Observation of Gamma Ray Bursts with the MAGIC Telescope

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I. INTRODUCTION

Gamma Ray Bursts (GRB) are the most energetic phenomena in the universe discovered up to date and outshine the entire universe in keV to MeV energies during periods of milliseconds to several hundreds of seconds. Since their discovery, lots of effort has been put into catching signatures at other wavelengths leading to the successful and now standard detection of GRB afterglows over a wide range of frequencies from X-rays down to the radio. On the other side of the spectrum, the satellite-born γ-ray detector EGRET[1] has detected several GRBs up to energies of GeV. Depite of many of these successful efforts, the nature of GRBs is still unknown and the gamma-ray emission mechanisms under investigation.
The 17 m diameter Air Cherenkov Telescope MAGIC[2], currently under commissioning at La Palma, will explore the 30 GeV – 300 GeV energy range of incident gamma rays with a sensitivity two orders of magnitude better than EGRET. A relatively light telescope mount construction consisting of carbon fiber tubes allows for fast rotation. In the case of GRBs, repositioning will be possible in less than 30 seconds after alert[3]. This will permit to observe about 20% of all bursts directly, assuming GRB alert time delays of about 10 seconds, as proposed by the SWIFT collaboration[4].

II. ALERTS FROM THE GRB SATELLITES

In 2003, direct links to the HETE-II satellite as well as the INTEGRAL satellite provide GRB alerts in reasonable time to start immediate follow-up observations with the MAGIC telescope. Expecting a duty cycle of about 10% and extrapolating BATSE spectra to the energy range of interest, we expect to be sensitive to about 1/100 of all burst at 5σ[5].. Assuming SSC or hadronic gamma-ray production mechanisms in the burst, this number should increase considerably. In the entire year 2002, MAGIC, if it had been operational already, would have been able to respond to 7 GRB alerts by HETE-II. The time delays of these alerts, however, range from 15 seconds to several hours. For INTEGRAL, less information is available up to date since only 4 bursts have been announced until the end of March 2003 and none of them would have been observable by MAGIC. In total, we expect to receive alerts for about 7-8 bursts in the MAGIC field of view during observation. This number should increase significantly from 2004 on, once the SWIFT satellite is launched providing us with twice the number of alerts.

III. SENSITITY TO HE-GAMMA PREDICTIONS

Current GRB models and their implications on the gamma-ray observability with MAGIC were studied. According to the fireball model[6], MAGIC could detect about 1/100 of all observed bursts at 5σ taking into account only electron synchrotron emission. Possible Inverse Compton[7] or gamma rays from π^0-decay[8] can increase the number of detected

bursts by about an order of magnitude. In the case of the Cannonball model[9], enormous fluxes during a very short period of time are expected, to trigger detection rates of 1 MHz. MAGIC is prepared for such high fluxes due to the installation of a high-frequency trigger capable of counting the number of hit photomultipliers in the camera at these rates. The limitation comes rather from the fact that fast spikes in the time structure are predicted and the telescope needs to turn fast not only into an ongoing burst, but rather into the beginning of a new spike in the time structure. We expect this to be the case in less than 10% of the bursts requiring a very detailed analysis of the time structures afterwards.
The last investigated model is the Compton Drag Model[10], predicting no observable fluxes at all due to inner absorption of gamma rays by electron-positron pair production at high energies. Any signal of gamma rays in the GeV range would rule out this model.

IV. CONCLUSION

The MAGIC telescope has been built with a focus on high sensitivity at the lowest energy threshold possible and with a special eye on fast re-positioning. Both aspects will make it possible to test or rule out most of the current GRB models' high-energy gamma ray emission mechanisms after three years of SWIFT operation.

Referencias

[1] Hartman R.C. et al., The Astrophysical Journal Supplement Series, 123: 79-202 (1999)
[2] Barrio J.A. et al., "The MAGIC Telescope", Max-Planck-Institut Report MPI-PHE/98-5
[3] D. Petry, "The MAGIC Telescope - Prospects for GRB research", Astron. Astrophys. Suppl. Ser 138-601 (1999).
[4] http://swift.gsfc.nasa.gov/public/instruments/bat.html

[5] Galante N., Diploma Thesis, Univ. de Padua, (2002)
[6] Meszaros P., Rees M., Astrophys. J. 418 L59 (1993)
[7] Zhang B., Meszaros P., Astrophys. J. 559 110 (2001)
[8] F. De Paolis, G. Ingrosso, D. Orlando, Astron. Astrophys. 359 (2000) 514
[9] A. Dar, A. De Rújula, CERN-TH/01-121, astro-ph/0105094
[10] G. Ghisellini, D. Lazzati, A. Celotti, M. Rees, accepted for publication in ApJ Letters, (1999)