NASA TECHNICAL MEMORANDUM

NASA TM-82526

(NASA-TM-82 26) STATISTICAL ASPECTS OF THE 1980 SOLAR LARES. PART 3: PARAMETRIC COMPARISON ND FINAL COMMENTS (NASA) 33 p HC A03/MF A 1 CSCL 03B

N83-37044

Unclas

G3/92 C3838

STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES – III. PARAMETRIC COMPARISON AND FINAL COMMENTS

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April 1983

NASA

George C. Marshall Space Flight Center
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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.
NASA TM-82526

2. GOVERNMENT ACCESSION NO.

3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE
Statistical Aspects of the 1980 Solar Flares - III. Parametric Comparisons and Final Comments

5. REPORT DATE
April 1983

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Robert M. Wilson

8. PERFORMING ORGANIZATION REPORT #

9. PERFORMING ORGANIZATION NAME AND ADDRESS

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.

13. TYPE OF REPORT & PERIOD COVERED
Technical Memorandum

12. SPONSORING AGENCY NAME AND ADDRESS
National Aeronautics and Space Administration
Washington, D.C. 20546

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared by Space Science Laboratory

16. ABSTRACT

Based on 1349 Hα flares with X-ray counterparts occurring near solar maximum, an investigation into the relationship between pairs of parameters, including rise time, decay time, Hα importance, and X-ray class, has been accomplished. As past experience has shown, it is found that, on average, long Hα rise-time flares tend to have long Hα decay time (on average about 2.9 times longer than the associated rise time), are more likely associated with areal class $\geq$ class 1 and relative brightness class bright, and are more likely associated with X-ray events of X-ray class $\geq$ C5. Also, it is noted that during 1980 2800-MHz radio flux (denoted F_{2800}) appeared to crudely track the south latitudinal regions for the first 10 months of the year and thereafter the north latitudinal regions, at least through December 1980. This series of reports has given associational aspects of flares occurring in 1980, the Solar Maximum Year, which met certain selection criteria. No effort has been made to model flare frequency correlation and distribution based on more advanced statistical techniques.

17. KEY WORDS
Sun, Solar Flare, Solar Maximum, Solar Cycle

18. DISTRIBUTION STATEMENT

Unclassified - Unlimited

R. E. Wilson

19. SECURITY CLASSIF. (of this report)
Unclassified

20. SECURITY CLASSIF. (of this page)
Unclassified

21. NO. OF PAGES
32

22. PRICE
NTIS

ACKNOWLEDGMENTS

The author is grateful to Dr. Ernest Hildner (NASA/MSFC) for reading the manuscript and to Mr. Jesse B. Smith, Jr. (NOAA/SEL) for providing helpful comments.

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TECHNICAL MEMORANDUM

STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES – III. PARAMETRIC COMPARISONS AND FINAL COMMENTS

I. INTRODUCTION

In a previous report [1], this author compiled a list of 1349 solar flares occurring in 1980 which met a specific set of selection criteria: namely, these study flares had known Hα start, maximum brightness and end times, latitudinal position, and importance; further, each Hα flare was associated with a specific X-ray event of known X-ray class. Frequency distributions of these parameters (Hα rise time, decay time and duration, latitude, Hα importance, and X-ray class) were tabulated and illustrated (monthly and for the year as a whole), and a number of conclusions, culminating in a brief description of the statistically typical study flare (for the Solar Maximum Year), was stated.

In a second report [2], this author continued his analysis of these study flares, stressing correlations of the aforementioned parameters with solar cycle, as adjudged by the 2800-MHz radio flux (denoted, F_{2800}) measured at Earth and corrected for solar bursts. An important finding in that study was that during 1980, both the number of Hα importance class 1 and the number of X-ray class M flares appeared to be rather strongly related to F_{2800}, in a positive sense; i.e., number of class 1 and class M events increased as F_{2800} increased.

In this third and final report in the series, the author completes his study of the 1349 study flares, addressing relationships between pairs of specific study parameters; namely, Hα rise time versus Hα importance, X-ray class and Hα decay time; Hα decay time versus Hα importance and X-ray class; and Hα importance versus X-ray class. Mean Hα rise time and decay time versus X-ray class and Hα importance will also be discussed, and some final comments regarding the study flares (see Appendix) and the previous reports will be given.

II. APPROACH

It may be important to remind the reader that the study flares were selected from Preliminary Report and Forecast of Solar Geophysical Data, a NOAA (Boulder, Colorado) weekly publication, not the Comprehensive Report of Solar Geophysical Data. The Preliminary Report was used because of the timeliness of the data. (The Comprehensive Report for the time period of interest is still, as yet, unpublished.) From the Preliminary Report listings, the specific set of selection criteria winnowed out a list of 1349 Hα/X-ray study flares that had, based on the lack of annotated remarks, known Hα start, maximum brightness and end times (thus, yielding rise time, decay time, and duration which equals rise time plus decay time), latitude of occurrence, importance (areal and relative brightness), and X-ray class. These flares, representing about one-fourth of all the Hα flares listed in the Preliminary Report with known positional information, form the data base for papers I, II, and III.

III. DISCUSSION

A. Rise Time Versus Hα Importance

Table 1 compares rise time in selected time bins (in minutes) against Hα flare importance and separately against areal class and relative brightness class for the 1349 study flares occurring in 1980. Totals for each subgroup are also given. Table 1 is shown in four parts. The upper-leftmost part gives the number of occurrences per rise time bin/importance bin; the lower-leftmost part gives the relative percent occurrence per rise time bin for each importance bin; the upper rightmost part gives the relative percent occurrence per importance bin for each rise time bin; and the lower-rightmost part gives the relative percent occurrence per subgroup pairs compared to the total number of study flares (i.e., a probability of occurrence). This same sequence of table construction and interpretation is used in Tables 2 through 6, as well. As an example for table usage, 166 study flares are observed to be subfaint (SF) flares that have Hα rise time ≤ 5 min (Table 1, upper-leftmost part); these 166 SF flares represent 19.9 percent of the 834 flares with rise time ≤ 5 min (Table 1, lower-leftmost part) and 79.8 percent of the 208 SF flares identified in the data base (Table 1, upper-rightmost part). Further, these 166 SF flares with rise time ≤ 5 min represent 12.3 percent of the 1349 study flares comprising the data base (Table 1, lower-rightmost part). Thus, the probability of occurrence for this subgroup pair is approximately 0.123.

Close examination of Table 1 reveals that nearly three-fourths of the study flares are subflares, with about two-thirds of these having rise time ≤ 5 min (i.e., about one-half of all study flares). Flares of importance $\geq$class 1 are more predominant as rise time increases, especially beyond rise time equal to about 15 min. Faint flares are more likely to be associated with rise time ≤ 5 min, although within this rise time bin, the probability of occurrence of normal or bright flares is higher. Bright flares are more predominant as rise time increases, especially beyond rise time equal to about 20 min. Thus, Table 1 suggests that longer, observed, Hα rise-time flares are more likely associated with flares of areal class ≥ 1 and relative brightness class bright.

B. Rise Time Versus X-Ray Class

Table 2 compares Hα rise time in selected time bins (in minutes) against various X-ray class groupings for the 1349 study flares occurring in 1980. Its construction and interpretation follow that of Table 1. Examination of Table 2 reveals that about three-fourths of all the study flares are X-ray class C flares, two-thirds of which have Hα rise time ≤ 5 min (i.e., about one-half of all study flares). About 40 percent of the study flares are of X-ray class <C5 with Hα rise time ≤ 5 min. As rise time increases beyond 5 min, the subgroup X-ray class $\geq$C5 predominates over X-ray class <C5. Thus, Table 2 suggests that longer, observed, Hα rise-time flares are more likely associated with X-ray events of higher X-ray class (i.e., $\geq$C5).

C. Decay Time Versus Hα Importance

Table 3 compares Hα decay time in selected time bins (in minutes) against Hα flare importance and separately against areal class and relative brightness class for the 1349 study flares occurring in 1980. As before, its construction and interpretation follow that of Table 1. Examination of Table 3 reveals, as previously noted, that about three-fourths of the study flares are subflares; of these, about 85 percent have Hα decay time $\leq$30 min. Flares of importance $\geq$class 1 predominate the subflares only at long decay time ($\geq$30 min). Faint flares are more often associated with short decay time ($\leq$15 min) and bright flares with long decay time (>15 min). Normal brightness flares usually predominate all decay time subgroups except those for long decay time (>25 min). Thus, Table 3 suggests that longer, observed, Hα decay-time flares are more likely associated with flares of areal class $\geq$class1 and relative brightness class bright.

D. Decay Time Versus X-Ray Class

Table 4 compares Hα decay time in selected time bins (in minutes) against various X-ray class groupings for the 1349 study flares occurring in 1980. As before, its construction and interpretation follow that of Table 1. Examination of Table 4 reveals, as previously noted, that about three-fourths of all the study flares are X-ray class C flares, about 85 percent of which have Hα decay time $\leq$30 min (i.e., about 65 percent of all study flares). Flares of X-ray class <C5 comprise about one-half of all the study flares and they usually have decay time $\leq$15 min. Flares of X-ray class $\geq$C5 usually have decay time >15 min. Thus, Table 4 suggests that longer, observed, Hα decay-time flares are more likely associated with X-ray events of higher X-ray class (i.e., $\geq$C5).

E. Rise Time Versus Decay Time

Table 5 compares Hα rise time in selected bins (in minutes) against decay time in analogous bins for the 1349 study flares occurring in 1980. The most populous rise time bin is $\leq$5 min, accounting for about 62 percent of all the study flares. The most populous decay time bin is >30 min, accounting for about 22 percent of all the study flares, although the other time bins are heavily populated too. The most populous combination rise time/decay time is rise time 0 to 5 min/decay time 6 to 10 min, accounting for 16 percent of all the study flares. About three-fourths of all the study flares have Hα rise time $\leq$15 min and Hα decay time $\leq$30 min; about two-thirds have rise time $\leq$10 min and decay time $\leq$30 min. About one-half of all study flares have rise time $\leq$5 min and decay time $\leq$30 min. Table 5 suggests that Hα flares with longer observed rise time are more likely to have longer, observed decay time, as well.

F. X-Ray Class Versus Hα Importance

Table 6 compares Hα importance and X-ray class. As before, the most populous Hα importance is subnormal (SN), accounting for about one-third of all study flares; subflares alone account for nearly three-fourths of all study flares. Also, about three-fourths of the study flares are X-ray class C flares, with about half of all study flares being <C5. About one-half of all study flares are subflares and X-ray class <C5; about one-fourth are subflares and X-ray class $\geq$C5. Less than 10 percent of the study flares have Hα importance $\geq$class 1 and X-ray class <C5; about 20 percent have Hα importance $\geq$ class 1 and X-ray class $\geq$C5. More than 80 percent of the study flares are of either normal or bright relative brightness. X-ray events of X-ray class <C5 are more apt to be associated with subflares of relative brightness faint or normal; X-ray events of X-ray class $\geq$C5 are more likely to be associated with sub-bright (SB) flares or flares of Hα importance $\geq$class 1 and either normal or bright relative brightness (usually the latter). All study flares of X-ray class $\geq$M5 are associated with bright (B) flares; three-fourths of the study flares of X-ray class $\geq$M1 are associated with bright flares. Thus, Table 6 suggests that flares of higher Hα importance (large areal extent and/or brighter in relative brightness) are more likely associated with X-ray events of higher X-ray class ($\geq$C5). This can, perhaps, be better demonstrated by way of using "mean" values.

