MASTER

PREPRINT UCRL- 79784

CONF-771136--12

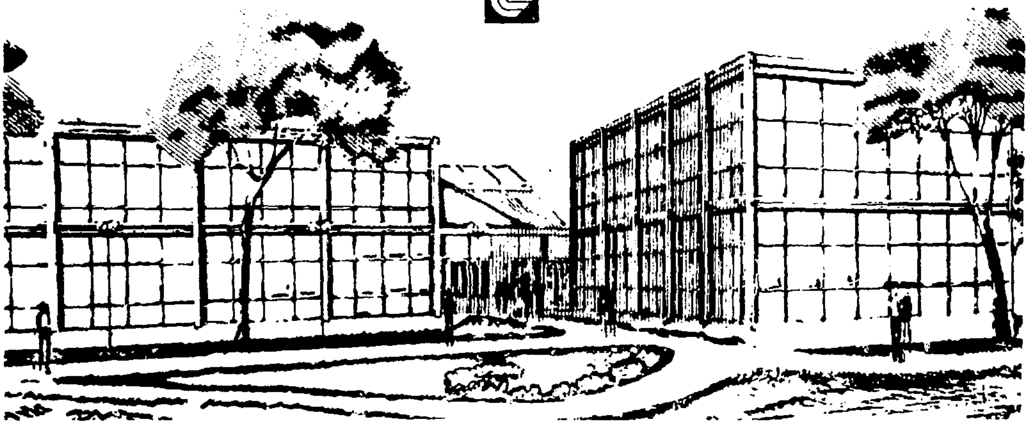
Lawrence Livermore Laboratory

THE SHIVA TARGET IRRADIATION FACILITY

K. R. Manes, H. G. Ahlstrom, L. W. Coleman, E. K. Storm, J. A. Glaze,
C. A. Hurley, F. Rienecker, and W. C. O'Neal

October 21, 1977

This paper was prepared for submission to the APS Plasma Physics Meeting of the American Physical Society, Atlanta, Georgia, November 5-11, 1977.



Abstract Submitted

for the APS Plasma Physics Meeting of the

American Physical Society

November 5-11, 1977

Physics and Astronomy Classification Scheme Number 52

Bulletin Subject Heading in which Paper should be placed
Lasers for Fusion

The Shiva Target Irradiation Facility. K. R. Manes, H. G. Ahlstrom, L. W. Coleman, E. K Storm, J. A. Glaze, C. A. Hurley, F. Rienecker, and W. C. O'Neal, Lawrence Livermore Laboratory.**--The first laser/plasma studies performed with the Shiva laser system will be two sided irradiations extending the data obtained by other LLL lasers to higher powers. The twenty $\sim$ 1 TW laser pulses will reach the target simultaneously from above and below in nested pentagonal clusters. The upper and lower clusters of ten beams each are radially polarized so that they strike the target in p-polarization and maximize absorption. This geometry introduces laser system isolation problems which will be briefly discussed. The layout and types of target diagnostics will be described and a brief status report on the facility given.

**Supported by U. S. ERDA Contract W-7405-ENG-48

Submitted by

Kenneth R. Manes

Kenneth R. Manes
University of California
Lawrence Livermore Laboratory
P. O. Box 808, L-549
Livermore, CA 94550

REA

The Shiva Target Irradiation Facility

Early in 1978 the Shiva target irradiation facility will extend the data base on laser driven inertially confined plasmas to higher laser powers.[1] The model in Figure 1 shows that the first laser/plasma studies performed with Shiva will be two-sided irradiations. Twenty ∿ 1 TW laser pulses will reach the target simultaneously from above and below in nested pentagonal clusters. After exiting the final amplifier, each 20 cm diameter beam will enter the target area and be directed to the target by two turning mirrors. A typical routing for a Shiva beam is shown in Figure 2. Approximately two percent of the pulse energy is transmitted by the second turning mirror and injected into an incident beam diagnostic package.[2] The balance of the incident energy, ∿ 98%, reflects off the second turning mirror and is focused by an aspherized f/6 lens through a vacuum window and onto the target. Laser light, which is either forwardscattered or backscattered into the opposed lens cones, is studied with reflected beam diagnostic packages located as shown in Figure 2.[2]

The twenty incident beam diagnostics packages each contain a television camera and appropriate optics to permit alignment of the spatial filters in each laser chain and inspection of the beam profile in the equivalent target plane. As shown in Figure 3, calorimeters are provided to determine the energy on target, an array camera monitors the time integrated beam profile in the equivalent target plane, and a port is provided for a streak camera to record the temporal pulse shape.

Each laser pulse, characterized in this way, is focused on the target by an aspherized f/6 lens. The position of this lens and the orientation of the second turning mirror are determined largely by the automated pointing, focusing and centering (PFC) system.[3] The television camera, lens turret and detector module parts of this system are included in the return beam diagnostics package displayed in Figure 4. A separate, diffused 1.06 μm source backlights the target so that the television cameras in the return beam diagnostic packages can be used to view both the target and the laser beams at the target in order to verify that the automatic system has performed satisfactorily. Each return beam diagnostic package also contains a calorimeter, a multiple image camera and has provision for a streak camera to monitor the temporal history of the reflected/forwardscattered laser pulse or an optical spectrograph.

One possible target illumination geometry is shown in Figure 5. The upper and lower clusters of ten beams each are radially polarized so that they strike the target in p-polarization, therefore maximizing absorption.[4] Alternative geometries include three spots surrounded by seven, a ring of ten, and superimposing the ten upper and the ten lower beams. In all cases, the clustered beams resemble a f/1.2 ray cone. Illumination nonuniformity on Shiva is consequently similar to those of the f/1.0 Argus target irradiation lenses facilitating comparison of target data.[5]

The evacuated target chamber within which the experiments will take place is shown in Figure 6. This artist's conception shows a number of target diagnostic devices in the 190 ports provided in the chamber. The first experiments will not require cryogenic target system and a smaller target positioner shown in Figure 6, is designed to manipulate room temperature targets. The target chamber is presently in place and diagnostic devices are being installed.

