NASA TECHNICAL MEMORANDUM

September 1974

NASA TM X-64879

MSFC SKYLAB KOHOUTEK EXPERIMENTS MISSION EVALUATION

Skylab Program Office

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

(NASA-TM-X-64879) MSFC SKYLAB KOHOUTEK EXPERIMENTS MISSION EVALUATION (NASA) 49 p HC $3.25 CSCL 22C

N74-34275

Unclas
G3/30 49284

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

NONSTANDARD ABBREVIATIONS

ATM	Apollo Telescope Mount
CM	Command Module
CMG	Control Moment Gyro
EVA	Extravehicular Activity
ICD	Interface Control Document
JSC	Lyndon B. Johnson Space Center
MAR	Mirror Auto Raster
MRD	Mission Requirements Document
MSFC	George C. Marshall Space Flight Center
SAL	Scientific Airlock
SL-4	Skylab-4
TV	Television
UV	Ultraviolet

SECTION I. SUMMARY

The Comet Kohoutek's, (1973f) appearance and orbital trajectory provided NASA with a unique opportunity to perform an observing program on the Skylab SL-4 mission. The comet was observed on over one hundred occasions by thirteen Skylab experiments in spectral bands from X-rays, through ultraviolet and visible bands. Observations were performed: by corollary experiments through the scientific airlock (SAL); by hand held photography (HH); during extravehicular activity (EVA) and by the Apollo Telescope Mount (ATM) experiments.

The observation program ran from November 25, 1973 to February 2, 1974 and should provide evolutionary comet data during its most active period. The comet's perihelion, or closest approach to the sun, occurred on December 28, 1973. The data taken by Skylab experiments provided minimum - atmosphere photography and is hoped will yield never-before-obtained ultraviolet spectrum data on a comet. Observations performed during the mission very closely approached premission desires, modified only by the difference in actual versus predicted comet brightness.

It is expected that the Skylab data will provide engineers and scientists with both useful design and scientific data to aid in the development of future cometary research. Skylab experiment results may be applied to anticipated fly-by and rendezvous missions to comets in the future.

SECTION II. INTRODUCTION

This report describes the utilization of various Skylab experiments which viewed the Comet Kohoutek, 1973f. Comet Kohoutek was discovered in March 1973 and passed nearest to the sun on December 28, 1973.

Realizing the unique opportunity to view a comet from above the earth's atmosphere the NASA Skylab program established a concentrated study using existing and new experiments. The Skylab Integrated Viewing Program's intent was to obtain broadband spectral evolutionary data of the comet during this dynamic period of its trajectory. The comet was readily visible from the Orbital Workshop (OWS) during the Skylab 4 mission.

Skylab 4 (SL-4) was the third OWS mission by a three man crew. The astronauts were Commander Gerald Carr, Science Pilot Edward Gibson, and Pilot William Pogue. The mission began on November 16, 1973 and ended February 8, 1974.

Included in the report are the Kohoutek Viewing Program Summary, discussion of premission experiment selection, definition of viewing constraints, and descriptions of each experiment and its observations. Detailed evaluations of the experiment hardware are covered in the references.

The Comet Kohoutek was viewed by selected Skylab experiments as identified in table I. Two new experiments, S201 and S233, were launched on SL-4 to photograph the comet. The total numbers of actual performances compared to the premission Mission Requirements Document (MRD) are listed in table I. A Kohoutek Viewing Program summary listing the experiments and the days on which they were performed is given in figure 1.

SAL observations began on November 25, 1973 and ended on February 2, 1974. The ATM experiments were less sensitive since they were designed to look directly at the sun. ATM observations were thereby initially constrained to occur between December 14, 1973 and January 10, 1974. The first ATM observation was on December 19, 1973 and the last on January 6, 1974 since the comet brightness was less than expected.

TABLE I. EXPERIMENT PERFORMANCE SUMMARY

EXPERIMENT	PERFORMANCE LOCATION	MINIMUM PER MRD	BASELINED PER MRD	ACTUAL
S019 UV Stellar Astronomy	SAL	7	20	13
S063 UV Airglow Horizon Photography	SAL	7	21	14
	and Hand Held	Target of Opportunity		8
S073 Gegenschein/Zodiacal Light	SAL	1	1	1
S183 Ultraviolet Panorama	SAL	7	13	6
S201 Far UV Electronographic Camera	SAL and ATM Truss during EVA	8	15	14
S233 Kohoutek Photometric Photography	Hand Held MDA and CM	34	72	69
T025 Coronograph Contamination Measurements	AM Truss during EVA	1	2	2
S052 White Light Coronagraph	ATM	*49/13	51/15	49/13
S054 X-Ray Spectrographic Telescope	ATM	*49/13	51/15	49/13
S055 UV Scanning Polychromator Spectroheliometer	ATM	*49/13	51/15	49/13
S056 X-Ray Telescope	ATM	*49/13	51/15	49/13
S082A XUV Spectroheliograph	ATM	*49/13	51/15	49/13
S082B Ultraviolet Spectrography	ATM	*49/13	51/15	49/13

*Number of orbits/number of observing days.

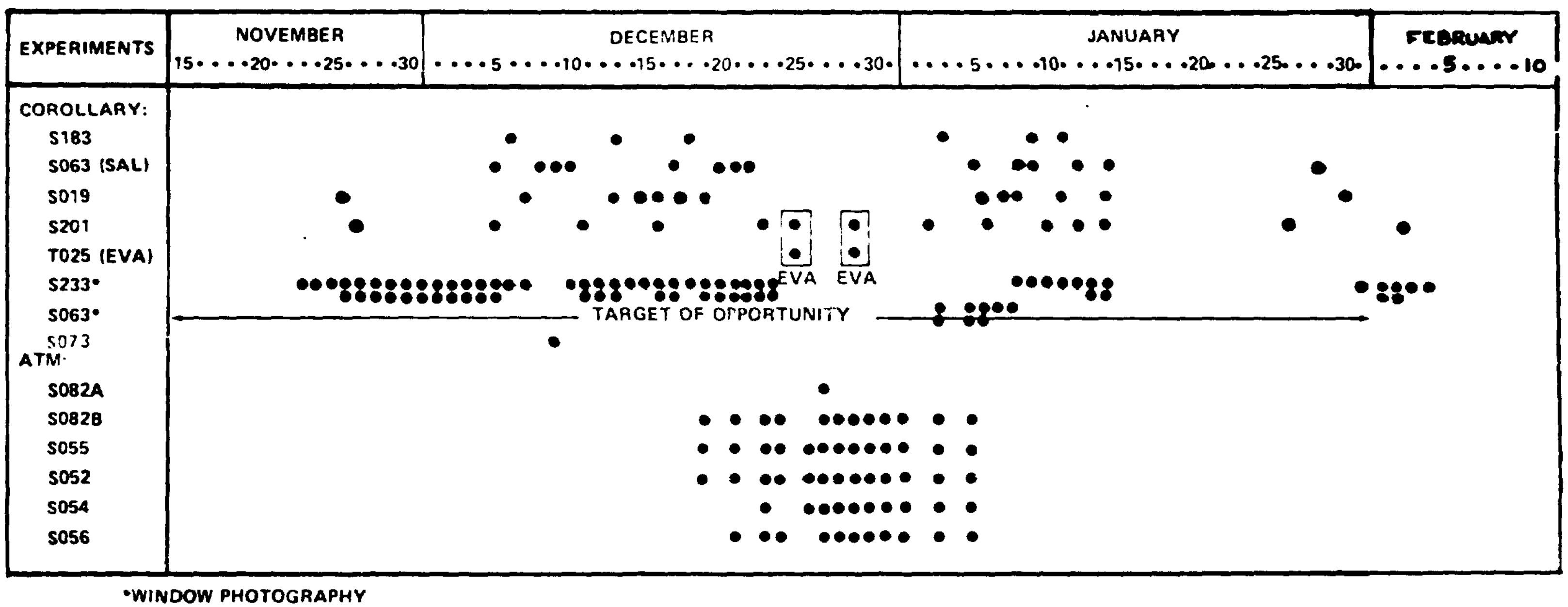


FIGURE 1. KOHOUTEK VIEWING PROGRAM

SECTION III. EXPERIMENT HARDWARE

There were six experiments designed to be operated through the SAL that were capable of taking scientific comet data (S019, S063, S073, S183, S201 and T025). However, only the anti-solar SAL was available for use. Therefore, the experiment line-of-sight (when using the anti-solar SAL) required reorientation as much as 180 degrees depending upon the comet's location and the OWS attitude. The S019 Articulated Mirror System (AMS) was used and provided a line-of-sight angular adjustment from a minimum of 60 degrees to a maximum of 90 degrees (see paragraph IV.A.1.c.). Additional angular adjustment was accomplished by rolling the OWS about the longitudinal axis.

Experiment S233 was selected to obtain a series of hand held photographs. The corollary experiment characteristics are shown in table II. The scientific objectives estab lished were based on these characteristics and the observation opportunities are shown in table III.

The ATM experiments were evaluated to determine their potential usefulness to observe the comet. ATM experiment observations required maneuvering the OWS to point the experiments at the comet rather than at the sun. The ATM experiment characteristics are shown in table IV and their scientific objectives are shown in table V.

TABLE II. CHARACTERISTICS OF COROLLARY EXPERIMENTS AVAILABLE FOR COMET VIEWING

EXPERIMENT	WAVELENGTH (Å)	SPECTRAL RESOLUTION (Å)	FIELD-OF-VIEW (degrees)	SPATIAL RESOLUTION (arc-min.)	DATA FORMAT
S019 UV Stellar Astronomy	1300-5000	2 at 1500	4 by 5	0.25	Film
		9 at 2000			
S063 UV Airglow Horizon Photography	2500	-	7 by 9	0.50	Film
	3090	-			
	3914	-			
	5577	-			
	6300				
S073 Gegenschein/ Zodiacal Light	White Light	-	7 by 9	0.50	Film
S183 Ultraviolet Panorama	1878	635	7 by 9	7	Plate
	2970	635	7 by 9	7	Plate
	2560	360	8	1	Film
S201 Far UV Electronographic Camera	1050-1600	-	7 by 9	2	Film
	1230-1600	-	20 (EVA)		
		-			
S233 Kohoutek Photometric Photography	White Light	-	43 (diagonals)	0.50	Film
T025 Coronograph Contamination Experiment	2530	115	24	0.50	Film
	2800	200			
	3100	60			
	3250	60			
	3361	30			
	3600	200			
	3873	30		0.33	
	3940	30			
	4262	20			
	4430	100			
	4700	60			
	4900	60			
	5500	200			
	5890	30			
	6000	Shortpass			

TABLE III. COMETARY SCIENCE OBJECTIVES OF COROLLARY EXPERIMENTS

EXPERIMENT	SCIENTIFIC OBJECTIVES
S019 UV Stellar Astronomy	Ultraviolet objective prism imaging of the coma and tail. Ultraviolet emission spectra of knots and transient structures and plasma tail filaments. Cometary absorption spectra of coma employing stellar occultation.
S063 UV Airglow Horizon Photography	Ultraviolet-visible polarimetry and bandpass photography of coma and tail. Temporal variation of emission isophotes of O(I), C_2, C_3 and OH. Degree of linear polarization of the coma and tail. Polarimetry.
S073 Gegenschein/Zodiacal Light	Particle distribution of debris in comet plane.
S183 Ultraviolet Panorama	Ultraviolet broad bandpass photographic photometry of coma and tail. Production rates, spatial distribution, and life times of OH in coma. Tri-color index of tail and coma.
S201 Far UV Electronographic Camera	Extreme UV dual bandpass photography. Obtain H Lyman-alpha imagery showing development of hydrogen halo. Determine atomic oxygen distribution.
S233 Kohoutek Photometric Photography	Visible light photography for photometric and synoptic history of comet.
T025 Coronograph Contamination Measurements	Ultraviolet and visible bandpass photography and polarimetry of coma and tail near perihelion. Particulate production and distribution. Production and distribution of OH, CN, C_2, NH, Na, CO+. Polarimetry of coma and tail. Spectral and spatial changes of comet near perihelion.

