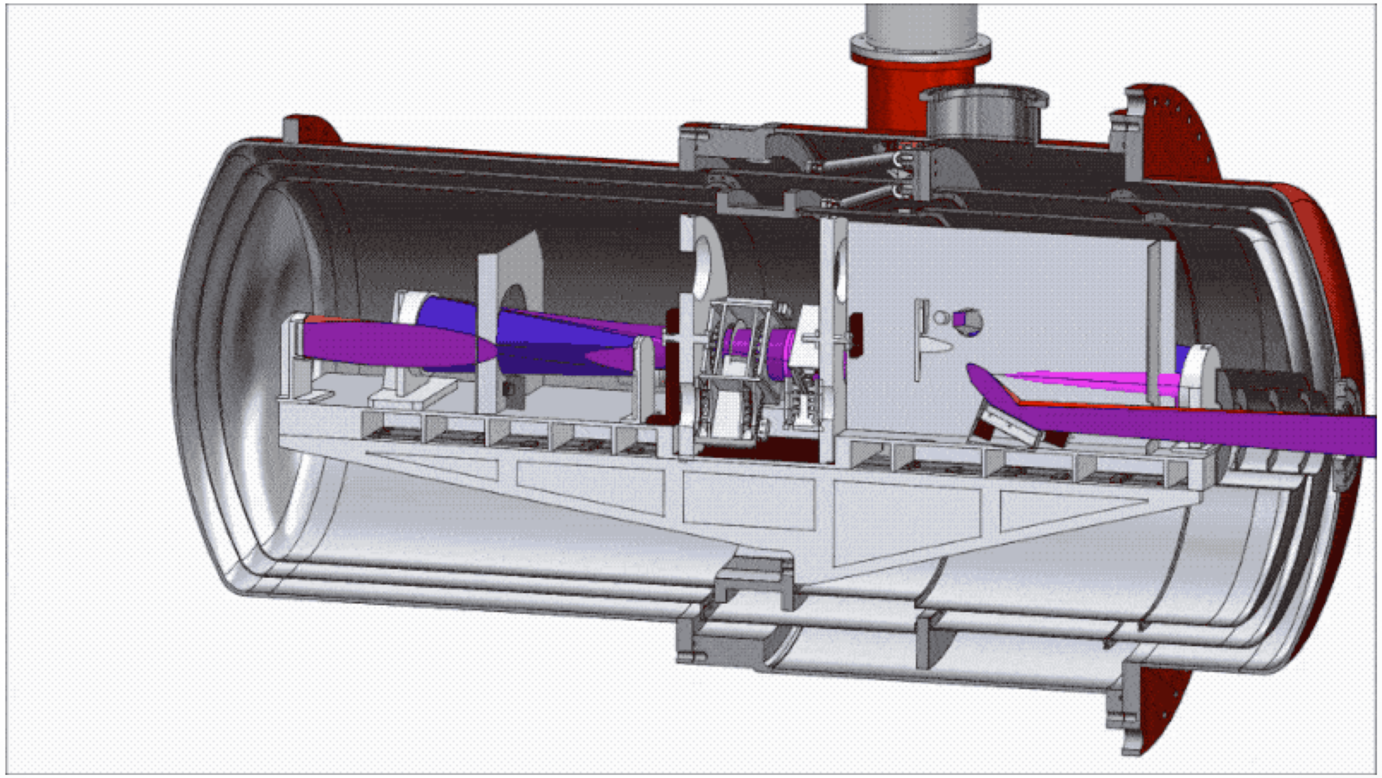
HIRMES

The 3rd gen hi-res FIR spectrometer for SOFIA



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