Building the 2020-2025 Instrument Roadmap Workshop II
Agenda
Monday, July 27, 2020

Click on a Presentation Title to see the abstract.

Time (PDT)	Speaker (Affiliation)	Presentation Title
Technology (Jackson, Chair)		
7:00–7:15am	Margaret Meixner (SMO)	Welcome
7:15–7:45am	Paul Goldsmith (JPL)	Next Generation Large-Format Spectroscopic Arrays for SOFIA
7:45–8:15am	Urs Graf (U Cologne)	Heterodyne Technology for Future SOFIA Instruments
8:15–8:25am	10 minute break	
8:25–8:55am	Steve Hailey-Dunsheath (Caltech)	Far-Infrared Kinetic Inductance Detectors
8:55–9:25am	Johannes Staguhn (JHU and NASA GSFC)	Transition Edge Sensors for (Far-)Infrared Astronomy
9:25–9:55am	30 minute break	
9:55–10:25am	Judy Pipher (U Rochester)	Possible Mid-IR Photodetector Technologies for SOFIA
10:25–10:55am	Samuel Lara-Avila (Chalmers University of Technology)	Epitaxial Graphene on Silicon Carbide for Terahertz Heterodyne Astronomy
10:55–11:25am	Darren Dowell (JPL)	Suggestions for Expanding the Science Capability of HAWC+
11:25–11:35am	10 minute break	
11:35am–12:05pm	B-G Andersson (SMO)	Discussion

Building the 2020-2025 Instrument Roadmap Workshop II Agenda

Tuesday, July 28, 2020

Click on a Presentation Title to see the abstract.

Time (PDT)	Speaker (Affiliation)	Presentation Title
Instruments I (Andersson, Chair)		
7:00–7:30am	James Jackson (SMO)	Summary of Workshop 1
7:30–8:00am	Erin Smith (NASA GSFC)	SOFIA Common Dewar Concepts
8:00–8:30am	Alexander Kutyrev (UMD)	HIRMES
8:30–8:40am	10 minute break	
8:40–9:10am	Leslie Looney (U Illinois)	FIFI+LS: A Timely Upgrade to FIFI-LS
9:10–9:40am	Mike Person (MIT)	FPI++
9:40–10:25am	45 minute break	
10:25–10:55am	Matt Richter (UC Davis)	GIGS: A High-Resolution Germanium Immersion Grating Spectrograph for 3–8 μm in a Single Observation
10:55–11:25am	Jason Glenn (NASA GSFC)	Mid-Infrared Kinetic Inductance Detector and Filter Technology Development for Low-Resolution Spectral Imaging
11:25–11:35am	10 minute break	
11:35am–12:05pm	Arielle Moullet (SMO)	Discussion

Building the 2020-2025 Instrument Roadmap Workshop II Agenda

Wednesday, July 29, 2020

Click on a Presentation Title to see the abstract.

Time (PDT)	Speaker (Affiliation)	Presentation Title
Instruments II (Moullet, Chair)		
7:00–7:30am	Bernd Klein (MPIfR)	GREAT Enhancements
7:30–8:00am	Chris Walker (U Arizona)	Large THz Arrays
8:00–8:30am	Thomas Goyette (UMass-Lowell)	Submillimeter Spectrometer for SOFIA
8:30–8:40am	10 minute break	
8:40–9:10am	Chris Packham (UTSA)	SOFIA Mid-IR Polarimeter: SMIRPh
9:10–9:40am	30 minute break	
Strategy and Programmatics (Meixner, Chair)		
9:40–9:55am	James Jackson (SMO)	Strategy and Phasing of the SOFIA Instrument Roadmap
9:55–10:25am	Pat Knezek (NASA HQ)	Potential Funding Structures and Options
10:25–10:40am	Matt Greenhouse (NASA GSFC)	A Strategy for the SOFIA instrument Roadmap: Take the Pioneer On-Ramp
10:40–10:50am	10 minute break	
10:50–11:20am	Erick Young (USRA)	Workshop Summary
11:20am–12:20pm	Margaret Meixner (SMO)	Discussion

Abstracts

Darren Dowell (JPL)

Title: Suggestions for Expanding the Science Capability of HAWC+

Abstract: HAWC+ joined the SOFIA operating instrument suite in 2016. With 5 filters covering 53 - 214 microns, polarization sensing, and ~1850 operating bolometer pixels in a 2x32x40 format, HAWC+ has mainly been used to map magnetic fields in Galactic clouds and infrared galaxies, to investigate dust grain alignment, and to provide additional wavelength and temporal coverage for a variety of far-infrared targets. Science benefits of increased instrument capability have been identified, with the key elements involving larger detector arrays, new observing modes for wider area coverage and/or greater efficiency, and exploration of polarized atomic emission lines. We discuss these ideas in further detail, including practical considerations from the existing instrument configuration, approaches which could bring the most benefit, and elements needing technical development.

