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Y-Z Positioners for lens, pinholes and objectives ***990-0050, 990-0051***
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Precision Pinholes
online

Microscope Objectives
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Unmounted Iris Diaphragms
online

Mounted Iris Diaphragms
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Mounts for iris diaphragms
online

Motorized Iris Diaphragms ***995 Series***
online

Motorized Iris Diaphragms ***996 Series***
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Motorized Iris Diaphragms ***997 Series***
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Variable Wheel Attenuator ***990-0604***
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Closed Variable Wheel Attenuator ***990-0704***
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Motorized Variable Two Wheels Attenuators ***991-0602***
online

Motorized Closed Variable Two Wheels Attenuators ***991-0702***
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Air-cooled Beam Dump ***990-0800***
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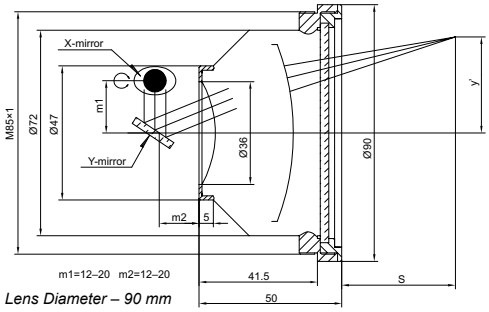
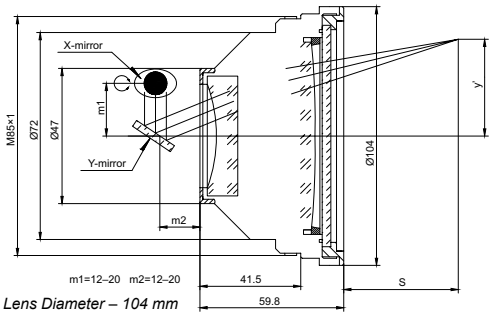
F-THETA LENS

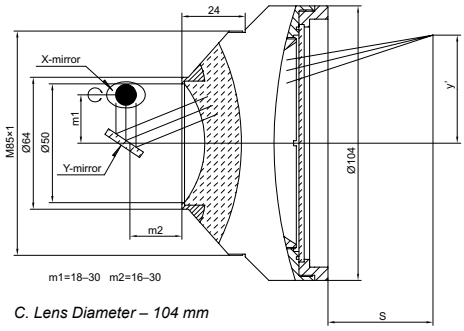
F-Theta lenses are designed to provide a flat field on the image plane for scanning and engraving applications where a high power laser and a set of rotating mirrors are used to scan across a given field.



A. Lens Diameter – 90 mm



B. Lens Diameter – 104 mm



C. Lens Diameter – 104 mm

Best mirror places m1/m2 – 16/16 mm, screw size – M85×1

Wavelength – 1064 nm, Lens Diameter – 90 mm

Catalogue number	Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Price, EUR
150-1001	100	115	70×70	±28°	12	16	A	420
150-1601	160	176	110×110	±28°	12	26	A	420
150-2101	210	230	145×145	±28°	12	34	A	420
150-2541	254	284	175×175	±28°	16	31	A	420
150-2901	290	324	200×200	±28°	16	31	A	420
150-3301	330	346	220×220	±28°	16	40	A	420
150-4201	420	467	300×300	±28°	16	50	A	420

Wavelength – 532 nm, Lens Diameter – 90 mm

Catalogue number	Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Price, EUR
150-1002	100	115	70×70	±28°	12	10	A	460
150-1602	160	186	110×110	±28°	12	16	A	460

Wavelength – 355 nm

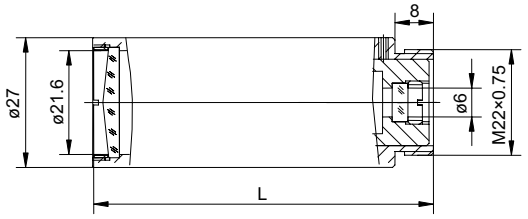
Catalogue number	Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Price, EUR
150-1003	100	136	70×70	±28°	7	10	A	930
150-1603	160	199	110×110	±28°	7	15	B	930

Best mirror places m1/m2 – 24/24 mm, screw size – M85×1

Wavelength – 1064 nm, Lens Diameter – 104 mm

Catalogue number	Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Price, EUR
151-1631	163	185	110×110	±28°	20	17	C	520
151-2101	210	255	150×150	±28°	20	24	C	520
151-2541	254	285	175×175	±28°	20	31	C	520
151-4201	420	467	300×300	±28°	20	55	C	520
151-6501	650	697	400×400	±25°	20	85	C	520

COMPACT BEAM EXPANDER



A laser beam expander is designed to increase the diameter of a collimated input beam to a larger collimated output beam. EKSMA OPTICS offers compact Galilean type beam expanders for 1064 nm, 532 nm and 355 nm wavelengths. Compact beam expander has the possibility to be adjusted for the input beam divergence angle to obtain collimated, divergent or focused beam at the output.

SPECIFICATIONS

Lens material	AR coated Fused Silica Lenses
Screw Size	M22×0.75

RELATED PRODUCT

Large Rod Small Mounting Clamp (aluminium) 810-0062A

See page 7.12

Catalogue number	Wavelength, nm	Expansion ratio	Beam expander size L, mm	Transmission, %	Price, EUR
160-0021	1064	2X	51	>96	235
160-0251	1064	2.5X	51	>96	235
160-0031	1064	3X	68	>96	235
160-0041	1064	4X	75	>96	235
160-0051	1064	5X	73	>96	235
160-0061	1064	6X	75	>96	235
160-0081	1064	8X	77	>96	235
160-0101	1064	10X	70	>96	235
160-0022	532	2X	51	>96	235
160-0252	532	2.5X	51	>96	235
160-0032	532	3X	68	>96	235
160-0042	532	4X	75	>96	235
160-0052	532	5X	73	>96	235
160-0062	532	6X	75	>96	235
160-0082	532	8X	77	>96	235
160-0102	532	10X	70	>96	235
160-0043	355	4X	75	>96	250
160-0063	355	6X	75	>96	250
160-0083	355	8X	68	>96	250
160-0103	355	10X	71	>96	250

Compact beam expanders of other expansion ratio are available upon request.

ZOOM BEAM EXPANDER

Compact Galilean type zoom beam expanders are designed for Nd:YAG fundamental and harmonic wavelengths: 1064 nm, 532 nm and 355 nm. Zoom beam expanders provide 1X – 8X or 2X – 8X continuous magnification with adjustable focus to correct for laser beam divergence.

Catalogue number	Wavelength, nm	Expantion ratio	Input Clear Aperture, mm	Output Clear Aperture, mm	Length, mm	Price, EUR
165-1181	1064	1x-8x	12	33	162	860
165-1281	1064	2x-8x	12	33	143.3	860
165-1185	532	1x-8x	12	33	162	860
165-1285	532	2x-8x	12	33	139.9	860
165-1183	355	1x-8x	12	33	162	1120
165-1283	355	2x-8x	12	33	158.5	860

- **Adjustable 1X – 8X or 2X – 8X expansion ratio**
- **Adjustable divergence**
- **Galilean design**

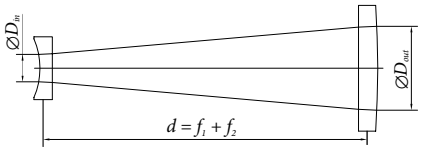
Visit our e-shop
www.eksmaoptics.com
and find the drawings of all zoom beam expanders

RELATED PRODUCT

Universal Adjustable Optics Mount 830-0035

See page 7.28

SIMPLE TELESCOPE KIT



Simple lenses are subject to optical aberrations. In many cases these aberrations can be compensated to a great extent by using a combination of simple lenses with complementary aberrations. A compound lens is a collection of simple lenses of different shapes and made of materials of different refractive indexes, arranged one after the other with a common axis.

If two thin lenses are separated in air by some distance d (where d is smaller than the focal length of the first lens), the focal length for the combined system is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 \cdot f_2}$$

The distance from the second lens to the focal point of the combined lenses is called the back focal length (BFL).

$$BFL = \frac{f_2 \cdot (d - f_1)}{d - (f_1 + f_2)}$$

If the separation distance is equal to the sum of the focal lengths ($d = f_1 + f_2$), the combined focal length and BFL are infinite. This corresponds to a pair of lenses that transform a parallel (collimated) beam into another collimated beam. This type of system is called an afocal system, since it produces no net convergence or divergence of the beam. Two lenses at this separation form the simplest type of optical telescope. Although the system does not alter the divergence of a collimated beam, it does alter the width of the beam. The magnification of such a telescope is given by

$$M = -\frac{f_2}{f_1} = \frac{D_{out}}{D_{in}} \quad \frac{(exit\ diameter)}{(input\ diameter)}$$

which is the ratio of the input beam width to the output beam width. Note the sign convention: a telescope with two convex lenses ($f_1 > 0, f_2 > 0$) produces a negative magnification, indicating an inverted image. A concave plus a convex lens ($f_1 < 0 < f_2$) produces a positive magnification and the image is upright.

Code	Material	Coating	Price, EUR
140-0008	BK7	Uncoated	771
141-0008	BK7	1064 nm, R<0.2%	1075
142-0008	BK7	532 nm + 1064 nm, R<0.5%	1110
147-0008	BK7	400-700 nm, R<0.9%	1260
140-1008	UV FS	Uncoated	1170
144-1008	UV FS	266 nm, R<0.4%	1470
146-1008	UV FS	210-400 nm, R<1.5%	1680
143-1008	UV FS	355 nm, R<0.25%	1465
141-1008	UV FS	532 nm + 1064 nm, R<0.5%	1485
145-1008	UV FS	350-900 nm, R<1.5%	1685
148-1008	UV FS	650-950 nm, R<1%	1645

Any other antireflection coating wavelength region is available on request.

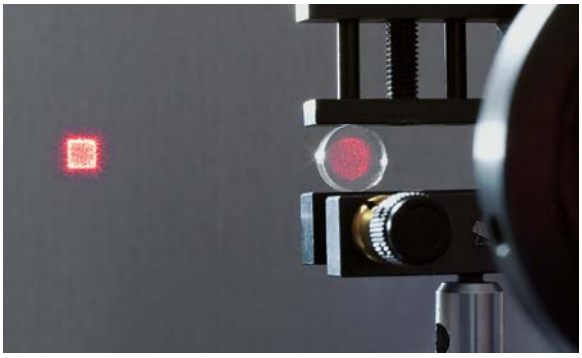
Each kit includes 8 lenses, aluminium optical rail 810-0005-02, two aluminium rail carriers 810-0007-06, self centering lens mounts 830-0010 and 830-0020, two rod holders 820-0050-02 and two rods 820-0010-02. Net weight – 1.4 kg.

