

# ***SALTUS: Single Aperture Large Telescope for Universe Studies***

- 14m Reflector
- $\leq 45K$  Optics
- Coherent & Incoherent Spectroscopy/Imaging
- $\sim 30$  to  $660 \mu\text{m}$
- $>5$  yrs Baseline Mission
- $>3.5$  yrs of Guest Observations



**NORTHROP GRUMMAN**

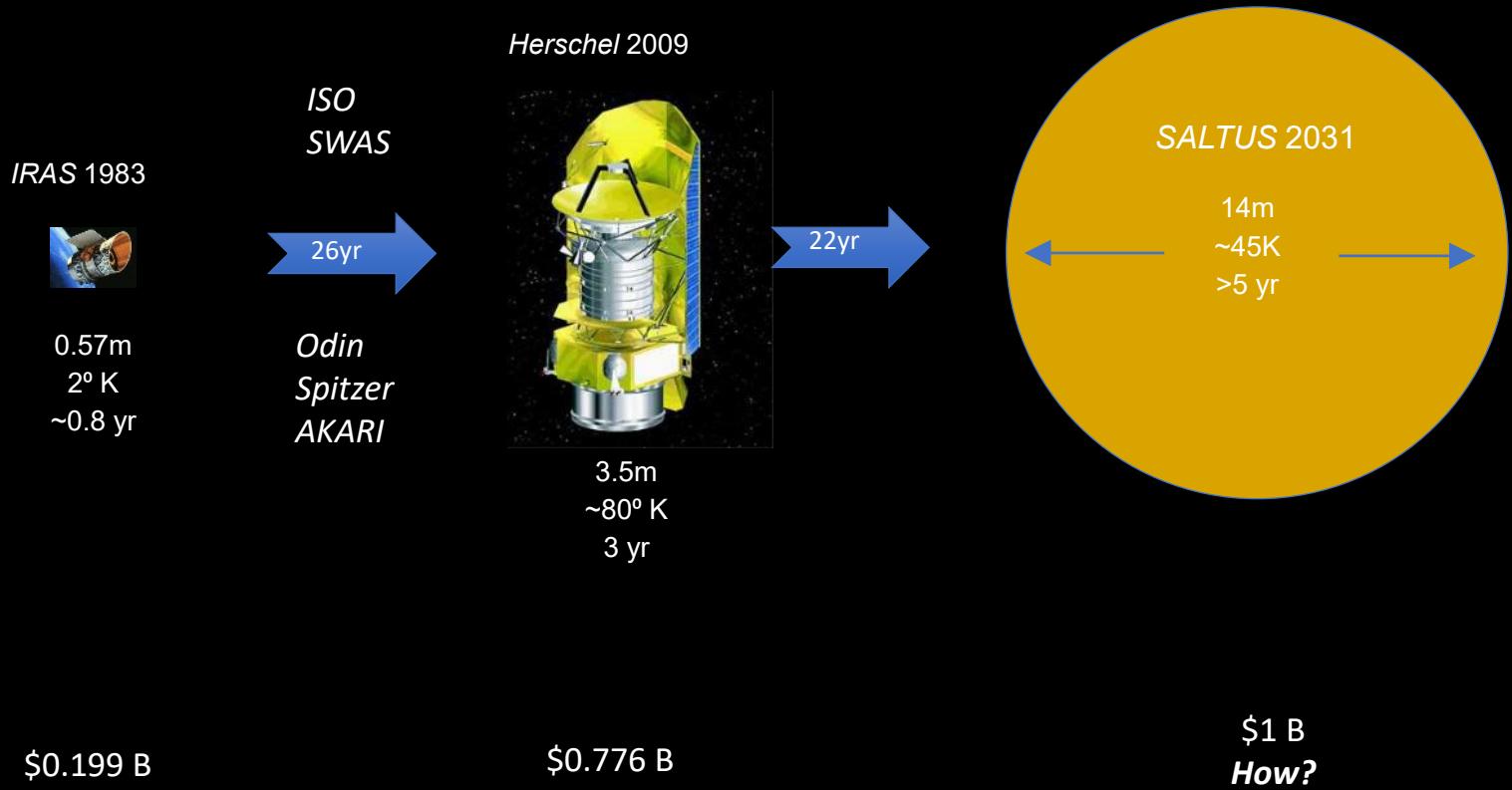


**SRON**



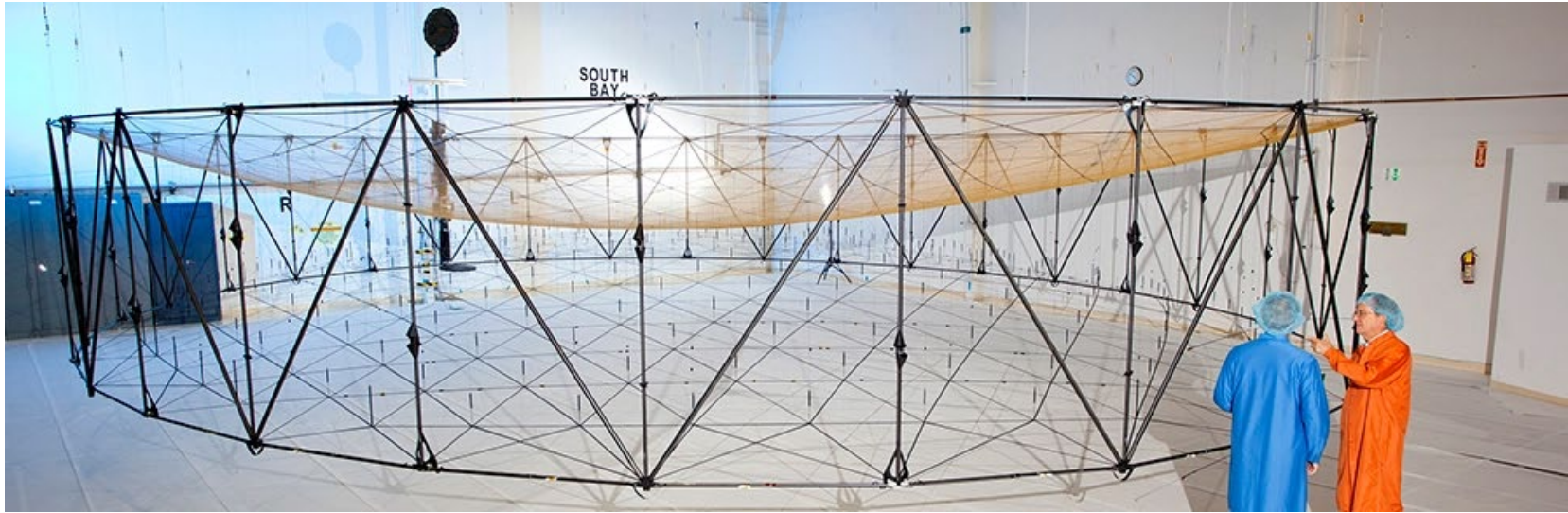
*Addresses many Science Objectives within the Astro 2020 Decadal*

