LAO Spectroscopy Lens

Prepared
For
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Arlington, MA
By
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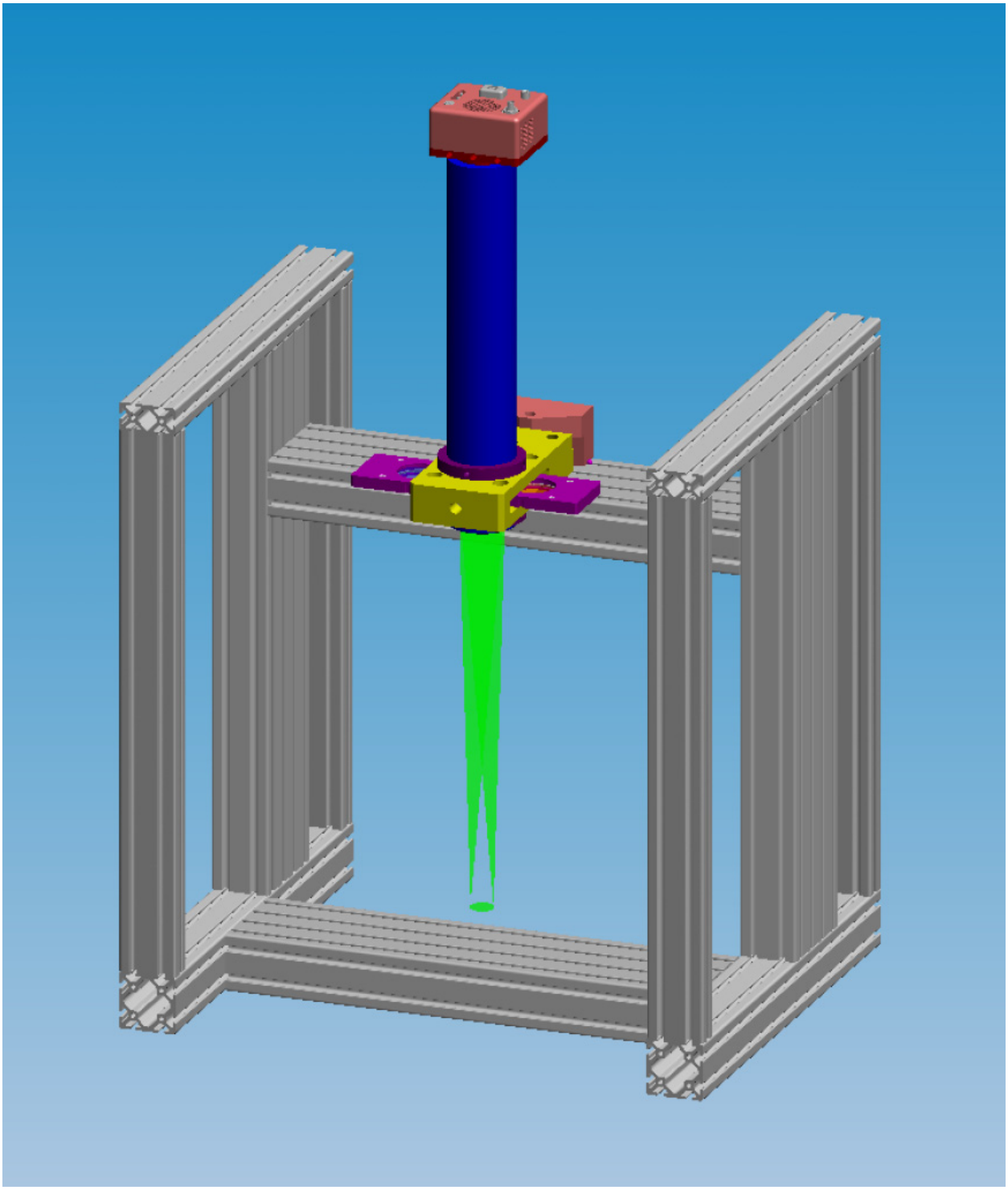