Simple Telescope Kit

Material: BK7		Material: UV FS		Focal length f_1, mm	Focal length f_2, mm	Distance between lenses $d=f_1+f_2$, mm *	Magnification, M
Lens 1	Lens 2	Lens 1	Lens 2				
BK7 bi/cv Ø12.7 mm 114-0104	BK7 pl/cx Ø50.8 mm	UV FS bi/cv Ø12.7 mm 114-1104	UV FS pl/cx Ø50.8 mm	-12.7			
	110-0502		110-1505		+75	62	5.9
	110-0505		110-1509		+100	87	7.7
	110-0507		110-1511		+150	137	11.8
	110-0509		110-1515		+200	187	15.7
	110-0511		110-1517		+250	237	19.7
BK7 bi/cv Ø25.4 mm 114-0204	BK7 pl/cx Ø50.8 mm	UV FS bi/cv Ø25.4 mm 114-1204	UV FS pl/cx Ø50.8 mm	-25			
	110-0502		110-1505		+75	50	3
	110-0505		110-1509		+100	75	4
	110-0507		110-1511		+150	125	6
	110-0509		110-1515		+200	175	8
	110-0511		110-1517		+250	225	10
BK7 pl/cv Ø25.4 mm 112-0209	BK7 pl/cx Ø50.8 mm	UV FS pl/cv Ø25.4 mm 112-1205	UV FS pl/cx Ø50.8 mm	-50			
	110-0502		110-1505		+75	25	1.5
	110-0505		110-1509		+100	50	2
	110-0507		110-1511		+150	100	3
	110-0509		110-1515		+200	150	4
	110-0511		110-1517		+250	200	5

* Note that distance between lenses d is the distance between focal planes of the lenses and is given theoretically (the thickness of lenses is not included into calculation). It also depends on wavelength. The distance should be adjusted ±10 mm in each particular case.

GAUSS-TO-TOP HAT BEAM SHAPING LENS



Gauss-to-Top Hat Beam Shaping Lens is a lens of a special form, used to distribute energy of Gaussian beam to Top Hat profile.

GTH beam shapers operate within a large wavelength range from VIS to NIR.

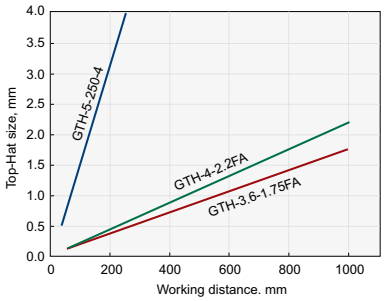
Top Hat beam shapers GTH-4-2.2 and GTH-3.6-1.75 work together with nearly any focusing optic. Top Hat profile is generated in the focal plane of this focusing optic. By varying the focal length it is possible to scale Top Hat size and working distance.

GTH-5-250-4 is an exception to the other beam shapers because a focal length of 250 mm is integrated. However, Top Hat size can also be scaled by using additional lenses.

- **Square Top Hat beam profile**
- **Efficiency >95 %**
- **Top Hat width from 50 µm to several cm**

LENS SPECIFICATIONS

Material	LF5 Schott glass n = 1.5659 @ 1060 nm, n = 1.5848 @ 546 nm, n = 1.6192 @ 365 nm
Clear aperture	Ø11.0 mm
Damage threshold (uncoated)	>3 J/cm² @ 532 nm, 10 ns
Mounting	Mounted into 1" ring holder



Top Hat width in relation to the working distance

GTH-5-250-4 GAUSS-TO-TOP-HAT BEAM SHAPING LENS

Square top hat size and corresponding working distance can be changed by placing an extra lens or objective behind beam shaping lens GTH-5-250-4.

Dependence of square size and working distance vs focal length of additional lens or objective:

Focal length, mm	**Top hat square size,** mm	**Working distance,** mm
+50	0.67 x 0.67	42
+100	1.1 x 1.1	71
+200	1.8 x 1.8	111
+300	2.2 x 2.2	136
-1000	5.3 x 5.3	333
-500	8.0 x 8.0	500

GTH-5-250-4 OPERATION SPECIFICATIONS

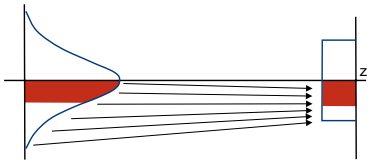
Recommended operation wavelength range	400-1500 nm
Input beam	TEM_{00}, diameter (1/e²): 5.0 ± 0.15 mm
Output beam	Top hat size at 250 mm working distance: 4 × 4 mm² (adjustable with additional lens)
Working distance	250 mm (adjustable with additional lens)
Beam energy distribution efficiency	> 95% of input energy within Top Hat profile
Beam homogenity	± 5 % (rel. to average intensity within top hat)
Lens diameter	12.0 +0.0/-0.1 mm
Thickness	4.0 ± 0.1 mm

Catalogue number	**Description**	**Price,** EUR
GTH-5-250-4	uncoated lens	565
GTH-5-250-4-VIS	VIS coated lens (400-700 nm (R<1% per face))	620
GTH-5-250-4-IR	IR coated lens (700-1300 nm (R<1% per face))	620

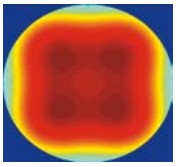
Other specific laser wavelengths are available on request.

GTH-5-250-4 OPERATION INSTRUCTIONS

Principles of Beam Shaper Operation and Lens Shape

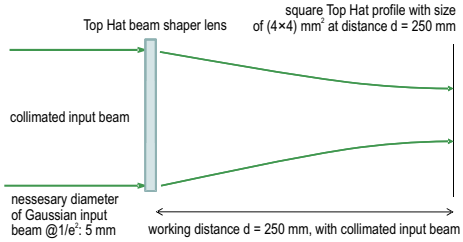


Energy of Gaussian input beam is re-distributed to a Top Hat beam profile by beam shaper lens (mapping).



Surface contour plot of beam shaper lens (free form optic).

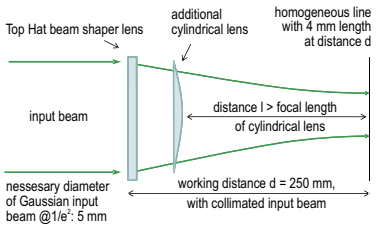
Optical Setup for Gauss-toTop Hat Beam Shaper Lens



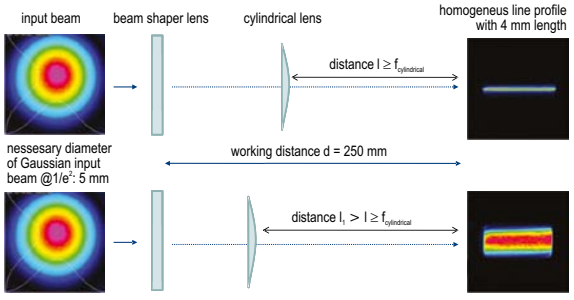
If a collimated Gaussian beam is used the Top Hat beam shaper lens delivers at the working distance d = 250 mm a square Top Hat beam profile with the size of (4×4) mm².

The Top Hat beam shaper lens works also for divergent and convergent Gaussian beams. Important: One has to consider that input beam diameter at beam shaper lens plane must be 5 mm @ 1/e². For divergent (or convergent) beams the size of Top Hat and working distance increase (or decrease).

Homogeneous Line Generation with Top Hat Beam Shapper Lens and Additional Cylindrical Lens

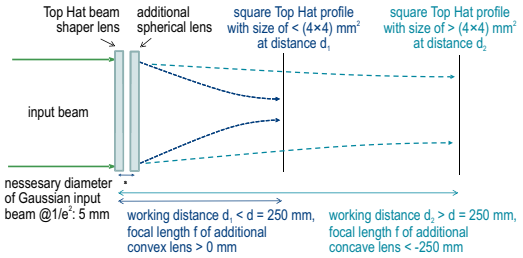


By introducing an additional cylindrical lens behind the Top Hat beam shaper lens (thereby one has to consider that the distance l between cylindrical lens and working plane must be bigger or same as focal length of cylindrical lens) it is possible to generate a line profile at working plane. Along the long axis the intensity profile is homogeneous. Along short axis, which is focused by cylindrical lens, the profile is near Gaussian.



By varying the distance l the width of line profile (short axis) can be changed from near diffraction limited size to several millimiters.

Adjustment of Square Top Hat Size by Additional Spherical Lens



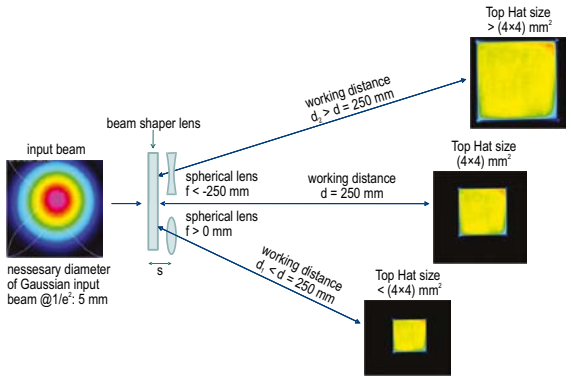
The working distance and the size of the Top Hat profile can be changed (same ratio) by an additional spherical lens. For a convex lens the size of the Top Hat profile and the working distance becomes smaller. For a concave lens the size of the Top Hat profile and the working distance becomes bigger.

The new working distance and the size of the Top Hat profile can be calculated:

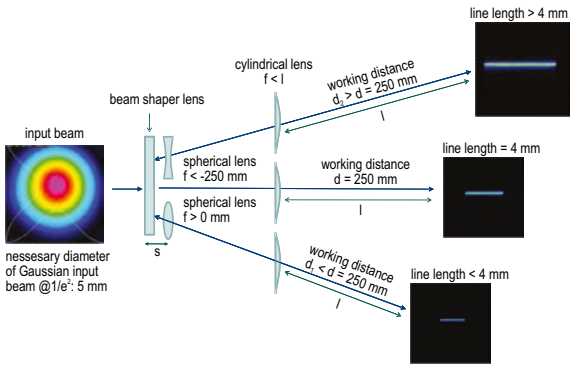
$$\text{Working distance} = \frac{250\,mm \cdot f}{250\,mm + f}$$

for focal length f>0 mm (additional convex lens) respectively focal length f<-250 mm (additional concave lens); s->0

$$\text{Square Top Hat Size} = \left(\frac{4mm \cdot \text{working distance}}{250\,mm}\right)^2 = \left(\frac{4mm \cdot f}{250\,mm + f}\right)^2$$



Adjustment of Length of Homogeneous Line by Additional Spherical Lens



GTH-4-2.2FA GAUSS-TO-TOP-HAT BEAM SHAPING LENS

Working distance of this lens is given by the focal length of an additional lens, which is always needed.

