Optical Systems
Selection Guide

F-Theta Lens
page 7.2

Compact Beam Expander
page 7.3

Zoom Beam Expander
page 7.4

Simple Telescope Kit
page 7.4

Gauss-to-Top Hat Beam Shaping Lens
page 7.5

990-0060
page 7.12

990-0070
page 7.13

990-0070M
page 7.14

990-0071
page 7.15

990-0071M
page 7.16

990-0072
page 7.17

990-0073
page 7.18

990-1000
page 7.19

990-0100
990-0200
page 7.20

990-0050
990-0051
page 7.20

Precision Pinholes
page 7.21

Microscope Objectives
page 7.21

Unmounted Iris Diaphragms
page 7.22

Mounted Iris Diaphragms
page 7.24

Mounts for Iris Diaphragms
page 7.25

Motorized Iris Diaphragms
995 Series
page 7.26

Motorized Iris Diaphragms
996 Series
page 7.27

Motorized Iris Diaphragms
997 Series
page 7.28

990-0604
page 7.29

990-0704
page 7.30

990-0400
page 7.32

991-0602
page 7.33

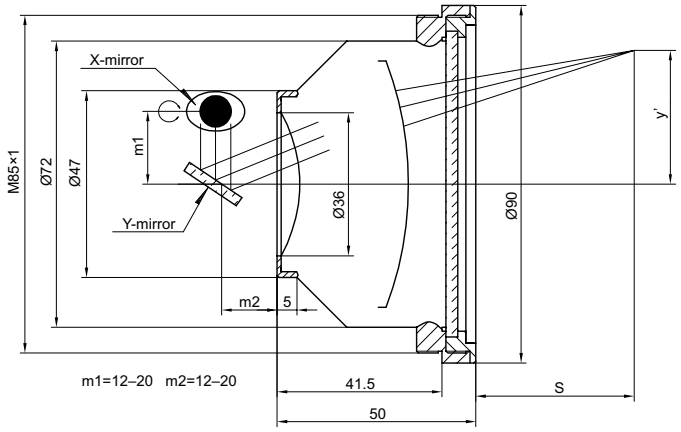
991-0702
page 7.34

990-0800
page 7.36

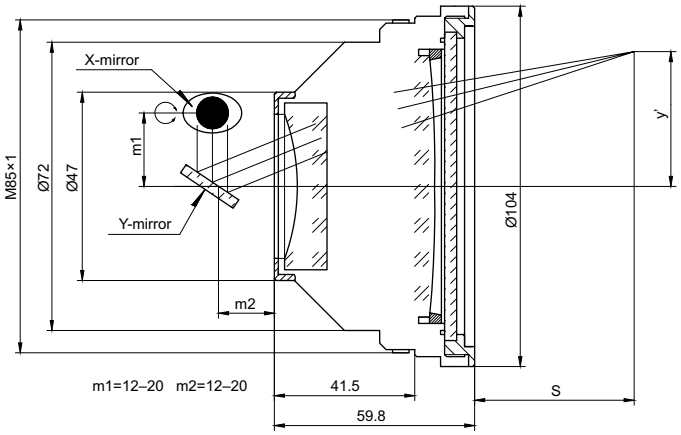
990-0820
page 7.36

F-THETA LENS

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



A. Lens Diameter – 90 mm



B. Lens Diameter – 104 mm

SPECIFICATIONS

Screw Size	M85×1
Best mirror places m1/m2	16/16 mm

Wavelength – 1064 nm, Lens Diameter – 90 mm

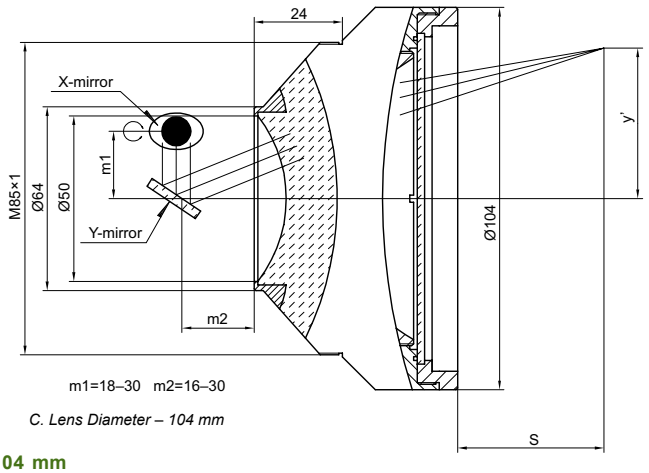
Catalogue number	Focus length, mm	Working distance S, mm	Max. scan area, mm²	Max. scan angle, θ max	Input beam diameter, mm	Spot size, µm	Drawing	Price, EUR
150-1001	100	115	70×70	±28°	12	16	A	420
150-1601	160	176	110×110	±28°	12	26	A	420
150-2101	210	230	145×145	±28°	12	34	A	420
150-2541	254	284	175×175	±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



C. Lens Diameter – 104 mm

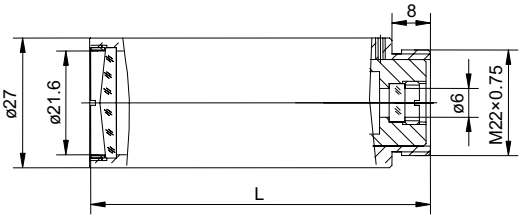
SPECIFICATIONS

Screw Size	M85×1
Best mirror places m1/m2	24/24 mm

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



Expansion ratio - 2X, 2,5X, 3X, 4X, 5X, 6X, 8X

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 8.22

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

EKSMA OPTICS offers compact Galilean type zoom beam expanders for Nd:YAG lasers fundamental and harmonics wavelength: 1064 nm, 532 nm and 355 nm.

Zoom beam expander provides variable expansion ratio of 1x-8x or 2x-8x 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	860
165-1283	355	2x-8x	12	33	158.5	860

- **Adjustable 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 8.47

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 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

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

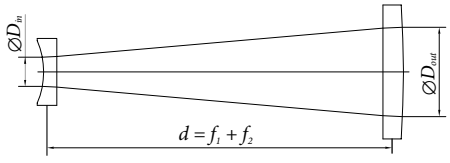
The distance from the second lens to the focal point of the combined lenses is called the back focal length (BFL).

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

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

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

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.



Lens material: BK7

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

Lens material: UVFS

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

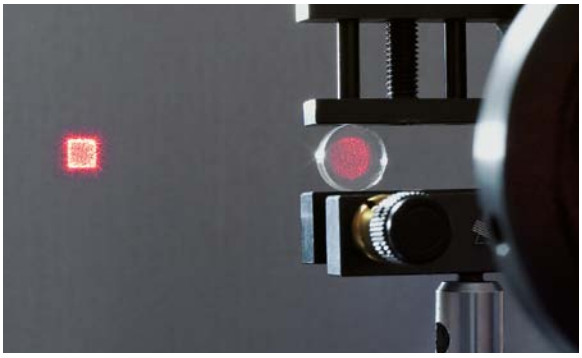
Each kit includes 8 lenses, Aluminium Optical Rail 810-0005-02, two Aluminium Rail Carriers 810-0007-06, Self Centering Lens Mounts 830-0010 and 830-0020, two Rod Holders 820-0050-02 and two Rods 820-0010-02.

Net weight: 1.4 kg

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
149-1008	UV FS	266 nm + 355 nm, R<0.6%	1480
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.

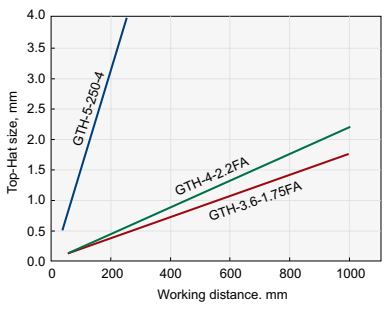
GAUSS-TO-TOP HAT BEAM SHAPING LENS



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.

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 in to 1" ring holder



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

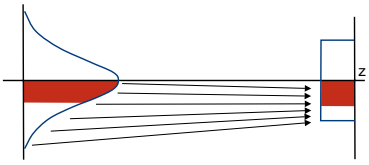
Recommended operation wavelength range	400-1500 nm
Input beam	TEM_{00}, diameter (1/e²): 5.0 ± 0.15 mm
Output beam	Top hat size at 250 mm working distance: 4 × 4 mm² (adjustable with additional lens)
Working distance	250 mm (adjustable with additional lens)
Beam energy distribution efficiency	> 95% of 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

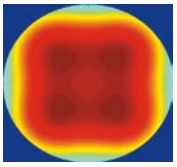
Other specific laser wavelengths are available on request.

GTH-5-250-4 OPERATION INSTRUCTIONS

Principles of Beam Shaper Operation and Lens Shape

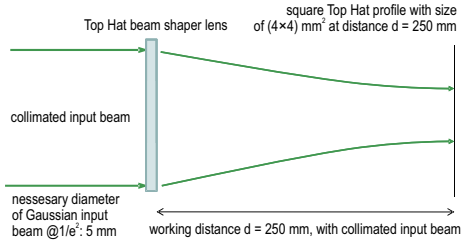


Energy of Gaussian input beam is re-distributed to a Top Hat beam profile by beam shaper lens (mapping).



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

Optical Setup for Gauss-toTop Hat Beam Shaper Lens

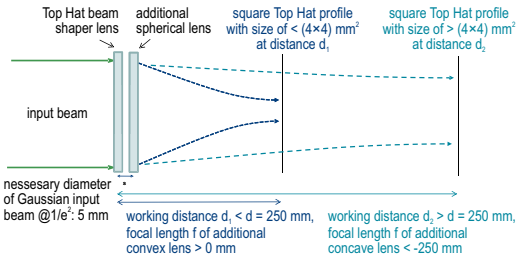


If a collimated Gaussian beam is used the Top Hat beam shaper lens delivers at the working distance d = 250 mm a square Top Hat beam profile with the size of (4×4) mm².

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).

Adjustment of Square Top Hat Size by Additional Spherical Lens



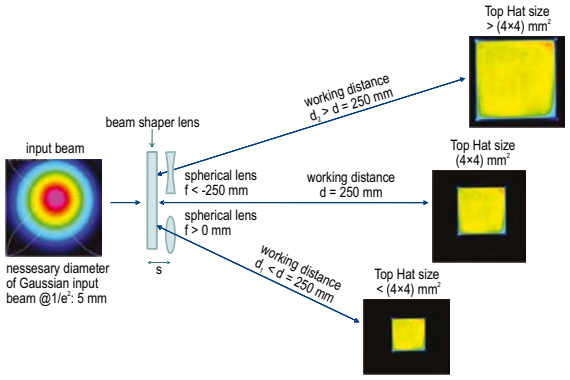
The working distance and the size of the Top Hat profile can be changed (same ratio) by an additional spherical lens. For a convex lens the size of the Top Hat profile and the working distance becomes smaller. For a concave lens the size of the Top Hat profile and the working distance becomes bigger.