Figure 7 is a polar plot of the 190 diagnostic port locations looking down. The $\theta = 0$ axis points up and $\phi = 0$ is defined by the target positioner. The planned locations of the diagnostic devices are indicated symbolically on this chart as are the locations of the five target space frame towers. The clustered,radially polarized beams are numbered such that opposing beam numbers differ by 10 and increase in the direction of positive ϕ chosen counterclockwise.

An accurate determination of energy balance is a fundamental part of most laser fusion target experiments. To this end, an energy balance module which has provision for optical, x-ray and ion energy measurements has been designed.[6] These modules, shown in Figure 8, are sized to be compatible with most of the target chamber ports so that they may be arrayed around the target and measure angular distributions. The time integrated energy measurements made by these devices are read into CAMAC modules and eventually processed by the Shiva computer system to provide angular distributions within minutes of a target shot.

Another important target diagnostic instrument is the x-ray microscope.[7] This by-now-familiar diagnostic tool has been redesigned for use with the Shiva facility as shown in Figure 9. Significant improvements have been made in the mechanical design of this device and the state of the art of x-ray microscopy.

The largest and perhaps the most important single target diagnostic system is the Shiva neutron time-of-flight measurement shown in Figure 10. The detection system is located 125 meters from the target and will, therefore, provide spectral measurements with $\sim$ 10 keV resolution for targets yielding $\geq 10^{10}$ neutrons. The NE 111 fluor/photomultiplier detection system will be read by Tektronix R 7912 transient digitizers and the data will be reduced by the Shiva computer system. While this system will provide a good measurement of the neutron yield, the primary neutron fluence measurement will be made by Cu activation detectors located inside the target chamber.

The decision to operate the Shiva irradiation facility with radially polarized beams introduced special isolation problems. Unlike other LLL lasers, as presently configured, Shiva has neither an output spatial filter nor a Faraday rotater isolater. Consequently, if the target were not in place, the incident pulses would be recollimated by the opposing lenses, amplified by the output amplifiers and almost certainly cause serious optical damage. To guard against this eventuality, one of the target viewers shown in Figure 11 has been provided with a monitoring system called Sentry. The Sentry system will be interrogated at 20 μsec intervals, and if the target moves out of place, oscillator pulse switch-out will not be enabled.

In summary, the Shiva target irradiation facility is nearing completion with laser driven inertial confinement fusion studies scheduled for early calendar 1978.

References

1. J. Glaze, et al, Status of Shiva, 1977 APS paper.

2. F. Rienecker, et al, Shiva Optical Diagnostics, 1977 APS paper.

3. E. Bliss, et al, The Shiva PFC System (or Automated Alignment System), 1977 APS paper.

4. K. R. Manes, V. C. Rupert, J. M. Auerbach, P. Lee, and J. E. Swain, "Polarization and Angular Dependence of 1.06 μm Laser-Light Absorption by Planar Plasmas", Phys. Rev. Letters, 39, pp. 281-284.

5. E. Storm, et al, "Laser Fusion Experiments at 4 TW", 1976 APS paper.

6. S. Glaros, et al, "New Shiva Target Diagnostics", 1977 APS paper.

7. H. Ahlstrom, et al, X-ray Microscopy, 1977 APS paper

Figures

1. Scale model of the Shiva target irradiation facility.
2. Typical Shiva beam routing showing 1st and 2nd turning mirrors, the IBD & RBD locations.
3. Artist's conception of the Shiva IBD package.
4. Artist's conception of the Shiva RBD package.
5. A possible Shiva target illumination geometry.
6. Artist's conception of the Shiva target chamber.
7. Polar plot showing the planned locations of the diagnostics for the initial target experiments on Shiva.
8. Exploded view of the Shiva energy balance module.
9. Shiva x-ray microscope.
10. Shiva neutron time-of-flight measurements.
11. Shiva target viewer contains provision for the Sentry system.

