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NASA TECHNICAL MEMORANDUM

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SPECTROMETER ON DYNAMICS EXPLORER-A (NASA)
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THE RETARDING ION MASS SPECTROMETER ON DYNAMICS EXPLORER-A

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
RECENT THERMAL PLASMA RESULTS	3
INSTRUMENT DESCRIPTION	4
A. Heritage	4
B. Sensor Design	4
C. Central Electronics Function	9
RIMS OPERATIONS	11
CALIBRATION APPROACH AND RESULTS	12
DATA REDUCTION AND ANTICIPATED RESULTS	16
REFERENCES	19

LIST OF ILLUSTRATIONS

<u>Figure No.</u>	<u>Title</u>	<u>Page</u>
1.	Cutaway view of a RIMS sensor head showing the path of thermal ions through the analyzer. The arrows show the ions' entry through the retarding potential analyzer and ion mass spectrometer sections with detection by the channel electron multipliers	6
2.	Sketch of the Dynamics Explorer-A spacecraft showing the location of the RIMS +Z and radial sensor heads together with the angular field of view of each sensor	7
3.	Schematic block diagram of the RIMS sensor head electronics showing the control of the ion analyzer and interfaces to the Central Electronics Assembly	8
4.	Schematic block diagram of the RIMS Central Electronics Assembly showing the control elements which drive the three sensor heads and the interface to the DE-A spacecraft	10
5.	A complete mass spectrum measured in the MSFC calibration facility showing a sweep of the low mass (1-8 amu) and high mass (4-32 amu) channels	14
6.	Examples of the angular response of the +Z RIMS sensor head showing contours fitted to measured responses along the X and Y axes of the sensors. The angular response for different ion beam energies and masses is shown in the four panels	15
7.	A typical RIMS operational profile illustrating the use of two survey modes: a low-altitude mode which concentrates on ion energy and pitch angle and a high-altitude mode which conducts a careful mass survey	17
8.	A variety of RIMS operating modes which address different science problems of interest in thermal plasma studies	18

NASA TECHNICAL MEMORANDUM

INTRODUCTION

Since its original discovery through the measurement of lightning-induced whistler signals [1], the low-energy thermal component of the magnetospheric plasma has been found to play an increasingly important role in the coupling of the magnetosphere, ionosphere, and atmosphere. During this same period of study, the complexity of the distributions of thermal plasma has become more evident, and the role of this plasma not only as a modifier but also as a source of the more energetic magnetospheric plasmas has been realized.

The remote whistler measurements gave no information on the details of the thermal plasma distribution, only its density at the magnetic equator and the total electron content along a magnetic flux tube extending from one hemisphere to the other. Based on the assumption that the ionosphere must be the source of this low-energy plasma component, early instrumentation for the measurement of magnetospheric thermal plasma was patterned after ionospheric instrumentation. Thus, both retarding potential analyzers and ion mass spectrometers were designed for magnetospheric application [2-4]. The operation and interpretation of data from these instruments were dependent on the ramming or scooping effect of the instrument through a cold, well-behaved Maxwellian distribution of the plasma, such as exists in the Earth's ionosphere. This approach met with some success [3,5,6], but at high altitudes the higher plasma temperatures and flow velocities combined with the slower spacecraft velocities and higher relative densities of energetic particles introduced uncertainties into the acquisition and interpretation of the thermal plasma data. It was realized, for example, that the simple measurement of density was dependent on the simultaneous measurement of the plasma temperature and flow velocity as well as on information on the spacecraft potential and its effects on the ambient plasma distribution.

This realization led to the design of the multi-headed Retarding Ion Mass Spectrometer (RIMS) series of instruments that combines the ion temperature-determining capability of the retarding potential analyzer with the compositional capabilities of the mass spectrometer and adds multiple sensor heads to sample all directions relative to the spacecraft ram direction. The multiple heads permit the determination of the thermal plasma flow characteristics. This instrument combination is also effective in eliminating the confusing effects caused by energetic particles impinging on the open collector of the retarding potential analyzer, since in this new instrument the detector element is well protected behind the baffled magnetic mass spectrometer. The RIMS instrument for Dynamics Explorer (DE) has been designed and developed to incorporate these features. Its capabilities will now be applied to the measurement of thermal ion dynamics in the inner magnetosphere and ionosphere. The specific geophysical parameters to be measured by the RIMS instrument are shown in Table 1.

TABLE 1. PARAMETERS MEASURED BY THE RIMS INSTRUMENT

	<u>RANGE</u>	<u>ACCURACY</u>	<u>RESOLUTION</u>
<u>PRINCIPAL APOGEE MODE*</u> (> 1500 km):			
DENSITY H ⁺ , He ⁺ , O ⁺ , He ⁺⁺ , O ⁺⁺	0.1 → 10 ⁶ IONS/cm ³	±10 %	NOMINALLY 0.5 s (1/64 s MAXIMUM) COMPLETE — 1 S/C SPIN (6 s)
TEMPERATURE H ⁺ , He ⁺ , O ⁺ , He ⁺⁺ , O ⁺⁺	0 → 45 eV	±5 %	0.5 s COMPLETE (6 s)
BULK FLOW H ⁺ , He ⁺ , O ⁺ , He ⁺⁺ , O ⁺⁺	0.5 km/s AND UP	HIGHLY TEMPERA- TURE DEPENDENT	(6 s)
SPACECRAFT POTENTIAL	FEW VOLTS POSI- TIVE → 45 V NEGATIVE	0.1 V	(6 s)
<u>PRINCIPAL PERIGEE MODE*</u> (< 1500 km):			
ION COMPOSITION	1 - 32 AMU 0.1 → 10 ⁶ IONS/cm ³	10 PTS/MASS PEAK	6 s

* THESE MODES OF OPERATION ARE COMMANDABLE. EITHER MODE CAN BE OPERATED THROUGHOUT THE ORBIT.

RECENT THERMAL PLASMA RESULTS

Before describing the details of the RIMS instrument design and operation, it is useful to discuss some recent results on magnetospheric low-energy plasma because it is in this context that the RIMS measurements on the Dynamics Explorer mission will be carried out. Since the time of the proposal submission for DE, several new characteristics of the thermal plasma distribution have emerged. First, it was discovered that in the outer plasmasphere and magnetosphere the "cold" plasma was much hotter than expected, reaching temperatures of one hundred thousand degrees Kelvin or higher [7-9]. This temperature is quite different from the few thousand degrees expected from an ionospheric source. Second, the thermal plasma has been found to exhibit a multitude of pitch angle distributions [10-12], including field-aligned, conical (peaked at 20° to 40° pitch angles) and trapped (peaked at 90° with respect to the magnetic field). This new information has come from the ATS-6, ISEE, and GEOS spacecraft. Thus, the simplifying assumptions which are normally used in the interpretation of retarding potential analyzers, such as cold, Maxwellian plasma distributions must be re-examined in the analysis of the RIMS data.

