The Stratospheric Observatory for Infrared Astronomy (SOFIA)

R. D. Gehrz\textsuperscript{a} and E. E. Becklin\textsuperscript{b}

\textsuperscript{a}University of Minnesota
\textsuperscript{b}Universities Space Research Association

http://www.sofia.usra.edu
Outline

- SOFIA Description and Status Report
- 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 µm to 1.6 mm
  - Emphasizes the obscured IR (30-300 µm)

- 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 in 2009
  - 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)

Door.mpg

scientist stations, telescope and instrument control, etc.

TELESCOPE

scientific instrument (1 of 9)

64th International Symposium on Molecular Spectroscopy, Columbus, OH, June 23, 2009

R. D. Gehrz
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
Primary Mirror Installed Oct. 8, 2008
Four First Light Instruments

Working/complete HIPO instrument in Waco on SOFIA during Aug 2004

Working/complete FLITECAM instrument at Lick in 2004/5

Working FORCAST instrument at Palomar in 2005

Successful lab demonstration of GREAT in July 2005
SOFIA First Generation Spectroscopy

![Graph showing spectral resolution vs. wavelength for various instruments including HIPPO, FLITECAM, FORCAST, EXES, GREAT, CASIMIR, IRAC, MIPS, JWST, HAWK, IRS HI, IRS LOW, and FIFI LS. The x-axis represents wavelength in micrometers, ranging from 1 to 1000, and the y-axis represents spectral resolution, ranging from $10^0$ to $10^8$. Each instrument is represented by a box with its spectral resolution and wavelength coverage.](image_url)
Photometric Sensitivity and Angular resolution

SOFIA is as sensitive as ISO

SOFIA is diffraction limited beyond 25 µm (θmin ~ λ/10 in arcseconds) and can produce images three times sharper than those made by Spitzer.
Early General Observer Opportunities

- **Open Door Flights** will begin at Palmdale in late 2009
- **First light images** will be obtained during winter 2009/2010
- **Early Short Science in 2010** with FORCAST (US 5-40 μm imager and GREAT (German heterodyne 60 to 200 μm Spectrometer)
  - Proposals are in and teams have been selected
  - Very limited number of flights (~3)
  - GO’s will not fly
- **Early Basic Science for GOs in 2010** with FORCAST and GREAT
  - Draft call was released in Jan 2009
  - Final call to be released in December 2009
  - Longer period (~15 Flights)
- **General Observer (GO) Science:** First Call for proposals in late 2010
  - ~20 flights per year until full science operations begin in 2014
SOFIA Instrumentation Development Program

- The next call for instruments will be at First Science ~ FY ’10

- The instrumentation development program will include:
  - New science instruments, both FSI and PSI
  - Studies of instruments and technology
  - Upgrades to present instruments

- 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!
  - Full envelope closed door flight testing is complete.
  - Open door flights will begin in Fall of 2009
  - First light will be in early 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
## SOFIA’s First-Generation Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Type</th>
<th>λλ (μm)</th>
<th>Resolution</th>
<th>PI</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIPO (Available 2010)</td>
<td>fast imager</td>
<td>0.3 - 1.1</td>
<td>filters</td>
<td>E. Dunham</td>
<td>Lowell Obs.</td>
</tr>
<tr>
<td>FLITECAM *</td>
<td>imager/grism</td>
<td>1.0 - 5.5</td>
<td>filters/R~2000</td>
<td>I. McLean</td>
<td>UCLA</td>
</tr>
<tr>
<td>FORCAST *</td>
<td>imager/(grism?)</td>
<td>5.6 - 38</td>
<td>filters/(R~2000)</td>
<td>T. Herter</td>
<td>Cornell U.</td>
</tr>
<tr>
<td>GREAT (Available 2009)</td>
<td>heterodyne receiver</td>
<td>62 - 65 111 - 12 158 - 187 200 - 240</td>
<td>R ~ 10^4 - 10^8</td>
<td>R. Güsten</td>
<td>MPIfR</td>
</tr>
<tr>
<td>CASIMIR (Available 2011)</td>
<td>heterodyne receiver</td>
<td>250 -264, 508 -588</td>
<td>R ~ 10^4 -10^8</td>
<td>J. Zmuidzinas</td>
<td>Caltech</td>
</tr>
<tr>
<td>FIFI LS **</td>
<td>imaging grating spectrograph</td>
<td>42 - 110, 110 - 210</td>
<td>R ~1000 - 2000</td>
<td>A. Poglitsch</td>
<td>MPE</td>
</tr>
<tr>
<td>EXES (Available 2011)</td>
<td>imaging echelle spectrograph</td>
<td>5 - 28.5</td>
<td>R ~ 3000 - 10^5</td>
<td>J. Lacy</td>
<td>U. Texas Austin</td>
</tr>
</tbody>
</table>

* Facility-class instrument

** Developed as a PI-class instrument, but will be converted to Facility-class during operations