CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
LABORATOIRE D'ASTRONOMIE SPATIALE
TRAVERSE DU SIPHON - LES TROIS LUCS - MARSEILLE (12e)

TÉLEX : 42584 F
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"VERY-WIDE-FIELD CAMERA"

PROPOSAL OF
LABORATOIRE D'ASTRONOMIE SPATIALE
FOR SECOND SPACELAB MISSION

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Sponsoring team :

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TABLE OF CONTENTS

1. - INTRODUCTION :

Past and present astronomical satellites have been designed for the study of stellar spectra, but only of relatively bright stars. Only a few direct photographs have been obtained by Carruthers and Page (1976) (Apollo and Skylab programs), Henize et al. (1975) (Skylab), Courtès et al. (1975) (Skylab, and Faust rocket experiments). Some wide-fields in the Milky Way (120° x 80°) have been photographed by Viton in the near UV (2600 A) easily detecting the Milky Way and the Zodiacal light (figure 1) as well as stars up to the 10^{th} magnitude for O stars (Viton 1967; Sivan and Viton, 1970, 1972; Viton 1974).

In the visible, Schmidt-Kaler and Schlosser (1973), Sivan (1974) and Suyama (1976) have shown how powerful this wide-field method of observation is. Sivan (1974) has discovered several unexpected extended and faint H II regions, as well as the general extension of the diffuse emission of the spiral arms. Suyama has shown the true shape of the Gegenshein and its large ecliptic extension.

This new mean of observation - faster and easier to interpret than systematic spectral scanning of many points over a large field - with a constant comparison with a large part of the sky background and photometric reference stars, is certainly a very efficient instrument in the particular observing conditions of the Spacelab (large field available, and relatively poor stabilisation). Before starting any deep survey program, it would give a first evaluation of the most interesting large scale phenomena which have been entirely neglected up to now.

The general observing program of the very-wide-field camera (VWFC) with ∿60° field was discussed carefully during the Woods Hole Summer School and described in the document "Use of the Space Shuttle" published by the national Academy of Sciences in 1973.

2. - SCIENTIFIC PROGRAM :

2.1. Detection and photometry mode : Direct photograph with filters

2.1.1. Large scale distribution of UV radiation in the Milky Way. The stellar clouds have to be studied as a whole for their geometrical extension and their energetic spectral distribution.

2.1.2. Diffusion of the galactic light above the galactic plane, and in front of the large absorbing clouds. Detection of large extensions of the galactic material and possible connections with the local group of Galaxies. A general study of the sky background will enable a discrimination of the galactic and extragalactic lightfrom interplanetary dust scattering (Zodiacal light, Gegenshein).

2.1.3. Detection of the optical emission of the interstellar matter which has been up to now observed in very few cases.

2.1.4. Detection and photometry of stars, especially the peculiar UV objects found with TDI satellite (Carnochan et al., 1975) and star like objects $< 3'$ (galaxies, globular clusters) up to the 14^{th} visual magnitude at 1500 A for O-type stars. Very general measure of the UV turn up of Galaxies. For comparison the TDI satellite is limited to the 9^{th} magnitude for this kind of survey.

2.2. Spectrographic mode :

Objective grating spectra for stars and star-like objects at 300 A /mm. Wide field (10° x 0°.6) slit spectra of the interstellar matter.

2.2.1. Objective grating spectra of several thousand stars for obtaining their colour diagrams and comparison with theoretical models. The statistics will be extended up to the 11^{th} visual magnitude for an O type star at 1500 A .

FIGURE 1

First wide-field photograph obtained from VCN rocket launched 4th april 1967.

- Field 80° x 120°
- Exposure time 210 sec. Film 103 aO UV
- Aperture 5 mm F ratio 1.
- Wave lenght 2600 A

O stars were detected up to the 8^{th} magnitude and the general radiation of the Milky Way and the Zodiacal light (bottom right) down to a level of 3.10^{-8} erg $(cm^2 . s. strd. A)^{-1}$

Over-exposed : The Orion cluster (bottom centre).

2.2.2. Long slit spectra (10 x 0°.6) of extended sources. Emission lines and continuum situated in the center of the field will be obtained during the same exposure. It will be the first nebular space spectrography in this UV wavelength range. A similar ground based spectrographic survey (figure 2) has been successfully made in the Milky Way by Sivan (1976).

The proposed experiment permits a very general UV survey of a large part of the celestial objects. In this connection, it must be emphasized that in the last ten years several successful rocket-borne wide-field experiments have been performed by LAS, and the proposed VWFC project is the logical extension of those past experiments (Courtès 1971) which were designed to give good pictures of the sky despite the low accuracy of the available pointing systems, as will be the case for the first Spacelab mission (figure 3).

Complementary informations on programme 2.1. :

Galactic observations : A good general study of the Milky Way needs a very-wide-field, not only to guard against the photometric difficulties of an overly complex mosaic, but also to make the photometric measures easier and safer ; for example, it is absolutely necessary to obtain, on the same image, the Milky Way with the extragalactic sky background on both sides.

Isophotes of the Milky Way and the Zodiacal Light have been obtained under very good conditions with the same method. One will see that the proposed instrument is practically free of vignetting for extended objects ; thus the image of the Milky Way and the Zodiacal Light is not affected, as is often the case in conventional pictures. From such multicolour isophotes, the characteristics of dust scattering in reflexion and dark nebulae of the Milky Way will be known as a function of wavelength and geometry with respect to young star clusters.

Another advantage of this design is the possibility of using narrow band interference filters, because of the small field and small aperture of the entrance beams of the final camera.

Thus a general survey of H II regions will be undertaken in the different wavelengths of nebular lines that are presently expected in such regions - i.e., mainly the Mg II lines around 2 800 A, the C III lines around 1910 A, and the C IV lines at 1550 A. Other detectable nebular lines such as the strong lines of Si IV around 1400 A are expected from the theoretical models by Code (1960) and Osterbrock (1963). Some of these have probably been detected recently in the Cygnus Loop (Carruthers, 1976) during the Apollo 19 electronographic experiment on the Moon. In planetary nebulae, additional nebular lines are expected, such as the 1640 A line of He II which was recently observed by Bohlin et al. (1975) in NGC 7027.

Extragalactic observations : In the extragalactic range, although it is of some interest to search for nebular lines in nearby resolved or unresolved Galaxies, the main work will be devoted to the search of the so-called "UV-turnup" of the largest Galaxies like the Magellanic clouds, M 31 (Code et al., 1972 ; Deharveng et al., 1976 ; Maucherat and Cruvellier, 1976) and to a survey of a large statistical sample of this turn-up in the nearest clusters of Galaxies (see "star-like objects", below).

In the same area, and of great significance, will be the survey of intergalactic matter like the long filaments extending over more than 20° from the LMC, and any other phenomena of this kind relating to our Galaxy, such as the possible scattering by high latitude clouds predicted by van den Bergh (1968), or possible intergalactic bridges, intergalactic matter in clusters of galaxies, etc.

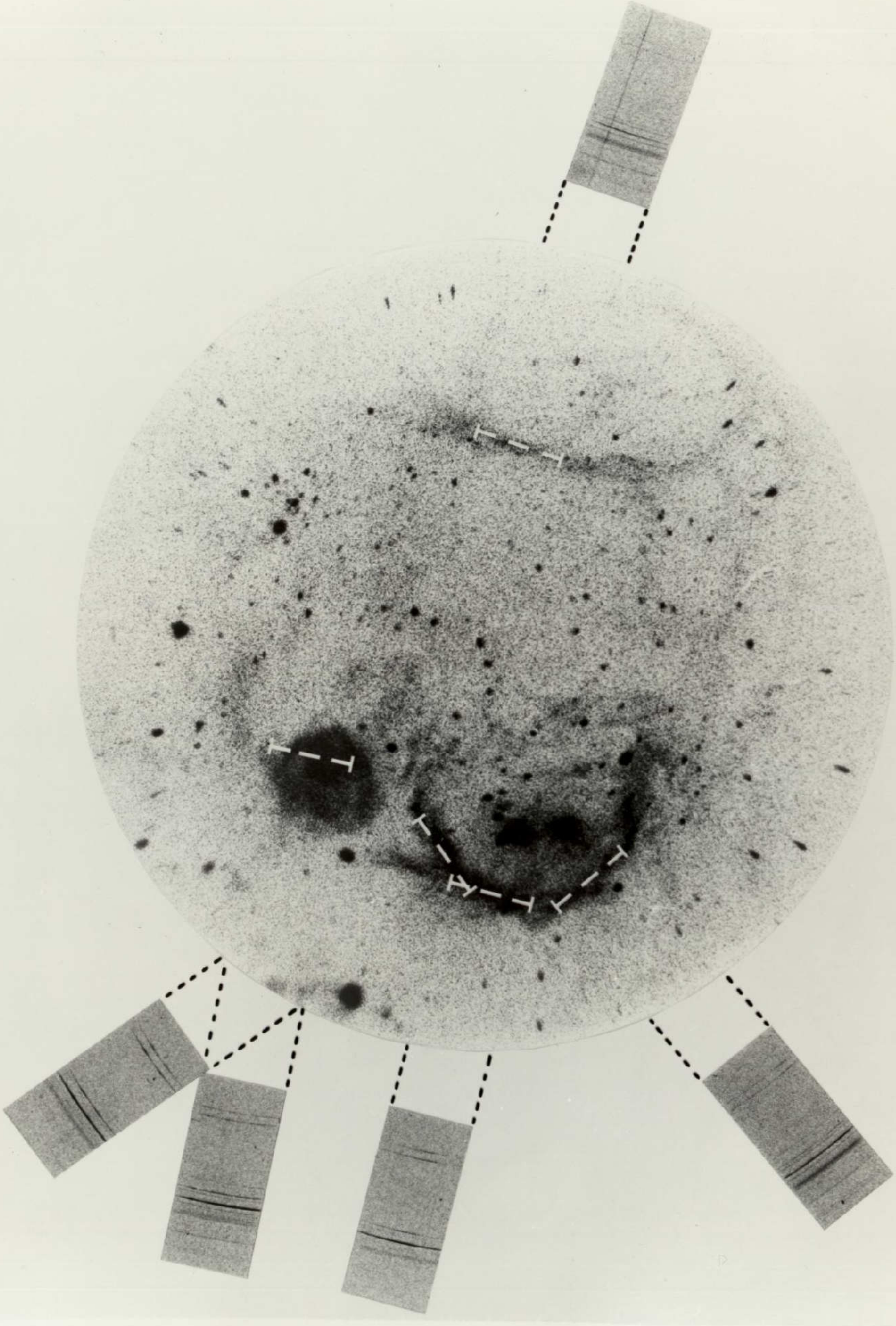
2.3. Stars and star-like objects ($\lesssim$ 3 arc minutes) :

In addition to the survey of UV turn-ups of the Galaxies and of the globular clusters in our Galaxy, a very large stellar program will be effected. Powerful

FIGURE 2

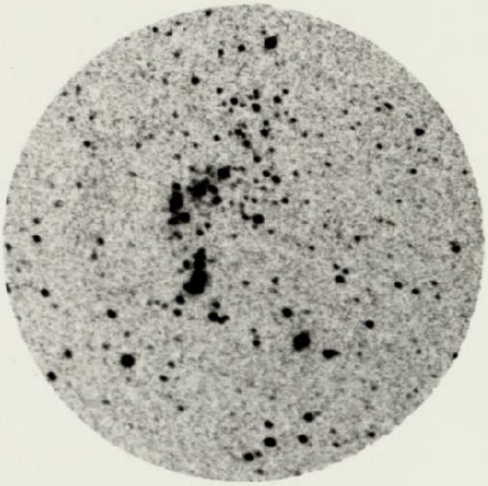
60° field f/0.7 $H\alpha$ photograph of the Orion - Cetus region, obtained with a wide-field, high spectral selectivity, camera (10 Å bandpass). This plate reveals new faint filamentary extensions to the Barnard Loop nebula (Sivan, 1974). Hatched lines indicate the projection on the sky of the slit of a spectrographic instrument, especially designed for the large-scale study of galactic emission regions (Sivan, 1976). The corresponding spectra are on the pourtour of the $H\alpha$ picture : $H\alpha$, [N II] $\lambda\lambda$ 6548, 6584 and [S II] $\lambda\lambda$ 6717, 6731 lines are recorded, within a 350 Å spectral range, with a mean linear dispersion of 50 Å mm^{-1} . The projected slit dimensions are 330 x 4 arc min.

