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HADRONS PRODUCED IN ATMOSPHERIC INTERACTIONS

by

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ABSTRACT

Systematic analysis is made on cosmic ray induced atmospheric interactions detected by Brasil-Japan Collaboration on Chacaltaya Emulsion Chamber Experiments to study the hadron multiple production. It is demonstrated that hadron rich events are not characterized only by super families (halo events). About 5% of the events with visible energy in the range of 100 - 1000 TeV. and transverse momentum density over the rapidity scale $\geq$ 1 GeV.Km, has an anomalously "hadron excess", already observed in super families (visible energy > 1000.TeV). The analysis did not include events identified as exotic ones (Centauro, Mini Centauro, Geminion and Chiron)[3].

Key-words: Nuclear atmospheric interactions; Hadron multiple production; A-jets families.

INTRODUCTION

The data of hadron and electromagnetic component in the denominated super families (halo events), in the energy range $\sum E_\gamma > 1000$ TeV.[1,2], are found inconsistent with the hypothesis of proton primary with pion multiple production.

The experimental power index, β_h of the hadron energy spectra compared with experimental power index, β_γ of electromagnetic energy spectra in super families shows the same tendency, $\beta_\gamma > \beta_h$, and large transverse momentum density in the rapidity scale are treated as evidence for the hard "hadron excess".

In this time, we will study the possible similar characteristics of super families in 160 events with visible energy in the range od 40 - 1000 TeV. We eliminate the events identified as exotic ones (Centauro, Mini Centauro, Geminion and Chiron).

2 SYSTEMATIC ANALYSIS

Event shape is examined by using the following quantities:

a) Transverse momentum density in the rapidity scale $\langle P_T\rangle dN/d\eta$. For A-Jet one can construct an analogous quantity from the observed descascaded variables of a family as $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma) \cong d \sum_R E_\gamma R_\gamma/d(\ell g R_\gamma)$.

$\sum_R E_\gamma R_\gamma$ is calculated for gamma/electron observed within a circle of radius R_γ.

For Super Families[1], this quantity is extremely large (> 6 GeV.Km) compared with the average value (~1 GeV.Km) for events in the energy range of 100 - 300 TeV.

b) Number of observed hadrons, N_h, and energy fraction of hadron component $q_h = \sum E_h/(\sum E_h + \sum E_\gamma)$.

c) The experimental power index β_h of the hadron and β_γ of the electromagnetic energy spectra.

3 RESULTS

The grasp gross features of the A-Jet families are used for all the 160 A-Jet families in the energy range of 40 – 1000 TeV.

After the decascading 106 events have more than one gamma ray and one hadron; then $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma)$, q_h are calculated for each event.

We can see from Fig. 1, that $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma)$ has a peak at around 1 GeV.Km. and a very long tail over 11 GeV.Km, the black squares are values for super families.

The correlation between number of hadron and gamma/electron as given in Fig. 2, shows a few number of events with large number of hadrons and large number of gamma/electron.

Fig. 3 shows the energy dependences of $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma)$ in the range 40 – 1000 TeV. We notice that $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma)$ increases when the energy rises, the circles are values for super families. That is this figure shows that large $\langle E^*_\gamma R^*_\gamma\rangle dN^*_\gamma/d(\ell g R_\gamma)$ region is occupied by super families and also by a few events with energy range of 100 - 1000 TeV.

Fig. 4 shows the correlation between the transverse momentum in the rapidity scale, energy fraction of hadrons and number of hadrons for events with $\langle E^*_\gamma R^*_\gamma\rangle dN^*/d(\ell g R_\gamma) \geq 1$. GeV.Km. As is seen in the figure about 3 events have the same tendency that the superfamilies with large values of q_h, $<E_\gamma^* R_\gamma^*> dN_\gamma^*/d(\ell g R)_\gamma$ and M_h.

