REPORT ON THE GEOPHYSICAL DESCRIPTION AND AVAILABLE DATA ASSOCIATED WITH ROCKET PF-NH-89 (IC 507.11-2A)

ALASKA UNIVERSITY, COLLEGE, ALASKA

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REPORT ON THE GEOPHYSICAL DESCRIPTION AND AVAILABLE DATA ASSOCIATED WITH ROCKET PF-NH-89 (IC 507.11-2A)

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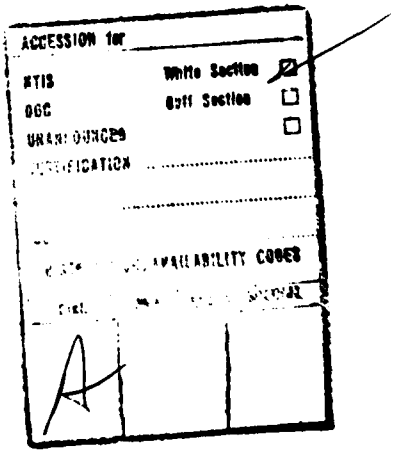
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A Nike-Hydac rocket was launched at 09:12:20 UT on March 10, 1975 from Poker Flat Research Rocket Range. This rocket reached an apogee altitude of 152 km with a total flight time greater than 454 seconds. The payload was successfully recovered. The rocket was launched during an intense auroral substorm (-600γ in ΔH) into a westward traveling surge. The sky at Ester Dome and Ft. Yukon was clear. No meridian scanning photometer data were recorded at either Ft. Yukon or Ester Dome due to camera malfunction. However, analysis of the

20. ground ASC data recorded at Ester Dome and Ft. Yukon can be used to assist in determining the relationship of the on-board data to the aurora.

Summary

The PF-NH-89 rocket launched 09:12:20 [illegible]ch 10, 1975, entered a very active auroral display. The region traversed by the rocket was the central intense region of a westward traveling surge. The magnetic activity at College was -600γ in ΔH initially, becoming less intense during launch; however, the Ft. Yukon magnetic activity increased from -350γ to -950γ over the same period. Absorption associated with this region which moved westward and poleward reached 5 db. Unfortunately, no photometric data were obtained at either Ft. Yukon or Ester Dome. However, all-sky camera data can be used to describe the activity associated with this launch.



PREFACE

The High Altitude Effects Simulation (HAES) Program sponsored by the Defense Nuclear Agency since the early 1970 time period, comprises several groupings of separate, but interrelated technical activities, e.g., ICECAP (Infrared Chemistry Experiments--Coordinated Auroral Program). Each of the latter have the common objective of providing information ascertained as essential for the development and validation of predictive computer codes designed for use with high priority DoD radar, communications, and optical defensive systems.

Since the inception of the HAES Program, significant achievements and results have been described in reports published by DNA, participating service laboratories, and supportive organizations. In order to provide greater visibility for such information and enhance its timely applications, significant reports published since early calendar 1974 shall be identified with an assigned HAES serial number and the appropriate activity acronym (e.g., ICECAP) as part of the report title. A complete and current bibliography of all HAES reports issued prior to and subsequent to HAES Report No. 1 dated 5 February 1974 entitled, "Rocket Launch of an SWIR Spectrometer into an Aurora (ICECAP 72)," AFCRL Environmental Research Paper No. 466, is maintained and available on request at DASIAC, DoD Nuclear Information and Analysis Center, 816 State Street, Santa Barbara, California 93102, Telephone: (805) 965-0551.

This report, which is the sixth report under DNA Contract F19628-74-C-0188 is the 54th report in the HAES series and covers technical activities performed during the period November 1975 through January

1976. The purpose of the work herein is to provide a geophysical description of the auroral and geomagnetic environment during the launch of ICECAP rocket PF-NH-89 (IC 507.11-2A); to assist in interpretation of the primary measurements obtained by the sensors onboard this specific experimental payload.

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INTRODUCTION

This report describes the general auroral activity associated with the launch of rocket PF-NH-89 on UT March 10, 1975 at Poker Flat Research Range. Included in this report are peripheral data pertinent to the launch, atmospheric meteorology and ground station instrumentation operation.

The format is arranged in sections to facilitate locating specific information on the various types of data and instruments that were in operation. Explanatory material is included with each section for completeness.

The summary that is presented pertains only to the description of the geomagnetic activity and our evaluation of the usefulness in proceeding to detailed absolute intensity and high time resolution studies of the available ground based data.

Section 1 - Launch Parameters

This section reviews all of the pertinent details known at the time of the preparation of this report on the launch parameters of the vehicle. The specific details of the launch are listed in Table 1.

TABLE 1 Launch Resume

Vehicle Type	Nike-Hydac
Poker Flat Research Range Vehicle Code Number	PF-NH-89
NASA or other Vehicle Code Number	IC507.11-2A
Launch Date and Time	UT March 10, 1975 09:12:20.04
Launch Azimuth	predicted, (actual setting) 45, (23.1)
QE	predicted, (actual setting) 83.5, (84.1)
Apogee Altitude	predicted, (actual) 147 km, (152 km)
Apogee Time	predicted, (actual) (200 sec)
Impact Range	predicted, (actual) 110 km, (112.1 km)
Impact Azimuth	predicted, (actual) 45, (35.84)
Impact Time	predicted, (actual) (454 sec) recovery payload
Payload Weight	284 lbs.

Table 2 lists the rocket and field line observation angles obtained from the trajectory supplied by Space Data Corporation. Listed in 10 second steps in time after the launch (T+0) are the Azimuth and Elevation angles to the vehicle and to the 100 km intercept point along the field line through the rocket as seen from Poker Flat, Ft. Yukon and Ester Dome. The magnetic field model used in this calculation is the Pogo 10-65 internal field model. The altitude of the rocket is also listed.

LOOK ANGLE DATA

ROCKET OBSERVATION ANGLES

(sec) T+	ESTER DOME ELEVATION	ESTER DOME AZIMUTH	POKER FLATS ELEVATION	POKER FLATS AZIMUTH	FT. YUKON ELEVATION	FT. YUKON AZIMUTH
60	20.3612	12.3601	78.2555	35.1456	29.9222	248.9761
70	23.8789	12.7307	77.6506	34.1042	35.6673	250.1432
80	26.8446	13.1117	77.2329	33.8853	40.5863	251.2312
90	29.4185	13.6621	76.5899	35.5148	44.6574	251.9193
100	31.3565	13.6926	76.3421	34.0888	48.4375	253.4580
110	32.9501	14.2578	75.7120	33.5472	51.5301	254.821
120	34.4570	14.8266	75.4326	35.6547	54.1877	255.3343
130	35.3525	14.9469	74.6515	34.1051	56.3516	257.3055
140	36.0587	15.2940	73.9203	34.0412	58.3312	259.2291
150	36.9258	15.8017	73.7717	35.5352	59.9737	259.4103
160	36.9964	15.9112	72.6003	34.1122	61.3052	[illegible]
170	37.1490	16.1919	71.8155	34.0587	62.5761	263.6760
180	37.4222	16.7485	71.4101	35.5507	63.7202	264.3081
190	37.0127	16.5582	70.1419	34.6552	64.5344	[illegible]
200	36.5674	16.9990	69.0502	34.0065	65.0913	269.7032
210	36.3144	17.6002	68.2709	35.4508	65.8922	270.5129
220	35.4070	17.5632	66.7215	34.2745	66.0326	274.0180
230	34.6178	17.9544	65.4206	34.5157	66.3390	276.1347
240	33.8284	18.3944	64.2152	35.4850	66.6095	277.4903
250	32.4910	18.4230	62.2607	34.7127	66.3460	281.0617
260	31.1151	18.6516	60.3113	34.6503	66.0353	283.9051
270	29.7431	19.0860	58.3800	35.4001	65.8243	285.9572
280	28.0312	19.3064	55.8728	35.2720	65.0534	289.0757
290	25.9907	19.3581	52.9101	34.8614	63.6574	292.0753
300	23.9439	19.6979	49.7317	35.2505	62.3812	295.5079
310	21.9743	19.9833	45.9505	35.4319	60.4430	298.9024
320	19.9170	20.2018	41.3917	35.4193	57.5844	302.6343
330	16.1369	20.3879	36.4683	35.4182	53.6565	305.8681
340	13.0975	20.5782	30.4888	35.3810	48.4926	309.5305
350	9.9758	20.7540	24.1027	35.2707	41.4942	312.8255
360	6.6456	20.9297	16.9393	35.3613	31.8474	316.3400
370	4.1596	21.0723	11.4597	35.3715	22.9917	318.7354

