[redacted]

#505

PIONEER 11

SATURN ENCOUNTER DATA

73-019A-07K

PIONEER 11

SATURN ENCOUNTER DATA

73-019A-07K

This data set has been restored. There was originally 6 ASCII 9-Track, 1600 BPI tapes, written as phase encoded (PE). There are 2 restored tapes. The DR tapes are 3480 cartridges and the DS tapes are 9-track, 6250 BPI. The tapes were created on CDC 6400 computer. The DR and DS numbers along with the corresponding D numbers and the time spans are as follows:

DR#	DS#	D#	FILES	TIME SPAN
DR 02622	DS 02622	DD 45257	1-21	08/25/79 - 08/27/79
		DD 45258	22-42	08/28/79 - 08/29/79
		DD 45259	43-55	08/30/79 - 08/30/79
		DD 45260	56-76	08/31/79 - 09/01/79
DR 02623	DS 02623	DD 45261	1-21	09/02/79 - 09/03/79
		DD 45262	22-34	09/04/79 - 09/05/79

REQ. AGENT	RAND NO.	ACQ. AGENT
GLS	V0097	WSC

PIONEER 11
SATURN ENCOUNTER DATA
73-019A-07K

This data set catalog consists of 6 magnetic tapes created on a CDC 6400 computer. Theses tapes are 9-track (written as phase encoded (PE)), 1600 BPI, ASCII and each tape is multi-filed. The data is not blocked, one physical record is one logical record. Each tape contains a copy of documentation followed by sets of 4 files. The format is identical to that of an Experimenter Data Record (EDR). The D numbers, C numbers, and time span are as follows:

D#	C#	TIME SPAN
D-45257	C-21818	08/25/79 - 08/27/79
D-45258	C-21819	08/28/79 - 08/29/79
D-45259	C-21820	08/30/79 - 08/30/79
D-45260	C-21821	08/31/79 - 09/01/79
D-45261	C-21822	09/02/79 - 09/03/79
D-45262	C-21823	09/04/79 - 09/05/79

The documentation files on these tapes may be missing some data. Requesters should be provided with copies of the documentation in this Data Set Catalog.

'77-019A-07
K?

THE UNIVERSITY OF ARIZONA

TUCSON, ARIZONA 85721

OPTICAL SCIENCES CENTER 26 March 1981

Ms. Winifred Cameron
Code 601
National Space Sciences Data Center
Goddard Space Flight Center
Greenbelt, MD 20771

Subject: Pioneer 11 Saturn and Pioneer Image Data for NSSDC

Dear Ms. Cameron:

This is the third and last shipment of Pioneer 11 Saturn Mode 4 image data. The first and second shipments were made on 28 October 1980 and 9 February 1981. This shipment consists of:

a) Two computer tapes labeled Saturn 2 and Saturn 4 to complete the set forwarded on 9 February 1981.

b) Two microfiche films containing DOY 241, Sequence 2, and DOY 243, Sequence 2.

c) One copy of the "Final Technical Report, Pioneer F1G, Imaging Photopolarimetric Instrument" by Santa Barbara Research Center." This is a useful archival document that fully describes the instrument, its operation, and design performance.

d) Pioneer 11 Jupiter encounter images D-5, D-6, and D-9 consisting of one black and white negative set and one black and white print each. These are described in the enclosed list of descriptive comments for each one. These three images, which show the north polar region of Jupiter, could not be successfully displayed until recently.

Mode 3 data for the Pioneer Saturn will be forwarded later. In this regard, any communications should be addressed to Dr. M. G. Tomasko, Lunar and Planetary Laboratory, Space Sciences Building, University of Arizona, Tucson, Arizona 85721, telephone (602) ~~626-3655~~.

~~621-2211~~
621-2836

Sincerely yours,

C. Blenman, Jr.
Pioneer Saturn Program Manager

Enclosures (all in same carton)

cc: Mr. Richard Fimmel, ARC N-244-8 (forwarding letter only)
Mr. Dorsel D. Anderson, ARC N-240-1 (forwarding letter only)
Dr. Tom Gehrels (forwarding letter only)

CB/ds

Descriptive Comments on

Pioneer 11 Jupiter Images D-5, D-6, and D-9

Forwarded to NSSDC on 26 March 1981

These images could not be processed until recently (March 1981) due to excessive data anomalies experienced during the Pioneer 11 encounter of Jupiter in December 1974. These could not be corrected for with the image processing techniques then available. Their processing, therefore, had to wait until the end of the Pioneer Saturn processing effort when the more sophisticated techniques, including iterative editing and display software and hardware, used for Saturn could be improved. No color images could be produced for these three images.

Caution, therefore, should be exercised in interpreting the surface features appearing in these images as many missing data rolls and other data vacancies were filled in for best visual effect. If an investigator wishes to differentiate between real and restored data, he should be referred to the Mode 4 Pioneer 11 image tapes previously furnished NSSDC.

Image No.	Doy	Comments
D-5	337	This image gives the highest global resolution obtained during the Pioneer 11 encounter. The mottled structure in the north polar region is quite pronounced as well as the latitudinal structure between the polar and temperate zones. One of the three previously observed white ovals is clearly visible in the center of the image, but the dark line extending horizontal from this oval is probably an artifact. The shape of the limb is somewhat imperfect because of severe instrument stepping anomalies in the raw data, as are the two discontinuities in the equitorial plane.
D-6	337	The swirls in the temperate latitudes are clearly visible. The shadow of satellite IO is prominent at the top of the image. Near the center of the image a dark linear cloud feature is seen in the North Equatorial Belt which appears somewhat darker in the blue than in the red image.
D-9	337	This is the closet Pioneer 11 image after periapsis that shows the Red Spot. Many swirling cloud features appear near the north edge of the North Equatorial Belt. Numerous small light spots are seen in the northern part of the North Temperate Region.

