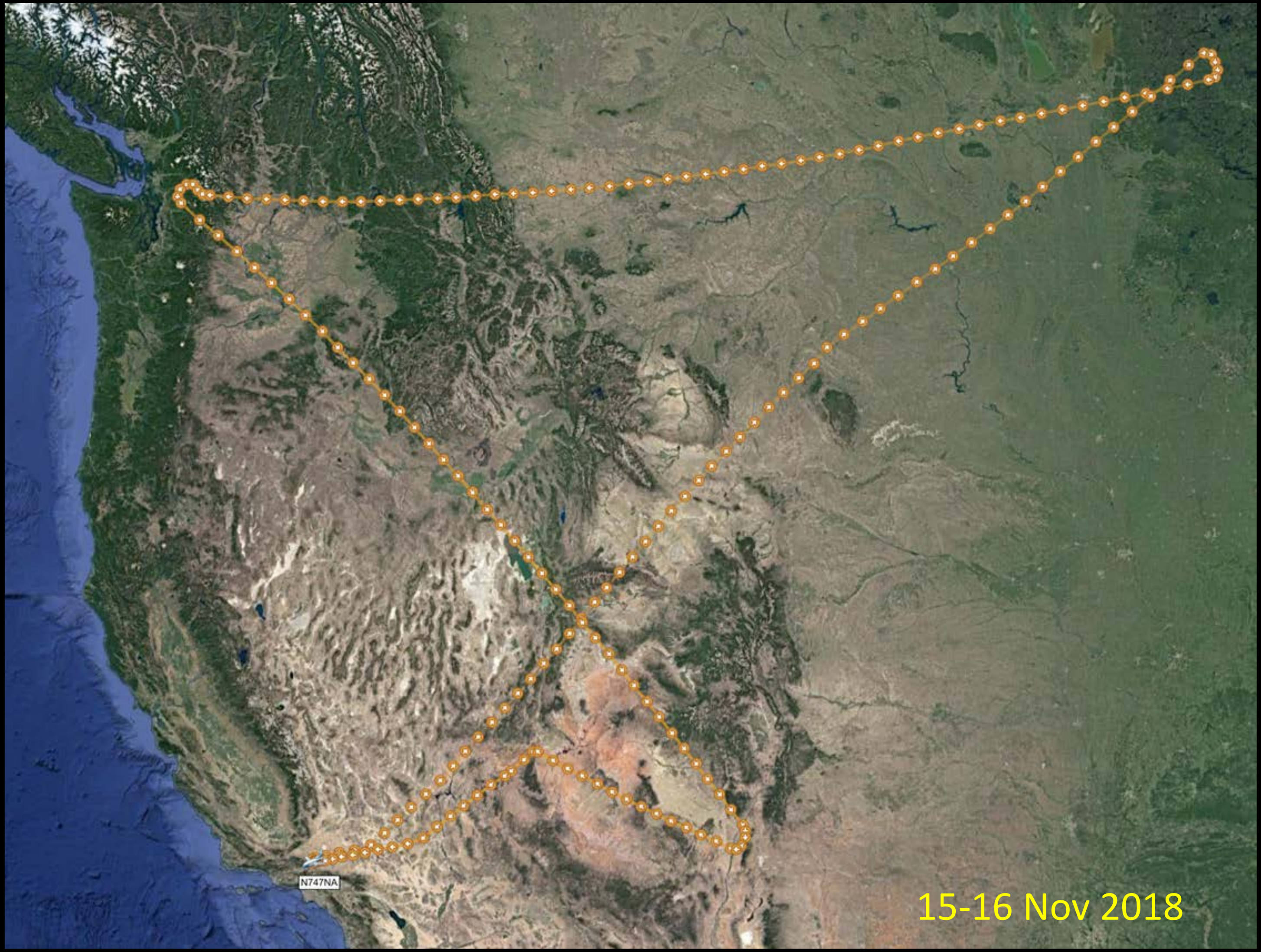
SOFIA Status: Director's Report

Harold Yorke

Director, SOFIA

Science Mission Operations

November 16, 2018



Topics

- SOFIA 5-Year Flagship Mission Review (FMR)
- Cycle 6 Status
- Cycle 7 Status
- Cycle 7 Selection
- Future SOFIA Instrumentation
- Challenges
- Science Highlights

SOFIA 5-Year Flagship Mission Review (1/3)

- SOFIA Senior Review (SR) initially planned for Spring 2019
  - 3/01: Blue Team 1 reviewed SR proposal concept
  - 8/13-14: Blue Team 2 reviewed SR proposal draft
  - 8/14: Memo from Thomas Zurbuchen announcing alternate plan for reviewing SOFIA
- First, there will be a study of SOFIA operations
  - SOFIA Operations & Maintenance Efficiency Review (SOMER)
  - First Palmdale meeting of SOMER on October 10-11
  - Study will consider alternate operations and maintenance models to execute a substantially greater number flights and/or reduce cost
- Next, there will be a SOFIA 5-Year Flagship Mission Review (FMR)
  - Draft Terms of Reference (ToR) for FMR received November 5
  - Response with suggested changes sent to NASA HQ week later
  - Final ToR expected end of November

SOFIA 5-Year Flagship Mission Review (2/3)

SOFIA SMO Director & Project Scientist are to deliver 2 documents ~Feb 1, 2019

- Each document should discuss innovative ideas, opportunities and desired changes leading to increased science return and increased science impact
- SOFIA Science (≤ 50 pages)
  - Descriptions of SOFIA's scientific merit and most recent accomplishments
  - Future scientific impact and productivity
  - Productivity and vitality of the scientific team
  - Current and future plans of data dissemination
  - Technical status of the instruments' health and safety
  - Level and quality of observatory stewardship
  - Detailed budget (including all FTEs/WYEs and their role, staffing effort) for FY20-22 and FY23-24 science operations.
- SOFIA Mission Operations (≤ 30 pages) – not included in SOMER
  - Current mission operations paradigm for the observatory
  - Vision for improved mission operations, maximizing science & minimizing costs
  - Detailed budget for mission operations personnel (include all FTEs/WYEs and their role, staffing effort) for FY20-22 and FY23-24

SOFIA 5-Year Flagship Mission Review (3/3)

Tentative schedule (tbc with FMR panel)

- ~Mid-Jan SOMER completed; Draft SOMER report shared with project
- ~Feb 1 Final SOMER report delivered
- ~Feb 1 FMR convenes; SOFIA Science Leadership provides the 2 documents to FMR which begins reviewing the documents (see previous page)
- ~Mid-Feb FMR site visit (Ames and Palmdale) / generates RFIs/RFAs
- ~Mar 1 SOFIA Science Leadership responds to RFIs/RFAs
- ~Mid-Mar FMR considers SOFIA Science Leadership responses / continues drafting
- ~Late Mar Draft report of FMR - Draft report shared with project for feedback / corrections of errors
- ~Late-Apr Final FMR report delivered
- May 2019 NASA formulates plan for SOFIA future based on two reports

Cycle 6 Status (1/2)

Changes with respect to Cycle 5

- Introduction of new priority scheme
  - P1 – “will do”; awarded ~25% of available time
  - P2 – “shall do”; awarded ~50% of available time
  - P3 – “do if time”; awarded ~50% of available time
- Funding scheme: ~$10k per hour
  - P1 – funded fully at acceptance
  - P2 – $7k at acceptance + rest after 1st segment flown
  - P3 – $7k at acceptance + incremental after each completed segment
- Instrument schedule driven by P1s; incomplete P1s carried over into Cy7
- Introduction of “thesis enabling” proposals (additional funding + ~P1)
- Introduction of “orange” flights (use as contingency flights or alternates)

Cycle 6 Status (2/2)

- SOFIA was scheduled to return from C-check (Hamburg) January 6, 2018
  - Extensive repairs were necessary, delaying return to May 18, 2018
  - Flight opportunities lost: 7 FORCAST, 7 GREAT, 8 FIFI-LS, 11 EXES, 11 HAWC+
- To recover, start/end of Cycle 6 delayed to May 19, 2018/April 26, 2019
  - All previously lost targets (except time-dependent ones) could be recovered
  - 24 of 25 flights executed in New Zealand - excellent results
  - Overall, 61 flights executed as of November 14 (2 contingencies exercised)
  - New leak repair October 2-12 eliminated 6 "orange flights" for FORCAST series (OC6J) and HAWC+ series (OC6K)

Future Cycle 6 Schedule

Series	Instruments	Start	End	Regular	Orange
OC6N	GREAT	11/15	12/19	15	5
OC6O	FORCAST	1/3	1/17	6	2
OC6P	EXES	1/22	1/31	6	2
OC6Q	HAWC+	2/5	2/13	6	2
OC6R	FIFI	2/19	2/28	6	2
Maintenance		3/1	4/11		
OC6S	EXES	4/16	4/25	6	2
Total Flights				45	15

Cycle 7 Status (1/4)