100 km FIELD LINE INTERCEPT OBSERVATION ANGLES

(sec) T+	ESTER DOME ELEVATION	ESTER DOME AZIMUTH	POKER FLATS ELEVATION	POKER FLATS AZIMUTH	FT. YUKON ELEVATION	FT. YUKON AZIMUTH	(km) ALT
60	33.4979	11.4029	87.6916	46.7193	41.9497	240.2561	55.57
70	32.4409	12.1277	84.1521	35.5839	43.3097	243.1777	72.70
80	31.5107	12.7581	80.9597	34.7846	44.6760	250.0366	84.45
90	30.7434	13.573	79.0411	35.7867	45.9626	251.5434	95.44
100	29.8435	13.7533	75.9657	33.9930	47.2395	253.9152	108.20
110	29.1253	14.1049	72.2672	33.5327	48.4965	256.1436	114.15
120	28.5833	15.1919	70.7551	34.0559	49.7263	257.5005	122.32
130	27.3069	15.4386	67.5401	33.4109	50.7451	[illegible]	129.26
140	27.2554	15.8192	65.2314	[illegible]	51.9385	[illegible]	135.77
150	25.9134	16.3773	63.7421	34.6797	52.9511	[illegible]	140.67
160	26.2039	16.5160	61.4731	33.3919	53.1746	267.7604	144.72
170	25.8097	16.9156	59.7455	33.2686	54.7334	270.7021	148.01
180	25.5564	17.3713	58.6845	34.0170	55.7210	271.6175	150.77
190	25.0523	17.5375	55.0460	33.7036	56.4371	274.6415	151.65
200	24.6577	17.5912	55.5080	33.7832	56.9817	277.7473	[illegible]
210	24.4819	18.1051	54.6070	34.0337	57.6614	278.9174	152.70
220	24.0423	18.1008	53.2320	33.5577	58.0465	282.4619	150.47
230	23.7915	18.3674	52.2843	33.8649	58.6226	284.5273	148.24
240	23.6455	18.4240	51.0402	34.7744	59.1866	285.6915	145.36
250	23.3327	18.8123	50.0256	34.1738	59.4037	286.0543	140.88
260	23.1177	[illegible]	[illegible]	[illegible]	59.7740	288.7273	135.70
270	23.0012	19.3459	49.3293	34.9749	60.4947	291.6841	129.98
280	22.8249	19.5345	48.7015	[illegible]	60.6506	293.7150	122.55
290	22.6357	19.4834	48.0949	34.6805	60.5847	295.5942	114.83
300	22.5401	19.7460	47.6979	35.1712	61.0183	295.7943	100.17
310	22.4259	19.9540	47.2620	35.4802	61.3371	293.1134	96.28
320	22.3381	20.0385	46.8423	35.6060	61.5181	299.4797	85.25
330	22.2452	20.1907	46.6083	35.7451	61.6545	300.2490	73.80
340	22.1705	20.2905	46.3365	35.8573	61.7956	301.1446	60.54
350	22.1319	20.3768	46.1892	35.9974	61.9244	301.6405	47.88
360	22.0867	20.4707	46.0148	36.1437	62.0510	302.2242	33.93
370	22.0725	20.5356	45.9489	36.2728	62.1680	302.4347	23.42

TABLE 2 Look Angle Data

Section 2 - Meteorological Data

The weather summaries are given in Table 3. The data are obtained from either station logs, ASC data, or weather bureau records. Also included in Table 4 (next page) are the complete 3 hour climatology data for the month of March at the U. S. Weather Bureau Station at the Fairbanks International Airport.

TABLE 3 Weather Summary March 10, 1975

Time (UT)	Ester Dome	Poker Flat	Ft. Yukon	Mould Bay	Sachs Harbor	Inuvik
05	Clear	Clear	Clear	Clear		Clear
06	Clear	Clear	Clear	Clear	NO	Clear
07	Clear	Clear	Clear	Clear	DATA	Clear
08	Clear	Clear	Clear	Clear	FOR	Clear
09	Clear	Clear	Clear	Clear	THIS	Clear
10	Clear	Clear	Clear	Clear	TIME	Clear
11	Clear	Clear	Clear	Clear		Clear
12	Clear	Clear	Clear	Clear		Clear

Table 5 gives the wind parameters at Poker Flat at the time of launch.

TABLE 5 Wind Data at Launch

Surface Wind Velocity	3.4 m/s	Az 146.2°
Ballistic Wind Velocity	6.1 m/s	Az 111.2

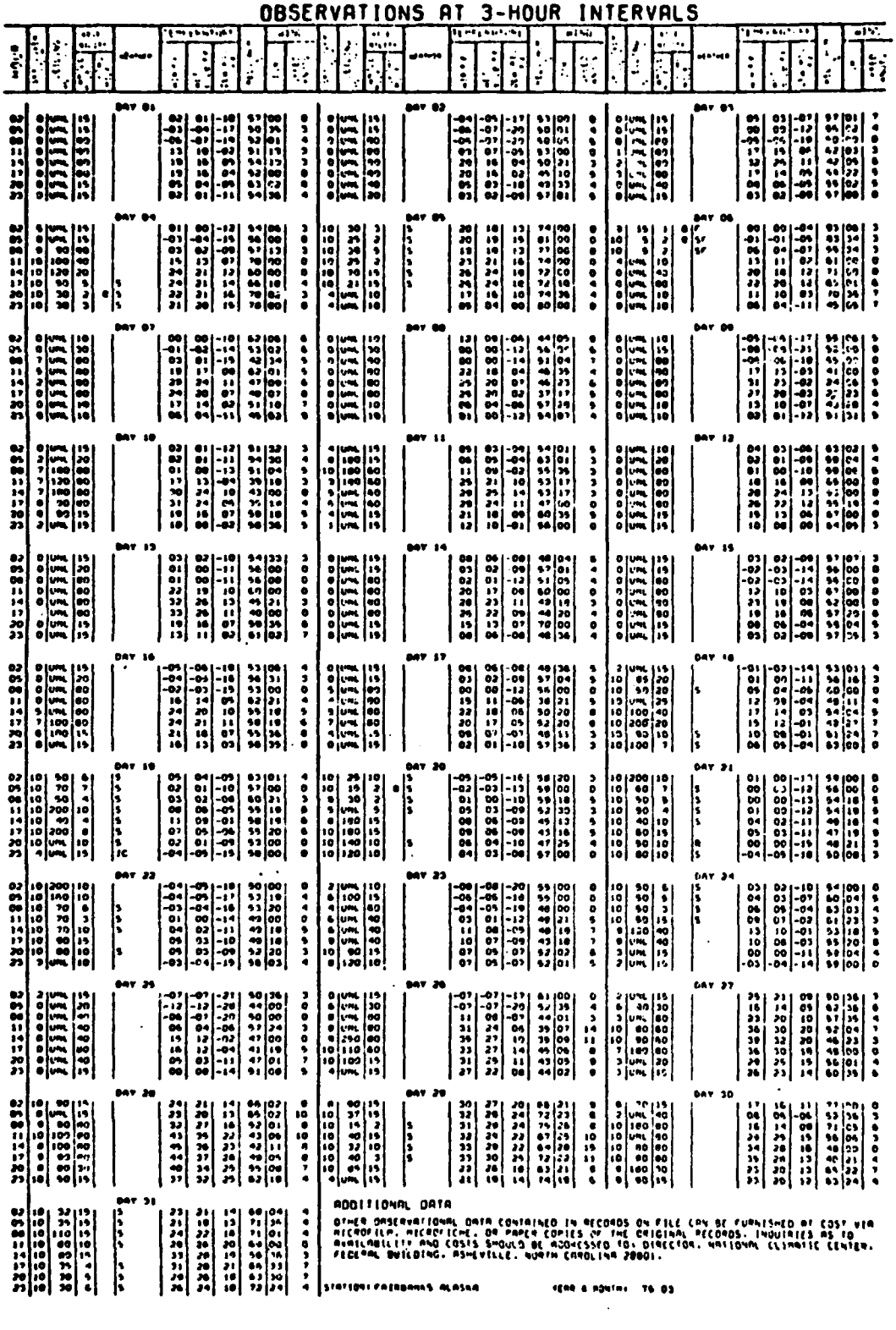

TABLE 4 3-Hour Climatological Data, March 1975

Figure 1 shows the Poker Flat Rocket Sounding data on temperature up to 60 km for the night of March 10, 1975. Launch of the meteorological rocket was at 1103 UT.

Examination of the ground station data shows that Ester Dome, Poker Flat and Ft. Yukon stations were clear during the launch of this rocket, thus corrections for extinction and scattering for these stations can be used which are appropriate for clear skies. However, the MSP recording cameras failed at both Ester Dome and Ft. Yukon so no photometric data are available. The general description of auroral activity can be obtained from the Poker Flat, Ester Dome and Ft. Yukon all-sky cameras.

