Poster Presentations

N94-15621

SATELLITE LASER STATION HELWAN
STATUS 1992

M Čech, K.Hamal, H.Jelínková, A.Novotný, I.Procházka

Faculty of Nuclear Science and Physical Engineering, Czech Technical University
Brehova 7, 115 19 Prague 1, Czechoslovakia
phone / fax +42 2 848840, telex 121254 fjfi c, E-mail tjean@csearn.bitnet

B.B.Baghos, Y. Helali, M.J.Tawadros

National Research Institute of Astronomy and Geophysics, Helwan, Egypt
phone / fax +20 2 782683, telex 93070 hiag un, E-mail nriag@egfrcuvx.bitnet

GENERAL

The Satellite Laser Station Helwan has been operated jointly by the National Research Institute of Astronomy and Geophysics in Helwan, Egypt and the Czech Technical University in Prague, Czechoslovakia (see Proceedings of the 7th International Workshop on Laser Ranging Instrumentation, Matera, 1989). The station components have been carefully tuned to increase the system overall stability and reliability critical for the remote location. The mount correction model based on the Gaussian smoothing (Kabeláč, 1990) has been implemented to simplify the blind satellite acquisition and tracking. The on-site normal points generation algorithm has been implemented, the station has been connected to the international information network. The ERS-1 satellite has been included into the tracking schedule. The station range capability has been verified by experimental Etalon 1 ranging by April 1992. The ranging precision of 2-3 centimeters is obtained when ranging to ERS-1, Starlette and Lageos satellites.

The station operation has been cosponsored by the DGFI contracts ERS-1/7831/91,92 and the Smithonian Astrophysical Observatory contract, whose support in acknowledged.

N94-15622

OPTICAL ATTENUATION MECHANISM

UPGRADES

MOBLAS and TLRS SYSTEMS

Richard Eichinger, Toni Johnson, Paul Malitson,
Tom Oldham, Loyal Stewart

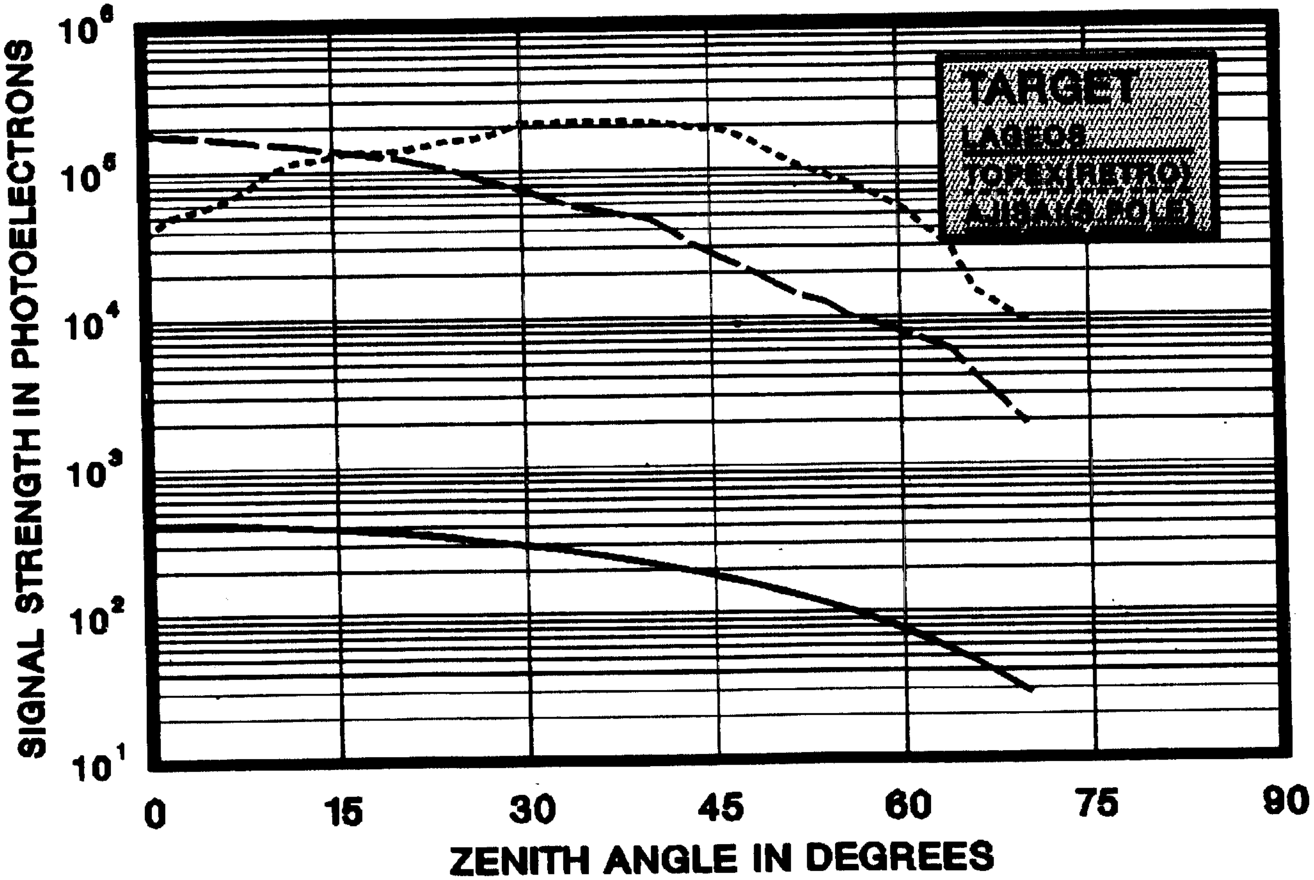
Allied Signal Aerospace Company
BFEC/CDSLR
10210 Greenbelt Road
Seabrook, MD 20706
USA

Abstract

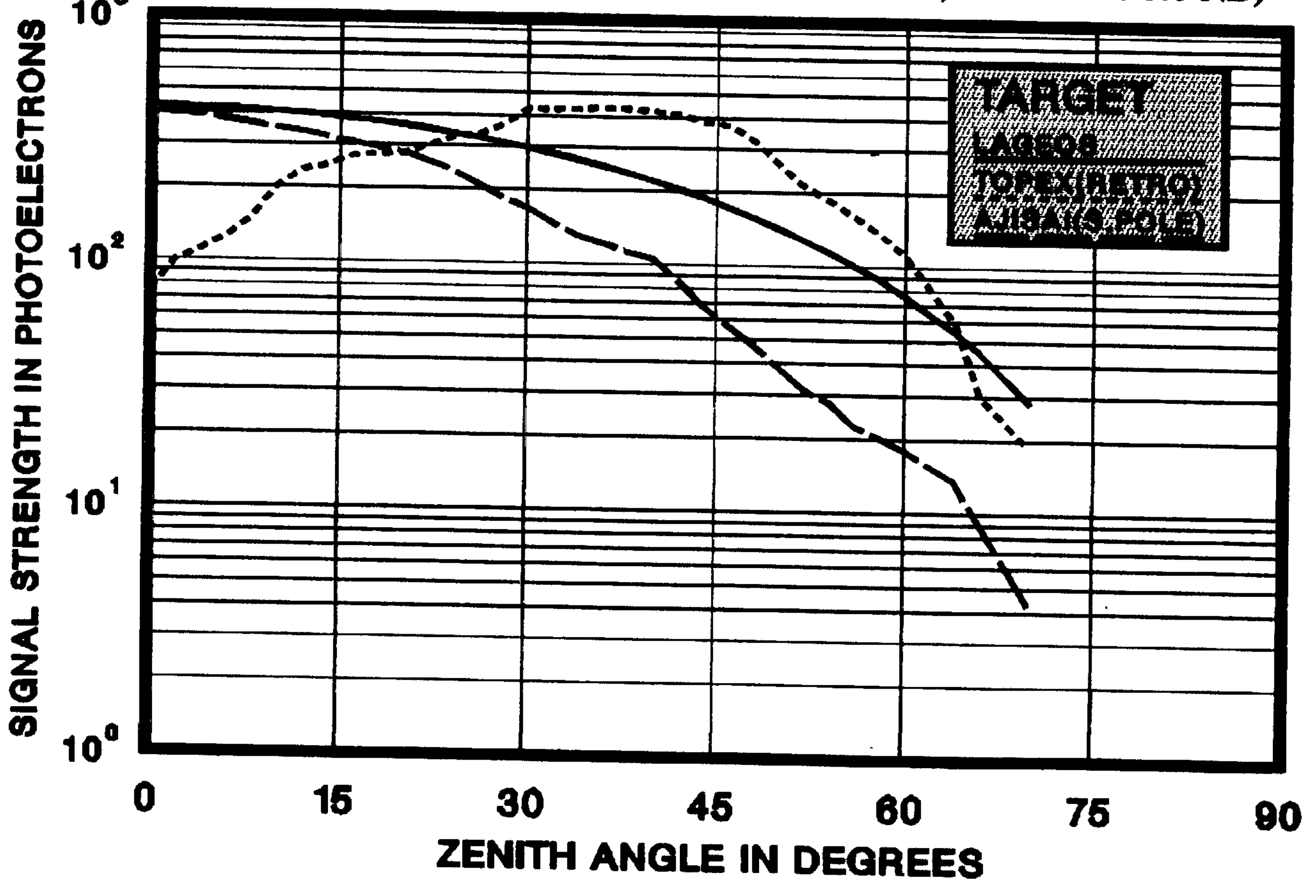
This poster presentation describes the Optical Attenuation Mechanism (OAM) Upgrades to the MOBLAS and TLRS Crustal Dynamics Satellite Laser Ranging (CDSLR) systems. The upgrades were for the purposes of preparing these systems to laser range to the TOPEX/POSEIDON spacecraft when it will be launched in the summer of 1992. The OAM permits the laser receiver to operate over the expected large signal dynamic range from TOPEX/POSEIDON and it reduces the number of pre and post calibrations for each satellite during multi-satellite tracking operations. It furthur simplifies the calibration bias corrections that had been made due to the pass-to-pass variation of the photomultiplier supply voltage and the transmit filter glass thickness. The upgrade incorporated improvements to the optical alignment capability of each CDSLR system through the addition of a CCD camera into the MOBLAS receive telescope and an alignment telescope onto the TLRS optical table.

The OAM is stepper motor and microprocessor based; and the system can be controlled either manually by a control switch panel or computer controlled via an EIA RS-232C serial interface. The OAM has a neutral density (ND) range of 0.0 to 4.0 and the positioning is absolute referenced in steps of 0.1 ND. Both the fixed transmit filter and the daylight filter are solenoid actuated with digital inputs and outputs to and from the OAM microprocessor. During automated operation, the operator has the option to overide the remote control and control the OAM system via a local control switch panel.

