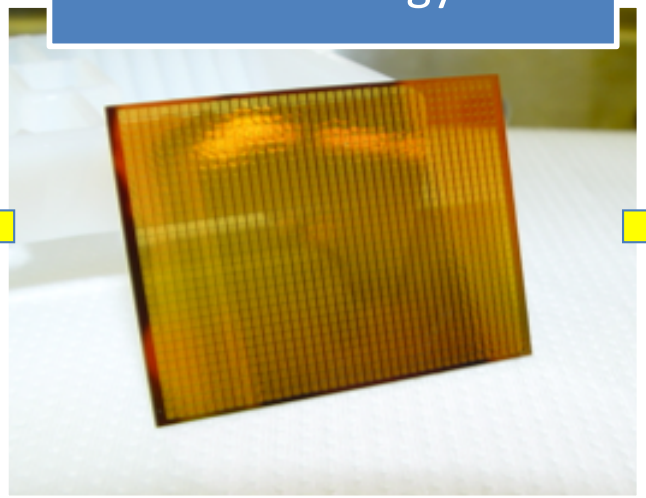
SOFIA: Basics
(Unique asset to astrophysics today)

People + Technology + Platform = Science

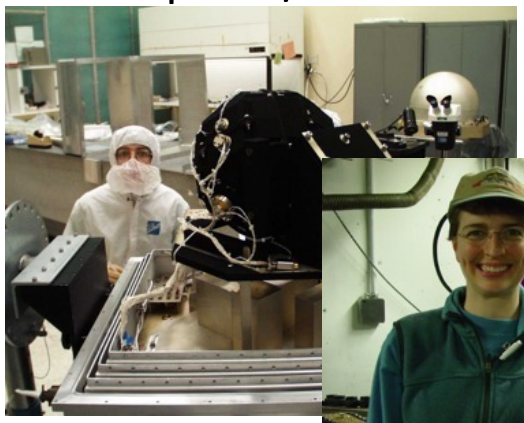


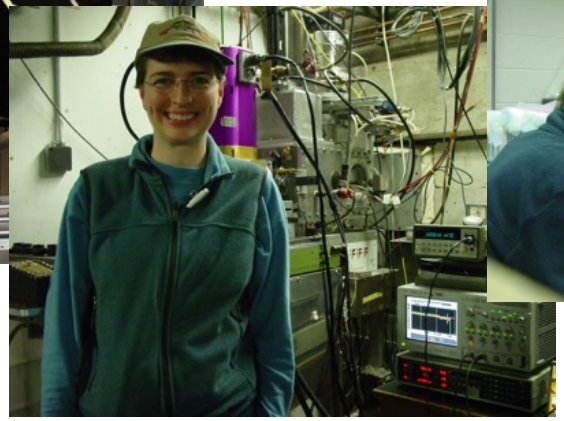
Dr. Kimberly Ennico Smith
NASA SOFIA Project Scientist
Kimberly.Ennico@nasa.gov

Dr. Kimberly Ennico Smith

- Started as SOFIA Project Scientist, December 5, 2016
- My primary role is to "**ensure the science potential of the Observatory through appropriate oversight.**"
- Based at NASA Ames Research Center, Moffett Field, California
- BA, Physics, Johns Hopkins
- MA, PhD, Astrophysics, Cambridge University, UK, Instrumentation focus

Spitzer/MIPS





JWST Detectors

SOFIA/FORCAST Grisms

LCROSS

New Horizons

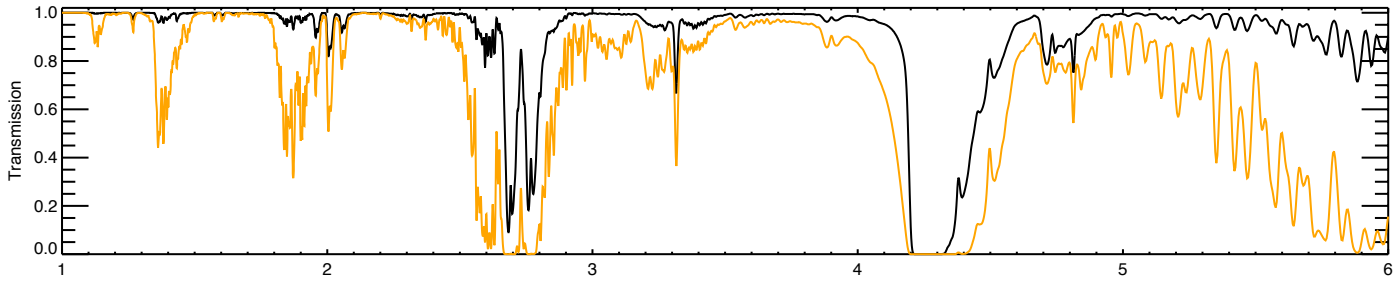
@kennicosmith

Stratospheric Observatory for Infrared Astronomy

Provides access to infrared to the worldwide astronomical community

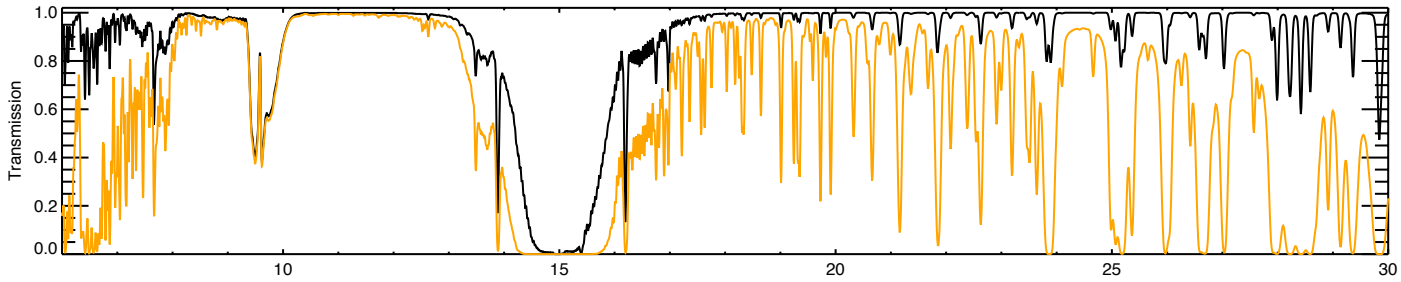
- Collaboration between NASA and DLR
- Highly modified 747-SP aircraft with a 2.7 m telescope (2.5 m unobscured)
- Flies up to 13.7 km (45,000 feet), above 99.9% of the water vapor in the atmosphere
- Elevation range: 20 – 60 degrees
- Wavelength range 0.3 to 1600 microns
- Suite of infrared imagers, spectrometers and a polarimeter
- Operational capability:
  - > 8 research flight hours per flight
  - > 70 GO programs per year
  - > 800 research flight hours per year
  - Global Operations occultations & targets of opportunity
  - Access to entire sky

