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by

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ABSTRACT

Inter-comparison measurements of the major ionospheric parameters of ion and electron density and temperature and ionic species made by direct measurement probes on the Explorer XXXI satellite are presented. Plasma density results are compared with simultaneous data from the Alouette II satellite. Probe results are from the following experiments - planar ion trap, planar electron trap, cylindrical electrostatic probes, high resolution magnetic ion mass spectrometer, planar Langmuir plate, and spherical ion probe.

The plasma density measured by the various probes generally agree with simultaneous Alouette II sounder values to within 20%. Electron temperatures measured by three different types of probes generally agree within 10%. Ion composition measurements by the planar ion trap and spherical probe show good agreement with the high resolution magnetic mass spectrometer. Ion temperature measurements from the ion trap are consistently higher than spherical ion probe results.

INTRODUCTION

The Explorer XXXI Satellite (Direct Measurements Explorer-A) was launched along with the Alouette II Topside Sounder Satellite on November 29, 1965 into an 80^{o} prograde polar orbit with a perigee of 500 km and an apogee of 3000 km. The combined launch of the two spacecraft is called the ISIS-X project.

The major purpose of the ISIS-X mission was the simultaneous measurement of ionospheric parameters by direct measurement probes and electron density profiles measured by the topside sounder experiment on Alouette II. The close proximity of the two satellites provided an excellent opportunity for such simultaneous data coverage for several months after launch. The orbital separation was about 105 seconds (about 800 km) two months after launch.

Explorer XXXI was instrumented with ionospheric direct measurement probes which provided measurements of the major ionospheric parameters through different techniques. The experiment complement, measured parameters pertinent to the comparison, and principal investigators are as follows:

1. Planar Ion Trap - ion density, temperature and composition; J. L. Donley.

2. Planar Electron Trap - electron density and temperature; J. L. Donley.

3. Cylindrical Electrostatic Probes - electron density and temperature; L. H. Brace and J. A. Findlay.

4. Magnetic Ion Mass Spectrometer - ion density and composition; J. H. Hoffman.

5. Planar Langmuir Plate - electron temperature; A. P. Willmore and G. L. Wrenn.

6. Spherical Ion Probe - ion density, temperature and composition; A. P. Willmore and G. L. Wrenn.

Nominal data accuracies for the experiments are as follows:

1. Ion Trap - ion density, $\pm 10\%$; ion temperature, $\pm 150^{\circ}K$.
2. Electron Trap - electron density, $\pm 20\%$; electron temperature, $\pm 200^{\circ}K$.
3. Cylindrical Probe - electron density, $\pm 10\%$; electron temperature, $\pm 150^{\circ}K$.
4. Ion Mass Spectrometer - ion density, $\pm 10\%$.
5. Langmuir Plate - electron temperature, $\pm 100^{\circ}K$.
6. Spherical Ion Probe - ion density, $\pm 2\%$; ion temperature, $\pm 200^{\circ}K$.

These accuracies are mainly indicative of data scaling error bounds and do not reflect a relationship between the measured quantity and the absolute value of the parameter under study.

The experimental implementation and data analysis procedures have been described in separate papers included in this issue.

COMPARISON PASSES

For the purpose of data intercomparison several passes have been selected for detailed study. The results of these passes are presented in this paper. These passes were selected on the basis that all experiments were operating satisfactorily, good aspect data was available, and simultaneous Alouette II sounder data was available. For the passes selected the maximum in orbit separation time between Explorer XXXI and Alouette II was less than 105 seconds (about 800 km). The passes cover a variety of geographic locations and plasma density conditions typical of the Explorer XXXI coverage. Passes in the northern auroral regions, which represent a large percentage of data coverage, have been excluded from this initial comparison study since such passes were at apogee altitudes and consequently very low plasma densities (about 10^2/cc) which are below the sensitivity threshold of some experiments are encountered. Also Alouette II data is generally not available for comparison at these low densities.

Details of the comparison passes are given in Table #1. The spacecraft was in sunlight for all passes.

DATA COMPARISON RESULTS

Plasma Density

The results of the comparison of electron and ion density values are summarized in Figure 1. Results are shown as the ratio of the Explorer XXXI probe measurements to the Alouette II values as a function of plasma density. The sounder values of electron density have been chosen to coincide in height and position with the

Explorer XXXI values. Since the maximum time separation of the two satellites during this comparison is less than two minutes and regions of ionospheric irregularities have been excluded, it is felt that a truly simultaneous value for local electron density at the satellite altitude is available to serve as a comparison standard. Alouette II ionogram data used has been scaled by the Defence Research Telecommunication Establishment in Ottawa, Canada and the Radio and Space Research Station in Slough, England. In cases where values furnished by the two sources have been in disagreement, a mean value has been employed for comparison purposes. The maximum scaling disagreement noted for the Alouette II data was about 10 percent.

The range of values of plasma density in the comparison passes was from a low of about 2×10^{3} el/cc to a high of about 4×10^{5} el/cc. For the RAL 546 and SNT 730 passes, which represent low altitude high density dominant oxygen ion conditions, all probes have yielded values which are within 20 percent of the Alouette values. For the passes with density less than 2×10^{4} el/cc, errors of up to 60 percent are noted.

The results of the spherical ion probe density measurements on the WNK 550 pass are lower than Alouette II densities due to insensitivity to oxygen (O^{+}) ions. The limiting sensitivity on O^{+} measurements for the ion probe is approximately 300/cc. The ion mass spectrometer indicates that for the WNK 550 pass the O^{+} density is in the range 200 to 500/cc.

The ion probe results indicate no O^+ on this pass and thus are lower than Alouette II values. On the KNO 368, which consists of essentially all hydrogen (H^+) ions, the probe results are in better agreement with Alouette values. It thus appears that the spherical ion probe as implemented on Explorer XXXI yields valid plasma density values provided the number density of O^+ ions is negligibly small (H^+ is the dominant species) or large compared to the O^+ sensitivity threshold.

The cylindrical electrostatic probe experiment yields electron density values in good agreement with Alouette on all passes except KNO 368. This pass yielded a value 60 percent high. No reason has been found to explain this discrepancy. Also on KNO 368, values of ion and electron density from the ion trap and electron trap are up to 40 percent low. Again no explanation for this behavior is evident. Otherwise good agreement is obtained on the other passes. Sufficient comparisons have not been made in order to ascertain the statistical significance of the occurrence of passes which show large discrepancies in plasma density results for the ion and electron trap experiments and the cylindrical probe.

Values of ion density obtained by the magnetic ion mass spectrometer show very good agreement with Alouette values with the exception of one measurement on the WNK 550 pass which is 25% low. Since a large number of Alouette II density values have been used in order to ascertain the effective collection volume of the mass spectrometer as a function of plasma density and ionic species (see paper by J. H. Hoffman in this issue) it is expected that the spectrometer results are a valid measure of the local ion density.

Values of electron density from the electron trap are not available for the WNK 550 pass since the sensor was illuminated by the sun when in the forward direction. Density values less than about 10^4/cc cannot be obtained reliably when the sensor is illuminated (see paper by J. L. Donley in this issue).

Figure 2 shows the detailed plasma density comparisons for the RAL 546 pass versus universal time. O^+ is the dominant constituent for this pass. All Explorer XXXI probes show agreement with Alouette II density values although in general they are 10 to 15% above the Alouette II values. Individual data points are connected by straight lines.

