

RELATION BETWEEN GAMMA-RAY FAMILY AND EAS CORE
- MONTE-CARLO SIMULATION OF EAS CORE -

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ABSTRACT

Preliminary results of Monte-Carlo simulation on EAS($N_e=10^5$) core is reported. As the first collision at the top of atmosphere, high multiplicity (high rapidity density) and large Pt (1.5GeV average) model is assumed. The most of the simulated cores show complicated structur.

1. Introduction. Several simulation studies on the EAS core structure were performed previously(Ref.1). Although various models or assumptions (fire ball, CKP, heavy primary or energy dependent Pt etc.) were tested in these works, the prominent frequency of the multi- or complicated core structure has not been simulated.

Recently, in the direct and pseudo-direct observation of nuclear interaction by EC (JACEE and CONCORDE, Ref.2, 3), very high multiplicity (high rapidity density) and comparatively large transverse momenta events were detected. The feature of these events gives us a motive for another EAS core simulation. We performed the core simulation taking these interaction feature in the simple model.

2. Simulation. The final output of the simulation calculation is the electron density map. We postulate 16×10 of packed array consist of 50×50 cm² density detectors, then area is 40 m² which is similar to the Norikura Spark Chamber Array(Ref.4).

The first collision depth (hereafter it is abbreviated as Z_0) is not sampled randomly, but is fixed to 10, 50 and 100 g/cm². The nuclear cascade is traced to observation depth(750g/cm²) and the gamma-rays produced through neutral pion decay are filed (x,y,z-coordinate, directional cosine and the energy). From the gamma-ray file the core density map is generated superposing each electromagnetic cascade. As the electron lateral distribution function of the electromagnetic cascade, the NKG-formula is used.

Tracing the nuclear cascade, only the forward region in the rapidity space is concerned but the central and backward regions are neglected in each interaction.

Model and Postulate for the first interaction :

- survival particles are not in concern
- total energy of produced particles is fixed to 600TeV.
- multiplicity of charged hadrons is fixed to 20.
- multiplicity of neutral pion is fixed to 10.
- production energy spectrum is exponential type.
- transverse momentum distribution is $\exp(-Pt/P_0)$,
 $P_0 = 1.5$ GeV/c

Other Interaction :

collision mean free path is 90 g/cm².

