



SOFIA Soaring Forward

Margaret Meixner
Director SOFIA Science
Mission Operations

January 10, 2022

SOFIA panel for questions at the end:

- Margaret Meixner, Director of SOFIA Science Mission Ops
- Bill Reach, Associate Director for Science Operations
- B-G Andersson, Principal Scientist
- Arielle Moullet, Science Outreach Manager
- Simon Coude, HAWC+ instrument lead
- Naseem Rangwala, NASA SOFIA Project Scientist

Please post questions in the Chat as we proceed

SOFIA is the only far-IR observatory for the next decade.

- SOFIA will help prepare the astronomical community both scientifically and technologically for Astro2020's ambitious future.
- SOFIA advances Astro2020 science by directly addressing **one third** of the decadal science priorities in all three science themes
 - Cosmic EcoSystems,
 - Worlds and Suns in Context,
 - New Messengers and New Physics.
- The community can exploit the opportunity SOFIA provides to train the next generation of astronomers and instrument builders who will define, develop, and use the future far-IR space observatories described in the Astro2020 report.



SOFIA – SMD and Astro2020 Decadal Science Traceability Matrix will be posted on SOFIA website soon.

SOFIA Science

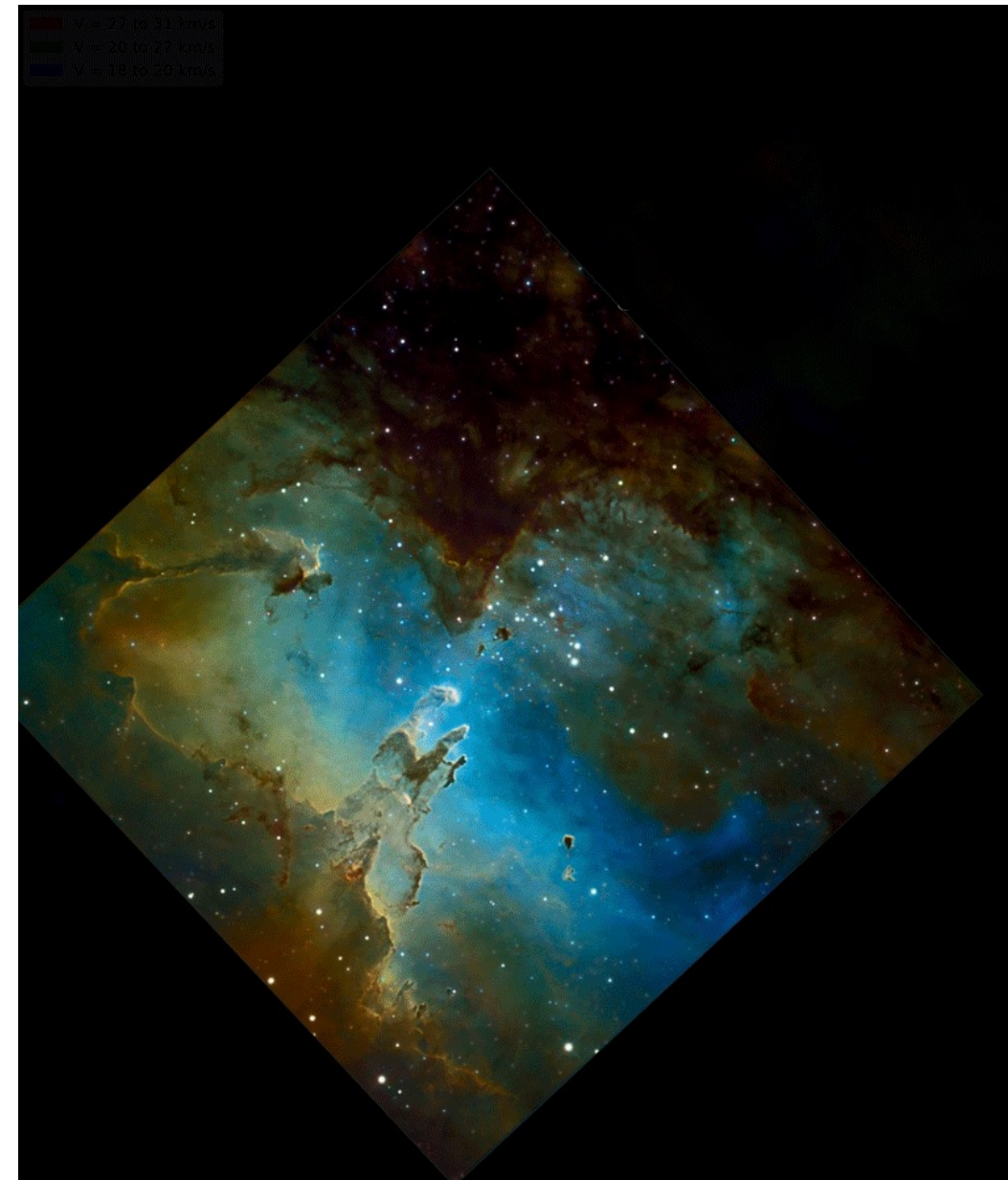
- SOFIA's efficiency and science productivity are on the right trajectory for SOFIA to achieve its full scientific potential.
- Annual publication rates for SOFIA have doubled over the past three years on topics ranging from the Earth to high-z galaxies.
 - <https://www.sofia.usra.edu/sites/default/files/2021-11/SOFIA-Science-2021.pdf>
- Legacy Science Programs are 30% of SOFIA schedule.
 - pilot phase, 6 months
 - Promotion process to full
 - All data is public immediately
 - Higher level products delivered



FEEDBACK:

co-PIs: Tielens & Schneider

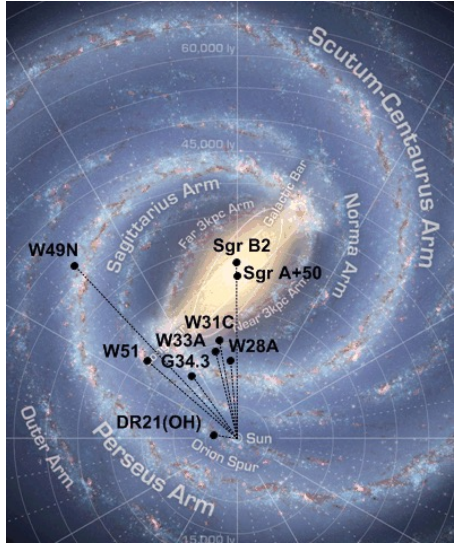
- F-Q1: How do star-forming structures arise from, and interact with, the diffuse interstellar medium?
- GREAT maps of [CII] 158 μm and [OI] 63 μm in 11 regions
- Studying massive stellar feedback in star-forming regions
- M16: Eagle nebula
- 70% complete