In addition to the high temperatures and surprising pitch angle distributions, new compositional elements have been discovered on GEOS and on ISEE [10,13,14]. These new ions, such as O^{++} and D^+ , have broadened the view and complexity of the processes which populate the magnetosphere with low-energy plasma and have added ion species to the list of those which should be routinely surveyed on the Dynamics Explorer mission. In each observed case the pitch angle distributions appear to have a mass and energy dependence, and the observer is led toward the idea of detailed plasma information more penetrating than can be adequately displayed by the simple bulk parameters of density, temperature, and flow. In the ionosphere and inner plasmasphere, the RIMS data can be understood using bulk parameters, but at higher altitudes the displays of flux versus energy, angle, and mass which are more characteristic of energetic plasma measurements will be required.

Low-energy plasma is today considered to be a strong source for the energetic plasmas of the magnetosphere. In the ISEE data [10,12] the low-energy ions are found to display a variety of energies from the less than one electron volt characteristic of the ionosphere and polar wind to energies of tens to hundreds of electron volts more typical of magnetospheric plasmas.

The RIMS instrument is designed to measure the specific characteristics of the thermal plasma. The multiple sensor heads containing retarding potential energy analysis and magnetic spectrometer mass analysis will permit the determination of bulk plasma parameters in the inner magnetosphere where such a characterization is appropriate. This will allow the exploration of the interchange of ions between the ionosphere and plasmasphere and determine, for example, the relationship between the plasma-pause and the ionospheric light ion trough. The multiple heads will reveal the bulk flow vector of the plasma, thereby contributing to our

knowledge of the convective motion of the magnetospheric plasma and the filling processes which connect the ionosphere and plasmasphere.

In the outer plasmasphere and plasma trough other RIMS features will be utilized. The narrower angular acceptance of the radial head ($\pm 10^\circ$) will permit the sampling of ion pitch angle distributions which when combined with the energy analysis capability permit the examination of ion energization processes. The programmable mass stepping of the spectrometer allows the surveying of different ion masses and energies to assess the ionosphere as a source of low-energy magnetospheric plasma. The preceding discussion represents a sampling of the science objectives which will be studied by the RIMS instrument that is described later.

INSTRUMENT DESCRIPTION

A. Heritage

The direct motivation for the RIMS instrument came from the Light Ion Mass Spectrometer (LIMS) that was flown on the OGO-5 satellite [4]. This instrument showed the value of the magnetic ion mass spectrometer technique in the measurement of magnetospheric low-energy plasma at high altitudes. The actual design of the RIMS spectrometer is based on the Magnetic Ion Mass Spectrometer (MIMS) which was flown on the ISIS and Atmospheric Explorer satellite [15]. The successful operation of this instrument served as strong proof of the reliability and desirability of this type of spectrometer.

The retarding potential analyzer section of the RIMS instrument was based on an earlier design that had been flown extensively during the OGO and Atmospheric Explorer series of satellites [16,17]. Early engineering studies showed that these two techniques could be successfully mated. This combined approach was verified through flight on the Air Force/NASA SCATHA satellite which returned data on ion composition, pitch angle, and energy characteristics [18].

The RIMS instrument for Dynamics Explorer has expanded the capability of the predecessor SCATHA instrument through the use of a programmable memory which permits an in-flight choice of the mass, energy, and angle sampling scheme that is employed for each science problem.

B. Sensor Design

The RIMS instrument consists of a central electronics assembly (CEA) and three separate sensor heads, one mounted viewing perpendicular to the spin axis and one each mounted with fields of view parallel and antiparallel to the spacecraft spin axis (+Z). The sensors are controlled by the CEA, and all data are channeled through the central electronics into the spacecraft telemetry stream. Each sensor head consists of a retarding potential analyzer followed by a magnetic mass analyzer with two separate

exit slits corresponding to two mass ranges in the ratio 1:4. The total mass range covered is 1 to 32 amu. Figure 1 is a cutaway view of one of the three sensor heads showing the entrance aperture, which is mounted flush with a ground plane on the outer surface of the spacecraft, the RPA grids, and ion collector plate, followed by the mass analyzer. The latter consists of an entrance (collimating) slit set, magnetic analyzer, collector slits, and the high-current channel electron multiplier detectors. The three sensor heads are identical except that the $+55^\circ$ conical field of view (FOV) of the $+Z$ sensors has been adjusted on the radial sensor to a rectangular angular acceptance of $+10^\circ$ and $+55^\circ$ in the planes perpendicular to and containing the spin axis, respectively (Fig. 2).

As shown in Figure 1, ambient ions enter through the front aperture into the retarding potential analyzer section. The front aperture potential may be selected by command to any of four values as a bias for a non-zero spacecraft potential. Ions having sufficient energy to pass the retarding grid may either be collected on the ion collector plate or pass into the mass analyzer. As a practical rule, the ion collector currents will only be significant around perigee in the topside ionosphere where the electron multipliers will be shut off for protection from high counting rates. The RPA retarding grid voltage is programmable over a 0 to 51.2 V range, referenced to the aperture potential. Any 32 of 1024 voltage steps may be selected in increments of 50 mV.

The ions passing into the mass analyzer are accelerated and then sorted according to their atomic mass per unit charge. The proper combination of ion accelerating voltage and magnetic field strength produces an ion beam radius in the magnetic field which focusses a particular mass on each collector slit. Varying the ion accelerating voltage varies the ion mass detected. Ions of mass 1 to 8 amu and 4 to 32 amu can be focused on the low and high mass slits, respectively. Ions exiting the slits are counted with the channel electron multiplier detectors. The ion mass range is also programmable by a minor mode command. Any 32 of 4096 voltage steps may be selected in increments of 0.5 V. All 32 may be the same, in which case the mass analyzer will be locked onto a given set of mass peaks having the ratio 1:4.

Each of the sensor assemblies contains the necessary complement of electronics to operate the RPA sensor and the IMS sensor sections under the control of the CEA. The sensor head circuits are shown schematically in Figure 3 and include the following functions: an RPA logarithmic amplifier which generates a logarithmic output voltage in the range 0 to 10 V for an input ion current to the collector in the range 10^{-11} to 10^{-6} A, a mass sweep high-voltage power supply which accelerates the ions prior to their entry into the magnet by generating a programmable voltage in the range -250 to -2250 Vdc, a multiplier high-voltage power supply which powers both electron multipliers and is capable of producing four selectable high-voltage outputs, and a pulse amplifier/counter which discriminates and counts the voltage pulses which have been converted from the charge pulses of the channel electron multiplier output. The basic