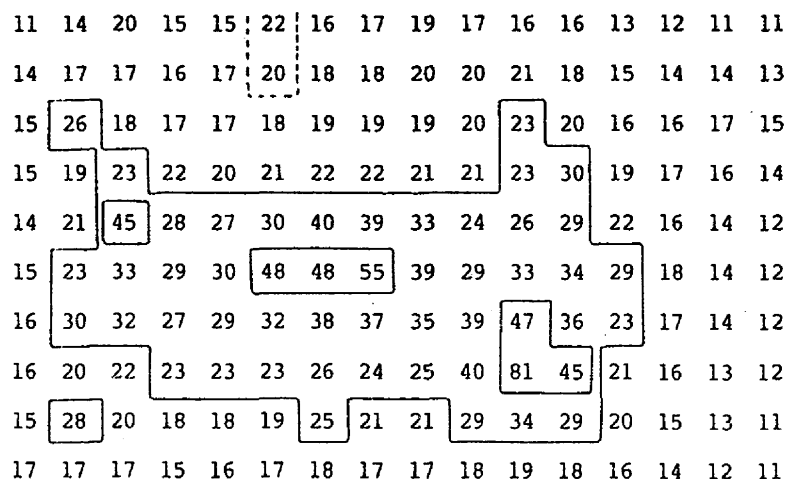
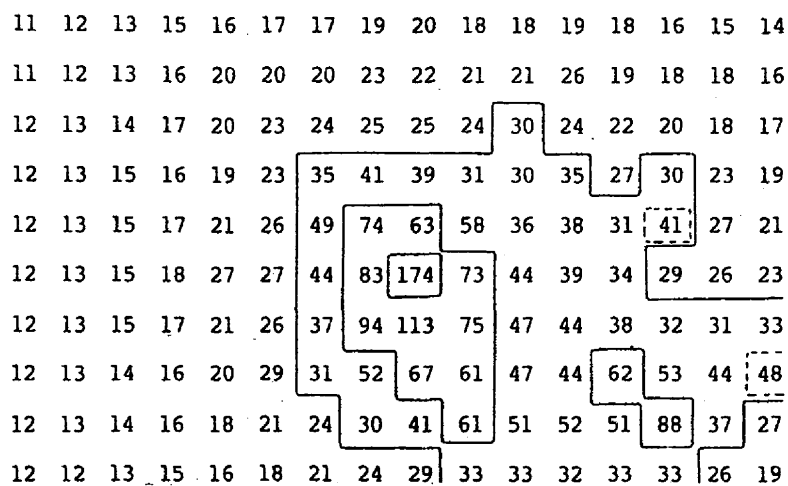
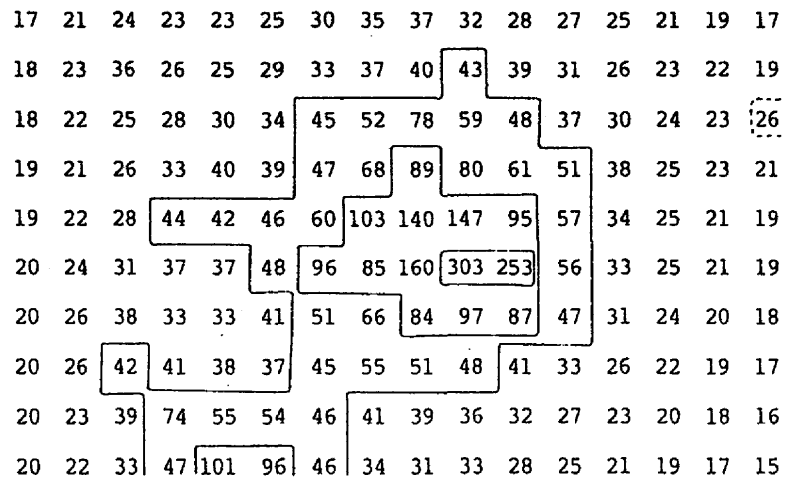
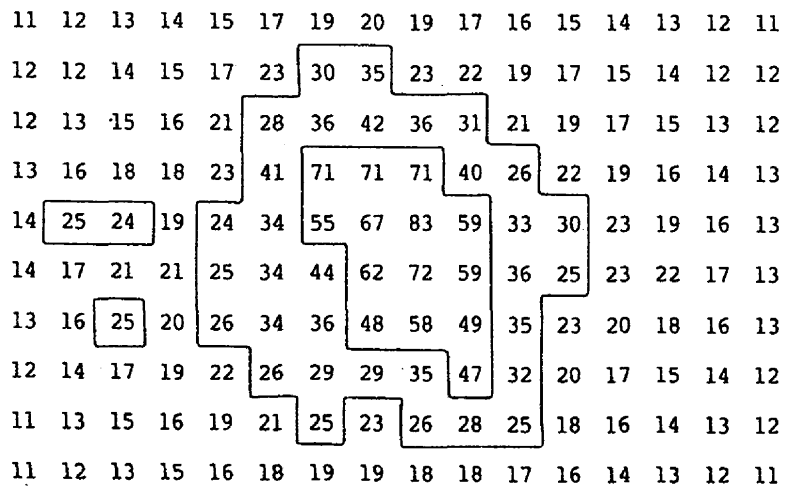


Fig.1-a,b,c,d. Core density maps for $Z_0=10\text{g}/\text{cm}^2$. One of the most simple example is in (a). Typical complicated examples are in (b), (c) and (d).

