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AN ATLAS OF SELECTED MULTI-FREQUENCY RADIO BURSTS FROM THE TWEN--ETC(U)
APR 80 W R BARRON, V L BADILLO, E W CLIVER
AFGL-TR-80-0098

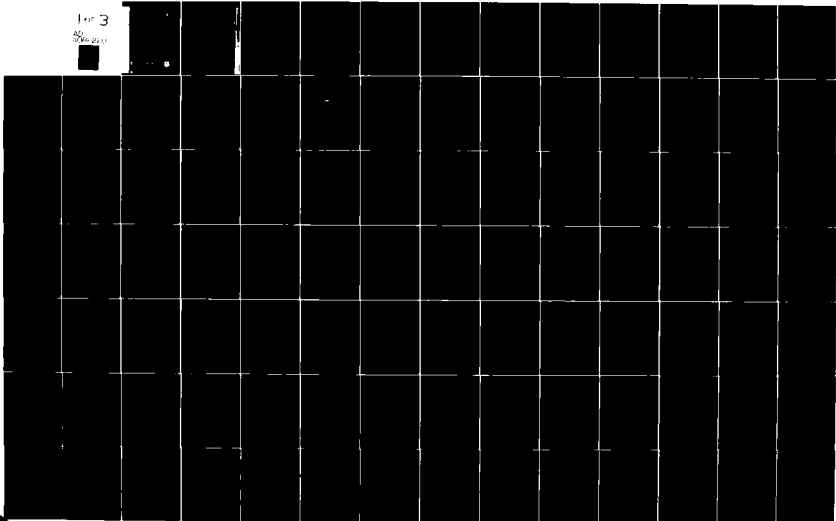
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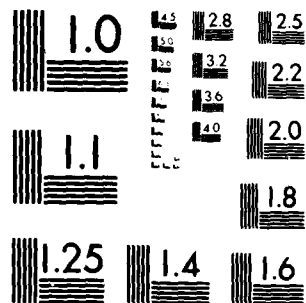
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LEVEL

(12)

AFGL-TR-80-0098

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An Atlas of Selected Multi-Frequency Radio Bursts From the Twentieth Solar Cycle

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2 April 1980

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This technical report has been reviewed and
is approved for publication.

FOR THE COMMANDER


Chief Scientist

Qualified representative of
Defense Research Agency
National Technical Information Service

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Illustrations or reconstructions of the analog records of significant and interesting solar radio bursts observed during Solar Cycle 20 at the AFGL Sagamore Hill Radio Observatory in Hamilton, Massachusetts, and the Manila Observatory in the Philippines are presented. Many of the illustrated burst records were associated with the emission of energetic solar protons and subsequent disturbances to the ionosphere and the geomagnetic field.			

409578 Jm

An Atlas of Selected Multi-Frequency Radio Bursts From the Twentieth Solar Cycle

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Donald A. Guidice
Air Force Geophysics Laboratory
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**Victor L. Badillo, S. J.
Manila Observatory, Philippines**

Multi-frequency patrol observations of the radio sun are now well into their fourth solar cycle. The radiometer systems used to observe solar radio emissions are in their second generation, and shortly the familiar strip chart records will give way to cathode ray tube displays and magnetic tape recordings. At this juncture we thought it would be useful to gather in one place a collection of illustrations of some of the outstanding multi-frequency solar radio events of solar cycle 20 as observed by the AFGL Sagamore Hill Radio Observatory and the Manila Observatory.

This report is not intended as a comprehensive atlas of all solar radio bursts observed by the two observatories. A majority of the bursts associated with flares having significant geophysical effects are included. The remainder of the burst illustrations are mainly ones which it was felt had some interesting characteristic(s) associated either with the temporal variation of the burst flux level or with the spectral character of the burst. Many of these burst illustrations have been

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reproduced elsewhere, either in Solar-Geophysical Data or in the open literature. Others have not. The early less polished burst illustrations have been included here to maintain the historical continuity of the observations.

The information obtained from the analysis of the burst data illustrated here has been used to assist in the derivation of algorithms predictive of flare-induced geophysical disturbances. The radio burst profiles have also been correlated with flare emissions at other wavelengths to provide an improved understanding of the flare phenomenon. The material in this atlas has been assembled as a contribution to further advances in the study of solar flares and their interplanetary and terrestrial effects.

Over the years, the solar radio program conducted by the Air Force Geophysics Laboratory (previously AFCRL) has benefited from the efforts of many individuals. We give blanket acknowledgement to the men and women of the Air Weather Service who have manned the Sagamore Hill Solar Radio Observatory since its inception. This atlas would not have been possible without the dedicated effort of Mr. John P. Castelli, former Chief of the Solar Radio Section of AFGL, and the continuing support of Dr. Jules Aarons, Chief of the Trans-Ionospheric Propagation Branch of AFGL. The Sagamore Hill burst illustrations were produced by SMSgt. Art Francis and TSgt. Dick Rickard.

NOTES ABOUT THE ILLUSTRATIONS

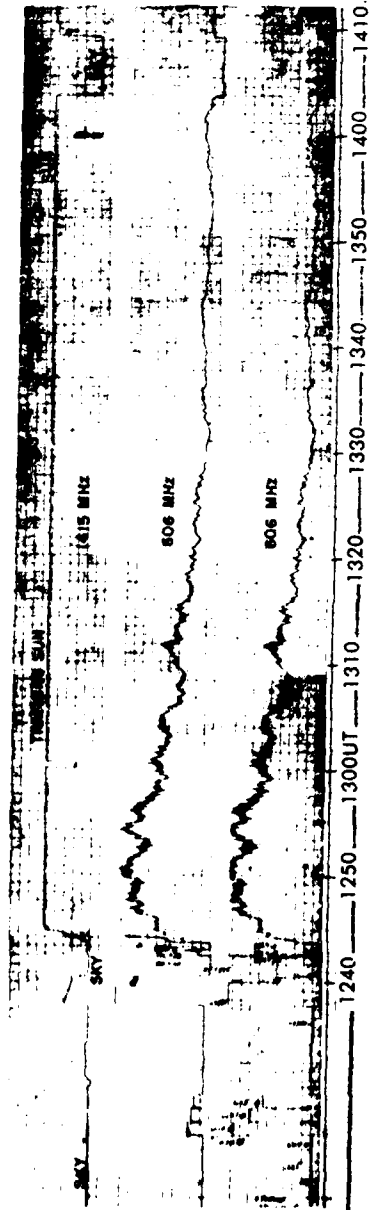
The time flow in most of the illustrations is from right → left, however a few of the illustrations have time running from left → right, so care should be exercised in reading the illustration time scales.

The amplitude scales in all of the illustrations are linear, except for 28 August 1966, 23 May 1967, and 29 October 1968 (two illustrations), which are logarithmic.

In some burst illustrations there are two adjacent lines at the same frequency with different amplitude scale factors, and in a few other cases the line of the analog trace is broken at a particular flux level and then picked up at a higher flux level to keep the illustration itself within reasonable dimensional bounds. This line break has been accomplished to produce as little loss of burst detail as possible.

Most of the illustrations given here are reconstructions of the original analog records. If more detail of a record is needed, the reporting observatory will answer reasonable requests for copies of the original analog records.

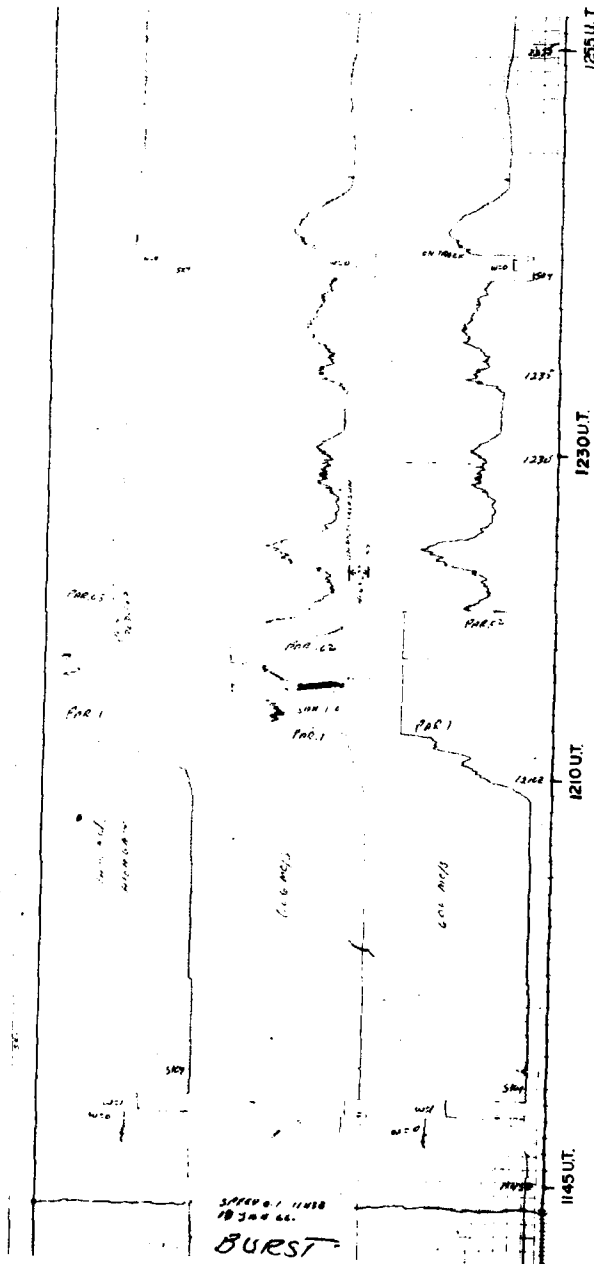
**Solar Radio Bursts
1965**

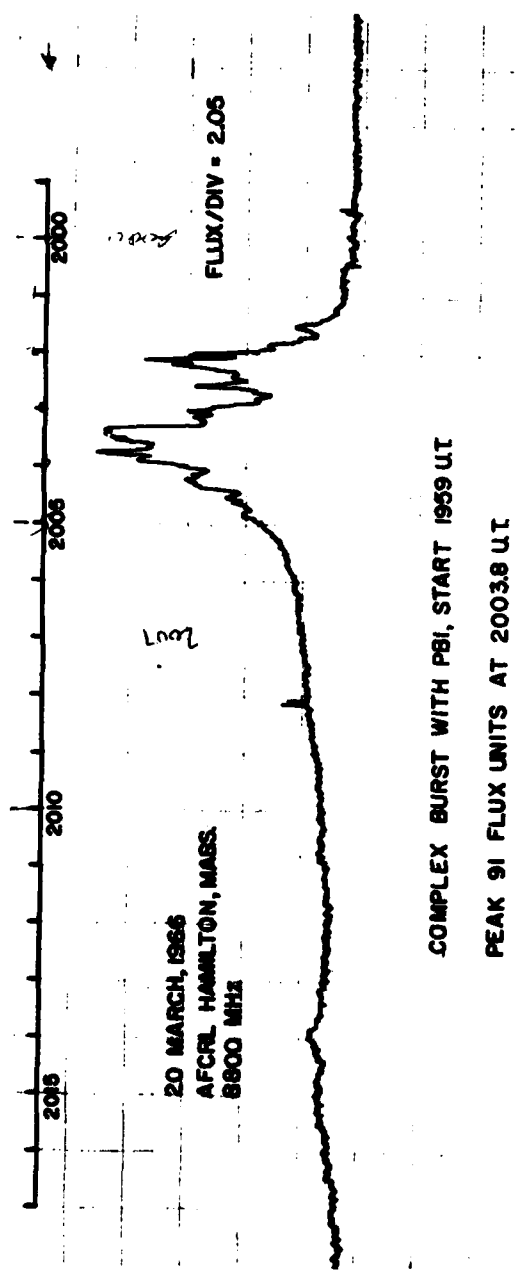


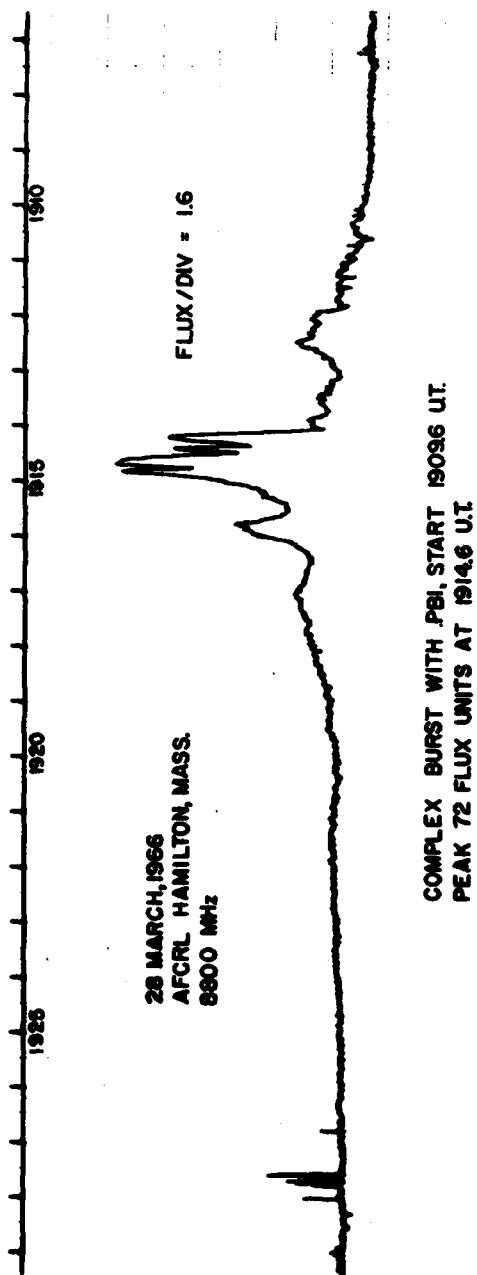
MAJOR SOLAR EVENT IN PROGRESS ON 606 MHz 4 OCTOBER 1965 WHEN DAILY OBSERVATIONS BEGAN.
PEAK FLUX = APPROXIMATELY 40 x FLUX OF 3 OCTOBER 1965. NO INCREASE ON 1415 MHz NOTED.

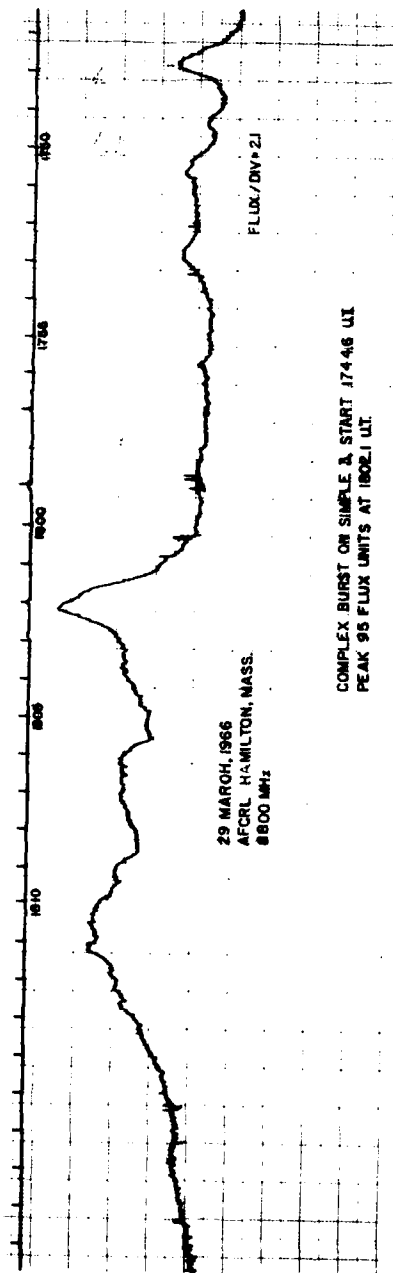
REPRODUCTION OF THIS DOCUMENT IS PROHIBITED

Solar Radio Bursts 1966

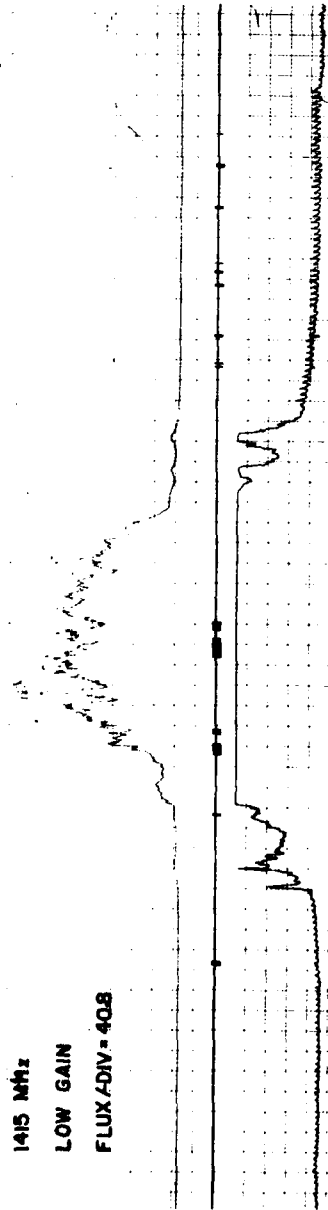






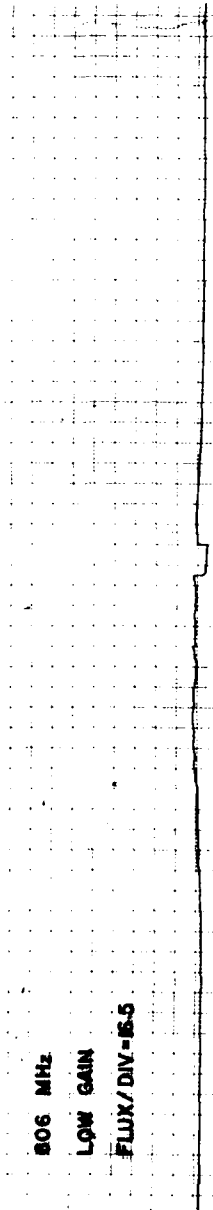


1415 MHz
LOW GAIN
FLUX/DIV = 40.8

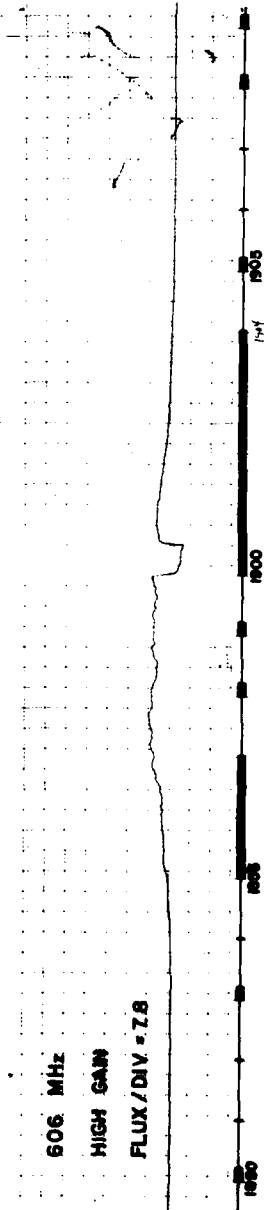


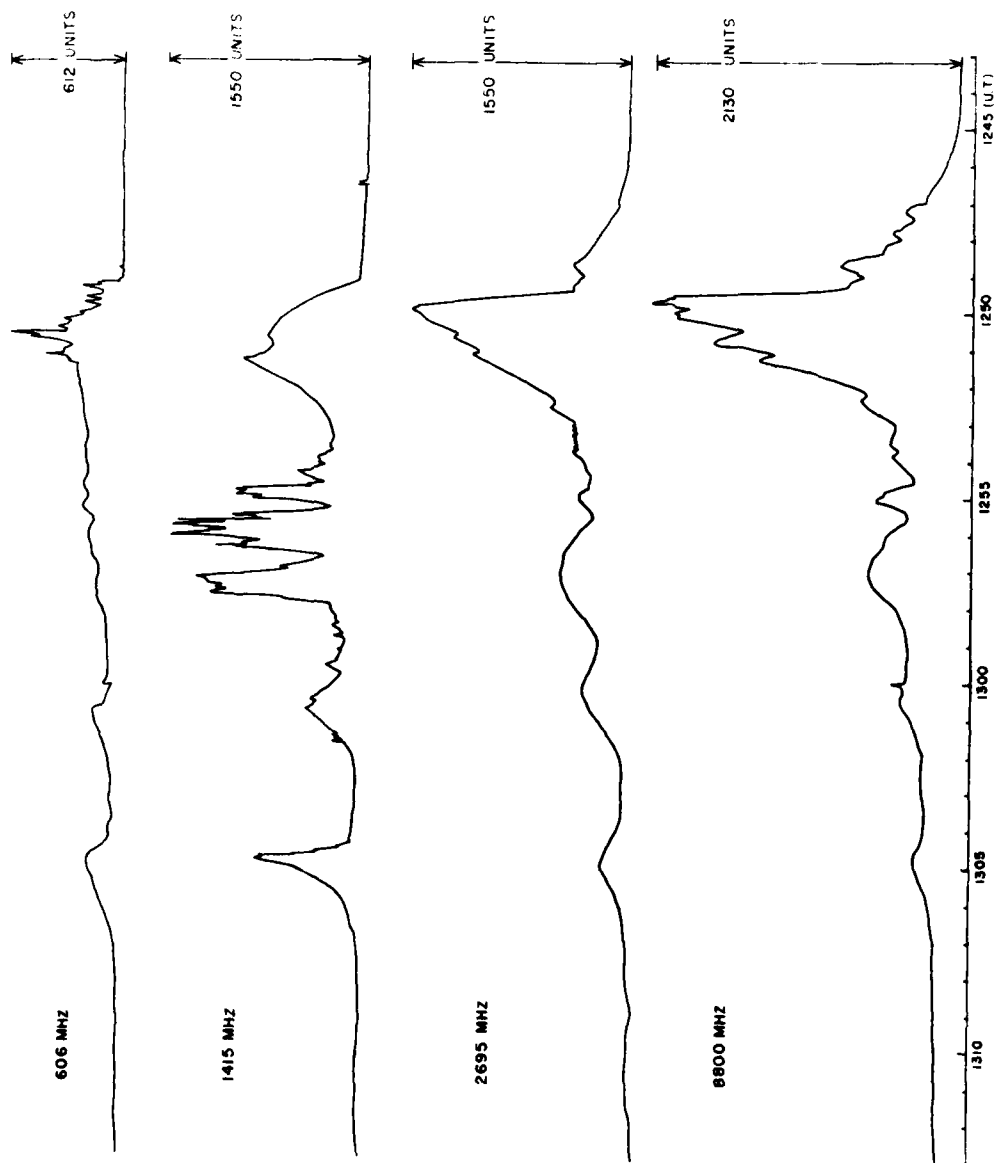
1415 MHz
HIGH GAIN
FLUX/DIV = 2.1
29 MARCH, 1966
AFCL HAMILTON, MASS.
COMPLEX BURST WITH PBI

806 MHz
LOW GAIN
FLUX/DIV = 5.5

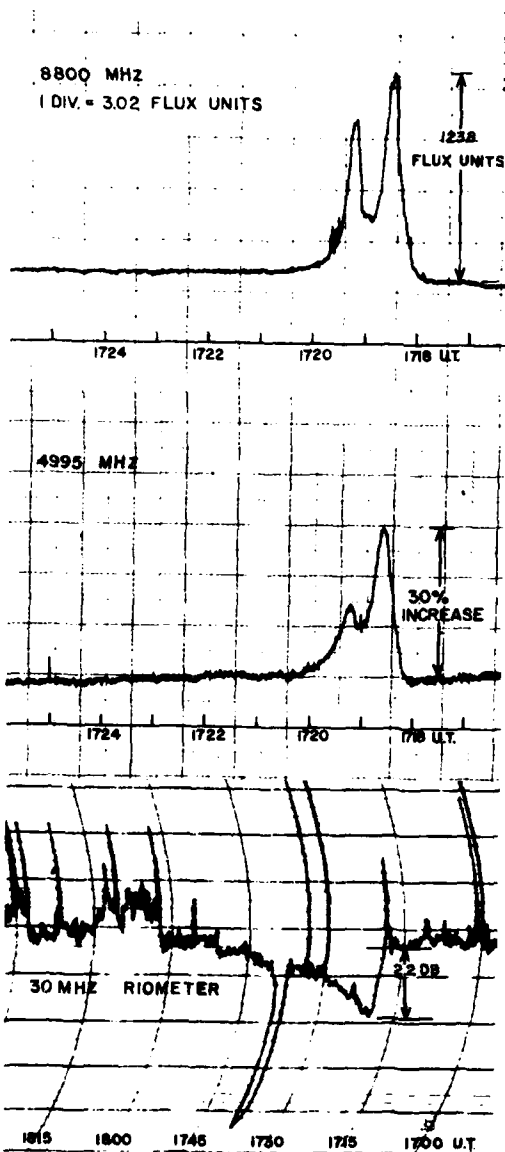


806 MHz
HIGH GAIN
FLUX/DIV = 7.8

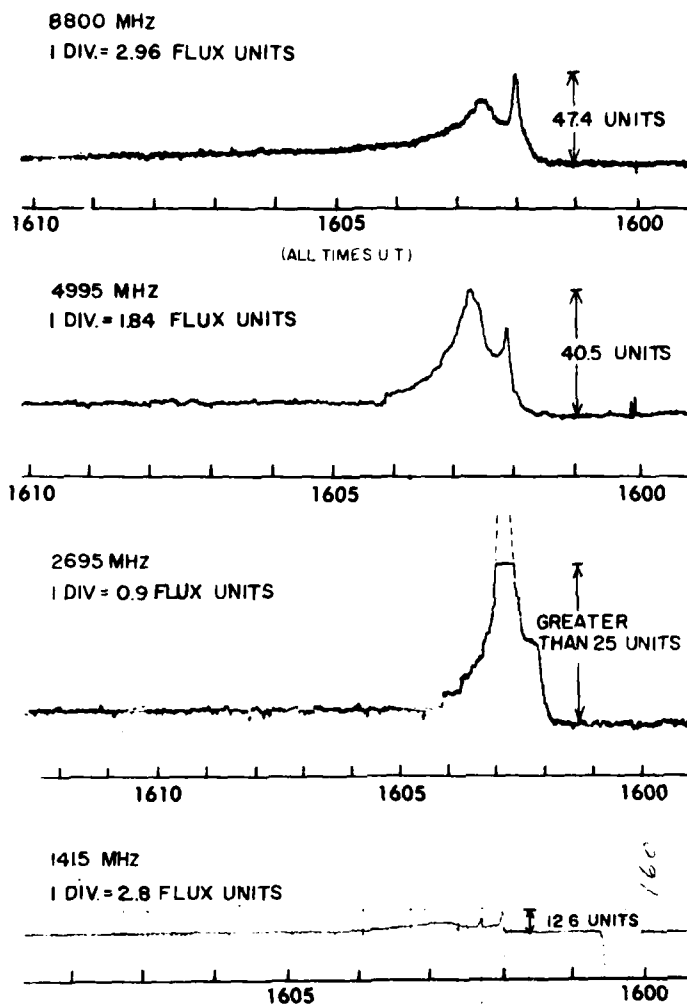




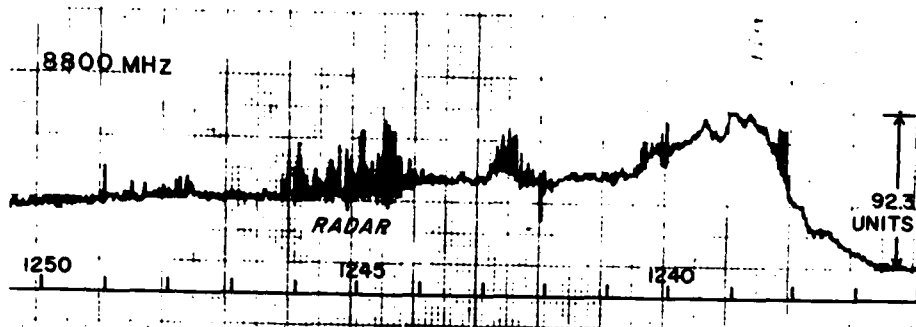
COMPLEX BURST WITH POST BURST INCREASE OBSERVED ON 30 MARCH, 1966
AT SAGAMORE HILL RADIO OBSERVATORY - AFCL - HAMILTON, MASS.



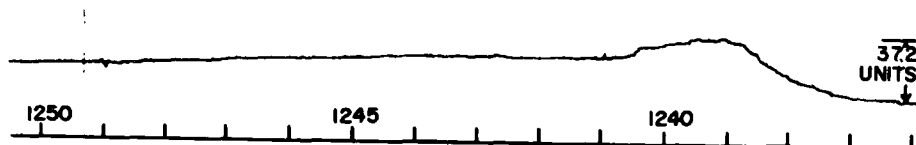
COMPLEX BURST OBSERVED AT APPROXIMATELY 1718 U.T.,
APRIL 12, 1966 AT AFCRL HAMILTON, MASS.
NO SIGNIFICANT FLUX INCREASE OBSERVED AT 2695, 1415, OR 606 MHz



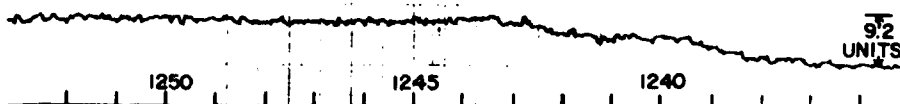
COMPLEX BURST WITH POST BURST INCREASE OBSERVED
AT APPROXIMATELY 1602 UT JUNE 12, 1966 AT SAGAMORE
HILL RADIO OBSERVATORY (AFRL) — HAMILTON, MASS.
(NO FLUX INCREASE OBSERVED ON 606 MHz)



4995 MHz

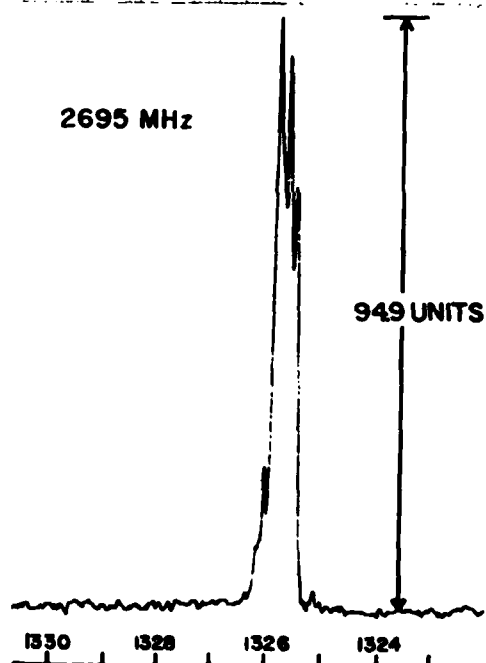
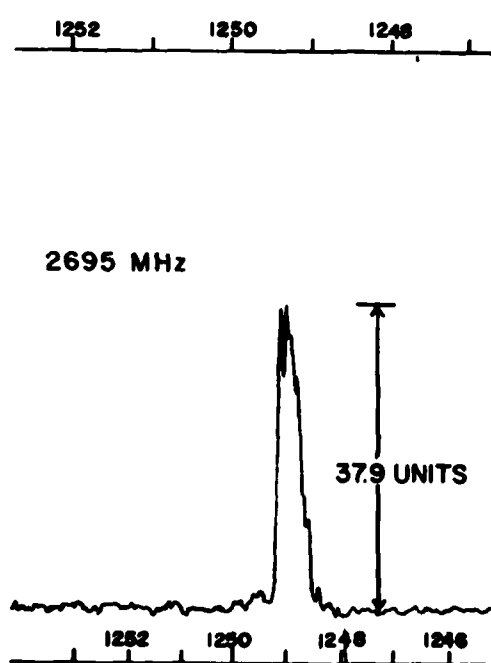
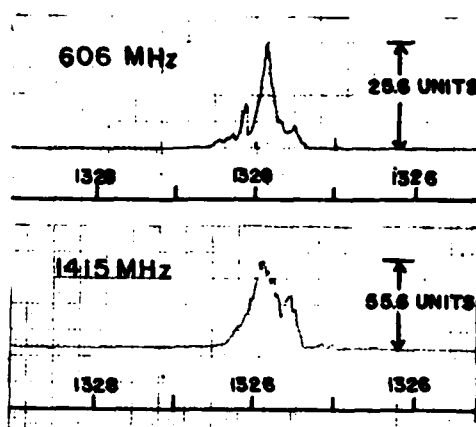
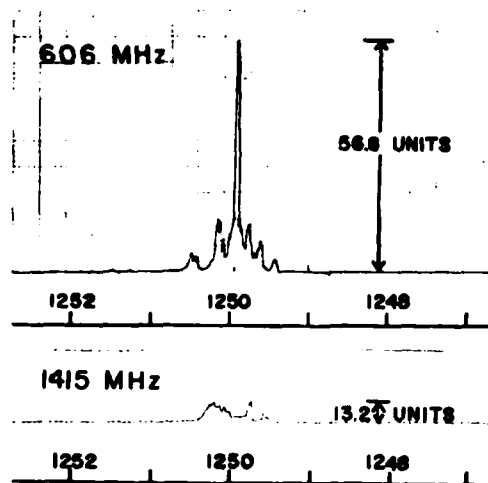


2695 MHz

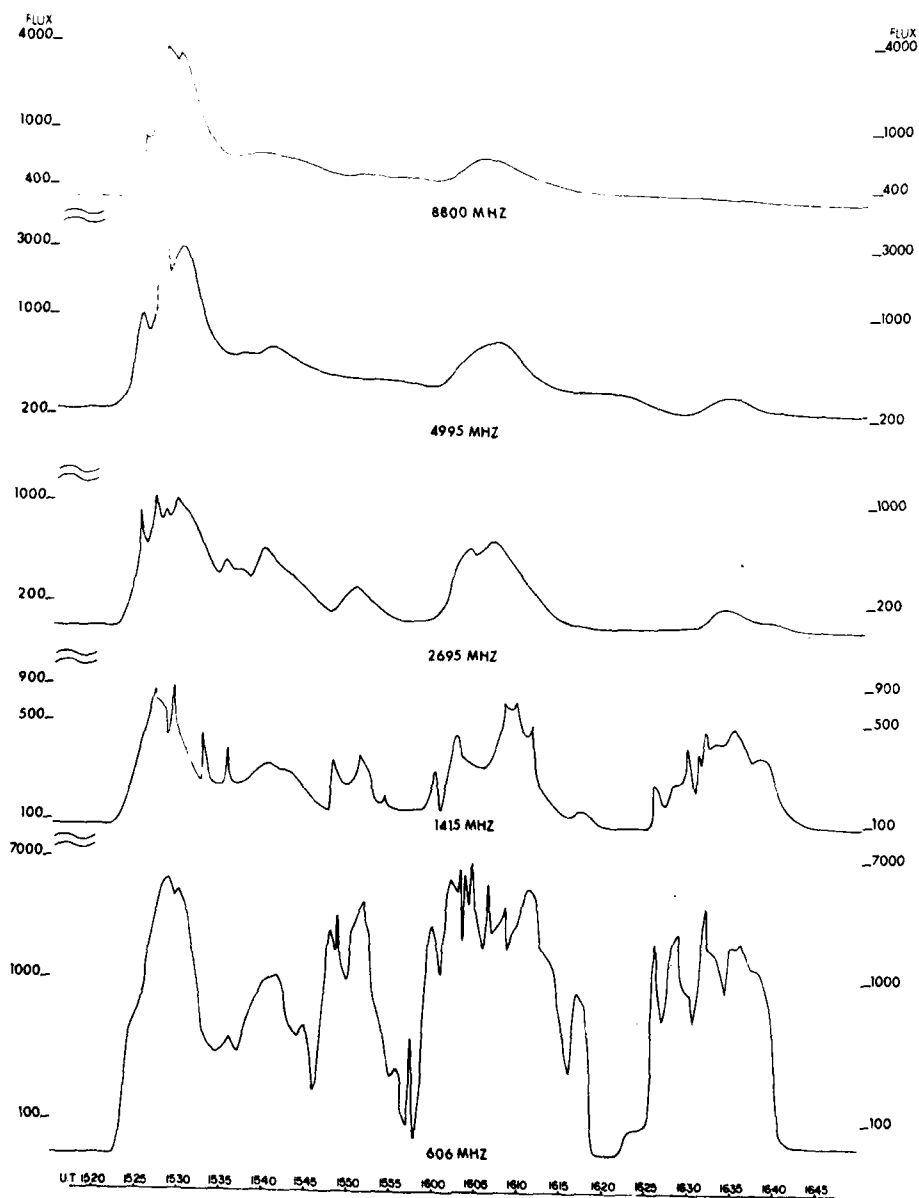


SIMPLE TWO BURST WITH POST BURST INCREASE OBSERVED AT APPROXIMATELY 1237 U.T. JULY 8, 1966 AT SAGAMORE HILL RADIO OBSERVATORY (AFCRL)—HAMILTON, MASS.

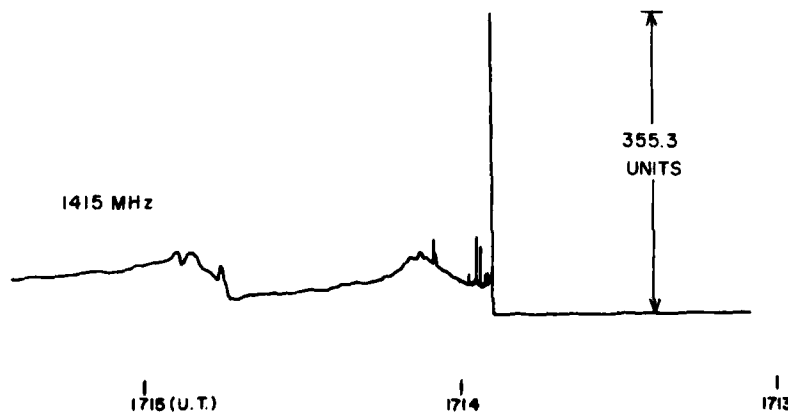
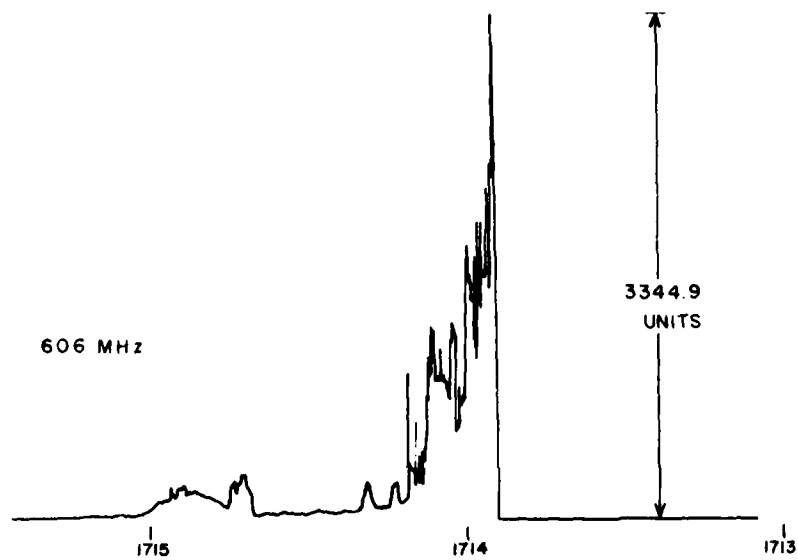
(SLIGHT FLUX INCREASES OBSERVED ON 1415 AND 606 MHz)



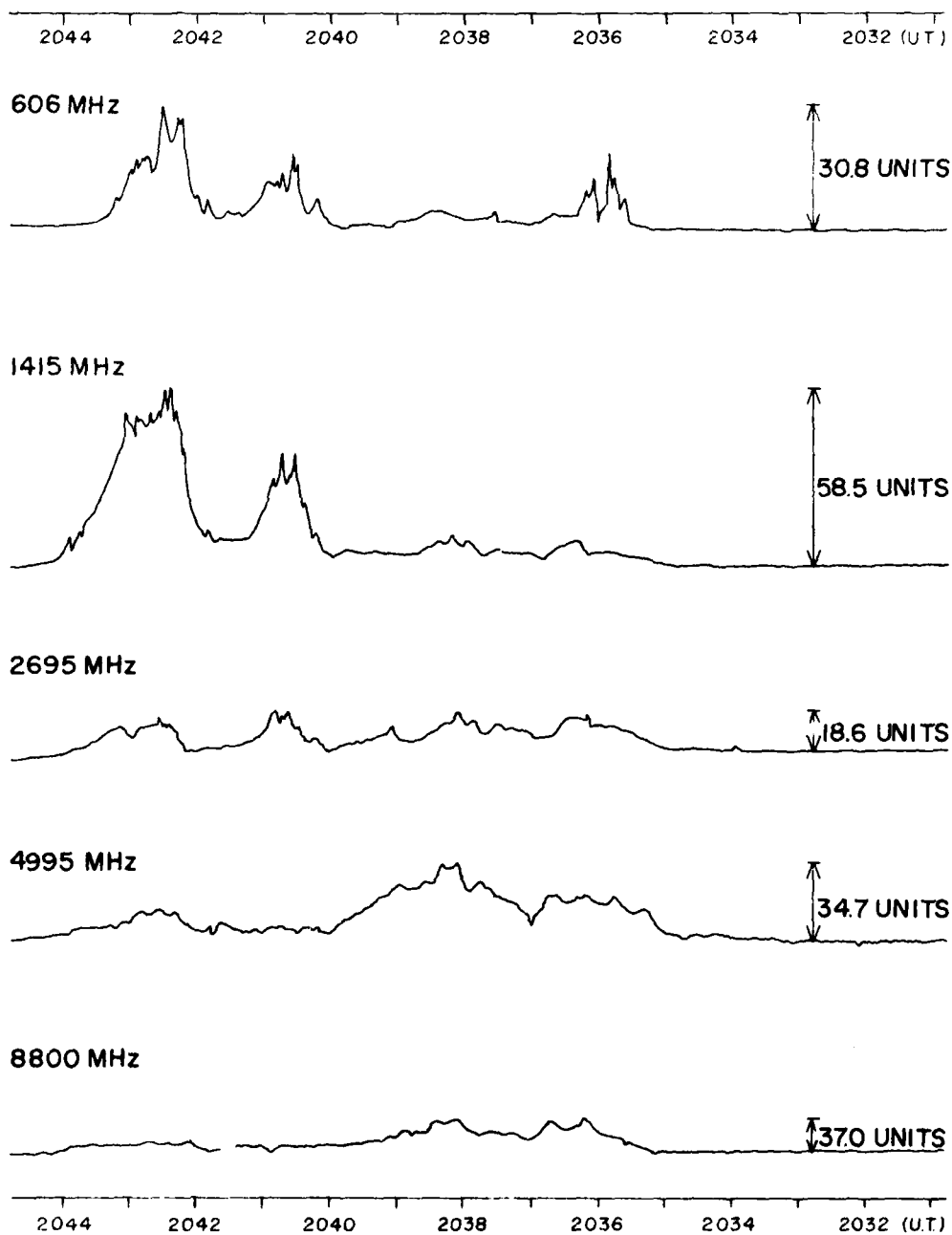
TWO SIMPLE 2(f) BURSTS OBSERVED ON 17 JULY, 1966 AT SAGAMORE HILL RADIO OBSERVATORY (AFCL) HAMILTON, MASS. (NO FLUX INCREASE OBSERVED ON 4995 OR 8800 MHz... ALL TIMES ABOVE ARE U.T.)



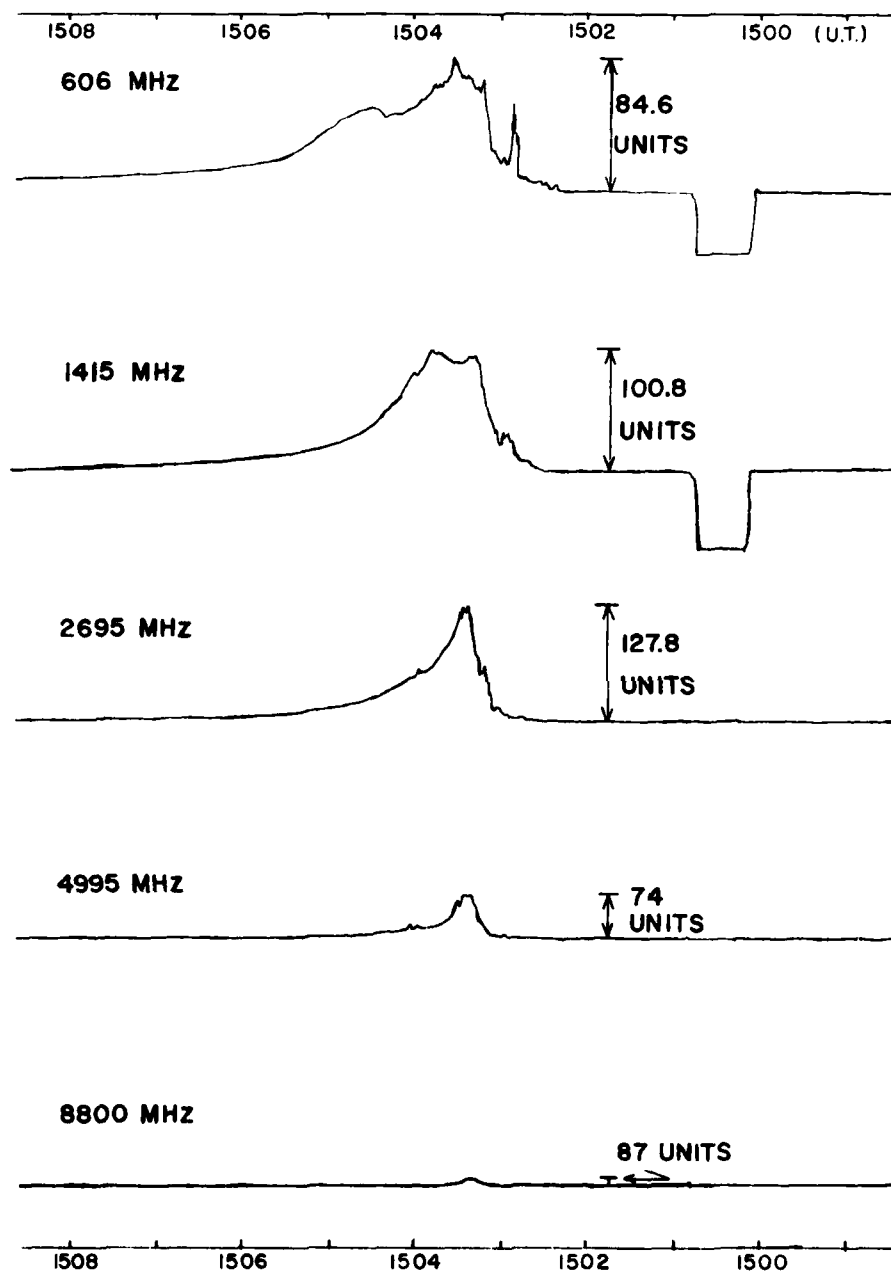
COMPLEX RADIO BURST OF THE SOLAR PROTON EVENT
28 AUGUST, 1966 SAGAMORE HILL RADIO OBSERVATORY (AFRL) HAMILTON, MASS.



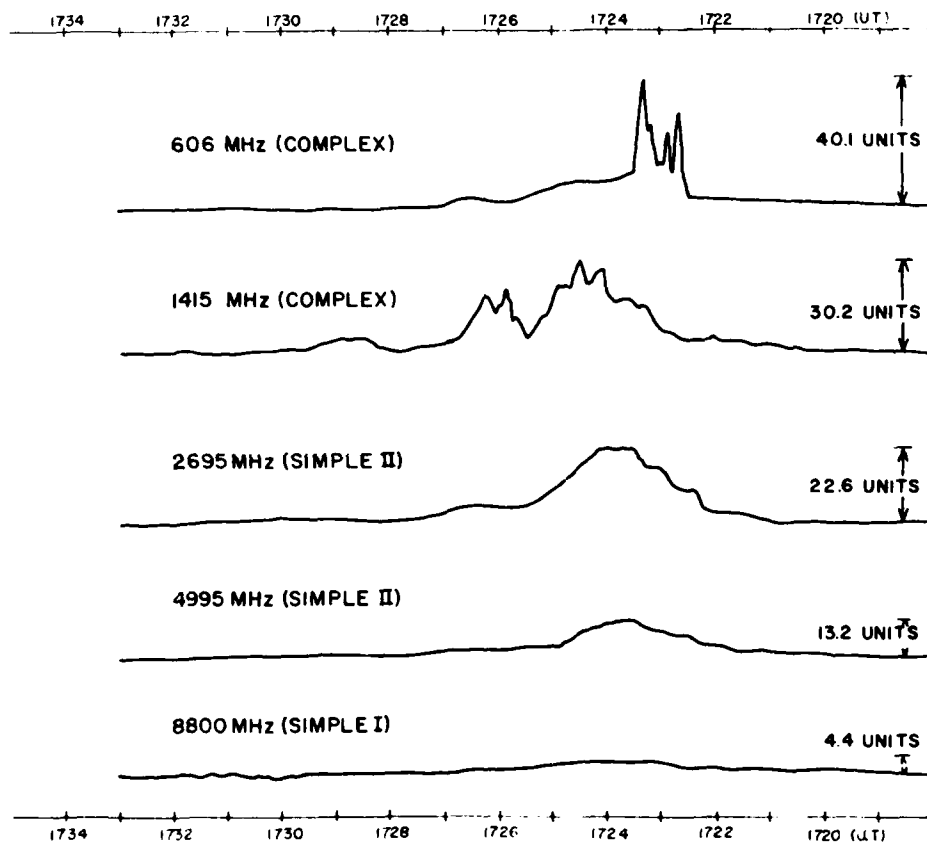
IMPULSIVE COMPLEX BURST OBSERVED ON 20 SEPTEMBER, 1966
SAGAMORE HILL RADIO OBSERVATORY (AFCRL) HAMILTON, MASS.



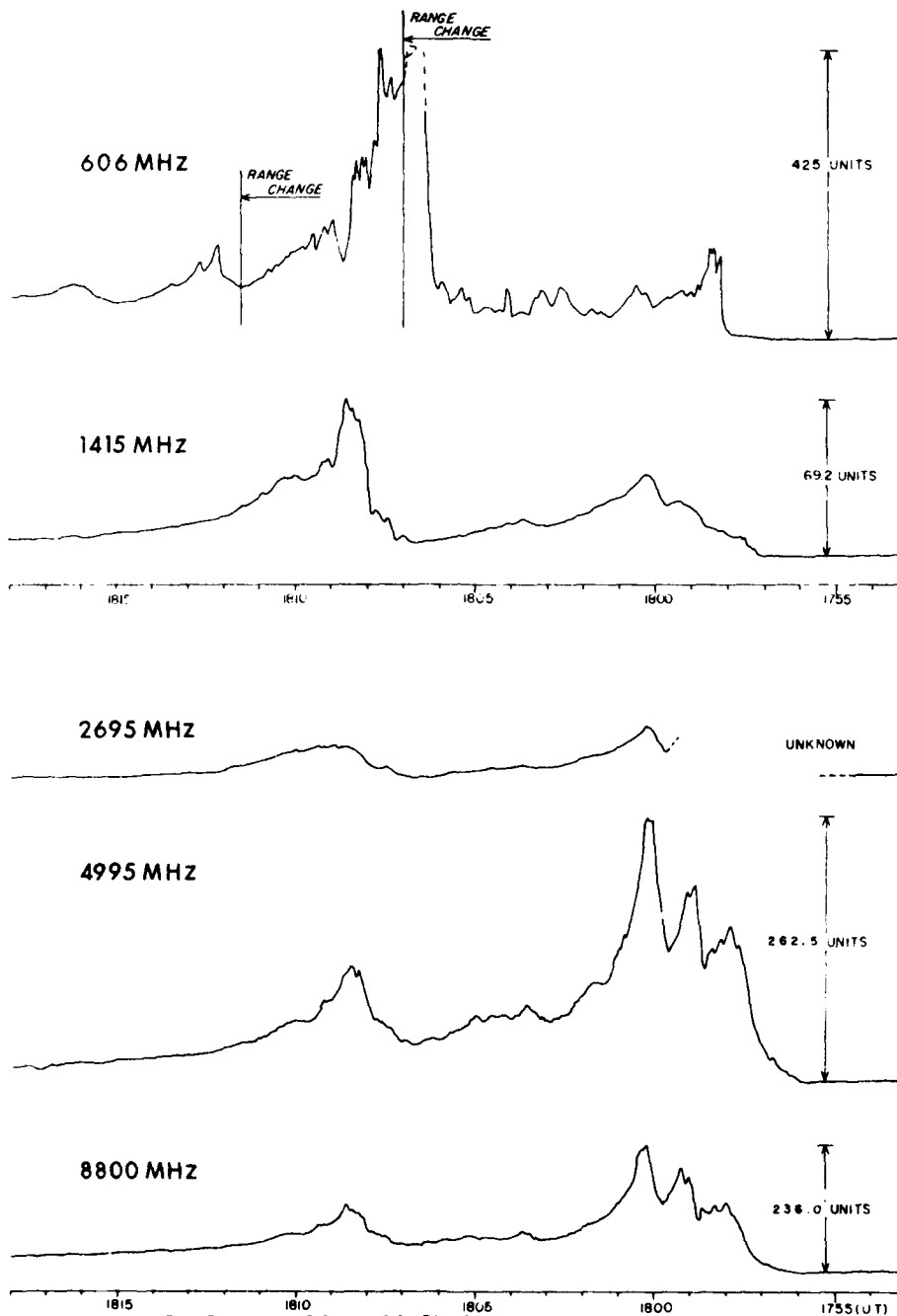
COMPLEX BURST OBSERVED 20 OCTOBER, 1966
AT SAGAMORE HILL RADIO OBSERVATORY (AFCL) HAMILTON, MASS.



SIMPLE II BURST OBSERVED 24 OCTOBER, 1966
 AT SAGAMORE HILL RADIO OBSERVATORY (AFCL) HAMILTON, MASS.
 (NOTE: 606 MHz BURST IS COMPLEX)



RADIO BURST RECORDED AT SAGAMORE HILL RADIO OBSERVATORY (AFRL)
HAMILTON, MASS. ON 2 NOVEMBER, 1966



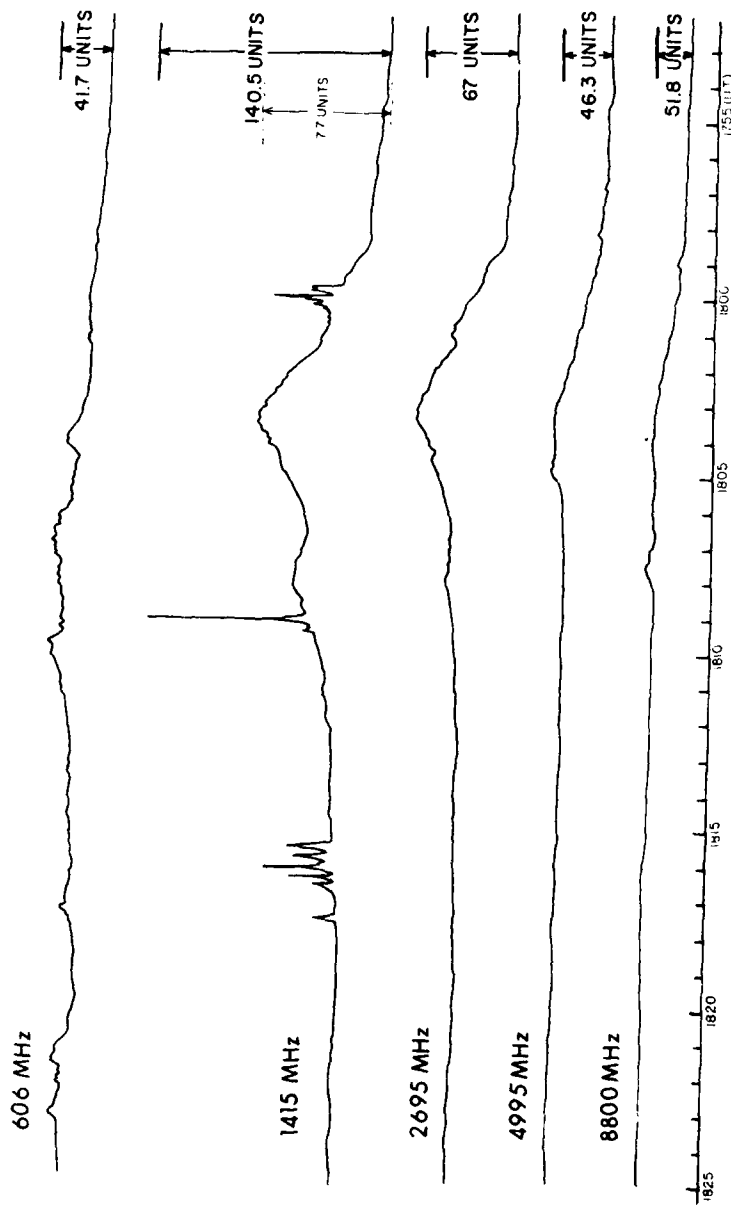
COMPLEX BURST OBSERVED 9 DECEMBER, 1966
OBSERVED AT SAGAMORE HILL RADIO OBSERVATORY (AFRL) HAMILTON, MASS.

**Solar Radio Bursts
1967**

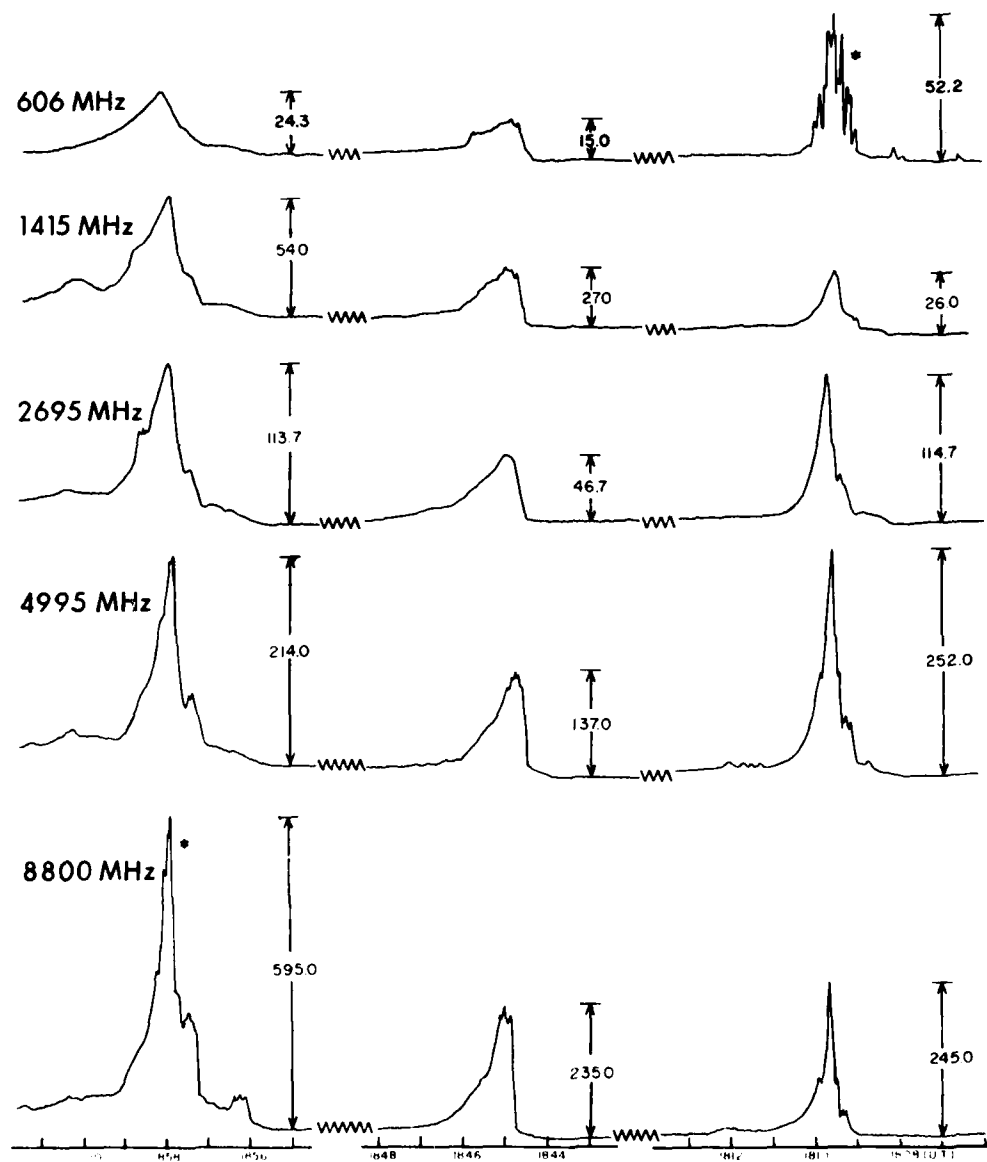
The figure displays five stacked NMR spectra of polyacetylene, showing the evolution of the signal as the frequency increases from 606 MHz to 8800 MHz. The x-axis at the top and bottom represents the chemical shift in ppm, with major ticks at 17.5, 17.0, 16.5, 16.0, and 15.5. The y-axis for each spectrum is indicated by a vertical scale bar on the right, representing intensity in units.

Frequency (MHz)	Intensity (Units)
606	737
1415	400
2695	467
4995	251
8800	1176

31

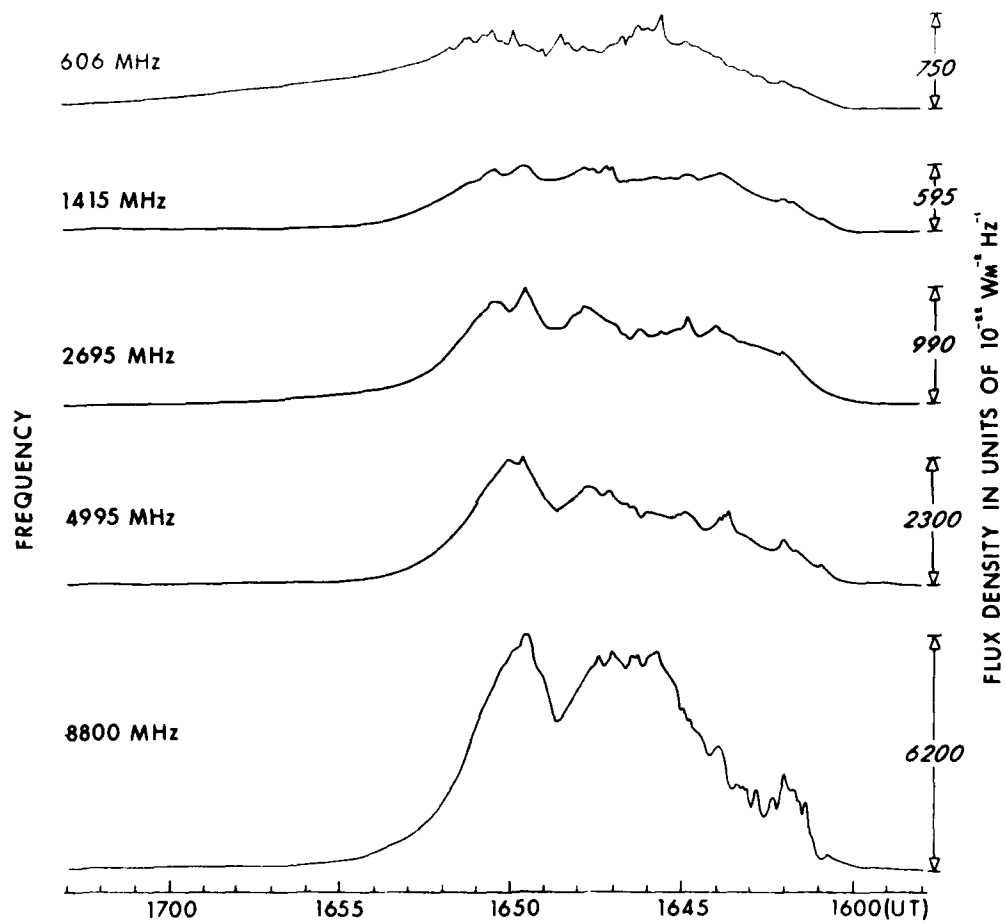


RADIO BURST OBSERVED 13 FEBRUARY, 1967 SAGAMORE HILL RADIO OBSERVATORY (AFRL)
 HAMILTON, MASS - LONG POST BURST INCREASE FOLLOWED, ENDING AT 2017 U.T.
 (note SACRAMENTO PEAK OBSERVED AT 4.8 OPTICAL FLARE, MAX 185 UT)

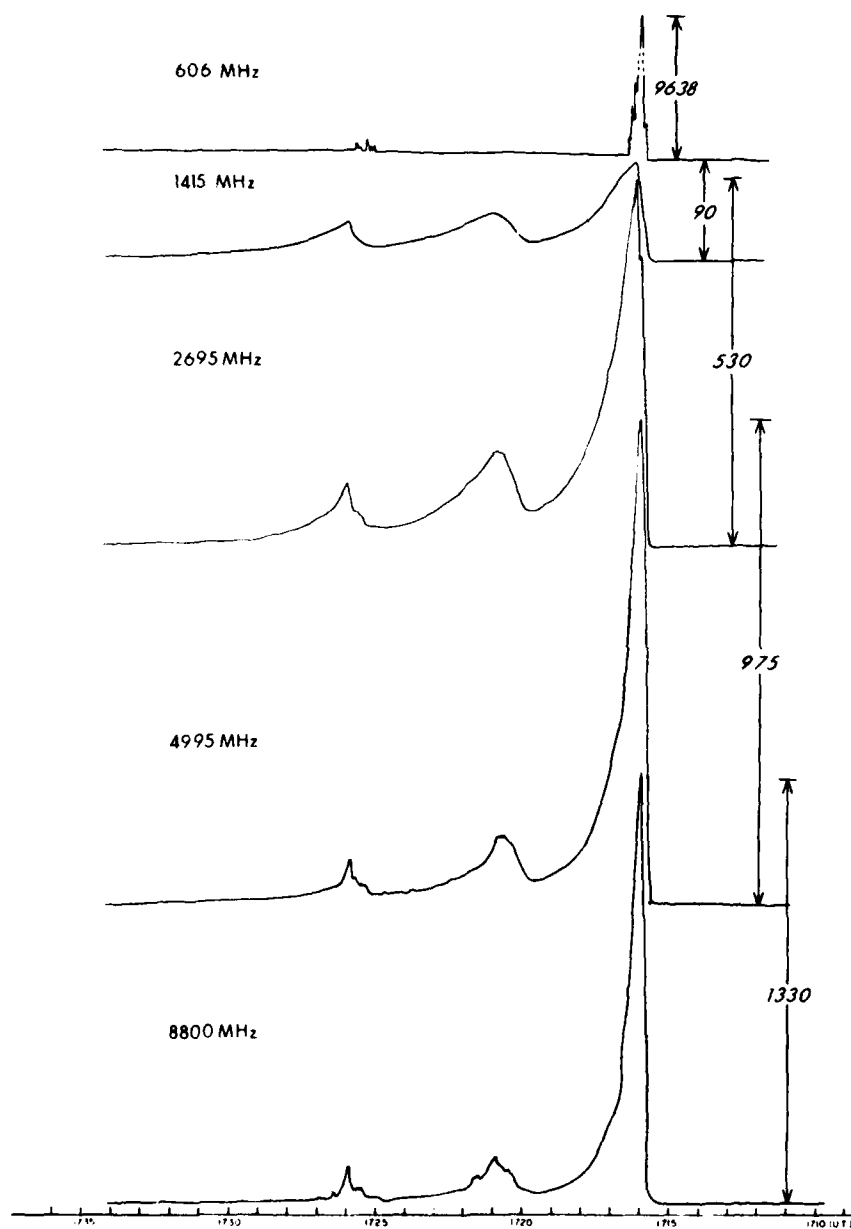


SIMPLE 2* BURSTS OBSERVED 25 FEB. 1967
AT SAGAMORE HILL RADIO OBSERVATORY (AFRL) HAMILTON, MASS.

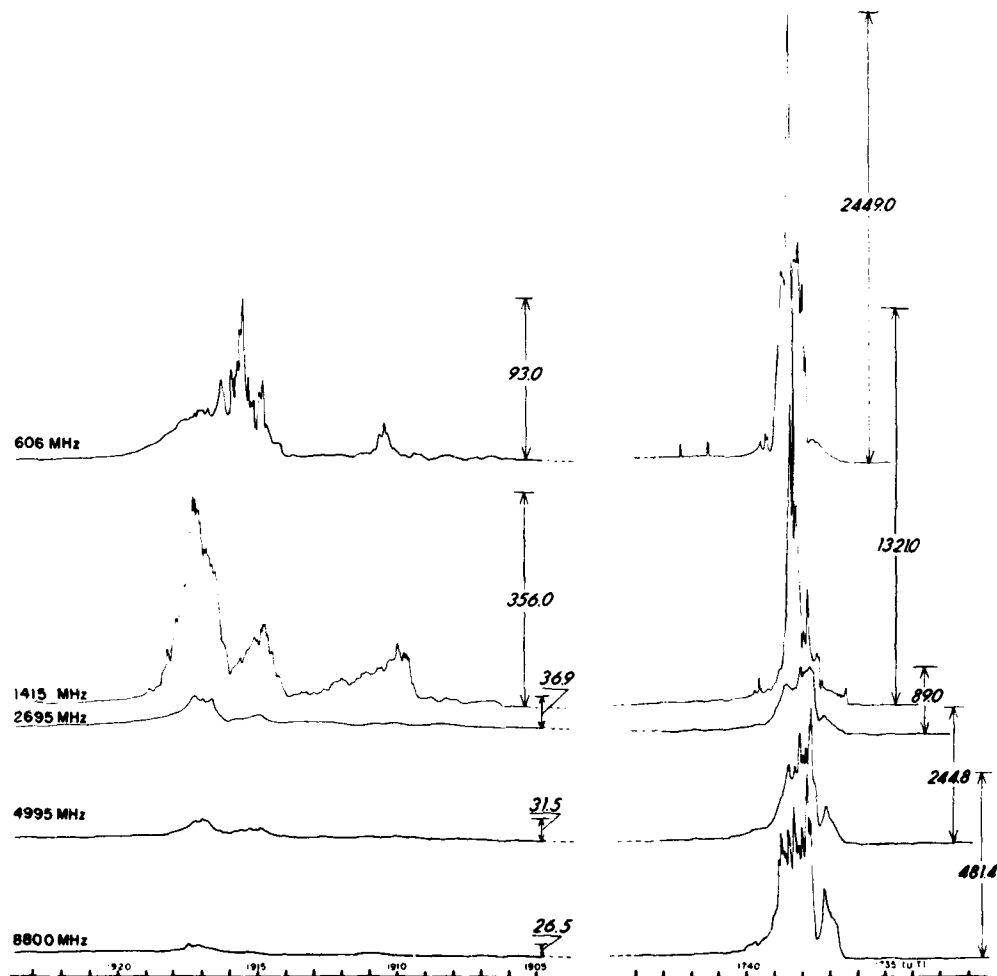
* NOT ATE * MUX BURST



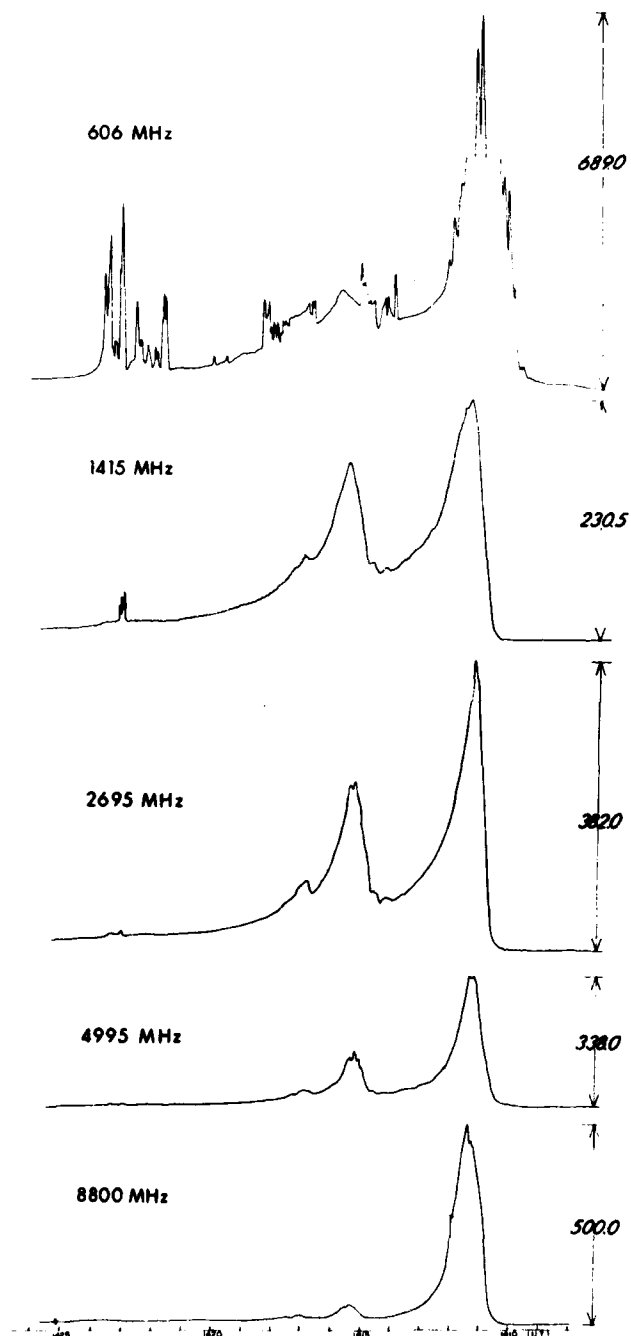
COMPLEX RADIO BURST OBSERVED 27 FEBRUARY, 1967
AT SAGAMORE HILL RADIO OBSERVATORY (AFCL) HAMILTON, MASS.



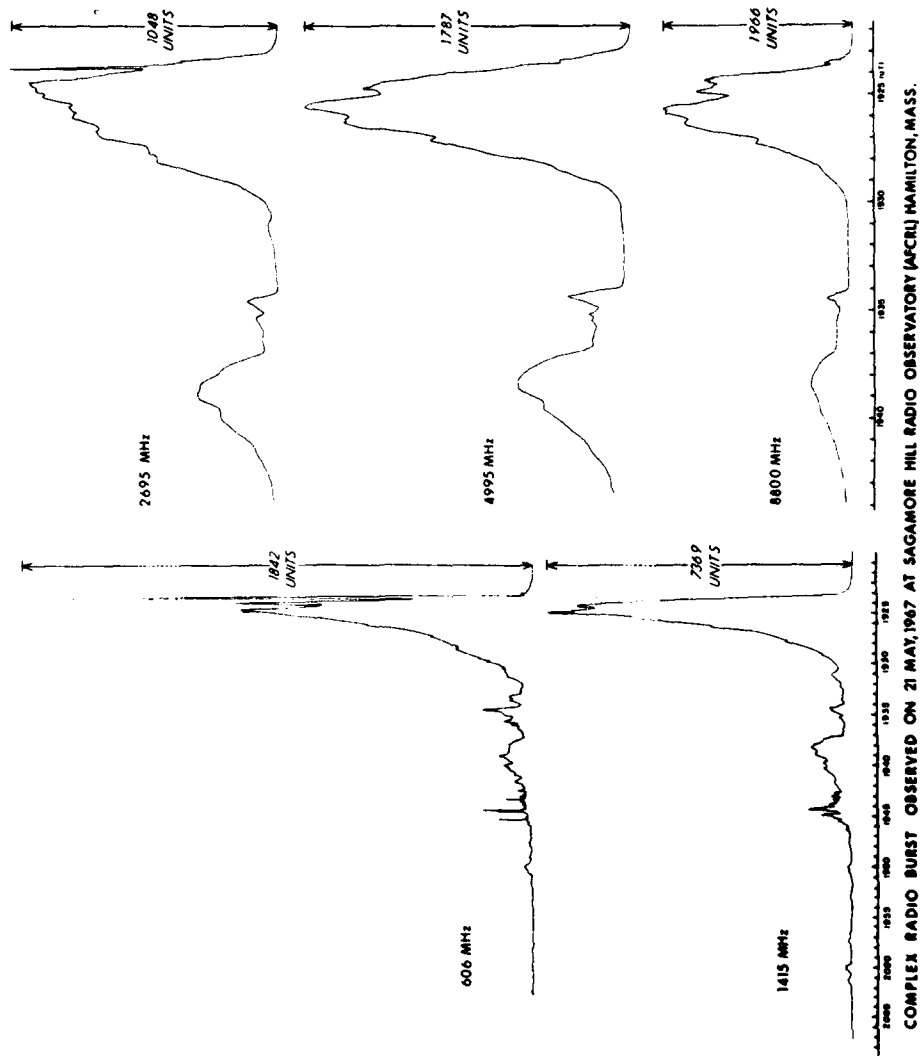
COMPLEX RADIO BURST OBSERVED 4 MARCH, 1967
AT SAGAMORE HILL RADIO OBSERVATORY (AFCL) HAMILTON, MASS.



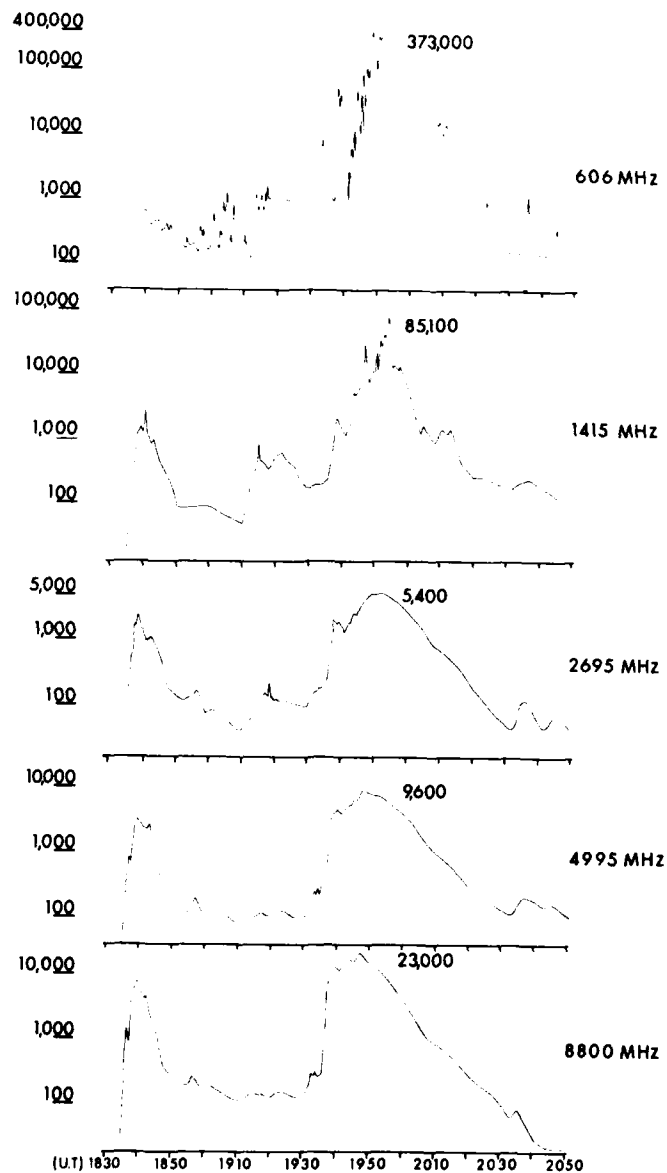
COMPLEX RADIO BURSTS OBSERVED 28 MARCH, 1967 BETWEEN 1732 AND 1923 UT.
AT SAGAMORE HILL RADIO OBSERVATORY (AFRL) HAMILTON, MASS.



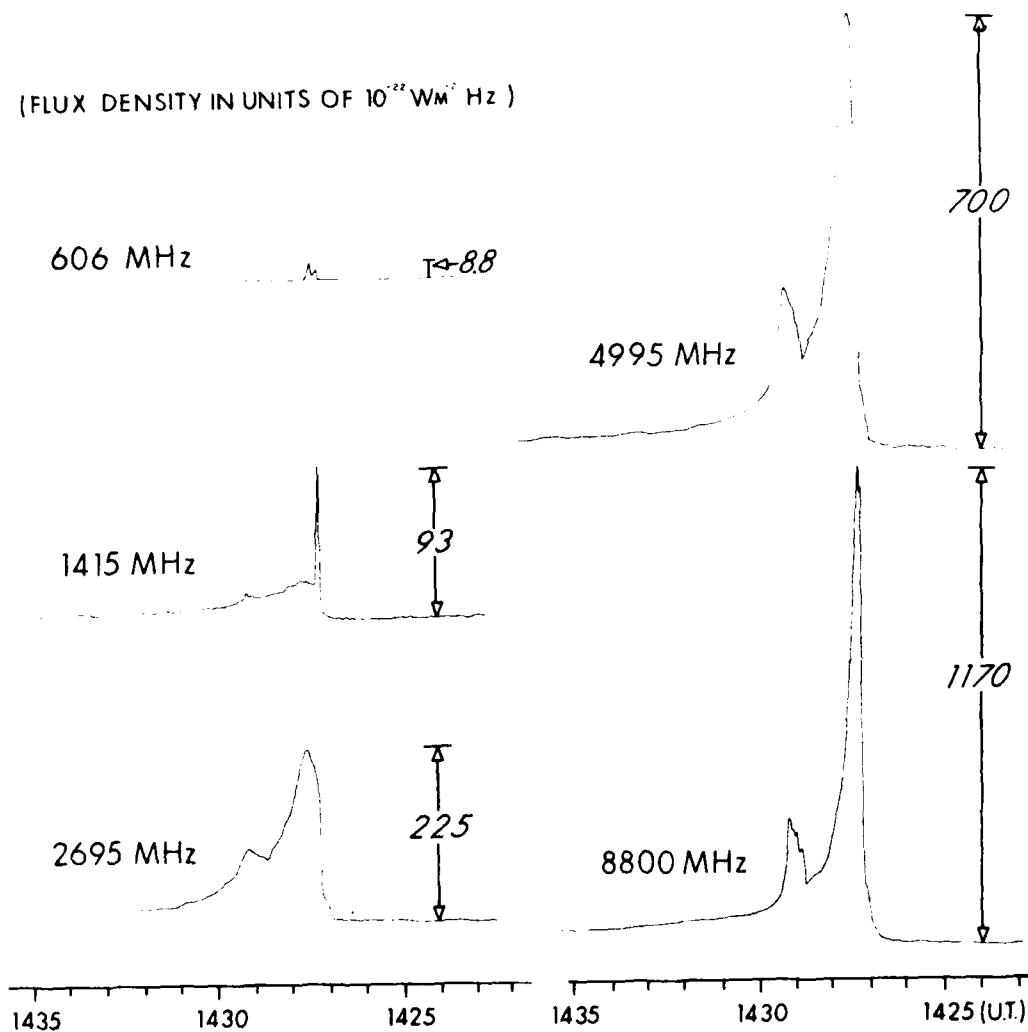
COMPLEX RADIO BURST OBSERVED ON 1 APRIL, 1967
AT SAGAMORE HILL RADIO OBSERVATORY-HAMILTON, MASS.



