A success story: 3C 454.3 in the γ-ray energy band

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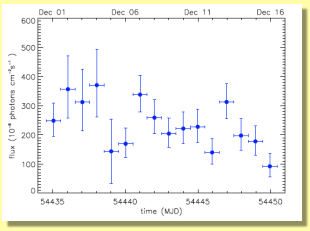
We review four years of observational properties of 3C 454.3, discussing both short- and long-term multi-wavelength campaigns.

Abstract

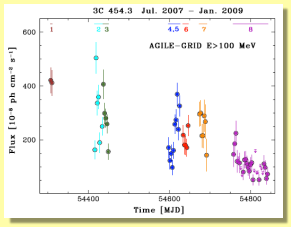
Since 2007, the blazar 3C 454.3 has become the most active and the brightest gamma-ray source of the sky, deserving the nickname of *Crazy Diamond*. The short-term variability in the gamma-ray energy band and the extremely high peak fluxes reached during intense flaring episodes make 3C 454.3 one of the best targets to investigate the blazar jet properties. We review almost four years of observational properties of this remarkable source, discussing both short- and long-term multi-wavelength campaigns, with particular emphasis on the recent flaring episode which occurred on 2010 November 20, when 3C 454.3 reached on a daily time-scale a gamma-ray flux (E>100 MeV) higher than 6×10^{-5} ph cm^{-2} s^{-1}, about six times the flux of the brightest gamma-ray steady source, the Vela Pulsar. .

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 [1,2,3,4,6], 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 [7].



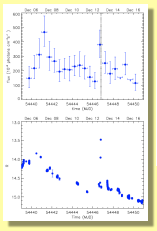
Example of a short-term monitoring of 3C 454.3 during the December 2007 campaign. From [3].



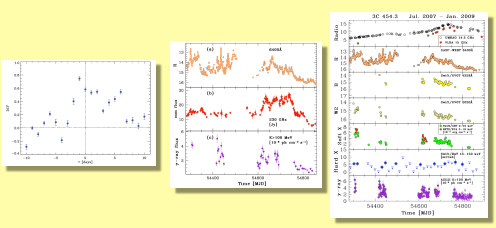
The AGILE long-term monitoring performed during the period July 2007 – January 2009. From [7].

The multi-wavelength domain

The extremely fast AGILE data processing and alert system (about 2.5 hours since the on-board data acquisition) allowed an almost simultaneous multi-wavelength coverage of 3C 454.3 flares, from the radio to the TeV energy band. The most relevant campaigns were presented in [2,3,5,6,7,8].



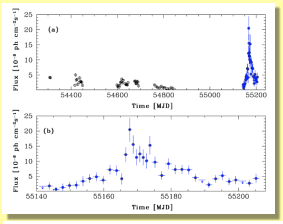
An extremely fast γ-ray and optical flare allowed to compute a ~0.5 day lag of the γ-ray flux w.r.t. the optical one. From [3].



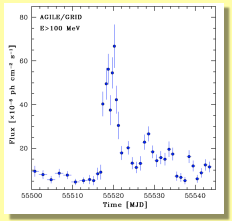
Radio to γ-ray coverage on a 18-month time-scale. mm-, R- and γ-ray bands shed light on the jet geometrical properties. From [7].

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 $F_\gamma=(2.0\pm0.4)\times10^{-5}$ ph cm^{-2} s^{-1} [4, 5], while on 2010-11-20 its flux reached $F_\gamma=(6.8\pm1.0)\times10^{-5}$ ph cm^{-2} s^{-1} [6]. These flares lasted a few days, after which the flux level remained high for weeks.



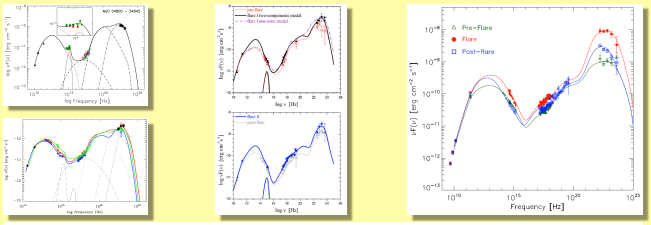
γ-ray light-curve during the Dec. 2009 super-flare. The flux remained above 0.5×10^{-5} ph cm^{-2} s^{-1} for about 2 weeks. From [4].



γ-ray light-curve during the Nov. 2010 super-flare. At the end of Apr. 2011, the flux dropped to less than 0.1×10^{-5} ph cm^{-2} s^{-1} . From [6].

The γ-ray emitting zone

Almost simultaneous and multi-wavelength observations allowed to compute detailed SEDs at different γ-ray flux levels. The modeling of the SEDs , 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 broad line region.



SEDs during low (top left, [7]), intermediate (bottom left, [3]) very high (center, [5]) and extreme (right, [6]) γ-ray flux levels. The traditional one-zone Synch+SSC+IC model is challenged during the most intense γ-ray flares.

Conclusions

3C 453.3 (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.

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] – Striani et al., 2010, ApJ, 718, 455. [5] – Pacciani et al., 2010, ApJL, 716, 170. [6] – Vercellone et al., 2011, ApJL, submitted. [7] – Vercellone et al., 2010, ApJ, 712, 405. [8] – Anderhub et al., 2009, A&A, 498, 83.