



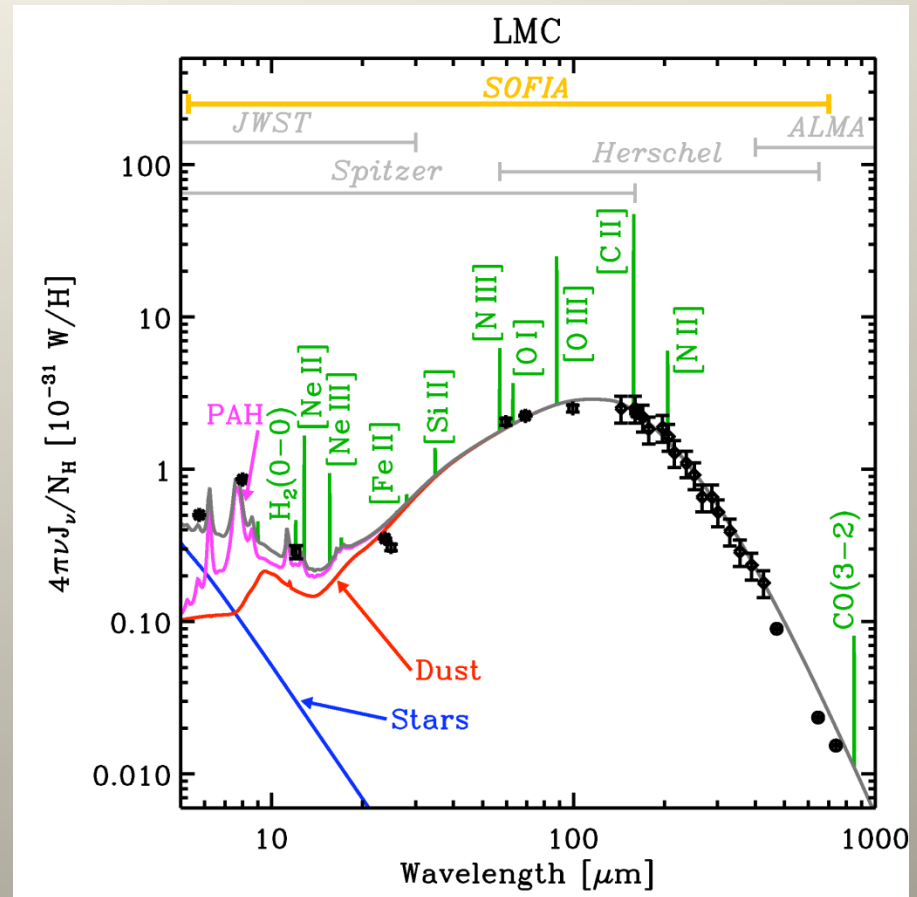
The SOFIA Facility and Opportunities for Spectroscopy

Erick Young
SOFIA Science Center

Spectroscopy with SOFIA
Schloss Ringberg
16 March 2015



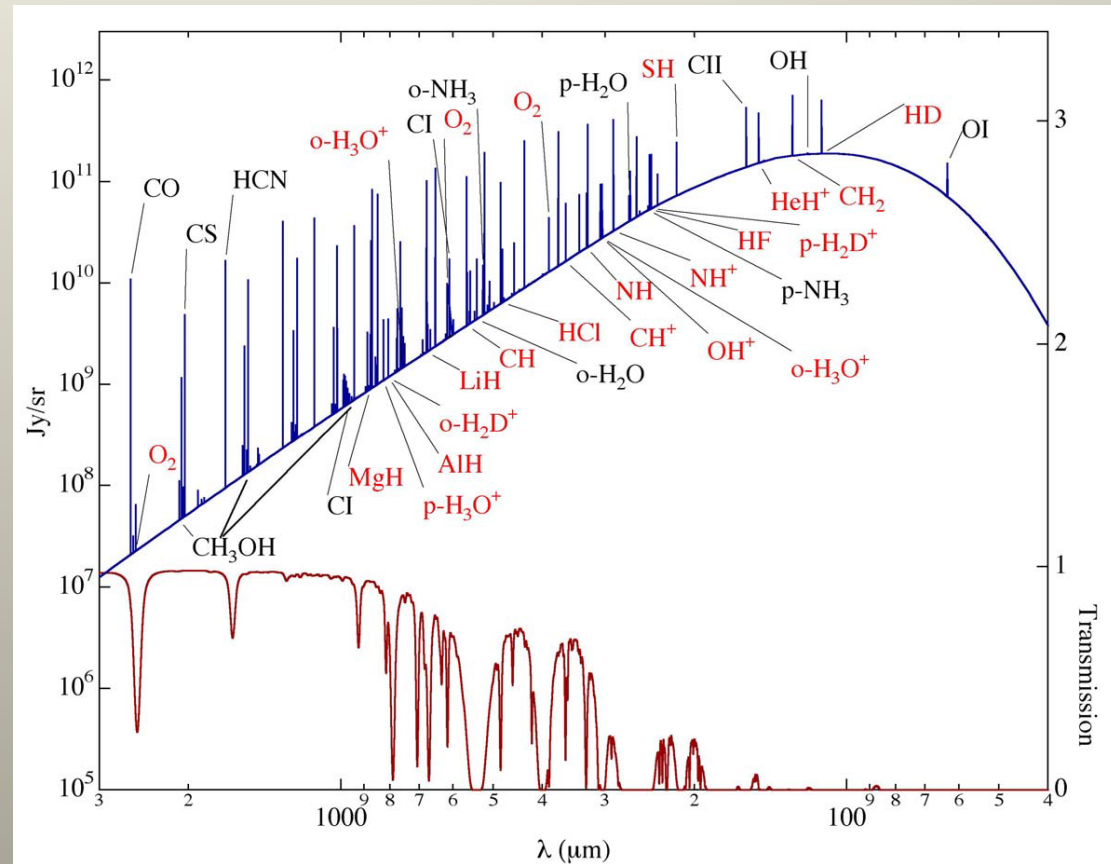
- Most of the energy of star formation regions, external galaxies, and cooler objects in the universe is in the far-IR and Sub-mm
- The most important emission lines responsible for the energy balance of the Interstellar Medium are in the far-infrared



The spectral energy distribution of the entire LMC, based on data from Spitzer, IRAS and FIRAS (Bernard et al. 2008). SEDs are fitted with the dusty PDR model of Galliano et al. (2008).
Figure courtesy of Galliano.

