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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.

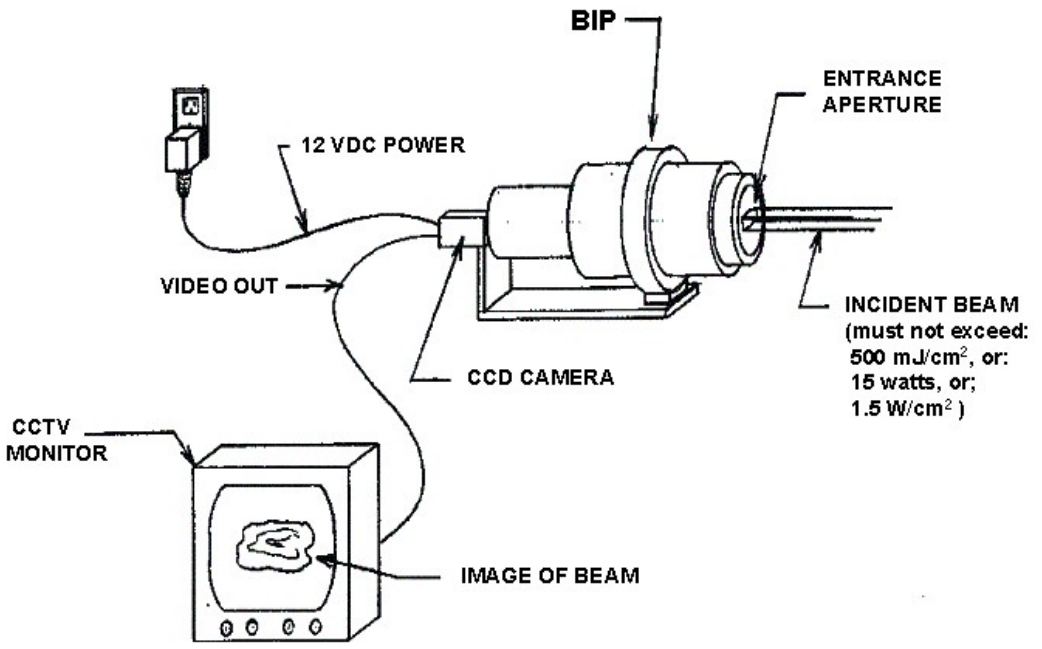


Figure 2. The BIP is a direct view imaging system for observing UV laser beams

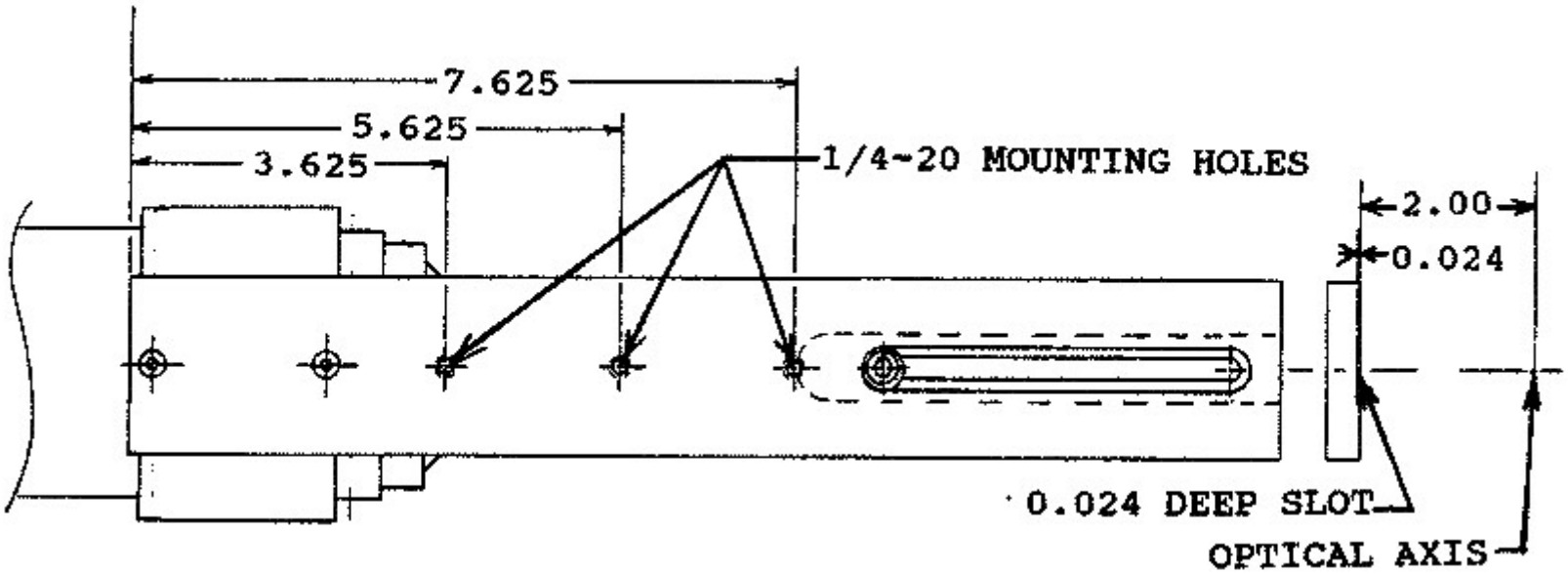


Figure 3. The ¼-20 mounting holes are on 2” centers to facilitate set-up on optical tables.