TABLE IV. ATM EXPERIMENT CHARACTERISTICS FOR KOHOUTEK

EXPERIMENT	WAVELENGTH (Å)	SPECTRAL RESOLUTION (Å)	FIELD-OF-VIEW (degrees)	SPATIAL RESOLUTION (arc-min.)	DATA FORMAT
S052 White Light Coronagraph (Auxil. Eq. - Video FOV 4.5 solar diams, spatial resolution-30 sec)	3500-7000	-	6 solar diam. ($\sim 3.2^{o}$)	8	Film
S054 X-Ray Spectrographic Telescope	3.0 - 60	$\frac{\lambda}{\Delta\lambda}$ + 30 at 7	43 $\widehat{min}$	3	Film + TV
S055 UV Scanning Polychromator Spectroheliometer	296-1350	1.4	5 $\widehat{min}$	5	Telemetry
S056 X-Ray Telescope	2-33	- 2.5	40 $\widehat{min}$	2.5	Film Telemetry
S082A XUV Spectroheliograph	150-335 321-625	.13 .13 (for 10" imagery)	56 $\widehat{min}$	5	Film
S082B Ultraviolet Spectrography (Auxil. Eq. - Video 170-550Å; 20 sec)	970-1970 1940-3940	08 .6	2 by 60 $\widehat{sec}$	3	Film

TABLE V. COMETARY SCIENCE OBJECTIVES OF ATM

EXPERIMENT	SCIENTIFIC OBJECTIVES
S052 Whitelight Coronagraph	Visible photographic polarimetry of coma and tail at perihelion. Polarization and morphological changes of coma and tail. Measurement of solar wind at comet.
S054 X-ray Spectrographic Telescope	X-ray absorption of tail to determine total mass density. X-ray fluorescence for imagery of coma. Determine possible concentrations of Si, Al, Mg, O, and C.
S055 UV Scanning Polychromator - Spectroheliometer	Extreme ultraviolet spectral observations of coma. High resolution UV maps of inner coma near perihelion. Spectral scans of C, N, Si, H_2. H Lyman-alpha scans to correlate with S201.
S056 X-ray Telescope	X-ray fluorescence for imagery of coma.
S082A XUV Spectroheliograph	Extreme ultraviolet monochromatic imagery. Possible images of He(I), He^+, O^-
S082B Ultraviolet Spectrography	Ultraviolet spectral observation of coma and tail. H Lyman-alpha profile and intensity. Spectral intensities. Search of metallic, diatomic, polyatomic emission lines (H, D, C, Mg, Al, H_2, OH, SO_2).

SECTION IV. EXPERIMENTS

This section discusses the objectives, concept, hardware description, experiment operations, constraints, hardware performance, experiment interfaces, return data and experiment anomalies of each experiment which viewed the comet.

A. S019 UV Stellar Astronomy

The Principal Investigator for experiment S019 is Dr. Karl G. Henize, Astronaut Office, at JSC; Houston, Texas. The telescope was built by Northwestern University, Evanston, Illinois and the mirror system was built by Boller and Chivens, Division of Perkin Elmer Corporation, Pasadena, California, under contract to JSC.

1. Experiment Description

a. Objective. The scientific objectives were: to obtain ultraviolet emission spectra of small knots and transient structures, and plasma-tail filaments when their orientation was approximately perpendicular to the instrument dispersion direction; to obtain coma ultraviolet spectra through short exposures and to obtain ultraviolet absorption spectra at various points in the tail using stars as the background source.

b. Concept. The data from the objective-prism spectra of the comet in the ultraviolet wavelengths were to be studied to understand: the composition of the comet; the astrophysical processes which occurred in the comet as it interacted with the solar radiation and solar wind and the overall temporal evolution of the comet.

These data were to be provided through spectroscopic analysis to determine the number and type of molecules and radicals present, the state of electron excitation, the ionization and dissociation rates of the radicals. The S019 equipment had the capability of producing simultaneous polychromatic images of that comet region within the 4 by 5 degree spectrograph field-of-view. Spectral data were to be obtained in the region between 1800 and 2400 Å and over the continuous range from 1300 to 5000 Å where molecular emission lines were to be sought to determine the parent molecules and hence the comet nucleus compositions.

c. Hardware Description. The telescope optical system was an f/3, six-inch aperture Ritchey-Chretien design (see figure 2.) that used a chromatically-corrected, lithium fluoride and calcium fluoride doublet as a field flattener. The four-degree objective prism was cut from a single-crystal calcium fluoride ingot. The field was four degrees by five degrees on a side and all stars of sufficient brightness within that field had their spectra recorded on each exposure.

A telescope cutaway view is shown in figure 3. The film magazine contained 164 frames of Kodak 101-06 emulsion mounted on metal plattens.

The instrument operated through the OWS anti-solar SAL. Since the spacecraft was not readily maneuverable, an AMS was first extended through the SAL to allow quick pointing to any area within a 30° band around the sky. All instrument functions were manually controlled.

The AMS (see figure 4.) contained an extendible reflective surface with 360 degree rotation and 15 degree tilt capability from its zero position. This tilt resulted in a 30-degree viewing angle capability (see figure 5).

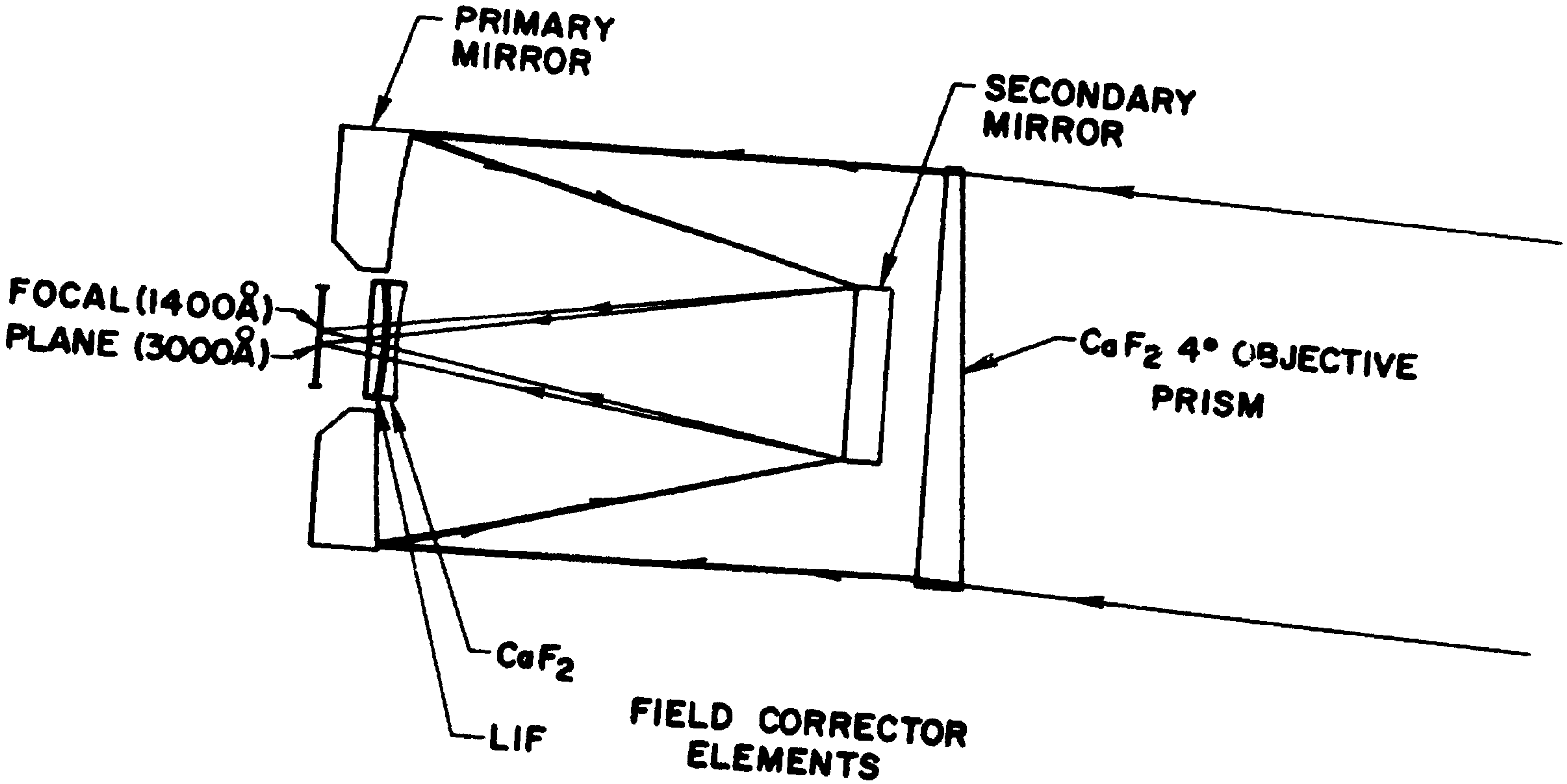
It incorporated a front sealing surface to interface with the SAL and a rear sealing surface to interface with the optical canister.

The mirror was a 7.5 by 15 inch, flat, elliptically shaped device. The reflective surface was a 1000 Å thick aluminum coating with a 250 Å thick magnetic fluoride overcoating. The mirror was not to deviate from a plane surface by more than a one-fourth wavelength of 5500 Å light.

The unit had a spectral widening drive mechanism which used a manually-wound spring motor. The mechanism total travel was 270 arc-seconds. The exposure times were 30, 90, and 270 seconds.

The AMS displayed accuracy was ± 0.05 degree.

2. Experiment Operations. The mode used for comet viewing, was similar in most respects to normal S019 operation. A cluster roll maneuver up to 90 degrees about the longitudinal-axis was required to view the comet. The comet viewing mode was combined with a normal S019 pass. Eighteen comet exposures were taken during fourteen experiment sessions.