Line intensity measurements are in agreement with the morphological unity of this large complex of $H\alpha$ emission revealed by the wide-angle monochromatic photograph.



PART OF AN ELARGEMENT OF WIDE FIELD OBTAINED FROM JANUS EXPERIMENT

λ 3350 A



Orion cluster from Janus camera.
Rocket experiment launched 7.12.1972

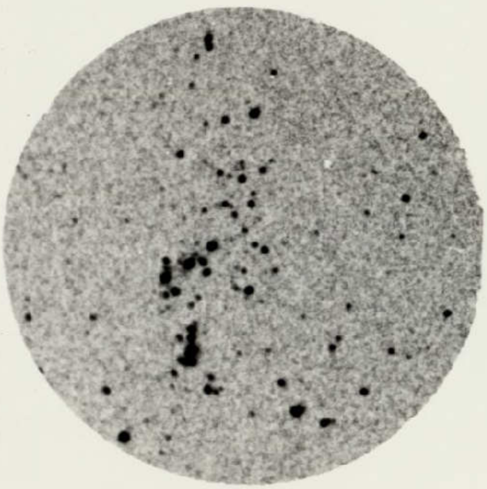
Exposure time	147 sec.
Plate without intensifier	103 aO Kodak
F ratio	1,35
Aperture	5 mm
Focal distance	5,73 mm

λ 3350 A - Limit magnitude V = 10,5 O star

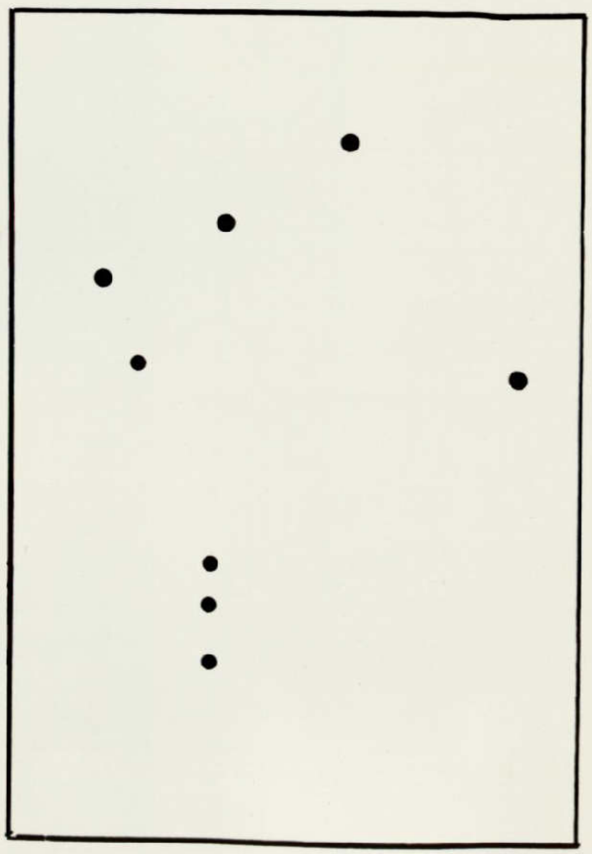
λ 2650 A - Limit magnitude V = 9 O star

Diameter of the elarged field 23°
Orion nebula and IC 434 are detected as well as the Barnard Loop.

λ 2650 A



×5



Expected scale for VWFC

F ratio	1,9
Aperture	15 mm
Focal distance	29 mm

The VWFC will give an image five times larger than the Janus rocket experiment.

(From Courtès et al. Phil. Trans. R. Soc. Lond. A 279-401, 1975)

Figure 3

statistical studies will be made of the distribution of interstellar reddening, and of colour diagrams and their comparison with theoretical model atmospheres.

But of particular interest will be the survey of very active objects like the T-Tauri stars, Be and/or shell stars, and the brightest flare stars, in which strong atmospheric events are to be understood and a systematic search for the bright UV objects discovered by Carnochan et al. (1975) with TD1. In the Orion region, there now appears to be one UV object per square degree up to the ninth visual magnitude. If their space density was better known, part or all of the UV turn-up of galaxies might be explained in terms of a discrete population of hot subluminous stars.

GENERAL PERFORMANCE EVALUATED FROM LAS ROCKETS JANUS AND FAUST

Scientific programme	Extended sources	Star and starlike objects
I. Detection and Photometric Mode : I. 1. Spectral range 1300 → 3000 A Wide band interference filter $\Delta\lambda$ = 300 A In Far UV wider band filters would be useful for the deepest UV survey but unfortunately are not available.	Continuum : Direct images of the stellar clouds of the Milky Way Reflection nebulae - Dark clouds - Extension of galactic and extragalactic material. Detection of sky background, Zodiacal Light Gegenshein and their correction. Sensitivity 5 x 10^{-8} erg $(cm^2. s. ster\ A)^{-1}$ (λ = 1500 A) or ∿ $[V_{lim} = 27.5$ (square arc sec$)^{-1}]$	Direct images of stars, galaxies, globular clusters. 60 sec exposure time Total number of detected stars in each field . galactic pole ≤ 20 000 . galactic plane ≤ 60 000* 1 star each 12' 60 sec exposure time λ = 1500 A V_{lim} = 14 - 14.5 average O star with E_{B-V} = 0.25 magnitude
I. 2. Narrow band interference filter $\Delta\lambda$ = 35 → 50 A	Monochromatic light - H II regions 120 sec exposure time Sensitivity 2 x 10^{-6} erg $(cm^2. s. ster)^{-1}$	Stars and star like emission objects ≤ 3' . Planetary and small nebulae. Stars from their continuum . galactic pole 2 500 . galactic plane 7 000
II. Spectrographic Mode $\Delta\lambda$ = 300 A spectral resolution 15 .... 20 A	Slit spectra over 10° field in the center of the 55° star field (recorded at the edge of the field) Emission lines of HII regions Spectral energetic distribution of the continuum of the stars clouds, and reflection nebulae.	Objective grating method 10 sec exposure time for minimum of overlapping V_{lim} = 11 average O star (see above) Stars spectra - about 500 for each field on galactic plane.

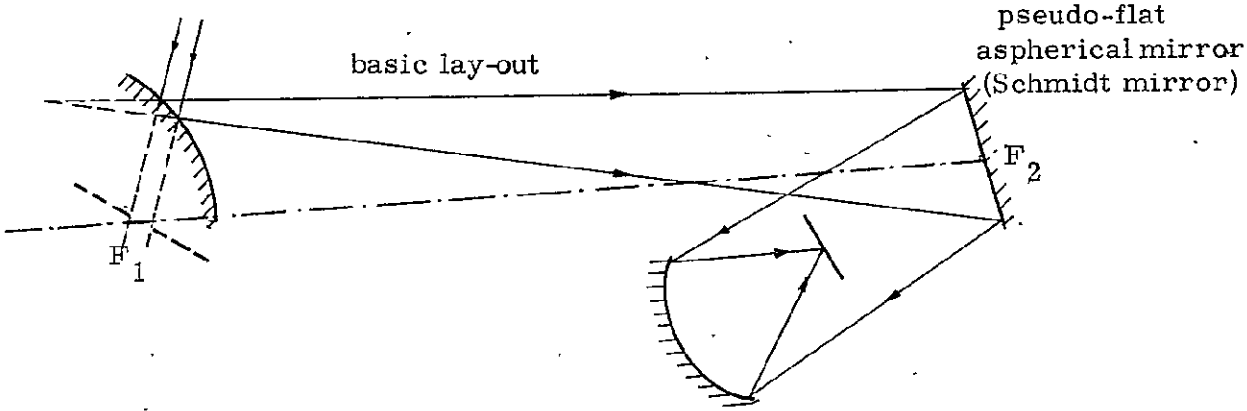
* One sees that, near the Galactic plane, exposure times less than 60 sec. allow to resolve individual stars, while longer exposures lead to wide-band photometry of the integrated starlight of the Milky Way.

3. - INSTRUMENT DESCRIPTION :

3.1. Optics :

3.1.1. Conception : In response to the requirements of the scientific programme, the very-wide-field camera should have the optical characteristics shown in the tableau the following page.

The achromatism is achieved by an all-reflection camera. Because anastigmatic two-mirror cameras allow a field of only 10° at F/2, the proposed solution consists of a hyperbolic collector followed by an anastigmatic Schmidt camera which is placed at the long focus of the hyperbolic mirror and which reduces the image of the sky formed by this mirror.



The object pupil of the instrument is the virtual image, in the hyperbolic mirror, of the real pupil of the Schmidt camera, symbolised by a diaphragm on the drawing. Thus, for each point of the field, the hyperbolic mirror functions over a small part of its surface.

This concept was previously developed in the successfully-launched rocket experiments "Caméras Nocturnes" (1967) and "Janus" (1972) (1970). The hyperbolic mirror gives an image of the sky at F/13, and a large (60°) object field ; then the Schmidt camera gives a final flat image plane with a large aperture ratio (F/2) and a small (around 10°) apparent field (the strong field curvature of the hyperbolic mirror is corrected by the field curvature of the Schmidt camera). The small convergence of the beam ahead of the Schmidt camera permits placement of various devices (interference filters, gratings, etc.) into the beam, and does not impose a high positional accuracy for the optical elements.

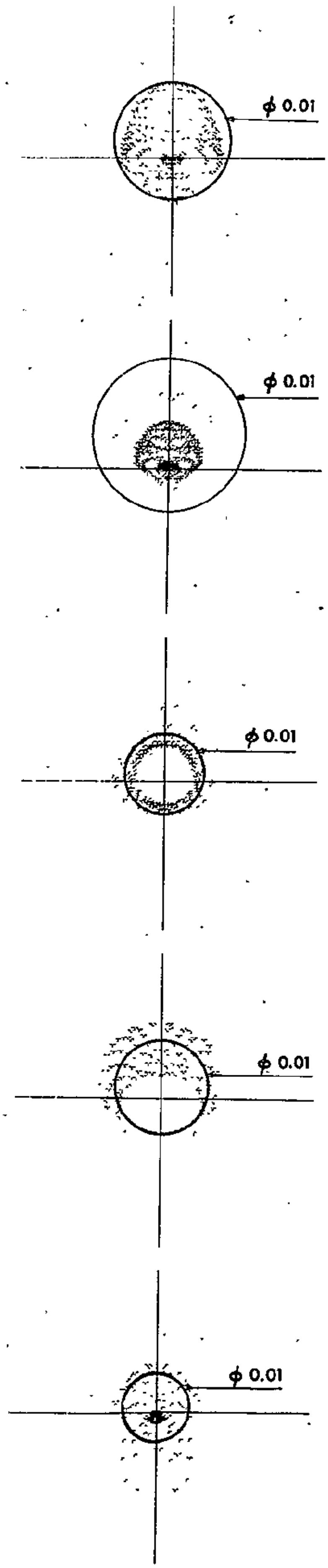
The geometrical properties of the hyperboloid artificially diaphragmed at one of its geometrical foci renders the system relatively insensitive to field aberrations. (Astigmatism is rigorously zero and the very weak third order coma is corrected by the Schmidt camera). The entrance pupil seen from the various object fields is always circular (stereographic projection). Its surface increases with the field (40 % at 60° off-axis) ; this tends to increase the sensitivity of the camera to stars when one goes farther from the optical axis. On the other hand, the sensitivity to extended sources is constant over the field since there is no limitation to the solid angle subtended by the pupil as a function of field angle. The advantage of this optical design is that it resolves the well-known paradox in optics between field, vignetting, and large aperture ratio.

It is interesting to note that this excellent performance is obtained with only three optical elements : a hyperbolic mirror, a pseudo-plane aspherical mirror, and a spherical concave mirror ; the two other (flat) mirrors are imposed for reasons of volume.