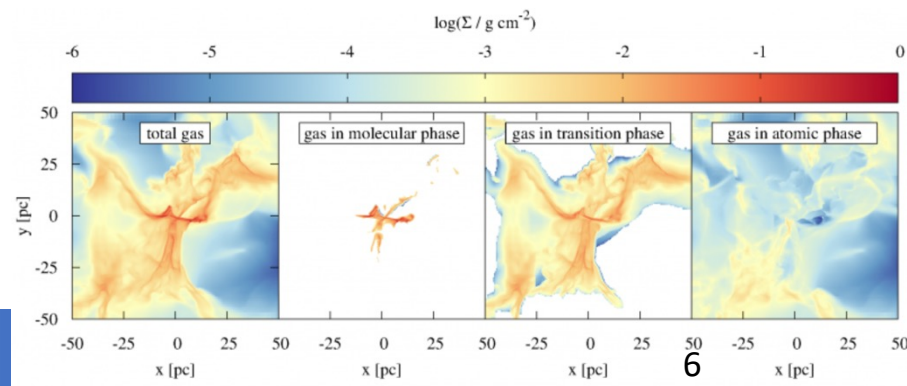
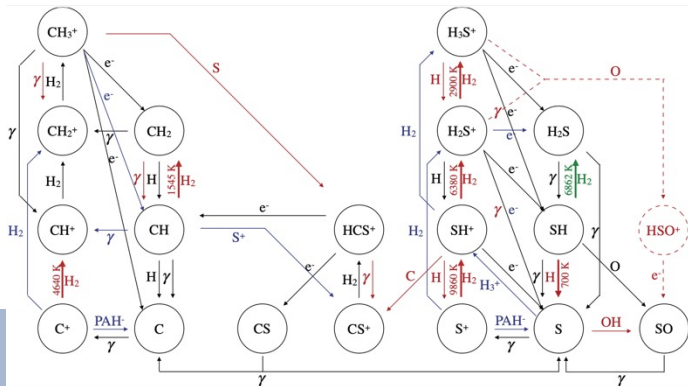
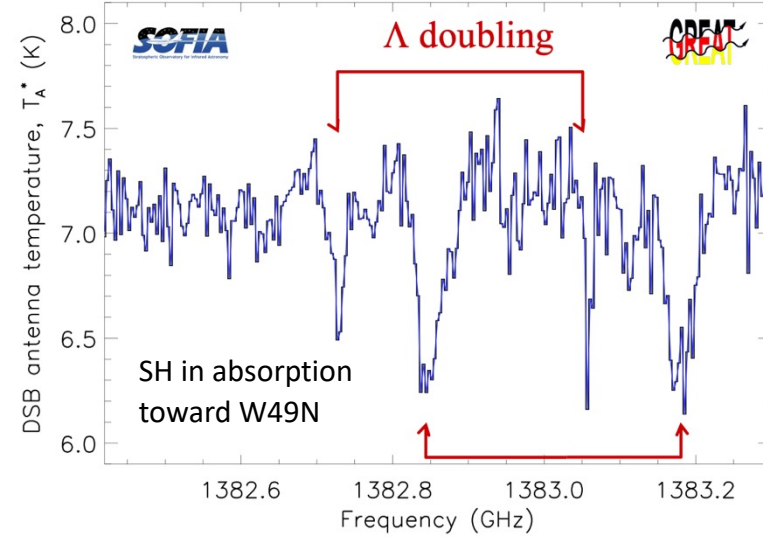
Karim et al, 2021; in prep

HyGAL: Characterizing the Galactic ISM with observations of hydrides with GREAT, PI: Neufeld, 42% complete

D-Q2: How do gas, metals, and dust flow into, through, and out of galaxies?
 F-Q2: What regulates the structure and motions within molecular clouds?
 F-Q3: How does gas flow from parsec scales down to proto-stars and their disks?

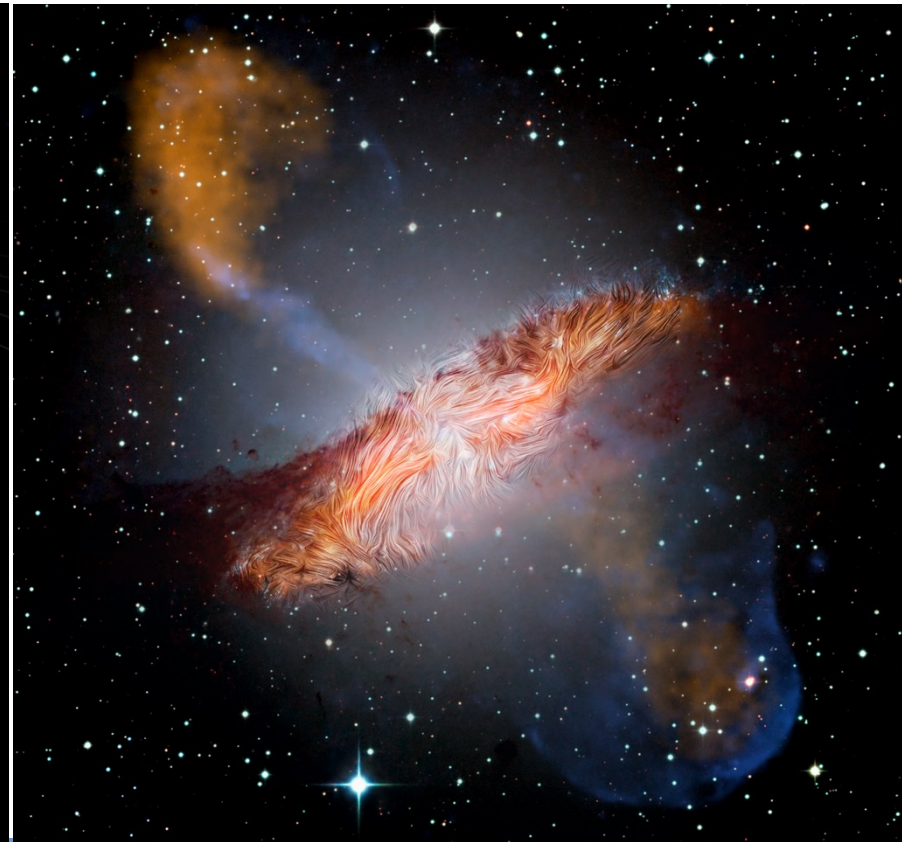
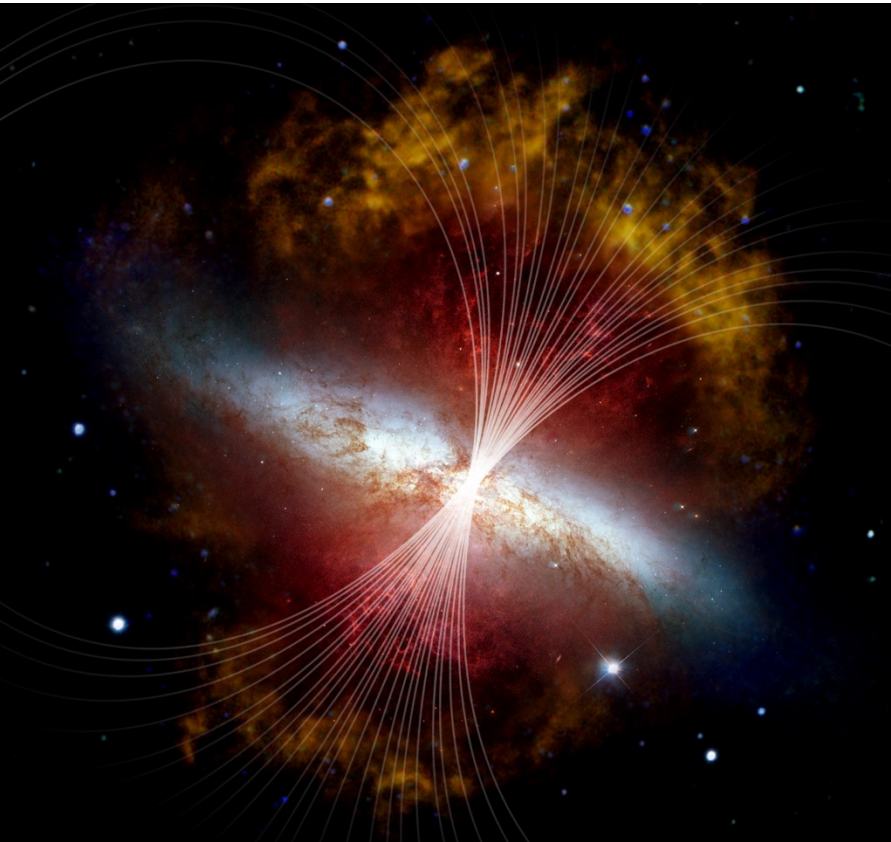


Absorption line spectroscopy of multiple hydride molecules
 to constrain astrochemical models of the turbulent interstellar medium



GalMag: Magnetic Fields of Galaxies, PI: Lopez-Rodriguez, HAWC+, 51% Complete

D-Q2: How do gas, metals, and dust flow into, through, and out of galaxies?
F-Q1: How do star-forming structures arise from, and interact with, the diffuse interstellar medium?

