Observation of a transiting exoplanet with NIRISS, NIRSpec, and MIRI

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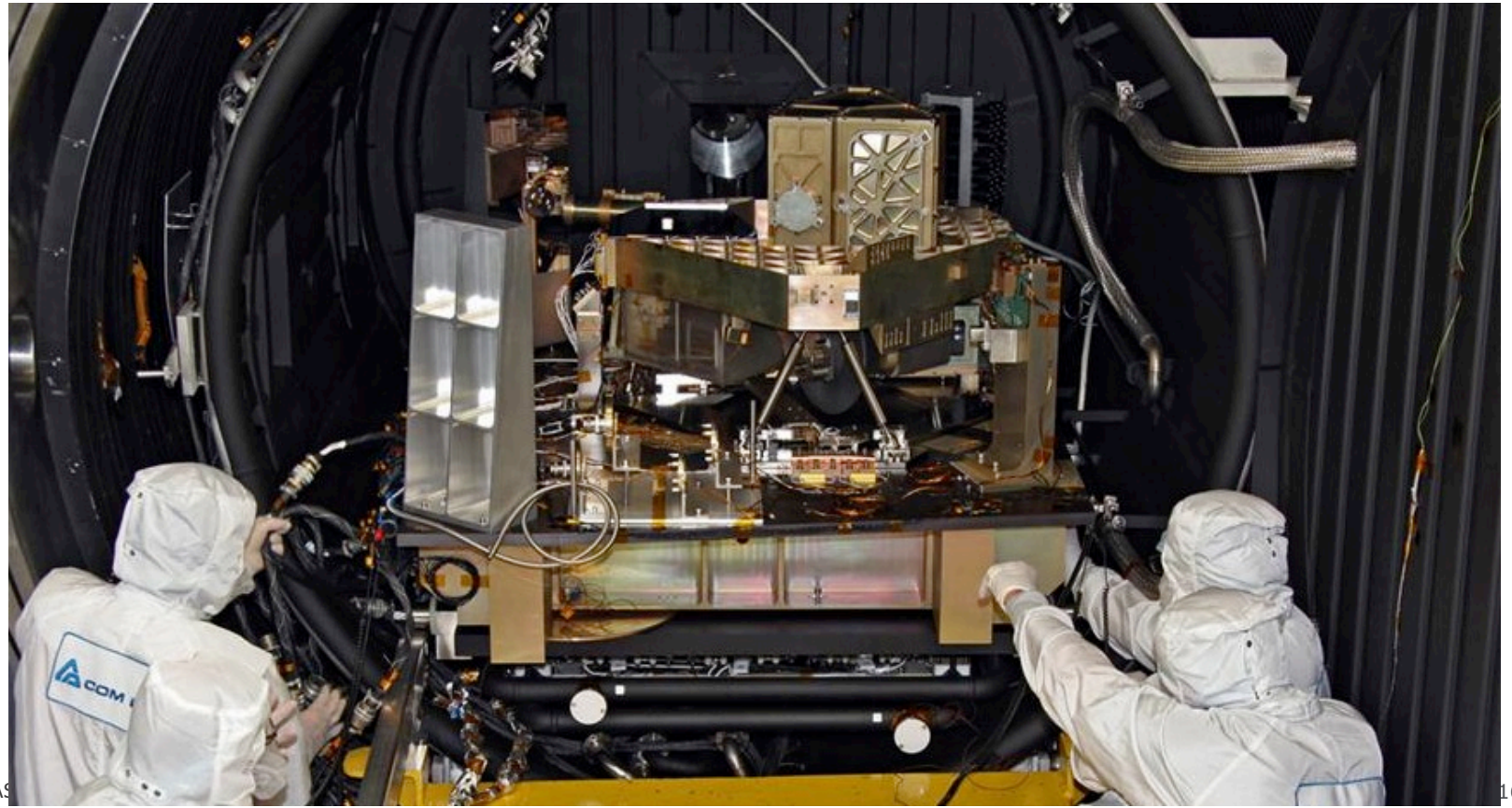
Jayesh Goyal, David Sing

EWASS Prague 2016

NIRISS: Single Object Slitless Spectroscopy (SOSS)



NIRISS: Single Object Slitless Spectroscopy (SOSS)

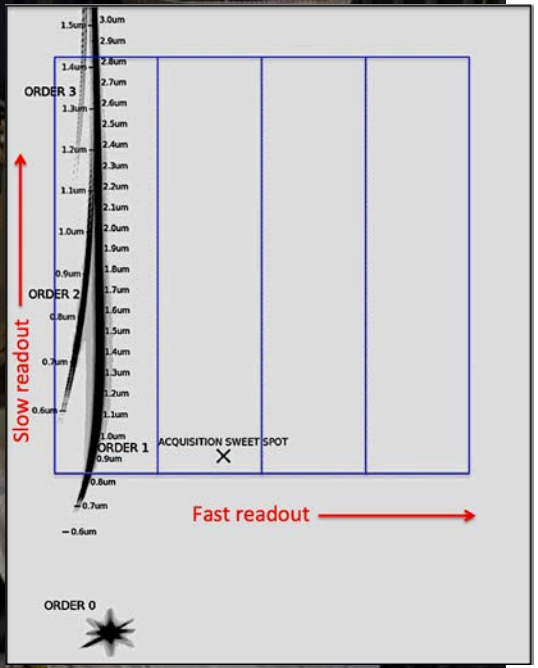
SOSS ➔medium resolution (R ≈ 700) spectroscopy: GR700XD 3 orders of cross-dispersed spectra for a single bright target

