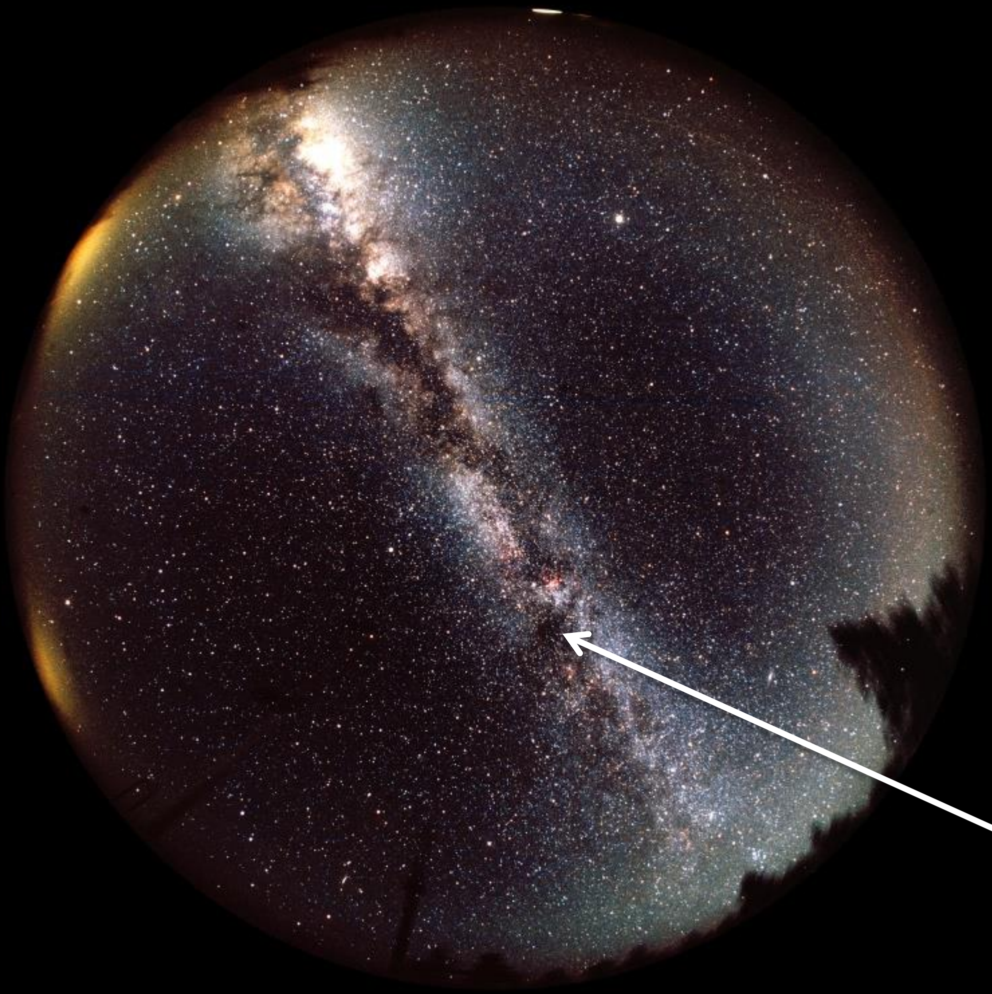
STO-2/GUSTO/LBR:
New Windows into Our Cosmic Origins

STO-2 Explores Cosmic Origins



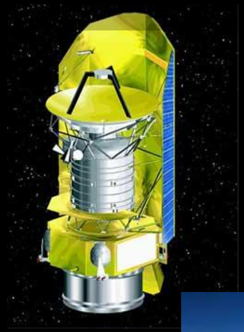
We live in a Galaxy comprised of stars, planets, and people.

Where did it all come from?

Interstellar Medium (ISM)

