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Model: BSZ50-__-____-__
S/N:_____

USERS MANUAL
FOR THE
MODEL BSZ50
BEAM PROFILER FOR THE DUV

Rev. 2.01, 02AP01



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THE MODEL BSZ50 BEAM PROFILER

The model BSZ50 beam profiler (Figure 1) is the most versatile of STI's family of **B**eam **I**ntensity **P**rofilers (BIP). The BIP was specifically designed for viewing and analyzing the structure of DUV sources in the soft X-ray region to 400nm spectral band. Under certain conditions, imaging can be extended into the middle of the visible band (see Table 1). The BIP family of beam profilers is based on a patented, direct-view lens system. It includes a high quality CCD camera that produces a standard video output signal.

SET UP

The BSZ50 is designed to be placed directly in the beam (Figure 2). The damage threshold is approximately 500 mJ/cm^2 per pulse and the maximum linear fluence (saturation level, see Table 1) is the level at which the optical output begins to deviate from a linear function of the input. The FPLATE will function at levels up to the damage threshold, but saturation will suppress the dynamic range in areas of the beam where the fluence exceeds the saturation level. A saturated image will seem to be smoother than it actually is.

MOUNTING

The mounting hole configuration of the BSZ50 base plate has three ¼-20 holes on 2" centers (Figure 3). When mounting the beam profiler, be very careful not to distort the base plate. Distortion will affect the alignment of the camera with the front tube, may cause focusing difficulties, and could damage the BSZ50.

The BIP can be used in any position.

CAVITY EMISSIONS

Although none of the incident DUV beam energy can reach the focal plane of the camera, visible emission produced by the laser cavity discharge can produce an annoying bright spot on the video image (Figure 4). This spot will occur when the BIP is close to the exit port of the laser and the optical axes of the BIP and the laser are parallel to one another. To eliminate cavity emission, tilt the BIP horizontally or vertically until the spot is out of the field of view (an angle of 5 to 10 degrees is usually sufficient). This small tilt does not noticeably affect the image quality.



Figure 2. The BSZ50 is a versatile imaging system for the DUV.

Table 1. Properties of the crystals used in STI's beam profilers.

Damage thresholds:

Maximum fluence	500 mJ/cm^2
Maximum power	5 Watts
Maximum irradiance	5 W/cm^2

Spectral bands:

Type	Spectral Band	Fluorescent Decay Time
C	110 to 225 nm	6 μs
R	110 to 532 nm	3 ms
P	110 to 350 nm	5 μs
G	X-ray to 400 nm	500 ns

Relative responsivities of the FPLATE materials:

Type	193 nm	248 nm	308nm
C	22	0.17	0.03
R	100	8	0.18
P	48	15	1
G	480	480	112

Saturation levels (mJ/cm^2):

Type	193nm	248nm	308nm
C	400	n/a	n/a
R	50	400	400
P	30	30	50
G	10	10	50

I/O Linearity

The crystals used in all STI beam profilers have wide dynamic ranges (to more than 5 or 6 orders of magnitude).

Long-term degradation

No color center formation or other changes after 10 million pulses when exposure is within the operating range of the crystal.

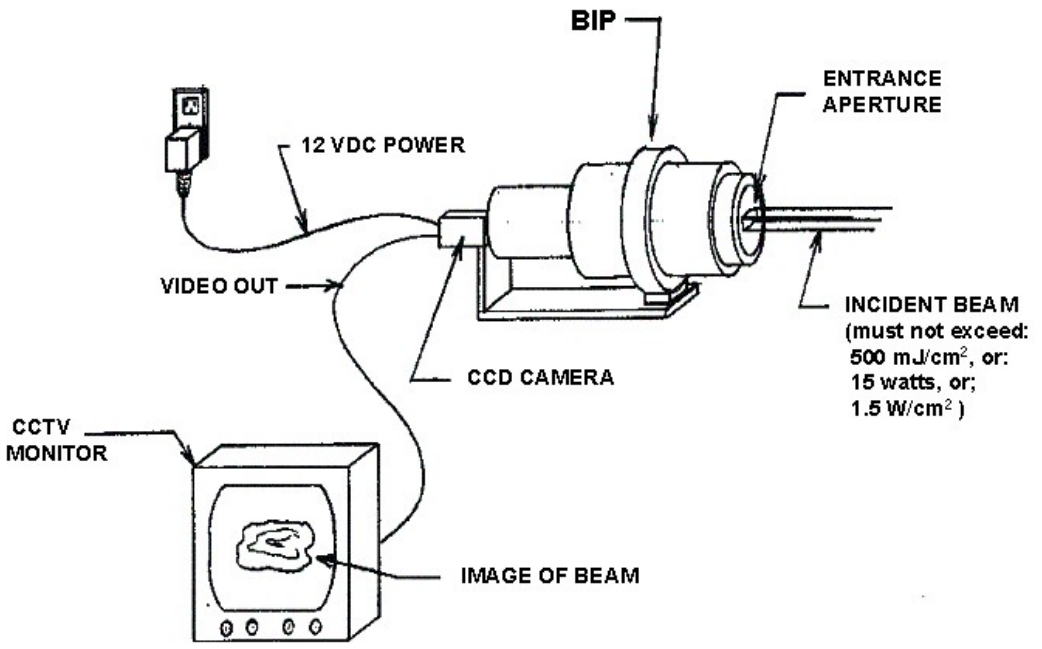


Figure 2. The BIP is a direct view imaging system for observing UV laser beams

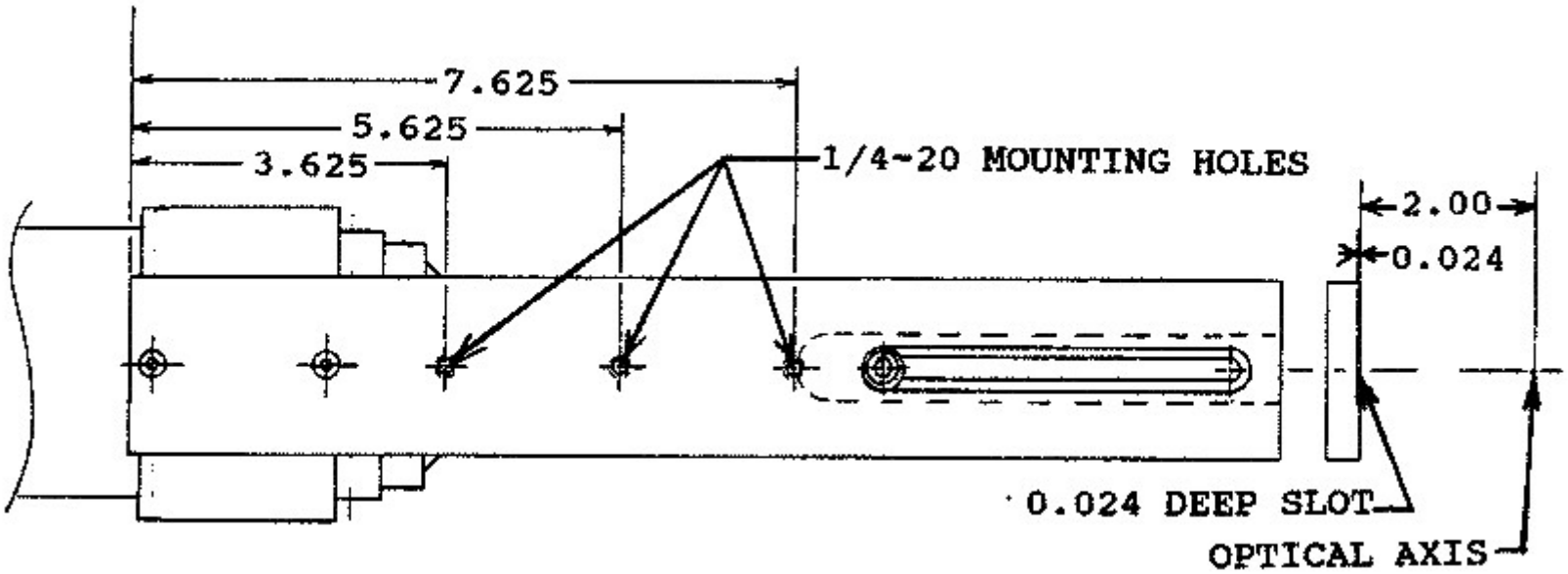


Figure 3. The ¼-20 mounting holes are on 2” centers to facilitate set-up on optical tables.

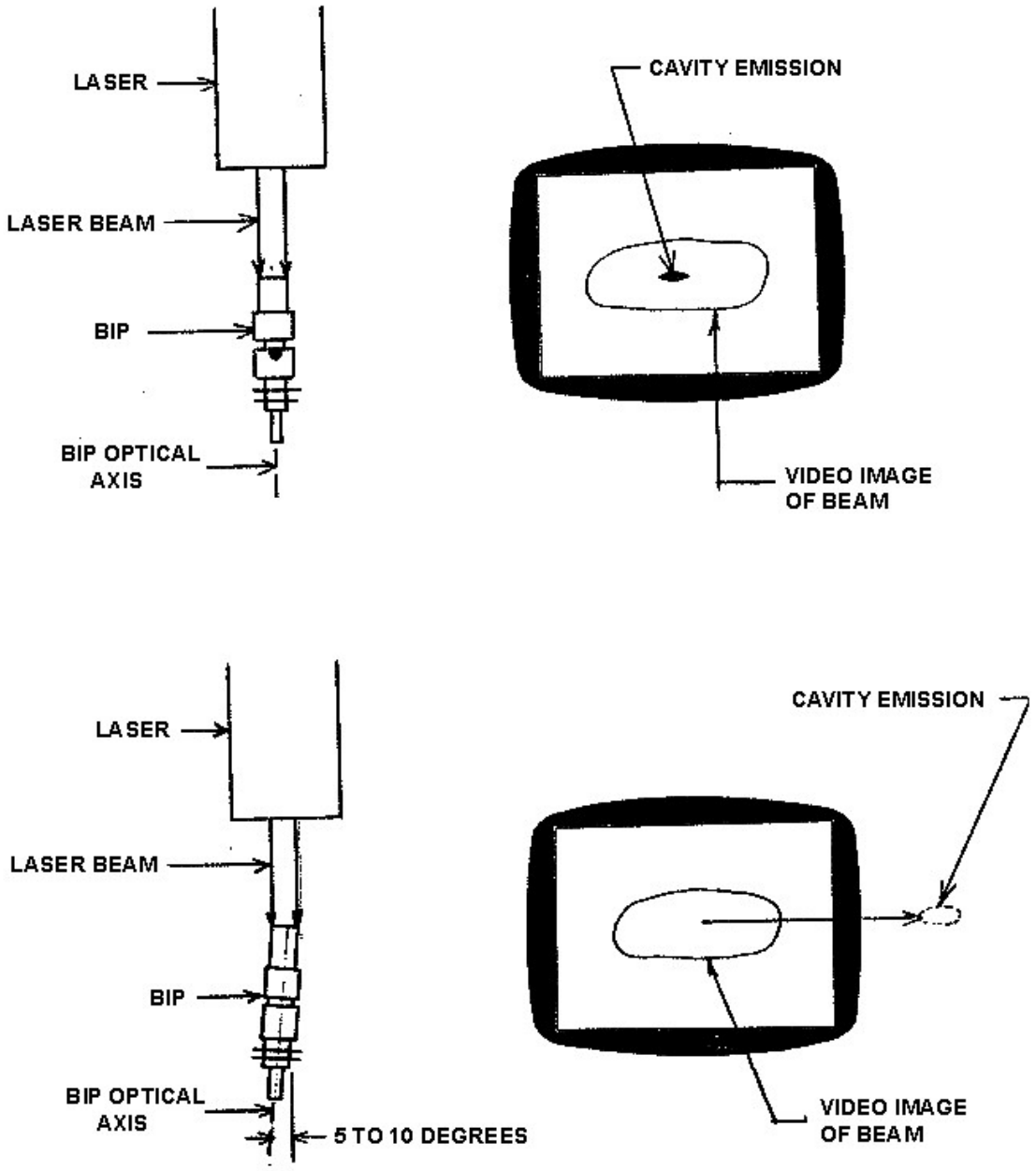


Figure 4. Cavity emission can be eliminated from the image by tilting the BIP a few degrees with no noticeable effect on the image quality.