# Far-IR Space Observatories



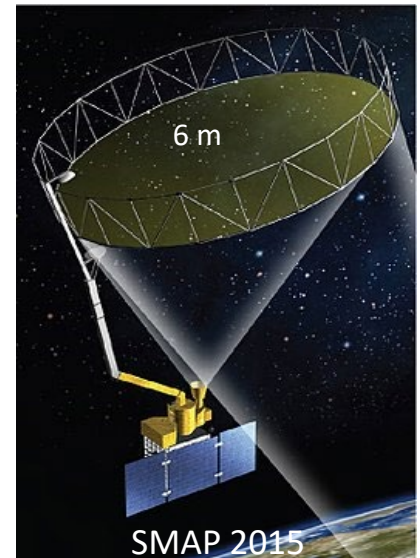
*Paradigm Shift in realizing far-IR space apertures*

# **SALTUS** Truss

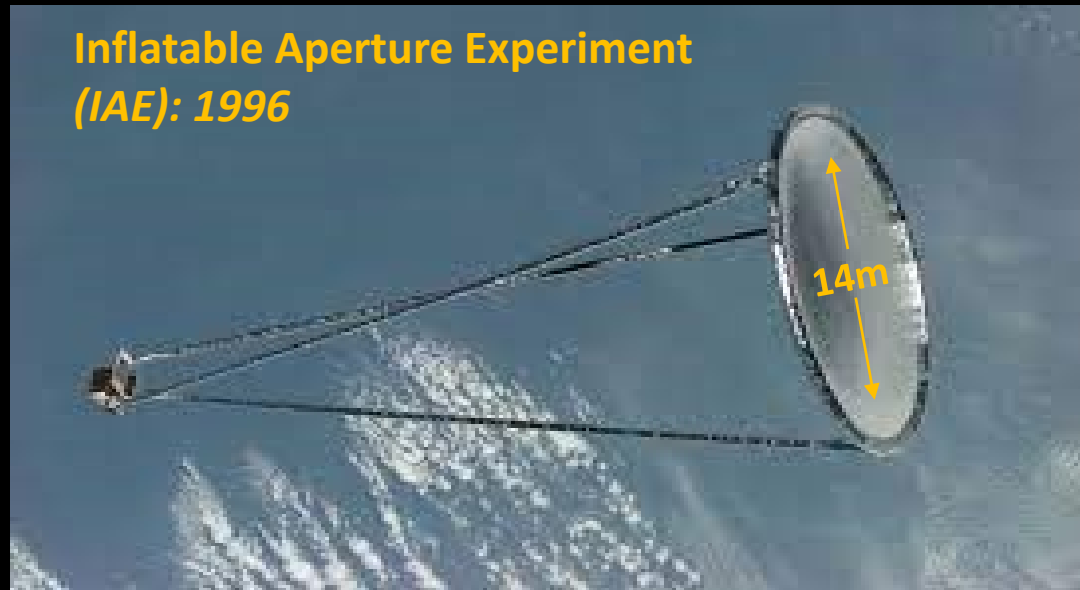


Space Rated 25 m version available

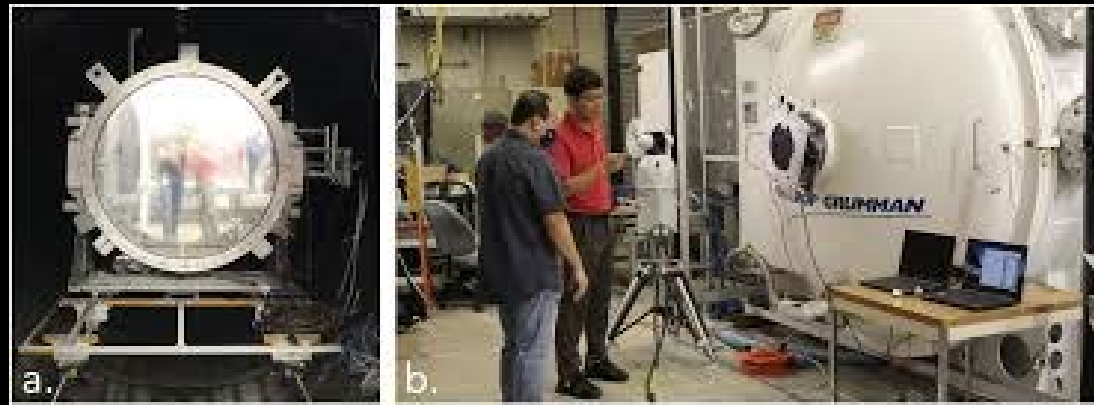
**AstroMesh® Reflector Technology**  
**100% On-Orbit Success – No Failures – No Anomalies**



