Paper No: 33	**Agenda item: 16.6**
SRP: AAA	SG: PS
Person Responsible:	Tony Travouillon

SCAR Delegates Meeting 2020

Astronomy and Astrophysics from Antarctica

2010-2018

Final Report

Summary

Report Authors:

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Introduction to the Program

The Astronomy and Astrophysics from Antarctica group (AAA). The group is led by a steering committee with representation from 9 countries. This program supports collaborations between astronomers using Antarctica as a platform to make observations of the cosmos that would be impossible from other locations on earth and at a fraction of the cost of operating in space. Astronomy is Antarctica represents over a thousand astronomers working with facilities located at 6 locations on the Antarctic plateau and spanning a wide spectrum of scientific specialties from cosmology to exoplanet searches. Facilities in Antarctica such as IceCube have played a central goal in the birth of “multi messenger astronomy” which has emerged over this decade.

The SCAR AAA SRP Planning Group was proposed at the Hobart XXIX SCAR in 2006. Creation of the AAA SRP was approved at the Moscow XXX SCAR Delegates meeting in 2008. AAA held its first formal meeting as a Scientific Research Program in August 2010 in Buenos Aires, followed by a kick-off meeting in Sydney in June 2011. At the end of the group tenure in 2018, a proposal was presented to the SCAR delegates for a SCAR Science Group dedicated to Astronomical and Spaces sciences called “Astro Sciences”

Major Achievements and legacies

In its first four years (2011-2014), SCAR AAA has worked hard to meet its initial objectives; providing a forum to facilitate international cooperation, clarify science goals, consolidate comparative site testing data, and raise the profile of SCAR within the international astronomical community and the general public. Major meetings took place in Portland (2012), Siena (2013), and Auckland (2014).

During the second 4 years (2015-2018), SCAR AAA completed the Testing Site for the future ‘data portal’, convened and supported both a half-day science session and business meetings at the SCAR OSC in Kuala Lumpur and at POLAR2018 in Davos and held a 3-day meeting in Chiang Mai, Thailand.

Final procedural recommendations to Delegates

ASTRO Sciences seeks the endorsement of SCAR AAA efforts which would maintain momentum of the AAA community, entice new SCAR member countries with AAA opportunities and spur increased coordination and reduce redundancy of equipment on the plateau.

Main report

Original rationale and objectives

Broadly stated, the objectives of the SCAR Scientific Research Programme Astronomy & Astrophysics from Antarctica are to coordinate astronomical activities in Antarctica in a way that ensures the best possible outcomes from international investment in Antarctic astronomy, and maximizes the opportunities for productive interaction with other disciplines.

In its first four years, SCAR AAA has worked hard to meet its initial objectives; providing a forum to facilitate international cooperation, clarify science goals, consolidate comparative site testing data, and raise the profile of SCAR within the international astronomical community and the general public.

In its second four years, SCAR AAA wishes to build upon the progress made so far by developing a robust international platform for astronomical cooperation in Antarctica. Specifically, SCAR AAA takes on board the recommendations of the external reviewers, who called upon us to:

- Formulate a clearer vision with informative advice on what type of observations are needed where,
- Encourage collaboration by all countries towards new accomplishments, not repetition of existing results,
- Extend the site-testing database to cover astronomical data, including consideration of joining the Astronomical Virtual Observatory,
- Increase education/outreach, especially to general public, colleges, high schools, museums,
- Build more capacity in countries with less developed Antarctic astronomy programs.

Main scientific achievements

We **built more capacity in countries with less developed Antarctic astronomy programs**. The LAGO Collaboration (Latin American Giant Observatory) decentralized Observatory of water Cherenkov detectors for cosmic rays studies, was preparing a pilot test for the future installation of an Antarctic node. This Collaboration includes nodes from Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Peru, Venezuela and the participation of Spanish researchers as well.

Regarding **supporting the interaction and instrumentation programs** in Antarctica where there are several projects active can be mentioned. In terms of instrumentation in Antarctic locations, ASTEP is a 40cm telescope installed at Concordia, centered on the characterization of transiting exoplanets through photometric observations at visible wavelengths. In 2017 and 2018, ASTEP has been part of an international campaign to monitor Beta Pic, the archetype of young stars with debris disks and planets (Kenworthy et al. 2021). The observations helped to characterize the star's pulsations (Mékarnia et al. 2017). The AST3 telescope at Dome A who's activities in exoplanets discovery are very fruitful.