The experimental power indices β_h of the hadron and β_γ of the electromagnetic energy spectra for these events show the same tendency $\beta_\gamma > \beta_h$ already observed in super families. These events are:

	β_γ	β_γ
Chamber 16S167	1.44 ± 0.21	0.45 ± 0.18
Chamber 19S47I17	2.00 ± 0.25	0.65 ± 0.22
Chamber 19S200I157	1.39 ± 0.19	0.78 ± 0.24

It may be concluded that there exist about 5% of A-Jet families with $<E_\gamma^* R_\gamma^*> dN_\gamma^*/d(\ell g R_\gamma) \geq 1$ GeV.Km which have q_h, and $<E_\gamma^* R_\gamma^*> dN_\gamma^*/d(\ell g R_\gamma)$ comparable with those of the super families, that are rich in hadrons over the charge symmetry on pions.

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FIGURE CAPTIONS

Fig. 1 - Transverse momentum density over rapidity scale distribution.

Fig. 2 - Correlation between hadrons and gamma rays. E_{min} = 2 TeV.

Fig. 3 - Energy dependence the transverse momentum over the density scale

Fig. 4 - Correlation between q_h, $\langle E_\gamma^* R_\gamma^* \rangle dN_\gamma^*/d(\ell g R_\gamma)$ and number of hadrons.

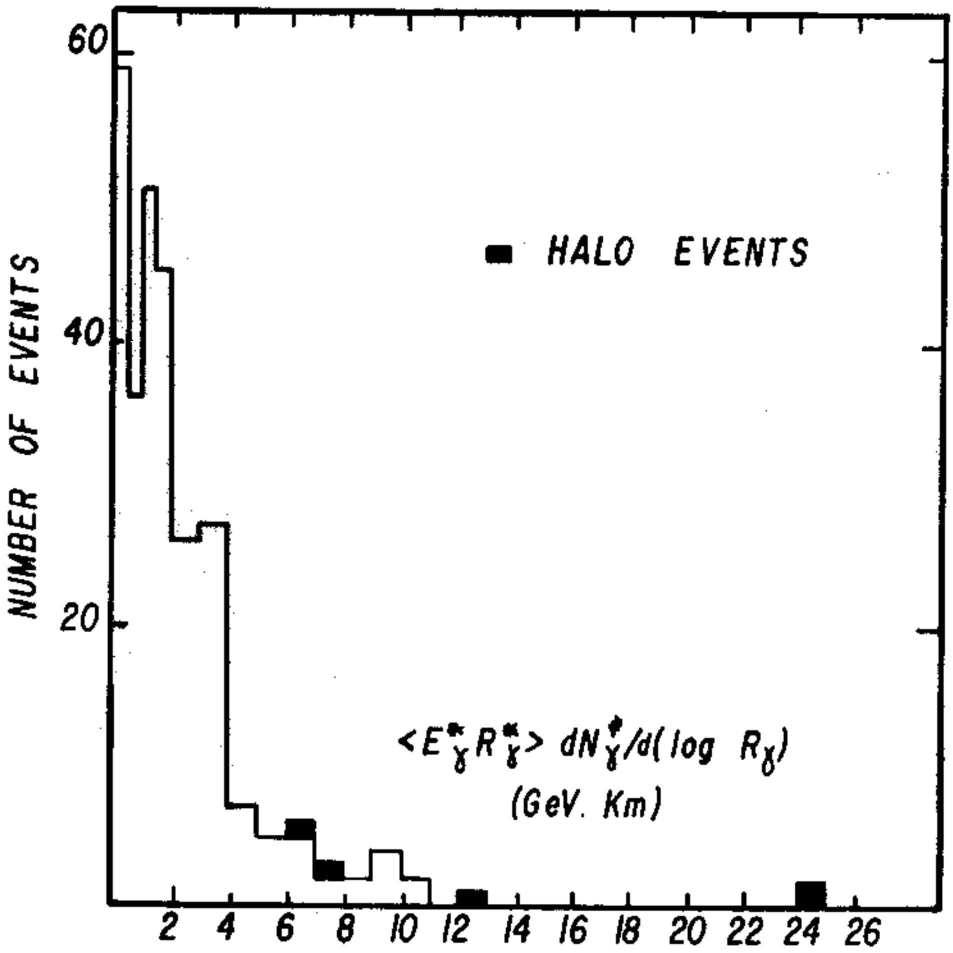
HALO EVENTS
NUMBER OF EVENTS
60
40
20
2 4 6 8 10 12 14 16 18 20 22 24 26
<E*γ R*γ> dN*γ/d(log Rγ)
(GeV. Km)

