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CASTEL: Capodimonte Antarctic Solar TELescope

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Abstract. The program of the CONCORDIASTRO/Italy project consists of the installation of a 40 cm telescope at Dome C. This telescope will be used to acquire time-series of filtergrams in the visible at both medium and high spatial resolution, with the aim to qualify Dome C for solar observations. In case the expectation of very good seeing at Dome C will be confirmed, this site will allow long-lasting, high spatial resolution data that are needed for many scientific purposes; one example, of interest for our group, is the study of small seismic events that are considered the best candidate to excite the solar global oscillations. This contribution focuses on the project planning of CONCORDIASTRO/Italy and on the telescope named CASTEL (Capodimonte (or Concordia) Antarctic Solar TELescope).

Key words. Sun – instrumentation

1. Introduction

The first solar observations in Antarctica were framed in the study of the solar oscillations. In fact, the chance of obtaining uninterrupted campaigns permitted to increase the visibility of the resonance peaks in the power spectra of solar intensity or velocity fluctuations (Fossat, Grec & Pomerantz 1981, Duvall et al. 1991).
Nowadays, *standard* observations for helioseismology, i.e. at spatial resolution worse than $1''/pix$ and low cadence (60 s typically), are currently carried out by networks of stations at different longitudes on the Earth in order to observe continuously the Sun (BISON, GONG, IRIS, LOW-l, RISE-PSPT, TON) or by the instrumentation on-board the SOHO satellite.
However, we think that Antarctica can still attract solar astronomers because of the

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site of Dome C, which is the best candidate in the world to allow long-lasting, high spatial resolution observations. Such kind of data are required by many present solar researches. One example, of interest for our group, is the study of the solar acoustic source.
Recently, the search for the source of the solar oscillations addressed the possibility that small scale events (of the order of one arcsec and duration of few minutes), could continuously excite the resonant modes (Goode et al. 1998). These events were associated to convective downflows whose global Sun occurrence rate is of the order of 5000 s^{-1} (Strous, Goode & Rimmele 2000).
Another hypothesis suggests the downflowing jets related to the chromospheric explosive evaporation events to be responsible of part of the acoustic excitation (Moretti et al. 2001). The penetration of the perturbations down to the photosphere was observed for different events energies (Kosovichev & Zharkova 1998, Moretti et al. 2003).
For both mechanisms, the effectiveness energy transfer to the global oscillations has still to be demonstrated.
For this reason, very high spatial resolution observations of the Sun, for long uninterrupted periods, are needed to investigate properly the source of the solar oscillations.

2. Scientific objective

Long observations at high spatial resolution cannot be performed easily. In fact, the best sites hosting big telescopes, even when taking advantage of adaptive optics techniques, can not guarantee at the moment the optimal spatial resolution for periods longer than a few hours.
Preliminary tests at Dome C, in Antarctica, suggest this site could be the best on the Earth for high spatial resolution and long period researches. In fact, thanks to the absence of wind and to its high elevation, the atmosphere above Dome C is very stable (Valenziano & Dall'Oglio 1999). Though the meteorology data predict excellent seeing conditions, they have to be statistically interpreted, that is the mean values are extremely good, but some campaigns could not show the best seeing in the world. Moreover, solar observations in Antarctica imply looking toward the Sun and low in the sky, because the Sun at Dome C is never higher than 40 degrees above the horizon. As a result, in planning solar observations, extreme care has to be devoted to avoid heat sources and the interception of large ice-crystal columns. For this reason, the expectation of excellent seeing characteristics has to be confirmed within the effective conditions of operation at Dome C by means of solar high resolution observations. To fulfill the above needs, we plan to install a solar telescope, named 'CASTEL' (Capodimonte Antarctic Solar TELescope) to test the quality and stability of the seeing directly from solar intensity images.

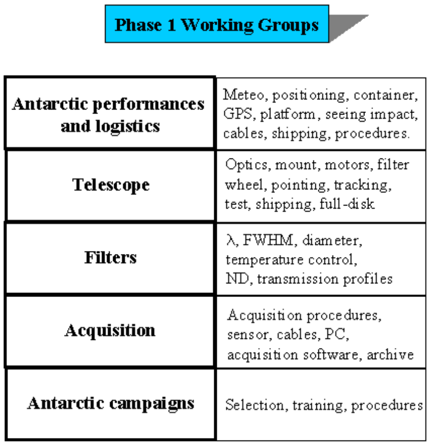

Fig. 1. The CASTEL phase 1 working groups and the corresponding duties.

