# An AGN Observation Catalogue For The MAGIC Cherenkov Telescope

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## Abstract

The 17m diameter MAGIC telescope will become operational in mid-2003. Active Galactic Nuclei (AGN) known to be $TeV$ $\gamma$–ray emitters will be observed by the telescope in its initial phase. But, due to the high sensitivity measuring fluxes and low Energy Threshold, MAGIC will be able to observe very high redshifted AGNs which have remained undetected by the present Cherenkov Telescopes. The EGRET AGNs and Constamante-Ghisellini $TeV$ BL Lacs candidates are taken as a reference to perform a study of source observability by evaluating their fluxes at the MAGIC energy detection range.

## 1. Introduction

The $\gamma$–ray emission by a subclass of AGNs, namely by BL Lac objects, has been established by the present ground-based Čerenkov Detectors, for energies above 250 $GeV$. Because of the steeply falling energy spectra, satellite experiments are limited to an energy detection range of up to $E_\gamma < 10\ GeV$, which implies a lack of measurements above this energy, although very recently a few measurements have been performed down to 50 $GeV$[1]. Due to its low energy threshold $\sim 30\ GeV$ and high sensitivity of $\sim 10^{-11} cm^2 s^{-1}$ at 30 $GeV$, at least 50 new sources at this yet unexplored energy range are expected to be detected by the novel MAGIC telescope[2], with redshifts extending up to $z \sim 2$.

Here we present possible candidates for an AGN observation campaign and an AGN population study. This comprises the revisiting of already known $\gamma$–ray sources as well as a systematic search for new sources. Scientific goals are the investigation of the inherent properties of AGNs, studies of the diffuse extragalactic background light (EBL), study of the cosmic gamma ray horizon (GRH), Quantum Gravity effects[3] and Cosmological Measurements[4]. The expected increase in statistics will allow to perform these studies with a high degree of accuracy.

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**Table 1.** Data for BL Lac objects observed in the $TeV$ band ([6] and references therein)

| Source | Redshift $z$ | Integrated flux $F(E > E_{thr}$ $[cm^{-2}s^{-1}]$ | $E_{thr}$ [TeV] | Significance |
|---|---|---|---|---|
| Mkn 421 | 0.031 | $(1-80)\cdot 10^{-11}$ | 0.3 | confirmed |
| 1ES 1426+428 | 0.129 | $0.9\cdot 10^{-11}$ | 0.4 | confirmed |
| Mkn 501 | 0.034 | $(0.8-49)\cdot 10^{-11}$ | 0.3 | confirmed |
| 1ES 1959+650 | 0.047 | - | - | confirmed |
| PKS 2155-304 | 0.116 | $4.2\cdot 10^{-11}$ | 0.3 | $6.8\sigma$ |
| 1ES 2344+514 | 0.044 | $1.7\cdot 10^{-11}$ | 0.35 | $5.2\sigma$ |

## 2. Candidate sources for AGN search

For the first observations, priority will be given to the investigation of the well-established $\gamma$–ray sources listed in Tab.1. which will allow to cross-check measurements with other experiments.

Apart from these few $\gamma$–ray sources detected by Čerenkov Telescopes, in order to draw a suitable observational AGN program for the MAGIC telescope we can basically follow two different approaches: one starting from the present phenomenology and another relying on some theoretical $\gamma$–ray models applied to some selected BL Lacs.

In the first case, we start from the third EGRET catalogue[5], which gives us the most complete and recent experimental situation for extragalactic sources at the highest satellite energies (from 100 $MeV$ up to 10 $GeV$). A suitable set of blazar candidates can be obtained by extrapolating the EGRET blazars fitted spectra (averaged spectra over the whole EGRET lifetime) to the MAGIC energy detection range. The $\gamma$–ray absorption due to pair production by the EBL has been taken into account[7]. Moreover, the blazar spectra at high energies have also been interpreted in the frame of leptonic SSC emission models, applying a moderate value of 50 $GeV$ for Inverse Compton spectral break. New recent blazar identifications in the Northern Sky with EGRET detections are also included[8]. Table 2. shows the fluxes of the brightest EGRET blazars. Note that source $3EGJ1605+1553$ has two possible blazar identifications, one performed by the EGRET group and a recent one made by Sowards et al.

