

Project Description

1 Overview

Mission Statement: *Antarctica holds tremendous potential for cosmology and astrophysics that can be best realized if the scientists involved understand and participate in the management, planning and oversight of the shared resources and logistical support. The Science Coordination Office for Astrophysical Research in Antarctica (SCOARA) is an intellectual partnership comprised of and directed by these scientists to ensure that the highest quality astrophysics is conducted at the South Pole.*

To carry out our mission, we are seeking to initiate a formal mechanism, SCOARA, which is structured to enable the scientists to work together to coordinate and maintain shared resources, to communicate lessons learned and new knowledge, and to provide a valuable advisory resource to the NSF/OPP Polar Research Support Section (PRSS) and its Antarctic support contractor. Funds are requested to facilitate this coordination, to maintain shared scientific equipment and to operate the South Pole Dark Sector model shop. No funds are requested for activities that are covered by the individual investigator grants.

Over the last decade the infrastructure for conducting astrophysics projects at the South Pole station has evolved from crude, makeshift laboratories with severely limited resources to modern, well-equipped laboratories. Concurrently the characteristics of the atmosphere above, and of the ice below, the station have been studied extensively. Due to the combination of low temperature, low water vapor content and high stability of its atmosphere, the South Pole has been demonstrated to be the best developed site on Earth for conducting millimeter through infrared wavelength observations, especially large area survey observations. Due to its exceptionally clear and thick ice, the South Pole is the best site available for deploying a large Cherenkov high energy neutrino detector. The Center for Astrophysics Research in Antarctica (CARA) and the Antarctic Muon and Neutrino Detector Array project (AMANDA) pioneered the development of these fields at the South Pole and ushered in an era in which complex, state-of-the-art instruments designed to take full advantage of the exceptional site conditions can be deployed and operated successfully. World-class cosmological and astrophysical research has resulted.

We firmly believe that the scientists must play an active role in the coordination of the shared and limited resources at the South Pole, and in the operation and maintenance of the scientific equipment and facilities that are critical to their research if our mission to ensure that the highest quality astrophysics is conducted at the South Pole.

The scientists must also work together to provide coherent and well-researched advice to OPP on issues critical to the success of the NSF South Pole astrophysics program, for example, issues related to the cryogen supply and information technology. Most important, especially for new projects, is to have communication mechanisms among the scientists and support staff that will ensure all projects benefit from the many lessons learned during the development of South Pole astrophysics over the last decade, and to ensure the best solutions to new challenges are found. While ad hoc measures have been used since CARA ended over two years ago to provide this science coordination, they have been insufficient. SCOARA is structured to officially provide this mechanism.

Some specific examples of science coordination among the many current and planned projects include:

- Liquid helium supply and usage.
- Dark Sector model shop operation, maintenance and supply.
- Dark Sector mechanical and electronic support.
- Information Technology, communications and data transfer.
- Shared Laboratory space and scheduling.

- Optimization of Austral summer and winter science staffing

In designing the structure of SCOARA we have drawn upon the considerable Antarctic experience of the astrophysics community. We have also carefully analyzed several models for science coordination, including that done by CARA.

The entire community was brought together for a two day workshop specifically to develop a mechanism to provide the science coordination. Common themes for what an umbrella organization should and should not do were identified. We believe the structure proposed here best represents the interests of the entire community as confirmed by the large number of supporting letters submitted with this proposal.

This proposal is organized into four main parts.

1. Overview
2. Recent History of South Pole Astrophysics.
3. Community Goals for a Science Coordination Office.
4. Science Coordination Office for Astrophysical Research in Antarctica (SCOARA)

Those already familiar with the need for an organization such as SCOARA may want to go directly to Section 4, where the specifics of SCOARA are discussed

2 Recent History of South Pole Astrophysics

It is useful to review the recent history of South Pole Astrophysics to understand the need and the benefits of the organization we wish to establish.

2.1 pre-CARA

Prior to the establishment of the NSF Science and Technology Center for Astrophysical Research in Antarctica (CARA) in 1991, astrophysics at the Pole was conducted by individual groups with no dedicated laboratory infrastructure. They were certainly pioneers and they quickly saw the potential of the site. Their ability to actually exploit the site for astrophysics was seriously hampered, however, by having to figure out how to work in the severe environment for the first time and with very little support. Makeshift laboratories were constructed from shipping crates and cryogenics were often lacking. Observations were only conducted during the Austral summer; they could only dream of taking advantage of the spectacular observing conditions believed to prevail during the Austral winter. Nevertheless, these pioneering exploratory projects sparked the interest and subsequent growth in South Pole astrophysics. It was clear that South Pole astrophysics could be greatly advanced by the scientists working together and with NSF/OPP.

2.2 CARA

The Center for Astrophysical Research in Antarctica (CARA) was established to develop astrophysics at the South Pole, including the full characterization of the atmospheric conditions at the Pole.

The South Pole site is now the best studied site on Earth. As expected the extremely dry and cold atmosphere and the high altitude of the site leads to exceptionally low atmospheric opacities at infrared to radio wavelengths (e.g., see Chamberlin and Bally 1994, 1995; Chamberlin *et al.* 1997; Lane 1998). The atmosphere was also found to be extremely stable (Lay and Halverson 2000; Peterson *et al.* 2003). Optical seeing measurements were initially disappointing, but the seeing was found to be dominated by turbulence in the inversion layer which is confined to a few hundred meters above the ground. The seeing

is sufficient for infrared and longer wavelengths, especially for large survey work. Low order adaptive optics can easily correct for the inversion layer resulting in very large corrected fields of view. As a result, large optical telescopes are being seriously considered for deployment at the South Pole or perhaps Dome C where the inversion layer is even thinner. The site testing was done in collaboration with CARA's Australian counterpart JACARA and is now being extended to Dome C.

