Status of the MAGIC Telescope

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Abstract

The 17 m diameter air Cherenkov telescope MAGIC for gamma ray astronomy between 30 GeV and 30 TeV is currently in its commissioning phase. The status of the telescope and first results on its performance will be reviewed.

1. Introduction

The MAGIC (Major Atmospheric Gamma Imaging Cherenkov) Telescope was designed in 1998 [1] with the main goal of being the Imaging Atmospheric Cherenkov Telescope (IACT) with the lowest gamma energy threshold possible with the technological improvements affordable by the MAGIC collaboration and based on the experience acquired with the first generation of Cherenkov telescopes.

There was a clear-case motivation for this effort: there was a well populated sky-map of sources detected by EGRET (but more than half of them still unidentified due to poor angular resolution) below around 10 GeV while just a handful of sources observed by the existing IACTs above 300 GeV and an unexplored observation gap in between. It was felt that covering that energy gap with detectors based on the IACT technique, which provide much large effective areas (and much superior flux sensitivity) than satellite detectors, good angular resolution, acceptable energy resolution and a well tested capability to separate gammas from backgrounds, was worth the effort. From the purely experimental point of view, covering that gap with IACTs could allow:

- To study the mechanisms which cut-off the spectrum for several of the EGRET sources precisely in this energy gap and that must explain why they were not detected by the first generation of IACTs above 300 GeV.
- To study all the EGRET sources with a much higher flux sensitivity and angular resolution and hence, identify the EGRET unidentified sources.
- To eventually discover a plethora of new sources since for most of known sources the energy spectrum is of power-law nature and therefore they

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should exhibit a much higher flux in that energy region than at higher energies.

Several innovative technical solutions started being worked out as early as in 1995 [2] and, since then the R&D has not stopped. During this time several options were discussed, such as the convenience of a single very large IACT incorporating the latest technological developments or a solution based on an array of somewhat smaller conventional telescopes. A cost and physics comparison led to the conclusion that a single very large diameter IACT would be cheaper and would allow us to cope better with the prime goal of reducing the threshold as much as possible. We were nevertheless aware that the single large telescope choice had a price to pay: to fight against higher backgrounds, to have a somewhat worse sensitivity at higher energies and to have a somewhat poorer angular and energy resolution than a system of telescopes.

Nevertheless, behind our choice, there was a clear route-map: since reducing the threshold is entering a new technological and physical domain, first we wanted to have a working telescope with the lowest possible threshold to EXPLORE this energy gap and then, if with the first telescope the technology proves to be adequate and the physics DISCOVERIES in this energy domain justify studying it in more detail, then go for more telescopes (at least one to two more) to benefit from all the advantages mentioned above and be able to perform PRECISION measurements.

In 1998 we wrote a Technical Design Report [1] in which we stated the above route-map and a clear concept for the construction of the first telescope, for which we decided to start with a ”classical” photomultiplier camera since a ”high quantum efficiency” camera required a longer R&D. The proposal was put forward in 1999 [3] , funding for the major investments were approved at the end of year 2000 and the actual construction started at the end of 2001.

In this talk the main elements of the MAGIC telescope are reviewed, as well as the main physics goals, and a report on the present status is given.

2. The MAGIC telescope concept

MAGIC is a large and lightweight Cherenkov telescope placed at the Roque de los Muchachos Observatory (ORM) at 2200 m asl (28.8^o latitude, -17.9^o longitude) in the Canary island of La Palma which incorporates the following NEW elements (see ref.[1] for a more detailed discussion on these elements and the expected performance):

- A 17 m diameter parabolic carbon-fibre frame with $f/D = 1$ able to reposition in any direction in less than 30 seconds.
- A tessellated reflector made of 956 half squared meter diamond-turned aluminium mirrors.

- A novel Active Mirror Control (AMC) able to correct the mirror pointing on-line for dish deformations.
- A camera made of 577 good quantum efficiency, fast photomultipliers with hemispherical photocathode to allow for light double-crossing and a special wavelength-shifting coating to provide red extended sensitivity and allow for light-trapping.
- Signal transmission to a distant Control House by using analog optical fibre signals.
- A multilevel trigger and a 300 MHz FADC system for pulse digitization.

3. The MAGIC physics goals

The main research targets for MAGIC are (see ref.[1] for a more detailed discussion):

- The study of Active Galactic Nuclei over the redshift range in the 3rd EGRET catalogue. Measurements of the energy flux between 20 GeV and 1 TeV will allow to determine the gamma ray horizon and eventually extract the cosmological parameters and the extragalactic background light density. Fast flares will be used to constrain Quantum Gravity effects.
- A deep field probe of the $\log N - \log S$ distribution. A deep exposure at high galactic latitudes may lead to the serendipitous discovery of faint sources.
- The systematic study of galactic gamma emitters such as Supernova Remnants, Plerions, x-ray binaries, Pulsars, unidentified EGRET sources, etc. where the observation in this energy range might allow to discriminate between different acceleration mechanisms and might hopefully lead to the identification of the main sources of cosmic rays up to about 10^{15} GeV.
- The observation of Gamma Ray Bursts in the new energy window and the use of their fast transients to constrain Quantum Gravity effects.
- The search for signals of Dark Matter annihilation into gamma rays.

4. Present Status

The construction of the foundation for the MAGIC telescope started in September 2001 and just few months later the whole telescope structure was completed (December 2001). For the rest of elements, the construction speed has been mainly limited by the funding profile.

Mirror installation started in summer 2002 and now about 100 m^2 of mirror area are already on place though it is foreseen that about 200 m^2 will be installed before the end of this summer. The AMC has proven to be very precise and fast. The telescope drive system was installed during past year and has recently being commissioned up the highest speed which turns out to lead to a maximum repositioning time of 20 seconds, well below the 30 seconds target. The tracking system is currently being calibrated using bright star pointings. The camera was completed in summer 2002 after extensive testing and characterization; it was installed on the site in November 2002 and has been commissioned in March 2003 after the winter break. First starlight using the DC current readout was recorded on the 8th of March. The installation of the optical links for the fast-pulse transmission started early this year and nice pulses using a novel calibration system were recorded already at the provisional counting room in March. Meanwhile the construction of a definitive Control House with an unique shape inspired upon the island Dancing-Dwarf traditions is reaching completion.

The 1st and 2nd level trigger systems have been already installed and commissioned as well as the whole computing system for the telescope control and DAQ. The installation of the FADC system is being completed after some on-place tests and measurements with the whole readout chain have already been performed. Integration of all subsystems into a central control is under way. We shall be able to record Cherenkov flashes during May-June 2003 with more than 100 m^2 reflector area and start doing calibration runs to characterize the whole telescope. The present commissioning phase is expected to finish during summer 2003 and source observation will start immediately after.

5. Summary

MAGIC, the very large new-generation IACT designed specifically for the exploration of the 10-300 GeV gamma energy gap is in its final commissioning phase and it is expected to start observations during this summer.

So far all the new technical components function as designed and therefore we are optimistic about the instrument performance, which is being extensively and intensively checked now. If the telescope behaves as expected in this new energy domain and the physics is as everything seems to point out, an exciting plethora of discoveries and new measurements is just around the corner . . .

6. References

1. Barrio J.A. et al. "The MAGIC Telescope Design report" 1998, MPI Institute Report MPI-PhE/98-5 (March 1998).
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3. Martinez M. et al. "The MAGIC Telescope project". OG 4.3.08. Proceedings of the 26th ICRC. Salt Lake City. Utah. August 1999.