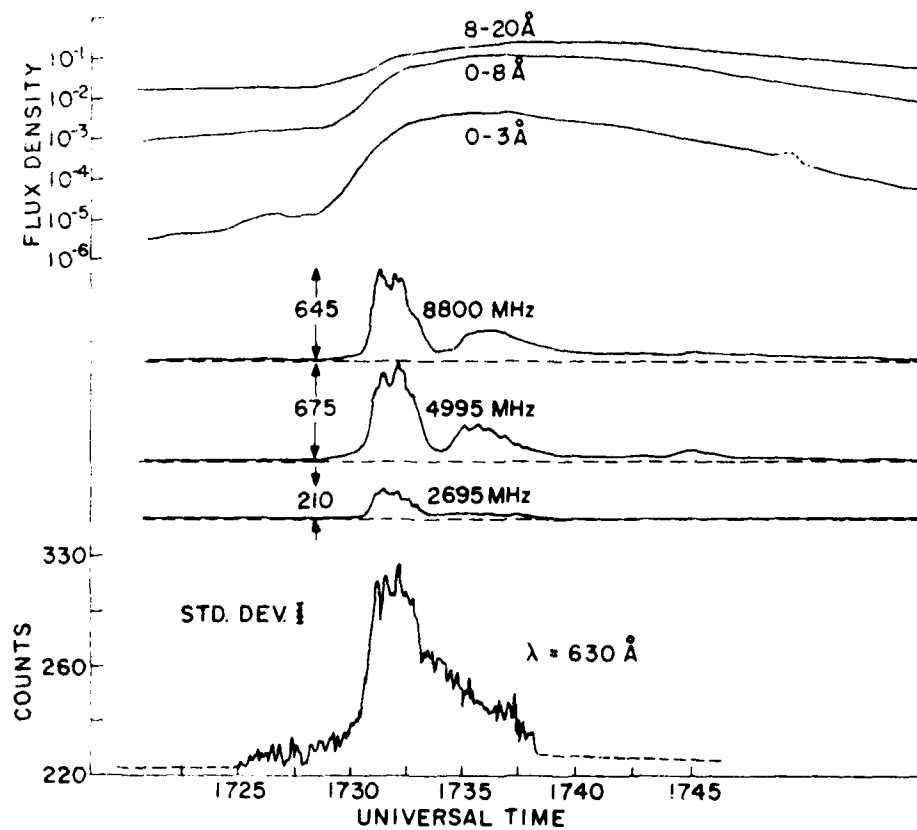
COMPLEX RADIO BURST OBSERVED ON 21 MAY, 1967 AT SAGAMORE HILL RADIO OBSERVATORY (AFCR) HAMILTON, MASS.



GREAT RADIO BURST OF THE SOLAR PROTON FLARE
 23 MAY, 1967 SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.
 (*CHART RECONSTRUCTED-FLUX VALUES PLOTTED AT INTERVALS OF ONE MINUTE OR LESS)
 (FLUX DENSITY IN UNITS OF $10^{-20} \text{ W m}^{-2} \text{ Hz}^{-1}$)

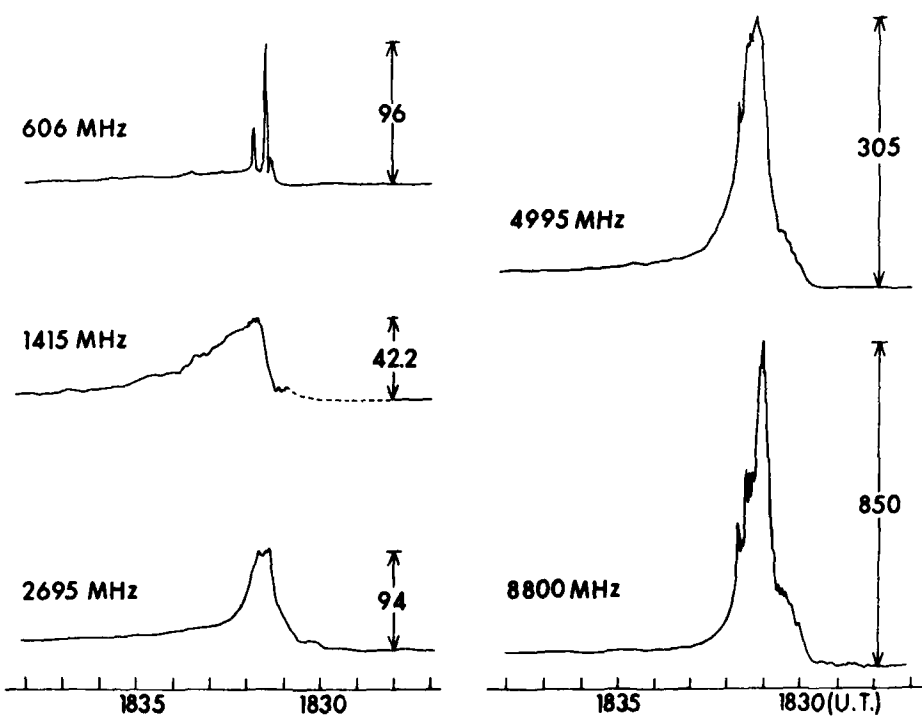


COMPLEX RADIO BURST OBSERVED ON 25 JULY, 1967
AT SAGAMORE HILL RADIO OBSERVATORY (AFCRL)
HAMILTON, MASS.

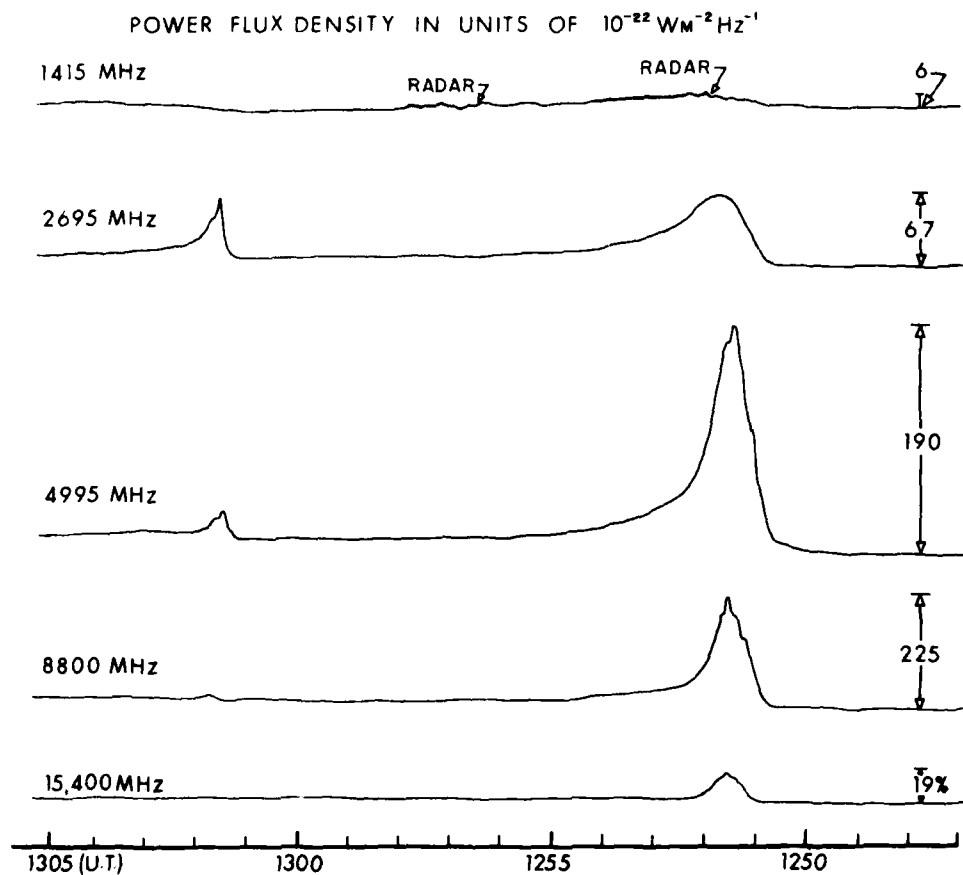


CM. RADIO, SOFT X-RAY AND ULTRA VIOLET BURSTS ASSOCIATED WITH 2B FLARE ON 1 AUGUST 1967. A SUDDEN FREQUENCY DEVIATION EVENT (SFD) WITH MAX. WAS OBSERVED AT 1731 U.T.

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ Wm}^{-2} \text{ Hz}^{-1}$

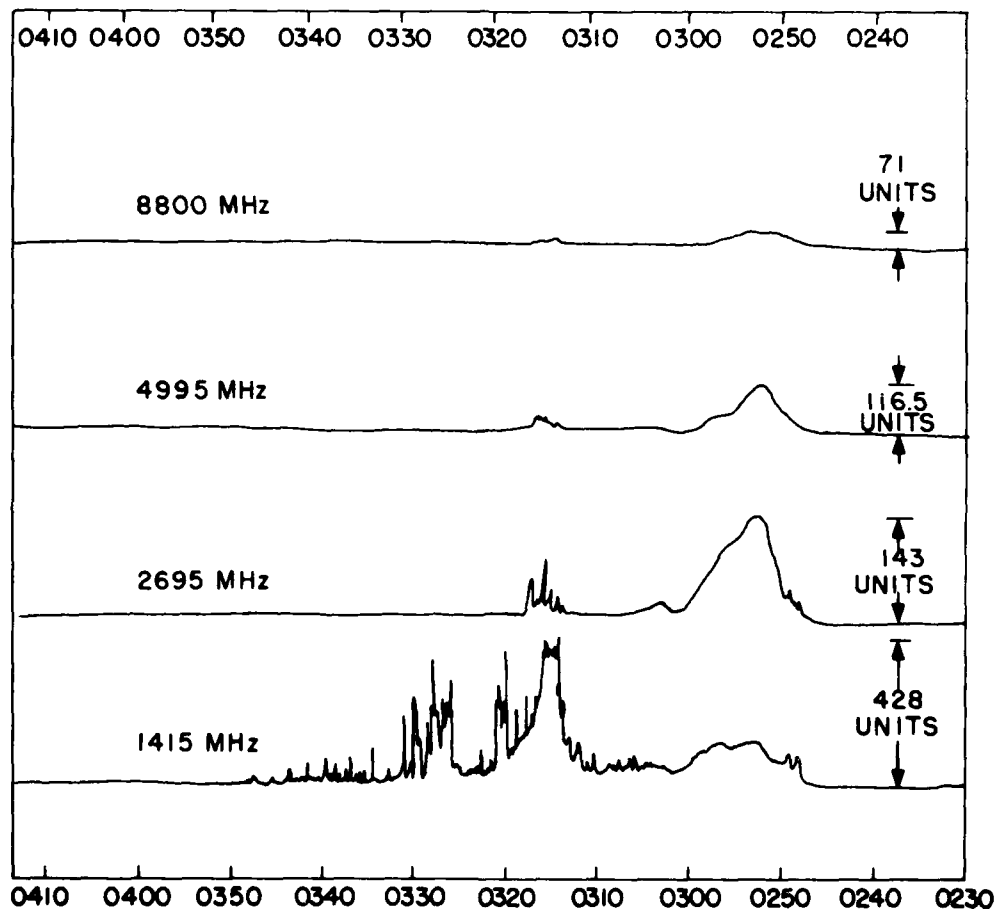


SIMPLE 2/COMPLEX RADIO BURST OBSERVED 29 AUGUST, 1967
AT SAGAMORE HILL RADIO OBSERVATORY (AFCRL)
HAMILTON, MASS.



SIMPLE 2* RADIO BURST OBSERVED ON 1 DECEMBER, 1967
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

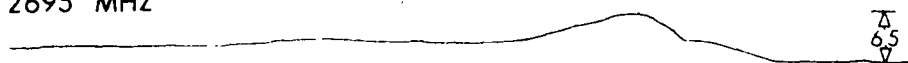
*SIMPLE 3 ON 1415 MHz



COMPLEX BURST OBSERVED AT MANILA OBSERVATORY
ON DECEMBER 16, 1967 STARTING AT 0248 U.T.
BURST INTENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$.

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ Wm}^{-2} \text{ Hz}^{-1}$

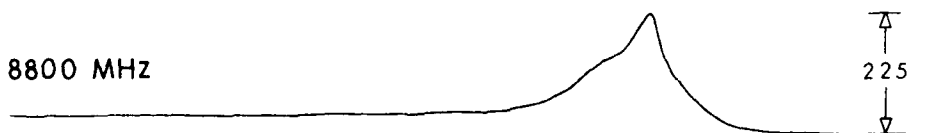
2695 MHz



4995 MHz



8800 MHz

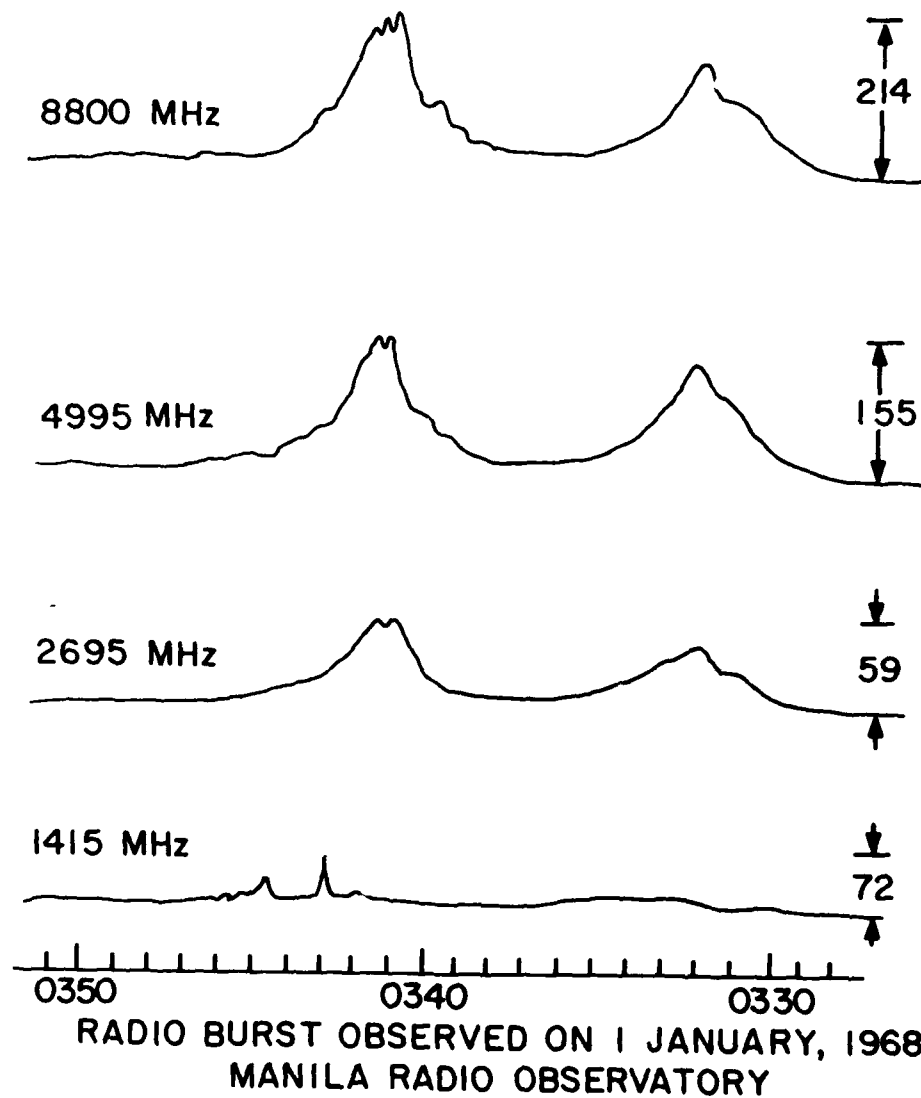


1420 (U.T.) 1415 1410 1405

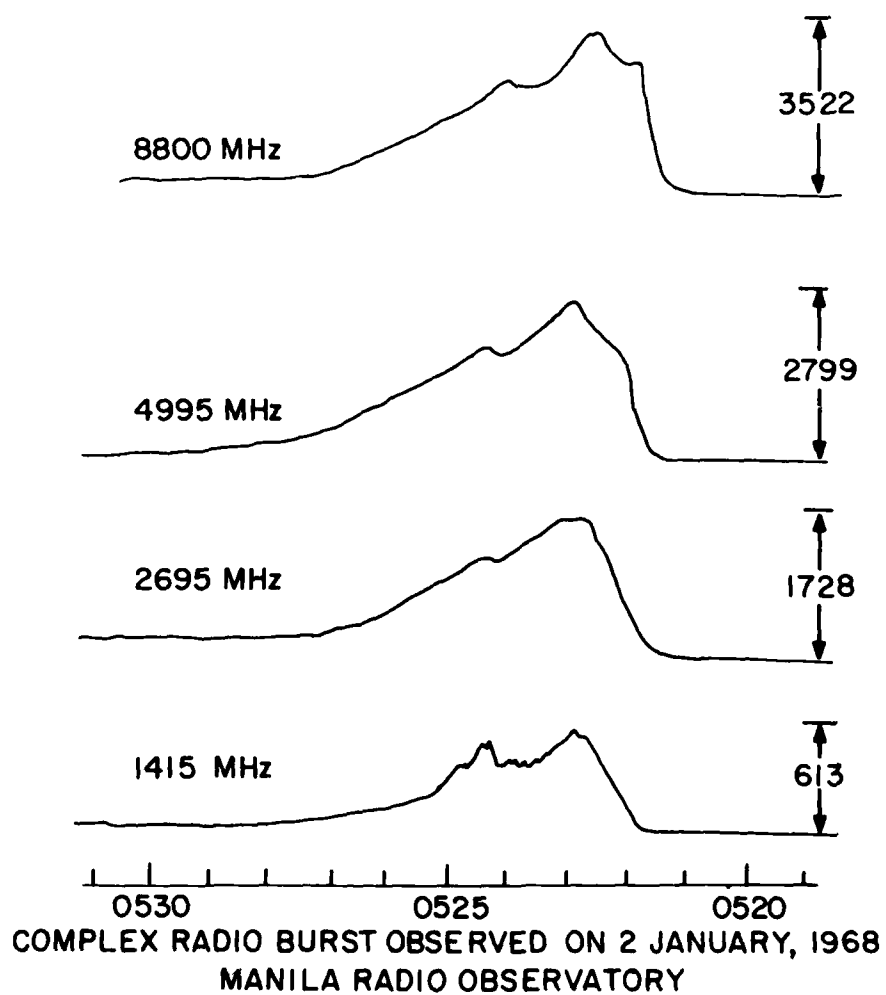
SIMPLE 2 RADIO BURST OBSERVED ON 27 DEC, 1967
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

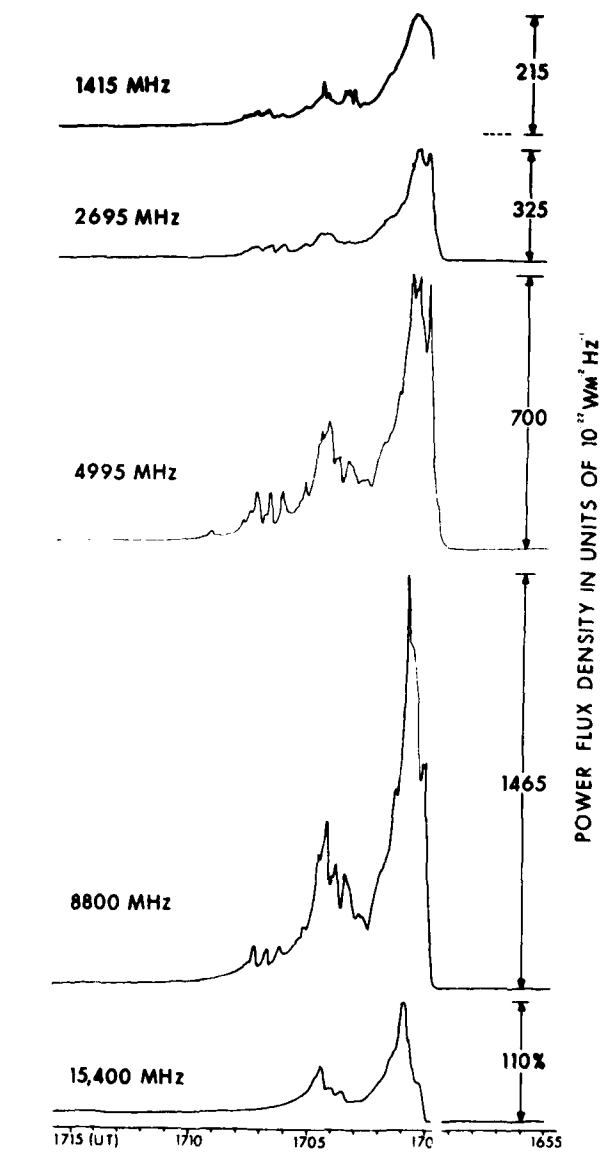
**Solar Radio Bursts
1968**

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$



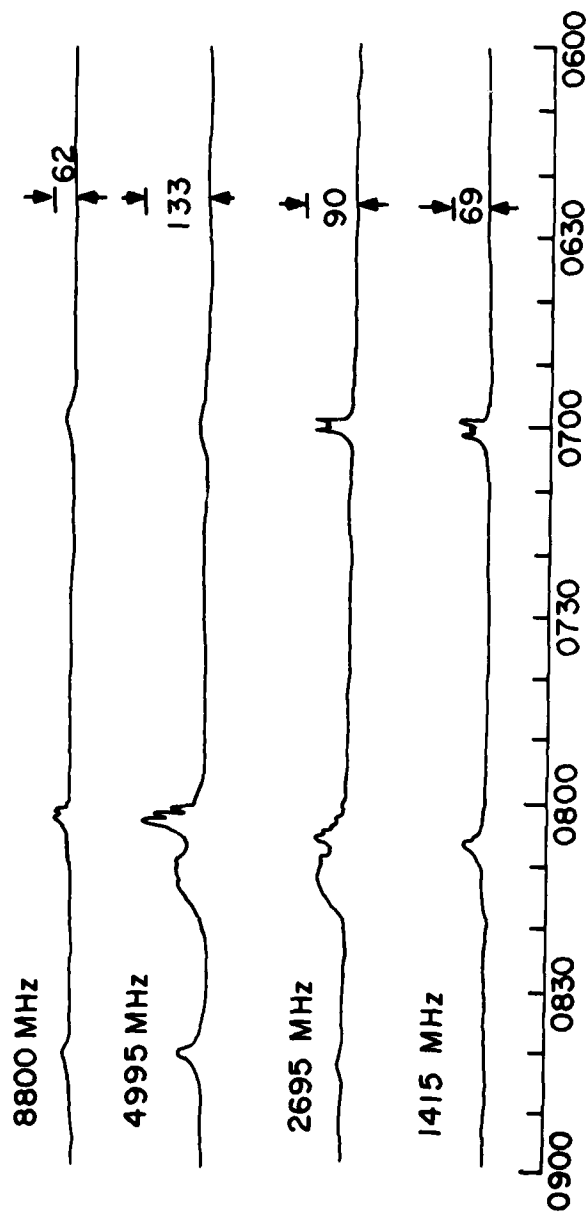
POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$





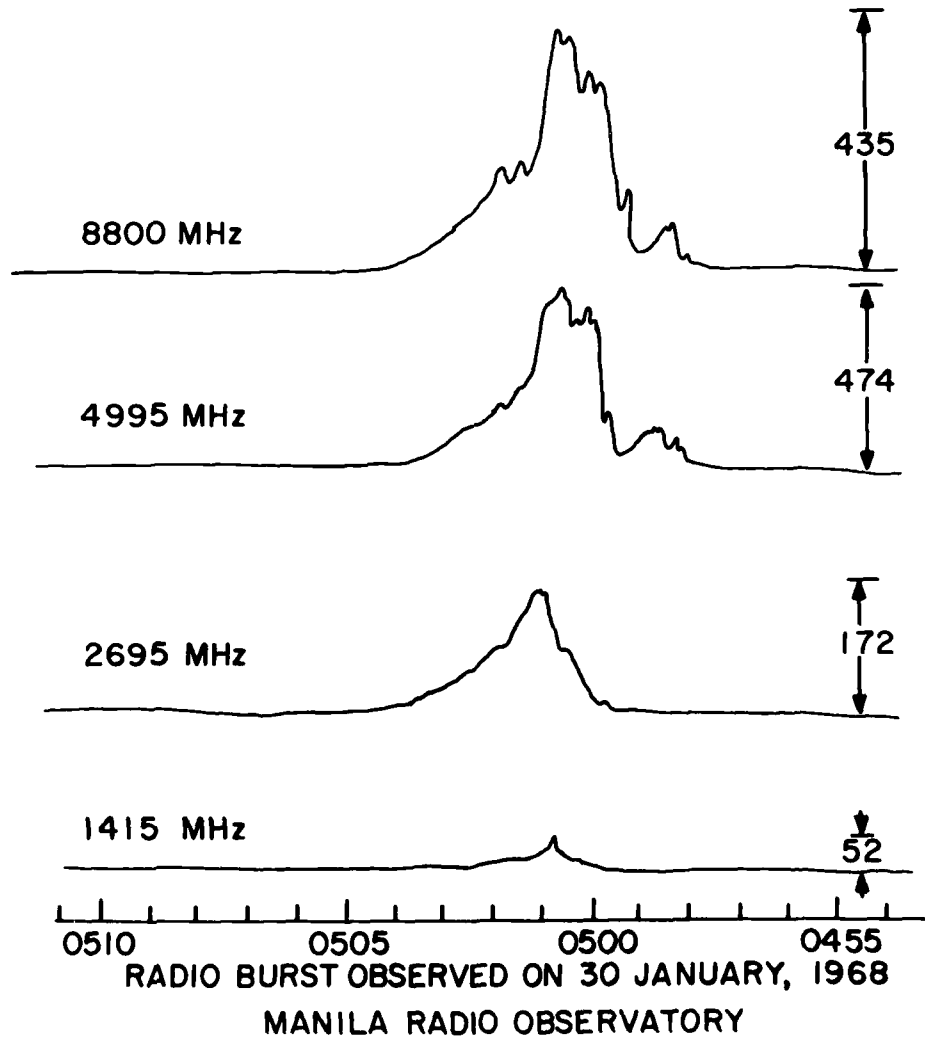
COMPLEX RADIO BURST OBSERVED 11 JANUARY, 1968
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

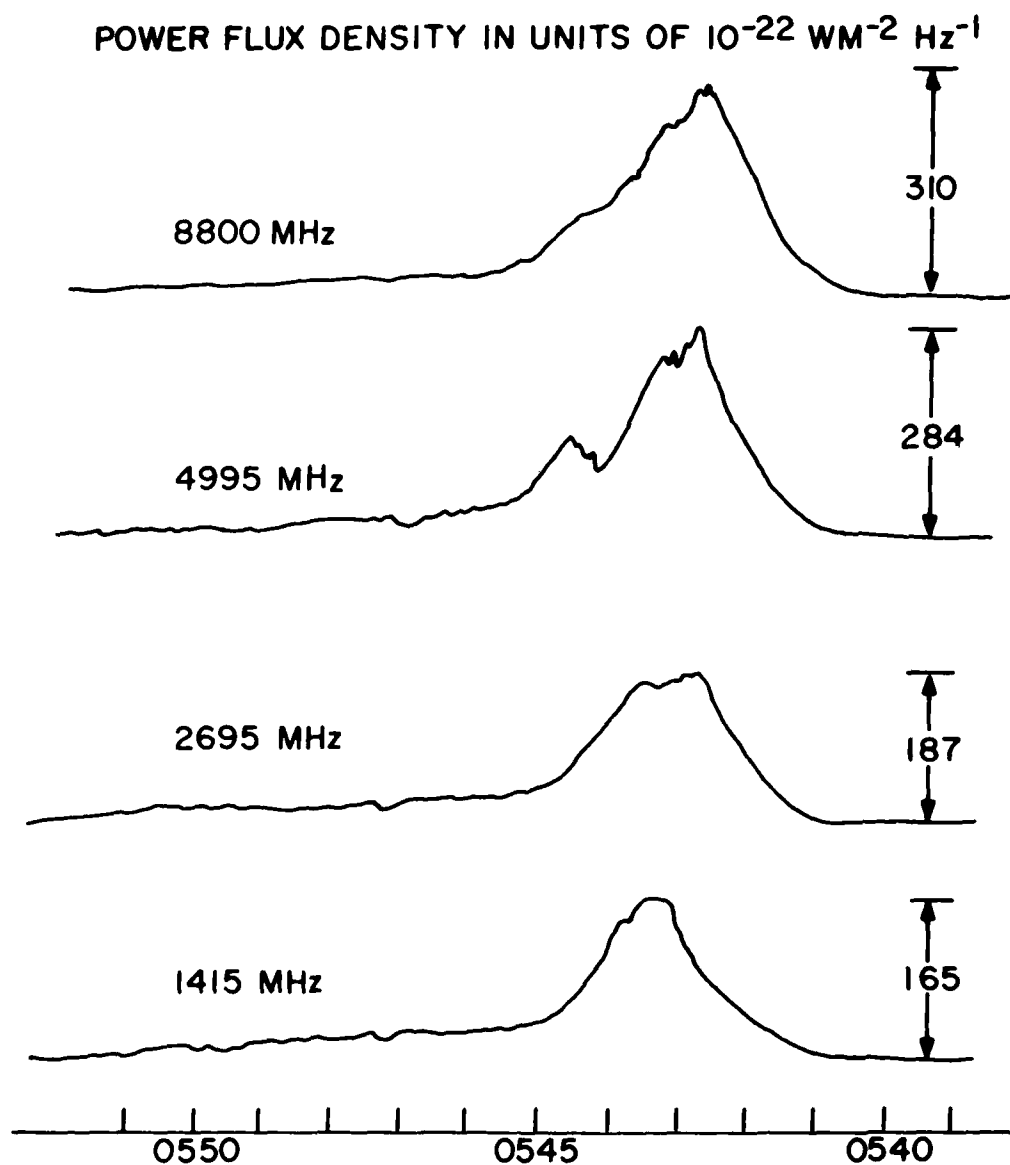
POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$



RADIO BURST OBSERVED ON 29 JANUARY, 1968
MANILA RADIO OBSERVATORY

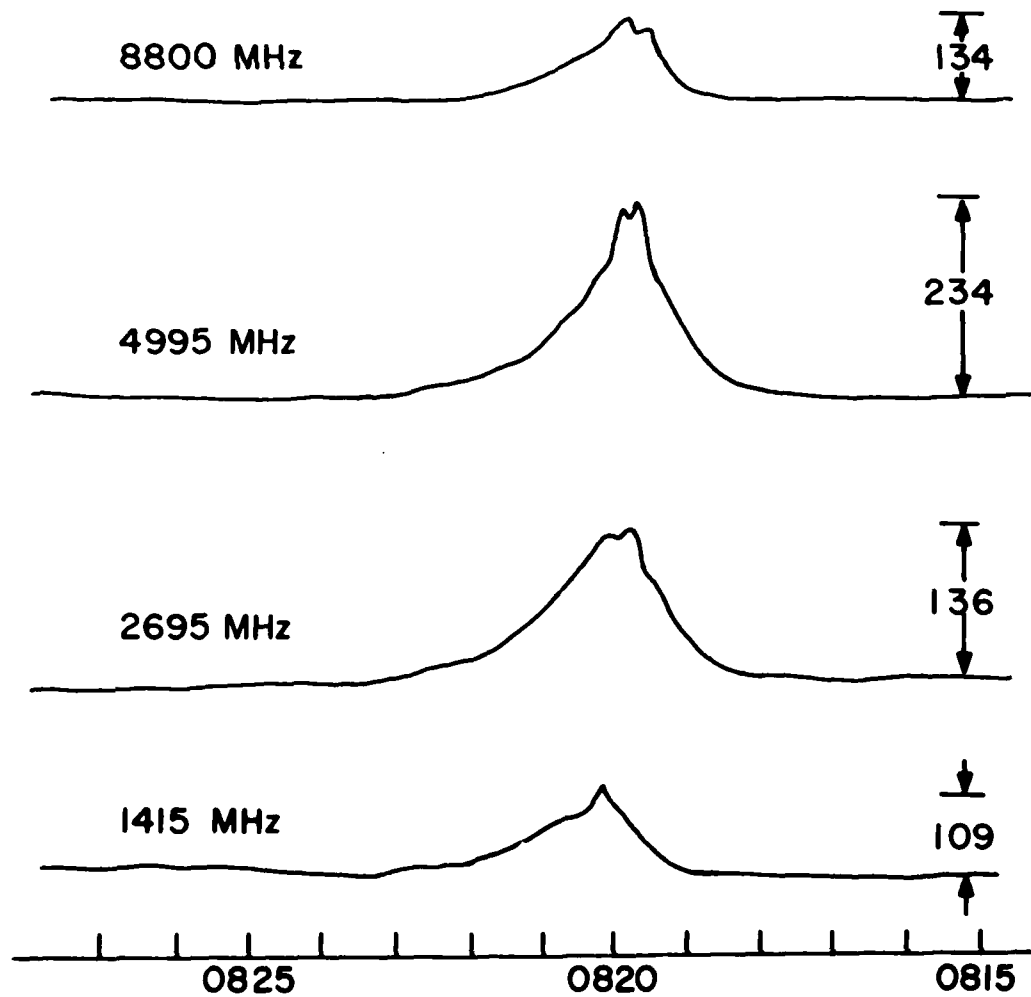
POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$



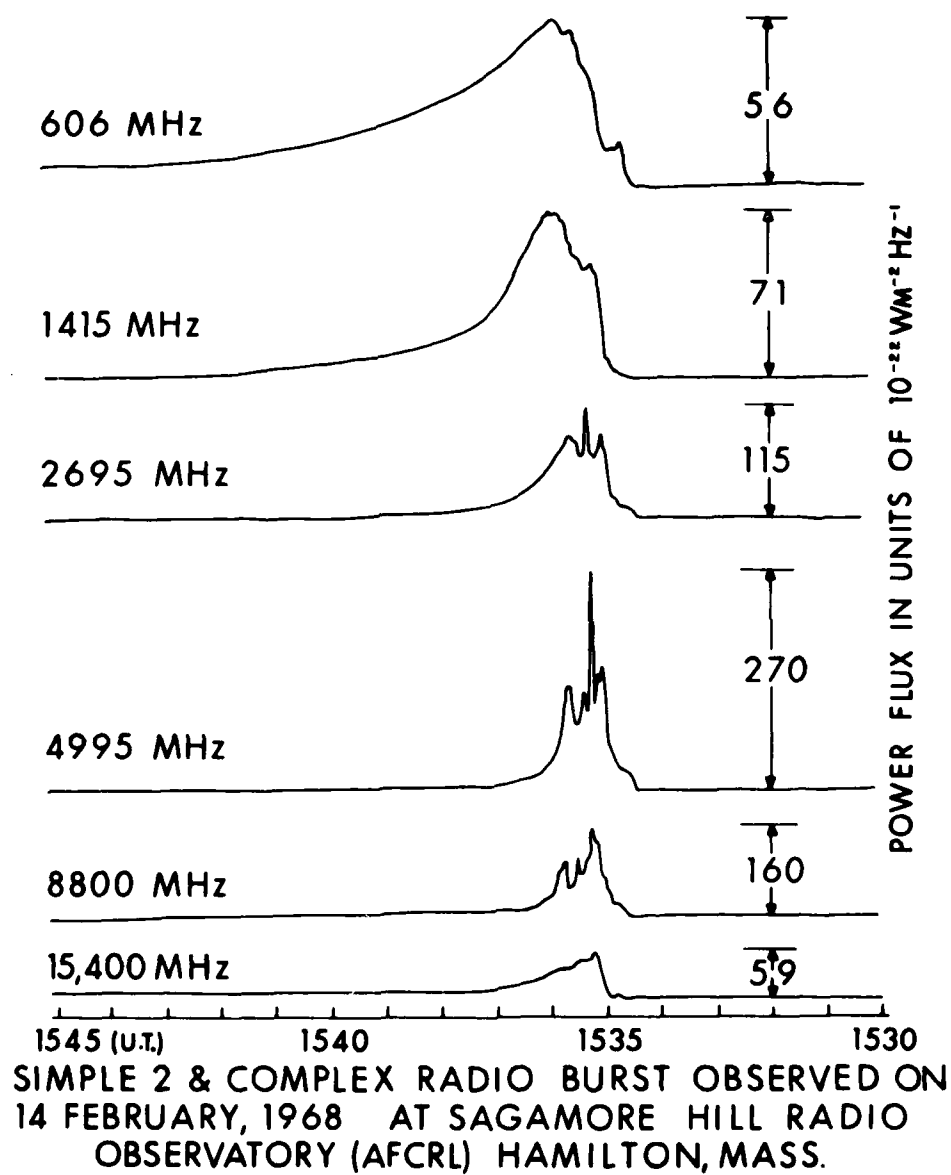


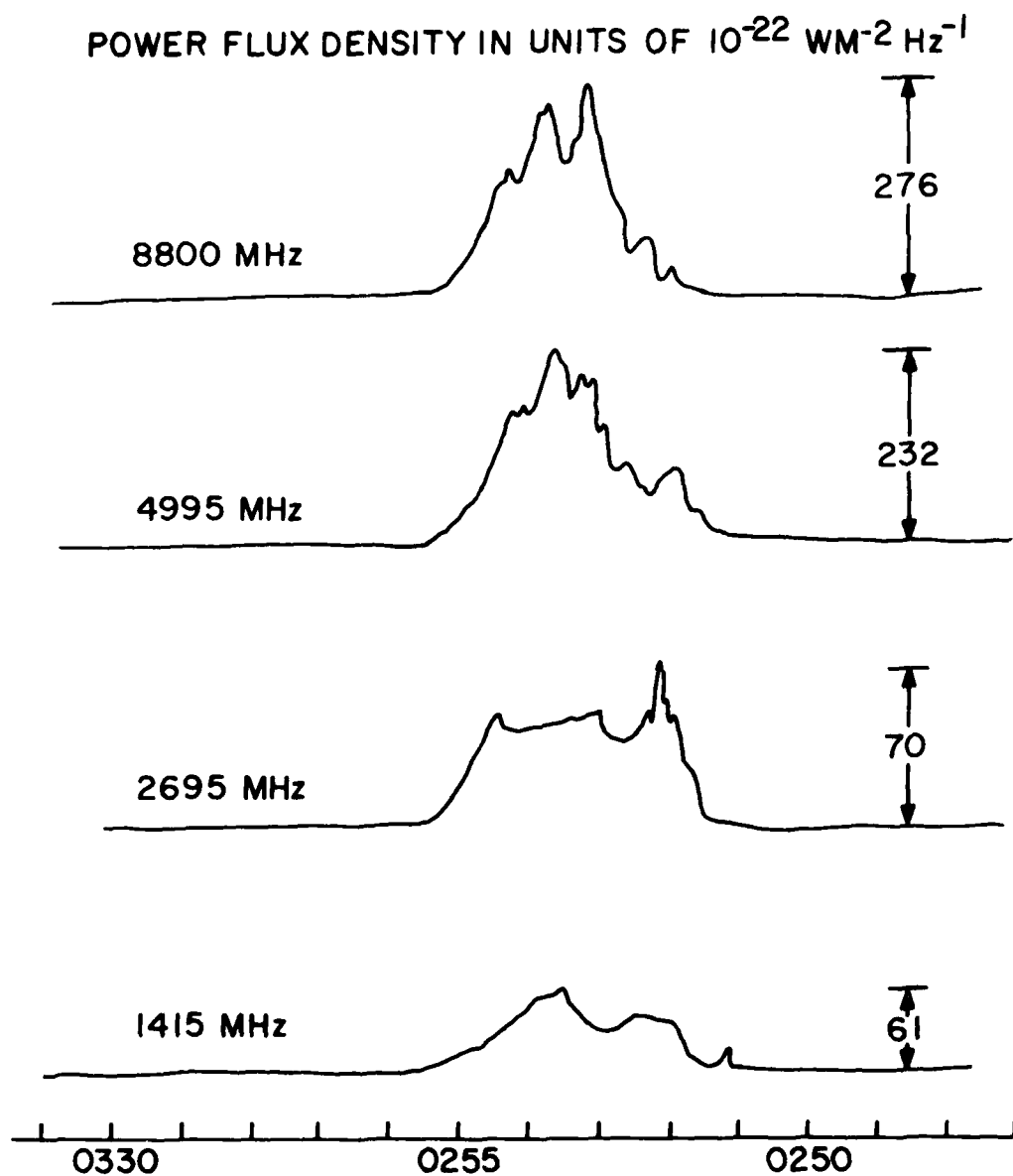
RADIO BURST OBSERVED ON 2 FEBRUARY, 1968
MANILA RADIO OBSERVATORY

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ WM}^{-2} \text{ Hz}^{-1}$



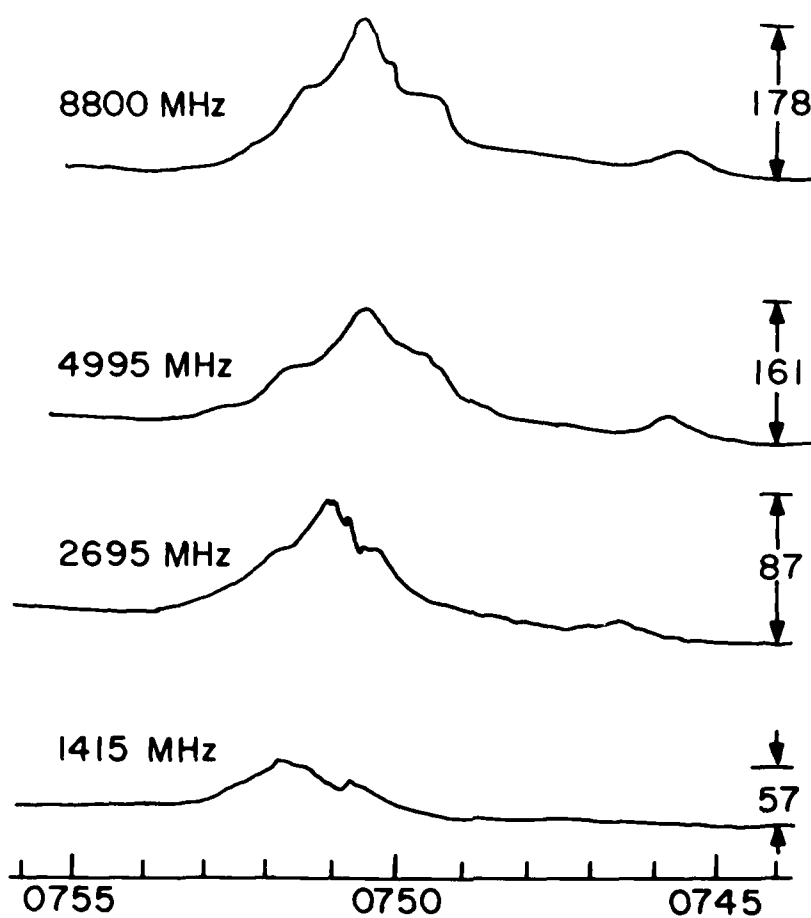
RADIO BURST OBSERVED ON 5 FEBRUARY, 1968
MANILA RADIO OBSERVATORY





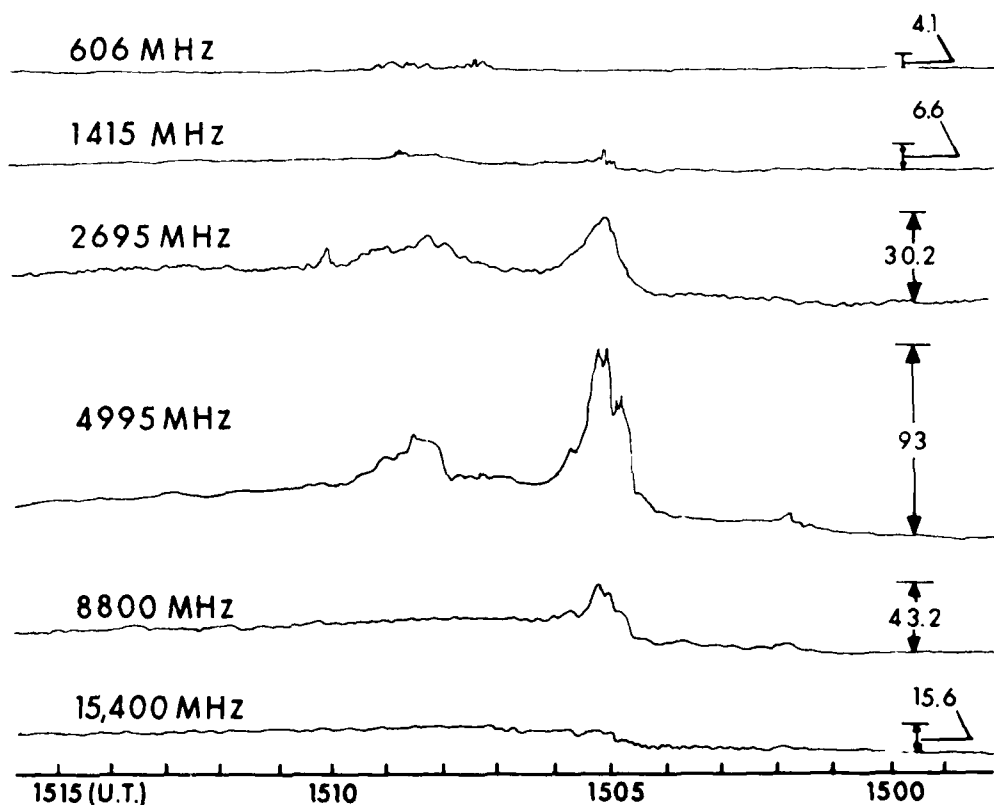
RADIO BURST OBSERVED ON 17 FEBRUARY, 1968
MANILA RADIO OBSERVATORY

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ WM}^{-2} \text{ Hz}^{-1}$

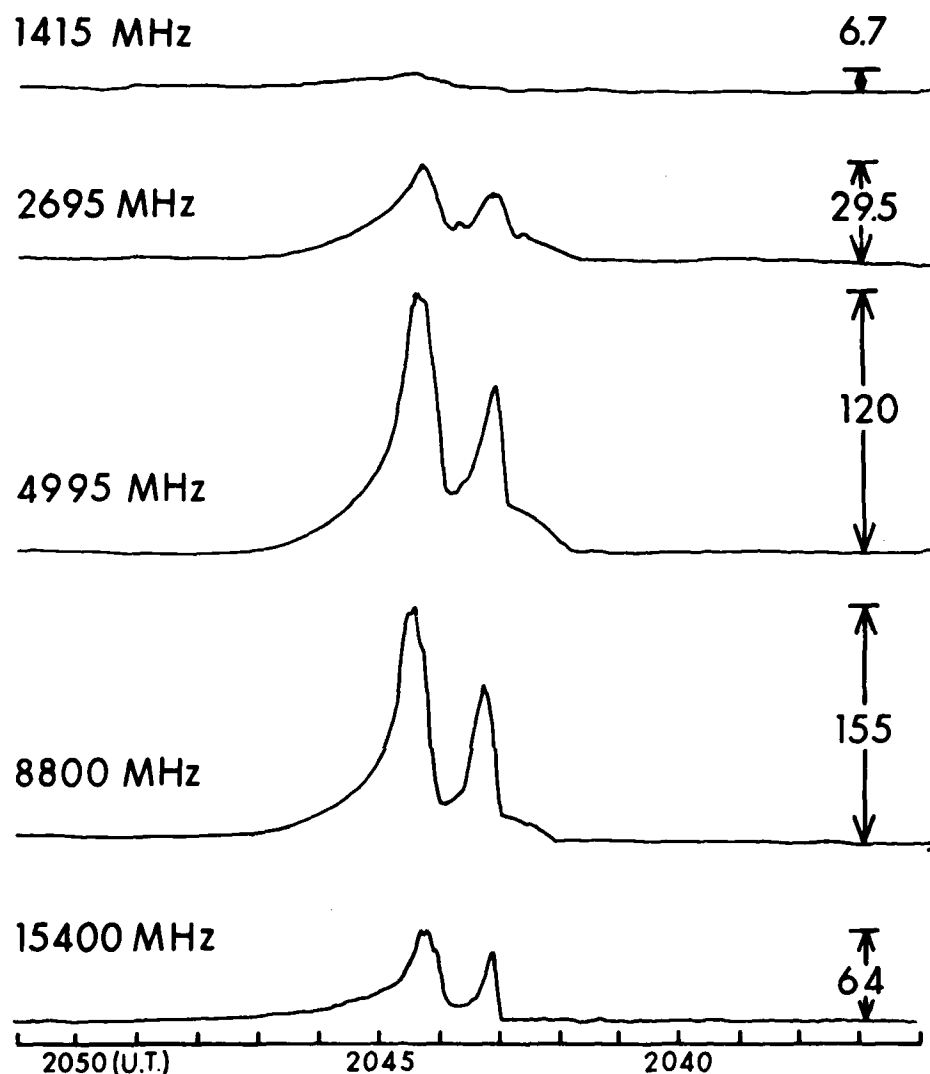


RADIO BURST OBSERVED ON 24 MARCH, 1968
MANILA RADIO OBSERVATORY

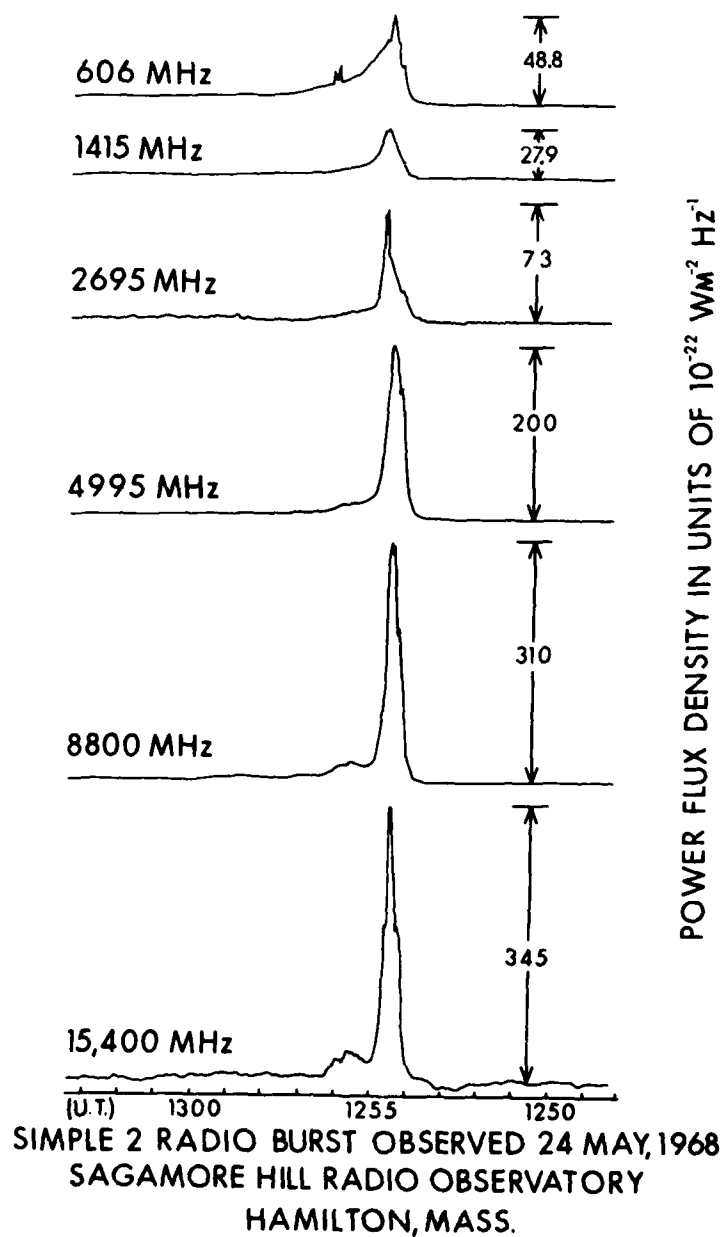
C1026

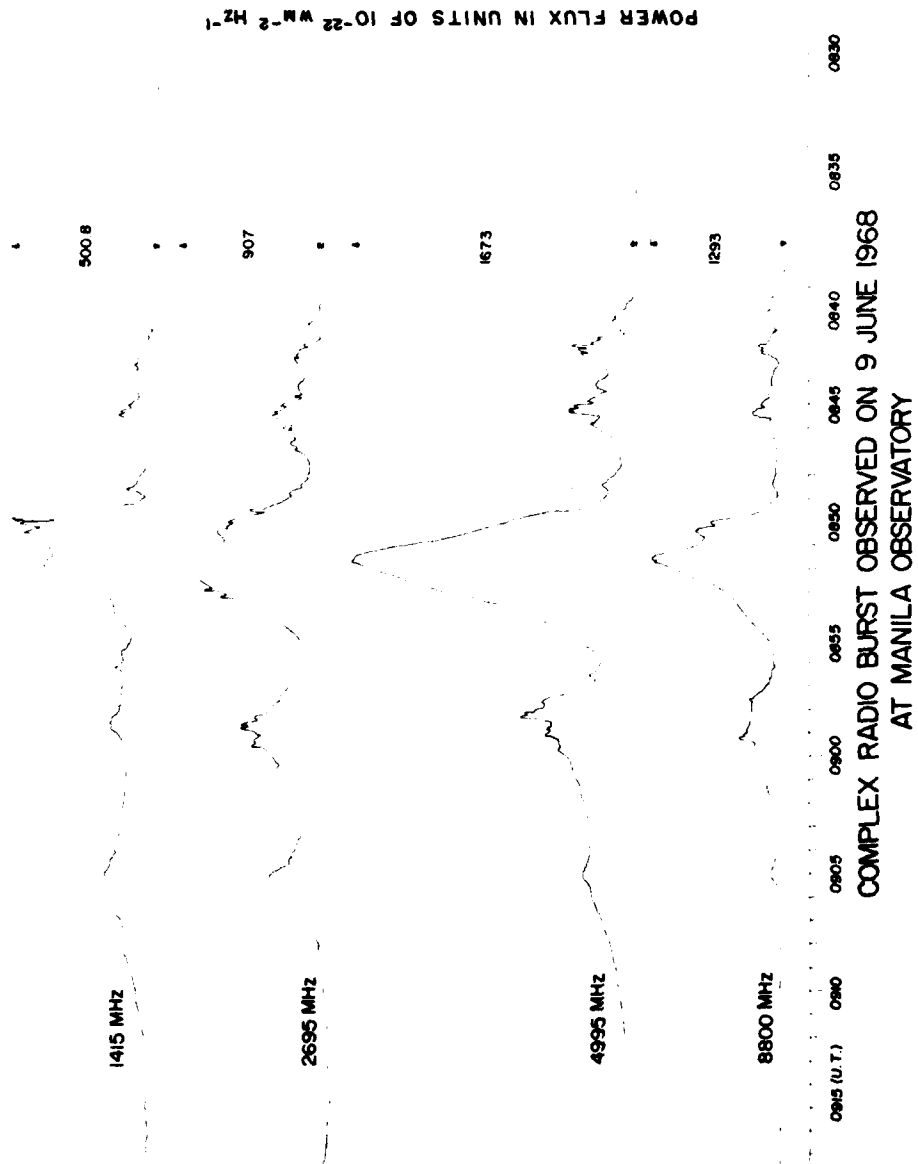


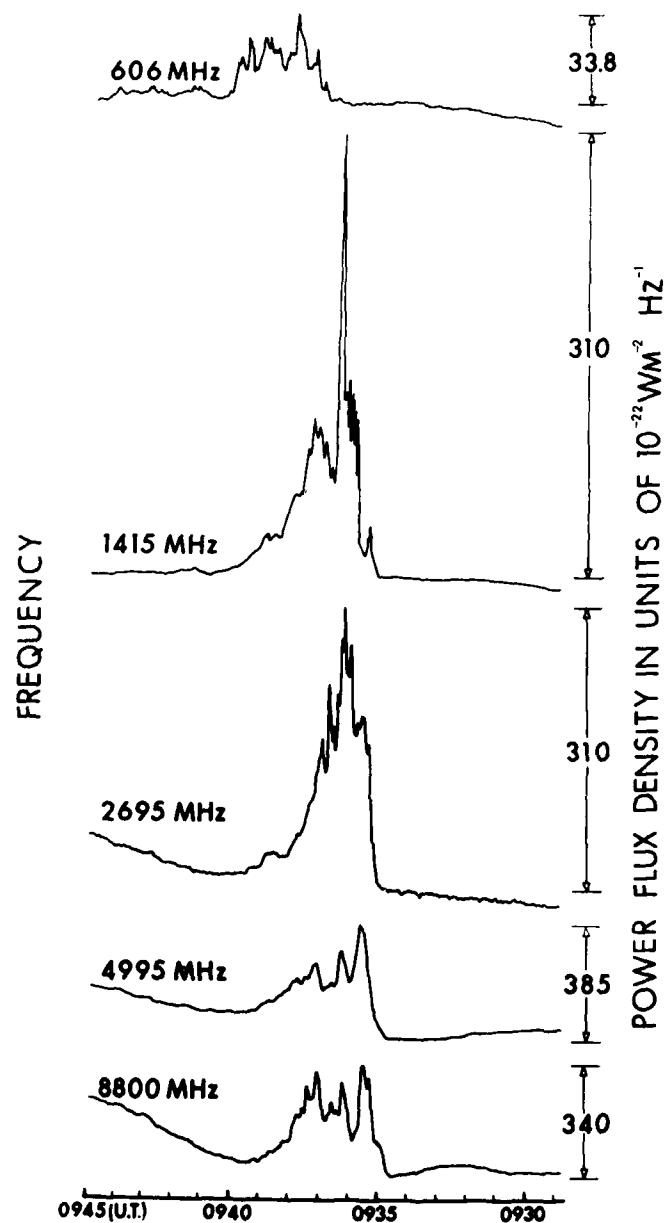
SIMPLE 3 AND COMPLEX RADIO BURST OBSERVED ON
25 MARCH, 1968 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



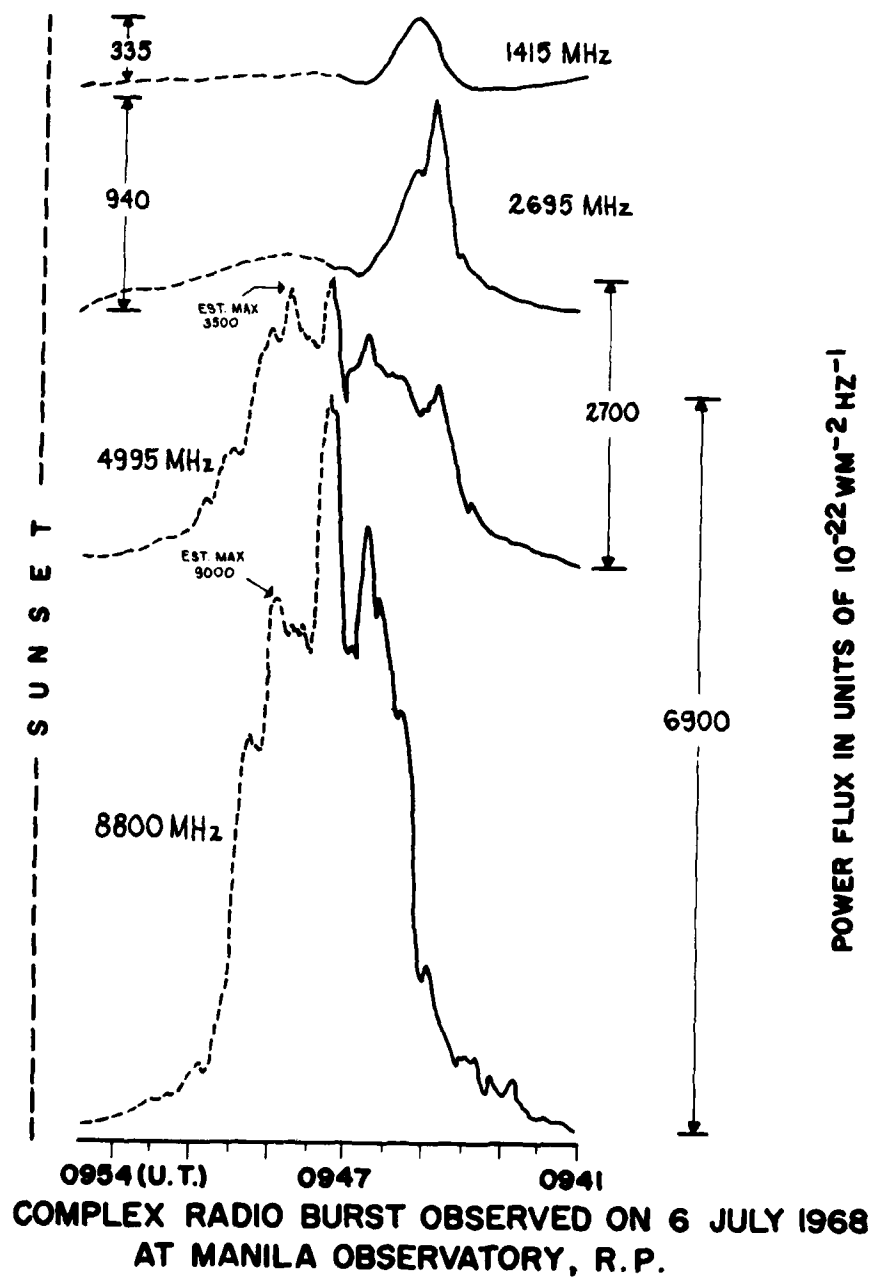
COMPLEX RADIO BURST OBSERVED
3 APRIL, 1968 AT SAGAMORE HILL
RADIO OBSERVATORY, HAMILTON, MASS.

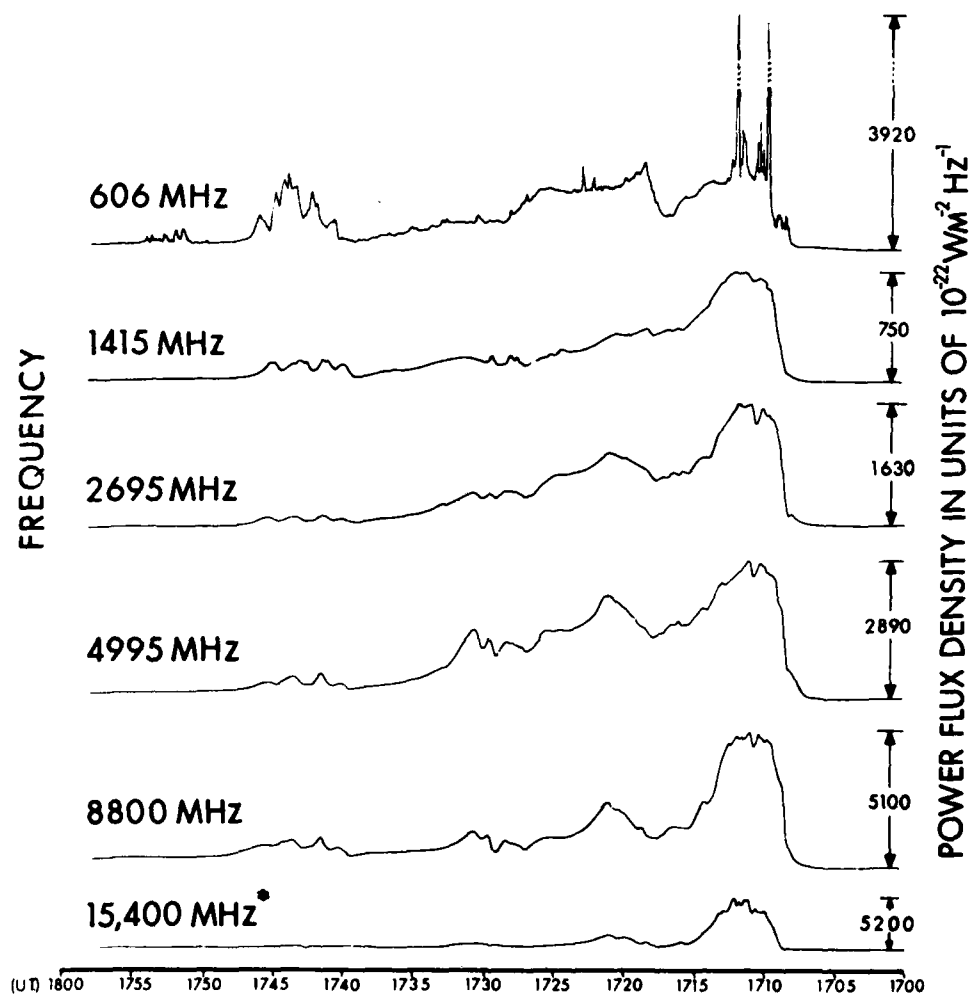




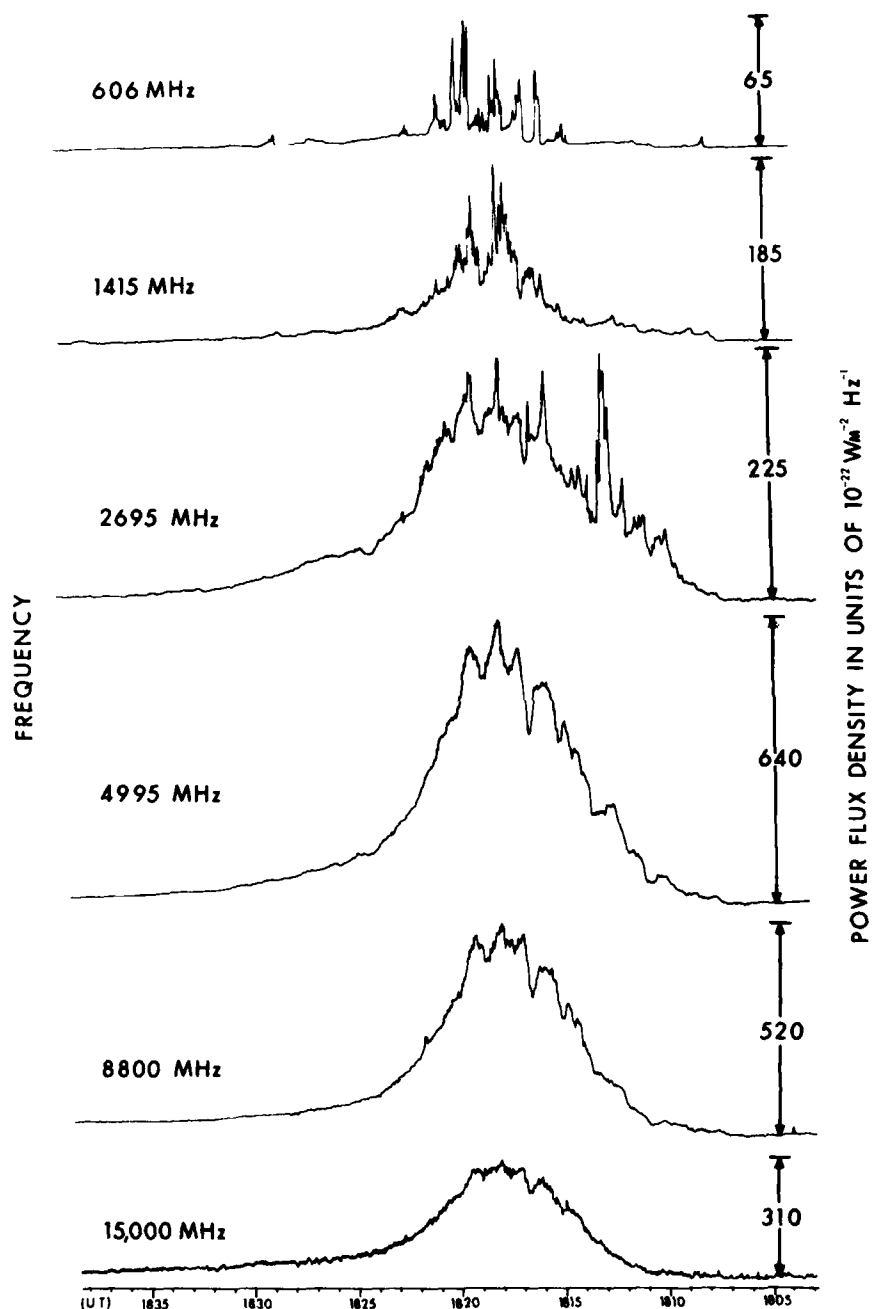


COMPLEX RADIO BURST OBSERVED 11 JUNE, 1968
AT SAGAMORE HILL OBSERVATORY, HAMILTON, MASS.
(BURST OCCURRED AT SUNRISE)

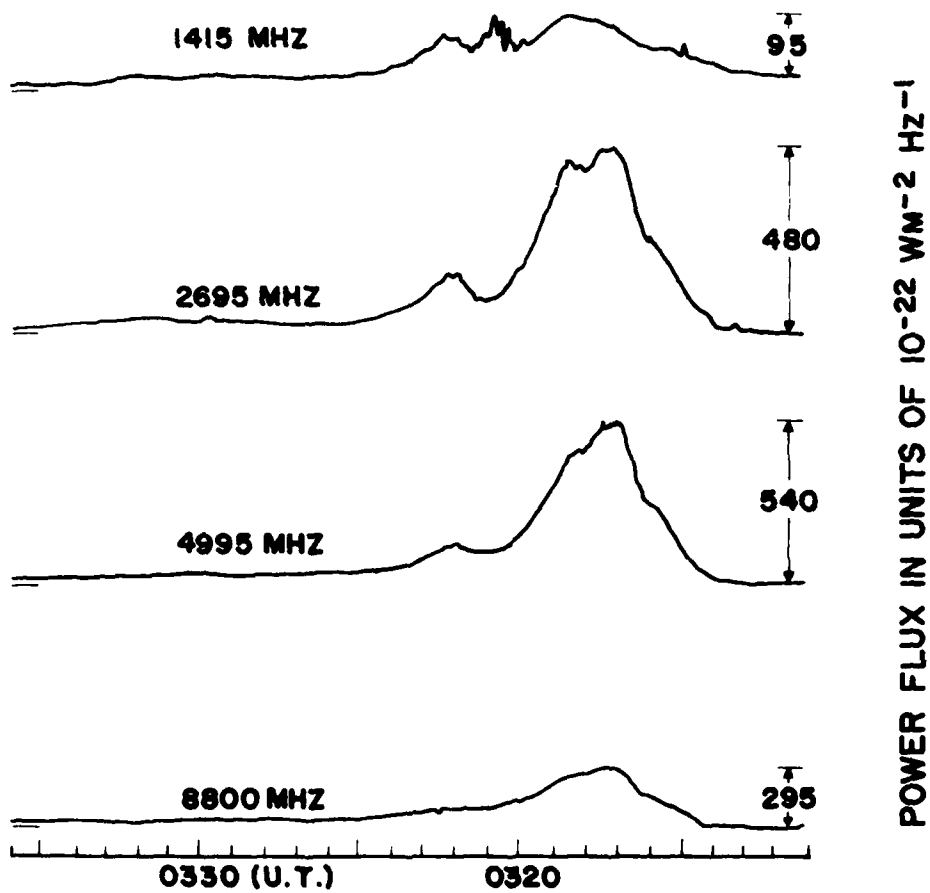




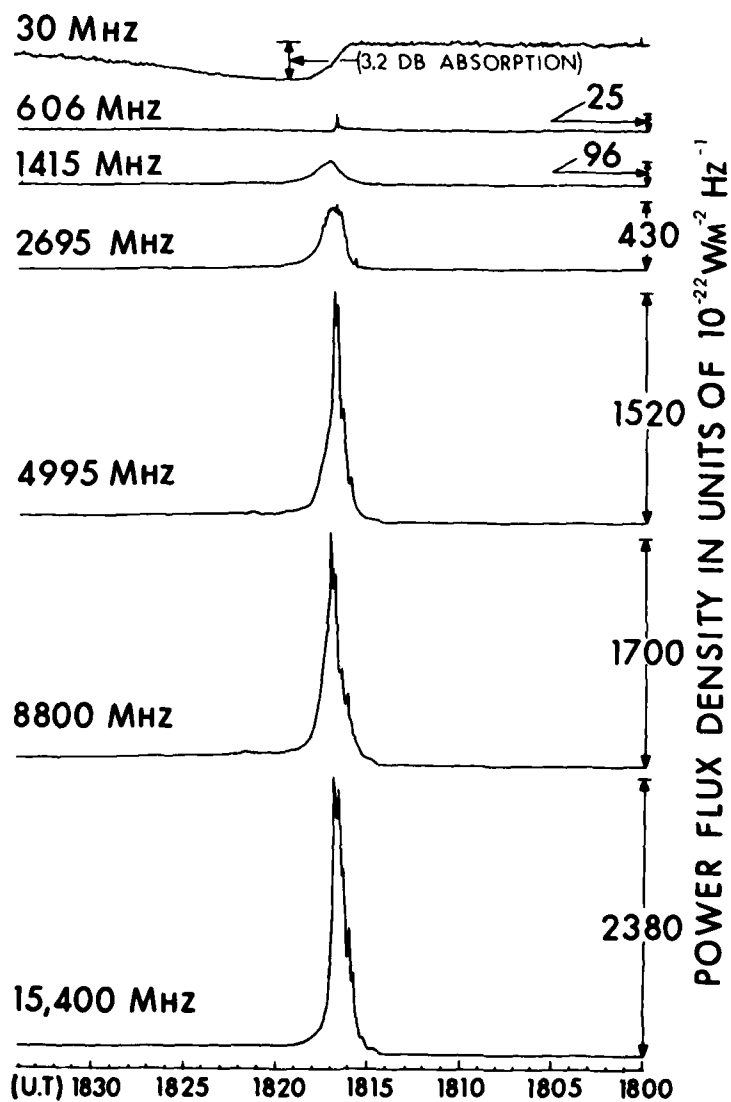
**COMPLEX RADIO BURST OBSERVED 8 JULY, 1968 AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.**
(*15,400 MHz RECORD TAKEN FROM LOW GAIN CHANNEL - ALL OTHER FREQUENCIES FROM MEDIUM GAIN)



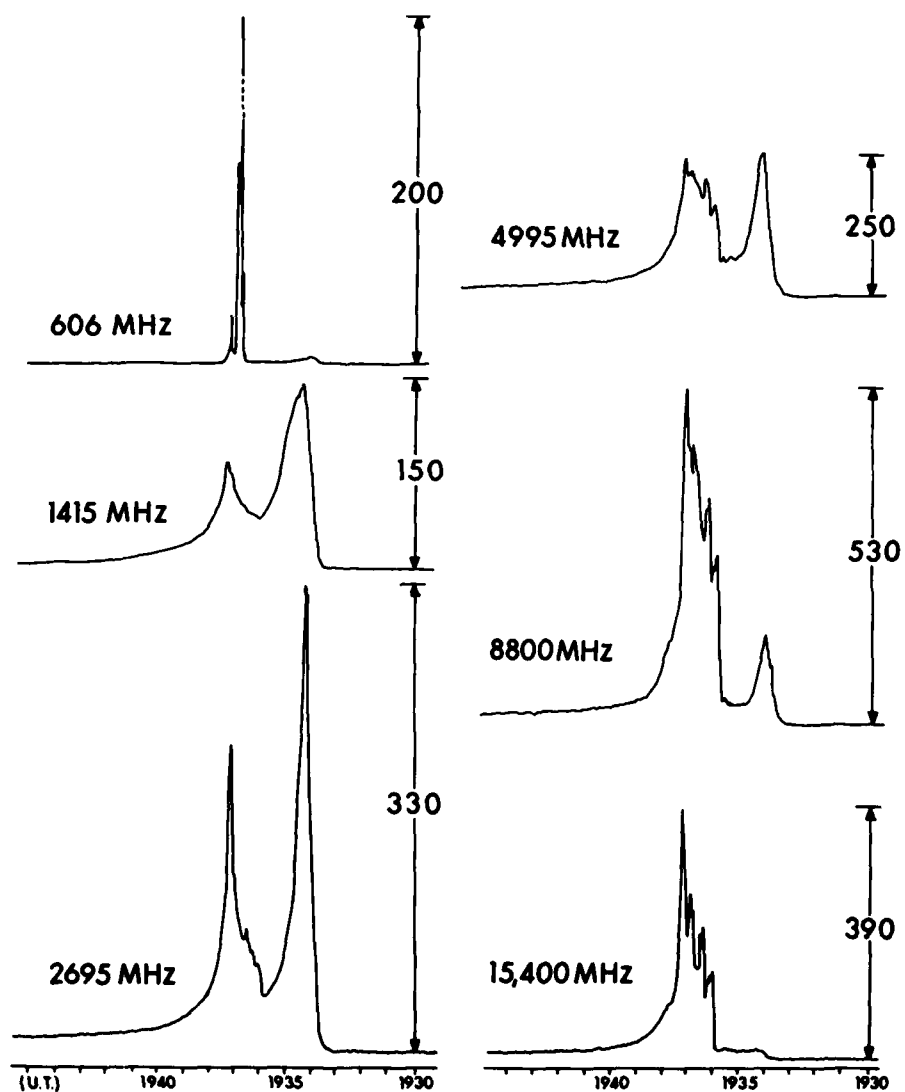
COMPLEX RADIO BURST OBSERVED ON 9 JULY, 1968 AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



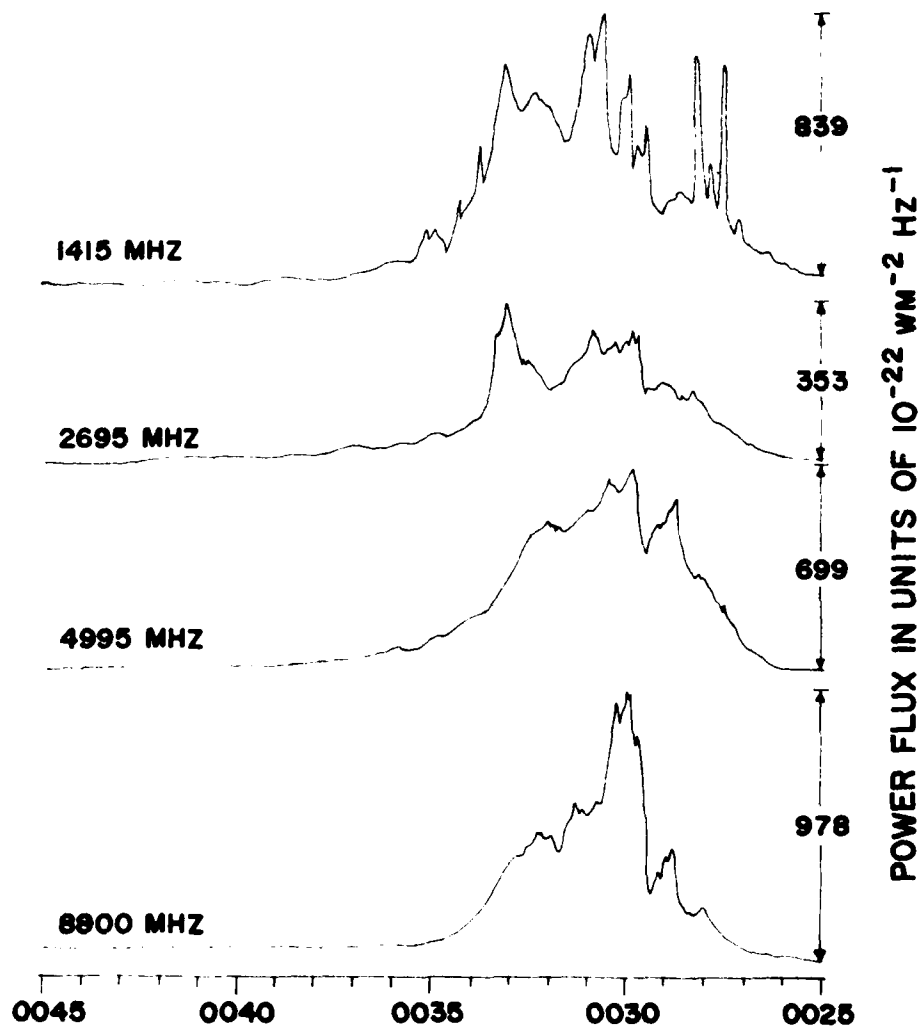
**SIMPLE 2 AND COMPLEX RADIO BURST OBSERVED ON
3 AUGUST 1968 AT MANILA OBSERVATORY, R.P.**



