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An Additional Characteristic Feature of Centauro Events

E.H. Shibuya[1], **Brazil-Japan Collaboration of Chacaltaya Emulsion Chamber Experiment**

[1] *Instituto de Física 'Gleb Wataghin', Universidade Estadual de Campinas, Campinas - SP, CP 6165 CEP 13083-970, Brasil*

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Abstract

Since the observation of Centauro events in 1972, one of the intriguing characteristic of these unusual events is the high content of hadrons. Extrapolating at the observed data in order to estimate the produced number of hadrons, led to the conclusion that these events are consistent with no production of eletromagnetic component, at the interaction point. Recently, an event with signal only in deepest layers of the chamber was observed. The identification of particle nature is one of crucial clue to the classification of Centauro events. So, a global analysis of all produced particles, without their previous identification, was done for some Centauro event candidates. Comparison with other usual events with similar characteristics on multiplicity and total observed energy shows that almost all of the candidates have quasi isotropic angular distribution, but have the quantity E/E_{total} (similar to the Feynman x_f) parameter rather different from the usual events.

1 Introduction

An unusual event was first observed by Brasil-Japan Collaboration on Cosmic Rays in 1972. Since then other similar events were classified as Centauro events, mainly characterized by their remarkable high content of hadrons. Recently an event was observed showing signal in the emulsion chamber only after passing through 15.0 r.l. (246 cm of lead plates, a carbon target, an air gap separating upper and lower parts of the detector). So, as Centauro are hadron-rich events, a clear identification/discrimination of hadrons is strongly desirable. But, the criteria we have for that purpose sometimes are questionable and so we are looking for an additional characteristic of Centauro events.

2 $E/\Sigma E_\gamma$ distribution

An attempt we realized was through a distribution of fractionally energy distribution, that is a distribution of $E/\Sigma E$, where E is the estimated energy of the shower induced by the secondary produced in the hadronic interaction, irrespectively of identification as hadrons or γ's

A sample of 228 events were analyzed. Its superposed distribution of $E/\Sigma E_\gamma$ (this is a traditional quantity in Cosmic Rays, nowadays called Feynman scaling x parameter - x_f) is shown in figure 1. A sample of 8 special events is also in the same figure, through dotted lines. Comparison between these two samples, shows that they have different shape, figure 2, and have shifted distributions, as figure 1 shows. Kolmogorov-Smirnov two sided test results probability of ≈ 0 for comparison of the distributions in both figures. The multiplicity of the 228 events is between 4 and 240, the total observed energy is in the range 17 TeV to 1,420 TeV. For the 8 special events, the observed multiplicity (γ's and hadrons) is between 31 and 297 and the range of total observed energy is 57 TeV to 1,227 TeV. To make more effective comparison, we selected comparable events in both samples. So, we selected that ones with similar multiplicity, total energy and height (vertex) of the interaction. To accomplish the height criterion we chosen events close in a region occupied by the 8 special events in the plot $mDW - r\Sigma E$ (figure 3). In this figure, the points shifts to right down side as an effect of transverse momenta P_t, in other words, the events with similar multiplicity, energy and height fall in the same region, because $P_t \simeq E\frac{r}{H}$. Doing this, the original sample of 228 events shrinks to 5 events, similar in observed multiplicity, total energy and height to the 8 special events.

Comparison between these two samples gives 0.0036 for the probability that they come from the same parent distribution.

Another comparison was done between each Centauro event and the 7 remaining superposed distribution. The result is in table 1. Same comparison was done in the shrunk sample. Results in table 2.

Centauro (special) event	Probability
I	0.17×10^{-2}
II	0.19×10^{0}
III	0.59×10^{-2}
IV	0.57×10^{-13}
V	0.25×10^{-3}
VI	0.98×10^{-4}
VIII	0.83×10^{0}
Pamir	0.57×10^{-10}

Table 1: Probability (from Kolmogorov-Smirnov test) resulting from comparing one of the 8 special events (Centauros) with the superposed distribution of the other 7.

Guaçú event	Probability
C132627S	0.35×10^{0}
C14B132	0.67×10^{-1}
C16B106S	0.11×10^{-3}
C17B112S	0.23×10^{-1}
C17b15S	0.81×10^{-3}

Table 2: Probability (from Kolmogorov-Smirnov test) resulting from comparing one of the 5 events of the shrunk sample (Guaçús) with the superposed distribution of the other 4.

3 Conclusion

It is interesting that the beforehand classified Centauro events, shows consistent probabilities between them but much different from other similar events (the shrunk sample). The first comparison results around 10^{-1} while the second presents a 10^{-3} probability to be from the same distribution. Then, we can conclude that they are different events and the main difference could be from their high hadronic components and so this kind of analysis could be an additional support for Centauro events.