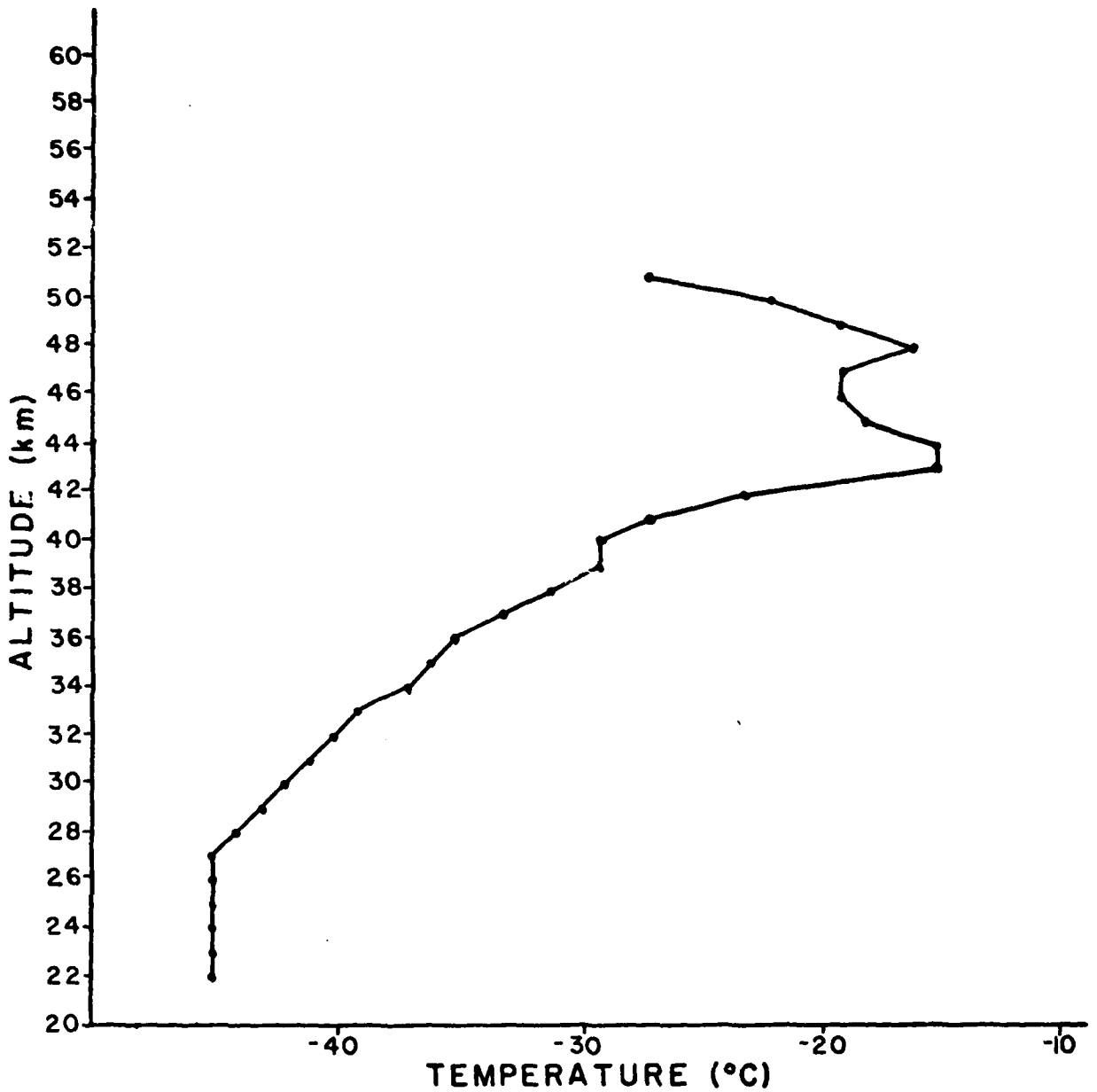

Figure 1 Temperature versus Altitude at Poker Flat

Section 3 - Solar and Lunar Data

Table 6 is a list of the geographic azimuth and elevation angles of the sun with respect to the true horizon on March 10, 1975 for Poker Flat.

TABLE 6 Solar Azimuth and Elevation

Station Location Lat = 65.13 Long = 147.48

UT Time	Azimuth	Elevation
0000	211.306	17.0572
1000	226.26	13.1275
2000	240.594	8.0858
3000	254.444	2.28356
4000	268.062	- 3.92312
5000	281.761	-10.18
6000	295.867	-16.1241
7000	310.672	-21.3736
8000	326.35	-25.5311
9000	342.863	-28.2175
10000	359.898	-29.1459
11000	16.9318	-28.207
12000	33.4413	-25.5091
13000	49.1131	-21.3378
14000	63.9096	-16.0707
15000	78.0057	-10.1049
16000	91.693	- 3.82071
17000	105.3	2.41999
18000	119.142	8.26302
19000	133.473	13.3529
20000	148.437	17.3365
21000	164.001	19.8934
22000	179.939	20.7901
23000	195.882	19.9391
24000	211.461	17.4254

Table 7 is a list of the geographic azimuth and the elevation angles of the moon with respect to the true horizon for Poker Flat during March 10, 1975.

TABLE 7 Lunar Azimuth and Elevation

Station Location Lat = 65.13 Long = 147.48

UT Time	Azimuth	Elevation
0000	240.223	.692168
1000	253.434	- 4.77787
2000	266.592	-10.65
3000	279.982	-16.6049
4000	293.916	-22.3036
5000	308.686	-27.3759
6000	324.479	-31.4237
7000	341.251	-34.0535
8000	358.642	-34.9577
9000	16.0338	-34.0104
10000	32.8048	-31.3167
11000	48.5832	-27.1679
12000	63.3175	-21.9453
13000	77.1916	-16.0384
14000	90.0003	- 9.80931
15000	103.577	- 3.5912
16000	116.72	2.30116
17000	130.185	7.55865
18000	144.138	11.8765
19000	158.618	14.9695
20000	173.513	16.6078
21000	188.575	16.6617
22000	203.502	15.1349
23000	218.048	12.1652
24000	232.099	7.99163

Section 4 - Magnetic Data and Indices

The magnetometer data from the stations listed in Table 8

TABLE 8 Location of Magnetic Observatories

Location	Geographic Latitude	Geographic Longitude	Invariant Latitude	Invariant Longitude	L
Pt. Barrow	N 71.60	W 156.4	N 66.9	W 109.35	8.47
Ft. Yukon	N 66.57	W 145.25	N 66.9	W 95.3	6.50
College	N 64.87	W 147.80	N 64.75	W 95.7	5.49

are presented in Figure 2a on the same time and magnitude scale for each of the three components of the magnetic field. The time of the rocket launch is indicated by a vertical line. Figure 2b is the magnetometer data expanded around ch time.

Figure 2c presents the magnetometer data in terms of variations of the magnitude of Z and H components with latitude. The magnetometer data shows that the westward electrojet lay between Pt. Barrow and College prior, during and after the launch. The ΔH component at College varied from -600γ at launch to -250γ at T+360. At Ft. Yukon, ΔH varied from -350γ to -950γ over the same period, indicating an intensification and poleward displacement of the westward current system. The magnitude of the current density to a first approximation (∞ sheet current) in Amp/km is the same numerical value as the H component magnitude in gamma. The actual value may be as much as two or more times that deduced from the magnitude of the magnetometer data but the temporal variation will be similar.

Figure 3 shows the total K index, planetary Kp index and DST values for UT, March 10, 1975. During the rocket flight, K_p and K were 6 and 7, respectively.