- R ≈ 700 at 1.25 μm in 1st order,
- R ≈ 700 at 0.63 μm in 2nd order

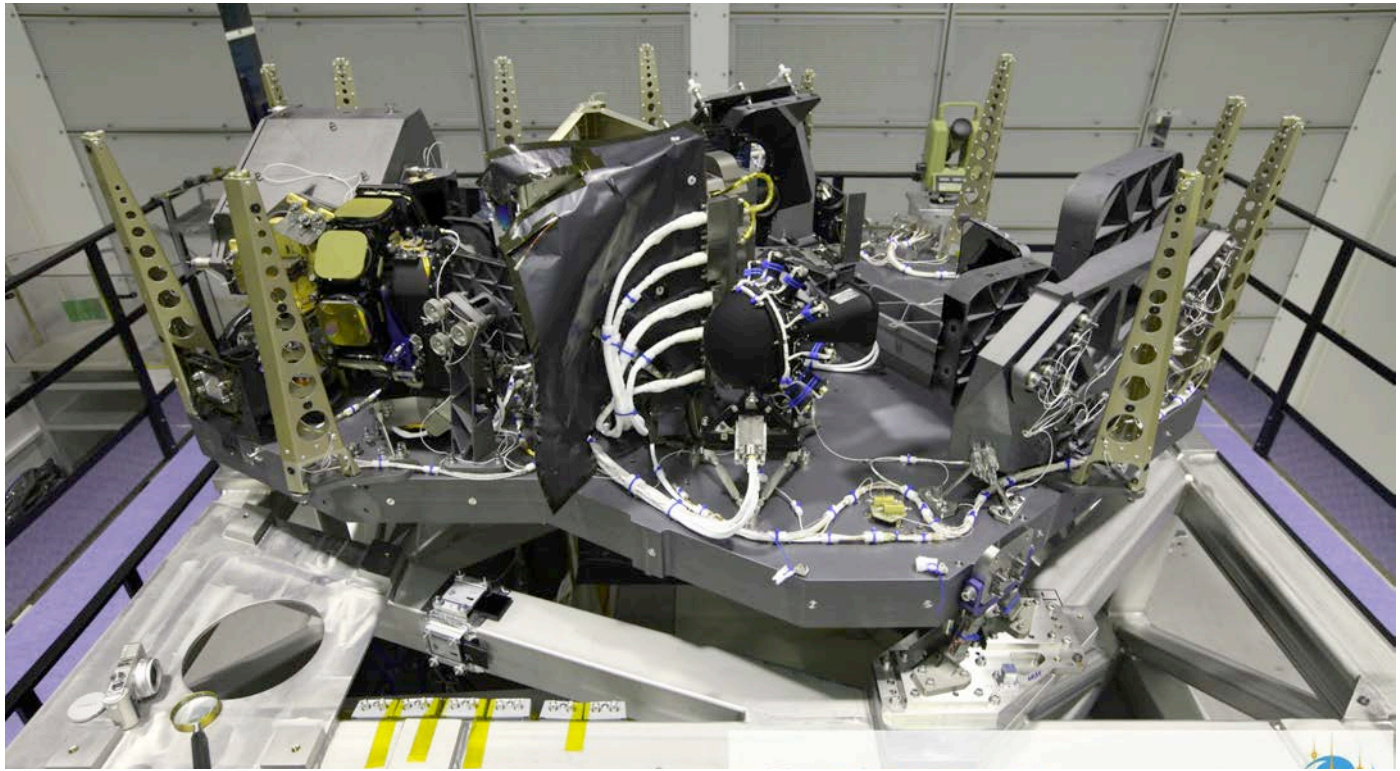
GR700XD optical element incorporate a cylindrical lens

- Mitigates flat-field errors and pointing jitter
- Brighter sources can be observed

Wavelngth range 0.6-2.8 micron



NIRSpec: Bright object time-series (BOTS) spectroscopy with the wide aperture



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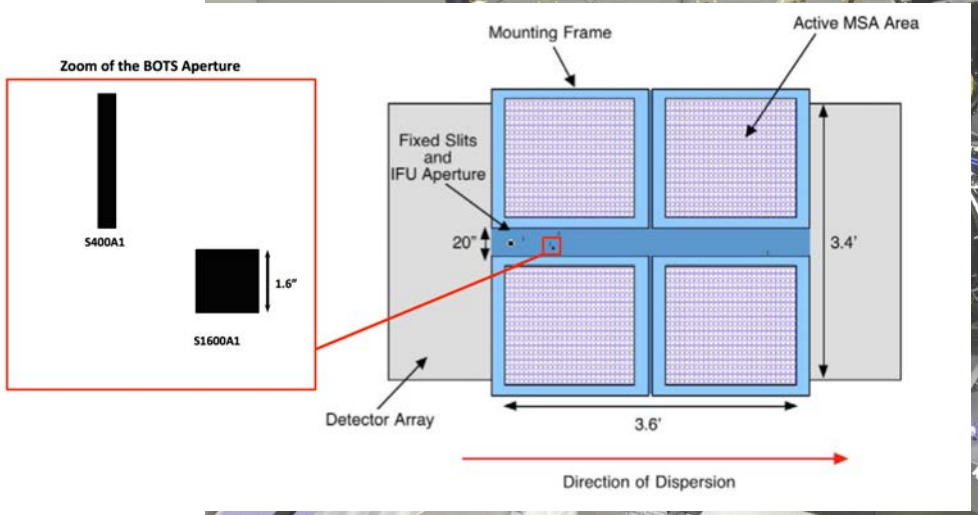

Disperser/filter combination	Nominal resolving power	Wavelength range (μm)
G140M/F070LP	~1000	0.7–1.27
G140M/F100LP		0.97–1.89
G235M/F170LP		1.66–3.17
G395M/F290LP		2.87–5.27
G140H/F070LP	~2700	0.7–1.27
G140H/F100LP		0.97–1.89
G235H/F170LP		1.66–3.17
G395H/F290LP		2.87–5.27
PRISM/CLEAR	~100	0.6–5.3

