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AGILE observation of gamma-ray variability of the bright blazar 3C 273 during the MWL campaign of Dec 2007 - Jan 2008

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PoS(BLAZARS2008)054

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Eight years after the last EGRET observations in gamma-ray, the GRID (30 MeV - 50 GeV) and SuperAGILE (18 - 60 keV) experiments on board the AGILE mission observed the Virgo sky from December 16, 2007 and January 6, 2008. We organized a multi-wavelength campaign for the FSRQ 3C 273 with joint observations from the REM observatory (covering the near-IR and optical), Swift (near-UV and 0.2-10 keV). We report the preliminary results from the campaign. The first week the source was not detectable in Gamma Rays. Then we detected gamma-ray activity, with a flux comparable to the EGRET detection in June 1991. The hard x light curve show a decrease in flux of ~ 20% during the period of activity in Gamma-ray.

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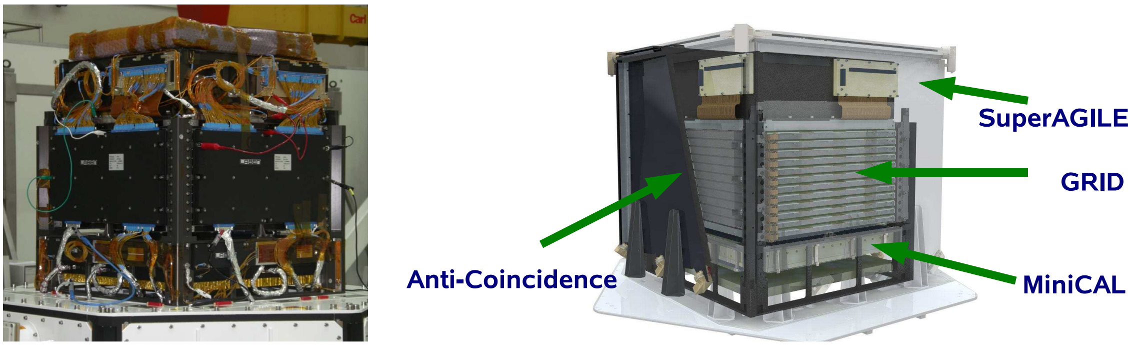
Figure 1: Left panel:The AGILE payload during the assembly, without the Anti-Coincidence system. Right Panel: Realistic drawn showing the payload without the interface electronics. The three detectors and the anti-coincidence system are indicated.