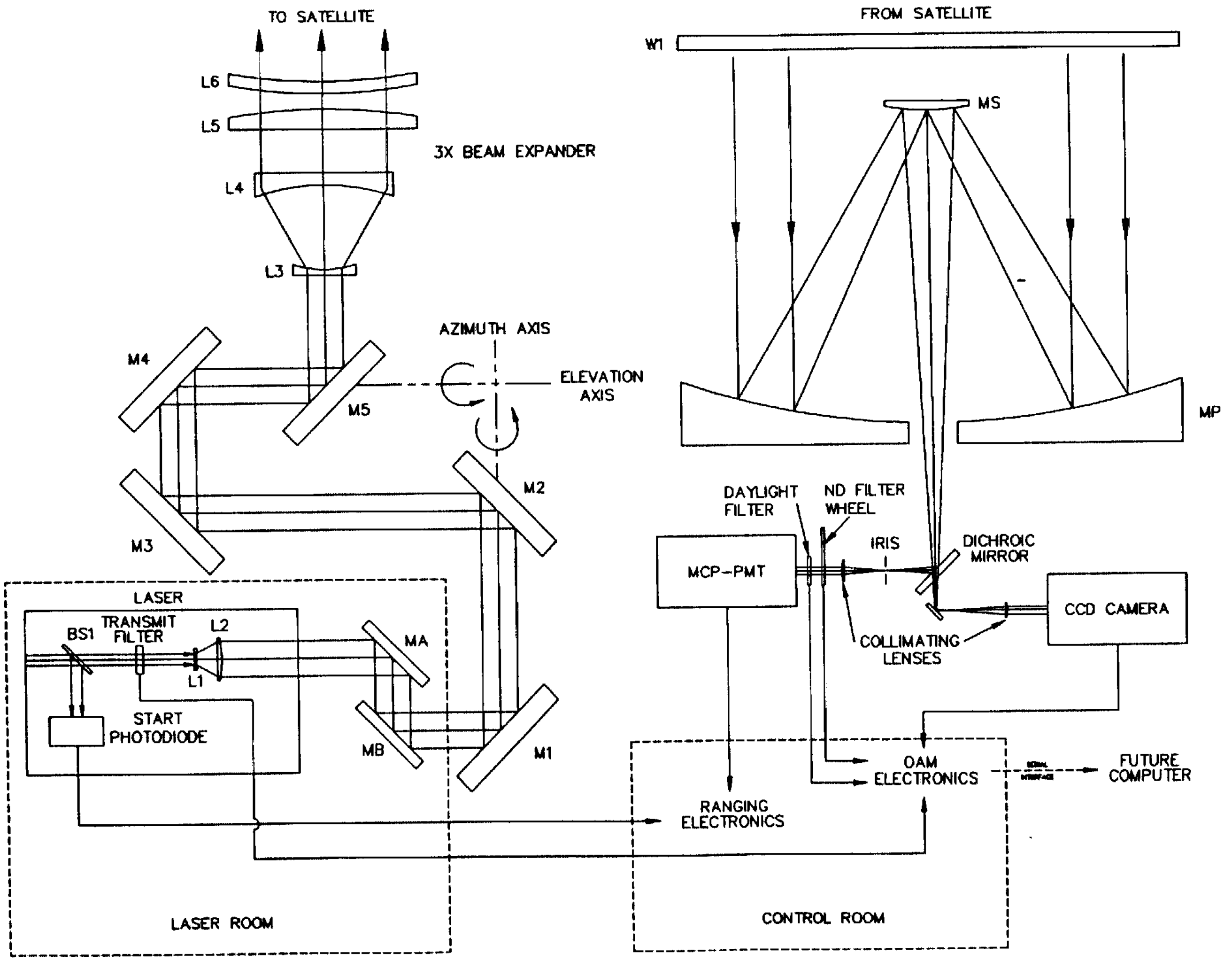
PHOTOELECTRONS RETURNED BY VARIOUS SATELLITES



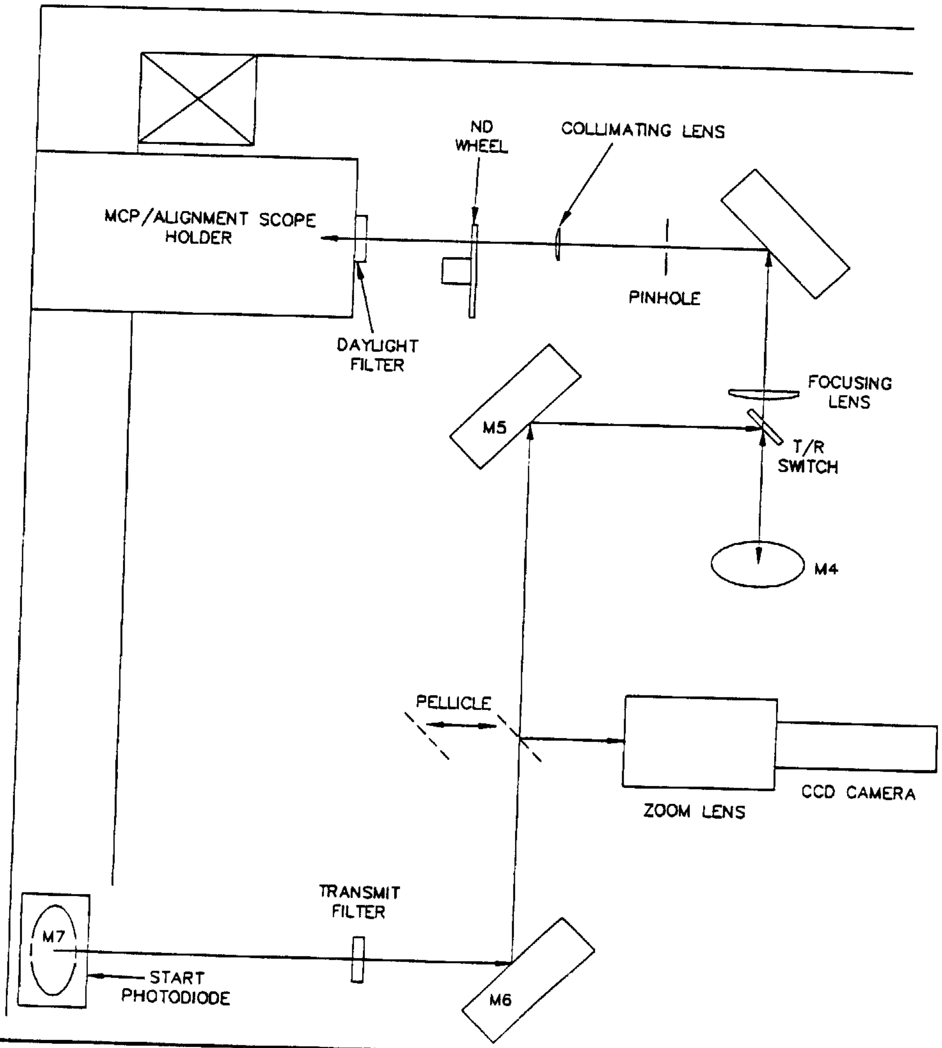
PHOTOELECTRONS RETURNED BY VARIOUS SATELLITES
WITH OAM
(TOPEX/POSEIDON: 2.6 ND; AJISAI: 2.2 ND; LAGEOS: 0.0 ND)



MOBLAS OAM UPGRADE SUBSYSTEM



TLRS OAM UPGRADE SUBSYSTEM



OAM UPGRADE SPECIFICATIONS

Stepper Motor and Control Electronics:
- Indexer/Controller: Compumotor model 500
  - Max. speed: 40 rps
  - Steps per revolution: 25,000
  - Digital I/O: 13 inputs, 8 outputs
  - Computer interface: EIA RS-232C
  - Software:
    - High level X-language
    - Variable assignments
    - Math functions
    - Conditional branching
    - Max. program locations: 99
    - Memory: 8k RAM
- Motor Drive: Compumotor model CT
- Miniature Stepper Motor: Compumotor model CT25-30

Neutral Density Wheel: Reynard part 522
- 0.0593 to 3.94 ND: 0 to 270 degrees, 7 mm dia. beam
- linearity of density: +/- 5%
- ar (532 nm, normal incidence, both sides): 0.1 % reflective
- substrate: 100 mm dia., BK-7, < 3 arcmin wedge

Dichroic Beam Splitter: Melles Griot substrate, coated by Omega
- 99 % reflective, 532 nm, unpolarized, 45 degree incidence
- approx. 85 nm FWHM relective about 532 nm
- 400 to 800 nm blocking
  - > 532 nm: 80-95 % transmitive
  - < 532 nm: 20-70 % transmitive
- ar (MgF) coating on one side
- substrate: BK-7, lambda/10, 1 arcmin wedge

Daylight Filters:
- Original MOBLAS: 10A @ 532 nm, Oriel
  - approx. 40 % trans. (GSFC meas.)
  - unknown blocking
- Original TLRS, new MOBLAS: 10A @ 532 nm, Omega
  - 60-65 % trans.
  - uv to 900 nm blocking
- New TLRS: 3A @ 532 nm, Omega
  - 45 % trans.
  - 400 to 700 nm blocking

TLRS Pellicle:
- Uncoated: 8 % refl.
- Flatness: 2 lambda per 25 mm

OAM UPGRADE SPECIFICATIONS (continued)

Lenses:

MOBLAS Collimating lens: 36 mm fl, BK-7, ar (MgF)
Field lens: 1000 mm fl, BK-7, ar (MgF)
Achromat lens: 80 mm fl, ar (MgF)
TLRS Focussing lens: 150 mm fl, BK-7, ar (MgF)
Collimating lens: 60 mm fl, BK-7, ~~ar~~ (MgF)

Mirrors:

MOBLAS turning mirror: Edmund Scientific
lambda/8
enhanced aluminum
TLRS turning mirror: CVI
lambda/10
> 99.5 % refl.
BK-7 substrate
< 5 arcmin wedge

***Alignment Telescopes**, K&E Electro-Optical Products, Cubic Precision*

Original MOBLAS: Model 71 2030 Bright Line Alignment Telescope
Magnification: 4x @ zero to 46x @ infinity
Resolving Power: 3.4 arcsec
Field of View: 42 mm @ zero, 37 min @ infinity focus
Effective Aperature: 42 mm
New TLRS: Model 71 2062 Line of Sight Telescope
Magnification: 23x @ 7 in. to 35x @ infinity
Resolving Power: 3.5 arcsec
Field of View: 7.4 mm @ 7 in., 47 min @ infinity focus
Effective Aperature: 38 mm

