UCRL -3481
Cy. 2

UNIVERSITY OF CALIFORNIA

Ernest O. Lawrence Radiation Laboratory

BERKELEY, CALIFORNIA

DISCLAIMER

UCRL-3481
Physics Distribution

UNIVERSITY OF CALIFORNIA
Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

THE DYNAMICS OF π-μ DECAY IN FLIGHT

M. Lynn Stevenson

July 25, 1956

Printed for the U. S. Atomic Energy Commission

THE DYNAMICS OF π-μ DECAY IN FLIGHT

M. Lynn Stevenson

Radiation Laboratory
University of California
Berkeley, California

July 25, 1956

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)

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

THE DYNAMICS OF π-μ DECAY IN FLIGHT

M. Lynn Stevenson

Radiation Laboratory
University of California
Berkeley, California

July 25, 1956

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

$\bar{\gamma}$ = $1/\sqrt{1 - \bar{\beta}^2}$

a = $\bar{\beta}/\beta'$

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.

---

[1] F. 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:

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

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

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

where

$$cp' = \frac{\pi^2 - \mu^2}{2\pi} \tag{4}$$

and

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

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

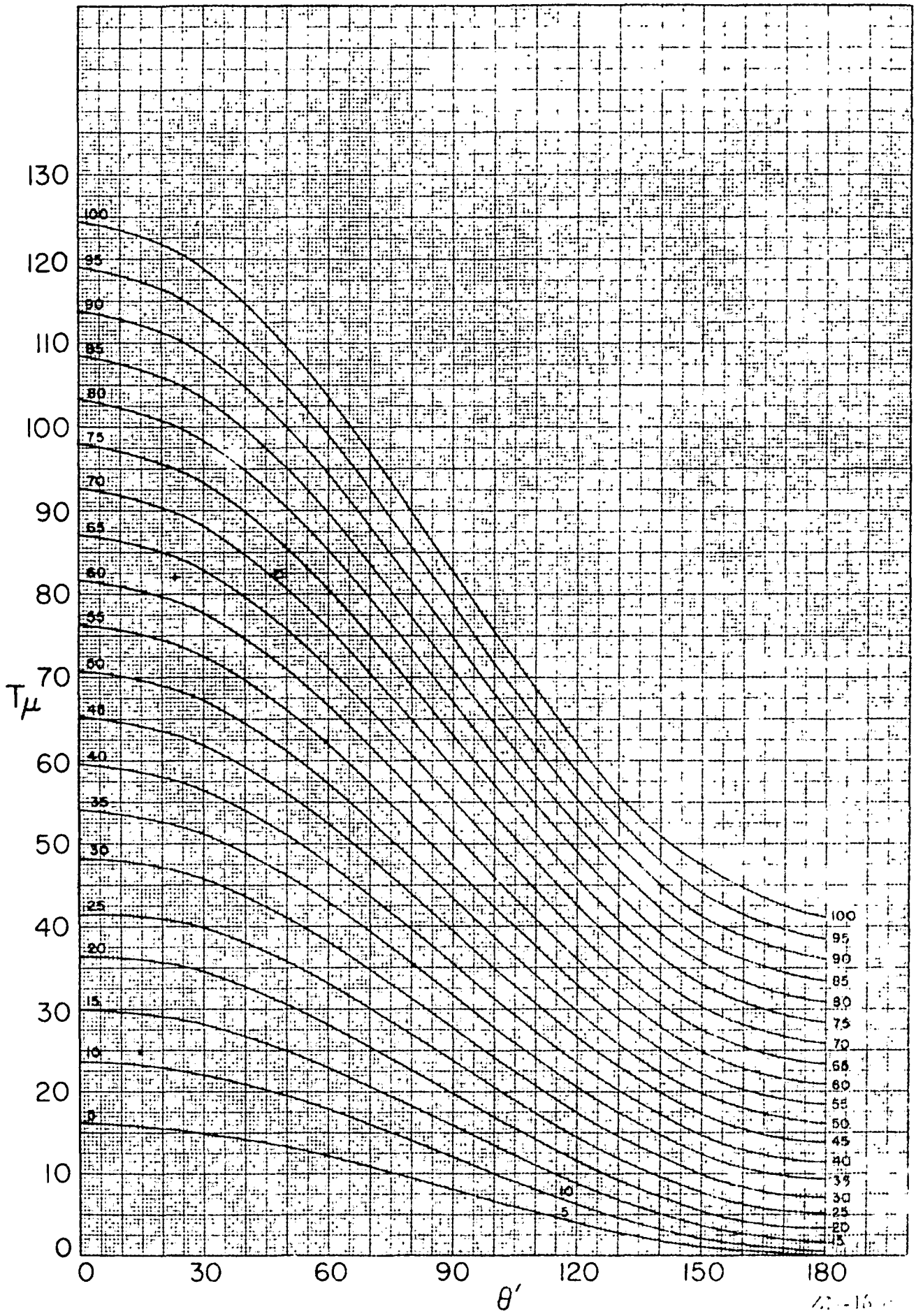
3. Quantities Plotted

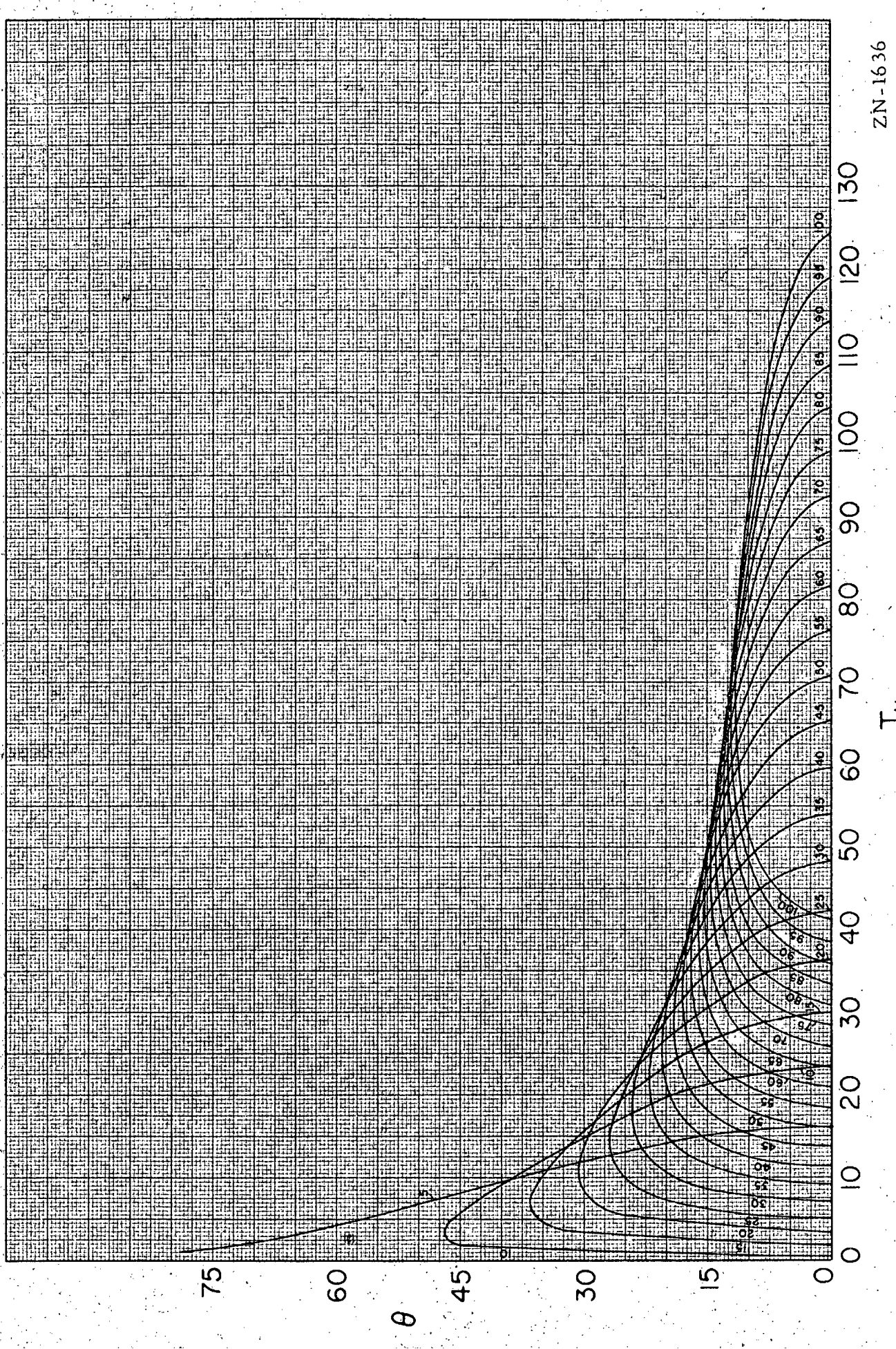
For each pion energy, the following quantities have been plotted:

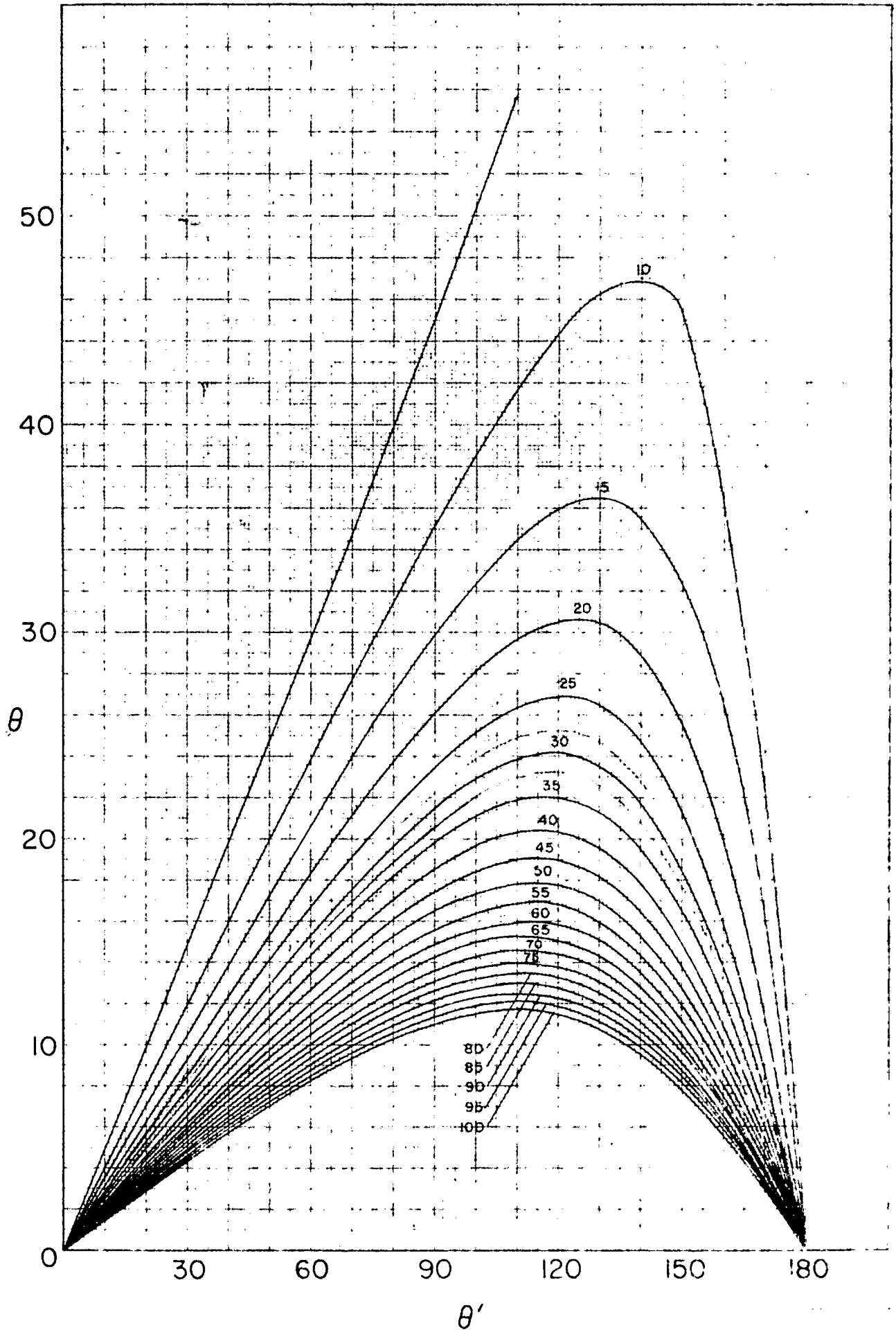
a. T_μ vs θ',
b. θ vs T_μ,
c. θ vs θ',
d. $d\Omega'/d\Omega$ vs θ',
e. $d\Omega'/d\Omega$ vs θ.