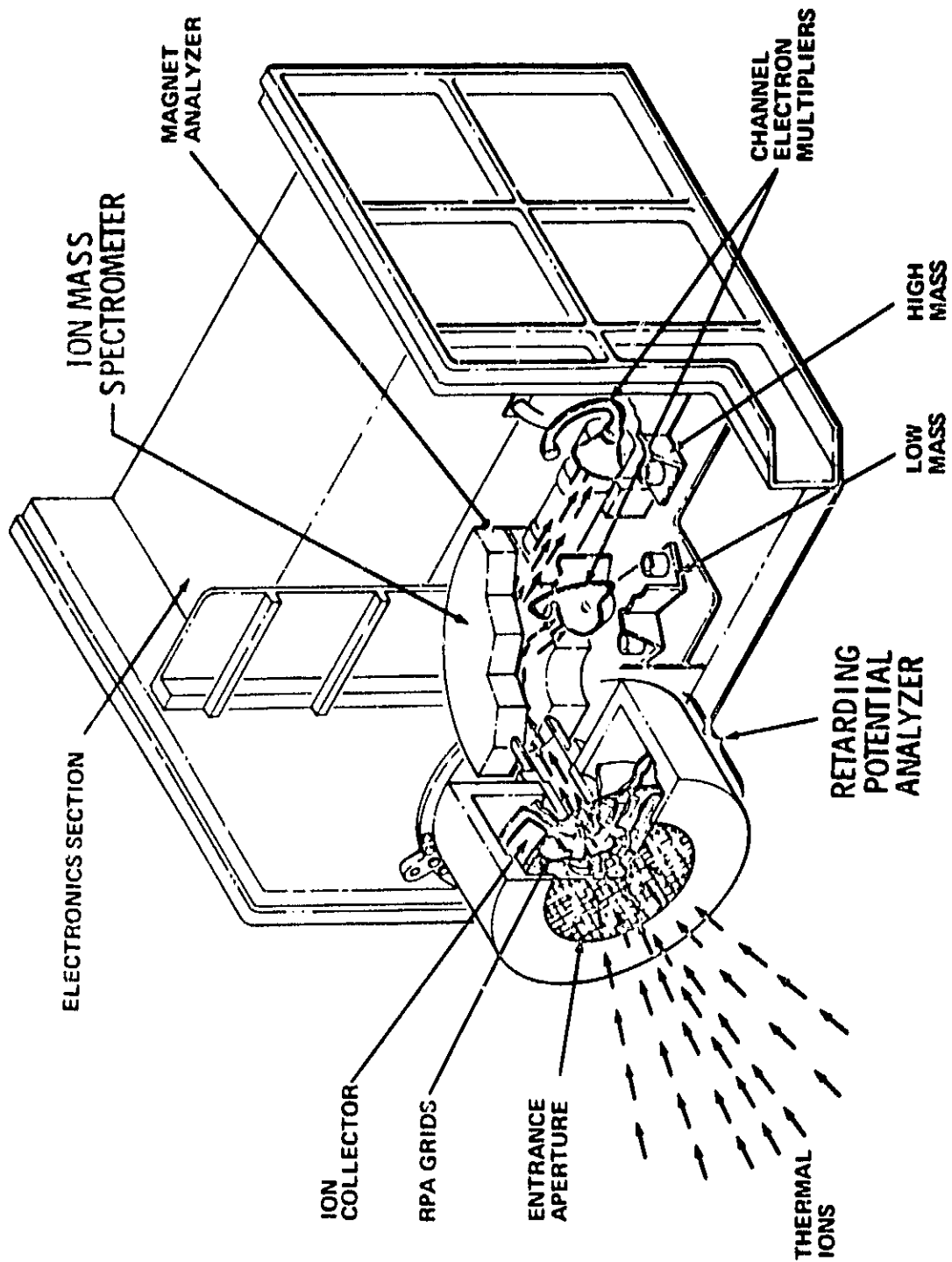


Figure 1. Cutaway view of a RIMS sensor head showing the path of thermal ions through the analyzer. The arrows show the ions' entry through the retarding potential analyzer and ion mass spectrometer sections with detection by the channel electron multipliers.