Fig. 1

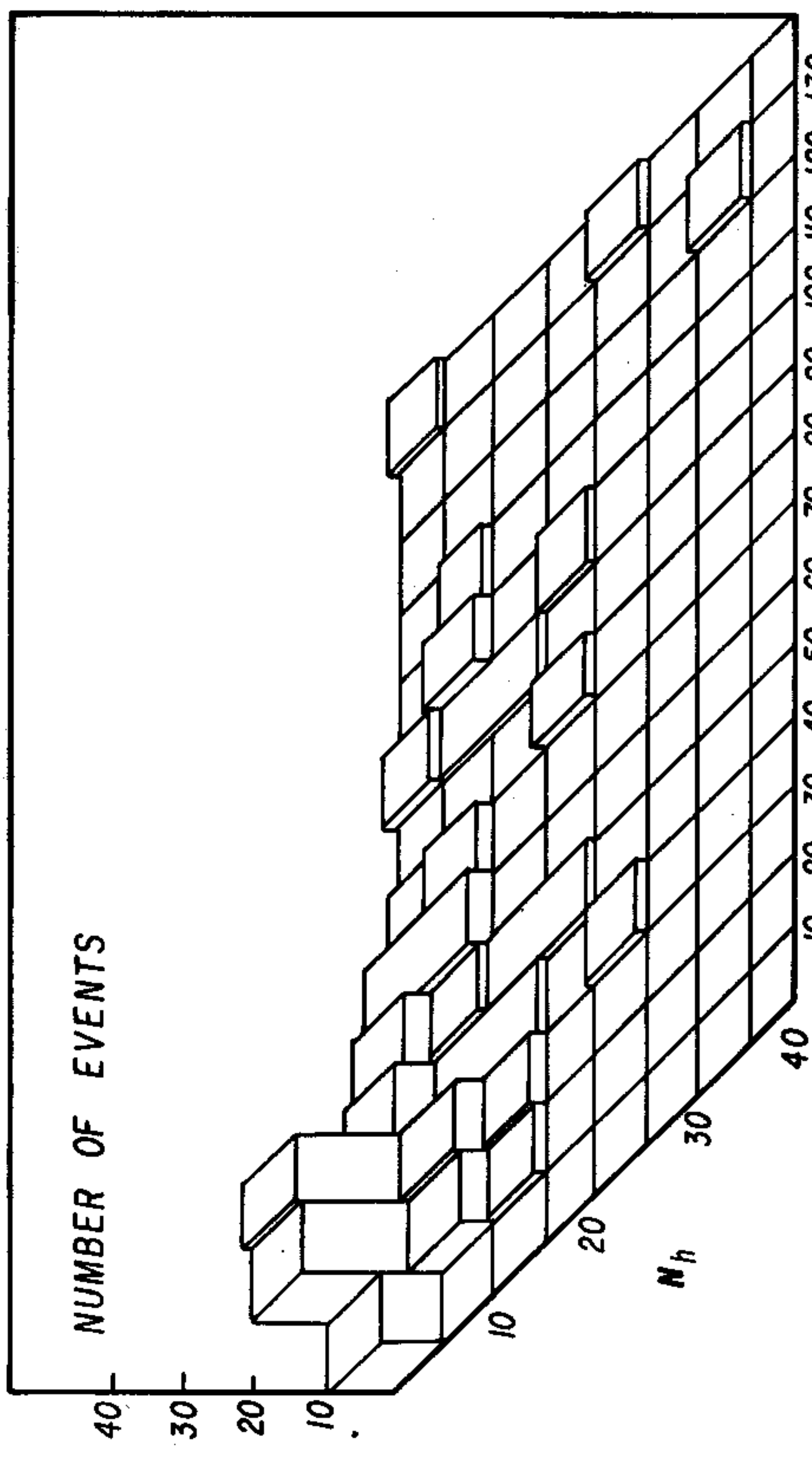
NUMBER OF EVENTS
40
30
20
10
10
20
30
40
N_h
10
20
30
40
50
60
70
80
90
100
110
120
130
N_γ

