Multiwavelength studies of the peculiar gamma-ray source 3EG J1835+5918

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Abstract. The source 3EG J1835+5918 was discovered early in the CGRO mission by EGRET as a bright unidentified γ-ray source outside the galactic plane. Especially remarkable, it has not been possible to identify this object with any known counterpart in any other wavelengths band since then. Analyzing our recent ROSAT HRI observation, for the first time we are able to suggest X-ray counterparts of 3EG J1835+5918. The discovered X-ray sources were subject of deep optical investigations in order to reveal their nature and conclude on the possibility of being counterparts for this peculiar γ-ray source.

GAMMA-RAY OBSERVATIONS

EGRET observations of the unidentified γ-ray source 3EG J1835+5918 above 100 MeV in CGRO observation cycles 1 to 4 are covered in the Third EGRET catalog [1]. Moreover, 3EG J1835+5918 has been reported as a GeV γ-ray emitter [2], [3]. In order to obtain the most comprehensive data base on 3EG J1835+5918, we expanded the analysis up to the most recent EGRET observations (CGRO cycle 7). Viewing periods with 3EG J1835+5918 in the field of view were examined separately at energies above 100 MeV and above 1 GeV. As reported earlier [4], 3EG J1835+5918 was only seen by EGRET at large off-axis angle early in the mission, resulting in the indication of flux variability. The most recent variability study of EGRET sources above 100 MeV [5] restricts the off-axis location of any γ-ray source to be within 25°. Considering only nine periods matching this criterion, 3EG J1835+5918 was found to be constant within statistics. In order to acknowledge this approach, we label observations with up to 25° off-axis location different than observations outside 25°, see fig.1. The flux of 3EG J1835+5918 during the observatins in cycle 7 (13-27 January 1998, aspect angle 5°) can be evaluated by

considering a similar on-axis observation of Geminga during 7-21 July 1998. If we assume that the EGRET sensitivity has not changed appreciably between these observations and that Geminga remains a stable emitter in γ-rays as previously observed, we can derive an normalization for the flux of 3EG J1835+5918 in cycle 7. Figure 1 shows the resulting flux history of 3EG J1835+59 above 100 MeV throughout the EGRET mission.

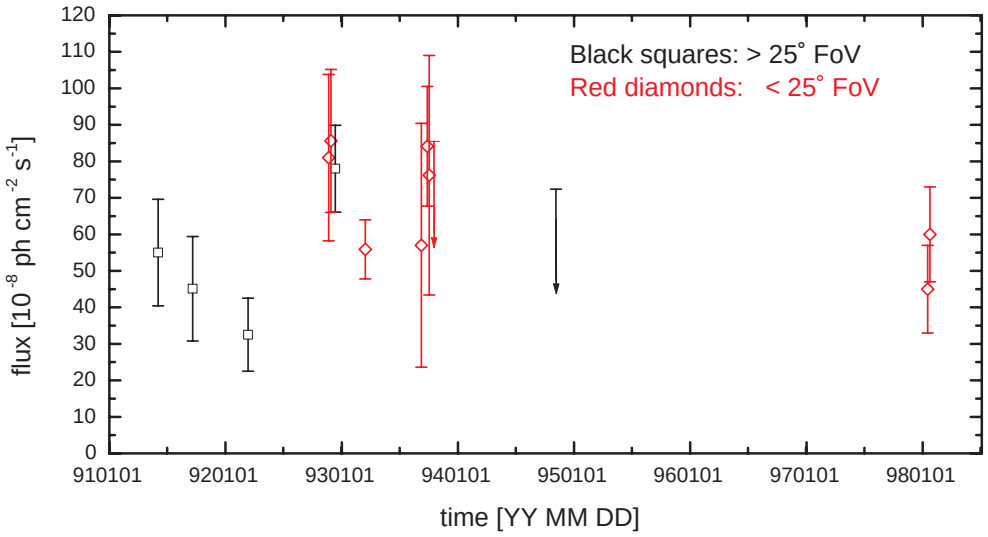

FIGURE 1. Flux history of EGRET observations on 3EG J1835+5918

The high-energy γ-ray spectrum is determined from EGRET observation of CGRO cycle 1 to 4. The power law spectral index is about -1.7 between 70 MeV and 4 GeV. Striking similarities to the γ-ray spectra of identified pulsars like Geminga and Vela can be seen in fig.2: the hard power law spectral index, a high-energy spectral cut-off or turnover and a low energy spectral softening.

The γ-ray source location is determined separately above 1 GeV using observations from cycle 1 to 7. Its precision (68% and 95% source location within a few arcminutes) allows us to cover the complete γ-ray error box with only one ROSAT HRI pointing. The γ-ray source confidence contours and the ROSAT HRI photon density is shown in fig.3.