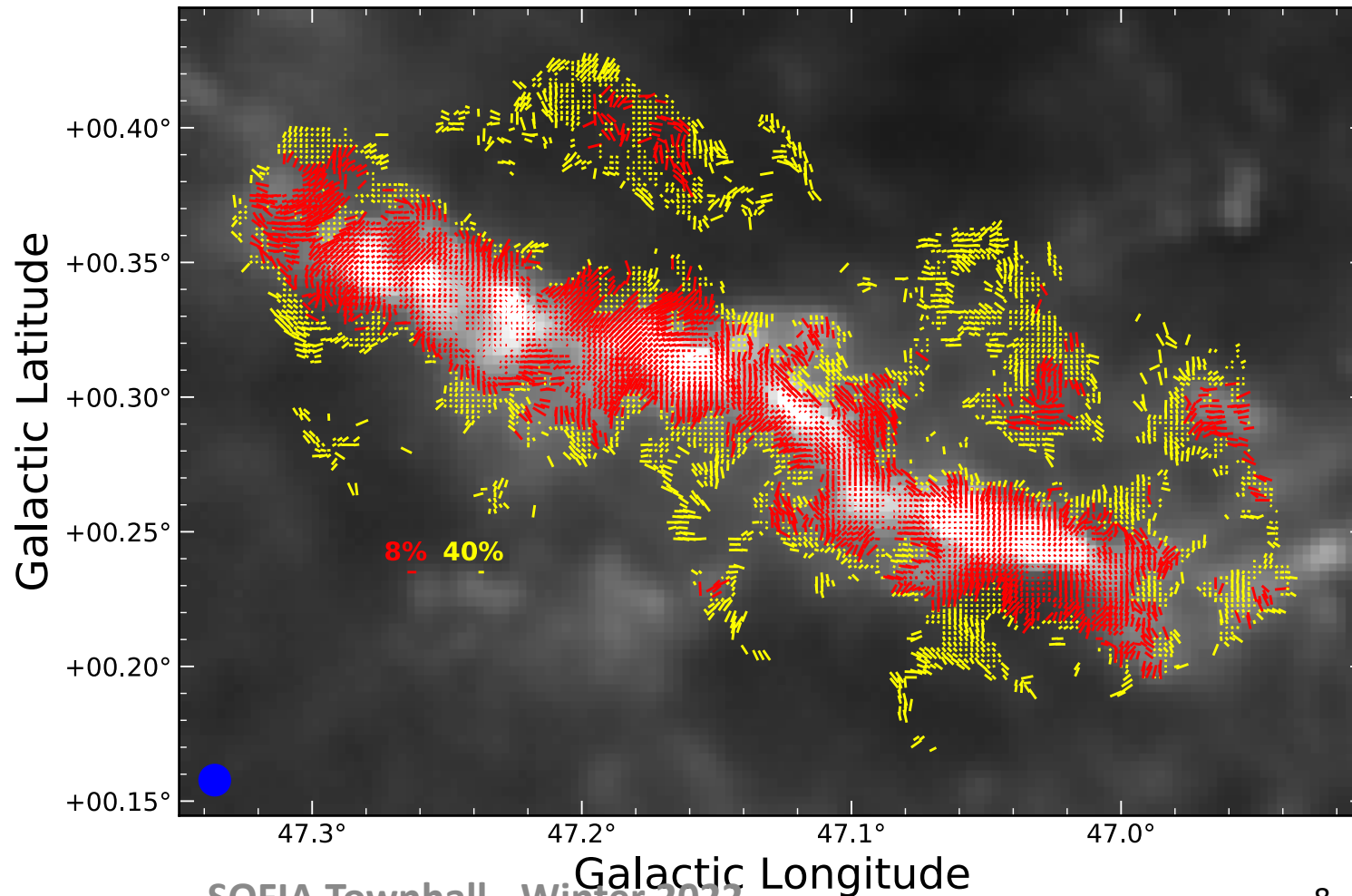


FIELDMAPS: Filaments Extremely Long and Dark: A Magnetic Polarization Survey

PI: Stephens, 51% complete, HAWC+

F-Q2: What regulates the structure and motions within molecular clouds?

F-Q3: How does gas flow from parsec scales down to proto-stars and their disks?



Study of Interstellar Magnetic Polarization: A Legacy of Filaments (SIMPLIFI)

PI: Pillai, Cycle 9 Legacy: pilot completed

- HAWC+: Magnetic Fields in Nearby Filaments
- Follow onto Serpens South, a magnetic collapse
- F-Q2: What regulates the structure and motions within molecular clouds?
- F-Q3: How does gas flow from parsec scales down to protostars and their disks?



Pillai, et al., 2020, Nature Astronomy

LMC⁺ : Survey of [CII] in the Large Magellanic Cloud (LMC)

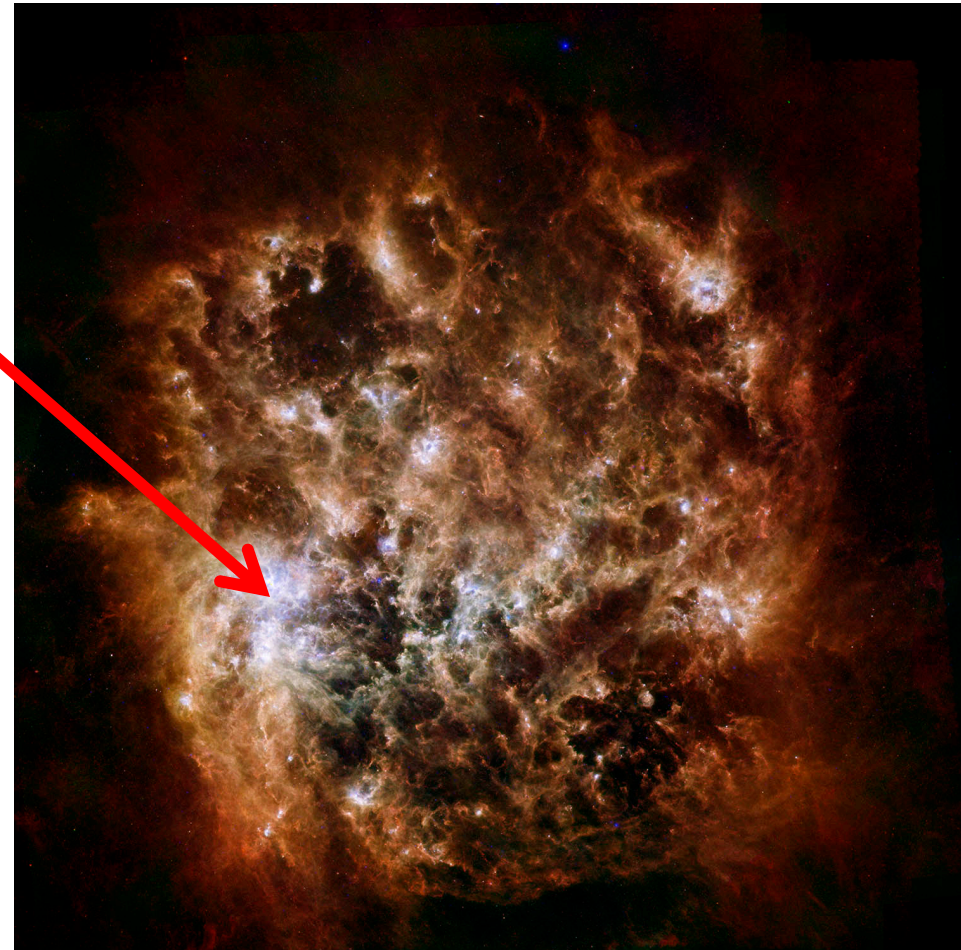
PI: Madden, pilot coming in Cycle 9 (March 2022)

- FIFI-LS
- [CII] 158 μm mapping of the south molecular ridge
- [OIII] 88 μm
- complements ALMA data

F-Q1: How do star-forming structures arise from, and interact with, the diffuse interstellar medium?