From Table 6, one can compute a mean Hα importance ($\overline{IMP}$) for each X-ray subgroup. This is accomplished by summing numerical equivalents for each importance group per X-ray group by the following scheme: (i) give each flare (per importance group) a number representing a product of an area (S = 1, class 1 = 2, class 2 = 3, class 3 = 4) and a relative brightness (F = 1, N = 2, B = 3), (ii) sum the products of class times brightness per importance group, and iii) sum the sums of the products and divide by the total number of flares for the X-ray group of interest. Similarly, a mean peak X-ray class equivalent ($\overline{XR}$) can be deduced for each X-ray group by adding the peak energy outputs of all flares (i.e., the X-ray class of each flare, counting a C1 X-ray flare as 1, a C5 X-ray flare as 5, an M1 X-ray flare as 10, an M5 X-ray flare as 50, an X1 X-ray flare as 100, and so on) within that group and dividing by the total number of flares within that X-ray group. (A table identifying the number of X-ray events by X-ray class is contained in [1], page 49.) Table 7 gives the results of such computations. Clearly, one observes a rather strong tendency to associate high mean X-ray class with high mean Hα importance, and low mean X-ray class with low mean Hα importance. Figure 11 illustrates this relationship in terms of $\overline{XR}$ and $\overline{IMP}$. The straight line plotted (a visual approximation) is given merely to guide the eye and is described by:

$$\overline{IMP} = 3.1 \log(\overline{XR}) + 0.87 \quad . \tag{1}$$

Figure 1 shows that C X-ray events, on average, are associated with subflares (often of normal brightness) and M X-ray events with flares of Hα importance $\geq$class 1 (often normal or bright relative brightness).

G. Mean Rise Time and Mean Decay Time Versus X-ray Class

Table 8 gives Hα mean rise time ($\overline{RT}$) and mean decay time ($\overline{DT}$), their ratio ($\overline{RT}/\overline{DT}$), and number of events used (N) in computing the mean values for various X-ray groupings. Clearly, the higher the X-ray class the longer the mean rise time and decay time. The ratio is observed to decrease with higher X-ray class above X-ray group M1-M4, implying that the mean decay time is getting progressively longer, in relation to the corresponding mean rise time, as peak X-ray flux increases. (The number of events above M5 is relatively low, so this observation is statistically weak.) X-ray events <C5 have the shortest mean rise time and decay time. Consequently, they have the shortest mean duration ($\overline{D} = \overline{RT} + \overline{DT}$). Table 8 reveals that over half of the study flares (about 56 percent) were associated with X-ray events <C5 and had Hα mean rise time equal to 5.9 min, mean decay time 17.8 min,

and mean duration about 24 min; about three-fourths of the study flares were C X-ray events with Hα mean rise time equal to 6.5 min, mean decay time 19.1 min and mean duration about 26 min. Approximately 44 percent of the study flares were associated with X-ray events >C5 and had Hα mean rise time equal to 9.9 min, mean decay time 27.6 min and mean duration about 38 min. M events accounted for approximately 21 percent of the study flares and had Hα mean rise time equal to 11.7 min, mean decay time 32.3 min and mean duration about 44 min. Table 8 also shows that the statistically average flare had an Hα mean rise time of 7.6 min, mean decay time 22.1 min, and mean duration about 30 min.

Figure 2 illustrates the relation between Hα mean rise time ($\overline{RT}$) and mean decay time ($\overline{DT}$), based on the findings of Table 8, for various X-ray class groupings. The plotted line passing through the data points (obtained by simply dividing $\overline{RT}$ by $\overline{DT}$ for all study flares and defining $\overline{RT} = 0$ when $\overline{DT} = 0$) is described by:

$$\overline{RT} = 0.35\ \overline{DT} \quad . \tag{2}$$

While Hα rise time and decay time for specific events often show considerable scatter on RT versus DT scatter plots, the mean Hα values show a particular, somewhat structured relationship. That is, on average, flares of short Hα rise time tend to have short decay time, to be located in the lower-left portion of Figure 2, and usually to be associated with C X-ray events; conversely, flares of long Hα rise time tend to have long decay time, to be located in the upper-right portion of Figure 2, and usually to be associated with M X-ray events.

H. Mean Rise Time and Mean Decay Time Versus Hα Importance

Table 9 gives mean Hα rise time ($\overline{RT}$) and decay time ($\overline{DT}$), their ratio ($\overline{RT}/\overline{DT}$), and number of events used (N) in computing the mean values for the flares by Hα importance, individually and by areal extent and relative brightness. Table 9 reveals that events with short mean rise time and decay time tend to be subflares, while long mean rise time and decay time events tend to be flares of Hα importance ≥class 1. Also, short mean rise time and decay time events tend to be faint flares, while long mean rise time and decay time events tend to be bright flares. In contrast to the situation discussed in the previous section where the flares were sorted into bins of increasing X-ray peak flux, the mean Hα rise time and decay time ratio $\overline{RT}/\overline{DT}$ is observed to <u>increase</u> with Hα importance. This implies that mean rise time is getting progressively <u>longer faster</u> than the corresponding mean decay time lengthening. Again, the paucity of large Hα events makes this interpretation less secure statistically. Table 9 reveals that the nearly three-fourths of the study flares which were subflares had Hα mean rise time equal to 5.8 min, mean decay time 18.4 min and mean duration about 24 min; about one-fourth of the study flares were flares of Hα importance ≥class 1, having Hα mean rise time equal to 12.4 min, mean decay time 31.6 min and mean duration about 44 min. Faint flares accounted for approximately 17 percent of the study flares and had Hα mean rise time equal to 4.7 min, mean decay time 14.4 min, and mean duration about 19 min; normal flares accounted for 44 percent of the study flares and had Hα mean rise time equal to 6.7 min, mean decay time 19.9 min, and mean duration about 27 min; and bright flares accounted for 39 percent of the study flares and had Hα mean rise time equal to about 10 min, mean decay time 27.9 min, and mean duration about 38 min.

Figure 3 illustrates the relation between Hα mean time rise time ($\overline{RT}$) and mean decay time ($\overline{DT}$), based on the findings of Table 9, for selected Hα importance groups. Again, the straight line is as given in Figure 2 and expressed by equation 2. We note that, while an individual flare may exhibit about any rise time and decay time combination, independent of Hα importance, the mean values suggest a particular, somewhat structured relationship. That is, flares with short Hα rise time and decay time tend to be located in the lower-left portion of Figure 3, and, thus, usually are subflares; flares with long Hα rise time and decay time tend to be located in the upper-right portion of Figure 3 and usually are flares of Hα importance ≥class 1. Similarly, faint flares usually tend to be located in the lower-left portion of Figure 3 and bright flares in the upper-right.

IV. SUMMARY AND CONCLUSIONS

Since this report ends a three-part series based on a study of 1349 flares occurring in 1980, the Solar Maximum Year, a discussion of the conclusions of the present study and one summarizing the findings of the entire series follows.

A. Conclusions

The present study has investigated relationships between pairs of specified parameters of the 1349 study flares occurring in 1980 or very near solar maximum. In particular, this study has examined Hα rise time versus Hα importance, Hα rise time versus X-ray class, Hα rise time versus Hα decay time, Hα decay time versus Hα importance, Hα decay time versus X-ray class, and X-ray class versus Hα importance. The outcome of this study is that, statistically speaking, long Hα rise-time flares tend to have long Hα decay time, are more likely associated with areal class ≥class 1 and relative brightness class bright, and are more likely associated with X-ray events of X-ray class ≥C5. Conversely, short Hα rise-time flares tend to have short Hα decay time, are more likely associated with subflares of faint or normal brightness, and are more likely associated with X-ray events of X-ray class <C5. Examination of Hα mean rise time and mean decay time clearly show these findings. Also, mean rise time is observed to be related to mean decay time, by the visually approximated relation:

$$\overline{RT} = 0.35\ \overline{DT}\ , \qquad (2)$$

where $\overline{RT}$ is the Hα mean rise time and $\overline{DT}$ is the Hα mean decay time. Thus, Hα flare decay time, on average, is about 2.9 times longer than Hα rise time and flare Hα duration is about 3.9 times longer than rise time. Using a numerical equivalence scheme (see text), mean Hα importance ($\overline{IMP}$) is observed to be related to mean peak X-ray class ($\overline{XR}$), on average, by the visually approximated relation:

$$\overline{IMP} = 3.1 \log (\overline{XR}) + 0.87\ . \qquad (1)$$

Thus, X-ray flares of low X-ray class tend to be associated with subflares and X-ray flares of high X-ray class with flares of Hα importance ≥class 1.

B. Series Summary

Paper I [1] initiated the series, giving the selection criteria, the source of information for flares, and the data base including parametric information on 1349 flares occuring in 1980, the Solar Maximum Year. Frequency distributions (or more simply, number counts) of parameters of interest were tabulated and plotted. Important findings from paper I are summarized below.

- The median Hα rise time was found to be 3.5 min and the 90th percentile Hα rise time 16.5 min.
- The mean Hα rise time for all study flares was 7.6 min.
- Flares occurring late in the calendar year had longer Hα rise time, on average, than flares early in the year.
- Only 4 percent of the events had Hα rise times longer than 30 min, only 1 percent had Hα rise times longer than 1 hour.
- The median Hα decay time was found to be about 16 min and the 90th percentile Hα decay time about 44 min.
- The mean Hα decay time for all study flares was 22.1 min.
- Flares occurring late in the year had longer Hα decay time, on average, than flares early in the year.
- About 30 percent of the events had Hα decay time longer than 30 min; 5 percent had Hα decay time longer than 1 hour.
- The median Hα duration was found to be about 21 min and the 90th percentile Hα duration about 58 min.
- The mean Hα duration for all study flares was approximately 30 min.
- Flares occurring late in the year had longer Hα duration, on average, than flares early in the year.
- About 34 percent of the events had Hα duration longer than 30 min; 9 percent had Hα duration longer than 1 hour.
- Mean Hα rise time to mean Hα decay time was equal to 0.35.
- Mean Hα rise time to mean Hα duration was equal to 0.26.
- More than three-fourths of the study flares were C class X-ray events (typically <C5); slightly less than one-fourth were M class X-ray events; only 1 percent were X class X-ray events.
- Flares occurring late in the year were more energetic, based on their X-ray classification, than flares early in the year.

- Slightly less than three-fourths of the study flares were subfares, with SN flares being the greatest single group in number.

- Flares occurring late in the year were brighter and of larger areal extent, on average, than flares early in the year.

- About two-thirds of the study flares occurred in the 10° to 19° latitude zone on the Sun, more often at south latitude.

- The monthly mean latitude of flare occurrence decreased through the year; the mean latitude of flare occurrence for the year was about 15°.