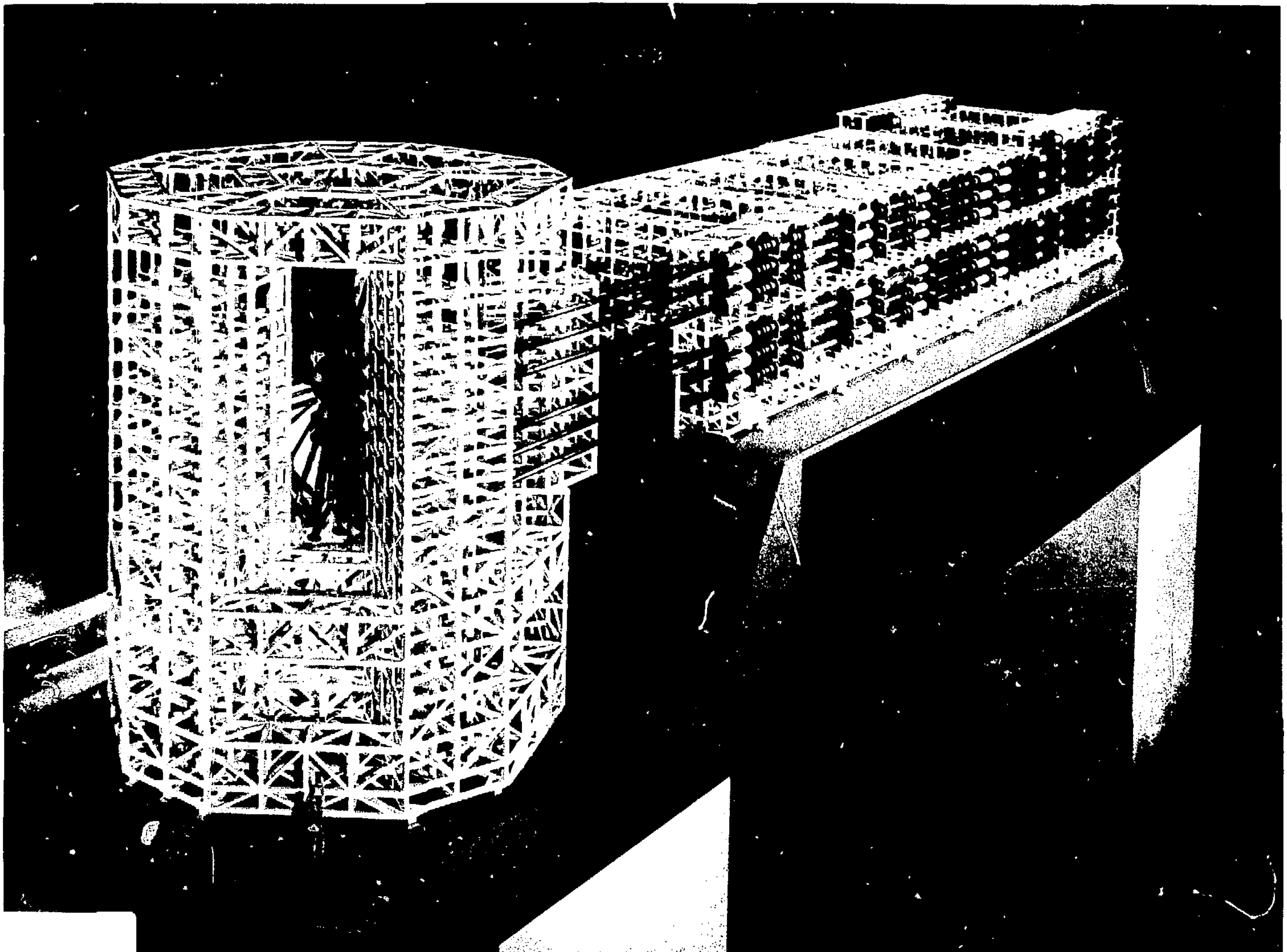
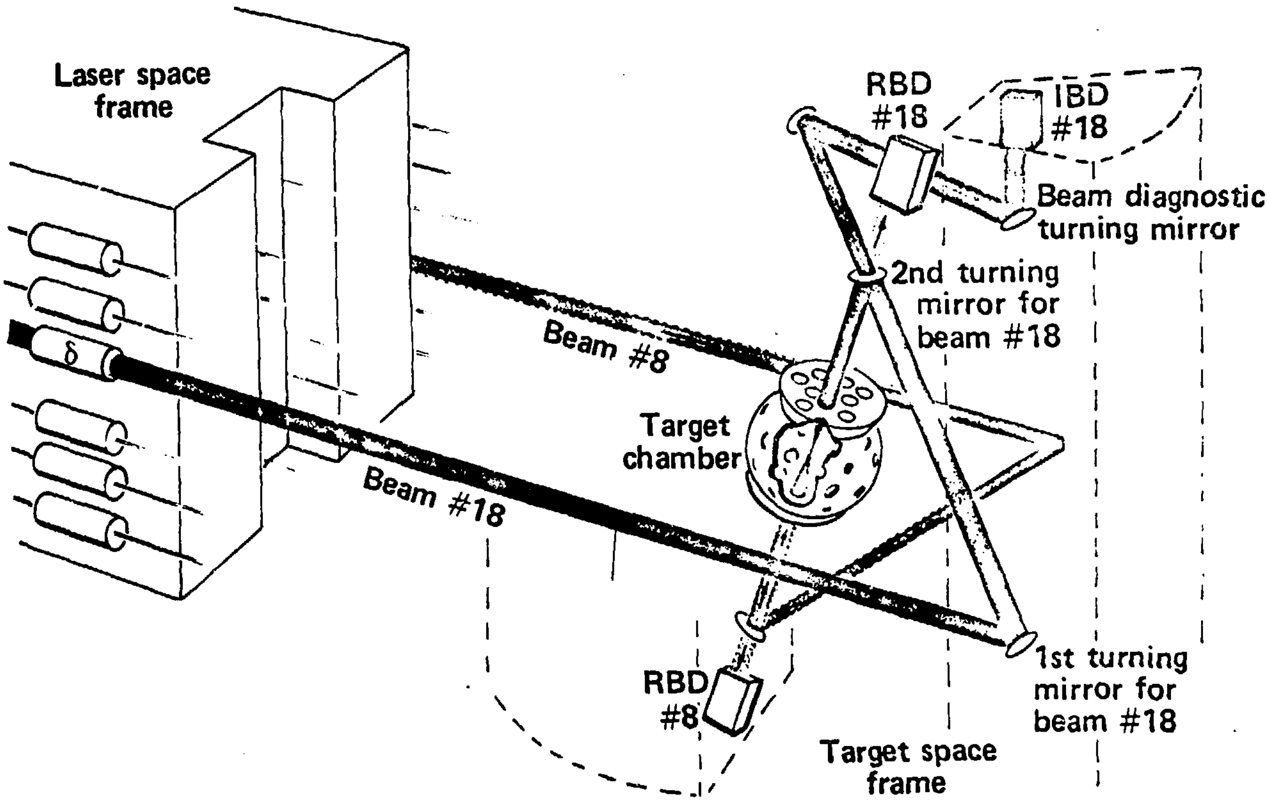