For instance if an additional lens f = 100 mm is used, Top Hat appears at 100 mm behind additional lens. So GTH-4-2.2FA could be easily put in front of objectives for example.

The distance between GTH-4-2.2FA and additional lens is not critical (up to several tens of centimeters).

The full fan angle of Top-Hat generation for GTH-4-2.2FA is 2.2 mrad. This leads to Top-Hat sizes:

Focal length, mm	**Top hat square size,** mm	**Working distance,** mm
+50	0.11 x 0.11	50
+100	0.22 x 0.22	100
+1000	2.2 x 2.2	1000
+2000	4.4 x 4.4	2000

GTH-4-2.2FA OPERATION SPECIFICATIONS

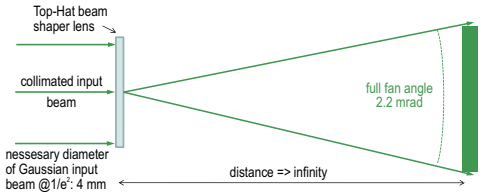
Recommended operation wavelength range	400-1550 nm
Input beam	TEM_{00}, diameter (1/e²): 4.0 ± 0.15 mm
Achievable Top Hat size	6x diffraction limited @ 1064 nm, 12x diffraction limited @ 532 nm
Full fan angle of Top-Hat generation	2.2 mrad
Beam energy distribution efficiency	> 95% of input energy within Top Hat profile
Beam homogenity	± 5 % (rel. to average intensity within Top Hat)
Lens diameter	12.0 +0.0/-0.1 mm
Lens thickness	4.0 ± 0.1 mm

Catalogue number	**Description**	**Price,** EUR
GTH-4-2.2FA	uncoated lens	565
GTH-4-2.2FA-VIS	VIS coated lens (400-700 nm (R<1% per face))	620
GTH-4-2.2FA-IR	IR coated lens (700-1300 nm (R<1% per face))	620

Other specific laser wavelengths are available on request.

GTH-4-2.2FA OPERATION INSTRUCTIONS

General function of Top-Hat beam shaper GTH-4-2.2FA



The Top-Hat beam shaper GTH-4-2.2FA is generating a square Top-Hat profile with a full fan angle of 2.2 mrad. To get best results it is necessary to use a Gaussian TEM_{00} input beam with a diameter of 4 mm @ 1/e².

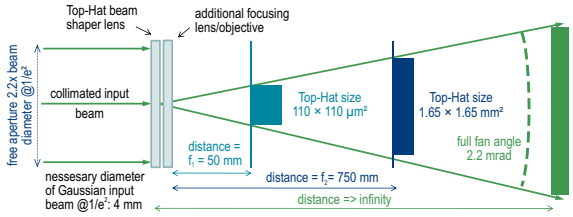
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ 1/e².

Optical setup for Top-Hat beam shaper GTH-4-2.2FA

There are different possibilities to integrate the GTH-4-2.2 beam shaper into an optical setup.

1. Beam shaper directly in front of focusing optic/objective (Top Hat size >100 µm).

Top Hat size is determined by focal length (f) of focusing optic/objective and can be calculated as follows: $\frac{2.2}{1000} \cdot f$



By introducing the GTH-4-2.2FA into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a square homogeneous Top-Hat profile.

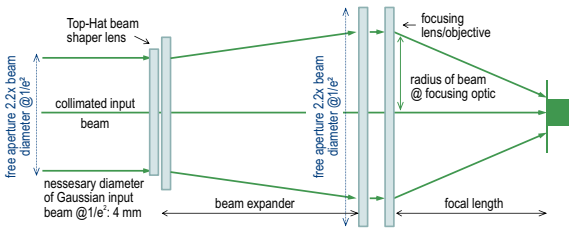
The necessary beam diameter at the position of GTH-4-2.2FA is 4 mm @ 1/e².

The resulting Top-Hat size is given by: $\frac{2.2}{1000} \cdot$ focal length, for example with f = 50 mm => 110 µm.

2. Beam shaper in front of beam expander (Top Hat size <100 µm)

Top Hat size is determined by numerical aperture (NA) of focused beam and can be calculated as follows:

$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx$ 6x diffraction limited @ 1064 nm (12x @ 532 nm)



To achieve Top Hat sizes smaller than 100 µm it's recommended to introduce the GTH-4-2.2FA into the beam path in front of a beam expander. Initially the necessary input beam diameter of 4 mm @ 1/e² is passing the GTH. Afterwards the beam is expanded and focused on working plane. The initial diffraction limited Gaussian spot at focal plane will be transformed into a square homogeneous Top-Hat profile. The resulting Top-Hat size is given by:

$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx$ 6x diffraction limited @ 1064 nm (12x @ 532 nm)

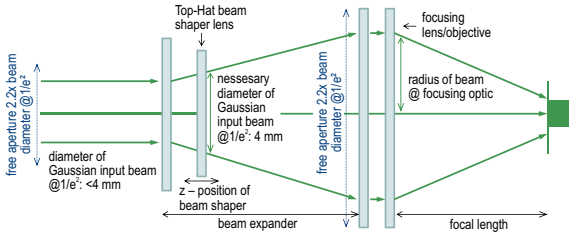
NA represents the numerical aperture of focused beam and is given by:

$$NA = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$$

3. Beam shaper within beam expander (Top Hat size <100 µm)

Top Hat size is determined by numerical aperture (NA) of focused beam and can be calculated as follows:

$$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx \text{6x diffraction limited @ 1064 nm (12x @ 532 nm)}$$



A further and even more flexible possibility is to introduce GTH-4-2.2FA into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of GTH-4-2.2FA by shifting shaper along z-axis. It's just necessary to consider that the beam diameter at the position of GTH is 4 mm @ 1/e². The resulting Top-Hat size is given by:

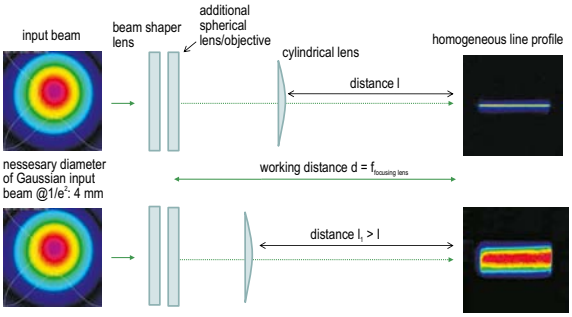
$$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx \text{6x diffraction limited @ 1064 nm (12x @ 532 nm)}$$

NA represents the numerical aperture of focused beam and is given by:

$$NA = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$$

Homogeneous line generation with additional cylindrical lens

Line thickness fixed, near diffraction limited.



If an additional cylindrical lens is used, one can generate homogeneous line profiles. By varying the distance l the width of line profile (short axis) can be changed from near diffraction limited size to several millimeters. We recommend the use of a cylindrical lens with a focal length of f = 2.25 m.

GTH-3.6-1.75FA GAUSS-TO-TOP-HAT BEAM SHAPING LENS

Working distance of this lens is given by the focal length of an additional lens, which is always needed.

For instance if an additional lens f = 100 mm is used, Top Hat appears at 100 mm behind additional lens. So GTH-3.6-1.75FA could be easily put in front of objectives for example.

The distance between GTH-3.6-1.75FA and additional lens is not critical (up to several tens of centimeters).

The full fan angle of Top-Hat generation for GTH-3.6-1.75FA is 1.75 mrad. This leads to Top-Hat sizes:

Focal length, mm	**Top hat square size,** mm	**Working distance,** mm
+50	0.088 x 0.088	50
+100	0.175 x 0.175	100
+1000	1.75 x 1.75	1000

GTH-3.6-1.75FA OPERATION SPECIFICATIONS

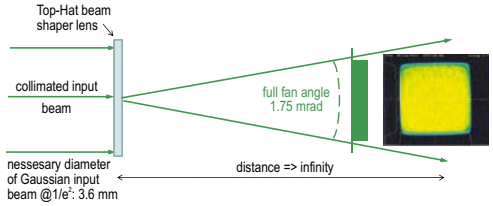
Recommended operation wavelength range	400-1550 nm
Necessary free aperture	always 2.2x beam diameter @ 1/e², along total beam path
Input beam	TEM_{00}, diameter (1/e²): 3.6 ± 0.15 mm
Achievable Top Hat size @ 1/e²	5x diffraction limited @ 1064 nm, 10x diffraction limited @ 532 nm
Full fan angle of Top-Hat generation	1.75 mrad
Beam energy distribution efficiency	> 95% of input energy within Top Hat profile
Beam homogenity	± 5 % (rel. to average intensity within Top Hat)
Lens diameter	12.0 +0.0/-0.1 mm
Lens thickness	2.0 ± 0.1 mm

Catalogue number	**Description**	**Price,** EUR
GTH-3.6-1.75FA	uncoated lens	565
GTH-3.6-1.75FA-VIS	VIS coated lens (400-700 nm (R<1% per face))	620
GTH-3.6-1.75FA-IR	IR coated lens (700-1300 nm (R<1% per face))	620

Other specific laser wavelengths are available on request.

GTH-3.6-1.75FA OPERATION INSTRUCTIONS

General function of Top-Hat beam shaper GTH-3.6-1.75FA



The Top-Hat beam shaper GTH-3.6-1.75FA is generating a square Top-Hat profile with a full fan angle of 1.75 mrad. To get the best results it is necessary to use a Gaussian TEM_{00} input beam with a diameter of 3.6 mm @ 1/e².

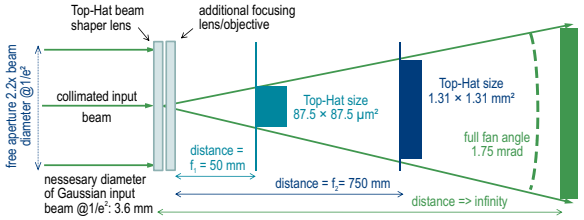
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ 1/e².

Optical setup for Top-Hat beam shaper GTH-3.6-1.75FA

There are different possibilities to integrate the GTH-3.6-1.75FA beam shaper into an optical setup.

1. Beam shaper directly in front of focusing optic/objective (Top Hat size @ 1/e² > 90 µm).

Top Hat size is determined by focal length (f) of focusing optic/objective and can be calculated as follows: $\frac{1.75}{1000} \cdot f$



By introducing the GTH-3.6-1.75FA into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a square homogeneous Top-Hat profile.

