

W-VIEW GEMINI-2C

Dual camera image splitting optics done right

Dual channel optics are simple... in principle. In practice, designing a device that enables quick, stable alignment and delivers images with minimal distortions over a large field of view requires attention to detail. The W-VIEW GEMINI-2C gets the details right and more. Building on our imaging and optical experience, the W-VIEW GEMINI-2C is the first dual camera, dual channel system engineered with super resolution quality, while simultaneously offering versatility, expandability and ease of use. The W-VIEW GEMINI-2C turns a simple optical concept into an elegant and useful tool that can help maximize the information content of every image acquisition.

HAMAMATSU
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Unrivalled Optical Quality Provides Superior Images

Custom Designed Lenses Optimized for Fluorescent Imaging

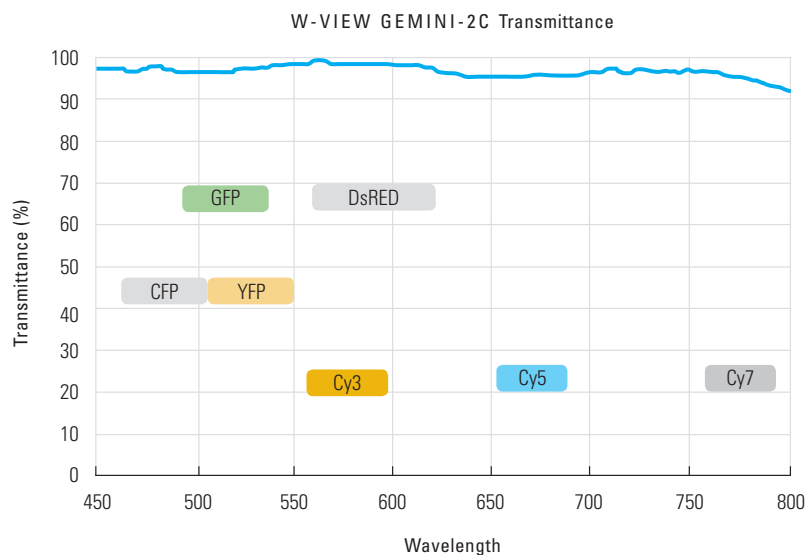
Using custom designed optics, our engineers fully optimized system performance, offering super resolution quality by minimizing point spread function (PSF) degradation, field curvature and wave front aberration.

Wide Field of View (20 mm for standard imaging, 12 mm for diffraction-limited imaging)

Maintaining optical quality at the edges of the field demands extra care. The W-VIEW GEMINI-2C delivers excellent performance over the entire field of two ORCA-Flash4.0 sCMOS cameras and diffraction-limited performance within the center 12 mm diameter FOV.

Ultra-Low Distortion (0.05 %), High Spatial Uniformity (98 %), High Transmission (98 % @ 450 nm to 800 nm)

This unmatched level of optical performance delivers bright, even, chromatic aberration-corrected images to both cameras.



Robust Opto-Mechanical Design for Ease of Alignment and Versatility

Dual Channel x, y, z and Rotational Alignment

The W-VIEW GEMINI-2C makes alignment easy and stable. Included alignment software provides direct visual feedback when using Hamamatsu cameras. An optional grid chart fits directly into the primary imaging plane making it possible to align images in the absence of feedback at the sample position.

Standard Filters and (Dichroic) Beamsplitters

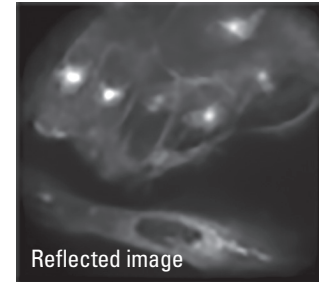
All filter and beamsplitter holders are designed to industry standard specifications, allowing researchers to freely choose their optical components.