- Flares were more prolific during the latter part of the year, subsequent to solar maximum, than early in the year.

- On average, there were 112.4 study flares observed per month or 3.7 flares per day; since study flares represented 26.7 percent of the flares listed in the NOAA flare informational source, flares occurred, on average, about 421 per month or about 14 per day during 1980. (These numbers may increase two times or more in the listings of the Comprehensive Report of Solar Geophysical Data.)

Paper II [2] continued the series, examining possible relationships with solar activity. Important findings from paper II are summarized below:

- During 1980, R_I (i.e., international mean monthly sunspot number) and F_{2800} were related in a positive sense.

- Mean relative brightness of the study flares was associated with mean areal extent, in a positive sense.

- Mean Hα rise time, decay time and duration all showed upward trends during the year; mean Hα importance class and X-ray class showed similar upward trends.

- Number of Hα importance class 1 flares and number of X-ray class M flares were both correlated with F_{2800}, in a positive sense.

Paper III completes the series, investigating relationships between pairs of parameters. Paper III results have been summarized above and in additional remarks contained in the attached Appendix.

TABLE 1. Hα RISE TIME VERSUS Hα IMPORTANCE (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

	RISE TIME (MIN)									
IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	106	27	7	3	2	1	2	193	208	208
SN	300	86	33	15	3	1	12	393	446	467
SB	206	52	15	4	7	1	16	258	286	300
1F	9	3	0	2	0	0	3	12	14	17
1N	54	43	9	9	3	5	4	97	123	127
1B	79	40	19	15	12	5	13	119	170	183
2F	0	1	1	0	0	0	0	1	2	2
2N	2	4	2	1	3	0	2	6	9	11
2B	10	16	6	2	0	2	7	26	36	43
3B	0	0	0	0	0	0	1	0	0	1
S	600	164	56	22	12	[illegible]	2[illegible]	844	936	985
1	142	86	28	26	15	10	20	228	307	327
2	12	21	9	3	0	2	9	33	47	56
3	0	0	0	0	0	0	1	0	6	1
≥1	154	107	37	29	15	12	30	261	354	384
F	175	31	8	5	2	1	5	206	222	227
N	304	132	44	25	6	6	18	406	577	595
B	296	100	40	21	19	8	36	403	491	527
TOTAL	834	271	92	51	27	15	58	1106	1290	1348

	RISE TIME (MIN)									
IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL*
SF	70.8	13.0	3.4	1.4	1.0	0.5	1.0	92.8	99.0	
SN	67.4	18.6	7.2	3.3	0.7	0.2	2.6	86.0	97.4	
SB	68.7	17.3	5.0	1.3	2.3	0.3	5.0	86.0	95.0	
1F	52.9	17.6	0	11.8	0	0	17.6	70.6	82.4	
1N	42.5	33.9	7.1	7.1	2.4	3.9	3.1	76.4	96.9	
1B	43.2	21.9	10.4	8.2	6.6	2.7	7.1	65.0	92.9	
2F	0	50.0	50.0	0	0	0	0	50.0	100.0	
2N	18.2	36.4	18.2	9.1	0	0	18.2	54.5	81.8	
2B	23.3	37.2	14.0	4.7	0	4.7	16.3	60.5	83.7	
3B	0	0	0	0	0	0	100.0	0	0	
S	70.5	17.0	5.7	2.3	1.2	0.3	3.0	87.5	97.0	
1	43.4	26.3	8.6	8.0	4.6	3.1	6.1	69.7	93.9	
2	21.4	37.5	16.1	5.4	0	3.6	16.1	58.9	83.9	
3	0	0	0	0	0	0	100.0	0	0	
≥1	40.1	27.9	9.6	7.6	3.9	3.1	7.8	68.0	92.2	
F	77.1	13.7	3.5	2.2	0.9	0.4	2.2	90.7	97.8	
N	61.2	22.2	7.4	4.2	1.0	1.0	3.0	83.4	97.0	
B	56.0	20.5	7.6	4.0	3.8	1.5	6.8	76.5	93.2	
TOTAL	61.8	29.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	

*EACH SUBHEADING EQUALS 100.0

	RISE TIME (MIN)									
IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	19.9	10.0	7.6	5.9	7.4	6.7	3.4	17.5	16.0	15.4
SN	36.9	31.4	35.9	29.4	11.1	6.7	20.3	35.6	34.5	33.9
SB	24.7	19.2	16.3	7.8	25.9	6.7	26.	23.3	22.1	22.2
1F	1.1	1.1	0	3.9	0	0	5.1	1.1	1.1	1.3
1N	6.5	15.9	9.8	17.6	11.1	33.3	6.8	8.8	9.5	9.4
1B	9.5	14.8	20.7	29.4	44.4	33.3	22.0	10.8	13.2	13.6
2F	0	0.4	1.1	0	0	0	0	0.1	0.2	0.1
2N	0.2	1.5	2.2	2.0	0	0	3.4	0.5	0.7	0.8
2B	1.2	5.9	6.5	3.9	0	13.3	11.9	2.4	2.8	3.2
3B	0	0	0	0	0	0	1.7	0	0	0.1
S	81.5	60.5	60.8	43.1	44.4	20.0	49.2	76.4	72.6	71.5
1	17.0	31.7	30.4	51.0	55.6	66.7	33.9	20.6	23.8	24.2
2	1.4	7.7	9.8	5.9	0	13.3	15.3	3.0	3.6	4.2
3	0	0	0	0	0	0	1.7	0	0	0.1
≥1	18.5	39.5	40.2	56.9	55.6	80.0	50.8	23.6	27.4	28.5
F	21.0	11.4	8.7	9.8	7.4	6.7	8.5	18.6	17.2	16.8
N	43.6	48.7	47.8	49.0	22.2	40.0	30.5	44.9	44.7	44.1
B	35.5	36.9	43.5	41.2	70.4	53.3	61.0	36.5	38.1	39.1
TOTAL*										

*EACH SUBHEADING EQUALS 100.0

	RISE TIME (MIN)									
IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	12.3	2.0	0.5	0.2	0.1	0.1	0.1	14.3	15.3	15.4
SN	22.8	6.3	2.4	1.1	0.2	0.1	0.9	29.1	33.0	33.9
SB	15.3	3.9	1.1	0.3	0.5	0.1	1.1	19.1	21.1	22.2
1F	0.7	0.2	0	0.1	0	0	0.2	0.9	1.0	1.3
1N	4.0	3.2	0.7	0.7	0.2	0.4	0.3	7.2	9.1	9.4
1B	5.9	3.0	1.4	1.1	0.9	0.4	1.0	8.8	12.6	13.6
2F	0	0.1	0.1	0	0	0	0	0.1	0.1	0.1
2N	0.1	0.3	0.1	0.1	0	0	0.1	0.4	0.7	0.8
2B	0.7	1.2	0.4	0.1	0	0.1	0.5	1.9	2.7	3.2
3B	0	0	0	0	0	0	0.1	0	0	0.1
S	50.4	12.2	4.1	1.6	0.9	0.2	2.1	62.6	69.4	71.5
1	10.5	6.4	2.1	1.9	1.1	0.7	1.5	16.9	22.8	24.2
2	0.9	1.6	0.7	0.2	0	0.1	0.7	2.4	3.5	4.2
3	0	0	0	0	0	0	0.1	0	0	0.1
≥1	11.4	7.9	2.7	2.1	1.1	0.8	2.2	19.3	26.2	28.5
F	13.0	2.3	0.6	0.4	0.1	0.1	0.4	15.3	16.5	16.8
N	27.0	8.8	3.3	1.9	0.4	0.4	1.3	36.0	42.9	44.1
B	21.9	8.0	3.0	1.6	1.4	0.6	2.7	29.9	36.4	39.1
TOTAL	61.8	20.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	100.0

TABLE 2. Hα RISE TIME VERSUS X-RAY CLASS (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

X-RAY CLASS	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	526	130	38	23	12	1	23	656	730	753
C5-C9	177	55	27	12	5	5	14	232	281	295
M1-M4	111	72	22	12	6	7	18	183	230	248
M5-M9	16	6	5	4	3	1	3	22	35	38
≥X1	4	8	0	0	1	1	1	12	14	15
C	703	185	65	35	17	6	37	888	1011	1048
M	127	78	27	16	9	8	21	205	265	286
≥C5	308	141	54	28	15	14	36	449	560	596
≥M1	131	86	27	16	10	9	22	217	279	301
≥M5	20	14	5	4	4	2	4	34	49	53
TOTAL	834	271	92	51	27	15	58	1105	1290	1349

X-RAY CLASS	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL*
C0-C4	68.9	17.3	5.0	3.1	1.6	0.1	3.1	87.1	96.9	
C5-C9	60.0	18.6	9.2	4.1	1.7	1.7	4.7	78.6	95.3	
M1-M4	44.8	29.0	8.9	4.8	2.4	2.8	7.3	73.8	92.7	
M5-M9	42.1	15.8	13.2	10.5	7.9	2.6	7.9	57.9	92.1	
≥X1	26.7	53.3	0	0	6.7	6.7	6.7	80.0	93.3	
C	67.1	17.7	6.2	3.3	1.6	0.6	3.5	84.7	96.5	
M	44.4	27.3	9.4	5.6	3.1	2.8	7.3	71.7	92.7	
≥C5	51.7	23.7	9.1	4.7	2.5	2.3	6.0	75.3	94.0	
≥M1	43.5	28.6	9.0	5.3	3.3	3.0	9.3	72.1	92.7	
≥M5	37.7	26.4	9.4	7.5	7.5	3.8	7.5	64.2	92.5	
TOTAL	61.8	20.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	

*EACH SUBHEADING EQUALS 100.0

X-RAY CLASS	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	63.1	48.0	41.0	45.1	44.4	6.7	39.0	59.4	56.6	55.8
C5-C9	21.1	20.3	29.3	23.5	18.5	33.3	23.7	21.0	21.8	21.9
M1-M4	13.3	26.6	23.9	23.5	22.2	46.7	30.5	16.6	17.8	18.4
M5-M9	1.9	2.2	5.4	7.8	11.1	6.7	5.1	2.0	2.7	2.8
≥X1	0.5	3.0	0	0	3.7	6.7	1.7	1.1	1.1	1.1
C	84.3	68.3	70.7	68.6	63.0	40.0	62.7	80.4	78.4	77.7
M	15.2	28.8	29.3	31.4	33.3	53.3	35.6	18.6	20.5	21.2
≥C5	36.9	52.2	58.7	54.9	55.6	93.3	61.0	40.6	43.4	44.2
≥M1	15.7	31.7	29.3	31.4	37.0	60.0	37.3	19.6	21.6	22.3
≥M5	2.4	5.2	5.4	7.8	14.8	13.3	6.8	3.1	3.8	3.9
TOTAL*										