Access through the atmosphere

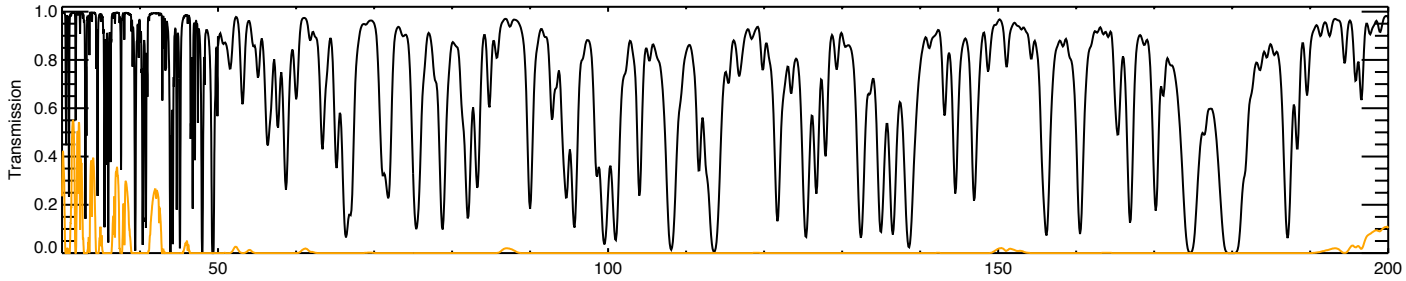


SOFIA 41K ft
ALMA 16K ft

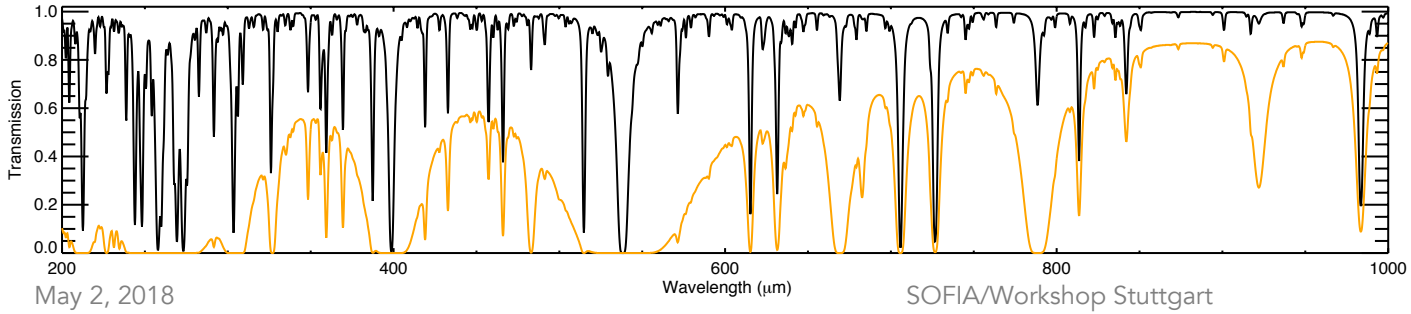
1-6 μm /
10,000 – 1667 cm^{-1}



6-30 μm
1667 – 333 cm^{-1}



30-200 μm /
10 - 1.5 THz

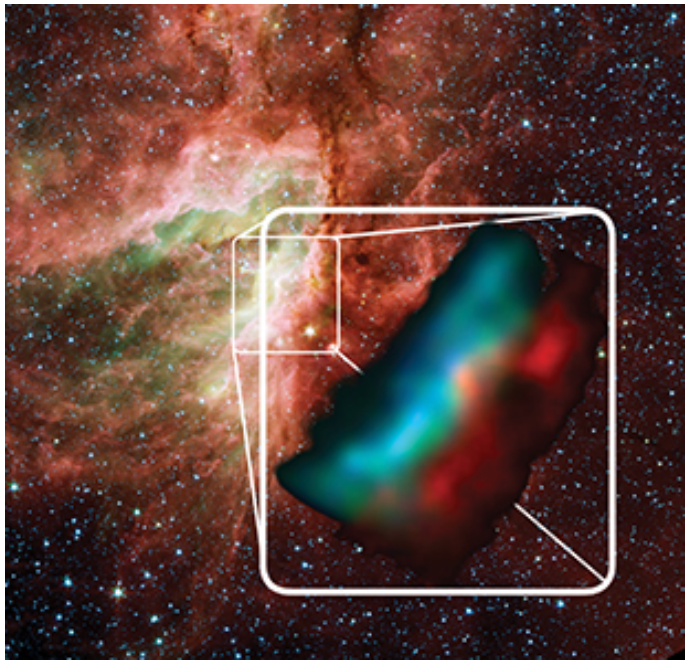


200-1000 μm /
1.5 THz - 300 GHz

NASA's Astrophysics Fleet

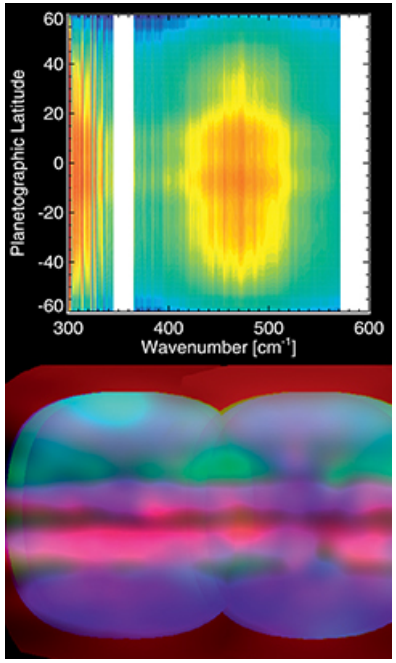
SOFIA Key Science Focus Areas

The Birth of Planets and Stars



Finally Charting the Infall

Origins: Path to Life



Water,
Organics, Dust

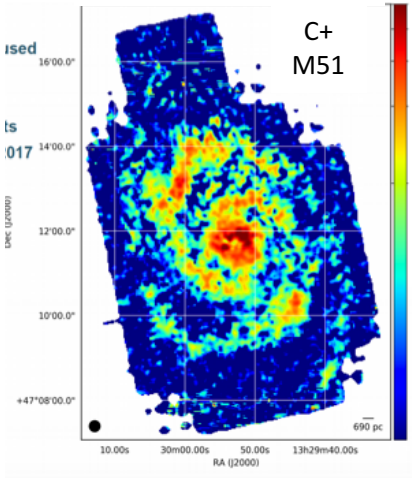
Extreme Environments

Stepping Stones to AGN
and Starbursts

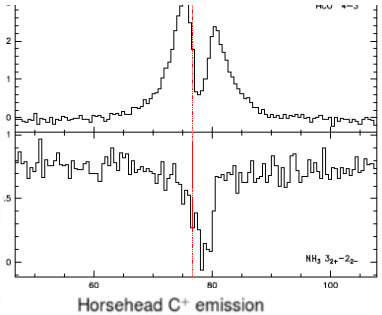
SOFIA Key Science Focus Areas

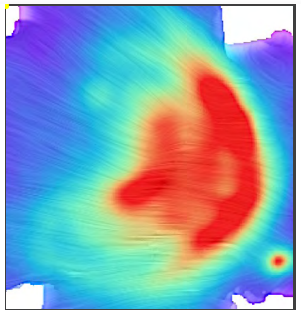
The Birth of Planets and Stars

Stutzki et al in prep

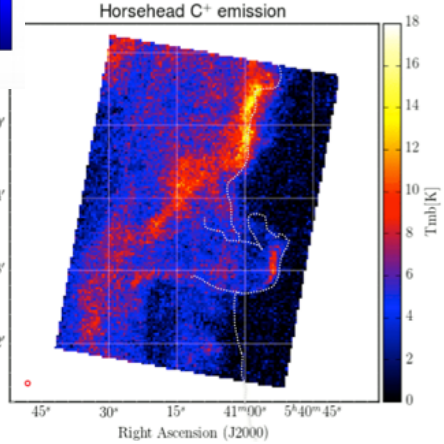


NH_3 Infall on Forming Stars
Wyrowski et al 2012, 2016





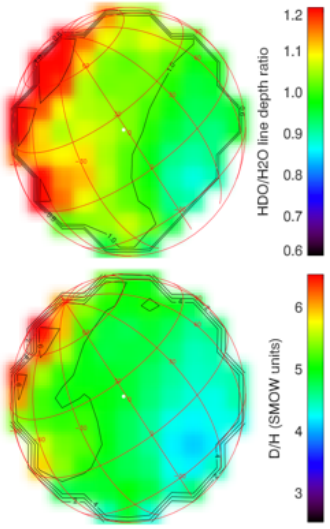
Rho Oph/Magnetic Fields
Santos et al in prep

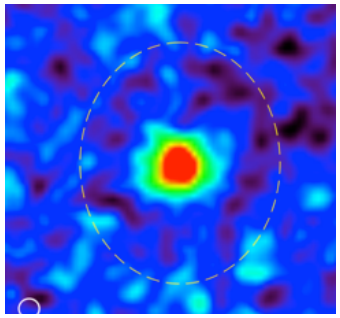


Horsehead Nebula
Pabst et al 2017;
Bally et al 2018

Origins: Path to Life

D/H on Mars
Encrenaz et al 2016

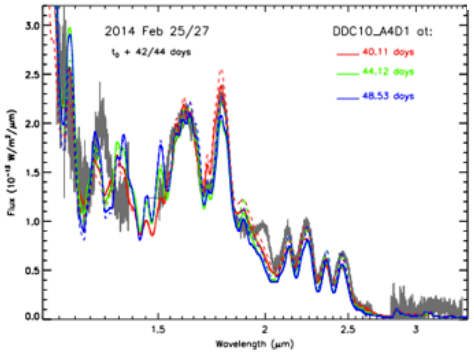




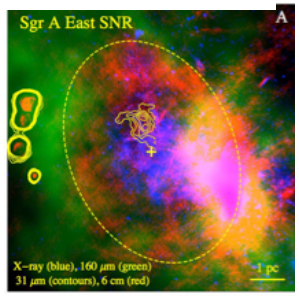
Debris disk dust
Su et al 2017

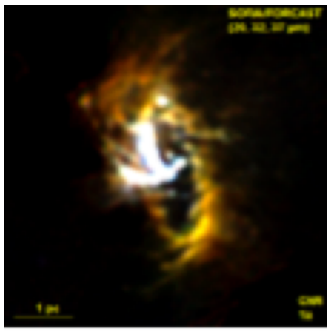
Extreme Environments

SN2014J in M82
Vacca et al 2015

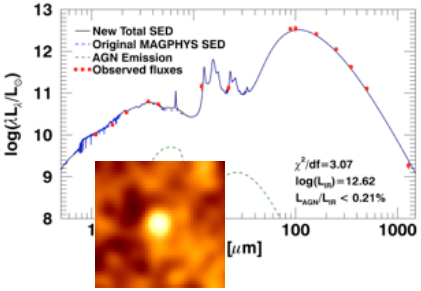


Dust in Supernova
Lau et al 2014





Circumnuclear Ring
Lau et al 2013



z~1 lensed galaxy
Ma et al 2018

SOFIA Key Science Focus Areas

How did we get here?

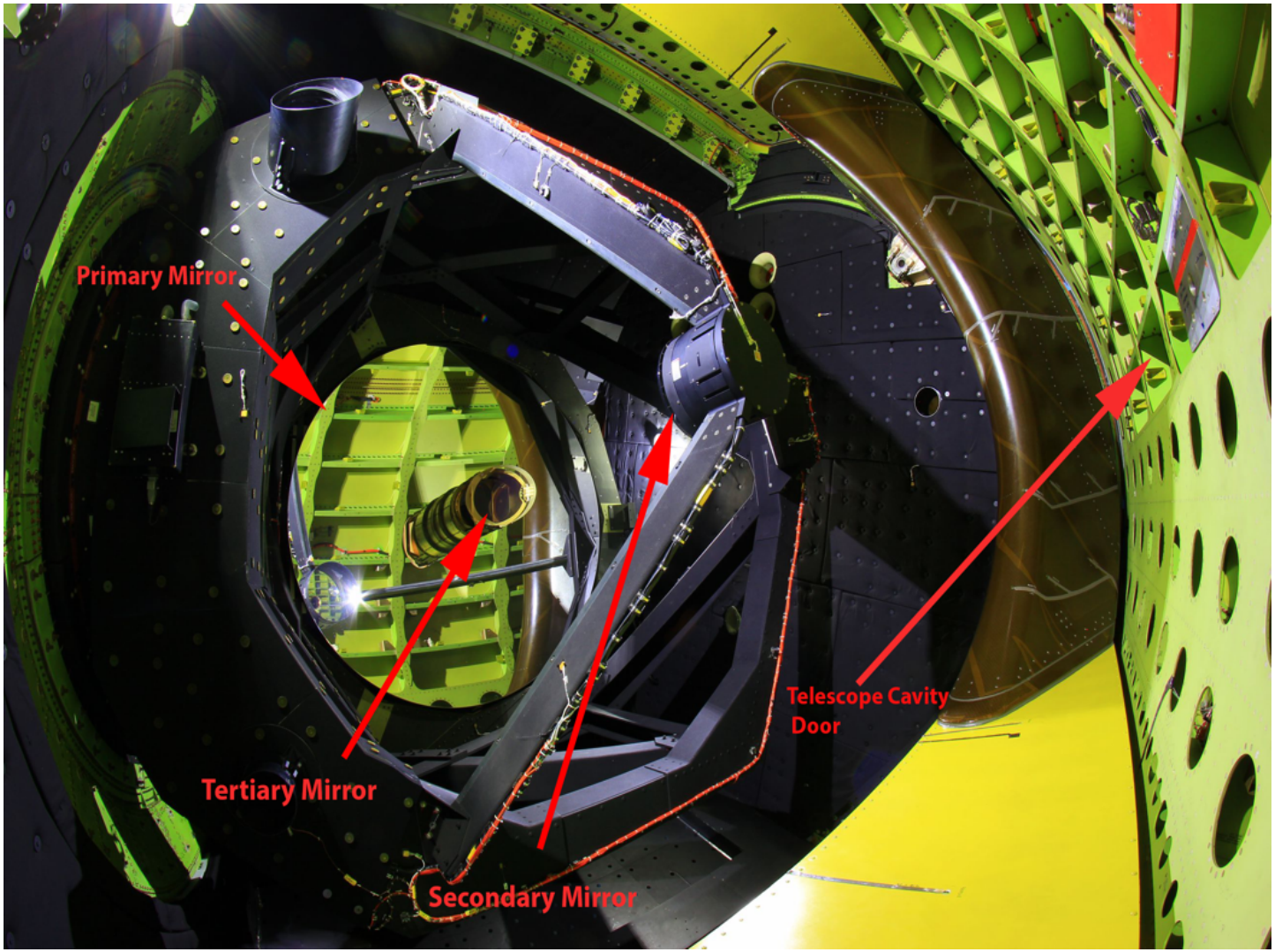
Are we alone?

How does the universe work?