The results of the site testing have shown that the South Pole is the best available site for conducting sensitive infrared through radio wavelength observations, especially for consistent data sets from large area surveys. Surveys and deep observations are also aided by the unique geographic location of the site, since sources remain at constant elevation while the earth simply rotates underneath the telescope.

CARA's approach to developing astrophysics at the South Pole was to field a suite of instruments in three broad areas: infrared, submillimeter and cosmic microwave background.

- The infrared was pursued with the SPIREX telescope, a 0.6 meter telescope equipped with a variety of optical to infrared detectors. SPIREX was last used with a large format Aladdin InSb array detector. Even with its modest collecting area, SPIREX was able to make the deepest thermal-infrared images ever taken from the ground (Burton *et al.* 2000). The SPIREX project has led to new major infrared instrument proposals such as the 2m AIRO telescope.
- The submillimeter was pursued primarily with the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO), a 1.7 m diameter telescope (Stark *et al.* 2001). AST/RO is used to host a full suite of submillimeter instruments including two Terahertz instruments: the Terahertz Receiver with NbN HEB Device (TREND) (Yngvesson *et al.* 2001; Gerecht *et al.* 2003), and the South Pole Imaging Fabry-Perot Interferometer (SPIFI) (Bradford *et al.* 2002). AST/RO has recently completed two key observatory projects (Martin *et al.* 2004; Lane *et al.* 2004) which demonstrate its unique capabilities for mapping the dominant cooling lines of molecular material in the Milky Way: the fine-structure lines of atomic carbon and the rotational lines of carbon monoxide.

The submillimeter has also been pursued with SPARO, the Submillimeter Polarimeter for Antarctic Remote Observations (SPARO), a sensitive multi-pixel bolometric polarimeter mounted on the Viper telescope (Renbarger *et al.* 2004). SPARO exploited the high atmospheric stability available at the South Pole to map the large scale magnetic field toward the center of the Galaxy Novak *et al.* (2003).

- Cosmic microwave background (CMB) measurements were initially pursued with the Python instrument which led to one of the first detections of CMB anisotropy on degree angular scales (Ruhl *et al.* 1995; Platt *et al.* 1997; Coble *et al.* 1999) and paved the way for the far more powerful and complex DASI and Viper ACBAR experiments. DASI, a thirteen element interferometric array, measured the angular power spectrum over a wide range of angular scales and was the first instrument to show the long sought harmonic peaks in the CMB angular power spectrum (Leitch *et al.* 2002; Halverson *et al.* 2002; Pryke *et al.* 2002). DASI was subsequently reconfigured to measure polarization and in September 2002 the DASI team announced the first detection of the CMB polarization (Leitch *et al.* 2002; Kovac *et al.* 2002). ACBAR (Runyan *et al.* 2003; Kuo *et al.* 2004) has produced the most detailed map of the CMB to date and is used throughout the community to extend the angular range of the *WMAP* results. The results from DASI and ACBAR have had enormous impact on modern cosmology and have clearly established the South Pole as the premier site for ground-based CMB measurements. They have been widely cited in the professional literature as well as featured in many news articles.

The success of CARA's instruments rested in large part on the scientists working together to learn how to deploy complex instruments in the harsh Polar environment. Many lessons were learned and applied to all

of the projects. CARA recognized the value in working together to solve problems and coordinate resources at the Pole. A “Polar Operations” section of CARA was dedicated to this purpose.

CARA Polar Operations also was pivotal in establishing a modern laboratory in the Dark Sector of the South Pole station (MAPO, the Martin A. Pomerantz Observatory) and in communications. The first Austral winter observations were obtained a few years after CARA was established. Winter observations are now the norm and the Austral summer season is dedicated to upgrading, deploying and testing instrumentation.

CARA played a critical role in organizing and scheduling the limited resources during the Austral summers. The limited MAPO laboratory space is shared among the projects and careful scheduling is required to ensure sufficient space will be available for the work to be done and to ensure the right support is available at the required time to do the work.

CARA was also able to provide expert advice to NSF/OPP on issues critical to the science, such as liquid helium supply and IT issues. As CARA represented all of the astrophysics projects, it could be an effective advocate to, and single point of contact for NSF/OPP .

2.3 post-CARA

CARA did its job and there is no longer justification for an umbrella organization such as CARA to initiate and direct the astrophysics projects at the South Pole. Now that the astrophysics at the Pole is established, such matters are clearly best left in the hands of NSF and its peer review process. However, after the closing of CARA in 2002, we run the risk of losing the common link that allows investigators to benefit from the many lessons learned over the last decade. We have also lost the mechanism that enabled scientists to work together to optimize the use of shared resources and to ensure the best return of the NSF investment in South Pole astrophysics.

2.4 AMANDA

AMANDA-II is a high-energy neutrino detector located at the South Pole that has been operating at full capability since 2000. It detects three neutrino events per day in the energy range of 10^1 to 10^{16} electron volts with a pointing accuracy of about 2 degrees. Construction of AMANDA-II began during the 1995-96 Austral Summer, and it was completed in 2000. AMANDA-II is composed of 19 detector strings, instrumenting a cylindrical volume of 200 meters diameter and 500 meters in height. Currently AMANDA has a very active program searching for both point and diffuse sources of VHE galactic neutrinos, neutrinos from terrestrial and solar WIMPs, and neutrinos from GRBs(Gamma Ray Bursts). The most recent results will be presented at Neutrino-2004 in Paris on July 14-19, 2004.