Figure 1

TYPICAL SHIVA BEAM ROUTING



20-01-0977-2092

Figure 2

SHIVA INCIDENT BEAM DIAGNOSTICS PACKAGE

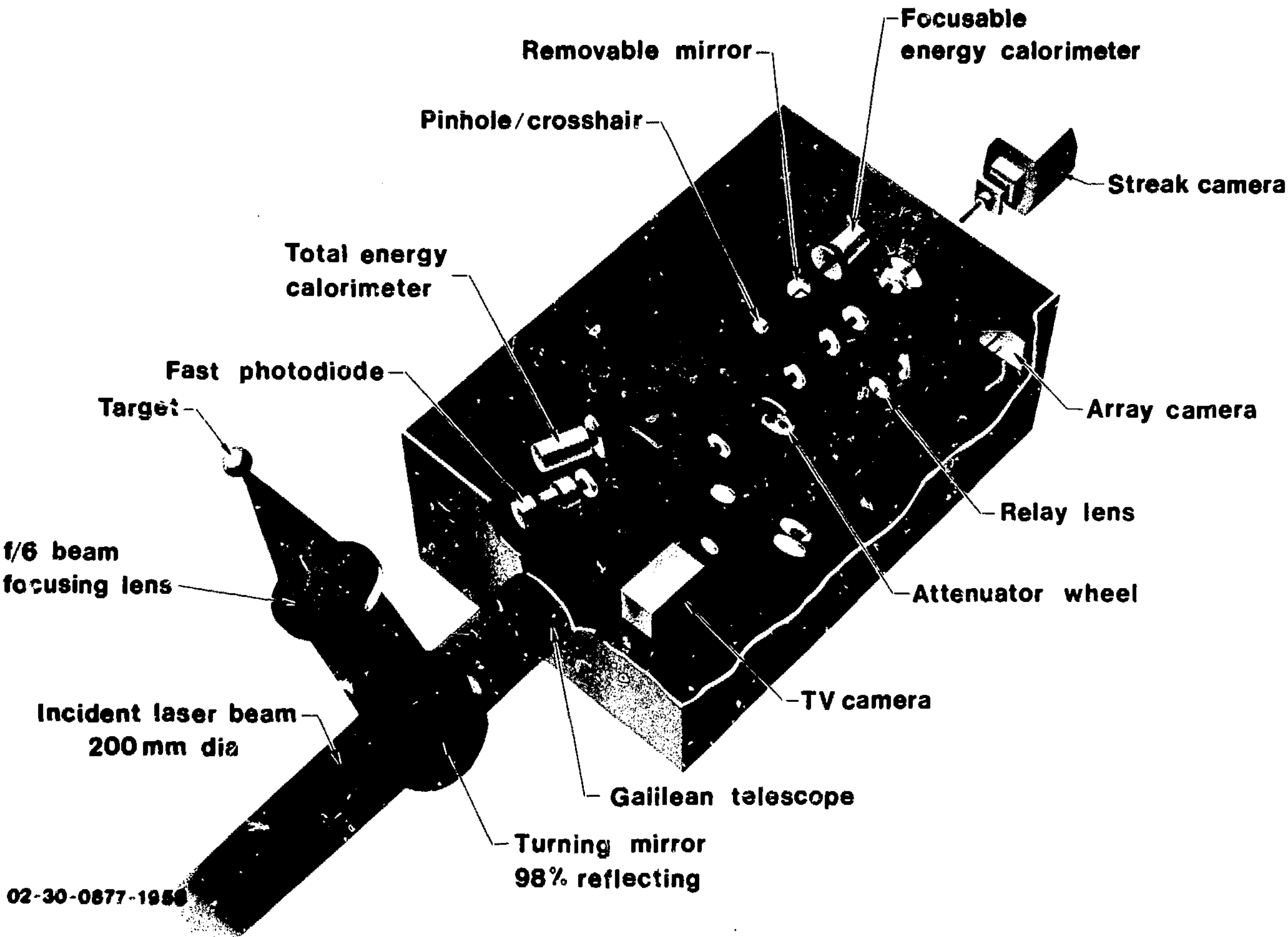
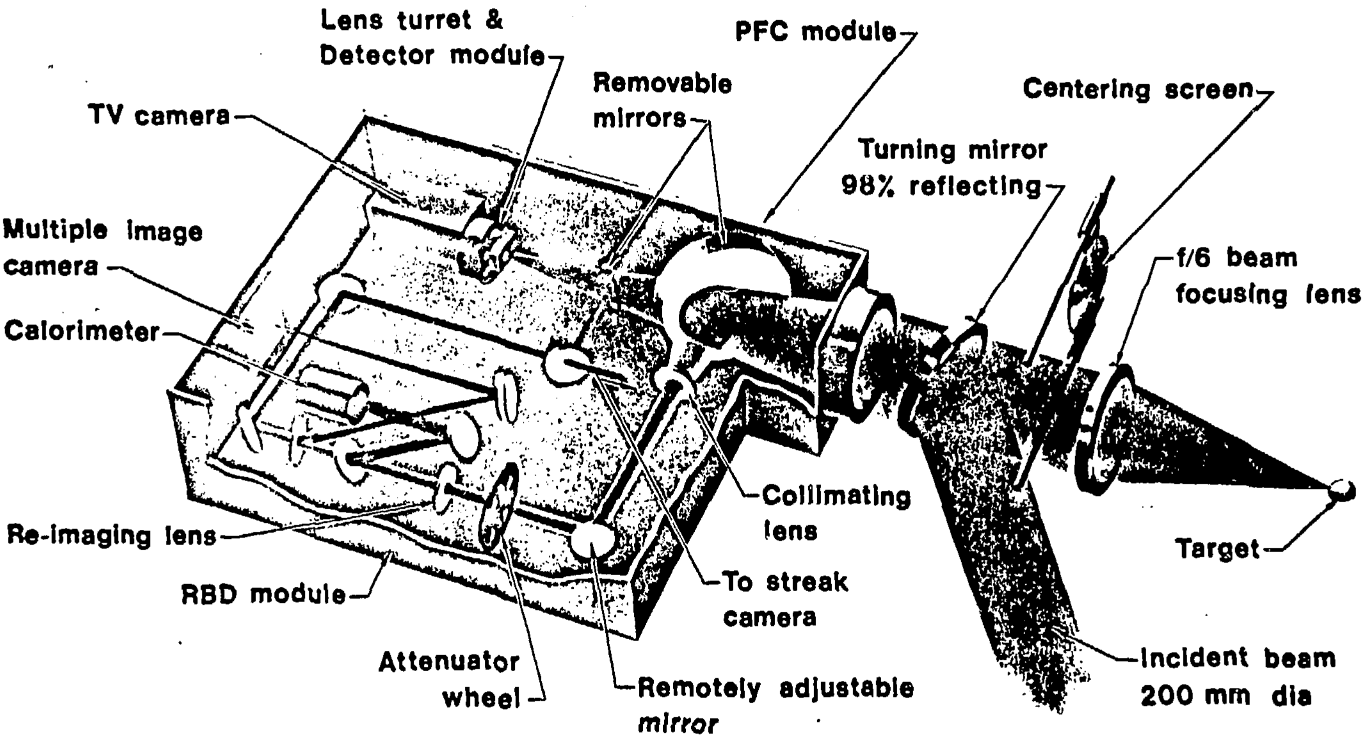


