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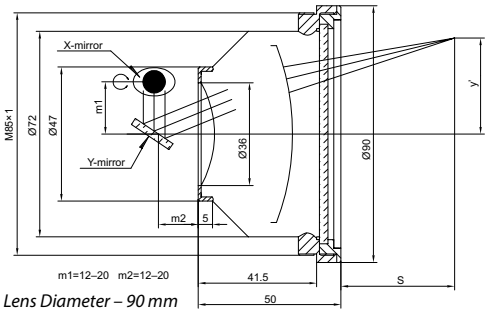
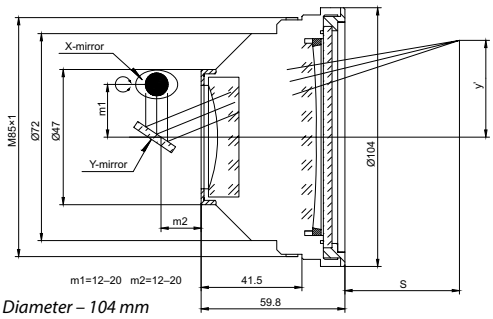
F-THETA LENS

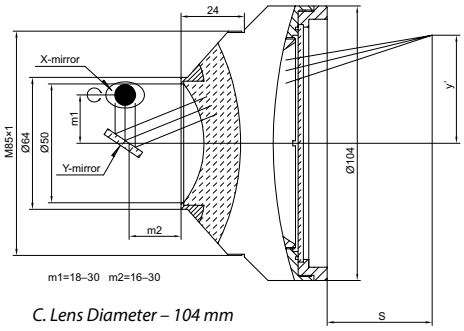
F-Theta lenses are designed to provide a flat field on the image plane for scanning and engraving applications where a high power laser and a set of rotating mirrors are used to scan across a given field.



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

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

Wavelength – 532 nm, Lens Diameter – 90 mm

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

Wavelength – 355 nm

Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Catalogue number	Price, EUR
100	126	70×70	±28°	7	10	A	150-1003	930
160	199	110×110	±28°	7	15	B	150-1603	930

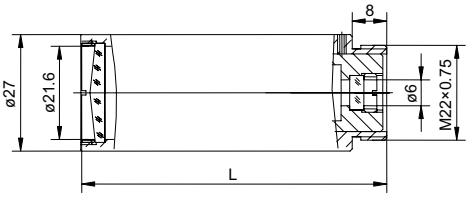
BEST MIRROR PLACES m1/m2 – 24/24 mm, screw size – M85×1

Wavelength – 1064 nm, Lens Diameter – 104 mm

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

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

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

RELATED PRODUCT

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

Find more at EksmaOptics.com

ZOOM BEAM EXPANDER

FEATURES

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

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.

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

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

RELATED PRODUCT

Universal Adjustable Optics Mount 830-0035

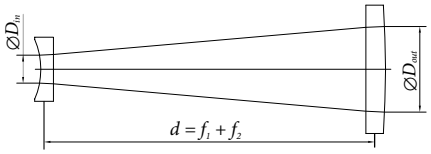
Find more at EksmaOptics.com

SIMPLE TELESCOPE KIT

Simple lenses are subject to optical aberrations. In many cases these aberrations can be compensated for 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 indices, 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.

Coating	Material	Catalogue number	Price, EUR
Uncoated	BK7	140-0008	771
1064 nm, R<0.2%	BK7	141-0008	1075
532 nm + 1064 nm, R<0.5%	BK7	142-0008	1110
400 – 700 nm, R<0.9%	BK7	147-0008	1260
Uncoated	UV FS	140-1008	1170
266 nm, R<0.4%	UV FS	144-1008	1470
266 nm + 355 nm, R<0.6%	UV FS	149-1008	1480
210 – 400 nm, R<1.5%	UV FS	146-1008	1680
355 nm, R<0.25%	UV FS	143-1008	1465
532 nm + 1064 nm, R<0.5%	UV FS	141-1008	1485
350 – 900 nm, R<1.5%	UV FS	145-1008	1685
650 – 950 nm, R<1%	UV FS	148-1008	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 *f1*, mm	Focal length *f2*, mm	Distance between lenses *d=f1+f2*, mm *	Magnification, M
Lens 1	Lens 2	Lens 1	Lens 2				
BK7 bi/cv Ø12.7 mm	BK7 pl/cx Ø50.8 mm	UV FS bi/cv Ø12.7 mm	UV FS pl/cx Ø50.8 mm				
114-0104	110-0502	114-1104	110-1505	-12.7	+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	BK7 pl/cx Ø50.8 mm	UV FS bi/cv Ø25.4 mm	UV FS pl/cx Ø50.8 mm				
114-0204	110-0502	114-1204	110-1505	-25	+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	BK7 pl/cx Ø50.8 mm	UV FS pl/cv Ø25.4 mm	UV FS pl/cx Ø50.8 mm				
112-0209	110-0502	112-1205	110-1505	-50	+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.*

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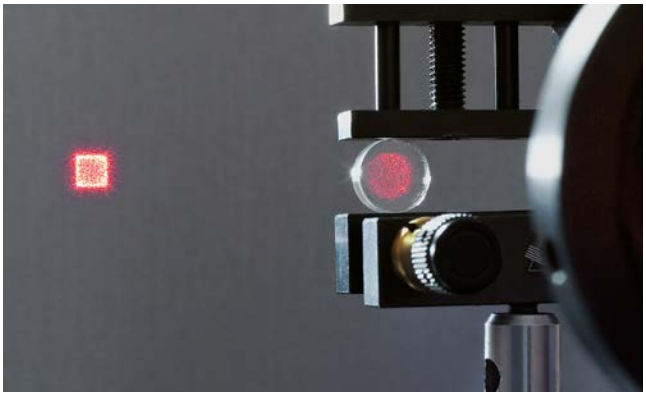
GAUSS-TO-TOP HAT BEAM SHAPING LENS

FEATURES

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



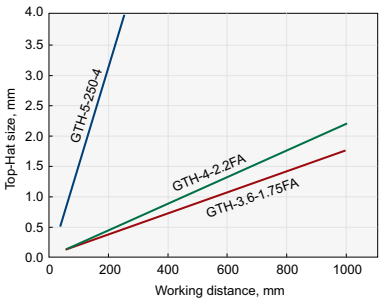
Gauss-to-Top Hat Beam Shaping Lens is a lens of a special form, used to distribute energy of Gaussian beam to Top Hat profile. GTH beam shapers operate within a large wavelength range from VIS to NIR.

