The γ-ray flaring properties of the blazar 3C 454.3

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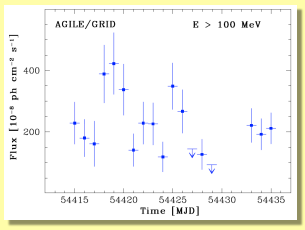
Abstract

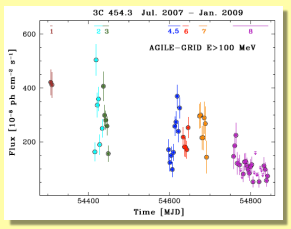
3C 454.3 is the most variable and intense extragalactic γ-ray blazar detected by AGILE and *Fermi* during the last 5 years. This remarkable source shows extreme flux variability (about a factor of 20) on a time-scale of 24-48 hours, as well as repeated flares on a time-scale of more than a year. The dynamic range, from the quiescence up to the most intense γ-ray super-flare, is of about two orders of magnitude. We discuss the γ-ray properties of 3C 454.3 by means of the available data, comparing both the characteristics of flares at different levels and their multi-λ behaviors. Moreover, an interpretation of both the long- and short-term properties of 3C 454.3 is reviewed, with particular emphasis on the two γ-ray super-flares observed in 2009 and 2010, when 3C 454.3 became the brightest source of the whole γ-ray sky.

Short- and long-term monitoring

AGILE detected intense γ-ray emission from 3C 454.3 since the beginning of the scientific mission, on July 2007, as reported in [1,2,3,4,5,6,7,8,9], covering γ-ray flares lasting from 1-2 days up to more than a week. Moreover, an 18-month long multi-wavelength monitoring of 3C 454.3 was presented in [4].



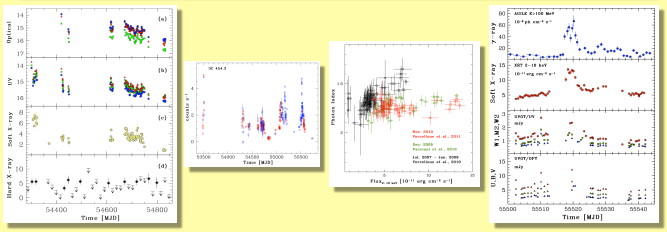
Example of a short-term monitoring of 3C 454.3 during the 2007 November campaign. From [2].



The AGILE long-term monitoring performed during the period 2007 July – 2009 January. From [4].

The X-ray and γ-ray connection

The extreme *Swift* scheduling flexibility allows us to obtain almost simultaneous observations from the optical to the γ-ray energy bands.

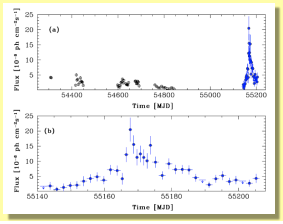


A simultaneous AGILE and *Swift* campaign was performed between 2007 and 2009 (left). From [4]. Accumulating all the XRT data, we obtained (right) one of the longest X-ray monitoring of a γ-ray Blazar, from 2005 to 2011 (blue=WT, red=PC).

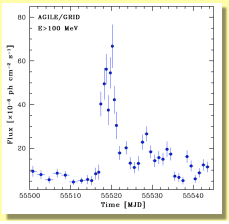
The correlation between the X-ray flux and Γ (left) vanishes during the extreme γ-ray flares because of a different balance between SSC and EC. From [9]. Multi-λ observations can reveal the presence of a *γ-ray orphan* UV-Optical flare (right). From [7].

The γ-ray superflares

3C 454.3 underwent the most intense γ-ray flares observed from a blazar. On 2009-12-02 it reached a peak flux (E>100 MeV) of about F_γ=(2.0±0.4)x10^{-5} ph cm^{-2} s^{-1} [5, 6], while on 2010-11-20 it reached F_γ=(6.8±1.0)x10^{-5} ph cm^{-2} s^{-1} [7]. These flares lasted a few days, after which the flux level remained high for weeks.



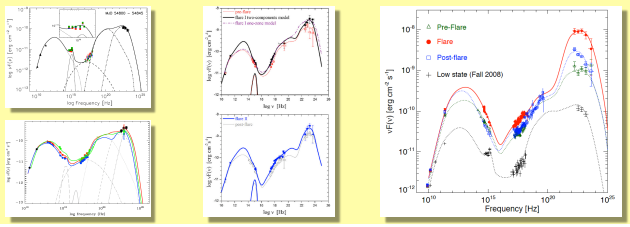
γ-ray light-curve during the Dec. 2009 super-flare. The flux remained above 0.5x10^{-5} ph cm^{-2} s^{-1} for about 2 weeks. From [5].



γ-ray light-curve during the Nov. 2010 super-flare. At the end of Oct. 2011, the flux dropped to less than 0.1x10^{-5} ph cm^{-2} s^{-1}. From [7].

The γ-ray emitting zone

Almost simultaneous and multi-wavelength observations allowed us to compute detailed SEDs at different γ-ray flux levels. The SED modeling, in conjunction with γ-ray variability analysis, put constraints on the size of the γ-ray emitting region, which we estimate to be within the BLR (see also [8]).



SEDs during low (top left, [4]), intermediate (bottom left, [3]) very high (center, [6]) and extreme (right, [7]) γ-ray flux levels. The traditional one-zone Synch+SSC+IC model is challenged during the most intense γ-ray flares (cfr. [6], [7], and [9]).

Conclusions

3C 454.3 (the *Crazy Diamond*) is, so far, the most variable and intense blazar in the γ-ray sky. Its dynamic range, from the quiescence up to the highest flux, is about two orders of magnitude. Moreover, during the brightest flares, flux variations are detectable down to a time-scale of 6 hours. These properties allowed us both to estimate the size of the γ-ray emitting region, and to establish the IC scattering of external photons from the BLR clouds off the relativistic electrons in the jet as the primary radiation mechanism in the AGILE energy band (0.05 < E[GeV] < 10).

References

[1] – Vercellone et al., 2008, ApJL, 676, 13. [2] – Vercellone et al., 2009, ApJ, 690, 1018. [3] – Donnarumma et al., 2009, ApJ, 707,1115. [4] – Vercellone et al., 2010, ApJ, 712, 405. [5] – Striani et al., 2010, ApJ, 718, 455. [6] – Pacciani et al., 2010, ApJL, 716, 170. [7] – Vercellone et al., 2011, ApJL, 736, L38. [8] – Anderhub et al., 2009, A&A, 498, 83. [9] – Vercellone, 2011, IJMP, in press.

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