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STANDARDIZATION OF PAWNEE SITE LYSIMETER
AND A NET RADIATION ANALYSIS

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ABSTRACT

Determination of the soil water content within the Pawnee Site lysimeter was accomplished by utilizing soil samples and neutron probe measurements. No significant difference in water content was found between inside and outside the lysimeter 1 year following construction. Net radiation was estimated by several different methods, and the results were correlated with actual net radiation values from the Pawnee Site.

STANDARDIZATION OF SOIL WATER CONTENT
WITHIN THE PAWNEE SITE LYSIMETER

The Pawnee Site lysimeter described by Armijo (1972) has proven to be reliable and has surpassed its expectations for detecting small amounts of evapotranspiration and rainfall. Although much work was done on calibration and operation procedures, a standard value for the absolute water content (mm of water) within the soil core of the lysimeter was not accomplished during 1972.

A cool May morning was selected to secure the necessary data for determining the water content. Fifty-four soil samples (cores) were secured from the area of the lysimeter core extraction and the immediate area where the lysimeter is situated. A neutron probe was used to determine soil water content within the lysimeter core, and from the immediate area surrounding the lysimeter.

Results

Standard weighing and oven drying procedures were utilized to determine bulk density and the wet and dry weights of the cores. These data and neutron probe data are summarized in Table 1.

Ratios of soil water values determined by coring and by use of the neutron probe measurements are equal, although absolute values for soil water determined with the neutron probe are 10 mm less than similar determinations made from core data. Differences in water content between the lysimeter location and the area of the lysimeter core extraction are contributed by local soil differences within the same soil type.

The value for soil water content determined by coring at the lysimeter core extraction area (142.8 mm) is assigned as the standard water equivalent in the 120 cm deep lysimeter at the Pawnee Site on 13 May 1973.

Table 1. Summarization of soil water calculations.

Location	Water content (% water dry wt basis)	Bulk density (dry wt basis)	Water equivalent (mm)	Ratio
Core extraction area	0.07943	1.4930	142.8	1.0664
Surrounding area of lysimeter	0.07456	1.4968	133.9	
Neutron probe (within lysimeter core)			132.0	1.0688
Neutron probe (outside lysimeter core)			123.5	

The day-to-day changes in lysimeter weight that have been recorded during the past years as well as future years are and will be referenced to this value. A continuous trace through time of the water equivalent in the 120 cm soil profile of the Pawnee Site lysimeter contains all lysimeter data collected to date and will be updated monthly for the remainder of the lysimeter's operation (Fig. 1, 2, and 3).

This trace will be utilized for future analysis of evaporation predictions. It will require a knowledge of soil water conductivities and diffusivities and be a function only of time (Black, Gardner, and Thurtell 1969).

ESTIMATION OF NET RADIATION

Surface energy balance and evapotranspiration determinations depend upon net radiation measurements and/or estimations; however, this variable is not readily available as a standard meteorological observation. The following discussion describes three methods for estimating daily net radiation by utilizing readily available meteorological observations.

Measurements of global solar radiation, net radiation, and reflected solar radiation from the Pawnee Site were utilized for this analysis.

Linacre (1968) has described an empirical method for estimating net radiation (QN) which takes the following form:

$$QN = (1 + 2 \frac{n}{N}) [QA (0.254 + 0.016 \frac{n}{N} - 0.25) - 0.25] + 0.032$$

where n = bright daylight hours

N = daylight hours

QA = extra-terrestrial radiation

Jensen et al. (1973) have shown that net radiation can be estimated by the following equation:

$$QN = (1 - \alpha) RS - RL$$

where QN = net radiation

α = albedo

RS = incoming solar radiation

$$RL = (1.35 \frac{RS}{RSO} - 0.35) RLO$$

RSO = clear day radiation

$$RLO = [0.98 - (0.67 + 0.044\sqrt{e_d})] (11.71 \times 10^{-8}) \frac{T2A^4 + T1A^4}{2}$$

T2A = daily maximum temperature

T1A = daily minimum temperature

$$e_d = e - \left(\frac{7482.6}{t + 398.39} \right) + 15.674$$

t = average daily temperature.

A relationship between net radiation and solar radiation was developed by Nunn (1973) through the use of simple regression and resulted in the following equation:

$$QN = 0.743 RS - 0.432$$

where QN = net radiation

RS = incoming solar radiation

Results

The initial step of the analysis was simple linear regression and correlation of net radiation and reflected radiation against total incoming radiation. These results are summarized by month in Table 2. The correlation coefficients for both parameters are good for some months and very poor for others due to improper screening of the data on a daily basis and the inclusion of daily values which were calculated for days in which only partial data were available. Net radiation values for winter days with average air temperatures below -10°C should have

Table 2. Monthly correlation coefficients for radiation variables over the Pawnee Site.

Month/year	Net radiation to total global radiation	Reflected radiation to total global radiation
6/72	0.60	0.99
7/72	0.61	0.98
8/72	0.60	0.99
9/72	0.58	0.23
10/72	0.67	--
11/72	0.26	0.82
12/72	0.15	0.29
1/73	0.07	0.72
2/73	0.24	0.88
3/73	0.35	0.50

been deleted because the net radiation transducer is not temperature-compensated below -10°C and results in invalid data. Snow cover during the winter months also changes the expected pattern of reflected short-wave radiation due to the increased reflectance of snow. Testing of the alternate methods and a summarization of recommendations for estimating net radiation over a shortgrass ecosystem is still underway at the Natural Resource Ecology Laboratory.

Data Collection

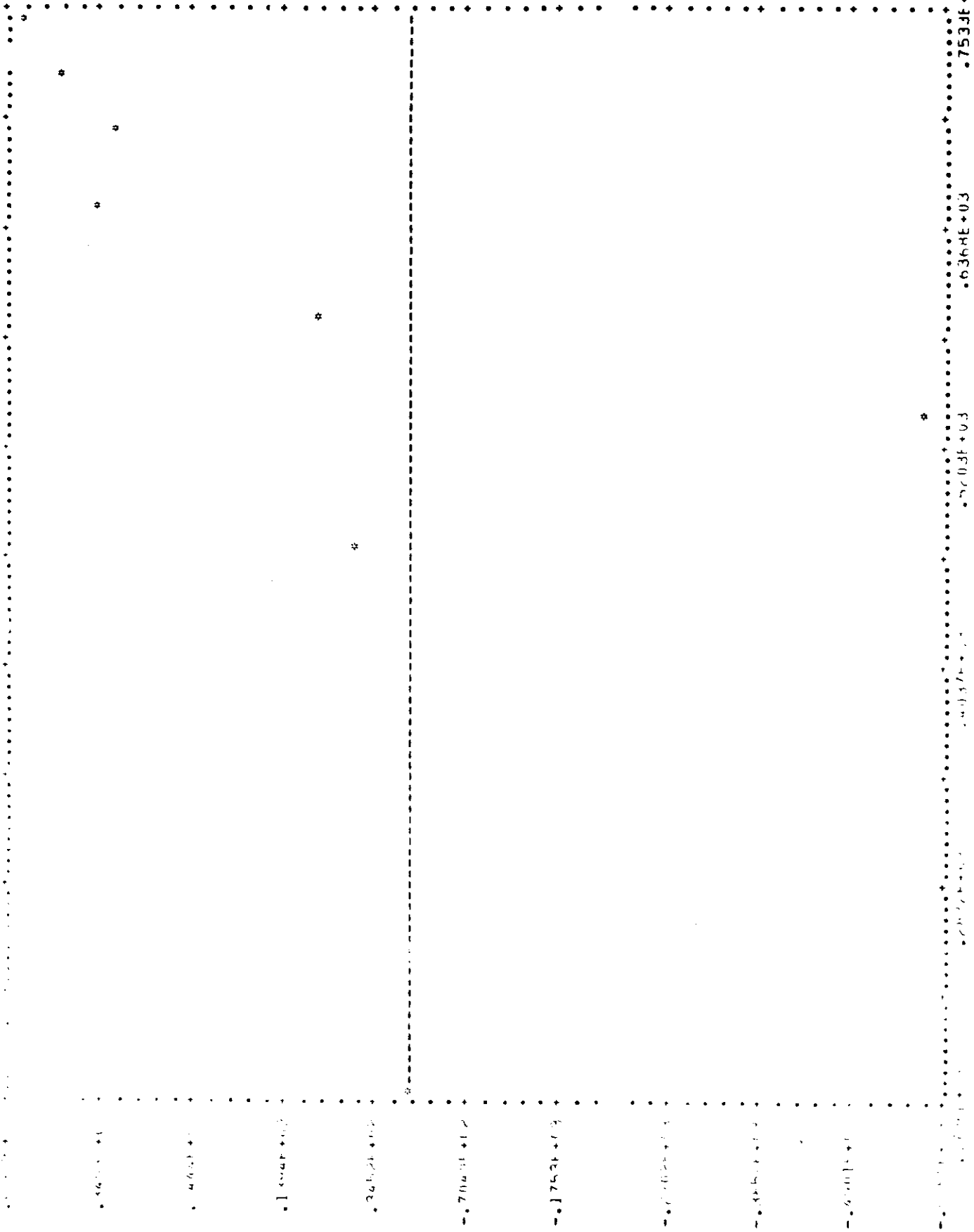
Data collecting during 1973 was continued from the Pawnee Site meteorological system, and the summary of the data was completed with new revised computer programs. Computer cards showing daily totals and averages were punched from the compacted 556 BPI labeled tapes (NREL Data Bank, A2U705B) for computations and synthesis work at the Natural Resource Ecology Laboratory.

