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SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

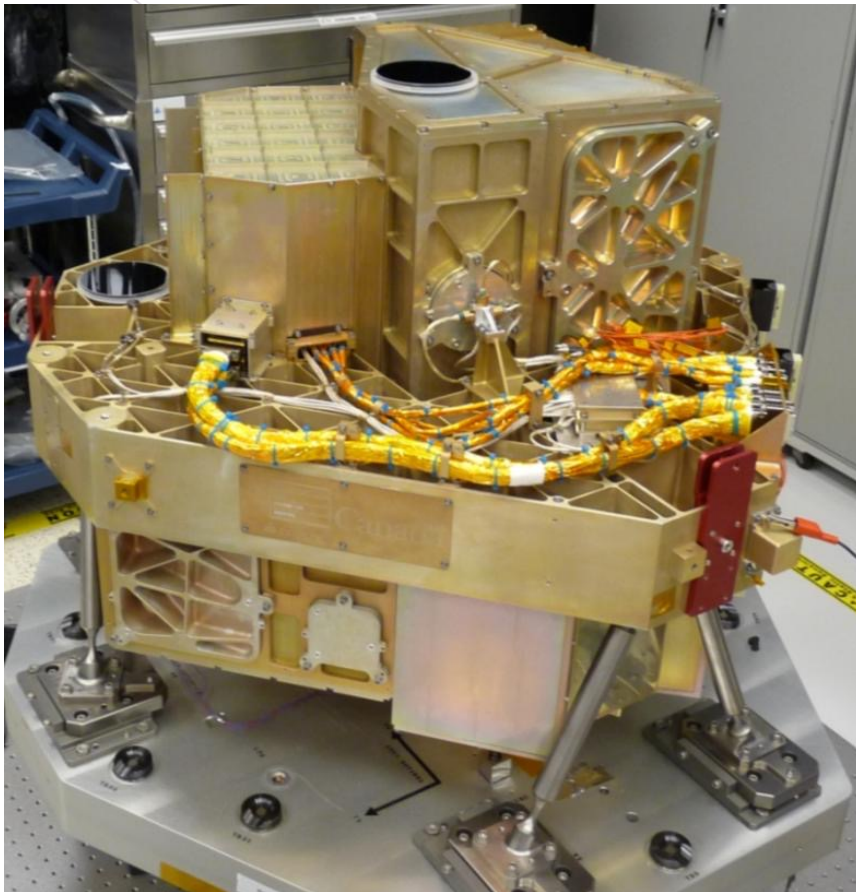
The Commissioning of the Near Infrared Imager and Slitless Spectrograph (**NIRISS**)

Stephanie LaMassa (NIRISS Branch Manager on behalf of the AMAZING NIRISS Team)

July 12, 2022



NIRISS & FGS provided by Canadian Space Agency



Principle Investigator:

Prof. René Doyon



Prime Contractor:

Honeywell



Technical Development:

National Research Council
of Canada (NRC)





NIRISS Commissioning Team



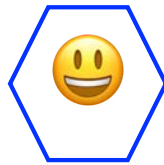
= NIRISS INS team member



René Doyon, PI
(UdeM)



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Commissioning Lead



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Project Scientist



Steph LaMassa
NIRISS Manager



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Jo Taylor
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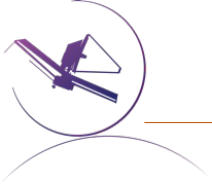
Deepashri Thatte
(STScI)



Thomas Vandal
(UdeM)



Kevin Volk
(STScI, CSA)

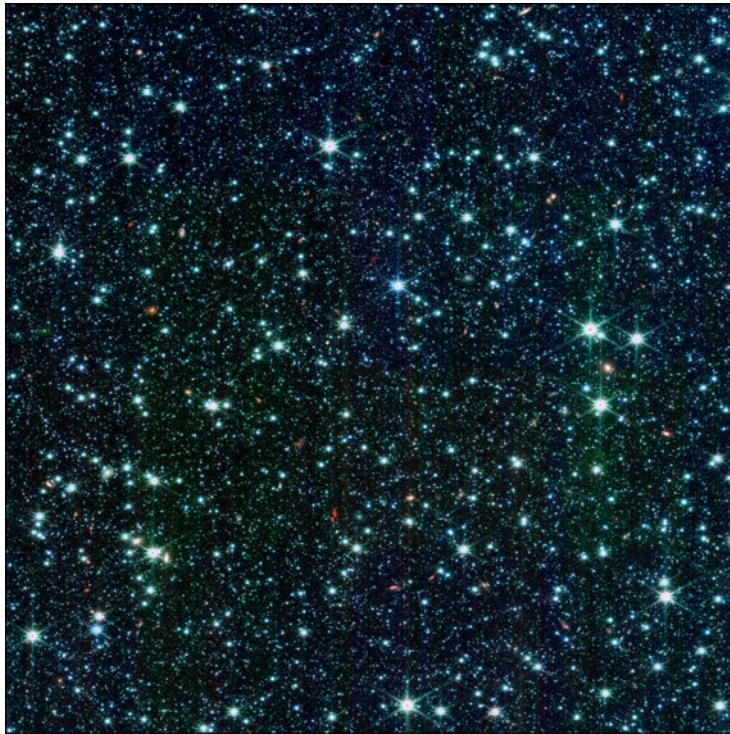


Performance exceeded requirements, though commissioning threw us some curve balls.



Imaging (Coordinated Parallel Only in Cycle 1): 0.9 – 4.8 μm

Red galaxies in a sea of stars



F115W F150W F356W

Data from APT 1085 (NIS-010)

Stars and more stars...