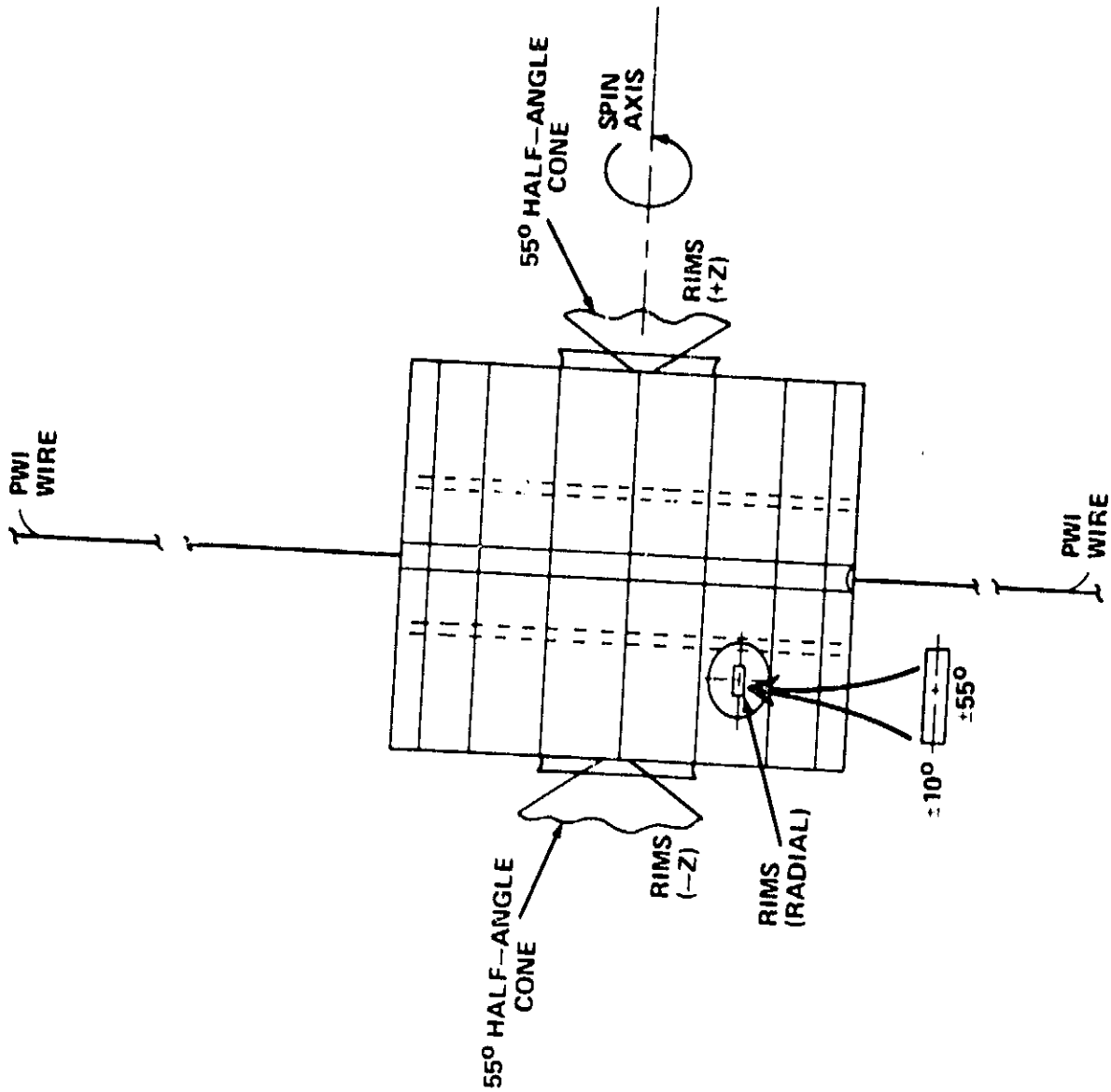
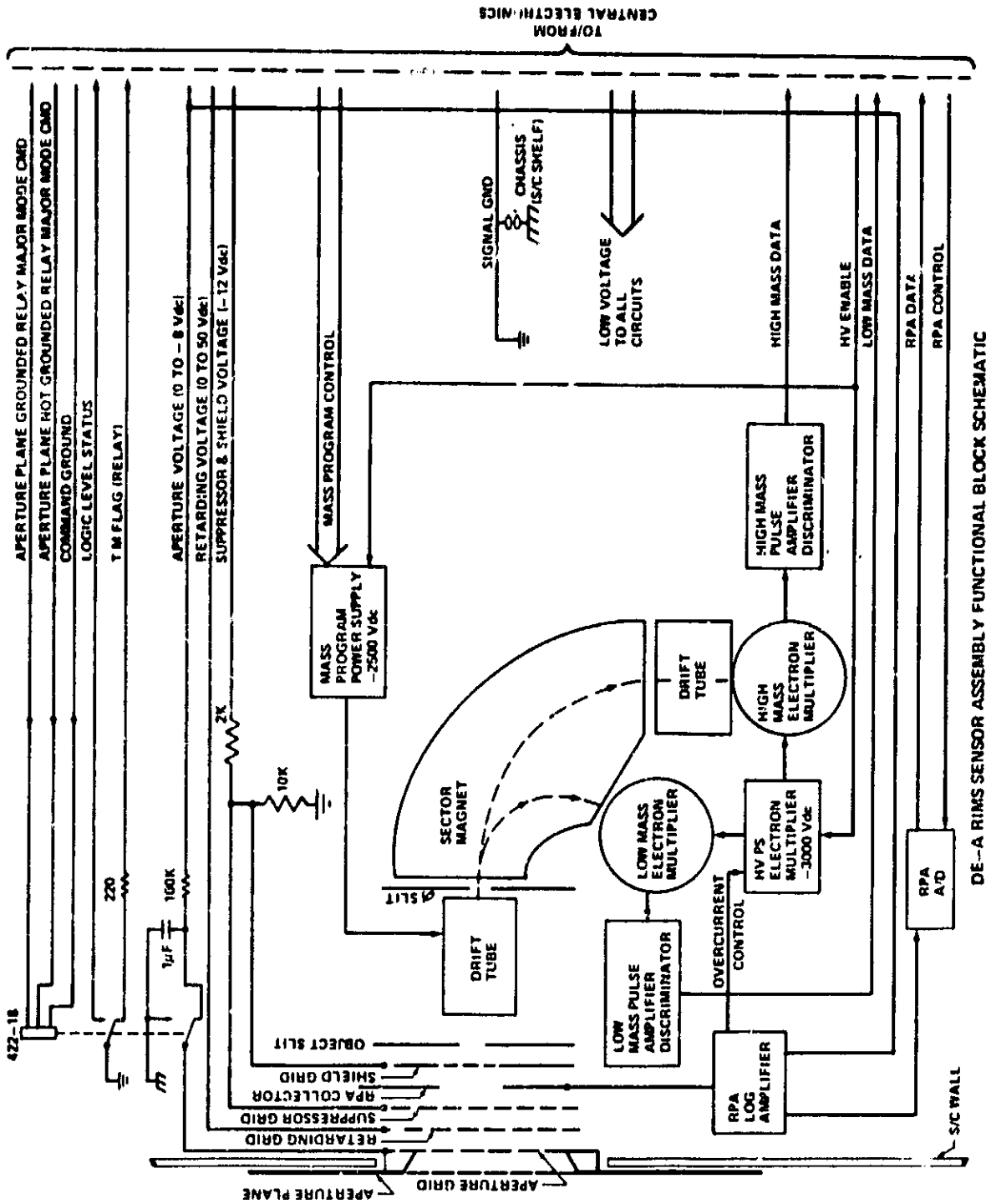


Figure 2. Sketch of the Dynamics Explorer-A spacecraft showing the location of the RIMS $\pm Z$ and radial sensor heads together with the angular field of view of each sensor.



DE--A RIMS SENSOR ASSEMBLY FUNCTIONAL BLOCK SCHEMATIC

Figure 3. Schematic block diagram of the RIMS sensor head electronics showing the control of the ion analyzer and interfaces to the Central Electronics Assembly.

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instrument cycle is 32 mass and energy steps over a period of 0.5 s with a basic data accumulation period of 12 ms. More details of the instrument operations are given later.

C. Central Electronics Function

The three sensor assemblies are controlled by the CEA. The particular RPA retarding sequence and mass stepping sequence are loaded into the CEA by minor mode ground commands. The sensor heads are then stepped through this sequence under the control of the central electronics. All sensor heads execute the same stepping sequences. The data from the three sensors are then routed through the CEA, where they are multiplexed and fed into the spacecraft telemetry stream. The selection of data channels and the timing of data channel switching are controlled by the central electronics based on a minor mode ground command. This ability to control the energy step, mass steps, and data multiplexing assures maximum flexibility in instrument operation during the mission.

A functional block diagram for the assembly is given in Figure 4. This figure shows the interface signals with the DE-A spacecraft. The data outputs are synchronized to the telemetry minor frame rate. A short description of each circuit function is given in the following subsections.

Instrument Memory. The instrument memory control assembly will do all read/write operations and monitor the health of the memory. All minor mode "B" commands will be received by this assembly which keeps the master sequencer updated as to its status and health. This assembly also generates the fixed scan address for the RPA sensor.

Data Accumulators/Data Compressors. There are six accumulators and holder registers associated with the six IMS channels. The data from each accumulator are multiplexed into the data compressor for outputting. The data compressor contains the circuitry for compressing each accumulator output into a 10-bit, base 2 floating point number (6-bit mantissa and 4-bit exponent) for outputting into the telemetry buffers. This assembly also contains the major mode command circuits and status bits.

Housekeeping Multiplexer and Telemetry Buffers. Sixteen instrument health and monitor outputs are received by this assembly and multiplexed into a single A/D converter for conversion to an 8-bit telemetry word.

Data Selector and Instrument Control Register. This assembly receives the minor mode "A" command and stores it in the Instrument Control Register. This register contains all information needed to reconfigure the instrument and to select various combinations of data outputs to be loaded into the telemetry buffers.