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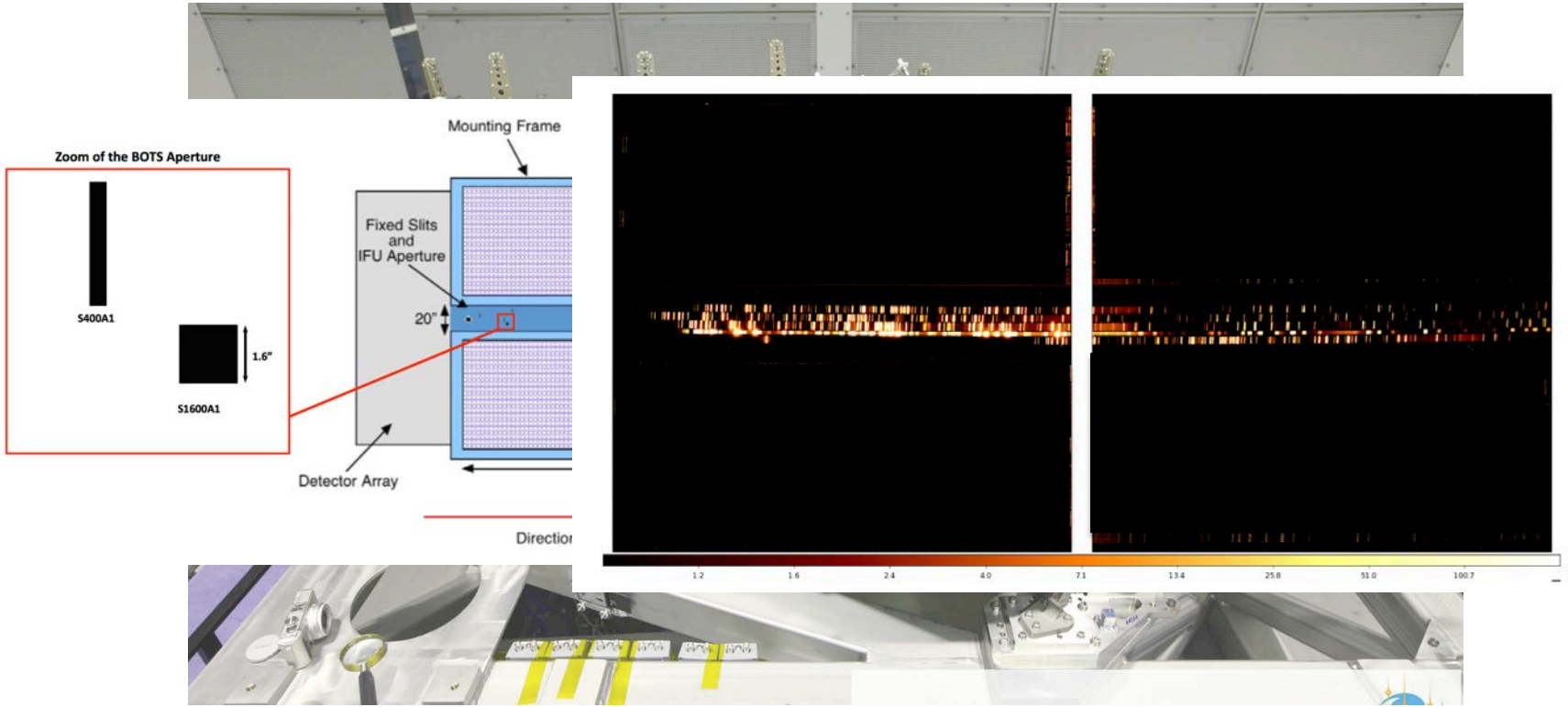
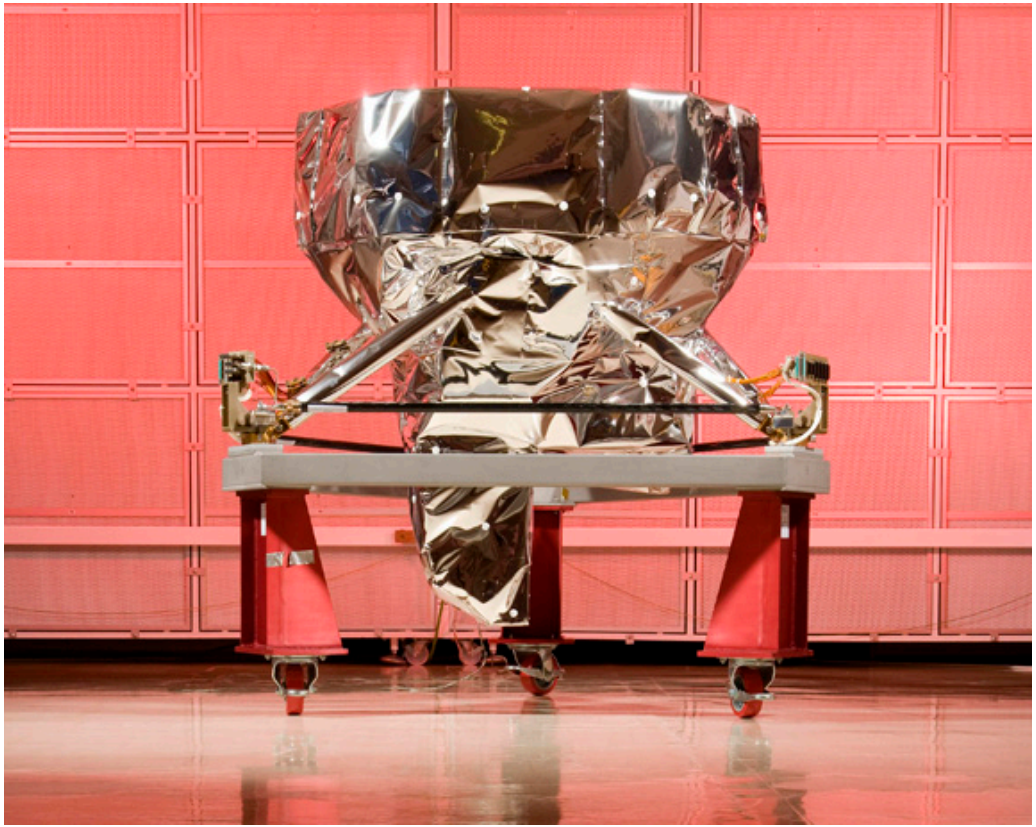


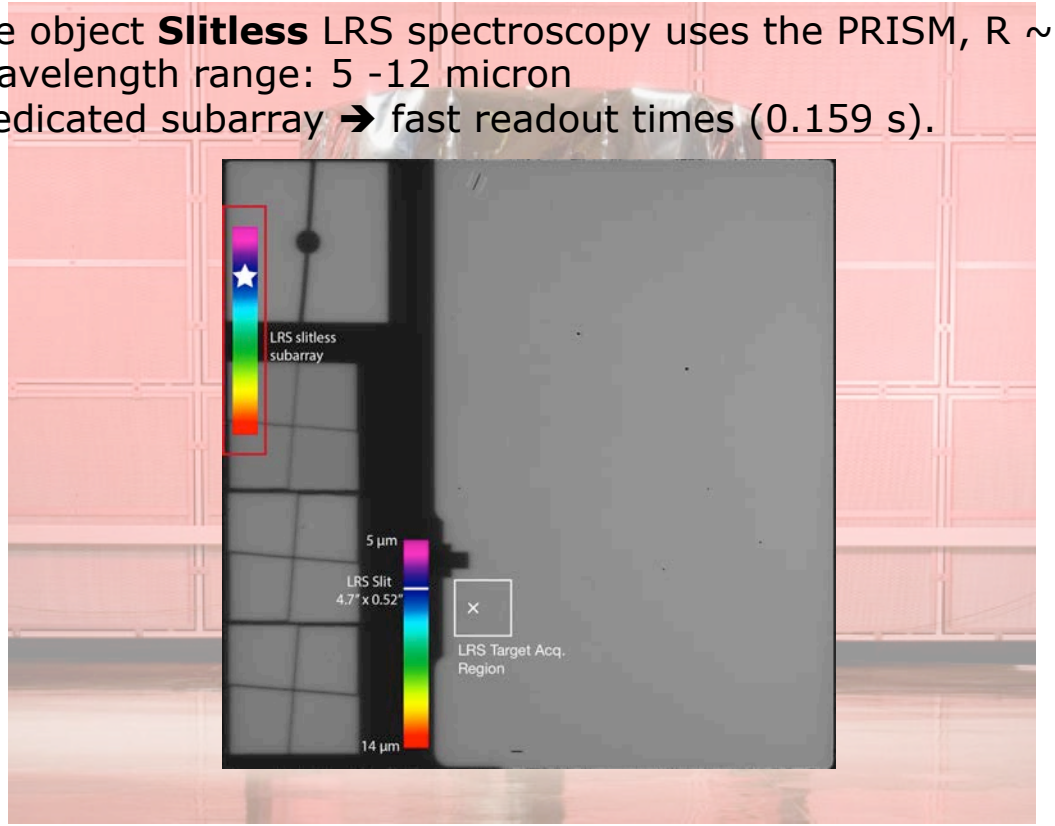
MIRI: Time Series Observations (TSOs)



MIRI: Time Series Observations (TSOs)

Single object **Slitless** LRS spectroscopy uses the PRISM, R ~ 100

- Wavelength range: 5 -12 micron
- Dedicated subarray ➔ fast readout times (0.159 s).