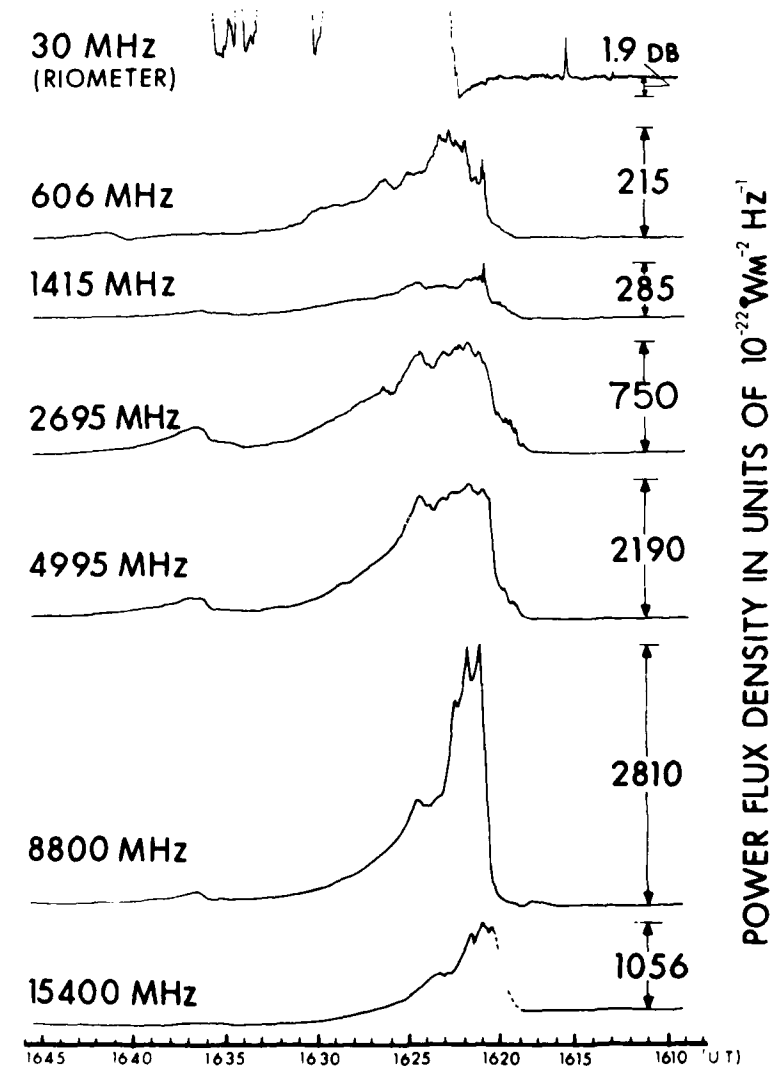
SIMPLE 2 RADIO BURST OBSERVED 8 AUGUST, 1968
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



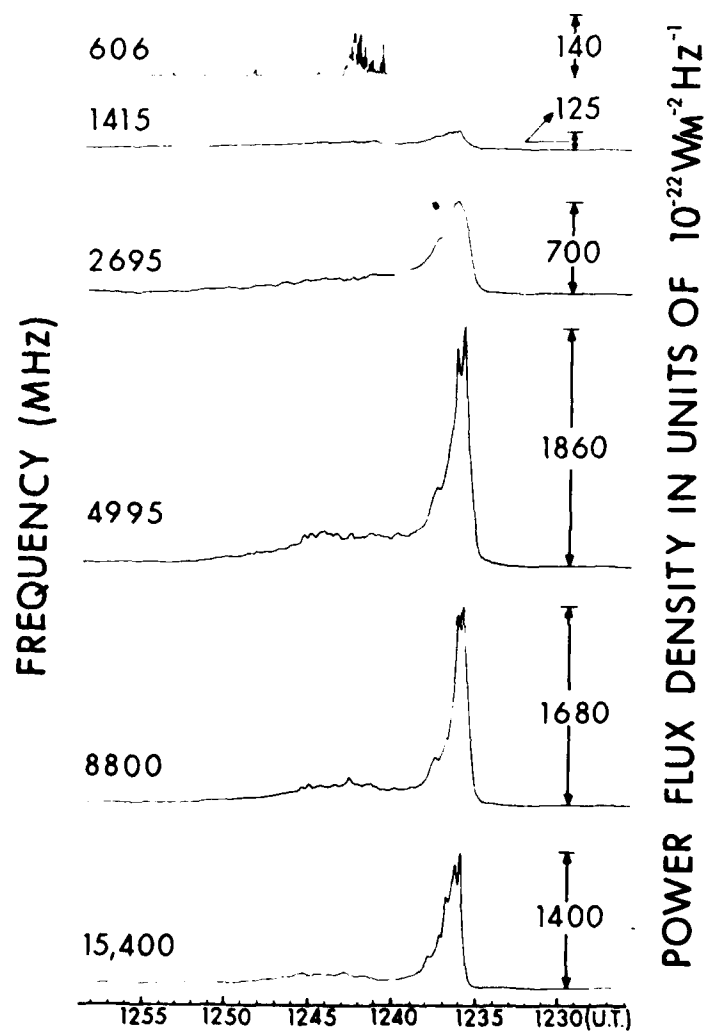
COMPLEX RADIO BURST OBSERVED ON 21 AUGUST, 1968 AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



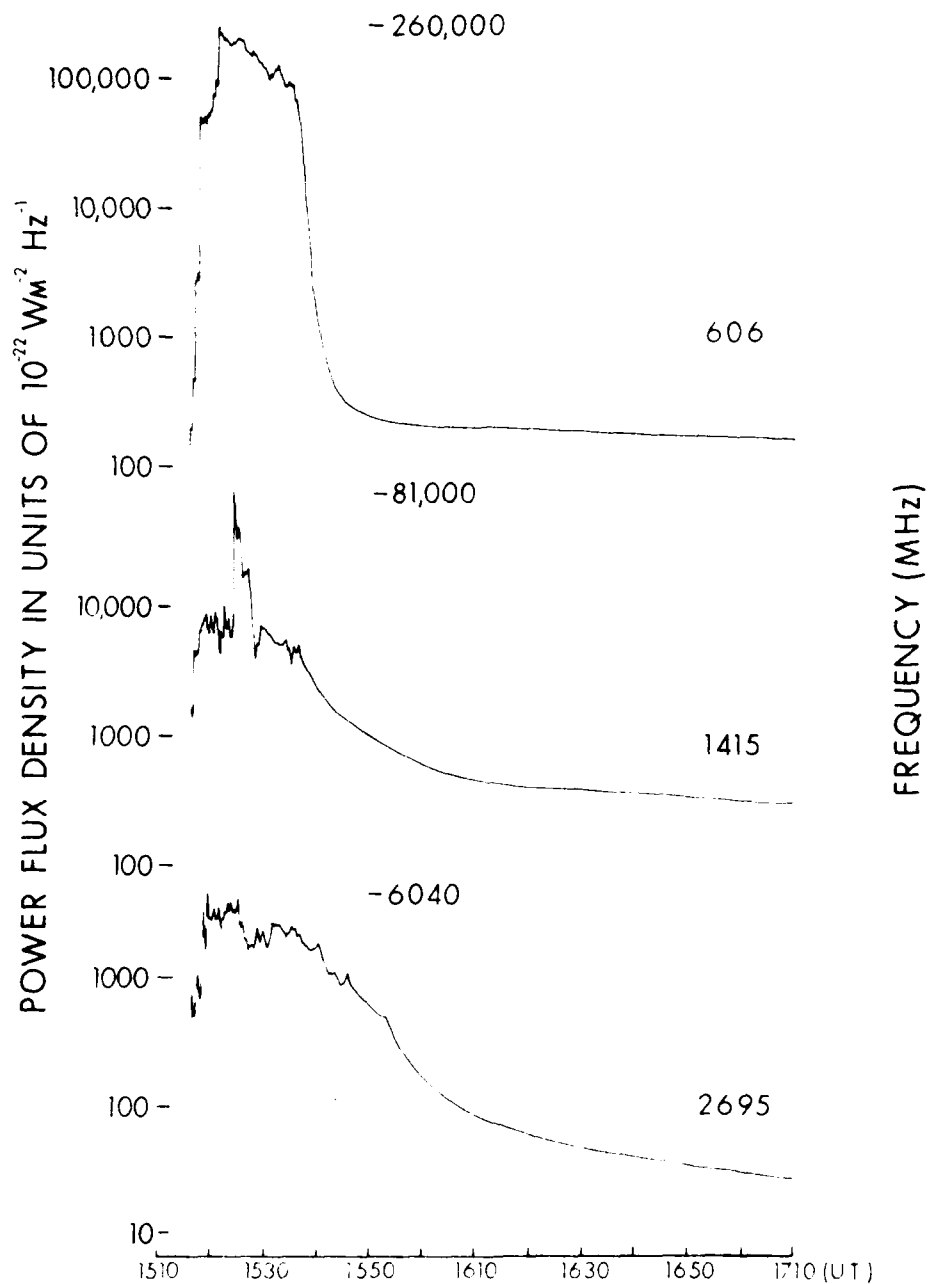
**COMPLEX RADIO BURST OBSERVED ON
26 SEP 68 AT MANILA OBSERVATORY, R.P.**



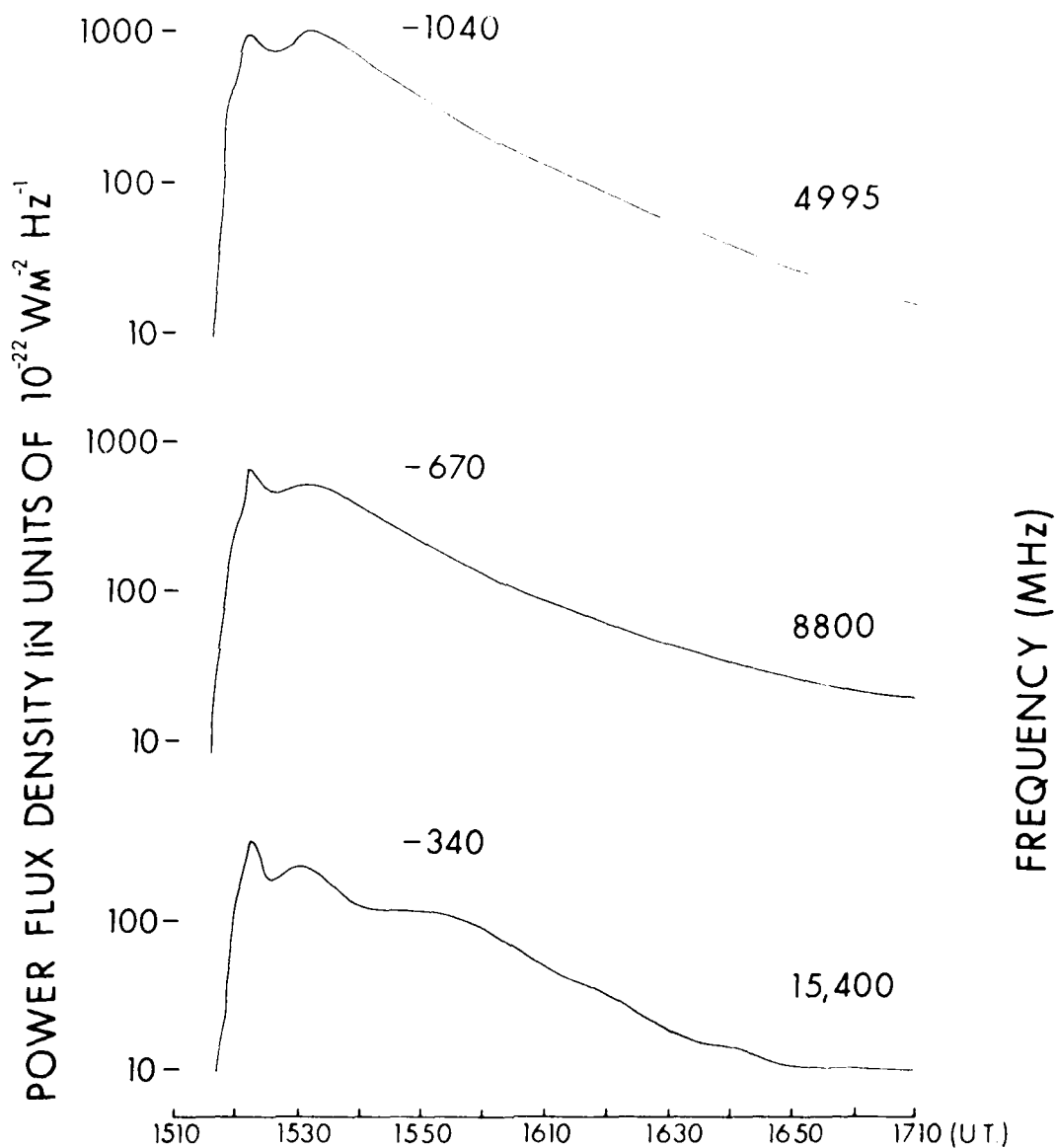
COMPLEX F RADIO BURST - 29 SEPTEMBER, 1968
 AT SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.
 (DEKAMETER TYPE II & IV BURSTS OBSERVED 1617-1644)



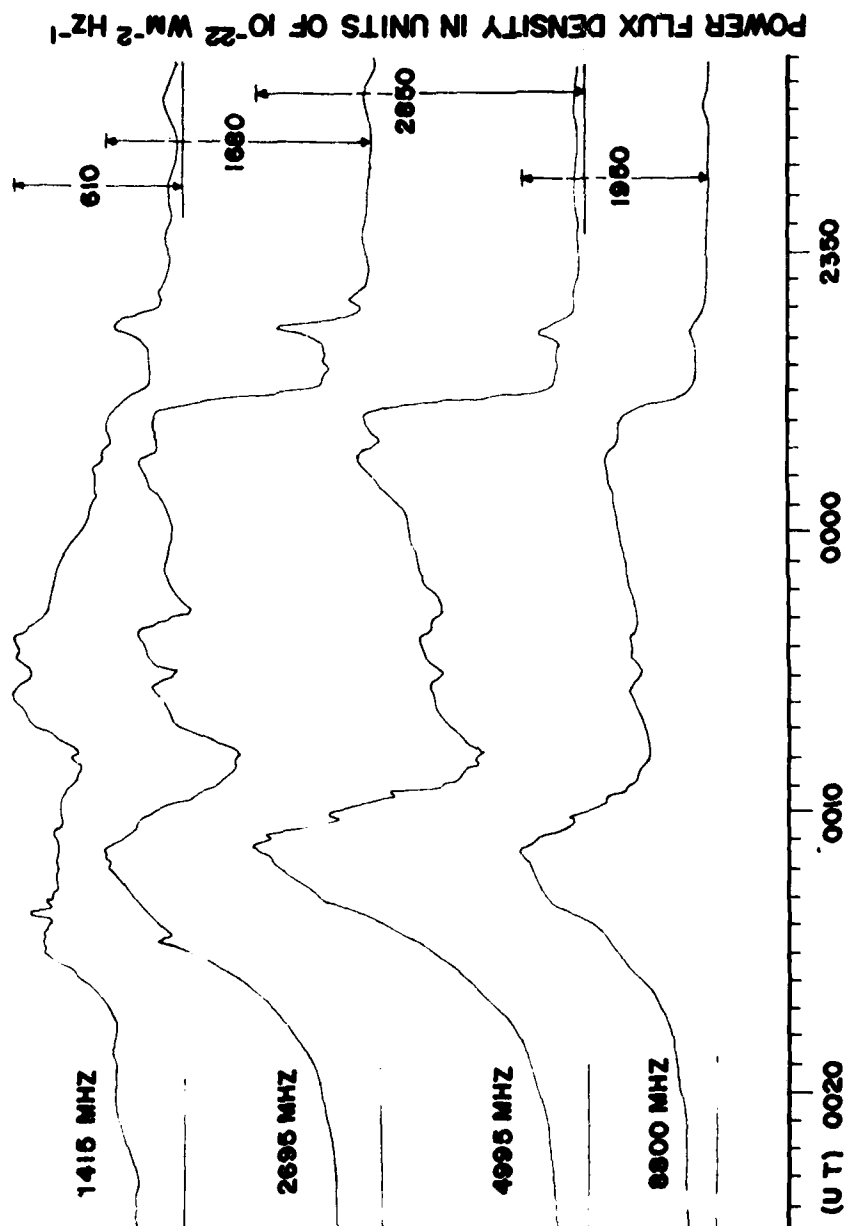
COMPLEX AND SIMPLE 2 RADIO BURST
OBSERVED ON 27 OCTOBER, 1968
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



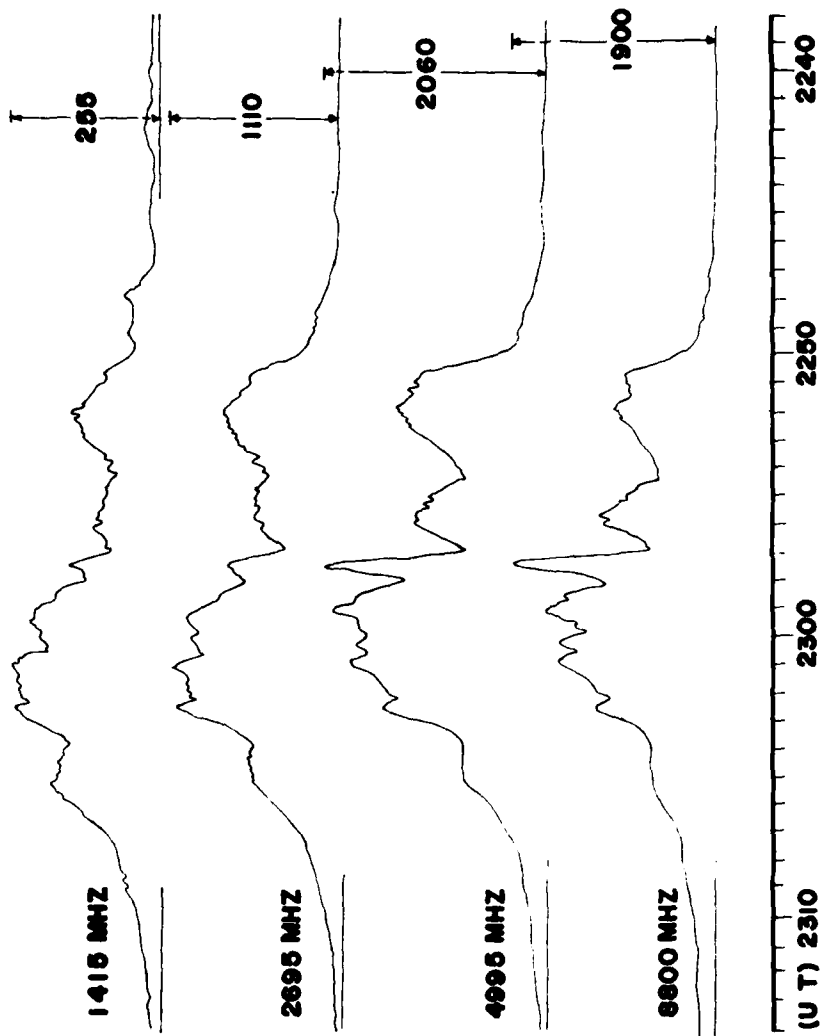
GREAT BURST OBSERVED ON 29 OCTOBER, 1968
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



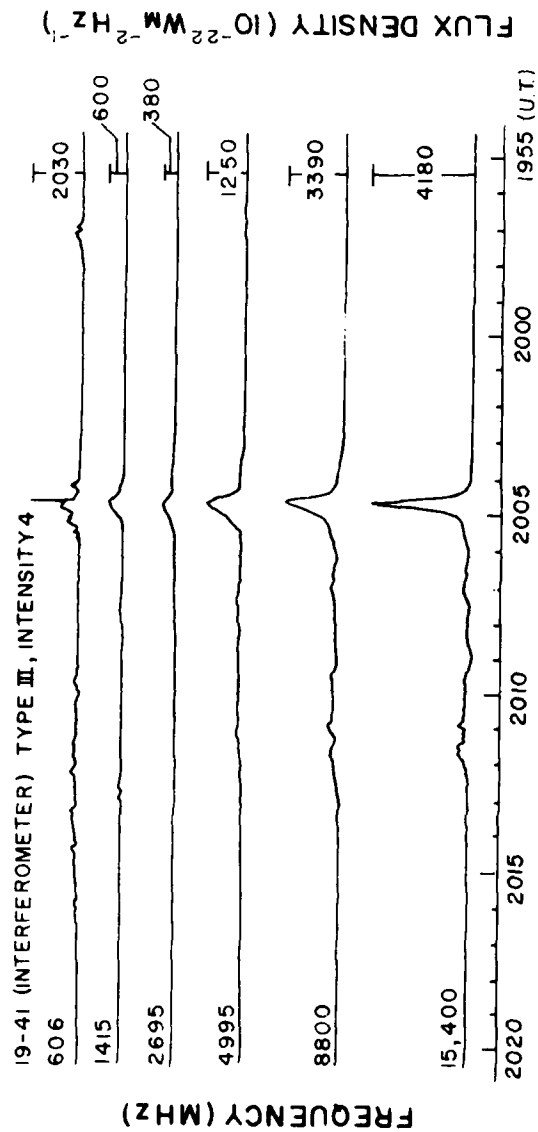
GREAT BURST OBSERVED ON 29 OCTOBER, 1968
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



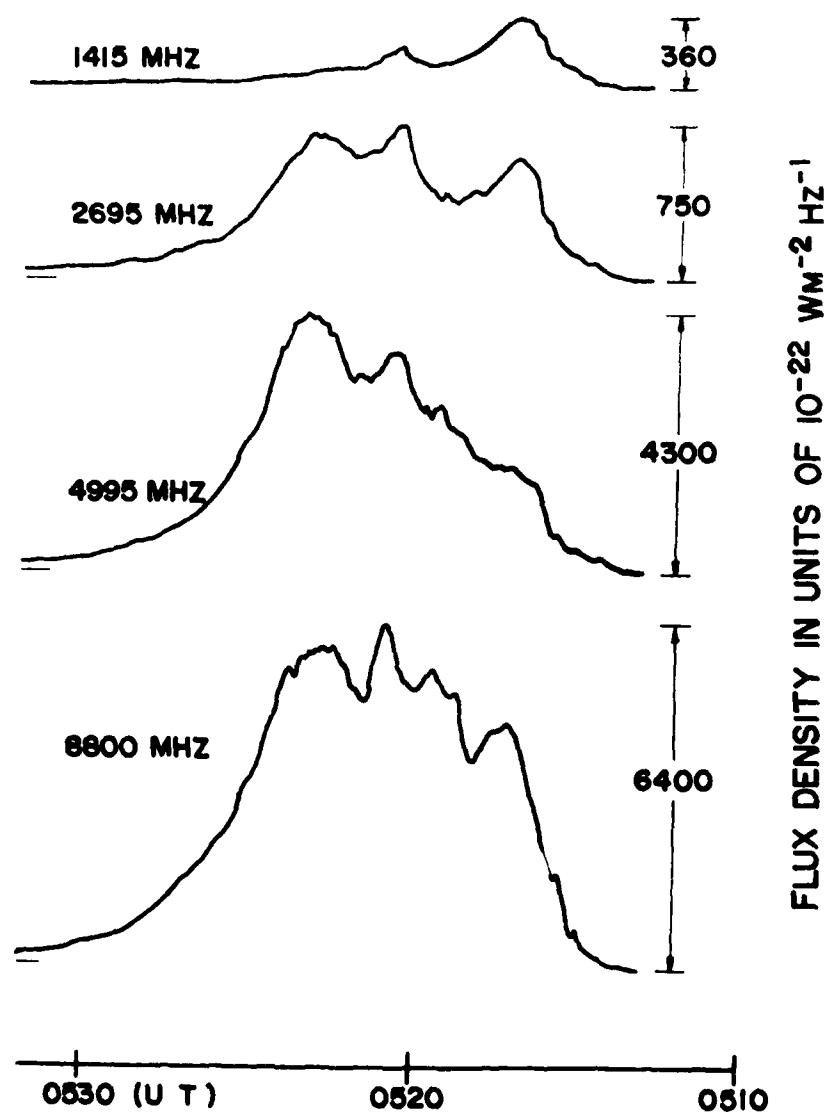
Complex with PBI Radio Burst Observed 30 October 1968 at Manila Radio Observatory



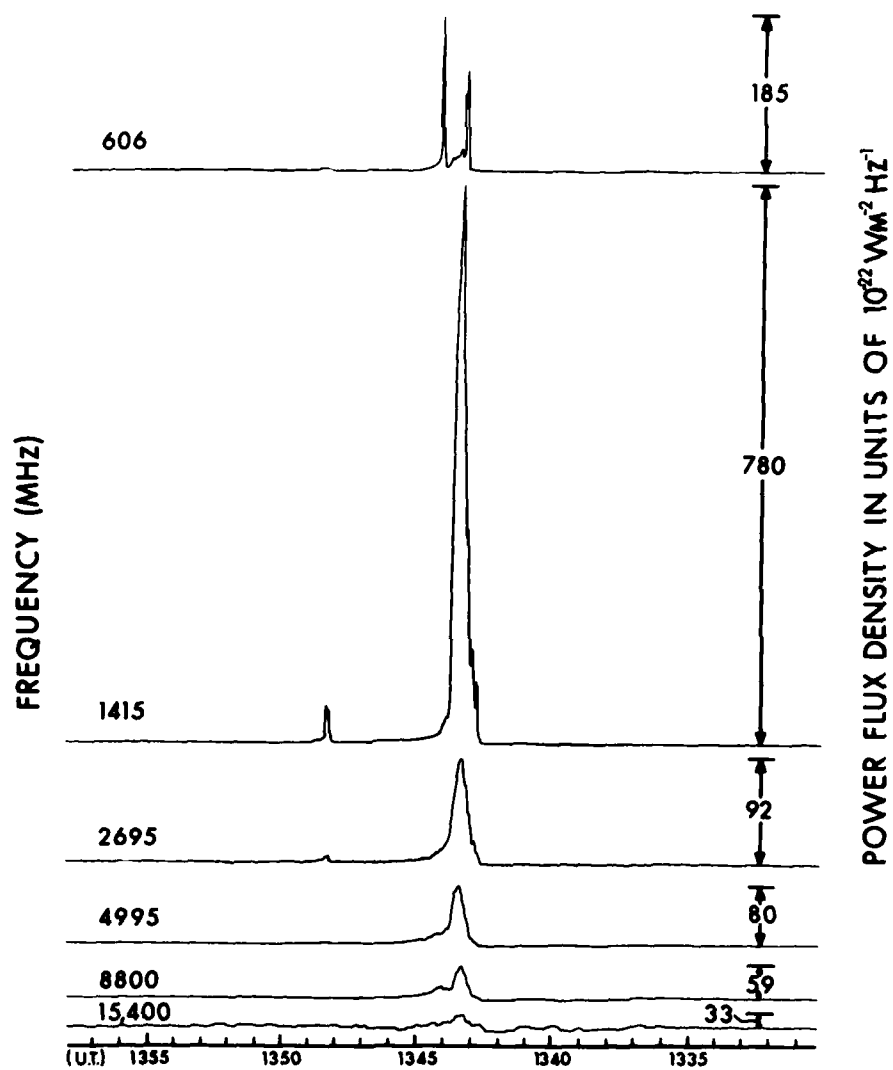
Complex with PBI Radio Burst Observed 31 October 1968 at Manila Radio Observatory



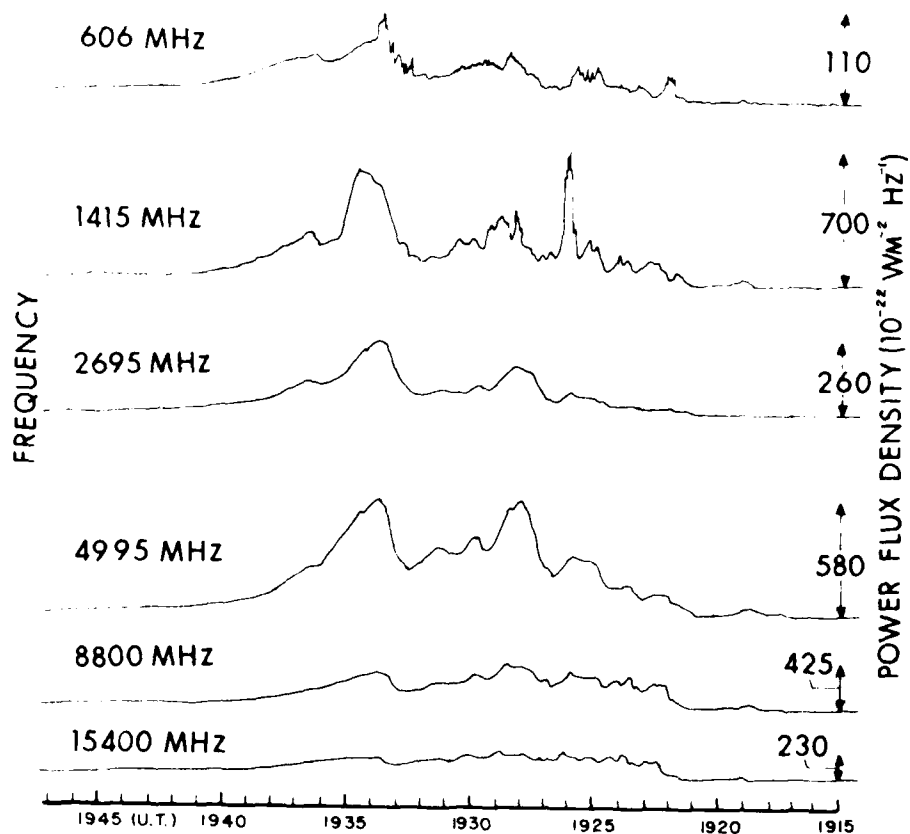
COMPLEX AND SIMPLE 2F RADIO BURST OBSERVED 1 NOV. 1968
AT SAGAMORE HILL RADIO OBSERVATORY - HAMILTON, MASS.



Complex with PBI Radio Burst Observed 4 November 1968
at Manila Radio Observatory

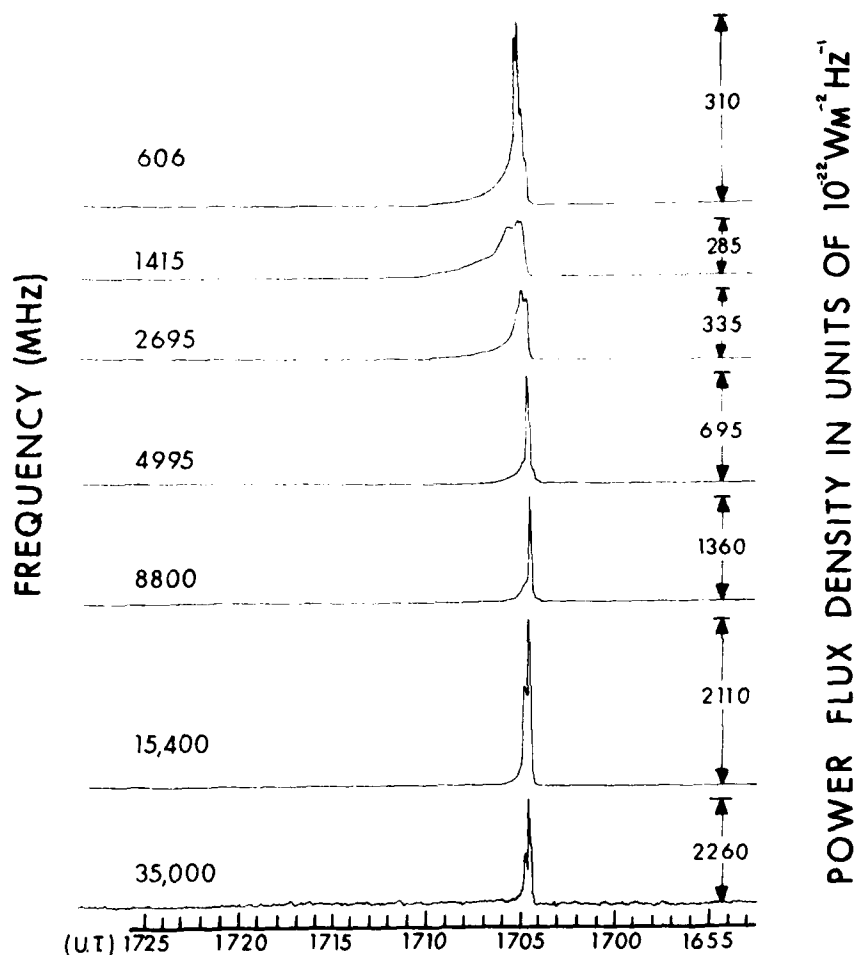


COMPLEX AND SIMPLE 2 RADIO BURST
OBSERVED 5 NOVEMBER, 1968
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

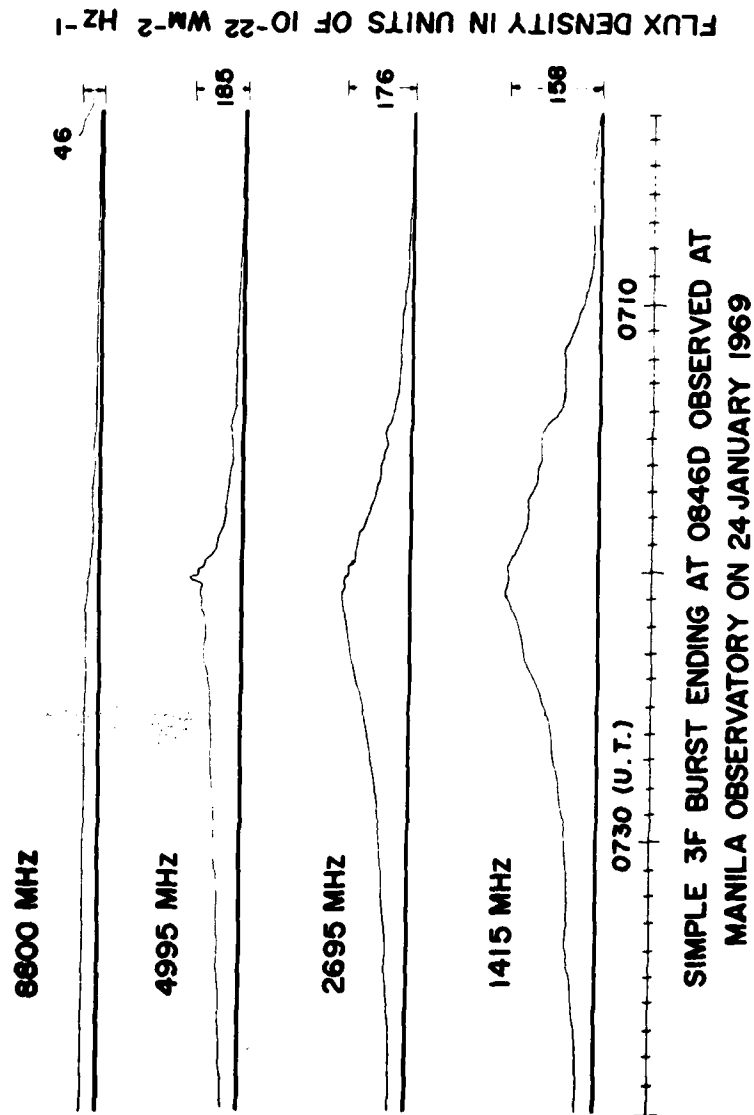


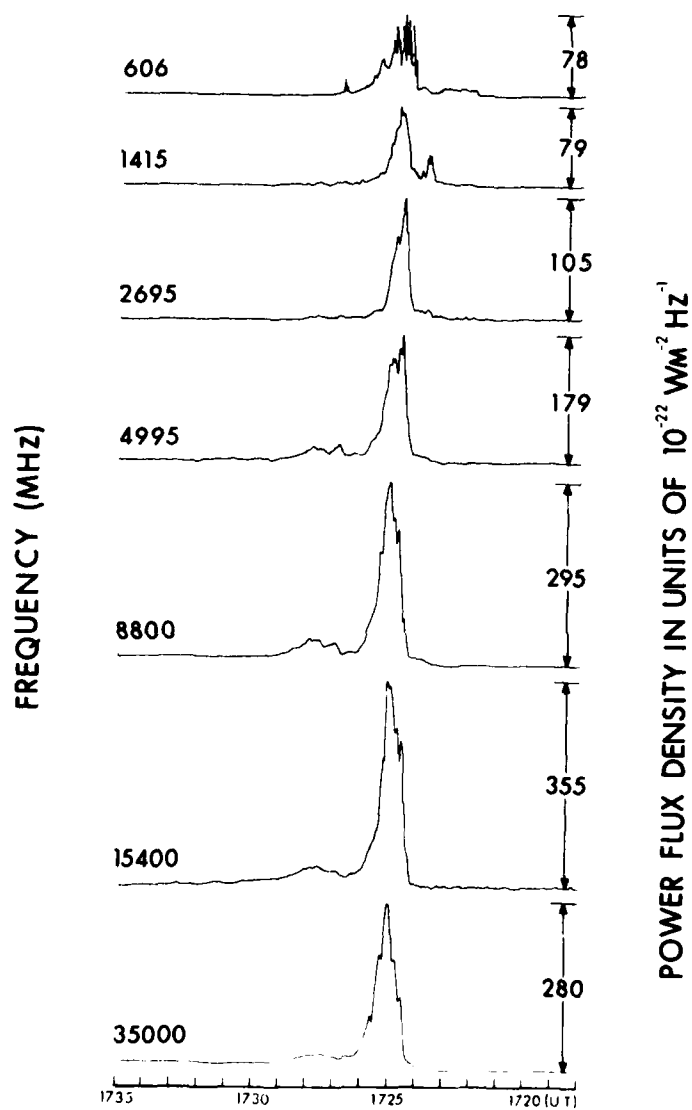
COMPLEX 'F' RADIO BURST-29 DECEMBER, 1968
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

**Solar Radio Bursts
1969**

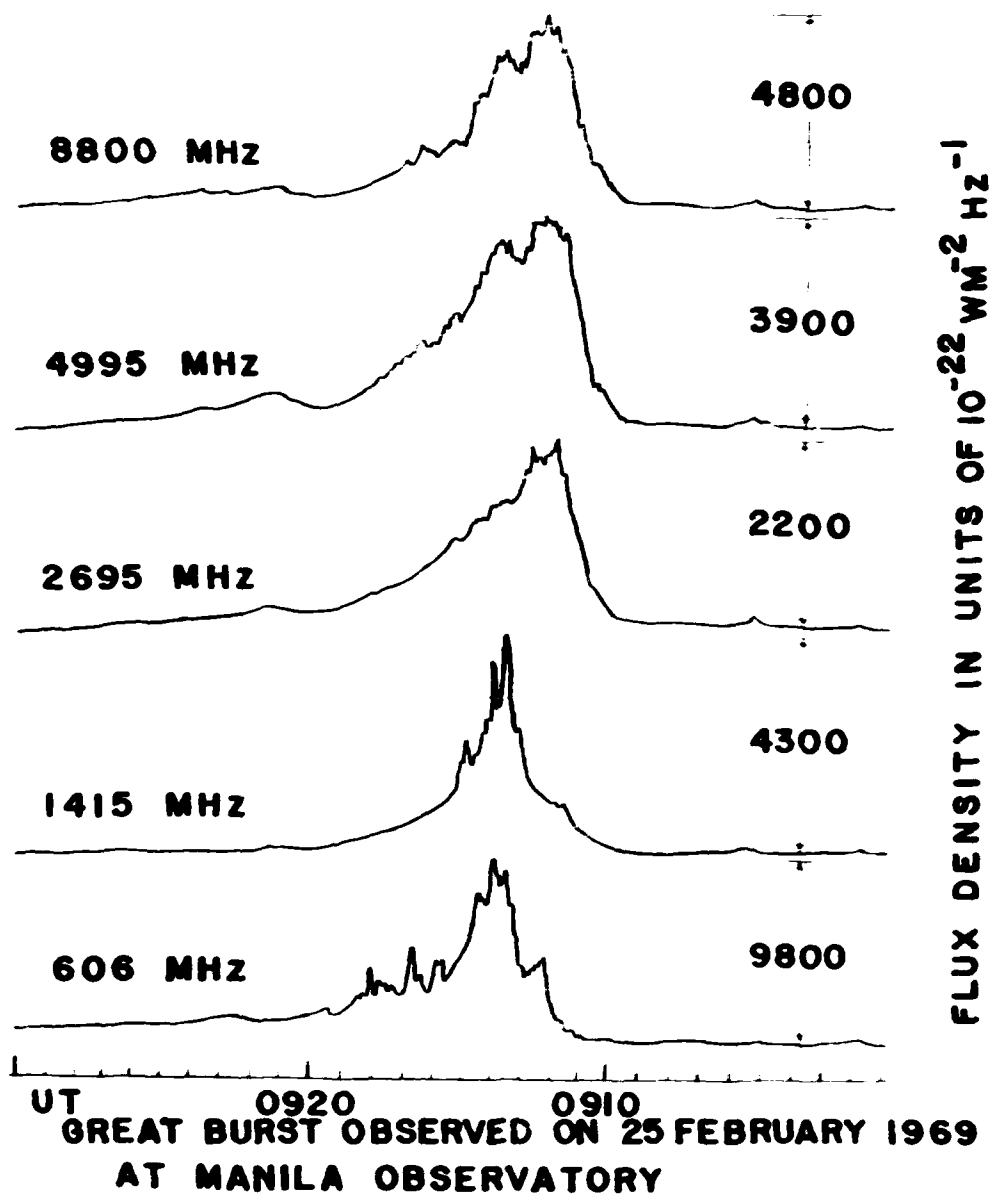


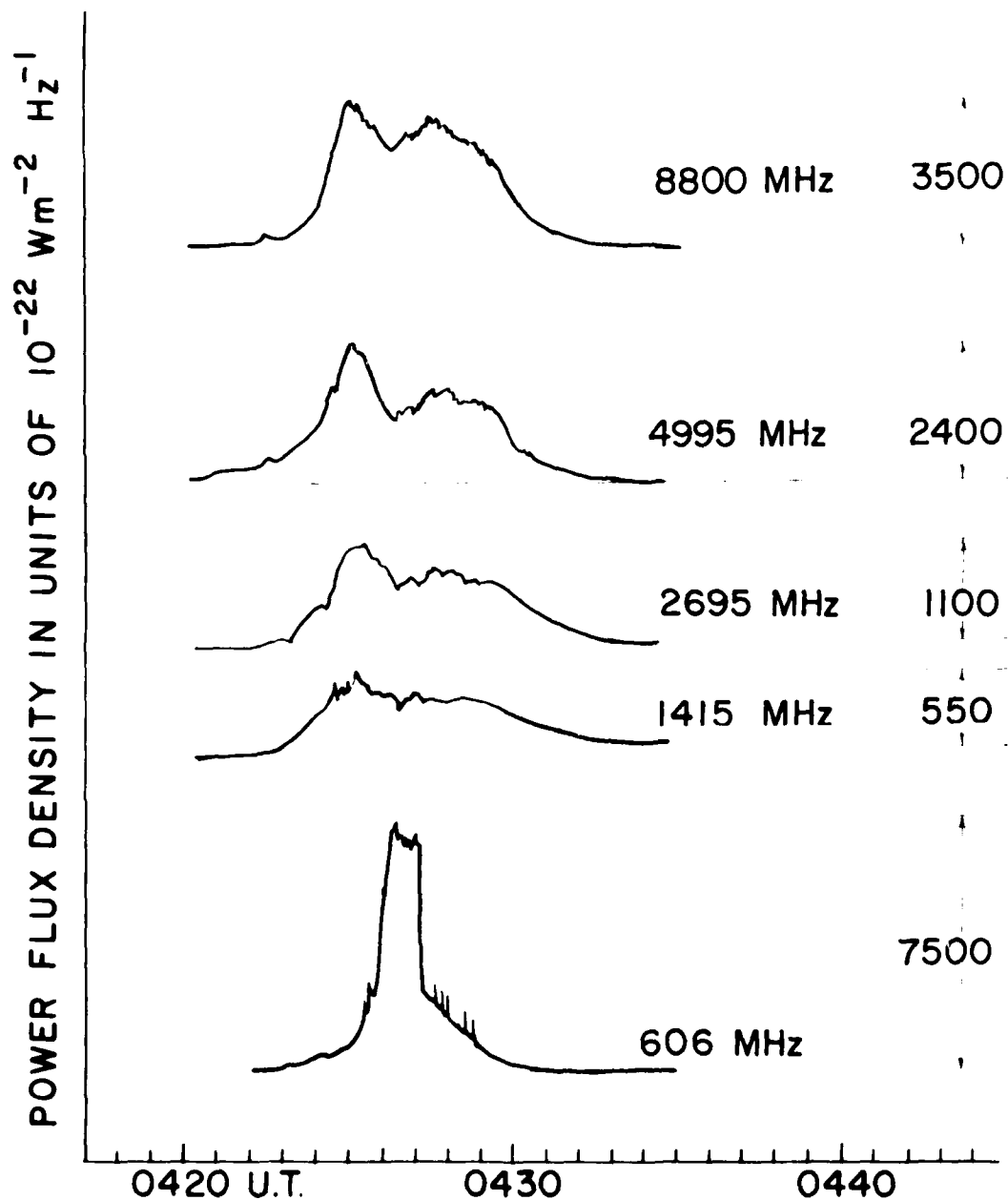
COMPLEX AND SIMPLE 2 RADIO BURST
OBSERVED 17 JANUARY, 1969
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



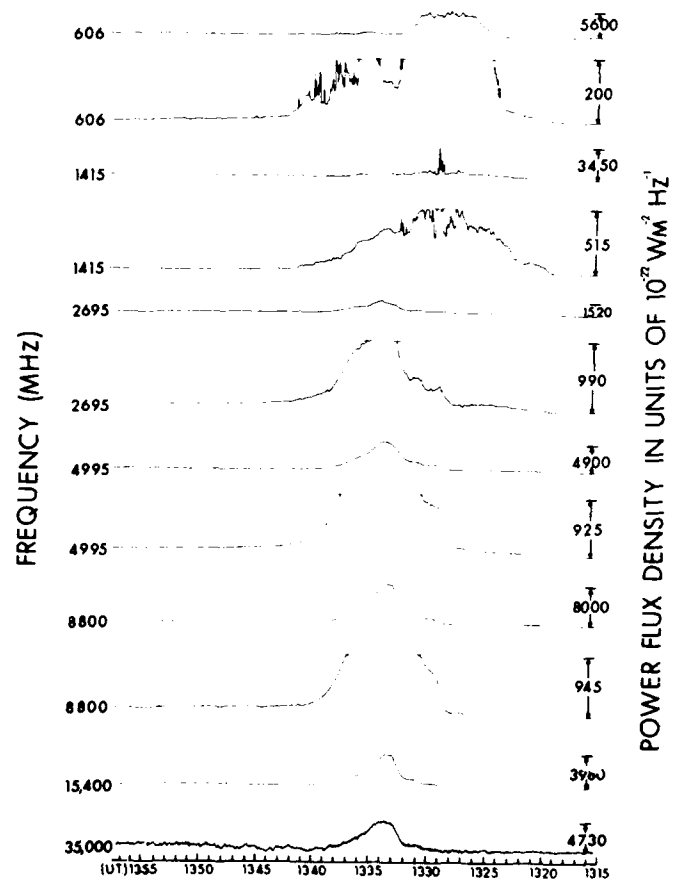


SIMPLE 2 F AND COMPLEX F RADIO BURST
OBSERVED 9 FEBRUARY, 1969
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

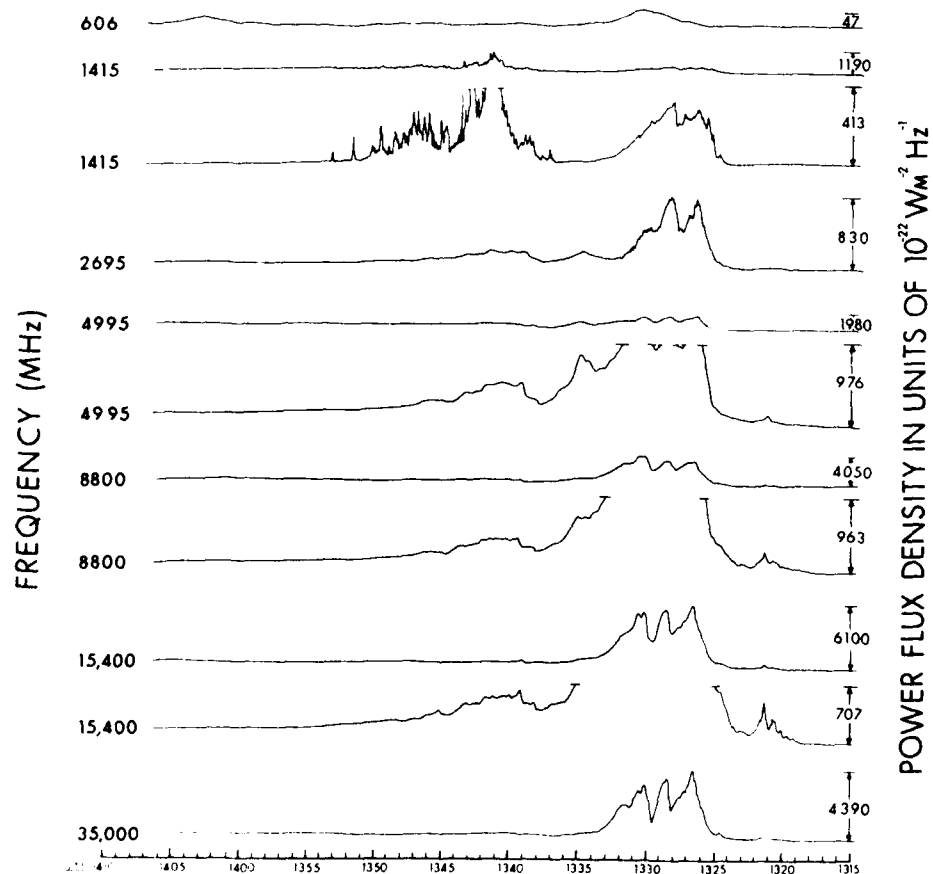




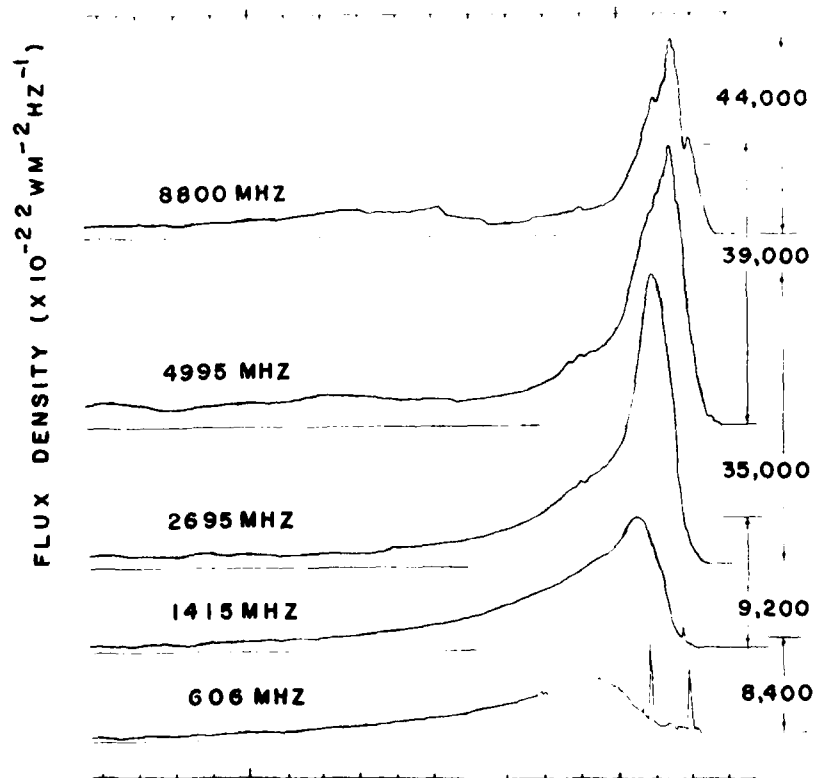
GREAT RADIO BURSTS ON 26 FEBRUARY 1969
OBSERVED AT MANILA OBSERVATORY.



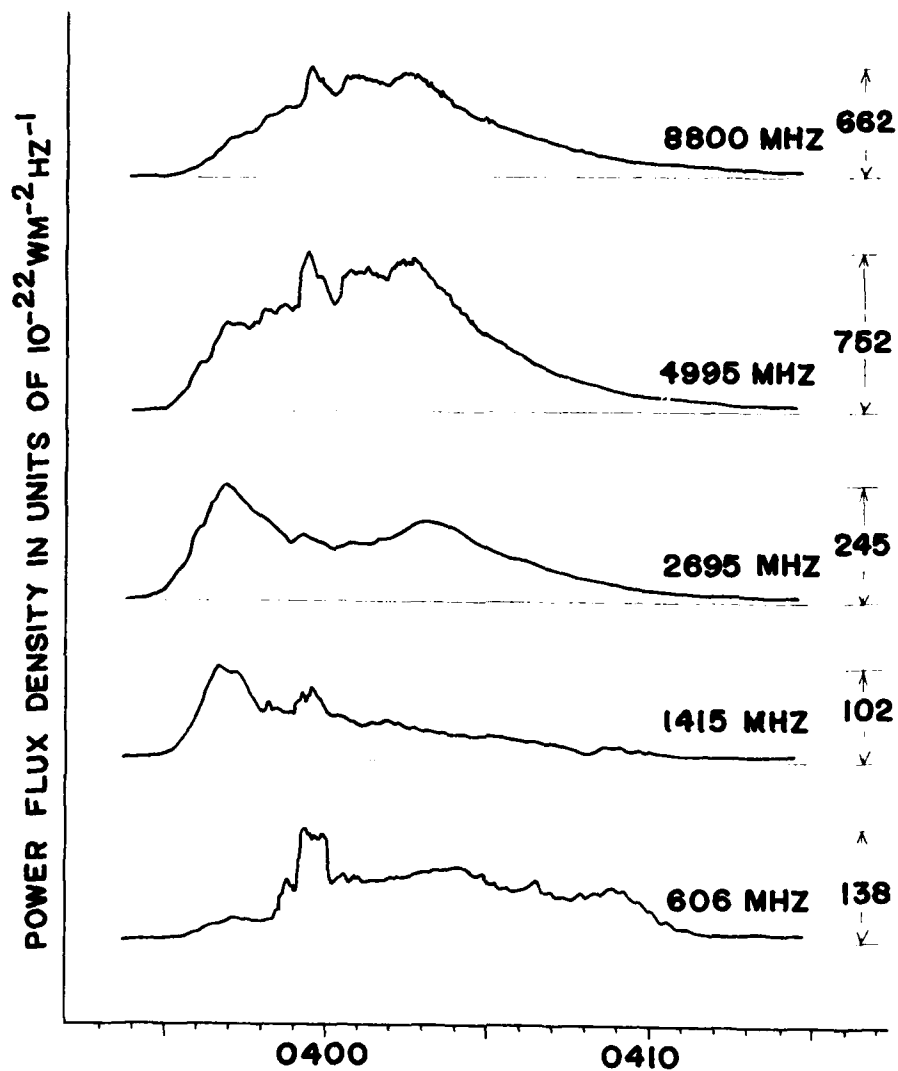
COMPLEX "F" & S2"F" RADIO BURST OBSERVED 21 MARCH, 1969
 AT SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.



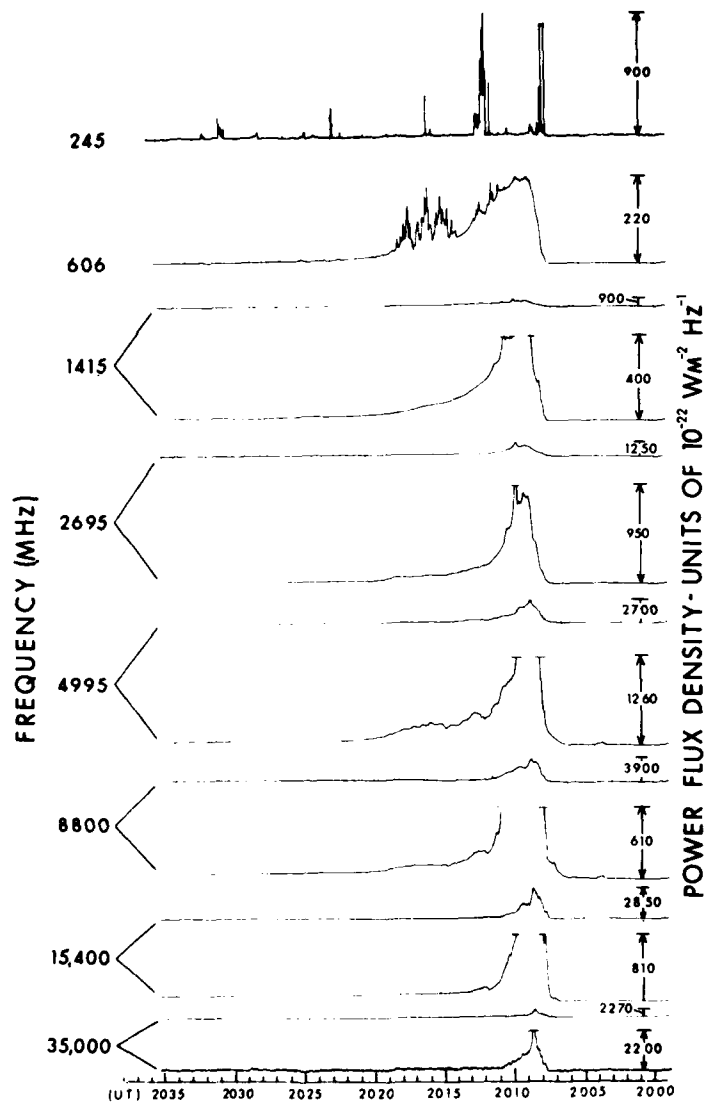
COMPLEX F RADIO BURST OBSERVED 27 MARCH, 1969
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



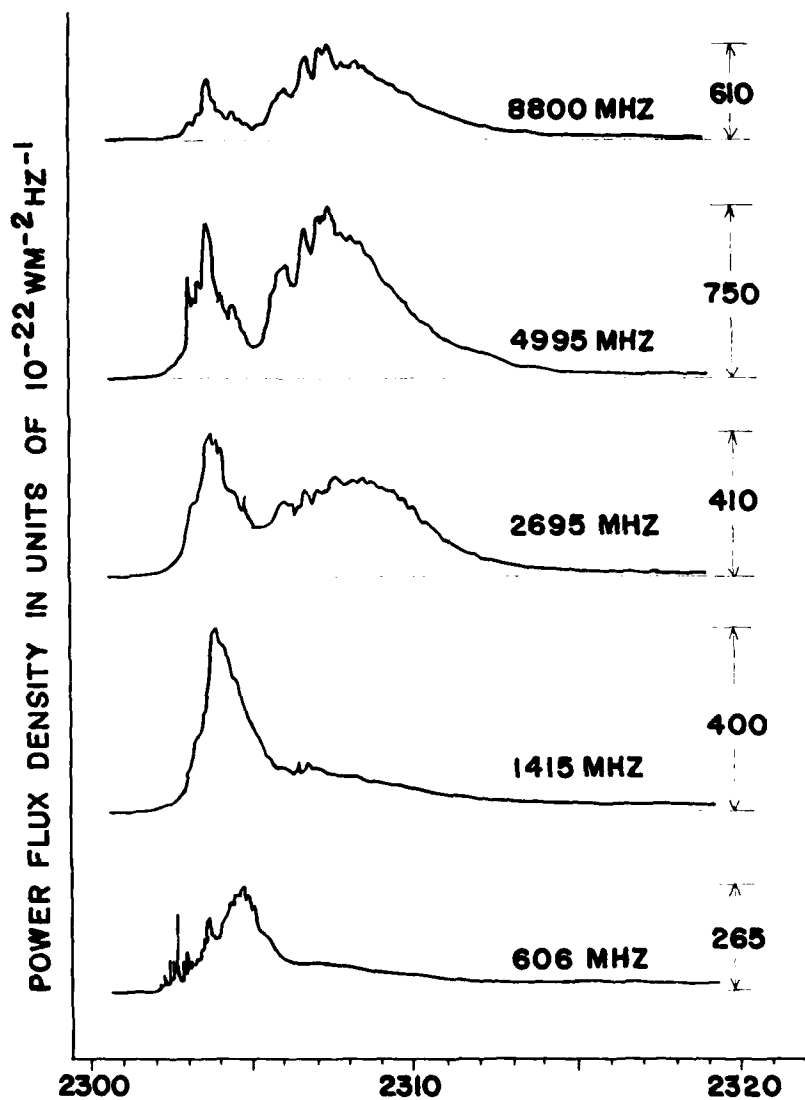
GREAT BURST OBSERVED ON 30 MARCH 1969
AT MANILA OBSERVATORY



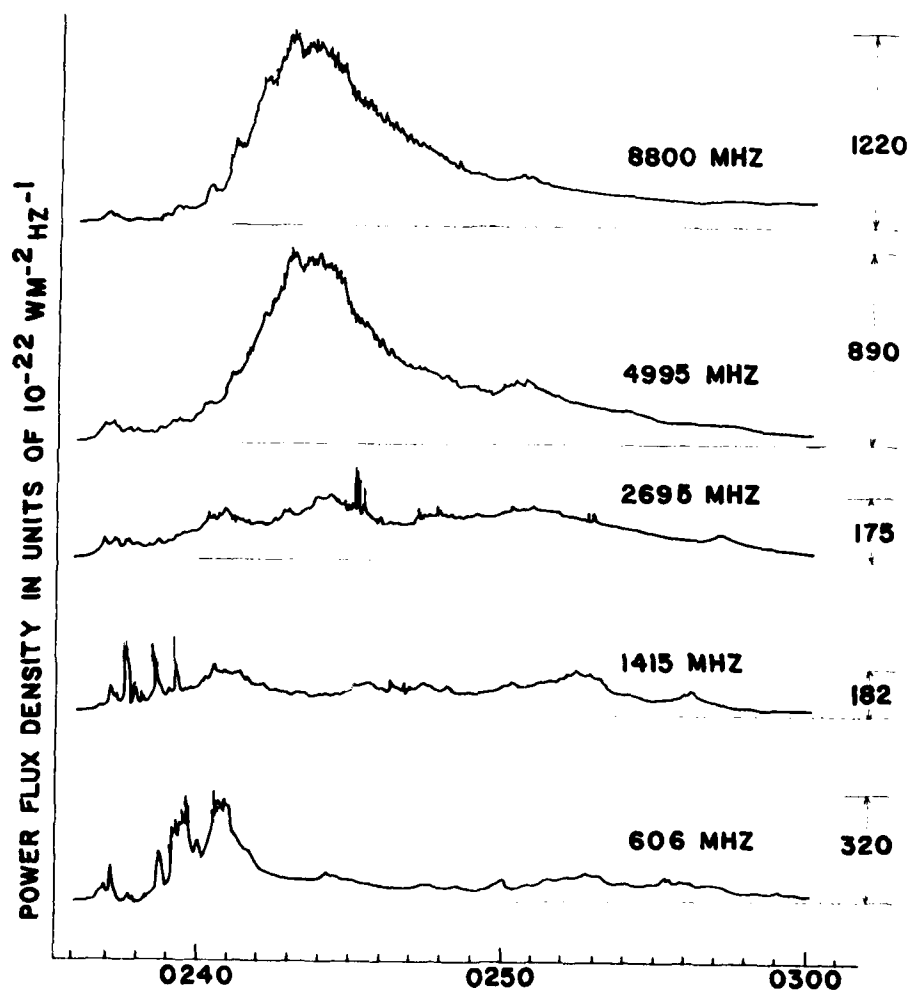
COMPLEX F RADIO BURST OBSERVED ON
10 APRIL 1969 AT MANILA OBSERVATORY
R. P.



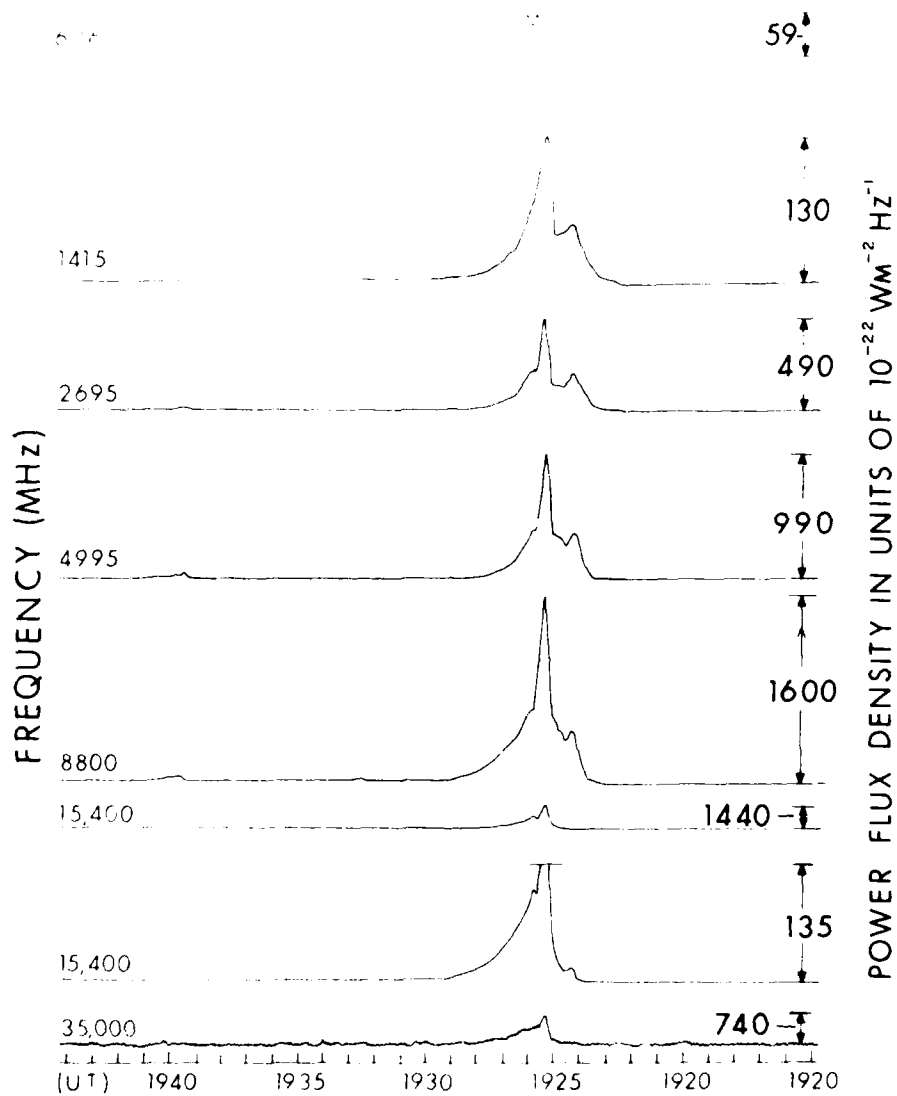
A COMPLEX RADIO BURST OBSERVED 21 APRIL, 1969
SAGAMORE HILL RADIO OBSERVATORY AT
HAMILTON, MASS.



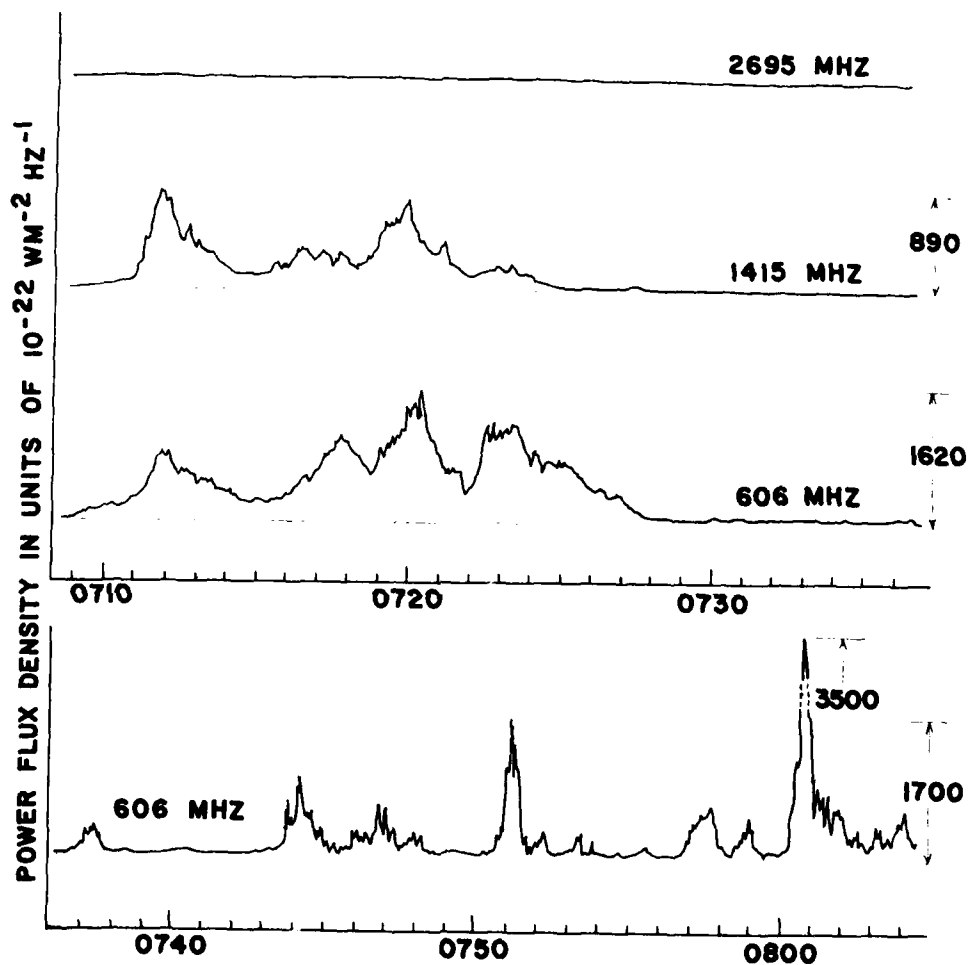
COMPLEX F & SIMPLE 2F RADIO BURSTS
OBSERVED ON 26 APRIL 1969 AT MANILA
OBSERVATORY, R. P.



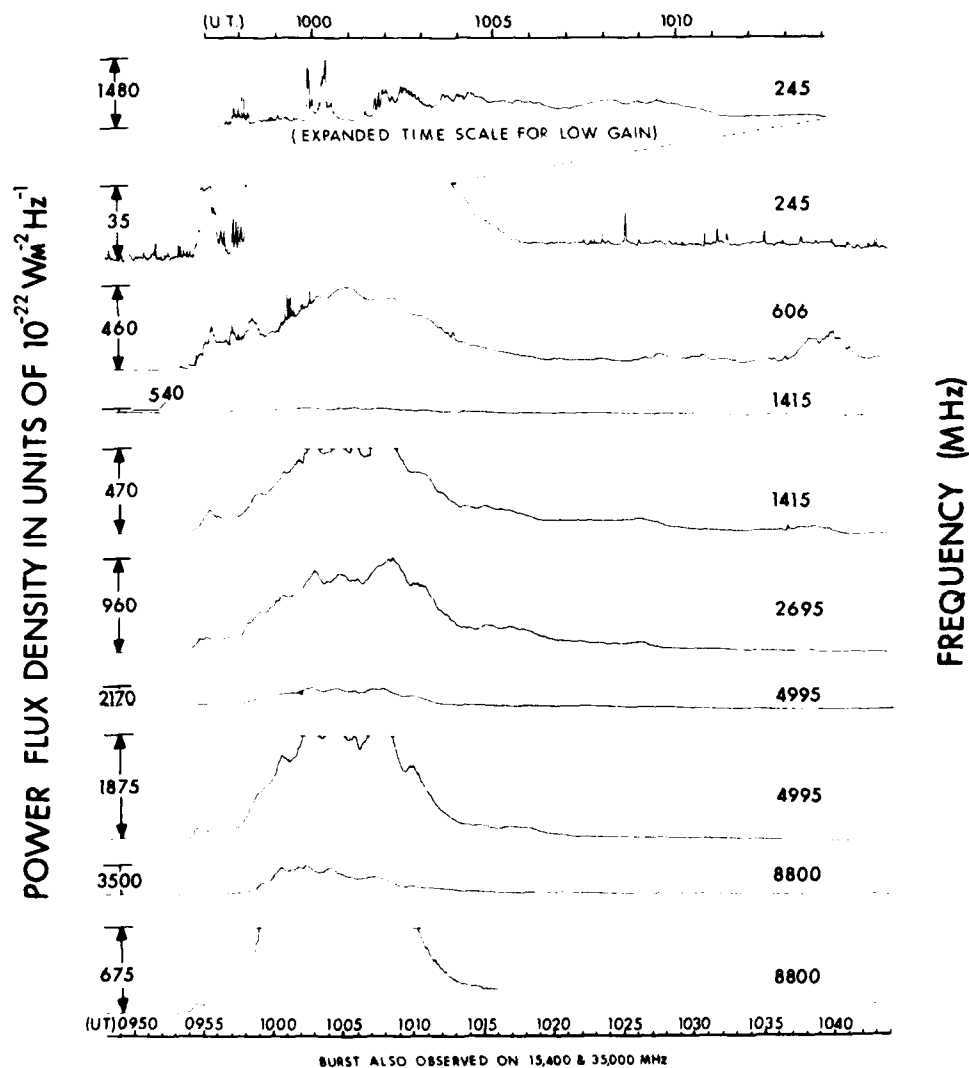
SIMPLE 2F & COMPLEX F RADIO BURSTS
OBSERVED ON 6 MAY 1969 AT MANILA
OBSERVATORY, R. P.



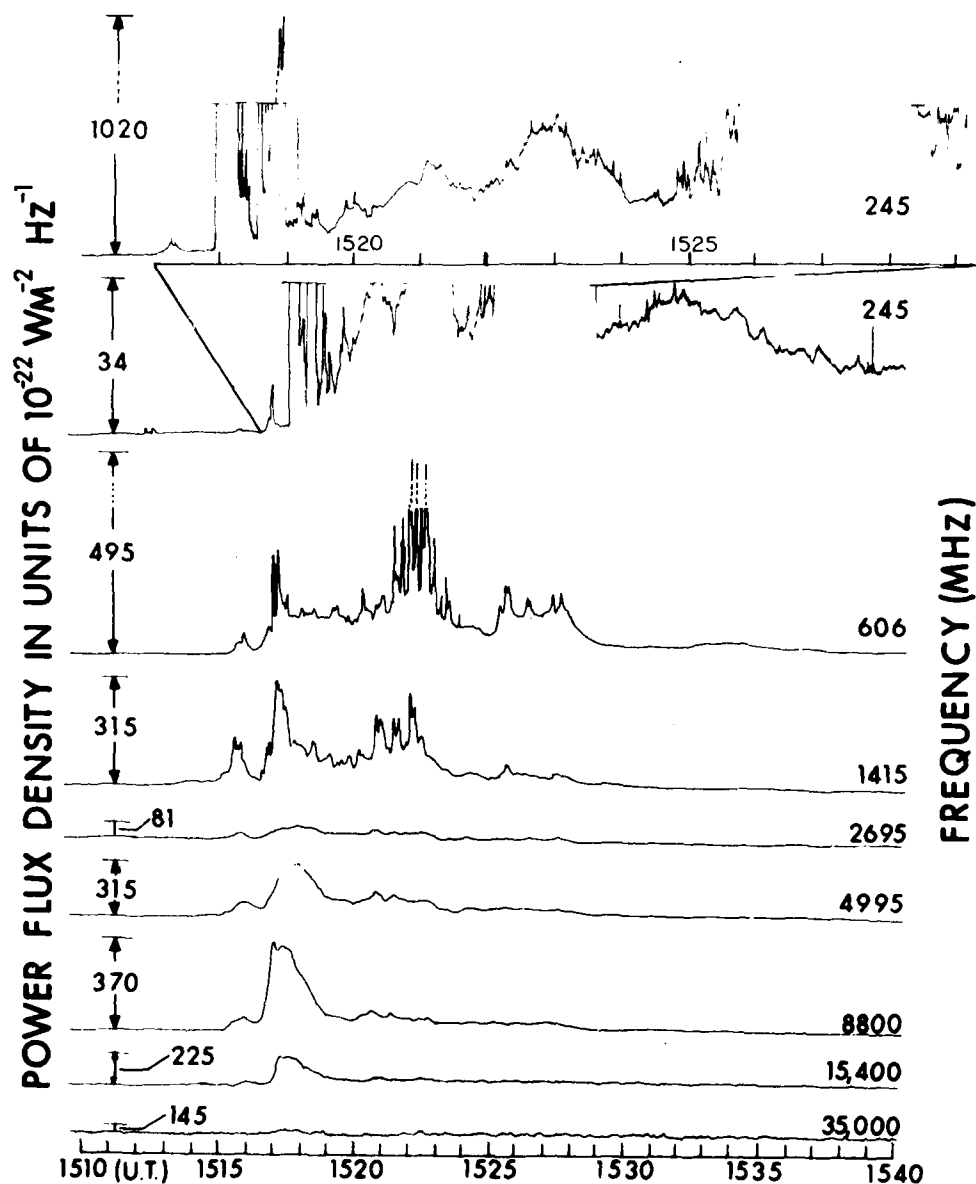
COMPLEX RADIO BURST OBSERVED ON 17 MAY, 1969
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



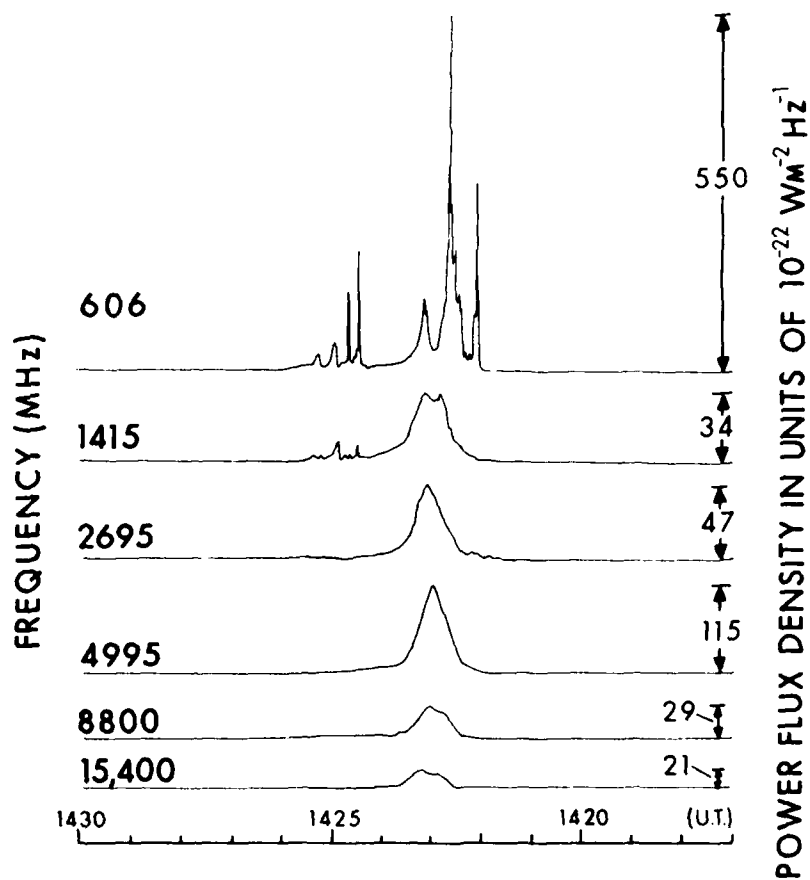
COMPLEX F RADIO BURST WITH HIGH FREQUENCY
CUT-OFF OBSERVED ON 24 MAY 1969 AT MANILA
OBSERVATORY, R. P.



