
The Active Mirror Control of the MAGIC Telescope

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Abstract

The MAGIC Cherenkov telescope with its 17 m diameter mirror is the worldwide largest dedicated Cherenkov telescope [1][2]. One of the main goals in the design of the telescope was the ability to point to any arbitrary position on the sky in less than 20 s to allow one observations of Gamma-Ray Bursts (GRBs) after an alert by satellite experiments. To achieve this goal, a stiff, lightweight space frame structure made of carbon fiber tubes was built to minimize the telescope's weight. Because of weight and financial limits it was not possible to construct a completely stiff frame. As a result some residual deformations, depending on the pointing direction, remain. This necessitates corrections. In this paper we present the design of the *active mirror control* (AMC) system that allows for readjustment of each of the 245 mirror panels during the observations [3].

1. Introduction

A large diameter telescope has strong requirements on the stiffness of the reflector frame. When directing the telescope to different elevation angles the reflector's surface deviates from its ideal shape under gravitation loads. Two solutions are possible to counteract the deformations: a) either to construct a very heavy and stiff frame or b) allow for small deformations by constructing a light-weight support structure and correct its mirror profile, for the construction of the MAGIC telescope. We have chosen the second option. A small-scale version of the AMC has been constructed and tested in 1996-1997 [4]. In the following years we have made several iterations and substantially improved the performance of the AMC. Since several months the AMC system is installed on the MAGIC telescope on the Canary Island La Palma and is under extensive tests. The AMC is one of the key elements of MAGIC and its proper operation is crucial to improve the performance of the telescope.

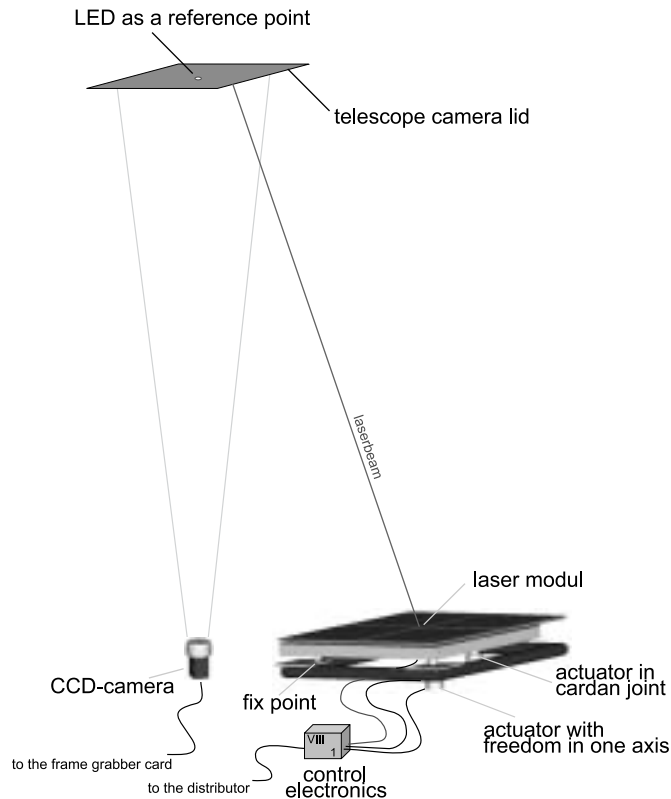


Fig. 1. Schematic drawing of the active mirror control.

2. The Basic Principle

The schematics of the AMC is shown in Fig. 1. The reflector of the MAGIC telescope consists of 956 square shaped mirror facettes with 49.5×49.5 cm² surface. Four mirror facettes are mounted on a single panel. The panels are attached to the carbon fiber support frame on three points. Two of the mounting points are equipped with actuators which can be used to adjust the position of the panel. The main elements of the actuator are:

- two phase stepping motor: full step 1.8^0 , holding torque 50 Ncm
- ballspindel: pitch 2 mm, maximal rating range 37 mm, longitudinal tolerance $< 10\mu\text{m}$

This construction allows a minimum displacement of $10 \mu\text{m}$ in full stepping mode which corresponds to a transverse focal displacement in the camera plane of ~ 1.6 mm.

The three points have different lateral freedom. One actuator has full lateral freedom while the other actuator can swing in only one axis. The third

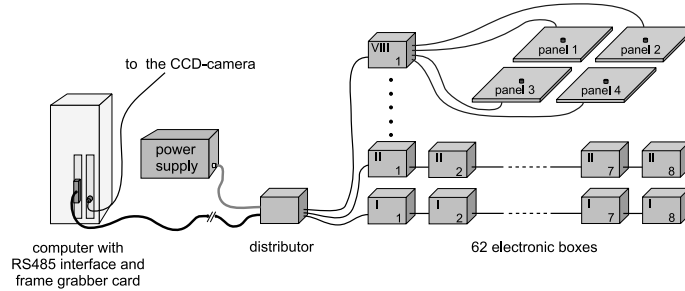


Fig. 2. Schematic drawing of the electronics of the AMC.

point has no lateral freedom. In the center of the panel a laser module - controlled by the computer - is preadjusted pointing towards the common focus of the four mirrors.

The electronics of the AMC is illustrated in Fig. 2. The design is custom made and is based on the use of micro controllers for driving the actuators and for communicating via RS-485 interface with the AMC central computer. Splitting of the control of the total number of electronic boxes into eight independent strings strongly reduces the probability of simultaneous breakdown of the whole system. We are preparing a quasi-simultaneous operation and control of the mirror panel alignments. The sequence is the following: switch on the laser of a given panel, measure by the CCD camera (which is fixed on the reflector frame close to its center) the corresponding laser spot location on the telescope camera lid (acting as a screen), calculate the deviations and send the command to the corresponding micro controller. While the motors are active the next panel can be already checked.

3. Discussion

We have constructed an advanced AMC system. All the components of the system, both mechanical and electronic, are selected to be water tight and to fulfill the IP67 standard. For the run-in phase we are using the AMC in a simple sequential mode. In the near future we are preparing, by using the quasi-simultaneous mode, to move about twenty panels “parallel” in time. To improve the AMC in the future we have started with preliminary studies using infrared lasers and an infrared sensitive camera which will allow us to use a *concurrent mirror control* (COMIC) without interfering with the on-going measurements [5].

In Fig. 3 we show the result of the focussing of 103 mirror panels. The recent tests showed that we can adjust one panel in ~ 10 seconds. The full adjustment of the 103 panels in a partially simultaneous mode takes ~ 220 seconds. The spot size of the 103 m² mirror surface in the right hand side picture of Fig. 3 is well below a pixel diameter.



Fig. 3. Pictures showing the focussing of the mirror segments with a ~ 1 km distant lamp. Left: spots of the 103 panels before the adjustment. Right: common spot after focussing.

4. Conclusion

The application of the AMC in the design of the MAGIC telescope allows us to overcome mechanical deformations of the mirror support frame under changing loads during operation. Hence, it was possible to build a light weight construction and allow for fast movements of the telescope. The possibility of changing the pointing to any position on the sky in approximately 20 seconds makes the MAGIC telescope the first of its class that can quickly respond on the GRB alerts given by satellite experiments and possibly catch the burst when it is still on-going. It is furthermore possible to operate the telescope under optimized optics for different shower distances in the atmosphere, defocus the mirror in case of accidental pointing towards the sun or to carry out special studies. The AMC opens new possibilities for the design of the next generation big telescopes.

5. References

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