SOFIA Science Highlights
Cycle 5 Progress
Cycle 6 Call for Proposals

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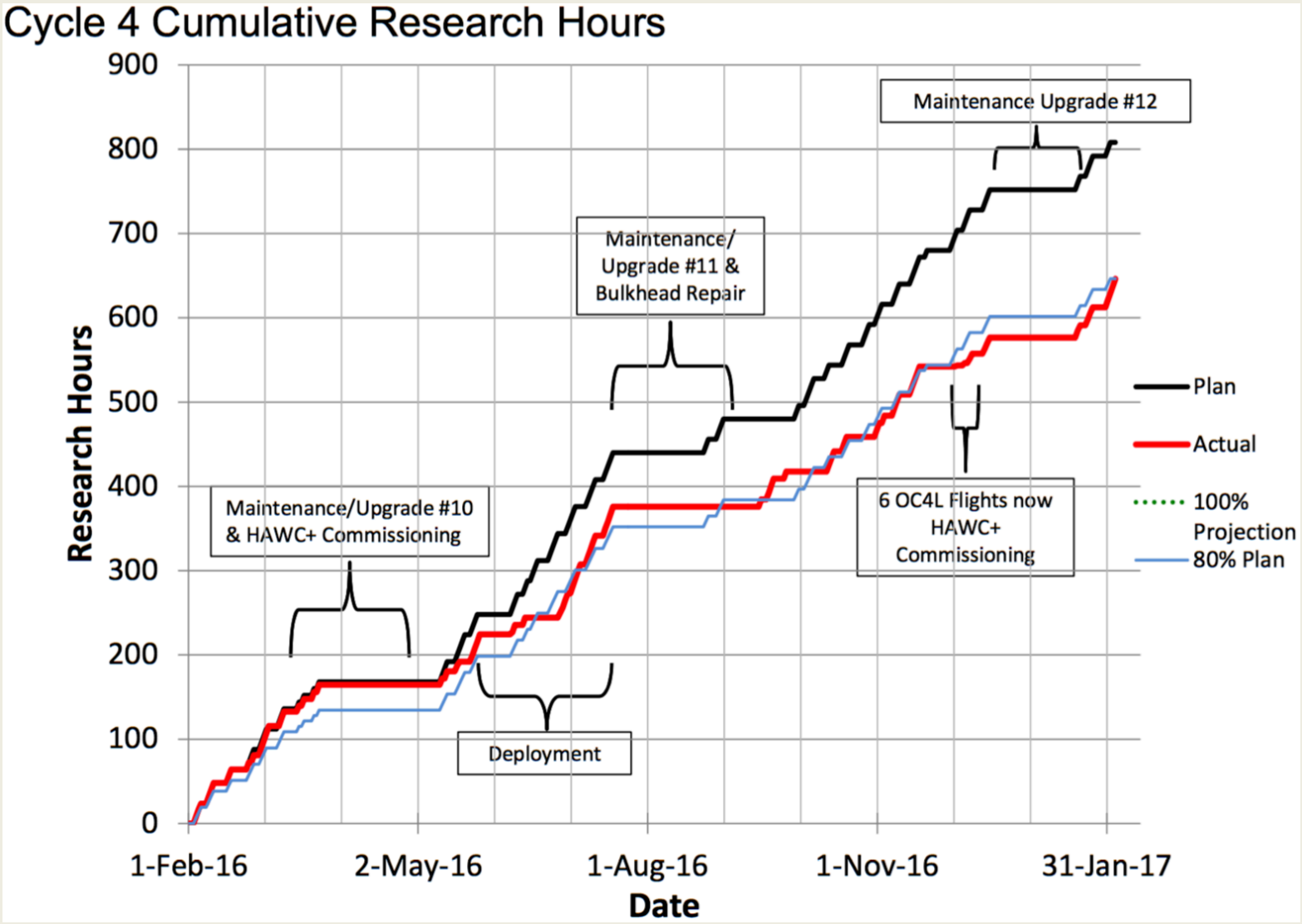
SOFIA Science Center

Executive Summary – Since Last SUG

- Completed Cycle 4
  - 400.1 Hours GO Time (without calibration)
  - 106.7 Hours GTO Time
  - 19.9 Hours DDT
- Started Cycle 5 on 4 Feb 2017
  - OC5A - 7 of 7 scheduled upGREAT (LFA) flights completed
  - OC5B - 8 of 8 scheduled FIFI-LS flights completed (one contingency used)
  - OC5C - 6 of 6 scheduled EXES flights completed
  - Maintenance #13 completed; engine check on ground caused problems
  - OC5D - 0 of 6 scheduled FORCAST flights completed
  - OC5E - 5 of 10 scheduled HAWC+ flights completed
  - OC5F - 3 of 3 scheduled EXES flights completed (one contingency used)
  - OC5G - 2 commissioning & 5 science upGREAT flights planned with 1 contingency
- Cycle 6 Call for Proposals Released
- We are currently replanning the rest of Cycle 5 to optimize science
- We are ready to go on NZ deployment **in three weeks**