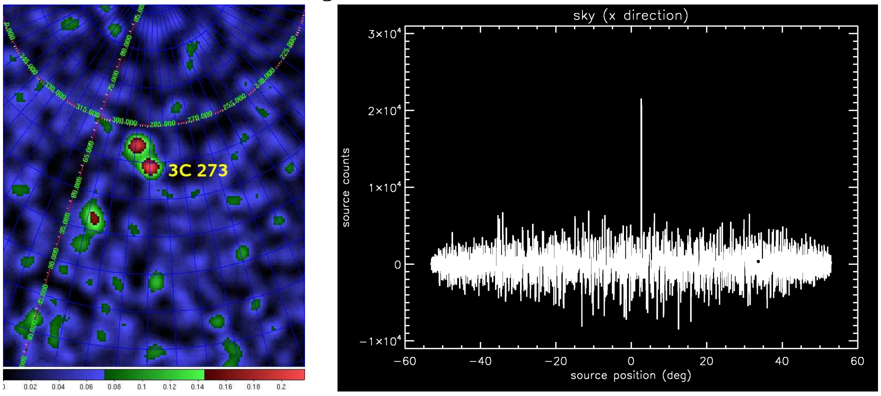
1. Introduction

The Flat Spectrum Radio Quasar 3C 273 (at a redshift of $z = 0.158$) is bright at all wavelengths and is a very peculiar AGN. It shows the jet-emission features of blazars [1], and both the big blue bump and the broad emission lines of Seyfert-galaxies. It is one of the most frequently observed active galactic nuclei, and it is continuously monitored in radio and optical.
This FSRQ was observed with EGRET several times, not always with a detection. It was detected in high flux activity in June 1991 [2], in October-November 1993 [3]. The source showed large Gamma-ray variability during a 7 weeks long EGRET observation (December 1996 - January 1997) [4]. In the same epoch, the source has been monitored in the near-IR (K band) with the UKIRT telescope on Hawaii, and in the 3-10 keV with RXTE/PCA [5], showing correlated variability (but with flux variation of 30-40%), and < 1 day lag of x-ray respect near-IR. The flares duration was similar for the two wavelengths. In another joint x-ray and near-IR campaign a lag of 1. days (of x-ray respect nIR) was found, the flare spanned for 2 days in the k-band and 4 days in x-rays [6].
A multiwavelength campaign has been organized during a period of low jet-emission state in June 2004 [7]. The observed sub-millimetre flux was almost half than the lowest state observed so far (campaign of march 1986).
AGILE pointed the Virgo region during the cycle 1 in December 2007 - January 2008. We organized a simultaneous multiwavelength campaign on the source.

2. The AGILE mission

The AGILE mission ([8]) is composed of three instruments and an anti-coincidence system. The image of the payload is shown in fig 1. The Gamma-Ray Imaging Detector (GRID) is a silicon tracker experiment, working in the energy range 30 MeV - 50 GeV, built with ten sensitive planes. Each sensitive plane is composed of a tungsten converter (of 0.07 radiation lengths) and two layers of Si-μstrip detectors, with strips orthogonally placed from a layer to the other. The field of view is 2.5 sr, the angular resolution 1.2 degrees (at 400 MeV), The on-axis effective area $\sim$500 cm^2 (at 100 MeV). A detailed description can be found in [9].
The Mini-Calorimeter ([10]) works in the 350 keV - 50 MeV energy range. It is composed of

Figure 2: Left panel: Sky Image of Virgo field in Gamma-ray obtained from GRID experiment aboard AGILE. Right Panel: One-dimensional sky image of Virgo field in Hard x obtained from SuperAGILE experiment aboard AGILE. Data were integrated from 2007-12-24 07:11:47 to 2007-12-30 23:03:06 UT.



30 CsI bars forming two layers of orthogonally placed crystals. The effective area is ~400 cm^2 (1-10 MeV). SuperAGILE ([11]) is the hard X monitor of the mission, operating in the 18 - 60 keV energy range, composed of four independent coded-mask instruments. Each instrument is equipped with a one-dimensional tungsten-made coded mask, and Si-μstrip detectors as sensitive plane. The sensitivity is 17 mCrab for on-axis sources, 50 ks exposed.

