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# TELECENTRIC F-THETA LENSES WITH SHORT FOCAL LENGTH

About 5 years ago, Sill Optics introduced the fused silica f-theta lens series S4LFT4010. The scan lenses have focal lengths of 100 mm, support beam diameters of 10 mm and achieve 35 mm x 35 mm fields. There are versions for 355 nm, 515 nm – 545 nm, 808 nm – 980 nm and 1030 nm – 1090 nm available.

The S4LFT4010/328, designed for 1030 – 1090 nm provides spot sizes of around 20  $\mu\text{m}$ .

The newest series of scan lens, S4LFT4065/328 with a focal length of 65 mm, is capable of accepting a 10 mm beam, generating a diffraction limited spot of around 10  $\mu\text{m}$  on a 15 mm x 15 mm field. The S4LFT4065/328 incorporates fused silica lenses and our industry proven low absorption coating. Of course, there are no internal ghosts in lens elements or on scan mirrors.



Ghosts are focused back reflections from lens surfaces and have high potential to destroy coatings and bulk material. Even though the lens elements are coated with anti-reflective coatings, which transitions the light from the index of refraction of the air to the refractive index of the bulk material of the lens, less than 0.2% reflection still remains from each surface, even using the special Sill Optics low absorption coating. In a pulsed pico- or femtosecond laser the peak power of a focused ghost spot can exceed the damage threshold of the coating or the bulk material. So it is critical to avoid any internal ghosts within the lens or focused spots on the galvo mirrors.

This new series of F-theta lenses with short focal lengths is now completed by versions for other wavelengths (e. g. 355 nm, 515 nm – 545 nm, and 808 nm – 980 nm) as shown in the table below. All of these lens can be used with short pulse lasers.

part number	focal length [mm]	scan area [mm x mm]	max. beam- $\emptyset$ [mm]	aperture stop [mm]	length [mm]	max. outside- $\emptyset$ [mm]	mounting thread	working distance [mm]	protective window
S4LFT4010/328	100.3	35 x 35	10.0	32.0	78.7	106.0	M85x1	129.8	S4LPG2250/328
S4LFT4010/094	98.9	35 x 35	10.0	32.0	78.7	106.0	M85x1	128.3	S4LPG2250/094
S4LFT4010/292	100.0	35 x 35	10.0	30.0	78.7	106.0	M85x1	130.2	S4LPG2250/292
S4LFT4010/075	100.2	35 x 35	10.0	34.6	78.7	106.0	M85x1	154.6	S4LPG2250/075
<b>NEW</b> S4LFT4065/094	64.5	15 x 15	10.0	24.0	76.5	94.0	M85x1	82.4	S4LPG0394/094
<b>NEW</b> S4LFT4065/328	65.1	15 x 15	10.0	24.0	76.5	94.0	M85x1	83.1	S4LPG0394/328
<b>NEW</b> S4LFT4066/292	67.2	15 x 15	10.0	24.0	73.3	94.0	M85x1	85.8	S4LPG0394/292
<b>NEW</b> S4LFT4067/075	65.5	15 x 15	10.0	24.0	79.0	94.0	M85x1	81.7	S4LPG0394/075

## EXAMPLE FOR CUSTOM MADE OPTICS: OBSERVATION OF TRAPPED IONS

Beside laser optics and lenses or illuminations for machine vision, the third main pillar of Sill Optics are custom made optics. With highly proficient optical designers and also developers of mechanical housings, our outstanding experience stands for itself. As mechanical workshop and the precision optical production are located in one place in Germany, we are able to provide customers or research institutes with prototypes or small to medium sized batches of optics specifically designed for the application.

A very recent example can be found in the field of trapped ions. Those cold ions are a research topic with increasing interest over the last years because of their possibility to store Qubits and the related use for quantum computers. Of course, it is not only important to use them, but to know their behaviour in detail via various basic experiments. Sill Optics has designed lenses both, for just observation or observation combined with laser focusing for such experiments.

Those lenses are furthermore exceptional for their high NA and adjustment to specific wavelengths. As the vacuum cryostats differ in dimension, e. g. the window thickness, every lens has to be designed specifically for the existing conditions.



## COLOR CORRECTED F-THETA LENS FOR ULTRA SHORT PULSE LASERS

First of its kind fully color corrected F- theta scan lens for ultra-short pulse lasers from Sill Optics GmbH & Co. KG.

Lasers with pulses shorter than 1 picosecond, the laser creates a noticeable spectral bandwidth which will degrade the spot performance via chromatic errors. For example, an 800 femtosecond Gaussian shaped pulse has a spectral width of about 2 nm and a 250 femtosecond pulse has a width of almost 7 nm (1064 nm, FWHM). This will aberrate the spot in an F-theta lens which is designed to focus only one wavelength. Two new scan lens from SILL uses multiple glass types in its design so all the wavelengths within a pulse are in focus at the work surface. The lenses have focal lengths of 100 mm, are telecentric, have scan areas of 35 mm x 35 mm and will accept a maximum 10 mm  $1/e^2$  input beam.



