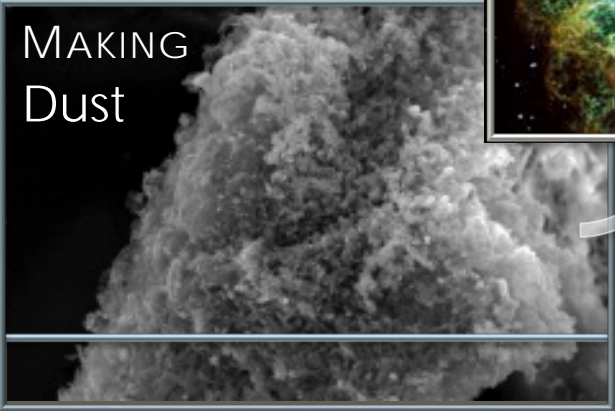
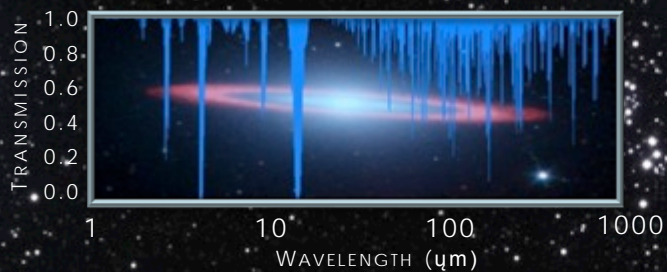


OBSERVING THE CYCLING OF Matter IN THE INFRARED



SOFIA Update
Science Vision

SOFIA
*Stratospheric Observatory
for Infrared Astronomy*



Presented to:
Spectroscopy with SOFIA
Ringberg

Presented by:
SOFIA Project Scientist
Kimberly Ennico Smith

Dr. Kimberly Ennico Smith

- Started as SOFIA Project Scientist, December 1, 2016
- Based at NASA Ames Research Center, Moffett Field, California
- Kimberly.Ennico@nasa.gov <- Love to capture all that's happening with SOFIA today