LAO SpecLens with Andor Luca-R Camera

SpecLens Features

L-A-Omega has developed a spectroscopy lens for the detection of flourophores. Its patent pending design specifies an F4 image with nearly diffraction–limited performance for maximum image contrast. Each pixel captures at least 24% of the point-spread within an 8 µm pixel. The F8 object field captures 0.2% of a hemisphere while maintaining a generous depth-of-focus at ±0.4mm. Filters may be swapped without affecting focus. An extruded aluminum frame provides a stable platform for the addition of excitation optics. Custom magnifications are available upon request. The LAO SpecLens is highly adaptable to numerous configurations during product development.

Lens Specifications	
Prescription number	2XR 3-5
Magnification	0.5
Reduction	2.0
Image F-number	4.0
F-number inflation	-8%
Distortion	-1.9%
Image field diameter (mm)	12
Wavelength range	
Minimum (nm)	514
Maximum (nm)	>656
Modulation transfer minimum	
30 cycles per mm	>75%
60 cycles per mm	>40%
Axial dimensions	
Front Focal Length (mm)	339
Back Focal Length (mm)	>10
Track length (mm)	337
Object Field diameter (mm)	24
Object F-number	8.0
Collection efficiency	
Hemispherical	0.20%
Pixel of 8um width	24%
Space-angle product	0.5 μm^2 H
Filter diameter (mm)	60

Background

Ordinary camera lenses

When comparing the LAO spectroscopy lens to other lenses, it is important to consider the ***F-number inflation***. The ***F-number*** is normally defined by a distant object at near zero ***magnification***. However, the ***image F-number*** increases rapidly as the magnification increases. At 0.5 magnification, the ***image F-number*** is at least 1.5 times the F-number which may be considered a 50% F-number inflation. Other effects can inflate the F-number such as vignetting and a cosine-cubed dependency upon field angle.

Many low F-number lenses display aberrations which spread light far beyond a single pixel. Thes aberrations are compounded by use of an extenteension collar.

Collection efficiency

A spectroscopy lens for a ***subpixel object*** can be rated by the angular collection efficiency at the object. The ***hemispherical collection efficiency*** HCE represents the fraction of a hemisphere as

$$\mathrm{HCE} = 2\sin^2\left(\frac{\theta}{2}\right) = 1 - \cos\theta = \frac{\mathrm{M}^2}{8 \cdot \mathrm{IFN}^2} = \frac{1}{8 \cdot \mathrm{OFN}^2}.$$

Wherein M is the magnification of the lens, IFN is the image F-number, and OFN is the object F-number. The HCE for the LAO spectroscopy lens is 0.2%.

The ***pixel collection efficiency*** PCE describes the overlap of the image point-spread with the detector pixel. For a subpixel object, the splitting by a block of 4 pixels restricts the maximum PCE to 25%. The PCE for the LAO spectroscopy lens is 24% for a 7.4um pixel. This indicates the ***image point-spread*** radius as nearly equal to a pixel width.