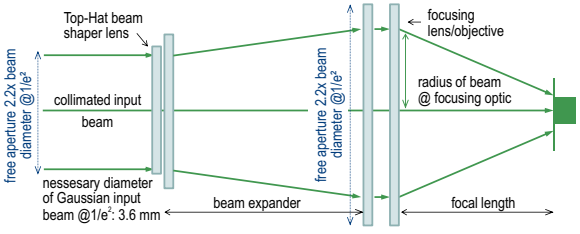
The necessary beam diameter at the position of GTH-3.6-1.75FA is 3.6 mm @ 1/e².

The resulting Top-Hat size is given by: $\frac{1.75}{1000}$ · focal length, for example with f = 50 mm => 87.5 µm.

2. Beam shaper in front of beam expander (Top Hat size @ 1/e² < 90 µm).

Top Hat size is determined by numerical aperture (NA) of focused beam and is given by:

$$\approx \frac{3.2\ \mu m}{NA} \Rightarrow \approx \text{ 5x diffraction limited @ 1064 nm (10x @ 532 nm)}$$



To achieve Top Hat sizes smaller than 90 µm it's recommended to introduce the GTH-3.6-1.75FA into the beam path in front of a beam expander. Initially the necessary input beam diameter of 3.6 mm @ 1/e² is passing the GTH. Afterwards the beam is expanded and focused on working plane. The initial diffraction limited Gaussian spot at focal plane will be transformed into a square homogeneous Top-Hat profile. The resulting Top-Hat size is given by:

$$\approx \frac{3.2\ \mu m}{NA} \Rightarrow \approx \text{ 5x diffraction limited @ 1064 nm (10x @ 532 nm)}$$

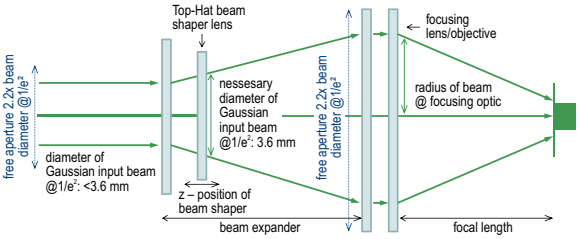
NA represents the numerical aperture of focused beam and is given by:

$$NA = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$$

3. Beam shaper within beam expander (Top Hat size @ 1/e² < 90 µm).

Top Hat size is determined by numerical aperture (NA) of focused beam and is given by:

$$\approx \frac{3.2\ \mu m}{NA} \Rightarrow \approx \text{ 5x diffraction limited @ 1064 nm (10x @ 532 nm)}$$



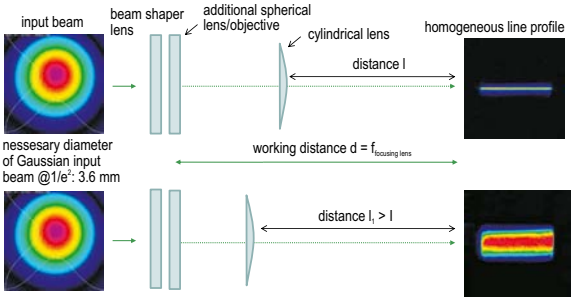
A further and even more flexible possibility is to introduce GTH-3.6-1.75FA into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of GTH-3.6-1.75FA by shifting shaper along z-axis. It's just necessary to consider that the beam diameter at the position of GTH is 3.6 mm @ 1/e². The resulting Top-Hat size is given by:

$$\approx \frac{3.2\ \mu m}{NA} \Rightarrow \approx \text{ 5x diffraction limited @ 1064 nm (10x @ 532 nm)}$$

NA represents the numerical aperture of focused beam and is given by:

$$NA = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$$

Homogeneous line generation with additional cylindrical lens



If an additional cylindrical lens is used, one can generate homogeneous line profiles. By varying the distance l the width of line profile (short axis) can be changed from near diffraction limited size to several millimeters. We recommend the use of a cylindrical lens or lens system with a focal length of = 1.8 m.

FBS TOP HAT BEAM SHAPING LENS FROM UVFS

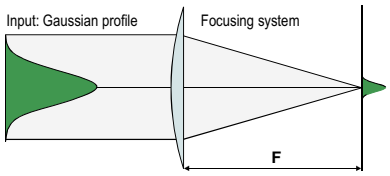
- **New Diffractive Beam Shaping Concept based on Fourier methods**
- **Transforming Gaussian TEM_{00} beam into square or round homogeneous Top-Hat profile**
- **Top Hat size is near diffraction limited and is given by: ~λ /NA**
- **Achievable Top Hat sizes: 1 µm – 200 µm**

SPECIFICATIONS

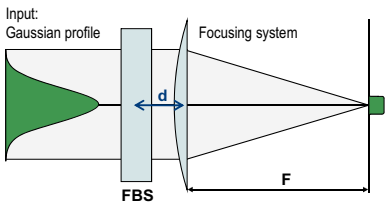
Material	fused silica	
Diameter	25.4 mm	tolerance ±0.1 mm
Input Beam	TEM_{00}, different models for diameter@1/e²: 2.0 ... 10.0 mm with 0.5 mm step	tolerance ±5%
Necessary Free Aperture	2.2x (or better 2.5x) beam diameter@1/e²	along total beam path
Top Hat Size	1.5x diffraction limited Gaussian spot	square form (round optional)
Homogenity	+/- 2.5%	rel. to average intensity within tophat
Wavelength	different models for: 1064 nm, 532 nm or 355 nm	others on request
Transmission	> 99%	AR/AR coating
Efficiency	> 90%	of input energy within tophat profile
Damage Threshold	4 J/cm² @ 532 nm, 10 ns	
Free Aperture	23 mm	

FBS OPERATION INSTRUCTIONS

FBS – Top-Hat Fundamental Beam Mode Shaper



Without FBS Beam Shaper: Gaussian-profile at focal plane



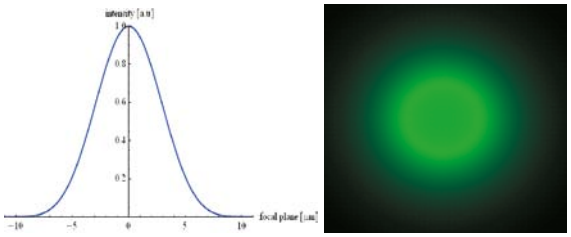
With FBS Beam Shaper: Top-Hat-profile at focal plane

– FBS works together with focusing system (FS)
– Top Hat size just depends on wavelength (λ) and numerical aperture (NA) of focused beam
– Distance d between FBS and FS up to several meters

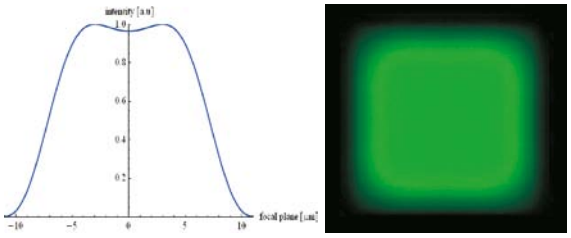
Intensity distribution at focal plane

Main FBS advantages:

– Smallest achievable Top-Hat size: ≈ always 1,5x of diffraction limited Gaussian-spot @ 1/e²
– Achievable Top Hat profiles: square or round
– Diffraction efficiency: > 95% of energy in Top Hat
– Homogeneity: modulation < ±2.5%
– Depth of focus: similar as for Gaussian beam
– Insensitive to misalignment, ellipticity and input diameter variation: ±5-10%



Without FBS shaper: diffraction limited Gaussian profile



With FBS shaper: near diffraction limited Top Hat profile

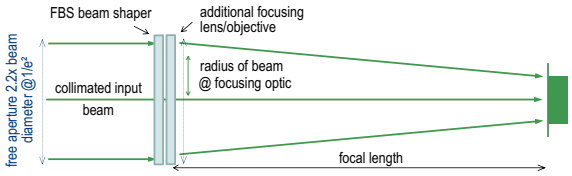
Optical setup for FBS Top-Hat beam shaper

Independent of optical setup the user has to consider that:

– The free aperture along the total beam path has to be at least 2.2x (better 2.5x) bigger than the beam diameter @ 1/ e²
– The Top Hat size is always given by: $\frac{\lambda}{NA}$
λ is the used wavelength;
NA is the numerical aperture of focused beam and is given by: $\frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$

There are different possibilities to integrate the FBS beam shaper into an optical setup.

1. Beam shaper directly in front of a focusing optic/objective

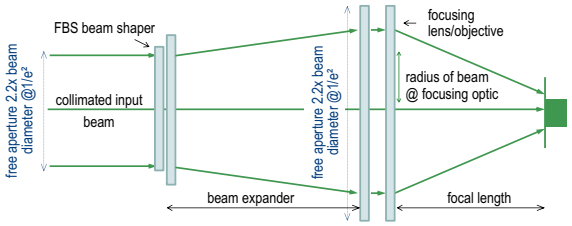


By introducing the FBS beam shaper into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a homogeneous Top-Hat profile.

When a Gaussian TEM_{00} input beam with a diameter of 5 mm@ 1/e² is used the diameter of the free aperture along the total beam path have to be at least 11 mm (better 13 mm).

If for example a wavelength with 532 nm, a Gaussian TEM_{00} input beam with a diameter of 5 mm@1/e² and a focusing lens with f=160 mm is used, ones will get a homogeneous Top Hat profile with a diameter of 34 µm.

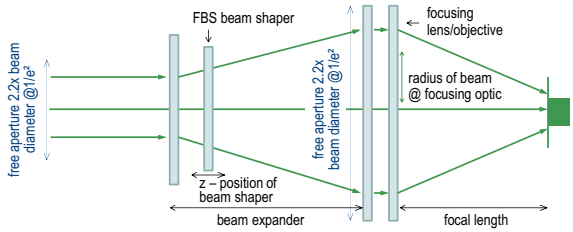
2. Beam shaper in front of a beam expander



There is also the possibility to introduce the FBS beam shaper into the beam path in front of a beam expander. This leads to a higher numerical aperture of the focused beam and to a smaller Top Hat profile.

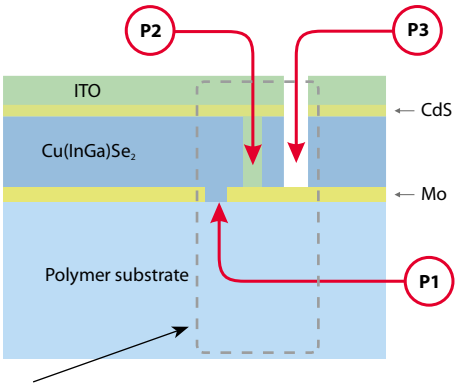
Example: A Gaussian beam with a diameter of 5 mm@1/e² illuminates the FBS beam shaper and is afterwards increased by a beam expander to a beam diameter of 8 mm. With an focusing optic with f=50 mm the user can generate a Top Hat with a diameter of 7 µm. The needed free aperture increases with the expanded beam. For a beam with a diameter of 8 mm the free aperture has to be at least 18 mm.

