Multifrequency VLBI follow up study of a strong gamma-ray flare in the blazar 3C273

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Summary: Results of our VLBI follow up study of a strong gamma-ray flare in the blazar 3C273 support a close connection between gamma-ray and parsec-scale radio emission. Radio/gamma-ray delay as well as evolution of physical properties of the apparent parsec-scale jet base are discussed.

Abstract. We present results of a five month long VLBA observing campaign for 3C273 between 5 and 43 GHz. This campaign was triggered by and started immediately after a strong gamma-ray flare detected by Fermi LAT from the blazar in August 2009. We have detected a flare in the parsec-scale radio core of 3C273. Flux density of the core at 43 GHz increased by a factor of about 3 within several months while its radio spectrum became inverted. The observed radio flare at 43 GHz peaks with a delay of 30-60 days after the gamma-ray one. A close connection between gamma-ray and parsec-scale radio emission in the blazar is supported. We discuss changes in physical properties which occurred in the apparent jet base during the flare.

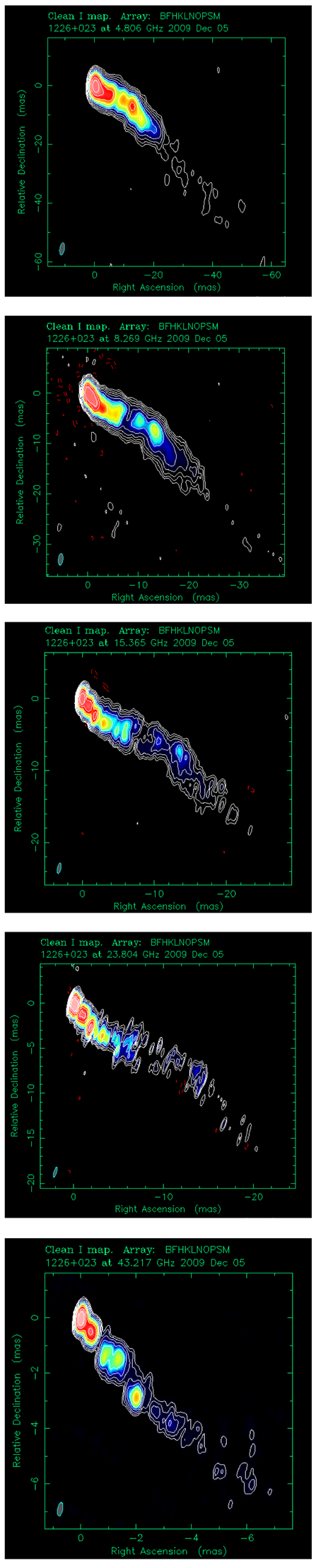

Fig.1
VLBI maps of 3C273 at 5, 8, 15, 24, 43 GHz (top to bottom)

Observations

A trigger to start our campaign occurred on 22 August 2009. We observed on VLBA simultaneously at 5, 8, 15, 24, 43 GHz with both circular polarizations. Observations were separated by interval of about 40 days and there were totally 4 epochs: 28 Aug 2009 (A), 25 Oct 2009 (B), 05 Dec 2009 (C) and 26 Jan 2010 (E).

Radio flare

Gamma-ray flare in the quasar 3C273 has peaked on 26 September 2009 (MJD 55100). We detected an increase of sub-parsec-scale VLBI core flux density on 43 GHz separated by 23 to 62 days from the gamma-ray peak. A delay between the gamma-ray flare and radio flare peaks appears to be 23 to 62 days with gamma-rays leading radio. This implies that even the very high frequency 43 GHz VLBA observations do not allow to directly detect the gamma-ray origin site but localizes it inside or in the vicinity of the core. Following Pushkarev, Kovalev, & Lister (2010), we explain this delay due to the synchrotron self absorption of radio emission in the jet base while it is transparent for gamma-rays which leave their origin site immediately. So the time delay is caused by the plasma perturbation reaching the $\tau=1$ jet zone. We estimated a distance between the gamma-ray and radio emission origin sites as $\Delta r = 4.5 – 11.6$ *pc.*

Spectral changes

Figure 3 shows spectra of 3C273 radio core between 15 and 43 GHz for every epoch. We used the highest frequencies of our observing VLBA campaign to construct this spectra in order to avoid considerable resolution mismatch. The evolution of radio flare is characterized by a classical change in spectrum from steep to inverted (spectral index from -0.45 to +0.50) and reflects changes in the synchrotron opacity of the apparent sub-parsec-scale core region from optically thin to thick. Opacity changes most probably are due to changes in physical conditions of the apparent jet base: an increase in the relativistic particles' density and/or magnetic field strength.

