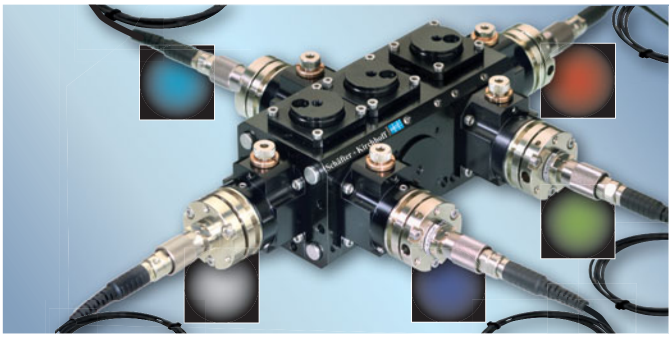
RGBV Fiber Optics from Schäfter+Kirchhoff

Specially designed for fluorescence microscopy, confocal microscopy and quantum optics



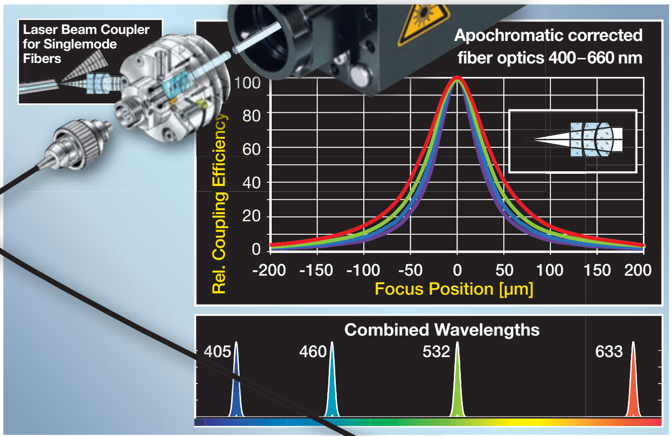
RGBV Laser Beam Combiner

48BC-RGBV / 48BC-RGB

Page 52

The RGBV Laser Beam Combiner is a stable optomechanical platform for superimposing red (630 nm), green (532 nm), blue (460/488 nm) and violet (405 nm) radiation into a single beam for coupling into a single polarization-maintaining singlemode fiber. Beam combination is performed using dichroic mirrors (long-pass filters). The combined beam emerges at the fiber end as a common point source and is linearly polarized, providing optimum conditions for the extremely demanding applications of confocal and fluorescence microscopy.

Schäfter+Kirchhoff also offers Laser Beam Combiners for only two or three beams each with a different wavelength.



RGBV Laser Beam Coupler

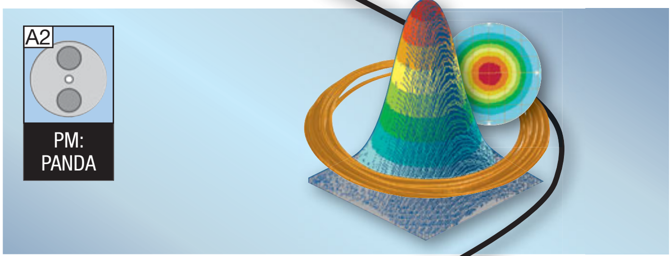
60SMS-1-4-RGBV11-47

Page 10

Efficient fiber coupling of a combined polychromatic beam requires that the chromatic aberration be corrected as accurately as possible, otherwise the focal lengths of the individual beams would vary with wavelength. For efficient coupling, all of the beams must be focussed onto a common point at the fiber face.

Since the correction of the available standard achromatic optics is not sufficient, Schäfter+Kirchhoff have developed their own range of apochromatically corrected optics for this purpose. In contrast with standard optics, the RGBV optics provide a superior correction in the spectral range of 400–660 nm.

The well-established Schäfter+Kirchhoff laser beam coupler, with integrated mechanical fine-adjustment elements for tilt and focussing, is coupled efficiently to a polarization-maintaining singlemode fiber. Back-reflection into the laser beam combiner is prevented using a type APC fiber connector with its inclined fiber coupling axis.



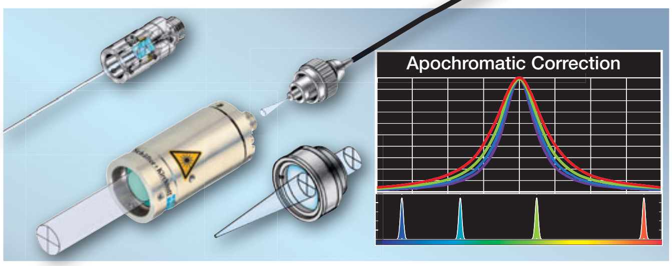
RGBV PM Fiber Cable

PMC-400-...