Commissioning FORCAST Grisms 2013



New Horizons Pluto Fly-By 2015



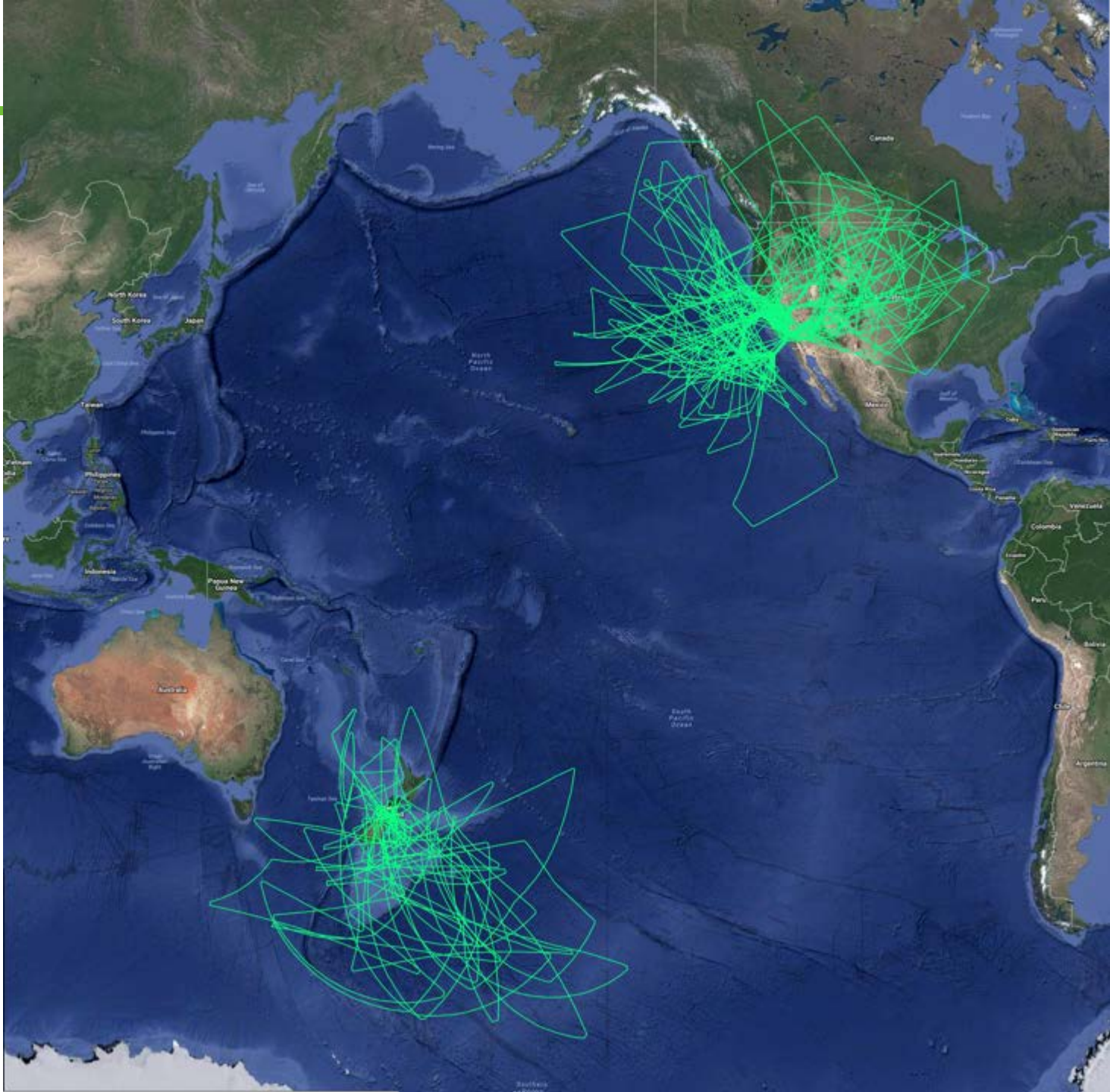
@kennicosmith

Completed Science Cycle 4 on February 3, 2017

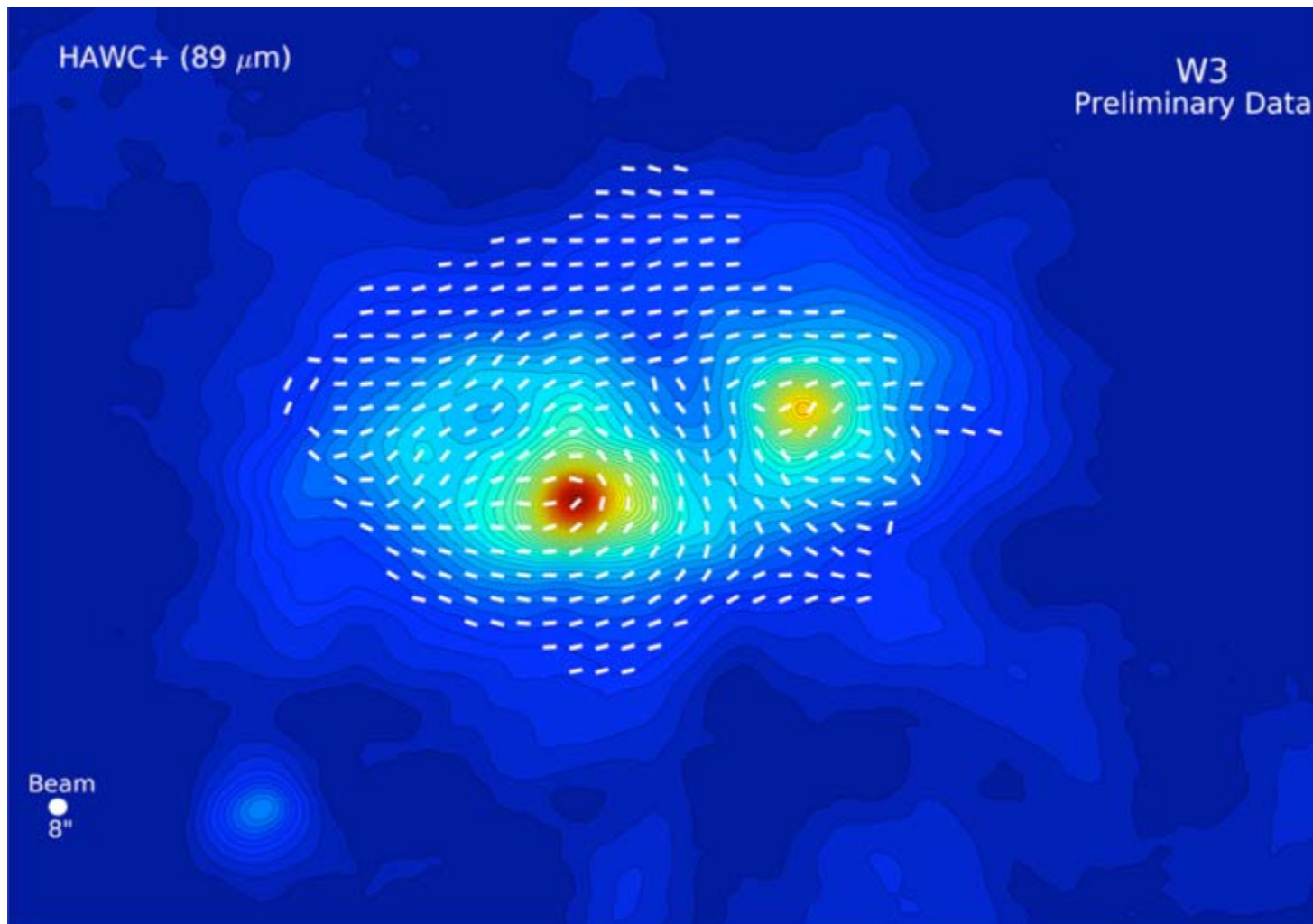
- Satisfied Level 1 Requirement to provide 80% of planned research hours
- **Completed 646 research hours: 386 General Observer**, 106 GTO, 20 DDT, 134 Calibration
- Completed commissioning and initiated observations with new science capability
 - upGREAT High Frequency Array (HFA):
October 3, 2016
 - HAWC+ science instrument:
December 15, 2016
- Completed planned Observatory Maintenance/Upgrades
 - Observatory System Software updates, including Telescope Systems
 - Avionics Communication System Upgrade – required for international operations



Cycle 4 (cont.)



Cycle 4 (cont.)



HAWC+ Bands

53 μm

63 μm

89 μm

154 μm

214 μm

Linear
Polarization
in all bands

First Images Demonstrate the Capabilities of SOFIA's New Instrument, HAWC+

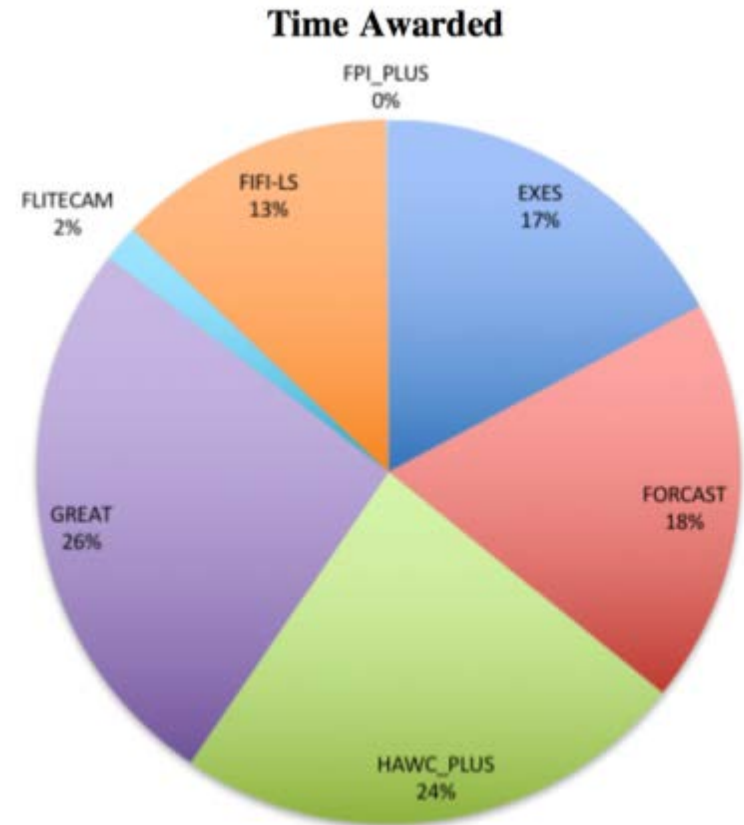
This image shows how dust grains are aligned in the W3 star-forming region, a giant molecular cloud in the constellation Cassiopeia approximately 6,200 light years from Earth. Researchers are now comparing data from these observations with models that predict how stars form.

Credit: NASA / SOFIA / Caltech / Darren Dowell

Initiated Science Cycle 5 on February 7, 2017

Science Cycle 5 Attributes

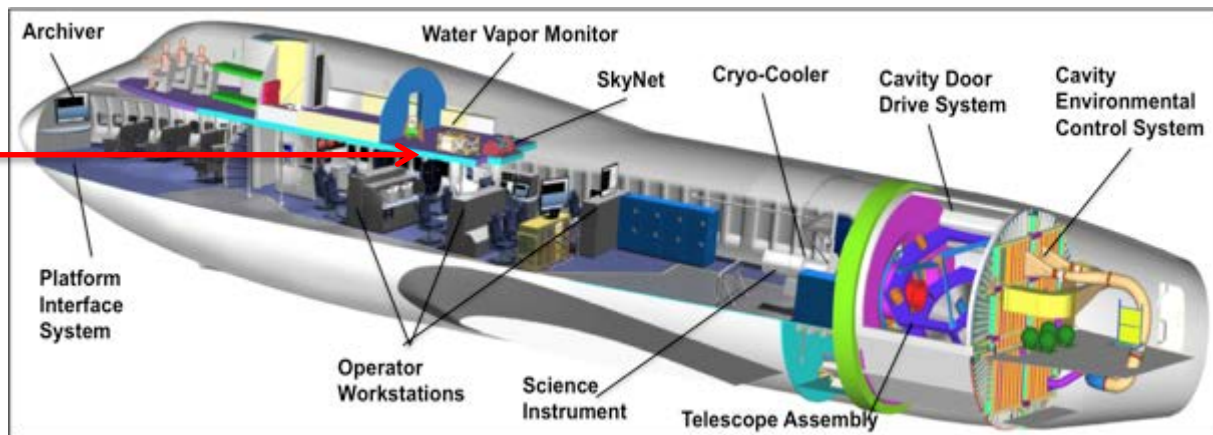
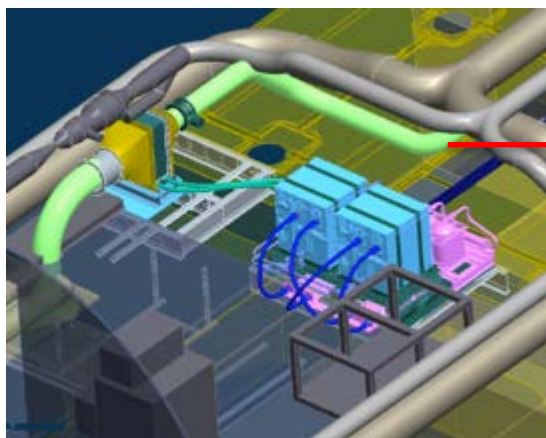
- 116 total flights: 102 science, 2 commissioning, 12 engineering/ferry, and increased contingency flight opportunities (22%)
- **758 Research Hours:** 505 General Observer, 100 GTO, 45 DDT, 108 Calibration
- Southern Hemisphere Deployment in Christchurch, New Zealand
 - June 21 – August 13, 2017
 - 3 Science Instruments (upGREAT, FIFI-LS, and FORCAST)
 - NASA HQ-directed Kuiper Belt Object (MU69) on July 10, 2017 in support of New Horizons Mission, provided path is within operational range for return-to-base to Christchurch, New Zealand