Figure 3 shows the comparisons for the KNO 368 pass. This pass shows the largest departures from Alouette data values for any of the comparison passes. Even though this large error is present in the cylindrical electrostatic probe data and the ion and electron trap data, the data from each experiment yields the same relative variations.

Electron Temperature

The electron temperature comparisons are shown in Table 2. Values obtained from the electron trap experiment were obtained when the sensor was oriented in the forward direction on all passes except WNK 550. These values were at angles of attack of 60 yo 90 degrees since forward looking values were distorted due to solar illumination of the sensor. Cylindrical electrostatic probe values are the average of data taken over a 30 second period which represents approximately one and a half satellite roll periods. Values for the two probes are shown only when there is a statistically significant difference between the results of the two identical probes. Planar Langmuir plate values are given for both forward and non-forward directions.

Excellent agreement in electron temperature was obtained on the KNO 368 pass. Individual probe results are all within 10 percent of each other. Figure 4 is a plot of electron temperature results for this pass versus universal time.

On the other comparison passes deviations of up to 20 percent from the mean measured electron temperature are evident. On the SNT 730 pass, cylindrical probe results agree with other measurements at the beginning of the pass but show significantly higher values at the middle and end of the pass. On RAL 546 the cylindrical probe is also higher than other values. On WNK 550 the electron trap values are higher than other results. Examination of the planar Langmuir plate results indicates significant difference between forward and non-forward values particularly on the BPO 730 pass. The same pass has the largest difference between the two cylindrical probes. This result suggests the presence of anisotropies in the electron energy distribution. A possible source of the anisotropy would be orientation with respect to the local magnetic field, however the BPO 730 pass does not represent a unique position or orientation compared with the other comparison passes. Therefore any anisotropy present in BPO 730 may be unique to the time of this pass.

Figure 5 is a plot of results for the WNK 550 pass. The data from this pass shows the largest difference between probe results for the comparison passes. Differences of up to about $1000^{\circ}K$ are present between the results of the electron trap and the Langmuir plate. Also significant anisotropy is present in the planar Langmuir plate results at the end of the pass.

If the passes included in this comparison are truly typical of the probe results, compared to the mean measured temperature the cylindrical probe is typically above the mean and the Langmuir plate is typically below the mean. The maximum deviation from the mean is about 20 percent.

Ion Temperature

Measurements of ion temperature were made by the planar ion trap and the spherical ion probe. The results of the planar ion trap experiment require detailed satellite aspect data. The spherical probe is essentially omni-directional and aspect data is not essential. The only restriction is that the probe be free of the satellite wake. For the comparison passes the aspect data is believed to be correct with a maximum error of not greater than ± 5 degrees.

Of the five comparison passes, the RAL 546 and SNT 730 passes have 0^+ as the dominant ionic constituent, KNO 368 and WNK 550 .ave H^+ dominant, and BPO 730 has 0^+ major with significant amounts of H^+. Table 3 shows the ion temperature results. In addition to the H^+ and 0^+ temperatures, the mean electron temperature results from the probes discussed in the previous section are included for comparison purposes.

On the KNO 368 pass the ion trap results for H^+ temperatures are consistently about $500^\circ K$ higher than results from the spherical probe. The H^+ temperatures from the ion trap are the result of excellent curve fits to the raw data showing deviations of less than $\pm 50^\circ K$. Both experiments yield ion temperatures which are considerably below measured electron temperatures. Figure 6 shows the ion temperature results from the KNO 368 pass.

The other dominant H^+ pass is WNK 550. The ion trap values are much higher than the spherical probe results. Within error bound the ion trap values are approximately equal to the electron temperature while the spherical probe results are about $1000^\circ K$ lower. The larger than nominal error limits indicated on the trap results are indicative of uncertainties in the curve fitting results. Sources of error are aspect errors (even though no greater than ± 5 degrees), presence of minor constituents particularly He^+ and solar illumination of the sensor causing secondary emission current which represents an error signal component.

The dominant 0^+ passes, RAL 546 and SNT 730, show ion trap temperatures above those of the spherical probe (see Figures 7 and 8). The difference ranges from about 500°K up to 1200°K. On SNT 730 the ion trap values are close to the measured electron temperature while the spherical probe results are closer to the neutral gas temperature. Backscatter radar results from Jicamarca (magnetic equator) in December 1965 show ion and electron temperatures equal at altitudes above 350 km (Farley et al, 1967). Results from Arecibo radar (30°N magnetic) in the summer of 1965 show afternoon electron temperatures of 1600° to 1900°K and ion temperatures of 1600° to 1700°K at altitudes of 500 to 550 km (Rao, 1968). The SNT 730 pass is at an altitude of about 530 km and at latitudes of from about -15° to -30° magnetic in the summer hemisphere. The ion trap ion temperature results are in agreement with this radar data. Also the measured electron temperatures from the electron trap and Langmuir plate are in agreement with this radar data.

The RAL 546 pass is midlatitude (-37° to -57° magnetic) southern hemisphere summer data. Midlatitude data from the Millstone Hill radar (58°N magnetic) at solar minimum in summer 1964 shows electron temperature of about 2600°K and ion temperature of about 1550°K at an altitude of 550 km (Evans, 1967). Probe measurements taken at 0637 UT (-57° magnetic, 550 km) on the RAL 546 pass give a mean electron temperature of 2850°K which is in agreement with the Millstone radar data. At this same time the ion temperature results are 1850°K from the ion trap and about 1200°K from the spherical probe. These results are not in direct agreement with radar data however the ratio of measured electron to ion temperature for the ion trap (1.5) is in closer agreement to the radar results (1.7) than the spherical probe result (2.4).

On the BPO 730 pass significant amounts of H^+ ions are present. As indicated in Table 3 the spherical probe measurements are for H^+ ions only while the ion trap shows results for both H^+ and 0^+ ions. The ion trap results indicate in general that the H^+ and 0^+ ion temperatures are equal. The trap results are again significantly higher than the results of the spherical probe. The ratio of electron to ion temperature for this pass is about 1.2 for the ion trap data and 1.7 for the spherical probe data. There is no radar data available for this altitude interval to serve as a comparison with the direct measurements. Millstone Hill radar results at midlatitudes for the winter of 1964 indicate an electron to ion temperature ratio of less than 1.6 for an altitude of 700 km with the ratio decreasing with increasing altitude.

<u>Ion Composition</u>

.he high resolution magnetic ion mass spectrometer as implemented on the Explorer XXXI satellite could detect ions in the mass range of from 1 to 20 AMU whose number density was greater than 1/cc. The ion trap and spherical ion probe through retarding potential techniques served as low resolution spectrometers. These devices cannot distinguish closely spaced ions such as N^+ and O^+ but can identify widely separated ions whose abundance was on the order of 5 percent or more of the total ion concentration. For the comparison passes the results of the ion trap and spherical probe are separated into two groups - light ions lumped together as H^+ and heavy ions lumped together as O^+. This is reasonable since He^+ ions were a minor constituent on all passes. The ionic composition results are given in Table 4. Data is given as percentage of total concentration. The magnetic ion mass spectrometer results are given for H^+, He^+, N^+ and O^+ ions.

The composition agreement obtained is quite good. On WNK 550 the insensitivity of the spherical probe to O^+ ions, as discussed in the section of plasma density, explains the composition disagreement with the other experiments.

These comparisons have indicated that the three experiments show good agreement on ion composition results. The only significant discrepancy has explanation in instrument sensitivity limitations.

