Galactic/Extragalactic Ultra/LDB Spectroscopic/Stratospheric Terahertz Observatory

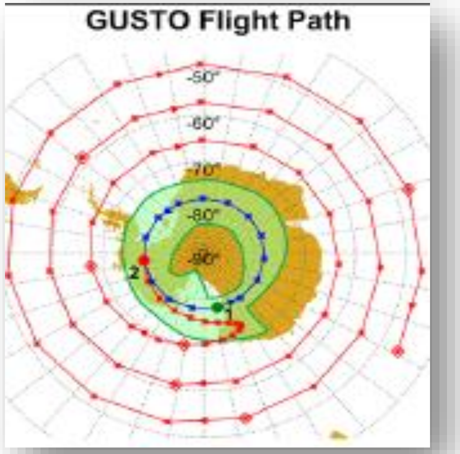
GUSTO

C. Walker, Univ. of Arizona, PI

P. Goldsmith, JPL, Project Scientist

GUSTO Mission Basics: Trace the Life cycle of ISM

- 90 cm dia. Telescope (~40” resolution)
- 8 pixel HEB arrays for **high resolution spectroscopy**
- [NII] 205 μm – ionized gas; HII regions D-WIM
- [CII] 158 μm – diffuse ISM, PDRs
- [OI] 63 μm – surroundings of massive young stars



Launch December 2022

Level 1 Requirements: Data Products

GPS: Galactic Plane Survey: $-25° < l < 25°$; $-1° < b < 1°$

LMCS: Large Magellanic Cloud Survey: 4° × 6° map of entire LMC

TDS: Targeted Deep Surveys: ~1 deg^2 of regions in Galaxy/LMC

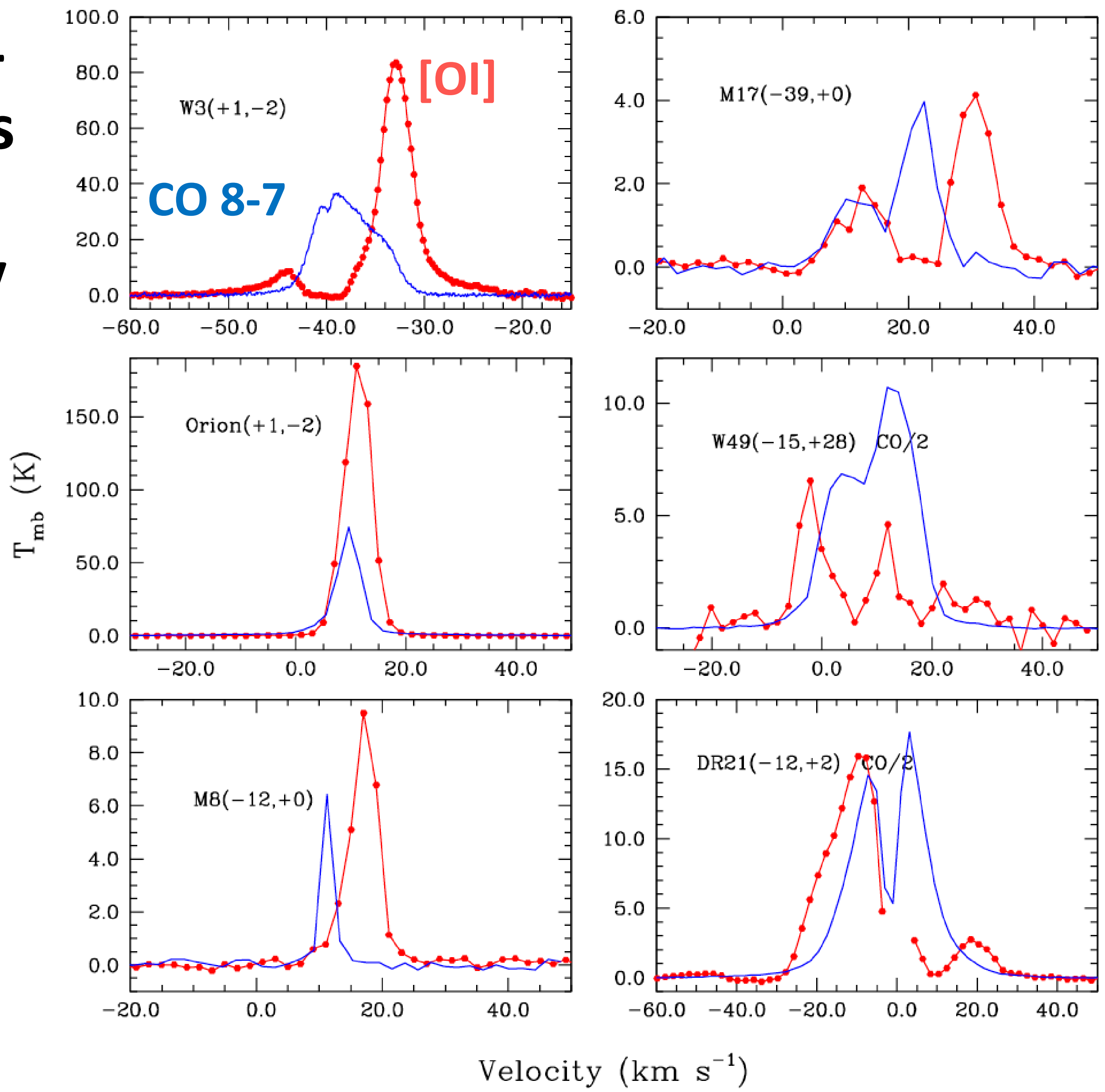
NASA Explorer Mission of Opportunity (MoO) balloon mission
Long Duration Balloon offers ~ **70** day lifetime, but payload recovery is not certain