General Observer Time

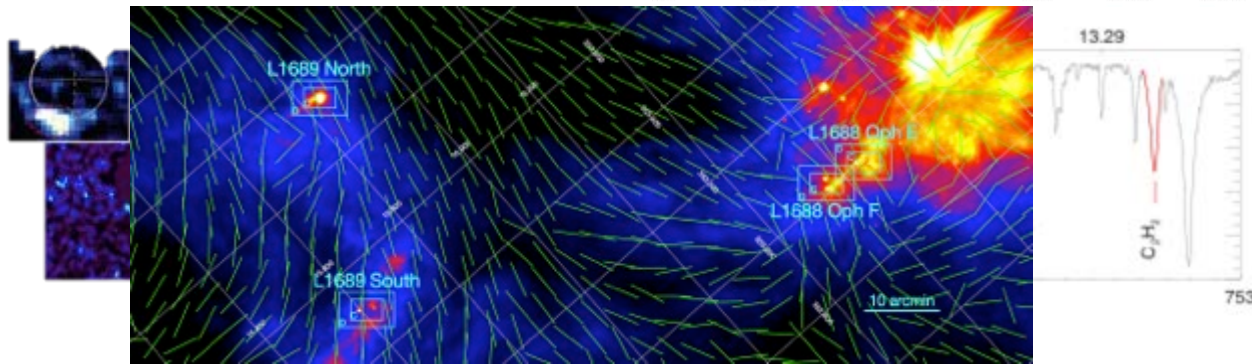
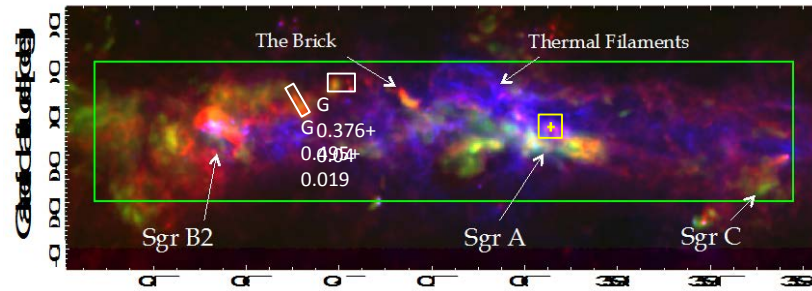
Cycle 5 (cont.)

- Planned Observatory Maintenance/Upgrades
 - 2 Channel Cryo-cooler upgrade to be installed during **March/April** Maintenance/Upgrade Period #13 to support upGREAT/4GREAT commissioning and New Zealand operations
 - HAWC+ ADR vibration heating issue to be repaired during **May 19 - Sept 11, 2017**
 - Aircraft C-Check planned for **November 18 – December 30, 2017**
- Science Community / Public Engagement Opportunities
 - Tours in support of AA Education request for Great American Eclipse, **August 21, 2017**
 - Deployment to American Astronomical Society (AAS) Meeting in Washington D.C. area, **January 6-12, 2018**

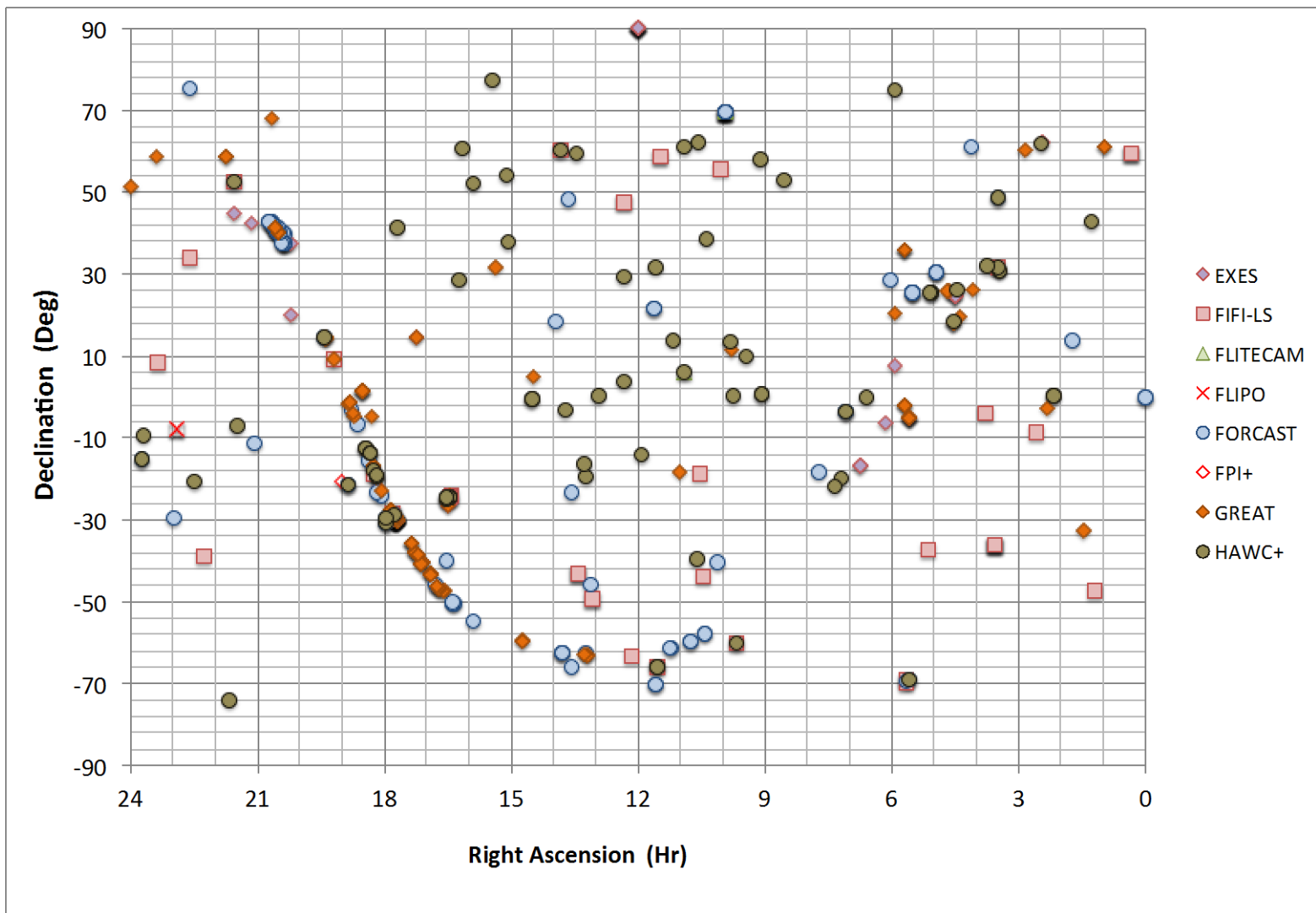


Cycle 5 (cont.)