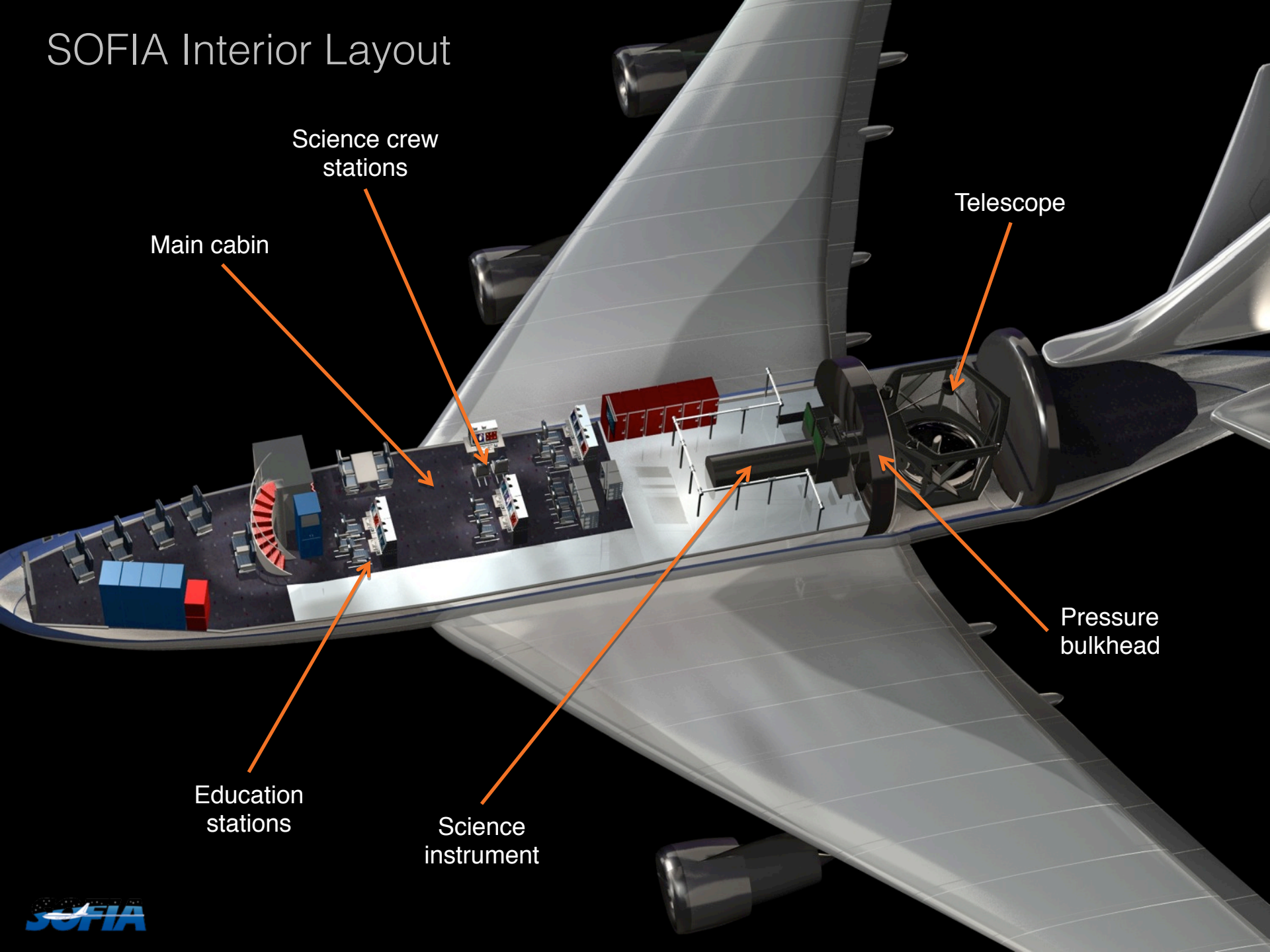
- Most of the key atomic and molecular tracers of the interstellar medium are in the Far Infrared and Sub-mm

