

# SALTUS/Ad ASTRA

Single Aperture Large Telescope for Universe Studies

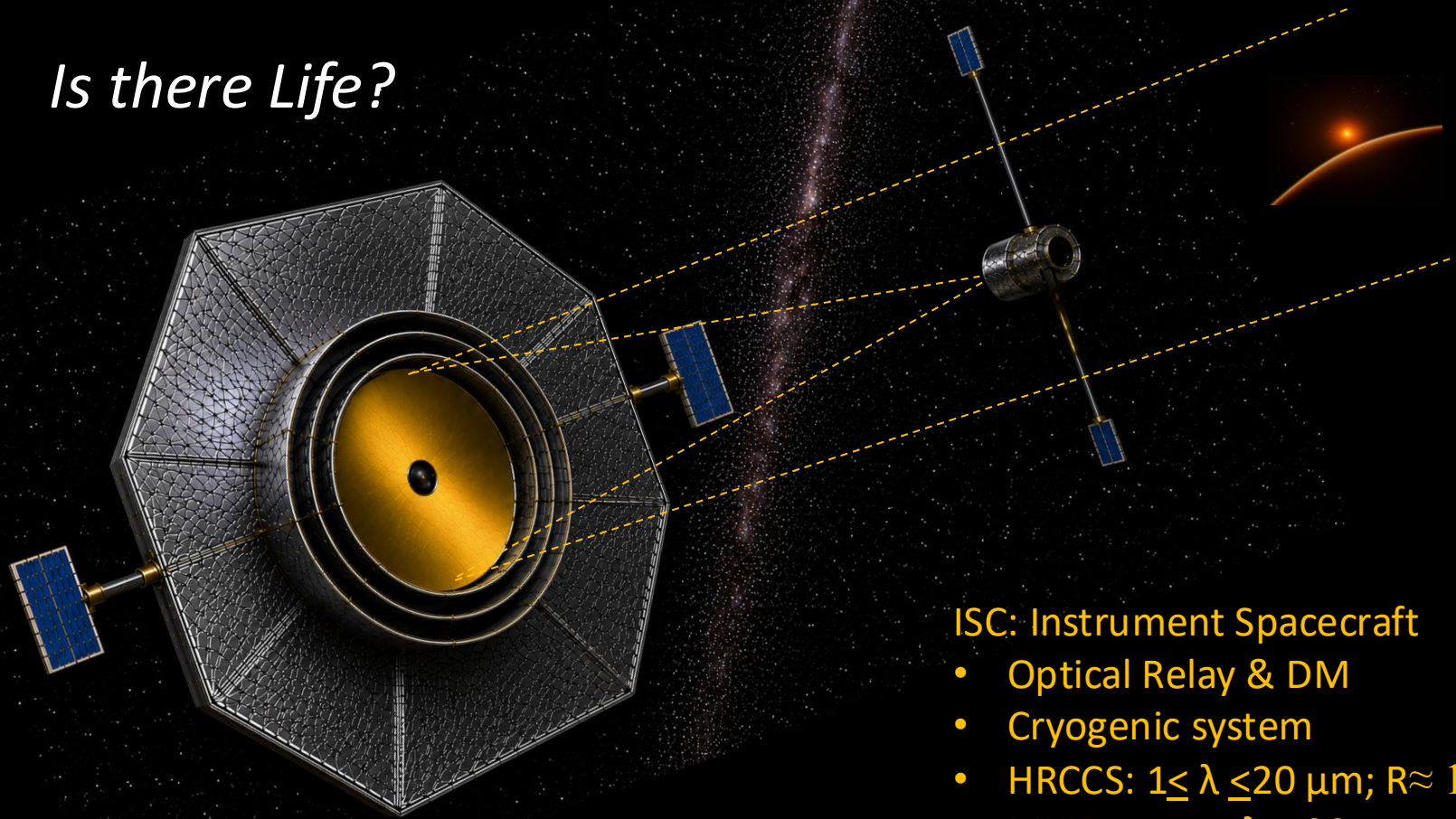


*Is there Life?*

NORTHROP  
GRUMMAN



SRON



ISC: Instrument Spacecraft

- Optical Relay & DM
- Cryogenic system
- HRCCS:  $1 \leq \lambda \leq 20 \mu\text{m}$ ;  $R \approx 10^5$
- MKID arrays:  $\lambda > 20 \mu\text{m}$
- Ion Thrusters  $\sim 220\text{m/s yr}^{-1}$
- Laser Metrology with nm precision
- $<12\%$  obscuration @ 10K