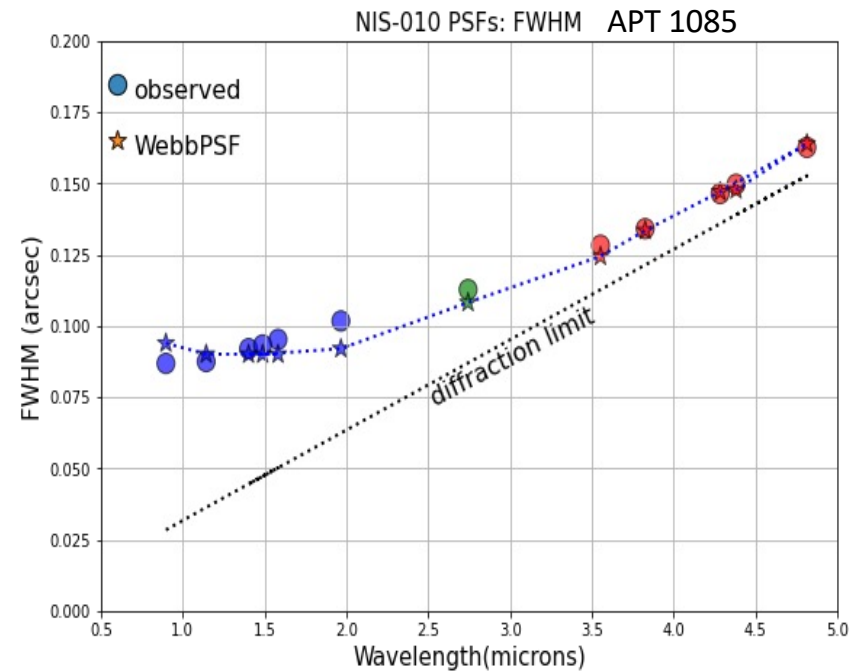
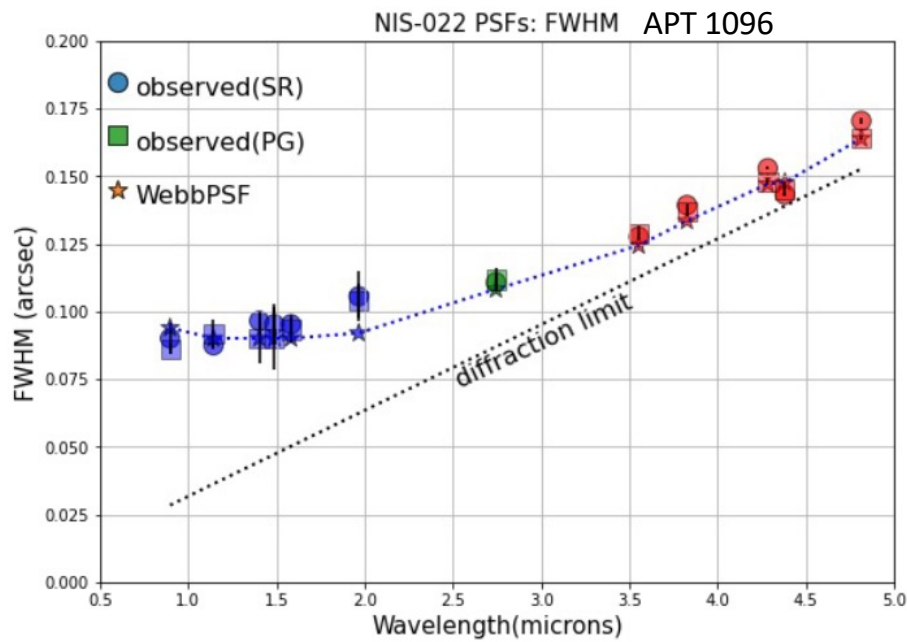
F090W F150W F277W

Credit: Swara Ravindranath



Point Spread Function (PSF): Excellent match to predictions

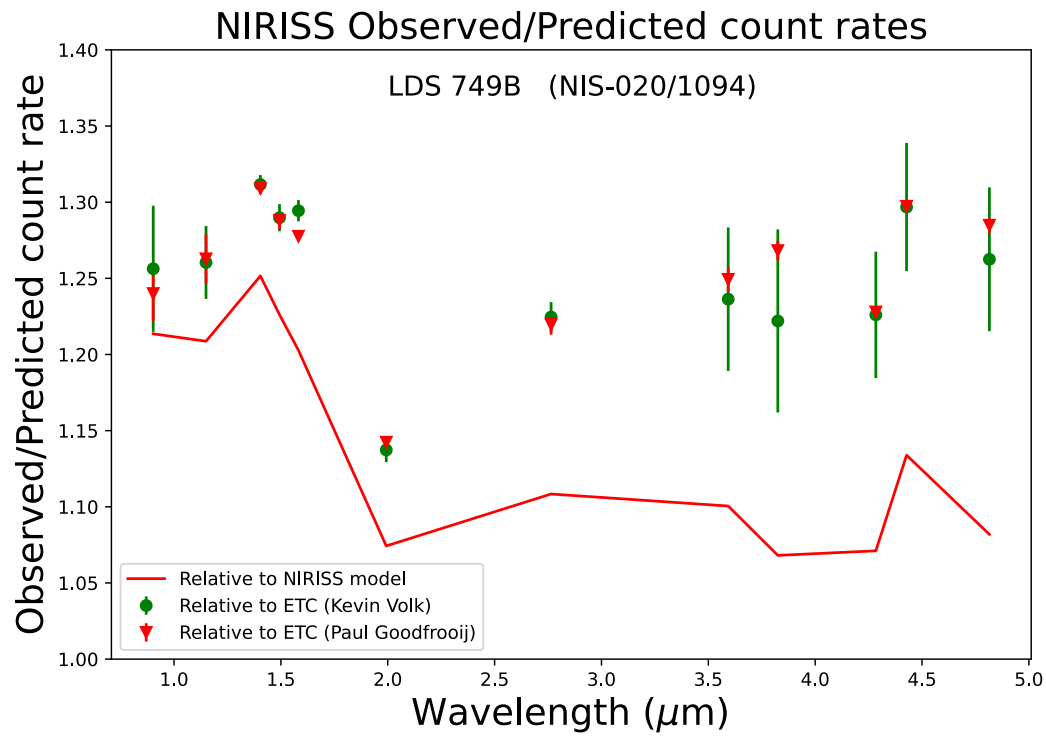
- Full width half maximum (FWHM) & Encircled energy (EE) within 1.3σ of WebbPSF
- PSF stable across the field



Analysts: Swara Ravindranath, Paul Goudfrooij



Imaging Sensitivity is 10-25% better than Exposure Time Calculator (ETC)



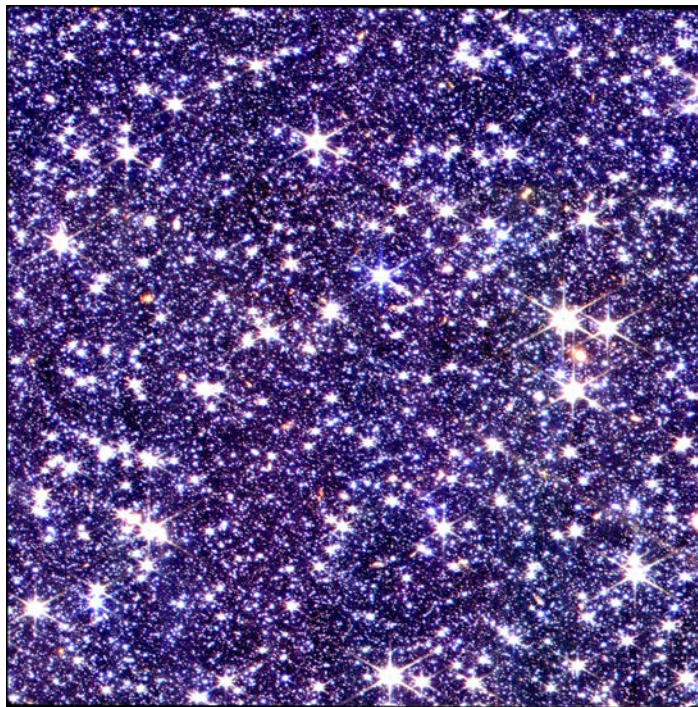
Analysts: Kevin Volk, Paul Goodfroit

Filter	Measured Count Rate/ ETC Count Rate
F090W	1.25
F115W	1.26
F140M	1.31
F150W	1.29
F158M	1.29
F200W	1.14
F277W	1.22
F356W	1.24
F380M	1.25
F430M	1.23
F444W	1.20
F480M	1.27



