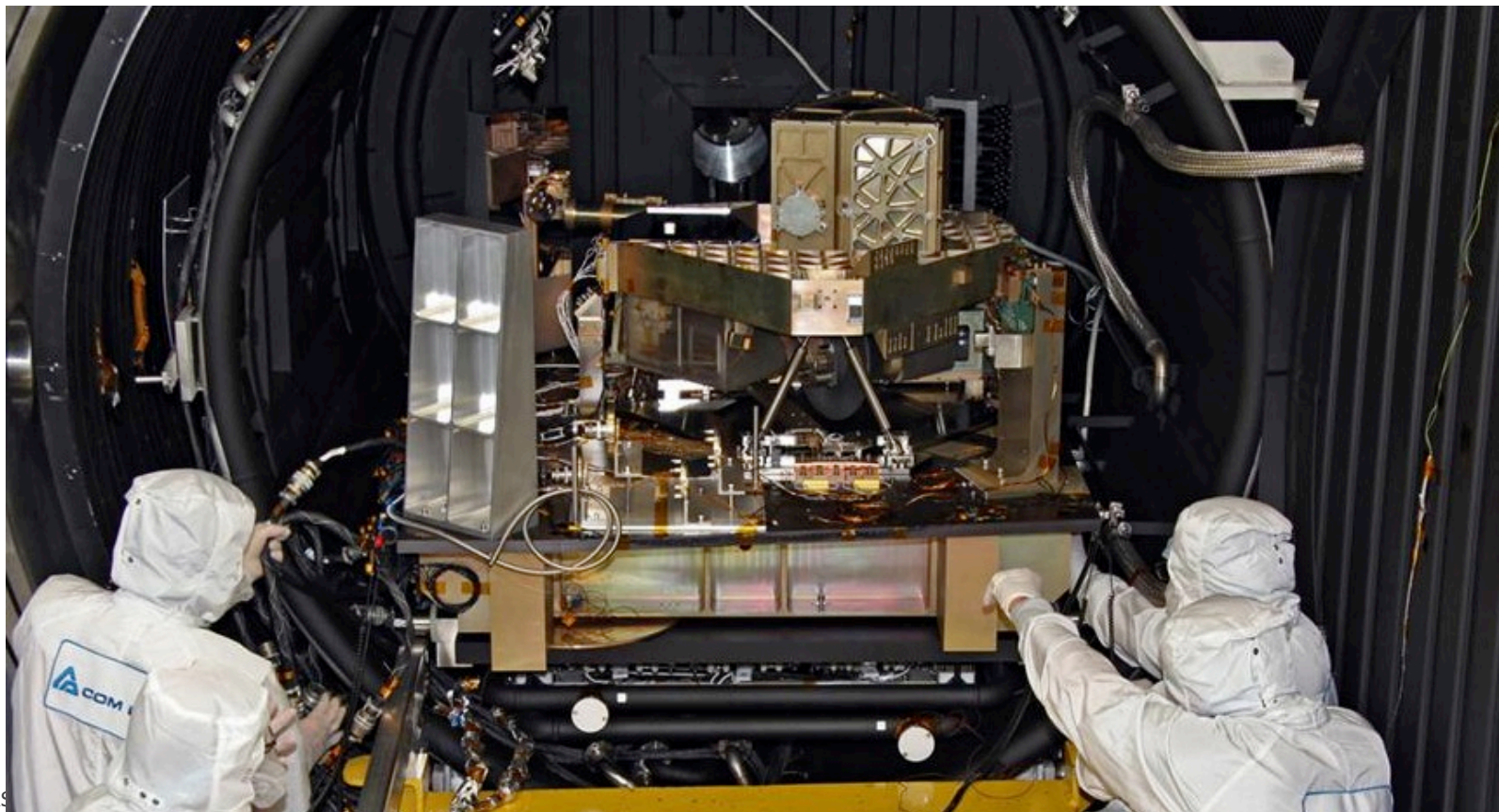


Observation of a transiting exoplanet with NIRISS, NIRSpec, and MIRI

Giovanna Giardino, Stephan Birkmann, Pierre Ferruit
Jayesh Goyal, David Sing

EWASS Prague 2016

NIRISS: Single Object Slitless Spectroscopy (SOSS)