Cycle 4 Summary Statistics

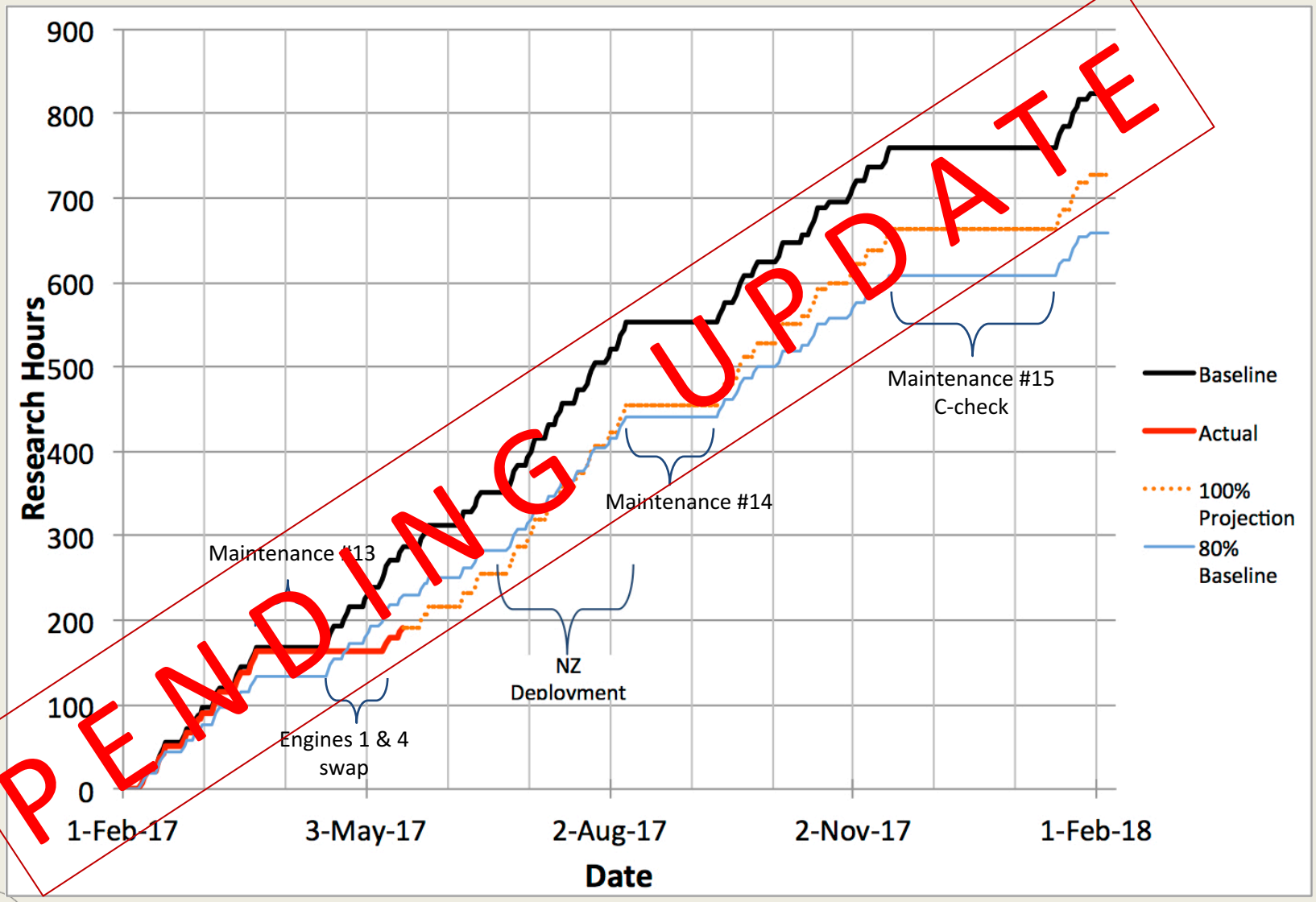


Cycle 4 Summary Statistics

Flight Series	# Flights	Instrument	Research Hours	GTO			GO Hours			Calibration Hours	DDT Hours
				Total	US	DE	Total	US	DE		
OC4A	8	FORCAST	66.3	2.8	2.8	-	48.7	47.7	1.0	11.9	-
OC4B	8	FIFI-LS	68.7	11.0	-	11.0	44.3	36.3	8.0	11.5	-
OC4C	4	EXES	31.9	-	-	-	28.3	28.3	-	2.4	-
HAWC+ Commisioning		HAWC+			-	-	-	-	-	-	-
OC4D	8	GREAT	59.9	8.0	-	8.0	46.1	39.4	6.7	5.7	-
OC4E	2.5	GREAT	19.9	7.0	-	7.0	9.3	8.1	1.2	2.4	-
OC4F	8	FIFI-LS	63.7	7.2	-	7.2	35.8	34.7	1.1	8.4	10.7
OC4G	8	FORCAST	67.6	6.0	6.0	-	53.2	53.2	-	8.3	-
OC4H		HAWC+		-	-	-	-	-	-	-	-
OC4I	5	FORCAST	41.9	8.3	8.3	-	26.7	26.7	-	5.8	-
HAWC+ Engineering		HAWC+					-				
OC4J	5	FLITECAM	[illegible]	17.9	17.9		12.3	8.2	4.0	9.3	-
OC4K	12	GREAT	33.5	28.2	-	28.2	40.3	35.8	4.5	6.9	8.0
OC4L	8	HAWC+	34.2	5.0	5.0	-	17.9	17.9	-	9.6	-
OC4M		EXES	35.8	5.2	5.2	-	23.0	22.1	0.9	2.3	1.3
OC4N		GREAT	34.0	14.1		14.1	14.2	13.3	0.9	4.1	
Cycle 4 Total	**76.5**		**648.5**	**106.7**	**45.2**	**75.5**	**400.1**	**371.8**	**28.2**	**88.5**	**19.9**

PENDING UPDATE

Cycle 5 Research Hours Progress



Cycle 5 Progress

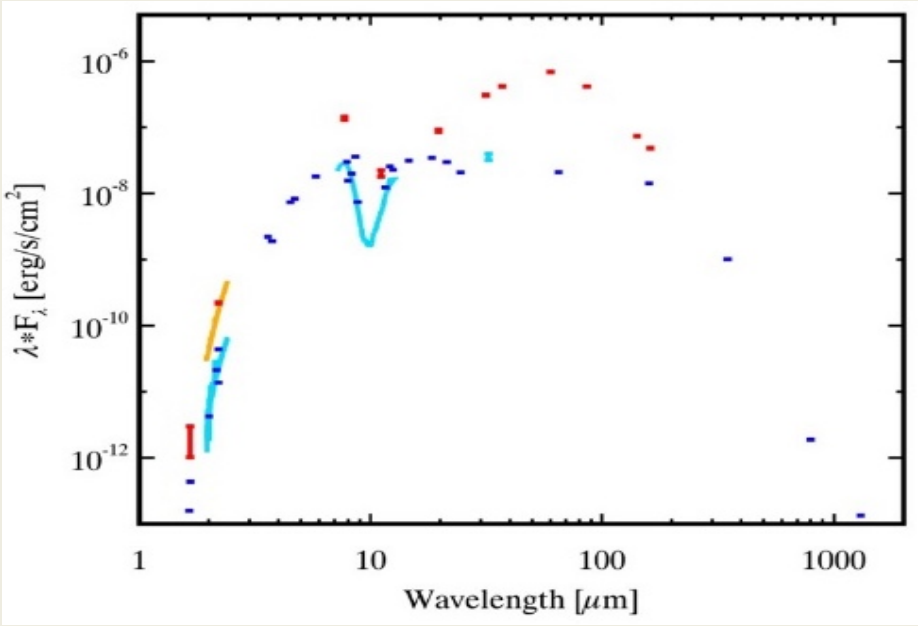
Flight Series	# Flights	Instrument	Research Hours	GTO			GO Hours			Calibration Hours	DDT Hours
				Total	US	DE	Total	US	DE		
OC5A	7	GREAT	50.8	0	-	-	47.43	39.53	7.9	1.8	-
OC5B	8	FIFI-LS	63.7	8.2		8.2	43.9	31.68	12.22	8.97	-
OC5C	6	EXES	48.1	-		-	39.16	39.16	-	4.27	2.6
OC5D	0	FORCAST									
OC5E	5	HAWC+	28.4	4.0	4.0		15.79	12.72	3.1	6.37	-
OC5F	3	EXES									
OC5G											
OC5H											
OC5I											
OC5J											
OC5K											
OC5L											
OC5M											
OC5N											
OC5O											
Cycle 5 Total	29		191.0	12.2	4.0	8.2	146.3	123.1	23.2	21.4	2.6

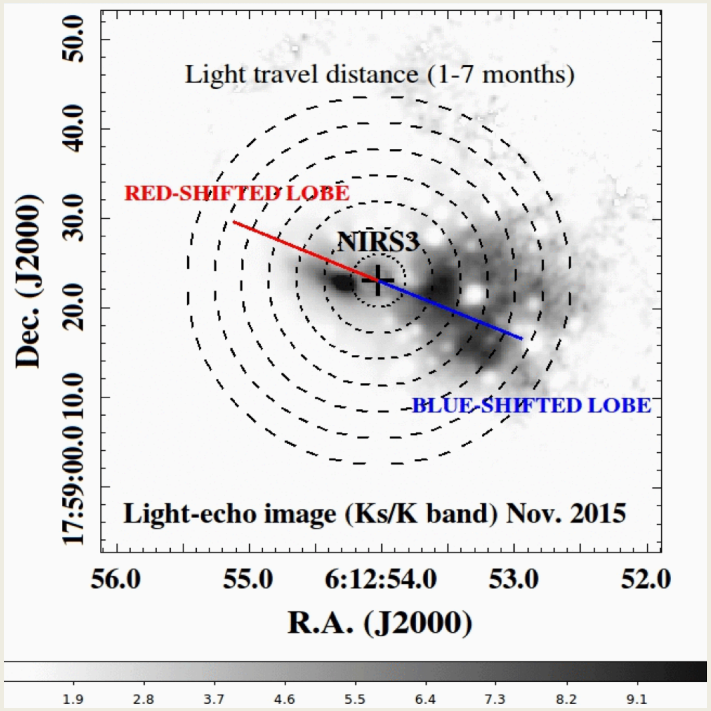
PENDING UPDATE

Through 22 May 2017

Disk-mediated accretion burst in a high-mass YSO

SOFIA data of S255IR NIRS 3 obtained using FORCAST (at 7.7, 11.1, 19.7, 31.5, and 37.1 microns) and FIFI-LS (at 90, 140, and 160 microns), were crucial to derive fundamental parameters of the accretion burst such as the mass accreted during the event and the total energy being released by the burst.





Images taken a few months apart reveal motion of light-echo, from which Caratti o Garatti, et al. (2016, *Nature Physics*) could infer that the burst began in June 2015.

FIFI-LS Field Imaging Far-Infrared Line Spectrometer

FORCAST Faint Object InfraRed CAmera for the SOFIA Telescope

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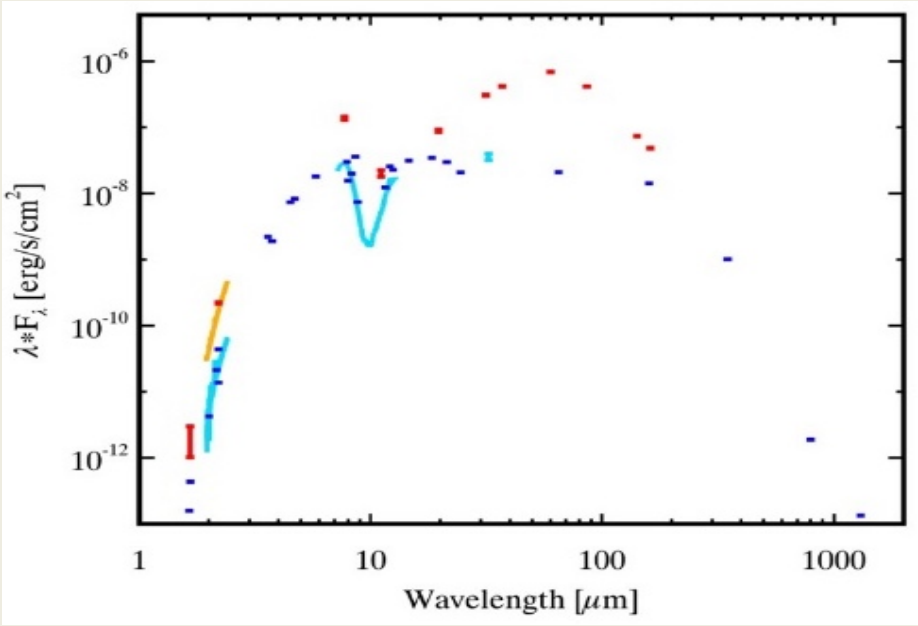