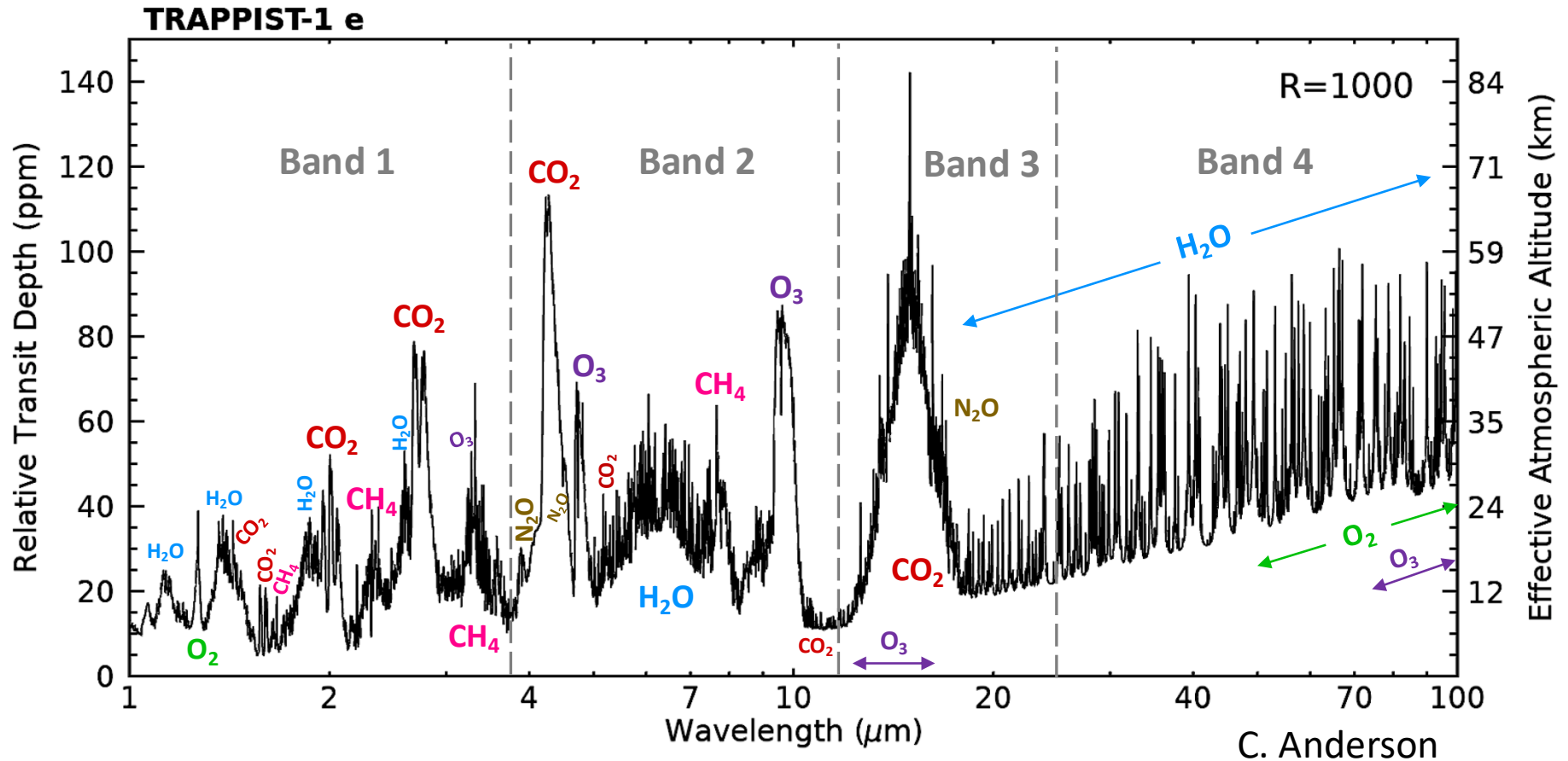
PSC: Primary Spacecraft

- Large Pressure Controlled Membrane Reflector
- Sunshield & Baffle
- $\sim 10\text{K}$  Operating Temp.

cwalker@arizona.edu

# Ad ASTRA-SALTUS: Best Case for Detecting Biosignatures

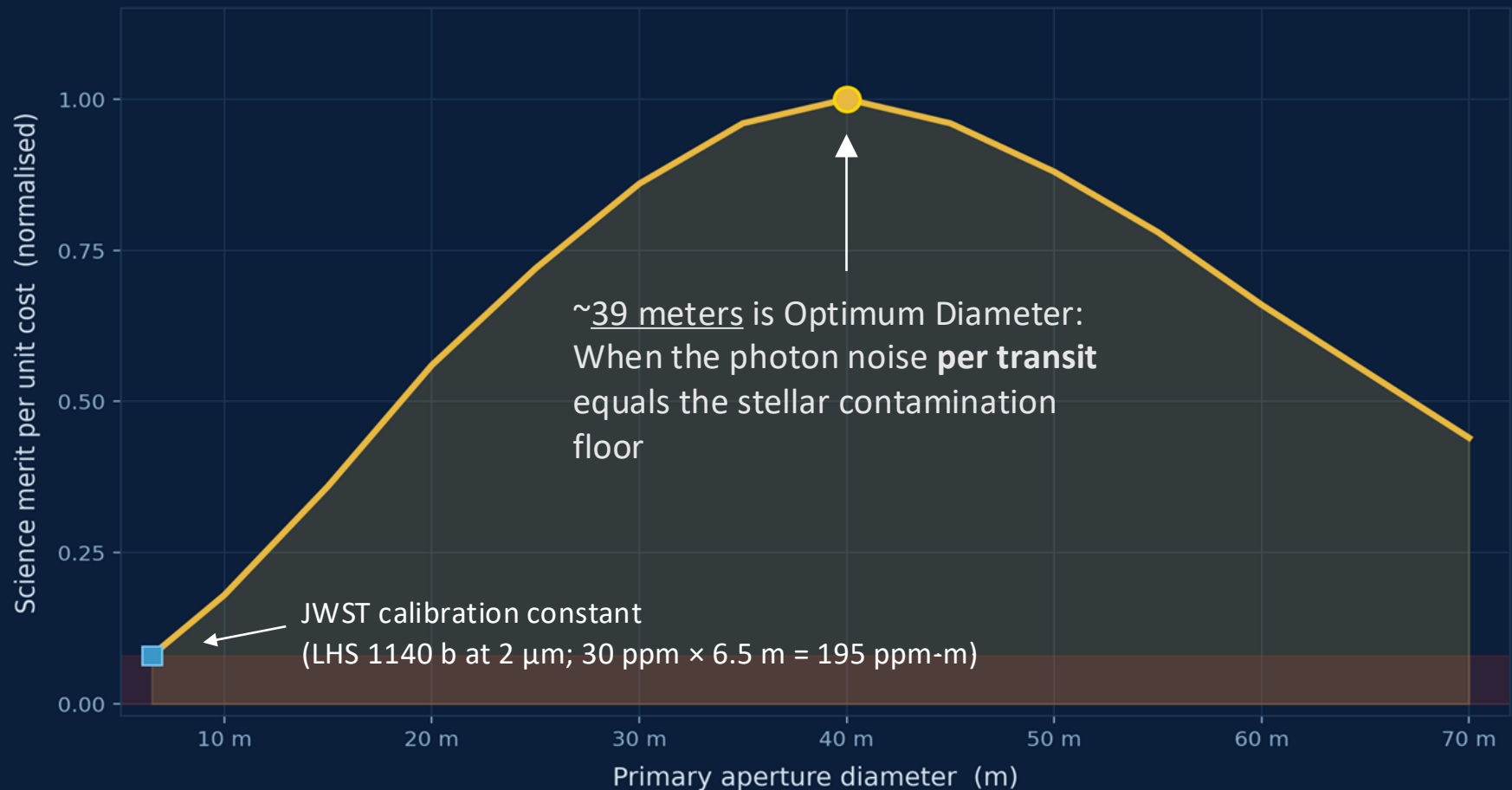
Full Biosignature Disequilibrium Observations at  $\sim 5$  ppm  
with High-Resolution Cross-Correlation Spectrometers



