

**Observation of Genetic Relation Among New Phenomena
Geminion, Chiron and Mini-Centauro**

Brasil-Japan Collaboration of Chacaltaya Emulsion Chamber Experiment

Abstract

The threshold energy problem of exotic type interactions is discussed on the basis of available information from Chacaltaya emulsion chamber experiment. The genetic hypothesis is proposed as a working hypothesis to explain the discrepancy seen in cosmic-ray study and CERN \bar{p} -p collider experiments.

1. Introduction.

Brasil-Japan collaboration of Chacaltaya emulsion chamber experiment have reported in several occasions observation on exotic type interactions which could hardly be reconciled with the known processes of pion production. They are the multi-particle production without association of neutral pions emission, and called "Centauro" family with reference to the first event Centauro-I in 1972. They include variety of phenomenologically similar events with different particle multiplicity and p_t [1]. The recent progress of collider technique made the energy region of the accelerator experiments overlap over a part of the region of the cosmic-ray study. \bar{p} -p collider experiment at CERN, covering the energy region of $E_0=155$ TeV in the laboratory frame, however, found none of these exotic interactions. In 1985, there is an increase of the energy of machine at CERN to the region $E_0 \approx 500$ TeV and also the start of collider experiments at FNAL up to the region of $E_0 \approx 2000$ TeV. Thus it is important to make guess on the threshold energy for such exotic interactions from the available information. At the same time, the problem requires to solve a puzzle that cosmic-ray experiments are observing exotic interactions of energy smaller than the available energy at CERN collider. The present paper concerns to an attempt at such guess and a working hypothesis of genetic relation of exotic interactions is proposed and studied[2].

2. C-jets and Pb-jets-lower in Chacaltaya chamber no.19.

In order to make clear the problem which we are faced with, here we present brief summary of the most recent observation of exotic phenomena in C-jets and Pb-jets-lower study. It was made a systematic study on 198 C-jets and special Pb-jets-lower of visible energy greater than 5 TeV in one half of lower detector of Chacaltaya chamber no.19, 28.8 m^2 year exposure[3]. Among those, there are found following exotic-type C-jets and Pb-jets-lower. Such exotic events are here triggered by studying non pi-naut emission events after asking whether the individual shower core is electromagnetic origin or hadronic in the lower detector. They are ;

- i) 8 C-jets of Mini-Centauro type, ($n \geq 3$)
- ii) 3 C-jets of $n = 2$ with very large invariant mass ($m(\gamma)(1-2) > 1.8$ GeV), consistently interpreted as Geminion-type interaction in target layer.
- iii) 2 Pb-jets-lower with large $p_t(\gamma) > 1$ GeV/c, with $n = 2$, consistently interpreted to be Geminion and Chiron type interactions in the lead of lower detector. n means number of shower cores.

It shows several % of the whole observed C-jets is of exotic type. All those exotic events range from 5 TeV -25 TeV in their visible

energy, then the energy of incident hadron are estimated to be as much as an order of \bar{p} -p collider energy or less.

3. Genetic hypothesis of exotic interactions.

We will propose a working hypothesis to explain why the CERN collider did not see those exotic phenomena, despite the cosmic-ray observation shows the existence of exotic type event even in lower energy than collider. The working hypothesis assumes that the concerned exotic interaction is generated by the "exotic hadrons", but not a proton, a pion, nor any of the known hadrons. It also assumes that the "exotic hadrons" are produced out of the exotic interactions. Under the above hypothesis we have the following picture as shown in Fig.1. An exotic event seen at Chacaltaya is, then, the last one in a chain of exotic interactions connected by a passage of an exotic hadron in the atmosphere. Thus the origin of exotic hadrons can be located high up in the atmosphere to the first point in the chain of exotic interactions, probably made by primary cosmic-ray particles.

4. A possible candidate of exotic hadrons, the "B-particles".

It is remarkable that we found such genetic relation in the systematic study of C-jets and Pb-jets-lower in chamber no.19, just introduced above. Among 8 C-jets of Mini-Centauro type, three associates with atmospheric families, two with Chiron type and one with super-family M.A.III[4], one Pb-jet-lower with large $p_t(\gamma)$ nature associates with M.A.III.