## Inflatable Aperture Experiment (IAE): 1996



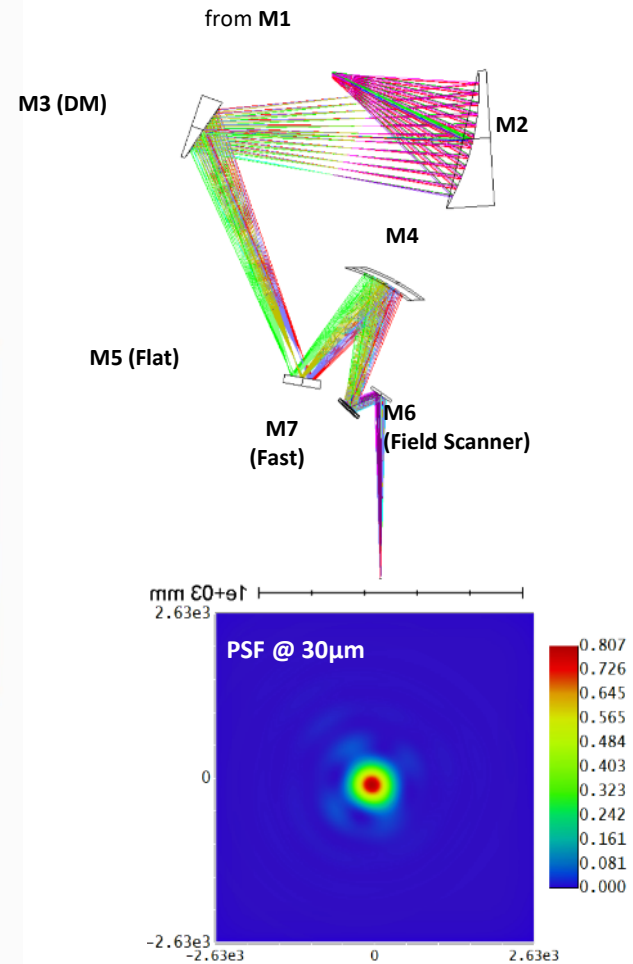
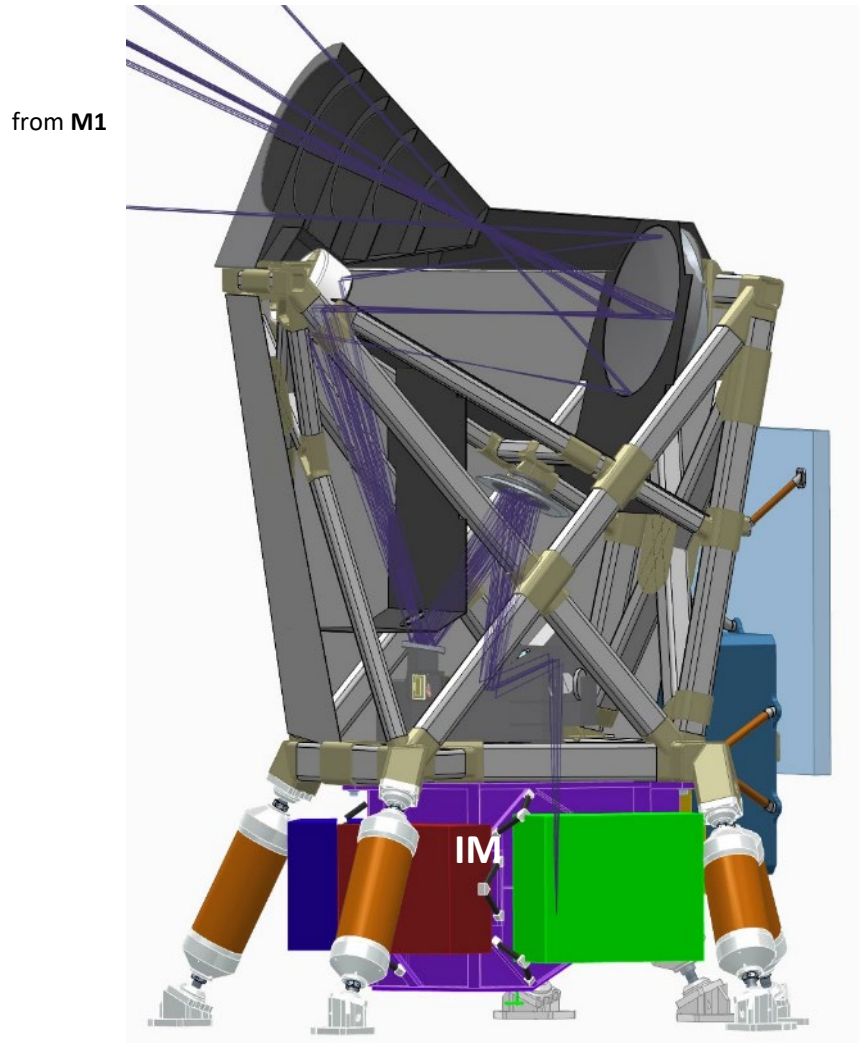
2021



25 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)
- *Constructing Highly Accurate Inflatable Parabolic Dish Reflector Antennas and Solar Concentrators*, A. Palisoc, et al, AIAA 2024-2435

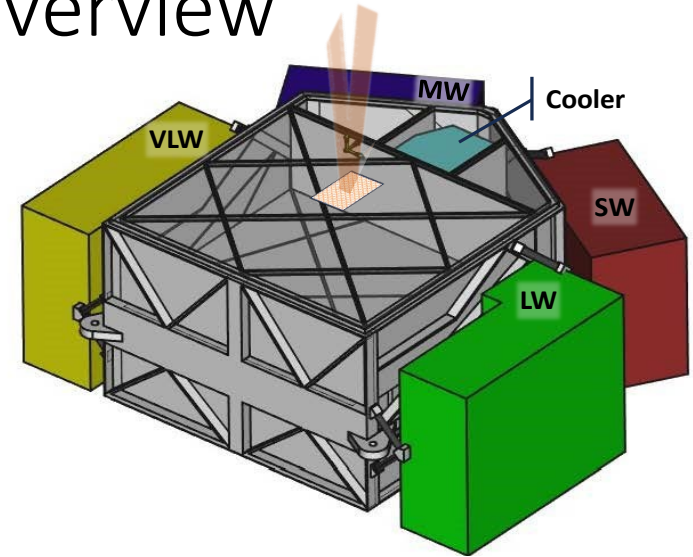
# SALTUS Corrector/Instrument Modules



# The SAFARI-*lite* instrument - overview

Far-IR grating spectrometer – 5K focal plane unit

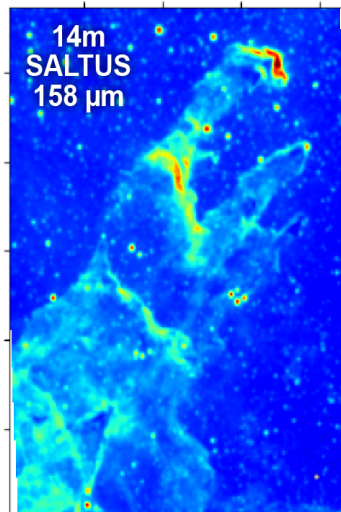
- 4 bands in the 35-240  $\mu\text{m}$  domain, co-aligned on sky
  - *Instantaneous contiguous coverage*
- Interlaced KID arrays provide  $R \sim 300$  after processing
  - $\sim 180$  pixels in spectral direction, 6 pixels in spatial direction
- Warm electronics in service module
  - Power, monitoring and control, detector control and read-out
- A 14 meter telescope with *sensitive KIDs*:



***Unprecedented FIR spectroscopic sensitivity at  $\sim 10^{-20} \text{ W/m}^2 5\sigma/1\text{hr}$  !***

**A new domain:**

*SALTUS/SAFAR-lite will provide the capability to do **CII mapping** of the 'Pillars of creation' at JWST resolution*



	SW	MW	LW	VLW
Band center / $\mu\text{m}$	45	72	115	185
Wavelength range / $\mu\text{m}$	34-56	54-89	87-143	140-230
Band center beam FWHM	0.66"	1.1"	1.7"	2.7"
Point source spectroscopy – R300 (5 $\sigma$ -1hr)				
Limiting flux / $\times 10^{-20} \text{ Wm}^{-2}$	0.5	1	2	2
Limiting flux density / $\mu\text{Jy}$	20	75	250	400
Mapping spectroscopy 1 arcmin <sup>2</sup> – R300 (5 $\sigma$ -1hr)				
Limiting flux / $\times 10^{-20} \text{ Wm}^{-2}$	5	5	6	4
Limiting flux density / mJy	2	4	7	7
Photometric mapping 1 arcmin <sup>2</sup> – R1 (5 $\sigma$ -1hr)				
Limiting flux density / $\mu\text{Jy}$	170	330	670	670
Confusion limit / $\mu\text{Jy}$	<0.1	0.6	12	60
Saturation flux density / Jy	15	25	40	50