Page 20

For polychromatic applications, a polarization-maintaining singlemode fiber (PM fiber) with broadband capabilities is used.

The singlemode begins at 400 nm and has low attenuation over the whole wavelength range up to 680 nm.



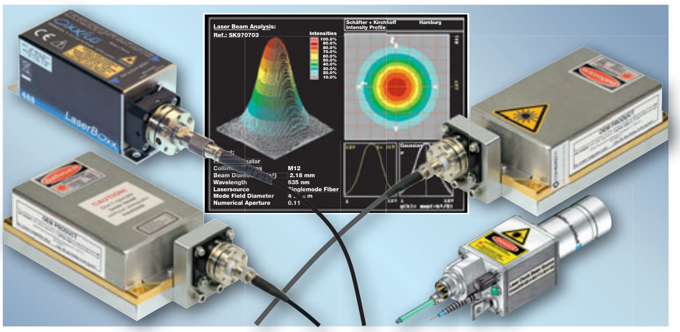
RGBV Fiber Collimator

60FC-T-4-RGBV42-47

Page 41

The superimposed but divergent beams emerging from the fiber require apochromatically corrected fiber collimators for generation of the collimated beams. This is an absolute requirement if the beam is later to be refocussed by a microscope lens.

Schäfter+Kirchhoff provides apochromatically corrected collimation lenses with focal lengths of 11 mm or 42 mm, producing collimated beams of 2 mm or 7 mm, respectively.

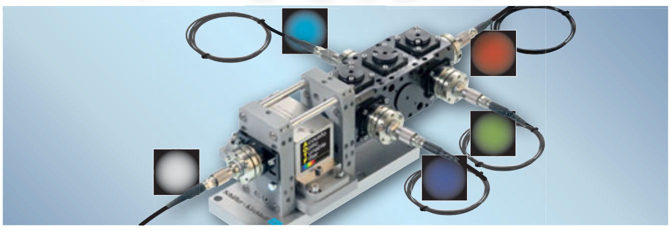


RGBV Laser Beam Sources

Page 58

with polarization-maintaining Fiber Optics

The sources used for multi-wavelength applications include diode lasers, frequency-doubled lasers, optically pumped semi-conductor lasers (OPSL) and gas lasers. Schäfter+Kirchhoff can also couple polarization-maintaining singlemode fibers to lasers owned or provided by the customer. A major advantage of fiber coupling is that it allows the spatial separation of the laser source and the RGBV beam combiner. Bulky laser sources that create excessive heat and vibration can be situated at a safe distance from the experiment and overly complex breadboard setups become redundant.



RGBV Laser Beam Combiner with AOTF

Switchable RGBV combiner

Page 53

An acousto-optical tunable filter (AOTF) uses sound waves of different frequencies to modulate and switch multiple, superimposed wavelengths simultaneously. Schäfter+Kirchhoff now offers a RGBV Beam Combiner with adjacent AOTF to generate a fiber-coupled switchable laser beam ideally suited for microscopy, biophotonics or life sciences.

Schäfter+Kirchhoff GmbH
Kieler Str. 212, 22525 Hamburg, Germany • Tel: +49 40 85 39 97-0 • Fax: +49 40 85 39 97-79 • info@SuKHamburg.de • www.SuKHamburg.com

Laser Beam Combiner 48BC-RGB / 48BC-RGBV

The Laser Beam Combiner takes each of the beams, coupled into its individual polarization-maintaining singlemode fiber, and combines them into a single output in a single polarization-maintaining fiber. This exemplary modular system combines up to four wavelengths in the 400–660 nm range. The individual laser power sources for each wavelength can be attenuated separately so that any desired power relationship can be obtained.

The fully optimized dichroics from Schäfter+Kirchhoff superimpose the individual laser beams and have a 0.3°-wedge profile to avoid interference from back-reflected light (Etalon effect). Propagation through parallel plates causes a beam offset, which is corrected by a compensatory axial displacement of the laser beam couplers.

An attenuator allows adjustment of the combined laser output.