DISCUSSION OF COMPARISONS

The comparison results presented, although few in number and not sufficient for a statistical study, are felt to be typical of the results from the Explorer XXXI satellite. In the measurement of plasma density, electron temperature, and ion composition there is no significant systematic disagreement between the various probes that cannot be recognized as arising from sensitivity or limiting considerations. There are some random disagreements which require additional study for possible explanations. In general plasma density results were within ±20 percent of simultaneous Alouette II density measurements with occasional variations of up to about ±50 percent. Electron temperature results generally agreed to within ±10 percent with maximum variations of up to ±20 percent.

Of the probes employed, four used planar flush-mounted sensors (ion trap, electron trap, magnetic mass spectrometer, and Langmuir plate). The cylindrical electrostatic probes and the spherical ion probe were mounted on short booms about one foot from the satellite surface. This indicates that correct plasma diagnostics can be achieved for flush sensors operating within the satellite sheath. It is to be noted however that electron density values from the planar Langmuir plate (these results are not included in this paper) are always a factor of from 2 to 5 lower than the correct value. The planar electron trap appears to give reasonable results. The only significant difference in the two planar sensors is that the electron trap employs a swept surface area of about 55 cm^2 while the Langmuir plate swept surface area is about

12 cm^2. This suggests that satellite sheath penetration was not adequately achieved with the smaller area.

The general agreement in electron density measurements between Alouette II, cylindrical probe, and electron trap also indicates that large magnetic field orientation effects are not present. The anisotropy noted in electron temperature measurements could indicate magnetic field influence.

The only area of major disagreement is in the measurement of ion temperature. The planar ion trap results are significantly greater than the results from the boom-mounted spherical probe. Although no serious conflict occurs in the relative trends observed, it is likely that in both cases there are measurement problems which preclude absolute significance for H^+ ion temperature results. A limited comparison of the measured ion temperatures with radar backscatter results has been attempted. This indicates that the spherical probe results for O^+ may be somewhat low. No comparison data is available to resolve discrepancies in the measured H^+ temperatures. A possible source of error in the ion trap measurement is sheath curvature. The analysis assumes a planar sheath. Knudsen (1966) has considered such perturbations to ion temperature measurements with planar traps and found the resultant error quite small. Additional effort is required to assess completely the ion temperature comparisons.

SUMMARY SECTION FOR PAPER ENTITLED COMPARISON OF RESULTS OF EXPLORER XXXI DIRECT MEASUREMENT PROBES

SUMMARY

Inter-comparison measurements of the major ionospheric parameters of ion and electron density and temperature and ionic species have been presented. The passes selected for comparison are considered to be typical of the ionosphere for the altitude ranges of 500 to 3000 km covered by the Explorer XXXI Satellite. The ranges of values of ionospheric parameters covered by the comparisons are from about 10^3 el/cc to 5×10^5 el/cc for plasma density, from about $1000^\circ K$ to $4500^\circ K$ for ion and electron temperatures and ionic composition variations from essentially 100 percent oxygen to 100 percent hydrogen.

Plasma density comparisons indicate that the various direct measurement probes generally agree with values of electron density obtained from the Alouette II topside sounder to within 20 percent. For ionospheric parameters other than plasma density there is not absolute simultaneous value to serve as a comparison standard. Electron temperatures measured by the three different probes generally agree to within 10 percent. Ionic composition measurements show good agreement between the retarding potential probes and the magnetic mass spectrometer. The only area of significant disagreement is in the measurement of ion temperature.

REFERENCES

Evans, J. V., Midlatitude F-region densities and temperatures at sunspot minimum, Planet. Space Sci. 15, 1387, 1967.

Farley, D. T., J. P. McClure, D. F. Sterling, and J. L. Green, Temperature and composition of the equatorial ionosphere, J. Geophys. Res., 72, 5837, 1967.

Knudsen, W. C., Evaluation and demonstration of the use of retarding potential analyzers for measuring several ionospheric quantities, J. Geophys. Res., 71, 4669, 1966.

Rao, P. B., Electron concentrations and electron and ion temperatures in the F region for magnetically quiet and disturbed conditions, J. Geophys. Res., 73, 1661, 1968.

TABLE 1. DETAILS OF COMPARISON PASSES

Station	Pass	Date	Universal Time		Height (km)		Latitude (Degrees)		Longitude (Degrees)	
			Start	End	Start	End	Start	End	Start	End
KANO (KNO)	368	30DEC65	0449	0458	1555	2120	2.2	27.7	12.3	15.0
ORRORAL (RAL)	546	14JAN66	0631	0638	709	538	-26.1	-53.1	144.6	151.6
WINKFIELD (WNK)	550	14JAN66	1411	1418	2224	1797	55.5	36.9	9.0	14.6
BLOSSOM POINT (BPO)	730	29JAN66	1842	1849	1359	935	44.6	21.1	-80.8	-76.4
SANTIAGO (SNT)	730	29JAN66	1900	1905	537	525	-20.9	-46.9	-71.3	-67.6

TABLE 2. ELECTRON TEMPERATURE COMPARISONS

Station	Pass	Universal Time	Electron Trap °K	Cylindrical Probe #1 °K	Cylindrical Probe #2 °K	Planar Forward °K	Langmuir Plate Non-Forward °K
Kano	368	0450:30	3300	3250	-	3600	3470
		0452:30	3200	3150	3250	3110	2910
		0454:15	3250	3150	3300	3370	3350
		0456:15	3350	3200	3350	3320	3360
Orroral	546	0631:45	3250	3500	-	2680	-
		0633:45	3150	3500	-	2880	2950
		0637:00	2650	3400	-	2480	2780
Winkfield	550	1412:00	4250	3950	-	3450	-
		1413:45	4200	3900	-	3270	3580
		1416:00	4100	3850	-	3890	-
		1417:15	4050	3750	-	3680	3060
Blossom Point	730	1843:00	3900	3900	3600	3390	3820
		1845:15	3750	3800	3550	2970	3790
		1847:00	3600	3800	3550	2930	3730
		1848:15	3650	3750	-	3400	-
Santiago	730	1901:45	1600	1500	-	1350	-
		1902:45	1600	2200	-	1560	-
		1904:00	1850	2400	-	1900	-

TABLE 3. ION TEMPERATURE RESULTS

Station	Pass	Time	Ion Trap T_{H^+} (^oK)	Ion Trap T_{O^+} (^oK)	Spherical Probe T_{H^+} (^oK)	Spherical Probe T_{O^+} (^oK)	Mean T_e (^oK)
Kano	368	0449:30	2580	-	2090	-	-
		0452:15	2420	-	1900	-	3250
		0454:14	2450	-	2130	-	3300
		0456:15	2480	-	1780	-	3350
Orroral	546	0631:30	-	2650	-	1430	-
		0633:15	-	2720	-	1560	3150
		0635:00	-	2220	-	1420	3050
		0637:00	-	1850	-	1200	2850
Winkfield	550	1411:45	3800 ± 550	-	3000	-	3850
		1413:45	4100 ± 550	-	3000	-	3750
		1416:00	4150 ± 200	-	2450	-	3850
		1417:30	3800 ± 200	-	2400	-	3650
Blossom Point	730	1843:15	3100 ± 350	3250	2650	-	3750
		1844:45	3250	3150	2100	-	3700
		1846:00	3000	3050	2200	-	3650
		1848:15	3050	2750	1900	-	3600
Santiago	730	1901:15	-	1600	-	1050	1300
		1902:15	-	1530	-	1150	1550
		1903:15	-	1670	-	1120	1700
		1903:40	-	1800	-	1030	1800