The target: WASP-107b

WASP-107b "super-neptune": twice the mass of Neptune but nearly the radius of Jupiter

- Hugely bloated and fluffy exoplanet
- Teq ~ 740 K
- High signal-to-noise target for transmission spectroscopy
- Transit duration: 2.75 h

System Parameters of WASP-107

Parameter		References
Stellar Parameters		
$T_{\rm eff}$ (K)	4430 ± 120	A
$\log g$ (dex)	4.5 ± 0.1	A
[Fe/H] (dex)	$+0.02 \pm 0.10$	A
$v \sin i_*$ (km s^{-1})	2.5 ± 0.8	A
M_* ($M_\odot$)	0.69 ± 0.05	A
R_* ($R_\odot$)	0.66 ± 0.02	A
Apparent V mag	11.6	A
$P_{\rm rot}$ (days)	17.1 ± 1.0	A
u_1	0.6666 ± 0.0062	B
u_2	0.015 ± 0.011	B
Planetary Parameters		
P (days)	5.7214742 ± 0.0000043	B
T_c (BJD)	$2457584.329897 \pm 0.000032$	B
a/R_*	18.164 ± 0.037	B
a (au)	0.0558 ± 0.0018	B
R_p/R_*	0.14434 ± 0.00018	B
R_p ($R_{\rm Jup}$)	0.948 ± 0.030	B
M_p ($M_{\rm Jup}$)	0.12 ± 0.01	B
i (°)	89.8 ± 0.2	B
$b \equiv a \cos i/R_*$	0.07 ± 0.07	B
e (assumed)	0	A

K6

Apparent K = 8.6

Anderson et al., 2017; Dai & Winn, 2017

The tools

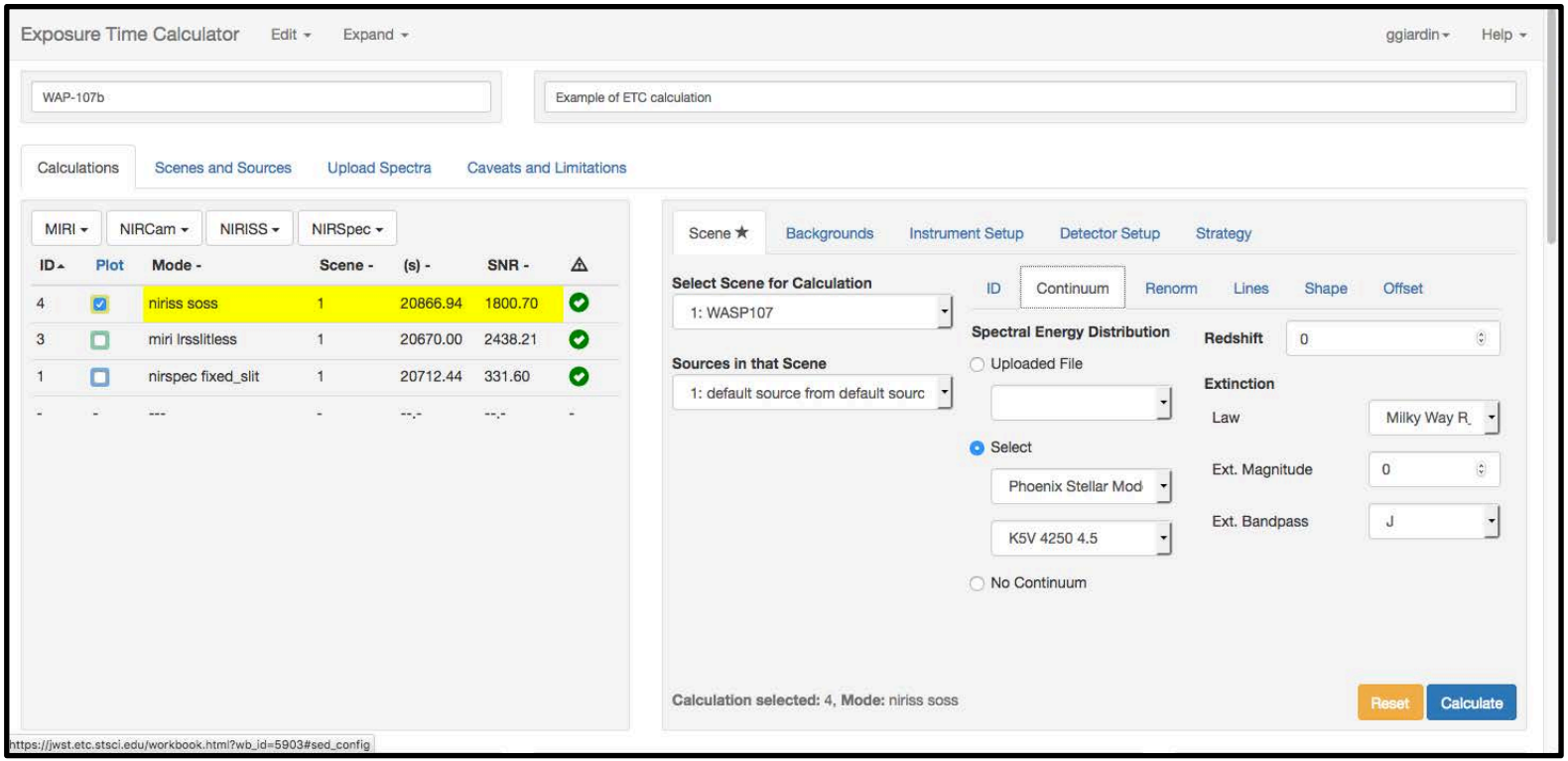
Pandeia: The JWST Exposure Time Calculator

PandExo: An Exoplanet ETC

Tools to help the community with planning exoplanet observations.