On a more theoretical side, let us refer to the Costamante & Ghisellini (CG) $TeV$ BL Lac candidates catalogue ([9] and references therein). This catalogue comes from the combination of two ingredients: one is the phenomenological analysis of the SED in a wide frequency range from radio to hard X-rays, and the second is a theoretical model based on a one-zone SSC $\gamma$–emission model. The optimal condition to be a good $TeV$ *emitter* takes into account the radio-optical luminosity and a catalogue is produced and fluxes are predicted. The effect of the EBL absorption was not taken into account in the CG flux predictions and it

**Table 2.** EGRET candidates observable from La Palma with predi cted fluxes (in $cm^{-2}s^{-1}$ above an Energy Threshold ($E_{Thr}$ in GeV; $F'$ the integral flux after consi dering EBL absorption; $F''$ includes also the effect of a SSC cut–off at 50 GeV). Comments given for some sources: CG = also Constamante–Ghisellini BL Lac candidate, C = Confirmed $\gamma$–ray source by IACTs, D = Detected $\gamma$–ray source by one telescope, SOW = Sowards et al.[8] new blazar Id. a nd ? = Possible blazar Id. by EGRET.

| | Source Name | z | $E_{Thr}$ | $F'(E > E_{Thr})$ | $F''(E > E_{Thr})$ | Comments |
|---|---|---|---|---|---|---|
| winter | | | | | | |
| | 3EG J0852-1216 | 0.566 | 53 | 6.25E-10 | 4.06E-10 | |
| OJ+287 | 3EG J0853+1941 | 0.306 | 31 | 1.58E-10 | 1.44E-10 | CG |
| | 3EG J0958+6533 | 0.368 | 47 | 4.80E-11 | 4.18E-11 | |
| spring | | | | | | |
| Mrk 421 | 3EG J1104+3809 | 0.031 | 31 | 3.05E-09 | 1.87E-09 | C |
| 3C 279 | 3EG J1255-0549 | 0.538 | 44 | 9.26E-10 | 7.75E-10 | |
| W Comae | 3EG J1222+2841 | 0.102 | 30 | 1.15E-09 | 8.73E-10 | D |
| | 3EG J1009+4855 | 0.2 | 34 | 1.46E-10 | 1.23E-10 | ?,CG |
| 4C+29.45 | 3EG J1200+2847 | 0.729 | 30 | 1.58E-10 | 1.46E-10 | |
| summer | | | | | | |
| | 3EG J1605+1553 | 0.11 | 32 | 1.82E-10 | 1.61E-10 | SOW |
| 4C+15.54 | 3EG J1605+1553 | 0.357 | 32 | 1.55E-10 | 1.42E-10 | |
| | 3EG J2027+3429 | 0.22 | 30 | 1.36E-10 | 1.32E-10 | SOW |
| PKS 2155-304 | 3EG J2158-3023 | 0.116 | 114 | 9.33E-12 | 7.19E-12 | D |
| autumn | | | | | | |
| OD+160 | 3EG J0237+1635 | 0.94 | 31 | 5.92E-10 | 5.42E-10 | |
| CTA026 | 3EG J0340-0201 | 0.852 | 41 | 2.49E-10 | 1.92E-10 | |
| 3C 66A | 3EG J0222+4253 | 0.444 | 32 | 3.43E-10 | 3.10E-10 | D, CG |
| 3C454.3 | 3EG J2254+1601 | 0.859 | 32 | 2.53E-10 | 2.29E-10 | D |

will be taken into account in our near future analysis to perform a more reliable flux prediction of these sources at high energies.

Concerning the CG sources, one confirmation has recently come from the detection of 1ES 1959+650[10] by the Whipple telescope. This is a rather close BL Lac ($z = 0.047$). However, it is not a very highly peaked one and indeed it was also predicted by a simpler SSC Stecker-de Jager-Salomon emission model[11], so it does not strongly discriminate the CG criterion. However, the position of the synchrotron peak and its relation with the gamma-loudness and spectrum is widely variable according to the flaring status of the source. Multi-wavelength observations will provide essential data both for the modeling of sources and for the determination of the cut-off energies due to intergalactic absorption.

## 3. Conclusions

Costamante & Ghisellini selected BL Lacs and blazars detected by the EGRET Telescope are taken into account to perform a catalogue of suitable AGNs to be observed with the MAGIC telescope. In case of EGRET blazars, the measured EGRET fluxes have been extrapolated to the MAGIC energy detection range by applying the $\gamma$–absorption of the radiation by the extragalactic infrared background as well as an intrinsic SSC spectral break at around 50 $GeV$. In case of Costamante & Ghisellini sources, the absorption by the EBL is necessary for our purposes and will be applied to the already published fluxes.

Moreover, the AGNs show really high flux variation in short-time scales. In this case the fluxes would be higher or lower than evaluated. So, it will also be investigated the possibility of selecting candidate sources depending on its flaring state, giving priority for those sources which show huge flux variations at other wavelengths (e.g. X-ray) at the time of MAGIC observations. We aim at creating a "self adapting" catalogue whose input is the state of the AGN at different wavelenghts (e.g. X-ray with ASM or $\gamma$–ray with GLAST) and whose output is the predicted detection time at MAGIC.

At the ICRC Conference, the expected fluxes and flaring state studies for all these sources will be presented. Observation times to detect the sources with the MAGIC telescope with $5\sigma$ significance will also be evaluated and the resulting prime candidates for MAGIC observations will be showed.

## 4. References

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