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NEURO
Hardware Catalog
SFN2019

Twist-on efocus
Miniaturized
Fluorescence
Microscope

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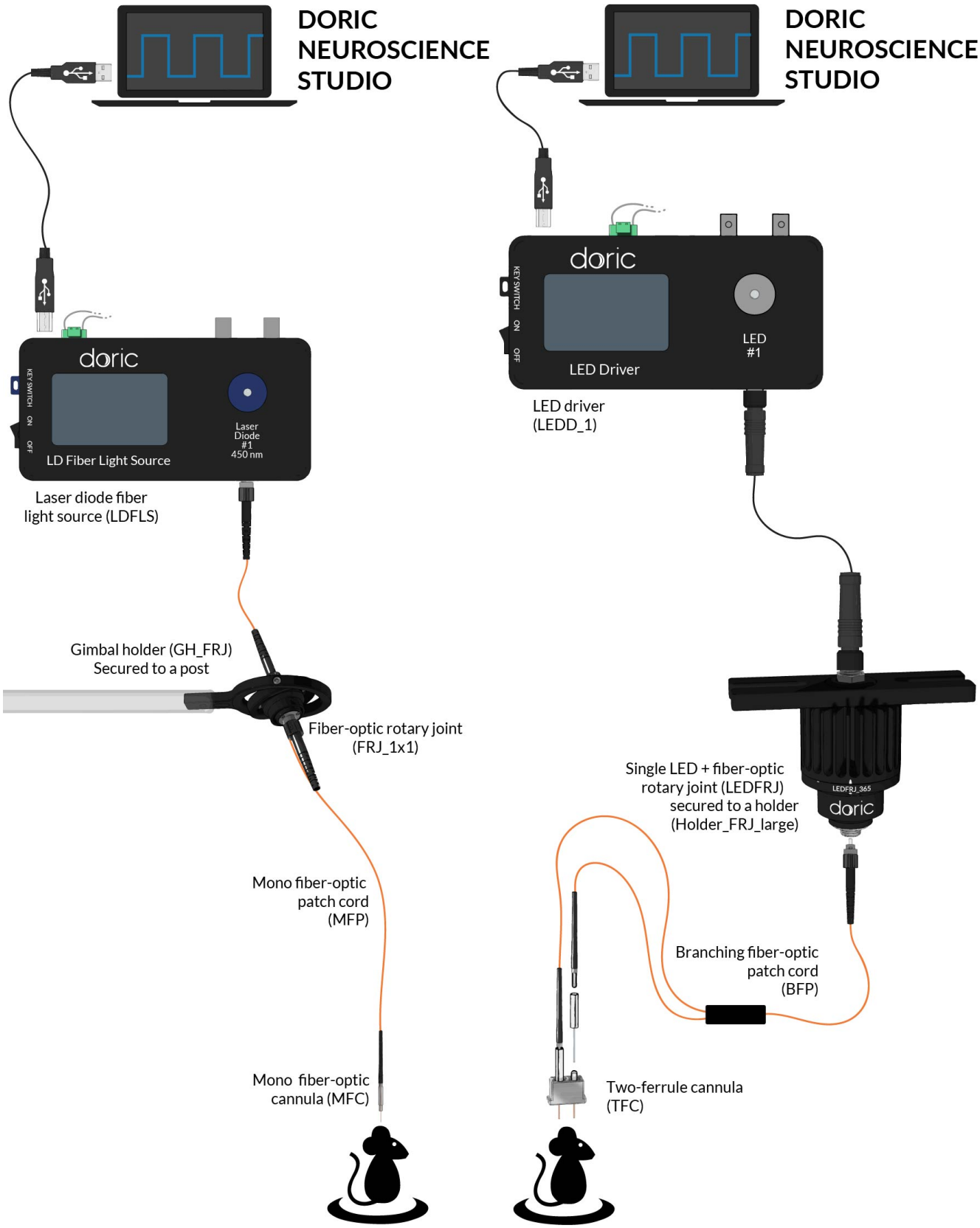
Contents

Overview of Neuro-photonics products catalog

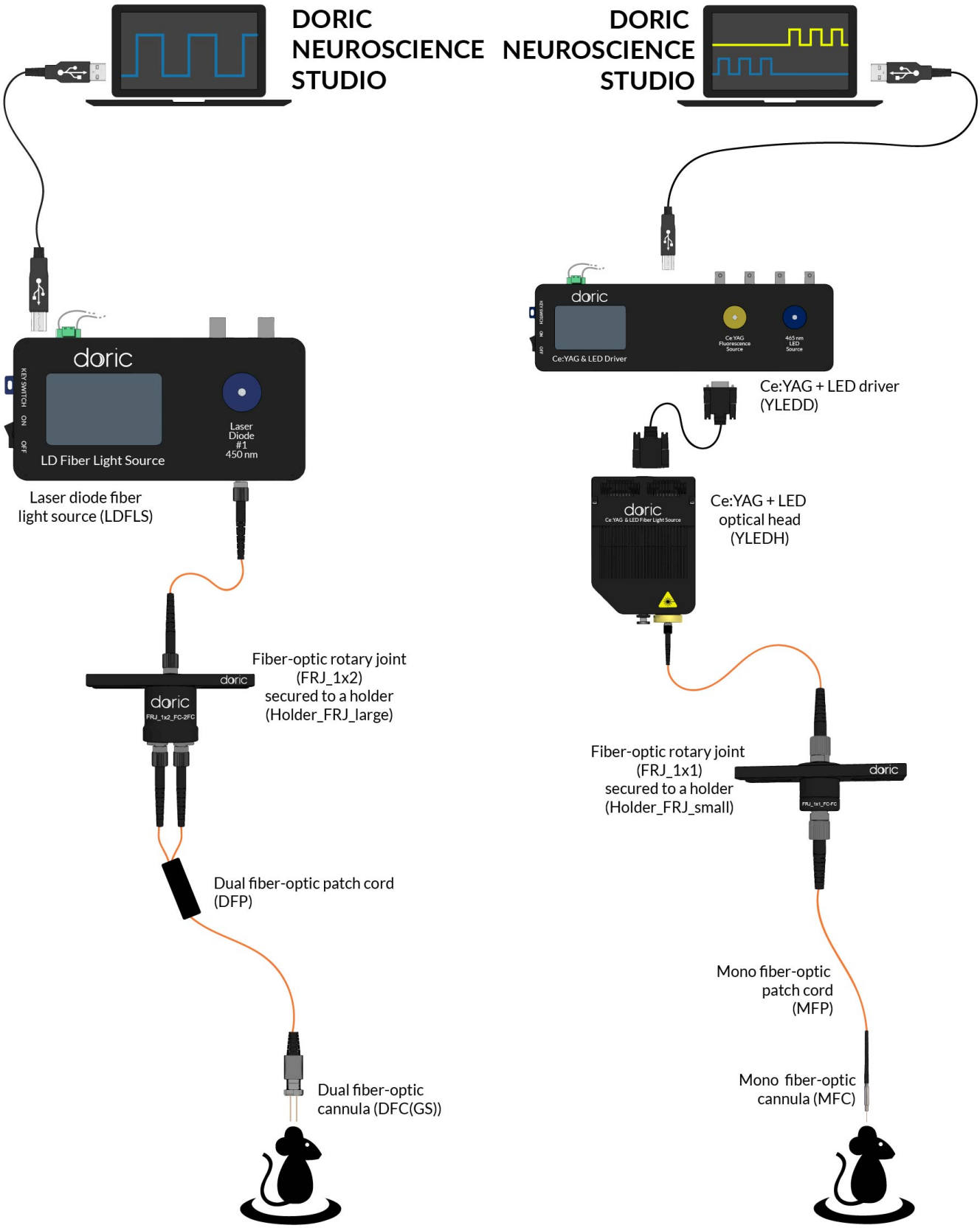
Over the years, this catalog has grown beyond its optogenetics roots to become a reference for neuro-photonics products. Initially, it covered only the hardware that was used for light stimulation and/or control of cells marked with genetically encoded light-sensitive proteins. In these experiments, the light from a laser or an LED source is sent through an optical fiber to a slice of brain tissue, or to the brain of a head-fixed or freely-moving animal. Overtime, this simple optical link has evolved into more complex circuitry, resembling the early days fiber-optic telecommunication networks. This fiber-to-the-brain network consists of fiber coupled light sources and their drivers, light shutters or modulators, rotary joints for experiments with freely-moving animals, beam-splitters, fiber-optic patch cords, various fiber-optic cannulas and much more. In addition to delivering light pulses to the tissue, this network monitors the interaction of tissue with light, sends and records electrical signals and administers different fluids.

Optogenetics uses light to control certain brain cells by opening/closing the ion channels in the membranes of genetically modified brain cells expressing light-sensitive ion channels. However, it does not generate any optical signal. On the other hand, fiber photometry and miniature fluorescence microscopy are perfect tools for monitoring changes in brain cell activity of freely-moving animals. Both use excitation light to generate fluorescence optical signal which is an indicator of neuronal activity. The difference between the two is that fiber photometry detects overall optical signal from a group of labelled cells while fluorescence microscopy records an image using optical signals from each neuron within the group.

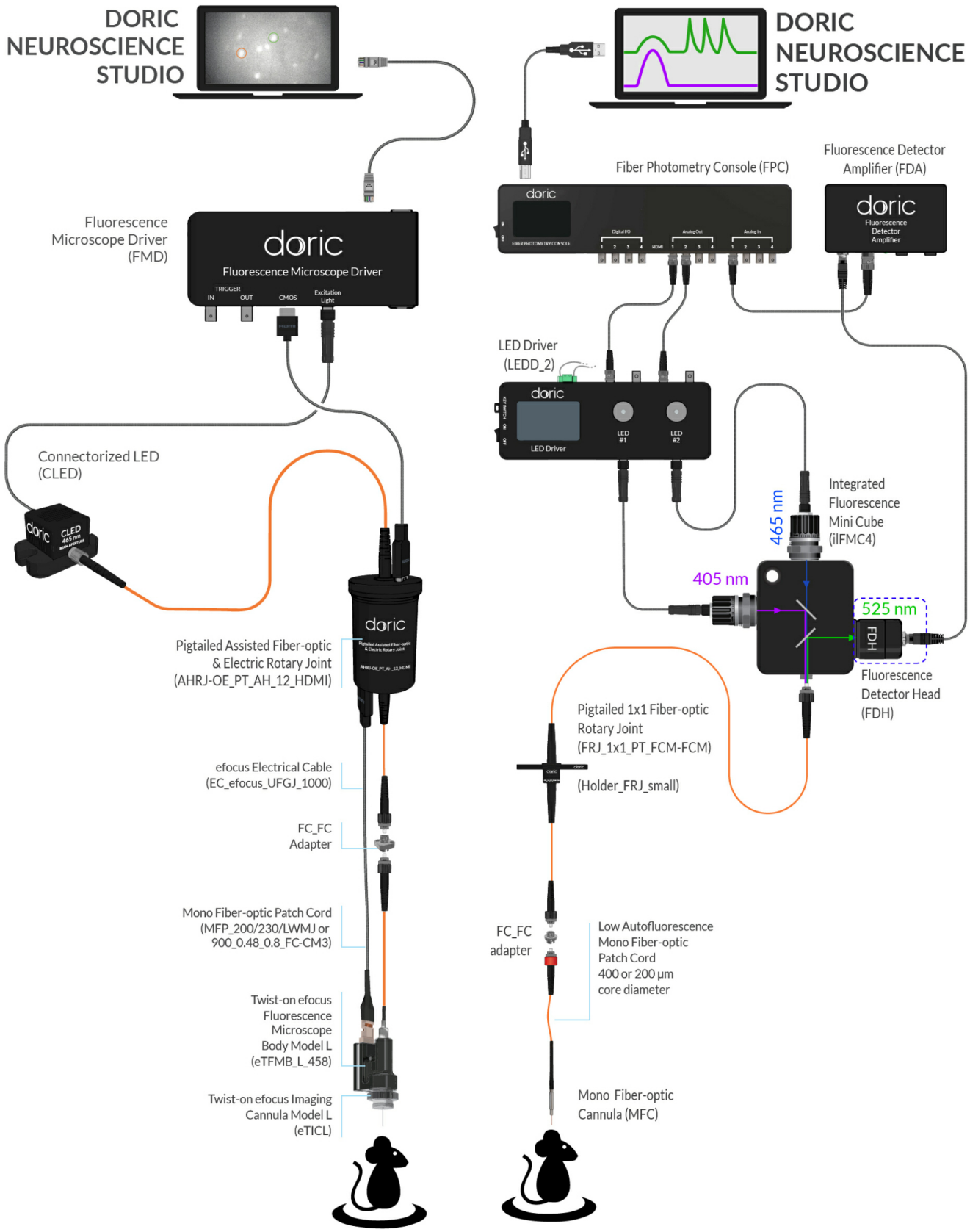
The aim of the catalog is to present each neuroscience application in the context of required optical hardware. In addition, there are several products combining these methods amongst themselves and with well-proven methods like electrophysiology. The following pages show system examples involving fiber-based optogenetics, fiber photometry, fluorescence microscopy systems and electrophysiology.



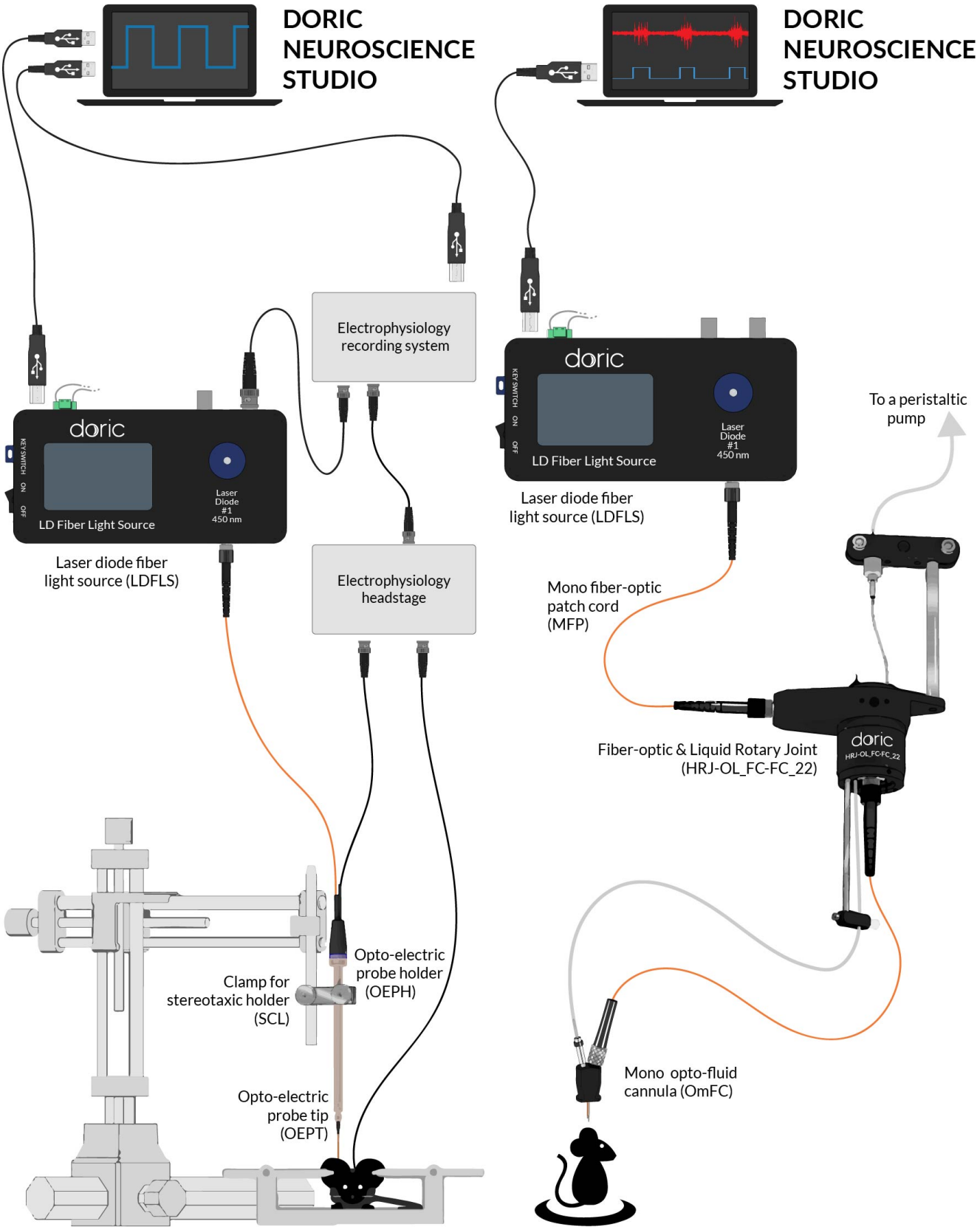
(Left) *Optogenetic stimulation with a Laser Diode Fiber Light Source.* ***(Right)*** *Bilateral optogenetic stimulation with a Connectorized LED with Fiber-optic Rotary Joint.*



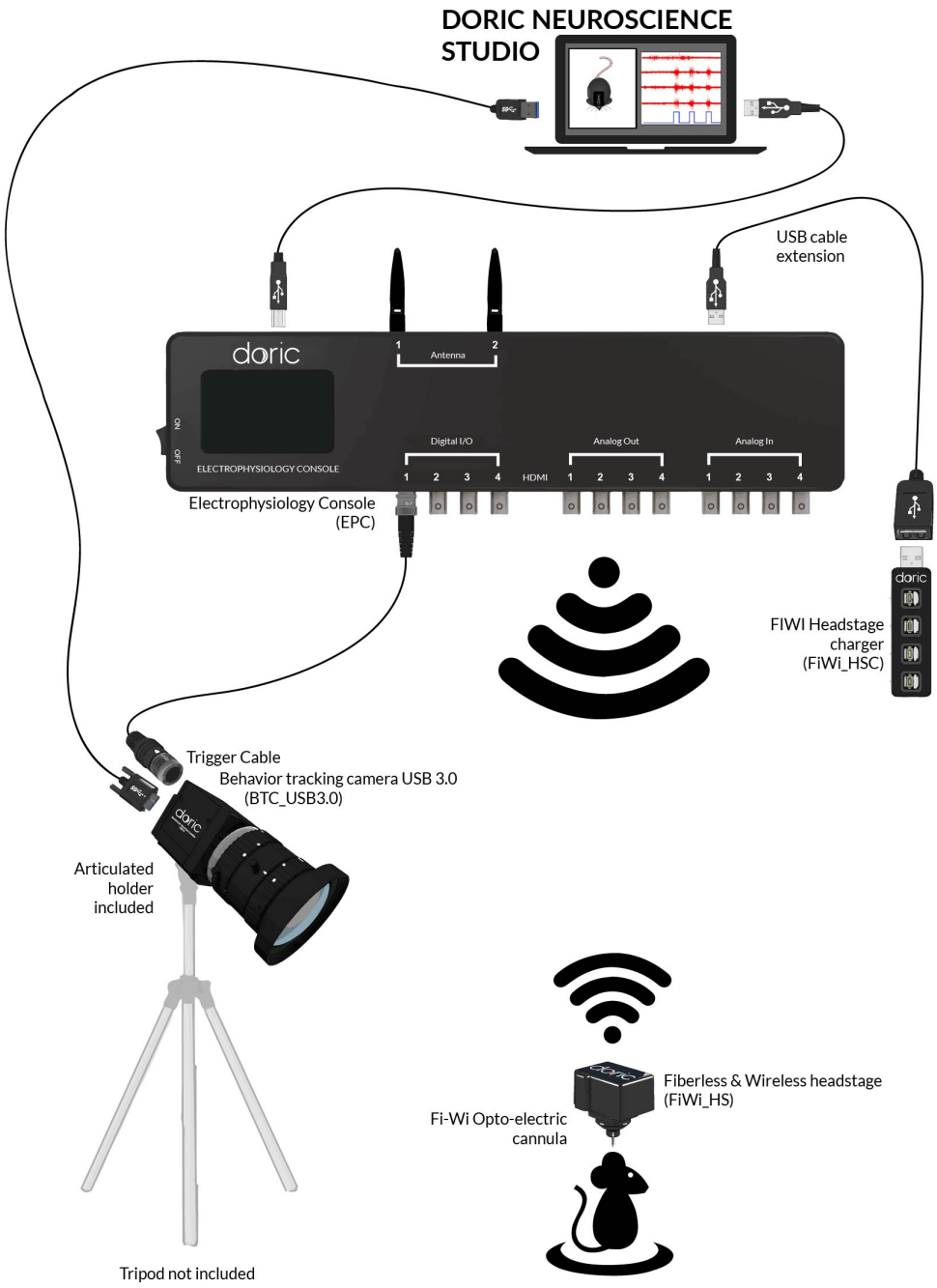
(Left) *Dual optogenetic stimulation with a Laser Diode Fiber Light Source.* ***(Right)*** *2-color optogenetic stimulation with a Ce:YAG + LED Fiber Light Source.*



(Left) *Miniaturized Fluorescence Microscopy System used for calcium imaging with GCaMP6.* ***(Right)*** *Fiber Photometry System with a 4 port Integrated Fluorescence Mini Cube and a Fiber Photometry Console.*



(Left) *Optogenetic stimulation and electrophysiology recordings with an Opto-electric Probe Tip.* ***(Right)*** *Optogenetic stimulation and fluid delivery with a Mono Opto-fluid Cannula.*



Fiberless & Wireless Optogenetically Synchronized Electrophysiology System and Behavior Tracking Camera

LED Illumination

Light emitting diodes (LEDs) coupled in an optical fiber are suitable for neuroscience experiments which need to bring light into the brain. LED light allows to control the excitation, inhibition or signalling of specific cells in optogenetic experiments. The uniform illumination of an LED makes it the preferred light source for miniature fluorescence microscopy and fiber photometry. Our compact *Connectorized LEDs* or multiple color combined LEDs are used with Doric programmable *LED Drivers*. We also offer LED Fiber Light Sources integrating 1, 2, or 4 independently controlled LEDs into the driver housing.

LED Modules

Connectorized LEDs

Doric *Connectorized LEDs* couple high brightness LEDs into an FC receptacle compatible with an FC connectorized fiber-optic patch cord. Each *Connectorized LED* is actively aligned for optimum output power and its optical design provides the maximum fiber-coupling efficiency into multimode optical fibers.

Connectorized LED

Each *Connectorized LED* includes an EPROM memory enabling its identification by the driver. The wavelength is recognized and the maximum current is automatically set to avoid accidental overdrive. Doric *Connectorized LEDs* are easily screwed on an optical table for a basic passive cooling suitable for low power and pulsed operations. During high power cw applications, an active cooling is obtained by connecting the internal fan with a micro-USB power supply. This is essential to maximize the device life span and obtain stable performances in terms of output power.

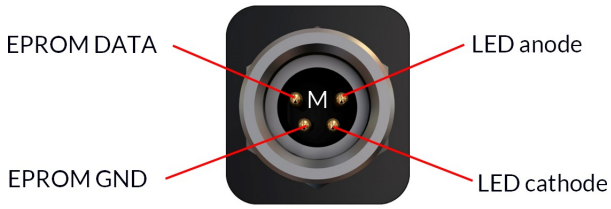
Notes:

- A micro-USB power supply is included with each *Connectorized LED*.
- A *Connectorized LED* does not include the corresponding LED Driver. See Table 4 for available LED Driver models.
- An *Optical Breadboard for Connectorized LED* (**LEDB**; see Table 116) is available to mount systems including two *Connectorized LEDs*.

Table 1: *Typical Connectorized LED Output Power vs Optical Fiber Core Diameter*

LED			TYPICAL OUTPUT POWER @1000 mA (mW)*			Overdrive @2000 mA (pulsed)
	Central Wavelength (nm)	Bandwidth FWHM (nm)	Core 200 µm 0.53 NA	Core 400 µm 0.53 NA	Core 960 µm 0.63 NA	
	365	~12	6.0	23	100	*
	385	~12	6.0	23	100	*
	405	~15	5.0	23	100	*
	420	~15	5.5	23	100	*
	450	~25	8.0	23	100	x1.7
	465	~25	7.5	23	100	x1.7
	505	~30	3.0	12	50	x1.6
	515	~40	3.0	9.5	40	x1.5
	560	~100	2.0	8.5	40	-
	595	~20	2.0	8.5	40	x1.2
	625	~20	3.5	14	70	x1.6
	635	~20	6.5	25	100	x1.6
	840	~35	6.0	22	40	-
	940	~35	2.0	10	40	-
	5500K	-	4.5	17	80	-

The power is given for *Connectorized LEDs* and *LEDs with Fiber-optic Rotary Joints* (LEDFRJ)†. Contact us for power levels for other *LED* products.



Connectorized LED male pinout

*All power values taken at a maximum current of 1000 mA, except for 365, 385, 405 and 420 nm LEDs (500 mA).
† In overdrive mode, LED drivers can produce current pulses of up to 2000 mA.

Table 2: *Connectorized LEDs Color Codes*

Color	Central Wavelength (nm)	LED Color Code
Near UV	365	**365**
Near UV	385	**385**
Near UV	405	**405**
Violet	420	**420**
Royal	450	**450**
Blue	465	**465**
Cyan	505	**505**
Green	515	**515**
Lime	560	**560**
Amber	595	**595**
Orange	625	**625**
Red	635	**635**
Infrared	840	**840**
Infrared	940	**940**
White	5500K	**W55**

ORDERING CODE: CLED_□□□

LED color code
(see Table 2)

LED Drivers

Doric programmable *LED Drivers* are available in 1-, 2-, and 4-channel versions. When connected to a Connectorized LED having an eprom memory, the *LED Driver* recognizes the LED wavelength and automatically sets the maximum current value to avoid accidental overdriving.

Two-channel LED Driver

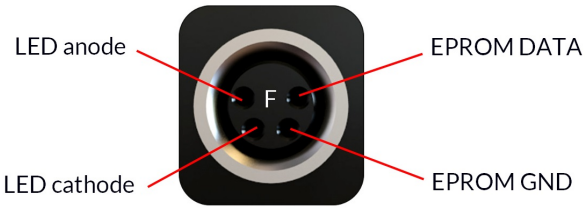
In stand-alone mode, all *LED Drivers* allow cw operation and external analog modulation through an input BNC connector for each channel. For each channel, there is also a current monitoring BNC output allowing data acquisition or triggering of other devices. When using Doric Neuroscience Studio Software, more advanced operating modes are available such as TTL modulation and software

defined illumination sequences, thus eliminating the need for a function generator. In low-duty cycle pulsed mode, the software allows to overdrive the LED sources if a higher power is needed. For multiple channel driver versions, each channel is controlled independently. Although not mandatory for LED sources, our *LED Drivers* come with a safety interlock connector and a main key switch. These safety features are of interest for UV and near infrared LEDs.

Note: The renewed line of Doric *LED Drivers* has a new connector pinout that does not include pins for fan power. It is thus essential to use a *Fan Power Adapter* (**FPA**; see Table 115) when using *Combined LEDs* or *Combined LEDs with a Fiber-optic Rotary Joint*. This power adapter is suitable for up to 4 channels and is sold with corresponding M8 cables.

Table 3: *LED Drivers Specifications*

SPECIFICATION	VALUE
Maximum current	1 A (2 A overdrive)
Input BNC modulation	0 - 5 V TTL or analog (400 mA/V)
Output BNC monitoring	0 - 5 V (2.5 V/A)
Output LED connector	M8 4-pin female



LED Driver female pinout

Table 4: *LED Drivers Ordering Codes*

Number of Channels	Ordering Code
1	**LEDD_1**
2	**LEDD_2**
4	**LEDD_4**
8	**LEDD_8***

*8-channel LED Driver is available on request

Combined LEDs

Doric *Combined LEDs* merge the light from multiple LEDs of different colors into a single output connector by using a patent pending regular pentagon mirrors configuration. The coupling efficiency for respective colors is near those of our Connectorized LEDs. Each LED of the *Combined LEDs* is driven independently via an M8 cable when connected to any of our driver(s).

Notes:

- A compatible holder is included to secure the *Combined LEDs*.
- *Combined LEDs* do not include the corresponding LED Driver. See Table 4 for available LED Driver models.
- The renewed line of Doric LED Drivers has a new connector pinout that does not include pins for fan power. When using the *LEDC2*, it is thus essential to use a *Fan Power Adapter* (**FPA**; see Table 115).

Table 5: *Combined LEDs*

2-LED Model	3-LED Model	4-LED Model
		
Ordering Code:	**Ordering Code:**	**Ordering Code:**
LEDC2_□□□/□□□	**LEDC3**_□□□/□□□/□□□	**LEDC4**_□□□/□□□/□□□/□□□

LED color code (see Table 2)

LED + Fiber-optic Rotary Joint

Connectorized LED with Fiber-optic Rotary Joint

It is a common practice to connect an LED with a rotary joint via a fiber-optic patch cord. If the tips of the patch cord are not coated, which is usually the case, at least 8% of the light power is lost from the Fresnel reflections, in addition to other connection losses. One way of getting around these losses is to integrate the LED source and the fiber-optic rotary joint in a single device, thus eliminating one fiber-optic patch cord. That is the purpose of Doric Connectorized LED sources with fiber-optic rotary joint.

Connectorized LED + Fiber-optic Rotary Joint

Notes:

- A compatible holder is included with the *Connectorized LED + Fiber-optic Rotary Joint* (**Holder_-FRJ_large**; see Table 118).
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).
- A *Connectorized LED with Fiber-optic Rotary Joint* does not include the corresponding LED Driver. See Table 4 for available LED Driver models.

ORDERING CODE: LEDFRJ_□□□

LED color code
(see Table 2)

Combined LEDs with Fiber-optic Rotary Joint

Combined LEDs with Fiber-optic Rotary Joint are perfect for the light activation of multiple opsins (*e.g.* channelrhodopsin and halorhodopsin). Other combinations of LED wavelengths are available as long as their spectra do not overlap.

New types of opsins are frequently emerging from ongoing research. Doric *Combined LEDs with Fiber-optic Rotary Joint* are easily customized to most sets of activation wavelengths. Our patent pending assemblies provide the possibility to combine up to four distinct wavelengths and couple them into a single output rotary joint.

Table 6: *Combined LEDs with Fiber-optic Rotary Joint*

2-LED model + FRJ	3-LED model + FRJ	4-LED model + FRJ
		
Ordering Code: **LEDFRJ_□□□/□□□**	**Ordering Code:** **LEDFRJ_□□□/□□□/□□□**	**Ordering Code:** **LEDFRJ_□□□/□□□/□□□/□□□**

LED color code
(see Table 2)

Notes:

- A compatible holder is included to secure the *Combined LEDs with Fiber-optic Rotary Joint*.
- A *Combined LEDs with Fiber-optic Rotary Joint* does not include the corresponding *LED Driver*. See Table 4 for available LED Driver models.
- The renewed line of Doric LED Drivers has a new connector pinout that does not include pins for fan power. It is thus essential to use a *Fan Power Adapter* (**FPA**; see Table 115) when using *Combined LEDs with Fiber-optic Rotary Joint*. This power adapter is suitable for up to 4 channels.

LED Fiber Light Sources

2-channel LED Fiber Light Source

The *LED Fiber Light Source* is an assembly of one or multiple independent LEDs and their driving electronics into a compact housing. Each LED has its own output FC connector.

The functionalities and software of Doric LED Fiber Light Sources are identical to those of LED Drivers. When ordering multi-channel models, any combination of LED wavelengths can be chosen according to the following ordering codes.