Changes with respect to Cycle 6

- Period of Cycle 7: April 27, 2019 – April 27, 2020
- A new proposal category, "SOFIA Legacy Program" (SLP), introduced
  - Replaces "impact proposals", which is discontinued
  - There is a separate Call for SLP => two separate Cycle 7 CfPs
  - SLPs are 2-year proposals of high legacy value to community
  - No proprietary period. Data publicly immediately available
- FLITECAM and HIPO retired, not available even as DDT
- 4GREAT available in all four bands (Bands 1 & 2 as shared risk)

Cycle 7 Status (2/4)

- For Cycle 7 two Calls for Proposals were issued on June 1, 2018
  - Regular Observing Cycle 7 (GO program) ~400 hours US, ~70 hours DE
  - SOFIA Legacy Science Program ~100 hours for Cycle 7 US
- Due date: September 7, 2018 21:00 PDT => Excellent proposal response
  - 190 US GO proposals, 33 DE GO, 10 Legacy proposals submitted
    - US GO: 178 regular, 7 Survey, 5 ToO
    - Requested hours: 1918 US GO, 184 DE GO, 943 Legacy
    - "oversubscription rate" (based on 670* hour total): 4.5
    - US GO "oversubscription rate" (based on 400 hours): 4.7
    - DE GO "oversubscription rate" (based on 70 hours): 2.6
  - 4 joint US-DE Legacy proposals; if successful, will be charged 80:20 between US and DE

*100 hour additional from Cycle 8

Cycle 7 Status (3/4)

Cycle 7 Proposals	US queue	DE queue	Legacy Prog.
Number of proposals	190	33	10
GREAT	48	18	4
HAWC_PLUS	40	8	4
FIFI-LS	36	5	1
EXES	22	1	0
FORCAST	43	1	1
FPI_PLUS	1	0	0
Regular Obs	178	32	
Survey Obs	7	1	
ToO	5	0	
Joint Proposals			4
Requested Time	1917.7	184.1	942.5
Total Available Time (no Legacy)	400	70	
Oversubscription (no Legacy)	4.79	2.63	
Total Available Time	500	70	
Legacy Time Split	871.8	70.8	
Oversubscription	4.71*	3.13	

Disclaimer: Some proposals request the use of multiple Instruments. This table lists the primary instrument only

Preliminary results: Do not quote

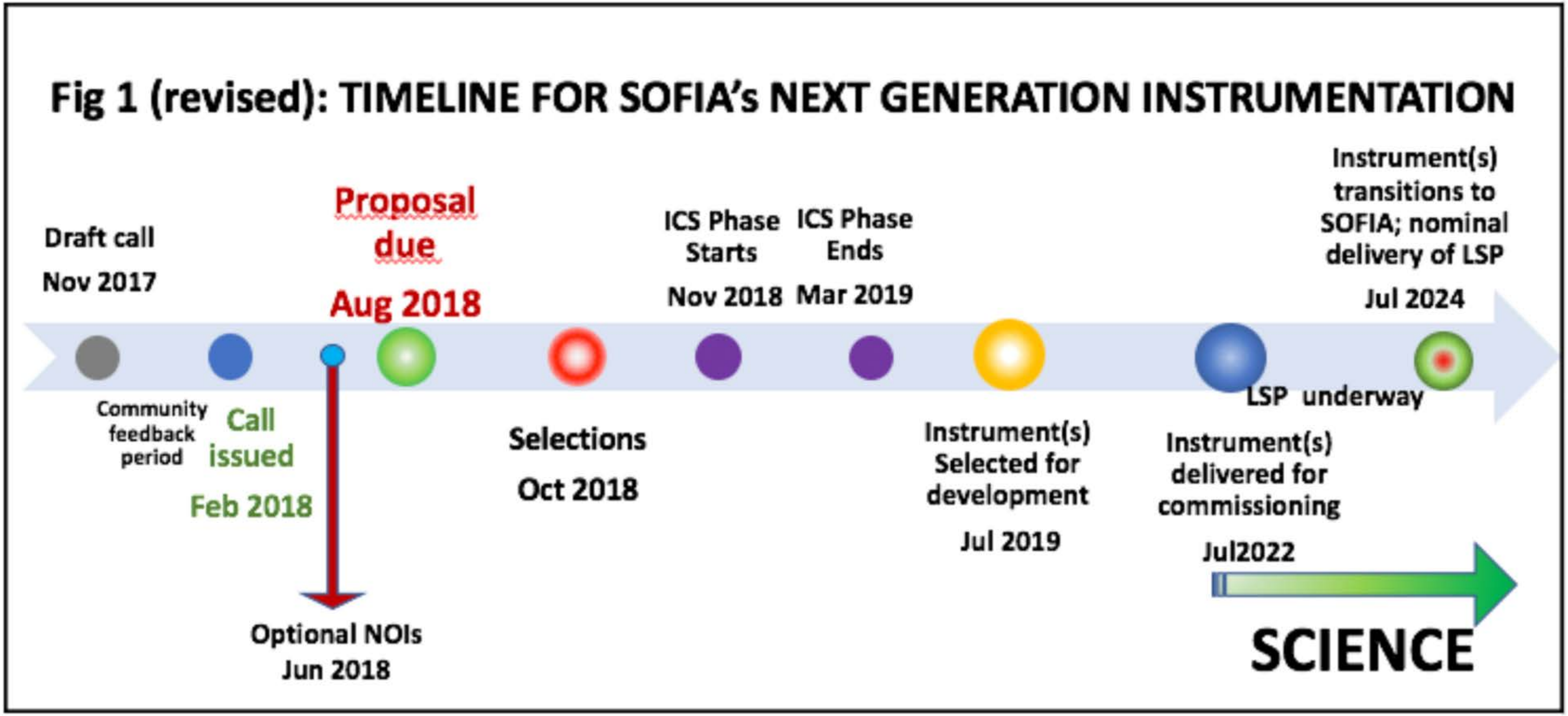
* Legacy Time accounted for 50% (Cycle 7)

Cycle 7 Status (4/4)

- Time Allocation Committee (TAC) met October 15-18
  - US and DE TACs co-located in DC area
  - Legacy TAC panel met October 15 (some members participated in US and DE GO panels)
  - 5 US GO program TAC panels met October 16-17, concurrently with the DE GO TAC panel for first time
  - US Panel chairs met on October 18 to finalize US TAC results
- Schedule planning began in earnest with known TAC results; proposal acceptance depends on feasibility of scheduling
- Draft schedule for Cycle 7 expected in November 2018
- Selection Letters and Selection Document mid-December 2018
- Cycle 7 observations begin April 27

Future SOFIA Instrumentation

- HIRMES currently scheduled for delivery Spring 2019
  - Independent Review on Dec 11/12; DPMP on Dec 13 to determine actual delivery date
  - Testing (e.g. air worthiness certification) two months
  - Commissioning begins after New Zealand deployment
  - HIRMES not offered in Cycle 7, unlikely to be available for DDT
- NGSI Step 1 review occurred in DC area (NASA-run)
  - Each proposal has its own Legacy Program
  - Delivery of instrument: nominally 2022
  - Step 1 “selection” ~October 2018; ICS Phase begins November 2018
  - Instrument(s) final selection ~July 2019



Schedule may move forward based on not having a Senior Review

Challenges

- Reliability of aircraft => Report by Project Manager
- Papers, papers, papers

Papers, Papers, Papers

- As of Nov 14: 130 science papers; 47 instrument papers, 34+ PhD

	cum. science	cum. instrument	num. science	num. instrument	Total papers	cum. Papers
2018	130	47	32	10	42	177
2017	98	37	23	3	26	135
2016	75	34	18	4	22	109
2015	57	30	21	1	22	87
2014	36	29	6	1	7	65
2013	30	28	3	3	6	58
2012	27	25	26	7	33	52
2011	1	18	1	1	2	19
prior	0	17	0	17	17	17

Choosing a Publication Rate Goal

<u>SOFIA Actuals</u>
2018: 32+ pub
Long-term avg: 17 hrs/paper

Preliminary study:
Do not quote

Observatory	# telescopes	Hours/tel/yr	pub/yr	hours/paper
Ground-based Observatories				
Gemini	2	4800	213	22.5
Keck	2	4800	165	29.1
Subaru	1	2400	101	23.7
IRTF	1	2400	108	22.1
VLT	4	9600	575	16.7
LaSillaESO	3	7200	235	30.6
Airborne Observatories				
SOFIA (*steady-state goal*)	**1**	**600**	**40-60**	**10-15**
Space-Based Observatories				
Hubble	1	7200	480	15.0
Herschel	1	5400	560	9.6
Chandra	1	7900	430	18.5