Mapping to NASA Astrophysics Roadmap “Enduring Quests – Daring Visions” 2013

Telescope

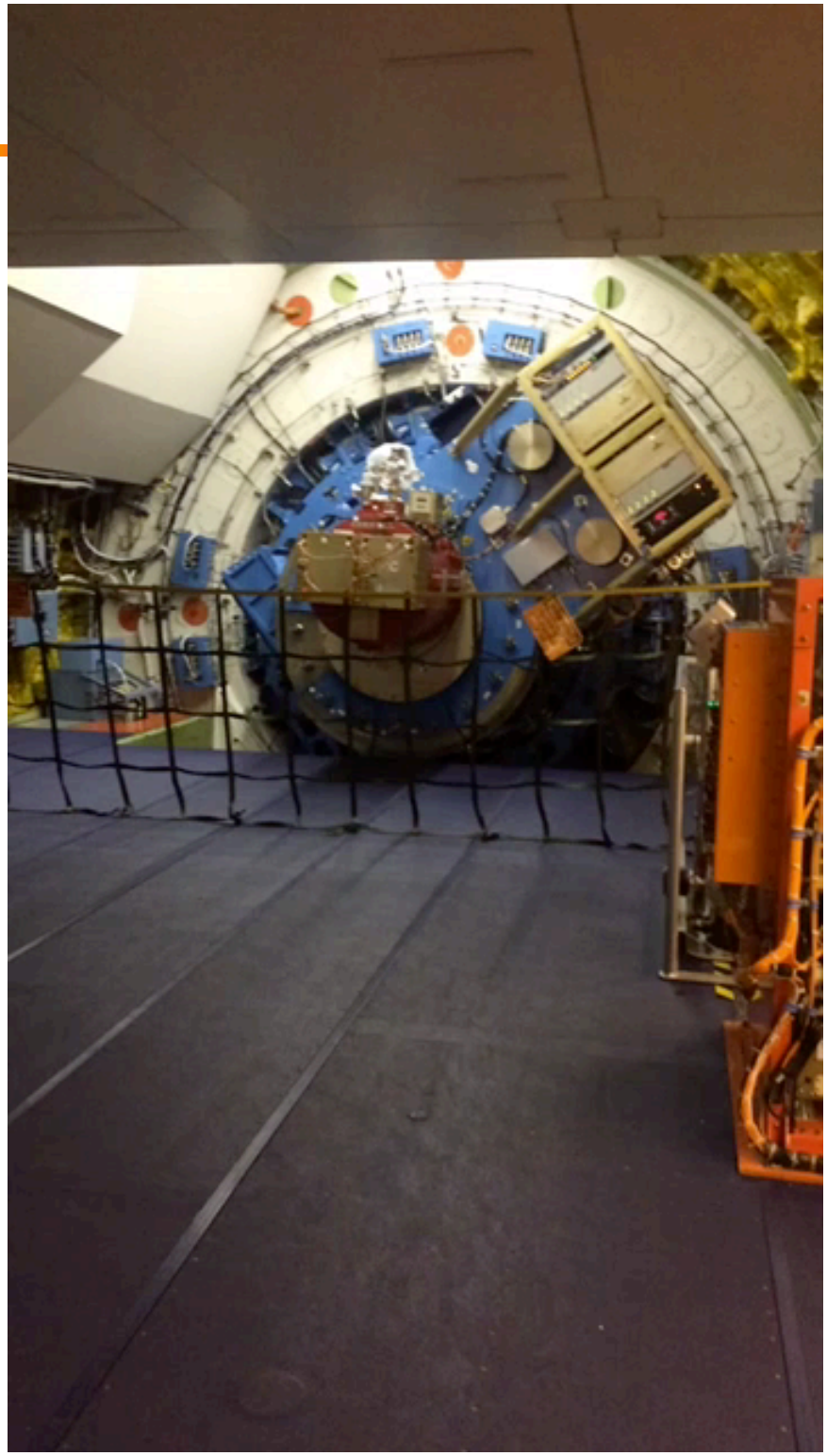
- During flight, the telescope door is open and the telescope is exposed to the atmosphere



Telescope

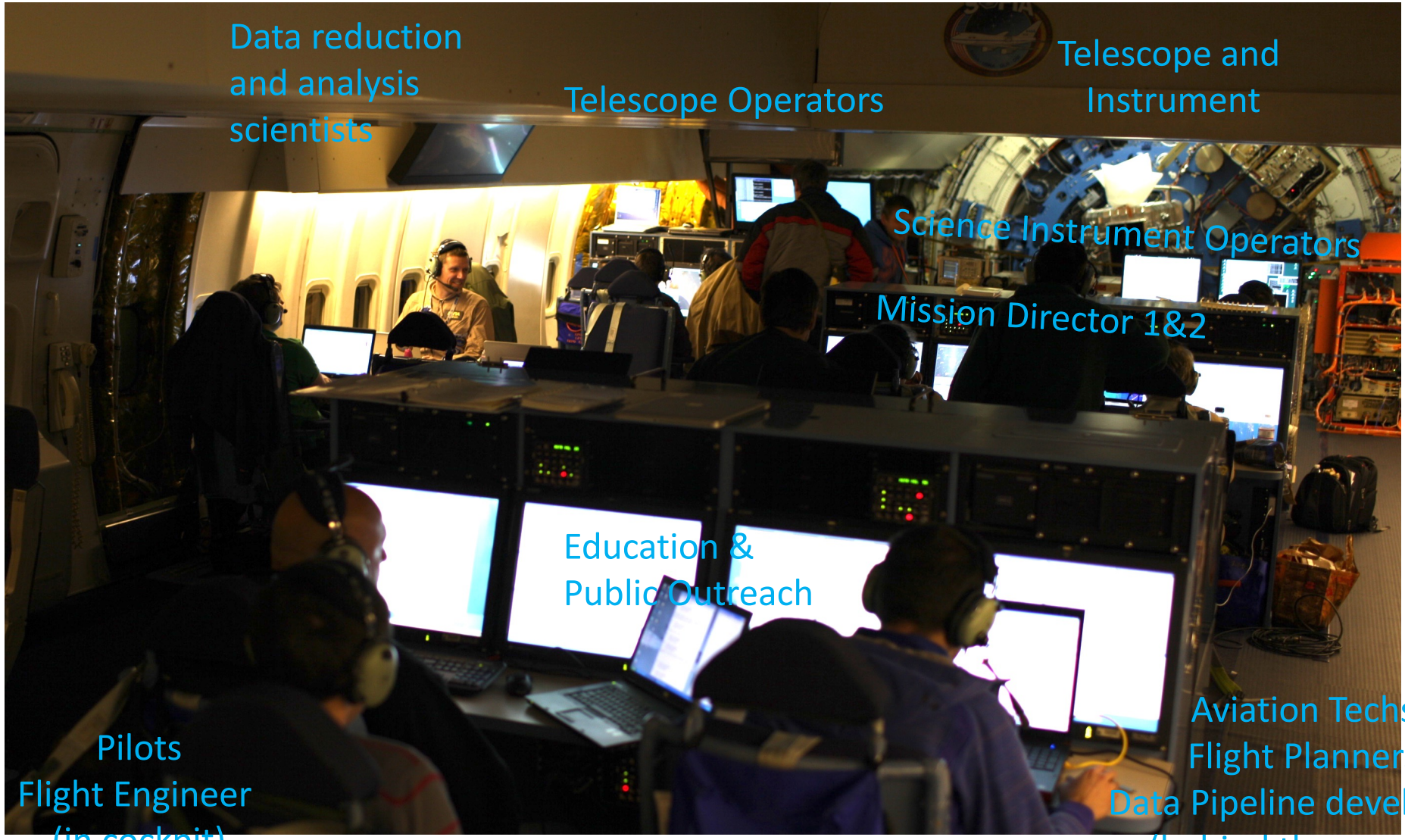
- Telescope stays stable during flight, locked onto its observing target

Inside SOFIA

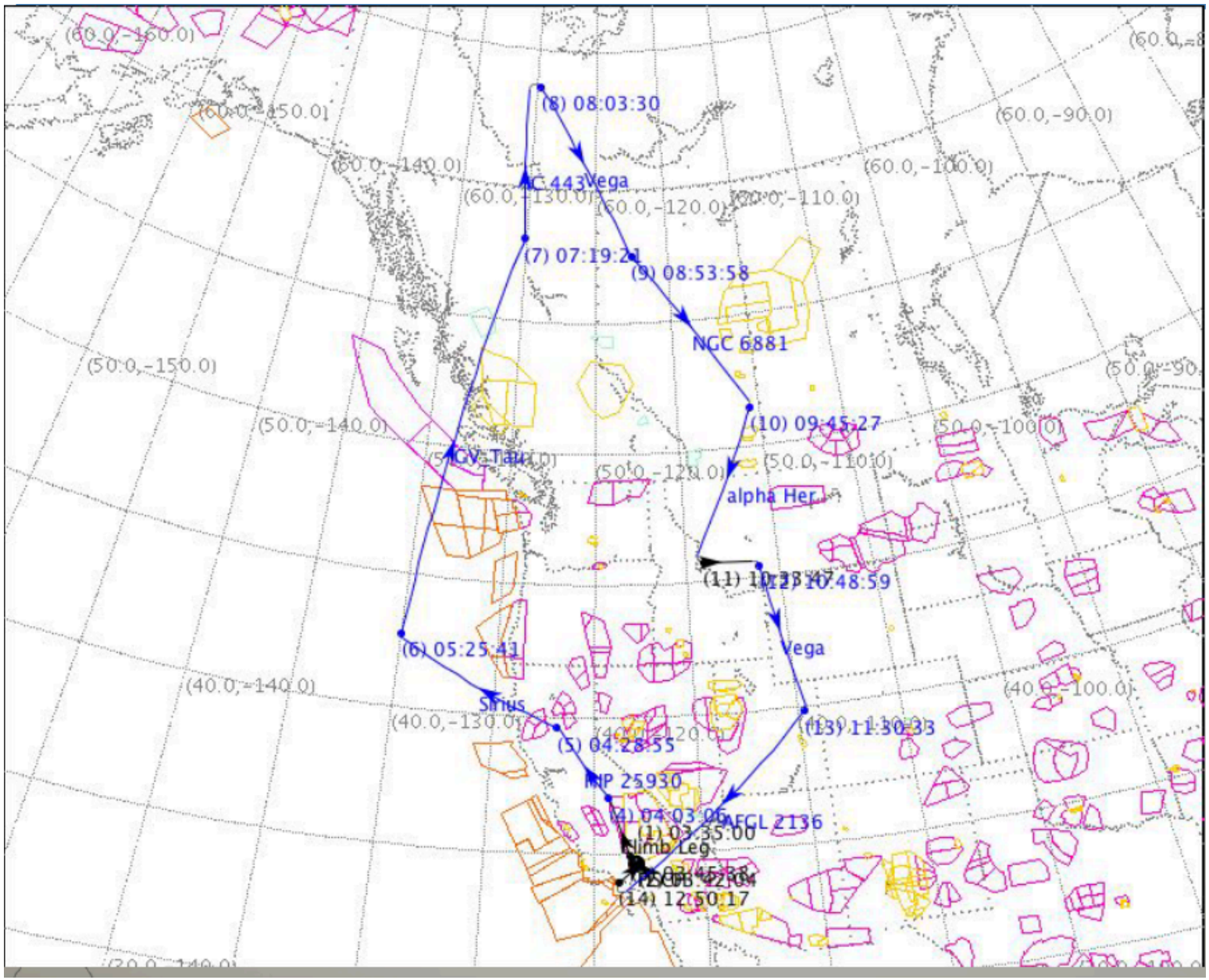


*(time-lapse video, not real time)