ORDERING CODE:

1-channel model **LEDFLS**_□□□

2-channel model **LEDFLS**_□□□_□□□

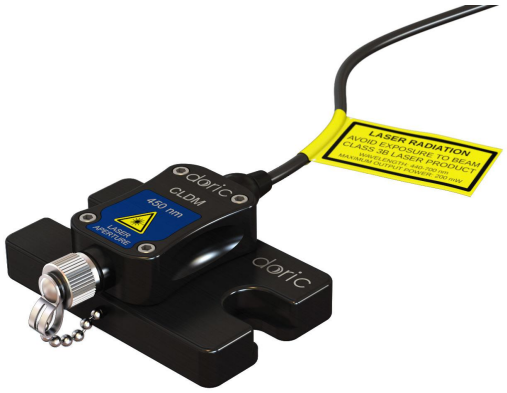
4-channel model **LEDFLS**_□□□_□□□_□□□_□□□

LED color codes (see Table 2)

Note: The typical output power of each LED is shown in Table 1.

Laser Diode Illumination

Connectorized Laser Diode Modules



Connectorized Laser Diode Module

Our miniature *Connectorized Laser Diode Modules* have FC/APC receptacles compatible with FC/APC connectorized multimode optical fibers having 50 µm or larger core diameters and at least 0.22 NA. With laser diode sources, using FC/APC connectors is essential to avoid optical feedback and the corresponding intensity noise. The laser diode module size is 24.6 x 36.8 x 12.0 mm^3, excluding the base plate and the electric cable. The base plate is used as a passive heat sink and can be used to secure the module on an optical table for an even better thermal stability. The module connects only to Doric Laser Diode Module Driver over the M8 electrical cable. Each module contains an EPROM memory allowing the Laser Diode Module Driver to recognize the device and set the corresponding maximum current, thus preventing accidental overdrive of the laser diode by the user. The available wavelengths and fiber-coupled output power values are given in Table 7.

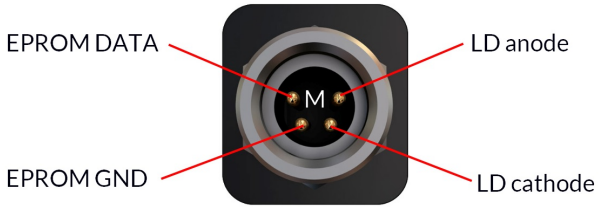
Table 7: *Connectorized Laser Diode Modules Codes*

	Central Wavelength(nm)	Bandwidth FWHM (nm)	Power (mW)*	Laser Diode Code
	405	<3	100	**405/100**
	450	<3	75	**450/075**
	473	<3	70	**473/070**†
	488	<3	50	**488/050**†
	520	<3	60	**520/060**
	638	<3	80	**638/080**
	638	<3	120	**638/120**

ORDERING CODE: CLDM_□□□/□□□

Laser diode code (see Table 7)

*Power coupled into 50 µm core, NA 0.22 optical fiber
†The unit prices of the 473 nm and 488 nm laser diode modules are significantly higher.



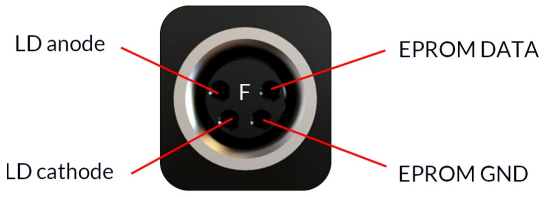
Connectorized Laser Diode Module male pinout

Note: A *Connectorized Laser Diode Module* does not include the corresponding Laser Diode Module Driver. See Table 8 for available Laser Diode Module Driver models.

Laser Diode Module Drivers

Laser Diode Module Driver: 2-channel model

The *Laser Diode Module Driver* available in 1-, 2- and 4-channel models is controlled manually or by a computer via USB. Each channel has a BNC input connector for up to 10 kHz TTL/analog modulation of the driving current and a BNC output connector for monitoring the driving current or for the synchronization with other devices. Doric drivers laser safety features include a rear panel interlock connector, a master key switch and white LED illuminated control knobs indicating laser diode operation. Unlike most commercial laser diode drivers, our linear driving electronics eliminates the leakage current and the corresponding residual light output when the current is set to zero. For optogenetics experiments it is of crucial importance to eliminate any light output when the driving current is set to zero. The *Laser Diode Module Driver* recognizes *Connectorized Laser Diode Modules* and automatically sets the corresponding maximum driving currents, thus preventing accidental overdrive.



Laser Diode Module Driver female pinout

Table 8: *Laser Diode Module Drivers Ordering Codes*

Number of channels	Ordering Code
1	**LDMD_1**
2	**LDMD_2**
4	**LDMD_4**

Laser Diode Fiber Light Sources

Laser Diode Fiber Light Source: 2-channel model

The *Laser Diode Fiber Light Source* is a more compact alternative to the combination of the *Connectorized Laser Diode Modules* and *Laser Diode Module Drivers*. Available in 1-, 2- and 4-channel models, the source is fully compatible with Doric free operating software. Each channel has a BNC input connector for up to 10 kHz TTL/analog modulation of the driving current and a BNC output connector for monitoring the driving current or for synchronization with other devices. Its laser safety features include a rear panel interlock connector, a master key switch and white LED illuminated control knobs indicating laser diode operation. Also, each FC/APC optical connector has a metal dust cap that acts as protective mechanical shutter in absence of optical fiber. Unlike most commercial laser diode drivers, our linear driving electronics eliminates leakage current and the corresponding residual light output when the current is set to zero. For optogenetics experiments it is of crucial importance to eliminate any light output when the driving current is set to zero. The available wavelengths and fiber-coupled power values are given in the table below. For multichannel models, any wavelength combination can be chosen at time of ordering.

ORDERING CODE:

1-channel model **LDFLS**_□□□/□□□

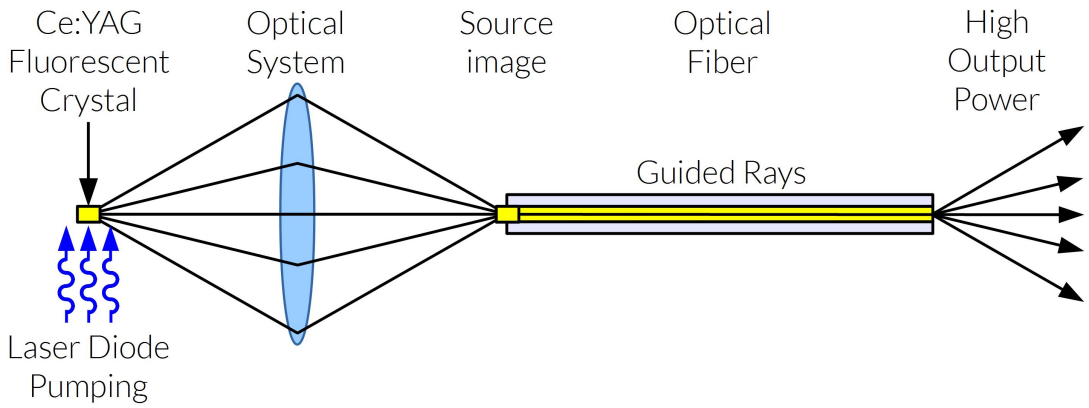
2-channel model **LDFLS**_□□□/□□□_□□□/□□□

4-channel model **LDFLS**_□□□/□□□_□□□/□□□_□□□/□□□_□□□/□□□

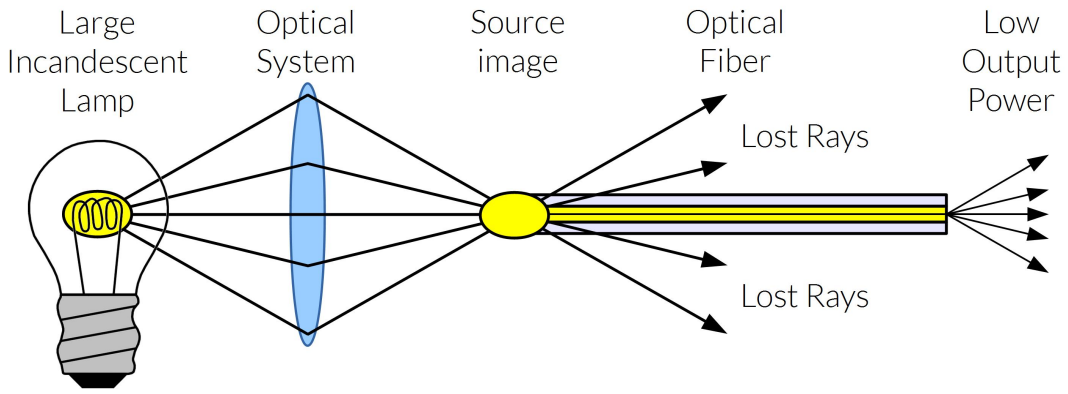
Laser diode codes (see Table 7)

Ce:YAG Fluorescent Illumination

As LED lighting made it obvious, white light can be generated by blue LED pumping of phosphors or fluorescent crystals such as Cerium-doped YAG crystals (Ce:YAG). However, the relatively large emitting area of blue LEDs and their highly divergent light beams result in a fluorescent light source of very large optical etendue (emitter area times light beam divergence) unsuitable for effective fluorescence coupling into small core optical fibers. Optogenetics and other life science applications require tens of milliwatts of suitable bandwidth into the small core diameter of optical fibers. Consequently, we designed fluorescent light sources, called the *Ce:YAG Fiber Light Sources*, in which a Ce:YAG crystal is pumped over a very small area with multiple high-power blue laser diodes instead of LEDs. As shown in the figure below, this patent pending laser diode pumping geometry creates a small area fluorescence light emitter. This is optimized for efficient coupling into the small core diameter of optical fibers, unlike the LED based light sources and other technologies such as arc lamps and incandescent lamps.

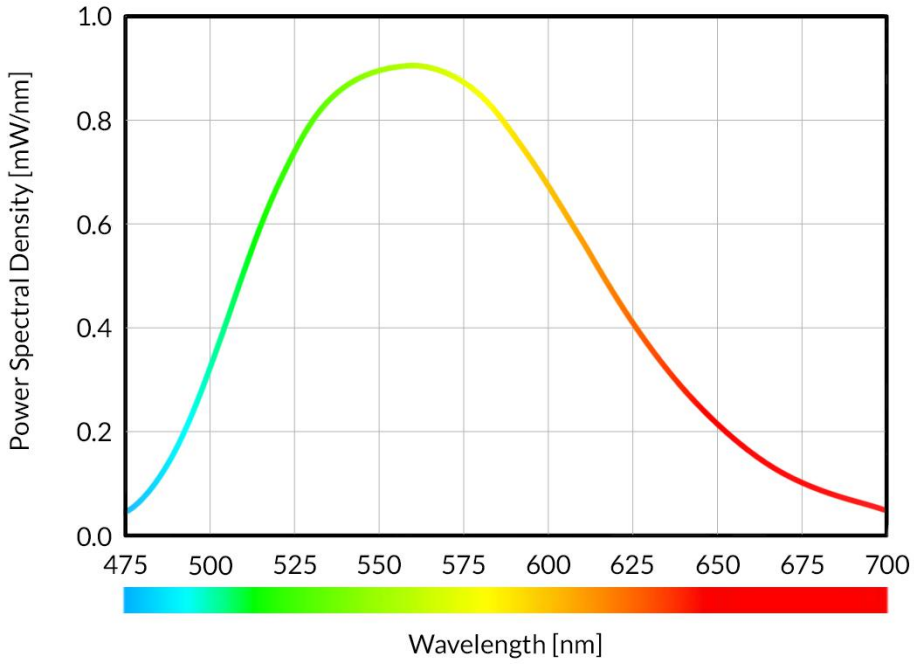


Laser diode pumped Doric Ce:YAG Fiber Light Source



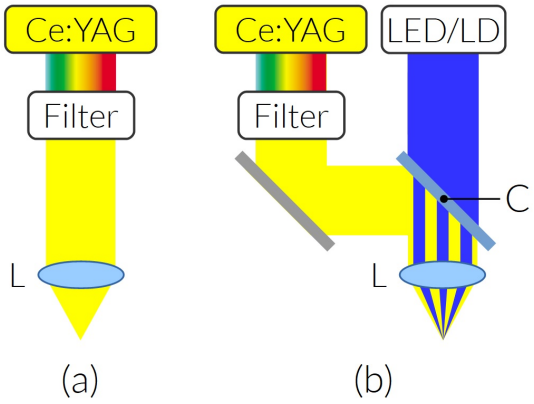
Conventional fiber light source

The *Ce:YAG Fiber Light Source* emits incoherent light in the green-yellow-red part of the spectrum (see the figure below) with brightness levels far exceeding those of LED based light sources. Unlike lasers, the output of the *Ce:YAG Fiber Light Source* is speckle-free due to the incoherent nature of fluorescence. Also, the *Ce:YAG Fiber Light Source* can be electronically modulated through its pumping laser diodes without the noisy intensity spiking encountered with most diode-pumped solid state (DPSS) lasers emitting in the same spectral range.



Output power spectral density (PSD) of a Ce:YAG Fiber Light Source using a 200 µm, 0.53 NA optical fiber. Power and irradiance specifications are respectively given in Table 13 and 14.

The optical head of the Doric *Ce:YAG Fiber Light Source* is offered in two models schematically shown in the figure on the right: (a) the *Ce:YAG Optical Head* and (b) the *Ce:YAG + LED Optical Head* or the *Ce:YAG + Laser Diode Optical Head*. For both models, a removable filter (see figure) can select the wavelength range within the broad emission band of the Ce:YAG fluorescence. Standard bandpass optical filters are given in Table 11 with their corresponding ordering codes. The optical head model shown in (b) includes a dichroic beam combiner C and a blue light source which is either a 465 nm LED, a 450 nm laser diode or a 473 nm laser diode. When combined with an LED or a LD source, the Ce:YAG source and the LED or LD can be modulated independently using Doric *Ce:YAG Drivers*. For both optical head models, a fiber coupling lens L focus the output beam into an FC receptacle for optimum fiber coupling.



Schematic representation of (a) the Ce:YAG Optical Head *and (b) the* Ce:YAG + LED Optical Head *or* Ce:YAG + Laser Diode Optical Head

Optical Heads of the Ce:YAG Fiber Light Source

A *Ce:YAG Fiber Light Source* is an optical head and an electronic driver linked by an HDB15 cable (see the section Drivers of the Ce:YAG Fiber Light Source). Optical heads of *Ce:YAG Fiber Light Sources* are optimized for optical fibers core diameters of 200 µm to 400 µm and numerical aperture NA = 0.53. The fiber-coupled output power increases with the core diameter up to about 600 µm.

Ce:YAG Optical Head

The optical output is thus well optimized for unilateral and bilateral activation/silencing in optogenetics experiments and for Doric Optogenetically Synchronized Fluorescence Microscopy Systems. A Ce:YAG optical head is also included with each 2-color Fluorescence Microscope System (using a different driver).

The optical specifications of Ce:YAG optical heads are given in Table 9.

Table 9: *Typical Ce:YAG Optical Heads Output Power (mW) vs Optical Fiber Core Diameter, NA*

				TYPICAL OUTPUT POWER (mW)			
		Central Wavelength (nm)	**Bandwidth FWHM (nm)**	**Core 100 µm (0.22 NA)**	**Core 200 µm (0.53 NA)**	**Core 400 µm (0.53 NA)**	**Core 960 µm (0.63 NA)**
Ce:YAG		Full spectrum	~110	8.6	94	230	350
		525	~30	2.1	21	55	94
		559	~34	2.7	29	72	108
		582	~75	4.7	51	125	181
		593	~40	2.5	28	67	93
		612	~69	3.0	33	79	112
LED		465	~27	-	5.4*	13*	43*
LD		450	<3	75	75	75	75
LD		473	<3	70	70	70	70

*Specifications in continuous (cw) mode. In overdrive mode, the LED output power is multiplied by ~1.7.

Table 10: *Ce:YAG Optical Heads Ordering Codes*

Ce:YAG Optical Head

Ordering Code:
YAGH

Ce:YAG + LED Optical Head

Ordering Code:
YLEDH

Ce:YAG + Laser Diode Optical Head

Ordering Code:
YLDH_□□□

Laser wavelength (nm)
450 or **473** nm

Notes:

- A *Ce:YAG Optical Head* does not include the corresponding Ce:YAG Driver. See Table 12 for available Ce:YAG Driver models.
- Each *Ce:YAG Optical Head* is delivered with an empty *Filter Holder for Ce:YAG Fiber Light Source* (**YFH**; see Table 117). The available *Bandpass filters for Ce:YAG Fiber Light Sources* (**YBPF**) are presented in Table 11.

Bandpass Filters for Ce:YAG Fiber Light Sources

Each Ce:YAG Optical Head is delivered with an empty Filter Holder for Ce:YAG Fiber Light Source (**YFH**; see Table 117). This holder can accept up to 5 mm thick filters of 25 or 25.4 mm diameter. Doric standard *Bandpass filters* are sold already mounted in a filter holder (**YBPF**, see Table 11).

Bandpass Filter for Ce:YAG Fiber Light Sources in its holder

Table 11: *Bandpass filters for Ce:YAG Optical Heads*

Central Wavelength (nm)	Bandwidth FWHM (nm)	Ordering Code
525	~30	**YBPF_525/030**
549	~15	**YBPF_549/015**
559	~34	**YBPF_559/034**
582	~75	**YBPF_582/075**
593	~40	**YBPF_593/040**
612	~69	**YBPF_612/069**

Drivers of the Ce:YAG Fiber Light Source

All *Ce:YAG Driver* models can be controlled manually or using a computer via a USB port and Doric Neuroscience Studio Software. Drivers are offered in 3 models shown in Table 12. All models include a first channel for controlling the Ce:YAG source driving current. For Ce:YAG Optical Heads including an internal blue source, either an LED or a laser diode (LD), the corresponding drivers include a second channel for the blue source. In these cases, both channels are controlled independently through software defined sequences or using the BNC input connector of each channel for an external control by analog or TTL signals. Each channel also includes a BNC output connector proportional to the driving current. This output signal can be used for the synchronization of other devices. Doric *Ce:YAG Drivers* safety features include a rear panel interlock connector, a master key switch and, for each channel, a white LED illuminated knob indicating if the corresponding source is activated. Unlike most commercial drivers, Doric driving electronics eliminates the leakage current and the corresponding light output when the current is set to zero. This is of crucial importance for optogenetics experiments.

Table 12: *Ce:YAG Drivers Ordering Codes*

Ce:YAG Drivers		**Ordering Code**
Ce:YAG Driver		**YAGD**
Ce:YAG + LED Driver		**YLEDD**
Ce:YAG + Laser Diode Driver		**YLDD**

Notes:

- A *Ce:YAG Driver* does not include the corresponding Ce:YAG Optical Head. See Table 10 for available Ce:YAG Optical Head models.
- The *Ce:YAG + Laser Diode Driver* is compatible with the Ce:YAG + 450 nm Laser Diode Optical Head and the Ce:YAG + 473 nm Laser Diode Optical Head.

Table 13: *Typical Light Sources Output Power vs Optical Fiber Core Diameter*

	λ (nm)	Δλ (nm)	Source	TYPICAL OUTPUT POWER (mW) 50 µm (0.22 NA)	100 µm (0.22 NA)	200 µm (0.53 NA)	400 µm (0.53 NA)	960 µm (0.63 NA)	Ordering Code
	365	~12	LED	-	-	6.0	23	100	**CLED_365**
	385	~12	LED	-	-	6.0	23	100	**CLED_385**
	405	<3	LD	100	100	100	100	100	**CLDM_405/100**
	405	~15	LED	-	-	5.0	23	100	**CLED_405**
	420	~15	LED	-	-	5.5	23	100	**CLED_420**
	450	<3	LD	75	75	75	75	75	**CLDM_450/075**
	450	~25	LED	-	-	8.0	23	100	**CLED_450**
	465	~25	LED	-	-	7.5	23	100	**CLED_465**
	473	<3	LD	70	70	70	70	70	**CLDM_473/070**
	488	<3	LD	50	50	50	50	50	**CLDM_488/050**
	505	~30	LED	-	-	3.0	12	50	**CLED_505**
	515	~40	LED	-	-	3.0	9.5	40	**CLED_515**
	520	<3	LD	60	60	60	60	60	**CLDM_520/060**
	525	~30	Ce:YAG	-	2.1	21	55	94	**Ce:YAG_525/030**
	550	~110	Ce:YAG	-	8.6	94	230	350	**Ce:YAG_550/000**
	559	~34	Ce:YAG	-	2.7	29	72	108	**Ce:YAG_559/034**
	560	~100	LED	-	-	2.0	8.5	40	**CLED_560**
	582	~75	Ce:YAG	-	4.7	51	125	181	**Ce:YAG_582/075**
	593	~40	Ce:YAG	-	2.5	28	67	93	**Ce:YAG_593/040**
	595	~20	LED	-	-	2.0	8.5	40	**CLED_595**
	612	~69	Ce:YAG	-	3.0	33	79	112	**Ce:YAG_612/069**
	625	~20	LED	-	-	3.5	14	70	**CLED_625**
	635	~20	LED	-	-	6.5	25	100	**CLED_635**
	638	<3	LD	80	80	80	80	80	**CLDM_638/080**
	638	<3	LD	120	120	120	120	120	**CLDM_638/120**
	840	~35	LED	-	-	6.0	22	40	**CLED_850**
	940	~35	LED	-	-	2.0	10	40	**CLED_940**
	5500K	-	LED	-	-	4.5	17	80	**CLED_W55**

Table 14: *Typical Light Sources Irradiance vs Optical Fiber Core Diameter*

				TYPICAL INTENSITY at FIBER TIP (mW/mm²)					
	λ (nm)	Δλ (nm)	Source	50 µm (0.22 NA)	100 µm (0.22 NA)	200 µm (0.53 NA)	400 µm (0.53 NA)	960 µm (0.63 NA)	Ordering Code
	365	~12	LED	-	-	190	183	138	**CLED_365**
	385	~12	LED	-	-	190	183	138	**CLED_385**
	405	<3	LD	51 000	13 000	3 200	800	140	**CLDM_405/100**
	405	~15	LED	-	-	159	183	138	**CLED_405**
	420	~15	LED	-	-	175	183	138	**CLED_420**
	450	<3	LD	38 000	9 500	2 400	600	100	**CLDM_450/075**
	450	~25	LED	-	-	254	183	138	**CLED_450**
	465	~25	LED	-	-	238	183	138	**CLED_465**
	473	<3	LD	36 000	8 900	2 200	560	97	**CLDM_473/070**
	488	<3	LD	25 000	6 400	1 600	400	69	**CLDM_488/050**
	505	~30	LED	-	-	95	95	69	**CLED_505**
	515	~40	LED	-	-	95	75	55	**CLED_515**
	520	<3	LD	31 000	7 600	1 900	480	83	**CLDM_520/060**
	525	~30	Ce:YAG	-	267	668	438	130	**Ce:YAG_525/030**
	550	~110	Ce:YAG	-	1 095	2 992	1 830	484	**Ce:YAG_550/000**
	559	~34	Ce:YAG	-	344	923	573	149	**Ce:YAG_559/034**
	560	~100	LED	-	-	63	67	55	**CLED_560**
	582	~75	Ce:YAG	-	596	1 633	996	250	**Ce:YAG_582/075**
	593	~40	Ce:YAG	-	318	891	533	128	**Ce:YAG_593/040**
	595	~20	LED	-	-	63	67	55	**CLED_595**
	612	~69	Ce:YAG	-	382	1 050	629	155	**Ce:YAG_612/069**
	625	~20	LED	-	-	111	111	96	**CLED_625**
	635	~20	LED	-	-	206	198	138	**CLED_635**
	638	<3	LD	41 000	10 000	2 500	640	110	**CLDM_638/080**
	638	<3	LD	61 000	15 000	3 800	960	170	**CLDM_638/120**
	840	~35	LED	-	-	190	175	55	**CLED_850**
	940	~35	LED	-	-	63	79	55	**CLED_940**
	5500K	-	LED	-	-	143	135	110	**CLED_W55**

Modulators

The optogenetics methods use light pulses to modulate the activity of genetically engineered light sensitive cells. Long gone are the days when a continuous streak of blue light, sent along an optical fiber to a mouse's brain to make it run, provokes worldwide scientific sensation. These days, even the simplest optogenetics experiments require programmable TTL pulse generators to modulate LED or laser diode drivers and create a desired light pulse train. When a direct modulation of the light source is not possible, as in the case of some solid state lasers, the continuous light beam is modulated using shutters.

Optogenetics TTL Pulse Generators

Our miniaturized TTL Pulse Generators connects to a computer with a USB cable and to a light source driver or a shutter with a BNC cable. They seamlessly integrate with our other optogenetics products. The pulse train parameters and its triggering are controlled via Doric Neuroscience Studio Software with which it is possible to program a sequence at a determined frequency and repeat this sequence several times. The Optogenetics TTL Pulse Generators have 4 input/output BNC and the 8-channel has 4 supplemental output BNC.

4-CHANNEL OTPG

ORDERING CODE: OTPG_4

8-CHANNEL OTPG

ORDERING CODE: OTPG_8

Connectorized Mechanical Shutter Heads and Adapters

The modulation of the light signal is essential for optogenetics experiments. The light sources, like LEDs or laser diodes are well-suited for the direct electrical modulation, while DPSS or fiber laser types require external modulation via mechanical shutters or acousto-optic modulators.

The mechanical shutters are more popular with laser based optogenetics set-ups as they are cheaper and better suited for use with multimode fibers. The inconvenience of mechanical shutters is that they require parallel beams of light and subsequent coupling into an optical fiber can be tricky and unstable. To facilitate the use of mechanical shutters, we are providing connectorized adapters for the Stanford Research Systems Model SR475 and the Vincent Associates Uniblitz Model LS-2 shutter heads.

Stanford Research Systems Model SR475 - Shutter Head and Adapter

The Stanford Research System Model SR475 Shutter Head is a high-precision shutter system with minimal vibration and a 4 ms minimum pulse duration. The shutter head of the Stanford Research Systems Model SR475 can not produce pulses duration as short as the Vincent Associates Uniblitz LS-2 shutter head (2 ms) but its level of audible noise is much lower. The Doric Lenses Adapter allows the integration of the shutter with fiber connectorized devices. The adapter can be supplied alone or pre-installed on the shutter head.

Stanford Research Systems Shutter Head - Model SR475 + Doric FC Adapter

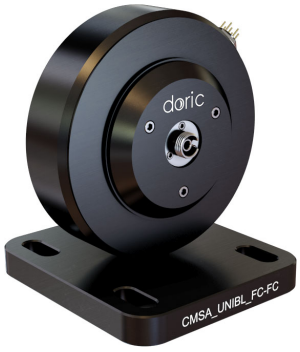
Table 15: *Stanford Research Systems Model SR475 Shutter Head and Adapter - Specifications and Ordering Code*

SPECIFICATION	VALUE
Typical input fiber configuration	200 µm core, NA=0.22
Typical output fiber configuration	200 µm core, NA=0.22
Wavelength range	450 - 650 nm
Collimated beam diameter	~2.0 mm
Coupling efficiency	>75%
Maximum optical power	500 mW
Minimum pulse duration	4 msec
Maximal operating frequency	100 Hz
PRODUCT	**Ordering Code**
Stanford Shutter Head + Doric FC Adapter	**CMSA-SR475_FC**
Doric FC Adapter only	**SR475_FOA**

Note: The Stanford Research Systems Model SR470 - Shutter Controller is compatible with the Shutter Head and Adapter Model SR475.

Vincent Associates Uniblitz Model LS-2 - Shutter Head and Adapter

The Vincent Associates Uniblitz Model LS-2 Shutter Head is a high-precision shutter system with high repeatability and a 2 ms minimum pulse duration. Despite its higher level of audible noise than the Stanford Research Systems Model SR475, the Uniblitz Model LS-2 is suitable for experiments requiring pulse duration as short as 2 ms. The Doric Lenses Adapter allows the integration of the shutter with fiber connectorized devices. The shutter is only sold with the adapter already installed, as precision optical alignement is necessary for optimal usage.



Vincent Associates Uniblitz Shutter Head - Model LS-2 + Doric FC Adapter

Table 16: *Vincent Associates Uniblitz Model LS-2 Shutter Head and Adapter - Specifications and Ordering Code*

SPECIFICATION	VALUE
Typical input fiber configuration	200 µm core, NA=0.22
Typical output fiber configuration	200 µm core, NA=0.22
Wavelength range	450 - 650 nm
Collimated beam diameter	~2.0 mm
Coupling efficiency	>75%
Maximum optical power	500 mW
Minimum pulse duration	2 msec
Maximal operating frequency	100 Hz
PRODUCT	**Ordering Code**
Vincent Associates Shutter Head + Doric FC Adapter	**CMSA-LS2_FC**

Note: The Vincent Associates Uniblitz Model VCM-D1 - Shutter Controller is compatible with the Shutter Head and Adapter Model LS-2.

Connectorized Mechanical Shutter Controllers

Stanford Research Systems Model SR470 - Shutter Controller

The Stanford Research Systems Model SR470 - Shutter Controller is compatible with the Shutter Head and Adapter Model SR475.

ORDERING CODE: MSC_SR470

Stanford Research Systems Model SR470 - Shutter Controller

Vincent Associates Uniblitz Model VCM-D1 - Shutter Controller

The Vincent Associates Uniblitz Model VCM-D1 - Shutter Controller is compatible with the Shutter Head and Adapter Model LS-2.

ORDERING CODE: MSC_VCM-D1

Vincent Associates Uniblitz Model VCM-D1 - Shutter Controller

Beam Splitters/Combiners

As multimode fiber optics is finding wider use in microscopy, optogenetics and life sciences in general, the need to combine or divide the light signals within fiber optic circuits is becoming evident. Beam-splitters have been used in optics for many years and almost exclusively within the parallel beam of light and at 45 degrees angle of incidence. Since the light coming out of the optical fiber is divergent, it needs to be made parallel or collimated before the beam-splitters can be used. Combining or splitting of the light output from optical fibers requires good collimation lenses, beam-splitters with steep transition curves and precision positioning to get efficient coupling. Inspired by the microscopy cubes and the need for user friendly beam-splitting in the fiber-optics applications, we have developed a family of mini cubes and multiple splitters that integrate beam-splitting glass plates, collimation lenses and fiber-optic receptacles in a small connectorized or pigtailed packages. Apart from shrinking the size of the so called microscope cubes, we have introduced highly efficient beam-splitters with unprecedented balance of the s and p polarization reflection curves based on our low angle of incidence design.

Doric Mini Cubes

Doric Mini Cubes: Intensity Division

This *Doric Mini Cube* contains a beam splitter that separates a beam in two output beams of equal power. This cube can be used effectively only as a splitter. If used as a combiner the power will not be doubled. The input and output NA is 0.22.

ORDERING CODE: DMC_1x2i_VIS_FC

VIS for 450 to 650 nm*

Receptacle code†

Doric Mini Cube Intensity Division

*Other ranges available as custom product
†FC is standard, SMA available on request

Doric Mini Cubes: Wavelength Division

The wavelength division mini cube has no other filters except the dichroic mirror which combines or separates different wavelengths. The angle of incidence of the light to the dichroic mirror found inside the standard version of wavelength division *Doric Mini Cubes* is 22.5 degrees. More conventional cubes with a 45 degrees angle of incidence is available only as a custom product. The input and output NA is 0.22.