The IceCube **research is delivering insights into neutrino astronomy** as well. In July 2018, IceCube, gamma-ray telescopes Fermi and MAGIC, and several other experiments announced the detection of neutrinos and photons from blazar TXS 0506+056. These results constitute the first-ever identification of a likely source of extragalactic neutrinos and of high-energy cosmic rays. This breakthrough detection is the outcome of a multimessenger collaboration with detectors and scientists across

the globe and in space. Follow-up observations by gamma-ray, X-ray and optical telescopes were triggered by a real-time neutrino alert from IceCube on September 22, 2017.

Establishing a new astronomy base at Dome A, the plateau's highest point. After a long site testing campaign, Dome A has been demonstrated to be the best astronomical site of earth for optical, infrared and terahertz observations. This is evidenced by the excellent free-atmosphere seeing, low precipitable water vapor, low sky background and continuous dark time.

Millimeter and sub-millimeter facilities in Antarctica such as the South Pole telescope, are **leading the world in cosmological discoveries**. Current cosmological data hint at the need for new physics. Particularly intriguing is the current tension between the Hubble constant measured from local probes of expansion and inferred by measurements of the Cosmic Background Radiation

Delivery against original implementation plan

A half-day session on Astronomy and Astrophysics from Antarctica was convened at the **SCAR Open Science Meeting in Kuala Lumpur** in August 2016. The oral presentations were heavily oversubscribed so an additional poster session was organized to accompany the session. Additionally, several young researchers presented at the session as a result of travel awards supported by the SCAR AAA budget.

A SCAR AAA SRP **business meeting** was held during the OSC. A large fraction of the steering committee attended this meeting, and it was the last to be chaired by Professor John Storey. Four of the steering committee members were rotated at this meeting as previously planned. The venue of the biannual SCAR AAA workshop was agreed by the committee to be in Chiang Mai, Thailand, following a very strong bid by our colleagues at the National Astronomical Research Institute of Thailand (NARIT). The NARIT hosted workshop will be the fourth and last in a long and productive series after Sydney (2011), Sienna (2013) and Hawaii (2015). Finally, the committee discussed the future of Astronomy and Astrophysics from Antarctica post 2018 and the steps required to gain community input in the process. This subject will form a large component of fourth workshop discussions.

A modernization of the **AAA website** and home of the Antarctic data repository began in November 2016 and will be completed mid-2018. The goals of the work are to permit easy searching of the extensive data set contributed by our SRP community over the early stages of the SRP, and to add a new feature which is to permit researchers to easily access current groups working in Antarctic Astronomy. This was felt extremely beneficial to early career researchers and to researchers from developing Antarctic countries. The breadth of Antarctic Astronomy research is large, encompassing instruments for particle, neutrino, cosmic rays, and wavelengths including radio, sub-mm, microwave, infrared and optical and little infrastructure exists around the world to capture and disseminate this information.

The **fourth SCAR AAA workshop** was hosted by NARIT in Chiang Mai, from July 31 – Aug 4, 2017. Nearly 50 people attended this meeting, including the majority of the steering group. The workshop provides an international forum for Antarctic astronomy researchers to present their work, and the SRP allocates a large fraction of its yearly budget to support early career researchers in particular to attend this workshop. The workshop this year will highlight Antarctic Astronomy in Thailand and this community's future aspirations. It also provides a convenient forum to create new ventures with our Thai colleagues.

While the SCAR AAA SRP does not fund instrument activities in Antarctica, it has certainly provided a means **for international groups to convene, plan and discuss large-scale projects**. The past year has seen the announcement from the Chinese government for a 2.5m class optical/infrared telescope (KDUST) and a 5m class sub-mm telescope (DATE5) to be built and located at Dome A, Antarctica. The South Pole Telescope joined the Event Horizon Telescope (EHT) to directly image the regions surrounding the black hole at the centre of our galaxy and that of nearby galaxy M87. The IceCube telescope continues to monitor high energy neutrino events from the heavens. These are only a fraction of the successful projects in Antarctic Astronomy with announcements over the past 12 months. There was a traverse to Dome A with the 35th CHINARE during the period. Routine maintenance work of AST3 and PLATO-A were done. New site testing instruments were installed, including KL-DIMM for seeing measurement, KLAWS-2G for temperature inversion monitoring, KLCAM (all-sky camera), and NISBM for IR background measurement. Daytime bright star observations were carried out with MARST and there was also microthermal experiment done during the traverse period. In January 2014, daytime seeing was measured for a short period with micro-thermal sensors and a DIMM, yielding a regular high-quality seeing window, median seeing ~0.73 arcsec, at ~16:00—19:00 local time daily.

SCAR AAA completed the Testing Site for the future 'data portal' where users can search for papers via a number of user-specified flags. It currently contains more than 300 papers and provides links to ADS, DOI, and any available data.

Database: http://www.astronomy.scar.org/WorkingGroupA/scar-db.php.