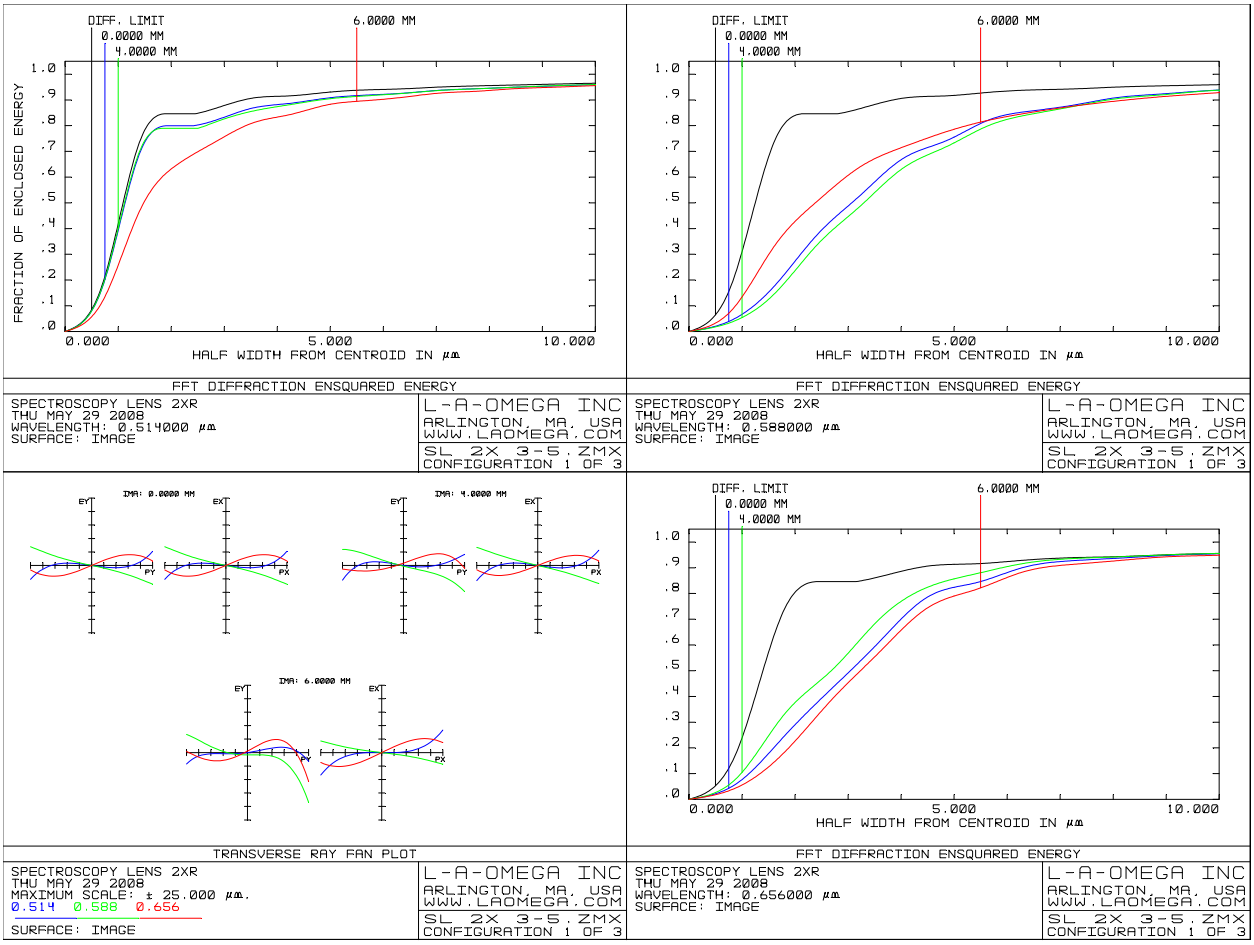
A spectroscopy lens for a ***full-pixel object*** can be rated by the ***space-angle product*** at the sensor as

$$\mathrm{SAP} = \mathrm{A}\Omega = \mathrm{d}_\mathrm{P}^2 \frac{\mathrm{H}}{8 \cdot \mathrm{IFN}^2},$$

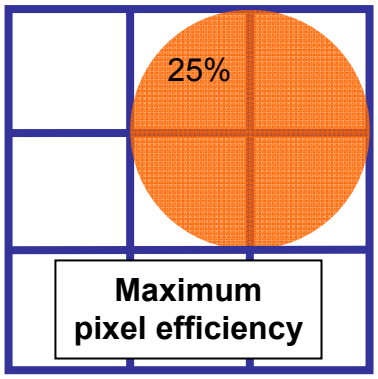
Wherein A is the area of collection, Ω is the solid angle of collection, d_P is the pixel dimension, and H is the solid angle of a hemisphere.