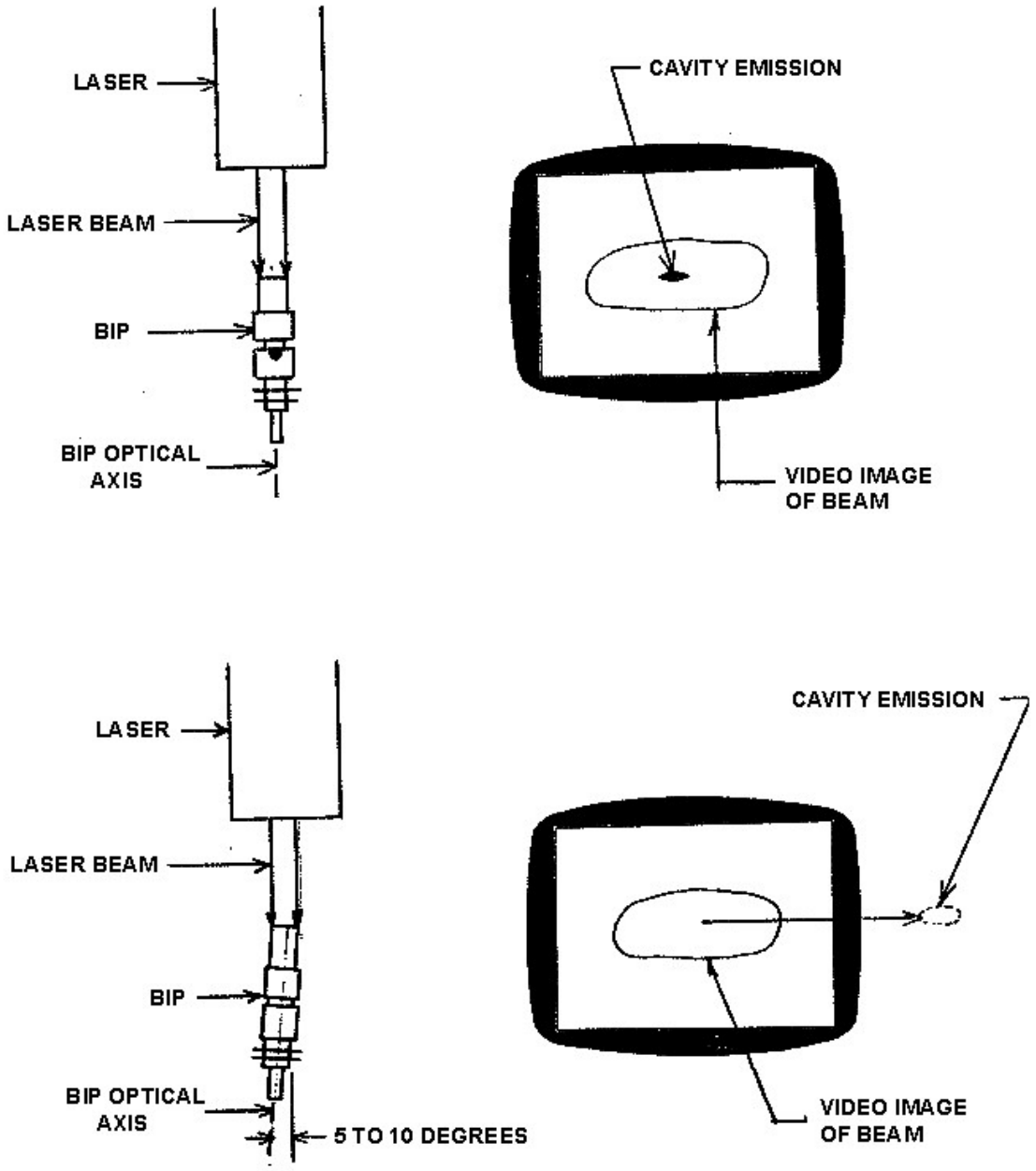


Figure 4. Cavity emission can be eliminated from the image by tilting the BIP a few degrees with no noticeable effect on the image quality.

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.