Asses exposure parameters using Pandeia (JWST ETC)

https://jwst.etc.stsci.edu



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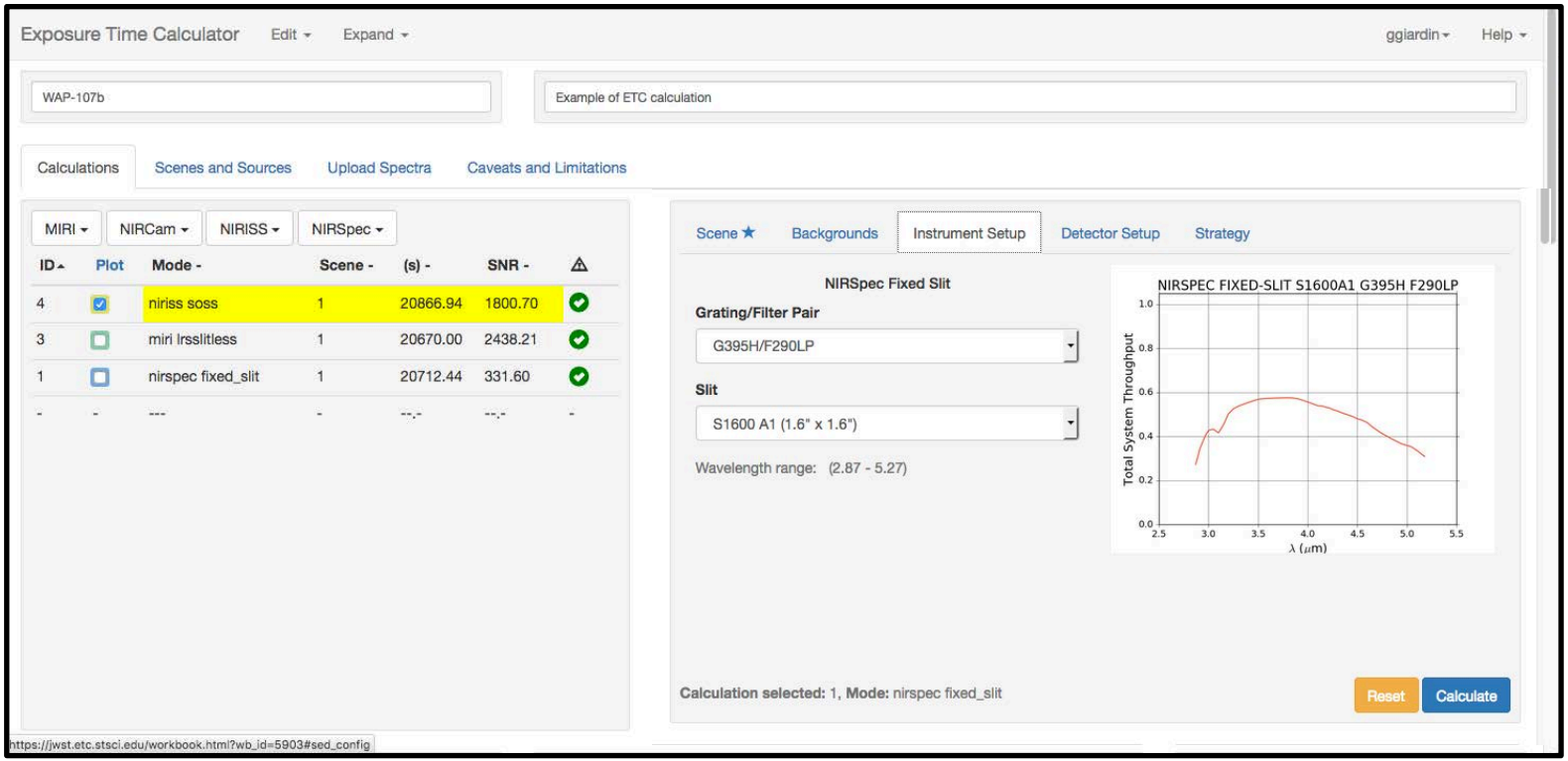

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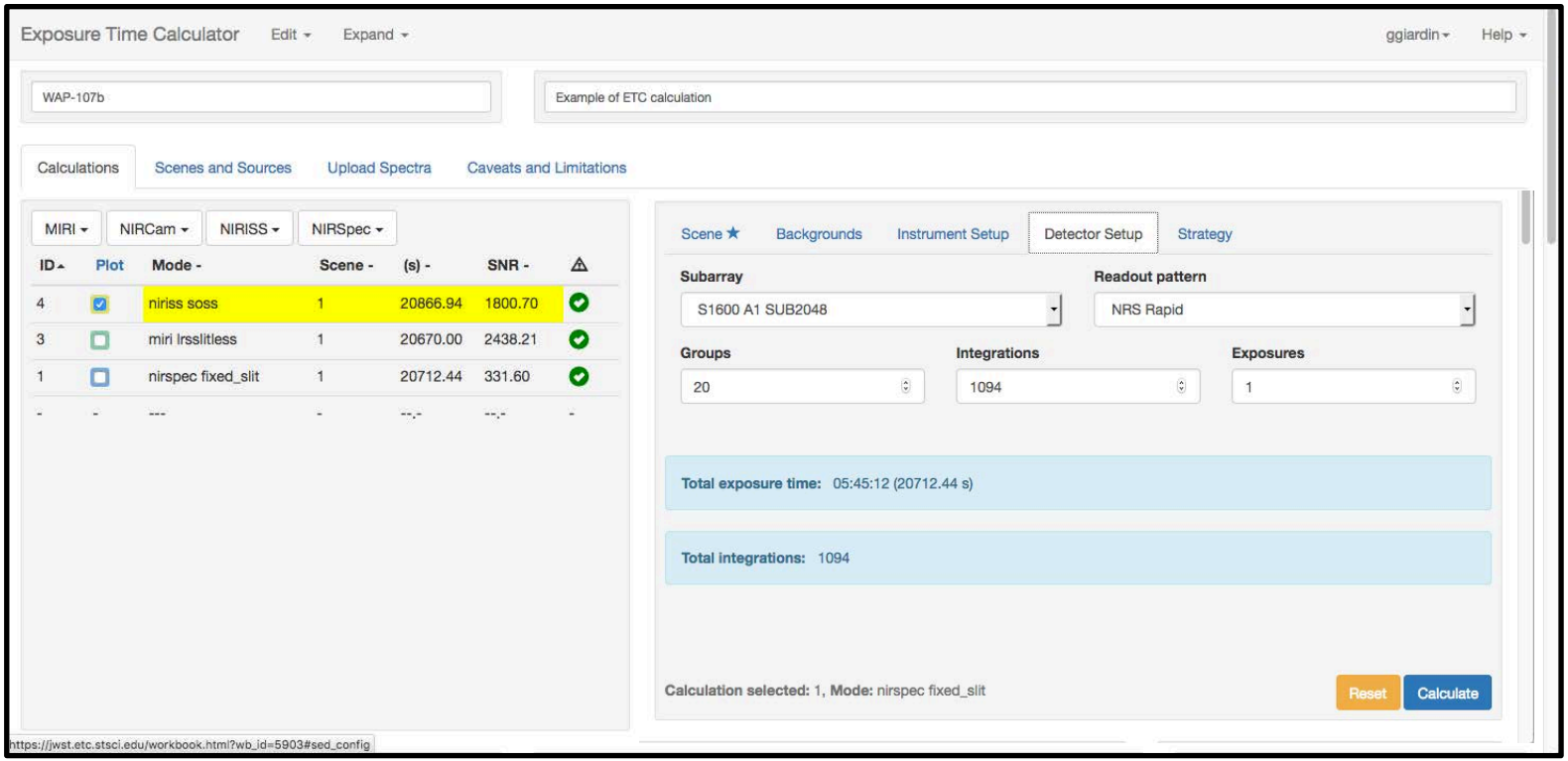