Figure 3

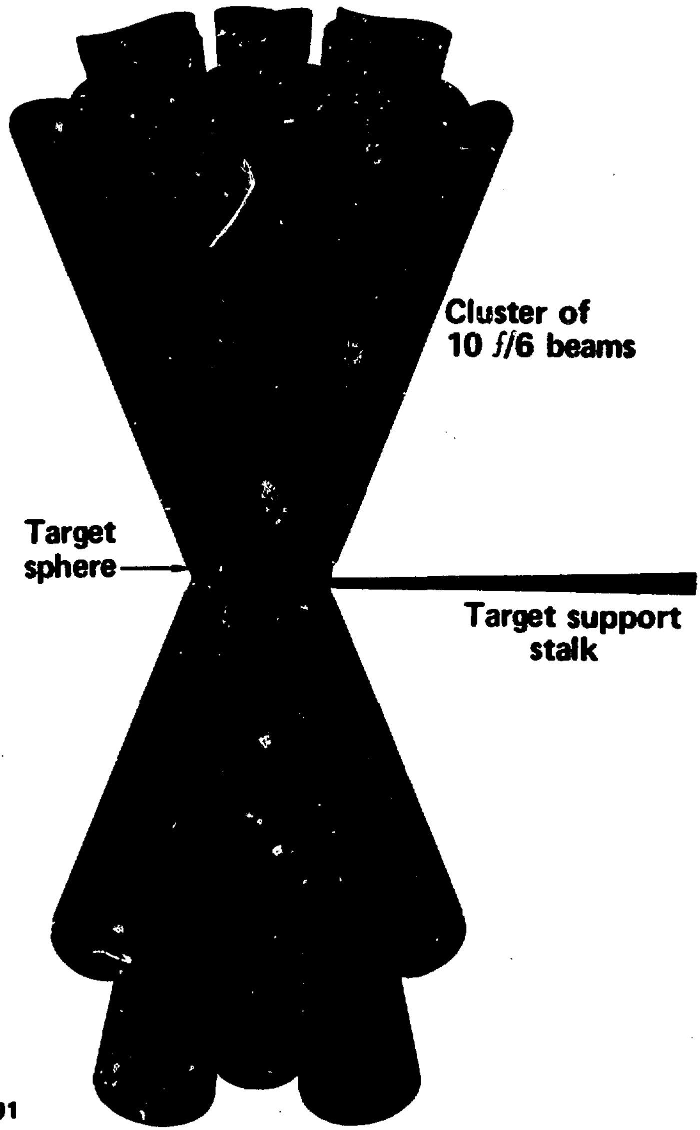
RETURN BEAM DIAGNOSTICS PACKAGE



20-01-0877-1957

Figure 4

SHIVA TARGET ILLUMINATION GEOMETRY



20-01-0977-2091

Figure 5

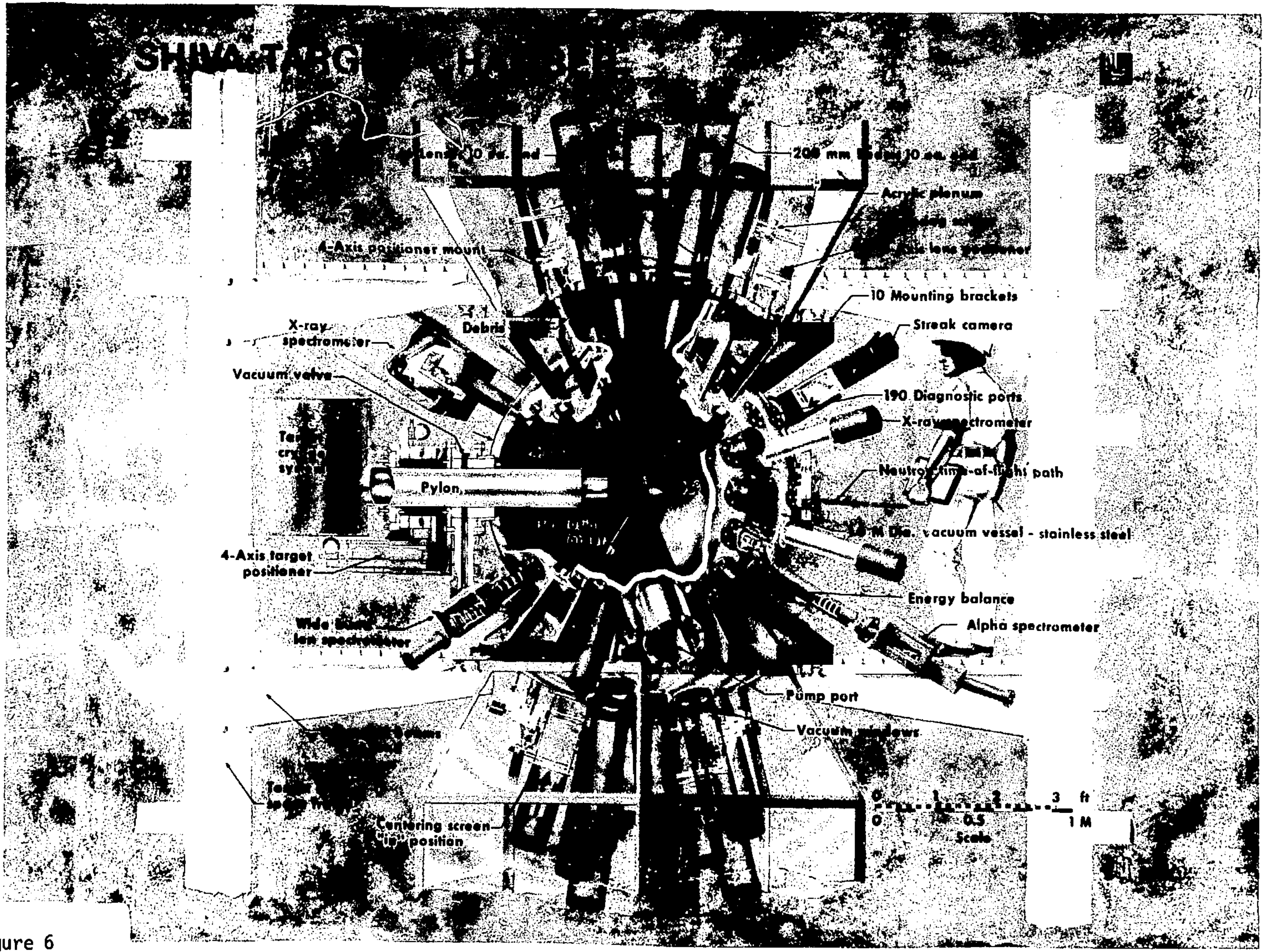
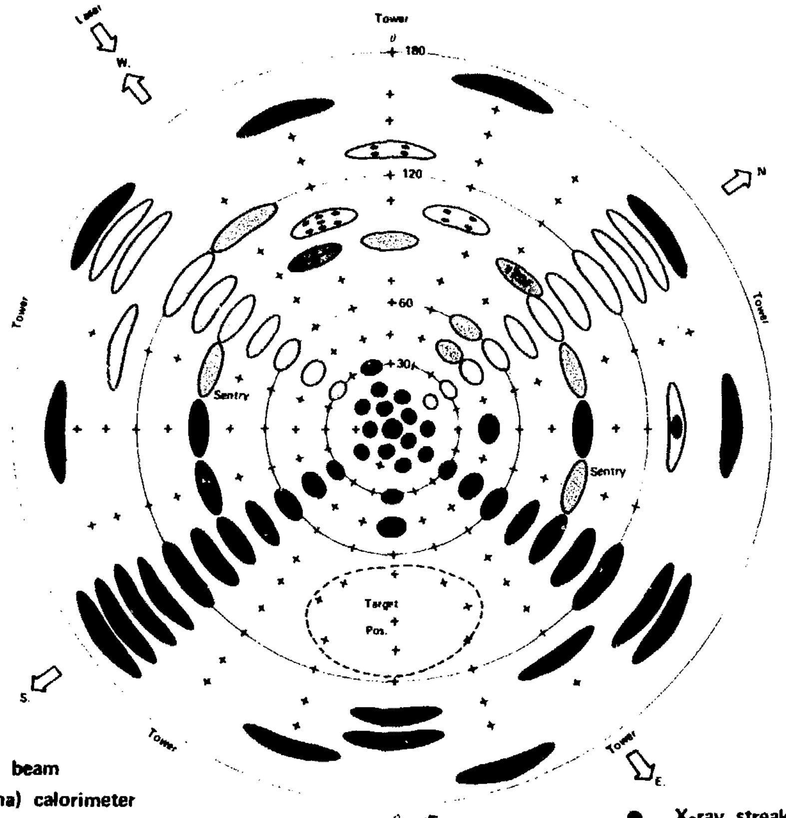

4-Axis positioner mount
10 Mounting brackets
Streak camera
X-ray spectrometer
Debris
Vacuum valve
190 Diagnostic ports
Pylon
4-Axis target positioner
Energy balance
Alpha spectrometer
Pump port
Centering screen in position
0 1 2 3 ft
0 0.5 1 M
Scale

Figure 6

DIAGNOSTICS FOR INITIAL HYPERION TARGET EXPERIMENTS ON SHIVA



- ● Laser beam
- ○ (Plasma) calorimeter
- ● X-ray microscope
- ● Energy balance package
- ○ X-ray spectrometer
- ● D-H_e^3 proton detector
- ● X-ray streak camera
- ○ Target viewers
- ◎ α-spectrometer
- ○ Neutron detector