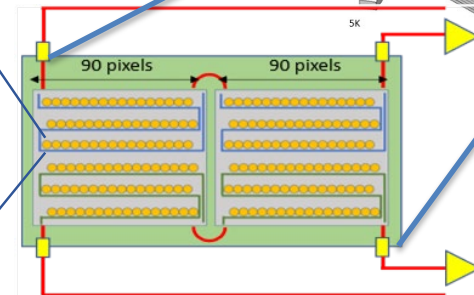
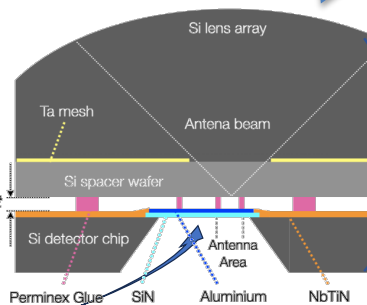
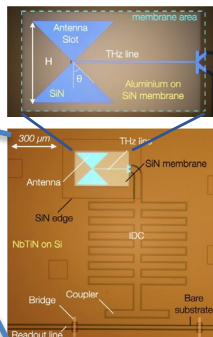
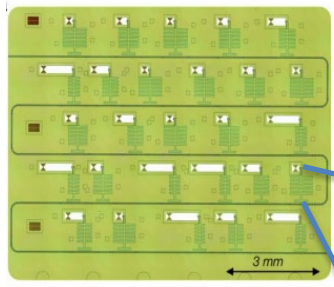
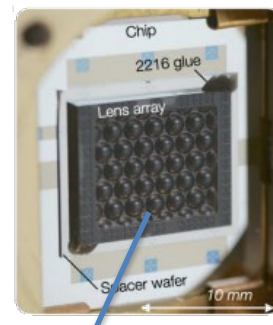
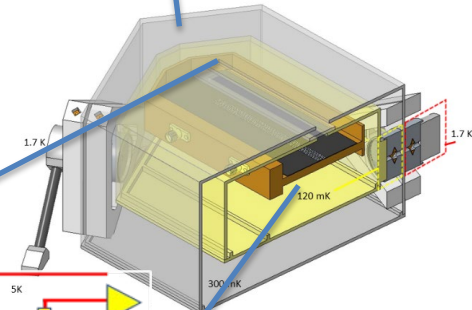
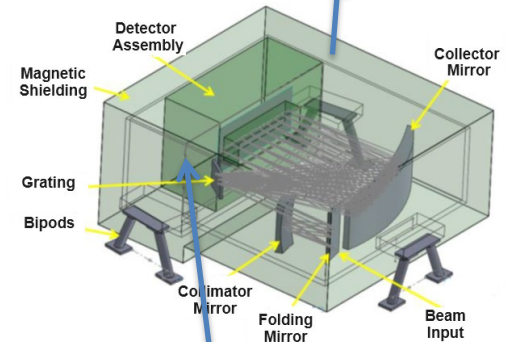
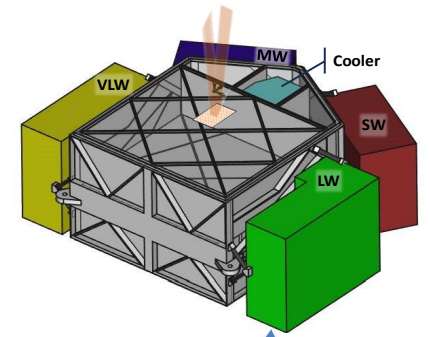