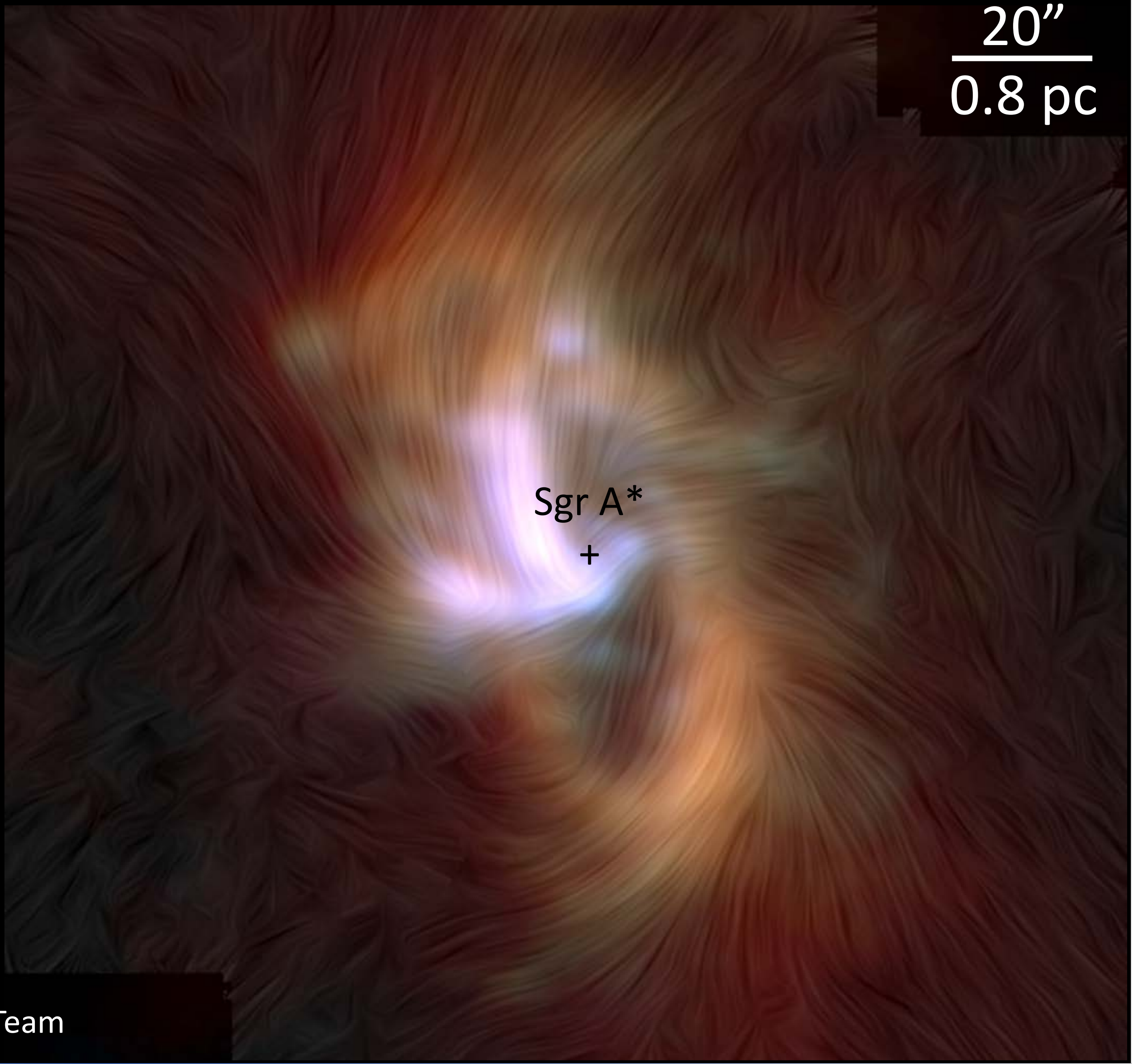
Improving SOFIA's Publication Output

- Find the proper carrots & sticks to getting existing data published
- Helping GO observers use data
  - Instrument reduction workshops (e.g. SOFIA Workshop in Stuttgart, 2018; planned data reduction workshop at 2019 AAS)
  - Cookbook: First recipes released (GREAT, FORCAST; FIFI-LS)
  - Support scientist assigned to each project
- Get more data => fly more
- Get better data => continue to upgrade and replace instruments
- Enable archival research
  - Transfer of data archive to IRSA ongoing
  - Legacy Science Programs (with no "exclusive use" period)
  - Establish SOFIA archival research program

Science Highlights

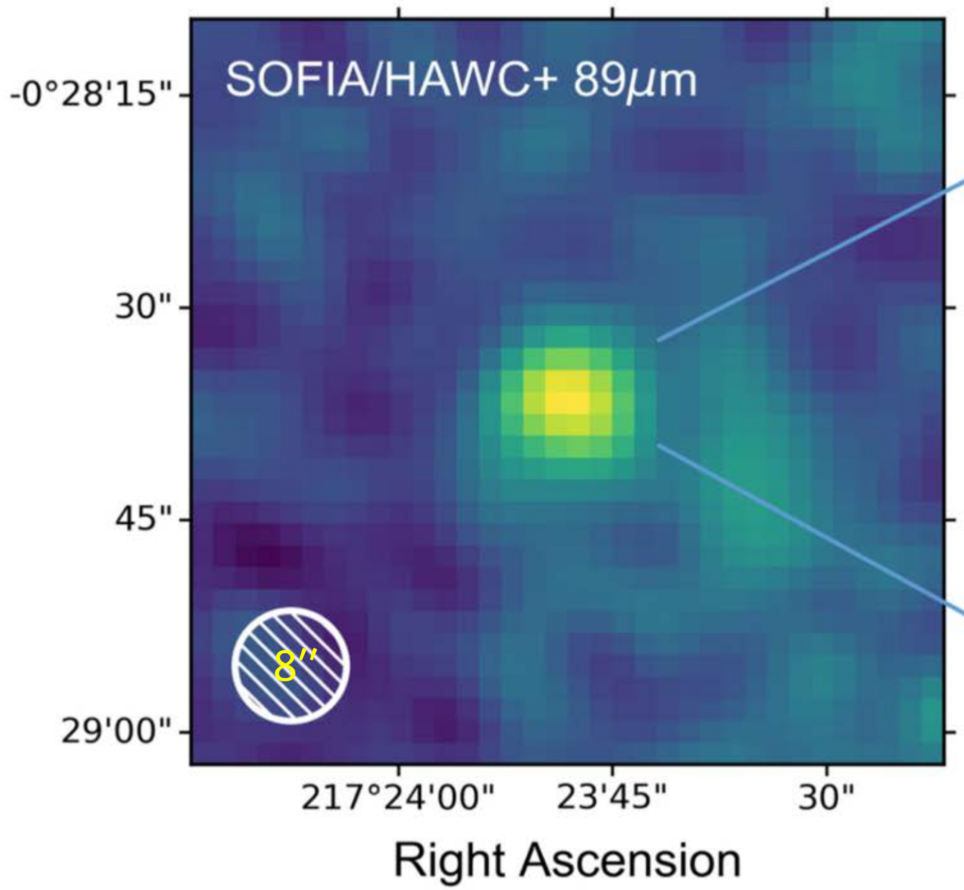
Magnetic Field at the Galactic Center

- SOFIA/HAWC+ polarimetry at 53µm traces magnetic field lines
- SOFIA/FORCAST reveals arcs of dusty material surrounding and possibly feeding the massive BH
- How strong would the magnetic field have to be to affect the galactic center dynamics?
- Does the magnetic field control or even quench the flow to the massive BH?

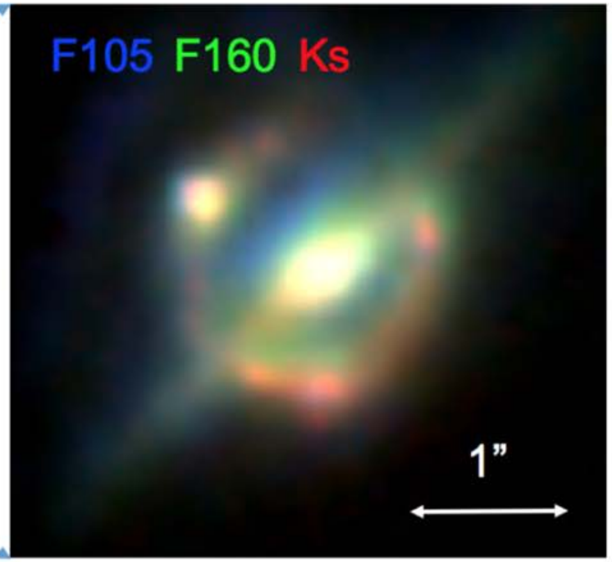


Lopez-Rodriguez, Lau & HAWC+ Science Team

SOFIA/HAWC+ Detection of a Gravitationally Lensed Starburst Galaxy at z= 1.03



SOFIA/HAWC+ 89µm detection of J1429-0028. The source is unresolved.



