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LETTER OF INTENTION

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To : Members of the EEC

From : G. Conforto (CERN)
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Subject : Proposed use of the HPD for a new measurement of the π^+ (and of the K^+) lifetime

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The recently developed HPD scanning machine has already completed the analysis of a spark chamber experiment and several others are scheduled to be analysed in the near future.

No attempt has so far been made to use such a device in order to analyse oscilloscope pictures.

We propose to study this possibility in connection with a simple experiment, i.e. the measurement of the π^+ lifetime. The same technique can be used in future for a better determination of the K^+ lifetime. This will give us the opportunity of learning as much as possible about the HPD and its operation. Since, at present, the main limitation in the use of the HPD seems to be the programming, we have in mind to take care of all the programmes needed for the suggested experiment. Due to the fact that the pictures we propose to take are by far simpler than the spark chamber pictures, this task does not seem too ambitious and the load for the DD Division should be restricted to give us, at the beginning, the information and the assistance we may need.

The theoretical considerations which make a measurement of the pion lifetime interesting, have been discussed by Goldberger and Treiman[1] and are well known; furthermore, the pion lifetime is one of the quantities which enter in the determination of the "Cabibbo angle"[2].

In addition to that, from a purely experimental point of view, one notices that pion decay physics is more and more becoming a few-percent accuracy type of physics, and that in some cases the main limitation comes from the imperfect knowledge of the pion lifetime. For instance:

i) the $\pi^+ \to \pi^0/\pi^+ \to \mu^+$ branching ratio as predicted from the CVC theory is expected to be $(1.06 \pm 0.02) \times 10^{-8}$ where the main contribution to the error comes from the π^+ lifetime[3]. The experimental determination of this branching ratio will very soon reach an accuracy better than 10%.

ii) The error in the recent measurement of the $\pi \to e/\pi \to \mu$ branching ratio[4] (2.25%) is to a large extent due to the poor accuracy of the pion lifetime.

The mean life of the positive pion has been measured by several groups, and the best value available at present is the one obtained at CERN by Ashkin et al.[5], $\tau_\pi = (25.46 \pm 0.32)$ nsec. This value comes from the analysis of oscilloscope pictures of ~ 8000 π-μ decays.

The quoted error, 1.25%, is mainly due to the small statistics. The systematic error, estimated to be of the order of 0.5%, is essentially due to:

i) the non-linearity of the scope sweep (0.3%);
ii) the ± 0.2 nsec uncertainty in the determination of the time position of the observed pulses (0.1%);
iii) the uncertainty in the π-μ-e background evaluation (0.1%).

It is clear from this data that the experimental approach described by Ashkin et al. can still be used, in order to improve the measurement of the pion lifetime. In fact, the K^+ lifetime, measured with the same technique, i.e. from the displayed pulses from K^+ decays, is better known than the pion lifetime, $\tau_K = (12.31 \pm 0.11)$ nsec (relative error = 0.9%)[6].

We propose therefore, a new measurement of the pion lifetime, following very closely the two above-mentioned experiments.

The use of a more modern oscilloscope with a very good linearity (for instance Tek. 519) should allow us to decrease considerably the main contribution to the systematic error[7].

As already mentioned, in order to analyse the oscilloscope pictures, we propose the use of the HPD, bearing in mind the following considerations.

i) The use of an automatic scanning device is essential if one wants to analyse a large number of pictures, as is imperative in this case;

ii) The use of the HPD also helps in reducing the systematic errors because:

   a) a much more detailed digitization of the event is possible (only 4 points per sweep were measured in the experiment of Ashkin et al.);

   b) a frequent and very accurate digitization of sweeps displaying a sinewave, is essential in order to have very precise empirical functions with which to correct the sweep non-linearity;

   c) the better space resolution obtainable with the HPD should decrease the source of systematic errors (ii) in the experiment[5].

iii) The pictures we propose to take satisfy the requirements of simplicity which we should like to have. All the events have to be measured, so that no scanning is required from the HPD; no space reconstruction and no optical corrections are needed.

The number of particles which is worth collecting, is of course, determined by the magnitude of the systematic errors.

Due to the above-mentioned improvements with respect to the experiment[5], even under rather pessimistic assumptions a systematic error less than 0.3% is expected. In this case, in order to match the statistics with the systematic errors, ~ 100,000 analysed events would be necessary, and the final error would be of the order of 0.4 - 0.5%. It is hoped, however, that a systematic error $\lesssim$ 0.1% could be obtained and then, with the appropriate statistics of ~ 10^6 analysed events, the measurement would reach an accuracy comparable with the one obtained in the measurement of the μ^+ lifetime.

In addition to what we have said above, we would like to point out the following:

i) All the programmes written for this experiment may be used in the future as a general HPD facility for analysing oscilloscope pictures.

ii) The above-mentioned considerations regarding the use of the HPD may possibly apply also to the Luciole scanning device. This point still deserves some investigation.

iii) In principle, no SC machine time as main users is needed. The complete experiment may be carried out entirely by parasiting on someone else.

iv) All the equipment we foresee using, already exists.

v) The time required for the experiment should be of the order of a few months.

vi) The experiment is very cheap, and Professor G. Fidecaro has kindly accepted that we carry out this experiment in his group.

vii) In case the load of HPD time should become excessive for CERN, the main production run could be carried out at the Italian HPD in Bologna.

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