Molecular Cloud Spectrum



Ted Bergin, 2008

SOFIA Interior Layout



Science crew stations

Main cabin

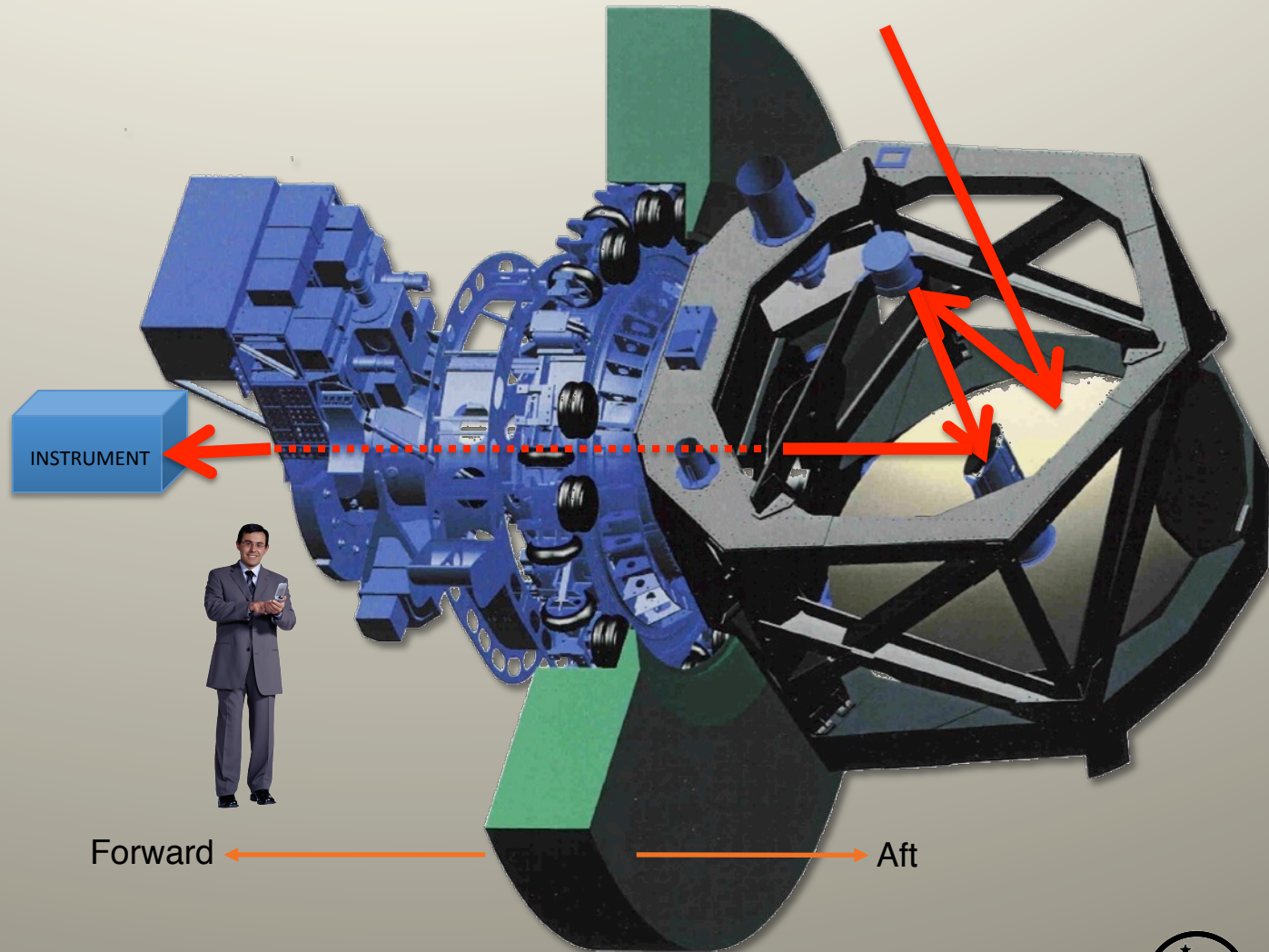
Telescope

Pressure bulkhead

Education stations

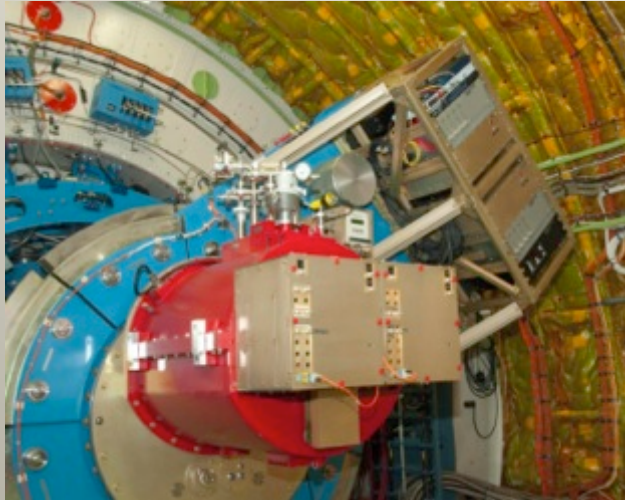
Science instrument

- The telescope is a major contribution from Germany
- 2.7 meter diameter mirror
- Wavelength: 0.3 to 1,600 microns
- Installed weight: 17 metric tons





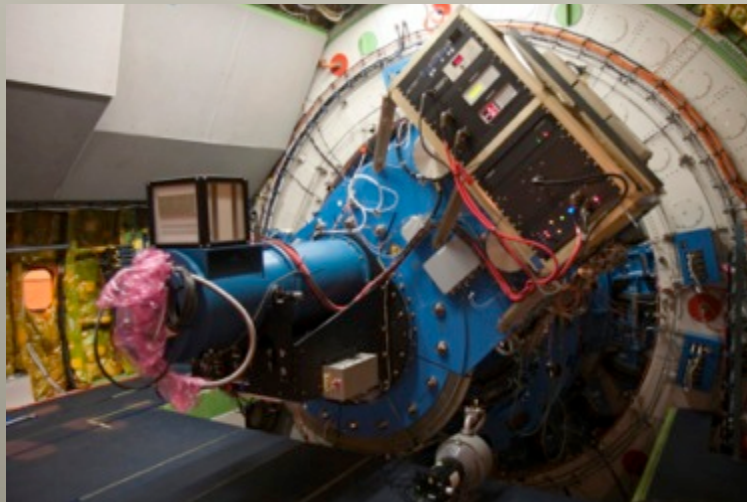
Instruments in Use by Astronomical Community



FORCAST
Mid-IR Camera



GREAT
Heterodyne spectrometer



FLITECAM
Near IR Camera

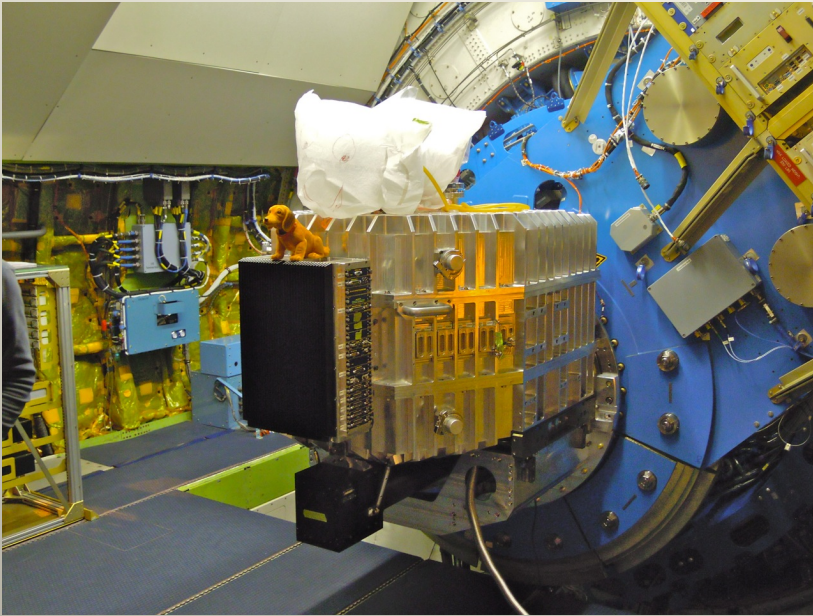
HIPO
Occultation Photometer

FLIPO
(co-mounted on SOFIA)





FIFI-LS and EXES First Flights in 2014



FIFI-LS on the telescope
First Light Flight 150

EXES Team after installation
First Light Flight 158





SOFIA First Generation Instruments



Science Instrument	Type*	Developing Institution	Principal Investigator	Instrument Description
FORCAST	FSI	Cornell University	Herter	Simultaneous Dual Channel Imaging and Grism Spectroscopy (5-25 μm and 25-40 μm)
GREAT	PSI	Max Planck Institute, Bonn	Güsten	High Resolution ($R > 10^6$) Heterodyne Spectrometer (1.6-1.9 THz; 2.4-2.7 THz; 4.7 THz)
HIPO	SSI	Lowell Observatory	Dunham	Visible Light High-Speed Camera (0.3-1.1 μm)
FLITECAM	FSI	UCLA	McLean	Near Infrared Imaging and Grism Spectroscopy, (1-5.5 μm); Can be used in combination with HIPO
FIFI-LS	PSI \rightarrow FSI	University of Stuttgart	Krabbe	Dual Channel Integral Field Grating Spectrometer (42-110 μm ; 100-210 μm)
EXES	PSI	UC Davis	Richter	High Resolution ($R > 10^5$) Echelle Spectrometer (5-28 μm)
HAWC \rightarrow HAWC+	FSI	University of Chicago \rightarrow JPL	Harper \rightarrow Dowell	High-Angular Resolution Wide-Band Camera with 4 Channels (50 μm , 100 μm , 160 μm , 200 μm)