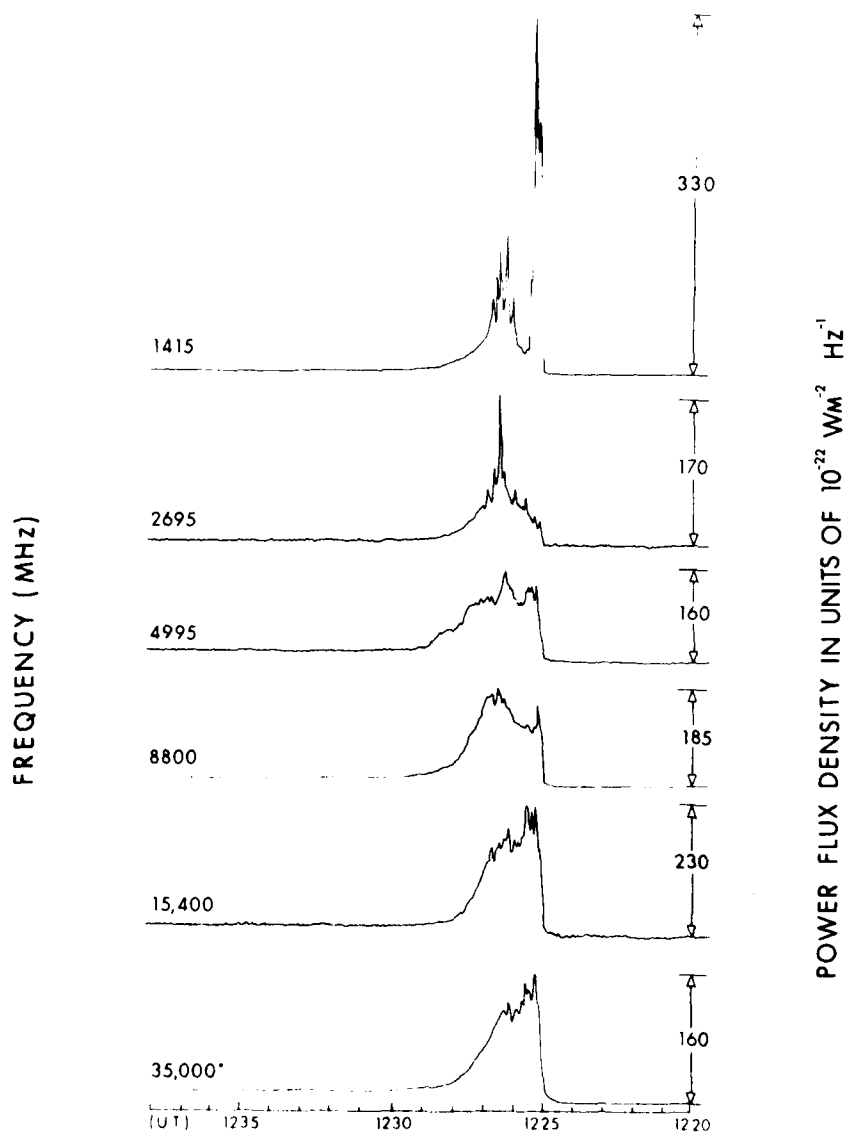
COMPLEX RADIO BURST OBSERVED 5 JUNE, 1969
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



**SIMPLE 2 AND COMPLEX RADIO BURST 3 JULY, 1969
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.**



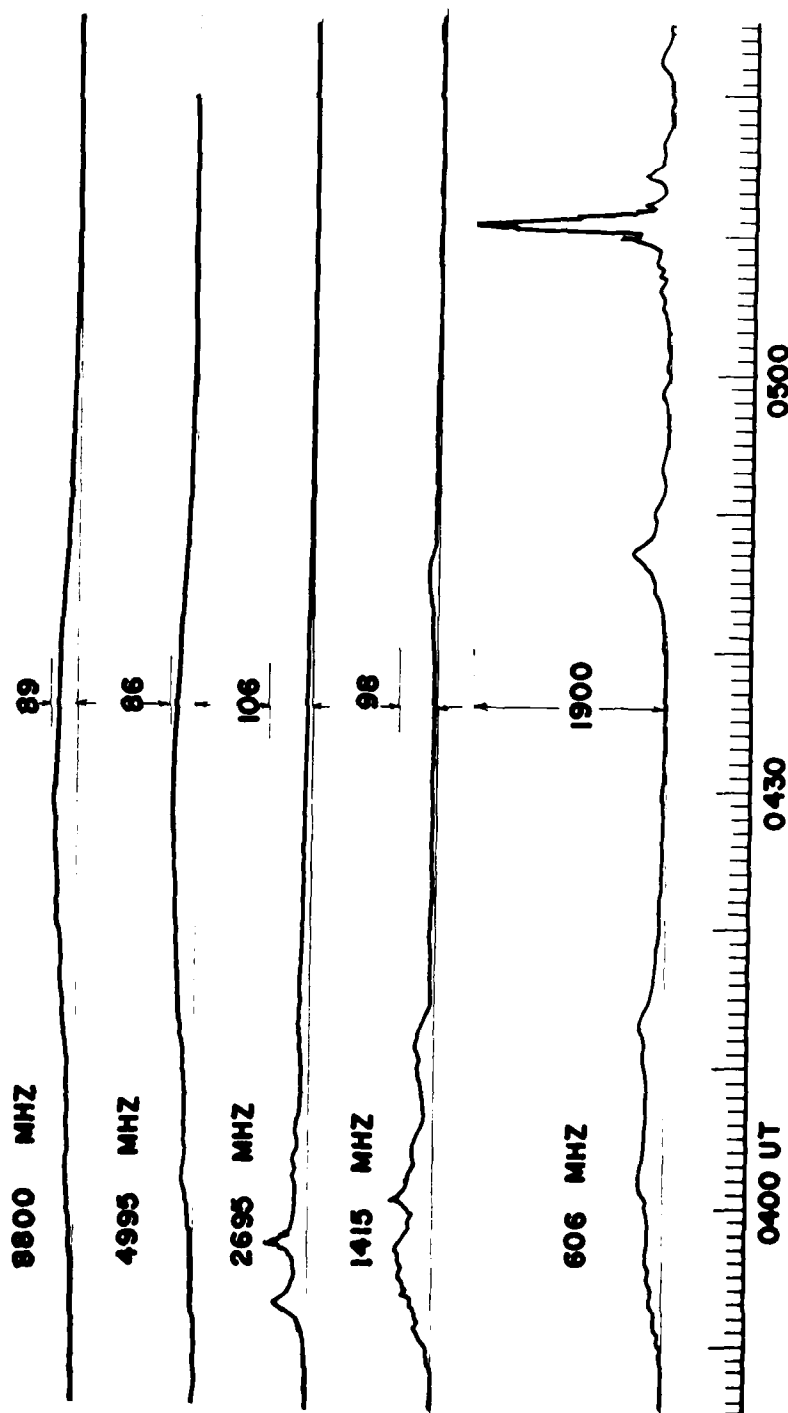
COMPLEX AND SIMPLE 2 RADIO BURST
OBSERVED ON 10 AUGUST, 1969 AT
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



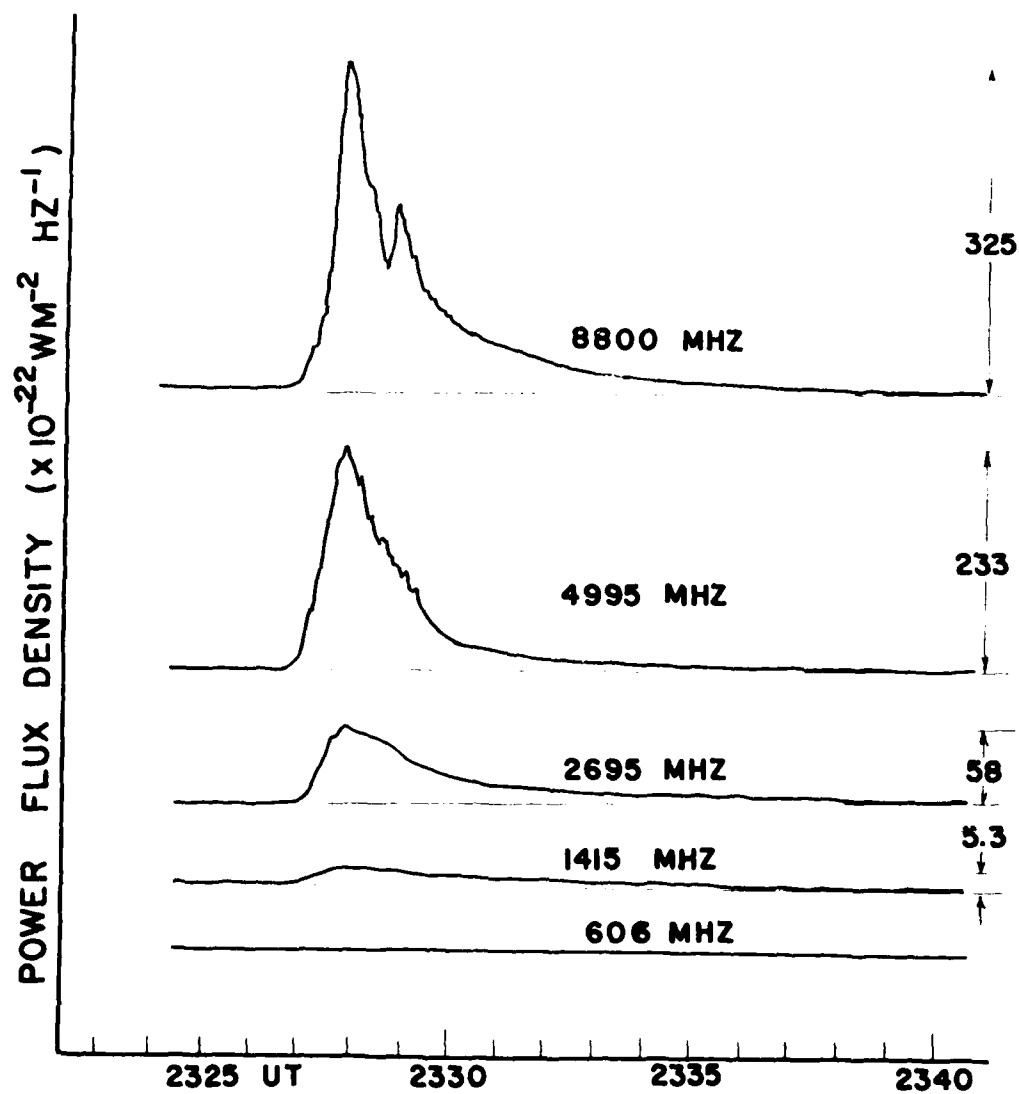
COMPLEX "F" AND SIMPLE 2"F" RADIO BURST OBSERVED ON
15 SEPT., 1969 AT SAGAMORE HILL RADIO OBSERVATORY AT
HAMILTON, MASS.

*BURST RECONSTRUCTED

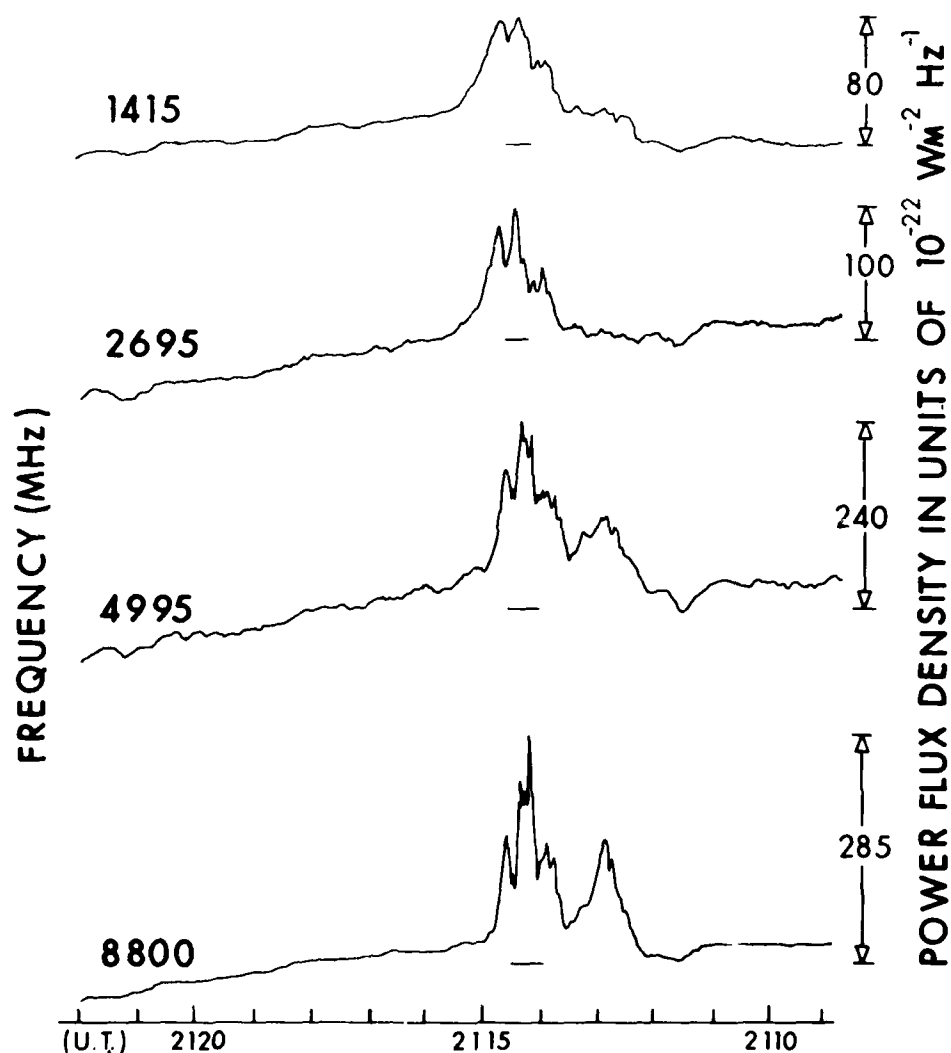
POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ WM}^{-2} \text{ HZ}^{-1}$



COMPLEX RADIO BURSTS ON 27 SEPTEMBER 1969
OBSERVED AT MANILA OBSERVATORY, R. P.



RADIO BURST OBSERVED
ON 11 OCTOBER, 1969
AT MANILA OBSERVATORY



COMPLEX F RADIO BURST OBSERVED ON
24 OCTOBER, 1969
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS

(NOTE: SUNSET TIME 2143 U.T.)

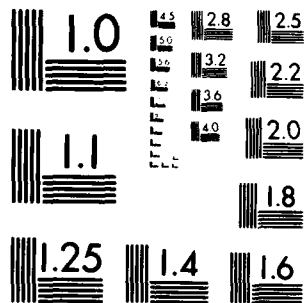
AD-A088 220

AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA F/O 3/2
AN ATLAS OF SELECTED MULTI-FREQUENCY RADIO BURSTS FROM THE TWEN--ETC(U)
APR 80 W R BARRON, V L BADILLO, E W CLIVER
AFOL-TR-80-0098

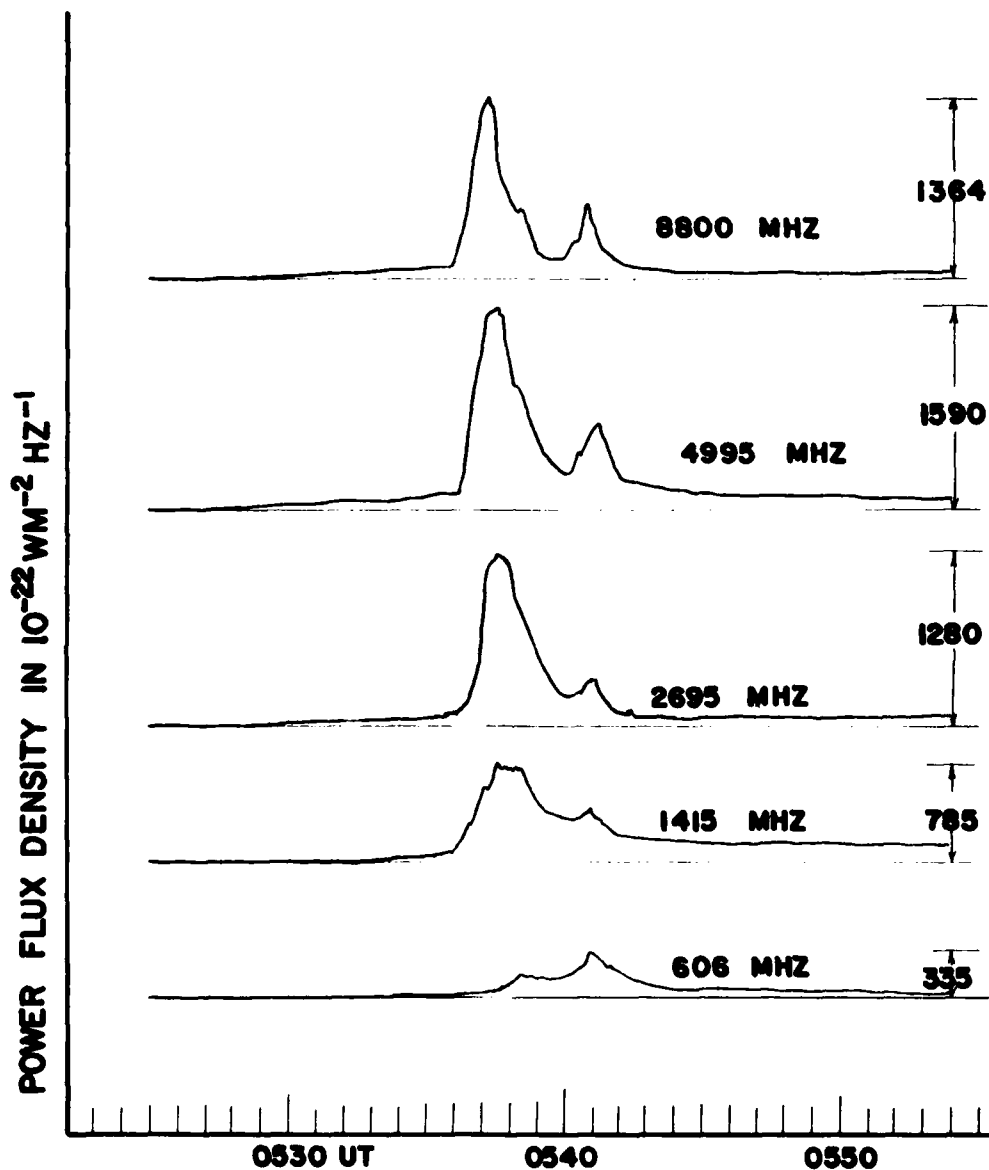
UNCLASSIFIED

2 of 3

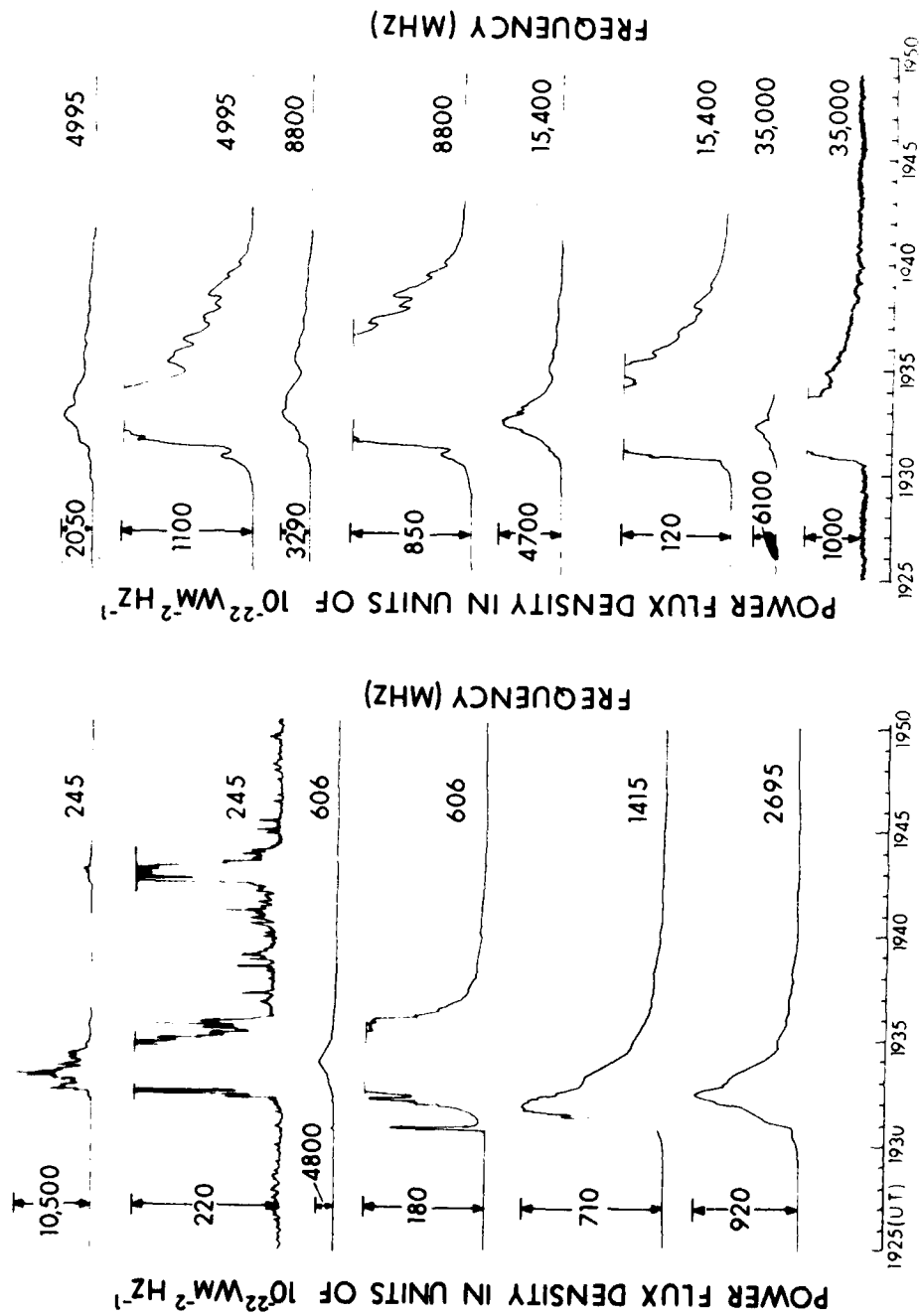
3064-224:



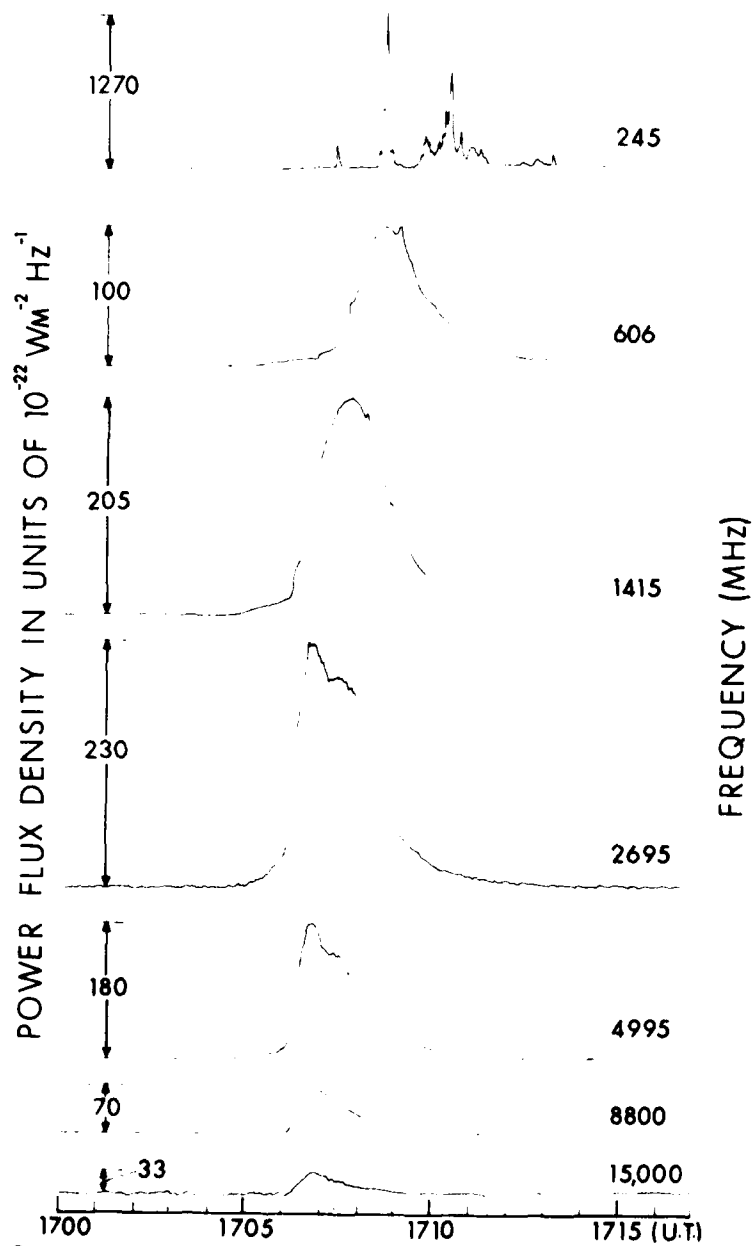
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A



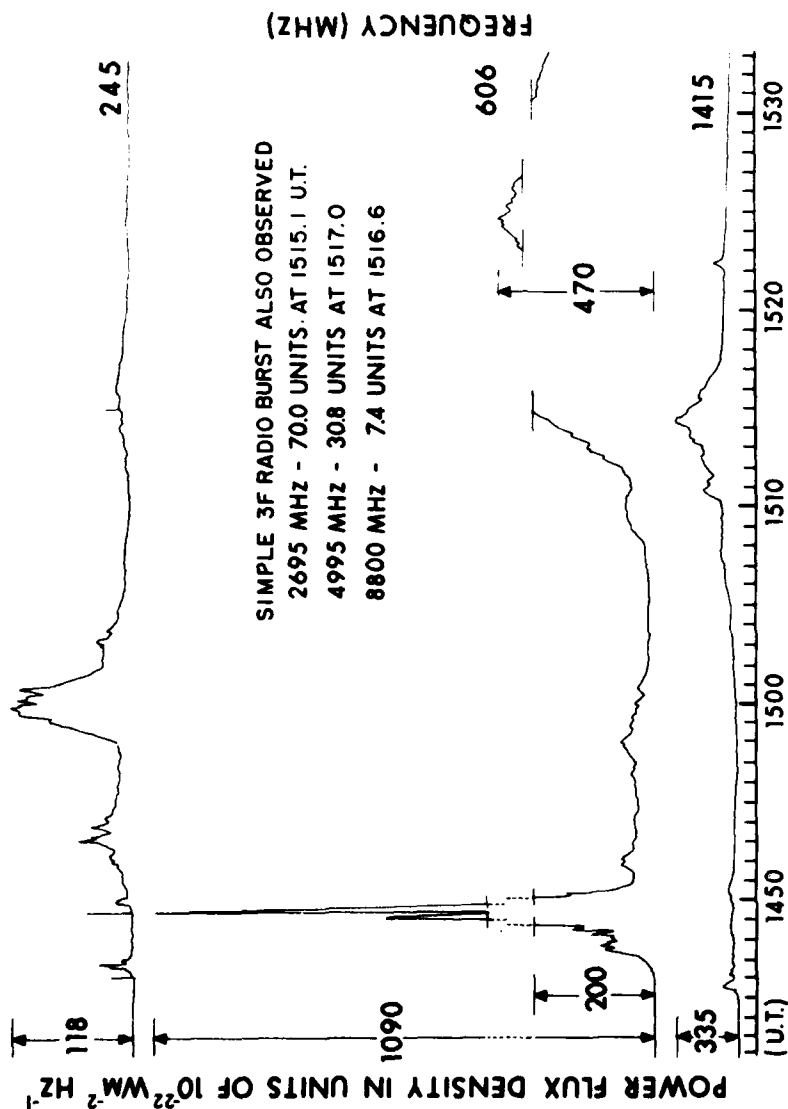
GREAT RADIO BURST PBI LASTED 60 MINUTES
OBSERVED ON 19 NOVEMBER, 1969 AT
MANILA OBSERVATORY



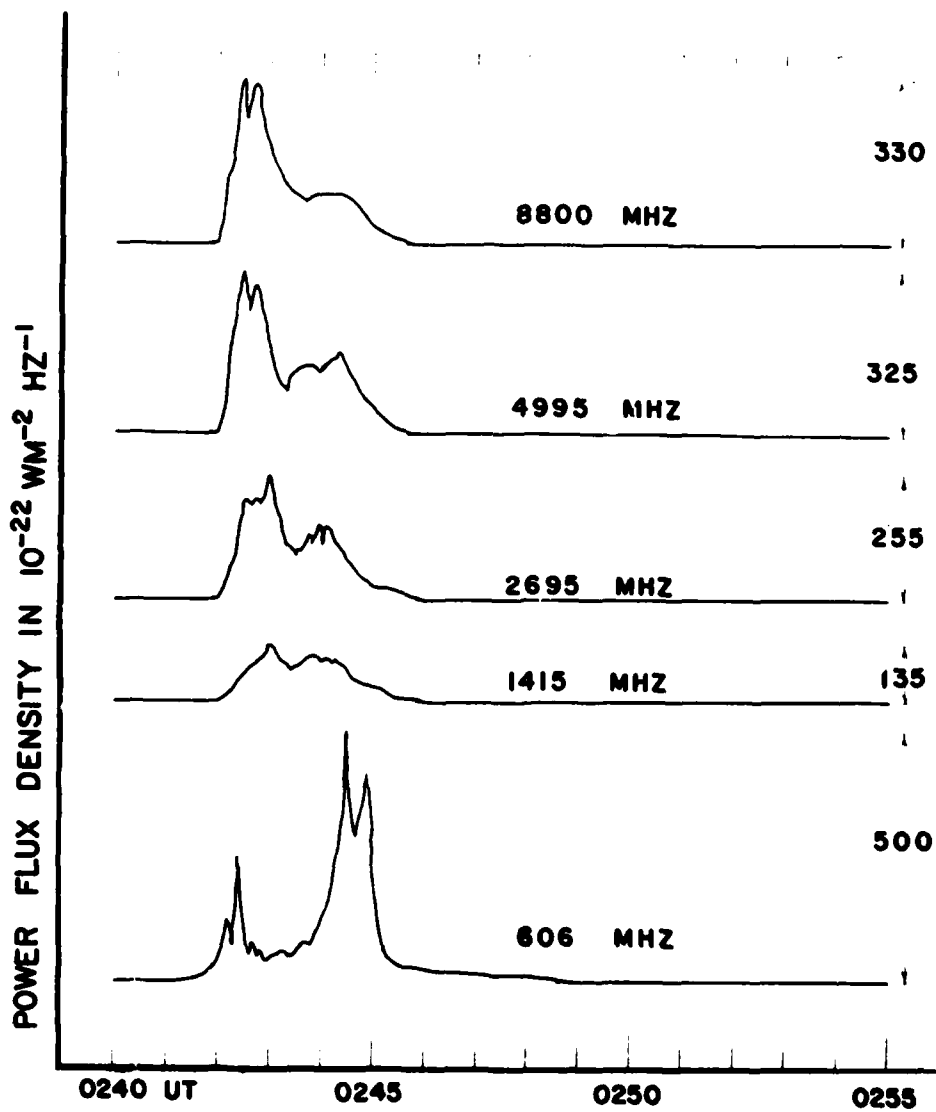
GREAT BURST OBSERVED 27 NOVEMBER, 1969 AT SAGAMORE HILL
RADIO OBSERVATORY, HAMILTON, MASS.



SIMPLE 2 AND 2F RADIO BURST OBSERVED ON
30 NOVEMBER, 1969
AT SAGAMORE HILL RADIO OBSERVATORY

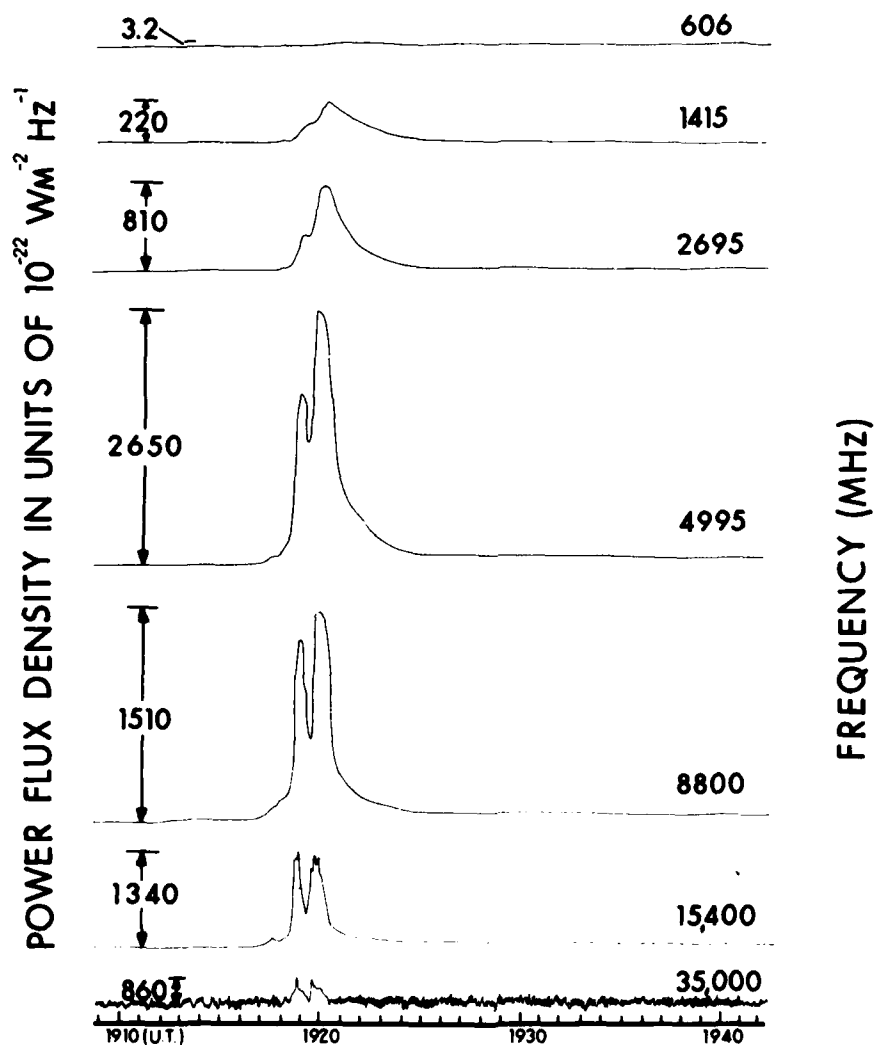


COMPLEX RADIO BURST OBSERVED 18 DECEMBER, 1969
 AT SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.

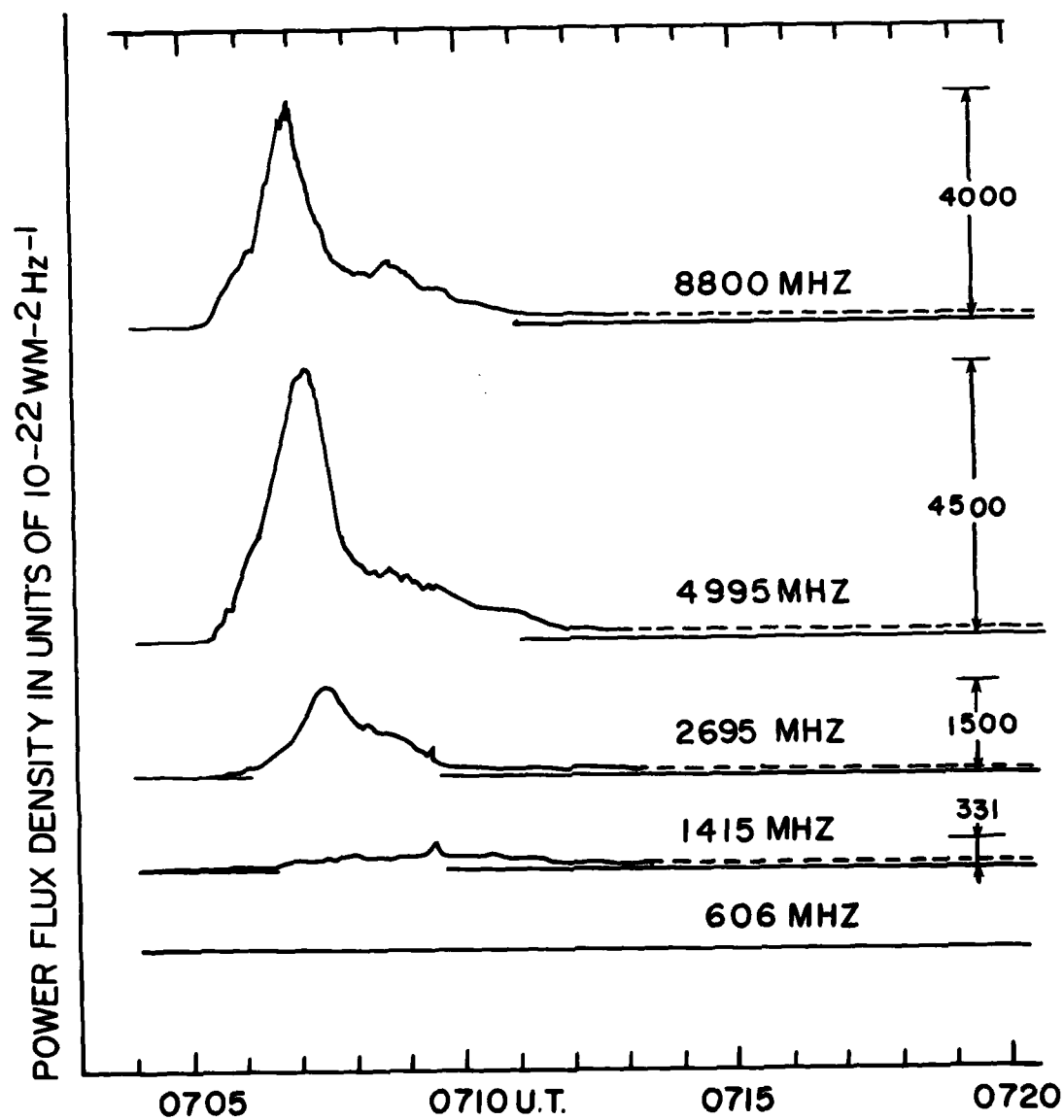


RADIO BURST OBSERVED
ON 26 DECEMBER 1969
AT MANILA OBSERVATORY

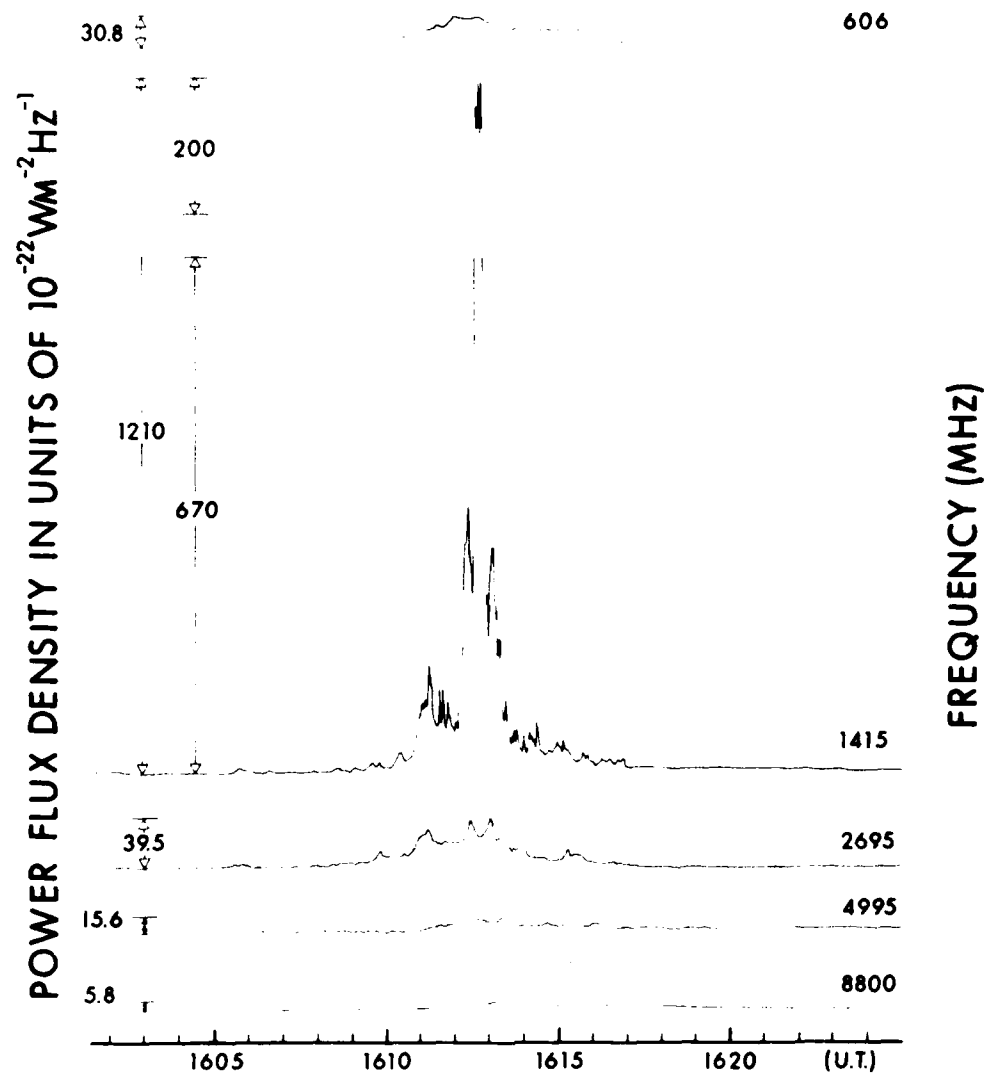
**Solar Radio Bursts
1970**



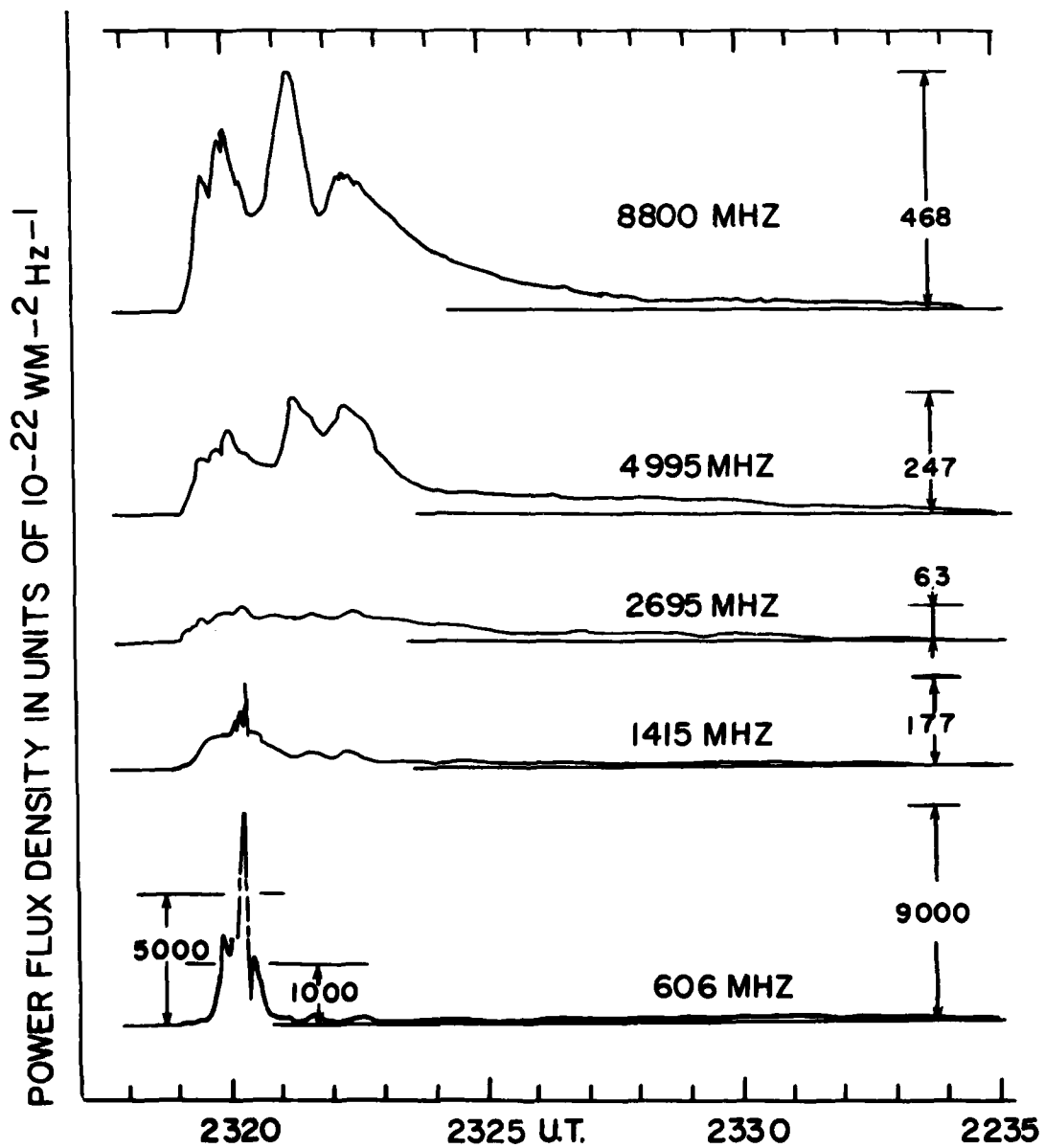
GREAT BURST OBSERVED ON 28 JANUARY, 1970
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



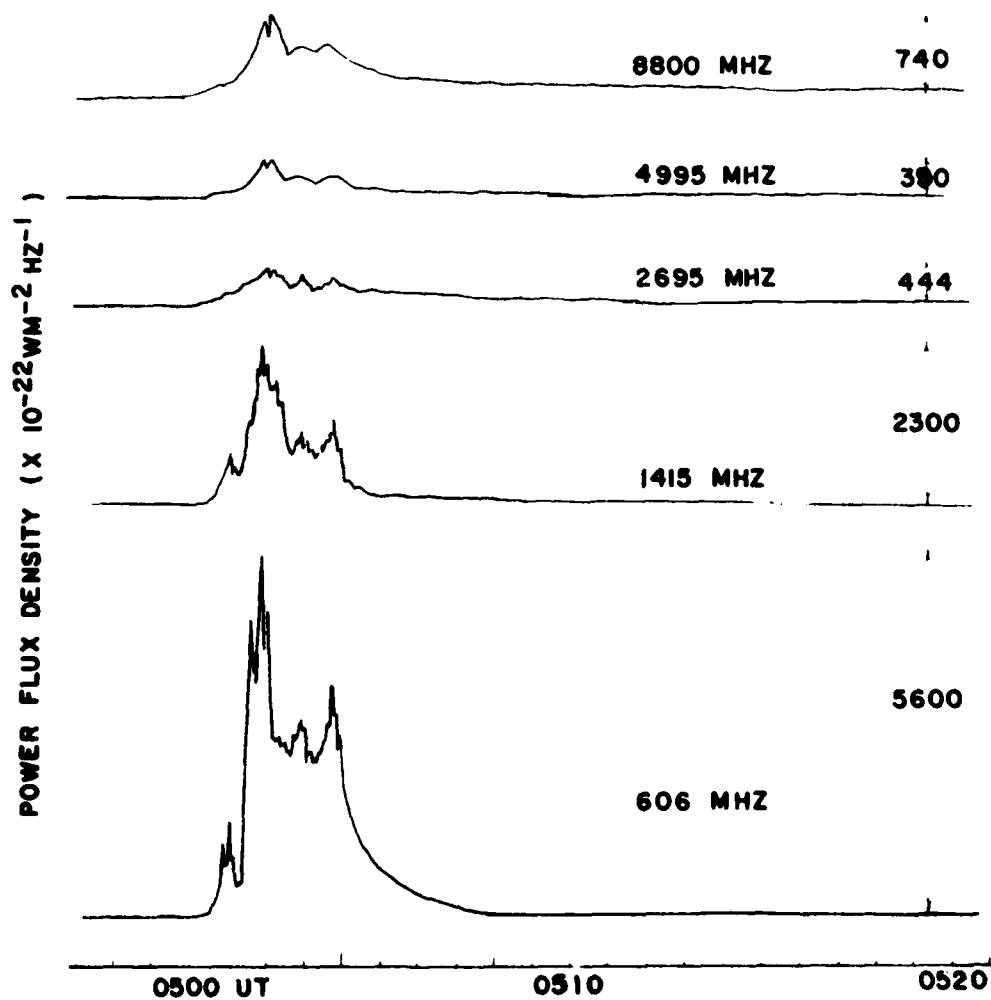
GREAT RADIO BURST OF 11 FEBRUARY, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.



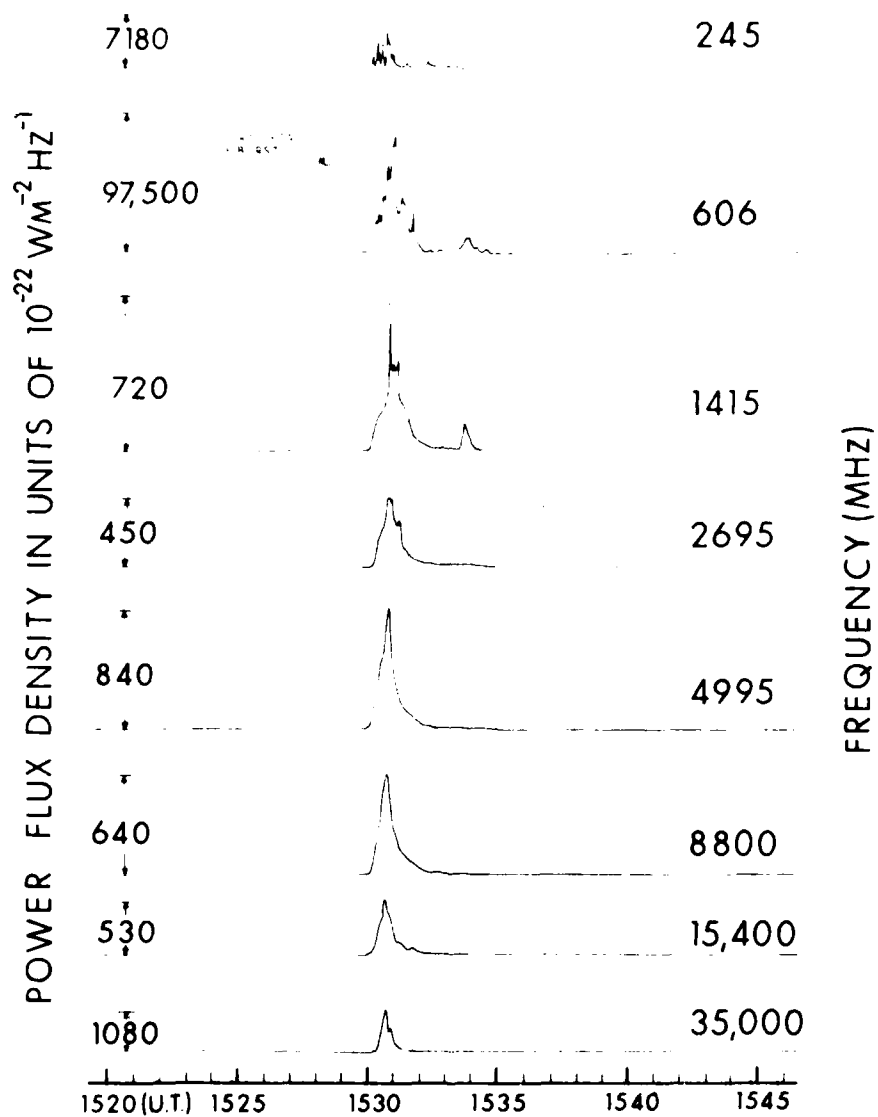
COMPLEX BURST OBSERVED 21 FEBRUARY, 1970
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



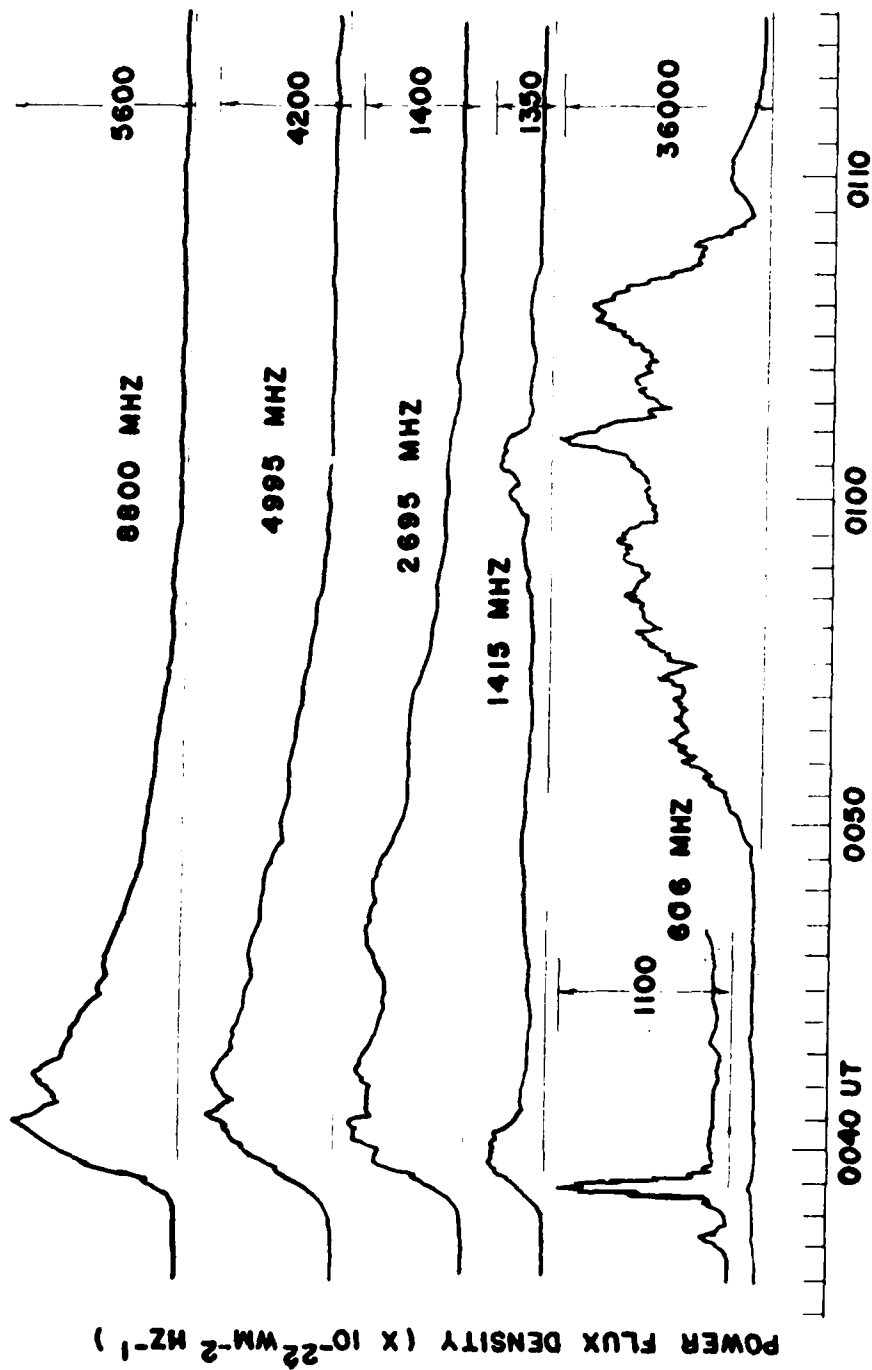
**COMPLEX RADIO BURST OF 27 FEBRUARY, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.**



SIMPLE 2F RADIO BURST OF 1 MARCH, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.

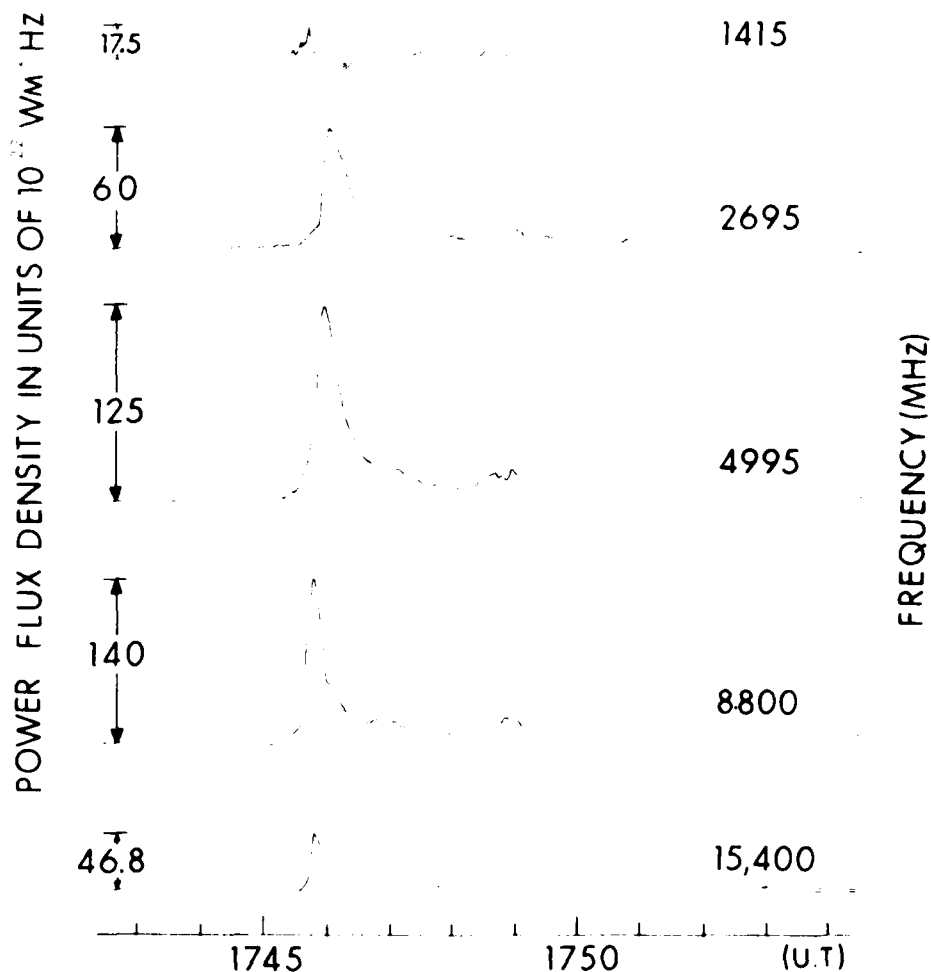


SIMPLE 2 AND COMPLEX RADIO BURST OBSERVED ON
1 MARCH, 1970 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

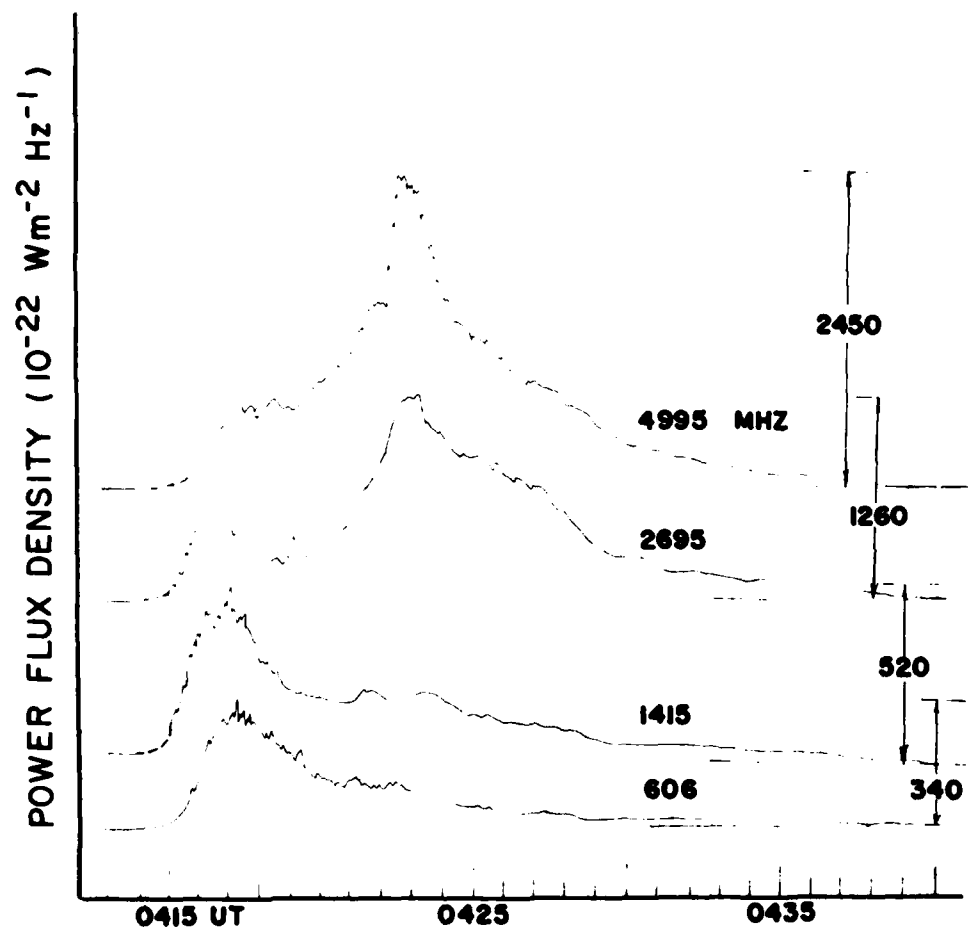


GREAT RADIO BURST OF 29 MARCH, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.

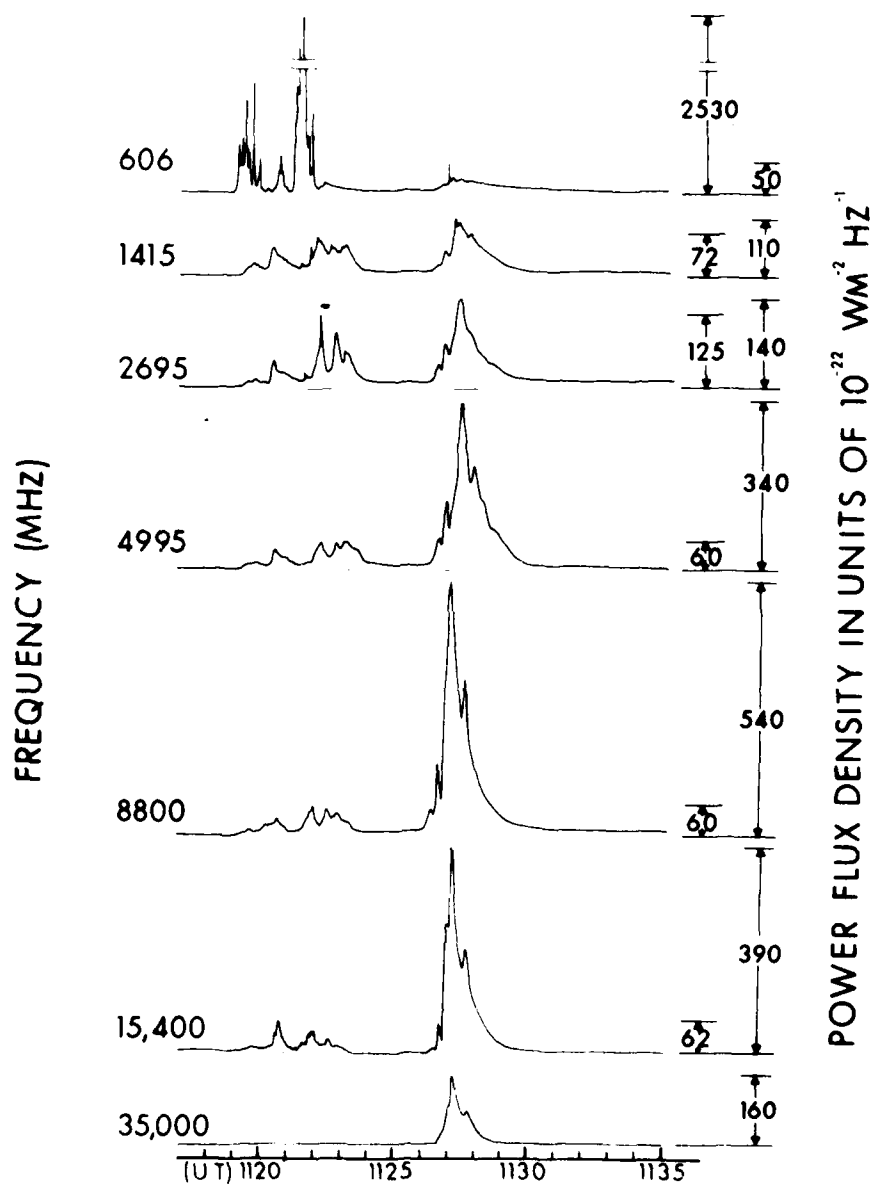
NOTE: 0.2 dB ABSORPTION BEGAN 1746, MAXIMUM
1751, ENDED 1800 (U.T.) AT 30 MHz



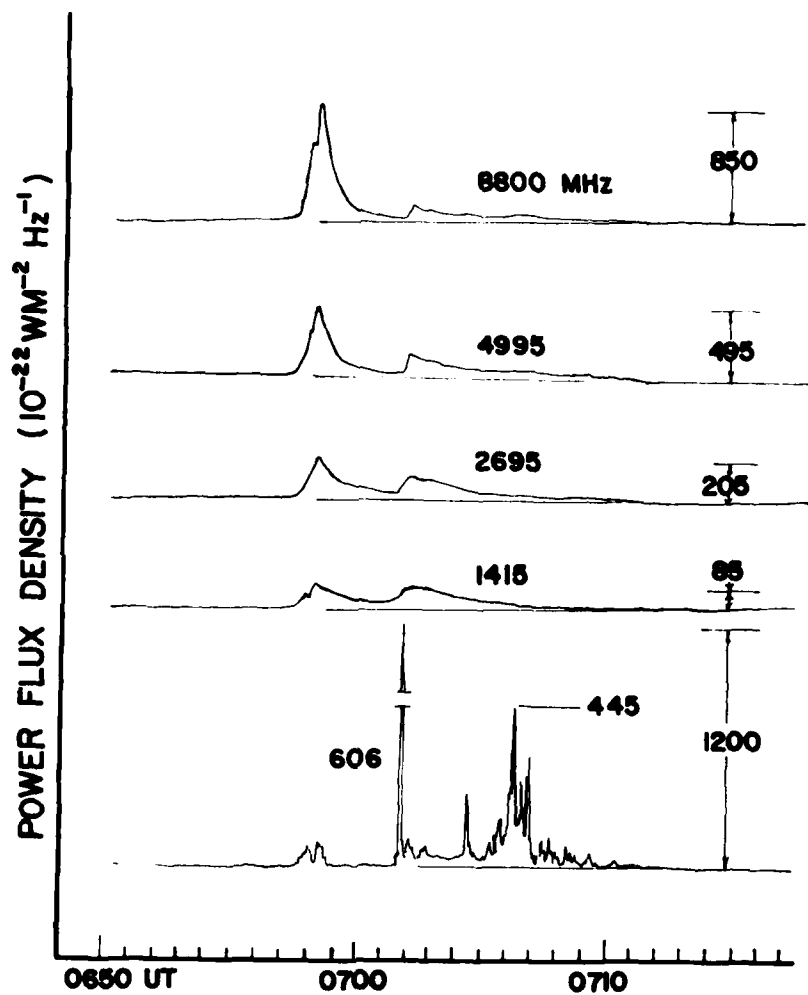
SIMPLE 2 RADIO BURST OBSERVED
ON 5 APRIL, 1970 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



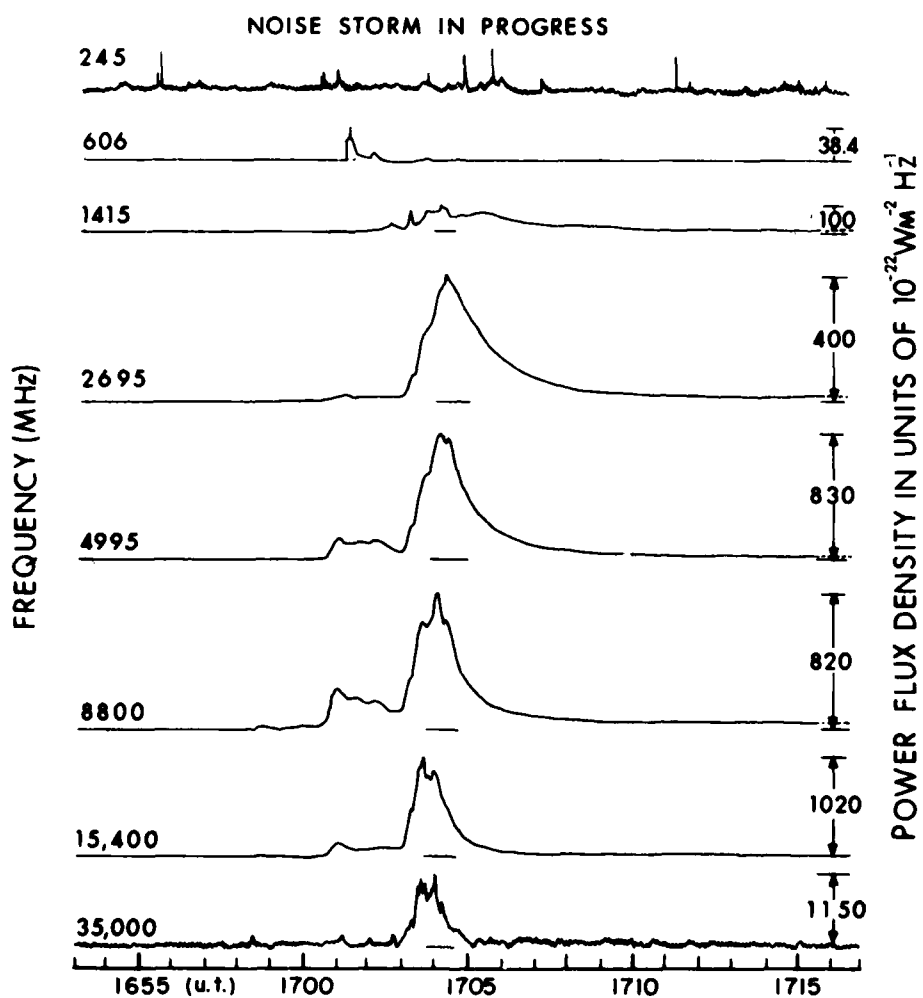
GREAT RADIO BURST OF APRIL 15, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.
OUTAGE ON X-BAND



COMPLEX & SIMPLE 2F RADIO BURST OBSERVED 29 MAY, 1970
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.

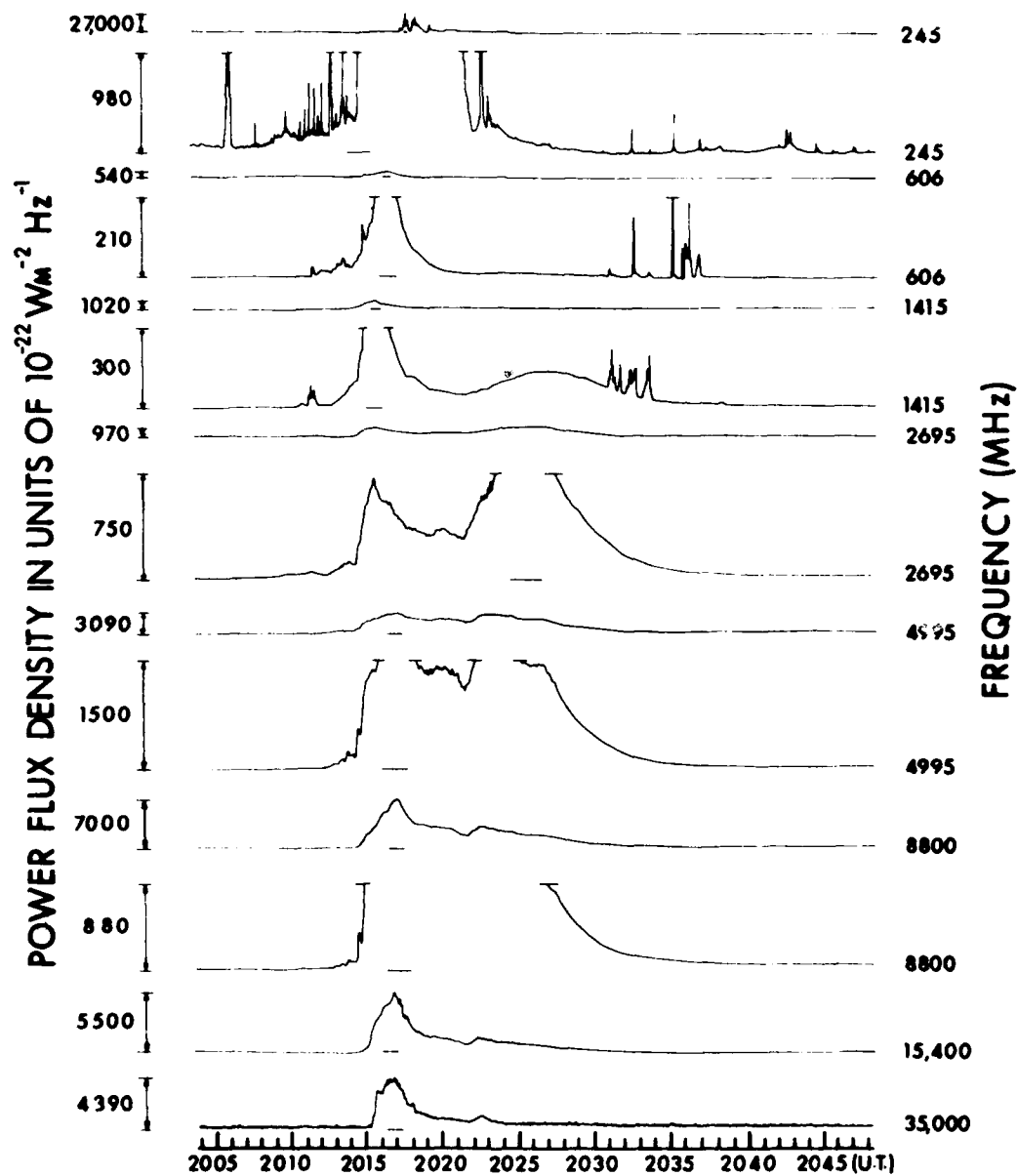


COMPLEX RADIO BURST OBSERVED ON
JUNE 13, 1970 AT MANILA OBSERVATORY,
R. P.

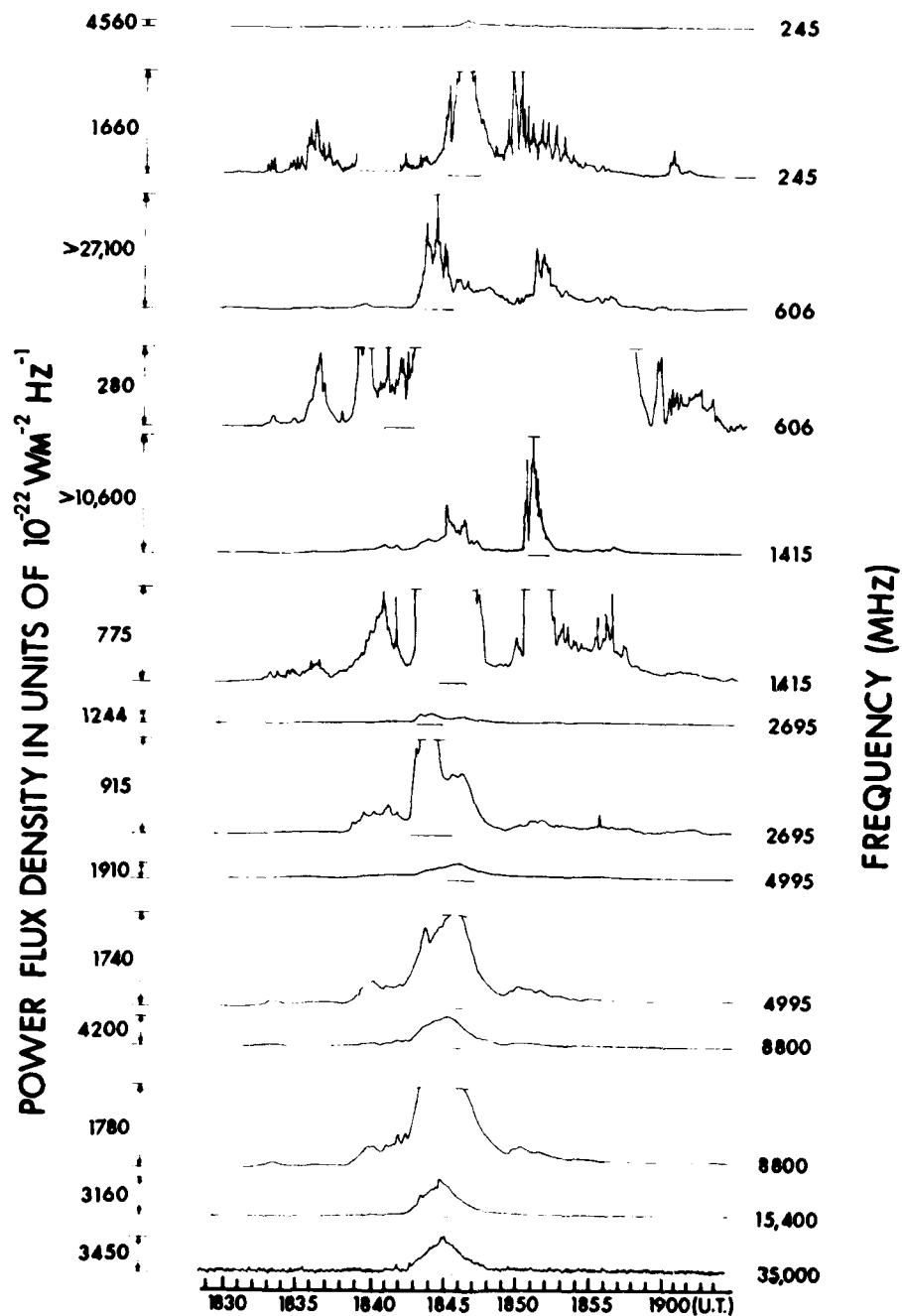


COMPLEX AND 2F RADIO BURST OBSERVED ON 14 JUNE, 1970
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

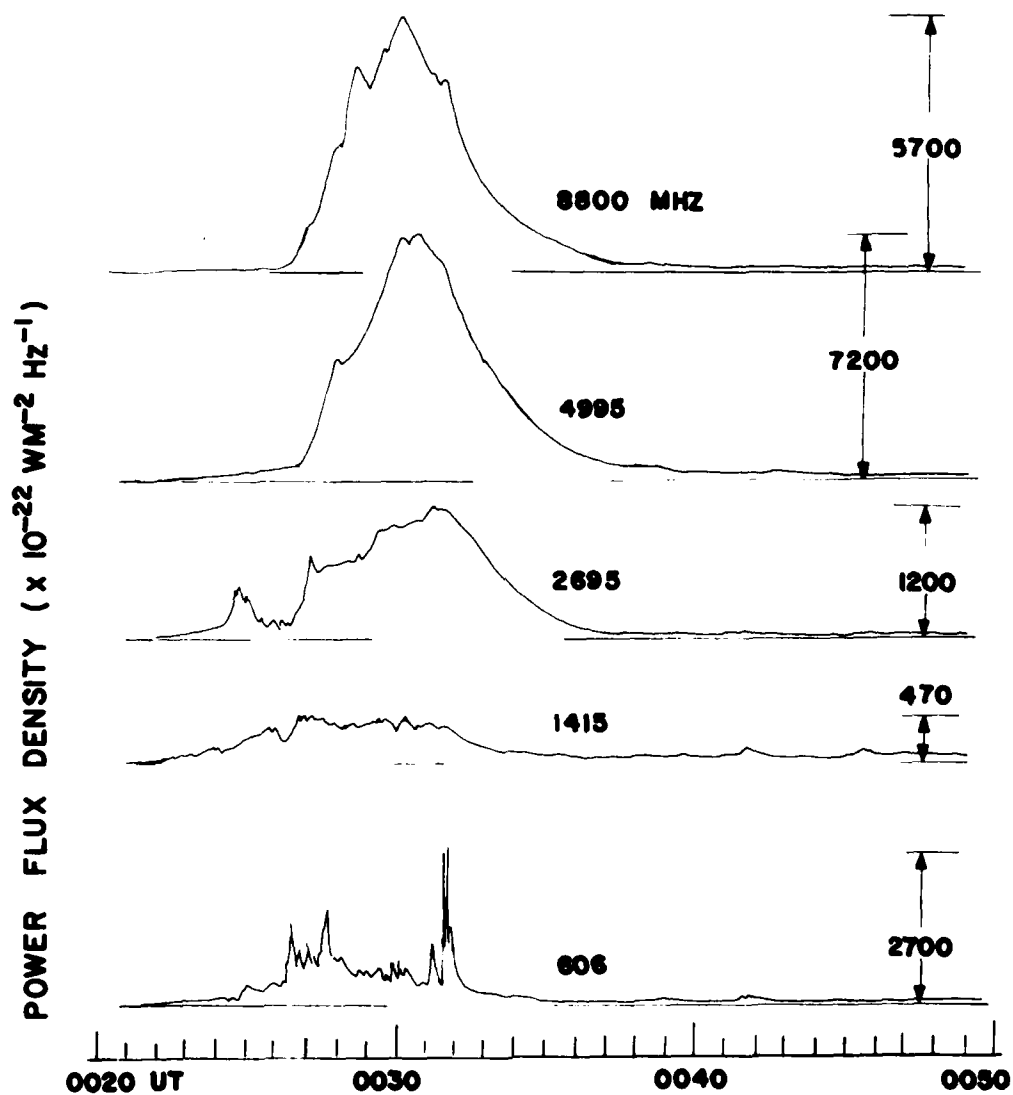
Note: 4.5 db. absorption observed at 1706 u.t. on 30 MHz riometer.