*EACH SUBHEADING EQUALS 100.0

X-RAY CLASS	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	39.0	9.6	2.8	1.7	0.9	0.1	1.7	48.6	54.1	56.8
C5-C9	13.1	4.1	2.0	0.9	0.4	0.4	1.0	17.2	20.8	21.9
M1-M4	8.2	5.3	1.6	0.9	0.4	0.5	1.3	13.6	17.0	18.4
M5-M9	1.2	0.4	0.4	0.3	0.2	0.1	0.2	1.6	2.6	2.8
≥X1	0.3	0.6	0	0	0.1	0.1	0.1	0.9	1.0	1.1
C	52.1	13.7	4.8	2.6	1.3	0.4	2.7	65.8	74.9	77.7
M	9.4	5.8	2.0	1.2	0.7	0.6	1.6	15.2	19.6	21.2
≥C5	22.8	10.5	4.0	2.1	1.1	1.0	2.7	33.3	41.5	44.2
≥M1	9.7	6.4	2.0	1.2	0.7	0.7	1.6	16.1	20.7	22.3
≥M5	1.5	1.0	0.4	0.3	0.3	0.1	0.3	2.5	3.6	3.9
TOTAL	61.8	20.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	100.0

TABLE 3. Hα DECAY TIME VERSUS Hα IMPORTANCE (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

DECAY TIME (MIN)

IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	36	66	42	26	15	9	14	102	194	208
SN	42	107	93	76	54	22	64	149	383	467
SB	33	54	40	52	24	27	61	87	230	300
1F	2	4	4	1	1	3	2	6	15	17
1N	14	16	18	24	10	18	27	30	100	127
1B	20	8	10	10	13	14	91	28	92	183
2F	0	0	0	1	0	1	0	0	2	2
2N	2	0	1	1	2	0	5	2	6	11
2B	6	1	1	1	1	3	30	7	13	43
3B	0	0	0	0	0	0	1	0	0	1
S	111	227	184	153	93	58	139	338	826	965
1	36	28	40	44	24	35	120	64	207	327
2	8	1	2	3	3	4	36	9	21	56
3	0	0	0	0	0	0	1	0	0	1
≥1	44	30	42	47	27	39	156	73	228	384
F	38	70	46	28	16	13	16	108	211	227
N	58	123	112	100	66	40	96	181	498	596
B	60	63	68	72	38	44	183	122	344	527
TOTAL	156	256	226	200	120	97	295	411	1064	1349

DECAY TIME (MIN)

IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL*
SF	17.3	31.7	20.2	12.5	7.2	4.3	6.7	49.0	93.3	
SN	9.2	23.4	20.4	16.4	11.6	4.8	14.0	32.6	86.0	
SB	11.0	18.0	16.3	17.3	8.0	9.0	20.3	29.0	79.7	
1F	11.8	23.5	23.5	5.9	5.9	17.6	11.8	35.3	88.2	
1N	11.0	12.6	14.2	18.9	7.9	14.2	21.3	23.6	78.7	
1B	10.9	4.4	5.5	10.4	7.1	7.7	49.7	15.3	50.3	
2F	0	0	0	50.0	0	50.0	0	0	100.0	
2N	18.2	0	9.1	9.1	18.2	0	45.5	18.2	54.5	
2B	14.0	2.3	2.3	2.3	2.3	7.0	69.8	16.3	30.2	
3B	0	0	0	0	0	0	100.0	0	0	
S	11.5	23.5	19.1	15.9	9.6	6.0	14.4	35.0	85.6	
1	11.0	8.6	12.2	13.5	7.3	10.7	36.7	19.6	63.3	
2	14.3	1.8	3.6	5.4	5.4	7.1	62.5	16.1	37.5	
3	0	0	0	0	0	0	100.0	0	0	
≥1	11.5	10.2	10.9	12.2	7.0	10.2	40.6	19.8	59.4	
F	16.7	30.8	20.3	12.3	7.0	5.7	7.0	47.6	93.0	
N	9.7	20.7	18.8	16.8	11.1	6.7	16.1	30.4	83.9	
B	11.2	12.0	12.9	13.7	7.2	8.3	34.7	23.1	65.3	
TOTAL	11.5	19.0	16.8	14.8	8.9	7.2	21.9	30.5	78.1	

*EACH SUBHEADING EQUALS 100.0

DECAY TIME (MIN)

IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	23.2	25.8	18.6	13.0	12.5	9.3	4.7	24.8	18.4	15.4
SN	27.1	41.8	41.2	37.5	45.0	22.7	21.7	36.3	37.3	33.9
SB	21.3	21.1	21.7	26.0	20.0	27.8	20.7	21.2	22.7	22.2
1F	1.3	1.6	1.8	0.5	0.8	3.1	0.7	1.5	1.4	1.3
1N	9.0	6.3	8.0	12.0	8.3	18.6	9.2	7.3	9.5	9.4
1B	12.9	3.1	8.0	9.5	10.8	14.4	30.8	6.8	8.7	13.6
2F	0	0	0	0.5	0	1.0	0	0	0.2	0.1
2N	1.3	0	0.4	0.5	1.7	0	1.7	0.5	0.6	0.8
2B	3.9	0.4	0.4	0.5	0.8	3.1	10.2	1.7	1.2	3.2
3B	0	0	0	0	0	0	0.3	0	0	0.1
S	71.8	88.7	81.4	76.5	77.5	59.8	47.1	82.2	78.4	71.6
1	23.2	10.9	17.7	22.0	20.0	36.1	40.7	15.6	19.6	24.2
2	5.2	0.4	0.9	1.5	2.5	4.1	11.9	2.2	2.0	4.2
3	0	0	0	0	0	0	0.3	0	0	0.1
≥1	28.4	15.2	18.6	23.5	22.5	40.2	52.9	17.8	21.6	28.5
F	24.5	27.3	20.4	14.0	13.3	13.4	5.4	26.3	20.0	16.8
N	37.4	48.0	49.6	50.0	55.0	41.2	32.5	44.0	47.3	44.1
B	38.1	24.6	30.1	36.0	31.7	45.4	62.0	29.7	32.6	39.1
TOTAL*										

*EACH SUBHEADING EQUALS 100.0

DECAY TIME (MIN)

IMP	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
SF	2.7	4.9	3.1	1.9	1.1	0.7	1.0	7.6	14.4	15.4
SN	3.1	7.9	6.9	5.6	4.0	1.6	4.7	11.0	28.1	33.9
SB	2.4	4.0	3.6	3.9	1.8	2.0	4.5	6.4	17.7	22.2
1F	0.1	0.3	0.3	0.1	0.1	0.2	0.1	0.4	1.1	1.3
1N	1.0	1.2	1.3	1.8	0.7	1.3	2.0	2.2	7.4	9.4
1B	1.5	0.6	1.3	1.4	1.0	1.0	6.7	2.1	6.8	13.6
2F	0	0	0	0.1	0	0.1	0	0	0.1	0.1
2N	0.1	0	0.1	0.1	0.1	0	0.4	0.1	0.4	0.8
2B	0.4	0.1	0.1	0.1	0.1	0.2	2.2	0.5	1.0	3.2
3B	0	0	0	0	0	0	0.1	0	0	0.1
S	8.2	16.8	13.6	11.3	6.9	4.3	10.3	25.1	61.2	71.6
1	2.7	2.1	3.0	3.3	1.8	2.6	8.9	4.7	15.3	24.2
2	0.6	0.1	0.1	0.2	0.2	0.3	2.6	0.7	1.6	4.2
3	0	0	0	0	0	0	0.1	0	0	0.1
≥1	3.3	2.9	3.1	3.6	2.0	2.9	11.6	5.4	16.9	28.5
F	2.8	5.2	3.4	2.1	1.2	1.0	1.2	8.0	15.6	16.8
N	4.3	9.1	8.3	7.4	4.9	3.0	7.1	13.4	37.0	44.1
B	4.4	4.7	5.0	5.3	2.8	3.3	13.6	9.0	25.5	39.1
TOTAL	11.5	19.0	16.8	14.8	8.9	7.2	21.9	30.5	78.1	100.0

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TABLE 4. Hα DECAY TIME VERSUS X-RAY CLASS (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

	DECAY TIME (MIN)									
X-RAY CLASS	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	91	185	141	106	81	51	98	276	655	753
C5-C9	25	47	49	58	20	28	68	72	227	296
M1-M4	34	22	34	34	17	14	93	56	155	248
M5-M9	3	2	0	1	2	1	29	5	9	38
≥X1	2	0	2	1	0	3	7	2	8	15
C	116	232	190	164	101	79	166	348	882	1048
M	37	24	34	35	19	15	122	61	164	286
≥C5	64	71	85	94	39	46	197	135	399	596
≥M1	39	24	36	36	19	18	129	63	172	301
≥M5	5	2	2	2	2	4	36	7	17	53
TOTAL	155	256	226	200	120	97	295	411	1054	1349

	DECAY TIME (MIN)									
X-RAY CLASS	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL*
C0-C4	12.1	24.6	18.7	14.1	10.8	6.8	13.0	36.7	87.0	
C5-C9	8.5	15.9	16.6	19.7	6.8	9.5	23.1	24.4	76.9	
M1-M4	13.7	8.9	13.7	13.7	6.9	5.6	37.5	22.6	62.5	
M5-M9	7.9	5.3	0	2.6	5.3	2.6	76.3	13.2	23.7	
≥X1	13.3	0	13.3	6.7	0	20.0	46.7	13.3	53.3	
C	11.1	22.1	18.1	15.6	9.6	7.5	15.8	33.2	84.2	
M	12.9	8.4	11.9	12.2	6.6	5.2	42.7	21.3	57.3	
≥C5	10.7	11.9	14.3	15.8	6.5	7.7	33.1	22.7	66.9	
≥M1	13.0	8.0	12.0	12.0	6.3	6.0	42.9	20.9	57.1	
≥M5	9.4	3.8	3.8	3.8	3.8	7.5	67.9	13.2	32.1	
TOTAL	11.5	19.0	16.8	14.8	8.9	7.2	21.9	30.5	78.1	

*EACH SUBHEADING EQUALS 100.0

	DECAY TIME (MIN)									
X-RAY CLASS	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	58.7	72.3	62.4	53.0	67.5	52.6	33.2	67.2	62.1	55.8
C5-C9	16.1	18.4	21.7	29.0	16.7	28.9	23.1	17.5	21.5	21.9
M1-M4	21.9	8.6	15.0	17.0	14.2	14.4	31.5	13.6	14.7	18.4
M5-M9	1.9	0.8	0	0.5	1.7	1.0	9.8	1.2	0.9	2.8
≥X1	1.3	0	0.9	0.5	0	3.1	2.4	0.5	0.8	1.1
C	74.8	90.6	84.1	82.0	84.2	81.4	56.3	84.7	83.7	77.7
M	23.9	9.4	15.0	17.5	15.8	15.5	41.4	14.8	15.6	21.2
≥C5	41.3	27.7	37.6	47.0	32.5	47.4	66.8	32.8	37.8	44.2
≥M1	25.2	9.4	15.9	18.0	15.8	18.6	43.7	15.3	16.3	22.3
≥M5	3.2	0.8	0.9	1.0	1.7	4.1	12.2	1.7	1.6	3.9
TOTAL*										

