Response to SMA Advisory Committee Report 16th November 2007

Overview

Staffing is the Committee's main concern for the SMA's continued health.

Agreed. As a minimum, we had prepared advertisements for immediate hire of the following:

Director of SMA Hilo Operations
Radio Astronomer (Hilo)
Receiver Engineer (Cambridge)
Astrophysicist with strong background in theory (Cambridge)

However, with US Government continuing resolutions and a recently imposed hiring freeze, we will need to work extra hard to convince SI to allow us to hire the most critical:

Radio Astronomer (Hilo)
Receiver Engineer (Cambridge)
Director of SMA Hilo Operations

Scientific productivity of the SMA is good and improving, but would be significantly enhanced by interaction with other members of SAO and particularly theorists.

Agreed, in fact it has been much easier to encourage interaction with individuals from outside millimeter-wave groups than scientists within other divisions at the CfA. We recently augmented the SMA Time Allocation Committee to include two scientists from other divisions, and will continue to rotate others on to the SMA TAC to both benefit from their experience and also to encourage selected individuals to become more familiar, and hopefully more involved with the type of science that can be done with the SMA. In addition, several recent Postdoc hires at the CfA are beginning to result in enhanced cross-divisional collaboration. We clearly we need to do better, so we are now actively pushing SMA scientists to foster collaborations with other groups within the CfA.

The Committee endorses plans to form a task force immediately that will investigate science cases for different possible future courses.

Agreed, we have a number of potential candidates in mind, both external and internal to SAO, and plan to form a Committee before the year's end.

A brief summary of the Committee's main recommendations is:

- Continue to focus strongly on
  - Observations in the 350 GHz atmospheric window
  - Polarimetry in the 350 and 650 GHz atmospheric windows
  - Studying small samples of sources in a coherent program rather than dissecting individual targets one-by-one
  - Phase correction using stratospheric ozone as a beacon for tropospheric water vapor absorption

    - Sensitivity and ease of use improvements
- Foster collaborative projects
    - Within the CfA; the connection with Spitzer is an outstanding example, and collaborations with ASIAA theorists would be valuable
    - With Herschel and SOFIA science teams
    - With scientists and engineers at CARMA, IRAM, and other observatories
    - With high-frequency mixer fabricators
- Move quickly on three key staff hires
- Continue eSMA work at moderate priority, and VLBI at low priority
- Form a task force to thoroughly explore the cases that will carry the SMA into the ALMA era.

Software

Increasing data rates are likely to stress the capabilities of IDL, perhaps severely.

Agreed. We have been pushing the development of SMA specific routines for Miriad. Unfortunately several of the senior scientific staff prefer to use MIR-IDL because it has been more thoroughly debugged and is flexible enough to fix most data problems. Recently we have been using Miriad to process all SMA data for a quick look and this has flushed out most of the remaining bugs in the data reading routines so that all recent SMA data has been successfully processed in Miriad.

Establishing an archive with both visibility and image data would enhance the usefulness of the SMA to the broader community. The SMA should consider interacting and collaborating with the CARMA or ALMA software groups in order to develop a pipeline processing capability.

Agreed, however, this is not straightforward as we have a limited staff and different projects will want different kinds of images. During the coming year, we expect to relieve the Radio Telescope Data Center from much of the routine archiving of SMA data. The RTDC staff member who had been doing that has recently been calibrating all of the SMA data as it comes in. This is in an early stage and her work has not been properly checked, but if this is successful, we should be able to archive calibrated visibility data - a big step toward making the images available after the proprietary period. It will also make SMA data much more available to people who have used other arrays. We also have the quick look pipeline under development.

