An association of a *Fermi*/LAT flaring activity with a blazar candidate behind the LMC

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Introduction

We present a detailed study of *Fermi* Large Area Telescope (LAT) data of the newly identified blazar candidate J0545−6846 behind the Large Magellanic Cloud (LMC) and a possible association of *Fermi*/LAT flaring activity with this source. The flaring activity was noticed in November and December 2008 and its position was estimated using two models, i.e. the 2DG model and the HII map [1]. The former model gives R.A. = 86.°5083, decl. = −69.°0167, a 95% containment radius of 36′, and a detection significance level of 4.5σ (TS = 29.3). The latter one provides R.A. = 86.°5167, decl. = −69.°0167 within a radius of 29′, and 4.6σ detection significance (TS = 30.1). In [2] we found the BL Lac candidate J0545−6846 located at R.A. = 86.°47, decl. = −68.°77, which could cause the flaring activity visible in the *Fermi*/LAT data. The object is characterized by a remarkably high radio-loudness parameter, R = $F_{5\,\mathrm{GHz}}/F_B$ [3], of $R = 6900$, high radio flux density, 176.3 ± 7.4 mJy at 843 MHz, and low optical brightness in the I filter, reaching 21.27 mag. The redshift of J0545−6846 is still unknown.

Fermi/LAT Analysis

We perform an unbinned spectral and localization analysis of *Fermi*/LAT data in the time range of MJD 54777 – 54808 and energy range from 100 MeV to 300 GeV. We use the *Fermi* Science Tools (v11r5p3) together with the reprocessed Pass 8 data and the P8R3_SOURCE_V2 instrument response functions. The model used in the likelihood analysis contains all 78 point sources and four extended sources of the LMC region. Our localization analysis uses an iterative approach based on *gtfindsrc*. Starting from the optical coordinates of J0545−6846 we run *gtfindsrc* until the best-fit position varies by less than 0.°05. The known pulsar 4FGL J0540.3−6920 at a distance of 0.°18 does not show variability on the studied time range and is therefore fixed to the catalog value [4].

Results

We have identified γ-ray flaring activity at a significance level of TS = 33.85, visible in the *Fermi*/LAT test statistic (TS) maps presented in Fig. 1. The iterative localization analysis results in the best-fit position of R.A. = 85.°45, decl. = −69.°24 and an error circle of $\Delta r = 0.°72$. Only the pulsar 4FGL J0540.3−6920, referred to as P1, at the distance of $d_{\mathrm{P1}} = 0.°18$, and the blazar candidate J0545−6846 with the distance of $d_{\mathrm{blazar}} = 0.°59$, are consistent with this position. The left panel of Fig. 1 shows emission with P1 and J0545−6846 excluded in the *Fermi*/LAT model. P1 clearly dominates the emission, reaching TS∼140. In the middle panel, P1 is included in the model, while J0545−6846 is omitted. The map still exhibits a significant γ-ray emission with TS>25, suggesting an additional source not listed in the 4FGL catalog in this region. The right panel shows the TS map with both sources included in the *Fermi*/LAT model. No significant emission is detected at the best-fit position. This indicates that the observed emission might be associated with J0545−6846.