- High Priority, High Impact Science Observations
 - upGREAT Galactic Center C+ Mapping and [O I] Mapping
 - Time-critical Europa observations on **March 15th** and **May 26th, 2017**
 - Triton Occultation from Daytona Beach, Florida on **October 5, 2017**
 - High-Resolution Molecular Line Survey towards Orion IRc2
 - Joint SOFIA HAWC+/ALMA study of magnetic fields



Cycle 5 Selected Targets



Cycle 6 – February 1, 2018 – January 31, 2019

Proposal Schedule

- Call issue: May 1, 2017
- Call update: June 5, 2017
- US Proposal deadline: June 30, 2017
- German TAC deadline: ~July 8, 2017
- US TAC: week of 14 August 2017
- German TAC: early September
- Selections announced: October 2017

Program Allocations

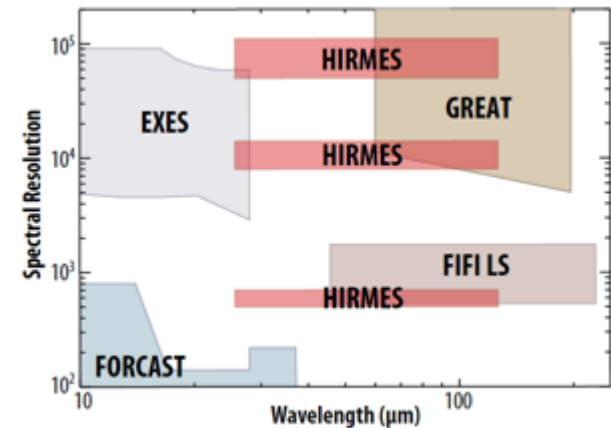
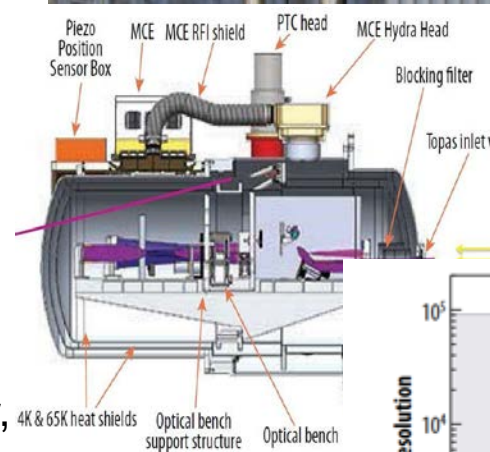
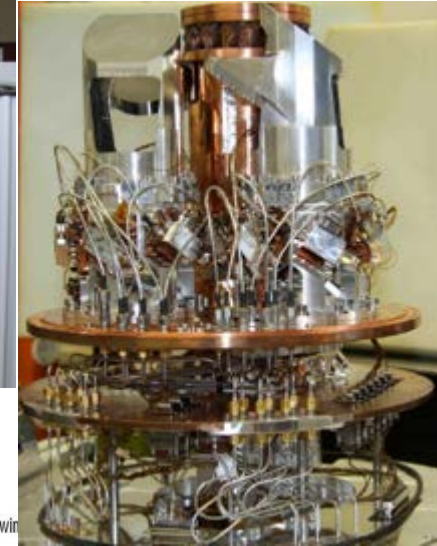
- 104 Science Flights, 560 Call for Proposal (CfP) Hours
- US: 476 CfP Hours (Assumes 50 US GTO hours)
- German: 84 CfP Hours (Assumes 55 DE GTO hours)
- Southern Hemisphere Deployment in June-July (two instrument baseline)

Program Manager considering changes to series and flight cadences

Science Capabilities Updates

- upGREAT 4GREAT and LFA/HFA configurations – **commissioning Summer 2017**
 - Enabled by the cryo-cooler upgrade
 - 4 GREAT (0.492– 0.635, 0.892–1.1, 1.2 – 1.5, 1.81–1.91 THz)
 - LFA 1.9 – 2.5 THz (14 pixels) OH lines, [CII], CO series, [OI]
 - HFA 4.7 THz (7 pixels) [OI]

- **HIRMES**
 - Delta-PDR Mar 8 & 9, 2017
 - CDR Aug 14, 2017
 - **Commissioning Spring 2019**
 - R = 600-100,000 over 25-122 μm
 - Characterize mass of gas, water vapor, water ice, measure ice to rock mass in protoplanetary disks, H/D ratios in stellar outflows, high states in the CO ladder to probe structure & kinematics of AGB stars, ...

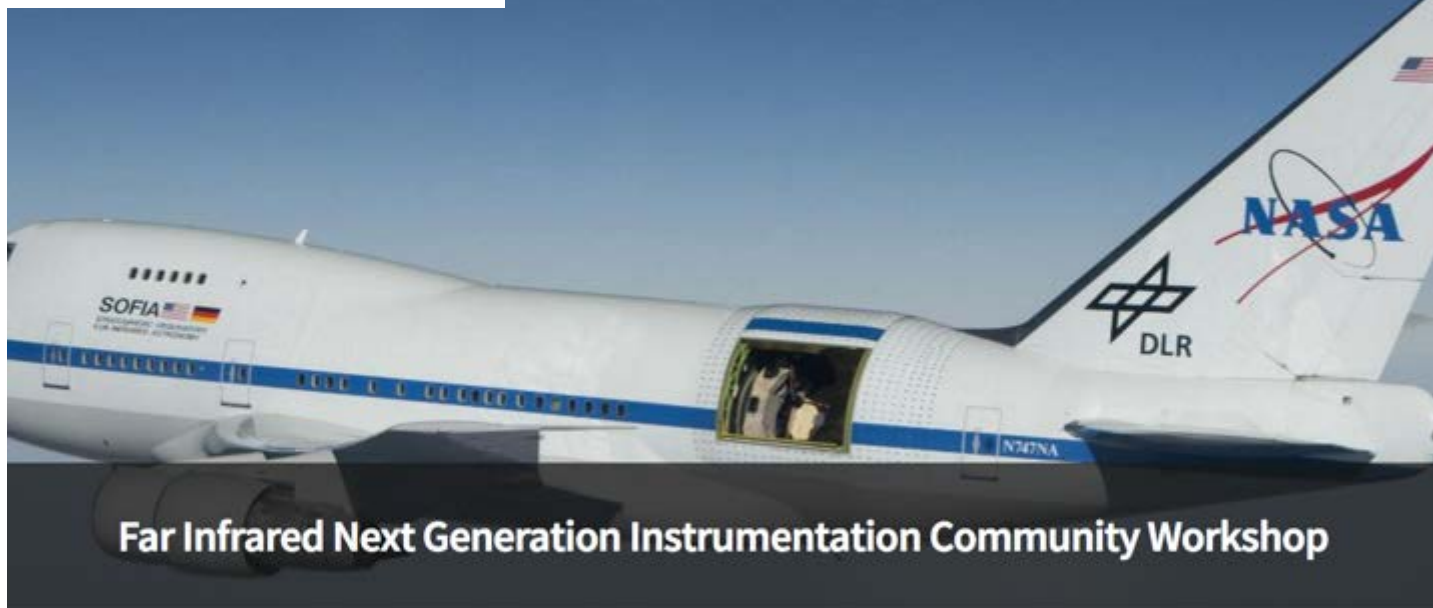


Instrumentation Updates (cont.)

Far-IR Science Interest Group (SIG)

Home SIG Leadership Council Seminars **Upcoming Events** Documents

March 23, 2017



If you were awarded 200 hrs on SOFIA or a series of many balloon campaigns what would you do with that time?
What science areas are not being addressed by our current far-IR (20-600 micron) platforms?
Where are our critical technology gaps?

We want to hear from you! Please bring your answers to those questions, and share your ideas to shape how we collect future Far-IR data at the Far Infrared Next Generation Instrument Community Workshop, at Caltech, on **Thursday March 23, 2017, 8:30am-5pm PST.**

Instrumentation Updates (cont.)