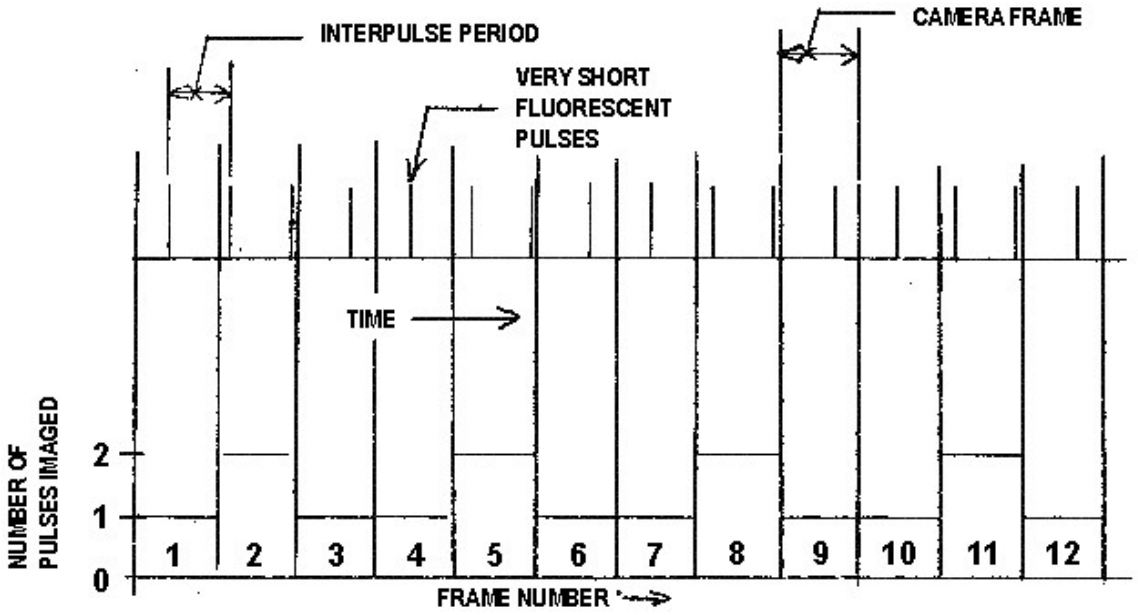


Figure 5a. Repetition rate of the laser is greater than the frame rate of the camera. Frames 2,5,8,11,… contain the images of two pulses.

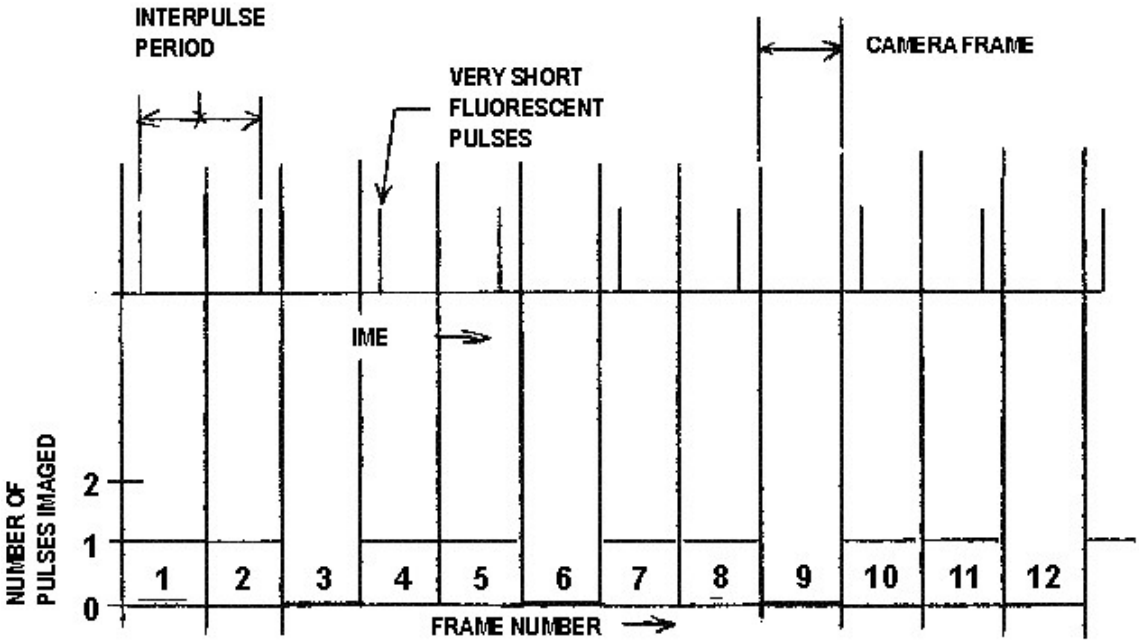


Figure 5b. Repetition rate of the laser is less than the frame rate of the camera. Frames 3,6,9,12,… contain no image.