ESA UNCLAS

16 | Slide 2

NIRISS: Single Object Slitless Spectroscopy (SOSS)

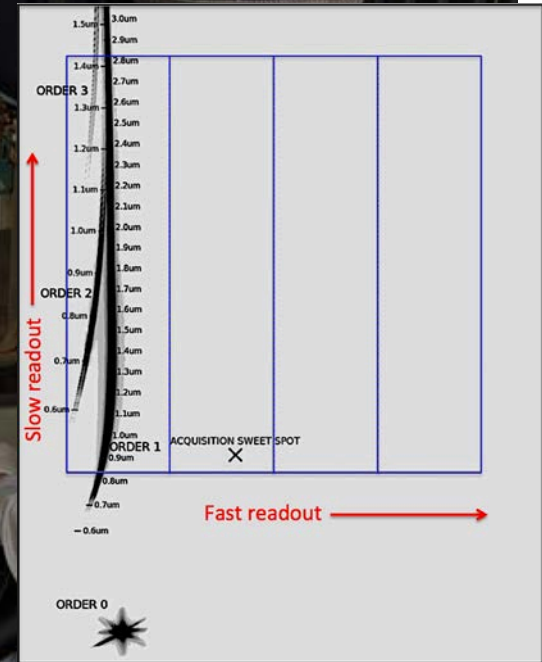
SOSS → medium resolution ($R \approx 700$) spectroscopy: GR700XD 3 orders of cross-dispersed spectra for a single bright target

- $R \approx 700$ at $1.25 \mu\text{m}$ in 1st order,
- $R \approx 700$ at $0.63 \mu\text{m}$ in 2nd order

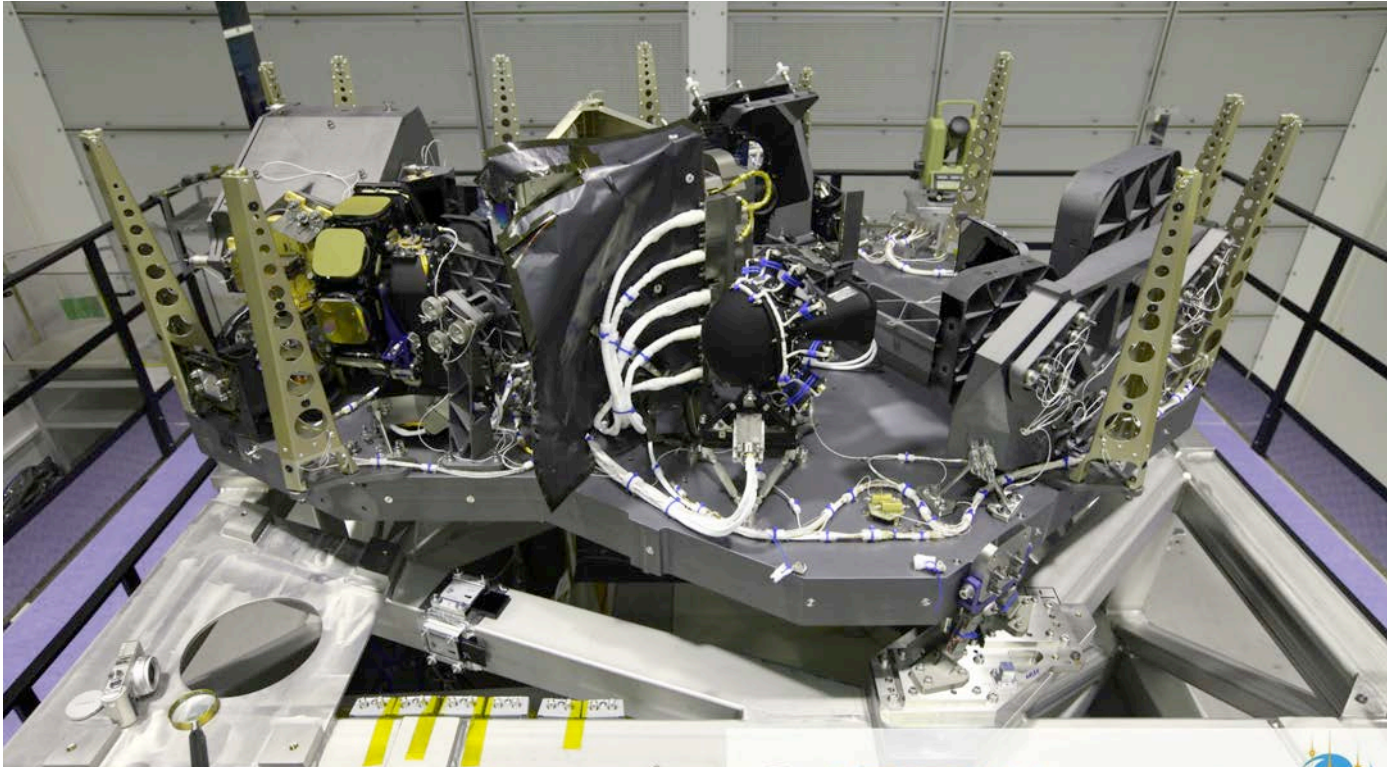
GR700XD optical element incorporate a cylindrical lens