Bypass and Camera Switching Mode

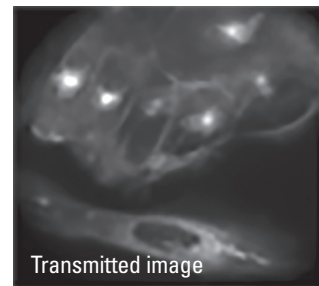
It's easy to bypass all the optics of the W-VIEW GEMINI-2C, simply remove the filters and beamsplitter and insert the port covers. In addition, by using a 100 % mirror instead of a beamsplitter, the W-VIEW GEMINI-2C can be used to switch between two different cameras.

C-mount Compatibility

With input and output C-mounts, the W-VIEW GEMINI-2C is compatible with and easily attached to standard inverted microscopes.

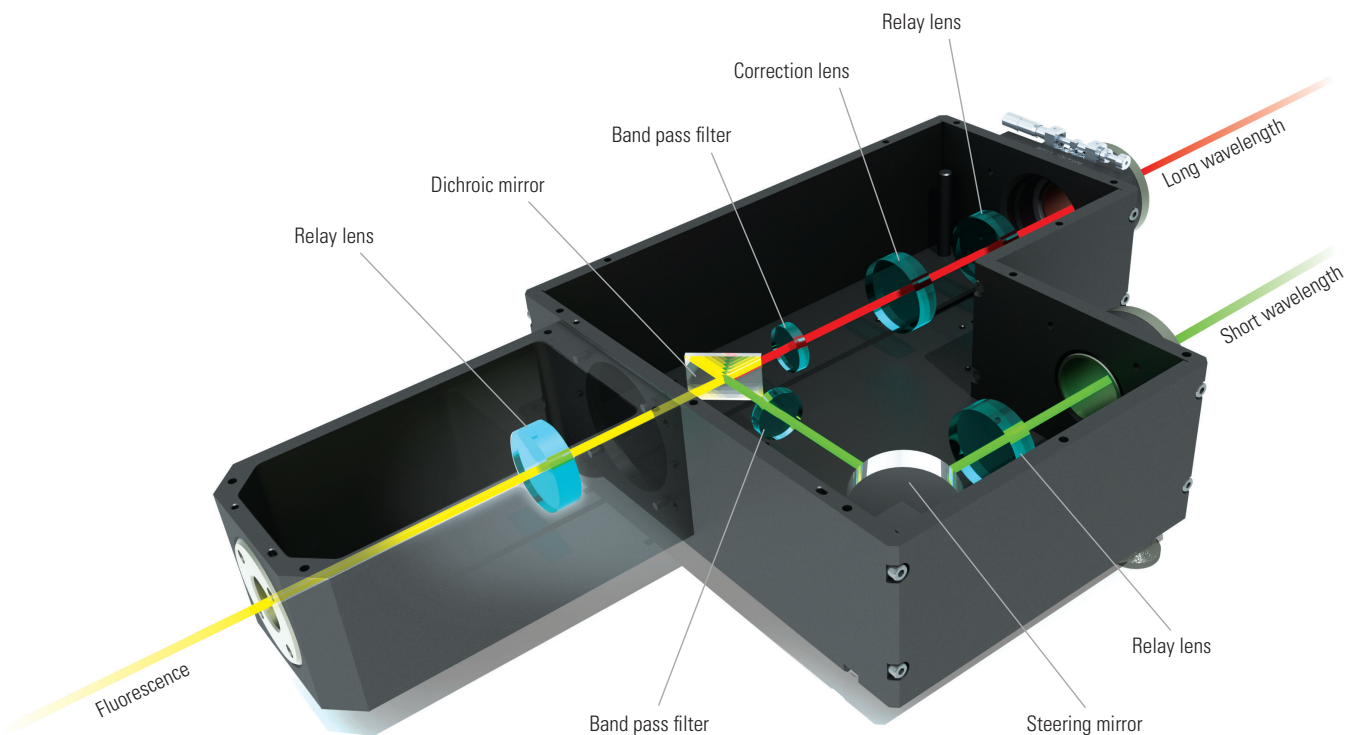


Reflected image



Transmitted image

The orientation of the W-VIEW GEMINI-2C dual images are identical, not mirrored, making alignment intuitive and avoiding the extra step of inverting in software.



