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THE DYNAMICS OF π - μ DECAY IN FLIGHT

M. Lynn Stevenson

July 25, 1956

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ABSTRACT

The dynamics of π - μ decay in flight are presented in graphical form for pion kinetic energies (T_π) from 5 Mev to 100 Mev. For each of these energies the following quantities have been plotted:

- a. T_μ (muon laboratory-system kinetic energy) vs θ' (muon center-of-mass angle) ^{μ}
- b. θ (muon lab angle) vs T_μ
- c. θ vs θ'
- d. $d\Omega'/d\Omega$ vs θ'
- e. $d\Omega'/d\Omega$ vs θ

$d\Omega = \sin \theta d\theta d\phi$ = differential solid angle, laboratory system

$d\Omega' = \sin \theta' d\theta' d\phi'$ = differential solid angle, center-of-mass system

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During the course of determining the absolute differential cross section of the reaction $p + p \rightarrow \pi^+ + d$,¹ we found it necessary to make a correction for the π - μ decay in flight. At that time we calculated the decay dynamics for π 's in flight with kinetic energies (T_π) from 5 Mev to 100 Mev. We felt that these calculations were of general utility and consequently are presenting the results in this report.

1. Definition of Terms T_π = pion kinetic energy in Mev, laboratory system T_μ = muon kinetic energy in Mev, laboratory system E_μ = muon total relativistic energy in Mev, laboratory system E'_μ = muon total relativistic energy in Mev, center-of-mass system P' = momentum of the muon, center-of-mass system π = pion rest energy μ = muon rest energy β = velocity of the muon/C, laboratory system β' = velocity of the muon/C, center-of-mass system $\bar{\beta}$ = lab velocity of the pion = velocity/C of the center-of-mass system $\bar{\gamma}$ = $1/\sqrt{1 - \bar{\beta}^2}$ α = $\bar{\beta}/\beta'$ θ = muon laboratory-system angle as measured relative to the direction of flight of the pion. θ' = muon angle measured in the pion's rest frame (center of mass) $d\Omega$ is the differential solid angle of the muon in the laboratory system $d\Omega'$ is the differential solid angle of the muon in the pion rest frame (or center-of-mass frame)The mass of the pion was taken as $273.2 m_e$ and the mass of the muon as $206.7 m_e$.¹F. S. Crawford, Jr., and M. L. Stevenson, Phys. Rev. 97, 1305 (1955).

2. Decay Dynamics

The following formulae summarize the Lorentz transformations of the quantities E_μ , θ , and $d\Omega$ from the center-of-mass system to the laboratory system:

$$E_\mu = T_\mu + \mu = \bar{\gamma} (\beta cp' \cos \theta' + E_\mu'), \quad (1)$$

$$\tan \theta = \frac{\sin \theta'}{\bar{\gamma} (a + \cos \theta')}, \quad (2)$$

$$d\Omega'/d\Omega = \frac{\bar{\gamma}^{-2}}{(1 + a \cos \theta')^2} \left(\frac{a + \cos \theta'}{\cos \theta} \right)^3, \quad (3)$$