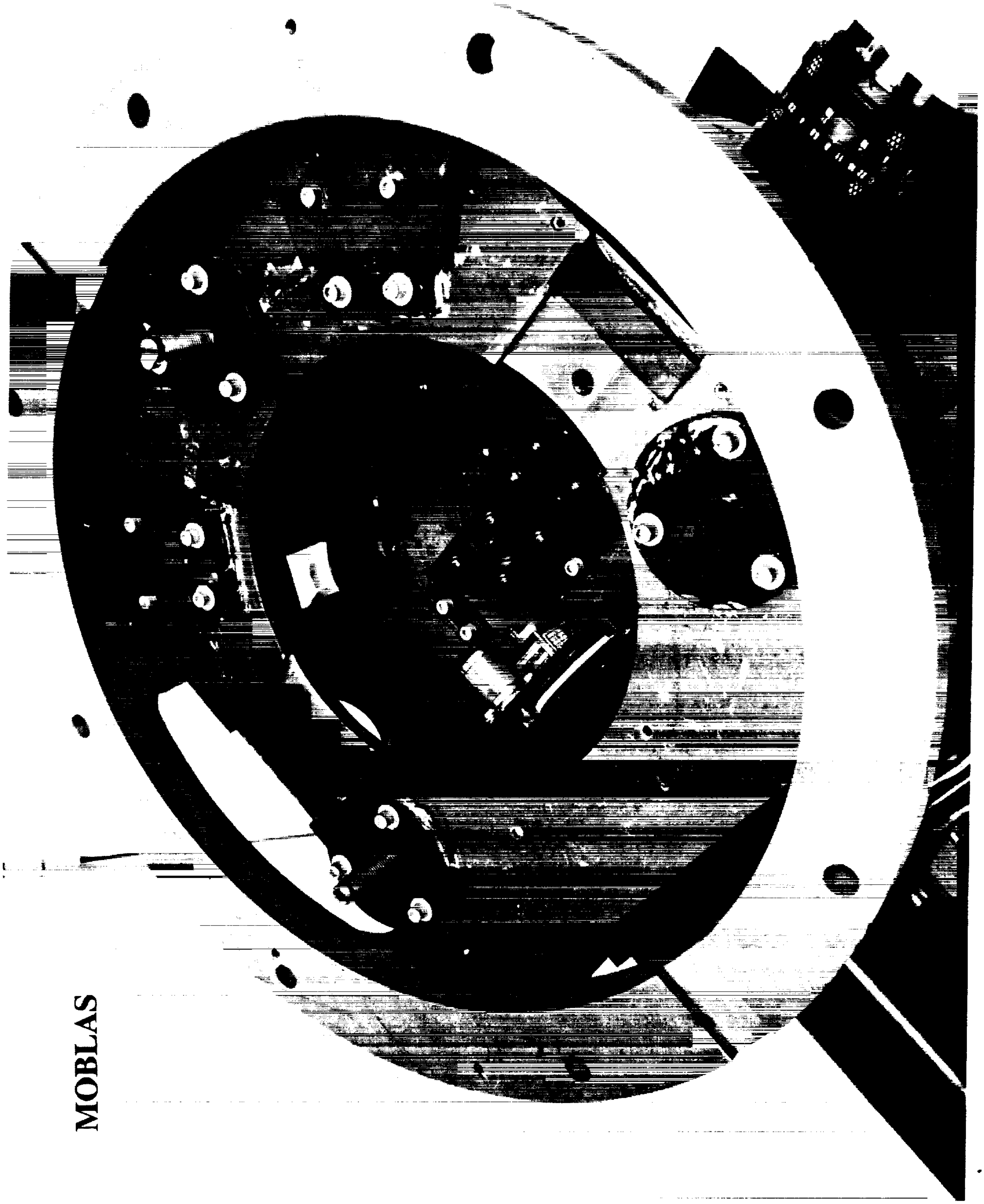
CCD Camera Systems:

MOBLAS CCD camera: Burle model TC652EA
510 (H) x 492 (V) pixels, EIA RS-170
Horizontal resolution: 383 TVL
Signal-to-noise: 50dB
Lens: 75 mm fl, F/1.4
Lens mount: Standard "C" or "CS"
Video Line Generator: Oracle model 1000
Video Monitor: Panasonic model TR-930B
TLRS CCD Camera: Pulnix model TM840
767 (H) x 483 (V) pixels, NTSC
TV resolution: 580 lines (H), 350 lines (V)
Signal-to-noise: 50 dB
Lens: 11-110 mm zoom
Lens mount: Standard "C"
Video Monitor: Panasonic model TR-930

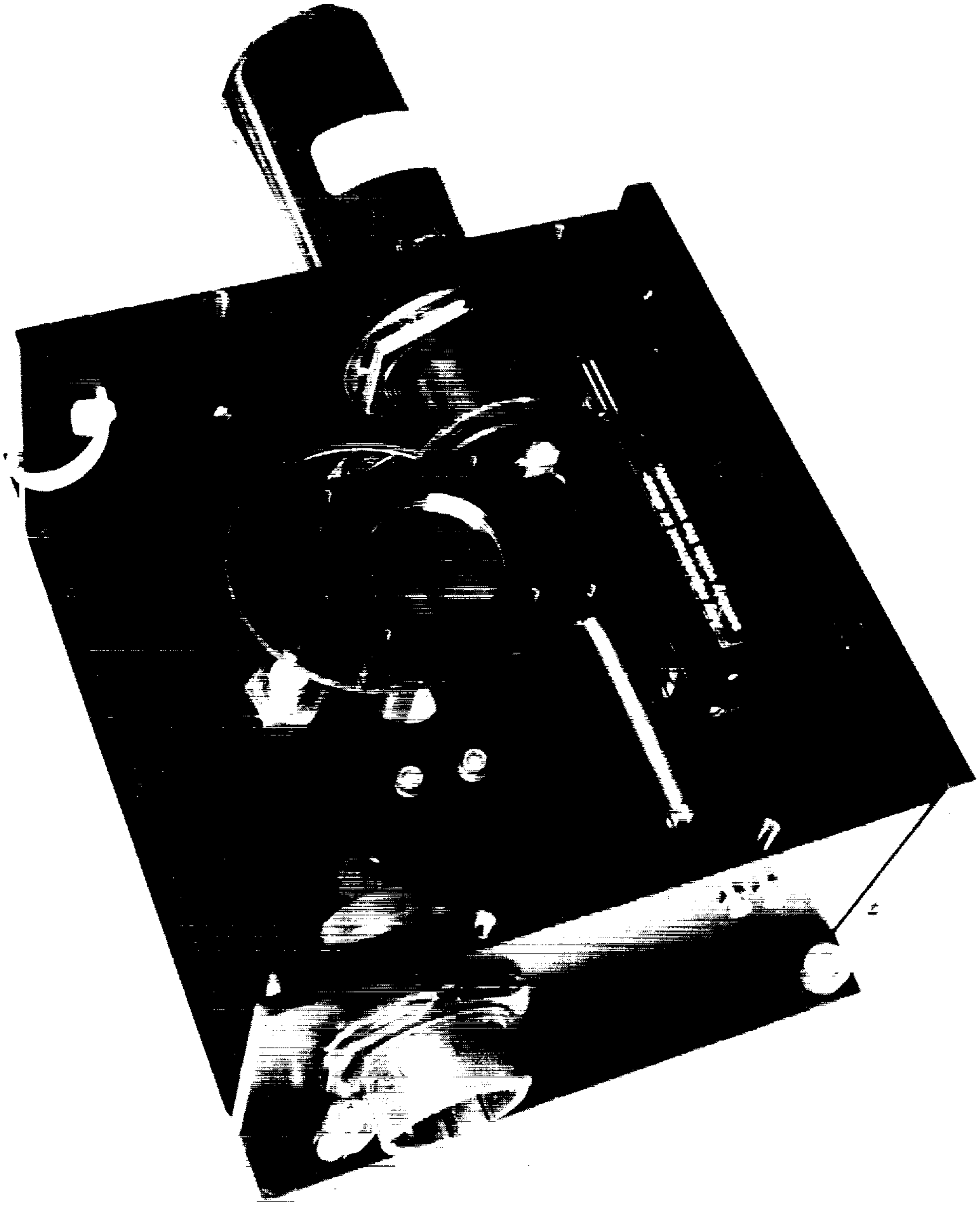
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