Main education, outreach and capacity building achievements

The SCAR AAA SRP is committed to expanding its reach and diversity. This starts with recruiting and appointing members to the steering committee from a wide range of countries and institutions, with a deliberate effort to include early career scientists. The thirteen steering committee members come from nine different countries and five continents. The AAA workshops, held by annually, are a fundamental part of AAA activities and provide an opportunity to build capacity.

The fourth SCAR AAA workshop, hosted jointly with NARIT, has attracted a large number of Thai participants. The attendees range from those working with large, established international projects to single investigators hoping to establish research Antarctic astronomy or astrophysics research programs. Working in Antarctica introduces an extra dimension of difficulty. The SCAR AAA SRP is a great starting point to make connections for both new and established researchers. For example, Steering committee member Madsen worked with an early career Thai scientist who submitted a proposal for a SCAR fellowship that would allow her and two undergraduates to work for a summer in the USA on data from Antarctica, and develop ideas for continued Antarctic research.

In addition to the workshops, SCAR AAA has a continual on-line presence through its website. These resources are undergoing significant revisions to better serve science and outreach goals. Opportunities for early career scientists, such as SCAR fellowships mentioned above, will be promoted. The data portal will allow access to Antarctic astronomy and astrophysics research as well as highlighting the unique opportunities the continent provides for exploring the universe.

In Latin America, we are encouraging Argentinean young researchers to join APECS and get more involved in Antarctic Astronomy activities.

The LAGO collaboration is generating a series of on-line courses within the collaboration to perform cosmic rays simulations among the nodes (including the Antarctic one) to have a critical mass of Latin American researchers in high energy Astronomy and cosmic rays studies.

Finally, we supported the SCAR AAA booth at the General Assembly of the International Astronomical Union (IAU) in Vienna, Austria, in August, 2018. Our first SCAR AAA booth appeared at the IAU general assembly In Oahu in 2015 and both were a great success.

Draft final Budget summary

	2017	2018	2019
	Spent	Spent	Allocated
(US$)	$14,200	$27,800	$5,000

Please also provide a breakdown of the following:

- Total expenditure
- Total direct support received from other sources
- Total budget used to support ECRs
- Total budget used to support countries with developing programmes

2017:

- $7,400 for travel awards to attend the SCAR AAA fourth workshop in Chiang Mai, Thailand (a detailed budget per awardee will be sent to SCAR shortly)
- $6,800 for professional salaries (early career) for developing the AAA website portal which will significantly update the existing website, provide straightforward navigation of the data portal, and permit our colleagues from around the world to access an up to date collection of active groups with contact details.

[SCAR SRP Name]: 2016-2017 Annual Report, cont.

2018:

- $6,800 for (continued) professional salaries (early career) for developing the AAA website portal, with benefits as described above in the 2017 line item
- $12,000 to support attendance from the Antarctic Astronomical community to attend the science and business meetings of the AAA SRP during the SCAR OSC in Davos, 2018
- $9,000 to support the SCAR AAA booth and outreach at the General Assembly of the International Astronomical Union (IAU) in Vienna, Austria, 2018

Provide an estimate on the % of the budget to be used for support of early career researchers:

2017: 82%
2018: 50%

Provide an estimate on the % of the budget to be used for support of scientists from countries with developing Antarctic

programmes:

2017: 14% - 79% (higher rate if website developer is located in NARIT as currently planned)

2018: 25% (goal)

Linkages

- Our colleagues at the National Astronomical Research Institute of Thailand (NARIT) are graciously hosting the upcoming AAA fourth workshop. NARIT contributed around 284,000 THB for 4 days venue, lunch, break, dinners (welcome, cultural, royal project), local transportation local, excursion, bag, badge and accessories.
- This amount would normally be covered by the SRP annual budget. This means we are able, for example, to be much more ambitious in our development of a new website and data portal for the Antarctic astronomical community.
- Many steering committee members have travel funds supported or co supported by other means, including institutional contributions. We will not list each one individually here, but the total amount is at least $20,000.

Final future research recommendations to Delegates

See attached proposal for the ASTRO science group.

Final procedural recommendations

N/A.

Notable Papers

(Five to ten most notable papers, one- to three-sentence summary for each)

There have been several hundred papers published in the past 12 months in the area of Astronomy and Astrophysics from Antarctica. The papers below highlight the diversity of the area, and work which has benefited directly from SCAR AAA activities.

1. "Optical Sky Brightness and Transparency during the Winter Season at Dome A Antarctica from the Gattini-All-Sky Camera", Y. Yang et al, *Astrophysical Journal* (2017), **154**, 1. A joint China-US-Australia investigation into the multi-year optical sky brightness measurements above the Dome A site. The paper formed part of a PHD thesis defense.