Optical analysis

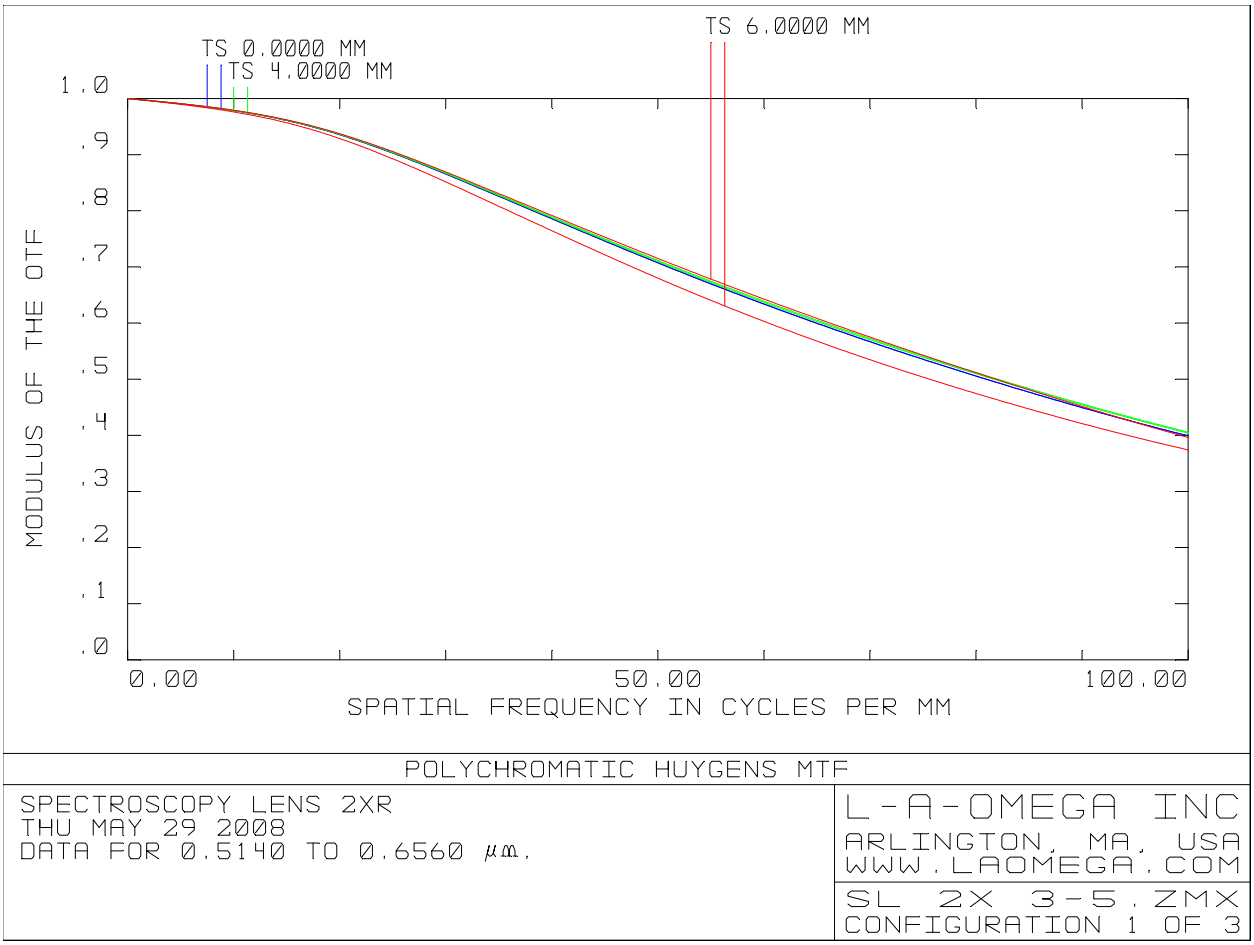
Ensquared energy by wavelength



Division of these values by 4 yields maximum pixel collection efficiency.