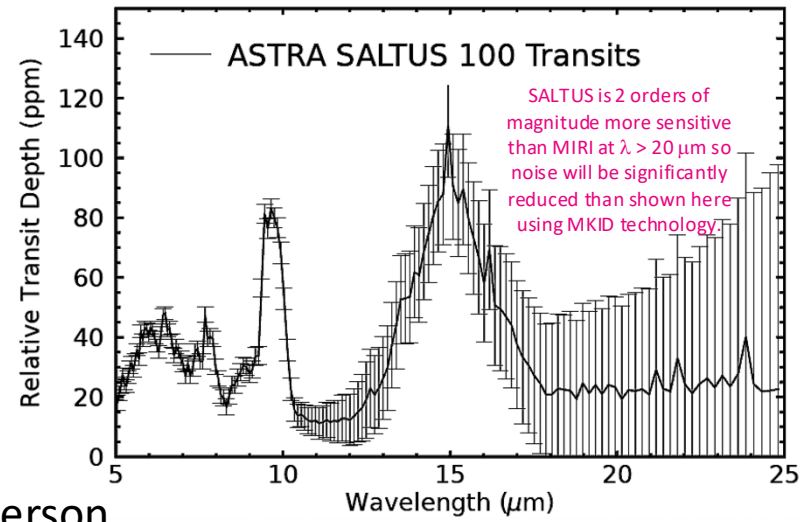
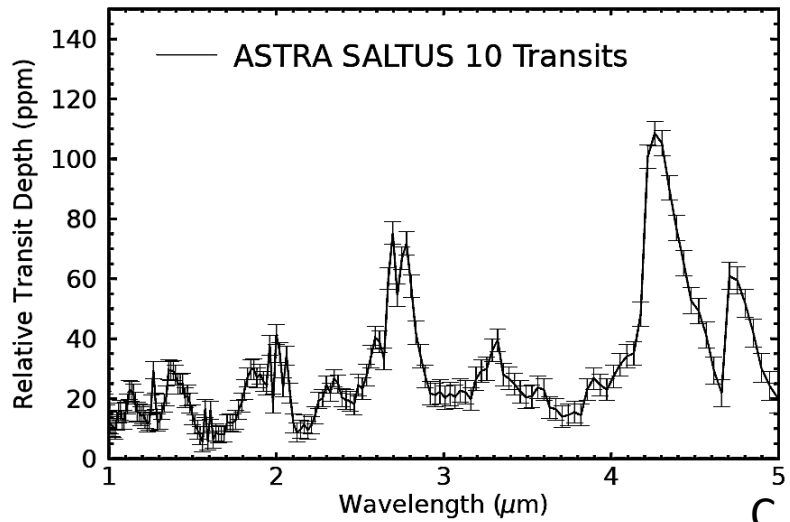
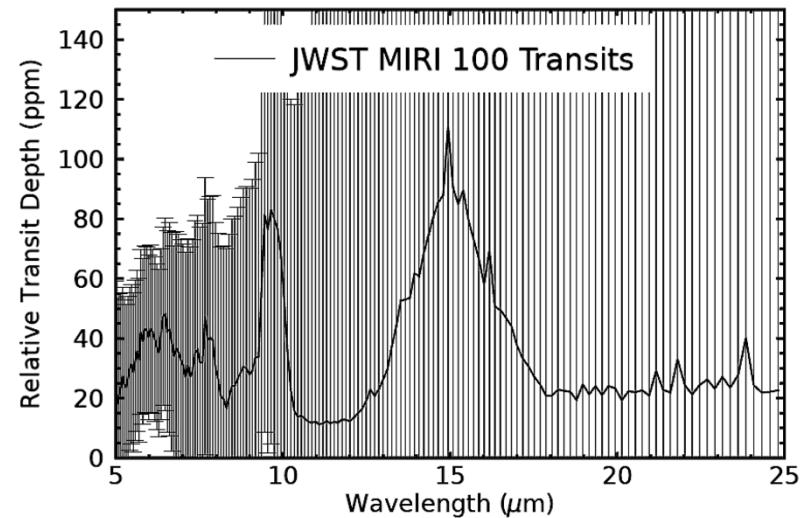
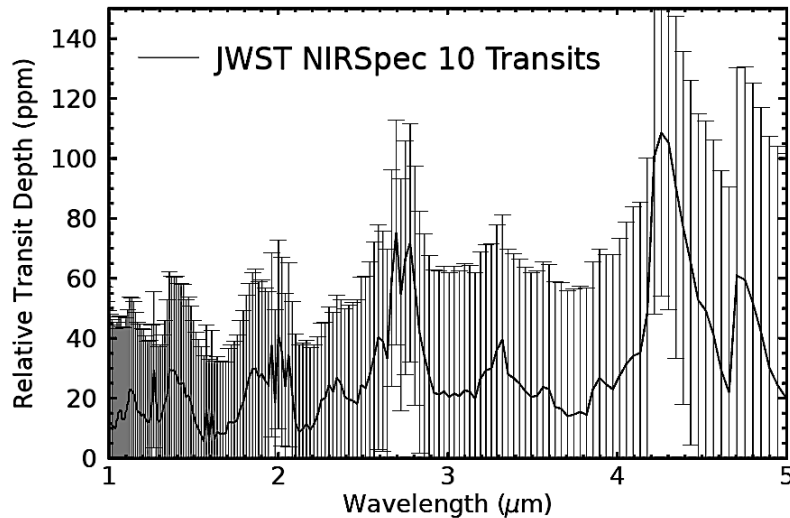
*Simulated TRAPPIST-1e transmission spectrum at R=1000 via the Planetary Spectrum Generator (PSG) with terrestrial-like vertical gas and P-T profiles, and no clouds.*

# How Big?

SALTUS Science Merit Function vs. Aperture Diameter



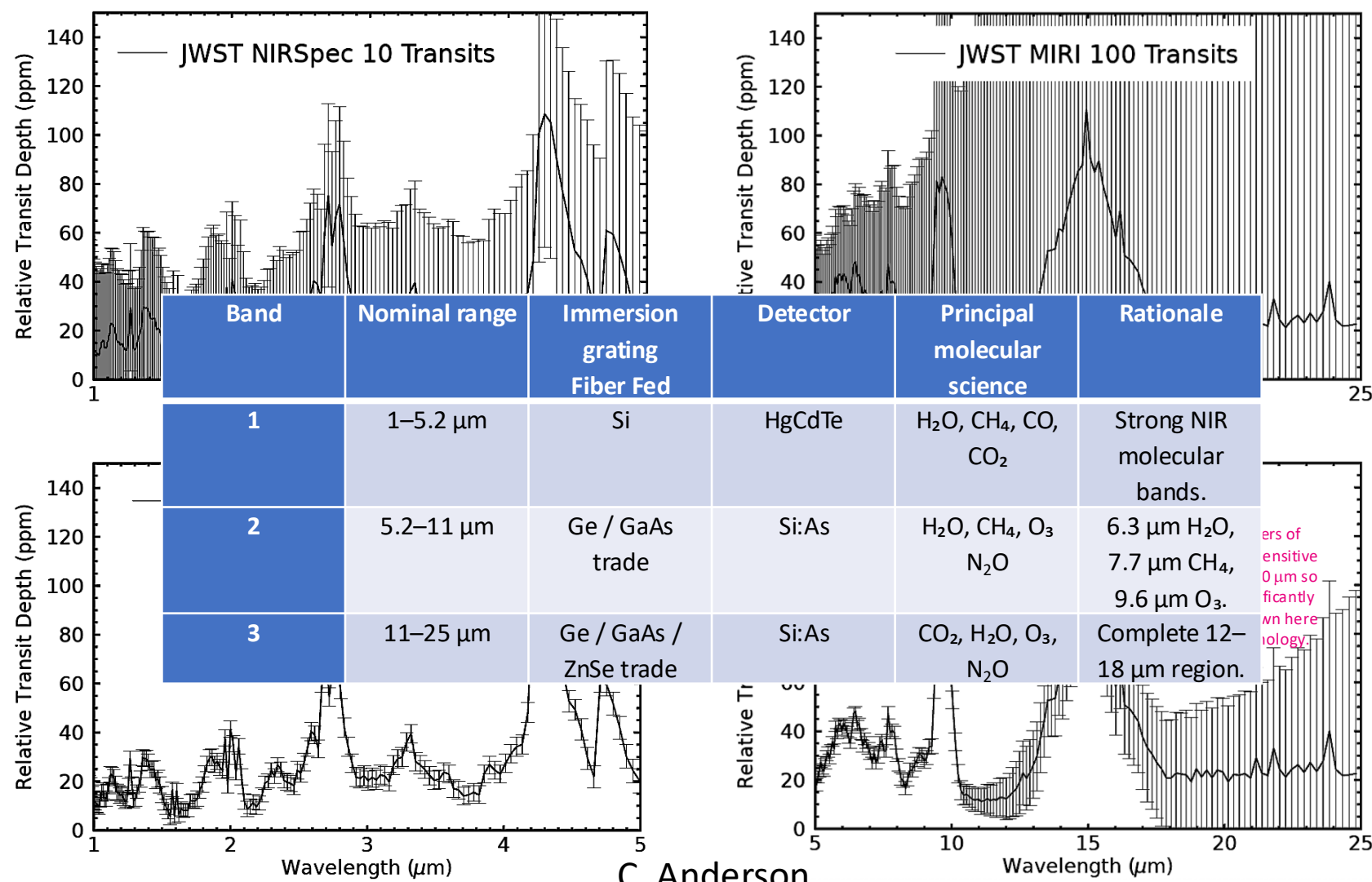
# Ad ASTRA-SALTUS: Impact of Number of Transits at First Glance