Doric Mini Cube for separation of 470 nm and 590 nm

ORDERING CODE: DMC_1x2w_470/590_FC

- Wavelength 1 (nm)
- Wavelength 2 (nm)
- Receptacle code*

Example of custom assembly

Doric Mini Cube for separation of 470 nm and 530 nm band

*FC is standard, SMA available on request

Doric Micro Splitters

To further reduce the body of the bulk optics splitters, they need to be pigtailed rather than connectorized. This product family we call *Doric Micro Splitters*. Their small size and low transmission losses make those micro splitters a superior alternative to branching fiber-optic patch cords. When combined with those splitters, the standard FRJ_1x1, HRJ-OL, HRJ-OE and AHRJ rotary joints can be turned into bilateral optical stimulation ready joints. As an illustration of its performance, 1x1 fiber-optic rotary joint combined with *Doric Micro Splitter* has over 30% transmission per channel, less than 5% transmission difference between the channels and less than 5% power variation during rotation. They are second only to 1x2 FRJ. They can be also used in OEM devices whenever the space is limited.

Doric Micro Splitters: Intensity Division

This micro splitter separates an incoming beam into two output beams of equal intensity. Unlike Doric Mini Cube, *Doric Micro Splitter* has input and output fibers on the opposite sides of the device. The standard product is designed for visible light from 450 nm to 650 nm. The input and output NA is 0.22.

Doric Micro Splitter

ORDERING CODE:

DMS_1x2i_□□□/□□□/□□□-□□□_□□_□□□_□□_□□□

Fiber-optic code
(see Table 17)

One-fiber side
Fiber length (m)
Termination code (see Table 48)

Two-fiber side
Fiber length (m)
Termination code (see Table 48)

Doric Micro Splitters: Wavelength Division

The wavelength division and intensity splitters have the same appearance inside-out and the only difference is in the respective dichroic filter. The input and output NA is 0.22.

ORDERING CODE:

DMS_1x2w_470/590_□□□/□□□/□□□-□□□_□□_□□□_□□_□□□

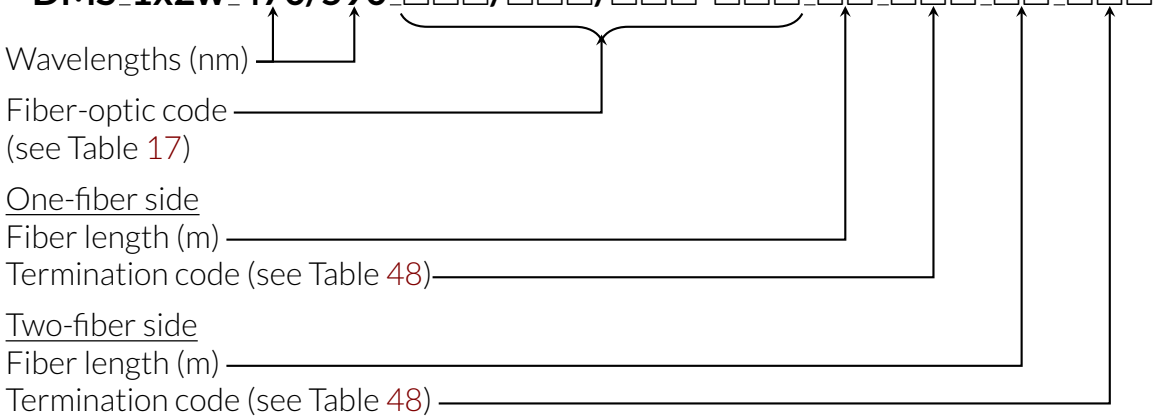


Table 17: *Micro Splitters Fiber-optic Codes*

		Outer diameter (µm)			
Core (µm)	**Cladding (µm)**	**Buffer**	**Jacket**	**NA**	**Fiber-optic Code**
100	110	125	900	0.22	**100/110/900-0.22**
100	110	125	900	0.37	**100/110/900-0.37**
105	125	250	900	0.22	**105/125/900-0.22**
200	220	240	900	0.22	**200/220/900-0.22**
200	220	245	900	0.37	**200/220/900-0.37**
200	240	400	900	0.22	**200/240/900-0.22**

Doric Multiple Splitters/Combiners

Light Intensity Distributors

The fiber coupled laser sources typically offer high intensity within a relatively small fiber diameter. When running several simultaneous *in vivo* experiments with those types of sources, it makes perfect sense to use the *Light Intensity Distributor* which is basically an intensity splitter. By doing this, the required number of modulation channels, drivers and optical sources can be reduced. Our patent pending *Light Intensity Distributor* provides a compact, connectorized package with the low insertion and polarization dependent loss (PDL), ideal for multimode fibers. The input and output NA is 0.22.

Light Intensity Distributor - 4 channels

Table 18: *Light Intensity Distributors Ordering Codes*

Number of Channels	Ordering Code*
3	**LID_1x3_VIS_FC**
4	**LID_1x4_VIS_FC**

Note:
FC is standard. Contact us for custom requests. VIS stands for visible wavelength range from 450 to 650 nm. Other ranges available as custom product. The expected intensity percentage in each channel is typically 80% divided by the number of channels*.

*Our standard products assume the use of identical fiber diameters, receptacles and equal intensity for each channel. However, this can be customized if needed at extra cost.

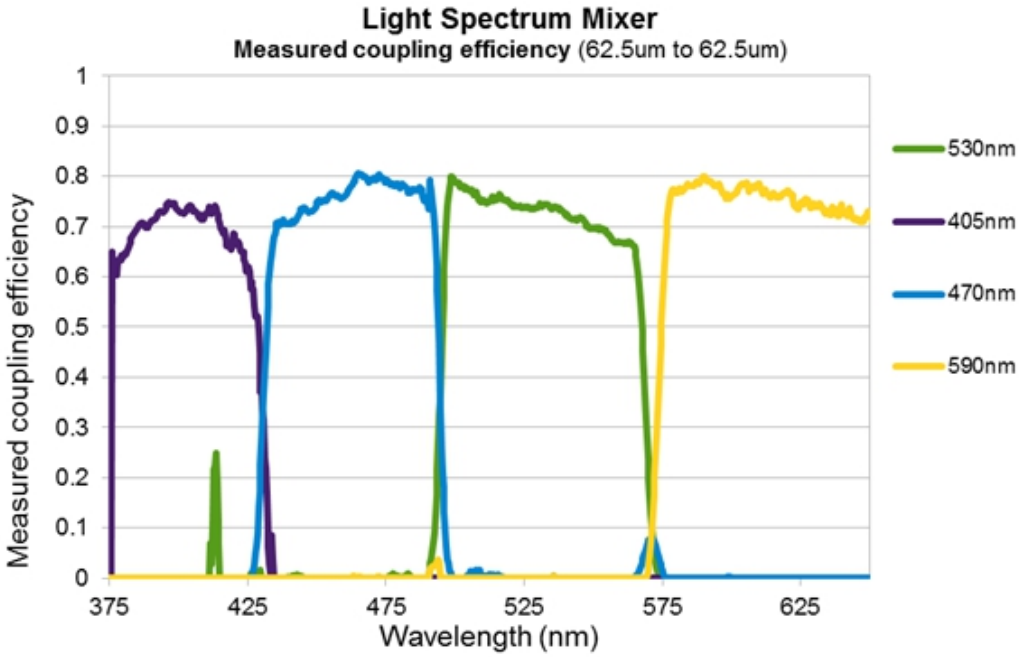
Light Spectrum Mixers

For *in vivo* optogenetics experiments there is a need to illuminate the tissue with specific pulses of spectrally different lights using the same fiber. To put it simply, the light from different fiber coupled LEDs or lasers needs to be combined into one beam and coupled to an optical fiber leading to a fiber-optic implant or cannula. Our patent pending *Light Spectrum Mixer* provides a compact, connectorized package with highly efficient coupling and low polarization dependent loss (PDL), ideal for multimode fibers. The input and output NA is 0.22.
The same device can be used in the opposite direction as a light spectrum separator. The concept of a spectrum mixer or splitter is analog to the concept of a wavelength division multiplexing and demultiplexing in optical telecommunication.

Light Spectrum Mixer

Table 19: *Light Spectrum Mixers Ordering Codes*

Number of Channels	Ordering Code*
3	**LSM_1x3_470/530/590_FC**
4	**LSM_1x4_405/470/530/590_FC**



*FC and center wavelengths are standard. Contact us for custom requests.

Filtering

Connectorized U-bracket

The attenuation or spectral filtering of the light within an optical fiber can be achieved with a simple *Connectorized U-bracket* and specific filter insert. To prevent dust entering the device, we recommend closing it with a filter insert at all times. For maximum transmission you can use the insert without a filter. For blocking the light use the insert without a hole. Unless some light loss is tolerated, it is necessary that NAs and diameters of input and output fibers are the same. The U-bracket comes with a blocking insert and an insert with hole but no filter. The specific filters have to be ordered separately.

Connectorized U-bracket and Filter Insert

ORDERING CODE: CUB_0.5_FC

Max fiber NA

Receptacle code*

U-bracket Inserts

The inserts can be fitted with attenuating filters or spectral filters made from a variety of glass materials. As a matter of fact, we can fit any commercially available filter to our standard insert and engrave its code. In this way you can build your set using off-the-shelf or custom filters. The narrow band filters can be useful for filtering the fluorescence excitation spectrum or for the fluorescence light.

Filter Insert

ORDERING CODE: UBI_□□□□□_□□□□□

Glass type or Filter glass manufacturer
e.g. Semrock, Omega, Chroma, Schott

Manufacturer part number or Attenuation (% or dB)

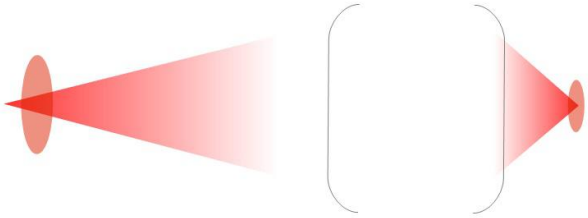
Example code: UBI_Semrock_FF01-474/23-25, UBI_Chroma_ET470/40x

*FC is standard, SMA available on request

NA Converter

Laser sources are valued for the large amount of power they deliver. However, one of their characteristics is that the beams they produce have small divergences. This can be a limitation for those who require a powerful illumination over a wide angle. To adress this issue, we have developped the *NA Converter*, that modifies the geometry of an input fiber guided light beam. Both the numerical aperture and the beam diameter are affected: their product is a constant, so called Lagrange invariant.

NA Converter



NA 2X magnification = Beam diameter 0.5X magnification

The typical application in optogenetics is when the laser source is coupled to an 0.22 NA fiber-optic while the fiber-optic cannula of interest is made of a fiber-optic with 0.48 NA. In this case, a magnification of x2 is well suited. In this example, if no NA converter is used, the fiber-optic cannula NA is not filled, and its output beam has an NA that is roughly 0.22.

ORDERING CODE: NAC_□□□_□□□_FC

- Input NA
- Output NA
- Receptacle code*

*FC is standard, SMA available on request

Fiber-optic Rotary Joints

Fiber-optic Rotary Joints consist of a lens system and high precision bearings which allow a rotation-insensitive optical power transfer between optical fibers. The fixed part of the rotary joint allows the connection to a light source and the rotating part releases the twisting of the optical fiber connected to the animal. In neurosciences, freely-moving optogenetics experiments need a stable light input to the brain even if the animal is moving in a confined space. Fiber-optic Rotary Joints avoid the damaging of the optical fibers while minimizing light fluctuations when rotating. The nomenclature used for our rotary joints is FRJ_m X n where m and n represent the number of the fibers on the fixed and on the rotating side respectively.

1x1 Fiber-optic Rotary Joints

The *1x1 Fiber-optic Rotary Joint* is the basic and the most popular type of rotary joints. It can either transmit the light from the sources to the sample and/or from the sample to a photodetector. When fiber-optic patch cord connectors are inserted in the rotary joint receptacles, the fiber tips are at the focal planes of the respective collimating lenses, and the beam is parallel between the lenses. *1x1 Fiber-optic Rotary Joints* are typically used with optical fibers with a core diameter of 200 µm and an NA of up to 0.5.

1x1 Fiber-optic Rotary Joint

Notes:

- The compatible holder for the 1x1 Fiber-optic Rotary Joints is sold separately (**Holder_FRJ_small**; see Table 118).
- The output fiber-optic patch cords are sold separately.
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).

Table 20: *1x1 Fiber-optic Rotary Joints Specifications and Ordering Codes*

SPECIFICATION	VALUE
Transmission*	> 85%
Maximum variation	± 3% of the mean
Start up torque	20 µN·m
Input NA	up to 0.5
Output NA	up to 0.5
Optimized for 62.5 µm†	**Ordering Code**
No	**FRJ_1x1_FC-FC**
Yes	**FRJ_1x1_FC-FC_62.5**

Input receptacle code

Output receptacle code

Pigtailed 1x1 Fiber-optic Rotary Joints

Fiber photometry experiments detect small power variations from a fluorophore and for that reason the fiber-optic rotary joints within the setup require minimal transmission variation. Because of large core multimode fibers and connector tolerances (i.e. 400 µm NA 0.48), transmission variation can only be minimized using a pigtailed version of 1x1 fiber-optic rotary joint. The pigtailed patch cords are made from 0.37 or 0.57 NA, 200 or 400 µm diameter optical fiber with a lightweight metal jacket and FC connectors. The fixed input patch cord is 1 m long, while the output or rotating patch cord is 0.15 m long. Different length fiber-optic patch cords can be connected to the output using an FC/FC mating adapter.

Notes:

- The compatible holder for the *Pigtailed 1x1 Fiber-optic Rotary Joints* is sold separately (**Holder_FRJ_small**; see Table 118).
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).
- An compatible FC/FC mating adapter (**ADAPTER_FC**; see Table 123) is sold separately and can be used to connect different patch cords to the optical fibers already linked to the rotary joint.

Pigtailed 1x1 Fiber-optic Rotary Joint

*Tested with 200 µm core NA 0.22 fiber-optic patch cords.

†Ideal for use with fiber-optic core from 62.5 µm to 200 µm. It is highly recommended to use our patch cords with these rotary joints to get appropriate coupling efficiency.

Table 21: *Pigtailed 1x1 Fiber-optic Rotary Joints Specifications*

SPECIFICATION	VALUE
Transmission*	> 70%
Maximum variation	<1% peak-to-peak
Start up torque	20 µN·m
Input Fiber	200 or 400 µm core - NA 0.37 or 0.57
Output Fiber	200 or 400 µm core - NA 0.37 or 0.57

ORDERING CODE:

FRJ_1x1_PT_□□□/□□□/□□□□-□.□□_1.0_FCM_0.15_FCM

Output optical fiber
200/220/LWMJ-0.37
200/230/LWMJ-0.57
400/430/LWMJ-0.57
400/440/LWMJ-0.37

Input fiber length (m)
1.0 m is standard.

Input receptacle code
FCM is standard (see Table 48).

Output fiber length (m)
0.15 m is standard.

Output receptacle code
FCM is standard (see Table 48).

*Tested with 400 µm core NA 0.48 fiber-optic patch cords.

1x2 Fiber-optic Rotary Joints

These rotary joints are used to divide the light coming from a single input optical fiber on a fixed side to two output optical fibers on a rotating side. We offer two distinct versions of this product, one for the intensity division and the other for the wavelength division of the light. Each version can be further customized if needed.

Notes:

- A compatible holder is included with the *1x2 Fiber-optic Rotary Joints* (**Holder_FRJ_large**; see Table 118).
- The output fiber-optic patch cords are included.
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).

Intensity division

The *intensity division* rotary joint sends half of the input light into each of the two output receptacles. This is particularly useful for bilateral stimulation experiments, where the illumination intensities must be the same in each channel.

1x2 Fiber-optic Rotary Joint - Intensity division

Table 22: *1x2 Fiber-optic Rotary Joints - Intensity division Specifications and Ordering Codes*

SPECIFICATION	VALUE
Transmission*	> 40% per channel
Maximum variation	± 3% of the mean
Start up torque	30 µN·m
Input NA	0.22
Output NA	**Ordering Code**
0.22	**FRJ_1x2i_FC-2FC_0.22**
0.5	**FRJ_1x2i_FC-2FC_0.50**

Input receptacle code

Output receptacles code

*Tested with 200 µm core NA 0.22 fiber-optic patch cords.

Wavelength division

The *wavelength division* rotary joint splits the spectral band originating from the input receptacle and sends each band to the corresponding rotating fiber receptacles. In some optogenetics experiments, it can be used for instance to separate the 473-488 nm blue light (activation signal) and the 590 nm orange light (inhibition signal). This rotary joint can also be used in the opposite direction as a spectral combiner.

1x2 Fiber-optic Rotary Joint - Wavelength division

Table 23: *1x2 Fiber-optic Rotary Joints - Wavelength division Specifications and Ordering Codes*

SPECIFICATION	VALUE
Transmission*	> 75% for each spectral band
Maximum variation	± 3% of the mean
Start up torque	30 µN·m
Input NA	0.22
Output NA	**Ordering Code**
0.22	**FRJ_1x2w_□□□/□□□_FC-2FC_0.22**
0.5	**FRJ_1x2w_□□□/□□□_FC-2FC_0.50**

Output wavelengths (nm)
Connector A / Connector B

Input receptacles code

Output receptacle code

Separate Light Path 2x2 Fiber-optic Rotary Joints

Separate Light Path 2x2 Fiber-optic Rotary Joints connect two arbitrary fiber-optic types on the stationary side of the rotary joint with their respective counterparts on the rotating side. This innovative patent pending technology offers unprecedented possibilities for laser or LED based optogenetics lighting requiring a compact and low loss dual channel fiber-optic rotary joint. This *Separate Light Path 2x2 Fiber-optic Rotary Joint* makes possible optogenetics and photometry experiments with an independent control of two different sites of illumination and/or detection of the light.

Separate Light Path 2x2 Fiber-optic Rotary Joint

Notes:

- A compatible holder is included with the *Separate Light Path 2x2 Fiber-optic Rotary Joints* (**Holder_FRJ_2x2**; see Table 118).
- Two output fiber-optic patch cords are also included.

Table 24: *Separate Light Path 2x2 Fiber-optic Rotary Joints Specifications*

SPECIFICATION	VALUE
Transmission*	> 80% for each channel
Maximum variation	± 3% of the mean per channel
Start up torque	< 3mN·m†
Input NA	0.22
Output NA	0.22

ORDERING CODE: FRJ_2x2_VIS_2FC-2FC

Wavelength range

Input receptacles code

Output receptacles code

*Tested with 200 µm core NA 0.22 fiber optic patch cords.
†Start up torque too high for mice but acceptable for rats or larger animals.

1x4 Fiber-optic Rotary Joints

The *1x4 Fiber-optic Rotary Joint* is used to send the light coming from a single optical fiber to 4 different regions on a moving animal via separate optical fibers. The fixed side consists of an FC receptacle and the rotating side of the joint is a 4-way optical connector specially developed for this application. A patch cord with a specific small footprint four-fiber connector designed to minimize the size and the inertia of the rotor is essential to the use of this rotary joint.

1x4 Fiber-optic Rotary Joint

Notes:

- A compatible holder is included with the *1x4 Fiber-optic Rotary Joint* (**Holder_FRJ_large**; see Table 118).
- One four-fold branching output patch cord is included. Contact us if spare patch cords are required to connect at the bottom of your *1x4 Fiber-optic Rotary Joint*.
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).

Table 25: *1x4 Fiber-optic Rotary Joint Specifications*

SPECIFICATION	VALUE
Transmission*	20% per channel (-2% as function of used fiber)
Maximum variation	± 2% of the mean per channel
Start up torque	< 50 µN·m
Input NA	0.22
Output NA	0.22

ORDERING CODE: FRJ_1x4i_FC

Input receptacles code

*Tested with 200 µm core NA 0.22 Fiber-optic Patch Cords.

Electrical Rotary Joints

Electrical Rotary Joints are used to transmit electrical signal from a moving sample to a fixed recording system (*e.g.* for *in vivo* electrophysiology experiments). Since it can be desirable to couple electrophysiological experiments with optogenetics stimulations, our Electrical Rotary Joints are designed with a central aperture (hollow bore) allowing the insertion (pass-through) of a fiber-optic patch cord. In this case, electrical and fiber-optic rotary joints (1x1 or 1x2) are used in tandem.

Electrical Rotary Joints

Electrical Rotary Joint with a HDMI Connector

We have developed a passive *Electrical Rotary Joint* usable for electrophysiological experiments that can be combined with fiber-optic rotary joints (1x1 or 1x2) to bring light to and/or from the sample. Its 7.2 mm through hole in the center is sufficient for passing fiber-optic patch cords with M3 connectors or ferrule/sleeve type connectors. It is also convenient for fluid tubing allowing drugs administration during electrophysiological experiments with freely-moving animals.

Our *Electrical Rotary Joint* has a torque as low as 0.9 mN·m (for 6 electrical contacts) or 1.8 mN·m (for 12 electrical contacts), acceptable for use with rats or larger animals. They are optimized to offer the best electric signal with the lowest torque, given that stable electrical transmission with small resistivity variations during rotation requires the increase of contact areas between each electrical contact. For small animals like mice, we recommend our *Assisted Electrical Rotary Joints* to remove the torque originating from the friction of the electrical contacts.

Notes:

- The number of electrical contacts does not necessarily equal the number of recording channels.
- Holders allowing the mounting of an *Electrical Rotary Joint* with a *Fiber-optic Rotary Joint* (1x1 or 1x2) are included (**Holder_ERJ**, **Holder_FRJ_small** and **Holder_FRJ_large**; see Table 119).
- If the *Electrical Rotary Joints* is used only for electrophysiology, without any additional fiber-optic rotary joints, a compatible holder is already included (**Holder_FRJ_large**; see Table 118).
- An optional horizontal cable holder keeping cables off-center can be added to increase the effective torque applied on the rotor (**HCH**; see Table 120). *Electrical Rotary Joints* come with the pre-installed adapter allowing the fixing on the optional horizontal cable holder.
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).
- An optional adapter kit can be provided to allow a Harwin-connectorized rotary joint to be used with an Omnetics-connectorized systems (**ADAPTER_HO12**; see Table 121).

Table 26: *Electrical Rotary Joints Specifications*

SPECIFICATION	VALUE
Number of contacts	6 or 12
Contact material	Gold
Maximum current	2 A per contact
Start up torque	0.9 mN·m (for 6 contacts) 1.8 mN·m (for 12 contacts)
Contact resistance	< 500 mΩ
Resistance variation during constant rotation	< 100 mΩ @ 5 VDC
Rotation speed	up to 300 rpm

Table 27: *HDMI Electrical Connector Pinout for Non-assisted Rotary Joints*

HDMI Blackrock 2

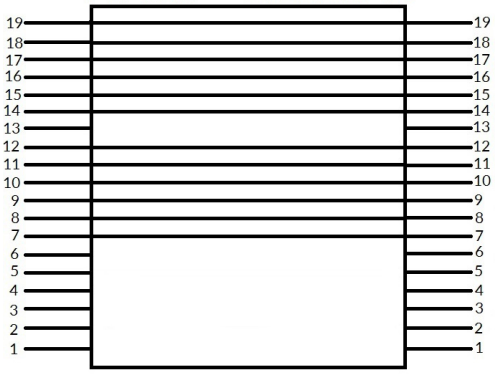


Table 28: *Electrical Rotary Joints Ordering Codes*

Connector type	Number of electrical contacts	Ordering Code
HARWIN*	6	**ERJ_06_HARW**
	12	**ERJ_12_HARW**
HDMI Blackrock pinout 2 (see table 27)	12	**ERJ_12_HDMI-B2**

*HARWIN 12 will be sold while stock lasts.

Assisted Electrical Rotary Joints

The *Assisted Electrical Rotary Joint* is a rotary joint that transmits electrical signal over 12 or 24 channels. Compared to our passive *Electrical Rotary Joint*, the motor *Assisted Electrical Rotary Joint* is effectively frictionless, thus allowing its use with mice. The rotary joint is primarily used in electrophysiology with small animal subjects.

Notes:

- If the *Assisted Electrical Rotary Joint* is used only for electrophysiology, a compatible holder is also included (See Table 118).
- Holders allowing the mounting of a 12-channel *Assisted Electrical Rotary Joint* with a *Fiber-optic Rotary Joint* (1x1 or 1x2) are included (**Holder_AERJ**, **Holder_FRJ_small** and **Holder_FRJ_large**; see Table 119).
- The torque sensor included with the *Assisted Electrical Rotary Joints* is also used as a cable holder with its rod and its clamp. The adapter to secure the rotary joint on the sensor is pre-installed.

Table 29: *Assisted Electrical Rotary Joint Specifications*

SPECIFICATIONS	VALUE	
Start-up Torque	< 20 µN·m	
Electrical Contact Material	Gold	
Number of Contacts	12	24
Contact Resistance	< 500 mΩ	< 800 mΩ
Resistance Variation during rotation	< 100 mΩ	< 25 mΩ
Rotation Speed	< 300 RPM	< 60 RPM
Through-hole diameter	6.0 mm	4.7 mm

Table 30: *Assisted Electrical Rotary Joints*

12-Channel Model	24-Channel Model
	
Ordering Code: **AERJ_12_□**	**Ordering Code:** **AERJ_24_□**

Electrical Connector Code (see Table 34)

Assisted Electrical Rotary Joint for Fluorescence Mini Cube

The *Assisted Electrical Rotary Joint for Fluorescence Mini-Cube* is an assisted electrical rotary joint designed to allow the direct integration of fluorescence mini cubes on its rotor. This reduced patch cord length between animal subject and mini cube maximizes light recovered. These are primarily used for fiber photometry or any application requiring the detection of very low-intensity light.

Notes:

- The holder for the *Assisted Electrical Rotary Joint for Fluorescence Mini Cube* is integrated directly onto the rotary joint.
- This rotary joint is always shipped with at least one *Rotary Fluorescence Mini Cube*, as well as any required *Fluorescence Detector Amplifiers*.
- The torque sensor included with the *Assisted Electrical Rotary Joints* is also used as a cable holder with its rod and its clamp. The adapter to secure the rotary joint on the sensor is pre-installed.
- The electrical rotary joint can be adapted to include the functions of an optical rotary joint. This is available on request.

Assisted Electrical Rotary Joint for Fluorescence Mini Cube

Table 31: *Assisted Electrical Rotary Joint for Fluorescence Mini Cube Specifications*

SPECIFICATIONS	VALUE
Start-up Torque	< 20 µN·m
Light source Connectors	6xM8
Detector Connectors	4xM5
Number of Contacts	24
Contact Resistance	< 800 mΩ
Resistance Variation during rotation	< 25 mΩ
Rotation Speed	< 60 RPM

ORDERING CODE: AERJ_24_FMC

Fiber-optic & Electric Rotary Joints

The electrical rotary joints have long been used for *in vivo* electrophysiology recordings. The arrival of optogenetics in neurosciences created the need of rotary joints allowing optical stimulations and electrophysiological recordings. This combination requires an opto-electric hybridization in the connecting cables and the rotary joints.

Fiber-optic & Electric Rotary Joint

To facilitate *in vivo* experiments combining the light stimulation and electrophysiological recordings in optogenetics experiments, we have developed a passive low torque hybrid rotary joint with a number of electrical channels and one optical channel. The FC receptacles on both ends of the rotary joint allow the connection of the input and output fiber-optic patch cords. This product is more compact than the combination of the electrical rotary joint and the 1x1 fiber-optic rotary joint where the optical fiber is passed through the central hole of the electrical joint.

Fiber-optic & Electric Rotary Joint with a HDMI connector

Notes:

- The holder for the *Fiber-optic & Electric Rotary Joint* is included (**Holder_FRJ_-large**; see Table 118).
- An optional horizontal cable holder keeping cables off-center can be added to increase the effective torque applied on the rotor and help the rotation (**HCH**; see Table 120). The *Fiber-optic & Electric Rotary Joints* come with the pre-installed adapter allowing the fixing on the optional horizontal cable holder.
- An optional gimbal holder allows pivoting the rotary joint along two additional axes, further reducing the mechanical stress on the animal (**GH_FRJ**; see Table 120).
- The output fiber-optic patch cords are sold separately.
- An optional adapter kit can be provided to allow a Harwin-connectorized rotary joint to be used with an Omnetics-connectorized systems (**ADAPTER_-HO12**; see Table 121).

Table 32: *Fiber-optic & Electric Rotary Joints Specifications*

SPECIFICATION	VALUE
Transmission*	80%
Maximum variation	2%
Start up torque	0.9 mN·m (for 6 contacts) 1.8 mN·m (for 12 contacts)
Input NA	0.22
Output NA	0.22
Number of contacts	6 or 12
Contact material	Gold
Maximum current	2 A per contact
Contact resistance	$< 500\ m\Omega$
Resistance variation during rotation (constant rotation)	$< 100\ m\Omega$ @ 5 VDC
Rotation speed	up to 300 rpm

Table 33: *Fiber-optic & Electric Rotary Joints Ordering Codes*

Connector Type	Number of electrical contacts	Ordering Code
HARWIN†	6	**HRJ-OE_FC_06_HARW**
	12	**HRJ-OE_FC_12_HARW**
HDMI Blackrock pinout 2 (see table 27)	12	**HRJ-OE_FC_12_HDMI-B2**

*Tested with 200 µm core NA 0.22 Fiber-optic Patch Cords.
†HARWIN 12 will be sold while stock lasts.

Assisted Fiber-optic & Electric Rotary Joint

The *Assisted Fiber-optic & Electric Rotary Joint* is electrically driven as it *senses and follows* the tethered animal's rotations. It detects the torsion of the optical cable during animal movement and releases it with a very high sensitivity. The assistance of this rotary joint helps to counter the frictional force of the internal slip-ring and offers quality transmission of electrical signal during any experiment with freely-moving small animals like mice. It comes with 12 or 24 electrical channels and one optical channel.

Notes:

- The *12-channel Assisted Fiber-optic & Electric Rotary Joints* can be designed with two types of lenses. The *24-channel Assisted Fiber-optic & Electric Rotary Joints* uses the aspheric (AH) lenses exclusively.
  - The achromatized doublets (AD) allow a near-equal focal distance for wavelengths between 450 nm and 650 nm, minimizing chromatic aberration. The AD models are designed for use with a 200 µm core, 0.22 NA optical fiber.
  - The 0.50 NA aspheric (AH) is optimized for reduced optical aberration. It is designed for use at a wavelength of 470 nm.
- The holder for the *Assisted Fiber-optic & Electric Rotary Joint* is included (See Table 118).
- The output fiber-optic patch cords are also included.
- An optional adapter kit can be provided to allow a Harwin-connectorized rotary joint to be used with an Omnetics-connectorized systems (**ADAPTER_-HO12**; see Table 121).

Table 34: *Assisted Rotary Joint Electrical Connector Codes*

Connector Type	# of Contacts	# of Channels	Maximum Current	Ordering Code
HARWIN*	12	12	2 A	**HARW**
HDMI Microscope	12	12	0.5 A	**HDMI**
HDMI Blackrock 2	12	12	0.5 A	**HDMI-B2**
USB-C	12	12	0.25 A	**USB-C**
HDMI	24	19	0.5 A	**USB-C**
USB-C	24	22	0.25 A	**USB-C**

*Available while stocks last

Table 35: *Assisted Opto-electric Rotary Joints*

12-Channel Model

Ordering Code:
AHRJ-OE_FC_□_12_□

24-Channel Model

Ordering Code:
AHRJ-OE_1x1_24_□

Optical Code
AD for achromatized doublet,
AH for aspheric.

