Fermilab

MODELING MATERIALS FOR CASIM

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In the process of constructing a computer model for CASIM calculations in addition to the geometrical figure it is necessary to model the materials involved accurately. For most cases this is relatively routine because standard materials such as iron, copper, aluminum, etc. are used. Occasions do arise where non-standard materials and/or mixtures occur that need to be modeled properly. According to A. Van Ginneken[1] the most important parameter of a material for CASIM modeling is the nuclear collision length (λ_T). Knowing this we can devise a method for modeling the "average" parameters of mixtures or unusual materials that are consistent with λ_T. The parameters we use to model materials in CASIM are:

Atomic weight	AT	(amu)
Atomic number	ZT	
Density	RHO	(gm/cm^3)
Elastic scattering cross section	SIGL	(barns)
Ionization potential	VIP	(electron volts)
Nuclear radius	RFM	(fermi)
Radiation length	RALG	(cm)

In a typical case we generally know information such as density and composition. The first step then is to determine the nuclear collision length of the material. For many materials this only requires looking it up in a suitable table(2). In some situations an estimation can be made by a weighted sum of the collision lengths of the constituent materials:

$$1/\lambda_T = \sum_i (p/\lambda_T)_i$$

Where p is the partial weight of the i th element present as determined by the ratio of the contributing weight of the i th element to the formula weight of the compound.

From a plot of atomic weight versus nuclear collision length we find a relatively nice fit with a fourth degree polynomial least squares curve (figs. 1 & 2) that allows us to estimate the "average" atomic weight of our material if it is a mixture/compound. Alternately if we know the atomic weight of an element but not its nuclear collision length we could estimate λ_T. The atomic number easily follows from the atomic weight (figs. 3 & 4 for "average" atomic number).

Using the results of Belletini[3] we plot the elastic scattering cross section versus atomic weight which is fit well by a linear least squares curve (figs. 5 & 6). From the same reference we plot nuclear radius versus atomic weight (figs. 7 & 8).

The radiation length, if unknown, can be estimated by the plot λ_T versus L_{RAD} (fig. 9). The ionization potential for mixtures may be computed using the "average" atomic number (ZT) determined earlier from λ_T and atomic weight (AT) by the formula

$$I = (9.1)*(ZT)*(1+1.9*(ZT)^{-2/3}) \quad (4)$$

The ionization potential for many elements are available in tables[5].

I would like to thank D. Cossairt for his helpful suggeestions.

REFERENCES

1. Private conversation.

2. 'Practicle Properties Data Booklet' April 82 from 'Review of Particle Properties' Physics Letters VOL 111B April 82