These, and the other D series images of the Pioneer 11 encounter, provide the only thorough coverage of the polar regions of Jupiter at relatively high resolution, including those obtained by Voyager I and to be recorded by Voyager II. The Voyager fly-by trajectories do not provide for high latitude coverage of the planet.

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Imaging Photopolarimeter Tape User's Guide

November 24, 1980

IMAGING PHOTOPOLARIMETER TAPE USER'S GUIDE

November 24, 1980

This document describes Pioneer 11 Saturn imaging mode data stored on magnetic computer tapes which are labeled SATURN1, SATURN2, SATURN3, SATURN4, SATURN5 and SATURN6. The data is provided to the National Space Science Data Center by the Optical Sciences Center at the University of Arizona.

TAPE STRUCTURE

These computer tapes are 2400 foot length, 3/4" width, 9-track tapes written as phase encoded (PE), 1600 bits per inch data. The data is not blocked - one physical record is one logical record.

TAPE DATA FORMAT

Each computer tape contains a copy of this document followed by sets of four files. Each set records all relevant data pertaining to the specific data-taking time-block. Refer to Table 1 below for a list of the number of characters per record in a four-file set. The data has been stored using the American Standard Code for Information Interchange (ASCII) character set.

The format is identical to that of an Experimenter Data Record (EDR). An EDR is divided into groups of four files:

- File 1 - contains logistics information
- File 2 - contains a list of all commands sent to the spacecraft during the time block.
- File 3 - contains spacecraft attitude data
- File 4 - contains housekeeping data plus all intensities telemetered during a data cycle (one rotation of the spacecraft about its spin axis) of the Imaging Photopolarimeter (IPP) instrument.

Table 2 details the content of each of the data files in a four-file set. Be aware that each record in File 4 begins with 77 "housekeeping" parameters which describe the status of the instrument, time of data receipt, data quality, et cetera. These parameters are decribed in appendices A and B, which are taken from NASA/AMES Research Center Pioneer Program documents PC-261.04,"Pioneer F:On-Line Ground Data System, Software Specifications, Instrument Monitoring and Data Processing" and PC-262.02,"Off-Line Data Processing System Detailed Processing Requirements." Appendix A (of the document) begins with a brief description of the imaging photopolarimeter operation.

TAPE USAGE

These tapes contain all of the intensity measurements made by the IPP. The measurements are shown in the Pioneer Saturn Image Prints (available from NSSDC). The prints are a sequential pictorial display of the contents of all of the file # 4's contained herein. The user may also be interested precisely where the IPP was pointed for each intensity measurement. It is left to the user to solve this problem. A complete description of how such a solution may be affected is beyond the scope of this document; however some brief guidelines follow.

The trajectory of Pioneer 11 past Saturn is described by the Saturn-spacecraft vector which can be found on the Pioneer Saturn Trajectory tape (available from NSSDC). From this vector the position of Pioneer 11 relative to Saturn can be found. A second vector describes the line of sight of the IPP for each intensity measurement. This vector always originates at the IPP and, if the planet is being viewed, intercepts the surface of Saturn. This vector is specified by four quantities:

1) the celestial longitude of the spacecraft spin axis;
2) the celestial latitude of the spacecraft spin axis;
3) the clock (sometimes called "roll") angle of the IPP;
4) the cone (sometimes called "look") angle of the IPP.

The celestial longitude and latitude are available in file 3. The clock and cone angles can be calculated from the IPP housekeeping parameters (see the instrument description in the "Final Technical Report" on the IPP, also available from NSSDC.)

Efficient use of the tapes can be made in conjunction with the Pioneer Image Log and the Pioneer Encounter Pre-Exams (which are supplied to NSSDC on microfiche.) The image log details the midtime of each image and also useful geometric data regarding the image including its phase angle, longitude of the central meridian, latitude of the sub-spacecraft point and the resolution of the image. The microfiche lists the time and certain housekeeping parameters for each data cycle. To access data for some given image, use the following steps: (Figure 1 details steps necessary to access image F-105.)

1. Consult the Pioneer Image Log (a table which follows) to determine the midtime of the image to be studied.
2. Locate the midtime on the Pioneer Encounter Pre-Exams and determine the starting and ending dates and times of the image.
3. Examine the Tape Table of Contents, or the labels on the computer tapes to determine which tape contains the image in question.

TABLE 1

FILE	RECORDS PER FILE	CHARACTERS PER RECORD
1	1	480
2	variable	1200
3	1	1920
4	variable	4080

TABLE 2
Detailed File Contents

File 1 (logistics information)

(physical record number 1)
(all unspecified character positions are ASCII spaces)

Character position(s)	Contents
1-7	"PIONEER"
9	"G" indicates Pioneer 11.
11-13	"EDR"
15-29	nn "ACQUISITIONS" where nn is the number of acquisistions.
33-38	"UA/IPP"
40-48	"S/C ID 24" where 24 is the spacecraft identification number.
50-67	"GENERATED" mm/dd/yy where the date indicates when the tape was generated.
69-88	"REGENERATED" mm/dd/yy where the date indicates when the tape was regenerated.
90-95	day of year and year covered by this four-file group.
97-120	List of deep space stations that tracked during the file time period. This list will be an ASCII conversion of the station codes (see PC-262.04, figure 5-50). The entries will be two characters separated by commas.
121-133	"TLM BIT RATES"
135-240	list of all telemetry formats contained on this EDR tape. The entries consist of five alpha characters separated by commas.
361-369	"MODES RT"
380-412	"START TIME" hh/mm "STOP TIME" hh/mm where the times indicate the Earth receipt start and stop times of the data on this EDR.
414-480	"TAPE SEQUENCE NO." n where n is the sequence number of the tape within the listed time period.

P*:1

File 2 (command data)

(an arbitrary physical record is described)

9-25	ddd hh mm ss where the day and time

indicates the Earth receipt time of the command.
Verification code. V indicates the command was verified; N indicates the command was not verified.

