An outdoor test facility for the Cherenkov Telescope Array mirrors

The Cherenkov Telescope Array (CTA) is planned to be an Observatory for very high energy γ-ray astronomy and will consist of several tens of telescopes which account for a reflective surface of more than 10000 m^2 . The mirrors of these telescopes will be formed by a set of facets. Different technological solutions are under test inside the CTA Consortium [1]. Most of them involve composite structures whose behavior under real observing conditions is not yet fully tested. An outdoor test facility has been built in one of the candidate sites for CTA, in Argentina (San Antonio de los Cobres [SAC], 3600m a.s.l) in order to monitor the optical and mechanical properties of these facets exposed to the local atmospheric conditions for a given period of time. In this work we present the preliminary results of the first Middle Size Telescope (MST) mirror-monitoring campaign, started in 2013.

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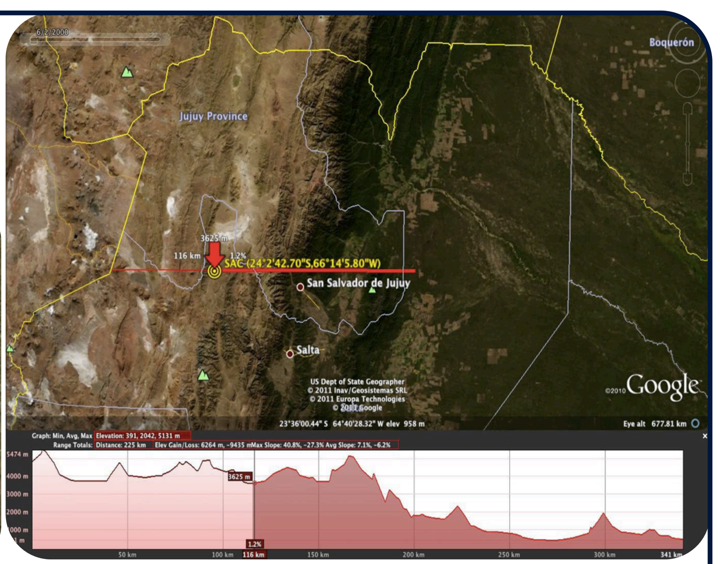
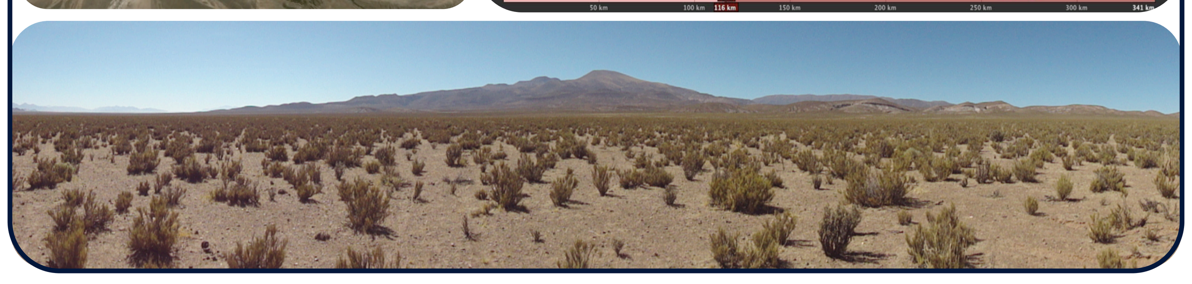
Introduction

- The reflector of a Cherenkov telescope of middle size (MST) is composed of individual hexagonal mirrors of 1.2m (flat to flat) diameter with a spherical shape (radius of ~32 m).
- CTA mirrors design involve a composite structure, supporting a slim reflective surface assembled and glued using the cold slump technique[2,3].
- Their optical quality is defined by 3 variables: the focal length, the size of the Point Spread Function (PSF) and the reflectivity (global and local).
- Within the operational temperature range (-25°C to +40°C) at the site, the percentage of reflected light focused by the mirror (at the nominal focal lenght) inside a circular area of 1 mrad diameter, shall not change more than 3%.