LITERATURE CITED

- Armijo, J. D. 1972. Development of a large, undisturbed weighing lysimeter for evapotranspiration studies on grassland. US/IBP Grassland Biome Tech. Rep. No. 165. Colorado State Univ., Fort Collins. 153 p.
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- Jensen, M. E. et al. 1973. Consumptive use of water and irrigation water requirements. Report of Irrigation Requirements Committee. (In press).
- Linacre, E. T. 1968. Estimating net radiation flux. Agr. Meteorol. 5(1968):49-63.
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APPENDIX I
FIELD DATA

Net radiation (langleys/day)



Total solar radiation (June, 1971) (langleys/day)

(

)

(

Reflected solar radiation (langleys/day)

.190E+00

.189E+00

.147E+00

.125E+00

.104E+00

.823E+00

.607E+00

.351E+00

.174E+00

.174E+00

.227E+03

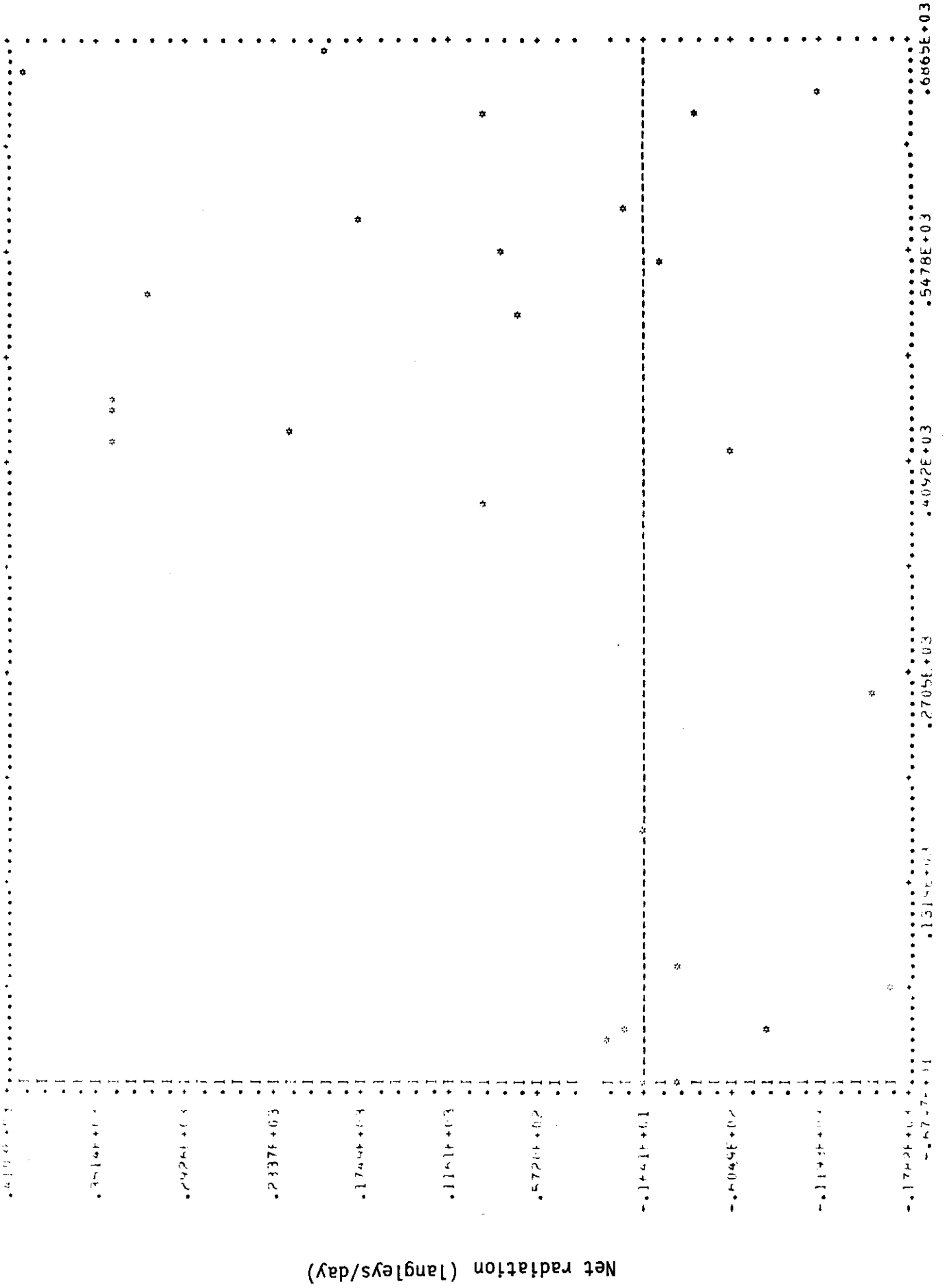
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.570E+03