Attention to Detail Enables Advanced Imaging Applications

Simulations of dual wavelength, dual camera imaging optics that use two commercially available doublet lenses, expose issues with astigmatism and field curvature, making such devices unacceptable for super resolution applications. To overcome this optical limitation, the W-VIEW GEMINI-2C uses custom designed and manufactured lenses that minimize wavefront aberrations (to less than $\lambda/14$ rms) to maintain the diffraction limit.

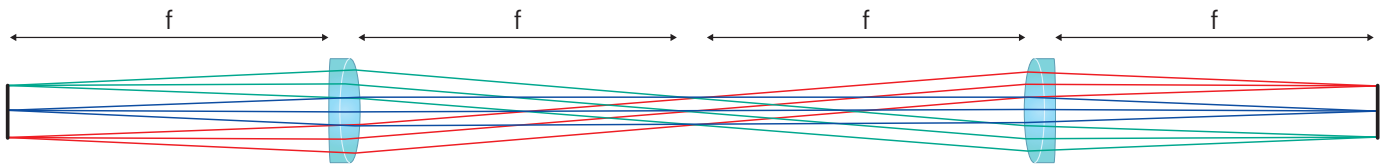
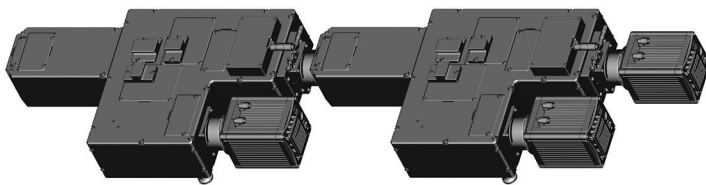


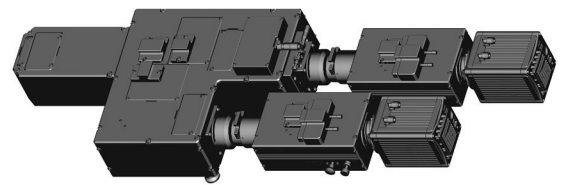
FIG. 01 The W-VIEW GEMINI-2C custom relay optics have a 4f optical configuration.

Lightsheet, Single Molecule Imaging and Super Resolution Microscopy

The W-VIEW GEMINI-2C was specifically developed to bring the temporal advantage of simultaneous dual channel imaging to cutting edge applications. To faithfully reproduce sample position, intensity and distribution characteristics across two sCMOS cameras requires refined optics. Using simulations of a spot projected through the optical system, the resolution of the W-VIEW GEMINI-2C, as shown by the size and shape of the beam at 0 mm, 3 mm and 6 mm from optical center, is significantly better. This data is shown for both high magnification (Fig 2), typical for single molecule and super resolution experiments, and low magnification (Fig 3), typical for lightsheet imaging systems.



