A Possible Discovery of a Flaring 10^{12} eV Gamma-Ray Source near the Red Dwarf EV Lac

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During the 1994 coordinated observations of the red dwarf flare star EV Lac, the star was monitored in the very high energy (VHE) γ-ray range around 10^{12} eV with the Crimean ground-based γ-ray telescope GT-48. This telescope consists of two identical optical systems (Vladimirsky et al. 1994) which were directed in parallel on EV Lac.

The detection principle of the VHE γ-rays is based on the Čerenkov radiation emitted by relativistic electrons and positrons. The latter are generated in the interaction of the γ-rays with nuclei in the Earth's atmosphere that leads to an appearance of a shower of charged particles and γ-quanta. The duration of the Čherenkov radiation flash is very short, just about a few nanoseconds. The angular size of the shower is $\sim 1^{\circ}$. To detect such flashes we use an optical system with large area mirrors and a set of 37 photomultipliers (PMs) in the focal plane. Using the information from these PMs which are spaced hexagonally and correspond to a field of view of $2\overset{\circ}{.}6$ on the sky, we can obtain the image of an optical flash. The electronic device permits us to detect nanosecond flashes (40 ns exposure time and 12 μs readout dead-time).

Unfortunately, the same kind of flashes are generated by VHE charged particles of cosmic rays. Using the differences in angular distributions of flash light permits us to reject the majority of this charged cosmic-ray particle background (Hillas 1985). The average number of flashes initiated by the cosmic-ray background is equal to 0.5 per second.

During several nights we carried out simultaneous optical (with the 1.25m reflector AZT-11) and VHE γ-ray monitoring of EV Lac. The most statistically reliable result in γ-rays was obtained just before the optical flare on August 31 at UT 19:40 (Fig. 1). The data from GT-48 were analysed to reject events due to charged cosmic-ray particles. It remains an excess in the number of selected flashes. The probability of 21 selected events occuring over one minute to be due to a random fluctuation is equal to $7 \cdot 10^{-9}$ according to Poisson statistics. We thus conclude that a VHE gamma-ray burst was detected with a duration of about 1 min.

The effective area for detecting Čerenkov flashes in the Earth atmosphere, initiated by γ-quantum, is about $4 \cdot 10^{8}$ cm^{2} (e.g. Stepanian 1994). Therefore, the detection of 21 flashes correspond to a fluence of $0.5 \cdot 10^{-7}$ γ-rays (of 10^{12} eV

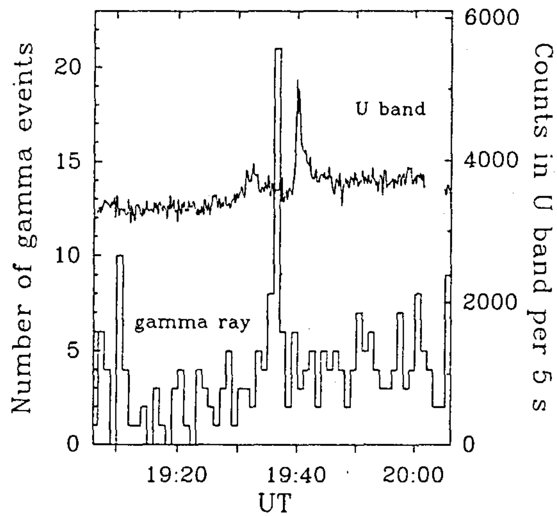

Fig. 1. EV Lac light curve in the U band around the flare on 1994 August 31 at UT 19:40, and the histogram of the 10^{12} eV γ-ray events.

energy) per cm^2 from the burst. With a mean energy of ~ 1.6 ergs per gamma-ray, placing the burst source at the distance of EV Lac of 5 pc, and assuming isotropic gamma-ray emission, we obtain a total burst energy of $\sim 2 \cdot 10^{32}$ erg.

Using the imaging capability of the camera for Čerenkov flashes we have determined the position of the γ-ray source. This position does not coincide with that of the flare star EV Lac: its 2000.0 coordinates are RA $= 22^h 43^m 45^s \pm 68^s$ and Dec $= +44°37' \pm 12'$, and thus is $0\overset{\circ}{.}6$ distant from EV Lac. We call this VHE γ-ray source Lac γ–1. Our attempts to identify Lac γ–1 with a known object has so far been unsuccessful. It would be very desirable to extend the survey by Seiradakis et al. (1993) to include the error box of Lac γ–1, and also to look for candidates in the ROSAT data and other short-wavelength surveys.

The upper limit of the VHE γ-ray flux from the EV Lac flare mentioned above is estimated to be 3 photons. The total optical energy release of the flare was $8 \cdot 10^{30}$ erg, and thus $E_\gamma / E_{\mathrm{opt}} < 4$. This limit is too weak to give any essential physical constraint on stellar flare theory.

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