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

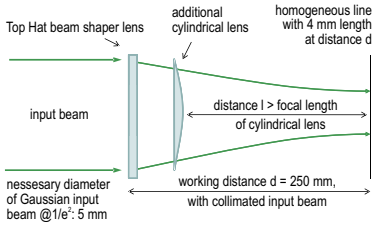
$$\text{Working distance} = \frac{250\,mm \cdot f}{250\,mm + f}$$

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

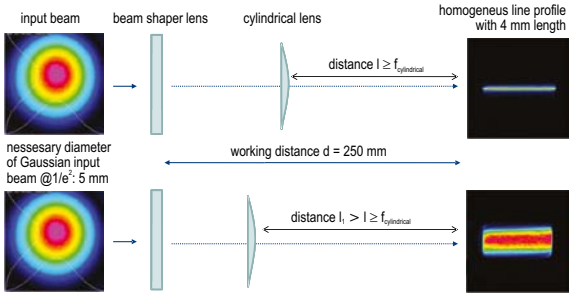
$$\text{Square Top Hat Size} = \left(\frac{4mm \cdot \text{working distance}}{250\,mm}\right)^2 = \left(\frac{4mm \cdot f}{250\,mm + f}\right)^2$$



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

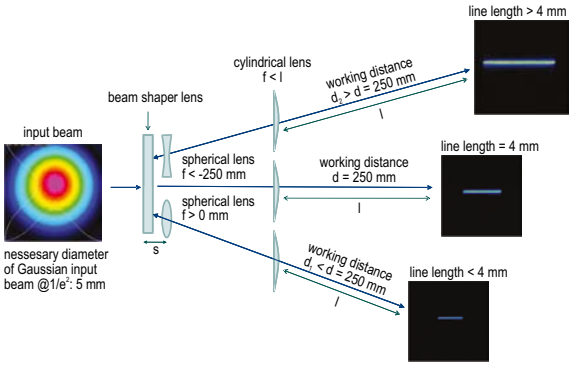


By introducing an additional cylindrical lens behind the Top Hat beam shaper lens (thereby one has to consider that the distance l between cylindrical lens and working plane must be bigger or same as focal length of cylindrical lens) it is possible to generate a line profile at working plane. Along the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

– 110×110 µm for lens with f = 50 at 50 mm distance
– 220×220 µm for lens with f = 100 at 100 mm distance
– 2.2×2.2 mm for lens with f = 1000 at 1000 mm distance
– 4.4×4.4 mm for lens with f = 2000 at 2000 mm distance

GTH-4-2.2FA OPERATION SPECIFICATIONS

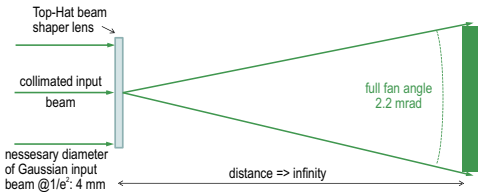
Recommended operation wavelength range	400-1550 nm
Input beam	TEM_{00}, diameter (1/e²): 4.0 ± 0.15 mm
Achievable Top Hat size	6x diffraction limited @ 1064 nm, 12x diffraction limited @ 532 nm
Full fan angle of Top-Hat generation	2.2 mrad
Beam energy distribution efficiency	> 95% of input energy within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

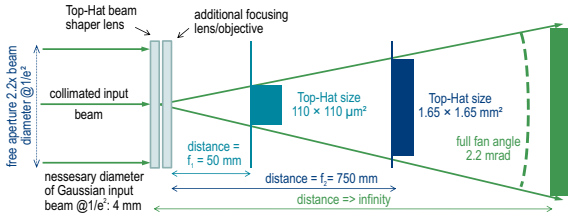
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ 1/e².

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.

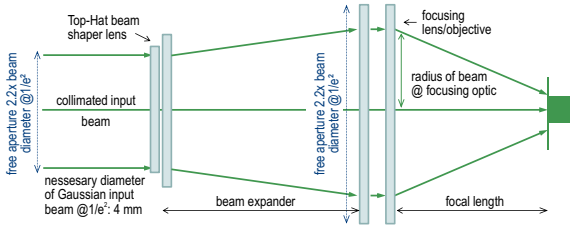
The necessary beam diameter at the position of GTH-4-2.2FA is 4 mm @ 1/e².

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:

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



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/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:

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

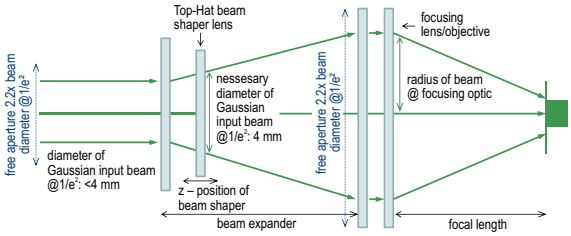
NA represents the numerical aperture of focused beam and is given by:

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

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 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:

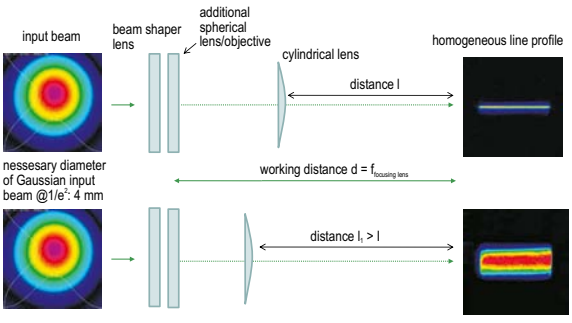
$$\approx \frac{4\ \mu m}{NA} \Rightarrow\approx \text{6x diffraction limited @ 1064 nm (12x @ 532 nm)}$$

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:

– 88×88 µm for lens with f = 50 at 50 mm distance
– 175×175 µm for lens with f = 100 at 100 mm distance
– 1.75×1.75 mm for lens with f = 1000 at 1000 mm distance

GTH-3.6-1.75FA OPERATION SPECIFICATIONS

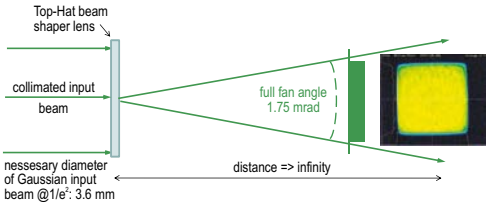
Recommended operation wavelength range	400-1550 nm
Necessary free aperture	always 2.2x beam diameter @ 1/e², along total beam path
Input beam	TEM_{00}, diameter (1/e²): 3.6 ± 0.15 mm
Achievable Top Hat size @ 1/e²	5x diffraction limited @ 1064 nm, 10x diffraction limited @ 532 nm
Full fan angle of Top-Hat 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.

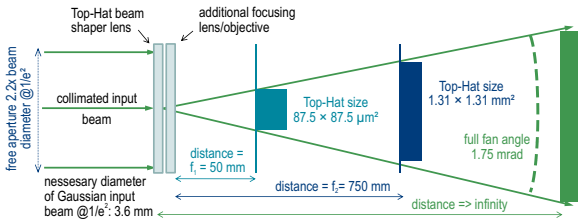
For all setups using GTH beam shaper the user has to consider that the free aperture along the total beam path has to be at least 2.2 (better 2.5) times bigger than the beam diameter @ 1/e².

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.

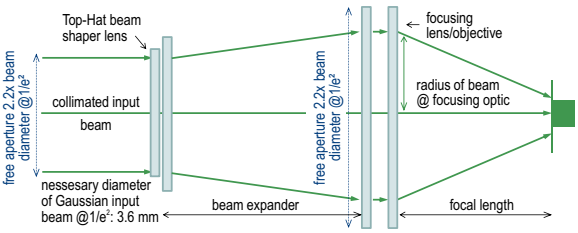
The necessary beam diameter at the position of GTH-3.6-1.75FA is 3.6 mm @ 1/e².

The resulting Top-Hat size is given by: $\frac{1.75}{1000} \cdot$ 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:

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

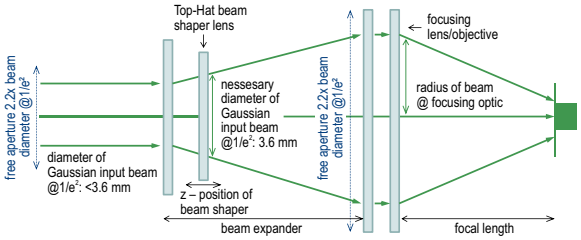
NA represents the numerical aperture of focused beam and is given by:

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

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:

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



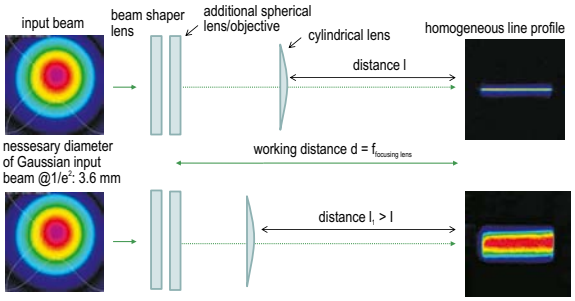
A further and even more flexible possibility is to introduce GTH-3.6-1.75FA into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of GTH-3.6-1.75FA by shifting shaper along z-axis. It's just necessary to consider that the beam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

$$\approx \frac{3.2\ \mu m}{NA} \Rightarrow\approx$$ 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

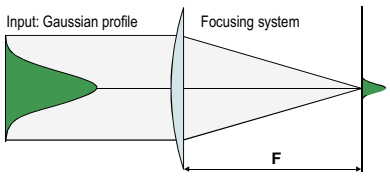
- **New Diffractive Beam Shaping Concept based on Fourier methods**
- **Transforming Gaussian TEM_{00} beam into square or round homogeneous Top-Hat profile**
- **Top Hat size is near diffraction limited and is given by: ~λ /NA**
- **Achievable Top Hat sizes: 1 µm – 200 µm**

SPECIFICATIONS

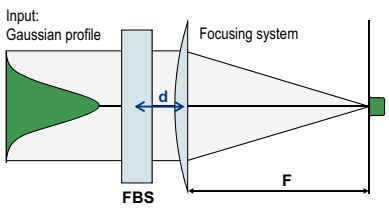
Material	fused silica	
Diameter	25.4 mm	tolerance ±0.1 mm
Input Beam	TEM_{00}, different models for diameter@1/e²: 2.0 ... 10.0 mm with 0.5 mm step	tolerance ±5%
Necessary Free Aperture	2.2x (or better 2.5x) beam diameter@1/e²	along total beam path
Top Hat Size	1.5x diffraction limited Gaussian spot	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	> 95%	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



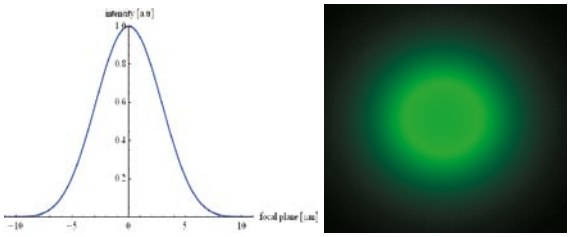
With FBS Beam Shaper: Top-Hat-profile at focal plane

- 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

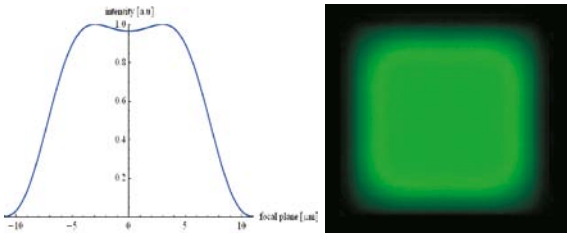
Intensity distribution at focal plane

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

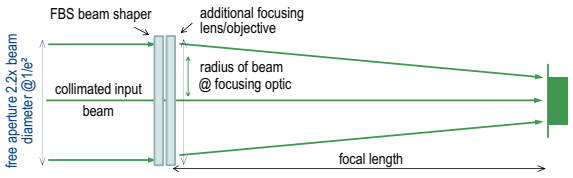
Optical setup for FBS Top-Hat beam shaper

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

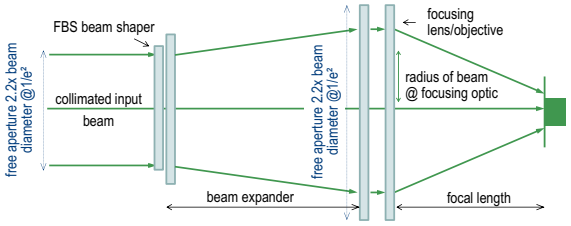


By introducing the FBS beam shaper into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a homogeneous Top-Hat profile.

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.

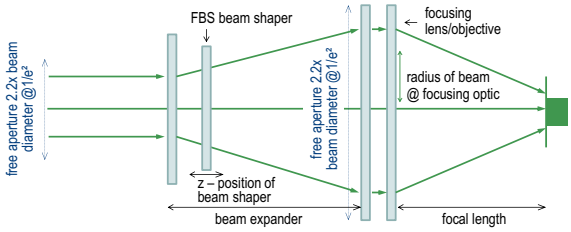
2. Beam shaper in front of a beam expander



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.

