Evolution of the SOFIA Science Instrument Suite

William T. Reach

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IT’S EVOLUTION, BABY!
SOFIA’s Scientific Instruments

- U.S. Principal Investigator Instrument
- U.S. Facility Instrument
- German Principal Investigator Instrument
- German Facility Instrument

Spectral Resolution ($\lambda/\Delta\lambda$)

Wavelength (μm)
Continuum Sensitivity

- SOFIA/FORCAST
- Planck
- SOFIA/HAWC+
- Herschel
- ISOPHOT
- ALMA
- WISE
- ISOCA
- JWST

Sensitivity (Jy)

Wavelength (μm)
Line Sensitivity

MDLF (10^{-11} W/m^2)

Wavelength (µm)

FLITECAM
ISO/SWS
ISO/LWS
GREAT2
FORCAST
H
FIFI-LS
PACS
HIFI
GEMINI
Spitzer
NIRCAM
MIRI
NIRSPEC
New Science Instruments

• NASA SI Development
  - intends to select 1 Third generation, Facility Science Instrument, to be completed in 2018
  - Future SI Calls are anticipated in notional long-term budget planning, with 4-5 years cadence

• DLR SI Development
  - GREAT continues to evolve:
    • upGREAT: 14-beam L2 array is operational and offered Cycle 5
    • H array: 7-beam H array commissioning now
    • downGREAT: Low-frequency extension planned
Minor Upgrades

• Upgrades were not part of the 3\textsuperscript{rd} generation SI call
• The SOFIA Program can upgrade current SI from within our budget
• Examples of minor upgrades known to be worthy of consideration:
  – Narrow filters in HAWC+ for [C II] and [O I], which were descoped from the 2\textsuperscript{nd} generation proposal for HAWC+
  – New detector for FLITECAM to improve QE, cosmetics, electronics
  – FIFI-LS filter to enable wider wavelength coverage
Science Instrument Offerings

• Present status: For Cycle 5, we offer 6 SI
  – Specific modes are not offered every Call
    • HIPO not available in Cycle 5
    • Removed cross-dispersed grisms (insufficient sensitivity to be worth the time spent calibrating) from Cycles 4-5
Science Instrument Life Cycle Flow Chart

- NASA Announcement of Opportunity for new SI
- TMCO Review
- Science Review
- INSTRUMENT DEVELOPMENT
- Commission/Acceptance Review
- Upgrade Review
- OPERATIONS and MAINTENANCE
- Retirement Review
- RETIRE

USRA

DLR
SI Retirement from: SOFIA Concept of Operations

- Each SI should reliably contribute high quality science to maximize SOFIA’s scientific return
- Retirement decisions are based primarily on scientific productivity
- PI instruments can be retired based on excessive maintenance requirements
- Facility SI will be retired after a time at which the cost of their maintenance and support is no longer commensurate with their ability to competitively deliver science
SI Retirement Criteria

- SI performance has degraded significantly from original capabilities
- SI has failed and requires costly repairs
- SI reliability significantly reduces successful flight hours
- SI operating constraints significantly limit science return
- SI scientific contribution has been marginalized by newer operational technologies, competing observations, or other factors
- The NASA Strategic Plan has restructured relevant scientific priorities
Retirement Process

- SMO Director and Project Scientist co-chair a review for any SI that is not scientifically productive
  - input from the Instrument Team, the general observer community, SMO science and operations staff, and others
- If review recommends retirement, SMO Director and Project Scientist communicate recommendation to NASA HQ (Program Scientist and SMD Astrophysics Director) for US instruments, or to DLR for German instruments
Current Status

- Considerations for continuing to offer an SI
  - Prior call proposal pressure (*next slide*)
  - Cost to continue to offer SI (balanced by SOFIA Program Office)
- Program judgment (**including external committees**) of future potential
  - August 2015: SI Analysis Group evaluation
  - May 2016: requests for input from the SOFIA Users Group
Guest Investigator Demand

Cycle 3 Awarded Time

Cycle 4 Awarded Time
SI Advisory Group Review

• The program convened a review in 2015 July in order to evaluate the current instrument suite. This was a strategic review.
• Chair: T. Roellig for project scientist

<table>
<thead>
<tr>
<th>Rank</th>
<th>Name</th>
<th>Science Instrument</th>
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<tbody>
<tr>
<td>1</td>
<td>FIFI-LS</td>
<td>Field-Imaging Far-Infrared Line Spectrometer</td>
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<tr>
<td>2</td>
<td>FORCAST</td>
<td>Faint Object InfraRed Camera for the SOFIA Telescope</td>
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<tr>
<td>2</td>
<td>EXES</td>
<td>Echelon-cross-Echelle Spectrograph</td>
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<tr>
<td>4</td>
<td>FLITECAM</td>
<td>First-Light Infrared Test Experiment Camera</td>
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<tr>
<td>5</td>
<td>HIPO</td>
<td>High-Speed Imaging Photometer for Occultations</td>
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## Summary of pros and cons for SIs

<table>
<thead>
<tr>
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<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>HIPO</td>
<td>Enables 2-color occultations from deployed large telescope</td>
<td>Schedule impact of dedicated flight campaigns</td>
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<tr>
<td>FLITECAM</td>
<td>Enables near-IR occultations from deployed large telescope</td>
<td>SI is marginally operable; ground &amp; JWST coverage</td>
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<tr>
<td>FORCAST</td>
<td>High proposal demand; well-integrated and works smoothly</td>
<td>WISE survey; ground &amp; JWST; offered 4 cycles average science</td>
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<td>EXES</td>
<td>Potential: unique phase space of high-resolution spectroscopy</td>
<td>Limited target pool and community; N-band from ground</td>
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## Notional Evolution of SI suite

<table>
<thead>
<tr>
<th>Year</th>
<th>CYCLE</th>
<th>HIPO</th>
<th>FLITECAM</th>
<th>FORCAST</th>
<th>EXES</th>
<th>GREAT</th>
<th>FIFI LS</th>
<th>HAWC+</th>
<th>3rd Gen</th>
<th>4th Gen</th>
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<tr>
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**Legend**

- HIPO
- FLITECAM
- FORCAST
- EXES
- GREAT
- FIFI LS
- HAWC+
- 3rd Gen
- 4th Gen

**Notes**

- *JWST launch*
- “distant future”
SOFIA Users Group Request

- Comments on overall scheme for SI suite management?

- Separate reviews will be convened to consider merits of individual SI. Inputs on the process are welcome.