Jason Glenn (NASA GSFC)

Title: Mid-Infrared Kinetic Inductance Detector and Filter Technology Development for Low-Resolution Spectral Imaging

Abstract: Mid-infrared spectra of galaxies contain thermal emission from warm dust and broad emission lines from transiently heated polycyclic aromatic hydrocarbon molecules. Low and moderate spectral resolution observations are sensitive to star-formation rates, radiation environments, and heating by active galactic nuclei. Multiple detector technologies and spectrometer architectures are viable for mid-infrared wavelengths. This talk will focus on kinetic inductance detector development and high mapping speed, low resolution spectral imaging enabled by a compact linear-variable filter spectrometer configuration in the range of approximately 10 to 30 microns and longer.

Thomas Goyette (UMass-Lowell)

Title: Description for a submillimeter spectrometer for SOFIA – S3

Abstract: A submillimeter spectrometer for SOFIA will be described. The spectrometer will optimize sensitivity in the 500 - 600 GHz frequency region. The maximization of sensitivity will employ methods previously used on the Herschel HIFI instrument. Additionally, new state-of-the-art detectors will be designed and built which have minimum noise temperatures. The instrument will be described, and the instrument response curve will be presented. Comparisons of the sensitivity to HIFI will also be discussed. Potential science measurements will be presented.

Urs Graf (U Cologne)

Title: Heterodyne Technology for Future SOFIA Instruments

Abstract: We will review the technology for high resolution heterodyne spectrometers for the Terahertz spectral range under the boundary conditions set by the airborne observatory SOFIA. The talk will discuss the possibilities and limitations of the optical system, possible detector and local oscillator schemes as well as the challenges of intermediate frequency processing and spectrometer backends.

Matt Greenhouse (NASA GSFC)

Title: A strategy for the SOFIA instrument roadmap: Take the Pioneer on-ramp

Abstract: I will share my thoughts on an optimal instrument acquisition strategy for SOFIA and observations from the HIRMES experience.

Steve Hailey-Dunsheath (Caltech)

Title: Far-Infrared Kinetic Inductance Detectors

Abstract: We will describe the lumped element Kinetic Inductance Detectors (KIDs) currently under development for the Terahertz Intensity Mapper (TIM), a ballon-borne far-IR spectrometer. TIM will use moderate resolution grating spectroscopy to map the sky over the 240 - 420 micron band, and will employ two KID arrays with a total of 7,000 detectors. We will also present our group's efforts to improve the sensitivity of the TIM devices, and develop detectors working at mid-IR wavelengths, in the context of detector development for future space missions. We will describe how kilo-pixel KID arrays based on this technology may be developed to meet the requirements of the next generation of SOFIA instruments.

James Jackson (SOFIA/USRA)

Title: Summary of Workshop 1

Abstract: I present a summary of the First SOFIA Instrument Roadmap Workshop. First, I outline the science cases presented. Second, I discuss the instrumental capability needed to deliver the potential science. Next, I discuss some of the gaps in capability identified in the first workshop. Finally, I discuss the process moving forward to produce the Instrument Roadmap for NASA.

James Jackson (SOFIA/USRA)

Title: Strategy and Phasing of the SOFIA Instrument Roadmap

Abstract: I discuss some potential recommendations that may form part of the SOFIA Instrument Roadmap. First, I discuss steps for a "science-driven" development process that first identifies the key science, then specifies the capabilities necessary to achieve that science, and then solicits the community to build an instrument with these capabilities. Next, I discuss two options for the phasing of instruments, one more sequential and the other more parallel.

Samuel Lara-Avila (Chalmers University of Technology)

Title: Epitaxial graphene on silicon carbide for terahertz heterodyne astronomy

Abstract: Further leaps in terahertz (THz) astronomy demand new detector materials and devices reaching the fundamental detection limit. Superconducting hot-electron bolometer (S-HEB) mixers form the baseline for modern astronomical receivers above 1 THz. In these, the wave beating between the Local Oscillator (LO) and the THz signal causes temperature oscillations in a metal around the transition temperature, at the Intermediate Frequency (IF), enabling read-out through changes in electrical resistance R (resistive read-out) as long as the temperature can follow the signal modulation. Despite huge efforts, the instantaneous bandwidth in practical niobium nitride (NbN)-based S-HEB mixers does not exceed 4-5GHz, limited by the electron temperature relaxation rates. Beyond superconducting materials, charge-neutral graphene has been discussed as an ideal platform for terahertz bolometric direct detectors due to its small heat capacity and weak electron-phonon coupling. Prior to this work, the absence of large-area graphene homogeneously doped to Dirac point had hindered any prospects for graphene-based practical detectors in astronomy and other sensing applications. Furthermore, a negligible temperature dependent resistance of graphene has kept this approach as not acceptable for bolometric mixers where voltage read-out is required.