3. Beam shaper within a beam expander



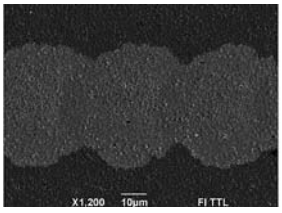
A further and even more flexible possibility is to introduce the FBS beam shaper into the beam path within a beam expander. The user has the possibility for an easy “fine tuning” of beam diameter at the position of FBS beam shaper by shifting shaper along z-axis.

Scribing of CIGS-solar cells

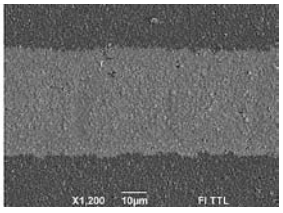


– Wasted area, reducing efficiency → need of smallest scribing lines
– Cut quality influence efficiency → need of small HAZ, no debris, smooth edges
– High scanning speed for high throughput → need of small pulse overlap

P1 – „Scribing“



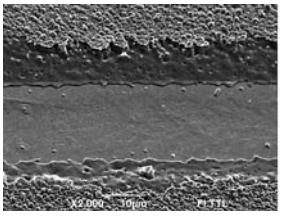
Gaussian Profile



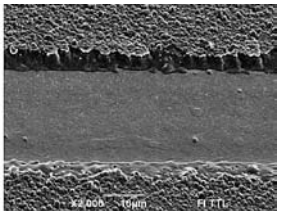
FBS-Top-Hat Profile
small overlap, smooth edges

Removal of a front contact in ZnO(1 µm)/CIGS/Mo/PI structure. Laser PL10100/SH, 10 ps, 370 mW, 100 kHz, 532 nm; scanning speed 4.3 m/s, single pass.

P3 – „Scribing“



Gaussian Profile



FBS-Top-Hat Profile
small HAZ, smooth edges

Tilted SEM pictures of the P3 scribe in ZnO(1 µm)/CIGS/ Mo/PI structure. Laser PL10100/SH, 10 ps, 370 mW, 100 kHz, 532 nm; scanning speed 60 mm/s, single pass.

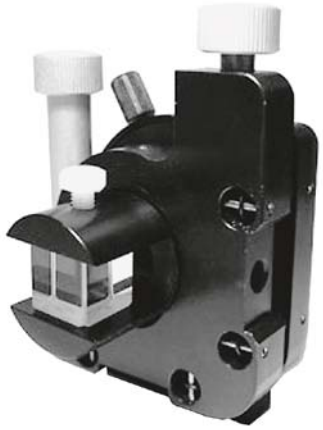
Raciukaitis et. al, JLMN-Vol. 6, No. 1, 2011

RECOMMENDED ACCESSORIES

Zoom Beam Expander
See page 6.3

Two Axes Translation Polarizer Holder 840-0240
See page 7.56

990-0060 CONTINUOUSLY VARIABLE ATTENUATOR / BEAMSPLITTER



- **Divides laser beam into two beams of manually adjustable intensity ratio**
- **Convenient 90° angle between reflected and transmitted beams**
- **Negligible beam deviation**
- **Large dynamic range**
- **Broadband transmission**
- **Weight – 0.16 kg**

Continuously Variable Attenuator/Beamsplitter is designed to be used for laser pulses as short as 100 fs. It consists of 2 high-performance polarizing optics components placed in precision opto-mechanical holder 840-0197. Variable attenuator/beamsplitter incorporates a high-performance Polarizing Cube Beamsplitter which reflects s-polarized light at 90° while transmitting p-polarized light.

A rotating λ/2 waveplate is placed in the incident polarized laser beam. The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, and their intensity ratio, can be controlled over a wide dynamic range. Pure p-polarization could be selected for maximum transmission, or pure s-polarization for maximum attenuation of the transmitted beam.

Achromatic Air-Spaced Waveplate and High Power Broadband Cube Polarizing Beamsplitter

SPECIFICATIONS

Extinction ratio	T_s/T_p < 1:200
Clear aperture	11 mm

for Broadband Region

Catalogue number	Central wavelength, nm	LDT, J/cm²	Price, EUR
990-0060-11VIS	450-680	1 [1)]	1030
990-0060-11IR	700-1000	2 [2)]	1030

[1)] LDT measured at 532 nm, 10 Hz, 10 ns pulses.
[2)] LDT measured at 1064 nm, 10 Hz, 10 ns pulses.

Multiple Order Half Waveplate and High Power Cube Polarizing Beamsplitter

SPECIFICATIONS

Extinction ratio	T_s/T_p < 1:500
Clear aperture	11 mm

Catalogue number	Central wavelength, nm	LDT, J/cm² *	Price, EUR
990-0061-11	1064	15	710
990-0062-11	1030	15	710
990-0063-11	800	8	710
990-0064-11	532	6	710
990-0065-11	355	3	740

** LDT measured at designed wavelength, 10 Hz, 10 ns pulses.*

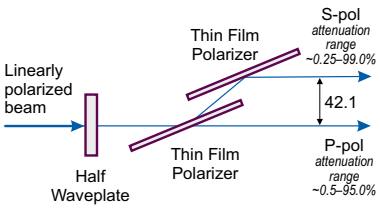
990-0070 VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM

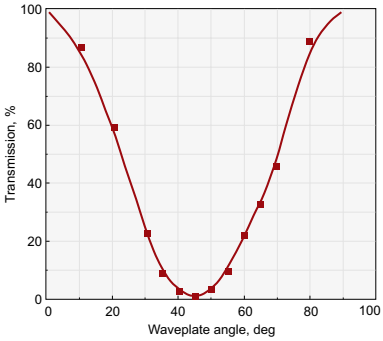
*Note: Movable base **820-0090**, Rod Holder **820-0050-02** and standard rod should be ordered seperately.*

- **Divides laser beam into two parallel beams of manually adjustable intensity ratio**
- **Large dynamic range**
- **Transmitted beam shift ~ 0.5 mm**
- **High optical damage threshold**

This variable attenuator/beamsplitter consists of special design opto-mechanical Adapter and precision opto-mechanical holder 840-0197. Two Thin Film Brewster type polarizers, which reflect s-polarized light while transmitting p-polarized light, are housed into Adapter. Quartz Half Waveplates are housed in rotating holder 840-0197.

The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place. The holder 840-0197 allows to adjust Angle Of Incidence of the Thin Film Brewster type polarizers by ±2° and to get the maximum polarization contrast.





For Nd:YAG Laser Applications

Aperture diameter	17 mm
Damage threshold	5 J/cm² pulsed at 1064 nm, typical
Polarization Contrast (after 1st polarizer)	>1:200
Polarization Contrast (after 2nd polarizer)	>1:500
Weight	0.35 kg

For Femtosecond Applications

Aperture diameter	17 mm
Damage threshold	>10 mJ/cm², 50 fs pulse at 800 nm, typical
for high power laser applications	>100 mJ/cm², 50 fs pulse at 800 nm, typical
Time dispersion	t<4 fs for 100 fs Ti:Sapphire laser pulses
Polarization Contrast (after 1st polarizer)	>1:200
Polarization Contrast (after 2nd polarizer)	>1:500
Weight	0.35 kg

RELATED PRODUCTS

Beam dumps 990-0800, 990-0820

See page 6.21

For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-266H *	266	1020
990-0070-355	355	750
990-0070-532	532	650
990-0070-1064	1064	650

Multi order half waveplate is housed in rotating holder 840-0197 for Nd:YAG laser pulses (laser damage threshold: 5 J/cm² pulsed at 1064 nm, typical).

** With Zero Order Air-Spaced half waveplate.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-257	257	945
990-0070-266	266	945
990-0070-343	343	840
990-0070-400	400	740
990-0070-400B	390-410	890
990-0070-515	515	740
990-0070-515B	505-525	890
990-0070-800	800	740
990-0070-800B	780-820	890
990-0070-1030	1030	740
990-0070-1030B	1010-1050	890

Zero order optically contacted half waveplate is housed in rotating holder 840-0197 for femtosecond laser pulses (laser damage threshold: >10 mJ/cm², 50 fsec pulse, 800 nm typical).

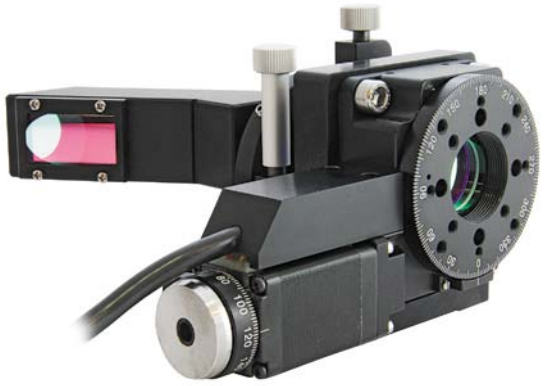
For High Power Femtosecond Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-257H	257	1020
990-0070-266H	266	1020
990-0070-343H	343	915
990-0070-400H	400	815
990-0070-400HB	390-410	965
990-0070-515H	515	815
990-0070-515HB	505-525	965
990-0070-800H	800	815
990-0070-800HB	780-820	965
990-0070-1030H	1030	815
990-0070-1030HB	1010-1050	965

Zero Order Air-Spaced half waveplate is housed in rotating holder 840-0197 for high power femtosecond applications (laser damage threshold: >100 mJ/cm², 50 fsec pulse, 800 nm typical).

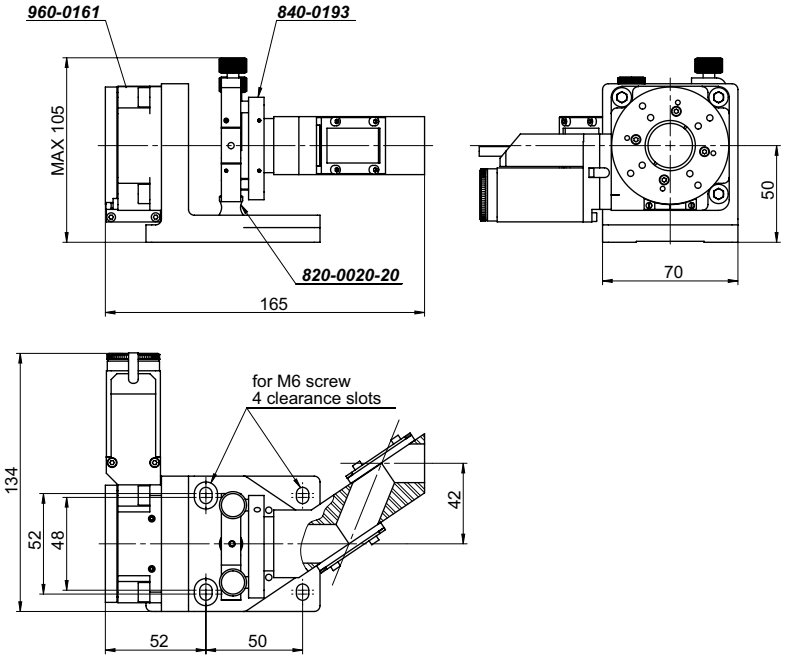
990-0070M

MOTORIZED VARIABLE ATTENUATOR FOR LINEARLY POLARIZED LASER BEAM



This motorized variable attenuator/beamsplitter consists of special design opto-mechanical Adapter and precision opto-mechanical holder 840-0193. Two Thin Film Brewster type polarizers, which reflect s-polarized light while transmitting p-polarized light, are housed into Adapter. Quartz Half Waveplates are housed in motorized rotation stage 960-0161.