Each physical record contains 50 commands. The above pattern is repeated in the following characters:

31-50	271-290	511-530	751-770	991-1010
53-72	293-312	533-552	773-792	1013-1032
75-94	315-334	555-574	795-814	1035-1054
97-116	337-356	577-596	817-836	1057-1076
129-148	369-388	609-628	849-868	1089-1108
151-170	391-410	631-650	871-890	1111-1130
173-192	413-432	653-762	893-912	1133-1152
195-214	435-454	675-694	915-934	1155-1174
217-236	457-476	697-716	937-956	1177-1196
249-268	489-508	729-748	969-988	

The last record may contain space (blank) characters in order to extend the record length to 1200 characters.

File 3 (spacecraft attitude data)
---- - ---------- -------- ----

(physical record number 1)

1-9	ddd hh mm ss, the day and time of the attitude measurement (UT).
10-15	Zero fill
16	FLAG: 0 = special refinement (+/- 0.1 degree). 1 = high-gain antenna (+/- 0.3 degree). 2 = medium-gain antenna (+/- 1.3 degree). 3 = dynamic position for delta V (+/-3.0 degree). This flag indicates the accuracy with which the direction of the spin axis is measured.
17-18	zero fill.
19-24	celestial longitude of the spin axis in degrees (includes decimal point and sign.)
25-31	celestial latitude of the spin axis in degrees (includes decimal point

	and sign.)
32-37	clock angle of the sun in degrees. Includes decimal point and sign. Refer to document PC-262, mentioned earlier in this document, for a definition of this parameter.
38-43	clock angle of star in degrees. Includes decimal point and sign. Again, refer to document PC-262 for details about this parameter.
44-60	Zero fill.

The above sequence is repeated every 60 characters for different dates and times. A history of spacecraft attitude data is hereby available. The most recent determination is the last one.

File 4 (experiment data)

(an arbitrary physical record is described)
(only those parameters marked "*" are of interest to the general user)

*5-12	integer universal Earth receipt time in in milliseconds of the start of the data cycle.
*16-16	integer day of year (DOY) the data was received.
	integer time correction flag. 0 = error; 7 = suspect time or corrected time.
30	integer reference select for spacecraft roll pulse: 0=error; 1=star; 2=SUNB; 3=SUNA.
33-36	real valued signal to noise ratio (signal + noise)/noise.
41-42	integer code of deep space station which was tracking.
48	integer bit rate at which the data record was taken:

ASCII	RATE IN BITS PER SECOND
0	16
1	32
2	64
3	128
4	256
5	512
6	1024
7	2048

52-53 mode and format are two data values, one byte and two bytes respectively, which describe the telemetry.
MODE: (ASCII codes)

0 or 1 = real time
2 or 3 = memory readout
4 or 5 = telemetry store

FORMAT: (format)

8 or 9 = A
0 or 1 = B
4 or 12 = C1
5 or 13 = C2
6 or 14 = C3
7 or 15 = C4
24 = D1 with A
16 = D1 with B
25 = D2 with A
17 = D2 with B
26 = D3 with A
18 = D3 with B

(refer to document PC-262.02 for details regarding meanings for A,B,C,D)

*58-66 the round trip light time given in total milliseconds.

69-72 the extended frame counter will be a combined word from the spacecraft telemetry of both the subcommutator identification word and the extended frame counter word. Together they comprise a counter from 0 to 8191.

74-78 star delay time

81-84 these are flags which indicate the validity of the values stored in character positions 88-96, 102-108, and 126-132, respectively.

88-96 roll attitude timer.

*102-108 spin period in seconds.

114 engineering word C-417.

126-132 roll pulse/roll index pulse phase error.

137-144 GMT time that C-112, the roll attitude timer, was received.

146-150 DC BUS VOLTAGE (C-107)

152-156 DC BUS CURRENT (C-129)

162-174 IPP power off/on indicator.

176-180 temperature nearest the IPP.

181-216 36 data quality indicators, one for each frame of IPP data. A frame is 192 bits long.

221-228 the millisecond received time of the last high voltage status check.

233-234 the IPP high voltage indicator

245-252 GMT time in milliseconds of the start of the data cycle.

256-258	SYNC CODE - IPP Barker code.
*264	uncorrected mode identifier
268-270	starting spoke.
*272	back step indicator.
*273	threshold indicator.
*274	low sample rate indicator.
*275-276	gain step.
*281-282	the starting look angle number in the SLA register.
*283-284	COARSE LOOK ANGLE.
*285-286	FINE LOOK ANGLE.
*287	APERTURE mode 3 (.5mr, 8mr, half-wave plate or depolarizer,D) or mode 4 (.5mr)
*288	step inhibit indicator.
291-318	IPP temperature readings.
*361-4080	1860 INTENSITIES. Each intensity is two characters. The intensities are in the order which they were measured, i.e. blue, red, blue, red, blue, red, etc. The time between consecutive measurements in one color is 1/1024 second (except in low sample rate when it is 1/512 second). Valid data numbers range from 0To 63. The value -1 indicates invalid data. No more than 1015 intensities can be valid on one data cycle.

TABLE 3

IPP STARTING LOOK ANGLE CALIBRATION DATA

SLA	INSTRUMENT LOOK ANGLE
END STOP	170.48
1 from END STOP	152.10
1 from 2	151.25
2 from 1	128.70
2 from 3	127.60
3 from 2	109.72
3 from 4	108.85
4 from 3	90.93
4 from 5	90.08
5 from 4	67.25
5 from 6	66.37
6 from 5	29.50
6 from 7	28.62

IPP HOUSEKEEPING
Definitions and Anomalies

1. Barker code (Sync code) [7 bits] value is almost always 114, but bits can be added when the spacecraft is irradiated.
2. Mode I.D. [3 bits] value =1 indicates mode 4 - imaging mode; value =2 indicates mode 3 - photopolarimeter mode; value =4 indicates mode 2.
3. Roll Spoke [8 bits] values 0 through 255 (1.40625 degrees per spoke). Spoke 40 (-3.75 degrees) is the reset value (varies per instrument and other things too numerous to mention). WARNING ! When the threshold bit is not on, the last two bits of the spoke are undefined, i.e. read the spoke as if the last two bits are zeroes whether they are zero or not. It is best to mask them off to zero when the threshold bit is not on (=0). When the threshold is on (=1) the reading is precise to the nearest spoke.
4. Backstep bit (BS) 1 = on, 0 = off. IPP backstep.
5. Threshold Bit (Th) 1 = on, 0 = off. Threshold scan. For a list of all the screwy things that this bit does read the IPP detailed instrument description. Good Luck !

