# The remarkable gamma-ray activity of the gravitationally lensed blazar PKS 1830-211

I. Donnarumma*, A. De Rosa, V. Vittorini, H. R. Miller, L. C. Popovic, E. Kuulkers, M. Tavani
and many others

* Affiliation: INAF/IASF Rome
E-mail address: immacolata.donnarumma@iasf-roma.inaf.it

We report the extraordinary γ-ray (E>100 MeV) activity of the gravitationally lensed blazar PKS 1830-211 (z=2.507) detected by AGILE between October and November 2010. The source experienced on October 14 a flux increase of a factor of ~12 with respect to its average value and kept brightest at this flux level for about 4 days. The 1-month gamma-ray light curve across the flare showed a mean flux F(E>100 MeV) ~200 $10^{-8}$ ph $cm^{-2}$ $s^{-1}$, which resulted in an enhancement by a factor of 4 with respect to the average value. Following the γ-ray flare, the source was observed in NIR-Optical energy bands at the Cerro Tololo Inter-American Observatory and in X-rays by Swift/XRT and INTEGRAL/IBIS. The main result of these multifrequency observations is that the large variability observed in γ-rays has not a significant counterpart at lower frequencies: variation not greater than a factor of 2.5 and 1.6 resulted in NIR and X-ray energy bands, respectively. We discuss the theoretical implications of our findings.

## The multiwavelength observations

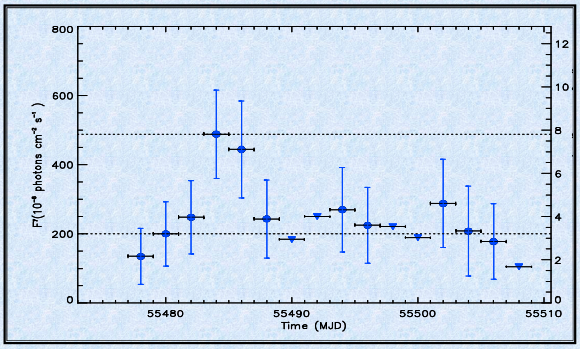


Fig. 1

Gamma-rays: the source experienced a 1-month enhancement by a factor of 4 (see bottom horizontal line in Fig. 1) with respect to the average flux (see Abdo et al. 2010); the 2-day binned AGILE light curve (Fig. 1) showed a maximum exceeding the average flux by a factor of 12, which lasted about 4 days.

Hard X-rays: during the gamma-ray flare INTEGRAL was monitoring the Galactic bulge region (since INTEGRAL ~ AO-3, Kuulkers et al. (2007) are observing this region regularly). The monitoring across the γ-ray flare did not allow for a detection of PKS 1830-211, obtaining an UL of 1.95 $10^{-11}$ erg $cm^{-2}$ $s^{-1}$ on 200 ksec integration time (October 14-18). It implied that variations greater than a factor of 1.5 in this energy band have to be excluded.

Soft X-rays: Swift/XRT pointed at PKS 1830-211 12 times, starting from 2010 October 15 up to 2010 October 27 (MJD 55484-55496). We fitted each spectrum with a continuum power-law absorbed both with a Galactic column density and an additional absorber located at a redshift z=0.886. The best fit values of the photon indexes as well as the flux in 0.3-10 keV are all consistent within 1-sigma given the large uncertainties. Our data analysis led to exclude variations greater than a factor of 1.6 with respect to the its average state (De Rosa et a. 2005).

NIR/Optical: Optical and infrared data were obtained using the 1.3m telescope at the Cerro Tololo Inter-American Observatory (CTIO) under the Small and ModerateAperture Research Telescope System (SMARTS) program. We obtained simultaneous data in NIR J-band and optical R-band using the ANDICAM instrument, taken between 2010 October 16 and 27 (MJD 55485-55496). The source was not detected in single images nor in the summed image. Nevertheless, thanks to the NIR upper limit we can exclude variation greater than a factor of 2.5 in both synchrotron + non thermal emission of this source.