NASA Next Generation Instrument Call

- Far Infrared Community Workshop, Caltech, Pasadena, CA: **March 23, 2017**
 - Details https://www.cfa.harvard.edu/~mmacgreg/FIR_SIG/workshop.html
 - **Registration / Input Ideas Form <http://tinyurl.com/FIRNextGen-2017>**
-
- Call for new SOFIA Instruments in ROSES-2017
 - <http://solicitation.nasaprs.com/ROSES2017>

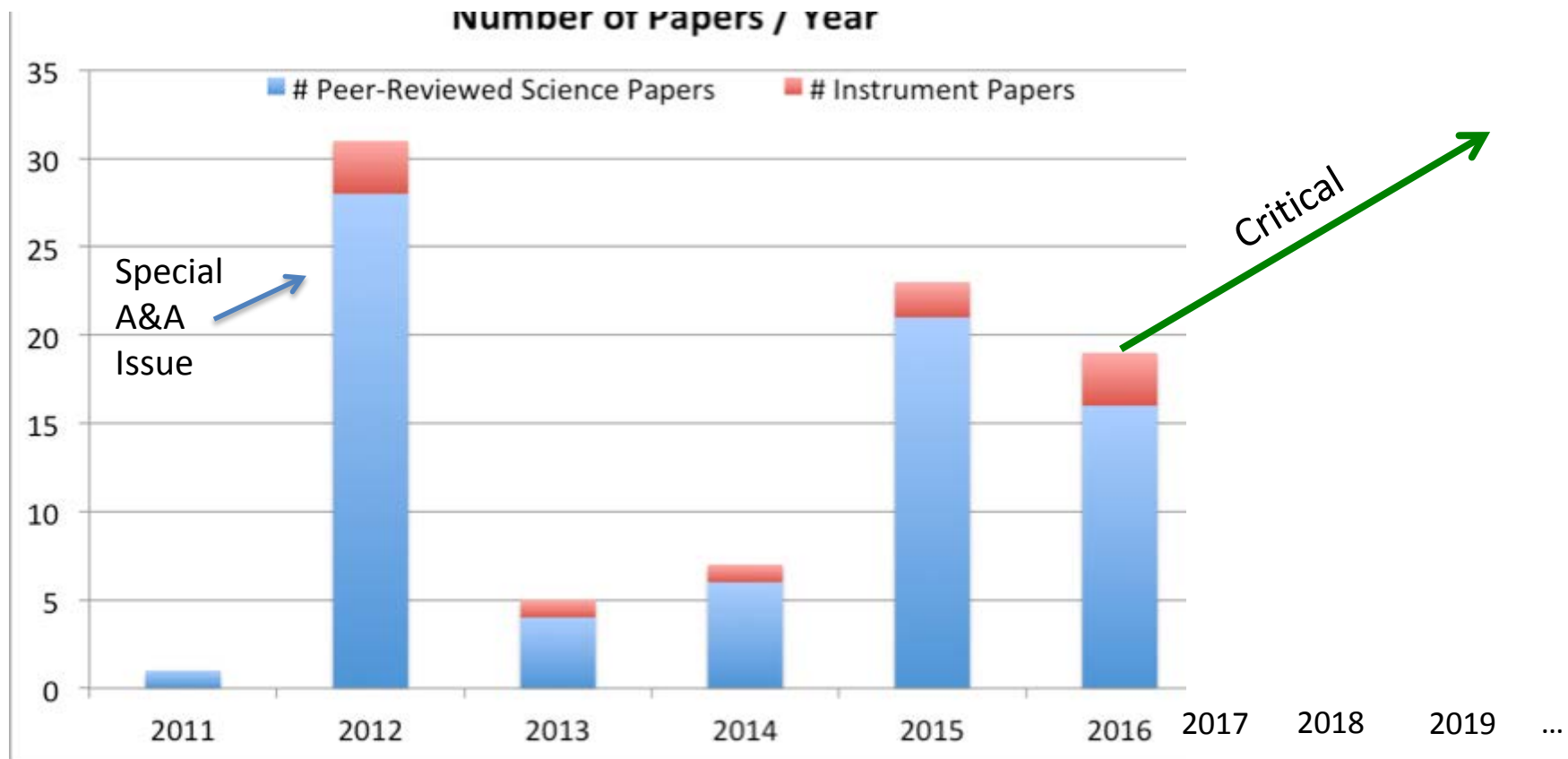
Program Prepares for Senior Review



The 2018 Senior Review is a **new opportunity to describe SOFIA's scientific future.**

- The Senior Review is part of the normal review process for all NASA missions in operations.
- Presents a unique opportunity to propose SOFIA for continued extended mission operations; **i.e. post-prime mission.**
- Central to the proposal must be a unified, integrated science proposal that will serve as the new science vision for the future.

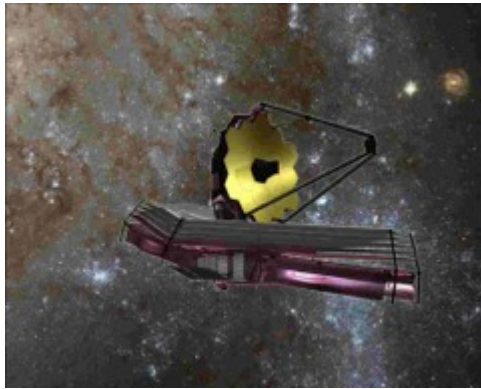
2017 is key for Senior Review – Must Publish!!!!



- As of Feb 28, 2017
- 82 science peer-reviewed papers (A&A, ApJ, Icarus, MNRAS, Nature, Science)
- 10 peer-reviewed instrument/calibration papers (PASP, A&A, JATIS, IEEE, MNRAS)
- Not counting SPIE, AAS Abstracts.

- SOFIA is now the world's prime access to 30-300 μm part of the spectrum.
- SOFIA provides for high-resolution mid-far IR spectroscopy (no other space mission can do that)
- SOFIA provides FIR polarimetry
- Future instrumentation could get us a factor of 3 in sensitivity. That is huge!
- We can be in the science regime Herschel opened up for us.
- How can we use SOFIA as that bridge between JWST & ALMA?
- How can we use SOFIA to fill in the gaps left by Herschel & Spitzer?
- Let's fill in vital missing information (FIR structure lines, energetics, thermal emission, eager to hear results from this conference) in this "era of complicated datasets."

SOFIA onwards and upwards



As we direct the Observatory to a Shared Vision, to be summarized in our upcoming [Senior Review Proposal](#) to NASA.

- What are the questions?
- What [specific questions](#) will we tackle in the next 5 years? Where will we [fill the gaps](#) explicitly? How will we do it?
- Then looking back at those 5 years, did we achieve what we set out to do?
- Can SOFIA continue to answer those specific questions? How then can we push forward for the next, next 5 years?



I look forward to getting to know this community and listen for those questions to shape the Shared Vision.

Kimberly.Ennico@nasa.gov

Die fliegende Sternwarte SOFIA



https://www.youtube.com/watch?v=km2c79_Pqwg

Back-up Charts

March 2017

SOFIA

*Stratospheric Observatory
for Infrared Astronomy*

Cycle 5 Daily Overview – Page 2 of 2



Tour Eclipse

MS

OC#5 J (FORCAST)										Maintenance / Upgrades #14										DC#5 K (HAWC+)														
Prep					Ferry PMD		Crew Rest			SI Rem.	MD Inst.	CR										Eng LO	Chk Fit	MD Rem	SI Install									
S	M	T	W	T	F	S	S	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9
August -- 2017																				September -- 2017														

Triton Occul

OC#5 K (HAWC+)										OC#5 L (FLIPO)										OC#5 M (FORCAST)														
9 Flights					SI Rem	SI Install	Ferry					Triton			Ferry		3 Flights			SI Rem	SI Install	SI Install												
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14
September -- 2017															October -- 2017																			

OC#5 M (FORCAST)										OC#5 N (HAWC+)										MD Inst.														
6 Flights					SI Rem	SI Install	9 Flights					SI Rem	FerryHAM																					
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S							
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
October -- 2017															November -- 2017																			

A/C in dock/ prep for maint.										Maintenance / Upgrades #15 w/ 'C Check'																								
										C-Check / Warranty CPCP / Deferred Items																								
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S							
19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
November -- 2017															December -- 2017																			

MS

AAS 231st Meeting - National Harbor, MD

Maintenance / Upgrades #15 w/ 'C Check'										OC#5 O' (EXES)																								
Schedule Margin					Gnd Chk	FCF Fit	Release	FerryPMD	Eng LO	MD Rem	SI Install	SI Install	Ferry DC	Tour - Strategic Capacity					Prep	Ferry	8 Flights													
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S							
24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
December -- 2017															January -- 2018																			