6. Low Sample Bit (LS) 1 = on, 0 = off. IPP in low sample in mode 4. Doubles the field of view in mode 4 by not taking overlapping samples. The low sampling rate reads in a blue intensity, steps the IPP by one pixel, reads a red intensity and then steps the IPP another pixel. This procedure is repeated until all 1016 pixels have been read. Stepping by one pixel does not allow the IPP to sample both the blue and red pixel data from the same location on the planet surface. (Note this when registering the blue and red data.) The high sample rate reads a blue intensity, steps the IPP one-half pixel, reasd a red intensity and then steps another one-half pixel. This allows an overlap between the blue and red planet surface sample area.
   In mode 3 sampling is not affected, it just turns off the calibration lamp.
7. Gain Step Setting (GS) [5 bits] values 0 through 27 steps with steps 12, 13, 14 and 15 missing (so that the contiguous step numbers are 9, 10, 11, 16, 17, 18, ...). If the gain is bigger than 11 then subtract 4 from it. Flag any invalid combinations when they occur.
8. Starting Look Angle (SLA) [4 bits] see table below:

SLA	Bits	Value	Approximate Cone Angle
1	0000	0	151 degrees
2	0001	1	127 (SLA reset)
3	0011	3	109 degrees
4	0111	7	90 degrees
5	1111	15	66 degrees
6	1110	14	29 degrees
7	1100	12	10 degrees

   An IPY3 command at SLA = 7 sets the register to SLA 1. All other values (2, 4, 5, 6, 8, 9, 10, 11, 13) are invalid.
9. Fine Encoder Position [5 bits] A 24 position shaft encoder attached to the telescope stepping motor. Each single position change is equivalent to a telescope look angle change of 0.5 milliradians (0.0286478 degrees). The step values are from 1 to 24. (About 0.688 degrees /revolution).
10. Coarse Encoder Position [5 bits] A 5 bit position code from wipers mounted on gating tracks attached to the telescope itself, each being about 4.7 degrees apart. A code of 0 = 170 degrees (end stop), and a code of 31 = 10 degrees (solar diffuser). (A code of 30 = 29 degrees, there are no extra wipers between the edge of the antenna and the diffuser. The rest, 29 degrees through 170 degrees are about 4.7 degrees apart. The exact values and spacings vary with each instrument.) Certain of the gate tracks are the starting look angles to which the instrument slews when given an IPW3 or IPW4 command (or when the telescope hits the end stop 170 degrees.) Note that the fine encoder takes about 6.8 turns for every gate track crossed.

11.Aperture Code [6 bits] This 6 bit code tells which aperture is in place for this IPP data roll. (Exception when in mode 3 the first 4 of 4, 5 , 6, 4 4 is really a 3 (lamp roll)). The aperture codes are as follows:

AP Code	Bits	What it is
1	001000	40 x 40 mr open
2	010000	phosphor source
3	100000	.5 mr (mode 3 lamp/mode 4 image)
4	000100	half wave 8 x 8
5	000010	depolarizer 8 x 8
6	000001	8 x 8 open (with corrector)

The aperture code has already been decoded for you on the EDR tapes. (This is the only field on the EDR which has been decoded for you.)

12.Step Inhibit Bit 1 = on, 0 = off. IPP stepping is inhibited. This bit tells the IPP to not step. (Has no effect in slew.) Also, if the threshold bit is on and no object which is in the 360 degree field of view (all the way around the roll) has 8 or more counts in channel 1 (BP - see note 20 below) then the IPP will go ahead and step anyway. If there are 8 or more counts the IPP will stay put.

13.Spare Bits (3) These bits were for things thought of later to be sent down but they were never used, fortunately. They are currently used (because they are always zero) to separate false Barker codes (data intensities that look like the start of housekeeping) from real Barker codes - the start of a new roll. This is mainly a problem in mode 4 at the lower bit rates - 256, 512, 1024 - when the entire data roll is not transmitted and a new roll starts right after the middle of the last one. The intensities are arranged such that the high order bits fall in the spare word and in the Barker code. These bits are on to make a false Barker code and off to make a false spare word. (This saved hand decoding data during the Pioneer 10 close approach to Jupiter.)

14., 15., 16., 17., 18. IPP Temperatures. Temperatures are thermistor voltage readings from inside the IPP which correspond to the temperature of various places inside the case. See chart below:

T1 = blue channeltron (#1) temperature
T2 = red channeltron (#2) temperature
T3 = phosphor source temperature
T4 = high voltage power supply temperature
T5 = electronic cavity temperature

The voltage-temperature calibration is different for each sensor and each instrument. It also changes slightly with time, but it can tell when anything is burning out. These temperatures are only taken in mode 3. Values in mode 4 are old mode 3 values.

19.Mode 4 Intensities. 508 picture elements (pixels) by 2 channels. Intensities are 6 bits in the order blue follwed by red. Note that the last two bits of the last intensity -508 red- are not sent. No room in the spacecraft 6144 bit buffer for them.