One Aspect of GUSTO Science: - Survey [OI] 63 µm from Regions of Massive Star Formation with Velocity-Resolved Spectroscopy

Earlier survey with SOFIA/upGREAT

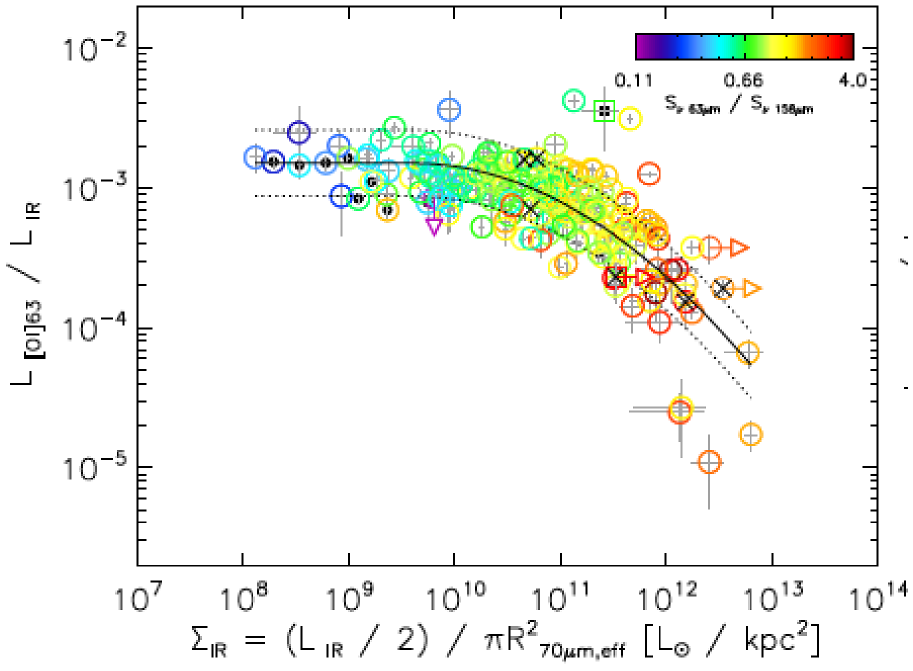
(Goldsmith+ 2021)

- [OI] 63µm observed in 12 regions
- CO J=5-4, J=8-7, and also [NII] 205µm observed simultaneously
- CO 8-7 traces warm molecular gas heated by UV from young star(s) and HII region
- [OI] shows **clear self-absorption** in half of the sources observed
- Consistent with large quantity of low-excitation O^0 in extended PDR with exciting stars at one edge of cloud