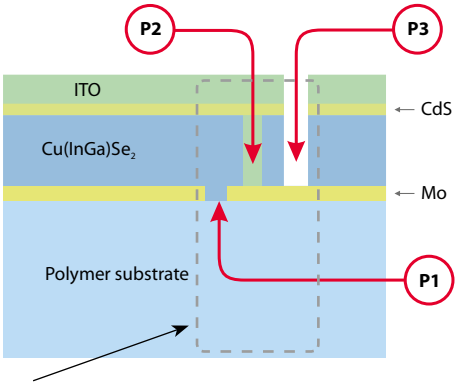
Example: A Gaussian beam with a diameter of 5 mm@1/e² illuminates the FBS beam shaper and is afterwards increased by a beam expander to a beam diameter of 8 mm. With an focusing optic with f=50 mm the user can generate a Top Hat with a diameter of 7 µm. The needed free aperture increases with the expanded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



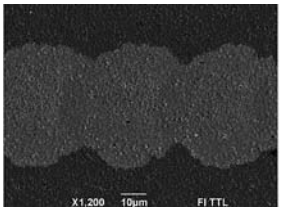
A further and even more flexible possibility is to introduce the FBS beam shaper into the beam path within a beam expander. The user has the possibility for an easy “fine tuning” of beam diameter at the position of FBS beam shaper by shifting shaper along z-axis.

Scribing of CIGS-solar cells

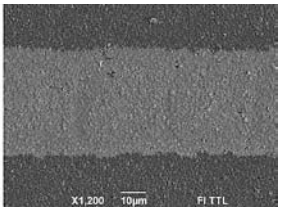


- Wasted area, reducing efficiency → need of smallest scribing lines
- Cut quality influence efficiency → need of small HAZ, no debris, smooth edges
- High scanning speed for high throughput → need of small pulse overlap

P1 – „Scribing“



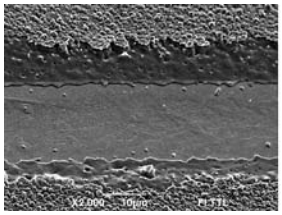
Gaussian Profile



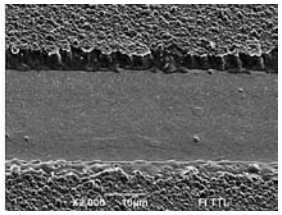
FBS-Top-Hat Profile
small overlap, smooth edges

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.

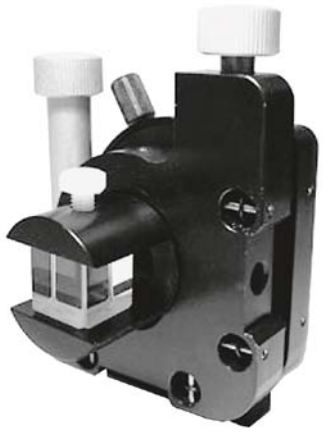
Raciukaitis et. al, JLMN-Vol. 6, No. 1, 2011

RECOMMENDED ACCESSORIES

Zoom Beam Expander
See page 7.4

Two Axes Translation Polarizer Holder 840-0240
See page 8.98

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.

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	810
990-0062-11	1030	15	810
990-0063-11	800	8	810
990-0064-11	532	6	810
990-0065-11	355	3	855

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

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]	1150
990-0060-11IR	700-1000	2 [2]	1150

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

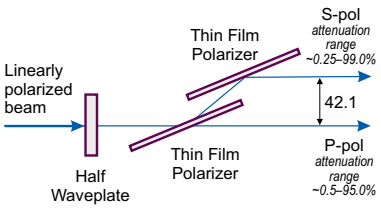
990-0070 VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM

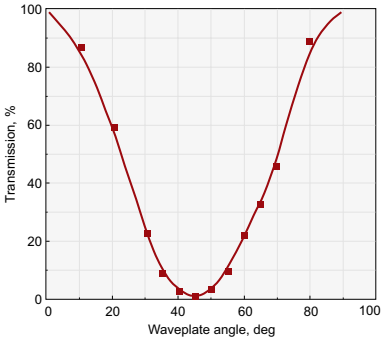
*Note: Movable base **820-0090**, Rod Holder **820-0050-02** and standard rod should be ordered seperately.*

- **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**
- **Weight – 0.35 kg**

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

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

RELATED PRODUCTS

Beam dumps 990-0800, 990-0820

See page 7.36

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
990-0070-266	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).

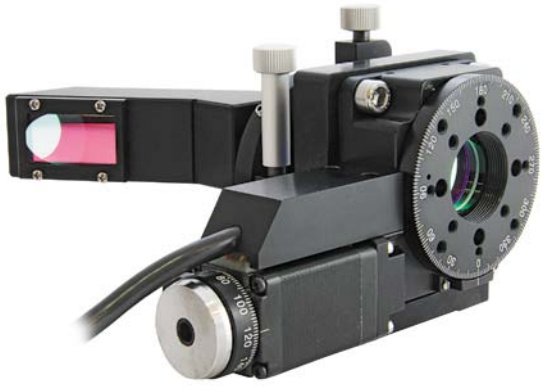
For High Power Femtosecond Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
990-0070-266H	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.

- **New compact design!**

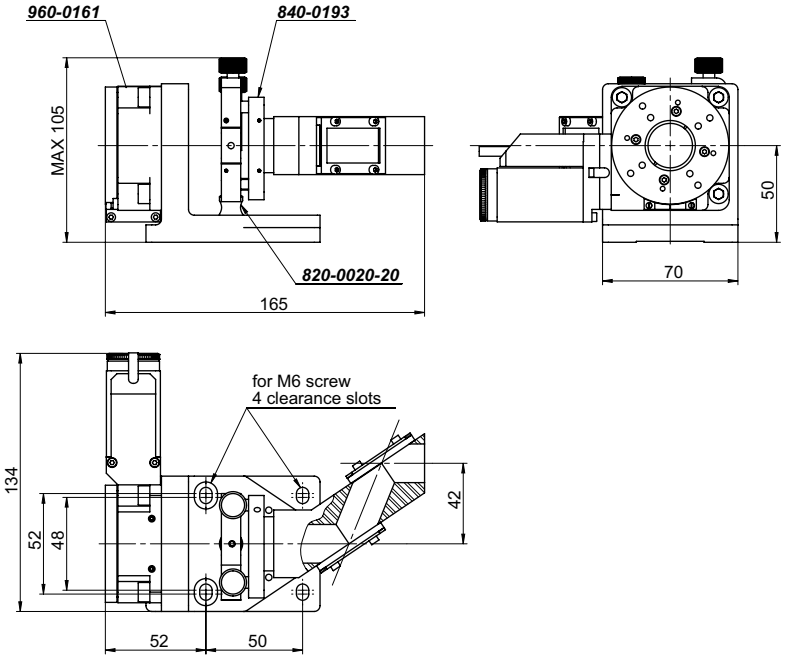
Ordering information

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 990-0841 and power supply: 980-0841), please ad CP to code and 600 EUR to price.

Example:

990-0070-266M – motorized attenuator without controller and power supply.
Price – 1630 EUR

990-0070-266M+CP – motorized attenuator with controller (990-0841) and power supply (980-0841).
Price – 2230 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/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
990-0070-266M	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/cm², 50 fsec pulse, 800 nm typical).

For High Power Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
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

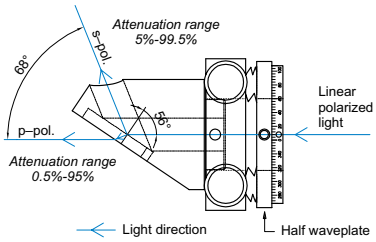
Zero Order Air-Spaced half waveplate is housed in Motorized Rotation Stage 960-0161 and Polarizer with adapter in Kinematic Optical Mount 840-0193 for high power femtosecond laser application (laser damage threshold: >100 mJ/cm², 50 fsec pulse, 800 nm typical).

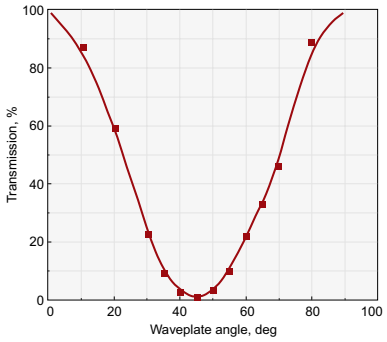
990-0071 VARIABLE ATTENUATORS FOR LINEARLY POLARIZED LASER BEAM

*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**
- **Weight – 0.25 kg**

For Nd:YAG Laser Applications

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

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

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/cm² pulsed at 1064 nm, typical).

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

For Femtosecond Applications

Catalogue number	Wavelength, nm	Price, EUR
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/cm², 50 fs pulse at 800 nm, typical).

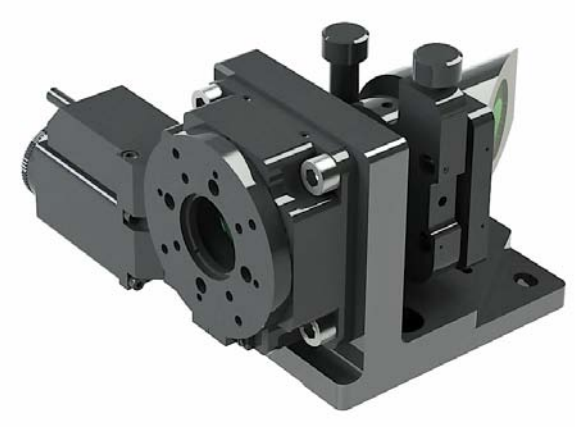
For High Power Femtosecond Laser Applications

Catalogue number	Wavelength, nm	Price, EUR
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/cm², 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!**

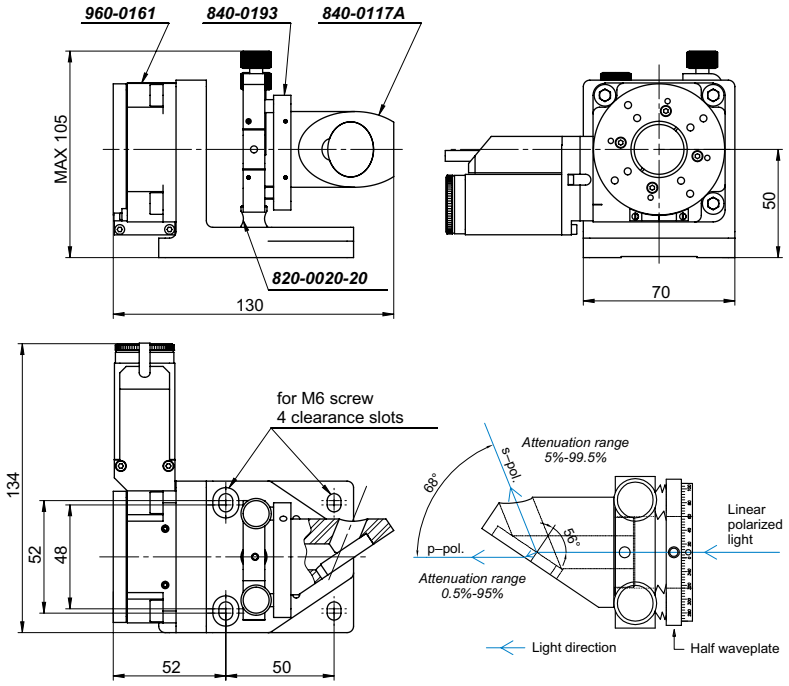
Ordering information

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 990-0841 and power supply: 980-0841), please ad CP to code and 600 EUR to price.

Example:

990-0071-266M – motorized attenuator without controller and power supply.
Price – 1295 EUR

990-0071-266M+CP – motorized attenuator with controller (990-0841) and power supply (980-0841).
Price – 1895 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

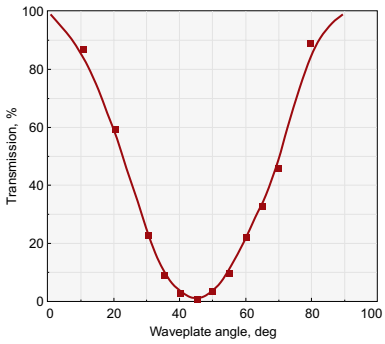
- **New compact design!**

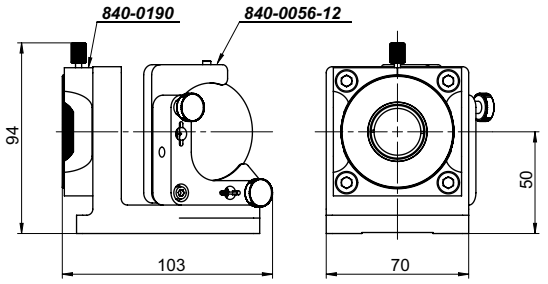
- **Divides laser beam into two parallel beams of manually adjustable intensity ratio**
- **Large dynamic range**
- **Trasmitted beam shift ~1 mm**
- **High optical damage threshold**
- **Look online for motorized version 990-0072M**

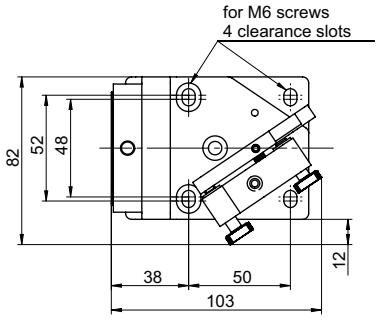
This variable attenuator/beamsplitter consists of Polarizer Holder 840-0180-A1 and Kinematic Mirror/Beamsplitter Mount 840-0056-12. UVFS Thin Film Brewster type polarizer diameter 50.8 mm, which reflect s-polarized light while transmitting p-polarized light, is housed into Beamsplitter Mount 840-0056-12. 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 840-0180-A2.