IR/THz Missions

Herschel 2009



Spitzer 2003

SWAS 1998

HST 1990

AKARI 2006

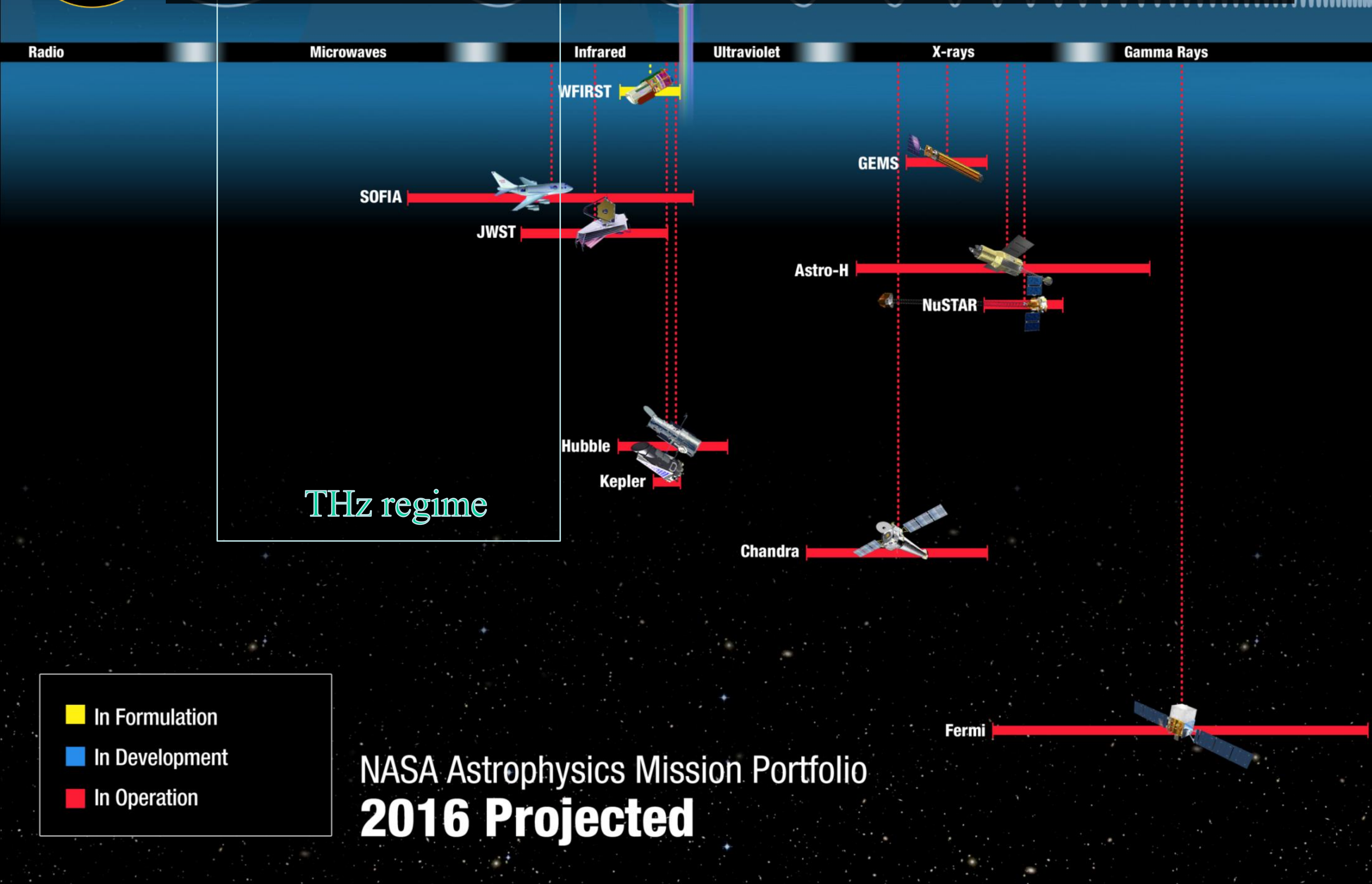
SOFIA 2010

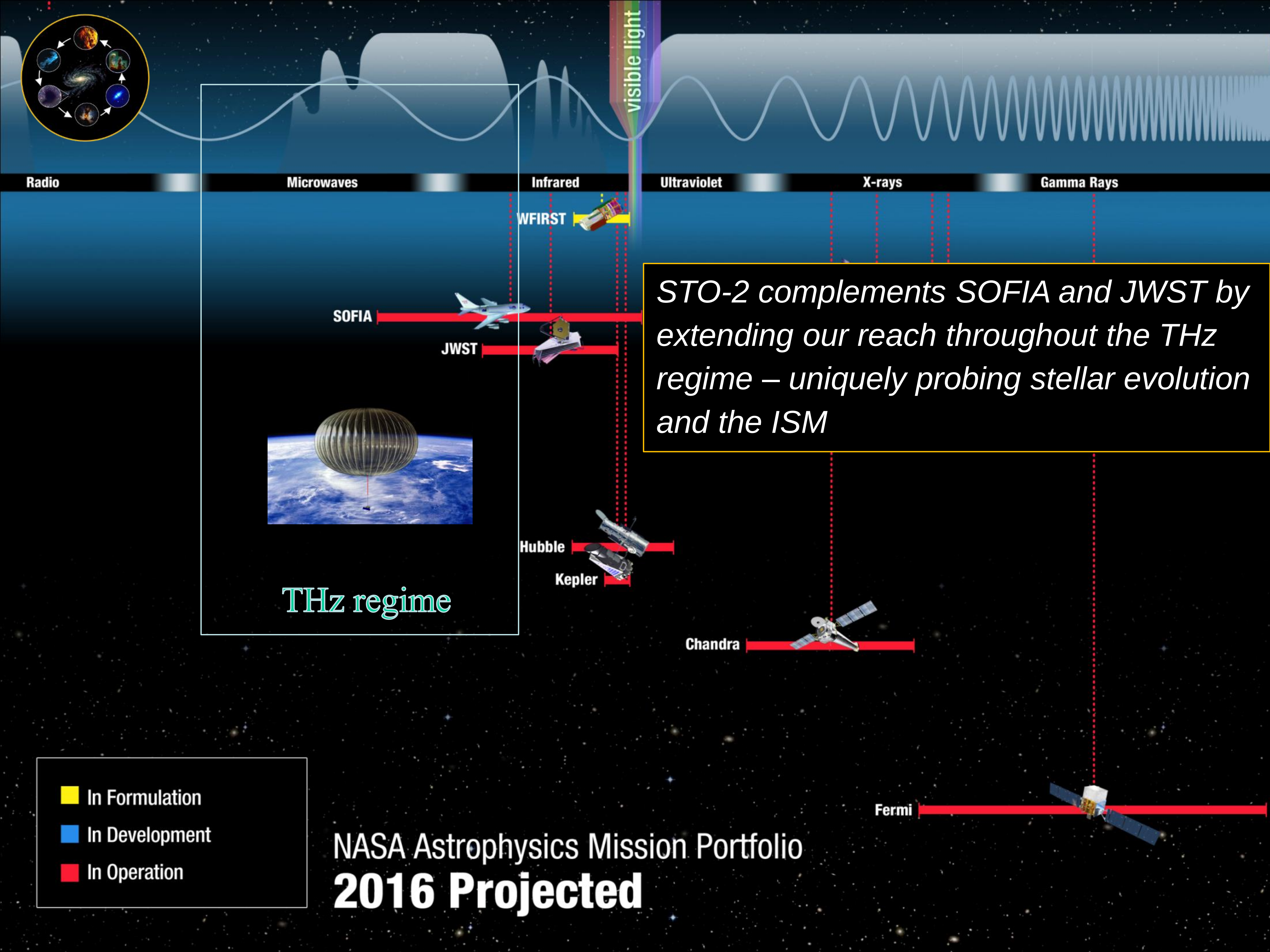
ISO 1995

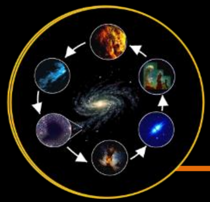
Odin 2001

IRAS 1983

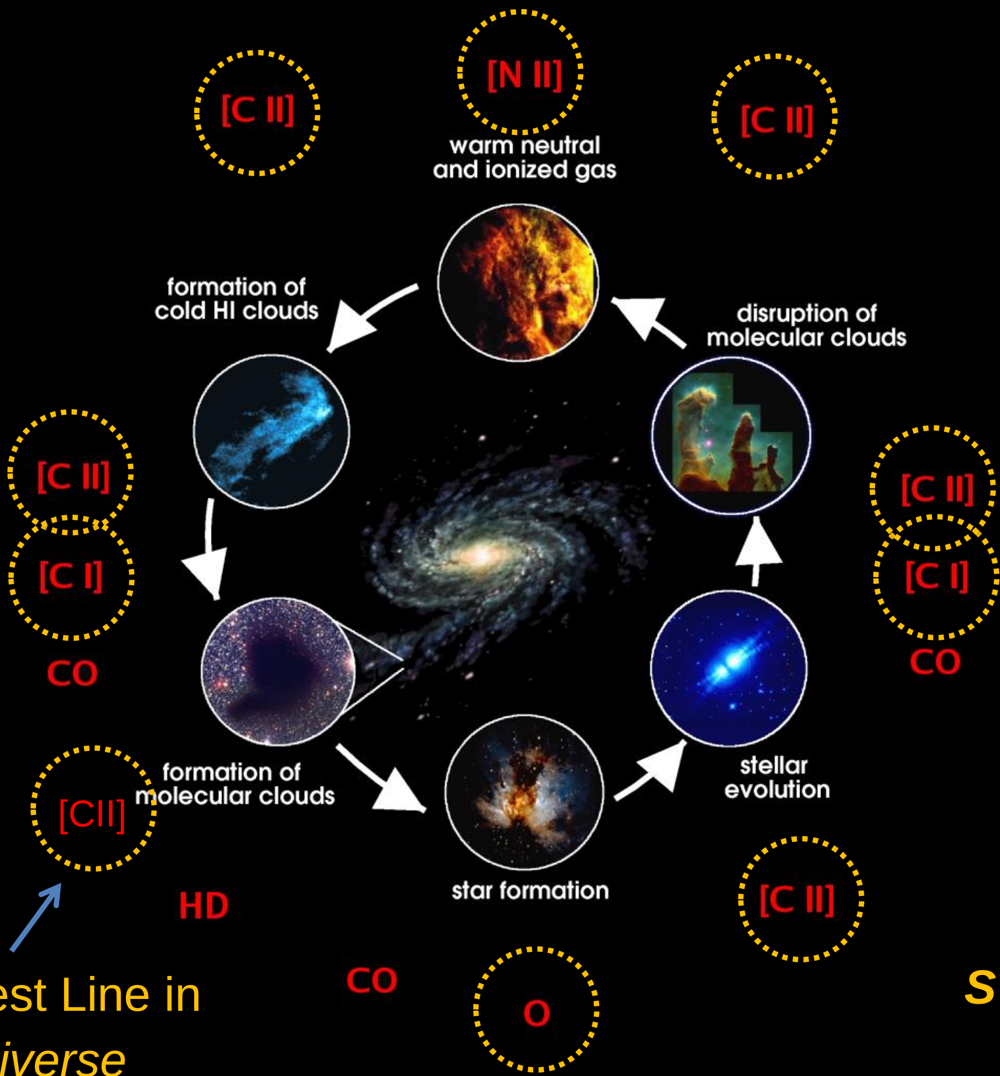
STO-2: Pathfinder for Low-Cost/High Return Missions




visible light
Radio
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Rays
WFIRST
SOFIA
JWST
STO-2 complements SOFIA and JWST by extending our reach throughout the THz regime – uniquely probing stellar evolution and the ISM
Hubble
Kepler
THz regime
Chandra
Fermi
In Formulation
In Development
In Operation
NASA Astrophysics Mission Portfolio
2016 Projected

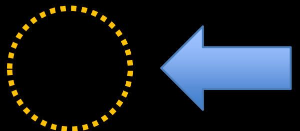


Life Cycle of Interstellar Medium (ISM)



Brightest Line in *the Universe*

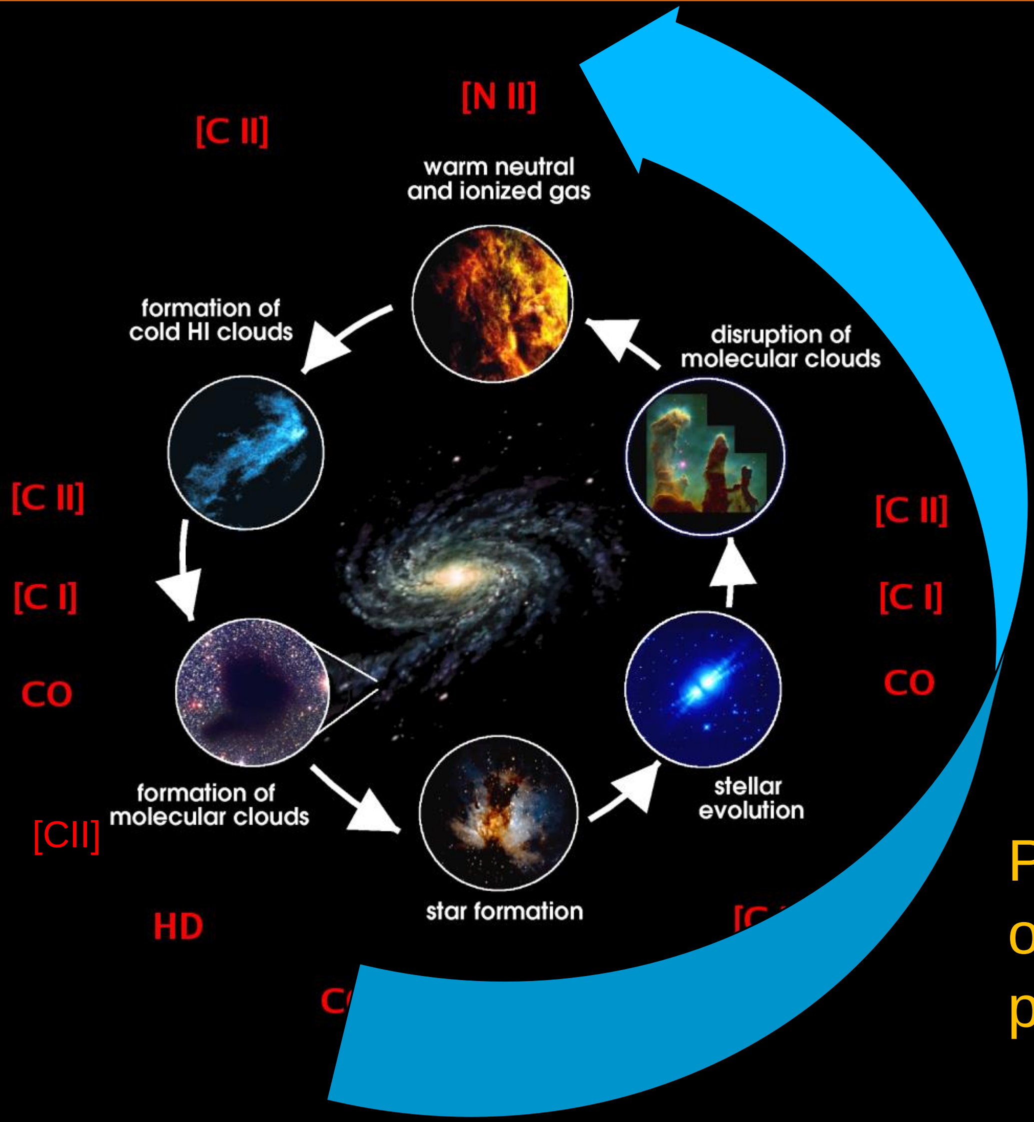
STO-2 uses *large scale surveys & spectral diagnostics* of the Interstellar Life Cycle to answer these questions.