*EACH SUBHEADING EQUALS 100.0

	DECAY TIME (MIN)									
X-RAY CLASS	0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	≤30	TOTAL
C0-C4	6.7	13.7	10.5	7.9	6.0	3.8	7.3	20.5	48.6	55.8
C5-C9	1.9	3.5	3.6	4.3	1.5	2.1	5.0	5.3	16.8	21.9
M1-M4	2.5	1.6	2.5	2.5	1.3	1.0	6.9	4.2	11.5	18.4
M5-M9	0.2	0.1	0	0.1	0.1	0.1	2.1	0.4	0.7	2.8
≥X1	0.1	0	0.1	0.1	0	0.2	0.5	0.1	0.6	1.1
C	8.6	17.2	14.1	12.2	7.5	5.9	12.3	25.8	65.4	77.7
M	2.7	1.8	2.5	2.6	1.4	1.1	9.0	4.5	12.2	21.2
≥C5	4.7	5.3	6.3	7.0	2.9	3.4	14.6	10.0	29.5	44.2
≥M1	2.9	1.8	2.7	2.7	1.4	1.3	9.6	4.7	12.8	22.3
≥M5	0.4	0.1	0.1	0.1	0.1	0.3	2.7	0.5	1.3	3.9
TOTAL	11.5	19.0	16.8	14.8	8.9	7.2	21.9	30.5	78.1	100.0

TABLE 5. Hα RISE TIME VERSUS DECAY TIME (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

DECAY TIME (MIN)	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	<30	TOTAL
0-5	93	34	5	5	4	5	9	127	146	155
6-10	216	25	5	4	3	0	3	241	253	256
11-15	158	42	14	4	3	3	2	200	224	226
16-20	137	37	9	8	2	1	6	174	194	200
21-25	64	39	8	4	1	1	3	103	117	120
26-30	52	20	17	5	2	0	1	72	96	97
>30	114	74	34	21	12	5	35	188	260	295
≤10	309	59	10	9	7	5	12	368	399	411
<30	720	197	58	30	15	10	24	917	1030	1054
TOTAL	834	271	92	51	27	15	59	1105	1290	1349

DECAY TIME (MIN)	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	<30	TOTAL*
0-5	60.0	21.9	3.2	3.2	2.6	3.2	5.8	81.9	94.2	
6-10	84.4	9.8	2.0	1.6	1.2	0	1.2	94.1	98.8	
11-15	69.9	18.6	6.2	1.8	1.3	1.3	0.9	88.5	99.1	
16-20	68.5	18.5	4.5	4.0	1.0	0.5	3.0	87.0	97.0	
21-25	53.3	32.5	6.7	3.3	0.8	0.8	2.5	85.8	97.5	
26-30	53.6	20.6	17.5	5.2	2.1	0	1.0	74.2	99.0	
>30	38.6	25.1	11.5	7.1	4.1	1.7	11.9	63.7	88.1	
≤10	75.2	14.4	2.4	2.2	1.7	1.2	2.9	89.5	97.1	
<30	68.3	18.7	5.5	2.8	1.4	0.9	2.3	87.0	97.7	
TOTAL	61.8	20.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	

* EACH SUBHEADING EQUALS 100.0

DECAY TIME (MIN)	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	<30	TOTAL
0-5	11.2	12.5	5.4	9.8	14.8	33.3	15.3	11.5	11.3	11.5
6-10	25.9	9.2	5.4	7.8	11.1	0	5.1	21.8	19.6	19.0
11-15	18.9	15.5	15.2	7.8	11.1	20.0	3.4	18.1	17.4	16.8
16-20	16.4	13.7	9.8	15.7	7.4	6.7	10.2	15.7	15.0	14.8
21-25	7.7	14.4	8.7	7.8	3.7	6.7	5.1	9.3	9.1	8.9
26-30	6.2	7.4	18.5	9.8	7.4	0	1.7	6.5	7.4	7.2
>30	13.7	27.3	37.0	41.2	44.4	33.3	59.3	17.0	20.2	21.9
≤10	37.1	21.8	10.9	17.6	25.9	33.3	20.3	33.3	30.9	30.5
<30	86.3	72.7	63.0	58.8	55.6	66.7	40.7	83.0	79.8	78.1
TOTAL*										

*EACH SUBHEADING EQUALS 100.0

DECAY TIME (MIN)	RISE TIME (MIN) 0-5	6-10	11-15	16-20	21-25	26-30	>30	≤10	<30	TOTAL
0-5	6.9	2.5	0.4	0.4	0.3	0.4	0.7	9.4	10.8	11.5
6-10	16.0	1.9	0.4	0.3	0.2	0	0.2	17.9	18.8	19.0
11-15	11.7	3.1	1.0	0.3	0.2	0.2	0.1	14.8	16.6	16.8
16-20	10.2	2.7	0.7	0.6	0.1	0.1	0.4	12.9	14.4	14.8
21-25	4.7	2.9	0.6	0.3	0.1	0.1	0.2	7.6	8.7	8.9
26-30	3.9	1.5	1.3	0.4	0.1	0	0.1	5.3	7.1	7.2
>30	8.5	5.5	2.5	1.6	0.9	0.4	2.6	13.9	19.3	21.9
≤10	22.9	4.4	0.7	0.7	0.5	0.4	0.9	27.3	29.6	30.5
<30	53.4	14.6	4.3	2.2	1.1	0.7	1.8	68.0	76.4	78.1
TOTAL	61.8	20.1	6.8	3.8	2.0	1.1	4.4	81.9	95.6	100.0

TABLE 6A. X-RAY CLASS VERSUS Hα IMPORTANCE (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

	Hα IMPORTANCE CLASS																		
X-RAY CLASS	SF	SN	SB	1F	1N	1B	2F	2N	2B	3B	S	1	2	3	≥1	F	N	B	TOTAL
C0-C4	168	368	118	11	58	28	0	2	0	0	654	97	2	0	99	179	428	146	763
C5-C9	31	65	111	4	40	36	2	3	3	0	207	80	8	0	88	37	108	150	295
M1-M4	9	14	66	2	29	97	0	6	15	0	89	128	21	0	149	11	59	178	248
M5-M9	0	0	5	0	0	16	0	0	17	0	5	16	17	0	33	0	0	38	38
≥X1	0	0	0	0	0	6	0	0	8	1	0	6	8	1	15	0	0	15	15
C	199	433	229	15	98	64	2	5	3	0	861	177	10	0	187	216	536	296	1048
M	9	24	71	2	29	113	0	6	32	0	104	144	38	0	182	11	59	216	286
≥C5	40	89	182	6	69	155	2	9	43	1	311	230	54	1	285	48	167	381	596
≥M1	9	24	71	2	29	119	0	6	40	1	104	150	46	1	197	11	59	231	301
≥M5	0	0	5	0	0	22	0	0	25	1	5	22	25	1	48	0	0	53	53
TOTAL	208	457	300	17	127	183	2	11	43	1	965	327	56	1	384	227	595	527	1349

*EACH SUBHEADING EQUALS 100.0

	H α IMPORTANCE CLASS																		
X-RAY CLASS	SF	SN	SB	1F	1N	1B	2F	2N	2B	3B	S	1	2	3	≥1	F	N	B	TOTAL
C0-C4	80.8	80.5	39.3	64.7	45.7	15.3	0	18.2	0	0	67.8	29.7	3.6	0	25.8	78.9	71.9	27.7	55.8
C5-C9	14.9	14.2	37.0	23.5	31.5	19.7	100.0	27.3	7.0	0	21.5	24.5	14.3	0	22.9	16.3	18.2	28.5	21.9
M1-M4	4.3	3.1	22.0	11.8	22.8	53.0	0	54.5	34.9	0	10.3	39.1	37.5	0	38.8	4.8	9.9	33.8	18.4
M5-M9	0	0	1.7	0	0	8.7	0	0	39.5	0	0.5	4.9	30.4	0	8.6	0	0	7.2	2.8
≥X1	0	0	0	0	0	3.3	0	0	18.6	100.0	0	1.8	14.3	100.0	3.9	0	0	2.8	1.1
C	95.7	94.7	76.3	88.2	77.2	35.0	100.0	45.5	7.0	0	89.2	54.1	17.9	0	48.7	95.2	90.1	56.2	77.7
M	4.3	5.3	23.7	11.8	22.8	61.7	0	54.5	74.4	0	10.8	44.0	67.9	0	47.4	4.8	9.9	41.0	21.2
≥C5	19.2	19.5	60.7	35.3	54.3	84.7	100.0	81.8	100.0	100.0	32.2	70.3	96.4	100.0	74.2	21.1	28.1	72.3	44.2
≥M1	4.3	5.3	23.7	11.8	22.8	65.0	0	54.5	93.0	100.0	10.8	45.9	82.1	100.0	51.3	4.8	9.9	43.8	22.3
≥M5	0	0	1.7	0	0	12.0	0	0	58.1	100.0	0.5	6.7	44.6	100.0	12.5	0	0	10.1	3.9
TOTAL*																			

TABLE 6B. X-RAY CLASS VERSUS Hα IMPORTANCE (FREQUENCY OF OCCURRENCE AND PERCENTS OF OCCURRENCE)

X-RAY CLASS	Hα IMPORTANCE CLASS																		
	SF	SN	SB	1F	1N	1B	2F	2N	2B	3B	S	1	2	3	≥1	F	N	B	TOTAL*
C0-C4	22.3	48.9	15.7	1.5	7.7	3.7	0	0.3	0	0	86.9	12.9	0.3	0	13.1	23.8	56.8	19.7	
C5-C9	10.5	22.0	37.6	1.4	13.6	12.2	0.7	1.0	1.0	0	70.2	27.1	2.7	0	29.8	12.5	36.6	50.8	
M1-M4	3.6	5.6	26.6	0.8	11.7	39.1	0	2.4	6.0	0	39.9	51.6	8.5	0	60.1	4.4	23.8	71.8	
M5-M9	0	0	13.2	0	0	42.1	0	0	44.7	0	13.2	42.1	44.7	0	86.8	0	0	100.0	
≥X1	0	0	0	0	0	40.0	0	0	53.3	6.7	0	40.0	53.3	6.7	100.0	0	0	100.0	
C	19.0	41.3	21.9	1.4	9.4	6.1	0.2	0.5	0.3	0	82.2	16.9	1.0	0	17.8	20.6	51.1	28.2	
M	3.1	8.4	24.8	0.7	10.1	39.5	0	2.1	11.2	0	36.4	50.3	13.3	0	63.6	3.8	20.6	75.5	
≥C5	6.7	14.9	30.5	1.0	11.6	26.0	0.3	1.5	7.2	0.2	52.2	38.6	9.1	0.2	47.8	8.1	28.0	63.9	
≥M1	3.0	8.0	23.6	0.7	9.6	39.5	0	2.0	13.3	0.3	34.6	49.8	15.3	0.3	65.4	3.7	19.6	76.7	
≥M5	0	0	9.4	0	0	41.5	0	0	47.2	1.9	9.4	41.5	47.2	1.9	90.6	0	0	100.0	
TOTAL	15.4	33.9	22.2	1.3	9.4	13.6	0.1	0.8	3.2	0.1	71.5	24.2	4.2	0.1	28.5	16.8	44.1	39.1	