(a) (b)
 (c) (d)

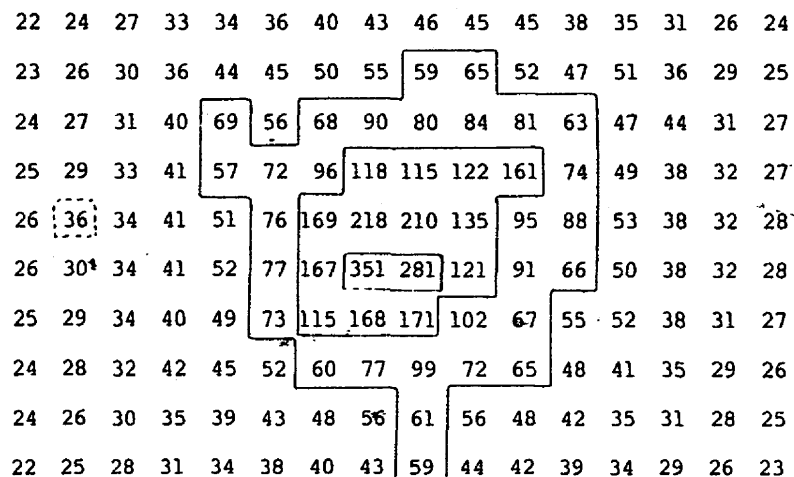
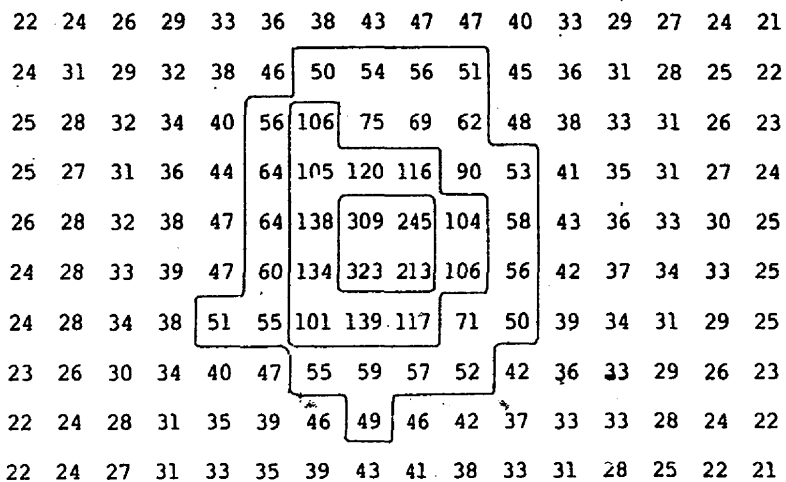
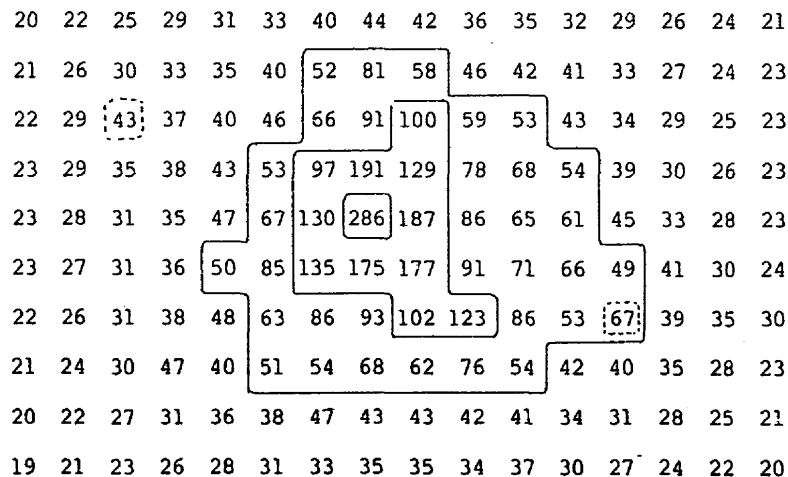
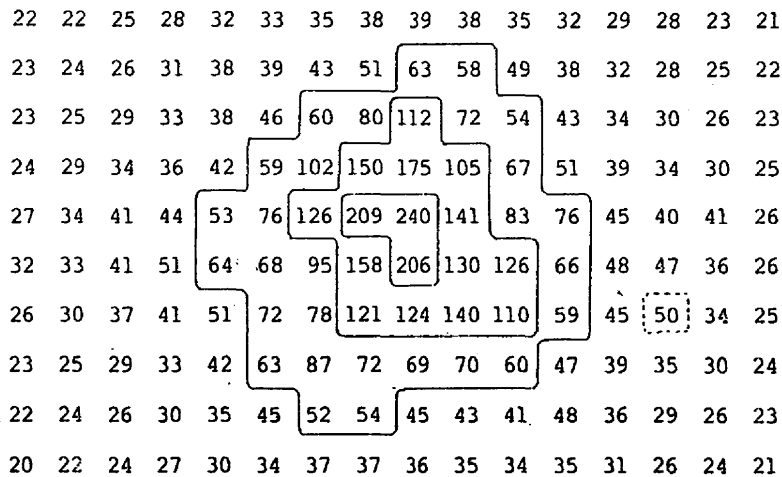