Presently, AMANDA-II is the largest VHE neutrino detector operating in the world. A smaller detector (NT-200, about 20% the size of AMANDA-II) located in Lake Baikal in Siberia is the only other operational detector. Other detectors similar in size to AMANDA-II, such as Antares and Nestor, both located in the Mediterranean, are coming on line in the near future. Given this, AMANDA-II is still a very unique device, since it use of ice as the detection medium, rather than water, gives it an intrinsic noise level of about 10 to 100 times less than the water detectors.

Three events lead to the development of the AMANDA Neutrino Astronomy at the South Pole. First was the GASP gamma-ray telescope, which gave Wisconsin experimenters valuable South Pole experience. Another was the off-chance remark made by glaciologist Ed Zeller of the University of Kansas to Francis Halzen during Halzen’s colloquium on the DUMAND neutrino detector. Zeller is to have said, “instead of water, why not use ice?” The third event was the CARA activities at the South Pole.

In the early AMANDA days when asked about their support needs for computing and satellite bandwidth they would reply “give us 20% of what CARA needs.” This was said in all seriousness, since the CARA group had so completely studied the problems of running large experiments in remote locations,

and had worked with the NSF so diligently to develop the best available solutions consistent with budgets and equipment available. AMANDA simply followed CARA's lead. The above is just one example of the excellent CARA support that AMANDA enjoyed. AMANDA also profited from CARA's machine and electronic shop support, software experts, and winter-overs. In turn, AMANDA was able to provide winter-over scientists whose skills aided CARA's efforts. The CARA-AMANDA experience is truly an example of a symbiotic relationship.

2.5 Current Projects

The biggest astrophysics project is the IceCube high energy neutrino detector and the most ambitious telescope project is the 10 m South Pole Telescope (SPT). They are described briefly below. In addition, AST/RO, ACBAR on Viper, and a small exploratory extra-solar planet experiment are currently being operated.

Next year, two new ambitious CMB experiments will be deployed, QUaD and BICEP. They are noteworthy in that they are being led by principal investigators with no previous South Pole experience. And while the teams each have experienced team members, they are dominated by new South Pole researchers. Based on the projects now being planned or proposed for Antarctic science (see Section 3.1), it is clear that the trend will continue; South Pole astrophysics has been extremely successful and the best scientists are now hoping to take advantage of the site. This will put enormous pressure on the infrastructure and shared resources. Clearly, the need for science coordination is greater now than it has ever been.

2.5.1 IceCube and SPT

It is humbling to consider the logistical support required for IceCube and SPT.

IceCube is truly a cubic-kilometer neutrino detector. It will study neutrinos in the energy range of 10^2 to 10^{17} electron volts with a pointing accuracy of about one to two degrees. It will have a surface area of one square kilometer, and will instrument the ice between depths of 1.4 to 2.4 kilometers. Thus it will have 50 times the volume of AMANDA-II and will collect between 150-200 neutrinos/day, or about 50 times AMANDA-II's present rate. IceCube will consist of 80 strings of detectors embedded in the ice, with a total of 5000 optical detectors. Despite its enormous size, ICECUBE is about the smallest detector that most workers in the field believe will have a significant discovery potential.

IceCube construction will begin in 2004-05 and continue until 2008-09. The construction phase will have enormous impact on cargo, power, and population; the operation phase will require enormous bandwidth. In all areas the requirements exceed the current station capacity. Clearly the IceCube project must work directly with NSF/OPP to carefully plan the logistical support. Due to its size and South Pole heritage, IceCube does not necessarily require a separate science coordination office such as SCOARA, although it will surely benefit from one.

The ways in which SCOARA can help IceCube and AMANDA, while not as dramatic as the CARA-AMANDA relationship, are still quite important. Just last Austral summer AMANDA efforts were aided by machine shop help from Bob Spatz and Alan Day; Day also aided AMANDA winter-over efforts by being not only an experienced extra pair of hands, but also an extra experienced "mind" to help the winter-over team sort out problems. One can certainly imagine that such help-needed situations (that arise in spite of careful planning) will be more numerous in IceCube because of the scale of the effort. IceCube, because of its large data handling requirements, now finds itself in the position of helping the CMB efforts as well as the general science efforts at the South Pole with their data handling and communications challenges. Such cooperation and coordination between experiments allows us to field the strongest support.

The SPT is a 10 meter diameter, off-axis, precision submillimeter-wave telescope. It will be outfitted with a new state-of-the-art 1000-element bolometer array. It is being designed to pursue the next generation

CMB temperature and polarization studies. The telescope is designed explicitly for conducting large area, high sensitivity survey observations of the temperature and polarization of the CMB. The off-axis 10 meter diameter aperture provides $1'$ resolution at 2mm wavelength with exceptionally low spillover. The optics will support a one degree diameter field of view. To further reduce signals due to scattering and spillover, the entire telescope will be deployed within a large reflecting ground screen. The ground screen itself weighs roughly 750,000 lbs, is as tall as six story building and is 50 meters across. The telescope will be deployed in late 2006 with first observations starting early 2007. In many ways the SPT is in a similar situation as IceCube. The team is composed of seasoned South Pole researchers, including experience with CARA, Viper, ACBAR, DASI and AST/RO. The project is large enough that it must coordinate its logistical support closely with NSF/OPP. The project is not big enough, however, to be expected to maintain and coordinate the shared resources in the dark sector, such as operating and maintaining the machine shop or the shared test equipment. The SPT project needs SCOARA. And the SPT project will provide enormous expertise to SCOARA.

