A figure of merit for blazar-like source identification in the gamma-ray energy band

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Abstract. We take into account the constraints from the observed extragalactic gamma-ray background to estimate the maximum duty cycle allowed for a selected sample of LBL blazars, in order to be detectable by AGILE and GLAST gamma-ray experiments. For the nominal sensitivity values of both instruments, we identify a subset of sources which can in principle always be detectable without over-predicting the extragalactic background. This work is based on the results of a recently derived blazar radio LogN-LogS obtained by combining several multi-frequency surveys. The microwave to gamma-ray slope can be used as a viable figure of merit for blazar-like source identification. Taking into account the constraints from the observed extragalactic gamma-ray background, one can estimate the maximum duty cycle allowed for the observed source based on the results of a recently derived blazar radio LogN-LogS obtained by combining several multi-frequency surveys. This provides an indicator for the goodness of the identification.

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INTRODUCTION

Blazars are the rarest ($\sim 5\%$) and most extreme type of Active Galactive Nuclei (AGN) known. All sources of this type can be seen as part of a general paradigm in which AGN are divided into Thermal Emission Dominated (TED) AGN, where the emitted radiation is mostly generated through the accretion process onto a super-massive black hole, and Non-Thermal Emission Dominated (NTED) AGN, where the observed emission is mostly non-thermal and is generated in a jet of material moving away from the nucleus at relativistic speeds [e.g. 1]. Within this framework blazars are the small subset of NTED AGN in which the jet is closely aligned to the line of sight causing their emission to be strongly amplified by relativistic effects [as originally proposed by 2].

We recognize a source as a blazar if it shows the properties usually associated to aligned beamed emission such as strong and rapidly variable emission in all energy bands, from radio to GeV, sometimes TeV energies, core dominated radio emission with flat radio spectral index, superluminal motion of radio compact regions, the presence of one sided jets (a jet on the other side is thought to exist, but with emission that is heavily dumped by relativistic effects) and high brightness temperatures ($T_b \sim 10^{11} - 10^{18} K$), close to or above the Compton limit ($T_b \approx 10^{12}$).

Despite the relatively low space density of Blazars, their strong emission across the entire electromagnetic spectrum makes them potential candidates as significant contributors to extragalactic Cosmic Backgrounds.Giommi et al. 2006 [3] have recently re-assesed the Blazar contribution to the microwave (CMB), X-ray (CXB), γ-ray (CGB) and TeV Cosmic backgrounds based on a new estimation of the Blazar radio LogN-LogS, assembled combining several radio and multi-frequency surveys. It was shown that Blazars add a non-thermal component to the overall Cosmic Background that at low frequencies contaminates the CMB fluctuation spectrum. At higher energies (E $>$100 MeV) the estimated Blazar collective emission over-predicts the extragalactic background by a large factor, thus implying that Blazars not only dominate the γ-ray sky but also that their average duty cycle at these frequencies must be rather low.

In this paper we analize a sample of WMAP detected Blazars and we estimate the maximum duty cycle allowed, taking into account the constraints from the observed extragalactic γ-ray background, in order to be detectable by AGILE and GLAST for the nominal sensitivity values of both instruments.