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 840-0180-A2.*

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

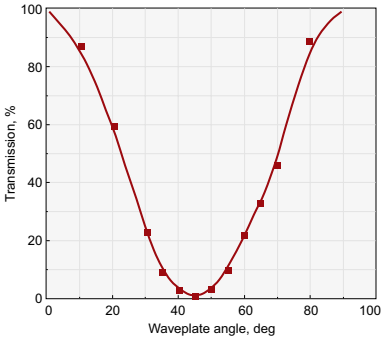
990-0073 VARIABLE ATTENUATOR FOR FEMTOSECOND AND Nd:YAG LASER PULSES

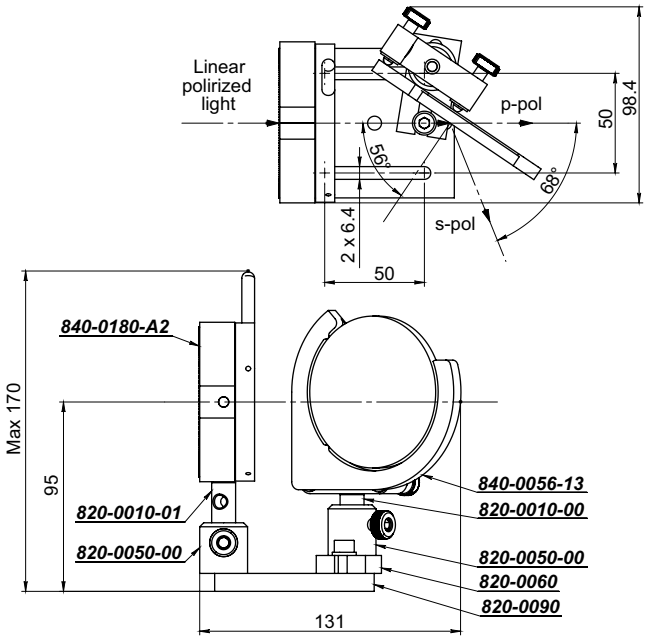
- **Divides laser beam into two parallel beams of manually adjustable intensity ratio**
- **Large dynamic range**
- **Trasmitted beam shift ~1.4 mm**
- **High optical damage threshold**
- **Motorized version available on request**

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

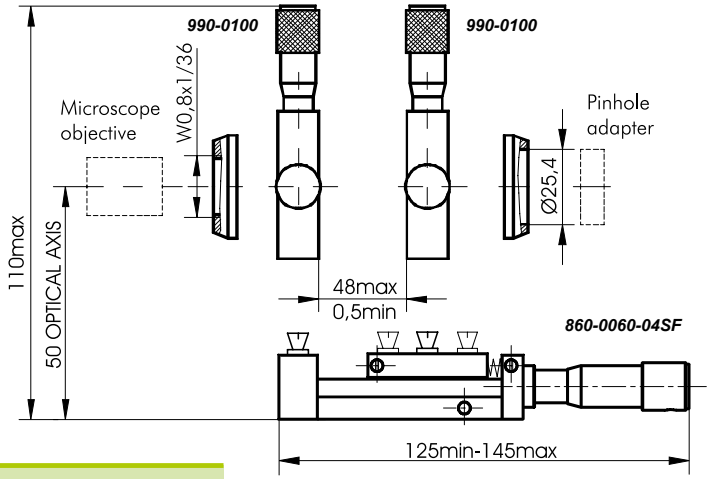
Catalogue number	Wavelength, nm	Price, EUR
990-0073-266	266	1690
990-0073-343	343	1560
990-0073-400	400	1540
990-0073-515	515	1540
990-0073-800	800	1560
990-0073-800B	780-820	1790
990-0073-1030	1030	1615
990-0073-1030B	1010-1050	1850

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

990-1000 PRECISION SPATIAL FILTER

***990-1000** with Precision Pinholes and Microscope Objectives*



- **3-axes adjustment with micrometers**
- **Accommodates virtually any microscope objective**
- **Unobscured view of a pinhole facilitates alignment**
- **Easy pinhole removal and replacement**

Microscope Objective and Precision Pinholes can be supplied as option.

Precision Spatial Filter 990-1000 can be used to filter a beam of any power, generated by visible to near infrared laser. The result – the output beam is delivered with a smooth, near ideal intensity profile. The Spatial Filter consists of two YZ Positioners 990-0100 and Translation Stage 860-0060-04SF (modification of 860-0060-04). YZ Positioner for Lens, Pinholes and Objectives 990-0100 provides adjustment of the pinhole and objective in two axes. The precision X axis motion is provided by Translation Stage 860-0060-04SF.

The pinhole and the objective should be selected and ordered separately. Provided selection of interchangeable microscope objective lenses and precision pinholes allow to build the best spatial filter for your laser.

Code	Weight, kg	Price, EUR
990-1000	0.87	480

Complementary Products

Code	Page
850-0040	8.102
860-0060-04	8.111
990-0100	7.20

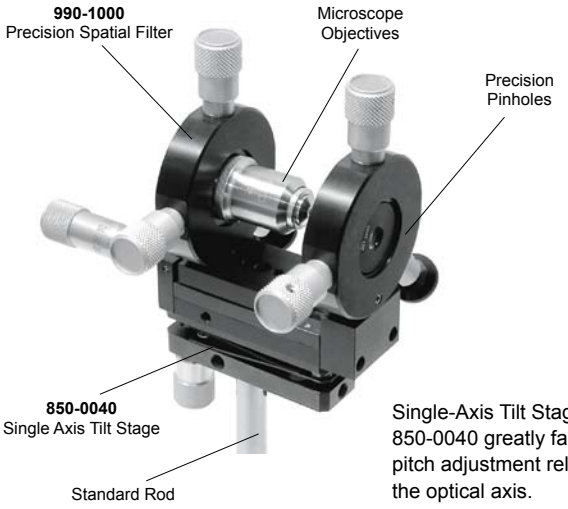
RELATED PRODUCTS

Precision pinholes

See page 7.21

Microscope objectives

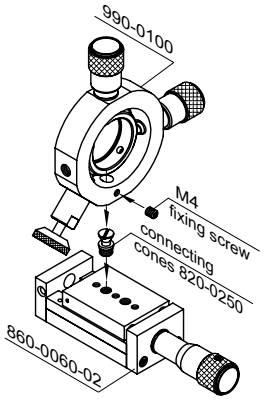
See page 7.21



Single-Axis Tilt Stage 850-0040 greatly facilitates pitch adjustment relative to the optical axis.

990-0100 • 990-0200 Y-Z POSITIONER FOR LENS, PINHOLES AND OBJECTIVES

990-0100



Y-Z Positioners for Lens, Pinholes and Objectives are compact mounts designed to precisely position optical components in the plane orthogonal to the optical axis. Ideal for microscope objectives, mounted pinholes, fiber optics chucks, and diode lasers.

The mounts provide 5 mm translation with sensitivity of 2 µm.

990-0100 may contain one of 1 inch rings: W0.8, A1 or B1.

990-0200 may contain one of 2 inch rings: A2 or B2.

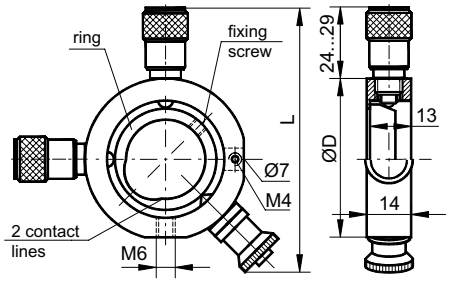
Two adjustment screws 870-0030 are used for positioning. They can be replaced with any screw or micrometer with M10×1 mounting thread.

Two ways to fasten positioner: mounting posts 820-0010 by an M6 hole; on a connecting cone 820-0250; 820-0254 by a Ø7 hole.

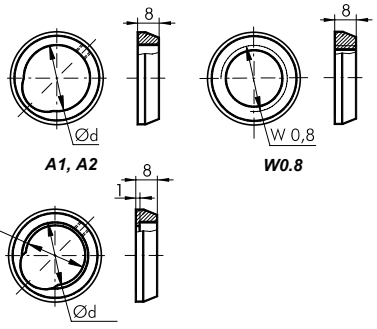
Material: black anodized aluminium.

ORDERING INFORMATION

990-0100-A1	1” Positioner with ring A1
990-0200-A2	2” Positioner with ring A2
990-0100-B1	1” Positioner with ring B1
990-0200-B2	2” Positioner with ring B2
990-0100-W0.8	1” Positioner with ring W0.8



Insert rings



Model	D, mm	d, mm	C, mm	L, mm	Weight, kg	Price, EUR
990-0100	58	25.5	24	102	0.26	149
990-0200	83	51	48	127	0.38	159

990-0050 • 990-0051 Y-Z POSITIONERS FOR LENS, PINHOLES AND OBJECTIVES

990-0050

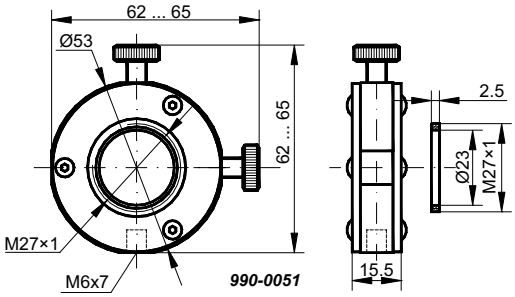
990-0051

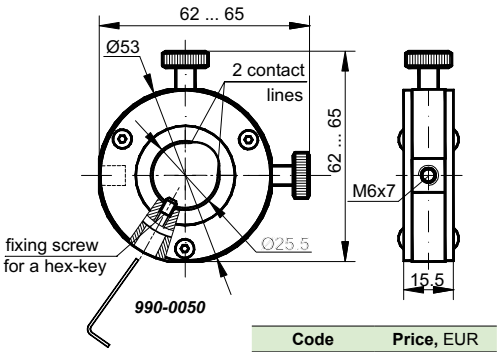
- **Travel range 3 mm**
- **Fine adjustment screws with 0.25 mm pitch**
- **The movable carriage could accept Ø25.4 optics up to 9 mm thick**
- **Alternatively, the movable carriage could be used to mount additional lens tubes**

Y-Z Positioner 990-0050 accepts optics Ø25.4 mm. Optics is stopped by a rest-flange inside the central aperture of the platform and is secured by a hex fixing screw with hard plastic tip. 990-0050 is ideal for microscope objectives, mounted pinholes, fiber optics chucks and diode lasers.

990-0051 includes two plastic padding rings and a retaining ring M27x1 to fix the optics.

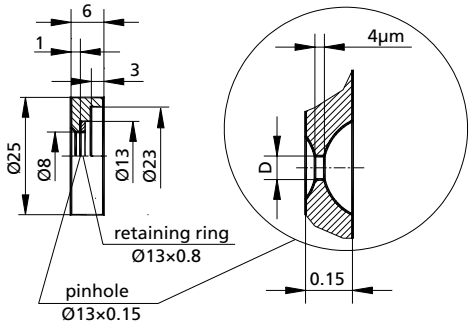
A tightening key for the retaining ring is available on request.





Code	Price, EUR
990-0050	119
990-0051	119

PRECISION PINHOLES



- **For diffraction experiments, alignment purposes, projection applications**
- **Chemically etched apertures**
- **Apertures formed in vacuum**
- **4 µm thick pinhole in a kovar foil**
- **Ultra-thin substrate minimizes laser power loss**
- **Chemically inert**

Precision Pinhole is a round aperture precisely formed and controlled in a kovar foil. To facilitate handling, a pinhole foil is mounted in Ø25 mm black metal donut.
Precision Pinholes can be used in Precision Spatial Filters 990-1000 or YZ Positioner for Lens, Pinholes and Objectives 990-0100.