MOBLAS OAM UPGRADE

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



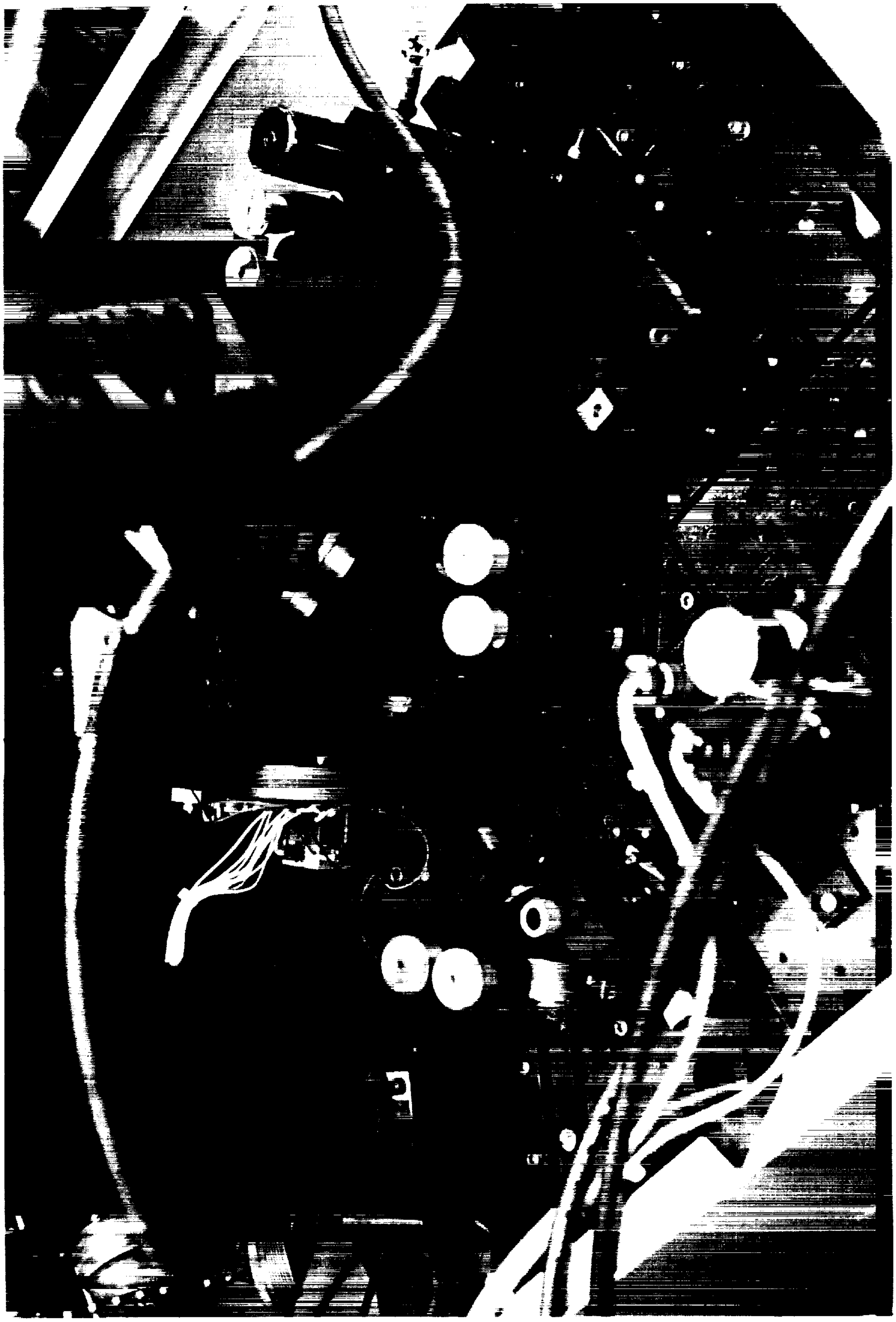
MOBLAS



MOBLAS OAM

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

TLRS OAM UPGRADE



N94-15623

THE THIRD GENERATION SLR STATION POTSDAM NO.7836

H.Fischer, L.Grunwaldt, R.Neubert
GeoForschungsZentrum Potsdam
Telegrafenberg A17, D-O-1561 Potsdam
Phone: (03733)-310-0
Fax: (03733)-310-648
(03733)-22824
E-Mail: lasgrp@gfz-potsdam.dbp.de

The new SLR station Potsdam has been installed during Winter 1991/1992 in an existing dome near to the old ruby laser at Helmert Tower. It has been built around a one-meter-Coude telescope and is equipped by a 50 ps Nd-YAG laser and a SPAD receiver. First successful LAGEOS passes were obtained in May 1992 demonstrating 2-3 cm rms at the single photon level.
The new station will be used for experimental work and selected observation campaigns as well.

HARDWARE SPECIFICATIONS

Mount and Telescope:

One-meter Coude system type TPL (Riga University)
common transmit-receive path switched by rotating mirrors
step motor drives for azimuth and elevation

Receiver Package:

Silicon avalanche photodiode type C 30902 S-TC (integrated Peltier cooling)
operated in the Geiger mode with passive quenching
standard interference filter, spectral width 2 nm

Laser:

Nd-YAG with passive modelocking by dye #3274 (own construction)
KTP frequency doubler
main data at 532 nm: 10-20 mJ, 35-50 ps, 10 Hz

Time Interval Counter:

Stanford Res. Labs. type SR 620

Time Base:

GPS- receiver Datum Inc. type 9390-55134, internal Rb- standard

Control System:

Standard PC (HP Vectra 386) interfaced via IEEE-488 to the
specially designed control unit (step motor controller,
gate pulse generator, epoch counter with 100 ns resolution)

SOFTWARE SPECIFICATIONS

Orbit Reconstruction:

numerical integrator using point mass model for the gravitational field representation (Ch. Foerste)

Input : IRV's
Output: reference points in a space-fixed system, arbitrary time spacing (usually 10 sec)

Real Time Tracking:

Input : reference points, real time corrections
Output: control information with 10 Hz rep. rate
raw data

Prefiltering:

Input : reference points, raw data
Output: filtered data
interactive filtering using the same reference orbit as for tracking, polynomial fitting to the O-C's
(J. del Pino)

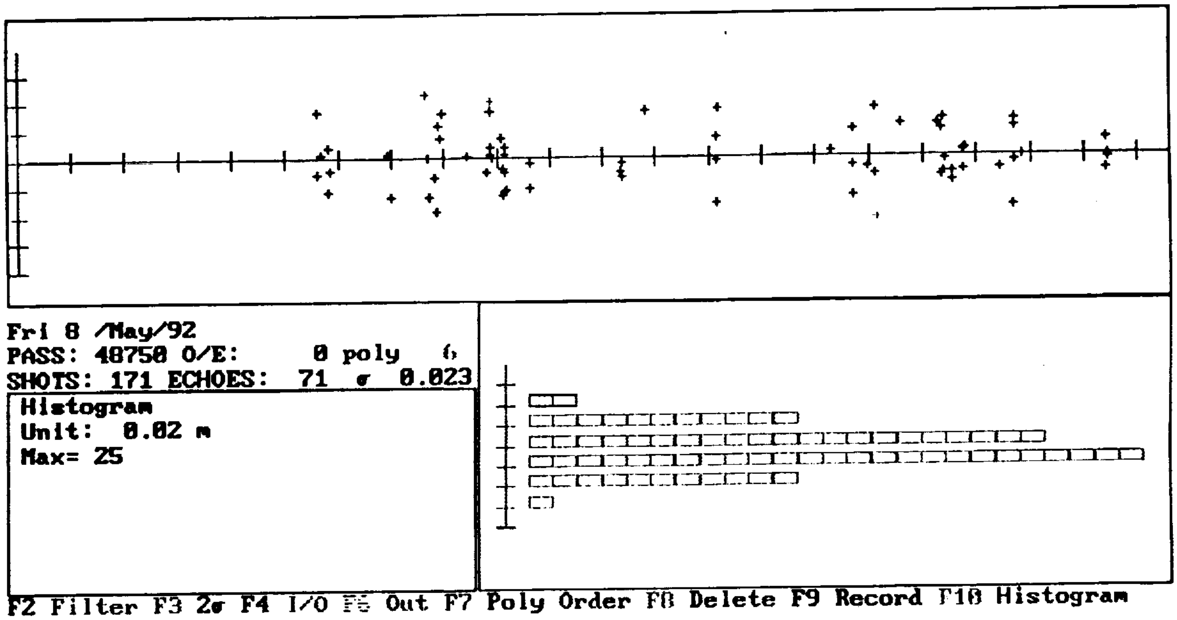
Star Calibration:

automatic star identification

Input : star positions (azimuth, elevation, epoch)
Output: mount-error-model parameters

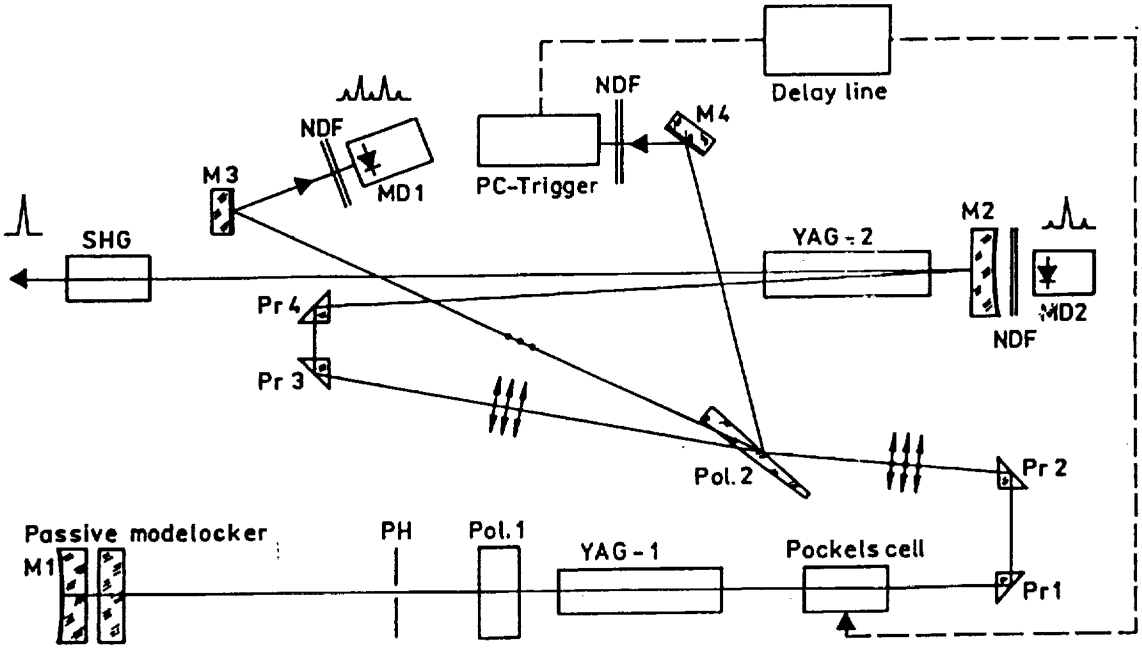
On Site Normal Point Software:

EUROLAS OPAN S/W (Appleby and Sinclair)