TABLE 4. ION COMPOSITION RESULTS

Station	Pass	Time	Magnetic Spectrometer				Ion Trap		Spherical Probe	
			H^+	He^+	N^+	O^+	H^+	O^+	H^+	O^+
Kano	368	0450	99	1	-	-	100	-	100	-
		0456	99	1	-	-	100	-	100	-
Orroral	546	0632	5	-	6	89	5	95	6	94
		0636	1	-	6	93	-	100	1	99
Winkfield	550	1412	78	12	2	8	84	16	100	-
		1417	86	7	1	6	96	4	100	-
Blossom Point	730	1841	6	1	7	86	7	93	3	97
		1844	23	3	5	69	28	72	29	71
		1848	35	3	3	59	36	64	43	57
Santiago	730	1902	1	-	2	97	-	100	2	98
		1904	1	-	3	96	-	100	2	98

FIGURE CAPTIONS

Figure 1 - Comparison of Explorer XXXI plasma density measurements with simultaneous Alouette II topside sounder density results. Results are plotted as the ratio of the Explorer XXXI probe measurements to the Alouette II values (a value of 1.0 indicates exact agreement) as a function of plasma density.

Figure 2 - Plasma density measurements for the RAL 546 pass on 14 January 1966. Individual data points are connected by straight lines.

Figure 3 - Plasma density measurements for the KNO 368 pass on 30 December 1965. The maximum error in density measurement for all the comparisons was evident on this pass. Values from the cylindrical probe are up to 60% high and values from the ion and electron trap are up to 40% low with respect to Alouette II density measurements.

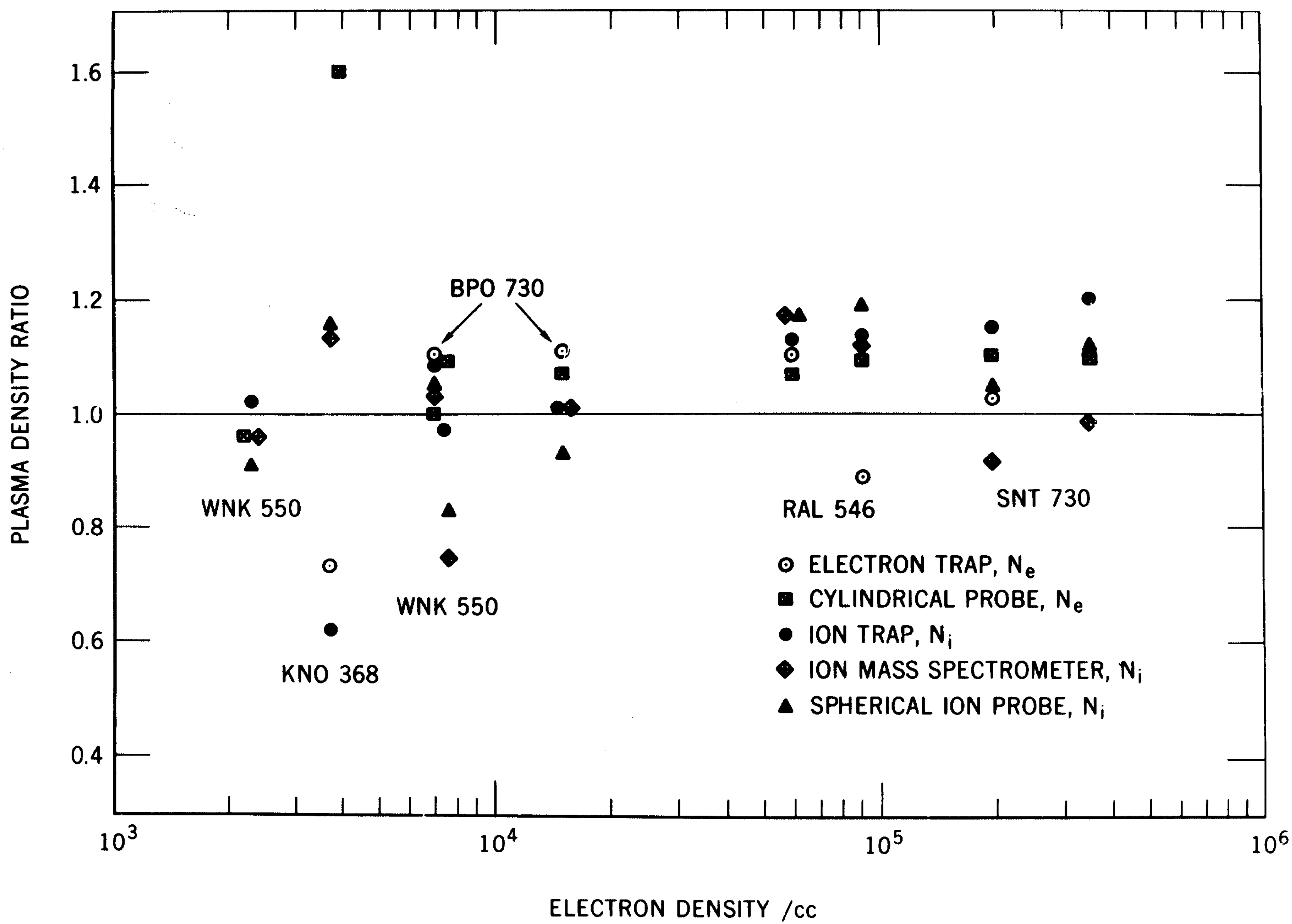
Figure 4 - Electron temperature measurements for the KNO 368 pass on 30 December 1965. All probe results are in good agreement with each other. For this pass, mean values for the two cylindrical probes and the forward and non-forward Langmuir plate results are shown since the individual differences were within the measurement error bounds.

Figure 5 - Electron temperature measurements for the WNK 550 pass on 14 January 1966. Of all comparison passes, the greatest differences between various probe results is evident on this pass. Differences on the order of $1000^{o}K$ are present between the electron trap and Langmuir plate results.

Figure 6 - Ion temperature measurements for the KNO 368 pass. Measurements are for hydrogen ions. Mean electron temperature is shown. Ion trap results are about $500^{o}K$ greater than spherical probe results.