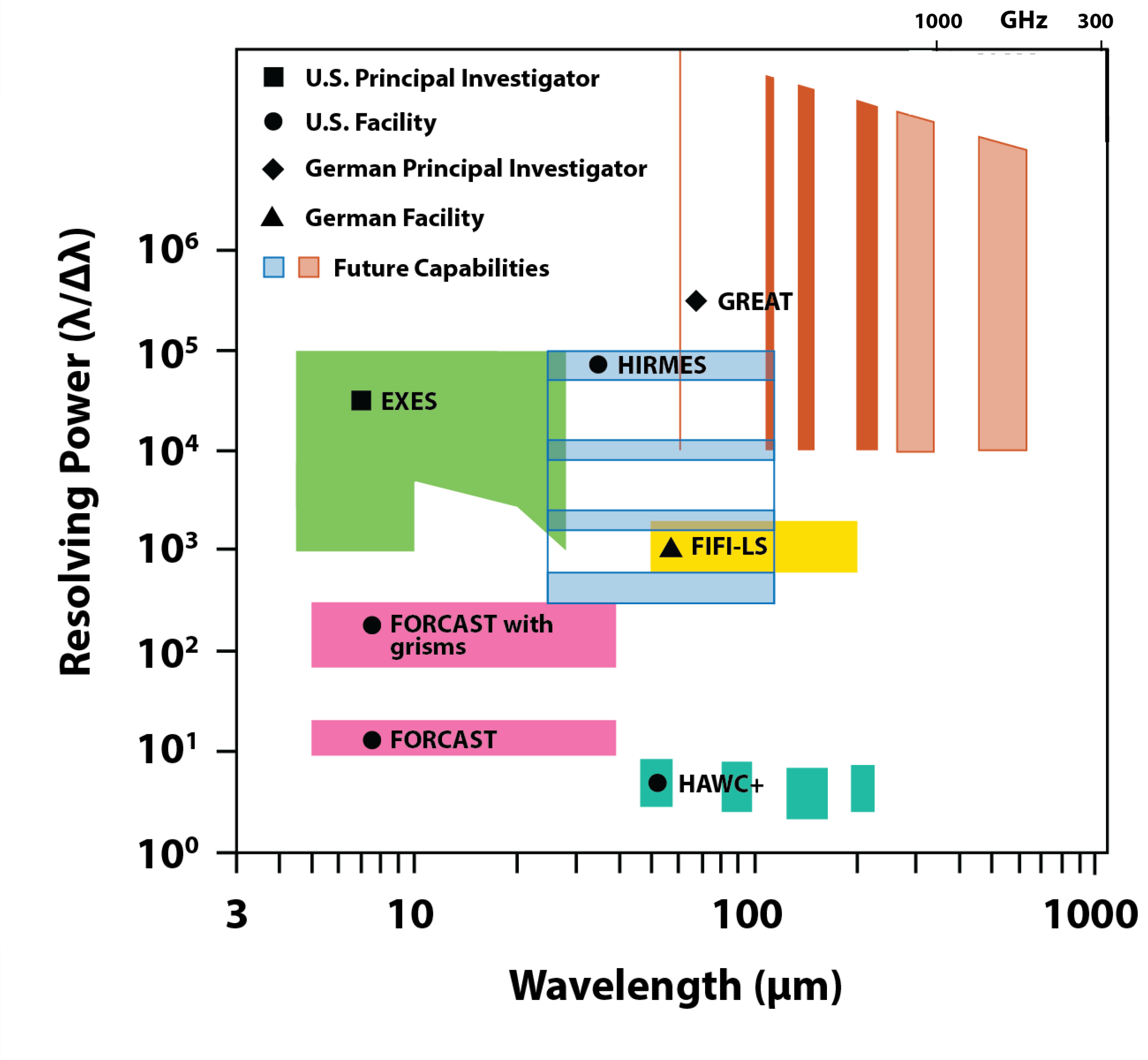
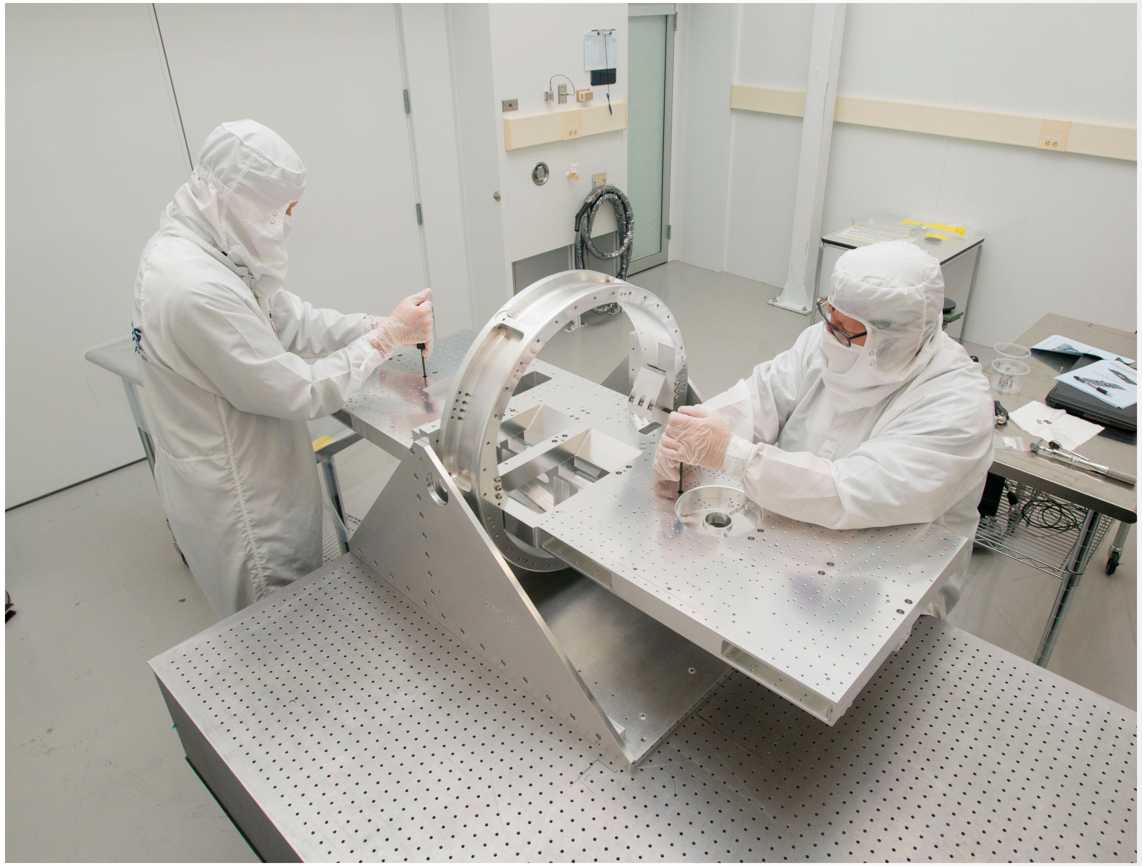
HIgh Resolution Mid-infrared Spectrometer