The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the wave-plate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place. The holder 840-0193 allows to adjust Angle Of Incidence of the Thin Film Brewster type polarizers by ±2° and to get the maximum polarization contrast.



Ordering information

Please note: these motorized variable attenuators for linearly polarized laser beam are provided without controller and power supply. If you would like to order the complete solution (controller 980-1045 and power supply: PS12-2.5-4), please ad CP to code and 600 EUR to price.

Example:

990-0070-266M – motorized attenuator without controller and power supply.

Price – 1725 EUR

990-0070-266M+CP – motorized attenuator with controller and power supply.

Price – 2325 EUR

For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-266HM *	266	1800
990-0070-355M	355	1530
990-0070-532M	532	1430
990-0070-1064M	1064	1430

Multi order half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for Nd:YAG laser application (laser damage threshold: 5 J/cm^2, 10 ns pulses, 10 Hz at 1064 nm, typical).

** With Zero Order Air-Spaced half waveplate.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-257M	266	1725
990-0070-266M	266	1725
990-0070-343M	343	1620
990-0070-400M	400	1520
990-0070-400BM	390-410	1670
990-0070-515M	515	1520
990-0070-515BM	505-525	1670
990-0070-800M	800	1520
990-0070-800BM	780-820	1670
990-0070-1030M	1030	1520
990-0070-1030BM	1010-1050	1670

Zero order optically contacted half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for femtosecond laser application (laser damage threshold: >10 mJ/cm^2, 50 fsec pulse, 800 nm typical).

For High Power Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-257HM	266	1800
990-0070-266HM	266	1800
990-0070-343HM	343	1695
990-0070-400HM	400	1595
990-0070-400HBM	390-410	1745
990-0070-515HM	515	1595
990-0070-515HBM	505-525	1745
990-0070-800HM	800	1595
990-0070-800HBM	780-820	1745
990-0070-1030HM	1030	1595
990-0070-1030HBM	1010-1050	1745

Zero Order Air-Spaced half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for high power femtosecond laser application (laser damage threshold: >100 mJ/cm^2, 50 fsec pulse, 800 nm typical).

990-0070HBBi70

BROADBAND VARIABLE ATTENUATOR FOR FEMTOSECOND LASER PULSES

990-0070-800HBBi70

990-0070-800HBBi70M

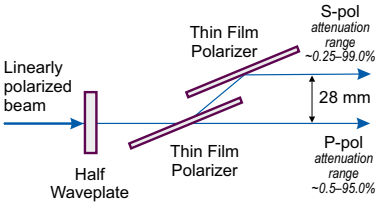
- **Divides laser beam into two parallel beams of manually adjustable intensity ratio**
- **Large dynamic range**
- **Transmitted beam shift ~ 2.6 mm**
- **High optical damage threshold**

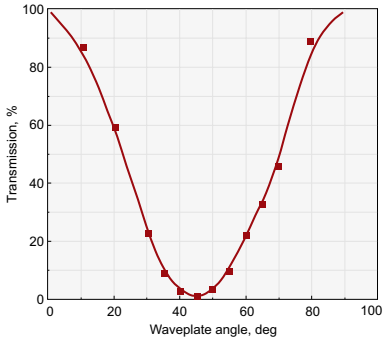
This variable attenuator/beamsplitter consists of a special design opto-mechanical adapter and a precision opto-mechanical holder 840-0197. Two thin film polarizers, operating at AOI=70° and reflecting s-polarized light while transmitting p-polarized light, are housed into the adapter. A quartz zero order air-spaced half waveplate is housed into the rotating holder 840-0197.

The intensity ratio of outgoing two parallel beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of the exit beam or outgoing beams intensity ratio can be controlled over a wide dynamic range.

P-polarized beam is transmitted straightly with a 2.6 mm shift and s-polarized beam (after 2 reflections) is parallel to the outgoing p-polarized beam, just separated by 28 mm.

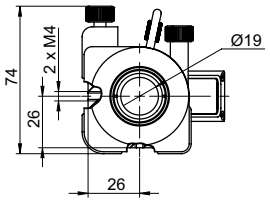
The 840-0197 holder allows to adjust angle of incidence of the thin film polarizers by ±2° and to achieve the maximum polarization contrast.

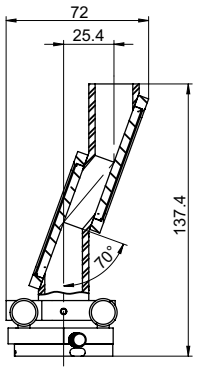




SPECIFICATIONS

Aperture diameter	12 mm
Operating bandwidth	100 nm
Damage treshold	50 mJ/cm² pulsed at 800 nm, 50 fsec, 50 Hz
Polarization contrast (after 1st polarizer)	>1:200
Polarization contrast (after 2nd polarizer)	>1:500





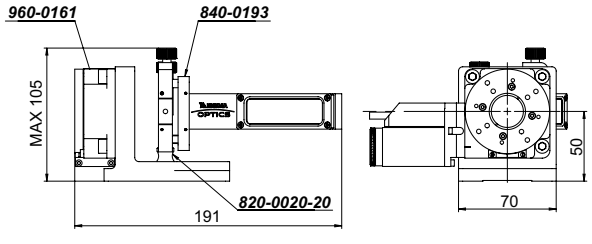
990-0070-800HBBi70

Manual attenuators

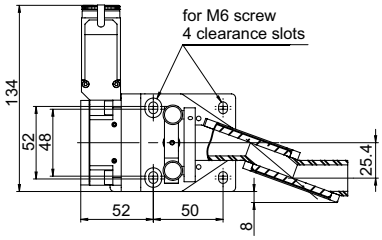
Catalogue number	Wavelength, nm	Price, EUR
990-0070-800HBBi70	750-850	1270
990-0070-1030HBBi70	980-1080	1270

Motorized attenuators

Catalogue number	Wavelength, nm	Price, EUR
990-0070-800HBBi70M	750-850	2050
990-0070-1030HBBi70M	980-1080	2050



990-0070-800HBBi70M



Ordering information

Please note: these motorized variable attenuators for linearly polarized laser beam are provided without controller and power supply. If you would like to order the complete solution (controller 980-1045 and power supply: PS12-2.5-4), please ad CP to code and 600 EUR to price.

Example:

990-0070-800HBBi70 – motorized attenuator without controller and power supply.

Price – 2050 EUR

990-0070-800HBBi70+CP – motorized attenuator with controller and power supply.

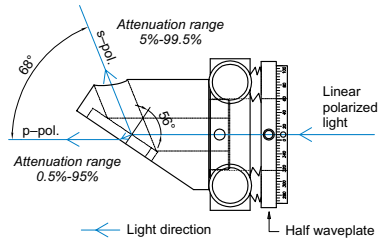
Price – 2650 EUR

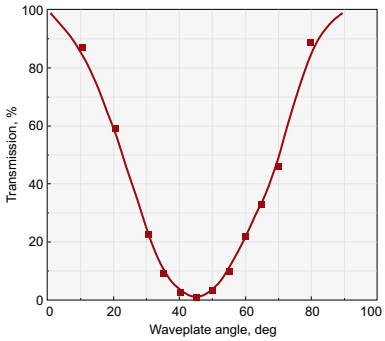
990-0071 VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM

*Note: Solid Base Height Extender **820-0210** and Standard Rod **820-0020-20** should be ordered separately*

This variable attenuator/beamsplitter consists of special design opto-mechanical adapter for polarizer at 56° 840-0117A or 840-0118A and precision opto-mechanical holder 840-0197. Thin Film Brewster type polarizer, which reflect s-polarized light at 56° while transmitting p-polarized light, is housed into adapter for polarizer at 56°. Quartz Half Waveplates are housed in rotating holder 840-0197.

The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place. The holder 840-0197 allows to adjust Angle Of Incidence of the Thin Film Brewster type polarizer by ±2° and to get the maximum polarization contrast.





- **Divides laser beam into separated by 68° angle two beams of manually adjustable intensity ratio**
- **Large dynamic range**
- **Transmitted beam shift ~0.5 mm**
- **High Optical damage threshold**

For Nd:YAG Laser Applications

Aperture diameter	10 mm
Damage threshold	5 J/cm^2 pulsed at 1064 nm, typical
Polarization Contrast	>1:200
Weight	0.25 kg

For Femtosecond Applications

Aperture diameter	10 mm
Damage threshold	>10 mJ/cm^2, 50 fs pulse at 800 nm, typical
for high power laser applications	>100 mJ/cm^2, 50 fsec pulse, 800 nm typical
Time dispersion	t<4 fs for 100 fs Ti:Sapphire laser pulses
Polarization Contrast	>1:200
Weight	0.25 kg

For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-266H *	266	690
990-0071-355	355	475
990-0071-532	532	445
990-0071-1064	1064	445

Multi order half waveplate is housed in rotating holder 840-0197 for Nd:YAG laser pulses (laser damage threshold: 5 J/cm^2 pulsed at 1064 nm, typical).

** With Zero Order Air-Spaced half waveplate.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-257	257	625
990-0071-266	266	625
990-0071-343	343	600
990-0071-400	400	550
990-0071-400B	390-410	650
990-0071-515	515	550
990-0071-515B	505-525	650
990-0071-800	800	550
990-0071-800B	780-820	650
990-0071-1030	1030	550
990-0071-1030B	1010-1050	650

Zero order optically contacted half waveplate is housed in rotating holder 840-0197 for femtosecond laser pulses (laser damage threshold: >10 mJ/cm^2, 50 fs pulse at 800 nm, typical).

