The Stratospheric Observatory for Infrared Astronomy (SOFIA)

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This talk is at: http://www.sofia.usra.edu/Science/speakers/index.html

38th COSPAR Scientific Assembly, Bremen, Germany, 21 July 2010

R. D. Gehrz
Outline

- SOFIA Description and Status Report
- SOFIA First-Light Images
- SOFIA Performance Specifications
- SOFIA Schedule and General Investigator (GI) Opportunities
- Summary
**SOFIA Overview**

- 2.5 m telescope in a modified Boeing 747SP aircraft
  - Imaging and spectroscopy from 0.3 \( \mu \text{m} \) to 1.6 mm
  - Emphasizes the obscured IR (30-300 \( \mu \text{m} \))

- **Operational Altitude**
  - 39,000 to 45,000 feet (12 to 14 km)
  - Above > 99.8% of obscuring water vapor

- **Joint Program between the US (80%) and Germany (20%)**
  - First Light images were obtained on May 26, 2010
  - 20 year design lifetime – can respond to changing technology
  - Ops: Science at NASA-Ames; Flight at Dryden FRC (Palmdale- Site 9)
  - Deployments to the Southern Hemisphere and elsewhere
  - >120 8-10 hour flights per year
The Advantages of SOFIA

- Above 99.8% of the water vapor
- Transmission at 14 km >80% from 1 to 800 µm; emphasis on the obscured IR regions from 30 to 300 µm
- Instrumentation: wide variety, rapidly interchangeable, state-of-the-art – SOFIA is a new observatory every few years!
- Mobility: anywhere, anytime
- Twenty year design lifetime
- A near-space observatory that comes home after every flight
The SOFIA Observatory

- Educators work station
- Pressure bulkhead
- Open cavity (door not shown)
- TeleSCOPE
- Scientific instrument
- Scientist stations, telescope and instrument control, etc.
Nasmyth: Optical Layout

Observers in pressurized cabin have ready access to the focal plane

Pressure bulkhead

Spherical Hydraulic Bearing

Nasmyth tube

f/19.6 Focal Plane

Focal Plane Imager

Primary Mirror M1

M2

M3-1

M3-2
Back End of the SOFIA Telescope
SOFIA First Generation Instruments

The Eight First Generation SOFIA Science Instruments (SIs)

- IRS LOW
- IRS HI
- MIPS
- IRAC
- FLITECAM w/ grisms
- HIPO
- FORCAST w/ grisms
- MIPS-HAWC
- EXES
- FIFI LS
- Herschel (outer limits)

Wavelength [μm]

Spectral resolution

10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8

1 10 100 1000
Photometric Sensitivity and Angular resolution

SOFIA is diffraction limited beyond 25 µm (θ_{min} ~ \lambda/10 in arcseconds) and can produce images three times sharper than those made by Spitzer.

SOFIA is as sensitive as ISO
Early Science with FORCAST and GREAT

Faint Object infraRed Camera for the SOFIA Telescope (FORCAST)

- Mid IR, two-channel camera
- 0.75”/pixel 4-8 µm, 16-40 µm
- R = 200 grisms beyond early science

German REceiver for Astronomy at Terahertz frequencies (GREAT)

- Heterodyne spectrometer
- Dual-channel 1.6-1.9 THz, 2.4-2.7 THZ (111-125 µm, 158-188 µm)
SOFIA First Generation Instruments

The Eight First Generation SOFIA Science Instruments (SIs)

Early Science SIs

Spectral resolution

Wavelength [μm]
SOFIA Airborne with Door Open!