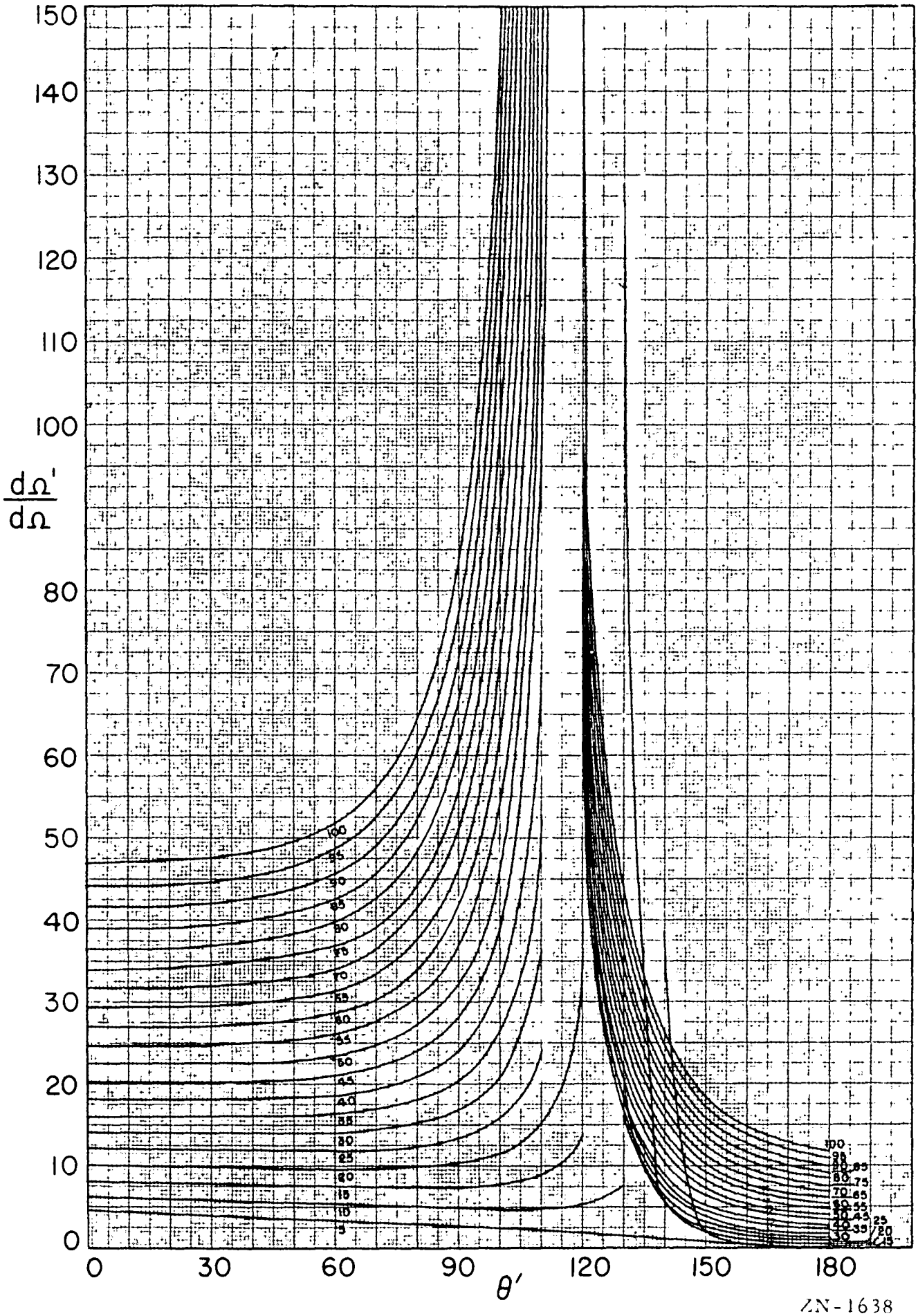
We wish to thank Mr. Roy P. Haddock for his computing assistance.

This work was performed under the auspices of the U. S. Atomic Energy Commission.