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.

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/cm^2 @ 532 nm, 10 ns
Mounting	Mounted into 1″ ring holder



Top Hat width in relation to the working distance

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

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

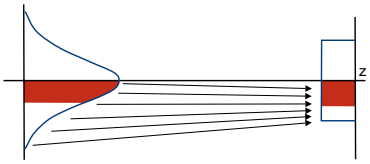
Recommended operation wavelength range	400 – 1500 nm
Input beam	TEM$_{00}$, diameter (1/e^2): 5.0 ± 0.15 mm
Output beam	Top hat size at 250 mm working distance: 4 × 4 mm^2 (adjustable with additional lens)
Working distance	250 mm (adjustable with additional lens)
Beam energy distribution efficiency	> 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

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

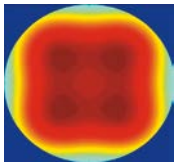
Other specific laser wavelengths are available on request.

GTH-5-250-4 OPERATION INSTRUCTIONS

PRINCIPLES OF BEAM SHAPER OPERATION AND LENS SHAPE

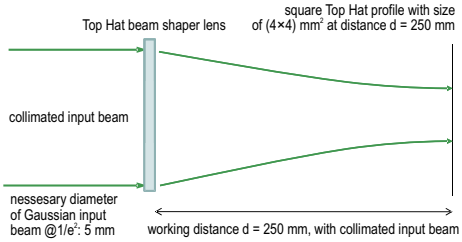


Energy of Gaussian input beam is redistributed to a Top Hat beam profile by beam shaper lens (mapping).



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

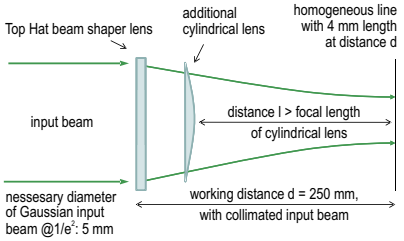
OPTICAL SETUP FOR GAUSS-TO-TOP HAT BEAM SHAPER LENS



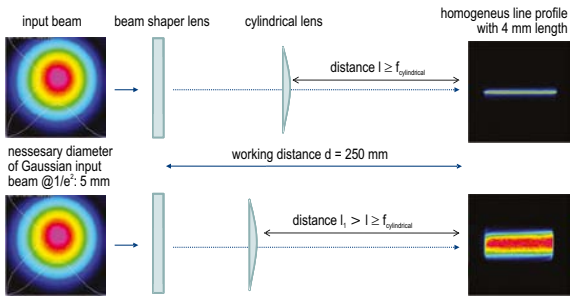
If a collimated Gaussian beam is used the Top Hat beam shaper lens delivers at the working distance d = 250 mm a square Top Hat beam profile with the size of (4×4) mm².

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

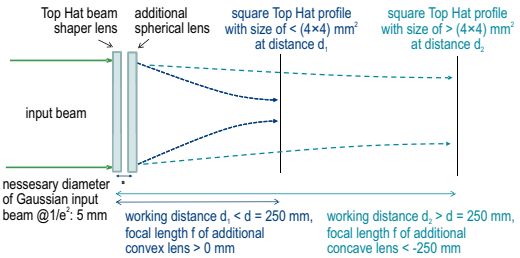


By introducing an additional cylindrical lens behind the Top Hat beam shaper lens (thereby one has to consider that the distance l between cylindrical lens and working plane must be bigger or same as focal length of cylindrical lens) it is possible to generate a line profile at working plane. Along the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



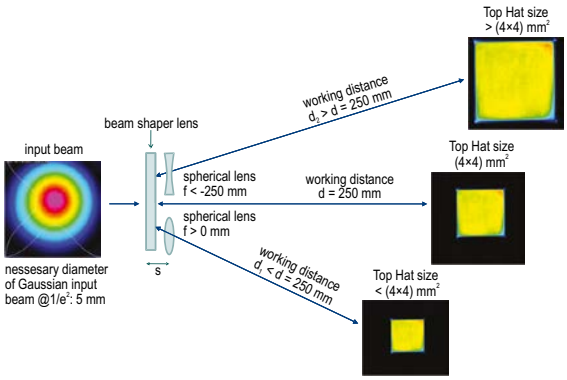
The working distance and the size of the Top Hat profile can be changed (same ratio) by an additional spherical lens. For a convex lens the size of the Top Hat profile and the working distance becomes smaller. For a concave lens the size of the Top Hat profile and the working distance becomes bigger.

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

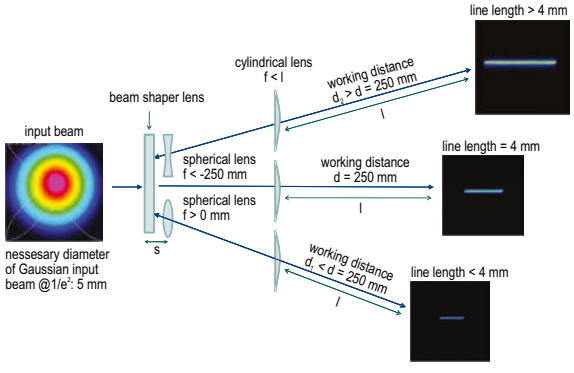
$$\text{Working distance} = \frac{250\,mm \cdot f}{250\,mm + f}$$

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



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

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

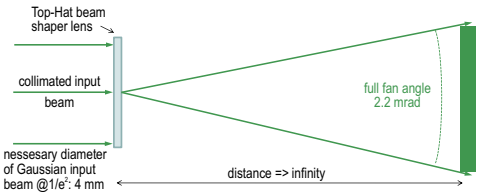
Recommended operation wavelength range	400-1550 nm
Input beam	TEM_{00}, diameter ($1/e^2$): 4.0 ± 0.15 mm
Achievable Top Hat size	6x diffraction limited @ 1064 nm, 12x diffraction limited @ 532 nm
Full fan angle of Top-Hat generation	2.2 mrad
Beam energy distribution efficiency	> 95% of input energy 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

Description	Catalogue number	Price, EUR
Uncoated lens	GTH-4-2.2FA	565
VIS coated lens (400-700 nm (R<1% per face))	GTH-4-2.2FA-VIS	620
IR coated lens (700-1300 nm (R<1% per face))	GTH-4-2.2FA-IR	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 @ $1/e^2$.