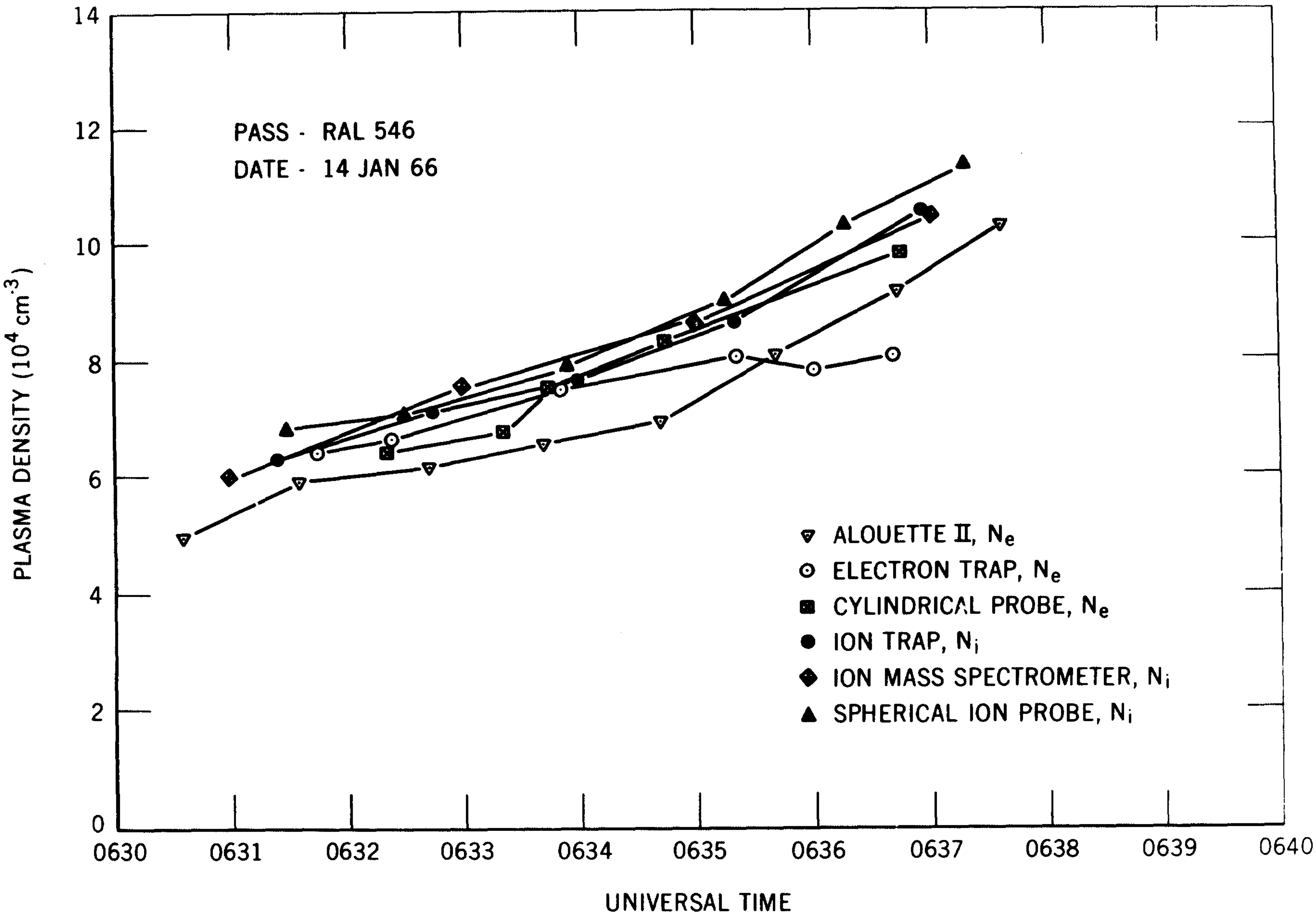
Figure 7 - Ion temperature measurements for the RAL 546 pass. Measurements are for oxygen ions. Ion trap results are from $500^{o}K$ to $1200^{o}K$ higher than spherical ion probe results.

Figure 8 - Ion temperature measurements for the SNT 730 pass. Measurements are for oxygen ions. Ion trap values are greater than spherical probe values and are in general agreement with measured electron temperature. The scatter in ion trap values is most likely due to errors in satellite attitude data.



PLASMA DENSITY RATIO
1.6
1.4
1.2
1.0
0.8
0.6
0.4
BPO 730
WNK 550
KNO 368
WNK 550
RAL 546
SNT 730
ELECTRON TRAP, N_e
CYLINDRICAL PROBE, N_e
ION TRAP, N_i
ION MASS SPECTROMETER, N_i
SPHERICAL ION PROBE, N_i
10^3
10^4
10^5
10^6
ELECTRON DENSITY /cc

Figure 1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DATE - 14 JAN 66
ALOUETTE II, N_e
ELECTRON TRAP, N_e
CYLINDRICAL PROBE, N_e
ION TRAP, N_i
ION MASS SPECTROMETER, N_i
SPHERICAL ION PROBE, N_i
PLASMA DENSITY (10^4 cm^{-3})
14
12
10
8
6
4
2
0
0630
0631
0632
0633
0634
0635
0636
0637
0638
0639
0640
UNIVERSAL TIME

