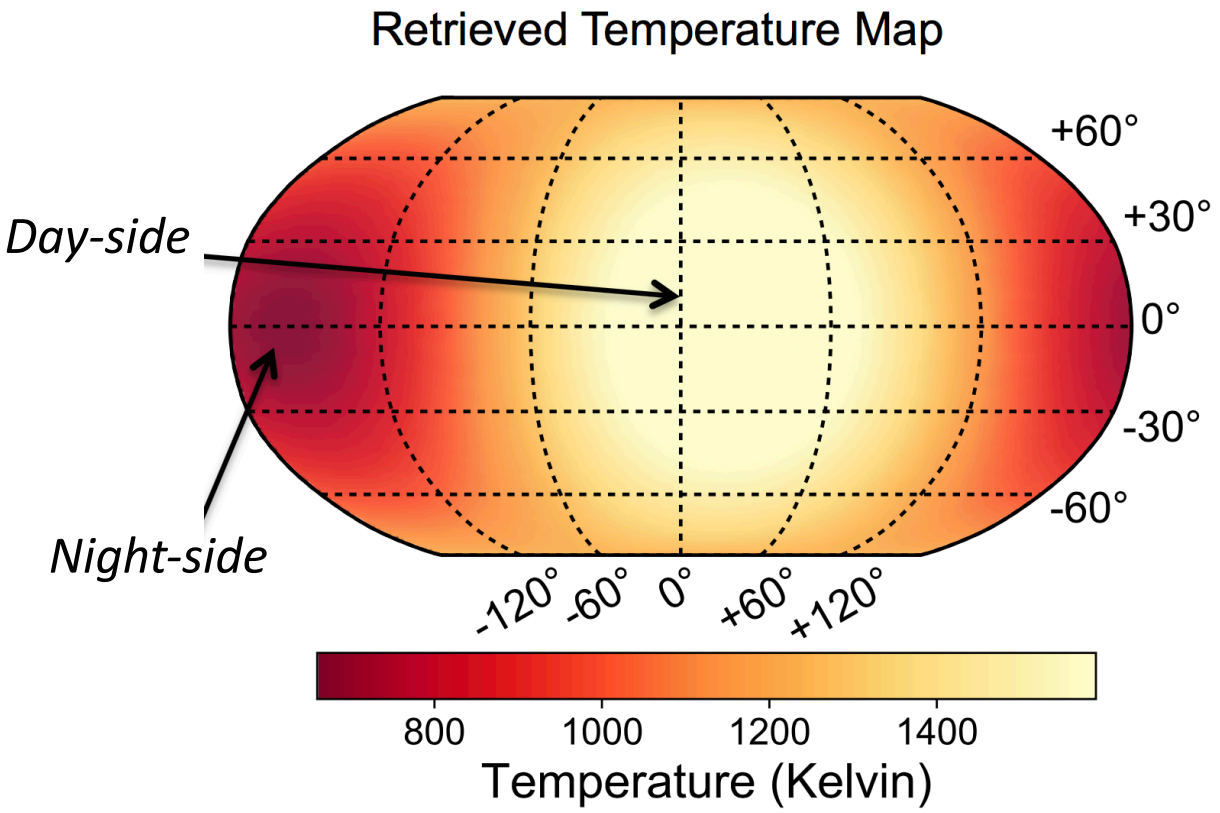


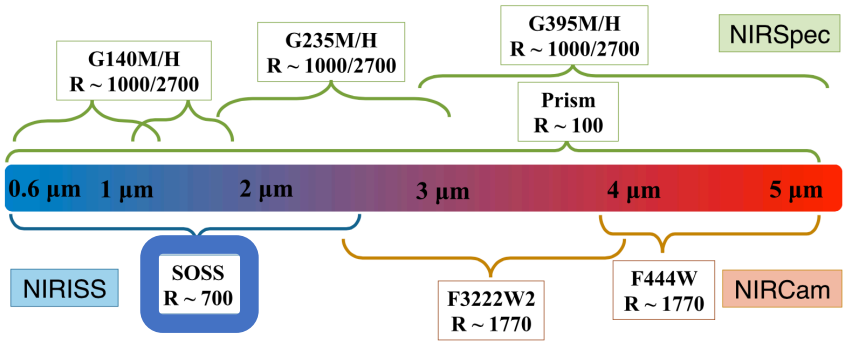
Program 3: “Bright star secondary eclipse”

- Chairs: Björn Benneke, Jacob Bean, Eliza Kempton (14 members)

- Goals:
  - Test JWST’s behavior at the **limit** of its achievable precision
  - Prepare for follow-up of **TESS** exoplanets
  - Obtain the **emission spectrum** of a highly-irradiated hot Jupiter in the NIR, measure its **energy budget** and **thermal structure**

