Search for Coincidences in Time and Arrival Direction of Auger Data with Astrophysical Transients

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Introduction

Gamma rays bursts (GRBs) are potential candidates for a site of origin of the highest energetic cosmic rays.
However, all searches for coincidences between the arrival direction of ultra-high energy cosmic rays (UHECRs) and positions of GRBs from the Third BATSE catalogue yield a negative result. These searches, may have been distorted by the poor angular resolution (about 3^0) of the GRB measurements. A sensitive anisotropy analysis is now feasible using data collected mainly by Swift mission and the Pierre Auger Observatory.

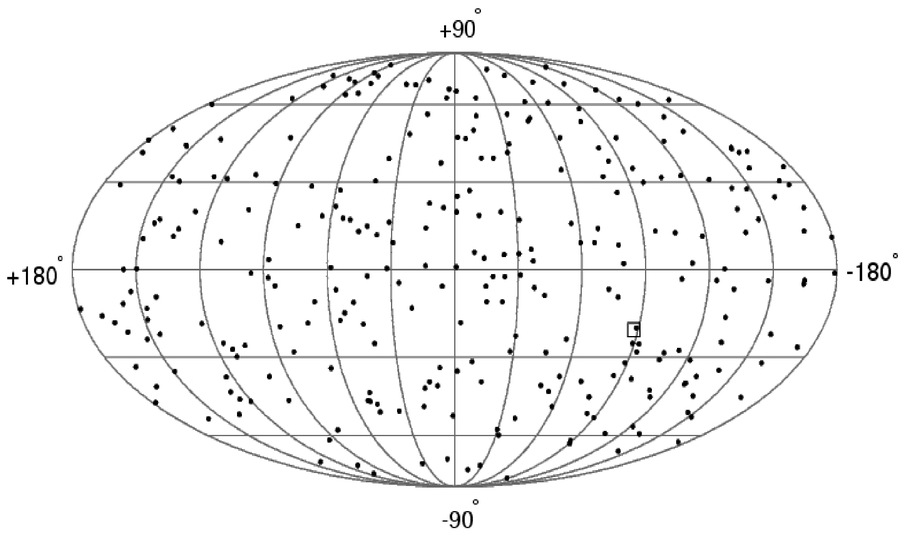

Figure 1*: The positions of 284 well-localized GRBs (dots) and the position of SGR 1806-20 (square).*

UHECRs and GRBs

A catalogue of 284 GRBs observed with an accuracy of better than 1^0 (from January 1, 2004 to April 1, 2007) was compiled. Out of the total GRB sample, 192 bursts are within the field of view (f.o.v.) of Auger and 62 were in the Auger f.o.v. at the time of their bursts (see Fig. 1).
We bin CR events coming from directions defined by spherical caps of radii 5^0 and 30^0 around each GRB position. The total number of coincidence candidates was determined by counting the number of CRs found within each of the specified cones. A 100-day period was considered before and after the GRB observation. No significant excess after the time of the bursts is evident in the data (Fig. 2).

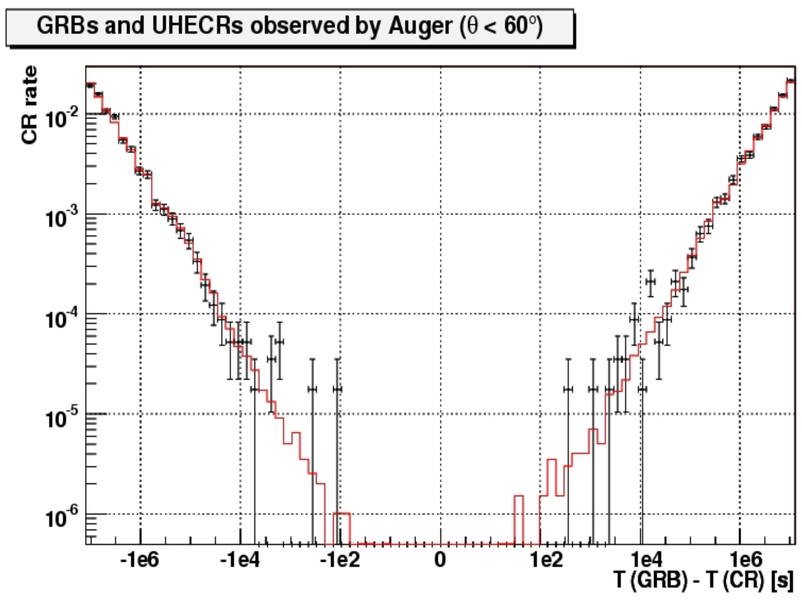

Figure 2*: The rates of CR events as a function of the difference between the GRB time and the CR arrival time. Data falling within 30^0 are indicated by histogram and within 5^0 by points.*

Conclusion

We used the Auger data sample to search for UHECRs which are consistent with the position and time of astrophysical transients. No such coincidences were found in the data.