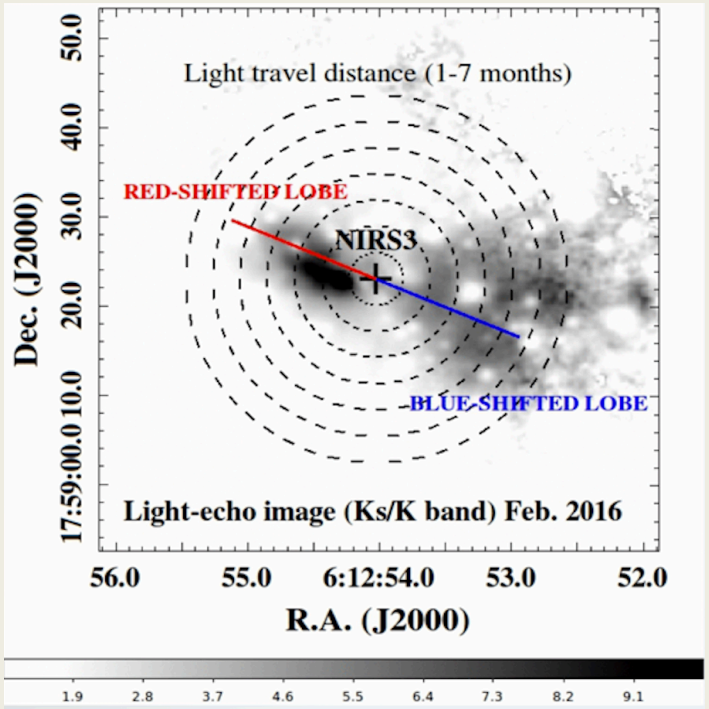

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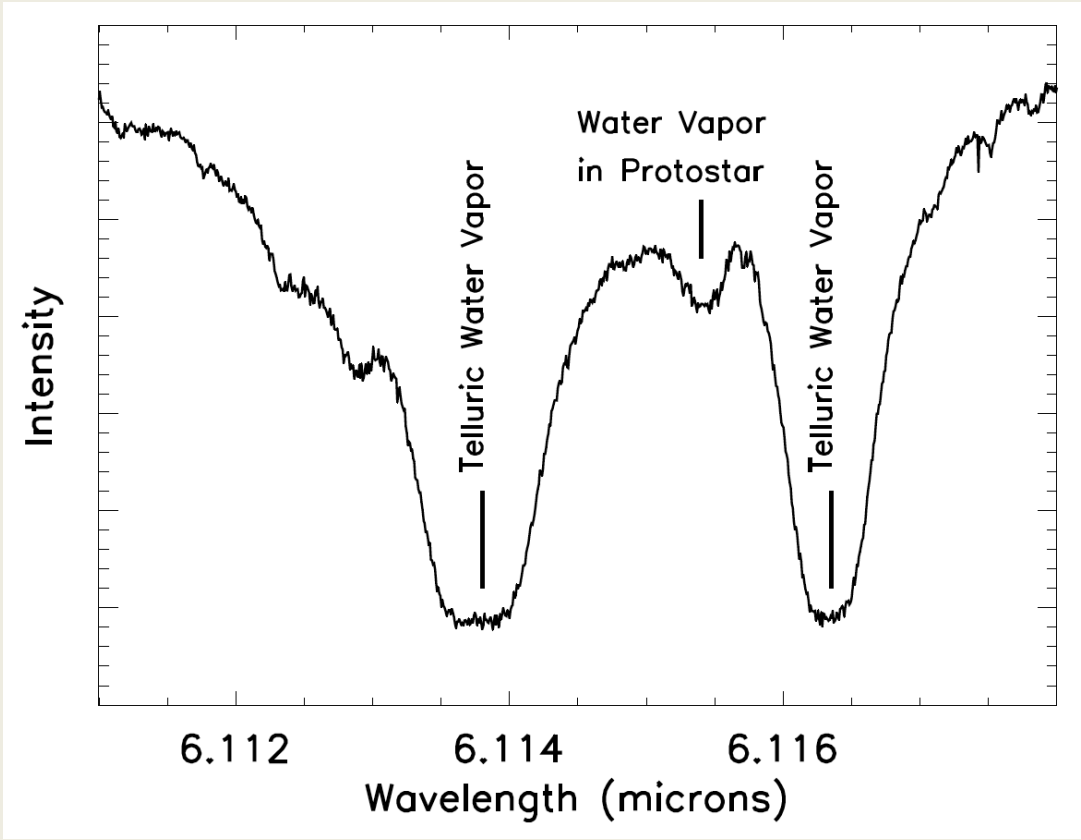
FIFI-LS Field Imaging Far-Infrared Line Spectrometer

FORCAST Faint Object InfraRed CAmera for the SOFIA Telescope

EXES Observations of Water in AFGL 2591

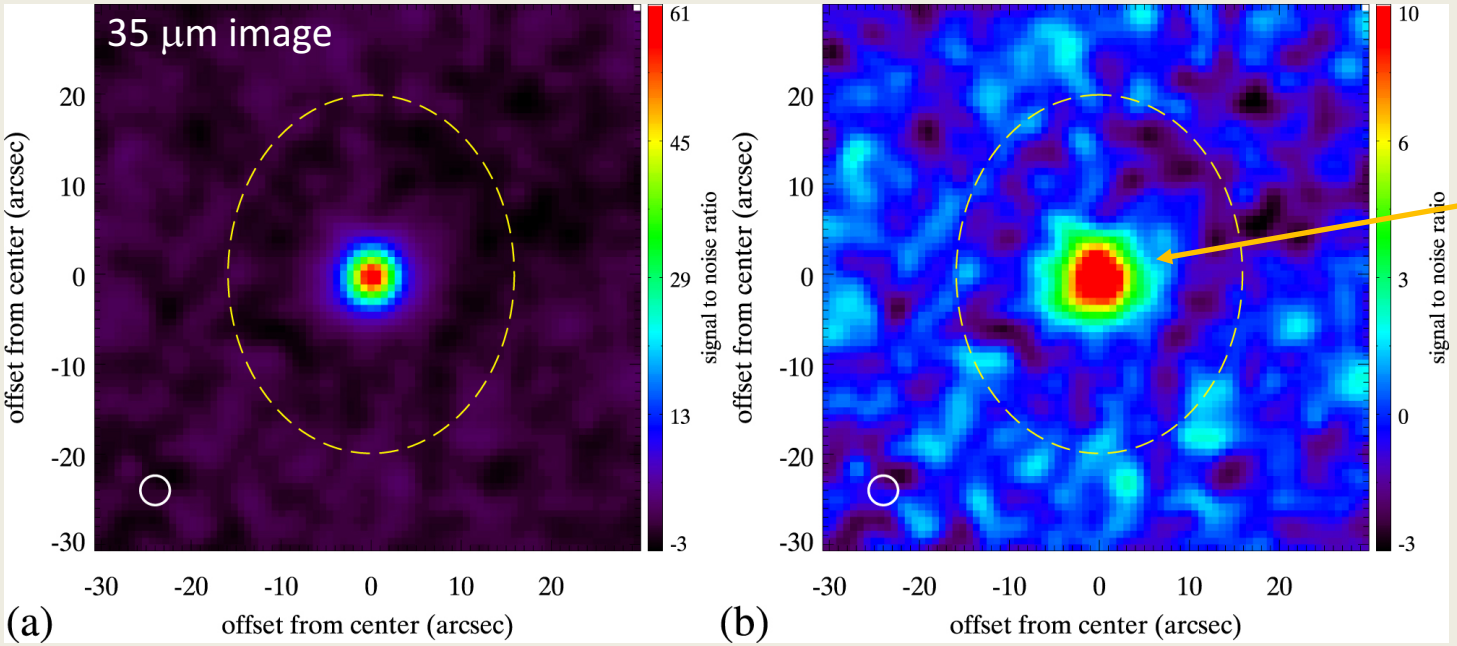
- ~10 M protostar in Cygnus region
- 0(0,0)→ 1(1,1) and other H_2O transitions
- T_{ex} ~ 500 K, likely produced by evaporation of grain mantles



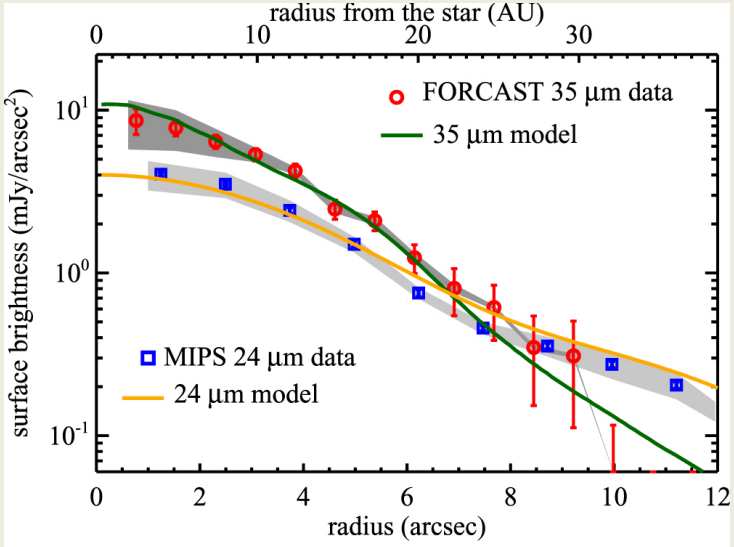
(C. de Witt, M. Richter, EXES Team)

(Colin Aspin et al. , NIRI, Gemini Obs.)