*EACH SUBHEADING EQUALS 100.0

X-RAY CLASS	H α IMPORTANCE CLASS																		
	SF	SN	SB	1F	1N	1B	2F	2N	2B	3B	S	1	2	3	≥1	F	N	B	TOTAL
C0-C4	12.5	27.3	8.7	0.8	4.3	2.1	0	0.1	0	0	48.5	7.2	0.1	0	7.3	13.3	31.7	10.8	55.8
C5-C9	2.3	4.8	8.2	0.3	3.0	2.7	0.1	0.2	0.2	0	15.3	5.9	0.6	0	6.5	2.7	8.0	11.1	21.8
M1-M4	0.7	1.0	4.9	0.1	2.1	7.2	0	0.4	1.1	0	7.3	9.5	1.6	0	11.0	0.8	4.4	13.2	18.4
M5-M9	0	0	0.4	0	0	1.2	0	0	1.3	0	0.4	1.2	1.3	0	2.4	0	0	2.8	2.8
≥X1	0	0	0	0	0	0.4	0	0	0.6	0.1	0	0.4	0.6	0.1	1.1	0	0	1.1	1.1
C	14.8	32.1	17.0	1.1	7.3	4.7	0.1	0.4	0.2	0	63.8	13.1	0.7	0	13.9	16.0	39.7	21.9	77.7
M	0.7	1.8	5.3	0.1	2.1	8.4	0	0.4	2.4	0	7.7	10.7	2.8	0	13.5	0.8	4.4	16.0	21.2
≥C5	3.0	6.6	1.3	0.4	5.1	11.5	0.1	0.7	3.2	0.1	23.1	17.0	4.0	0.1	21.1	3.6	12.4	28.2	44.2
≥M1	0.7	1.8	5.3	0.1	2.1	8.8	0	0.4	3.0	0.1	7.7	11.1	3.4	0.1	14.6	0.8	4.4	17.1	22.3
≥M5	0	0	0.4	0	0	1.6	0	0	1.9	0.1	0.4	1.6	1.9	0.1	3.6	0	0	3.9	3.9
TOTAL	15.4	33.9	22.2	1.3	9.4	13.6	0.1	0.8	3.2	0.1	71.5	24.2	4.2	0.1	28.5	16.8	44.1	39.1	100.0

TABLE 7. MEAN X-RAY CLASS VERSUS MEAN Hα IMPORTANCE

X-RAY CLASS	$\overline{XR}$ (x 10^{-6} Wm^{-2})	$\overline{IMP}$
CO-C4	2.41*	2.25
C5-C9	6.70	3.15
M1-M4	16.77	4.47
M5-M9	65.53	6.95
≥X1	240.00	8.00

* $\overline{XR}$ calculated for X-ray group C1-C4 (The six CO events were deleted)

TABLE 8. MEAN Hα RISE TIME AND MEAN Hα DECAY TIME VERSUS X-RAY CLASS

X-RAY CLASS	N	$\overline{RT}$	$\overline{DT}$	$\overline{RT}/\overline{DT}$
CO-C4	753	5.86*	17.84	0.33*
C5-C9	295	8.14	22.46	0.36
M1-M4	248	10.73	28.65	0.37
M5-M9	38	17.68	55.95	0.32
≥X1	15	11.00	37.60	0.29
C	1048	6.49*	19.14	0.34*
M	286	11.66	32.28	0.36
≥C5	596	9.90	27.55	0.36
≥M1	301	11.62	32.54	0.36
≥M5	53	15.79	50.75	0.31
TOTAL	1349	7.64*	22.13	0.35*

* MEANS EXCLUDE ANOMALOUS OCTOBER 2N FLARE, RT = 953 MIN

TABLE 9. MEAN Hα RISE TIME AND MEAN Hα DECAY TIME VERSUS Hα IMPORTANCE

IMP	N	$\overline{RT}$	$\overline{DT}$	$\overline{RT}/\overline{DT}$
SF	208	3.86	13.87	0.28
SN	457	5.96	18.75	0.32
SB	300	6.73	20.92	0.32
1F	17	14.24	19.29	0.74
1N	127	8.91	22.85	0.39
1B	183	12.32	32.12	0.38
2F	2	9.00	23.00	0.39
2N	11	12.60*	31.64	0.40*
2B	43	21.88	59.12	0.37
3B	1	31.00	81.00	0.38
S	965	5.75	18.37	0.31
1	327	11.09	27.85	0.40
2	56	19.73*	52.43	0.38*
3	1	31.00	81.00	0.38
≥ 1	384	12.39*	31.58	0.39*
F	227	4.68	14.35	0.33
N	595	6.71*	19.87	0.34*
B	527	9.95	27.89	0.36
TOTAL	1349	7.64*	22.13	0.35*

* MEANS EXCLUDE ANOMALOUS OCTOBER 2N FLARE, RT = 953 MIN

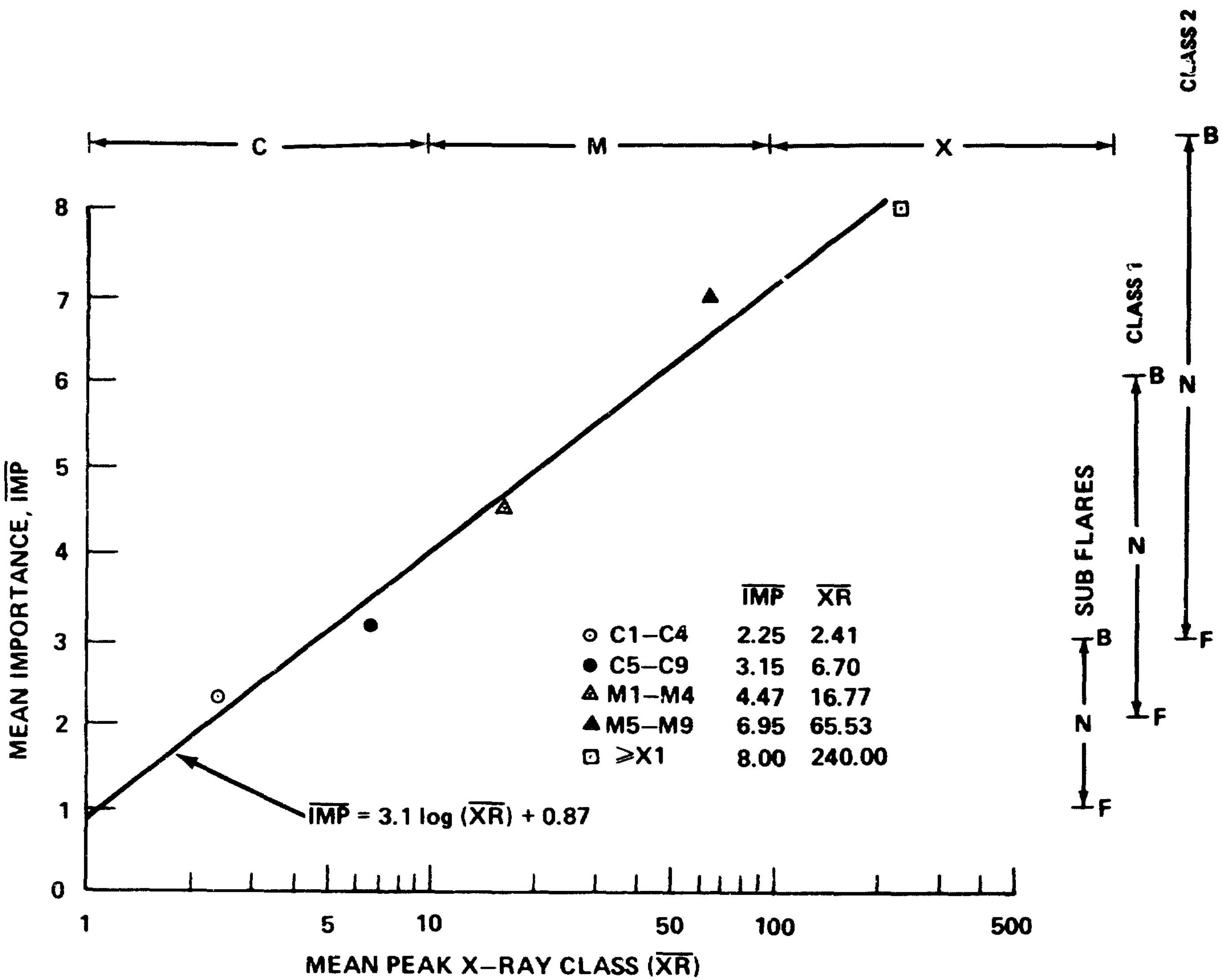

Figure 1. Mean Hα Importance Versus Mean Peak X-Ray Class.

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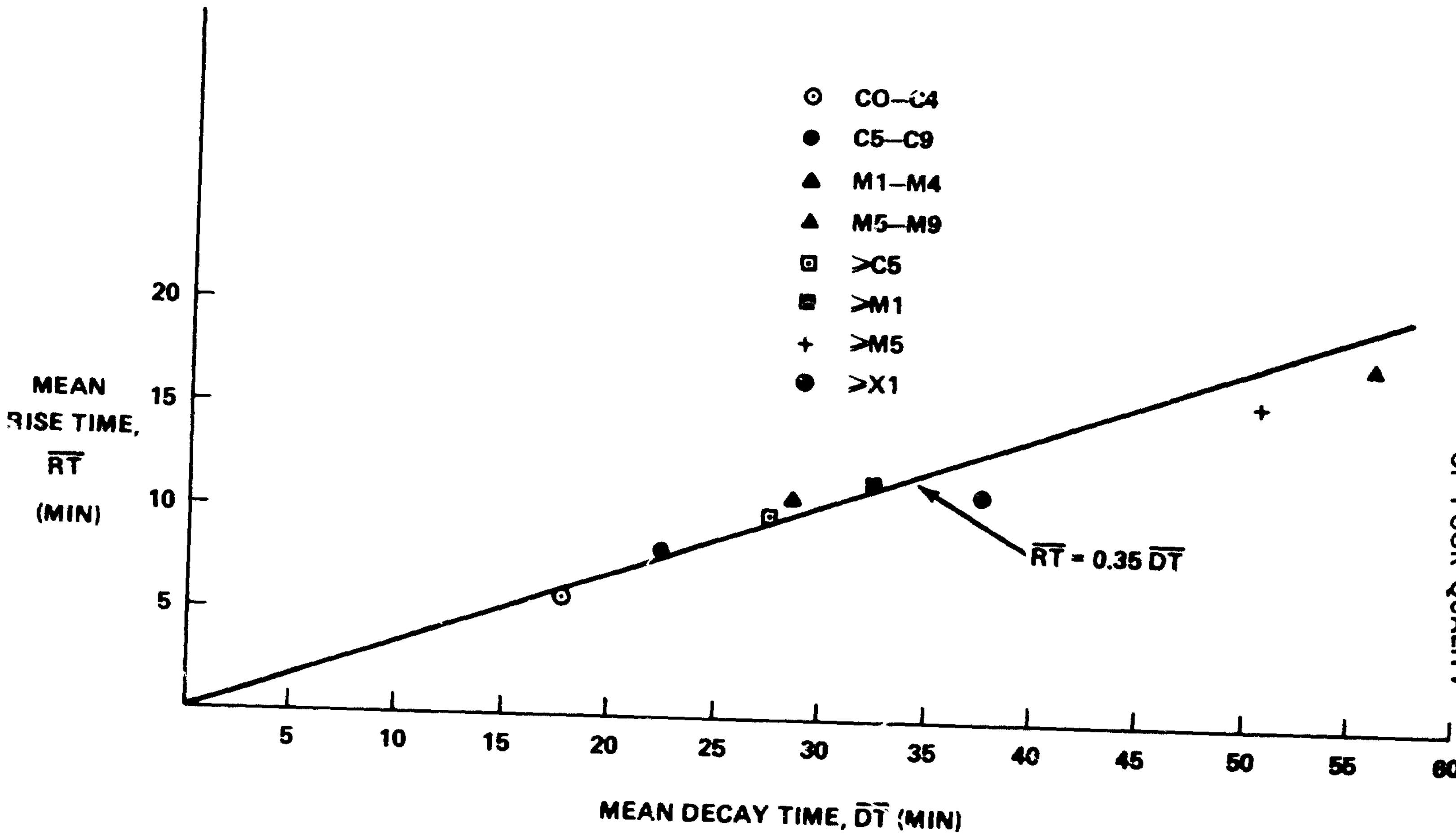

Figure 2. Mean Hα Rise Time Versus Mean Hα Decay Time (Per X-Ray Grouping).