Electrical Connector Code
(see Table 34)

Table 36: *Assisted Fiber-optic & Electric Rotary Joint Specifications*

SPECIFICATIONS	VALUE	
Start-up Torque	< 20 µN·m	
Input/Output NA	up to 0.5	
Electrical Contact Material	Gold	
Number of Contacts	12	24
Contact Resistance	< 500 mΩ	< 800 mΩ
Resistance Variation During Rotation	< 100 mΩ	< 25 mΩ
Transmission*	75%	85%
Maximum Variation (Peak to Peak)	2%	3%
Rotation Speed	< 300 RPM	< 60 RPM
Optical Connectors (Stator/Rotor)	FC/FC	FC/FC

*Tested with 200 µm core/0.22 NA optical fiber

Pigtailed Assisted Fiber-optic & Electric Rotary Joint

The *Pigtailed Assisted Fiber-optic & Electric Rotary Joint* is recommended for experiments that demand an extremely stable transmission. It is typically used in miniature fluorescence microscopy and fiber photometry.

Notes:

- The holder for the *Pigtailed Assisted Fiber-optic & Electric Rotary Joint* is included (**Holder_ARJ**; see Table 118).
- A compatible FC/FC mating adapter (**ADAPTER_FC**; see Table 123) is sold separately and can be used to connect different patch cords to the pigtailed patch cord.

Table 37: *Pigtailed Assisted Fiber-optic & Electric Rotary Joint Specifications*

SPECIFICATIONS	VALUE	
Start-up Torque	< 20 µN·m	
Input/Output Fiber Core Diameter	200 or 400 µm	
Input/Output Fiber NA	NA-0.37 or 0.57	
Electrical Contact Material	Gold	
Number of Contacts	12	24
Contact Resistance	< 500 mΩ	< 800 mΩ
Resistance Variation During Rotation	< 100 mΩ	< 25 mΩ
Transmission	45%*	70%†
Maximum Variation (peak to peak)	< 2%	< 1%
Rotation Speed	< 300 RPM	< 60 RPM
Optical Connectors (Rotor/Stator)	FC/FC	FC/M3

Table 38: *1-channel Assisted Rotary Joints*

12-Channel Model

Ordering Code:
AHRJ-OE_PT_AH_12_□

24-Channel Model

Ordering Code:
AHRJ-OE_400-0.48_FC_SM3_PT_24_□

Electrical Connector Code (see Table 34)

*Tested with 200 µm core/0.48 NA fiber
†Tested with 400 µm core/0.48 NA fiber

Assisted 1x2 Fiber-optic & Electric Rotary Joint

Assisted 1x2 Fiber-optic & Electric Rotary Joint

The *Assisted 1x2 Fiber-optic & Electric Rotary Joint* is an assisted rotary joint that splits a single fiber-optic channel into two. They are primarily used for bilateral optogenetic stimulation.

Notes:

- The holder for the *Assisted 1x2 Fiber-optic & Electric Rotary Joint* is included (**Holder_ARJ**; see Table 118).
- The output fiber-optic patch cords are also included.

Table 39: *Assisted 1x2 Fiber-optic & Electric Rotary Joint Specifications*

SPECIFICATIONS	VALUE
Start-up Torque	< 20 µN·m
Input/Output NA	up to NA 0.22
Electrical Contact Material	Gold
Number of Contacts	24
Contact Resistance	< 800 mΩ
Resistance Variation During Rotation	< 25 mΩ
Transmission (per channel)	>40%
Maximum Variation (peak to peak)	3%
Rotation Speed	< 60 RPM
Optical Connectors (Rotor/Stator)	FC/2FC

ORDERING CODE: AHRJ-OE_1x2_□_□□□/□□□_FC_24_□

1x2 rotary joint type
i for intensity division,
w for wavelength division.

Output wavelengths A/B
For wavelength division only.

Input receptacle code
FC is standard.

Electrical connector code
HDMI or **USB-C**.
(see Table 34)

2x2 Assisted Fiber-optic & Electric Rotary Joint

2x2 Assisted Fiber-optic & Electric Rotary Joint

The 2x2 Assisted Fiber-optic & Electric Rotary Joint allows frictionless rotation of 2 independent optical channels and 24 electrical contacts thanks to motorized assistance. The rotary joint detects torsion in optical fiber patch cords connected to a moving animal, which turns the rotor and allows the animal to move freely without discomfort. The two optical inputs use a standard FC connector, while the optical output uses a 1.0 mm guiding socket connector. Each optical channel is independent and features near zero crosstalk. The 24 electrical contacts are accessible using a standard USB-C connector (see Table 42). This rotary joint is optimal for use in optogenetics, allowing two regions of the brain to be activated independently.

Note:

- The holder for the *2x2 Assisted Fiber-optic & Electric Rotary Joint* is included (**Holder_AHRJ-OE_2x2**; see Table 118).
- The output patch cord with a 1.0 mm guiding socket connector is included.

Table 40: *Assisted 2x2 Fiber-optic & Electric Rotary Joints Specifications*

SPECIFICATION	VALUE
Optical Channels	2 independent
Maximum variation	<3 % of maximum
Optimal Wavelength	Achromatic
Start up torque	< 20 µN·m
Input Fiber Connector	2 FC
Output Fiber Connector	GS 1.0
Electrical Inputs	22 data contacts, 2 power contacts
Electrical Outputs	22 data contacts, 2 power contacts
Contact material	Gold
Contact resistance	< 800 mΩ
Recommended Optical Fiber Patch Cord	200 µm/0.22
Transmission (Typical)*	65%

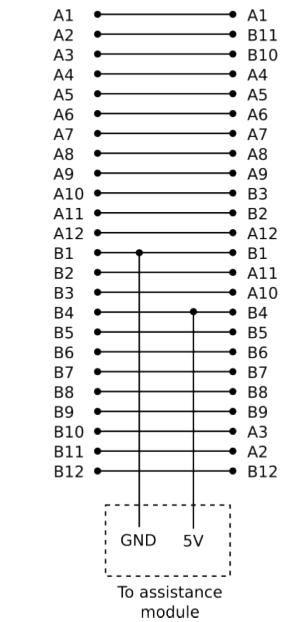
Table 41: *2x2 Assisted Fiber-optic & Electric Rotary Joints Ordering Code*

Connector Type	Ordering Code
USB-C	**AHRJ-OE_2x2_AD_200-0.22_24_USB-C**

*Includes an output patch cord of the same type

Table 42: *USB-C Pinout*

Male (on rotary joint)



Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joint

This *Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joint* is optimal for experiments requiring a highly stable output (e.g. fiber photometry), and allows multiple regions to be illuminated independently. These rotary joints have pigtailed input (1 m) fiber-optic patch cords of 200 or 400 µm diameter (NA 0.37 or 0.57) with a light weight metal jacket.

Note: The holder for the *Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joint* is included (**Holder_AHRJ-OE_2x2**; see Table 118).

Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joint

Table 43: *Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joints Specifications*

SPECIFICATION	VALUE			
Optical Channels	2 independent			
Maximum variation	<1.5 % of maximum			
Optimal Wavelength	530 nm			
Start up torque	< 20 µN·m			
Input Fiber Connector	2 FCM			
Output Fiber Connector	GS 1.0			
Electrical Inputs	22 data contacts, 2 power contacts			
Electrical Outputs	22 data contacts, 2 power contacts			
Contact material	Gold			
Contact resistance	< 800 mΩ			
Fiber Core/NA	*200 µm/0.37*	*200 µm/0.57*	*400 µm/0.37*	*400 µm/0.57*
Transmission (Typical)*	55%	50%	45%	35%

Table 44: *Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joints Ordering Codes*

Fiber-optic Patch Cord	Ordering Code
200 µm core - NA 0.37	**AHRJ-OE_2x2_PT_AH_200-0.37_24_USB-C**
200 µm core - NA 0.57	**AHRJ-OE_2x2_PT_AH_200-0.57_24_USB-C**
400 µm core - NA 0.37	**AHRJ-OE_2x2_PT_AH_400-0.37_24_USB-C**
400 µm core - NA 0.57	**AHRJ-OE_2x2_PT_AH_400-0.57_24_USB-C**

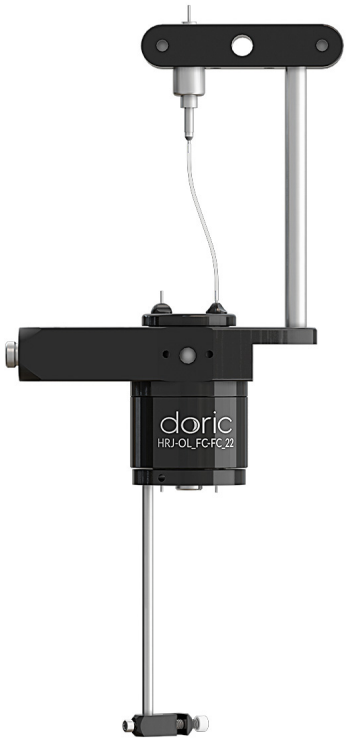
*Includes an output patch cord of the same type

Fiber-optic & Liquid Rotary Joints

To get better insights of the brain functions, it is desirable to combine different methods for deep brain manipulation of neuronal activity. In order to allow for the delivery of light and fluid simultaneously in freely-moving animals, the rotary joint needs to combine functions of the fiber-optic and liquid rotary joints within one instrument.

Fiber-optic & Liquid Rotary Joint

Our *Fiber-optic & Liquid Rotary Joint* consists of an optical arrangement allowing the passage of fluid into a small tubing that minimize the perturbation of the light transmission during the rotation. Stainless steel fluid swivels from Instech Solomon are required for the use of this rotary joint. The 1-channel fluid swivel comes with the *Fiber-optic & Liquid Rotary Joint* and if more channels are needed, it can be adapted to work with the 2- or 5-channel fluid swivel. Two versions of the product are available depending on the liquid tubing size (22 or 25 gauge).



Fiber-optic & Liquid Rotary Joint - 1 channel liquid swivel

Notes:

- The output fiber-optic patch cords are also included.
- The joint comes with a pre-installed metal tube for the insertion of plastic tubing and a box of 50 supplemental metal tubes. Eight different positions are possible on the rotary joint for the metal tubes.
- The package includes 1 m of plastic tubing.
- The 1-channel fluid swivel and its attachments are included.
- To prevent cross-contamination, we recommend to replace plastic and metal tubes with clean ones when

changing liquid solutions. Spare metal tubes can be ordered in lots of 25 units.

Table 45: *General Specifications*

SPECIFICATIONS	VALUE	NOTES
Transmission	60-65%	With 200 µm core, 0.22 NA optical fiber
Maximum Variation	± 5%	Additional +10% power drop when tubing crosses light path
Start-up Torque	≈ 150 µN·m	Without Fluid Swivel
	≈ 600 µN·m	With 1-channel Fluid Swivel *
Input/Output NA	0.22	-

Table 46: *Fiber-optic & Liquid Rotary Joint Ordering Codes*

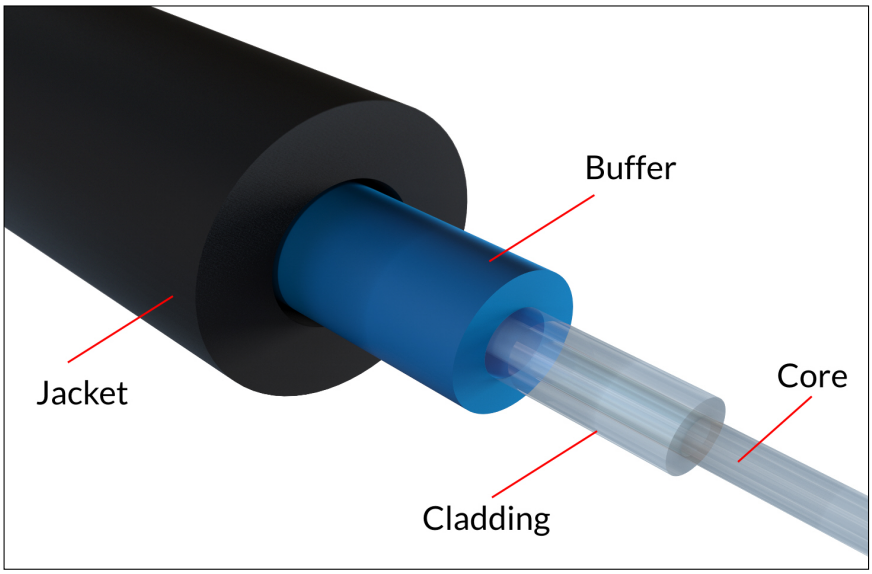
	Ordering Code		
		Tubing	
Gauge	Rotary joint	Metal	Flexible
22	**HRJ-OL_FC-FC_22**	**tube_metal_22**	**tube_PE/PVC_22**
25	**HRJ-OL_FC-FC_25**	**tube_metal_25**	**tube_PE/PVC_25**

*See supplier specifications on the INSTECH website

Fiber-optic Patch Cords

In the context of optogenetics experiments with the rotary joint, a *Fiber-optic Patch Cord* is needed to connect the light source and the rotary joint and yet another patch cord to connect the rotary joint and the fiber-optic cannula.

Structure of a Fiber-optic Patch Cord



The *core* and the *cladding* are two layers that make up the lightguide. However, the light travels inside the core of the fiber-optic, barely or not inside the cladding. For this reason, interconnected fiber-optics should have the same core diameter. Different cladding diameters have no influence on the coupling efficiency.

The *buffer* is a protective layer that tightly encircles the cladding. For patch cords, we usually recommend the use of another protective layer, called *jacket*, which is a loose tube covering the previously mentioned layers of the cable.

Mono Fiber-optic Patch Cords

Standard Mono Fiber-optic Patch Cords

Standard Mono Fiber-optic Patch Cord

The simplest form of the patch cord is a piece of fiber with buffer coating and two ferrules on its ends. So far, the most popular fiber in optogenetics research is a fiber with a 200 µm core diameter and NA 0.22.

ORDERING CODE:

MFP_□□□/□□□/□□□-□□□_□.□_□□□-□□□

Fiber-optic code
(see Table 47)

Fiber length (m)
From ferrule to tip

Termination codes
(see Table 48)

Note:

- The fiber diameter and its numerical aperture (collection angle) limit the coupling efficiency into the fiber. Therefore, for higher coupling from sources like LEDs into an optical fiber of a specific diameter, please select a higher NA fiber and follow it all the way through to the fiber-optic cannula.

Table 47: *Standard Mono Fiber-optic Patch Cords Codes*

	Core (µm)	Cladding (µm)	Outer diameter (µm)		NA	Fiber-optic Code
			Buffer	Jacket*		
Silica	50	125	250	900	0.22	**50/125/900-0.22**
	60	65	75	900	0.37	**60/65/900-0.37**
	62.5	125	250	900	0.27	**62.5/125/900-0.27**
	100	110	125	900	0.22	**100/110/900-0.22**
	100	110	125	900	0.37	**100/110/900-0.37**
	105	125	250	900	0.22	**105/125/900-0.22**
	200	220	240	900	0.22	**200/220/900-0.22**
	200	220	245	900	0.37	**200/220/900-0.37**
	200	230	500	900	0.48	**200/230/900-0.48**
	200	240	400	900	0.22	**200/240/900-0.22**
	300	330	360	900	0.37	**300/330/900-0.37**
	300	330	370	900	0.22	**300/330/900-0.22**
	300	330	650	1000	0.48	**300/330/1000-0.48**
	300	335	650	1000	0.37	**300/335/1000-0.37**
	400	430	730	1100	0.37	**400/430/1100-0.37**
	400	430	730	1100	0.48	**400/430/1100-0.48**
	400	440	480	900	0.22	**400/440/900-0.22**
	400	460	680	1100	0.48	**400/460/1100-0.48**
	550	600	1040	PVC 3 mm	0.22	**550/600/3000-0.22**
	600	630	1040	PVC 3 mm	0.37	**600/630/3000-0.37**
	600	630	1040	PVC 3 mm	0.48	**600/630/3000-0.48**
	600	660	710	1100	0.22	**600/660/1100-0.22**
Plastic	240	250	-	PVC 1 mm	0.63	**240/250/900-0.63**
	480	500	-	PVC 1 mm	0.63	**480/500/900-0.63**
	960	1000	-	PVC 2.2 mm	0.63	**960/1000/2200-0.63**
	1480	1500	-	PVC 3 mm	0.50	**1480/1500/3000-0.50**

*Standard jacket; other jackets are also available, see Protective Jackets.

Table 48: *Termination Codes for Fiber-optic Patch Cords*

Description	Product	Termination Code
FC Connector with Zirconia Ferrule		**FC**
FC Connector with Metal Ferrule		**FCM**
FC/APC Connector with Zirconia Ferrule*		**FCA**
FC/APC Connector with Metal Ferrule*		**FCMA**
SMA Connector with Metal Ferrule		**SMA**
Zirconia Ferrule OD = 1.25 mm		**ZF1.25**
Zirconia Ferrule OD = 1.25 mm with Flange		**ZF1.25(F)**
Zirconia Ferrule OD = 1.25 mm with Peek Flange		**ZF1.25(FP)**
Metal Ferrule OD = 1.25 mm		**MF1.25**
Zirconia Ferrule OD = 2.5 mm		**ZF2.5**
Zirconia Ferrule OD = 2.5 mm with Flange		**ZF2.5(F)**
Zirconia Ferrule OD = 2.5 mm with Peek Flange		**ZF2.5(FP)**
Metal Ferrule OD = 2.5 mm		**MF2.5**
Slim Magnetic Connector		**SMC**
M3 Connector		**CM3**
M3 Connector Peek Plastic		**CM3(P)**
M2 Connector		**CM2**
M2 Connector Peek Plastic		**CM2(P)**

*FC/APC Connectors available for Fiber-optic Patch Cords NA 0.22 only.

Attenuating Mono Fiber-optic Patch Cords

Attenuating Mono Fiber-optic Patch Cord

Optical fiber patch cords with an integrated attenuating filter are ideal for applications where optical power coupled into a fiber is too high, i.e. fiber photometry excitation. Addition of attenuating filter does not affect light distribution inside the optical fibre, only transmission is reduced. Different optical fibers or attenuating factors are possible.

ORDERING CODE:

MFP_□□□/□□□/LWMJ-□□□_1.0_FCM-FCM_T□.□□

Fiber-optic code
(see Table 49)

Fiber length (m)
From ferrule to tip
0.3, **0.5** or **1.0**
(**1.0 m is standard)**

Termination codes

Optical transmission at a 465 nm wavelength*
0.01, **0.02**, **0.05** or **0.10**

Table 49: *Attenuating Mono Fiber-optic Patch Cords Codes*

		Outer diameter (µm)			
Core (µm)	Cladding (µm)	Buffer	Jacket	NA	Fiber-optic Code
200	220	240	LWMJ	0.22	**200/220/LWMJ-0.22**
200	220	245	LWMJ	0.37	**200/220/LWMJ-0.37**
200	230	500	LWMJ	0.48	**200/230/LWMJ-0.48**
200	230	500	LWMJ	0.57	**200/230/LWMJ-0.57**
400	430	730	LWMJ	0.48	**400/430/LWMJ-0.48**
400	430	730	LWMJ	0.57	**400/430/LWMJ-0.57**
400	440	470	LWMJ	0.37	**400/440/LWMJ-0.37**
400	440	480	LWMJ	0.22	**400/440/LWMJ-0.22**

*Optical transmission is specified for visible light, and measured at a 465 nm wavelength. Please note that for a 405 nm wavelength (UV), the transmission value is about half of the specification for visible light.

Low Autofluorescence Mono Fiber-optic Patch Cords

Low Autofluorescence Mono Fiber-optic Patch Cord

The *Low Autofluorescence Mono Patch Cords* are specially designed to minimize the fluorescence caused by photo-active compounds in the optical fiber and associated elements. Fibers with a low natural fluorescence are selected and used with glues, ferrules and protective coatings that have low or no-fluorescence. To ensure its minimal autofluorescence, each patch cord undergoes a 12-hour photobleaching process that decreases their remaining natural fluorescence.

ORDERING CODE:

MFP_□□□/□□□/□□□□-□□□_□.□_□□□-□□□_LAF

Fiber-optic code
(see Table 50)

Fiber length (m)
From ferrule to tip

Termination codes
(see Table 48)

Notes:

- The autofluorescence is dependent on the length of the patch cord and the fiber core diameter. In order to minimize autofluorescence, we recommend that the patch cord be as short as possible.
- The photobleaching process creates a temporary and reversible decrease of autofluorescence. It is recommended to repeat this process before each use to minimize autofluorescence. The instructions are provided with the product.

Table 50: *Low Autofluorescence Fiber-optic Patch Cords Codes*

		Outer diameter (µm)			
Core (µm)	**Cladding (µm)**	**Buffer**	**Jacket***	**NA**	**Fiber-optic Code**
200	230	500	900	0.57	**200/230/900-0.57**
400	430	730	1100	0.57	**400/430/1100-0.57**

*Standard jacket; other jackets are also available, see Protective Jackets.

Dual Fiber-optic Patch Cords

A *Dual Fiber-optic Patch Cord* has two optically isolated fibers. One side ends with a dual ferrule guiding pin or a guiding socket connector. The other side of the patch cord can also end with a dual ferrule connector or with separate FC connectors for each fiber. The dual fiber-optic patch cord can transmit independent optical signals when used with a Separate Light Path 2x2 Fiber-optic Rotary Joint. Using dual patch cords with a 1x2 Fiber-optic Rotary Joint is optically more efficient but more expensive than using a branching patch cord with a 1x1 Fiber-optic Rotary Joint.

Dual Fiber-optic Patch Cord

ORDERING CODE:DFP_□□□/□□□/□□□-□□□_□.□_□□□-□□□

Fiber-optic code
Core diameter must be 200 µm or larger
(see Table 52)

Fiber length (m), From ferrule to tip

Termination code: Single connector side
(see Table 51)

Termination code: Dual connectors side
(see Table 48)

Table 51: *Termination Codes for Dual Fiber-optic Patch Cord (1 connector side)*

Description	Product	Termination Code
Dual ferrule with a guiding pin		**DF□.□**
Guiding socket*		**GS□.□**

Pitch from 0.7 mm to 1.7 mm

*Recommended termination for Dual Fiber-optic Patch Cord

Table 52: *Dual Fiber-optic Patch Cords Codes*

			Outer diameter (µm)			
	Core (µm)	Cladding (µm)	Buffer	Jacket*	NA	Fiber-optic Code
Silica	200	220	240	900	0.22	**200/220/900-0.22**
	200	220	245	900	0.37	**200/220/900-0.37**
	200	230	500	900	0.48	**200/230/900-0.48**
	200	240	400	900	0.22	**200/240/900-0.22**
	300	330	360	900	0.37	**300/330/1000-0.37**
	300	330	370	900	0.22	**300/330/900-0.22**
	300	330	650	1000	0.48	**300/330/1000-0.48**
	300	335	650	1000	0.37	**300/335/1000-0.37**
	400	430	730	1100	0.37	**400/430/1100-0.37**
	400	430	730	1100	0.48	**400/430/1100-0.48**
	400	440	480	900	0.22	**400/440/900-0.22**
	400	460	680	1100	0.48	**400/460/1100-0.48**
	550	600	1040	PVC 3 mm	0.22	**550/600/3000-0.22**
	600	630	1040	PVC 3 mm	0.37	**600/630/3000-0.37**
	600	630	1040	PVC 3 mm	0.48	**600/630/3000-0.48**
	600	660	710	1100	0.22	**600/660/1100-0.22**
Plastic	240	250	-	PVC 1 mm	0.63	**240/250/900-0.63**
	480	500	-	PVC 1 mm	0.63	**480/500/900-0.63**

*Standard jacket; other jackets are also available, see Protective Jackets.

Low Autofluorescence Dual Fiber-optic Patch Cords

The *Low Autofluorescence Dual Patch Cords* are specially designed to minimize the fluorescence caused by photo-active compounds in the optical fiber and associated elements. Fibers with a low natural fluorescence are selected and used with glues, ferrules and protective coatings that have low or no-fluorescence. To ensure its minimal autofluorescence, each patch cord undergoes a 12-hour photobleaching process that decreases their remaining natural fluorescence.

Low Autofluorescence Dual Fiber-optic Patch Cord

ORDERING CODE:

DFP_□□□/□□□/□□□-□□□_□.□_□□□-□□□_LAF

Fiber-optic code
(see Table 50)

Fiber length (m)
From ferrule to tip

Termination code: Single connector side
(see Table 51)

Termination code: Dual connectors side
(see Table 48)

Notes:

- The autofluorescence is dependent on the length of the patch cord and the fiber core diameter. In order to minimize autofluorescence, we recommend that the patch cord should be as short as possible.
- The photobleaching process creates a temporary and reversible decrease of autofluorescence. It is recommended to repeat this process before each use to minimize autofluorescence. The instructions are provided with the product.

Branching Fiber-optic Patch Cords

The *Branching Fiber-optic Patch Cord* takes light entering a single fiber-optical connector and evenly splits said light into multiple different outputs. There are two types of branching patch cords-*Splitter* and *Bundle* branching patch cords.

Splitter Branching Fiber-optic Patch Cord

The *Splitter Branching Patch Cords* take light entering a single large-diameter optical fiber and split it evenly amongst two or more smaller-diameter optical fibers, each with their own connector. These patch cords are typically used in optogenetics or illumination applications.

Bundle Branching Fiber-optic Patch Cord, 2 Branches

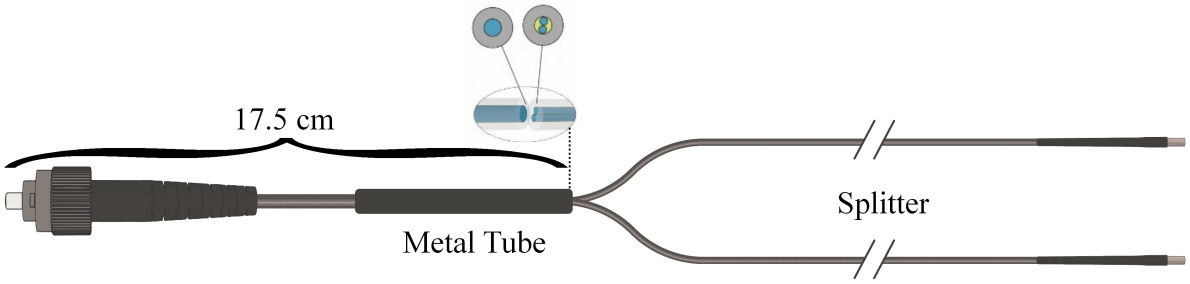
The *Bundle Branching Fiber-Optic Patch Cords* consist of two or more optical fibers bundled into a single optical connector with multiple branches on the opposite side. These patch cords are typically used in fiber photometry and similar low-autofluorescence applications.

Splitter Branching Fiber-optic Patch Cords

The *Splitter Branching Patch Cords* take light entering a single large-diameter and large numerical aperture optical fiber and split it evenly amongst several smaller-diameter optical fibers, each with their own connector. These patch cords are typically used in optogenetics, splitting a single powerful light source between several sites. They are particularly effective at splitting laser light uniformly into each output. The splitter patch-cord also conserves light intensity (mW/mm^2) over all outputs. This means that each output will have the same intensity as a single optical fiber of the same type, allowing a single LED light source to be used for multiple sites with sufficient intensity.

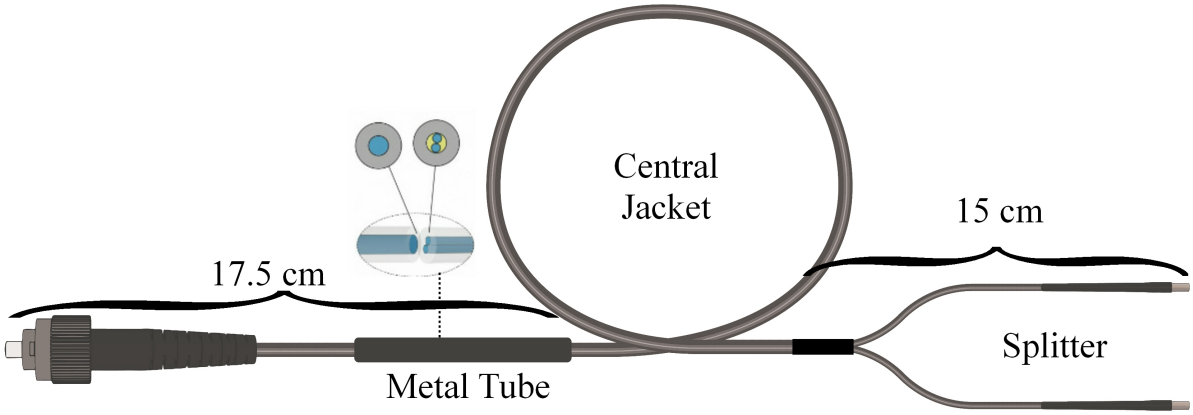
While the standard *Splitter Branching Fiber-optic Patch Cords* has 2 branches, more are available if requested. A two-branch patch cord splitter typically outputs between 16 and 20% of the power entering the input optical connector, with variations depending on fiber type and the area recovery ratio. This approach uses a 50 mm long metal tube with a 6.35 mm diameter to protect the passage from 1 to several fibers. The length of patch-cord from the metal tube to the patch-cord split, called the central jacket, can be protected using a different jacket type. Splitter patch cords are not suitable for short cables less than 30 cm long. This version allows improved splitting of laser light over older models. In all other applications, the *Splitter Branching Patch Cords* maintain the same high-quality performance as our legacy *Standard Branching Patch Cords*.

- The **Type-A** (*AX* identifier) patch cords have no central jacket, with the splitter starting at the metal tube. The split is done 17.5 cm from the input.



Type-A Splitter Branching Fiber-optic Patch Cord Layout, Without Central Jacket

- The **Type-B** (*BX* identifier) patch cords have a central jacket covering the length between the metal tube and the splitter. The split is done at 15 cm from the output.



