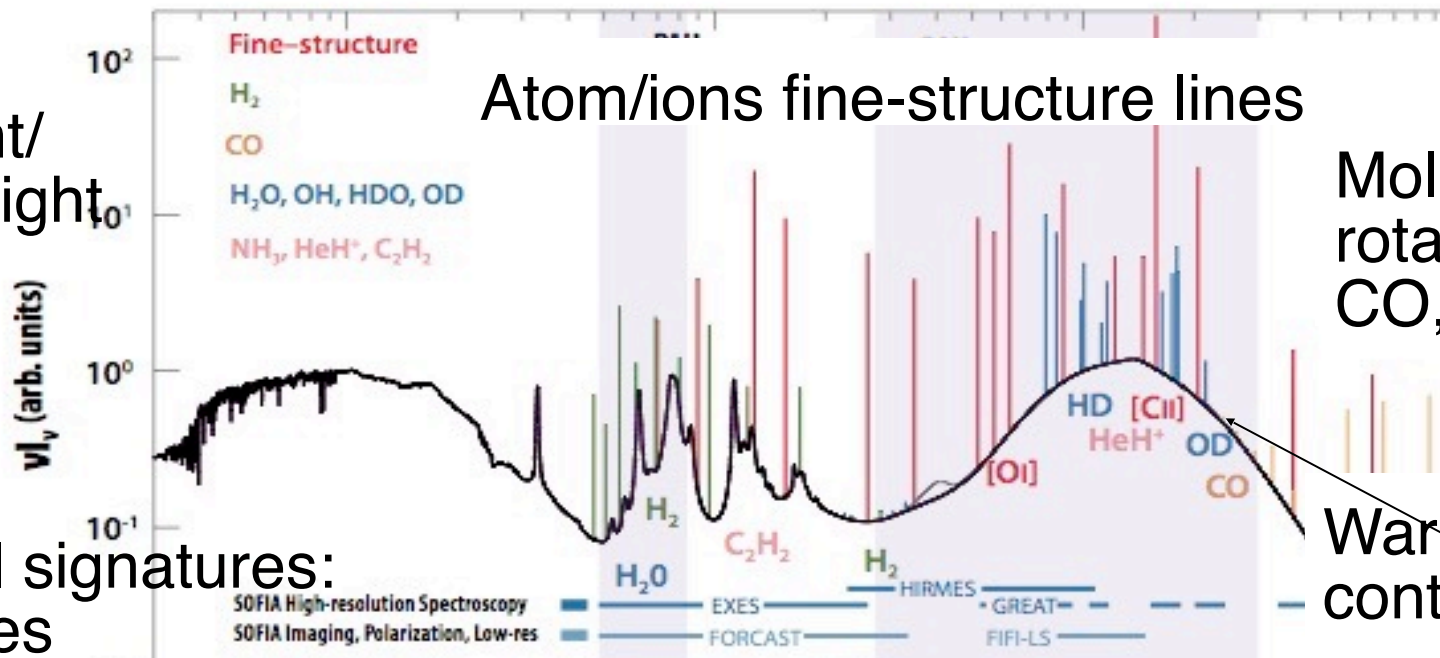


# SOFIA Open Calls for Proposals: what you need to know



# Why Infrared Astronomy?

Some starlight/  
reflected starlight



Atom/ions fine-structure lines

Molecular ro-vibrational /  
rotational lines: HDO, HD,  
CO, H<sub>2</sub>O

Warm and cold dust  
continuum thermal emission

Dust spectral signatures:  
PAHs, silicates

Mostly re-radiated starlight, probes the cold-ish universe

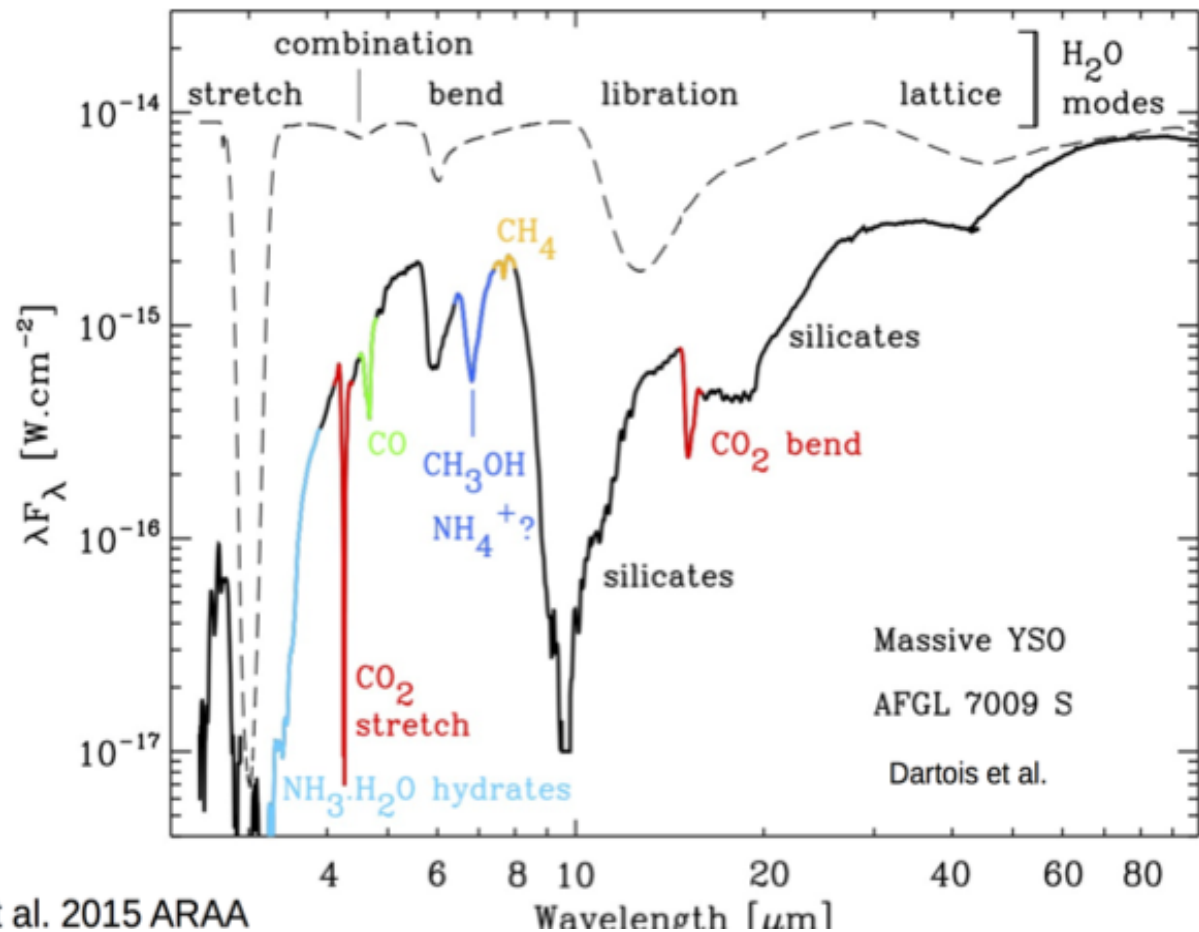
1                      10                      100                      1000  
Wavelength (μm)

# Why Infrared Astronomy?

## Dust/ice spectroscopy/photometry:

- composition
- size distribution
- morphology (imaging)
- polarization fraction/orientation

- role in heating / cooling
- role in solid/gas chemistry
- role in hydrodynamics
- magnetic field coupling