It was already reported that the secondary particles in Chiron type family show several strange features not seen in a common type family, and we put the name "B-particle" for them[1].

Though the observation is still in preliminary stage and is being continued, we may try to see how it can be a candidate for exotic hadrons. First of all, its large p_t at the momentum transfer, and it is outside the region of soft lnS physics. This can be considered as one of the necessary conditions to be a candidate for the exotic hadrons.

5. Example of cascade of exotic interactions ; Chiron families.

Under the genetic hypothesis as described above, experimental study was extended to every C-jet and Pb-jet-lower of $\Sigma E(\gamma) > 5$ TeV from 30 Chiron families, all the statistics in Chacaltaya chamber no.19 and a high energy Chiron type family from chamber no.18. Out of those 30 Chiron-type families, there are, in lower chamber, 20 showers with $\Sigma E(\gamma) > 5$ TeV which satisfy the criteria of the multi-core structure. The following gives a list of those observed showers.

9 showers of ordinary pion production in the target -- pi-nauts are found

5 showers of successive interactions in the chamber -- upper and target layers

1 shower of Chiron candidate -- Pb-jet-lower

3 showers of Mini-Centauro candidate from the target

2 showers of mini-cluster candidate in the target

It indicates about one third, 6/15, is of exotic type. Among them, the case of a Chiron candidate is most impressive, #507(47S-17I). It is a shower with three diverging cores, and the geometry measurement on the core position allows us to locate the point of vertex in the lower chamber itself as shown Fig.2. We obtain average p_t of three cores as

$\langle p_t(\gamma) \rangle = 1.7 \pm 0.4 \text{ GeV/c}$, a quite high value. If we correspond each core to a quantum of gamma-ray, it will be hard to explain them by the ordinary pion production. Under the Chiron hypothesis, it is just what we expect. From the Chiron interaction in the lower chamber, a number of B-particles will be emitted with large p_t . Because of the limited material thickness in the lower chamber, some or most of B-particles created will penetrate through the chamber, thus the three cores of the event will be mini-clusters.

During extending the study to chamber no.18, we found a special high energy Chiron type family, C18-154S-133I[5]. The family is of wide spread and hadron rich character. We found a strongly penetrative mini-cluster of the spread of 1 mm in radius in upper chamber, and in lower chamber one C-jet and one Pb-jet-lower are found inside the region of the shower continuation from the upper mini-cluster. What is remarkable is that the C-jet, consists of seven cores with $\Sigma E(\gamma) = 12.2 \text{ TeV}$, is of the nature of Mini-Centauro candidate, having no-pi-naut coupling among constituent showers, and the Pb-jet-lower with diverging four cores is of the nature of Chiron type candidate. Fig.3a shows the target map and Fig.3b the divergence measurement among four cores and Table 1 gives some details of the Pb-jet-lower. We see similar characteristics of large $p_t(\gamma)$ nature in this Pb-jet-lower with the one of Chiron type, #507(C19-47S-17I). What is especially interesting in this example is that hadrons(plural) which make different types of exotic interactions are in the same mini-cluster.

6. Discussions.

We do not know yet much about primary cosmic-ray particles in very high energy region. If we extrapolate the knowledge of lower energy region, the primary particles will be more likely to be protons. At the level of Chacaltaya, the observed rate of exotic event is about $0.5 \text{ m}^2 \text{ year}^{-1}$. This value corresponds to the rate of a primary proton with $E_{\text{inc}} > 10^{16} \text{ eV}$. In this means, we may expect that the exotic interaction is produced by a primary proton with energy E_{inc} as shown in Fig.1 because of the steep energy spectrum of primary protons and the sharp rise of cross section near the threshold.. Since the cosmic-ray experiment pick up only events of the type which occupies a substantial fraction in the nuclear collision, the real threshold value of the exotic interaction will be lower than 10^{16} eV . Thus we may think that there is a fair chance of seeing the exotic interactions produced artificially by the collider of FNAL with energy $2 \times 10^{15} \text{ eV}$. Here, we should mention other possibilities, too. The one is the proposal of new phase of the hadronic matter, quark-gluon plasma formation, in nucleus-nucleus collision[6], different from \bar{p} -p collisions and the other is that the primary cosmic-ray contain exotic objects such as quark globs[7] besides known nuclei. It is an interesting hypothesis and if it is the case the observation of exotic type interactions will have a connection with the astrophysical problems.