CLEANING

Clean the FPLATE by wiping its surface with a clean, soft cloth, moistened with alcohol. Never allow the alcohol to puddle up on the surface since it could leak into the lens assembly. The optics could fog up distorting the image, and flammable liquids could ignite causing damage to the BIP.

LENS CAP

The BSZ50 comes with a lens cap to protect the FPLATE. Replacing the lens cap when the beam profiler is not in use protects the FPLATE from possible damage and keeps the front surface clean.

SYNCHRONIZING PULSED SOURCES

If the pulse repetition rate of the source is not synchronized with the frame rate of the camera (30 Hz), a heterodyning effect of the image brightness may occur, even when the fluorescence pulse length is very short. When the repetition rate is higher than the frame rate of the camera, some frames may contain more than one pulse image (Figure 5a, frame 2) and result in brighter images. When the pulse repetition rate of the laser is less than the frame rate of the camera, it is possible to obtain empty frames with no image (e.g., Figure 5b, frame 3). To reduce image brightness fluctuations due to synchronization issues, adjust the repetition rate of the source to a multiple of 30 Hz (e.g., 30, 60, 90, 120, etc.), or asynchronously trigger the camera with a trigger pulse from the laser to synchronize the camera and the laser.

The WINCAM-ST image analysis software provides an alternate method to control image brightness fluctuations. It only displays images with brightness levels that lie within a user selectable range.

MAXIMUM PULSE REPETITION RATE

The BIP can be used at any pulse repetition rate. Because the “C”, “P”, and “G” FPLATE materials have short fluorescence lifetimes (see Table 1), images of individual pulses can be obtained with these materials with an asynchronously triggered camera for lasers running at repetition rates as high as 10 KHz.

The fluorescent lifetime of the “R” type material, however, is approximately 3 ms (1/e) so that the maximum repetition rate for individual, non-overlapping pulse images is about 50 Hz. At low repetition rates, the image will occasionally contain fluorescence from only the beginning or end of a pulse (Figure 6, frames 4 and 5 respectively). At high repetition rates, the fluorescence from the “R” material will contain the integrated images of more than one pulse (Figure 7).

The optical signal will be comprised of a residual fluorescence with the current pulse riding on top of it. The residual fluorescence is the summation of the exponential tails of all prior pulses, and the pulse is the signal produced by the current pulse. The resultant image is a weighted average of all pulses within a time span of 5 or 6 pulse widths (15 to 20 msec).

MINIMUM DETECTABLE FLUENCE

The minimum detectable fluence (MDF) (video S/N = 1.0) for the BSZ50 is about 12 $\mu J/cm^2$. The MDF is limited by noise in the video signal (~ 2mV). The MDF for other F/#'s is shown in Figure 8.

CONVERGING BEAMS

Irradiating the BSZ50 with a converging beam that focuses inside the optical system of the BSZ50 (Figure 9) can permanently damage internal optical elements.

CRYSTALS

The crystals used in all STI DUV instruments were chosen because they have good signal output, high damage thresholds, do not degrade when exposed to intense, long-term DUV radiation (Figures 10 and 11) and have a wide linear dynamic range (Figures 12 and 13).

BSZ50 SPECIFICATIONS

The BSZ50 specifications (Table 2) are typical values. Some of the optical specifications are determined by the specific crystal type and can be estimated from crystal data in Table 1.

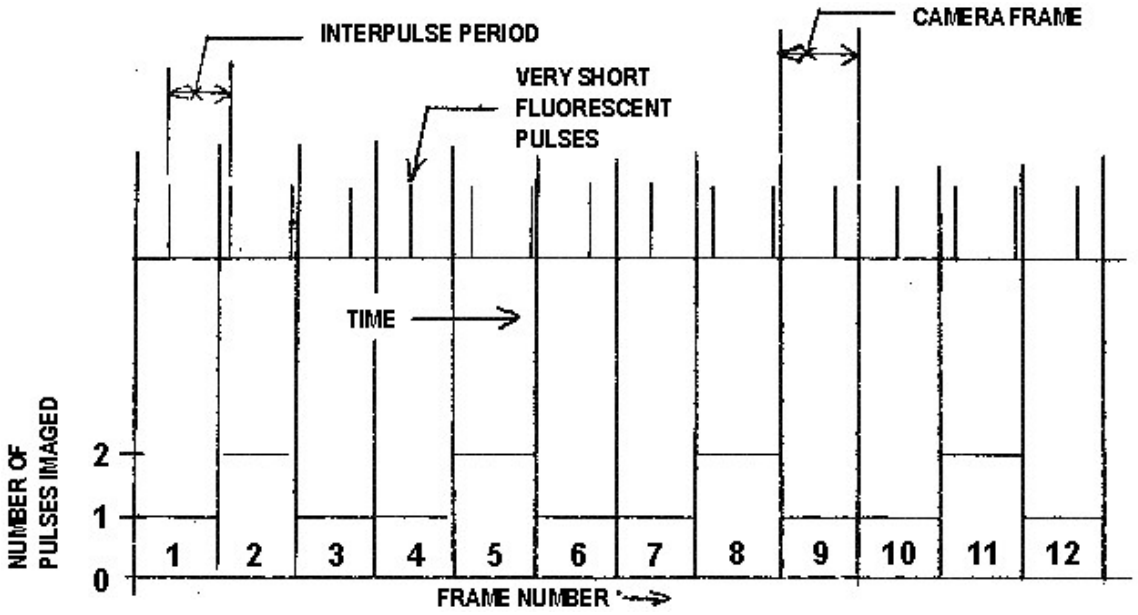


Figure 5a. Repetition rate of the laser is greater than the frame rate of the camera. Frames 2,5,8,11,… contain the images of two pulses.

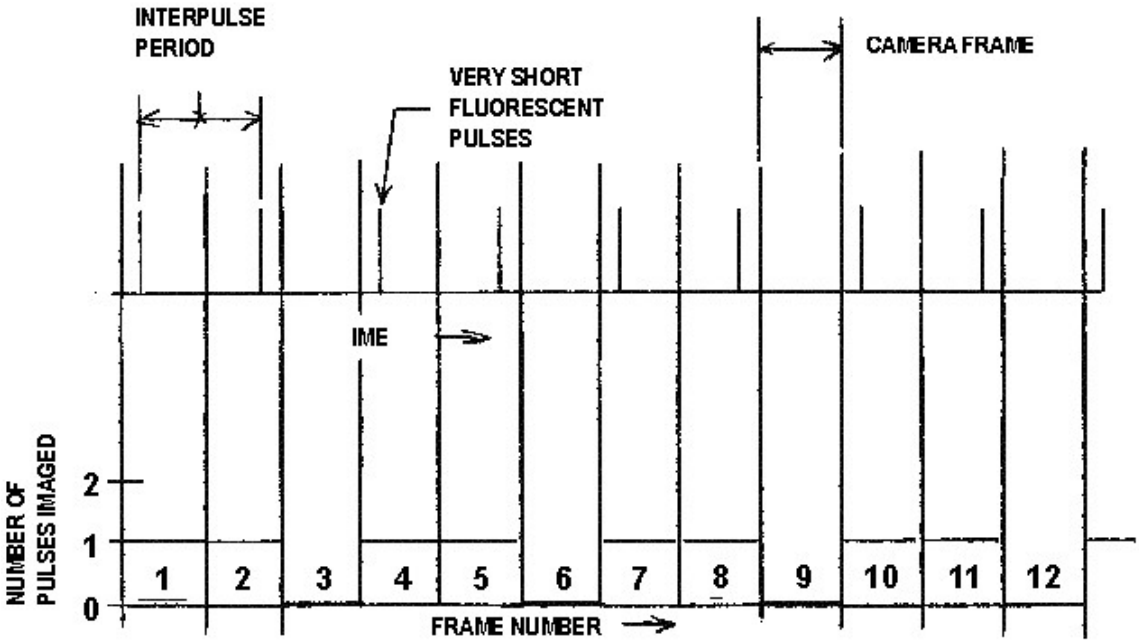


Figure 5b. Repetition rate of the laser is less than the frame rate of the camera. Frames 3,6,9,12,… contain no image.

Figure 5. A “beating” of the image brightness will occur unless the repetition rate of the laser and the frame rate are synchronized.