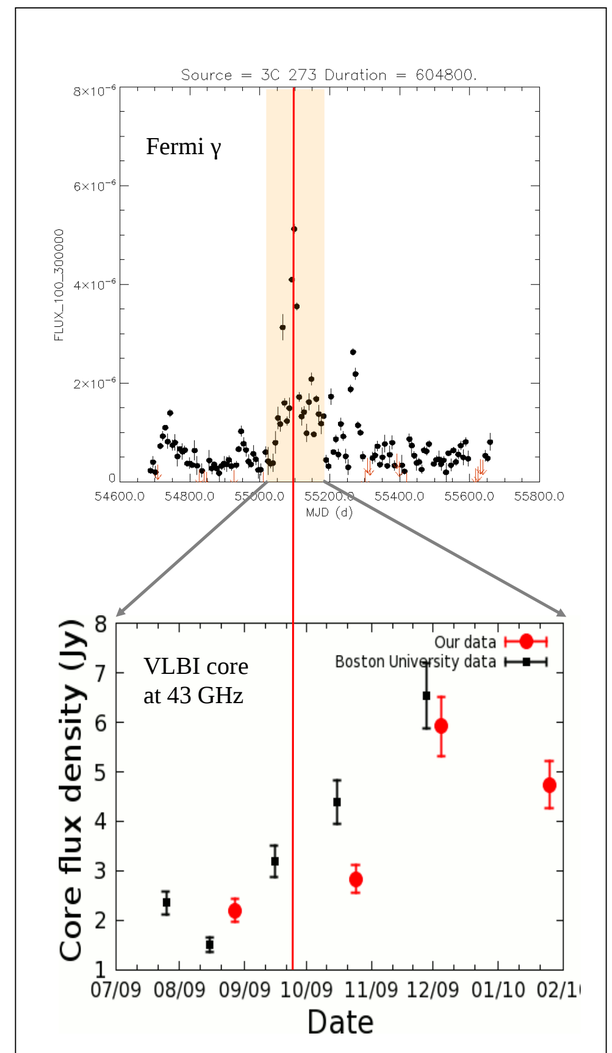

Fig. 2

Light curves of the quasar in gamma (Fermi LAT) and radio (VLBA, sub-parsec core, 43 GHz): this campaign VLBA data are combined with the Boston University program measurements. Red line marks the peak of the γ-ray flare. Shaded area shows the time interval covered by our observing campaign.

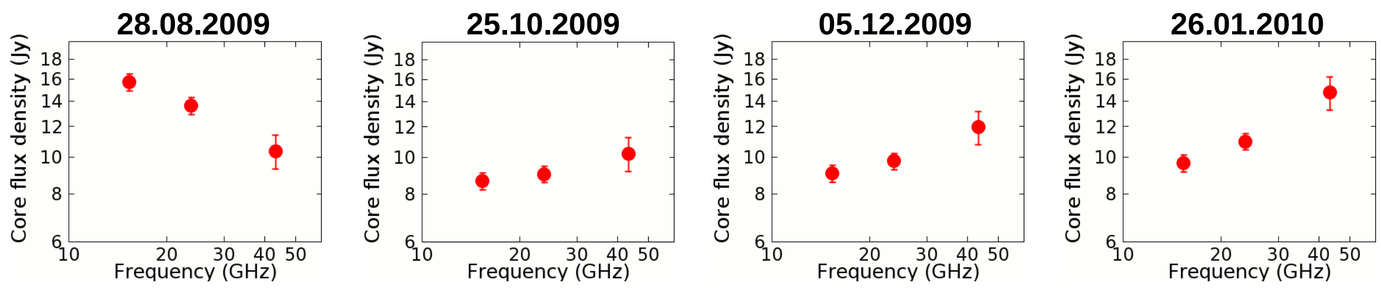

Fig. 3. Spectral evolution of 3C273 parsec-scale radio core

Conclusions

Analysis shows that synchrotron (radio) and Compton (gamma-ray) emission are tightly connected and have origin sites located in the sub-parsec region of the active galactic nucleus. In the future, we will include polarization, kinematics and SED-variability analysis in our study and search for new-born jet component which could be associated with this huge flare.

This project is part of the Fermi guest investigator Cycle 2 program 21087.

Success of this approach has led us to a one year long more intensive multi-band monitoring of two bright blazars, 3C273 and 3C279, – see the poster by Savolainen et al. at this symposium.

1. A.A. Abdo et al. 2009 ApJ, 700, 597
2. A.B. Pushkarev, Y.Y. Kovalev, M.L. Lister , 2010, arXiv:1006.1867v2
3. Fermi LAT Monitored Source List Light Curves http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/
4. Boston University blazar monitoring programme http://www.bu.edu/blazars/VLBAproject.html