The S4LFT7010/008 covers from 1500 – 1600 nm, the S4LFT7010/450 from 1000 – 100 nm and the S4LFT7012/292 from 510 – 590 nm. All three lenses are designed to have no internal ghosts or back reflections which can damage lens elements within the lens.

Our product range also includes an ultra-short pulse compatible beam expander with fixed magnification factor of three and designed for 1000 – 1100 nm range. The S6ASS4803/450 has a 10 mm ( $1/e^2$ ) maximum input beam diameter and M30x1 mounting.

part number	focal length [mm]	scan area [mm x mm]	max. beam-Ø [mm]	aperture stop [mm]	length [mm]	max. outside-Ø [mm]	mounting thread	working distance [mm]	protective window
S4LFT7010/008	100.0	35 x 35	10.0	32.0	98.8	94.0	M85x1	115.0	S4LPG0005/008
S4LFT7010/450	100.2	35 x 35	10.0	32.0	98.8	94.0	M85x1	113.2	S4LPG0005/450
S4LFT7012/292	100.0	35 x 35	10.0	36.1	98.8	94.0	M85x1	101.9	S4LPG0005/292

part number	magnification	max. entrance aperture [mm]	max. exit aperture [mm]	max. outside-Ø [mm]	length [mm]
S6ASS4803/450	1x – 3x	10.0	31.0	46.0	85.0

## LARGE DIAMETER ASPHERES FOR FIBER COLLIMATION

Aspheres offer the great advantage to accomplish monochromatic imaging tasks with one optical element where multiple lens elements would otherwise be needed.

Main advantages of aspheres are:

- less spherical aberrations
- larger aperture
- less weight
- less transmission loss
- no internal ghosts

The combination of high purity fused silica and low absorption coatings decreases thermal shift. The capability of Sill Optics MRF machines allows production of aspheres up to diameter 180 mm, sometimes restricted by curvature. Measurement setup (interferometric wavefront test, tactile and optical 3D profilometry) enables us to ensure a surface quality of 0.2 µm PV and 0.05 µm RMSi depending on material and geometry. Even sagittal heights up to 21 mm are measurable enabling the production and test of very steep radii at certain diameters.

This adds up to a perfect option for a fiber collimation system. For example a collimator for 1550 nm with a focal length of  $f = 275$  mm and a clear aperture of 120 mm in diameter can be created just with one aspheric lens element and still be nearly diffraction limited. The mechanical housing includes a practical solution for the fiber mounting with possible precision adjustment in X, Y and Z direction. Custom design to your requirements in NA, focal length, size and other parameters is always an option. Please feel free to contact us.

# LARGE APERTURE ZOOM BEAM EXPANDERS

Many high-performance applications require a beam expander with a large aperture. The S6EXZ5312/328 is optimized for such applications and provides stepless magnifications between 1.2x to 3x. A beam diameter of 18 mm is relayed at a magnification of 1.2x without vignetting (1% loss). That means for a Gaussian beam, the maximum input size at  $1/e^2$  is defined as 12 mm. With a magnification of 1.5x, a maximum beam of 11 mm ( $1/e^2$ ) can be expanded by the optic, and at 3x magnification, the system allows a free incoming beam diameter of 9 mm ( $1/e^2$ ).

The beam expander is designed as a diffraction-limited Galilean system without internal focus and consists of four high-grade fused silica lenses coated with a broadband low absorption coating to decrease the thermal focal shift.

Also a version designed for the wavelength range of 515 nm – 545 nm is available and furthermore a motorized version (S6EZM5412/328) has been added to our product range.



NEW

part number	magnification	max. entrance aperture [mm]	max. exit aperture [mm]	max. outside-Ø [mm]	length [mm]	motorized
S6EZM5312/328	1.2x – 3.0x	18.5	43.05	80.0	230.2	no
S6EZM5312/292	1.2x – 3.0x	18.5	43.05	80.0	230.2	no
S6EZM5412/328	1.2x – 3.0x	18.5	43.05	special	230.2	yes

## CUSTOMIZED SOLUTIONS

Sill Optics keeps at the principle “Made in Germany” and manufactures almost all components and the whole product range at our location in Wendelstein. Thereby we offer a high quality next to flexibility, short distances and individual services.

For customized products – also available as prototypes and short runs – we are first contact in many cases. Our product line-up covers always more than the catalog content.

A small choice of topics, we are looking forward to cooperate with you:

- F-Theta lenses for large apertures (e. g. 30 mm)
- Optics for multiple beams in DOE (diffractive optical elements) applications
- Scan lenses for polygon scanner systems
- Compensation elements for thermal focus shift

### We are pleased to answer your questions



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