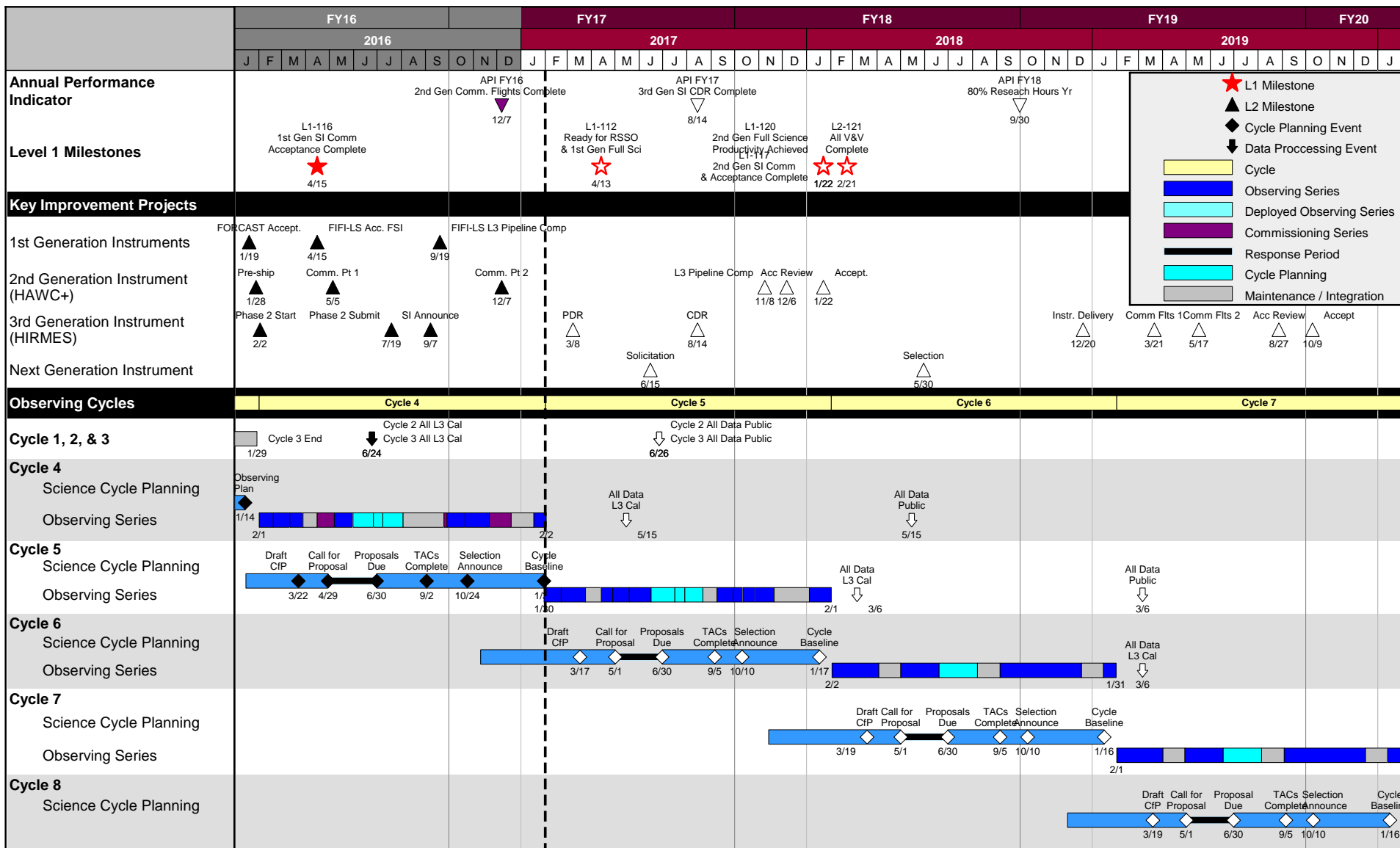
PMB Approved → Cycle 6 Start

OC#5 O' (EXES)										OC#6 A										OC#6 B														
SI Rem					SI Install					SI Rem					SI Install					SI Rem				SI Install										
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3
January -- 2018										February -- 2018										March -- 2018														

Key Observing Cycle: 5 Baseline Science Flights: 102 Baseline RHs: 758 Planned Science Flights: 104 Estimated RHs*: 766 (*Year to date + Estimate) *PMB sequence approval: 2/13/17*

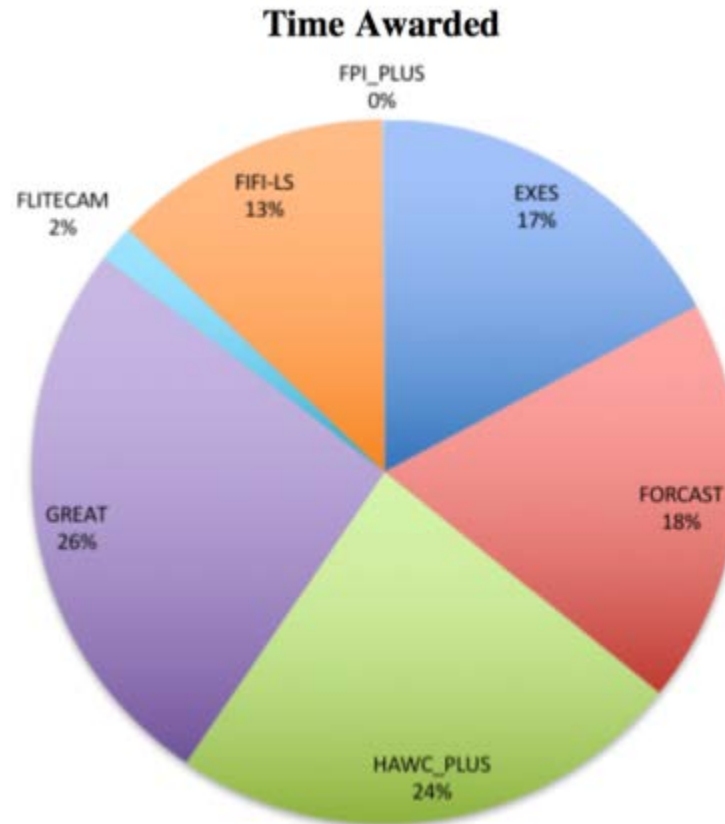
S 7 (black text with no fill)	H 4 (day of week box H or GH w/ red fill)	F 6 (bold white text, purple fill, bold border)	F 6 (bold white text, blue fill, bold border)	F 6 (bold white text, green fill, bold border)	F 6 (white star on day of week)	F 6 (single slash through day and date)
W 6 (black text w/ day box grey fill)	F 6 (bold border)	F 6 (day box with purple fill)	F 6 (day box with blue fill)	F 6 (day box with green fill)	F 6 (yellow star on date)	F 6 (x through day and date)
F 6 (day and date shown in red)	F 6 (day and date box filled with lt. green)	F 6 (bold white text, light blue fill, bold border)	S 28 (colored fill only lower half, bold bdr.)	S 13 (two colored fill)	<input checked="" type="checkbox"/>	F 6 (orange fill on day of week)
Weekend day	US or German Holiday	Instr. Commissioning Flight	Observing Flight	Ferry/Maint./Non-Sci Flight	Educator on Flight	Return to Base (RTB) Flight
Work day	Line Operations	Contingency Instr. Comm. Flight	Contingency Obser. Flight	Contingency Ferry/Maint./Non-Sci Flt	Media/VIP on Flight	Canceled Flight
AFRC Regular Day Off	Possible Maint/Up. Check Fit	Deployment Observing Flights	Short Flight	Half Sci. & Half Ferry/Maint./Non-Sci	Restored Flight	Strategic Capacity

SOFIA Top-Level Schedule



Cycle 5

- 7 Instruments in Use
- 3 New Capabilities (HAWC+, upGREAT 4G/HFA and LFA/HFA)
- 3 Instrument Southern Deployment (upGREAT, FIFI-LS, FORCAST)



Four very highly rated proposals were selected to investigate the Galactic Center with **upGREAT**