STO-2 Lines

***STO-2**: **C**arbon, **N**itrogen, **O**xygen explorer*

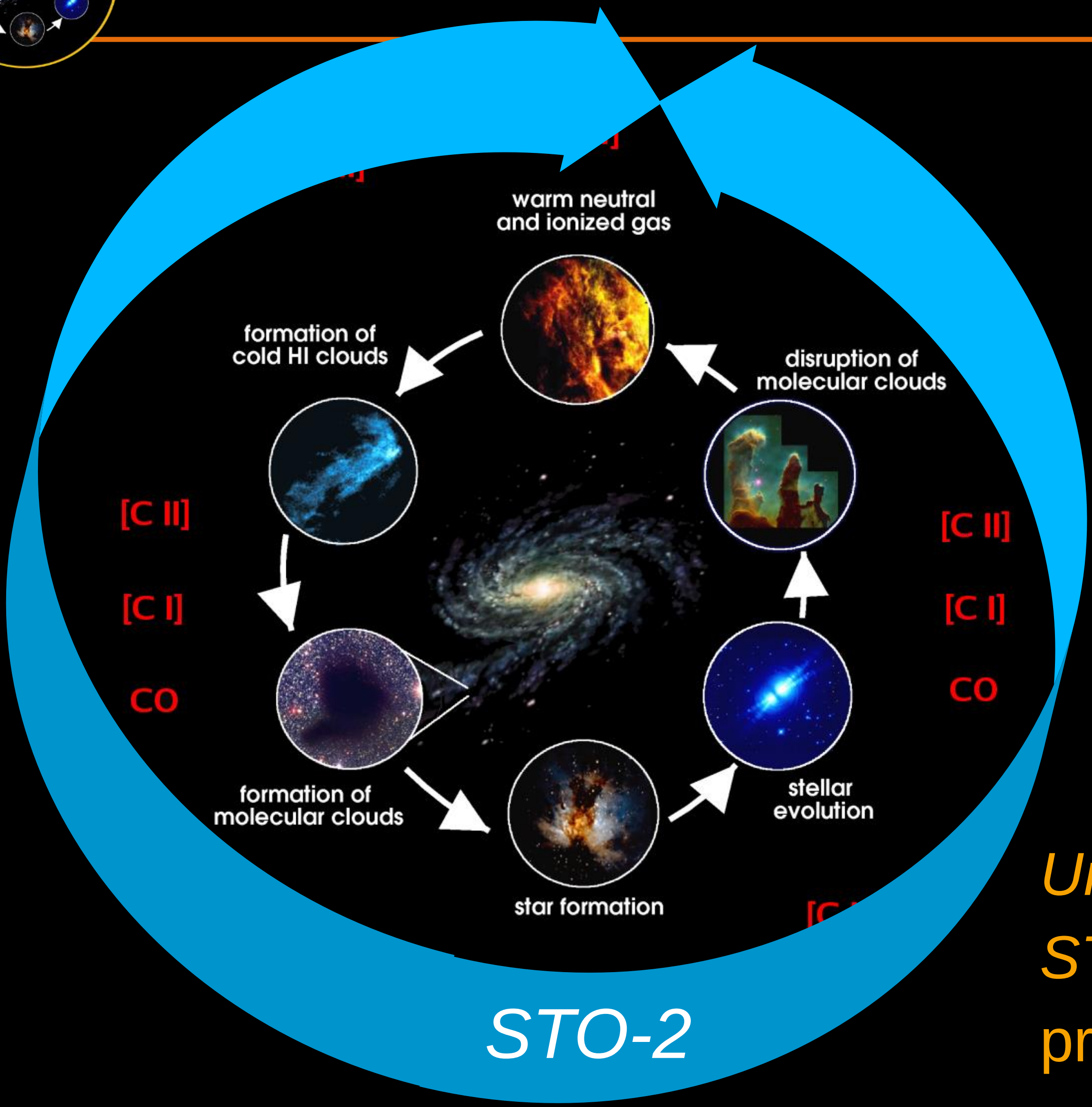
STO-2's Most Compelling Science Driver



STO-2 uses *large scale surveys & spectral diagnostics* to Unveil the Life Cycle of the ISM.

Previous missions optimized to probe only ~1/2 the cycle

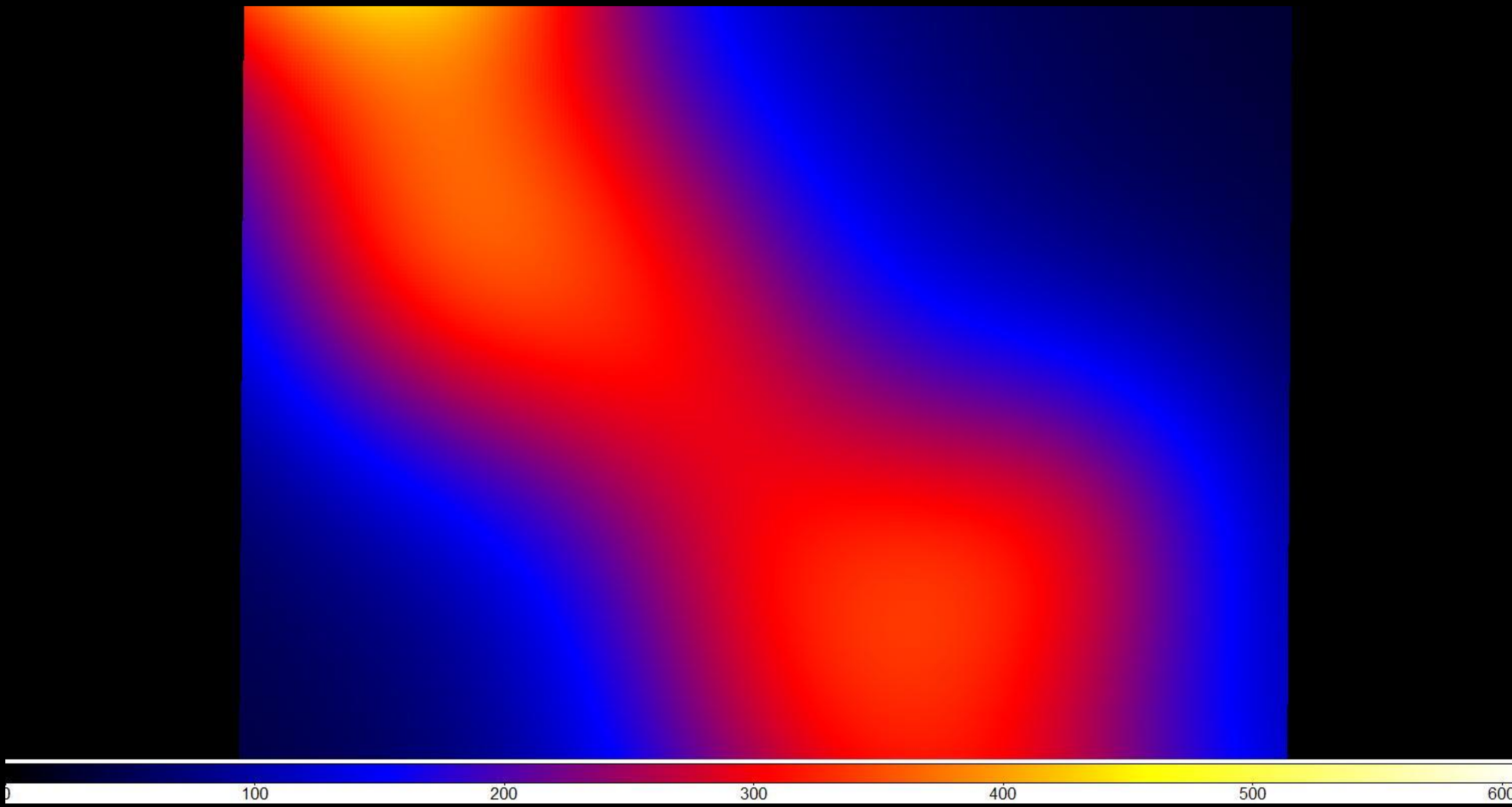
STO-2's Most Compelling Science Result



Understanding how [CII] traces the formation of molecular clouds and star formation throughout cosmic time.

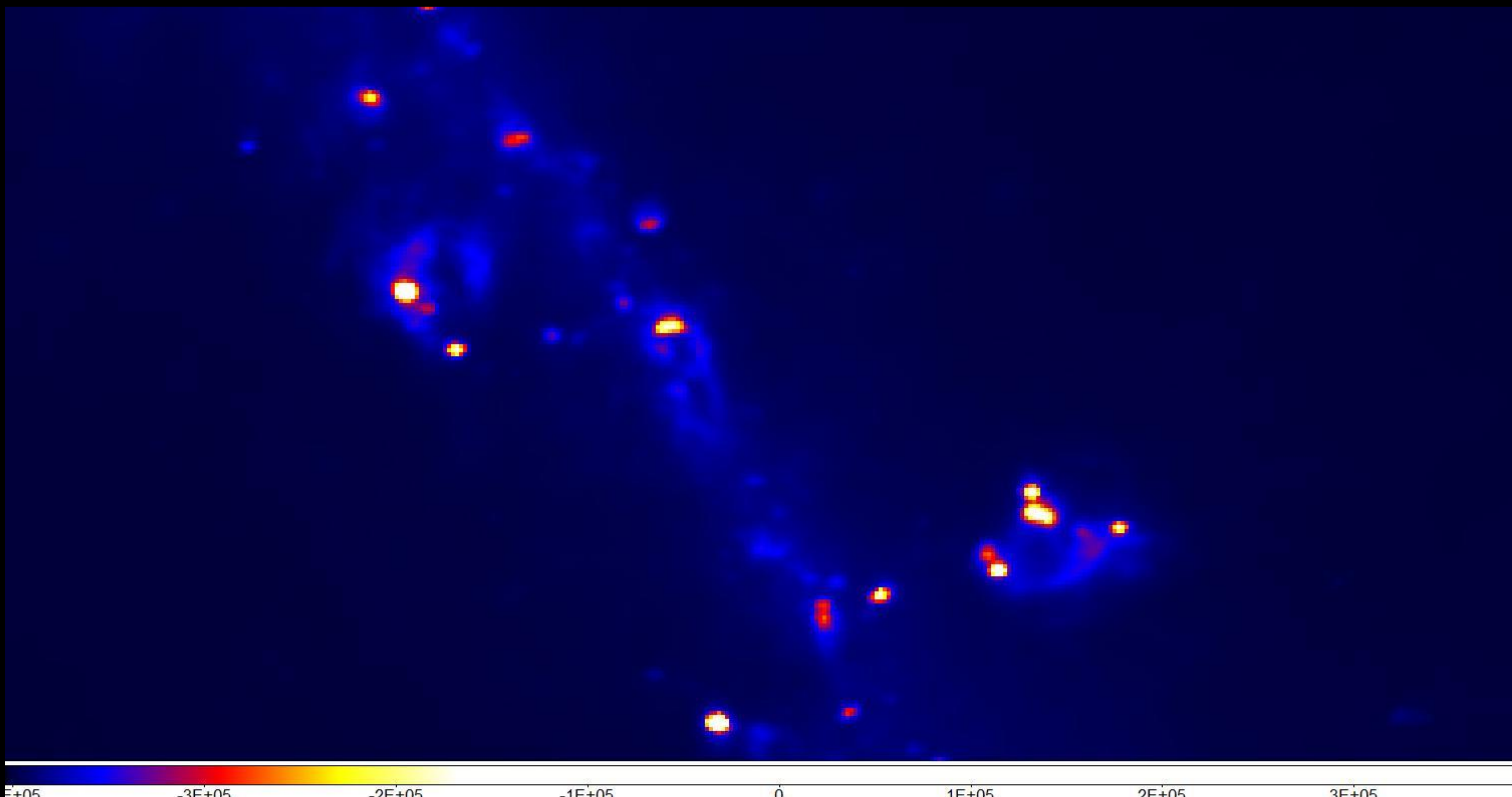
Uniqueness:
STO-2 ***ONLY*** Mission to probe ***Full Cycle***

