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# SEARCH FOR SHORT LIVED PARTICLES PRODUCED BY 300 GeV PROTONS IN EMULSIONS


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## Summary

It is proposed to search for short-lived particles with lifetimes in the range of $10^{-12} - 10^{-14}$ sec., produced in the interactions of 300 GeV protons with emulsion nuclei. The signal would be a neutral or charged decay close to the primary proton-nucleus interaction.

We request the exposure of two stacks of Ilford G5 emulsions, each of 80 plates of 10 x 10 x 0.06 $cm^3$, to 300 GeV protons with a density of $10^5$ protons/$cm^2$, with a total exposure of 4 x $10^6$ incident protons per stack over an area of 5 x 8 $cm^2$.

The experiment should be sensitive to the production of new particles if they have a mass of 1 - 8 GeV and if their production cross-section is larger than 1 $\mu$b.

# 1 INTRODUCTION

The recent discovery of the $\Psi$-particles has given new impetus to the search for charm particles[1]. These should have masses of 2 - 5 GeV, lifetimes of the order of $10^{-13}$ sec. and should be produced in pairs in hadron-hadron collisions.

The short lifetimes mean that their direct detection (direct in the sense of separating production and decay vertices) is at present possible only with nuclear emulsions.

A charm event candidate would have one or two decays of charged or neutral particles in two or more particles. The decay vertices should be connected to a neighbouring production vertex.

Estimates of the production cross-section of charm particle pairs in very high energy hadron-hadron collisions are very uncertain, ranging from 1 mb down to a fraction of a $\mu$b.

The purpose of the proposed experiment is to detect heavy short-lived particles with lifetimes in the range of $10^{-12}$ - $10^{-14}$ sec., produced in proton-emulsion nuclei collisions by 300 GeV protons to a cross-section limit of $\simeq 1 \mu$b.

# 2 EXPERIMENTAL

## 2.1 Exposure and scanning

We propose to expose two stacks of Ilford G5 emulsions to protons of 300 GeV/c. The first stack will be made of 80 pellicles, each 600 $\mu$ thick and 10 x 10 $cm^2$ in area. Assuming a proton beam of uniform density over an area of 5 x 8 $cm^2$, we request a total exposure of 4 x $10^6$ protons, corresponding to $10^5$ protons per $cm^2$ (Fig. 1).

We plan to perform a fast area scan over the first 5 cm of the plates, that is for 5 x 8 = 40 $cm^2$ of each plate (see Fig. 1). This restriction comes primarily from the necessity to reduce the observation of secondary interactions.

As already stated, the signal we are looking for is a neutral or charged decay vertex associated with the primary interaction. Thus when an interaction is observed we will look for decays, following the jet of particles produced from about 20 $\mu$ to 500 $\mu$. The lower limit of 20 $\mu$ is dictated by the difficulty of observation at small distances from the vertex when the number of charged particles produced is large.

### 2.2 Detection efficiency

There are a number of factors affecting the detection efficiency of charm particle candidates. These have been studied in detail in ref.2 and will be summarized here:

1. Decay lifetime. We estimate that we shall be able to observe events with decay lengths between 20 and 500 $\mu$. This results in losses at both small and relatively long lifetimes.

2. Minimum decay angles observable. Assuming masses of 2 - 5 GeV and a minimum detectable angle of a few degrees, all the neutral decays ($V^o$ events) and about 80% of the charged decays will be visible for secondary momenta below 50 GeV. For higher momenta the scanning efficiencies will be about 40% and 20% respectively.

3. Geometrical losses, including losses due to confused multiprong events, dip losses of events at the borders of the plates, should limit scanning efficiencies to 60 - 80%. The overall detection has been estimated to be about $\gtrsim$ 20%.[2]

### 2.3 Background

Background events may originate from interactions on neutrons, $e^+e^-$ pairs, decays of strange particles, etc. Most of this background occurs with equal probability over the distances of 20 - 500 $\mu$ envisaged in this experiment. Thus in principle one could discriminate real events from background ones on the basis of the time-distribution. In practice this would require a very large number of events. Thus one probably relies more on the detection of "lucky" events, for instance with leptonic decays, and on associated production of charm particles, that is on the simultaneous detection of the decays of two particles produced in the same event.

For this type of events we estimate one background event in about $10^5$ interactions.

### 2.4 Cross-section limit

The cross-section limit is probably dictated by background problems at the level of approximately one in $10^5$ interactions, that is $10^{-5}$ x 40 mb $\approx 0.4\ \mu b$.

## 3. SCANNING AND MEASURING

For this experiment we will resurrect the microscopes and the equipment used over ten years ago by the old emulsion group in Bologna. Several of the proponents were members of that group. The experiment will be carried out in collaboration with the graduate school (Scuola di Perfezionamento in Fisica) and will thus involve young physicists and students.

## 4. CONCLUSION

The experiment will allow us to see the production of new particles if they are produced with a cross-section larger than $1\ \mu b$, have masses in the range of 1 - 8 GeV and lifetimes of $10^{-12} - 10^{-14}$ sec.

REFERENCES

1. M.K. Gaillard, B.W. Lee and J.L. Rosner, Search for charm, FERMILAB- Pub-74/86 -THY and 75/14.

2. P. Capiluppi, Ricerca di Particelle con charm in emulsioni nucleari, Scuola di Perfezionamento in Fisica, Università di Bologna (1975).

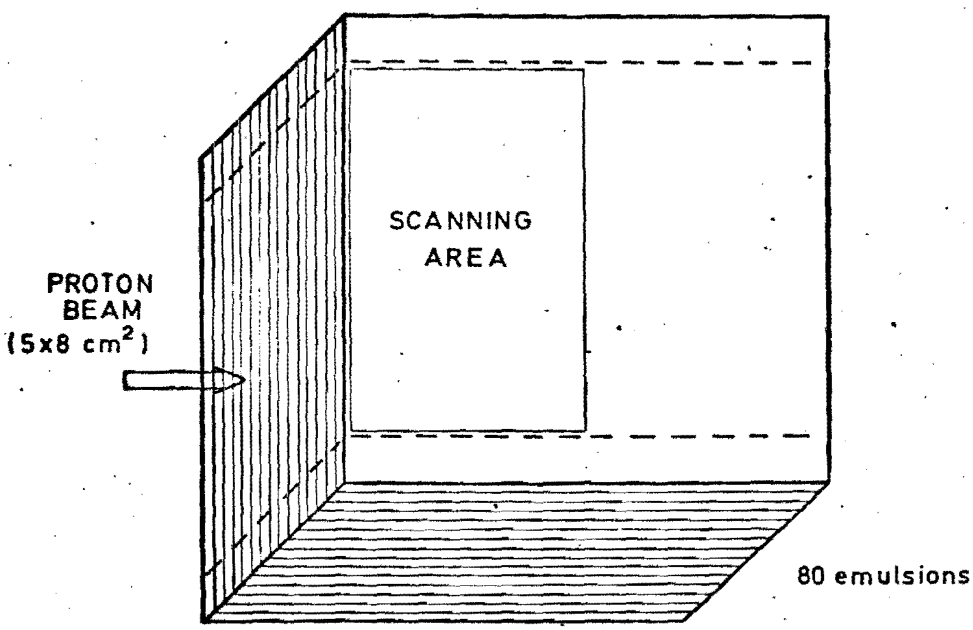


Fig. 1 Layout of the proposed stack of 80 pellicles of Ilford G5 emulsions exposed to a beam of 300 GeV protons having a uniform illumination over 5 x 8 cm$^2$.