FIGURE 1
MODE 4 DATA ACCESS EXAMPLE

1) Choose to examine image F-105. (First in image log list.)
2) Consult the image log (near the end of this document) to determine that the Earth receipt midtime of the image is DOY 237 at time 01:19.
3) From the Pioneer Saturn encounter Pre-exams (on microfiche) determine that the image starts at DOY 237 at time 01:17:04. Notice also that this image STOPS at time 01:22:34. These times correspond to records numbered 589 through 632. Read note 21 in the section above labeled "IPP HOUSEKEEPING" to learn how to determine image START and STOP times.
4) Consult TAPE TABLE of CONTENTS (the last table in this document) to determine that image F-105 is on the computer tape labeled "SATURN1".
5) Skip 1 file (the first file on each tape is a copy of this ASCII text.)
6) Skip three files (the logistics, command and attitude data.)
7) Read a record. (4080 ASCII characters)
8) End-Of-File encountered ?   Yes: go back to step 6.
9) Does the DOY, time >= image START time ? No: go to step 7.
10) Is the DOY, time > image STOP time ?
    No: a. Print 77 housekeeping parameters and 1016 intensities
        b. Read a record
        c. Repeat step 10
11) Rewind the computer tape.
12) Stop.

20. Channel associations are as follows:

number	abbreviation code
1	BP
2	BS
3	RP
4	RS

where "B" means blue filter, "R" means red filter, "P" means polarized and parallel light while "S" means polarized and perpendicular light.

21. Determination of an image START and STOP times. Example: image F-105 has midtime 237:01:19. Examine the EDR Pre-exam (recorded on microfiche) for day 237. The data in the EDR Pre-exam is grouped the same way that the EDR is grouped. A summary of files 1, 2, 3 precedes the IPP data summary. The IPP data in the Pre-exams include summaries for mode 3 data. Mode 3 data is not included on the computer tapes at NSSDC. A data summary page (as seen on the microfiche) has column headings for record number (REC.), hour (HR.), minute (MN), second (SEC), the mode 4 record number (M4-NO.) or the mode 3 record number (M3-NO.) if that page details mode 3 data, some other columns, the instrument gain setting (GAIN), other columns, the blue channel high and low intensity values (B-H/L), the red channel high and low intensity (R-H/L). Follow the HR, MN columns until a time near 01:19 (01 hours, 19 minutes time on day 237) occurs. Record 605 is the first of these. Notice that under the column heading R-H/L are "4/ 0". The brightest pixel seen by the red channeltron during the scanning of record 605 has value 4. Read lines above record 605 (the midtime record) until find a line which reads "1/ 0" under column R-H/L while the line above it reads "0/ 0". This is the first line in the image. Record the time for this line - this is the image START time. Reads lines below the midtime record until finding that the highest red intensity value is small and the successive line has a maximum red intensity value of zero. This unfortunately does not happen with image F-105 because the IPP was switched from mode 4 to mode 3 at record number 633. So use the time for record 632 as the image STOP time.

PIONEER 11 IMAGE LOG DEFINITIONS

The attached table lists the Saturn images from the Pioneer 11 fly-by. The images are identified by a series letter and a sequence number. The letter identifies whether the image was taken before (F) or after (G) pericenter. The numbers are sequential beginning with the image closest to the pericenter. In addition to the image designations, the time of the image and and certain geometric parameters are listed in the table. They are defined as follows:

ERT Midtime -	the Earth-receipt midtime (UT) of the image, i.e., the actual spacecraft event midtime (mean of the image START time and STOP time) plus the light travel time from the Earth to the spacecraft. This time can be used for comparison with ground-based observations.
Range -	the distance from the spacecraft to the center of Saturn at the midtime. (Measured in kilometers.)
Pixel size -	the distance at the sub-spacecraft point on Saturn subtended by a 0.5 milliradian angle at the spacecraft. This is a measure of the resolution of the image. (Measured in kilometers.)
Phase Angle -	the Sun-Saturn-spacecraft angle.
Latitude -	the planetocentric latitude of the sub-spacecraft point.
LCM -	the IAU system Longitude of the Central Meridian as seen from the spacecraft.

Descriptive Comments on Selected Images

image #	DOY	comments
F-105	236	No satellites visible. Dark ring silhouetted against planet with its shadow above it. Two belts can now be seen above and below the ring shadow. Several spots are barely visible in the north hemisphere.
F-48	240	Satellite Enceladus appears at 2:30 o'clock, close to planet. Some faint band structure is present.
F-37	241	Titan at 11 o'clock. Cassini Division is clearly resolved and distinct from Encke Division. Ring A has MUCH higher optical depth as it nears Cassini Division due to more pariculate matter. There are suggestions of division (or divisions) in Ring C. Polar and temperate belts are becoming more visible on the planet. However, northern hemisphere bands are more evident than those in southern hemisphere. Also the red image is slightly saturated due to IPP gain settings when image data was taken.
F-33	242	Satellite Rhea at 4 o'clock. Rings are cropped due to missing IPP data.
F-32	242	The satellite Dione is at 1 o'clock. The satellite shadow at 10 o'clock on the planet is that of the satellite Rhea. The right limb of the planet suffers irregular IPP stepping.
F-29	242	Satellite Enceladus appears faintly at 8:30 o'clock below left side of ring. Shadow of satellite Iapetus is seen on the planet surface at about 70 degrees north latitude. The planet is somewhat saturated in the red image due to high IPP gain settings.
F-16	243	This high resolution picture of Saturn and its ring system show major ring features and planetary cloud belts in detail.
F-13	243	This image shows the south polar region of Saturn (the South Pole is not visible but is close to the lower left corner of the image), the south equatorial belt appears faintly below the ring silhouette.
F-12	244	This is the "discovery" image of the Pioneer 11 Saturn encounter. The provisional "new" satellite 1979S1 is seen about 5 o'clock. The new F ring appears faintly just outside Ring A. The bright satellite at 2 o'clock is Tethys.