where

$$cp' = \frac{\pi^2 - \mu^2}{2\pi} \quad (4)$$

and

$$E_\mu' = \frac{\pi^2 + \mu^2}{2\pi},$$

$$d\Omega = \sin \theta \, d\theta \, d\phi.$$

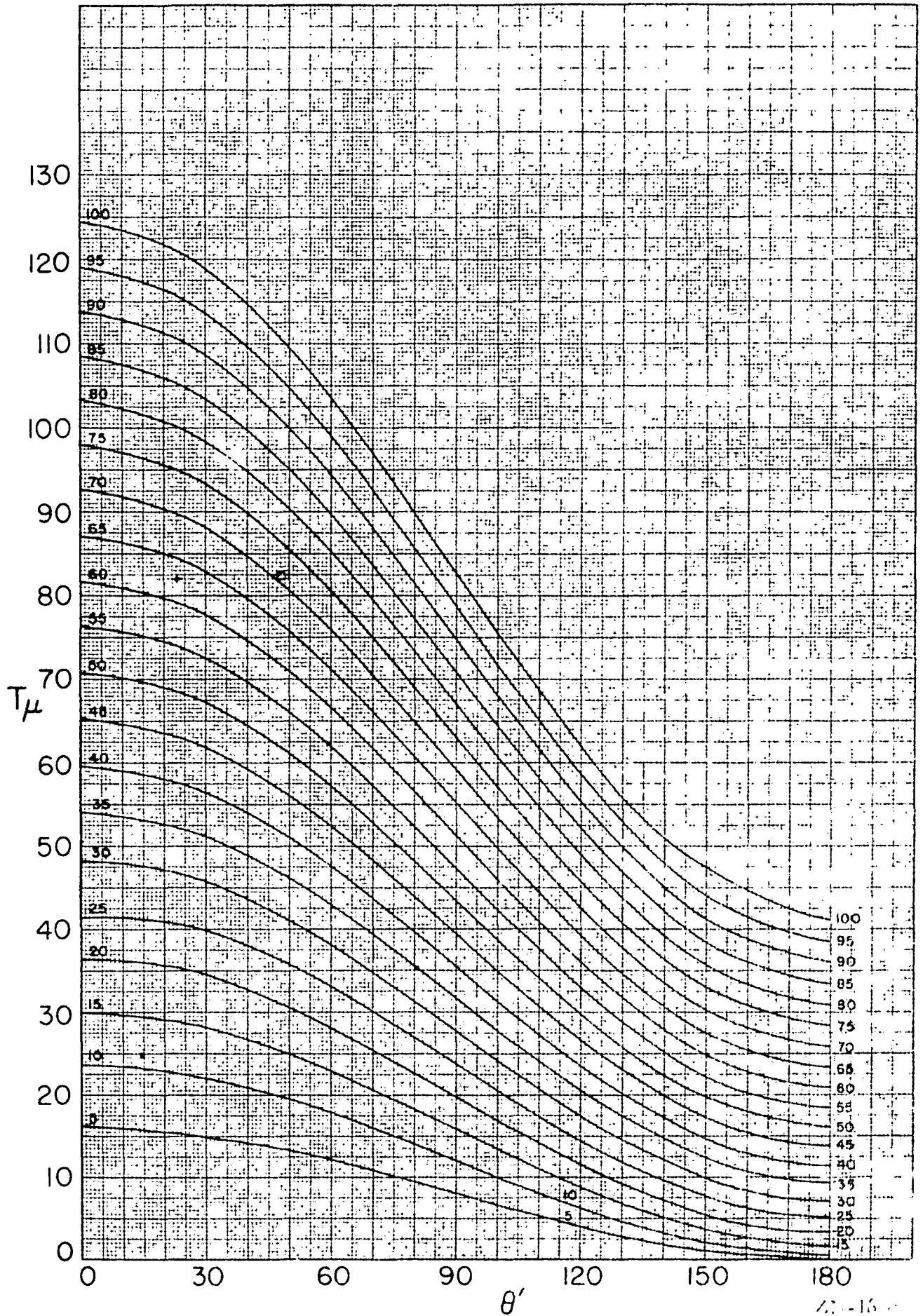
3. Quantities Plotted

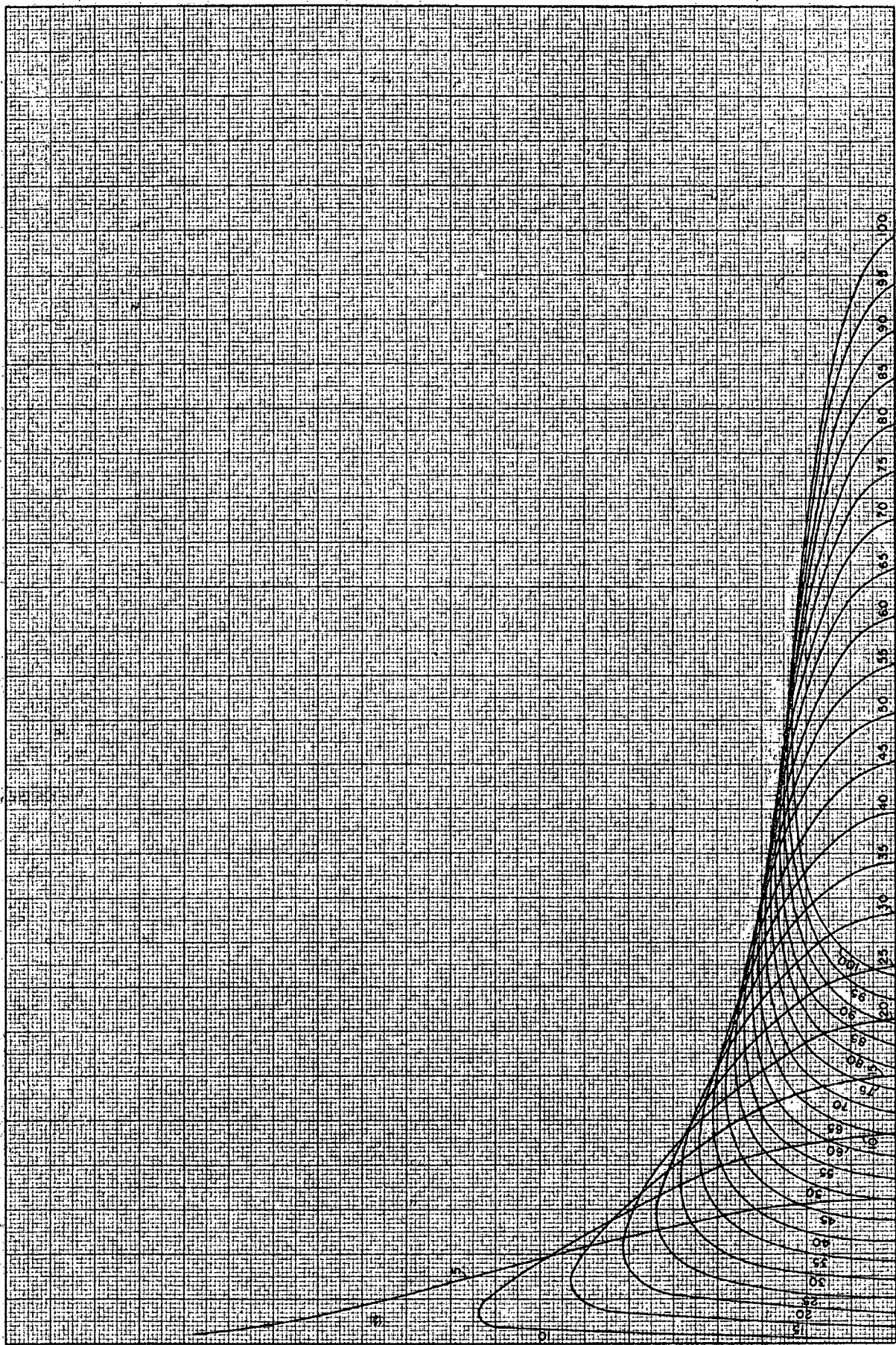
For each pion energy, the following quantities have been plotted:

- a. T_μ vs θ' ,
- b. θ vs T_μ ,
- c. θ vs θ' ,
- d. $d\Omega'/d\Omega$ vs θ' ,
- e. $d\Omega'/d\Omega$ vs θ .

We wish to thank Mr. Roy P. Haddock for his computing assistance.

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T_μ