Inside SOFIA



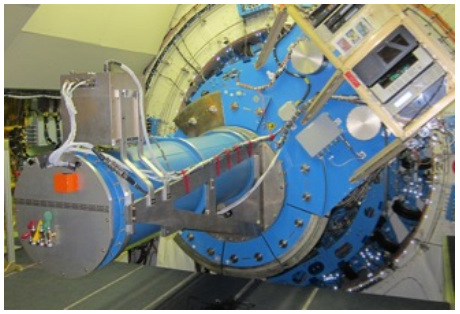
Designing Flight Plans



Wide Range of Interchangeable Instruments Available

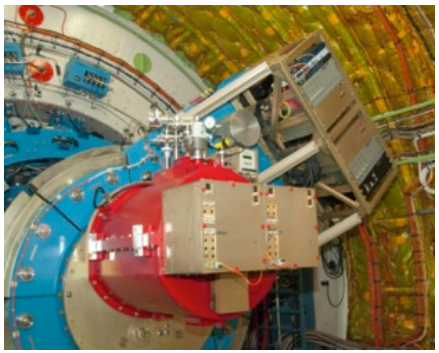
FPI+
Focal Plane
Imager

λ = 0.36–1.10 µm
R = 0.9–29.0



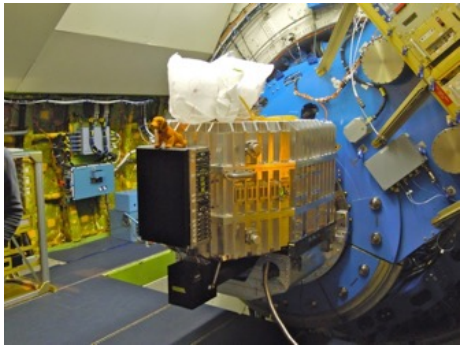
EXES
Echelon-Cross-Echelle
Spectrometer

λ = 4.5–28.3 µm
R = 1,000–10^5



FORCAST
Faint Object Infrared
Camera for the SOFIA
Telescope

λ = 5–40 µm
R = 100–300
Grism Spectrometer



FIFI-LS
Far Infrared
Field-Imaging Line
Spectrometer

λ = 51–203 µm
R = 600–2,000
Grating Spectrometer

HAWC+
High-resolution
Airborne Wideband
Camera Plus

λ = 50–240 µm
R = 2.3–8.8
Far Infrared Camera
& Polarimeter

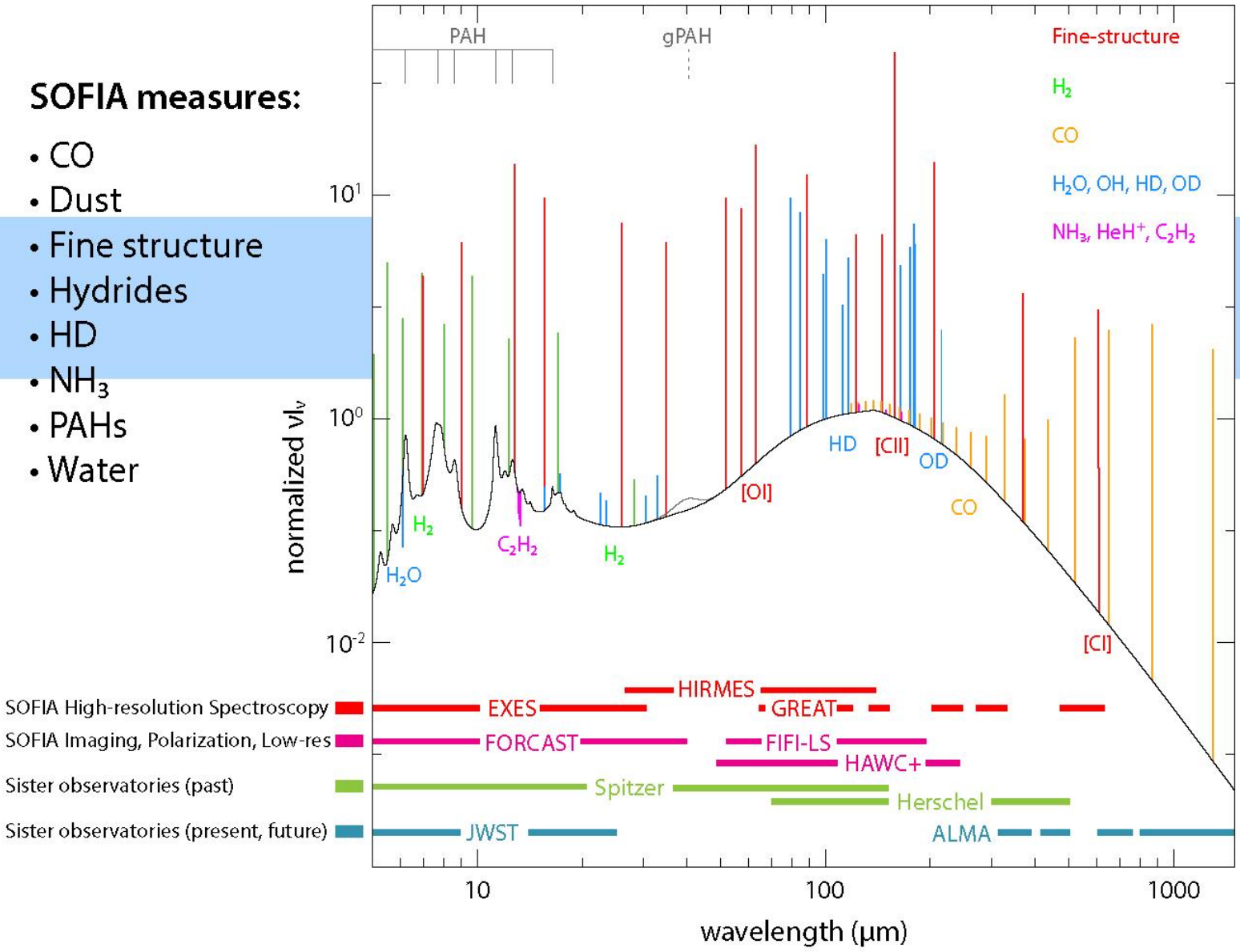
GREAT
German Receiver for Astronomy
at Terahertz Frequencies

λ = 63–612 µm
R = 10^6–10^8
Heterodyne Spectrometer

SOFIA covers a lot of infrared real estate

SOFIA measures:

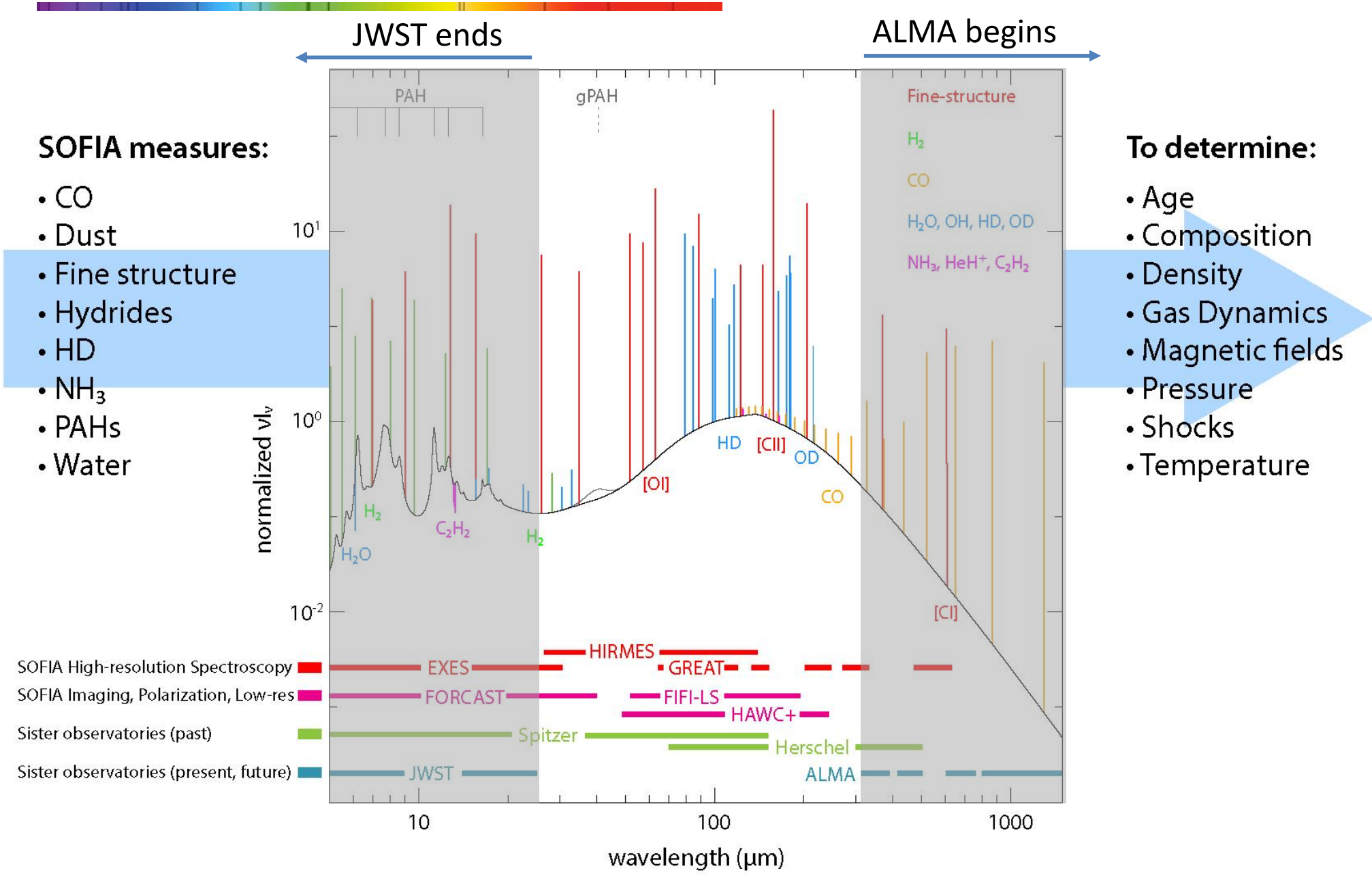
- CO
- Dust
- Fine structure
- Hydrides
- HD
- NH_3
- PAHs
- Water



To determine:

- Age
- Composition
- Density
- Gas Dynamics
- Magnetic fields
- Pressure
- Shocks
- Temperature

