

## Report of the SOFIA International Summit Meeting at NASA Ames Research Center, 14-15 November 2017

The SOFIA International Summit (SIS) met at NASA Ames Research Center on 14 and 15 November 2017. Members Matt Greenhouse, Andy Harris (co-Chair), Jay Lockman, Harvey Moseley, John Nousek, Lisa Storrie-Lombardi, Jürgen Stutzki (co-Chair), and Mike Werner were present at the meeting, and Karl Menten joined remotely. The SIS heard presentations on a variety of topics, most related to the impending Senior Review scheduled for Spring 2019.

***The Senior Review is the main focus of this report: preparing for that will strengthen the observatory in every dimension.*** We begin with a summary of our main findings before providing more detail on individual items. Members of the SIS found themselves in agreement on all major points, so for the sake of brevity this report does not contain individual reports, but notes individual viewpoints where appropriate.

### **Summary of main findings**

1. Strengthening SOFIA's scientific standing in the community, and therefore for the Senior Review, requires demonstrating that SOFIA makes important contributions to scientific questions of widespread interest.
2. SOFIA science themes must evolve from potential topics to well-justified science cases that look to the future.
3. Clear criteria for evaluating and preparing SOFIA science cases are still not apparent to the SIS. Developing evaluation criteria and then preparing science cases is very urgent. The SIS strongly suggests a February 2018 deadline for rough drafts of potential science cases for the Senior Review, and we propose to review them in a teleconference with the SOFIA team. This should lead to well-developed cases available for full review at the next SIS meeting later in the spring.
4. The SIS has not seen a plan for who will write the science cases. Establishing this must take very high priority; this cannot be considered supplemental activity for program staff with other responsibilities.
5. The Senior Review proposal must make compelling arguments that new instrumentation, leaner approaches to operations, and new concepts for the observatory's science projects will dominate and enhance the science return in the extended mission phase
6. SOFIA presentations and publications must demonstrate scientific depth as well as uniqueness.
7. Understanding and optimizing SOFIA's role requires a broad understanding of related projects. Linking SOFIA data to ALMA results, JWST's promise, and other highly-regarded data is essential.
8. The Observatory should identify one or more projects proposed for Cycle 6 that could be given support to complete release of major studies by the time of the Senior Review. Encouraging major projects related to the science cases in the Senior Review is essential for Cycle 7.
9. A review of all observatory science instrumentations should take place within the next six months. Instruments that do not carry Observatory science into the future should be retired.
10. The number of invested parties makes contingency plans and agreements for ramping down SOFIA operations complex. Given the relatively short Senior Review cycle, discussions of potential timelines and approaches should begin soon, whenever a ramp down might occur.

11. Uncertainties introduced by the 3-year Senior Review cycle makes it difficult to obtain funding to support instrumentation and science for the German partners. German participation here has been a major contributor to SOFIA's success.
12. Disbanding the SNOAC and making the SIS the principal group for providing scientific strategy comments to SOFIA management is appropriate. Assuring good communications between the community groups is essential.

### **1. Observatory science cases and proposal plans**

There is considerable urgency in identifying and promoting the best science cases. Until now the emphasis has been on collecting the raw material to support plausible directions. Science leadership must now shift to making really solid cases for the best topics to explore and ultimately demonstrate SOFIA's scientific impact. We heard a wide range of perspectives on potential science cases and potential interactions with other observatories, and saw the beginning of convergence on the science cases that will become the centerpieces of the Senior Review proposal. For these to become compelling cases, however, the motivation, context, and criteria for choosing and supporting them must be considerably sharper.

#### *1.1 The SOFIA observatory's context*

The SIS agrees that SOFIA's unique strengths remain high resolution spectroscopy of far-IR fine structure lines, far-IR polarimetry, and the ability to put a 2.5m telescope high above the clouds anywhere in the world. Long-duration balloon platforms may be competitive with or superior to SOFIA for some types of observations, and SOFIA's science case must take this into account.

A unique strength of SOFIA is that it can accommodate new instruments relatively easily. It thus serves as a platform for instrument development and is not locked into technology that is obsolete. Many of the most exciting results the SIS saw came from new instruments.

Most importantly, SOFIA's results are bracketed to either side in wavelength by much-anticipated results from JWST and ALMA. To a large extent the astronomical community has declared the problems that JWST and ALMA will solve are central to current astronomy. Connections to JWST and ALMA science topics are therefore essential. SOFIA's position as a bridge in wavelength, its ability to make high-resolution studies of local analogs to more distant sources, and its sensitivity to large scale structure that would escape instruments with much higher spatial resolution, must be elements in evaluating science cases.