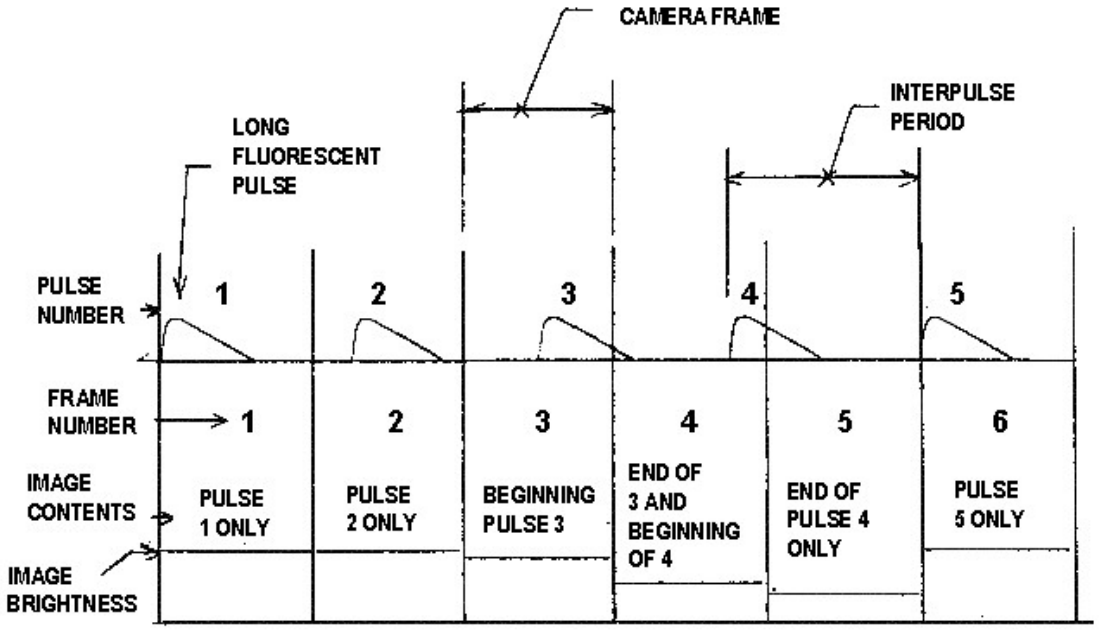


Figure 6. A long fluorescent pulse such as produced by the ‘R’ type crystal will produce images that contain more than one pulse (frame 4). Synchronizing the laser pulses with the frame rate of the camera will prevent this problem.

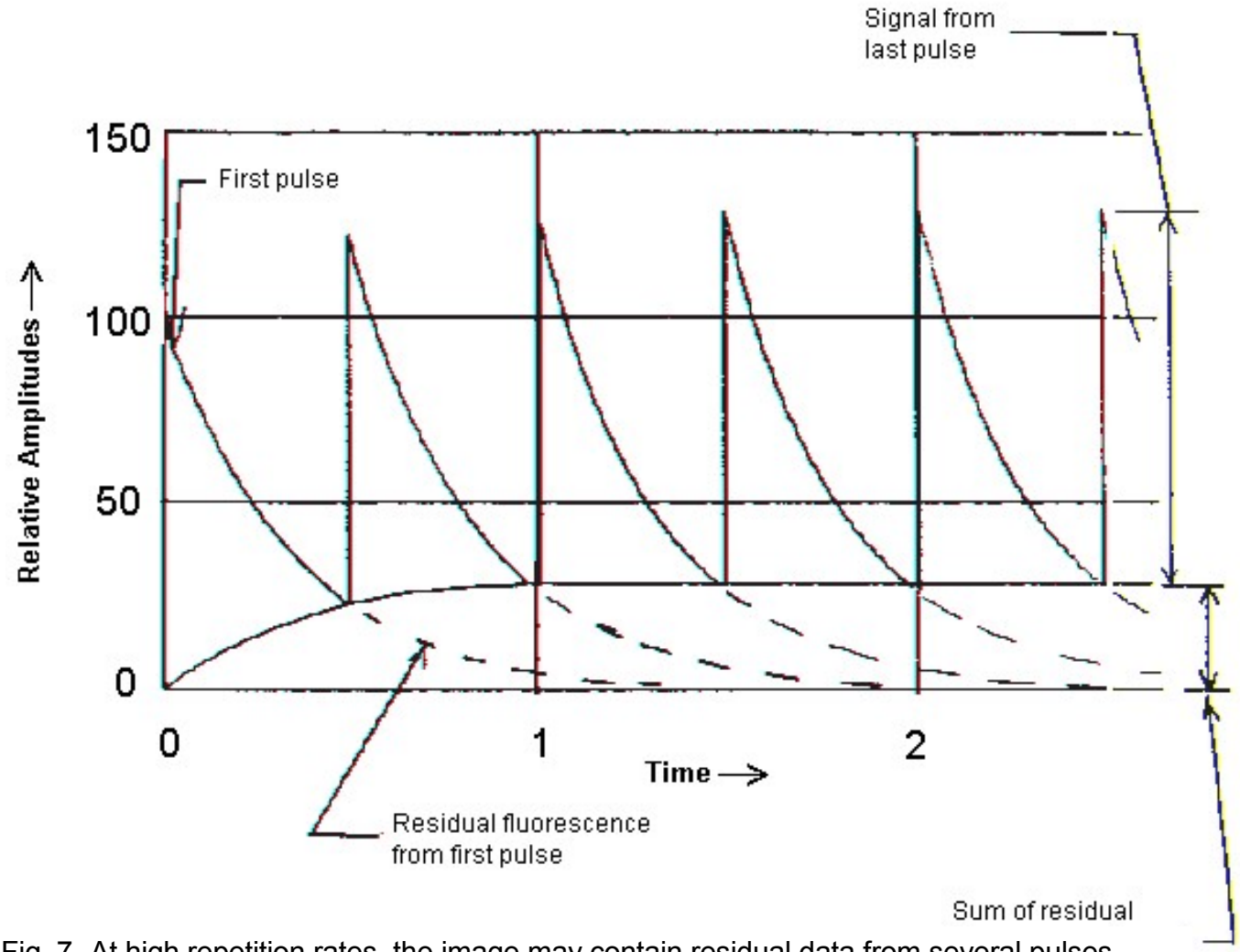


Fig. 7- At high repetition rates, the image may contain residual data from several pulses when the R-type crystal is used.

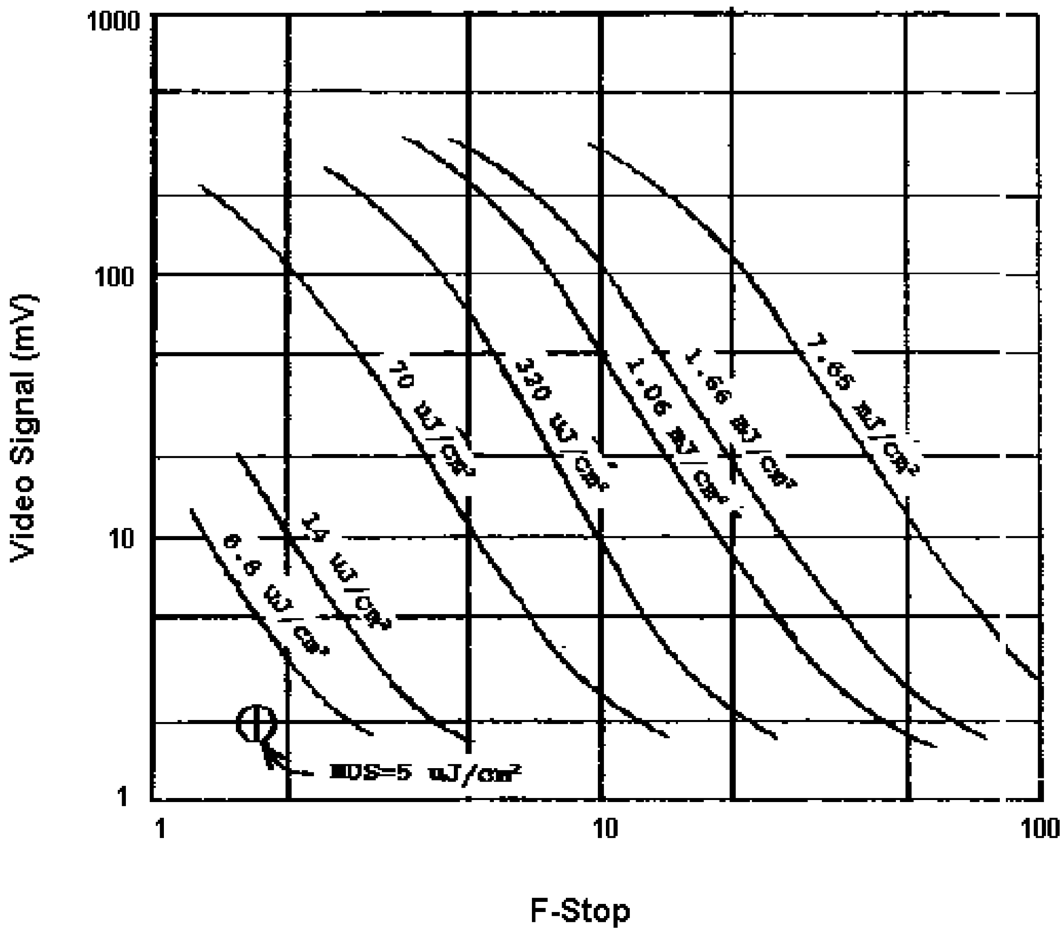


Fig 8.- The BIP can be used over a large range of fluences.