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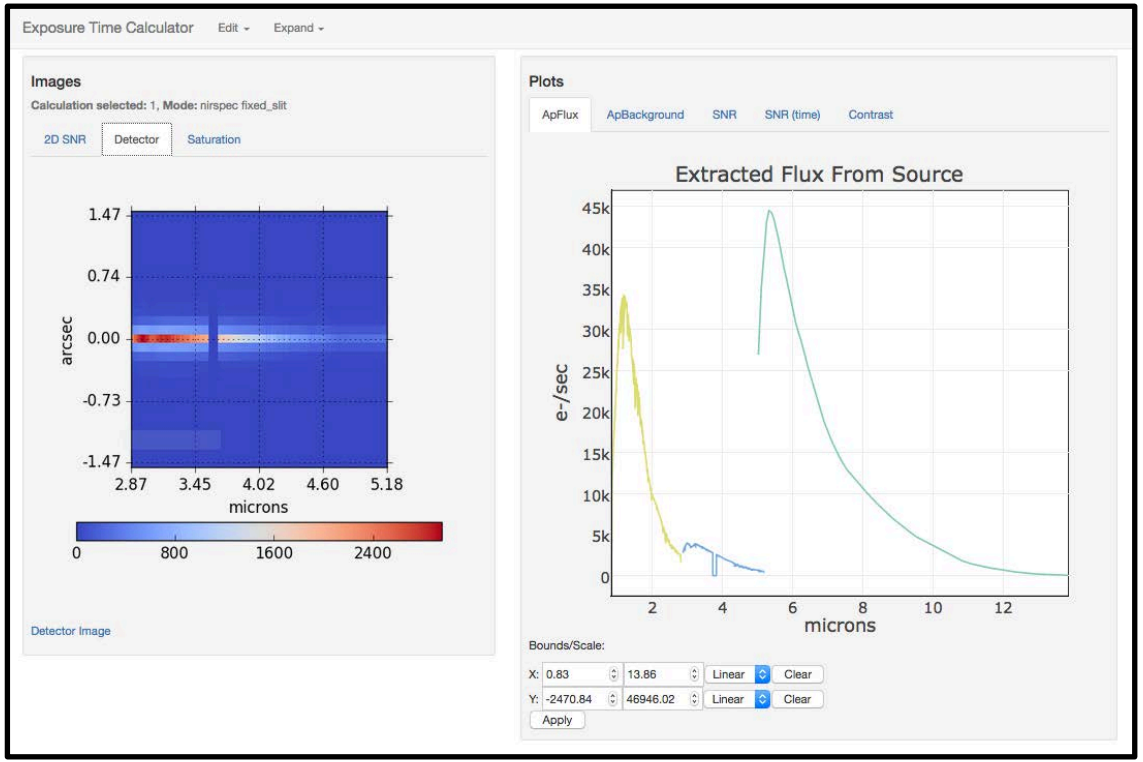
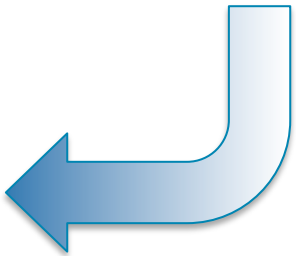


The parameters

Instrument	Disperser	Detector Mode	N groups
NIRISS	GR700	SUBSTRIP256-NRSRAPID	4
NIRSpec	G395H	S1600 A1 SUB2048-NRSRAPID	20
MIRI	P750L	SLITLESSPRISM-FAST	50