ε Eridani Analogy to Solar System



Point source subtracted residual



Well fit models:
Narrow planetesimal belts
Puffed up disk

Kate Su et al. 2017, AJ, 153, 226

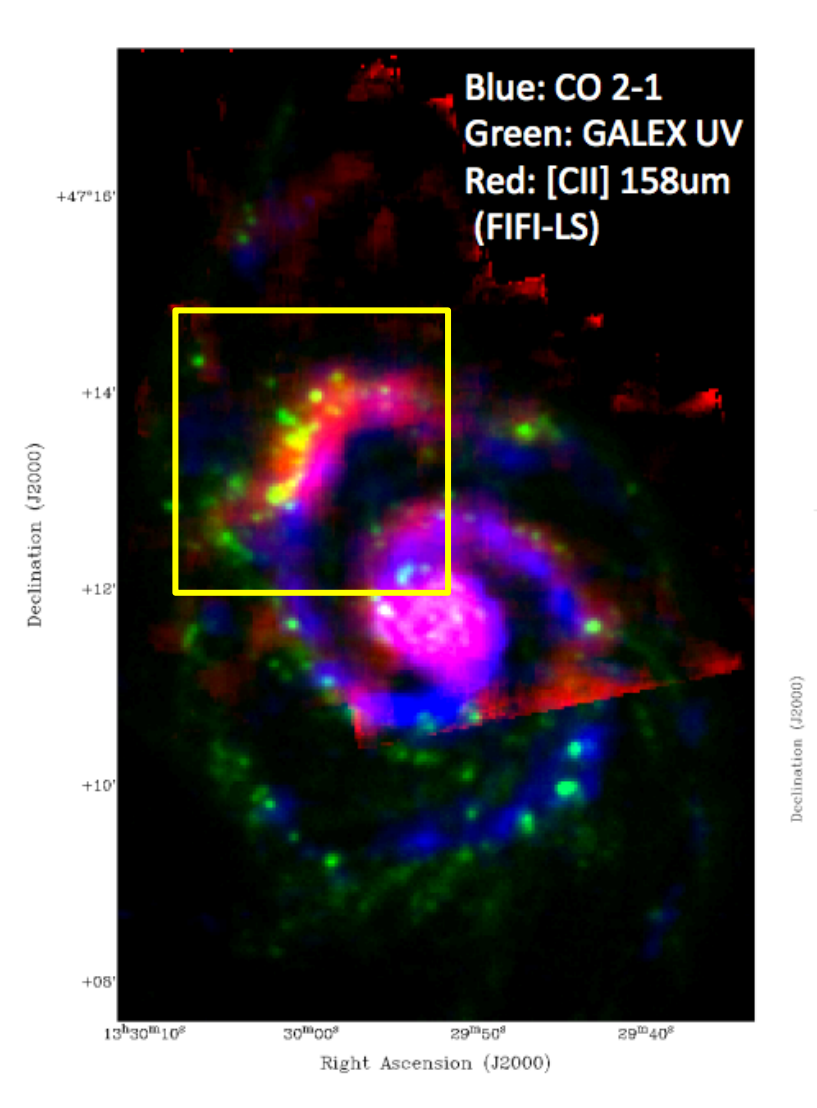
SOFIA Accomplishments: Cycle 4

- SOFIA [CII] mapping has now well exceeded the area that Herschel-HIFI mapped in [CII], which constituted about 10% of the entire Herschel observing time.
  - Technological advances in high frequency heterodyne technology has increased SOFIA-upGREAT's [CII] mapping speed by a factor of about 50 in comparison to Herschel-HIFI's band 7.
  - Further improvements are planned for later this year that will allow simultaneous mapping of [CII] 158 µm and [OI] at 63 µm.
- The January-February upGREAT series (OC4N & OC5A) provided the first heterodyne observations of the [OI] 145µm line
  - Together with the [OI] 63µm line, the 145µm line gives important diagnostic information on structure & temperature and whether [OI] 63µm is optically thick in 63µm-bright regions.

SOFIA Accomplishments: Cycle 5

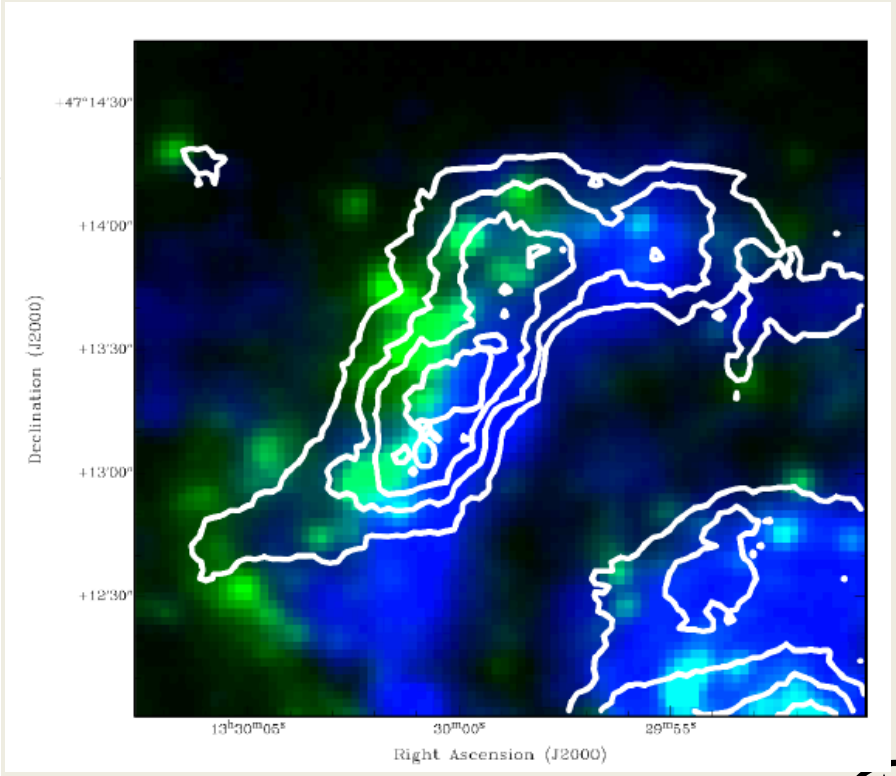
- Engine anomaly resulted in a loss of all 6 FORCAST flights and 5 of 10 planned HAWC+ flights (to date); my initial (optimistic) prediction last month was 3 FORCAST flights
- Replanning and re-replanning of individual flights, flight series and the rest of Cycle 5 (until 1 Feb 2018) necessary to optimize science output
- Current schedule expects installation of two cryocoolers to work in tandem allowing GREAT instrument to operate either in HFA+LFA or HFA+4G mode
  - HFA is a 7 pixel array around [OI] 63µm line
  - LFA is 7 pixel array at two LO polarizations overlapping around the [CII] 158µm line, resulting in 14 effective pixels
  - 4G (4GREAT) has four different 1-pixel frequencies for simultaneous observing
- Uncertainties in dual cryocooler installation schedule forces consideration of alternate OC5G (May 31) & OC5H (July 7) flight series