HIRMES will allow high-res spectroscopy in the mid-IR range with limited mapping capabilities.

Main features

- 3rd Gen Instrument
- PI: S.H. Moseley (GSFC)
- Commissioning scheduled for Spring 2019
- **Available for DDT Programs in Cycle 7**
- Spectrometer: 25-122 μm
- Background limited TES bolometers
- Fabry-Perot interferometers and gratings

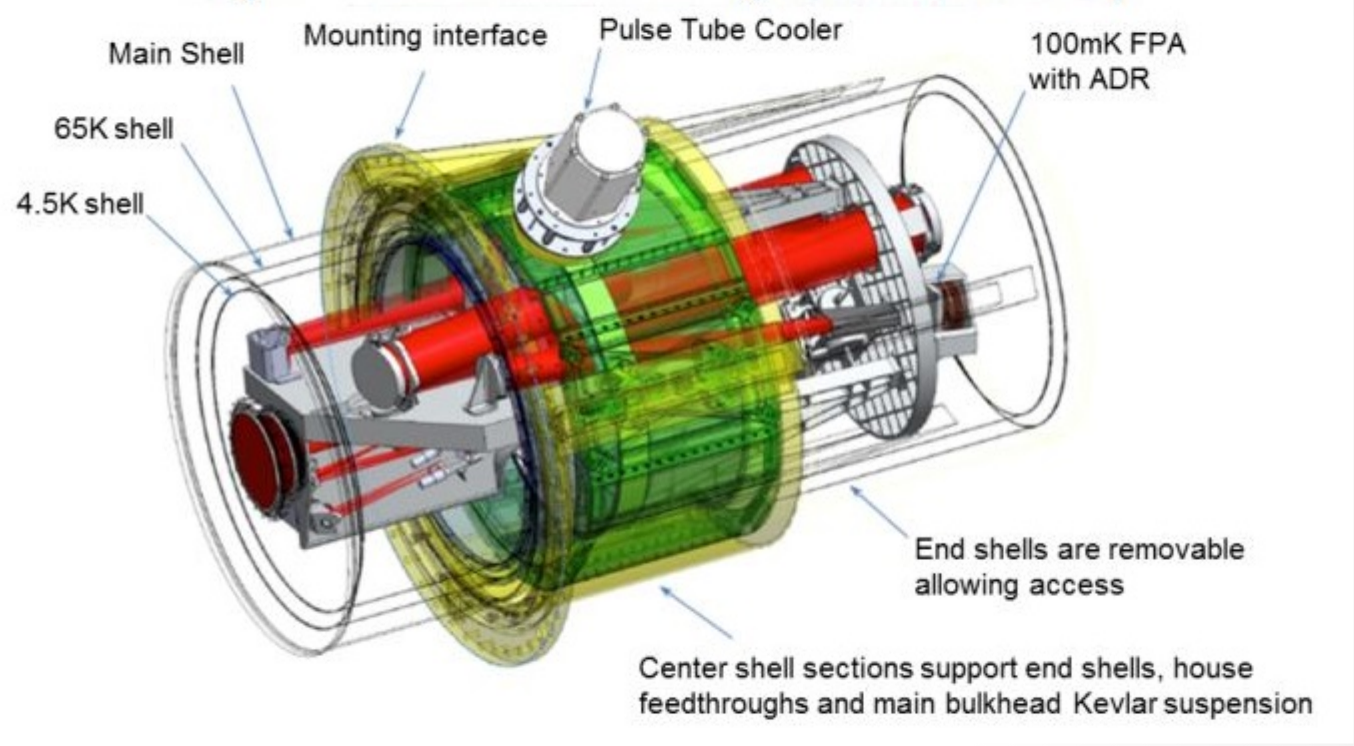


Modes

HIRMES is a direct detection spectrometer covering the spectral range from 25 to 122 µm, where SOFIA is diffraction limited.

