Full Proposals for International Polar Year 2007-2008 Activities

Proposed IPY Activity Details

1.0 PROPOSER INFORMATION

(Activity ID No: 124)

1.1 Title of Activity
Astronomy from the Polar Plateaus

1.2 Short Form Title of Proposed Activity
Astronomy from the Poles (AstroPoles)

1.3 Activity Leader Details
Michael Burton
University of New South Wales
Australia

1.4 Lead International Organisation(s) (if applicable)

1.5 Other Countries involved in the activity
China
Denmark
France
Germany
Italy
Japan
New Zealand
UK
USA
Canada
Belgium
Australia
Austria
Spain
Poland

1.6 Expression of Intent ID #'s brought together in this proposed activity
348,155,195,369,389,549,588,736,986

1.7 Location of Field Activities
Bipolar

1.8 Which IPY themes are addressed
1. Current state of the environment
4. Exploring new frontiers
5. The polar regions as vantage points

1.9 What is the main IPY target addressed by this activity
1. Natural or social science

2.0 SUMMARY OF THE ACTIVITY

It has long been recognised that the polar plateaus provide the best sites on the Earth's surface for the conduct of a wide range of astronomical observations, from optical to millimetre wavelengths. This is on account of the extremely cold, dry and stable air found there. The exceptional site conditions would allow observations to be made of the cosmos, with greater sensitivity and clarity, and across a wider part of the electromagnetic spectrum, than from temperate-latitude sites. This IPY project aims to quantify these conditions at four sites, Summit in Greenland, Ellesmere Island in Canada, and Domes A and C on the Antarctic plateau, and then to begin the process of turning these sites into frontline observatories. Dome A is likely to be the pre-eminent location on the Earth for observational astronomy, but has only recently been visited by humans (China in 2005). Dome C is the site for a new station (France/Italy, fully operational in 2005), and already shows indications for better seeing conditions than for any existing observatory. Summit Station (Denmark/USA) and Ellesmere Island (Canada) are also extremely cold and dry. They are the best prospective observing sites in the northern polar regions and their conditions have not yet been quantified.

The project builds upon a decade of site testing experience, at both the South Pole and at Dome C, including the development of autonomous observatories that can gather the data over the winter. In particular, it will make use of AASTINOs (Automated Astrophysical Site Testing International Observatories) to conduct a range of experiments at each site, and to transmit the data to their operations centres via satellite phones. Measurements made will include the sky brightness (auroral in the optical, thermal emission in the infrared), the optical seeing and the transparency, precipitable water vapour content and microturbulence levels in the atmosphere, as well as the meteorological conditions. These will provide the baseline data needed to quantitatively assess what future astronomical facilities could be built in the polar regions, and the science programs they could tackle. The AASTINO's and their experimental suites will need to be brought to the four sites by overland traverse or by air transportation, with the scientists taken in by air to assemble them.

While the sites have not been fully characterised, it is already clear that the Antarctic plateau sites are superior to any existing observatories for a range of frontline experiments. This IPY project will also be used to instigate pathfinder experiments aimed at tackling fundamental problems in astrophysics, in particular to test enabling technologies that will make them possible. These experiments will, in turn, lead to the development of new frontline facilities beyond the IPY. The science program we would conduct with these facilities includes measurements of the polarization of the cosmic microwave radiation background resulting from the Big Bang, the use of optical and infrared telescopes to examine the formation of galaxies, sub-millimetre and terahertz frequency telescopes and interferometers to probe the dense molecular clouds where stars are born, the search for other earth-like planets in the Galaxy using interferometric and microlensing techniques, and the measurement of the earthshine from the Moon to probe the variations in the Earth's albedo, primarily resulting from changing cloud cover.

A critical design review of the project will be held during the SCAR meeting in Hobart in 2006. An international science meeting on Astronomy in the Polar Regions will also be organised for 2007, possibly in the UK or Greenland.

2.1 What is the evidence of inter-disciplinarity in this activity?
The site quantification measurements needed to assess the astronomical observing conditions involve measurement of the properties of atmosphere. These are also relevant to meteorological and climatic studies (e.g. the earthshine experiment). The enabling technologies required to make the necessary astronomical instrumentation work in the harsh polar climate is an application

engineering science, involving inter-disciplinarily activity through, for instance, material design, robotics and remote control, cryogenics and the use of novel optical designs.

2.2 What will be the significant advances/developments from this activity? What will be the major deliverables? What are the outputs for your peers?
The principal outcome will be a quantification of several key parameters that determine how well astronomical observations can be made from a given site, allowing the sensitivity of a telescope, the wavelength range across which it can operate, and the clarity of images it could obtain, to be determined. These are essential characteristics that determine whether a telescope could be used to tackle a particular science problem. These results will be published in peer-reviewed journals, allowing comparison of sites, both within the polar regions, and between temperate and/or space-based locations, to be made. This then will allow a cost/benefit analysis to be undertaken to determine the location where future facilities should be built, in particular whether some fundamental science investigations could be undertaken from Antarctica, or will require a future space mission.

The science program will also provide information on enabling technologies that need to be developed in order that observatories can be constructed to achieve the sensitivities the site conditions permit.