RITCHEY - CHRETIEN OPTICAL SYSTEM

FIGURE 2. S019 TELESCOPE OPTICAL SYSTEM

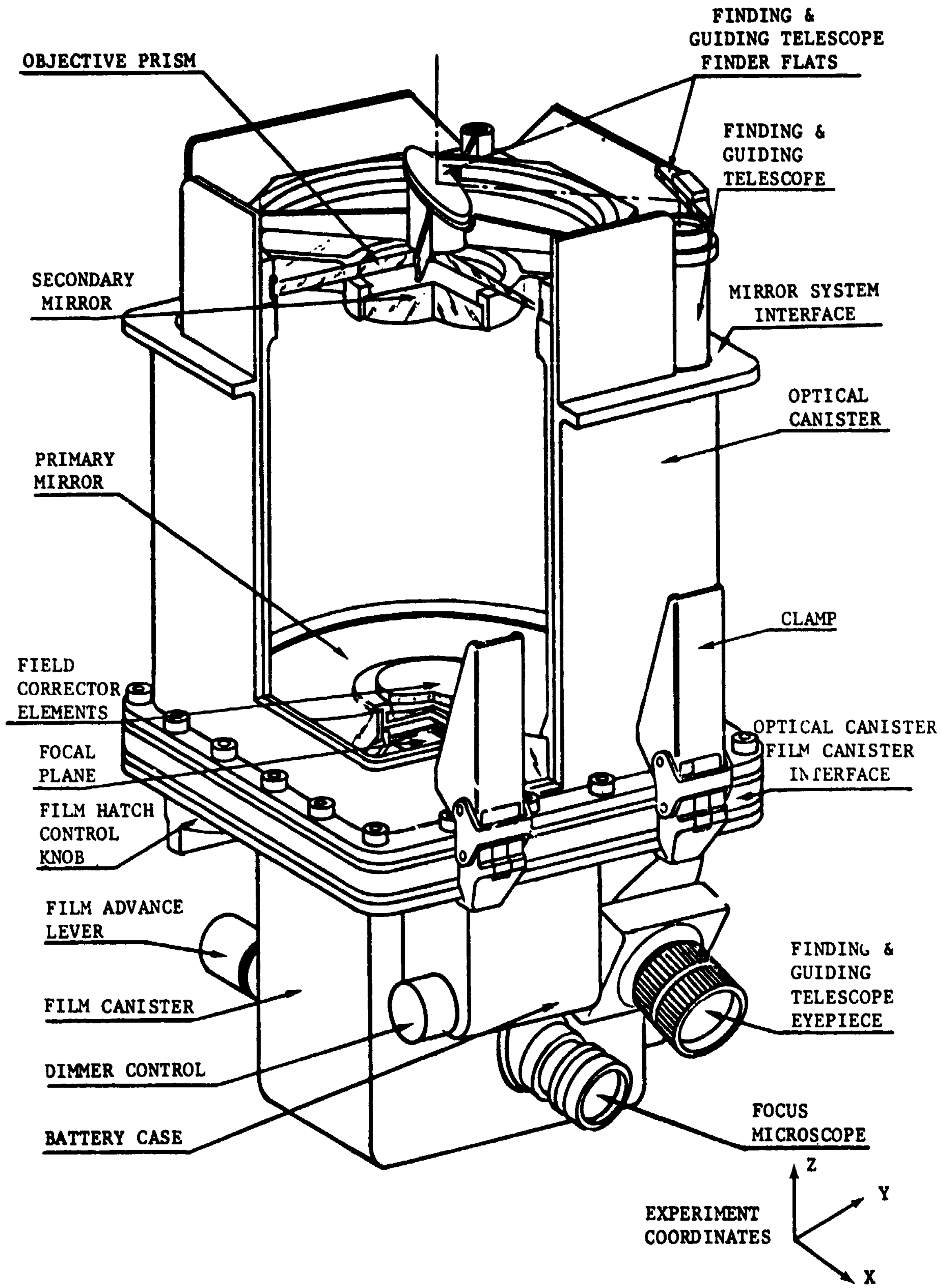


FIGURE 3. OPTICAL CANISTER WITH FILM CANISTER INSTALLED

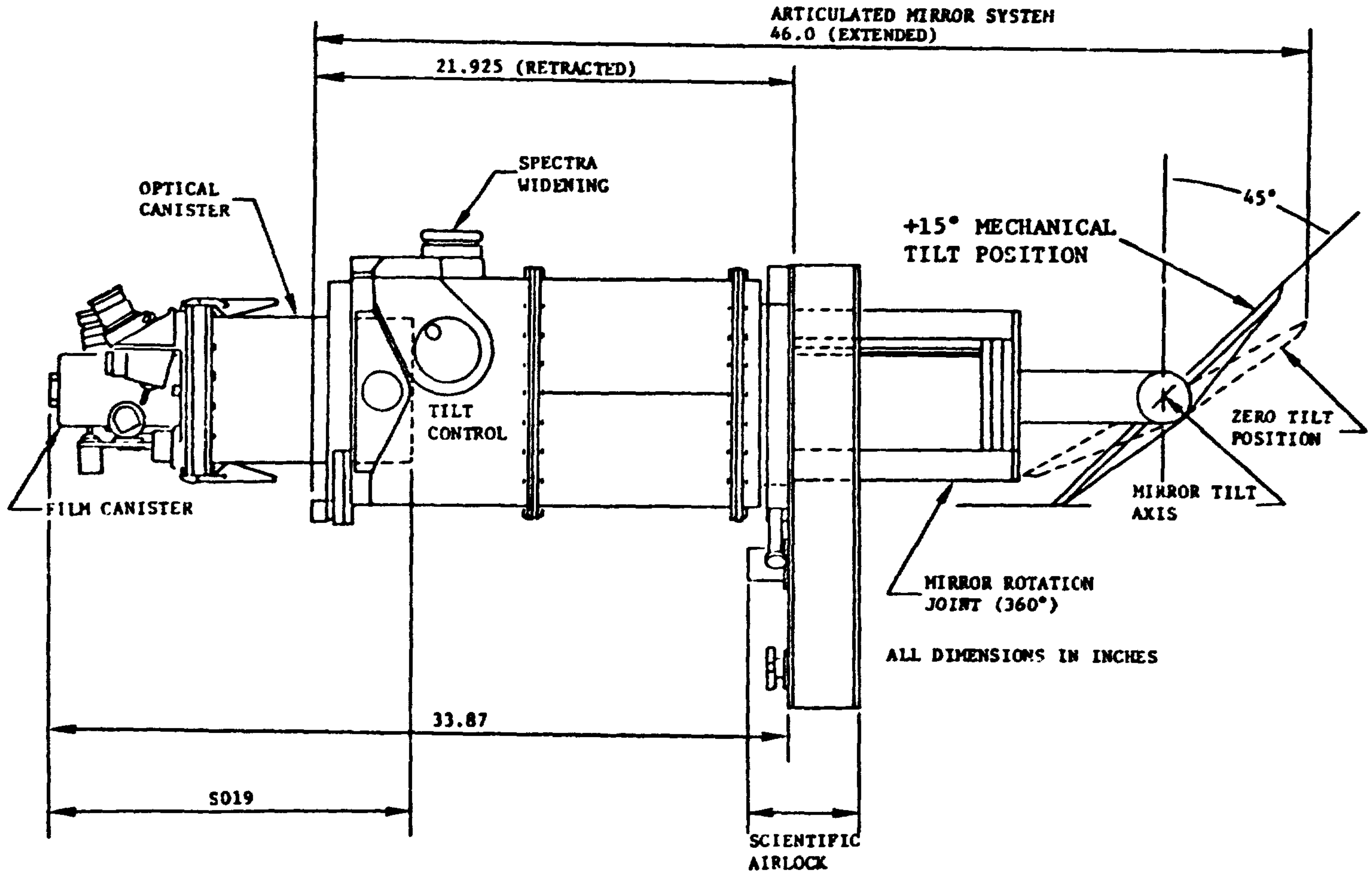


FIGURE 4. ARTICULATED MIRROR OPERATING CONFIGURATION

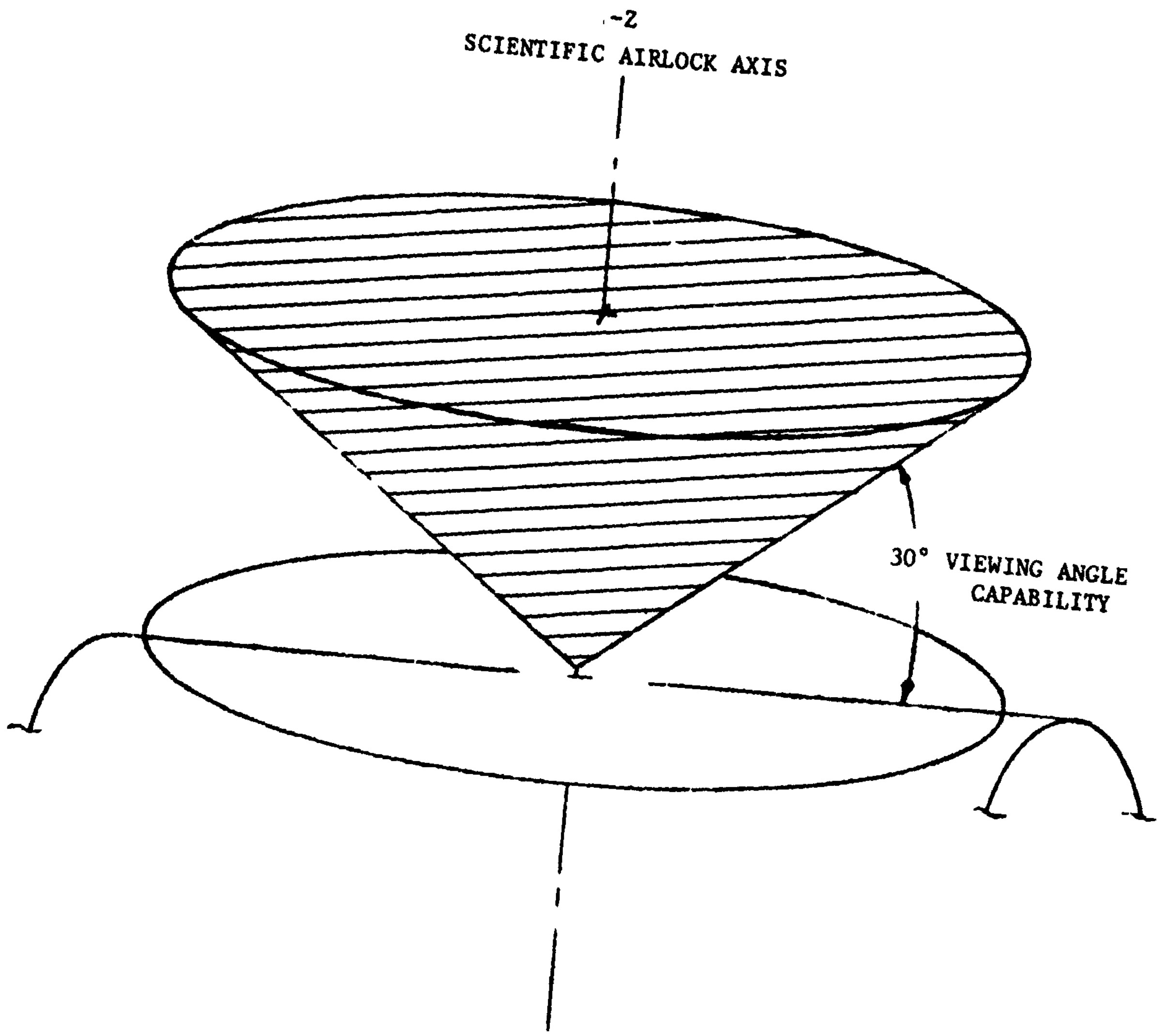


FIGURE 5. AMS VIEWING CAPABILITY

3. Constraints. The experiment constraints were successfully met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [1] .

5. Experiment Interfaces. Experiment interfaces are contained in reference [1] .

6. Return Data. Film Canisters 002 and 003 were returned for evaluation.

7. Anomalies. The Principal Investigator (PI) reported preliminary results at the crew debriefing on March 4, 1974. The last three performances with cassette 002 did not yield any useable data due to an S019 shutter/slide retract problem.

B. S063 UV Airglow Horizon Photography

The Principal Investigator for Experiment S063 is Dr. Donald M. Packer, Naval Research Laboratory, Washington, D.C. The hardware developer was Martin Marietta Aerospace, Denver, Colorado, under contract to JSC.

1. Experiment Description

a. Objectives. The scientific objectives were: to obtain ultraviolet and visible monochromatic emission isophotes of O(I), C_2, C_3 and OH; to obtain photographic polarimetry of the coma and tail and to obtain color photography of the comet.

b. Concept. The OH (3090 Å) photography was to be correlated with other Skylab experiments to determine the ratio of H to OH to establish water's presence. The photography of O(I), C_2, C_3 and OH emission would allow a determination of these constituents' production rates. The study was to provide data on interaction of the coma and tail with the solar wind and solar radiation. The S063 equipment had a capability for selected bandpass photography, such as the addition of a OH (3090 Å) filter.