3 Community Goals for a Science Coordination Office

3.1 Workshop for South Pole Cosmology and Astrophysics

On 2004 May 3-4, we brought together a wide spectrum of scientists interested in Antarctic astrophysics for a workshop on “South Pole Cosmology and Astrophysics.” The list of participants given in Table 1 includes scientists with decades of experience with astrophysics projects at the South Pole, representatives of all the ongoing South Pole astrophysics projects, and many scientists who are actively planning new projects for the South Pole and other Antarctic sites.

The focus of the workshop was to discuss how best to put in place a mechanism to ensure the best planning, allocation, management and scientific support for the shared resources required for the cosmology and astrophysics experiments at the U.S. Amundsen-Scott South Pole Station, i.e., experiments within the Dark Sector.

The first morning of the workshop was dedicated to reviewing the history of the development of South Pole astrophysics, especially the roles of CARA and AMANDA. The unique site conditions were summarized, and then the current status of the station and the grants program was reviewed by the NSF/OPP participants. All of the science participants then gave short presentations on their ongoing or planned science projects to provide context for the rest of the workshop which focused on models for science coordination.

All participants were struck by the breadth of the science projects. They ranged from studying the earliest instants of the universe through CMB polarization measurements to searches for extrasolar planets, to observations of earthshine and to the highest energy neutrinos.

The rest of the afternoon and the second day of the workshop was dedicated to discussing the goals for a science coordination office as well as a structure to meet these goals. The Science Coordination Office for Astrophysical Research in Antarctica (SCOARA) proposed here is the model developed and agreed upon by the workshop participants. There was unanimous support for SCOARA. Many of the participants have written letters expressing their support; the letters are included as supplemental documents to this proposal.

Details of the workshop and the presentations will be posted at <http://astro.uchicago.edu/scoara>.

3.2 Guiding Principles of SCOARA

An important outcome of the workshop was a clear vision for the guiding principles for an umbrella organization for science coordination:

- **Participation of Scientists:** It was stressed that organization should be run by the scientists who are engaged in Antarctic astrophysics. The organization should not be an additional support organization simply tasked by scientists. Without the involvement of the scientists, the organization should not exist.
- **Inclusive:** It was stressed that astrophysics at the South Pole should be open to the entire community. Any organization to help coordinate activities and shared resources must serve the entire community. The organization should not have the power to decide which science projects will be approved.
- **NSF is Final Arbiter:** SCOARA should work hard to help negotiate the use limited and shared resources. However, power to allocate resources and to adjudicate disputes should remain with NSF. For example, everyone agreed that all major instruments should go through a “readiness review” prior to deployment and that the organization’s scientists are best able to conduct the review. It was strongly suggested, however, that NSF sets up the readiness reviews and makes the final decision on whether an instrument can go forward with deployment.
- **Advocacy:** The science office should provide advocacy for South Pole astrophysics. It should build consensus and then be able to speak for the entire community on issues that will impact science research in the Dark Sector. It should also work with NSF on planning future capabilities of the Dark Sector.
- **Minimal Bureaucracy:** It was agreed that the organization should strive to undertake only those responsibilities that are critical to the science goals and that are benefited by the unique expertise of the scientists. Every attempt should be made to avoid adding unnecessary bureaucracy.
- **Non-Redundant:** SCOARA should not take on responsibilities that are covered by the individual PI project grants. For example, since each project is funded to conduct their education and outreach activities, it was decided not to include a central education and outreach component to SCOARA.
- **The whole is greater than the sum of its parts.** The organization should seek to coordinate activities, scheduling, shared resources, communications to take full advantage of the combined expertise of the scientists and the support staff at the South Pole.
- **Responsive:** Challenges for Antarctic astrophysics must be met quickly or serious delays can result. Only 3.5 months during the Austral summer are available for teams to deploy, test and maintain their instruments. Even short delays are extremely costly for Antarctic science projects as they can cause the loss of data for an entire year. An organization for science coordination should be able to help meet unexpected challenges quickly and effectively. It was strongly suggested that SCOARA have a small amount of funds available for urgent items and shipping costs. It was understood that most funds must come from the individual projects or Raytheon Polar Services Company (RPSC).
- **Help new investigators:** The organization should be especially responsive to new investigators, providing guidance and the benefits of the extensive Antarctic experience of the SCOARA participants.

Table 1: Participants of the South Pole Cosmology and Astrophysics Workshop, May 3-4, 2004.