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

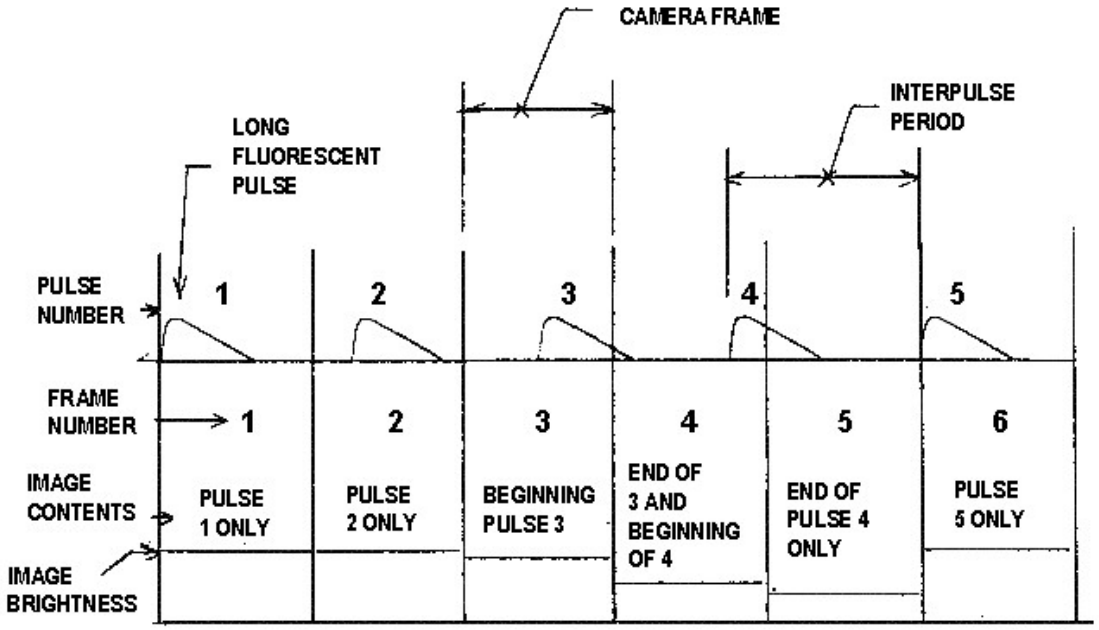


Figure 6. A long fluorescent pulse such as produced by the ‘R’ type crystal will produce images that contain more than one pulse (frame 4). Synchronizing the laser pulses with the frame rate of the camera will prevent this problem.

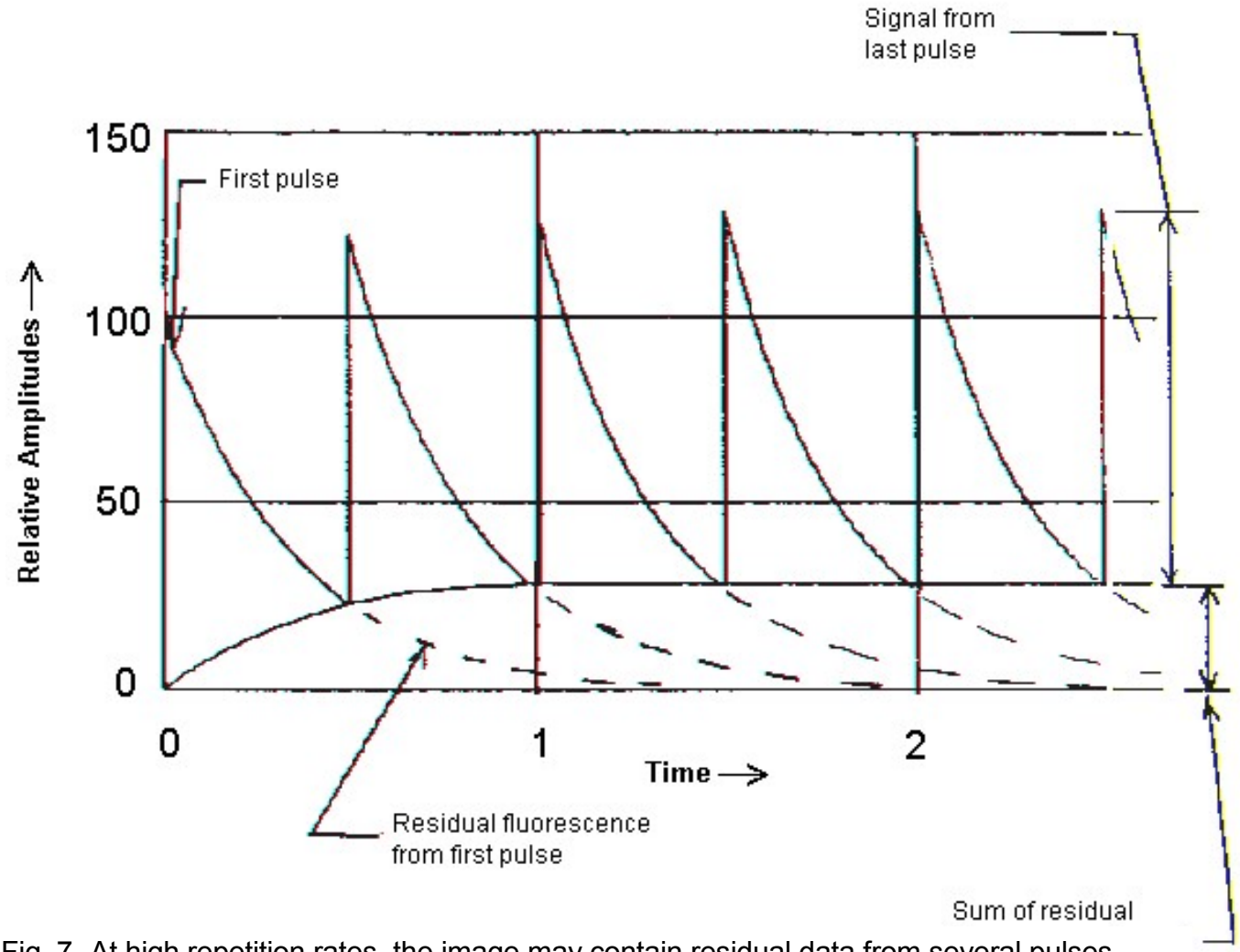


Fig. 7- At high repetition rates, the image may contain residual data from several pulses when the R-type crystal is used.