There are four spectroscopic modes:

- High-res mode R ~ 100,000
- Mid-res mode R ~ 10,000
- Low-res mode R ~ 600
- Imaging spectroscopy mode: R ~ 2000



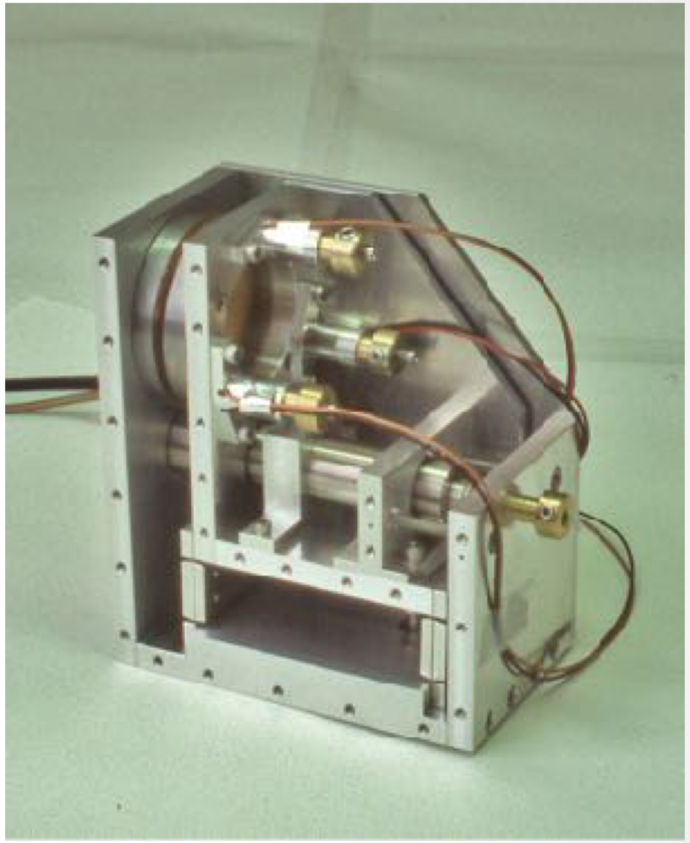
The modes are optimized to deliver the maximum sensitivity achievable with SOFIA.

New technology

HIRMES bridges the spectroscopic gap between EXES/FORECAST and GREAT/FIFI-LS.

- Background limited TES Bolometer arrays to enhance sensitivity:
  - 16 x 64 for medium and low resolutions
  - 8 x 16 for high-resolutions.

- Scanning Fabry-Perot interferometers and gratings provide high resolving power and enables wide-field medium-resolution imaging spectroscopy.



A scanning FPI example:
KWIC KAO (Latvakoski PhD 1997).

HIRMES vs GREAT

- Coherent detection fundamentally limited in sensitivity by the quantum noise limit inherent in the detection of phase
- Direct detection in principle wins by factors of 12 (122 μm) to 58 (26 μm) over coherent detection.
- Sensitivity ratio estimates based on public upGREAT sensitivities:

[OI] 63 μm 10:1
HD 112 μm 10:1

HIRMES vs FIFI-LS

Both are direct detection spectrometers, so they do not suffer from quantum noise limit. HIRMES overlap the coverage of the blue array of FIFI-LS (up to 100µm).

Bolometers have two advantages wrt photoconductors:

- 90% quantum efficiency over broad band
- Bolometers do not have generation recombination noise

On the other hand, FIFI-LS is a spectral multiplexer and HIRMES is not.
The two factors combine resulting in a similar sensitivity.

HIRMES Spectral Imaging Mode ≈ FIFI-LS IFU Mode

HIRMES will not allow to map extended regions as efficiently as FIFI-LS.

However, in the Hi-Res mode, it is anticipated that a factor 10x better spectral resolution than FIFI-LS will lead to better line sensitivity by increasing the contrast between line and continuum.

HIRMES vs EXES

HIRMES overlap the mid-IR part of EXES at similar spectral resolution.