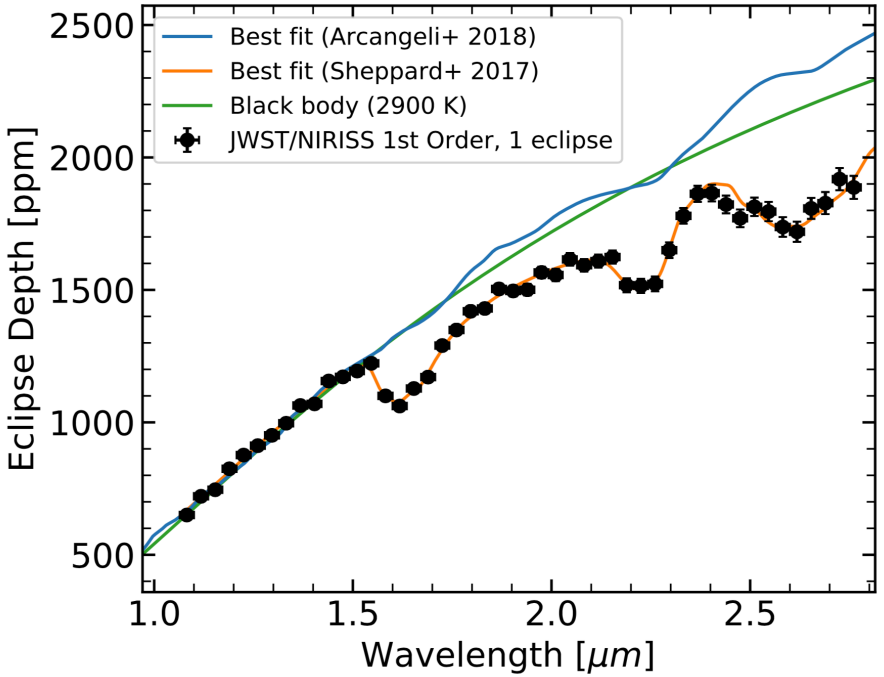
- Observations: **One secondary eclipse** of a hot Jupiter orbiting a bright star with **NIRISS/SOSS**

Program 3: “Bright star secondary eclipse”



A single eclipse of the hot Jupiter WASP-18b with NIRISS SOSS

(Single Object Slitless Spectroscopy, 0.85 – 2.8 µm)