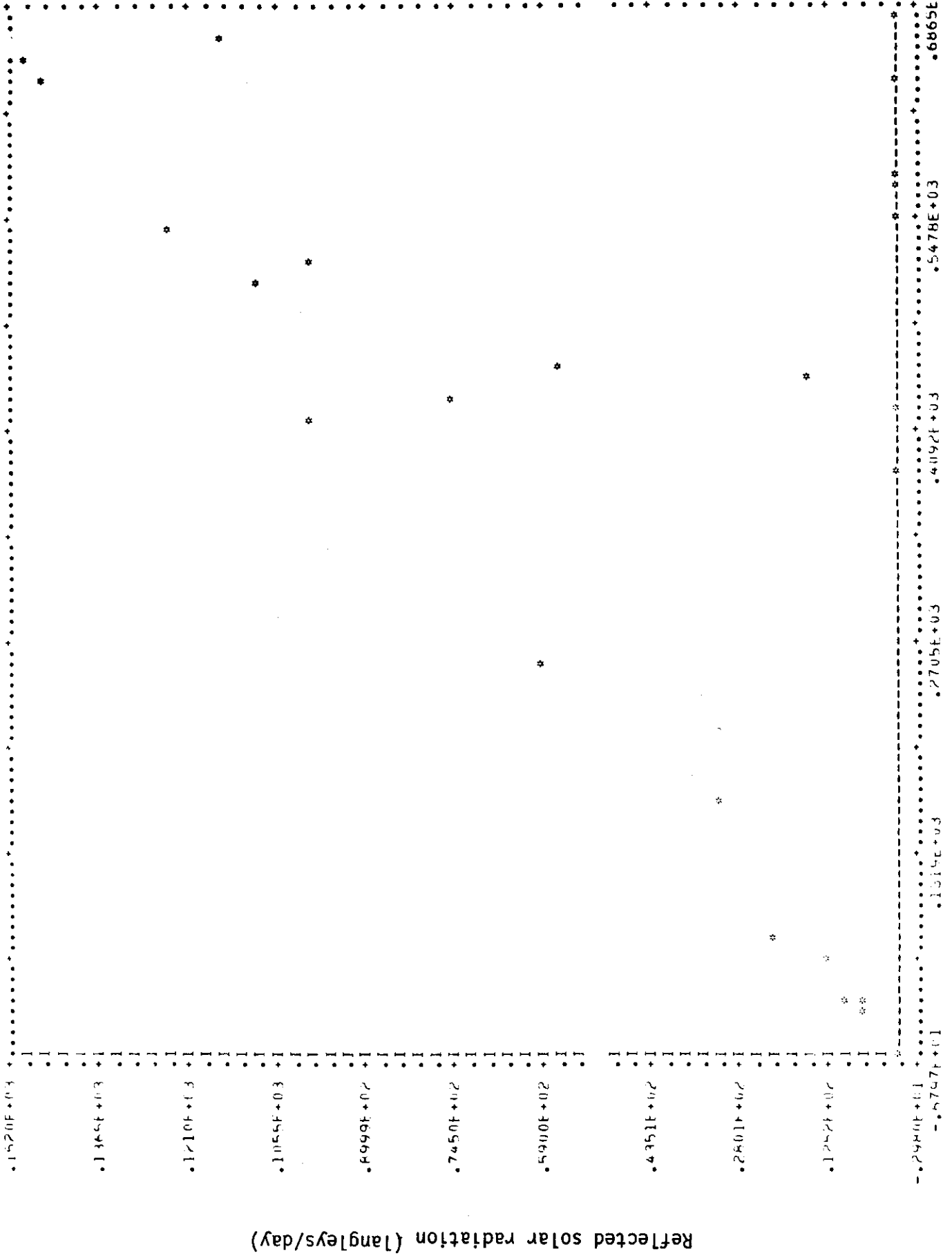
.636E+03

.753E+03

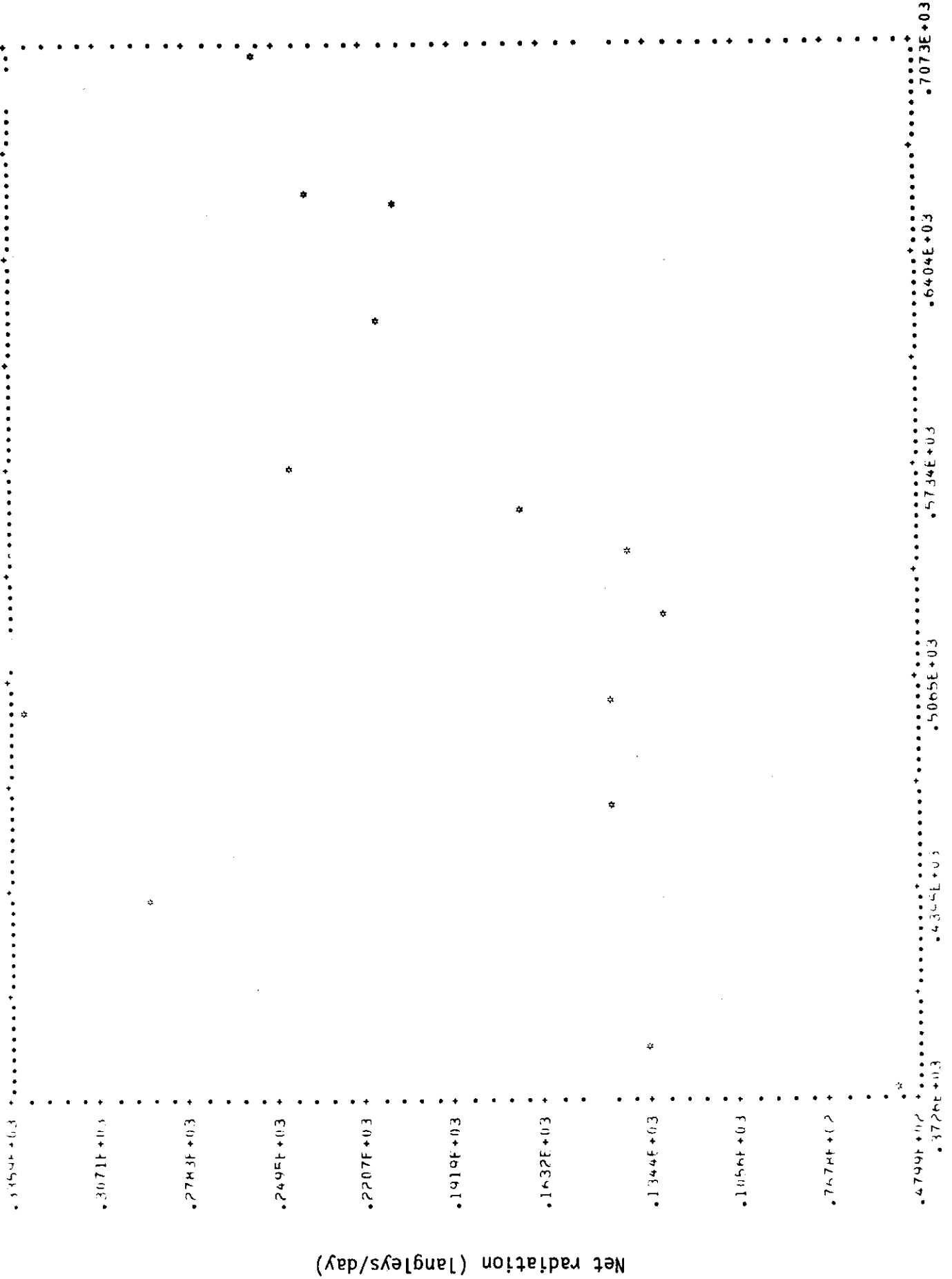
Total solar radiation (June, 1971) (langleys/day)



Total solar radiation (July, 1971) (langley/day)

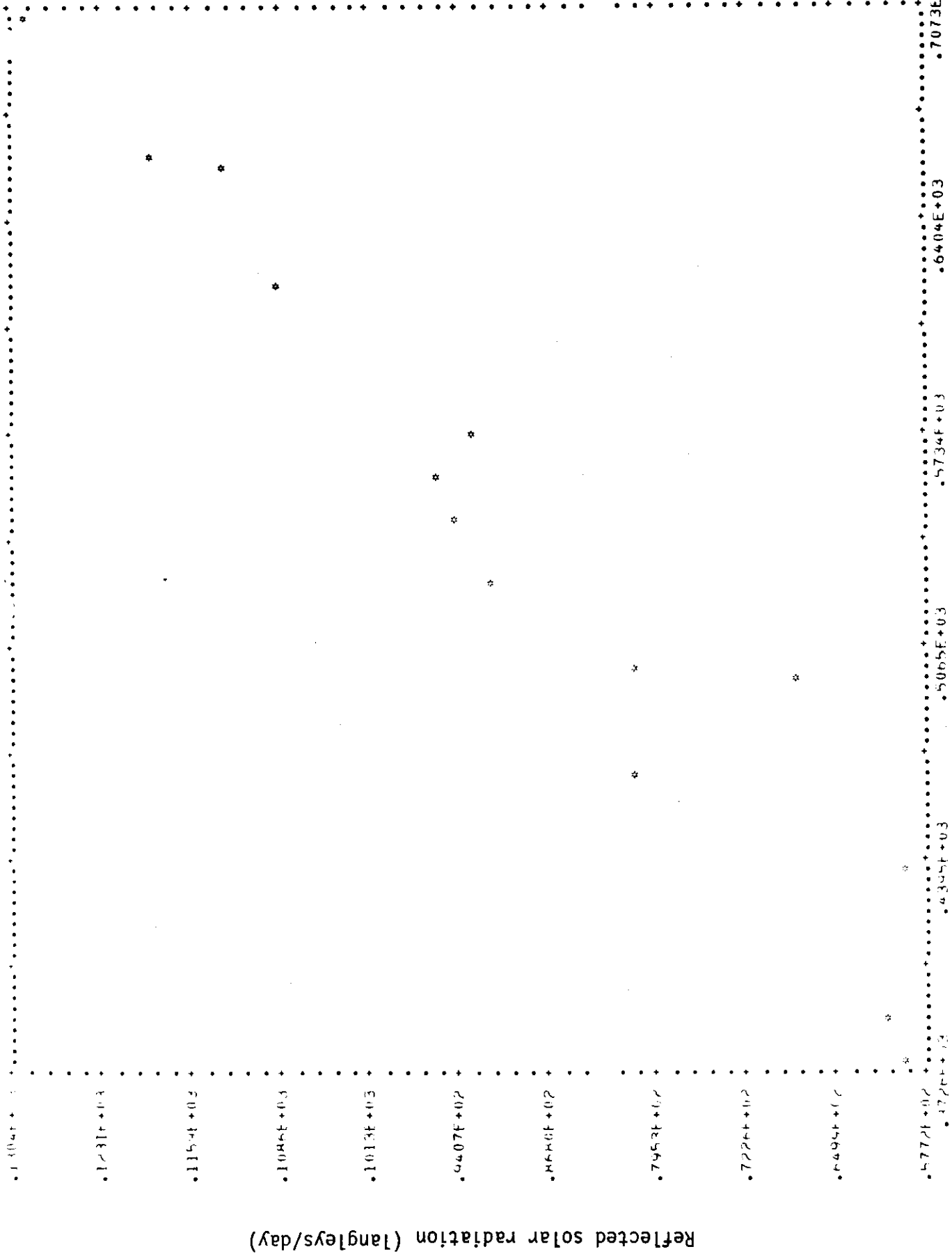


Total solar radiation (July, 1971) (langley/day)