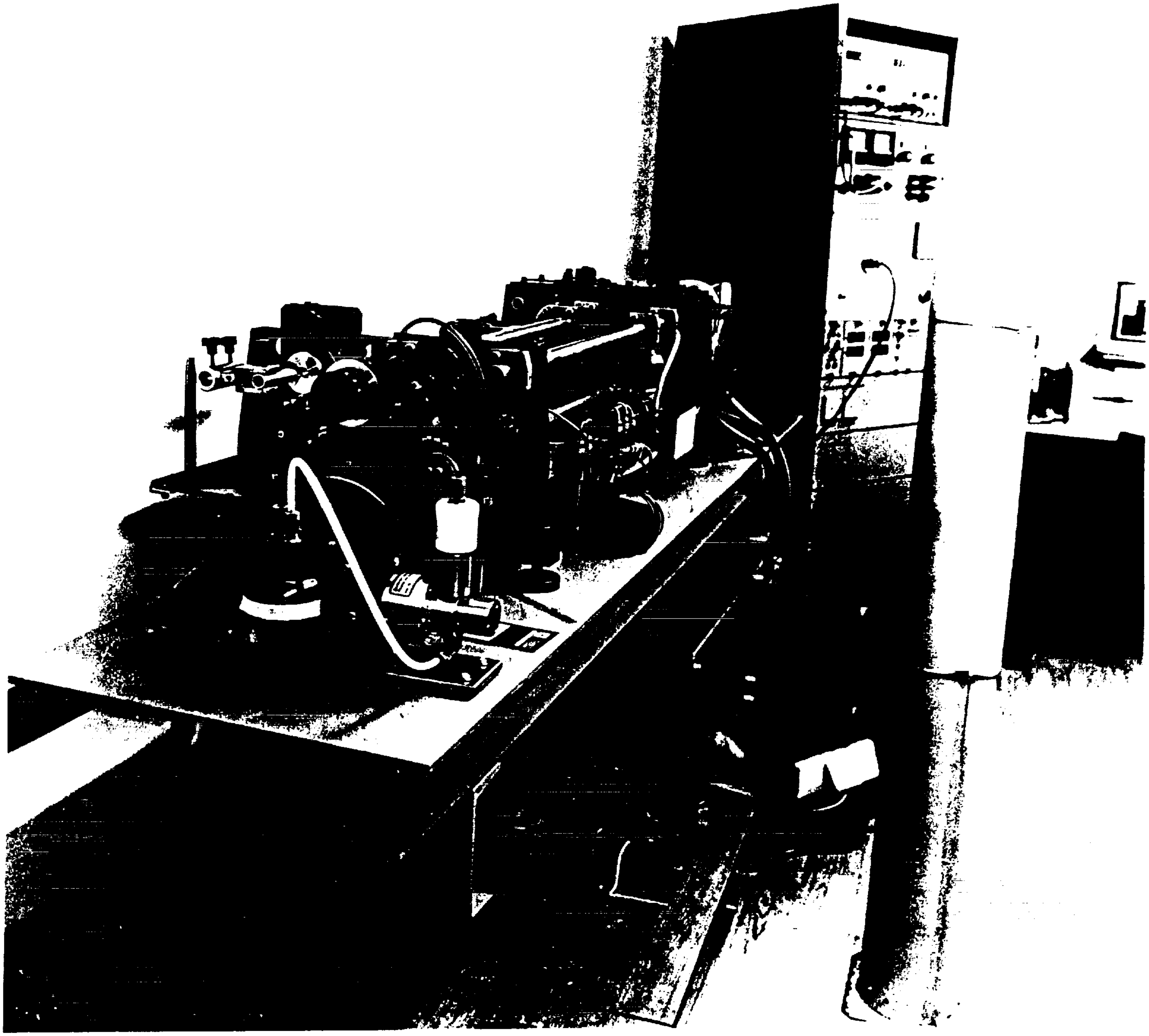


```
Fri 8 /May/92
PASS: 40750 O/E:      0 poly   6
SHOTS: 171 ECHOES:  71  σ  0.023
Histogram
Unit:  0.02 m
Max= 25
F2 Filter F3 2σ F4 I/O F6 Out F7 Poly Order F8 Delete F9 Record F10 Histogram
```

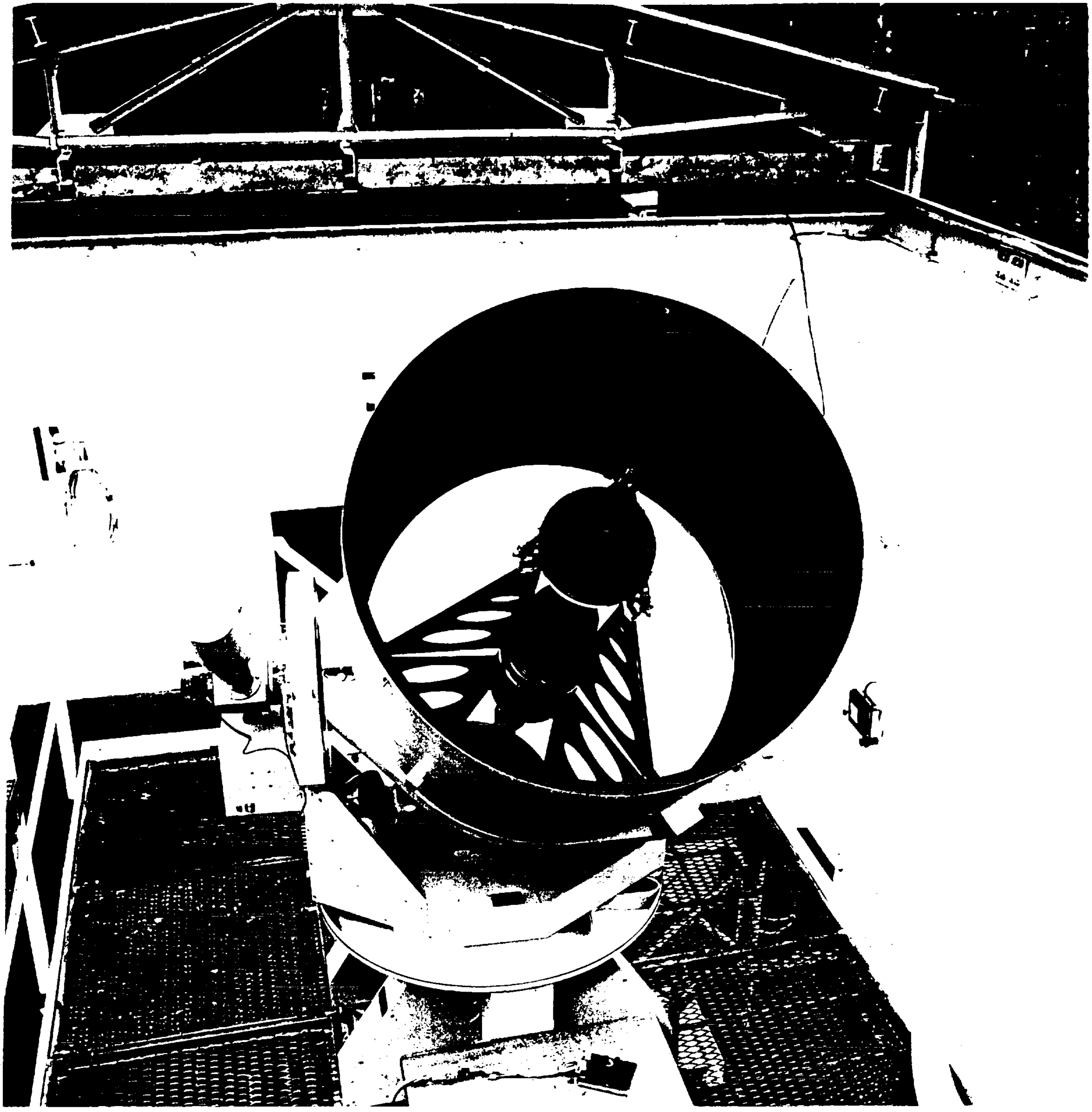
Screen copy of a LAGEOS test pass after filtering and polynomial fitting
upper part: residuals versus time (23 mm rms)
lower right: histogram of the residuals



Optical scheme of the laser PLS-5
Symbols: Pr- prisms ; M- mirrors ; NDF- neutral density filters
MD- monitor photodiodes ; Pol- polarizers



Laser control room



Close-up view of the TPL mount and telescope

N94-15624

PERFORMANCE COMPARISON OF HIGH SPEED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBES

Thomas Varghese, Michael Selden, Thomas Oldham
Allied-Signal Aerospace Company
Bendix/CDSLR Network
Seabrook, Maryland 20706
U.S.A.

The transit time spread characteristics of high speed microchannel photomultipliers has improved since the upgrade of the NASA CDSLR network to MCP-PMT's in the mid 1980's. The improvement comes from the incorporation of 6μm (pore size) microchannels and offers significant improvement to the satellite ranging precision. To examine the impact on ranging precision, two microchannel plate photomultiplier tubes (MCP-PMT) were evaluated for output pulse characteristics and temporal jitter. These were a Hamamatsu R 2566 U-7 MCP-PMT (6μm) and an ITT 4129f MCP-PMT (12μm).

An Opto-Electronics diode laser and a Hewlett Packard 50 GHz digital sampling scope were used to sample a large number of pulses from each tube. The jitter of the sampling scope trigger was independently measured by splitting the diode laser pretrigger signal; one portion of the signal was used to trigger the scope, while the remaining signal was measured by the sampling scope. The scope trigger jitter was found to be about 2.6 ps. The laser pulses were $\simeq$ 40 ps in duration with a wavelength of 764 nm; the pretrigger-to-fire jitter of the diode laser is $\simeq$ 5 ps. During the experiment the pre-fire output ,of the diode laser control unit was used to trigger the sampling scope while the output responses of each MCP-PMT was captured by the sampling scope.

The optical input from the laser diode was adjusted to produce ~ 7 - 10 photoelectrons on the average. To measure the detector response, several thousand MCP-PMT output pulses were digitized to construct a pulse-distribution for each detector. Measurements were taken around the single (1 - 3 pe) photoelectron level as well as the multi-photoelectron ($\simeq$ 5 - 10 pe) level for each PMT. An average waveform was used to determine pulse rise-time and duration, while the standard deviation of the pulse distributions at the half-maximum point were used to determine the RMS of the temporal distribution within each sample set. Statistical information is printed below each graph. Each MCP-PMT was tested separately but under identical conditions. For the above experimental conditions, the ITT MCP-PMT produced about 36 ps jitter while the Hamamatsu MCP-PMT produced 9.1 ps jitter.

The sampling scope jitter and diode laser jitter has no significant effect on the 12μm PMT measurement while deconvolution improves the jitter of the 6μm tube to ~ 7 ps. The single photoelectron jitter can be estimated from these measurements to be ~ 110 ps and ~ 25 ps respectively for each tube.

The results of these tests suggest that the MCP-PMTs with 6 micron pore size has the potential to offer improved (x 2) satellite laser ranging data quality, especially at low photoelectron levels. Further testing of a gated Hamamatsu MCP tube in MOBLAS-7 in a parallel configuration using the NASA Portable Standard is planned for later this year. These tests will focus on relative performance at various signal levels as well as the response of the constant fraction discriminator to the higher bandwidth detector output.