F-11	244	This close-in image of Saturn's southern hemisphere shows that the south polar region appears darker than the temperate region above it, with a clear line of demarkation. Several faint belts can be seen in the temperate region with a small but discreet, orange spot in the center. Such spots are rare in Pioneer Saturn imagery.
F-9	244	This is one of the highest resolution images of Saturn during the Pioneer 11 encounter. The south polar region is clearly seen, as well as several belts in the south temperate latitudes. The absence of other structures is notable, suggesting a highly stable and uniform system of atmospheric dynamics.
F-7	244	Silhouetted against the planet, the rings appear jet-black except where the light from the planet shines through the ring divisions. The Encke Gap is barely visible. The Cassini Division is seen extending out from the ball. Subtle differences in color and form are seen in the northern and southern cloud structure. The bright spot near the left limb of the planet is the satellite Mimas, and its shadow is cast near the right edge of the image.
F-5	244	This image of Saturn extends from latitude 31 degrees north in the upper left to the equator at the bottom of the image, thus covering the north temperate and equatorial reqions. numerous low contrast cloud features can be seen.
F-4	244	This is the highest resolution pre-periapsis Mode 4 image. The aperture size projected onto the planet is approximately 250 kilometers. Since the spacecraft was moving at about the same rate as the planet's rotation, the scan lines were overlapped. The remarkable lack of detail at this resolution demonstrates the dramatic differences between the atmospheric dynamics of Jupiter and Saturn. The mottled structure of the image is due to noise in the data at the high gain setting.
G-3	244	This is the closest Mode 4 image of Saturn, the size of the IPP aperture projected onto the planet being approximately 250 kilometers. No belt structure or spots are visible on the planet because of the large (137 degrees) phase angle. This image spans from latitude -46.7 degrees to the rings at latitude -6.4 degrees. The two bright lines at the top are the Encke Gap (lower) and the Cassini Division (upper) of the rings. The dark lines (data "comb") protruding into the image from above are a result of the IPP sampling process. They are caused by data from other spacecraft experiments stored in the data buffer which thus appears as a comb-like structure near the exremity of the IPP's data boundary when it approaches sector 150 degrees.

G-4	244	As the phase angle decreases the planet's belt structure becomes more apparent, hence at 114 degrees phase angle the belts become marginally visible. The Encke Gap may be seen in the rings against the planet. The decreasing width of the ring shadow on the planet is the result of a change of scale as the spacecraft moves away from Saturn.
G-8	245	At phase angle 95 degrees the contrast of the belts increases substantially. The data saturated the IPP during a part of the image. The discontinuity results from a gain reduction (in order to avoid saturation.)
G-10	245	Bands are clearly seen across the planet and are much more conspicuous than images taken at the same phase angle of Jupiter during Pioneer 10 encounter.
G-14	245	The Titan satellite images. These four images are lumped together under the name G-14. Their START TIMEs are listed below.

	START TIME	STOP TIME
G-14a	17:53:03	17:56:54
G-14b	18:18:56	18:24:19
G-14c	18:46:46	18:52:32
G-14d	19:29:04	19:41:31

Descriptive Comments on List

of Pioneer Saturn Encounter Images

Forwarded to NSSDC on 9 February 1981

IMAGE NO.	DOY	COMMENTS
F-81	238	As the spacecraft neared Saturn on 26 August 1979, details of its belts and rings became visible, as the resolution began to approach that possible from Earth observations.
F-59	239	Small dark spot at about 5 o'clock of red image is due to one pixel of bad data from the IPP. It shows as a small blue spot on the color transparency. It can be corrected on future reproductions. A notch appears on the edge of the planet at about 11 o'clock which is due to defective pixels. Many new features are beginning to show. The Encke Division of the rings is clearly resolved. (Before it was blended with the Cassini Division.) Belts across the planet are becoming more distinct.
F-35	242	Satellite Titan appears at 9 o'clock. The outer portion of the left ring (ansa) is cropped because no data beyond same was taken by the IPP.
F-34	242	Satellite Rhea seen at 6 o'clock; Titan appears at 9 o'clock. End of left ring is cropped because no data beyond that point was taken.
G-14	245	Four images of Titan have been displayed from a series of close together images, and are displayed as B, C, D, and E clockwise on a single negative. The D image is obviously unsatisfactory due to dropped frames, and other data or instrument anomalies, which could not be corrected. The other three B, C, and E are the best Titan renditions possible and have been color-processed using Saturn's color appearance. As no one has seen Titan from this aspect and range, we have no standard by which to judge its color. The magnifications of the images are arbitrary. No surface details are apparent as Titan is covered by clouds of which no specfic structure or patterns can be seen. The optimum Titan image is G14B, because it had the best data and therefore required less processing.

IMAGE NO.	DOY	COMMENTS
G-21	246	As the spacecraft moved further away from Saturn, the cloud features became less visible. In this image, gain changes were not corrected for in order to improve visibility of the rings. A scattered light halo is visible to the front and rear of the planet which is most probably due to light scattering within the IPP optics.
F-6	244	Oblique structure can be seen in the belts and a few faint light spots appear on the planet. The shadow of the rings on the planet shows the Cassini Division clearly as well as a division between Rings B and C. This latter division has not heretofore been widely accepted. This image shows more structure on the planet than any other Pioneer Saturn image.
G-4	244	As the phase angle decreases the planet's belt structure becomes more apparent, hence at 114° phase angle the belts become marginally visible. The Encke Gap may be seen in the rings against the planet. The decreasing width of the ring shadow on the planet is the result of a change of scale as the spacecraft moves away from Saturn.
R-1	244	This "image" was reconstructed from red intensity data from images F-12 and F-6; such display shows how the rings might appear from the dark side. A radial intensity plot was made to produce the picture. (The plot is attached hereto.) We observe an azimuthal brightness in Ring A. It is not depicted in this display.