C. Anderson

*Simulated TRAPPIST-1e transmission spectra via the PSG at  $R=100$ . SALTUS simulations adopted JWST NIRSpec and MIRI instrument noise – only the M1 diameter changed to 40 m.*

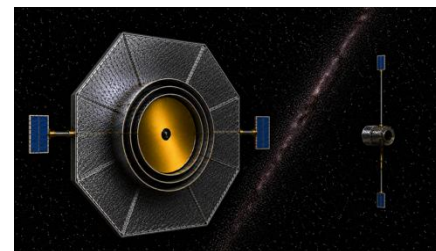
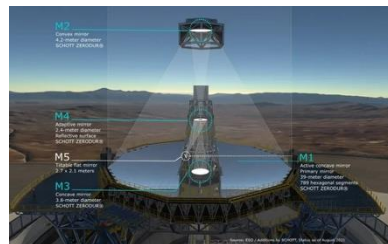
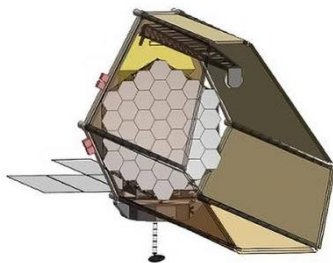
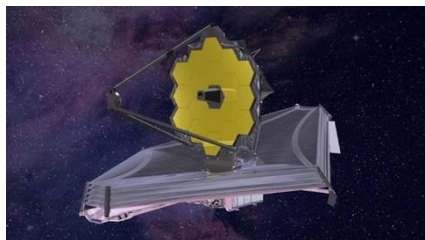
# Ad ASTRA-SALTUS: Impact of Number of Transits at First Glance



C. Anderson

*Simulated TRAPPIST-1e transmission spectra via the PSG at R=100. SALTUS simulations adopted JWST NIRSpec and MIRI instrument noise – only the M1 diameter changed to 40 m.*

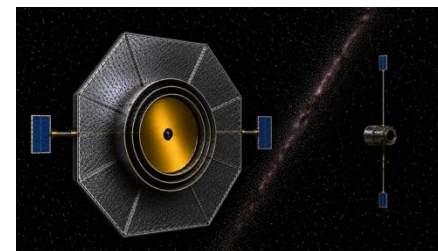
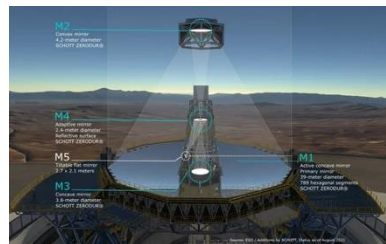
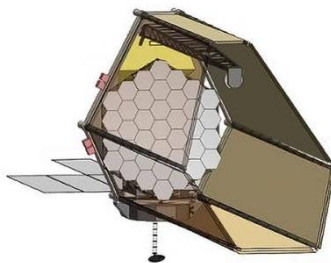
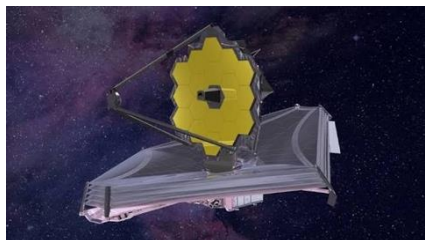
# How do they Compare?



| Capability                                           | JWST                       | HWO (planned)       | ELT<br>(METIS+ANDES)    | SALTUS                                    |
|------------------------------------------------------|----------------------------|---------------------|-------------------------|-------------------------------------------|
| <b>Aperture</b>                                      | 6.5 m<br>(~35,700 kg @39m) | ~6 m                | 39 m<br>(~200,000 kg)   | <b>~39 m inflatable<br/>(~100 kg)</b>     |
| <b>Primary type</b>                                  | Rigid segments             | Rigid segments      | Rigid segments          | <b>Hencky membrane</b>                    |
| <b>Operating temp.</b>                               | 50 K                       | ~50 K               | 280 K (ground)          | <b>10 K</b>                               |
| <b>Wavefront control</b>                             | Passive                    | Passive             | SCAO/MCAO               | <b>Offner relay + DM</b>                  |
| <b>Wavelength range</b>                              | 0.6–28 $\mu\text{m}$       | 0.1–2 $\mu\text{m}$ | 0.35–14 $\mu\text{m}^*$ | <b>1–25+ <math>\mu\text{m}</math></b>     |
| <b>O<sub>3</sub> at 9.6 <math>\mu\text{m}</math></b> | Marginal                   | No                  | Difficult*              | <b>Yes (single transit)</b>               |
| <b>N<sub>2</sub>O at 17 <math>\mu\text{m}</math></b> | No                         | No                  | No                      | <b>Yes</b>                                |
| <b>Telluric confusion</b>                            | None                       | None                | Severe                  | <b>None</b>                               |
| <b>Photon noise floor</b>                            | ~30 ppm                    | ~10 ppm             | ~20 ppm (NIR)           | <b>~5 ppm</b>                             |
| <b>Biosig. ensemble</b>                              | Partial                    | NIR only            | Partial                 | <b>Full 1–25 <math>\mu\text{m}</math></b> |
| <b>Transit capture</b>                               | ~95%                       | ~95%                | ~60%                    | <b>~98%</b>                               |

\* ELT mid-IR access is partial, weather-dependent, and severely background-limited beyond 5  $\mu\text{m}$ .

