

The ARENA roadmap

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Abstract. We present the main achievements of the ARENA network and a set of recommendations for the development of astronomy and astrophysics at CONCORDIA (Dome C)

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1. The ARENA network

ARENA (*Antarctic Research, a European network for Astrophysics*) is an initiative to draw out a roadmap for the development of Astronomy and Astrophysics at the French Italian Station Concordia at Dome C sponsored by the European Commission. It gathers some 100 scientists, engineers and polar technicians from 7 countries (6 in Europe and Australia). The activity of the network covers the 4-year period 2006-2009 encompassing the International Polar Year (IPY, 2008-9).

Dome C is one of the highest loci in Antarctica, and CONCORDIA (see Figure 1) one of the rare stations run all year round inside the continent. Created mainly to undertake the deepest drilling of the ice cap down to 3,000 m, Dome C happens to offer also compelling conditions for astronomical observations in a wide range of frequencies and techniques.

In 2005, several laboratories in Europe were struck by the exceptional seeing conditions reported by an Australian team. The atmosphere above a thin boundary layer of some 30 m is free of turbulence and, thus, the seeing exceptionally good (300 mas) above this layer. Dome C appears as an extremely appealing site for the rapid build-up of the first multispectral international observatory in Antarctica.

Realizing the potential of Dome C, a successful proposal was submitted to the EC in 2005, which had the following goals, i) aggregate and give access to the site assessment data collected so far, ii) identify the most compelling science programmes, iii) propose a few case studies of instrumental devices compliant with the polar conditions, iv) evaluate the logistics requests to set up one or several astronomical facilities, v) stimulate the interest of the public (especially during the IPY).

The ultimate goal of the network is to raise strong arguments in favour of the creation of an International Observatory in the forthcoming decade at Dome C (the so called "ARENA roadmap"). A set of some 25 specific tasks led by experts were carried out and, later on, 6 working groups were set up to prepare independently their roadmaps in their respective areas. The latter are briefly described in the following section.

2. Working Groups achievements

Wide field optical/infrared surveys. Under a grant of the Australian government UNSW/AAO carried out in 2008 a phase A study for the PILOT project, a 2.5 m class telescope that would serve as a pathfinder for future larger telescopes equipped with a suite of focal imaging instruments from the visible to the far infrared. European and



Figure 1. The Concordia station in 2007: main buildings, the site testing instruments, and the Concordiastro towers (*courtesy E. Aristidi*)

Australian astronomers came to a less ambitious project that would basically focus on the spectral range in which Antarctica brings an obvious advantage: the near thermal infrared and especially the 2.3–3.5 μm window hardly accessible from the ground. The PLT (*Polar Large telescope*) is a descoped version of PILOT. This project is considered as the most mature in its cost range and is fully supported for an immediate phase B study (2010–2013). In the meantime, IRAIT, an 80-cm IR dedicated telescope will provide rapidly (as of 2011) the first IR images and invaluable clues on the IR sky at Dome C.

Submillimetre-wave dish. Measurements of water vapour content definitely show that Dome C supersedes any other site in the THz regime and in particular in the 200 μm window. After ruling out a project to clone a 12 m ALMA antenna, configured for Antarctic conditions and installed shortly as a pathfinder, the working group eventually proposed a 25 m diameter dish (*the Antarctic Submillimetre Telescope*), envisioning a much more scientifically compelling project to exploit the 200–400 μm windows. It should rapidly enter a phase A study through a joint venture between Italy (INAF- IEE) and France (ThalesAleniaSpace, CEA, Saclay).

Optical/infrared interferometry. The ultimate goal of the interferometric community is to set up a kilometric array of optical/NIR telescopes. The Antarctic plateau with its immense flat areas and its unique atmospheric conditions would be the perfect location to install such an instrument (KEOPS project). The best pathway to this gigantic instrument is, however, still uncertain. Several pathfinders have been proposed among which the Aladdin concept (a nulling interferometer to measure “*exozodis*”) is currently the most advanced, essentially by Observatoire de Paris, Nice and Liège Universities and AMOS. This instrument is described in more details by V. Coudé du Foresto elsewhere in this session.

Long time series. The basic advantage of polar sites is to provide long dark periods perfectly suited to the study of periodic variations of astronomical objects (sun, stars, planet transits). Several projects are underway, among them the most advanced is A-STEP, a 40 cm telescope aimed to measure planetary transits. This instrument led by Nice Observatory/UNSA is under construction at Dome C and should provide first images in 2010. Other more complex and robotic projects are proposed and supported by ARENA such as ICE-T (a twin telescope with an ultra precise photometer) at AIP/Germany, and SIAMOIS (an interferometer to measure oscillations of stars) at Paris Observatory.

Cosmic Microwave Background. Antarctic sites have a very stable atmosphere and allow long integration times of the same area of the sky. They are very appropriate

to measure tiny flux variations in the millimetre wave range and Dome C is likely to be even more stable than the South Pole. A French-Italian consortium (APC University of Paris 7 and University of Roma, la Sapienza) is undertaking a project to measure the B polarization of the CMB using a bolometer and an interferometer (BRAIN/QUBIC). Dome C has an additional advantage being 15° away from the pole in latitude. For polarization experiments it is actually crucial to measure the same polarization direction with different inclinations of the axis of the polarimeter.

High angular resolution imaging solar physics. Dome C is an outstanding site for high angular resolution especially during Summer. Simultaneously, the sky is coronal and the seeing is excellent. Antarctica is suitable for very high angular resolution imaging of the solar photosphere and corona. An instrument consisting of a solar interferometric imager (AFSIIC) is proposed, consisting of 3 telescopes of 70 cm on top of a tower of about 30 m.

More details on all this are given in the ARENA website (<http://arena.unice.fr>) and in the Proceedings of the 3 conferences organized by ARENA (Epchtein & Candidi, 2007), (Zinnecker *et al.*, 2008), and in particular (Spinoglio & Epchtein, 2010).

3. Conclusions and Recommendations

Dome C is the only place where one can expect to undertake outstanding programmes of astronomy in Antarctica in the next decade from the visible to the submillimetre range. The executive committee of ARENA is preparing a series of recommendations in conclusion of the ARENA roadmap. Among them, it is recommended to create an astronomical observatory at Dome C with a stable structure, to proceed with the internationalization of the CONCORDIA station, to pursue the site assessment, open wide access to the site qualification data, and facilitate the comparison of site characteristics, to strongly support the currently on-going instruments (IRAIT, A-STEP, QUBIC), to seek funding and support for a couple of additional small instruments (ICE-T, SIAMOIS) to start phase B studies of PLT for a first light before 2020, and phase A studies for ALADDIN, AFSIIC and AST. It is also highly recommended that a strong cooperation be initiated between all the countries involved in astronomical developments on the Antarctic continent in order to define a global policy.

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