## The SED modeling

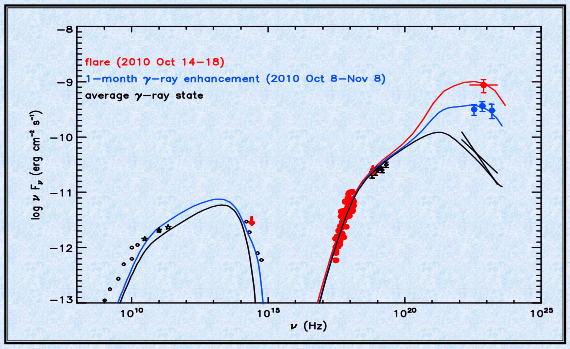


Fig. 2

The main results of our multifrequency campaign may be summarized as follows:

- the simultaneous NIR-optical, soft and hard X-ray emissions of this source did not follow the significant changes observed in γ-rays; the observed variations of the SED rule out the hypothesis that the γ-rays emission was connected to macrolensing, since its effects would be energy-independent.
- the chromaticism of the SED variability could suggest that microlensing from stars in the lensing galaxy may cause the observed gamma-ray variability (see e.g. Torres et al. 2003). We found that this option seems to be disfavored due to the longer time scale (compared with the observed variability) required for microlensing to affect the gamma-ray emission of this source.

Therefore, we ascribed the observed multifrequency variability to intrinsic variations occurred in the source and then we modeled three γ-ray states of the source:

- steady state (black points in Fig. 2)
- 1-month enhancement detected between October and November 2010 (blue points in Fig. 2)
- flare (2010 October 14-18, red point in Fig. 2).

We note that the multifrequency behavior of the source, i.e. the lack of correlated variability between the low (NIR-optical bands, X-rays) and high energy (γ -rays) portions of the SEDs, disfavors the one-zone leptonic model for this event. Therefore we assumed two relativistic electron populations:

- a 1st electron population is responsible of the average γ-ray state (black line in Fig.2)
- an additional electron population (a smaller size, higher electrons density and higher $\gamma_{break}$) is responsible for the 1-month enhancement (see red line in Fig. 2), i.e. it is produced by external Compton (EC) of the 2nd population on the photon density field while moving inside the Broad Line Region.
- the flare started at October 14 is still produced by EC of the second electron population on the BLR photon field, but a local increase of the seed photons is required (likely due to a blob-cloud interaction (see Araudo et al. 2010)).

## Conclusions

We underline that the γ-ray behavior of PKS 1830-211 recorded by AGILE and Fermi/LAT between October-November 2010 is rare as probed by the lack of similar variability since 2007. Similarly, no significant hard X-ray variability has been observed during the 7-year monitoring by INTEGRAL/IBIS. In conclusion, we can attribute these properties to those of "γ-ray only flaring" blazars. These evidences strongly support our interpretation of a ``steady" electron population, filling the jet below the BLR, that is responsible for the average γ -ray emission recorded by both EGRET and Fermi/LAT, more than ten years apart.

It is worth noticing that the inspection of the AGILE light curve on a longer period across the γ-ray flare did not show any evidence of the time delay between the emissions of the two lensed images A and B as measured in the radio maps (~ 26 days, Lovell et al. 1998). We can claim the lack of the delay between A and B only if the flux ratio of the 2 components is ~1. If it was lower than 1, we are prevented to draw any conclusion, because the emission would be occurred below the AGILE sensitivity level. See Donnarumma et al. 2011 for further details.

References

Abdo, A. A. et al. 2010, ApJS, 188, 405
Araudo, A. et al. 2010, A&A, 522, A97
De Rosa A. et al. 2005, A&A, 438, 121
Donnarumma et al. 2011, submitted to ApJL
Kuukers, E. et al. 2007, A&A, 465, 595
Lovell, J. E. J. et al. 1998, ApJ, 577, 78
Torres, D. F. et al. 2003, MNRAS, 339, 335