Figure 2

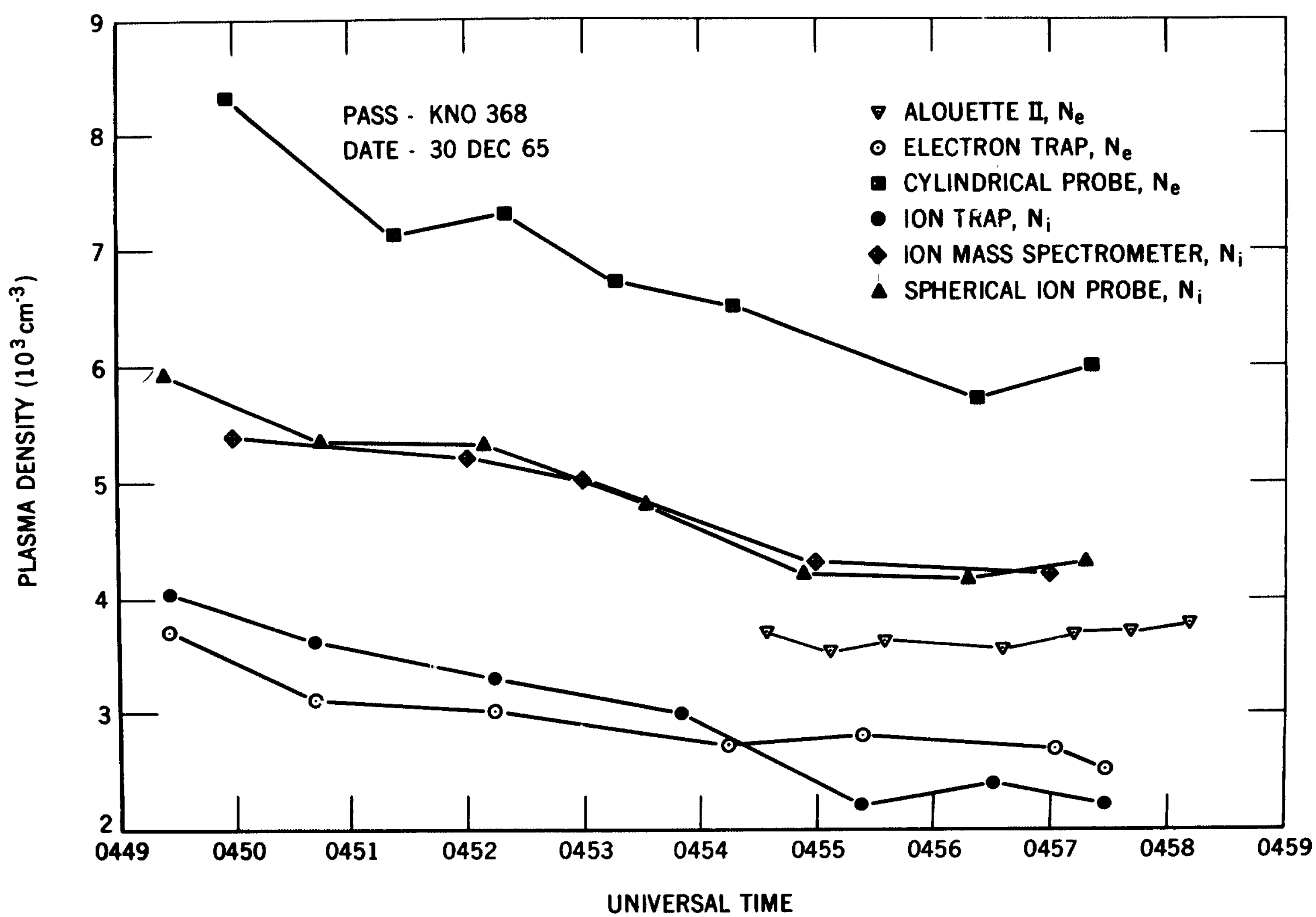

PASS - KNO 368
DATE - 30 DEC 65
ALOUETTE II, N_e
ELECTRON TRAP, N_e
CYLINDRICAL PROBE, N_e
ION TRAP, N_i
ION MASS SPECTROMETER, N_i
SPHERICAL ION PROBE, N_i
PLASMA DENSITY ($10^3 cm^{-3}$)
UNIVERSAL TIME
2
3
4
5
6
7
8
9
0449
0450
0451
0452
0453
0454
0455
0456
0457
0458
0459

Figure 3

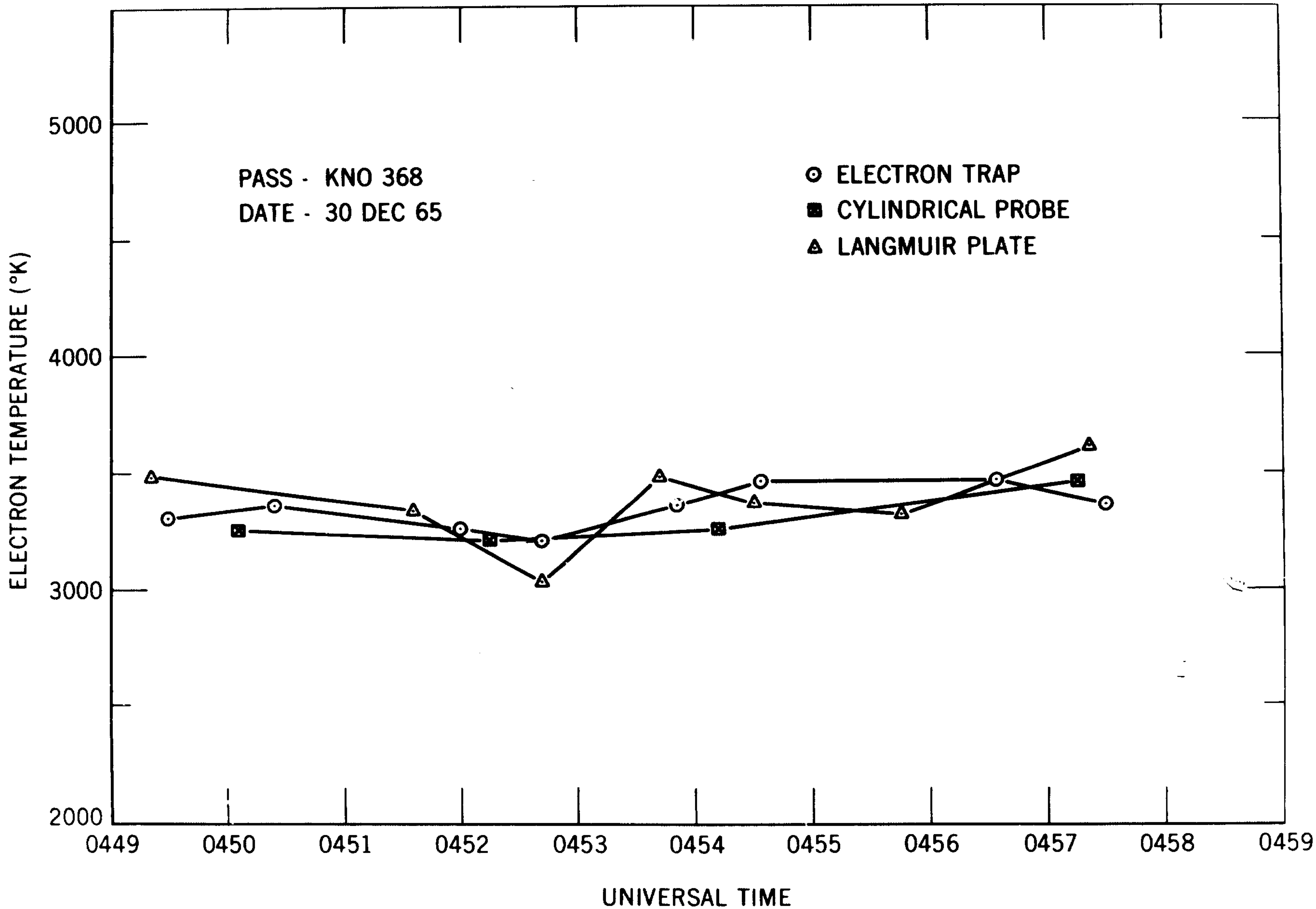
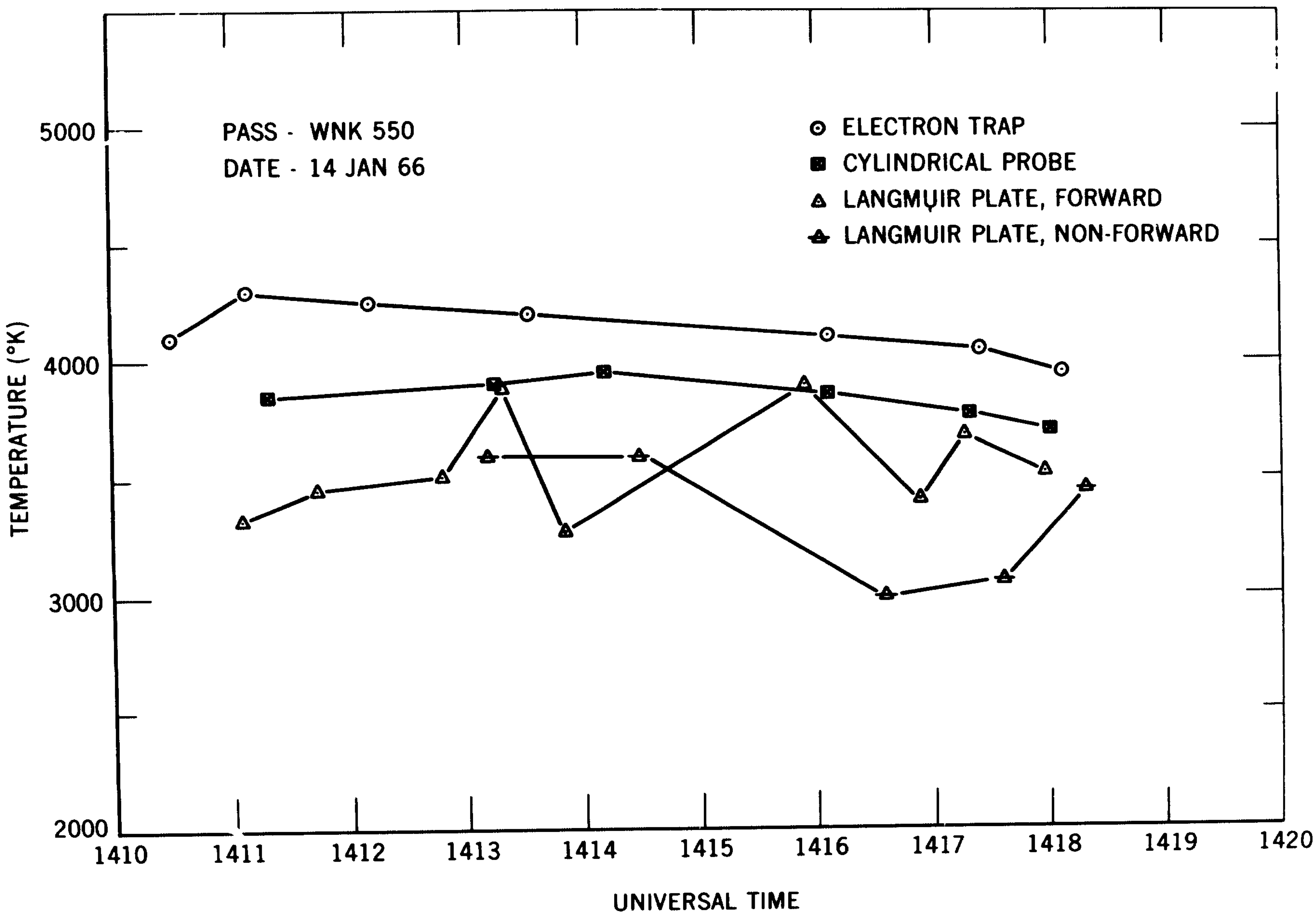