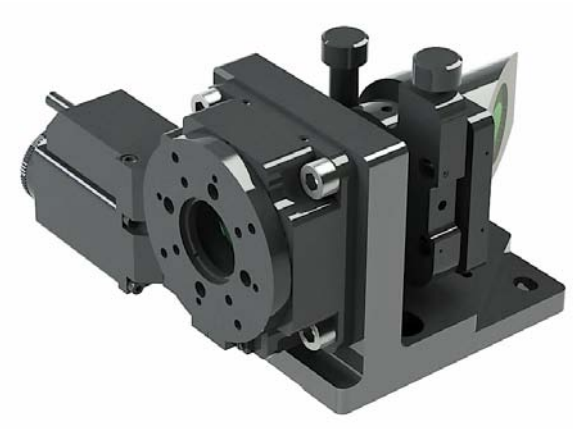
For High Power Femtosecond Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-257H	257	690
990-0071-266H	266	690
990-0071-343H	343	665
990-0071-400H	400	615
990-0071-400HB	390-410	715
990-0071-515H	515	615
990-0071-515HB	505-525	715
990-0071-800H	800	615
990-0071-800HB	780-820	715
990-0071-1030H	1030	615
990-0071-1030HB	1010-1050	715

Zero Order Air-Spaced half waveplate is housed in rotating holder 840-0197 for high power femtosecond applications (laser damage threshold: >100 mJ/cm^2, 50 fsec pulse, 800 nm typical).

990-0071M

MOTORIZED VARIABLE ATTENUATOR FOR LINEARLY POLARIZED LASER BEAM



This motorized variable attenuator/beamsplitter consists of special design opto-mechanical adapter for polarizer at 56° 840-0117A or 840-0118A and precision opto-mechanical holder 840-0193. Thin Film Brewster type polarizer, which reflect s-polarized light at 56° while transmitting p-polarized light, is housed into adapter for polarizer at 56°. Quartz Half Waveplates are housed in motorized rotation stage 960-0161.

The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place. The holder 840-0193 allows to adjust Angle of Incidence of the Thin Film Brewster type polarizer by ±2° and to get the maximum polarization contrast.

- **New compact design!**

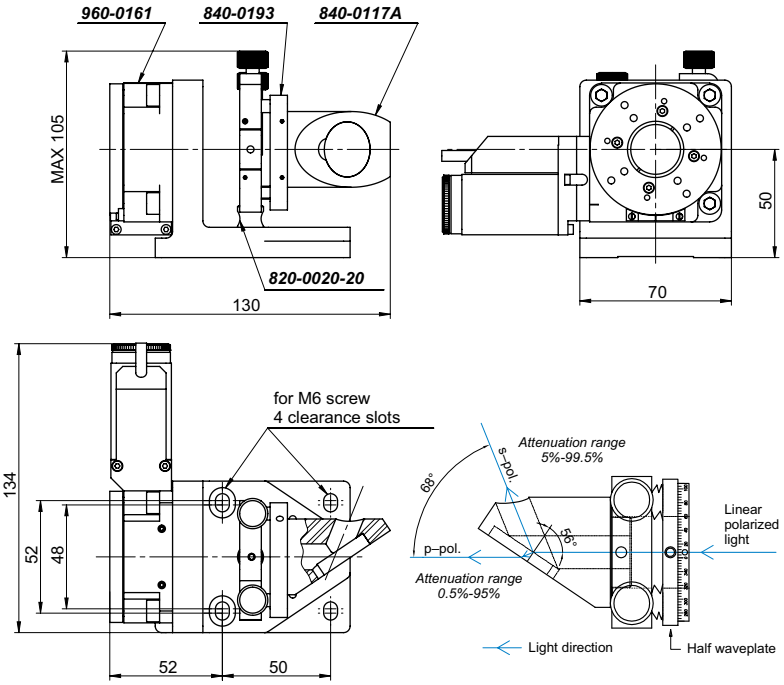
Ordering information

Please note: these motorized variable attenuators for linearly polarized laser beam are provided without controller and power supply. If you would like to order the complete solution (controller 980-1045 and power supply: PS12-2.5-4), please ad CP to code and 600 EUR to price.

Example:

990-0071-266M – motorized attenuator without controller and power supply.
Price – 1405 EUR

990-0071-266M+CP – motorized attenuator with controller and power supply.
Price – 2005 EUR



For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-266HM *	266	1470
990-0071-355M	355	1260
990-0071-532M	532	1230
990-0071-1064M	1064	1230

Multi order half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for Nd:YAG laser application (laser damage threshold: 5 J/cm², 10 ns pulses, 10 Hz at 1064 nm, typical).

** With Zero Order Air-Spaced half waveplate.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-266M	266	1405
990-0071-343M	343	1380
990-0071-400M	400	1330
990-0071-400BM	390-410	1430
990-0071-515M	515	1330
990-0071-515BM	505-525	1430
990-0071-800M	800	1330
990-0071-800BM	780-820	1430
990-0071-1030M	1030	1330
990-0071-1030BM	1010-1050	1430

Zero order optically contacted half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for femtosecond laser application (laser damage threshold: >10 mJ/cm², 50 fsec pulse, 800 nm typical).

For High Power Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0071-266HM	266	1470
990-0071-343HM	343	1445
990-0071-400HM	400	1395
990-0071-400HBM	390-410	1495
990-0071-515HM	515	1395
990-0071-515HBM	505-525	1495
990-0071-800HM	800	1395
990-0071-800HBM	780-820	1495
990-0071-1030HM	1030	1395
990-0071-1030HBM	1010-1050	1495

Zero Order Air-Spaced half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for high power femtosecond laser application (laser damage threshold: >100 mJ/cm², 50 fsec pulse, 800 nm typical).

990-0072 VARIABLE ATTENUATOR FOR FEMTOSECOND LASER PULSES

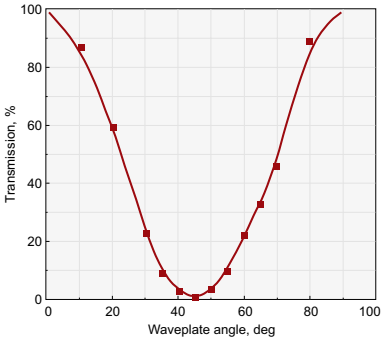
- **New compact design!**

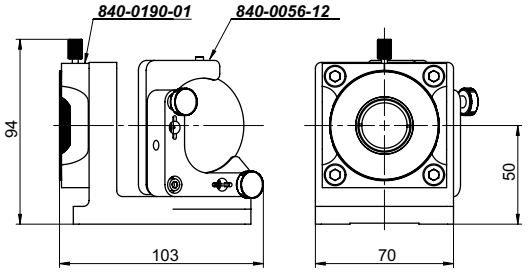
- **Divides laser beam into two beams of manually adjustable intensity ratio separated by 68° angle**
- **Large dynamic range**
- **Trasmitted beam shift ~1 mm**
- **High optical damage threshold**
- **Look online for motorized version 990-0072M**

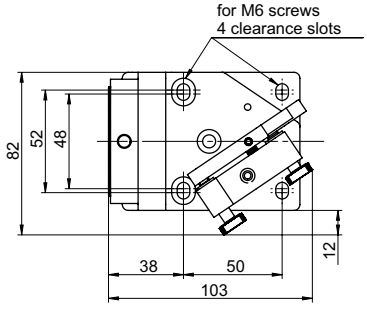
This variable attenuator/beamsplitter consists of Polarizer Holder 840-0190-01 and Kinematic Mirror/Beamsplitter Mount 840-0056-12. UVFS Thin Film Brewster type polarizer diameter 50.8 mm, which reflect s-polarized light while transmitting p-polarized light, is housed into Beamsplitter Mount 840-0056-12. A quartz Zero Order (optically contacted) Half Waveplate Ø25.4 mm (for femtosecond applications), quartz Zero Order Air-Spaced Half Waveplate (for high power femtosecond applications) or quartz Multi Order Half Waveplate Ø25.4 mm (for Nd:YAG laser applications) is housed in rotating polarizer holder 840-0180-A1 and placed in the incident linearly polarized laser beam.

The intensity ratio of those two separated and different polarized beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place.

The holder 840-0056-12 allows to adjust Angle Of Incidence of the Thin Film Brewster type polarizers by ±4.5° and to get the maximum extinction contrast. The mounts are on rods, rod holders and Movable Base 820-0090. The optical axis height from the table top can be adjusted in the range 78-88 mm. Other height can be offered as custom changing the standard rods and rod holders into higher.







*Check **www.eksmaoptics.com** for motorized version **990-0072M***

For Nd:YAG Laser Applications

Clear Aperture diameter	22 mm
Damage threshold	>5 J/cm², 10 ns pulse, 10 Hz at 1064 nm, typical
Polarization Contrast	>1:200
Transmitted beam shift	~ 1 mm
Weight	0.45 kg

A quartz Multi Order Half Waveplate Ø25.4 mm is housed in rotating holder 840-0180-A1.

For Femtosecond Applications

Clear Aperture diameter	22 mm
Damage threshold	>10 mJ/cm², 50 fs pulse at 800 nm, typical
for high power applications	>100 mJ/cm², 50 fs pulse at 800 nm, typical
Polarization Contrast	>1:200
Transmitted beam shift	~ 1 mm
Weight	0.45 kg

A quartz Zero Order (optically contacted) Half Waveplate (for femtosecond applications) or Zero Order Air-Spaced Half Waveplate (for high power applications) Ø25.4 mm are housed in rotating holder 840-0190-01.