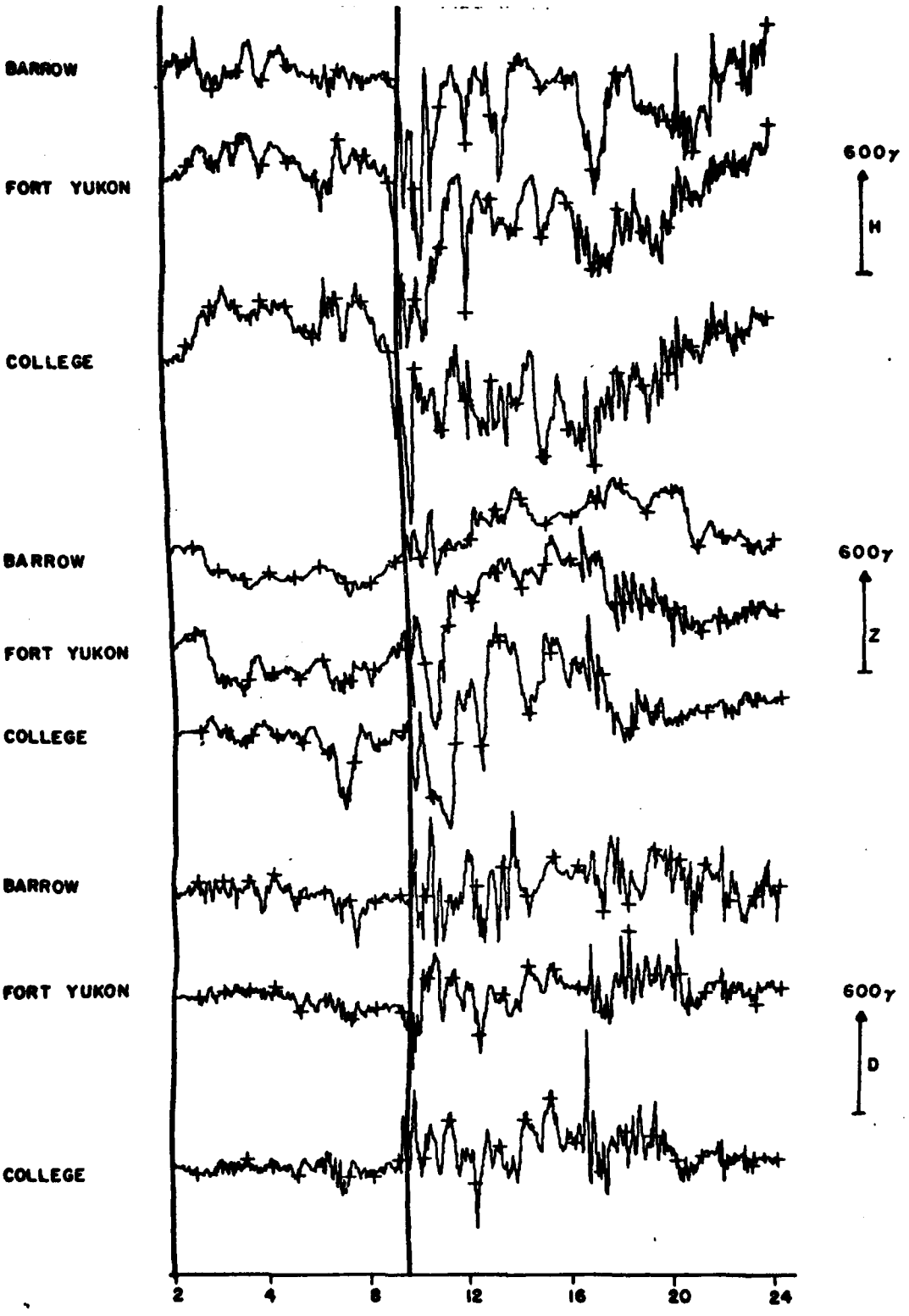

Figure 2a Magnetometer Data from Various Locations

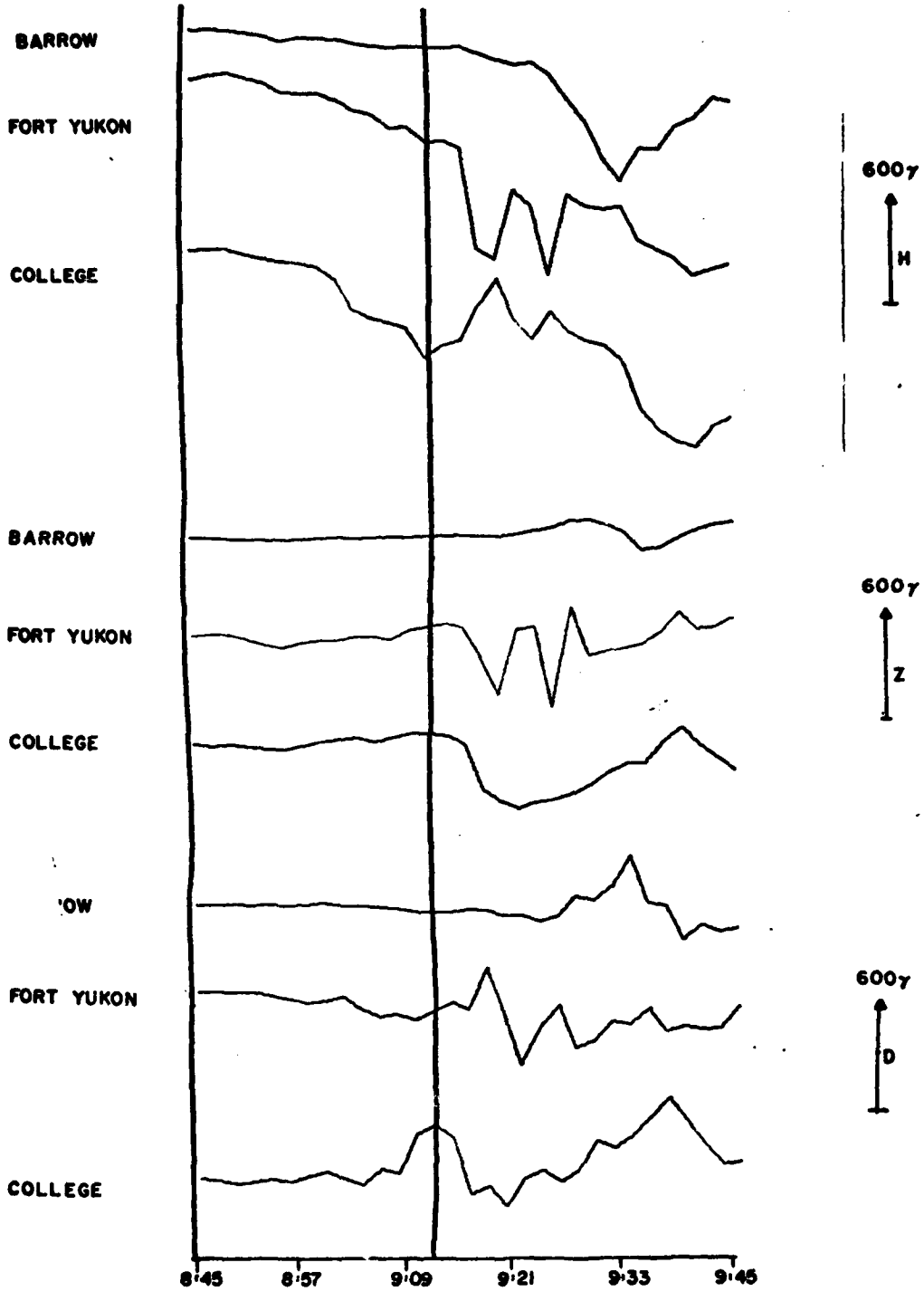

Figure 2b High Time Resolution Magnetometer Data from Various Locations.