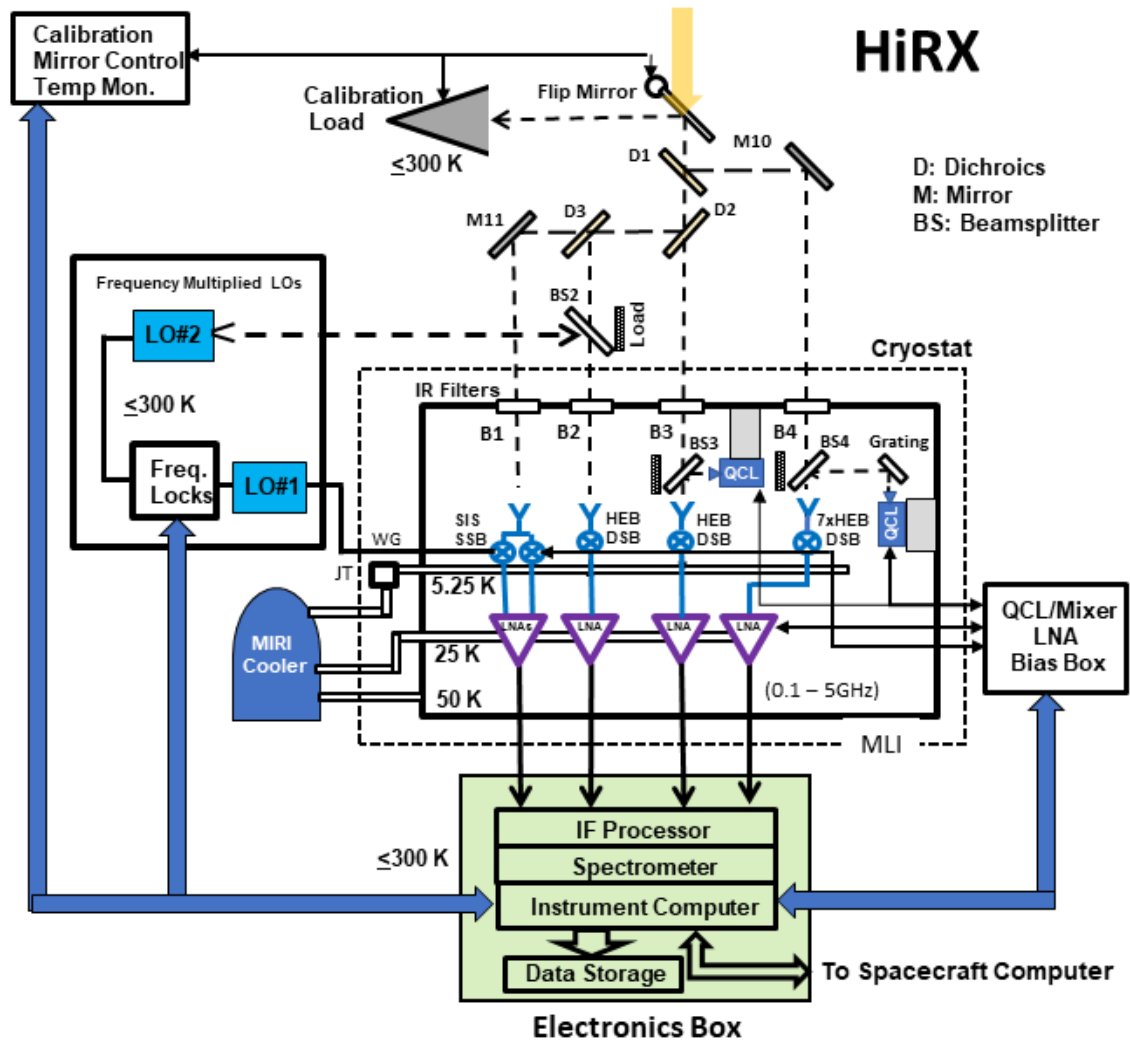
SAFARI-*lite*

SRON

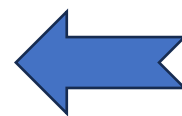
# The SAFARI-*lite* Detector Modules

- Cold focal plane instrument unit at 5K
  - Reuses original SPICA/SAFARI optomechanical design
- KID arrays with lenses and readout at 120mK
  - Technology well understood
  - Required performance *already achieved*





Beam/Band	HiRX Bands					
	B1	B2L	B2M	B2H	B3	B4
$\Omega$ (")	10.4	4.8	3.6	2.4	2	1
$\lambda$ ( $\mu\text{m}$ )	590	272	204	136	112	60



Bands Observed Simultaneously



# HiRX: GUSTO Heritage



12/20/23



**Payload Release**



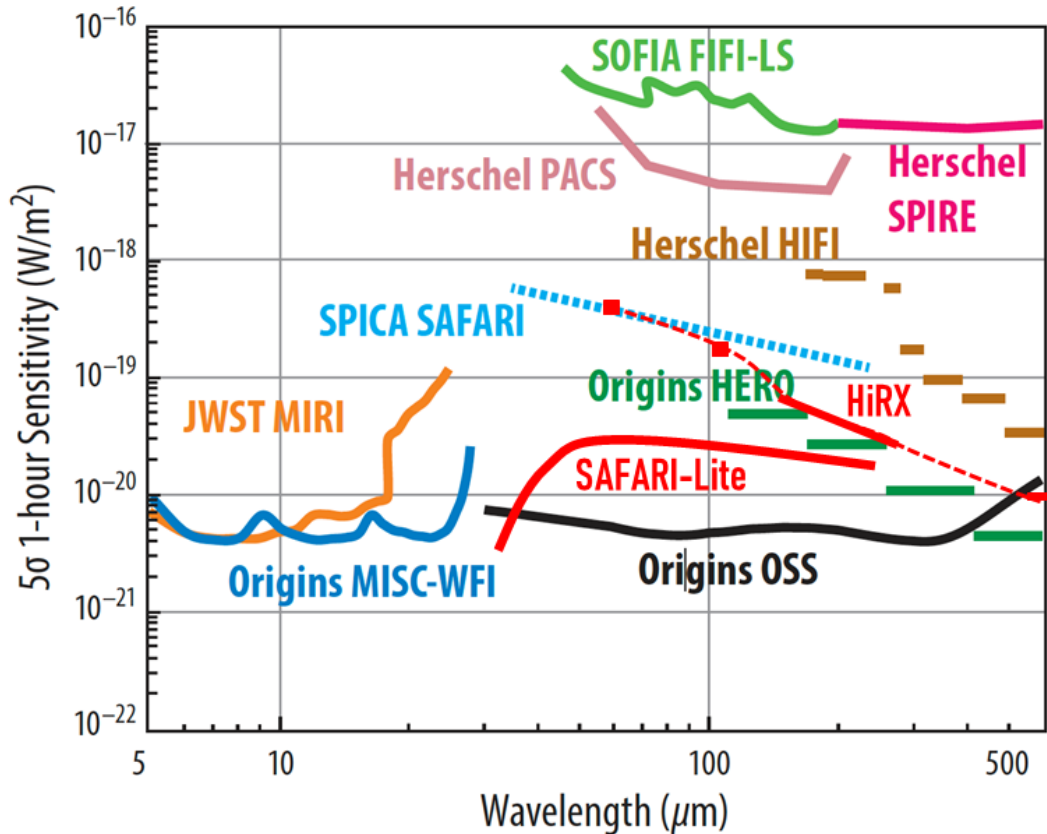
**Balloon Release**



**→ Payload**

**Balloon Inflation**

# Large Aperture Provides High Sensitivity



## Instruments

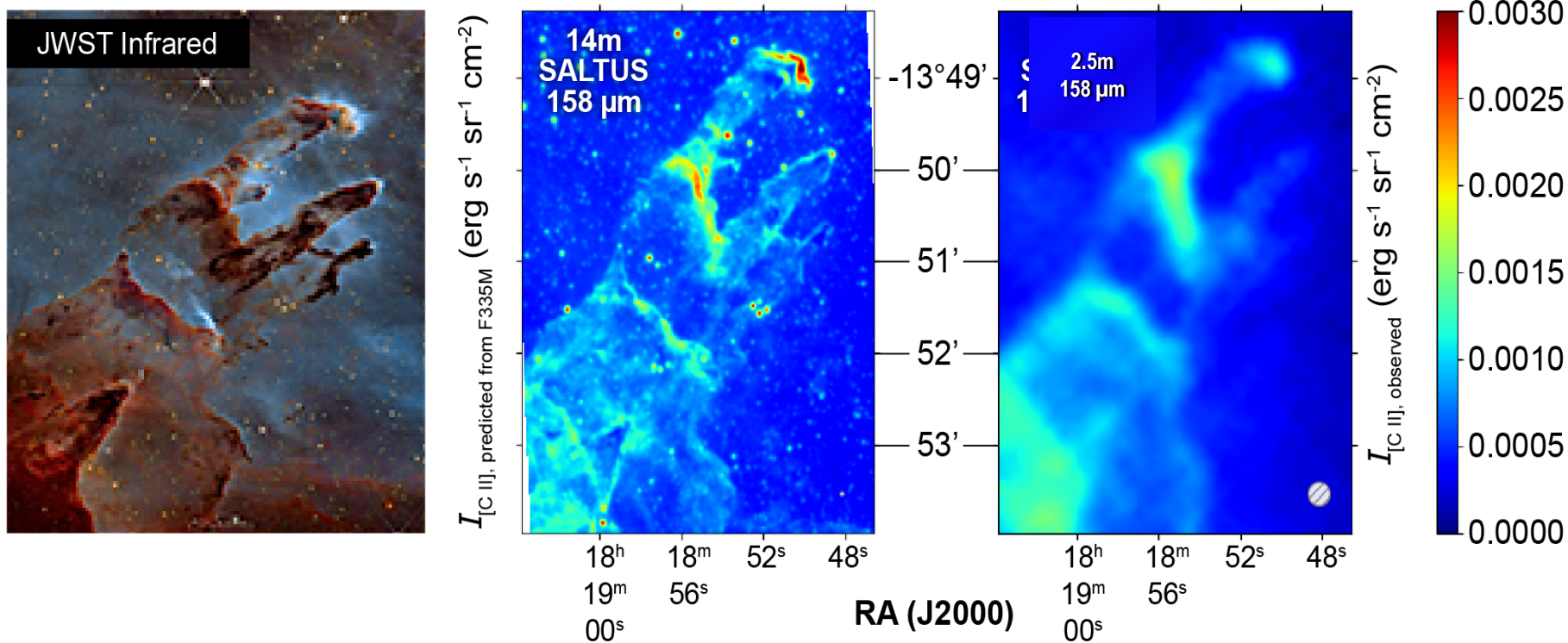
SALTUS Far-IR Spectrometer (**SAFARI-Lite**)