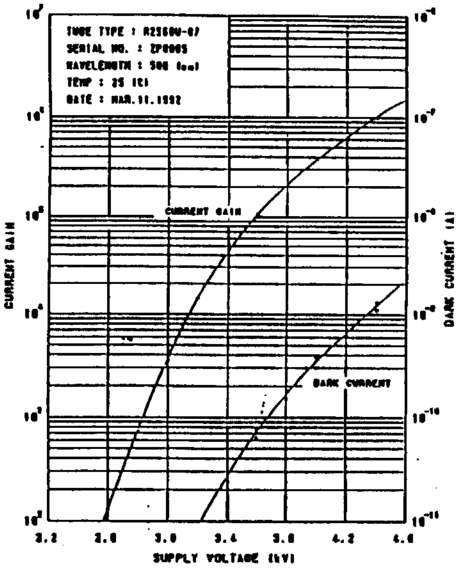
DEVICE CHARACTERISTICS

FEATURE	HAMAMATSU R 2566 U-7	ITT MCP-PMT 4129f
Microchannel Plate	2-Stage (V-Type)	3-Stage (Z-Type)
Microchannel Dia	6um	12um
Max. Operating Voltage	-4600V	-3700V
Max. MCP Gain	$3x10^6$	$1x10^6$
Rise Time	≈108ps	~350ps
Fall Time	≈100ps	≈500ps
Full Width	≈160ps	≈550ps
Single Photoelectron Jitter	≈25ps	≤100ps

GAIN CHARACTERISTICS

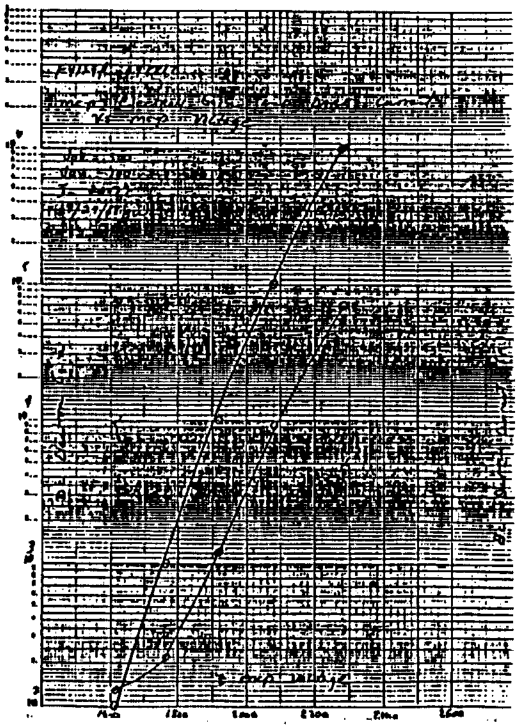
HAMAMATSU R 2566 U-7

CURRENT GAIN . DARK CURRENT
VS. SUPPLY VOLTAGE



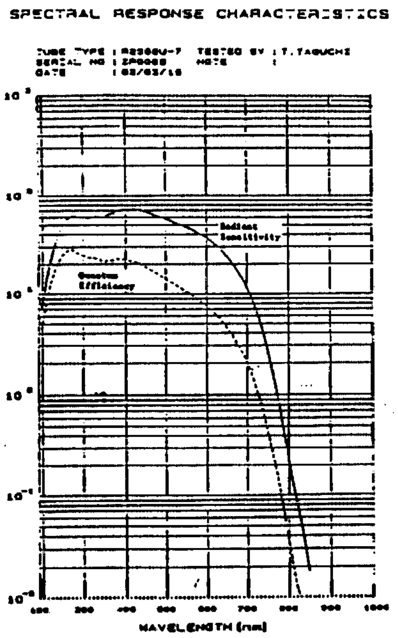
HAMAMATSU PHOTONICS K.K.

ITT MCP-PMT 4129f



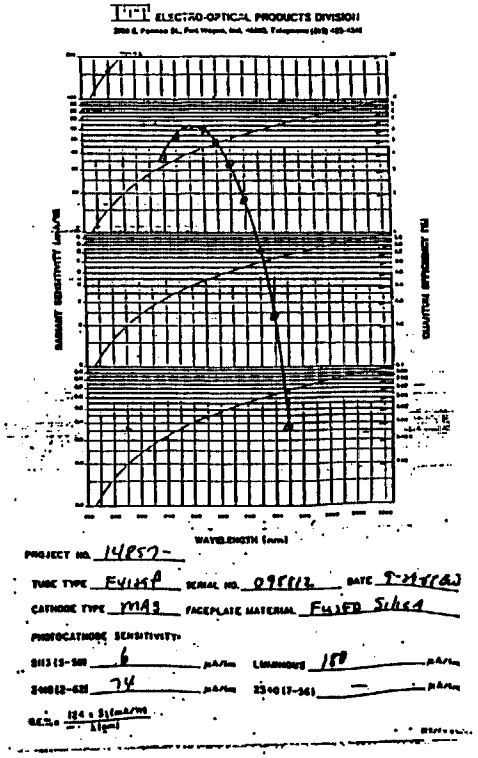
SPECTRAL RESPONSE

HAMAMATSU R 2566 U-7


SPECTRAL RESPONSE CHARACTERISTICS

TUBE TYPE : R2566U-7 TESTED BY : T.TAGUCHI
SERIAL NO : 2P0008 NOTE :
DATE : 88/03/16

ITT MCP-PMT 4129f


ITT ELECTRO-OPTICAL PRODUCTS DIVISION

PROJECT NO. 14857-

TUBE TYPE F4135P SERIAL NO. 095112 DATE 9-24-[illegible]

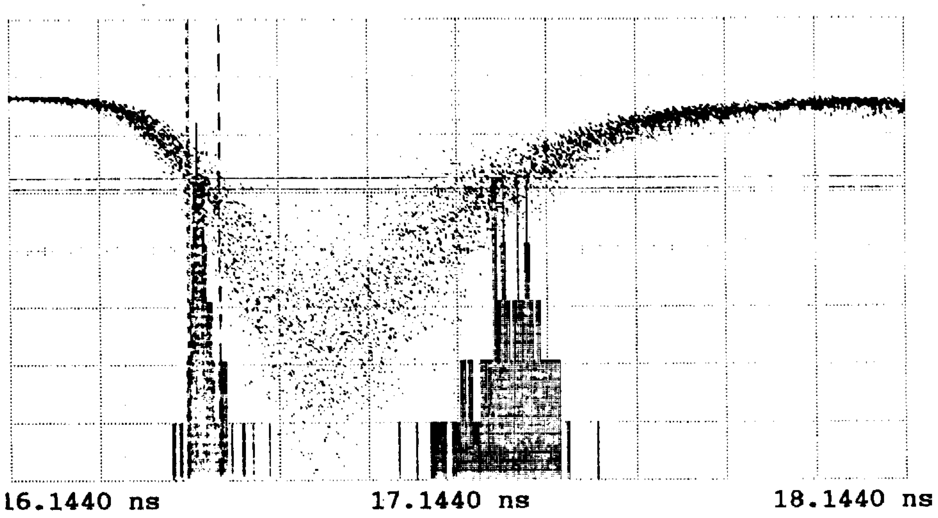
CATHODE TYPE MA3 FACEPLATE MATERIAL Fused Silica

PHOTOCATHODE SENSITIVITY:

S11 (S-50) 6 μA/lm LUMINOUS 180 μA/lm

S20 (S-62) 74 μA/lm S20 (T-56) — μA/lm

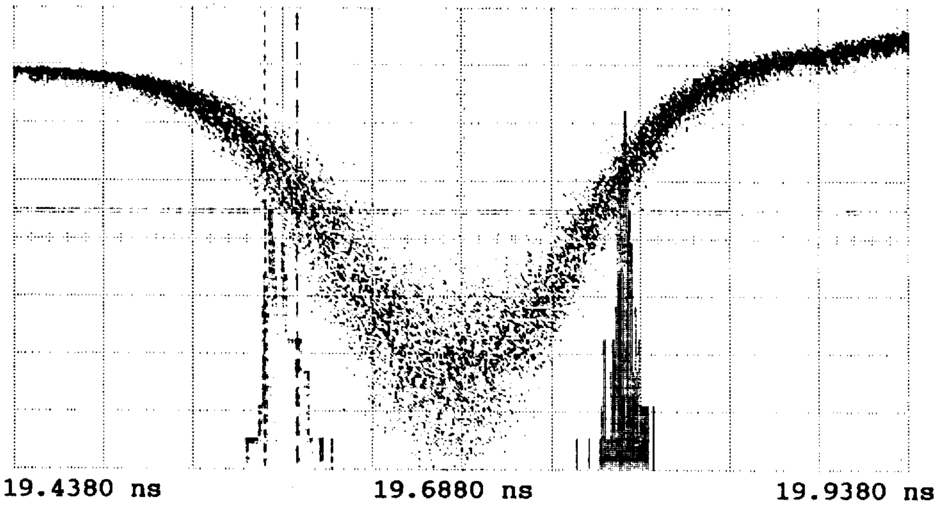
$Q.E.\% = \frac{124 \times S(mA/W)}{\lambda(nm)}$



```
Ch. 1       =  80.00 mVolts/div           Offset     = -204.7 mVolts
 Timebase   =  200   ps/div               Delay      =  16.1440 ns
Delta Windo= 15.000 mVolts
Window 1    = -105.00 mVolts              Window 2   = -120.00 mVolts
Delta %     =  77.10  %
Upper       =  86.74  %                   Lower      =  9.638  %
Delta T     =  71.9     ps
Start       =  16.6126 ns                 Stop       =  16.5407 ns
 # Samples  =  255
Mean        =  16.5767 ns                 Sigma      =  35.9     ps

    Trigger on External at Pos. Edge at  409.5 mVolts
```

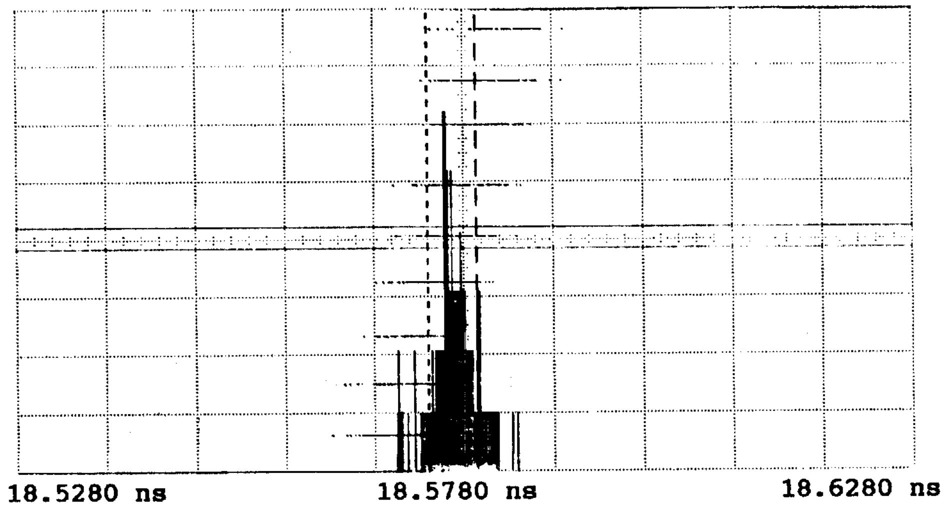
MULTIPHOTOELECTON (8–10) RESPONSE OF SAMPLIING SCOPE MEASUREMENTS OF THE ITT MCP–PMT (F4129F).



```
Ch. 1      =  50.00 mVolts/div          Offset    = -140.0 mVolts
 Timebase  =  50.0 ps/div               Delay     =  19.4380 ns
Delta Windo= 3.1250 mVolts
Window 1  = -115.62 mVolts              Window 2  = -118.75 mVolts
Delta %    =  66.02  %
Upper      =  83.33  %                  Lower     =  17.30  %
Delta T    =  18.2     ps
Start      =  19.5960 ns                Stop      =  19.5778 ns
 # Samples =  295
Mean       =  19.5869 ns                Sigma     =  9.1     ps

    Trigger on External at Pos. Edge at  409.5 mVolts
```