Participant	Current Investigator?	Research (Antarctic Astrophysics Projects)	Affiliation
<i>Investigator Participants:</i>			
Roger Angel	No	Antarctic Large Optical and Infrard Telescope ²	U. Arizona
Douglas Caldwell	PI	Search for Extra Solar Planets	NASA/Ames
John Carlstrom	PI	CMB (past CARA Director, DASI, QUaD,SPT)	U. Chicago
Richard Chamberlin	Co-I	Millimeter and Submm Astrophysics (AST/RO)	Caltech
Sarah Church	PI	CMB (QUaD)	Stanford
Tom Gaiser	Co-I	High Energy Astrophys. (ICECUBE, IceTop)	Bartol
Al Harper	No	Infrared Obs. (past CARA Director, SPIREX)	U. Chicago
William Holzapfel	PI	CMB (ACBAR, BICEP, SPT)	U.C. Berkeley
James Jackson	No	ISM Infrared (AIRO ²)	Boston U.
Adair Lane ¹	Co-I	Molecular Clouds (AST/RO)	S.A.O.
Andrew Lange	PI	CMB, Detector development (BICEP, QUaD)	Caltech
Adrian Lee	Co-PI	CMB, Detector development (SPT, Polarbear ²)	U.C. Berkeley
Robert Loewenstein	No	Infrared Astronomy (CARA polar ops and IT)	U. Chicago
Philip Lubin	No	CMB, First South Pole CMB experiments	U.C.S.B.
Stephen Meyer ¹	No	CMB, CIB (past Director of CARA, SPT)	U. Chicago
Robert Morse	PI	Neutrino Astrophysics (AMANDA, ICECUBE)	U.W. Madison
Giles Novak ¹	PI	Galactic Dust Polarization (SPARO)	NWU
Steve Padin	Co-I	CMB (SPT project manager)	U. Chicago
Robert Pernic	No	Past Director of CARA's Polar Operations	U. Chicago
Jeffrey Peterson	Co-I	CMB, High-z HI, (ACBAR, PAST ²)	C.M.U./
Clem Pryke ¹	Co-I	CMB (QUaD, DASI, SPT)	U. Chicago
John Ruhl	Co-I	CMB (member of OPP-OAC, ACBAR, SPT)	C.W.R.U.
Darryn Schneider ¹	Co-I	Neutrino Astrophysics (AMANDA, ICECUBE)	U.W. Madison
Gordon Stacey	PI	Interstellar Medium (SPIFI)	Cornell
Antony Stark	PI	Galactic, CMB (Chair of SPUC, AST/RO, SPT)	S.A.O.
Mark Swain	No	Extrasolar planets (IR Interferometer ²)	Caltech/JPL
Wesley Traub ¹	No	Extrasolar planets (Moonshine ² , IR Int. ²)	Harvard
Christopher Walker	Co-I	Star Formation (AST/RO, HEAT ²)	U. Arizona
Jim Yeck	Co-I	ICECUBE Project Director	U.W. Madison
<i>Raytheon Polar Service Corporation Participants:</i>			
Charles Kaminski	n/a	Science Support Planning Manager	RPSC
Paul Sullivan	n/a	Science Support Manager	RPSC
<i>NSF Office of Polar Programs Participants:</i>			
George Blaisdell	n/a	South Pole Operations Support	NSF
Scott Borg	n/a	Antarctic Section Head	NSF-OPP
Kevin Cullin	n/a	IT technical representative	NSF-OPP
Jerry Marty	n/a	South Pole Science Support	NSF-OPP
Vladimir Papitashvili	n/a	Astronomy & Aeronomy Program Manager	NSF-OPP
Brian Stone	n/a	Science Support Manager	NSF-OPP

¹ Participant contributed to workshop but was not able to attend.

² Planned or pending Antarctic astrophysics project.

4 Science Coordination Office for Astrophysical Research in Antarctica

In this Section we present the proposed structure for SCOARA which we believe meets all of the community's goals.

4.1 SCOARA Organization and Management

We first describe the overall organization and management structure of SCOARA. For the following discussion it is useful to refer to the organizational chart provided in Figure 1. The director and associate director are scientists with major roles in the SPT and IceCube projects, respectively. Their role is to provide oversight and direction to ensure SCOARA remains focused on issues directly affecting South Pole Astrophysics. The assistant director serves the directorship and manages the day to day business of the organization. The larger scientific community is brought in through the Projects Committee and through the science working groups. We now discuss the various components in more detail.

4.1.1 SCOARA Staff

A key component of SCOARA is a dedicated, full time assistant director. The assistant director will supervise the SCOARA activities. He/she will spend the Austral summer at the South Pole station overseeing the daily scheduling of science support activities in the dark sector and be the projects' liaison with RPSC. The assistant director will also coordinate the SCOARA communications, workshops, and working groups.

SCOARA staff with considerable experience working with the astrophysical instruments at the South Pole are available to hire as needed during the Austral summer from the University of Chicago Engineering Center (UCEC). We propose to hire a machinist to operate the model shop for six 9 hour days per week. Each year, we also propose to send two additional UCEC specialists to the Pole for one month each to work on maintenance on shared equipment, such as shared vacuum equipment and laboratory electronics.

For the Austral winter science support at the Pole, SCOARA plans to hire an experienced model builder. Currently, Alan Day holds a similar position and he has agreed to winterover again. Mr. Day is a perfect role model for this position. He is an expert machinist and has considerable experience with cryogenics. This job requires assisting the winterovers of individual projects as well as providing help station wide. Many projects can not afford and do not require an additional full time winterover, but do occasionally require additional support. Having an expert machinist on site during the winter also makes it possible to fix major problems that otherwise could cause a project to be shut down for the remainder of the season.

In addition, administrative support will be provided for the assistant director at the University of Chicago.

4.2 Scientists Involvement

There are no funds requested for salary support of scientists as they are provided by the individual project grants. The entire focus of SCOARA, however, is to provide coordination and support with the scientists playing the major role in all of SCOARA's activities. The research scientists are brought into SCOARA throughout the Projects Committee and through the science working groups described below.