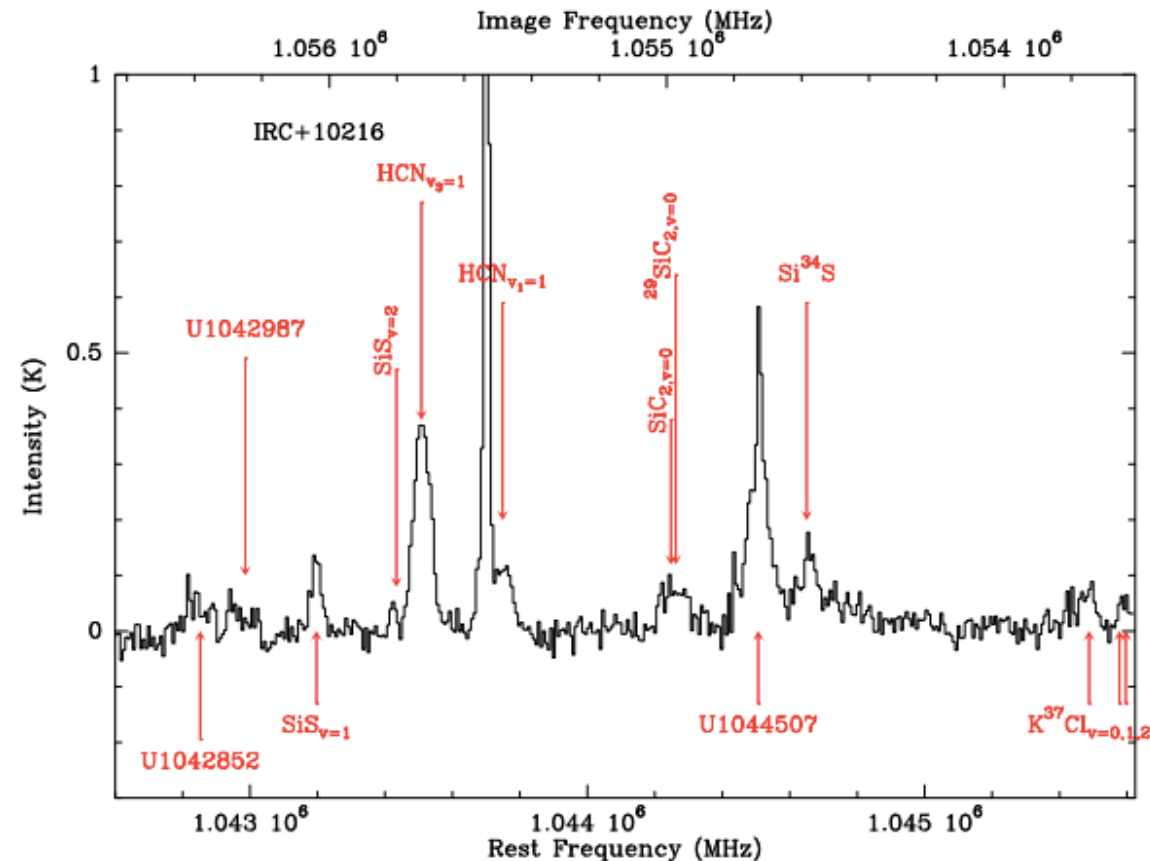


Boogert et al. 2015 ARAA

# Why Infrared Astronomy?

## Gas spectroscopy:

- composition
- kinematics
- temperature structure
- $\text{H}_2(2-0)$ -para: 28  $\mu\text{m}$ ,  $\text{H}_2(3-1)$ -ortho: 17  $\mu\text{m}$ , water rotational lines  $> 35 \mu\text{m}$
- morphology (imaging): [OIII] tracing energetic UV fields
- [CII] role in heating/ cooling ([CII])
- C, Na, Mg, Al, Si, S, Ca, Fe, Ni can all be easily ionized by background starlight -



Siebert et al, 2020: GREAT spectrum of IRC+10216

# SOFIA: a flying platform for IR at 45+ feet

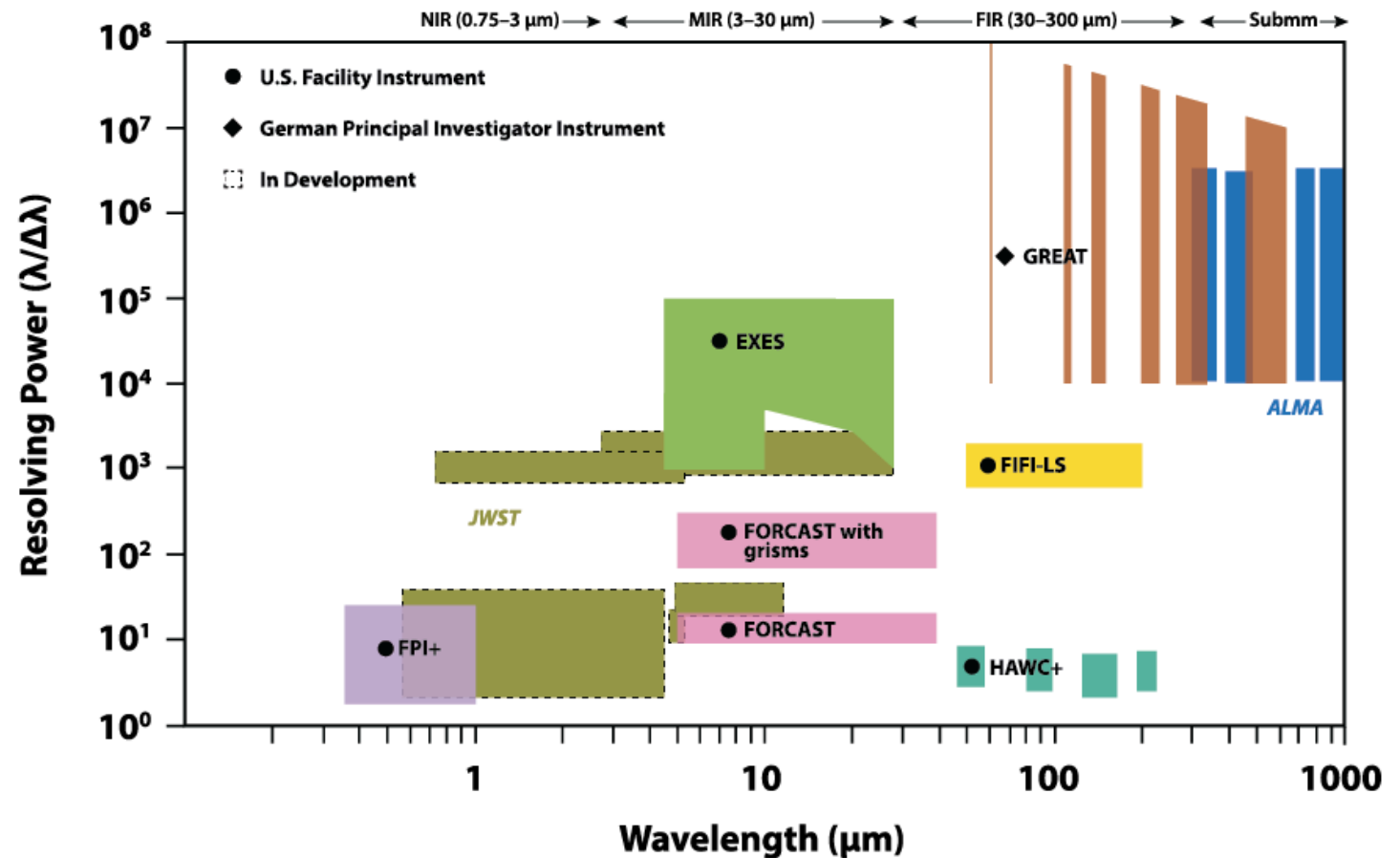
2.5 m effective diameter mirror

Covers most of the Mid and Far-IR spectrum (5-600  $\mu\text{m}$ ), at a variety of spectral resolutions

Instruments installed for series of flights (1-4 weeks each)