We also offer pinholes with diameter D in the range of 45–100 µm every 5 µm.
Pinholes of custom diameters up-to 200 µm are available on request.

Model	D, µm	Price, EUR
990-0010	10±0.5	39
990-0020	20±0.5	34
990-0030	30±0.5	29
990-0040	40±0.5	29
990-0049	50±0.5	29
990-0075	75±0.5	29
990-0110	100±0.5	29

***990-1000** Precision Spatial Filter with Precision Pinholes and Microscope Objectives*

990-0100

Single-Axis Tilt Stage 850-0040 greatly facilitates pitch adjustment relative to the optical axis.

Complementary Products

Code	Page
990-1000	7.19
990-0100	7.20

MICROSCOPE OBJECTIVES

- **Plan Achromat or Achromat Design**
- **Wide range of magnifications available**
- **Ideal for Imaging or Focusing Laser Light**
- **RMS (0.800"-36) Threading**

Model	990-0410	990-1125	990-2040	990-4065	990-1025
Magnification	4x	10x	20x	40x	100x
Numerical aperture	0.10	0.25	0.40	0.65	1.25
Focal length, mm	40	16	8	4	1.6
Working distance, mm	23.40	13.13	1.70	0.41	0.10
Design type	Air immersion				Oil immersion
Mechanical tube length, mm	160				
Optical scheme	Plan Achromat		Achromat		
Mounting thread	0.8"-36 RMS				
Wavelength range	Visible Spectrum				

Complementary Products

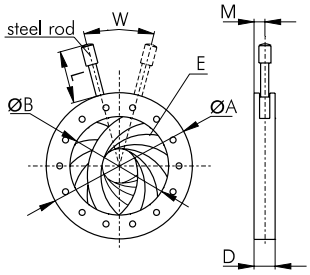
Code	Page
840-0120	8.83
990-1000	7.19

992 • 993 • 994 UNMOUNTED IRIS DIAPHRAGMS

EKSMA OPTICS offers three types of unmounted Iris Diaphragms: Zero aperture Iris Diaphragms (992 series), standard iris diaphragms with retainer (993 series), standard iris diaphragms screwed (994 series).

Iris diaphragm provides a continuously variable field stop for controlling the focal length of an optical system or for adjusting the diameter of a beam. Iris diaphragms enable smooth operation over the lever travel, from maximum to minimum aperture. Lever actuators of the iris diaphragms are either of plastic tab or steel pin. Zero Aperture iris diaphragms provide total light extinction.

Zero Aperture Iris Diaphragms (992 Series)



AR - Leaves with AR coating, for temperatures up to 180 ºC

N - Springsteel, black finished, for temperatures up to 250 ºC

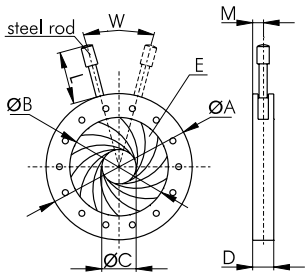
H - Stainless steel, for temperatures up to 400 ºC

HT - High-temperature alloy for up to 1000 ºC

Code	A, Outer Diameter, mm	B, Max. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	N/H/HT
992-2008	20	8	4	8	Tab	6	2	90	H/N
992-2512	25	12	5	12	Pin	12	2.5	96	H/N
992-2915	29	15	5	12	Pin	12	2.5	97	H/N
992-3922	39	22	5	14	Pin	12	2.5	99	H/N
992-4830	48	30	5	14	Tab	11	2.5	100	H/N/HT
992-6940	69	40	6.5	14	Tab	16	3.3	96	H/N/HT
992-7950	79	50	7	18	Pin	20	3.5	100	H/N/HT
992-9460	94	60	9	16	Tab	25	4.5	98	H/N/HT
992-1177	117	75	9.5	18	Tab	53	4.8	97	H/N/HT
992-1258	125	85	9.5	18	Tab	50	4.8	98	H/N/HT
992-1359	135	98	8.5	20	Tab	50	4.3	102	H/N/HT
992-1601	160	113	13	20	Pin	18	6.5	99	N/H/NT

Please add letter H, N or HT to code to indicate temperature needed.

Iris Diaphragms with Retainer (993 Series)



AR - Leaves with AR coating, for temperatures up to 180 ºC

N - Springsteel, black finished, for temperatures up to 250 ºC

H - Stainless steel, for temperatures up to 400 ºC

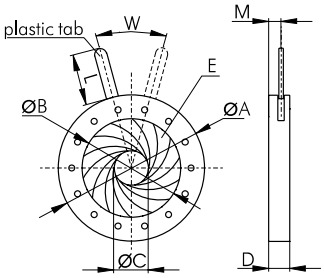
HT - High-temperature alloy for up to 1000 ºC

Code	A, Outer Diameter, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	AR/N/H
993-1005	10	5	0.5	4	8	Pin	4	2.4	78	AR/N
993-1207	12	7	0.5	4	8	Pin	6	2.4	88	AR/N
993-1482	14	8.2	0.8	4	8	Pin	6	2.4	80	N
993-1488	14.8	8	1	4.5	9	Pin	6	2.5	77	N
993-1610	16	10	1	4	10	Pin	6	2.4	83	N
993-1912	19.8	12	1	5	11	Pin	10	2.7	89	AR/H/N
993-2214	22	14	1	5	10	Pin	10	2.7	94	AR/N
993-2415	24	15	1	5	12	Pin	13	2.7	89	H/N
993-2818	28	18	1	5	12	Pin	13	2.7	90	AR
993-3020	30	20	1.2	5.5	12	Pin	13	2.9	90	AR/H/N

Code	A, Outer Diameter, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	AR/N/H
993-3322	33	22	1.5	5.5	14	Pin	13	2.9	94	N
993-3725	37	25	1.5	5.5	15	Pin	13	3	93	H/N
993-4027	40	27	1.5	5.5	12	Pin	13	3	90	AR/H/N
993-4330	43	30	1.5	5.5	14	Pin	13	3	92	AR/H/N
993-4934	49	34	2	6.5	14	Pin	13	3.5	91	AR/H/N
993-5036	50	36	2.5	6	16	Pin	13	3.2	92	H/N
993-5337	53	37	2.5	6	16	Pin	13	3.2	89	N
993-5842	58	42	2.5	6.5	18	Pin	13	3.3	93	H/N
993-6040	60	40	2.5	6.5	12	Pin	13	3.3	88	H/N
993-6445	64	45	2.5	7	14	Pin	13	3.8	92	H/N
993-7050	70	50	2.5	7	18	Pin	15	4	94	H/N
993-8260	82	60	4	8	17	Pin	13	4.4	91	H/N
993-1075	100	75	4	9	20	Pin	15	4.5	95	H/N
993-1181	110	81	3	10	16	Pin	15	5	94	AR
993-1290	120	90	3.5	12	20	Pin	15	6.5	97	AR
993-1398	130	98	4	12	20	Pin	20	6.5	97	H/N
993-1513	150	113	6	13	20	Pin	20	7.2	95	H/N
993-1612	165	120	6	15	18	Pin	20	7.9	94	H/N
993-1914	195	145	8	16	18	Pin	18	8.9	93	N

Please add letter AR, N or H to code to indicate temperature needed.

Screwed Iris Diaphragms (994 Series)



AR - Leaves with AR coating, for temperatures up to 180 °C

N - Springsteel, black finished, for temperatures up to 250 °C

H - Stainless steel, for temperatures up to 400 °C

HT - High-temperature alloy for up to 1000 °C

Code	A, Outer Diameter, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	N
994-1508	15	8	1	5.3	9	Tab	5	2.5	81	N
994-1585	15.5	8.5	1	5.3	9	Tab	8	2.6	75	N
994-2214	22	14	1	6	10	Tab	12	3	90	AR/N
994-3118	31	18	1.5	6.5	11	Tab	10	3.4	85	N
994-4027	40	27	1.5	6.2	12	Tab	11	3.5	90	AR/N
994-4830	48.5	30	1.2	7	10	Tab	10	3.6	86	N
994-6040	60	40	2.5	7.8	12	Tab	13	4.6	88	N
994-7050	70	50	2.5	7	18	Tab	13	4	94	N
994-8260	82	60	4	10	17	Tab	11	5.4	91	N

Please add letter AR or N to code to indicate temperature needed.

992 • 993 • 994 MOUNTED IRIS DIAPHRAGMS

992-2915M

993-2415M

In optics there are a lot of fields where accurate amount of light, precise projection, specific depth of focus and other requirements are necessary. For such areas the use of iris diaphragms is one of the best options. These applications are met in industry of optics, opto-electronics, laser and medical technology, lightening technology and other. Our iris diaphragms are made of high quality materials. Also, we use highest manufacturing standards. These points lead to reliability and durability of our products.

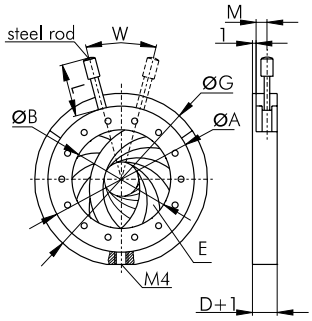
DESIGN

Our iris diaphragms consist of leaves and case. Leaves are made of hardened spring steel. Stainless chrome nickel steel can be used when better resistance to heat is necessary. The surface of leaves is polished and reducing the reflections. The edges of the leaves are rounded to achieve smooth operation. For increasing the slip of leaves an invisible coating is applied. Next, protection from corrosion is guaranteed by particular polishing process. Further, for producing the case, corrosion resistant aluminum alloy is used. Fine mat black look is achieved by black-anodizing the surface of the case.

CUSTOM MODELS

We have a wide variety of iris diaphragms that suit to different applications. Also, we introduce the series of fully closing iris diaphragms to meet the needs of all customers. Nevertheless, if you don't find a suitable model, we can make custom iris diaphragm. The changes can be made in dimensions, form; it can be adapted to high temperatures, adapted for special fastening or modified according to your other requests.

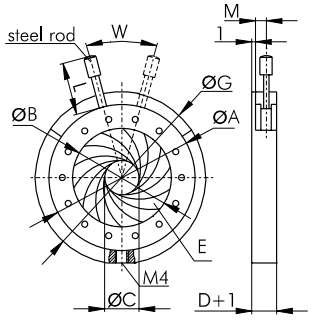
Mounted Zero Aperture Iris Diaphragms (992 Series)



Code	A, Outer Diameter, mm	G, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	N/H
992-2512M	25	32.5	12	-	5	12	Pin	12	2.5	96	H/N
992-2915M	29	36.5	15	-	5	12	Pin	12	2.5	97	H/N
992-3922M	39	46	22	-	5	14	Pin	11	2.5	99	H/N

AR - Leaves with AR coating, for temperatures up to 180 ºC
H - Stainless steel, for temperatures up to 400 ºC
N - Springsteel, black finished, for temperatures up to 250 ºC
HT - High-temperature alloy for up to 1000 ºC

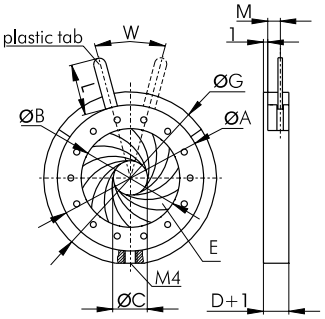
Mounted Iris Diaphragms with Retainer (993 Series)



Code	A, Outer Diameter, mm	G, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	AR/N/H
993-2214M	22	29.5	14	1	5	10	Pin	10	2.7	94	AR/N
993-2415M	24	31	15	1	5	12	Pin	13	2.7	89	N/H
993-3725M	37	44	25	1.5	5.5	15	Pin	13	3	94	N/H
993-4934M	49	56	34	2	6.5	14	Pin	13	3.4	93	AR/H
993-5036M	50	57	36	2.5	6	16	Pin	13	3.2	93	N
993-7050M	70	77	50	2.5	7	18	Pin	15	3.8	93	N
993-1488M	14.8	23	8	1	4.5	9	Pin	6	2.5	77	N
993-1482M	14	22	8.2	0.5	4	8	Pin	6	2.4	84	N