PASS - KNO 368
DATE - 30 DEC 65
ELECTRON TRAP
CYLINDRICAL PROBE
LANGMUIR PLATE
ELECTRON TEMPERATURE (°K)
5000
4000
3000
2000
0449
0450
0451
0452
0453
0454
0455
0456
0457
0458
0459
UNIVERSAL TIME

Figure 4



PASS - WNK 550
DATE - 14 JAN 66
ELECTRON TRAP
CYLINDRICAL PROBE
LANGMUIR PLATE, FORWARD
LANGMUIR PLATE, NON-FORWARD
TEMPERATURE (°K)
5000
4000
3000
2000
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
UNIVERSAL TIME

Figure 5

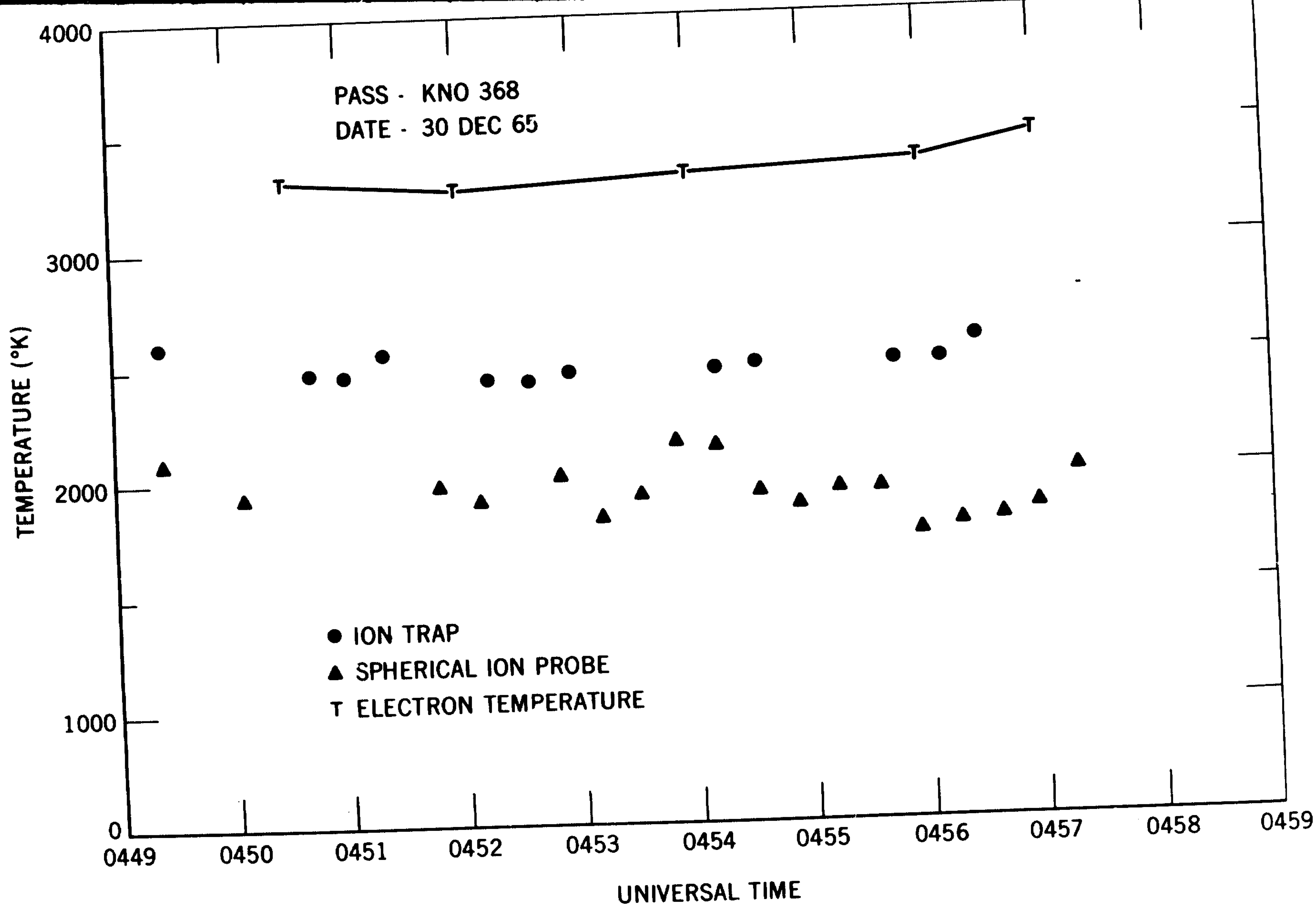

PASS - KNO 368
DATE - 30 DEC 65
ION TRAP
SPHERICAL ION PROBE
T ELECTRON TEMPERATURE
TEMPERATURE (°K)
4000
3000
2000
1000
0
0449
0450
0451
0452
0453
0454
0455
0456
0457
0458
0459
UNIVERSAL TIME