STO-2 Vastly Improves Available Angular Resolution



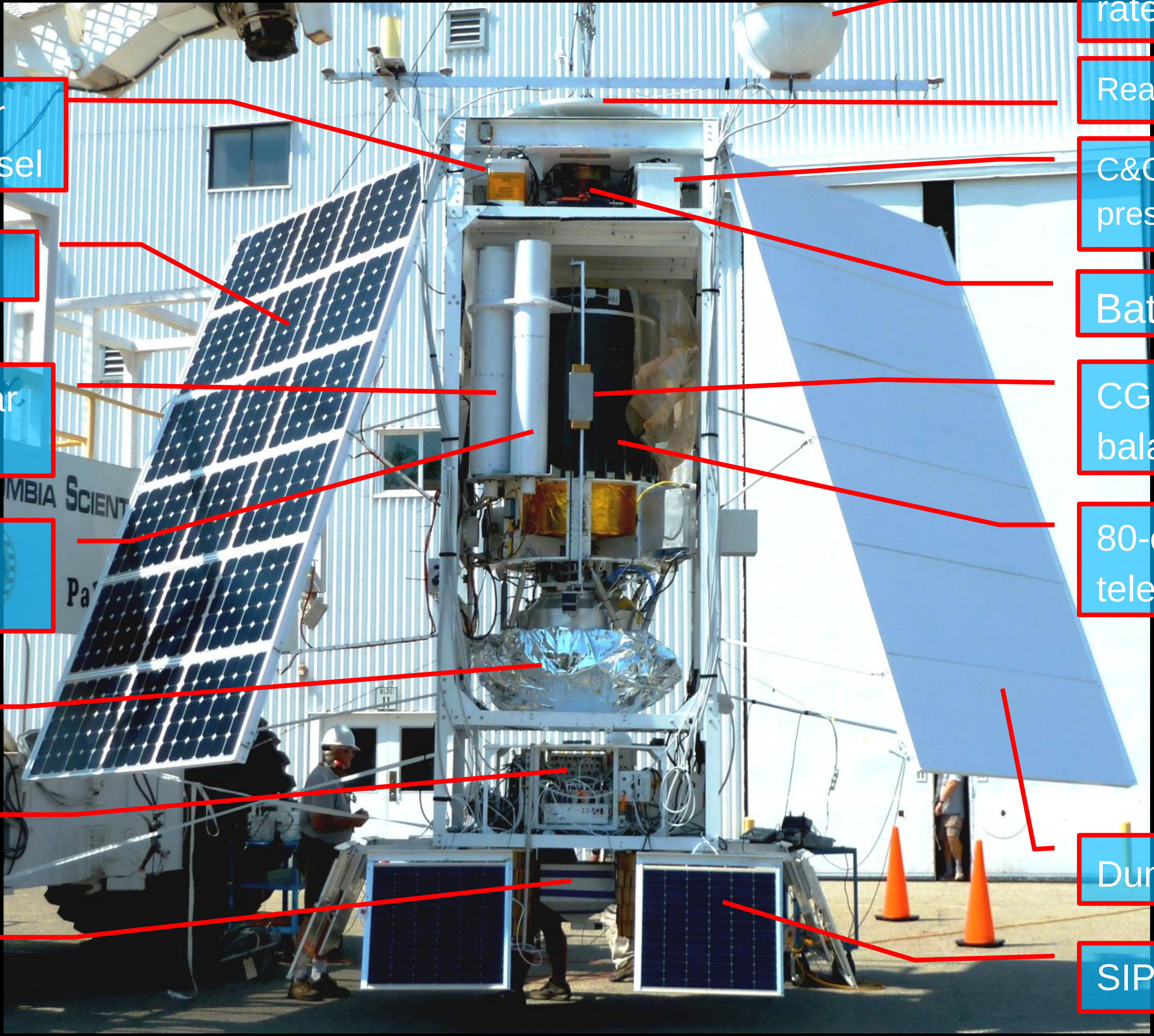
Galactic Plane Region Near $l = 340$ IRAS 60 μm Smoothed to 3°

STO-2 Vastly Improves Available Angular Resolution



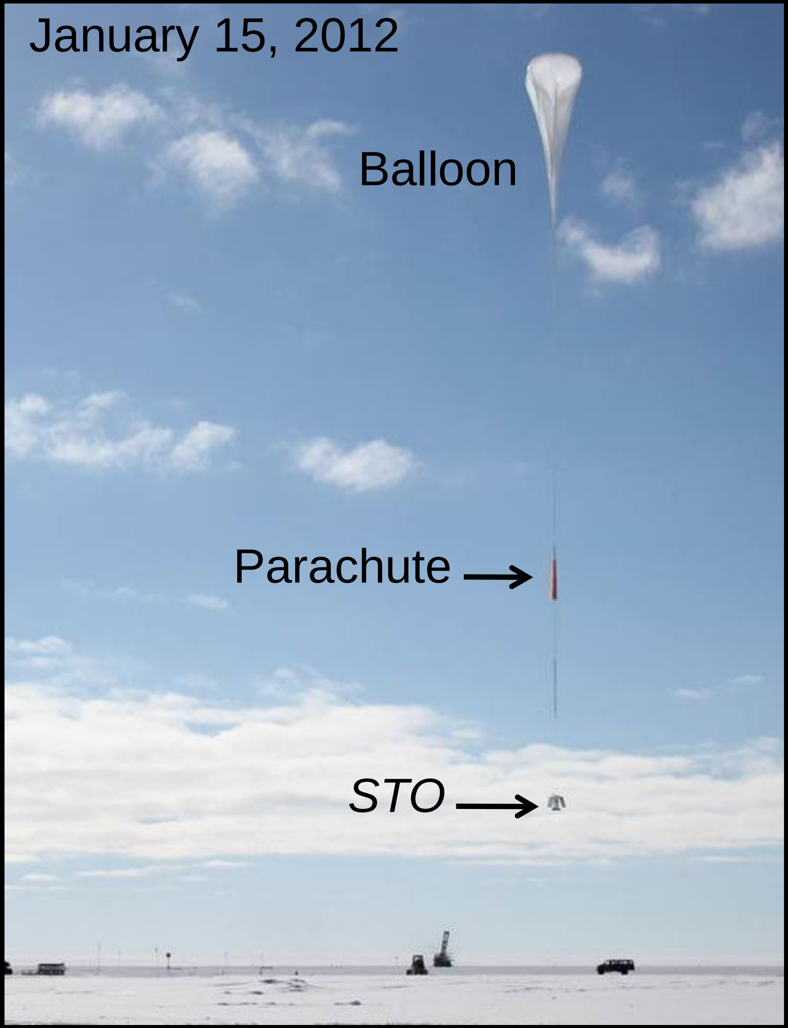
Galactic Plane Region Near $l = 340$ IRAS 60 μm 2’ Resolution

STO-1 Observing Platform



Stratospheric Terahertz Observatory (STO-1) *1st Antarctic Flight*:

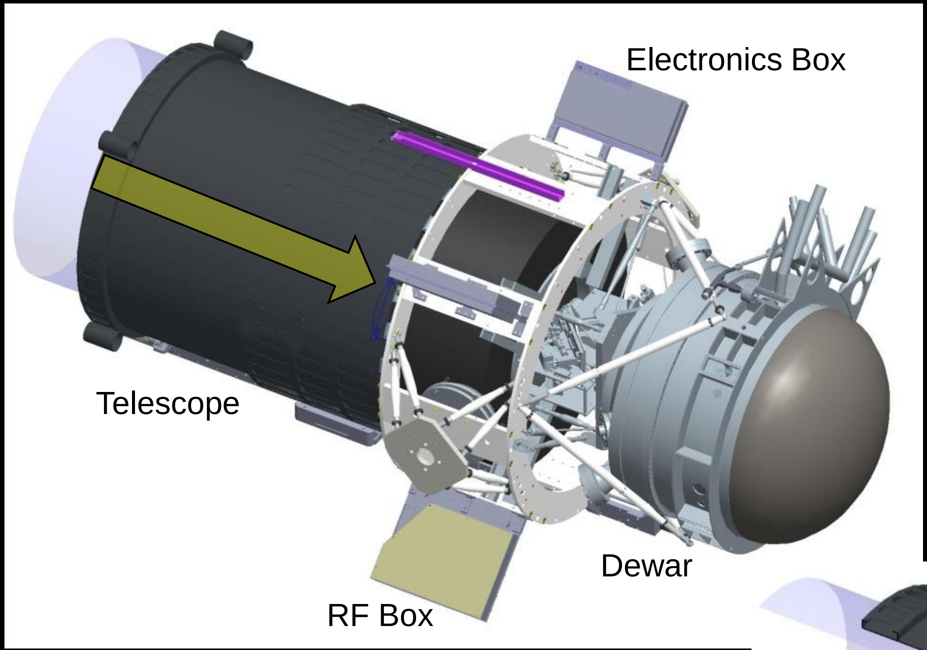
STO **at Launch: Williams Field, Antarctica**



STO-1 provides STO-2:

- Team experience
- Gondola and instrument architecture
- Observing profile and mission plan
- Data product management