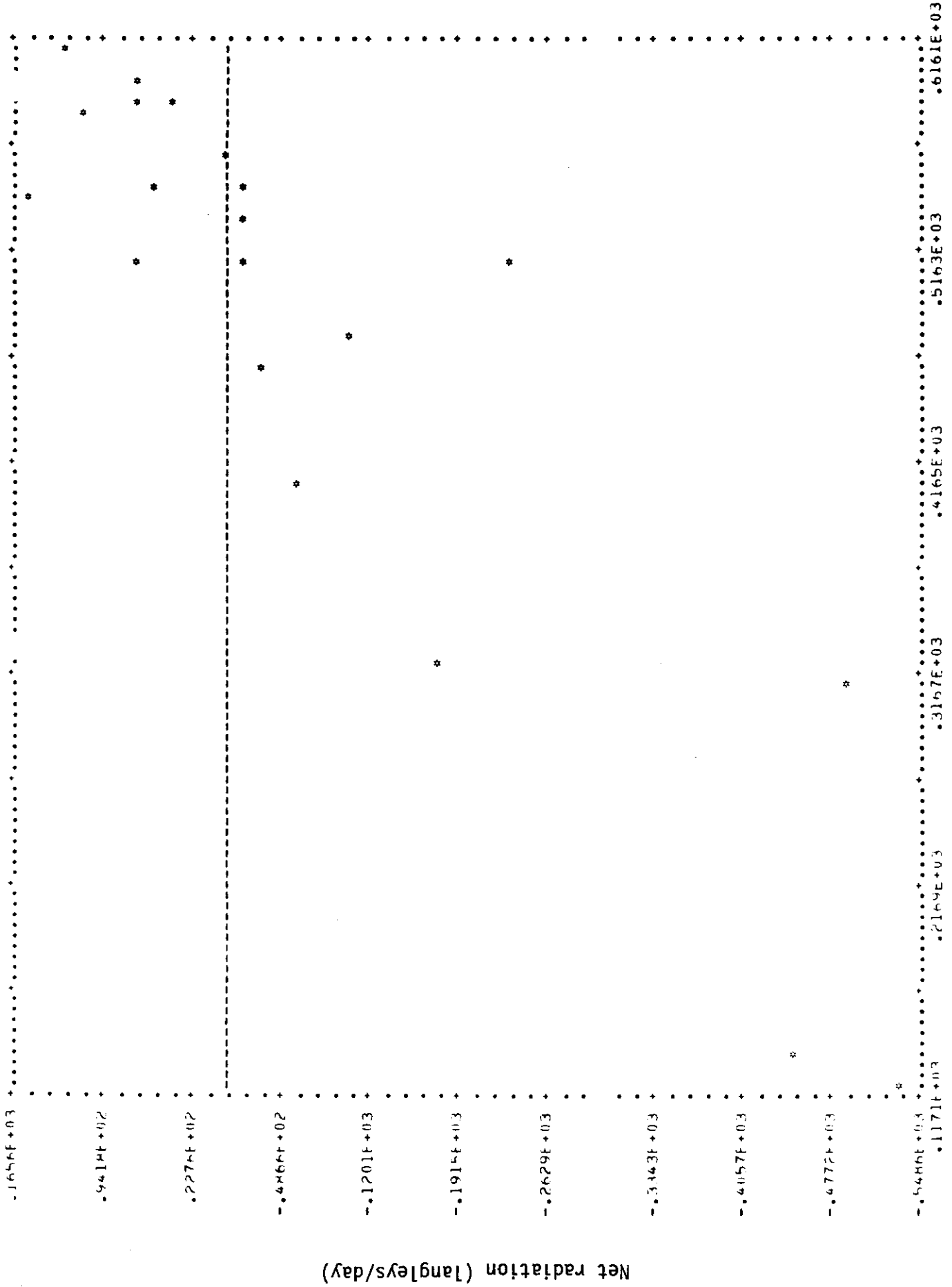


Total solar radiation (August, 1971) (langley/day)

()