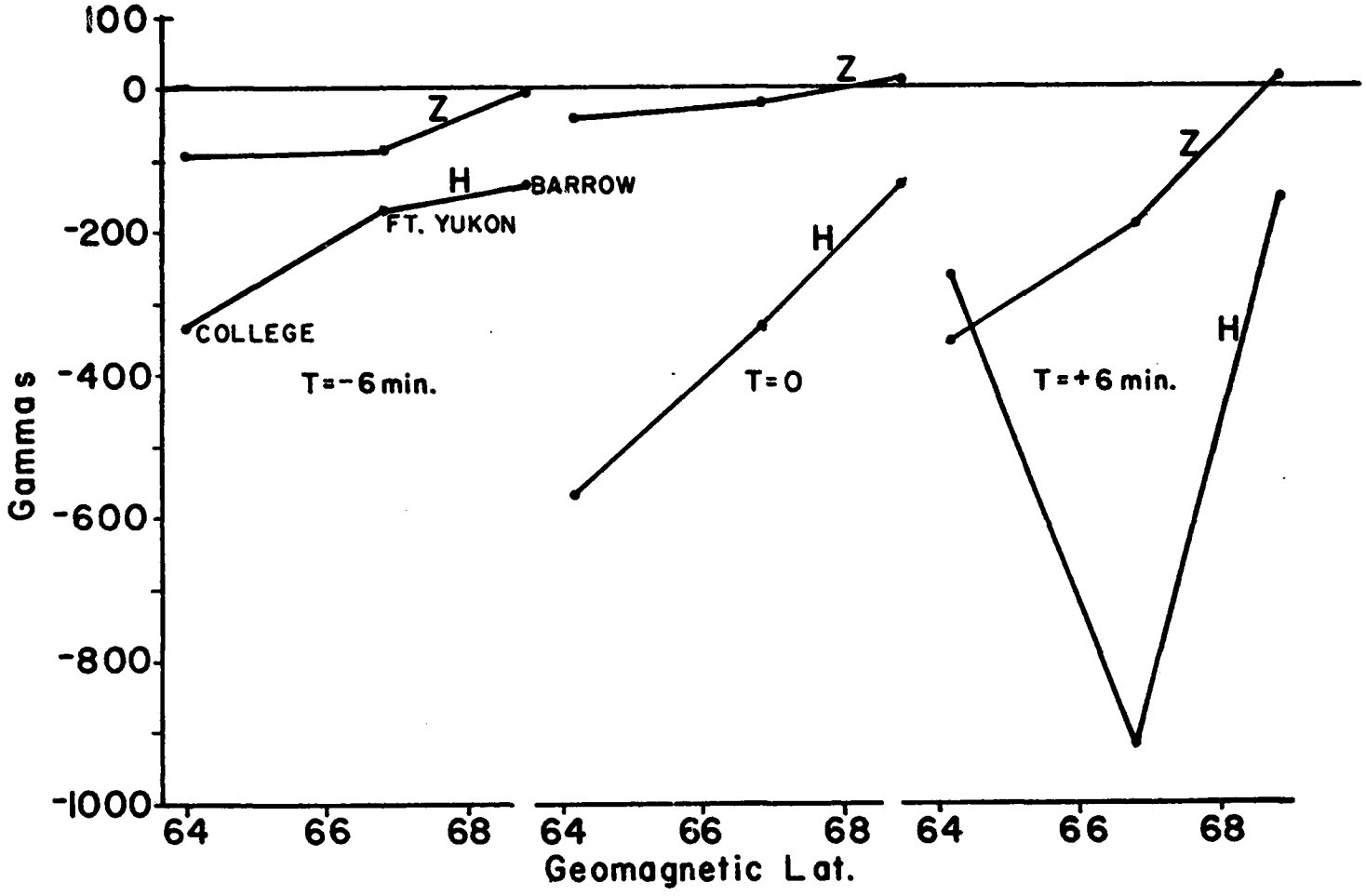

Figure 2c Variation of the Z and H Magnetic Components with Latitude

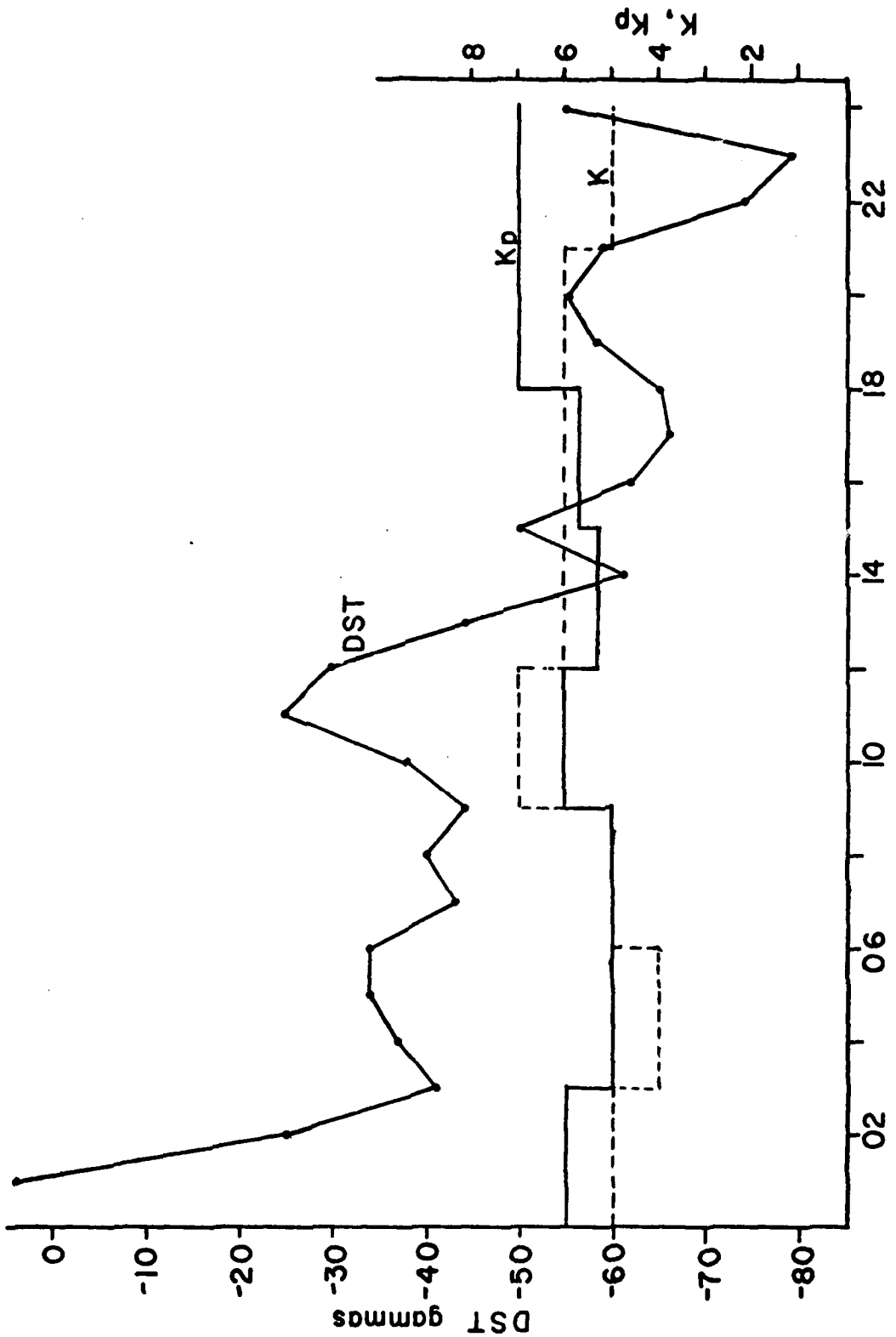

Figure 3 K, K_p, DST for March 10, 1975.

The rocket flight occurred in the initial phase of one of many auroral substorms within a large magnetospheric substorm which reached a peak intensity of -80γ in DST at 2300 UT March 10, 1975.

The DST value, as seen from Figure 3, was near -35γ during this launch, which implies using the data in Figure 4 that the cut-off trapping boundary for high energy electrons was poleward of College. The rocket probably traversed the region primarily equatorward of the high energy trapping boundary. However, since this was an active westward auroral surge, the boundary could have been in the process of moving poleward during this launch.

2030 - 2230 MLT

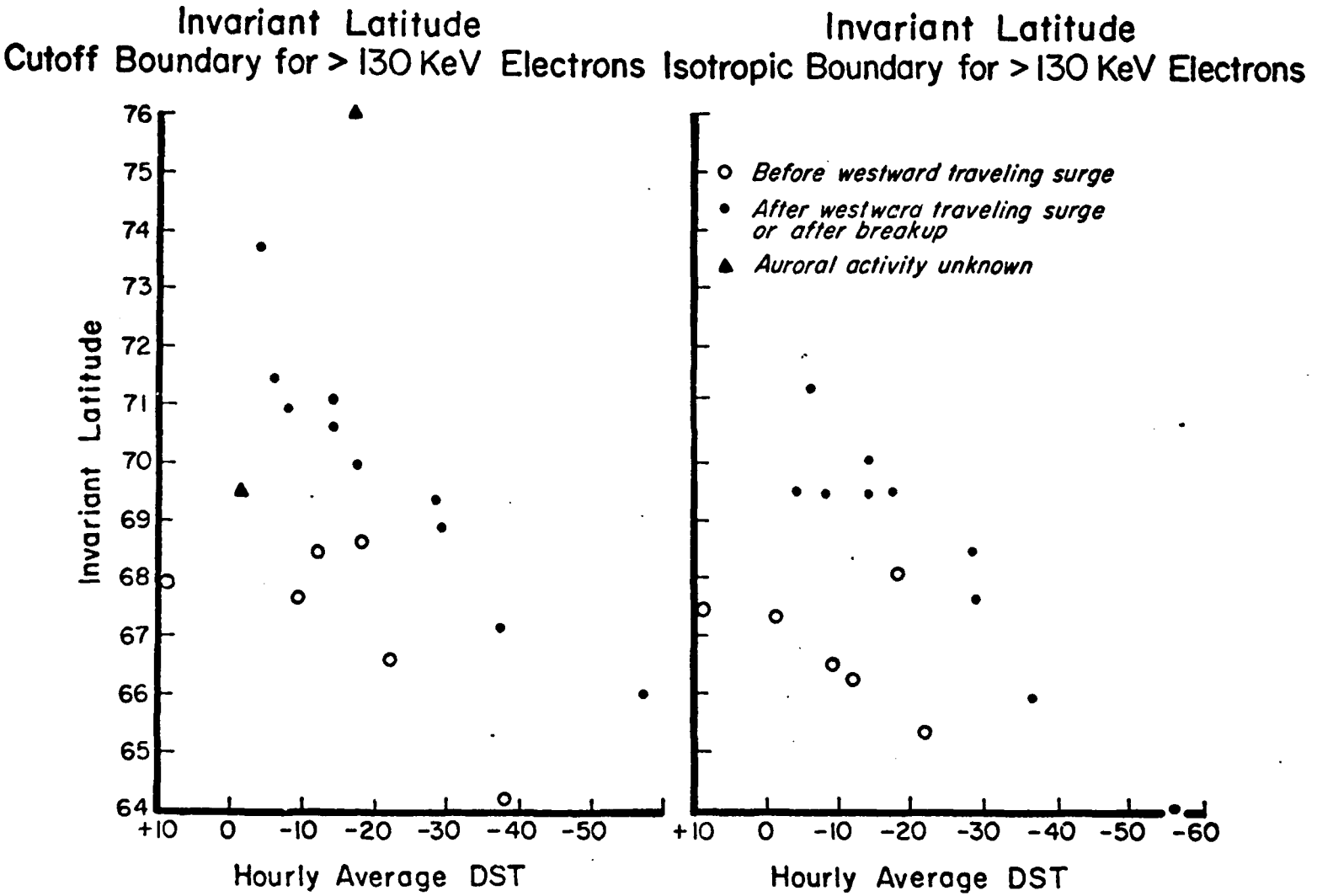

Figure 4 Latitudinal Variation in the Trapping Boundaries for > 130 kev electrons in the Evening Sector of the Auroral Oval as a Function of Dst, Before or After Substorm Activity.

