Beam Diagnostics Accessories

- *Laser-Grade Attenuation Optics*
- *Small spot, fiber and diode images*
- *Extreme-UV Beam Intensity Profiler Optics*
- *Compatible with BeamView™ Analyzer Laser Beam Diagnostic Cameras*

Laser-Grade Attenuation Optics for Cameras

- *Virtually undistorted and interference-free attenuation*
- *Variable and fixed high-power attenuation for beams up to 2000W/cm² or 50J/cm²*
- *C-Mount threads couple directly to cameras*

Most cameras are too sensitive for direct viewing of laser beams. For example, a typical diagnostics camera saturates at only ~0.5 µW/cm² power density (at ~633 nm) or ~9 nJ/cm² (at 1060 nm) pulsed energy density. If the camera has an electronic shutter, it can be used for some CW beam attenuation, but there is more flexibility in using optical attenuation (see the Optical Dynamic Range section on page 66). Any attenuation optics introduced in the beam path must be manufactured to exacting specifications. The optics must be laser-grade substrate, and to avoid etaloning and fringing, the proper flatness and wedge must be used, so the beam is not distorted by the introduction of the attenuation. We offer attenuation optics that are designed to these specifications and packaged for use with our cameras. Typical attenuations are 1:1 to 400,000:1, but even larger attenuations are possible. All standard CCD cameras accept C-Mount optics and accessories and are delivered without a standard window in front of the sensor array. Such windows are liable to distort the optical beam. However, a "LDFP" (Low-Distortion Face Plate) filter is supplied with each camera purchased from Coherent. The LDFP is a laser-grade ND filter glass (attenuation of ~2,500:1 at 633 nm) specified and polished for diagnostics use. It is mounted in a C-Mount thread and provides sufficient attenuation of room light so that the camera can be used with the lights on. For operation below 400 nm, the LDFP must be removed. For more details, see the Beam Diagnostic Cameras and BeamView Analyzer sections on pages 60 and 65.

The BeamCube Fixed-Attenuator Modules (BCUBE and UV-BCUBE) provide fixed attenuation and beam pickoff for performing diagnostics on high-power laser sources. The BCUBE and UV-BCUBE utilize the front surface reflection from an uncoated laser mirror to achieve beam samples at 2-10% of the incident radiation, depending upon beam polarization. Multiple BCUBEs can be coupled together for even higher fixed attenuation levels.

The Variable Attenuator Module (VARM) is a triple-wheel filter holder that contains three filters per wheel. The filters are made to our exacting specifications for transmission value and material quality. The VARM is adjustable in attenuation in 64 discrete steps of approximately 16% reduction each time from 400,000:1 down to 1:1. The VARM can be easily returned to exactly the same attenuation level as previously used.

The Continuously Variable Attenuator Modules (C-VARM and UV C-VARM) contain two wedge attenuators that are continuously variable and a step attenuator that will allow attenuation from 10^7:1 down to 3,000:1. The C-VARM and UV C-VARM can be finely adjusted to achieve both precise attenuation levels and maximum use of the camera's optical dynamic range.

Beam Diagnostics Accessories

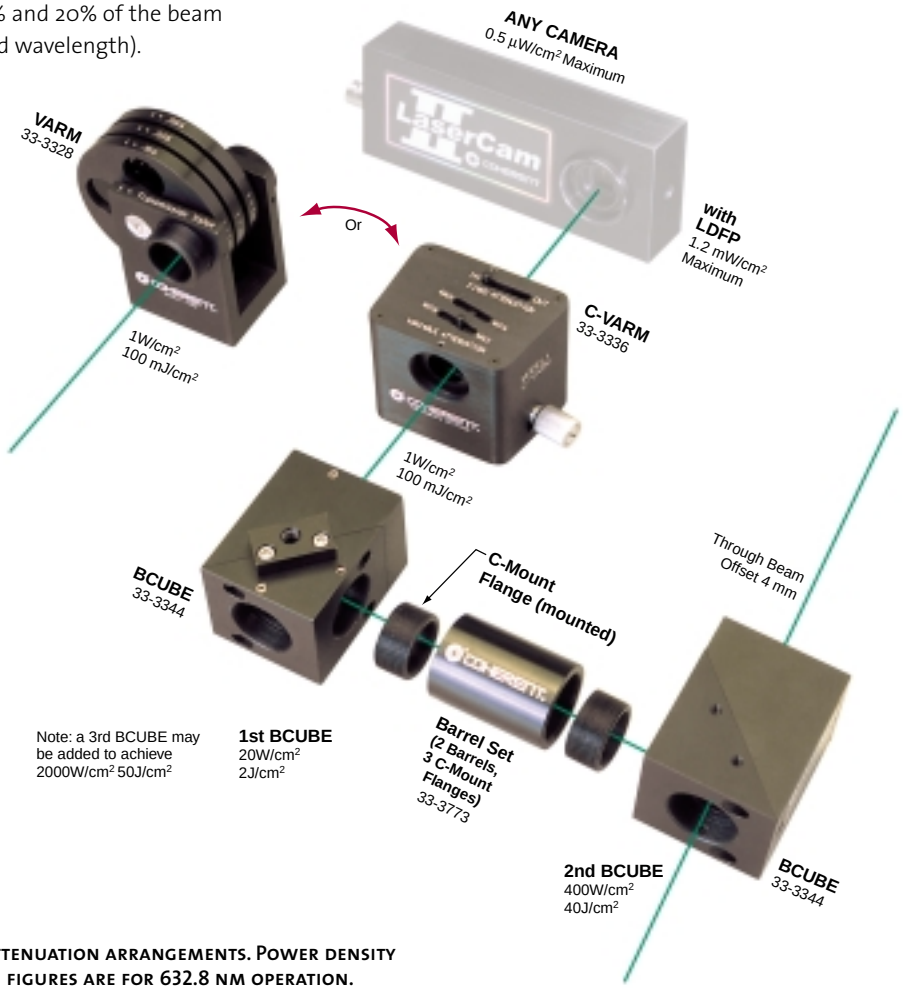
BCUBE, UV-BCUBE, VARM, C-VARM, UV C-VARM and all other cameras have female C-Mount threading, making them easy to connect with the male C-Mount connection flange provided with each attenuator. Also, all attenuators have 1/4-20 tapped holes for independent post or plate mounting. In addition, a set of three flanges and two extension barrels are available as catalog number 33-3773.