The site characterization at Dome A using a Gattini-All-Sky camera is shown..

2. "IceCube Seeks to Expand", Francis Halzen and Spencer Klein, CERN Courier **56** (2016) 40-41, no. 6, July/August 2016, "PINGU: A Vision for Neutrino and Particle Physics at the South Pole,

IceCube-Gen2 Collaboration: M. G. Aartsen et al, Journal of Physics **G44** (2017) 054006.

The IceCube, projected expansion in Antarctica is targeted in the paper..

3. “Terahertz and far-infrared windows opened at Dome A in Antarctica”, Shi, S.-C., Paine, S., Yao, Q.-J., Lin, Z.-H., Li, X.-X., Duan, W.-Y., et al. Nature Astronomy (2016), **1**, 1. }

Exciting opportunities for Terahertz and far-infrared astronomy at Dome A site are explored in this work.

4. “Variable Stars Observed in the Galactic Disk by AST3-1 from Dome A, Antarctica”, Wang, L., Bin Ma, Li, G., Hu, Y., Fu, J. et al, *The Astronomical Journal* (2017), **153**, 1.

Results from AST3-1 .Observations at Dome A of variable stars are analyzed.

5. “The AST3 controlling and operating software suite for automatic sky survey”, Hu, Y., Shang, Z., Ma, B., & Hu, K. (2016). In G. Chiozzi & J. C. Guzman, (Vol. 9913, pp. 99130M–7). Presented at the SPIE Astronomical Telescopes + Instrumentation, SPIE.

In this paper it is explained the operational features of the automatic sky survey software of the AST3 at Dome A.

6. “Atmospheric seeing measurement from bright star trails with frame transfer CCDs”, Ma, B., Shang, Z., Hu, Y., Hu, K., Pei, C., & Yuan, X. (2016).. In H. J. Hall, R. Gilmozzi, & H. K. Marshall, (Vol. 9906, pp. 99060A–7). Presented at the SPIE Astronomical Telescopes + Instrumentation, SPIE.

Study of seeing using bright star trails, to site characterization purposes.

7. “Operation of AST3 telescope and site testing at Dome A, Antarctica”, Shang, Z., Hu, Y., Ma, B., Hu, K., Ashley, M. C. B., Wang, L., & Yuan, X. (2016).. In A. B. Peck, R. L. Seaman, & C. R. Benn, (Vol. 9910, pp. 991023–8). Presented at the SPIE Astronomical Telescopes + Instrumentation, SPIE.

In the paper the Operation of the AST3 telescope at Dome A is depicted.

8. “The data acquisition system of the Latin American Giant Observatory (LAGO) “Sofo Haro, M.; Arnaldi, L. H.; Alvarez, W.; Alvarez, C.; Araujo, C.; Areso, O.; Arnaldi, H.; Asorey, H.; Audelo, M.; Barros, H.; Bertou, X.; Bonnett, M.; Calderon, R.; Calderon, M.; Campos-Fauth, A.; Carramiñana, A.; Carrasco, E.; Carrera, E.; Cazar, D.; Cifuentes, E.; "Cogollo, D.; Conde, R.; Cotzomi, J.; Dasso, S.; De Castro, A.; De La Torre, J.; De León, R.; Estupiñan, A.; Galindo, A.; Garcia, L.; Gómez Berisso, M.; González, M.; Guevara, W.; **Gulisano, A. M.;** Hernández, H.; Jaimes, A.; López, J.; Mantilla, C.; Martín, R.; Martinez-Mendez, A.; Martínez, O.; Martins, E.; Masías-Meza, J. J.; Mayo-García, R.; Melo, T.; Mendoza, J.; Miranda, P.; Montes, E.; Morales, E.; Morales, I.; Moreno, E.; Murrugarra, C.; Nina, C.; Núñez, L. A.; Núñez-Castiñeyra, A.; Otiniano, L.; Peña-Rodríguez, J.; Perenguez, J.; Pérez, H.; Perez, Y.; Perez,

G.; Pinilla-Velandia, S.; Ponce, E.; Quishpe, R.; Quispe, F.; Reyes, K.; Rivera, H.; Rodriguez, J.; Rodríguez-Pascual, M.; Romero, M.; Rubio-Montero, A. J.; Salazar, H.; Salinas, J.; Sarmiento-Cano, C.; Sidelnik, I.; Haro, M. Sofo; Suárez-Durán, M.; Subieta, M.; Tello, J.; Ticona, R.; Torres, I.; Torres-Niño, L.; Truyenque, J.; Valencia-Otero, M.; Vargas, S.; Vásquez, N.; Villasenor, L.; Zamalloa, M.; Zavala, L. Nuclear Inst. and Methods in Physics Research, A, Volume 820, p. 34- 39.2016.