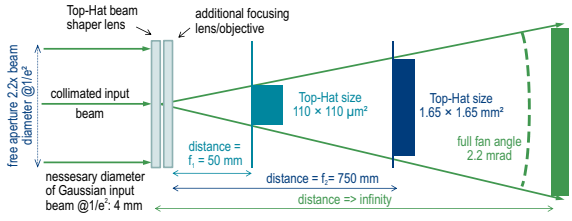
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ $1/e^2$.

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.

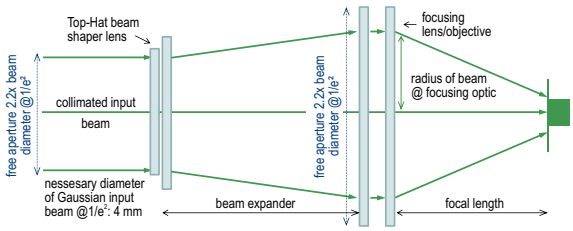
The necessary beam diameter at the position of GTH-4-2.2FA is 4 mm @ $1/e^2$.

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:

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



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 @ $1/e^2$ 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:

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

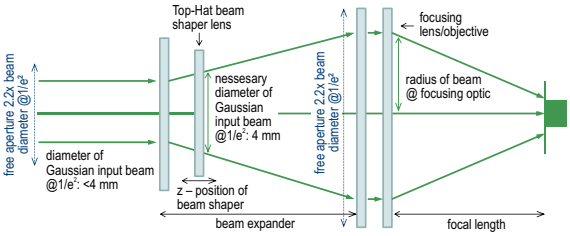
NA represents the numerical aperture of focused beam and is given by:

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

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 justnecessary to consider that the beam diameter at the position of GTH is 4 mm @ $1/e^2$. The resulting Top-Hat size is given by:

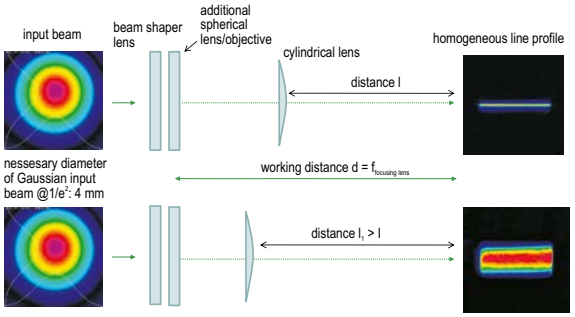
$$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx \text{6x diffraction limited @ 1064 nm (12x @ 532 nm)}$$

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.

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

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

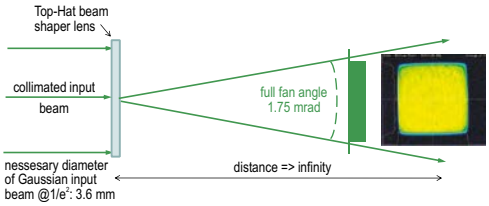
Recommended operation wavelength range	400-1550 nm
Necessary free aperture	always 2.2x beam diameter @ $1/e^2$, along total beam path
Input beam	TEM_{00}, diameter ($1/e^2$): 3.6 ± 0.15 mm
Achievable Top Hat size @ $1/e^2$	5x diffraction limited @ 1064 nm, 10x diffraction limited @ 532 nm
Full fan angle 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

Description	Catalogue number	Price, EUR
Uncoated lens	GTH-3.6-1.75FA	565
VIS coated lens (400-700 nm (R<1% per face))	GTH-3.6-1.75FA-VIS	620
IR coated lens (700-1300 nm (R<1% per face))	GTH-3.6-1.75FA-IR	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 @ $1/e^2$.

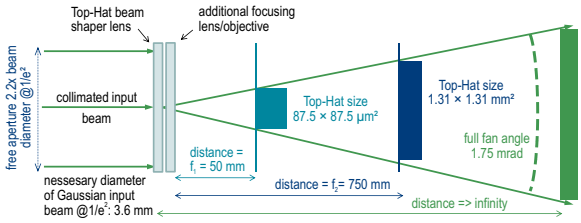
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ $1/e^2$.

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 @ $1/e^2$ > 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.

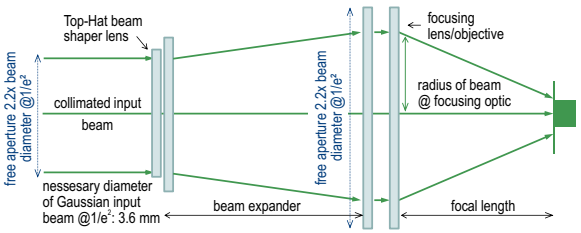
The necessary beam diameter at the position of GTH-3.6-1.75FA is 3.6 mm @ $1/e^2$.