Simultaneous tri-color measuring



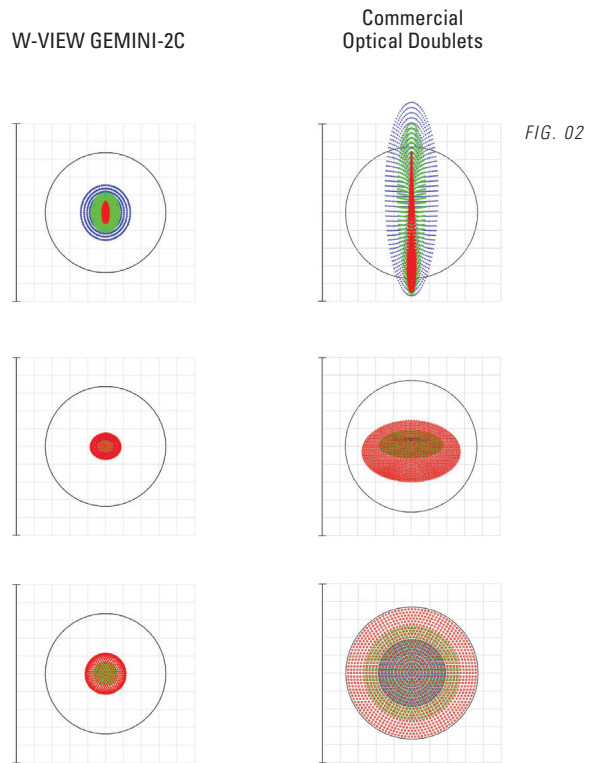
Simultaneous quad-color measuring

Tri-Color and Quad-Color Imaging

The 4f configuration of the optics makes it possible to connect multiple W-VIEW GEMINI-2Cs for full-field, tri-color, three-camera imaging. Alternatively, the addition of two single camera W-VIEW GEMINI devices provides quad channels imaged onto two ORCA-Flash4.0 series cameras.

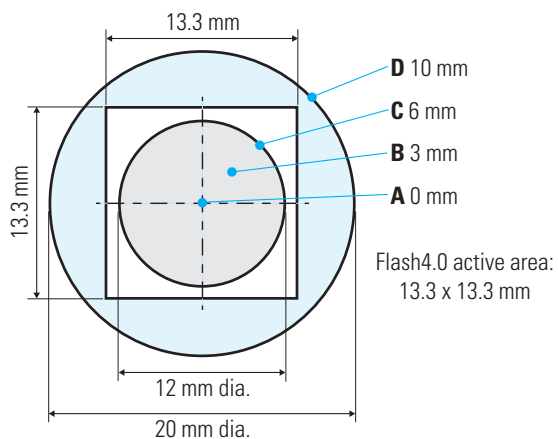
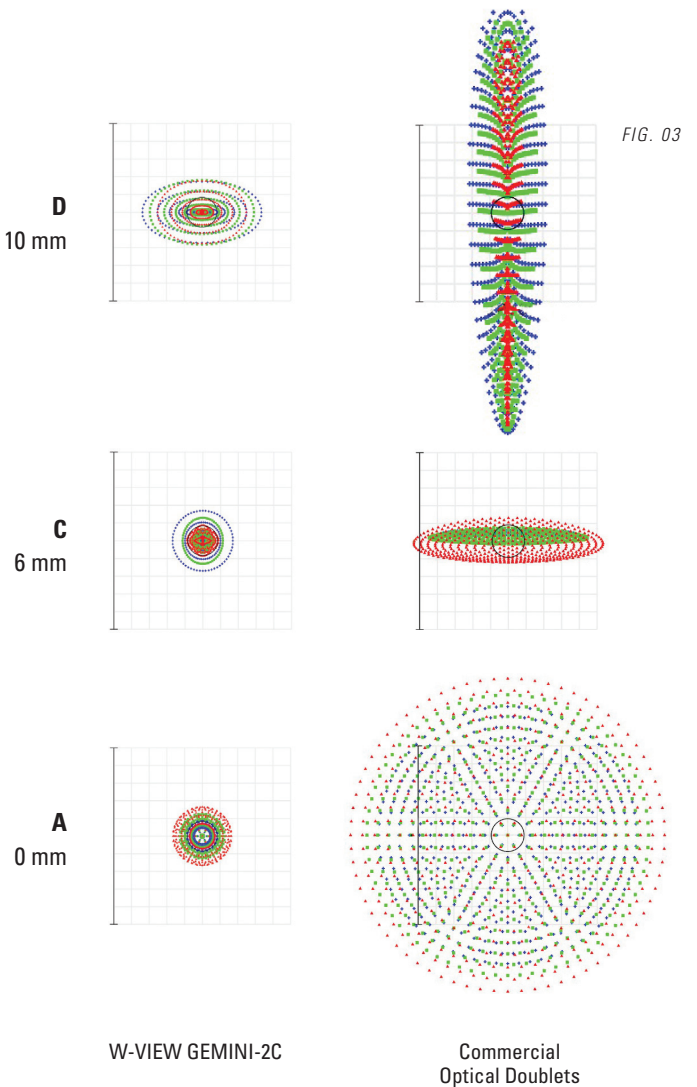
**Resolution at 60x Magnification,
Emulating Super Resolution Imaging Conditions**