This work provides a comprehensive overview of the data acquisition system improved for the functioning of the WCD at the LAGO collaboration that has planned an Antarctic Node.

9. ”Typical Profiles and Distributions of Plasma and Magnetic Field Parameters in Magnetic Clouds at 1 AU”. L. Rodriguez, Jimmy Joel Masías-Meza, S. Dasso, P. Demoulin, A.N. Zhukov, **A. M. Gulisano**, M. Mierla, E. Kilpua, M. West, D. Lacatus, A. R. Paraschiv, M. Janvier .Solar Physics, Volume 291, Issue 7, pp.2145-2163.

This work studies the more geoeffective magnetohydrodynamic structures in the Sun-Earth relationship and Space Weather, magnetic clouds, that are being characterized at 1AU. These structures oriented in a certain way can open the geomagnetic shield injecting energetic particles into our polar zones.

10. “Characteristics of Four Upward-pointing Cosmic-ray-like Events Observed with ANITA”. P.W.Gorham, J.Nam, A.Romero Wolf, S.Hoover, P.Allison, O.Banerjee, J.J.Beatty, K.Belov, D.Z.Besson , W.R.Binns, V.Bugaev, P.Cao, C.Chen, P.Chen, J.M.Clem, A.Connolly , B.Dailey, C.Deaconu, L.Cremonesi, P.F.Dowkonnt, M.A.Duvernois, R. C.Field, B.D.Fox, D.Goldstein, J.Gordon, C.Hast, C.L.Hebert, B.Hill, K. Hughes, R.Hupe, M.H.Israel, A.Javaid, J.Kowalski, J.Lam, J.G.Learned , K.M.Liewer, T.C.Liu, J.T.Link, E.Lusczek, S.Matsuno, B.C.Mercurio, C .Miki, P.Miocinovic, M.Mottram, K.Mulrey, C.J.Naudet, J.Ng, R.J.Nichol , K.Palladino, B.F.Rauch, K.Reil, J.Roberts, M.Rosen, B.Rotter, J.Russ ell, L.Ruckman, D.Saltzberg, D.Seckel, H.Schoorlemmer, S.Stafford, J.Stockham, M.Stockham, B.Strutt, K.Tatem, G.S.Varner, A.G.Vieregg, D.Walz, S.A.Wissel, F.Wu. Phys. Rev. Lett. 117, 071101 (2016).

In this paper the Cosmic Ray like events measured with ANITA are addressed..

Membership

Leadership

Role	First Name	Last Name	Affiliation	Country	Email	Date Started
Chair of Steering Committee	Tony	Tony Travouillon	ANU	Australia	Tony.Travouillon@anu.edu.au	2016
Steering Committee Member	Jenny	Adams	UC	New Zealand	jenni.adams@canterbury.ac.nz	2016
Steering Committee Member	Michael	Ashley	University of New South Wales	Australia	m.ashley@unsw.edu.au	2016
Steering Committee Member	Elia	Battistelli	Sapienza Università di Roma	Italy	elia.battistelli@roma1.infn.it	2016
Steering Committee Member	Adriana	Gulisano	Instituto Antártico Argentino	Argentina	adrianagulisano@gmail.com	2016
Steering Committee Member	Nicholas	Crouzet	ASTEP	Canada/France	Nicolas.Crouzet@esa.int	2016
Steering Committee Member	*Jennifer	Cooper	APECS	USA	jrc323@cornell.edu	2016
Steering Committee Member	XueFei	Gong	NIAOT	China	xfgong@niaot.ac.cn	2016
Steering Committee Member	James	Madsen	UW-River Falls&IceCube	USA	jim.madsen@icecube.wisc.edu	2016
Steering Committee Member	Naomasa	Nakai	kwansei Gakuin University	Japan	nakai@physics.px.tsukuba.ac.jp	2016
Steering Committee Member	Zhaohui	Shang	Tianjin Normal University	China	zshang@gmail.com	2016
Steering Committee Member	**Lifan**	Wang	Texas A&M University	USA/China	lifanwang@gmail.com	2016
Steering Committee Member	**Anna**	Moore	ANU	Australia	anna.moore@anu.edu.au	2016

*Please identify early-career researchers with * in first column*

Other members

First Name	Last Name	Affiliation	Country	Email
Waraporn	NUNTIYAKUL	Chiang Mai University	Thailand	waraporn.n@cmu.ac.th
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Andrea	Richichi	NARIT	Italy	andrea4work@gmail.com
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Peter	Tuhill	Sydney Institute for Astronomy	Australia	p.tuthill@physics.usyd.edu.au

*Please identify early-career researchers with * in first column*

Credit: ESA/IPEV/PNRA

ASTRO Sciences

A proposal for a SCAR Science Group dedicated to Antarctic Astronomy

May 2018

CONTENTS

EXECUTIVE SUMMARY

Antarctica offer a unique platform for astronomical science. For decades, astronomy and astrophysics have been performed there with great success. While the experimenters' goals have been diverse, Antarctic astronomers and astrophysicists share an appreciation of the unique geographical and environmental features of the southern continent; features which permit new science that would otherwise be impossible in temperate climates.