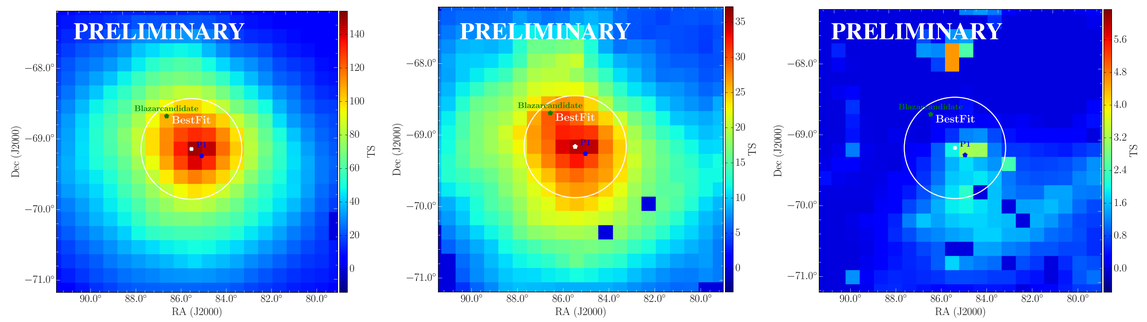

Figure 1: 6×6° *Fermi*/LAT TS maps of the flaring region (MJD 54777 – 54808). *Left panel:* Emission of P1 and the new γ-ray source is shown, with P1 clearly dominating the γ-ray activity. *Middle panel:* Significant emission of only the new γ-ray source is shown. *Right panel:* No additional emission not related to P1 or our new γ-ray source is shown. The deep blue pixels, that appear amongst the lighter blue colours, indicate bins with not enough statistics to perform a likelihood fit.

The long-term variability analysis (left panel of Fig. 2) uncovers only one single significant γ-ray flare of J0545−6846 above the *Fermi*/LAT detection threshold, which additionally confirms the flaring activity visible in the TS maps. This makes J0545−6846 one of the rarest γ-ray emitters monitored by *Fermi*/LAT. The broad-band spectral energy distribution (SED), which is built from archival, non-simultaneous data and the γ-ray spectrum during the flaring activity, shows a characteristic blazar-like double-hump structure, with the γ-ray emission peaking in the MeV regime (right panel of Fig. 2).

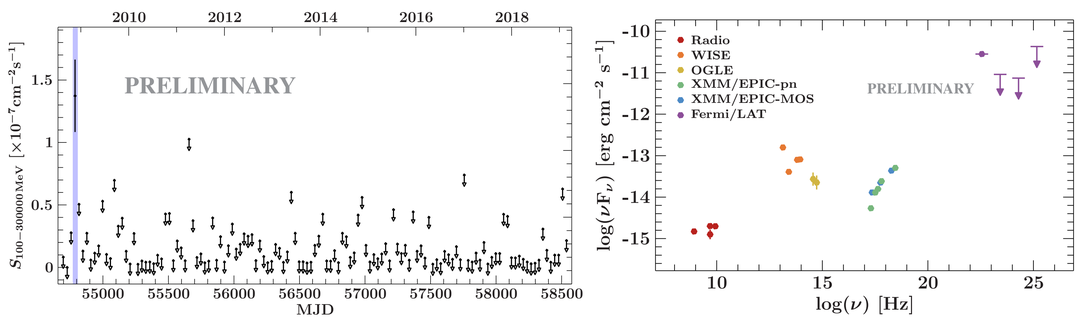

Figure 2: *Left panel:* Long-term monthly-binned *Fermi*-LAT LC. The shaded area indicates the time range of significant (TS > 25) emission. *Right panel:* Broad-band SED of J0545−6846.

Conclusions & Next Steps

We have investigated the origin and the possible association of the flaring γ-ray activity observed by Fermi/LAT in November–December 2008, with the blazar candidate J0545−6846. We have found that:

- Only J0545−6846 and 4FGL J0540.3−6920, already detected in γ-rays, coincide with the best-fit position, i.e. R.A. = 85.°45, decl. = −69.°24, and $\Delta r = 0.°72$, revealed in this study. No other counterpart for the γ-ray flaring emission in the vicinity was found so far.
- The optical location of J0545−6846 is 0.°59 away from the reconstructed γ-ray best-fit position.
- The observed γ-ray activity does not seem to be caused by the pulsar emission based on the likelihood *Fermi*/LAT data modeling.
- The X-ray photon index derived with a power law fit is consistent with typical values for both flat spectrum radio quasars (FSRQs) or low-frequency-peaked BL Lacs (LBLs) [5].
- The broad-band SED of J0545−6846 indicates a blazar-like double hump structure, which is characteristic of an FSRQ or an LBL.

We are checking the nearby sources to verify other possible associations with the γ-ray activity. A binned and composite likelihood analyzes are in preparation to establish the significance level of the observed emission.

As a next step, we plan to analyze in the same way the remaining 43 blazar candidates behind the LMC from [2].

References

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