Detection and Photometric Mode	Scientific requirements	1300 → 3000 A $\Delta\lambda$ = 300 A (3 filters) and $\Delta\lambda$ = 50 A (1 filter)	angular field 60° f number 2 image resolution 1 arc min	
	Technical solution	. C_sT_e photocathode 1300-3500 A . all reflective camera . interference filters near the real pupil	. hyperbolic collector and Schmidt camera focal length 29.2 mm . microchannel or electrostatic detector with a 60 μ m pixel and Φ 40 mm useful area . observable field : 56° in the sky, covering 32 mm in the focal plane . final numerical aperture F/N N = 2	
Spectrographic Mode	Scientific requirements	1300 → 3000 A $\Delta\lambda$ = 300 A	stellar spectrography $\Delta\lambda$ = 15 → 20 A	Nebular spectrography field 10° x 0°.6 $\Delta\lambda$ = 15 → 20 A
	Technical solution	Objective grating coupled with filters	Schmidt objective grating 100 grooves/mm	Nebular slit spectrography (afocal system before the hyperbolic mirror)

VERY-WIDE-FIELD CAMERA

SPOT DIAGRAM



Field θ = 12°.5

Field θ = 24°.1

Field θ = 42°

Field θ = 57°

Field θ = 66°

FIGURE 5

The camera was designed with the following functional properties taken into account :

- Free access to the focal plane (which explains the presence of a tilted, pierced, flat mirror)
- Spectral filtering thanks to four retractible interference filters placed near the real pupil.
- Possibility of functioning in a spectrographic mode (replacement of the deformed mirror by a deformed grating). A dispersion of 30 nm/mm is obtained for a grating with 100 g/mm. To obtain a very good spectral resolution in the chosen passband and a spectrum height of several hundreds of microns, the grating works on the tangential focal length. An afocal system composed of two concave mirrors and of a slit situated at the common focal plane of the two mirrors is added in front of the hyperbolic mirror. This slit and the first mirror select an elongated ($\sim 10°$) field of the observation field, and the second mirror reforms an image of this field at infinity, which is seen by the hyperbolic mirror outside of the plane of symmetry of the instrument (see optical diagram). Thanks to the grating, one can obtain, on the same picture, the spectrum of the stars of the field and the spectrum of the sky background corresponding to the star field centre.

3.1.2. Feasibility of the optical elements : The optical elements that are the hardest to make are the hyperbolic mirror and the deformed mirror. The hyperbolic mirror of the laboratory mock-up has a good figure with little variation of slope always less than 0.6 min of arc with respect to the theoretical shape, as one may verify by the quality of the Hartmann test and of the direct photographs of the sky.

The deformed mirror and deformed grating are made by the method of mechanical deformation (Lemaître 1975). These techniques were used successfully by LAS for the FAUST experiments, with more severe specifications.

3.1.3. Image quality of the camera : Computer optimisation of the camera led to the optical design (see figure 4). Figure 5 shows the spot diagrams of the laboratory mock-up of the camera. The theoretical image spot has dimensions of the order of one arc minute , corresponding to around ten microns. The spot diagrams of the definitive camera will have dimensions of the same order of magnitude.

3.2. Receptor :

3.2.1. The intensifier : Our philosophy is to use standard image intensifiers with Mg F_2 windows and Cs Te photocathodes. Given these conditions there are three possibilities, as follows :

- Magnetically-focused intensifiers have very bulky permanent magnets. It is impossible to place such an intensifier behind the flat folding mirror without an unacceptable increase of vignetting.
- Proximity focused intensifier including a channel electron multiplier array. A radiant gain as large as 510, was obtained in previous experiments with photographic readout. Its compactness is very attractive but the equivalent background input as well as the photometric accuracy are still questionable.
- Proximity focused intensifier + electrostatic intensifier. The first tube acts as a converter and is optically coupled to a common electrostatic inverter tube. The gain is of the order of 100 and the background due to the first stage has also to be checked. The possibility of a magnification ratio smaller than one (0.6) in the second tube enables one to record the whole field on a 35 mm emulsion.

GENERAL DESIGN

VERY WIDE FIELD CAMERA

FIG.: 7

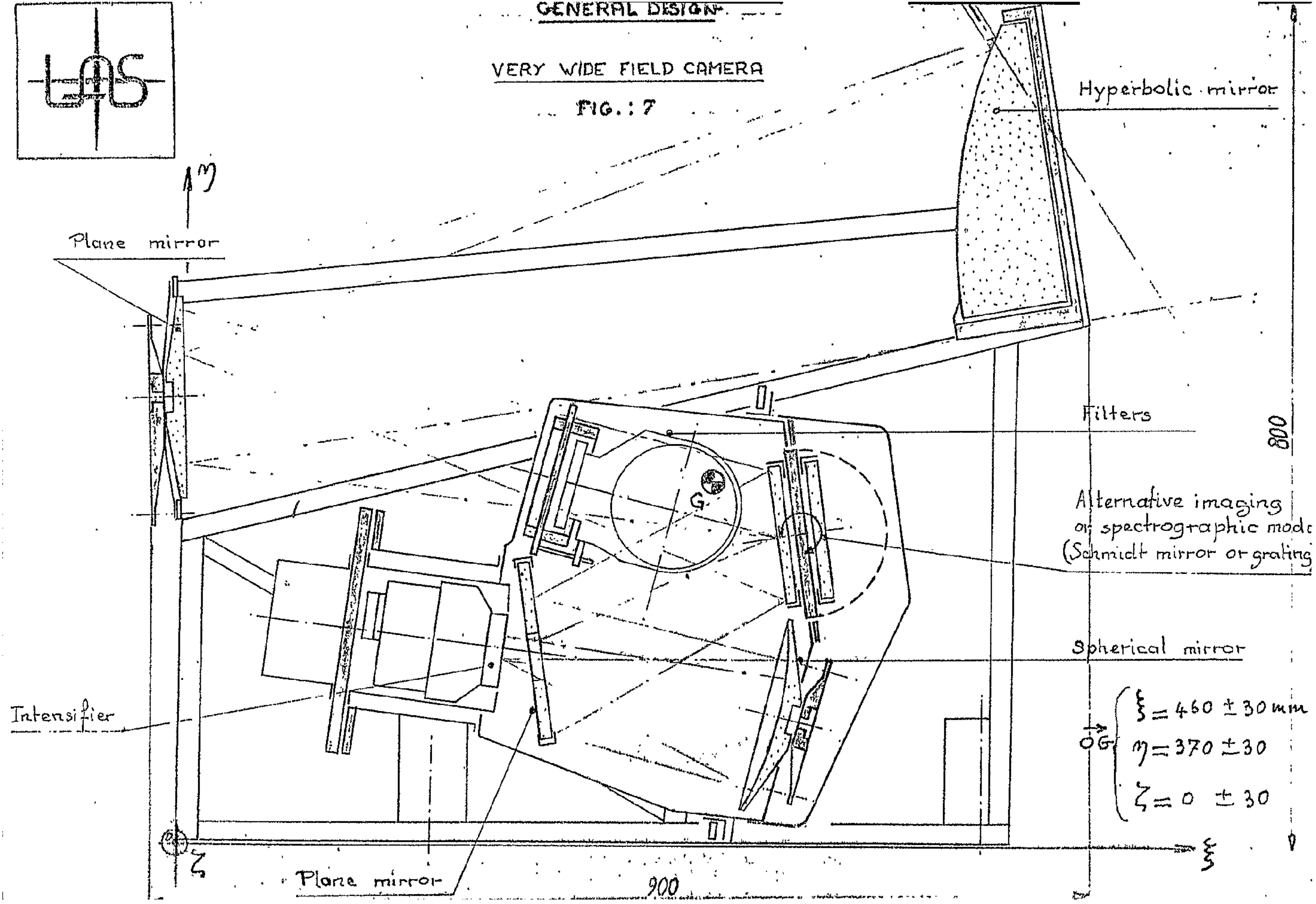
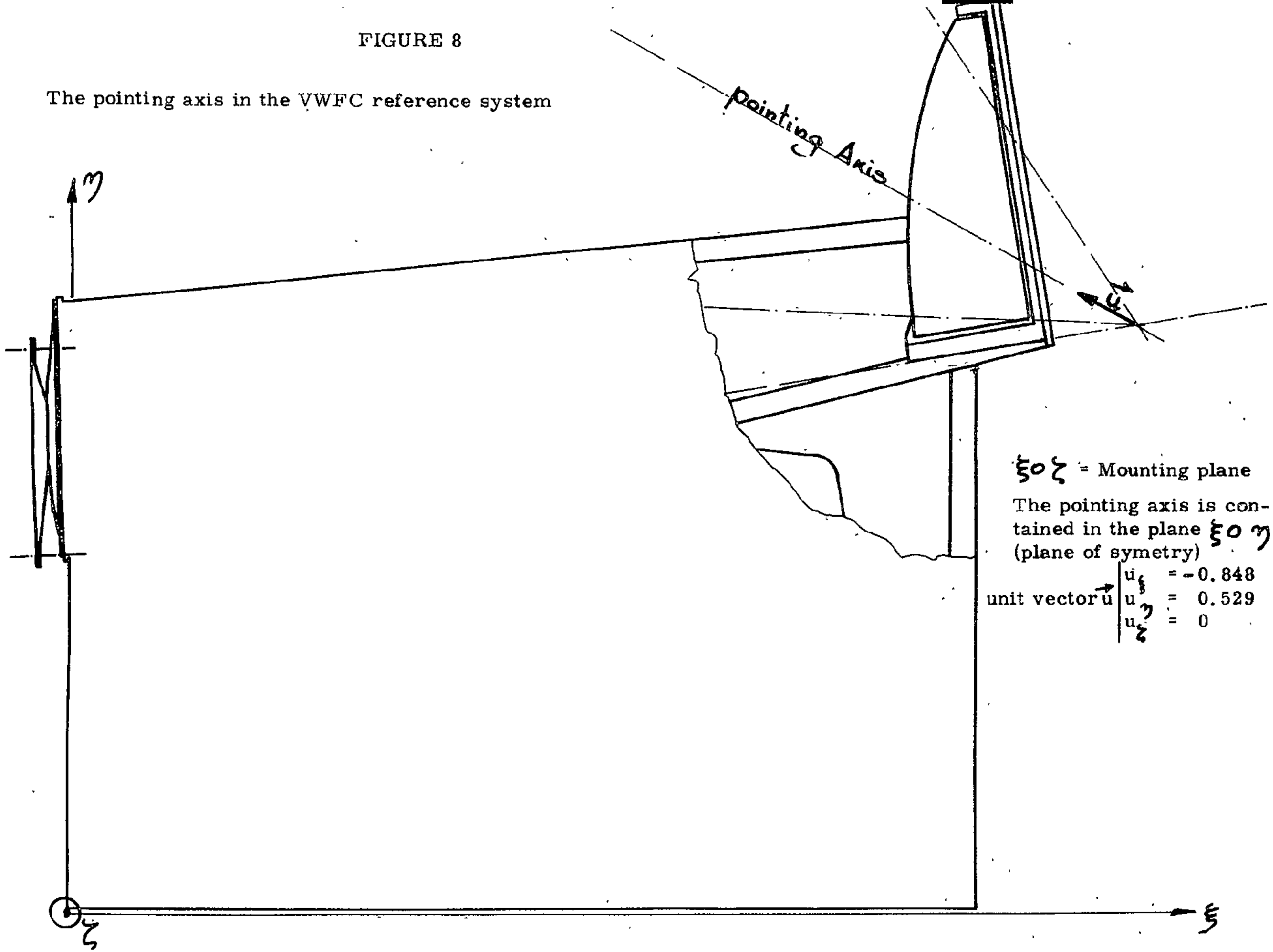
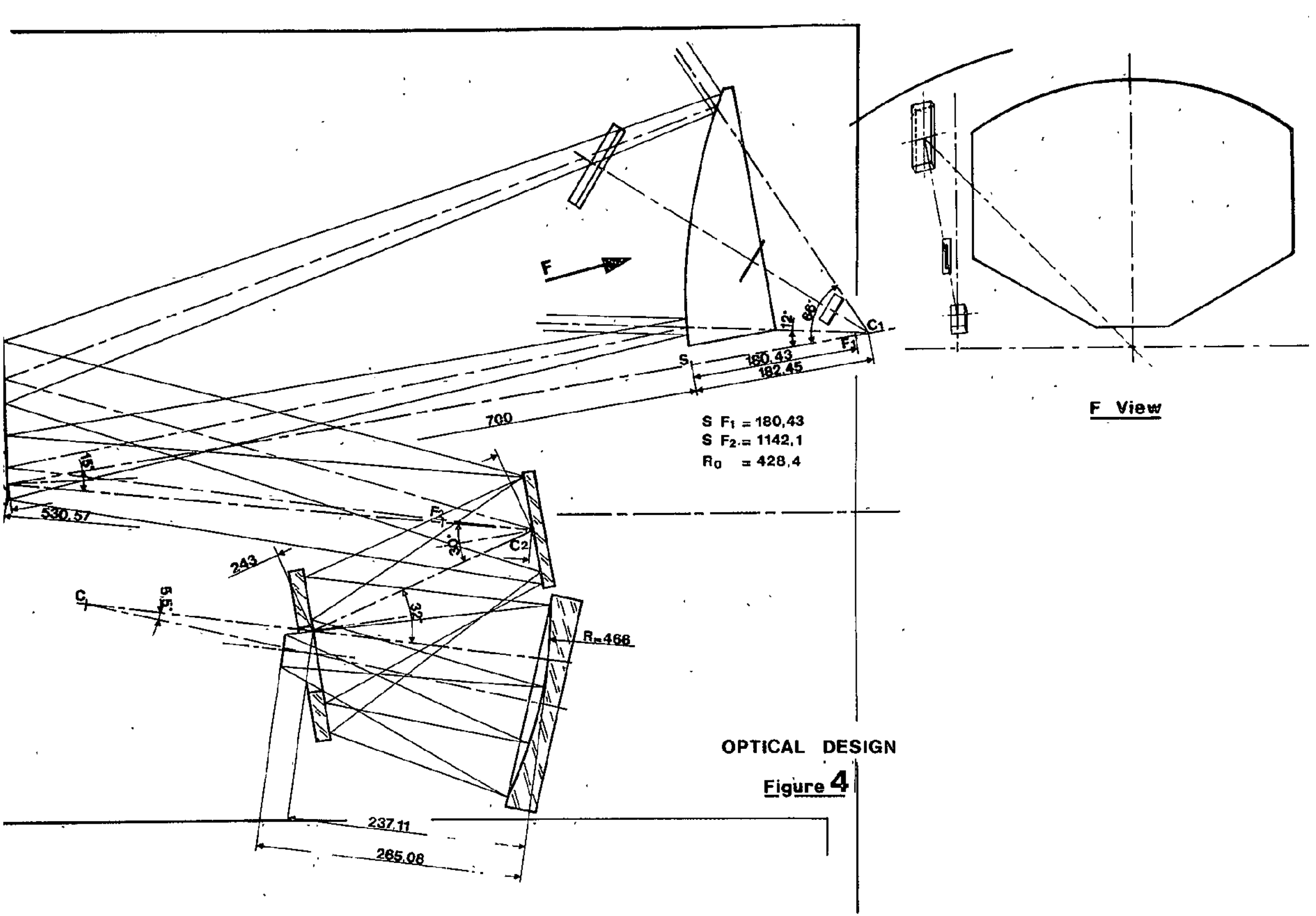