AR - Leaves with AR coating, for temperatures up to 180 ºC
H - Stainless steel, for temperatures up to 400 ºC
N - Springsteel, black finished, for temperatures up to 250 ºC
HT - High-temperature alloy for up to 1000 ºC

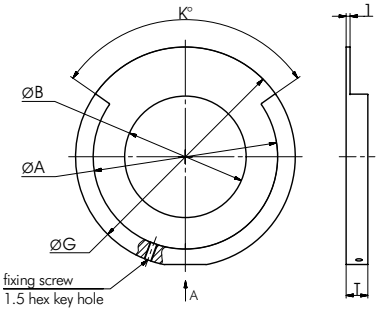
Mounted Screwed Iris Diaphragms (994 Series)

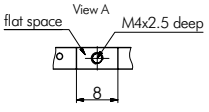


Code	A, Outer Diameter, mm	G, mm	B, Max. Aperture, mm	C, Min. Aperture, mm	D, Thickness, mm	E, Number of Leaves	Tab/ Pin	L, mm	M, mm	W, mm	AR/N/H
994-2214M	22	29.5	14	1	6	10	Tab	12	2,8	91	N
994-3118M	31	38	18	1,5	6.5	11	Tab	10	3,4	85	N
994-4830M	48.5	55.5	30	1,2	7	10	Tab	10	3,7	87	N
994-7050M	70	77	50	2,5	7	18	Tab	13	3,9	93	N
994-1508M	15	23	8	1	5,3	9	Tab	5	2,3	75	N
994-1585M	15,5	23	8,5	1	5,3	9	Tab	8	2,3	85	N

AR - Leaves with AR coating, for temperatures up to 180 ºC
N - Springsteel, black finished, for temperatures up to 250 ºC
H - Stainless steel, for temperatures up to 400 ºC
HT - High-temperature alloy for up to 1000 ºC

992-34 MOUNTS FOR IRIS DIAPHRAGMS



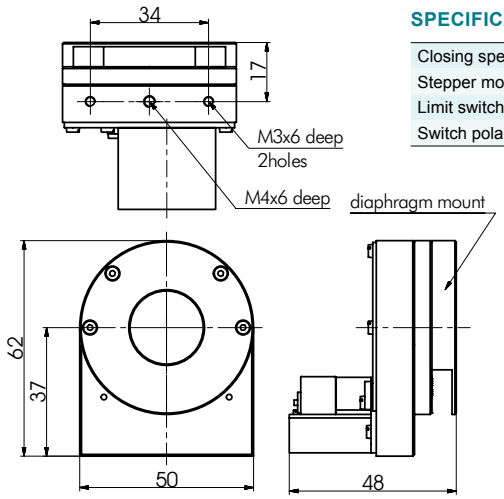


Code	G, mm	A, mm	B, mm	T, mm	K, deg
992-34-10	18	10	6	6	106
992-34-12	20	12	9	6	122
992-34-14	22	14	10	6	140
992-34-14.8	23	14.8	10	6	130
992-34-15	23	15	10	6.3	123
992-34-15.5	23	15.5	10.5	6.3	125
992-34-19.8	28	19.8	14	7	125
992-34-22	29.5	22	16	7	130
992-34-24	31	24	17	6	123
992-34-25	32.5	25	14	6	127
992-34-28	35.5	28	20	6	125
992-34-29	36.5	29	17	6	125
992-34-30	37.5	30	22	6.5	125
992-34-31	38	31	20	7.5	110
992-34-37	44	37	27	6.5	116
992-34-39	46	39	24	6	120
992-34-40	48	40	29	7	112
992-34-48	55.5	48	32	6	116
992-34-48.5	55.5	48.5	32	8	104
992-34-49	56	49	36	7.5	110
992-34-50	57	50	38	7	110
992-34-60	67	60	42	8	104
992-34-70	77	70	52	8	105
992-34-82	89	82	62	9	105

995 Series

MOTORIZED IRIS DIAPHRAGMS (Max. Aperture Range 5-27 mm)

995 Series Motorized Iris Diaphragms are available with a wide range of apertures (from 5 mm to 98 mm). Irises with max. apertures from 5 mm to 27 mm are shown on this page. Irises with max. apertures up to 27 mm close from min. to max. in 1.2 seconds with resolution depending on aperture size (see table below). Zero aperture motorized iris diaphragms are available on request, max. aperture sizes from 12 mm to 40 mm.



SPECIFICATIONS

Closing speed (min to max)	1.2 seconds
Stepper motor/gear	50:1
Limit switch	2 mechanical
Switch polarity	pushed is closed

TEMPERATURE LIMITS

AR - Leaves with AR coating, for temperatures up to 180 ºC

N - Springsteel, black finished, for temperatures up to 250 ºC

H - Stainless steel, for temperatures up to 400 ºC

Catalogue number	Diaphragm Used	Min. Clear Aperture, mm	Max. Clear Aperture, mm	Resolution, steps per mm	Price, EUR
995-1005-AR	993-1005-AR	0.5	5	444	855
995-1005-N	993-1005-N	0.5	5	444	855
995-1207-AR	993-1207-AR	0.5	7	308	855
995-1207-N	993-1207-N	0.5	7	308	855
995-1488-N	993-1488-N	1	8	286	855
995-1482-N	993-1482-N	0.5	8.2	260	855
995-1912-AR	993-1912-AR	1	12	182	855
995-1912-H	993-1912-H	1	12	182	855
995-1912-N	993-1912-N	1	12	182	855
995-2214-AR	993-2214-AR	1	14	154	855
995-2214-N	993-2214-N	1	14	154	855
995-2415-H	993-2415-H	1	15	143	855
995-2415-N	993-2415-N	1	15	143	855
995-2818-AR	993-2818-AR	1	18	118	855
995-3020-AR	993-3020-AR	1.2	20	106	855
995-3020-H	993-3020-H	1.2	20	106	855
995-3020-N	993-3020-N	1.2	20	106	855
995-3322-N	993-3322-N	1.5	22	98	855
995-3725-N	993-3725-N	1.5	25	85	855
995-4027-AR	993-4027-AR	1.5	26	78	855
995-4027-H	993-4027-H	1.5	26	78	855
995-4027-N	993-4027-N	1.5	26	78	855

RECOMMENDED CONTROLLERS

980-0040-USB

see page 8.196

996 Series

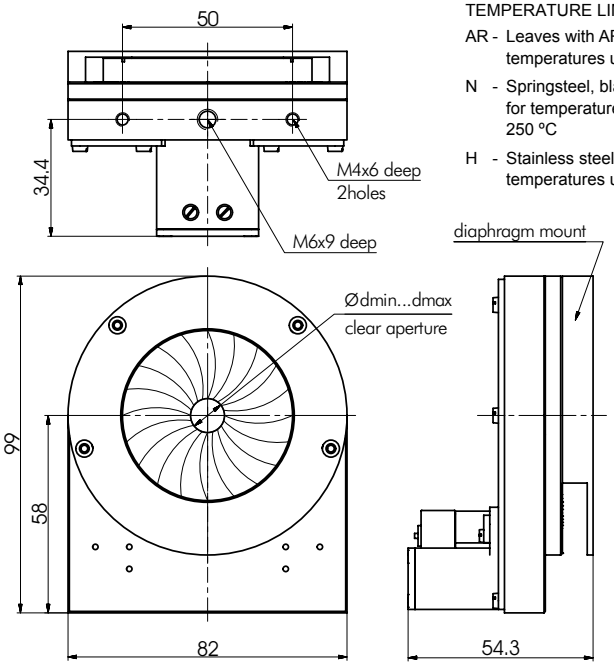
MOTORIZED IRIS DIAPHRAGMS (Max. Aperture Range 30-50 mm)

Irises with max. apertures from 30 mm to 50 mm close from min. to max. in 2 seconds with resolution depending on aperture size (see table below).

Zero aperture motorized iris diaphragms are available on request, max. aperture sizes from 12 mm to 40 mm.

SPECIFICATIONS

Closing speed (min to max)	2 seconds
Stepper motor/gear	50:1
Limit switch	2 mechanical
Switch polarity	pushed is closed
Stepper motor	PG15/50



TEMPERATURE LIMITS

AR - Leaves with AR coating, for temperatures up to 180 °C

N - Springsteel, black finished, for temperatures up to 250 °C

H - Stainless steel, for temperatures up to 400 °C

Catalogue number	Diaphragm Used	dmin Aperture, mm	dmax Aperture, mm	Resolution, steps per mm	Price, EUR
996-4330-H	993-4330-H	1.5	30	70	951
996-4330-N	993-4330-N	1.5	30	70	951
996-4934-AR	993-4934-AR	2	34	62	951
996-4934-N	993-4934-N	2	34	62	951
996-5036-N	993-5036-N	2.5	36	60	951
996-5337-N	993-5337-N	2.5	37	58	951
996-6040-N	993-6040-N	2.5	40	53	951
996-5842-N	993-5842-N	2.5	42	51	951
996-6445-H	993-6445-H	2.5	45	47	951
996-6445-N	993-6445-N	2.5	45	47	951
996-7050-N	993-7050-N	2.5	50	42	951

RECOMMENDED CONTROLLERS

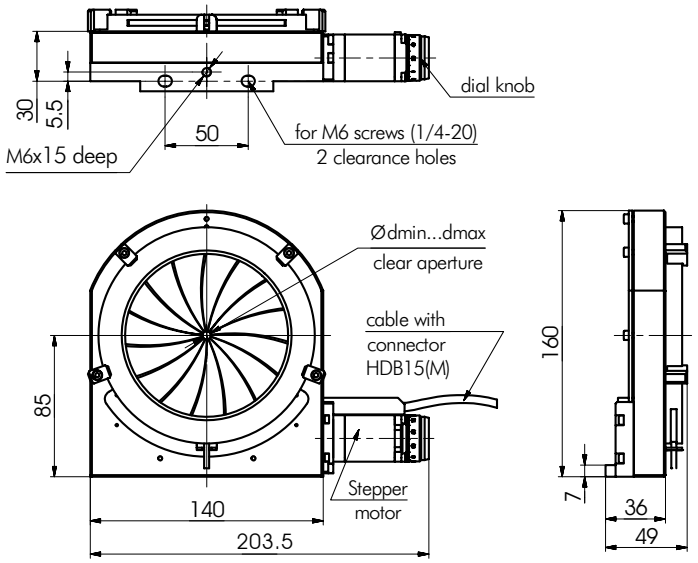
980-0040-USB

see page 8.196

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

997 Series

MOTORIZED IRIS DIAPHRAGMS (Max. Aperture Range 60-98 mm)



- **Smooth and fast operation**
- **Continuously adjustable light attenuation**
- **Compact design**
- **Control via PC through USB or RS232**
- **Adjustable inserts**

997 Series Motorized Iris Diaphragm Mount was developed due to interest in our previously presented motorized iris 993 Series. Iris diaphragms cannot be changed by the user, because every diaphragm has its own adapter ring and requires calibration.

SPECIFICATIONS

Closing speed (min to max)	3 sec
Stepper motor/gear	195:1
Limit switch	2, mechanical
Switch polarity	pushed is closed

TEMPERATURE LIMITS

AR - Leaves with AR coating, for temperatures up to 180 ºC

N - Springsteel, black finished, for temperatures up to 250 ºC

H - Stainless steel, for temperatures up to 400 ºC

Catalogue number	Diaphragm used	Max. aperture, mm	Min. aperture, mm	Resolution, steps per mm
997-8260-H	993-8260-H	60	4	696
997-8260-N	993-8260-N	60	4	696
997-1075-H	993-1075-H	75	4	549
997-1075-N	993-1075-N	75	4	549
997-1181-AR	993-1181-AR	81	3	500
997-1290-AR	993-1290-AR	90	3.5	451
997-1398-H	993-1398-H	98	4	415
997-1398-N	993-1398-N	98	4	415

RECOMMENDED CONTROLLERS

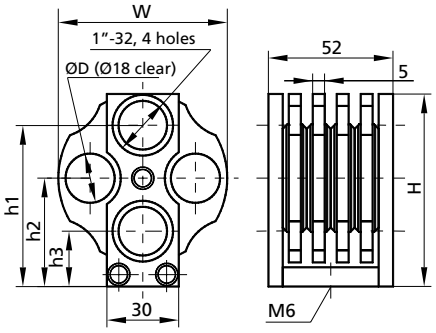
980-0040-USB

see page 8.196

990-0604 VARIABLE WHEEL ATTENUATOR

990-0604-01

- **4 wheels**
- **3 filter per wheel (12 filters in total)**
- **Filter diameter 20 or 25.4 mm**
- **Maximum deviation 0.09 mm**
- **Clear aperture Ø18/Ø20 mm**
- **C-mount threads on both ends**
- **Connecting adapters available**



Variable Wheel Attenuator 990-0604 is a basic model with 4 filter-set wheels. Each wheel contains 4 filter slots each for Ø20 mm with clear aperture of Ø18 mm.