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

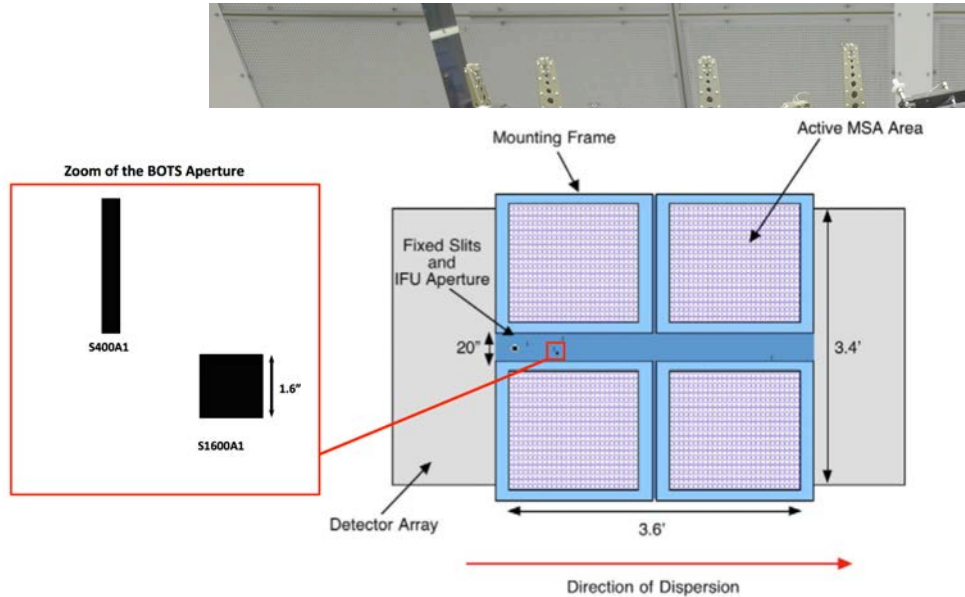
Wavelength range 0.6-2.8 micron



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



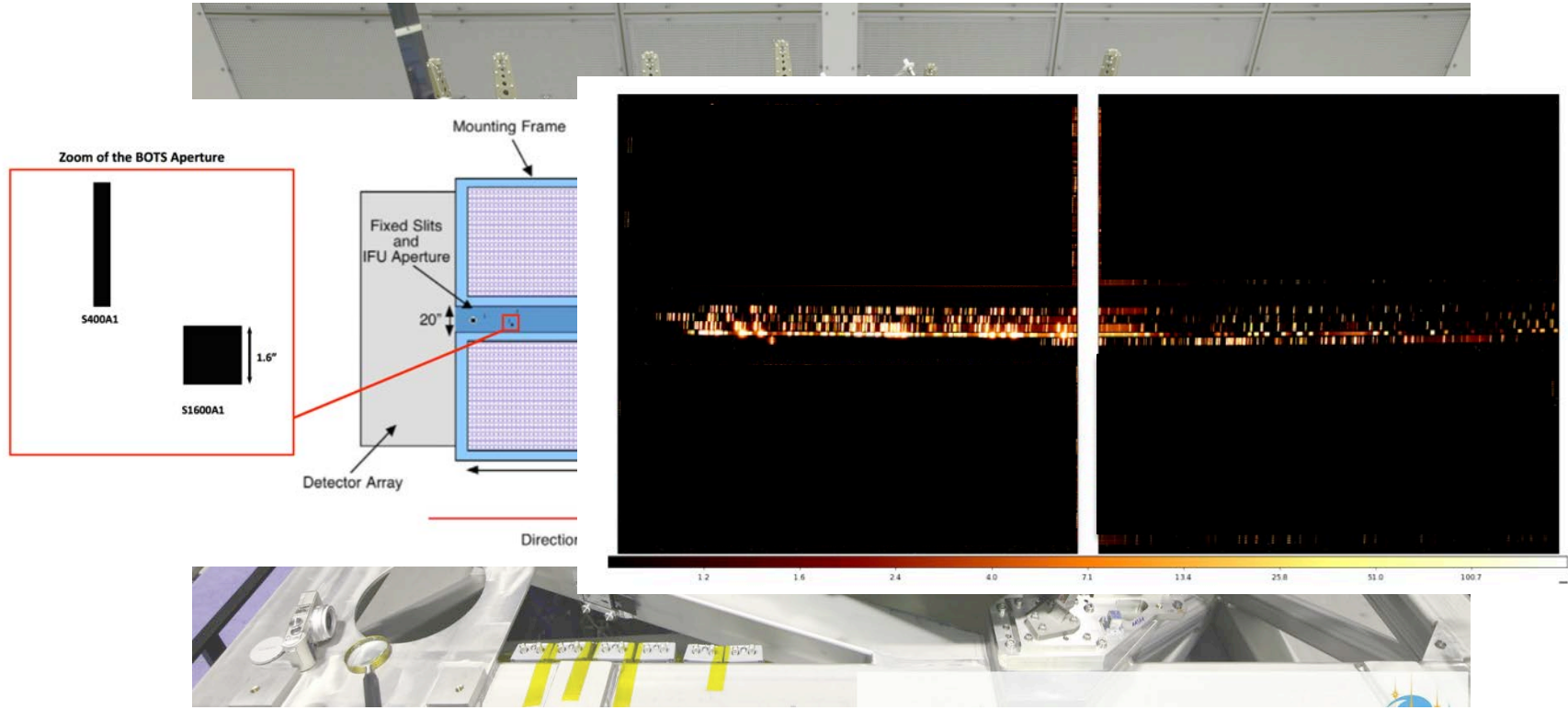