FIGURE 8

The pointing axis in the VWFC reference system





OPTICAL DESIGN

Figure 4

For a maximum of flexibility and for possible detector development, it is suggested to maintain solutions 2 and 3 insofar as no mechanical constraints appear.

3.2.2. The film advance device : (figure 6)

The major part of the technology of this film advance device was qualified during the successful launches of the FAUST sounding rockets with 35 frames of Kodak 103 aO film. LAS is now studying some modifications to obtain 100 frames.

3.3. Mechanical structure :

3.3.1. Description : The Very-Wide-Field Camera consists of a soldered mechanical structure in invar tubing which supports optical components and electromechanical systems (filter changing device, mirror/grating interchanging device). An external envelope serves simultaneously to :

. protect the optics from pollution
. avoid the entrance of stray light into the apparatus
. thermally protect the overall experiment

3.3.2. Receptor block : It forms a sealed block containing the film advance device and of which the front face carries the image intensifier.

Remark : A shutter, which is part of the receptor block, could be mounted in front of the intensifier to permit the measurement of the latter dark current during the experiment.

3.3.3. Thermal protection : An antiradiative thermal protection is planned on the outer envelope of the experiment.

3.3.4. Optical protection from contamination : Optical components are protected by covers. At the begining of operation, these covers are withdrawn, either by an automatic system or by crew orders (to be determined)

3.3.5. Volume, centre of gravity, mass : (figure 7)

3.3.6. Interface with the shuttle : The experiment is mounted on the pallet by an interface structure to be determined. This structure will be mounted on the pallet by means of hard points.

The pointing axis direction referred to the VWFC hardware is shown on the figure 8.

The thermal control is proposed either by electric heater or by cold plates (solution to be determined).

4. - SCIENTIFIC CONSTRAINTS :

4.1. Celestial objects sighted and pointing plans :

ASTRONOMICAL OBJECTIVES

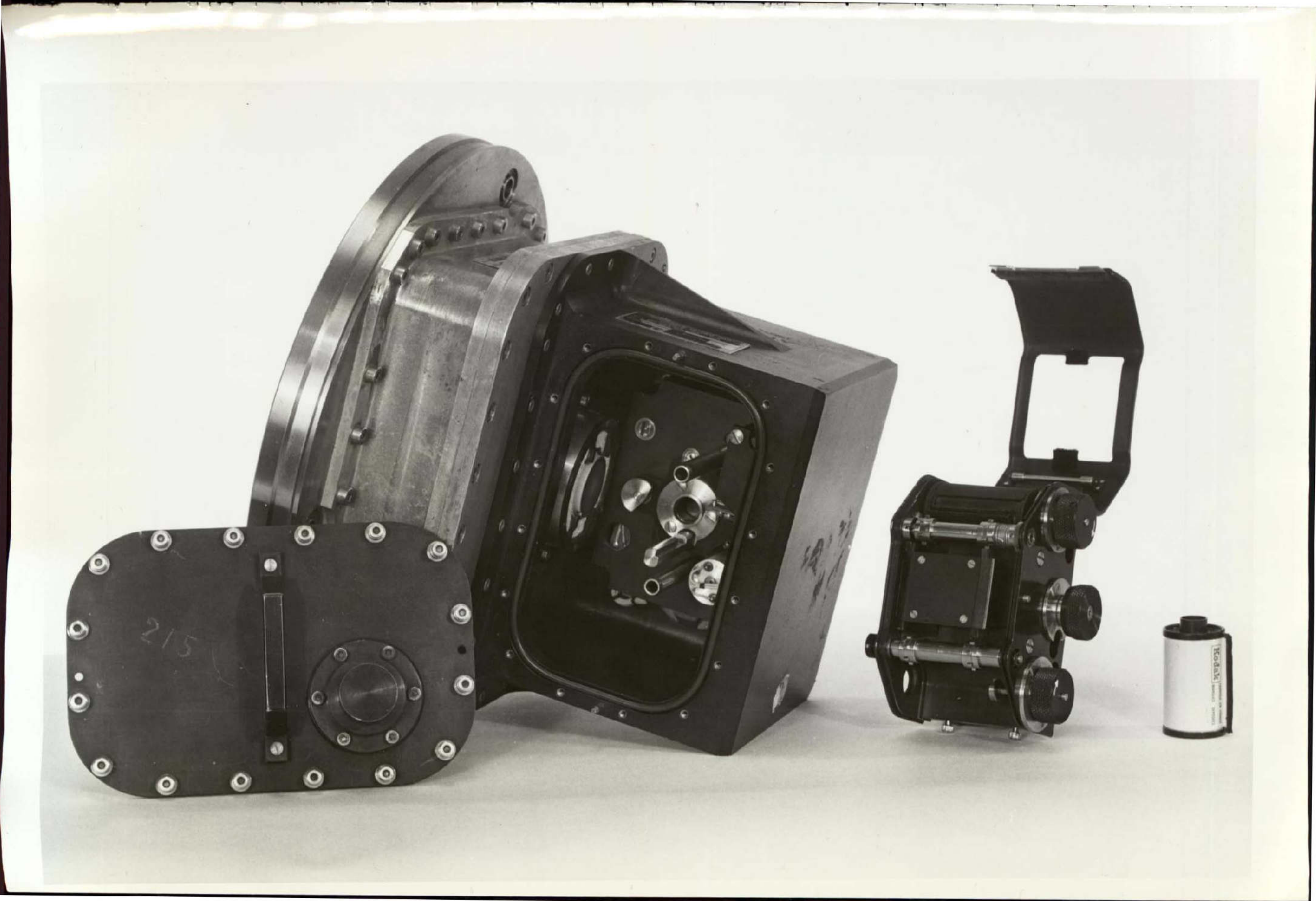
Field designation	Coordonates (center)		Distance to sun in October *
1°) Magellanic clouds (LMC and SMC) Milky Way from Puppis to Carena	$6^h\ 30^m$	- 70°	87°
2°) Eridanus Fornax and Doradus galaxies	4 00	- 40	117°
3°) Milky Way from Orion to Puppis	6 00	- 15	100°
4°) M. 31, M. 33 Galaxies Milky Way from Cassiopeia to Perseus	1 30	45	145°
5°) Milky Way from Cygnus to Aquila	19 30	30	102°
6°) Eridanus, South Galactic Pole, Cetus	2 30	- 15	150°
7°) Milky Way from Aquila to Scorpius	18 00	- 10	80°
8°) Milky Way from Carina to Ara	15 00	70	68°
9°) Gegenschein	Ecliptic		180°

* Distance from the center of the field to the sun.

FIGURE 6

FILM ADVANCE DEVICE

Previously used in the Faust-rocket-experiment, this device will be adapted to the VWFC.


2/5
Kodak

These objectives can be observed in other combinations depending on orbital characteristics.

4.2. Constraints due to the sun :

Depending on the case, the sun could be as little as 5° below the satellite horizon.

This instrument could possibly serve to study the contamination in the vicinity of the Shuttle taking photographs at grazing incidence (see CGC-3/76 annexe). In this case the sun is above the horizon but should never be in the field of the experiment.

4.3. Constraints due to the moon :

At $\pm$ 7 days from full moon, the moon should be more than 5° below the satellite's horizon. In any case the moon cannot be in the 60° field.

4.4. Standard cycle :

By standard cycle we mean the totality of operations to be effected during a single orbital night (pointing at one objective).

	Filter 1			Filter 2			Filter 3			Filter 4
photometric mode (mirror) (10 frames)	6s	20s	60s	6s	20s	60s	6s	20s	60s	120s
spectrographic mode (8 frames)	5s-10s-60s-120s			5s - 10s - 60s - 120s						

The required pointing precision is $\pm$ 5°. Stabilisation should be better than 0°.1 during three minutes. The rotational orientation of the VWFC around the pointing axis is unimportant. (figure 8)

5. - TECHNICAL CONSTRAINTS :

The needs of the Wery Wide Field Camera are largely compatible with the Spacelab specifications.

However, the instrument is s e n s i t i v e to pollution by dust particles and by organic matter. The cleanliness class requirements are : better than 10.000 in stowage and better than 100.000 in operation.

6. - FUNCTIONING MODE :

General control and data handling of the V.W.F.C. will be done by the intermediary of a console mounted in the standard 19-inch NASA rack. This console will function in two modes : automatic or manual.

In the automatic mode we ask for a "start experiment" order. Starting from there, the control console will execute the programmed sequence. By analogy with the scientific programme, we have organised the functioning of the V.W.F.C. in nine sequences (or nine objectives). We do not ask for any activity from the astronauts except possibly to activate the protection covers or, in the case of alarm provoked by the automatic detection of some failure of the system, to execute particular orders. In this case it is possible to change to the manual mode to carry out the desired verifications and operations.

