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SEARCH FOR HIGH ENERGY MULTIGAMMA EVENTS AT THE ISR*

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ABSTRACT

This is a report of the preliminary results of our exploratory experiment at the CERN ISR on the search for multigamma events in proton-proton collisions. In this experiment we have observed an overwhelmingly large number of multigamma events especially at high multiplicities. The preliminary results also show a prominent peak in the energy distribution of the individual γ rays as measured by the 3-radiation lengths thick lead glass Cerenkov counters under the present triggering conditions.

This experiment was carried out by sharing the detection equipment of the CERN-Columbia-Rockefeller (CCR) group at the ISR. This group has been very kind to let us split the signals from some of the lead glass Cerenkov detector elements (the so-called HV counters) and generously provided us with the information on the energy measurements obtained in all the lead glass Cerenkov counter elements (the LB counters, as well as the HV counters). This was accomplished by using a common computer system which records our specific data as called for under our desired trigger signals.

The main objective of our experiment is to look for prompt multigamma ray events which may or may not be caused by non- π^0 origin. One of the reasons which prompted us into such an experiment is the fact that in 1955 Schein and later deBenedetti, Koshiba and others¹ had observed in cosmic ray experiments some multiple high energy γ events which could not be explained by ordinary shower processes. In 1969 Zwanziger and Ruderman² speculated that these showers could be accounted for by the production and subsequent annihilation of magnetic monopole pairs. A monopole pair, after being produced possess such a strong interaction between them that they will reannihilate unless they are produced with extremely high momenta so that they can escape from each other. According to Zwanziger and Ruderman such annihilation process with a mass of at least

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MASTER

Fig

10 GeV for each member of the pole pair, i.e., with a total mass of at least 20 GeV could be responsible for the observed high energy multigamma events. T.D. Lee pointed out that there could be other processes which may also be speculated as the source of such high energy multigamma rays, such as the creation and annihilation of high Z lepton pairs, etc. In any case, the existence of such high energy multigamma events could be extremely interesting and the center-of-mass energy of the ISR of ~ 56 GeV is sufficiently high to make such an investigation entirely feasible and worthwhile.

A sketch of the experimental setup is shown in Fig. 1 which is placed in duplicate sets at 90° on either side of the interaction region of the colliding beams of the ISR. The HV counters are lead glass blocks each $15\text{ cm} \times 35\text{ cm}$ in area and 7.5 cm or 3-radiation lengths in thickness. The LB counters also are lead glass blocks $15 \times 15\text{ cm} \times 35\text{ cm}$ thick. There are altogether 32 HV counters and 120 LB counters. The solid angle subtended by the whole detector system at the interaction region is about 20% of the total solid angle and only at the 90° region.

One should emphasize the fact that the present experiment is only of an exploratory nature since the detection system we used was the sharing of the existing equipment designed by the CCR group specifically for detecting electron pairs in their experiment. Furthermore, as mentioned earlier, this detection system covers only 20% of the total solid angle at the 90° region. The resolution in the γ multiplicity measurement is rather poor owing to the large size of the HV counters, each of which is $15\text{ cm} \times 35\text{ cm}$ in area. However, we do have 16 such counter elements on each side of the interaction region which enabled us to obtain an indication of multiplicity of up to 32 γ -rays in each event. Such an exploratory experiment could provide us sufficient information on the possible existence of multigamma events to decide whether a more sophisticated experiment would be justifiable to be pursued.

Since our primary objective is to obtain multigamma events, our trigger is based on the simultaneous firing of a number of the HV counters, mostly four out of the 32 and each is fired with a threshold energy of 160 MeV. This would most likely ensure that these triggered events are γ -rays and not charged particles since the average energy of a charged particle in such a HV counter deposits only ~ 70 MeV. We also had trigger modes of ≥ 3 , ≥ 2 , and ≥ 1 with the same energy threshold of 160 MeV in each of these triggered counters. Once an event was obtained by any trigger mode, we would then measure the respective energies and positions of all the counters fired together with the corresponding information on the charged tracks as determined in regard to their respective angles and positions as well as the pulse height as shown by the HV and LB counters traversed by these tracks.

It is imperative to ascertain pure γ -ray counts that are free from the charged particle and possible background effects. In order to achieve this, the following criteria and background measurements were taken into consideration:

1. After reconstructing all the individual charged tracks in each event then subtract out any HV counter which is fired but which contains one or more charged tracks traversing it. The resultant counts are then due to γ -rays only.