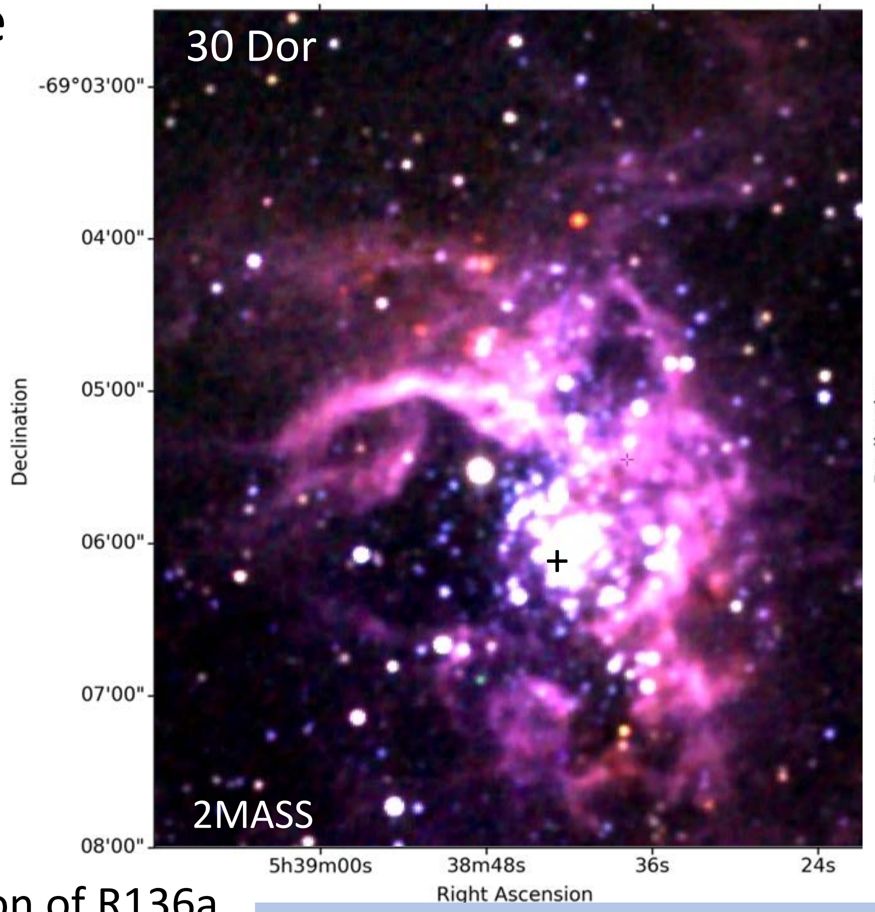
3-color image of the gravitationally lensed system using HSTF105W (blue), F160W (green), and Keck Ks (red) imaging data (Timmons et al. 2015)

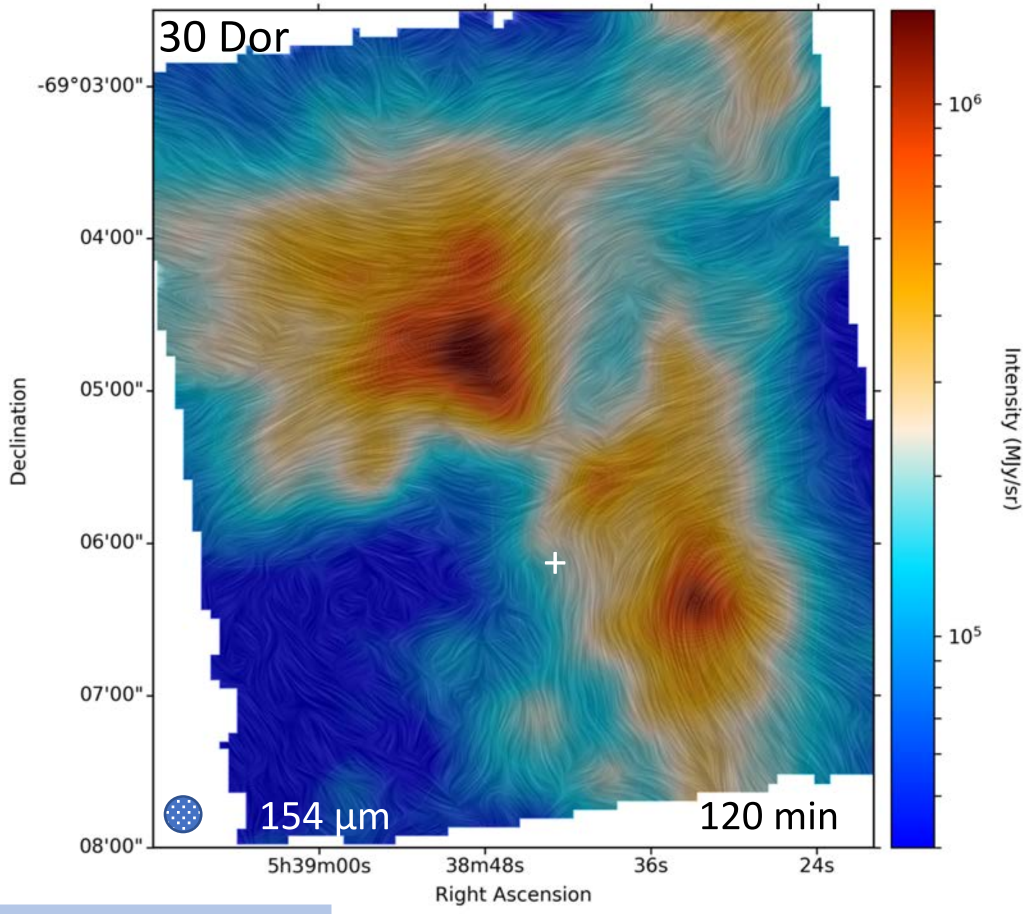
Ma, et al (2018) perform a 27-band multi-wavelength spectral energy distribution modeling (SED) including the new SOFIA/HAWC+ data to constrain the fractional AGN contribution to the total IR luminosity. The AGN fraction in the IR turns out to be negligible.

This detection "… demonstrates the potential of utilizing this facility for distant galaxy studies including the decomposition of SF/AGN components, which cannot be accomplished with other current facilities."

Magnetic Field 30 Dor (LMC) Mini-Starburst

- Far-IR reveals intense star forming activity in 30 Dor
- Polarization/ photometric data reveal magnetic field structure in star forming molecular clouds in LMC
- Evidence of Parker Instability?





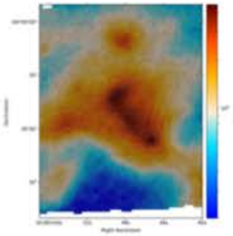
+ location of R136a

DDT observations: Non-proprietary HAWC+ data available for download August 2018

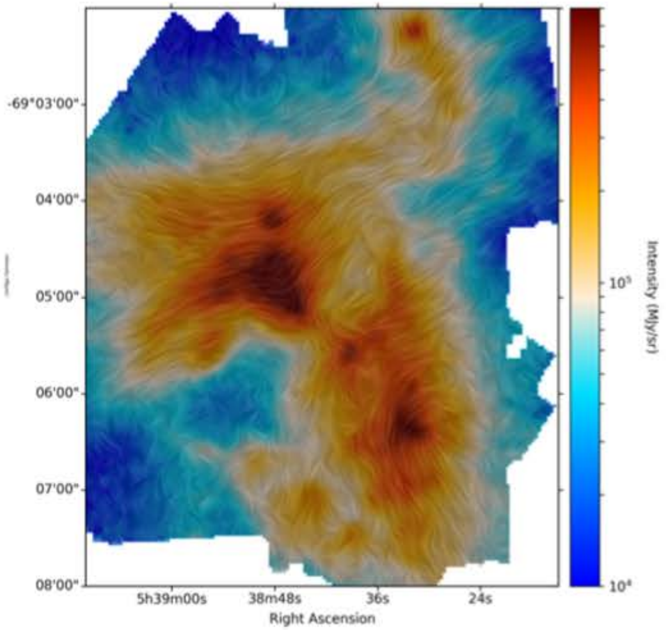
SOFIA/HAWC+ image prepared by Lopez-Rodriguez

Magnetic Field 30 Dor (LMC) Mini-Starburst

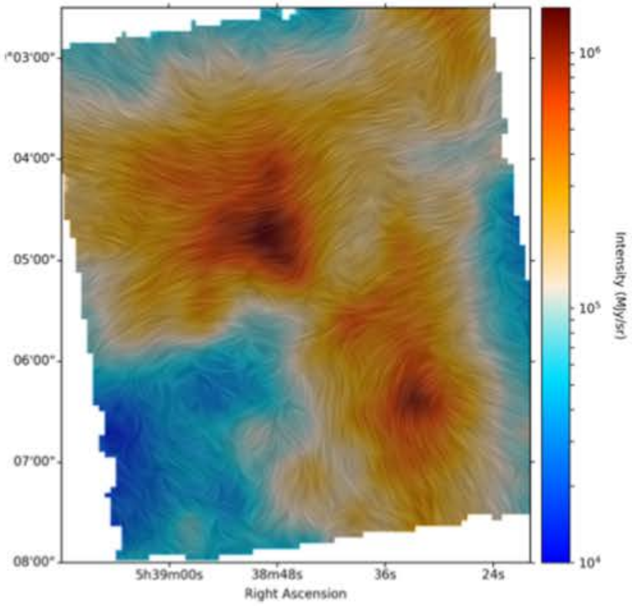
HAWC+ Band A
(53 microns)