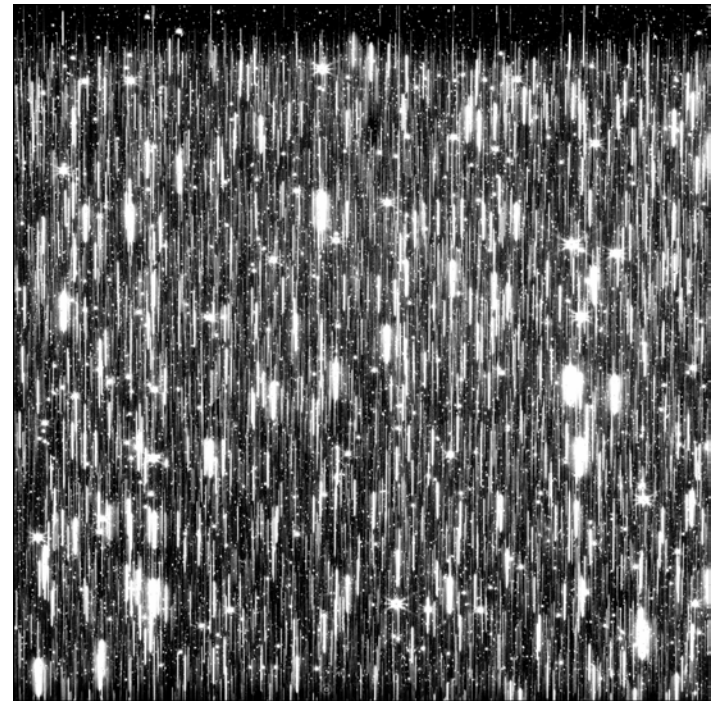
Wide Field Slitless Spectroscopy (WFSS): $0.8 - 2.2 \mu\text{m}$, $R \sim 150$

Direct image (F200W)



Data from APT 1085 (CAR NIS-010)

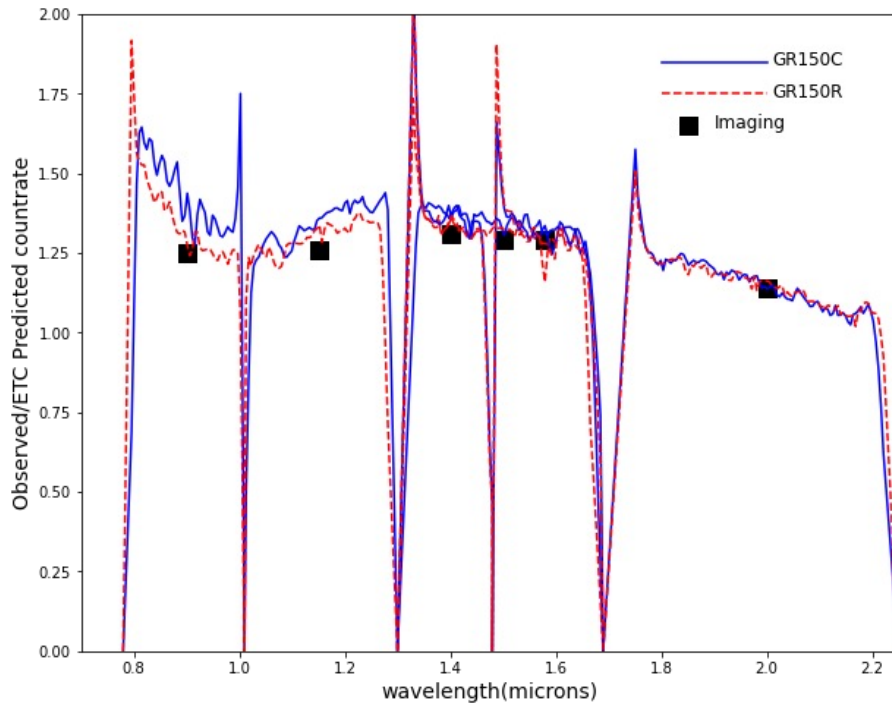
F200W + GR150C GR150R



Credit: Swara Ravindranth



WFSS Performance: Better than predicted throughput; grism differences



Data from APT 1089

(Observed Count Rates)/(ETC Count Rates)

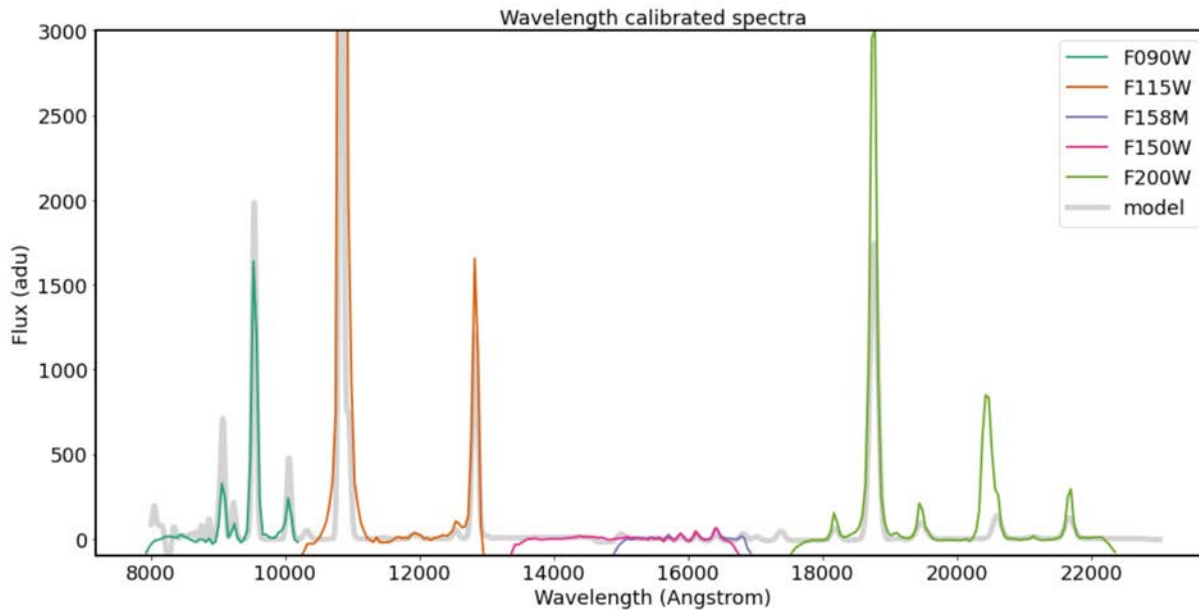
Wavelength	GR150C	GR150R	Imaging
0.90	1.43	1.27	1.25
1.15	1.35	1.33	1.26
1.40	1.37	1.36	1.31
1.50	1.30	1.32	1.29
1.58	1.30	1.27	1.29
2.00	1.14	1.16	1.14