# How do they Compare?

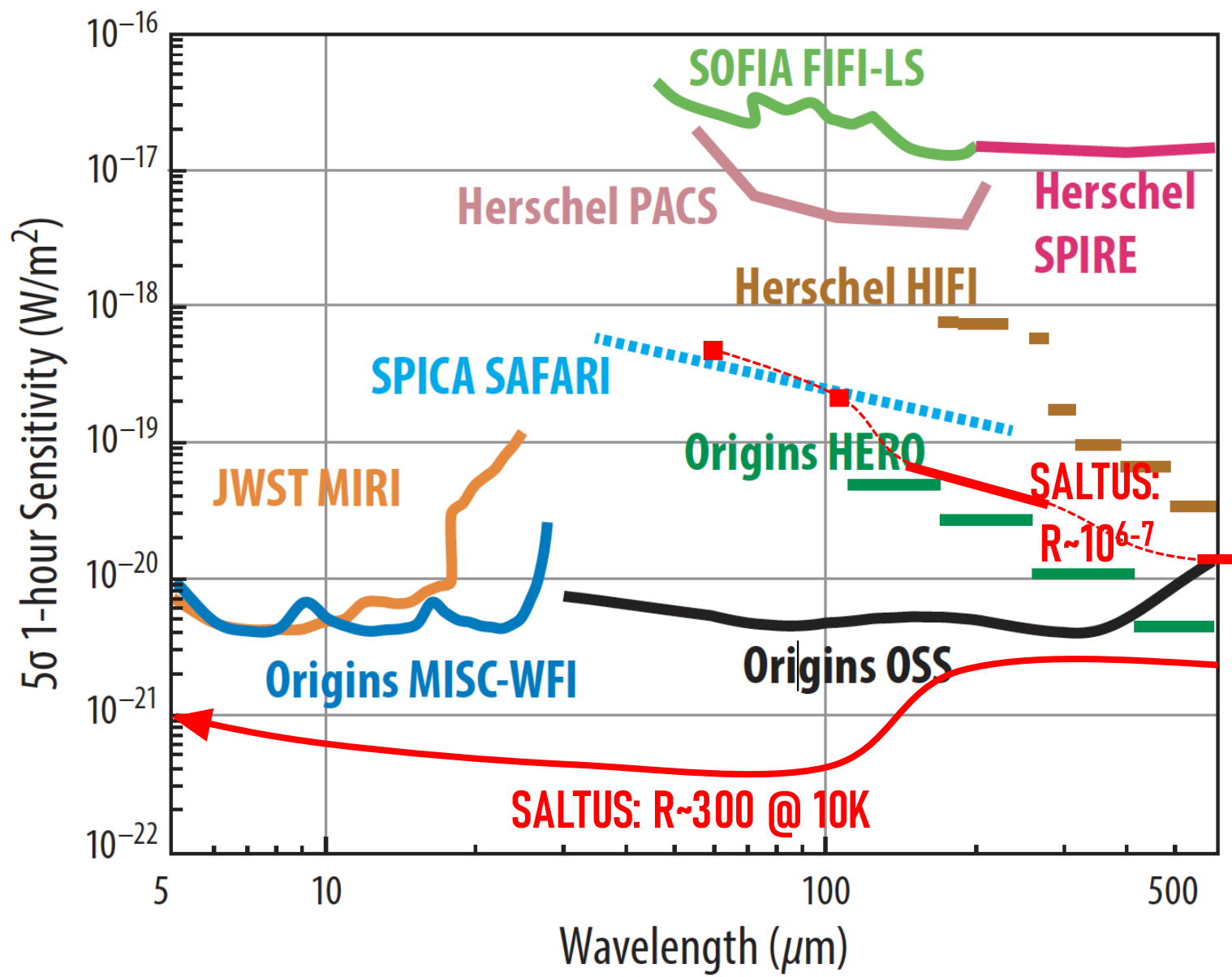


Only One

| Capability                           | JWST                       | HWO (planned)         | ELT (METIS+ANDES)     | SALTUS                        |
|--------------------------------------|----------------------------|-----------------------|-----------------------|-------------------------------|
| Aperture                             | 6.5 m<br>(~35,700 kg @39m) | ~6 m                  | 39 m<br>(~200,000 kg) | ~39 m inflatable<br>(~100 kg) |
| Primary type                         | Rigid segments             | Rigid segments        | Rigid segments        | Hencky membrane               |
| Operating temp.                      | 50 K                       | 50 K                  | 50 K                  | 10 K                          |
| Wavefront control                    | Passive                    | Passive               | Passive               | Offner relay + DM             |
| Wavelength range                     | 0.6–2.5 $\mu\text{m}$      | 0.6–2.5 $\mu\text{m}$ | 0.6–2.5 $\mu\text{m}$ | 1–25+ $\mu\text{m}$           |
| O <sub>3</sub> at 9.6 $\mu\text{m}$  | Marginal                   | No                    | Difficult             | Yes (single transit)          |
| N <sub>2</sub> O at 17 $\mu\text{m}$ | No                         | No                    | No                    | Yes                           |
| Telluric confusion                   | None                       | None                  | Severe                | None                          |
| Photon noise floor                   | ~30 ppm                    | ~10 ppm               | ~20 ppm (NIR)         | ~5 ppm                        |
| Biosig. ensemble                     | Partial                    | NIR only              | Partial               | Full 1–25 $\mu\text{m}$       |
| Transit capture                      | ~95%                       | ~95%                  | ~60%                  | ~98%                          |

*Deployable Gossamer  
Primaries are the only  
viable solution.*

\* ELT mid-IR access is partial, weather-dependent, and severely background-limited beyond 5  $\mu\text{m}$ .