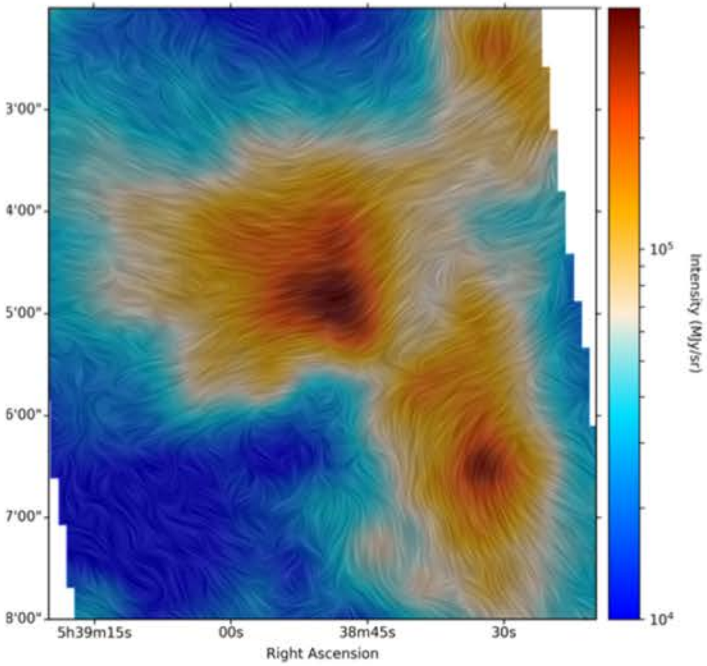
HAWC+ Band C
(89 microns)



HAWC+ Band D
(154 microns)



HAWC+ Band E
(214 microns)



DDT observations: Non-proprietary HAWC+ data available for download August 2018

SOFIA Science Center
Stratospheric Observatory for Infrared Astronomy

Home | For Researchers | Multimedia

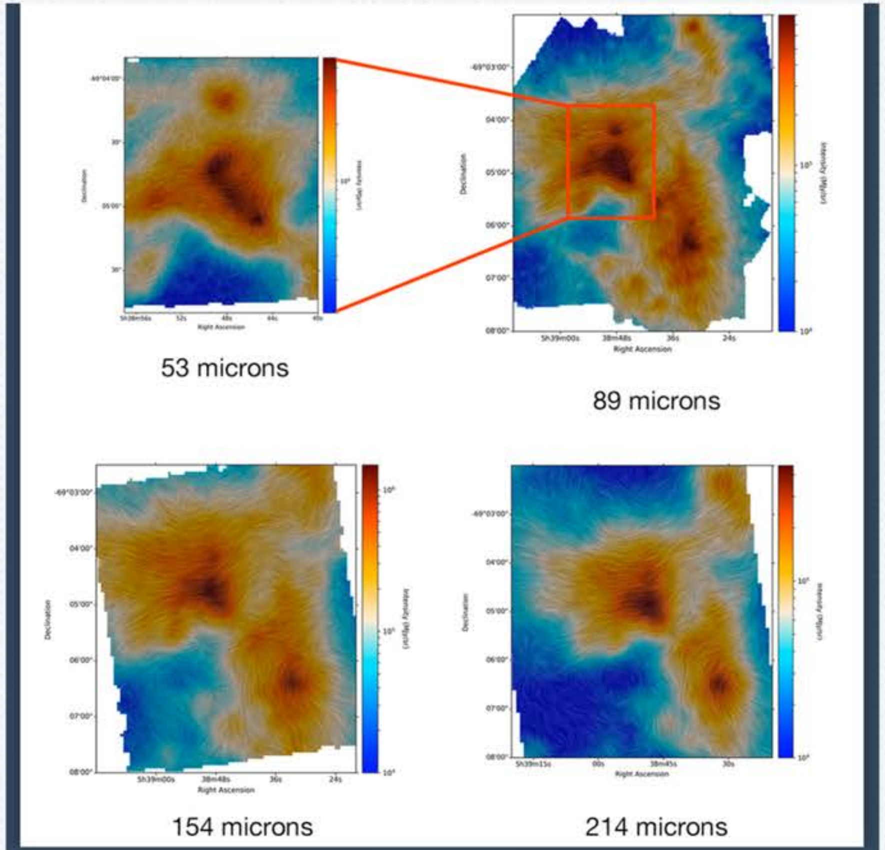
About SOFIA | Science Results Archive | SOFIA Outreach | Image Galleries

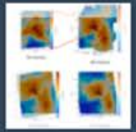
Science Results Archive

- New Zealand Science Summaries
- Media Portal

Home » Multimedia » Science Results Archive » SOFIA Reveals Never-Before-Seen Magnetic Field Details

SOFIA Reveals Never-Before-Seen Magnetic Field Details





30 Dor

Search

Science Results Archive

- 2018 (12)
- 2017 (15)
- 2016 (12)
- 2015 (12)
- 2014 (18)
- 2013 (12)
- 2012 (16)
- 2011 (19)
- 2010 (2)
- 2004 (4)

Stratospheric O

The Stratospheric Observatory for Infrared Astronomy, SOFIA, released new data from its recent Southern Hemisphere observations revealing the structure of celestial magnetic fields in the region known as 30 Doradus, or 30 Dor, at a scale that has never been seen before. The data set is now available to the scientific community to facilitate studies of how magnetic fields affect stars forming in nearby galaxies.

These images show the infrared radiation emitted by the dust and the magnetic fields in 30 Dor which is a star-forming region within the Tarantula Nebula located in the satellite galaxy called the Large Magellanic Cloud. Observations have shown that 30 Dor is one of the best and closest laboratories to study the starburst phenomenon — in which large numbers of massive stars and stellar clusters are formed rapidly in a small volume. But the effect magnetic fields have on these processes is not well understood.

Using the observatory's newest instrument, HAWC+, which has a device called a polarimeter that maps celestial magnetic fields, the SOFIA team observed 30 Dor in a range of wavelengths sensitive to dust temperatures between 10-100 Kelvin (-441 to -280 F). The images taken at the shorter wavelengths reveal warmer dust, while the images taken at the longer wavelengths show cooler dust. These can be used to study potential disturbances on the magnetic fields in the dense and compact regions of 30 Dor, as well as the large-scale magnetic fields governing the whole structure of the nebula — both of which may impact star formation.

See also: Gordon, et al, 2018arXiv181103100G

Instructions to download HAWC+ 30Dor data.

- If you don't have a DCS account, yet, register for one here: https://dcs.sofia.usra.edu/userSupport/registration.jsp
- Log into DCS: https://dcs.sofia.usra.edu
- Go to "Search Science Archive"
- Fill in:
  - Instrument: HAWC_PLUS from drop-down menu
  - Processing State: LEVEL_4 from drop-down menu
  - Target: 30Dor (No need to resolve the name via Simbad or NED. If resolved use a large search radius, e.g. 600")
  - Click the "search" button
- Consult the HAWC+ Data Handbook accessible on this page: https://www.sofia.usra.edu/science/proposing-and-observing/data-products/data-resources

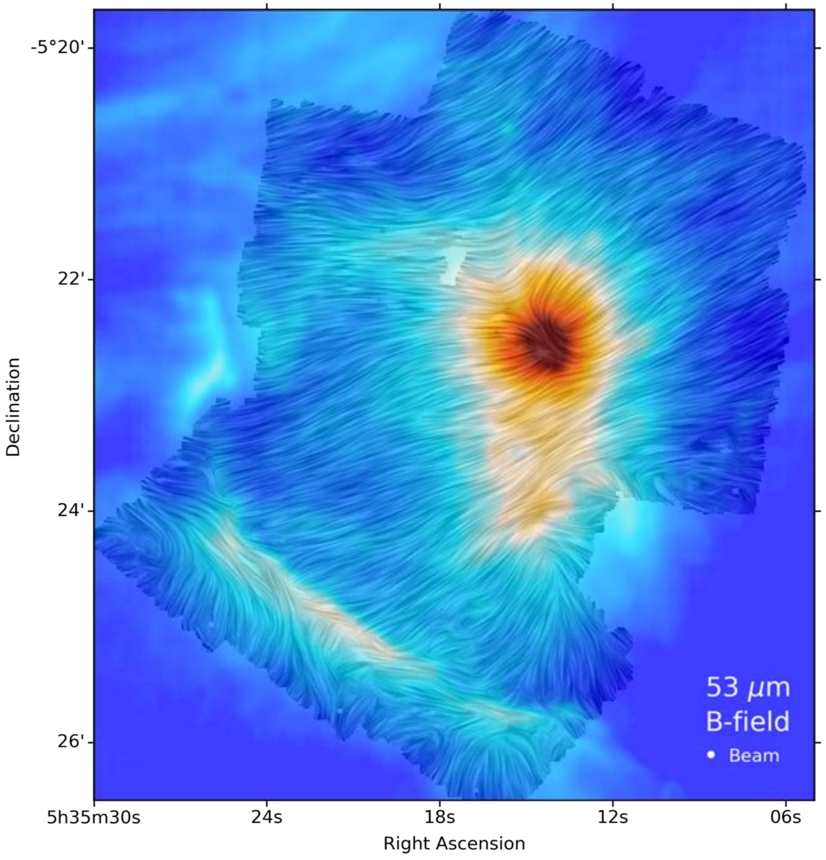
SOFIA is a Boeing 747SP jetliner modified to carry a 106-inch diameter telescope. It is a joint project of NASA and the German Aerospace Center, DLR. NASA's Ames Research Center in California's Silicon Valley manages the SOFIA program, science and mission operations in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute (DSI) at the University of Stuttgart. The aircraft is operated and maintained from NASA's Armstrong Flight Research Center Hangar 703, in Palmdale, California.