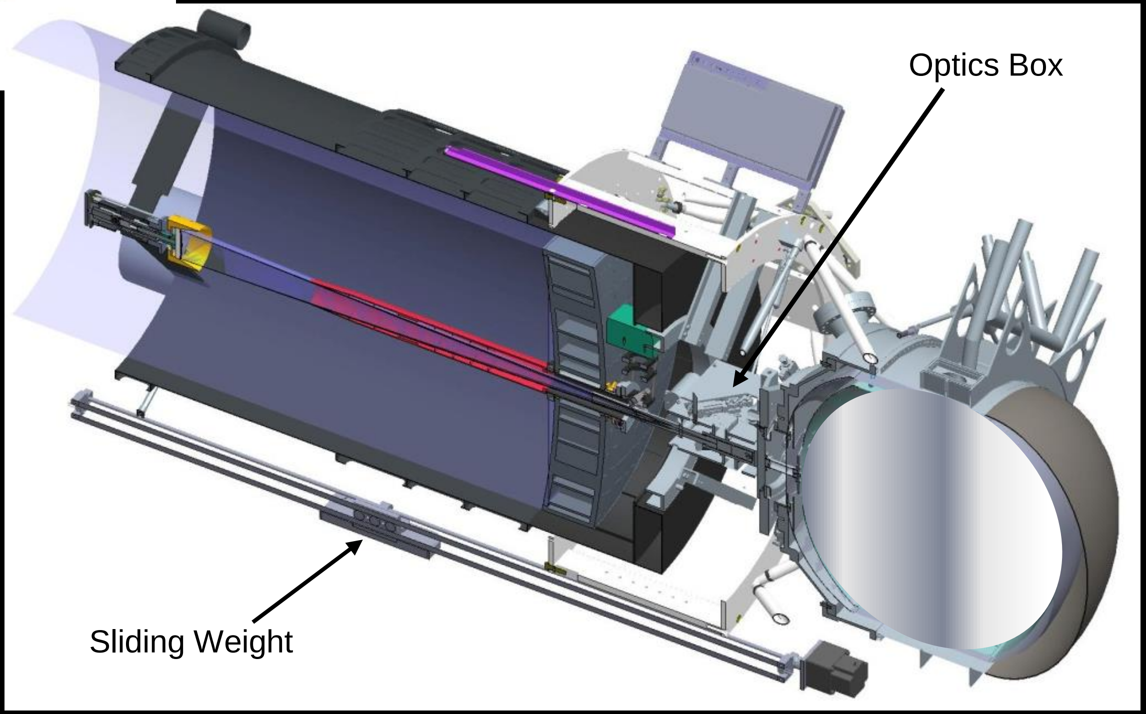
STO-2 Science Flight Configuration



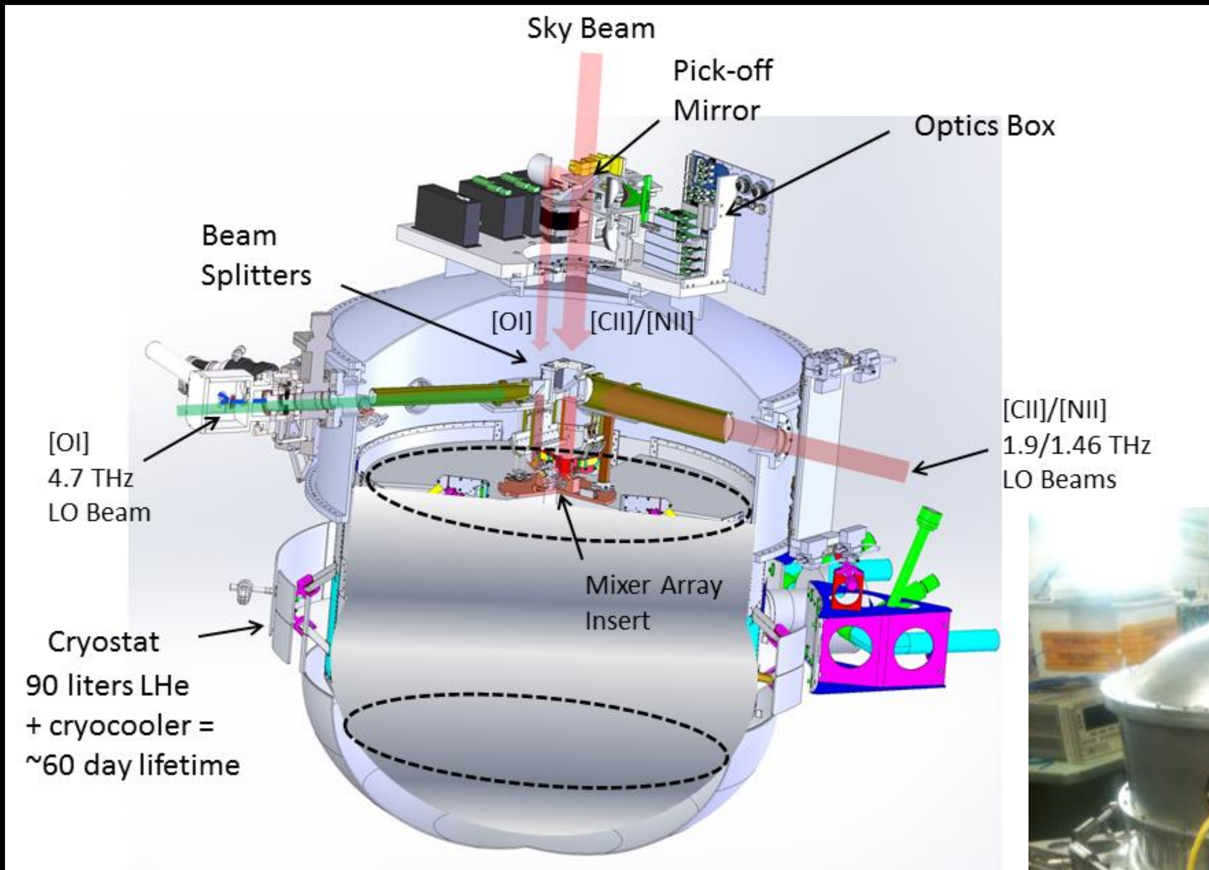
Telescope Specifications:

- 1^{ary} aperture: 80 cm
- Length: ~1.2 m
- F-ratio: F/17.5
- ½ angle FOV: 3.5 arcmin
- 1^{ary} material: ULE glass honeycombed
- Weight: 420 lbs

- HEB Mixers
  - 1x4 [CII] 1.9 THz array/JPL
  - 1x4 [OI] 1.4 THz array/JPL
  - 1 pixel [OI] 4.7 THz/ SRON & MIT
  - 2x more sensitive than STO-1
- Cryogenic System keeps FPA
  Keeps FPA @ 4K with 90 l liquid He cryostat up to **~60 days**
- 492 GHz Schottky RX for Warm Mission



STO-2 Flight Instrument

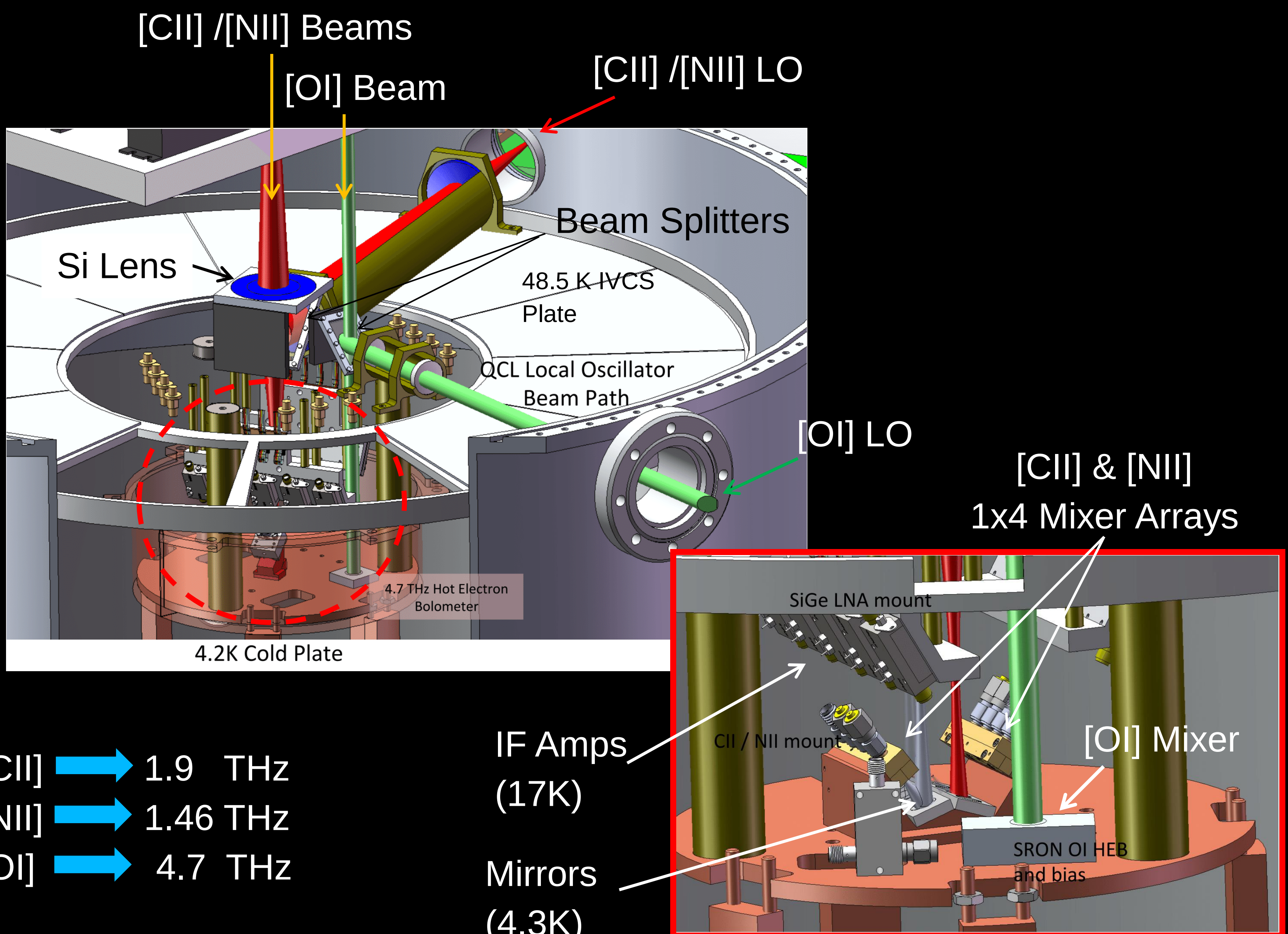


STO-2 Flight dewar
Undergoing tests

Hybrid Dewar design provides ~60 day hold-time

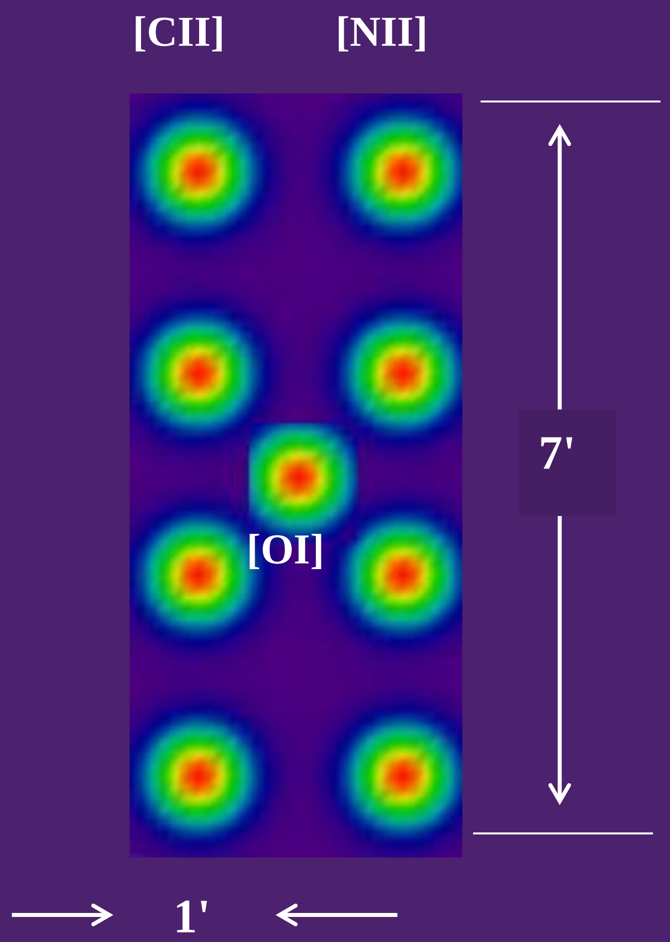
LO's mounted to dewar collar, injected with simple beam splitter