- Observed count rates > ETC predictions
- GR150C has better throughput in blue compared to GR150R

Analysts: Swara Ravindranath, Chris Willottt, Kevin Volk

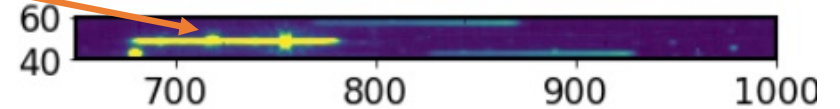


WFSS Performance: Lovely emission lines for wavecal



- Wavelength dispersion solution less than 5-10% of a resolution element
 - Dispersion solution error: 5.9 A/pix (R), 9.1 A/pix (C) -> 0.12-0.2 pixel
- Distortion solution adds another ~1/20 pixel (3 mas) uncertainty at other field positions
 - Wavelength solution will be refined in Cycle 1 calibration plan

Emission lines!



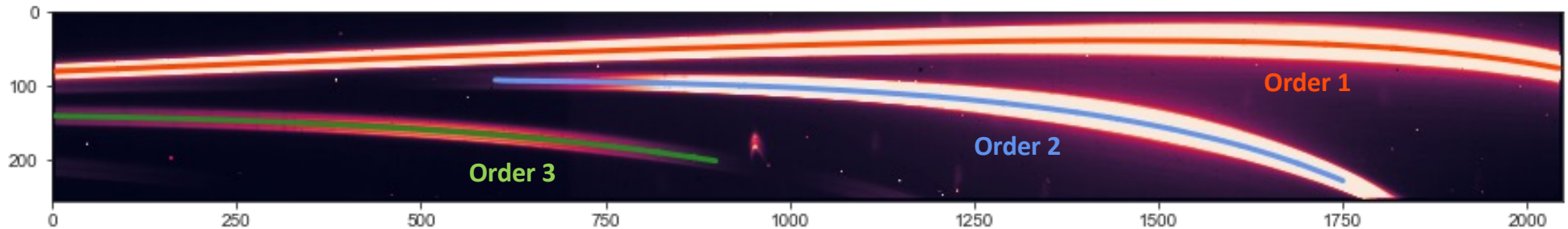
Data from APT 1090

Analysts: Cami Pacifici, Chris Willott

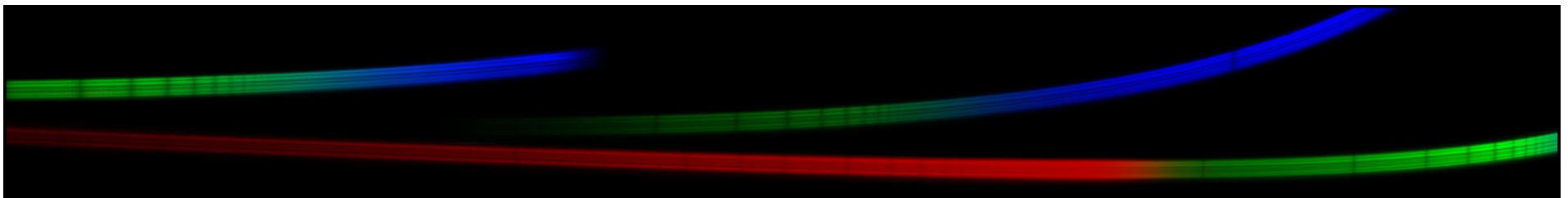


Single Object Slitless Spectroscopy (SOSS): 0.6 – 2.8 μm , R ~700

SOSS is Time Series Observation (TSO) mode for NIRISS – optimized to characterize atmospheres of transiting exoplanets



Data from APT 1541 (CAR NIS-034)



Data from APT 1092 (CAR NIS-018)