- 34 to 230  $\mu$ m (4 Bands)
- Instantaneous coverage
- $\sim 180$  pixel KID arrays, spectroscopic
- $R = 300$
- *Existing technology*

SALTUS High Resolution Receiver (**HiRX**)

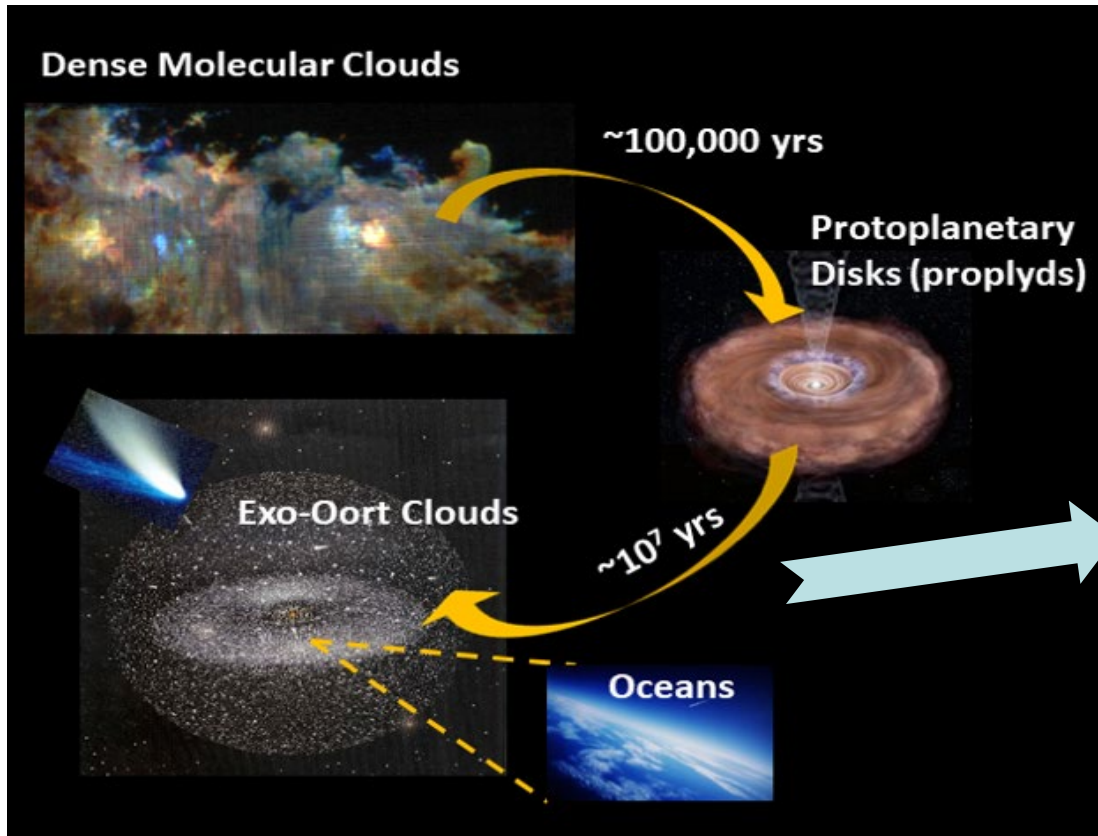
- 56 to 300  $\mu$ m
- 4 Bands HEB mixers
- 520 to 660  $\mu$ m
- Dual Polarization SIS
- $R = \sim 10^{6-7}$
- *GUSTO Heritage*

# Large Aperture Provides High Angular Resolution

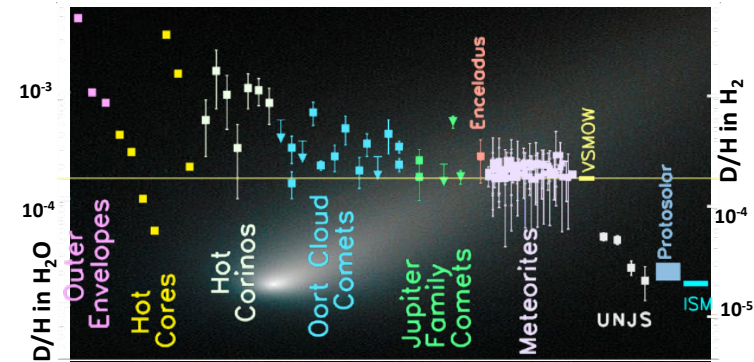


Simulated *SALTUS* image at 2.5" angular resolution (middle) of the [CII] 158μm emission in NGC 6611 (Pillars of Creation) is similar to the *JWST* image (left) and compared to a 2.5m reflecting telescope-created map (right). *SAFARI-Lite* can map this 10 arcmin<sup>2</sup> region in 10 hours and simultaneously provide maps in all diagnostic lines of photo-dissociation regions (PDRs) and HII regions in our galaxy and the local group, probing the physical environment produced by radiation feedback of massive stars and its link to stellar clusters and its molecular core.

# SALTUS follows the Water Trail from Molecular Clouds to Oceans



Measure D/H in solar system objects to investigate the fractionation of water at low temperatures.