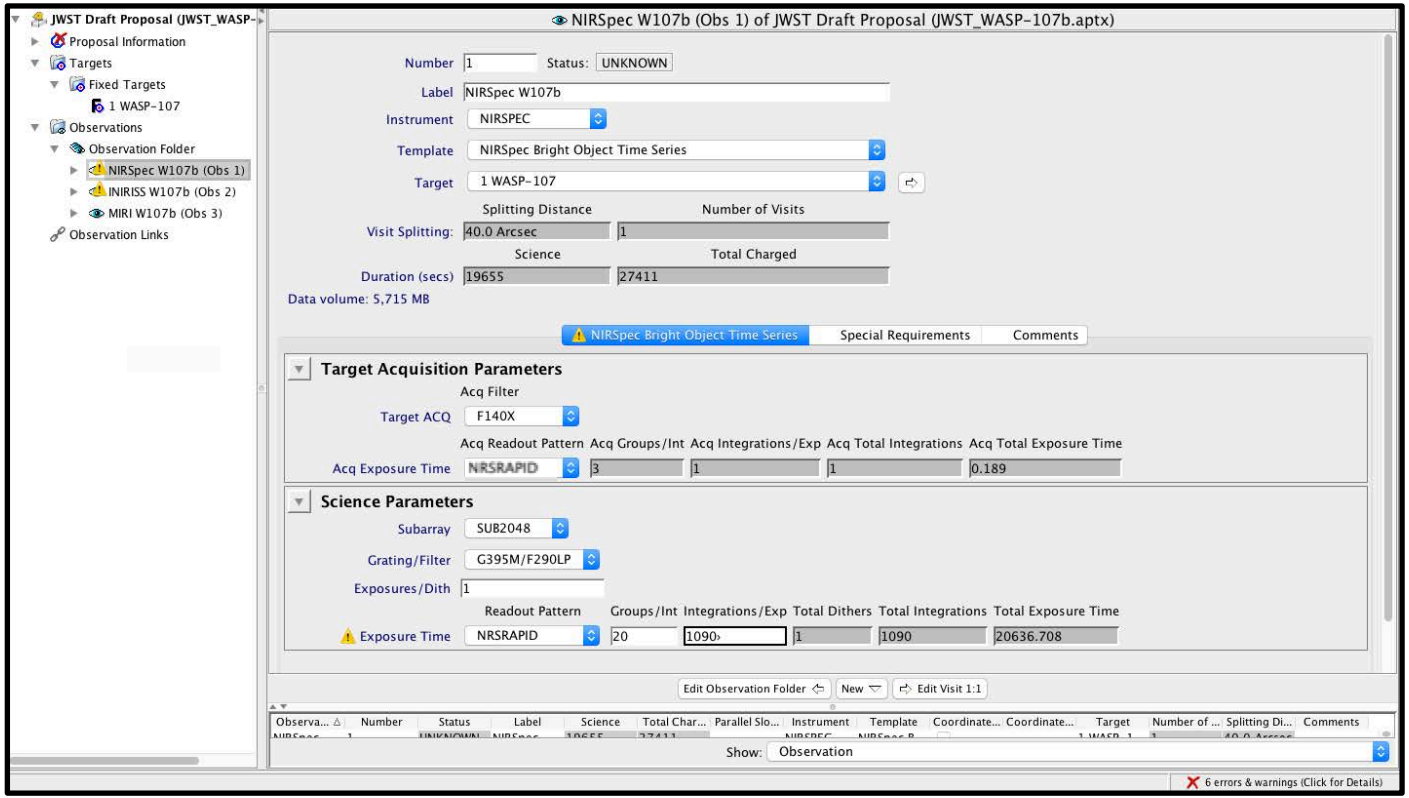
N. Integrations

- NIRISS: 760
- NIRSpec: 1090
- MIRI: 870 x 3

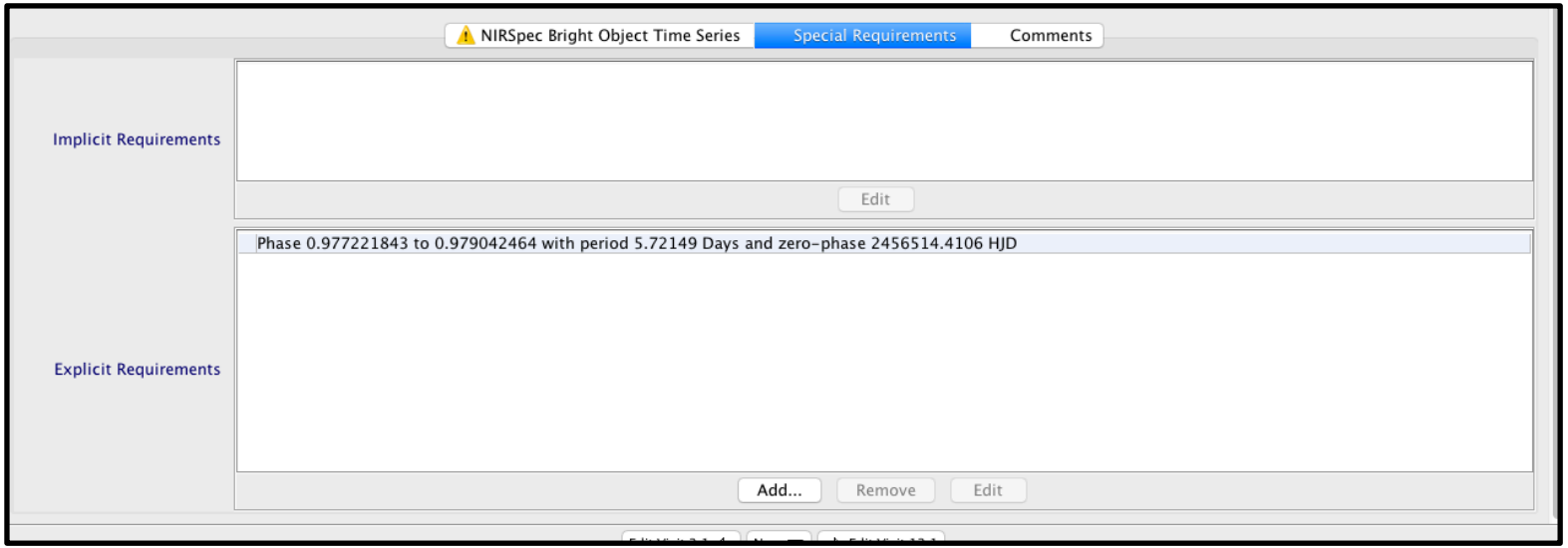


Transit duration: 9900 sec
Integration time ~ 5:45 h

Prepare APT proposal: Detector params + TA

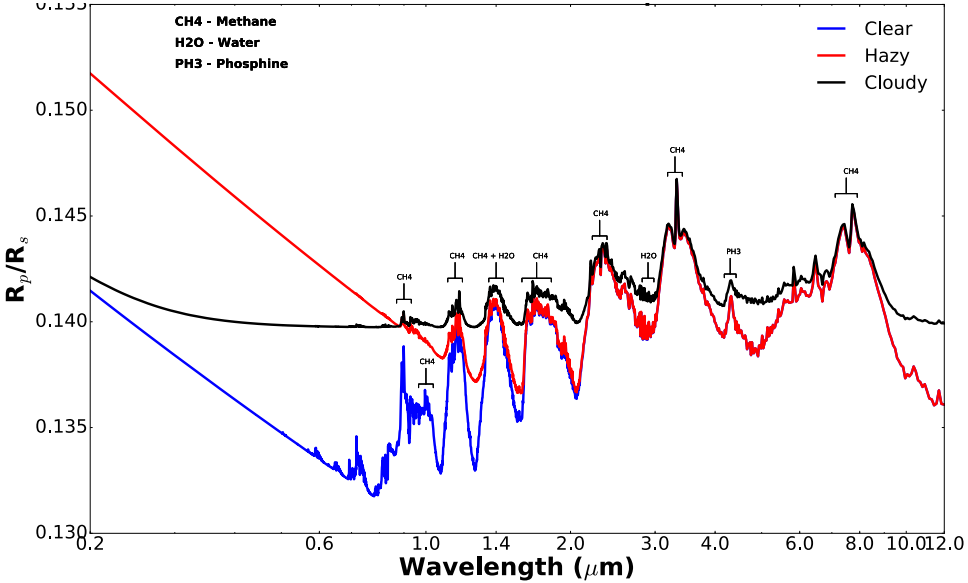


Prepare APT proposal: Transit parameters



Perform simulation of transit observation with PandExo

Models of Wasp-107b transmission spectrum



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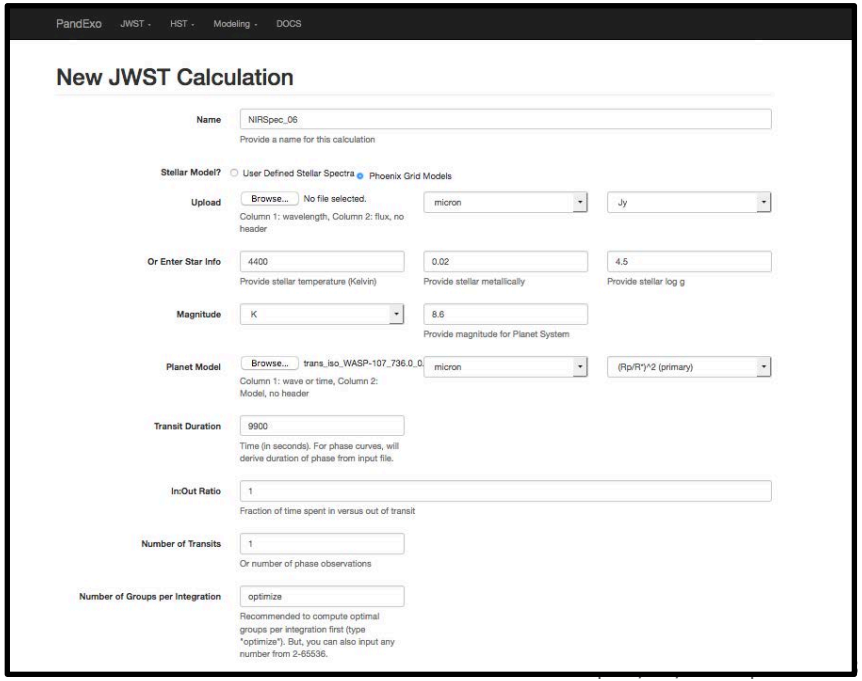
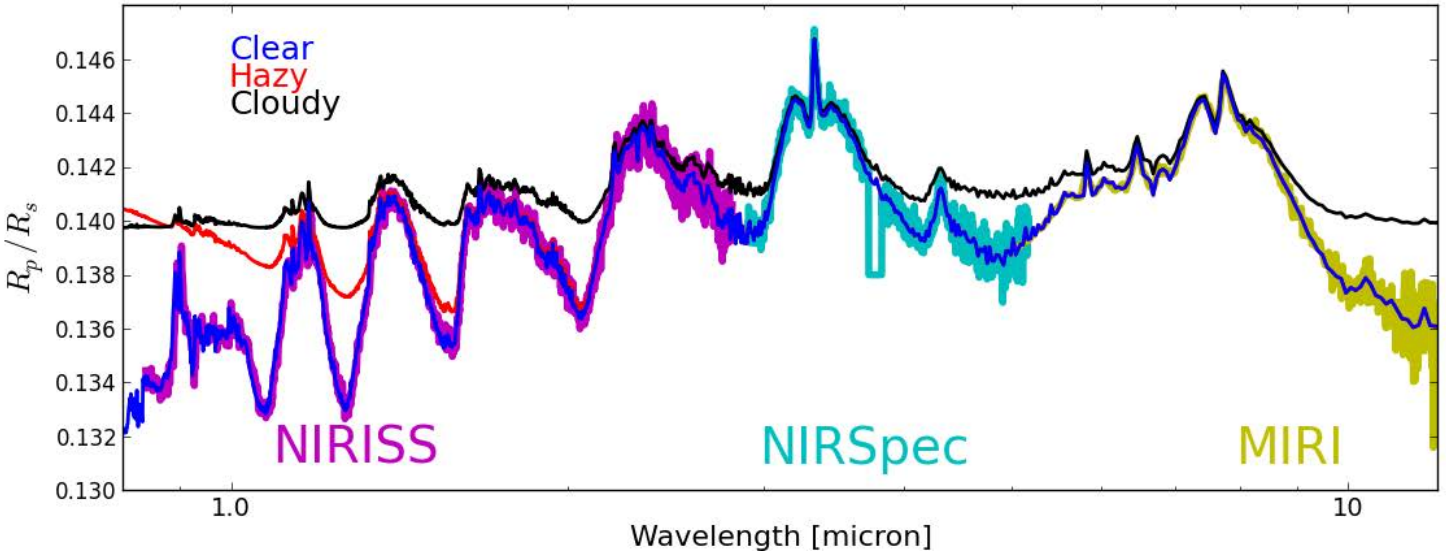
