Far Infrared Next Generation Instrumentation Community Workshop

Pasadena, CA March 23, 2017

THREE OPEN DISCUSSION SESSIONS

1. **The future of FIR Instrumentation: what is needed and what can NASA do? (30 min)**
2. **What should happen next with SOFIA (105 min)**
3. **Access above 80,000 ft [i.e. balloons] (60 min)**

Questions from the community have been received. These, together with additional questions from the audience here, will be moderated by P. Goldsmith (JPL)

Continue to provide inputs via discussions or…

- Continue to use online form

  tinyurl.com/FIRNextGen-2017

  - Names and affiliations are not required anymore
- Inputs on sheets
  - Collected before lunch & 3:15pm coffee break to use during afternoon discussion
- Email
  - Ravi Sankrit (FIRSIG) - rsankrit@sofia.usra.edu
  - Kimberly Ennico (OST STDT) - kimberly.ennico@nasa.gov
- Chat window on Webex

Please take note…

- The following were the inputs, not ranked in any order, collected from the the online registration/ forms to help frame the discussion.
- A formal report of this workshop will be prepared by the FIRSIG based on that input plus the input received during the workshop.

The Future of FIR Instrumentation: What is Needed and What can NASA do? (30 min)

Are there specific science areas that we should emphasize in our future ROSES far-IR instrument calls?

Science areas? Or should we emphasize technology areas more ? those that support future missions
Rapid, large-area spectrally-resolved imaging
Large scale mapping of the Milky Way in THz lines (in post-Herschel era)
Advancing heterodyne arrays and related technologies
Spectropolarimetery - at a minimum, polarimetry; coronographic/eclipse geometry science
A dedicated SAT like call for SOFIA instrumentation: develop and support lower TRL technologies for future SOFIA specific instruments.

What are the critical new technologies needed for the next generation Far-IR instruments?

Direct detectors: large (kilopixel) format with extremely low noise (background-limited) and high multiplex factor readouts
Photon-counting detectors, wide-band quantum-limited microwave amplifiers
High resolution spectroscopy - detectors, arrays, spectrometers
Requirements for the future flagship and in the technology roadmap necessary to get us there

Large-format heterodyne array receivers, including: SIS and HEB mixers that can operate at higher temperatures (e.g. >20K)
Integrated focal planes of mixers and LNA's
HEB mixers with large (up to 8-10 GHz) IF bandwidth
High frequency (e.g., 4.7 THz) arrays: high-power (5-10 mW) QCL local oscillators, beam multiplexors (e.g., Fourier phase gratings)
Local Oscillator systems with low DC power
Low power IF amplifiers; ASIC backends with multi-GHz bandwidth

THz optics (lenses, polarizers, filters, diplexers), low-loss cryogenic cable (DC and rf)
Coronagraph for bright sources such as AGB and Mira stars
Reducing cost of building telescopes
Aerospace quality Sub-Kelvin cooling

What Should Happen Next with SOFIA (105 min)

If you were awarded 200 hours on SOFIA what science would you do?

Large scale mapping in the MW and nearby galaxies
[CII] maps of spiral and interarm regions
Make a careful survey of the Galactic center that provides legacy value as well as immediate results
Large scale surveys of fine structure line emission in the Milky Way and image nearby galaxies in [CII] [NII], [OI]
Demonstrate large-format detectors in a balloon-borne spectrometer carrying out an intensity mapping experiment
Creating templates of the ISM in the local universe in order to better understand star formation through cosmic time
Time-dependent astronomy at far IR wavelengths
Polarimetric mapping
Polarized CIB at 700 microns. Would be great for high-z science, and for characterizing dusty foregrounds
Can I invent my own instrument? FIR spectroscopy of galaxies -- perhaps integral-field style
Observe the mid-IR and short far-IR lines in $z < 0.3$ galaxies including polarimetry
Study collisional and AGN excited gas in Galaxies with extensive C+ mapping (FIFI-LS &GREAT)
Anything that can provide further information on the make-up of the atmospheres of exoplanets
Circumstellar dust characterization of symbiotic systems and stellar pulsating systems with binary companions
A combined far-infrared imaging/spectroscopic survey of water and other specific species in the solar
Characterization in the mid-IR of asteroid surfaces
Identification of methane and organics molecules on Ice Giants

Looking at the instrument suite (FLITECAM, FORCAST, FIFI-LS, EXES, GREAT/upGREAT, HAWC+, and HIRMES), what science measurements are not being addressed by these capabilities?

What knowledge gaps has SOFIA left since its first flight?

What Should Happen Next with SOFIA (cont.)

If we did not give people a "cost cap" what could they deliver?

If we did not give people a "timeline" what could they deliver? What would be a minimum timeline?

Is there a desire for international participation?
If so, to what extent [full instrument, part of instrument, specific unique contribution to the science return such as laboratory spectra, calibration techniques, etc.]

Is there a desire for international participation or a specific German-US joint instrument for SOFIA?
That sounds like a suitable partnering opportunity for a large-pixel-count heterodyne receiver.
Sounds good. But will NASA be OK with that?
Any cooperation that improves the capabilities of SOFIA is welcome
Yes, Large Heterodyne arrays in the Far IR for Key lines
While a good idea, the problems of having to answer to two bosses would need to be resolved.

Are there ways we can use what's on SOFIA now to make a new capability more feasible to develop?
Standard cryostat, gutting & reusing an existing facility science instrument?

Is there a new model out there to combine Balloon Instrument Builders with SOFIA Instrument Builders?
Build instruments to be used on either platform for different purposes.

From the US community, is there a desire to have a PI vs. FSI instrument and, for what reasons?

Access above 80,000 ft [i.e. balloons & suborbital] (60 min)

What are the capabilities of LDB and ULDB balloons?

What are the key shortcomings of ballooning?

What science areas are ideal for the ultra long balloon capability ?

How do these science areas synergize with SOFIA and OST?

Picture the model of BLAST-Pol: a balloon-borne telescope on an LDB that can acquire a few hundred hours of on-sky time with a 2m telescope at high altitude. This could open up the FIR to suborbital research more cost-effectively than SOFIA and likely with more responsive instrument upgrades.

Should we investigate a stratospheric unmanned blimp or zeppelin observatory as a successor to SOFIA that can be operating continuously over longer campaigns of many months at high altitudes hosting a large mirror telescope or perhaps an interferometer? [Vulcan Stratolaunch]