Master Sequencer. The instrument sequencer is the controller for the RIMS instrument. It sequentially determines when all circuits are to perform their various duties and keeps a status check on all commands and

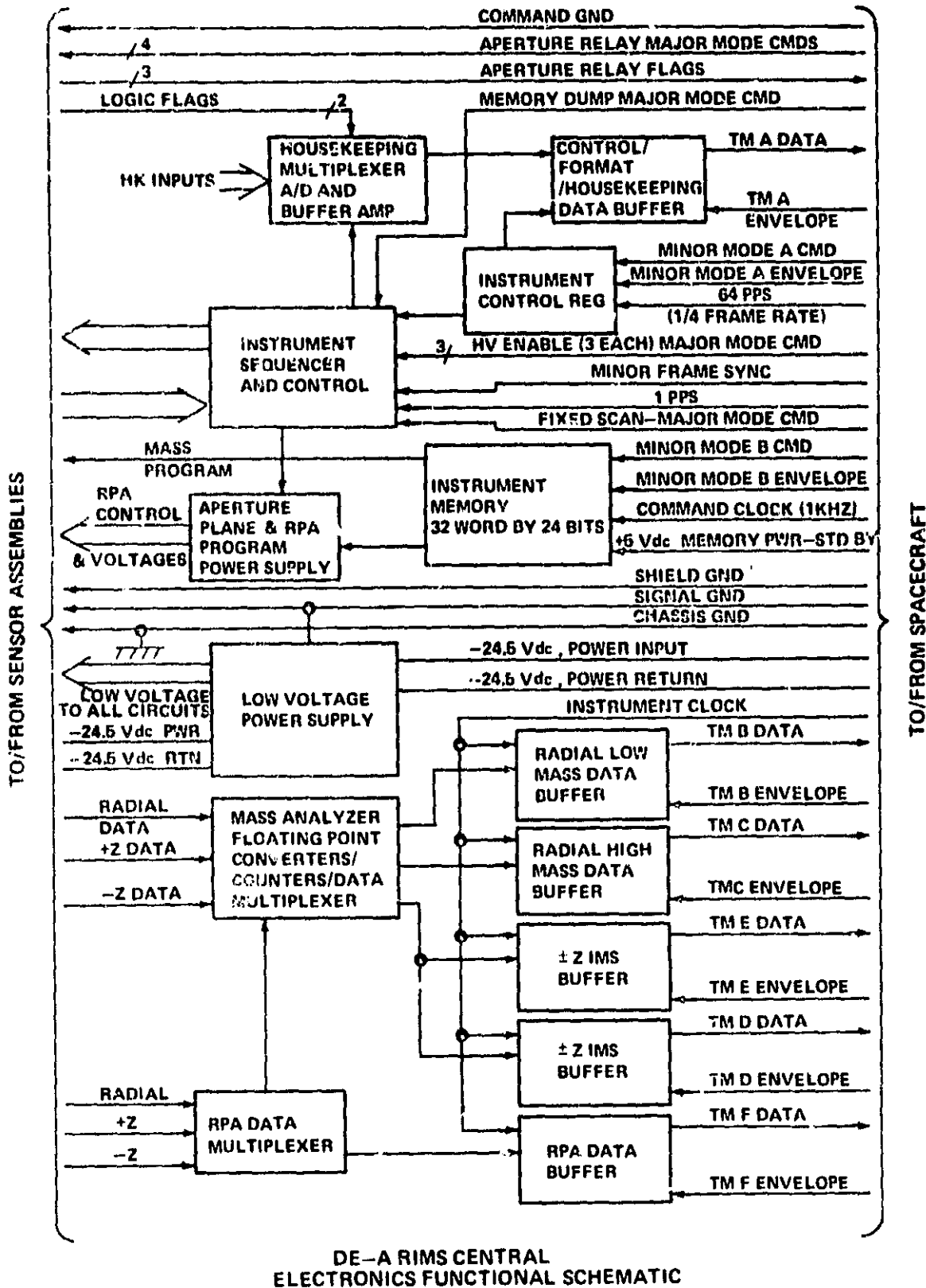


Figure 4. Schematic block diagram of the RIMS Central Electronics Assembly showing the control elements which drive the three sensor heads and the interface to the DE-A spacecraft.

timing required to maintain instrument health and operation. All data collection and processing by the RIMS instrument are under the control of this assembly.

Retarding Potential Power Supply. The output range of this supply is 0 to 51.2 V and is referenced to the aperture grid potential. Input control is a 10-bit word, and the output can be selected in either 50 or 75 mV steps on command.

Aperture Grid Power Supply. A 2-bit input signal is used to command this power supply to one of four output voltages: 0, -2, -4, or -8 V. The output voltages are compared to a reference through selectable resistors to produce the four voltages. A high-current output stage is used to provide a low impedance output, since other circuits are referenced to this supply output.

Low-Voltage Power Supply. The low-voltage power supply provides the interface between the instrument circuits and the spacecraft primary power. The spacecraft primary power (-24.5 Vdc, $\pm 2\%$) is received by a filter and current limit circuit. A dc-to-dc converter operating at 20 kHz is used to generate the various voltages needed by the instrument electronics.

RIMS OPERATIONS

The RIMS operating sequence is controlled by an internal memory in the CEA which is programmable by ground command. This feature is mandated by the versatility of the instrument and the intrinsic variability of the plasma it is designed to analyze. The memory itself is divided into two independent sections: one which controls the RPA grid voltages and one which controls the ion mass spectrometer settings. Each section contains 32 commands which are cycled sequentially in 0.5 s. This arrangement allows any combination of 32 mass and energy steps to be executed each 30 degrees of spacecraft spin.

In addition to the standard memory operation, a selectable option has been included which can periodically override the contents of the mass spectrometer section of the memory and set the mass spectrometer to hydrogen and helium. This override occurs for 8 s, each 16 s, and effectively doubles the control capability on the mass spectrometer by freeing the memory to be utilized for a search of minor constituents, with a periodic return to the major constituents occurring automatically. This feature of toggling every 8 s between major and minor constituent settings can be utilized upon command from the ground. All three heads are under common CEA control.

With three measurements available from each of the three heads (two mass spectrometer channels and the ion collector), together with the 64 samples per second rate, the instrument is capable of producing a substantial number of measurements per unit time. To ease the burden on the

spacecraft telemetry system, a multiplexing scheme has been incorporated which selects only two of the six measurements from the $\pm Z$ heads for transmission at any one time. The rate of the switching between $\pm Z$ head measurements and the selection of specific data channel pairs are programmable. The two mass spectrometer data channels from the radial head are sampled continuously with the radial ion collector data available on command.

With this versatility of instrument operation, it is quite evident that the instrument can be configured to conduct measurements for a broad range of scientific problems with the data acquisition optimized to the specific needs of each problem. In a general sense the observer has a set of choices ranging from the extremes of high mass resolution or high energy/pitch angle resolution to survey modes which sample many masses and energies averaging over time and angle.

For preflight planning purposes, it is assumed that the measurement sequences which will be employed during the flight will be divided into three broad and mutually exclusive categories. These are: (1) a limited resolution-combined mass/energy survey which samples only the most probable mass species (for example, H^+ , He^{++} , He^+ , O^{++} , and O^+) using a minimum number of energy steps, (2) a comprehensive mass analysis of the ambient plasma in the range of 1 to 32 amu with no energy analysis, and (3) a high-resolution energy/pitch angle analysis of a selected pair of ionic species.

It is anticipated that the first and second of these modes will be employed on a fairly regular basis in the earliest phases of the mission to obtain a general survey of the plasma. The third mode will be reserved for special studies such as those, for example, which might require particularly accurate density determinations or high time resolution information on ion pitch angle and energy spectral distributions.

The RIMS operational flexibility will clearly permit the study and understanding of the science problems discussed in the earlier sections and will give the scientist observer the possibility of learning during the DE mission and modifying the instrument operation to explore the next level of scientific problems which are uncovered.