D-Q2: How do gas, metals, and dust flow into, through, and out of galaxies?

D-Q4: How do the histories of galaxies and their dark matter halos shape their observable properties?



Galactic Center

PI: Hankins, Completed, FORCAST

F-Q2: What regulates the structure and motions within molecular clouds?

F-Q3: How does gas flow from parsec scales down to proto-stars and their disks?

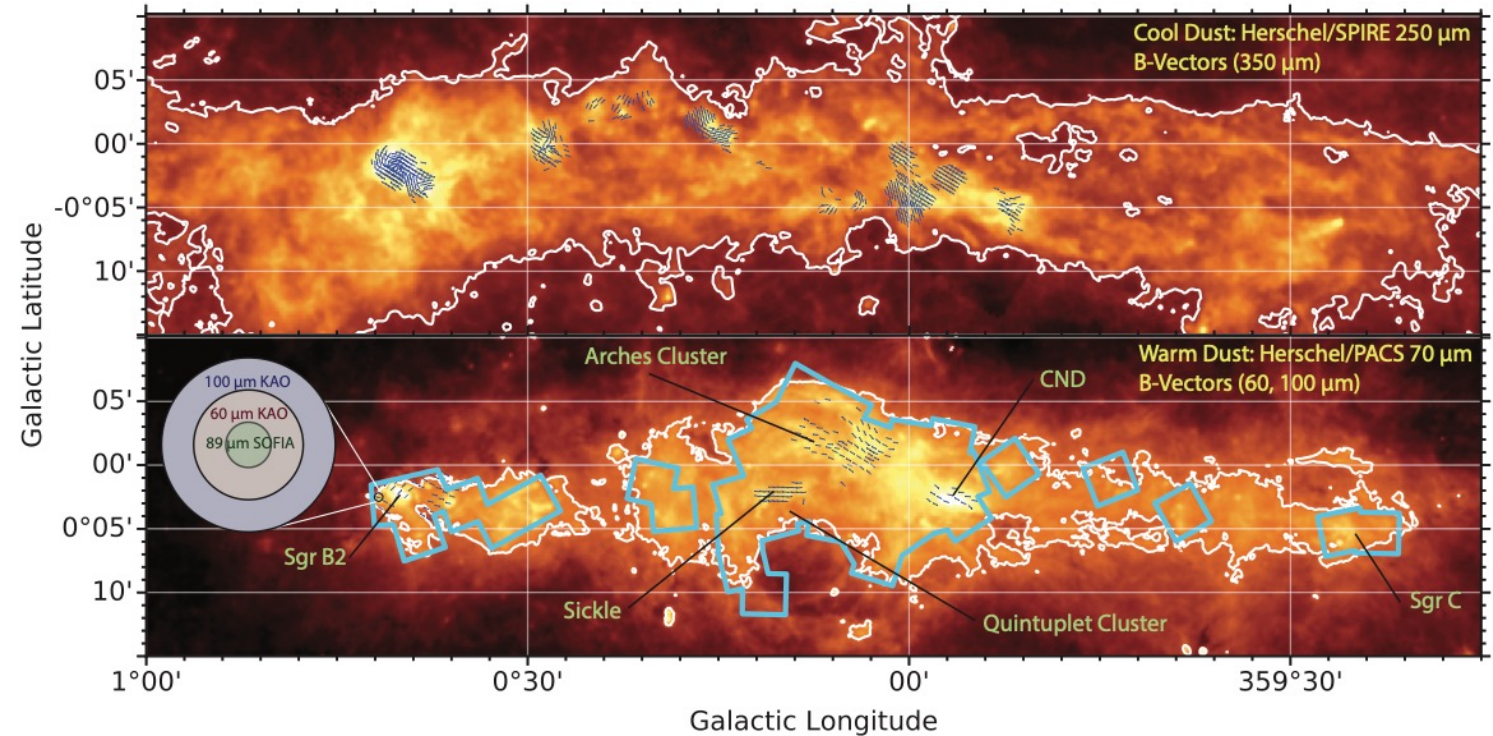


Blue = SOFIA 25 μ m
Green = SOFIA 37 μ m
Red = Herschel 70 μ m
White/stars = Spitzer 5.8 μ m

Galactic Center Magnetic Fields

PI: Chuss pilot completed in Cycle 9, HAWC+

- Map the magnetic fields in the central 200 pc of the Milky Way with the HAWC+ instrument
- This is a much-needed piece of the puzzle to understand our previous Galactic Center legacy results
- F-Q2: What regulates the structure and motions within molecular clouds?
- B-Q4: What seeds supermassive black holes and how do they grow?