Instrument schedule based on proposal pressure

## The SOFIA Instruments



# FORCAST: MIR Imager + gratings

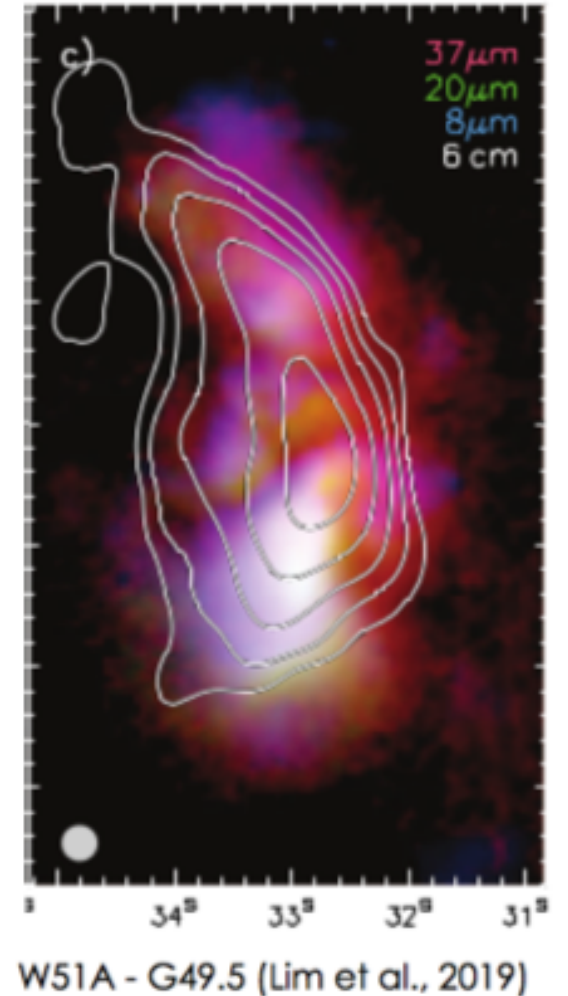
- 5-40 microns
- 256x256 pixels array
- $R \sim 70-300$  with gratings
- PAHs, amorphous silicates, atomic/ionized features, does not saturate on bright sources

Grism Details

| Grism | Coverage ( $\mu\text{m}$ ) | $R (\lambda/\Delta\lambda)^a$ |
|-------|----------------------------|-------------------------------|
| G063  | 4.9–8.0                    | 120 <sup>c</sup> /180         |
| G111  | 8.4–13.7                   | 130 <sup>c</sup> /260         |
| G227  | 17.6–27.7                  | 110/120                       |
| G329  | 28.7–37.1                  | 160/170 <sup>b</sup>          |

Filter Parameters

| SWC Filters                          |                               | LWC Filters   |                               |
|--------------------------------------|-------------------------------|---|-------------------------------|
| $\lambda_{\text{eff}} (\mu\text{m})$ | $\Delta\lambda (\mu\text{m})$ | $\lambda_{\text{eff}} (\mu\text{m})$                            | $\Delta\lambda (\mu\text{m})$ |
| 5.4                                  | 0.16                          | 24.2  | 2.9                           |
| 5.6                                  | 0.08                          | 31.5  | 5.7                           |
| 6.4                                  | 0.14                          | 33.6  | 1.9                           |
| 6.6                                  | 0.24                          | 34.8  | 3.8                           |
| 7.7                                  | 0.47                          | 37.1  | 3.3                           |
| 8.8                                  | 0.41                          | A subset of these will be chosen each cycle as the nominal set. |                               |
| 11.1                                 | 0.95                          |   |                               |
| 11.2                                 | 2.7                           |   |                               |
| 11.3                                 | 0.24                          |   |                               |
| 11.8                                 | 0.74                          |   |                               |
| 19.7                                 | 5.5                           |   |                               |
| 25.4                                 | 1.86                          |   |                               |

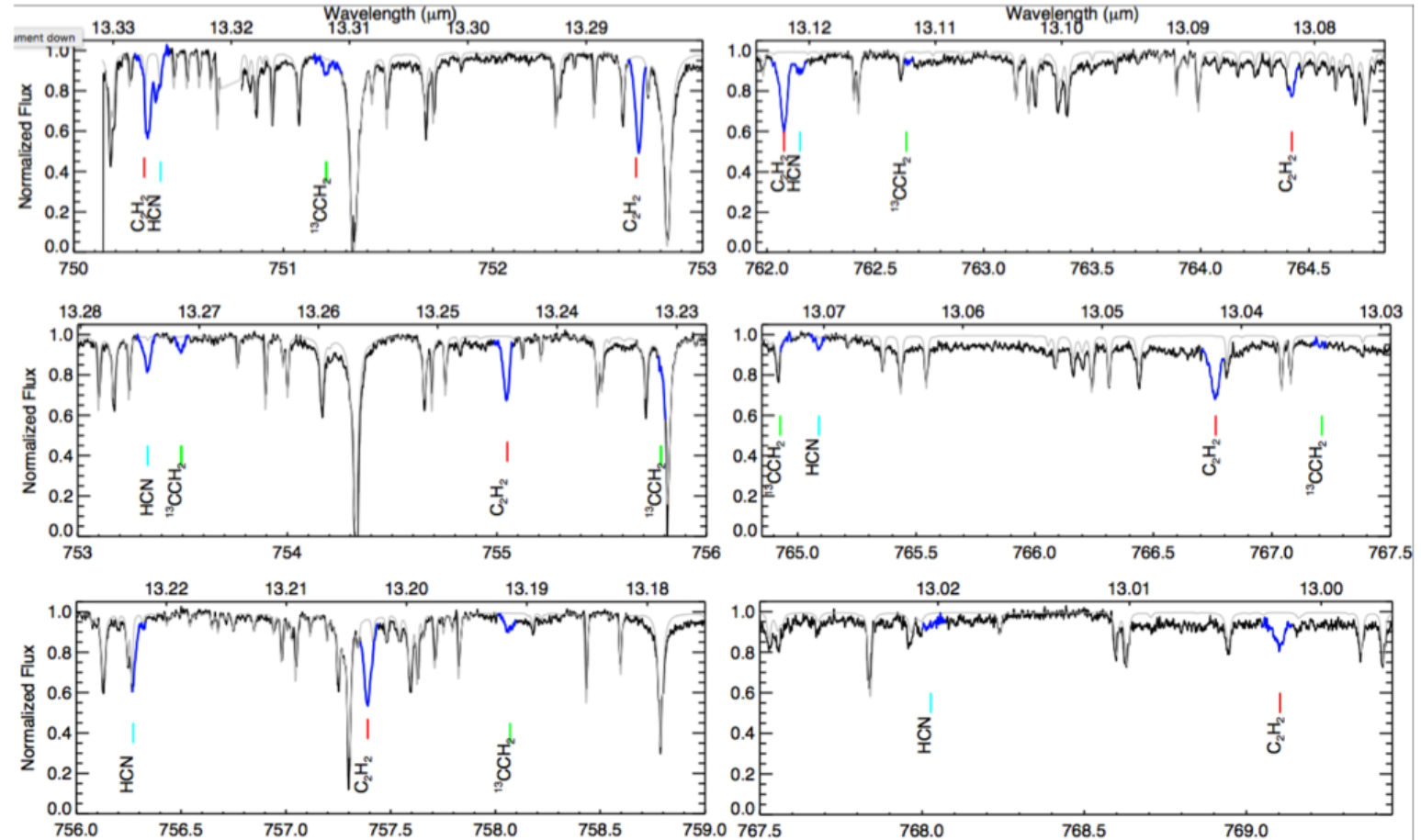


# EXES: High-res MIR Spectrometer

- Mid-IR High-Resolution Spectrograph: **4.5-28.3  $\mu\text{m}$**
- *Slit mapping mode available*

| Configuration | Slit Length | Spectral Resolution |
|---------------|-------------|---------------------|
| Low           | 25" – 180"  | 1,000 – 3,000       |
| Medium        |             | 5,000 – 20,000      |
| HIGH_MED      | 1.5" – 45"  | 50,000 – 100,000    |
| HIGH_LOW      | 1" – 12"    |                     |

In the Medium and Low configurations the slit lengths vary from 25" to 180" depending on the number of rows to be read.