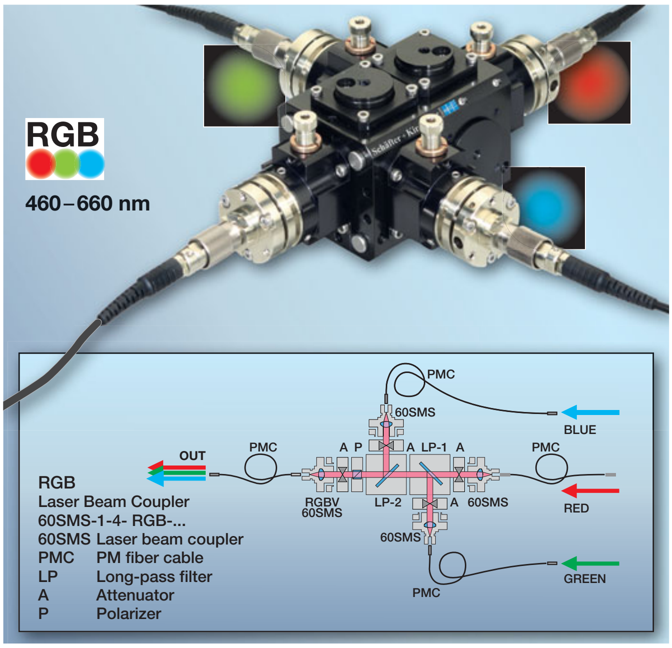
The tilt adjustment and inner focussing mechanism of the laser beam couplers, as well as the tilt adjustment of the dichroics, provide all of the degrees of freedom needed for alignment.

The design ensures a highly stable structure that can be immediately and confidently put to discriminatory use.

- **Systems for combination of 405, 460, 532 and 660 nm laser radiation into a single collimated fiber-coupled beam**
- **Apochromatically corrected RGBV Laser Beam Coupler**
- **Long-pass (LP) broad transmission band for cascaded use of various long-pass filters (with transmission reaching 95 % and reflection up to 99 %)**
- **Fused silica substrates with 0.3°-wedge angle for suppressing interference**
- **Inclined coupling axes to avoid back-reflection**

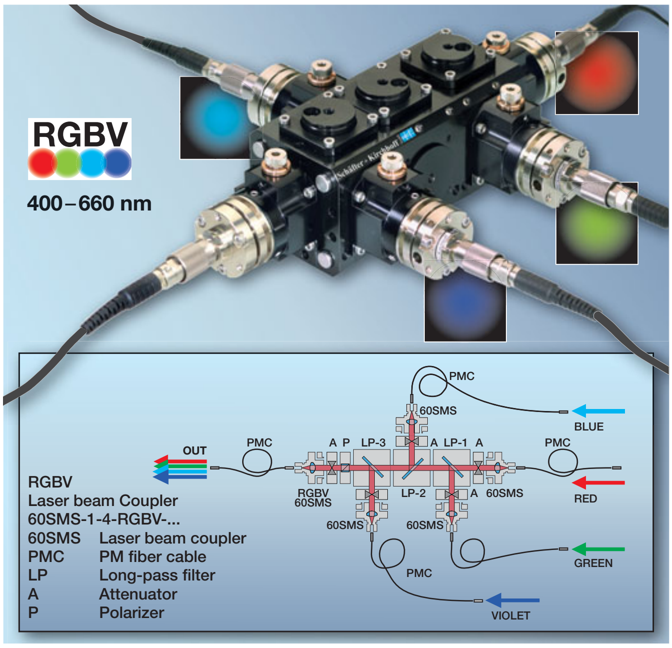
RGB Laser Beam Combiner 48BC-RGB

- **Combination of three different wavelengths in the spectral range of 460–660 nm**
- **Two dichroics for superposition**

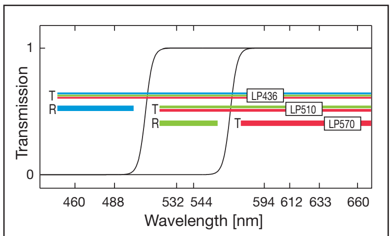


RGBV Laser Beam Combiner 48BC-RGBV

- **Combination of four different wavelengths in the spectral range of 400–660 nm**
- **Three dichroics for superposition**

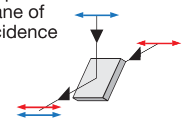


Transmission Spectra of Beam Combiners RGB



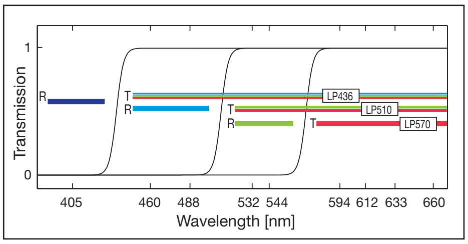
Optical scheme for 48BC-CC-LP... beam combiner

with *s*-polarization optimization: for all linear states of polarization perpendicular to the plane of incidence