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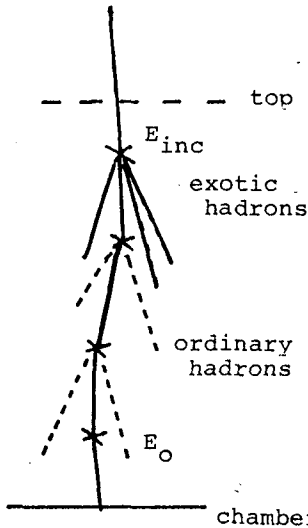


Fig.1 Explanation of genetic hypothesis.

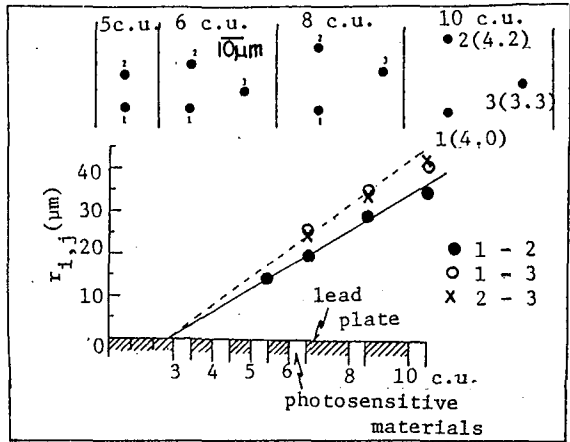


Fig.2 Target map and convergence measurement of #507 (47S-17I)

Table 1. Details of Pb-jet-lower in the event C18-154S-133I

#	$E^{(\gamma)}$ (TeV)	$\Theta (\times 10^{-4})$	$p_t^{(\gamma)}$ (GeV/c)
1	15.0	1.05	1.6
2	15.0	1.05	1.6
3	3.5	6.90	2.4
4	2.4	15.0	3.6

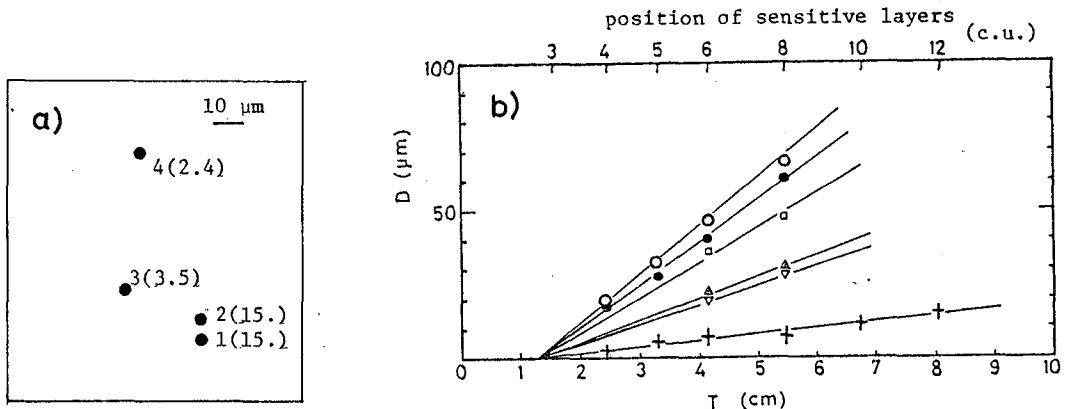


Fig.3 a) target map and b) convergence measurement of Pb-jet-lower in the event C18-154S-133I.