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

2. Beam shaper in front of beam expander (Top Hat size @ $1/e^2$ < 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 @ $1/e^2$ 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:

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

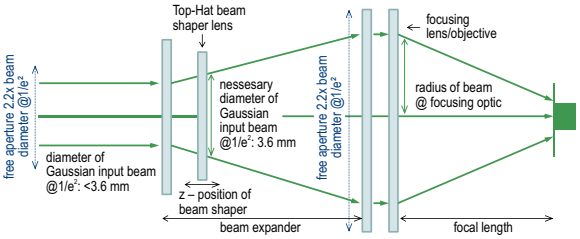
NA represents the numerical aperture of focused beam and is given by:

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

3. Beam shaper within beam expander (Top Hat size @ $1/e^2$ < 90 µm).

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

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



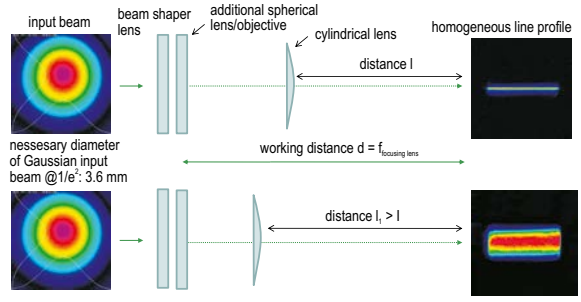
A further and even more flexible possibility is to introduce GTH-3.6-1.75FA into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of GTH-3.6-1.75FA by shifting shaper along z-axis. It's just necessary to consider that the beam diameter at the position of GTH is 3.6 mm @ $1/e^2$. 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.

TOP HAT BEAM SHAPING LENS FROM UVFS – FBS

FEATURES

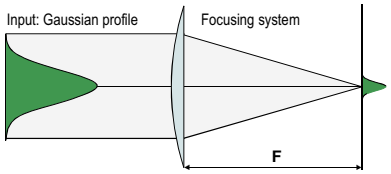
- New Diffractive Beam Shaping Concept based on Fourier methods
- Transforming Gaussian TEM_{00} beam into square or round homogeneous Top-Hat profile
- Top Hat size is near diffraction limited and is given by: ~λ/NA
- Achievable Top Hat sizes: 1 – 200 µm

SPECIFICATIONS

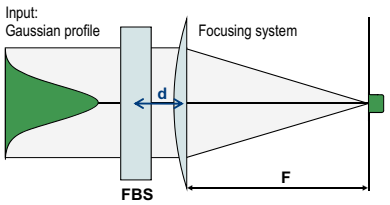
Material	fused silica	
Diameter	25.4 mm	tolerance ±0.1 mm
Input Beam	TEM_{00}, different models for diameter@1/e²: 2.0 ... 10.0 mm with 0.5 mm step	tolerance ±5%
Necessary Free Aperture	2.2x (or better 2.5x) beam diameter@1/e²	along total beam path
Top Hat Size	1.5x diffraction limited Gaussian spot	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



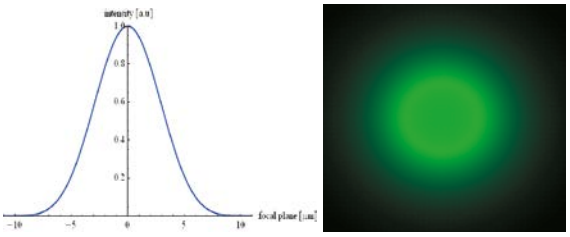
With FBS Beam Shaper: Top-Hat-profile at focal plane

- 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

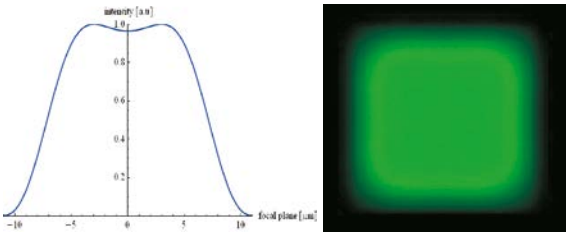
INTENSITY DISTRIBUTION AT FOCAL PLANE

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: $\frac{\lambda}{NA}$

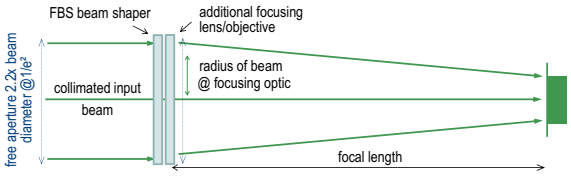
  λ is the used wavelength;

  NA is the numerical aperture of focused beam and is given by: $\frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$

EKSMA OPTICS • Tel.: +370 5 272 99 00 • Fax: +370 5 272 92 99 • info@eksmaoptics.com • www.eksmaoptics.com

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

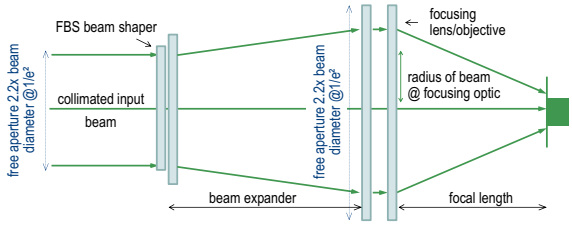


By introducing the FBS beam shaper into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a homogeneous Top-Hat profile.

When a Gaussian TEM_{00} input beam with a diameter of 5 mm @ $1/e^2$ 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@$1/e^2$ and a focusing lens with f=160 mm is used, ones will get a homogeneous Top Hat profile with a diameter of 34 µm.

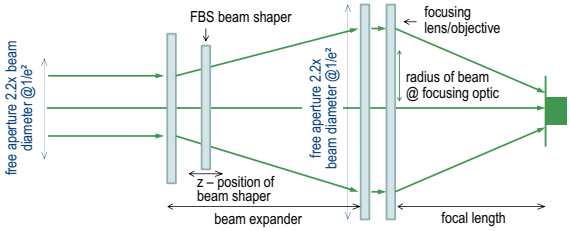
2. Beam shaper in front of a beam expander



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.