CII Cooling in M51



Cycle 4 joint impact program Pineda/Stutzki

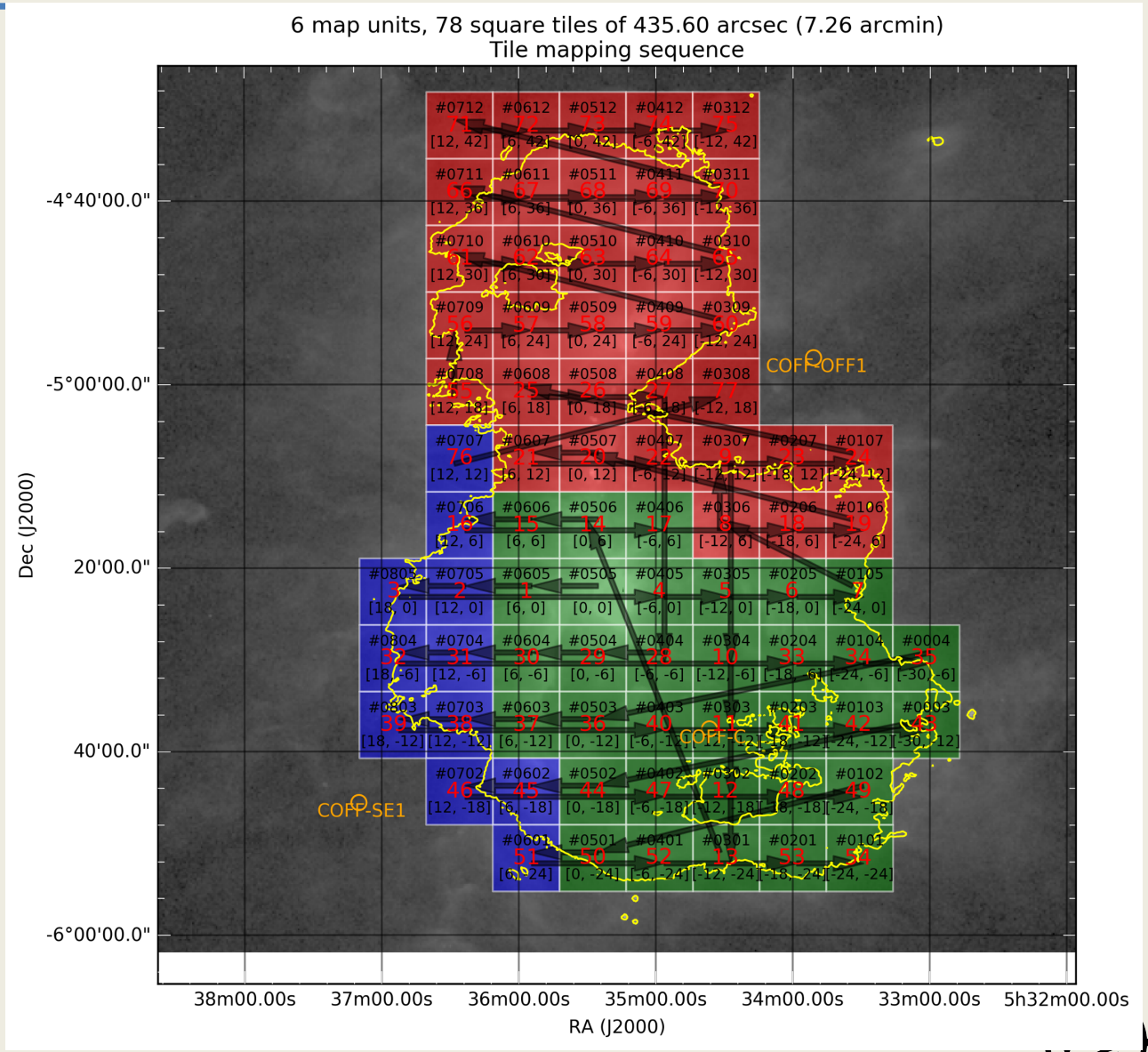
Here [CII] is shown with contours overlaid over the dense gas (blue) and hot stars (green)



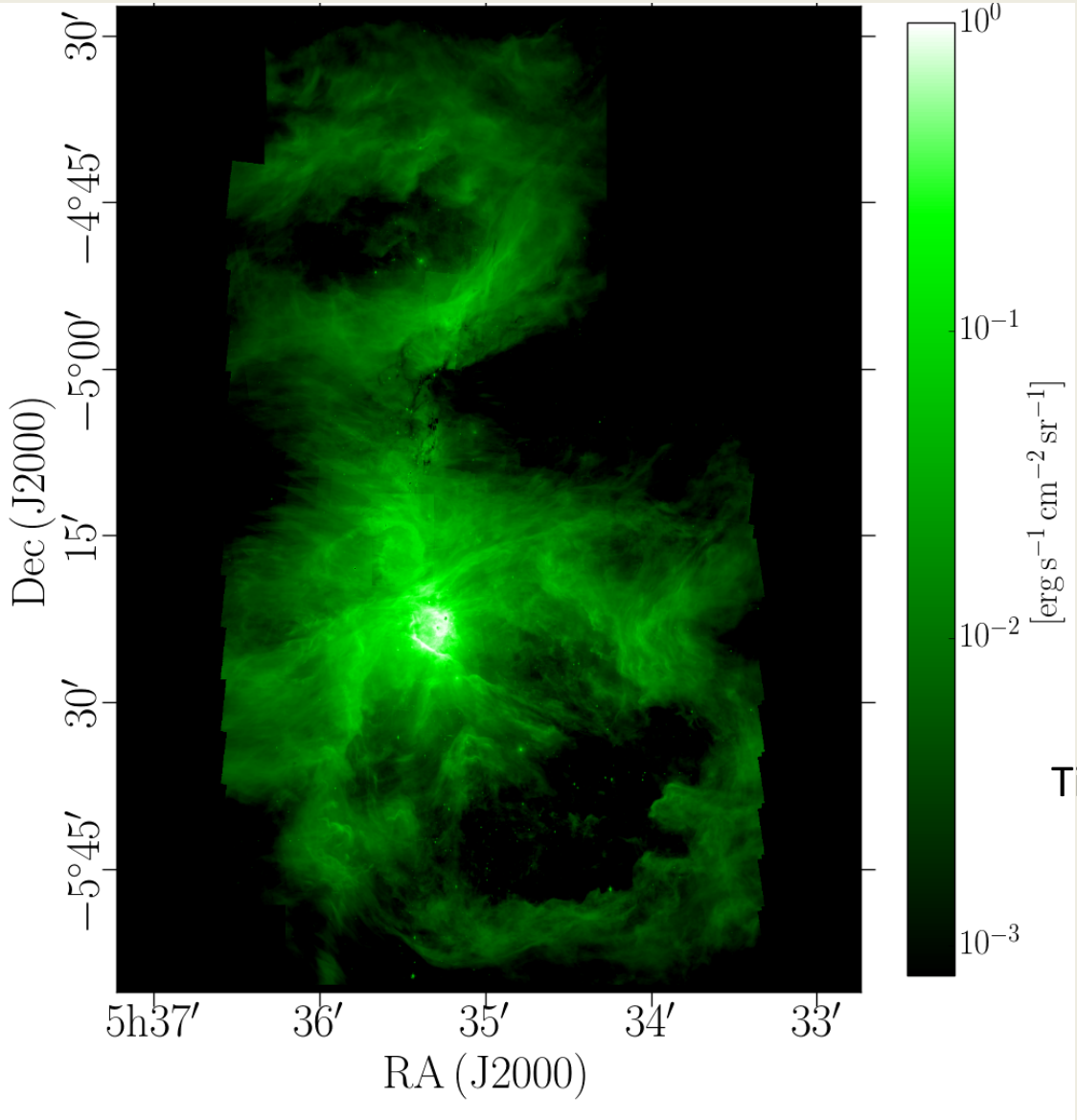
Pineda, J. et al, 2017 in prep.

upGREAT C+ Map of Orion

- Cycle 4 Impact program
- PI (Tielens) showed movie of C+ emission while moving through velocities (Ringberg)
- GO requested modification of observing plan to take advantage of efficient observing strategies and map larger region
  - Approved and executed
  - Subject of several PhD theses