3. Belletini et al. "Proton-Nuclei Cross Sections At 20 GeV" Nuclear Physics 79 (1966), 609-624

4. Marmier & Sheldon VOL 1 Physics of Nuclei and Particles pg 159

5. Radiological Health Handbook January 1970 Pg. 65

FIGURES

Nuclear Collision Length

VS

Atomic Weight

Ref. 'Particle Properties Data Booklet' April 1982

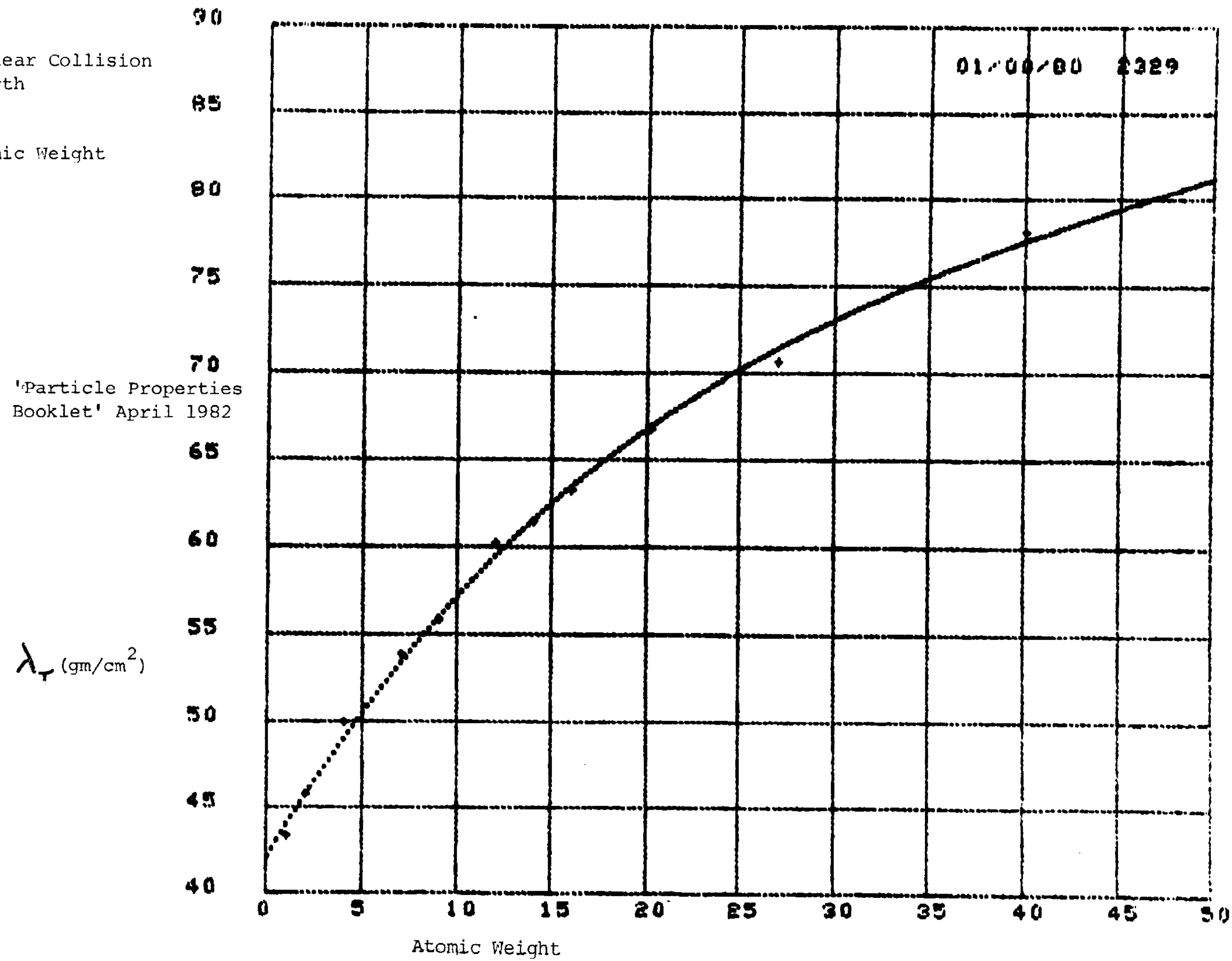


FIG 1

Nuclear Collision
Length

VS

Atomic Weight

Ref. 'Particle Properties
Data Booklet' April 1982

λ_I (gm/cm^2)