Staffing

The staffing level is clearly a limiting factor on progress, especially in the area of developing and bringing new receivers on line. The Committee identifies three immediate key hires:

- Hawaii operations manager. While the Hawaii operations are going well at present, having an operations manager based in Cambridge who commutes to Hawaii is not healthy or sustainable in the long run.
- Receiver lab engineer. Staff has moved from this area into management or into positions outside the CfA, and lack of high level engineering has slowed the SMA's progress. Fortunately, this is a good time to advertise for a top-level receiver engineer: Herschel/HIFI is in satellite integration, so experienced engineers will be coming on the job market.
- Instrumentalist/observer. In addition to a receiver specialist, strengthening staff to work at the system level is important for bringing new systems and operating modes on line and testing them.

Agreed, the above hires are critical to the well-being and stability of the SMA and to any future developments and upgrades to instrumentation.

The idea of bringing in a senior scientist to motivate and lead a larger effort in a given research area is good. As open a search as possible is needed to find someone whose expertise and interests are best matched to the SMA's capabilities and needs.

Agreed, however with the recently imposed hiring freeze, this position will probably not receive funding for at least a year.

The Committee urges that the SMA continue to encourage postdocs and students to be deeply involved in instrumental and software work.

Agreed, we recently recruited Abigail Hedden to a Postdoc appointment – as a former Chris Walker student with hardware experience, she spends a large fraction of her time (>50%) in the receiver lab; have a visiting student from MPI Heidelberg (Cassandra Fallscheer) who spends one day a week in the lab; will shortly host a student in the receiver lab from ASIAA for about a 6-month period; and expect to recruit another Postdoc, with instrumental/software leanings, to the SMA by fall 2008.

eSMA

There are specific, separate problems related to both the JCMT and the CSO, which must be smoothed out before operations can start. Science projects should start as soon as possible. However full science operations can only start once the system is debugged and well understood, and once all the telescopes have receivers with approximately equivalent system temperatures, so as to fully take advantage of the potential increase in sensitivity. A detailed and firm project plan is necessary and a coordination management team should be formed. These efforts should be led by one of the other partners (e.g., JCMT staff) who will make the eSMA a high scientific priority.

Agreed, the development of the eSMA has been, and continues to be fraught with difficulty. On a more positive note, we recently held a meeting with JCMT staff in

Cambridge to develop a plan for future testing which will include test astronomical observations in the New Year, to be followed by real e-SMA science later in the year pending a successful outcome.

VLBI

The Committee sees the SgrA* experiment to be the *only* science driver for VLBI, this activity should not consume huge amounts of resources.

Agreed, the SgrA experiment is of high interest. We expect to continue the current level of effort: 1 person ~ 20% time.*

Near-term recommendations

A primary requirement for the SMA is a strong and innovative technical group. This will be the case whether considering the near or the long term. The greatest need is in receiver development and correlator development. Receiver development for frequencies up to about 700 GHz will be of most near-term value for astronomical observations. All of the SMA's receivers need to state-of-the-art in sensitivity and easy to tune. The Committee recommends concentrating on the 690 GHz band more than the 460 GHz band.

Agreed, the retention and reinforcement of a strong and innovative technical group is essential to maintain and improve the technical performance of the SMA. We need to make every effort to hire an experienced Receiver Engineer in the Cambridge labs. This will enable Edward Tong to direct Abigail Hedden towards an improved mixer design for the 690 GHz band. We have made contact with the SIS fabrication group at U. Cologne (responsible for the Herschel Band 2 mixer at ~ 700 GHz) to speed up the process. The SMA currently has no Digital Correlator Engineer, however, we expect Jonathan Weintroub to provide guidance towards the best approach to procuring a wideband correlator to complement SMA wide-band receiver developments.

Polarization is an area where the SMA can excel in the near term and beyond. Dual polarization observations are needed for the best sensitivity, first at 350 GHz by completing the 400 GHz receivers, and then at 690 GHz. Maximizing the observing efficiency at 690 GHz is especially important because of limited periods of good atmospheric transparency – observing simultaneously in orthogonal polarizations will increase effective observing time by a factor of five compared to sequential observations of a single polarization.