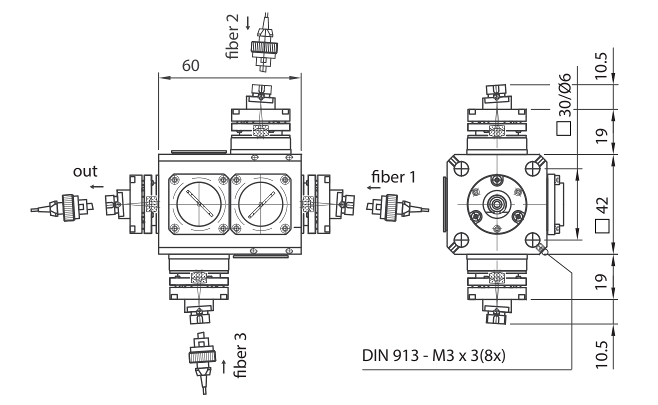


Beam Combiner/ Long Pass		
Spectral range	Reflection	Transmission
nm	99 %	95%
436	370 - 412	460 - 700
510	405 - 488	532 - 660
570	532 - 544	594 - 660

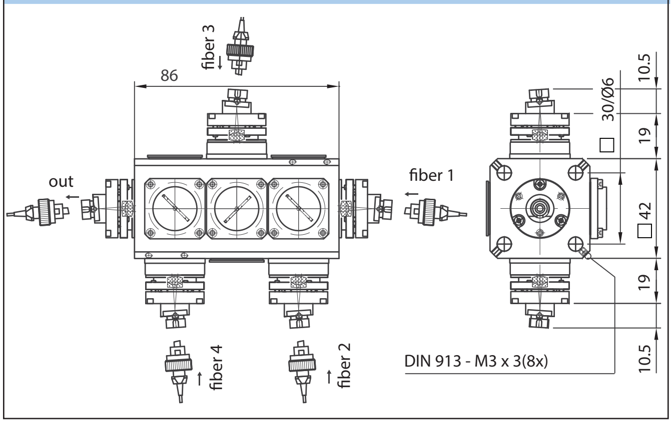
Transmission Spectra of Beam Combiners RGBV



Dimensions



Dimensions



Schäfter+Kirchhoff GmbH
Kieler Str. 212, 22525 Hamburg, Germany • Tel: +49 40 85 39 97-0 • Fax: +49 40 85 39 97-79 • info@SuKHamburg.de • www.SuKHamburg.com

Laser Beam Combiner with AOTF

Switchable RGBV combiner for Microscopy, Biophotonics or Life Sciences

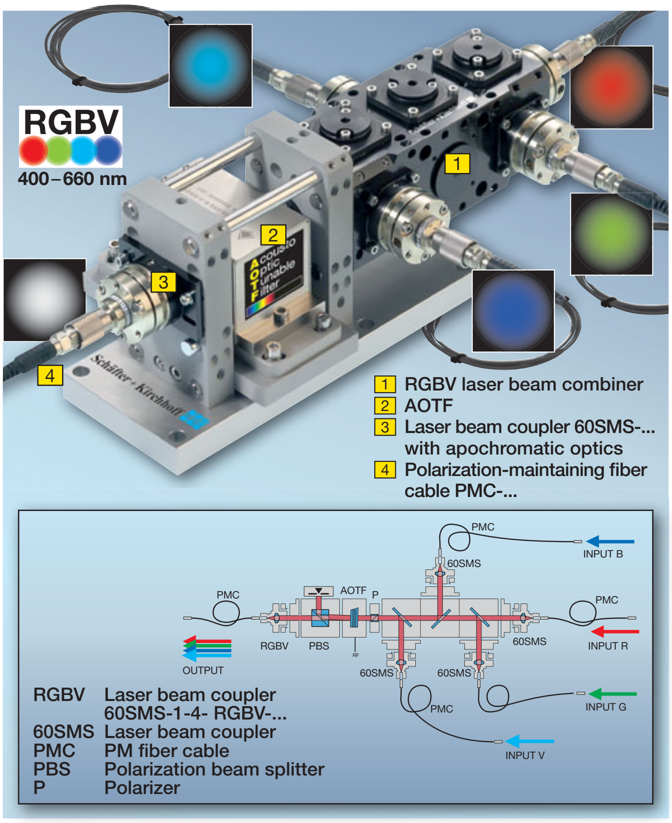
System for combining up to four wavelengths from 405–660 nm into a common singlemode fiber with switching between the wavelengths via adjacent AOTF and PC-interface.