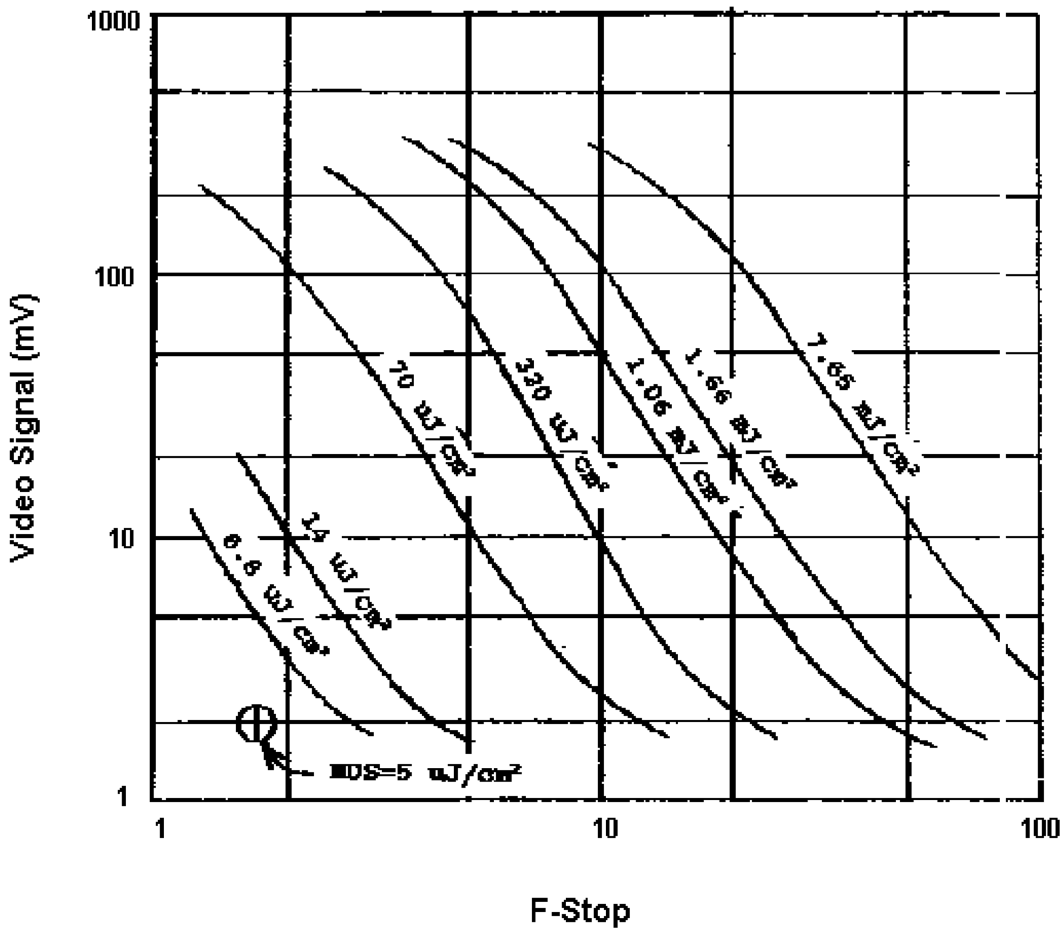


Fig 8.- The BIP can be used over a large range of fluences.