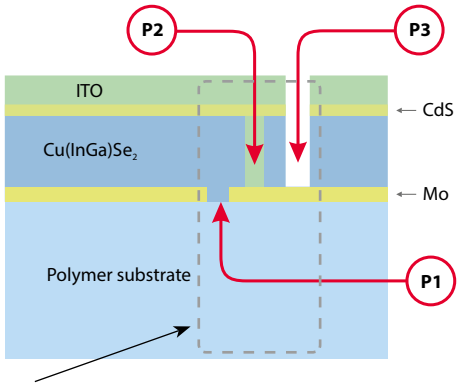
Example: A Gaussian beam with a diameter of 5 mm@$1/e^2$ illuminates the FBS beam shaper and is afterwards increased by a beam expander to a beam diameter of 8 mm. With an focusing optic with f=50 mm the user can generate a Top Hat with a diameter of 7 µm. The needed free aperture increases with the 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



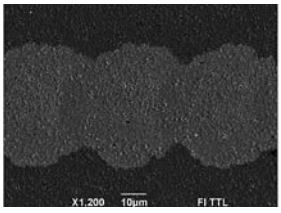
A further and even more flexible possibility is to introduce the FBS beam shaper into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of FBS beam shaper by shifting shaper along z-axis.

SCRIBING OF CIGS-SOLAR CELLS

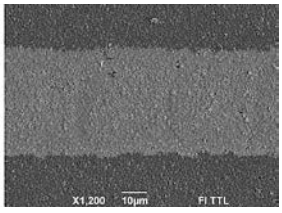


- Wasted area, reducing efficiency → need of smallest scribing lines
- Cut quality influence efficiency → need of small HAZ, no debris, smooth edges
- High scanning speed for high throughput → need of small pulse overlap

P1 – „Scribing"



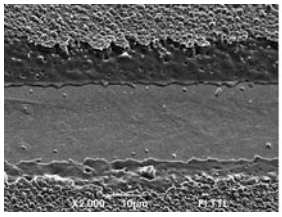
Gaussian Profile



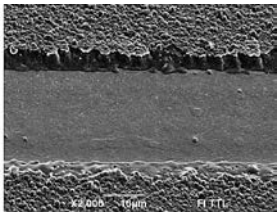
FBS-Top-Hat Profile
small overlap, smooth edges

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 5.4

Two Axes Translation Polarizer Holder 840-0240
Find more at EksmaOptics.com

CONTINUOUSLY VARIABLE ATTENUATOR / BEAMSPLITTER – 990-0060

FEATURES

- 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	Ts/Tp < 1:200
Clear aperture	11 mm

FOR BROADBAND REGION

Central wavelength, nm	LDT, J/cm²	Catalogue number	Price, EUR
450-680	1 [1)]	990-0060-11VIS	1030
700-1000	2 [2)]	990-0060-11IR	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	Ts/Tp < 1:500
Clear aperture	11 mm

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

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

VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM – 990-0070

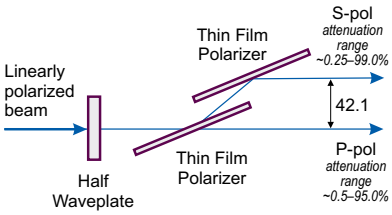
FEATURES

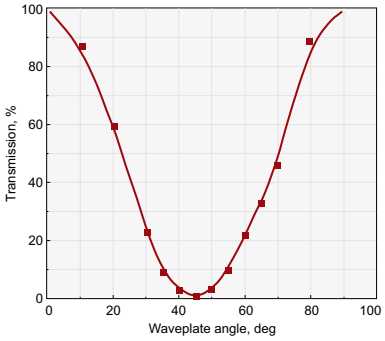
- Divides laser beam into two parallel beams of manually adjustable intensity ratio
- Large dynamic range
- Transmitted beam shift ~ 0.5 mm
- High optical damage threshold

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

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 Nd:YAG LASER APPLICATIONS

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

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

FOR FEMTOSECOND APPLICATIONS

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

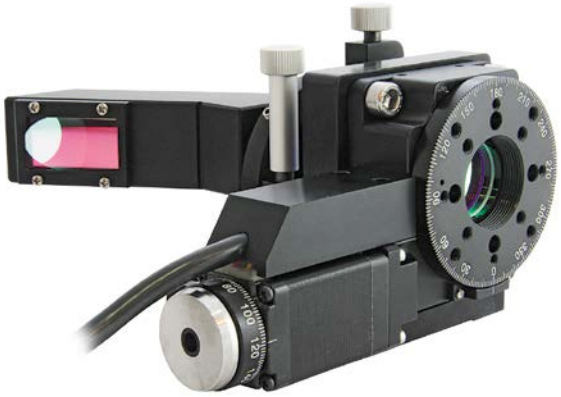
Wavelength, nm	Catalogue number	Price, EUR
257	990-0070-257H	1020
266	990-0070-266H	1020
343	990-0070-343H	915
400	990-0070-400H	815
390-410	990-0070-400HB	965
515	990-0070-515H	815
505-525	990-0070-515HB	965
800	990-0070-800H	815
780-820	990-0070-800HB	965
1030	990-0070-1030H	815
1010-1050	990-0070-1030HB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

RELATED PRODUCTS

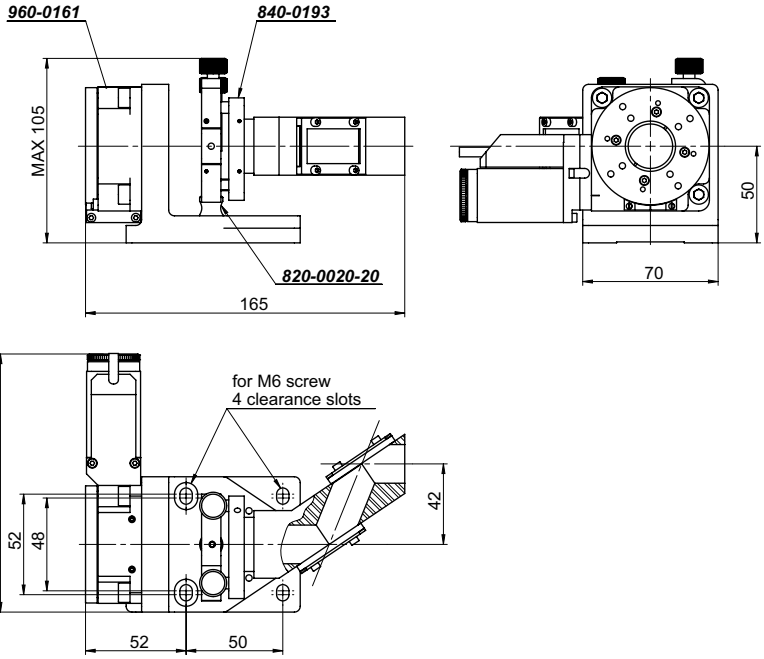
Beam dumps
990-0800,
990-0820
See page 5.22

