CERN ISRC 71-14

3/11/71

EXPERIMENTAL PROPOSAL TO THE ISR AT CERN TO SEARCH FOR MULTIGAMMA EVENTS FROM MAGNETIC MONOPOLE PAIRS

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(See last page for Summary)

The purpose of this experiment is to look for events that have associated with them multigamma rays with multiplicities too high to be attributed to known sources. Such multigamma events, would, in the light of the explanation given by Ruderman and Zwanziger (Phys. Rev. Letters 22, 146 (1969)), be evidence for the existence of the Dirac Magnetic Monopole.

Ruderman and Zwanziger point out that magnetic monopoles, if they exist, could hardly ever be created in a free state because the extremely strong and long range attractive force experienced by a pair during their production results in the dissipation of most of the available energy as bremsstrahlung before they can succeed in getting apart. It is not possible to predict the characteristics of the expected gamma rays because these depend on the unknown details of the production dynamics (monopole mass coupling, etc). A good guess, however, is that both hard (~ 1 GeV) and soft (1 MeV) gamma rays will be produced in profusion. Lower limits can be put on the multiplicity of photons using classical electrodynamics when the separation of the paired monopoles exceeds the range of nuclear forces ($r_o > 10^{-13}$cm). For soft photons, R & Z have made an analog between the radiation emitted during beta decay, the so called inner bremsstrahlung, and that from monopole pairs at $r > r_o$ and predict multiplicities of the order of 10^2 at center of mass energies on the order of those available at the ISR. Additional hard gamma rays associated with the production process and additional soft ones associated with the decay of the bound system of monopoles will also exist. In all, R & Z predict that most of the center of mass energy going into monopole pair production will be converted into gamma rays, hard and soft.

The key point in our preliminary search will be to detect multigamma events and to distinguish possible monopole gammas from multimeson decay gamma rays on the basis of their different multiplicity distributions. Fortunately, we now know fairly well what to expect from π^o mesons as a result of the cosmic ray experiment by L.W. Jones et al., (PRL 25, 1679 (1970)). The total charged multiplicity was found to average about 7, and to extend up to something like 14 for p-p collisions at center of mass energies comparable to those at the ISR. Since the average number of π^+ plus π^- might be expected to approximate the number of γ-rays from π^o mesons, these distribution curves of Jones can be used directly to estimate π^o gammas. The expected multiplicity from monopoles is thus expected to exceed π^o gammas by an order of magnitude.

The apparatus to detect these multigamma events is quite simple. Two proportional chambers (75cm x 75cm) are separated by a converter of lead and this combination would be placed above and quite close to one of the intersection volumes to subtend a solid angle as large as 2 steradians. Gamma rays will be distinguished from charged particles by using the first proportional counter as a point by point anticoincidence device. If initially gamma rays of unusually high multiplicity are observed there are three types of further observations one can make to investigate their origin.

1. The frequency distribution of multiplicities from these gamma ray events.
2. The energy distribution of the constituent gamma rays with multiplicity.
3. The angular distribution.

The energy and angular distributions in the model of R & Z are not predictable since they depend on the details of the interaction, of course, not known. Thus energy and angular distributions will not be helpful at the start in distinguishing monopole pair gammas from π^o gammas. Positive results, however, from the measurement of multiplicity distributions indicating that anomalous high multiplicities of gamma rays exist would motivate us to measure the angular and energy distributions as well. Each of our chambers for reasons of simplicity and cost will have only one set of 350 wires. The chambers will be orientated with the wires parallel to one another. When the need is to count the number of gammas, poor resolution is wanted so as not to resolve the individual electrons in the shower. When we wish to determine the spread of the shower from individual gammas to get some idea of its energy, the back chamber can be separated from the converter and moved further back.

We propose to observe the number of charged particles and the number of converted gamma rays traversing our detector when place above the intersection and estimate the total number of each by assuming isotopic distribution around the beam direction. If our detector is placed 50cm from the intersection point we should detect 1/10 of the produced γ's or ~ 10 for monopoles and .5 for π^o gammas assuming isotropic distribution of the gamma rays. On the basis of 10^5 interactions per second, our resolving time of 60ns provides assurance against accidentals (particularly since most charged particles are concentrated at small angles to the beams.) At the closest possible position of the detector, about 10cm, the detector would subtend one third of the 4π sr. solid angle. At a luminosity of $4 \times 10^{30} cm^{-2} sec^{-1}$, a counting rate of one in 100 seconds would correspond to a cross section of about $5 \times 10^{-33} cm^2$. There is no reason to think monopole production cross sections are this small and luminosities a factor 10 to 100 less would still make a preliminary search advisable.

We measure simultaneously charged particles and gamma rays. By assuming π^o mesons have similar distributions and are one half as numerous as charged ones we will, using Monte Carlo methods estimate for the three detector positions, (listed below) the gamma rays to be attributed to π^o mesons. Thus we will know roughly what numerical distributions to expect from π^o gammas and any observed departure from these distributions will constitute evidence for monopole pair gammas. We are aware that our apparatus lacks redundancy, a consequence of the small number of proportional chambers. This leaves us somewhat vulnerable to unexpected backgrounds and misinterpretations of some incident charged particles.

However, the process of subtracting the estimated π^o gamma ray distributions from the observed distributions will tend to compensate for such errors.

We propose to appear at CERN with the detector and readout system tested in cosmic rays as soon after October of this year as possible. We propose further to place this detector in three positions with respect to the center of Intersection 6, all, as far as we can see, compatible with the deployment of the Cern, Aachen, Geneva Torino experiment or the Pisa-Stony Brook experiment. These positions are:

1. 10cm directly above the center of the intersection.
2. 50cm directly above the center of the intersection.
3. 50cm from the center of the intersection but tilted 45^o to the plane of the intersecting proton beams.

We estimate that a preliminary search could be carried out in about two hundred hours of running time depending on beam intensity. This time would be used in establishing the proper functioning of the apparatus, in determining various background rates and in collecting data at the three positions. Analysis of the data collected could be carried out within a few hours.

If high multiplicities were found one would want to modify our detector and expand the experiment to determine the energy distribution of the gamma rays and the effect of incident proton energy on the phenomena.

The participating institutions in this proposed experiment are CERN, the Brookhaven National Laboratory and the Virginia Polytechnic Institute-State University. Dr. Arne Lundby and members of his group will in addition to participating in the experiment act as liason at CERN. Dr. Joachim Fischer and members of his group at BNL are already developing and constructing suitable chambers and readout system. The VPISU group (Professors Collins, Ficenec, and Trower together with two graduate students) and the BNL group will jointly test the system and develop the software necessary to record and interpret the results during the run. George Collins is acting as coordinator of the program.

Summary of Requests

Space Needed Near Intersection: An area above Intersection 6, 90cm along beams x 125cm across beams, located (a) 10cm and (b) 50cm directly above the center of the intersection and (c) center of detector 50cm from center of intersection and at 45^o to plane of the beams.(See sketch below)

Running Time: Approximately 200 hours after October 1971.

Space Needed at Remote Location: 20 to 30cm^2 to house controls and computer.