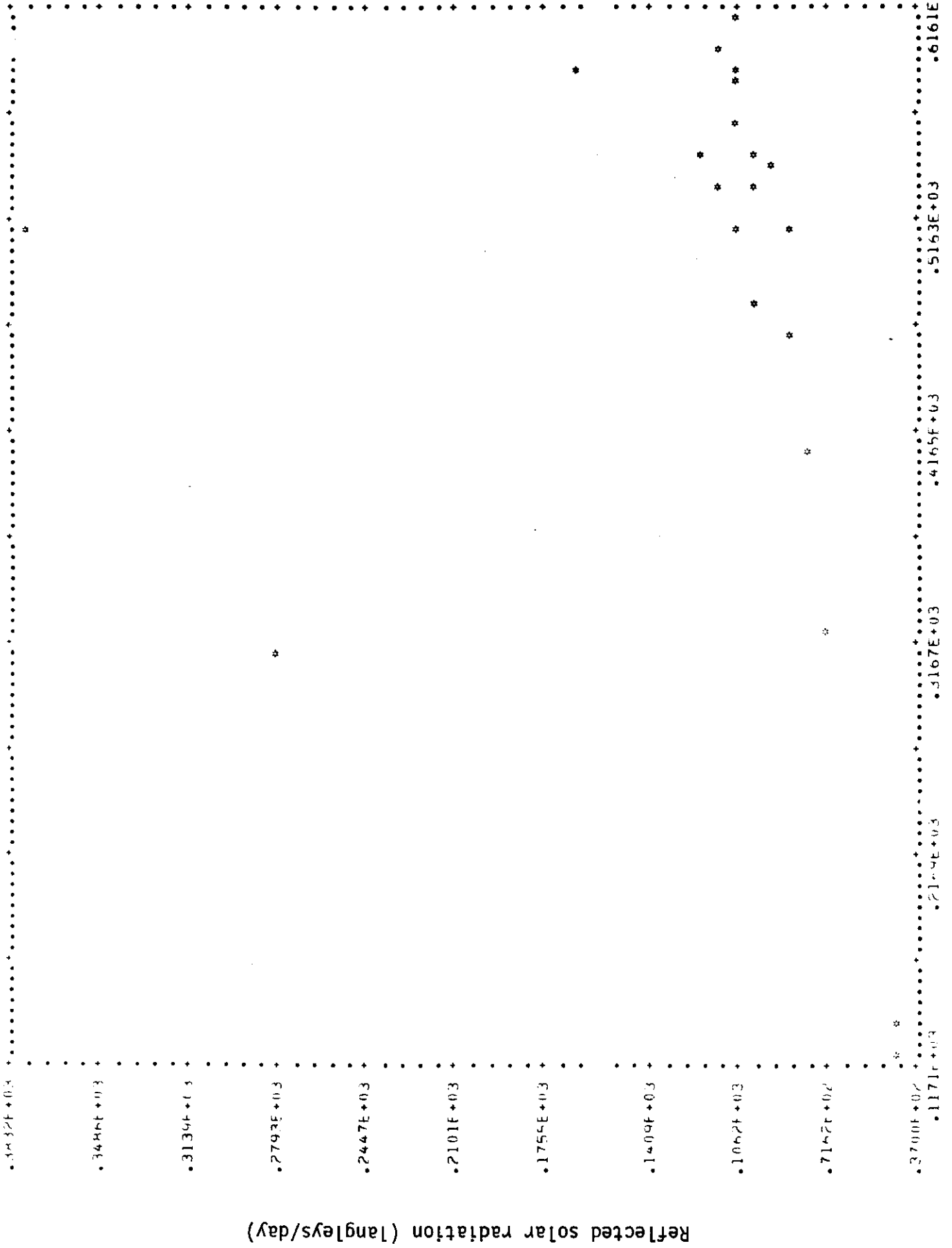


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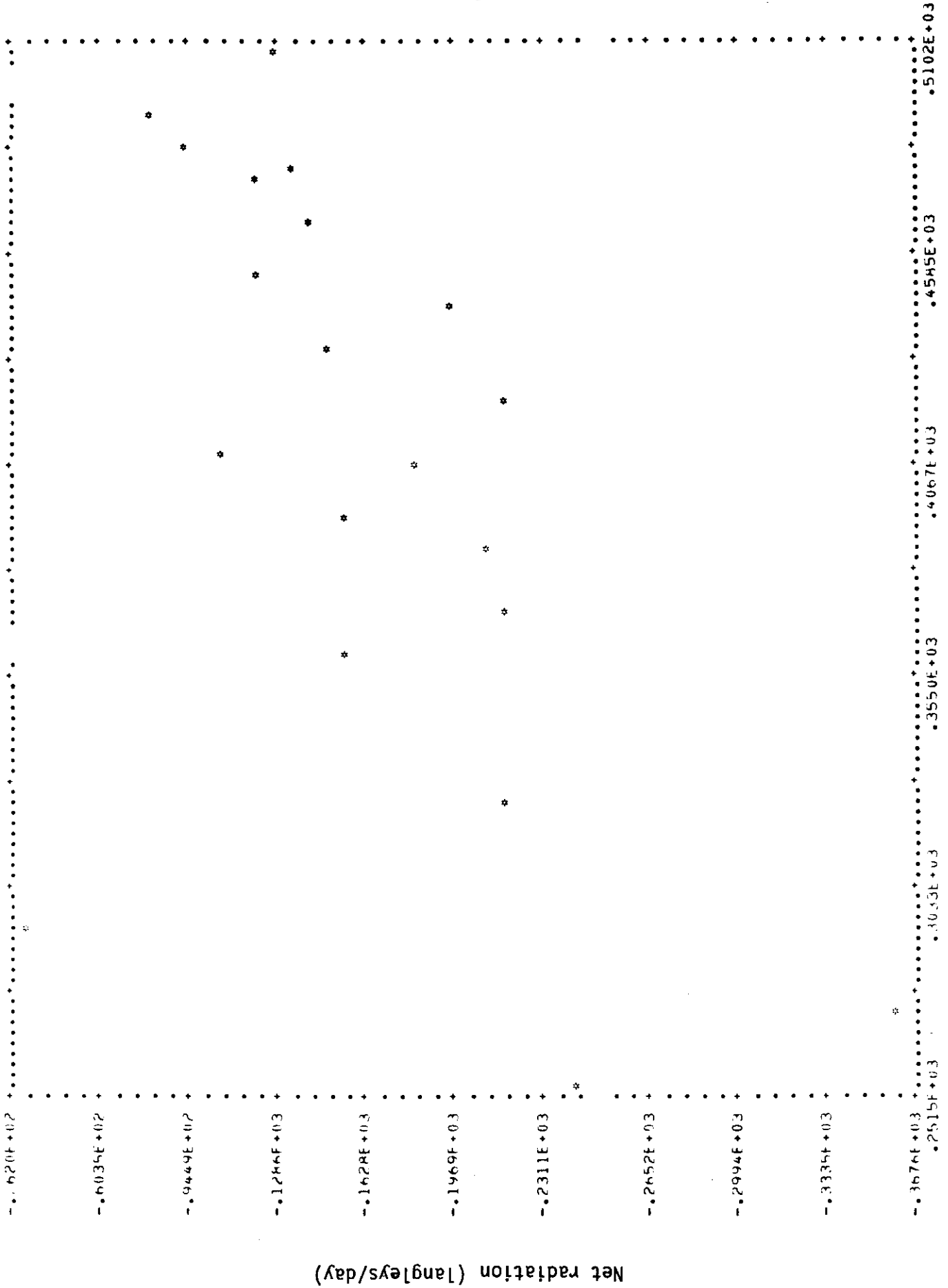


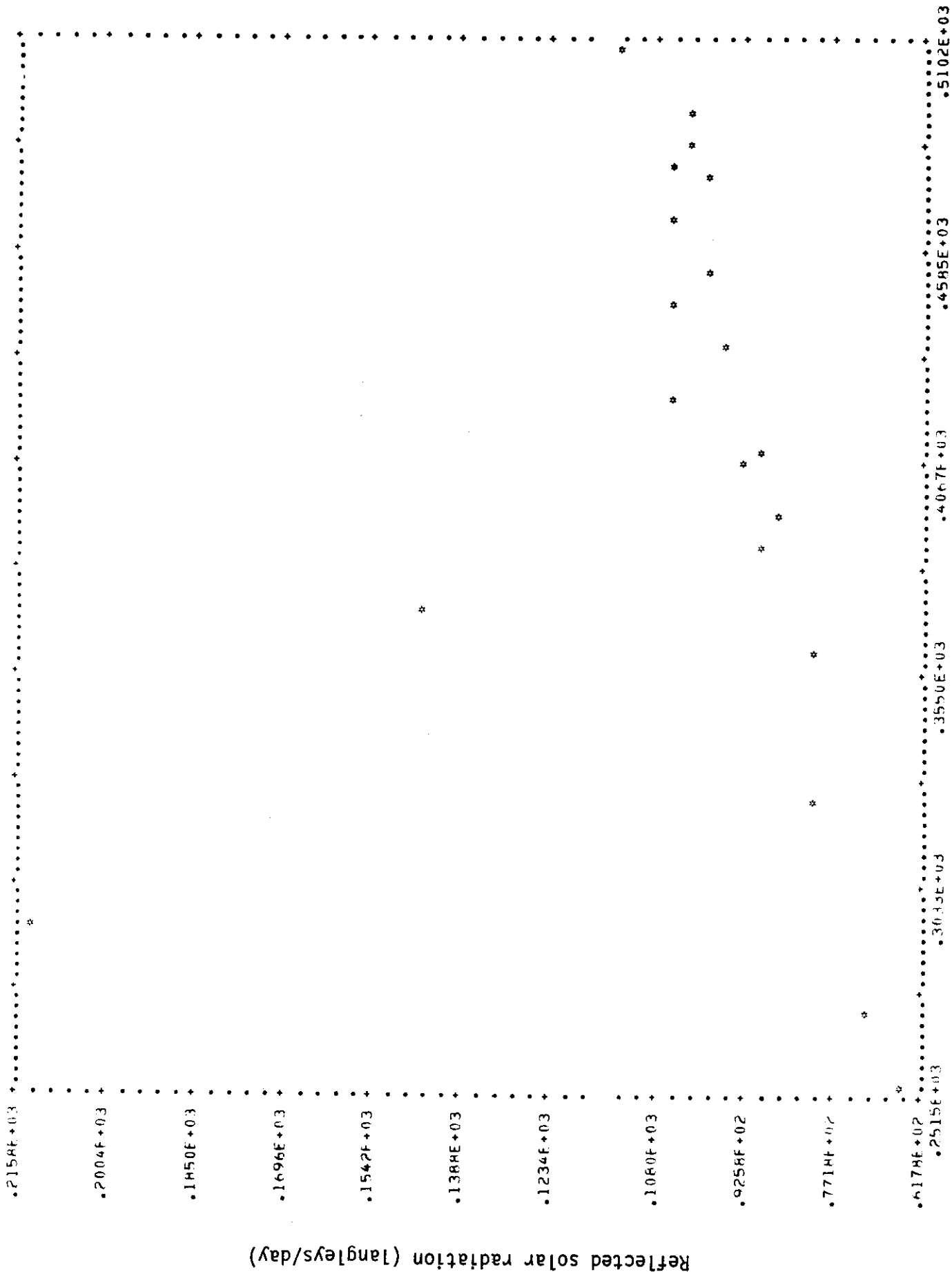
Total solar radiation (September 1971) (langleys/day)