3/77

Figure 7

Energy balance module details

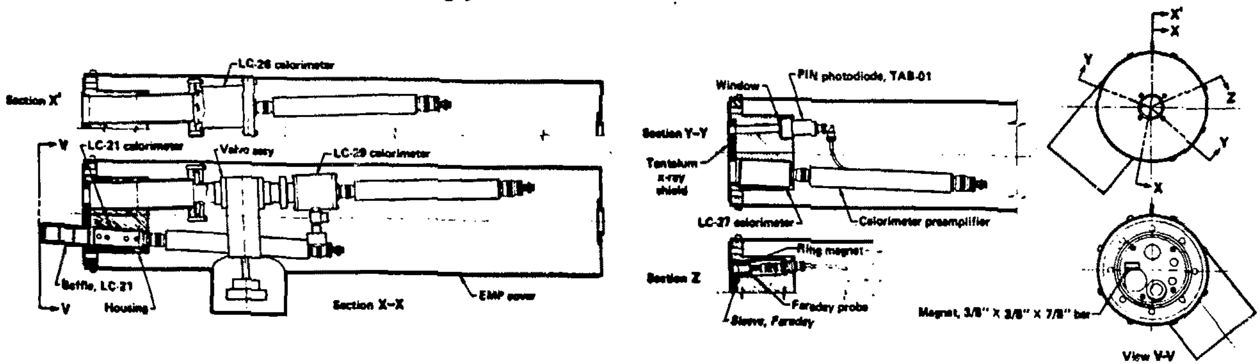


Figure 8

X-RAY MICROSCOPE

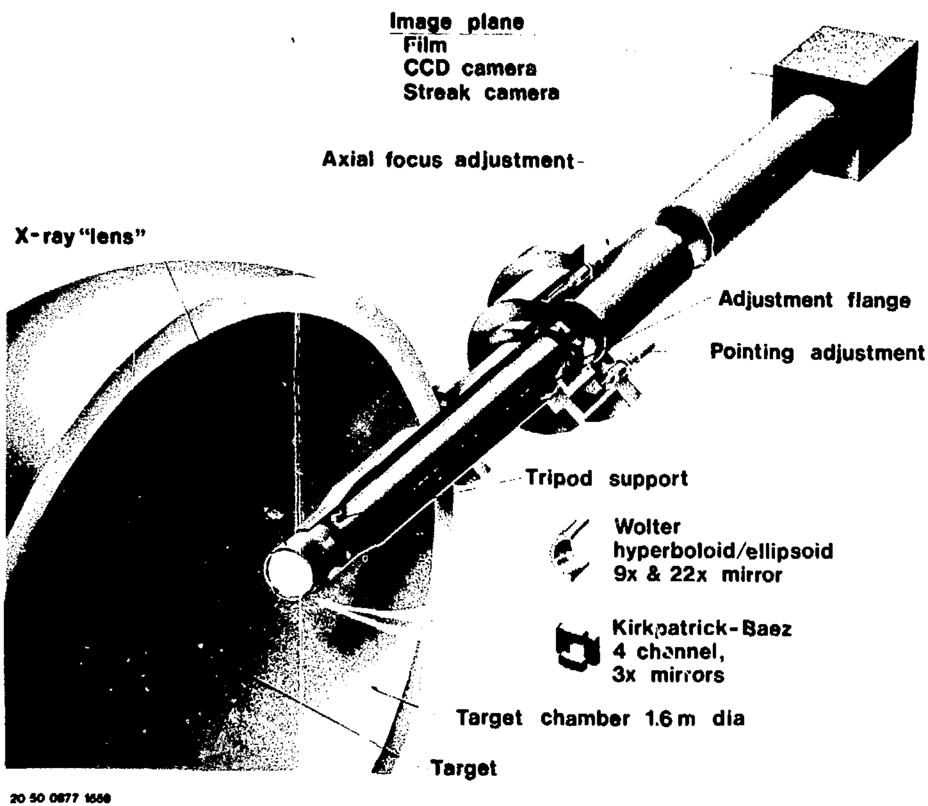


Figure 9

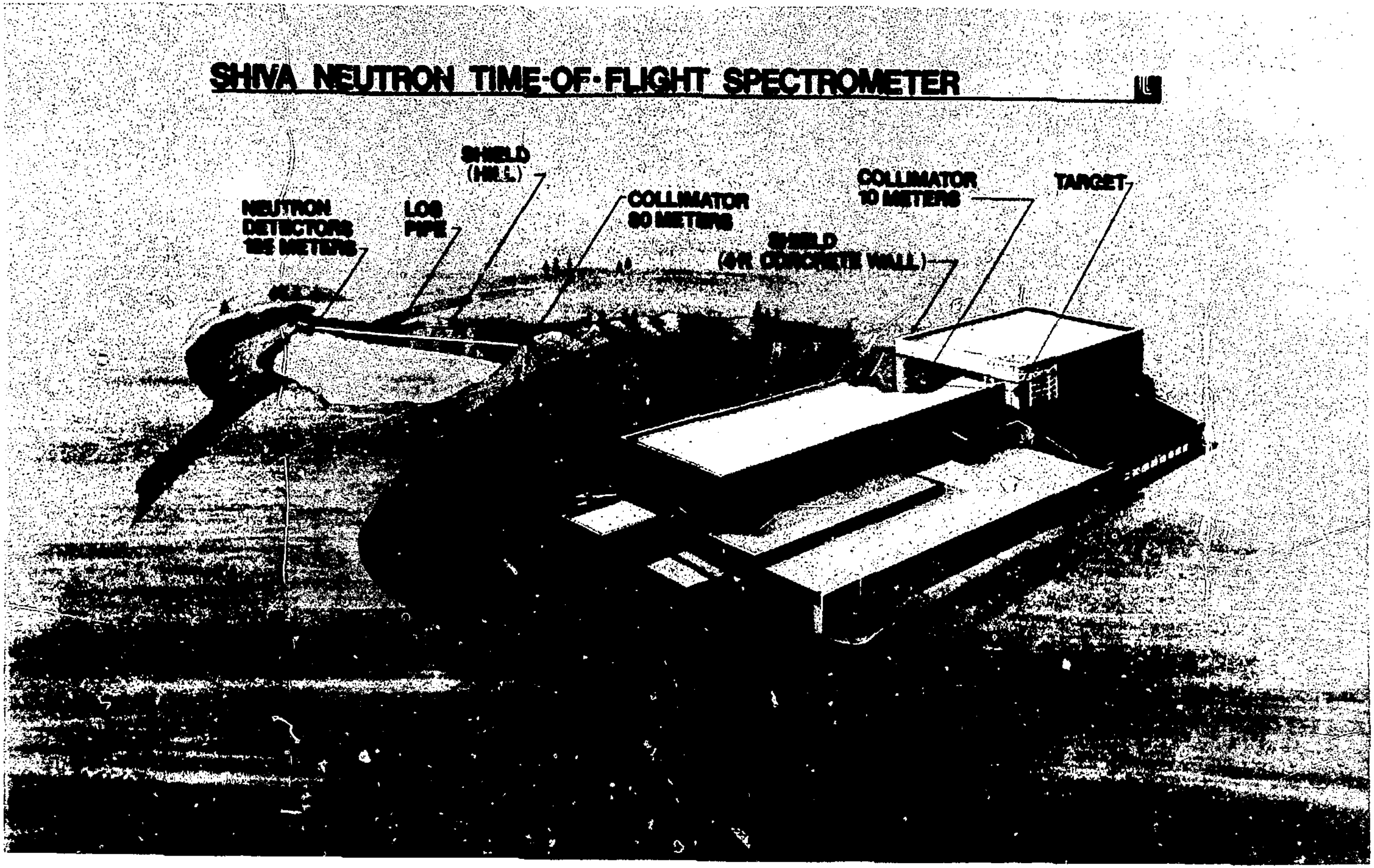