Type-B Splitter Branching Fiber-optic Patch Cord Layout, With Central Jacket

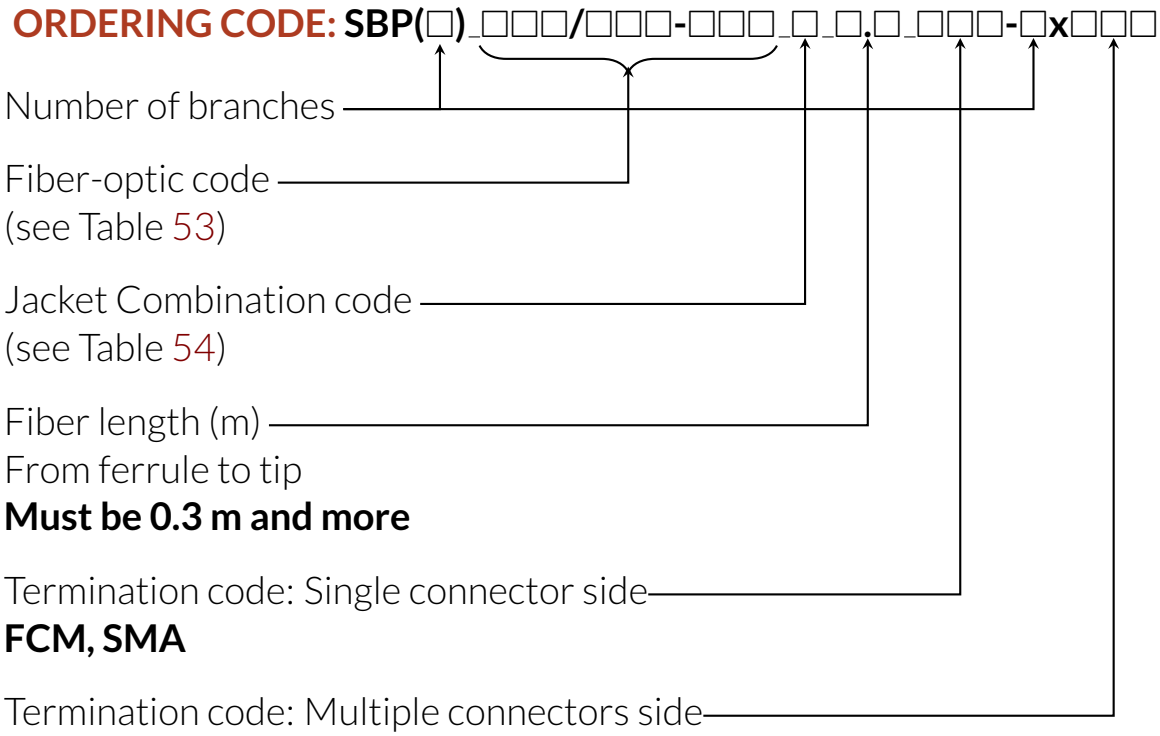
Note: The splitter makes use of multiple different jackets, as shown in the preceding figure. These result in two different patch cord types

Table 53: *Splitter Branching Fiber-optic Patch Cords Codes*

	Outer diameter (µm)			NA	Standard Jacket Combinations *	Fiber-optic Code
	Core	Cladding	Buffer			
Silica	50	125	250	0.22	A1 or B1	**50/125-0.22**
	60	65	75	0.37	A1 or B1	**60/65-0.37**
	62.5	125	250	0.27	A1 or B1	**62.5/125-0.27**
	100	110	125	0.22	A1 or B1	**100/110-0.22**
	100	110	125	0.37	A1 or B1	**100/110-0.37**
	105	125	250	0.22	A1 or B1	**105/125-0.22**
	200	220	240	0.22	A1 or B1	**200/220-0.22**
	200	220	245	0.37	A1 or B1	**200/220/900-0.37**
	200	230	500	0.57	A1 or B1	**200/230-0.57**
	400	430	730	0.48	A2 or B2	**400/430-0.48**
	400	440	470	0.37	A1 or B2	**400/440-0.37**
	400	430	730	0.57	A1 or B2	**400/430-0.57**
	400	440	480	0.22	A1 or B2	**400/440-0.22**
Plastic	240	250	-	0.63	A1 or B1	**240/250-0.63**
	480	500	-	0.63	A1 or B2	**480/500-0.63**

Table 54: *Jacket Combinations*

Identifier	Central Jacket	Split Jacket	Jacket Combination Code
A1	None	900	**900**
A2	None	1100	**1100**
A3	None	2000	**2000**
A4	None	3000	**3000**
A5	None	LWMJ	**LWMJ**
A6	None	ARMO	**ARMO**
B1	900	900	**900/900**
B2	2000	1100	**2000/1100**
B3	LWMJ	LWMJ	**LWMJ/LWMJ**
B4	LWMJ	900	**LWMJ/900**
B5	LWMJ	1100	**LWMJ/1100**
B6	ARMO	ARMO	**ARMO/ARMO**



Note: If Dual Fiber-optic Patch Cord connectors (**DF□.□** or **GS□.□**; Table 51) are required, remove the 2x before the termination code. Example: Splitter Branching Fiber-optic Patch Cord with dual connector and no central jacket: **BFP(2)_-200/230-0.57_900_1.5_FCM-GS1.5**

*Standard jacket combination; other jacket combinations (AX and BX) can be found in Table 54

Bundle Branching Fiber-optic Patch Cords

The *Bundle Branching Patch Cords* use a bundle of multiple optical fibers rather than a single one. This bundle is together as the entry connector, and is split to multiple different connectors just after the input. This splits the light evenly amongst the different output connectors. There is no limitation in the choice of optical fiber, connector type or the number of branches. They are also assembled with transparent glue to prevent heat absorption in case of high intensity input light. This approach has many possible uses and many different configurations are available. These patch cords are typically used in fiber photometry, and are used to illuminate and recover light from multiple sites. Such bundles can also be used with an imaging camera to measure the input of each fiber at the same time. Other optical fiber and connector types can be made available on request. Different optical fiber types and more branches are possible on request.

Bundle Branching Fiber-optic Patch Cord With Central Jacket, 2 Branches

ORDERING CODE: BBP(□)_□□□/□□□/□□□-□□□_□.□_□□□-□x□□□

Number of optical fibers
≤7 Optical Fibers

Fiber-optic code
(see Table 55)

Fiber length (m)
From ferrule to tip

Termination code: Single connector side
FCM, SMA

Number of output connectors

Termination code: Multiple connectors side
(see Tables 48 & 51)

Example:
Branching Fiber-optic Patch Cord with three fibers: **BBP(3)_200/230/900-0.57_-1.5_FCM*-3xZF1.25**

Table 55: *Bundle Branching Fiber-optic Patch Cords*

			Outer diameter (µm)			
	Core (µm)	Cladding (µm)	Buffer	Jacket*	NA	Fiber-optic Code
Silica	50	125	250	900	0.22	**50/125/900-0.22**
	60	65	75	900	0.37	**60/65/900-0.37**
	62.5	125	250	900	0.27	**62.5/125/900-0.27**
	100	110	125	900	0.22	**100/110/900-0.22**
	100	110	125	900	0.37	**100/110/900-0.37**
	105	125	250	900	0.22	**105/125/900-0.22**
	200	220	240	900	0.22	**200/220/900-0.22**
	200	220	245	900	0.37	**200/220/900-0.37**
	200	230	500	900	0.57	**200/230/900-0.57**
	200	230	500	900	0.48	**200/230/900-0.48**
	200	240	400	900	0.22	**200/240/900-0.22**
	300	330	360	900	0.37	**300/330/1000-0.37**
	300	330	370	900	0.22	**300/330/900-0.22**
	300	330	650	1000	0.48	**300/330/1000-0.48**
	300	335	650	1000	0.37	**300/335/1000-0.37**
	400	430	730	1100	0.48	**400/430/1100-0.48**
	400	440	470	900	0.37	**400/440/900-0.37**
	400	430	730	1100	0.57	**400/430/1100-0.57**
	400	440	480	900	0.22	**400/440/900-0.22**
	400	460	680	1100	0.48	**400/460/1100-0.48**
	550	600	1040	PVC 3 mm	0.22	**550/600/3000-0.22**
	600	630	1040	PVC 3 mm	0.37	**600/630/3000-0.37**
	600	630	1040	PVC 3 mm	0.48	**600/630/3000-0.48**
	600	660	710	1100	0.22	**600/660/1100-0.22**
Plastic	240	250	-	PVC 1 mm	0.63	**240/250/900-0.63**
	480	500	-	PVC 1 mm	0.63	**480/500/900-0.63**
	960	1000	-	PVC 2.2 mm	0.63	**960/1000/2200-0.63**
	1480	1500	-	PVC 3 mm	0.50	**1480/1500/3000-0.50**

*Standard jacket; other jackets are also available, see Protective Jackets.

Low Autofluorescence Bundle Branching Fiber-optic Patch Cords

The *Low Autofluorescence Bundle Branching Fiber-Optic Patch Cords* consist of two or more low autofluorescence optical fibers bundled into a single optical connector with multiple branches on the opposite side. There is no limitation in the connector type or the number of branches. The patch cord is assembled using low autofluorescence materials, such as high-absorption glue that minimizes cross-talk as well. To ensure minimal autofluorescence, and each patch cord undergoes a 12-hour photobleaching process that temporarily decreases the remaining natural fluorescence. This patch cord model is primarily used in multi-site fiber photometry, though it is useful in any application where low patch cord autofluorescence is required. Different optical fiber types and more branches are possible on request.

ORDERING CODE:

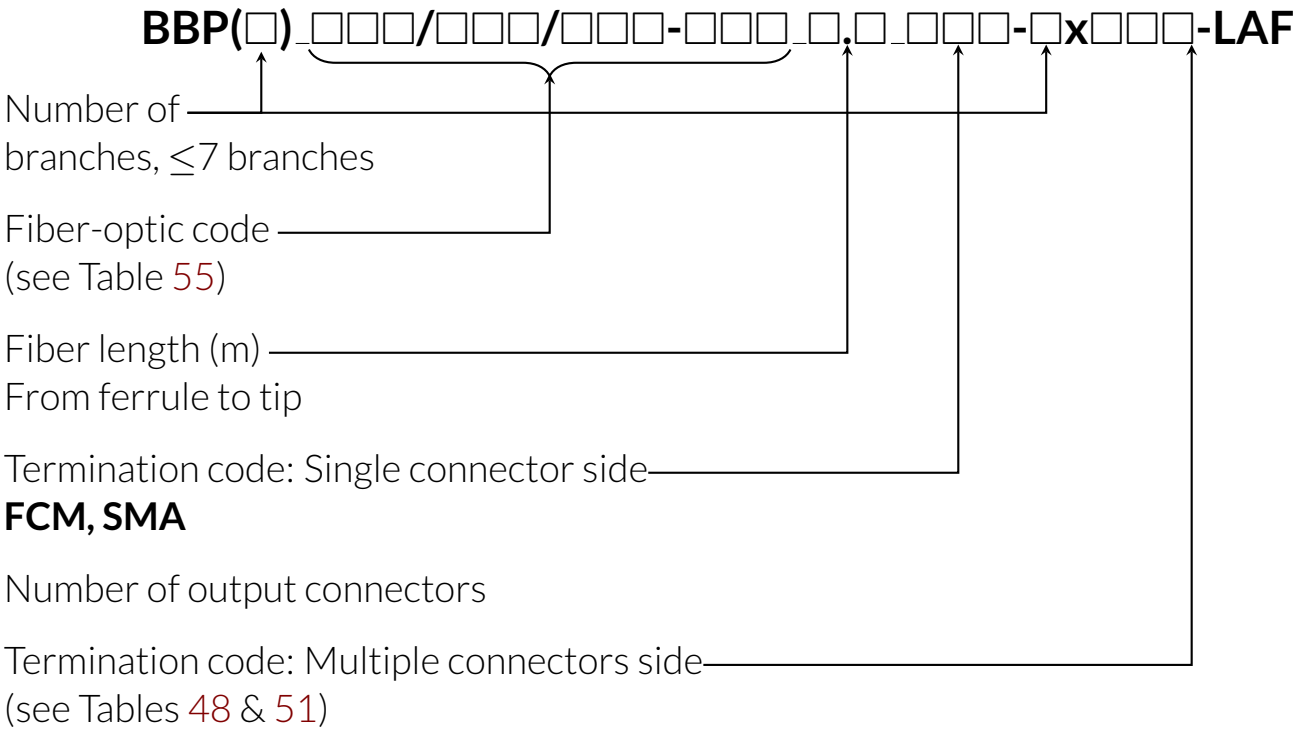


Table 56: *Low Autofluorescence Fiber-optic Patch Cords Codes*

		Outer diameter (µm)			
Core (µm)	Cladding (µm)	Buffer	Jacket*	NA	Fiber-optic Code
200	230	500	900	0.57	**200/230/900-0.57**
400	430	730	1100	0.57	**400/430/1100-0.57**

*Standard jacket; other jackets are also available, see Protective Jackets.

Protective Jackets

For a better fiber protection, we also offer larger jackets made of PVC tubing. Metal jackets or jackets made of other materials are also available on request.
If you want other jacket than those in Table 47, 52, 53 and 55, just replace corresponding jacket code with:

2000 for PVC jacket OD 2 mm

3000 for PVC jacket OD 3 mm

LWMJ for Lightweight metal jacket (black, OD 2.4 mm, 8 g/m)

ARMO for Armored jacket (OD 3 mm, 12 g/m)

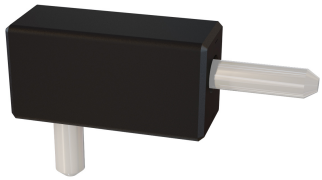
Table 57: *Codes for Fiber-optic Patch Cord Jackets*

Description	Outer Diamter (mm)	Mass (g/m)	Product	Jacket Code
900 µm	0.9	0.5		-
PVC Jacket-OD2	2.0	2.5		**2000**
PVC Jacket-OD3	3.0	5.8		**3000**
Lightweight Metal Jacket	2.4	8.0		**LWMJ**
Armored Jacket	3.0	12.0		**ARMO**

Adapters

Low Profile Patch Cord Adapter

This adapter can be used to modify the direction path of a patch cord without bending the fiber cable. It can help to minimize stress constraints and allow to do a 90° bend within 6 mm radius.



Low Profile Patch Cord Adapter ZF1.25 to ZF1.25 - 90 °

Table 58: *Low Profile Patch Cord Adaptor Specifications*

SPECIFICATION	VALUE
Receptacle Size (W x L x H)	3.2 mm x 8.0 mm x 4.5 mm
Connection	ZF1.25, ZF2.5, MF1.25, MF2.5 ferrules
Fiber-optic Type	200/250-0.66; 400/430-0.66
Angle	Standard angles: 90°; Tolerance of +/- 0.5°
Material	Peek plastic/zirconia ferrule
Light transmission output	> 60%

ORDERING CODE: LPPA_□□□/□□□-□.□□_□□□□_□□□□

Fiber-optic code
200/250-0.66 or **400/430-0.66**

Termination code: Patch cord to adapter side
ZF1.25, **ZF2.5**, **MF1.25**, **MF2.5**

Termination code: Adapter to cannula side
ZF1.25, **ZF2.5**, **MF1.25**, **MF2.5**

Electrical Patch Cords

Electrical Patch Cords

The electrical patch cord or cable is offered to assure an interconnection with the electrical part of some of our opto-electric cannula. It could be used to interconnect a Mono Opto-electric Cannula to a recording headstage or to an electrical stimulator.

Mono Electric Patch cord

ORDERING CODE: MEP_□.□_□□□-□□□_□□□

Length (m)
From ferrule tip to ferrule tip

Electrical connectors
SCI, **PCI** or **BNC** (see Table 59)

Wire gauge
22, **24**, **28**

Table 59: *Connectors for Electrical Patch Cords*

Description	Product	Termination Code
Socket Cooper Interconnect		**SCI**
Pin Cooper Interconnect		**PCI**
BNC		**BNC**

Opto-electric Patch Cords

Mono Opto-electric Patch Cords

Mono Opto-electric Patch Cord

We offer an opto-electric patch cord that connects both modality on cannula with a single easy step. This M3E connection was inspired by our very popular M3 cannula connector, where we added an electrical pin within the connector. This patch cord is light and compact on the animal head and can be connected independently on most common electrophysiological headstage and light sources. In order to minimize the electrical noise, we recommend short length between the cannula and the pre-amplification system, consequently the electrical wire length should be shorter as possible.

ORDERING CODE:

MOE_□□□/□□□/□□□□-□□□_□.□_□.□_□□□_□□□-CM3E

Fiber-optic code
(see Table 47)

Fiber length (m)
From ferrule tip to ferrule tip

Electrical cable length (m)

Optical connector
(see Table 48)

Electrical connector
SCI, **PCI** or **BNC** (see Table 59)

Opto-electric connector
CM3E

Fiber-optic Cannulas

A fluid cannula is an assembly of a metal tube and a fluid tube receptacle, used for administering fluids when the metal tube is inserted into the body. As an example, a venous cannula is inserted into a vein to obtain blood samples or to deliver medicines. The body of a cannula has a form that easily connects to or disconnects from the fluid tubing. The tubing is often disconnected while the cannula remains attached to the body surface with the hollow needle (tube) inserted into the body for the later use. Similarly, biomedical and optogenetics applications need *Fiber-optic Cannulas* to deliver the light into the body tissue and/or to collect fluorescence or scattered light coming from the tissue.

The illumination of neurons within the mouse's brain with the blue or amber light has become an essential tool for studying the processes within genetically modified photosensitive neurons. In the early days of optogenetics, a fluid cannula was used to insert the optical fibers into the brain tissue, where the metal tube was guiding the fiber to the point of interest. Occasionally, the optical fiber was removed from the fluid cannula only to be reinserted later. The optical fiber removal and re-entry often led to infections and clogging of the fluid cannula.

Mono Fiber-optic Cannula - M3 slim

With some exceptions, the *Fiber-optic Cannula* is used without the metal tube of the fluid cannula. It consists of a fiber-optic ferrule with some sort of a fiber-optic receptacle on one side and the implantable fiber protruding from the other side. When the fiber-optic cannula is secured to the body and the fiber implanted, the light can be delivered to the tissue and the fluorescence or scatter from the tissue can be captured. In these experiments, it is imperative that the connection between the delivery fiber and the cannula is light, small and simple to connect and disconnect. For a mono fiber delivery, the connec-

tion between the ferrules of the light delivery fiber patch cord and the fiber-optic cannula is achieved, in its simplest form, via the fiber-optic sleeve.

The connector type connection is preferred but it is not always applicable. In some optogenetics experiments it is necessary to introduce two or more implantable fibers within a small and precise distance. Those applications call for the dual or multiple fiber-optic cannula easily connectable to the matching delivery fibers.
The concept of *Fiber-optic Cannulas* with different optical fibers, receptacle types and fiber terminations is bound to be further fragmented. So far we carry Mono Fiber-optic Cannulas, Dual Fiber-optic Cannulas, and Two-ferrule Cannulas. In effect, we are developing hybrid cannulas that transmit a combination of light, liquid and electrical signals. Tables 61 and 62 show different possibilities for each cannula type.

Mono Fiber-optic Cannulas

Mono Fiber-optic Cannula ZF2.5 with grooves

The *Mono Fiber-optic Cannula* is an assembly of a bare optical fiber, a fiber ferrule and a receptacle or a sleeve. One side of the ferrule is polished while the implantable part of the fiber protrudes from the opposite end of the ferrule. The ferrule is placed within the receptacle or sleeve to allow connection to the fiber-optic patch cord. The protruding fiber can be implanted into the body while the ferrule or the receptacle is attached to the skin. When the cannula is connected with the patch cord, it is possible to send the light signals to and from the tissue close to the fiber tip. It is imperative for *in vivo* optogenetics applications that the fiber-optic cannula allows for an efficient, plug and play type connection with the fiber-optic patch cord.
A receptacle is a mechanical holder that defines the positions of the fiber tip and guides the connecting ferrule to the optical coupling position. For *Mono Fiber-optic Cannulas* we offer zirconia sleeves as the simplest form of a receptacle, M2, M3 and rectangular magnetic receptacles.

ORDERING CODE: MFC_□□□/□□□-□.□□_□□□_□□□_□□□

- Fiber-optic code (see Table 61)
- Fiber length (mm)
- Receptacle code (see Table 60)
- Termination codes (see Table 62)

Notes:

- The tolerance on the length of the protruding fiber is better than 0.1 mm.
- Sleeves required to connection with a patch cord are ordered separately (**SLEEVE**; see Table 123).
- Adapters (Receptacle adapters) are available for M2 and M3 receptacles (**FCA**; see Table 75).
- A Stereotaxic Cannula Holder (Stereotaxic Cannula Holders) is available for implantation to secure the Mono Fiber-optic Cannulas (**SCH**; see Table 72).

Table 60: *Receptacle Codes for Mono Fiber-optic Cannulas*

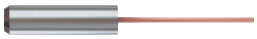
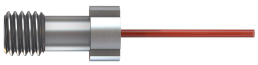
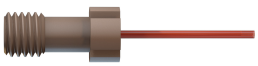
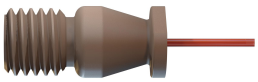
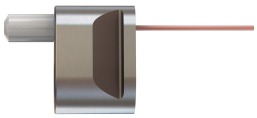
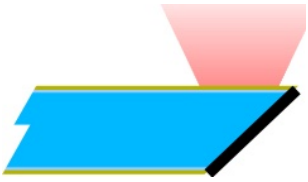
Description	Product	Receptacle Code
Zirconia ferrule OD 1.25 mm		**ZF1.25**
Zirconia ferrule OD 1.25 mm with grooves		**ZF1.25(G)**
Metal ferrule OD 1.25 mm		**MF1.25**
Zirconia ferrule OD 2.5 mm		**ZF2.5**
Zirconia ferrule OD 2.5 mm with grooves		**ZF2.5(G)**
Metal ferrule OD 2.5 mm		**MF2.5**
Receptacle with M2 thread Titanium		**RM2**
Receptacle with M2 thread Peek plastic		**RM2(P)**
Receptacle with M3 thread Titanium		**SM3**
Receptacle with M3 thread Peek plastic		**SM3(P)**
Slim Magnetic Receptacle Aluminum		**SMR**

Table 61: *Fiber-optic Codes for Cannulas*

	Core Diameter (µm)	Outer Diameter (µm)	NA	Buffer Color	Outer Layer	Fiber-optic Code
Silica	44*†‡	50	0.66	clear	Borosilicate (fragile)	**044/050-0.66**
	50*	70	0.22	yellow	Polyimide buffer	**050/070-0.22**
	60*	75	0.37	yellow	Polyimide buffer	**060/075-0.37**
	100	125	0.22	yellow	Polyimide buffer	**100/125-0.22**
	100	125	0.37	yellow	Polyimide buffer	**100/125-0.37**
	100	125	0.66	clear	Borosilicate (fragile)	**100/125-0.66**
	200	230	0.48	clear	Hard polymer cladding	**200/230-0.48**
	200	240	0.22	yellow	Polyimide buffer	**200/240-0.22**
	200	245	0.37	yellow	Polyimide buffer	**200/245-0.37**
	200	250	0.66	clear	Borosilicate (fragile)	**200/250-0.66**
	200	260	0.22	clear	Silicone buffer	**200/260-0.22**
	300	330	0.37	clear	Hard polymer cladding	**300/330-0.37**
	300	360	0.37	yellow	Polyimide buffer	**300/360-0.37**
	300	370	0.22	yellow	Polyimide buffer	**300/370-0.22**
	400	430	0.37	clear	Hard polymer cladding	**400/430-0.37**
	400†	430	0.48	clear	Hard polymer cladding	**400/430-0.48**
	400	430	0.66	clear	Borosilicate (fragile)	**400/430-0.66**
	400	470	0.37	yellow	Polyimide buffer	**400/470-0.37**
	400	480	0.22	yellow	Polyimide buffer	**400/480-0.22**
	600	630	0.48	clear	Hard polymer cladding	**600/630-0.48**
	600	710	0.37	yellow	Polyimide buffer	**600/710-0.37**
	200	230	0.57	clear	Hard polymer cladding	**200/230-0.57**
	400	430	0.57	clear	Hard polymer cladding	**400/430-0.57**
Plastic	120*,†§	125	0.63	clear	PMMA	**120/125-0.63**
	240*,†,§	250	0.63	clear	PMMA	**240/250-0.63**
	480*,†,§	500	0.63	clear	PMMA	**480/500-0.63**

*Not offered with a conical tip (**C45**, **C60**; see Table 62).
†Not offered with a 45° mirror tip (**MA45**; see Table 62).
‡Not offered with a diffuse layer tip (**DFL**; see Table 62).
§Only for fiber lengths inferior to 5 mm

Table 62: *Fiber-optic Termination Codes for Cannulas*

Description	Drawing	Termination Code	Note
Flat tip		**FLT**	
Angled tip*		**A45** **A60**	Standard angles: 45°; 60° Other angles on request (max 60°)
Conical tip†		**C45** **C60**	Rounded tip thickness: ~ 0.1x to 0.2x core diameter Standard angles: 45° Other angles on request (max 60°)
45° mirror tip *		**MA45**	
Diffuser layer †		**DFL**	

* Angled and 45° mirror tips are not offered with Opto-fluid Cannulas (**OsFC**, **OmFC**, **iOFC**, **DiOFC**), Opto-electric Cannulas (**OEC**), Opto-electric Probe Tips (**OEPT**), Low Profile Cannulas (**MFC_LPB**) and Two-ferrule Low Profile Cannulas. See other exceptions on Table 61.

† Some Optical Fibers are not offered with this type of termination. See Table 61.

Low Profile Cannulas

Low Profile Cannula - 90 °

Low Profile Cannulas are designed to minimize the height over the animal's head. The patch cord connection is in the same axis as the animal's body instead of hanging over its head. This cannula allows for the fiber optic implantation in a standard stereotaxic dorso-ventral axis, but the interconnection is along the antero-posterior plane. This cannula design minimizes the pressure applied on the animal's head during the connection/disconnection of the patch cord. Furthermore, the *Low Profile Cannula* facilitates the motion of the animal's head in restraint areas. A shortened version is also available.

Table 63: *Low Profile Cannulas Specifications*

SPECIFICATION	VALUE
Receptacle Size (W x L x H)	2.4 mm x 6.0 mm x 2.0 mm
Connection	ZF1.25 ferrule (height 1.02 mm) and ZF1.25 patch cord
Fiber Type	200/250-0.66; 400/430-0.66
Angle	Angle Standard = 90 deg. Custom on request. Tolerance +/- 2 deg
Protrusion Length	1.0 to 30.0 mm. Tolerance +/- 0.2 mm
Material	Peek plastic/zirconia ferrule, Aluminium on custom demand
Light transmission output	> 60%

ORDERING CODE:

MFC_□□□/□□□-□.□□_□.□_LPB90(P)_□□□

Fiber-optic code
200/250-0.66, **400/430-0.66**

Fiber length (mm)
1.0 to 30.0

Receptacle code
90° standard; other angles on request

Termination codes*
(see Table 62)

Note: A Low Profile Cannulas Holder (Low Profile Cannulas Holder) is available for implantation to secure the Low Profile Cannula (**SCH_LP90**).

*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Low Profile Cannulas (see Table 62).

Dual Fiber-optic Cannulas

A *Dual Fiber-optic Cannula* features two implantable fibers at a prescribed distance and protrusion length held by a single ferrule. The tolerance on the protrusion for each fiber is better than 0.1 mm. These cannulas are perfectly suited for a bilateral brain stimulation or silencing. The alternatives to a dual fiber-optic cannula are two mono fiber cannulas. However, positioning two cannulas with stereotaxic equipment, one at a time, has a greater likelihood of positioning errors, prolongs the duration of the operation, complicates the fixation of the cannulas and increases the minimum possible distance between the two fiber tips. With *Dual Fiber-optic Cannula* the insertion of the fiber is faster (single shot), while the distance between the fiber tips and the protrusion depth are factory set. The precision fiber-to-fiber mating of the cannula with the corresponding fiber-optic patch cord is vital for good coupling and this is achieved by a guiding pin or by a guiding socket.

Patch Cord / Cannula connection with a guiding pin

Patch Cord / Cannula connection with a guiding socket

Dual Fiber-optic Cannula with a guiding pin

This cannula with a circular metal ferrule and two optical fibers has a guiding hole to insure precise alignment when connecting to the equivalent dual fiber-optic connector loaded with a guiding pin. The smallest optical fiber core diameter it can accept is 200 µm while the fiber-to-fiber distance is in 0.7 to 1.7 mm range. For larger inter-fiber distances, please refer to dual fiber-optic cannula with a guiding socket or to Two-ferrule Cannulas. A typical transmission of the cannula with a guiding pin is higher than 70% for either fiber channel.

Dual Fiber-optic Cannula with a guiding pin

Dual Fiber-optic Cannula with a guiding socket

Dual Fiber-optic Cannula with a guiding socket

In spite of the huge popularity of our dual fiber-optic cannulas with a guiding pin, the need for a stronger and more user friendly connection led to development of a new *Dual Fiber-optic Cannula with a guiding socket*. In a way, it resembles M3 cannulas with its screw-in connecting feature. The guiding socket assures the orientation of the fiber tips of the corresponding connector. The fiber ferrule is an assembly of precision ground zirconia ferrules that can have fiber holes as small as 125 µm diameter. These cannulas have thread diameter of 3.2 mm and provide the possibility of larger pitch distances. The *Dual Fiber-optic Cannula with a guiding socket* has a typical transmission higher than 75% for each fiber channel. It is important to note that the maximum pitch of 1.7 mm relates to standard 3.2 mm outside thread. If larger diameter thread or cannula studs are permitted, then the pitch between two fibers can be greater.

ORDERING CODE:

DFC_□□□/□□□-□.□□_□□□_□□□.□_□□□

Fiber-optic code (see Table 65)

Fiber length (mm)

Receptacle code (see Table 64)

Termination codes (see Table 62)

Notes:

- The *Dual Fiber-optic Cannula* with guiding pin is implanted using the Stereotaxic Cannula Holders 2.5, while the guiding socket model requires a specific adapter (available for 1.25 or 2.5 Stereotaxic Cannula Holders).
- Angled and conical tips (Axx and Cxx) are offered to facilitate the insertion of the fiber-optic in the tissue (see Table 62). However, they have little influence on the light spread.

Table 64: *Receptacle Codes for Dual Fiber-optic Cannulas*

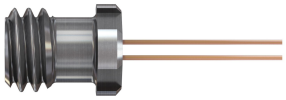
Description	Product	Receptacle Code
Dual ferrule with a guiding pin Pitch from 0.7 mm to 1.7 mm		**DF□.□**
Guiding socket* Pitch from 0.7 mm to 1.7 mm		**GS□.□**

Table 65: *Fiber-optic Codes for Dual Cannulas*

	Core Diameter (µm)	Outer Diameter (µm)	NA	Buffer Color	Outer Layer	Fiber-optic Code
Silica	200	230	0.48	clear	Hard polymer cladding	**200/230-0.48**
	200	240	0.22	yellow	Polyimide buffer	**200/240-0.22**
	200	245	0.37	yellow	Polyimide buffer	**200/245-0.37**
	200	250	0.66	clear	Borosilicate (fragile)	**200/250-0.66**
	200	260	0.22	clear	Silicone buffer	**200/260-0.22**
	300	330	0.37	clear	Hard polymer cladding	**300/330-0.37**
	300	360	0.37	yellow	Polyimide buffer	**300/360-0.37**
	300	370	0.22	yellow	Polyimide buffer	**300/370-0.22**
	400	430	0.37	clear	Hard polymer cladding	**400/430-0.37**
	400†	430	0.48	clear	Hard polymer cladding	**400/430-0.48**
	400	430	0.66	clear	Borosilicate (fragile)	**400/430-0.66**
	400	470	0.37	yellow	Polyimide buffer	**400/470-0.37**
	400	480	0.22	yellow	Polyimide buffer	**400/480-0.22**
	200	230	0.57	clear	Hard polymer cladding	**200/230-0.57**
	400	430	0.57	clear	Hard polymer cladding	**400/430-0.57**

*Recommended receptacle for Dual Fiber-optic Cannulas

Two-ferrule Cannulas

Two-ferrule Cannula

The *Two-ferrule Cannula* provides two implantable fibers, each within its own ferrule, at a precise distance exceeding 1.7 mm. The tolerance on the protrusion for each fiber is less than 0.1 mm. These cannulas are perfectly suited for the applications where two brain centers at a distance larger than 1.7 mm from each other are optically stimulated or controlled. The positioning of one mono fiber cannula at a time with the stereotaxic equipment has a greater likelihood of 3D positioning errors (lateral and depth). With a two-ferrule cannula the insertion of the fiber is faster (single shot), the distance between the fiber tips is predefined and the protrusion depth is assured.