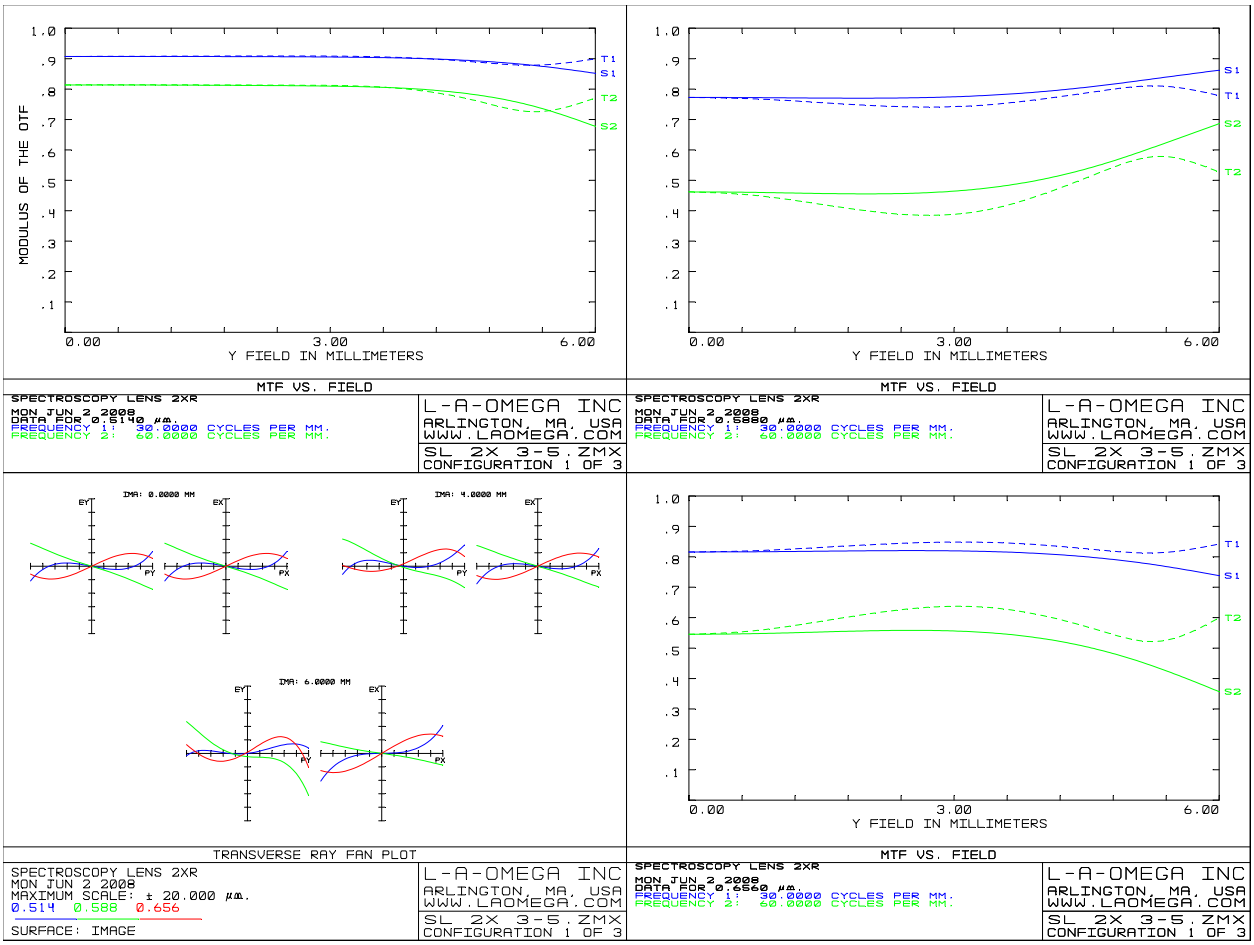


MTF polychromatic



The spatial frequency of an 8um pixel is 125 cycles per mm.

MTF by wavelength and field



60 cycles per mm is frequently cited for an 8um pixel.

30 cycles per mm is frequently cited for a 16um super pixel of 4 pixels.