CALIBRATION APPROACH AND RESULTS

The RIMS instrument was calibrated in the low-energy plasma calibration facility at the Marshall Space Flight Center (MSFC). This specially designed facility utilizes a large cylindrical vacuum chamber (1 m diameter by 2 m length) which employs hydrocarbon-free pumping with sorption and ion pumps. The low-energy ion source is an ion gun designed at MSFC based on the principles utilized in the Kaufmann ion engine [19]. The neutral gases which are bled into the source are controllable to permit the measurement of different composition ratios. The ion beam energies can be varied from a few electron volts to hundreds of electron volts.

The beam diameter is approximately 6 cm for beam energies of tens of electron volts. Typical beam currents range from 5×10^{-12} to 1×10^{10} A. The beam current is measured by a small Faraday cup which can be moved into the beam on a swing arm. The RIMS instrument is mounted in the beam on an angular motion device which permits the two-dimensional measurement of instrument angular response in a polar coordinate system with respect to the instrument normal.

The RIMS calibration activities were conducted in three increments: an initial calibration in the MSFC facility, a comparative calibration in the University of Bern plasma facility [20], and a final calibration using the flight multipliers in the MSFC facility. The goal of these three tests was the determination of the instrument mass resolution, the angular response, and the absolute sensitivity.

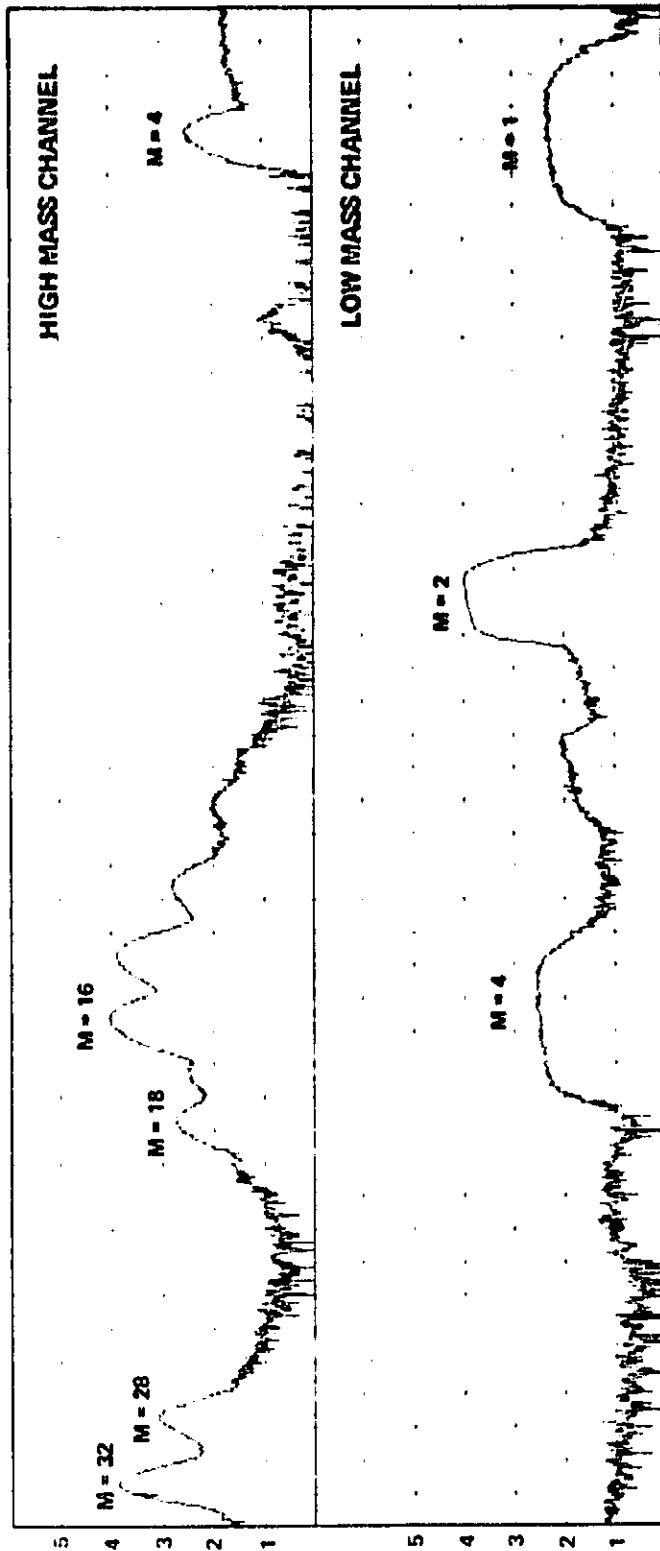
Figure 5 shows a typical mass spectrum taken in the MSFC chamber during the bleeding of multiple gases into the ion source. Note the excellent mass resolution throughout the mass range of 1 to 32 amu. The mass peaks are clearly separated and defined with a possible in-flight sample density of greater than 10 points/mass peak at the high masses to hundreds of points/mass peak at the low masses.

Figure 6 shows a typical angular response of the +Z sensor head for two energies and two masses. The angular response is determined by the physical collimation of the apertures for low energies and low masses. As the beam energy and mass number increase, the angular acceptance becomes increasingly affected by the angular acceptance of the magnet assembly. This results in a narrowing of the angular acceptance for higher energies and masses and a transition from a circular to an elliptical angular response function. The radial sensor angular response is sharply rectangular because of the narrowed aperture collimation of $\pm 10^\circ$ by $\pm 55^\circ$.

The RIMS absolute sensitivity was determined by comparisons of count rate from the channel electron multipliers in the mass spectrometer section with a simple measure of ion beam current from a Faraday cup that is moved into the beam at the sensor head entrance aperture. The knowledge of the beam current and composition combined with the spectrometer multiplier response determines the instrument transmission factors and establishes the instrument absolute sensitivity. The sensitivity determination was done in a multicomponent beam at MSFC and in a single-component, mass-analyzed beam in the University of Bern facility. Calibration activities in the University of Bern facility also gave an intercomparison with the Energetic Ion Composition Spectrometer on DE-A [21] which was calibrated in this facility.

These calibration results on mass and angular resolution and absolute sensitivity will be incorporated in the data reduction of software which will convert count rates to equivalent ion fluxes as a function of energy and angle.

E = 50eV



MASS SWEEP VOLTAGE

Figure 5. A complete mass spectrum measured in the MSFC calibration facility showing a sweep of the low mass (1-8 amu) and high mass (4-32 amu) channels.