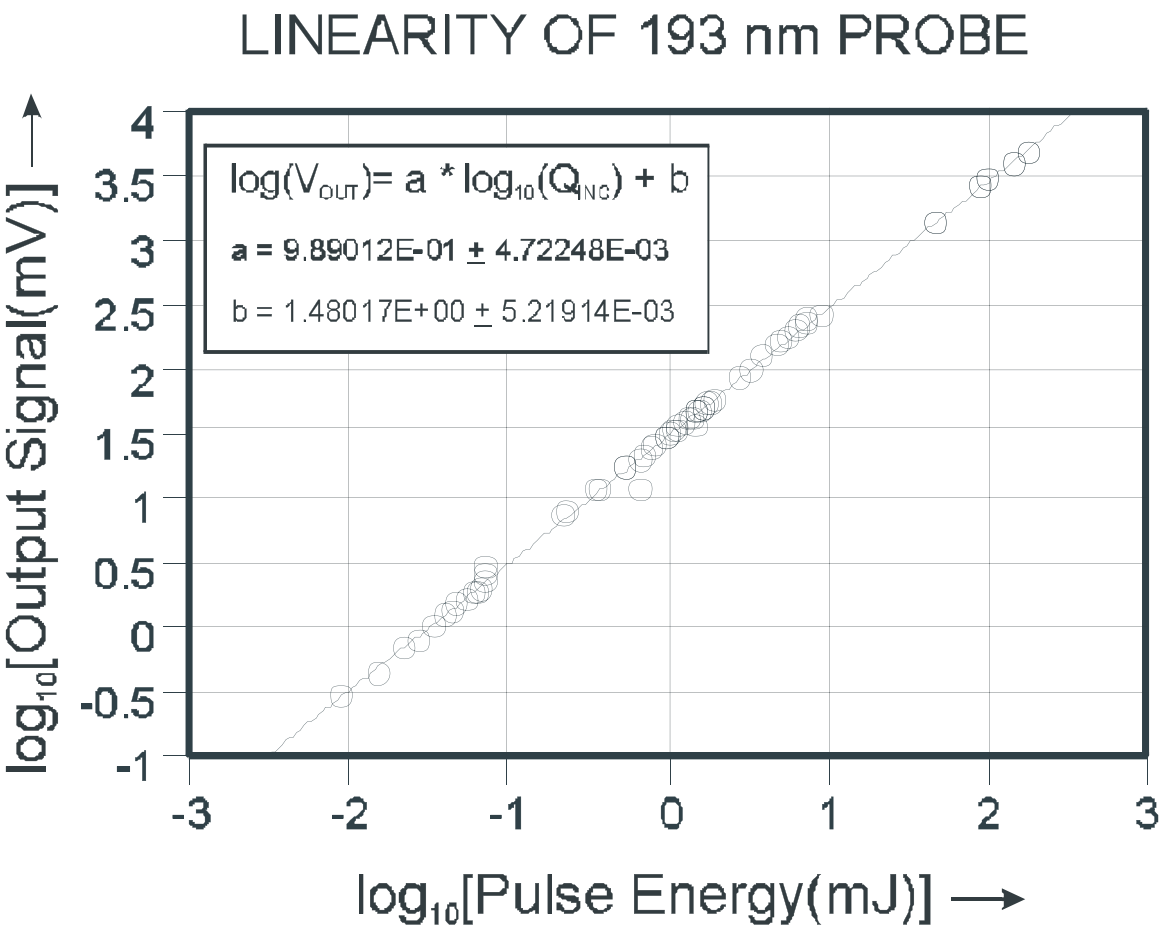


Figure 12. The dynamic range of the "C" crystal is over 5 ½ orders of magnitude

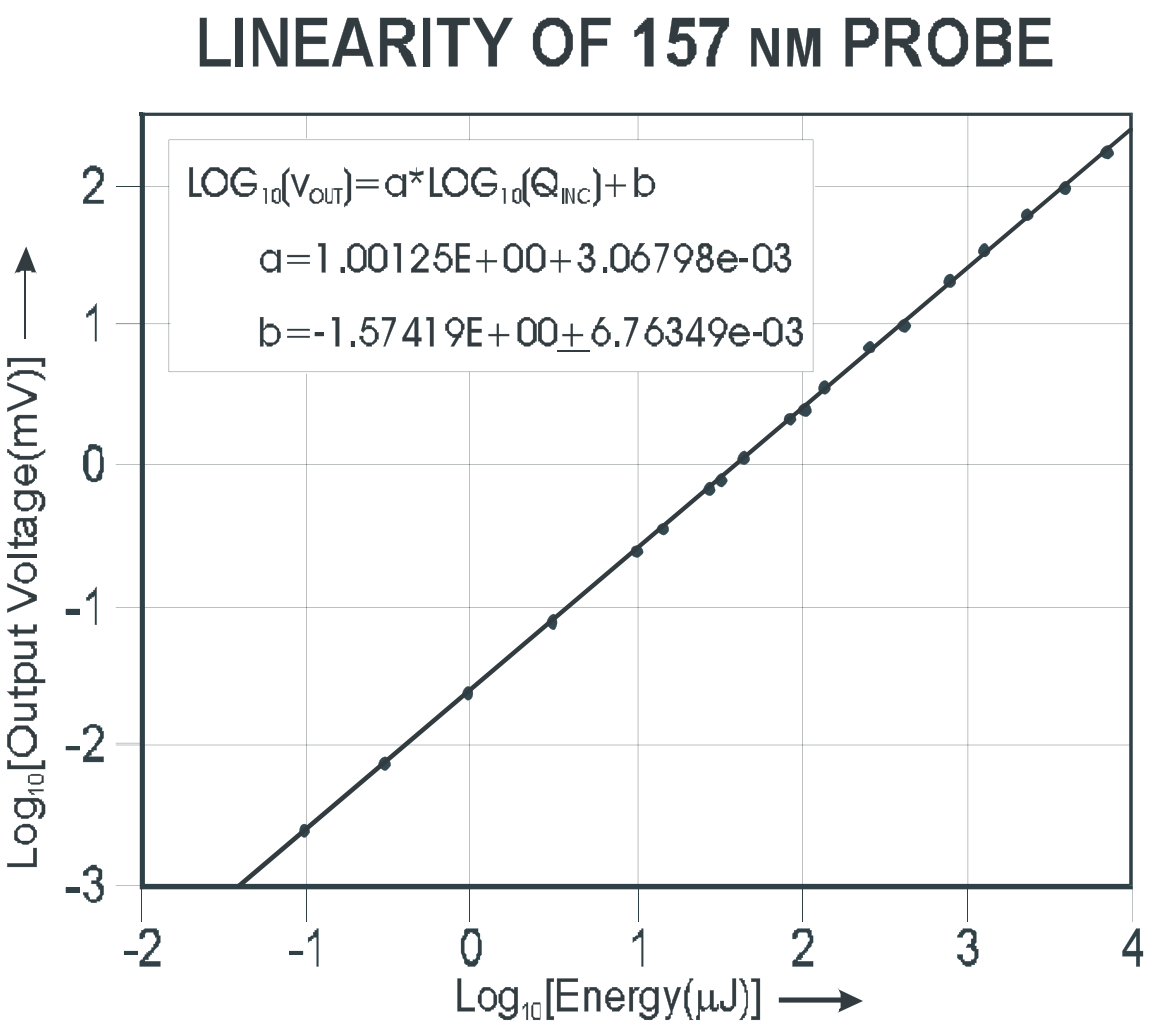


Figure 12. Input/output linearity of the "C" type crystal at 157 nm is over 5 ½ orders of magnitude