- [CII] Mapping

- 05_0076 Bally – “Impact Program: The Outer CMZ C+ Survey”
- 05_0022 Harris & 05_0033 Guesten – “Joint Impact Proposal: Mapping C+ Across the Galaxy's Central Molecular Zone”

- [O I] Mapping

- 05_0021 Ragan – “Cooling and kinematics in the Central Molecular Zone”
- 05_0102 Morris – “Characterizing Neutral Gas in the Central Parsec of the Galaxy”

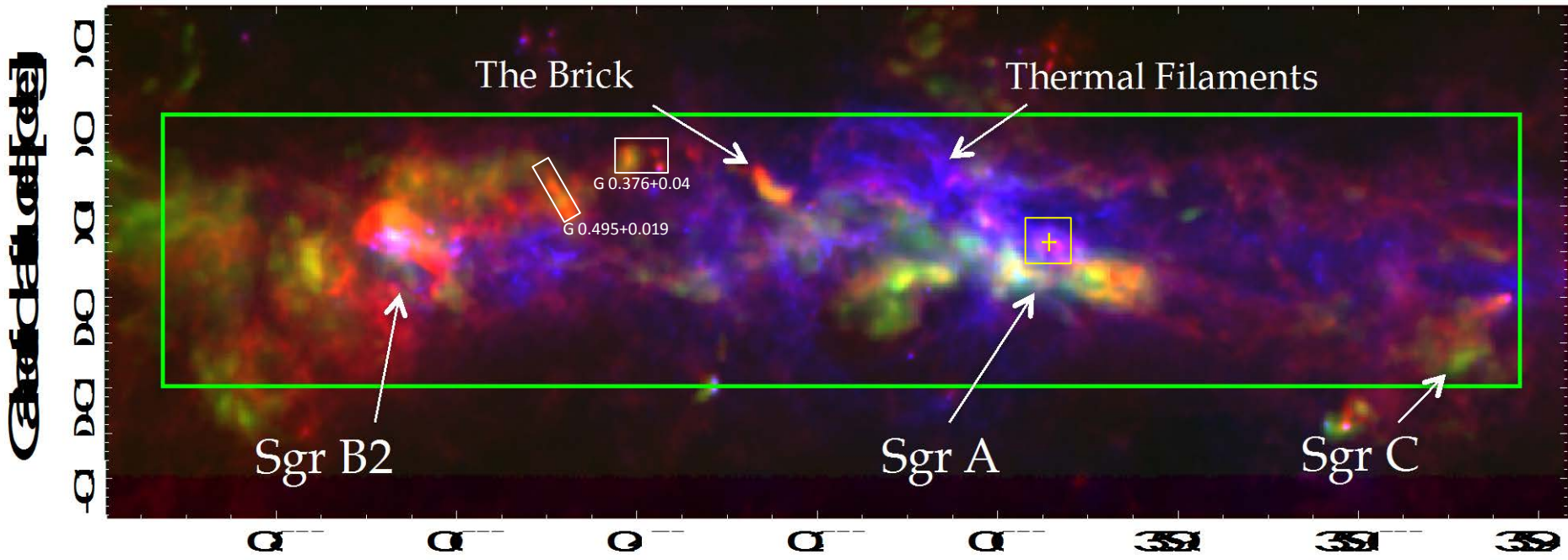
Comparison of Mapped Regions



Yellow: 05_0076 Bally

White: 05_0022/0033 Harris-Güsten

Ragan and Morris Fields



White Boxes: 05_0022 Ragan
Yellow Box: 05_0102 Morris

Cycle 5 Highlight – Water on Europa



- 05_0153 Sparks
“Confirmation of Water Plumes on Europa”
- Observations with **EXES** at $6.27 \mu\text{m}$ (H_2O vibrational band) to confirm HST observations of water plumes on the moon of Jupiter.
 - SOFIA observations Mar 15 & May 26
 - HST observations Mar 12 & 23
- These observations would provide input to a future Europa probe mission.

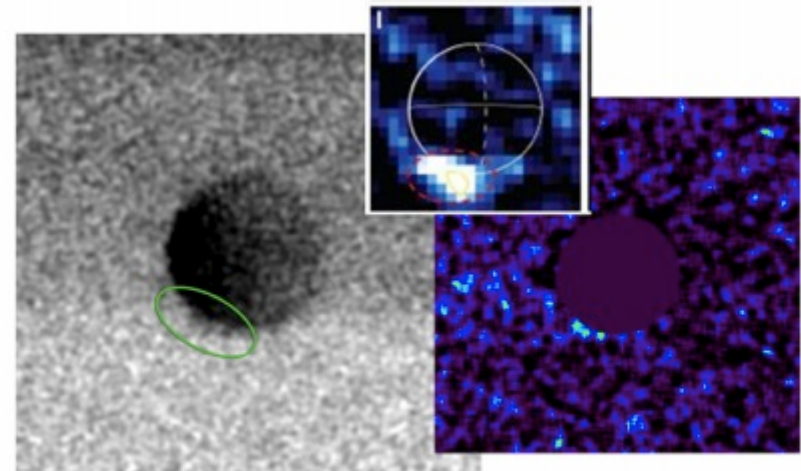
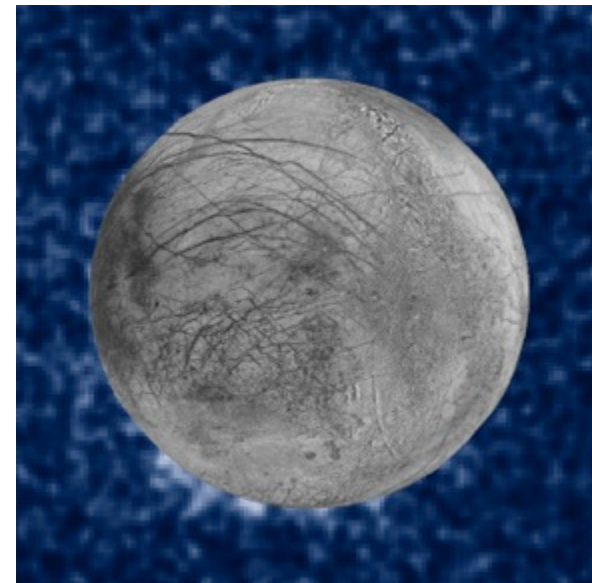
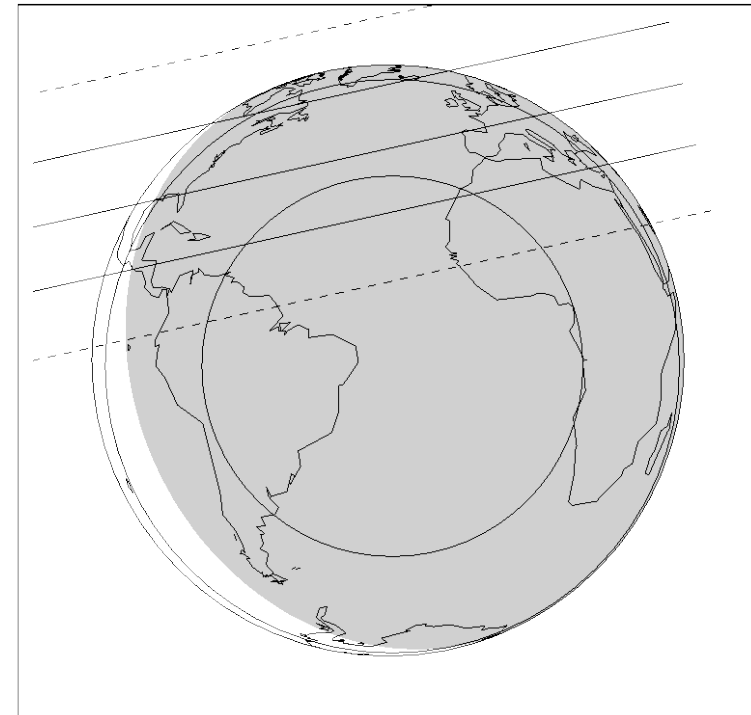


Fig. 1. Left, STIS transit image Jan 2014 with ellipse indicating dark off-limb features. Upper center, “plume” image from Roth et al (2014). Lower right, probability image for transit, indicating significance, formally (Sparks et al 2016). Peak is $\approx 4.0\sigma$.