Figure 6

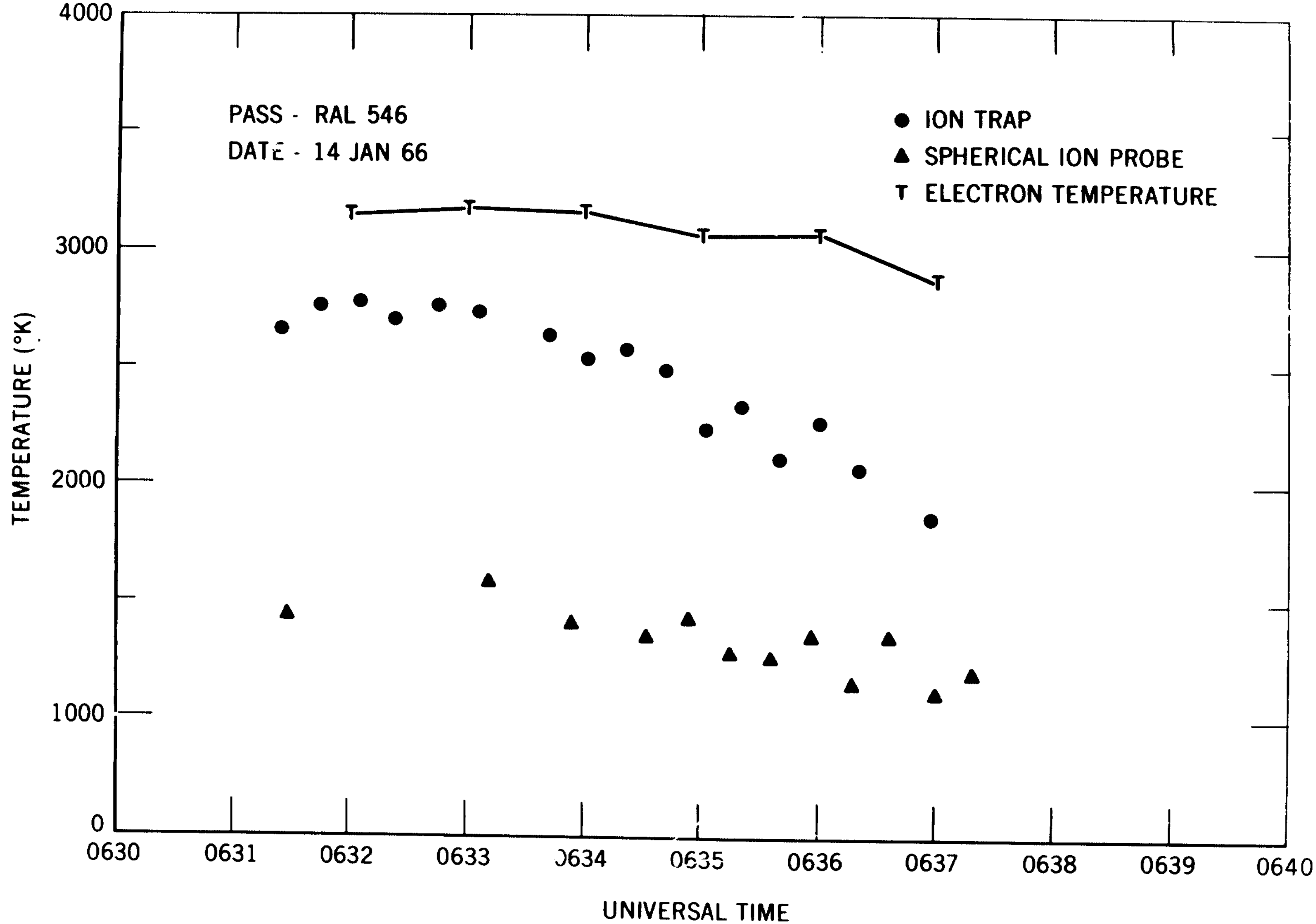

PASS - RAL 546
DATE - 14 JAN 66
ION TRAP
SPHERICAL ION PROBE
ELECTRON TEMPERATURE
TEMPERATURE (°K)
4000
3000
2000
1000
0
0630
0631
0632
0633
0634
0635
0636
0637
0638
0639
0640
UNIVERSAL TIME

Figure 7

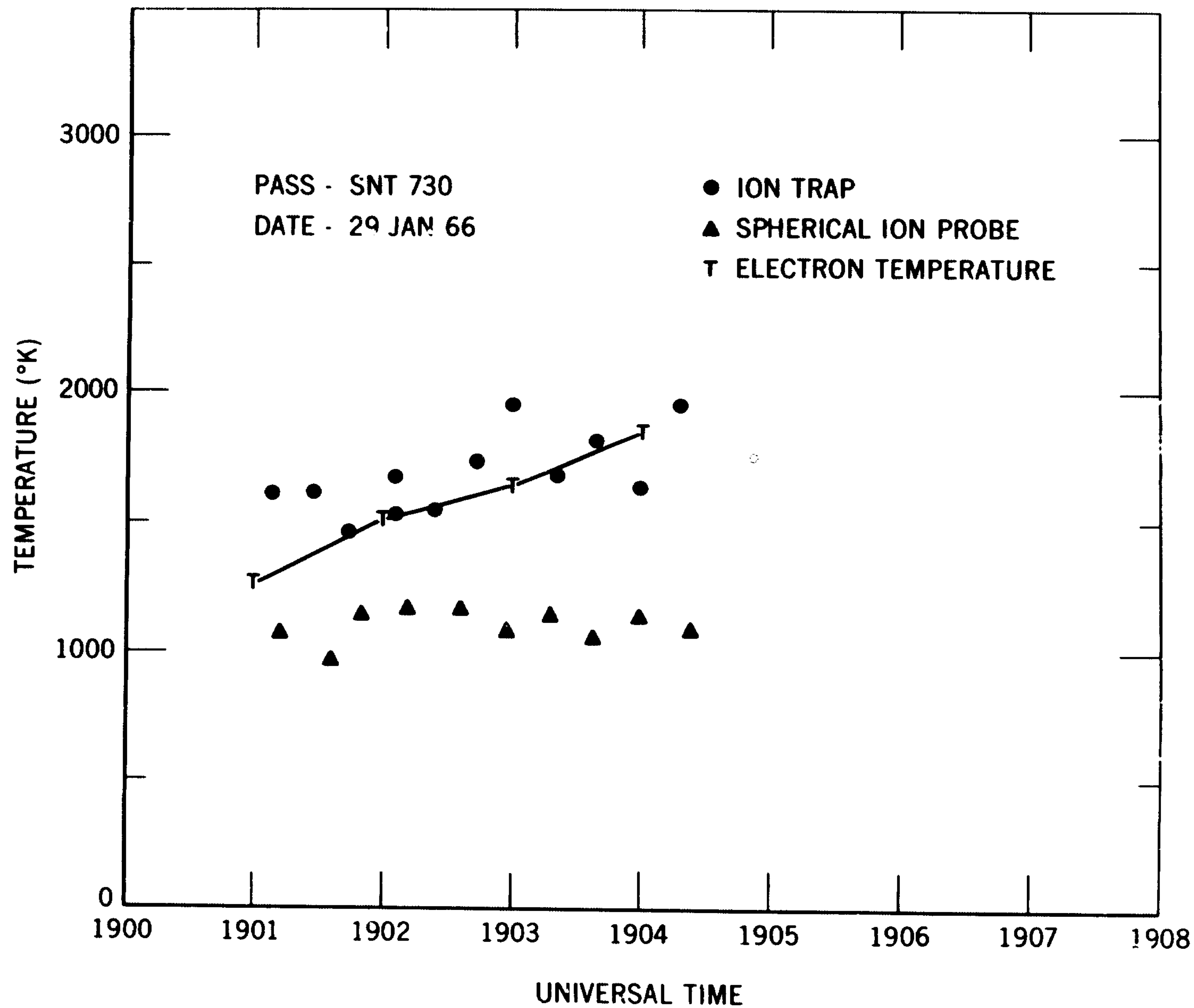

PASS - SNT 730
DATE - 29 JAN 66
ION TRAP
SPHERICAL ION PROBE
ELECTRON TEMPERATURE
TEMPERATURE (°K)
3000
2000
1000
0
1900
1901
1902
1903
1904
1905
1906
1907
1908
UNIVERSAL TIME

Figure 8