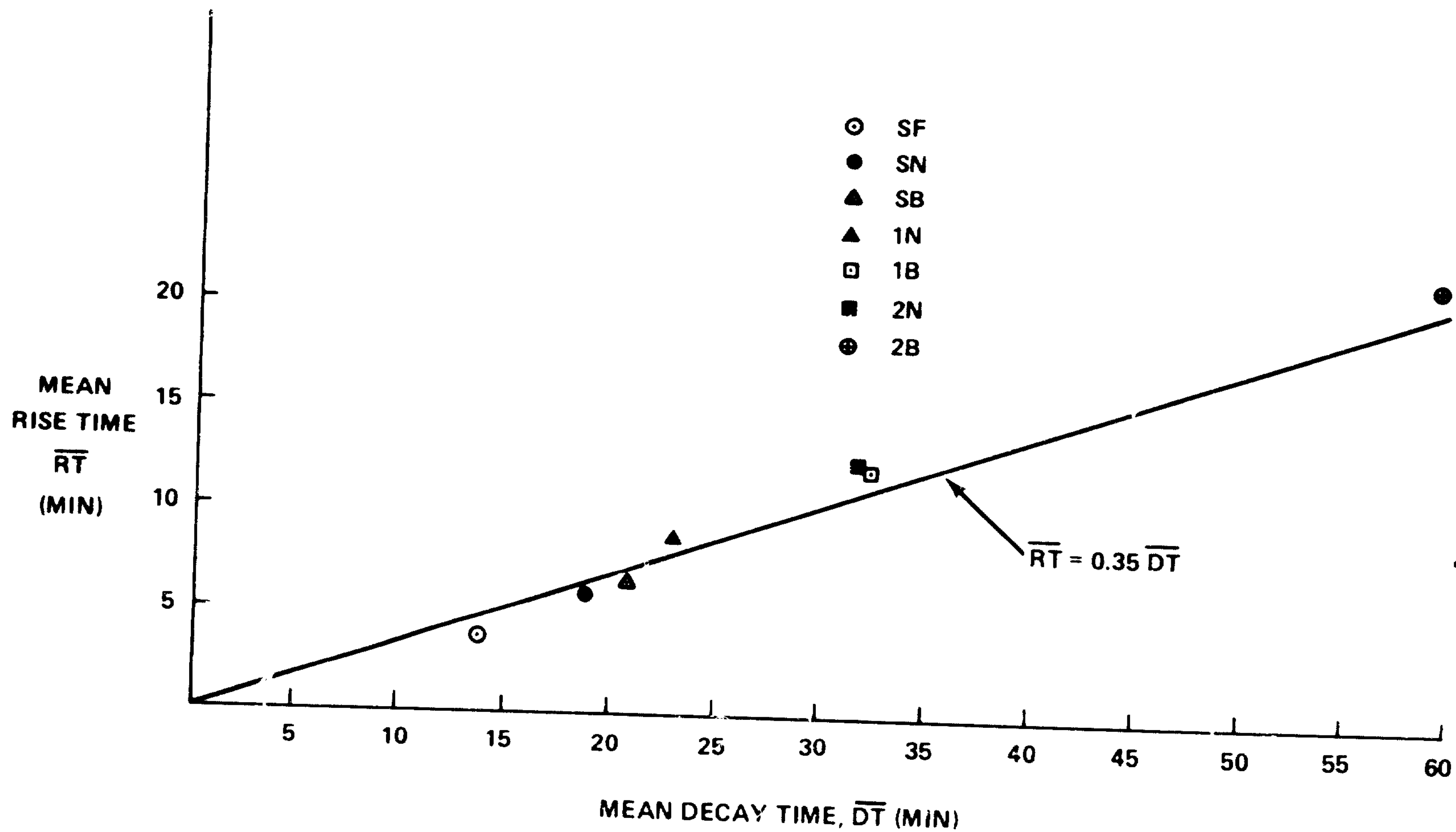

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Figure 3. Mean Hα Rise Time Versus Mean Hα Decay Time (Per Hα Importance).

REFERENCES

1. Wilson, Robert M.: Statistical Aspects of the 1980 Solar Flares-I. Data Base, Frequency Distributions, and Overview Remarks. NASA TM-82465, Marshall Space Flight Center, AL, January 1982.

2. Wilson, Robert M.: Statistical Aspects of the 1980 Solar Flares: II. Solar Cycle Activity Relationships and Additional Remarks. NASA TM-82475, Marshall Space Flight Center, AL, February 1982.

APPENDIX

In paper I, an overall pictorial summary of Hα rise time, decay time, duration, X-ray class and Hα importance, along with mean values, standard deviations, median values and 90th percentiles of Hα rise time, decay time and duration, were given for the 1349 study flares occurring in 1980 (Figure 15, p. 66). A pictorial summary chart for latitude was inadvertently omitted. Figure A-1 is an overall pictorial summary chart for latitude of the 1349 study flares, in terms of running percent (Rp), where 100 percent represents inclusion of all 1349 study flares. Also given in Figure A-1 are the mean latitude, standard deviation, median latitude and 90th percentile latitude. Thus, ignoring whether a flare's latitude was north or south, the mean latitude of occurrence for the study flares is found to be 15.3°, the median latitude 13.5°, and the 90th percentile latitude 24.5°. (That is, 90 percent of the 1349 study flares occurred at latitudes less than or equal to 24.5°; median latitude means that 50 percent occurred at latitudes less than or equal to 13.5°.)

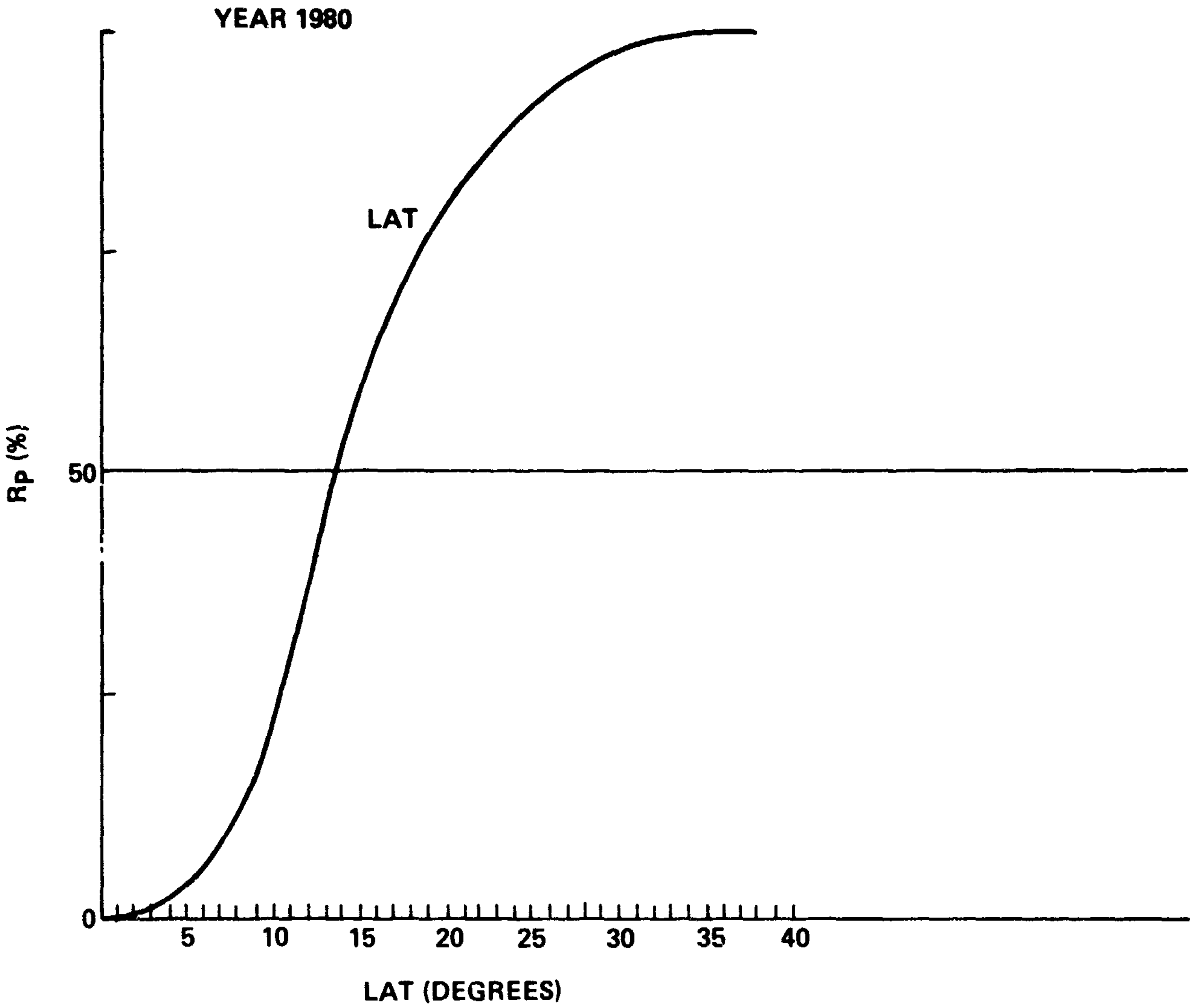
Also in paper I, a linear histogram of number versus X-ray class was given for the 1349 study flares (Figure 18, p. 69). The figure, while correct, could easily be misunderstood. It is to be recalled that X-ray class is logarithmic; thus, the flux range encompassed in an M1 X-ray event is equivalent to the entire C X-ray class range (i.e., from C1 through C9). Figure A-2 is a log histogram plot of number versus X-ray class for the 1349 study flares. It clearly shows the generally diminishing number of X-ray flares from X-ray class C through X-ray class M9.