TABLE 4

PIONEER 11 G SATURN IMAGE LOG

IMAGE NO SEQUENCE	MID TIME DOY HR MIN	RANGE (KM)	PIXEL SIZE (KM)	PHASE ANGLE DEGREES	LAT	LCM
F105	237:01:19	6749000	3345	18.0	5.5	223.1
F71	239:02:25	5144000	2542	17.4	5.5	143.6
F70	239:03:06	5121000	2531	17.4	5.5	168.1
F69	239:06:10	5019000	2480	17.4	5.5	275.5
F68	239:06:55	4995000	2468	17.3	5.5	301.3
F67	239:07:41	4969000	2455	17.3	5.5	328.5
F66	239:08:26	4944000	2442	17.3	5.5	354.5
F65	239:09:27	4910000	2425	17.3	5.5	30.4
F64	239:10:10	4887000	2414	17.3	5.5	55.2
F63	239:11:27	4844000	2392	17.3	5.4	100.7
F62	239:12:08	4821000	2381	17.3	5.4	124.6
F61	239:13:00	4793000	2367	17.2	5.4	154.4
F60	239:13:38	4772000	2356	17.2	5.4	176.8
F59	239:14:26	4745000	2343	17.2	5.4	204.9
F58	239:15:11	4720000	2330	17.2	5.4	231.4
F57	239:16:16	4684000	2312	17.2	5.4	269.1
F56	239:17:01	4659000	2300	17.2	5.4	295.6
F55	239:23:35	4439000	2190	17.0	5.4	165.7
F54	240:00:17	4416000	2178	17.0	5.4	190.2
F53	240:01:03	4390000	2165	17.0	5.4	216.7
F52	240:01:48	4365000	2153	17.0	5.4	243.0
F51	240:02:37	4338000	2139	17.0	5.4	271.5
F50	240:03:17	4315000	2128	16.9	5.4	294.9
F49	240:05:05	4254000	2097	16.9	5.4	358.2
F48	240:05:52	4228000	2084	16.9	5.4	25.7
F47	241:03:38	3488000	1714	16.2	5.4	68.4
F46	241:04:30	3458000	1699	16.2	5.4	98.6
F45	241:05:53	3411000	1676	16.2	5.4	146.9
F44	241:06:45	3381000	1661	16.1	5.4	177.3
F43	241:07:46	3346000	1643	16.1	5.4	212.9
F42	241:08:35	3318000	1629	16.1	5.4	241.6
F41	241:09:48	3276000	1608	16.0	5.4	283.8
F40	241:10:33	3250000	1595	16.0	5.3	310.1
F39	241:11:37	3213000	1577	15.9	5.3	347.7
F38	241:12:27	3184000	1562	15.9	5.3	16.6
F37	241:22:07	2846000	1393	15.4	5.3	355.0
F36	241:22:57	2817000	1379	15.4	5.3	24.3
F36B	242:00:41	2756000	1348	15.3	5.3	84.8
F35A	242:01:53	2713000	1327	15.2	5.3	127.1
F35B	242:02:40	2685000	1313	15.2	5.3	154.7
F34	242:03:41	2649000	1295	15.1	5.3	190.0
F33	242:05:43	2577000	1259	14.9	5.3	261.0
F32	242:07:17	2521000	1231	14.8	5.3	315.7

F31	242:09:04	2457000	1199	14.7	5.2	18.1
F30	242:09:34	2438000	1189	14.7	5.2	35.9
F29	242:10:23	2409000	1175	14.6	5.2	64.5
F28	242:13:25	2299000	1120	14.4	5.2	170.6
F27	242:13:53	2283000	1112	14.3	5.2	186.5
F26	242:15:32	2222000	1081	14.2	5.2	244.8
F25	242:17:31	2150000	1045	14.0	5.2	313.6
F24	242:19:24	2081000	1011	13.8	5.2	19.3
F23	242:21:32	2002000	971	13.6	5.2	94.2
F22	242:23:24	1933000	937	13.4	5.1	159.1
F21	243:04:54	1725000	833	12.7	5.1	351.5
F20	243:07:53	1611000	776	12.2	5.0	95.5
F19	243:09:21	1555000	748	12.0	5.0	146.5
F18	243:12:50	1418000	679	11.4	5.0	267.8
F17	243:15:16	1322000	631	10.8	4.9	352.4
F16	243:16:57	1254000	597	10.5	4.9	50.9
F15	243:19:01	1170000	555	9.9	4.8	122.7
F14	243:21:08	1082000	511	9.4	4.7	196.2
F13	243:23:00	1004000	472	8.8	4.7	260.7
F12A	244:00:03	960000	450	8.5	4.6	296.4
F12B	244:00:29	941000	441	8.4	4.6	311.7
F11	244:02:49	839000	390	7.8	4.5	31.8
F10	244:05:13	731000	336	7.4	4.3	114.1
F9	244:06:21	678000	309	7.4	4.2	152.8
F8	244:08:05	597000	269	7.9	4.0	210.8
F7	244:09:58	505000	223	9.7	3.7	273.7
F6	244:12:02	398000	169	13.8	3.2	340.6
F5	244:13:35	313000	127	19.7	2.5	28.7
F4	244:14:40	251000	96	26.5	1.7	59.1
G3	244:20:07	183000	62	135.1	.5	51.7
G4	244:22:43	335000	138	113.2	3.0	120.8
G5	245:02:28	531000	236	102.2	4.0	241.4
G6	245:05:08	659000	300	98.2	4.4	330.5
G7	245:07:51	783000	362	95.5	4.6	63.1
G8	245:09:31	858000	399	94.2	4.7	120.2
G10	245:14:05	1053000	497	91.6	4.9	277.5
G11	245:14:39	1077000	509	91.3	4.9	297.1
G12	245:15:10	1099000	520	91.1	4.9	315.1
G13	245:16:30	1154000	547	90.5	5.0	1.6
G14	245:18:48	360000	179	23.0	19.3	94.0
G17	246:11:45	1904000	922	86.1	5.3	311.7
G18	246:12:59	1950000	945	85.9	5.3	355.0
G19	246:14:16	1998000	969	85.7	5.3	39.8
G20	246:15:31	2044000	992	85.6	5.3	83.2
G21	246:18:19	2147000	1044	85.3	5.4	181.0
G22	246:19:16	2182000	1061	85.2	5.4	214.2
G23	246:22:01	2282000	1111	84.9	5.4	310.2
G24	246:22:53	2313000	1127	84.8	5.4	340.6
G25	247:00:09	2359000	1150	84.7	5.4	25.0
G26	247:03:01	2463000	1202	84.4	5.4	125.4
G27	247:04:31	2516000	1228	84.3	5.4	177.8
G28	247:05:09	2539000	1240	84.3	5.4	200.3
G32	247:20:42	3087000	1514	83.3	5.5	24.1
G33	247:21:24	3112000	1526	83.3	5.5	48.6