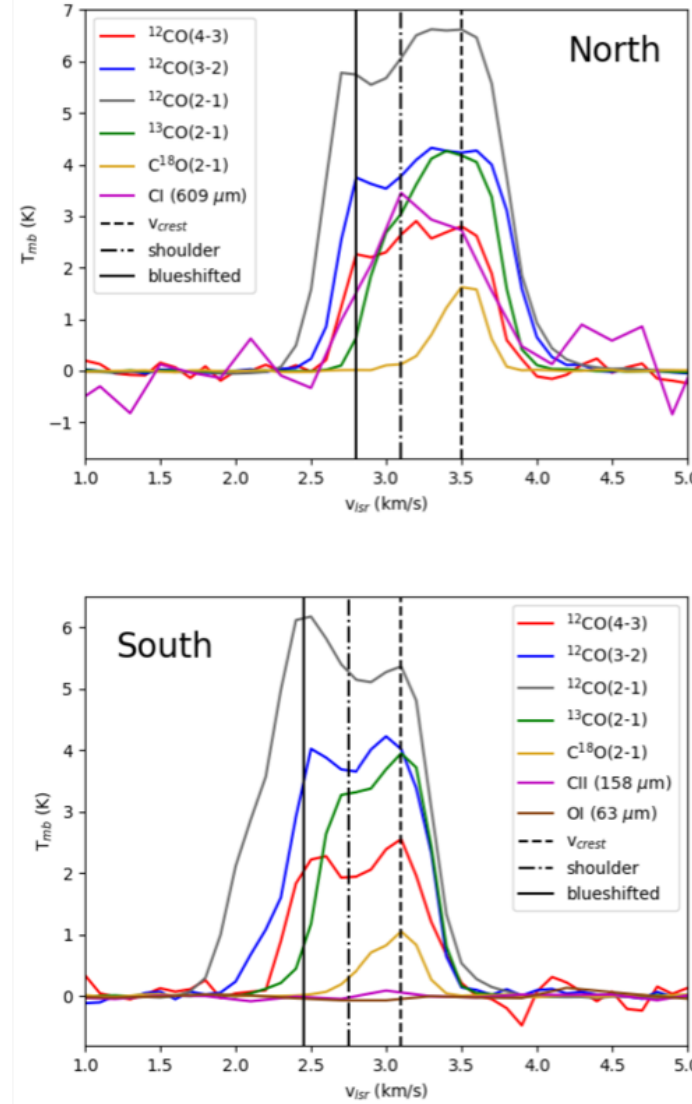
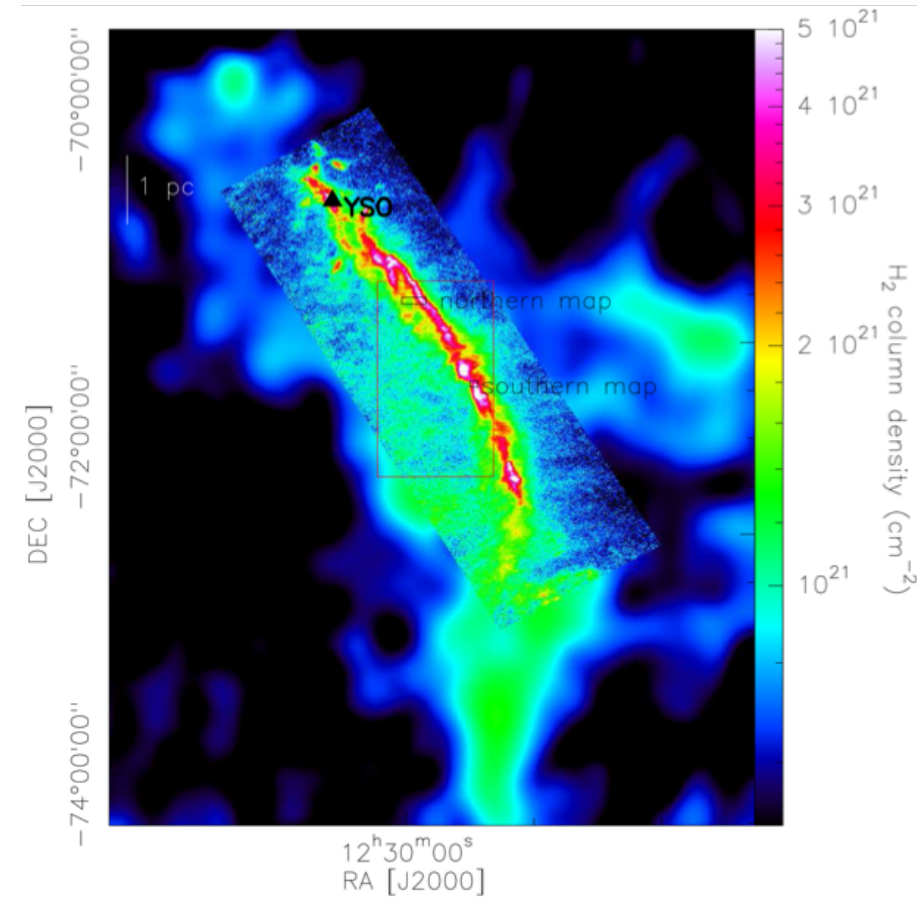


Lunar: Water on the Moon Legacy Program, PI: Lucey, 4% completed

- FORCAST Grism
- Follow-up to first direct detection of molecular water on the sunlit surface
- study the distribution of water across the lunar surface
- E-Q3: How do habitable environments arise and evolve with-in the context of their planetary systems?



Musca Filament



**USRA Prize,
Best Thesis:
Dr. Lars
Bonne**



Bonne et al. 2020



The 2022 USRA prize for best SOFIA-based PhD thesis is awarded to

Dr. Lars Bonne

In recognition of his thesis

“The formation of dense gas in low- and high-mass star forming regions”

January 10, 2022

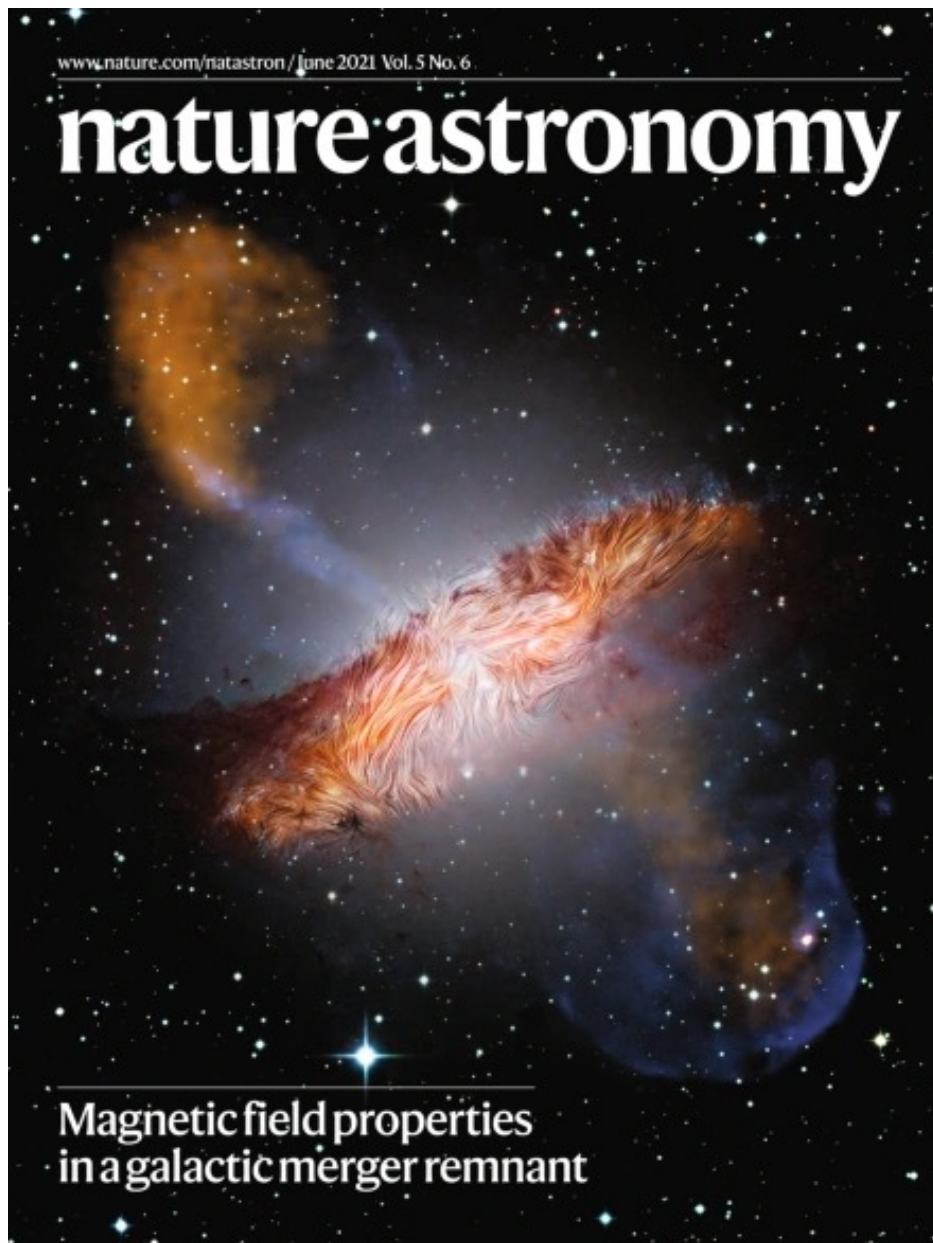


Margaret Meixner

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SOFIA Mission Operations Director

Ghassem Asrar

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USRA Senior Vice President for Science



USRA Prize, Best Paper: Dr. Enrique Lopez-Rodriguez





The 2022 USRA prize for best SOFIA-based research publication is awarded to

Dr. Enrique Lopez-Rodriguez

In recognition of his paper

“The magnetic field across the molecular warped disk of Centaurus A”