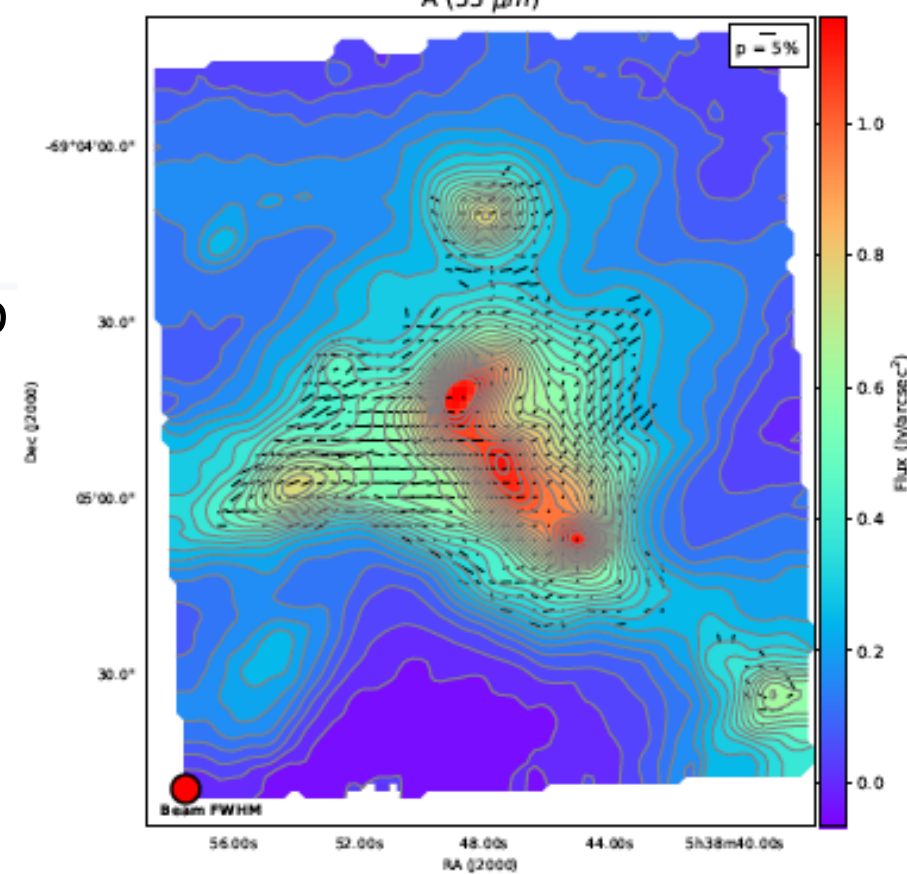


Orion Hot Core line survey (Rangwala et al. 2018)

# HAWC+: FIR Polarimetric Imager

- **53-220 microns , 64x40 array**
- Superconducting TES
- **Polarimeter (half wave plates)**
- Diffraction limited at all bands
- dust polarization and distribution

30Dor polarization map  
(Gordon et al., 2018)



| Band / Wavelength     | $\Delta\lambda/\lambda$ | Angular Resolution | Total Intensity FOV (arcmin) | Polarization FOV (arcmin) |
|-----------------------|-------------------------|--------------------|------------------------------|---------------------------|
| A / 53 $\mu\text{m}$  | 0.17                    | 4.7" FWHM          | 2.7 x 1.7                    | 1.3 x 1.7                 |
| C / 89 $\mu\text{m}$  | 0.19                    | 7.8" FWHM          | 4.2 x 2.6                    | 2.1 x 2.6                 |
| D / 154 $\mu\text{m}$ | 0.22                    | 14" FWHM           | 7.3 x 4.5                    | 3.6 x 4.5                 |
| E / 214 $\mu\text{m}$ | 0.20                    | 19" FWHM           | 8.0 x 6.1                    | 4.0 x 6.1                 |

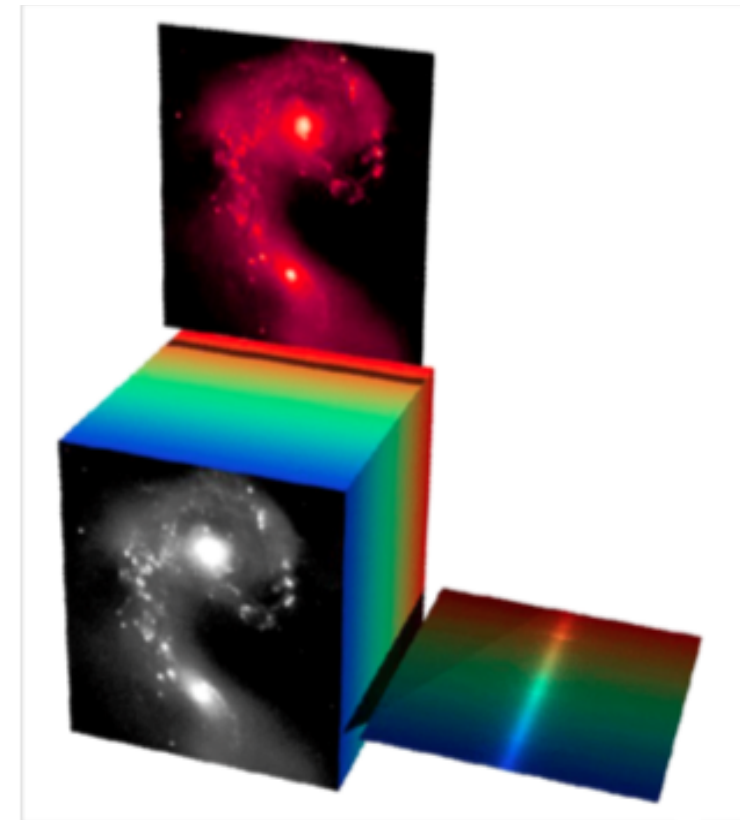
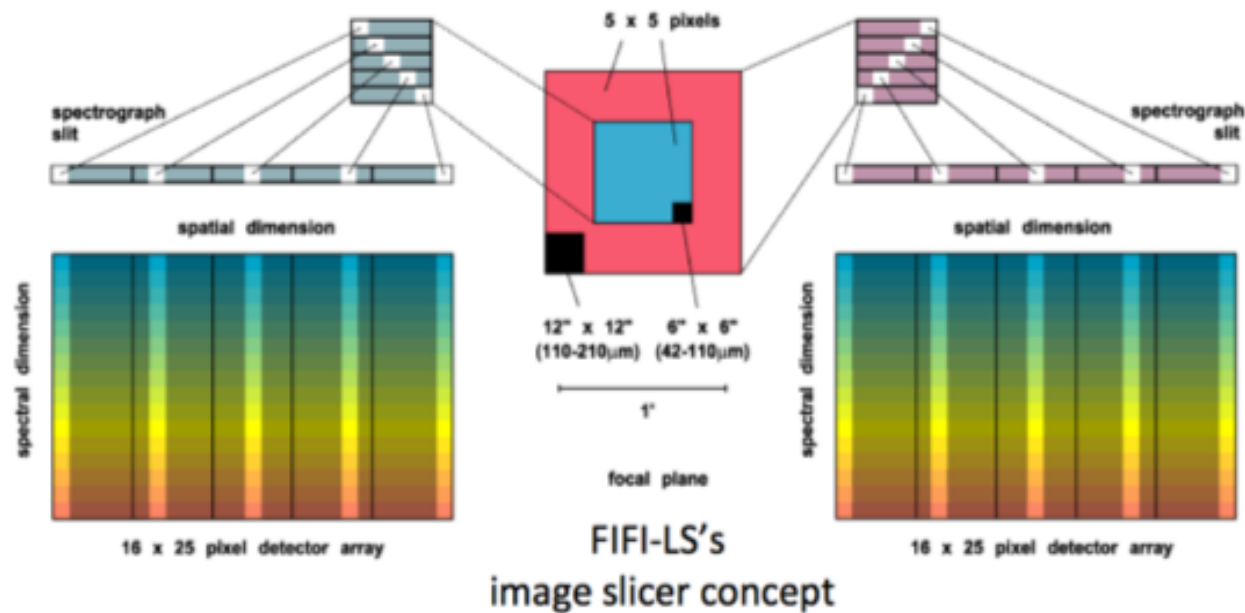


# FIFI-LS: FIR Integral field Spectrometer

FIFI-LS: Far-infrared spectrometer with two parallel channels and an integral field unit:

Blue 50-110  $\mu\text{m}$  & Red 110-200  $\mu\text{m}$

Spectral resolution:  $R=500-2000$

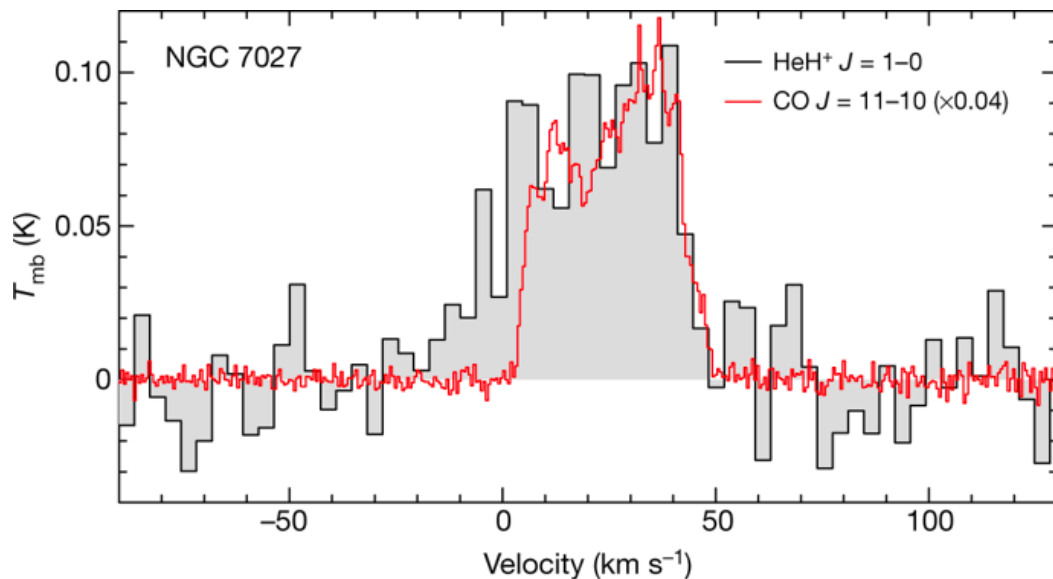


Standard pipeline product is a *datacube*.

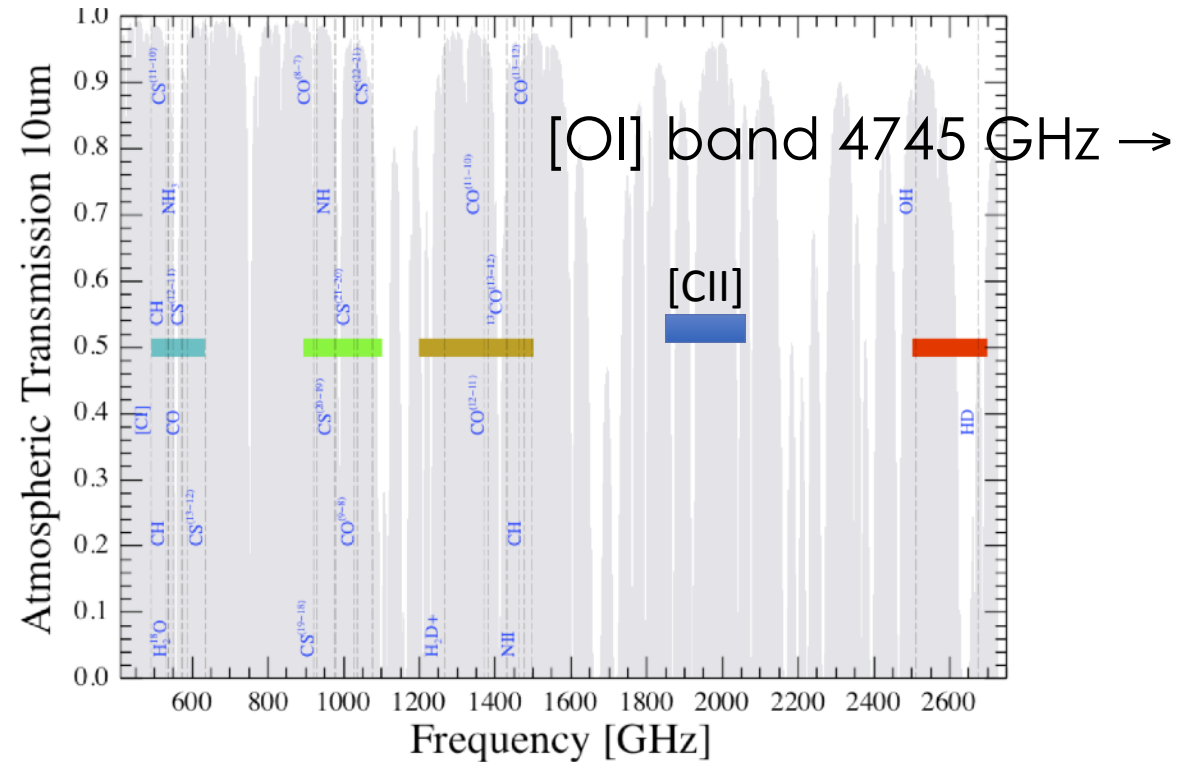
# GREAT: THz heterodyne spectroscopy

- Six bands in the 0.5 – 4.7 THz range
- Two bands with 7-beam array ( 2 polarization), 4 bands with 1 pixel

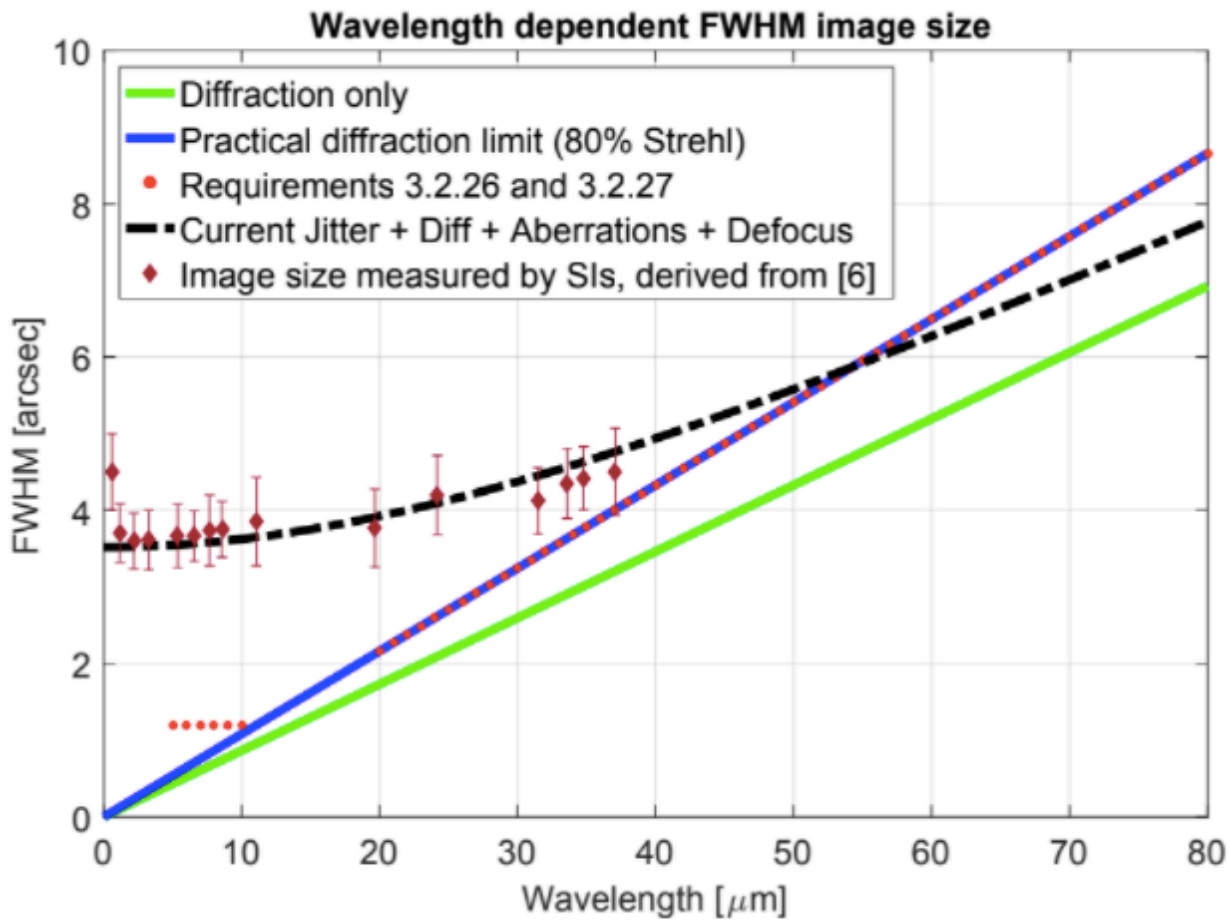
- $R = 10^8$  (<0.1 km/s!)
- Compares to Herschel-HIFI, with faster mapping and similar point source sensitivity



HeH<sup>+</sup> first detection (149 $\mu$ m, NGC 7027),  
Güsten et al. (2019) Nature 568, 357.