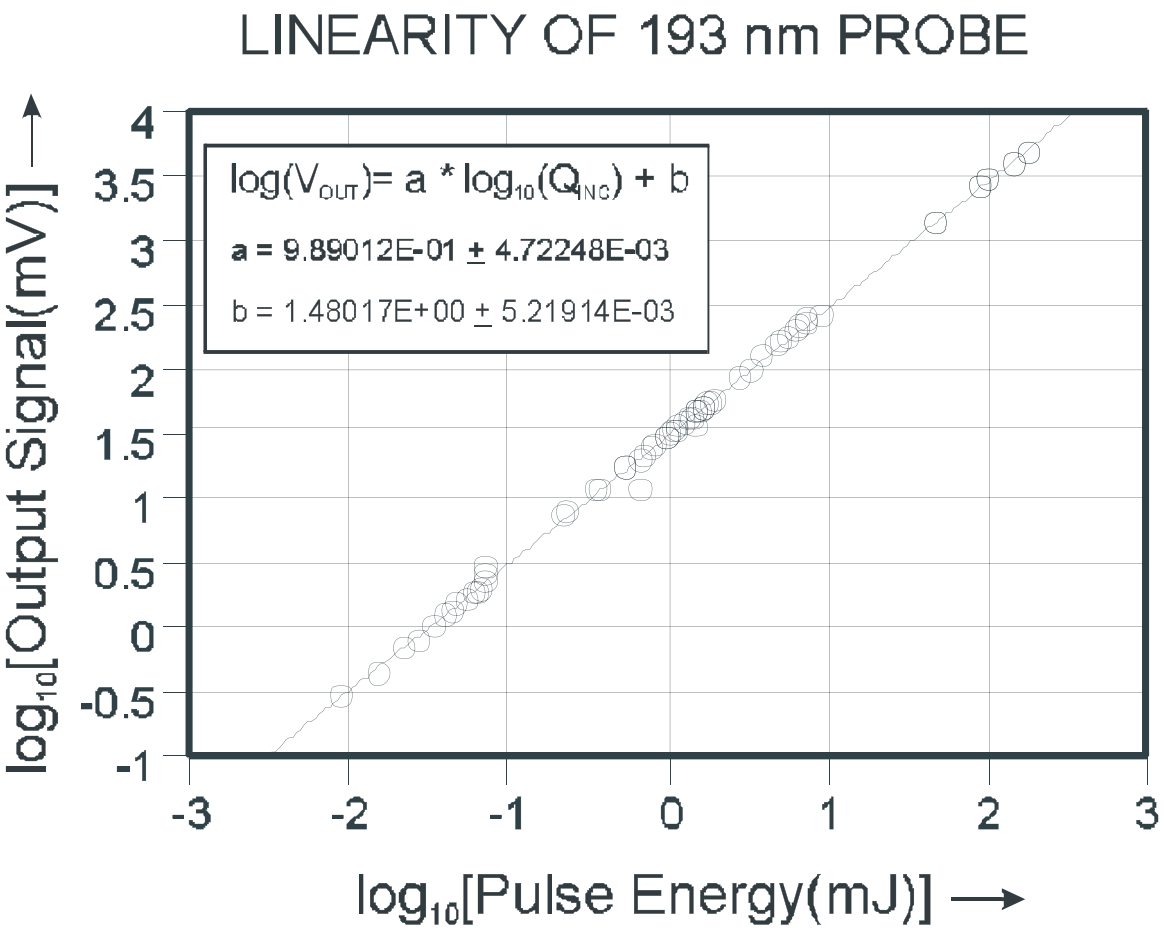


Figure 12. The dynamic range of the "C" crystal is over 5 ½ orders of magnitude

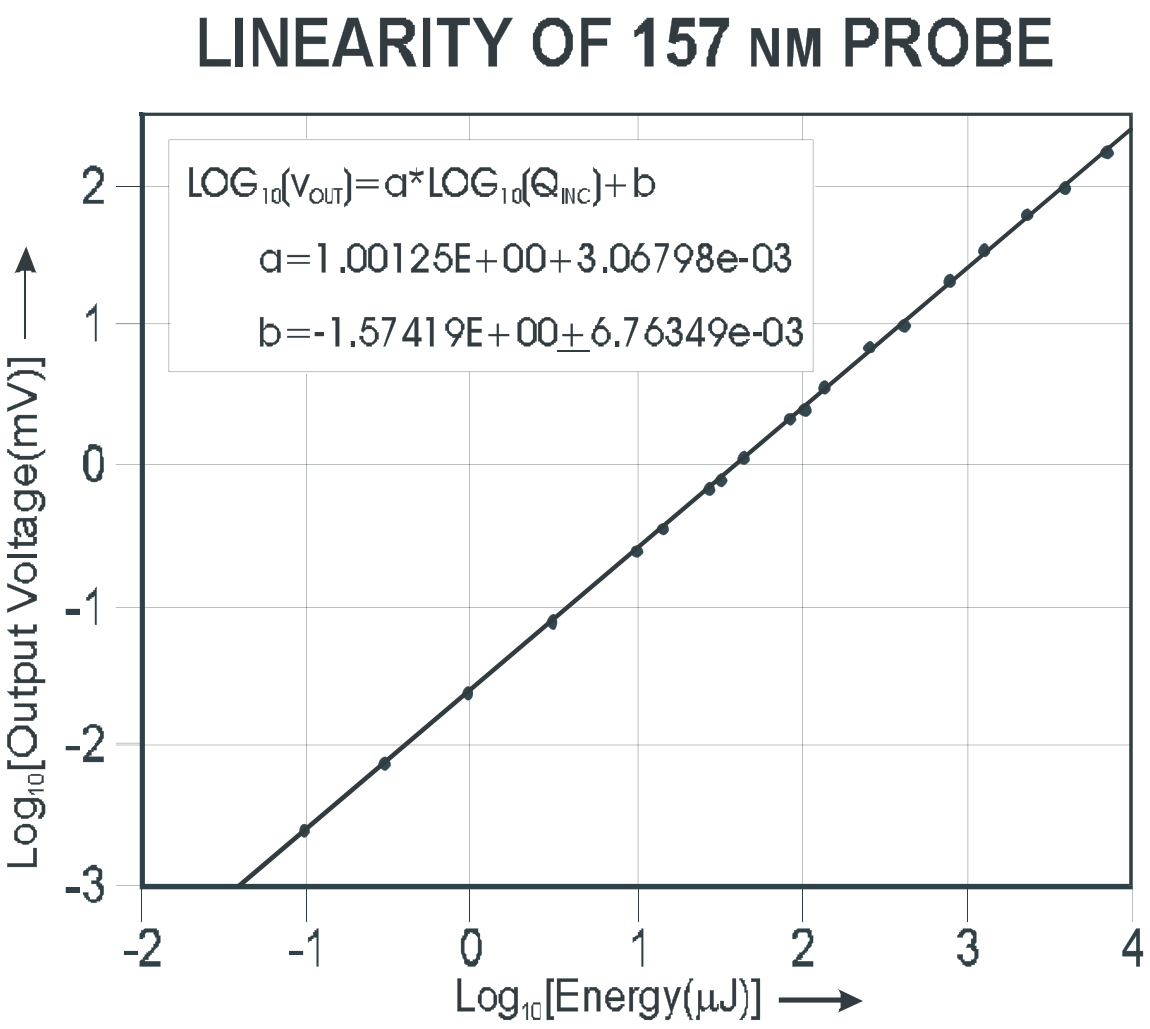


Figure 12. Input/output linearity of the "C" type crystal at 157 nm is over 5 ½ orders of magnitude

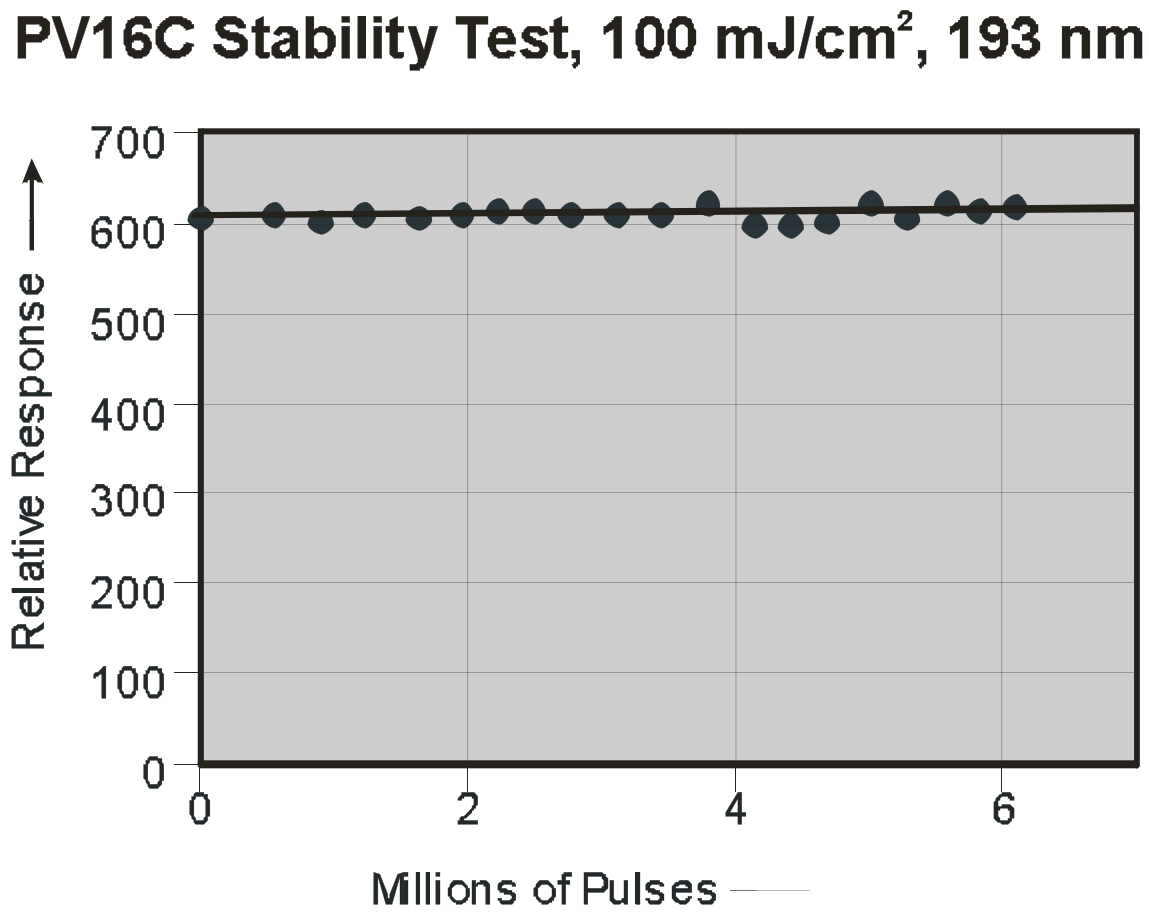


Figure 10. The “C” type crystal shows little change after millions of pulses at 193 nm.

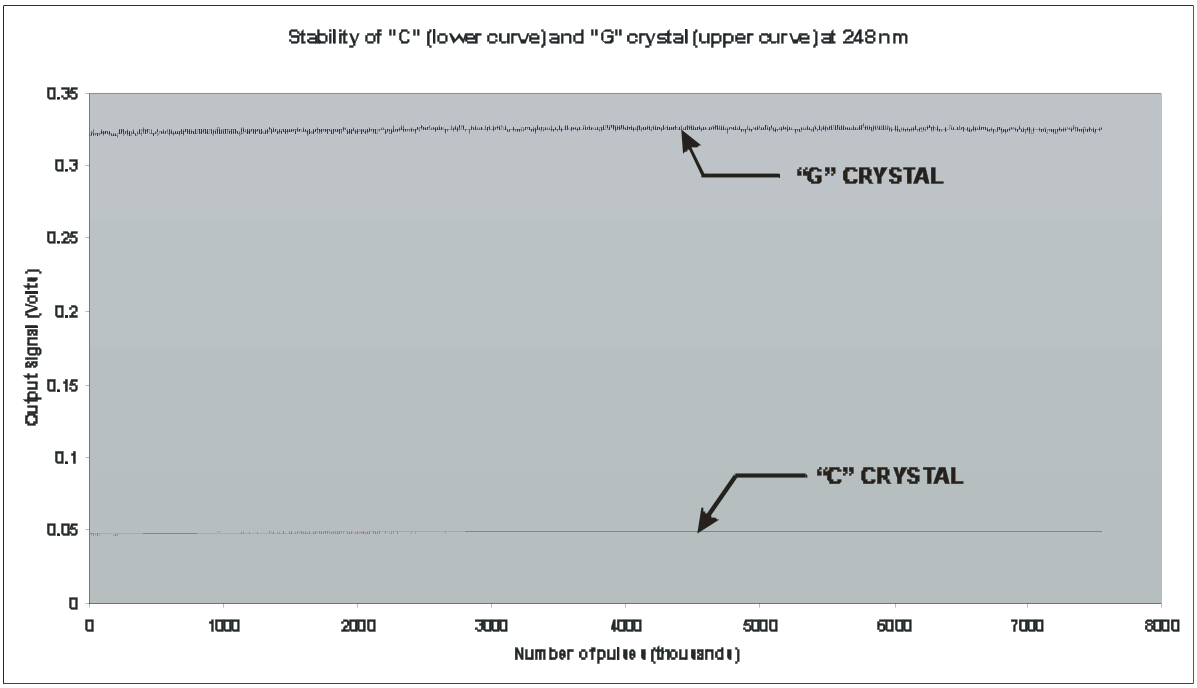


Figure 11. The response of the “C” and “G” crystals is virtually unchanged after nearly 8 million pulses at 248 nm.