#### *1.2 SOFIA science cases*

In all cases the main emphasis in developing science cases must be on scientific questions, not on technical capabilities. These capabilities, while impressive, are not by themselves a rationale for continued operation. The Senior Review and the community judge the Program's worth by the importance of the scientific questions it answers.

So far, the science themes the SIS has seen have contained interesting and plausible ideas, but their justifications are shallow and have little broad context. This must change rapidly. A clear expression and acknowledgement of related work from the past or from other observatories is necessary to convince the broad community of the value of SOFIA's contributions. Stretching too hard to make connections to

topics where skeptical experts can easily find the cases weak or parochial is counterproductive. To take two examples from the presentations: Complex organic molecules that are precursors to bio-molecules have been studied for decades at radio wavelengths, so the ability to observe some simple organic molecules is not obviously transformative. Understanding the role of magnetic fields in dense cores is important for understanding star formation, but seem less relevant for issues in galaxy formation, where the SOFIA size scales and field strengths do not easily tie to the large body of work on galactic-scale fields. Finally, showing provisional figures with errors leads audiences to question other parts of the presentation. Bringing the science cases up to a high standard will take time and resources; this cannot be an afterthought.

To gauge the strength of SOFIA's science cases, the SIS suggests that the science team should take the Observatory's best results so far and build the case that they can carry the Program into the future. This case should be compelling to a general scientific audience. As new results come in, these must be judged as well. It is important to identify and encourage science that is best suited to answering current key questions in astrophysics and astronomy. Identifying and understanding the key questions will involve a great deal of listening as well as introspection.

### *1.3 Senior Review considerations*

SIS members had a variety of opinions on the emphasis for the Senior Review proposal. Most members, and especially those with experience preparing Senior Review proposals, stressed the importance of concentrating on new possibilities for the observatory. An extended mission is not the same as the prime mission: SOFIA must move into a new phase and a new way of operating. Other members, some with experience as reviewers in Senior Reviews, felt that SOFIA should capitalize on its unique capabilities as a platform with instruments that can evolve and improve to track scientific questions, rather than attempting to reinvent itself into a radically new form. Whatever the tenor of the proposal presentation, the SIS members felt strongly that SOFIA must make compelling arguments that new instrumentation, leaner approaches to operations, and new concepts for its science projects will dominate and enhance the science return in the extended mission phase.

The SIS briefly considered program cost and operations as elements in the Senior Review. SOFIA's operational cost and mode cannot be directly compared against orbital missions, where the observatory is complete and untouchable after launch. The Senior Review will almost certainly impose budget reductions on the SOFIA project, so the overall approach has to anticipate and be robust against funding reductions. The planned operations and budget reviews will be very valuable here. As the SIS reviewed this report, the question of combining all observatory operations at one site also came up as a topic the Senior Review will likely consider. Establishing how the science support, instrumentation, and operations will adapt to a 3 year/6-year Senior Review cycle is also essential.

All SIS members felt very strongly that NASA should provide the SOFIA project with guidance about the Senior Review process as it applies to SOFIA as soon as possible. We attach a copy of a letter to NASA Headquarters for reference.

### *1.4 Scientific leadership and Senior Review proposal management*

The SIS saw a delineation of scientific leadership roles for the proposal, showing that the Project Scientist and SMO Director, aided by a small local team of experts, will decide on the science cases and

otherwise manage the process of producing the Senior Review proposal. This is entirely appropriate. Wisely, this team apparently includes experts not only on astronomical results, but also on operational constraints for sky coverage, deployment strategies, and maximizing science-driven flight hours.

The SIS is, however, concerned that the Project Scientist and SMO Director seem to have little time to strategize and plan together in advance of deadlines. Unfortunately, clear descriptions of how the science cases will be produced and selected were missing in the presentations. Some elements of this were scattered throughout the meeting, but they must be consolidated and evaluated. A focus on strategic thinking about SOFIA's science is necessary, but it was unclear who was responsible for this and how the different possibilities would be evaluated.

To clarify the decision process, the SIS encourages the Observatory's science team to make and articulate clear plans for promoting the strategic thinking and criteria needed for deeper and more critical assessments of the science cases. Evaluation criteria must be explicit and used as requirements for the "mini whitepapers" that will explore candidate science cases. The SIS agrees with the whitepaper approach to winnowing cases, and suggests 5-6 pages (including figures) as an appropriate length. Whitepapers of this length will enable the authors to explore cases critically, identifying weaknesses as well as strengths. This length is also well-matched to the length of the cases in the Senior Review proposal itself. Obtaining evaluations from scientists from broad backgrounds is an essential element in reviewing the whitepapers.