Fig. 2

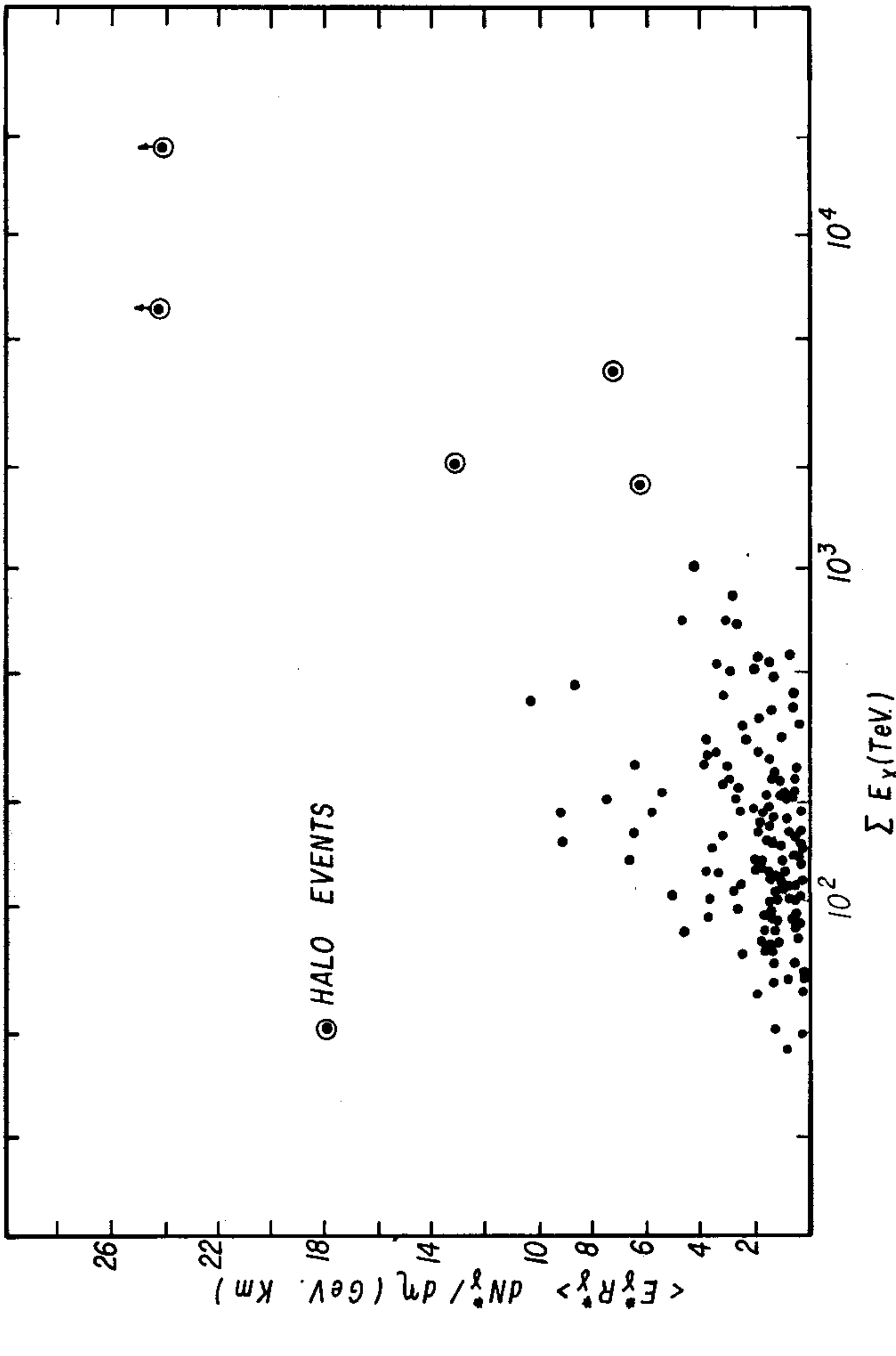
HALO EVENTS
Σ E_γ (TeV)
10^2
10^3
10^4
2
4
6
8
10
14
18
22
26
< E*γ R*γ > dN*γ / dη (GeV. Km)