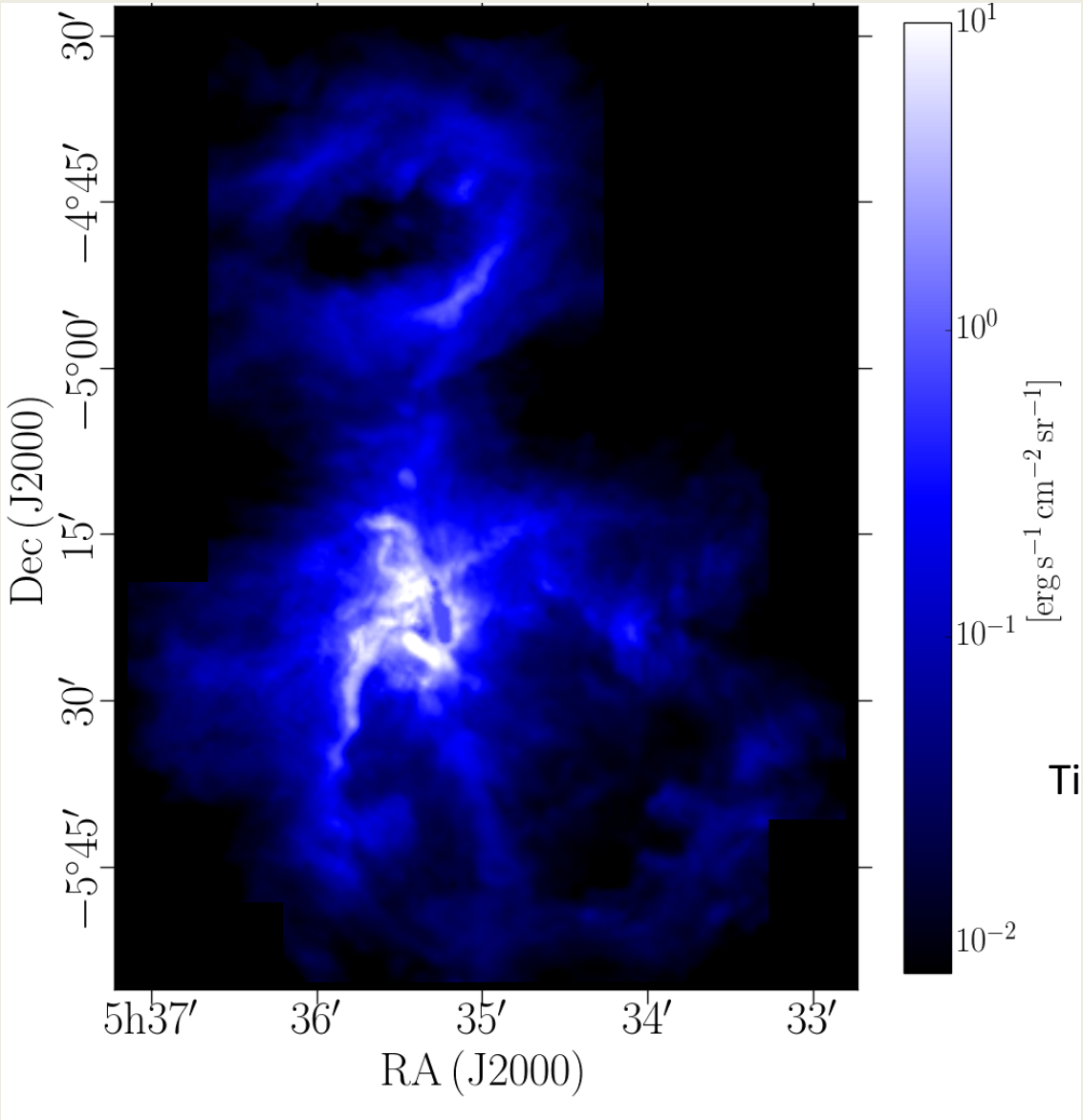


Spitzer IRAC/8um PAHs



Tielens & C+Squad

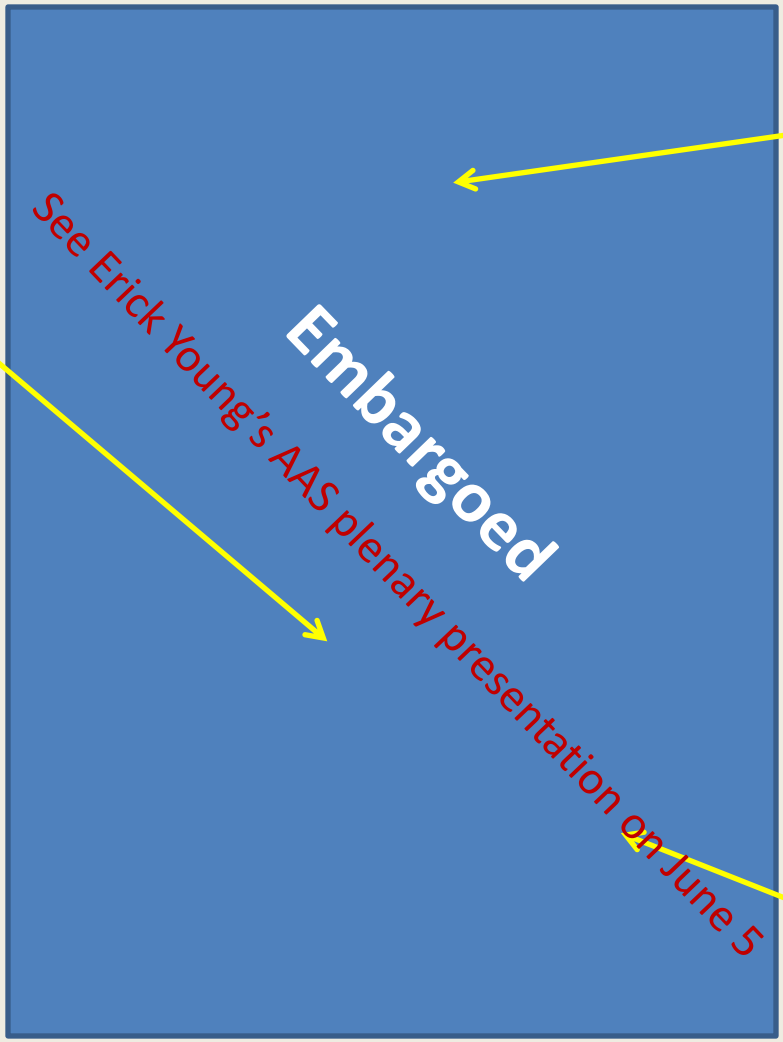
Herschel PACS/70um dust



Tielens & C+Squad

SOFIA upGREAT @ [CII] 158µm

Central bright PDR associated with the HII region



Northern bubble blown by radiation pressure on dust associated with the NGC 1973, 1975, 1977 area

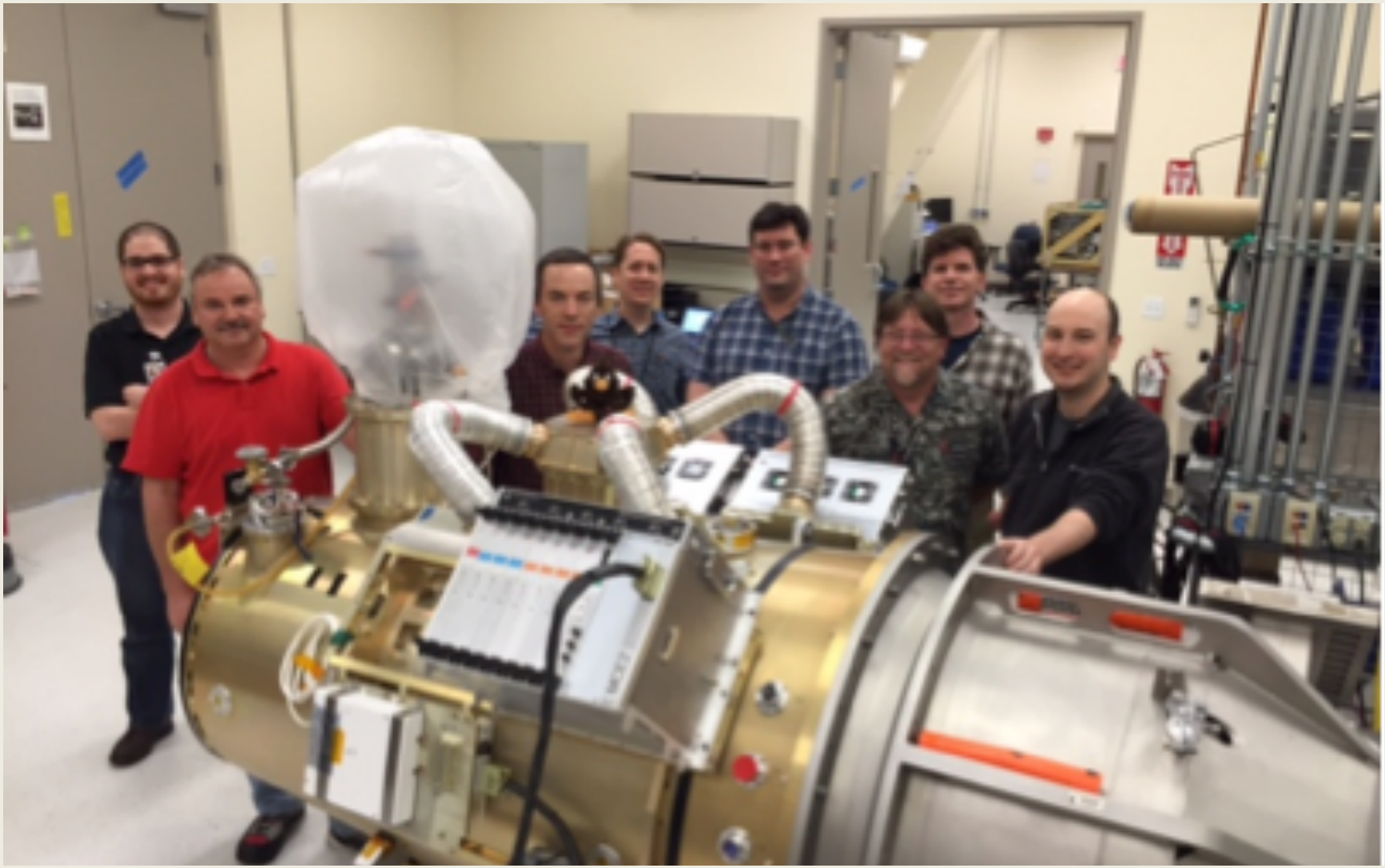
C+ provides unique velocity information not present in other tracers