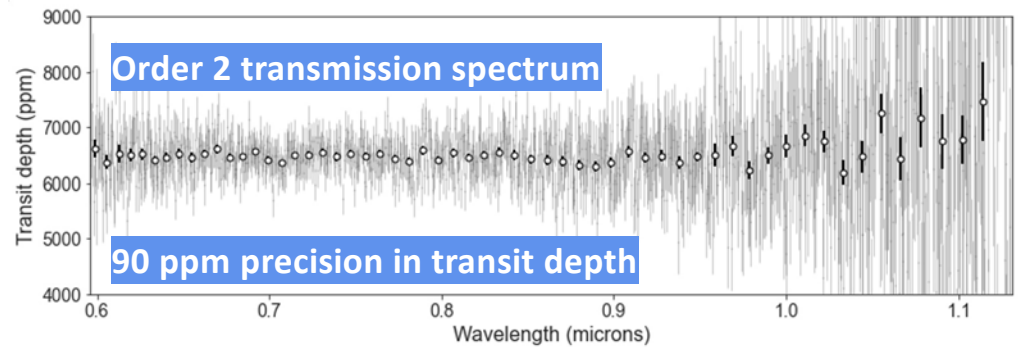
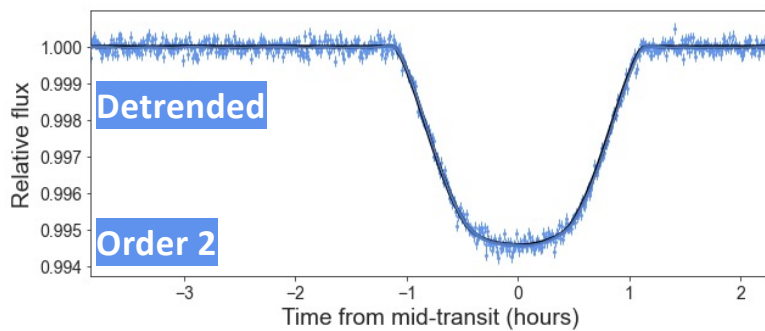
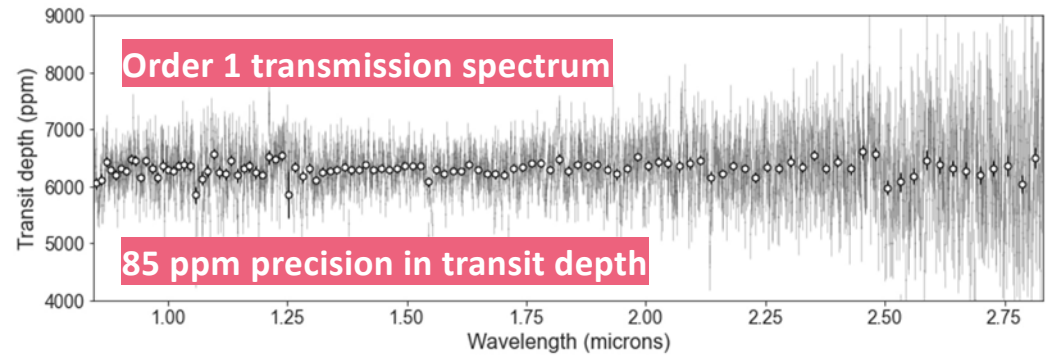
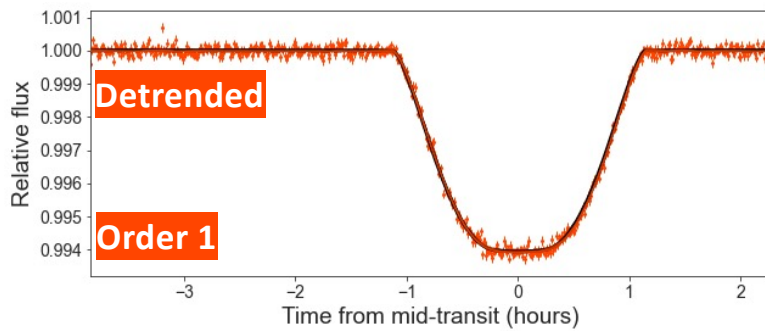
Credit: Néstor Espinoza (top), René Doyon & Loïc Albert (bottom)



SOSS Performance: Transits are beautiful

Light curve fits

(observing starlight dim from transiting exoplanet)



Data from APT 1541

Analysts: Néstor Espinoza

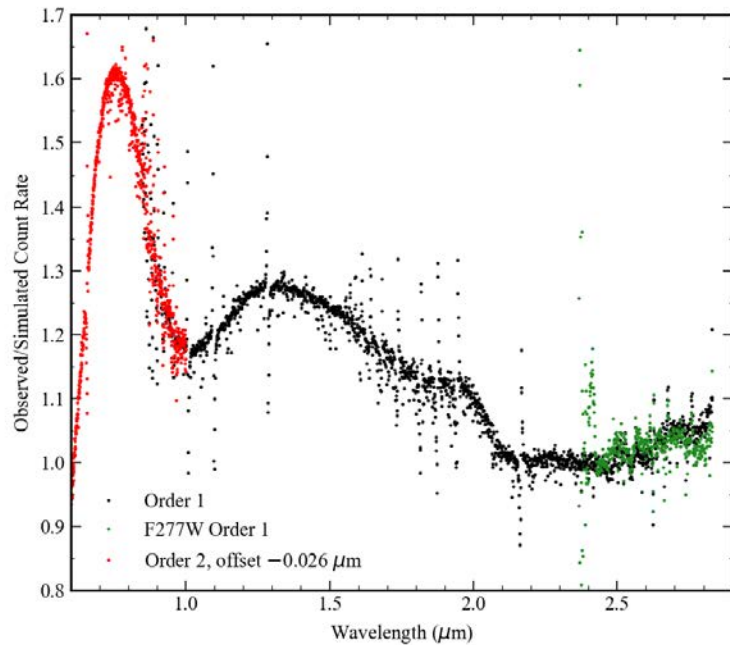
Binned at $R = 100$



SOSS Performance: Throughput overperforms, wavecal under investigation

SOSS throughput is better by:

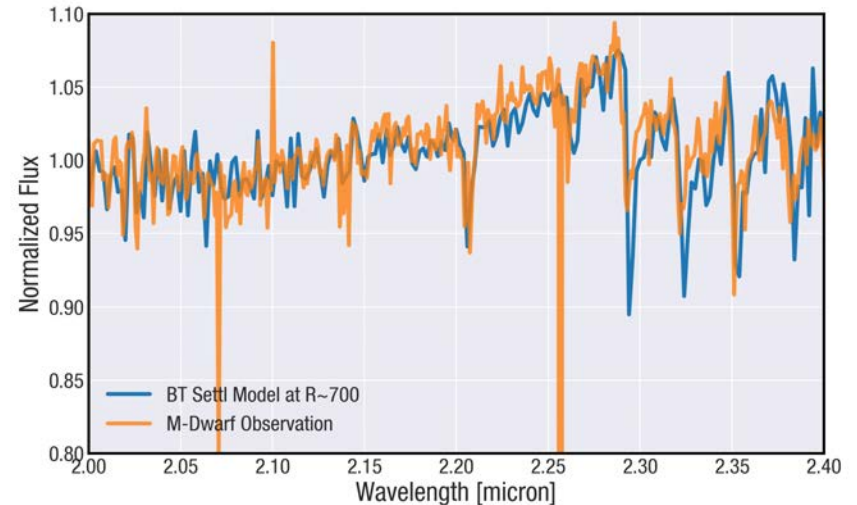
- 25% order 1 near blaze wavelength ($1.3 \mu\text{m}$)
- 50% order 2



Analyst: Kevin Volk (Data from APT 1091)

Wavelength calibration offset by $\sim 1\text{-}2$ pixels $\geq 2.3 \mu\text{m}$

- wavelength solution shifts from visit-to-visit by ~ 1 pixel
- under investigation



Analyst: Arpita Roy (Data from APT 1092)

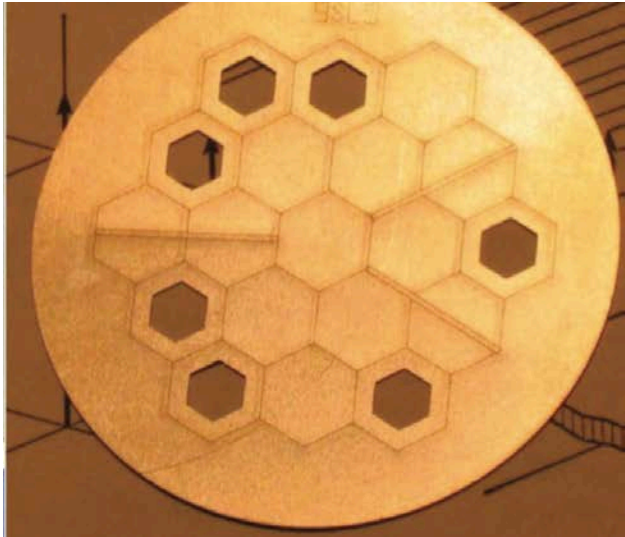
Other on-going SOSS work:

Joe Filippazzo investigating source contamination overlap tool accuracy



Aperture Masking Interferometry (AMI): 2.8, 3.8, 4.3, 4.8 μm

AMI is High Contrast Imaging (HCI) mode for NIRISS – resolve separations of $\sim 70\text{-}400$ mas for contrast ratios of $\sim 10^{-4}$



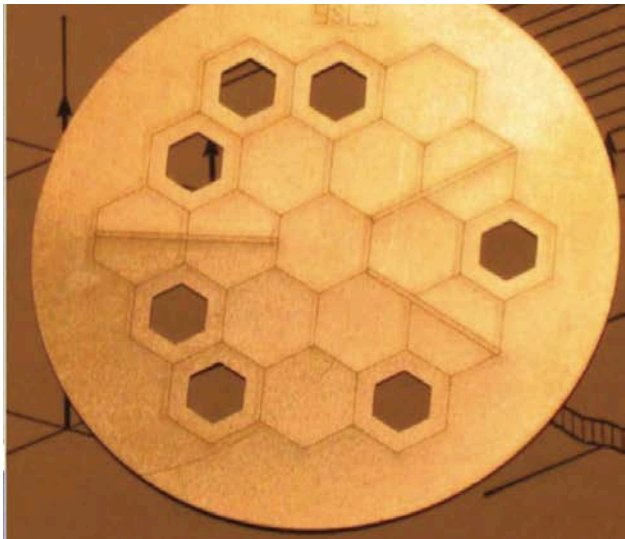
Non-Redundant Mask (NRM)

Credit: Anand Sivaramakrishnan, Deepashri Thatte, Rachel Cooper

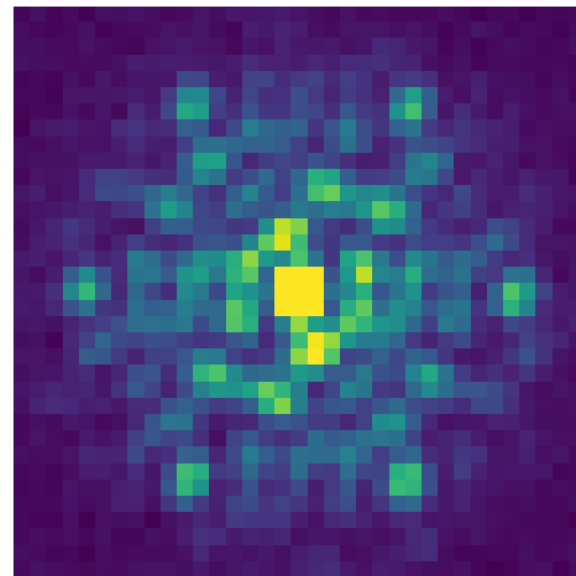


Aperture Masking Interferometry (AMI): 2.8- 4.8 μm

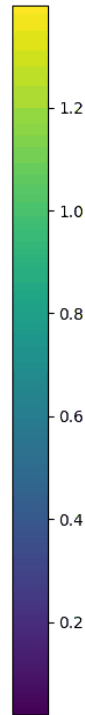
FIRST EVER INFRARED INTERFEROMETRIC IMAGE FROM SPACE



Non-Redundant Mask (NRM)



Data from APT 1085 (NIS-010)

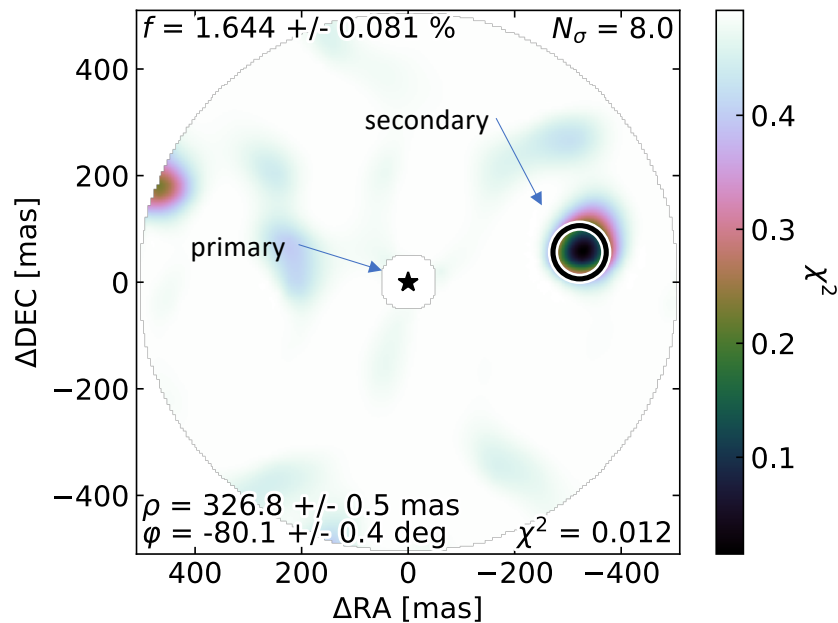


Credit: Anand Sivaramakrishnan, Deepashri Thatte, Rachel Cooper



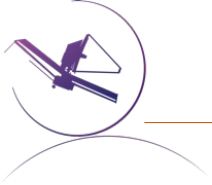
AMI Performance: AB Dor c detected with ease!