- **Apochromatic RGBV laser beam coupler 60SMS-... with high coupling efficiencies in the spectral range 405–660 nm**
- **Dichroic long-pass filters with a broad spectral transmission**
- **Fused silica substrates with 0.3°-wedge angle (suppression of interference)**
- **Fiber coupler and fiber cables with inclined coupling axes to avoid back-reflection**

RGBV Laser Beam Combiner with AOTF

- **Three dichroics for superposition**
- **AOTF with PC-interface for switching between wavelengths**

For further details, see www.SuKHamburg.com



Many applications in biophotonics or microscopy require switchable laser sources in a wide spectral range, with which it is possible to switch between several wavelengths at a high frequency (up to several hundred kHz). This is usually accomplished by using an AOTF (**a**cousto-**o**ptic **t**unable **f**ilter, for details, see page 54).

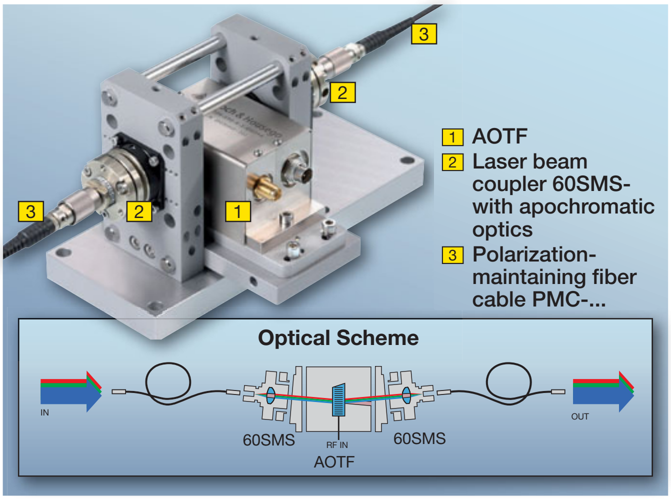
Schäfter+Kirchhoff now offers RGBV laser beam combiners with an adjacent AOTF to perform these features. The modulated beam produced by the AOTF is coupled into a polarization-maintaining fiber for launching into the experimental setup with high efficiency and a defined polarization.

AOTFs are acousto-optical filters that allow the selection and modulation of one or several wavelengths simultaneously via the PC-interface and can produce, for example, a defined sequence of pulses for each of the different wavelengths. The switching frequency depends on the beam diameter within the AOTF and on the AOTF itself. The modulated light beam is then coupled into the experimental discriminator, microscope or analyzer. These features cannot be readily achieved in a free beam setup because of the many problems of mechanical stability and the time-consuming alignment procedures that are required.

The ultimate solution is the coupling of the combined laser beam sources into a single polarization-maintaining fiber by use of an AOTF. The laser beam combiner (details see page 52) combines **R**ed, **B**lue, **G**reen and ultra-**V**iolet laser light without significant losses from a variety of laser sources with dichroic optics. The apochromatic optics used in the laser beam couplers (for details, see page 10), at the input/output ports of the laser beam combiner, ensure high coupling efficiencies in the whole spectral range between 405–660 nm.

The RGBV fiber optic system has a number of distinct advantages. As a defined interface between laser source and experiment, it is possible to separate and decouple the laser beam sources and the measurement setups mechanically and thermally from each other, thus obviating any mutual negative influences. The guidance of the laser beams is insensitive to vibration and the system exhibits remarkable stability. Already existing measurement setups can be readily upgraded to fiber optics and then they would also benefit from the stability, easy handling and heightened safety features enjoyed by this modular system.

Fiber-coupled AOTF



Schäfter+Kirchhoff also offers fiber-coupled AOTFs. The combined beams are coupled into the AOTF via a polarization-maintaining fiber and a laser beam coupler 60SMS-... with apochromatic optics, achieving high coupling efficiencies in a broad spectral range. The modulated light exits from the AOTF in a polarization-maintaining fiber, for coupling into the experiment with high efficiency and defined polarization. For theoretical details, see page 54.

The advantages of a fiber-coupled AOTF include:

- **decoupling of the laser beam source from the measurement setup, both thermally and mechanically**
- **defined interface between laser source and experiment**
- **improved stability, working safety and handling.**

Please contact Schäfter+Kirchhoff for further details.
For further information about fiber-coupled AOMs, see page 54.

Schäfter+Kirchhoff GmbH
Kieler Str. 212, 22525 Hamburg, Germany • Tel: +49 40 85 39 97-0 • Fax: +49 40 85 39 97-79 • info@SuKHamburg.de • www.SuKHamburg.com