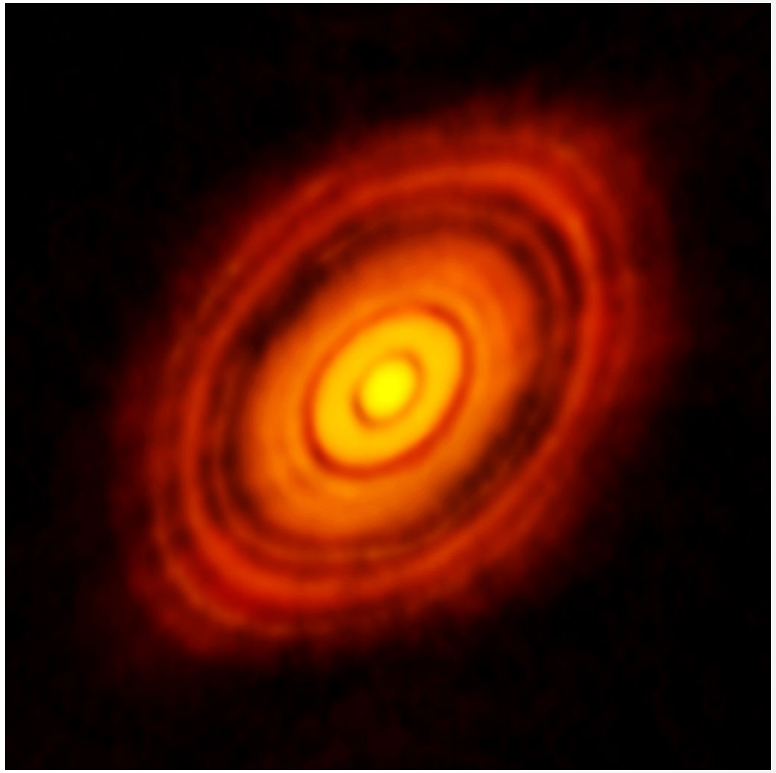
Because of the more efficient detectors, it is expected to be more sensitive than EXES for wavelength larger than 25µm.

A significant advantage is expected for the observation of the H_2 S(0) 28.3µm line.

Guaranteed time: evolution of circumstellar disks

Primary science will be to investigate protoplanetary disk physics and addresses the questions:

- How does the disk mass evolve during planetary formation?
- What is the distribution of oxygen, water ice, and water vapor in different phases of planet formation?
- What are the kinematics of water vapor and oxygen in protoplanetary disks?



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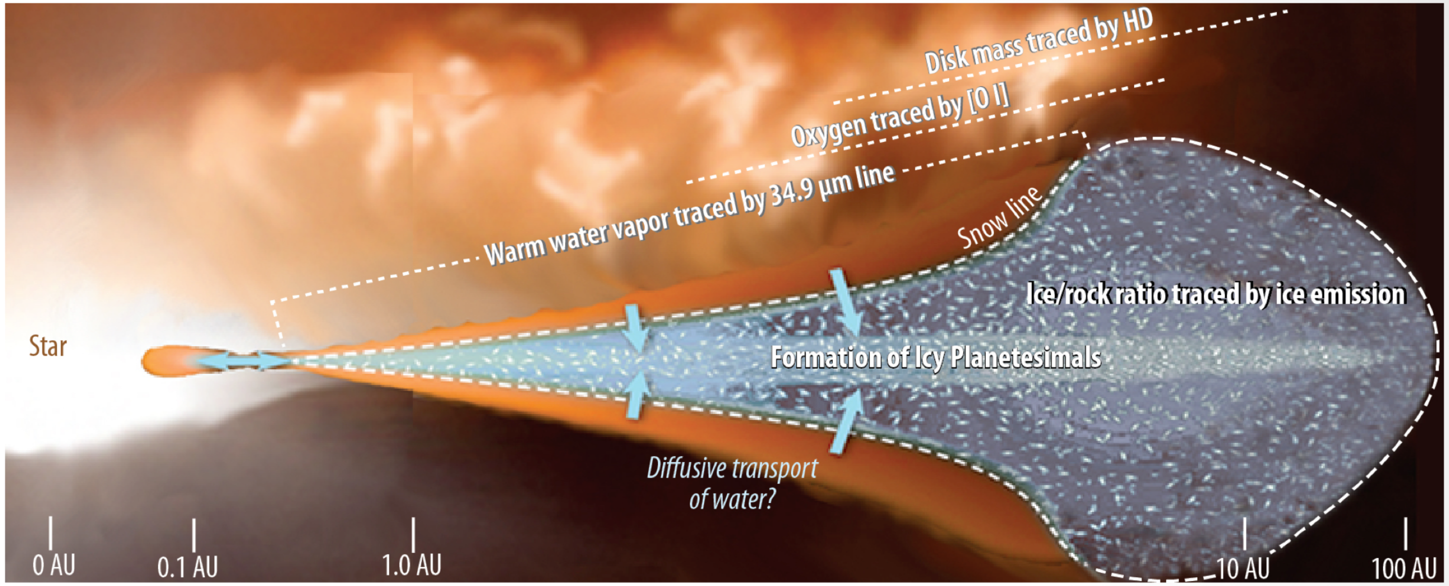
An important wavelength range

HIRMES covers and important wavelength range for protoplanetary disk science.