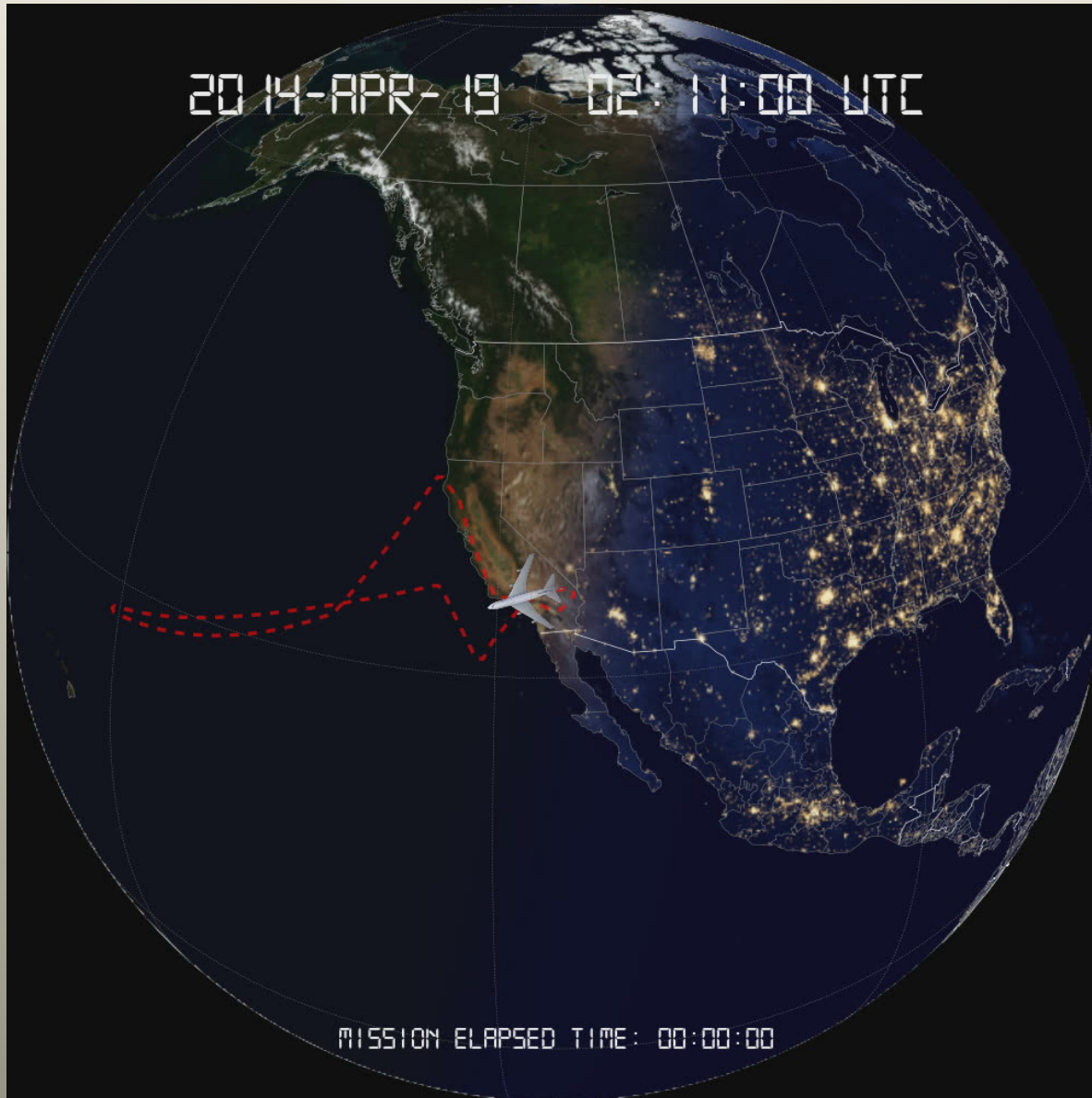


SOFIA Science and Operations Centers





SOFIA Flight 161 with FIFI-LS





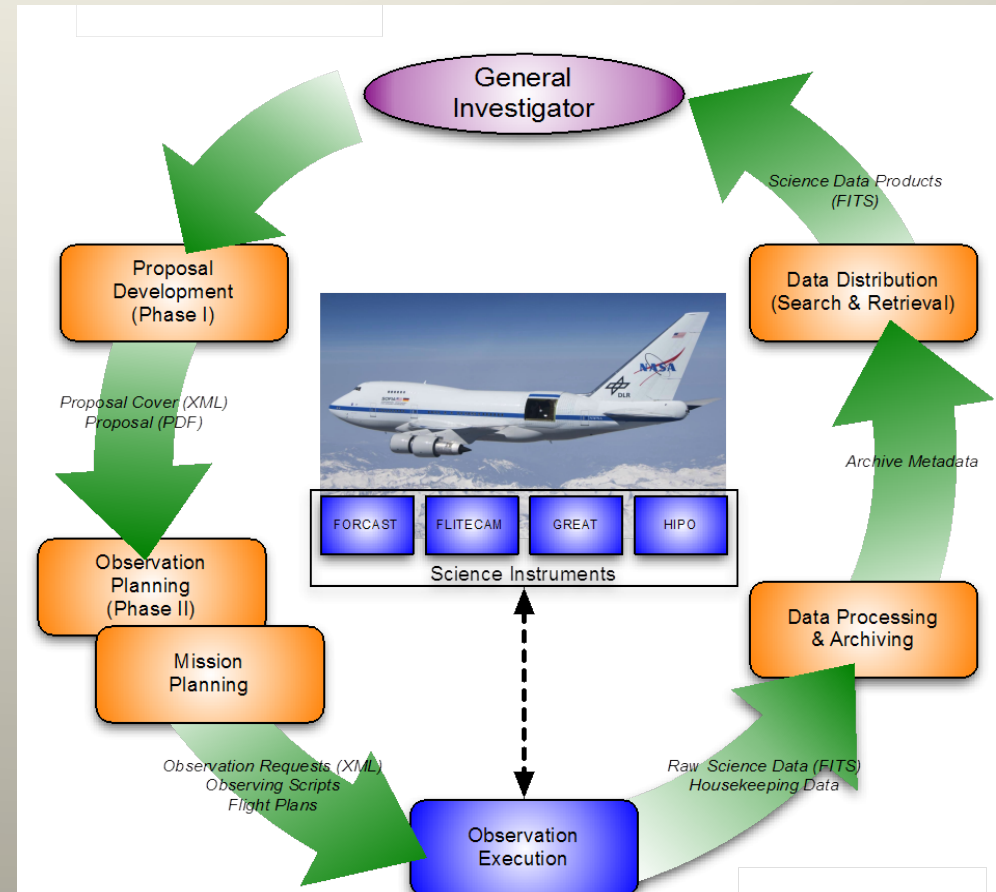
Project Update



- SOFIA was declared a “Fully Operational Mission” in February 2014 but was to be “put in storage” according to the FY2015 NASA budget proposal.
- SOFIA was restored by Congress at the end of 2014.
- We have just finished a Heavy Maintenance as required every 5 or 6 years
- We are in NASA’s budget at full funding for FY2016
- A Senior Review of the Program has been mandated by NASA to take place in Spring 2016
- We have just started Cycle 3 observations