SALTUS is designed to probe the water trail using low lying rotational  $H_2O$  lines that probe cold gas with HiRX and the icy grain reservoir through their phonon modes in emission with SAFARI-Lite

# 1) Trace Formation and Evolution of Planetary Systems

## How does habitability develop during planet formation?

### Distribution of mass and C/N/O in 1000 protoplanetary disks

- What is the mass?: Target HD
- Where is O?: Target H<sub>2</sub>O vapor & ice
- Where is N?: Target NH<sub>3</sub>
- Where is C?: Target High J CO

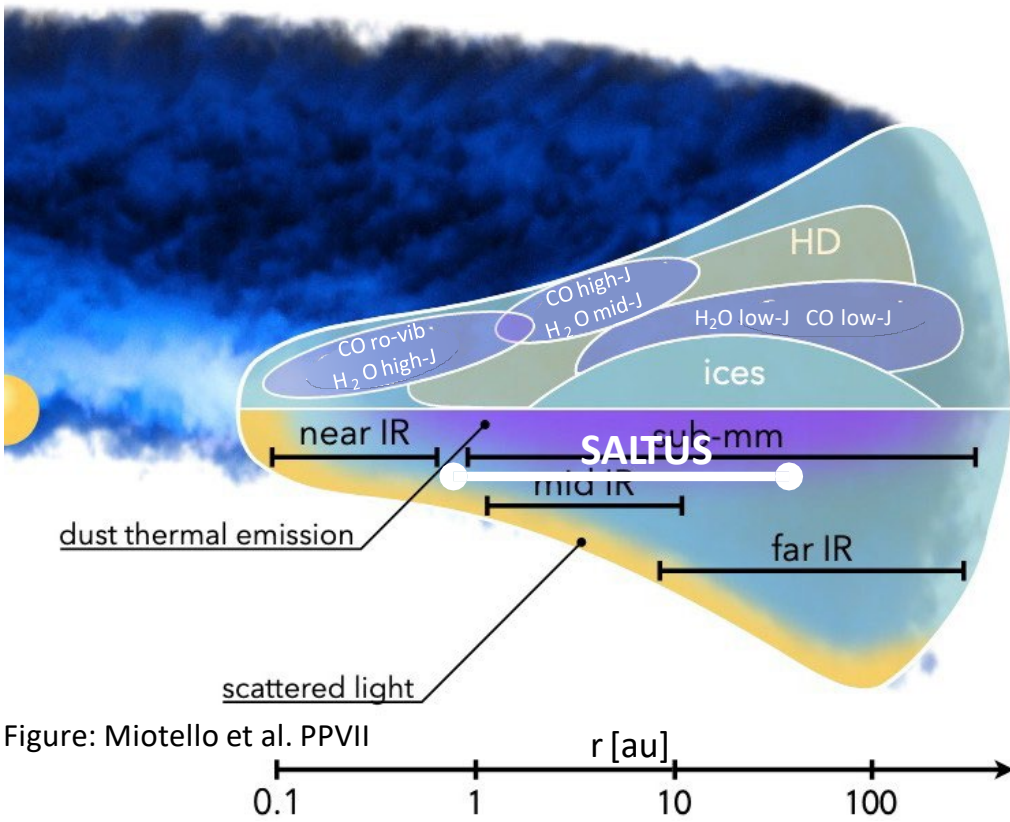
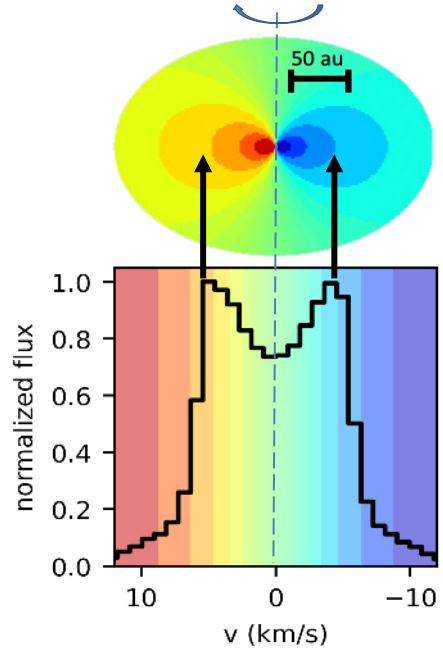