(For more details see astro-ph/0706.0989)

Cosmic Ray Data Sample

In our analysis we use data collected with the Pierre Auger Observatory, located in Argentina at Southern latitude 35.2^0 and Western longitude 69.3^0. We consider events with zenith angle $\theta < 60^0$, detected from January 1, 2004 to April 1, 2007. A total of 609,161 CRs have passed the selection criteria.

UHECRs from SGR 1806-20?

The soft gamma repeater (SGR) emitted a hyperflare on December 27, 2004. Such an energetic event constitutes a potential candidate for acceleration of UHECRs. Secondary neutrons can be produced in collisions of relativistic protons (and nuclei) with the ambient plasma. Those produced with an energy $E > 10^{18}$ eV have a boosted lifetime sufficiently large to serve as Galactic messengers (about 20% of the neutrons survive the trip at 10^{18} eV and about 58% at $10^{18.5}$ eV).
The location of the source is within the f.o.v. of Auger for about 9 hours per day. At the flaring emission its zenith angle was 70.3^0 and it remained for 50 minute interval above the horizon. Unfortunately, this is outside well understood behaviour of the detector.
The similar analysis described in the previous section was used here. In Fig. 3 the results indicating that no excess in the CR flux is evident after the burst are shown.

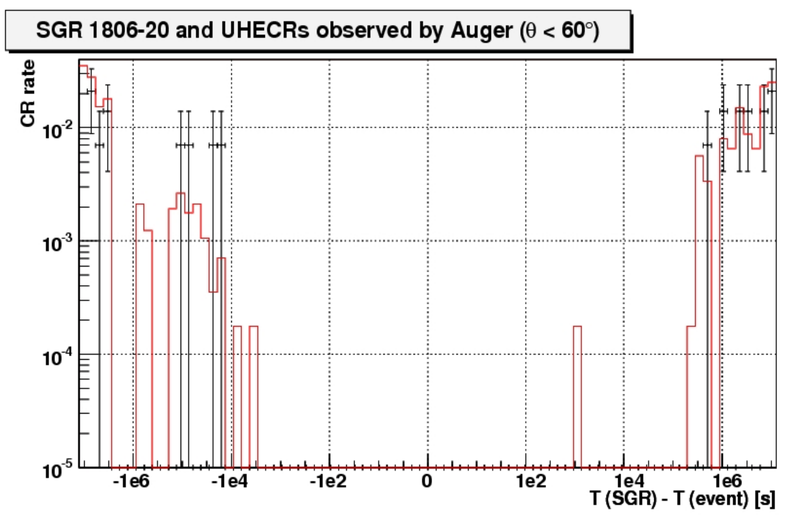

Figure 3*: The rates of CR events from the direction of SGR 1806-20. Conventions are the same as in Fig. 2.*

By extending our data analysis to higher zenith angles, it was verified that no events have been observed within a 5^0 cone during 300 s of the flare, where $\theta \sim 70^0$.
The absence of a signal can then be exploited to place an upper bound on the primary neutron flux, without assumptions on the Galactic magnetic field. The trigger efficiency for 70^0 is shown in Fig. 4. The 95% CL upper limits on the energy weighted flux of neutrons from SGR 1806-20 are shown in Fig. 4.

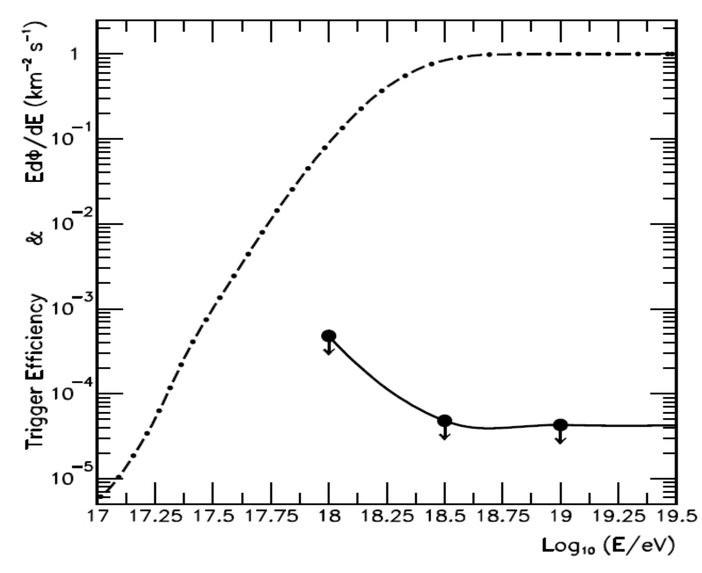

Figure 4*: The upper limits on the energy weighted flux of neutrons from SGR 1806-20 (arrowed circles) and the trigger efficiency of Auger for 70^0 (dot-dashed line) are shown.*