We ask that it be possible to store the information given by the following verification data :

- V.W.F.C. environment — - telescope subsystem
- V.W.F.C. operation { - telescope subsystem / - film advance subsystem }

This information will appear in digital or analog form. The requested storage capacity will not be great. The required recording speed will be small.

For example, if we decide in favour of binary data it would suffice to be able to store 100 kilobits for the whole nine flight objectives. The average data acquisition speed would be 100 bits per minute with maximum speeds possibly reaching 100 bits per second.

7. - LABORATORY MOCK-UP :

To verify the feasibility of the optical components, to develop the integration, adjustment and precalibration procedures, and to test the image quality obtained, LAS has constructed a laboratory mock-up (figure 9) using a transmission Schmidt plate instead of the Schmidt mirror. This mock-up was used to take the photograph shown in figure 10. This has no scientific value but allows one to see in spite of the lack of tracking the very good stellar image quality (in excellent agreement with the spot diagram) and to estimate the limiting magnitude.

8. - CALIBRATION :

The calibrations will be done in two steps :

- Reception and checking of physical parameters of the different components, most especially optical and electro-optical.
- Calibration of the instrument, consisting essentially of measurement of the photometric characteristics.

In all cases the procedures will be written up by the department of physical measurements, after definition of the physical principles by the Principal Investigator.

8.1. Reception of the different components :

8.1.1. Mechanical reception : This is a matter of checking compliance with specifications (dimensions, weight, reliability, etc.).

8.1.2. Physical parameter reception : This concerns the checking of the optical and electronic parameters of each component. Particular care will be taken with the examination of filters, mirrors, gratings, and intensifiers.

It is at this stage that the components of the engineering model and the flight model will be selected as a function of their performance.

The following will be checked particularly :

Filters :
- surface state of substrates
- optical thickness of substrate
- transmission, "feet" of the transmission curve
- point-by-point homogeneity.

Mirrors :
- quality of polish
- general form
- point-by-point efficiency
- global reflectivity
- quality of the copies

Intensifier :
- optimisation of the functional electrical parameters
- quantum efficiency
- gain
- homogeneity
- remanence
- resolution
- linearity, dynamic range
- dark current
- saturation

FIGURE 9

Very-Wide-Field Camera : Laboratory mock-up

Bottom : hyperbolic collector with 2π steradian field

top left : plane mirror

top right : Schmidt camera

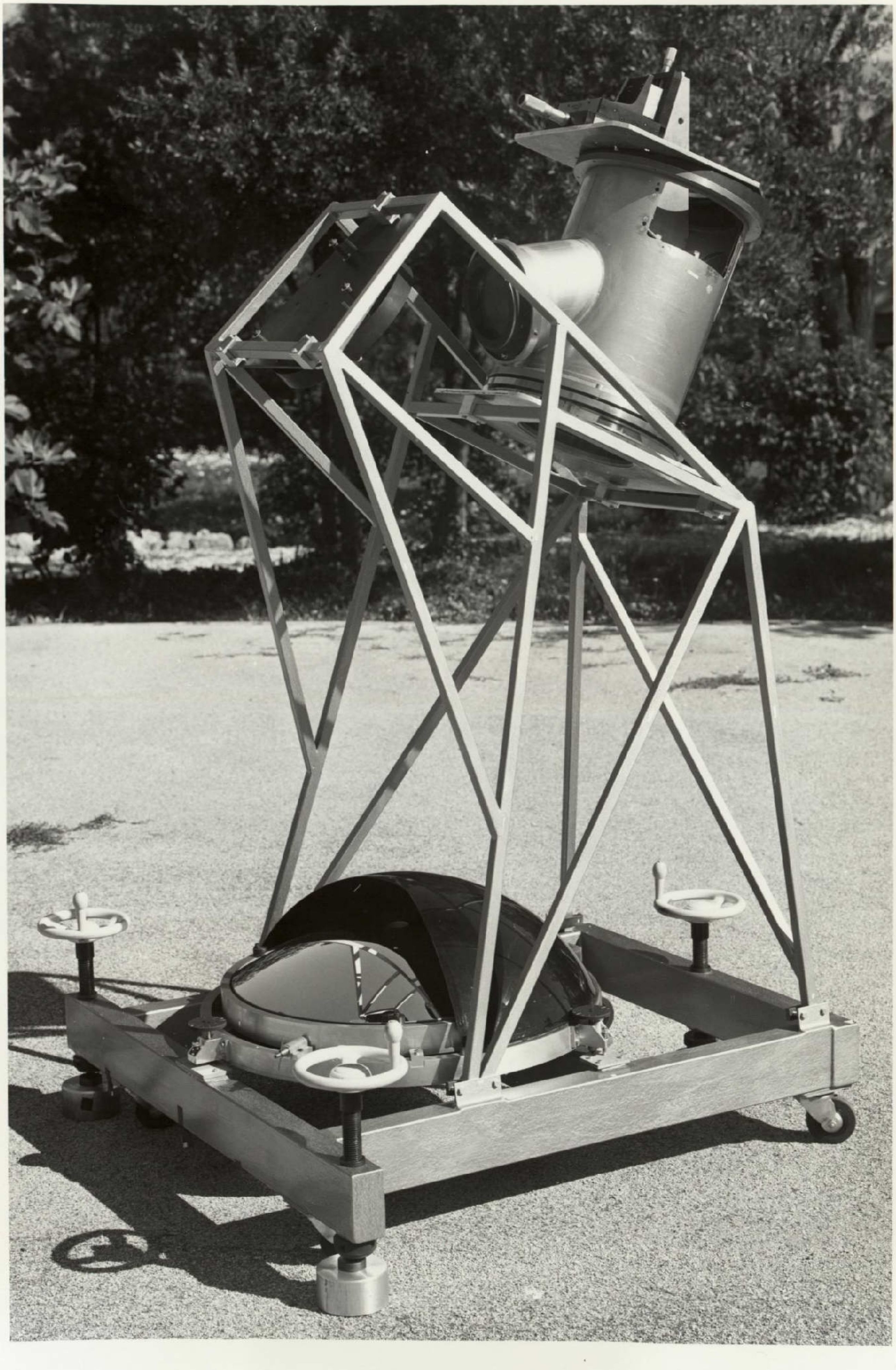


FIGURE 10

This photograph is a 1.5. minute ground-based exposure on 103 a O emulsion, without intensifier and with a slight defocusing to simulate the image quality that will be obtained with an image intensifier.

The bandpass was about 1500 Å and a limiting magnitude of V $\gtrsim$ 6.2 was reached for AO stars. The sensitivity was limited by the city night sky background.

The enlargement of this picture is 14.6.

The brightest star near the center is Polaris.

Grating :
- blaze angle
- homogeneity
- efficiency

8.2. Instrument calibration :

8.2.1. Measurement of the photometric characteristics :

This concerns calibration, properly so called, of the instrumentation.
- passband,
- sensitivity to extended sources,
- sensitivity to point sources,
- dynamic range (magnitude sequence),
- variation of sensitivity as a function of field angle,
- absolute calibration of plate density as a function of incident flux,
- geometric distortions,
- parasitic light.

8.2.2. Variation of the characteristics as a function of the space environment :
- sensitivity to polluting dust,
- study of the variation of the characteristics as a function of the temperature,
- degradation of the photometric characteristics as a function of the limit cycle.

8.3. Necessary means :

The means necessary for reception of components and for calibration are practically identical to these developed for the Janus experiment (Detaille et al., 1973).

The equipment developed for D2B will also be used, and most especially the computer control of all the calibration operations.

Remark : The various verification procedures will in fact be definitively fixed only after the construction of the evolving mock-up.

9.- DEVELOPMENT PLAN :

9.1. General principle :

LAS will have the responsibility of making the instruments. The Principal Investigator, G. Courtès, aided by his Co-Investigators, will direct the project. A project Manager J. Raynard (LAS engineer) will coordinate the various tasks and will assume connections with ESA.

The technical design is simple and takes into account the experience gained by other space experiments (D2B satellite, Faust rocket programme etc.).

CNES is now studying this proposal, after which it must agree to finance this programme and give technical support to LAS.

9.2. Development underway or planned :

9.2.1. The film transporter : increase of number of frames (up to around a hundred or so), increase in size of the photograph.

9.2.2. The intensifier : LAS is currently studying the characteristics of many tubes whose interfaces are compatible with the receptor : passband, gain, background noise, resolution, uniformity, photometric qualities, lifetime, etc.

9.2.3. The filter holder mechanism : construction of a mock-up valid for vibration and thermal tests. Endurance trials.

9.2.4. The mirror-grating mechanism : construction of a mechanical mock-up valid for vibration and thermal tests. Optical performance trials. Endurance trials.

9.2.5. Optical coatings and filters : We are taking up the coating methods of the Matra-Seavom catalogue ($Al-MgF_2$ and interference filters of type 5 MDM metal-dielectric metal with five layers). The improvements to develop concern the fourth interference filter with a narrow passband.

9.2.6. Fabrication of the Schmidt mirror and Schmidt grating : Trials of the fabrication of the mechanically deformed matrix and of the copies of the aspherical plates (grating and mirror) (grating copying technique), performed for the Faust project, proved the feasibility of the methods. It remains to adapt them to the mirror and grating of the project. (Lemaître,1975)

9.3. Number of models and their function :

It is planned to construct an optical and technological mock-up and two models : an engineering model and a flight model.

- The feasibility mock-up : It will be constructed shortly at LAS. It follows the laboratory mock-up, of which it uses a certain number of elements. This new mock-up should be very similar to the flight model. It will serve at LAS to verify the principle of the mechanical devices and the optical validity of the definitive diagram before calling for bids for the construction of the two following models. It will then be used for developing the calibration procedures.
- One evolving engineering model : It will first undergo mechanical qualification trials with simulation optics. Afterwards the real optics will be mounted to have an optical model on which the definitive devices (baffles, monitoring mirror, etc.) will be tried out. This model will then undergo the complete qualification trials. After that, it will serve as a training model. During the integration phases, it can also serve to simulate possible incidents and to develop small modifications that will affect the flight model. And finally, in case of a last minute accident due to an exterior cause this model could be used as a substitute.
- One flight model : It will undergo reception trials. A complete set of substitute optics is planned for this model.

10. - DATA REDUCTION :

10.1. Description of the operations :

During the two months following reception of the photographs at LAS we will effect a first selection of the photographs that are the most interesting astronomically and of good quality.

The reduction properly speaking will consist, first, of establishing the isophotes of the stellar and nebular sky background in several colours depending on the filters chosen and the colour index corresponding to the sky background. It will then be necessary to reconstitute the position of the optical axis of each field in the sky and, as a function of the calibrations, to take into account the variation of sensitivity from one edge of the field to the other. This work will be done by computer at LAS thanks to a programme developed for the reduction of the Camera Nocturne (VCN) and JANUS rocket experiments.

The second stage will consist of reconstituting the magnitude of the stellar objects. In the case where the image quality is not affected by the amplitude of the limit cycle of the pointing (< 1 arc minute) the reduction will be made with the PDS microdensitometer of the LAS by means of a classical programme of bidimensional densitometry. We foresee to apply the method currently being studied at LAS for the reduction of the Wide Field JANUS photographs where the limit cycle (5 to 6 arc minutes) had comparable effects on the image quality. This methode already developed is designed to evaluate directly the degradation of the calculated magnitude as a function of position in the field and of the value of the magnitude.

10.2. LAS and CNES resources :

LAS has a PDS digitised microdensitometer piloted by a Digital PDP 11 computer. Data storage can be done on seven-track magnetic tapes and the computer is operated from a Tektronix 4010 visualisation console.

Conversational type software, using the graphical possibilities of the console, allow the selection of interesting zones and the pre-reduction of files of around 250000 points. The files thus pre-reduced and judged interesting can be transmitted to the CNES computing center in Toulouse for specific reduction procedures, to be defined, on a CDC 7000 + 6000 computer accessible from LAS by a T 200 terminal.