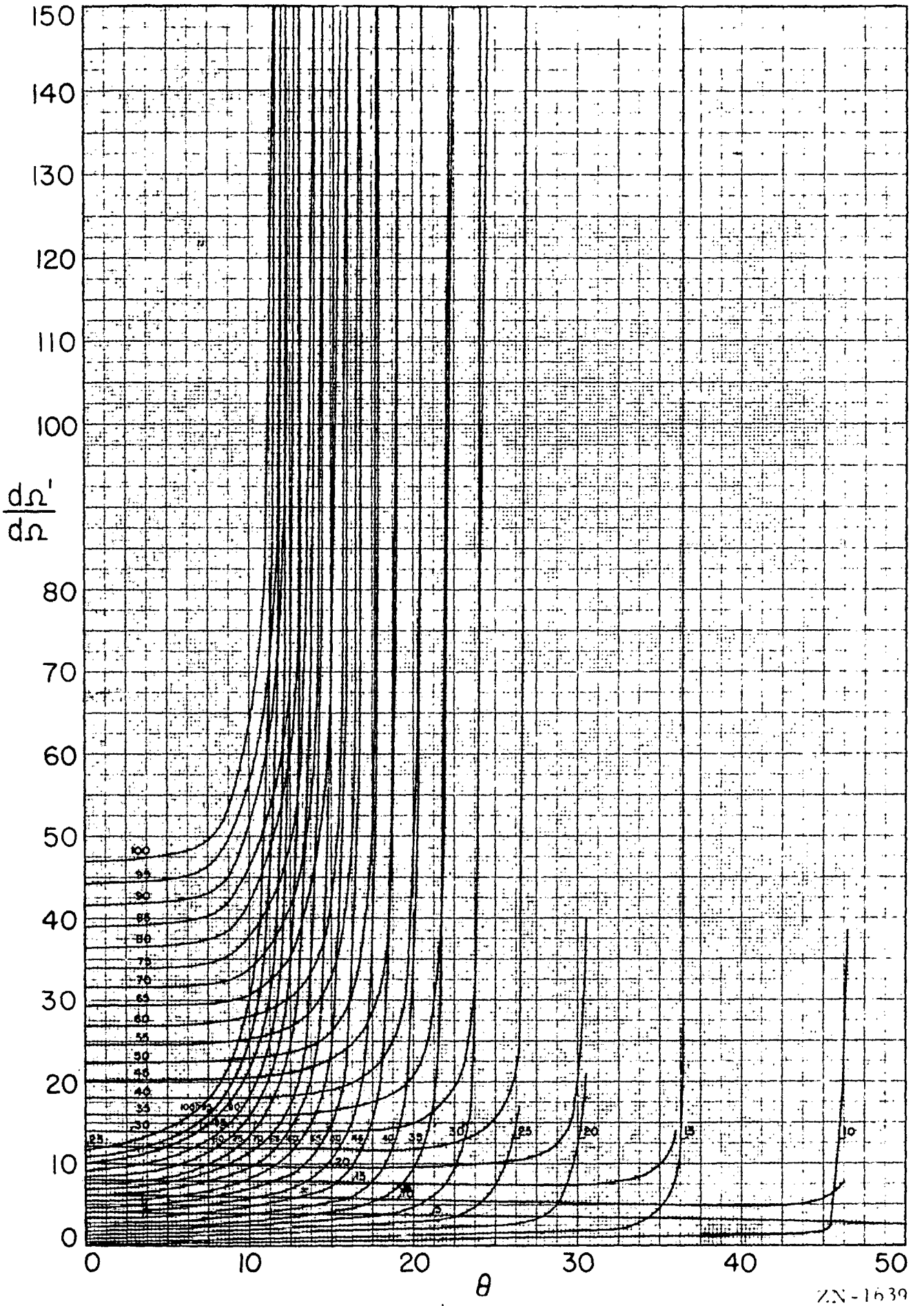

T_μ
θ'
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
30
60
90
120
150
180
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5


ZN-1636
θ
0
15
30
45
60
75
Tμ
0
10
20
30
40
50
60
70
80
90
100
110
120
130


50
40
30
20
10
0
θ
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
30
60
90
120
150
180
θ'


150
140
130
120
110
100
80
70
60
50
40
30
20
10
0
$\frac{d\Omega'}{d\Omega}$
0
30
60
90
120
150
180
θ'
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5

ZN-1638


150
140
130
120
110
100
80
70
60
50
40
30
20
10
0
$\frac{d\Omega'}{d\Omega}$
0
10
20
30
40
50
θ
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5

ZN-1639