Fig. 3

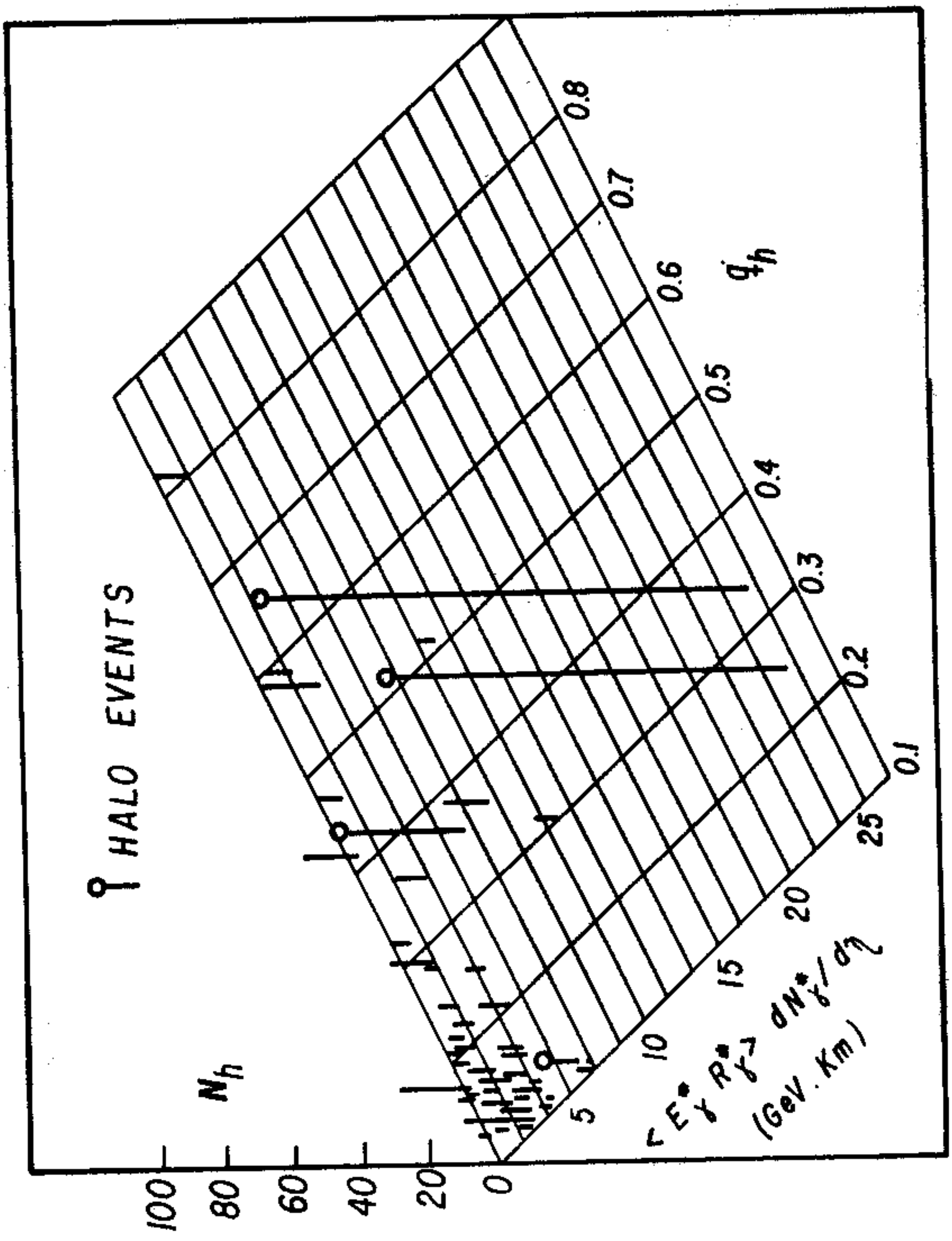
HALO EVENTS
N_h
q_h
(GeV.Km)
0
20
40
60
80
100
5
10
15
20
25
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Fig. 4

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