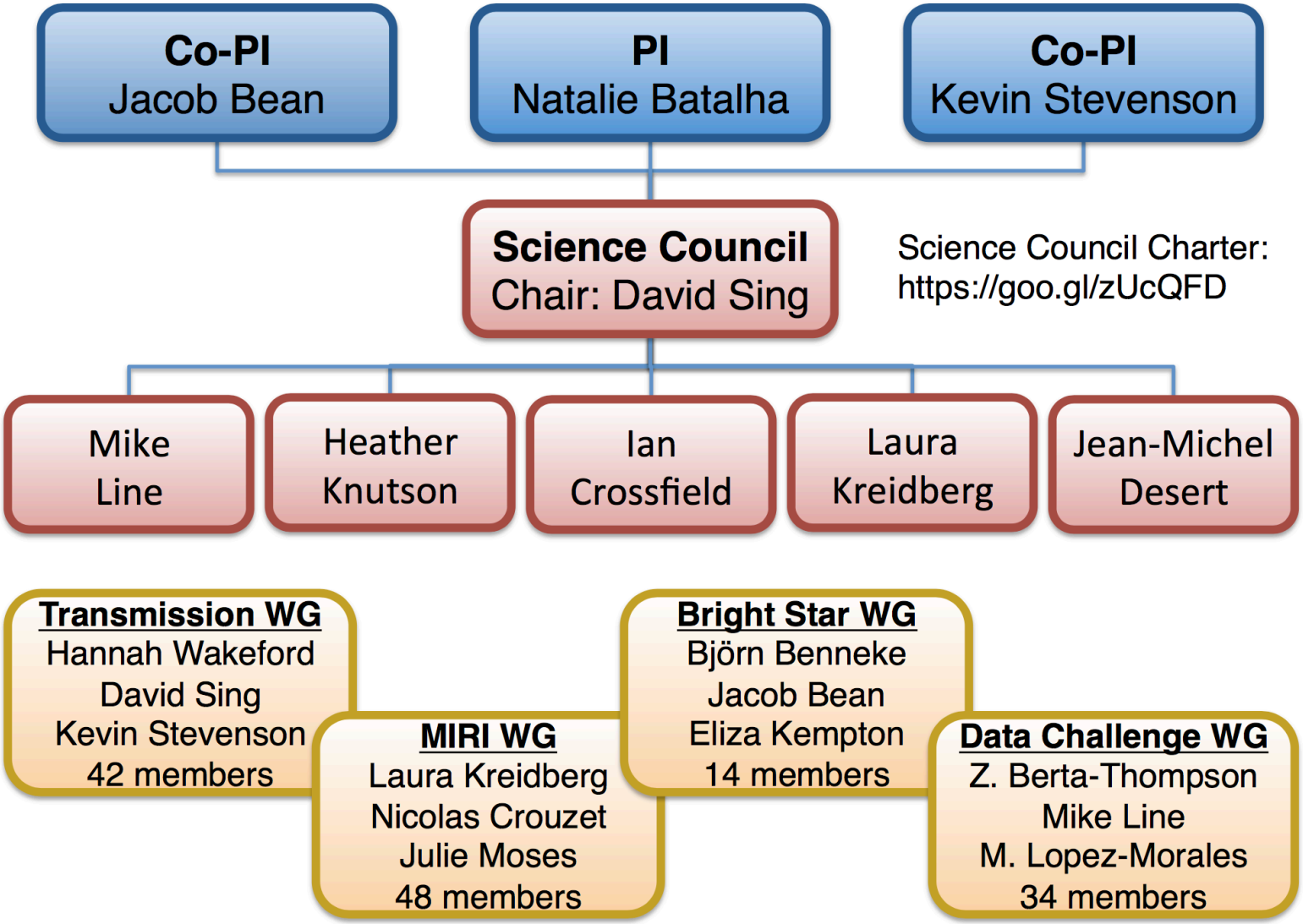


Program 4: “Data challenge”

Chairs: Zach Berta-Thomson, Mike Line, Mercedes Lopez-Morales
(34 members)

- **Prepare tools** to enable quick and accurate analysis and interpretation of the data, make them available to the community.
- Assess the achieved precision, **identify the major systematic noise** sources, their quantitative impact, and potential avenues for mitigating them.
- Internally **validate the scientific conclusions** drawn from JWST data through comparison of results by different team members, and **determine best practices** and required ingredients for JWST analyses.
- **Inform** the planning and selection of future JWST exoplanet programs.
- Deliverables: Data Analysis Toolkits, Instrumental Performance Reports, Field guides

Management Team



Allocated time

Full program: **78.1 hours** allocated

- Panchromatic Transmission: 39.6 hours
- MIRI Phase Curve: 29.4 hours
- Bright star secondary eclipse: 9.1 hours

Requested: 78.1 hours

Science time: 52.1 hours

JWST Exoplanet Tools

PandExo

Search docs

Getting Started
Pre-installation Data Download
Installation for Users With Conda
Installation for Users With PIP
Troubleshooting-Common Errors
The Importance of Upgrading PandExo
JWST Tutorial
Possible Instrument Input Params
Py Dict Structure of JWST Output
HST Tutorial
The Code

Docs » PandExo: An Exoplanet ETC View page source

PandExo: An Exoplanet ETC

Tools to help the community with planning exoplanet observations.

Note

The online PandExo module has moved to STScI's ExoCTK.

PandExo is both an online tool and a python package for generating instrument simulations of JWST's NIRSpec, NIRCam, NIRISS and NIRCam and HST WFC3

Contents:

ExoCTK | Observation Planning | Forward Modeling | Limb Darkening Calculator | PandExo

PandExo: The Exoplanet ETC

Tools to help the community with planning exoplanet observations.

Exoplanet Characterization Toolkit

ExoCTK

On-line version

James Webb Space Telescope

New Calculation | Dashboard

Hubble Space Telescope

New Calculation | Dashboard

JWST Exoplanet Tools

Pandexo:

https://natashabatalha.github.io/PandExo/index.html
https://github.com/natashabatalha/PandExo
https://exoctk.stsci.edu/pandexo/

+ APT (Astronomer's Proposal Tool)

+ ETC (Exposure Time Calculator)

+ Visibility Tool, ESA Sky, JWST User Documentation

Conclusion

- JWST **ERS program**: engage the community to use and evaluate JWST
- JWST will offer **unique capabilities** for transiting exoplanet spectroscopy
- The transiting exoplanet community developed a **collaborative proposal**
- **Four sub-programs**:
  "Panchromatic Transmission", "MIRI Phase Curve",
  "Bright star secondary eclipse", "Data challenge"
- Proposal accepted, **78.1 hours allocated**
- Data and tools will be **available to the community**
- Everyone is welcome to contribute!!