# IR Space Observatories

IRAS 1983



0.57m  
2° K  
~0.8 yr

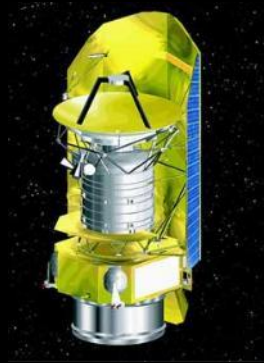
\$0.199 B

ISO  
SWAS

26yr

*Odin*  
*Spitzer*  
*AKARI*

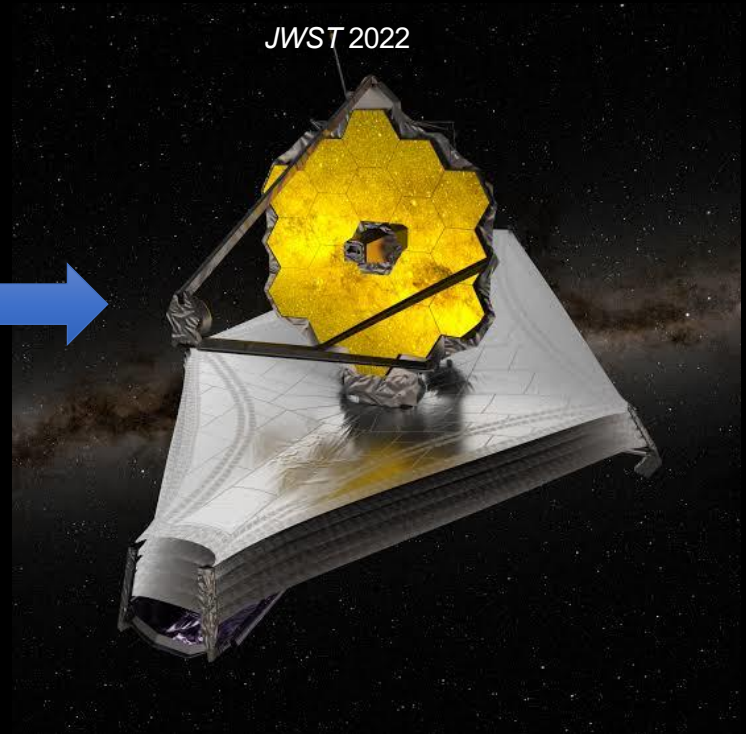
Herschel 2009



3.5m  
~80° K  
3 yr

\$0.776 B

JWST 2022



~\$10 B

# IR Space Observatories

IRAS 1983

ISO  
SWAS

Herschel 2009



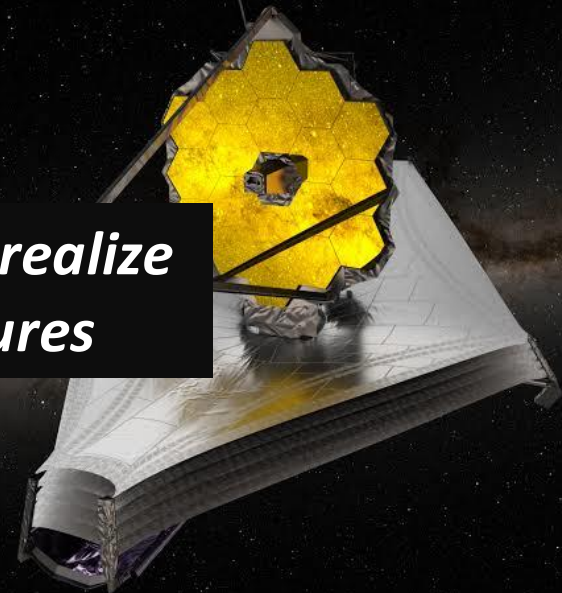
***A Paradigm Shift is required to realize  
Larger IR/Far-IR space apertures***

~0.8 yr

Spritzer  
AKARI

3.5m  
~80° K  
3 yr

JWST 2022



\$0.199 B

\$0.776 B

~\$10 B

## Inflatable Aperture Experiment (IAE): 1996



2021



2026



30 years of Advancement

*Surface Measurement of a Large Inflatable Reflector in Cryogenic Vacuum*  
(Quach, et. al. 2021; Special Session, Proceedings SPIE, 24 August 2021, >100 pages)

# Surface Characterization

Used Optical Deflectometry  
(Precision >100 nm)

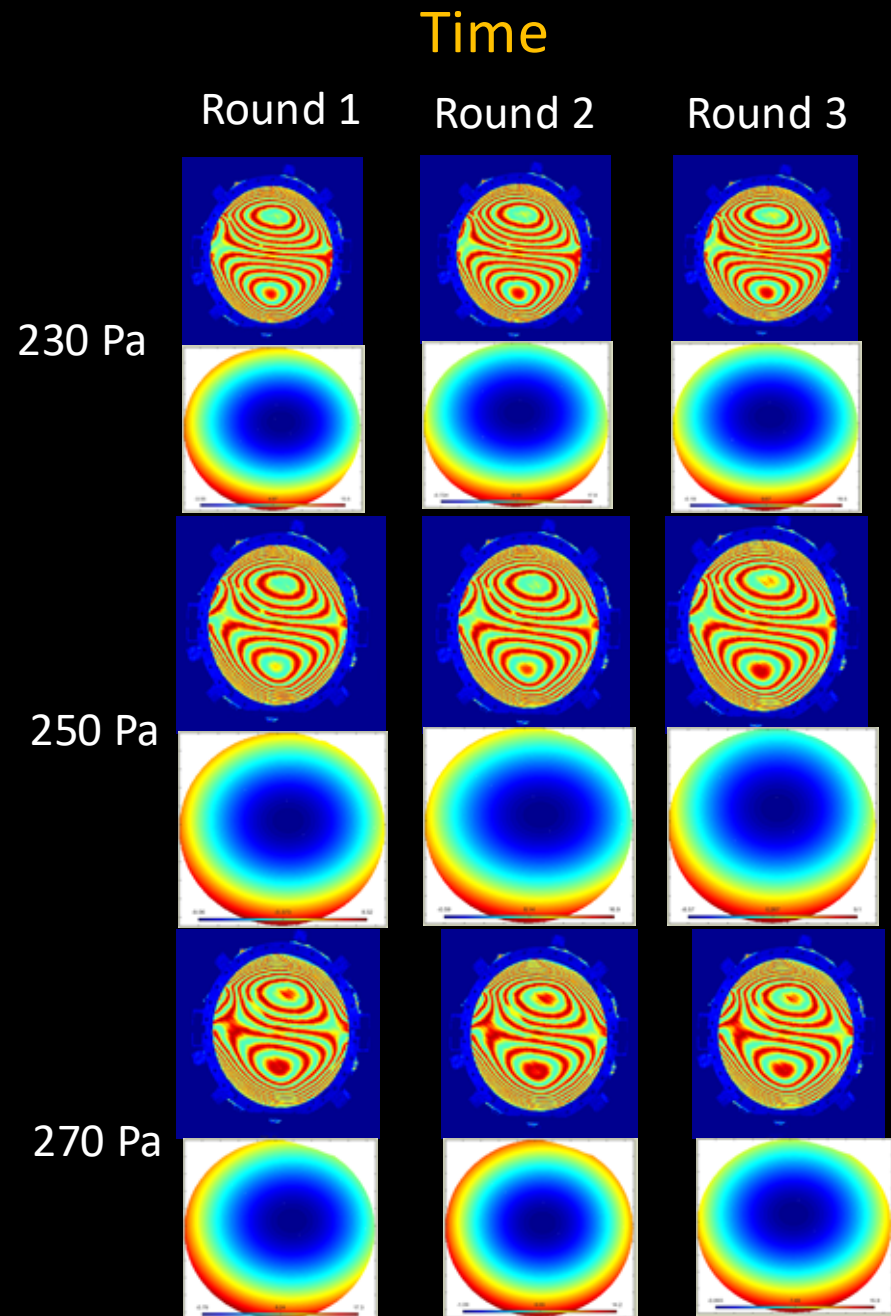
Measured at Multiple Pressures  
and Times

Results Demonstrated

- Repeatable Surface
- Figure Control
- Focus Control
- Capable of Operation in Near IR
  - High Strehl  $\sim 1 \mu\text{m}$