Agreed, due primarily to the departure of key receiver personnel, deployment of the 400 GHz receiver sets has gone more slowly than originally planned. Furthermore, the overall performance of the 400 GHz receiver sets fielded thus far remains below expectations. The poor performance has recently been tracked down to an error in the

400 GHz SIS mixer mask set made at JPL and is currently being addressed. While dual receiver operation at 690 GHz will significantly enhance (enable) the ability of the SMA to conduct polarimetry, cuts to the SMA budget will not enable component parts for a second receiver set to be purchased this fiscal year. Indeed, cuts to the SMA budget last fiscal year have delayed improvements to both the sensitivity and tunability of the current 690 GHz receivers.

A real time atmospheric phase correction scheme is needed for the SMA to efficiently operate at high frequencies. The O_3 technique described to the Committee represents a clever and innovative scheme and work should continue with high priority.

Agreed, in fact the development of a real time atmospheric phase correction scheme is also essential for efficient exploitation of the SMA at its highest angular resolution, and will also be needed for efficient operation of the SMA. We currently plan to make tests at the SMA in the coming weeks to validate the approach. However, cuts made to the SMA budget this past fiscal year have resulted in the absolute minimum purchase. If the U.S. Government continues to operate under continuing resolutions, currently imposed on the Smithsonian Institution, for the whole fiscal year, the deployment and implementation of the real time atmospheric phase correction scheme (which needs equipment in each antenna) will be significantly delayed.

Many of the exciting recent scientific results were enabled by unglamorous work. This is central to the observatory's success and evolution in operations and in speeding up the science for both internal and external users. The Committee recommends that this effort to bring new capabilities on line continues.

Agreed, this effort is only limited by current staffing levels. With the expected departure of John Barrett (January 2008), we need to work hard to replace critical members of the receiver lab staff.

Mid- and long- term perspectives

The current successes of the SMA, and existing plans to upgrade SMA receivers, ensure that – even without additional major upgrades – the SMA will remain a valuable scientific resource into the ALMA era. With ALMA expected to have six or more elements functioning within four years, it is clear that the SMA should be developing a plan for the ALMA era now. This planning will need to be informed not only of ALMA's anticipated performance, but also by what is expected to occur at other sites, such as PdBI, CARMA, and CCAT if it becomes a reality. In addition Herschel, Plank, ad SOFIA, when they begin scientific operations, may disclose new classes of astrophysical systems that might call for submillimeter interferometric imaging and follow-up.

The detailed choices for the future are complex, but there appear to be two main options:

- To remain on Mauna Kea. If so, hardware upgrades should continue to take place. At a minimum, these upgrades should include improvements in the bandwidth useable for continuum observations, dual polarization capability at high frequencies, and improvement in receiver sensitivity and correlator capability as permitted by technical developments in these areas.
- To move the 8 SMA telescopes to a site with improved atmospheric transmission, perhaps in Chile. Such a site, allowing interferometric operation at frequencies as high as 1.5 THz would create a facility with unique capability.

The Committee strongly endorses the plan for SAO and ASIAA to create a task force to analyze the scientific case for each of the two options.

In any eventuality, innovation will be central to the SMA's progress into the future. It will be important to reinforce the technical group, especially in the specialized areas of receiver and correlator development to continue SMA's high standard of technical development and to provide realistic assessments for new instrumentation. Forming connections with high-frequency mixer materials and fabrication laboratories is an essential part of any plan involving THz observations. The SAO, ASIAA, and the SMA have provided an environment that encourages and enables excellent and imaginative science and technology by the SMA's staff; maintaining and developing these strengths will carry the SMA into the future.

Agreed, the SMA technical groups (in particular the receiver lab staff) have been key to developing the SMA into a world-class facility, making astronomical observations on a nightly basis. In recent years, the size of the technical groups has diminished significantly – additional hires in the receiver development area remain a priority for the SMA. Many of the recent high frequency mixer developments have occurred in connection with the Herschel satellite, and many of the quality submillimeter engineers are non-US citizens. The SMA will therefore also need to aggressively and immediately recruit in key areas. Time is critical because the hire of non-US citizens can only occur following demonstrated failure to hire qualified US citizens.