Figure: Miotello et al. PPVII

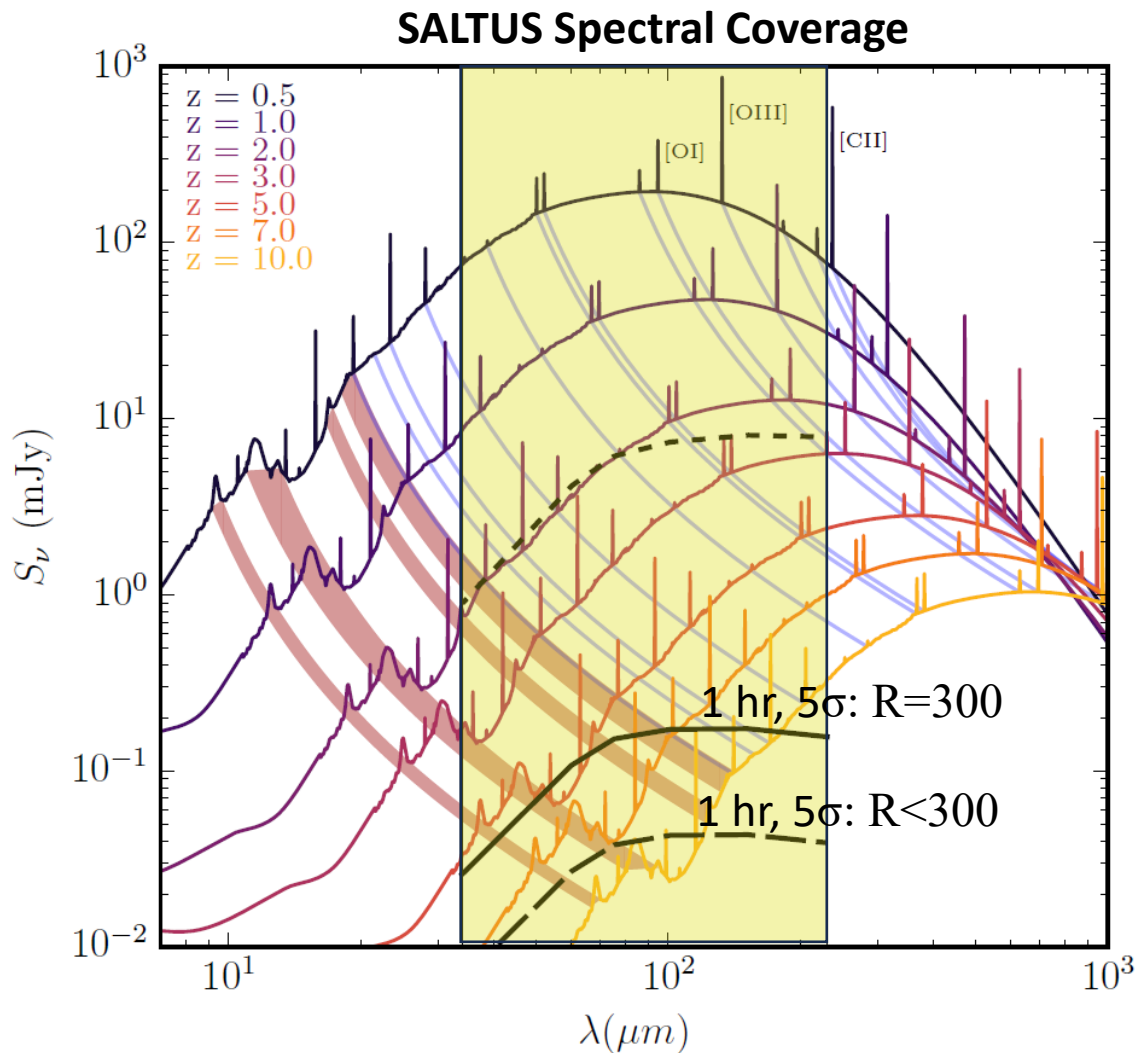


Heterodyne Spectroscopy →

Doppler Tomography of HD and H<sub>2</sub>O Disk Spectra  
R~10<sup>6</sup>

## 2) Trace Galaxy Evolution

SALTUS will *spatially resolve* and measure the peak of the IR SED of Star Forming Galaxies **in addition** to spectral lines

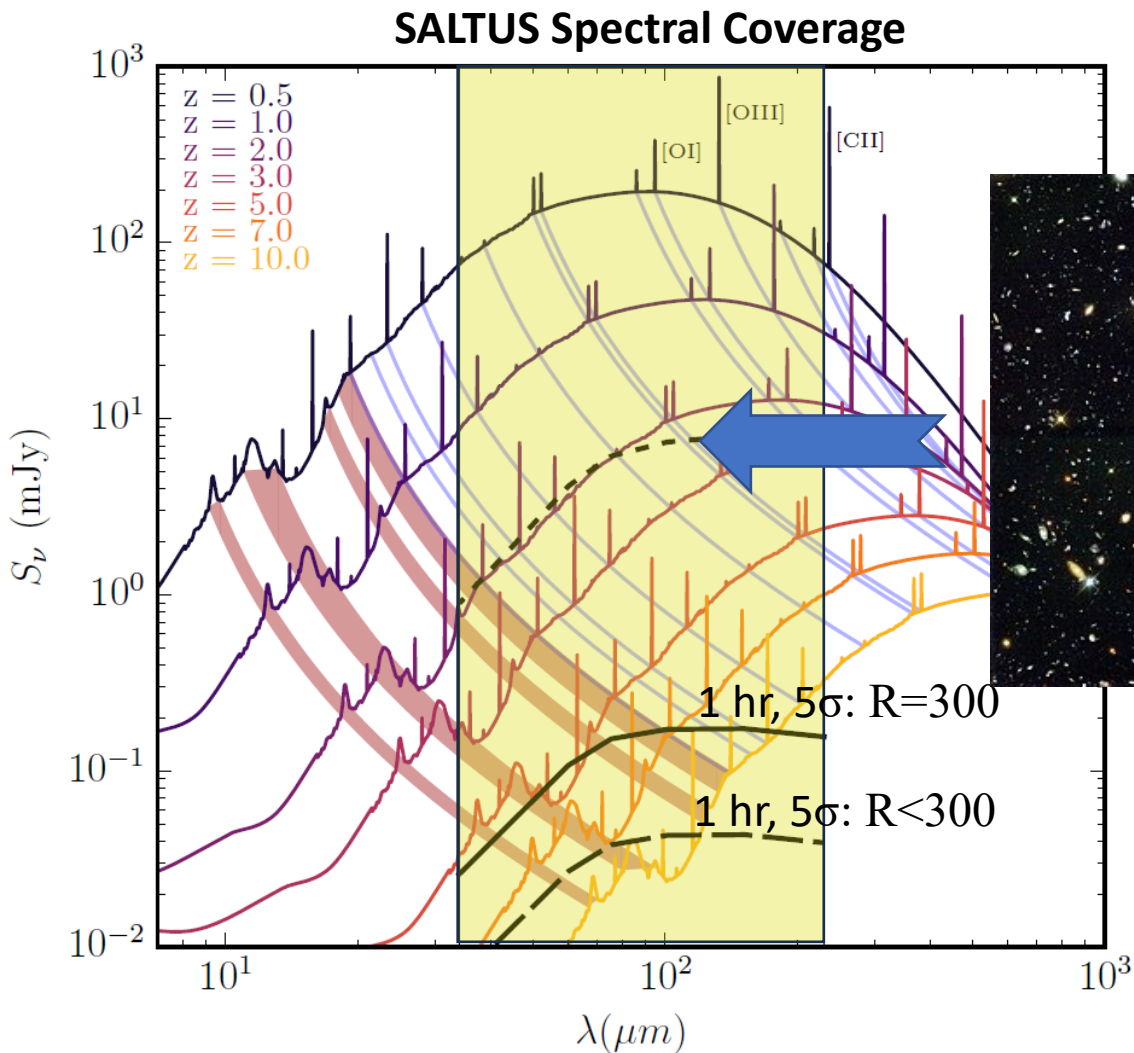


Spectral Energy Distribution (SED) of  $3 \times 10^{12} L_\odot$  star forming galaxy with redshift.

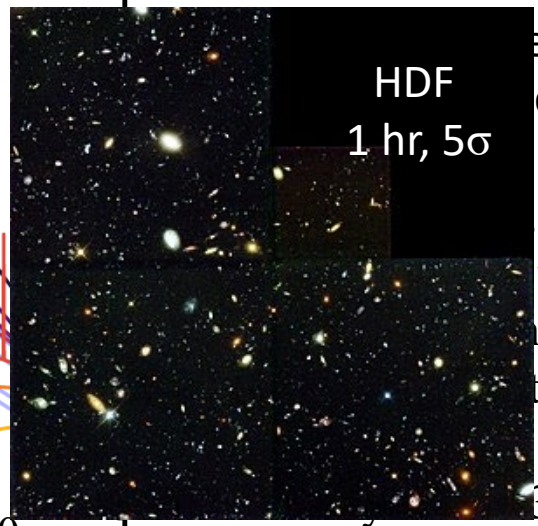
- Spectral lines and PAH features traced through redshift
- Out to  $z \sim 3$ , SAFARI-Lite probes the peak of the dust continuum and the bulk of the dust emission.
- Beyond  $z \sim 3$ , SAFARI-Lite takes over from *JWST*/MIRI

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# SALTUS Schedule

SALTUS Meeting (UofA/Virtual)	March 6-7, 2023
Probe AO Release	July 2023
Probe Proposal	Nov. 16, 2023
Probe Phase A Down select	Mid 2024
CSR Due	Early 2025
Probe Phase B Down select	Mid/Late 2025
Launch Readiness	~2031
Flight Operations	~2031-2036+

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