The C-Mount flanges also have a female RMS microscope thread. This allows a microscope objective to be coupled to the attenuators and extension barrels in order to to create a flexible close-up imaging system for analysis of small/focused beams, fiber optics, laser diodes or LEDs.

Attenuator Selection

Attenuation selection for cameras is an easy process. Attenuation is selected on the basis of power density in W/cm^2 or energy density in J/cm^2. The attenuation from the camera's LDFP will allow an average power density of up to 1.2 mW/cm^2. After that, there are only two more steps to attenuation selection:

1. Choose either the VARM or the C-VARM for up to 1W/cm^2.
2. In addition or alternatively, use a BCUBE beamsplitter module to pick off between 5% and 20% of the beam (depending on polarization and wavelength).



Possible CCD camera optical attenuation arrangements. Power density and energy density saturation figures are for 632.8 nm operation.

Beam Diagnostics Accessories

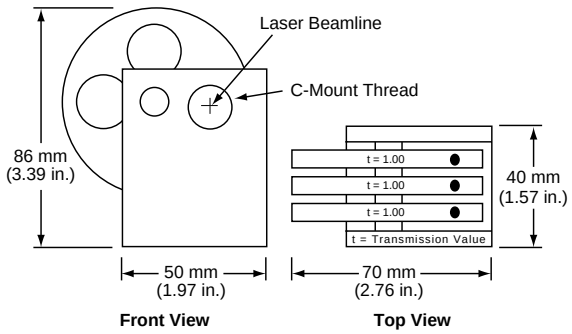
Avoiding Multi-filter Beam Distortion

The wavefront distortion through a number of optical filters can be calculated by taking the square root of the sum of the squares of the wavefront distortion of the individual components. For example, if the individual optics are made to λ/10 specifications and we use six of them, a total λ/4 RMS wavefront distortion will be introduced to the beam:

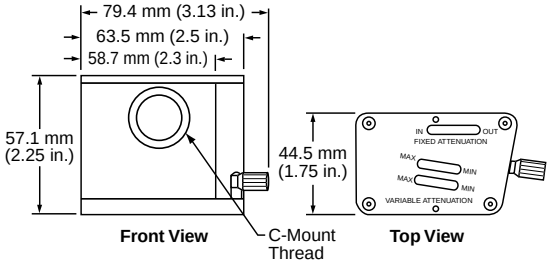
$$\sqrt{0.1^2 + 0.1^2 + 0.1^2 + 0.1^2 + 0.1^2 + 0.1^2} = 0.25$$

In general, a camera cannot sense less than ~λ/4 total distortion in the beam, so if a series of filters is used, they must be made to very exacting laser-grade specifications. Coherent attenuating optics are manufactured to better than a λ/10 surface specification, so at least six optics in series can be used. Calculate the Low-Distortion Face Plate (LDFP) and each BCUBE as one optic, and the VARM or C-VARM as three optics each.

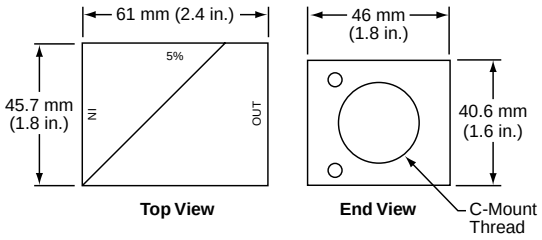
VARM



C-VARM AND UV-VARM



BCUBE AND UV-BCUBE



Attenuation Optics for Cameras

Part Number	Description	Wavelength		Attenuation		Aperture (mm)	Max. Power Density (W/cm^2)	Max. Energy Density (J/cm^2)	Damage Limit		Beam Offset (mm)
		Min. (nm)	Max. (nm)	From	To				(W/cm^2)	(J/cm^2)	
33-3328-000	VARM (Variable Attenuator)	380	2200	4×10^5:1	1:1	19	1*	0.1*	5×10^7	10	–
33-3336-000	C-VARM (Continuously Variable Attenuator)	380	2200	10^7:1	3000:1	17	1*	0.1*	5×10^7	10	–
33-6859-000	UV C-VARM (Continuously Variable Attenuator)	190	1100	1×10^5:1	300:1	17	1*	0.008	–	0.008	–
33-3344-000	BCUBE (BeamCube Fixed Attenuator)	380	2200	50:1	10:1	19	2.0×10^9	50	2.5×10^9	50	4.0
33-3351-000	UV-BCUBE (UV BeamCube Fixed Attenuator)	190	2200	50:1	10:1	19	2.0×10^9	50	2.5×10^9	50	4.0
33-3773-000	Barrel set (2 Barrels, 3 C-Mount Flanges)	–	–	–	–	–	–	–	–	–	–

* The Maximum Power and Energy Density listed are the levels at which thermal lensing occurs.