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SEARCH FOR HEAVY, SHORTLIVED PARTICLES

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Aim: To search for possible new, heavy particles with lifetimes around 10^{-13} sec. The signal would be a decay near the production vertex, using nuclear emulsions as target and detector.

Physics: The existing speculations that charmed particles might exist are taken as basis for the planning (Ref. 1,) Well above the treshhold energy, the production cross section is expected to be reasonably large, i.e. of the order of 1mb. This means that in nuclear emulsions, associated production would occur in a few procent of all reactions. The detection efficiency might be low, but still sufficient to make a search sûccessful among some 10.000 reactions. Depending on the magnitude of the detection probability observation of associated production might or might not be possible in the present proposal. As a first step we propose to search only for a signal with a lifetime of about $10^{-13\pm1}$ sec.

Method: The detector with highest space and therefor highest time resolution seems to be nuclear emulsions. A lifetime, τ, will give a visible track length of $\gamma\beta c\tau$ cm. Using a γ-factor around 10 and a lifetime around 10^{-13} sec, the tracks would be around 300 μm. Since one usually develops to 20 grains/100μm this is an easily resolved distance. Some considerable latitude in lifetimes around 10^{-13} can still be detected (Ref. 2). Lifetimes in this range are expected to occur (Ref. 1).

The signal would be a mixture of topologies, such as neutral particle decays into charged states, and decays of charged particles into one, three, five or more charged particles. Particular care has to be observed in the case of topologies with one or three final state particles. In the first case only high transverse momentum decays would be detectable. However, a heavy new particle should quite often give rise to such final states. In the case of the topology with three charged particles great care has to exercised to distinguish this mode from background events (see below).

Background problems

We have considered the following sources of background.

1) Strong interactions of secondary particles near the production vertex

2) Weak decays of secondary particles near the production vertex.

3) Electromagnetic events, preceeded by π^0 decay, and giving e^+e^- pairs near the production vertex.

All of these backgrounds will be constant per unit interval of range in the important region near the vertex, wheras the signal from new particles will decay with increasing range. However, chance juxtaposition of an e^+e^- pair and a charged secondary track will appear as "pseudo-tridents" with a frequency that diminishes with increasing distance from the vertex. This kind of π^0-produced background (topology with three particles) constitutes therefore a confusing background. It can be experimentally accounted for by observing pairs further downstream and might be resolved from the signal on a statistical basis. It could also be that opening angles are different for the signal and the background, thus making it possible to greatly reduce this type of background.

Request

We propose to expose an emulsion stack to a 400 GeV proton beam over an entrance area of 10 cm^2. We would like to have a flux of about (2-3) x 10^5 protons/cm^2. The emulsion surfaces would be placed parallell to the beam.

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References

1. - B.J. Bjørken, S.L. Glashow, Ph.L. 11, 255(1964)
   - D. Amati et al. Nuovo Cimento 34, 1732(1964)
   - P. Dittner, S. Eliezer, T.K. Kuo, Phys.Rev. l. 30, 1274(1973)
   - S.L. Glashow, J. Illiopoulus, L. Maiani, Phys. Rev. D2, 1285 (1970)

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2. One of us was in 1950 concerned with the first attempt to measure the π^0 lifetime (Phil.Mag. 41, 701, 1950, Carlson (=Ekspong) Hooper and King). During this Bristol-work professor C.F. Powell remarked that he had such a great confidence in Nature that he thought that the lifetime of π^0 would be measurable by us. His remark was a reply to my remark that it would be coincidental if the π^0 lifetime was adjusted to our then available technique which put a limit at a few times 10^{-14} sec. Maybe, Nature is living up to Cecil Powell´s expectations now some 25 years later.