Table 2. Specifications of the BSZ50 DUV beam profiler.

BS**Z**50 (6x zoom lens)	
Zoom ratio	6 :1
Focus adjust	manual
Iris	F/2.5 to close
Overall system	
Magnification (Note 1)	1.85 : 1 to 11.1 : 1
Entrance aperture:	
High magnification	6.1 mm Vert x 8.1 mm Hor
Low magnification	36 mm Vert x 48 mm Hor
Pixel size at entrance aperture:	
High magnification	14 μm Vert x 12 μm Hor
Low magnification	82 μm Vert x 70 μm Hor
BS**F**50 (fixed magnification lens, special order item)	
Focus adjust	manual
Iris	F/1.3 to close
Overall system	
Magnification (Note 1)	8.0
Entrance aperture	27mm V 36 mm H
Camera	
type	XC-73 (standard)
mount	"C" mount
format	1/3 in (3.3 x 4.4 mm)
power	12 VDC, 150 mA, reg.
gain controls	AGC Fixed (factory set (0 dB)) Manual (0 dB to +18dB)
Number of pixels	
Horizontal	768
Vertical	492
Pixel size	
horizontal	6.35 μm
vertical	7.4 μm
Minimum detectable fluence ("G" type crystal)	12 $\mu J/cm^2$ (BSZ50; 5 $\mu J/cm^2$ for the BSF50)

Spatial responsivity variation
(areal uniformity at entrance aperture):

FPLATE	less than 1%
Lens system (cos^4)	less than 3%

Mounting:

Base plate dimensions	2.0” x 13.25”
Number of ¼-20 holes	3
Hole locations from front edge of base plate	3 5/8”, 5 5/8”, 7 5/8”
Camera base slot	¾ “ wide x 0.024” deep

Overall dimensions

length	473 mm
height	103 mm
width	90 mm

Weight 4.7 lbs

Note 1. The overall system magnification is the ratio of the entrance aperture size to the camera faceplate size.

ADJUSTMENTS

Camera

The XC-73 camera has provisions for three user selectable gain settings (Figure 14, rear view):

AGC

(The AGC setting will not produce a linear relationship between the incident laser fluence and the video image since the gain is automatically adjusted to prevent camera saturation.)

Fixed gain (built –in "factory" setting of 0 dB)

Manual gain control (of 0 dB to 18 dB).

Zoom Lens

Focus

If you purchased a BIP with a CCD camera, it will be in focus, parfocal and ready for use when you receive it. We do not recommend adjusting the focus setting.

To focus the BSZ50, loosen the brass (focus lock) thumbscrew on the mounting ring (Figure 15) and rotate the main barrel until the focus is sharpest. Tighten the thumbscrew to prevent accidental focus changes during use. A fine mesh screen wire makes an excellent focussing aid. For best results, cut a small piece of screen and gently hold it against the FPLATE while irradiating the screen with the laser or an incandescent bulb (Figure 16).

Iris

The iris ring is the narrow knurled ring near the C-mount (Figure 15). Adjust the iris opening so that no part of the image is saturated (Figure 17a). A saturated image produces an absolutely flat high amplitude energy "distribution" (Figure 17b) and yields little information about the beam. We recommend using the smallest iris opening that produces a satisfactory image, since the best spatial resolution occurs for the smallest iris opening.

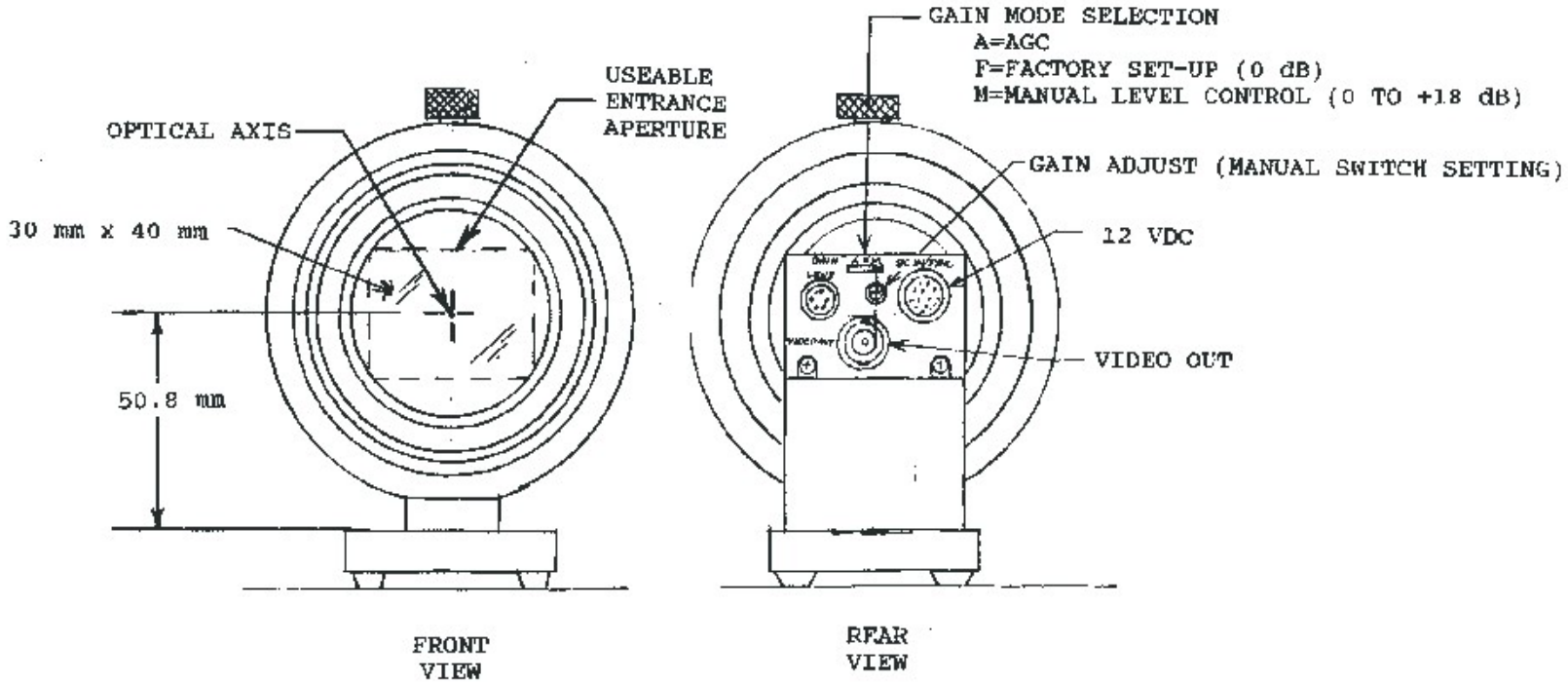


Figure 14. Front and rear views of the model BSZ50 beam profiler.

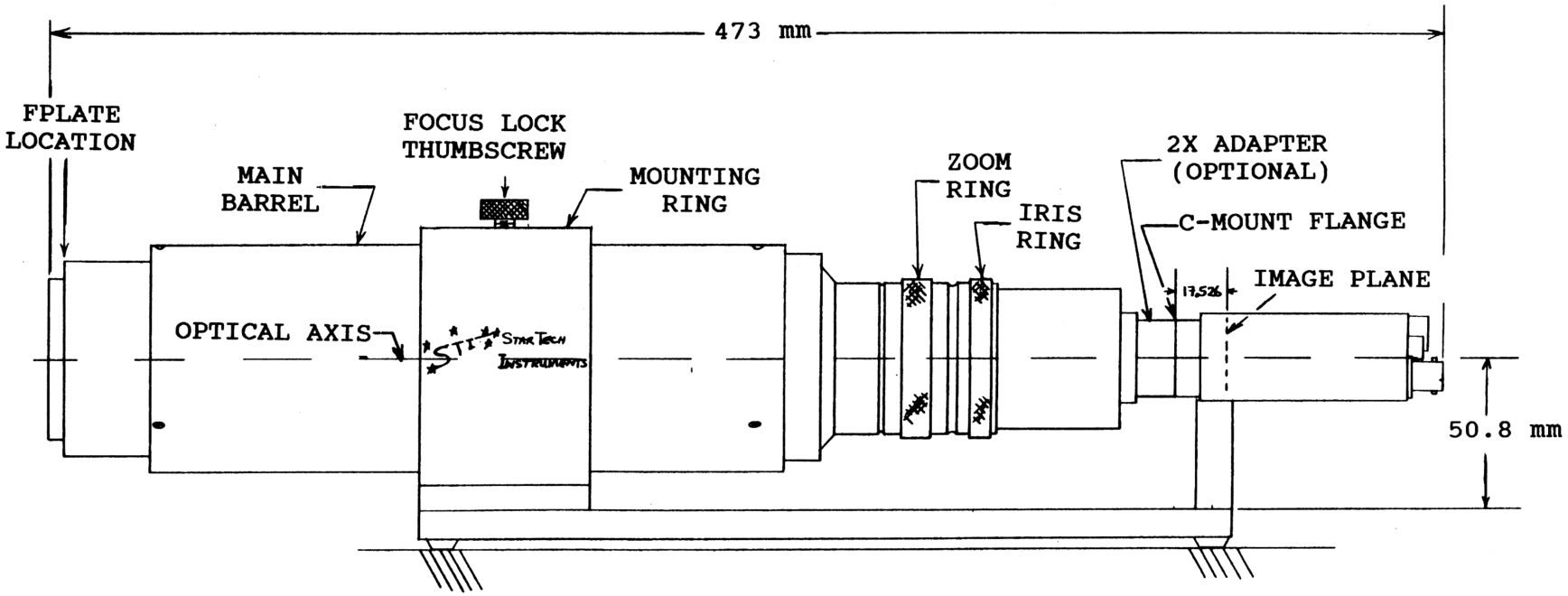
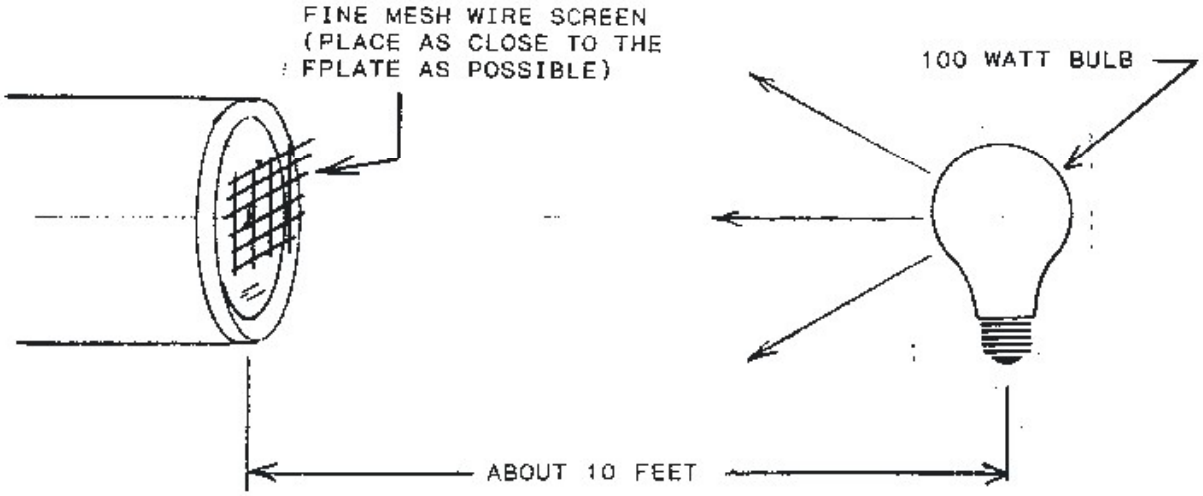