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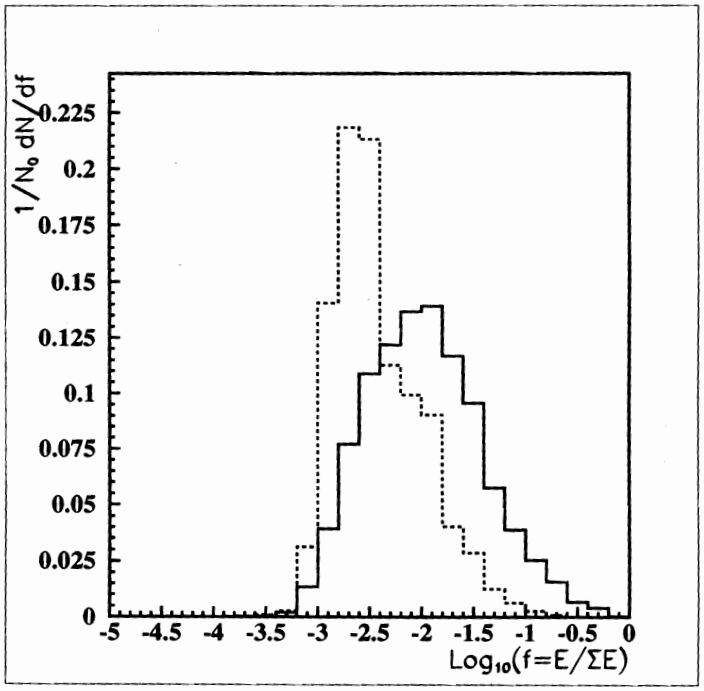

Figure 1: $\frac{E}{\Sigma E}$ distribution of the normal sample (solid line - 228 events) and the special sample (dashed line - 8 events).

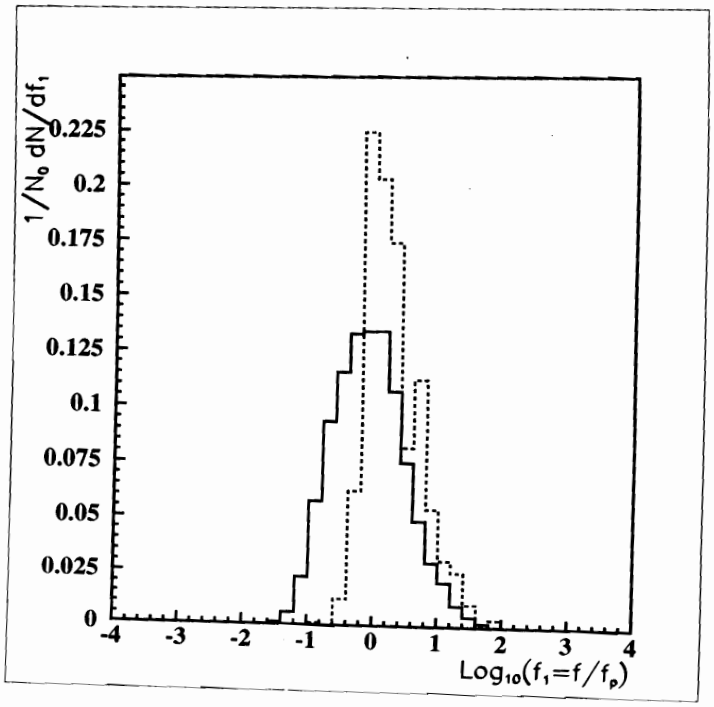

Figure 2: The same as figure 1, but here the distributions have been shifted, in order to allow the comparision of the shapes of the distributions. The peaks of the distributions in figure 1 were used as shifting factor.

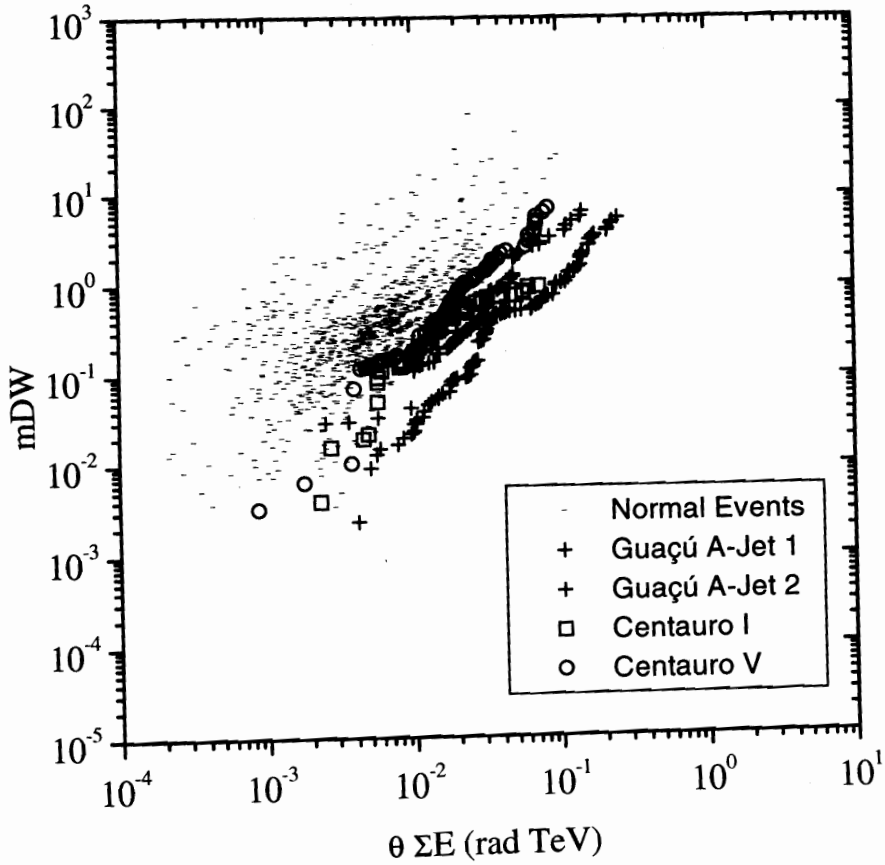

Figure 3: The $mDW - r\Sigma E$ plot for some of the events used in the analysis.

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