SOFIA covers unique & complementary infrared real estate



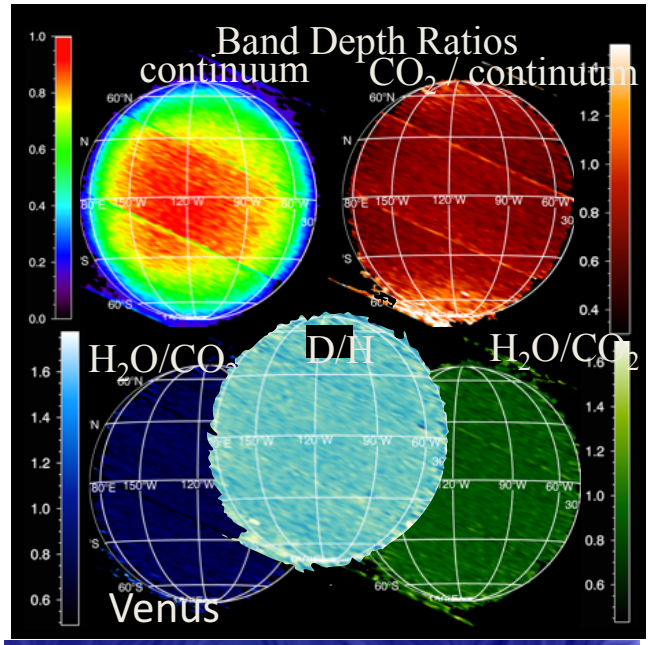
Looking Back in 2017

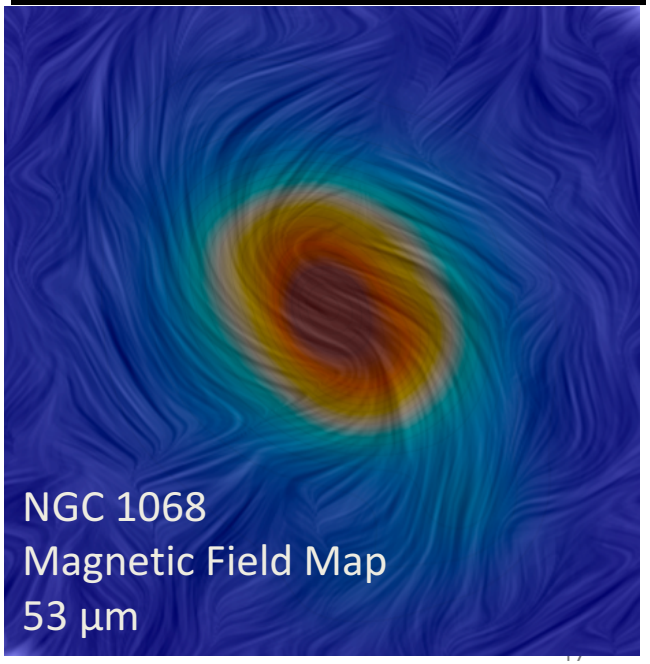
Science

- We observed everything from Venus to z=3.9 galaxy!
- 1st time made large C+ and [OI] programs across the Galactic Center
- Observed destruction of dust in SN1987A
- Looked for water in Europa in coordination with HST
- Occultation measurements Triton & KBO 2014MU69

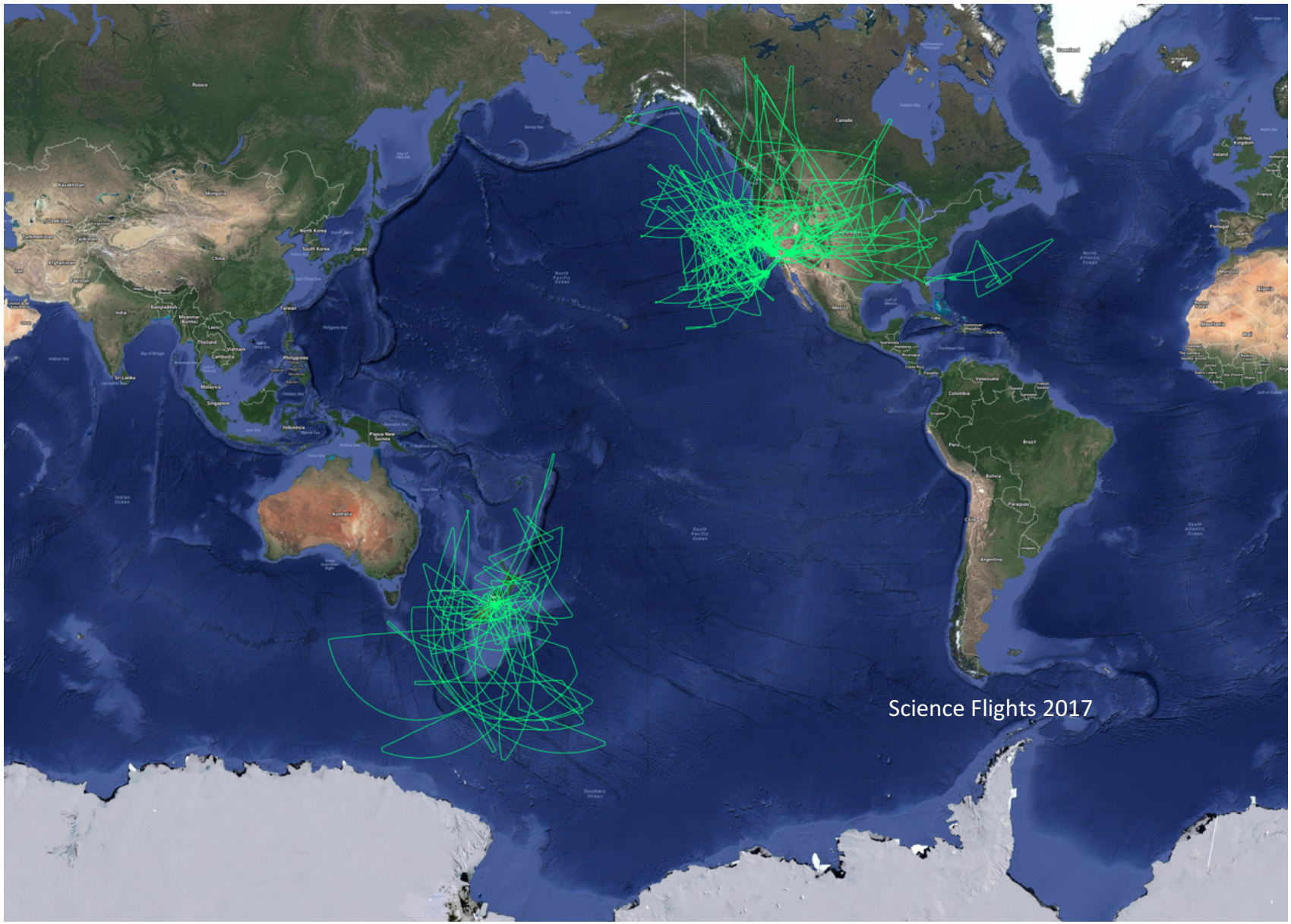
Instruments

- Commissioned dual 4K cryo-cooler capability
- Commissioned two new modes of GREAT
  - 1st time parallel LFA (14 pix) & HFA (7 pix)
  - 4-GREAT configuration
- 2nd Gen HAWC+ Acceptance
- 3rd Gen HIRMES Passed CDR





Global Reach of the Observatory in 2017



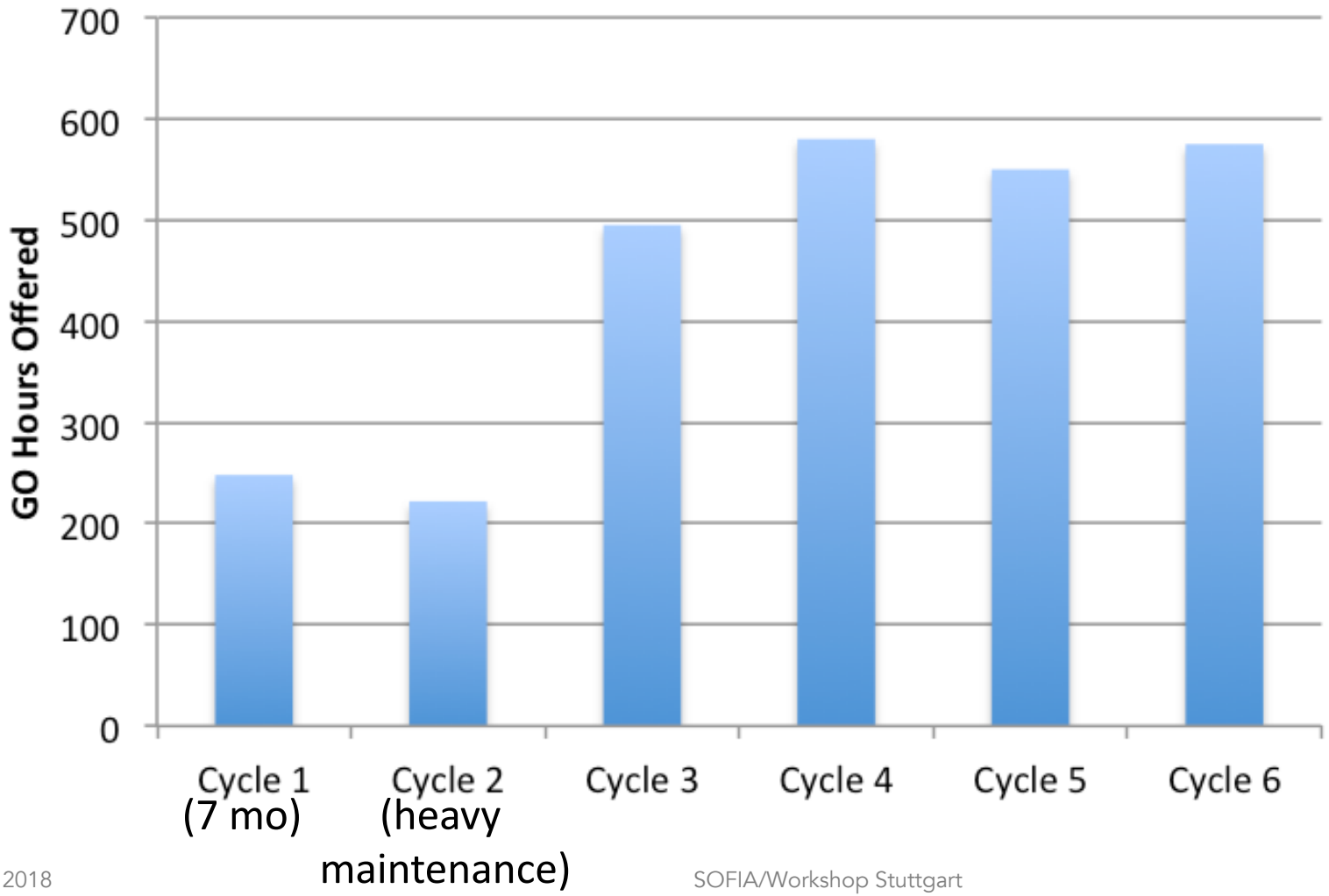
GO Program Background

- <u>One Annual Call</u> for Proposals for the General Observer (GO) Program
- SOFIA has two independent TACs (Telescope Allocation Committees), US and German, that rank GO proposals scientifically, with a review of their technical feasibility for the unique operational needs of an airborne observatory.
  - Proposers from other countries are part of the US-TAC time.
  - US: German time is 80:20 ratio per NASA/DLR SOFIA Joint Program Plan.
- GO Program began with Basic Science (call released Apr 28, 2010).
- Full Operational Capacity reached in May 2014 during Cycle 2
- Increased funding for US GOs ($10,000/hr) began in Cycle 4
- Large Impact Programs began in Cycle 4*
- Introduction of Thesis Enabling Programs in Cycle 6
- Cycle 6 starts May 2018
- Coming: Cycle 7 Call For Proposals