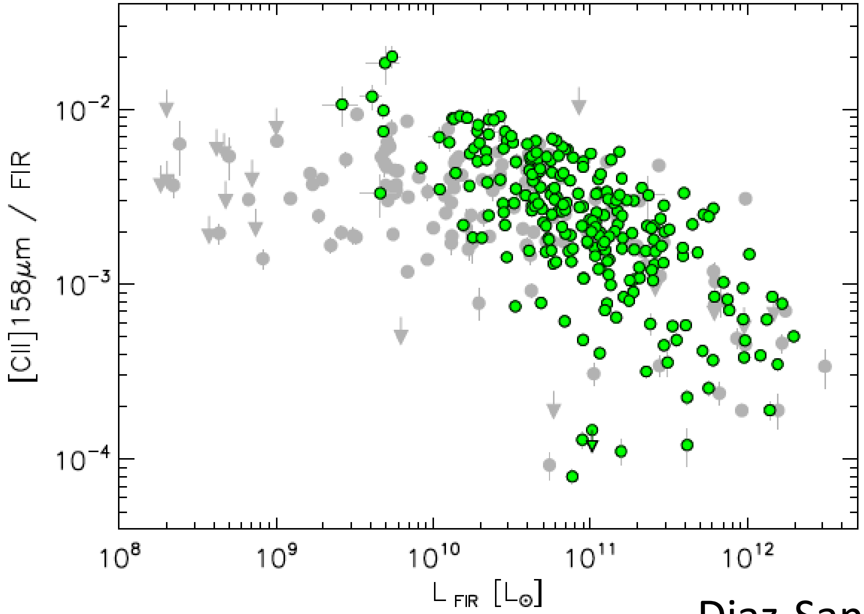


[OI] 63 µm as Tracer of Star Formation Rate

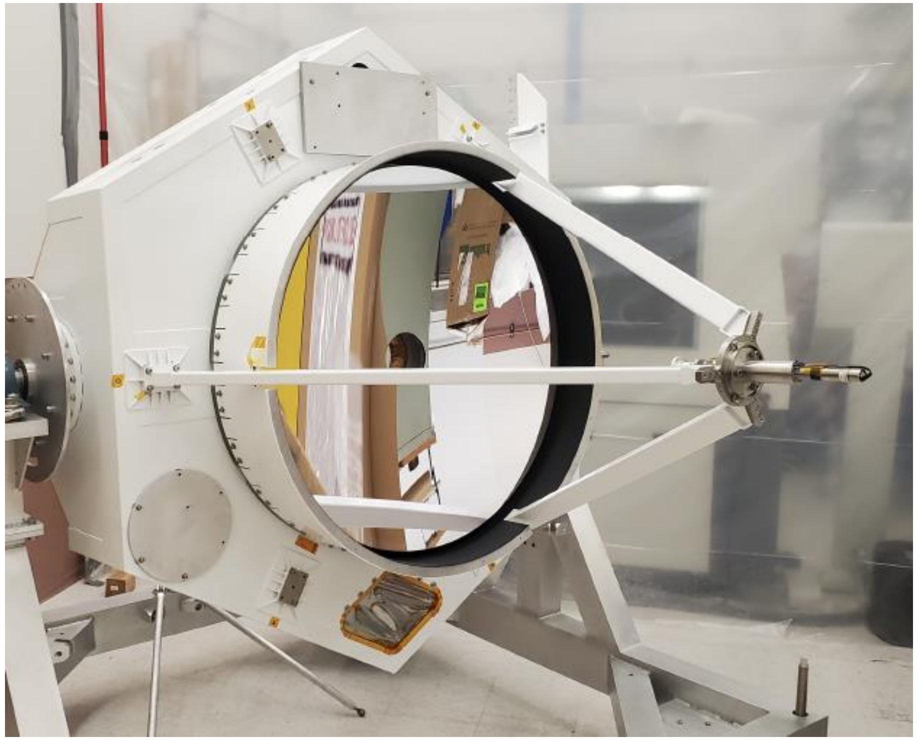
- Generally does a reasonably good job for “normal” galaxies but a “deficit” appears for more luminous galaxies with warmer dust
- Higher T_{dust} if reflected in higher T_{gas} would enhance [OI] 63 µm
- Oxygen can remain largely atomic to large A_v when irradiated by large flux from HII region/hot PDR
- It the deficit a result of absorption by foreground low-excitation O^0?
- Does the greater density or column density of star-forming clouds in ULIRGS contribute?
- Is it related to the infamous “[CII] deficit”?