For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0072-266H*	266	1085
990-0072-355	355	765
990-0072-532	532	735
990-0072-1064	1064	755

* *A quartz Zero Order Air-Spaced Half Waveplate clear aperture Ø22 mm is housed in rotating holder 840-0190-01.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0072-266	266	950
990-0072-343	343	895
990-0072-400	400	865
990-0072-515	515	865
990-0072-800	800	880
990-0072-800B	780-820	980
990-0072-1030	1030	890
990-0072-1030B	1010-1050	980

For High Power Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0072-266H	266	1085
990-0072-343H	343	1030
990-0072-400H	400	1000
990-0072-515H	515	1000
990-0072-800H	800	1015
990-0072-800HB	780-820	1115
990-0072-1030H	1030	1025
990-0072-1030HB	1010-1050	1115

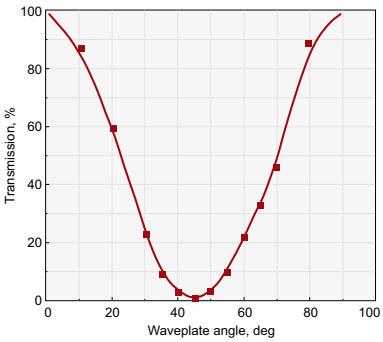
990-0073 VARIABLE ATTENUATOR FOR FEMTOSECOND AND Nd:YAG LASER PULSES

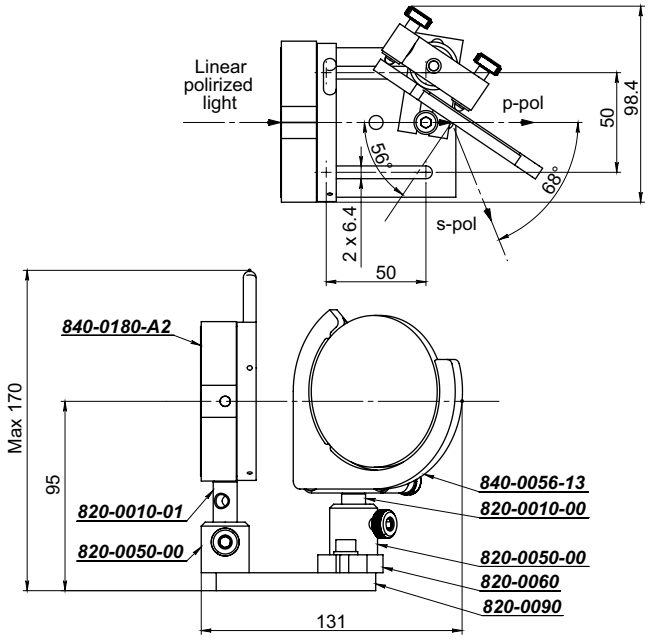
- **Divides laser beam into two beams of manually adjustable intensity ratio separated by 68° angle**
- **Large dynamic range**
- **Trasmitted beam shift ~1.4 mm**
- **High optical damage threshold**
- **Motorized version available on request**

This variable attenuator/beamsplitter consists of Polarizer Holder 840-0180-A2 and Kinematic Mirror/Beamsplitter Mount 840-0056-13. UVFS Thin Film Brewster type polarizer Ø76.2 mm, which reflect s-polarized light while transmitting p-polarized light, is housed into Beamsplitter Mount 840-0056-13. A quartz Zero Order (optically contacted) Half Waveplate Ø40 mm (for femtosecond applications), Zero Order Air-Spaced Half Waveplate (for high power femtosecond applications) or quartz Multi Order Half Waveplate Ø40 mm (for Nd:YAG laser applications) is housed in rotating polarizer holder 840-0180-A2 and placed in the incident linearly polarized laser beam.

The intensity ratio of those two separated and different polarized beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place.

The holder 840-0056-13 allows to adjust Angle Of Incidence of the Thin Film Brewster type polarizers by ±4.5° and to get the maximum extinction contrast. The mounts are on rods, rod holders and Movable Base 820-0090. The optical axis height from the table top can be adjusted in the range 92-98 mm. Other height can be offered as custom changing the standard rods and rod holders into higher.





For Nd:YAG Laser Applications

Clear Aperture diameter	36 mm
Damage threshold	>5 J/cm², 10 ns pulse, 10 Hz at 1064 nm, typical
Polarization Contrast	>1:200
Transmitted beam shift	~ 1.4 mm
Weight	0.6 kg

Quartz Multi Order Half Waveplate Ø40 mm is housed in rotating polarizer holder 840-0180-A2.

For Femtosecond Applications

Clear Aperture diameter	36 mm
Damage threshold	>10 mJ/cm², 50 fs pulse at 800 nm, typical
for high power applications	>100 mJ/cm², 50 fs pulse at 800 nm, typical
Polarization Contrast	>1:200
Transmitted beam shift	~ 1.4 mm
Weight	0.6 kg

A quartz Zero Order (optically contacted) Half Waveplate Ø40 mm (for femtosecond applications) or Zero Order Air-Spaced Half Waveplate (for high power applications) is housed in rotating polarizer holder 840-0180-A2.

For Nd:YAG Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0073-266H*	266	1790
990-0073-355	355	1460
990-0073-532	532	1440
990-0073-1064	1064	1515

* *Zero Order Air-Spaced half waveplate is housed in rotating holder.*

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0073-266	266	1690
990-0073-343	343	1560
990-0073-400	400	1540
990-0073-515	515	1540
990-0073-800	800	1560
990-0073-800B	780-820	1790
990-0073-1030	1030	1615
990-0073-1030B	1010-1050	1850

For High Power Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0073-266H	266	1790
990-0073-343H	343	1660
990-0073-400H	400	1640
990-0073-515H	515	1640
990-0073-800H	800	1660
990-0073-800HB	780-820	1890
990-0073-1030H	1030	1715
990-0073-1030HB	1010-1050	1950

990-0400 FILTERS HOLDER WITH 90° FLIP

990-0415

990-0423

The holder of 1 inch filters **990-0415** allows the fixation of up to 5 filters into 1 inch optics ring holders. The thickness of optical filters (or any other optical elements) to be held is from 0.5 mm to 8.0 mm. Filters can be easily replaced in ring holders. This filter holder allows fast filter removal from beam path flipping it at 90° position. Any position of filters can be fixed with fixing screw. The firm 0° position can be fixed with the second brass screw (included).

The holder of 2 inch filters 990-0423 allows the fixation of up to 3 filters into 2 inch optics ring holders. The thickness of optical filters (or any other optical elements) to be held is from 0.5 mm to 14.0 mm.

The holder 990-0415ND is the same holder 990-0415 but with Neutral Density filters that operates as step energy attenuator and allows adjusting transmission from 100% (all 5 filters are at 90° position) till 0.015% (all 5 filters are at 0° position) at visible region. If you need other adjustment you can choose any other Neutral Density filter Ø25.4 mm.

Using the holder **990-0415** with various color glass or dielectric filters various transmitted band pass regions can be achieved. The Filters Holder with 90° Flip is made of black anodized aluminium and brass screws.

Catalogue number	Acceptable filters number	Suitable filters diameter, mm	Clear aperture diameter, mm	Weight, kg	Price, EUR
990-0415	5	25.4	23	0.16	155
990-0415ND	5	25.4	23	0.19	250
990-0423	3	50.8	48	0.22	145

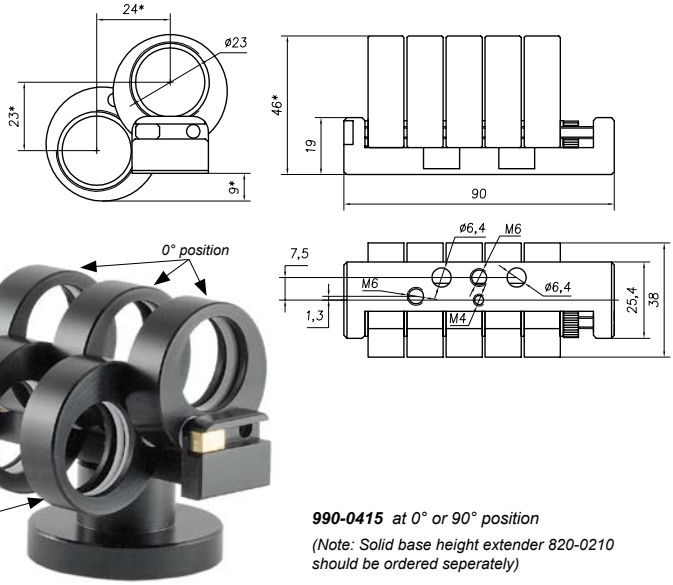
- **Allows stacking of 5 filters of Ø25,4 mm (1"), or 3 filters of Ø50,8 (2")**
- **Fast flipping in and out of beam path**
- **Available to be used in 90° position**
- **Has one M4, two M6 and two holes Ø 6.4mm for mounting on posts or table bases**
- **Large aperture allows to attenuate large diameter laser beam**
- **Black Anodized Aluminium and Brass screws**

***990-0415** at 0° position*

(Note: Solid base height extender 820-0210 should be ordered seperately)

***990-0423** at 0° position*

(Note: Solid base height extender 820-0210 should be ordered seperately)



***990-0415** at 0° or 90° position*

(Note: Solid base height extender 820-0210 should be ordered seperately)

RELATED PRODUCTS

Neutral Density Filters Ø25.4 mm

See page 1.14

990-0800 AIR-COOLED BEAM DUMP

990-0800

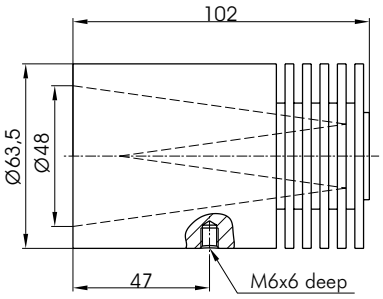
Beam Dump 990-0800 is designed to block CW or pulsed laser beams. It can be used on beams of up to 50 W in the wavelength range from 0.1 to 30 µm.

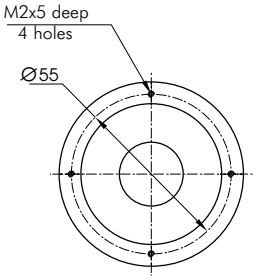
Due to the design of the beam dump, even if the non-reflective coating is damaged by high intensity pulses, there is no backward reflection.

SPECIFICATIONS

Wavelength range	0.1-30 µm
Max. Handling power	50 W
Max. Energy	2.5 J (20 Hz)
Acceptance aperture	48 mm (1.89")
Laser type	pulsed, CW

Code	Weight, kg	Price, EUR
990-0800	0.57	169





990-0820 WATER-COOLED BEAM DUMP

990-0820

Beam Dump 990-0820 is designed to block CW or pulsed laser beams. It is mainly intended for beams 2 inch wide.

The dump is best suited for beams of up to 1 kW from 0.1–30 µm wavelength range.

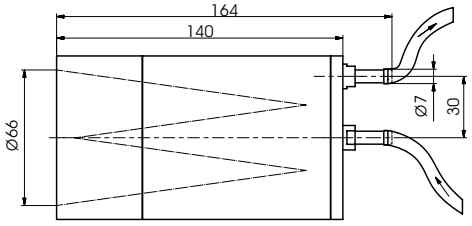
Even if the non-reflective coating is damaged by high intensity pulses, the beam is not reflected back into your optical scheme.

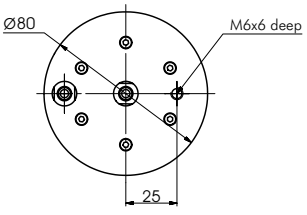
The dump mounts on M6 hole on its back.

SPECIFICATIONS

Wavelength range	0.1-30 µm
Max. Handling power	1 kW
Max. Energy	50 J (20 Hz)
Acceptance aperture	48 mm (1.89")
Laser type	pulsed, CW

Code	Weight, kg	Price, EUR
990-0820	1.2	239





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