*Replaced by SOFIA Legacy Science Program

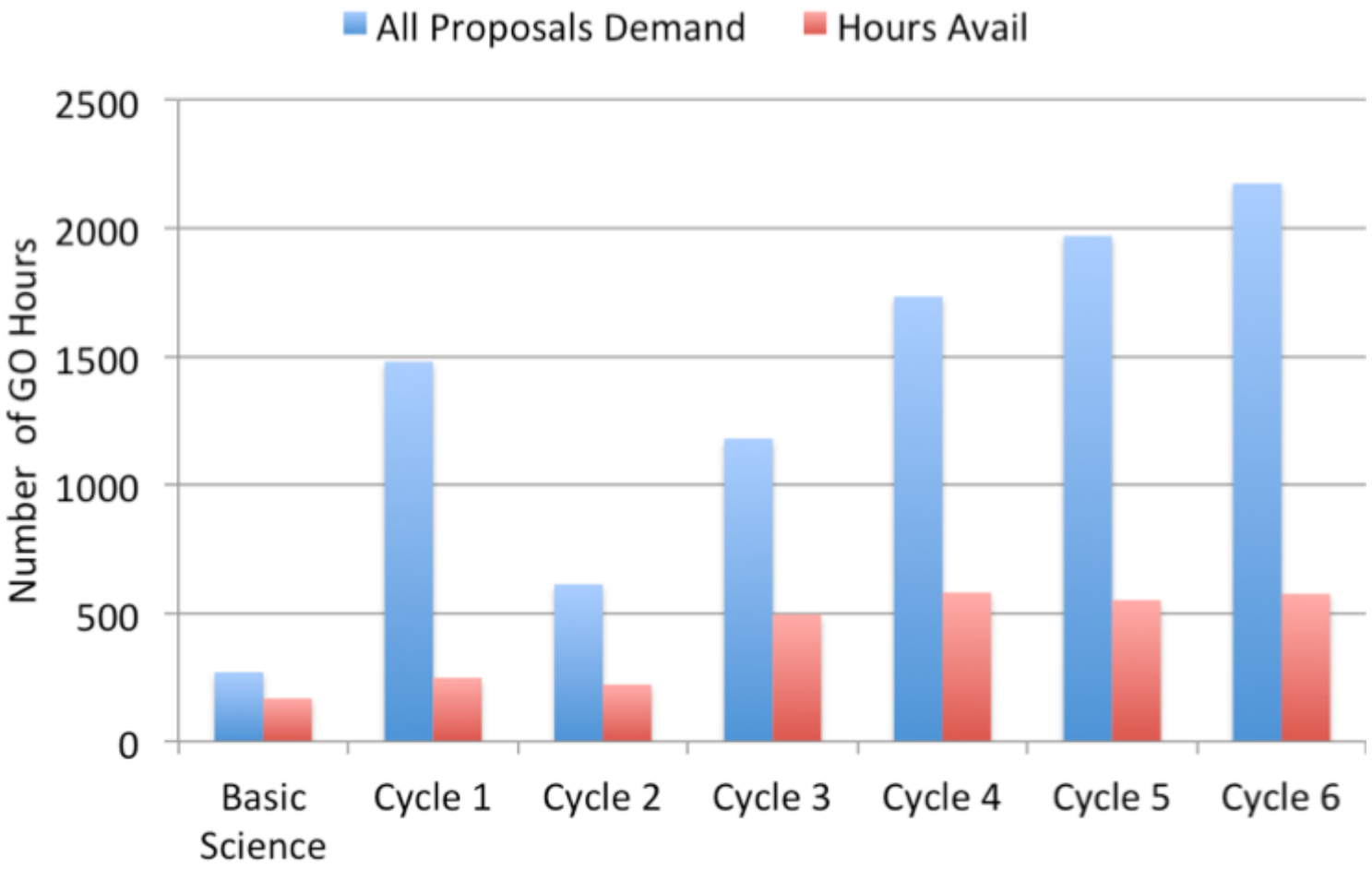
GO Hours Available

- Time on the observatory with door open is split among General Observer (GO), Instrument Guaranteed Time (GTO), Calibration/Engineering, and Director's Discretionary Time (DDT).
- Call for Proposals for GO time has had different allocations each Cycle.



General Observer Program

- Demand for SOFIA has outpaced available hours

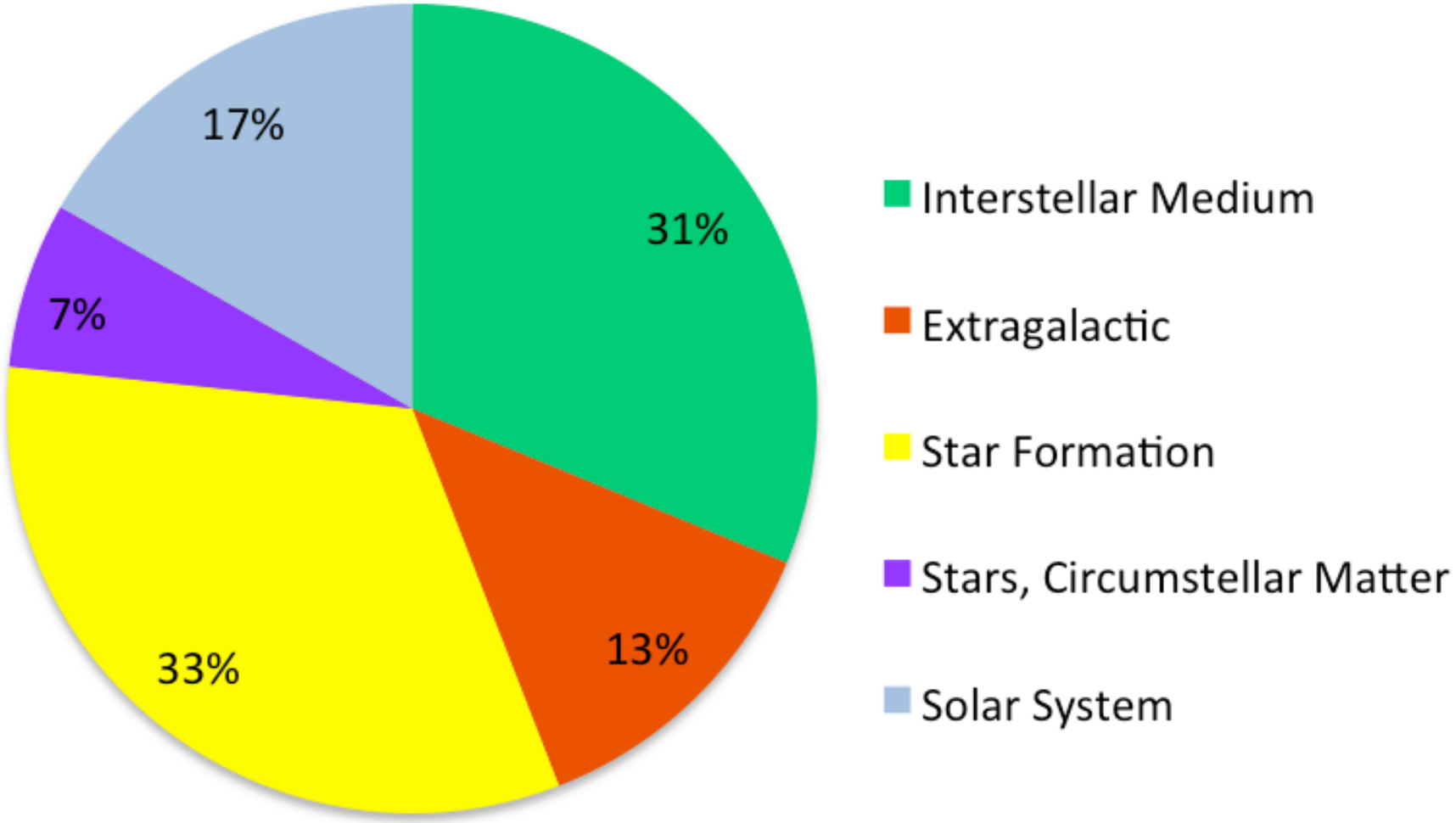


Full Operations began May 2014

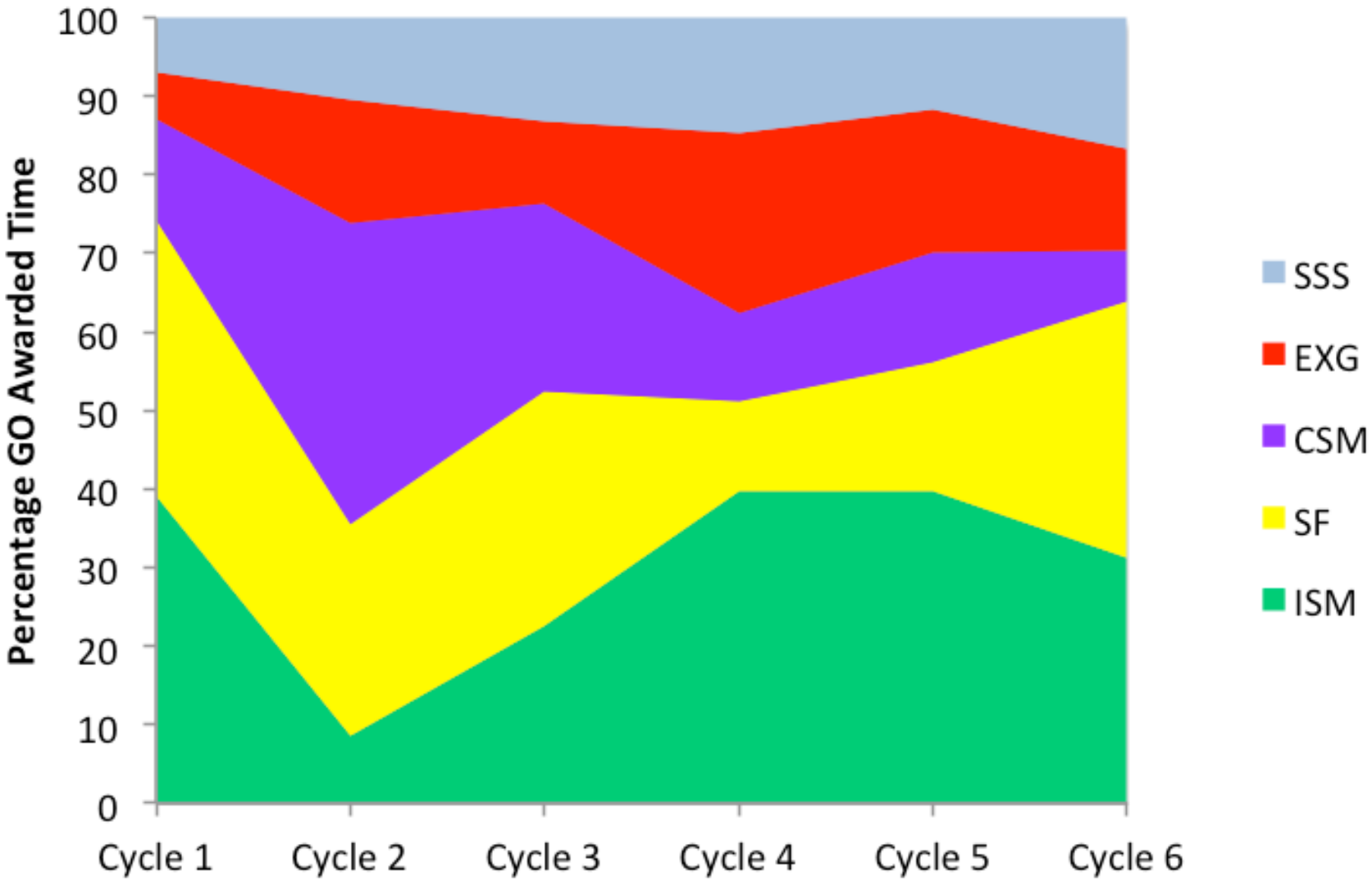
Due Dates: Basic Science: July 2010 Cycle 1: Jan 2012 Cycle 2: June 2013
Cycle 3: June 2014 Cycle 4: June 2015 Cycle 5: June 2016 Cycle 6: June 2017