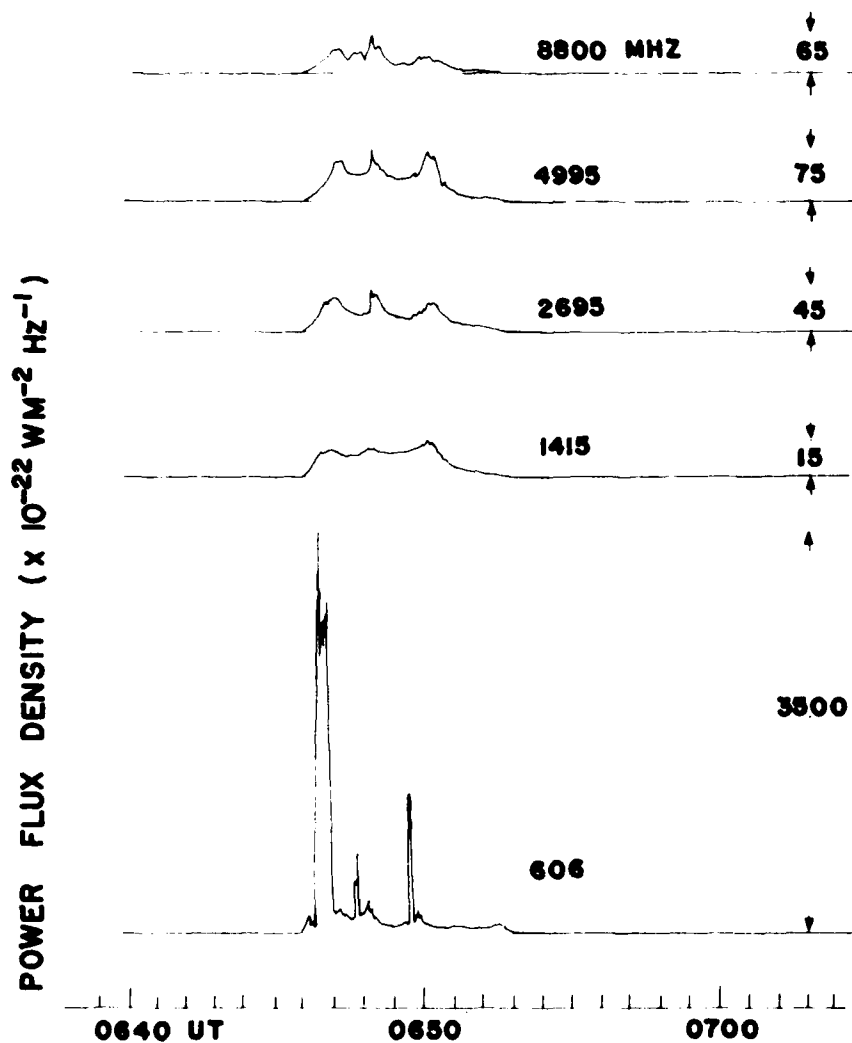
GREAT BURST OBSERVED 12 AUGUST, 1970 AT SAGAMORE HILL
RADIO OBSERVATORY, HAMILTON, MASS.



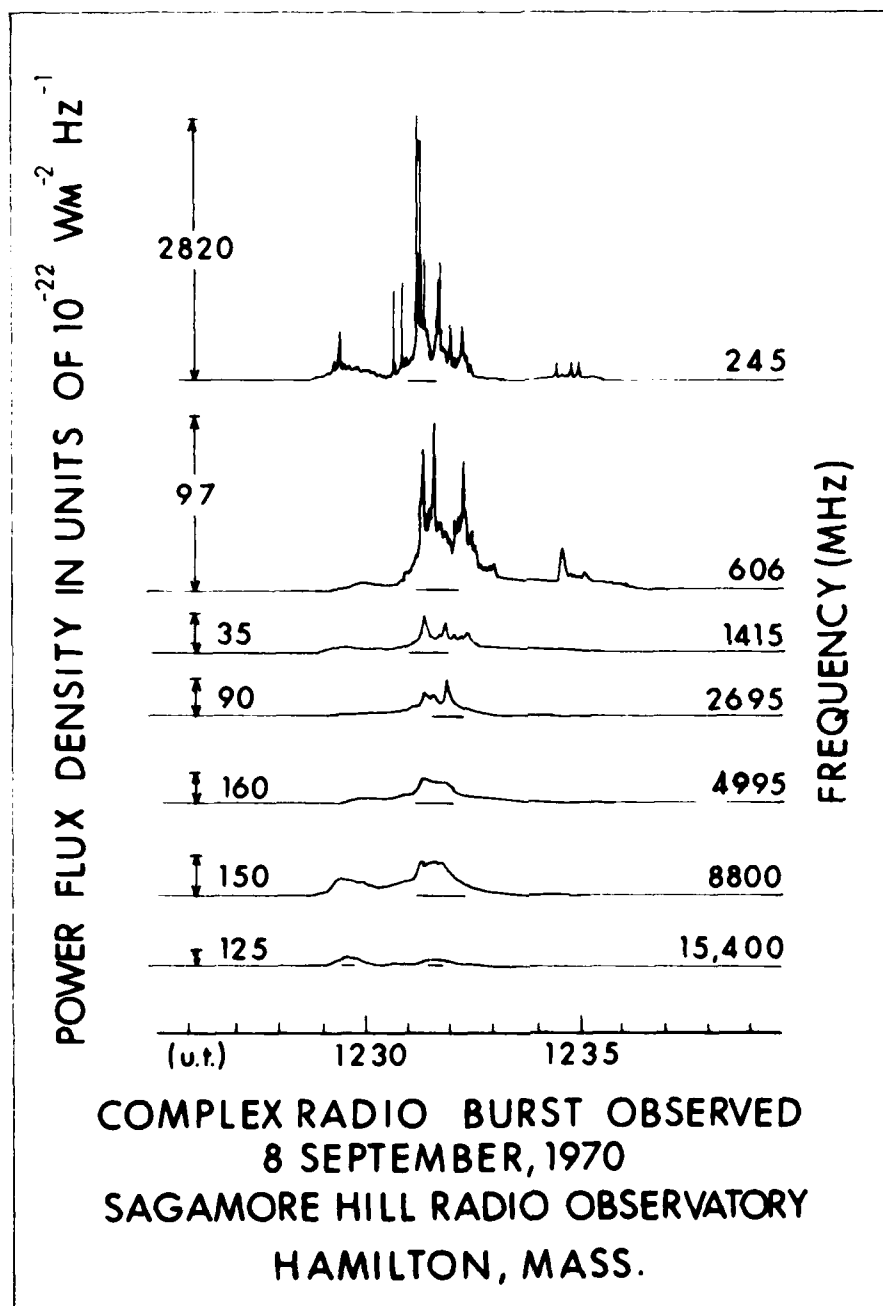
GREAT BURST OBSERVED 23 JULY, 1970 AT SAGAMORE HILL
RADIO OBSERVATORY, HAMILTON, MASS.

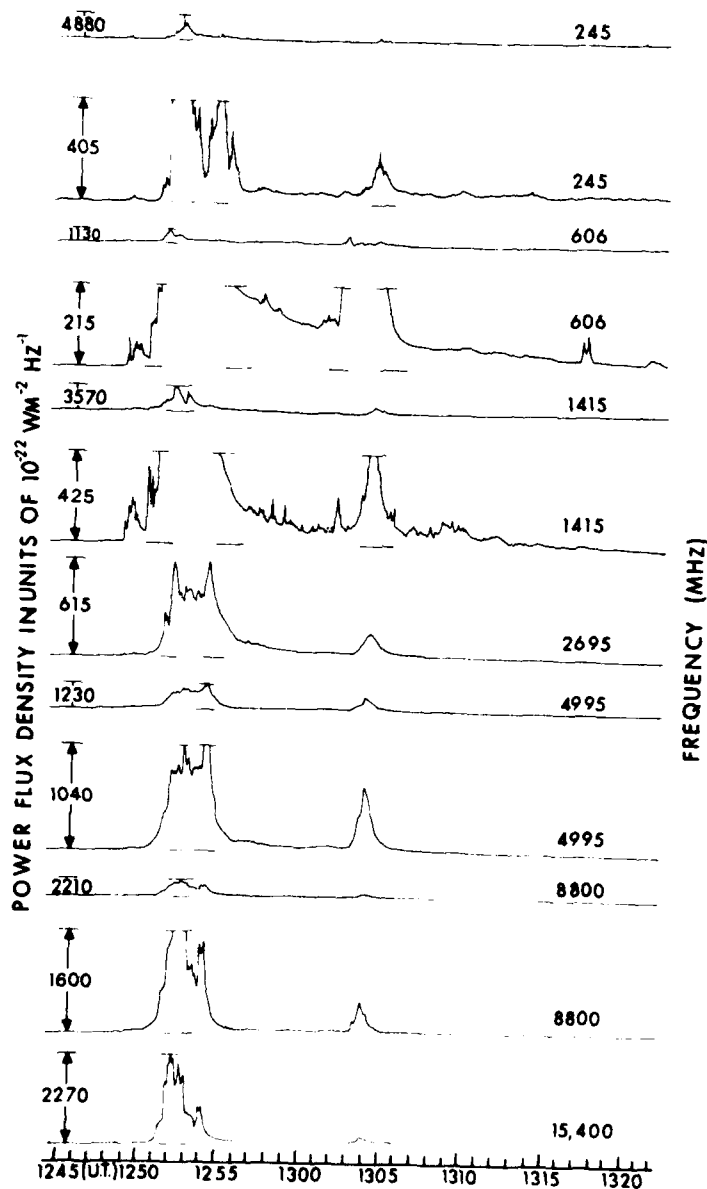


**GREAT RADIO BURST OF JULY 22, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.**

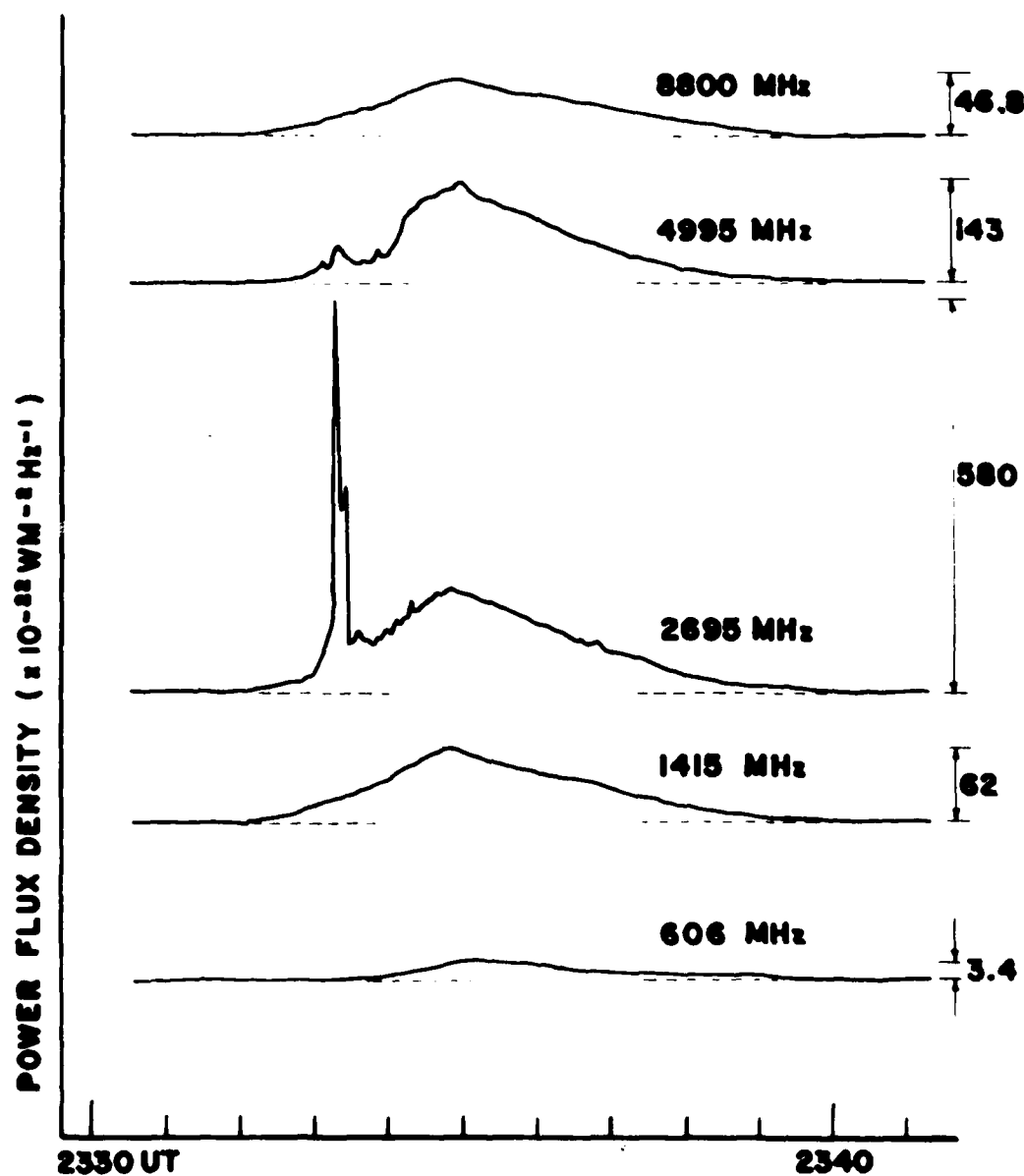


COMPLEX F RADIO BURST OF AUGUST 29, 1970
OBSERVED AT MANILA OBSERVATORY, R.P.

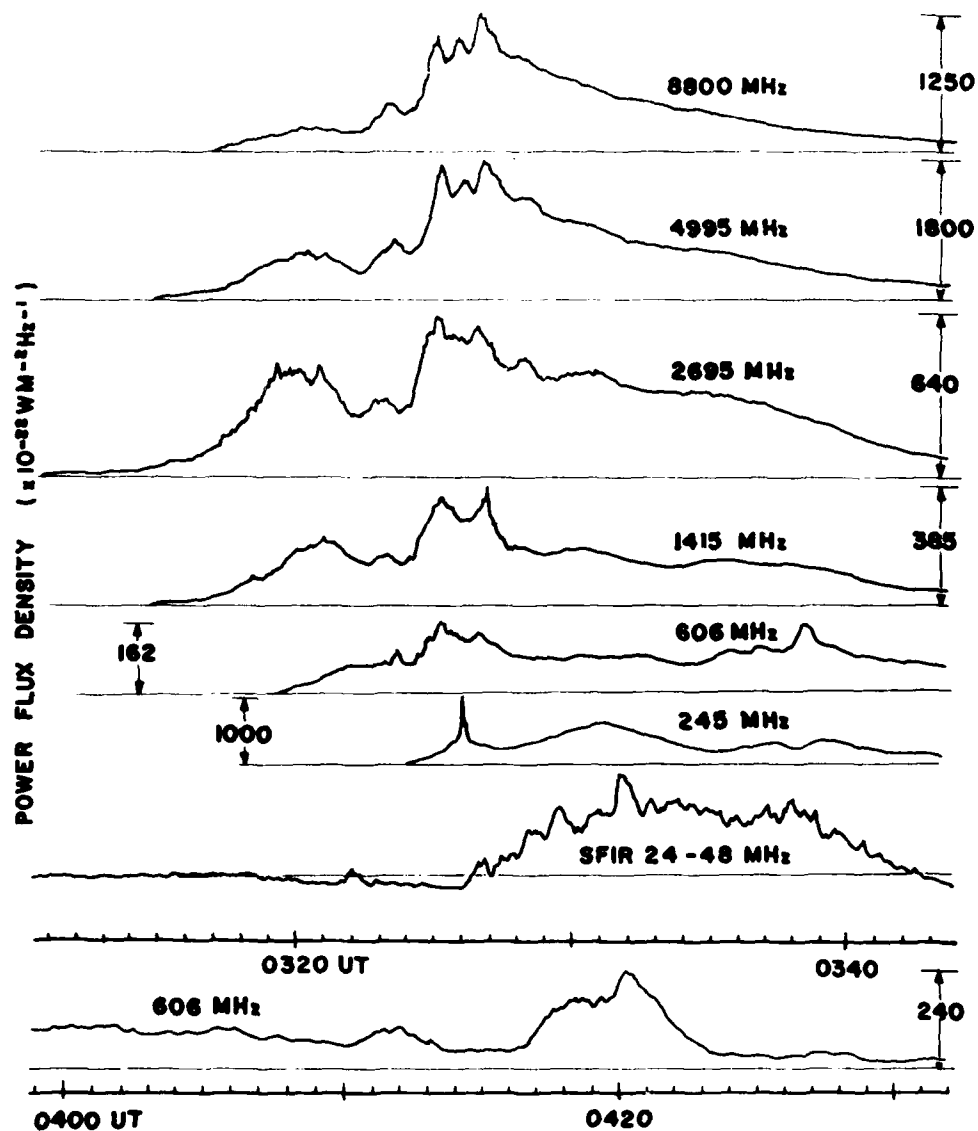




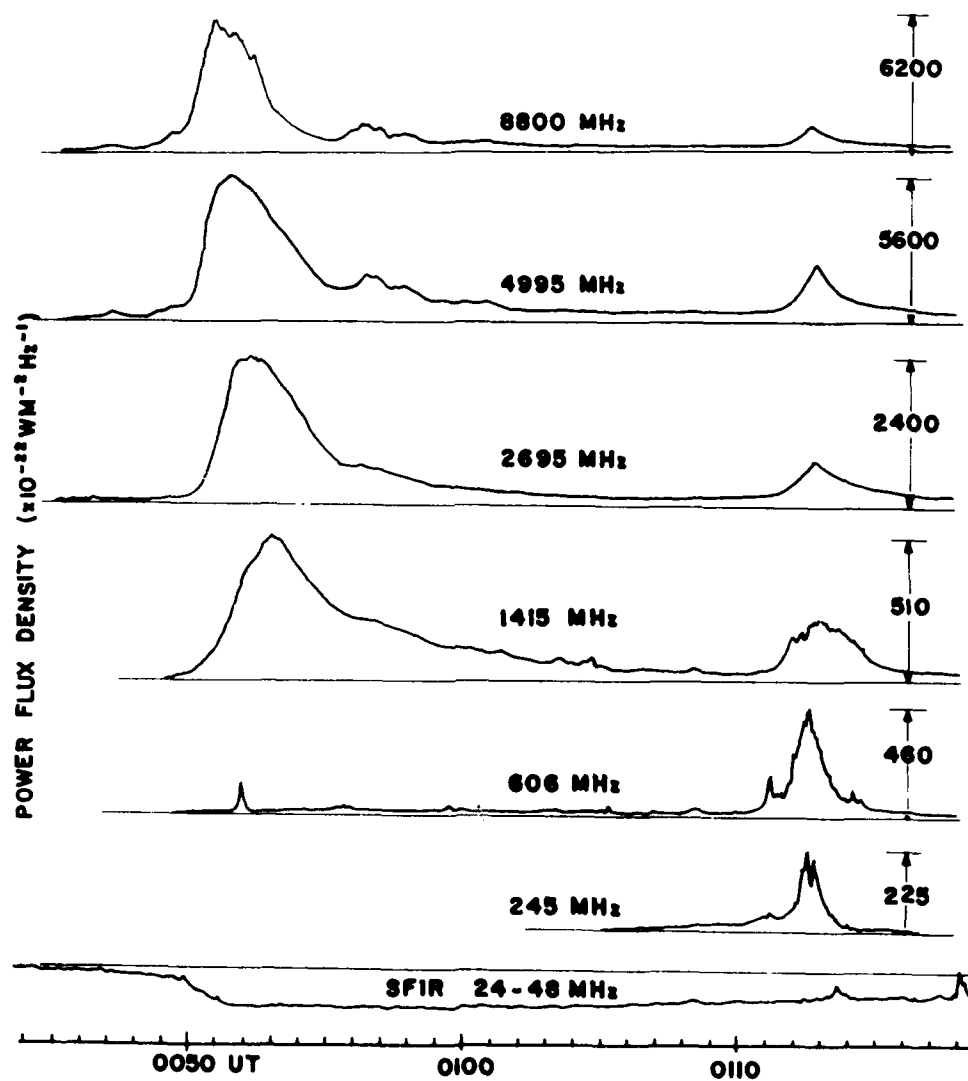
GREAT BURST OBSERVED 28 OCTOBER, 1970 AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



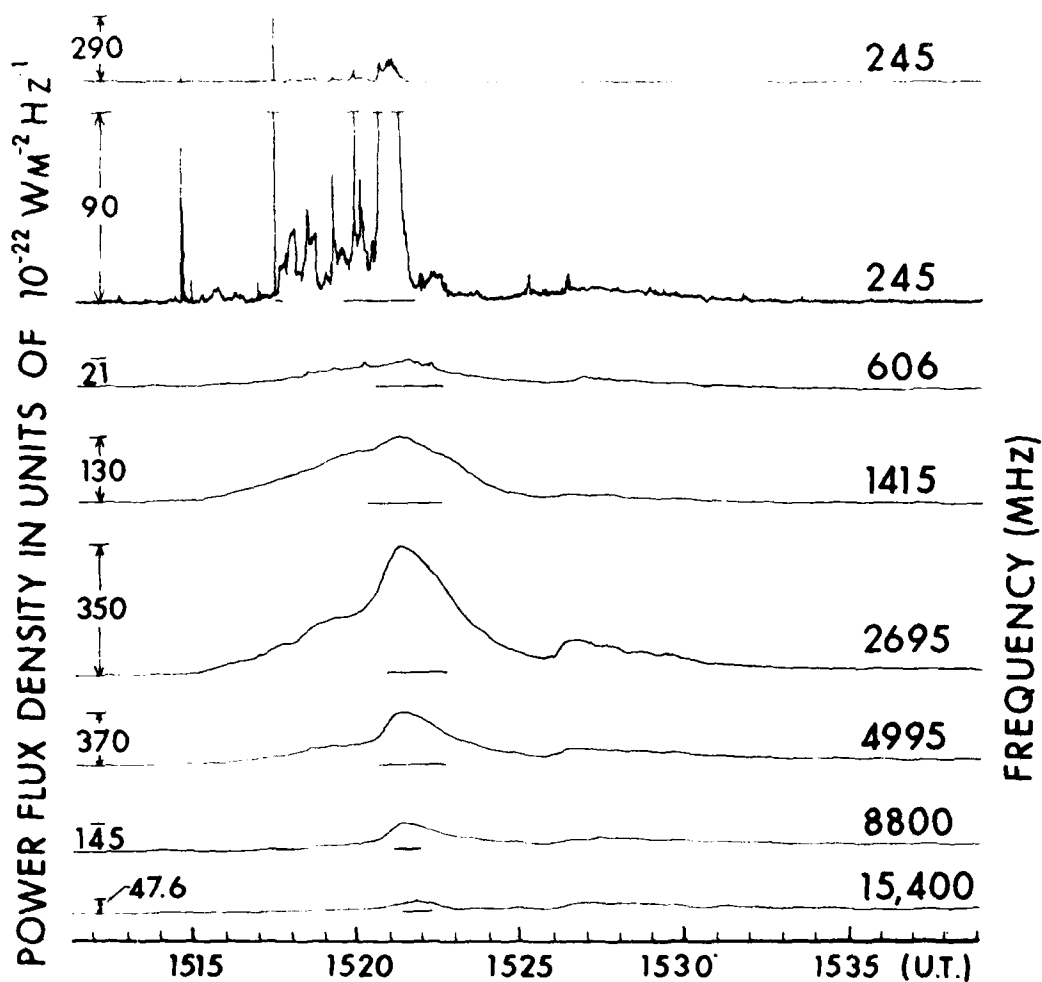
**SIMPLE 2 & COMPLEX F BURSTS OBSERVED ON
30 OCTOBER 1970 AT MANILA OBSERVATORY, R.P.**



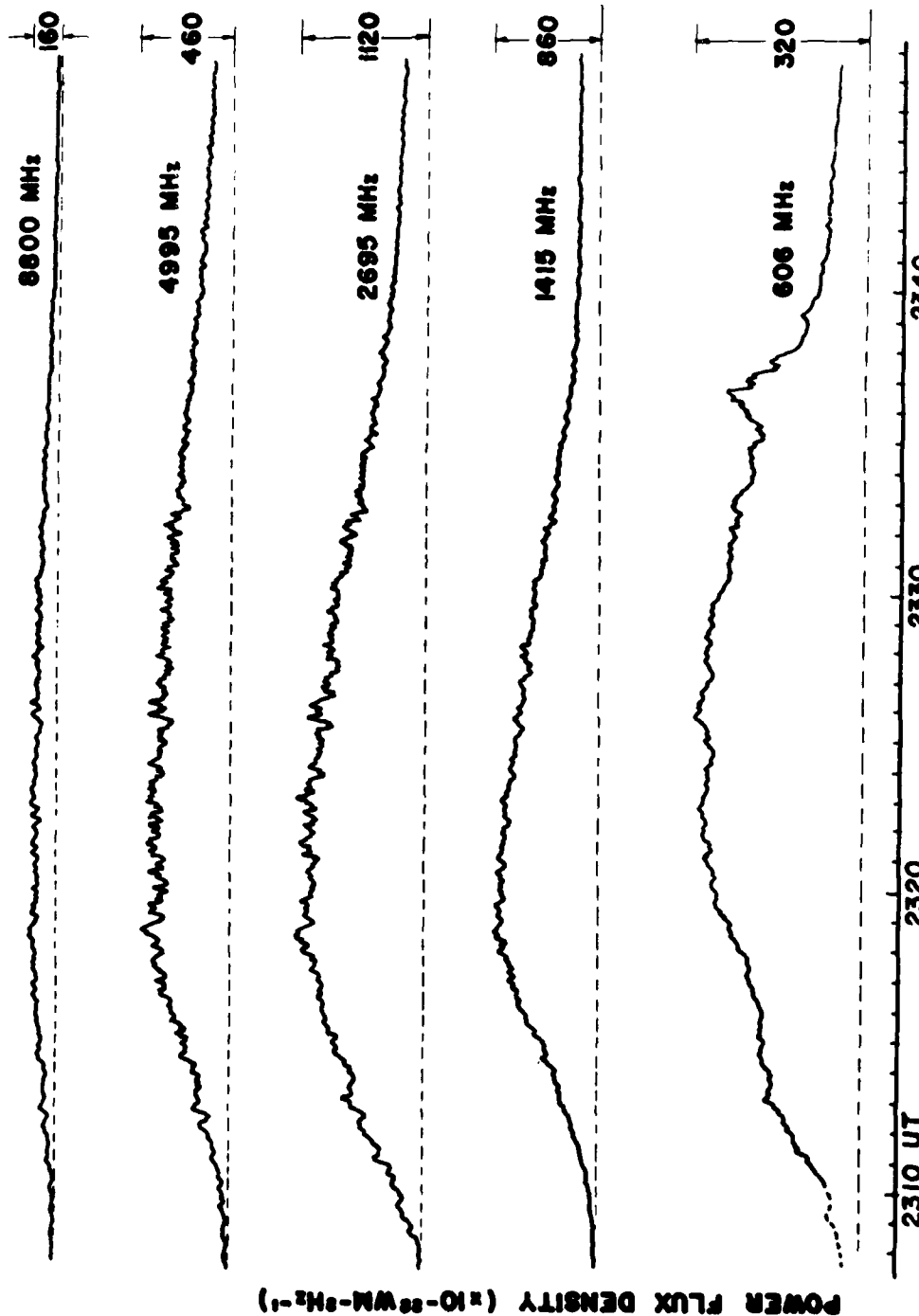
**COMPLEX F RADIO BURST OBSERVED AT MANILA
OBSERVATORY, R.P., ON 5 NOVEMBER 1970**



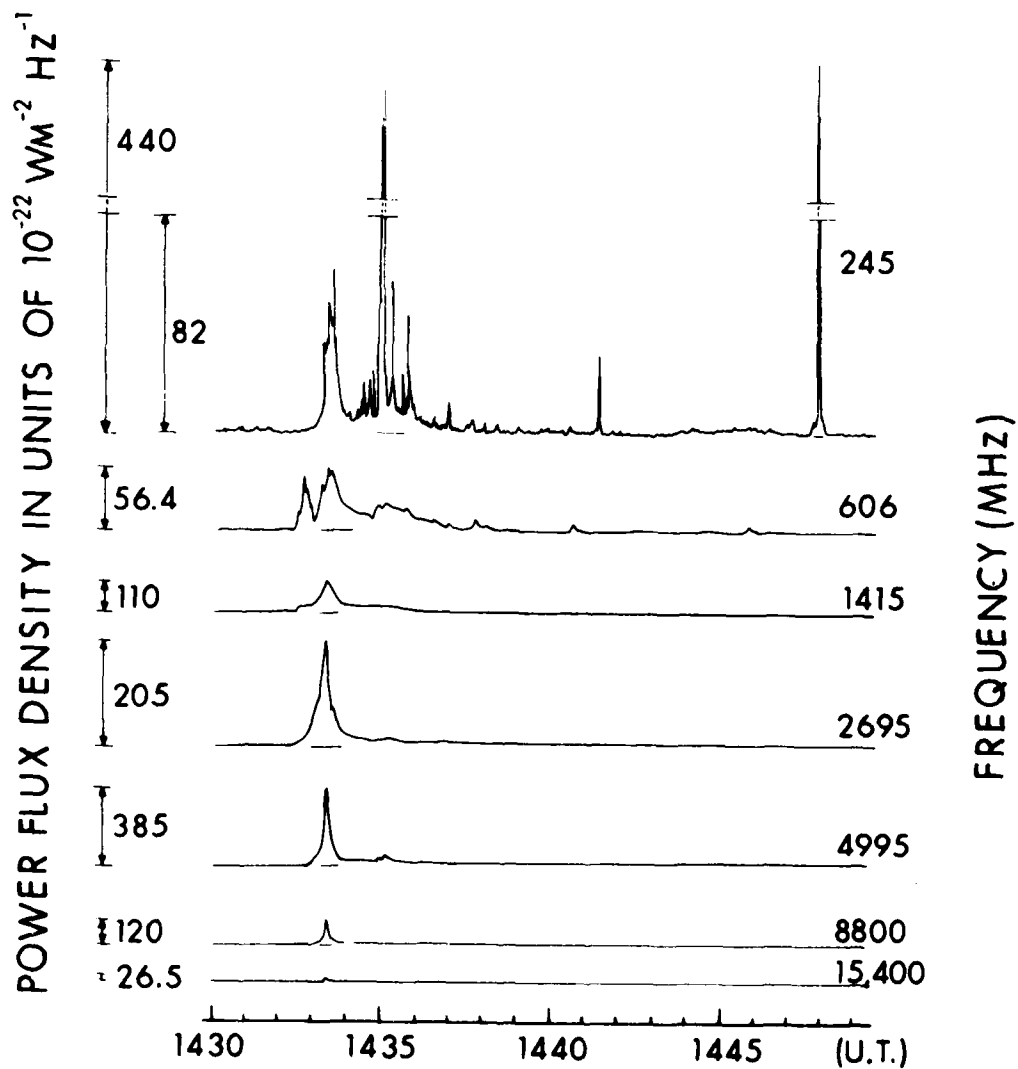
GREAT RADIO BURST OBSERVED ON 16 NOVEMBER 1970
AT MANILA OBSERVATORY, R.P.



SIMPLE 2 AND COMPLEX RADIO BURST OBSERVED
21 NOVEMBER, 1970-SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

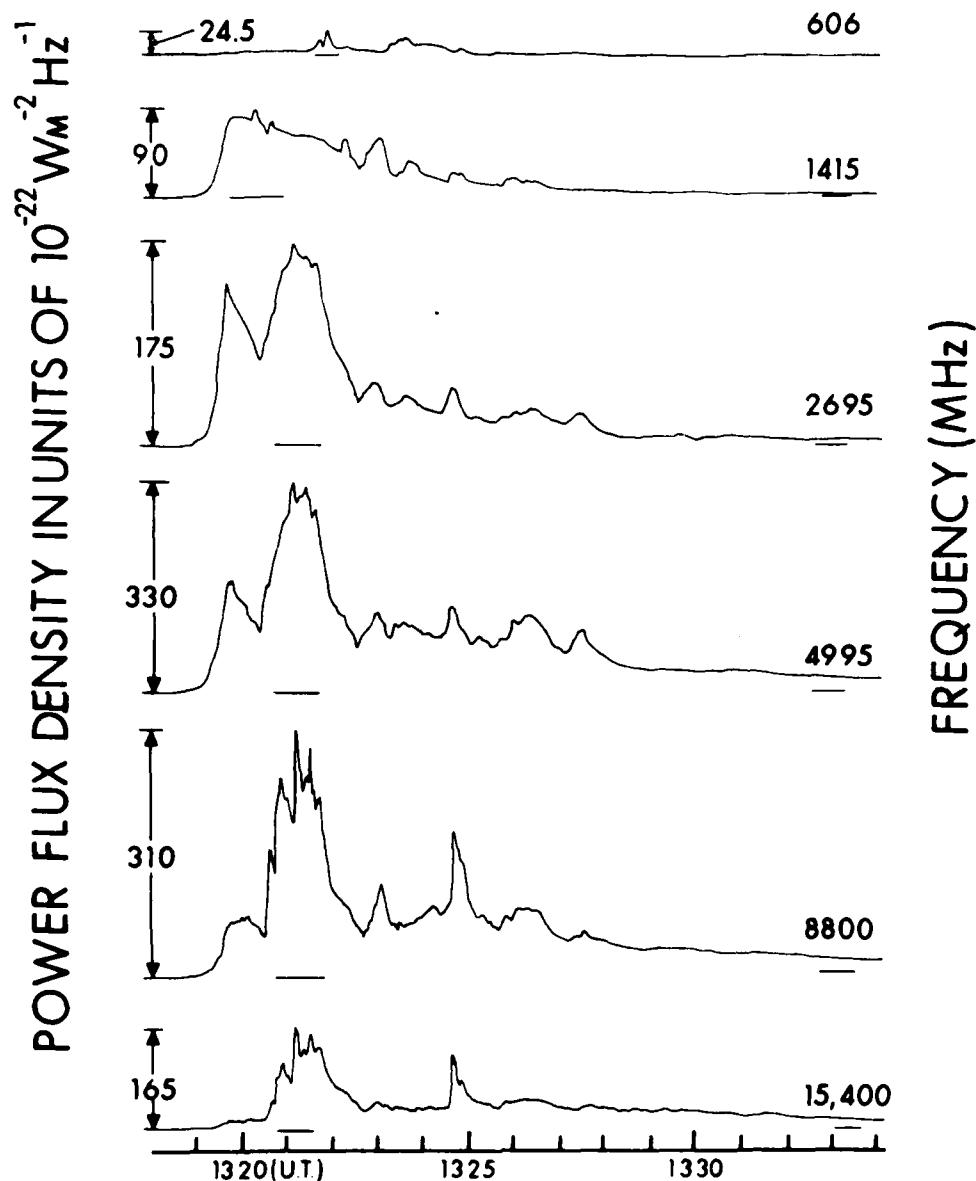


SIMPLE 2F & GREAT RADIO BURST OBSERVED ON 11 DEC 1970
AT MANILA OBSERVATORY, R. P.

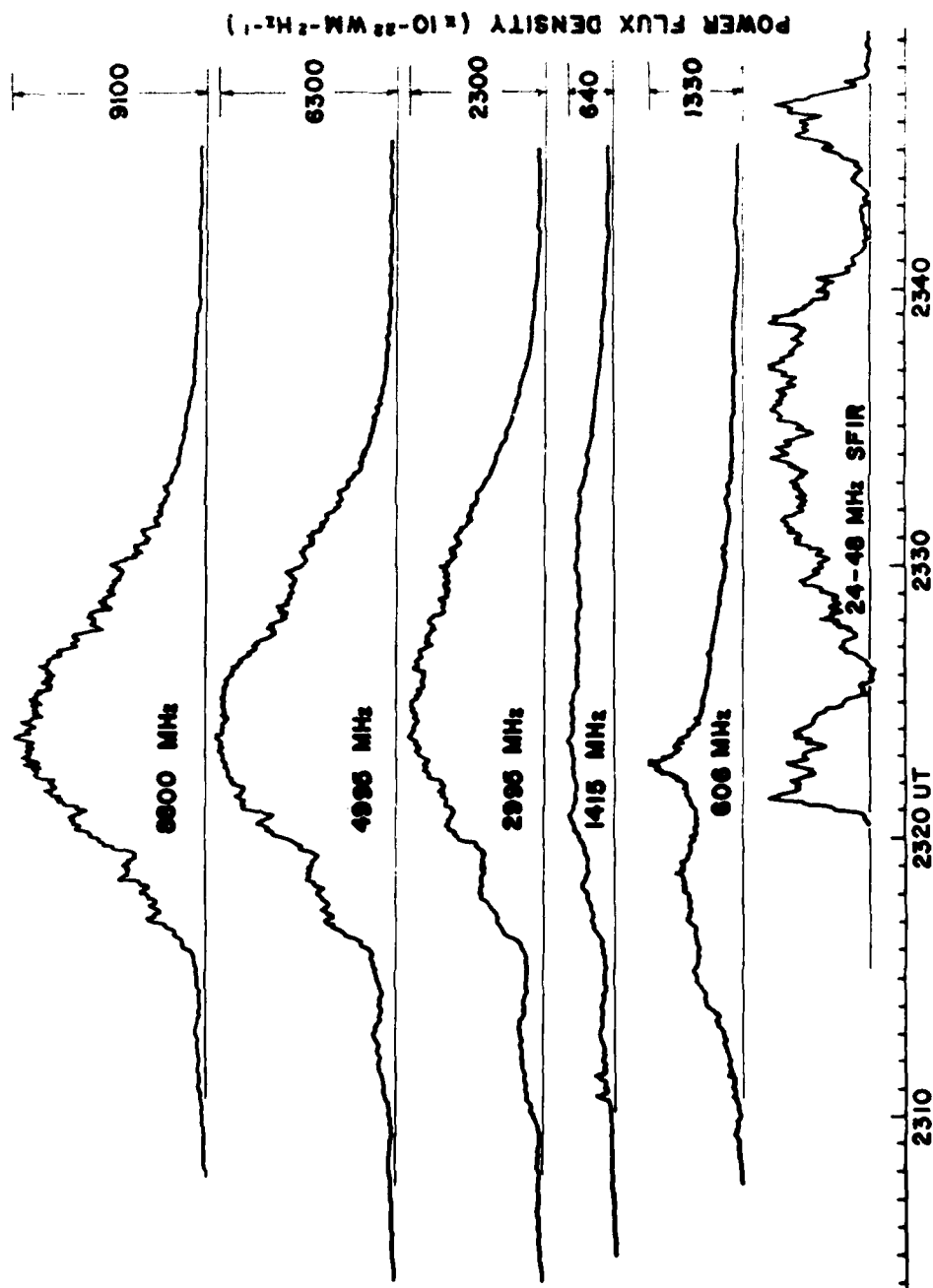


SIMPLE 2 AND COMPLEX RADIO BURST OBSERVED
 12 DECEMBER, 1970
 AT SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.

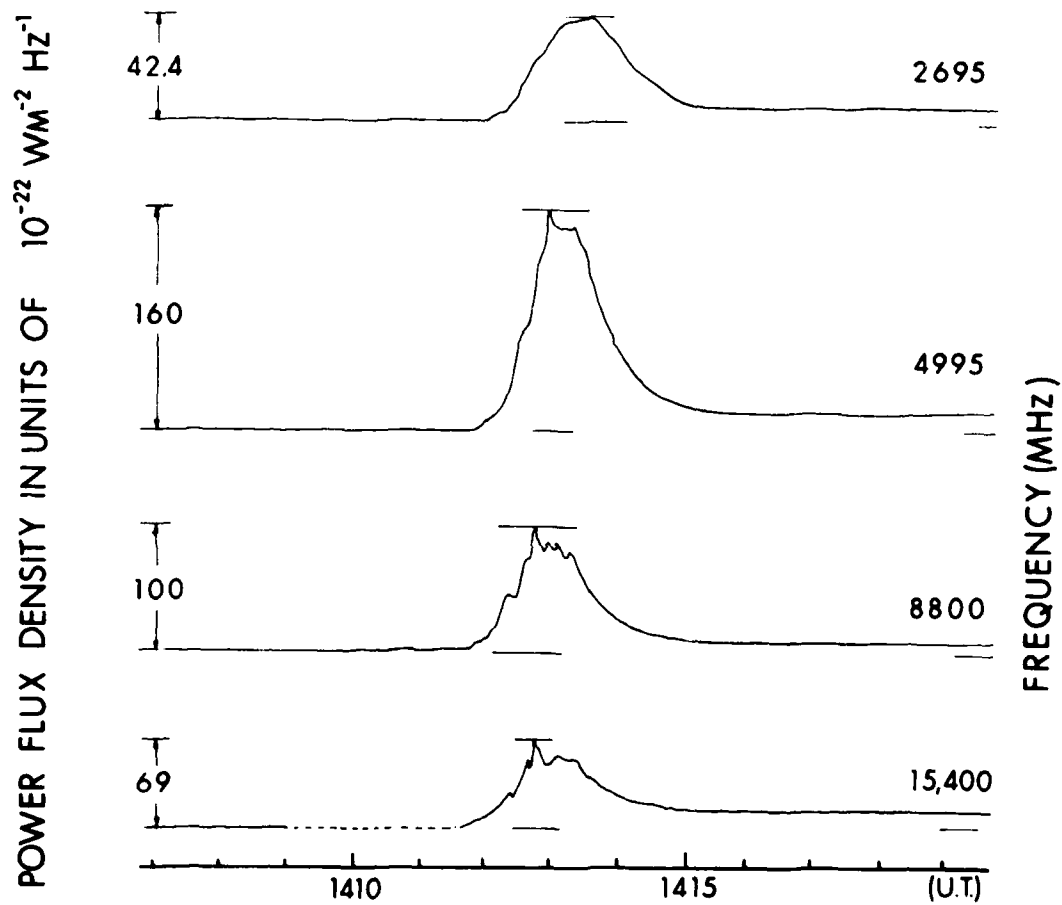
**Solar Radio Bursts
1971**



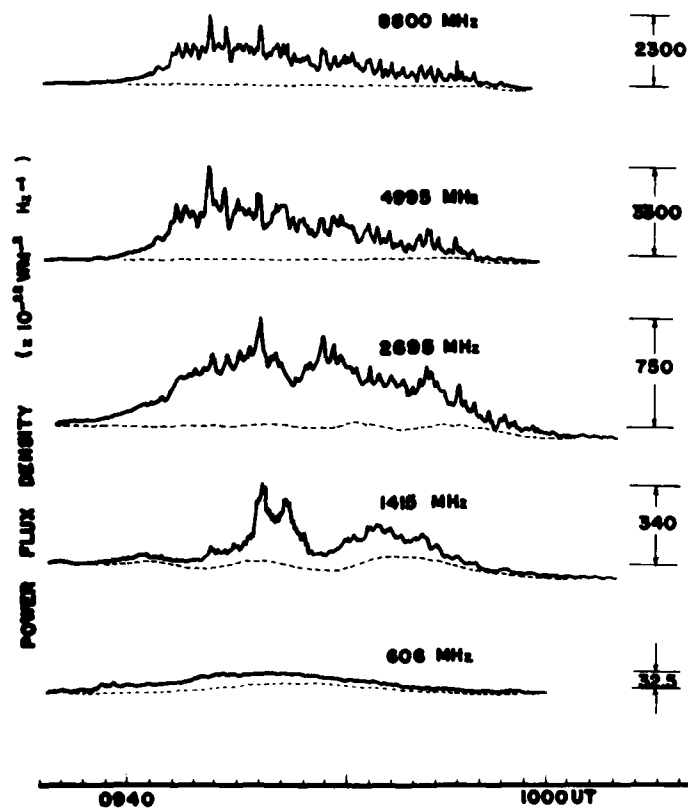
COMPLEX F RADIO BURST OBSERVED ON
21 JANUARY, 1971
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



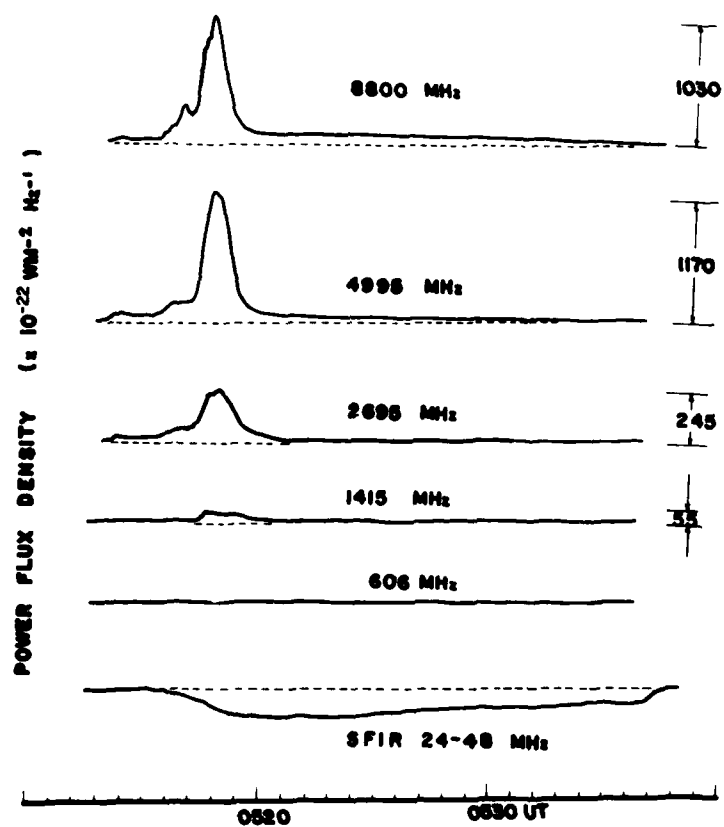
GREAT RADIO BURST OBSERVED ON 24 JAN 1971 AT MANILA OBSERVATORY



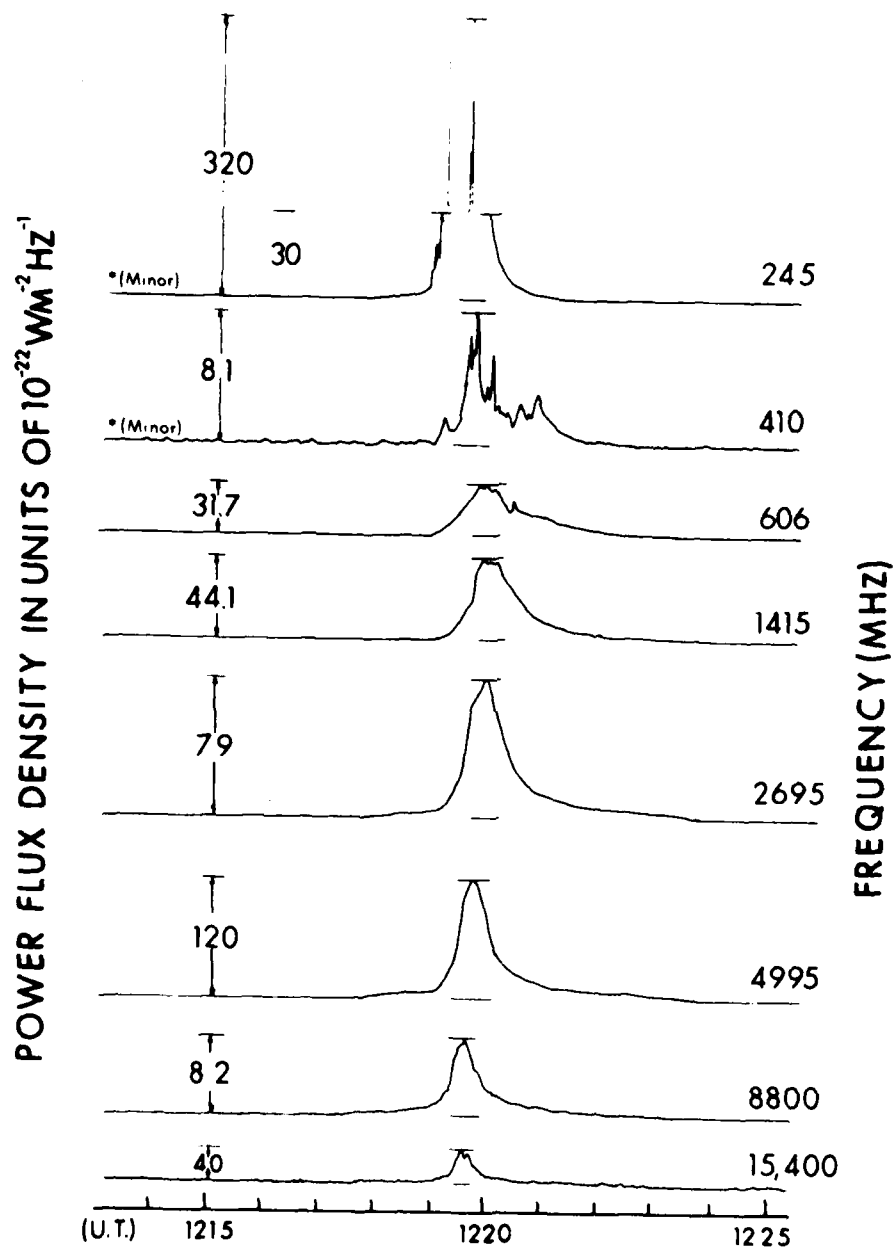
SIMPLE 2 AND 2F RADIO BURST OBSERVED ON
29 MARCH, 1971
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



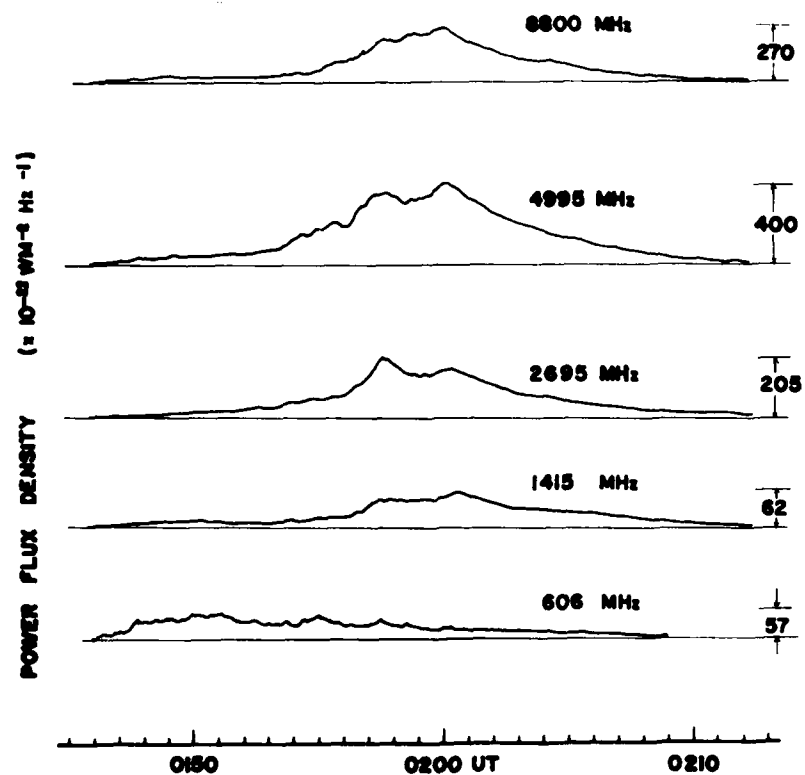
GREAT RADIO BURST OBSERVED AT SUNSET OF 6 APRIL
1971 AT MANILA OBSERVATORY, R.P.
DASHED LINES ARE TYPICAL QUIET SUN TRACES



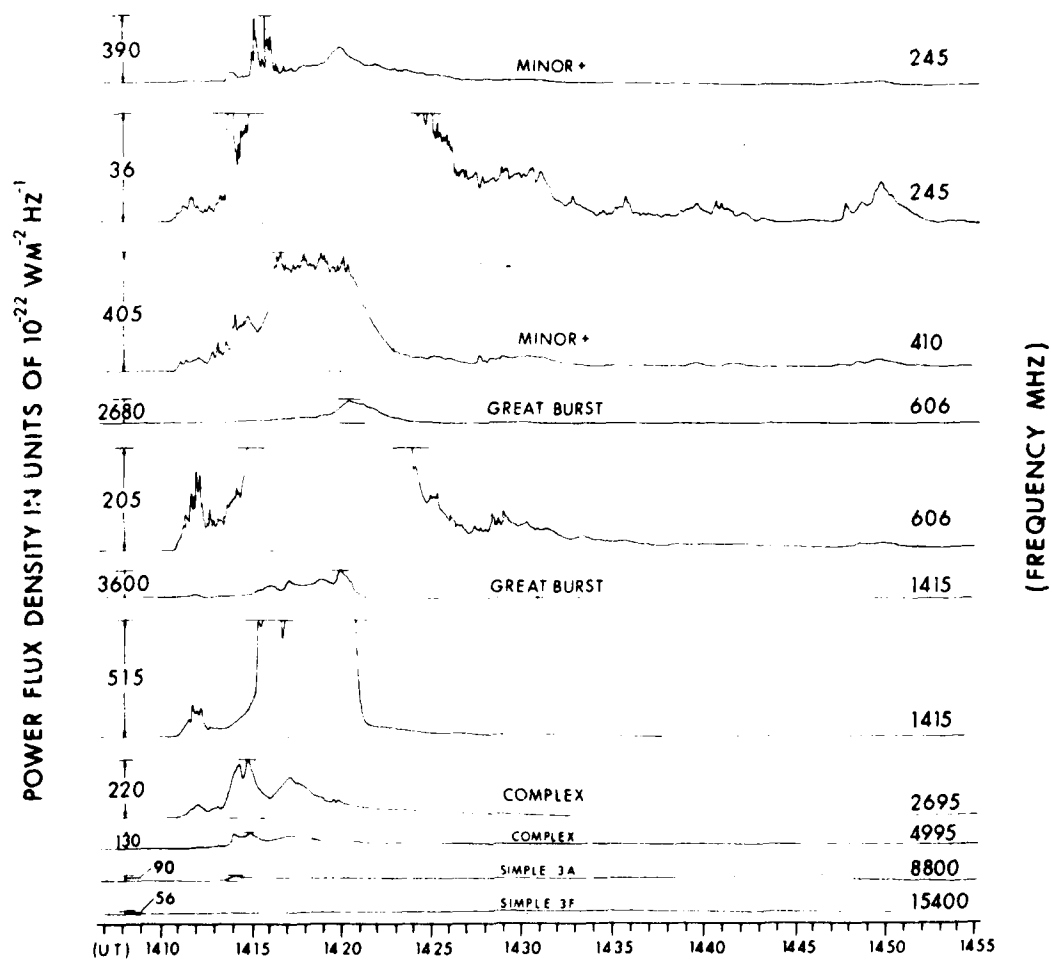
SAMPLE 2 & GREAT RADIO BURST OBSERVED ON
20 APRIL 1971 AT MANILA OBSERVATORY, R.P.



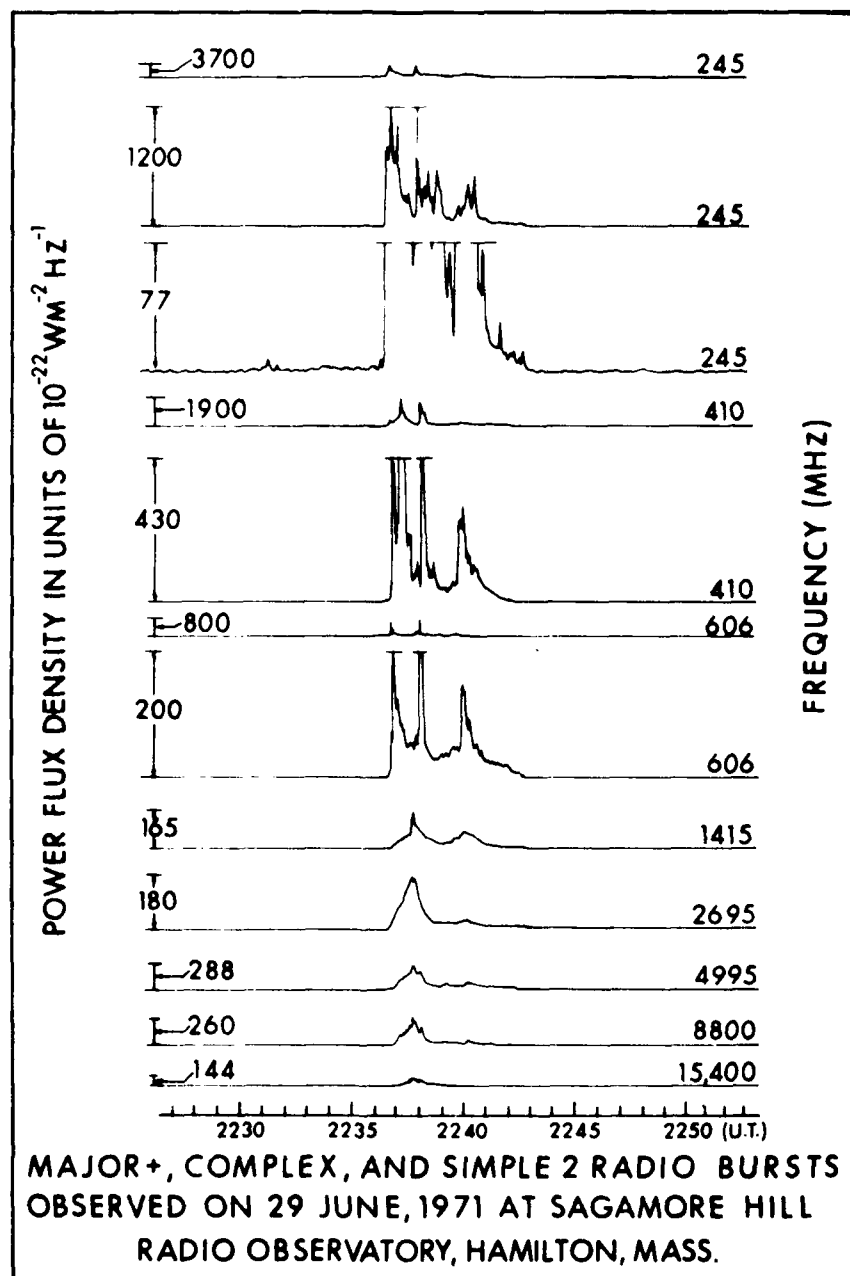
SIMPLE 2 & 2F* RADIO BURST OBSERVED 20 APRIL, 1971
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

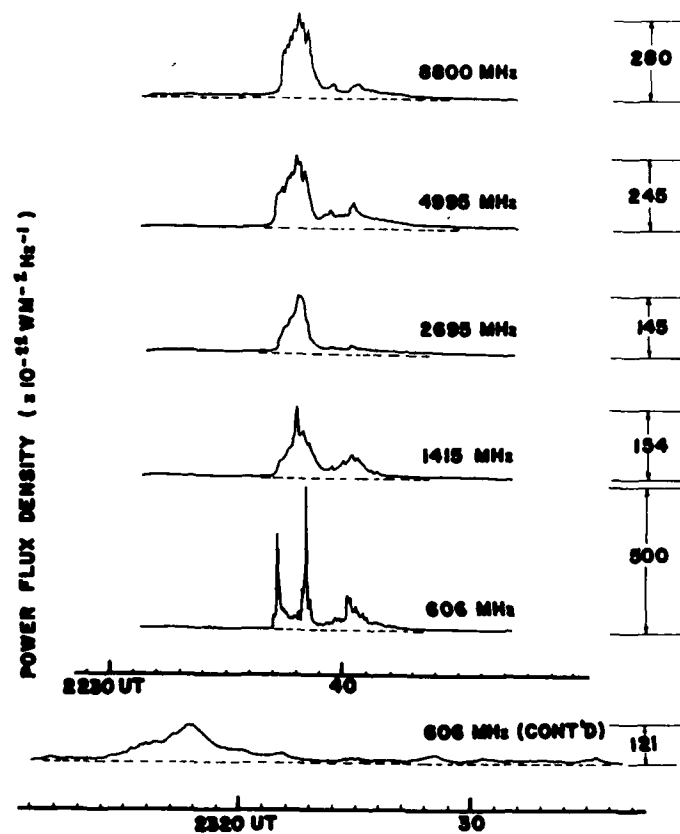


COMPLEX F & SIMPLE 2F RADIO BURST OBSERVED ON
12 MAY 1971 AT MANILA OBSERVATORY, R.P.

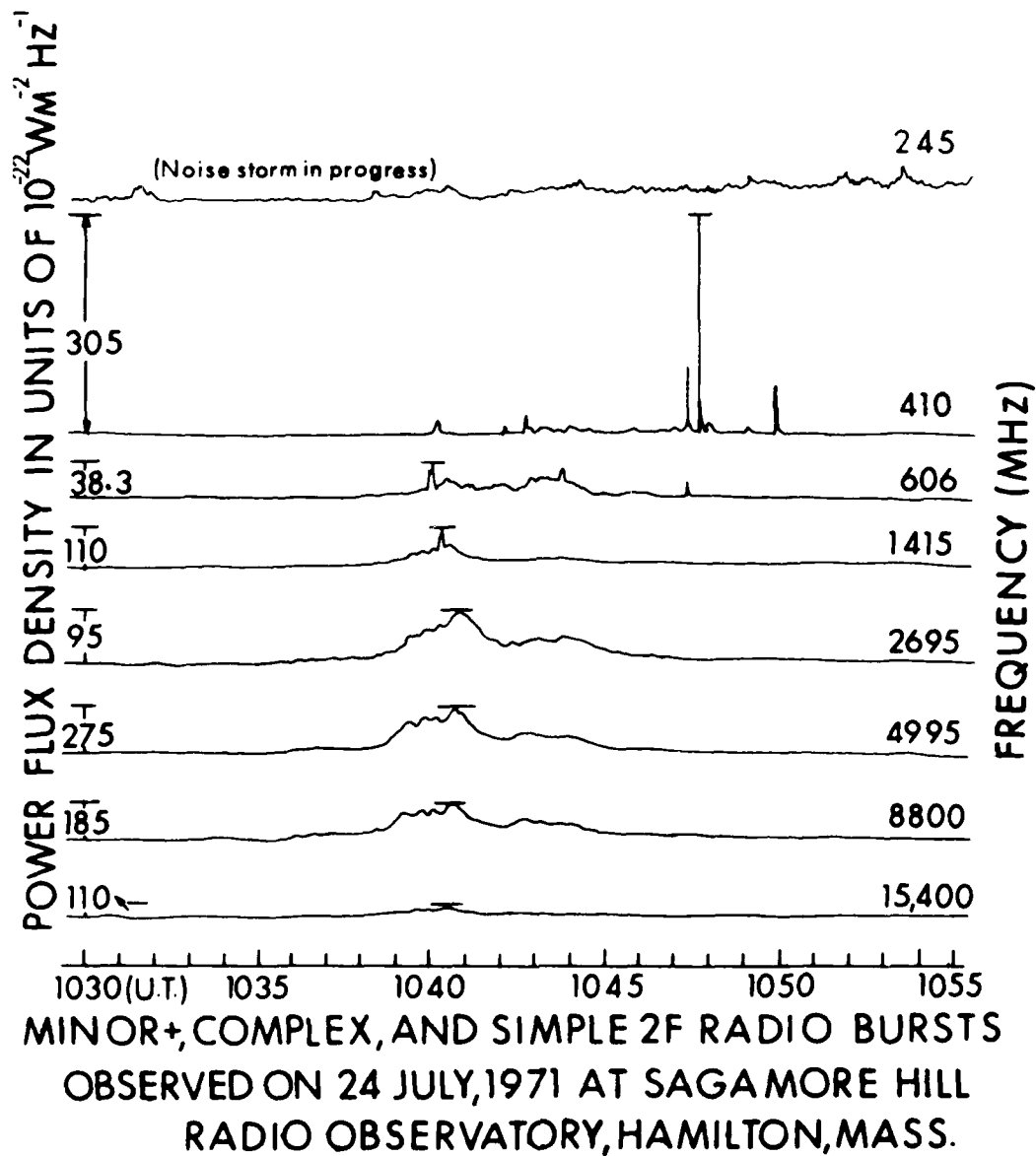


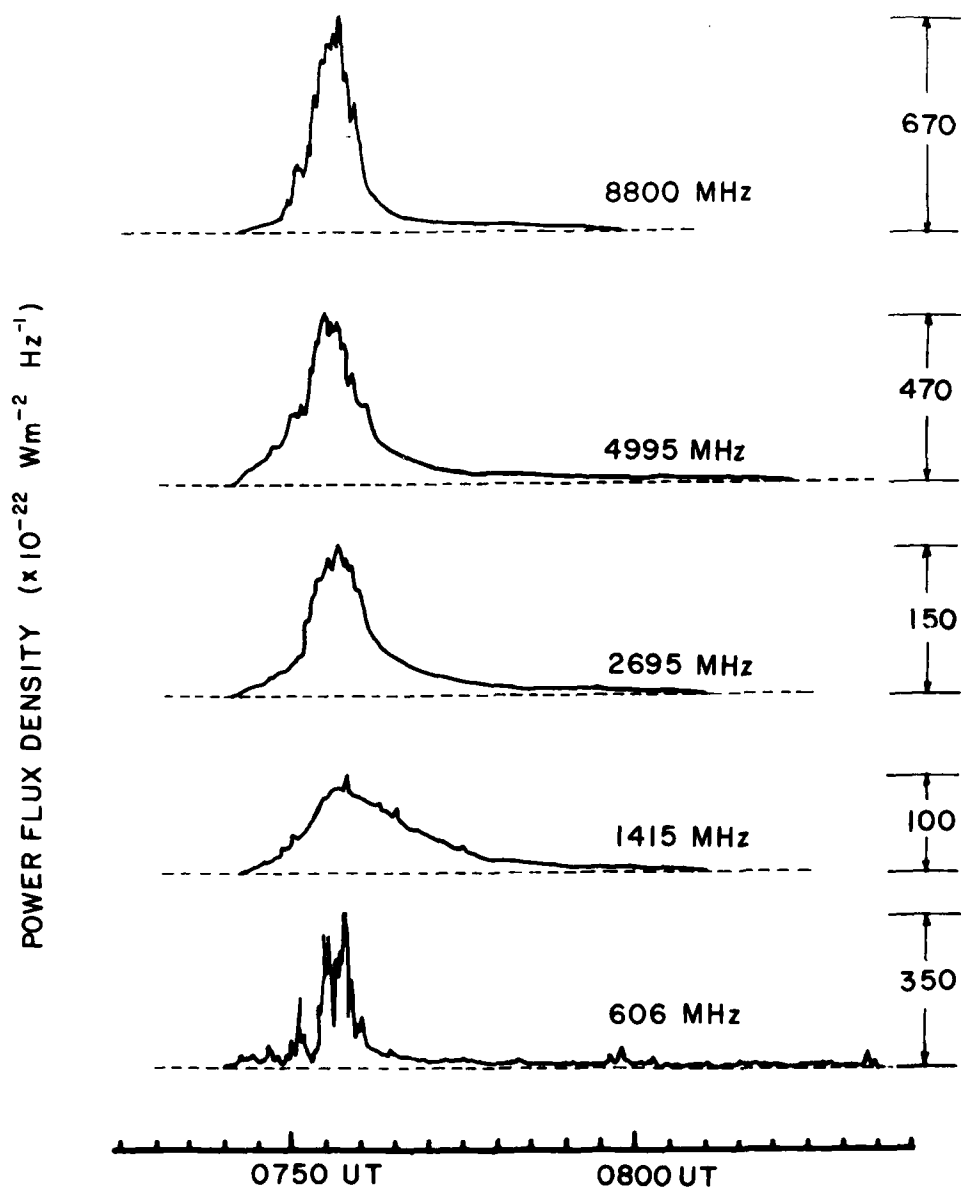
RADIO BURST OBSERVED 14 MAY, 1971 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON



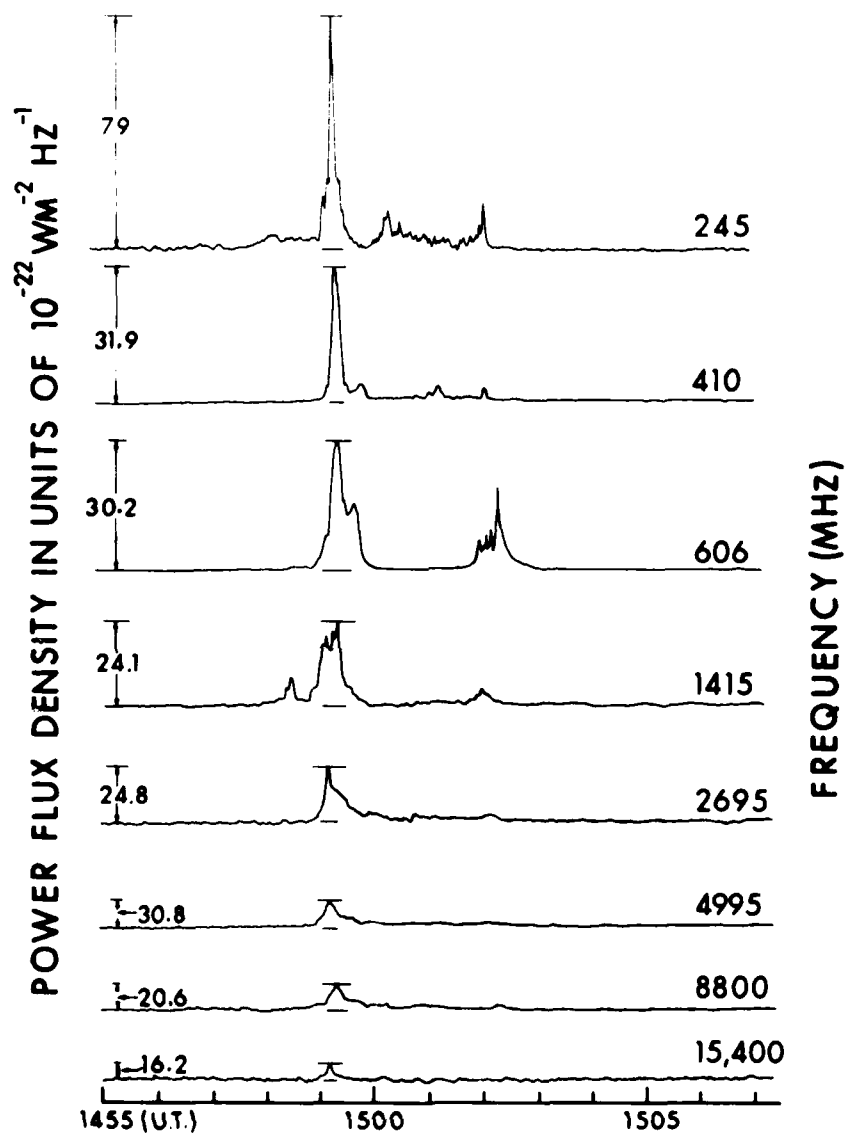


SIMPLE 2F RADIO BURST WITH SPIKES ON 606 MHz
OBSERVED 29 JUNE 1971 AT MANILA OBSERVATORY,
PHILIPPINES.