Figure 15. The BSZ50 is a compact optical system for viewing DUV laser beams.

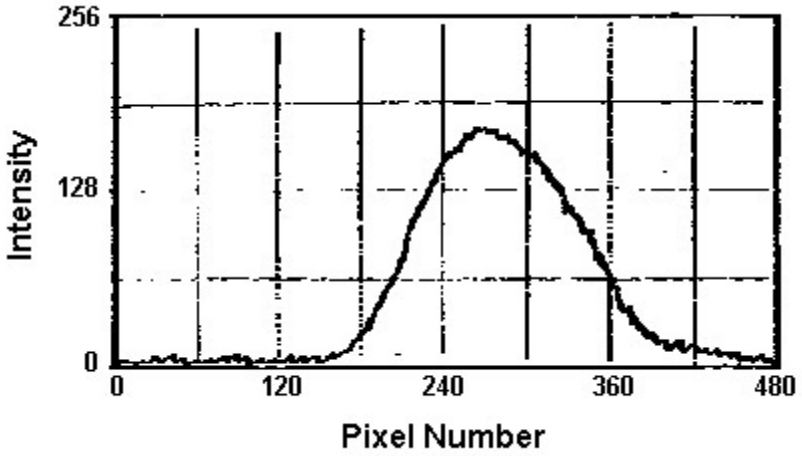




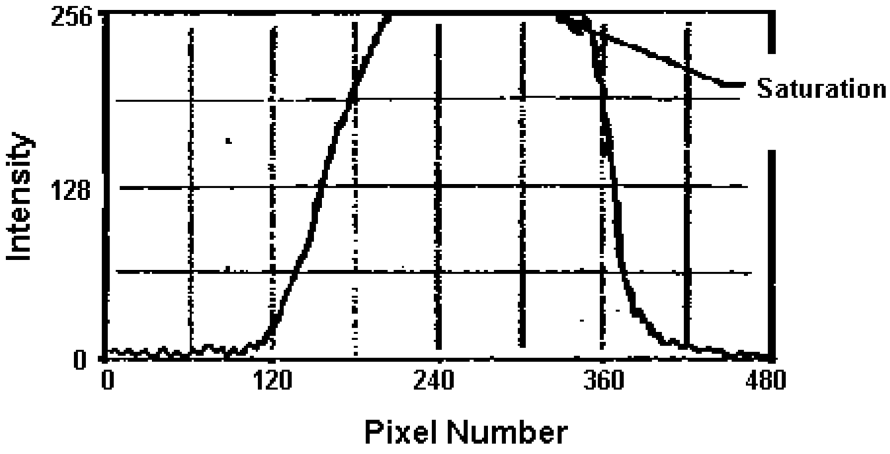
HIGH MAGNIFICATION

LOW MAGNIFICATION

Figure 15. Setup for checking the operation of the BIP with an incandescent bulb and a fine mesh wire screen.



a. Unsaturated image



b. Saturated image

Fig.17a,b – Saturation may occur when the iris opening is too large.

Zoom

The wide knurled ring, located between the main barrel and the iris ring (Figure 15), controls the magnification. The lowest magnification corresponds to a nominal input aperture of about 30 mm x 40 mm; the highest magnification, to an input aperture of approximately 6 mm x 8 mm. To obtain the best focus over the entire zoom range, focus the lens when in the highest magnification. Use the zoom chart (Figure 18) and the vernier scale on the zoom ring to estimate the image magnification.

Frame grabber and camera gain

The gain of the camera and the gain of the frame grabber should be set so that both saturate at the same incident fluence. If the camera saturates first, then the amplitude of high frequency structure in the brightest parts of the beam will not be accurately represented in the video image. If the frame grabber saturates first, then the dynamic range of the system will be reduced; the input-output, however, will be linear.

CAMERA INSTALLATION

If you purchased a BSZ50 with a video camera, it is ready for use. If you purchased it without a video camera, please note the following:

1) Camera format:

   The optics are designed for a 1/3 inch camera. If you use the 1/3 inch BSZ50 with a larger format camera, the images will be smaller and have a lower resolution than with a 1/3 inch camera. (see Figure 19 for standard camera format sizes). Use the appropriate STI adapter to convert the 1/3 inch system format to your camera image format (Figure 20).

2) Photometric and other filters:

   The optical system of the BIP has internal filters that ensure proper operation of the system. If you use your own camera, we recommend that you remove all filters from the camera prior to use.

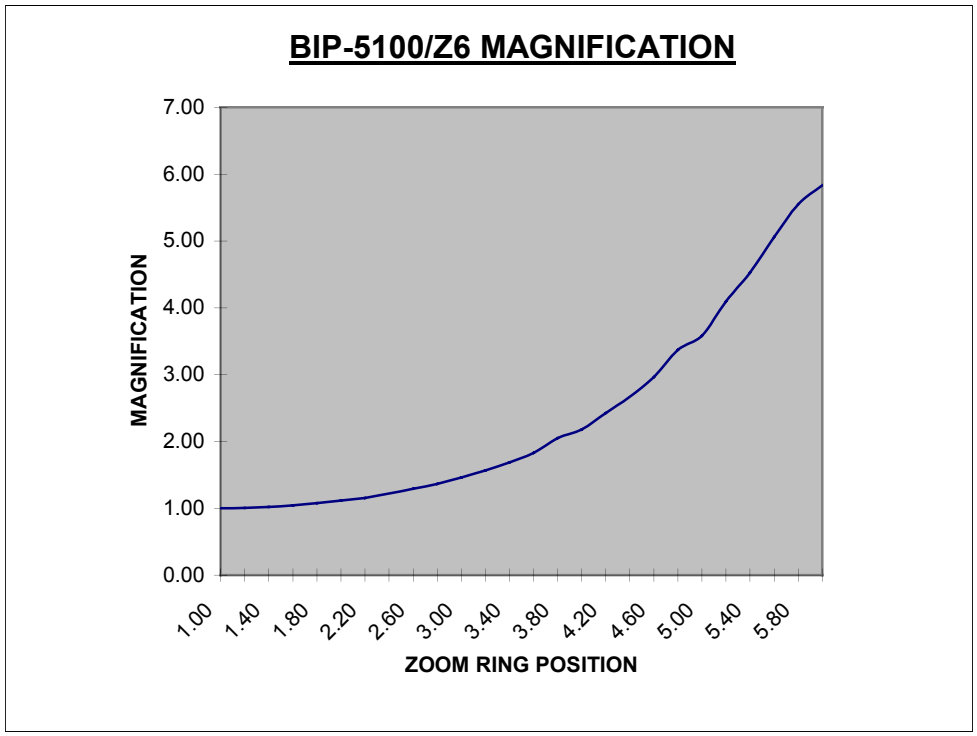


Figure 18. Zoom setting chart for the 6 : 1 zoom lens.

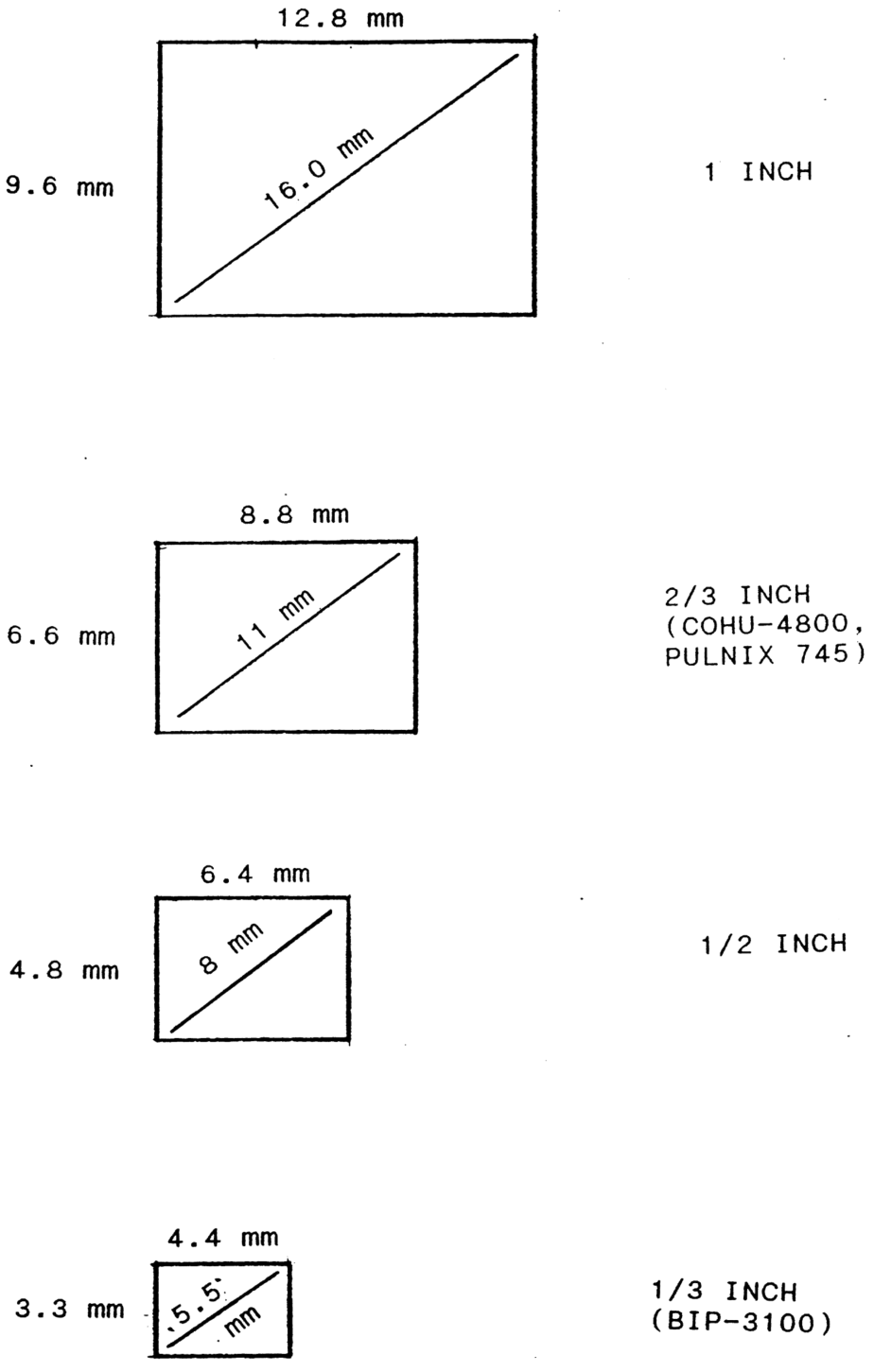


Figure 18. Standard CCD camera formats.