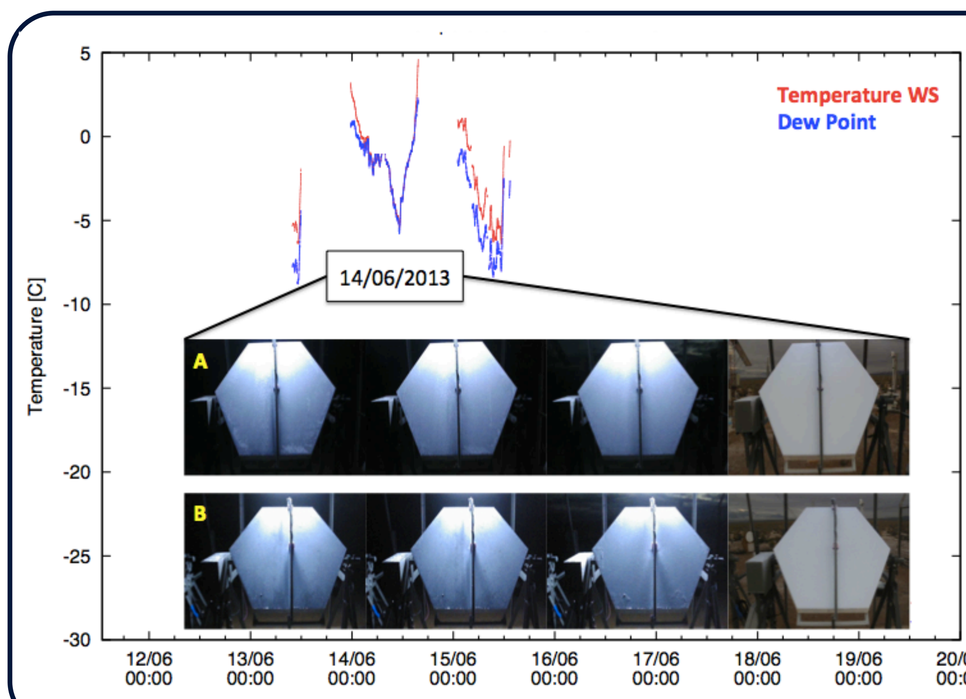
Argentinean Site





Misting & frost problem

Net heat transfer from the mirrors to the air at night will cool the reflective surface.
If the mirrors temperature drops below the dew point condensation (frost) will be formed.
This reduce the available observation time[6].



When the Dew Point is close to WS temperature condensation and frosting are possible. The mirror surface is covered by frost

Fig. 3: Temperature at the mirror surfaces and dew point. Images showing the status of the mirrors.

Outdoor Test Facility

- Structures to hold the mirrors in different positions controlled remotly
- IP cameras (Ubiquiti Air-Cam) taking pictures of the mirrors each 10 minutrd
- High intensity white LED
- Cameras and movement of the mirrors controlled by a SBC TS-7260.
- Temperature and rel. humidity sensors (RTD4 & HIH-4005) on the mirror surfaces.
- Data sent via the RS-232 port.