Two types of receptacles are currently available for the two-ferrule cannula (see pictures on next page). They both consist of precision machined holders that house zirconia ferrules and determine the spacing between the ferrule centers. The first type of two-ferrule cannula connects to a pair of patch cords terminated with 1.25 mm ferrules by using two zirconia sleeves (ID 1.25 mm). In the other case, the holder also includes a pair of magnets, so that the cannula can connect to a pair of rectangular magnetic connectors.

The two-ferrule cannula can be made for distances larger than 1.7 mm. For shorter distances between the brain centers, please refer to Dual Fiber-optic Cannulas.

ORDERING CODE: TFC_□□□/□□□-□.□□_□□□_□□□.□_□□□

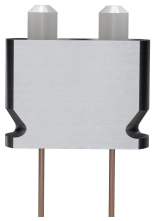
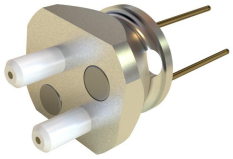
- Fiber-optic code (see Table 61)
- Fiber length (mm)
- Receptacle code (see Table 66)
- Termination codes (see Table 62)

Notes:

- Unless otherwise specified, an aluminum housing and 1.25 mm zirconia ferrules are being used.

- The *Two-ferrule Cannula* is implanted using the Stereotaxic Cannula Holders 1.25 mm. For pitch less than 2 mm, ask for a customized stereotaxic cannula holder.

Table 66: *Receptacle Codes for Two-ferrule Cannulas*

Center To Center Distance Between Ferrules (mm)	Product	Receptacle Code
Sleeve Connection		
(x)		**TFx***
2.0 mm 2.5 mm 3.0 mm 3.5 mm 4.0 mm Other (x)		**TS2** **TS2.5** **TS3** **TS3.5** **TS4** **TSx**
Magnetic Connection		
3.0 mm 4.0 mm Other (x)		**TSM3** **TSM4** **TSMx**

Two-ferrule Low Profile Cannulas

On custom basis, we can do *Two-ferrule Low Profile Cannulas* with the appropriate fiber pitch distance, up to 10 mm.†

Two-ferrule Low Profile Cannula - 90°

Note: A Low Profile Cannulas Holder (Low Profile Cannulas Holder) is available for implantation to secure the Two-ferrule Low Profile Cannula (**SCH_LP90**).

ORDERING:

Contact our sales department (sales@doriclenses.com)

*Will be sold while stock lasts.
†Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Two-ferrule Low Profile Cannulas (see Table 62).

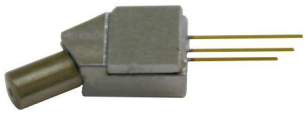
Fiber-optic Array Cannulas

Optogenetics experiments that target multiple excitation sites require cannulas with multiple fibers arranged within an fiber array. A one dimensional fiber array has several parallel fibers within the same plane at various distances and protrusions. Two dimensional fiber arrays are also possible (m x n). Currently, only the cannulas with well-arranged fiber-optic arrays on the tissue side and a bundled fibers on the side connecting to fiber patch cord are being offered. In this way similar levels of illumination are obtained around each fiber tip. The *Fiber-optic Array Cannula* where each fiber within the cannula is connected to corresponding fiber in the patch cord array is a possibility.

Array of m x n Fibers

For experiments that require specific spatial brain targets, we are able to offer customized fiber arrays to reach those places. It is possible to determine center-to-center distance between the fibers within a few microns and protrusion length of those fibers with a precision of 100 µm. Such components are available with all standard fiber diameters and numerical aperture of 0.22 or 0.37.

Examples of Fiber-optic Array Cannulas

Description	Product
Eight fibers in-line as a patch cord array termination	
One dimensional three fiber array with different pitch and length	
12 fibers divided into 2 groups of 2 x 3 fibers	

ORDERING:

Contact our sales department (sales@doriclenses.com)

Fiber-optic Cannulas with LED

Fiber-optic Cannula + Single LED

Fiber-optic Cannula + Single LED

We have developed an assembly where the LED is the integral part of the fiber-optic cannula thus providing a lightweight optical source attached to the head of the animal suitable for a deep brain illumination. The protruding optical fiber is implanted into the skull. In order to keep the assembly small and light there is no heat sink. To avoid heating, the maximum current should be limited.

Table 67: *Fiber-optic Cannula + Single LED Specifications*

SPECIFICATION	VALUE	NOTE
Maximum current	150 mA 300 mA	Continuous (CW) 10 msec pulse, 10% duty cycle
Dimensions	6 x 6 x 6 mm	
Mass	200 mg	Without cable
Interface	3 pins header, 1.27 mm	Sullins #GRPB031VWVN-RC
Pinout	Pin 1, Pin 3 = Cathode (-) Pin 2 (centre) = Anode (+)	

Table 68: *Fiber-optic Cannula + Single LED Color Codes*

Color	Central Wavelength (nm)	Typical Output Power @150 mA (mW)*	LED Color Code
Blue	465	8.0	**465**
Green	525	3.5	**525**
Amber	595	1.5	**595**
Red	635	4.0	**635**

Note: A bare cable connection is provided to interface with a current source.

*Power coupled into 200 µm core, NA 0.66 optical fiber.

ORDERING CODE: LFC_□□□_□□□/□□□-□.□□_□□□

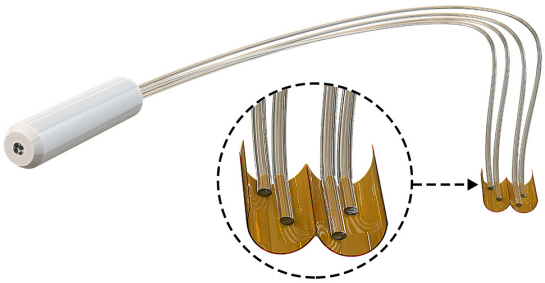
LED Color Code (see Table 68)

Fiber-optic code*
200/250-0.66 or **480/500-0.63**

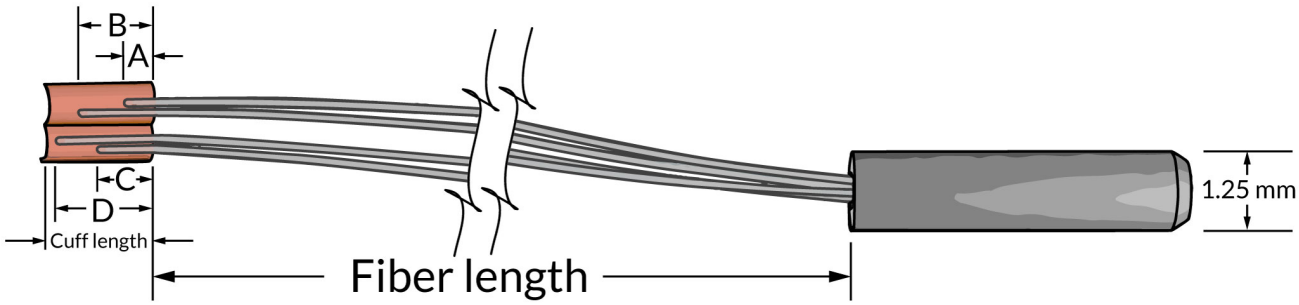
Fiber length (mm)

Optical Fiber Cuffs

Optical Fiber Cuffs are designed to perform optogenetic excitation/inhibition on muscles and/or nerve fibers. Light and flexible plastic optical fibers terminated with an angled mirror (MA45 tip) allow multiple illumination spots around fibrous tissues. Our design provides a polyimide based cuff composed of two half-cylindrical parts that can surround the muscle or the nerve. At the opposite end, all fibers are bundled into a standard ferrule to allow connection to a patch cord.



Optical Fiber Cuffs

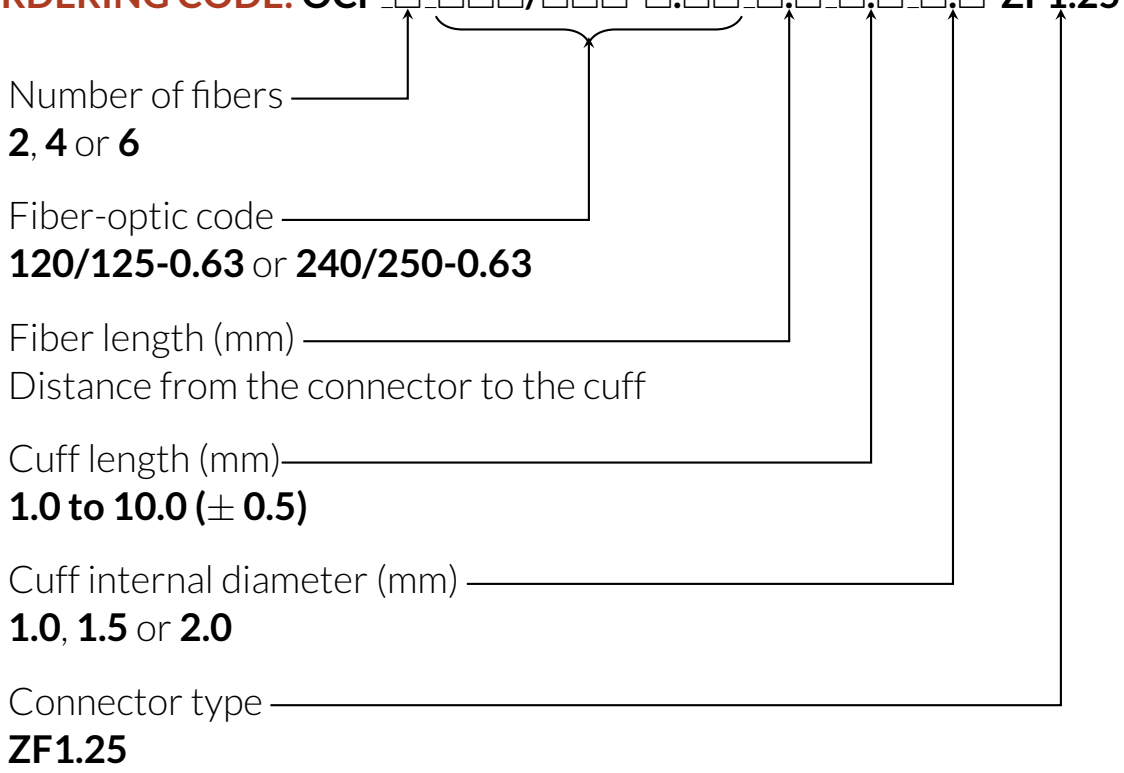


Optical Fiber Cuffs Schematic

Note: Complete the ordering code below. Use the PDF on our website to indicate the depth of each optical fiber in the cuff and the distance from the edge of the cuff to the end of the fiber.

*Contact us if different specification is required

ORDERING CODE: OCF_□_□□□/□□□-□.□□_□.□_□.□_□.□-ZF1.25



Opto-electric Cannulas

Indispensable when combining optogenetics and electrophysiology in freely moving animals, these chronically implanted cannulas enable optical and electrical contact with a specific group of neurons.

Mono Opto-electric Cannulas

The simplest configuration is made-up of a single 200 µm core diameter optical fiber of 0.22 NA and 75 µm diameter and a 3 MΩ impedance metallic wire as electrode. The fiber and the wire are held together by a grooved 1.25 mm zirconia ferrule with a fiber in the central hole and the electrode imbedded in the groove. The optical and electrical contacts with corresponding opto-electric patchcord are maintained with the help of a bronze sleeve.

Mono Opto-electric Cannula with a ZF 1.25 receptacle

ORDERING CODE:

OEC-□□□/□□□-□.□□-□□□-□□□-□□□-□□□-□.□-□□□-□□□

- Fiber-optic code (see Table 69)
- Fiber length (mm)
- Receptacle code
  M3E, **ZF1.25**
- Fiber-optic termination code* (see Table 62)
- Impedance (MΩ)
  0.1, **1**, **2**, **3**
- Electrode diameter (µm)
  25, **50**, **75**
- Electrode protrusion (mm)
  Distance in mm between the fiber tip and the electrode tip. Positive means the electrode is longer.

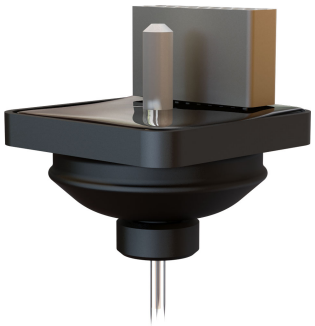
*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Mono Opto-electric Cannulas (see Table 62).

Note: Stereotaxic Cannula Holders and Ferrule Receptacle Adapter are available for implantation to secure the Mono Opto-electric Cannulas (**SCH** and **FCA**; see Tables 72 and 76).

Table 69: *Fiber-optic Codes for Mono Opto-electric Cannulas*

	Core Diameter (µm)	Outer Diameter (µm)	NA	Buffer Color	Outer Layer	Fiber-optic Code
Silica	50	70	0.22	yellow	Polyimide buffer	**050/070-0.22**
	60	75	0.37	yellow	Polyimide buffer	**060/075-0.37**
	100	125	0.22	yellow	Polyimide buffer	**100/125-0.22**
	100	125	0.37	yellow	Polyimide buffer	**100/125-0.37**
	100	125	0.66	clear	Borosilicate (fragile)	**100/125-0.66**
	200	240	0.22	yellow	Polyimide buffer	**200/240-0.22**
	200	245	0.37	yellow	Polyimide buffer	**200/245-0.37**
	200	250	0.66	clear	Borosilicate (fragile)	**200/250-0.66**
	200	260	0.22	clear	Silicone buffer	**200/260-0.22**
	300	360	0.37	yellow	Polyimide buffer	**300/360-0.37**
	300	370	0.22	yellow	Polyimide buffer	**300/370-0.22**
	400	430	0.66	clear	Borosilicate (fragile)	**400/430-0.66**
	400	470	0.37	yellow	Polyimide buffer	**400/470-0.37**
	400	480	0.22	yellow	Polyimide buffer	**400/480-0.22**
	600	710	0.37	yellow	Polyimide buffer	**600/710-0.37**

Opto-electric Cannula Arrays for Recording and/or Stimulation



Opto-electric Cannula Arrays

Our Opto-electric Cannula Arrays combine optogenetics and/or photometry with multi-site electrophysiology in freely-moving animals. Our opto-electric cannula arrays consist of an optical fiber (200/250 µm NA 0.66) surrounded by up to 32 electrodes. This product allows electrophysiological recording and/or stimulation depending on the electrode type. We offer tungsten electrodes (diameter of 25 or 50 µm) for single-, multi- or field potential recording and platinium/iridium electrodes (diameter of 100 µm) for electrical stimulation. Custom configurations are available upon request, like the type of electrodes, the number of optical fibers and the disposition of the optical fibers and electrodes.

ORDERING:

Contact our sales department (sales@doriclenses.com)

Opto-fluid Cannulas

As the convergence of different techniques for cell monitoring like optogenetics, electrophysiology and fluorescence gathers speed, the cannula hybridization and fluid administration becomes imperative. For classification purposes we consider a cannula as port of entry that can be chronically implanted while injectors connect to and disconnect from cannulas. The simplest way to allow passage of liquids, optical and electrical signals in and out of the body is by using universal guiding cannula with a plastic body in the shape of a receptacle and a shaft.

Mono Opto-fluid Cannulas

Single-shot Fluid Injection Cannulas

Optogenetics experiments often require introduction of virus born opsins near targeted cells or neurons that will be subsequently activated or silenced by light. The *Mono Opto-fluid Cannula* for *Single-shot Fluid injection* has an optical fiber and a side tubing that should be pre-loaded with a virus. The virus is injected after the cannula implantation surgery. Upon the first injection, the liquid passage is often clogged and for this reason the second injection is not recommended and should not be planned. This cannula connects to the liquid delivery system with a plastic tube that attaches to the metal tube on the cannula.

Single-shot Fluid Injection Cannula

ORDERING CODE: OsFC_□□□/□□□-□.□□_□□□_□□□_100/170_□□□

Fiber-optic code (see Table 61)

Fiber length (mm)

Fiber-optic termination code* (see Table 62)

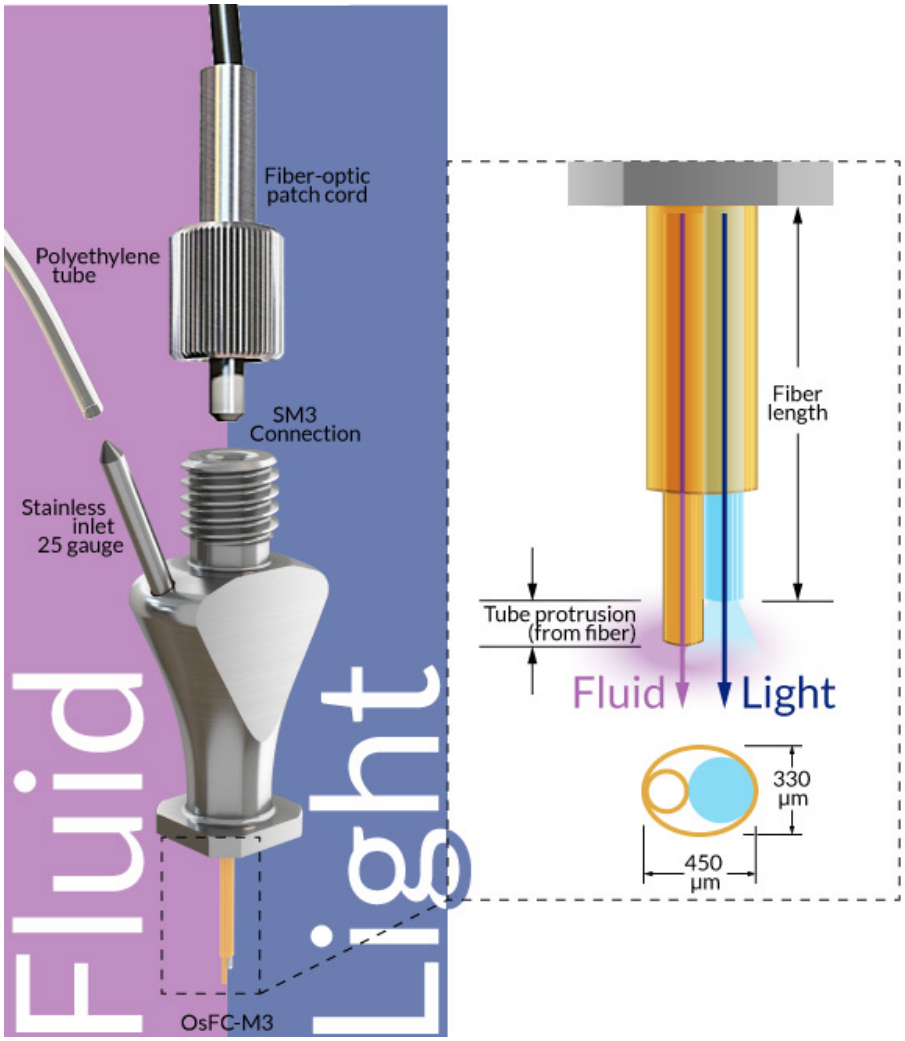
Fluid tubing code
100/170 is standard. Other values on request.

Fluid tubing protrusion from fiber tip (mm)

*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Mono Opto-fluid Cannulas (see Table 62).

Notes:

- Stereotaxic Cannula Holders and Receptacle adapters are available for implantation to secure the Single-shot Fluid Injection Cannula (**SCH** and **FCA**; see Tables 72 and 75).
- A 2-meter length of polyethylene tube is sold separately to connect a fluid delivery system to the cannula (**PT_OFC_2**, see Table 122).



Connection diagram and protrusion geometry of the Single-shot Fluid Injection Cannula

Multiple Fluid Injections Cannulas

Multiple Fluid Injections Cannula

This cannula is used for repeated drug or light sensitive dye injections and has a continous fluid path that permits multiple insertion of a liquid loaded micro-injector. The length of optical fiber and micro-injector can be precisely defined to reach targeted brain region. The post surgery fluid injection requires the use of an external micro-injector needle, pre-loaded with pharmacological agents, viruses or plasmids. The fluid delivery can start when the injector is fully inserted into the cannula guiding tube. The fluid injector consists of a 1.25 mm ferrule and corresponding sleeve connector. The cannula includes a plug with ZF sleeve to fill the guiding tube when the micro-injector is not in place. The plug is 100 µm longer than the guiding tube protrusion.

ORDERING CODE: OmFC_□□_□□□/□□□-□.□□_□□.□_□□□_□□.□

Receptacle
ZF1.25, **MF1.25**, **SM3** or **SMR**

Fiber-optic code
(see Table 61)

Fiber length (mm)

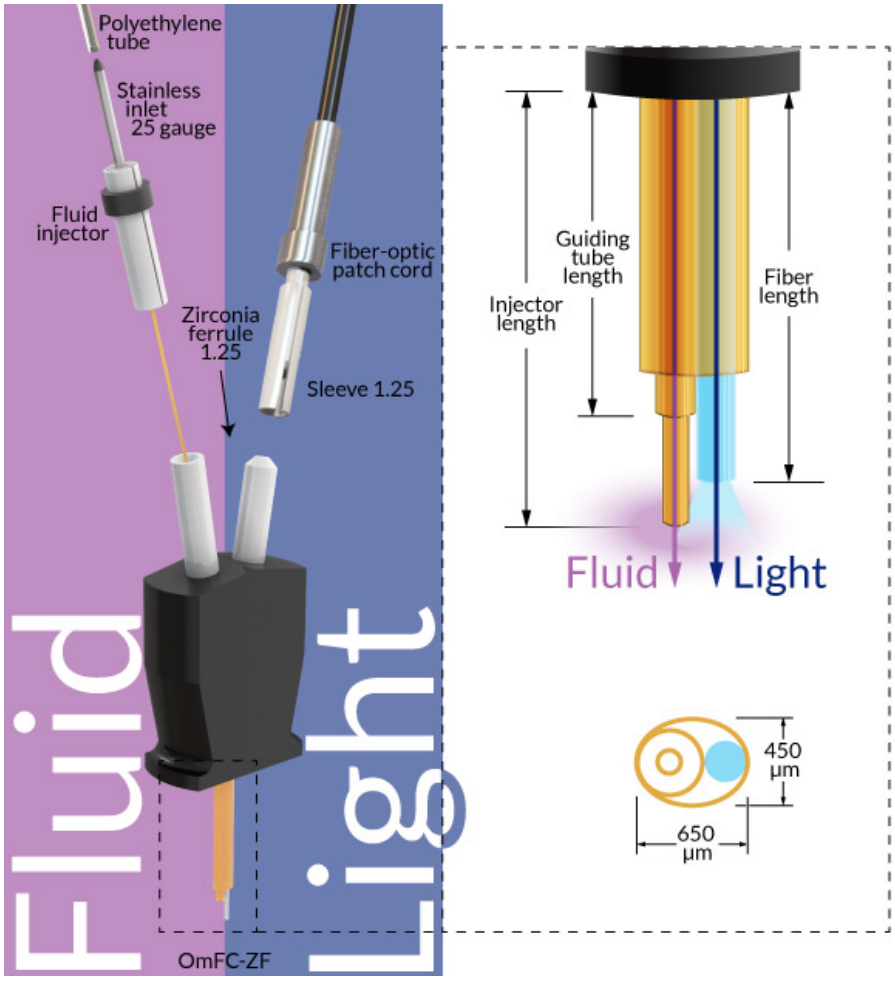
Fiber-optic termination code*
(see Table 62)

Injector guiding tube length from receptacle (mm)

Notes:

- A specially designed holder is available for implantation to secure the Multiple Fluid Injections Cannula (**SCH_OmFC**).
- The Fluid Injector for the Multiple Fluid Injections Cannulas must be ordered separately (**FI_OmFC**).
- A 2-meter length of polyethylene tube is sold separately to connect a fluid delivery system to the cannula (**PT_OFC_2**, see Table 122).

*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Mono Opto-fluid Cannulas (see Table 62).



Connection diagram and protrusion geometry of the Multiple Fluid Injections Cannula

Fluid Injector for Multiple Fluid Injections Cannulas

ORDERING CODE: FI_OmFC-□□□_100/170_□□□

Receptacle
ZF, **SM3** or **SMR**

Injector length (mm)

Fluid Injector for Multiple Fluid Injections Cannulas

Opto-fluid Cannula with interchangeable injectors

The *Opto-fluid Cannula with interchangeable injectors* provides a simple way to use both light and fluid injection when they are not required at the same time. The interchangeable configuration saves space and weight and can be used with optical and fluid injector of different lengths. The threaded body ensures a secure connection for the injectors.
Each cannula ships with a plug to prevent the guiding tube from clogging at implantation and between uses. Since both the optical and fluid injector does not stay inside the brain for a prolonged time, the plug is placed back when the cannula is not in use to keep it free of biological debris.

Opto-fluid Cannula with interchangeable injectors

Table 70: *Guiding Tube Codes for Opto-fluid Cannulas with interchangeable injectors*

Optical injector	**Guiding tube**		
Fiber diameter (µm) (see table 71)	**Inner diameter (µm)**	**Outer diameter (µm)**	**Guiding Tube Code**
70 to 125	250	350	**250/350**
230 to 250	320	430	**320/430**
360 to 500	530	660	**530/660**

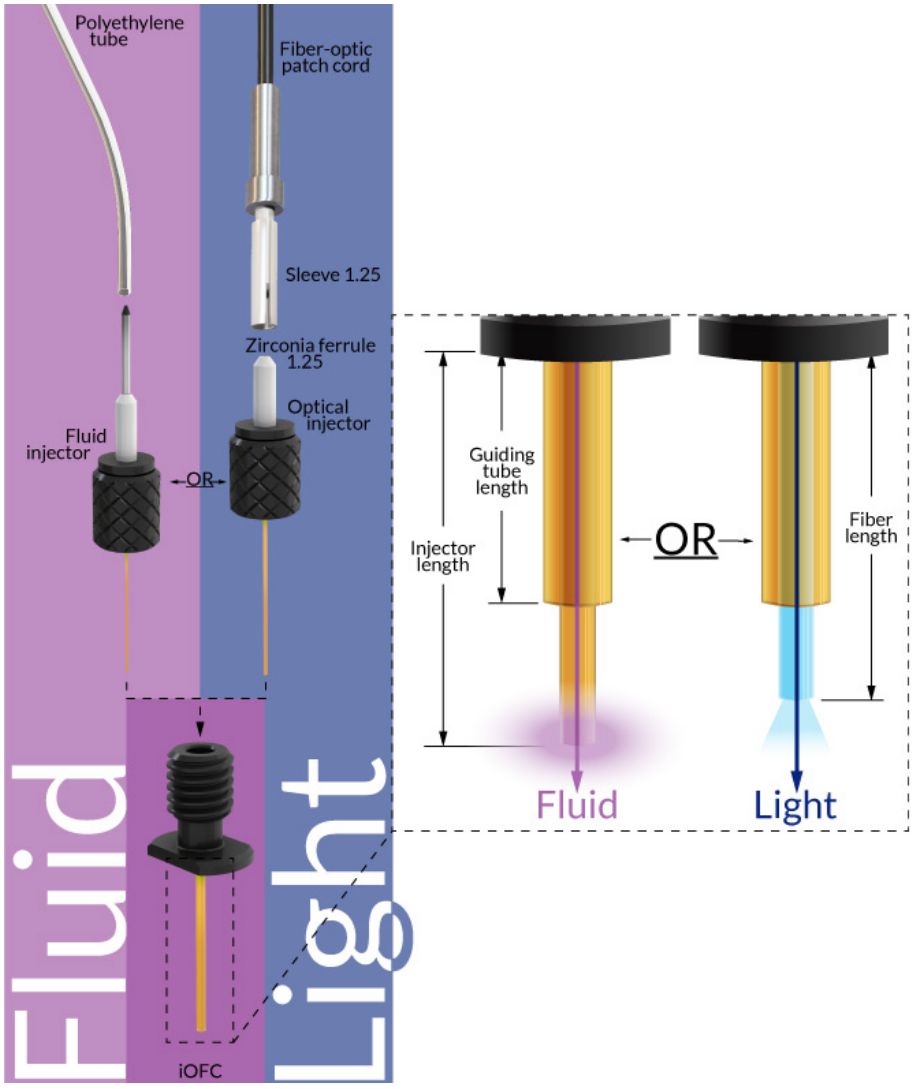
ORDERING CODE: iOFC_M3_□□□/□□□_□□□

Guiding tube code (see Table 70)

Guiding tube length from receptacle (mm)

Notes:

- The tubing internal diameter must match the optical injector external diameter (see Tables 70 and 71).
- A Stereotaxic Cannula Holder is available for implantation to secure the Opto-fluid Cannula with interchangeable injectors. The plug (included with the cannula) is used to fix the holder on the Opto-fluid Cannula (**SCH**; see Table 72).



Connection diagram and protrusion geometry of the Opto-fluid Cannula with interchangeable injectors

- Optic and Fluid Injectors for Opto-fluid Cannula with interchangeable injectors must be ordered separately (**OI_iOFC** and **FI_iOFC**).
- A 2-meter length of polyethylene tube is sold separately to connect a fluid delivery system to the cannula (**PT_OFC_2**, see Table 122).

Optical injector for Opto-fluid Cannula with interchangeable injectors

ORDERING CODE: OI_iOFC-M3_□□□/□□□-□.□□_□□□_□□□

Fiber-optic code (see Table 71)

Fiber-optic termination code* (see Table 62)

Fiber length from receptacle (mm)

Optical Injector for Opto-fluid Cannula with interchangeable injectors

Table 71: *Fiber-optic Codes for Optical Injectors*

	Core Diameter (µm)	Outer Diameter (µm)	NA	Buffer Color	Outer Layer	Fiber-optic Code
Silica	50	70	0.22	Yellow	Polyimide buffer	**050/070-0.22**
	60	75	0.37	Yellow	Polyimide buffer	**060/075-0.37**
	100	125	0.22	Yellow	Polyimide buffer	**100/125-0.22**
	100	125	0.37	Yellow	Polyimide buffer	**100/125-0.37**
	100	125	0.66	Clear	Borosilicate (fragile)	**100/125-0.66**
	200	240	0.22	Yellow	Polyimide buffer	**200/240-0.22**
	200	245	0.37	Yellow	Polyimide buffer	**200/245-0.37**
	200	250	0.66	Clear	Borosilicate (fragile)	**200/250-0.66**
	300	360	0.37	Yellow	Polyimide buffer	**300/360-0.37**
	300	370	0.22	Yellow	Polyimide buffer	**300/370-0.22**
	400	430	0.66	clear	Borosilicate (fragile)	**400/430-0.66**
	400	470	0.37	yellow	Polyimide buffer	**400/470-0.37**
	400	480	0.22	Yellow	Polyimide buffer	**400/480-0.22**
Plastic	120†	125	0.63	Clear	PMMA	**120/125-0.63**
	240†	250	0.63	Clear	PMMA	**240/250-0.63**
	480†	500	0.63	Clear	PMMA	**480/500-0.63**

*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Mono Opto-fluid Cannulas (see Table 62).
†Only for fiber lengths inferior to 5 mm

Fluid Injector for Opto-fluid Cannula with interchangeable injectors

ORDERING CODE: FI_iOFC-M3_100/170_□□□

Injector length from receptacle (mm)

Fluid Injector for Opto-fluid Cannula with interchangeable injectors

Dual Opto-fluid Cannulas

Dual Opto-fluid Cannula with interchangeable injectors

Dual Opto-fluid Cannula (L) with interchangeable injectors

The precise pitch of the *Dual Opto-fluid Cannula with interchangeable injectors* guarantees an optimal bilateral implantation where both light and fluid injection can be used. The interchangeable configuration saves space and weight and can be used with multiple lengths of optical and fluid injector.
Each cannula ships with two plugs to prevent the guiding tubes from being clogged at implantation and between uses. Since both the optical and fluid injectors do not stay inside the brain for a long time, this cannula has the additional benefit of keeping them free of biological debris.