Spot diagram simulation for 60x, 1.49 NA, 550 nm (blue lines), 600 nm (green lines), 650 nm (red lines) comparing the W-VIEW GEMINI-2C to commercially available doublet optics. Spot diagrams show how beams radiating from a single point are focused and provide insight into resolution of an optical system. The spot shapes are the result of imaging a beam at positions (A) 0 mm, (B) 3 mm and (C) 6 mm from the optical axis. The dark circle represents the diffraction-limited Airy disk. For the W-VIEW GEMINI-2C, the beam is nearly circular and well-within the Airy disk. For the doublet lenses, the beam spot is larger, not diffraction-limited and becomes distorted towards the edges of the field, demonstrating reduced resolution and possibility of image artifact creation.



**Resolution at 10x Magnification,
Emulating Lightsheet Imaging Conditions**

Spot diagram simulation for 10x, 0.5 NA, 550 nm (blue lines), 600 nm (green lines), 650 nm (red lines). The spot shapes are the result of imaging a beam at positions (A) 0 mm, (C) 6 mm and (D) 10 mm from the optical axis. Near the edges of the FOV (D), the beam image expands non-uniformly beyond the Airy disk (dark circle in center), indicating aberrations. For the W-VIEW GEMINI-2C, the spots at 0 mm and 6 mm are highly circular; this is not the case for the doublet lenses. Again, the W-VIEW GEMINI-2C optics deliver better resolution with fewer distortions.



Modular Design Supports Expansion into Engineered Point Spread Function Imaging

The W-VIEW GEMINI-2C is the first dual channel imaging device supporting engineered point spread function (PSF) imaging. For example, by using phase masks, (offered by Double Helix, www.doublehelicoptics.com) to create known modifications to the PSF, additional z position information can be extracted from a single plane permitting rapid 3D imaging and 3D tracking. Other mask designs can provide different functionalities. With the W-VIEW GEMINI-2C's triaxial adjustment mount and field lens unit installed, the phase masks are positioned into the relayed pupil plane. The field lens determines the macro positioning of the phase mask for each microscope system and triaxial adjustment mount provides fine x, y, z adjustment for each wavelength. With the complete W-VIEW GEMINI-2C PSF module installed, plus Double Helix phase masks and image processing software, any inverted microscope evolves into an advanced two color, 3D imaging system with super resolution capabilities.

Pupil position is moving

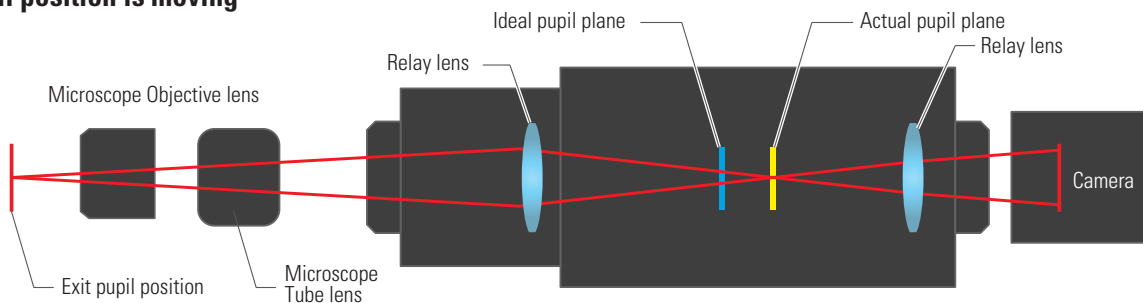
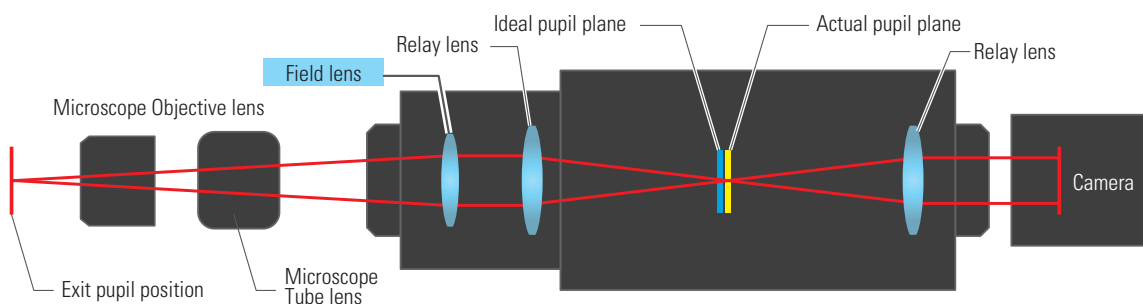