NIRSpec: Bright object time-series (BOTS) spectroscopy with the wide aperture



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



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



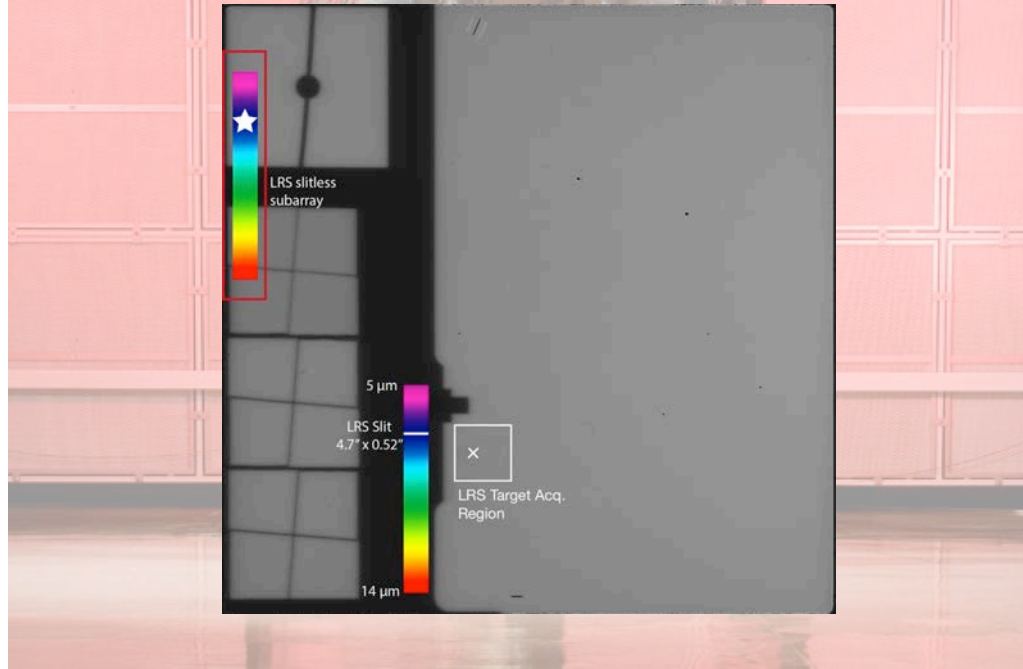
MIRI: Time Series Observations (TSOs)