The data was to be studied to understand the spatial and temporal variation of the selected atomic and molecular constituents and to obtain the degree of linear polarization of the coma and tail.

c. Hardware Description. Experiment S063 used an operational Nikon camera, the T025 canister without the occulting disks, the S063 mounting adapter, the T025 filters and the S019 AMS. The camera had interchangeable lenses, which included an f/1.2 aperture, 55mm focal length visible lens; an f/2.8 aperture, 135mm focal length visible lens; and an f/2 aperture, 55mm focal length ultraviolet lens. The T025 filters mounted in an adapter for quick interchangeability. Nikon cameras also were interchangeable.

2. Experiment Operations. The anti-solar SAL desired observational procedure was to mount the experiment hardware to the anti-solar SAL and roll the cluster as required up to 90° about the longitudinal axis.

The handheld photography mode was performed with the 55mm visible lens only, as the windows available were glass, coated to exclude UV transmittance. However, this field-of-view was greater than the anti-solar SAL's, so that the entire comet could be included in a photograph. S063 photographed the comet on twenty-two occasions, fourteen sessions thru the SAL and eight handheld sessions. The former technique was used for eighty exposures, the latter for fifty exposures.

3. Constraints. All S063 constraints were satisfied during comet viewing.

4. Hardware Performance. Hardware performance is covered in reference [1] .

5. Experiment Interfaces. Experiment interfaces are contained in reference [1] .

6. Return Data. S063 cassettes BE08, BV26, BE09, BV27, BV28, CI113, and BE11 were returned for evaluation.

7. Anomalies. The exposures taken with camera NK02 were out of focus. The PI reports the last three experiment sessions (20 exposures) did not yield any useful data due to a pointing problem.

C. S073 Gegenschein/Zodiacal Light

The Principal Investigator for Experiment S073 is Dr. J. Weinberg, The State University of New York at Albany, Albany, New York.

1. Experiment Description

a. Objectives. The objective was to obtain particulate distribution data in the region of the comet's path.

b. Concept. S073 was to photograph the cometary debris when the Skylab vehicle passed through the comet's plane, on December 10, 1973. The hope was that this experiment, which studied low brightness sources, would enable an estimation of the comet particle distribution.

c. Hardware Description. Experiment S073 used a 35mm Nikon camera, the T025 canister, the S063 mounting adapter, and the S019 AMS mounted to the anti-solar SAL. The camera contained Kodak 2485 high speed black-and-white film.

2. Experiment Operations. Experiment S073 operations were performed three exposures in a session on December 10, 1973.

3. Constraints. There were no comet-peculiar constraints for S073.

4. Hardware Performance. Hardware appeared to perform satisfactorily during the mission. However, when the photographs were developed they were out of focus. The hardware performance is covered in reference [2] .

5. Experiment Interfaces. All experiment interfaces performed satisfactorily during the mission.

6. Return Data. Cassette BV 44 was returned for evaluation.

7. Anomalies. All exposures taken with camera NK02 were out of focus.

D. S183 - Ultraviolet Panorama

The Principal Investigator for Experiment S183 is Dr. George Courtes, Laboratoire d'Astronomie Spatiale, Marseilles, France. The Experiment Developer was the Centre National d'Etudes Spatiale, Laboratoire d'Astronomie Spatiale, Marseille, France (Mr. A. Magnan, Integration Engineer).

1. Experiment Description

a. Objectives. The scientific objective was to obtain ultraviolet, broad bandpass photographic photometry of the coma and tail at 1878 Å, 2558 Å, and 2970 Å. This data was to enable understanding of production rates, spatial distribution, lifetime and the effect of OH in the coma.

b. Concept. OH emission data from S183 and other experiments (S019, S063, T025) combined with the H Lyman-alpha emission data obtained by S201 and S082B of various heliocentric distances were to provide data on the amount of water, ice or snow in the comet. The S183 equipment had the special advantage of using a Fabry lens system which allowed high sensitivity microphotometry of the wavelength region under study.

c. Hardware Description. The S183 Spectrograph Assembly (SA) was a broad-band photographic photometer that measured the color indices of stellar objects in the field-of-view. Two SA bandpasses were approximately 635 Å wide and were centered at 1878 Å and 2970 Å. A third direct photographic record at 2560 Å was obtained by using the Skylab Maurer 16mm camera and a type 103a0 UV-sensitive film. The S019 AMS was used to view the comet.

2. Experiment Operations. S183 experiment operations for viewing the comet differed from the stellar observations only in maneuvering the vehicle.

3. Constraints. The experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [2].

5. Experiment Interfaces. Experiment interfaces are covered in reference [2].

6. Return Data. Carrousels 1-1 and 2-2, and one data acquisition camera (DAC) 140 ft. magazine were returned for evaluation.

7. Anomalies. None of the carrousel 1-1 or 2-2 cometary plates were exposed, due to hardware problems.

E. S201 - Far-UV Electronographic Camera

The Principal Investigator is Dr. Thorton L. Page, Naval Research Laboratory (NRL), Washington, D.C.; Dr. George R. Carruthers, NRL, is a co-investigator. The experiment developer was NRL.

1. Experiment Description

a. Objectives. The scientific objectives were to obtain H Lyman-alpha and atomic oxygen emission imagery of the coma.

b. Concept. Data from the far-ultraviolet camera was to be studied to understand the growth and structure of the hydrogen halo with heliocentric distance and the atomic oxygen production rate and distribution.

The data was to be provided through analysis of photographs with bandpasses of 1050-1600 and 1230-1600 Å. The S201 equipment had the special advantage of being designed for H Lyman-alpha emission imagery, having been used on the lunar surface for galactic and geocorona photography. The large FOV allowed the largest structure of the coma produced by the most abundant atom to be photographed.

c. Hardware Description. The sensor optics consisted of an f/1 Schmidt camera mounted in a pressure vessel, which permitted both anti-solar SAL and EVA operation. The instrument had an FOV of 20 degrees. The FOV was reduced to 7 degrees when used with the S019 AMS.

A cutaway view of the basic sensor is shown in figure 6. Far-UV exposures were made through a lithium fluoride filter-corrector plate and alternately through a calcium fluoride filter. The optical image was formed on a potassium bromide photocathode which generated photoelectrons. A -25 kV potential accelerated them toward 35mm special order nuclear-track emulsion (Eastman Kodak Film NTB-3). Between the cathode and the film, a strong axial magnetic field cylinder focused the electrons, which passed through a thin, light proof membrane just ahead of the film. Corrector plate selection, film advance and exposure times were semiautomatically controlled. In a complete sequence, the lithium fluoride plate was selected first and exposures of 1, 2.5, 6 and 15 seconds obtained, yielding H Lyman-alpha imagery. Next, the calcium fluoride plate was selected and 3, 10, 30 and 107 second exposures were taken yielding atomic oxygen imagery. There was no shutter, so each of the eight exposures started and ended with a film advance. The total time required for this sequence was 205 seconds. It could be interrupted at any point by the astronaut pressing the start switch. An option also existed to obtain an exposure after the 107 seconds elapsed through the CaF_2 filter by waiting for the desired time and then pressing the start switch.

2. Experiment Operations. The camera interfaced with the S019 AMS and anti-solar SAL. The spacecraft was rolled up to 90 degrees about the longitudinal axis and the AMS was aligned for comet observations. At each pointing a sequence was performed to obtain the desired number of comet images.

In the EVA mode, the crewman would attach the S201 to the ATM truss using a modified S020 mounting bracket and point the camera at the comet using an integral sight. A vehicle roll about the longitudinal axis up to 16 degrees during pre-perihelion and up to 45 degrees post-perihelion was utilized to put the camera in the ATM solar panel shadow. This was required during EVA operations while the spacecraft was in sunlight and the comet was near perihelion.

S201 was operated fourteen times and obtained 108 exposures.

3. Constraints. The experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [1] .

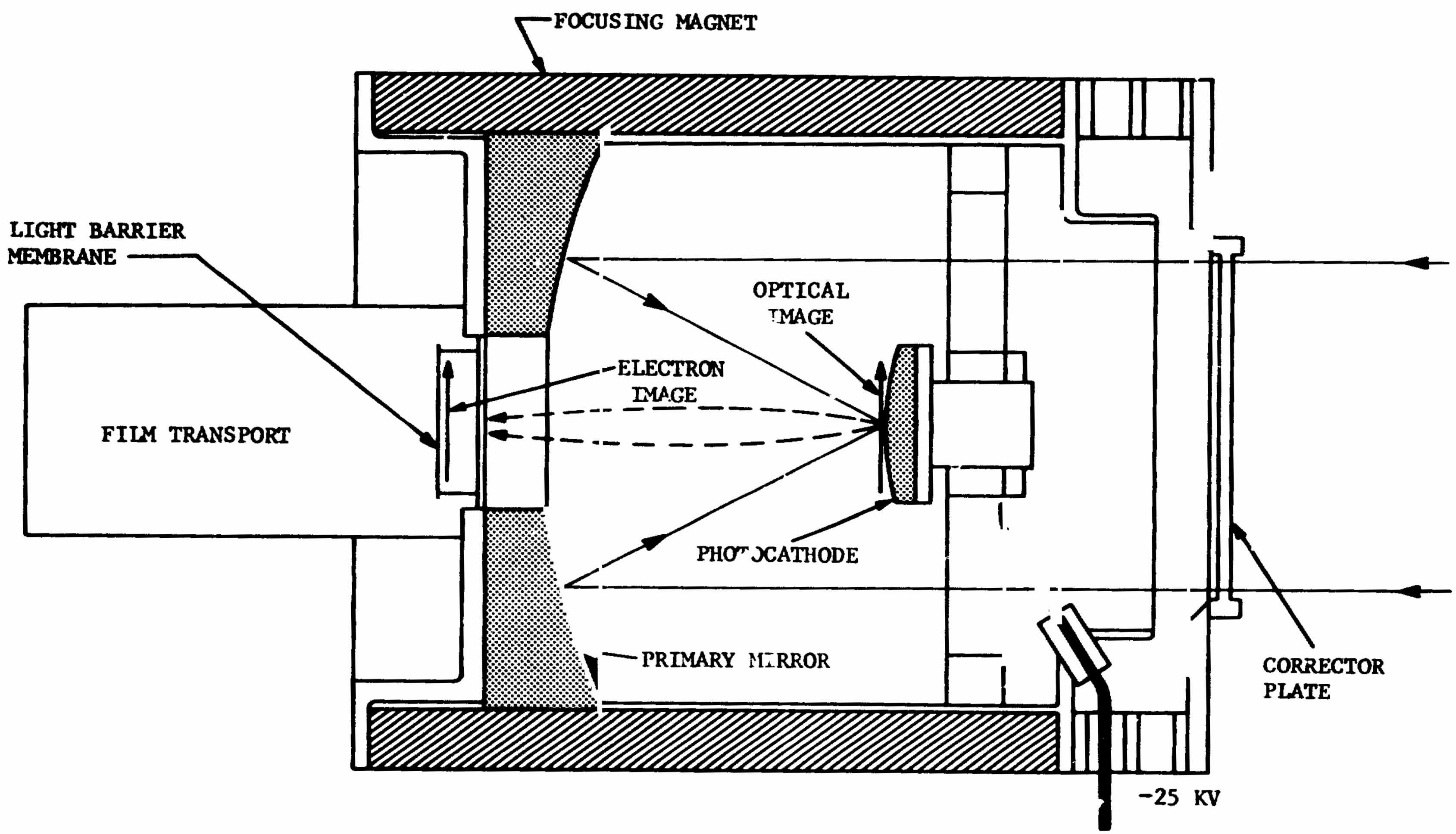


FIGURE 6. S201 FAR UV CAMERA

5. Experiment Interfaces. Experiment interfaces are contained in reference [1] .

6. Return Data. Film transports 1, 2, and 3 were returned.

7. Anomalies. The PI reported 500 frames were exposed on 3 rolls of film, and that the film advance mechanism was advancing more frames than indicated, such that no available film remained in the camera when the second EVA took place on Dec. 29, 1973. He further noted water damage to film which caused fogging, a reduction in camera sensitivity caused by coronal discharge of the photocathode, and graininess to the film in transport #3. Description of these anomalies is contained in reference [1] .

