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PROPOSAL TO SEARCH FOR MULTIPHOTON EVENTS

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We wish to resubmit, in a new form, our previous proposal to look for multiphoton events produced in high energy proton-proton collisions at the ISR.[1)]

We would look for these events at small angles with respect to the circulating protons in order to be able to observe the Schein-type γ-ray jets (apparently small production and opening angle[2)]).

As a first priority we would look for jets consisting of γ-rays only. We would set the multiplicity triggering level (see enclosed figure) at such a value that we observe the tail of the γ-multiplicity distribution due to the emission of π^os. A peak above this tail would indicate a new phenomenon. The detailed form of these γ-ray multiplicity distributions would of course depend on the cuts we introduce in angle and position. The combined information on multiplicity and angular distribution should in principle give the information we need. In addition, a γ-ray calorimeter will give us information on the energy of the shower.

As a second priority (and if space permits) we would look for γ-ray jets correlated with the emission of hadrons. Scintillation counters would have to be added (or possible derived from another experiment) around the intersection region (not indicated in the figure). This would be desirable if for example the γ-ray jets are emitted in the decay of excited hadrons, as suggested by T.D. Lee and M. Gell Mann.

A reason given for postponing our previous proposal was that searches for new particles should await higher beam intensities. Fortunately, this condition has now been fulfilled.

SCHEIN-type Events

A review of the literature on Schein type events[2] has revealed a total of 5 similar events, all observed in photographic emulsion flown at high altitudes. These five events are so similar that the possibility of their being flukes is remote and instead an unexplained physical process is indicated. They are all composed of pure photons numbering 10-20 whose combined energy as determined from the converted electron pairs is about 10^{11}eV and all have very small divergences, of 10^{-3} to 10^{-4} radians. They are unaccompanied by any hadronic particles, which suggests production in peripheral interactions similar to electron pair production. Since no incident charged particles are observed we assume production is by photons. Thus, the observed energy of these photon jets must represent nearly the full incident energy. Accordingly, using 10^{11} eV as a threshold energy for the production of these events together with the emulsion flight data and the known intensity of cosmic ray photons of $E\gamma > 10^{11}$ eV, one obtains the large production cross section of 10^{-27} cm^2 as a rough estimate.

At first we were not too hopeful of producing these events at the ISR because of the absence there of high intensity photons. We now believe, however, that virtual photons produced in p-p collisions may be equally effective. The Schein type photon jets have an unexplained and possibly very important origin. These events can be "rediscovered" at accelerators where a systematic study of their characteristics could lead to an understanding of their origin. Since the threshold and production cross section seem within reach of the ISR, a search specifically directed toward their detection has a good chance of success.

Experimental Equipment

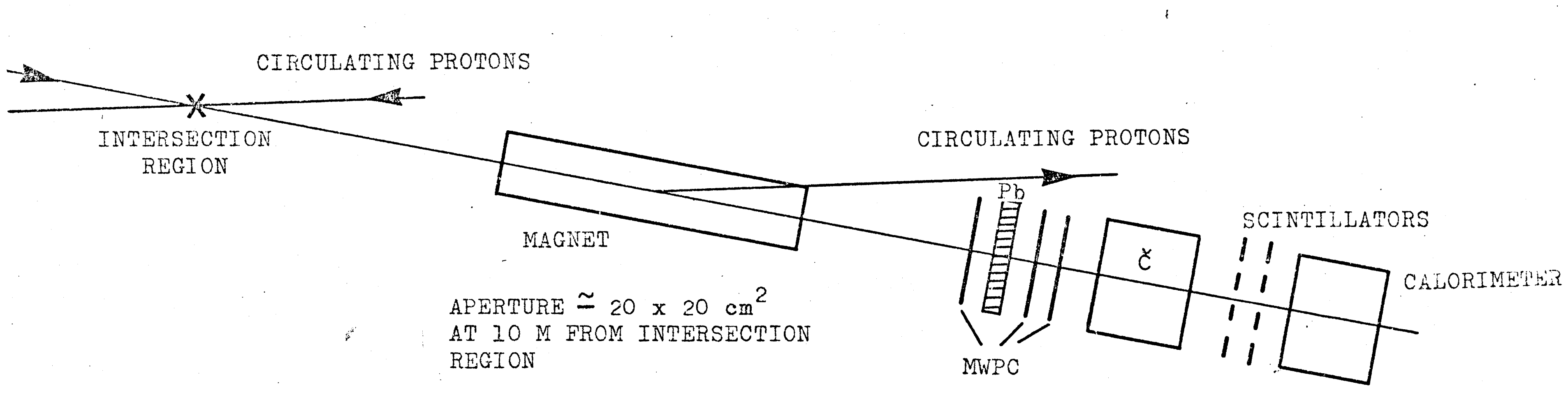
The needed characteristic of a suitable detection system is ability to detect simultaneous multiphotons diverging at very small angles (~ 10 mrad) with good time resolution. Spatial and multiplicity distributions should be obtained in order to distinguish photons from neutrons and multiphotons of the Schein type from multiphotons from decaying multi-π^o mesons.

Such a detection system is nearing completion in preparation for a run at the National Accelerator Laboratory. It is a largely self-sufficient apparatus which needs only to be located in a neutral 0^o beam (see figure) at a distance (for the ISR) of about 20 to 30 meters from an intersection. Recording may be accomplished at distances up to 30 meters from the detecting apparatus.