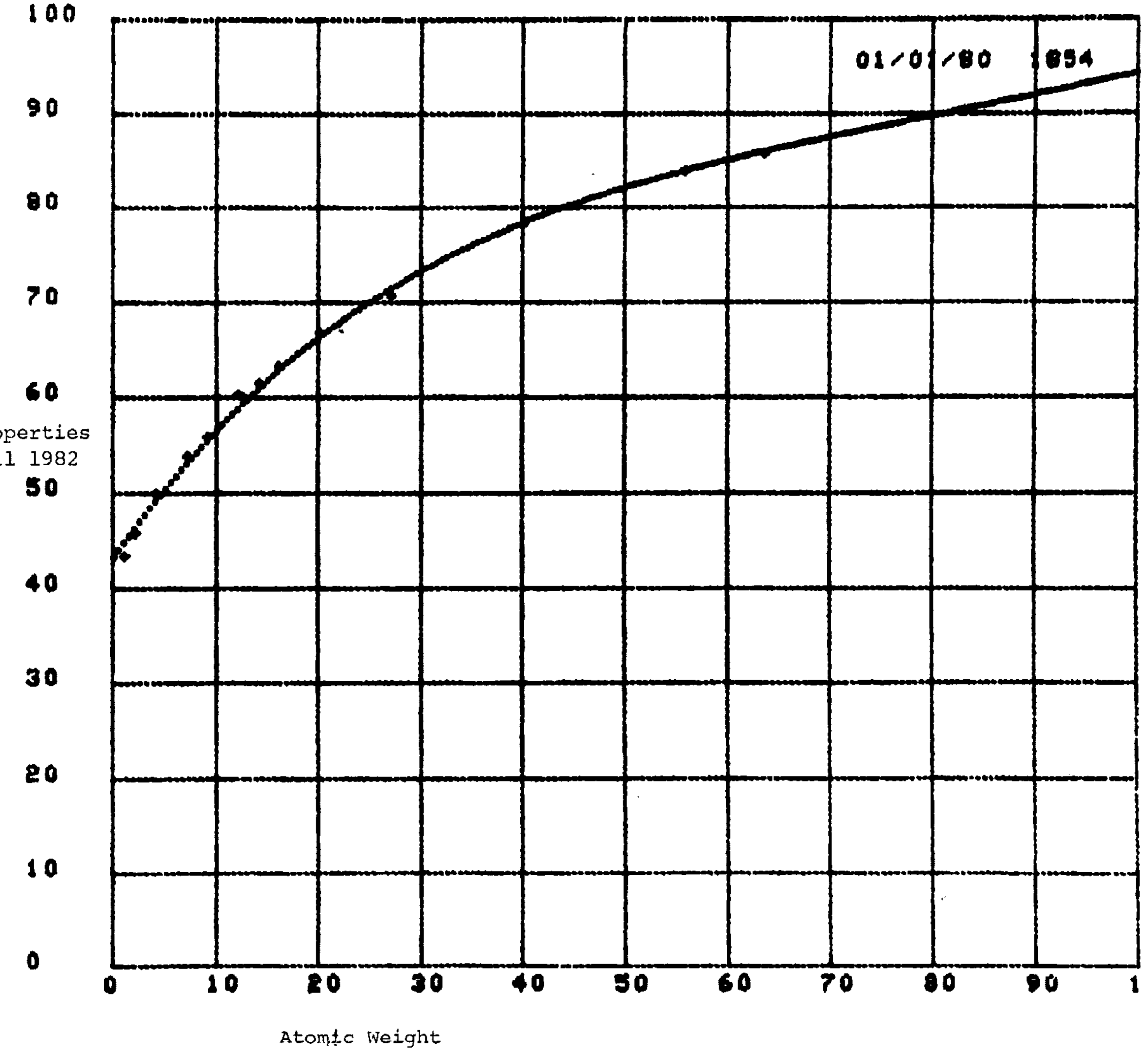


FIG 2

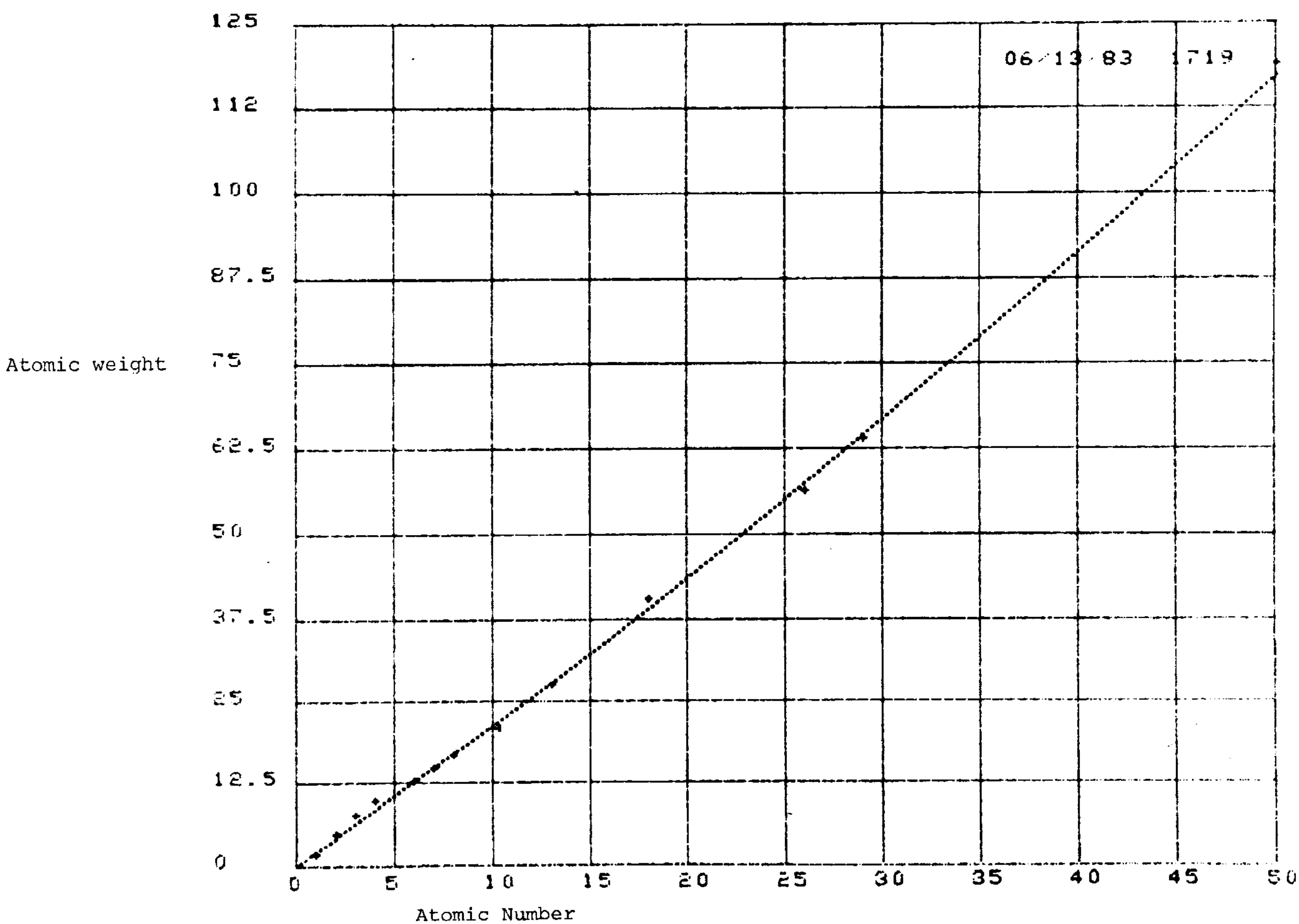

06/13/83 1719
Atomic weight
125
112
100
87.5
75
62.5
50
37.5
25
12.5
0
0
5
10
15
20
25
30
35
40
45
50
Atomic Number