(

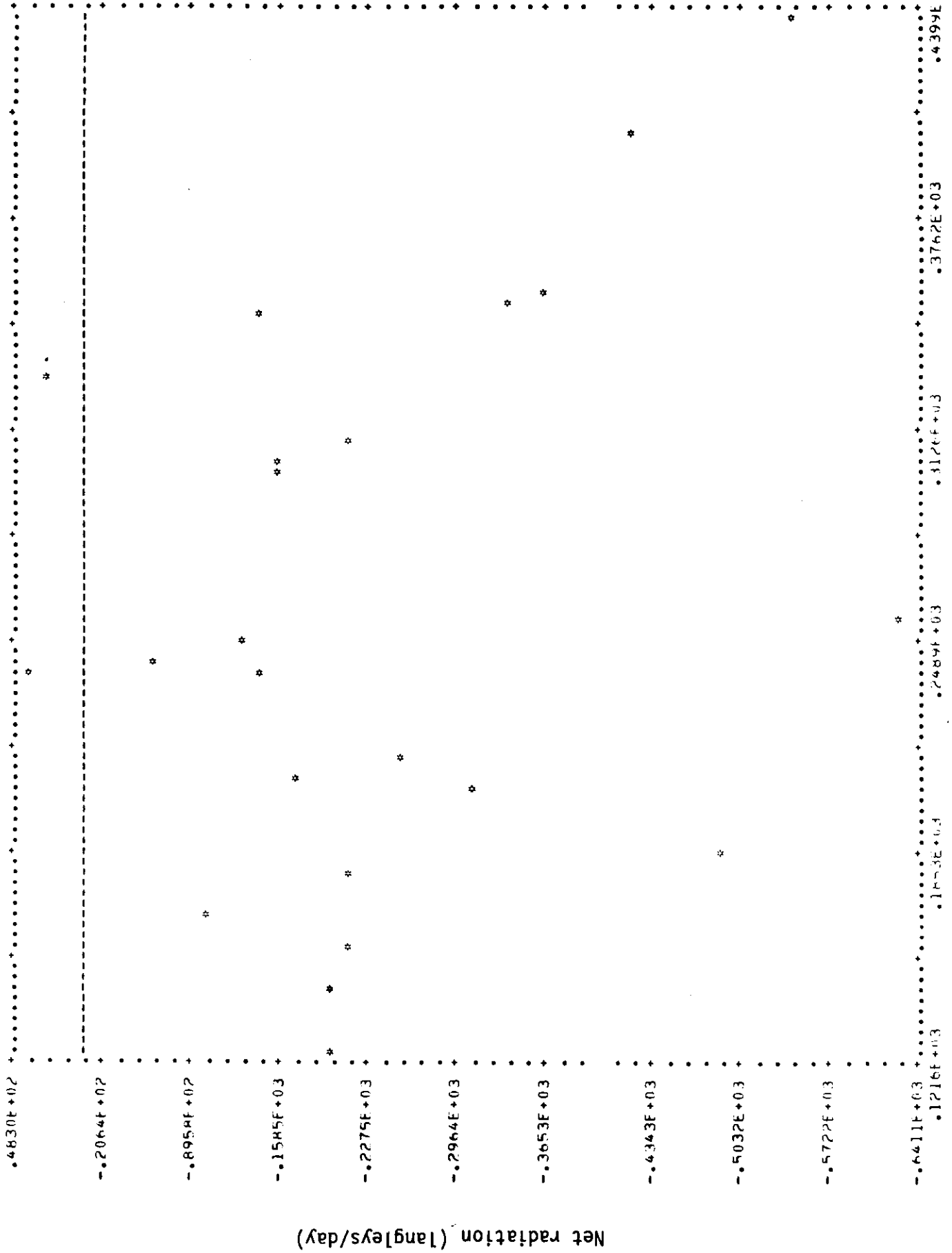


Total solar radiation (September 1971) (langley/day)

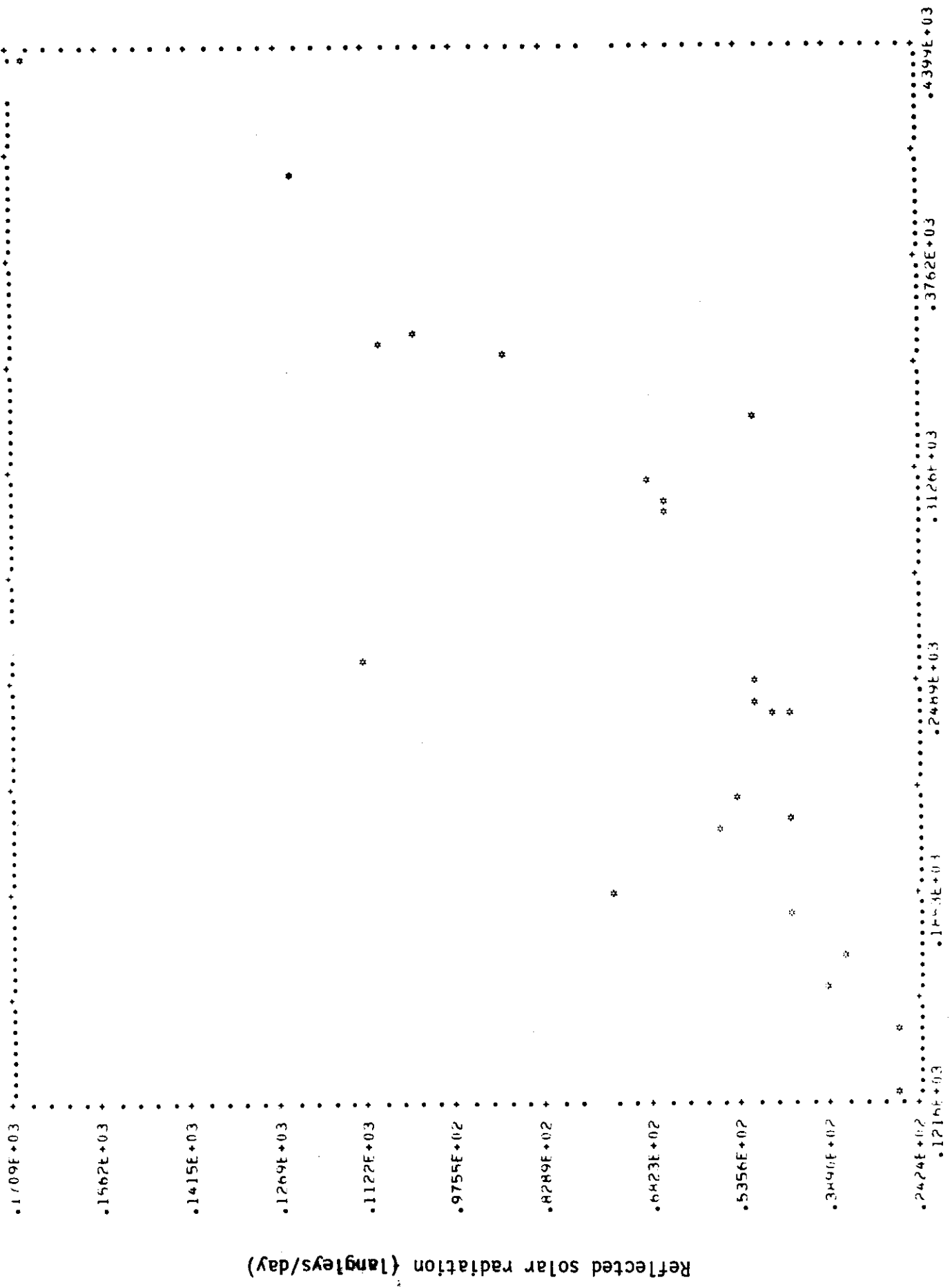




Total solar radiation (October, 1971) (langley/day)