STO-2 Signal Path Through Dewar

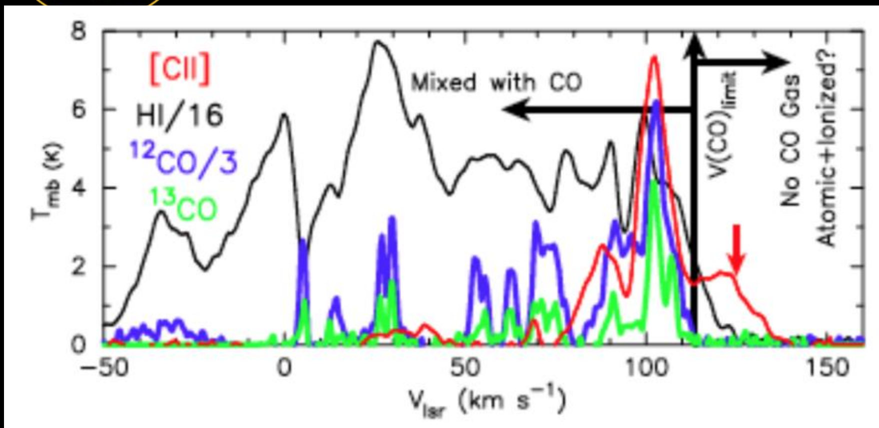


[CII] → 1.9 THz
[NII] → 1.46 THz
[OI] → 4.7 THz

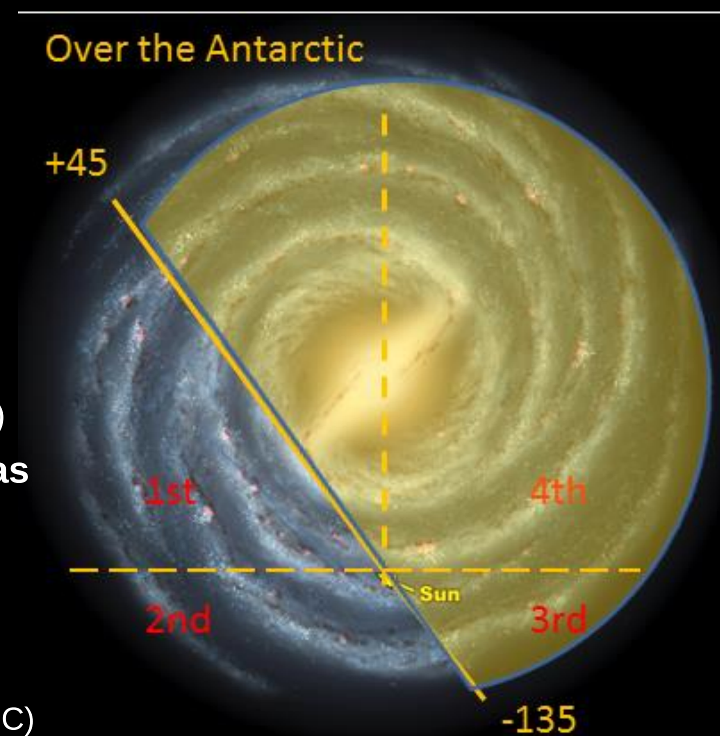
STO-2 Sky Beams



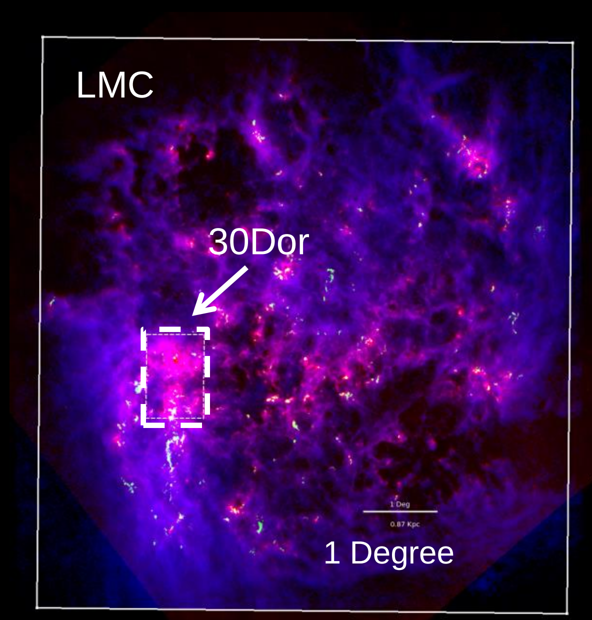
STO-2 Observational Objectives: [CII], [OI], & [NII] Surveys of MW and LMC



Above: One of ~500 line of sight (LOS) [CII] spectra (*Herschel HIFI)*
STO 's surveys will observe **><u>10,000 LOS</u>, more than *20x* what was done with *Herschel* HIFI in [CII] + [NII] + [OI] !**



STO Galactic Plane Visibility

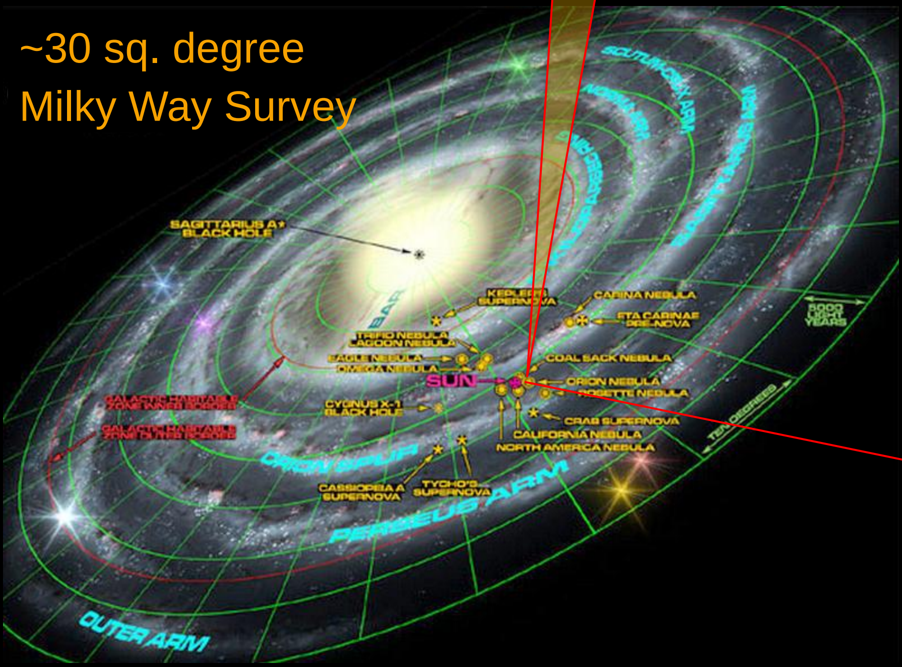


And…

The Large Magellanic Cloud (LMC) in HI (blue), CO (green), *Spitzer* 160μm emission (Red). The <u>dashed</u> box is the proposed 30 Dor deep integration map.

STO-2 Observing Strategy

~30 sq. degree
Milky Way Survey

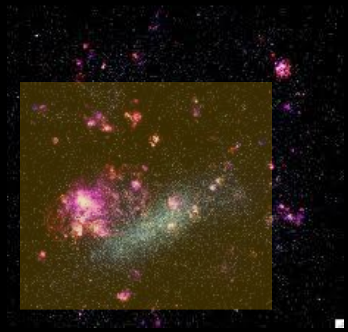


On-the-Fly Mapping

Key Features of the *STO-2* Mapping Mission:

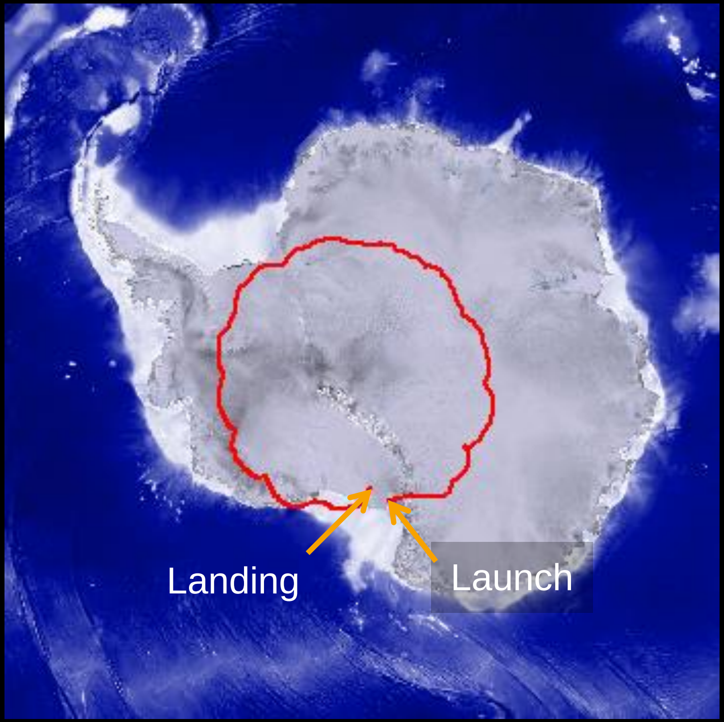
- Simple and stable optics optimized for THz observations
- Cryogenic detector arrays for high sensitivity
- Automated Scheduler for low-cost operations
- Efficient slewing to reference points and new targets

~1 sq. degree
30 Dor Survey

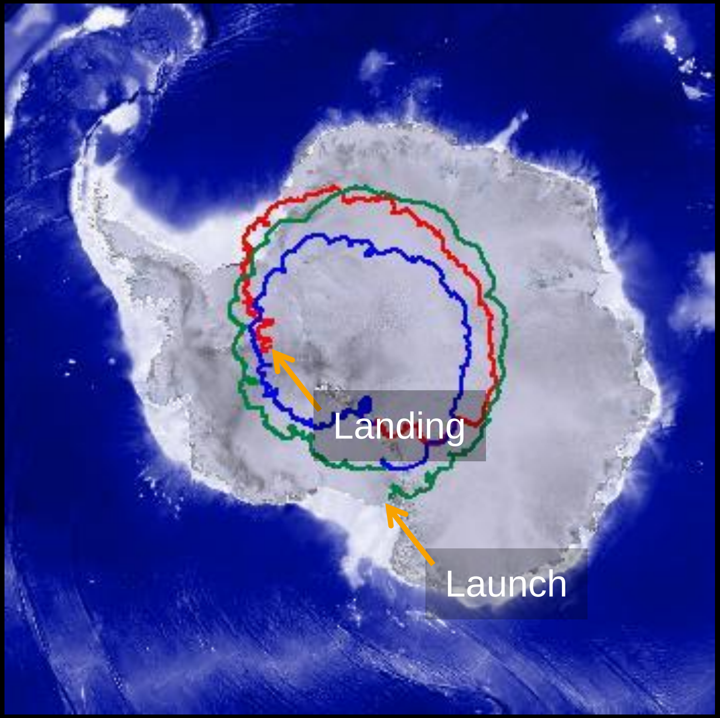


NASA’s LDB: A “Satellite on a String”