FIG 3

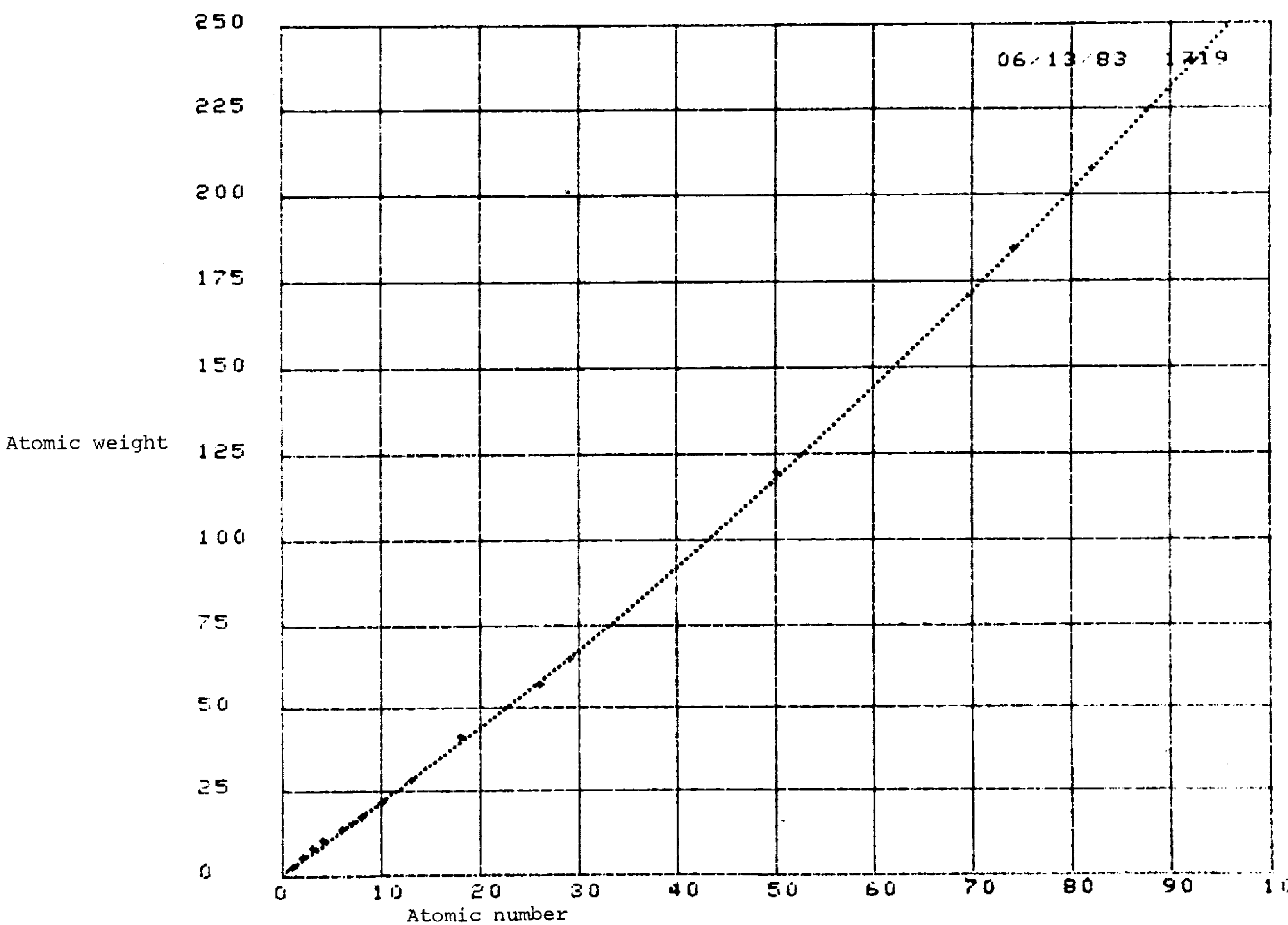

06/13/83 1719
Atomic weight
250
225
200
175
150
125
100
75
50
25
0
0
10
20
30
40
50
60
70
80
90
10
Atomic number