Based on this success, now is the right time for the Antarctic astronomy and astrophysics community to be elevated to a dedicated SCAR science group. The proposed science group, **ASTRO Sciences**, is based on the firm foundation laid by the long-standing Astronomy and Astrophysics from Antarctica Scientific Research Program of the Physical Sciences group

The proposal is fully endorsed by the Antarctic astronomy and astrophysics community. Establishing ASTRO Sciences is the needed next step in AAA's journey and to catalyse the international community, and fully realise its potential, which requires a higher profile, longer term entity within SCAR.

The goals of ASTRO Sciences, as laid out by the community in late 2016, include

- A strong emphasis on multi-national projects to enable cutting edge science not possible by one member alone,
- New science enabled by coordination of instrumentation at multiple stations,
- New science enabled by linking ice-based and space-based experiments,
- Coordinated approaches to the polar regions as windows to the sky in the era of low cost space missions and associated traffic management needs,
- Using astronomy and astrophysics as a way of engaging countries that are currently not members of SCAR,
- Maintaining and increasing synergistic links with our Arctic counterparts, and
- Increased public awareness of Antarctic astronomy activities.

The astronomical and astrophysical sciences are a powerful motivator for the initiation of new members into SCAR (e.g. Thailand) and new collaborative partners to the Antarctic astronomy community (e.g., the Republic of Korea). We look forward to working with SCAR in building global membership in the future.

On behalf of the global Antarctic astronomy community, we kindly request support for this initiative.

Sincerely,

The SCAR AAA SRP Steering Committee

Assoc. Prof. Jenni Adams	New Zealand
Prof. Michael Ashley	Australia
Dr. Elia Battistelli	Italy
Ms. Jennifer Cooper	USA

Dr. Nicolas Crouzet	France
Dr. Adriana Gulisano	Argentina
Prof. James Madsen (co-chief officer)	USA
Prof. Anna Moore (chief officer)	Australia
Prof. Naomasa Nakai	Japan
Dr. Zhaohui Shang	China
Prof. Charling Tao	China
Prof. Lifan Wang	USA/China

Introduction

Astronomy and Astrophysics from Antarctica (AAA, www.astronomy.scar.org), became a Scientific Committee on Antarctic Research (SCAR) Science Research Program (SRP) in 2010. The group is currently led by a steering committee with twelve members from eight different countries and five continents.

Figure 1: The SCAR SRP "Astronomy and Astrophysics from Antarctica (AAA)" has met as an international group every year since the formation of the SRP in 2010.The last meeting of the SRP will be in Davos, Switzerland during POLAR2018.

The mission of the AAA SRP is to coordinate astronomical and astrophysical activities in Antarctica to ensure the best possible outcomes from international investment in Antarctic, and to maximize the opportunities for productive interaction with other disciplines.

The chief officer of the AAA steering committee is Professor Anna Moore, Director of the Advanced Instrumentation Technology Centre at The Australian National University. Networking and capacity building are essential AAA activities. To sustain these efforts, support from SCAR and local hosts have enabled four geographically dispersed biannual AAA workshops held in odd calendar years (2011: Sydney, Australia, 2013: Siena, Italy, 2015: Hawaii, USA, and 2017: Chiang Mai, Thailand) and have been well-attended with very wide international representation

During the even calendar years, the AAA steering committee has met prior to SCAR Open Science Conference meetings and organized productive oral and poster sessions with similar numbers of attendees representing ten or more countries (2018: Argentina, Australia, Austria, China, Columbia, France, Germany, Italy, Japan, New Zealand, Spain, Switzerland, Thailand, and USA).