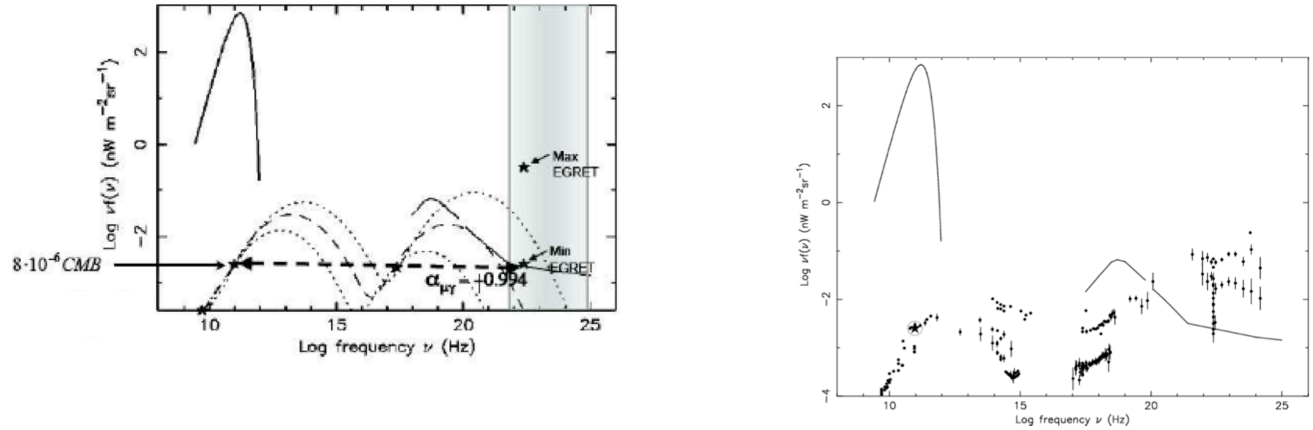

FIGURE 1. **Left** The possible contribution of LBL Blazars to the Hard X-ray soft γ-ray Background (shaded area). The three SSC curves corresponds to different ν_{peak} values (log $\nu_{peak} = 12.8, 13.5 and 13.8$), constrained as described in the text. **Right** The CMB, X-ray and γ-ray cosmic backgrounds with superimposed the SED of the Blazar 3C279 scaled as described in the text.

OBSERVATIONAL CONSTRAINTS

In ref.[3] the integrated Blazar intensity at microwave frequencies was computed by using their updated radio LogN-LogS and it was than extrapolated to the hard X-rays and soft γ-rays by using simple SSC models for the SEDs. Figure 1 shows the CMB, CXB and CGB observed levels, depicted as simple solid lines, together with three SEDs from a simple homogeneous SSC models. The SED parameters are constrained to: a) be consistent with the expected integrated flux at 94 GHz, b) have the $\alpha_{\mu x}$ slope equal to the mean value of the WMAP Blazars ($\alpha_{\mu x}$ = 1.07), c) possess a radio spectral slope equal to the average value of the WMAP microwave selected Blazars. The three curves, forced to pass through the three star symbols graphically representing the three constraints listed above, are characterized by three different synchrotron ν_{peak} values.

From Fig. 1 we see that a high value of ν_{peak} over-predicts by a large factor the observed hard-X-ray to soft γ-ray Cosmic Background, whereas a too low value of ν_{peak} predicts a negligible contribution. The case Log (ν_{peak}) = 13.5 Hz predicts 100% of the Hard-Xray/Soft γ-ray Cosmic Background. Since the Log (ν_{peak}) values of Blazars in the 1Jy-ARN survey and WMAP catalog peak near 13.5 and range from 12.8-13.7 within one sigma from the mean value, the data presently available indicate that Blazars may be responsible for a large fraction, possibly 100% of the Hard-Xray/Soft γ-ray Cosmic Background.

Blazars are the large majority of the extragalactic γ-ray (E> 100 MeV) identified sources detected by the EGRET experiment. In order to estimate Blazar contribution to the γ-ray Cosmic Backgrounds, one can analogously scale the full SED of EGRET detected LBL Blazars, such for example the bright 3C279, to the integrated Blazar flux intensity at CMB energies. In Fig. 1 we show the SED of the Blazar 3C279 scaled so that its flux at 94 GHz matches the cumulative emission of the entire Blazar population (encircled star symbol).

From the Fig. 1 one can see that while at X-ray frequencies the contribution to the CXB ranges from a few percent to over 10% in the higher states, the predicted flux at γ-ray frequencies ranges from about 100% to several times the observed Cosmic Background intensity. This large excess implies that either 3C279 is highly non representative of the class of Blazars, despite the contribution to the CXB is consistent with other estimates, or its duty cycle at γ-ray [eq. 2] frequencies is very low. The same approach can be followed with other Blazars detected at γ-ray frequencies. In all EGRET detected WMAP Blazars the SED of LBL Blazars over-predicts the CGB by a large factor.