Kinematic & morphological structures associated with HH objects & YSOs

Tielens & C+Squad

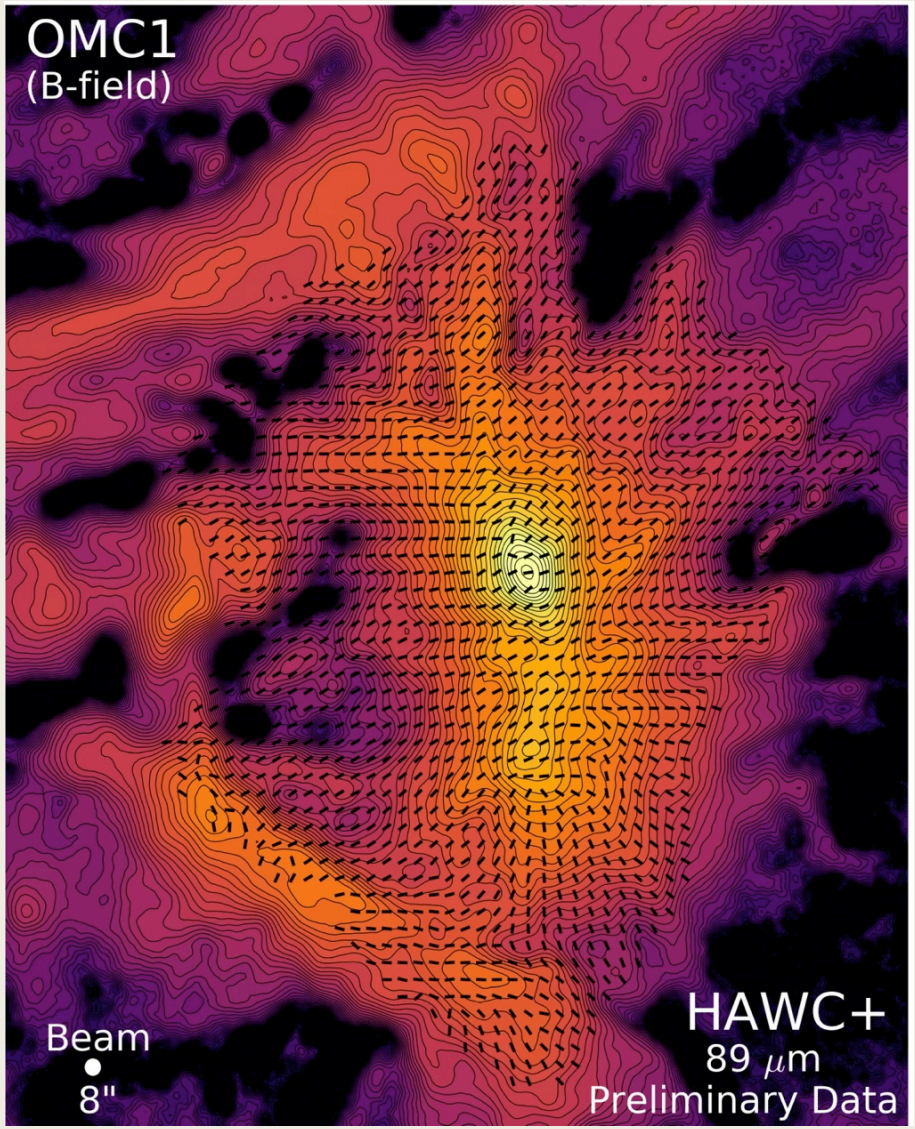
Large scale, wind-blown, stellar bubble to the South

HAWC+

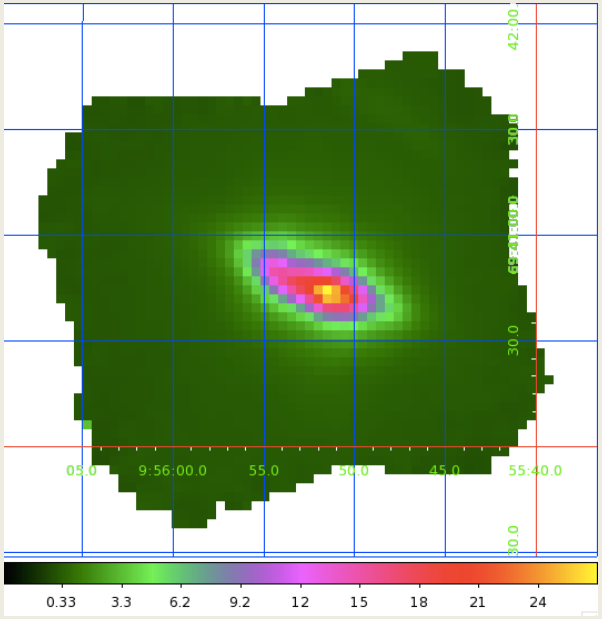


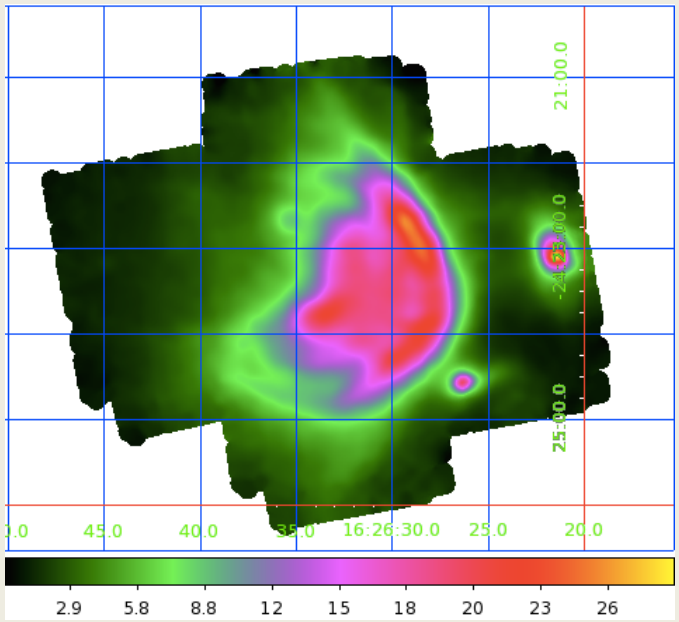
Orion wi HAWC+ – Magnetic Fields

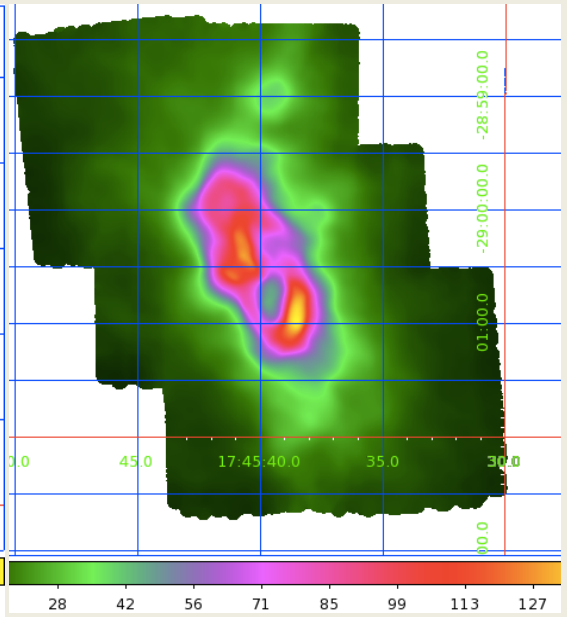
- Recently commissioned HAWC+ adds the capability of observing polarization in the Far-IR
- Far-IR polarization of thermal radiation is due to emission of aligned dust grains, whereas Near-IR polarization has the component of scattered light.
- Far-IR gives the orientation of magnetic fields



HAWC+ Observations during OC5E: Very Nice!