FIG 4

Elastic Scattering
Cross section
VS
Atomic Weight

Ref. Bellettini et al
Nucl. Phys. 79 (1966)
pg. 609

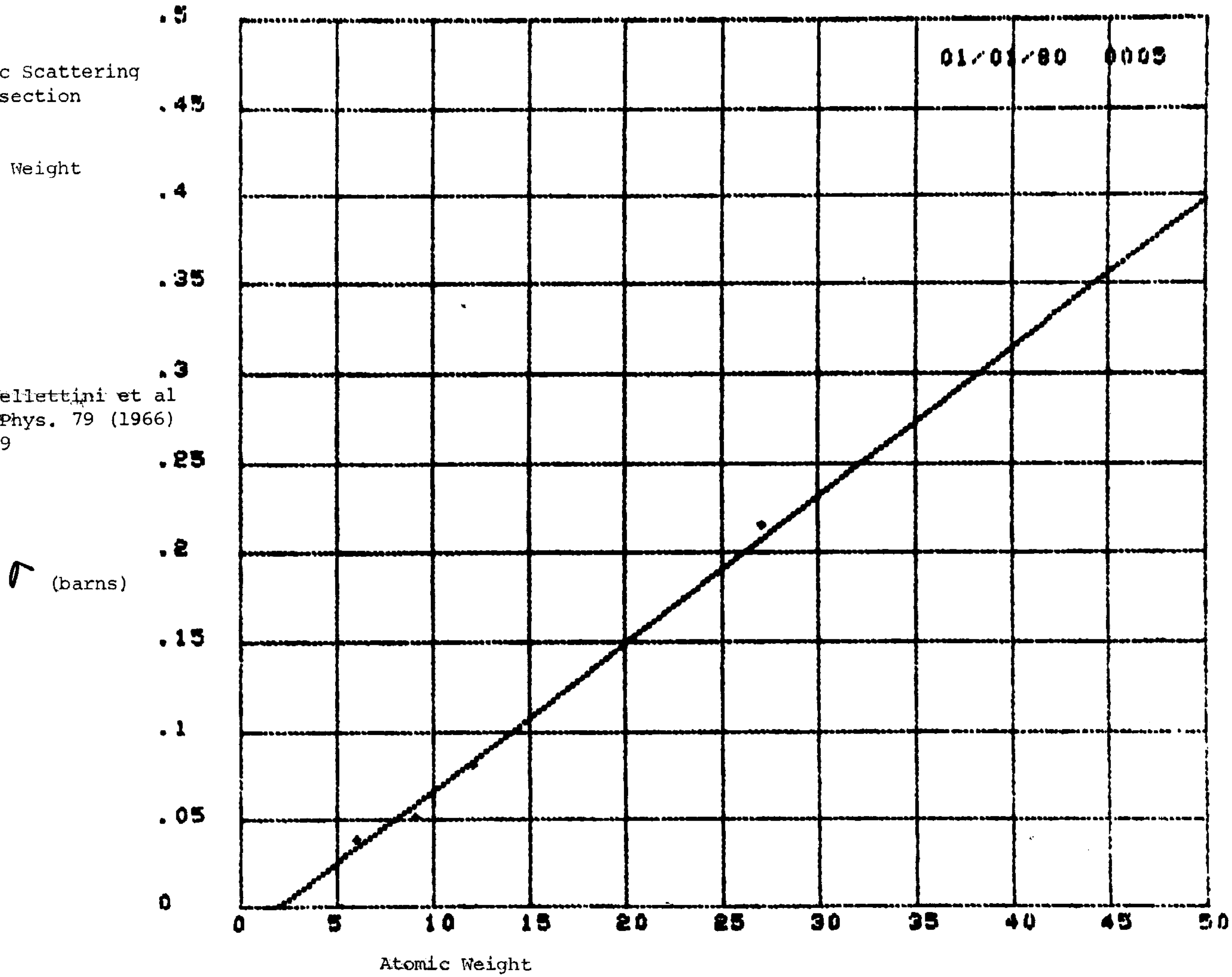


FIG 5