Diaz-Santos+ (2017)



Diaz-Santos+ (2013)



GUSTO Telescope

90 cm symmetric Cassegrain telescope

- Glass primary reflector
- Diamond turned aluminum secondary reflector

Status:

- Assembly completed
- Surface accuracy verified
- Final alignment underway at U of A Mirror Laboratory

Shortest GUSTO wavelength is 63 μm so required accuracy is ~2 μm, far larger than measured. Will be enclosed in “trash can” style sunshield

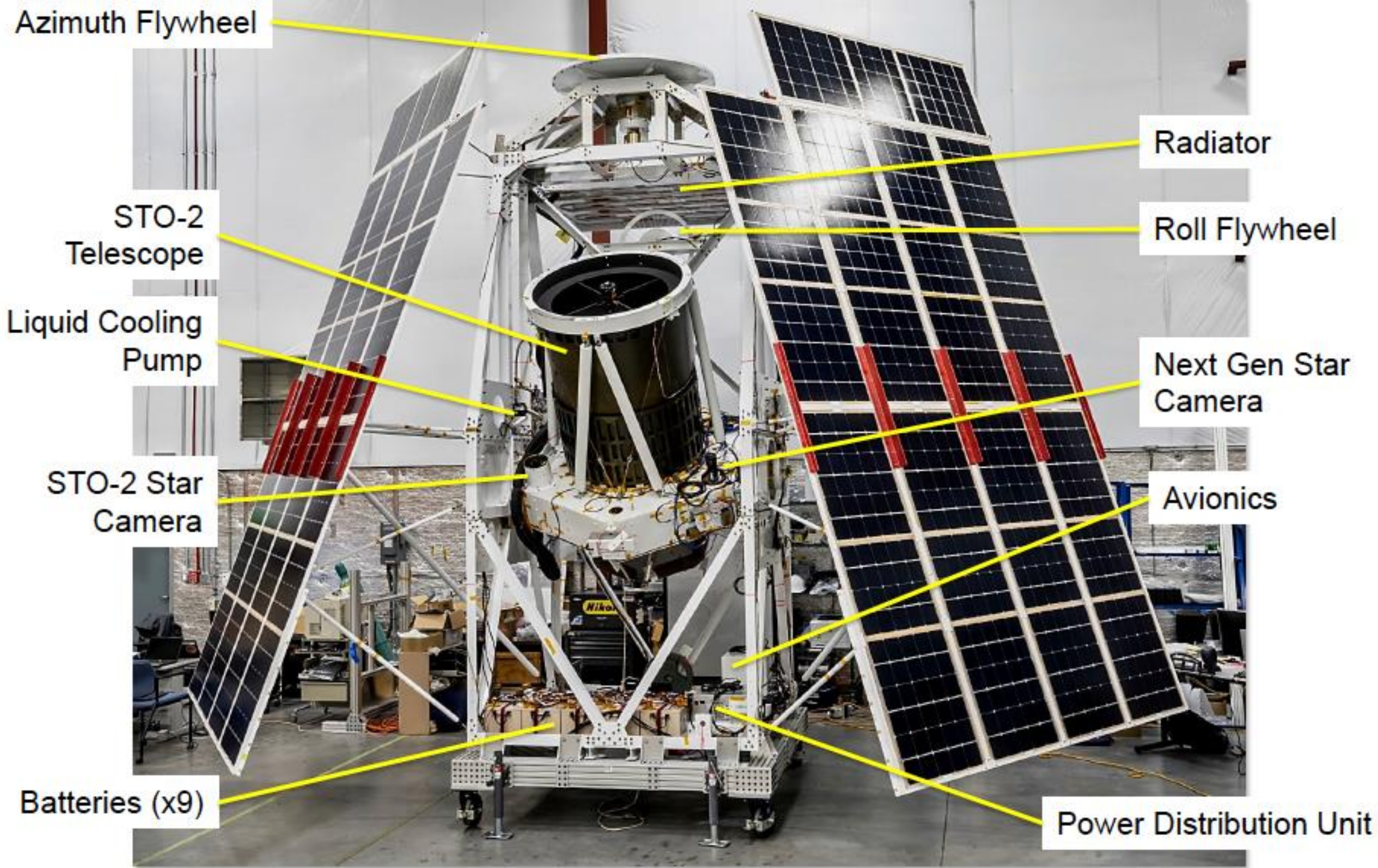
Gusto Gondola (JHU/APL)