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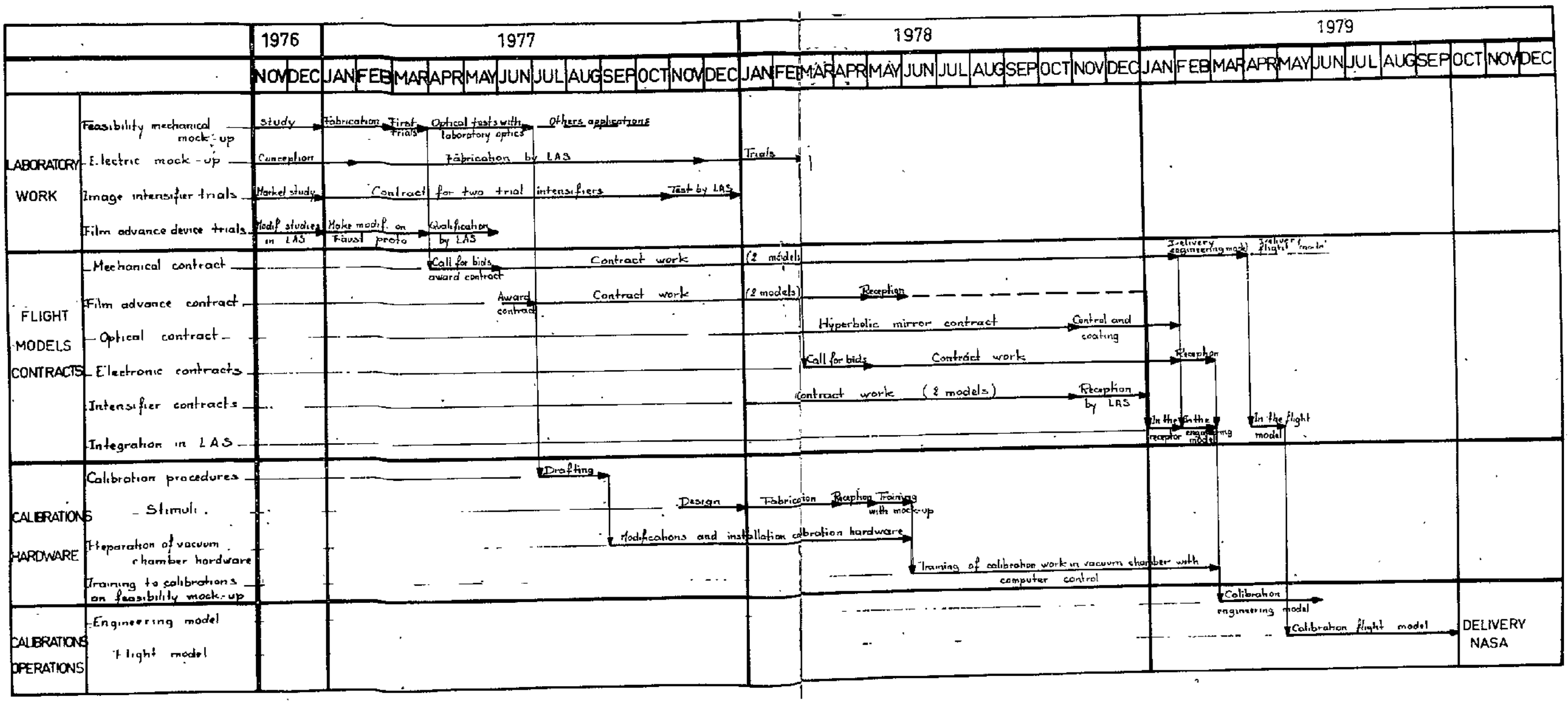
BIBLIOGRAPHY

- Bohlin R., Marionni P., Stecher T., 1975, Ap J 202, 415
- Carnochan D. J., Dworetsky M. M., Todd J. J., Willis A. J. and Wilson R. 1975, Phil. Trans. R. Soc. Lond. A 279, 297.
- Carruthers G. and Page T., 1976, Ap J 205, 397.
- Code A. D., 1960, Astronomical Journal, 65, 278.
- Code A. D., Welch G. A., Page T. L., 1972, The Scientific Results from the OAO 2 - NASA SP 310.
- Courtès G., 1971, IAU Symp. 41 p. 273.
- Courtès G., Laget M., Sivan J. P., Viton M., Vuillemin A. and Atkins H. 1975, Phil. Trans. R. Soc. Lond. A. 279, p 401-404.
- Deharveng J. M., Laget M., Monnet G., Vuillemin A., 1976, Astron. and Astrophys. 50, 371.
- Detaille M., David J. C., Viton M., 1973, Fourth conference on space optics, p 71-84, CNES Ed.
- Henize K. G., Wrag J. D., Parsons S. B., Benedict G. F., Bruhweiler F. C., Rybski P. M., O'Callaghan F. G., 1975, Ap J Letters, 199, 119.
- Lemaître G., 1975, Astron. and Astrophys. 44, 305.
- Maucherat M., Cruvellier P., 1976, Grenoble IAU Symp.
- Osterbrock D. E., 1963, Planet. and Space Sci. 11, 621.
- Schmidt-Kaler Th. and Schlosser W., 1973, Astron. and Astrophys. 29, 409.
- Sivan J. P. and Viton M., 1970, IAU Symp. 36 p. 120.
- Sivan J. P. and Viton M., 1972, Space Research XII, p. 1603.
- Sivan J. P. 1974, Astron. Astrophys. Suppl. 16, 163.
- Sivan J. P. 1976, Astron. Astrophys. 49, 173.
- Suyama S., 1976, Astron. and Astrophys. 52, 145.
- Viton M., 1967, Compt-Rend. Acad. Sci. Paris, 264, 1761.
- Viton M.; 1974, Thèse de Doctorat d'Etat, Université de Provence, Marseille.
- Van Den Bergh S., 1968, Journal of the Royal Astronomical Society of Canada, vol. 62.



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LABORATORY WORK
Feasibility mechanical mock-up
Study
Fabrication
First trials
Optical tests with laboratory optics
Others applications
Electric mock-up
Conception
Fabrication by LAS
Trials
Image intensifier trials
Market study
Contract for two trial intensifiers
Test by LAS
Film advance device trials
Modif. studies in LAS
Make modif. on Faust proto
Qualification by LAS
FLIGHT MODELS CONTRACTS
Mechanical contract
Call for bids award contract
Contract work
(2 models)
Delivery engineering model
Delivery flight model
Film advance contract
Award contract
Contract work
(2 models)
Reception
Optical contract
Hyperbolic mirror contract
Control and coating
Reception
Electronic contracts
Call for bids
Contract work
Intensifier contracts
Contract work (2 models)
Reception by LAS
Integration in LAS
In the receptor
In the engineering model
In the flight model
CALIBRATIONS HARDWARE
Calibration procedures
Drafting
Stimuli
Design
Fabrication
Reception
Training with mock-up
Preparation of vacuum chamber hardware
Modifications and installation calibration hardware
Training to calibrations on feasibility mock-up
Training of calibration work in vacuum chamber with computer control
CALIBRATIONS OPERATIONS
Engineering model
Calibration engineering model
Flight model
Calibration flight model
DELIVERY NASA

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ANNEXE

STUDY OF THE DUST CONTAMINATION OF SPACELAB USING THE VERY WIDE-FIELD CAMERA

Report prepared by : LAMY
VITON
RAYNARD.

Marseille, le 19 février 1976
Réf. C.G.C. /3/76

1. - POSSIBLE USES OF THE CAMERA :

Beside its astronomical function during the night phases, the wide-field camera could be used for :

- Photographing polluting dust grains of size larger than 0.1 micron, in a field of 60° x 60° and in various spectral bands of the available spectral domain (1 300 to 8 000 Å depending upon the detector).

- Measuring tangential velocities by cinematographical technics using either a rotating shutter or an electronic switch of the image intensifier low-voltage power-supply, and a magazine allowing up to 200 frames.

- Determining the spatial distribution of grains as a function of distance by sliding plane-parallel plates of various theckness in front of the focal plane (focus from 1 meter to ∞). This system requires an additionnal filter-holder.

2. - SCATTERING FUNCTION :

We computed the scattering function S (θ) using Mie theory for graphite spherical grains of various sizes. For the proposed observations, the scattering angle is always larger than 20° ; in the interval 20° - 180°, S (θ) may, in a first approximation, be averaged as follows :

radius \ λ	2 000 Å	5 000 Å	8 000 Å
10 μm	10	2	2
1 μm	5.10^{-2}	4.10^{-2}	4.10^{-2}
0,1 μm	10^{-3}	4.10^{-4}	4.10^{-5}

3. - SENSIBILITY OF THE WIDE-FIELD CAMERA :

The detector is a proximity-focused intensifier including a micro-channel plate (M.C.P.) plus photographic film.

.../...

For astronomical observations, a maximum magnitude of 14 is reached with a bandwidth of 100 Å . In the case of dust grains, three spectral bandwidths, 1 000 Å wide, could be used in the visible (U. B. V. filter) in order to improve the irradiance by a factor of 10. The limiting magnitude would then be 16.5.

4. - MAXIMUM DISTANCES OF DETECTION OF DUST GRAINS :

For a given wavelength λ, the magnitude M_λ of a grain is given by :

$$M_\lambda = 30 + m_{\odot,\lambda} - 2.5. \log S(\theta) + 5 \log r$$

where r is the distance between the grain and the camera ande $m_{\odot,\lambda}$ is the apparent magnitude of the sun. In the V - band (5 500 Å), $m_{\odot,\lambda} = - 26.85$ and the maximum value of r is given by :

$$\log r = 2.67 + 0.5. \log S(\theta)$$

which yields the following results :

radius of grain (μm)	r_{max} (meter)
10	660
1	90
0.1	10

5. - PRACTICAL DISTANCES OF DETECTION :

Practically, it seems reasonnable to divide the above maximum distances by 10 in order to

- increase the sensibility (particularly in the case of cinematography)
- eliminate stray light and the diffused stellar background.

-=-=-=-=-=-=-=-=-=-=-

Proposal No. (NASA Use)

ATTACHMENT I

FACT SHEET

SPACELAB 2

This Fact Sheet (20 pages) must be completed and returned as part of each proposal.

Principal Investigator (Name): COURTES (Last) Georges (First) (MI)

Title: x Prof. ___ MD ___ Mr/Mrs/Ms ___ Other (Specify)

AO Objective Supported ___

Complete Business Address:

Name C. N. R. S.

Laboratory/Div/Etc. LABORATOIRE D'ASTRONOMIE SPATIALE

Street Allée Peiresc -Les Trois-Lucs

City/State (Country)/Zip 13 012 - MARSEILLE (FRANCE)

Office Phone: (91) (Area Code) 66.08.32 (Number) ___ (Extension)

Title of Proposal: VERY WIDE FIELD CAMERA

Status of Proposal Experiment/Equipment: Laboratory mock-up Existing

Film advance device Existing with Mods mechanisms (filter-grating) New Development ___ Not Applicable

___ Other (Specify)

Experiment Facilities Required (On-Orbit): none

___

Other Facilities Required (Ground): none

___

Co-Investigator(s) (Name): SIVAN Jean-Pierre

(Last) (First) (MI)

Title: x Dr ____ MD ____ Mr/Mrs/Ms ____________ Other (Specify)

Complete Business Address:

Name C. N. R. S.

Laboratory/Div/Etc. LABORATOIRE D'ASTRONOMIE SPATIALE

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City/State (Country)/Zip 13 012 - MARSEILLE (FRANCE)

Business Phone: (91) 66.08.32 ____

(Area Code) (Number) (Extension)

Co-Investigator(s) (Name): VITON Maurice

(Last) (First) (MI)

Title: X Dr ____ MD ____ Mr/Mrs/Ms ____________ Other (Specify)

Complete Business Address:

Name C.N.R.S.

Laboratory/Div/Etc. LABORATOIRE D'ASTRONOMIE SPATIALE

Street Allée Peiresc - Les Trois-Lucs

City/State (Country)/Zip 13 012 - MARSEILLE (FRANCE)

Business Phone: (91) 66.08.32 ____

(Area Code) (Number) (Extension)

Attach additional sheets for more than two Co-Investigators.