January 10, 2022



Margaret Meixner

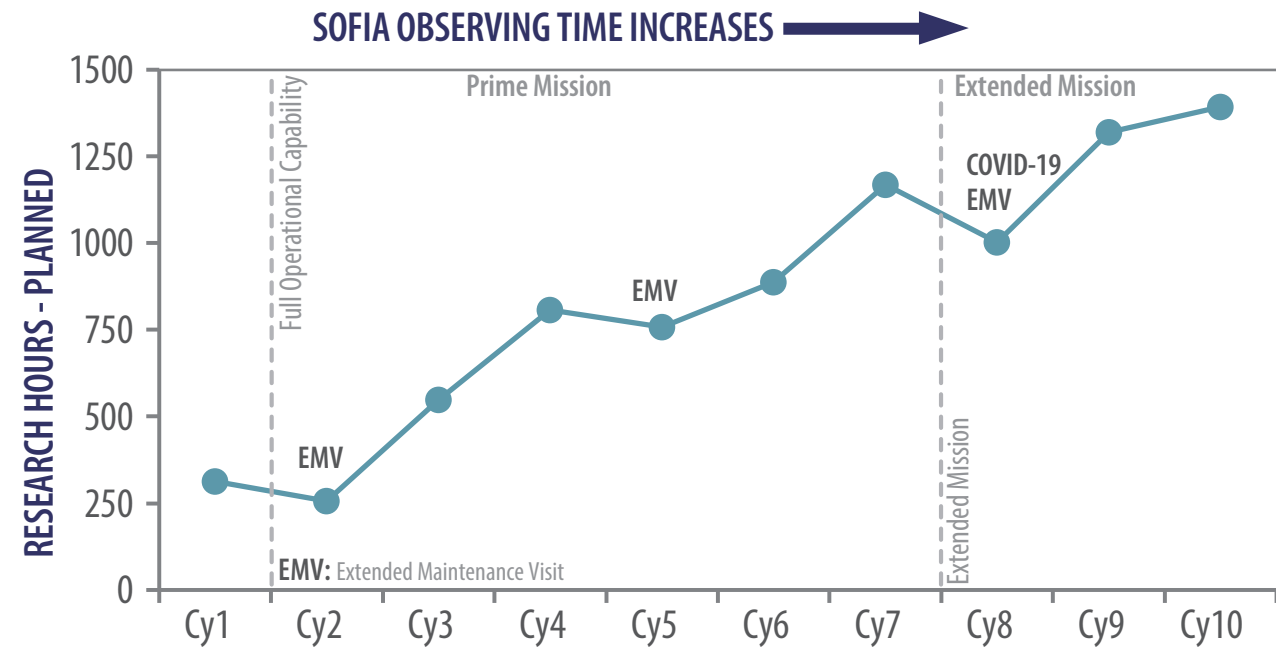
Margaret Meixner
SOFIA Mission Operations Director

Ghassem Asrar

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USRA Senior Vice President for Science

SOFIA Science Opportunities

- Cycle 10 Call for proposals: **Due January 28**
<https://www.sofia.usra.edu/proposing-observing/proposal-calls/cycle-10>
- Observing time is increasing
 - 50% more than Cy6
 - X2 more in the southern hemisphere
 - 3 southern deployments in Cycle 10
- GO (550 hrs) and Legacy programs (200 hrs)
- Minimum grant \$75K for observing programs
- New multi-cycle time domain category
- Local Supernova science team members
- SOFIA offers joint observing programs with GBT and IRTF
- SOFIA programs with JWST synergy



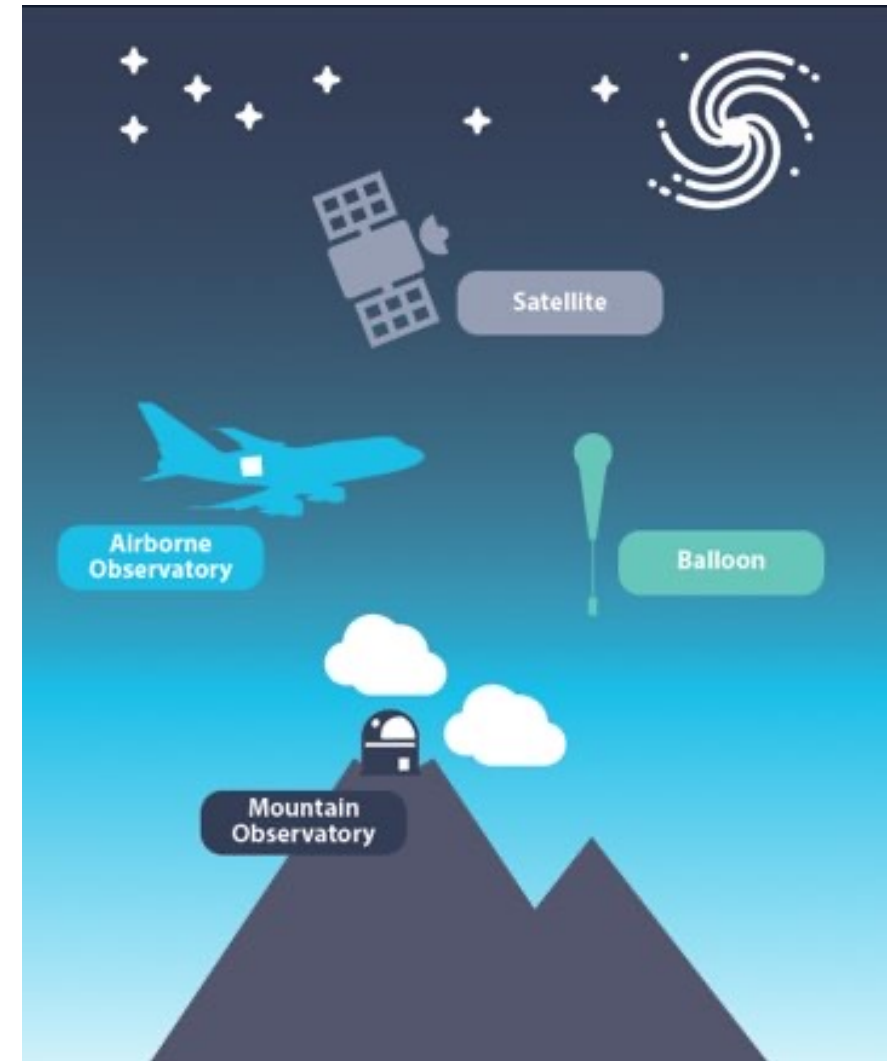
SOFIA Science Opportunities

- SOFIA School 2022: Feb. 2-4, virtual and free
 - <https://sofia-school-2022.constantcontactsites.com>
- In-person conference on Our Galactic Ecosystem,
 - Feb. 28-March 4 2022
 - <https://arrowhead-2022.constantcontactsites.com>
 - Late reg and abstract deadline is **Feb. 14**
 - Safety protocols: vaccination, masking, testing



SOFIA is an important sub-orbital mission

- Suborbitals such as SOFIA are essential to further science and technology to be used in space missions.
- The balloon program, which is another suborbital portfolio, focuses on PI-driven far-infrared observations
- Far-IR technology developed in balloon platforms can be applied in a more capable instrument on SOFIA which has larger aperture, power, mass and volume envelopes.
- SOFIA offers the only reliable and repeatable suborbital platform
 - Astronomical community proposals direct SOFIA's observational program
 - Instruments can be updated or replaced with new ones
 - Stepping stone between balloon program and space missions
 - Supports a scientifically diverse opportunity for the astronomical community.