- Water and ice: water and ice play a critical role in the formation of giant planet cores and, producing habitable conditions in terrestrial planets:
    - H_2O 34.9823 µm 651-624 rotational line
    - Ice 43, 63 µm (crystalline) and 47 µm (amorphous)
- Neutral Oxygen: a tracer of disk chemistry and radial structure
    - [OI] 63.1837 µm $^2P_1$-$^3P_2$ fine-structure line
- Deuterated hydrogen: a tracer of disk mass
    - HD 112.0725 µm J = 2-0 rotational line

HIRMES resolves these narrow lines and determines their origins from velocity profiles

Exp times and expected S/N

Targets from the Guaranteed Time Observations:

- AS 205, 15 Jy T-Tauri star
- RNO 90, 3 Jy T-Tauri star

Water vapor at 34.9 um

- S/N = 35 in 180 min for AS 205, 15 Jy
- S/N = 27 in 270 min for RNO 90, 3 Jy

Ice band at 46 um

- S/N = 300 in 45 min for AS 205, 15 Jy
- S/N = 64 in 45 min for RNO 90, 3 Jy

Table D-1: GTO Observing Program Targets (observing times are calculated based on 1×10^{-17} W m^{-2} 5σ in 1 hour)*.

Program	Intensity (W/m^2)	SNR	Total time with overhead (hours)
Optimal $H_2^{16}O$ water lines for Protoplanetary disks with HIRMES (transition/wavelength µm)			
4 4 0 -> 3 1 3 (28.914)	3.10E-17	27.00	4.5
6 4 3 -> 6 1 6 (32.313)	3.30E-17	29.00	4.5
6 5 1 -> 6 2 4 (34.987)	2.20E-17	19.00	4.5
Subtotal			13.5
H_2O vapor targets			
RNO 90	3.10E-17	26.85	4.5
AS 205	4.96E-17	35.07	3
HD 163296	3.10E 17	31.00	6
Subtotal			13.5
Targets (HD (1-0) transition)			
HD 163296	1.00E 17	24.7	5
TW Hya	5.00E 18	17.5	10
Subtotal			**15**
[OI] 63 µm targets			
RNO 90	1.29E-16	45.61	0.75
AS 205	2.15E-16	76.01	0.75
HD 163296	2.08E-16	73.68	0.75
TW Hya	3.65E-17	12.90	1.5
Subtotal			**3.75**
H_2O ice targets **	**Flux density (Jy)**		
RNO 90	3.2	64.0	0.75
AS 205	15.5	310.0	0.75
HD 163296	17	340.0	0.75
TW Hya	2.5	50.0	0.75
Subtotal			3
Total Time			**48.75**

*The expected performance is significantly better (depending on the line), e.g., the observing time gain margin for HD, H_2O and [OI] lines are 7.3, 16.0 and 2.5, respectively.