2.3 Outline the geographical location(s) for the proposed field work (approximate coordinates will be helpful if possible)

Locations	Coordindates
Dome A, Antarctica	81S, 77E, 4100m
Dome C, Antarctica	75S, 123E, 3200m
Summit, Greenland	73N, 38W, 3200m
Northern Ellesmere Island, North West Territories, Canada	82N, 80W, 2500m

2.4 Define the approximate timeframe(s) for proposed field activities?

Arctic Fieldwork time frame(s)	Antarctic Fieldwork time frame(s)
06/07 – 09/08	11/07 – 02/09

2.5 What major logistic support/facilities will be required for this project?
Fixed wing transport aircraft
Inland traverse support
Existing stations (Dome C, Summit)
New field station (Dome A, Ellesmere Island)
Automated observatories (AASTINOs, multi-instrumented platforms)

Further details – AASTINOs need to be transported to the four sites. This can be done using either LC-130 (ski-equipped) aircraft, or overland traverses on a separate trailer. These would take the laboratories to their sites, together with the fuel and the bulk of the experiments. They weigh about 4 tonnes each. Personnel would need to be taken to the sites by fixed wing aircraft. 4-6 people, working from 2-4 weeks at each site, are required. Traverses may readily be shared with other projects simply by adding a trailer containing the AASTINO. The project also needs logistic support to bring the pathfinder experiments to their sites, in particular that associated with the cosmic microwave background experiments at Dome C.

2.6 How will the required logistics be supplied? Have operators been approached?

Source of logistic support	Likely potential sources	Support agreed
Consortium of national polar operators	Y	
Own national polar operator		

Another national polar operator		
National agency		
Military support	Y	
Commercial operator	Y	
Own support		
Other		

2.7 If working in the Arctic regions, has there been contact with local indigenous groups or relevant authorities regarding access?

3.0 STRUCTURE OF THE ACTIVITY

3.1 Origin of the activity
This is a new activity developed for the IPY period

If part of an existing programme please name the programme – The project builds upon previous site testing activities at South Pole and Dome C, but is a new activity. For some of the pathfinder science programs the IPY represents a pulse of activity that will continue afterwards.

3.2 How will the activity be organised and managed? Describe the proposed management structure and means for coordinating across the cluster
The project will be organised as a collaboration between scientists of the participating countries. The lead organisation will be the University of New South Wales (UNSW) in Australia, who designed and operate the AASTINO. A management board will consist of representatives from the collaborating countries. Each investigation within the project will have its own PI, the person responsible for a particular instrument or instrument suite. A science team will be appointed by the management board to recommend the final experiment suite. A website will be used to provide project information for all members, and most communication will be conducted through email. When necessary, conference calls will be organised when more immediate decisions are required. Dialogue will also be maintained with other groups involved in any shared traverses and flights to ensure that the scientific requirements of all projects can be met.

The individual experiments are to be funded through applications to national and EC funding agencies. These include both science and polar funding bodies in the relevant countries. Proposals are already under consideration by Australia (AASTINO for Dome A), Denmark (AASTINO for Summit), the USA (HEAT experiment for Dome A) and Canada (AASTINO for Ellesmere Island). Some aspects are already funded, for instance the CLOVER microwave background experiment for Dome C by the UK and the ARENA network by the EC. Proposals range from feasibility studies to the full design phase across the project.

Support is needed from national polar operators to provide logistics, in particular the access to Summit, Dome C and Dome A for equipment and personnel. This is best handled as a combination of overland traverse and air transportation.

A critical design review of the project will be held during the AAA/PASTA workshop at the next SCAR meeting, in Hobart in 2006.

3.3 Will the activity leave a legacy of infrastructure and if so in what form?
The AASTINO will provide a laboratory that can be used to support future scientific experiments after the IPY has finished. Yearly maintenance (conducted via air support), including replenishment of fuel and replacement of instrumentation, would allow for a variety of future scientific uses. The CLOVER telescope mount and support facilities will also remain at Dome C after completion (around 2010) and then be available for use by other projects.

3.4 Will the activity involve nations other than traditional polar nations? How will this be addressed?
The two experiments to be conducted from Summit involve scientists from Austria and Spain (earthshine) and Poland (site quantification).

3.5 Will this activity be linked with other IPY core activities? If yes please specify
This project has direct synergies with any IPY activity that requires traverse capability to Domes A or C, along the ridge of the Antarctic plateau. It would also be possible to deploy an AASTINO to other high point along the plateau ridge (e.g. Domes B and F, Vostok) if a traverse went to those locations.

3.6 How will the activity manage its data? Is there a viable plan and which data management organisations/structures will be involved?
Data will be published in peer-reviewed scientific journals, as has been the practice over the entire astronomical site testing program. The data itself will be made publicly available through the Antarctic Data Centre system, again as has been standard practice, with appropriate metadata records to allow easy access to electronic queries. Its format will be complaint with the Virtual Observatory (a world-wide collaborative data management effort by the astronomical community). Web sites of the partners will also provide direct access to the available material. The various site data obtained from the participants in this project will also be used to refine design requirements and for optimisation of instrument parameters.