STO-1 (14 day* flight)



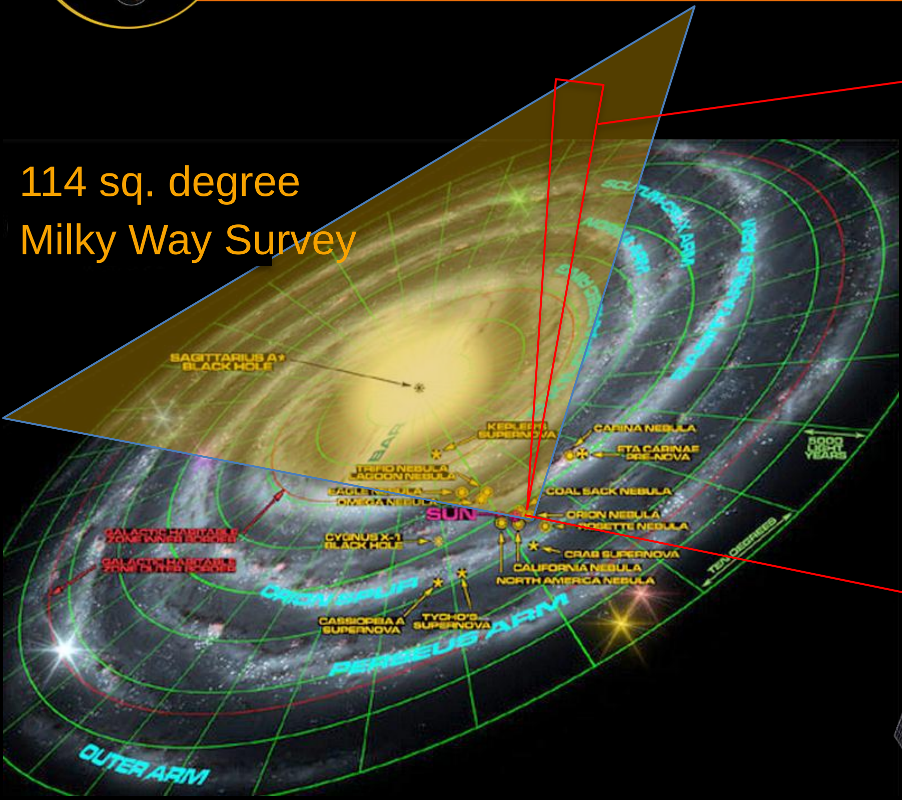
Super-TIGER (55 day flight)

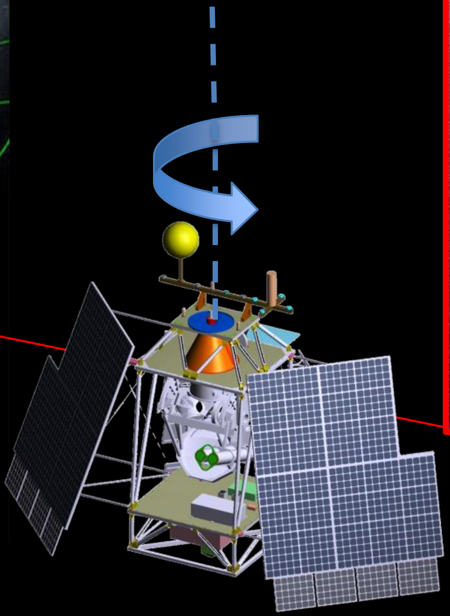


STO-2 can fly for ~60 days

GUSTO

114 sq. degree
Milky Way Survey

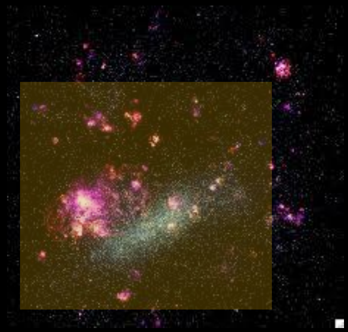




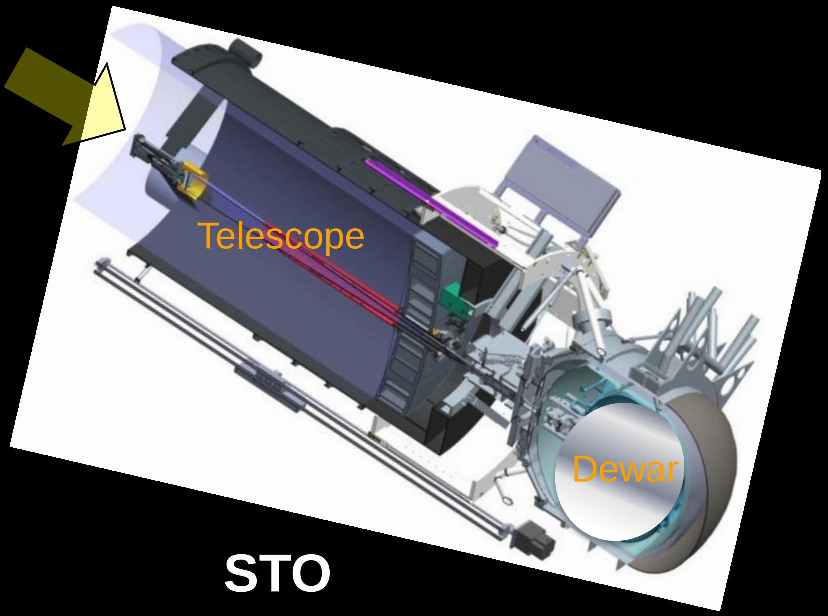
On-the-Fly Mapping

Selected for Phase A Concept Study
in 2011 Explorer round….will try again!

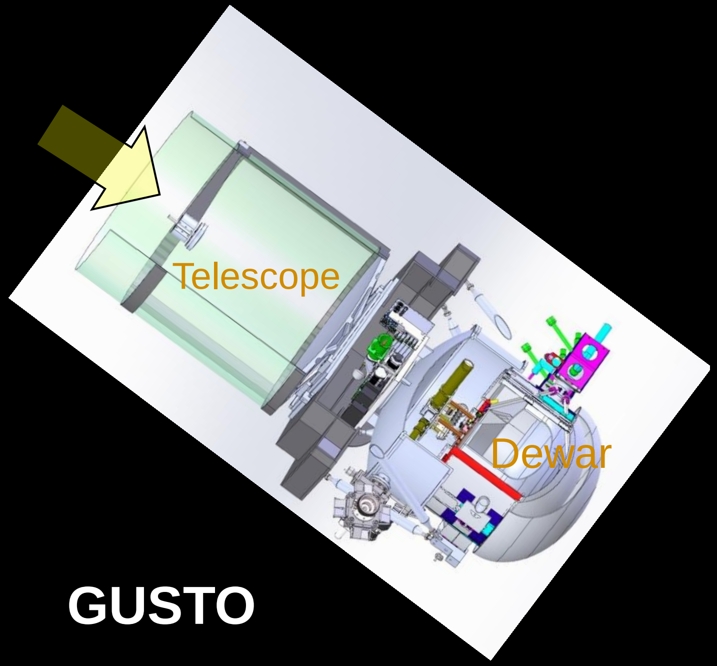
30 sq. degree
LMC Survey



Advancing from *STO* to *GUSTO*



STO



GUSTO

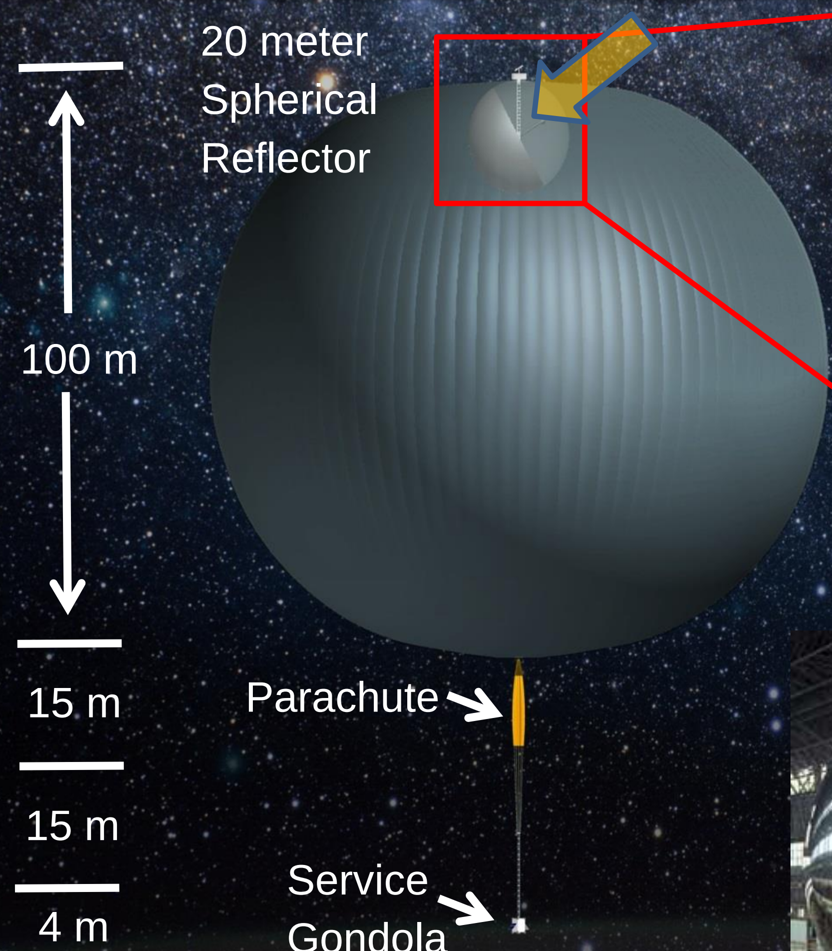
GUSTO will be a mapping machine

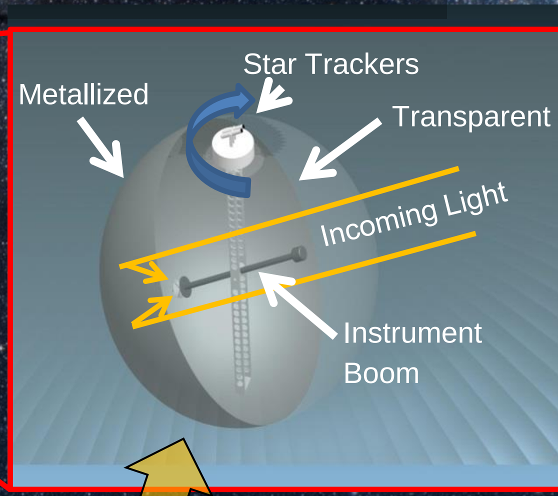
- Larger, integrated focal plane receiver arrays; adding [OI] capability: 8 pixels at 1.46 THz [NII], 1.9 THz [CII], and 4.7 THz [OI]
- Mapping-optimized observing profile and mission plan
- Mission lifetime up to ~170 days; >300,000 LOS in all three lines