Chi-squared map



	Separation [mas]	Position angle [deg]	Δ Magnitudes
Model	369.392 +/- 15.0	286.656 +/- 20.0	4.203 +/- 0.34
Epoch 1	326.163 +/- 3.58	279.627 +/- 0.63	4.557 +/- 0.06
Epoch 2	326.850 +/- 2.45	279.899 +/- 0.43	4.460 +/- 0.04
Pass?	✓	✓	✓

Analysts: **Rachel Cooper**, Deepashri Thatte, Anand Sivaramakrishnan (Data from APT 1093)



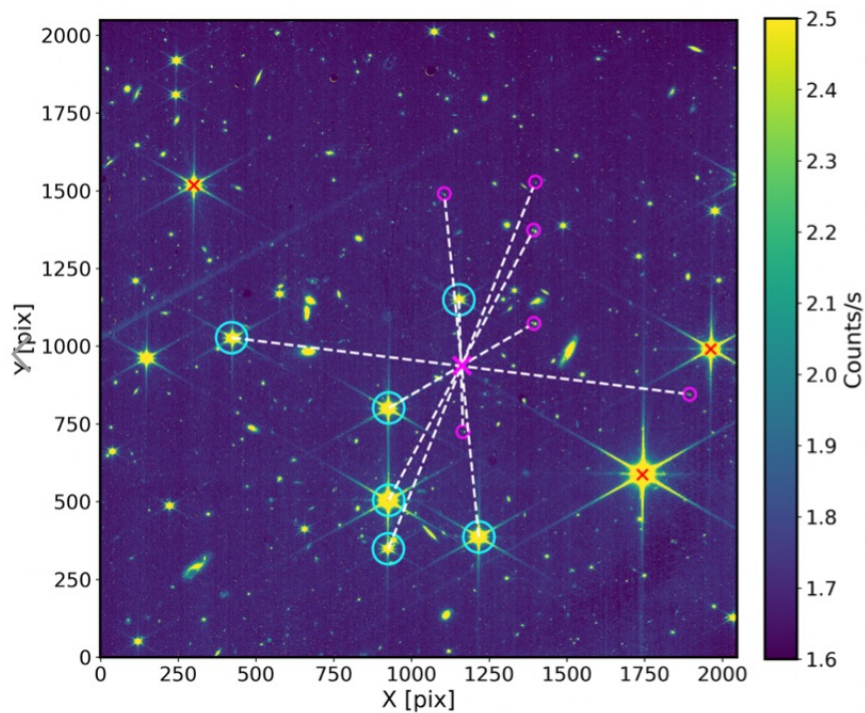
*Detector features that will be with us
throughout the mission...*

(Don't worry, impact to awesome science is low!)



Features we expected (see NIRISS Features & Caveats JDoc article)

Ghosts



Data from APT 1063

- source causing ghost
- X ghost axis point (GAP)
- ghost

From commissioning:

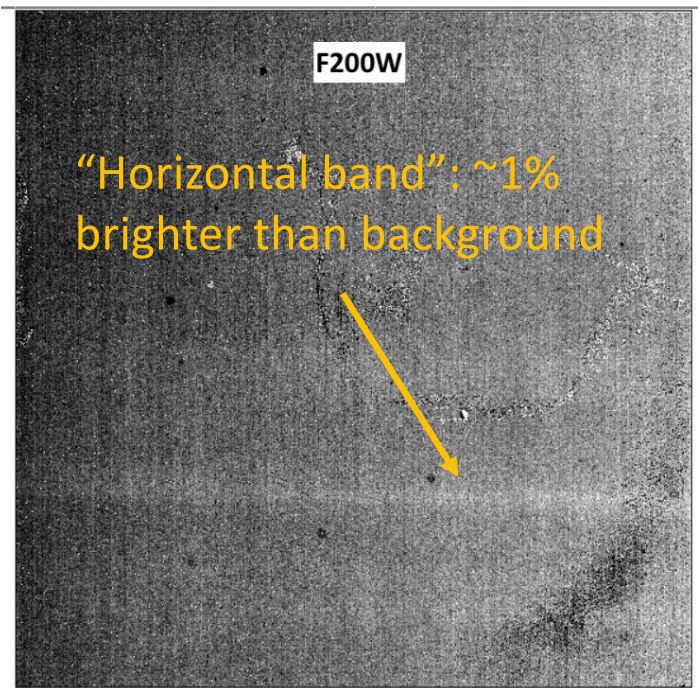
- Updated GAPs for some filters
- Discovered “ghosting zone”: some sources expected to form ghosts don’t (red Xs)

Credit: Jo Taylor, Chris Willott, André Martel

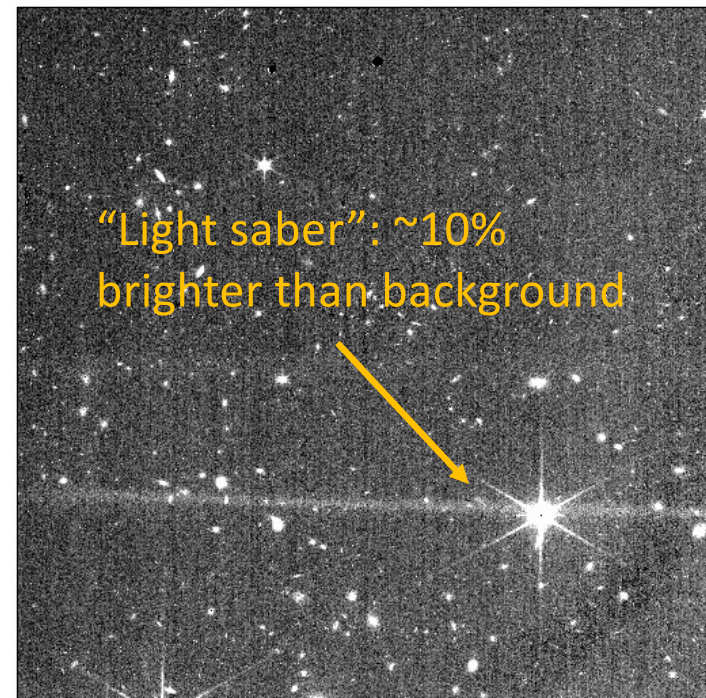


Features we didn't expect...

Flat field image



Sky image

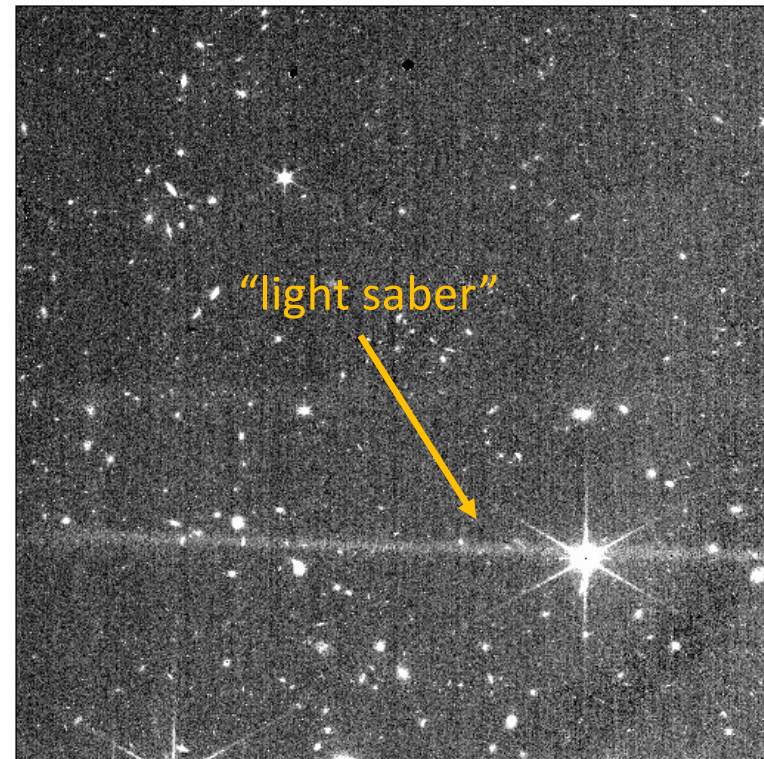


Credit: Loïc Albert, Chris Willott, Etienne Artigau (Data from APT 1063)