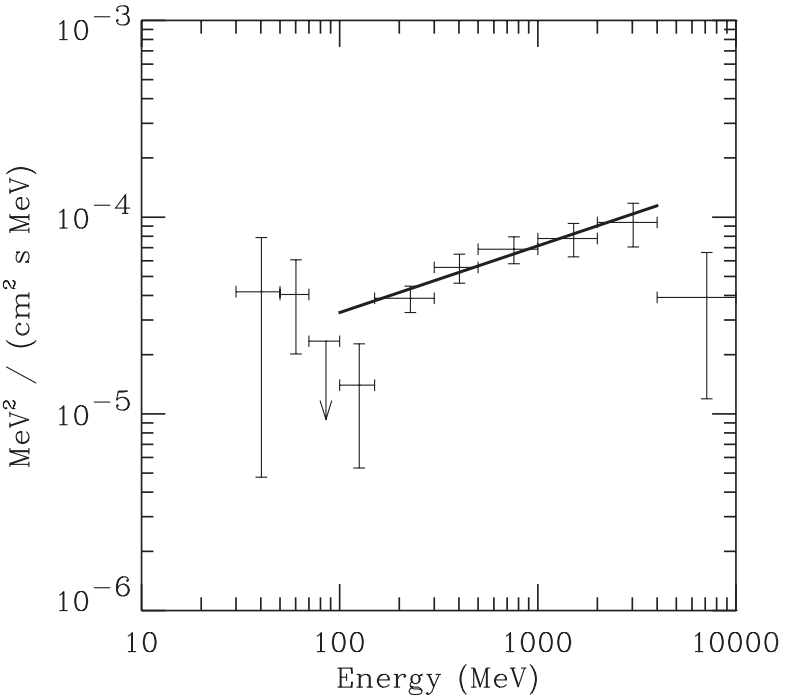

FIGURE 2. High energy gamma-ray spectrum of 3EG J1835+5918

X-RAY OBSERVATIONS

With the 60 ksec ROSAT High Resolution Imager observation from December 1997/January 1998, the only previous HRI X-ray exposure of this source could be increased by a factor of 12. For the first time, we discovered point sources at X-ray energies between 0.1 and 2.4 keV. The sources are all faint with typical HRI count rates of 1-3 $10^{-3}s^{-1}$. Two of the ten discovered sources are not in positional agreement with the determined > 1 GeV γ-ray source location contour, and therefore not considered as counterpart candidates. Using only ROSAT HRI data at this time, no spectral information on the discovered X-ray point sources is available.

OPTICAL OBSERVATIONS

The discovered X-ray sources were subject of optical identification campaigns at the 2.12m telescope of the Observatorio Astrofísico Guillermo Haro (Cananea, México). A detailed description of the optical observations on 3EG J1835+5918 is presented elsewere in these proceedings [6].

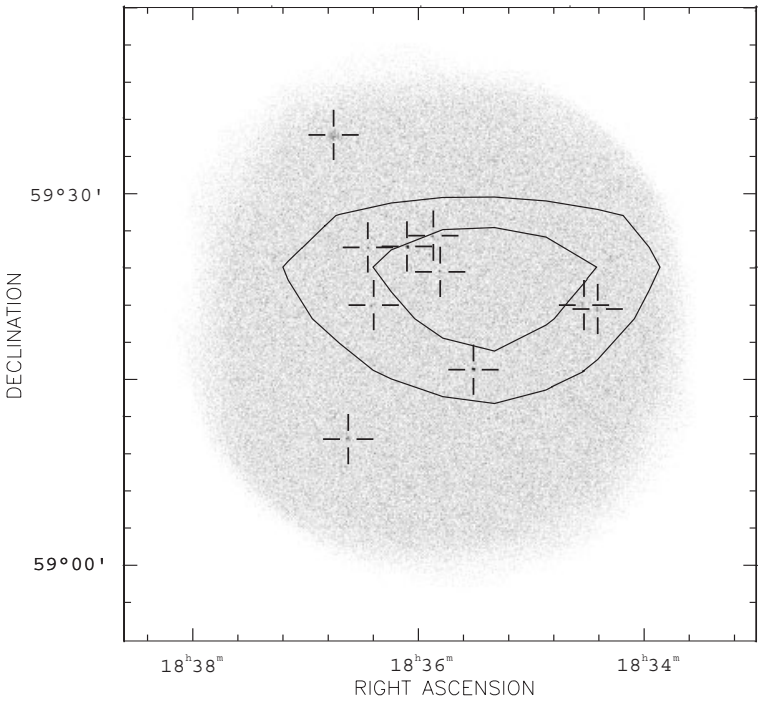

FIGURE 3. EGRET > 1 GeV source location contours (68% and 95%) overlaid on the 60 ksec ROSAT HRI image

RADIO OBSERVATIONS

Deep searches at radio wavelengths (770 MHz) at the position of 2EG J1835+59 have not detected any object above 0.5 Jy [7]. This result is in agreement with the correlation study between unidentified EGRET sources and catalogued flat-spectrum radio sources using the Green Bank 4.85 MHz and Parkes-MIT-NRAO 4.85 MHz surveys, which also did not find any counterpart for 2EG J1835+59 [8].

SUMMARY & CONCLUSIONS

The brightest unidentified EGRET source at high galactic latitudes was subject of a multifrequency identification campaign. For the first time, counterparts in X-rays are suggested. The optical identification of the X-ray counterparts has been finished for the brighter sources [6], resulting in the elimination of four of the viable eight X-ray candidates. The eliminated X-ray sources are identified with stars or distant galaxies unlikely to be the γ-ray source. Spectra for the fainter candidates will have to be obtained at larger telescopes. This is currently in progress at the 6m telescope of the Special Astrophysical Observatory (Zelenchuk, Russia). The pulsar-like spectrum in γ-rays, the high-galactic latitude source location and the

lack of any blazar class object or flat spectrum radio source would suggest a nearby radio-quiet pulsar. Such pulsars are predicted [9] to exist among the unidentified γ-ray sources seen by EGRET. Perhaps the first ones were already found within the γCygni supernova remnant [10], the CTA1 SNR [11], with GeV J1417-6100 [12], and 2EG J0635+0521 [13]. We will conclude on the nature of this enigmatic γ-ray source when we will have completed the optical identifications of the remaining four weak X-ray sources coincident with 3EG J1835+5918.

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