Co-Investigator(s) (Name): ATKINS Harry

(Last) (First) (MI)

Title: ____ Dr ____ MD ____ Mr/Mrs/Ms ____________ Other (Specify)

Complete Business Address:

Name: N. A. S. A. GEORGE C. MARSHALL SPACE

Laboratory/Div/Etc. FLIGHT CENTER

Street: TE Building 35 812

City/State (Country)/Zip: HUNTSVILLE, Alabama (U.S.A.)

Business Phone: (205) 453.01.09

(Area Code) (Number) (Extension)

Co-Investigator(s) (Name): ____________

(Last) (First) (MI)

Title: ____ Dr ____ MD ____ Mr/Mrs/Ms ____________ Other (Specify)

Complete Business Address:

Name ____________

Laboratory/Div/Etc. ____________

Street ____________

City/State (Country)/Zip ____________

Business Phone:

(Area Code) (Number) (Extension)

Attach additional sheets for more than two Co-Investigators.

1. Instrument/Investigation Operations Summary

A. Purpose 1) Photometric mode. To obtain photographs of the sky wi filters of $\Delta\lambda$=300 Å and $\Delta\lambda$= 50 Å in a range 1300-3000 and a 60° field.
2) Spectographic mode. To obtain, in the same field, spectral energetic distributions of stellar clouds and reflection nebulae continua.

B. Method Photographic and spectrographic exposures made by a ver wide field camera ($\cong$ 60°) consisting of a hyperbolic mirror, a Schmidt Camera, an UV image intensifier and a Kodak 103 aO film positioned by the film advance device of the Faust rocket program.

C. Investigative Procedure

(Describe) Pointed observations of preselected targets for preselected exposure times. Observation cycles are set up and initiated by the CDMS. A single film pack with about 100 exposures is used and retrieved after landing. There is not telemetry.

D. Prime Obstacles or Uncertainties

(Describe) 1) Shuttle launch and reentry thermal environment

2) Shuttle pointing stability

3) Pollution by dust particles and by organic matter

E. Investigation External Interfaces (i.e., Power, RAU, TV, C&W, etc.) Pallet interface module for power (28 VDC ± 4 V and 115/200 VAC ± 5 V) and housekeeping data acquisition (analog or digital).

F. Present State of Development

(Describe) We have developed a laboratory mock-up using the same optical components except that a Schmidt plate is substitued for the Schmidt mirror. We have obtained several photographs of the sky in the visible. We use the film advance device of the Faust programme. We are studying some intensifiers: magnetically focused and proximity focused.

G. Supporting Investigations Required

(Describe) None

Impact on This Investigation if Supporting Investigation Not Conducted

H. Special Mechanical Linkage or Control Requirements

Describe Booms, Platforms, or Other Special Instrument Mounting

Required Hard mount to pallet. Thermal regulation required (electric heaters or cool plate, to be determined)

I. Design Life/Reflight Potential

(Describe) Can be reflown after routine refurbishment.

2. WEIGHT AND SIZE

A. Aft Flight Deck Mounted* (standard rack dimensions) W = ____ cm, D = ____ cm, H = ____ cm (

WT ≤ 15 kg

B. Pallet Mounted Eqpt.* W = 50 cm, L = 90 cm, H = 80 cm

WT ≤ 85 kg

C. Total Experiment Weight

(1) Launch ≤ 100 kg

(2) Orbital ≤ 100 kg

(3) Landing ≤ 100 kg

D. Dimensioned Sketch Attached, No. See figure (7)

E. Instrument Block Diagram Attached, No. (*)

F. Bending (Flexible Body) Characteristics (If Available) N/A

3. POWER PROFILE AND ELECTRICAL NETWORKS

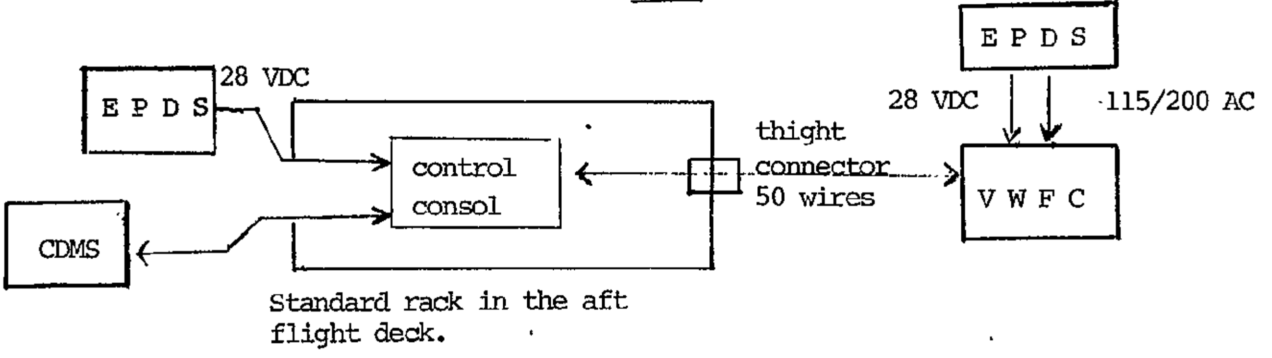
A. Operation - Normal 25 W 400 Hz 115/200V ac 25 W28Vdc

Peak 30 W 400 Hz 115/200V ac 30 W28Vdc

Standby 0 W 400 Hz 115/200V ac 0 W28Vdc (possibly, heating see 1-H)

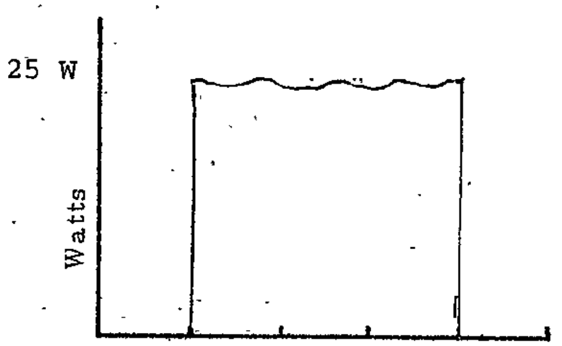
B. Voltage Limits: 400 HzAC + 3% Vac - 3% Vac

28VDC + 4 VDC - 4 VDC

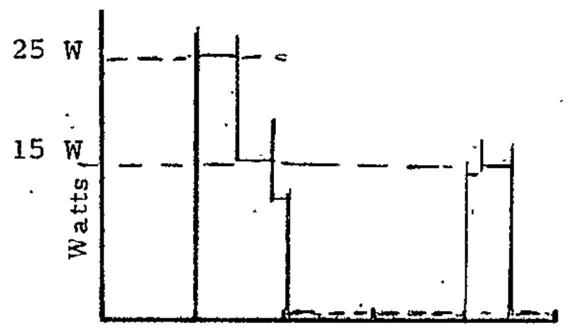


(*) Block-diagram

C. Profile of Typical Single Cycle Operation Sequence



Denote Time (for 1 cycle only)/Units



Denote Time (for 1 cycle only)/Units

D. Aft Flight Deck/Pallet-Mounted Equipment Interface Method

(1) Spacelab Command and Data Management Subsystem (CDMS) yes

(2) Other (describe) After initial CDMS signal, LAS console assumes the experience management.

(3) Hardwires Required

a. Twisted Shielded Pairs (No. Required) TBD

b. Twisted Pairs (No. Required) TBD

c. Coax TBD

TELEMETRY

A. Real Time Not necessary

B. Near Real Time not necessary kbps (Within One Orbit)

C. Other (Describe) The stowage capacity necessary is of the order of 100 k bits.

5. DATA ACQUISITION (CORRELATE TO EXPERIMENT CYCLE)

A. Digital — a cycle is the totality of operations to be effected during a single orbital night (pointing at one objective). see § 4.4 in the main proposer.

(1) Rate 100 bps

(2) Burst Rate TBD

a. How Often ______

(3) Annotation

a. Voice ______ b. Time X c. *GN&C X

(4) During: Setup ______ Standby ______

Operating ≤ 20 min Shutdown ______

Other (Explain) ______

B. Analog

(1) Sampling Rate 2 Hz

(2) Duration of Sampling ≤ 20 Min/Cycle

(3) Annotation

a. Voice ______ b. Time X c. GN&C X

(4) During: Setup ______ Standby ______

Operating · 20 min. Shutdown ______

Other ______

(5) Real Time Required ? Not necessary

C. TV N/A

(1) Bandwidth ______ MHz

(2) Duration ______ Min/Cycle

* Guidance Navigation and Control (GN&C)

(3) Annotation

a. Voice __________ b. Time __________

(4) During: Setup __________ Standby __________

Operating __________ Shutdown __________ Other __________

(5) Real Time Required ? ______

D. Discrete Signals

(1) Number 1

(2) Sample Rate 1 per cycle

6. ONBOARD STORAGE (PROPOSER SUPPLIED EQUIPMENT)

Type	No. of Reels Required
Digital	2 channels (2 x 16 bits)
Analog	5 channels
TV	0

7. COMMAND REQUIREMENTS (TO EXPERIMENT)

A. Source (Spacelab CDMS, Ground, Instrument Control & Display)

one 16 bit word

B. Rate N/A kbps

C. Duration TBD (0 ⟶ 20 min)

D. Frequency of Operation __________

8. FLIGHT OPERATIONS

A. Desired Orbit Characterisitcs (If insensitive denote NA)

(1) Altitude $>$ 120 km shuttle altitude

(2) Inclination no requirement deg

(3) Launch Time no requirement GMT hrs

(4) Launch Date no requirement

(5) Requirements Influencing Orbital Characteristics none

(6) Phase of Moon At ± 7 days from full moon, the moon should be more than 5° below the satellite horizon. In any case the moon cannot be in the 60° field.

New ______ 1st ______ Full ______ Last ______ Insensitive ______

B. Effect of Deviations in Orbit Characteristics on Objectives

Not critical within 5°

C. (1) Target Locations (Specific if available or general).

o Inertial Targets: Right Ascension and Declination for 1950 Epoch

See § 4.1 in the main proposer (deg)

o Earth Target: Geodetic Latitude and Longitude

none (deg)

(2) Total Viewing Time Desired for Each Target For each target there is one cycle of operations made during a single orbital night of $\lesssim$20 min. There are 5 complete cycles in the mission or 5-9 incomplete cycles (100 frames max.) (min)

(3) Minimum Acceptable Viewing Time Per Observation

1 cycle (≤20 min) (min)

D. Payload Operations Control Center Support Requirements

(1) Planned location of experiment operator (orbit, ground) orbit

(2) Flight operations ground support will require: (Denote by NA, TBD, Yes, No)

Real Time

No	Monitoring of data
No	Commanding/Control of Experiment
No	Software computer program to support experiment
TBD	Advising onboard expt operators
No	Trend analysis of data
No	Evaluation of data
TBD	Realtime decision making
No	Data Validation
No	Displays with Experiment Data
TBD	Voice Contact with Crew
	No Requirements

E. Experiment Cycles/Performances/Observations Per Mission

(1) Desired 5 complete cycles (5x20 = 100 frames) or 5→9 incomplete cycles (100 frames max.)

(2) Required 20 frames minimum (1 complete cycle or 5→9 incomplete cycles)

F. Time Between Experiment Cycles/Performances/Observations

(1) Maximum unlimited min

(2) Minimum time between 2 orbital nights

(*) Normaly, the entire operation is programmed in advance and proceeds entirely under LAS console control. The crew must intervene in case of program modifications required by the ground support. The crew time is then the time corresponding to one cycle (< 20 min). Crew intervention should be rare (manual operation on the control consol).

G. Time Per Experiment Cycle/Performance/Observation

	Avg Time (Min)	Crew Time (Min)
(1) Setup		
(2) Standby	Unlimited (time between 2 cycles)	
(*) (3) Operating/Monitoring	1 cycle (≲ 20 min)	1 cycle if required
(4) Shutdown		
(5) Other		

H. Payload Crew Operation Tasks (Describe)

(1) Setup Possibly, to activate the protection covers.