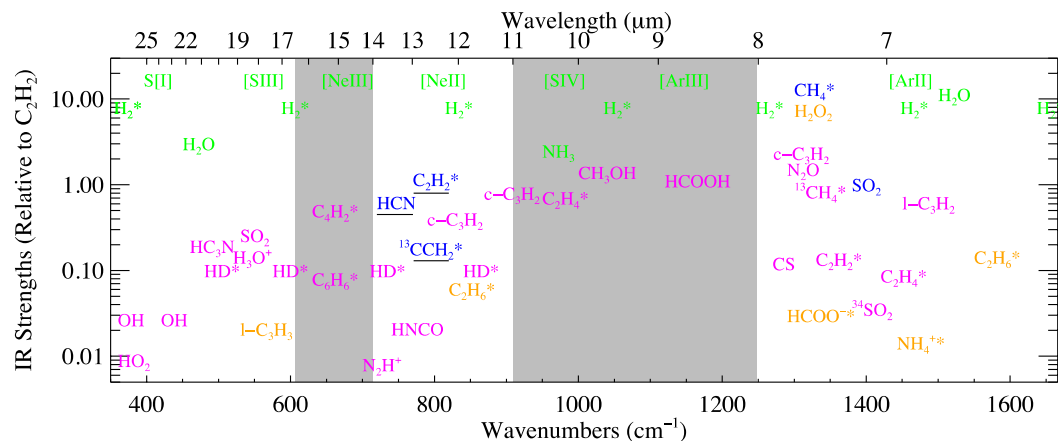


- 05_0125 Person – “A New Look at Triton's Atmosphere”
- To characterize the atmosphere of Neptune’s moon Triton. Monitoring of Triton’s expanding atmosphere has not been re-examined since 2001.
- **FLITECAM/HIPO** observations of Triton occulting a R=12 mag star Oct 6, 2017.
- Will be conducted using GTO time.
- Requires a mini-deployment to the US East Coast.



Cycle 5 Highlight - High Resolution Spectral Survey

- 05_0043 Naseem Rangwala
An **EXES** High-Resolution Molecular Line Survey towards Orion IRc2, a prototypical hot-core source.
- Unprecedented resolving power ($R = 50,000$) will be 5 to 50 times more powerful than ISO in identifying narrow lines
- Study will provide a wealth of information on hot core chemistry

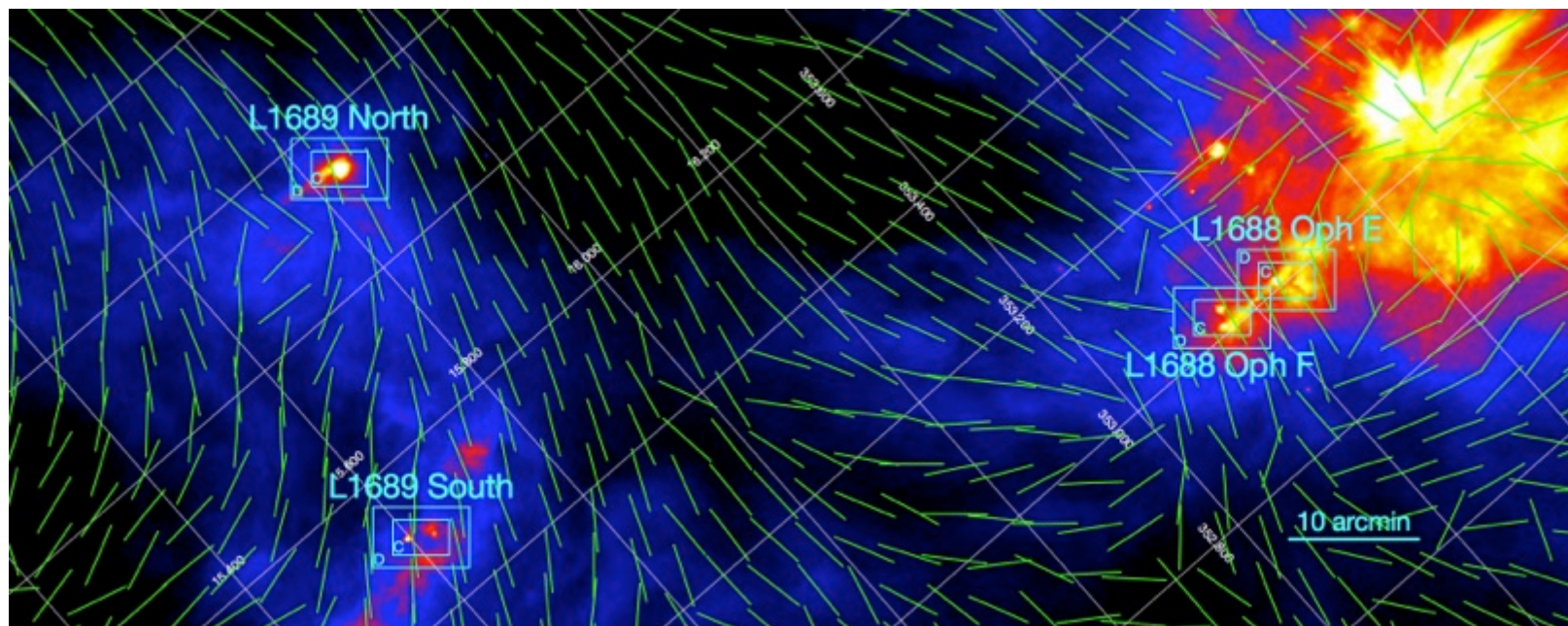


● IR bands detected towards IRc2 ● Not detected in IR towards IRc2 ● Never detected in ISM ● Very bright/not to scale

- Spectrum from Cycle 3 pilot program toward IRc2
- Likely molecules from hot core models

Cycle 5 Highlight - Studying Magnetic Fields

- 05_0133 Novak - “Joint **HAWC+**/ALMA study of magnetic fields in Ophiuchus”
- HAWC+ will have 35x better angular resolution than the Planck polarimeter and provides a bridge to the very much higher resolution observations of ALMA



Large scale B-field directions from Planck 850 μm polarimetry superposed on Herschel 160 μm dust emission. Individual targets are being studied using ALMA.

State of the Observatory

Program Completed Science Cycle 4 on February 3, 2017

– Satisfied Level 1 Req to provide 80% of planned research hours (**646 RHs**)

RH Trend Chart



	Cycle 1 CY13	Cycle 2 CY14	Cycle 3 CY15	Cycle 4 CY16	Cycle 5 CY17
■ Baseline RH (Beginning of Cycle)	313.30	256.30	548.00	808.00	757.80
■ Actual (and Projected) RH	200.20	278.90	518.13	646.50	

■ Baseline RH (Beginning of Cycle) ■ Actual (and Projected) RH

Cycle Comparison Table

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
CfP Date	14-Nov-11	29-Apr-13	29-May-14	1-May-15	29-Apr-16
Cycle Execution	Jun 2013- Feb 2014	Feb 2014- Feb 2015	Mar 2015 - Jan 2016	Feb 2016 - Jan 2017	Feb 2017 - Jan 2018
US Hours Offered	200	175	450	500	476
DE Hours Offered	48	47	45	80	75
US Proposals	132	89	122	155	179
DE Proposals	39	27	31	30	26
US Hours Requested	1293	545	1075	1582	1749
DE Hours Requested	186	67	104	150	221
US Approved Proposals	42	62	63	80	71
DE Approved Proposals	18	19	24	18	15
US Hours Awarded*	178	165	419.5	478.3	462
DE Hours Awarded*	52.5	43.8	45.8	80.4	74
Hours Executed	149	173	327	275	

* Does not include "Do If Time"

As of 1 Oct 2016