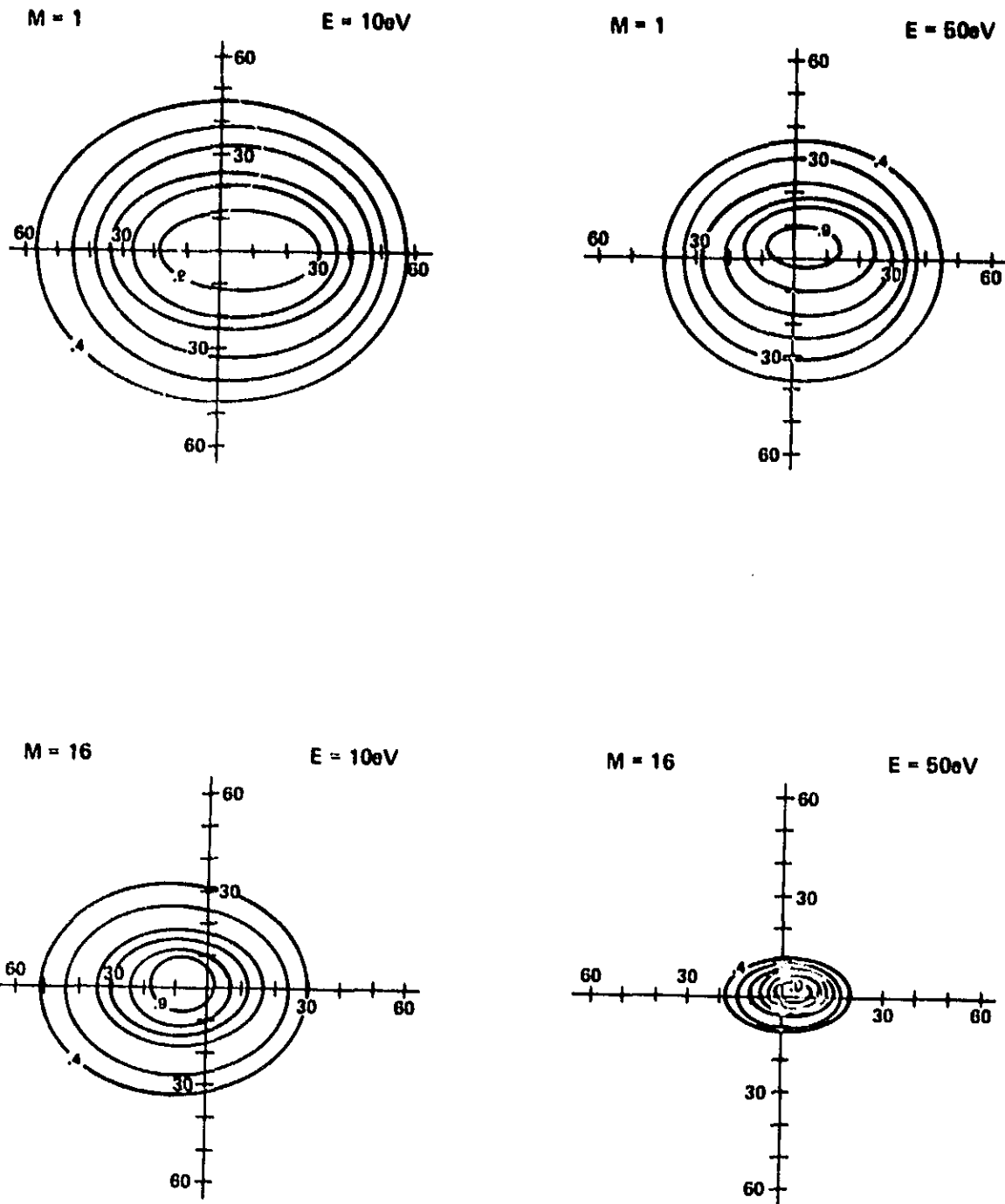


Figure 6. Examples of the angular response of the +Z RIMS sensor head showing contours fitted to measured responses along the X and Y axes of the sensors. The angular response for different ion beam energies and masses is shown in the four panels.

DATA REDUCTION AND ANTICIPATED RESULTS

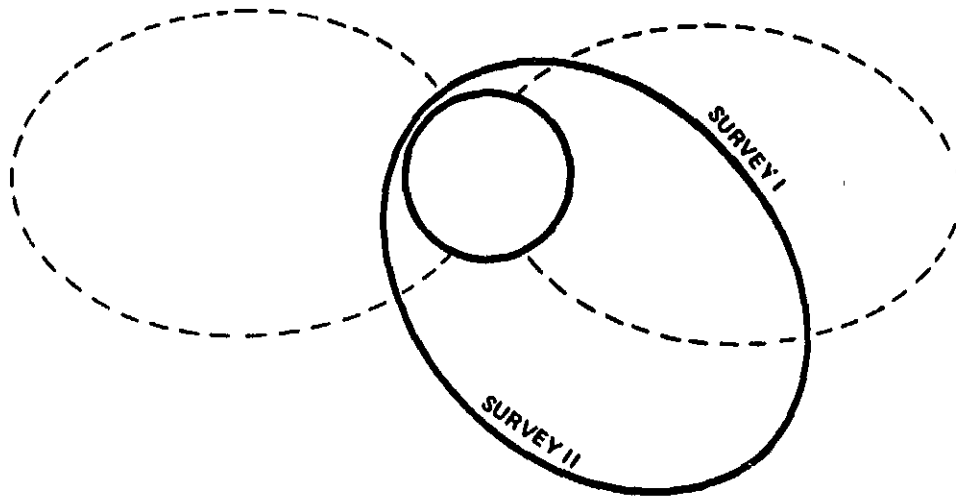
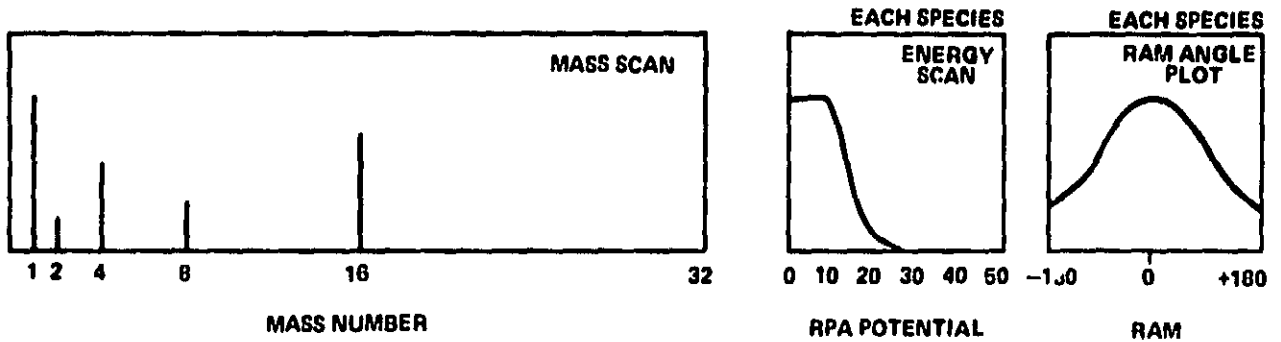
As was mentioned in the introductory sections, the thermal plasma characteristics can be quite variable in the different magnetospheric locations sampled by the DE-A spacecraft. The frequent non-Maxwellian character of the plasma prohibits the routine reduction to bulk parameters and leads to data displays which are more characteristic of energetic particle measurements such as energy-time and pitch angle-time spectrograms. In the inner plasmasphere and ionosphere where Maxwellian characteristics are more common, simple algorithms and curve-fitting routines will be employed to derive the bulk parameters of ion density, temperature, and bulk flow. However, RIMS operations around apogee will be characterized by pitch angle and energy spectral distributions.