MIRI: Time Series Observations (TSOs)

Single object **Slitless** LRS spectroscopy uses the PRISM, $R \sim 100$

- 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
- $T_{eq} \sim 740$ K
- High signal-to-noise target for transmission spectroscopy
- Transit duration: 2.75 h

System Parameters of WASP-107

Parameter	References	
Stellar Parameters		
T_{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_{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_{Jup})	0.948 ± 0.030	B
M_p (M_{Jup})	0.12 ± 0.01	B
i ($^\circ$)	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

Pandeia: The JWST Exposure Time Calculator



APT



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>

Exposure Time Calculator Edit Expand ggirdin Help

WAP-107b Example of ETC calculation

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

MIRI NIRCam NIRISS NIRSpec

ID	Plot	Mode	Scene	(s)	SNR	
4	☒	niriss soss	1	20866.94	1800.70	✓
3	☐	miri lrslitless	1	20670.00	2438.21	✓
1	☐	nirspec fixed_slit	1	20712.44	331.60	✓
-	-	---	-	---	---	-

Scene Backgrounds Instrument Setup Detector Setup Strategy

Select Scene for Calculation ID Continuum Renorm Lines Shape Offset

1: WASP107

Sources in that Scene

1: default source from default sourc

Spectral Energy Distribution

☐ Uploaded File

☐ Select

Phoenix Stellar Mod

K5V 4250 4.5

☐ No Continuum

Redshift 0

Extinction

Law Milky Way R_v

Ext. Magnitude 0

Ext. Bandpass J

Calculation selected: 4, Mode: niriss soss

Reset Calculate

https://jwst.etc.stsci.edu/workbook.html?wb_id=5903#sed_config

Asses exposure parameters using Pandeia (JWST ETC)



<https://jwst.etc.stsci.edu>

Exposure Time Calculator

Edit

Expand

ggiardin

Help

WAP-107b

Example of ETC calculation

Calculations

Scenes and Sources

Upload Spectra

Caveats and Limitations

MIRI

NIRCam

NIRISS

NIRSpec

ID	Plot	Mode	Scene	(s)	SNR	
4	☒	niriss_soss	1	20866.94	1800.70	
3	☐	miri_irsslittless	1	20670.00	2438.21	
1	☐	nirspec_fixed_slit	1	20712.44	331.60	
-	-	---	-	--:-	--:-	-

Scene

Backgrounds

Instrument Setup

Detector Setup

Strategy

NIRSpec Fixed Slit

Grating/Filter Pair

G395H/F290LP

Slit

S1600 A1 (1.6" x 1.6")

Wavelength range: (2.87 - 5.27)

NIRSPEC FIXED-SLIT S1600A1 G395H F290LP

Calculation selected: 1, Mode: nirspec fixed_slit

Reset

Calculate

https://jwst.etc.stsci.edu/workbook.html?wb_id=5903#sed_config

Asses exposure parameters using Pandeia (JWST ETC)



<https://jwst.etc.stsci.edu>

Exposure Time Calculator Edit Expand ggiardin Help

WAP-107b Example of ETC calculation

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

MIRI NIRCam NIRISS NIRSpec

ID	Plot	Mode	Scene	(s)	SNR	
4	☒	niriss_soss	1	20866.94	1800.70	✓
3	☐	miri_irsslittless	1	20670.00	2438.21	✓
1	☐	nirspec_fixed_slit	1	20712.44	331.60	✓
-	-	---	-	--.-	--.-	-

Scene ★ Backgrounds Instrument Setup Detector Setup Strategy

Subarray: S1600 A1 SUB2048 Readout pattern: NRS Rapid

Groups: 20 Integrations: 1094 Exposures: 1

Total exposure time: 05:45:12 (20712.44 s)