F. S233 - Kohoutek Photometric Photography

The Principal Investigator for Experiment S233 is Dr. Charles Lundquist, Director of the Space Sciences Laboratory (SSL), MSFC, Huntsville, Alabama. Co-investigators are Mr. Ray V. Hembree, Assistant Director of the SSL and Mr. Paul D. Craven, SSL.

1. Experiment Description

a. Objectives. The objectives were to obtain a series of visible light photographs suitable for photometry and to provide a photographic history of the comet.

b. Concept. Emphasis was to be placed on the use of defocused photographs of starfields and the comet coma to obtain calibrated photometric data. These photographs were to be made with specified focus settings of the camera lens (15 ft.). The defocused star images for which magnitude and spectral type are known, were to serve as a total optical system absolute calibration, including the window, scattered light, etc.

Long duration in-focus exposures were to be taken as part of the observational sequence to record as much tail structure as possible. Previous and/or subsequent out-of-focus starfield photographs were to provide calibration for these in-focus photographs.

The photographs were taken twice each day, when possible, to provide a more frequent and uniform photographic record of the comet than was possible from any single earth-based observatory.

c. Hardware Description. Photographs of the comet and starfields were taken with an operational 35mm Nikon Camera using the 55mm focal length lens. The camera has a focal range from 2 feet to infinity, an aperture range from f/1.2 to f/16 and a 43 degree field-of-view across diagonals.

2. Experiment Operations. Photographs were taken through the Structural Transition Section (STS) and Command Module (CM) windows (STS 242 (S-4), STS-243 (S-3) and CM-1). The experiment was operated on 73 separate occasions and obtained 240 exposures.

3. Constraints. The experiment constraints were satisfactorily met except that:

Some sessions did not inhibit momentum dumps (IMD);

Some photographs extended into sunrise;

Two performances were not scheduled on some days;

Some photos did not use remote cable release; and the

Requirement to stow film in the vault between performances was waived.

The control moment gyro, CMG #1 loss caused momentum management problems and reordering of priorities for IMD.

The photographs taken without the remote cable release were handheld since the S073 experiment was also using the remote cable release.

The camera installation at the window required approximately 30 minutes of crew time. Camera stowage in the film vault after each use would have required excessive installation time for the next operation. Radiation problem analysis indicated that the loss of film sensitivity would not be serious, if the film remained in the operational position. Therefore the requirement was waived.

4. Hardware Performance. The Nikon camera performed satisfactorily while mounted at CM-1, STS-242 (S-4) and STS-243 (S-3) windows.

5. Experiment Interfaces. There was no formal interface control documentation. However, the astronauts taped the camera to a rotatable mirror structure over the CM-1 window and improvised cardboard to tape the camera in place at the STS-242 and STS-243 windows.

6. Return Data. The four exposed cassettes of 35mm film were returned.

7. Anomalies. Anomalies experienced were not of a catastrophic nature and the experiment operations continued following them. The problems were one double exposure, excessive background lighting from moon or sun, and smearing or loss of exposures due to pointing in the wrong direction.

G. T025 - Coronagraph Contamination Measurements

The Principal Investigator for Experiment T025 is Dr. Mayo Greenberg, Dudley Observatory, Albany, New York. The experiment developer was Martin Marietta Aerospace, Denver, Colorado.

1. Experiment Description

a. Objectives. The scientific objective was to obtain ultraviolet and visible bandpass photography of the coma and tail near perihelion.

b. Concept. The data was to be studied to understand the particulate production rates and spatial distribution and the production and distribution of OH, CN, C_2, Na, NH, CO^+ molecular components of the coma and tail.

This data was to be obtained through a set of selected filters which were centered on desired emission line wavelengths. The T025 equipment was ideally suited to photograph Comet Kohoutek for a nine-day period centered on the time of minimum elongation. The scientific benefit of near-perihelion imagery was important in that the solar radiation pressure, solar wind, and solar tidal forces were acting on the head and tail of the comet. Photographs of the comet's reactions to these forces could help determine their magnitude and time scale interaction.

c. Hardware Description. The experiment canister assembly, (see figure 7.) in its original design configuration at the SAL, was used to house the occulting disc assembly and the view window. The quartz view window provided the interface between the space environment and the camera lens. It permitted light passage down to approximately 1800 Å. The occulting disc assembly was used to occult the solar disc. The extension boom assembly served to extend the occulting disc assembly.

A Nikon camera with the UV lens and a filter holder was inserted. The UV lens focal length adapter allowed hard focusing down to 28 inches. The neutral density filter was inserted during direct sighting on the sun.

The hardware was modified for EVA sequences. These modifications included changing the T025 occulting disc and the addition of an EVA mount (see figure 8.). T025 filters, which were contained in four filter holders A, B, C and D, are shown in table VI.

2. Experiment Operations. T025 was performed for ~ 50 minutes on December 25 and December 29 during the daylight portion of the EVAs taking 40 exposures each time.

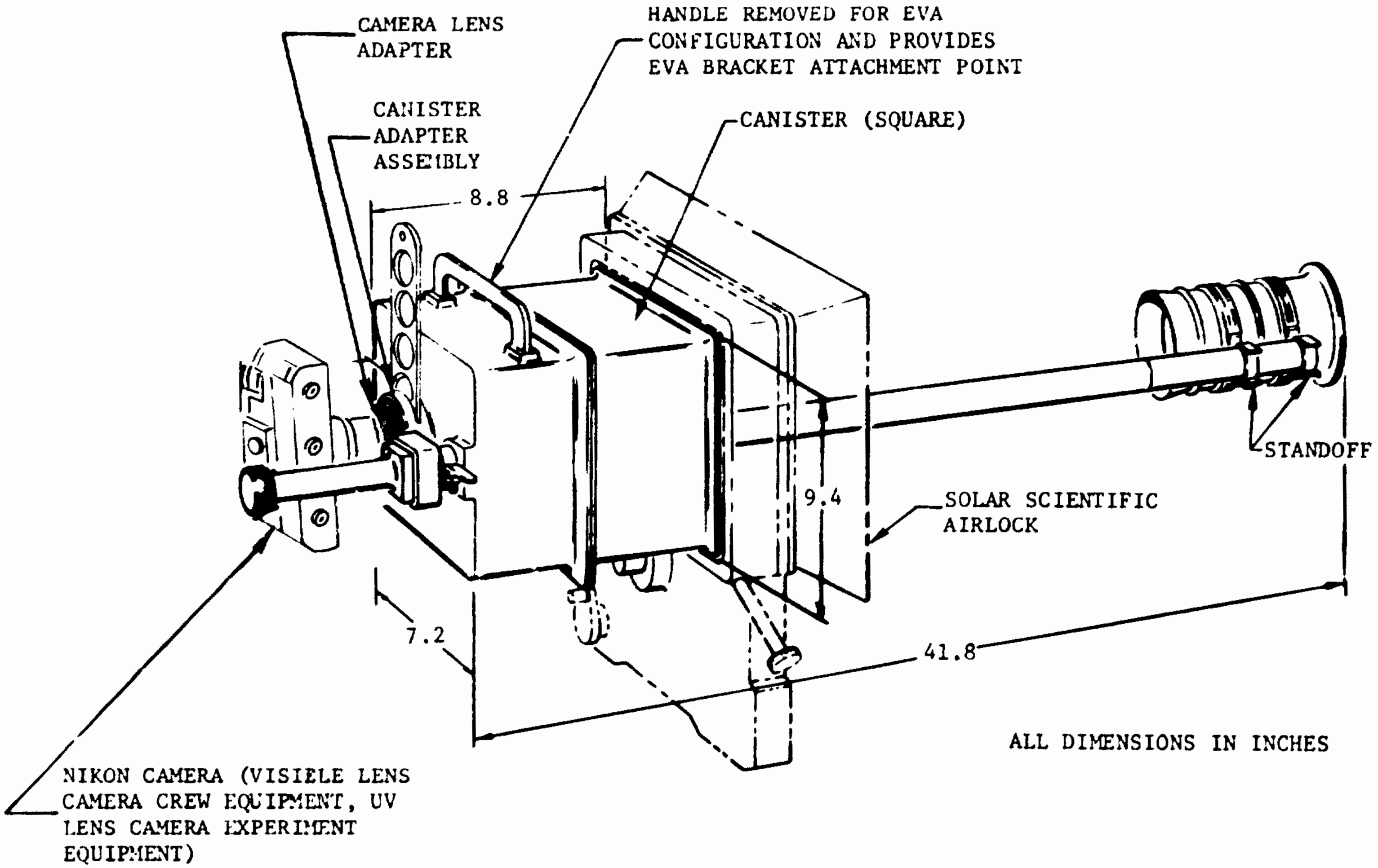


FIGURE 7. CORONAGRAPH CONTAMINATION MEASUREMENT ASSEMBLY IN SAL

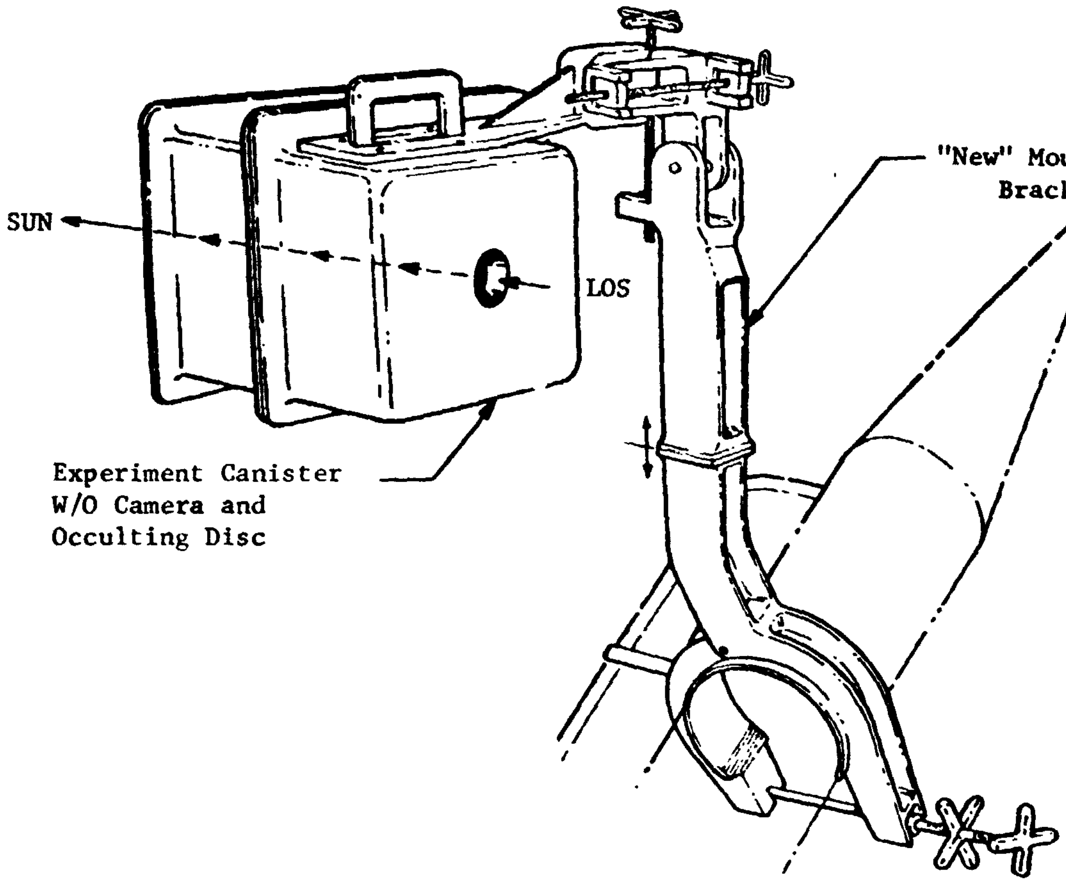


FIGURE 8. T025 MOUNTING BRACKET

Table VI. T025 Filter Characteristics

Filter	Filter No.	Wavelength Å	Bandpass Å
1	A2	2530	11[illegible]
2	B2	2800	200
3	C3	3100	60
4	B1	3250	60
5	A4	3361	30
6	A3	3600	200
7	C1	3873	30
8	D2	3940	30
9	D1	4262	20
10	B3	4430	100
11	C2	4700	60
12	D3	4900	60
13	B4	5500	200
14	D4	5890	30
15	C4	6000	1 Short pass
16	A1	Blank	

The pointing was acquired using a new occulting disc with a special long pass 6000 Å filter mounted in the center to allow the astronaut to view the sun.