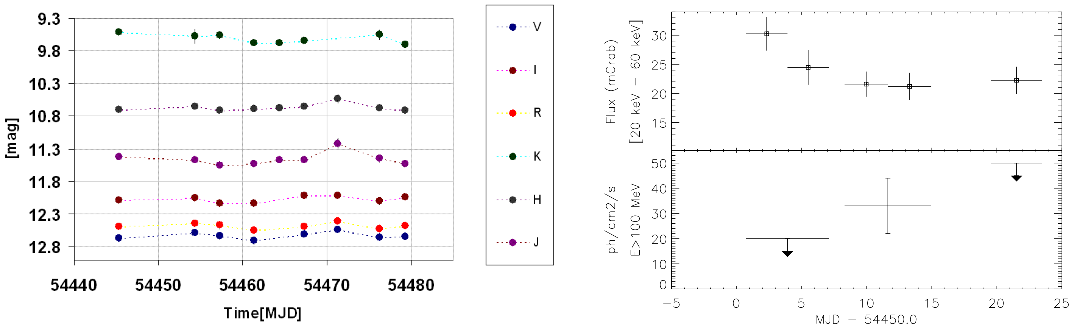
3. Observations

The Gamma rays band was observed with the GRID aboard AGILE. The satellite pointed the Virgo region for three weeks (from 2007-12-16 17:14 to 2008-01-08 11:06 UT) with two gaps in the observations (the first gap lasted one day, the second one lasted four days and an half). The gamma-ray image of the Virgo-field for the second week of the campaign is shown in the left panel of fig. 2. One of the one-dimensional hard x image of 3C 273 obtained with SuperAGILE is reported in the right panel of fig.2. The nIR and optical monitoring has been performed with the Rapid Eye Mount (REM) telescope [12]. REM is a 60 cm robotic-telescope, with two parallel cameras: REM-IR for nIR observations covering 0.95-2.3 μm range with 4 filters (z, J,H and K); ROSS (REM optical slitless Spectrograph) for optical observations covering the range 0.45- 0.95 μm (V,R,I filters). The observations had a monitoring period of 2/3 days during the AGILE pointing.
Swift pointed the source twice (the first time from 2008-01-04 16:11 to 2008-01-04 17:47 UT, the second one from 2008-01-06 11:57 to 2008-01-06 15:24). The observations with the UVOT [13] where performed with the V, B, U, UVW1, UVM2 and UVW2 filters. The first observation of the Swift/X-Ray Telescope (XRT, see [14] for details), covering the 0.2-10 keV range, have an exposure of 454 s in Windowed Timing (WT) mode and 2.5 ks in Photon Counting (PC) mode; the second lasted for a total exposure of 448 s in WT mode and 2.8 ks in Photon Counting (PC) mode. The analysis of Gamma-ray data from the GRID experiment has been performed with the *BUILD-15* of the AGILE Standard Pipeline. we reject the events collected during the passage in the south-Atlantic anomaly. A Kalman filtering technique is applied to the events to identify the tracks, and to reconstruct the direction and the energy of the incident Gamma-rays. The *good quality* Gamma-ray

Table 1: UVOT data for the multiwavelength campaign

date (aaaammdd)	MJD	filter	magn	energy flux (mJy)
20080106	54471.5	UVM2	11.16 ± 0.03	31.0 ± 0.9
20080104	54469.7	UVM2	11.17 ± 0.03	30.7 ± 0.9
20080106	54471.5	B	12.86 ± 0.02	33.2 ± 0.6
20080106	54471.5	V	12.67 ± 0.01	33.1 ± 0.3
20080104	54469.7	V	12.63 ± 0.01	34.4 ± 0.3

Figure 3: 3C 273 light curves in near-IR and optical (left panel), and in Hard X (top-right panel) and Gamma-ray (bottom-right panel).



events were selected from the Level-1 data to reduce the charged particle background. Then earth-albedo background was rejected, excluding the Gamma-ray coming from the earth limb. Maps were generated with a bin size of $0.3^0 \times 0.3^0$ for $E > 100\ MeV$. The last step is a likelihood based analysis (see [15] for details). Due to the continuous slewing of the satellite, the source moves in the field of view, but remained in the central region (within 10 degrees from the on-axis), thence the flux estimate is corrected using the on-axis calibration factor. In the second half of the observation, an unidentified source appeared at 5 degrees from 3C273, rather bright in the last days of the pointing. Thence the statistical uncertainties in the subtraction procedure reduced the signal to noise ratio for 3C 273 mainly for the third observing bin. The sky image from the 7 central days of the observation is shown in the left panel of figure 2. Three sources appear: 3C 273, the unidentified source, and 3C 279 (faint with $\sqrt{TS} = 2.9$).

4. Light Curves

The light curves over a 34 days monitoring for the K,H,J,I,R,V bands of the *REM* observatory are shown in the left panel of figure 3. The huge errors for some data point is due to the presence of the moon, causing errors in the photometry. Fluxes remained constant within 10 %.

UVOT data are reported in table 1.