M82 is a galaxy with active ongoing star formation (star-burst galaxy)

Rho Oph is a nearby region of active star formation in our Galaxy

The Galactic Center region houses the closest Supermassive Black Hole (~4 Million solar masses)

All targets also mapped in polarization, not shown here

Cycle 6: Feb 2, 2018 – Feb 1, 2019

Stratospheric Observatory for Infrared Astronomy

(SOFIA)

Observing Cycle 6

Call for Proposals

May 1, 2017

Version 1.0

US Proposal Deadline:
June 30, 2017 21:00 PDT
(July 1, 2017 04:00 UTC)

Please check the USRA website on June 5th for updates to call.

This document and all other information pertaining to SOFIA observing Cycle 6 may be found at https://www.sofia.usra.edu/Science/proposals/Cycle6/.

SOFIA Cycle 6 Assumptions

- Program Office Guidance
  - 104 Science Flights @ 8 Research Hours per flight
  - NASA: ~500 CfP Hours
  - DLR: ~70 CfP Hours
  - No commissioning time planned
  - 25 hours GTO for HAWC+ and 16 hours GTO for FIFI-LS
- Cycle 5 period: 2 February 2018 – 1 February 2019
- Single Southern Hemisphere Deployment in June-July with two instruments
- Available US GO funding: $5M for US Guest Observers, including optional (SMO Dir discretion) funding for US lead on non-US (but US queue) proposals

Cycle 6 Schedule & Funding Information

- US TAC: Week of August 14 (classes begin for many/most universities Aug 21)
- DE TAC: September 12-13
- Proposal selection in October
- US GO Funding consistent with Cy 5, i.e. approx. $10k/h

Cycle 6 Call for Proposals

Instruments/modes offered:

- EXES – all modes including Low-Resolution (MOU signed)
  - PI has caveats to offering the Low-Resolution mode because of saturation and persistence issues
- FIFI-LS – all modes
- FORCAST – all modes
  - Except cross-dispersed spectroscopy mode, because of low throughput (as in Cy 5)
- FPI+ – All modes
- GREAT – LFA/HFA, 4GREAT (bands 3 & 4)/HFA (MOU signed)
- HAWC+ – All modes, but 63μm as shared risk
  - SI team considering acquiring a narrower 63μm filter to overcome saturation

Instruments <u>not</u> offered:

- FLITECAM - New
  - Note in CfP that DDT can be submitted through Cy 5, particularly for the "Triton Series"
- HIPO

Cycle 6 Call for Proposals

Selection Categories:

- Explicit, selection bands to be introduced and advertised in CfP
  - **Priority 1**– Will strongly drive scheduling; carry-over to next cycle if incomplete, ~25% of time
  - **Priority 2**– Similar to "Must do" category in previous cycles, ~50% of time
  - **Priority 3**– Similar to "Do if time" category in previous cycles, ~50% of time
  - Exact selection fractions in each band will depend on target locations and competition
- Funding schedule
  - **Priority 1**– can release full GO funding at acceptance
  - **Priority 2**– release $7k at acceptance, remainder after first target observations executed
  - **Priority 3**– release $7k at acceptance, increment after each observation executed

Cycle 6 Call for Proposals

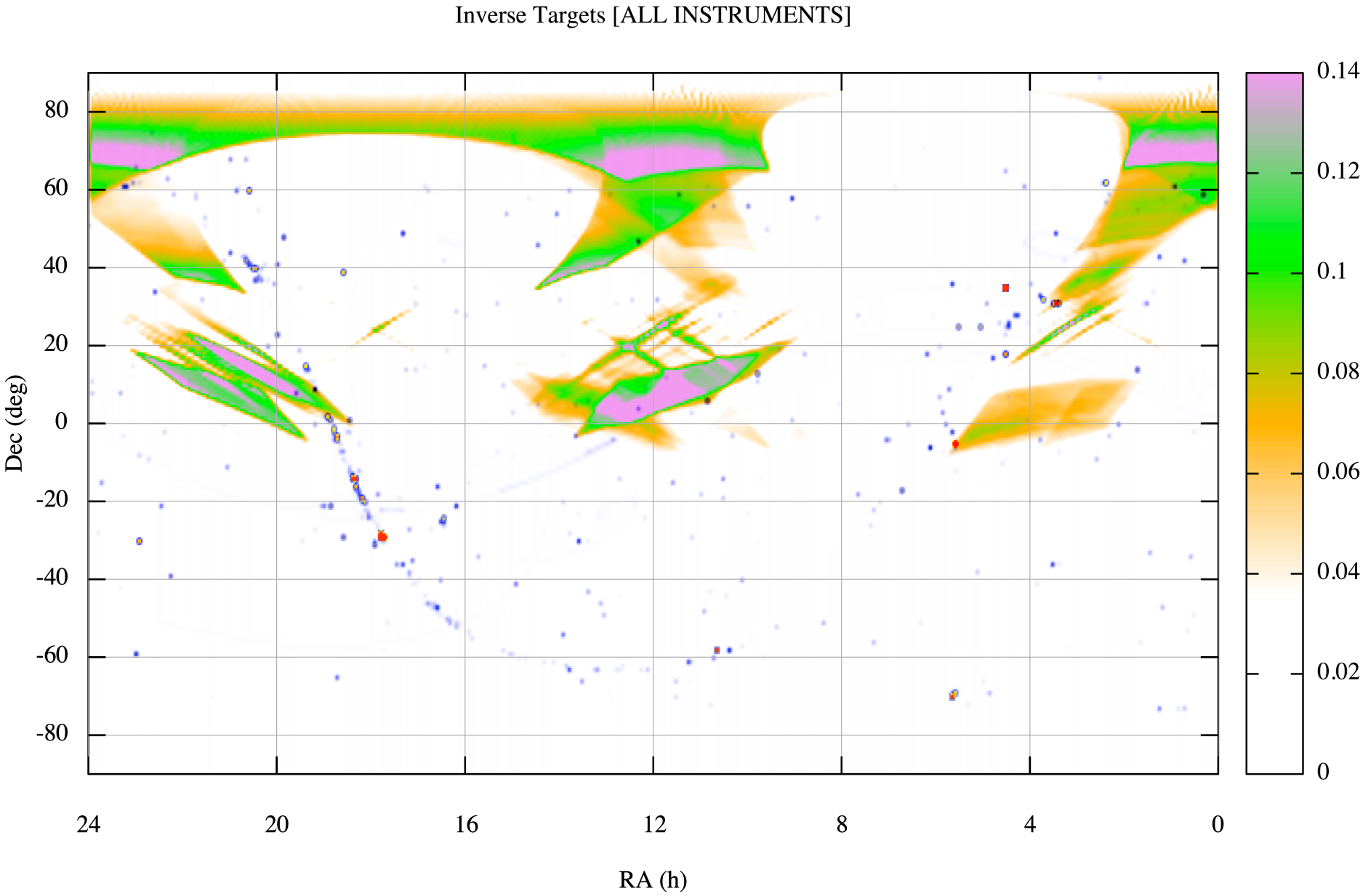
- Standard
- Impact/ Joint Impact
- Thesis Enabling Program - New
  - Enabling PhD thesis research "based in a substantial part" on SOFIA observations.
  - If accepted, place in the "Priority 1" category
  - Grant funding
    - Up to 2 yrs of fully burdened grad. student cost plus travel support; bounded by $100k per year
- SOFIA Survey
  - Include additional visual guidance to under-represented areas of the sky in CfP - New
- ToO

New SOFIA Policies

- Advertise “dead legs” to the community with a short turn-around time ~1 week => Flash Email and post on SOFIA website requesting DDT proposal
- Allow “mini deployments” to airports other than Palmdale
- Include “sky density maps” for each instrument with Cycle 6 Call for Proposals, emphasizing where targets are needed to complement popular areas of the sky

(https://www.sofia.usra.edu/science/proposing-and-observing/proposal-calls/cycle-6/complementary-sky-positions-cycle-6)

Example of Sky density map for Palmdale deployment



Preparing for the Senior Review 2019

- Formulate the most important science accessible to SOFIA based on NASA's strategic vision
- Define how SOFIA can uniquely address this science or uniquely contribute important pieces in synergy with other observatories
- Must make investments and prioritize efforts to focus on the science themes that SOFIA can do well and can do uniquely

  => filling gaps between JWST & ALMA
- Must restrict the suite of instruments offered

Ask not what SOFIA can do for you, but what you can do for SOFIA

- It is time for every SOFIA observer to exercise his/her duty to vote.
- For the upcoming Senior Review of SOFIA, two metrics will be important: published papers and proposals for observing time.
- If continuing SOFIA beyond 2019 is important to you, we are asking you to vote with your feet, namely by *writing* SOFIA papers and *proposing* to Cycle 6.
- Lots of papers need to be published asap:

  "Vote early and vote often"