Pressure



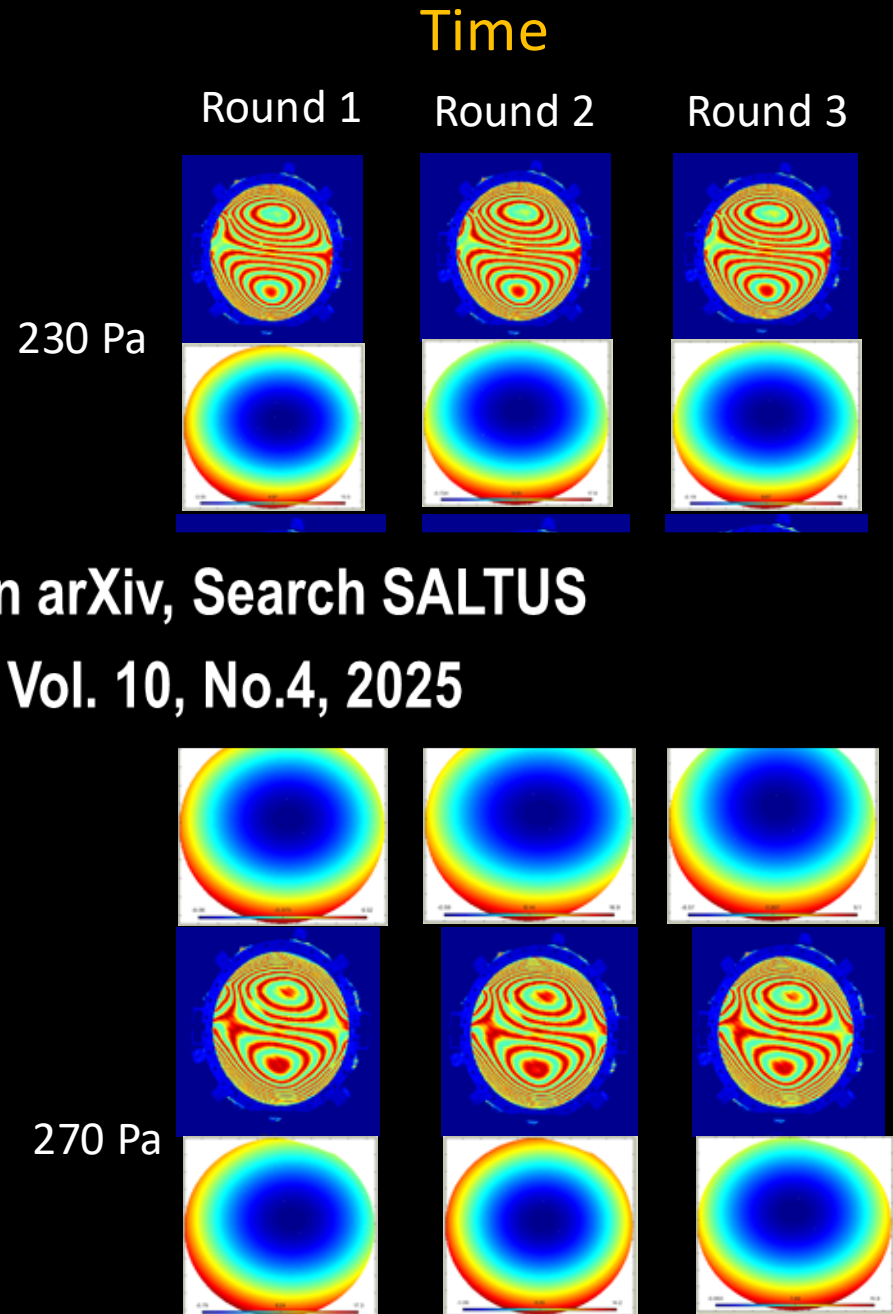
# Surface Characterization

Used Optical Deflectometry  
(Precision >100 nm)

Measured at Multiple Pressures  
and Times

≥7 (~300 pages) papers on arXiv, Search SALTUS  
*JATIS* Special Issue, Vol. 10, No.4, 2025

- Figure Control
- Focus Control
- Capable of Operation in Near IR
  - High Strehl ~1  $\mu\text{m}$



# SALTUS Light Bucket Mode: Unlocking a Universe of Time-Domain Science

**38×**

JWST collecting area

**6.2×**

SNR gain (same time)

**1.9 mag**

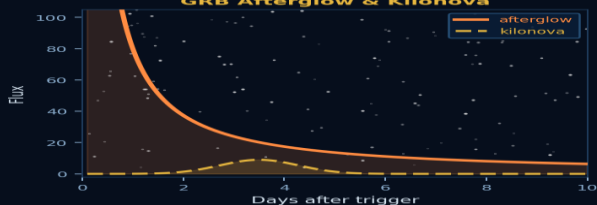
deeper than JWST

**<35 min**

trigger → first photons (ToO)

## GRBs & Kilonovae

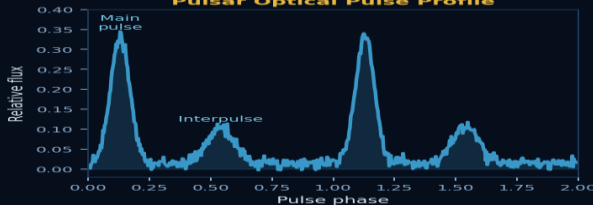
### GRB Afterglow & Kilonova



r-process absorption (Sr II, Ba II) at late times  
→ kilonova spectroscopy in < 5 min

## Compact Object Variability

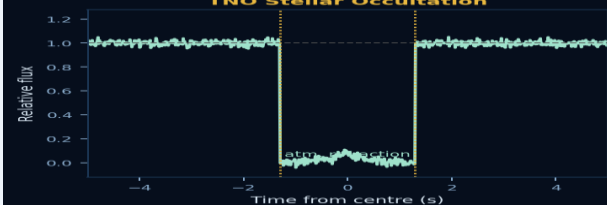
### Pulsar Optical Pulse Profile



ms-cadence Pulsar & QPO photometry —  
6,000 photons/ms

## TNO Stellar Occultations

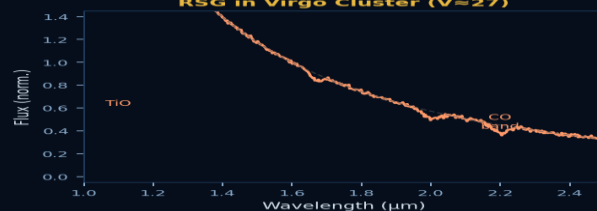
### TNO Stellar Occultation



Single-chord light curves at ground-impossible  
SNR.

## Extragalactic Stellar Pops

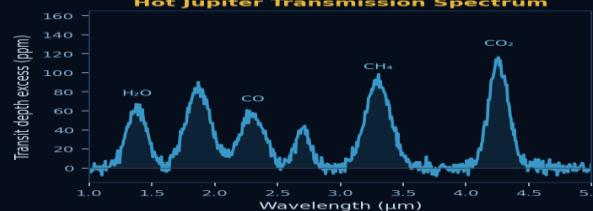
### RSG in Virgo Cluster (V=27)



Individual RSGs in Virgo Cluster (V≈27) at  
R=5,000 in 2 hr.

## Hot Jupiter & Warm Neptune

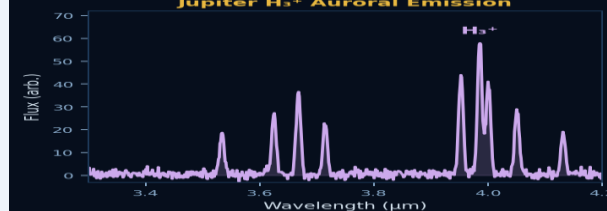
### Hot Jupiter Transmission Spectrum



H<sub>2</sub>O, CO, CH<sub>4</sub>, CO<sub>2</sub> at R~5,000–  
20,000.