Breadth of General Observer Science

- Cycle 6 – Priority 1 & 2 Time Awarded (US+DE)



Tracking shifts in the science areas awarded



Our International User Base

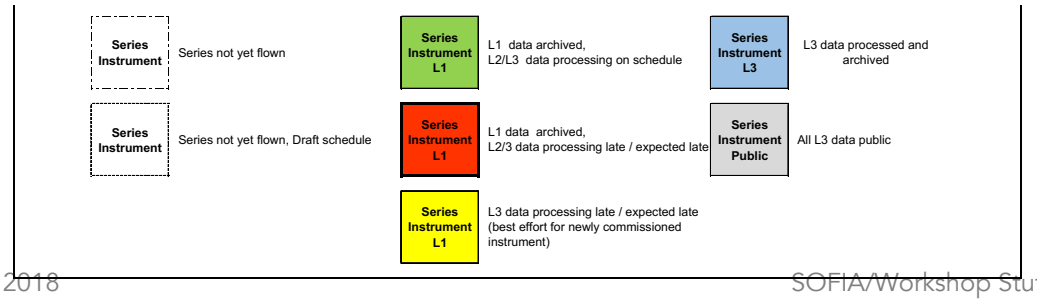
- Cycle 6 – PI & Co-I Institutions

European Cycle 6 – PI & Co-I Institutions

Majority of SOFIA data is now Public

- Access the Science Data Archive at https://dcs.sofia.usra.edu/
- Transition to Infrared Science Archive (IRSA) in 2019 http://irsa.ipac.caltech.edu/

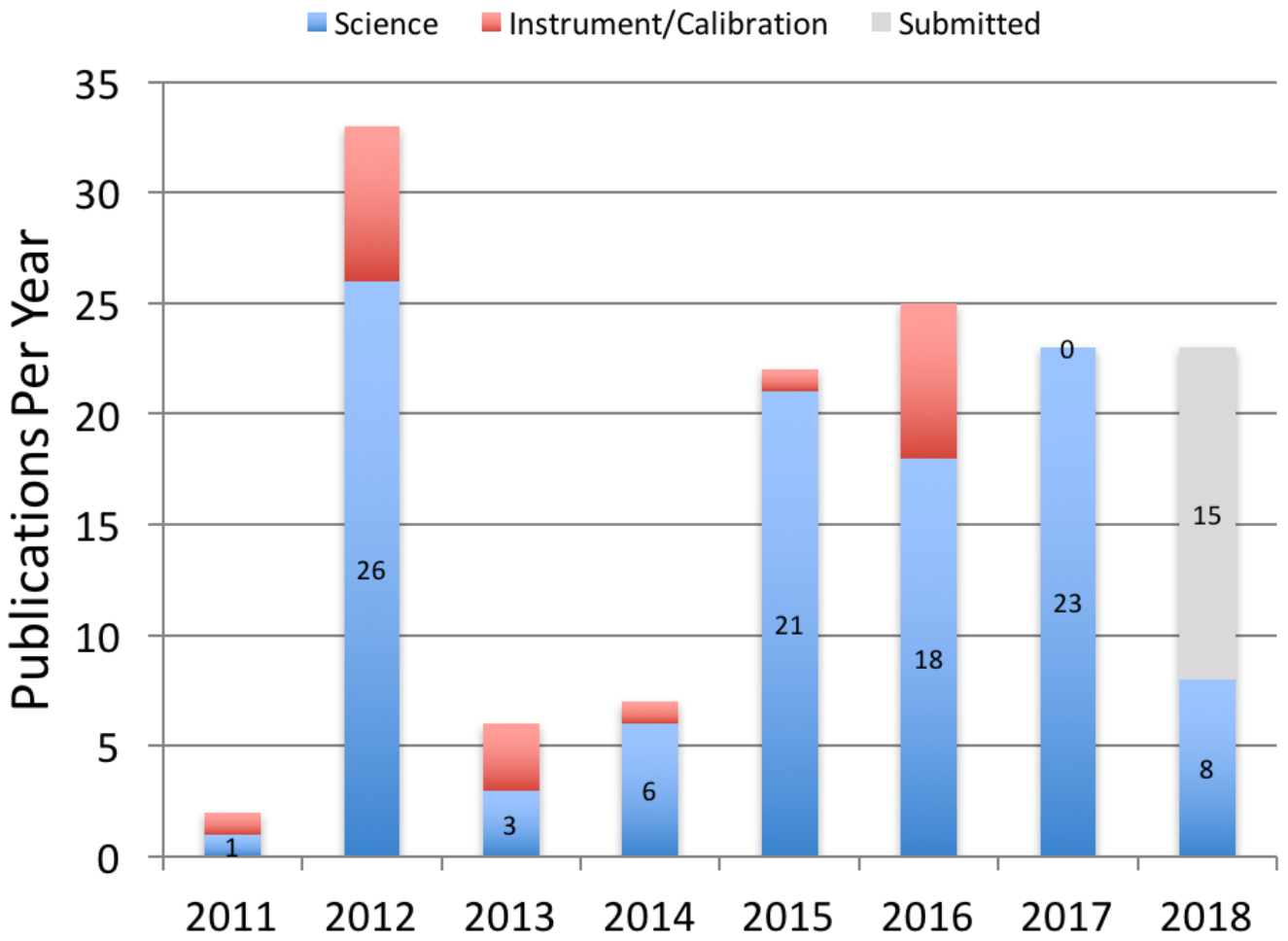
Cycle 1	OC-1B FORCAST Public	OC-1C GREAT Public	OC-1D FORCAST Public	OC-1F FORCAST Public	OC-1G GREAT Public							
Cycle 2	OC-2A FLIPO Public	OC-2B FORCAST Public	OC-2C FIFI-LS Public	OC-2D FORCAST Public	OC-2E GREAT Public	OC-2F FORCAST Public	OC-2G GREAT Public	OC-2H FORCAST Public				
Cycle 3	OC-3A EXES Public	OC-3B FIFI-LS Public	OC-3C FORCAST Public	OC-3D FORCAST Public	OC-3E FLIPO Public	OC-3G GREAT Public	OC-3H EXES Public	OC-3I FORCAST Public	OC-3J FLITECAM Public	OC-3K FIFI-LS Public	OC-3L FORCAST Public	OC-3M GREAT Public
Cycle 4	OC-4A FORCAST Public	OC-4B FIFI-LS Public	OC-4C EXES Public	OC-4D GREAT Public	OC-4E GREAT Public	OC-4F FIFI-LS Public	OC-4G FORCAST Public	OC-4I FORCAST Public	OC-4J FLITECAM Public	OC-4K GREAT L3	OC-4L HAWC+ L3	OC-4M EXES Public	OC-4N GREAT L3
Cycle 5	OC-5A GREAT L3	OC-5B FIFI-LS L3	OC-5C EXES L3	OC-5E HAWC+ L1	OC-5F EXES L3	OC-5G GREAT L3	OC-5H GREAT L3	OC-5I FIFI-LS L3	OC-5J FORCAST L3	OC-5K FORCAST L3	OC-5L FLIPO L3	OC-5N HAWC+ L1	
Cycle 6	OC-6E	OC-6F	OC-6G	OC-6H	OC-6I	OC-6J	OC-6K	OC-6L	OC-6M	OC-6N	OC-6O	OC-6P	



All Cycle 2 & 3 data went public **June 26, 2017**
All Cycle 4 data will be public by **June 14, 2018**

Publications - Monitoring

- Science ApJL Focus Issue – submission July/Aug 2018 (POC Bill Reach, WReach@usra.edu)
- Technology JAI Special Issue – submission Apr/May (POC P. Temi, pasquale.temi@nasa.gov)



Source: ADS

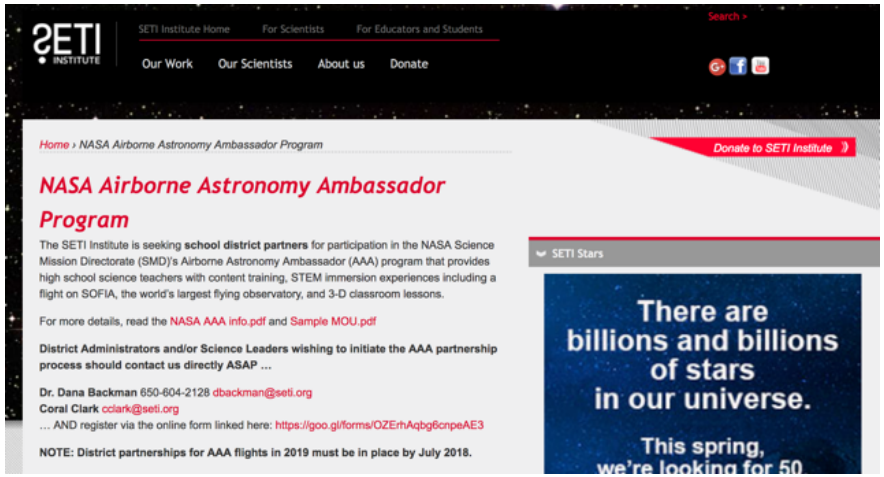
If a paper has been submitted/under review the Project would like to know.