NASA’s Stratospheric Observatory for Infrared Astronomy 747SP on Dec. 18, 2009. (NASA Photo / Carla Thomas)

EM-0095-27.mov
SOFIA_OpenDoor_100.wmv
SOFIA’s FORCAST First-Light Images: M82

May 26, 2010 UT

SOFIA infrared image (19.7, 31.5, and 37.1 µm)

Inset (visible light)

Visible light image
SOFIA’s FORCAST First-Light Images: Jupiter

Visible light image

SOFIA infrared image (5.4, 24.2, and 37.1 μm)

May 26, 2010 UT
Early General Observer Opportunities

- **First light images** were obtained with FORCAST on May 25, 2010
- **Early Short Science** begins during 2010 with FORCAST and GREAT
  - Teams have been selected
  - Very limited number of flights (~3 per instrument)
  - GO’s will not fly
- **Early Basic Science for General Investigators (GIs)** with FORCAST and GREAT
  - Longer period (~15 Flights) during early 2011
  - The SOFIA Basic Science Call will be released on April 19, 2010; Due date is July 30, 2010
  - [http://www.sofia.usra.edu/Science/proposals/basic_science/index.html](http://www.sofia.usra.edu/Science/proposals/basic_science/index.html)
- **General Investigator (GI) Science**
  - Next call for proposals will be in 2011
  - Flights rate ramps up to over 100 per year by 2014
SOFIA Instrumentation Development Program

• The second call for instruments expected in 2011

• The instrumentation development program will include:
  – New Facility and PI Class science instruments
  – Upgrades to present instruments
  – New technology investigations

• There will be additional calls every 3 years

• There will be one new instrument or upgrade per year

• Funding for new instruments and technology is ~$10 M/yr
Summary

- The Program is making progress!
  - Open door flights began in December 2009
  - First light was achieved on May 26, 2010
  - Science flights will begin in late 2010

- SOFIA will be a premier facility for far-IR and submm astronomy for many years

Our Web site: http://www.sofia.usra.edu/

This talk: http://www.sofia.usra.edu/Science/speakers/index.html
BACKUP
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>Institution and PI</th>
<th>λ range (µm)</th>
<th>Field of View</th>
<th>Date Available</th>
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<tbody>
<tr>
<td>FORCAST (Facility SI)</td>
<td>Faint Object InfraRed Camera for the SOFIA Telescope: Facility Instrument - mid-IR camera and grism spectrometer</td>
<td>Cornell University T. Herter</td>
<td>5 - 40</td>
<td>3.2' x 3.2'</td>
<td>2010</td>
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<td></td>
<td></td>
<td></td>
<td>R ~ 200</td>
<td>256 x 256 @ 0.75&quot; Si:As, Si:Sb</td>
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<td>R = 10⁶ - 10⁸</td>
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<tr>
<td>FIFI-LS (Facility SI - like modes)</td>
<td>Field Imaging Far-Infrared Line Spectrometer: PI Instrument with facility-like capabilities – imaging grating spectrometer</td>
<td>MPE, Garching A. Poglitsch</td>
<td>42 - 210</td>
<td>30&quot; x 30&quot; (Blue)</td>
<td>2011</td>
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<td>R = 1000 - 3750</td>
<td>60&quot; x 60&quot; (Red)</td>
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<td></td>
<td>R = 10⁶ - 10⁸</td>
<td>2 -16 x 5 x 5 Gα:Ge</td>
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<tr>
<td>HIPO</td>
<td>High-speed Imaging Photometer for Occulation: Special PI Instrument – high speed imaging photometer</td>
<td>Lowell Observatory E. Dunham</td>
<td>0.3 – 1.1</td>
<td>5.6' x 5.6'</td>
<td>2012</td>
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<td>R = UBVRI; custom NB filters</td>
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<td>FLITECAM (Facility SI)</td>
<td>First Light Infrared Test Experiment CAMera: Facility Instrument – near-IR test camera and grism spectrometer</td>
<td>UCLA I. McLean</td>
<td>1 – 5</td>
<td>8.2' x 8.2'</td>
<td>2012</td>
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<td>R ~ 2000</td>
<td>1024 x 1024 @ 0.48&quot; InSb</td>
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<td>R = 3x10⁴ – 4x10⁵</td>
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<td>R = 5 - 10</td>
<td>12 x 32 Bolometer</td>
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<td>R = 10⁴, 10⁵, or 3000</td>
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<td>1&quot; – 4&quot; slit width</td>
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**Table 2: SOFIA’s First Generation Instrument Complex**

**SOFIA’s First-Generation Instruments**
Line Sensitivities with Spectrometers
(4σ in 900 sec on source time)
Primary Mirror Installed Oct. 8, 2008