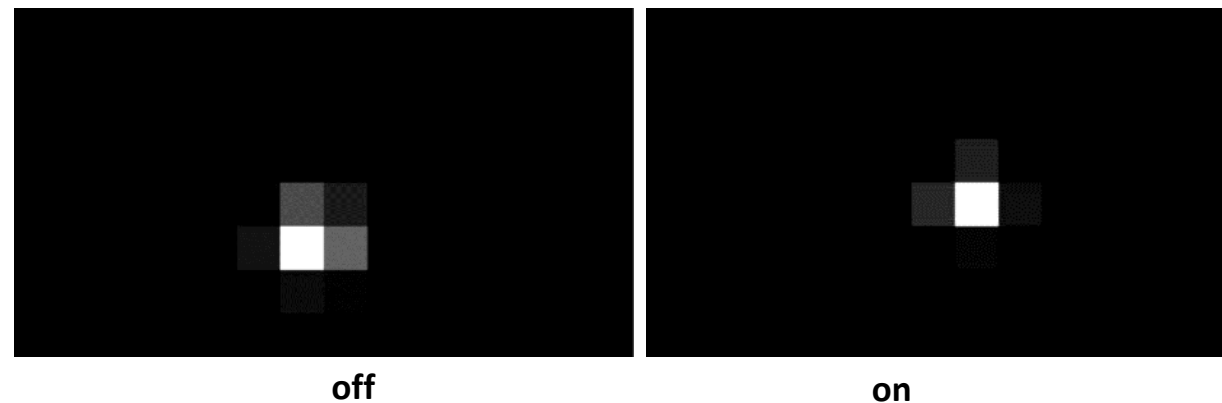
# Optics and Imaging



PSF FWHM  $\sim 3.5''$  at short wavelengths,  
**diffraction limited  $>35 \mu\text{m}$ .**

PSF contribution comes from Pointing jitter + Diffraction + Aberrations + Defocus

Image stabilization : 50 Hz updates to tip-tilt secondary mirror

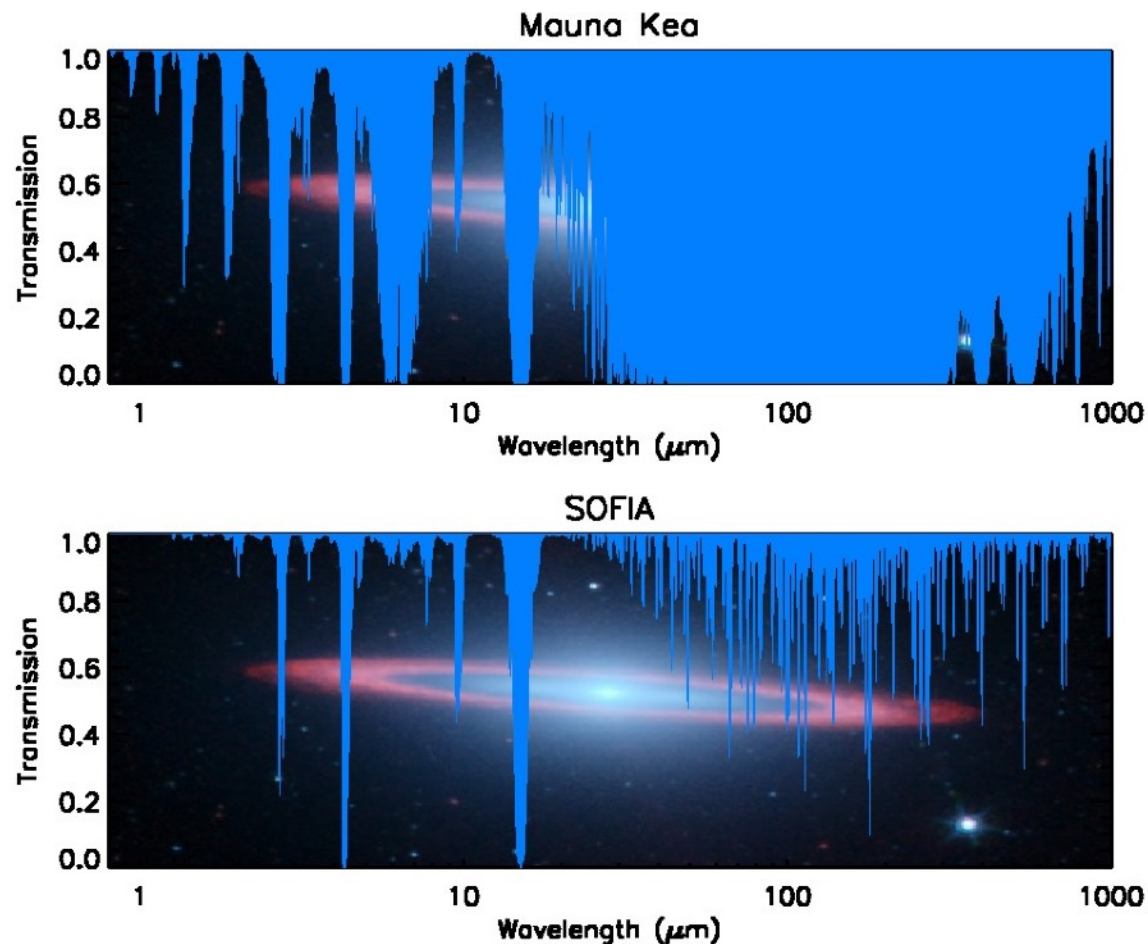


# A flying telescope: some considerations

SOFIA flies above ~99% of water vapor in the atmosphere, **but remaining 1% is still significant...**

- SOFIA pwv: 4 – 27  $\mu\text{m}$  (45k – 35k feet)
- Mauna Kea pwv: 0.8 – 4.5 \*mm\*

Maximum leg length ~ 4 hours : easier to schedule observations which can be easily 'chopped' in a few hours chunks



# SOFIA Open observing calls

- Cycle 10 Call For Proposals: observations + funding  
**Deadline January 28, 2022 21:00 PST (January 29, 2022 05:00 UTC)**
- Directors' Discretionary Time (DDT): observations  
**Proposals accepted year long**  
New sources / time-critical / pilot technique testing / flight plans gaps / Short observations necessary to complete a publication / PhD

# What is offered in Cycle 10

## In short:

- Oct 1, 2022 to Sep 30, 2023
- All six instruments
- **4 instruments deployed to the South**  
GREAT and HAWC + (June-Sep 2022)  
FIFI-LS (Fall 2022), EXES (Spring 2023)

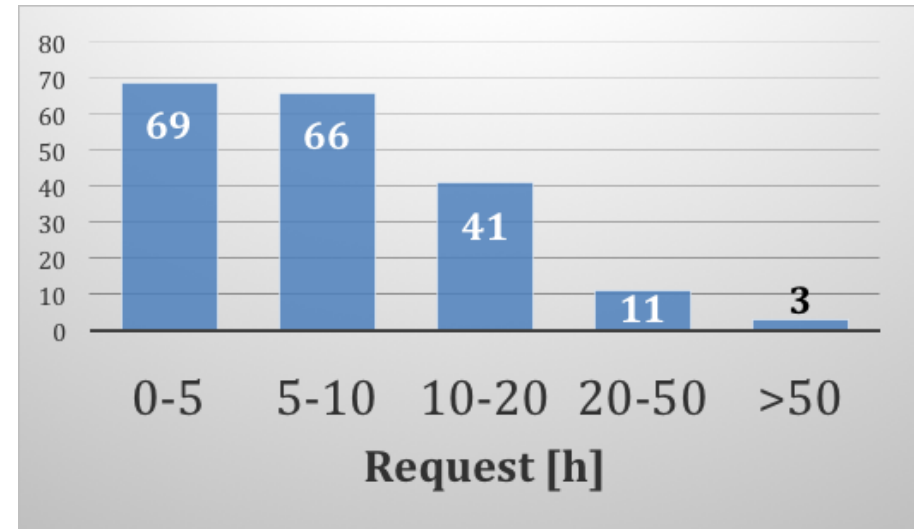
## New:

- new sub-category of programs '**Multi-Cycle Target Monitoring**', for up to three cycles
- EXES going to the South
- Joint proposal opportunity with GBO, IRTF
- Up to 20 hours reserved for JWST support

# What is offered in Cycle 10

## 2 different types of proposals

- **Regular:** ~ 550h total



- **Legacy:** “programs targeting a rich archival dataset of significant scientific value to the astronomical community for future analysis.”