FIG. 04

In a near ideal state thanks to the field lens



Enabling engineered PSF Imaging with the W-VIEW GEMINI-2C

Engineered PSF imaging requires the phase masks be in the pupil plane. This is problematic since the microscope pupil plane is in the objective lens. To make engineered PSF imaging practical, it's necessary to relay the pupil plane to an accessible location. However, each microscope system has different optics, requiring flexibility in the positioning of the projected pupil plane. Hamamatsu has overcome this problem with a patent pending design that inserts a standard field lens near the primary image plane, bringing the actual pupil plane in line with the ideal pupil plane for most microscopes and objective lenses. By choosing the appropriate focal length field lens, the phase masks (set inside the triaxial adjustment mount) align into the pupil plane. To easily visualize each phase mask, a Bertrand lens projects the pupil plane/phase mask onto the camera. All the necessary components for engineered PSF imaging are listed on inside back cover. Although not included with the W-VIEW GEMINI-2C, Hamamatsu can recommend commercially available phase masks for your application and field lenses for your microscope brand and configuration.

Parts for engineered PSF module

Part Number	Part Description	Function
A12801-10 1 required	W-VIEW GEMINI-2C	Standard parts for dual camera imaging.
A12802-12 2 required	Triaxial adjustment mount (phase masks not included)	Mounts phase masks into pupil plane and provides micrometers for fine x, y and z alignment.
A12802-13 1 required (Patent Pending)	Bertrand lens unit	Projects plane of triaxial adjustment mount to camera. Allows visualization of phase masks/pupil plane alignment using field lens and triaxial adjustment mount micrometers.
A12802-20 1 required (Patent Pending)	Field lens unit (lenses not included)	Machined part that houses 1 field lens holder. Necessary for alignment of pupil plane with triaxial adjustment mount.
A12802-21 1 required	Field lens holder (lenses not included)	Frame for field lens; allows field lens to be inserted into field lens unit.
A12802-11 1 recommended	ZOOM correction lens unit	Changes magnification ratio and provides fine adjustment for lateral chromatic aberration correction.
A12802-15 1 recommended	PSF parts case	Case designed to hold all optional parts for PSF engineering including 2 triaxial adjustment mounts, 1 Bertrand lens and 1 field lens holder.

Optional parts for dual channel imaging

Part Number	Part Description	Function
A12802-11	ZOOM correction lens unit (Recommended for lightsheet and super resolution experiments)	Changes magnification ratio and provides fine adjustment for lateral chromatic aberration correction.
A12802-14	Grid chart unit (Recommended for lightsheet)	Designed to be placed in primary image position; allows grid to be projected to both cameras for ease of dual wavelength alignment.
A12802-10	Additional wavelength pair holder set for A12801-10. Set includes 1 dichroic holder and 2 filter holders (filters and dichroics not included)	Makes swapping wavelength pairs easy.