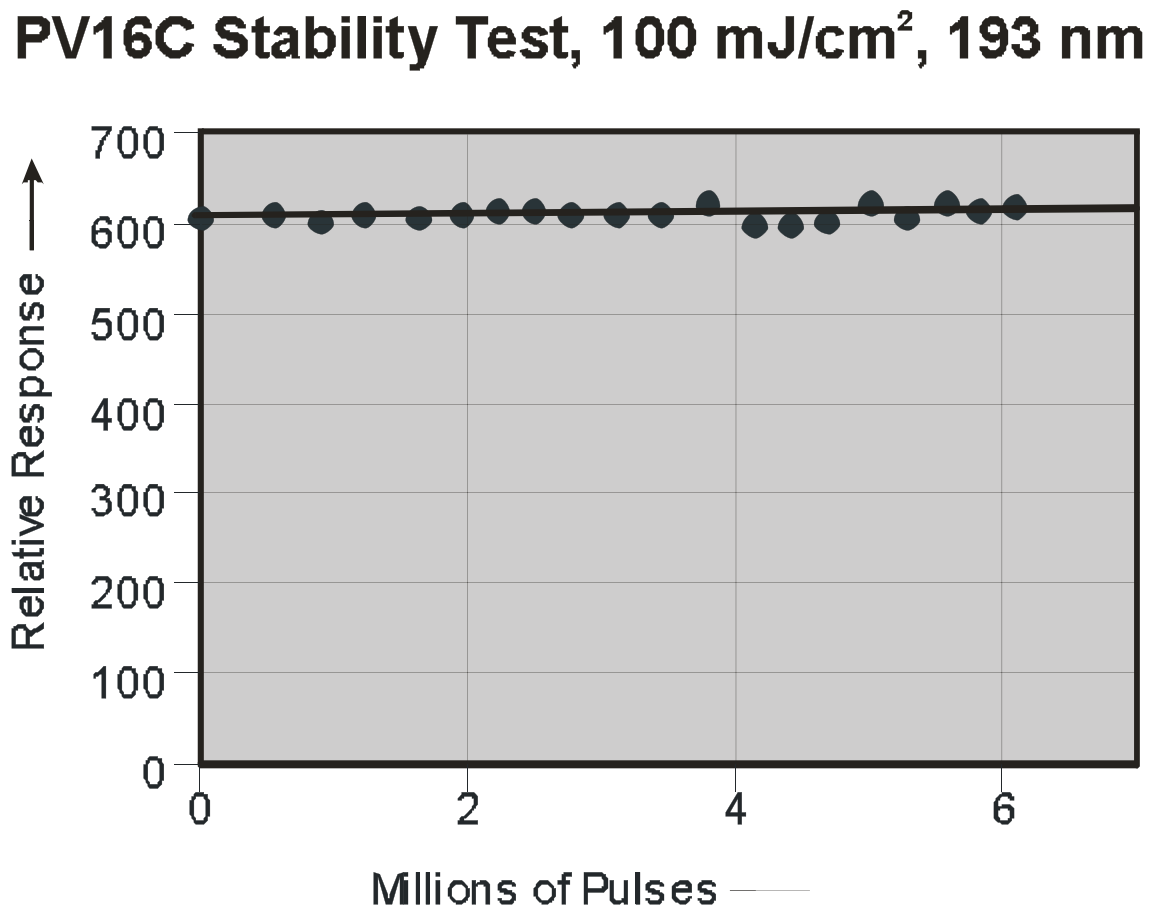


Figure 10. The “C” type crystal shows little change after millions of pulses at 193 nm.

