SOFIA Science Highlights
Cycle 4 Progress
Cycle 5 Call for Proposals

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SOFIA Science Center
Executive Summary - Since Last SUG

• Completed Cycle 3
  – 319 Hours GI Time
  – 122 Hours GTO Time
  – 5 Hours DDT

• Horsehead Nebula DDT Data Released

• Started Cycle 4 on 1 Feb 2016
  – OC4A - 8 FORCAST Flights Scheduled
  – OC4B - 9 FIFI-LS Flights Scheduled
    • -2 cancelled, +1 contingency
  – OC4C - 4 EXES Flights Scheduled
  – OC4D - 10 upGREAT Flights Scheduled
    • In progress
    • 3.5 flights lost, 1 contingency scheduled

• HAWC+ Commissioning started

• Cycle 5 Call for Proposals Released

• We are ready to go on deployment next week
## Cycle 3 Summary Statistics

<table>
<thead>
<tr>
<th>Campaign</th>
<th>Net Rights</th>
<th>Instrument</th>
<th>Flight Hours</th>
<th>GTO Hours</th>
<th>GI Hours</th>
<th>Cal Hours</th>
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| Totals   | 69         | 640.18     | 121.75       | 319.40    | 101.30   | 5.08      | 81.15     |

Note: CAL Hours includes 0.5 hour per flight for TA setup. OTHER includes Climb and Descent Time of typically 1 hour per flight, dead legs, and engineering legs.
SOFIA Demonstration Observations

• Motivation for this observation was multifold:
  – Highlight a new capability that would be of wide interest to the SOFIA community
  – Provide a scientifically relevant data set for analysis
  – Demonstrate SOFIA’s capability to deploy state-of-the-art instrumentation
  – Provide useful materials for science and public outreach

• Observations
  – Director’s Discretionary Time
  – [C II] 158 μm map of the Horsehead Nebula with the upGREAT 14-pixel heterodyne array
  – Observations made on 10 December 2015
  – Comparable observations would have taken ~200 hours on Herschel

  Calibrated data cubes are available to the astronomical community with no proprietary restrictions
DDT Demonstration Observation
upGREAT [C II] Map

Averaged line profile over mapped region. Smoothed to 0.76 km/s velocity resolution.
DDT Demonstration Observation
upGREAT [C II] Map

Horsehead C+ emission

Averaged line profile over mapped region. Smoothed to 0.76 km/s velocity resolution

GO 3-2 SuperCam on the APEX Telescope (Stanke 2015)
## Cycle 4 Progress

Through 25 May 2016

<table>
<thead>
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<th>Campaign</th>
<th>Net Rights</th>
<th>Instrument</th>
<th>Flight Hours</th>
<th>GTO Hours</th>
<th>GI Hours</th>
<th>Calibration Hours</th>
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<th>Engineering Hours</th>
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Cycle 4 Research Hours Progress

HAWC+ Commissioning and Maintenance/Upgrade #10 swapped
M42 Observed with FIFI-LS

M42 - continuum at 158 µm

M42 - [CII] flux

Image: log stretch; linear contours for [CII] flux

Image: linear stretch; log contours for 158 µm continuum
• What is the role of density waves on star formation in grand design spirals?

• Joint Impact Proposals:
  04_0116 Pineda (JPL)
  04_0122 Stutzki (Köln)

• Velocity-resolved observations of 158 μm [C II] line with upGREAT heterodyne spectrometer and mapping with FIFI-LS of inter-arm regions in classic spiral galaxy M51

• For the first time, the molecular gas will be mapped in the principal cooling line of the ISM over an entire galaxy

• Project is also a demonstration of the technological advancements of SOFIA, providing mapping speeds more than an order of magnitude faster than Herschel.
Results recently published by Encrenaz et al., 2016, A&A, 586, A62

D/H ratio is a diagnostic of the past history of water
- Global enrichment of the heavier deuterated water gives a measure of the original amount of water on the planet
- Local variations in D/H ratio can reveal sources and sinks of water vapor on Mars

Measurements made with EXES at 7.2 mm where lines of both $\text{H}_2\text{O}$ and HDO are present.
- Maps of abundance ratio obtained over surface of Mars at $R \sim 100,000$

Disk integrated D/H is 4.4 times Vienna Standard Mean Ocean Water (VSMOW) abundance.
- Consistent with previous determinations that vast majority of the primordial water on Mars has escaped

Deuterium/ Hydrogen ratio expressed as factor of Vienna Standard Mean Ocean Water abundance. Observed enrichment of Mars is a factor of 4 to 5 times Earth abundance.
Mid-infrared spectral maps of Jupiter for ortho/para H$_2$

Equatorial/high-lat para fraction is below/above equilibrium value

Low-para H$_2$ from depth is upward transported to equator

Low-para H$_2$ rapidly equilibrates on aerosols at high-latitude, and sinks back

(Fletcher w/Reach, Submitted to Icarus)
HAWC+ First Light

Jupiter and family at 53 μm
SOFIA Cycle 5 Assumptions

• Program Office Guidance
  – 104 Science Flights
  – NASA: 476 CfP Hours
    • Note: Assumes 50 US GTO hours
  – DLR: 84 CfP Hours
    • Note: Assumes 55 DE GTO hours (33% German of allocation)

• Cycle 5 period: 1 February 2017 - 31 January 2018

• Southern Hemisphere Deployment in June-July
  – Two instrument baseline

• Available US funding: $5 M
Major Changes from Cycle 4

• Added capabilities:
  – HAWC+ commissioned, FIFI-LS as Facility Instrument
  – upGREAT High Frequency Array availability pending successful commissioning

• Capabilities Not Offered:
  – Cross dispersed FORCAST spectroscopy
  – M channel (2.7 THz) for GREAT
New capabilities - details

- FIFI-LS will be operated as a Facility Instrument with full support of SMO.
- GREAT H-channel will be offered in standard L2/H configuration. HFA will be commissioned after proposal selection. Availability of array is listed as “contingent on successful commissioning”, and L2/H proposals may be changed to L2/HFA if successful.
- HAWC+ will be operated as a Facility Instrument with full support of SMO, but performance is shared risk.
• The cross-dispersed modes of FORCAST spectroscopy will not be offered in Cycle 5
• Grism G4 is not usable - severe ghosting
  – Throughput in cross-dispersed mode is only ~10%
  – Low proposal pressure in Cycle 3
  – Same wavelength coverage is available in non-X-dispersed FORCAST
    • To get “decent” S/N in the X-modes you have to smooth to ~the resolution of the non-X modes
  – For individual lines or narrow wavelength ranges, EXES is a better choice
• The M-channel for GREAT will not be offered in Cy 5.
  – Low proposal pressure
  – Too many modes to support and not enough flight opportunities to support configuration changes (Güsten)
“Impact Programs”

- Large, multi-year (2-3 cycles) programs, aimed at specific scientific questions of high potential impact (not, primarily, “just” surveys).
  - Anticipate selecting 2-3 with 100hr-class observing each
  - Any instrument combination (except no mix of FSI/PSI and SSI)
- To encourage US-German scientific collaboration, the queues will allow submission of joint “Impact program” proposals to the US and German queues. If the two proposals are both successful the programs will be merged with the US and DE PIs becoming co-PIs on the resulting program and the time charged 80:20.

- Continuation of successful category introduced in Cycle 4
- Added language to emphasize importance of broader impact of investigations
Timeline

- Call issued: April 29, 2016
- Call update: June 10, 2016
- Proposal deadline: July 1, 2016
- German TAC: early September 2016
- Selection announced: October 1, 2016