** Smoothed down to 1 µm resolution.

SOFIA

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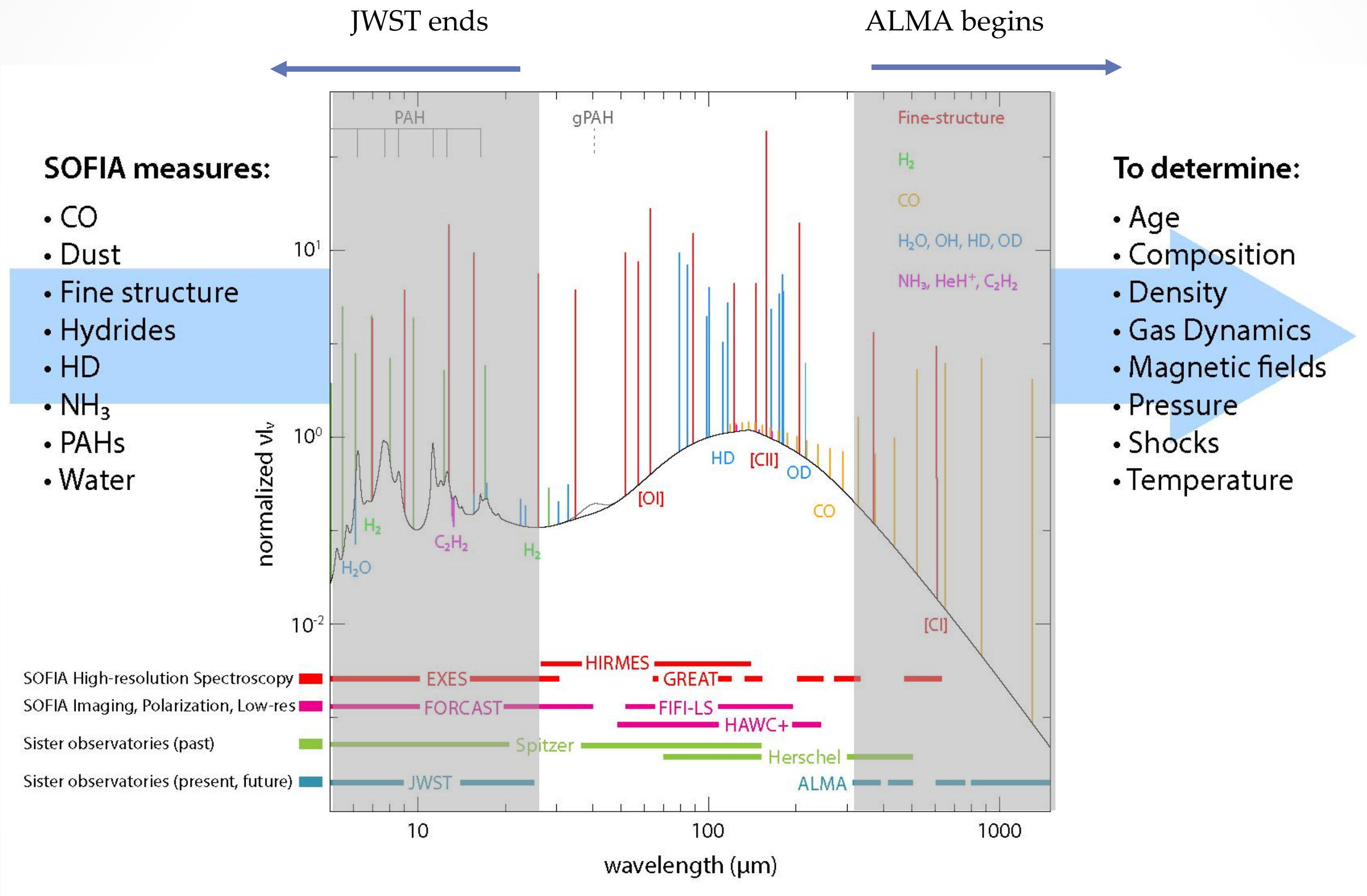
Development schedule

- Preliminary Design Review: November 2016
- Critical Design Review: May 2017
- Integration and Testing at GSFC: *since Nov '17*
- Delivery to Armstrong: December 2018
- *First Commissioning Flights: Spring 2019*

USRA Instrument Support Scientist:

Sam Richards (samuel.n.richards@nasa.gov)

4th generation instrument(s)