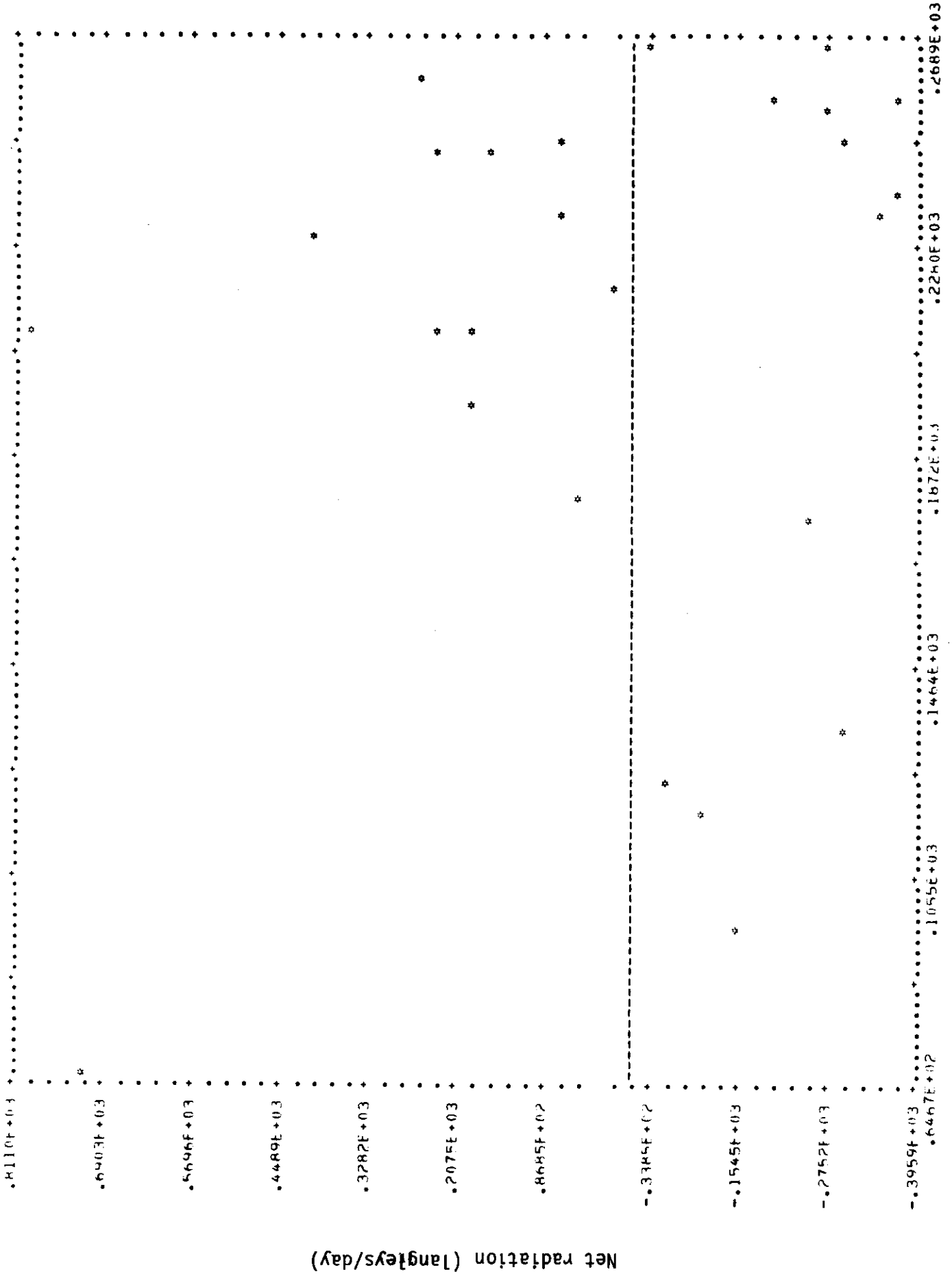


Total solar radiation (November, 1971) (langleys/day)

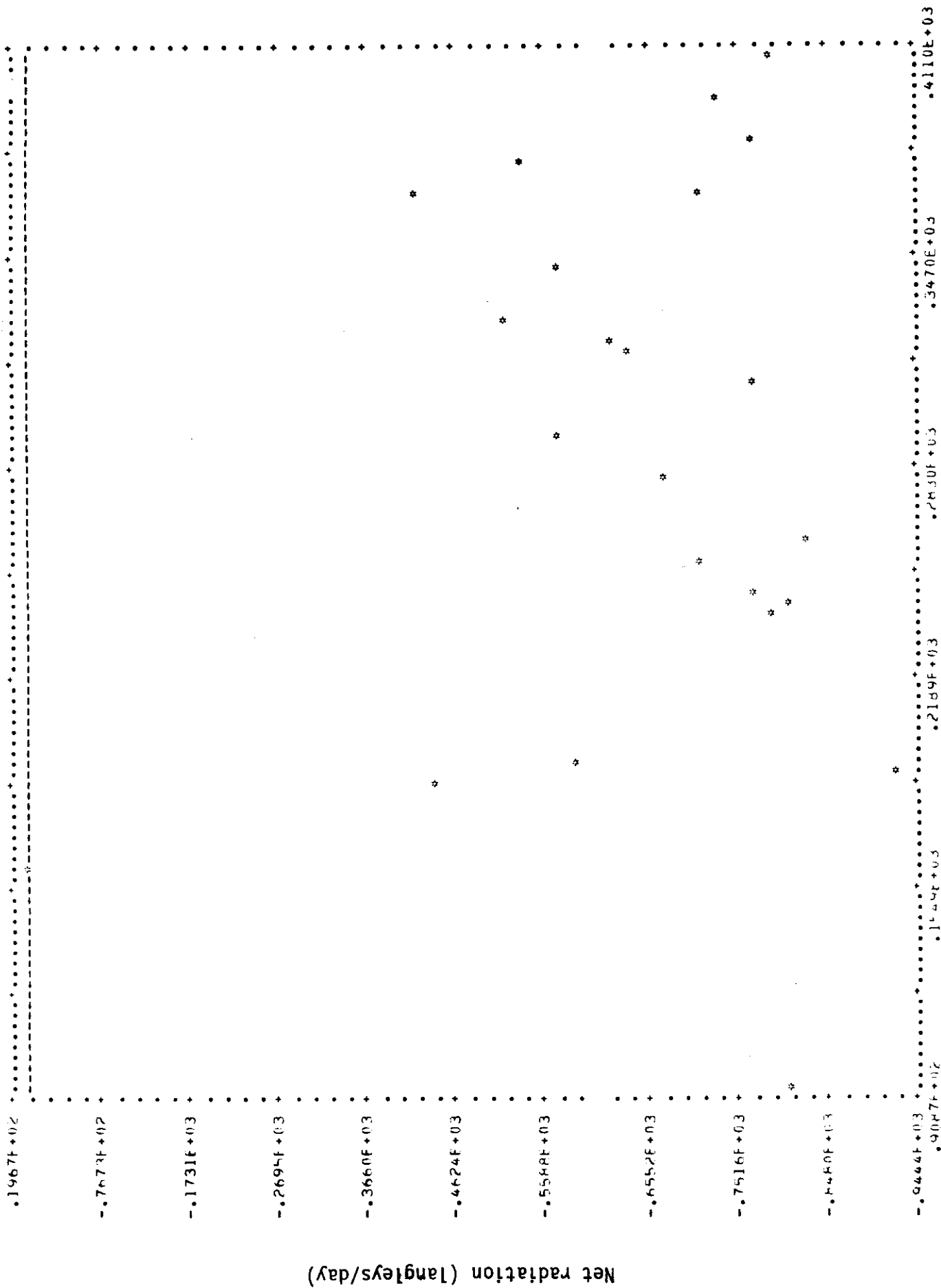


Total solar radiation (November, 1971) (langleys/day)