This SIS is very concerned that there was no direct statement about who would prepare these cases, and that the number of person-hours available may be inadequate. Producing these cases requires dedicated time from groups of experts, and cannot be treated as a supplemental activity. Incorporating German scientists in the process is important to bring further expertise and effort into the mix.

Ideally, at its next meeting, the SIS would be able to review the selection of really solid science cases short-listed for the core of the proposal. The SIS will be calling for at least one teleconference to review material starting in February 2018. SIS members must be able to see all potential material in and for the science cases, and we are willing to sign non-disclosure agreements if necessary. The confidentiality required is really no different than the conditions imposed by normal Agency proposal reviews.

## **2. Major projects**

One question the SIS considered is what SOFIA needs to produce for a Senior Review that it hasn't yet done. There are several possibilities, but demonstrating that SOFIA can support major projects, in the sense that their results are seen as major contributions to multi-element large-scale projects, is vital.

For Cycle 6, the SIS recommends that the SMO Director, in consultation with the Project Scientist, identifies one (or more) projects from the Cycle 6 proposals that will produce a major body of scientifically important work within a year, and give it high priority for completion. If the observing team agrees and can comply with the urgency, then fully fund the team immediately and ensure SMO and flight time support as needed to complete the program in time for inclusion in the Senior Review. Observations for the selected project[s] should begin in Cycle 5 if feasible, rather than awaiting the nominal start of Cycle 6.

The SIS strongly opposes a crash effort to quickly define a new candidate project to be squeezed it into Cycle 6 planning at this stage. New Cycle 6 projects -- defined or vetted by a committee -- are likely to be poorly motivated and rushed, and would be unlikely to achieve the desired results for SOFIA.

In Cycle 7, however, there must be major projects with real concentration on topics that support the central science cases presented to the Senior Review.

### **3. Science outreach**

Well-researched science topics, whether the top whitepapers for inclusion in the Senior Review proposal or not, will be valuable elements in educating the wider community about SOFIA's scientific contributions. SOFIA is a mature observatory, and the time for emphasizing its capabilities alone has passed. It is essential to present publications and talks showing its scientific impact on questions that scientists recognize as important. Especially so close to the Senior Review, holding back interesting new results until they have received a final polish is deeply counterproductive to the Observatory's success. This point must be hammered home to the instrument teams and observers. Showing new and exciting results is the key to building broad community interest and support for the Observatory.

In this vein, the SIS recommends concentrating on having Observatory and GO scientists present results at as many conferences as possible and at institutional colloquia. Visibility is part of the story, dispelling the impression that SOFIA has been unproductive. But participants at conferences should also be encouraged to identify questions of general interest where SOFIA results contribute, and shape their presentations accordingly -- listening carefully as well as presenting.

Ensuring that SOFIA is well represented at conferences is far more important than organizing meetings that bring SOFIA users together, and the SIS strongly suggests that the SOFIA conference planned for 2018 be dropped to allow Observatory scientists and resources to go toward the wider community building and proposal activities that will demand attention at that time. The SOFIA team should angle for a plenary talk at the January 2019 AAS meeting, as well as the summer 2018 meeting if possible.

Heightening awareness through publications is another essential activity. Observatory scientists have been nudging observers to publish data, and offering help where there are bottlenecks that the SMO can resolve. Further energizing the user community is essential, these efforts should be expanded. Some observers will respond to letters (rather than emails) reminding them of the situation's gravity. Frequent reminder emails will motivate others. Others may respond to coordinated opportunities to publish clusters of papers on astro-ph. Activities such as this that provide deadlines to work toward will help motivate submissions; other ideas for providing deadlines or incentives to publish are possible. It is fine to mildly irritate the user base, especially if the message that the Observatory's future depends on their actions.

The SIS was impressed by the quality and activities of outreach to the general public. Much of that material can be used to impress and educate the science community. Younger scientists especially find social media platforms appealing. Providing data reduction and USPOT cookbooks and short video tutorials showing e.g. simple data reduction steps will reduce barriers for scientists who feel their unfamiliarity with infrared observations keep them from proposing, or from effectively reducing SOFIA data.