SOFIA Operations 2021

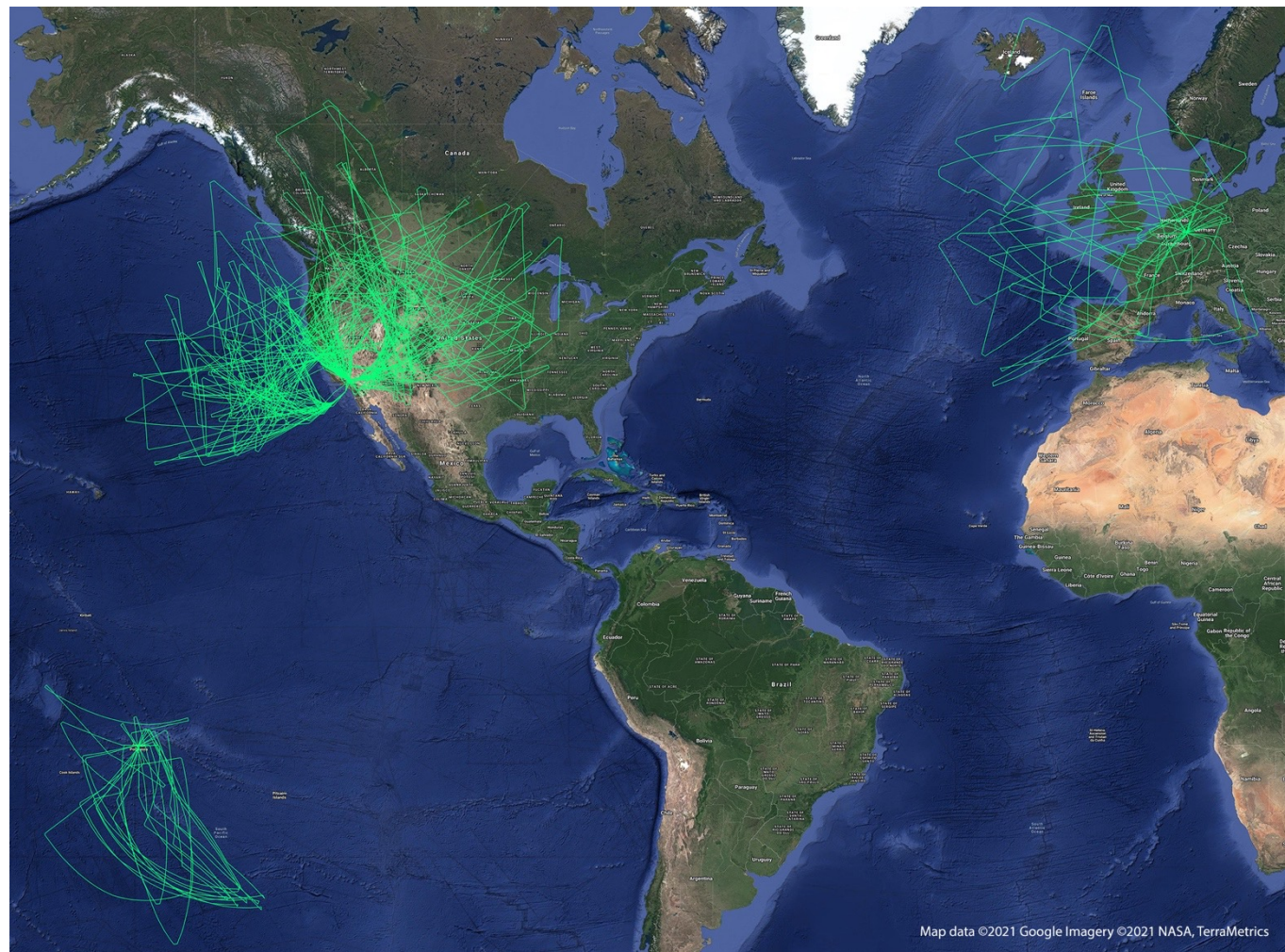
- Crewed mission
- Safely flying during COVID
- Heroic, dedicated team
- Flights from Palmdale
- Deployment in Cologne Germany (Jan.-Feb. 2021)
- Deployment in French Polynesia (July-Aug. 2021)



Follow SOFIA as it flies!

- SOFIA typically flies 4 times a week, Monday to Thursday nights
- You can follow SOFIA as it flies on e.g. <https://flightaware.com>
- Just type in NASA747

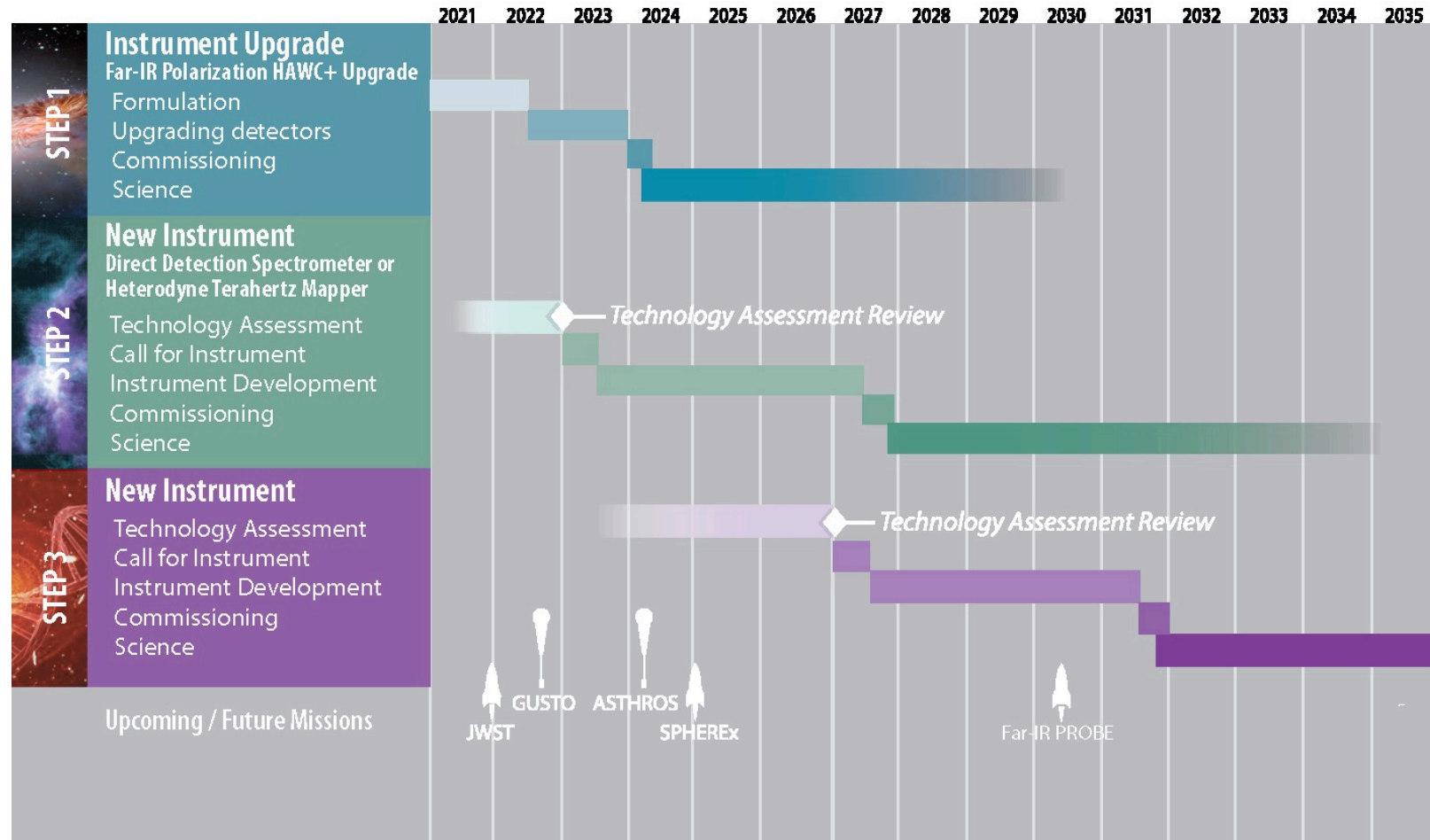
All SOFIA 2021 flight paths



Map data ©2021 Google Imagery ©2021 NASA, TerraMetrics

SOFIA Instrument Roadmap

- SOFIA can increase its capability by up to X10 in better sensitivity or mapping speed with new instrument.