Follows design of successful STO2 gondola, with

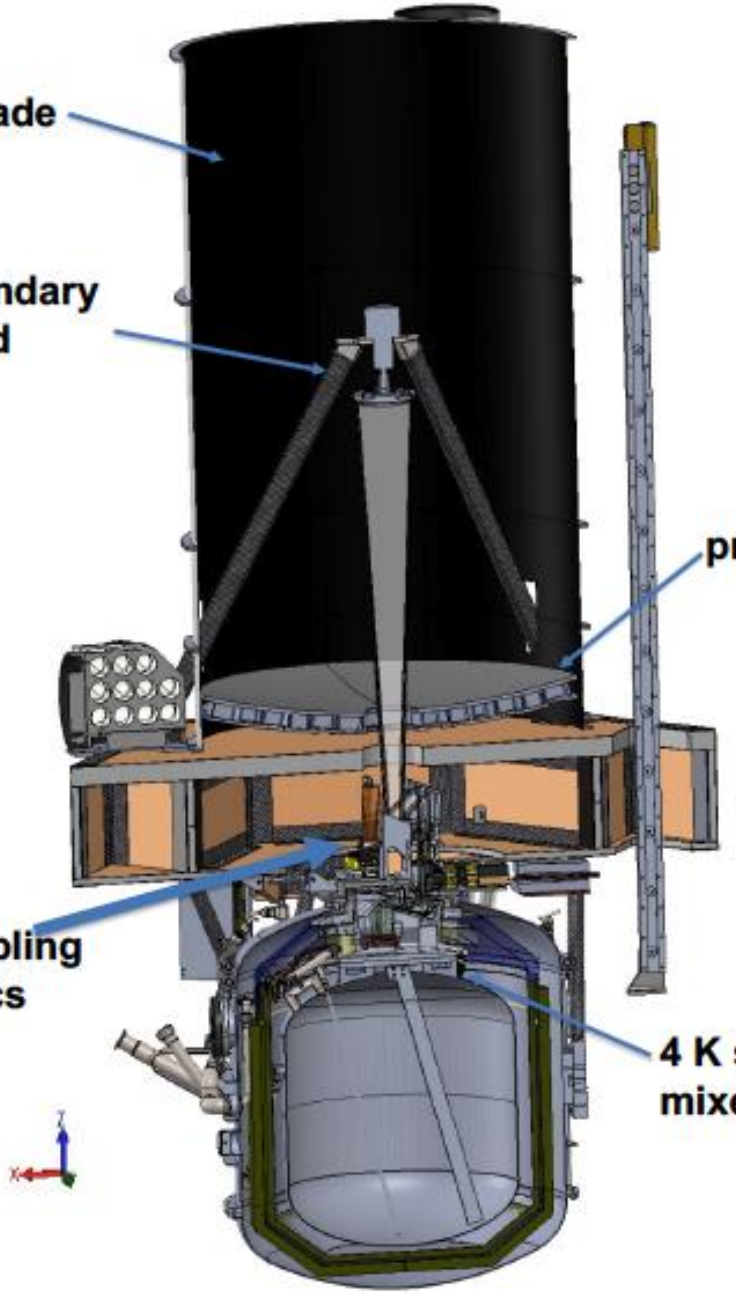
- Improved star trackers
- More capable liquid cooling loop for thermal control of high-dissipation electronics (local oscillators, digital spectrometer)

Indoor and outdoor “hang tests” completed at APL using STO2 telescope with gondola suspended from crane

- Test/Exercise both star cameras
- Verify Pointing Accuracy
- Calibrate IMU bias drift
- Verify capability to point at and track planets
- Verify capability to point at, and track the Moon


Azimuth Flywheel
Radiator
STO-2
Telescope
Roll Flywheel
Liquid Cooling
Pump
Next Gen Star
Camera
STO-2 Star
Camera
Avionics
Batteries (x9)
Power Distribution Unit

GUSTO OPTICS



Telescope Optical Design	
Focal Ratio	10.4
Focal Length	9350 mm
Primary Diameter	900 mm
Field of View	0.07° x 0.07°
Total track	2400 mm

Materials	
Primary	Lightweight Borosilicate on Titanium flexures
Secondary	Diamond turned Aluminum
Optical Bench & Tripod	CFRP
Sunshade	Aluminum white exterior Black interior
Coupling optics	Diamond milled off-axis mirrors