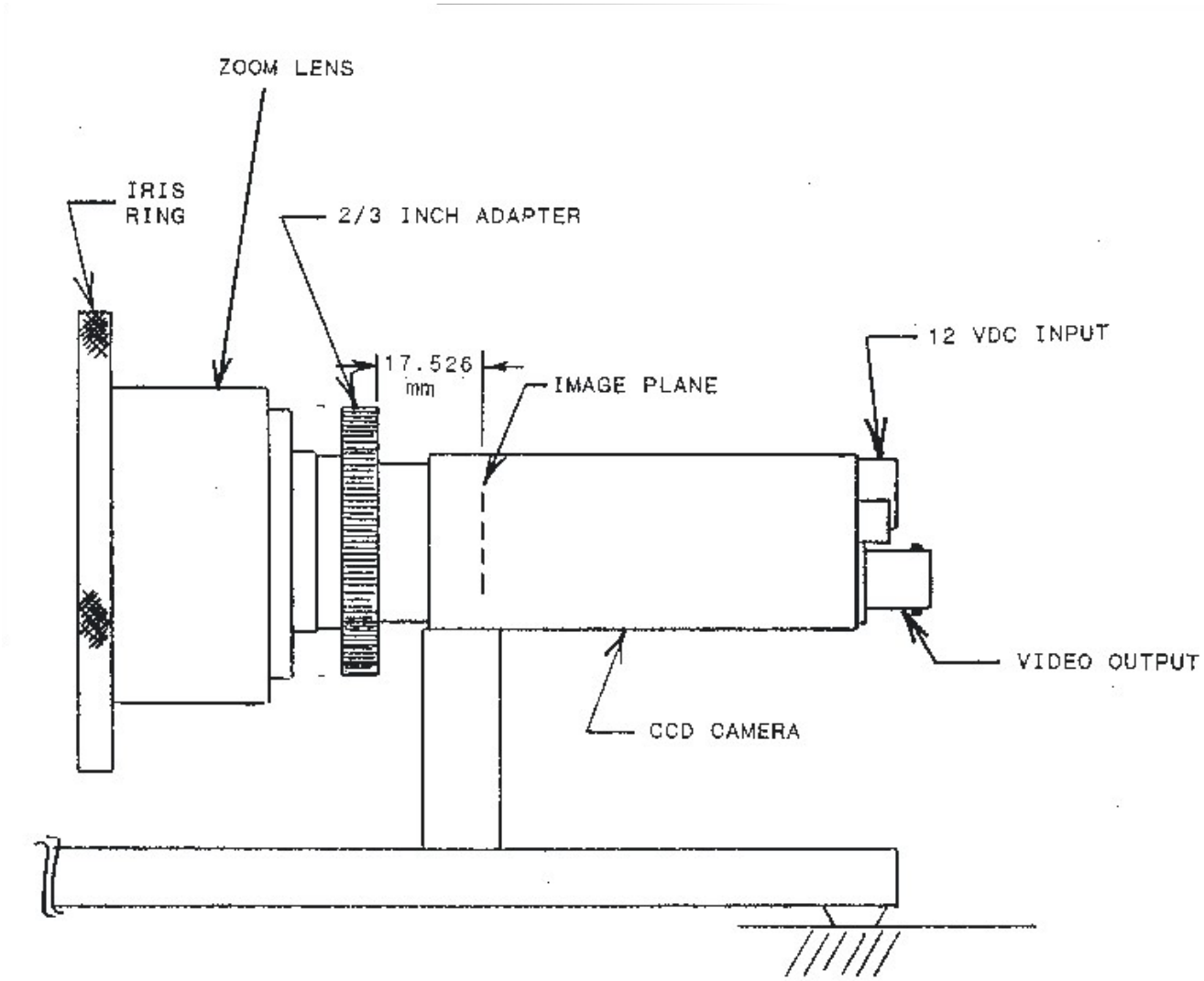


Figure 20. CCD format adapters are available for all standard CCD camera formats.

3) Camera installation:

The camera installation procedure is as follows (referring to Figure 15):

a) Loosen the thumbscrew on the mounting ring.
a) Carefully slide the main tube and lens assembly far enough out of the mounting ring that the C-mount is clear of the slotted end of the base plate.
b) Attach the camera base to the camera. If you make a base for a special camera, the center of the camera faceplate must be 2.000 inches above the top surface of the base plate. It is very important that the camera be mounted the correct distance above the top surface of the base plate. If it is not, the main barrel will not turn freely in the mounting ring, causing focussing difficulties. Gross misalignments could damage the beam profiler. Note that the base plate has a 0.750" wide x 0.024" deep alignment slot in the surface of the base plate (Figure 3).
c) Slide the main tube into the mounting ring.
d) Install the ¼-20 SHCS and the curved washer into the camera base (the curved side of the washer toward the head of the screw) and tighten it.
e) Turn the main barrel to verify that it turns freely.

4) Parfocal Adjustment

The BIP was designed for the Sony XC series cameras (-73, -75 and -77). If you are using another camera, you may need to adjust the position of the image plane of the optical system so that it coincides with the faceplate of the camera. This is especially important for parfocal operation throughout the entire zoom range of the lens. If the system is not parfocal, you will need to re-focus whenever you change magnification. This operation involves disassembly of the zoom lens and it is recommended that the beam profiler and camera be returned to the factory if this is necessary.

IF YOU PLAN TO USE YOUR OWN CAMERA, WE RECOMMEND THAT YOU SEND IT TO US FOR INSTALLATION AND SETUP.

OPTIONS

The BVZ50 (beam profiler for a vacuum/purge line application)

The BVZ50 (Figure 22) is optically identical to the BSZ50 but it has a sealed flange for vacuum/purge line applications. It is also available with an energy probe attachment (Figure 23).

Image analysis software (WINCAM-ST)

STI offers an imaging analysis software package (Figure 24) for use with its family of DUV beam profilers. A typical screen image is shown in Figure 24b. You may download the latest version of WINCAM-ST from our web site at WWW.STARTECHINST.COM.

Right angle attachment (the RA5050)

The right angle attachment (Figure 25) allows imaging in only 90 mm of space along the beam path. It also attenuates the beam fluence by a factor of 20.

BIP lenses for other beam sizes

The BSZ50 can image beams up to 30 mm x 40 mm. Other standard and custom sizes are available. STI has manufactured beam profilers with input apertures from 8 mm diameter to as large as 90 mm (Figure 26).

Energy probe attachment

For situations when you need to simultaneously measure the beam profile and monitor the pulse energy, STI manufactures an energy probe attachment for the BSZ50 series beam profilers (Figure 27).

Low insertion loss BIP

The low insertion loss BIP (Figure 28) transmits most of the incident DUV light enabling its use for processing while providing continuous real-time image analysis and monitoring.

OEM and custom beam profilers

The unsurpassed long-term stability and low cost of the BIP series beam profilers for the DUV make them an attractive built-in option for a laser beam delivery system. The BRF25G12N (Figure 29) is a beam profiler that requires only 50 mm of beam path. Consult STI for more Information.



Figure 22. The BVZ50 is sealed for vacuum/purge line applications.



Figure 23. The Model BVZ50 beam profiler with integral energy probe attachment.

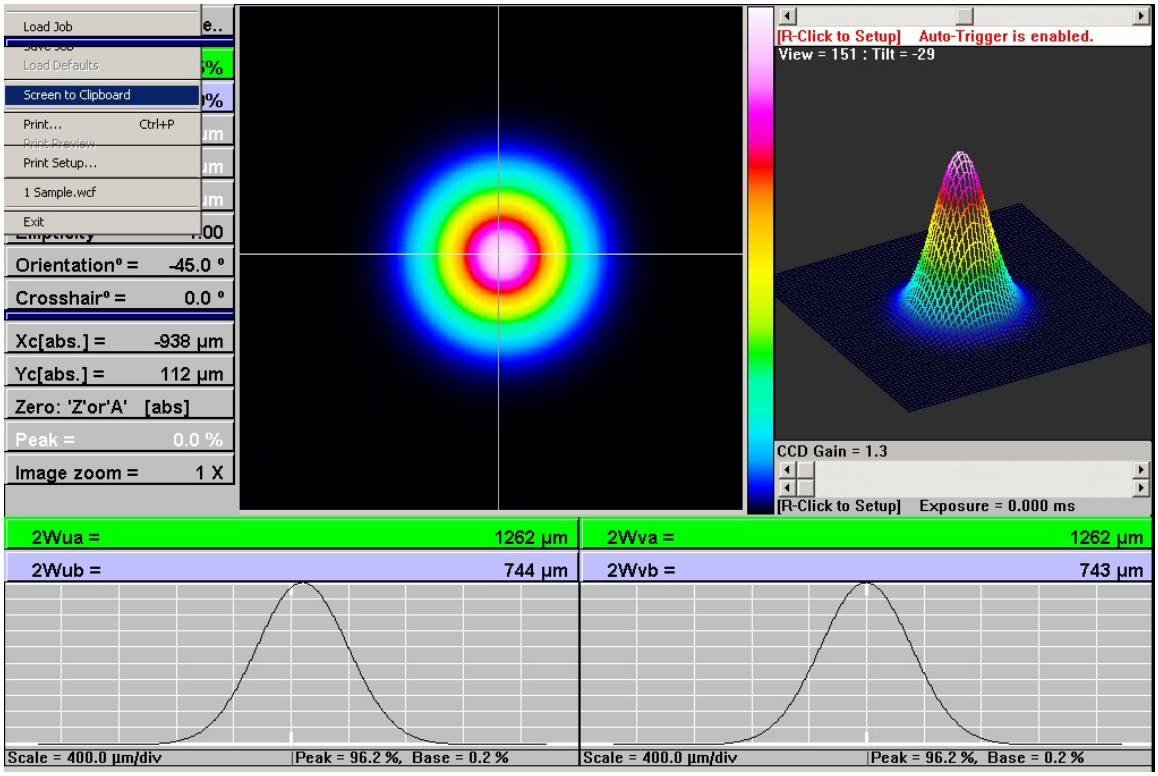


Fig. 24- The WinCam-D beam profiling package includes software, digital camera and framegrabber. It offers 1024X1024 pixel, 14-bit image analysis.