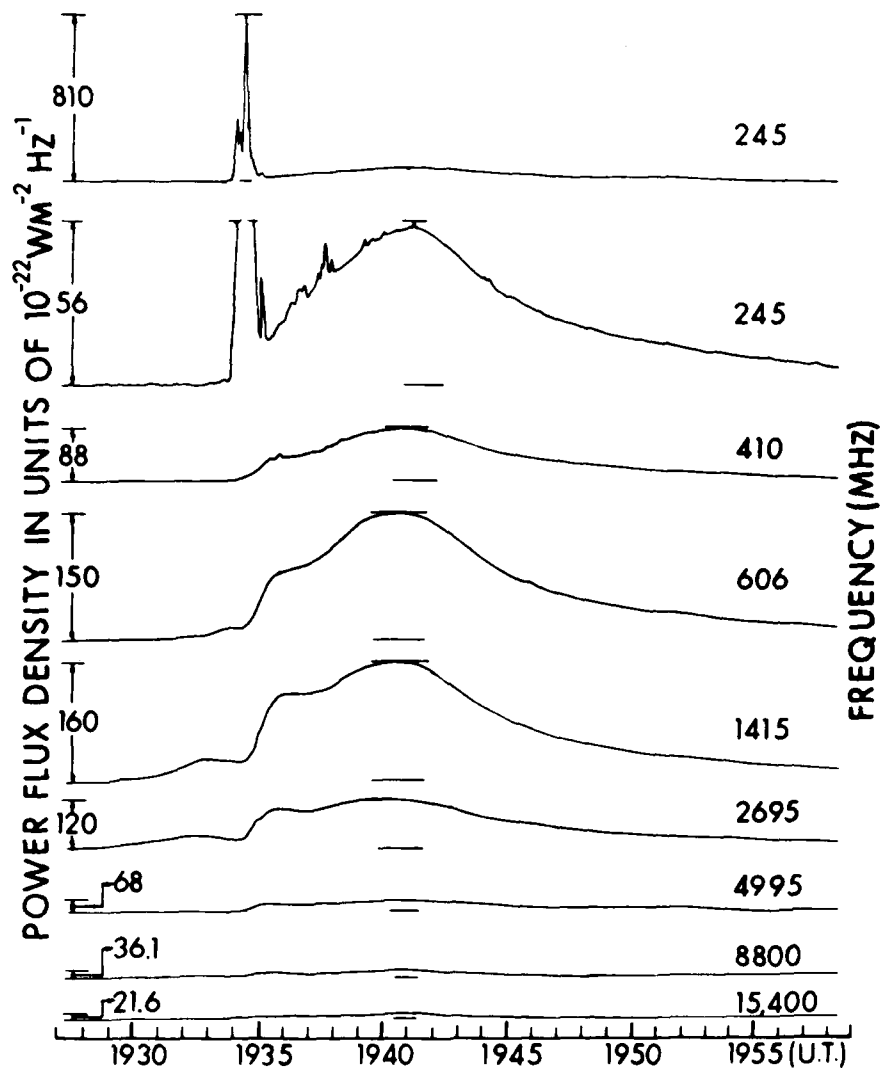




**SIMPLE 2F, FLUCTUATIONS & GREAT RADIO BURST
OBSERVED ON 22 AUGUST 1971 AT MANILA OBSERVATORY.**

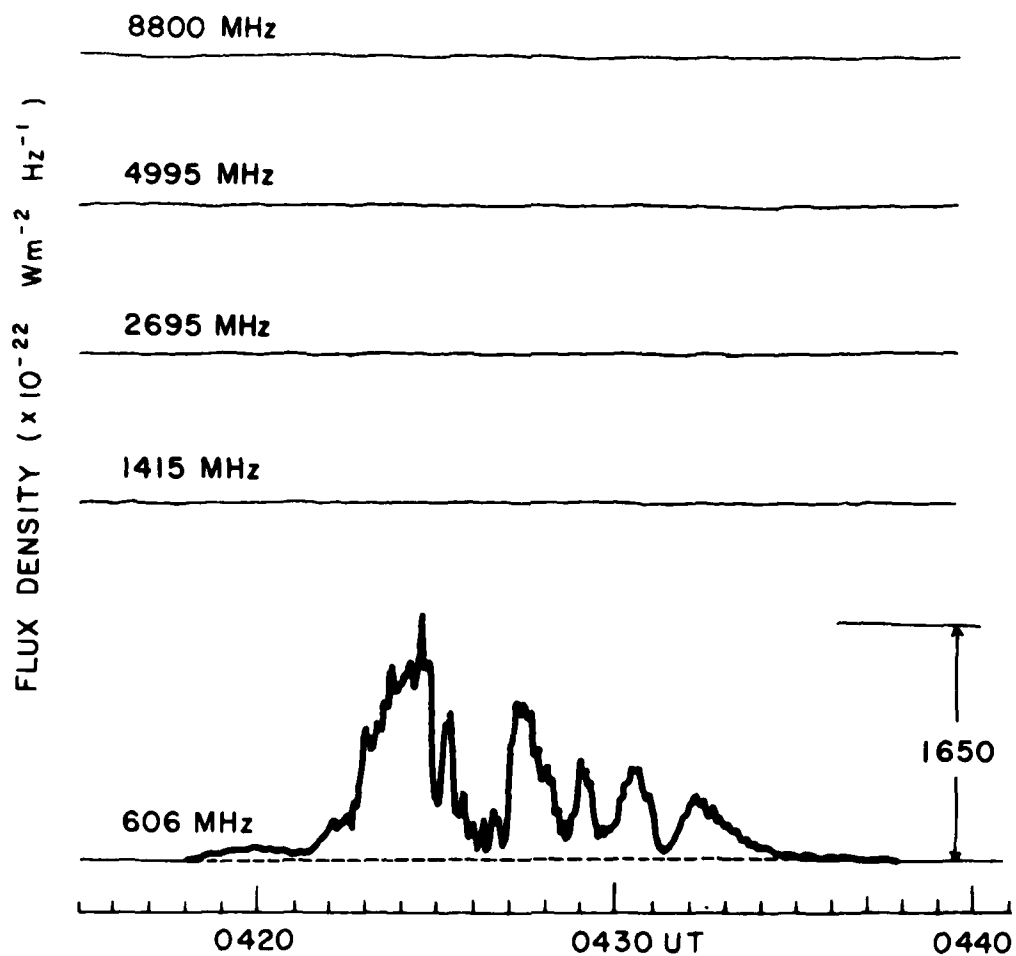


MINOR, COMPLEX, & SIMPLE 2 RADIO BURST
OBSERVED ON 27 AUGUST, 1971 AT
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

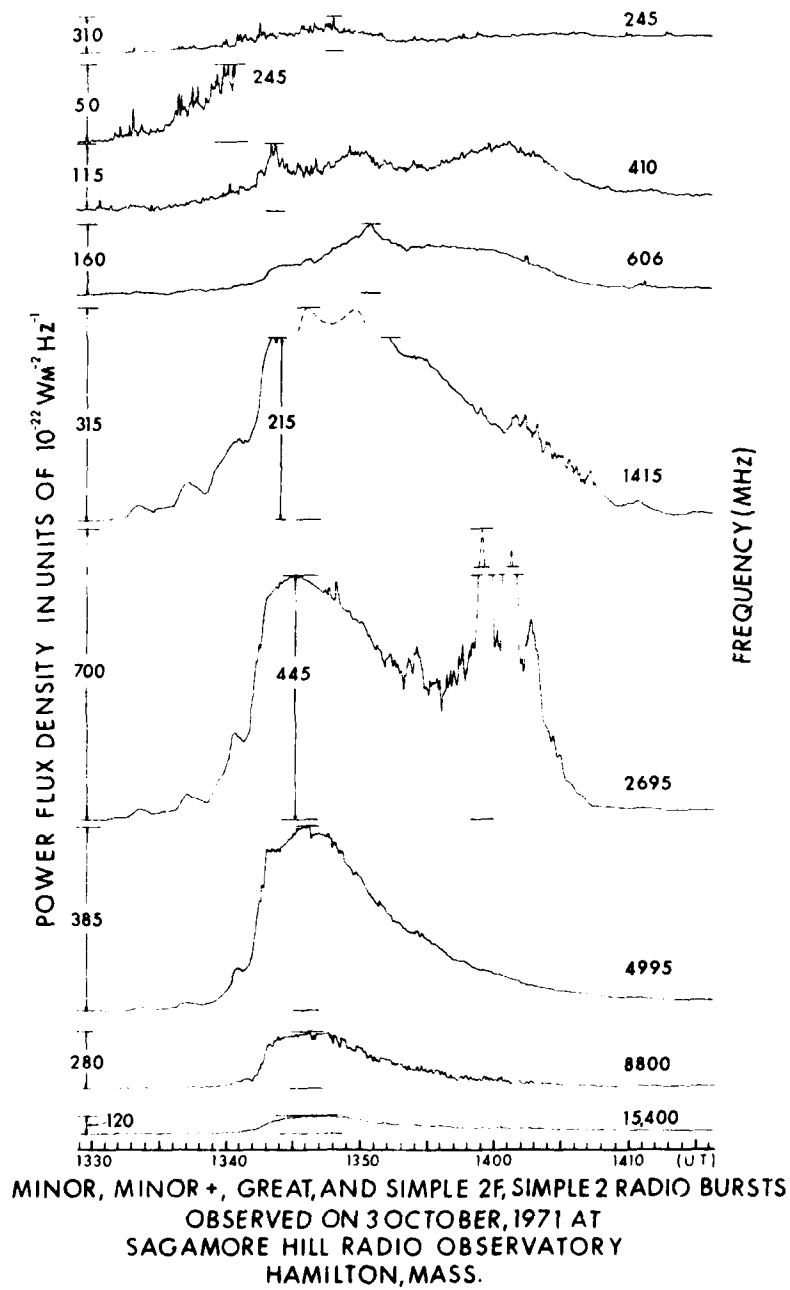


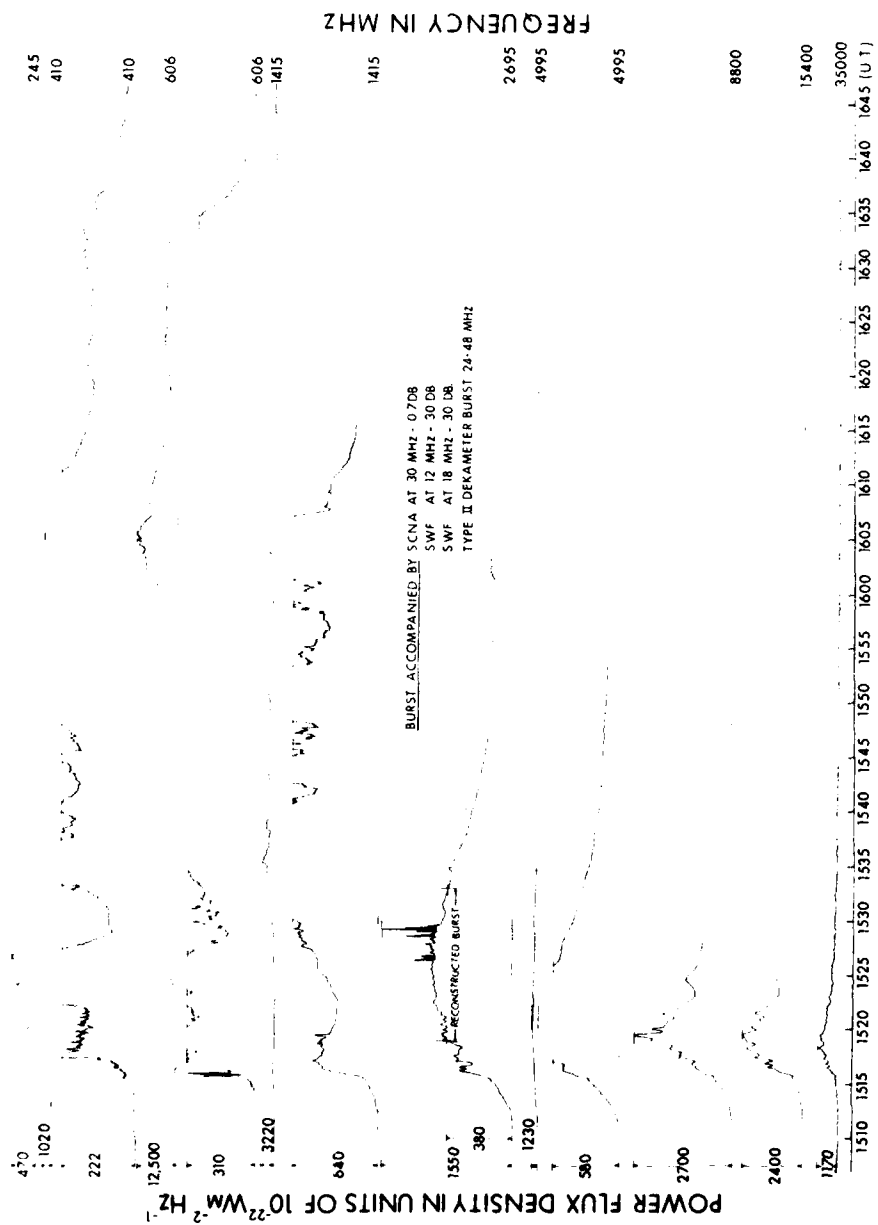
SIMPLE 2F, 3F, MINOR & MAJOR RADIO BURST*
OBSERVED ON 1 SEPTEMBER, 1971 AT THE
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

*BEHIND LIMB EVENT

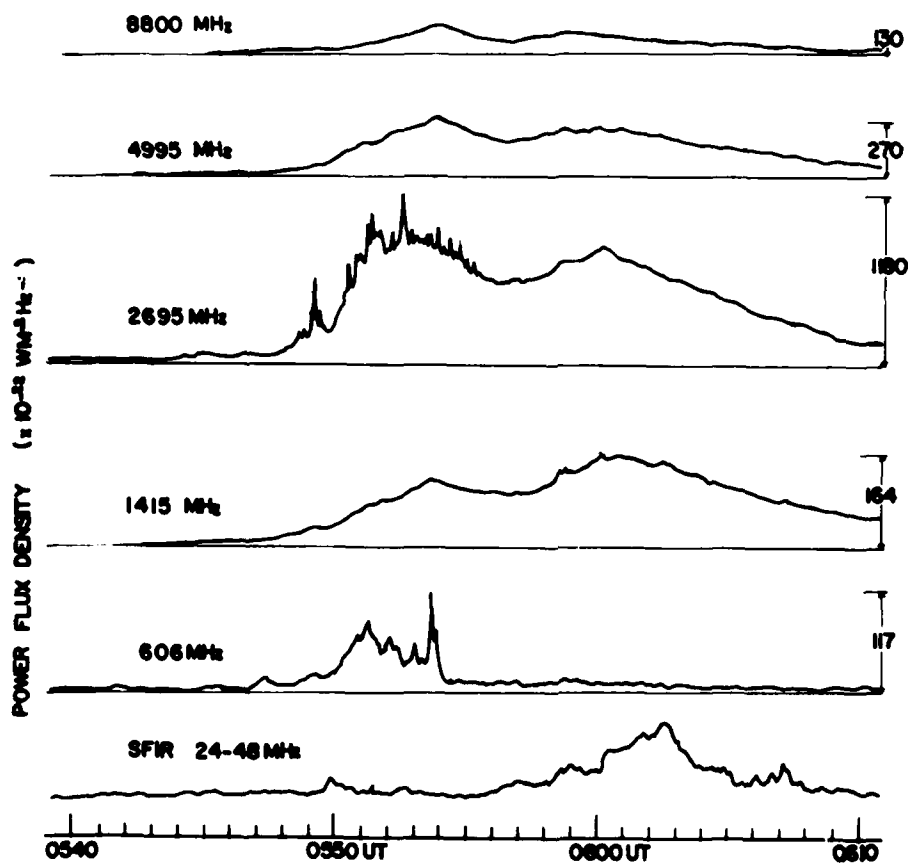


SINGLE FREQUENCY GREAT RADIO BURST ON 606 MHz
OBSERVED AT MANILA OBSERVATORY ON 9 SEPTEMBER 1971

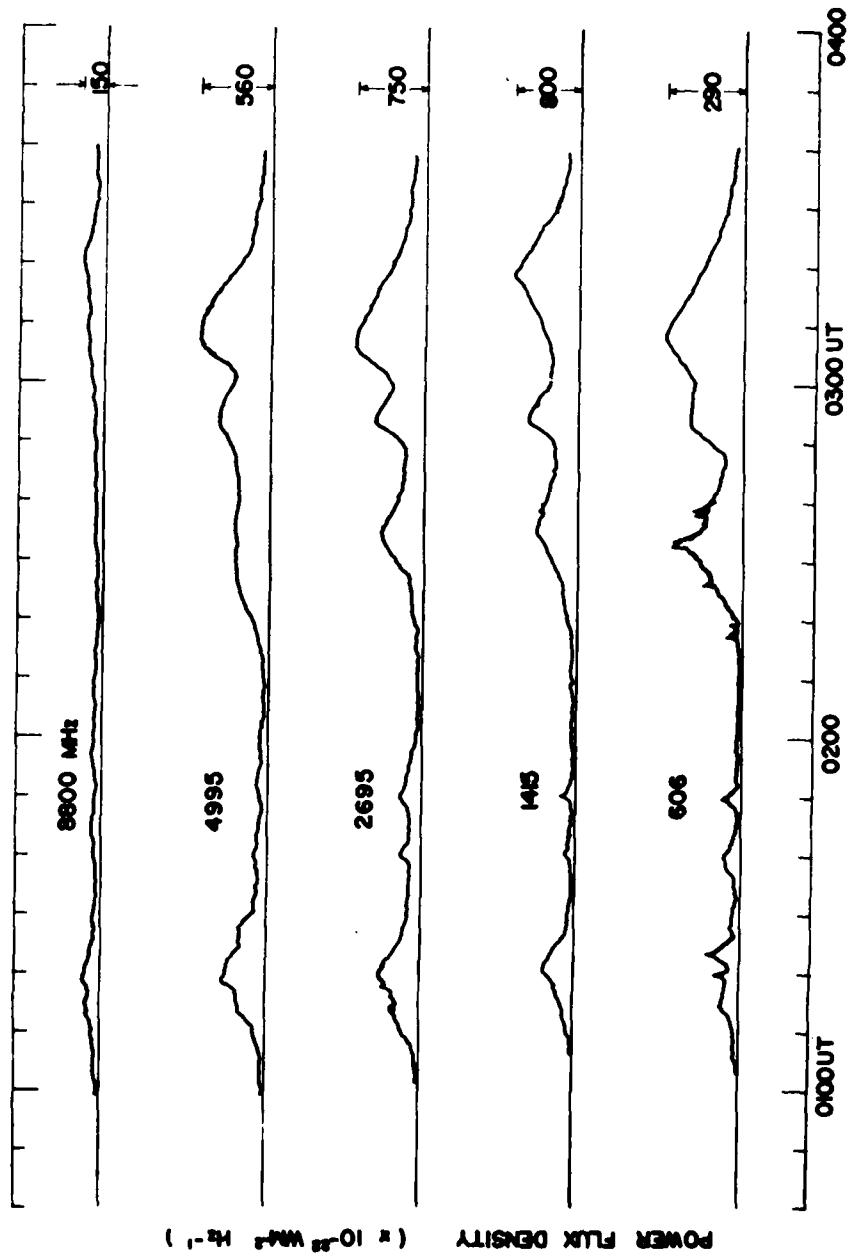




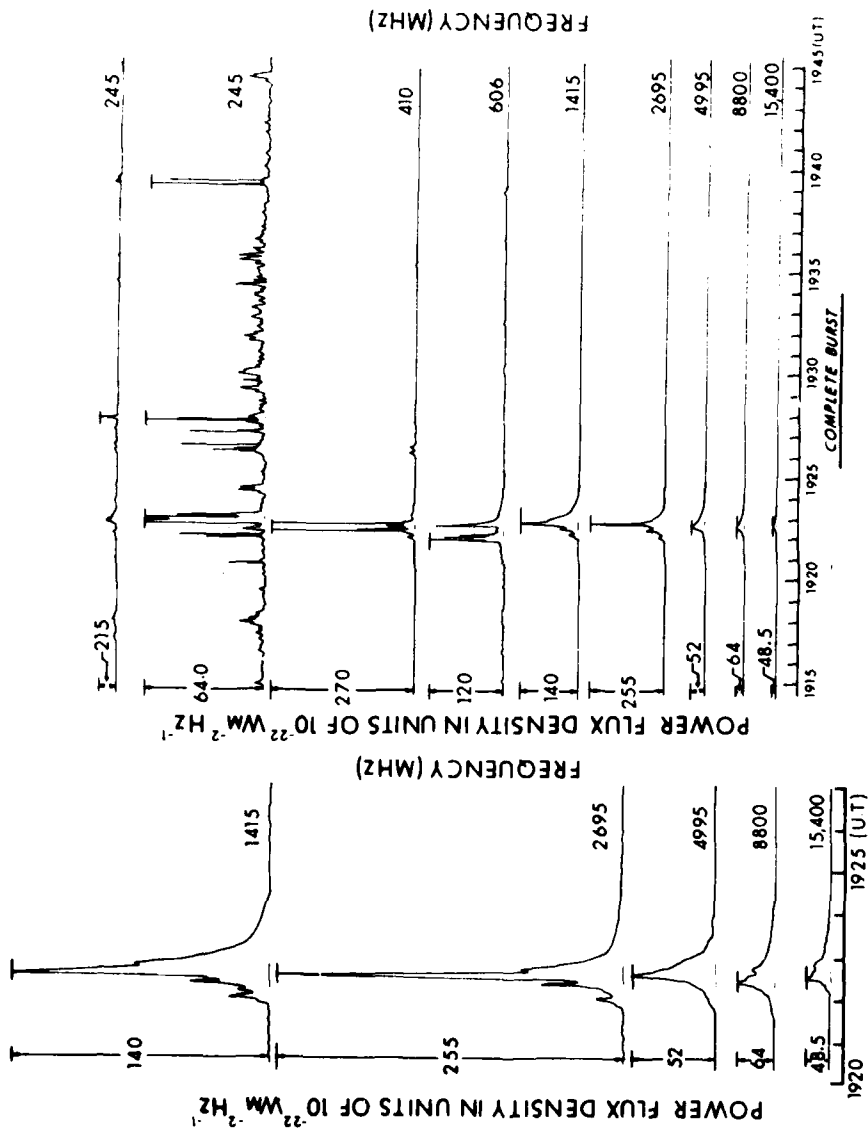
GREAT BURST OBSERVED ON 22 NOVEMBER, 1971 AT
 SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



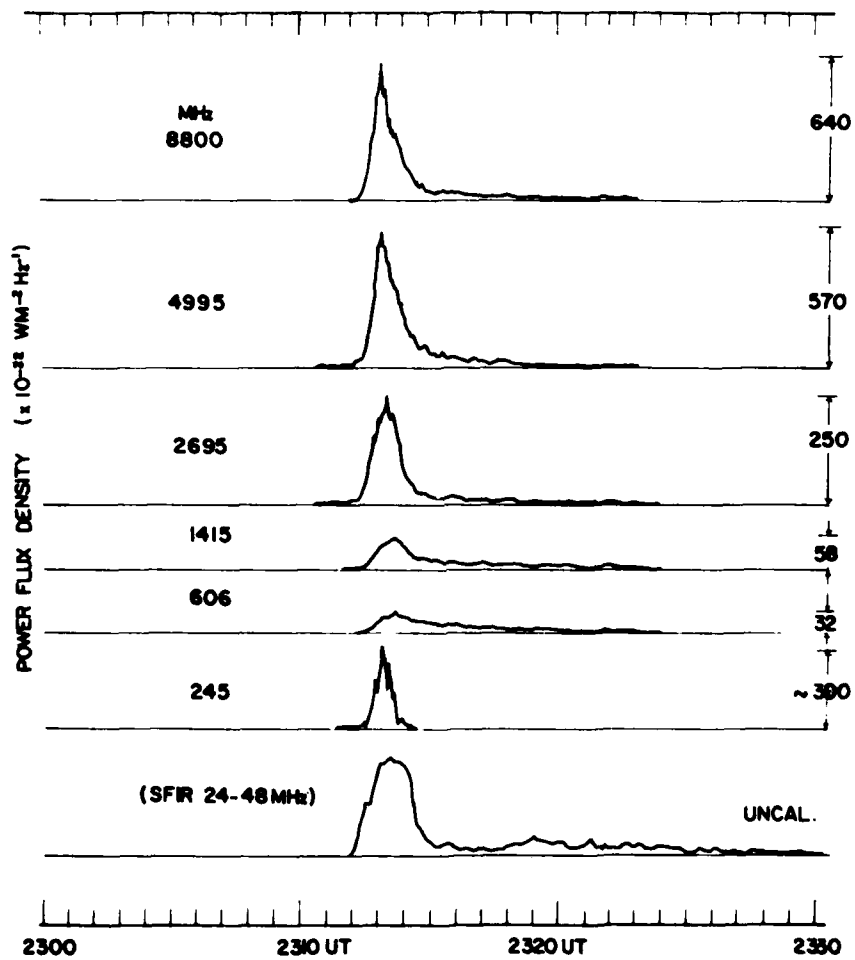
COMPLEX & GREAT RADIO BURST OF 23 NOVEMBER 1971
OBSERVED AT MANILA OBSERVATORY R.P.



GREAT RADIO BURST OBSERVED ON 02 DECEMBER 1971
AT MANILA OBSERVATORY R. P.



COMPLEX AND SIMPLE 2 RADIO BURST OBSERVED ON 18 DECEMBER, 1971
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASSACHUSETTS

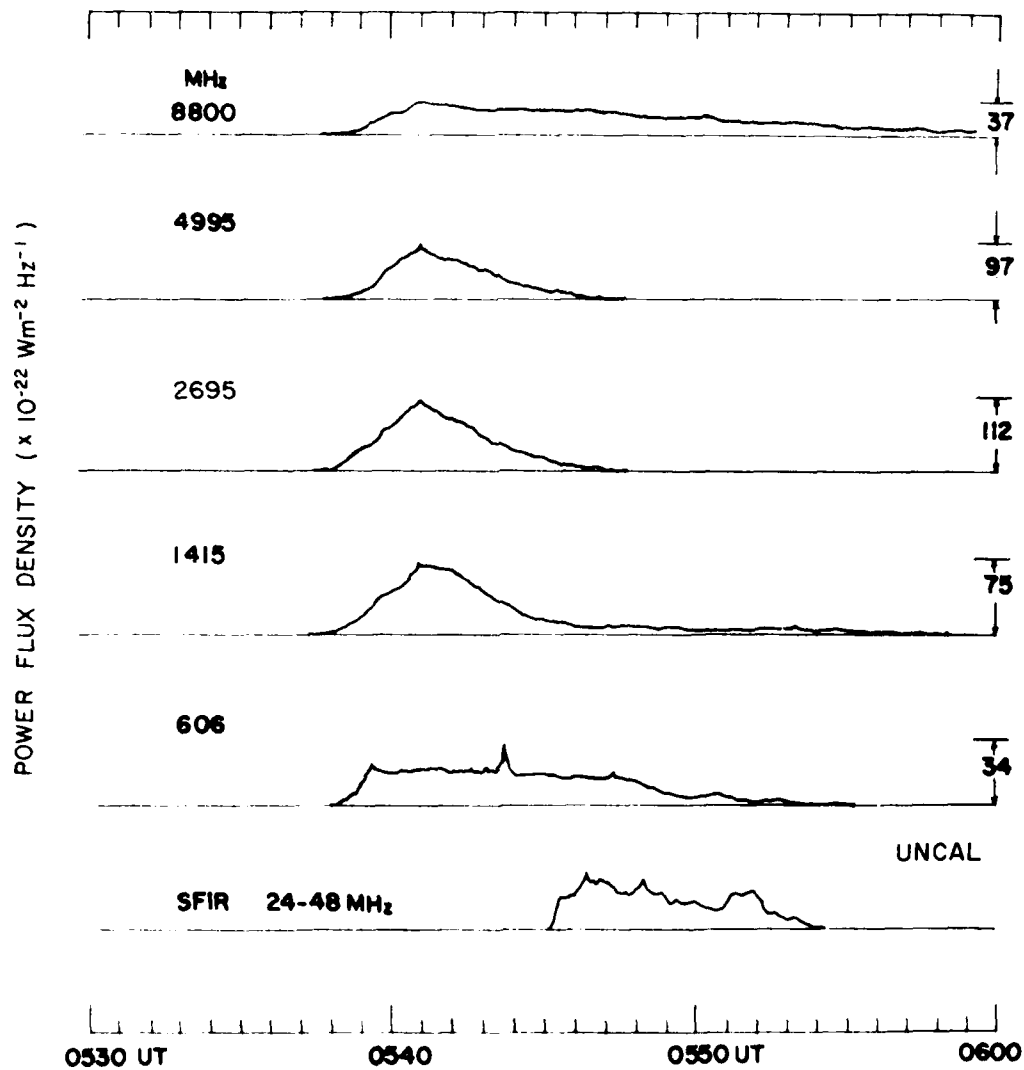


SIMPLE 2F & GREAT RADIO BURST OBSERVED ON
29 DECEMBER 1971 AT MANILA OBSERVATORY, R.P.

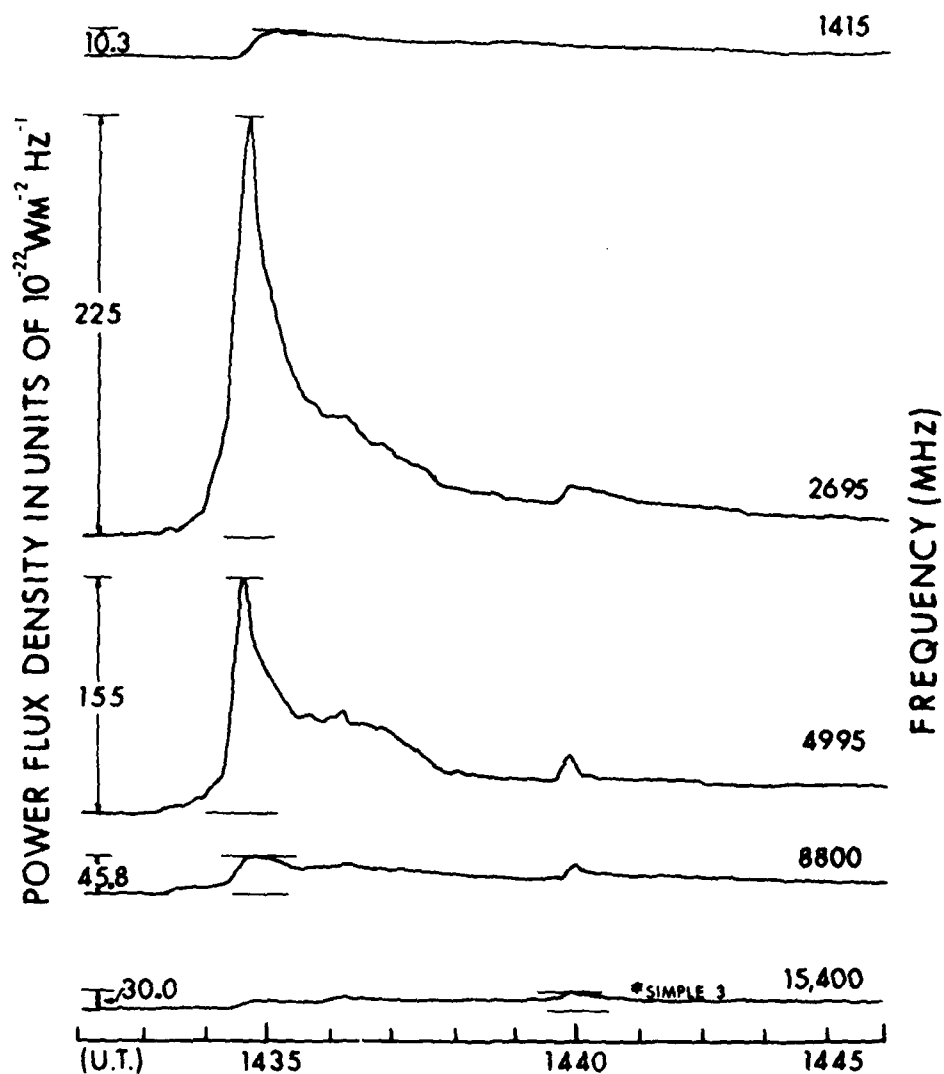
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**Solar Radio Bursts
1972**

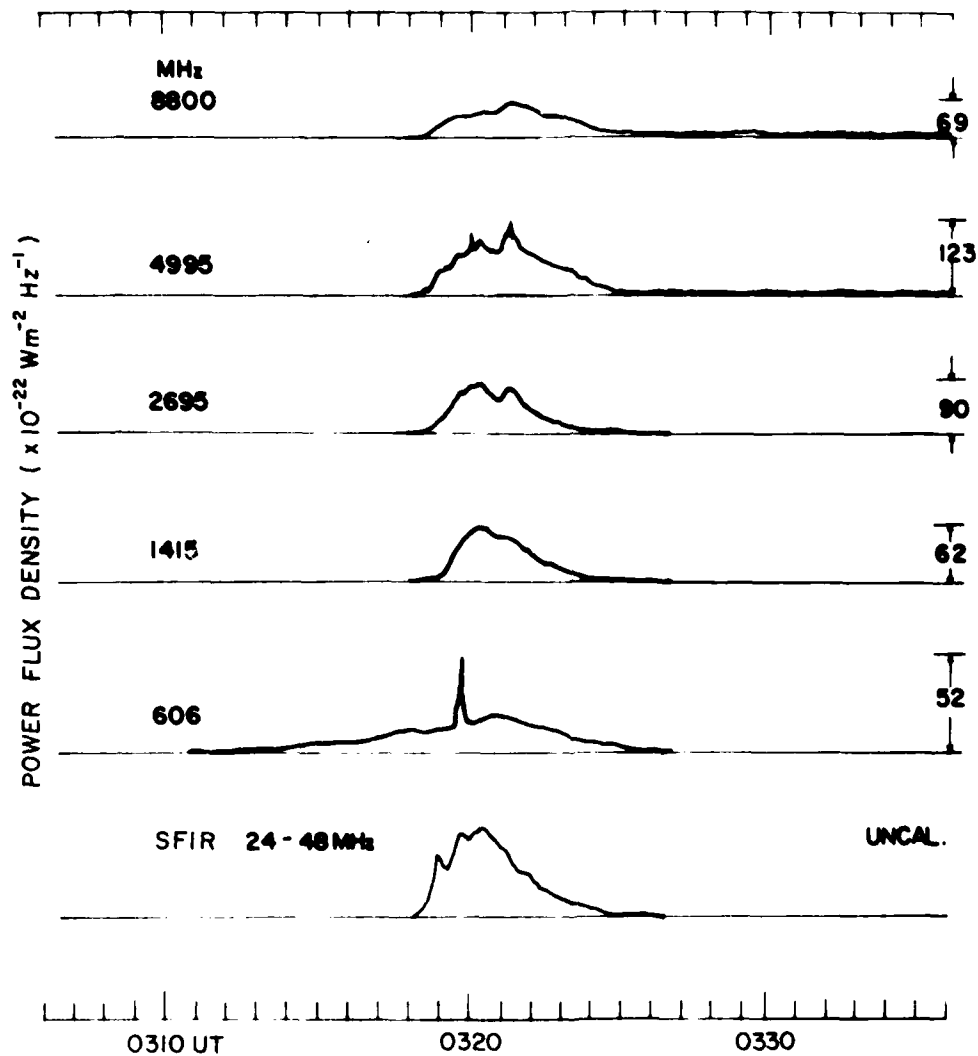
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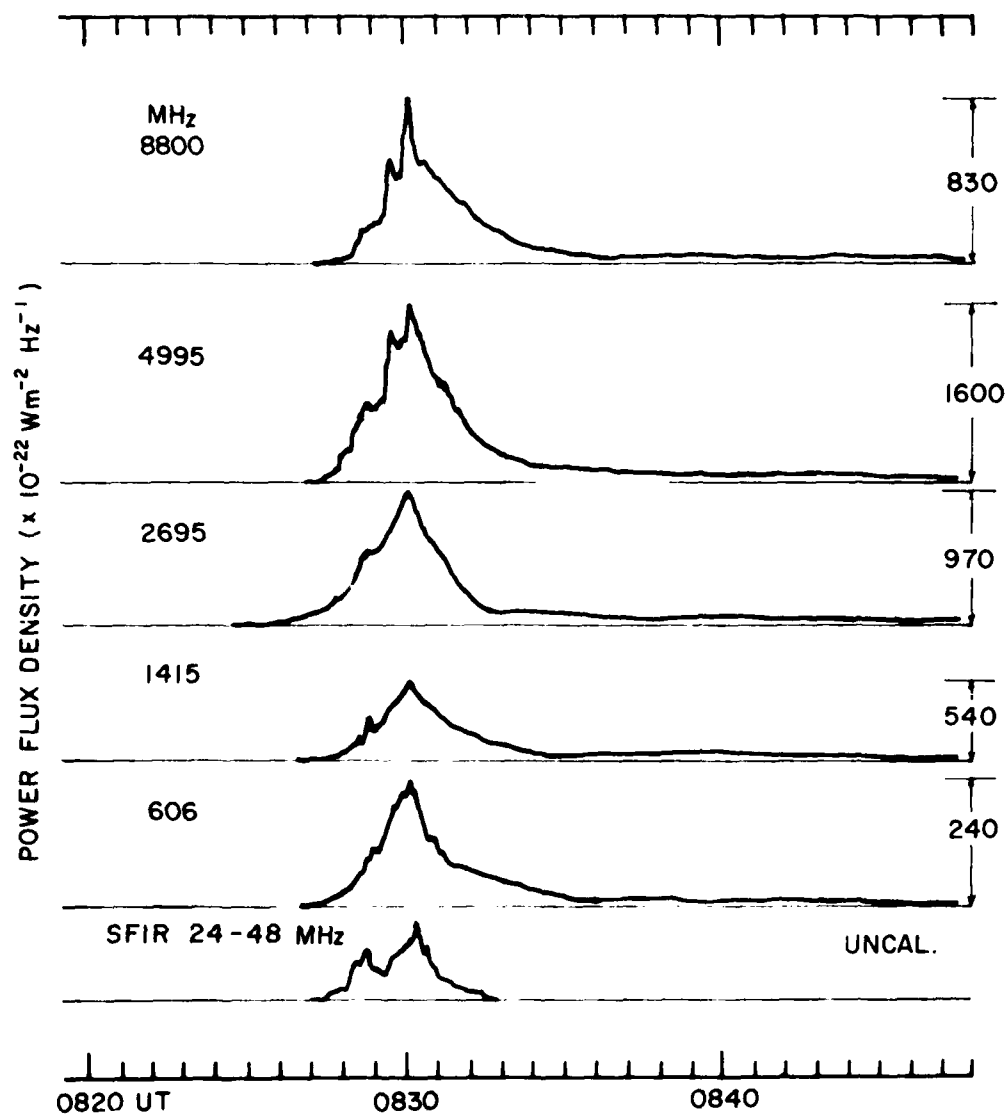
SIMPLE 3 & 2F RADIO BURST OBSERVED ON 22 JANUARY
1972 AT MANILA OBSERVATORY, R.P.



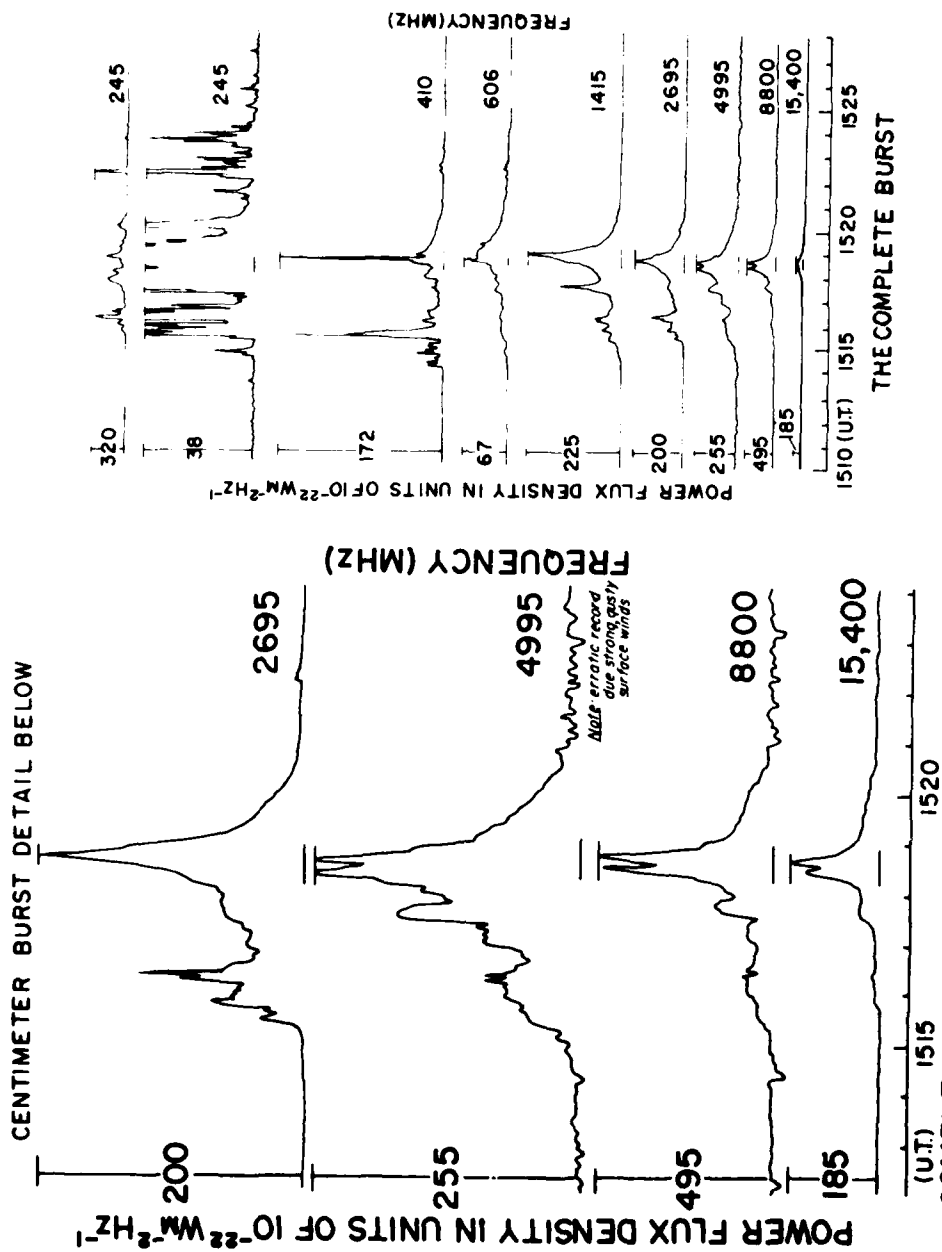
A SIMPLE 2 & 2F* RADIO BURST OBSERVED ON 22 JAN. 1972
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



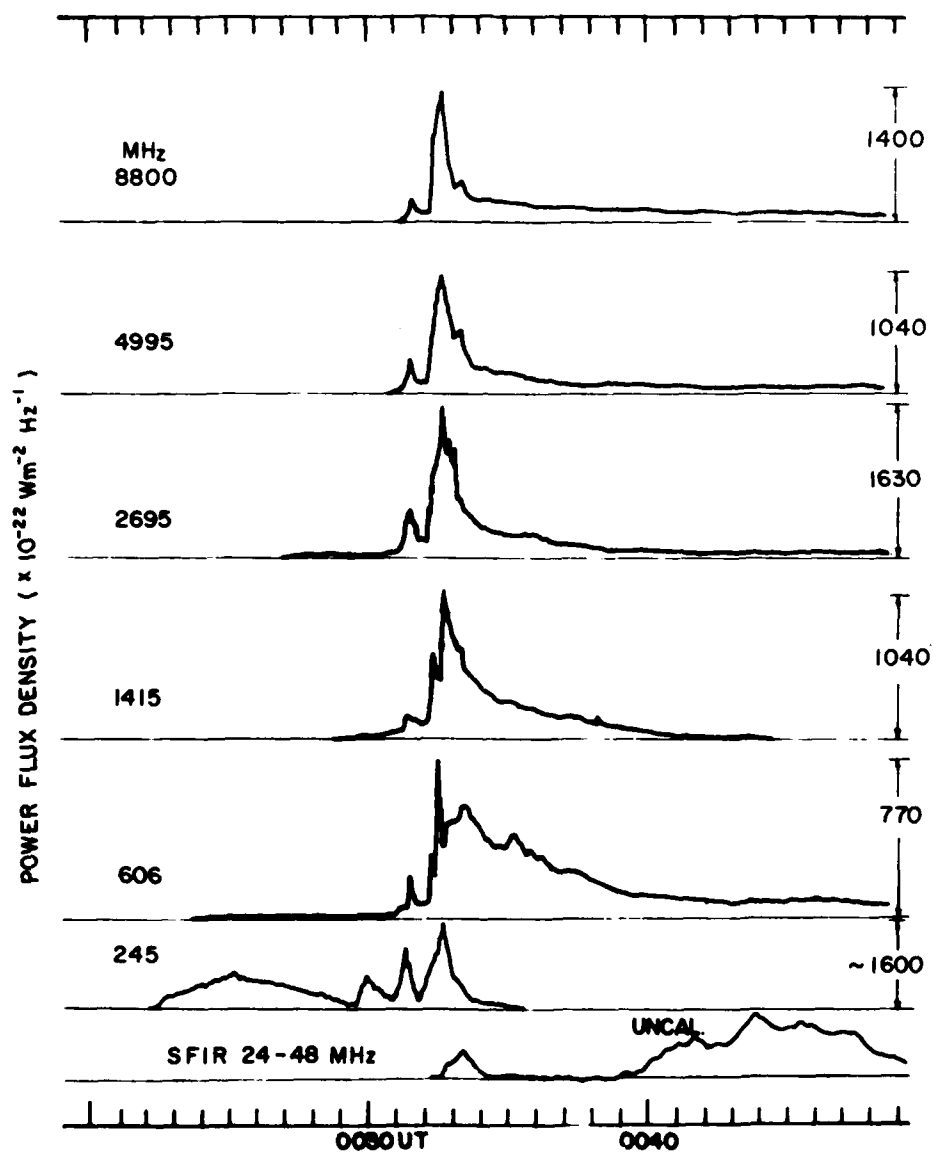
COMPLEX F & SIMPLE 2F RADIO BURST OBSERVED ON
23 JANUARY 1972 AT MANILA OBSERVATORY, R. P.



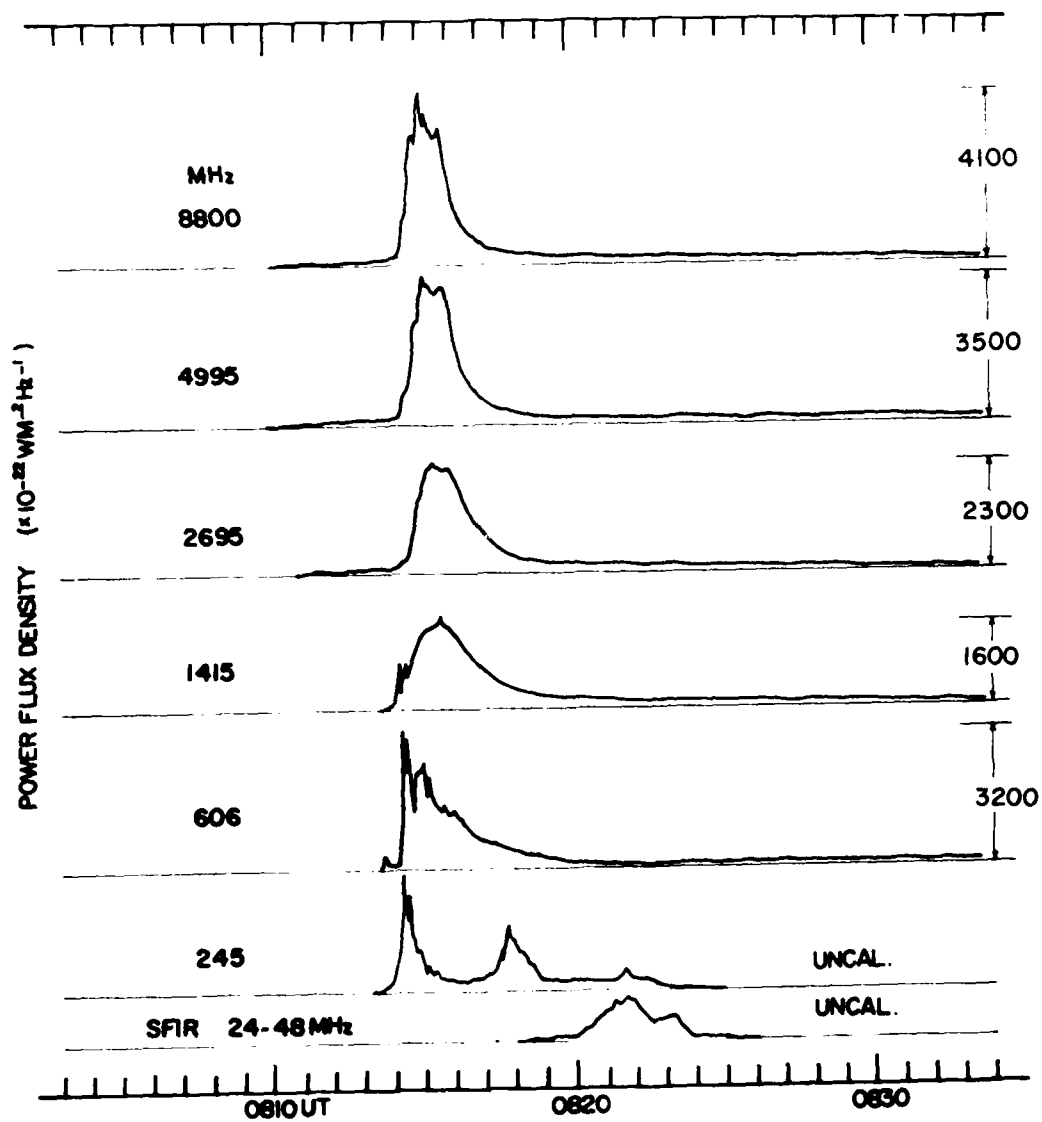
SIMPLE 2F & GREAT RADIO BURST OBSERVED ON
13 FEBRUARY 1972 AT MANILA OBSERVATORY, R. P.



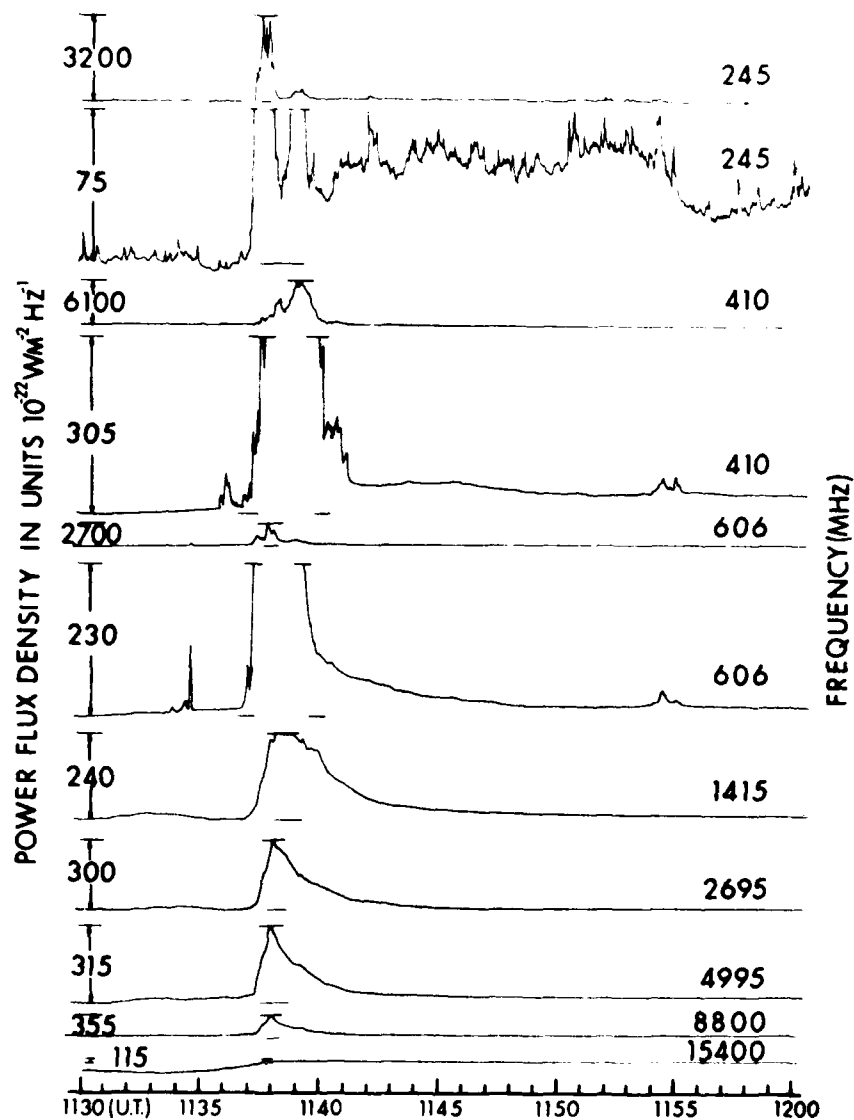
COMPLEX AND SIMPLE 2 RADIO BURST OBSERVED ON 19 FEBRUARY, 1972
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASSACHUSETTS



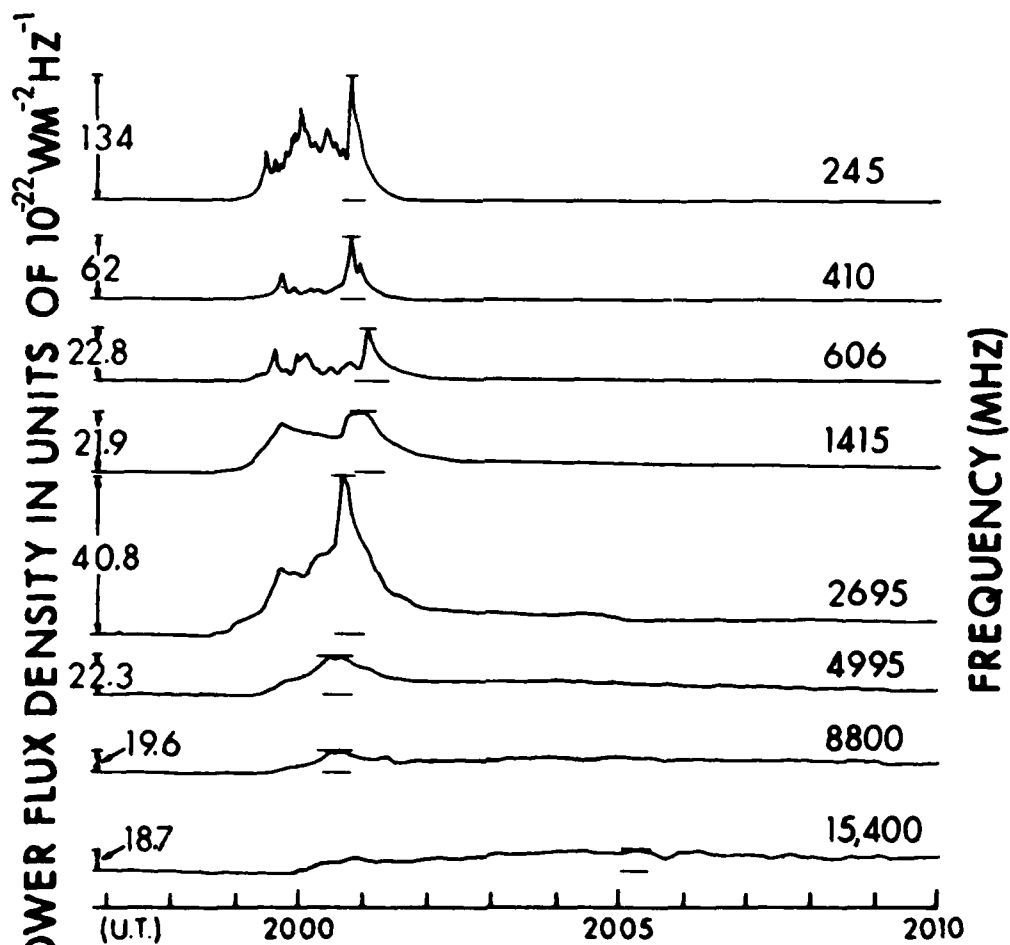
GREAT RADIO BURST OBSERVED ON 22 FEBRUARY 1972 AT
MANILA OBSERVATORY, R.P.



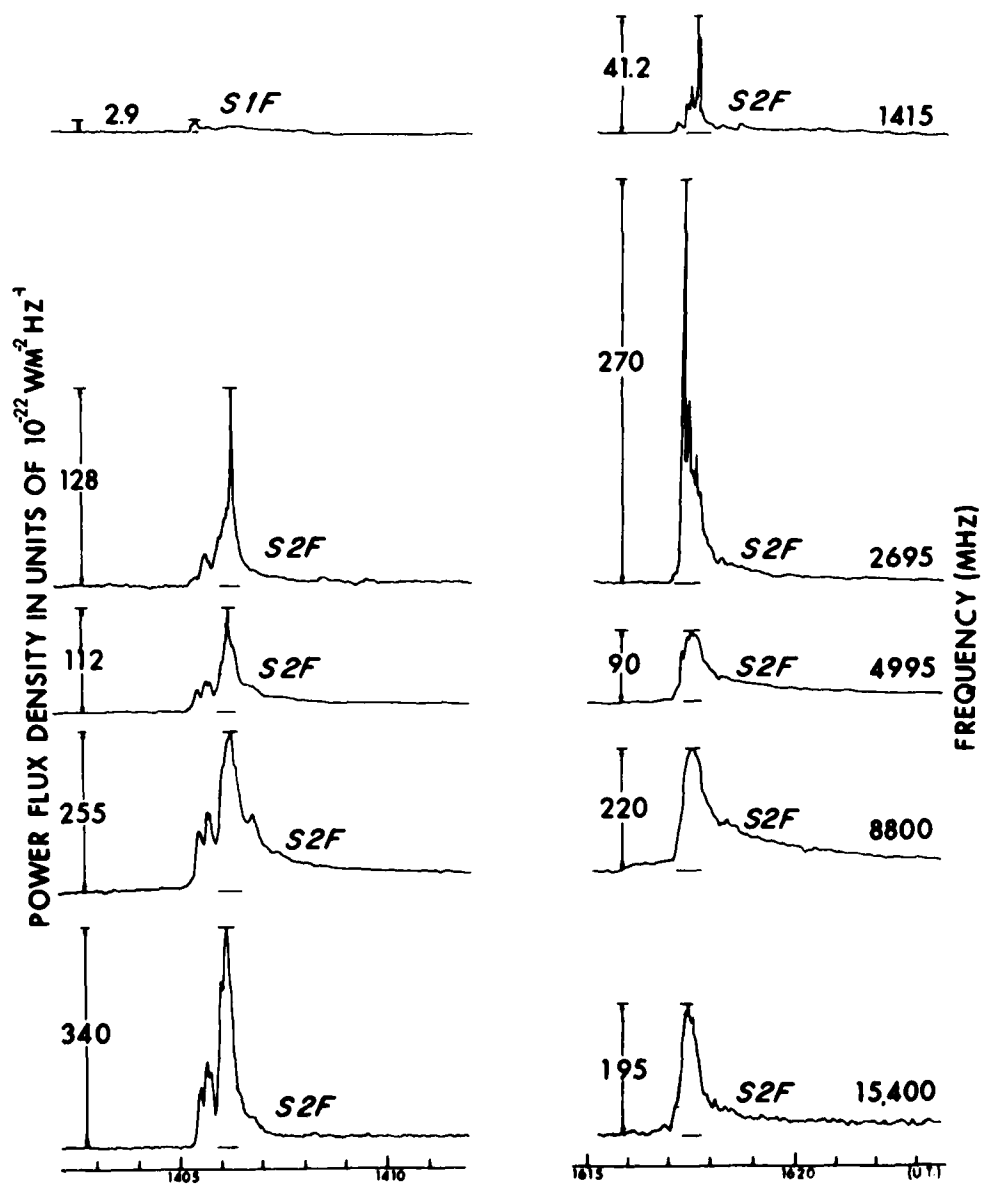
GREAT RADIO BURST OBSERVED ON 05 MARCH 1972
AT MANILA OBSERVATORY, R.P.



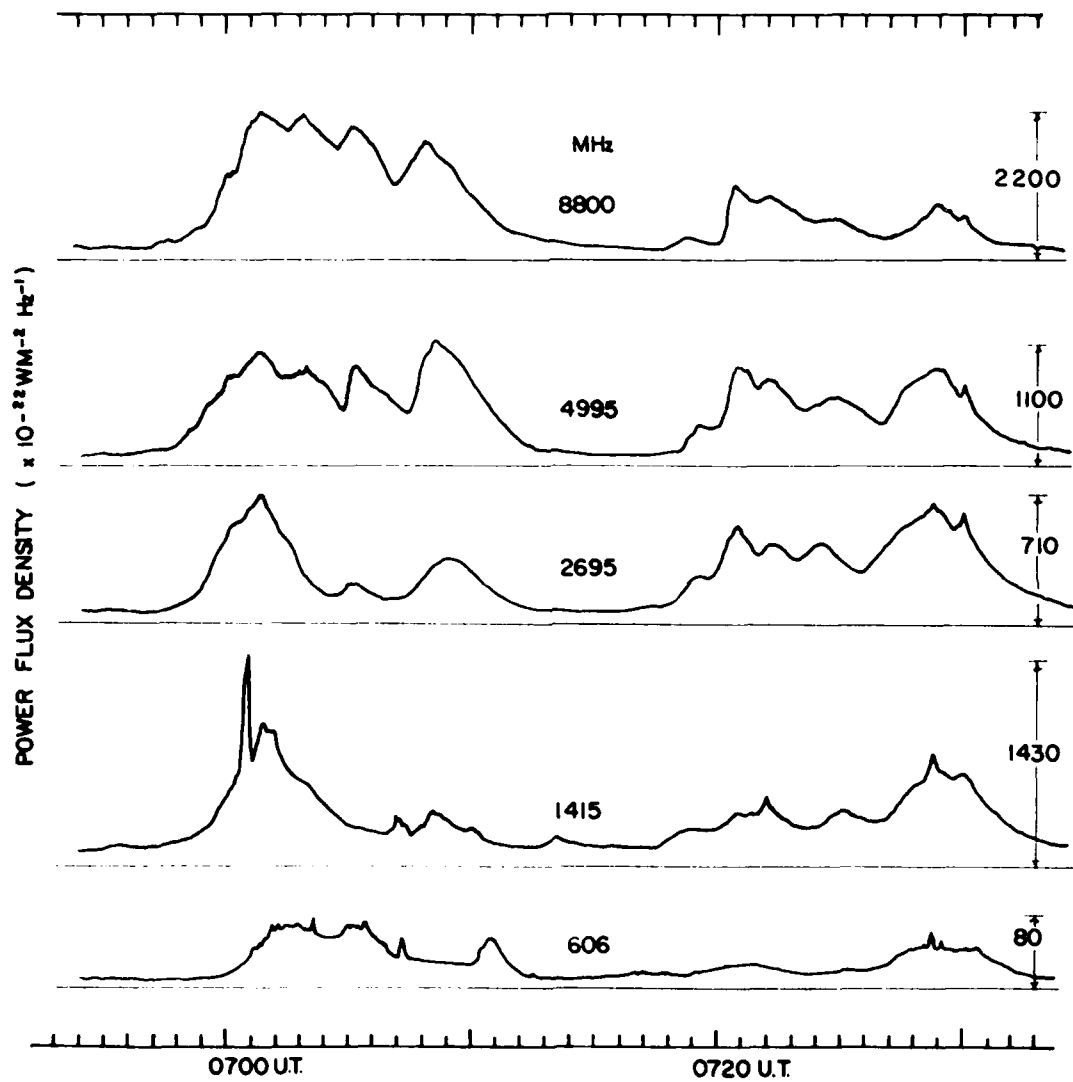
MAJOR+, GREAT, AND SIMPLE 2 RADIO BURST OBSERVED
5 MARCH, 1972 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



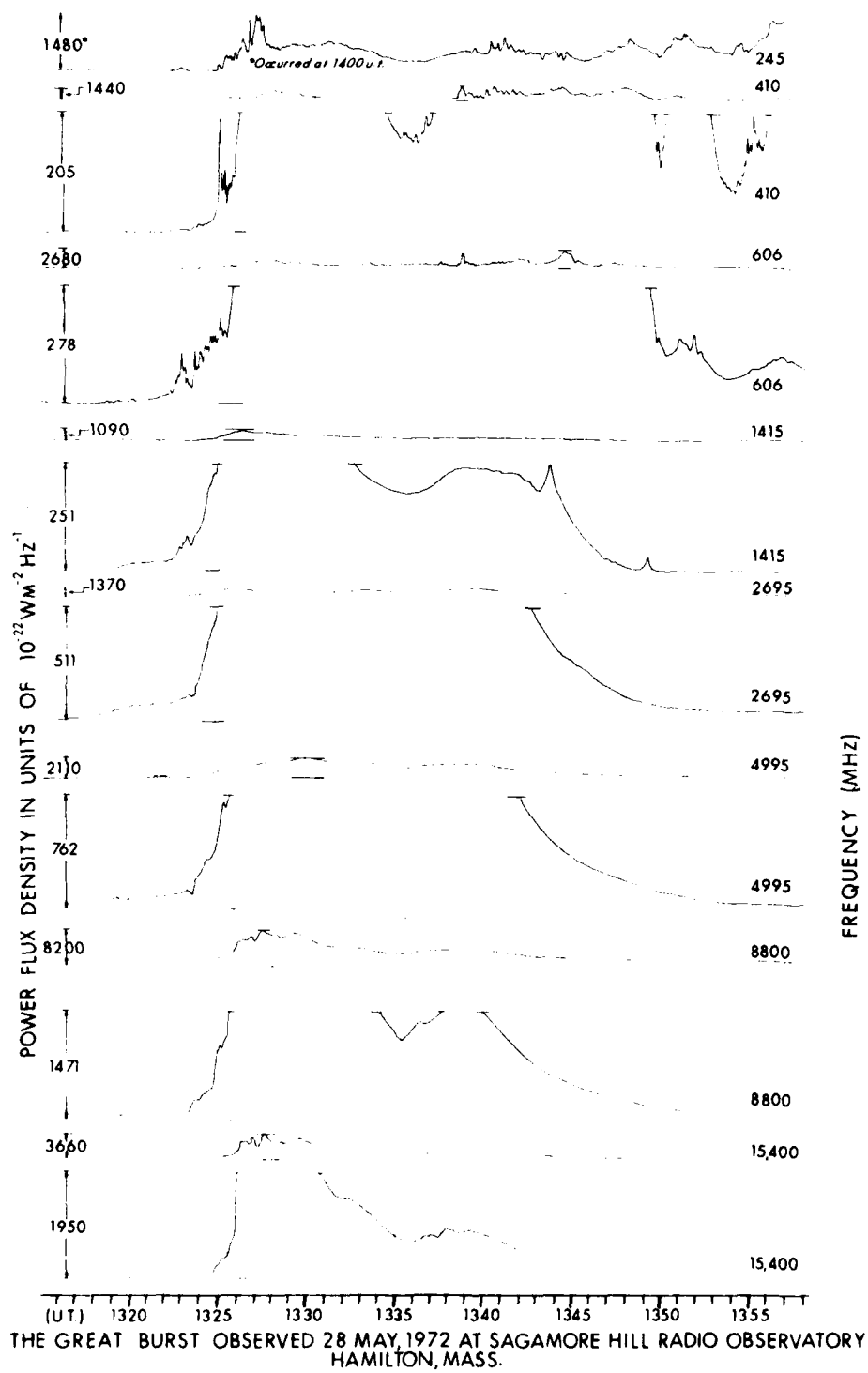
SIMPLE 2F AND 3F RADIO BURST
 OBSERVED 14 APRIL, 1972
 SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.

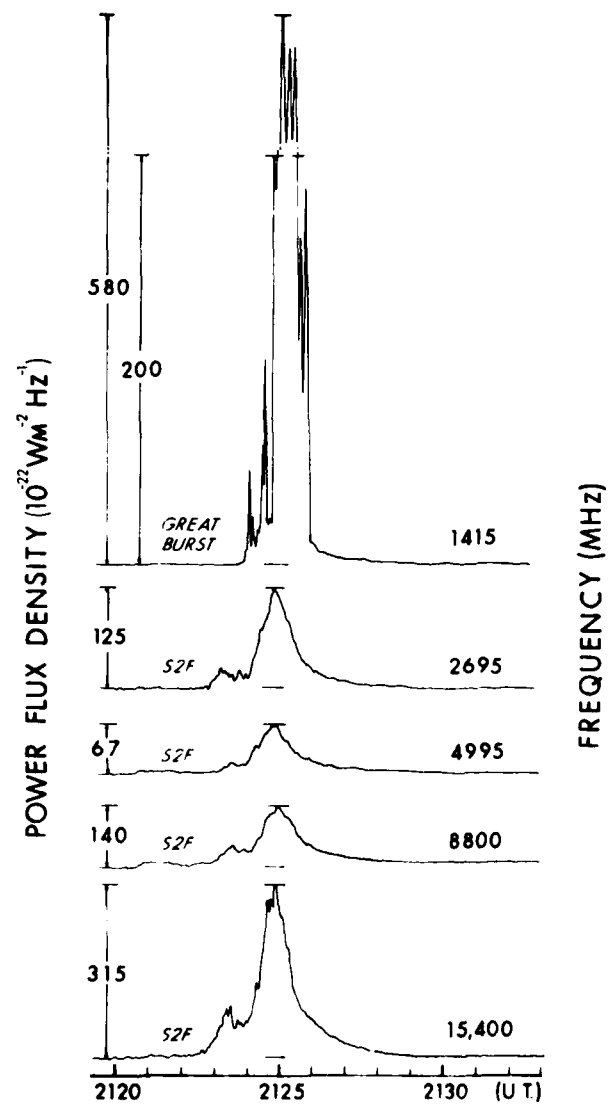


SIMPLE 2F AND 1F RADIOBURSTS OBSERVED ON 18 MAY, 1972
SAGAMORE HILL RADIO OBSERVATORY-HAMILTON, MASS.

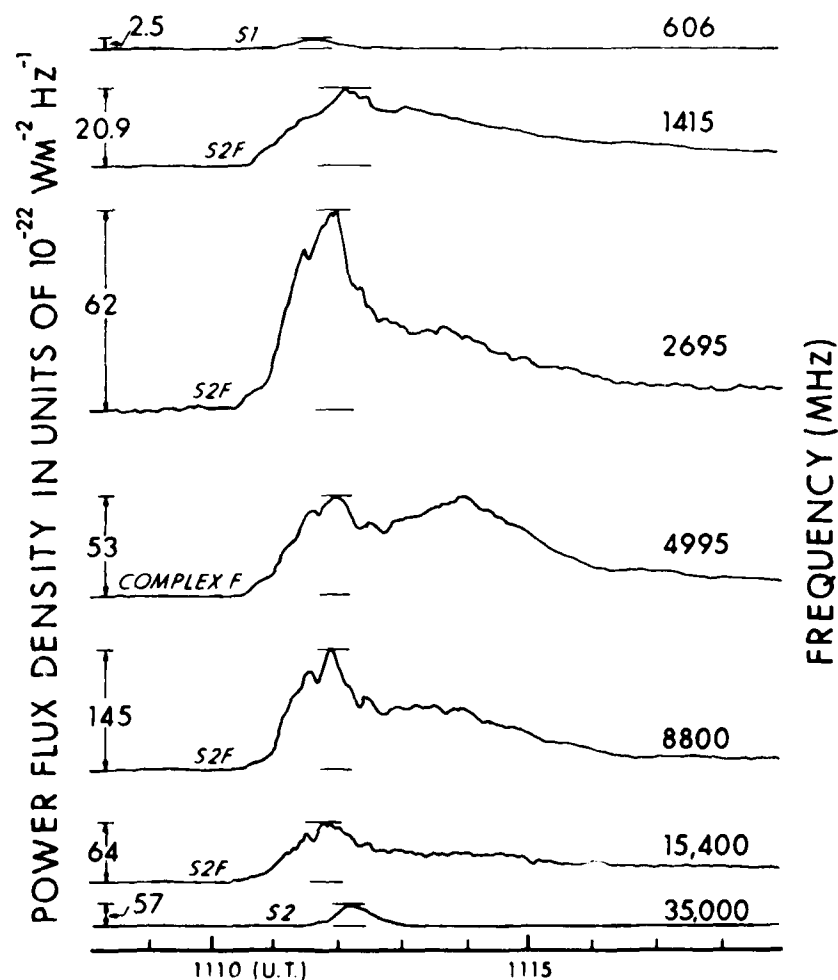


GREAT RADIO BURST OBSERVED ON 24 MAY 1972 AT
MANILA OBSERVATORY , R. P.

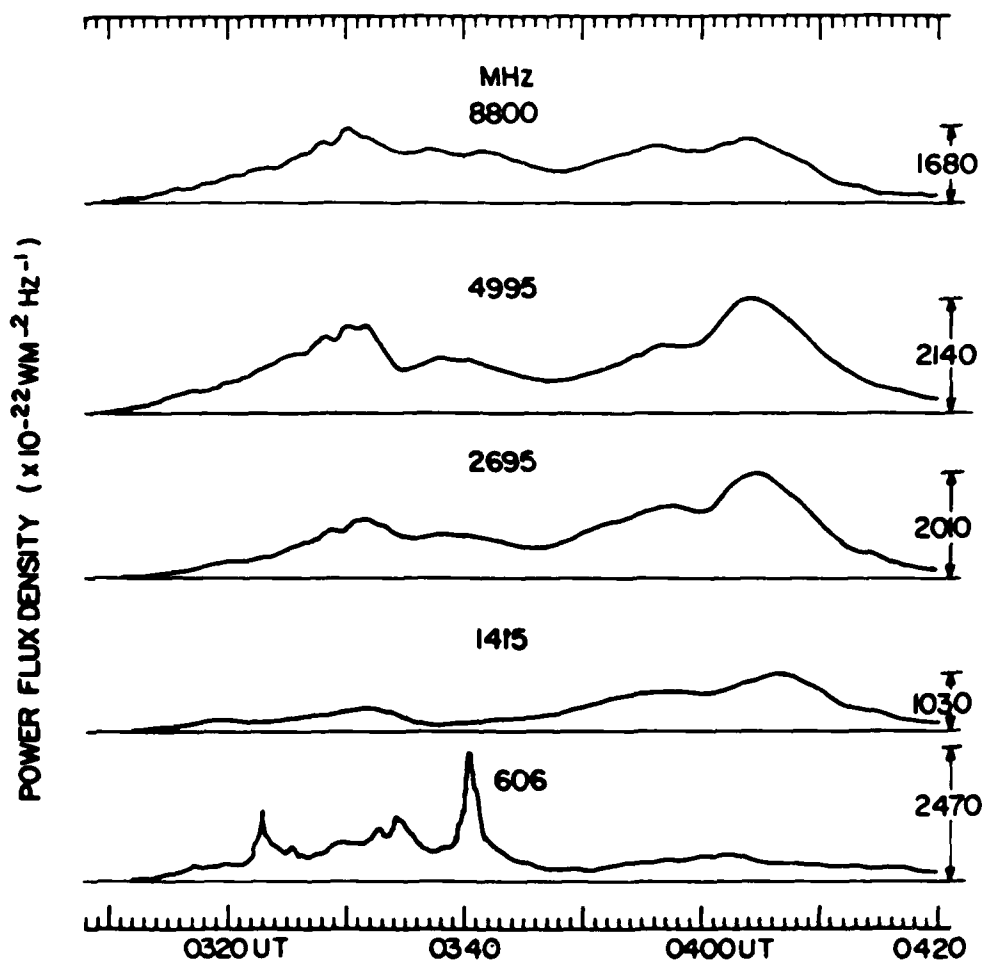




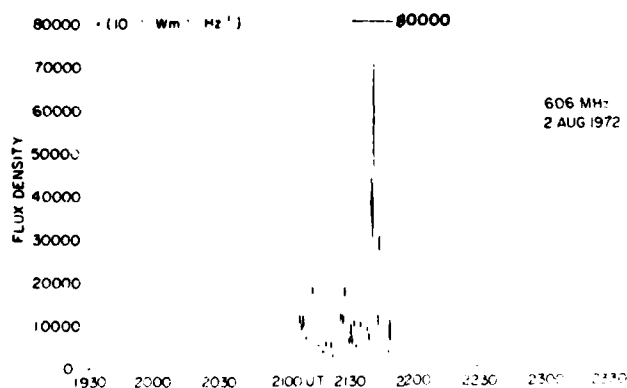
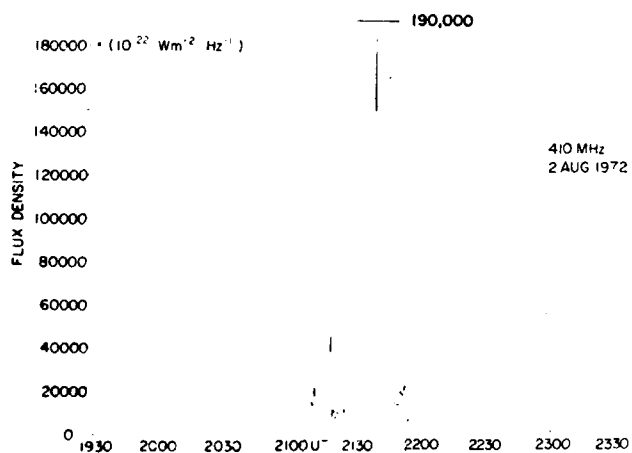
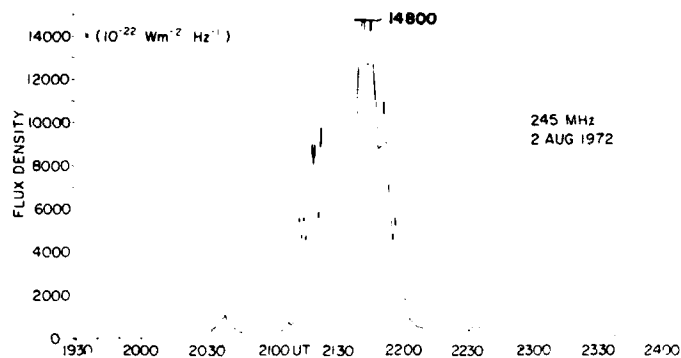
RADIO BURST OBSERVED 5 JUNE, 1972
SAGAMORE HILL RADIO OBSERVATORY
AT HAMILTON, MASS



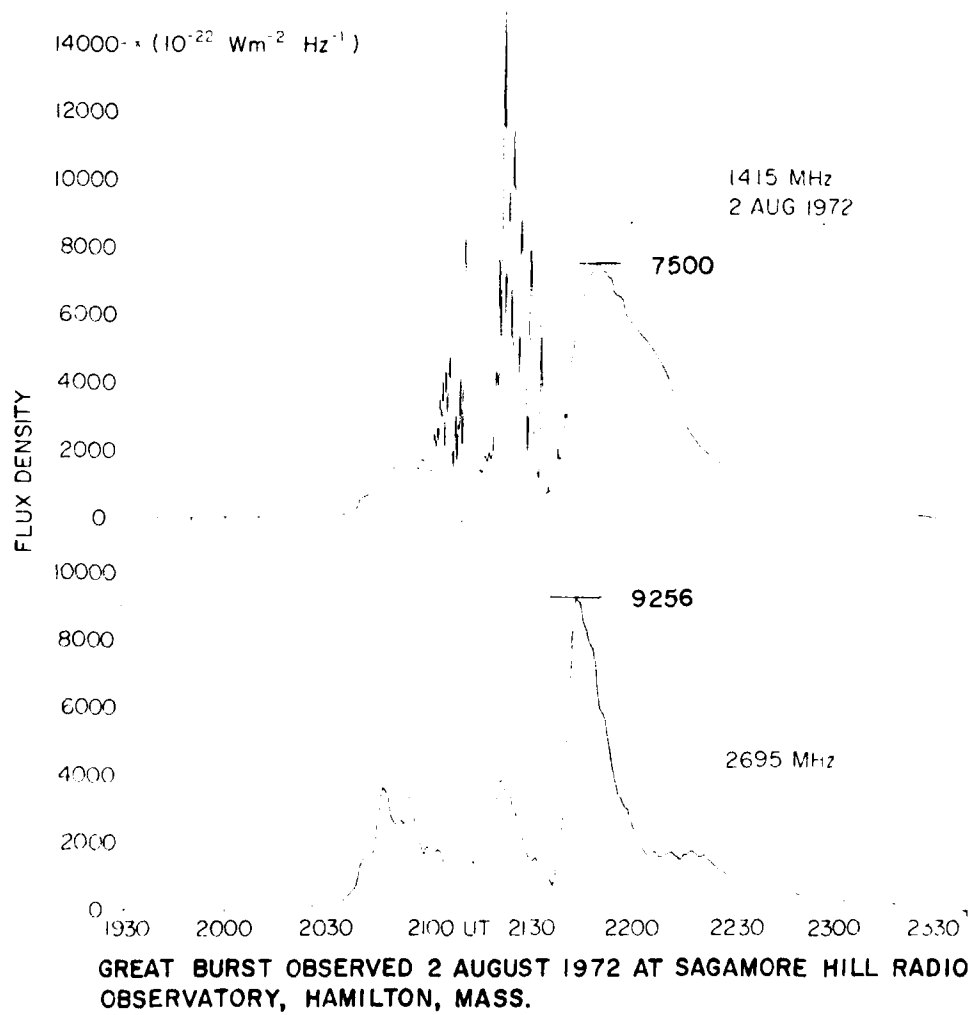
RADIO BURST OBSERVED 31 JULY, 1972
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

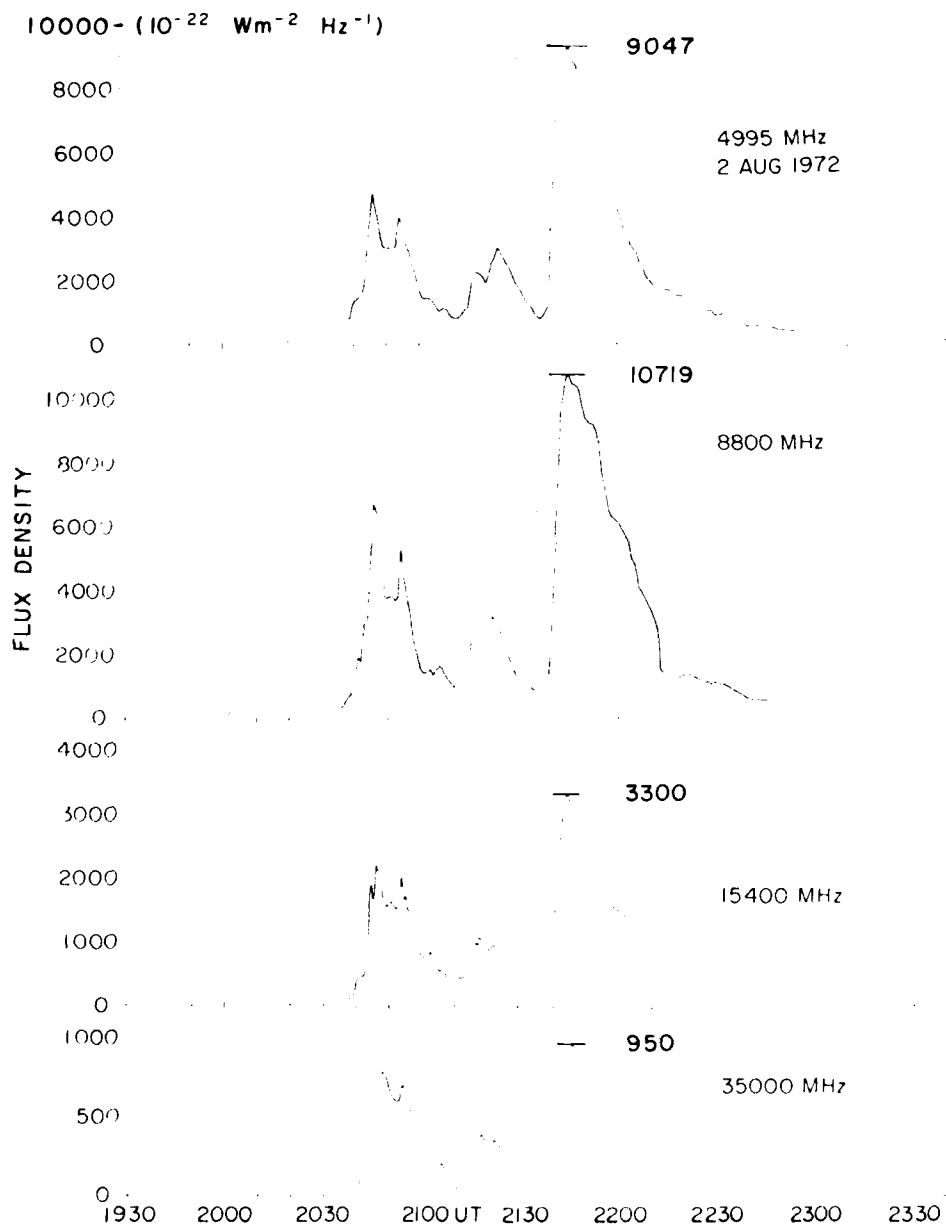


GREAT RADIO BURST OBSERVED ON 02 AUGUST 1972
AT MANILA OBSERVATORY, R.P.

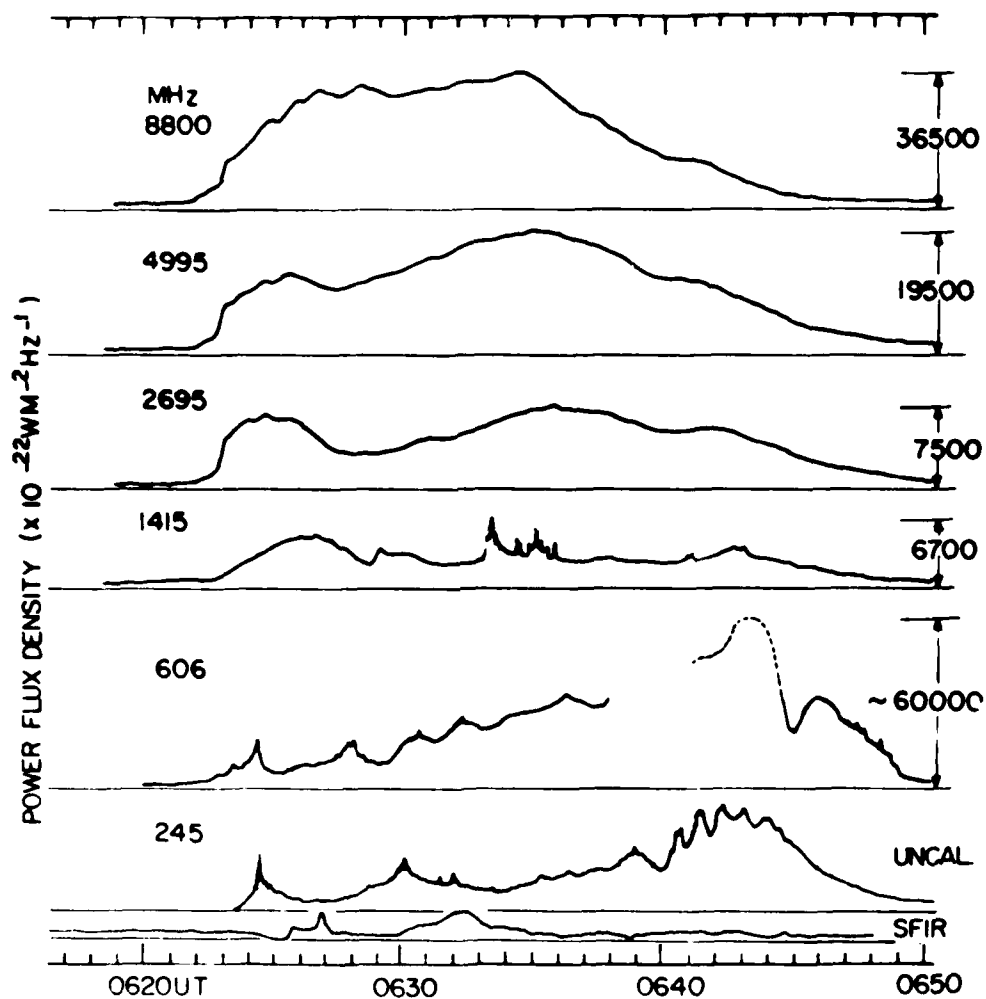


GREAT BURST OBSERVED 2 AUGUST 1972 AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS

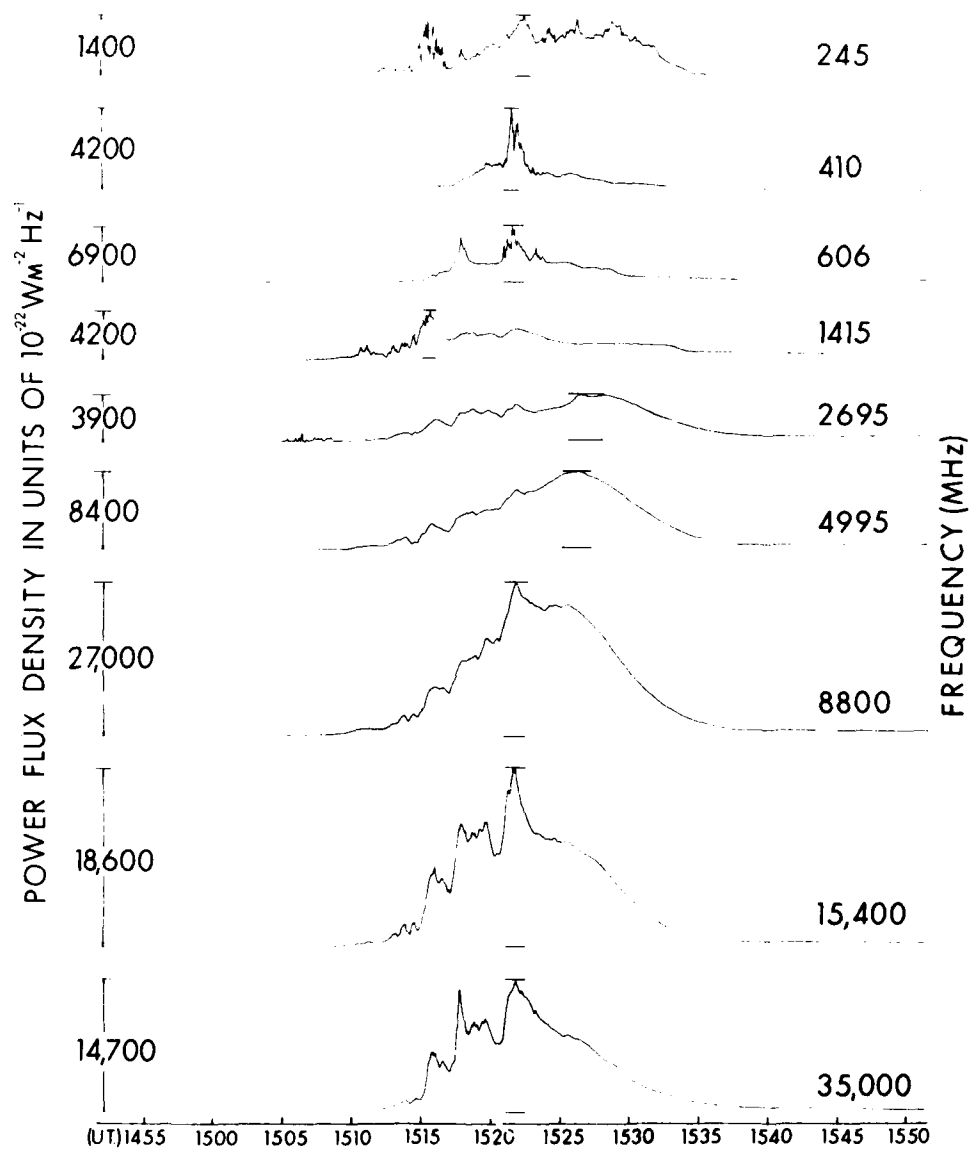




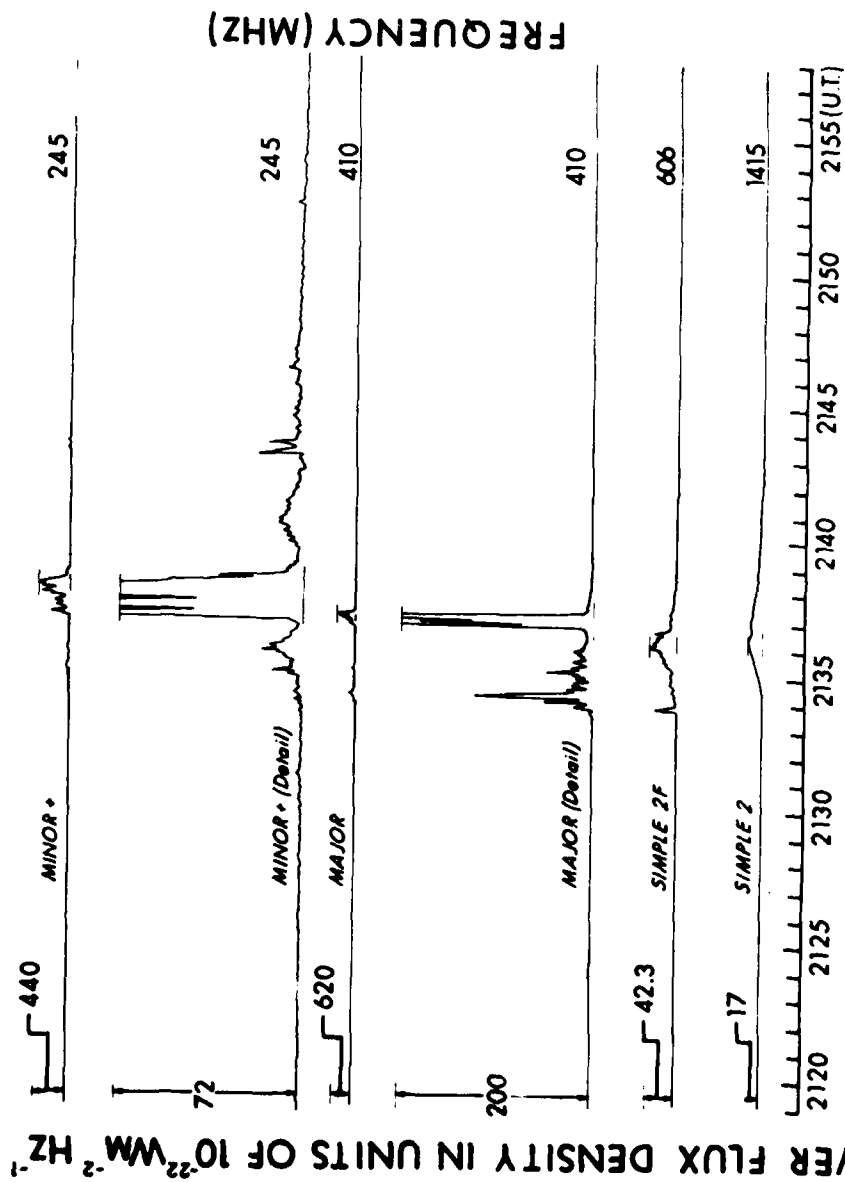
GREAT BURST OBSERVED 2 AUGUST 1972 AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



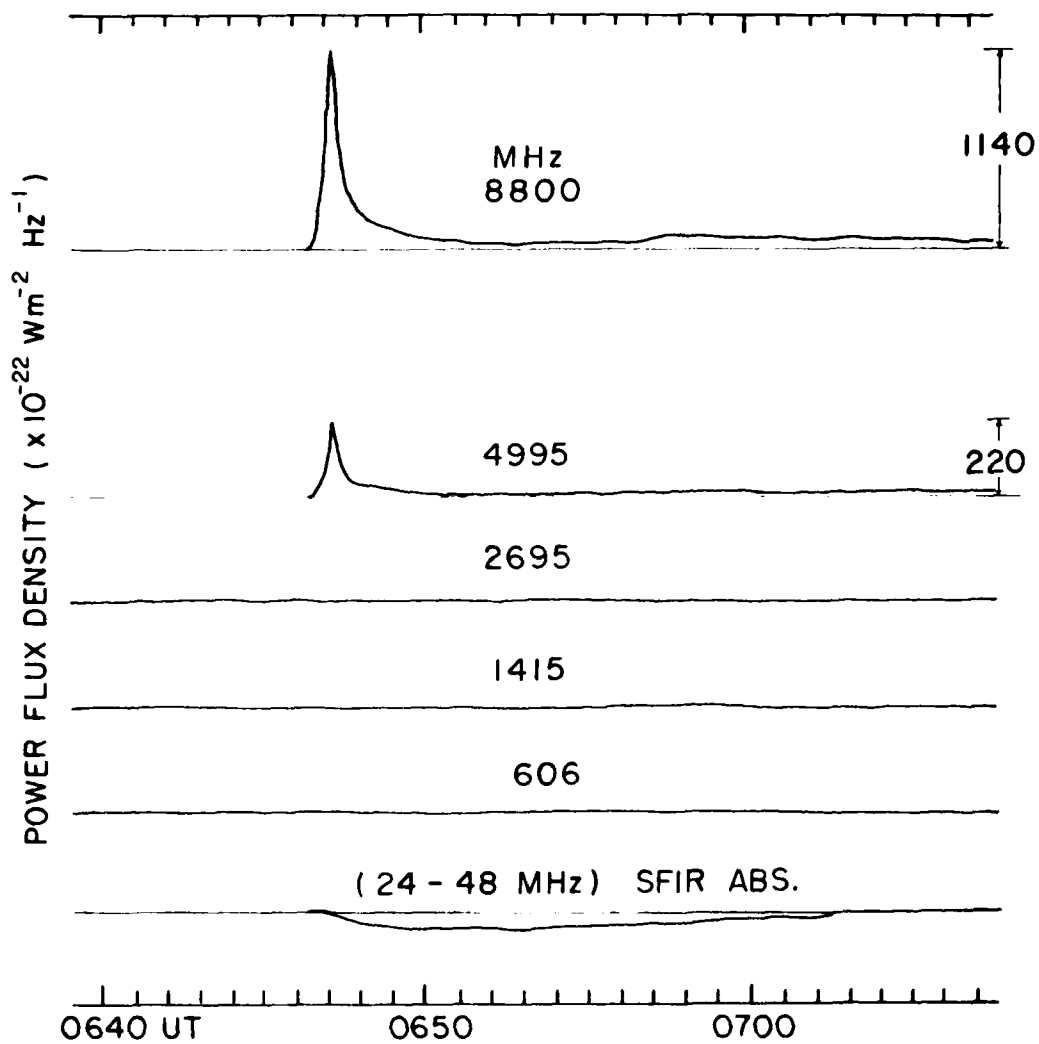
GREAT RADIO BURST OBSERVED ON 04 AUGUST 1972
AT MANILA OBSERVATORY, R. P.