3. Constraints. The experiment constraints were successfully met during the mission.

4. Hardware Performance. Hardware performance is in reference [1].

5. Experiment Interfaces. Experiment interfaces are contained in reference [1].

6. Return Data. All T025 film used for the comet was returned.

7. Anomalies. None of the T025 comet photos were in focus due to a focusing problem with Nikon camera NK02.

H. S052 - White Light Coronagraph

The Principal Investigator for Experiment S052 is Dr. Robert MacQueen, High Altitude Observatory, Boulder, Colorado. The experiment developer was Ball Brothers Research Corporation, Boulder, Colorado.

1. Experiment Description

a. Objectives. The scientific objectives were to obtain:

Polarization and morphological variation of the coma and tail at minimum elongation (1 day before perihelion);

Measurement of the solar wind at the comet and

Observations of coma and tail, pre- and post-helion.

b. Concept. Data to be obtained would provide the comet density structure and its evolution over a several week period, and provide determination of the comet tail mass changes near the perihelion passage. Fluctuations in the solar wind could produce changes in the comet's tail. Observations of these changes could provide information on the solar wind propagating past the comet at 30 solar radii, in a region inaccessible to earth-orbiting solar wind probes. The S052 equipment had the advantage of being a visible (3500 to 7000 Å) solar coronagraph operating outside of the Earth's atmosphere, which provided high contrast photography, when the comet was near the sun.

c. Hardware Description. The S052 coronagraph was designed to block the sun's disc image (see figure 9.) and to take pictures of the faint corona which extends from the sun far into space. Light scattering by optical elements and by structural surfaces was carefully avoided. The instrument contained four coaxial occulting discs and photodetectors for alignment corrections. Pictures were recorded on film and were taken either in polarized or unpolarized light. The instrument operated in a video mode which permitted display for the astronauts or TV transmission to the ground. The data was recorded on 35mm film. The ATM experiments' arrangment in the canister is shown in figure 10.

2. Experiment Operations. Three automatically-programmed film-exposure modes were used. The standard (STD) mode, exposed a set of 9, 27, and 3-second frames in each of three polaroid filter orientations and in one clear (non-filtered) position in a 5.5 minute automatic operation. The continuous (CONT) mode exposed a set of 9, 27, and 3-second frames every 82.5 seconds until stopped. The FAST SCAN mode used the clear (unfiltered) position and took 72 frames of 27, 3, and 9-seconds for 16.2 minutes duration.

3. Constraints. The experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. The hardware performance is covered in reference [3] .

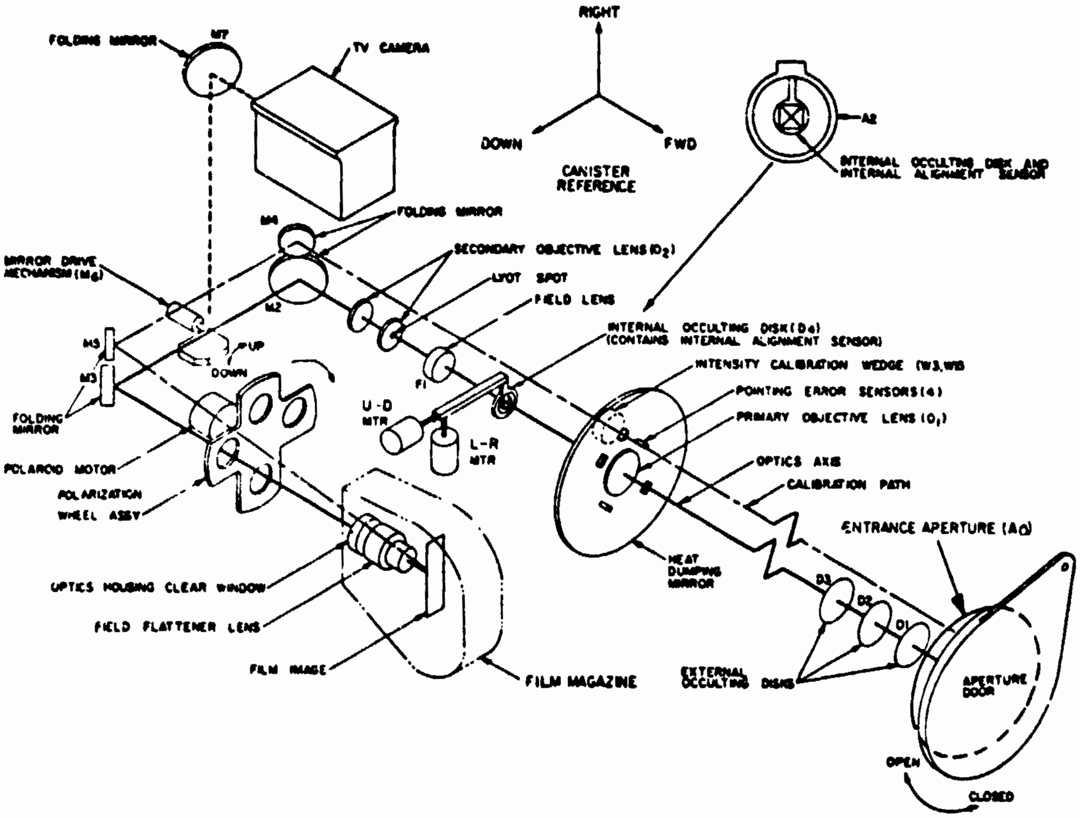


FIGURE 9. S052 CORONAGRAPH

SOLAR NORTH

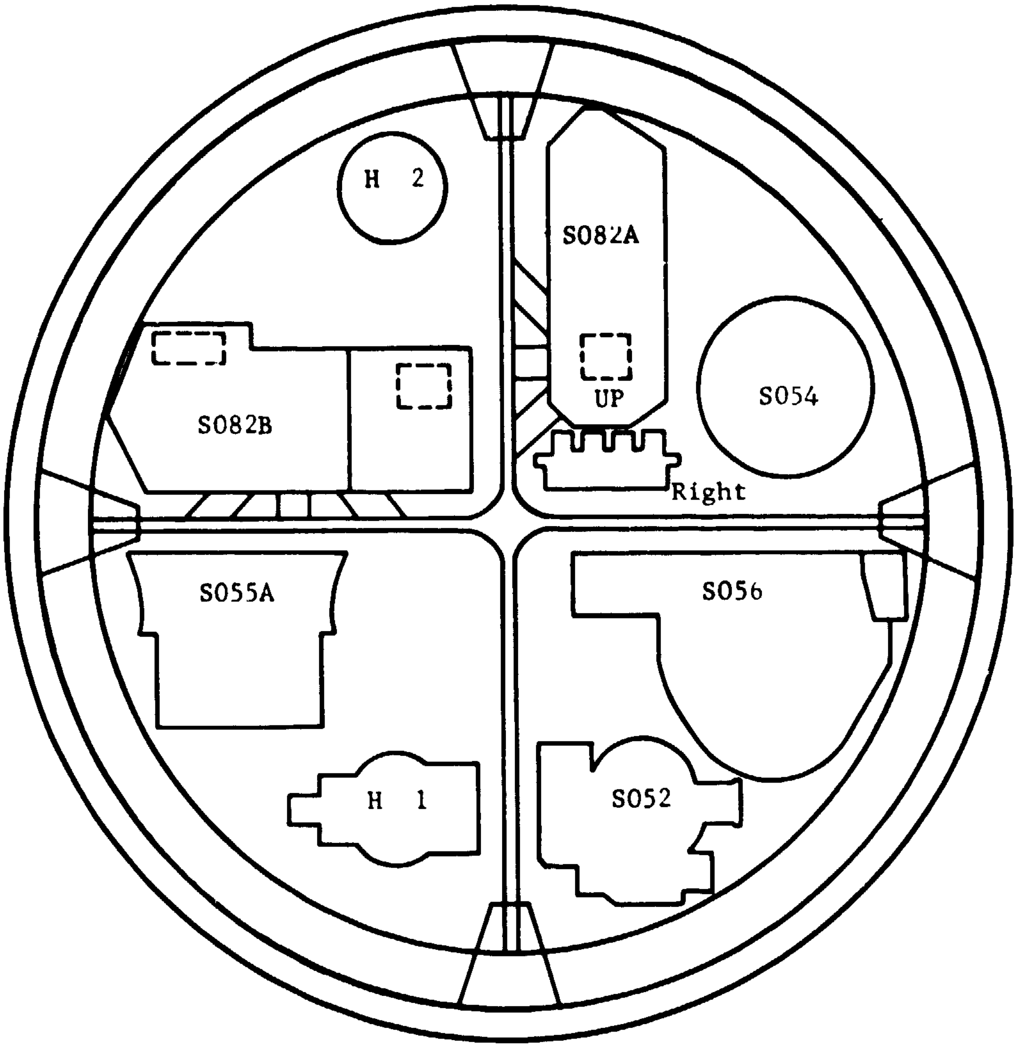


FIGURE 10. ATM CANISTER, EXPERIMENT ARRANGEMENT

5. Experiment Interfaces. Experiment interfaces are in reference [3] .

6. Return Data. All the comet-related S052 exposed film was returned for data evaluation (~1600 exposures).

7. Anomalies. No major operational problems were experienced while viewing the comet.

I. S054 X-Ray Spectrographic Telescope

The Principal Investigator for Experiment S054 is Dr. G. Vaiana, American Science and Engineering, Inc. (AS&E), Cambridge, Massachusetts. The experiment developer was AS&E.

1. Experiment Description

a. Objectives. The scientific objectives were to obtain X-ray absorption spectra of the comet tail and X-ray fluorescence imagery of the coma.

b. Concept. The data to be obtained is expected to reveal the total mass density along the line-of-sight of medium weight elements (such as carbon, nitrogen, and oxygen). A cross-section computation of the tail could be computed if the tail passed in front of an x-ray source by measuring the absorption as a function of position. X-ray fluorescence from the comet, during high solar activity periods, may provide an image of the head in soft x-rays. A slitless x-ray spectrum could provide concentration of such elements as Si, Al, Mg, O, and possibly C. The observations were unique and exploratory in nature.

c. Hardware Description. The experiment configuration (see figure 11) consisted of an x-ray spectrographic telescope and a camera.

The x-ray spectrographic telescope optics section consisted of two concentric grazing-incidence mirrors. This nested configuration provided an increased mirror aperture for collecting x-ray energy.

The grazing incidence optics central area was used for x-ray alarm and astronaut TV sensing.