MOTORIZED VARIABLE ATTENUATOR FOR LINEARLY POLARIZED LASER BEAM – 990-0070M



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 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 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: PS12-1.5-4), 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

Wavelength, nm	Catalogue number	Price, EUR
266	990-0070-266HM *	1800
355	990-0070-355M	1530
532	990-0070-532M	1430
1064	990-0070-1064M	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/cm², 10 ns pulses, 10 Hz at 1064 nm, typical).

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

FOR FEMTOSECOND APPLICATIONS

Wavelength, nm	Catalogue number	Price, EUR
257	990-0070-257M	1725
266	990-0070-266M	1725
343	990-0070-343M	1620
400	990-0070-400M	1520
390-410	990-0070-400BM	1670
515	990-0070-515M	1520
505-525	990-0070-515BM	1670
800	990-0070-800M	1520
780-820	990-0070-800BM	1670
1030	990-0070-1030M	1520
1010-1050	990-0070-1030BM	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/cm², 50 fsec pulse, 800 nm typical).

FOR HIGH POWER FEMTOSECOND APPLICATIONS

Wavelength, nm	Catalogue number	Price, EUR
257	990-0070-257HM	1800
266	990-0070-266HM	1800
343	990-0070-343HM	1695
400	990-0070-400HM	1595
390-410	990-0070-400HBM	1745
515	990-0070-515HM	1595
505-525	990-0070-515HBM	1745
800	990-0070-800HM	1595
780-820	990-0070-800HBM	1745
1030	990-0070-1030HM	1595
1010-1050	990-0070-1030HBM	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/cm², 50 fsec pulse, 800 nm typical).

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BROADBAND VARIABLE ATTENUATOR FOR FEMTOSECOND LASER PULSES – 990-0070HBBI70

FEATURES

- 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

990-0070-800HBBi70

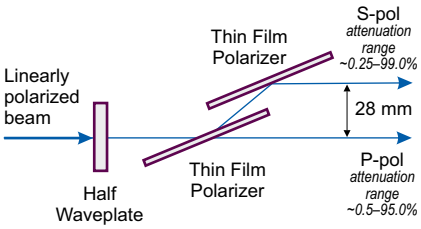
990-0070-800HBBi70M

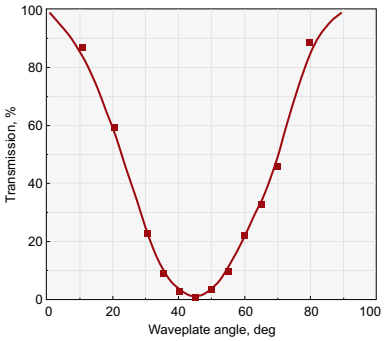
This variable attenuator/beamsplitter consists of a special design opto-mechanical adapter and a precision opto-mechanical holder 840-0197. Two thin film polarizers, operating at AOI=70° and reflecting s-polarized light while transmitting p-polarized light, are housed into the adapter. A quartz zero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

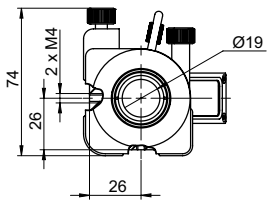
The 840-0197 holder allows to adjust angle of incidence of the thin film polarizers by ±2° and to achieve the maximum polarization contrast.

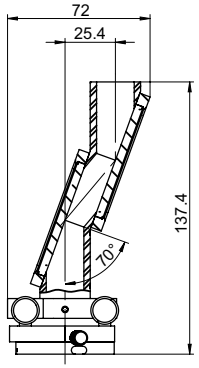




SPECIFICATIONS

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





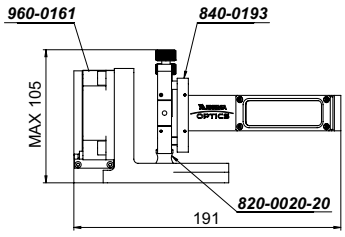
990-0070-800HBBi70

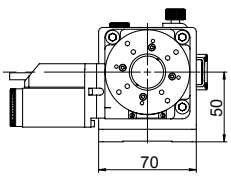
MANUAL ATTENUATORS

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

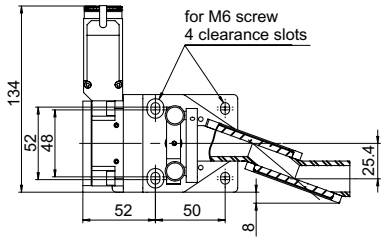
MOTORIZED ATTENUATORS

Wavelength, nm	Catalogue number	Price, EUR
750-850	990-0070-800HBBi70M	2050
980-1080	990-0070-1030HBBi70M	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: PS12-1.5-4), 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

VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM – 990-0071

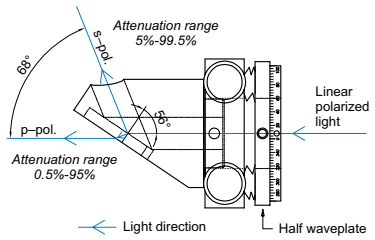
FEATURES

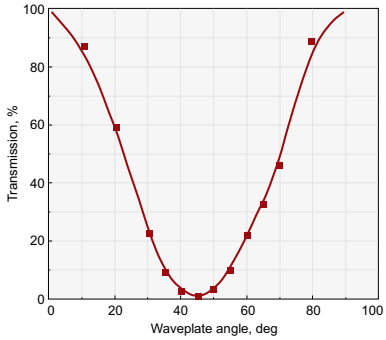
- Divides laser beam into separated by 68° angle two beams of manually adjustable intensity ratio
- Large dynamic range
- Transmitted beam shift ~0.5 mm
- High Optical damage threshold

*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.