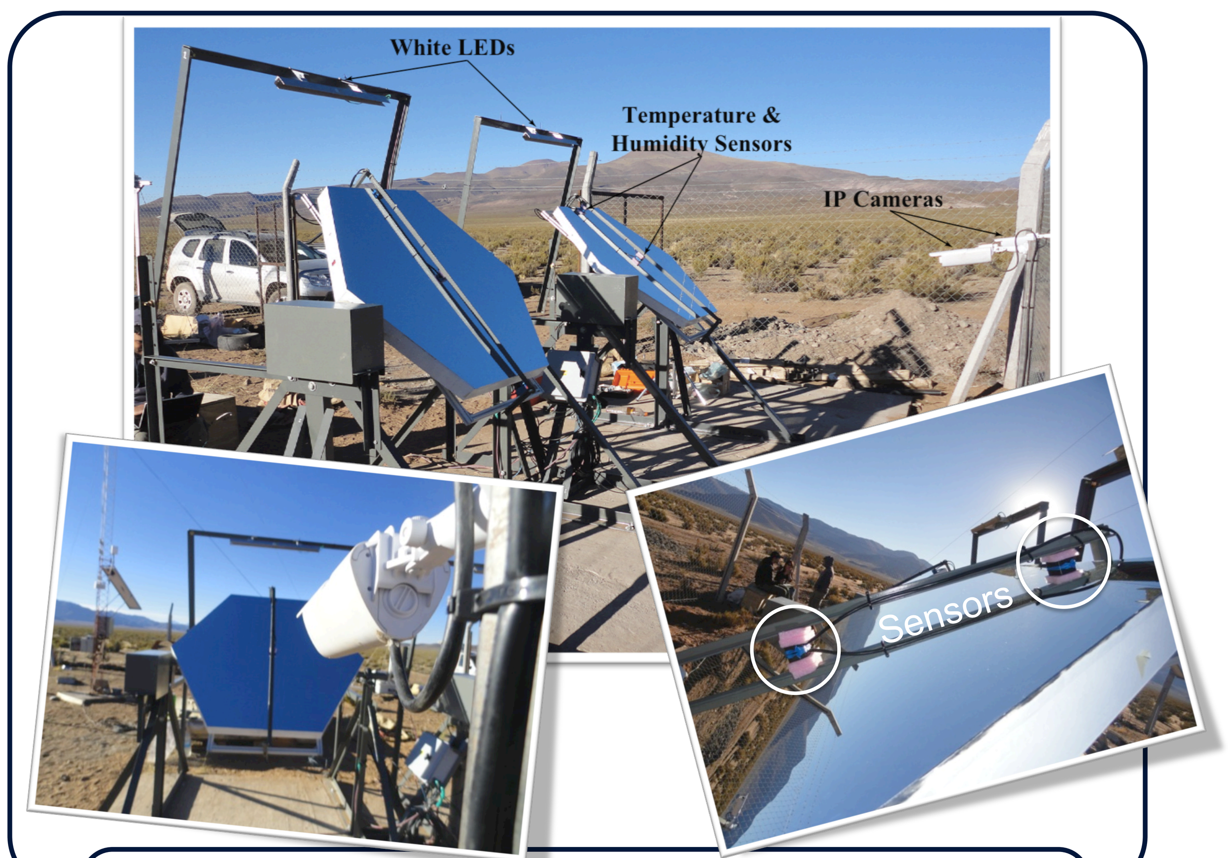


Fig. 2: Outdoor test facility at San Antonio de los Cobres. Two Irfu-Kerdry mirrors already installed.

Optical Tests

For evaluating the evolution of the optical properties with time, the focal distance (with a 2f system [2], Fig. 3) and the local reflectivity (comercial spectrometer) are monitored.