For More Information

For more information about SOFIA, visit:
http://www.nasa.gov/sofia • http://www.dlr.de/en/sofia

For information about SOFIA's science mission and scientific instruments, visit:
http://www.sofia.usra.edu • http://www.dsi.uni-stuttgart.de/index.en.html

Use of multi-wavelength studies to untangle role of magnetic fields in star-forming regions: The case in Orion

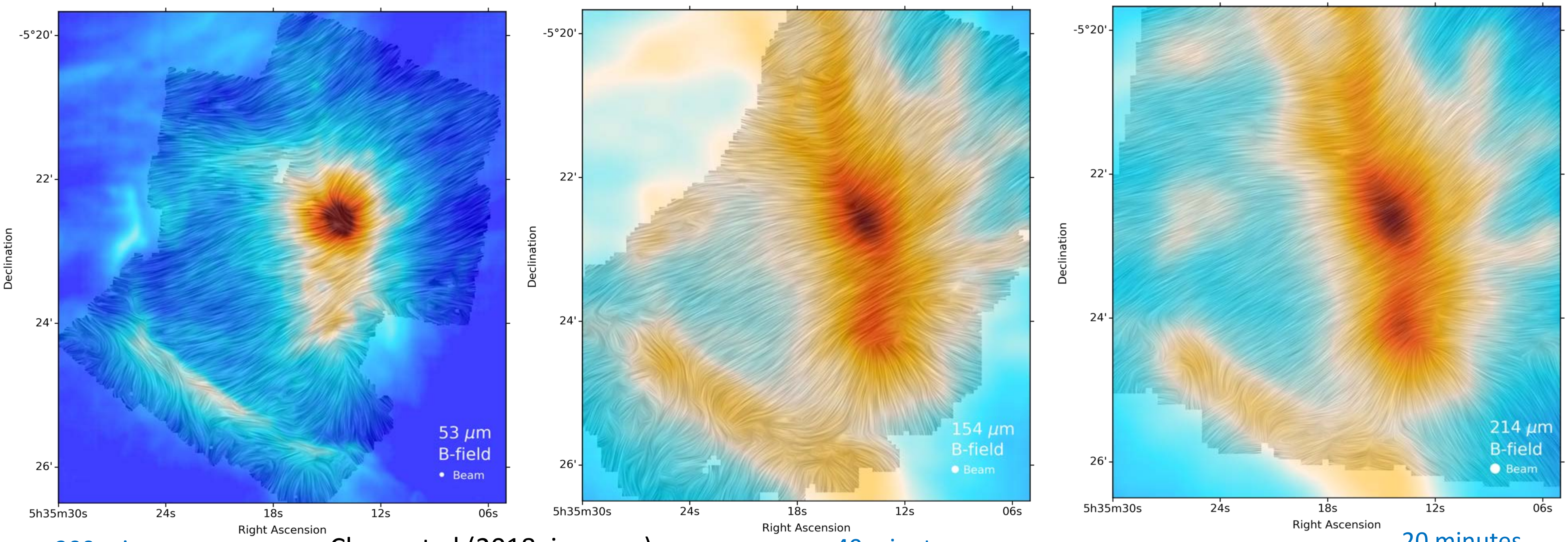


200 minutes

- Far-IR polarization of thermal radiation is due to emission of aligned dust grains
- Near-IR polarization has the component of scattered light; sub-mm & radio include synchrotron emission. Neither is present in the Far-IR
- Far-IR gives the orientation of magnetic fields at maximum emission of each wavelength

Chuss et al (2018, arXiv:1810.08233v1), in press

Use of multi-wavelength studies to untangle role of magnetic fields in star-forming regions: The case in Orion



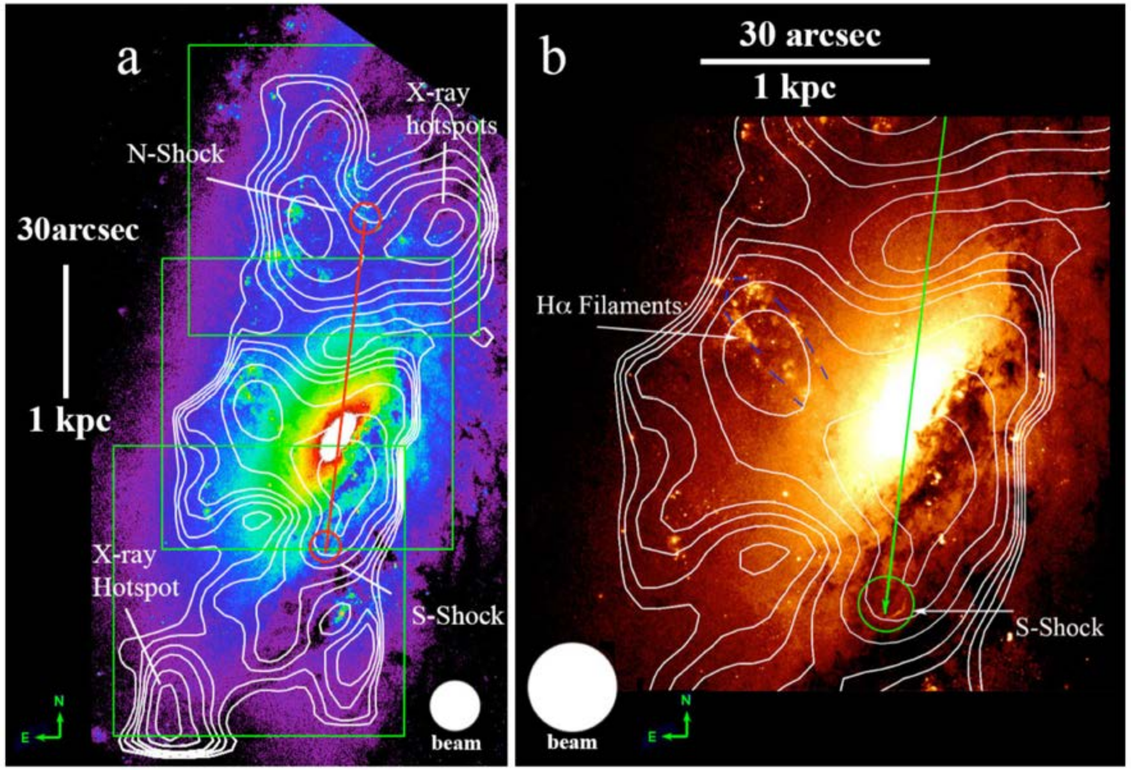
200 minutes   Chuss et al (2018, in press)   40 minutes   20 minutes

How the angle of the field changes with wavelength (different regions) has the potential to provide an insight into the 3-D morphology of the field structure.

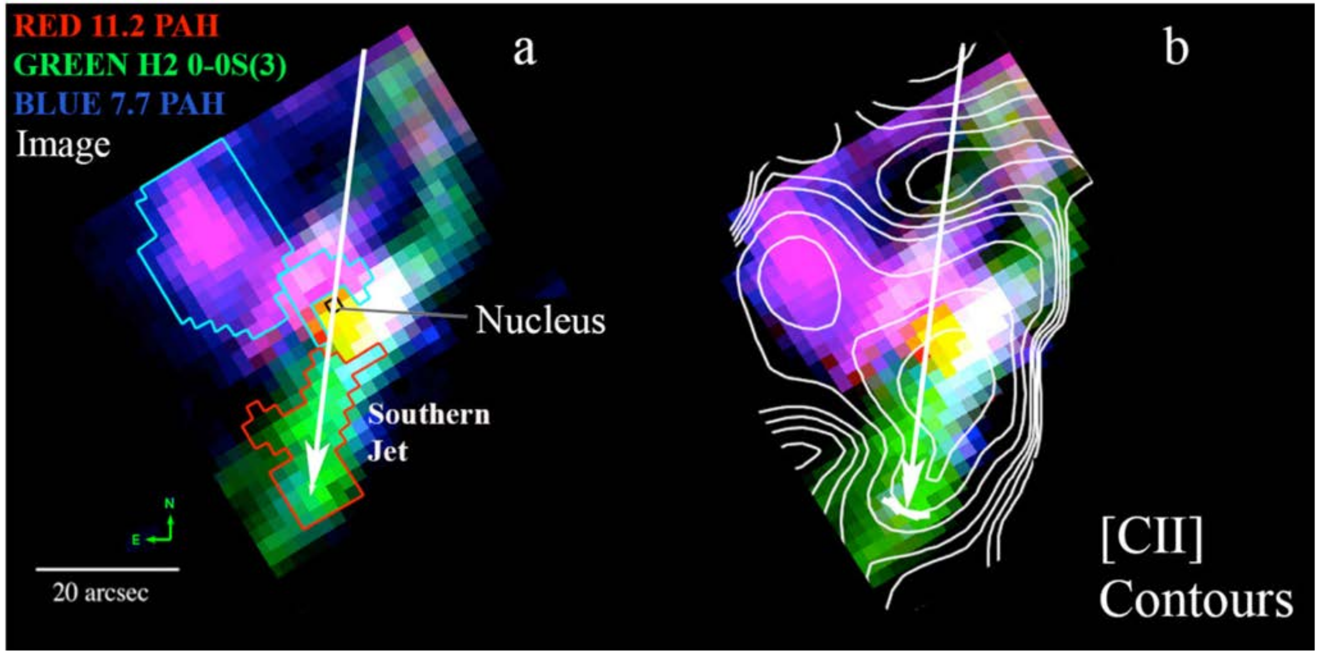
Jet-related Excitation of the [C II] Emission in the Active Galaxy NGC 4258 with SOFIA/FIFI-LS

Appleton, et al. (2018, arXiv:1810.12883)

"… as much as 40% (3.8×10^{39} erg s^{-1}) of the total [C II] luminosity from the inner 5 kpc of NGC 4258 arises in shocks and turbulence […], the rest being consistent with [C II] excitation associated with star formation.