FOR Nd:YAG LASER APPLICATIONS

Aperture diameter	10 mm
Damage threshold	5 J/cm² pulsed at 1064 nm, typical
Polarization Contrast	>1:200
Weight	0.25 kg

FOR Nd:YAG LASER APPLICATIONS

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

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

Aperture diameter	10 mm
Damage threshold	>10 mJ/cm², 50 fs pulse at 800 nm, typical
for high power laser applications	>100 mJ/cm², 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 FEMTOSECOND APPLICATIONS

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

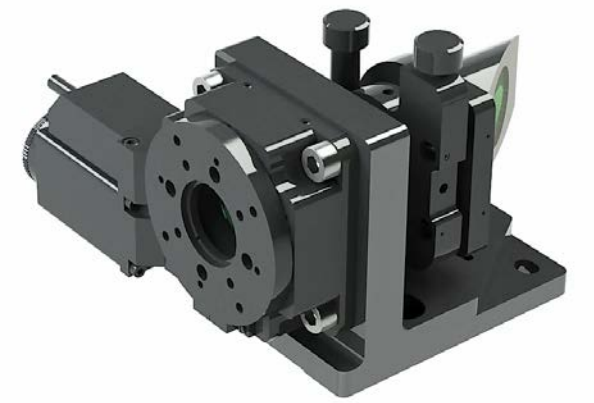
Zero order optically contacted half waveplate is housed in rotating holder 840-0197 for femtosecond laser pulses (laser damage threshold: >10 mJ/cm², 50 fs pulse at 800 nm, typical).

FOR HIGH POWER FEMTOSECOND LASER APPLICATIONS

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

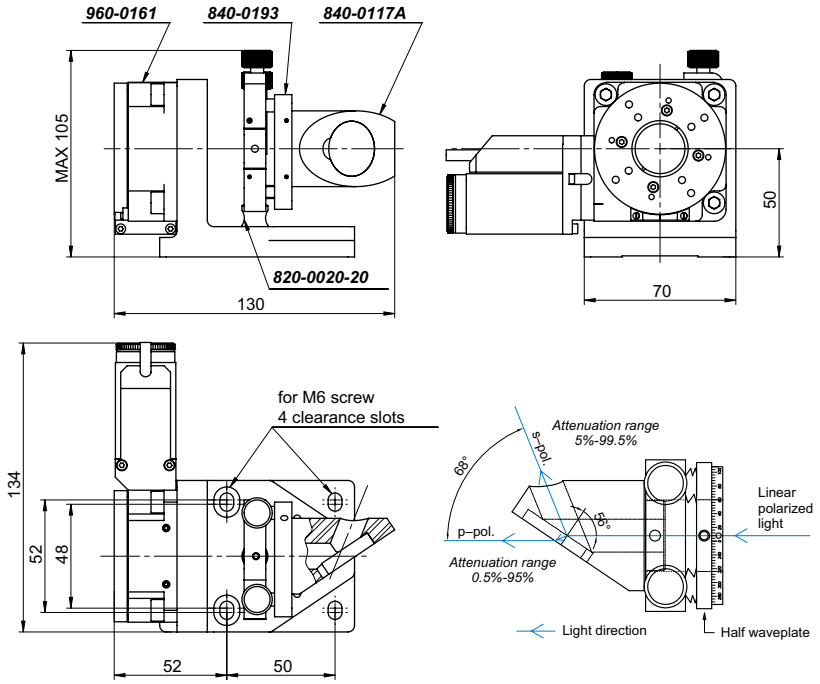
Zero Order Air-Spaced half waveplate is housed in rotating holder 840-0197 for high power femtosecond applications (laser damage threshold: >100 mJ/cm², 50 fsec pulse, 800 nm typical).

MOTORIZED VARIABLE ATTENUATOR FOR LINEARLY POLARIZED LASER BEAM – 990-0071M



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.



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: PS12-1.5-4), 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

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

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

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

VARIABLE ATTENUATOR FOR FEMTOSECOND LASER PULSES – 990-0072

FEATURES

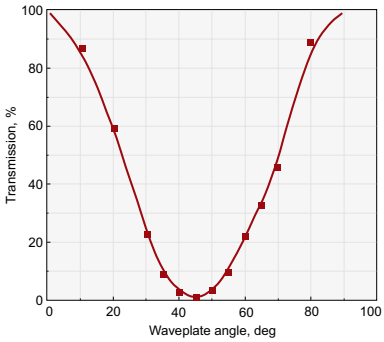
- Divides laser beam into two beams of manually adjustable intensity ratio separated by 68° angle
- Large dynamic range
- Trasmitted beam shift ~1 mm
- High optical damage threshold

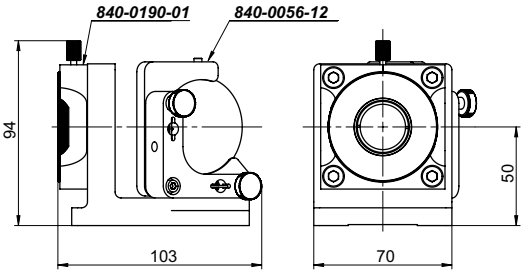
*Check **www.eksmaoptics.com** for motorized version **990-0072M***

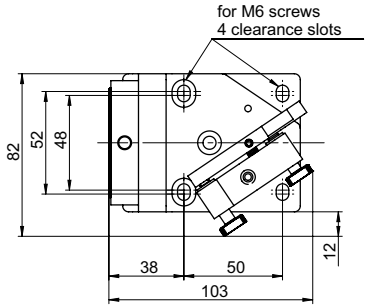
This variable attenuator/beamsplitter consists of Polarizer Holder 840-0190-01 and Kinematic Mirror/Beamsplitter Mount 840-0056-12. UVFS Thin Film Brewster type polarizer diameter 50.8 mm, which reflect s-polarized light while transmitting p-polarized light, is housed into Beamsplitter Mount 840-0056-12. 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.