3.7 Data Policy Agreement
Will this activity sign up to the IPY draft Data Policy (see website)
Yes

3.8 How will the activity contribute to developing the next generation of polar scientists, logisticians, etc.?
The polar regions provide the finest locations on the planet for the conduct of frontline astronomical observations, able to facilitate experiments that peer back in time to over 13 billion years ago, to the beginning of the universe. Such a grand vision will provide inspiration for the next generation of scientists. All those involved in polar exploration will know they are contributing to humanities quest to explore the universe, and to understand where we came from.

3.9 How will this activity address education, outreach and communication issues outlined in the Framework document?
A successful, and long-established outreach program has been conducted during the past decade of astronomical site testing activity in Antarctica. This centres on the daily Antarctic diaries published electronically by the participating scientists, the web cameras at South Pole and Dome C, and an ongoing program of public talks and magazine articles (see, for instance, www.phys.unsw.edu.au/jacara). We aim to continue this program, in particular making use of satellite communications to bring the immediacy of the project to the target audiences, such as the participation in live exchanges with the scientists working in the field. We will also appoint an "ambassador to Greenland" whose task will be to involve local schools in the use of data gathered at Summit in the classroom.

This project will directly contribute to several educational goals for it will allow participation by graduate and higher-year undergraduate students at universities, as taking part in it will contribute to the research projects they need to conduct for their degrees.

3.10 What are the proposed sources of funding for this activity?
Logistical support from National Program Operators is required to bring the experiments and personnel to the four sites (Ellesmere Island, Summit, Dome A, Dome C). Funding for the experiments will be sought by investigators from individual countries. Current support includes:
• Dome C CLOVER CMBR experiment fully funded (UK PPARC, £5m, PI Piccirillo). The related BRAIN instrument has applied for Italian funding (PI Masi). A pathfinder experiment has been funded for £200K by France, Italy and the UK.

• Dome C measurement of ground layer turbulence (US NSF, US$114K, PI Travouillon).
• Dome C ARENA Network from European Union (1.5m, PI Epchtein).
• Design studies for Antarctic interferometer from Belgium (35K, PI Surdej).
The following grant applications are also awaiting funding decisions:
• Summit AASTINO and experiment suite (Denmark, 500K, PI Rasmussen).
• Dome A HEAT (High Elevation Antarctic Telescope) (US NSF, US$5m, PI Walker).
• Dome A AASTINO to house HEAT (Australia ARC, A$300K, PI Walsh).
• Dome C feasibility study for sub-mm telescope (Italian PNRA, PI Olmi).
• Marsden Fund, feasibility study for detecting planets by microlensing (NZ, PI Bond).
• Ellesmere Island site, to Canadian NSERC (science) and PCSP (logistics) (PI Carlberg).

3.11 Additional Comments
2.7If working in the Arctic regions, has there been contact with local indigenous groups or relevant authorities regarding access? - Yes for Summit Station.

Dome A is the last frontier in Antarctica to be explored, the most remote and extreme environment on the Earth's surface. At the start of the third millennium, human ingenuity has driven the development of technology to the level where it can now support scientific endeavours at this last outpost on the Earth. Furthermore, it is expected that Dome A will provide the foremost location on our planet for the exploration of the cosmos, including the search for earth-like planets in the Galaxy. It is fitting and beautiful that Antarctica, the last place on our own Earth to be fully explored, may turn out to be the best place from which to discover new earths.

4.0 CONSORTIUM INFORMATION

4.1 Contact Details

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4.2 Other significant consortium members and their affiliation

Name	Organisation	Country
Maurizio Candidi	Instituto Fisica dello Spazio Interplanetario	Italy

Eric Fossat	Laboratoire d'Astrophysique Universitaire de Nice	France
Chris Walker	University of Arizona	USA
Tony Travouillon	Caltech	USA
Mark McCaughrean	University of Exeter	UK
Ian Bond	Massey University	New Zealand
Cui Xiangqun	Nanjing Institute of Astronomical Optics and Technology	China
Yongheng Zhao	National Astronomical Observatories	China
Shoji Torii	Kanagawa University	Japan
John Storey	University of New South Wales	Australia
Michael Ashley	University of New South Wales	Australia
Jon Lawrence	University of New South Wales	Australia
Wilfred Walsh	University of New South Wales	Australia
Li Yuansheng	Polar Research Institute of China	China
Yongqiang Yao	Beijing Astronomical Observatory	China
Nicolas Epchtein	Universite de Nice	France
Jean Surdej	Universite de Liege	Belgium
Peter Thejll	Danish Meteorological Institute	Denmark
Michael Andersen	Astrophysikalisches Institut Potsdam	Germany
Luca Olmi	Arcetri Observatory	Italy
Giorgio Sironi	Universita di Milano Bicocca	Italy
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Giuseppe Pelosi	Universita di Firenze	Italy
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Klaus Strassmeier	Astrophysikalisches Institut Potsdam	Germany
Lech Mankiewicz	Polish Academy of Sciences	Poland
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Giampaolo Vettolani	INAF	Italy