Depending on the pitch between the two optical fibers, two receptacle types are offered: small (S) and large (L). The model S is required when the pitch is between the guiding tube outer diameter and 1.7 mm. For pitch more than 1.7 mm, the model L is needed.

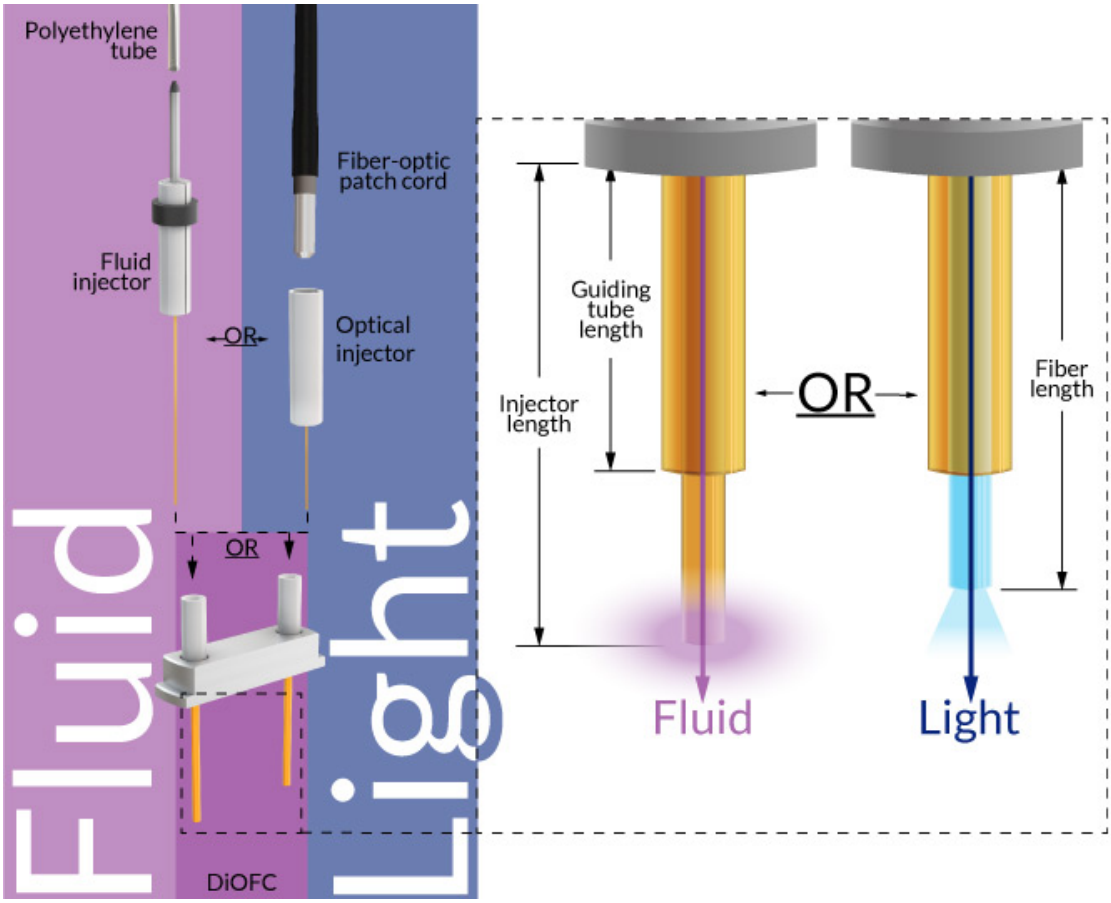
ORDERING CODE: DiOFC-□_ZF_□.□_□□□/□□□_□.□

Receptacle type
S or **L**

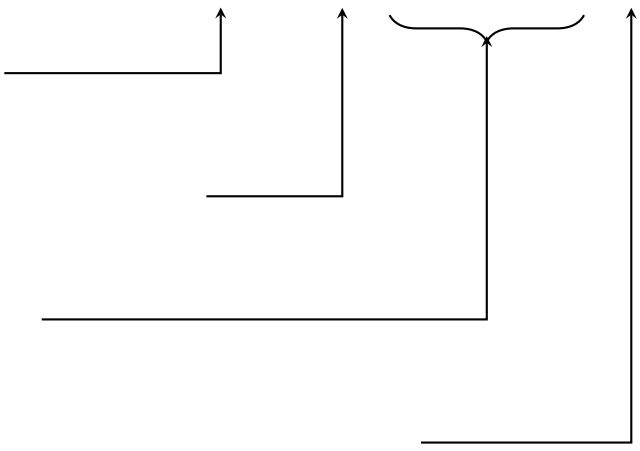
Center-to-center pitch (mm)
Between the 2 guiding tubes

Guiding tube code
(see Table 70)

Guiding tube length from receptacle (mm)



Connection diagram and protrusion geometry of the Dual Opto-fluid Cannula with interchangeable injectors



Notes:

- For the model S, the minimum possible distance between the tubes is the guiding tube diameter.
- Optical and Fluid Injectors for Dual Opto-fluid Cannulas must be ordered separately (**OI_DiOFC** and **FI_DiOFC**). Be careful to order the right amount of injectors.
- The tubing internal diameter must match the optical injector external diameter (see Tables 70 and 71).
- A 2-meter length of polyethylene tube is sold separately to connect a fluid delivery system to the cannula (**PT_OFC_2**, see Table 122).

Optical Injector for Dual Opto-fluid Cannula with interchangeable injectors

ORDERING CODE: OI_DiOFC-□_ZF_□□□/□□□-□.□□_□□□_□□

Receptacle type
S or **L** (depending on DiOFC receptacle)

Fiber-optic code
(see Table 71)

Fiber-optic termination code*
(see Table 62)

Fiber length from receptacle (mm)

Optical Injector for Dual Opto-fluid Cannula with interchangeable injectors

Fluid Injector for Dual Opto-fluid Cannula with interchangeable injectors

ORDERING CODE: FI_DiOFC-□_100/170_□□□

Receptacle type
S or **L** (depending on DiOFC receptacle)

Injector length from receptacle (mm)

*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Dual Opto-fluid Cannulas (see Table 62).

Stereotaxic Tools

Stereotaxic arm is valued for its positioning precision. However, when it comes to positioning the fiber-optic cannula, some of the precision is lost when attaching or detaching the cannula to/from the arm. To simplify the implantation of the cannula and maintain the precision, we have developed a *Stereotaxic Cannula Holder* and *Fiber-optic Cannula Adapters* for attaching our cannulas to the stereotaxic arm.

Stereotaxic Cannula Holders

Stereotaxic Cannula Holder 1.25

Notes:

- The diameter of the *Stereotaxic Cannula Holder* is 6.35 mm. Its length is 7.9 cm and an adapter of 10 cm long can be added at one end (**SIA**; see Table 73).
- An optional clamp (**SCL**) can be used to fix the Stereotaxic Cannula Holder on stereotaxic apparatus.
- The Stereotaxic Cannula Holder 1.25 mm allows the implantation of Two-ferrule Cannula with a pitch of 1.8 mm.

Table 72: *Stereotaxic Cannula Holders Ordering Codes*

Ferrule Diameter (mm)	Ordering Code
1.25	**SCH_1.25**
2.5	**SCH_2.5**

OmFC Cannulas Holder

The *OmFC Cannula Holder* is an adapter designed to maintain the OmFC cannula protrusion straight during the implantation. The upper part is compatible with our *In-line Adapters*. The bottom side holds the OmFC cannula steady with a screw. The configuration of the holder allows the use of a fluid injector and/or an optical connection during the implantation.

OmFC ZF Cannulas Holder

Notes:

- An adapter of 10 cm long can be added at one end of the holder (**SIA**; see Table 73).
- An optional clamp (**SCL**) can be used to fix the Stereotaxic Cannula Holder on stereotaxic apparatus.

ORDERING CODE: SCH_OmFC_□□□

Receptacle of the cannula
ZF or **SM3**

Low Profile Cannulas Holder

This stereotaxic holder is related to low profile cannulas. It is used to keep the fiber along the dorso-ventral axis during the implantation. Other inclined holders are available to be compatible with custom angle cannulas. The diameter of the holder is 7.9 mm.

Low Profile Cannulas Holder - 90 °

Notes:

- An adapter of 10 cm long can be added at one end of the holder (**SIA**; see Table 73).
- An optional clamp (**SCL**) can be used to fix the Stereotaxic Cannula Holder on stereotaxic apparatus.

ORDERING CODE: SCH_LP90

Adapters for Stereotaxic Cannula Holders

We offer adapters to attach our stereotaxic holders on stereotaxic frames that use 7.9 mm or 5 mm diameter rods as standard. We can offer other adapters on request.

In-line Adapter and Stereotaxic Holder

In-line Adapter

This adapter consists of a rod, with 8-32 threads at one end.
Notes:

- The *In-line Adapters* are 10 cm long and compatible with our *Stereotaxic Cannula Holders*.
- An optional clamp (**SCL**) can be used to fix the Stereotaxic Cannula Holder on stereotaxic apparatus.
- For diameter 7.9 mm, there is a $^1/_4''$ threaded hole at the other end.

Table 73: *In-line Adapters Ordering Codes*

Diameter (mm)	Ordering Code
5	**SIA_5**
6.35	**SIA_6.35**
7.9	**SIA_7.9**

Clamp

This adapter is a double clamp, designed to hold a 5.0 or 7.9 mm diameter rod on one side and a 6.35 mm diameter rod on the other side.

Clamp

Note: The Clamp is compatible with our Stereotaxic Cannula Holders (**SCH**), OmFC Cannulas Holder (**SCH_OmFC**), Low Profile Cannulas Holder (**SCH_LP90**) and In-line Adapters (**SIA**).

Table 74: *Clamp Ordering Codes*

Diameter (mm)	Ordering Code
5.0	**SCL_5**
7.9	**SCL_7.9**

Receptacle adapters

M2, M3 or GS Receptacle Adapters

This adapter allows the use of M2, M3 or GS Cannula Receptacles with a *Stereotaxic Cannula Holder*.

Receptacle Adapter SM3 1.25 mm for Fiber-optic Cannula

Table 75: *Receptacle Adapters Ordering Codes*

Attachment Diameter (mm)	Receptacle Adapter		
	RM2	SM3	GS
1.25	**FCA_1.25_RM2**	**FCA_1.25_SM3**	**FCA_1.25_GS**
2.5	**FCA_2.5_RM2**	**FCA_2.5_SM3**	**FCA_2.5_GS**

Note: **GS** for a Dual Fiber-optic Cannula with a guiding socket.

Ferrule Receptacle Adapter

This adapter allows an extension of the ferrule in cases where the clearance on the receptacle is insufficient to use the *Stereotaxic Cannula Holder*. This adapter can be useful to implant all types of Opto-electric Cannula Receptacles.

Ferrule Receptacle Adapter

Table 76: *Ferrule Receptacle Adapters Ordering Codes*

Diameter (mm)	Ordering Code
1.25	**FCA_1.25_1.25**
2.5	**FCA_2.5_2.5**

Optical Fiber Probes

Instead of cannulation, *in vitro* and *in vivo* head-fixed animal optogenetics experiments require thin and long optical probes that easily connect to micro-manipulator probe holders and have minimal obstruction of the observation site.

Optical Fiber Probe Holder

Optical Fiber Probe Holder

Our *Optical fiber probe holder* is a stainless steel rod having an FC receptacle on one end that allows a light delivery patch cord to be plugged in and at the other end an M3 receptacle where a probe can be screwed on. The two receptacles are mutually connected with an internal optical fiber housed within the 6.35 mm diameter rod that fits most popular micro-manipulators. To avoid unnecessary optical losses, the selected optical fiber parameters such as the core diameter and NA should match those of the connecting fibers. The type of fiber within the holder is marked with a color code. The fiber NA is engraved on the holder.

Note: An optional clamp (**SCL**) can be used to fix the holder on stereotaxic apparatus.

ORDERING CODE: OFPH_150_□□□-.□□_FC

Rod length (mm)
150 mm is standard.
100 mm is also available.

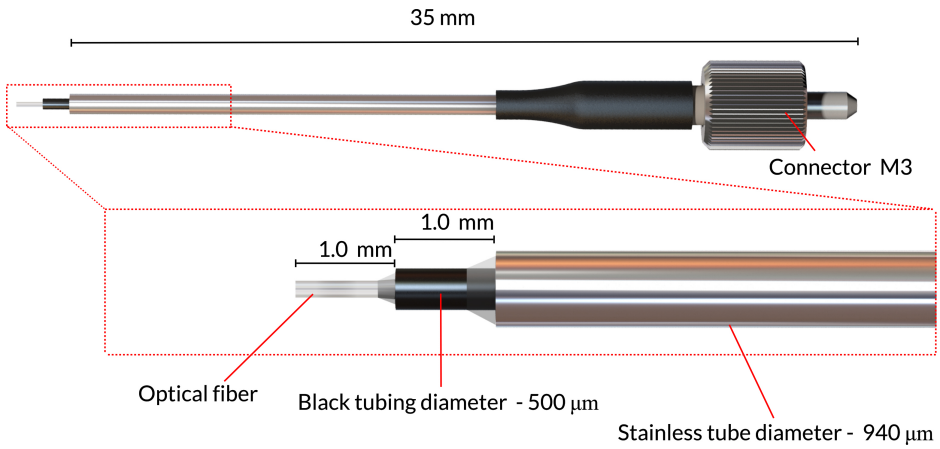
Fiber-optic core diameter (µm)

Fiber NA

Possible fiber combinations are : 500 µm / NA 0.63 for LED sources, 200 µm / NA 0.22 for laser sources and 50 µm / NA 0.22 for small area laser illumination.

Optical Probe Tips

Like fiber-optic cannulas, the optical probe is an optical fiber of the specific NA and core diameter with an M3 connector at one end while its loose end is much longer and suitably protected and strengthened to keep its direction. The fiber tip can even be pulled to diameters smaller than the original fiber diameter. When used with micro-manipulators and its holders, it can precisely illuminate a very small area of interest.



Optical Probe Tip

ORDERING CODE: OPT_□□□-.□□_□□□_□□□

Fiber-optic core diameter (µm)

Fiber NA

Fiber-optic termination code (see Table 62)

Fiber tip diameter (µm)
10, **20**, **50**, if a taper is needed with the 100 µm / NA 0.37 combination

The possible combinations (core diameter / NA) are:

500 µm / NA 0.63	100 µm / NA 0.37 (with taper)
400 µm / NA 0.66 or 0.22	50 µm / NA 0.66 or 0.22
200 µm / NA 0.66 or 0.22	
100 µm / NA 0.66 or 0.22	25 µm / NA 0.66

Note: For the 100 µm / NA 0.37 combination, tapered tips down to 10 µm are available upon request.

Opto-electric Probes

Opto-electric Probe Holder

The *Opto-electrical probe holder* has a similar function as the optical probe holder with the addition of an electrical contact. In order to reduce cable congestion around the specimen, the opto-electrical probe holder permits bringing the optical and electrical contact to the back of the holder. It is recommended to plug a shielded cable to the BNC cable.

Opto-electric Probe Holder

ORDERING CODE: OEPH_□□□-.□□_□.□_□□_0.2_□□

Fiber-optic core diameter (µm)

Fiber NA

Possible fiber combinations are:

- 500 µm / NA 0.63 for LED sources
- 200 µm / NA 0.22 for laser sources
- 50 µm / NA 0.22 for small area laser sources

Optical fiber length (m)

Fiber-optic patch cord termination (see Table 48)

Electrical cable length (m)
0.2 m is standard. Other values on request.

Electrical connector
BNC or **pin**

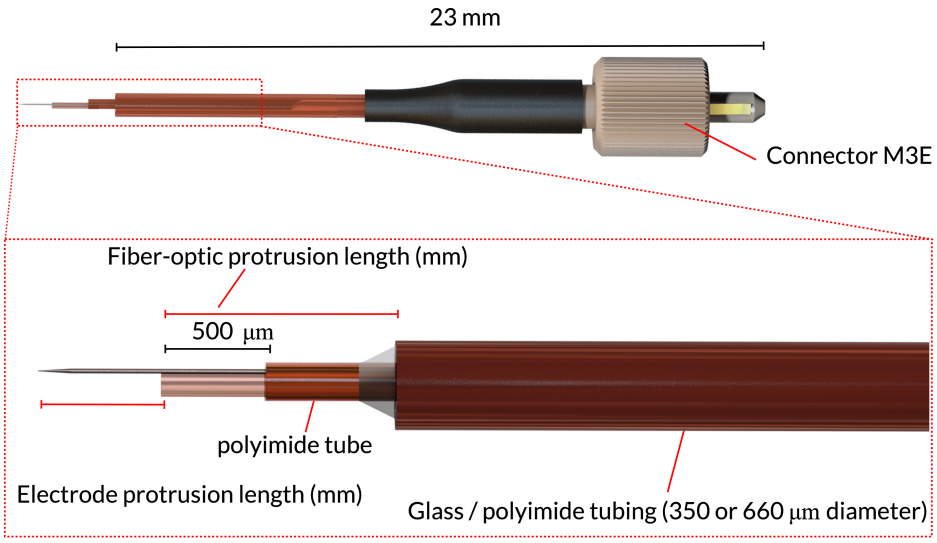
Notes:

- The length of the optical fiber and the electrical cable is measured from the coming out of the rod to the tip of the connector.

- The rod has a standard length of 150 mm.
- An optional clamp (**SCL**) can be used to fix the holder on stereotaxic apparatus.

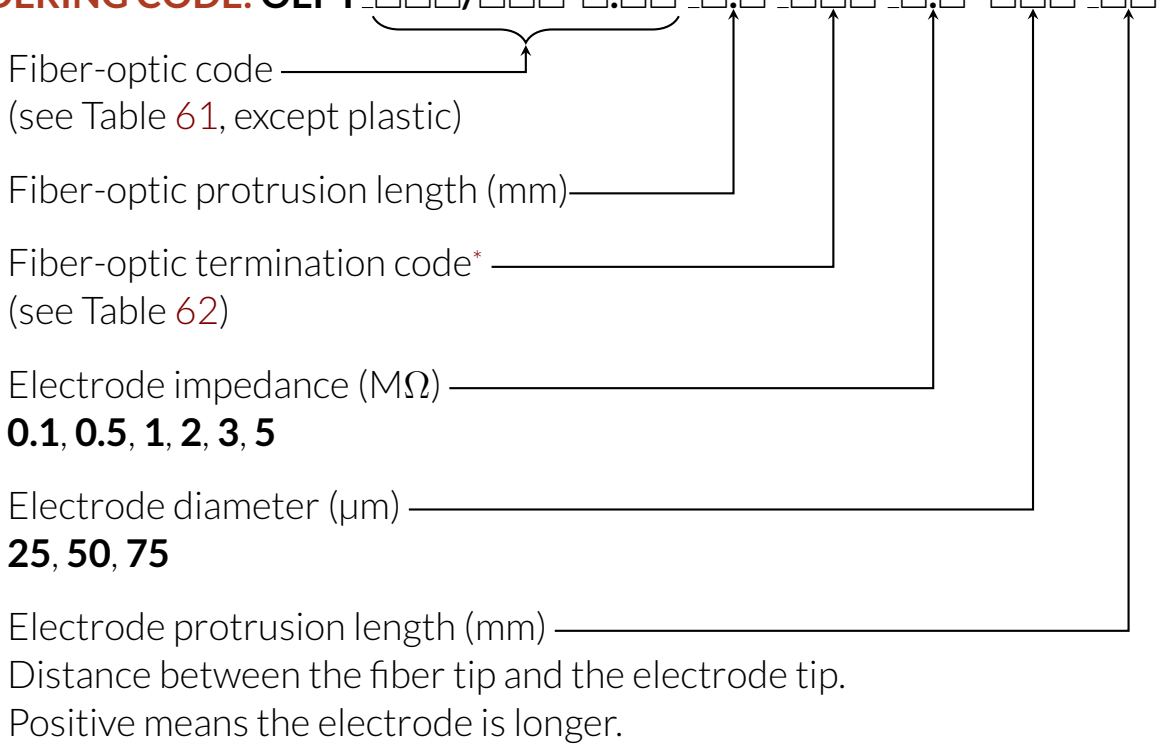
Opto-electric Probe Tips

Like optical probe tips, the *Opto-electric Probe Tips* have an optical fiber of the specific NA and core diameter with an M3 connector at one end while its loose end is much longer and suitably protected and strengthened to keep its direction. In addition, this probe has an electrical wire that goes along the optical fiber, from near the tip to the groove in the zirconia ferrule.



Opto-electric Probe Tip

ORDERING CODE: OEPT _□□□/□□□-□.□□ _□.□ _□□□ _□.□ -□□□ _□□



*Angled (**A45**, **A60**) and mirror (**MA45**) tips are not offered with Opto-electric Probe Tips (see Table 62).

Single-cell Recording Opto-electric Probe

Single-cell recordings require an optical fiber core diameter at the fiber end comparable with the size of the cell under observation. The electrode tip has to be of the similar size and in close proximity to the fiber core. One way to achieve those specifications is by making a dual core optical fiber having the light guiding core and the capillary within its cladding[*] [†], and pulling or tapering one fiber end into the small diameter tip. When the capillary is filled with electrolyte, the fiber end becomes a usable single-cell opto-electric interface smaller than the cell itself.

These Single-cell Recording Opto-electric Probes are perfectly suited for *in vivo* single-cell electrophysiological recordings, optogenetic stimulation and photometry monitoring (see animation by Stuart Jantzen from University of Toronto).

NB: This particular probe is used for *in vivo* experiments with head-fixed animals.

Single-cell Recording Opto-electric Probe

[*] LeChasseur Y, et al., Nature Methods 8, 319325 (2011)
[†] Dufour S, et al., PLoS ONE 8 (2): e57703 (2013)

Single-cell Recording Opto-electric Probe Systems

This section contains complete Single-cell Recording Opto-electric Probe systems bundled with a single ordering code for convenience.

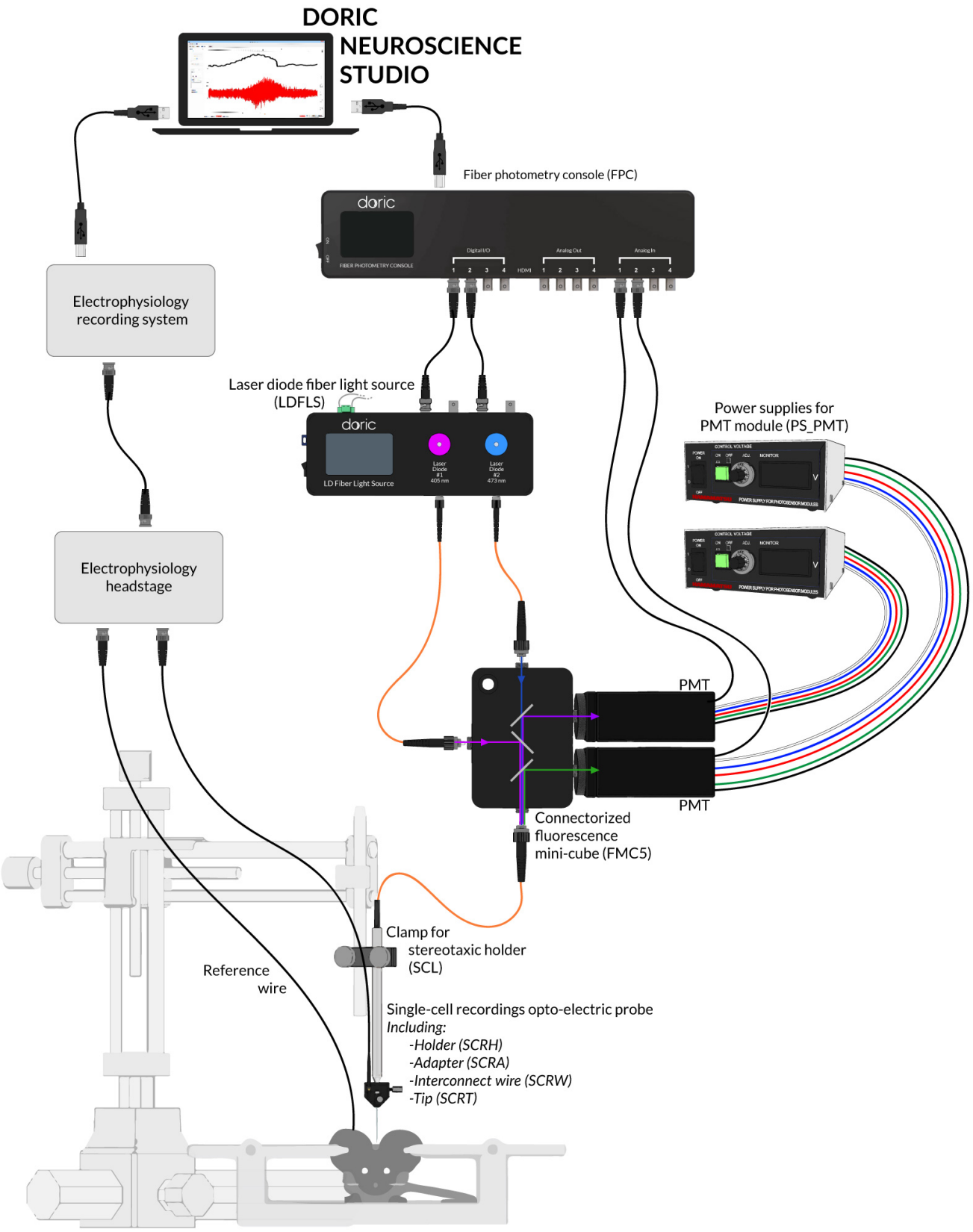
Single-cell Photometry and Electrophysiology Recording System

This system is designed to do extracellular electrophysiology recordings and photometry detection at a single-cell resolution in a head-fixed configuration. Its optical sensitivity allows detection of standard fluorophores (GFP, mCherry, quantum dot, etc.) or functional fluorophores (GCaMP, Oregon Green, FURA-2, etc). Extracellular electrophysiology is possible by filling the fiber probe hollow core with an electrolyte solution to get an electrode impedance in the range of 1 to 20 MΩ, allowing a single-unit or multi-unit spikes detection.

This system includes specifically:

- Fiber Photometry Console
- Connectorized Fluorescence Mini Cube (single or multiple wavelengths with appropriate filters)
- Photosensor Module (1 or 2x)
- Power Supply for PMT Module (1 or 2x)
- Laser Diode Fiber Light Sources (1 or 2x)
- Single-cell Opto-electric Probe Holder
- Clamp for Single-cell Opto-electric Probe Holder
- Single-cell Opto-electric Probe Adapter
- Single-cell Opto-electric Probe Interconnect Wire (5x)
- Single-cell Opto-electric Probe Tips (20x)
- Extracellular Electrophysiology Recording System (under development)
- All electrical cables and optical patch cords

ORDERING CODE: SCRS-PE



Single-cell Photometry and Electrophysiology Recording System

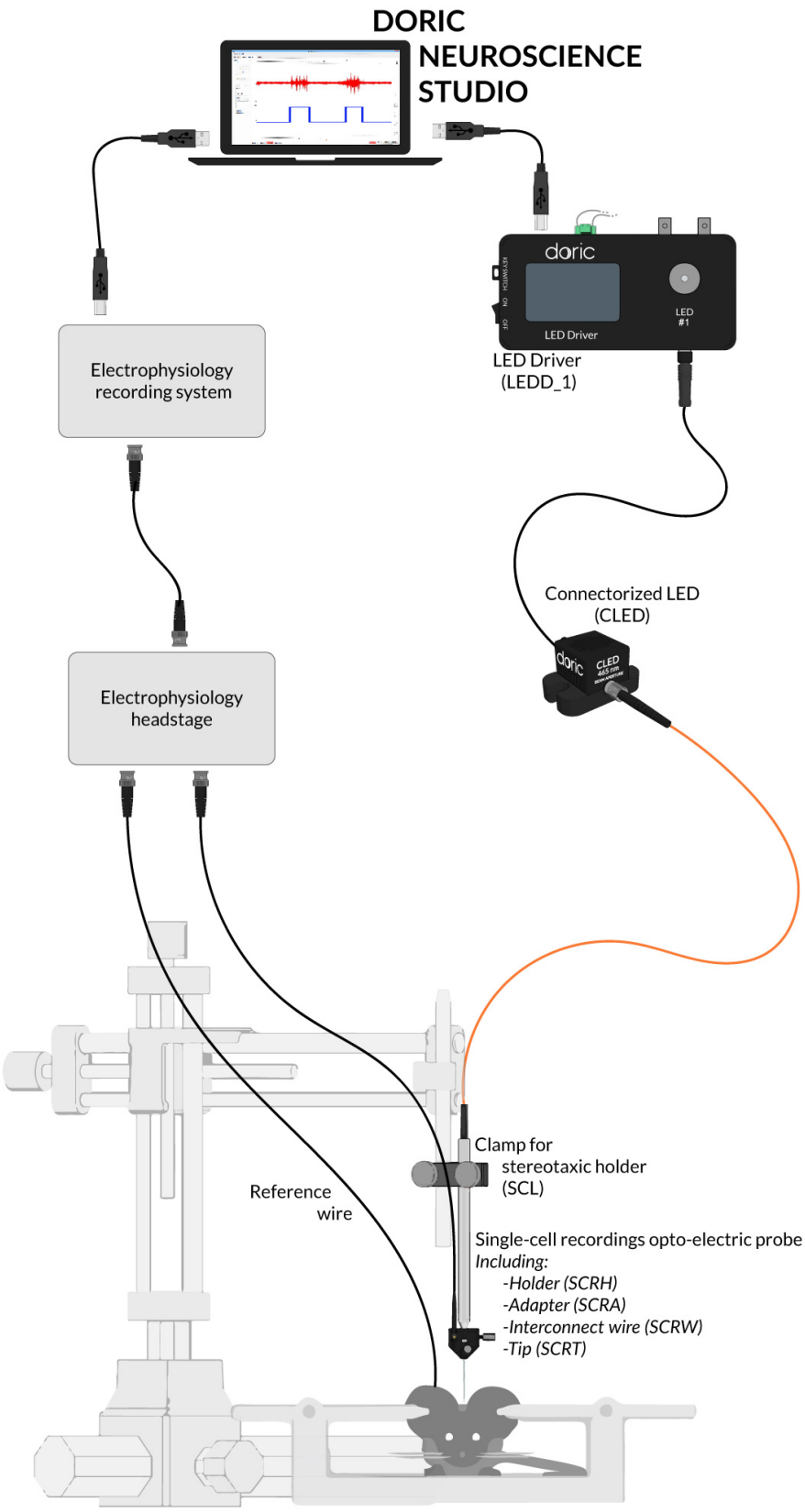
Single-cell Optogenetic Illumination and Electrophysiology Recording System

Optogenetics and electrophysiology are combined in this system to allow recordings of synaptic events at a single-cell resolution in a head-fixed configuration. It is designed to activate optogenetic proteins such as channelrhodopsine or to inhibit light-gated ion pumps like halorhodopsin. By adjusting the illumination output power, it is possible to illuminate a single cell or a group of neurons. Extracellular electrophysiology is possible by filling the fiber probe hollow core with an electrolyte solution to get an electrode impedance in the range of 1 to 20 MΩ, allowing a single-unit or multi-unit spikes detection.

