HIGH ENERGY γ-RAYS FROM THE DIRECTION OF THE CRAB PULSAR

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A search has been made for very high energy photons from the direction of the Crab Pulsar using the Lodz extensive air shower array. This device is particularly suitable for such a study because it consists of a large muon detector which can be used to search for the characteristic muon poor showers.

The method involved selecting those showers falling within 15° of the Crab direction, the observation time being chosen in the interval when the Crab was not lower than 40° from the zenith. For the Lodz geographical latitude (51.6°N) this corresponds to 8 hours observation per day. The Crab has been observed for 5600 hours from 1975 to 1979. The sample from the general direction of the Crab has been compared with three background samples taken from the points on the sky located at the Crab declination but with R.A. displaced by 90°, 180° and 270°. The background samples were taken in this way to make sure that these showers were observed from the same direction with respect to the apparatus as the showers coming from the direction of the Crab.

The results of observation are summarised in the Table.

	Crab	RA+90°	RA+180°	RA+270°	Excess
$N_e > 4 \times 10^5$	313	292	290	310	52.3 ± 20.0
$N_e > 10^6$	156	108	115	120	41.7 ± 13.9
$N_e > 2 \times 10^6$	52	28	36	36	18.7 ± 7.9

It is seen that a clear excess of showers from the direction of the Crab is observed and that the fractional excess is increasing with shower size.

The result is confirmed by preliminary analysis of an earlier set of data taken in the period 1968 - 72. For that period we have compared only the excess in the intensity at very high densities corresponding to large showers, $N_e > 10^6$ particles. Here, there

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exists an excess amounting to 20.0 ± 7.4 showers. The joint probability of obtaining the two results by chance is 2.8 x 10^{-4} (3.6 σ for a Gaussian distribution).

The excess showers seem to be deficient in muons. The average muon content in the Crab showers amounts to (0.60 ± 0.12) of that in the normal showers. Normal showers contain ∿ 7 muons per 55 m^2 detector, whereas the excess showers contain 4 ± 1 per detector (we note that photon-induced showers should contain ∿ 2 muons per detector: Wdowczyk, 1965, not too far from observation).

The intensity of the excess showers observed in the present experiment can be evaluated taking into account the fact that the collection area of our device is approximately 1000 m^2 and is virtually energy independent; however it is dependent on angle and this gives a significant uncertainty in the absolute magnitude of the intensity. Including all uncertainties the overall flux from the Crab direction (in excess of our background level) is (3 ± 2) x $10^{-13} cm^{-2} sec^{-1}$ above an energy of ∿ 10^{16}eV.

In view of the large angular region round the Crab direction considered the evidence that the excess events are due to the Crab itself is circumstantial. A number of possibilities need to be considered including: a general enhancement over several degrees in the direction of the Crab, a discrete source within a few degrees of the Crab etc. (we are grateful to Dr. K.J. Orford for discussions on this point). Further, more detailed work is necessary to distinguish the possibilities.

If the excess flux is indeed to be identified with photons from the Crab, a possible model is one where protons accelerated by the pulsar interact with visible light. The results would not conflict with the measurements summarized by Weekes, 1979, if the spectrum between 10^{12}eV and 10^{16}eV was rather flat (or indeed if there were a negligible flux of photons below 10^{15}eV). A flat spectrum would be expected from the model referred to.

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