G34	247:22:09	3138000	1539	83.3	5.5	75.1
G35	248:01:17	3247000	1594	83.1	5.5	184.6
G36	248:02:05	3275000	1608	83.1	5.5	212.8
G37	248:02:54	3302000	1621	83.0	5.5	241.1
G38	248:03:35	3326000	1633	83.0	5.5	265.2
G39	248:04:45	3366000	1653	83.0	5.5	305.9
G40	248:05:29	3392000	1666	82.9	5.5	331.6
G41	248:06:15	3418000	1679	82.9	5.5	358.6
G42	248:06:55	3441000	1691	82.9	5.5	21.9

TABLE 5

PIONEER 11 SATURN COMPUTER TAPE TABLE OF CONTENTS

tape name	Days-Of-Year included on tape
SATURN1	237 (first 8 hours only), 239
SATURN2	240, 241
SATURN3	242
SATURN4	243, 244
SATURN5	245, 246
SATURN6	247, 248

(All Mode 4 records for a given DOY have been included on the tapes as specified above - with the exception of DOY 237. No data from a given DOY is continued from one tape to another.)

Satellite Identification

Identification of Saturn's satellites is possible through the use of Pioneer encounter Pre-exams, Table 3, and a host of other details.
When a satellite is found in the data, it can be identified by computing the LOOK and ROLL angles of the telescope when the satellite was observed. By consulting Figures 2 and 3, satellite trajectory plots available through NSSDC separately, the satellite which has look and roll angles coinciding with the line of sight of the telescope can then be identified.
The procedure to be followed is:

1. Compute the Earth transmit time of the satellite observation. Whether the satellite was found in the Pioneer Encounter Pre-exams or on the Imaging Photo-polarimeter tapes, the midtime of the image can readily be found. The midtime will be in Earth receipt time. The Earth transmit time is one roundtrip light time earlier: Earth Transmit Time (ETT) is approximately Earth Receipt Time (ERT) minus 2 hours 51 minutes 52 seconds.
2. Compute the look angle of the telescope when the satellite was observed. The telescope is frequently slewed to one of the starting look angles. During an observation it is stepped off of the starting look angle by an amount which can be determined by counting the look angle fine encoder. By counting the number of fine encoder steps which have been made at the time of satellite observation, the look angle can be determined: Look Angle = Starting Look Angle (SLA) +/- .02851 degrees*(number of fine encoder steps from SLA). The stepping history of the telescope is in the Pioneer Encounter Pre-exams. Table 3 gives the look angles of the Starting Look Angles. Note that in mode 3 the telescope nominally moves 16 fine encoder steps at a time. The + sign is to be used in the case of forward stepping during which the fine encoder value decreases. The fine encoder readout is a number between 1 and 24 which "wraps around", i.e. a forward stepping sequence might be 3, 2, 1, 24, 23, 22, etc. The - sign is used in the case of backstepping. The B and I housekeeping bits should indicate the direction of stepping, but instrument anomalies sometimes make them unreliable. The fine encoder is the best indicator of the look angle.

3.) Compute the roll angle of the telescope when the satellite was observed. The Pioneer Encounter Pre-exams show the spoke at which the data taking began. If S is the spoke for the observation and N is the sector number of the center of the satellite, the roll angle is given by:
Roll Angle = (S-40)*(360degrees/256) - 3.75 degrees + N*(360 degrees/1024*7.69)*L
where 7.69 is the spacecraft spin period in seconds and L is 1 if low sample rate is off and 2 if low sample rate is on. The accuracy of the roll angle is limited by the accuracy of the spacecraft roll-pulse sensor. It is usually accurate to +/-1 degree.

The Look and Roll angles of the telescope can then be plotted on figures 2 and 3. If the calculations have been done correctly, the position of the telescope should match one of the satellites. Usually the look angle alone is sufficient to identify the satellite and the roll angle angle can be used for verification.

Address further questions to:
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Lunar and Planetary Laboratory
University of Arizona
Tucson, Arizona 85721

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INPUT PARAMETERS ARE:  AS SR=1=1 1

 TAPE NO.   1              FILE NO.   1
 RECORD   1     DOY        LENGTH    4080
     426879   237     0      2  -.12      14      6    016     10294161   4130      0  0000         1.1484
   7.6952      6              .0000         370356 27.92 2.373       1        422862  32.3333333333333333333
3300000000000000000            432240       2              426879    114       1      40 00016       0 21730     367
369    366    566    643                                                     0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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1-1-1-1-1-1-1-1-1-1

***** JOB DONE.
$WEO LPS

$$
$ASS IN TB1
$NOP
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PIONEER 11 73-019A-07K

D-45257 C-21818

8/25/79 - 8/27/79

ALL DATA TIMES ARE LOCATED IN THE FOURTH FILE OF EACH SET OF 4 FILES.

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$AVF IN 20
$ASS LO LPS
$EXE TPLIST BS

INPUT PARAMETERS ARE:  AS SR=118=1 1

 TAPE NO.   1                FILE NO.   1
 RECORD   118                LENGTH   4080
   86391980  239    0    2  -.65     14      6   016     10320106  6729      0  0100        4.2421
   7.6952     6         -1.9531     86320831 27.92 2.467       1       86373337     .0333303333300303330
3030000000000000000      86358715       2               86391980    114      1    127 10022      0 12130      0
  0      0      0      0                                                      0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0-1-1-1-1
-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-
1-1-1-1-1-1-1-1-1-1-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0-1-1-1-1-1-1
-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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1-1-1-1-1-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0-1-1-1-1-1-1-1
-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
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***** JOB DONE.
$WEO LPS

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$EOJ  12:38:20
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