NAL PROPOSAL 195

Scientific Spokesman:

Y. K. Lim
Department of Physics
University of Singapore
Bukit Timan Road
Singapore, 10

Phone: 50451

PROPOSAL TO MEASURE THE LIFETIME OF THE NEUTRAL PION

Y.K. LIM

INTRODUCTION.

We propose here an experiment to measure the lifetime of the neutral pion using high energy proton-nucleon and proton-nucleus interactions in nuclear emulsions. Many attempts have been made in the past to measure the π^o lifetime. Shwe reported the lifetime to be $2.0 \, ^{+.5}_{-.3} \times 10^{-16}$sec in 1962[1]. His method relied on the relativistic time dilation and the π^o path length was measured directly in nuclear emulsions. The path lengths ranged from .2 to 2.3μ which represent the limit of length measurability in nuclear emulsions. The two most recent measurements of the π^o lifetime through Primakoff Effect give $(.64 \pm .06) \times 10^{-16}$ sec[2] and $(.4 \pm .04) \times 10^{-16}$ sec[3], while the particle Data Group gives the weighted average value of the lifetime as $(.84 \pm 1) \times 10^{-16}$ sec[4]. Although most of the discrepancies may be due to experimental biases, there is reason to believe that there may also be theoretical uncertainty of interpreting the data in the experiment using the Primakoff Effect. Now that we can have 20-30μ path lengths before π^o decay in nuclear emulsions using 200-300 GeV protons, we believe that a new measurement of the π^o lifetime by direct method is clearly needed and desirable.

EXPERIMENTAL PROCEDURE.

The decay path length of π^o is the distance between the π^o production vertex and the decay point. The production vertex is found from the intersection of the trajectories of the relativistic charged secondaries and the incident proton. The π^o decay point is taken to be the vertex of the e^+e^- Dalitz pair. The average decay path length of 70 Gev π^o is 15 μ. Here we assume the lifetime to be

1×10^{-16} sec.

The path lengths can be measured accurately to one or two grain diameters, i.e. 0.5 to 1 μ. This will not introduce any appreciable error in the measured path length distribution.

RATES AND ACCURACY.

The multiplicity of charged secondary particles from 200 Gev P-P collision is reported to be $7.65 \pm .17$[5]. Assuming that the number of π^o is half of the total number of charged pions, we expect ~ 3 π^o's per collision.

The Dalitz mode of neutral pion decay occurs with a frequency of about one in eighty. The number of Dalitz pair expected per event is therefore 0.038.

The accuracy in the measured lifetime value is primarily determined by statistical errors. These in turn depend on the number of Dalitz pairs analysed. Based on the experience of Shwe[1], a total accuracy of better than 25% error may be achieved with 100 pairs.

A serious objection to Shwe's experiment has been the small neutral pion path lengths available for measurement. This might conceivably cause a systematic shift of the observation towards higher lifetime. Such an objection will not apply in the proposed project, where the path lengths are increased by at least one order of magnitude.

EQUIPMENT AND RUNNING TIME.

In Table I we list the equipment which are available to us. In Table II we list the exposure requirements.

Working on the basis of 100 Dalitz pairs, 3000 proton-nucleus collisions are to be scanned. The scanning is

expected to take 800 to 1200 man-days. Measurements, including a determination of charged pion momentum spectrum, will take about 2 man-years.

PROPOSER'S QUALIFICATIONS.

Y.K. Lim, Ph.D. 1957, University of Melbourne.

Present position: Associate Professor, University of Singapore.

Past employment:

(1) Research Associate, University of Illinois (1961-1962)

(2) Research Physicist, Emmanuel College, Boston (1964-1965, 1967, 1968).

Relevant publications:

(1) 'Meson Production in Interactions of 26.7 BeV/c Protons with Emulsion Nuclei' - Nuo. Cim. 26 1221 (1963).

(2) 'Effective Target Mass in Interactions of 26.7 GeV/c Protons with Nucleons - Nuo. Cim. 28 1228 (1963)

(3) 'Low Energy Primary Cosmic Ray Nuclei of Charges ≥ 6' - Nuo. Cim. 40 102 (1965)

(4) 'Direct Pair Production Cross Sections of Positrons of Energies 1-4 GeV' (In preparation).

REFERENCES

1. Shwe: UCRL - 10118 (1962)
2. Kryshkin et al: JETP 30, 1037 (1970)
3. Belletin et al: Nuovo Cimento 66A, 243 (1970)
4. Particle Data Group: Phys Letters 39B (1972)
5. G. Charlton et al: Phys Rev Letters 29, 515, (1972).

Table 1. Equipment available at University of Singapore

1 Leitz nuclear track microscope

1 Leitz Ortholux scanning microscope

2 Cooke Troughton & Simons scanning microscope

1 Olivetti P102 programmable calculator.

Table 2. Exposure requirements

3 packets of Ilford G5 nuclear emulsions, each consisting of 10 stripped 600μ thick 4 in x 7 in emulsions, to be exposed end-on (target area: 6 cm^2/packet).

Packet	Total beam intensity
A	5×10^4 protons/cm^2
B	10^5 protons/cm^2
C	5×10^5 protons/cm^2

Coordinate grids are to be imprinted on the emulsions.

Note: The above may be adjusted to suit machine requirements.

****