#### **4. Science operations**

The SIS finds that the recent emphasis on completing projects is excellent, and fully supports the new priority system that includes the “must do” category. Increased operations flexibility, including short “suitcase” deployments, has demonstrated scientific impact. The operations concentration on increasing flight time as well as reducing costs shows the Program’s breadth of understanding in optimizing science return from aircraft operations. We also applaud the newly initiated program which guarantees observing time and investigation completeness to projects that lead to student theses.

#### **5. Instrumentation review plans**

SIS members fully endorse convening a Science Instruments Assessment Group (SIAG) within the next six months to thoroughly examine the entire instrumentation suite provided by the U.S. and German communities, with the exception of HIRMES, which will not have entered operation. It is essential to convene a committee with a very broad overview of science and operations. Criteria for evaluation should include the promise of tackling new science questions (in contrast to simply doing a more efficient job on an old science question), demonstrated scientific impact, and operational complexity. Criteria should not include quotas or any determination to eliminate one or more instruments from the complement for any reasons other than the observatory’s scientific productivity.

For the Senior Review, it will be important to demonstrate that the Observatory is capable of critically examining its instrument complement, and can prune it as needed to enable completely new science. Obtaining NASA headquarters agreement to completely eliminate FliteCam and HIPO will help to make this point. To the extent that instrumentation technical development matters in the Senior Review, the real point will be to show that SOFIA’s ability to keep capabilities very close to the laboratory state of the art has produced important new science. The upGREAT and HAWC+ instrument upgrades are excellent examples of this.

#### **6. New instrument development**

After considerable analysis and discussion, the SIS believes that NASA’s fourth call for instrument development is something of a misnomer: It really seems to call for the creation of a legacy project of importance to the broader community, along with the necessary instrumentation. This is very much in the spirit of the Senior Review, where every new instrument defines a new scientific emphasis for the observatory, and demonstrates how SOFIA unlocks new science. Publicizing it as an instrument call is likely to miss many potential proposers. First, there are only a very small number of places capable of building or even supervising construction of the complex instruments called for here, so few instrument builders will respond. Second, for this “legacy project” approach to succeed, it is essential to sufficiently support the proposing team to design and carry out the program, and not focus only on the instrument itself. These points are important in this report only to the extent that SOFIA management contributes to drafts of the Call; the SIS will convey their opinions separately to NASA Headquarters.

On the German side, the SIS reiterates how important the German instrument contributions have been to SOFIA. The *Denkschrift Astronomie 2017* that evaluates and ranks German science priorities prominently mentions SOFIA’s importance, and summarizes SOFIA’s issues well. Funding uncertainty related to the NASA’s Senior Review cycle is a very serious problem for science and instrument development – it is difficult for funding agencies to commit support, and instrument teams to provide

upgrades, when there is such uncertainty in the future on timescales equal or shorter than instrument development, commissioning, and exploitation. For the German partners, funding for instruments, science, and operations support requires coordination across multiple Federal Ministries, adding to the complexity. The SIS recognizes the problems caused by international timing, and feels that the approach of DLR program personnel building on success with their “home” Ministry while encouraging communication with other Ministries is a fruitful approach. The SIS also remarks that the tone of enthusiasm presented by DLR’s representatives is beneficial to the entire Program.

#### **7. Planning for a potential ramp-down**

A potential outcome of the Senior Review is a decision by NASA to ramp down its support for the SOFIA observatory. The SIS considered the effects on both US and German partners from a science perspective. If a ramp-down is required, a plan that ensures sufficient science return on the investments made is essential. This plan must include support for science exploitation and archiving of SOFIA data. This process is simpler for the US partner, since science and instrument funding originate from NASA. The situation is more complicated for the German partner, since multiple funding sources are involved, and broader discussions will be necessary.

#### **8. Advisory groups**

The US members of the SIS unanimously endorsed disbanding the SNOPAC as a separate group, and replacing it with the proposed modifications to SIS structure. The German members agreed with the new structure as well. Communication between all of the groups that provide input to SOFIA’s management – including but not limited to the SOFIA Users Group, the SOFIA Science Council, and the German SOFIA Science Working Group – is important and must be encouraged. This may be accomplished through the exchange of relevant excerpts from the minutes, reports by members who sit on multiple committees, or other suitable methods.

The new structure allows the SIS to concentrate on strategy. A complementary group, the SOFIA Users Group (SUG), functions very well at capturing user experience and wishes from the users. Reports on the SUG’s findings and materials prepared for the SUG meetings are valuable resources for the SIS.