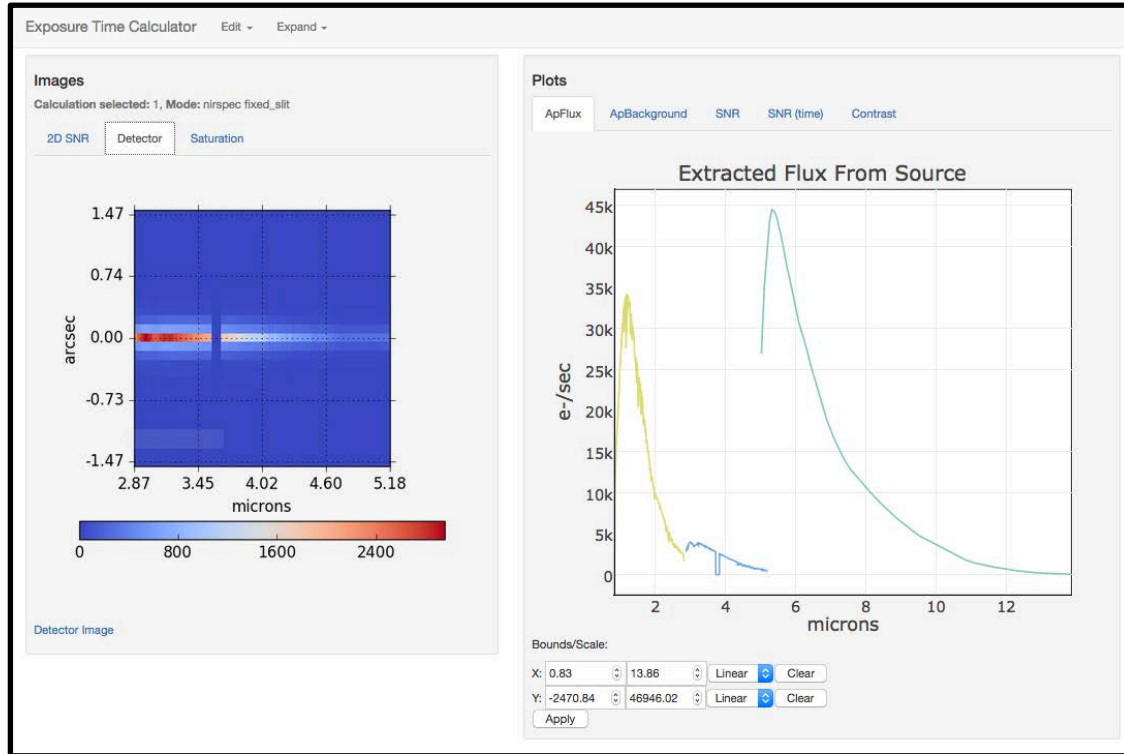
Total integrations: 1094

Calculation selected: 1, Mode: nirspec fixed_slit

Reset Calculate

https://jwst.etc.stsci.edu/workbook.html?wb_id=5903#sed_config

Asses exposure parameters using Pandeia (JWST ETC)

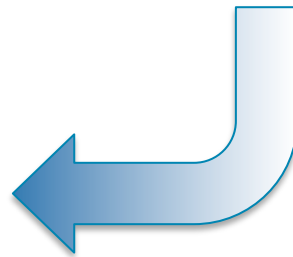


The parameters

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

JWST Draft Proposal (JWST_WASP-107b)

NIRSpec W107b (Obs 1) of JWST Draft Proposal (JWST_WASP-107b.aptx)

Number: 1 Status: UNKNOWN

Label: NIRSpec W107b

Instrument: NIRSPEC

Template: NIRSpec Bright Object Time Series

Target: 1 WASP-107

Splitting Distance: 40.0 Arcsec Number of Visits: 1

Science: 19655 Total Charged: 27411

Duration (secs): 19655

Data volume: 5,715 MB

Target Acquisition Parameters

Acq Filter: F140X

Acq Readout Pattern: NRSRAPID Acq Groups/Int: 3 Acq Integrations/Exp: 1 Acq Total Integrations: 1 Acq Total Exposure Time: 0.189

Science Parameters

Subarray: SUB2048

Grating/Filter: G395M/F290LP

Exposures/Dith: 1

Readout Pattern: NRSRAPID Groups/Int: 20 Integrations/Exp: 1090 Total Dithers: 1 Total Integrations: 1090 Total Exposure Time: 20636.708