We have investigated epitaxial graphene grown on silicon carbide (epigraphene) that is doped to the Dirac point with a high uniformity across the wafer. With the resistance dominated by quantum localization, and thermal relaxation of carriers governed by electron diffusion, we demonstrate an epigraphene bolometric terahertz mixer with a gain bandwidth (presently) of 9 GHz (relaxation time 20 ps) and a mixer noise temperature of 475 K. We conclude that with the present quality of graphene, optimization of the device layout will result in a mixer noise temperature as low as 36 K and a gain bandwidth exceeding 20 GHz, with a Local Oscillator power of < 100 pW for operation temperatures <1K. Given the scalability of the material and in conjunction with emerging quantum-limited amplifiers in the GHz domain, we envisage large arrays of quantum–limited sensors in the THz domain for radio astronomy, potentially surpassing superconductor-based heterodyne detectors.

Leslie Looney (U Illiniois)

Title: FIFI+LS: a timely upgrade to FIFI-LS

Abstract: The Field-imaging Far-Infrared Line Spectrometer (FIFI-LS) is a science instrument observing onboard SOFIA for the last 6+ years with 27+ cooling cycles. FIFI-LS provides simultaneous observations in two spectral channels. The Blue channel is sensitive from 51 to 125 μm and the Red channel from 115 to 203 μm. The instantaneous spectral coverage is 1000–3000 km/s in the Blue and 800–2500 km/s in the Red channel with a spectral resolution between 150 km/s and 600 km/s. Each spectral channel observes a field of view of 5x5 spatial pixels on the sky (6" for Blue and 12" for Red) with 16 spectral pixels for each spatial pixel. With the unique capability of dual-line integral-field observations, FIFI-LS can measure multiple fine structure cooling lines, as well as some molecular lines, which deliver critical constraints of the Interstellar Medium and star forming environments. Although PACS on Herschel covered much of the FIFI-LS band, their observations of the ISM and star formation environments have opened many questions that FIFI-LS is now addressing. However, the 90s-era Ge:Ga photoconductor detectors on FIFI-LS limit large surveys of galaxies due to the limited time of flight series. In this talk, we present an upgrade path for FIFI-LS, named FIFI+LS that takes advantage of advances in the new kinetic inductance detector (KID) arrays available. Such an upgrade will 1) increase sensitivity by ≥ sqrt(2) (possibly up to 2.5) and mapping speed by a factor of ≥ 3.5 for extended objects, 2) increase the number of spaxels to 9 x 7 and the FOV by factor of 1.75, 3) improve the beam sampling by using 5" pixels in the blue (FOV of 45" x 35") and 10" pixels in the red (FOV of 90" x 70"), and 4) increased spectral pixels to 64 to allow better, simultaneous determinations of the PWV from the target spectra themselves, providing more observing efficiency.

Chris Packham (UTSA)

Title: SOFIA Mid-IR Polarimeter: SMIRPh

Abstract: A key contribution from SOFIA to advancing various scientific cases has been the provision of excellent and unique polarimetric observations. From AGN to young stars, solar system to dust grain chemistry, polarimetry is a powerful and insightful tool. HAWC+ offers polarimetry at ~50-210 mm, and ground-based polarimeters operate at ll <~14 mm. Thus, there is a 'desert' between ~15-50 mm. In this presentation we discuss selected science cases and

a feasibility level design concept for SMIRPh, an instrument designed to quench that desert.

Judy Pipher (U Rochester)

Title: Possible Mid-IR Photodetector Technologies for SOFIA

Abstract: The status of various photovoltaic, BIB/IBC, Superlattice technologies to produce arrays sensitive from ~20 - 40 mm will be reviewed to assess where reasonable investments should be made by NASA for SOFIA instruments. These include HgCdTe, Si:As IBC, Si:Sb BIBs and Type 2 Superlattice arrays of both III-V and II-VI materials. I will not discuss either TES or MKID technologies for this wavelength region, because they will be described by other speakers.

Erin Smith (NASA GSFC)

Title: SOFIA Common Dewar concepts

Abstract: One innovative approach to enabling SOFIA instrument development is the concept of designing and potentially manufacturing a 'Common Dewar', which would be usable by a wide range of Astronomical experiments, but would fulfill SOFIA requirements (e.g. airworthiness, EMC/EMI and flange interface tolerances). One investigation of this concept was the Standard New Astronomy Cryostat for SOFIA (SNACS) While partially used to enable adoption of cryocoolers onboard SOFIA, the system was also used as a testbed for a potential common dewar concept, featuring a cryostat with a 4K Optical bench and optional support for additional cooling stages (such as an ADR). Other approaches to a Common Dewar could also include development of a common dewar design or utilization of already-approved cryostats from retired instruments in new SOFIA instruments, technology demonstrations or testbeds. This talk will examine these approaches, the SNACS design study and potential future applications of a Common Dewar concept for SOFIA instrument development.

Johannes Staguhn (JHU and NASA GSFC)

Title: Transition Edge Sensors for (Far-)Infrared Astronomy

Abstract: We will provide an introduction and overview of Transition Edge Sensors (TES) used for far-infrared astronomy and beyond. Important properties of TES making them suitable for future instrumentation will be highlighted together with an outlook on potential suborbital and space-based instruments and missions.