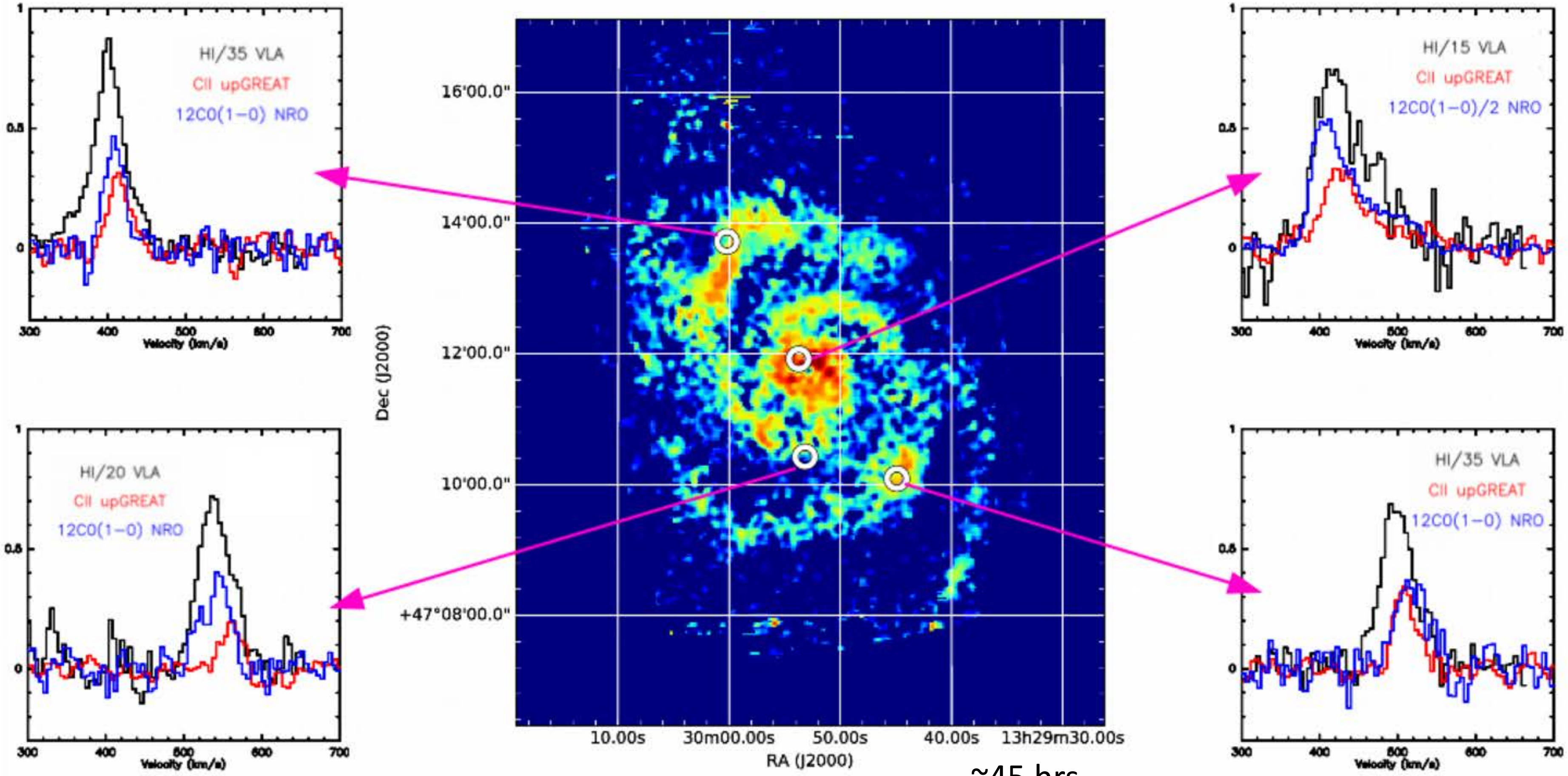
(a) Contours of the [C II] emission superimposed on a false-color representation of the HST F657N WFC3 image over the inner 3 kpc of NGC 4258, and (b) a zoom-in on the [C II] emission associated with the minor-axis optical emission, with the same background image as (a) but with a different color table and stretch.



a) Spitzer IRS color-coded image of the integrated emission from PAH 11.2μm (red), H2 0-0 S(3) 9.7μm (green) and PAH 7.7μm (blue). The blue and red boxes show the areas dominated by PAH and H2 line emission respectively. (b) The SOFIA [C II] integrated emission contours superimposed on the same image.

[C II] in M51

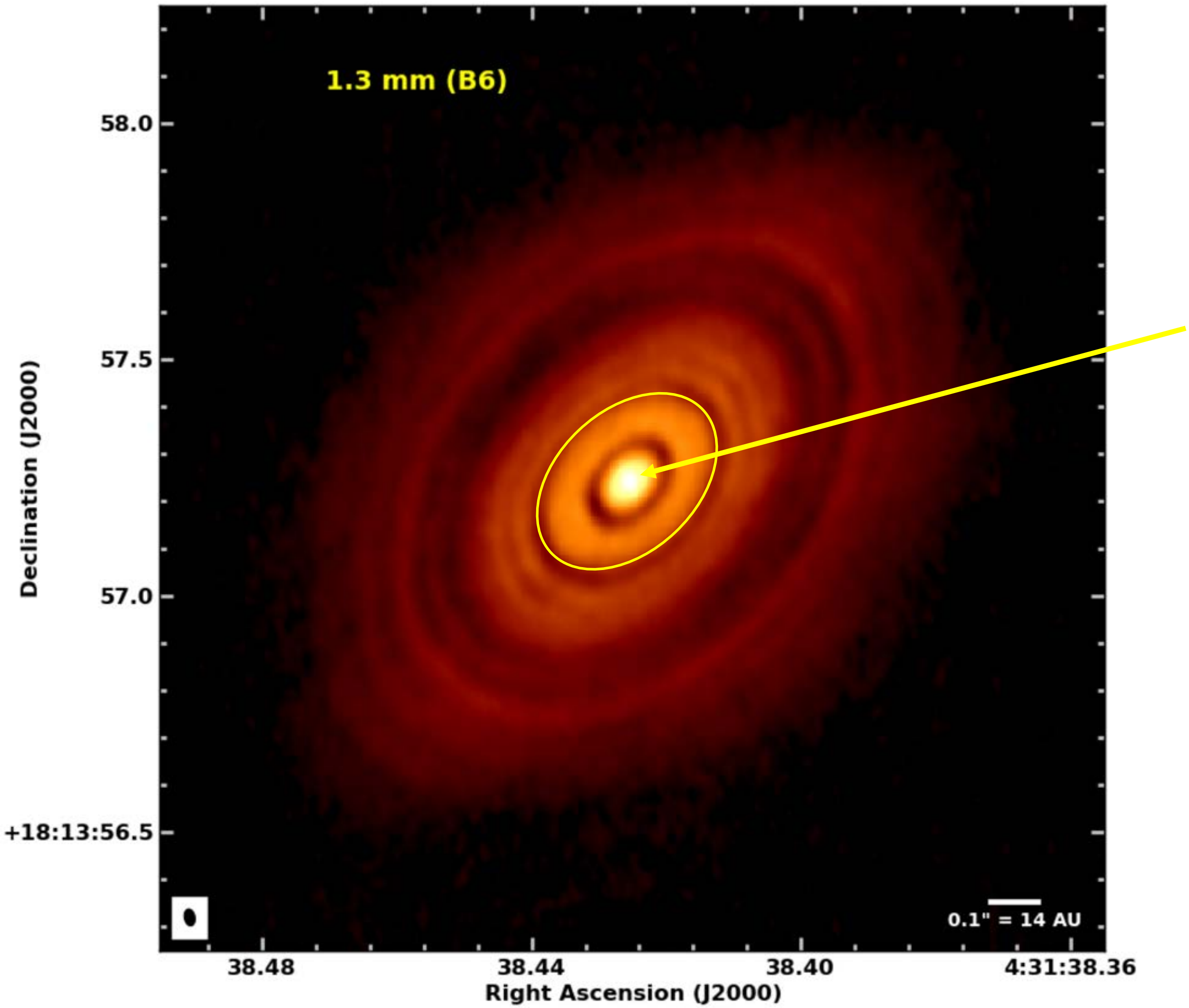
Pineda & Stutzki (in prep.)