Origin of horizontal band & light saber

- Ray tracing model from Scott Rohrbach (GSFC) identified a susceptibility region: light enters NIRISS through “rogue path”
- *Horizontal band* (~1% brighter than background) from zodiacal light & fainter stars in susceptibility region
 - Will always be present in imaging & WFSS observations: model to subtract out in pipeline processing
- *Light saber* (~10% brighter than background) from bright star in region ($K < 2$ mag, Vega)
 - Can mostly avoid this feature by setting aperture angle constraints



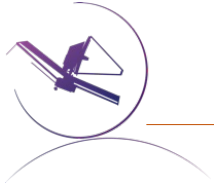
Data from APT 1063

Credit: Loïc Albert, Chris Willott, Etienne Artigau

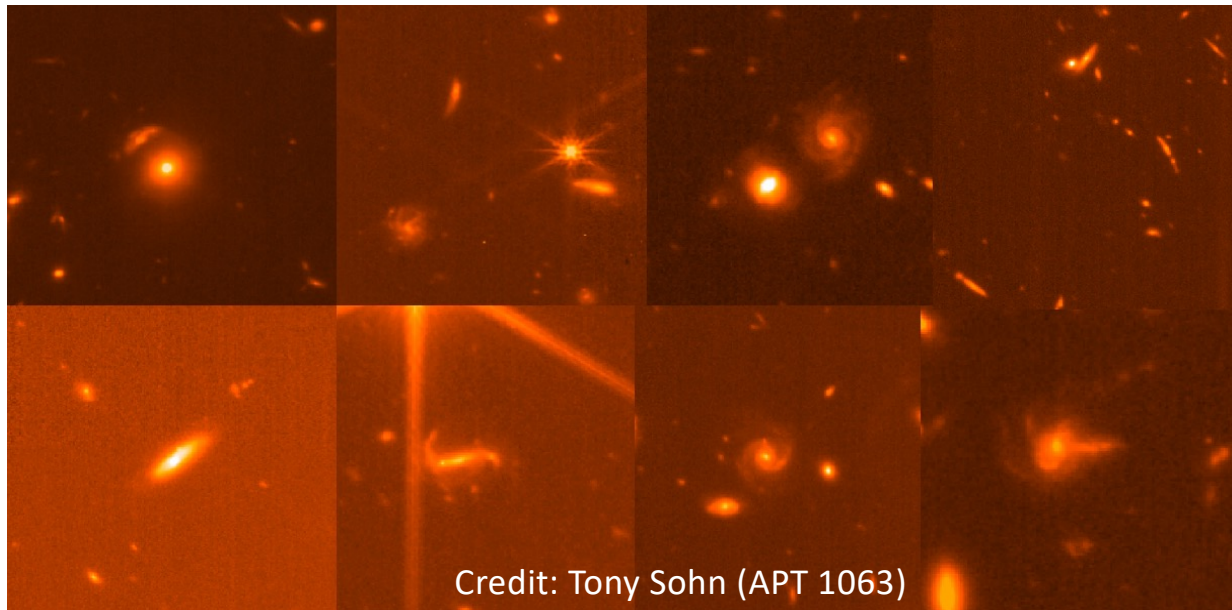


Impacts to Science Programs based on Commissioning Knowledge

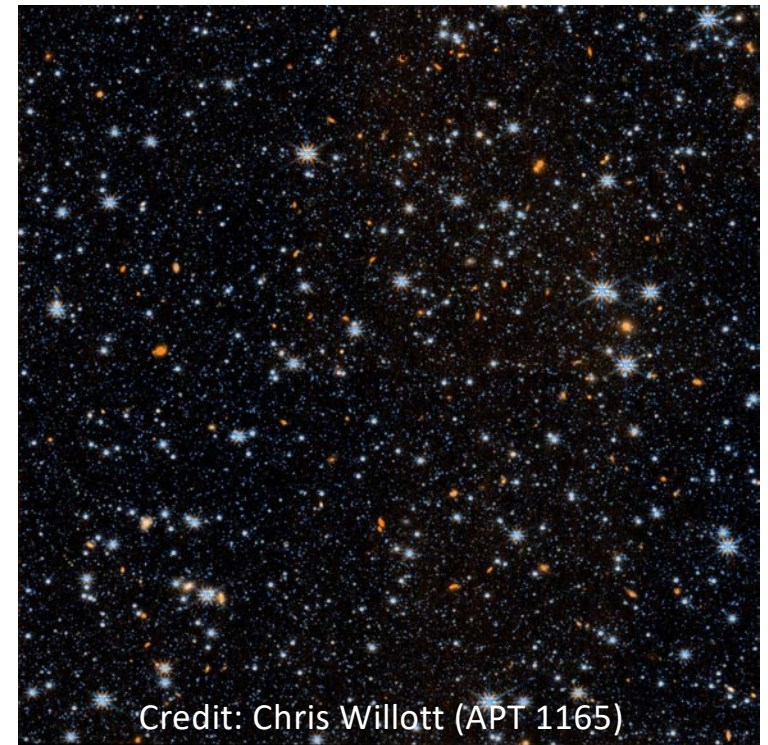
- Increased sensitivity & throughput
 - **Short term:** work with AMI and SOSS PIs to update their APT programs to minimize saturation risk (or obtain consent to accept risk)
 - **By Cycle 2 Call for Proposals:** update ETC and JDox to reflect measured in-flight performance values
- Light saber
 - **Short term:**
 - Review WFSS programs to impose aperture angle constraints to avoid bright stars in susceptibility region
 - Test background subtraction model of horizontal band for imaging & WFSS modes
 - **By Cycle 2 Call for Proposals:** release tool to community to identify position angles free from $K < 2$ mag stars in susceptibility region
- Ghosts
 - Update imaging ghost ID & removal tool with new GAPs (ghost axis points) derived from in-flight data
 - **Long term:** release WFSS ghost ID & removal tool, characterize ghost properties from additional data to optimize ID & removal tools



NIRISS IS A GO FOR SCIENCE



Credit: Tony Sohn (APT 1063)



Credit: Chris Willott (APT 1165)