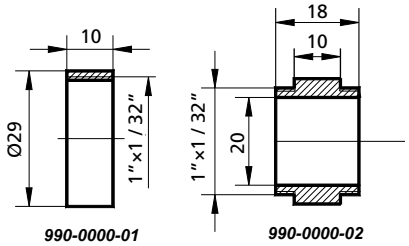
Each filter slot is inclined by 4°to avoid retroreflections.

Each wheel has 4 fixed positions. You can use any of these 4 filter positions as an optical axis. The back and front panels do not to obscure.

Both panels have 1"–32 threaded holes (C-Mounts). Separately you may order standard connecting adapters 990-0000-01, 990-0000-02 and 990-0000-03. Custom adapters are available.

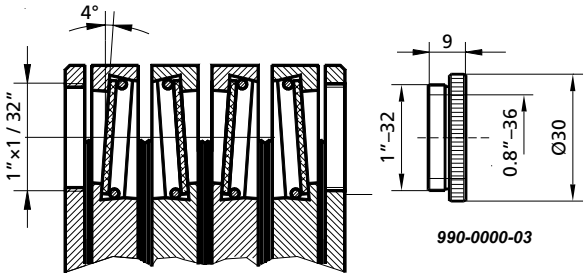
M6 mounting hole is provided in the bottom plate.

990-0604-02 model is designed to accept 1" (25.4 mm) filters with maximum thickness of 3 mm. This model comes without filters.



990-0000-01

990-0000-02



990-0000-03

Model	H, mm	W, mm	h1, mm	h2, mm	h3, mm	D, mm	Weight, kg	Price, EUR
990-0604-01	84	70	67	45	23	Ø20	0.35	457
990-0604-02	95	80	75	50	25	Ø25.4	0.40	297

Note:
960-0604-01 is with filters Ø20 mm.
990-0604-02 is without filters. 960-0604-02 is suitable for Neutral Density and Colour Glass filters Ø25.4 mm that should be ordered seperately.

RELATED PRODUCTS

Neutral Density Filters Ø25.4 mm
See page 1.13

Colour Glass Filters Ø25.4 mm
See page 1.15

990-0704 CLOSED VARIABLE WHEEL ATTENUATOR

990-0704

***991-0704** with a CCD camera*

Close Variable Wheel Attenuator 991-0704
ideally suits for use with CCD cameras. Adapters 990-0000-01 or 990-0000-02 are used for connection.

- **4 wheels, each containing 3 filters & 1 empty space**
- **4 fixed positions per wheel**
- **C-mount threads on both ends**
- **Connecting adapters available**
- **Stray light fully eliminated**
- **Variable height of the optical axis**
- **Three mounting holes**

SPECIFICATIONS

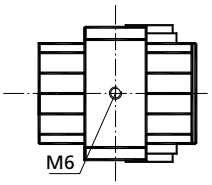
Diameter NDF	20 mm
Maximum thickness	3 mm
Non-parallel filters	(inclined by 4°)
Maximum deviation	0.09 mm
Clear aperture	Ø18 mm

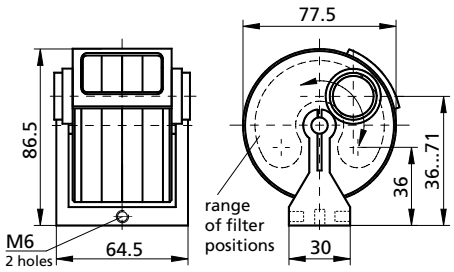
Code	Weight, kg	Price, EUR
990-0704	0.55	549

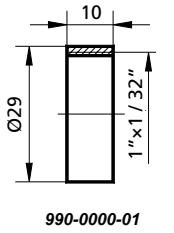
Close Variable Wheel Attenuator is used when it is necessary to fully eliminate the side background lighting when using photodetectors with high sensitivity (e.g. CCD, photomultiplier, etc.). You may order standard connecting adapters 990-0000-01 and 990-0000-02 separately. Custom adapters are available too.

Loosen the central axis and rotate the whole body of the filter to set the desired position of an optical axis at a height between 36–71 mm.

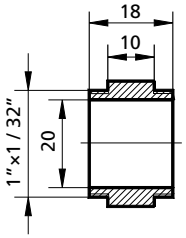
The base of the attenuator has M6 holes on 3 sides for mounting versatility.



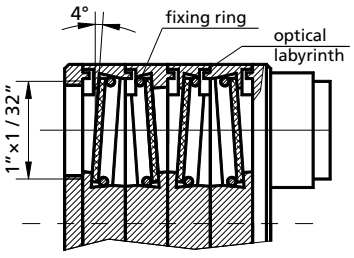




990-0000-01



990-0000-02



SOME APPLICATIONS OF OPTICAL FILTERS

- **In systems for laser beam diagnostics with CCD-cameras**
- **Measurement of laser power, pulse energy and pulse duration**
- **Spectroscopy**
- **We can offer a set of bandpass filters for mercury lamp, laser lines, and for your other needs**

A choice of filters is available for our standard 4-wheel attenuators, allowing 256 relative positions of wheels, rendering 99 different transmission values, of which you can find a very close match to the desired value. Discrete filters permit to establish accurate optical density.

Also we can offer designs with 1, 2, 3 and more wheels.

Variable wheel attenuators come with a standard, most popular, set of filters listed in Table 1. The standard filters are made of neutral grey glass with spectral characteristics according to Figure 3.

Alternatively, attenuators (wheels and optics) can be manufactured according individual orders. We can also supply variable wheel attenuators without filters, which you can fit by yourself.

In most cases detectors (CCDs, photodiodes, photomultipliers, etc.), used for diagnostics of laser radiations, are too delicate for direct measurement of high powers, such as from ion lasers or pulsed solid-state lasers. An attenuator may be required to reduce laser power density at the surface of detector. Optical attenuators must be used when the laser output-power or power density exceeds working (linear) range or damage threshold of a detector. (Draft International Standard ISO/TC172/SC9/WG1)

For example, the damage threshold for a typical commercially available CCD is about 100 mW/cm², for the ultra high speed photodetectors series AR-S (Antel Optronic Inc.) it is about 200 mW/cm². On the other hand, laser power must be adjusted to the optimum point, which is typically just below the saturation level of the detector. For example, a typical commercially available CCD saturates at only 0.05 mW/cm² at 632.8 nm and at 5.5 mW/cm² at 1.06 mm (see R. Rypma "Dimming the Light ...", in Photonics Spectra N.10, 1995, p.145).

For preliminary attenuation of very high power lasers the simplest approach is to use just the first surface reflection of an uncoated laser-grade substrate.

It is useful to have an intensity adjustment range of at least 1000:1 or more in this final stage. Even when working with a single-wavelength laser, operated at one power level, this range may be encountered when making measurements at different points in the optical train.

After major reduction in intensity by reflection off an uncoated substrate is achieved, some of the low-power neutral density filters of the high optical quality can bring the beam power to the exact level necessary for optimum measurement by detection system.

Table 1. *List of a standard filter-set*

Transmission		Filter #1	Filter #2	Filter #3	Filter #4
Wheel #1	T	1.00	0.90	0.80	0.50
	dB	0.00	0.46	0.97	3.00
Wheel #2	T	1.00	0.30	0.10	0.03
	dB	0.00	5.20	10.00	15.20
Wheel #3	T	1.00	0.01	0.003	0.001
	dB	0.00	20.00	25.00	30.00
Wheel #4	T	1.00	0.0003	0.0001	0.00003
	dB	0.00	35.00	40.00	45.00

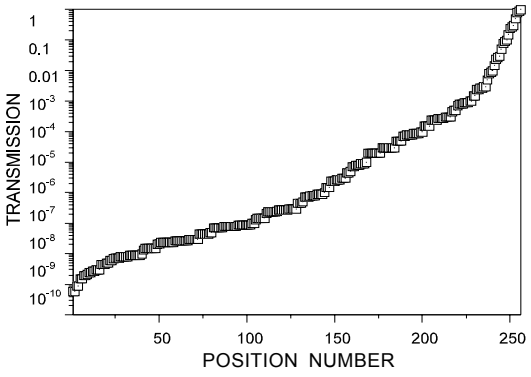


Figure 1

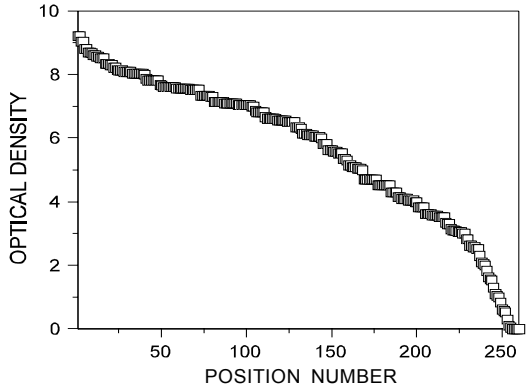


Figure 2

Charts for the standard filter-set: possible filter positions versus resulting transmission/density.

RELATED PRODUCTS

990-0604 Variable Wheel Attenuator

See page 7.29

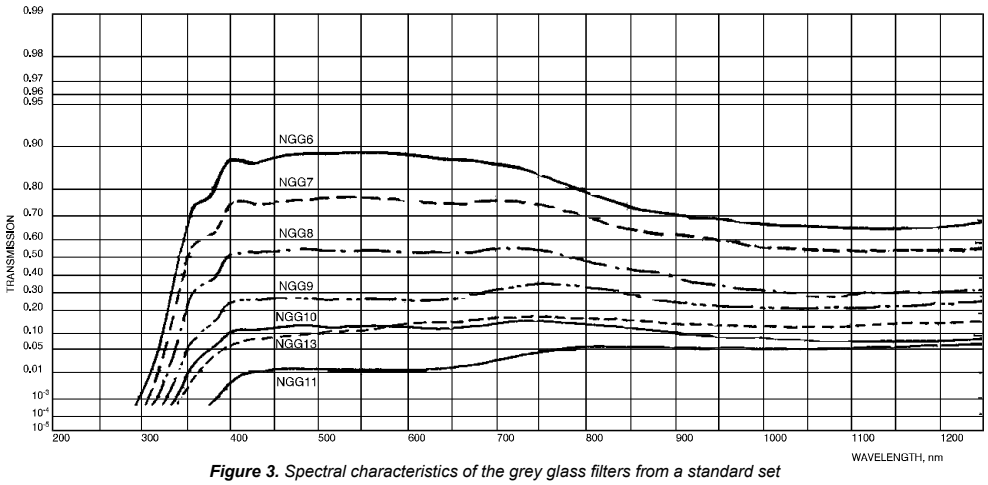


Figure 3. *Spectral characteristics of the grey glass filters from a standard set*

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

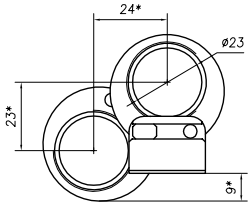
- **Allows stacking of 5 filters of Ø25,4 mm (1"), or 3 filters of Ø50,8 (2")**
- **Fast flipping in and out of beam path**
- **Available to be used in 90° position**
- **Has one M4, two M6 and two holes Ø 6.4mm for mounting on posts or table bases**
- **Large aperture allows to attenuate large diameter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

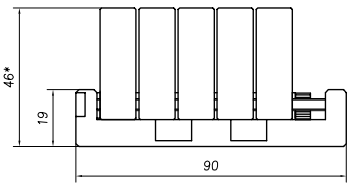
***990-0415** at 0° position*

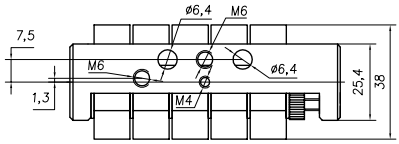
(Note: Solid base height extender 820-0210 should be ordered seperately)