Section 5 - Radar Observations

During this period in the spring of 1975 the 50 MHz NOAA radar at Anchorage was in operation on a routine basis. Resumes of their data, instrumentation, and operational details are available from NOAA in Boulder, Colorado.

In addition, data from the Chatanika Incoherent Scatter radar are also available from SRI.

Any detailed study of the rocket data should incorporate a detailed examination of the available radar data. It is particularly applicable to the spatial structure of electron density irregularities, electric fields, neutral winds, and spatial and temporal dynamics of the particle precipitation.

Section 6 - All Sky Camera Observations

Table 9 lists the stations from which either 16mm or 35mm all sky camera and other instrument data are available during the period of interest on March 10, 1975. The auroral data quality from each site depends on the cloud coverage as indicated in Section 2.

Figure 5 is a composite of 35mm all sky camera photographs for the period prior to, during and after the launch of PF-NH-89. Figure 6 shows the details of the aurora during launch.

The stations used were Ft. Yukon and Poker Flat. Time in UT as well as in seconds (or minutes) with respect to launch are indicated on each print.

From these photographs and a review of all of the data available, we describe the general auroral situation covering this rocket launch.

TABLE 9 Geophysical Instruments Operating
March 10, 1975

Chatanika

Incoh. Scat. Radar - 05:58-14:56 UT
35ASC - 05:39-14:53 UT
16ASC - patrol
Photometer - 06:00-14:53 UT

Fort Yukon

MSP - 06:04-11:45 UT
35ASC - 06:08-11:45 UT
16ASC - 02:30-13:15 UT
Riometer - Continuous
Magnetometer - Continuous

Poker Flat

TV - 09:10-09:15 UT
Magnetometer - Continuous
Riometer - Continuous

Ester Dome

MSP - 05:13-12:13 UT
35ASC - 05:28-12:14 UT
16ASC - patrol

College

Riometer - Continuous
Magnetometer - Continuous
Ebert Spectrophotometer - 08:00-15:00 UT
Zenith Photometer - 06:45-15:30 UT

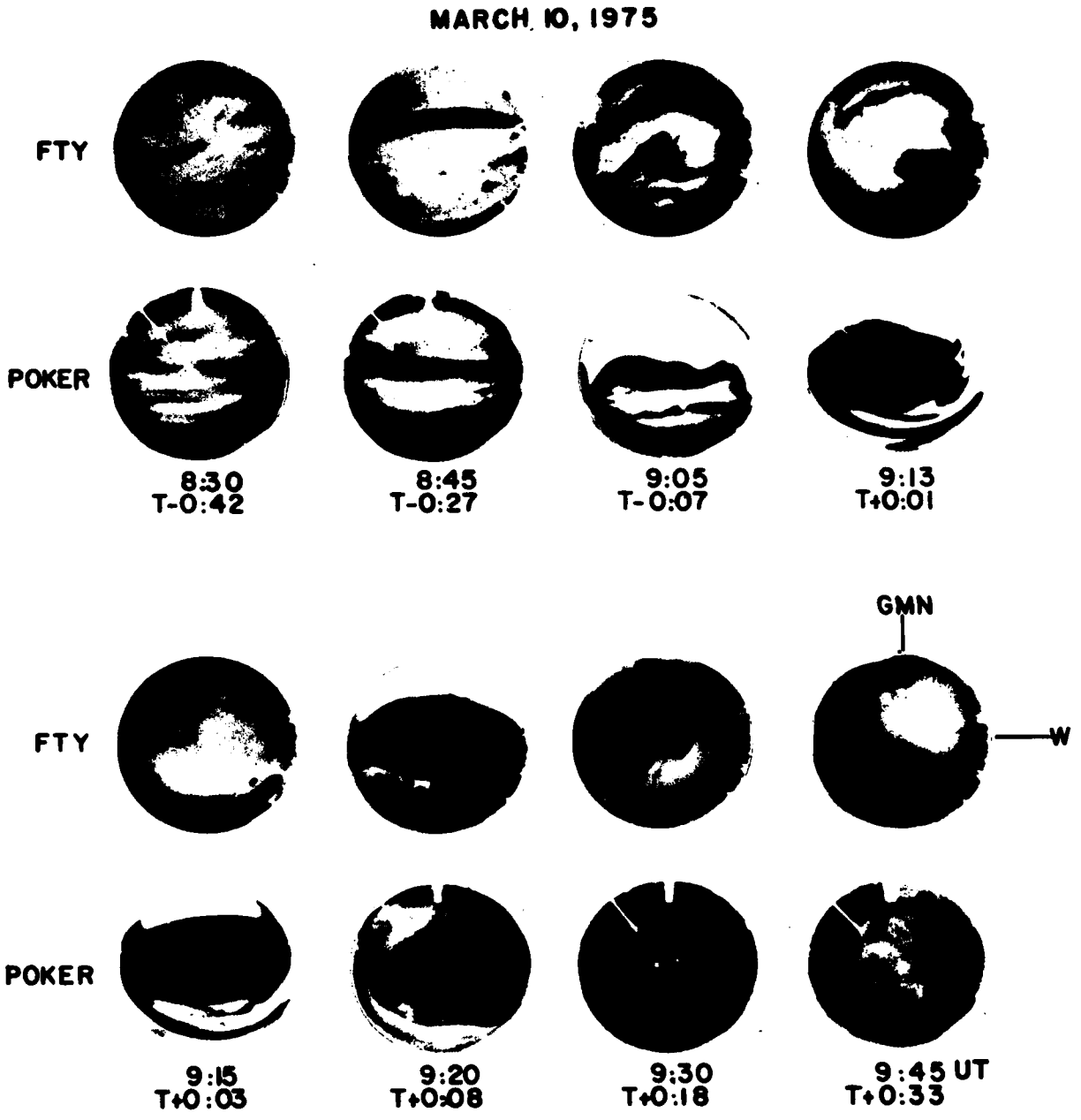

Figure 5 All Sky Camera Data Prior To, During, and After Launch (Bright Aurora are Printed Black).