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 Nd:YAG LASER APPLICATIONS

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

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

FOR FEMTOSECOND APPLICATIONS

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 FEMTOSECOND APPLICATIONS

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

FOR HIGH POWER FEMTOSECOND LASER APPLICATIONS

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

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

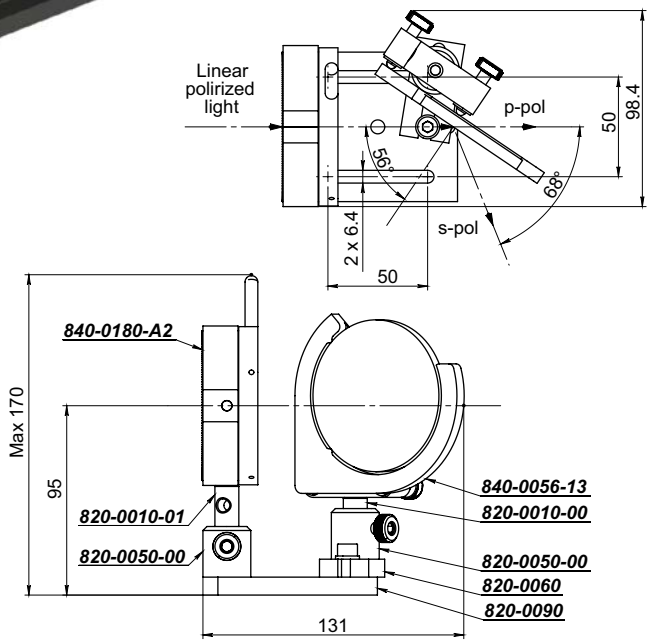
FEATURES

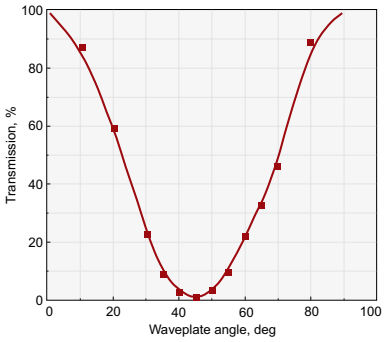
- Divides laser beam into two beams of manually adjustable intensity ratio separated by 68° angle
- Large dynamic range
- Trasmitted beam shift ~1.4 mm
- High optical damage threshold
- Motorized version available on request

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 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 FEMTOSECOND APPLICATIONS

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

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 Nd:YAG LASER APPLICATIONS

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

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

FOR HIGH POWER FEMTOSECOND LASER APPLICATIONS

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

FILTERS HOLDER WITH 90° FLIP – 990-0400

FEATURES

- 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 Ø6.4mm for mounting on posts or table bases
- Large aperture allows to attenuate large diameter laser beam
- Black Anodized Aluminium and Brass screws

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.

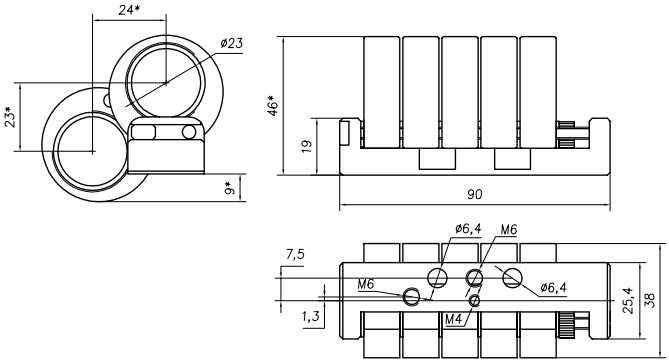
Acceptable filters number	Suitable filters diameter, mm	Clear aperture diameter, mm	Weight, kg	Catalogue number	Price, EUR
5	25.4	23	0.16	990-0415	155
5	25.4	23	0.19	990-0415ND	250
3	50.8	48	0.22	990-0423	145

990-0415

990-0423

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 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

AIR-COOLED BEAM DUMP – 990-0800

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.

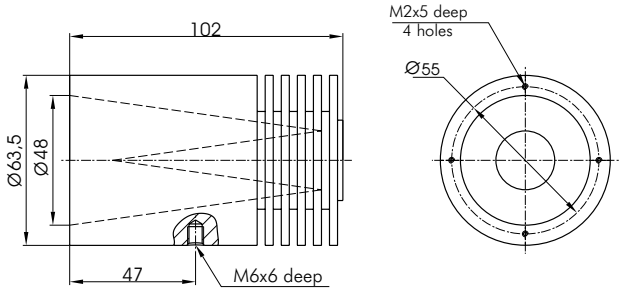
Due to the design of the beam dump, even if the non-reflective coating is damaged by high intensity pulses, there is no backward reflection.

990-0801 is a smaller beam dump designed to block a CW or a pulsed laser beam. It can be used on beams of up to 5 Watts in the wavelength range from 0.1 to 30 µm.

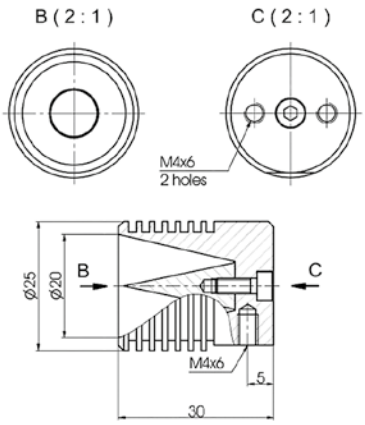
SPECIFICATIONS

Wavelength range	0.1 – 30 µm
Laser type	pulsed, CW

Aperture	Description	Catalogue number	Price, EUR
48 mm	for beams up to 50 W	990-0800	169
20 mm	for beams up to 5 W	990-0801	119



*Drawing of **990-0800***



*Drawing of **990-0801***

WATER-COOLED BEAM DUMP – 990-0820

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
Weight	1.2 kg

Catalogue number	Price, EUR
990-0820	239