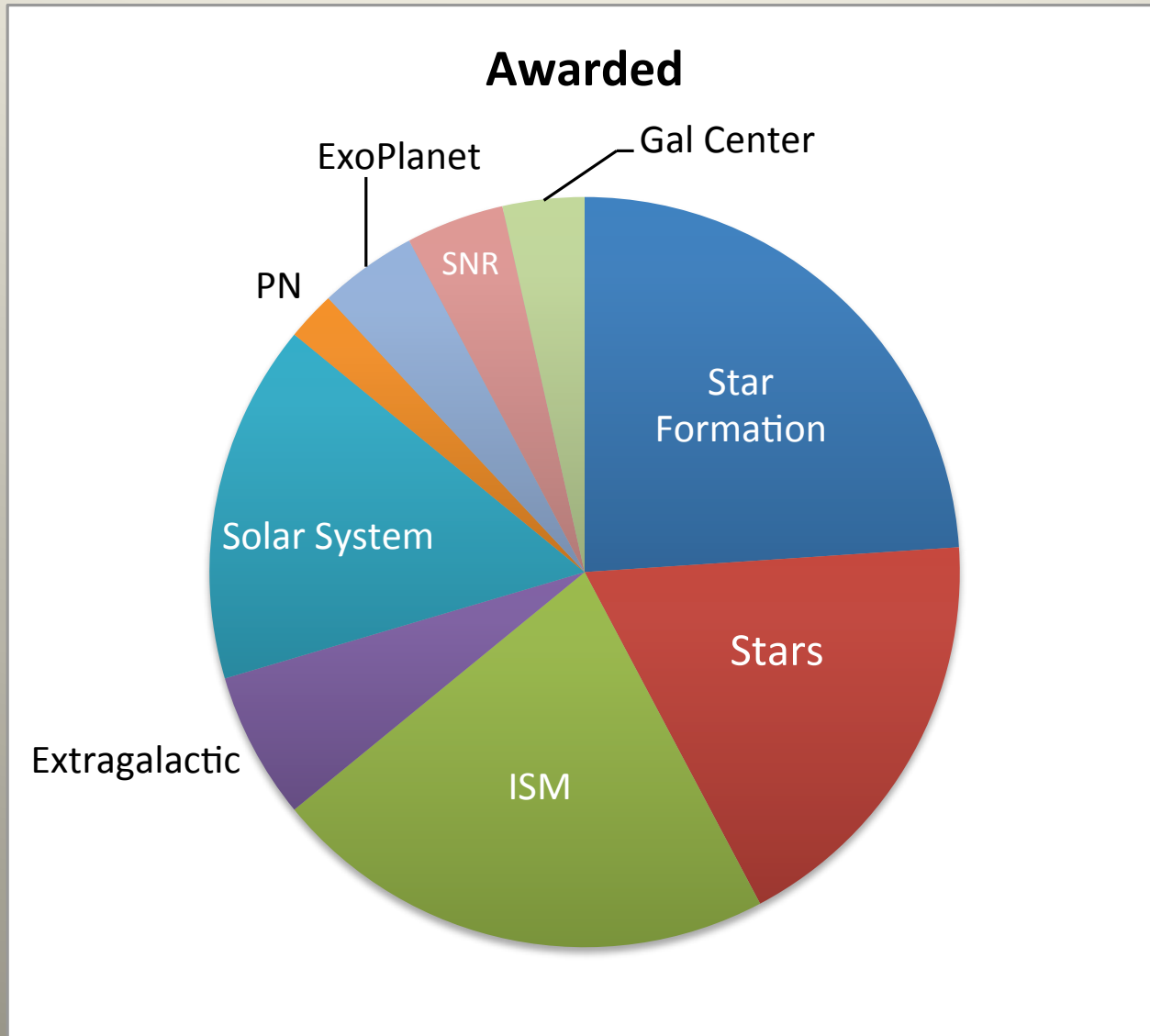


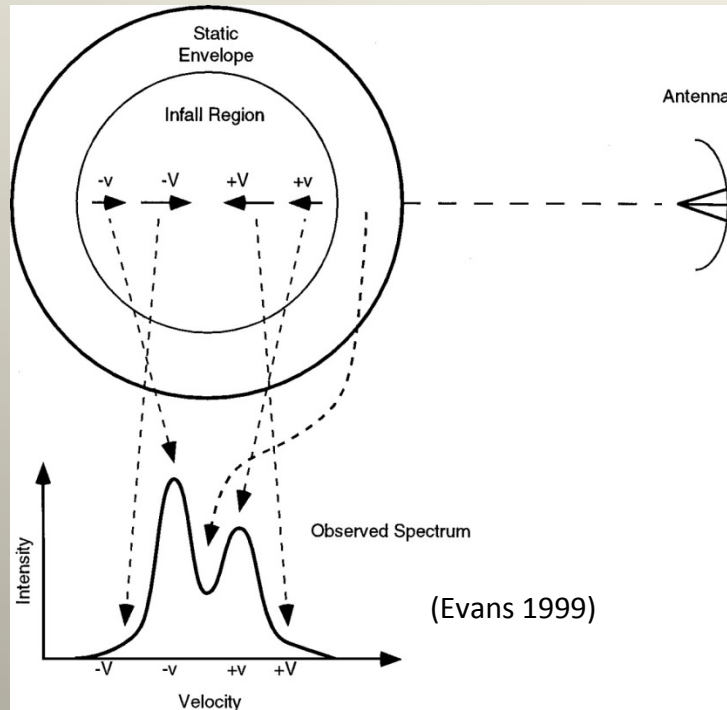
- Issuing Call for Proposals
- User Support
- Selection of Investigators
- Observation Planning
- Observations
- Data Reduction
- Archive