Specifications

Product Name W-VIEW GEMINI-2C Image Splitting Optics
Model Number A12801-10
Structure Dual camera, parallel arrangement for inverted microscopes

Performance Specs

Wavelength range ¹ (nm)	450 to 800
Maximum transmittance ² (typ.)	98 %
Uniformity ³ (typ.)	98 %
Distortion ⁴ (typ.)	0.05 %
Lateral color shift ^{4,5} (typ.) (μm)	6
Relay magnification	1.0x
Relay lens focal length (mm)	130
Field of view ⁶ (mm)	φ20
Field of view, diffraction limited ⁷ (mm)	φ12

Special Features

Longitudinal chromatic aberration correcting mechanism	Yes
Lateral chromatic aberration correcting mechanism	Optional
Mirror image inversion	No
X-Y position adjustment	Yes
Rotational adjustment	Yes
Bypass mode	Yes

Customer Supplied Optical Parts

Dichroic mirror size (mm)	25.1 x 35.5 to 26.1 x 38.1
Dichroic mirror thickness ⁸ (mm)	0.9 to 3.1
Band-pass and ND filter size (mm)	φ25.4
Band-pass and ND filter tolerance (mm)	+0, -0.6
Max thickness of band pass and ND filters ⁹ (mm)	6

Installation, Operation & Storage

Input mount	C-mount, female
Output mount	C-mount, male
Ambient operating temperature (°C)	0 to +40
Ambient storage temperature (°C)	-10 to +50
Operating and storage humidity	70 % max with no condensation

¹ When in bypass mode

² Peak wavelength in bypass mode

³ Min/max difference of images obtained with and without W-VIEW GEMINI-2C optics
 ORCA-Flash4.0 V3 camera used for imaging

⁴ Values calculated without objective lens

⁵ Amount of peripheral position shift when aligned at center

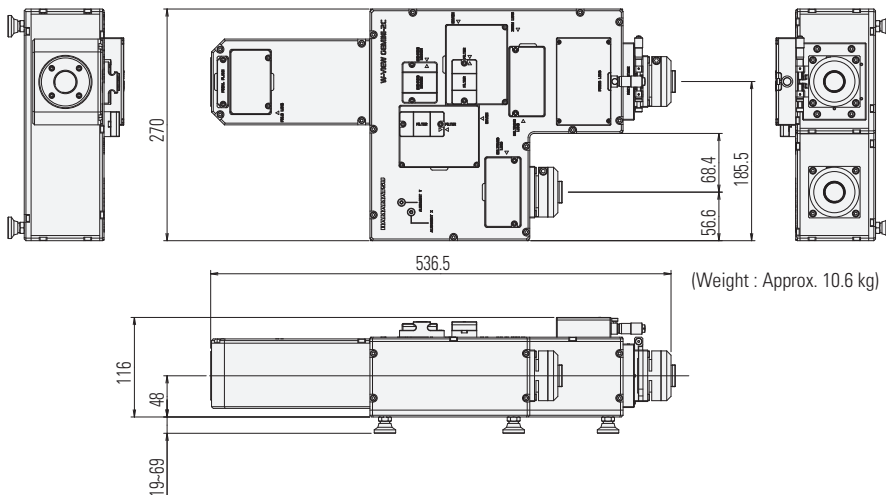
⁶ Vignetting may occur if used with relay or variable magnification lens

⁷ Simulation value for 0.025 imaging side N.A. of objective lens

⁸ Recommend 3 mm thick, high flatness on reflection side; typically called "imaging grade"

⁹ Sum of bandpass and ND filters used

Dimensional Outlines (mm)



W-VIEW GEMINI-2C (A12801-10)

- **Filter holders (2)** (filters not included)
- **Dichroic holder** (dichroic not included)
- **C-mount cap** (1 male, 2 female)
- **Hexagonal screwdriver** (2.5 & 4 mm)
- **Flathead screwdriver**
- **Concentric chart for alignment**
- **Accessory storage case**
- **Instruction manual**
- **Covers for following positions:**
 filters (2), dichroic, field lens,
 triaxial adjustment unit (2),
 Bertrand lens (2), image plane

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