1-3 large proposals, up to 200h observations each over 2 cycles. No proprietary period, team contributes enhanced products. GREAT not offered

# What is offered in Cycle 10

## Associated funding (for US-institutions only)

- Up to \$5.5M for Regular Proposals (~\$10k/ h)
  - **New: minimum \$75K grant**
  - Up to \$2M / year for Legacy Proposals
- 
- Additional funding can be requested through the Thesis-enabling Program (up to two years of graduate student funding)



# Preparing your proposal

Science case

Evaluate feasibility

Define observations in USPOT

Upload justification and bio pdfs

Validate then Submit!

**Deadline Jan 28th, 21h PST**



# Science case tips

- Substantial investigations that demonstrate significant scientific impact
- Degree to which the investigation uses SOFIA's Unique capabilities.
  
- Programs using multi-wavelength data from major facilities (ALMA, HST, Spitzer, etc) are highly encouraged
- Up to 20 hours reserved for programs informing accepted JWST observations
- Survey proposals are encouraged. Plan is to have up to 100 hours for survey proposals.

# Support documents and tools

About SOFIA

Proposing & Observing

Data

Instru

## Cycle 10 Documentation

[Call for Proposals \(for regular proposals\)](#)

[Call for Proposals for the SOFIA Legacy Program \(SLP\)](#)

[Observer's Handbook for Cycle 10](#)

[USPOT Manual](#)

[AOR and projects examples](#) (Proposal prep webinars proceedings)

[SLP & SARP Budget Template](#) (not cycle-specific)

Call For Proposals

Observers' Handbook

Time estimates: SITE

USPOT (to download)

## SOFIA Instrument Time Estimator (SITE)

Please Check 'Notes and Known Issues' Before Proceeding

### Spectroscopic Time Estimators and Tools

[FIFI-LS](#)

[FORCAST GRISM](#)

[FLITECAM GRISM](#)

[GREAT](#)

[EXES](#)

### Imaging Time Estimators

[FORCAST](#)

[FLITECAM](#)

[FLITECAM\\_HIPO](#)

[HAWC\\_Plus](#)

[FPI\\_Plus](#)

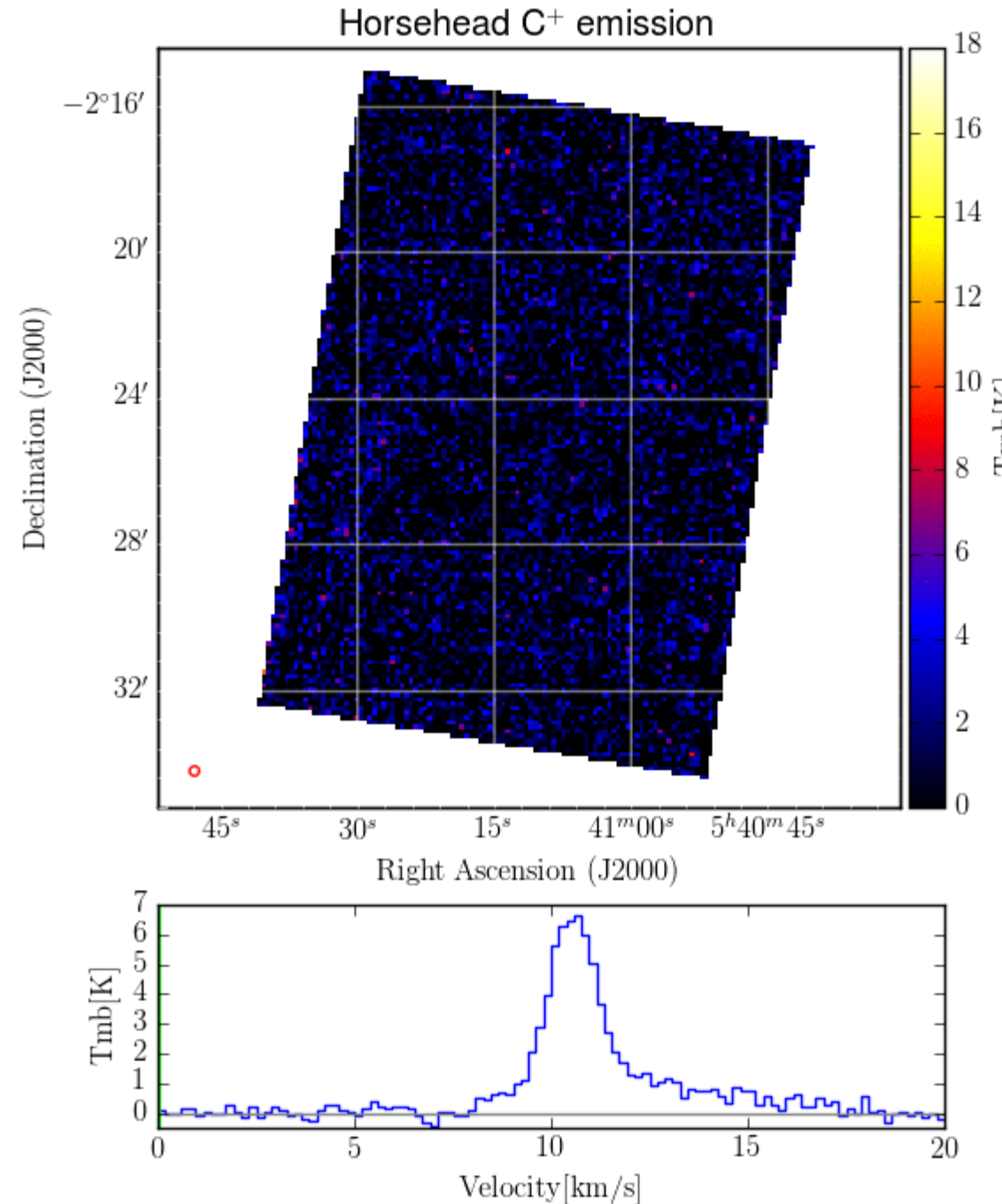
Any missing information: Help Desk  
[sofia\\_help@sofia.usra.edu](mailto:sofia_help@sofia.usra.edu)

# Feasibility: Signal

**Expected source signal:** needs to be soundly justified!

- archival data (possibly w. SED extrapolation)
- your own radiative transfer model (describe)
- classic models/ correlations: Hyperion (dust), Planetary Spectrum Calculator, Meudon PDR ...

Signal must be defined by **flux density by beam/ pixel or surface brightness** (depends on instruments)