***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

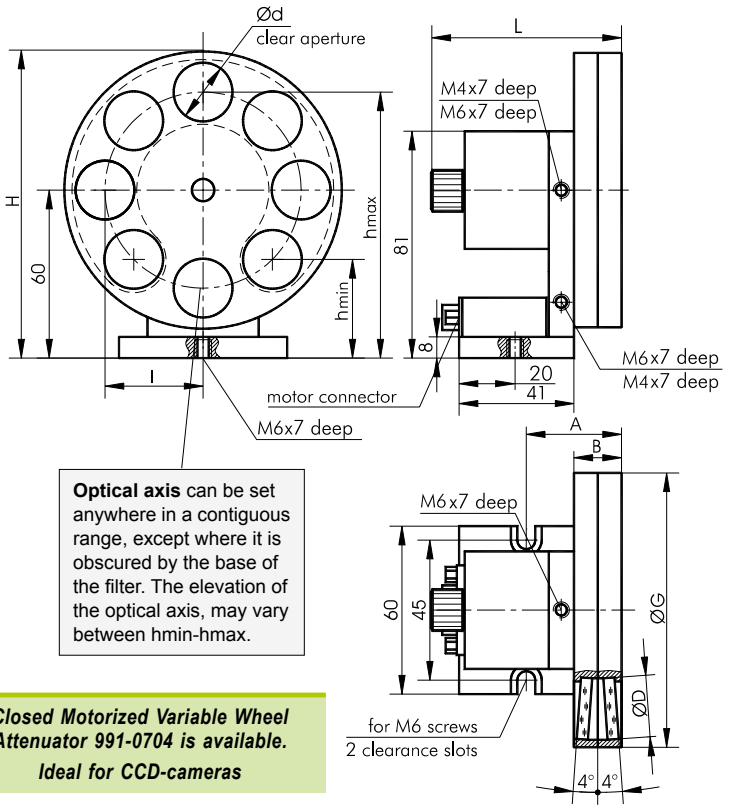
Neutral Density Filters Ø25.4 mm

See page 1.13

991-0602 MOTORIZED VARIABLE TWO WHEELS ATTENUATORS

991-0602-01

- **Filter diameter – Ø20/Ø25.4 mm**
- **Clear aperture Ø18/Ø23 mm**
- **Non parallel filters (inclined by 4°)**
- **Maximum thickness of filters – 2 mm**
- **Custom design available**



Optical axis can be set anywhere in a contiguous range, except where it is obscured by the base of the filter. The elevation of the optical axis, may vary between hmin-hmax.

Closed Motorized Variable Wheel Attenuator 991-0704 is available.
Ideal for CCD-cameras

Motorized Variable Two Wheel Attenuator 991-0602 consists of two filter wheels. Each wheel contains eight filter mounts of ØD mm with clear aperture Ød mm. Each mount is inclined by 4° to prevent mutual reflections between filters.

We supply the attenuators 991-0602-01 with a standard, most popular, set of filters. *(See the table below.)* Alternatively, optics can be manufactured according individual orders. Or we can supply the attenuators without filters, which you can fit by yourself.

Bring a filter of each wheel into the optical path easily by hand or using automation.

Two wheels are driven by a single step motor. A computer can operate it via a controller. The Step Motor Controller Card 980-0030F-USB / 980-0030-RS232 and Position Control Software come separately.

For fastening, attenuator has clearance slots for M6 and M4 screws. There are also two M6 holes, and one M4 hole (opposite to one of the M6 holes).

Material: black anodized aluminium.

Model	D, mm	d, mm	H, mm	G, mm	A, mm	B, mm	L, mm	h_{min}, mm	h_{max}, mm	l, mm	Price, EUR
991-0602-01	Ø20	Ø18	110	Ø100	35	16.5	73.5	34	97	37	918
991-0602-02	Ø25.4	Ø23	115	Ø110	39	20.5	78	32	99.5	39.5	738

Note:
991-0602-01 is with filters dia 20 mm.

991-0602-02 is without filters. 991-0602-02 is suitable for Neutral Density and Colour Glass Filters Ø25.4 mm that should be ordered seperately.

RELATED PRODUCTS

Neutral Density Filters Ø25.4 mm
See page 1.13

Colour Glass Filters Ø25.4 mm
See page 1.15

Stepper, BLDC and DC Motor Controller 980-0040-USB
see page 8.196

Standard set filters transmittance

Wheel N1	Wheel N2
1	1
0	0
0.9	0.8
0.5	0.3
0.1	0.03
0.01	0.003
0.001	0.0003
0.0001	0.00003

Stepping motor specifications

Rated Current	0.4 A
Resistance	33 Ω
Inductance	52 mH
Holding torque	0.12 N·m
Step angle	1.8 °
Step angle accuracy	5 minutes
Required electrical powe	5.6 W

Motors of other types are available.

991-0702 MOTORIZED CLOSED VARIABLE TWO WHEELS ATTENUATORS

991-0702-01

Motorized Closed Variable Two Wheel Attenuator 991-0702 consists of two filter wheels. Each wheel contains eight filter mounts of ØD mm with clear aperture of Ød mm. Each mount is inclined by 4 degrees to prevent mutual reflections between filters.

We supply the attenuator 991-0702-01 with a standard, most popular, set of filters. See the table below. Alternatively, optics could be manufactured to individual orders. Or we could supply the attenuator without filters, which you can fit by yourself.

You bring a filter of each wheel into the optical path easily by hand or using automation. The two wheels are driven by a single step motor. A computer can operate it via a controller and Computer Software which come separately.

For fastening, the attenuator has clearance slots for M6 and M4 screws. There are also two M6 holes, and one M4 hole (opposite to one of the M6 holes).

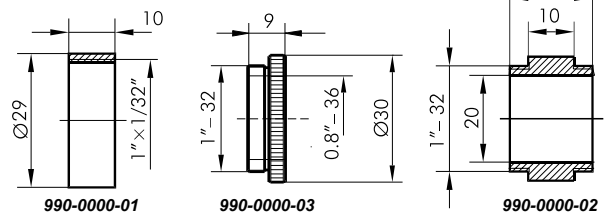
Material: black anodized aluminium.

SPECIFICATIONS

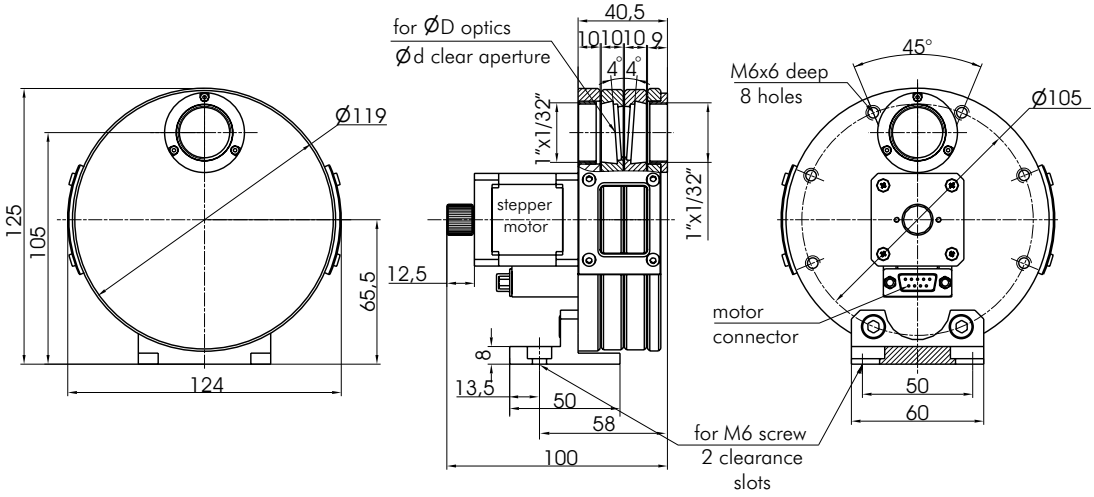
Step angle	1.8°
Step angle accuracy	5 minutes
Required electrical power	5.6 W
Weight	0,75 kg
Motor	4247
Mechanical reference switch	1
Switch polarity	pushed is closed

- **Filter diameter – Ø20/Ø25.4 mm**
- **Clear aperture Ø18/Ø23 mm**
- **Non parallel filters (inclined by 4°)**
- **Maximum thickness of filters – 4 mm**
- **C-mount threads on both ends**

Adapters for Attenuators



990-0000-01 *990-0000-03* *990-0000-02*



Model	D, mm	d, mm	Weight, kg	Price, EUR
991-0702-01	Ø20	Ø18	0.7	1118
991-0702-02	Ø25.4	Ø23	0.75	938

Note:

991-0702-01 is with filters Ø20 mm.

991-0702-02 is without filters. 991-0702-02 is suitable for Neutral Density and Colour Glass Filters Ø25.4 mm that should be ordered seperately.

RELATED PRODUCTS

Neutral Density Filters Ø25.4 mm
See page 1.13

Colour Glass Filters Ø25.4 mm
See page 1.15

Stepper, BLDC and DC Motor Controller 980-0040-USB
see page 8.196

Standard set filters transmittance

Wheel N1	Wheel N2
1	1
0	0
0.9	0.8
0.5	0.3
0.1	0.03
0.01	0.003
0.001	0.0003
0.0001	0.00003

Stepping motor specifications

Rated Current	0.4 A
Resistance	33 Ω
Inductance	52 mH
Holding torque	0.12 N·m
Step angle	1.8 °
Step angle accuracy	5 minutes
Required electrical powe	5.6 W

Motors of other types are available.

COMPUTER SOFTWARE FOR MOTORIZED ATTENUATORS

- **Control of single stepper motor with two wheels and up to 8 filters in every wheel**
- **Three different transmittance tables can be configured for three different wavelengths**
- **Operation in transmittance and optical density modes**
- **Program can choose the best combination for required transmittance or optical density, or filters defined by user can be set**
- **Different speed and step division options**

Computer Software is designed to control motorized attenuator unit with our stepper motor controller 980-0040-USB (page 8.196).

Motorized attenuator together with program can be applied in all kinds of optical circuitry where variable transmittance has to be achieved.

Program allows to change easily transmittance or optical density of an attenuator **991-0602** and **991-0702**. Just enter transmittance or optical density values, and the program will select the closest two filters. Or you can select the filters directly.

The simple interface allows to use the program right away. For each of the three different wavelengths it stores a set of filter transmittance values, which a user can modify. "**Density/Transmittance**" button switches between these modes at any time.

All system configuration information and current state of an attenuator is stored in a file and is automatically reloaded after the program starts.

Any of our software works only with our controllers.

Standard set filters transmittance

Wheel N1	Wheel N2
1	1
0	0
0.9	0.8
0.5	0.3
0.1	0.03
0.01	0.003
0.001	0.0003
0.0001	0.00003

REQUIREMENTS

PC compatible computer with any minimal Windows 95/98/ME/2000/XP installation
Display
Step Motor Controllers

Stepper Motor Controlers for MOTORIZED VARIABLE TWO WHEELS ATTENUATORS

Motorized Variable Two Wheels Attenuator ***991-0602***
see page 7.33

980-0040-USB
see page 8.196

Motorized Closed Variable Two Wheels Attenuators ***991-0702***
see page 7.34

990-0800 AIR-COOLED BEAM DUMP

990-0800

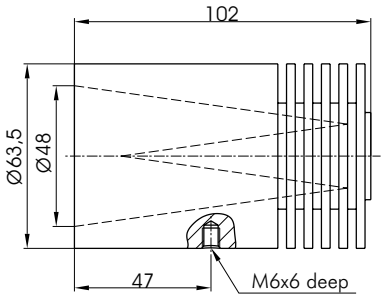
Beam Dump 990-0800 is designed to block a CW or a pulsed laser beam. It can be used on beams of up to 50 W in the wavelength range from 0.1 to 30 µm.

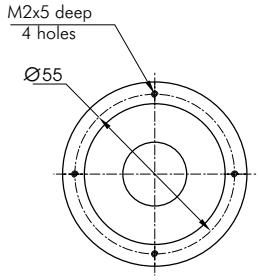
The design is such, that, even if the non-reflective coating is damaged by high intensity pulses, there's no backward reflection.

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 blocks a CW or a pulsed laser beam. It is mainly intended for beams 2 inch wide.

Water absorbs much energy. So, the dump is best suited for beams of up to 1 kW. The wavelength range is from 0.1 to 30 µm.

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