<https://www.sofia.usra.edu/sites/default/files/Other/Documents/instrument-roadmap-public.pdf>

The next generation mid/far-IR space missions – formulating a European perspective January 19-21 2022

- <https://spaceir.sciencesconf.org/>
- Provide a broad overview of the key science questions that can be uniquely addressed through mid/far-IR observations
- Presentations of planned M/F missions in response to the ESA call
- Presentations of international missions and mission proposals in preparation
- Identify capabilities and limits of mid/far-IR facilities in operation (airplane observatories, balloons and ground based telescopes)
- The SOC: Susanne Aalto, Denis Burgarella, Paola Caselli, Laure Ciesla, Maryvonne Gerin, Javier Goicoechea, Matt Griffin, Carlotta Gruppioni, Paul Hartogh, Shoko Jin, David T. Leisawitz, Jérôme Pety, Dimitra Rigopoulou, Peter Roelfsema, Marc Sauvage, Bernhard Schulz, Silvia Spezzano, Floris van der Tak, Martina C. Wiedner and Toru Yamada

Astro2020 and IR Astrophysics: Planning for the Next Decade

In Person Workshop Mar 30 – Apr 1, 2022

This workshop will give the IR science and technology community an opportunity to synthesize the priorities and recommendations of the Astro2020 Decadal Survey, and to provide a forum for thoughtful discussion and deliberation about the future of our field over the next decade and beyond.

Sessions will include a mix of structured and unstructured time to allow participants to talk in small groups and collaborate:

- **Precursor Science - What Science Do We Need to Do Now?**
- **Future Science - What are the Science Cases for Future Missions?**
- **Technology Development for the Future**
- **Probes and Flaglets for the FIR**
- **The Role of Sub-Orbital in Technology and Science**
- **The Future of SOFIA**
- **Putting the 'IR' in LUVUOIR**
- **Creating a Coherent Vision Over Three Decades in Wavelength**

Pre-registration https://bit.ly/irstig_workshop_preregistration, January 24 deadline,
join IRSTIG mailing list for future announcements:

https://cor.gsfc.nasa.gov/sigs/irsig/maillist/irsig_maillist.php



In Person @ Colorado University, Boulder
March 30 - April 1, 2022

Meeting Chairs

Meredith MacGregor Michael Zemcov

Scientific Organizing Committee

Stacey Alberts Pete Barry
Jake Connors Jens Kauffmann
Lisa Locke Arielle Moullet
Omid Noroozian Roberta Paladini
Johannes Staguhn Kevin Stevenson
Volker Tolls



Far-IR Probe Science Development Workshop

Monday March 21 - Wednesday March 23 (ending 1 PM)

Caltech Campus, Pasadena, CA

(With virtual component)

Objectives:

- Identify leading scientific questions for the Probe
- Outline measurement approaches and capabilities
- Chart final trades / decisions to guide formulation

<https://www.ipac.caltech.edu/event/farirprobe>

Questions: matt.bradford@jpl.nasa.gov, jason.glenn@nasa.gov

Decadal context for SOFIA

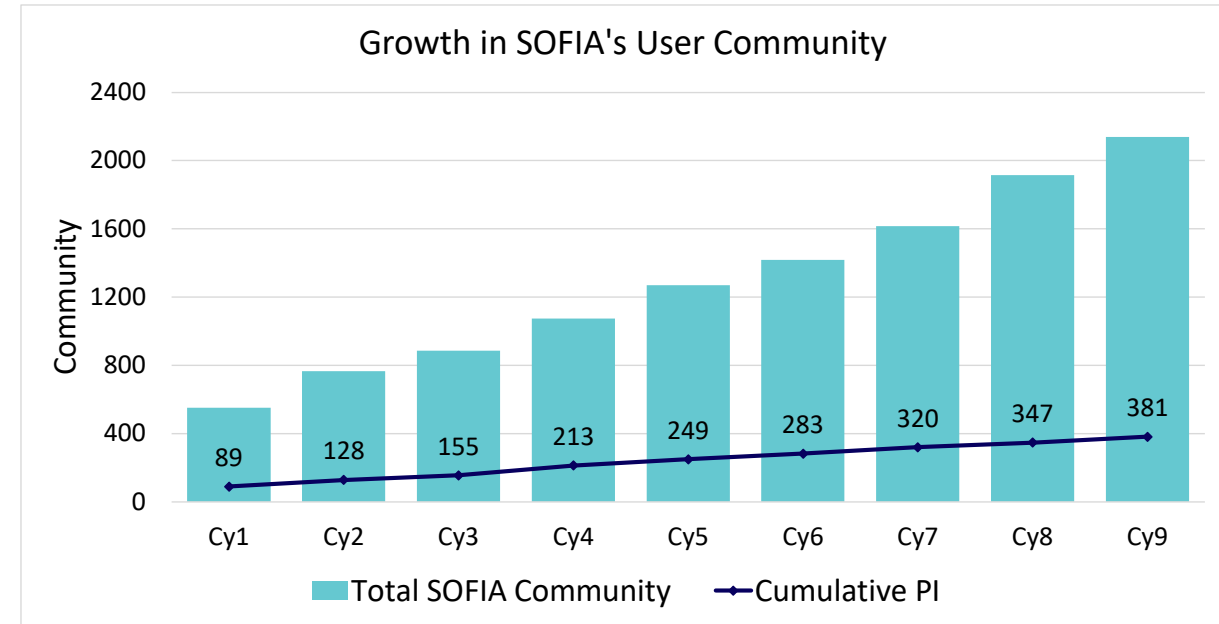
- Current and future science of SOFIA is exciting and compelling.
- Over the past 2 years, SOFIA has experienced tremendous scientific growth.
- Astro2020 comments are based on information pre-March 2020, missed this growth and put SOFIA into a static box.
- NASA's Astrophysics Advisory Committee (APAC) applauded recent efforts to improve the scientific productivity of SOFIA in their letter for the March 2021 meeting.
- Decadal acknowledges the importance of Senior Review process.
- SOFIA was put into Senior Review last summer, post-Astro2020 is pending
- SOFIA is finalizing its proposal for Senior Review, due Feb. 11.
- We have a strong case and hope to deliver it.



Join the SOFIA Community!

- Our SOFIA User community of investigators and authors is 2,138 strong and growing (12% last year).
- Virtual science workshops and other community engagement activities have increased our wider SOFIA community size by an additional 30% of new to SOFIA astronomers.
- To learn more about SOFIA opportunities visit our website:

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



Questions for the SOFIA panel?

Raise your hand or put question in the Chat

- Margaret Meixner, Director of SOFIA Science Mission Ops
- Bill Reach, Associate Director for Science Operations
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- Simon Coude, HAWC+ instrument lead
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Backup

SOFIA and JWST together cover the Universe

SOFIA

- Only Far-IR observatory
- Ability to fix, update and replace with new instruments to meet new science demands
- Probes bright iconic objects that are too bright for JWST and offers high spectral resolving power.
- Detailed observations of nearby Universe that calibrate the more distant objects observed by JWST.

JWST

- Largest space observatory in history working at near and mid-IR wavelengths
- Robust design with 10 yr goal, but not serviceable
- Observe distant universe and faint nearby objects
- JWST offers detailed observations in near/mid-IR that complement what SOFIA finds in the far-IR.