The MAGIC Telescope - prospects for GRB research

D. Petry

Institut de Física d’Altes Energies, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain
e-mail: petry@ifae.es

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Abstract. The Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) Telescope collaboration is constructing a large Cherenkov telescope (17 m diameter) for the exploration of the gamma-ray energy regime above 10 GeV with high sensitivity. One of the highlights in the science program of this future observatory are the plans for fast follow-up observations of of GRBs. By “fast” we mean delays of less than 30 s between notification and the beginning of observations. The expected gamma counting rates are of the order of 100 Hz for a EGRET counting rate of 0.1 Hz above 100 MeV and a spectral index of 2.0 (this would correspond to a fluence of $10^{-5}$ erg cm$^{-2}$ for 60 s burst duration).

The good photon statistics will permit determination of spectra, search for cutoffs and measurement of light-curves with a time resolution of the order of 1 s.

Key words: gamma-rays: bursts — gamma-rays: observations

1. Introduction

The Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) Telescope will be a large imaging air Cherenkov telescope for ground-based $\gamma$-ray observations above 10 GeV. Details of its design, the scientific motivation, the feasibility of the project, and other issues have been described elsewhere (Barrio et al. 1998). The telescope is expected to become operational by the middle of 2001.

The telescope is optimised to achieve the lowest energy threshold and highest flux sensitivity achievable with present technology. This makes it applicable to a large range of astrophysical research fields:

- Blazars (study of EGRET blazars, possible discovery of additional sources).
- Cosmology (measurements of the near-infrared background via $\gamma$-$\gamma$ absorption).
- Investigation of the pulsed $\gamma$-ray emission from pulsars.
- Search for gamma-emission from Supernova remnants.
  (and hence search for evidence of production and acceleration of cosmic rays).
- Search for decay/annihilation line-emission from WIMPs clustering at the galactic centre.
- Identification of “unidentified EGRET sources” (position accuracy $\approx 1.2$ arcmin).
- Search for high-energy counterparts of gamma-ray bursts.

The last part of this scientific program will briefly be discussed in this article.

2. Fast follow-up observations

In order to make fast follow-up observations of GRBs possible, the MAGIC Telescope will have an interface (probably a socket connection) to the GRB Coordinate Network GCN (Barthelmy et al. 1994 and these proceedings) and a secondary ground station for direct communication with HETE II (Ricker et al., these proceedings). HETE II is a dedicated GRB research satellite which is expected to be launched in 2000. It will provide approx. 30 burst positions per year with accuracies better than 10 arcmin. These notifications are expected to arrive with a delay of less than 5 s. The MAGIC Telescope is specially designed to have...
The expected performance in terms of sensitivity is summarised in Fig. 1. This is the performance we expect for the second phase of the project in which high quantum efficiency hybrid photo sensors will replace the photo-multipliers of the telescope’s camera. In the first phase our threshold will be $\approx 30$ GeV, in the second phase $10$ GeV. It is not yet clear how soon the second phase will follow after the first. The sensitivity at energies $> 30$ GeV is to a good approximation independent of these changes.

Given the diverse shape of GRB light-curves it is difficult to predict an average counting rate for gamma-rays in successful burst observations. We note instead that the MAGIC Telescope will have an effective collection area for primary gamma photons of $10^8$ cm$^2$ at the threshold rising to $10^9$ cm$^2$ at 100 GeV. For a hypothetical counting rate of $0.1$ Hz for EGRET above $100$ MeV, we expect (assuming a spectral index of $2.0$) a counting rate of $\approx 100$ Hz above $10$ GeV. A rate of $\approx 6$ Hz for 30 s will suffice for a $5 \sigma$ detection with a moderate background rejection applied. For strong bursts such as GRB 930131, gamma counting rates of the order of $1$ kHz may occur. The data acquisition will therefore be prepared to sustain such rates without additional dead-time.

4. Conclusions

The MAGIC Telescope will be able to make a major contribution to GRB research by providing high sensitivity measurements in the (for GRBs) essentially unexplored regime above $10$ GeV. The high counting rates in strong bursts will also permit to study the shape of the light-curve in more detail than previously possible (time resolutions of the order of 1 s). Search for small delays with respect to the low energy emission is thus possible. As an interesting side-result this may provide one of the best possible lower limits to the quantum gravity energy scale as pointed out by Amelino-Camelia et al. (1998).

References

Amelino-Camelia G., et al., 1998, Nat 393, 763