Directly behind the grazing incidence optics, there was a transmission grating that produced x-ray spectroheliograms to control the amount of x-ray energy at the camera. The grating could be moved out of the optical path when desired.

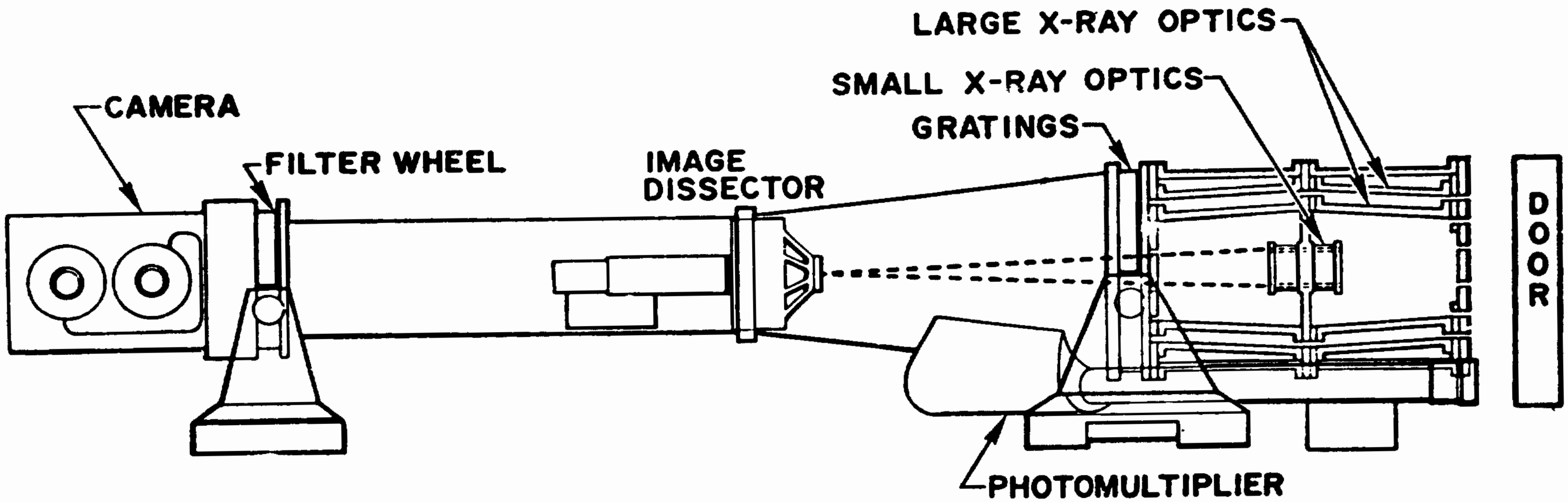


FIGURE 11. S054 X-RAY SPECTROGRAPHIC TELESCOPE

The telescope was equipped with a 70mm camera. Exposure time of the camera was variable from 1/64 to 256 seconds.

2. Experiment Operations. S054 was operated pre- and post-perihelion, with its operating incidence highest while the comet was near perihelion on the far side of the sun in anticipation of detecting x-ray fluorescence from cometary material.

3. Constraints. The experiment constraints were successfully met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [3] .

5. Experiment Interfaces. Experiment interfaces are contained in reference [3] .

6. Return Data. All the comet-related S054 exposed film was returned for data evaluation.

7. Anomalies. No major operational problems were experienced while viewing the comet.

J. S055 - UV Scanning Polychromator - Spectroheliometer

The Principal Investigator for Experiment S055 is Dr. Edward M. Reeves, Harvard College Observatory, Cambridge, Massachusetts. The experiment developer was Ball Brothers Research Corporation, Boulder, Colorado, under contract to Harvard College Observatory.

1. Experiment Description

a. Objectives. The scienfic objectives were to obtain:

High resolution ultraviolet maps of the coma near perihelion;

Spectral scans of C, N, S, and H_2 and

Lyman-alpha emission with S201.

b. Concept. The data to be obtained would provide information on the hydrogen emission simultaneously in H-Lyman-alpha -beta, and -gamma lines and the Lyman continuum giving data on the comet's hydrogen halo radiance. Molecular systems of other neutral and ionized species have bands in the extreme ultraviolet below the 1350 Å upper limit of the S055 instrument. The observations could complement ground based cometary observations in determing structure and excitation mechanisms. The cometary nucleus spectra could yield unexpected new lines in the region 296 Å to 1350 Å, in addition to the expected data from lines such as Lyman-alpha, and -beta O(I) (1350 Å) and C(II) (1335 Å).

c. Hardware Description. The optical schematic of the UV scanning polychromator spectroheliometer is illustrated in figure 12. An off-axis paraboloidal primary mirror formed a solar image on the 56 micron by 56 micron entrance slit of the spectrometer, corresponding to a five arc-seconds by five arc-seconds area on the target. Diffraction by a concave grating, ruled in gold with 1800 grooves per mm, produced a spectrum on the Rowland circle where seven photomultiplier detectors in fixed positions, simultaneously recorded the intensities of the six lines and the Lyman continuum. The primary mirror bi-axial motion generated a mirror auto raster (MAR) scanning pattern (polychromator mode) of five arc-minutes by five arc-minutes. The MAR scan took 5.5 minutes. In the grating auto scan (GAS) mode, the primary mirror remained fixed while the grating was tilted to scan the entire operating spectrum past one or more photomultiplier detectors. One GAS required 3.8 minutes. The signals from the detectors were transmitted to the ground by telemetry. The detector characteristics are listed in table VII.

TABLE VII. DETECTOR CHARACTERISTICS

Detector	Spectral Line	Wavelength (Å)	Steps from Det 1
1	C (II)	1335	0
2	HLyα	1216	568
3	O (VI)	1032	1436
4	C (III)	977	1696
5	HLy	896	2079
6	MG (X)	625	3358
7	O (IV)	554	3692

2. <u>Experiment Operations</u>

a. Mirror Auto Raster Near Sun. During the mission all seven detectors or selected detectors were chosen for this mode. The particular grating position selected was used to position the wavelength of primary interest at the opening to detector 1, to establish a reference. See table VII for grating positions vs wavelengths.

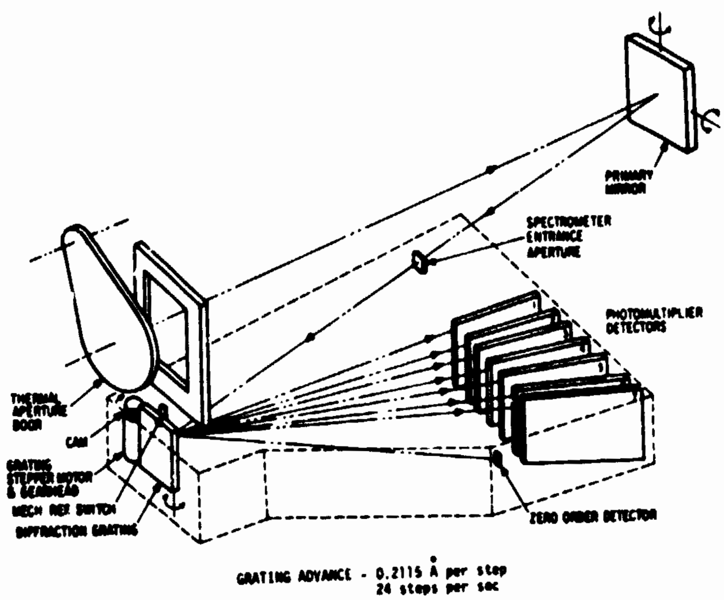


FIGURE 12. S055 OPTICAL SCHEMATIC

b. Grating Auto Scan. These modes were used while the vehicle was in the solar inertial mode or offset from the sun. The S052 display and the S055 counter display were used to assist pointing S055 and S082B at the comet.

3. Constraints. The experiment constraints were successfully met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [3] .

5. Experiment Interfaces. Experiment interfaces are contained in reference [3] .

6. Return Data. All data was telemetered to the ground during the mission.

7. Anomalies. No major operational problems occurred during the mission.

K. S056 - X-ray Telescope

The Principal Investigator for Experiment S056 is Mr. James E. Milligan, MSFC, Huntsville, Alabama. The experiment was developed by the MSFC.

1. Experiment Description

a. Objectives. The objective was to observe x-ray fluorescence and brehmstahlung radiation in the 2 to 33 Å range when excited by solar x-ray activity. The observations were unique and exploratory in nature.

b. Concept. The S056 experiment was to photograph any soft x-ray fluorescence of cometary material following the onset of x-ray activity as detected by the X-ray event analyzer.

c. Hardware Description. The experiment schematic layout is illustrated in figure 13. The experiment is comprised of two different instruments:

A grazing incidence x-ray telescope to photograph x-ray images of the comet in the spectral region (5 to 33 Å) on 35mm film.

An electronic x-ray event analyzer to analyze the spectrum between 2 and 20 Å by means of gas filled proportional counter tubes; tube output is telemetered to ground.

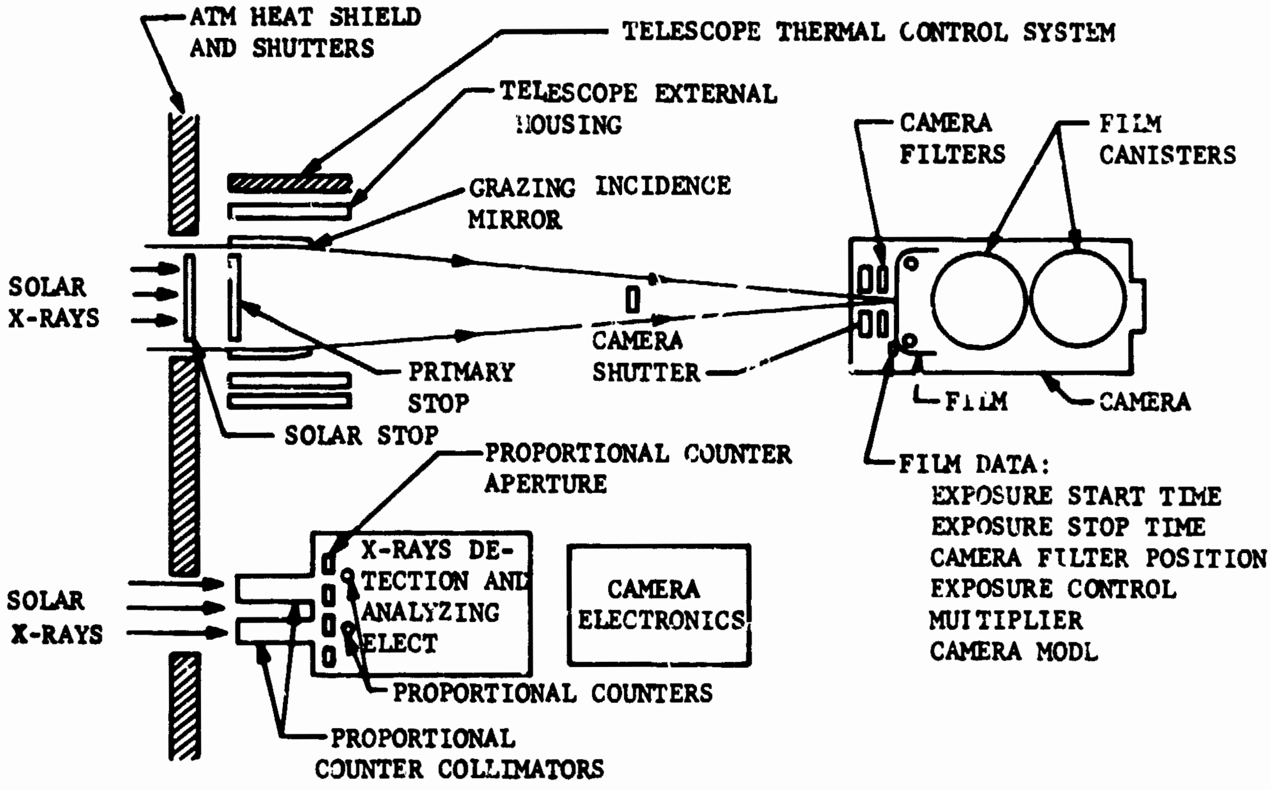


FIGURE 13. S056 SCHEMATIC

2. Experiment Operations. S056 performed long exposures, pre- and post-perihelion, with its incidence of operation highest, while the comet was near perihelion on the far side of the sun.