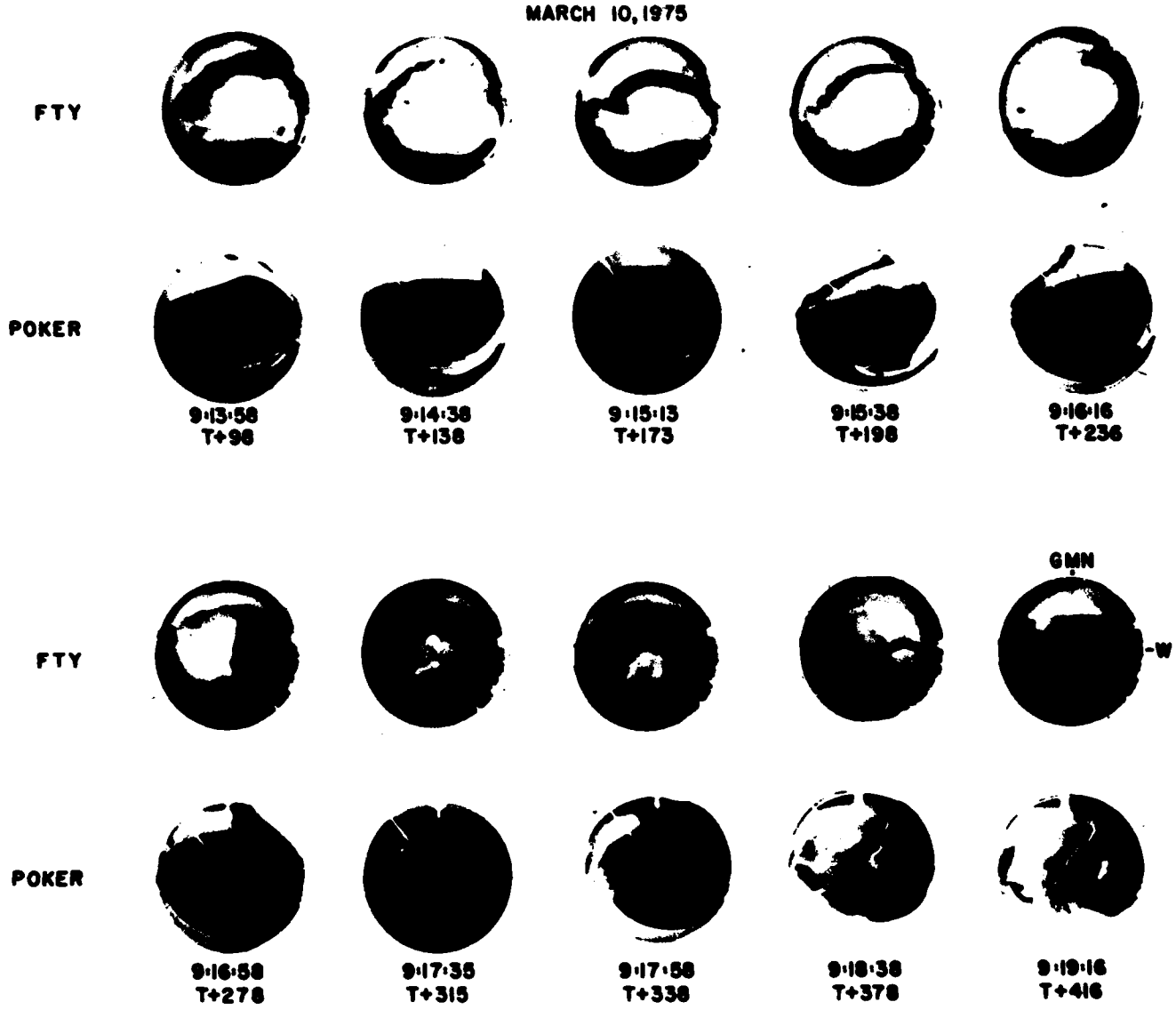

Figure 6 35mm All Sky Camera Data During Launch

MURPHY DOME

March 10, 1975

05:00	Dusk
05:00-06:00	Active equatorward moving arc system
06:00-06:40	Poleward expansion; very active arc system covering entire sky
06:50-08:20	Arcs on the northern horizon with diffuse aurora covering the entire sky
08:20-09:00	Arc system covering entire sky
09:04	Bright arc appears on southern horizon with very intense westward traveling intensity enhancements
09:20-11:20	Very intense diffuse aurora covering entire sky
11:20	Diffuse aurora erodes equatorward; rayed arcs appear out of the north
11:20-12:00	Active arc system covering entire sky
12:04	Westward traveling surge
12:10-dawn	Diffuse aurora

FORT YUKON

March 10, 1975

05:00	Dusk
05:00-05:40	Equatorward moving arc system
05:40-06:00	Arc system in the south
06:05-07:00	Poleward expansion; active arc system covering entire sky
07:00-07:40	Active arcs in the northern half of sky with diffuse aurora covering the entire sky
07:40-09:00	Active arc system covering entire sky
09:10	Intense westward traveling surge in the south
09:20-11:00	Intense diffuse aurora covering the entire sky
11:00-11:50	Diffuse aurora erodes equatorward; active rayed arcs appear out of the north; move rapidly to southern horizon
11:50-14:00	Poleward expansion begins; active arc system covers entire sky

Section 7 - Meridian Scanning Photometer

Meridian scanning photometers were operated by the Poker Flat Research Range at Ester Dome and Ft. Yukon during this rocket launch. However, failure of the recording camera at both sites provides no usable photometric data during this launch.

Section 8 - Television Coverage

Television data from Ester Dome and Poker Flat were obtained during this rocket launch.

Section 9 - Riometer Data

Riometers are operated at Ft. Yukon, Poker Flat and College. Absorption is measured at 30 MHz. Figure 7 shows the records from 8:00 to 12:00 UT on March 10, 1975 for Ft. Yukon and Poker Flat. There was absorption greater than 5 db at both stations during the time interval of interest which indicates that high energy particles were precipitating during this rocket flight. The exact values of absorption are accurate to $\pm$ 2 db for this level of activity.

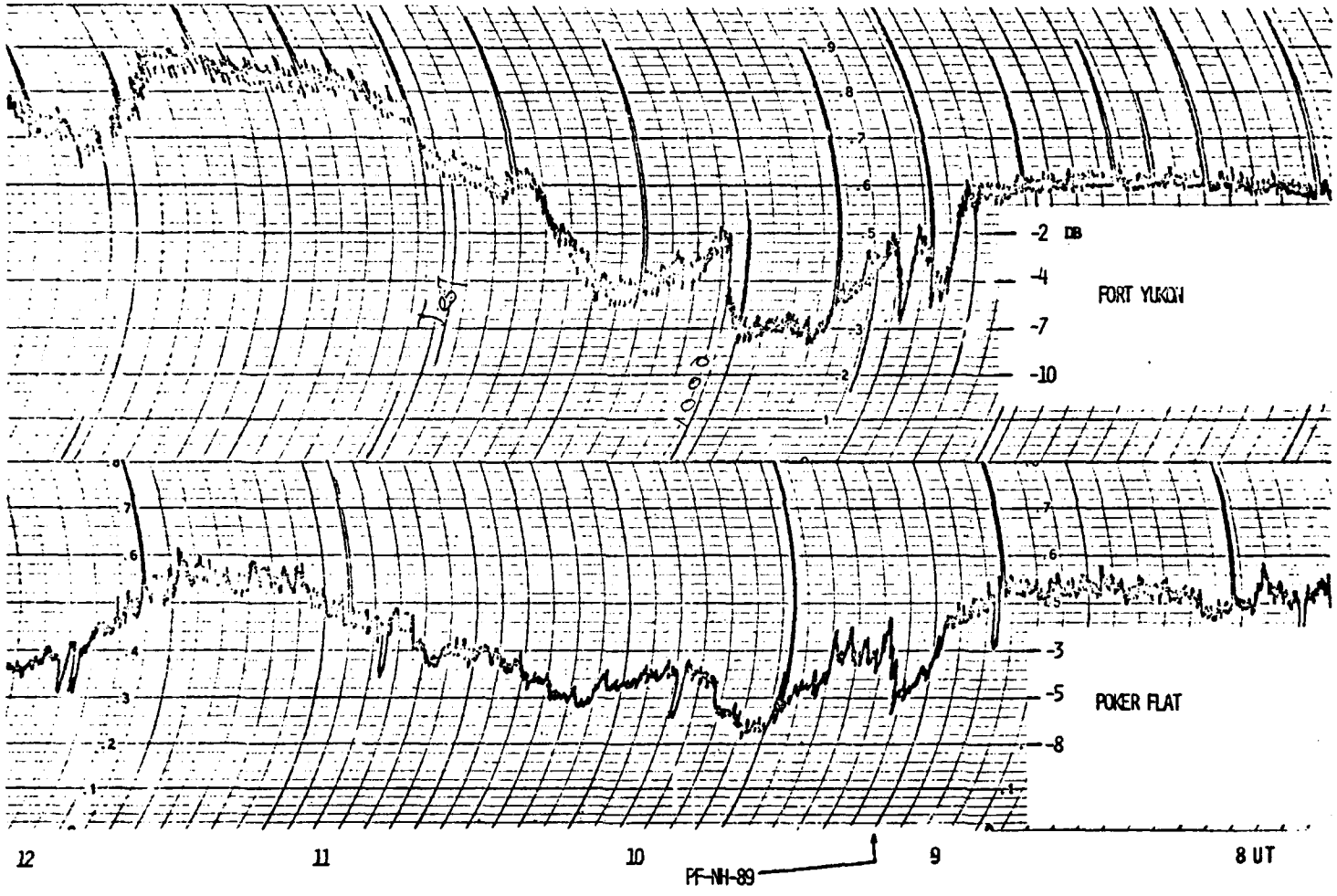

Figure 7 Riometer Absorption from Poker Flat and Ft. Yukon

Section 10 - Ionosonde Data

The ionosonde at College operates between .5 and 20 MHz at vertical incidence. It requires approximately 30 seconds to sweep over the complete frequency range and is normally programmed to operate once every 15 minutes, on the minute. Data for the 3 periods closest to launch are presented here. The earliest trace shows evidence of a thick E layer with peak electron density $\sim 7.5 \times 10^5$ electrons/cm^3 with the presence of oblique echoes from scattering due to rayed structures. The middle trace shows a thinner E-layer with enhanced lower E-layer absorption, but with similar electron densities and oblique echoes to the earlier trace. The lower trace shows a thicker E-layer, but little change in peak electron density or absorption.