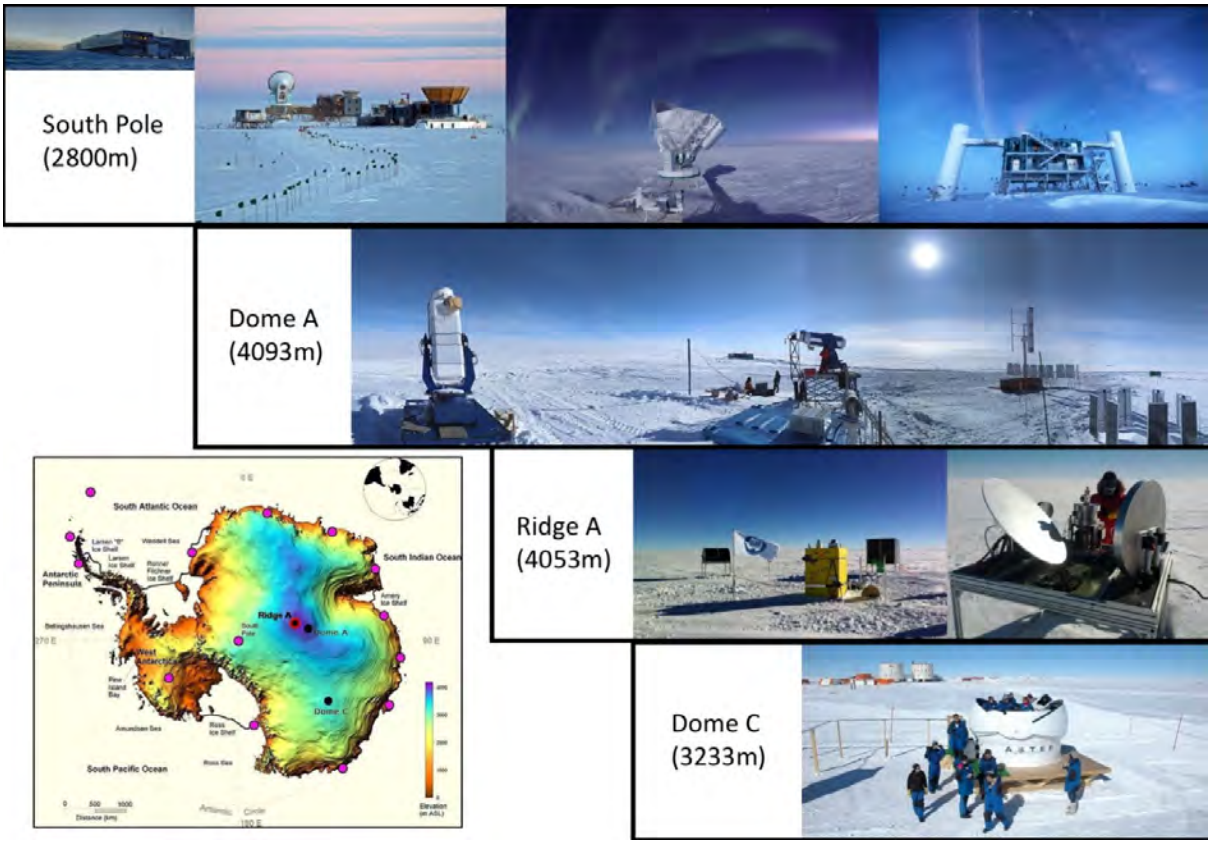

Figure 2: A selection of the on-going Astronomical experiments operating on the high Antarctic plateau. Further Antarctic Astronomy infrastructure is located in Antarctica at Dome F, and the coastal bases (primarily balloon launches), and in the Arctic including Ellesmere Island, Canada and Greenland.

SCAR AAA SRP

The SCAR AAA SRP began with four working groups: 1) Site testing, validation and data archiving, 2) Arctic site testing, 3) Science goals, and 4) Major new facilities. In addition to giving a voice to the polar astronomy and astrophysics community, the groups did important work measuring metrological and atmospheric conditions to establish the viability of sites for research. The results of these studies and other measurements are collected in a searchable, regularly updated, database of over 300 scientific papers by AAA. AAA has also maintained a regularly updated website with Antarctic astronomy news, resources and links.

Currently, AAA is one of two SRPs in the Physical Sciences Group, along with Antarctic Climate Change in the 21st Century - AntClim21. The majority (11 of 13) of the Physical Sciences Action and Expert Groups involve climate and/or environmental studies.

The need for ASTRO Sciences

While the environment is a unifying factor for all research activities in Antarctica, the focus of the AAA on ***Antarctica as a platform*** to study the Universe is fundamentally different.

While polar astronomers share the goals of observing objects in space, the range of topics and techniques is quite broad, ranging from microwaves, to infrared and optical astronomy, to high energy neutrinos and cosmic rays. Instruments and observing sites also vary, from ground-based instruments that can be brought in tested and complete, to major installations that require multiple seasons to construct, to balloon-based campaigns.

The last decade has seen the completion of two major astrophysics projects at the South Pole; the IceCube Neutrino Observatory, and the South Pole Telescope. These projects have demonstrated that the challenging logistics and extreme weather conditions of the Antarctic plateau can be overcome. More recently, infrastructure has been installed at the Chinese Kunlun station at Dome A, and the French/Italian Concordia station at Dome C with the primary purpose of Astronomy and Astrophysics.