Exposure Time: 1090

Observations table:

Observation	Number	Status	Label	Science	Total Char...	Parallel Slo...	Instrument	Template	Coordinate...	Coordinate...	Target	Number of ...	Splitting Di...	Comments
NIRSPEC	1	UNKNOWN	NIRSPEC	W107b	27411		NIRSPEC	NIRSPEC			1 WASP-107	1	40.0 Arcsec	

Show: Observation

6 errors & warnings (Click for Details)

Prepare APT proposal: Transit parameters

⚠ NIRSpec Bright Object Time Series **Special Requirements** Comments

Implicit Requirements

Edit

Phase 0.977221843 to 0.979042464 with period 5.72149 Days and zero-phase 2456514.4106 HJD

Explicit Requirements

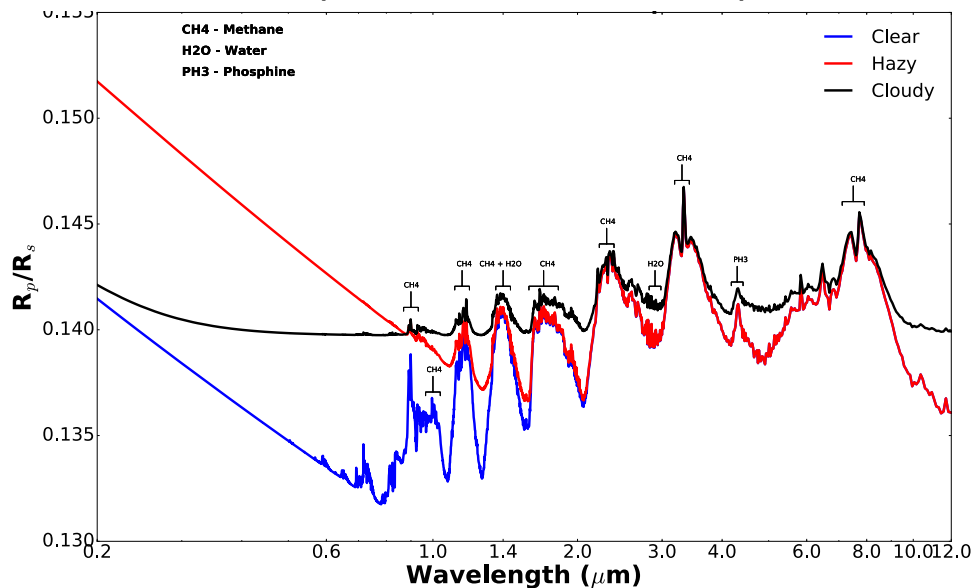
Add... Remove Edit

Perform simulation of transit observation with PandExo



Models of Wasp-107b transmission spectrum

Batalha et al. (2017)



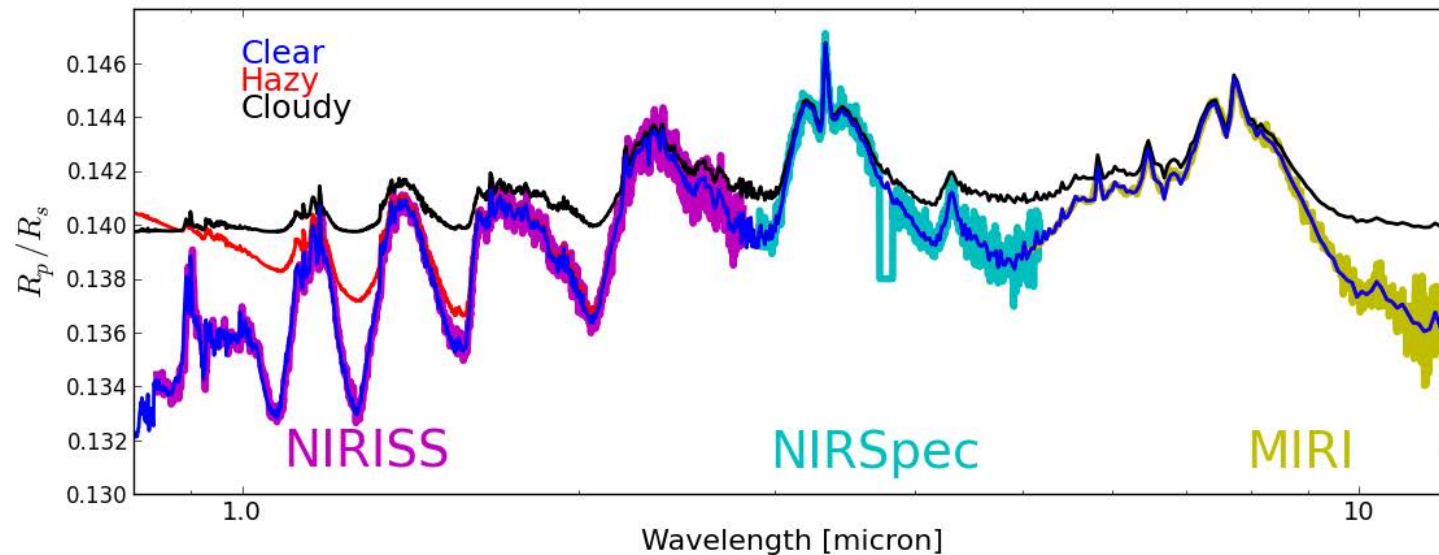
Jayesh Goyal, David Sing, University of Exeter