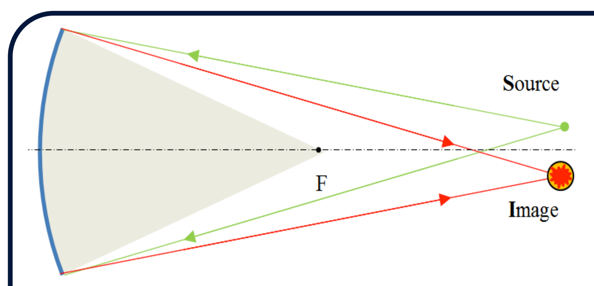


Fig. 3: 2f system principle and the portable device

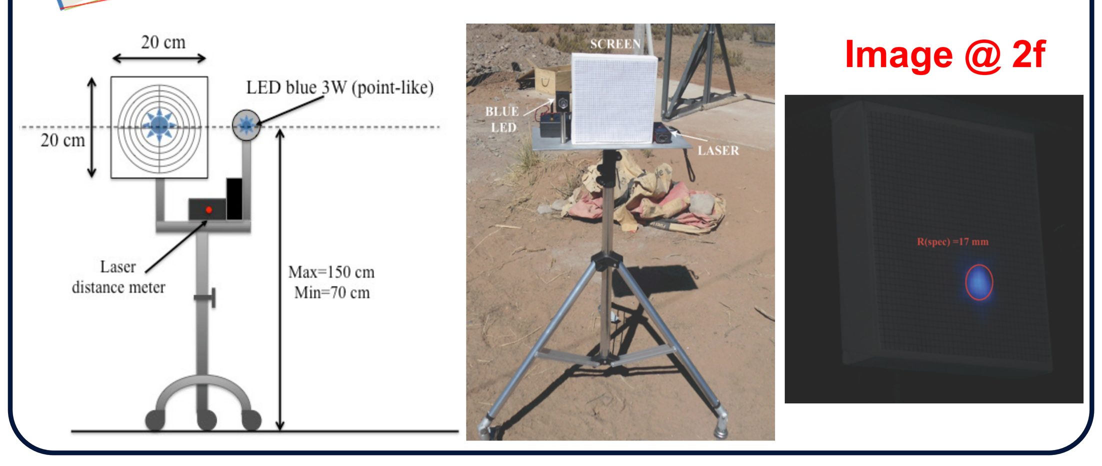
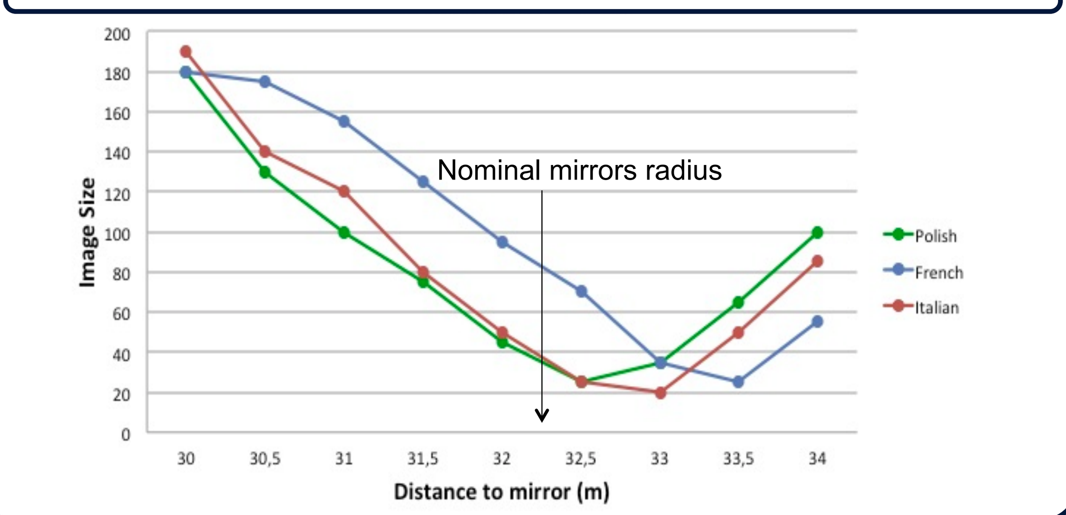
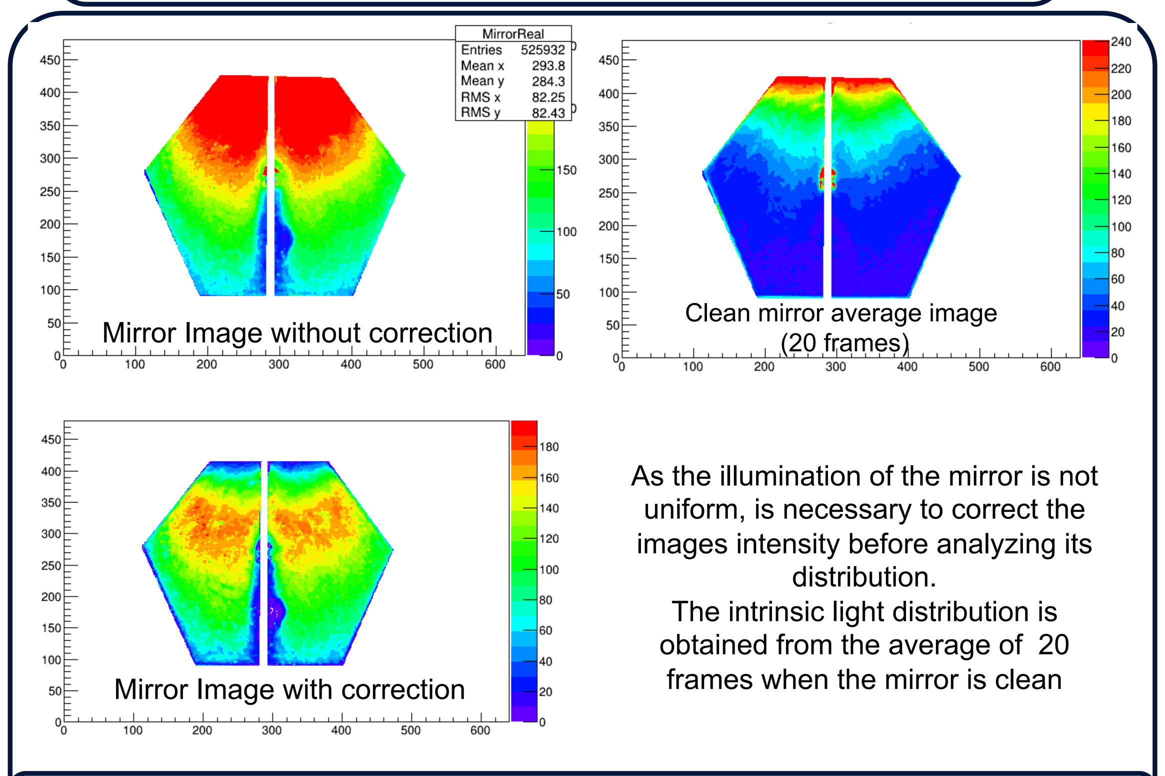