Fig.1-e,f. Core density maps for $Z_o=50\text{g/cm}^2$.
 Fig.1-g,h. Core density maps for $Z_o=100\text{g/cm}^2$.

(e)	(f)
(g)	(h)

inelasticity is uniform distribution of 0-1.
multiplicity is fixed to 9 and 1/3 of these are pi-zero.
production energy spectrum is exponential type.
transverse momentum distribution is $\exp(-P_t/P_m)$,
 $P_m = 0.4 \text{ GeV}/c$.

Decay of hadrons were not concerned except neutral pion.
Atmosphere is isothermal and the scale height is 7.0 km.

3. Results. In the case of $Z_0=10\text{g}/\text{cm}^2$, almost 50 percent of the cores have multi- and/or complicated structure. On the other hand, scarce cores (10 or less percents) have complicated structure, when $Z_0=50$ and $100\text{g}/\text{cm}^2$.

In Fig.1, typical examples of the core map are presented. The contour lines in the maps are drawn at the densities of (average density of the 16×10 detectors) $\times 2^n$, where $n=0, 1$, and so on. Small sub-peaks are marked by the broken line.

Even in the most simple structured cores, we can find some small scale sub-peaks in the case of $Z_0=10\text{g}/\text{cm}^2$. There is no examples having well separated multi-core, when $Z_0=50$ and $100\text{g}/\text{cm}^2$.

4. Discussion and Concluding Remarks. Multi-cored EAS was observed at the prominent rate at a mountain altitude (Ref.4). And, the balloon and airplane born EC detected gamma-ray families with large multiplicity, high rapidity density and large transverse momentum. And in the JACEE events the projectiles are identified to He and heavier nuclei.

Our simulation results indicate that these phenomena are closely connected. It can be said that the interaction feature like the gamma-ray families mentioned above and the sufficiently high first interaction point can produce multi-cored EAS at the prominent rate, but steep and simple structured cores scarcely.

References:

1. Ogita, N. et al. Canad. J. Phys., Vol.46, (1968)S164.
Thielheim, K.O. et al. Acta Physica 29, Supl.3(1970)519.
Dake, S. et al. Contribution to Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge (1984), and ICR-Report=121-85-2, University of Tokyo, (1985).
2. Burnett, T.H. et al.
3. Iwai, J. et al. Nuovo Cimento A, Vol.69, (1982)295.
4. Kino, S. et al. Rproc. ICCR, Vol.8, EA(1977)79.
Sasaki, H. et al. Proc. ICCR, Vol.8 EA(1979)190.
5. Nakatsuka, T. et al. proc.ICCR, Vol.11, (1981)326.