Elastic Scattering Cross section

vs

Atomic Weight

Ref. Bellettini et al Nucl. Phys. 79 (1966) pg. 609

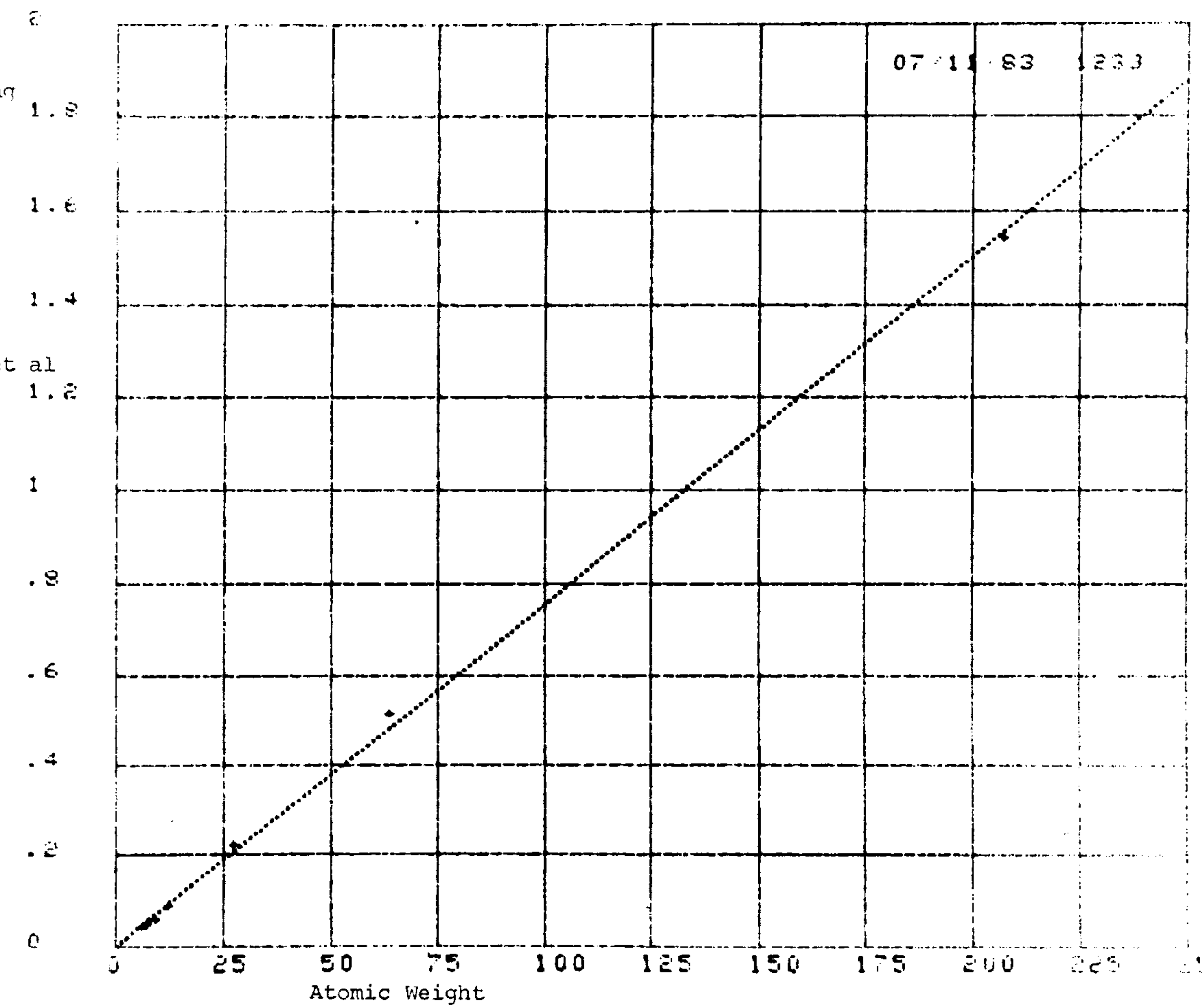
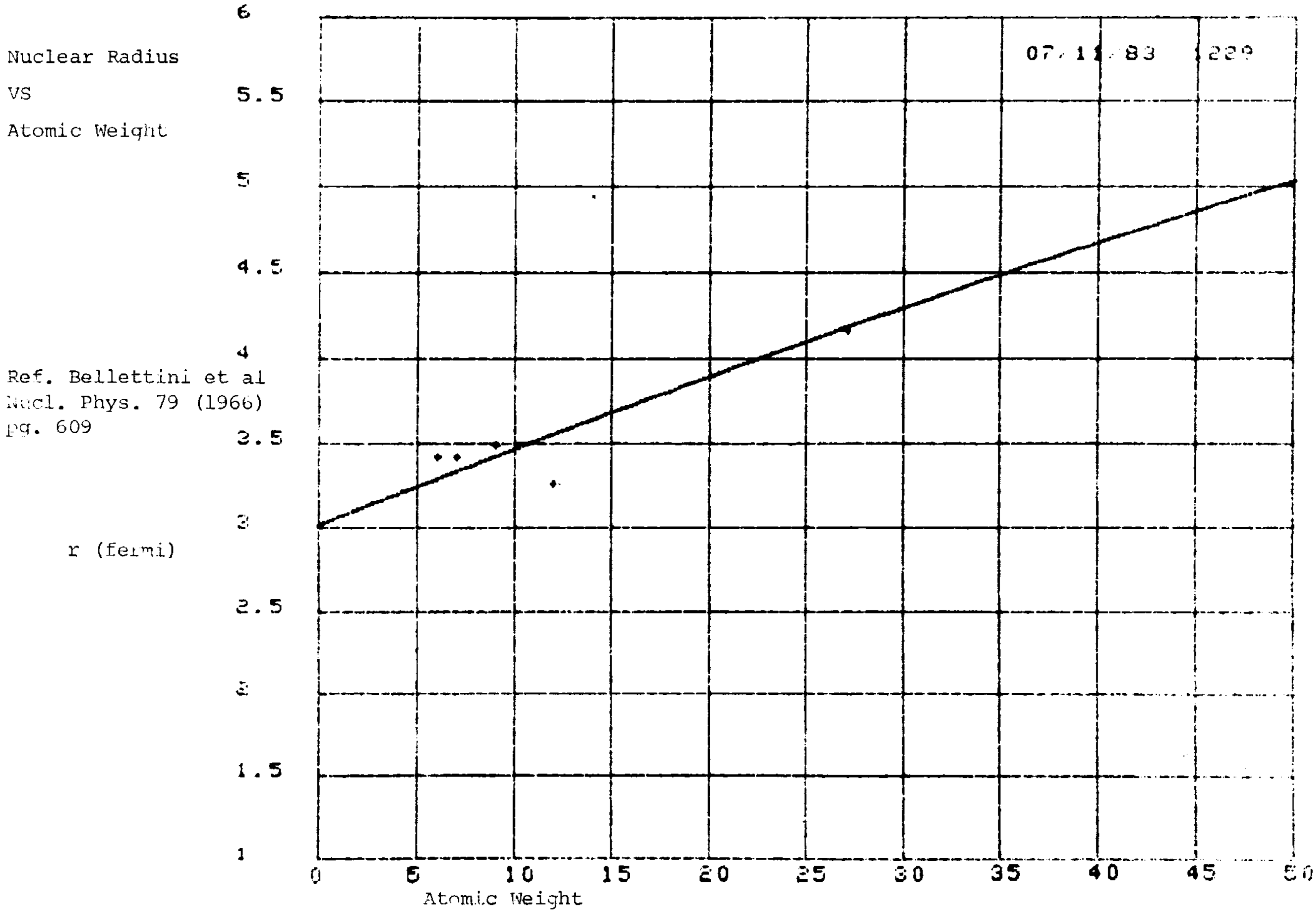