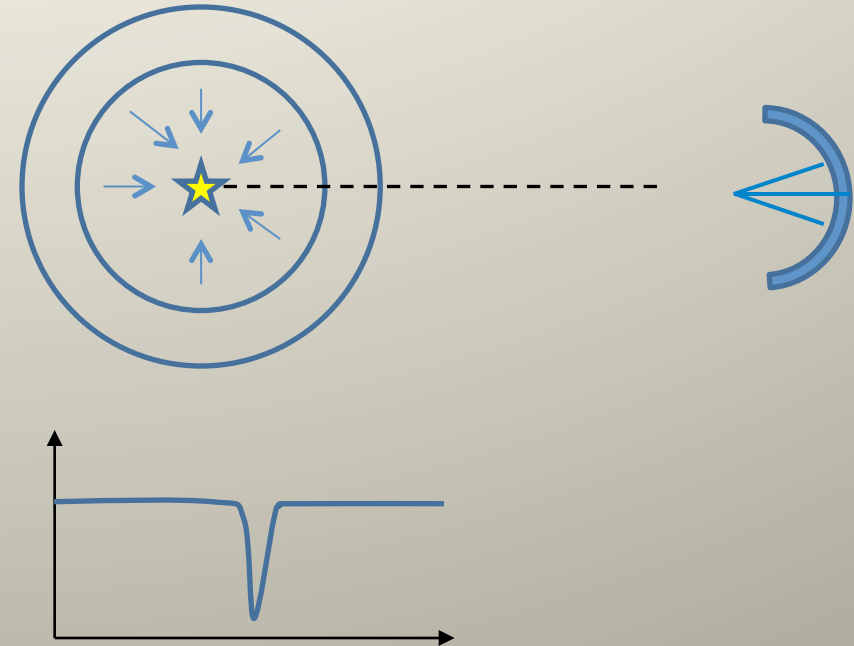


Guest Investigator Research Areas



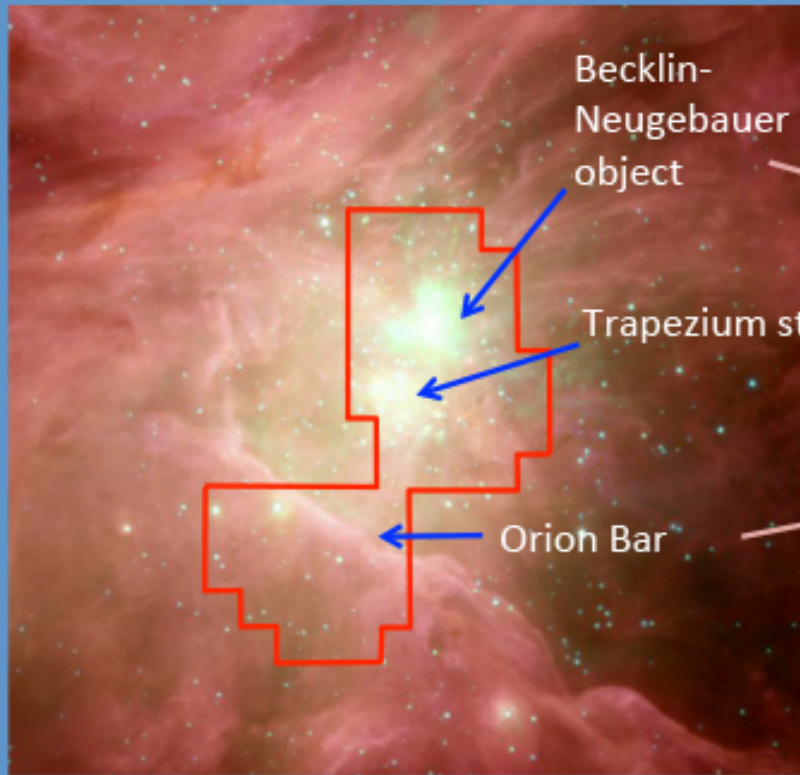


Interpretation of infall using optically thin emission lines is challenging because of complicated radiative transfer and possible contributions from outflowing gas



Absorption measurements against a continuum source are much more straightforward to interpret

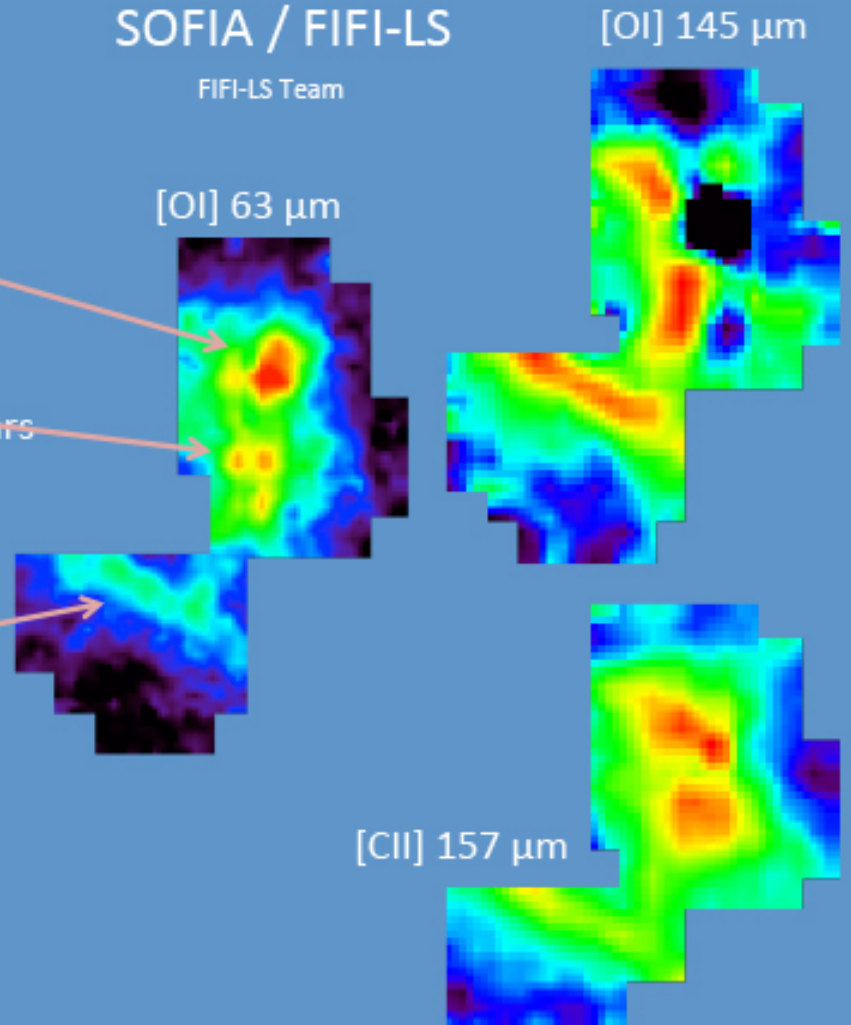
Orion Nebula

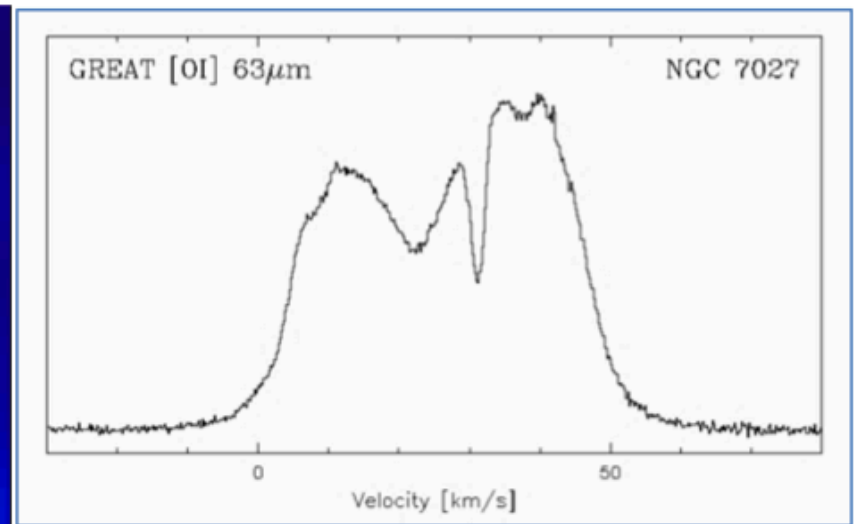
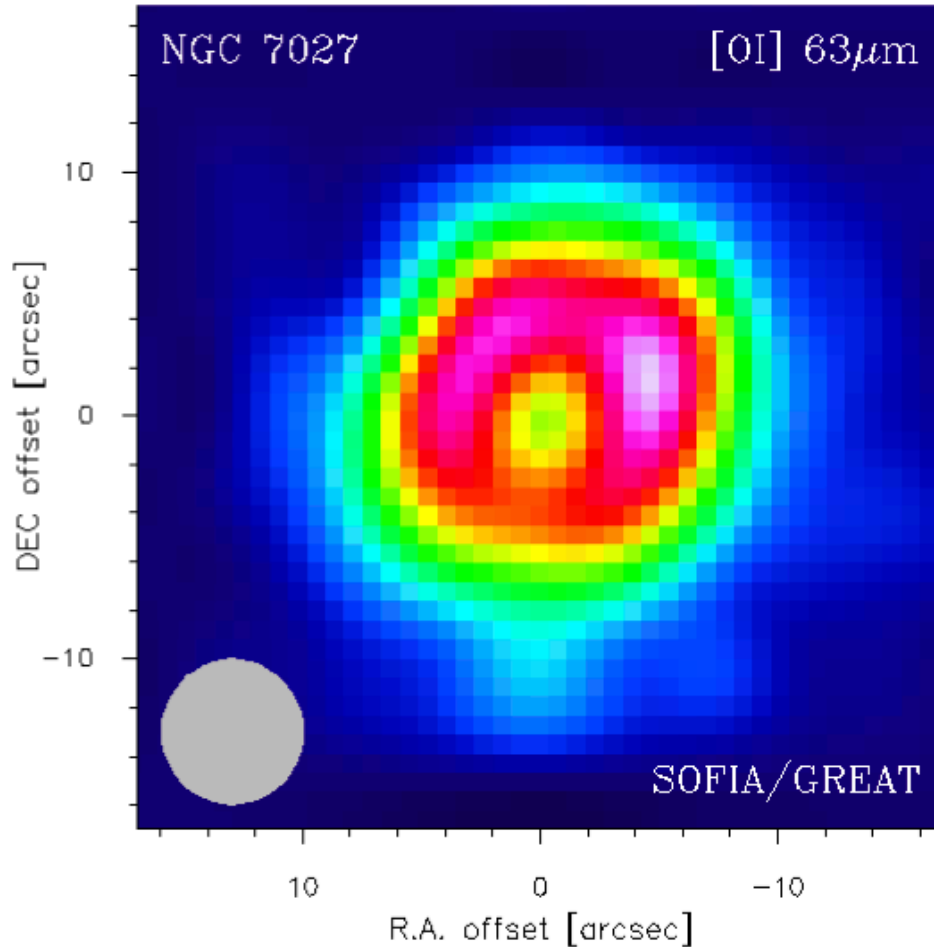