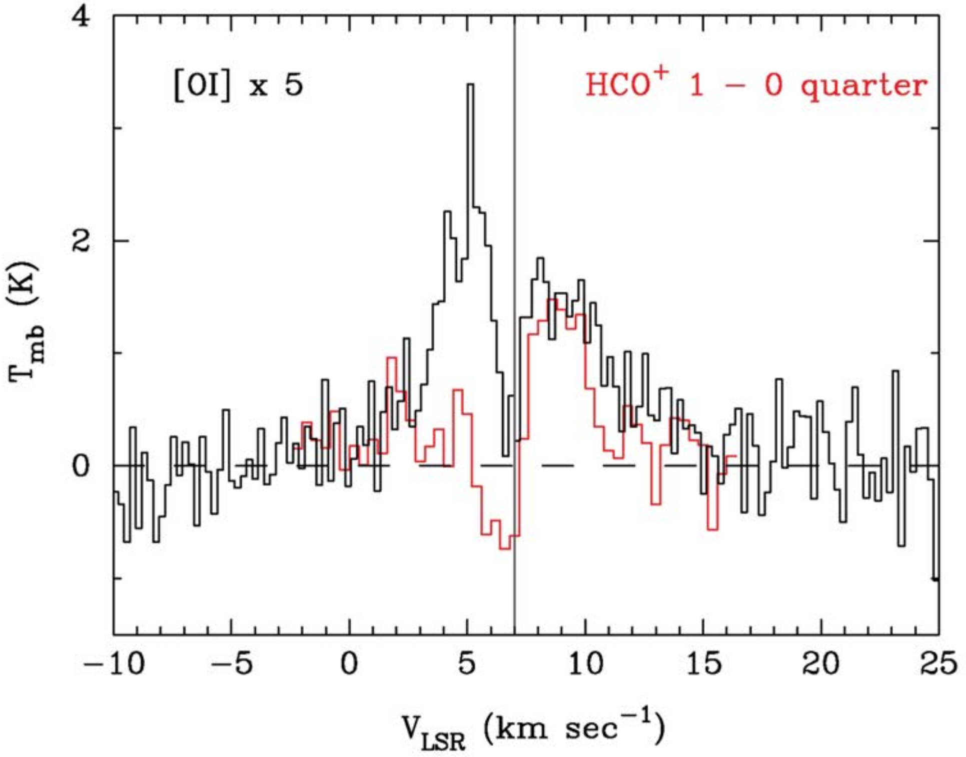


~45 hrs

=> [C II] emission generally separated from CO & HI emission in both space and velocity; Sequence: CO maximum, [C II] maximum, Hα/UV maximum as material flows through spiral arms

Oxygen in the Planet-forming Zone of HL Tau



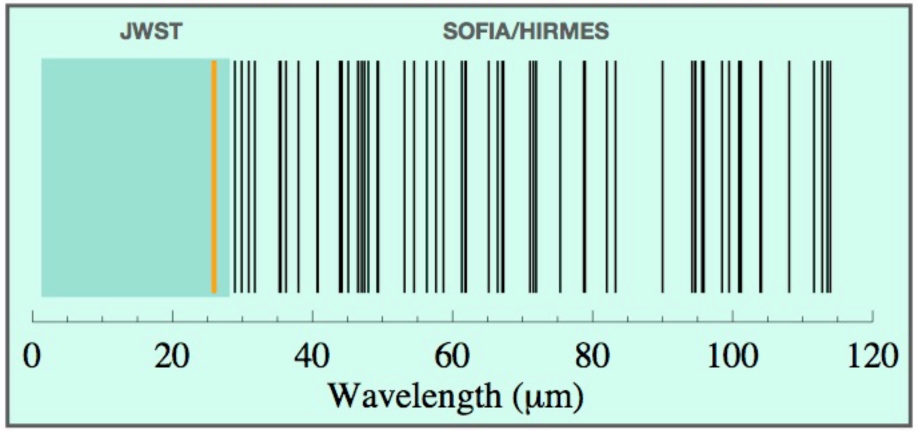


SOFIA atomic oxygen [OI] 63 µm emission (black line). ALMA HCO^+ from the inner 25 AU disk region (red line), shown by the area enclosed by the yellow ellipse to left.

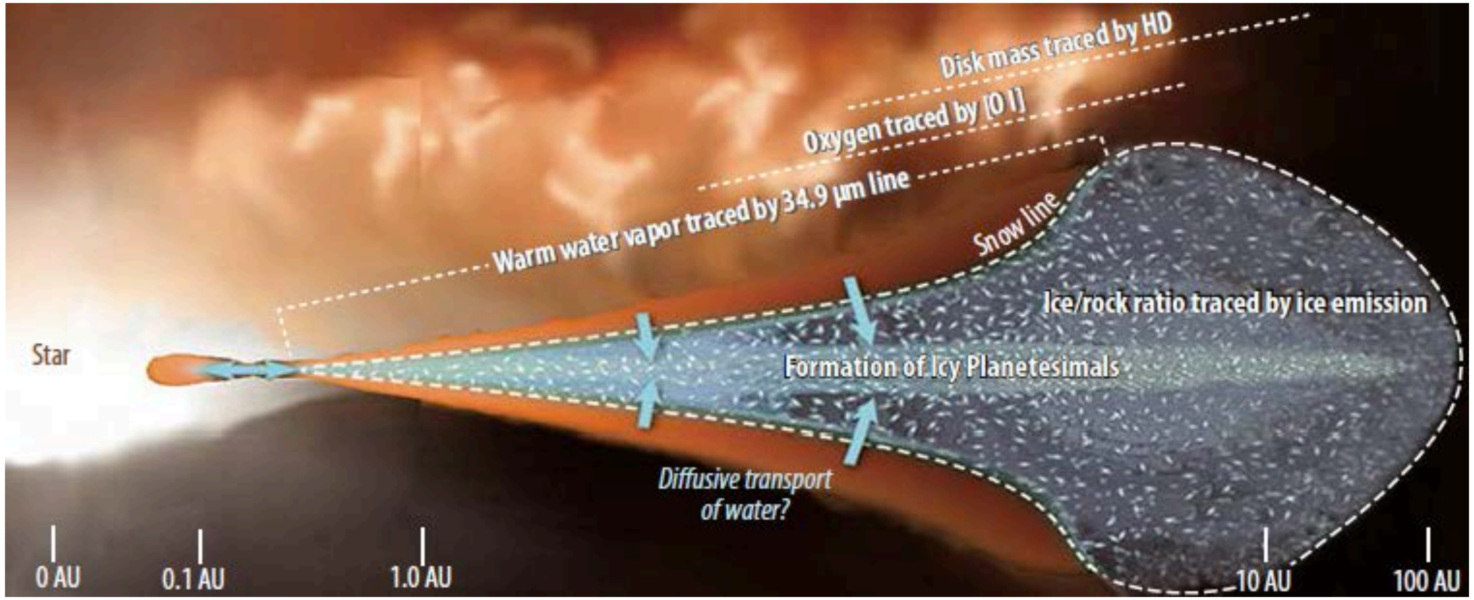
G. Sandell (2018, in prep)

HIRMES (HIgh Resolution Mid-infrarEd Spectrometer)

- Spectroscopy with R=600 - 100,000: 25µm – 122µm; mostly diffraction-limited
- Spectral imaging capabilities for a few selected emission lines
  - HD (112µm): How does the disk mass evolve during planetary formation?
  - What is the distribution of O, H_2O-ice, and H_2O-vapor in different phases of planet formation?
  - What are the kinematics of oxygen and H_2O-vapor in protoplanetary disks ?
- 100's of disks within 500 pc are within HIRMES' grasp



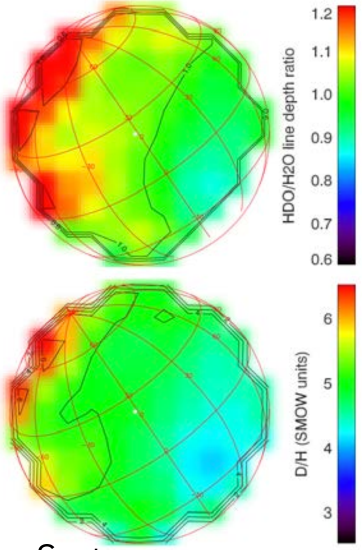
Protoplanetary Disks: Water transitions with $E_u/k < 1000$ K (figure courtesy G. Melnick)



The Era of SOFIA Science

- SOFIA is delivering high-quality science
- Instrument upgrades enable SOFIA to expand its capabilities to remain state-of-the-art to serve the international community

D/H Mars



Solar System