Fig. 4: Focal distance determination





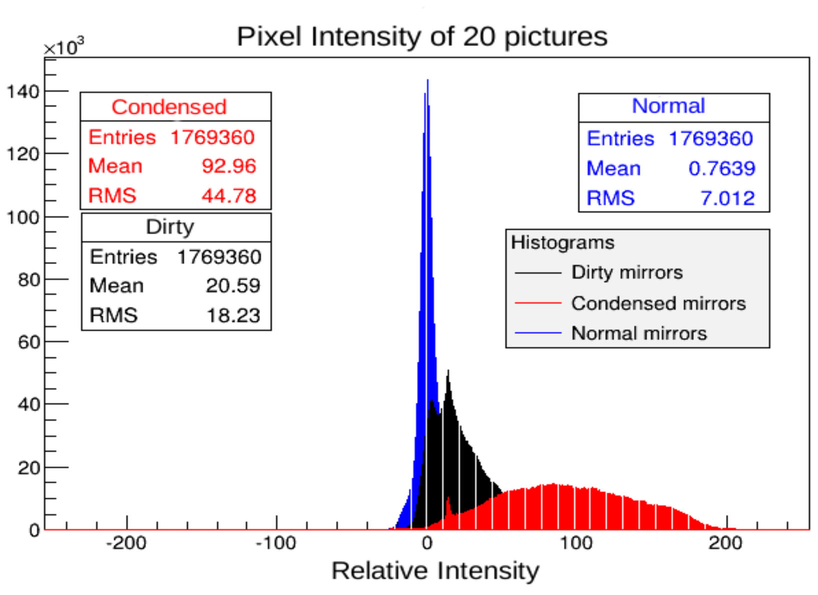
As the illumination of the mirror is not uniform, is necessary to correct the images intensity before analyzing its distribution.
The intrinsic light distribution is obtained from the average of 20 frames when the mirror is clean

Fig. 5: Light intensity at the mirrors surface recorded by the cameras

There is a correlation between light intensity on each pixel and surface status (precense of condensation, presence of dust and cleaness).

Identify condensed mirror

- Pixel Intensity Average > 40
  - Find condensed pixel
    - Signal > 0.76 + 14



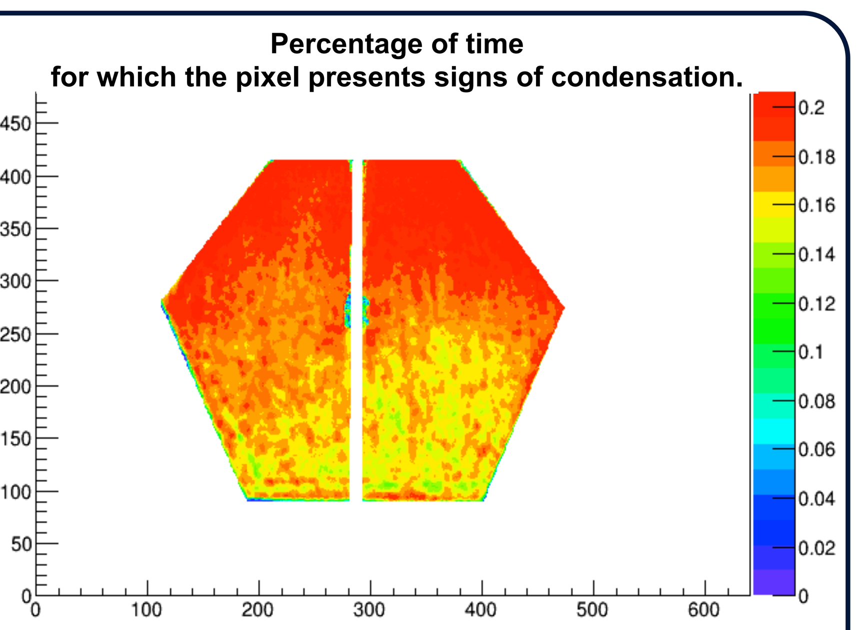


Fig. 6: Preliminary results on time loss due to condensation over the mirrors surface

Next steps: correlate with weather data, include all the gathered data (6 months) and test the results against condensation models.

Ref: 1) M. Actis E. et al., Exp. Astr. 32 (2011); 2) P. Brun et al., NIM A 714 (2013) 58-66; 3) R. Canestrari et. al., Proc. SPIE 7739 (2010) 77390; 4) M. Dyrda et al., Poster N°0281, ICRC2013; 5) I. Allekotte et al., Poster N°0960, ICRC2013; 6) P. Chadwick et al., Poster N°084è, ICRC2013; 7) A. Föster et. al., Proc. SPIE 7437 (2009) 743712.

ACKNOWLEDGEMENTS

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