Figure 7 displays a typical operational profile for an orbit of DE-A. At low altitudes around perigee the instrument is in a survey mode which does rapid energy/angle scans on the major ion species expected to be present. As the spacecraft moves out of the plasmasphere, across the auroral zone and into the plasma trough, the operations are shifted to a different survey mode in which the emphasis is changed to looking for minor ions and determining the mean energies of the ions found. Figure 7 represents only one possible set of RIMS modes through an orbit.

Figure 8 illustrates RIMS operational modes which can be used to study specific thermal plasma phenomena. At low altitudes ion composition would be measured using both the RPA and mass spectrometer capabilities. In this region a mass spectrum versus time, latitude, and local time is shown. As the spacecraft moves over the pole, pitch angle measurements of different ion species are measured to search for polar wind effects. In this region a pitch angle-time spectrogram is utilized for data display. Moving on through apogee the spacecraft can examine the plasmasphere filling and energization processes. Here, both pitch angle-time and energy-time spectrograms are employed. DE-A moves through apogee to higher latitudes where the interface between the thermal plasma of the plasmasphere and the hot plasma of the ring current can be studied simultaneously. The effects of the low-energy ions on the hot ring current ions are traced using simultaneous energy-time spectrograms for hot and cold plasma as a function of time, L-shell and local time.

The Retarding Ion Mass Spectrometer is a flexible and unique instrument which will furnish extensive new knowledge on thermal plasma dynamics in the inner magnetosphere and ionosphere.

SURVEY MODE I – PLASMASPHERE
CYCLE TIME 16 SECONDS
H+ AND HE+ FOR 8 SECONDS. THEN ALTERNATING D+ AND O++
WITH HE+ AND O+ EACH 1/4 SECOND FOR 8 SECONDS.
RPA SCANS EACH 1/4 SECOND



SURVEY MODE II – PLASMATROUGH AND AURORAL ZONE
CYCLE TIME 16 SECONDS
H+ AND HE+ FOR 8 SECONDS WITH 1/2 SECOND RPA SCANS
MASS RANGES 4 THROUGH 8, 14 THROUGH 18 AND 28 THROUGH
32 FOR 8 SECONDS

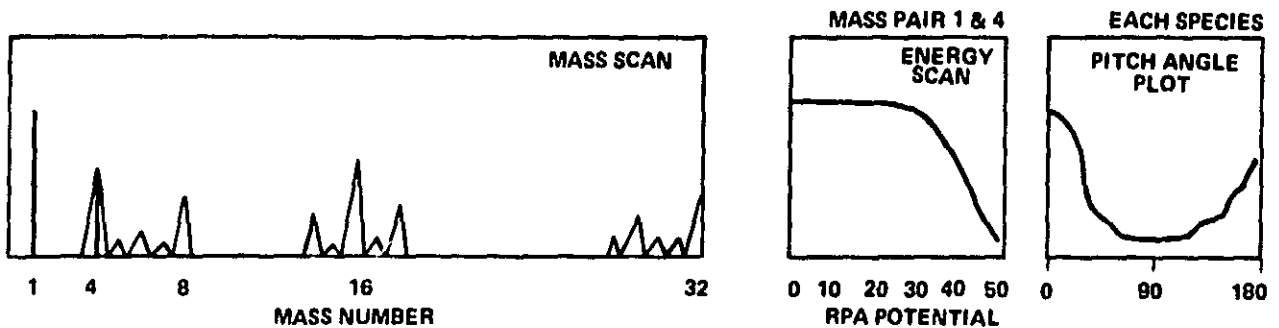


Figure 7. A typical RIMS operational profile illustrating the use of two survey modes: a low-altitude mode which concentrates on ion energy and pitch angle and a high-altitude mode which conducts a careful mass survey.

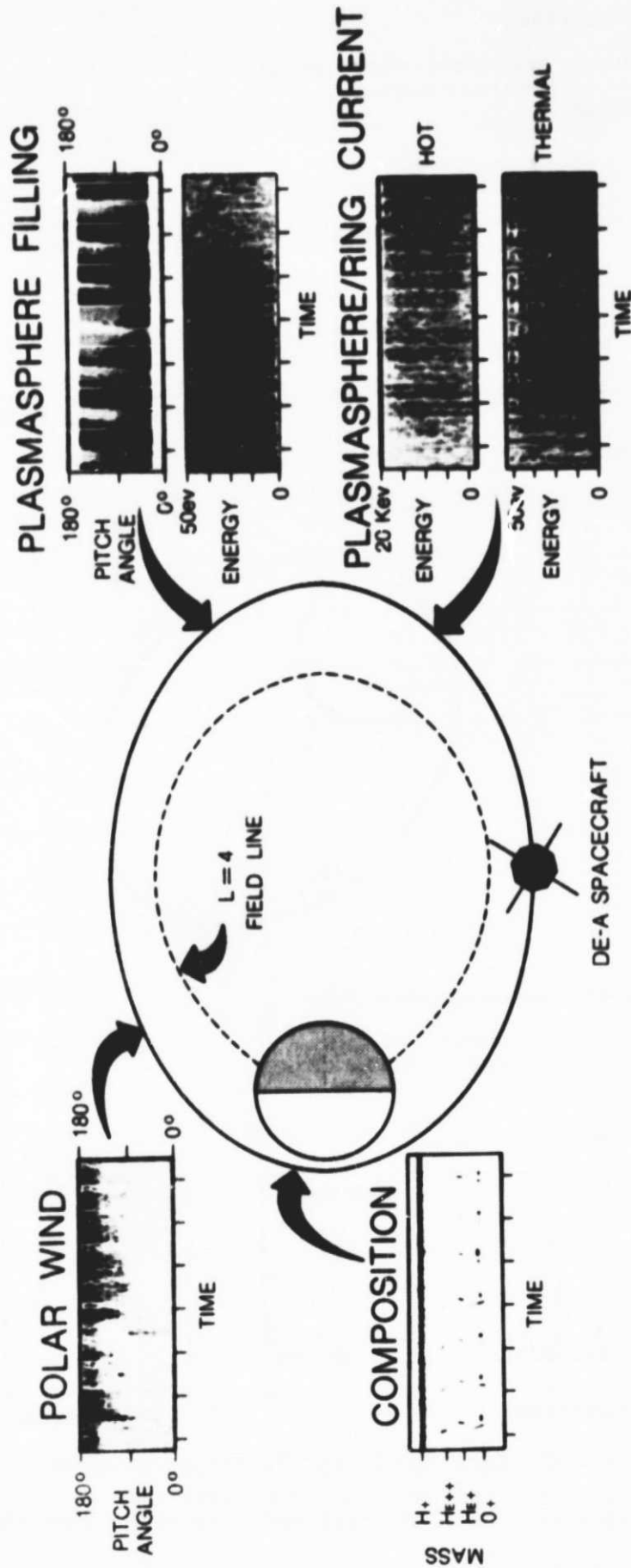


Figure 8. A variety of RIMS operating modes which address different science problems of interest in thermal plasma studies.

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APPROVAL

THE RETARDING ION MASS SPECTROMETER ON DYNAMICS EXPLORER-A

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



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