We define a microwave to γ-ray slope as

$$\alpha_{\mu\gamma} = -\frac{Log(f_{94GHz}/f_{100MeV})}{Log(\nu_{94GHz}/\nu_{100MeV})} , \quad (1)$$

and a limiting value: $\alpha_{\mu\gamma_{100\%CGB}} = 0.994$ which is the value of an hypotetical source that would produce 100% of the

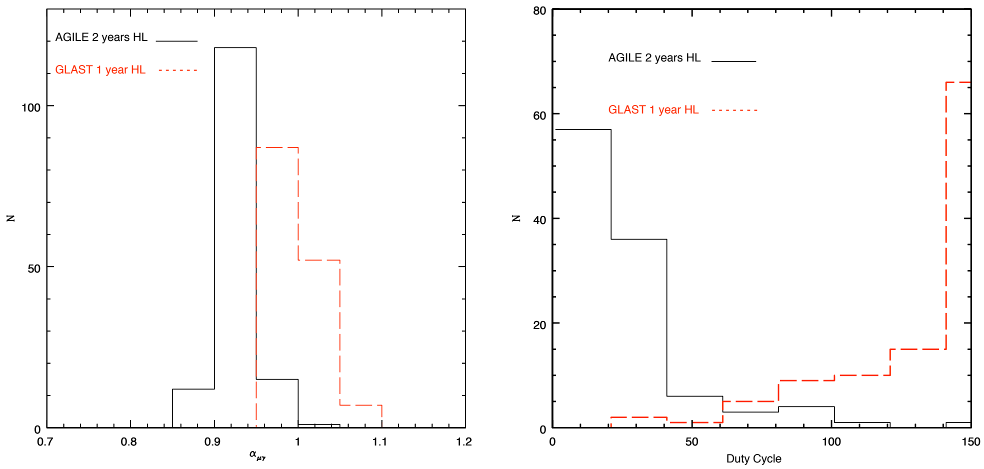

FIGURE 2. **Left** $\alpha_{\mu\gamma}$ histogram for the whole 2 years AGILE sensitivity and the 1 year GLAST sensitivity. $\alpha_{\mu\gamma} > 0.994$ corresponds to a duty cycle $> 100\%$ that is no background constraints on the observing capability. **Right** Duty cycle for the 146 LBL sources of our subsample. GLAST will have no background constraints in observing them.

CGB if representative of the class. Any source with $\alpha_{\mu\gamma} < 0.994$ should have a duty cycle lower than 100% in order not to overproduce the extragalactic diffuse γ-ray background. We define the duty cycle as

$$Duty\ Cycle = 10^{-11.41(0.994-\alpha_{\mu\gamma})}100\ , \tag{2}$$

where Log $(\nu_{94GHz}/\nu_{100MeV}) = 11.41$.

PRELIMINARY RESULTS ON A WMAP SELECTED SAMPLE

We selected a sample of blazars from the WMAP 3rd year bright source catalog, we estimated the maximum duty cycle allowed for the nominal sensitivity values AGILE and GLAST instruments and we identified a subset of sources which can in principle be detectable also in a steady state without over-predicting the background. We use the general "handy" sensitivity formula in [4]. We evaluated AGILE sensitivity at high latitude for the nominal lifetime of the mission: T = 2 yrs. GLAST high latitude sensitivity is evaluated for T = 1 yr.

The subsample we analysed is made of 146 LBL sources selected at high latitude $|b| > 30$ deg.

In Fig. 2 we show our preliminary results for all the 146 High Latitude sources in term of $\alpha_{\mu\gamma}$ and duty cycle. We note that GLAST in one year would be able to detect almost all High Latitude WMAP sources in the sample, also in a low-flux steady state with no background constraints. AGILE in two years would be able to detect a few High Latitude WMAP sources with no duty cycle constraints such as 3C279, 3C273 and all other sources in the sample with duty cycle greater than $\sim 20\%$. In particular we note that GLAST will not have any background constraints in observing the sources belongin to our subsample because their $\alpha_{\mu\gamma}$ and duty cycles are respectively greater than 0.994 and 100%.

We estimated also the $\alpha_{\mu\gamma}$ and duty cycle parameters for 73 Medium Latitude WMAP sources ($10 < |b| < 30$, l > 30) and results show a lower sensitivity consistent with the higher background at those latitudes: Medium Latitude sources are detectable if in a high state.

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