3. Constraints. The experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [3] .

5. Experiment Interfaces. Experiment interfaces are contained in reference [3] .

6. Return Data. All film associated with cometary exposures was returned for data evaluation.

7. Anomalies. No major operational anomalies were experienced.

L. S082A - XUV Spectroheliograph

The Principal Investigator for Experiment S082A is Dr. Richard Tousey, Naval Research Laboratory, Washington, D.C. The experiment was built by Ball Brothers Research Corporation, Boulder, Colorado, under contract to NRL.

1. Experiment Description

a. Objective. The scientific objectives were to obtain monochromatic images of the extended comet source in the 150 Å to 625 Å range at minimum elongation. The major resonance lines of neutral and ionized helium at 584 Å and 304 Å and ionized oxygen at 539 Å were the prime candidates for study.

b. Concept. The data to be obtained could provide important information about the comet chemical composition and the ratio of helium to hydrogen. The imagery to be obtained could provide information of the solar radiation and solar wind effects on the comets. Due to sensitivity, this experiment is exploratory with little expectation for obtaining any comet data.

c. Hardware Description. The spectroheliograph optical system is illustrated in figure 14. The spectroheliograph entrance aperture permitted the spherical concave diffraction grating to view the entire sun. The grating diffracted image into its spectral components. However, as a spherical mirror it also focused the diffracted images onto the film strip. The resulting photograph was a series of pictures in different wavelengths.

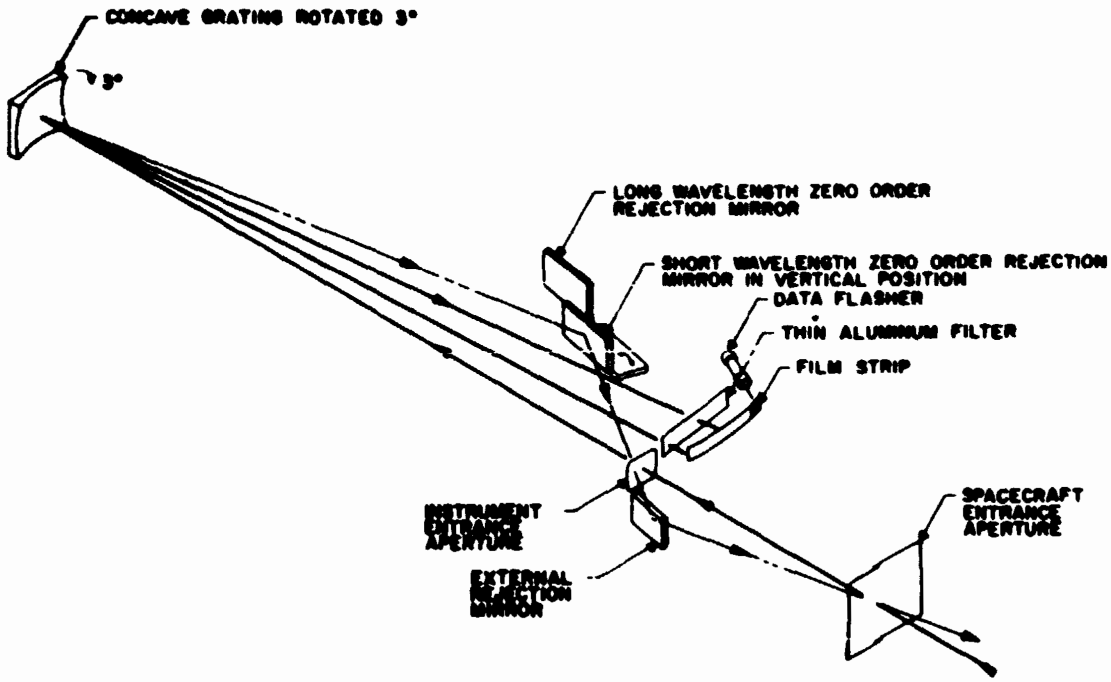


FIGURE 14. S082A OPERATIONAL SCHEMATIC

The ge. ·:ric field-of-view was 56 arc-minutes. accommodate the desired spe. .rum width on the film strip, the diffraction grating was rotated through an angle of three degrees. This rotation focused either the short wavelength, 150 to 335 Å, or long wavelength 321 to 625 Å, bands on the film strip.

2. Experiment Operations. The experiment obtained five frames of data on December 27 near the comet's minimum elongation.

3. Constraints. All experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [3].

5. Experiment Interfaces. Experiment interfaces are contained in reference [3].

6. Return Data. The S082A comet-related film was returned for evaluation.

7. Anomalies. There were no anomalies associated with S082A's operations.

M. S082B Ultraviolet Spectrography

The Principal Investigator for Experiment S082B is Dr. Richard Tousey, Naval Research Laboratory, Washington, D.C. The cometary science co-investigator is Dr. Horst I. Keller, University of Colorado, Boulder, Colorado. The experiment was built by Ball Brothers Research Corporation, Boulder, Colorado under contract to NRL.

1. Experiment Description

a. Objectives. The scientific objectives were to obtain:

H Lyman-alpha profile and intensity,

Deuterium Lyman-alpha profile and intensity,

Spectral intensities of the atomic and molecular emission lines over the wavelength range of 970 to 3940 Å.

b. Concept. The data obtained is to be analyzed to determine if metallic, diatomic, and polyatomic emission lines were recorded, thus providing unique comet chemical composition data. The spectral resolution could allow analysis of line profiles to determine temperature and pressure. The spatial resolution could allow analysis for solar radiation and solar wind effects, and the ionization and decay rates of the observed constituents. The equipment had the special advantage of being able to obtain high resolution spectrography in the ultraviolet region of particular interest to cometary science.

c. Hardware Description. An experiment optical system schematic is illustrated in figure 15. A predisperser grating assembly with two gratings generated a light beam containing the desired wavelength regions. The main grating, a concave mirror ruled at 600 grooves per mm, was to produce a spectrum on photographic film with a resolution of 0.08Å in the 970 to 1970 Å range and a resolution of 0.16 Å in the 1940 to 3940 Å range. The entrance slit admitted light from a two by 60 arc-seconds area on the sun.

2. Experiment Operation. The experiment observed the comet both pre-, near, and post-perihelion to map spatial structure changes. Exposures were taken in both the long and short wavelengths.

3. Constraints. The experiment constraints were satisfactorily met during the mission.

4. Hardware Performance. Hardware performance is covered in reference [3] .

5. Experiment Interfaces. Experiment interfaces are covered in reference [3] .

6. Return Data. All the comet-related S082B exposed film was returned for data evaluation.

7. Anomalies. No major operational problems were experienced.

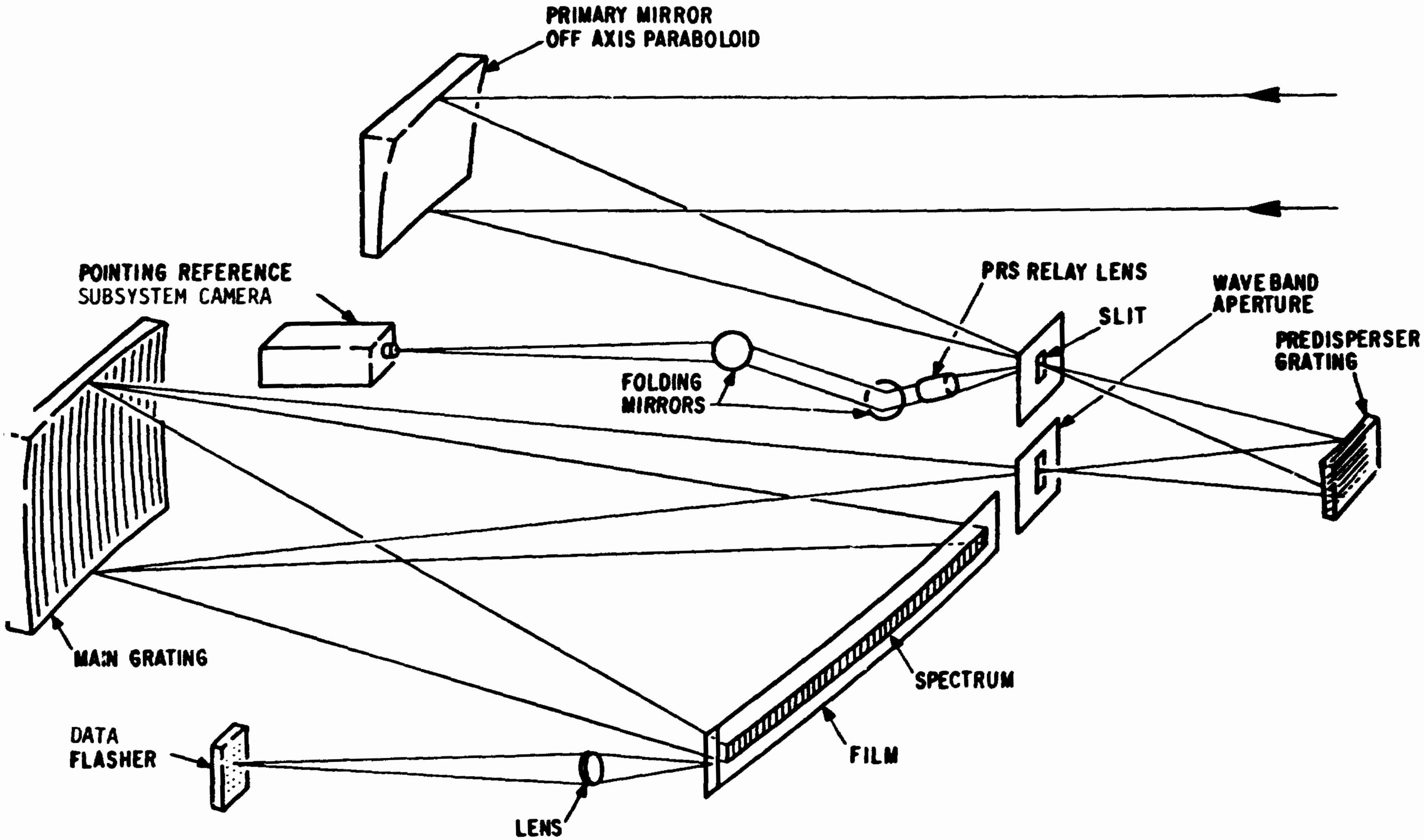


FIGURE 15. S082B OPTICAL SCHEMATIC

REFERENCES

1. JSC-08963, Skylab Mission Report, Third Visit. (In Preparation)

2. NASA TMX-64820, MSFC Skylab Corollary Experiments Systems Mission Evaluation Report. (In Preparation)

3. NASA TMX-64821, MSFC Skylab Apollo Telescope Mount Experiment Systems Mission Evaluation Report. (In Preparation)

APPROVAL

MSFC KOHOUTEK EXPERIMENTS
MISSION EVALUATION

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has been reviewed and approved for technical accuracy.

Henry B. Floyd
Henry B. Floyd, Manager
Experiment Development and
Payload Evaluation Project Office

Rein Ise
Rein Ise, Manager
Skylab Program Office