Creating Future IR Leaders

Author	Year	Title
Fuller, Lindsay	2017	Observing cool dust in active galactic nuclei on the SOFIA telescope
McAdam, Maggie	2017	Water in the early solar system: Mid-infrared studies of aqueous alteration on asteroids
Logsdon, Sarah	2017	FLITECAM/SOFIA Commissioning and Early Science and A Study of Late-T Dwarf Color Outliers with NIRSPEC/Keck
Büchel, Denis	2017	Hot Electron Bolometer Mixers for THz Arrays
Pfüller, Enrico	2016	Fast EMCCD Cameras for the Optical Characterization of the SOFIA Observatory and its Telescope Subsystems
Wiedemann, Manuel	2016	Improving the Sensitivity of the SOFIA Target Acquisition and Tracking Cameras
Glück, Christian	2016	A Study of the Distribution of Carbon in the nearby Universe
Kaswekar, Prashat	2016	Integrated motion measurement of three-dimensional lightweight structures
Colditz, Sebastian	2016	FIFI-LS – A Field-Imaging Far-Infrared Line Spectrometer for SOFIA: Completion of the Instrument, Laboratory and In-flight Calibration and Characterization
Shenoy, Dinesh	2016	A Study of Hypergiant Mass Loss in the Near-To-Mid Infrared: VY CMa, IRC +10420, mu Cep and rho Cas
Selig, Stefan	2016	Superconductor Insulator Superconductor Mixer Devices with Gold Energy Relaxation Layers
Guan, Xin	2015	Atmospheric calibration for sub-millimeter radio astronomy
Lau, Ryan	2014	Probing the Extreme Environment of the Galactic Center with Observations from SOFIA/FORCAST
Ricken, Oliver	2011	Setup, characterization and commissioning of the 1.4 THz channel of the heterodyne receiver GREAT
Angerhausen, Daniel	2010	Spectroscopic characterization of extrasolar planets from ground-, space- and airborne-based observatories
Smith, Erin	2008	Investigation of PAHs in Planetary Nebulae using FLITECAM
Wagner-Gentner, Armin	2007	SOFIA GREAT 1.9THz Heterodynereceiver, astigmatic optics, low loss THz windows
Munoz, Pedro	2007	Waveguide Heterodyne Mixers at THz-Frequencies - Superconducting Hot Electron Bolometers on 2-micron Si3N4 Membranes for GREAT and CONDOR
Philipp, Martin	2007	Development and construction of a BWO-based 1.9 THz Local oscillators for the heterodyne receiver
Bedorf, Sven	2005	Development of Ultrathin Niobium Nitride and Niobium Titanium Nitride Films for THz Hot-Electron Bolometers
Villanueva, Geronimo	2004	The High Resolution Spectrometer for SOFIA-GREAT: Instrumentation, Atmospheric Modeling and Observations
Mainzer, Amy	2003	Searching for Young Low Mass Objects Using FLITECAM

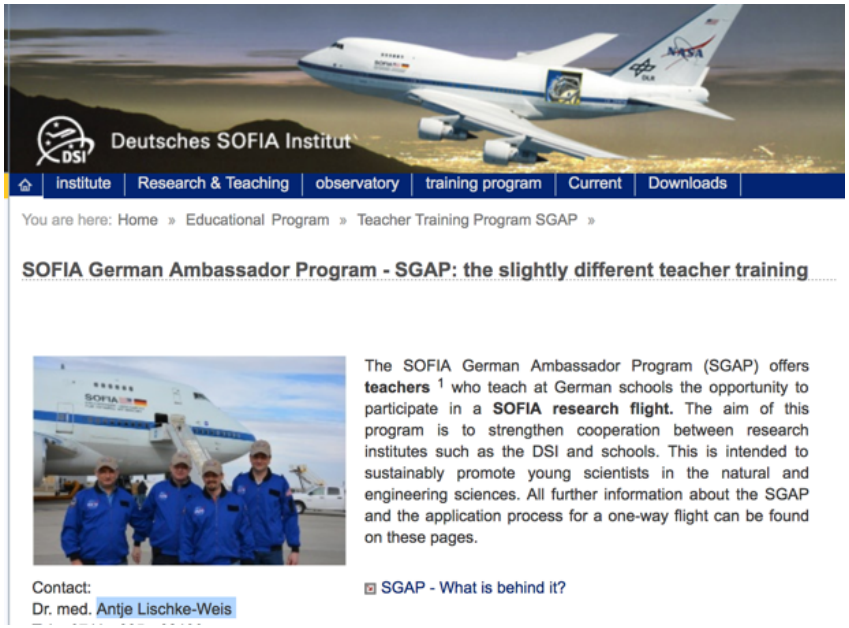
Airborne Ambassador Programs

- US Airborne Astronomy Ambassadors (AAA) program is funded & managed via a cooperative agreement between NASA Science Mission Directorate and the SETI Institute.
- POC Dana Backman (dbackman@seti.org)



https://www.seti.org/AAA

- SOFIA German Ambassador Program (SGAP)
- POC Dörte Mehlert (mehlert@dsi.uni-stuttgart.de) & Antje Lischke-Weis (lischke@dsi.uni-stuttgart.de)

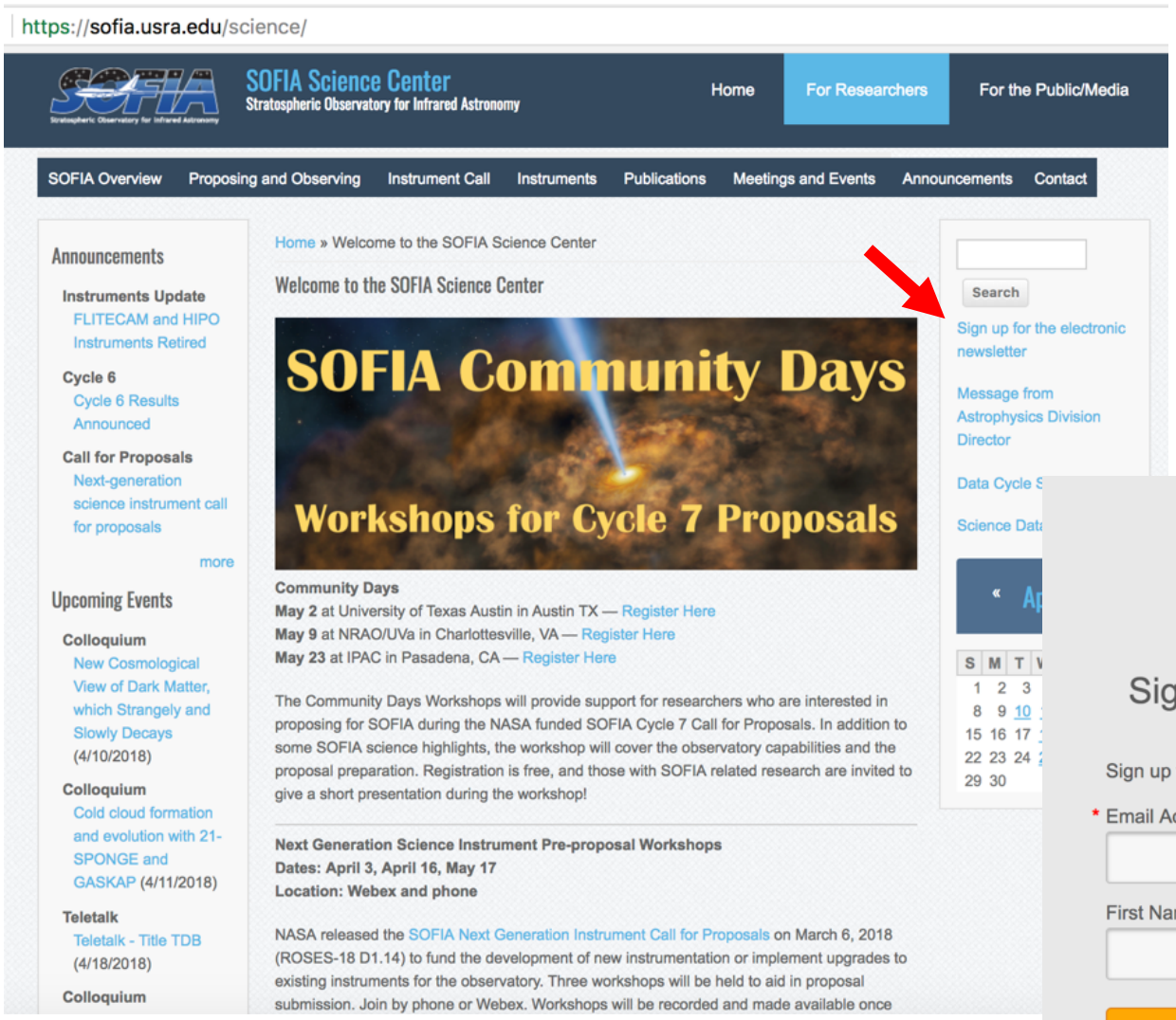


http://www.sofia-partnerschulen.de/
http://www.dsi.uni-stuttgart.de/bildungsprogramm/SGAP/index.html

Are you plugged in?

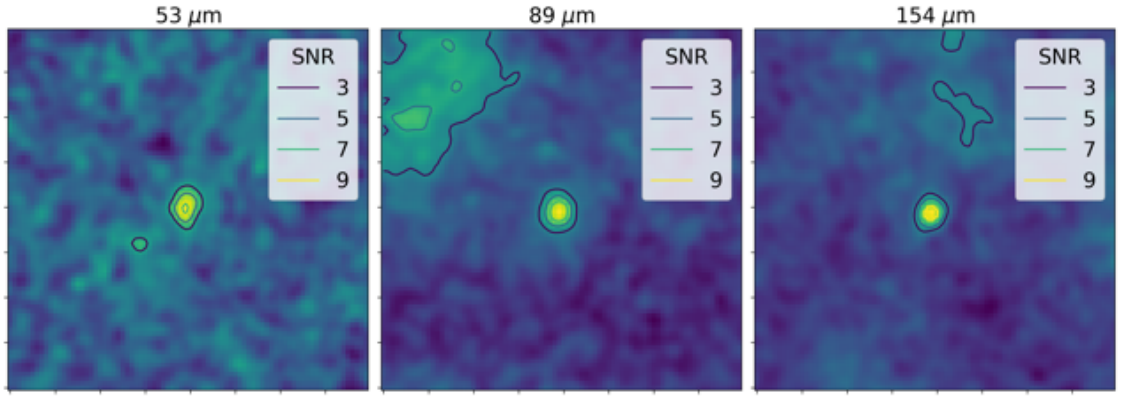
- SOFIA Community Forum Tele-talks (Wednesdays, 9-10am PT)
  - Toll Free call-in number, download the PDF, follow along at home, office, café.
  - https://sofia.usra.edu/science/meetings-and-events/events/sofia-community-forum-scf-teletalks
  - Recorded, download the mp3 to meet your schedule
- SOFIA Colloquia (Wednesdays, 3:30-4:30pm PT)
  - Held at NASA Ames, Building N232 plus Remote Access
  - https://sofia.usra.edu/science/meetings-and-events/events/colloquia
  - Sign up to get Webex access
  - https://mail.sofia.usra.edu/cgi-bin/mailman/listinfo/colloquia
- Follow us: @SOFIAtelescope on Facebook, Twitter, Instagram, and YouTube

Latest updates at http://sofia.usra.edu/science

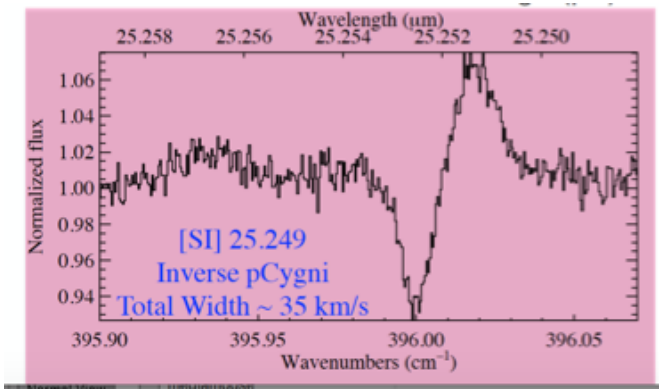


You are our ambassadors!

- SOFIA is preparing for its 1st Senior Review to be held in 2019.
- There are already realized results. There are new opportunities.
- There is tremendous potential in the years ahead.
- Give seminars, colloquia, and talks at conferences, get on LOC/SOCs
  - Tell your story why SOFIA is valuable & essential to the astrophysical community today
- Propose to Cycle 7, DDT, & be part of Next Gen Science Instrument Teams
- Write your science papers!



z=3.9 galaxy/AGN HAWC+ taken Oct 2017



EXES reveals infall (not seen in prior ISO data) taken Jan 2017