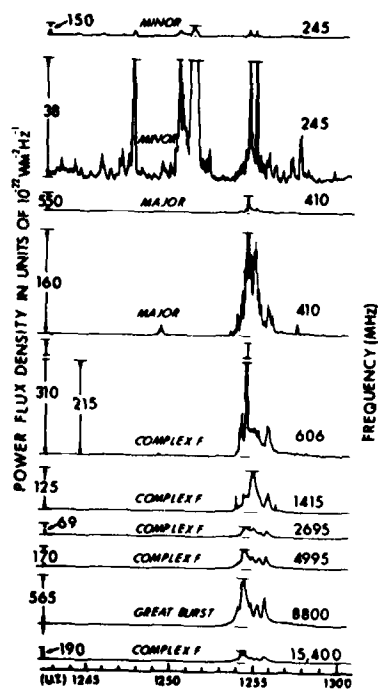
GREAT BURST OBSERVED 7 AUGUST, 1972
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



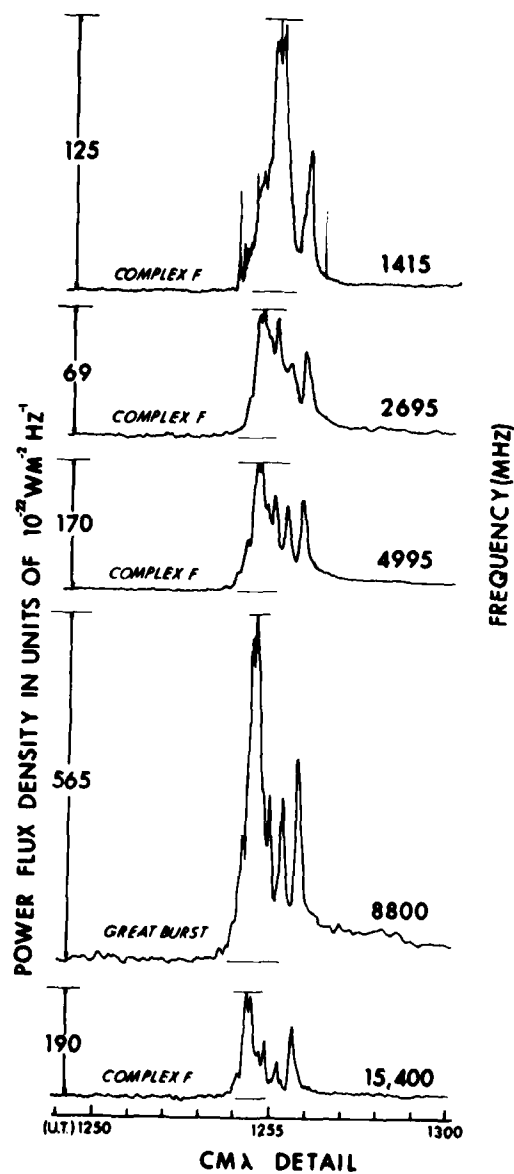
RADIO BURST OBSERVED ON 6 SEPTEMBER, 1972
 SAGAMORE HILL RADIO OBSERVATORY
 HAMILTON, MASS.

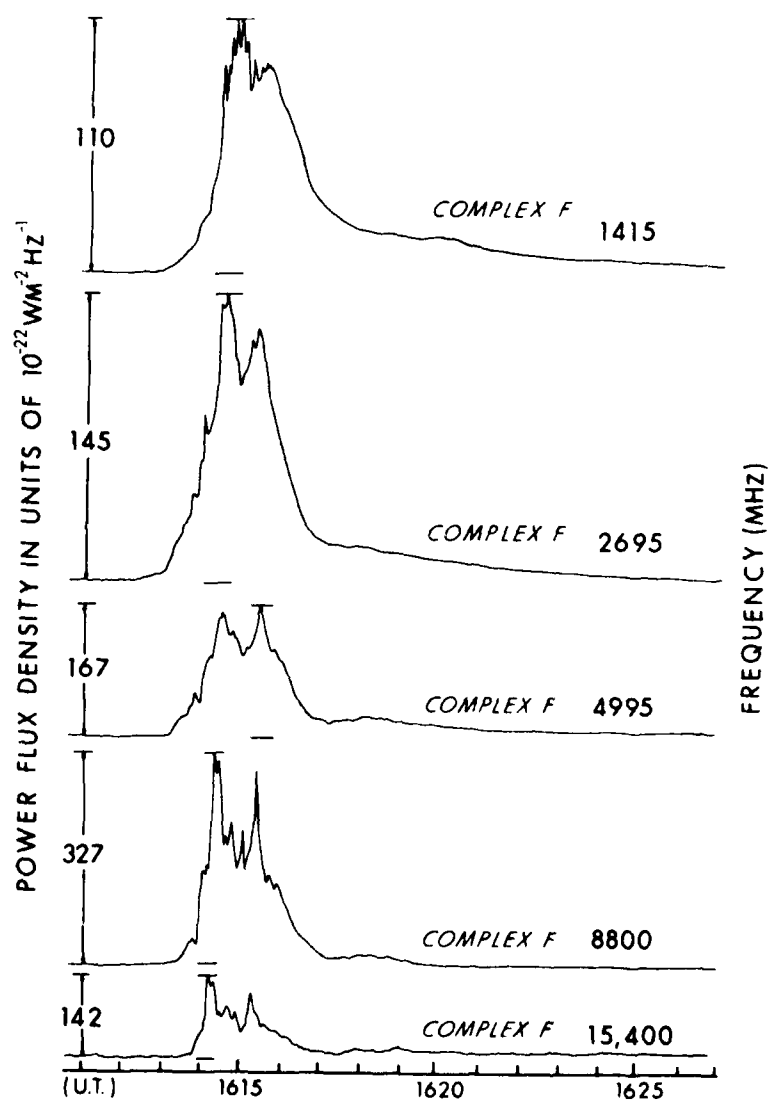


SIMPLE 2 & GREAT RADIO BURST OBSERVED ON
OCTOBER 26, 1972 AT MANILA OBSERVATORY, R.P.

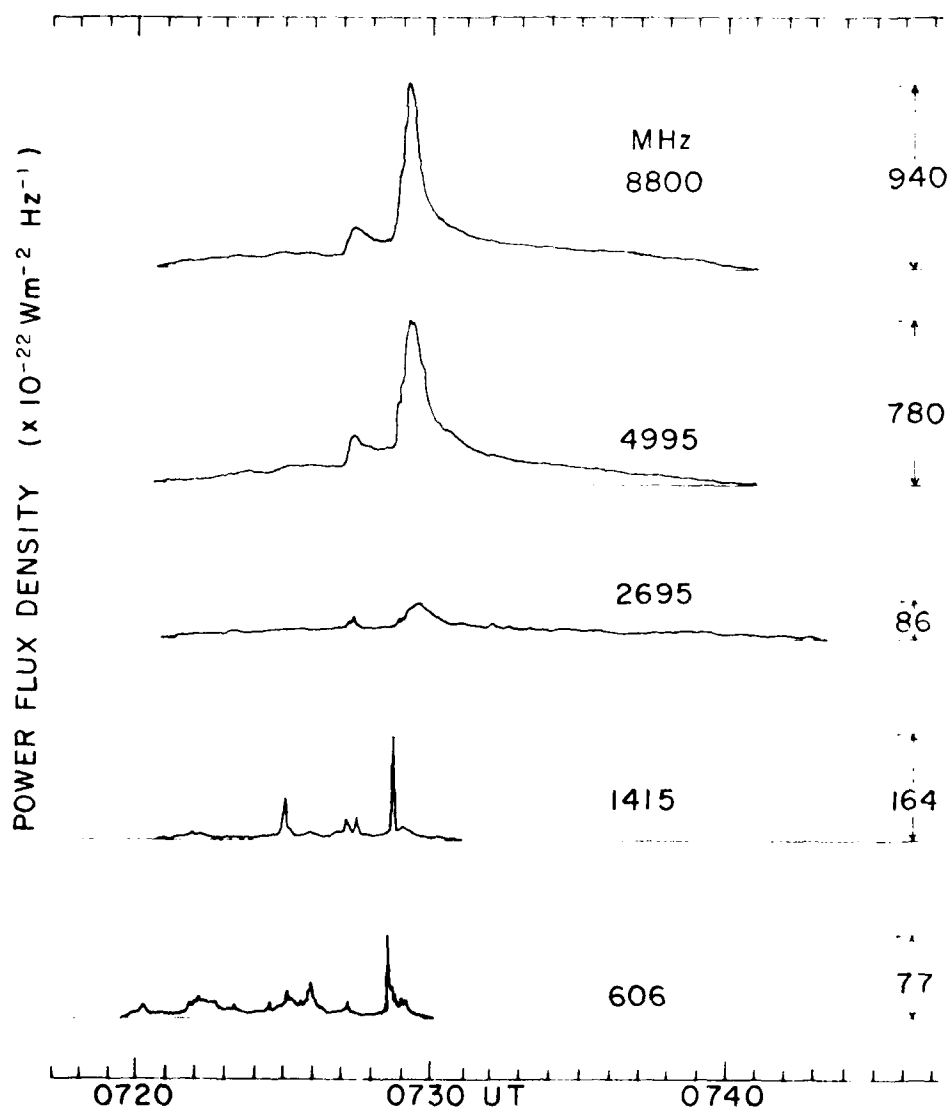


**SOLAR RADIO BURST
OBSERVED 26 OCTOBER, 1972
AT SAGAMORE HILL
RADIO OBSERVATORY
HAMILTON, MASS.**

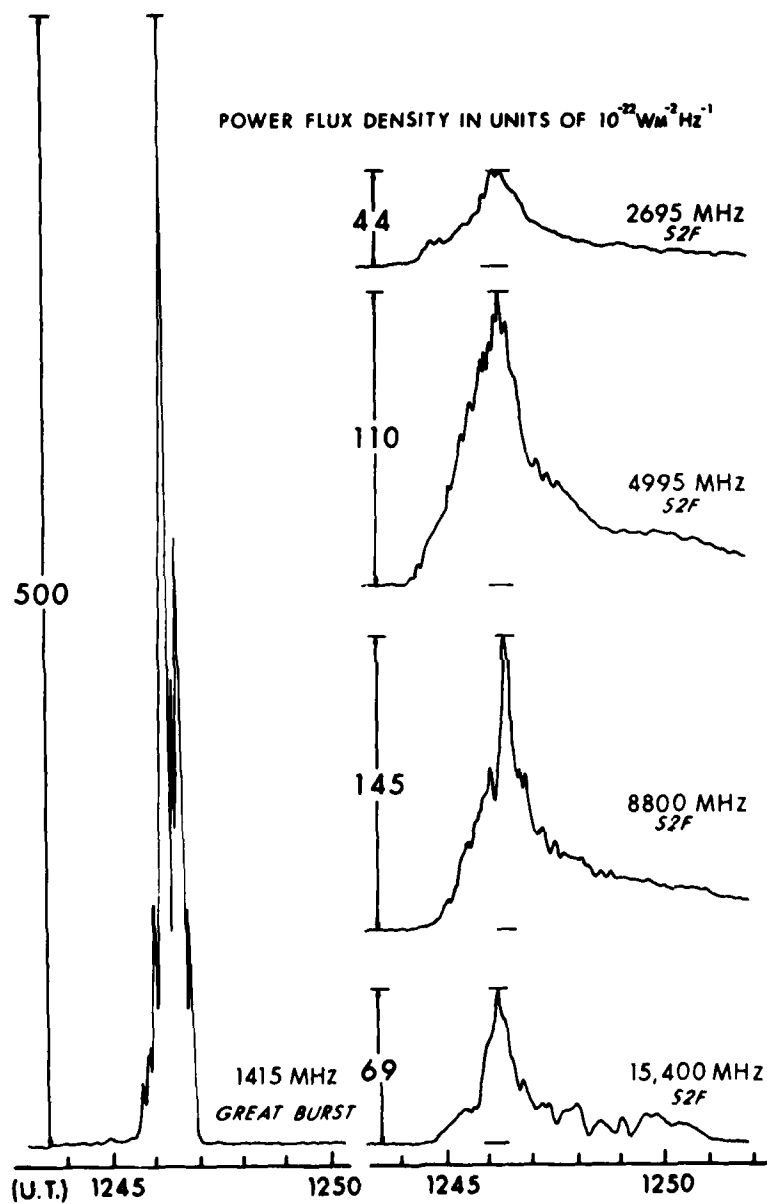




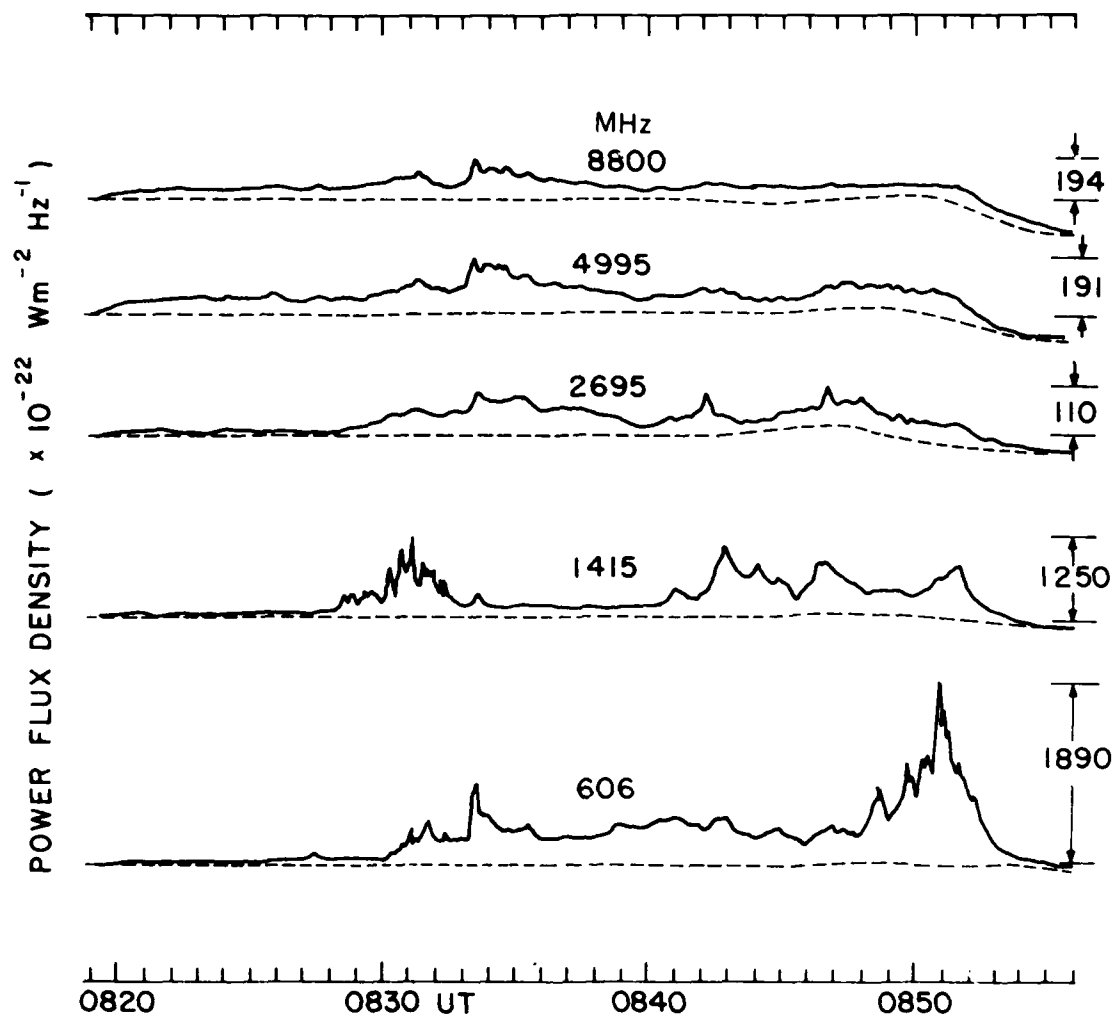
CMX RADIO BURST OBSERVED ON 29 OCTOBER, 1972
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



SIMPLE 2F & GREAT RADIO BURST OBSERVED ON
OCTOBER 30, 1972 AT MANILA OBSERVATORY, R.P.



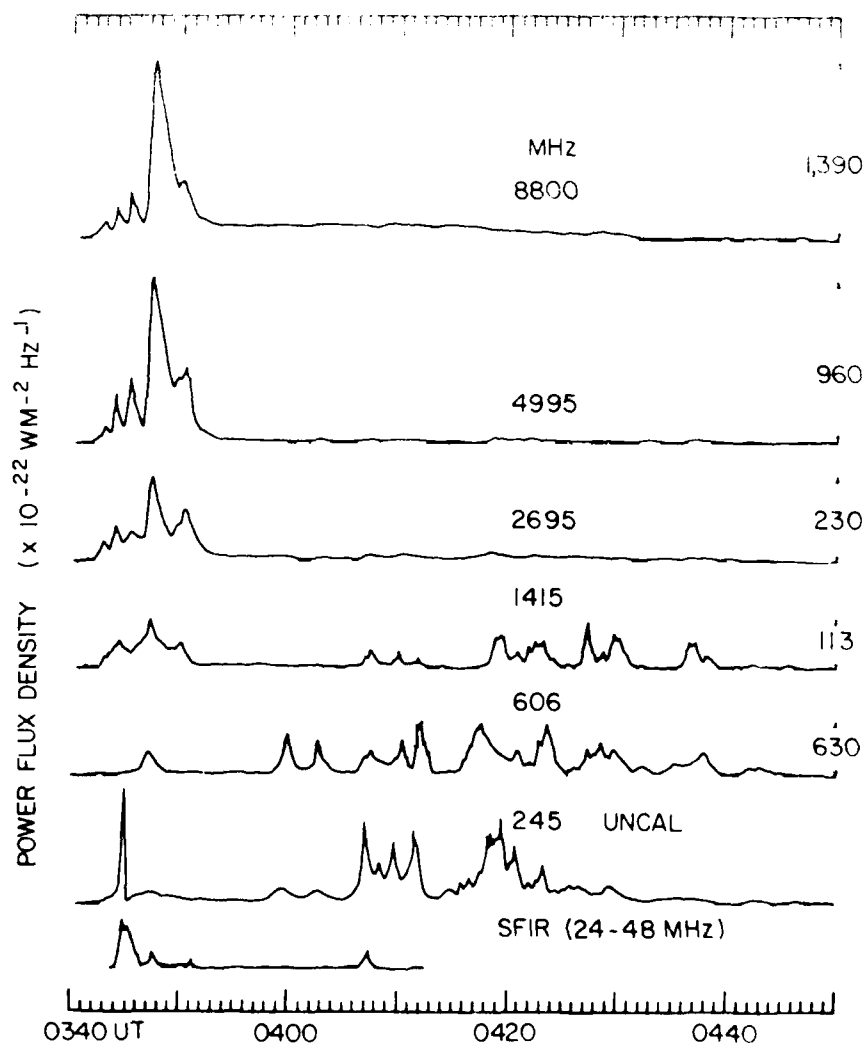
RADIO BURST OBSERVED ON 3 NOVEMBER, 1972
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



SIMPLE 2F & GREAT RADIO BURST OBSERVED ON 25
 NOVEMBER 1972 AT MANILA OBSERVATORY, R. P.
 ---- BROKEN LINES ARE QUIET SUN SUNSET CURVES



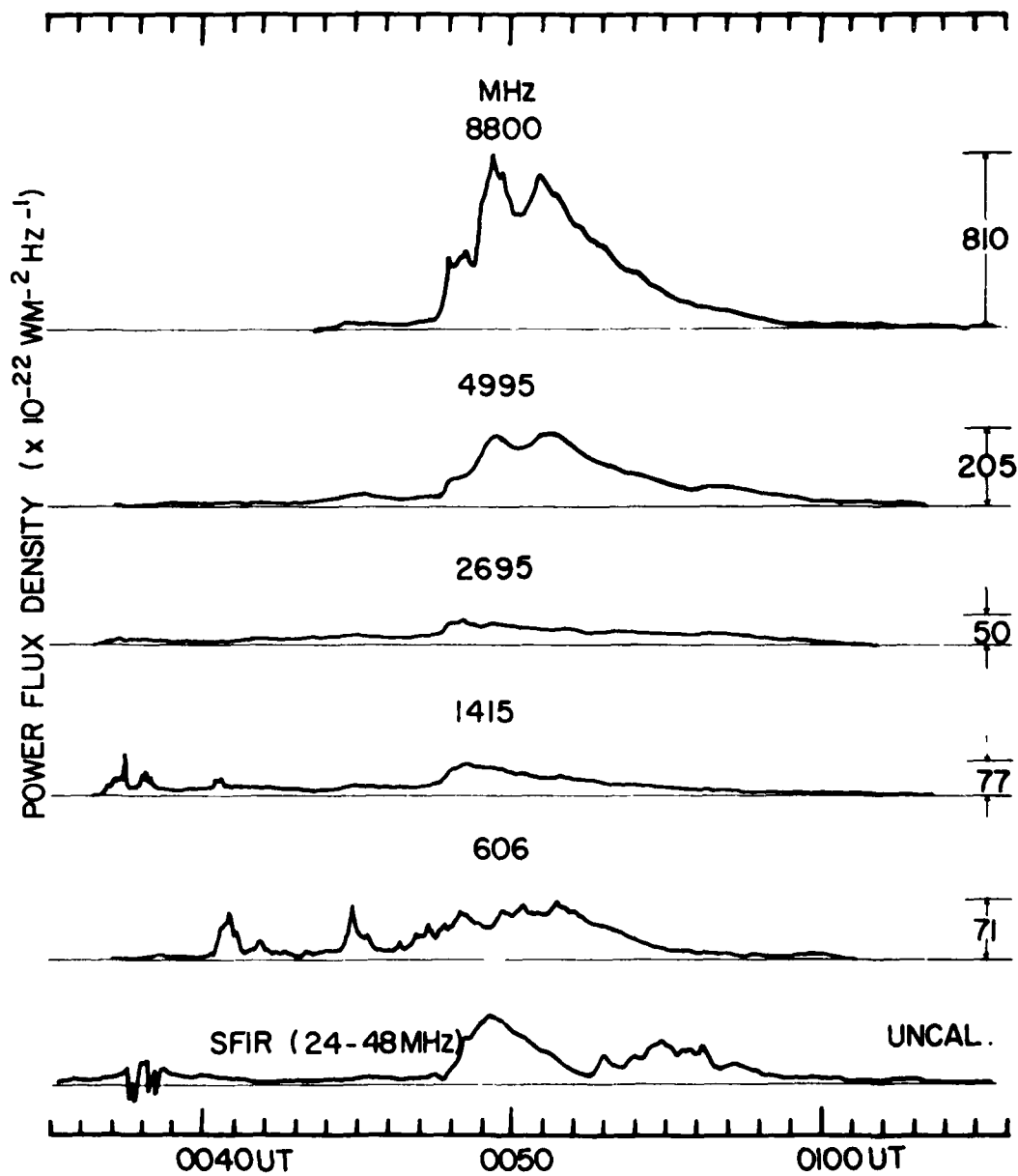
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASSACHUSETTS



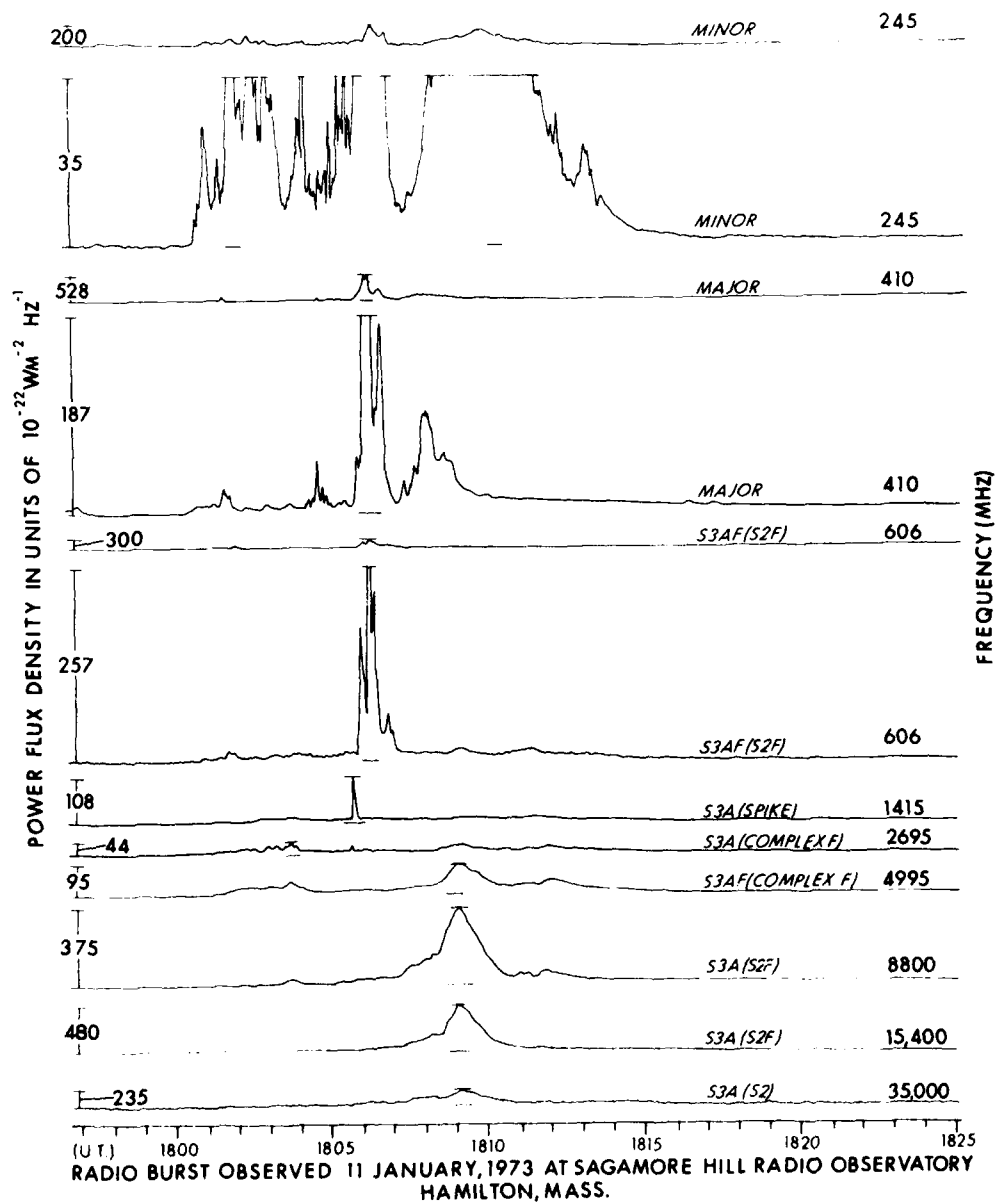
GREAT RADIO BURST OBSERVED ON DECEMBER 16, 1972
AT THE MANILA OBSERVATORY, R P

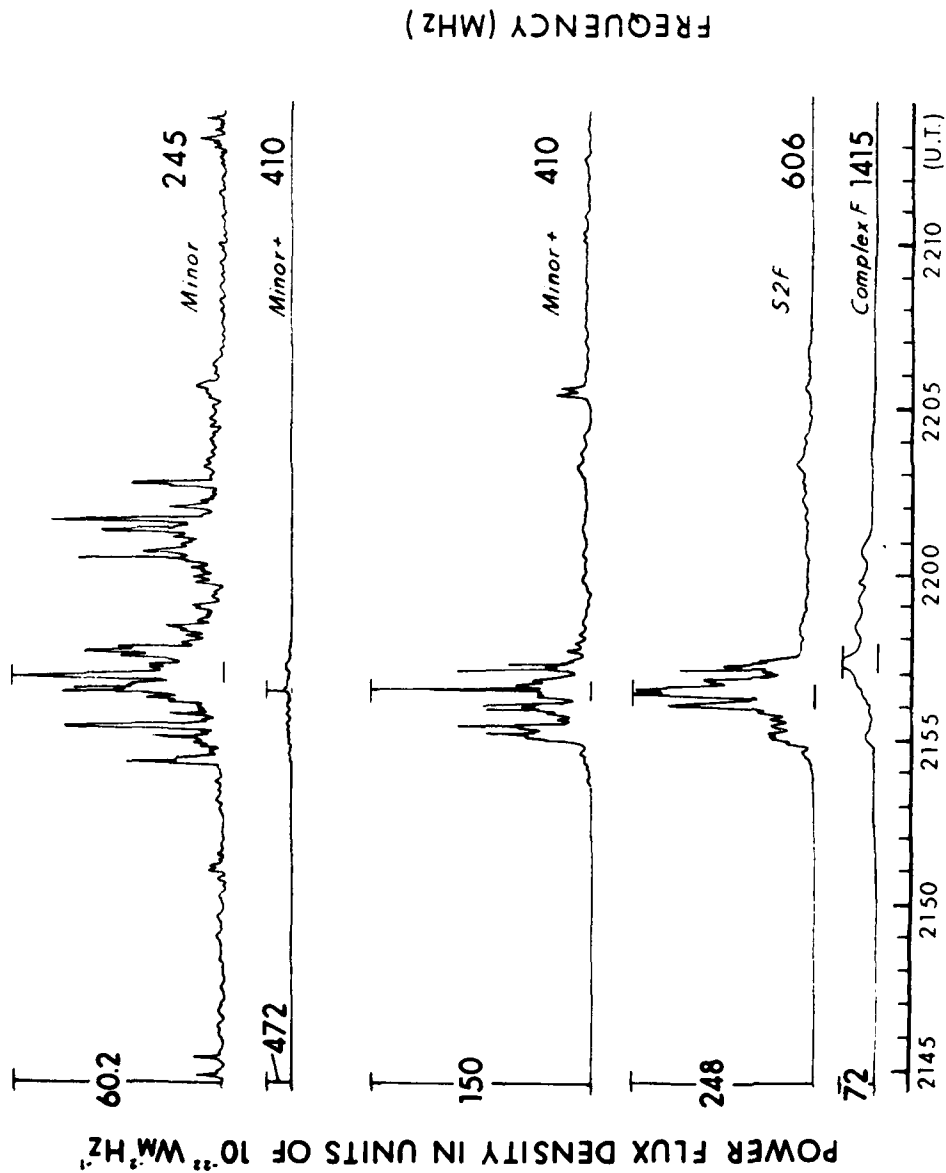
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**Solar Radio Bursts
1973**

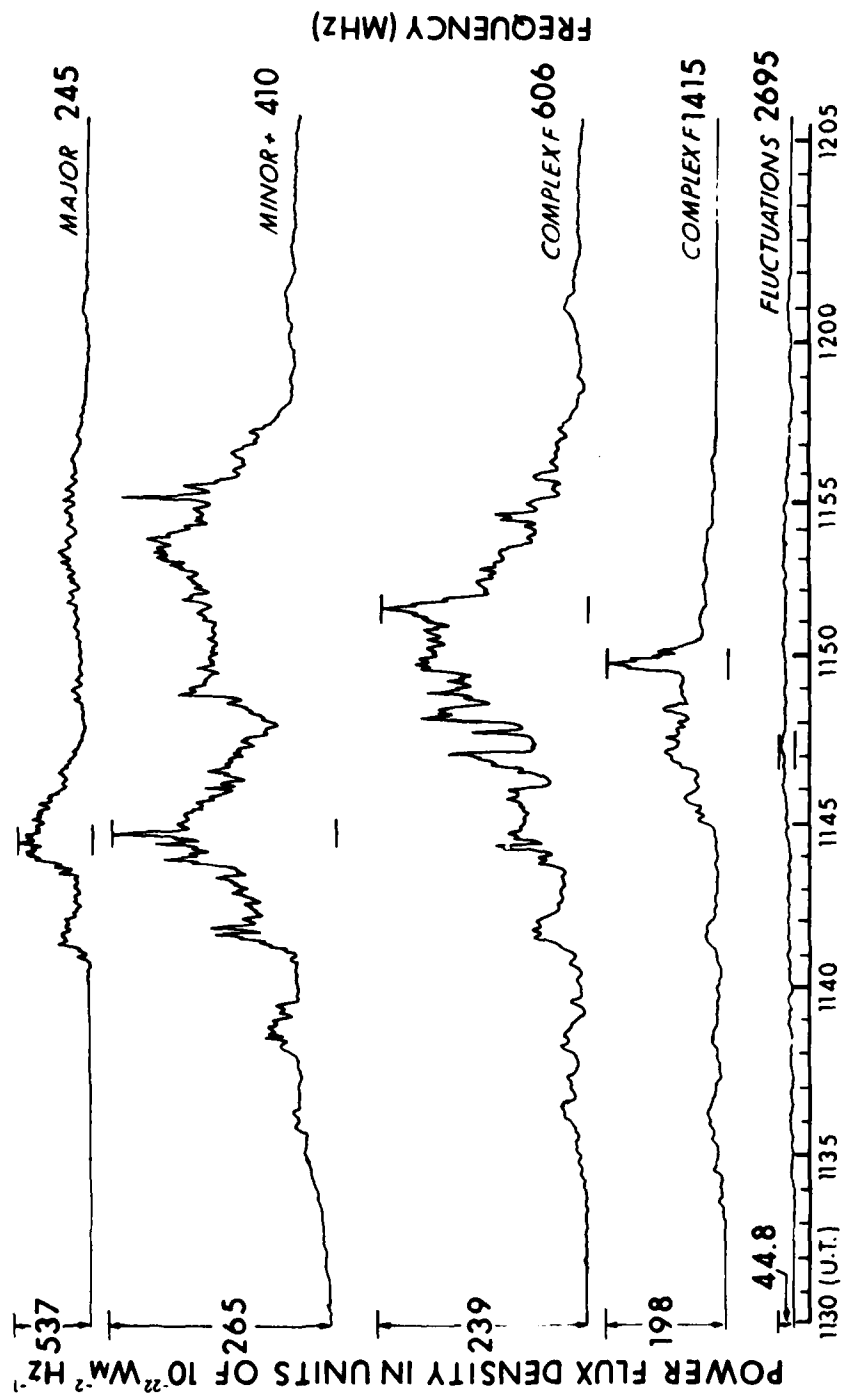


COMPLEX F & GREAT RADIO BURST OBSERVED ON
JANUARY 11, 1973 AT MANILA OBSERVATORY, R.P.

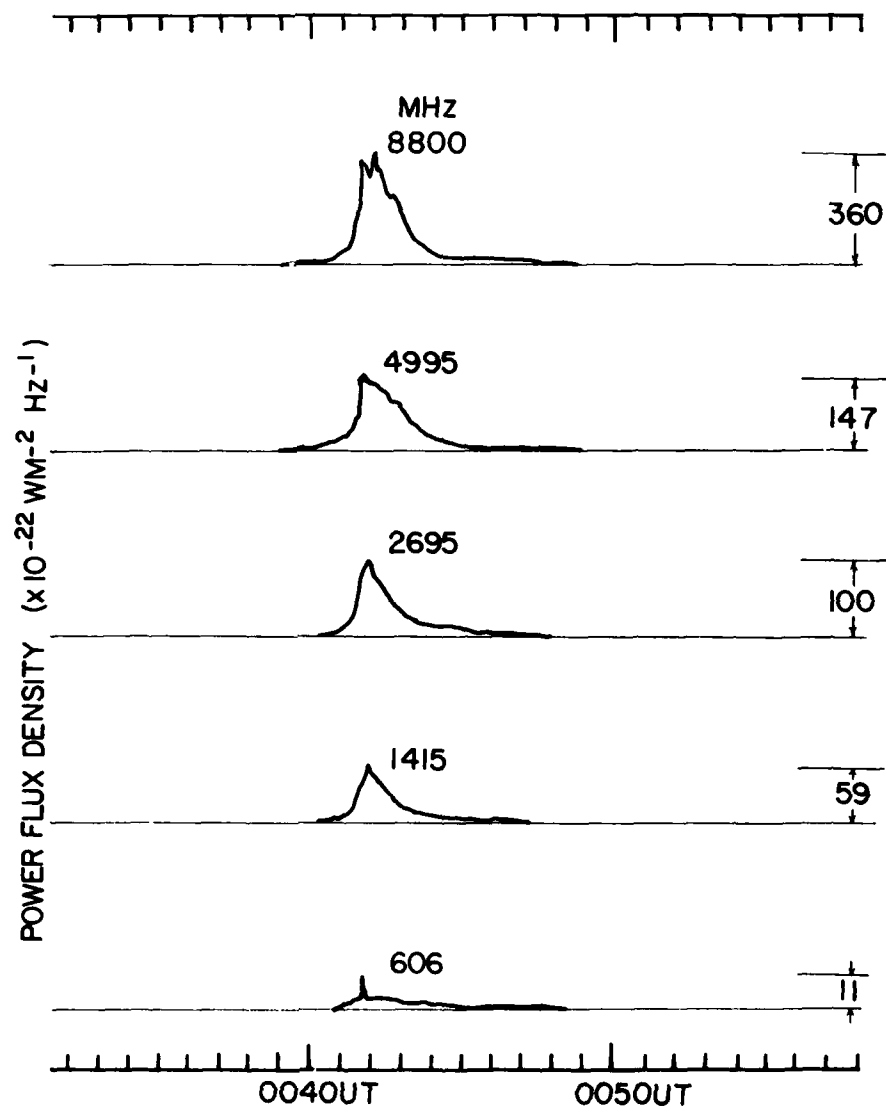




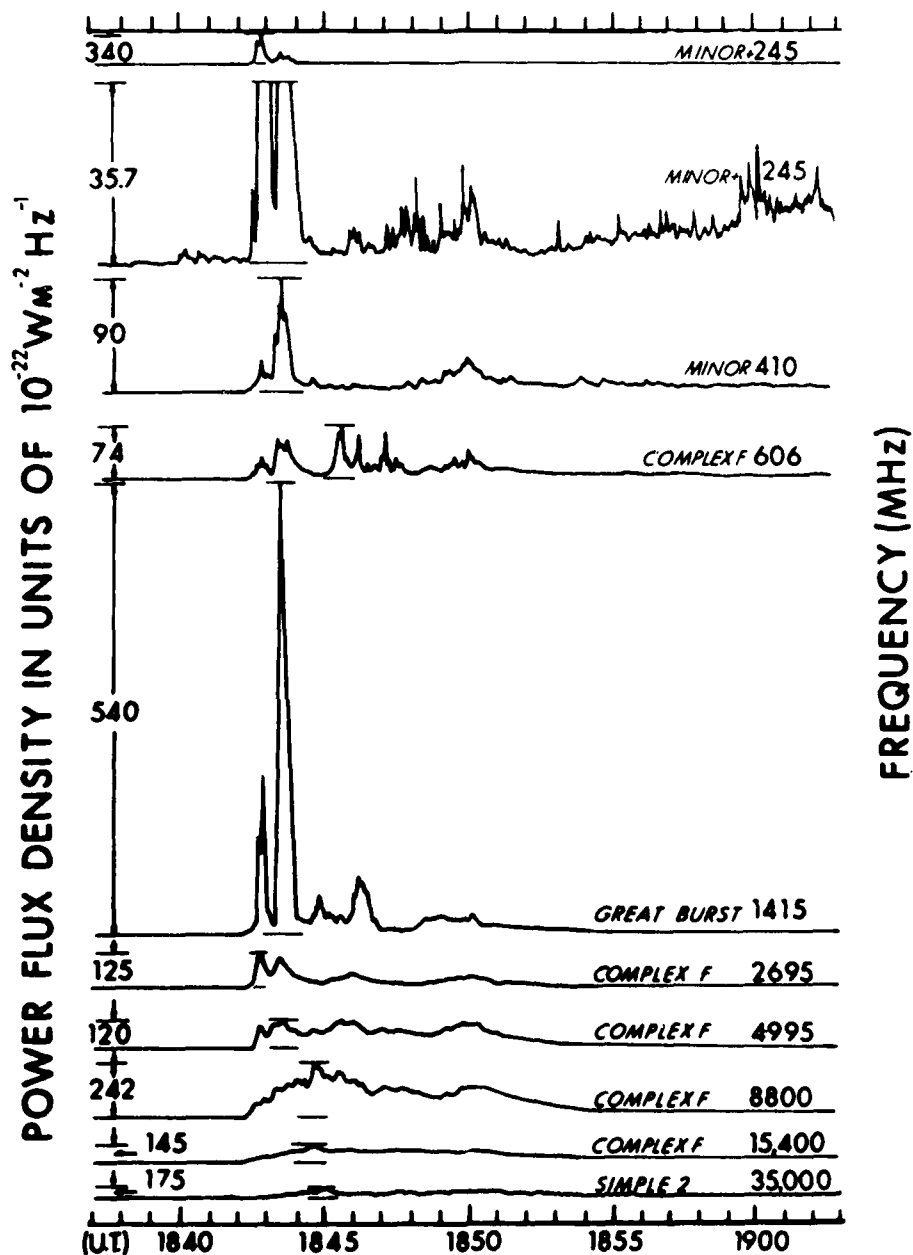
RADIO BURST OBSERVED 28 FEBRUARY, 1973
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



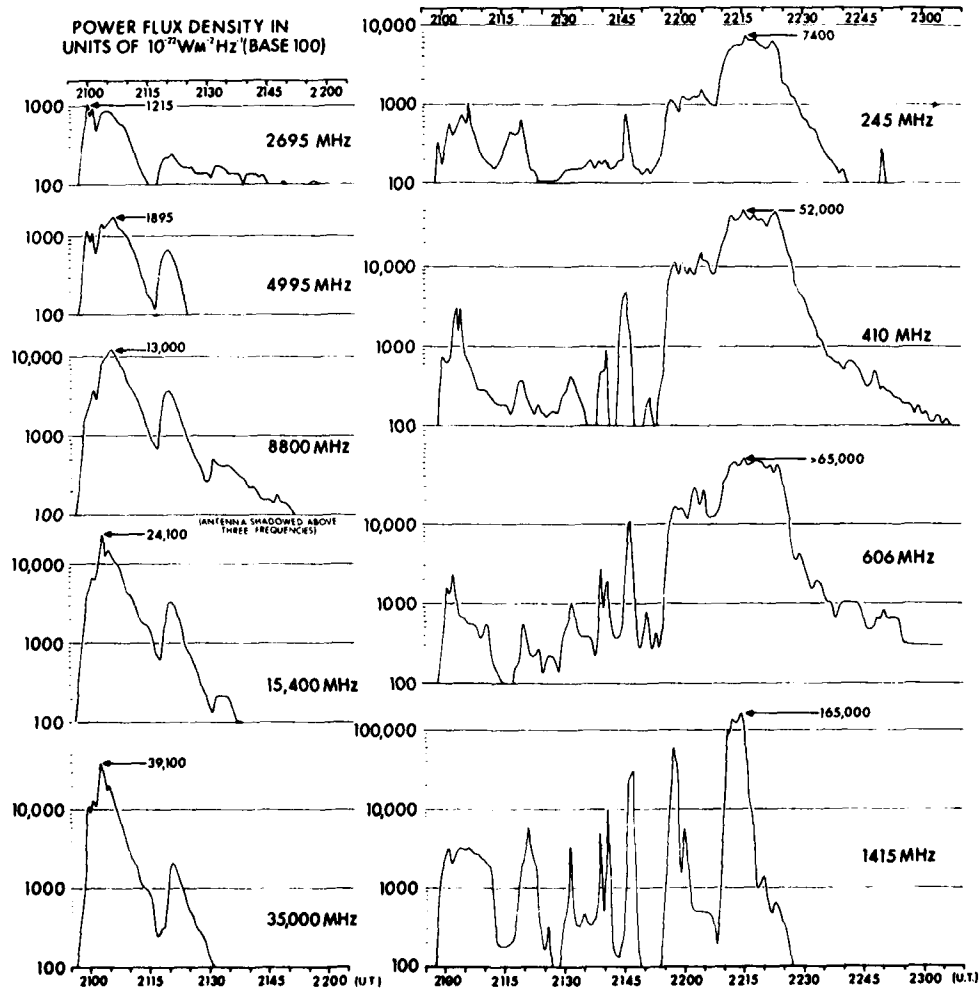
RADIO BURST OBSERVED 12 MARCH, 1973 AT SAGAMORE HILL
RADIO OBSERVATORY, HAMILTON, MASS.



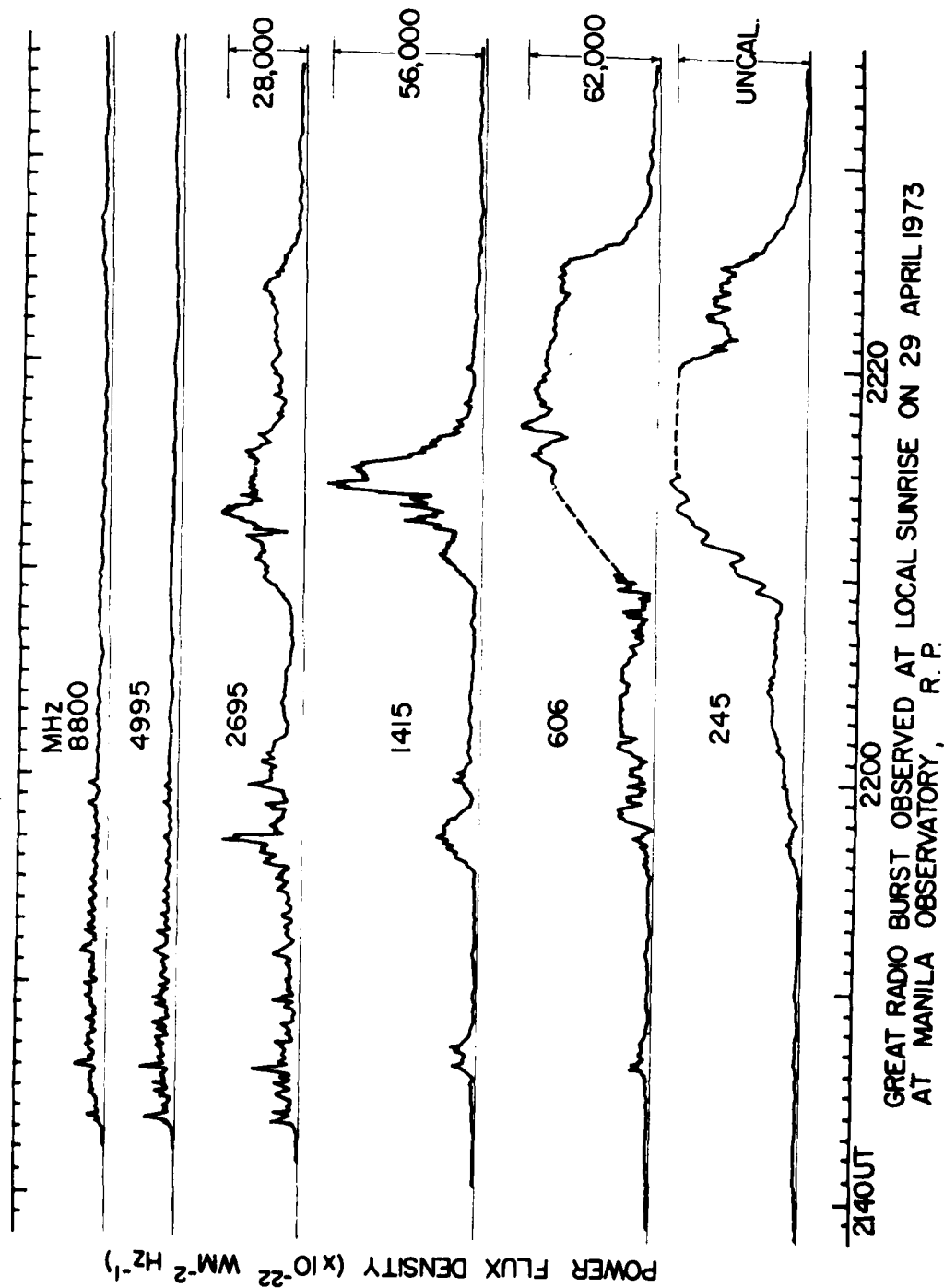
SIMPLE 2F RADIO BURST OBSERVED ON 25 MARCH
1973 AT MANILA OBSERVATORY, R. P.

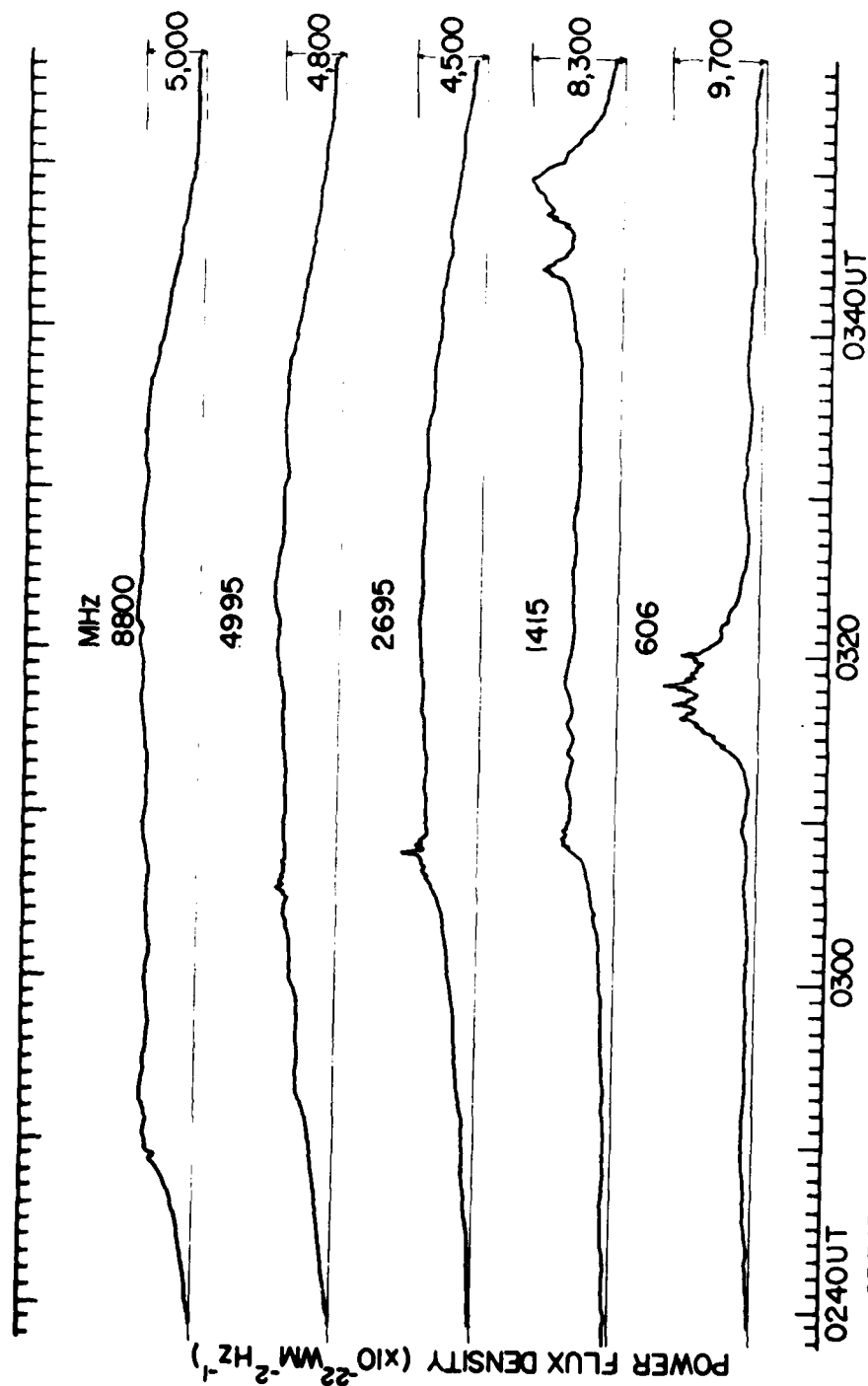


**RADIO BURST OBSERVED 11 APRIL, 1973
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.**

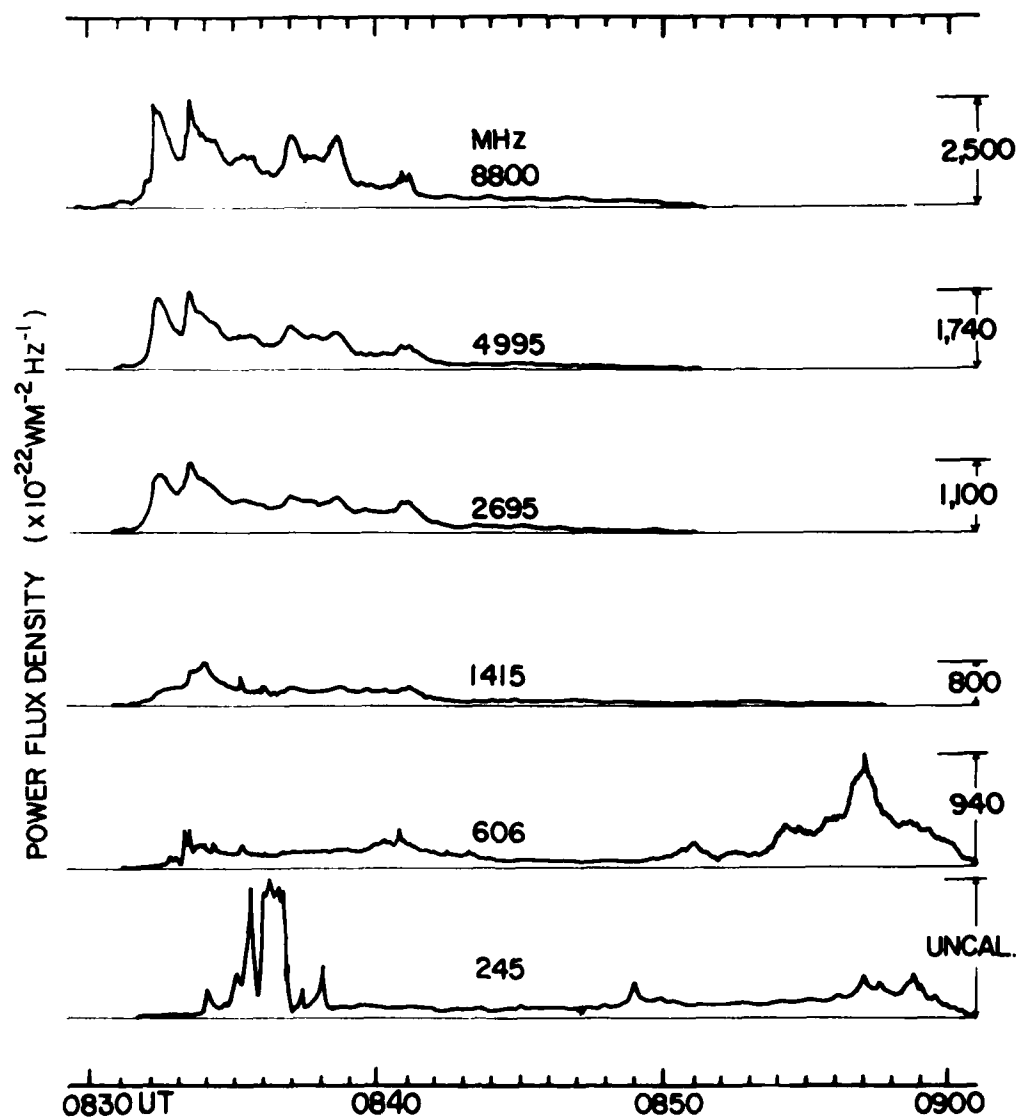


GREAT BURST OBSERVED ON 29 APRIL, 1973
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.

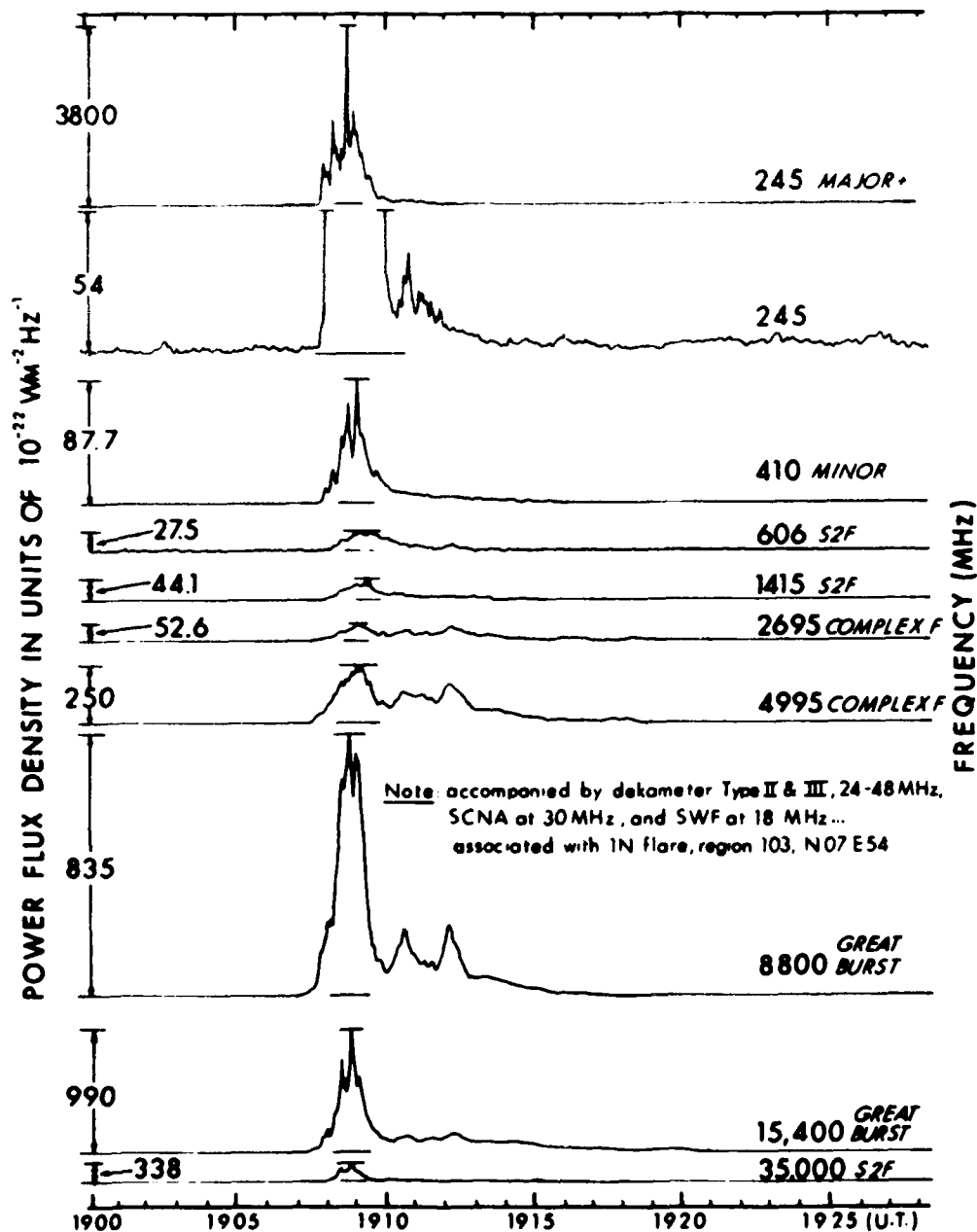




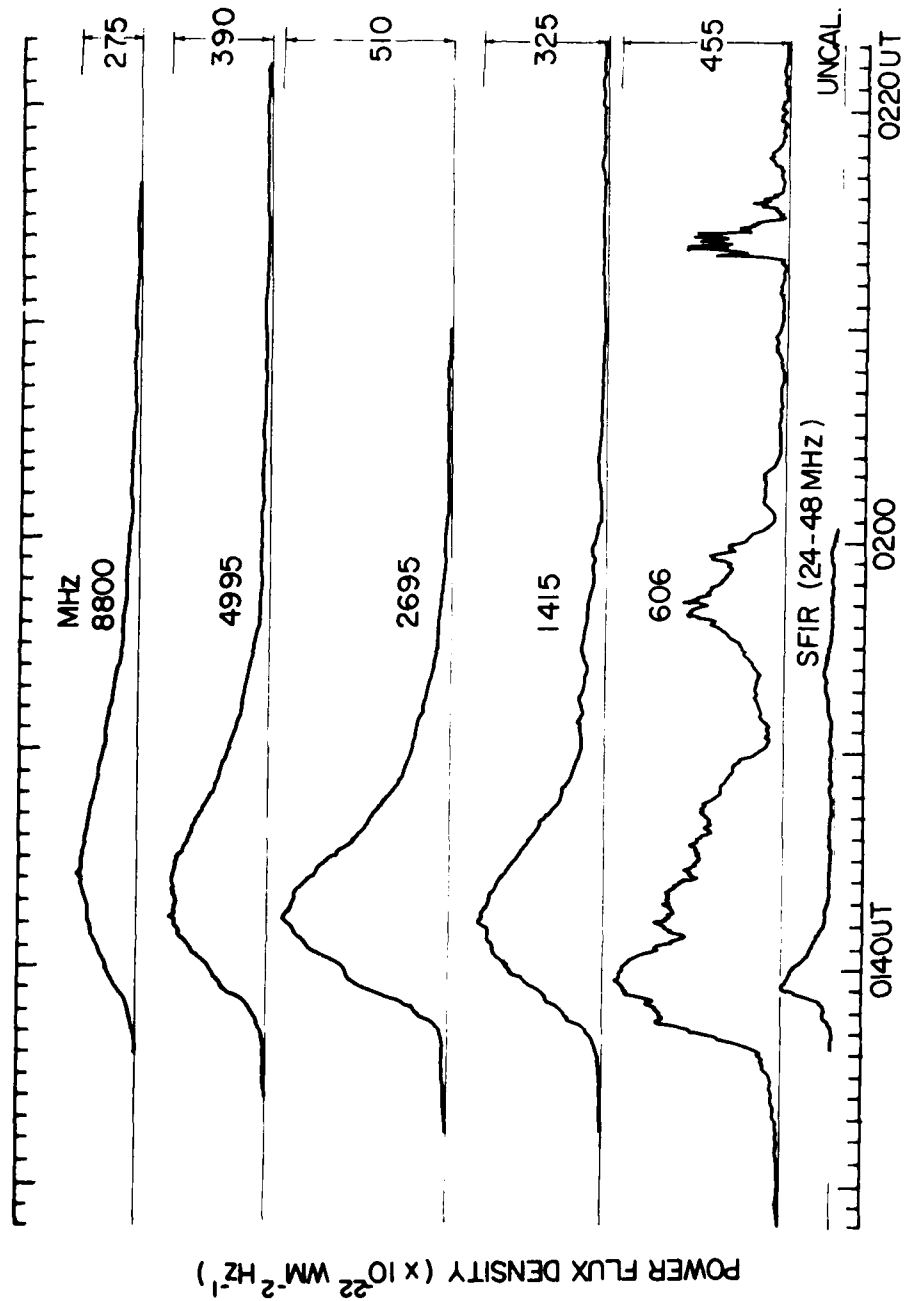
GREAT RADIO BURST OBSERVED ON 1 MAY 1973 AT MANILA OBSERVATORY, R.P.



GREAT RADIO BURST OBSERVED ON 3 MAY 1973 AT
MANILA OBSERVATORY, R. P.



RADIO BURST OBSERVED ON 17 MAY, 1973
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



SIMPLE 2F, COMPLEX F & A GREAT RADIO BURST OBSERVED ON
26 JUNE 1973 AT MANILA OBSERVATORY, R. P.

AD-A088 220

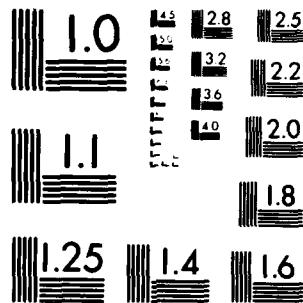
AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA F/O 3/2
AN ATLAS OF SELECTED MULTI-FREQUENCY RADIO BURSTS FROM THE TWEN--ETC(U)
APR 80 W R BARRON, V L BADILLO, E W CLIVER

UNCLASSIFIED

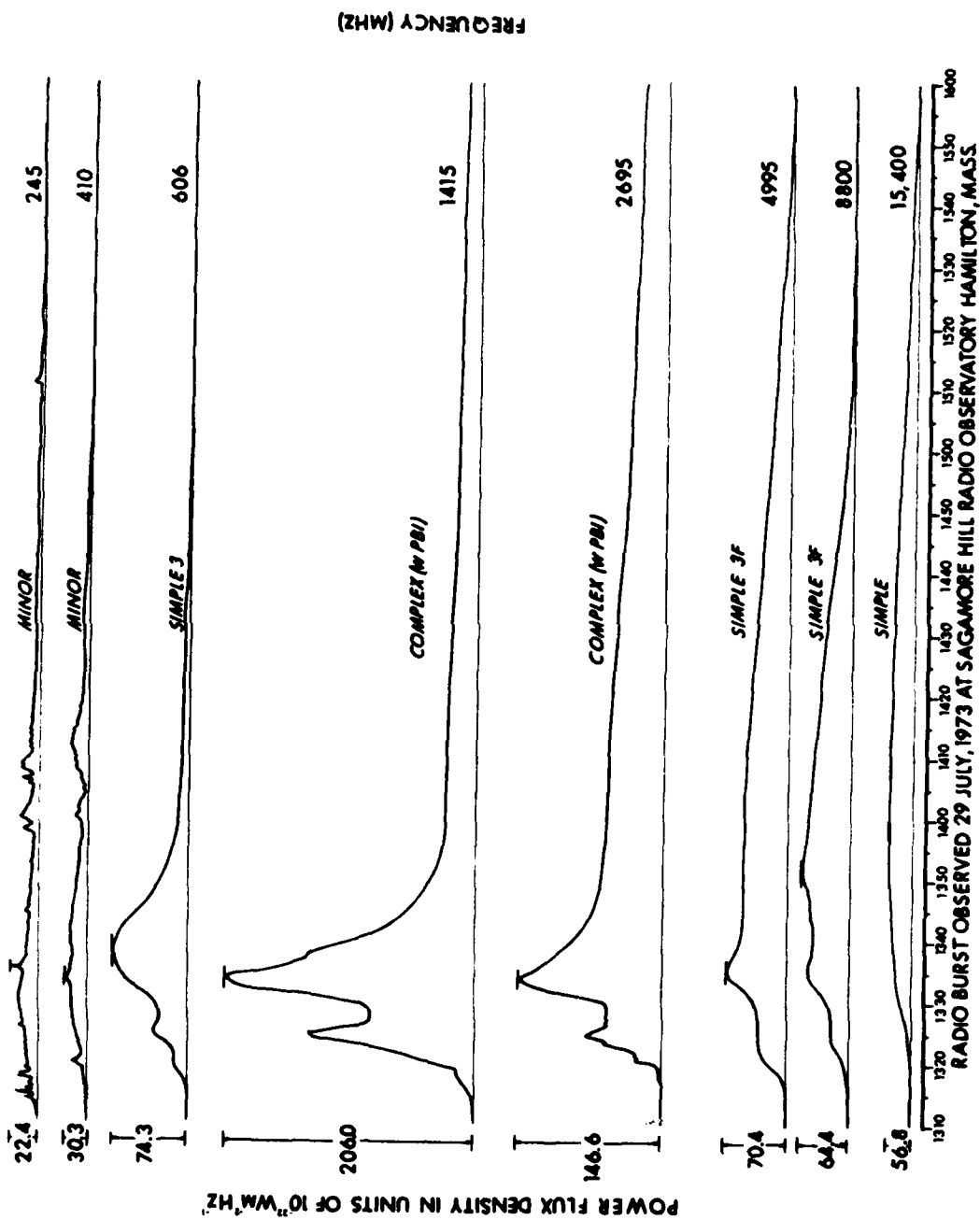
NL

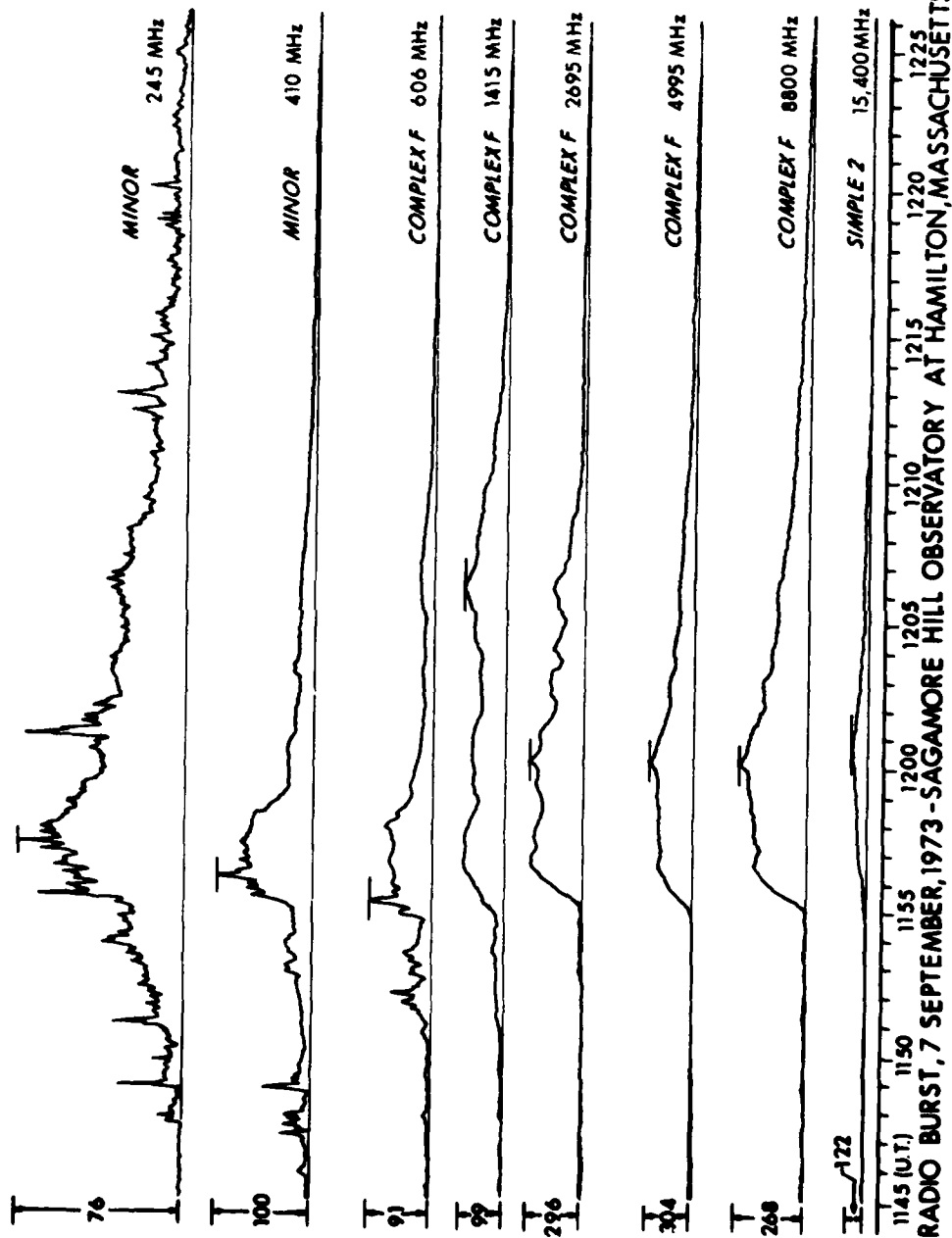
30. 3

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DATE
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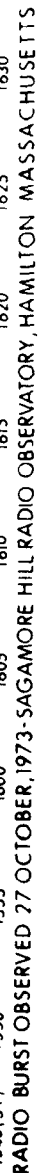


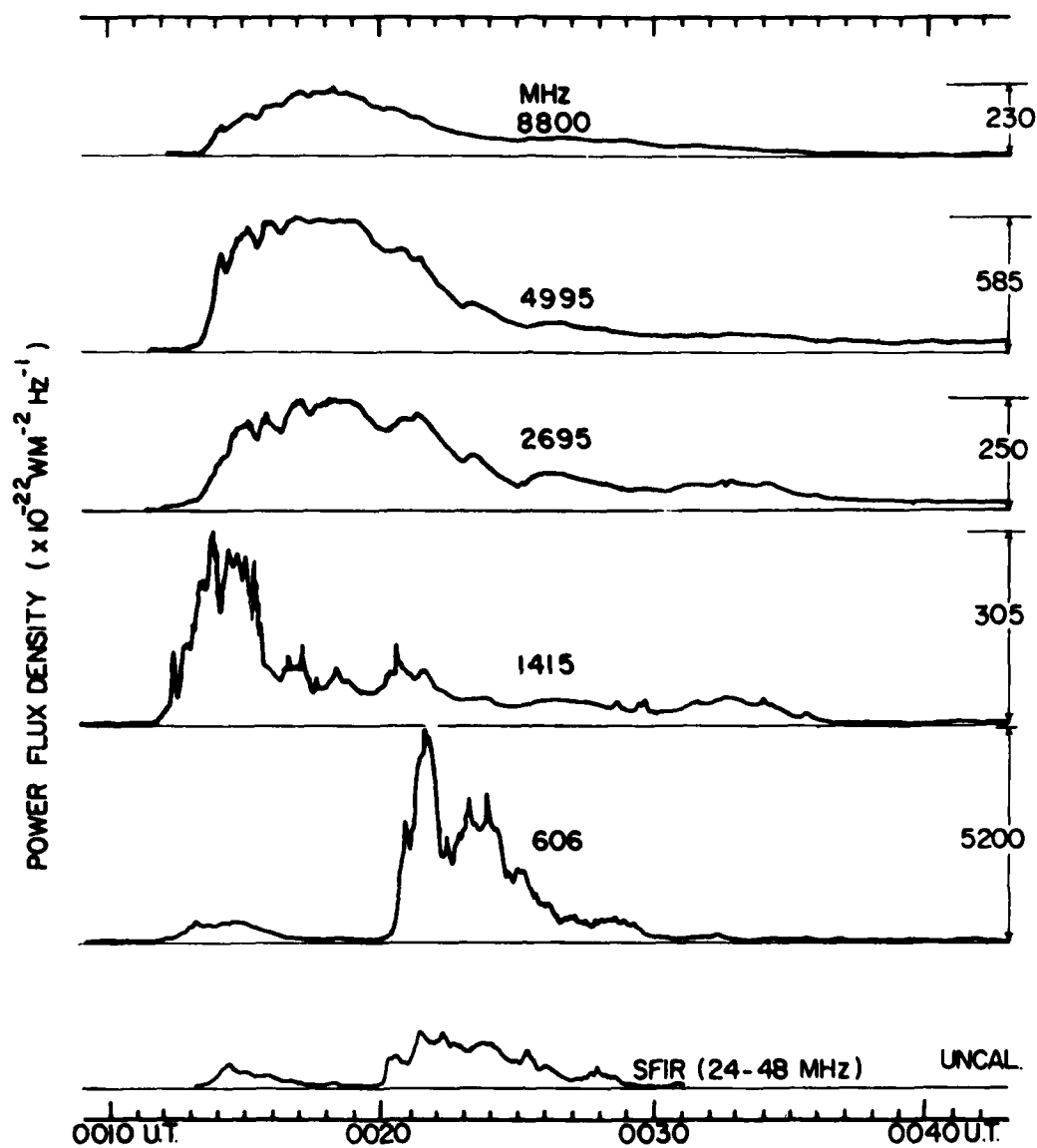
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



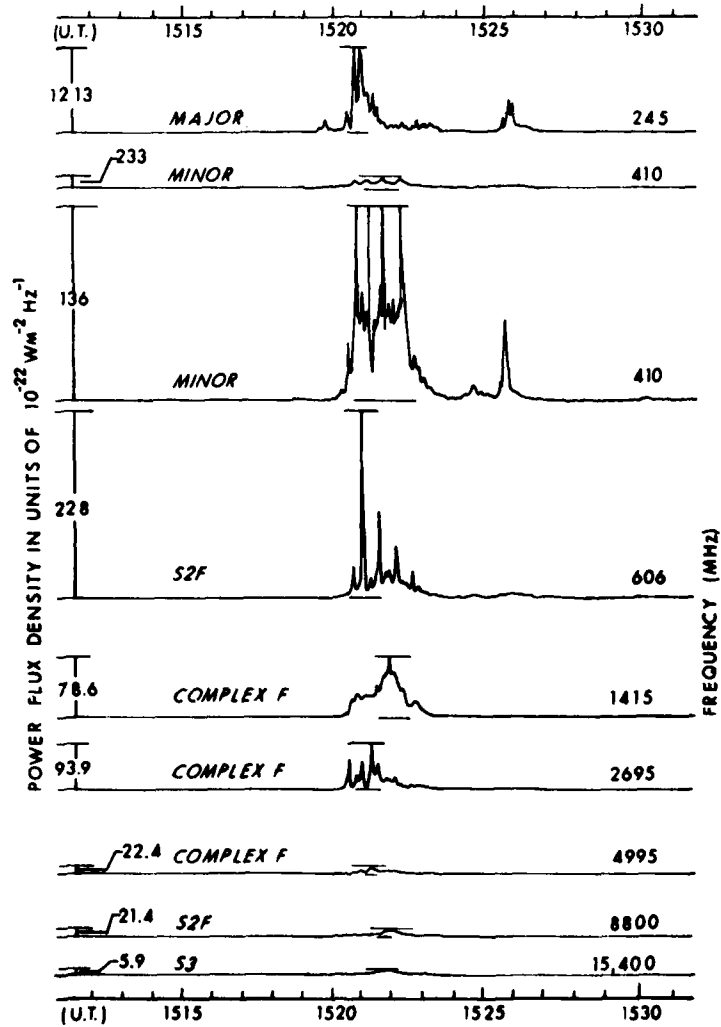


RADIO BURST, 7 SEPTEMBER, 1973 - SAGAMORE HILL OBSERVATORY AT HAMILTON, MASSACHUSETTS

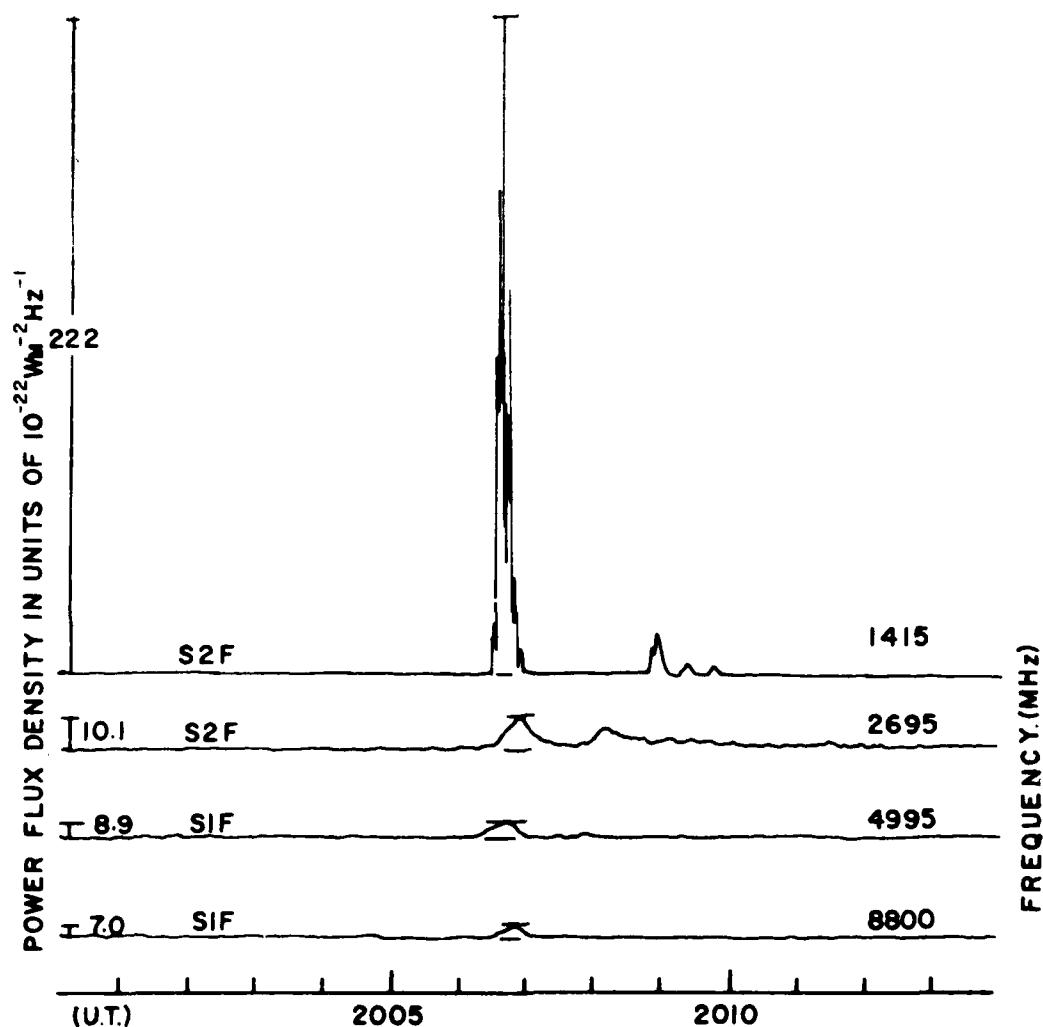




SIMPLE 2F 8 A GREAT RADIO BURST OBSERVED ON
03 NOVEMBER 1973, AT MANILA OBSERVATORY, R.P.