MULTIPHOTOELECTON (8–10) RESPONSE OF SAMPLIING SCOPE MEASUREMENTS OF THE HAMAMATSU MCP–PMT (R 2566U–7).



```
■Ch. 1      =  1.000 mVolts/div           Offset     =  237.2 mVolts
 Timebase   =  10.0 ps/div                Delay      = .18.5280 ns
■Delta Windo=-375.00 uVolts
■Window 1   =  237.09 mVolts              Window 2   =  237.46 mVolts
■Delta %    =  71.84  %
■Upper      =  85.43  %                   Lower      =  13.59  %
■Delta T    =  5.3     ps
■Start      =  18.5794 ns                 Stop       =  18.5741 ns
 # Samples  =  100
■Mean       =  18.5767 ns                 Sigma      =  2.6      ps

    Trigger on External at Pos. Edge at  409.5 mVolts
```

SAMPLING SCOPE JITTER CALIBRATION USING PULSES WITH FIXED SEPARATION.

SUMMARY

- 6 um core diameter microchannel plate photomultiplier tubes demonstrate significantly improved (4x) transit time spread than the 12 um core diameter tubes (25 pscosecond vs 110 picosecond)
- The state of the art Hamamatsu MCP-PMT 2566U has a bandwidth of ~3GHz which is approximately 3x better than the 12 um core diameter tubes; this will improve the bandwidth for post detection signal processing and the laser ranging precision.
- Sub-cm single photoelectron ranging to Lageos can be obtained using current SLR instrumentation.
- Advantageous especially for low aperture telescope systems.

N94-15625

STATION REPORT ON THE GODDARD SPACE FLIGHT CENTER (GSFC) 1.2 METER TELESCOPE FACILITY

Jan F. McGarry
Thomas W. Zagwodzki
Arnold Abbott
John J. Degnan
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771, USA

Jack W. Cheek
Hughes/STX
Lanham, Maryland 20706, USA

Richard S. Chabot
David A. Grolemund
Jim D. Fitzgerald
Bendix Field Engineering Corporation
Seabrook, Maryland 20706, USA

ABSTRACT

The 1.2 meter telescope system was built for the Goddard Space Flight Center (GSFC) in 1973-74 by the Kollmorgen Corporation as a highly accurate tracking telescope. The telescope is an azimuth-elevation mounted six mirror Coude system. The facility has been used for a wide range of experimentation including helioseismology, two color refractometry, lunar laser ranging, satellite laser ranging, visual tracking of rocket launches, and most recently satellite and aircraft streak camera work. The telescope is a multi-user facility housed in a two story dome with the telescope located on the second floor above the experimenter's area. Up to six experiments can be accommodated at a given time, with actual use of the telescope being determined by the location of the final Coude mirror. The telescope facility is currently one of the primary test sites for the Crustal Dynamics Network's new UNIX based telescope controller software, and is also the site of the joint Crustal Dynamics Project / Photonics Branch two color research into atmospheric refraction.

INTRODUCTION

The 1.2 meter telescope is located about 5 kilometers from the Goddard Space Flight Center in the middle of the Beltsville Agricultural Research Center (see Table 1). This telescope has been part of a wide variety of experiments since its development in

1973-74 by the Kollmorgen Corporation (now part of Contraves). It was originally built for Goddard as a highly accurate tracking telescope to use in the development and testing of satellite laser ranging (SLR) systems. Although there was preliminary work done in this area by both T.Johnson (GSFC) and C.O.Alley (University of Maryland), it was not until the mid 1980s that the telescope facility realized its full potential in this area with the development of the Experimental Satellite Laser Ranging System (ESLRS). The telescope's primary usefulness is in the areas of photon gathering and astronomical testing. As an astronomical observatory, it has drawbacks; these include the air bearings which distort the images, and the poor quality of seeing in the Baltimore-Washington region. The proximity to Goddard, however, makes the 1.2m telescope an excellent test facility for astronomical experiments, and the large aperture, highly accurate tracking capability, and excellent laboratory facilities make it an ideal system for developing and testing new ideas in satellite laser ranging.

TELESCOPE CHARACTERISTICS

The 1.2 meter telescope system is a multi-user azimuth-elevation mount housed in a two story dome (see Figure 1). The telescope is located on the second floor above the experimenters' area. The 15 ton assembly, as seen in Figure 2, consists of three sections: the yoke assembly, the trunnion with the primary mirror cell, and the forward tube truss (holding the secondary mirror). Air bearings, which raise the mount 0.005 millimeters above the support, are used for azimuth rotation to avoid the friction caused by roller bearings. The telescope is a six mirror Coude system with an effective system focal length of 33.13 meters (shown in Figure 3). The primary mirror is paraboloidal, 1.2 meters in diameter, with a focal distance of 3.2 meters. The secondary mirror is hyperboloidal, 0.4m in diameter, and is motor driven over a range of approximately 1.5 centimeters, giving the system the ability to focus from one kilometer to infinity. Three other flats direct the light from the telescope down into the experimenters' area below. Here a sixth mirror (the steering or pit mirror) can be rotated to direct the light to any of six experimenters' ports located at equidistant points around the circular pit area. All mirrors have been recently recoated with a broadband aluminum coating and SiOx overcoating. Peak reflectivity ranges from 88% to 92%.

The telescope was designed to meet a 20 arcsecond absolute positioning with a 5 arcsecond repeatability. In the current configuration the pointing is actually around 1 arcsecond due to the 28 term trigonometric error model used by the servo system computer. The servo system computer is a COMPAQ 386/20Mhz with 4Mbytes of memory. The tracking programs are written mainly in FORTRAN and run under the MS-DOS operating system. Timing for the software tasking is provided by 1Hz and 20Hz signals (accurate to 1 microsecond) and by the 36-bit NASA time code generator which consists of day of year and time of day. The computer closes the servo loop by reading the 22-bit encoders and performing software servo compensation; the telescope drive signals are output at 20Hz to provide a smooth track. The mount is able to track to the 1 arcsecond level at rates of up to 1 deg/sec in azimuth and up to 0.5 deg/sec in elevation. The actual speed of the mount is software limited to under 6 degrees per second in both axes.

The telescope facility has the ability to track satellites, aircraft, planets, the moon, the sun, and the stars. Predictions for satellites can either be in the form of Inter-Range-Vectors or NORADs. Aircraft acquisition uses onboard GPS data relayed to the ground in real-time or just visual observation; tracking is accomplished by using the digitized camera image of an onboard light source (such as running lights or laser diode beacon). The right ascension and declination of stars comes from the FK4 (soon to be FK5) catalog or from operator type-in of apparent position. Planetary prediction data, as well as the moon and the sun, comes yearly from the Flight Dynamics Support Branch at Goddard in the form of Chebyshev polynomials.

Acquisition aids are also available with the telescope. Operators in the dome can view through a 0.3 meter finder telescope boresighted with the main telescope. Also boresighted on the 1.2m telescope are an RCA Silicon Intensified Tube (SIT) camera and a CCD camera. An RCA SIT camera is also located in the pit area below the telescope in the focal plane. This camera was used during the RME experiment (see experiments listed below) and is also used for star calibrations. The video image from all three cameras can be viewed in the telescope control room and can be sent through the Colorado Video X-Y Digitizer for closed loop tracking by the servo computer. Table 2 lists the pertinent information on the finder scope and cameras.

PAST TELESCOPE EXPERIMENTS

PLANETARY OBSERVATION

The telescope served as a field test facility for bread board optical heterodyne spectrometers in the near and thermal infrared. This work was in support of earth and planetary atmospheric observations and was performed in the 1970s and early 1980s by M. Mumma and colleagues at NASA/GSFC.

A Laser Heterodyne Spectrometer for Helioseismology was an experiment performed at the telescope facility in the early 1980s to measure solar oscillations by mixing solar radiation with the output of a frequency stabilized CO_2 laser. D. Glenar of Colgate University was the principal investigator in support of ongoing work at GSFC.

ATMOSPHERIC LIDAR

A laser induced resonant fluorescence experiment took place in the early 1980s. This experiment, conducted by C.Gardner of the University of Illinois Department of Electrical Engineering, measured the density of atomic sodium at altitudes up to 100km using a dye laser mounted to the telescope trunnion.

LUNAR LASER RANGING

The design and testing of a high average power laser and special electronics for lunar ranging was overseen by C.O.Alley of the University of Maryland Department of Physics. Limited lunar ranging from the telescope was also accomplished during the early 1980s.

TIME COMPARISONS

C.O.Alley and colleagues at the University of Maryland set up and operated a laser link to the United States Naval Observatory (USNO) from the 1.2m telescope facility for time comparisons in support of the LASSO experiment. This link provided the highest precision time comparison (30 psec) as of that date (1983).

A comparison of East-West versus West-East one way propagation times of laser light pulses was also performed by C.O.Alley and R.A.Nelson. This was the first experiment to make such a direct measurement and provided the highest precision ever achieved in a time comparison with a transported atomic clock (40 picoseconds to USNO and back).

AUTOMATED GUIDING AND TWO-COLOR REFRACTOMETRY

D.Currie and D.Wellnitz of the University of Maryland Department of Physics developed the Automatic Guider System (AGS) during the period from 1975 to 1978 for automated tracking of continuous light sources. The AGS was used to perform automated star calibrations at the 1.2m telescope during the late 1970s.

D.Currie and D.Wellnitz also developed and tested at the 1.2m telescope a Two Color Refractometer, based on the AGS design, to measure atmospheric refraction. The final experiment performed at the USNO measured atmospheric refraction in a single night to a precision previously requiring one month's observations.

SINGLE COLOR SATELLITE LASER RANGING

The Experimental Satellite Laser Ranging System (ESLRS) operated as an R&D facility from 1982 to 1986. It was one of the first centimeter level, high return to transmit ratio satellite laser ranging systems. This system was developed by T.Zagwodzki, J.McGarry and J.Degnan of NASA/GSFC.