SCOARA Organizational Chart

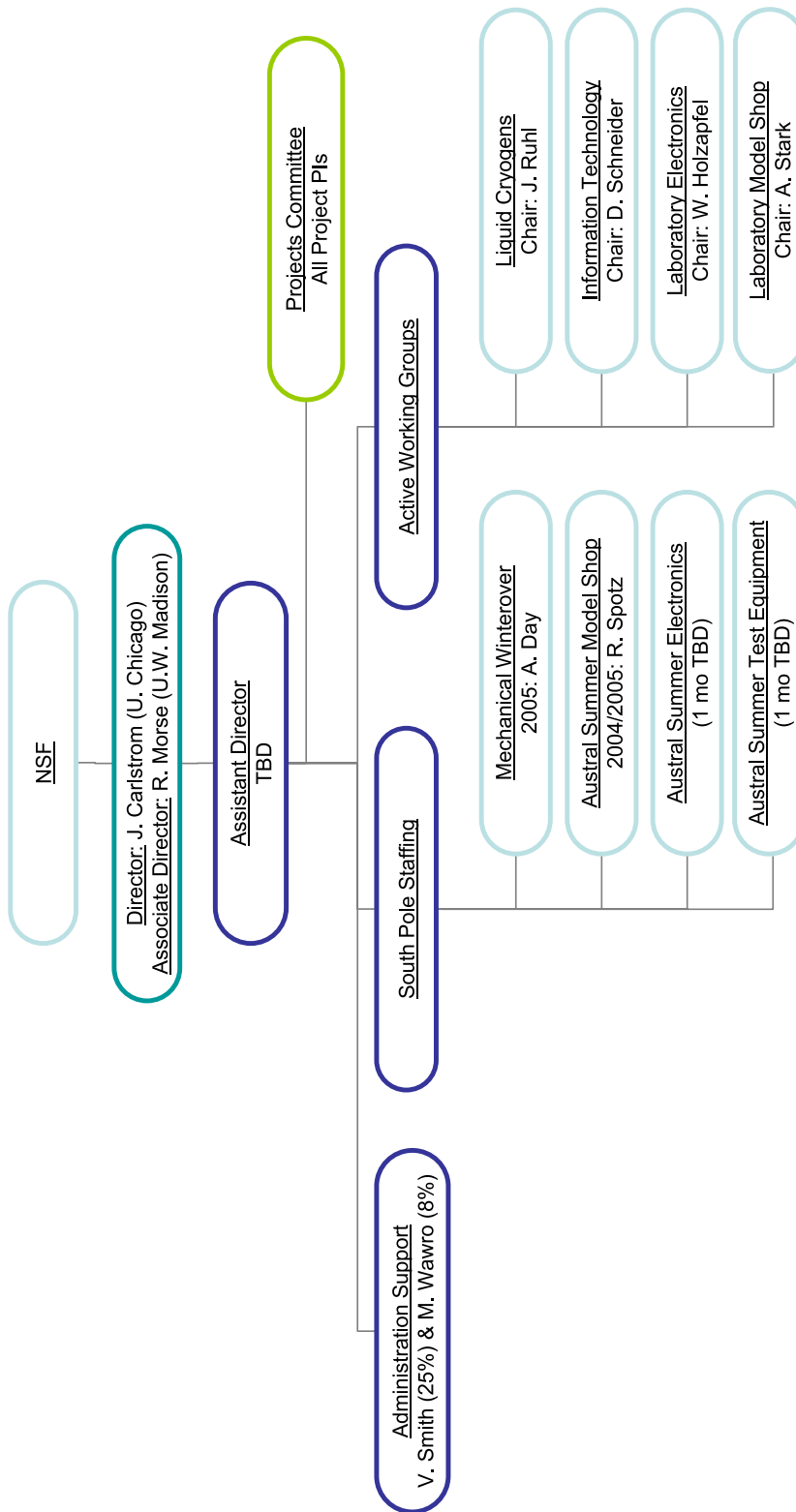


Figure 1: SCOARA Organizational Chart. Note that the “South Pole Staffing” and “Active Working Groups” boxes are only composite headings for the boxes listed below them and do not represent additional staffing.

4.2.1 Projects Committee

The Projects Committee is composed of the principal investigators of all funded South Pole astrophysics projects. Membership is automatic. They are expected to participate in weekly telecons to the South Pole and contribute their expertise to the appropriate science working groups. The management, scheduling, minutes, etc., of the Projects Committee will be the responsibility of the assistant director. However, the decisions will be made by the scientists.

4.2.2 Purpose of Science Working Groups

There are issues and challenges which are best pursued by smaller groups of scientists that have the appropriate expertise and vested interest. A few such groups are discussed below. These groups will each be chaired by a scientist and are responsible for researching the matter at hand and developing the best solution in collaboration with NSF/OPP and RPSC. The assistant director and administrative staff will help coordinate these groups and help the working group chairs run the groups. Specific examples of working groups are shown on the org-chart and discussed further below.

4.2.3 Communications

Good communication is essential to keeping the scientists involved and for bringing the full power of the combined expertise of the scientists to the matter at hand. SCOARA will continue the weekly South Pole telecons initiated by CARA. These telecons keep everyone up to date on the status of the South Pole experiments and frequently provide a valuable heads-up on emerging problems. They are extremely important for the science project winterovers by providing them with a weekly connection to a much larger science community.

Once a year we plan to have a meeting of all the projects, similar in size and scope to the May 2004 Workshop discussed in Section 3.1. These project meetings will be split between discussions of issues facing the South Pole astrophysics community, and to sharing ongoing and planned science plans. They will further foster collaborations and will be especially beneficial for new investigators.

It will also occasionally be necessary for science working groups to have face to face meetings or to meet with NSF or RPSS.

4.3 Coordination of Shared Resources

The success of astrophysics at the South Pole depends as much on the established infrastructure and resources as the unique conditions of the site. Each season, these resources need to be shared between several groups of researchers. By identifying common interests and coordinating activities at the Pole it will be possible to make the most efficient use of these precious resources.