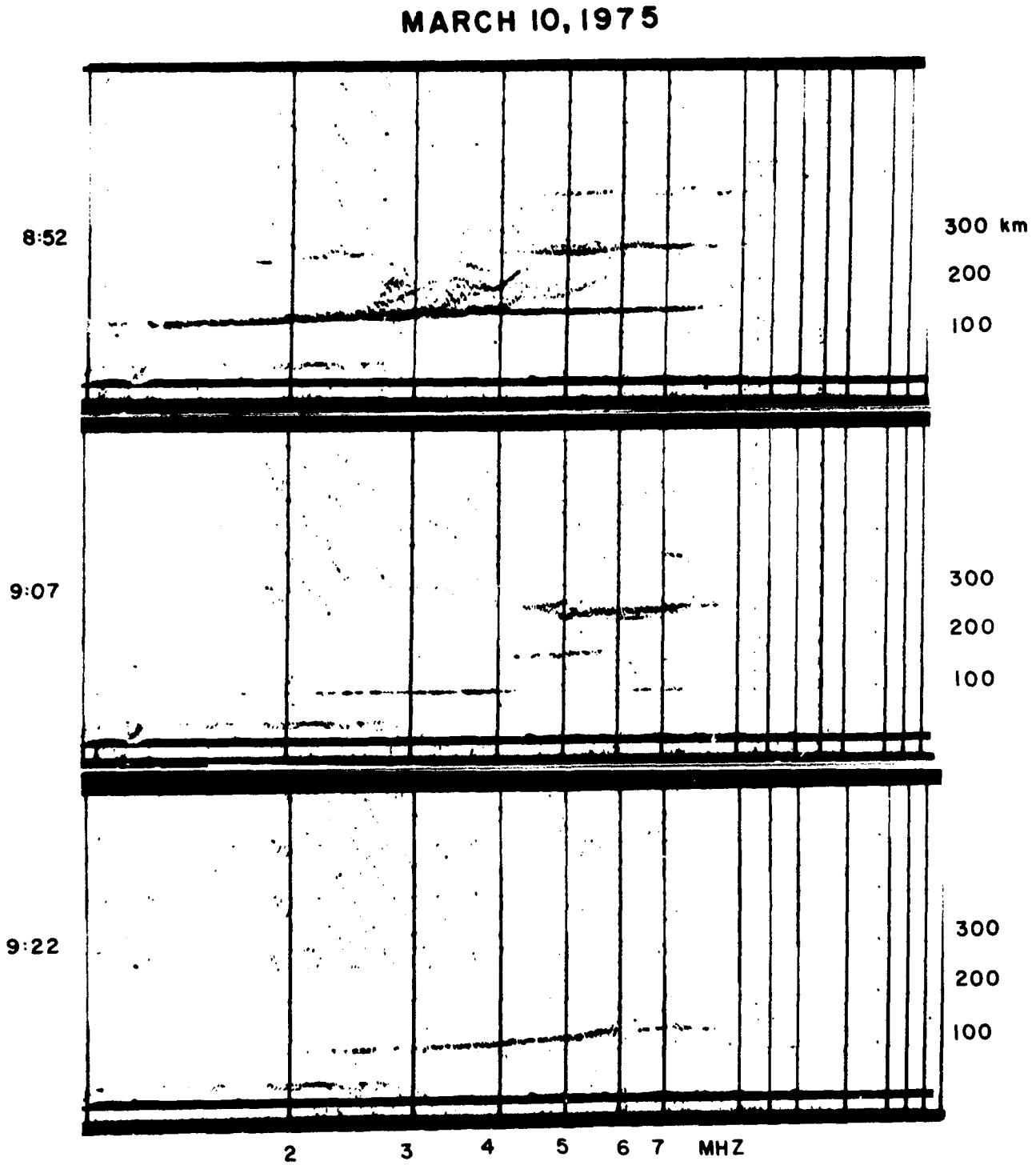

Figure 8 Ionosonde Data from College.

Section 11 - DMSP Satellite Photographic Data

The Air Force weather DMSP satellites record auroral activity on nighttime passes over the auroral zone. We have included in Figure 9 the closest satellite pass to the launch of Rocket PF-NH-89. The aurora seen on this photograph covers the period 0855 UT to 0857 UT. A map of Alaska is superimposed on the satellite photograph for orientation purposes. The satellite orbit passed along the center of the original photograph through Point Barrow (BRW). The rocket launch occurred approximately 16 minutes after the satellite had passed over the same latitude, thus these DMSP data can be used to help describe the situation prior to launch.

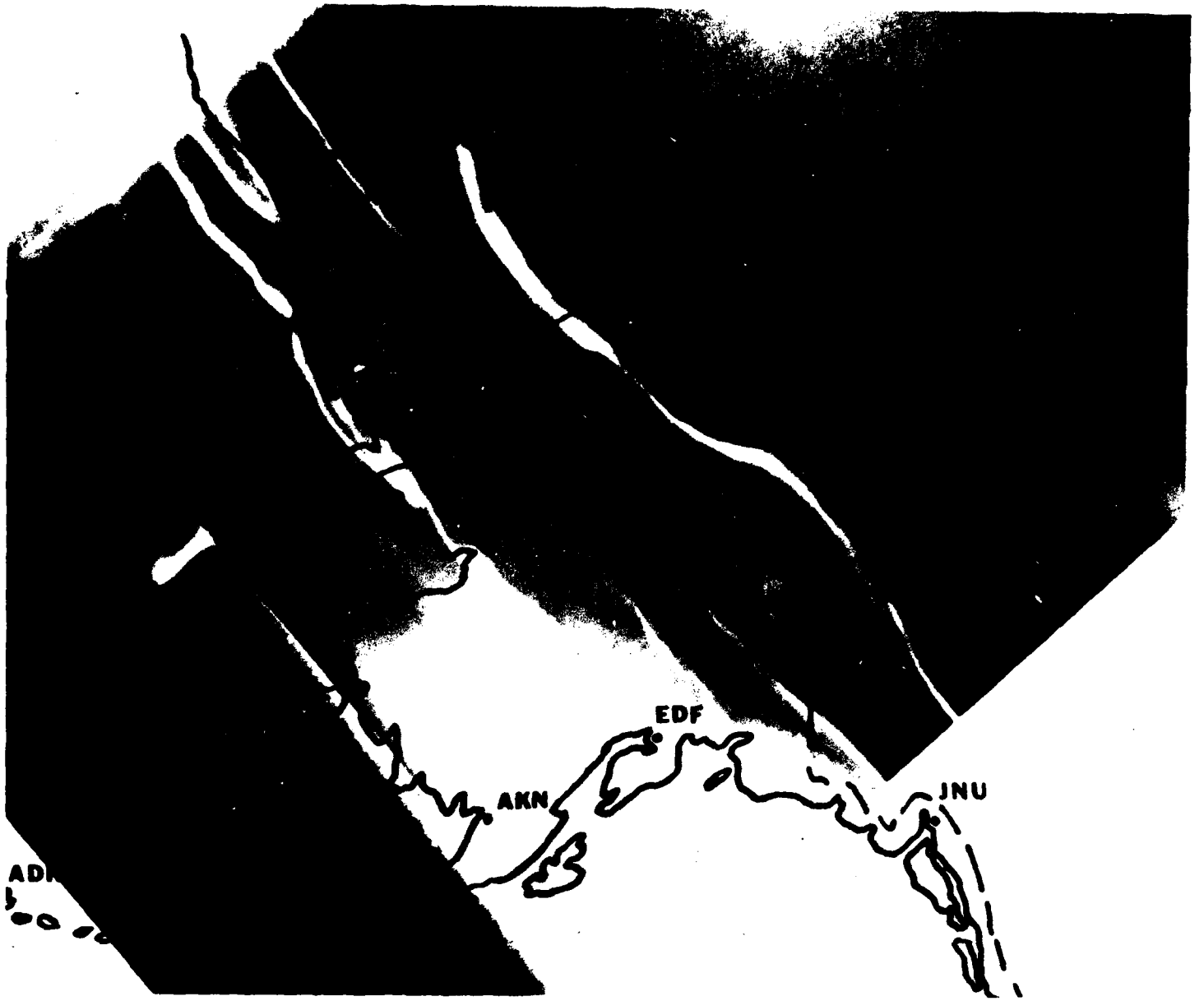

Figure 9 DMSP Satellite Photograph at 08:55-08:57 UT, March 10, 1975

References

Akasofu, S.-I., Polar and Magnetospheric Substorms, D. Reidel Publishing Company, Dordrecht, Holland, 1968.