Proprietary Information/Competition Sensitive

THz Large Balloon Reflector

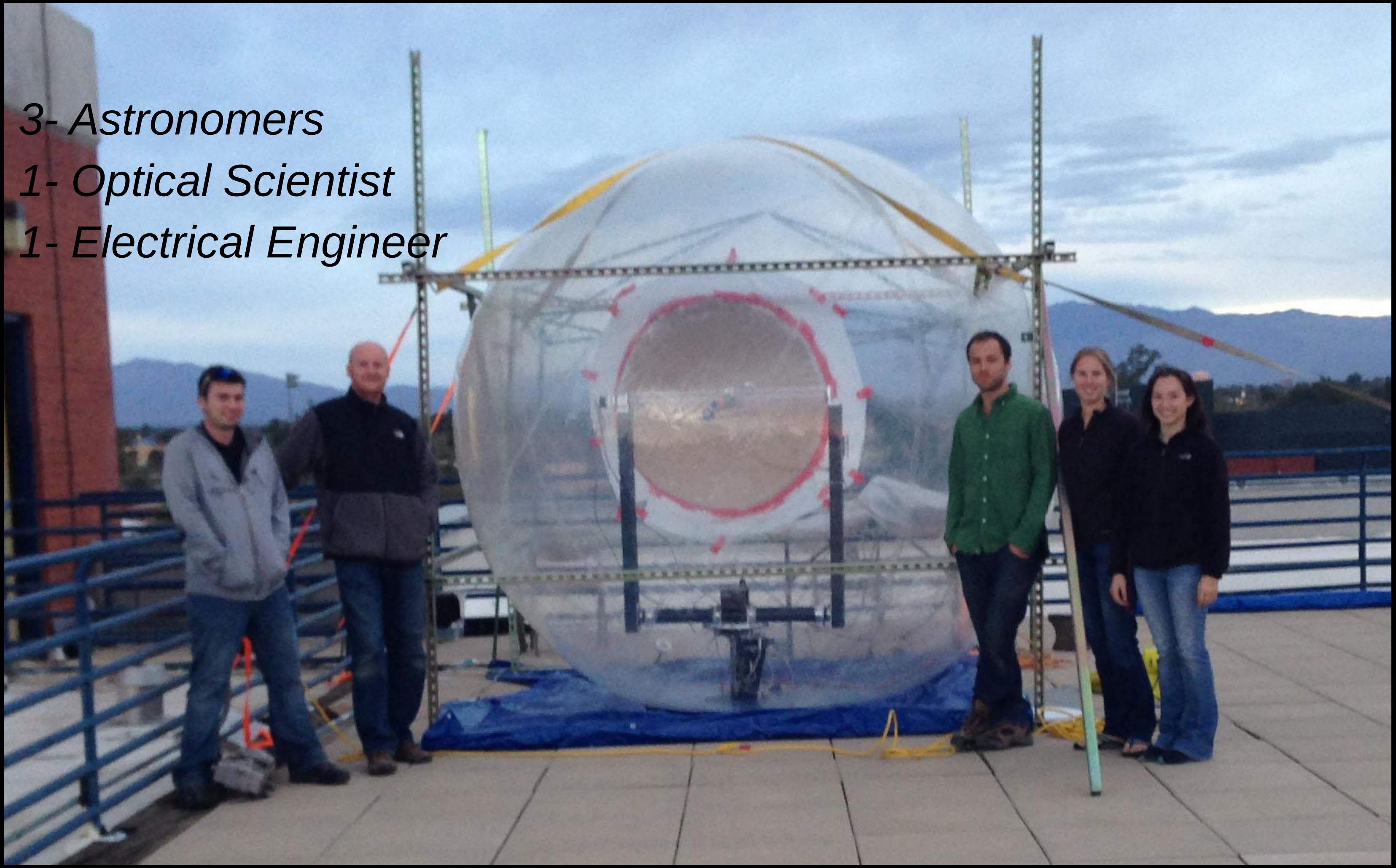
LBR





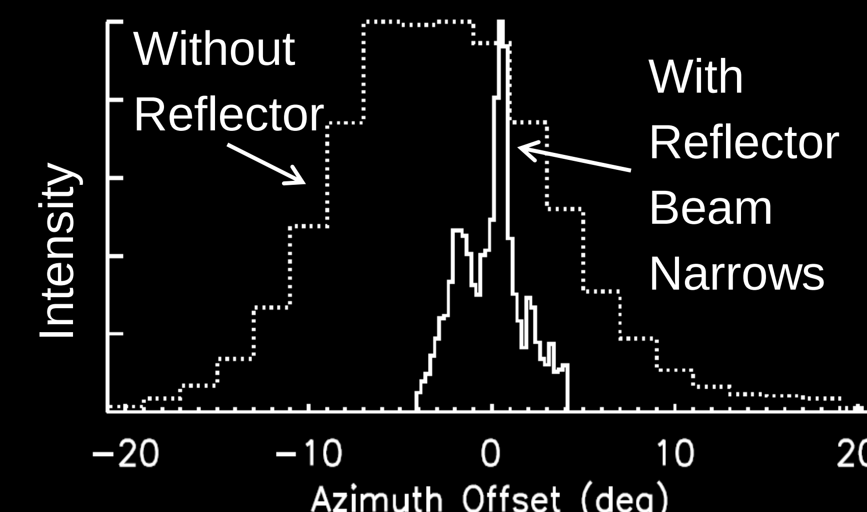
Echo I Satellite
30.5 m sphere
L band
ca. 1960

LBR NIAC Phase 1

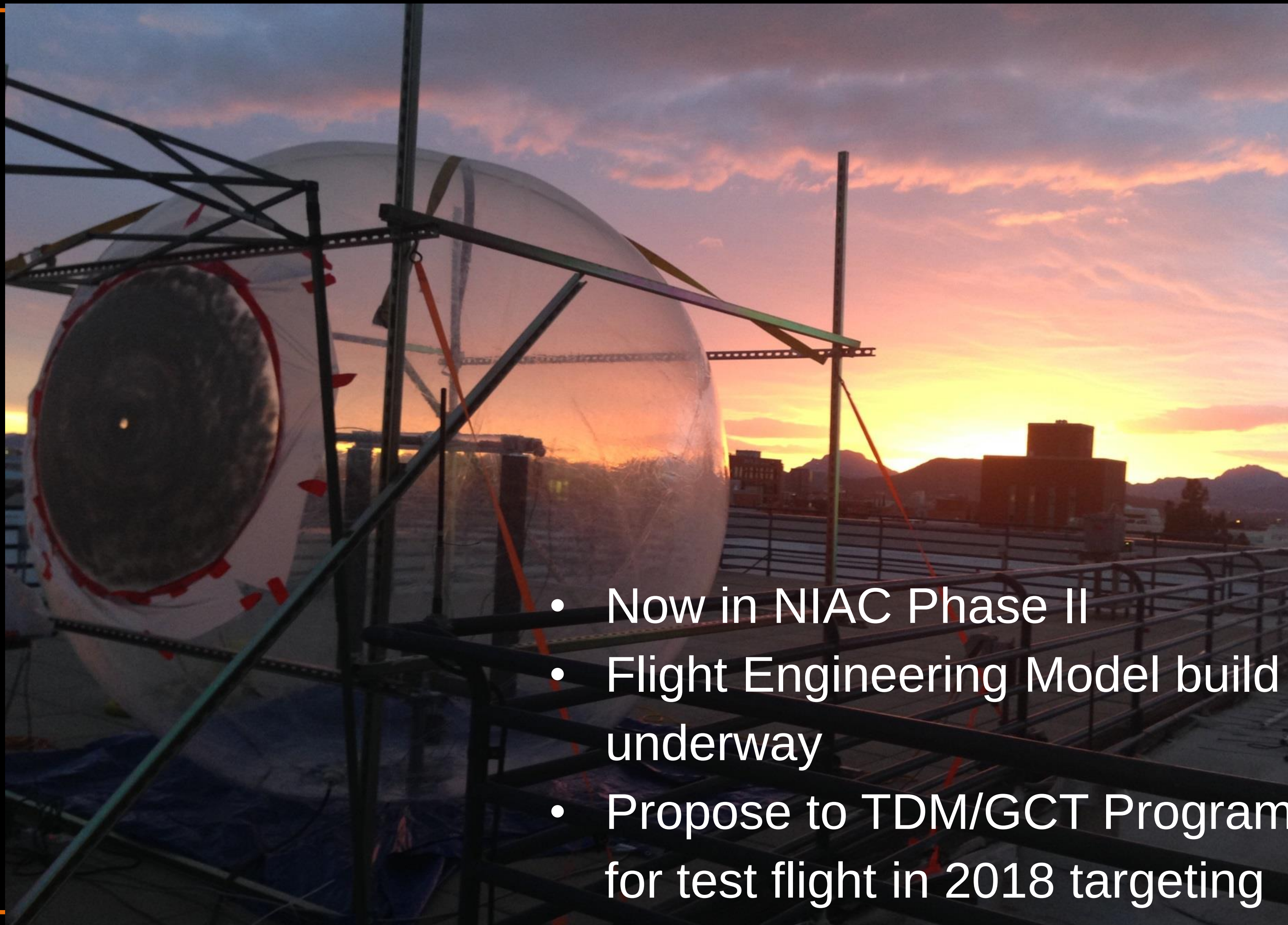


LBR NIAC Phase 1

3- Astronomers
1- Optical Scientist
1- Electrical Engineer



LBR: Ready for the next step….



- Now in NIAC Phase II
- Flight Engineering Model build underway
- Propose to TDM/GCT Program for test flight in 2018 targeting 557 GHz water line

THz Balloon-Borne Astronomy….

The Future is Now!