NASA/Spitzer/Harvard-Smithsonian CfA, Thomas Megeath

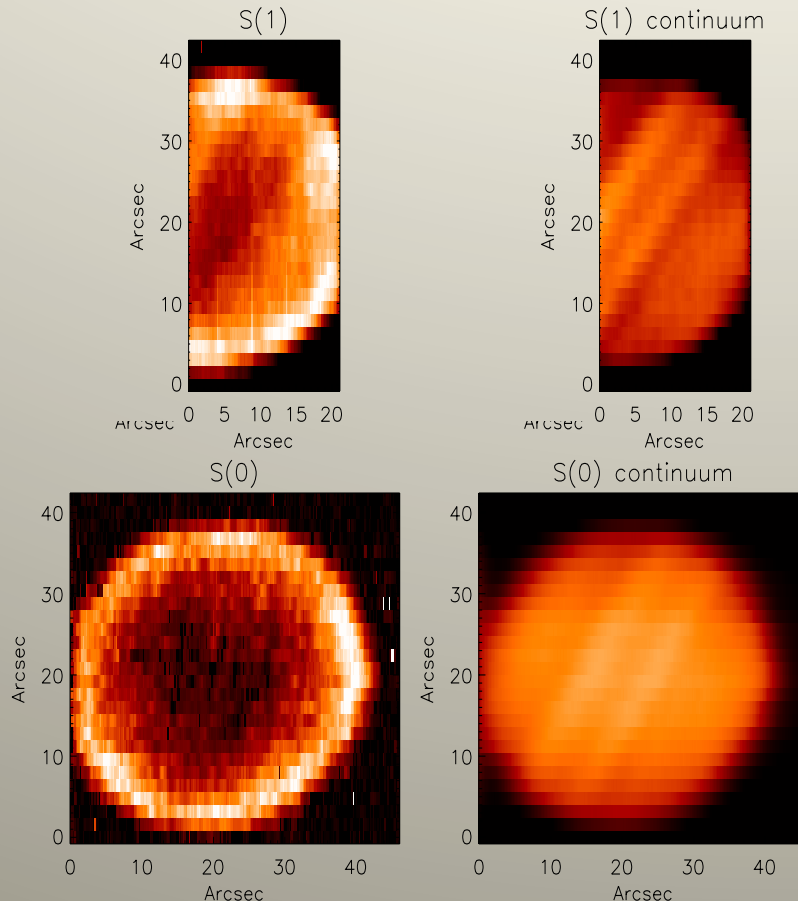
SOFIA / FIFI-LS

FIFI-LS Team

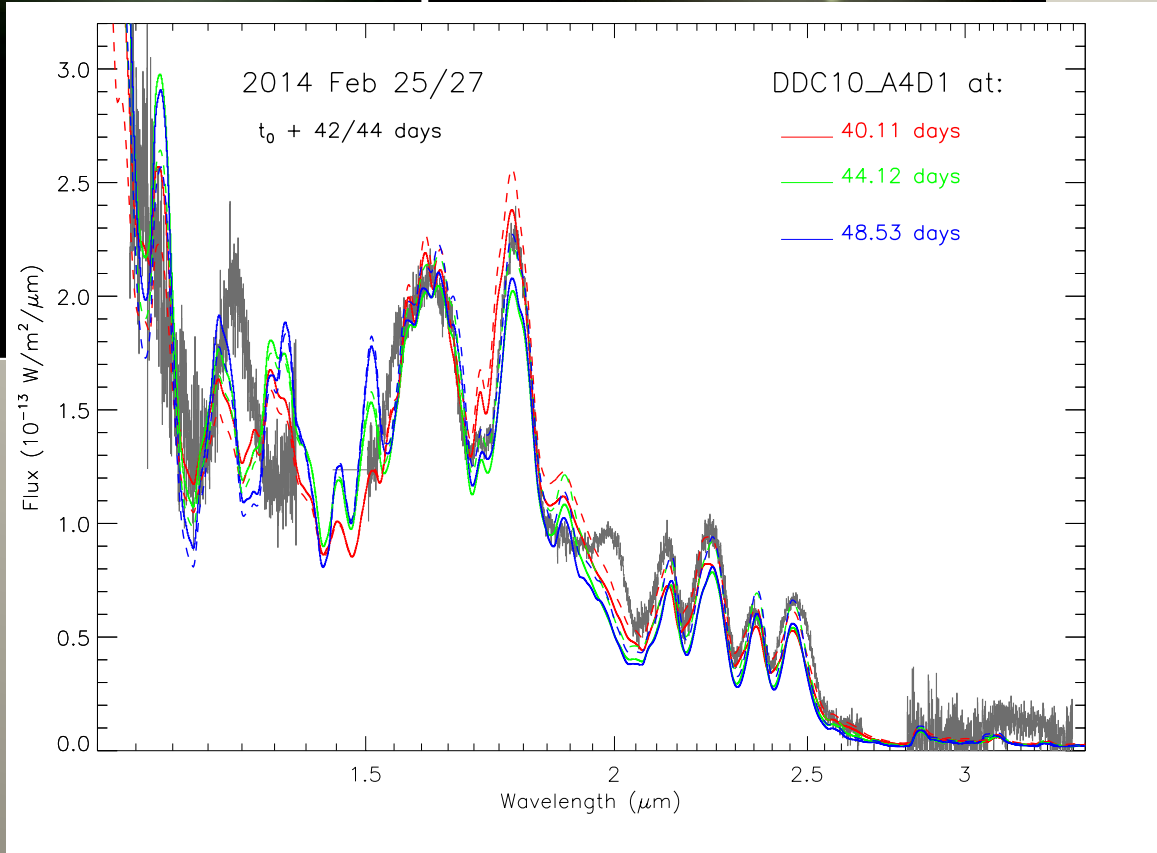
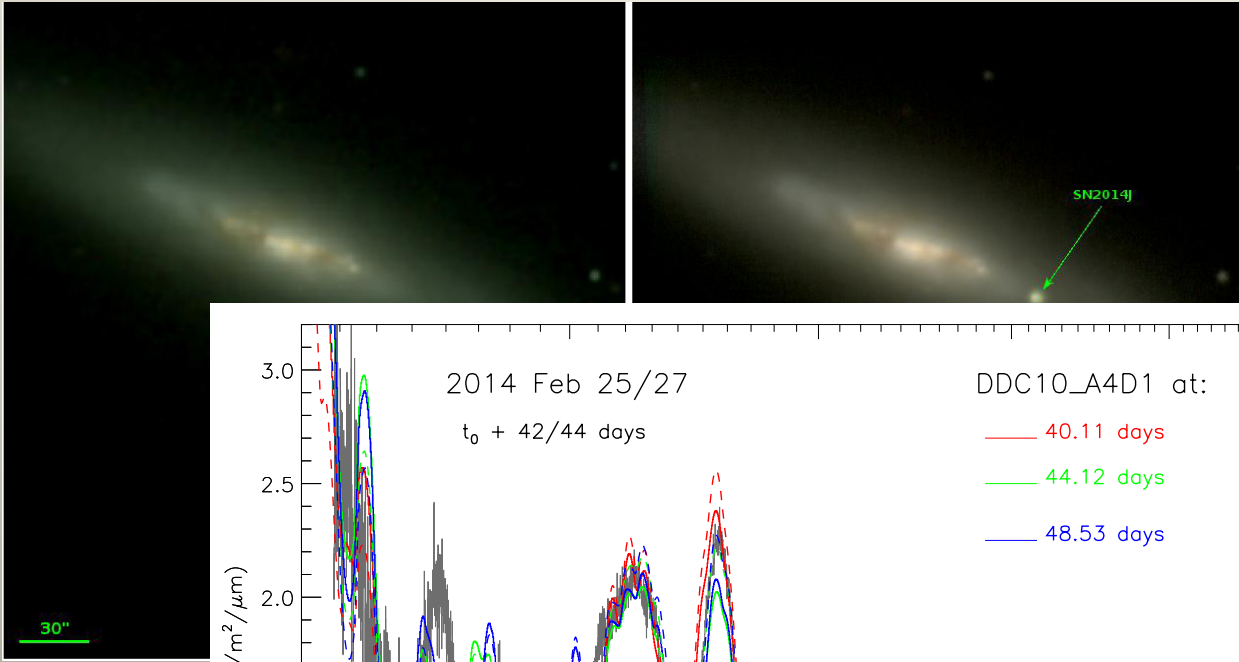