4.3.1 Deployment Scheduling

Each year, the requirements of the scientific and support teams stress the capacity of the South Pole station and the associated logistics to the limit. One of the perennial problems at the South Pole station has been the limited space for science team members during the Austral summer. As anyone associated with the planning process can confirm, the deployment schedules requested in the Support Information Planning (SIP) documents typically result in an oversubscription of the population allocated to science. However, the schedules of individual research teams are often quite flexible and with some coordination can be made to fit within the science population allocation. It is, of course, impossible for RPSC, or NSF for that matter, to resolve problems with the science population without detailed input from the PIs.

We are proposing that the SCOARA Projects Committee meet to coordinate the astrophysics deployment schedules and resource requirements. This group will be tasked by NSF with resolving conflicts that arise in the SIPs concerning the scheduling of astrophysics activities at the Pole. By including those with an intimate understanding of the experiments and their associated schedules and support needs in the planning process, we will be able to identify and quickly solve potential problems. In particular, we want to coordinate the scheduling so that we can optimize the use of the highly trained technicians and engineers across all projects in the short time that they deploy. Some of the issues likely to be addressed by this group will include science population, flight schedules, and cargo. In addition, this group would be able to facilitate the scheduling and coordination of Jamesway usage, crane-lifts, or other intensive science support requirements.

4.3.2 MAPO and Dark Sector Shared Equipment

The Martin A. Pomerantz Observatory (MAPO) building (and soon the new Dark Sector Laboratory, DSL) is home to extensive shared facilities and resources for the South Pole astrophysics community. In order to deploy a complex experiment to a remote location such as the South Pole, a variety of specialized equipment and supplies are required. Fortunately, there is an economy of scale in which much of this equipment can be used by a number of experiments. These common facilities eliminate the need for each experiment to deploy infrequently used, costly, and fragile lab equipment to the Pole for each season. By investing in, organizing, and maintaining common facility equipment at the Pole, the astrophysics community is able to make more efficient use of total funds, station resources (such as shipping), and laboratory space.

For example, all cryogenic receivers require vacuum pumps and leak checkers for operation and service. Leak checkers are bulky, relatively expensive, and require regular service to be kept in operational condition. It is obvious that individual research groups should collaborate on the maintenance of this equipment. The same is true for electronics test equipment. Each experiment may not need a costly audio or RF spectrum analyzer, but project PIs need a guarantee that this equipment will be available should the need arise.

The need for coordination is clear, but a framework is required in which this will occur. For example, no single experiment has the resources to perform regular inventory, testing, and calibration of the electronic test and vacuum equipment at the Pole. However, it is absolutely essential that this is done. Dedicating a few weeks of technician and administrative support during the Austral summer of each season to these tasks will help to maintain MAPO and establish the DSL as a state of the art facility. Due to the intimate relationship of the researchers with these facilities, it is essential that the Projects Committee take a leading role in this effort. A science working group will be tasked with generating a list of maintenance tasks and evaluating the list of yearly test equipment purchases. With this system in place, project PIs can be assured that their needs will be addressed when they arrive at the Pole. In particular, the updated complete inventory of existing test equipment will be essential for the PIs of new experiments.

4.3.3 Dark Sector Model Shop

Exploiting the full potential of the South Pole site requires the fielding of state-of-the-art astrophysics instrumentation. Due to limited access to the site, much of the work upgrading and maintaining these instruments must be carried out at the Pole. Establishing and maintaining the necessary facilities would be a huge burden for a single experiment, but the concentration of several experiments at the Pole creates a clear economy of scale. The operation of the shop requires professionally maintained equipment and material stock as well as highly skilled technicians with experience in the construction of astronomical instrumentation. In order to ensure that the shop capabilities meet the requirements of the individual experiments, we are proposing that a working group of the Project Committee be formed to specify and implement the required shop support.

Establishing the facilities to modify and maintain world class astrophysics instrumentation at the South Pole site was a major goal and success of CARA. Throughout the tenure of CARA and past its sunset,

astrophysics researchers at the Pole made use of these facilities and the associated base of experience. However, these facilities do not maintain themselves and require constant attention. Common usage machine tools such as a mill, lathe, drill-press, and bandsaw need to be maintained in working order and operated by an experienced machinist. A full set of hand tools needs to be stocked and replaced frequently. In addition, expendable supplies such as fasteners, drills, cutters, metal and plastic stock, solvents, epoxy, and tape need to be made available to researchers. Detailed inventories of the supplies at the Pole need to be maintained so that researchers can plan their supply purchases and minimize unnecessary duplication. The facilities maintained in MAPO were generically useful to each of the experiments, and resulted in a very efficient use of resources within CARA and space within MAPO. By coordinating this effort between projects, individual PIs could be confident that the required facilities and skilled technicians would be available at the Pole in the most cost effective way possible.

The PIs of existing experiments have detailed first hand knowledge of what facilities are required to field a new astronomical instrument and to keep it working. The researchers fielding new experiments need a way to draw on and benefit from the collected experience of researchers that have successfully fielded experiments to the South Pole. We propose that SCOARA be responsible for the organization and operation of the astrophysics machine shop to be located in the new DSL facility. Specifically, we seek support for year-round staffing of the shop with highly skilled machinists. Although the level of staffing will depend on the activities for that season, two machinists in the summer with one continuing through the winter is likely to be sufficient for the foreseeable future. A working group will assist the staff of SCOARA to select the candidates and participate in their training. The Projects Committee will meet in order to coordinate logistics, supplies, and labor for the coming season. SCOARA will be responsible for maintaining the inventory of supplies at the Pole and coordinating purchases for the coming year.