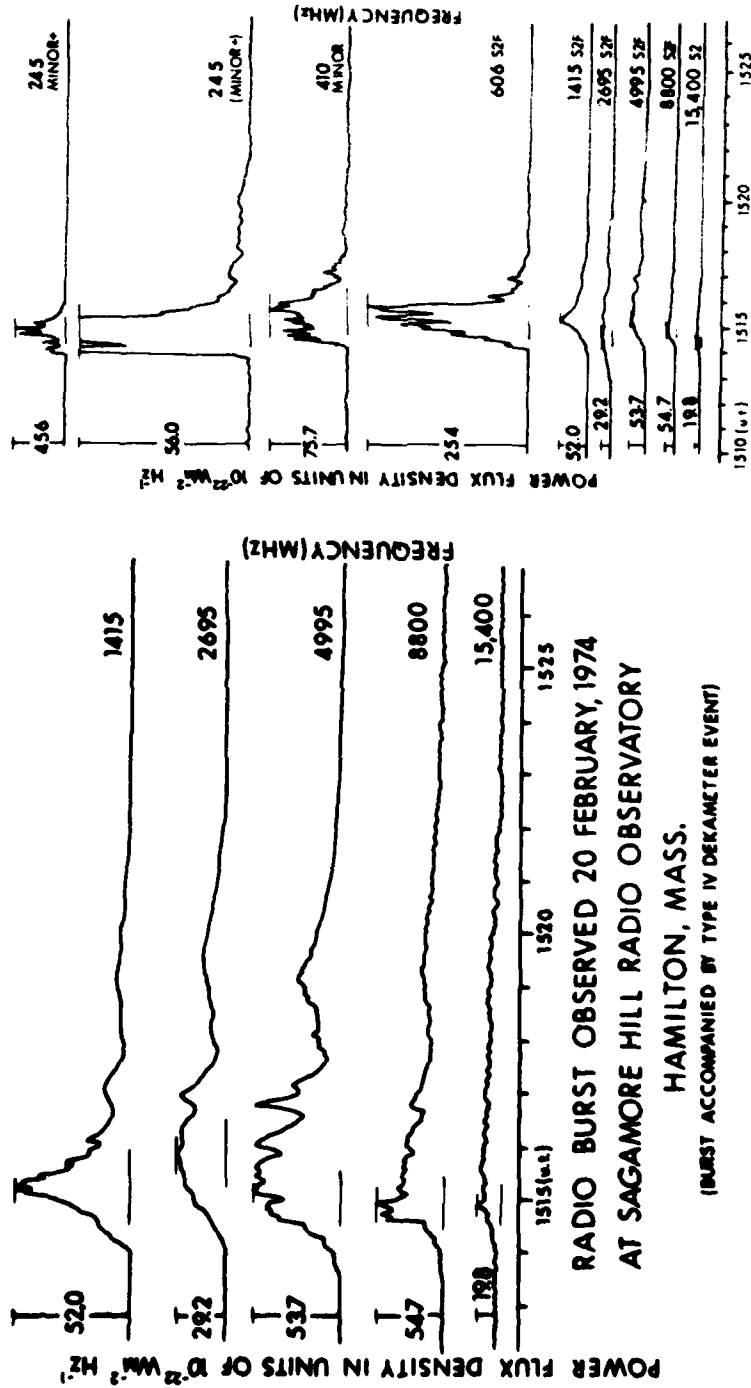


RADIO BURST OBSERVED AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS. ON 26 NOVEMBER, 1973



RADIO BURST OBSERVED ON 2 DECEMBER, 1973
AT SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASSACHUSETTS

**Solar Radio Bursts
1974**

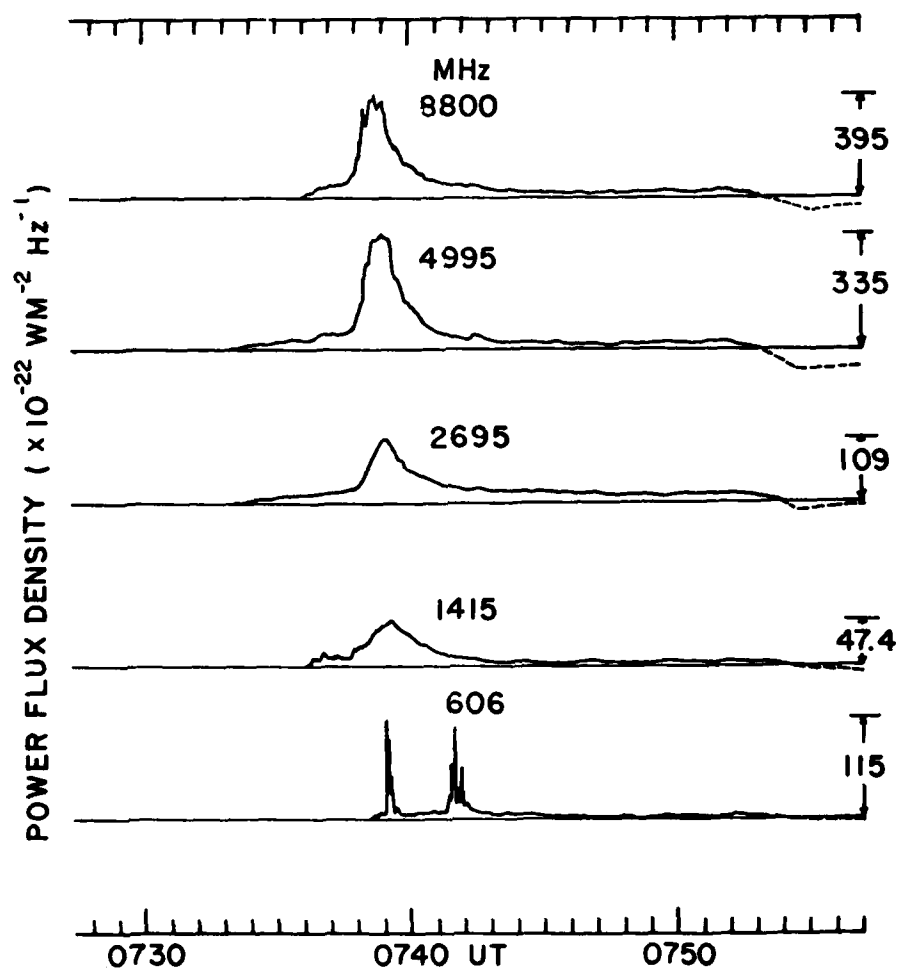


RADIO BURST OBSERVED 20 FEBRUARY, 1974

AT SAGAMORE HILL RADIO OBSERVATORY

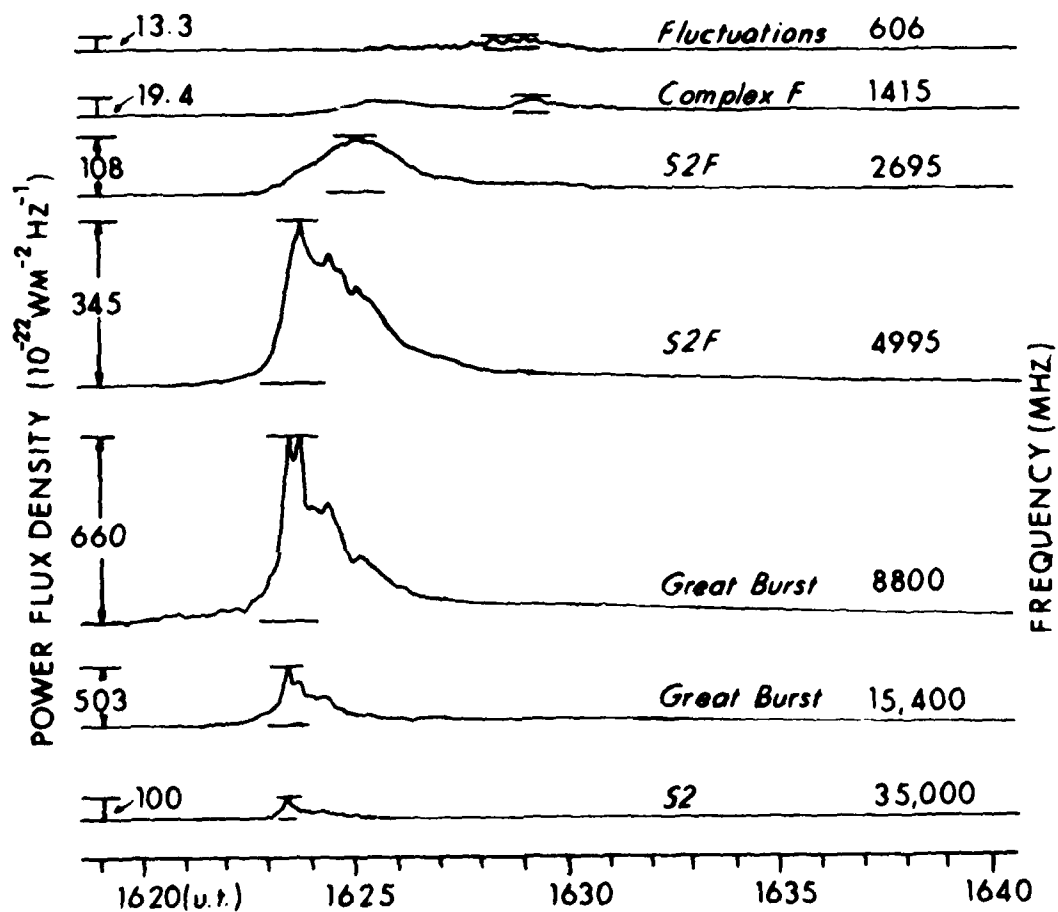
HAMILTON, MASS.

(BURST ACCOMPANIED BY TYPE IV DEKAMETER EVENT)

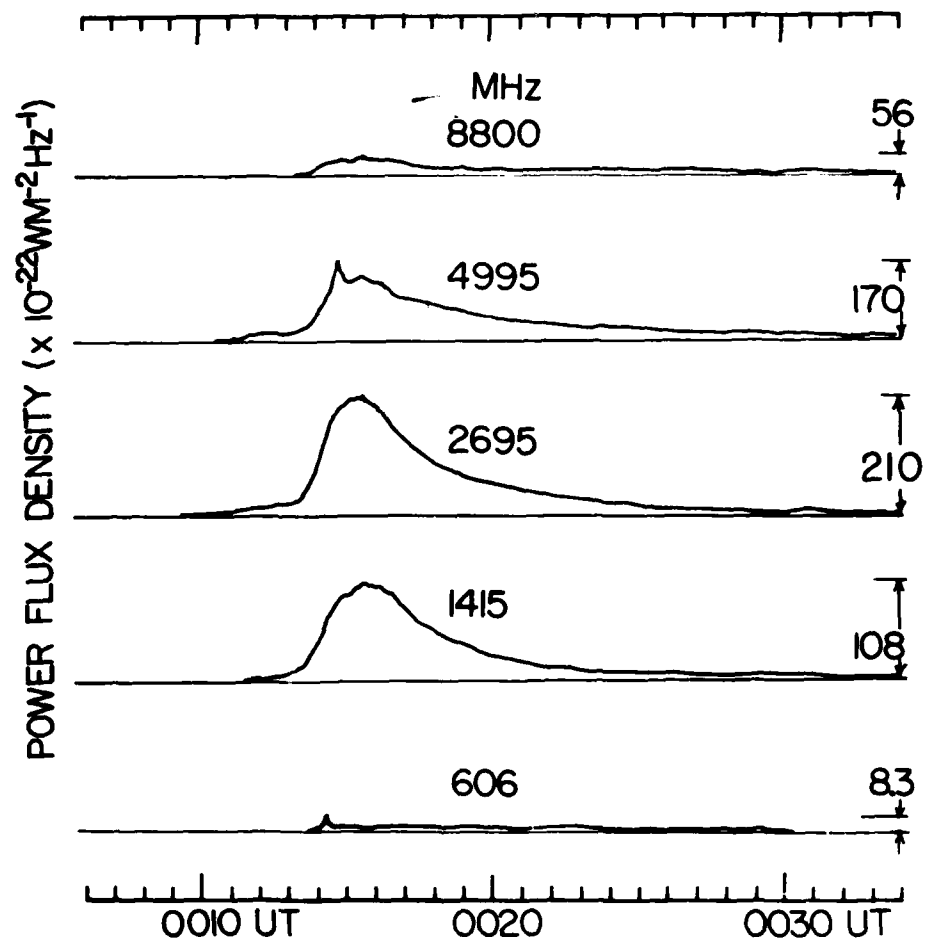


SIMPLE 2F RADIO BURST OBSERVED ON 16 APRIL
1974 AT MANILA OBSERVATORY, R.P.

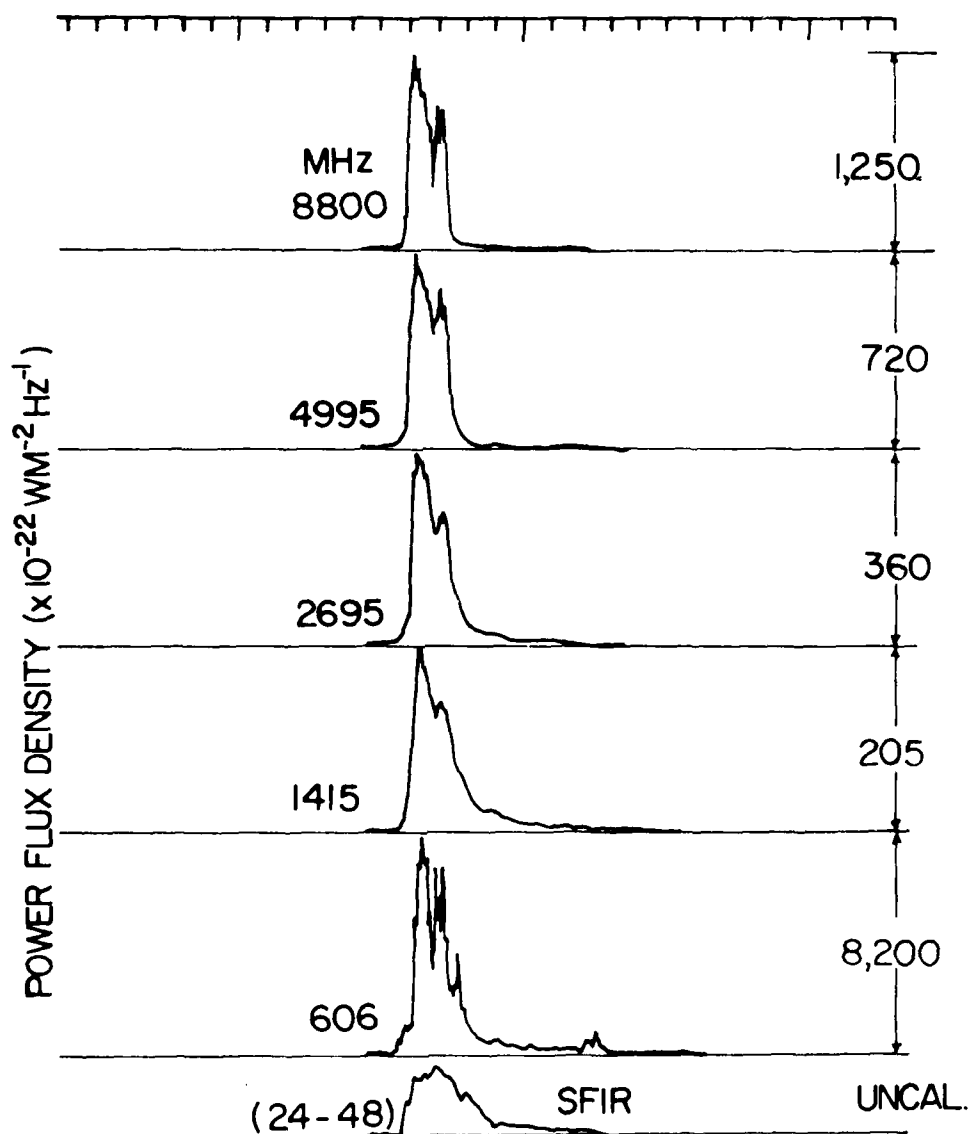
----- ENDTIME UNCERTAIN DUE TO HVY. RAIN



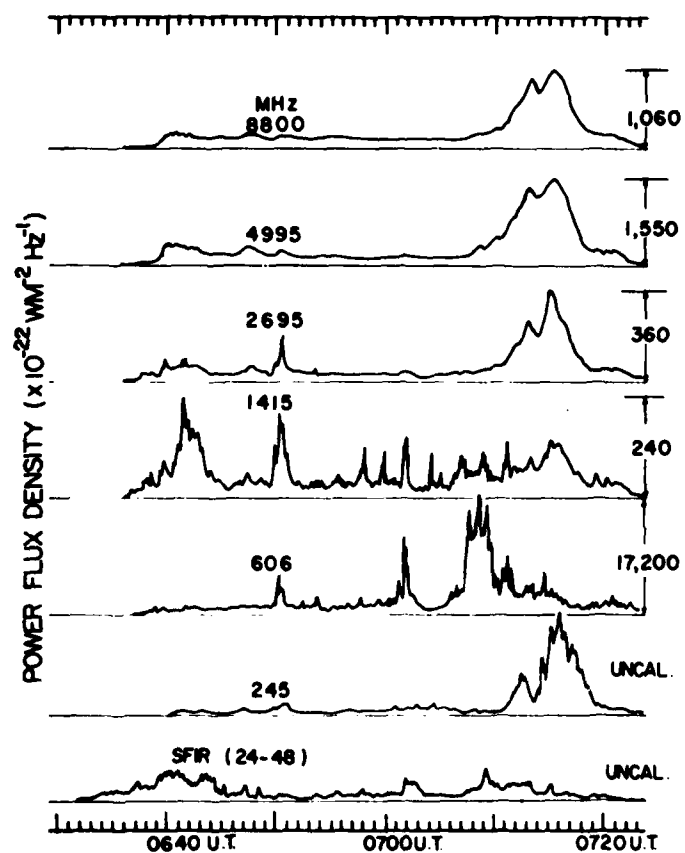
RADIO BURST OBSERVED 16 APRIL, 1974
SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.



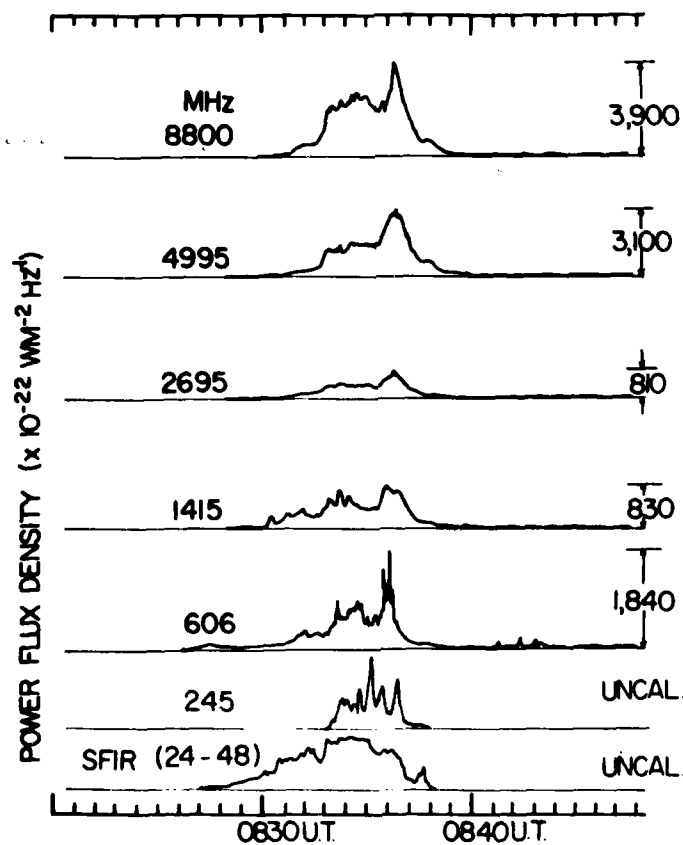
SIMPLE 2F RADIO BURST OBSERVED ON
08 MAY 1974 AT MANILA OBSERVATORY, R.P.



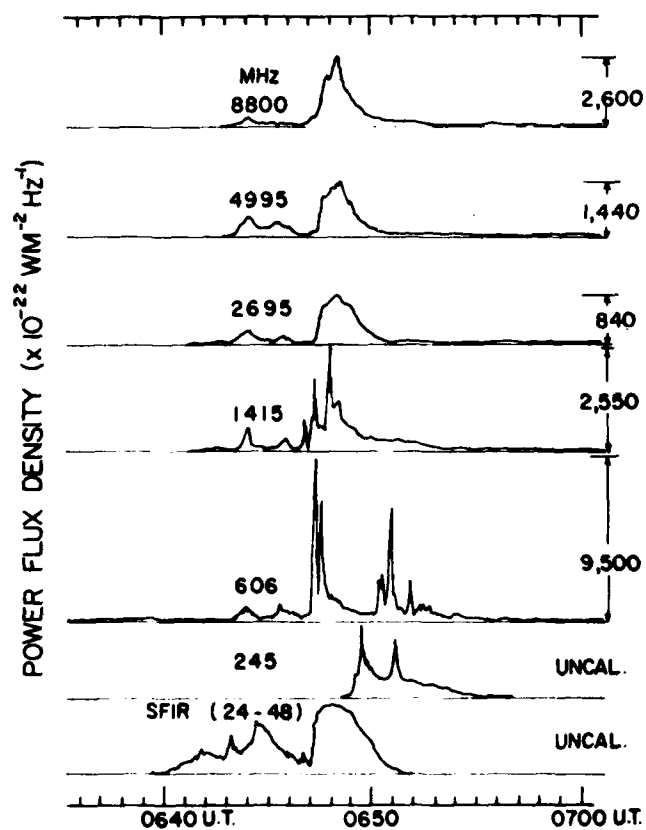
0420U.T. 0440U.T.
 GREAT RADIO BURST OBSERVED ON 02 JUNE 1974
 AT MANILA OBSERVATORY, R.P.



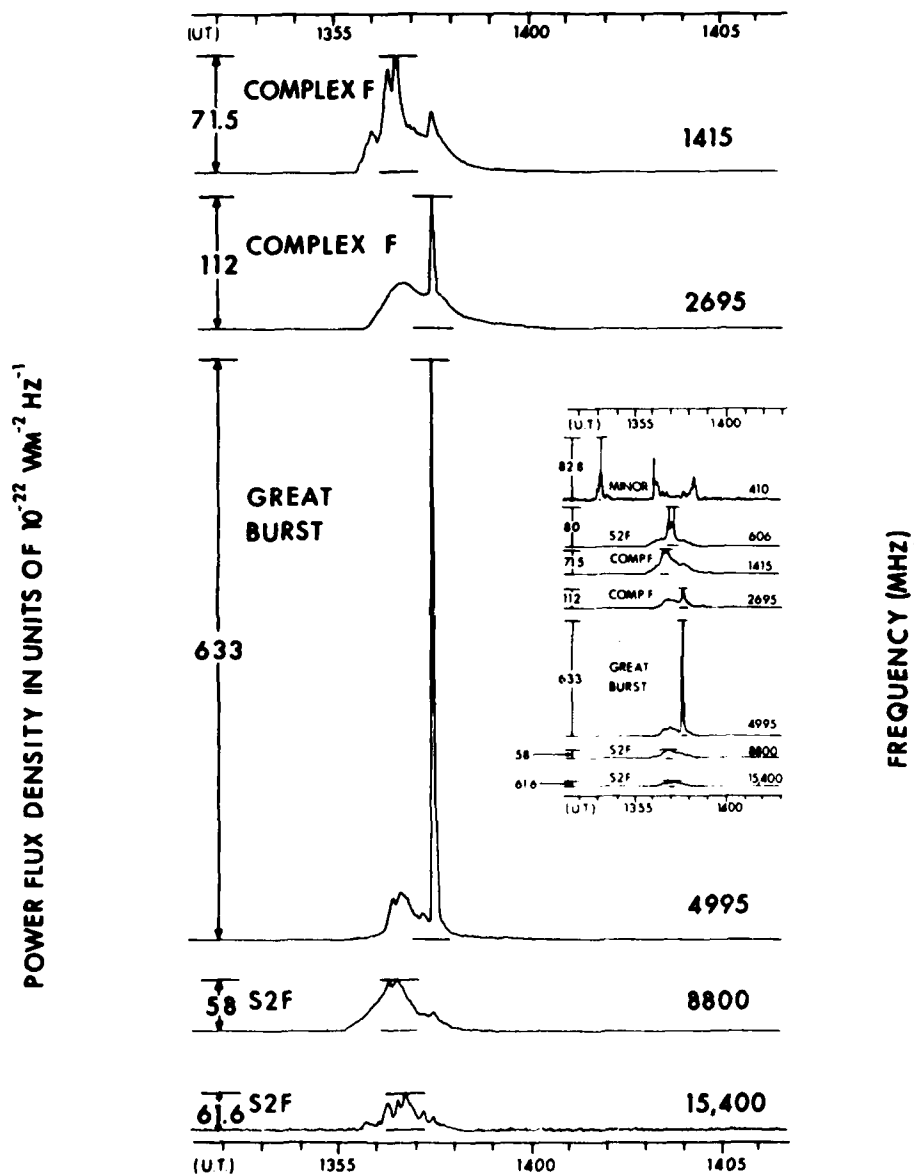
GREAT RADIO BURST OBSERVED ON 02 JULY 1974
AT MANILA OBSERVATORY, R.P.



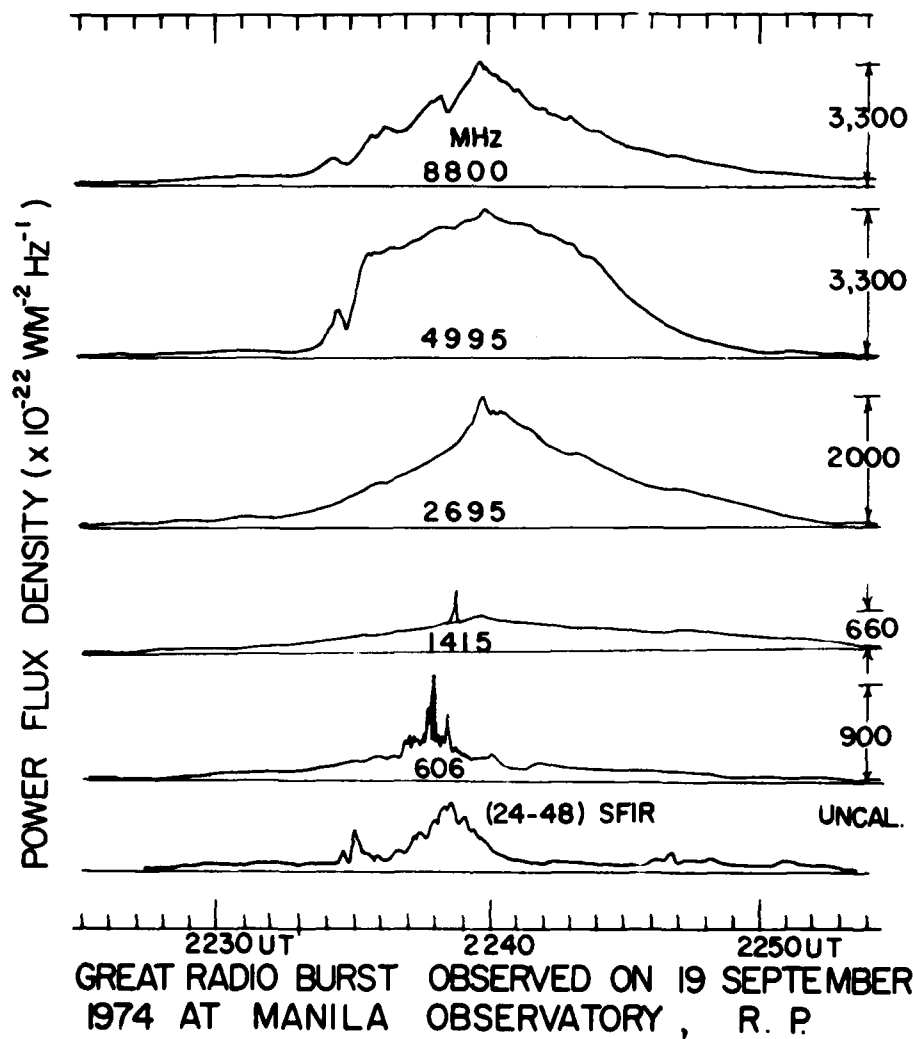
GREAT RADIO BURST OBSERVED ON 03 JULY 1974
AT MANILA OBSERVATORY, R. P.

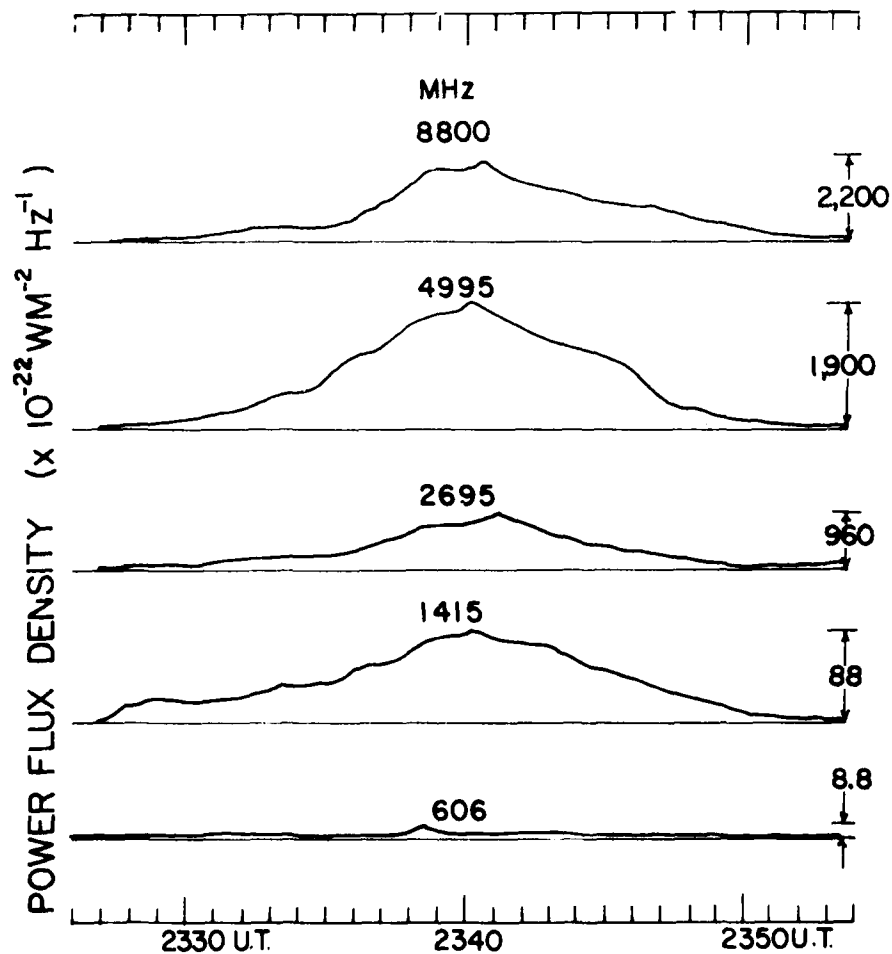


GREAT RADIO BURST OBSERVED ON 04 JULY 1974
AT MANILA OBSERVATORY, R. P.

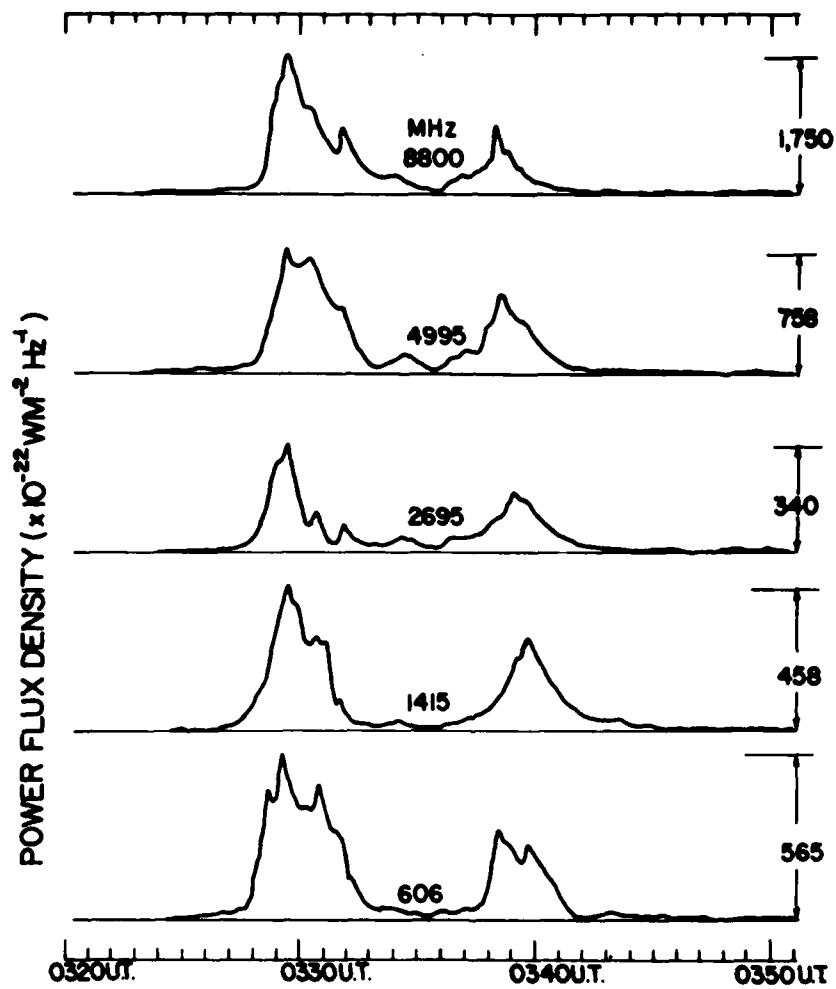


RADIO BURST OBSERVED 9 JULY, 1974 SAGAMORE HILL RADIO OBSERVATORY
HAMILTON, MASS.

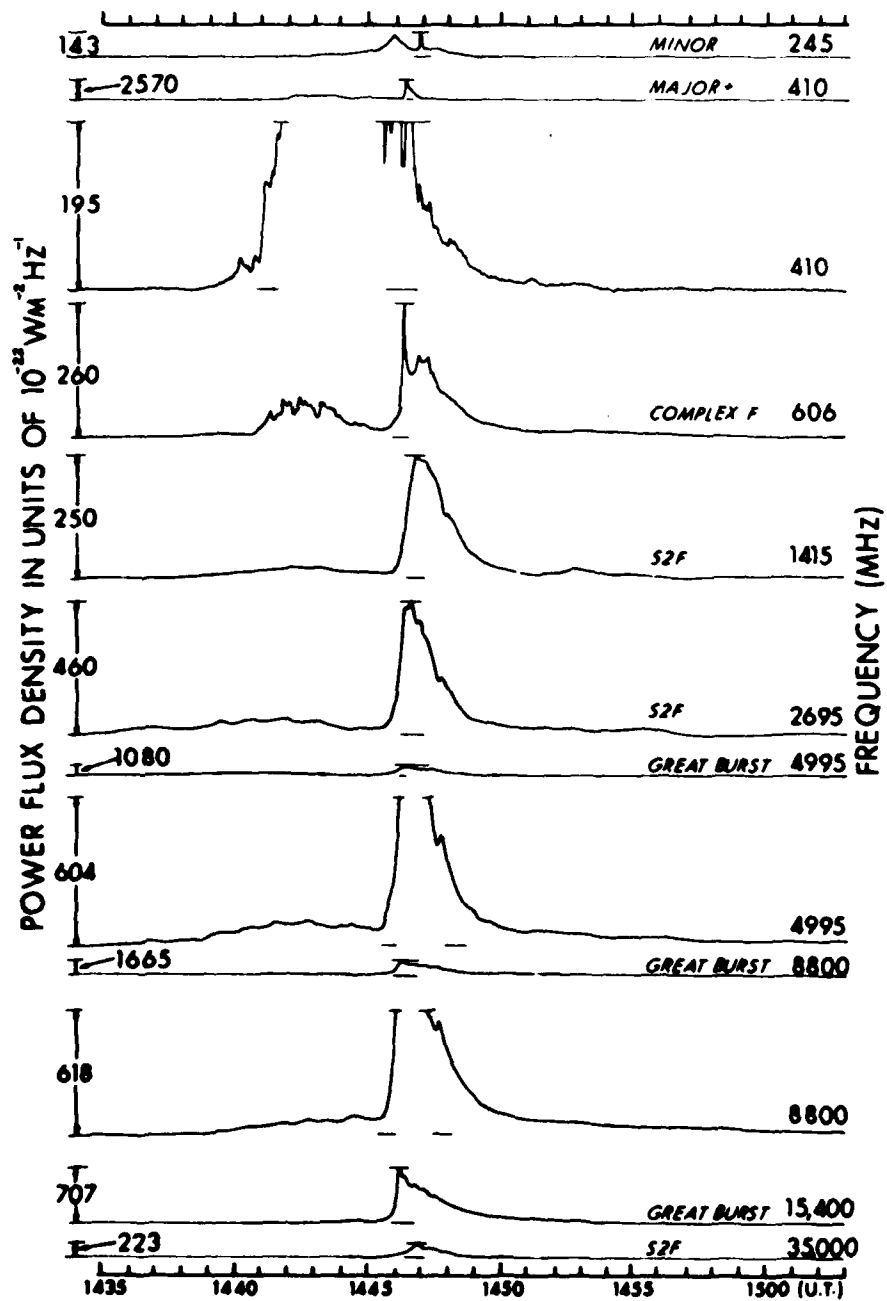




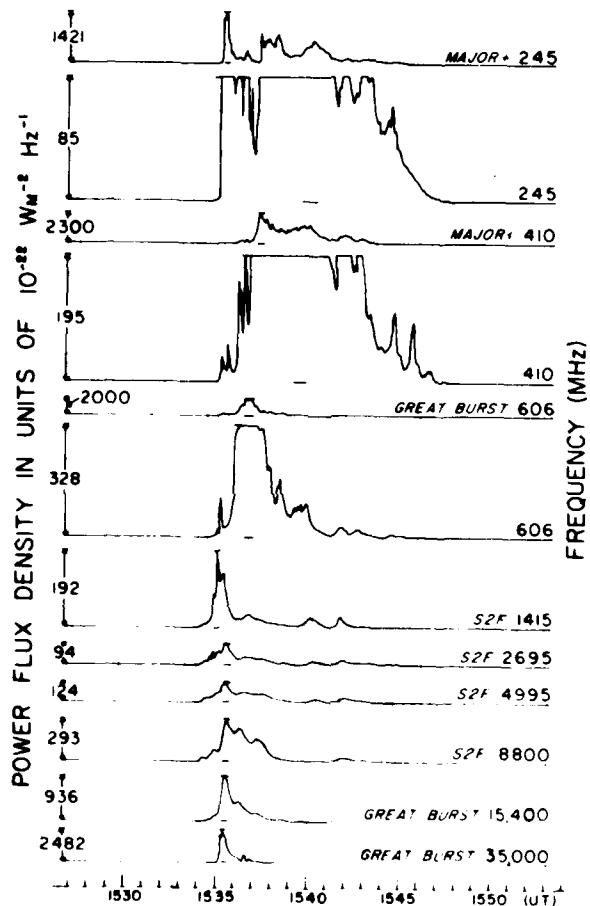
GREAT RADIO BURST OBSERVED ON 22 SEP-
TEMBER 1974 AT MANILA OBSERVATORY, R.P.



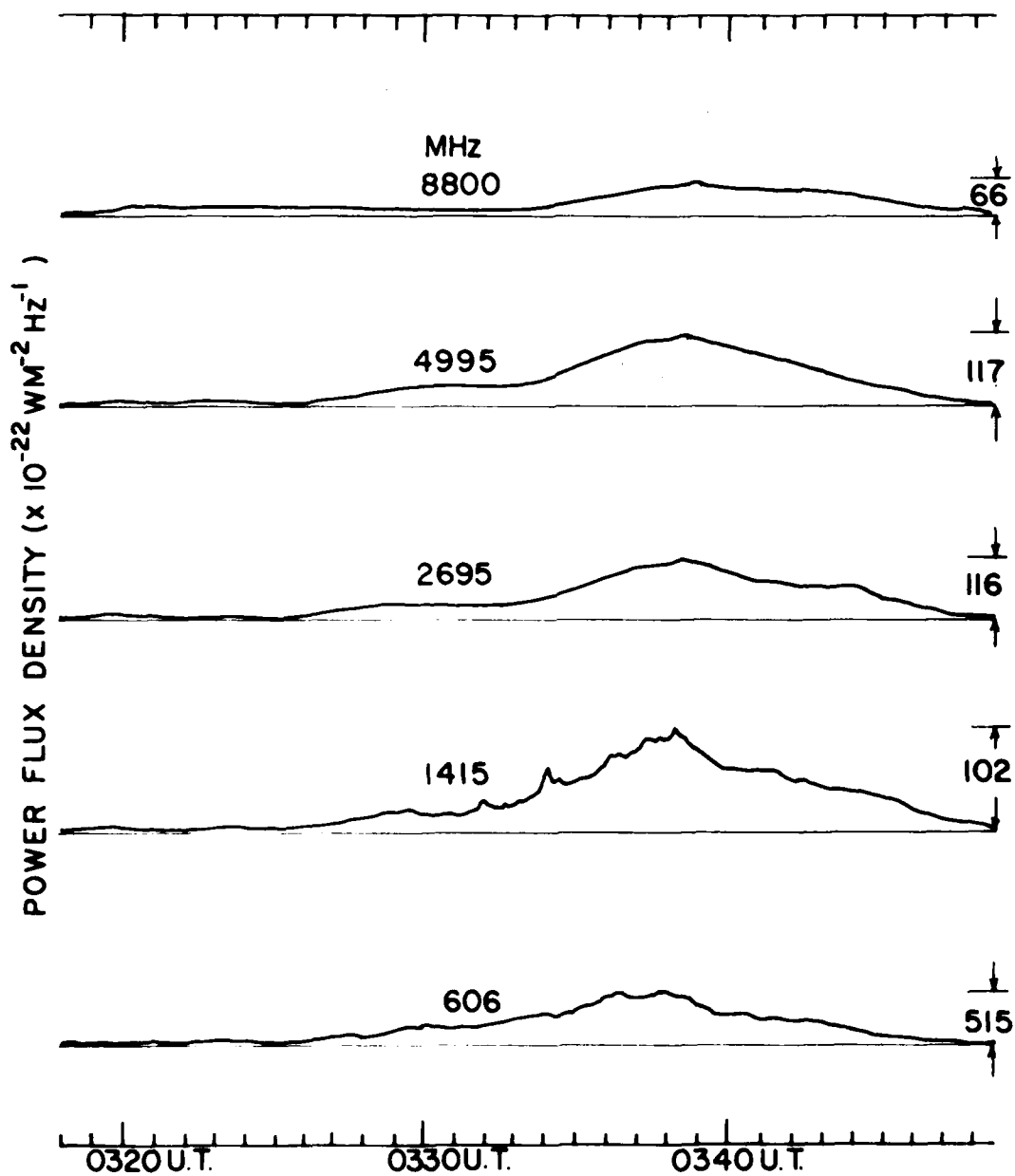
GREAT RADIO BURST OBSERVED ON 11 OCTOBER 1974
AT MANILA OBSERVATORY, R.P.



RADIO BURST OBSERVED 11 OCTOBER, 1974
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



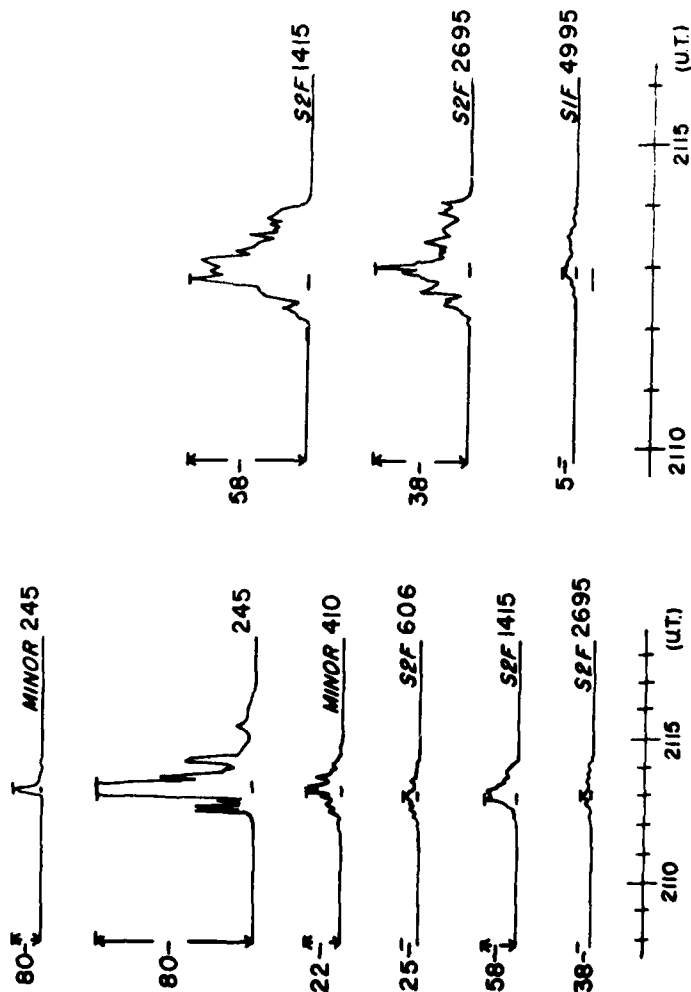
RADIO BURST OBSERVED 5 NOVEMBER, 1974
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



SIMPLE 2F & A GREAT RADIO BURST OBSERVED
ON NOVEMBER 06, 1974 AT MANILA OB-
SERVATORY, R.P.

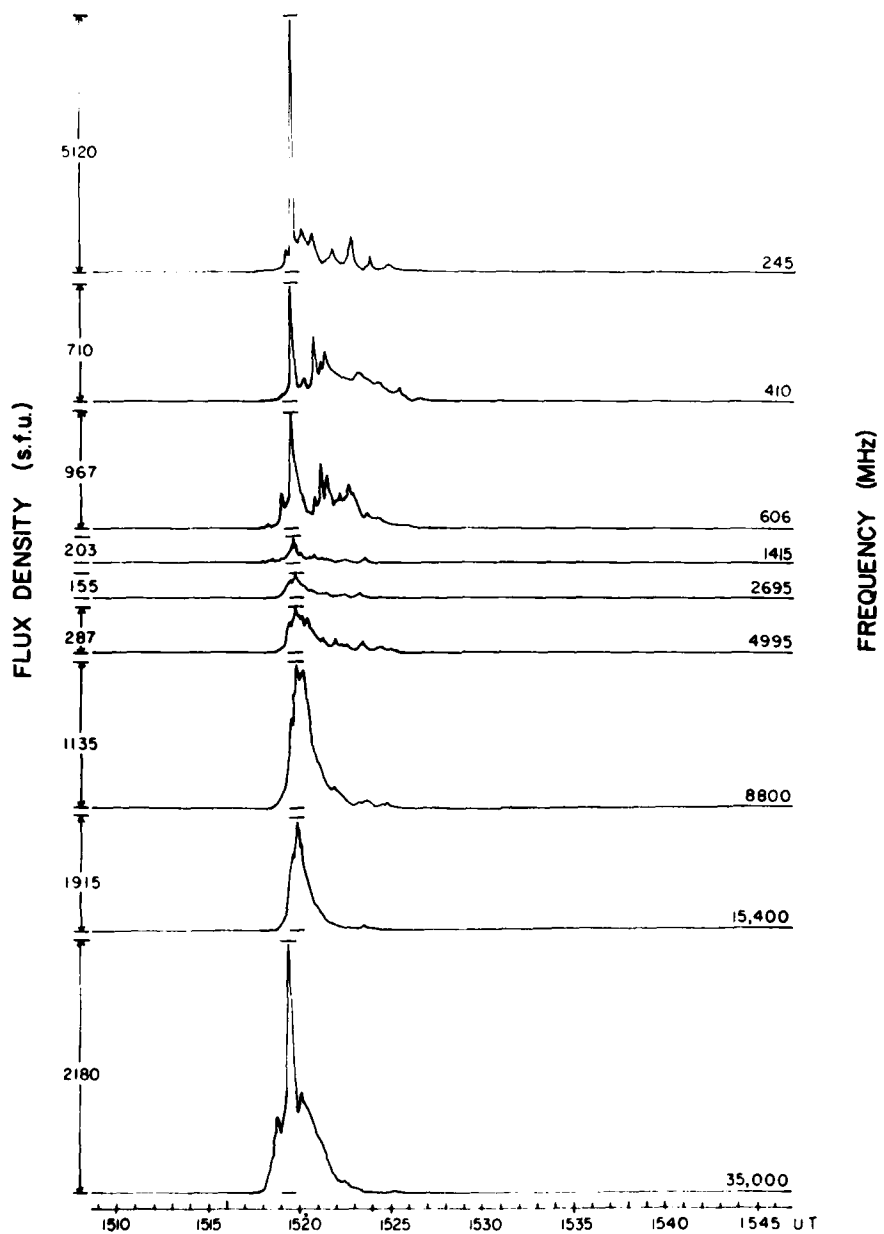
**Solar Radio Bursts
1975**

POWER FLUX DENSITY IN UNITS OF $10^{-22} \text{ W m}^{-2} \text{ Hz}^{-1}$



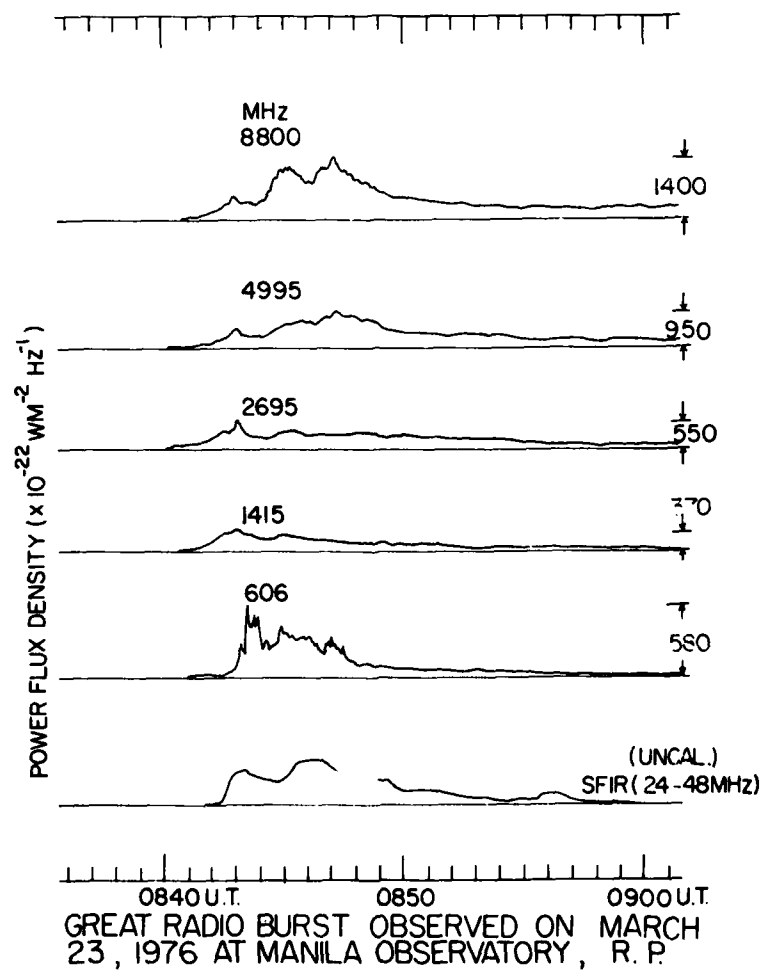
FREQUENCY (MHz)

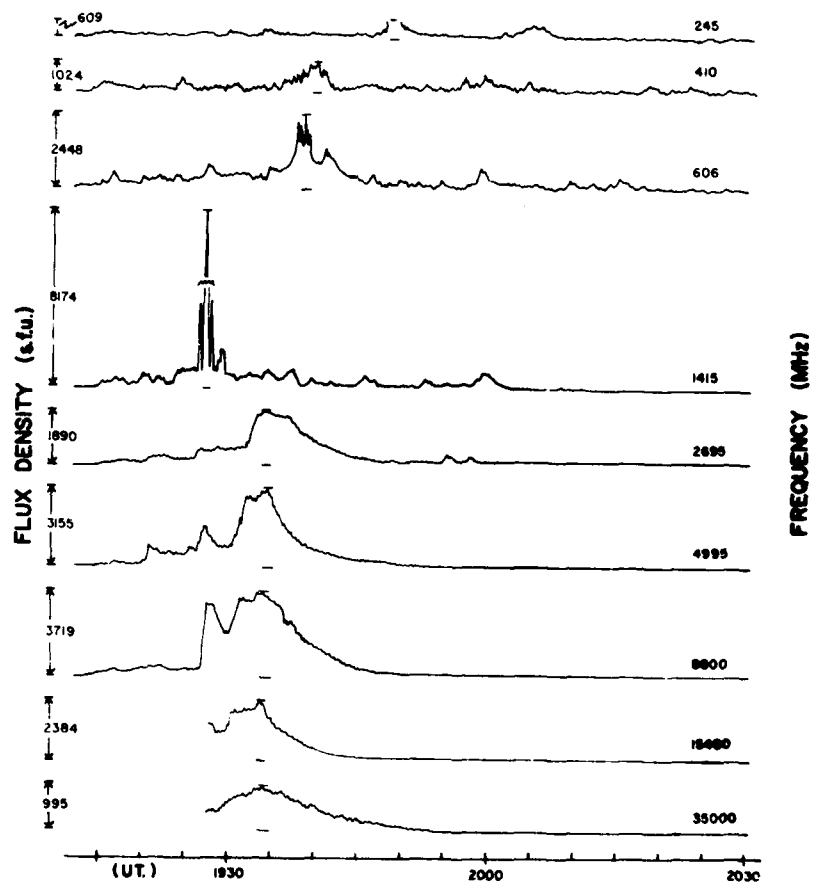
RADIO BURST OBSERVED 9 JANUARY, 1975
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



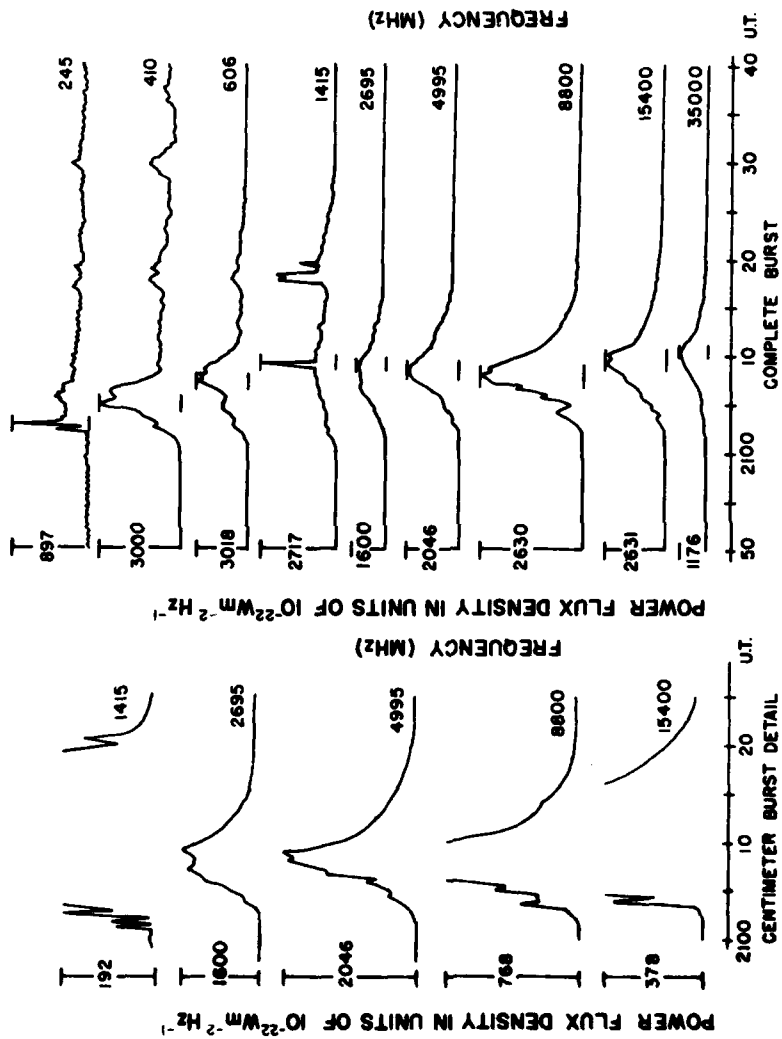
GREAT BURST OBSERVED 21 AUGUST 1975, AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.

**Solar Radio Bursts
1976**





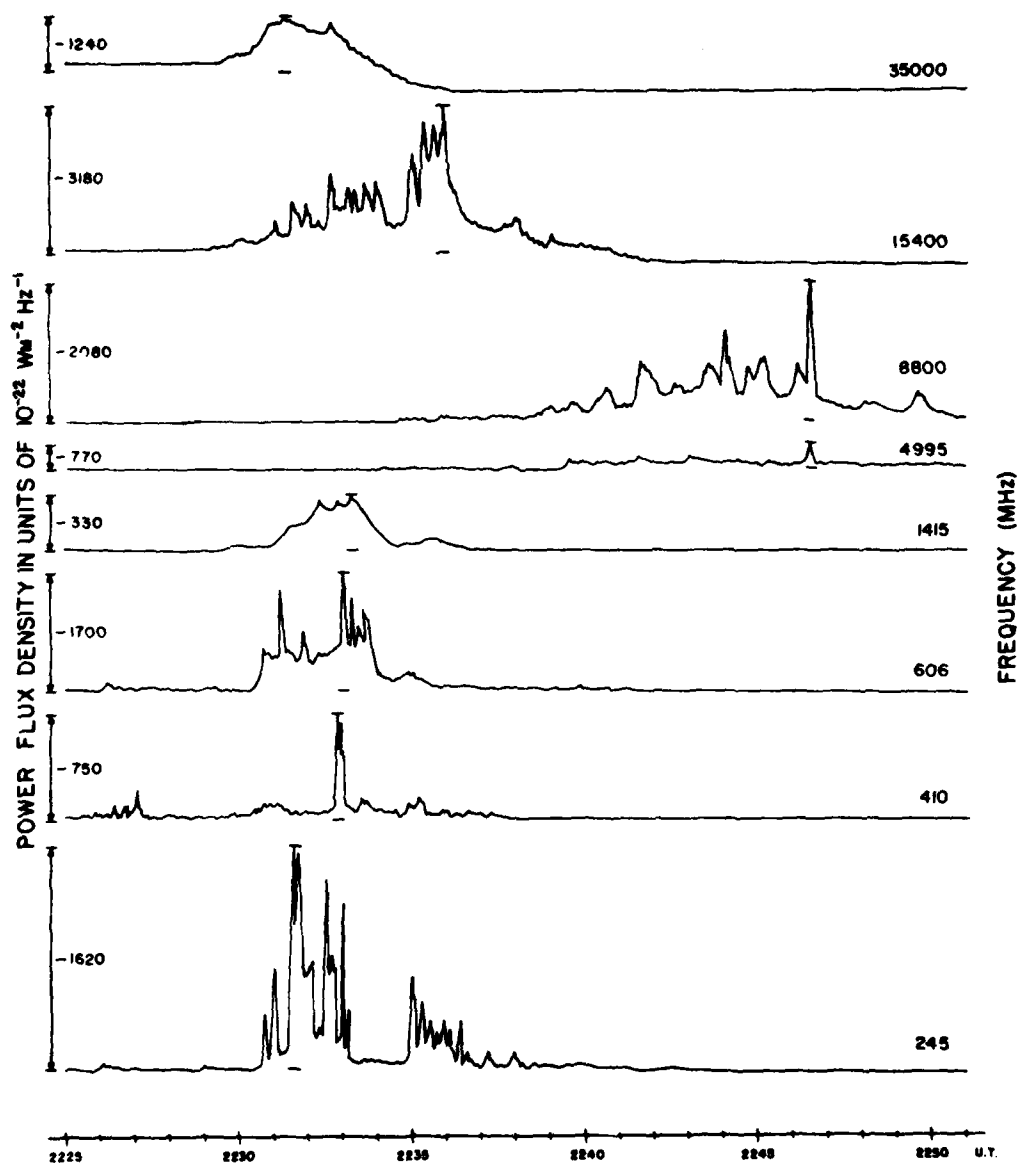
GREAT BURST OBSERVED 28 MAR. 1976 AT
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.



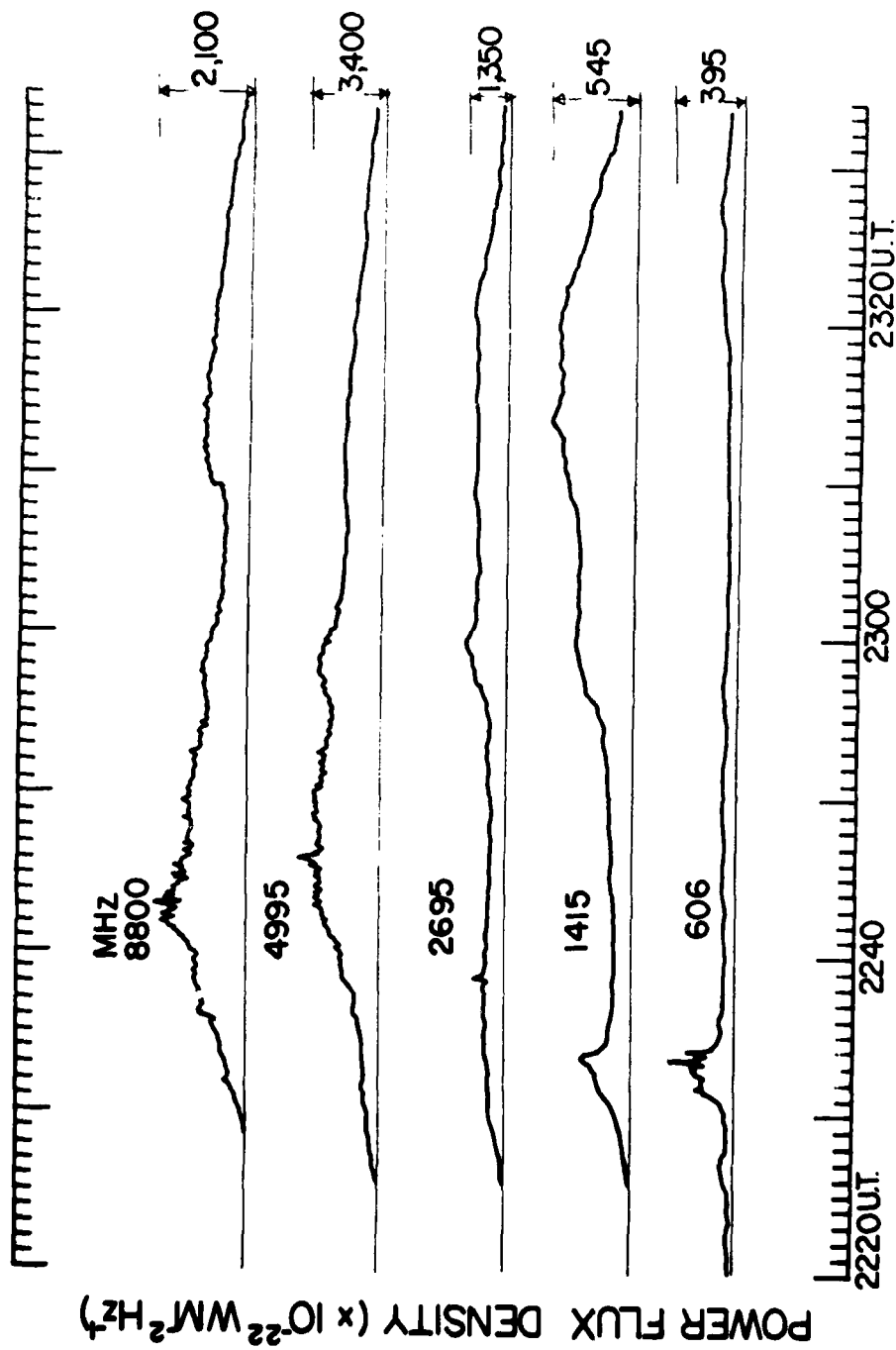
GREAT BURST OBSERVED ON 30 APR 1976
AT SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.

Solar Radio Bursts
1977

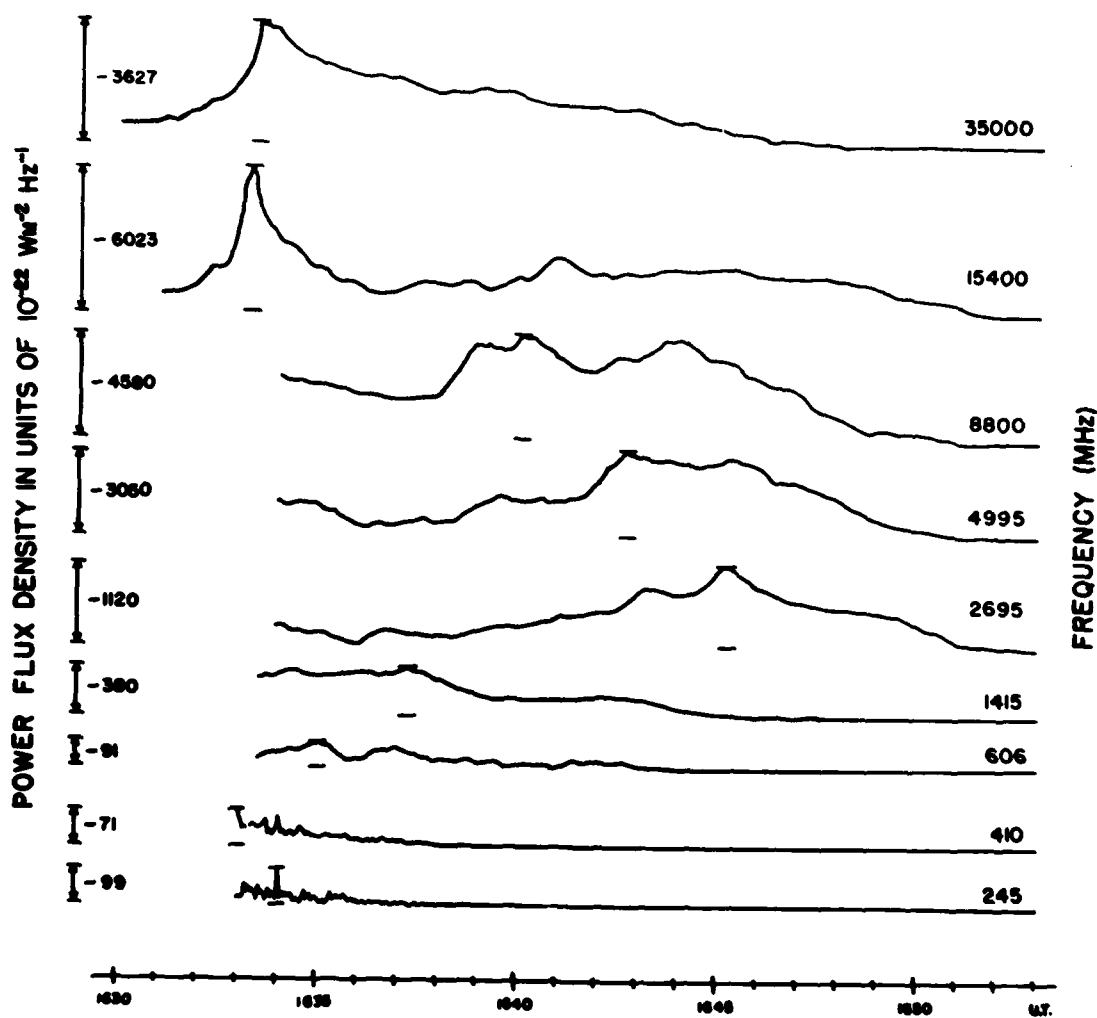
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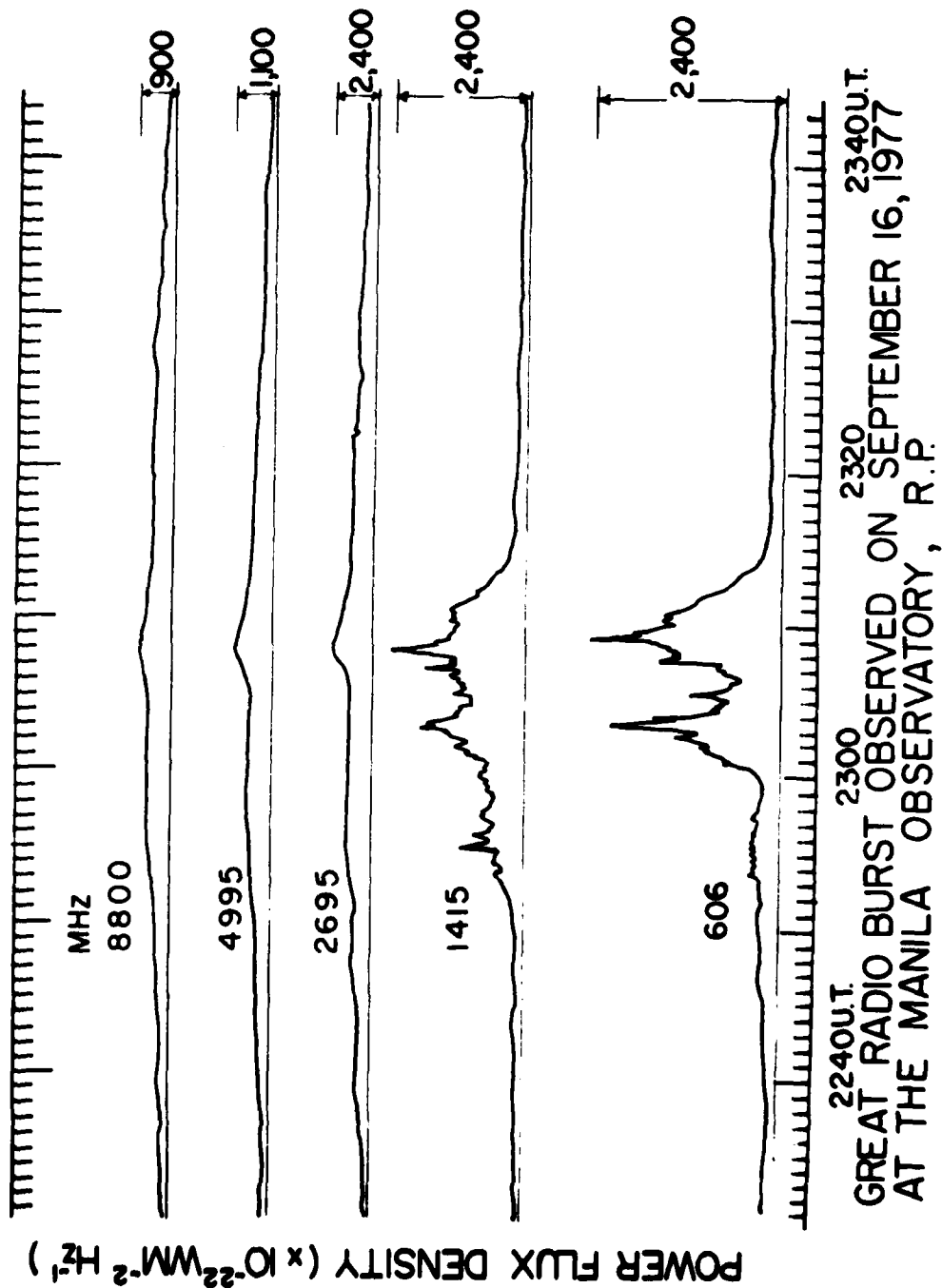
GREAT RADIO BURST OBSERVED 7 SEPTEMBER 1977
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.

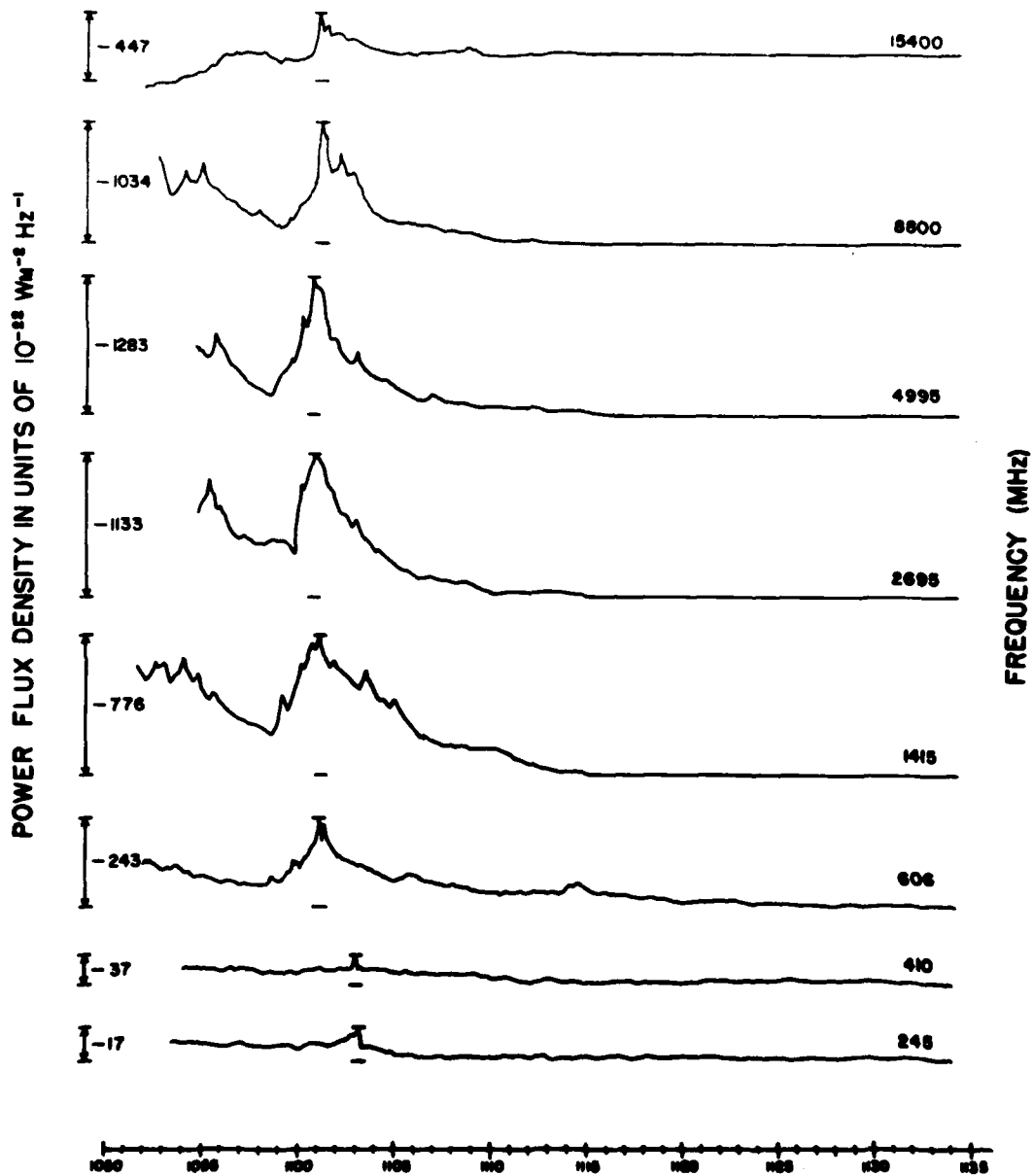


GREAT RADIO BURST OBSERVED ON SEPTEMBER 07, 1977
AT THE MANILA OBSERVATORY, R.P.



**GREAT RADIO BURST OBSERVED 9 SEPTEMBER 1977
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.**





**GREAT RADIO BURST OBSERVED 19 SEPTEMBER 1977
SAGAMORE HILL RADIO OBSERVATORY, HAMILTON, MASS.**

DATE
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