



I. Donnarumma on behalf of the AGILE Team

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7th AGILE workshop

I. Donnarumma

### Markarian 421 properties

> redshift z=0.0308

 It belongs to the High Energy Peaked BL Lac objects (Padovani & Giommi 1995)

 $\succ$  first extragalactic object detected at E > 500 GeV (IACTs; Punch et al. 1992)

> among the brightest BL Lac objects in the UV and X-ray energy bands

### The June 2008 flare: AGILE detection

*(Donnarumma et al. 2009, ApJ 691, L13)* AGILE detected Mrk 421 during a ToO on W Comae: 2008-06-09 -- 2008-06-15

SuperAGILE detected the source (24-hour average) with  $F(20-60 \text{ keV}) \sim 30 \text{ mCrab}$  (a factor of 5 greater than its average flux)

AGILE-GRID detected the source with  $\sqrt{TS} = 4.5$  integrating on all the period, F(E> 100 MeV) ~  $42 \cdot 10^{-8}$  ph cm<sup>-2</sup> s<sup>-1</sup> (Egret average flux ~ 13 x10<sup>-8</sup> ph cm<sup>-2</sup> s<sup>-1</sup>).

### Other observatories were looking at Mrk 421

The Collaborating Teams from Optical to TeV energies (12-decades of energy)

GASP-WEBT (R-band; May 24 to June 23)
SWIFT (UVOT & XRT; June 12-13)
AGILE (E > 100 MeV; June 9-15)
MAGIC and VERITAS (E> 400 GeV; May 27 - June 8)

complemented by publicly-available data from RossiXTE/ASM (2-12 keV) and Swift/BAT (15-50 keV).



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#### A few remarkable results from the multi-wavelength light curves

•The optical light curve shows variations of the order of 10% on a time scale of  $\sim$  few days, superimposed on a long decay during the entire period.

•Soft, hard X-ray and (likely) TeV emissions seem to be correlated; the optical emission correlates with the other energy bands on a short time scales (individual flares) and possibly anti-correlated on a longer one.

•Individual soft and hard X-ray peaks result in increased fluxes by a factor of  $\sim 2.5$ ,  $\sim 5$  respectively with growing peak-to-valley flare amplitudes on longer time scales.

•Evident spectral hardening of the source during the flaring activity. ...but the scenario was not complete:

TeV data were missing during the major

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### Mrk 421: The Spectral Energy Distribution

period 1: June 6 period 2: June 9 – 15

VHE in period 2: just a possible theoretical prediction



TABLE 1 SSC MODEL PARAMETERS. parameter period 1 period 2

parameter	period 1	period 2
$\gamma_b$	$3.6 \cdot 10^{5}$	$4.2 \cdot 10^{5}$
$\gamma_{max}$	$1.3 \cdot 10^{6}$	$1.3 \cdot 10^{6}$
$p_1$	2.22	2.1
$p_2$	4.5	5
B [G]	0.1	0.1
$K  [\mathrm{cm}^{-3}]$	$4 \cdot 10^{-4}$	$6\cdot 10^{-4}$
δ	20	20
θ[°]	2	2

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### The theoretical interpretation: one-zone SSC model

Variability my be caused by:

A) hardening/softening of the electron energy distribution function caused by particle acceleration
B) increase/decrease of the co-moving particle density as a consequence of additional particle injection/loss by shock processes

Our AGILE, MAGIC and VERITAS data seem to support the dominance of case A).

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### The Spectral Energy Distribution

*TeV data on period 2 would be the key to discriminate between the proposed scenarios:* 

• if TeV variations between period 1 and period 2 have a trend proportional to the X-ray one then particle acceleration dominates;

• Otherwise if a quadratic trend between X-ray and TeV should emerge then a charges injection into the blob plays a dominant role.

# Mrk 421:

## **ARGO-YBJ detection in June 2008**

Di Sciascio et al., arXiv:0907.2526v1

- ARGO-YBJ is a full coverage air shower detector located at Yangbajing Cosmic Ray Laboratory (Tibet):
- a large field of view (2 sr)
- high duty cycle allowing for the monitoring of VHE gamma-ray source (E>600 GeV)







## SED during period 2 with the ARGO spectrum



Multiwavelength observations of a TeV flare from W Comae: still June 2008 (Acciari et al. 2009, submitted to ApJ)

The Collaborating Teams:

> GASP (radio to optical monitoring)

Swift (UVOT & XRT)

> XMM/Newton

➤ AGILE (E > 100 MeV)

VERITAS (TeV energies)

### The multiwavelength light curve

- Swift (ToO on June 7-9)
- XMM (ToO on June 14-18)
- GASP (monitoring 14.5 GHz, 36.8 GHz, 43 GHz, R-optical band )
- AGILE (June 9-15)
- VERITAS (June 7-9)

#### Evidences:

strong X-ay variability in less than one day.
F(E> 200 GeV) x Crab (between June 7- 8),
2.5-3 times higher than the one detected in
March 2008
F(E> 100 MeV) = 90 x 10<sup>-8</sup> ph cm<sup>-2</sup> s<sup>-1</sup>
(3.7 sigma, June 12-13)



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TeV spectrum



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### W Comae SEDs: VERITAS flare and high X-ray state

in flaring state no one-zone SSC model was possible with the emission region being close to equipartition. AGILE-GRID UL put strict constraints on the SED modelling.



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### W Comae theoretical interpretation

The well constrained SED in the high state (in Xray and TeV energies) is successfully fitted by a leptonic SSC+EC model which provides magnetic field parameters close to equipartition: an EC radiation peaking at 1.5 x 10<sup>14</sup> Hz is requested (IR emission from a dusty torus).

### PG 1553+113:

### multi-frequency campaign March-April 2008

Mankuzhiyil et al., proc ICRC 2009

KVA, REM (optical)
 *Rossi*XTE/ASM (X-ray)
 AGILE (E> 100 MeV)
 MAGIC (TeV energies)

one zone SSC model



Time period	Energy	U.L. Flux [photons cm <sup>-2</sup> s <sup>-1</sup> ]
16-21 March	> 100 MeV	$56  imes 10^{-8}$
	> 200  MeV	$36 \times 10^{-8}$
10-30 April	> 100 MeV	$34 \times 10^{-8}$
	> 200  MeV	$21 \times 10^{-8}$



evidence for HE γ-rays variability

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### Conclusions

In the first 2 years in orbit, AGILE cooperated several times with observatories operating in the TeV energy range:VERITAS, MAGIC, ARGO-YBJ.

This sinergy gave rise to several multifrequency campaigns which provided us with simultaneous HE and VHE gamma-rays observations of blazars, allowing for a deep theoretical interpretation of the emission processes of the blazars.