The NASA/RME experiment in 1991 used the U.S.Air Force low orbiting, high lidar cross-section Relay Mirror Experiment satellite to investigate streak camera returns from satellites, and to develop and test a system design for later two color work. Streak camera waveforms from RME showed clearly resolved responses from the individual cubes on the satellite. This experiment was conducted by T.Zagwodzki and J.McGarry.

TWO-COLOR STREAK CAMERA AIRCRAFT LASER RANGING

The goal of this experiment was to determine the azimuthal variations in the atmospheric induced range delay using doubled (532nm) and tripled (355nm) frequencies from the facility's Nd:YAG laser to a corner cube mounted on the NASA T-39 aircraft. Waveforms were recorded with a Hamamatsu C1370 2-psec resolution streak camera. The aircraft was acquired by using a GPS receiver onboard the aircraft whose output was transmitted to the ground computer via a radio link. Once the aircraft was visually acquired, the ground computer was able to lock onto and track the aircraft's laser diode beacon by digitizing the image seen in a camera mounted on the telescope. This experiment was successfully completed in early August 1992. The principal experimenters were P.Millar, J.Abshire, J.McGarry, and T.Zagwodzki, all of NASA/GSFC.

CURRENT TELESCOPE PROJECTS

TWO-COLOR STREAK CAMERA SATELLITE LASER RANGING

Recent upgrades to the ESLRS at the 1.2m telescope facility have been made to allow measurements of two color differential delay to the ERS-1, STARLETTE and AJISAI satellites using a single-photoelectron sensitive Hamamatsu Streak Camera. Differential two color measurements will be used to analyze the accuracy of existing satellite ranging atmospheric refractivity models. This work is being performed by T.Zagwodzki, J.McGarry, J.Degnan, all of GSFC, T.Varghese of Bendix, and colleagues from GSFC, Bendix and Hughes-STX.

SATELLITE LAUNCH TRAJECTORY TRACKING

In support of the Office of Naval Research and later the Air Force SDIO work, the University of Maryland has been observing the Firefly and Firebird series of launches from Wallops and Cape Canaveral using a wide field camera installed on the 1.2m telescope and the University of Maryland Optical Metric Mapper at the Coude focus. Acquisition is provided by realtime Launch Trajectory Acquisition System (LTAS) data via a high speed direct link. This work is being performed by D.Currie and D.Wellnitz of the University of Maryland.

SUPPORT OF LASSO EXPERIMENT

Attempts at visual acquisition of the Meteosat satellite (MP2), in order to range to the LASSO experiment, have been attempted using both the RCA Silicon Intensified Target camera on the mount and at the Coude focus, and using the University of Maryland Zibion camera installed on an auxiliary 12-inch telescope mounted to the 1.2m telescope. Due to the low magnitude of the visual MP2 and the poor seeing in the Baltimore-Washington area, all attempts at seeing MP2 to date have been unsuccessful. This work has been a joint effort between the Crustal Dynamics Project at GSFC, the Photonics Branch at GSFC, and the University of Maryland Physics Department.

MONITORING LAGEOS SATELLITE'S SPIN

Evaluation is in progress to determine the feasibility of monitoring the spin vector of the LAGEOS satellite (and later LAGEOS II) to support the prospective experiment to measure the Lense-Thirring Effect predicted by General Relativity. This is a joint experiment involving NASA, the Italian Space Agency, and the U.S.Air Force. The University of Maryland effort is being conducted by D.Currie, D.Wellnitz and P.Avizonis.

SOFTWARE DEVELOPMENT AND CHECKOUT

New CDP Network Telescope Controller Software is being designed to replace all of the telescope computers in the NASA Network with 486 compatible computers. The 1.2m telescope is the primary test system for the new software which will operate in the UNIX environment and will provide a user friendly, menu driven, graphical interface for the crews. The software team consists of J.McGarry (GSFC), J.Cheek (Hughes-STX), R.Ricklefs (University of Texas), P. Seery (Bendix), and K.Emenheiser (Bendix).

ACKNOWLEDGEMENTS

The authors would like to thank Jack Bufton (GSFC), Carol Alley (University of Maryland), and Dennis Wellnitz (University of Maryland) for detailed information on past projects at the telescope. A special thanks goes to the CDP SLR Manager, Larry Jessie, for photographing the telescope.

Table 1: 1.2 meter telescope location

1.2m TELESCOPE LOCATION	North American Datum 1927 CLARK 1866 ellipsoid
LATITUDE (geodetic)	39.02136044 degrees
LONGITUDE (east)	283.31712961 degrees
HEIGHT (above ellipsoid)	0.053198 km

Table 2: Acquisition and Tracking Aids

	Field of View	Dimmest object that can be seen
SIT camera in pier	70 mdeg diameter	8th magnitude
Finder scope	250 mdeg diameter	9th magnitude
CCD camera	200 by 300 mdeg	3rd magnitude
SIT camera on mount	2 by 3 degrees	8th magnitude

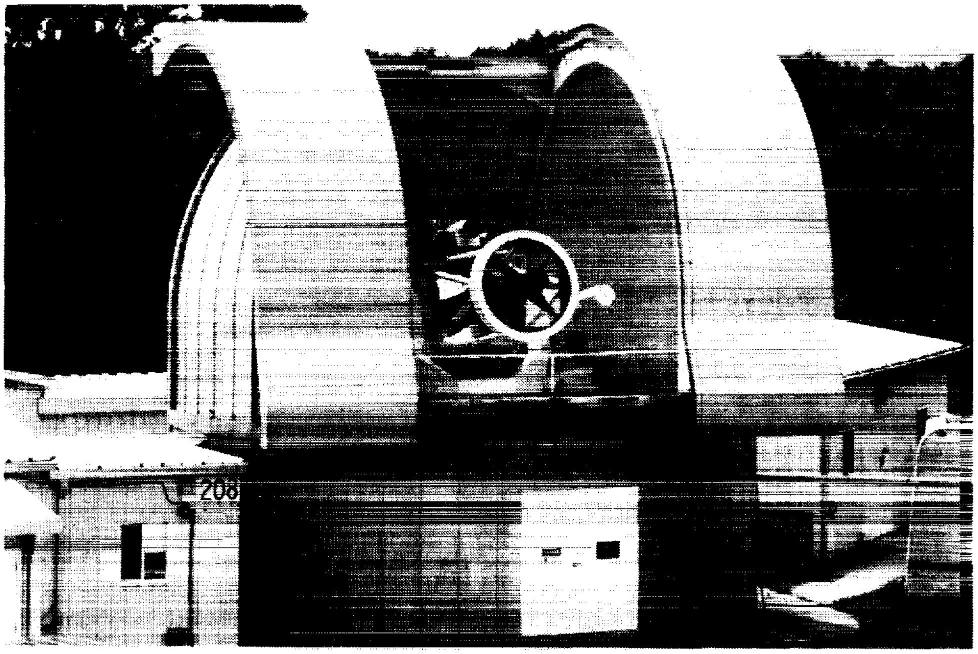


Figure 1: 1.2 meter telescope facility

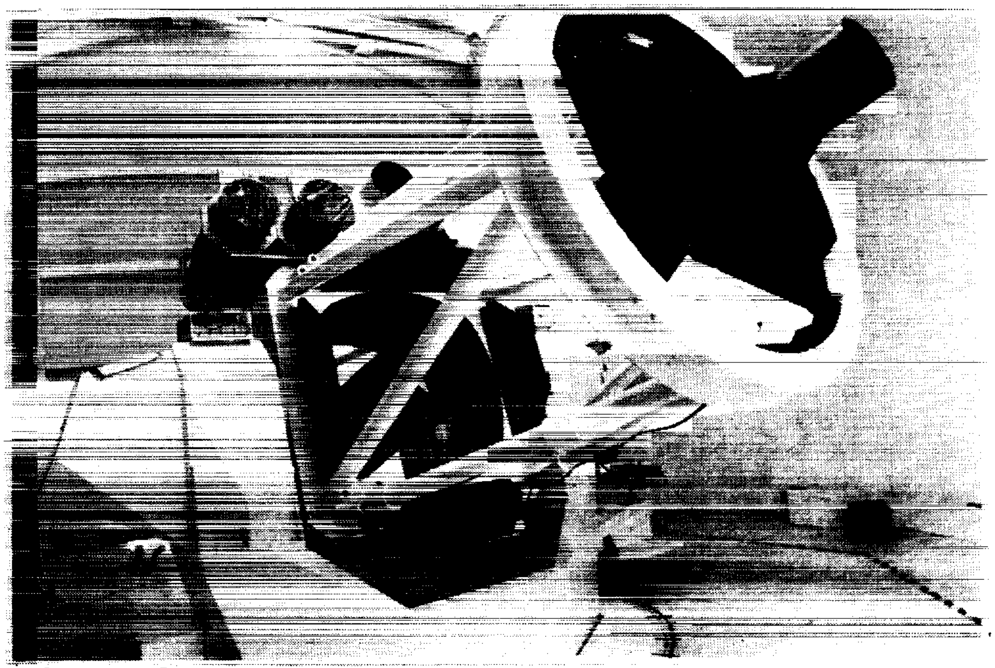


Figure 2: Mount assembly

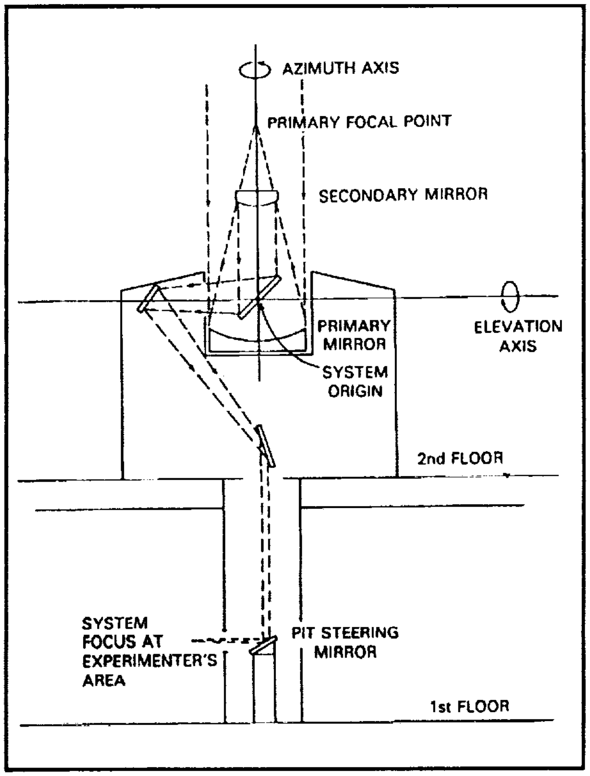


Figure 3: Coude system