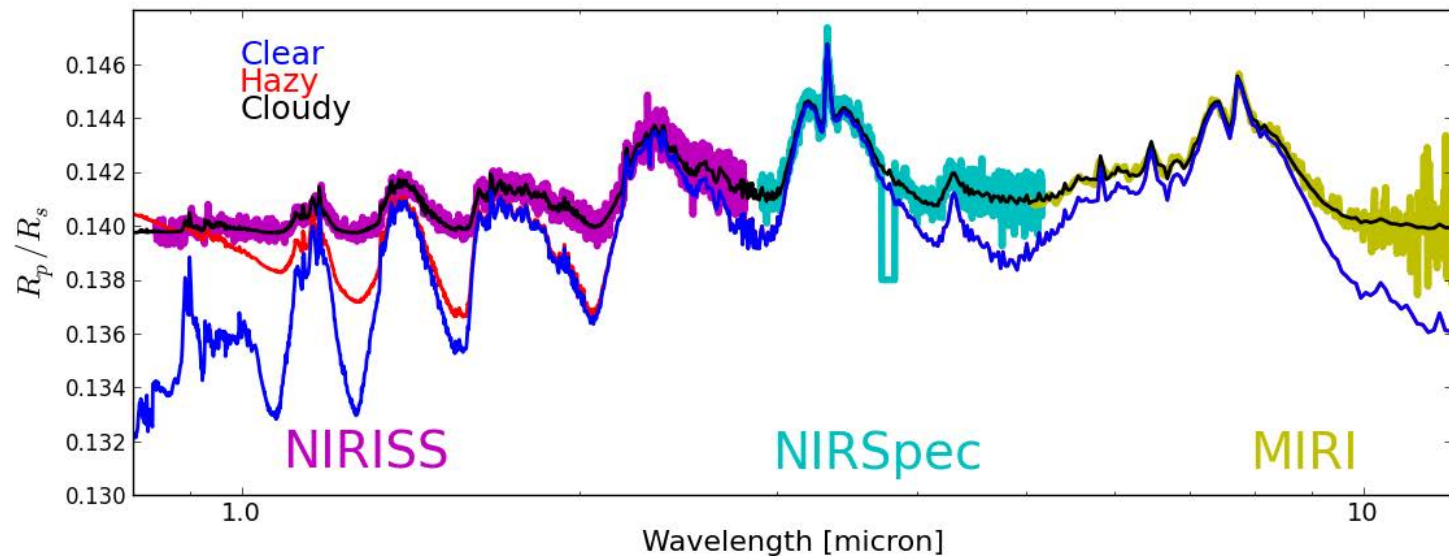
<http://pandexo.science.psu.edu:1111/calculation/new>

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European Space Agency





Conclusion

Submit the proposal



Useful addresses



- STScI JWST documentation pages: `jwst-docs.stsci.edu`
- NIRISS SOSS 1d-simulator: `maestria.astro.umontreal.ca/niriss/simulD/simulD.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`