The light curves for Hard X in the range $20 - 60\ keV$ from SuperAGILE are shown in the top-right panel of figure 3. The Gamma-ray light curve is reported in the bottom right panel of figure 3 and in table 2. Upper limits with 95 % confidence level are provided when the extracted flux is below

Table 2: 3C 273 flux measurements from the GRID experiment

energy range (MeV)	flux during week 1 ($10^{-8}\gamma/cm^2/s$)	$\sqrt{TS}$	flux during week 2 ($10^{-8}\gamma/cm^2/s$)	$\sqrt{TS}$	flux during week 3 ($10^{-8}\gamma/cm^2/s$)	$\sqrt{TS}$
> 100	< 20	1.4	33 ± 11	4.4	< 50	1.5

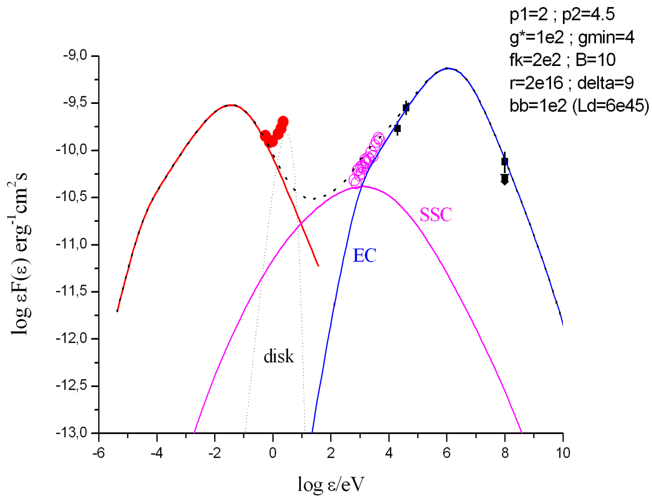


Figure 4: Spectral Energy Distribution for 3C 273 for the second week of observation. Both the lower (first week) and the high gamma activity flux (second week) are represented. The fitted model is reported.

$\sqrt{TS} < 3$ [15].

In the third gamma-ray light-curve the upper limit is rather high, being the source pointed four days only, and the unidentified source very bright.

Even if not statistically significative, the period of gamma activity corresponds to a flux reduction in the hard x.

5. A preliminary Spectral Energy Distribution

We report the preliminary SED for the second week of the observation, when the source showed gamma-ray activity. The resulting spectral energy distribution is reported in fig. 4; both the lower (during the first week of observation) and the higher gamma activity flux (during the second week of observation) are shown. The data are simultaneous except for the XRT taken during the last week of observation. We modelled the emission in the framework of the popular scenario of Synchrotron emission + Synchrotron Self Compton + External Compton (see [16], [17], [18]). In the figure, the lines represent the fit for the moderate gamma-ray activity period.

The multiwavelength campaign covers the synchrotron region with the near infrared photometry, the rise of the big blue bump with the optical photometry, and the inverse Compton region with the x and gamma observations.

The fluxes from the higher state period in gamma-ray are similar to the ones measured during the multiwavelength campaign performed in June 1991, when gamma-ray variability was not observed.

6. Discussion and Conclusions

Around 2007 December 16, 3C273 was in a high state in hard x-ray, with the 20-60 keV flux increased by a factor ~3 with respect to historical INTEGRAL observations. We observed the flux to vary of a factor 20-30% in this energy band during the campaign. The source varied intensity in gamma ray too, being 3C 273 not detected in the first week, but gamma-ray activity was detected in the second week.

Even if not compelling, the variability behaviour in hard X and gamma can be interpreted as a shift toward higher energy of the inverse-Compton region. A Shift of the peak of the inverse-Compton emission has been already suggested from year to year observations ([19]) of 3C 273 during the EGRET era. We are refining the analysis of gamma-ray data, in order to reduce the error on the flux, being the unidentified source the main contribution to the uncertainty on the flux evaluation. We are also analysing data from other observatories in Hard-X, to give statistical significance to the variability behaviour. The definitive results will be published in [20].

The observed variability in hard X and Gamma-ray was not observed at near-IR/optical wavelengths, the flux remaining almost constant during the campaign. We retain the optical flux to be dominated by thermal emission of disk and/or BLR, thence we don't expect to detect small Blazar variability at these wavelengths.

We remark the rather flat light curve in the near-IR. Turler et al. 2006 [7] reported the spectral energy distribution of the source during a period of jet-emission minimum , showing a similar near-IR flux, despite the flux in hard x was a factor 3 lower then in our campaign.

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PoS(BLAZARS2008)054

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