The opportunities for unique science are incredible, ranging from studies of the earliest epochs of the Universe through measurements of the cosmic microwave background radiation, to establishing and instrumenting viewing sites with unmatched performance for infrared and optical astronomy, to building next generation instruments to capture astrophysical neutrinos from the most powerful cosmic engines and extreme astrophysical environments. The experiments are not using Antarctica as “just another observing site”, but as by far the best place on earth for some types of astronomical observations.

Most of these activities require significant investments that the AAA Science group could help coordinate to ensure best use of resources and share expertise with building, operating, and maintaining equipment in the harsh climate.

We believe that the vitality of the AAA SRP, along with the diversity and breadth of activities accelerating into the future, merits the establishment of a new SCAR Science Group.

Figure 3: The goals of the SCAR ASTRO Sciences group span science, collaboration and outreach activities.

Horizon 2020

The Horizon 2020 report encapsulates the driving science questions for the astronomical sciences. Contained within the section "NEAR EARTH SPACE AND BEYOND EYES ON THE SKY", these questions are:

> Q69. What happened in the first second after the Universe began?
>
> Q70. What is the nature of the dark Universe and how is it affecting us?

The answers to these questions require ambitious solutions. Next generation cosmic microwave background experiments probe the very early Universe immediately after the Big Bang. Thermal infrared telescopes obtain exquisite sensitivity, due to the cold atmosphere in Antarctica, and can unveil the dark Universe to show its riches, such as the direct detection of supernovae from the first stars formed in the Universe. Long baseline terahertz interferometers, ideally suited for Antarctica given the ultra-low water content and stability of the atmosphere, can probe dusty regions and search for the building blocks of stellar systems.

The next steps to solve some of the biggest questions in astronomy require multi-partner collaborations and accelerated coordination between existing infrastructures. This is where the SCAR ASTRO Sciences group can be uniquely positioned to facilitate such collaborations.

ASTRO Sciences' Goals

During the fourth SCAR AAA SRP workshop, hosted by our NARIT colleagues in Chiang Mai in August 2016, the polar astronomy community were consulted on the most critical goals of a potential ASTRO Sciences group. The requests broadly fall into three categories: Science, Collaboration and Outreach, as expanded in Figure 3. We introduce these themes below, as identified by the community.

Science: In addition to providing an international foundation for collaborative teams to tackle Horizon 2020 grand questions, ASTRO Sciences can offer at least three further goals that are eminently suited for a SCAR expert or action group. These are (i) investigate the applicability of polar regions as windows to the sky for space based applications, such as global satellite traffic management; (ii) maximise the scientific productivity of all polar deployed experiments by reaching out to other communities that can participate in data reduction and; (iii) by raising Antarctic astronomy to a new level, ensure as many astronomy research papers as possible acknowledge SCAR.

Collaboration: Several goals fall under the theme of collaboration, including increased knowledge dissemination between researchers from different communities and bases so as not to reinvent the wheel, increased contact especially before and during deployments, and reaching out to communities interested in polar astronomy but with currently limited access.

Outreach: Communicating polar astronomy to the public and, in particular, the younger generation of researchers worldwide, was a strong message from the community. With the profile and elevation of a SCAR science group, ASTRO Sciences can provide a coordinated outreach program using social and local news media, while tapping into existing outreach programs targeted for specific communities to get accelerated quickly.

Responsibilities

SCAR Science Group Responsibilities	AAA SRP	Astro Sciences
Sharing information on disciplinary scientific research being conducted by national Antarctic programmes	✓	✓
Identifying research areas or fields where current research is lacking		✓
Coordinating proposals for future research by national Antarctic programmes to achieve maximum scientific and logistic effectiveness		✓
Identifying research areas or fields that might be best investigated by a SCAR Scientific Research Programme and establishing Scientific Programme Planning Groups to develop formal proposals to the Executive Committee		✓
Establishing Action and Expert Groups to address specific research topics within the discipline	✓	✓

Figure 4: ASTRO Sciences fulfils all five responsibilities set by SCAR for a science group. The AAA SPR is included for reference and, as an SRP, is expected to fulfil only a portion of requirements.

Budget and timeline

The requested budget for the SCAR ASTRO Sciences group is in line with existing Science Groups: around $30k/yr to establish priority action and expert groups. As with the AAA SRP, we expect a high degree of financial leveraging across the community towards this international effort.

The current AAA SRP committee will establish the ASTRO Sciences leadership team in late 2018, with action and expert groups beginning start of Jan 2019, based on topics presented above.

Future ASTRO Science SRPs will be competed on an as-needed basis.