References

1. CERN/ISRC/71-14
2. See enclesed preprint

SCHEMATIC DIAGRAM OF EXPERIMENTAL LAYOUT



An Unexplained Multiphoton Phenomenon

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During the period from 1954 to 1956 there were several reports [1,2,3,4] of unusual events observed in photographic emulsions exposed to high altitude cosmic rays. These events all involved the conversion of multiphoton jets into electron pairs within the emulsion. None of the authors had an explanation of their event but most pointed out they were not cascade showers nor multiphotons from the decay of π^o mesons. Since then, no new events of this type have been reported and the original ones remain unexplained, perhaps examples of an undiscovered phenomenon. It is the purpose of this letter to compare these events (there are five of them), and point out why it is difficult to explain them in terms of accepted physical processes. Individually, these events may be considered to be "flukes" but when compared with one another they show so many similar characteristics it is difficult to escape the conclusion that they have a common origin.

The first of these events was reported by Marcel Schein, D. M. Haskin, and R. G. Glasser[1] in emulsions exposed for six hours at 100,000 ft. altitude. Subsequently, four more rather similar events were reported by other [2,3,4] under similar conditions. All these events consist of multiphotons number 10-20, as evidenced by electron pair production occuring in the emulsions. In all of

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these events: a) the total energy of the photons approximates 10^{11} eV; b) no charged particles of any kind are found to accompany the incident photons; c) the angular spread of the photons with energy $E > 1$ GeV/c^2 and converted in the first radiation length of emulsion is 10^{-3} to 10^{-4} radians. Table I gives the total energy of the various events, the number of photons converted in the first radiation length and the angular spread, all as reported by the various authors.

The uniqueness of these events is centered on two questions:

1. Can they be extreme statistical fluctuations of a conventional electromagnetic shower produced by a single photon?

2. Are they multiphotons originating from the decay of multiply produced π^o mesons?

Concerning question 1, the authors make the following observations:

a) The number of electron pairs occuring in the first radiation length of emulsion measured from the beginning of the events is large compared to the one or two to be expected in a normal electromagnetic shower.

b) Multiphotons incident on one radiation length of converter would be converted, neglecting attenuation, with uniform probability throughout the converter. A conventional electromagnetic shower, which developed unusually rapidly from a single photon, however, must show conversions which increase with depth. A comparison of all five events shows a distribution of pair formation which is more or less uniform within the first radiation length of emulsion. Figure 4 of reference 3 shows this in a quantitative manner for their event.

c) In electromagnetic showers produced by single photons the energy of the first pair must be greater than all succeeding pairs and in general, the pair energy is degraded with depth. The five events all depart from these conditions and specifically Fig. 4 and Fig. 5 of Reference 2 show that the energy distributions of the electrons observed in their two events is very different from the energy distribution expected from electromagnetic showers as calculated by Arley[5].

d) If the jets represented an advanced stage in the development of a conventional shower the multiphotons would be accompanied by electrons. In all five events all electrons observed are attributed by the author to photon produced electron pairs indicating a jet of pure photons.

In summary: the possibility of explaining these multiphoton events as statistical fluctuations of single photon-produced electromagnetic showers seems excluded.

Concerning question 2, it is not possible to explain the events as multiphotons from multiply produced π^o mesons for the following reasons:

a) the two photons from a decaying π^o meson are emitted at a laboratory angle which depends on the energy of the meson ($\langle\theta\rangle \sim \frac{2M_{\pi^o}}{E_{\pi^o}}$). For example, an event with 10 photons and a total energy $E \sim 10^{11}$ eV would, if the photons came from π^o mesons, have an angular divergence $\theta > 1.5 \times 10^{-2}$ radians even neglecting the divergence of the π^o mesons. This angle is inconsistent with the small observed divergences of $\theta \sim 10^{-3}$ to 10^{-4} radians.

b) Multi π^o production is a consequence of nuclear or nucleonic interactions from which charged mesons should also be produced. The absence of charged particles in <u>all</u> the events argues against the production of multi π^o mesons.

A most significant feature of these five events is the absence of any other charged particles in the vicinity of the multiphoton jets. In spite of careful researches no charged particles other than the electron pairs could be found in the neighborhood of the jets. This suggests first, that the jets were initiated by an uncharged particle, presumably a photon, and second that the interactions must have been peripheral in character because secondary charged particles would be expected if appreciable momentum were transferred to the struck nucleon. Almost the full incident energy must then appear in the jets which suggests that photons with 10^{11} eV or greater can produce them. Measured intensities of cosmic ray photons (NASA, TTF594) combined with the reported duration of the exposures and area of the exposed emulsions can be used to estimate the production corss section for these jets on the assumption they are produced by photons. This yields the surprisingly large cross section of $\sigma \sim 3 \times 10^{-25} cm^{-2}$. These estimates for the threshold energy and production cross section mean that the uncertainties [6] concerning the origin of these jets can be settled by an experiment at the National Accelerator Laboratory where the expected photon intensities above 10^{11} eV should be sufficient to produce several thousand events per hour.

Table I

MULTIPHOTON EVENTS PRODUCED BY COSMIC RAYS
RECORDED IN PHOTOGRAPHIC EMULSIONS

Reference	Total Energy of Photons in eV	Number of Photons Converted in 1st Radiation Length	Angular Spread of Photons in Radians
M. Schein *et al.* Phys. Rev. 95, 855(1954)	$> 5 \times 10^{10}$	16	$\sim 10^{-3}$
A. Debenedetti *et al.* Nuovo Cimento 12, 954(1954) 1)	$> 4 \times 10^{10}$	12	10^{-3}
2)	$> 6 \times 10^{10}$	6 (25 in 1.5 r)	10^{-4}
M. Koshiba *et al.* Phys. Rev. 100, 327(1955)	$\sim 10^{11}$	11	$\sim 10^{3}$
L. B. Silva *et al.* Nuovo Cimento 3, 1465(1956)	$> 10^{11}$	15	$< 10^{-4}$

References

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