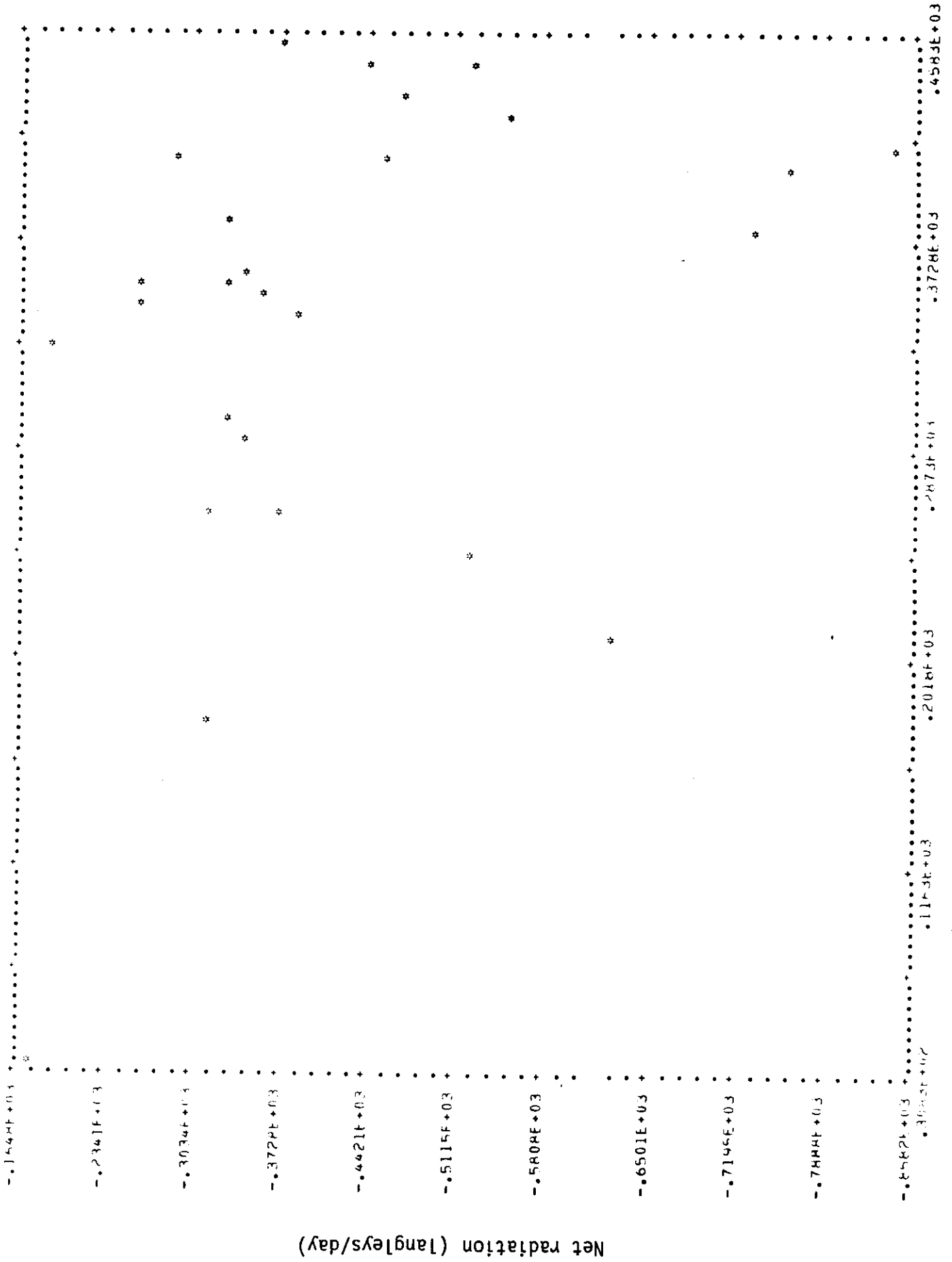
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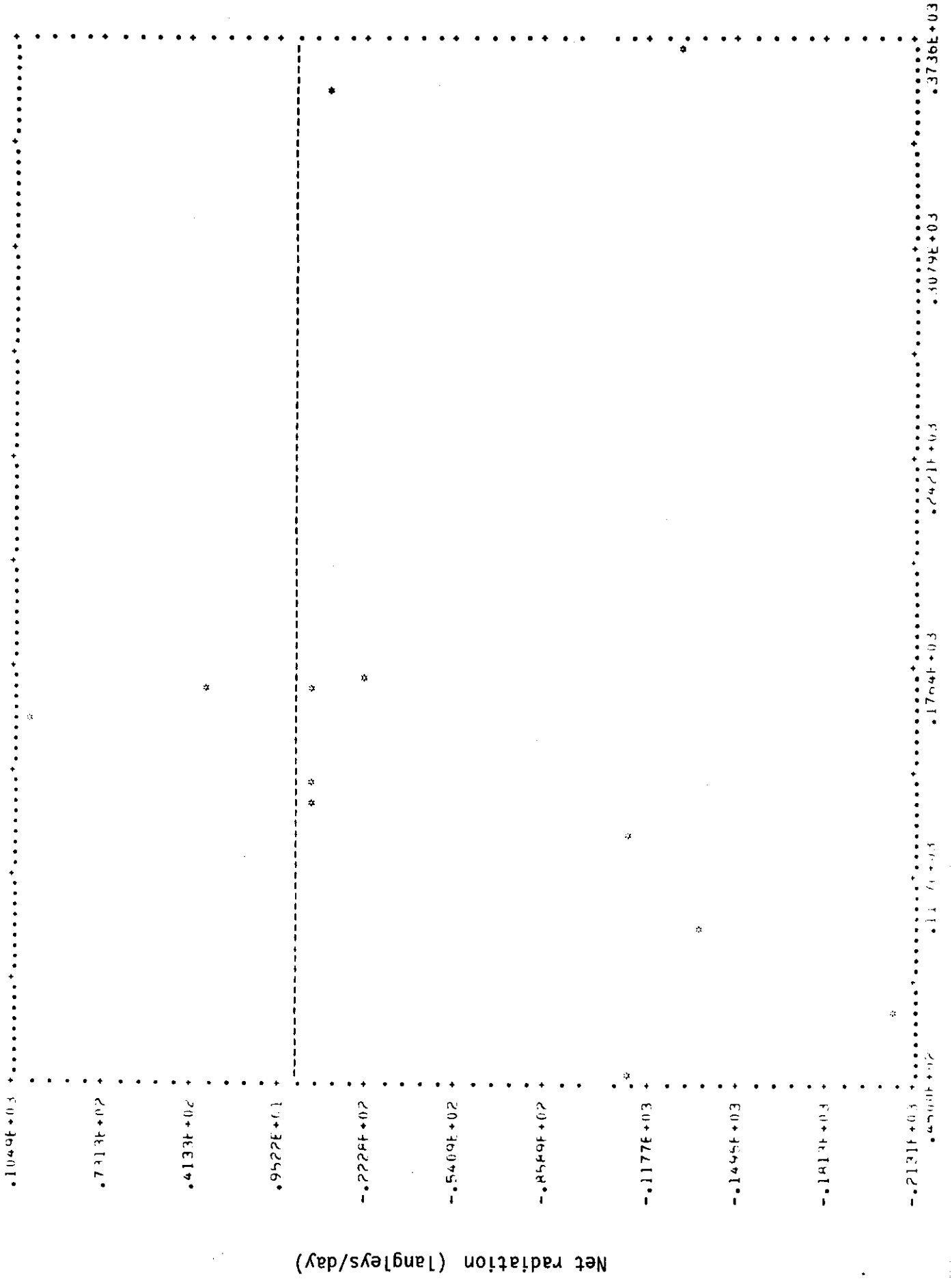
Total solar radiation (December, 1971) (Langley's/day)



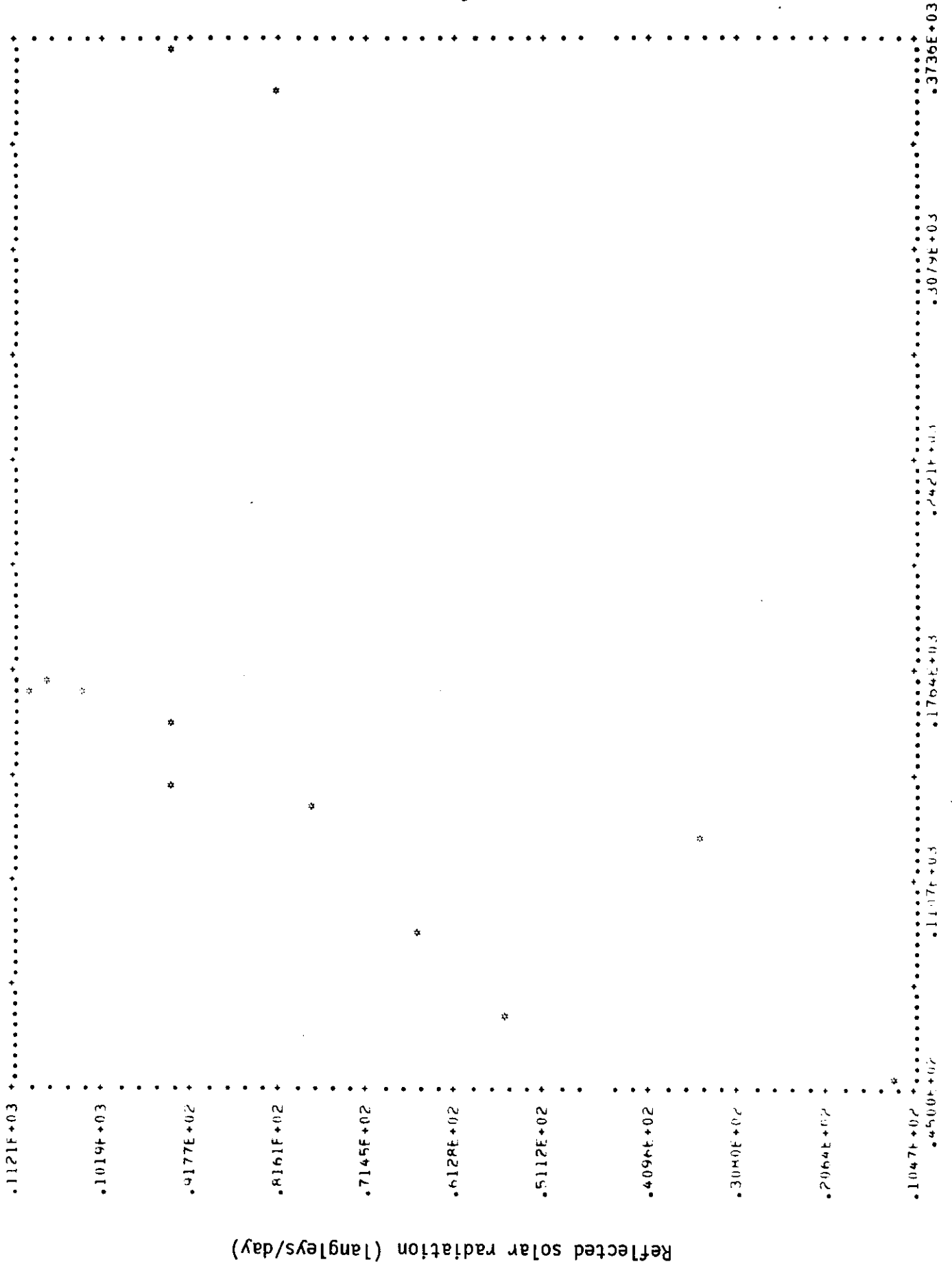
Total solar radiation (January, 1972) (Langley's/day)



Total solar radiation (February, 1972) (Tangleys/day)



Total solar radiation (March, 1972) (Langleys/day)



Total solar radiation (March, 1972) (Langley's/day)