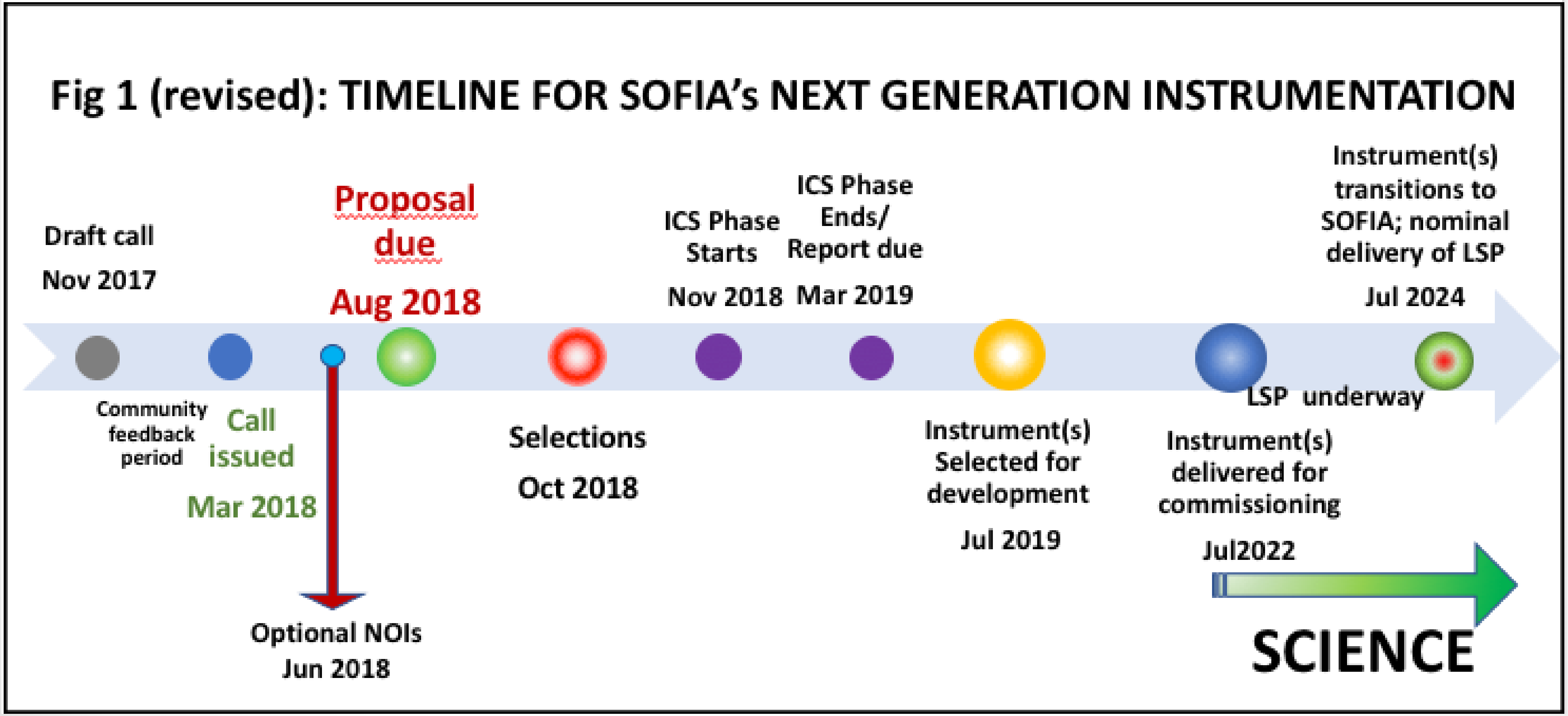
SOFIA fills the gap between the two most advanced observatories and it will be unique for the next ~10 years.

A new type of call

Three Phases

- Phase 1
  - 25 Pages
  - Focus on the science
  - Propose whatever the science needs
  - Due: 1 AUG 2018
- Phase 2
  - Pull together the team
  - Develop the detailed plan
  - Resources become available
- Phase 3
  - Carry out the plan from Phase 2

Timeline



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Philosophy of solicitation

- **Science Leads the Way**
  - Selected team(s) must execute and deliver well-defined Legacy Science Program(s)
  - Prioritize instruments that enable broad community usage and/or data of high archival value, but also allow for agile, "niche" instruments to solve important / outstanding science questions
- **Technology to Meet the Needs of Science**
  - Solicitation allows for:
    - new instruments
    - upgrades/modifications to existing instruments
  - Allow for flexibility for future enhancements and modifications to NGSI
- **Flexibility to Propose What The Science Needs**
  - Allow for a nominal three-year development period after funding begins but also allow for longer or shorter development timescales for optimal science return
  - Allow for schedule and budget flexibility; make selections based on science return on investment
  - Reduce requirements for the Instrument Concept Study (ICS) phase compared to previous solicitations
  - Make instrument development and acceptance process easier for teams (using lessons learned from past experience)

Legacy Science Programs (LSP) required !

- The LSP **must** contain:
  - A detailed scientific justification
  - An observing plan which clearly describes the science targets, instrument modes and the time required to achieve the scientific goals
  - The roles and expertise of the science team that will execute the LSP.

- It **should** be executable within a two year period following commissioning

- Nominally LSP data have **no period** of exclusive use

- In the ICS phase and after commissioning, the proposing team(s) **may refine** the needed observing time (possibly based on a better understanding of the instrument) but may not change the scope of the scientific investigation.

Solicitation

- Solicitation at:
  - https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=610959/solicitationId=%7B1ABFE215-9C65-3204-9B6F-8E97A9A01E36%7D/viewSolicitationDocument=1/D.14%20SOFIA%204th%20Gen%20Instruments%20Amend%202_rev.pdf
  - https://www.sofia.usra.edu/science/announcements/next-generation-science-instrument-call-proposals

- SOFIA Science Instrument Library and frequently asked questions (FAQ) (more information on SOFIA and Instrument Development Requirements)
  - https://www.sofia.usra.edu/science/instrument-call

- Questions:
  - Specific to Solicitation – send to Kartik Sheth: kartik.sheth@nasa.gov
  - General SOFIA or Instrument Development – send to SOFIA Science Instrument Development: arc-sofia-sidev@mail.nasa.gov

- Tell your friends and colleagues