GUSTO Receivers

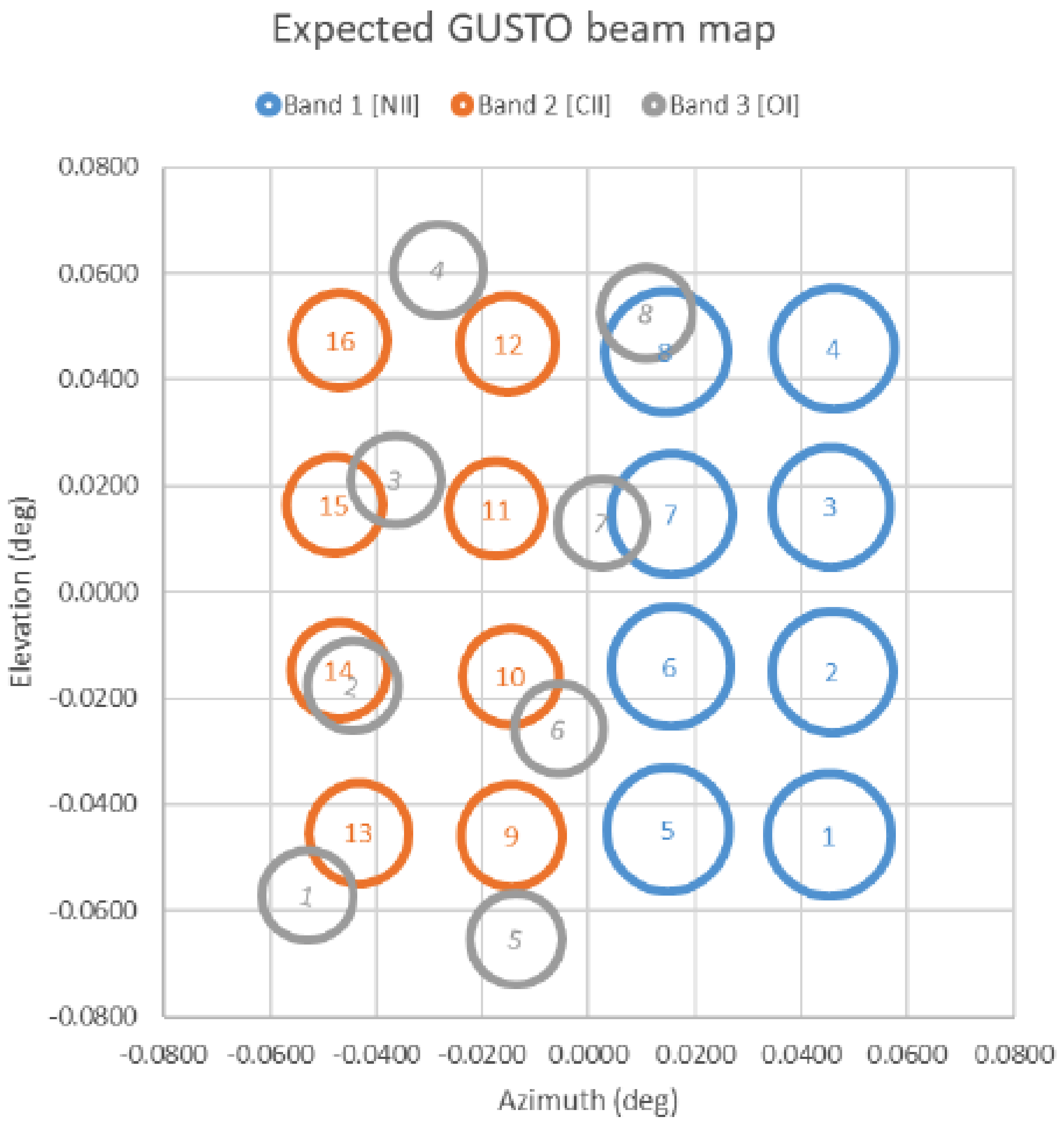
24 Heterodyne receivers in 3 bands with 8 pixels each

B1	1.4 THz	[NII] 205 μm	$\Delta\theta$ = 55”
B2	1.9 THz	[CII] 158 μm	$\Delta\theta$ = 42”
B3	2.7 THz	[OI] 63 μm	$\Delta\theta$ = 37”

All employ spiral antennas and HEB mixer elements

B1 and B2 local oscillators are frequency-multiplied microwave sources

B3 local oscillator is frequency-locked quantum cascade laser (QCL)



GUSTO Dewar

Cold, 24 mixers in focal plane
With addition of external LO box and optics the system temperature testing has now started