Heavy Primary Spectrum Obtained By "Jet Trigger" Method

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Abstract

In our chamber, multiple produced pions leave the dark spot on X-ray film just after the interaction point. We can detect the interaction events in our chamber by this dark spots ("Jet Trigger"). We construct the energy spectrum of the events detected by this way. This method is more efficient for heavy primaries. The detection efficiency of this method and the absolute flux of iron group primaries are reported here.

1. Introduction

In RUNJOB experiments, we detected the events by the shower spots on the X-ray films in the calorimeter layers. This method is efficient to detect high

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energy events. But it is not very much efficient to detect the events induced by the heavy primaries with the same energy par particle as protons, because the effective energy involved in the interaction is less in the nucleus interaction.

To avoid this inefficiency for the heavy component detection, we have been developing the new detection method, so called "jet trigger". In the jet trigger method, we detect the secondary particles near the interaction vertex as the small dark spot on the X-ray films. This depends on the multiplicity of the secondary particles, therefore this method is favored for the heavy components.

2. procedure of jet trigger method

1. automatic scan on the X-ray film

   X-ray films (40 cm x 50 cm) are scanned for the dark spot on the large stage equipped with CCD camera and coordinate encoders under the very loose conditions. For each spot,

   - the coordinates of the darkest point(peak) in the spot
   - average darkness of the spot
   - "volume" $= \int_{spot}$ darkness above a threshold dS

   are recorded.

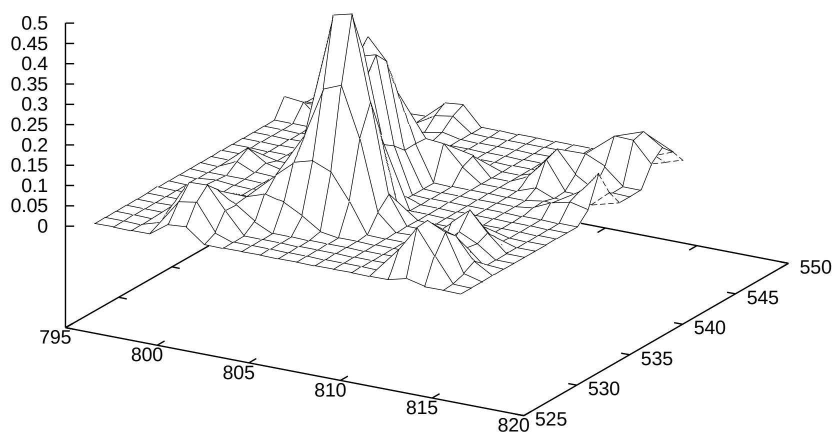

Fig.1 Jet spot after processed

More than several hundred thousands dark spots are detected par layer. Most of them are due to the following unwanted cause:

(1)scratches

(2)accidental dust

(3)low energy heavy primaries

(1) is removed as the spots on the line and (2) was removed by taking the data twice after cleaning up the film. (Most of the dust are accumulated during the data taking which takes 13 hours par sheet.) (3) are removed by the volume defined above. The volume due to the low energy heavy primaries is smaller than that of the spot produced by the secondary particles produced by the high energy interactions.

By these procedures, number of the candidate spots are reduced to about 3% of the original number.

2. scan on the nuclear emulsion plates

   After reducing the number, the emulsion plate just below the X-ray film is scanned for the real interaction events on the large stage, which is the same stage used for the X-ray scan. This stage guide to the point where we should check the spot found by the previous procedures. Most of them are noise spot which cannot be removed by the processes before. And the total number of the spots after this check turns out to be about 1000 par layer which is subject to the precise check by the higher magnification. Eventually we find 31 interaction events.

3. primary identification

   After we locate the interaction point explained above, we follow the same procedures as for the events found by the cascade showers to identify the primary track.

4. energy determination

   As for the energy determination, we employ the angular distribution method, using the pseudo rapidity parameter.

3. detection efficiency

To find the detection efficiency, we follow down the secondary particles and see how low the track density can be seen on the X-ray films. If the number of the secondary tracks within the radius of 20 μm is greater than 30, we can detect the event on the X-ray film.

Using this condition, we estimate the average detection efficiency for various primary energies of each primary nucleus with a certain zenith angle. The empirical formula of the detection efficiency is

$$\eta = \frac{a}{1+\exp\left\{\frac{b-\log E_0}{c}\right\}}$$

the parameters, a, b, and c depend on the zenith angle and our estimation is shown in Table 1 in the right.

$\cos\theta$	a	b	c
0.1∼ 0.2	18.6	2.15	0.330
∼ 0.3	34.3	2.47	0.403
∼ 0.4	38.6	2.32	0.457
∼ 0.5	31.2	2.09	0.447
∼ 0.6	30.8	2.05	0.468
∼ 0.7	27.3	1.97	0.502
∼ 0.8	26.8	1.94	0.521
∼ 0.9	27.9	1.96	0.589
∼ 1.0	27.5	1.89	0.559

4. absolute flux

Taking into the detection efficiency, the absorption and fragmentation in the residual atmosphere above our detectors, the absolute flux of the iron group of 8 events is shown in Fig. 2 with our RUNJOB and other experiment results which is obtained by the usual cascade trigger method.

So far we have analyzed only one block, but we can see that this method is really efficient for heavy primaries. So we can have more heavy primary events and extend the spectrum range.

Fig. 2 Absolute flux of cosmic ray iron primaries by jet trigger