(2) Standby During standby (time between 2 cycles) the experiment is cut off.

(3) Operating/Monitoring CDMS autorizes observing sequence, (Shuttle pointing to celestial target, good conditions for run and moon, covers withdrawn), records house keeping data and Shuttle pointing.

(4) Shutdown The experiment gives an indication of the end of the cycle to the CDMS, ~~which corrects the voltage and replaces the covers.~~

(5) Other The temperature regulation (by electric heater or cold plate to be determined) is effected during the entire mission.

I. Discipline Background and Specific Research Background Required of the Operator of Your Instrument: No scientific background required.

J. Training:

If the operator of your instrument has a general discipline competence, how much training time would you anticipate to familiarize the operator with your instrument and research? Few (5 - 10) Hours

K. Viewing Constraints - Celestial

(1) Center of Field of View at Least

a. In some cases, the sun could be as little as 5° below the satellite horizon..

b. At ± 7 days from full moon, the moon should be more than 5° below the satellite horizon. In any case the moon cannot be in the 60° field.

c. ___35___ degrees away from nearest bright Earth point

d. ___10___ degrees away from dark Earth Limb
or
___120___ kilometer atmospheric altitude constraint

e. ___10___ degrees away from bright Shuttle surface

f. ___--___ degrees away from dark Shuttle Surface

(2) Orbital Shadow Viewing Only ___X___ Yes ______ No

(3) Viewing in Orbiter Shadow Permissible ___X___ Yes ______ No

(4) Sun at Least ___5___ degrees below the horizon for orbital shadow viewing case only.

L. Viewing Constraints - Earth N/A

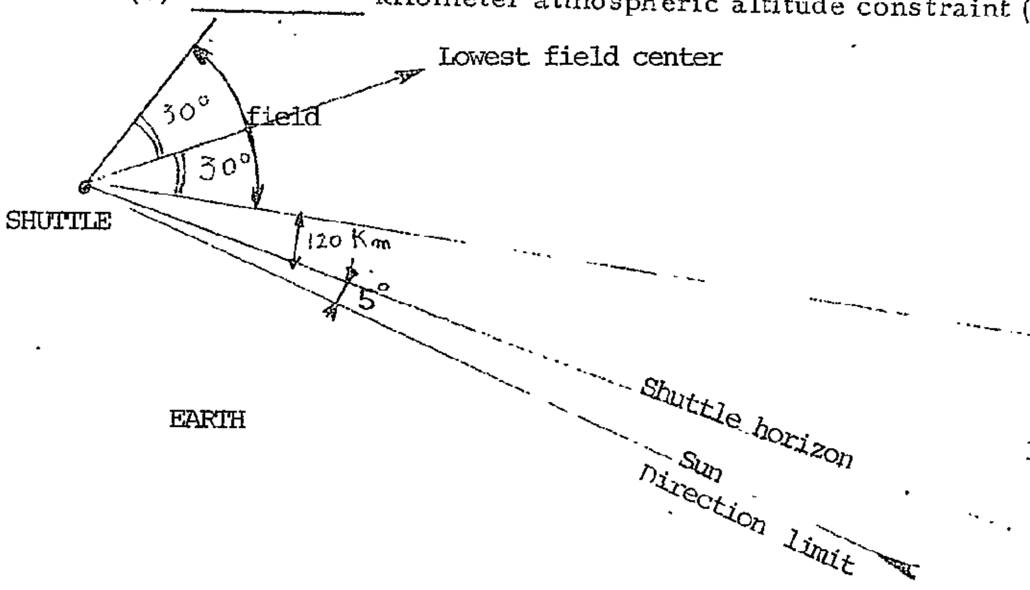
Sun Elevation Angle ___--___ to ___--___ (Deg)
(Target local horizon up to sun)

M. Viewing Constraints - Solar See K (1)

(1) Sun Centered ______ Yes ______ No

(2) Offset ______ Yes ______ No

(3) ______ kilometer atmospheric altitude constraint (attenuation)



N. Other Operational Requirements/Constraints ______________

O. Constraints On Other Instruments

(Describe) None

9. ENVIRONMENTAL LIMITS

	AFT FLIGHT DECK	PALLET MOUNTED EQUIPMENT
Temperature		
Proper Operation	10 °C to 50 °C	- 30°C + 30°C
Out of Calibration (No Damage)	- 30 °C to +60 °C	-40 °C +38 °C
Preference Temp	20 °C	20 °C
Type Thermal Control Reqd. or Preferred (Air, Cold Plate, Coatings)	Air	Cold plate and coatings
Non-Operating Min/Max No Damage to Instru.	-30 °C +60 °C	-40 °C +38 °C
Humidity Limits	No condensation	
Proper Operation	0 % to 90 %	(N/A)
Non-Oper (No Damage)	0 % to 90 %	0 % to 70 %
Acoustic Limits Non-Oper (Launch)	No requirement dB	T B D dB
(*) Accelerations		
Non-Oper (Launch)	25 g	10 g
Operating (On-Orbit)	1 x 10⁻ N/A g	1 x 10⁻ N/A g
Susceptibility to RFI (Describe) Magnetic Other	T B D	T B D

(*) These values are approximate and can be increased if necessary.

Production of RFI	T B D		T B D
(Describe)			
Magnetic			
Other			

Radiation (On Orbit Natural)

Non-Operating

a. Proton			
Energy Level	T B D	Mev	T B D
Flux		particles/cm^2/sec	
Dosage		Rads	
b. Electron			
Energy Level	T B D	Mev	T B D
Flux		particles/cm^2/sec	
Dosage		Rads	

Operating

a. Proton			
Energy Level	T B D	Mev	T B D
Flux		particles/cm^2/sec	
Dosage		Rads	
b. Electron			
Energy Level	T B D	Mev	T B D
Flux		particles/cm^2/sec	
Dosage		Rads	

G. Other

(1) Atmospheric Pressure — No requirement : non operating; below 10^{-4} Torr: operating

(2) Earth Magnetic Field — N/A

PHOTOGRAPHIC REQUIREMENTS

A. Proposer to supply camera, film, and associated equipment X Yes ___ No

B. Type Camera: N/A

C. Type Camera Attachments: N/A

D. Type Film: Scientific film, possibly Kodak 103 aO

E. Number of Rolls: One (100 frames inside film advance device)

F. Cold Plate Cooling Required ___ Yes ___ No T B D

G. Vacuum Required

(1) Pressure Required: below 10^{-4} Torr operating

(2) Usage: ___

H. Film Storage Yes Rolls, Type This operation is effected by the film advance device

I. Film Usage Rate ___ Frames/Min See standard cycle parag. 4.4.

11. GROUND SUPPORT EQUIPMENT AND OPERATIONS page 11 of the main proposer

Pre-Flight Yes	Pre-Flight No	Post-Flight Yes	Post-Flight No	
				A. Special Ground Support Services Required
	X		X	(1) Cryogenic loading (identify cryogens, when to be loaded)
X				(2) Fluid or Gas Services Required (specify fluid or gas where?) Possibly dry nitrogen purge inside the receptor
X		X		(3) Calibration (specify equipment, facilities) The necessary equipment exists in LAS. Before flight a check is done by LAS crew with the aide of LAS test equipment (stimuli).
X		X		(4) Checkout (specify equipment) Control rack provided
	X			(5) Refrigeration (specify temperature range) See paragr. 9 (environmantal limits)

Pre-Flight Yes	Pre-Flight No	Post-Flight Yes	Post-Flight No			
X		X		(6)	Clean Room (10K) (100K) (Laminar Flow Bench) ______	
	X		X	(7)	Autoclave (size and quantity of items to be sterilized) ______	
	X		X	(8)	Radioactive Material Storage (identify isotope) ______	
	X		X	(9)	Specimen Holding Provisions (specify equipment and specimens) ______	
	X		X	(10)	Hazardous Chemical Storage (identify chemical) ______	
				B.	Special Instrument Requirements	
X		X		(1)	Temperature Control	Range ___ °C to ___ °C (See parag. 9)
X		X		(2)	Humidity Control	Range 0 % R.H. to 70 % R.H. (No conde satic)
	X		X	(3)	Lighting Control	___ lumens/m^2, Special Day/Night Cycle
	X		X	(4)	Ventilation Control	___ m^3/sec to ___ m^3/sec
	X		X	(5)	Vibration Control	(specify maximum curve - g's/sec^2
	X		X	(6)	Noise Control	(specify maximum curve - 1/3 Octave Band)

Pre-Flight		Post-Flight		
Yes	No	Yes	No	
X		X		(7) Bonded Storage
X		X		C. Special Ground Transportation and/or Handling Required?

D. Time before launch that access is required to instrument?
T - TBD Hours. Discuss related activities. No special requiremen

E. Time after landing that access is required to instrument?
As soon as possible
L + TBD Hours. Discuss related activities. Removal of film Pack (duration 30 min.).

F. Integration Requirements/Activities (Describe in a function block diagram the major activities and sequences of events necessary for the physical integration and electrical connection of the instrument into Spacelab.) TBD

12. SAFETY AND CONTAMINATION

A. From STS to Equipment

(1) Safing Commands ________

B. Fluids Carried Onboard

(1) Type None (4) Flow Rate ________

(2) Pressure ________

(3) Equipment Requiring Appreciable Flow ________

C. Gasses Carried Onboard The film advance device is pressurized (nitrogen)

(1) Type None (4) Flow Rate ________

(2) Pressure ________

(3) Equipment Requiring Appreciable Flow ________

D. Radioactive Material

(1) Type ___None___ (2) Quantity ______________

E. Aerosols (Particularly Toxic Compounds)

(1) Type ___None___ (2) Quantity ______________

F. Automated Parts of Payloads Which are Capable of Motion External to Stationary Containers ___None___

G. Overboard Vents ___None___

H. Additional Comments on Possible Contaminants ______________

____

____

13. COMPUTER PROCESSING FUNCTIONS N/A

A. Instrument

(1) Checkout _____ Yes _____ No

(2) Calibration _____ Yes _____ No

(3) Operation _____ Yes _____ No

(4) Display Formatting _____ Yes _____ No

(5) Data Formatting _____ Yes _____ No

B. Support Estimate

(1) Speed __________ Equivalent Fixed-Point Adds/sec

(2) Mass Memory __________ K 16 Bit Words

(3) Main Memory __________ K 16 Bit Words

(4) Instruction Words __________

K. Maximum Slew Rate No limit deg/sec

L. Position Accuracy No requirement (*)

(1) Velocity ± ________ m/s

(2) Altitude ± ________ km

(3) Downrange ________ km

(4) Crossrange Position ________ km

M. Mounting Type

(1) Experiment Provided Yes ______ No ______

(2) Rigid X

(3) Gimbal

(4) Scan

(5) Other (describe) ________________________________

____

____

(*) The pointing axis of the experiment is indicated on the figure (8) with respect to the VWFC hardware.

When the definitive VWFC position on the pallet is determined, the pointing axis is known with respect to the Shuttle. This axis should be pointed towards the celest targets with an accuracy better than 5°. While pointing, the pitch, yaw and roll stability should be less than ± 0.1 deg/axis and the stability rate should be better than ± 0.1 deg/sec/axis.

The angular position of the VWFC around the pointing axis is not important.

C. Experiment Software

(1) Applications Development Support Required ____ Yes ____ No

(2) Furnished With Experiment ____ Yes ____ No

D. Mini and/or Micro Computers Contained Within Expmt ____ Yes ____ No

E. Additional Computer Functions Required by Experiment

____

____

____

14. POINTING

A. Locations

(1) Pallet Yes

(2) IPS No

(3) Remote Manipulator System No

B. Viewing Direction According to selected targets

C. Scan ± No deg.

D. Field of View 60 Deg circular

E. Accuracy 5 deg ~~or Arc Sec~~

F. Stability ± 0.1 deg or Arc Sec

G. Stability Rate ± 0.1 deg/sec ~~or Arc Sec/Sec~~ (Shuttle specifications

H. Raster Scan Required ____ Yes x No

I. Fixed Point Earth Tracking ____ Yes X No

J. Experiment Has Image Motion Compensation ____ Yes x No