INTRODUCTION

MAGIC [1] is a stereoscopic system composed by two Imaging Atmospheric Cherenkov Telescopes (IACT) called MAGIC I and MAGIC II used for the detection of Cherenkov light produced in the atmosphere by the very high energy (VHE) gamma-rays component of the cosmic radiation. The MAGIC detector is located in the Canary Island La Palma (28.75 N, 17.89 W) where MAGIC I has been operating since fall 2003, while MAGIC II was commissioned at the end of 2009, allowing stereoscopic observations with improved energy and angular resolution and enhanced sensitivity [2].

By their excellent performance, the current IACT generation (MAGIC, HESS and Veritas) is producing a substantial body of important scientific results. However, a future generation of IACT represented by the Cherenkov Telescope Array (CTA) project is approaching. CTA is currently in the preparatory phase and is expected to be completed within the next five years (see figure 1). Along with this, an effort from worldwide distributed Cherenkov telescopes towards one new major installation of hundred Cherenkov telescopes for simultaneous operation is made resulting in a performance enhancement.

The planning of CTA foresees the installation of telescopes of three different sizes, sensitive to different energy ranges of the VHE regime: several 6 m diameter small size telescopes (SST), several 12 m diameter mid size telescopes (MST) and few large size telescopes (LST) of 23 m diameter requiring reflectors up to 400 m² composed of light-weight, robust mirror facets of suited reflectance and focusing quality without demanding much maintenance. Usually, IACTs are not protected by domes, so that the mirror facets are continuously exposed to the environment. The challenge for CTA is to develop low-cost mirrors of 1–2 m² area with the potential for high production rate. Currently, several technologies pursuing different mirror assembly methods and investigating different materials are explored to build mirror prototypes that meet the CTA mirror specifications [8].

In this scenario, INFN Padova is investigating a new production method for CTA mirror prototypes based on the techniques used for the MAGIC mirrors with the potential of high production rate. An effort from worldwide distributed Cherenkov telescopes towards one new major installation of hundred Cherenkov telescopes for simultaneous operation is made resulting in a performance enhancement.

OPTICAL MIRROR VERIFICATION WITH A 2f-SETUP

In order to verify that the IACT mirrors stay within the optical specifications required by MAGIC and CTA, a test facility located at the LNL has been set up. To measure the optical quality as close as possible to the needs of the telescopes would mean to have a parallel and homogenous light beam illuminating the full mirror surface and to observe the image at a distance of the focal length of the mirror. As it is technically demanding to create such parallel, homogenous light beam, the approximation most widely used and currently employed is the so-called 2f-method as shown in figure 2. A pointlike light source

With its two 17 m diameter dishes tessellated with squared mirrors of 0.25 m² (MAGIC I [4]) and 1 m² (MAGIC II [5]) area, MAGIC represents currently the IACT installation with the largest reflectors worldwide. INFN Padova contributed significantly to the production of both reflective surfaces. The MAGIC I mirror assembling has been entirely carried out at the LNL, while the larger MAGIC II mirrors were built at the companies Compositex Srl [6] and LT-Ultra [7] after the design and construction of some prototypes at the LNL. Despite their robustness, after eight years of operation the MAGIC I reflector needs to be partly refurbished. For this reason, few tens of new mirror facets have been produced in collaboration with the Compositex Srl and LT-Ultra companies.
focal length. At the same distance a detector is placed to record the return image. The detector system consists of a fine pixelised CCD [9] focused on an opaque glass screen on which the return image is projected. A 3-axis stepping motor [10] with a range of 200 mm each axis provides a fine tuned, simultaneous movement of both CCD and screen. By scanning over the estimated distance of approximately 35 m for the position of the return image with best focused shape, the exact radius of curvature is determined. The scan can be performed very precisely as the stepping size is 1 mm. The distance of the detector system with respect to the mirror is measured with a laser distance meter of high accuracy [11]. The individual equipment is mounted on an optical bench as shown in figure 3. The focusing quality is characterised by the point spread function (PSF). In general, the detailed shape of the PSF is not of critical importance for Cherenkov telescopes as long as it is small enough, i.e. smaller than the size of a pixel of the Cherenkov light detecting system. Therefore, it is usually sufficient to characterise the PSF by the diameter of a circle that contains a certain fraction of the reflected light, e.g. d90 for a 90% light containment diameter calculated from the recorded return image.

Currently, some modifications to the setup are applied to increase the remote control of the individual instruments. Further investigations into additional equipment are ongoing, offering the possibility of performing the measurement of the absolute reflectance of the mirror into the focus at different wavelengths.

THE MAGIC-D OUTREACH PROJECT

Since 2009 the outreach project MAGIC-D is proposing their study program to senior secondary school years in the Veneto region involving not only students but also teachers. Within this framework, three meetings in 2011 were arranged at the LNL where a small group of secondary school teachers participated in the measurement of the optical mirror parameters in order to evaluate the potential of such practice involving also students (figure 4). The second purpose of these workshops is to provide them with the possibility to get in touch with didactical research, aiming the focus on a transversal approach to the scientific problem they were introduced to. They were actively involved into the entire measurement procedure beginning from the preparation and alignment procedure of the setup and the control of the individual instruments, ending with the actual measure. As a merit of the positive feedback, further workshops are planned to be hold with some support of the teachers and the MAGIC researchers for small groups of students at the LNL in 2012.

Fig. 3. Optical bench of the 2f-setup installed at the LNL.

Fig. 4. Workshop with secondary school teachers on the optical verification measurement at the LNL held in the framework of the MAGIC-D outreach project.