4.3.4 Electronics Workspace and Stock

Many of the instruments deployed to the Pole require complex electronics for data acquisition and control. This equipment often needs to be repaired at the Pole. In practice, each experiment maintains a stock of crucial spare parts for this purpose. However, there are a number of general purpose components such as resistors, capacitors, cables, and connectors that it makes sense to make available for all experiments. In addition, basic electronics assembly and rework tools such as a microscope, soldering equipment, circuit board vices, and anti-static workstations need to be supplied and maintained in working order.

Although the requirements are much more modest, the situation is not unlike that of the mechanical shop. We need central coordination of these facilities if they are to remain effective. We propose that a SCOARA recruits an experienced electronics technician who will deploy to the Pole for approximately four weeks each year. The electronics working group will participate in the recruiting and training of this individual. During this time, the technician will organize the electronic parts stock and workspace and provide general electronics support to projects at the Pole. Supplies needed for the coming year will also be identified. It is often the case that a project will need the dedicated services of an electronics technician at the Pole. In this case, we will attempt to extend the deployment of the technician as needed, although SCOARA will not financially support extended use by a single experiment.

4.4 Advocacy and Advice on Critical Science Support Issues

The amount and scale of science activity in the Dark Sector at the South Pole has grown enormously over the last decade. NSF supplies a large amount of infrastructure and logistical support to Dark Sector science projects. Using this support efficiently and planning well for future use and needs depends on scientists' input. SCOARA will provide a mechanism for this community input, via science working groups tasked with discussing issues and planning for the future. We discuss two such working groups below.

4.4.1 Liquid Helium Working Group

Liquid nitrogen (LN₂) and liquid helium (LHe) are used to cool astronomical instruments at the South Pole. Liquid nitrogen is produced on-site by a liquefaction plant. Liquid Helium, however, is flown into the Pole and rationed to the various experiments until the supply is gone or rejuvenated. The summer supply of LHe has historically been adequately met, as the frequent flights and short season allow a sufficient influx of LHe. The winter season, however, is much more difficult to supply. Unfortunately this is the critical time for science, when the LHe is most needed.

The demand for LHe is typically spread across several science groups; managing this limited resource requires coordination between the scientists. In the past, CARA was able to provide this coordination. Currently, it is done in a less structured and more ad-hoc manner, and we envision SCOARA stepping in to fill this role.

Projecting future cryogen needs is an important task that is best discussed in the science community before action is taken. The Liquid Helium Working Group (LHWG) run by CARA was able to compile cryogen use estimates, submit them via the SIPs, and discuss such projections (both short and long term) with NSF and RPSC. This has now grown much more difficult, with coordination faltering as groups supply different information to RPSC (via the SIPs) and the current unofficial LHWG. We envision SCOARA resolidifying the ties between the community, so this coordination grows stronger.

Meeting future cryogen needs, reliably and with low risk, has long been a major support issue. The storage and disbursement of such a large amount of cryogen, in such a harsh environment, over such a long time between resupply, is a very demanding technical challenge that, quite frankly, we have yet to solve.

However, progress has been made and the key to future progress is the continuation of a dialog between NSF, RPSC, and the science community. The LHWG has long been active in helping NSF and RPSC find ways to improve the cryogen supply. The Wessington dewars, for example, were identified by a member of the LHWG as a way to increase winter supply. The cold-finger reliquifiers now being proposed for use on the Wessingtons were similarly identified by the LHWG at that time. Input and guidance from the science community is historically important component, and SCOARA will ensure the coordination that makes this possible.

4.4.2 Information Technology Working Group

Information Technology (IT) infrastructure is vital to science operations at the South Pole. It provides the backbone for communication between scientists in the US and those on station. It enables control of Dark Sector instruments by scientists in the main station, and even by those in the US. It allows large transfers of science data back to the US for immediate analysis. It is difficult to overstate the importance of IT for science operations.

The level of IT infrastructure support is challenged both by hardware drivers, e.g, satellite access, and by real network security issues. In addition, there is a yearly changeover of IT personnel on station, and a significant flux of researchers during the austral summer. These facts, along with the necessarily heterogeneous nature of the scientific computing platforms, provide an IT challenge that is significantly more difficult than most corporate climates.

If astrophysical science is to flourish and grow at the South Pole, scientists must pay close attention to IT. The SCOARA IT Working Group (ITWG) will provide a well researched information and a common voice representing all the science projects for on-going discussions with RPSC and NSF. This group will work to outline IT priorities as seen by the science community, and to help RPSC and NSF set policies that enhance the ability of scientists to operate at the South Pole.

Concluding Remark

As PI, I would like to conclude with a personal remark on SCOARA and South Pole astrophysics. I have often been asked why I would be willing to commit to SCOARA? What's in it for me? Can't the SPT project take care of itself? I know that IceCube scientists have been asked similar questions. The reason is that we truly believe an organization such as SCOARA is in the best interest of South Pole astrophysics. We believe that all South Pole astrophysics must be involved and that all will benefit, including our large projects. Also, I have in fact been working on South Pole astrophysics for a long time, starting with my involvement with CARA and continuing to the present day. Since CARA ended, however, the work has continued without sufficient support and I have not been pleased with our ability to conduct the activities discussed in this proposal. I have great hopes for South Pole astrophysics and I believe SCOARA, especially with a full time assistant director, is an important step forward. So my last remark is to repeat the first paragraph of this proposal:

Antarctica holds tremendous potential for cosmology and astrophysics that can be best realized if the scientists involved understand and participate in the management, planning and oversight of the shared resources and logistical support. The Science Coordination Office for Astrophysical Research in Antarctica (SCOARA) is an intellectual partnership comprised of and directed by these scientists to ensure that the highest quality astrophysics is conducted at the South Pole.