2.1. The organisation of CASTEL

The construction of CASTEL has been organised in three main phases. Note that the effective time schedule will depend on the availability of the allocated funds. In

fact, the Concordiastro/Italy project, approved in 2002 and presented at the Third International Workshop on Astrophysics at Dome C (Moretti et al. 2002), has been partially financed and we are waiting for the complete funding.
The first phase consists in defining all the operative characteristics of the instrumentation, the selection of the companies and the updated estimate of the costs with respect to the original proposal.
A preliminary test of the solar seeing with a simple instrument (named SHABAR, SHAdow BAnd Ranger, Beckers and Liu 2002) is planned to be performed in collaboration with the NSO (National Solar Observatory, USA), after a confirmation by the P.N.R.A. This phase has been organised in five working groups: telescope, acquisition system, filters, Antarctic performances and logistic, Antarctic campaigns, whose duties are shown in Fig. 1.
The second phase consists in ordering the instrumentation and performing the tests at low temperatures. During this phase all the software procedures for the data analysis will be prepared and personnel participating at the installation and observations at Dome C will be trained. This phase ends with the shipping of the instrumentation to Dome C.
The third phase consists of the Antarctic campaign for the installation of the 40 cm telescope and the first observations. The data will be analysed to obtain an estimate of the solar seeing to be compared with the atmospheric parameters provided by other experiments at Dome C.
If the excellent stable seeing conditions will be confirmed, we plan to upgrade the instrumentation for obtaining simultaneous full-disk images.

3. The instrumentation

3.1. The telescope

We plan to install a 40 cm aperture Maksutov-Cassegrain telescope on a platform at approximately 4 m elevation from the ice-sheet at Dome C. The platform will be provided by the French group developing at Dome C the CONCORDIASTRO project for asteroseismology.
The diameter of the telescope has been suggested by a compromise between the dimensions and the cost: this is the largest for a class of small size telescopes.
The entrance window and all the components will be designed to reduce the heating of the telescope.

3.2. The filters

Intensity images will be acquired in white light and in the Ca II K line at 393.4 nm. The spectral range close to the blue wavelengths of the visible spectrum was chosen to obtain the largest diffraction limit compatible with standard CCD (the effective spatial resolution will be of the order of $0.25''$) and the Ca II K line was selected to take advantage of the complementary data from running networks at $2''$spatial resolution (TON, Chou et al. 1995 and RISE-PSPT, Ermolli et al. 1998) and to compare the data with previous Antarctic campaigns at South Pole (Duvall et al. 1991).
All the filters will be designed to work at low temperatures and no temperature stabilisation will be introduced in order to make the system as simple as possible. For this reason, filters with the lowest temperature coefficient, produced by Barr Associates, were selected. The intensity variations due to the temperature fluctuations were simulated with the result that, during the day, these variations yield a 10% contribution to those from the quiet Sun (see Fig 2).

3.3. The acquisition system

Many of the constraints on the detector are related to the scientific objective.
A $0.15''$ sampling (from the Rayleigh criterion) with a field of view of at least $60''$ implies a minimum 512 x 512 pixels detector, while the intensity fluctuations to be

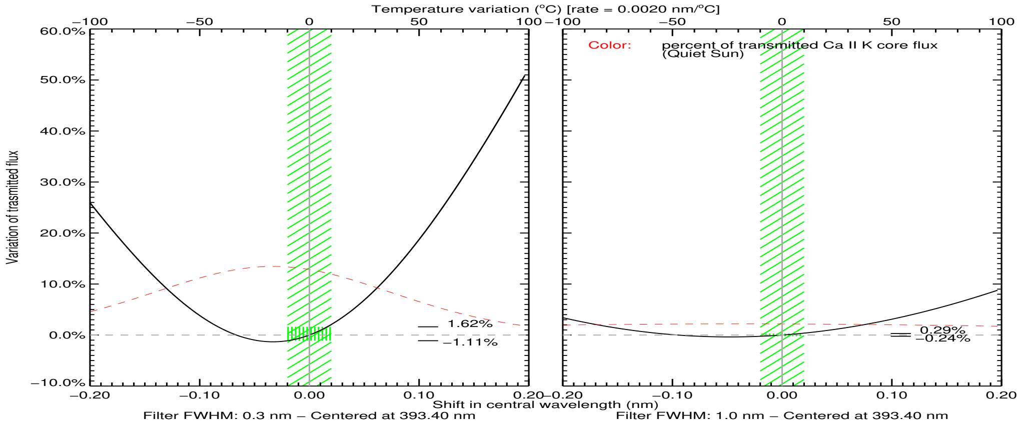

Fig. 2. Variation of flux transmitted by gaussian filters (FWHM=0.3 nm left, FWHM = 1 nm right) as a function of the central wavelength shift (solid line). The percentage of flux variations due to the line core in the quiet Sun (calibrated accordingly to Oranje 1983) is indicated with the dashed line. The dashed zone indicates the maximum daily variations expected from the temperature variations at Dome C using a Barr filter.

revealed select a signal-to-noise ratio of the order of 1000.
Integration times of the order of 0.1 s and an acquisition time of 15 s are required.
Low temperature cabling has to be still studied. CMOS sensor arrays performances are currently studied at the Tor Vergata Physics Department in Rome, but at this moment, no specific system has been yet selected. In fact, the characteristics and costs of detectors and acquisition systems available on the market change rapidly. We wait for the complete funding to make the definitive choice.

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