FIG 6



Nuclear Radius
VS
Atomic Weight
Ref. Bellettini et al
Nucl. Phys. 79 (1966)
pg. 609
r (fermi)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0
5
10
15
20
25
30
35
40
45
50
Atomic Weight

FIG 7

Nuclear Radius

VS

Atomic Weight

Ref. Belletini et al
Nucl. Phys. 79 (1966)
pg. 609

r (fermi)

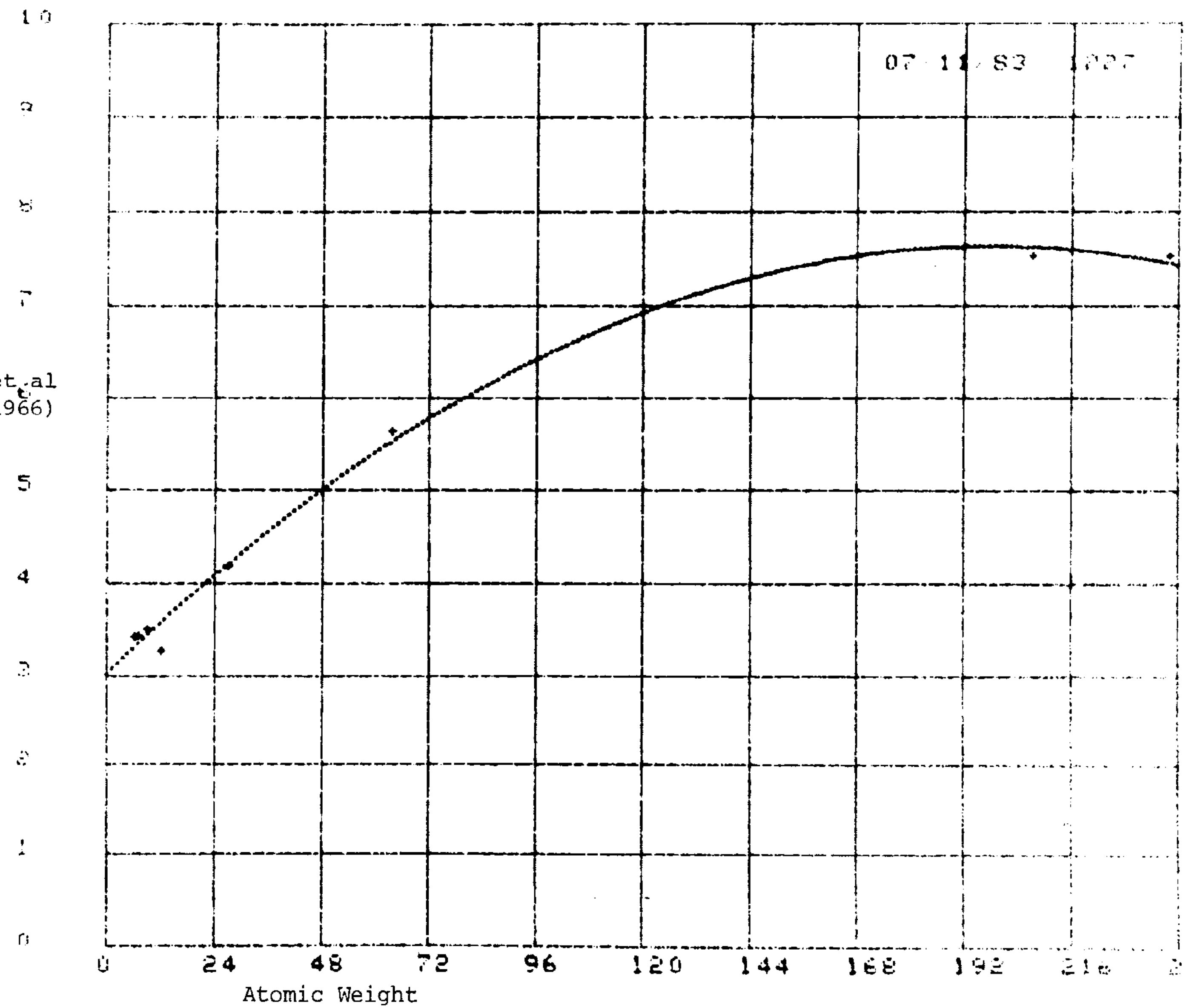
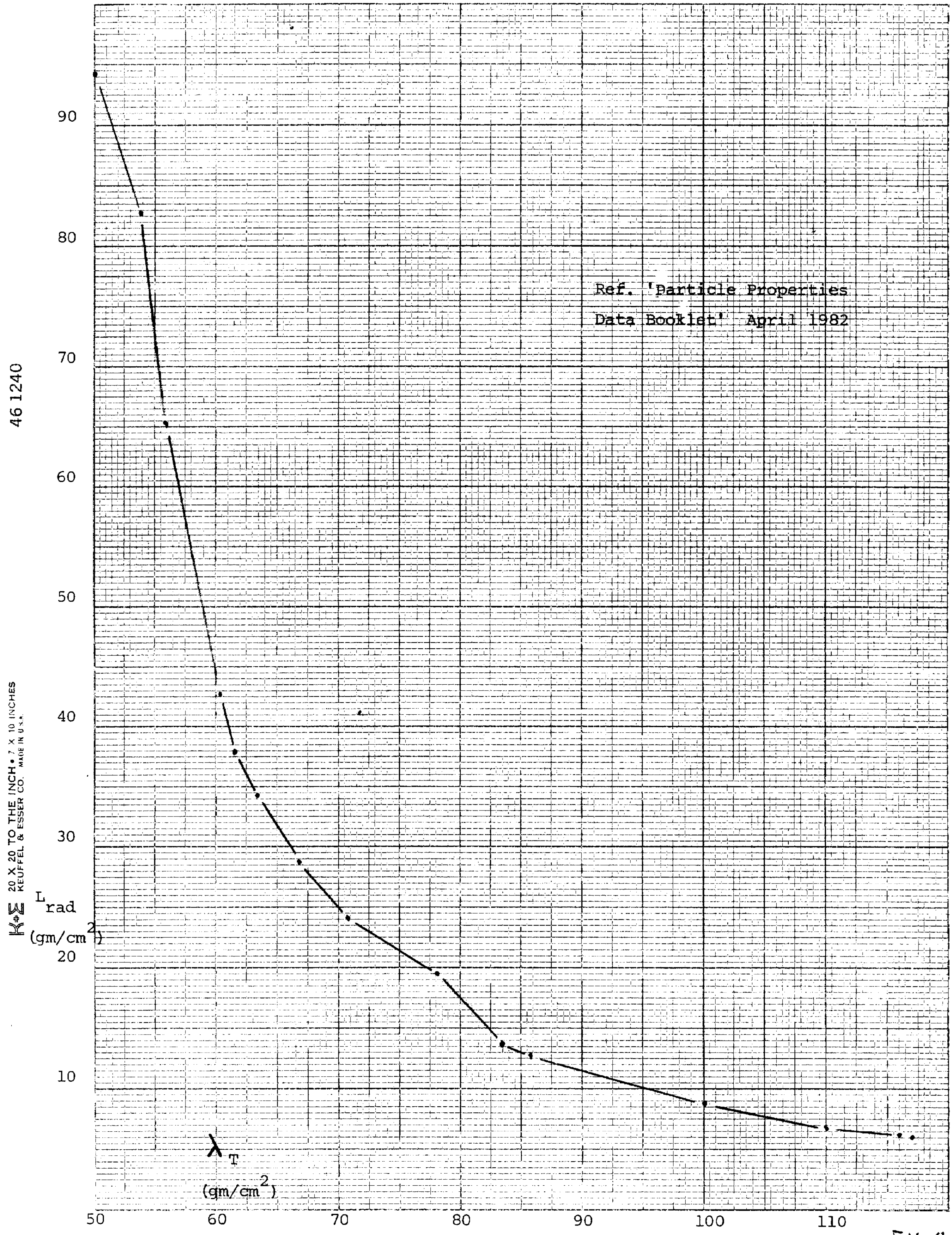


FIG 8



Ref. 'Particle Properties
Data Booklet' April 1982
90
80
70
60
50
40
30
20
10
50
60
70
80
90
100
110
L rad
(gm/cm²)
λ T
(gm/cm²)
46 1240
20 X 20 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

FIG 9