2. From the profile of the charged tracks originating from the interaction region as well as the surrounding regions of two colliding beams, it is evident that the tracks originating from outside the interaction region is only a few percent of the total number of tracks as shown in Fig. 2.

3. From a similar profile of a single beam alone (Fig. 3) and from the background measurements, the background values range from $\sim 3\%$ with a small size beam-beam (40 cm x 40 cm) counter to $\sim 10\%$ with the large size beam-beam (1 m x 1 m) counter.

4. Basing on (2) and (3) we select only those charged tracks which originate from the interaction of the colliding beams. Those tracks outside the interaction region are considered as either background or back scattering tracks.

5. After checking on a number of runs on the event-by-event basis, we found that less than 1% of the total events raise any suspicion of being caused by a charged or neutral particle entering from either side of the HV counters.

6. This holds true also for the LB counters.

7. The threshold energies of all the measured γ -rays were varied in the neighborhood of 70 MeV (which is the average energy loss by a charged particle in an HV counter) and compare the energy distribution of the γ 's to observe if there is any effect which would be attributed to charged particles. No change in shape of these distributions were observed except with slight change in the average multiplicity value.

The following results represent only a fraction of our total data. The rest are still being analyzed. These results are preliminary in nature since the small percentage of background due to various causes has not been subtracted out although the background effect is small and insignificant as far as our general conclusions are concerned.

All of our results obtained were based on the following trigger signal

$$(\geq n) \cdot (\Sigma_1 \cdot \Sigma_2) \cdot \bar{V}$$

where n is the number of HV counters fired, each with a threshold energy of 160 MeV, $\Sigma_1 \cdot \Sigma_2$ is the coincident beam counter signal; V is the veto signal from all the noise pick up, signal spikes and other known interferences which are gated out.

Figure 4 shows the integral γ -ray multiplicity distribution for four colliding beam energies from 11.7 GeV to 26.6 GeV in each beam. These results were obtained with a trigger mode of ≥ 4 HV counters at a trigger threshold of 160 MeV.

Figure 5 shows the average multiplicity of both the γ -rays and the charged particles as a function of the center-of-mass energy.

The charged multiplicity is correct quantitatively whereas the γ multiplicity should be viewed as a crude approximation since the resolution in the γ multiplicity determination is rather poor because of the large size of the HV counters. Therefore the comparison can be only qualitative in nature.

Figure 6 shows the integral γ multiplicity distribution for various trigger modes from ≥ 1 to ≥ 4 at a center-of-mass energy of 53.2 GeV. For comparison, an expected γ multiplicity distribution calculated from an uncorrelated π^0 production theory within the same angular region is also presented. It is strikingly evident that the detected high multiplicity γ -rays are several orders of magnitude higher than those predicted by the uncorrelated π^0 production theory.

Figure 7 shows the energy distribution of the γ -rays measured in the HV counters (3-radiation lengths thick) also at 53.2 GeV center-of-mass energy. A very prominent peak shows up at ~ 350 MeV, basing on the original energy calibration of the CCR group while detailed corrections basing on a new energy calibration is being worked out. However, the corrected energy values of the γ 's from the new calibration would probably push this peak energy to an even higher value than the present 350 MeV. This peak remains prominently even when the trigger mode was changed from ≥ 4 to ≥ 3 , and ≥ 2 and ≥ 1 respectively, and the energy value of this peak also remains unchanged (see Figs. 8 through 10). This seems to indicate that the peak is probably not caused by a trigger bias effect. Data from widely separated runs, i.e., runs separated by an appreciable period of time, also give rise to the same peak.

In spite of these evidences, we are not convinced that this peak is necessarily of a physical origin, but rather due to some combined instrumental and background effects. To better understand the nature of this peak, we are in the process of further investigation in analyzing the rest of our data in detail especially those which were obtained with different threshold conditions and at different beam energies.

Tentative conclusions can be drawn as follows:

1. Established existence of abundant number of high multiplicity γ events.
2. The estimated cross section for these high multiplicity γ events is several orders of magnitude higher than that of the γ 's from π_0 's in an uncorrelated theory.
3. The average multiplicity of both charged particles and γ -rays increases with increasing center-of-mass energy.
4. There exists a prominent peak in the γ energy distribution at ~ 350 MeV indicating some possible threshold phenomenon. (not excluding possible instrumental origin), which is under further investigation.

References

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Fig. 1

 

COMBINATION AMOBIAS IS SOLVENTE
LARGE & CIRCULAR - 10 TO 100 NM - NO

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THE FRINGE (40) CONTAINING THE OVERSPILL 1361 ENTRIES IN ALL

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7