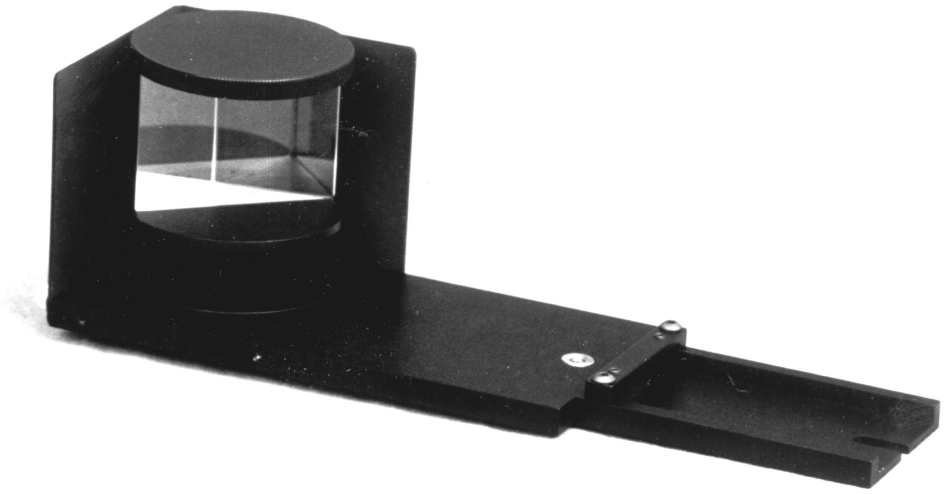


Figure 25. The RA5050 requires only 90 mm of space along the beam path.



a. The BIP-TC; a custom, 90 mm diameter input aperture beam profiler.



b. The BSF10G13; This miniature beam profiler has an 8 mm diameter input aperture.

Figure 26. STI manufactures BIP's with a wide range of input apertures.

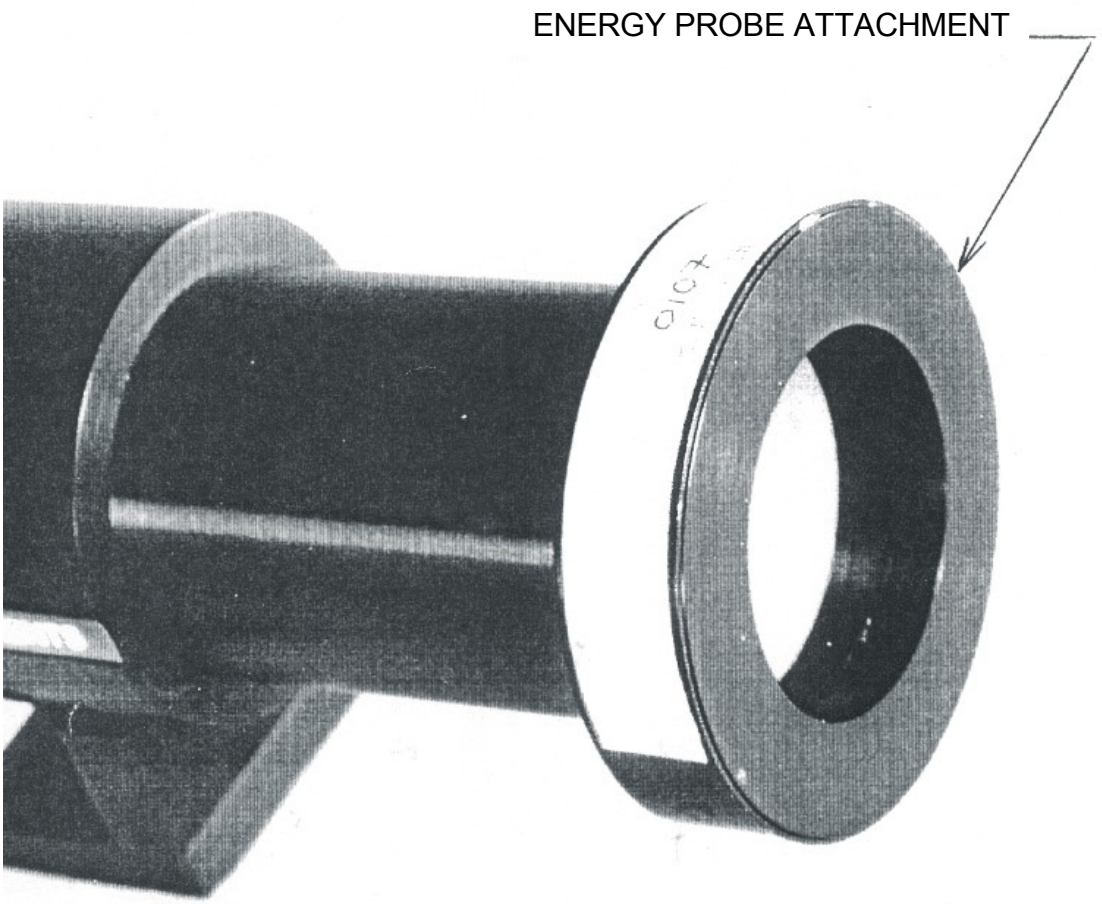
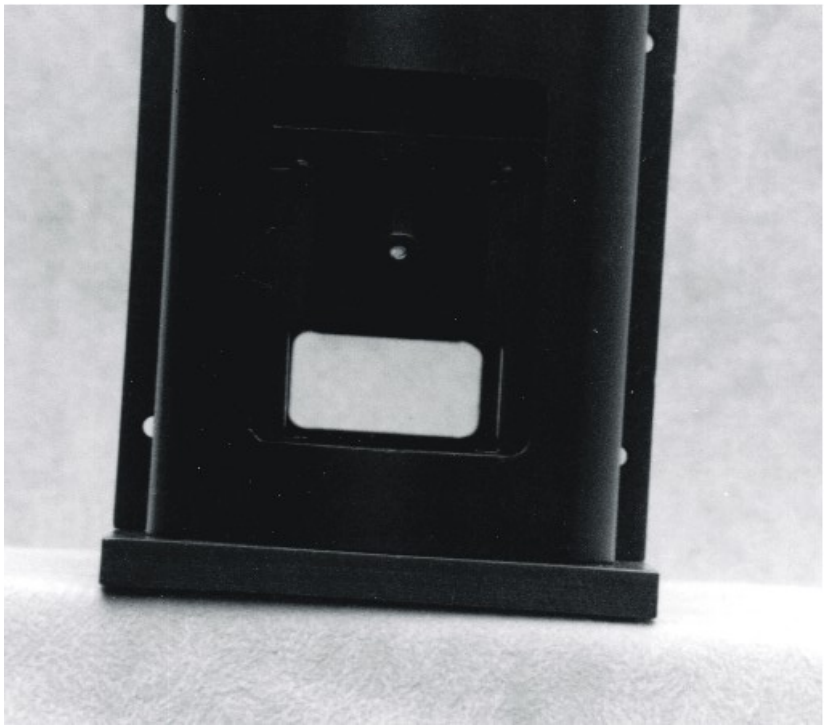
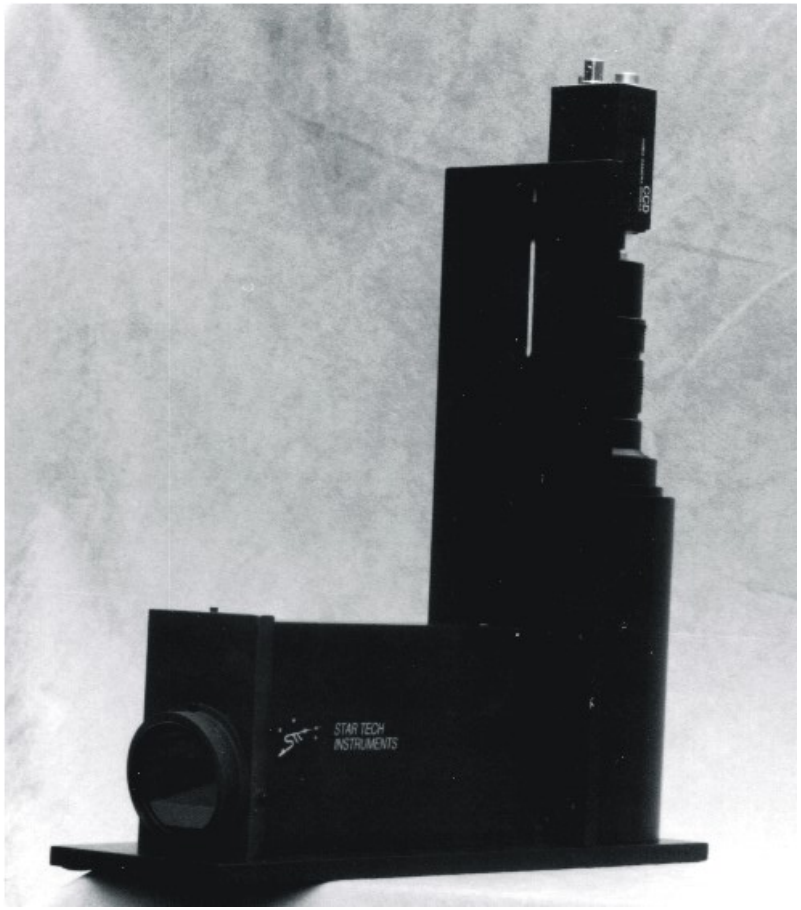


Figure 27. The energy probe attachment for the model BSZ50 beam profiler permits both the beam profile and the pulse energy to be monitored and recorded simultaneously.



b. View through the beam profiler.



a. The BTZ50 beam profiler transmits over 95% of the incident DUV beam.

Figure 28. The BTZ50 beam profiler transmits most of the incident DUV beam, enabling the beam profile to be monitored and recorded during critical process applications.



Figure 29. STI routinely manufactures custom beam profilers for the DUV. This custom beam profiler has a 25 mm diameter input aperture and requires less than 55 mm of beam path.

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