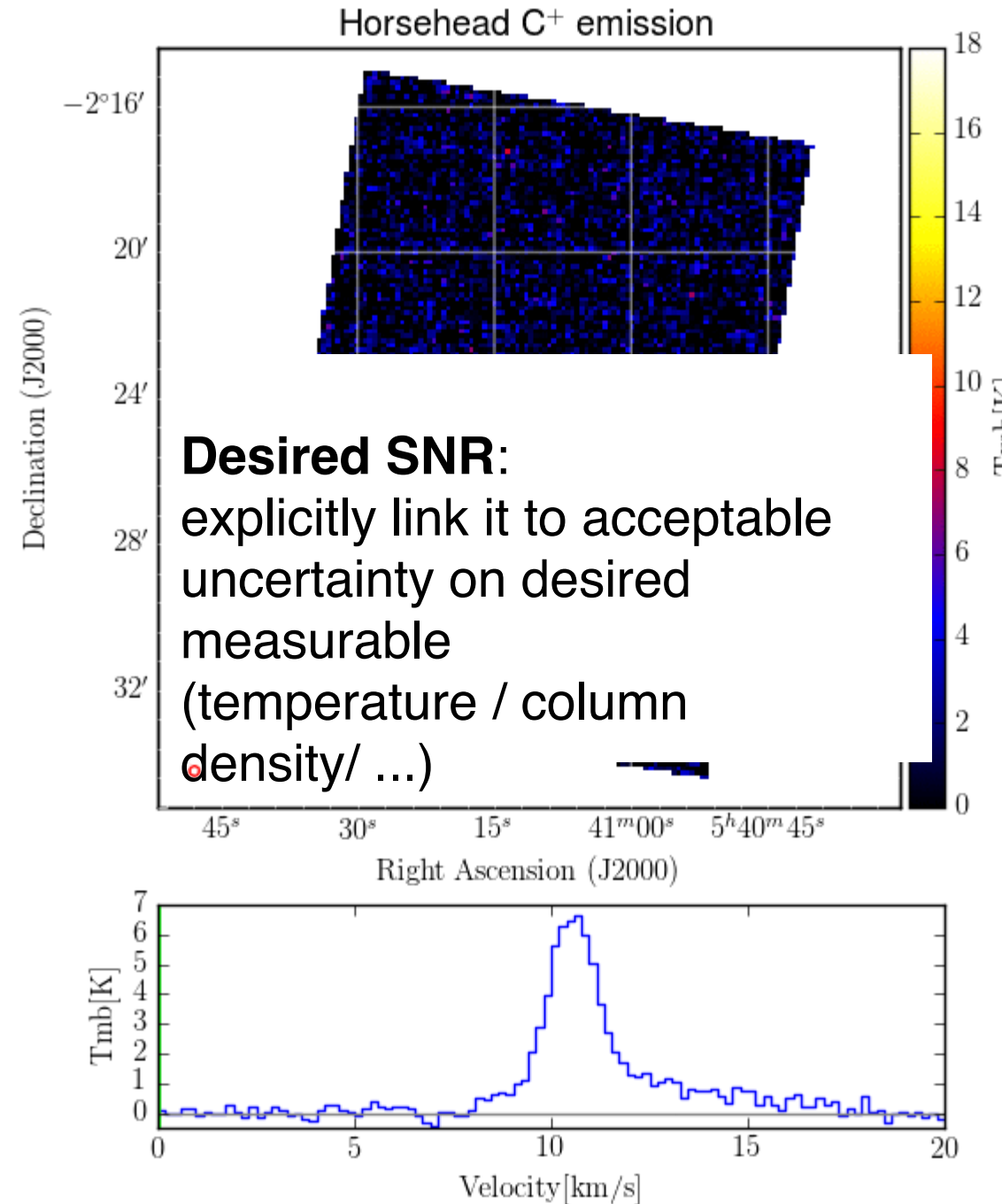


# Feasibility: Signal

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- your own radiative transfer model (describe)
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Signal must be defined by **flux density by beam/ pixel or surface brightness** (depends on instruments)



# SITE: estimating corresponding observing time

<https://dcs.arc.nasa.gov/proposalDevelopment/SITE/index.jsp>

**SOFIA Instrument Time Estimator (SITE)**  
**Please Check 'Notes and Known Issues' Before Proceeding**

**Spectroscopic Time Estimators and Tools**

**FIFI-LS**    FORCAST GRISM    FLITECAM GRISM    GREAT    EXES    ATRAN

**Imaging Time Estimators**

FORCAST    FLITECAM    FLITECAM\_HIPO    HAWC\_Plus    FPI\_Plus

The following four sections of this form are for imaging configurations: select the instrument, astronomical source, telescope, observing condition constraints and calculation method. Click on the **Calculate** button to submit the parameters from all the sections to the server. The results are reported in a separate web page that can be resized and printed.

**Instrument properties**  
*(more info, input parameter details)*

Instrument properties:  
Wavelength:  microns (51 to 203)  
Bandwidth:   km/s  microns  
Observer Velocity (VLSR, km/s):  OR  Compute Velocity

**Calculation Method**  
*(more info)*  
Select the calculation method

S/N ratio resulting from a Total Integration Time of  secs  
 Total Integration Time to achieve a S/N ratio of

**Astronomical Source Definition**

Source Flux:   line (W/m<sup>2</sup>)  continuum (Jy)  
Source Velocity:   LSR, km/s  redshift

## Output Parameters

|   |                            |
|---|----------------------------|
| <b>V<sub>LSR</sub>:</b>                     | 0.000 km/s                 |
| <b>Velocity corrected Wavelength:</b>       | 157.741 microns            |
| <b>Plotted wavelength range:</b>            | 156.938 - 158.544 microns  |
| <b>Interpolated values from data table:</b> |                            |
| Bandwidth =                                 | 0.803 microns              |
| MDLF =                                      | 2.087e-17 W/m <sup>2</sup> |
| MDCF =                                      | 0.570 Jy                   |
| <b>Atmospheric Transmission:</b>            | 0.843      0.862           |
|   | (smoothed) (unsmoothed)    |
| <b>Integration time (t<sub>on</sub>):</b>   | 0.107      0.102 minutes   |
|   | (smoothed) (unsmoothed)    |

This is a time estimate per ON point or ON-OFF pair , per array element, does not include calibration overheads

# USPOT: define AOR

File Edit **Observation** Tools Images Overlays Options Window View Help

Proposal

\* Title

Proposal Info Investigators

\* TAC Queue US

Category None Selected

Cycle ID OPEN CYCLE

\* Science Keywords

\* Proposal PDF Attachment

\* Proposal Abstract Related Proposals Status of Observations Special Instructions

0/2000

Proposal Observations

Target: None Specified

Proposal - <No File>

FIFI-LS [AOR ID: N/A]

Unique AOR Label: FIFI\_LS-0000

Target: None Specified

New Target Modify Target Target List...

Observing Condition & Acquisition / Tracking

Observation Order 0

\* Rest Wavelength Blue (micron) 63.184

\* Width of Spectrum Blue (km/s OR micron) 0.000

Width of Spectral Feature Blue (km/s OR micron) 0.000

\* Rest Wavelength Red (micron) 157.741

\* Width of Spectrum Red (km/s OR micron) 0.000

Width of Spectral Feature Red (km/s OR micron) 0.000

Width Unit km/s

\* Source Velocity (km/s) 0.00000

Dichroic 105\_micron

Pointing Array Blue

Spectral 1 FIF\_BLUE

Spectral 2 FIF\_RED

On-source exp. time (sec) 60

\* On source exp. time per cycle (sec) 30.000

\* Cycles 1

Min Contiguous Exp Time (sec) 0.000

\* MapType Grid

\* Number of Points Along Lat (Grid Only) 1

\* Number of Points Along Lon (Grid Only) 1

Step Size Along Lat (arcsec) 30.000

Step Size Along Lon (arcsec) 30.000

Map Offset RA (arcsec) 0.000

Map Offset Dec (arcsec) 0.000

Map Priority Map order

FOV Angle (deg) 0.000

Custom Map Area (arcsec^2) 0.000

\* Instrument Mode Symmetric Chop

Chop Type Sym

Total Chop Throw (arcsec) 120.000

Chop Angle Coordinate J2000

Chop Pos Angle (deg) 90.000

Set Chop Angle Ranges

Reference Position

Ref Type

By Offset

By Position

Map Ref. Pos. false

Reference Name

RA Offset (arcsec) 600.000

Dec Offset (arcsec) 600.000

RA (deg) 0.000000

Dec (deg) 0.000000

Position: 0h00m00.0000s, +0d00m00.000s

Choose Position

(\*\* = Advanced) (\* = required for Phase I)

\*Import Map Offsets (Custom Only) Export Map Offsets Export Map Positions

Observation Est... Comments... Proposal Info...

OK Apply Cancel Help

Total Duration: 0 min Awarded: 0 min

Net Up



# Write and upload justification pdf (main body)

- Context, aim, methods, synergies, anticipated results (0.5p / 1p)
- Scientific justification (3p + references / 5 p)
  - Don't forget instrument and data justification
- Feasibility + path to publication (3p)
  - Instrument and modes, exposure time, time constraints
- For Legacy only: Budget (2p), Implementation (2p)
- Thesis enabling program (1 p)

## **Justification PDF must follow Dual Anonymous Guidelines**

The TAC will not know the identity of the proposers during the science review



SOFIA Townhall: now! (10 am Pacific)

Helpdesk: [sofia\\_help@sofia.usra.edu](mailto:sofia_help@sofia.usra.edu)

Newsletter sign up:



### Next opportunities in 2022

- SOFIA School: February 2-4, online
- ‘Galactic Ecosystems’ conference, Feb 28- March 4, Lake Arrowhead CA
- Archival Research Funding Call Spring 2022 (details TBD)