Batalha et al. (2017)

http://pandexo.science.psu.edu:1111/calculation/new



PandExo simulation



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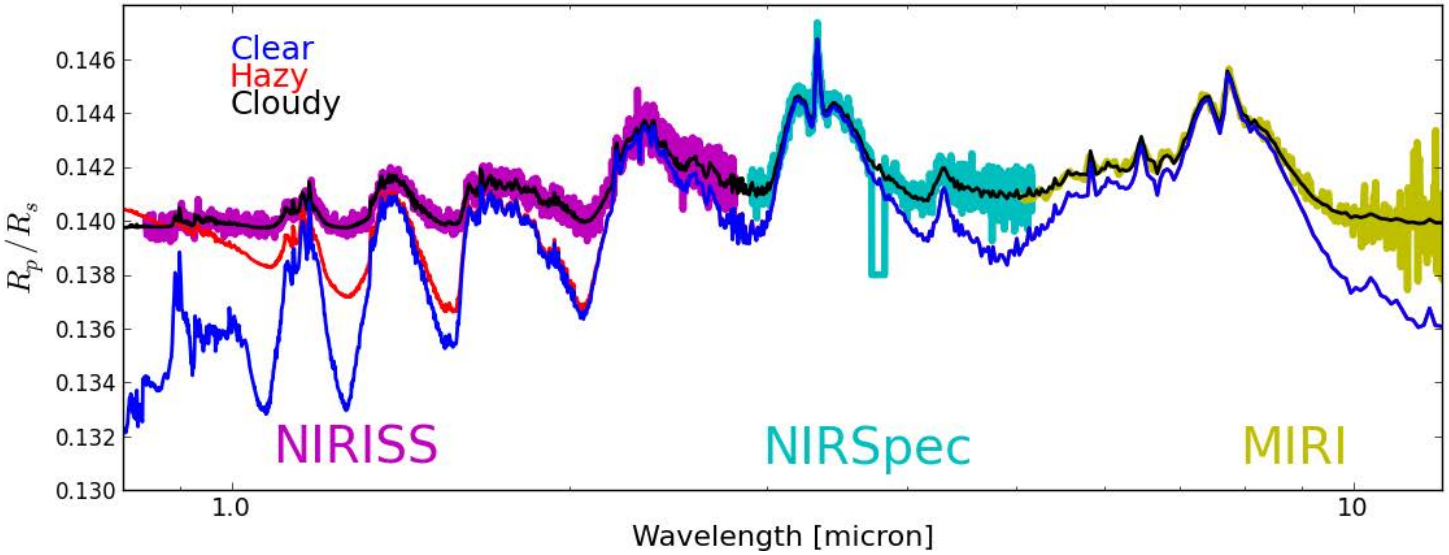

Conclusion

Submit the proposal

Useful addresses

- STScI JWST documentation pages: `jwst-docs.stsci.edu`
- NIRISS SOSS 1d-simulator: `maestria.astro.umontreal.ca/niriss/simu1D/simu1D.php`
- NIRSpec: `cosmos.esa.int/web/jwst-nirspec`
- STScI APT page: `www.stsci.edu/hst/proposing/apt`
- STScI ETC: `jwst.etc.stsci.edu`
- PandExo: `http://pandexo.science.psu.edu:1111/calculation/new`