SHIVA NEUTRON TIME-OF-FLIGHT SPECTROMETER
SHIELD (HILL)
NEUTRON DETECTORS
LOS PIPE
COLLIMATOR
SHIELD
COLLIMATOR 10 METERS
TARGET

Figure 10

SHIVA TARGET ALIGNMENT MULTIPLE FIELD INSTRUMENT

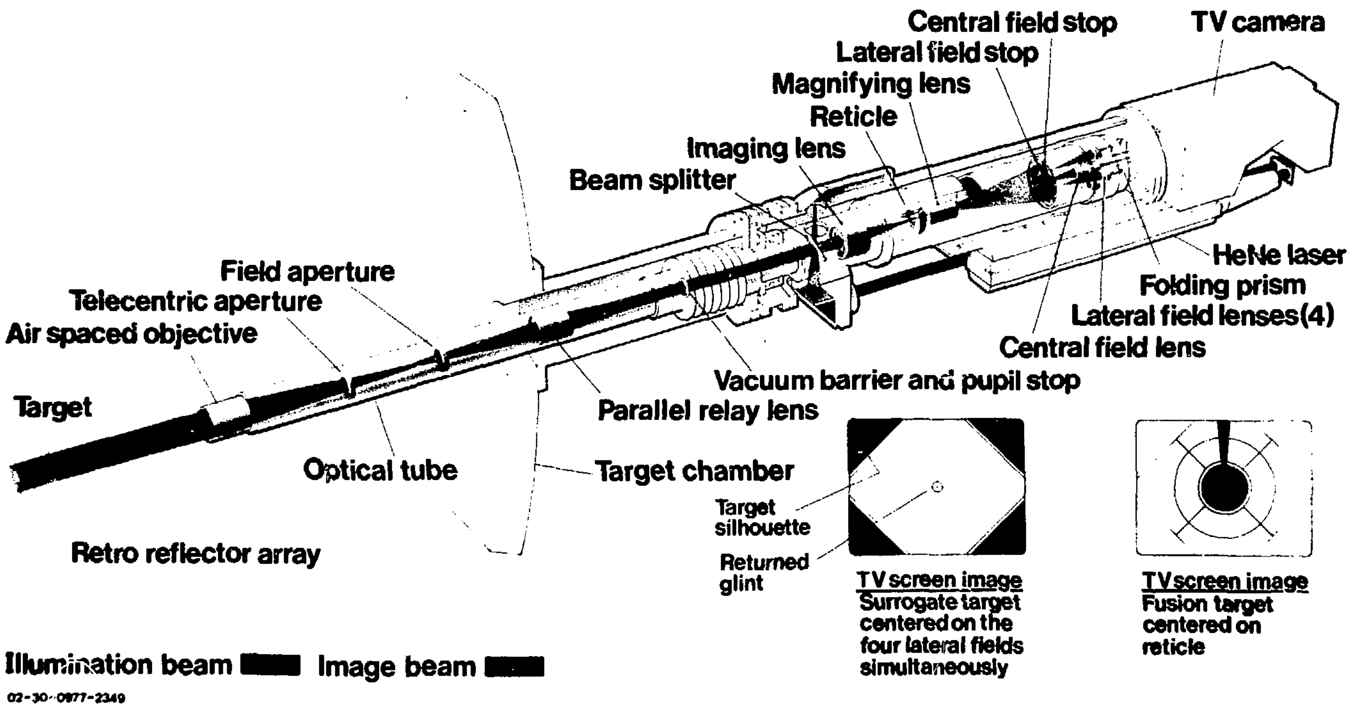


Figure 11