(Rolf Güsten & the GREAT Team)



- Spectral maps produced by stepping slit position across extended sources
- Stratospheric emission from H₂; limb brightening
- S(0) at 28.3 μ m is unobservable from ground.
- S(1)/S(0) gives temperature, with long latency
- Combined with other temperature measures, maps convective motion into the stratosphere and circulation



Vacca et al. 2015



Cycle 4 Call for Proposals

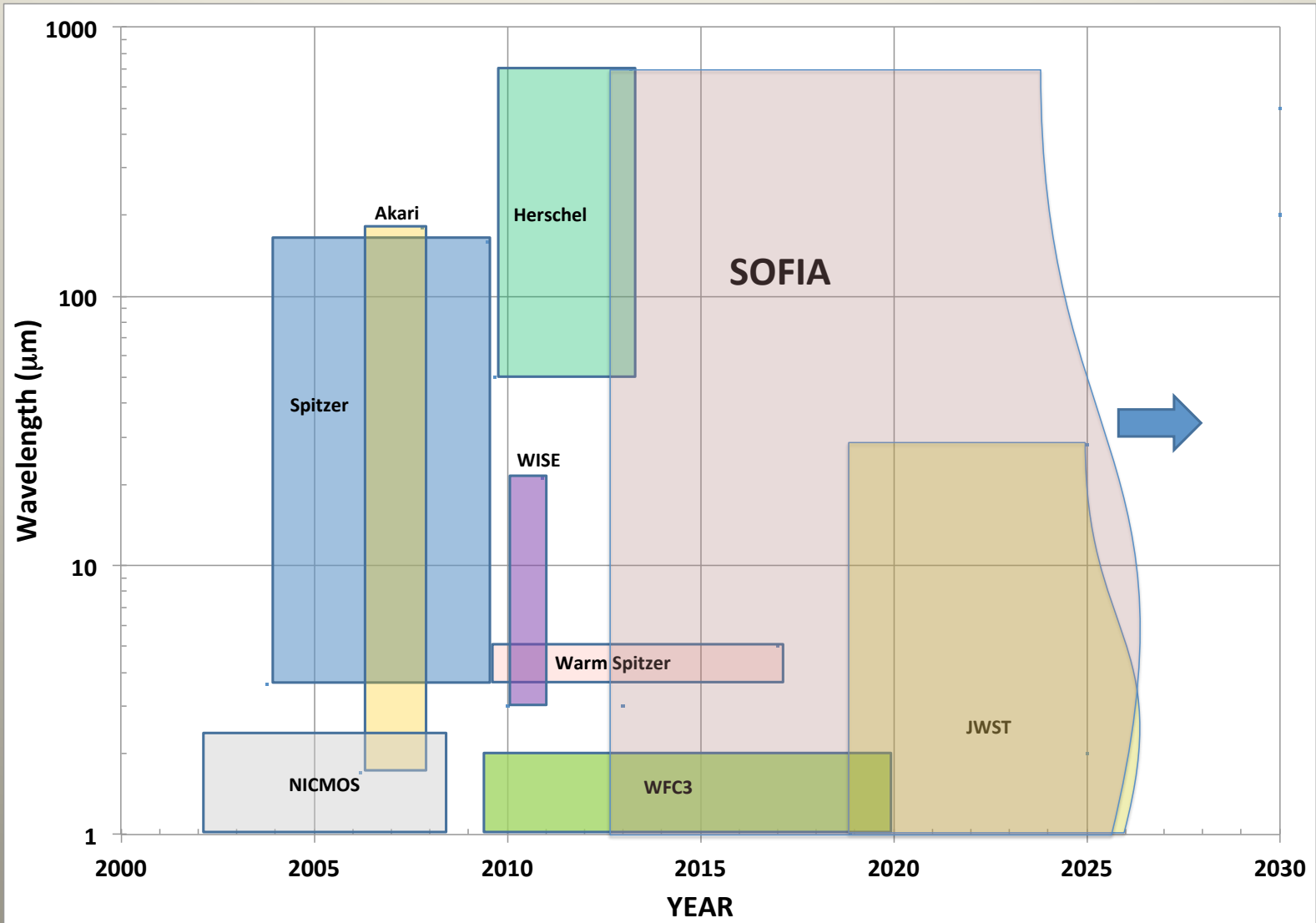


- Anticipated release will be end of April 2015
- 7 Instruments will be available
 - FORCAST
 - GREAT
 - FLITECAM
 - FIFI-LS
 - EXES
 - HIPO
 - HAWC+
- More the 500 Hours will be available to the worldwide astronomical community





Infrared Mission Coverage



<http://www.sofia.usra.edu>