Further, in paper I (Figure 22, p. 74), north and south latitude flares were plotted (in terms of percent) against month of year; F_{2800} was plotted, as well. The figure suggested that, in terms of percent, F_{2800} may have been crudely tracking the south latitude regions associated with the occurrence of these flares, especially through the first ten months of 1980. Figure A-3 illustrates F_{2800} and south latitudinal flares versus month of year [both in terms of relative percent occurrence (Fig. A-3a) and number (Fig. A-3b)] and F_{2800} versus south latitudinal flares [percent (Fig. A-3c) and number (Fig. A-3d)]. A rather crude relationship may be suggested. For F_{2800} versus number (N) of south latitudinal flares the visually approximated relation is expressed as:

$$F_{2300} = 0.76\ N + 150\ , \tag{A-1}$$

excluding the November (11) and December (12) data points. (The numbers beside each data point represents the month of occurrence, where 1 is January, 2 February, and so on.)

Finally, since the Hα decay time of an Hα flare is almost always longer than its Hα rise time, examination of Table 5 suggests that the tabulated Hα rise time and/or decay time of as many as about 8 percent of the data set may not be as accurately observed as originally thought. Exclusion of these events where rise time is greater than decay time probably would not affect the ratio results appreciably and should not significantly affect mean Hα rise time or decay time results. (The effect should be to slightly reduce the mean Hα rise time and decay time.)



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$\overline{X}$= 15.3 , s = 16.6; $Q_{50} \sim 13.5$; $Q_{90} \sim 24.5$

Figure A-1. Latitude Summary Chart for 1980 (Rp, $\bar{x}$, s, Q_{50}, Q_{90}).

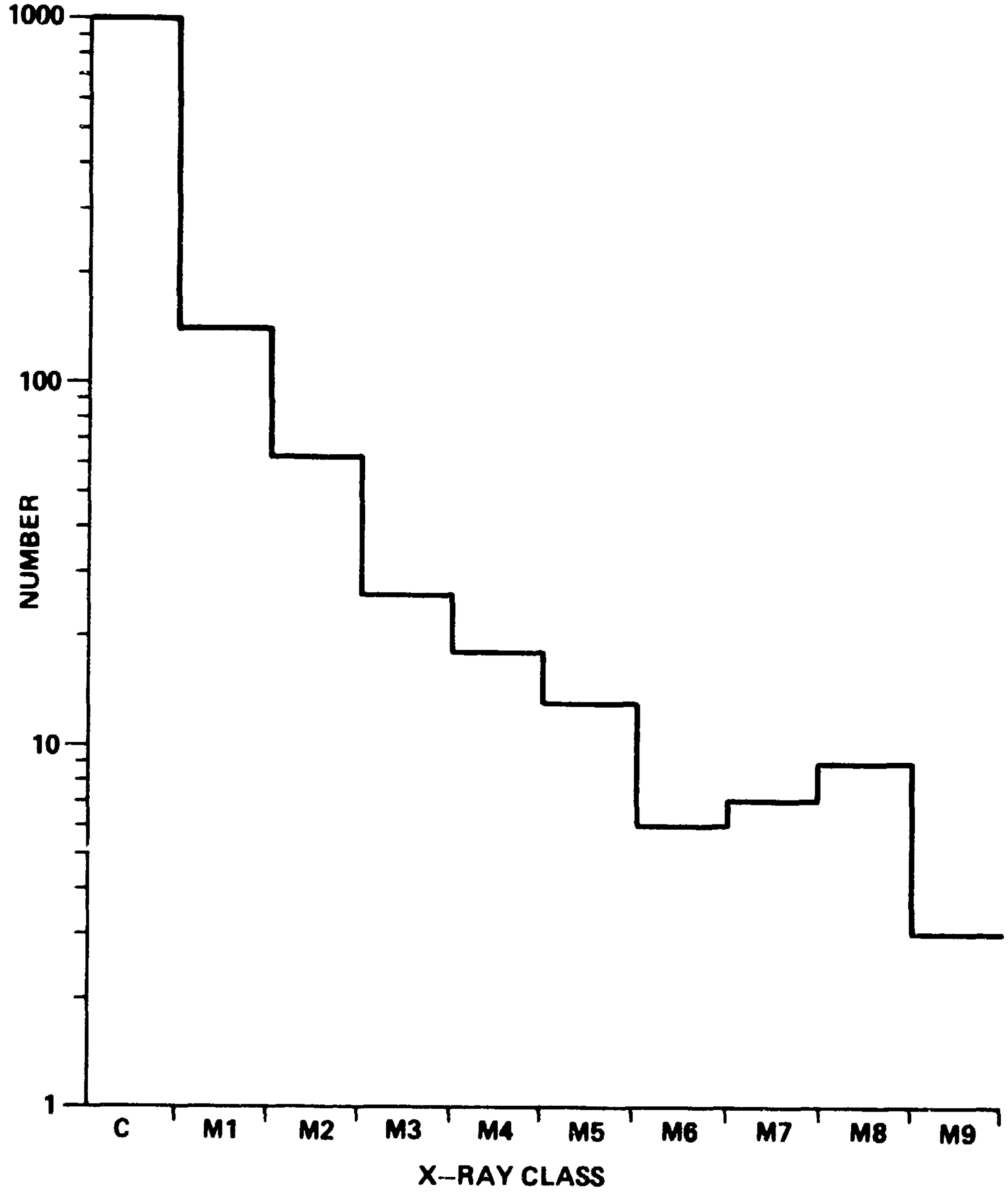

Figure A-2. Number Versus X-Ray Class (Log Plot).

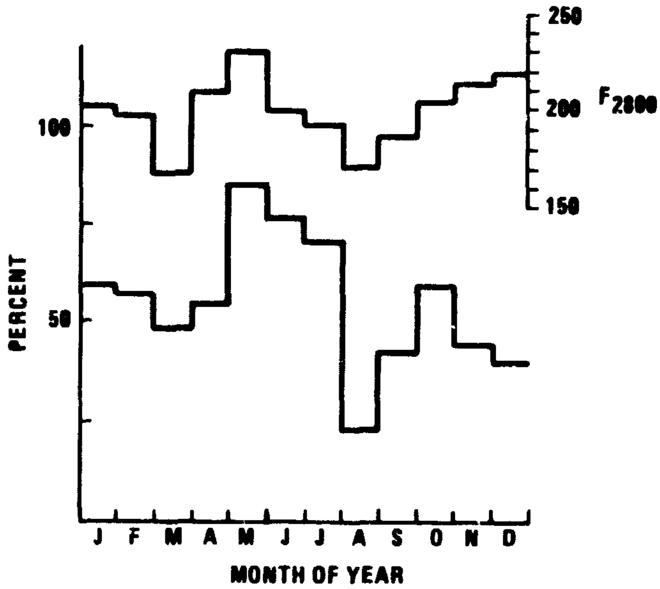

Figure A-3a. Comparison of F_{2800} and Relative Percent Occurrence of South Latitudinal Flares by Month, 1980.

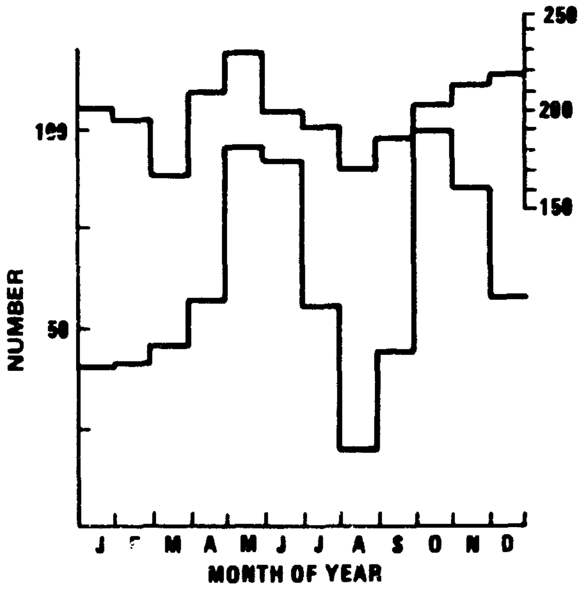

Figure A-3b. Comparison of F_{2800} and Number of South Latitudinal Flares by Month, 1980.

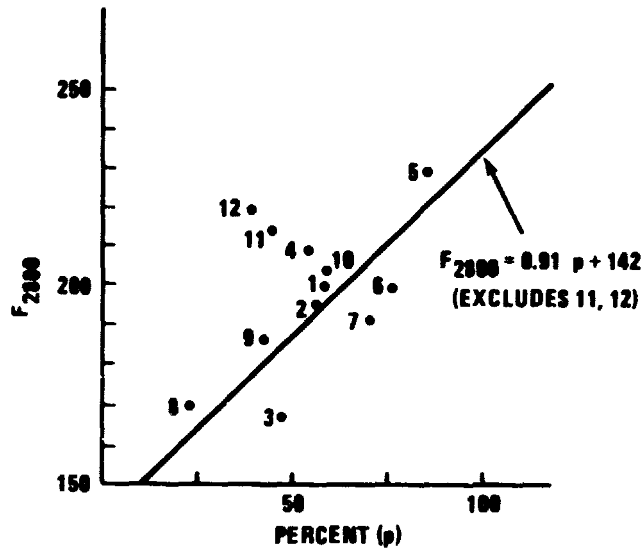

Figure A-3c. F_{2800} Versus Relative Percent Occurrence of South Latitudinal Flares (Line Equation Excludes November and December Data Points).

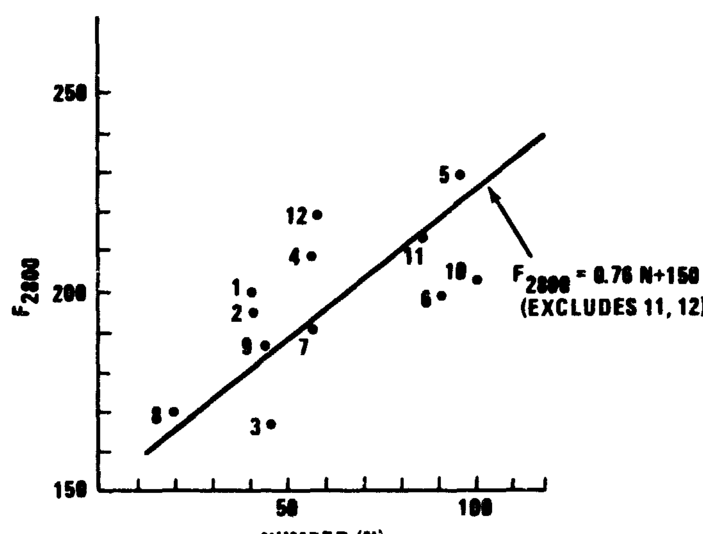

Figure A-3d. F_{2800} Versus Number of South Latitudinal Flares (Line Equation Excludes November and December Data Points).

APPROVAL

STATISTICAL ASPECTS OF THE 1980 SOLAR FLARES – III. PARAMETRIC COMPARISONS AND FINAL COMMENTS

By Robert M. Wilson

This information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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Director, Space Science Laboratory

☆U.S. GOVERNMENT PRINTING OFFICE 1983–646–058/193