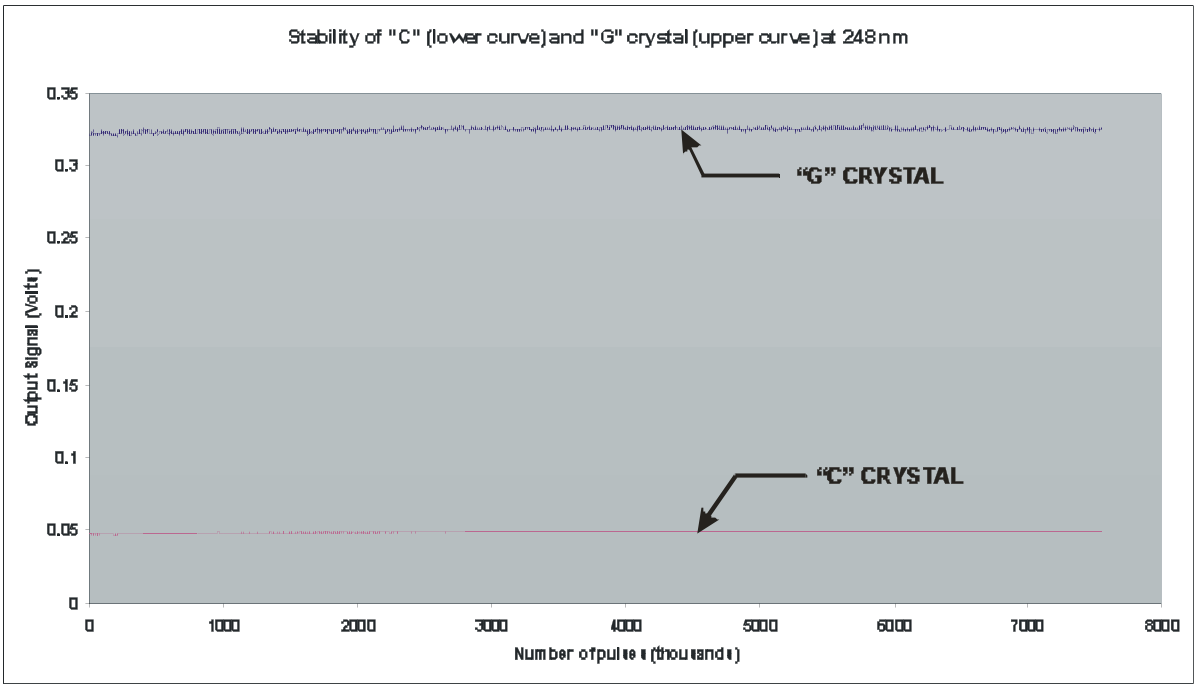


Figure 11. The response of the “C” and “G” crystals is virtually unchanged after nearly 8 million pulses at 248 nm.

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.

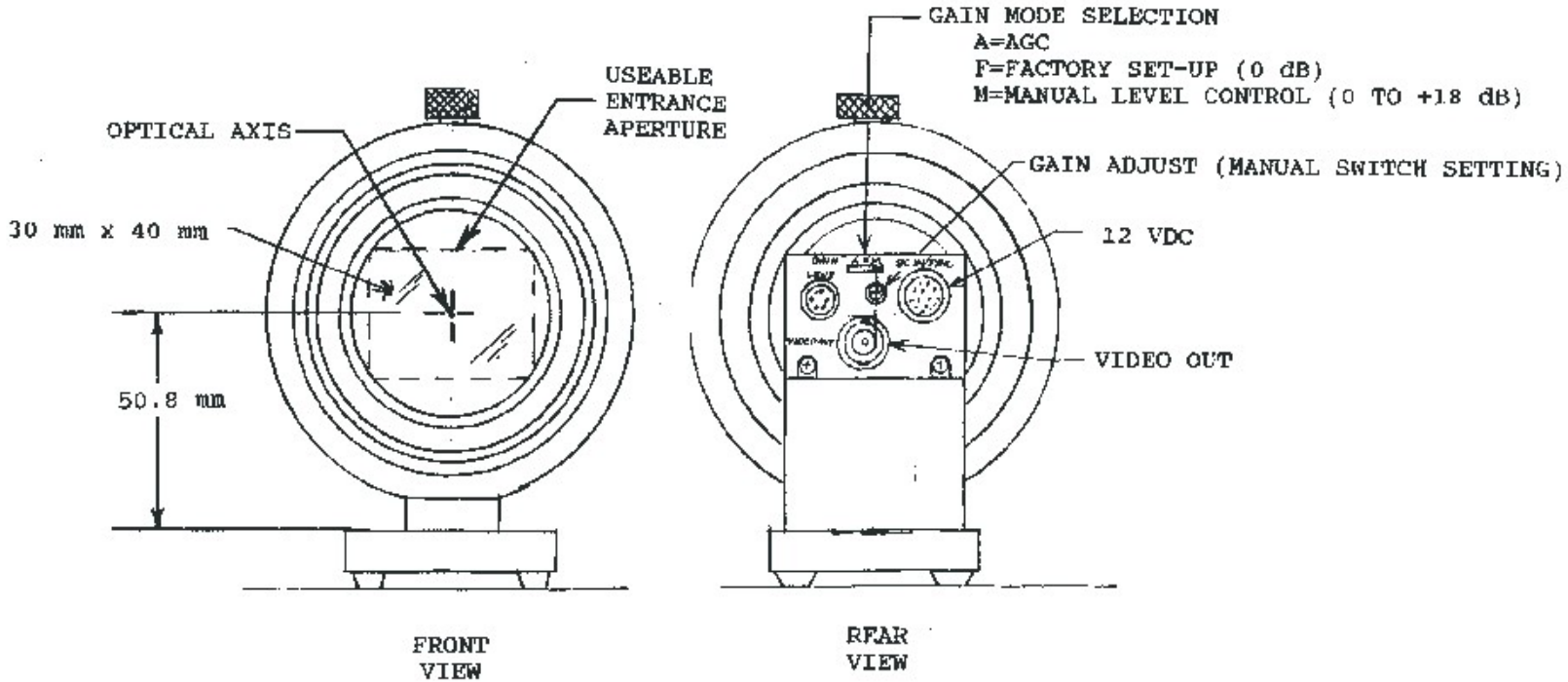


Figure 14. Front and rear views of the model BSZ50 beam profiler.

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