## Solar System Auroras & Io

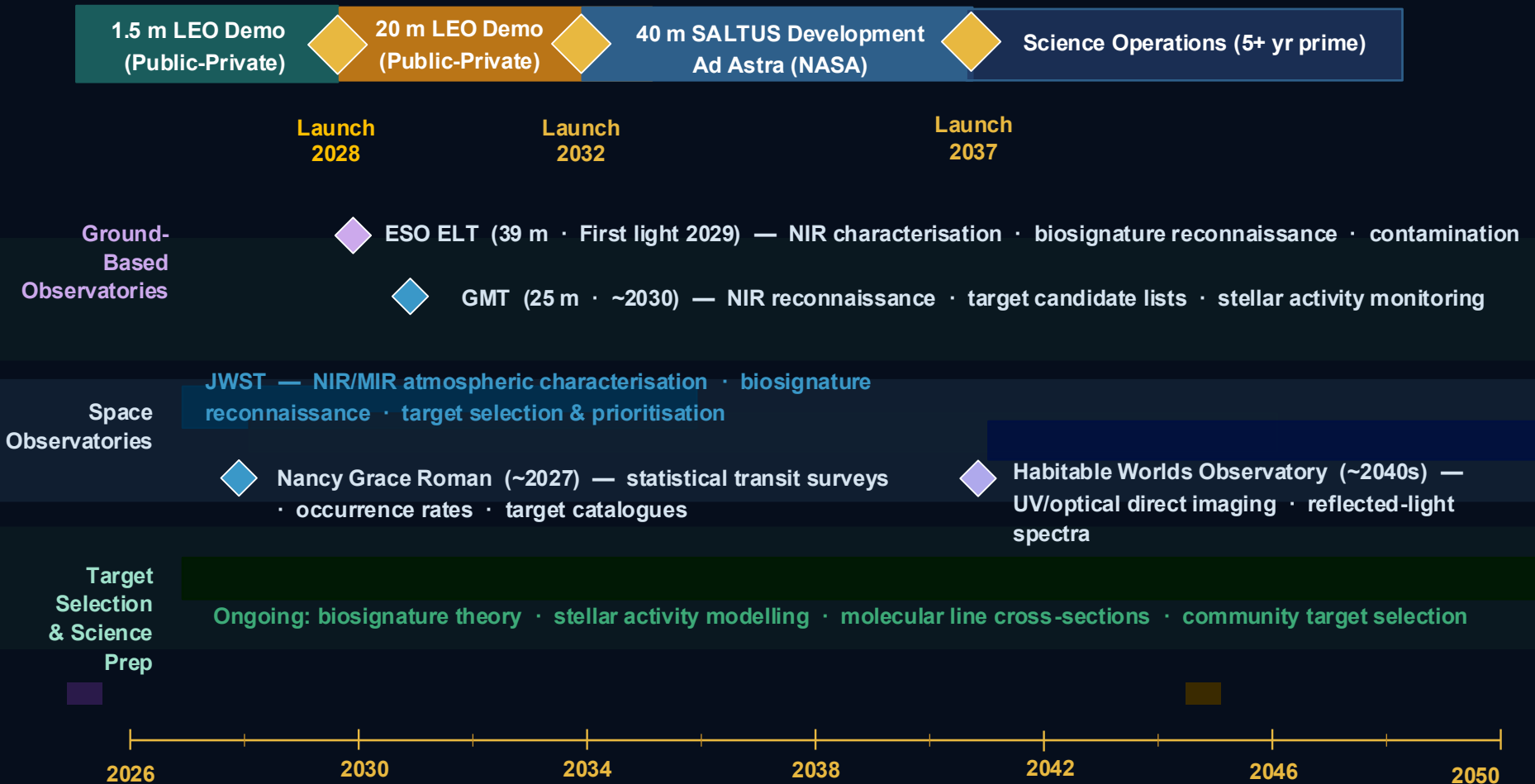
### Jupiter H<sub>3</sub><sup>+</sup> Auroral Emission



H<sub>3</sub><sup>+</sup> auroral lines on giant planets at R=10,000  
in 2 min.

*No AO Needed!*

# SALTUS Development Roadmap



# SALTUS/Ad ASTRA

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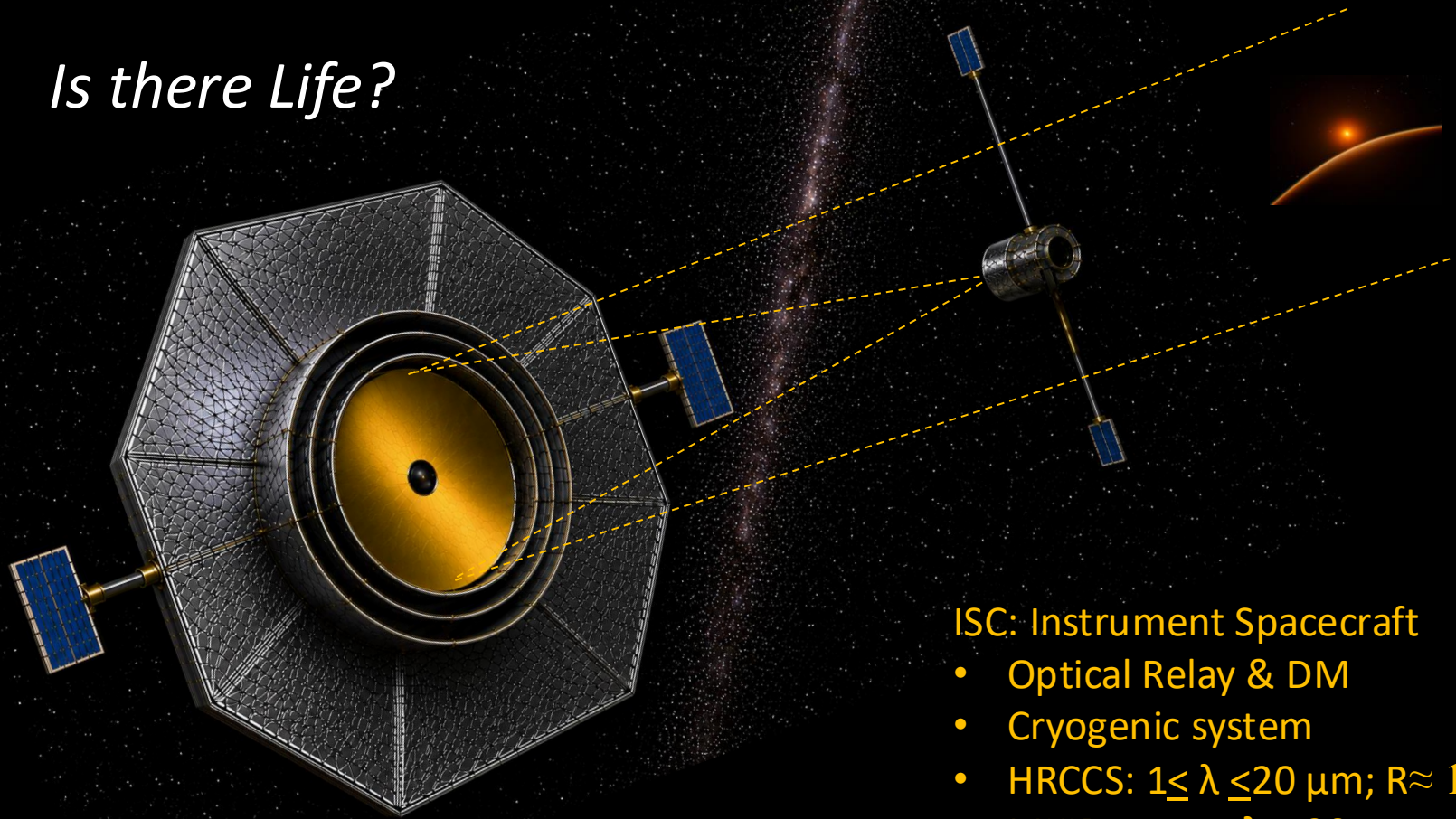


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