This system includes specifically:

- Connectorized Single LED (1x or 2x)
- LED Driver
- Single-cell Opto-electric Probe Holder
- Clamp for Single-cell Opto-electric Probe Holder
- Single-cell Opto-electric Probe Adapter
- Single-cell Opto-electric Probe Interconnect Wire (5x)
- Single-cell Opto-electric Probe Tips (20x)
- Extracellular Electrophysiology Recording System (under development)
- All electrical cables

ORDERING CODE: SCRS-OE



Single-cell Optogenetic Illumination and Electrophysiology Recording System

Single-cell Recording Opto-electric Probe Holder

Single-cell Recording Opto-electric Probe Holder

The *Single-cell Recording Opto-electric Probe Holder* consists of a fiber-optic patch cord in a rigid tubing. It offers an appropriate optical connection between the probe core in the *Single-cell Opto-electric Probe Adapter* and the light module. It can be secured in a stereotaxic apparatus with our *Stereotaxic Clamp*.

ORDERING CODE: SCRH_550/600/3000-0.22_□.□_FCA

Fiber-optic code

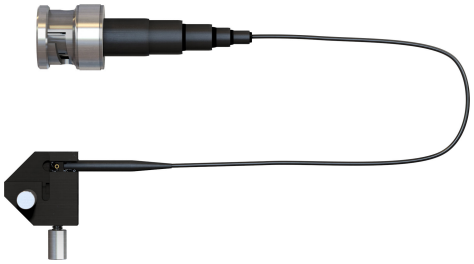
Optical fiber length (m)
1 to 1.5 m is recommended.

Fiber-optic patch cord termination

Notes:

- The length of the optical fiber is measured from the coming out of the rod to the tip of the connector.
- The rod has a standard length of 150 mm.
- An optional clamp (**SCL**) can be used to fix the holder on stereotaxic apparatus.

Single-cell Recording Opto-electric Probe Adapter



Single-cell Recording Opto-electric Probe Adaptor

The link between the *Single-cell Opto-electric Probe Holder* and the *Single-cell Opto-electric Probe Tip* is assured by the *Single-cell Opto-electric Probe Adapter*. This junction component maintains and aligns the two optical cores together allowing a maximum amount of light to be guided towards the tip. Its electrical output ensures the electrical connection between the electrophysiological recording system and the electrolyte filled core. The electrical ends with a standard BNC connector can be modified upon request.

ORDERING CODE: SCRA_□□□_0.2

Electrical connector
BNC or **pin**

Cable length (m)
0.2 m is standard. Short length is recommended.

Single-cell Recording Opto-electric Interconnect Wire

The *Single-cell Opto-electric Interconnect Wire* makes the connection between the electrolyte solution within the optical fiber hollow core and the electrophysiology system. The part inserted in the *Single-cell Opto-electric Probe Tip* is a 100 µm silver wire and the other side is connected to the probe adaptor with a pin. Other types of wires could be offered on demand.

Single-cell Recording Opto-electric Interconnect Wire

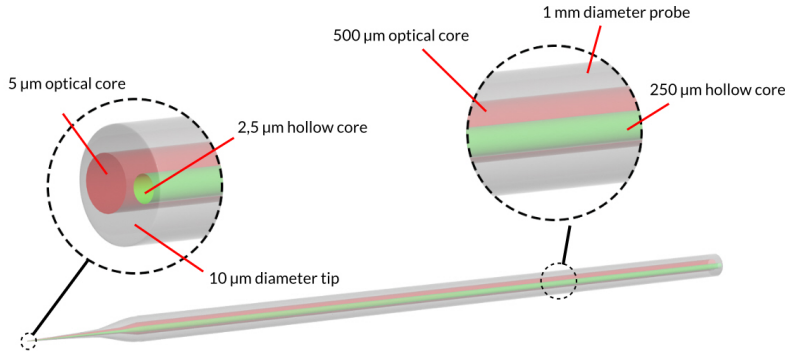
ORDERING CODE: SCRW_□□□□

Type of wire
Silver wire 100 µm (**AG100**) or stainless steel wire 50 µm (**SS50**)

Single-cell Recording Opto-electric Probe Tips

Single-cell Recording Opto-electric Probe Tip

A *Single-cell Recording Opto-electric Probe Tip* is a piece of dual core optical fiber with a 500 µm optical core and a 250 µm hollow core for electrolyte filling with one end pulled and cut to a 10 µm diameter tip as illustrated above. The probe tip is simply inserted into the dedicated Single-cell Recording Opto-electric Probe Holder. A black coating can be added to minimize the light output/input in the shoulder of the tapered part of the probe.



Single-cell Recording Opto-electric Probe Tip of 10 µm diameter

Table 77: *Single-cell Recording Opto-electric Probe Tips Specifications*

SPECIFICATION	VALUE	NOTE
Optical fiber diameter	1 mm	
Optical fiber core diameter	500 µm	Off-Centered
Optical fiber NA	0.23	
Hollow core diameter	250 µm	For electrolyte filling, off-centered
Pulled tip diameter	10 µm	Optical core and hollow core ratio is preserved
Shank (taper) length	3-7 mm	
Total length	30 - 35 mm	

Note: Opto-electric probe tips are sold in lots of 20 units.

ORDERING CODE: **SCRT_10_ □□**

Fiber tip diameter (µm)
10 µm is standard.
Other values on request.

Coating
BK, if a black coating is needed

Single-cell Recording Opto-electric Probe - Raw Fiber

Silica raw dual core fiber in lengths of 55 mm are available for proficient users who prefer to pull and cut the tip by themselves. Suitable with Sutter Instrument P-2000 Laser-based microcropipette puller.

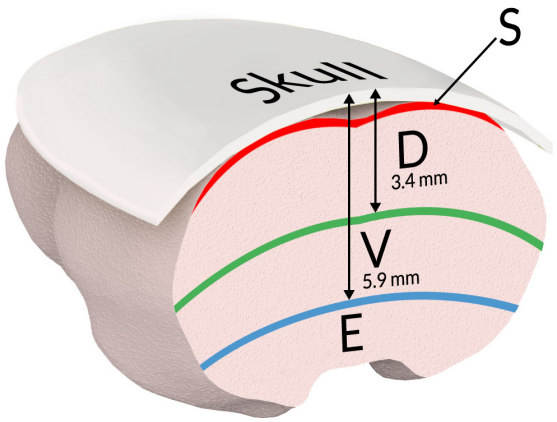
ORDERING CODE: **SCRF_55**

Fiber length (mm)
55 mm is standard.

Single-cell Recording Opto-electric Probe - Raw Fiber

Miniaturized Fluorescence Microscopy

Until recently, fluorescence microscopy was dominated by large microscope installations, sometimes referred to as the rigs. The observations of neural circuitry in freely moving animals like mice or rats require a wearable fluorescence microscope attached to imaging cannulas chronically implanted in the animal's brain. To make this microscope mice-wearable, the smallest fluorescence microscope body ever was built. It easily snaps into a chronically implanted imaging cannula via a self-centering latching mechanism. The snap-in microscope body is electrically pigtailed and optically connectorized. In the middle of the visible spectrum, the scattering through the brain tissue limits imaging to about 150 µm. The imaging limited to those depths from the brain surface can be performed without insertion of all-glass relay lenses. At larger brain depths, it is absolutely necessary to use relay lens systems that may consist of homogeneous or gradient-index glass rods or lenses that bring the image into focus of the microscope objective and effectively reduce the optical path through the brain tissue.
Here are some simple rules for selecting the appropriate microscope body and imaging cannula design when imaging different brain tissue zones:



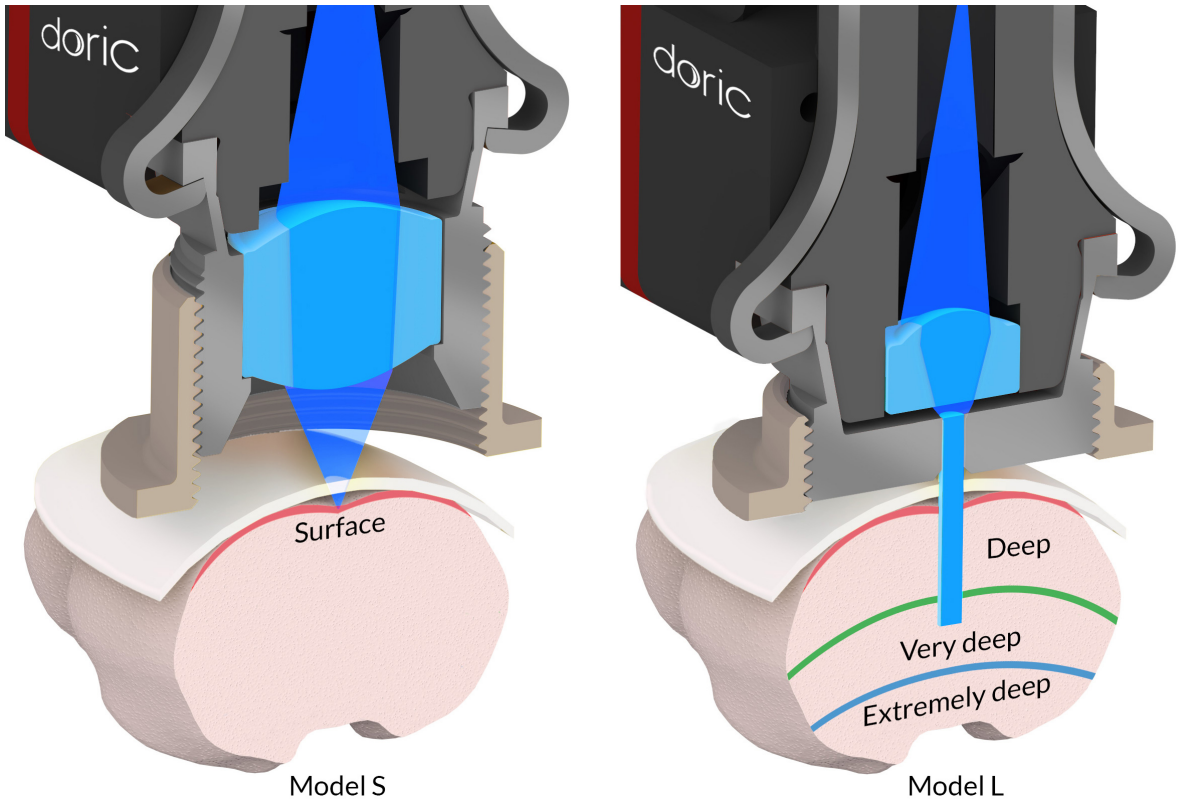
S: Surface *(up to 150 µm deep)*
D: Deep
V: Very deep
E: Extremely deep

The focusing of the imaging cannulas to a specific tissue area is achieved with a mechanical depth adjustment mechanism on top of the skull. The electrical cable jacket can be customized with a lighter and more flexible cable, the *Ultralight Fiberglass*

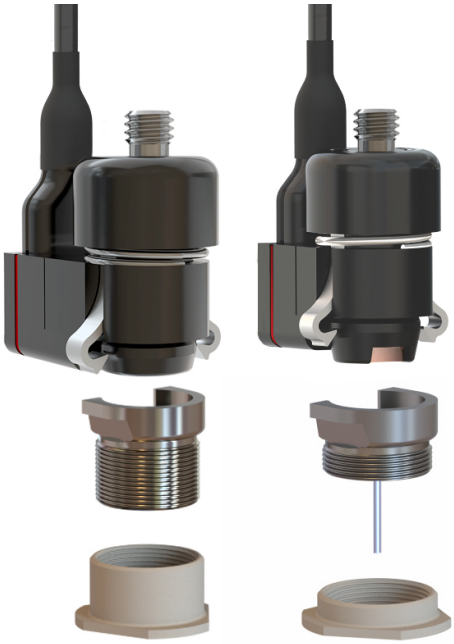
* Including the thickness of the skull.

Table 78: *Microscope Body and Imaging Cannula models for specific brain zones*

Brain Zones	Microscope Body Model	Cannula Model
(S) 0 to 150 µm below the brain surface	S	S
(D) 0 to 3.4 mm below the skull surface*	L	L type D
(V) 3.0 to 5.9 mm below the skull surface*	L	L type V
(E) 5.4 to 8.3 mm below the skull surface*	L	L type E



Jacket, or **UFGJ**, or a more robust but heavier one, the *Lightweight Metal Jacket*, or **LWMJ**.



Snap-in Fluorescence Microscope Model S (left), and Model L (right)

Miniaturized Fluorescence Microscopy Systems

Basic Fluorescence Microscopy Systems

For Surface Imaging (<150 µm depth)

This system contains all the items necessary to do surface brain calcium imaging of freely-moving animals. This system includes specifically:

- Connectorized LED or Ce:YAG Optical Head
- Fluorescence Microscope Driver
- Snap-in Fluorescence Microscope Body *Model S*
- Snap-in Imaging Cannula *Model S* (3x)
- Protrusion Adjustment Ring Set *Model S*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Fluorescence Microscope Snapping Tool
- Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: BFMS-S_□□□□_1000_□□□_□□□

Electrical cable jacket
UFGJ or **LWMJ**†

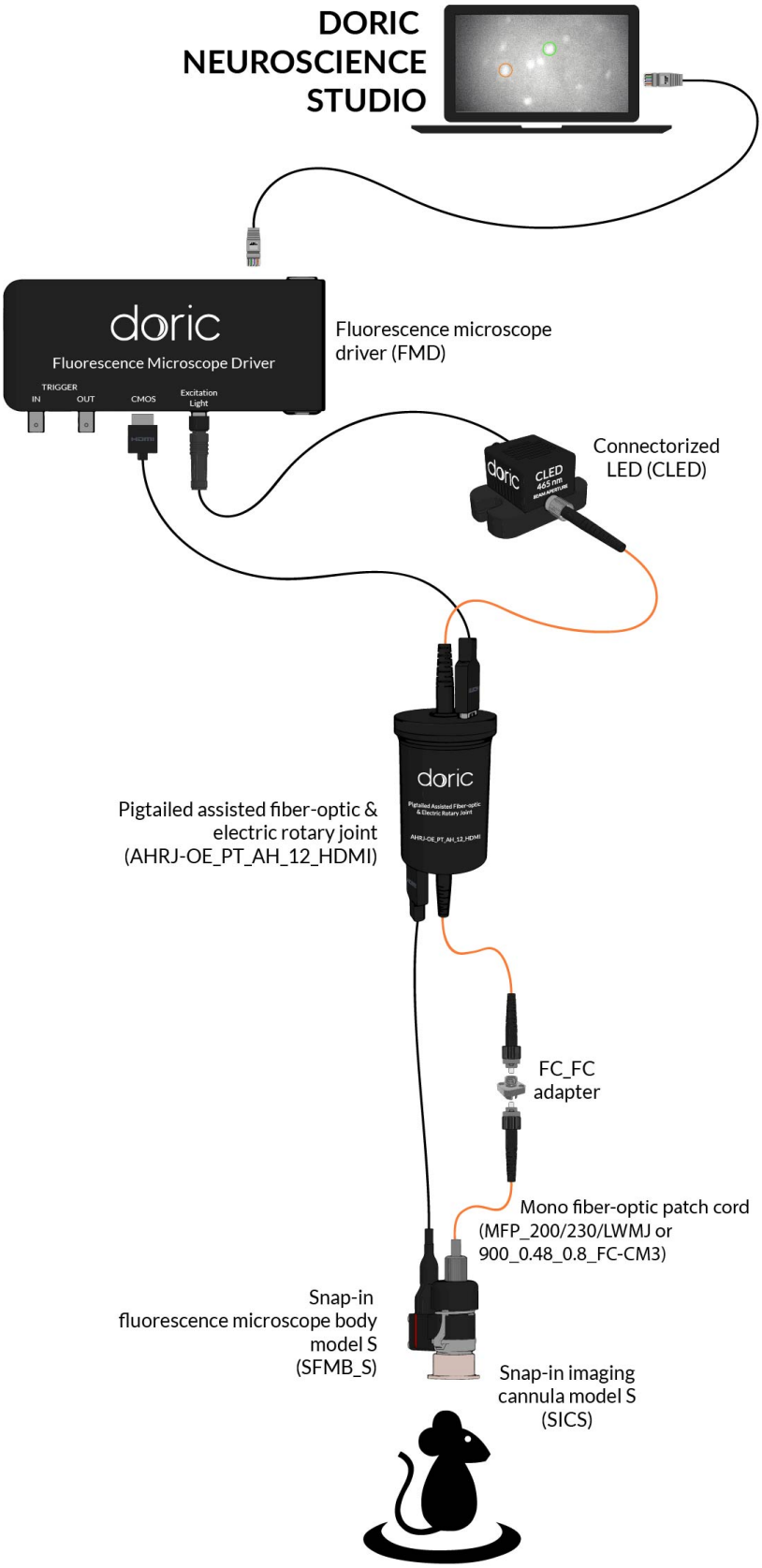
Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Optical fiber jacket
900 or **LWMJ**†

Excitation wavelength (nm)
458 or **550**

*The optical fiber length is adjusted to fit the desired electrical cable length.

†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



Basic Fluorescence Microscopy System for Surface Imaging of GCaMP6

For Deep-brain Imaging (150 µm to 8 mm depth)

This system contains all the items necessary to do deep-brain calcium imaging of freely-moving animals.

This system includes specifically:

- Connectorized LED or Ce:YAG Optical Head
- Fluorescence Microscope Driver
- Snap-in Fluorescence Microscope Body *Model L*
- Snap-in Imaging Cannula *Model L* (3x)
- Protrusion Adjustment Ring Set *Model L*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Fluorescence Microscope Snapping Tool
- Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: BFMS-L_□□□□_1000_□□□_□□□_□

Electrical cable jacket
UFGJ or **LWMJ**†

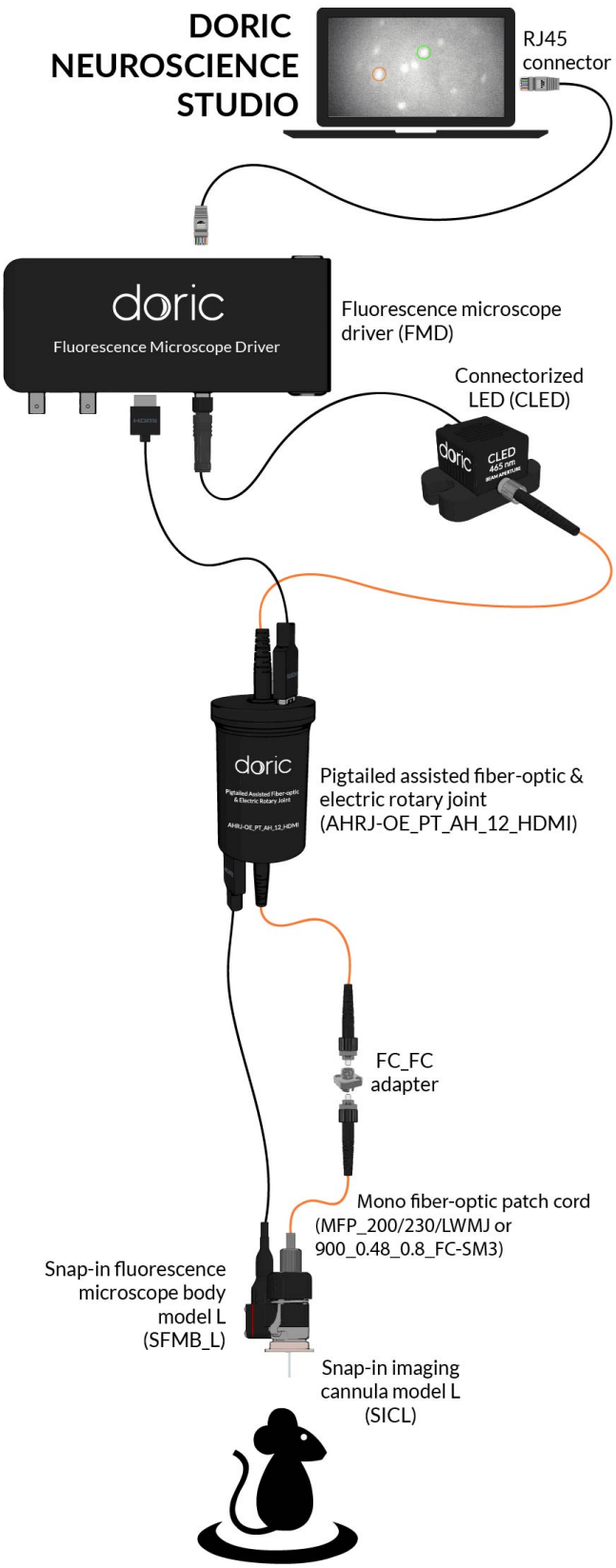
Electrical cable length (mm)
1000 mm is standard.
Other values on request.

Optical fiber jacket
900 or **LWMJ**†

Excitation wavelength (nm)
458 or **550**

Cannula type
D, **V** or **E** (see Standard Imaging Cannula Model L)

*The optical fiber length is adjusted to fit the desired electrical cable length.
†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



Basic Fluorescence Microscopy System for Deep-brain Imaging of GCaMP6

Optogenetically Synchronized Fluorescence Microscopy Systems

The OSFM systems include the Ce:YAG Fiber Light Source in order to synchronize the fluorophore excitation light with the opsin activation light output in the same optical fiber.

For Surface Imaging (<150 µm depth)

This system contains all the items necessary to do surface brain calcium imaging synchronized with opsin activation of freely-moving animals. This system includes specifically:

- Ce:YAG + LED (465 nm) or Laser (450 nm) Optical Head
- Ce:YAG + LED (465 nm) or Laser (450 nm) Driver
- Optogenetics TTL Generator 4-channel
- Fluorescence Microscope Driver
- OSFM Microscope Body *Model S*
- Snap-in Imaging Cannula *Model S* (3x)
- Protrusion Adjustment Ring Set *Model S*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Fluorescence Microscope Snapping Tool
- Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: OSMS-S_□□□□_1000_□□□_□□□/□□□

Electrical cable jacket
UFGJ or **LWMJ**†

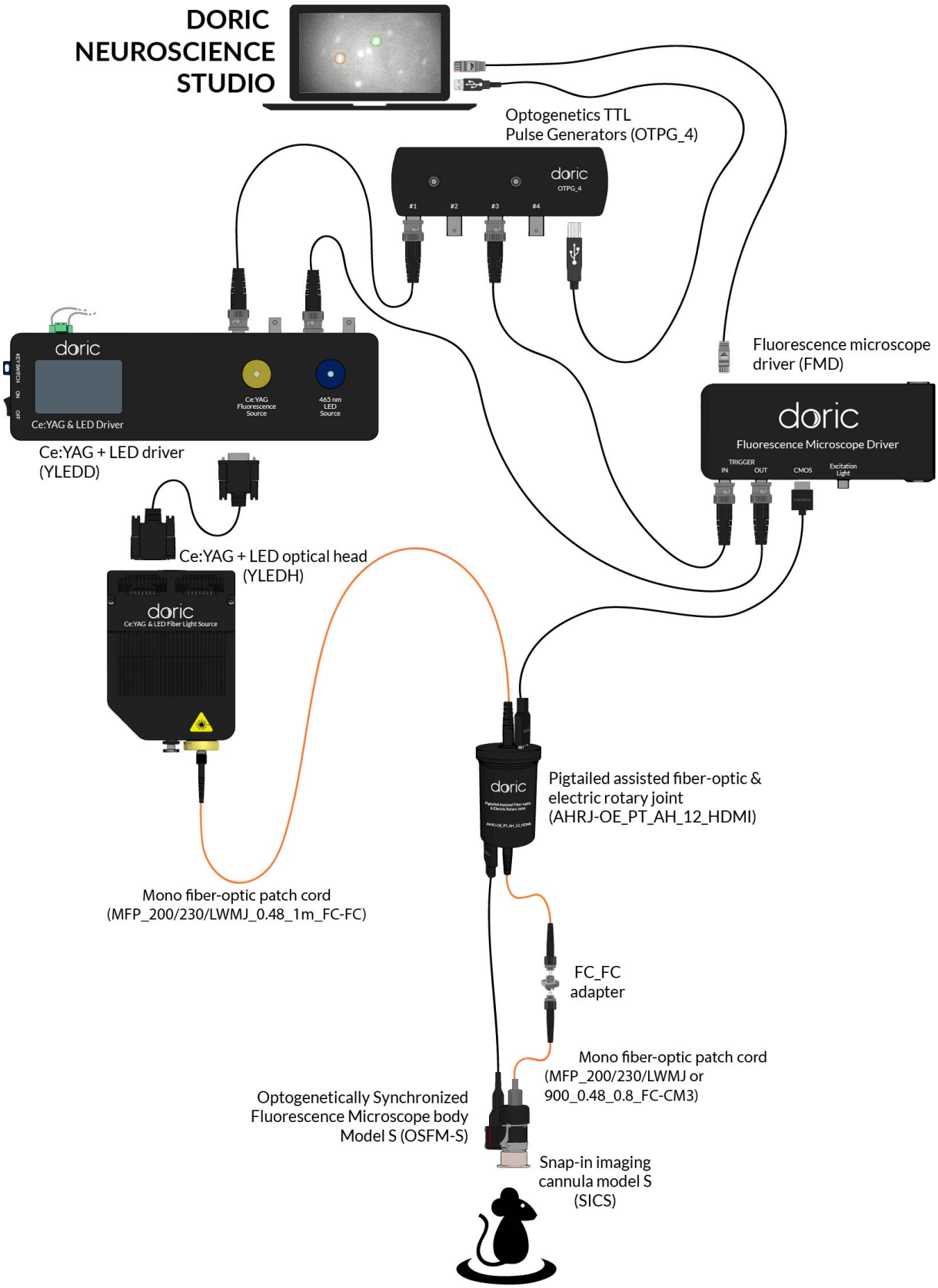
Electrical cable length (mm)
1000 mm is standard.

Optical fiber jacket
900 or **LWMJ**†

Excitation/activation wavelengths (nm)
445/616 or **550/475**

*The optical fiber length is adjusted to fit the desired electrical cable length.

†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



Optogenetically Synchronized Microscopy System for Surface Imaging of GCaMP6 + NpHR3.0

For Deep-brain Imaging (150 µm to 8 mm depth)

This system contains all the items necessary to do deep-brain calcium imaging synchronized with opsin activation of freely-moving animals. This system includes specifically:

- Ce:YAG + LED (465 nm) or Laser (450 nm) Optical Head
- Ce:YAG + LED (465 nm) or Laser (450 nm) Driver
- Optogenetics TTL Generator 4-channel
- Fluorescence Microscope Driver
- OSFM Microscope Body *Model L*
- Snap-in Imaging Cannula *Model L* (3x)
- Protrusion Adjustment Ring Set *Model L*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Fluorescence Microscope Snapping Tool
- Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: OSMS-L_□□□□_1000_□□□_□□□/□□□_□

Electrical cable jacket
UFGJ or **LWMJ**†

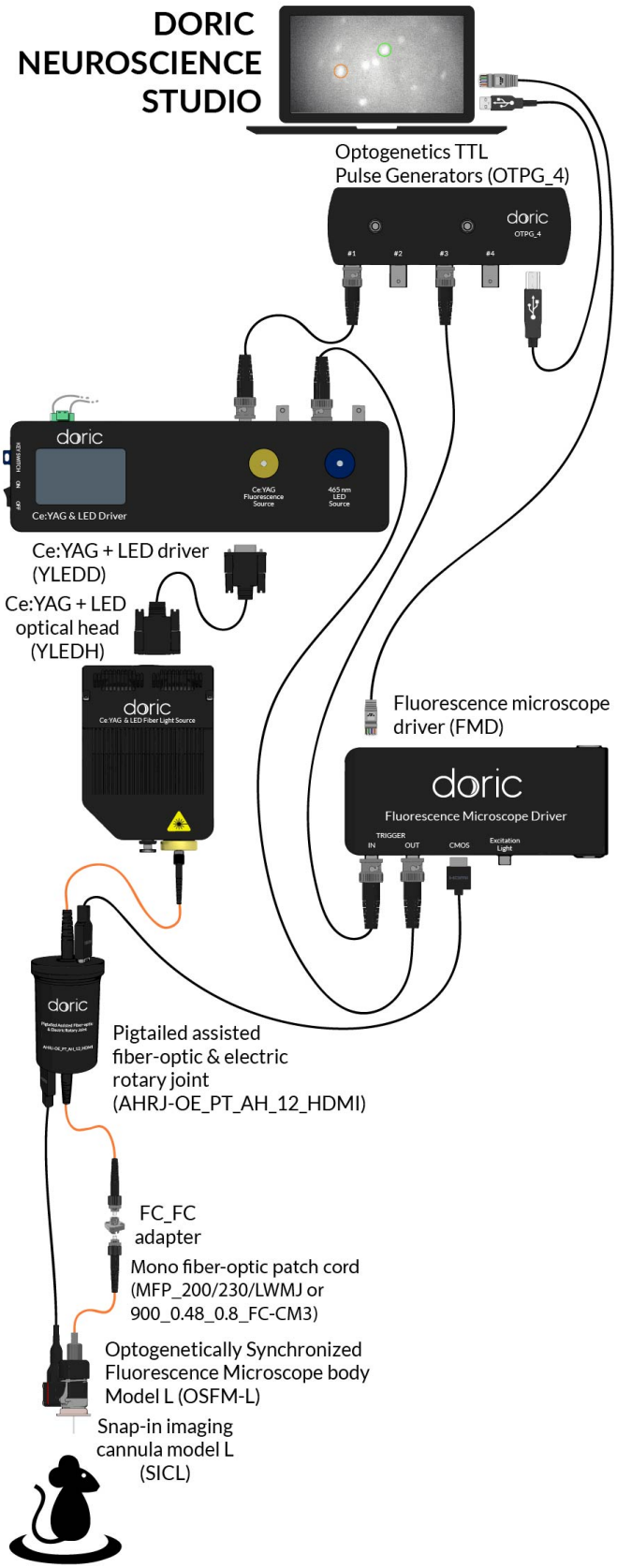
Electrical cable length (mm)
1000 mm is standard.
Other values on request.

Optical fiber jacket
900 or **LWMJ**†

Excitation/activation wavelengths (nm)
445/616 or **550/475**

Cannula type
D, **V** or **E** (see Standard Imaging Cannula Model L)

*The optical fiber length is adjusted to fit the desired electrical cable length.
†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



OSFM System for Deep-brain Imaging
of GCaMP6 + NpHR3.0

2-color Fluorescence Microscope Systems

For Surface Imaging (<150 µm depth)

This system contains all the items necessary to do surface brain calcium imaging with GFP-like and RFP-like fluorophores of freely-moving animals.

This system includes specifically:

- Ce:YAG + LED (465 nm) Optical Head
- 2-color Fluorescence Microscope Driver
- 2-color Fluorescence Microscope Body *Model S*
- Snap-in Imaging Cannula *Model S* (3x)
- Protrusion Adjustment Ring Set *Model S*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder 2
- Clamp for Fluorescence Microscope Holder 2
- 2-color Fluorescence Microscope Snapping Tool
- 2-color Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: 2CMS-S_□□□□_1000_□□□_458/561

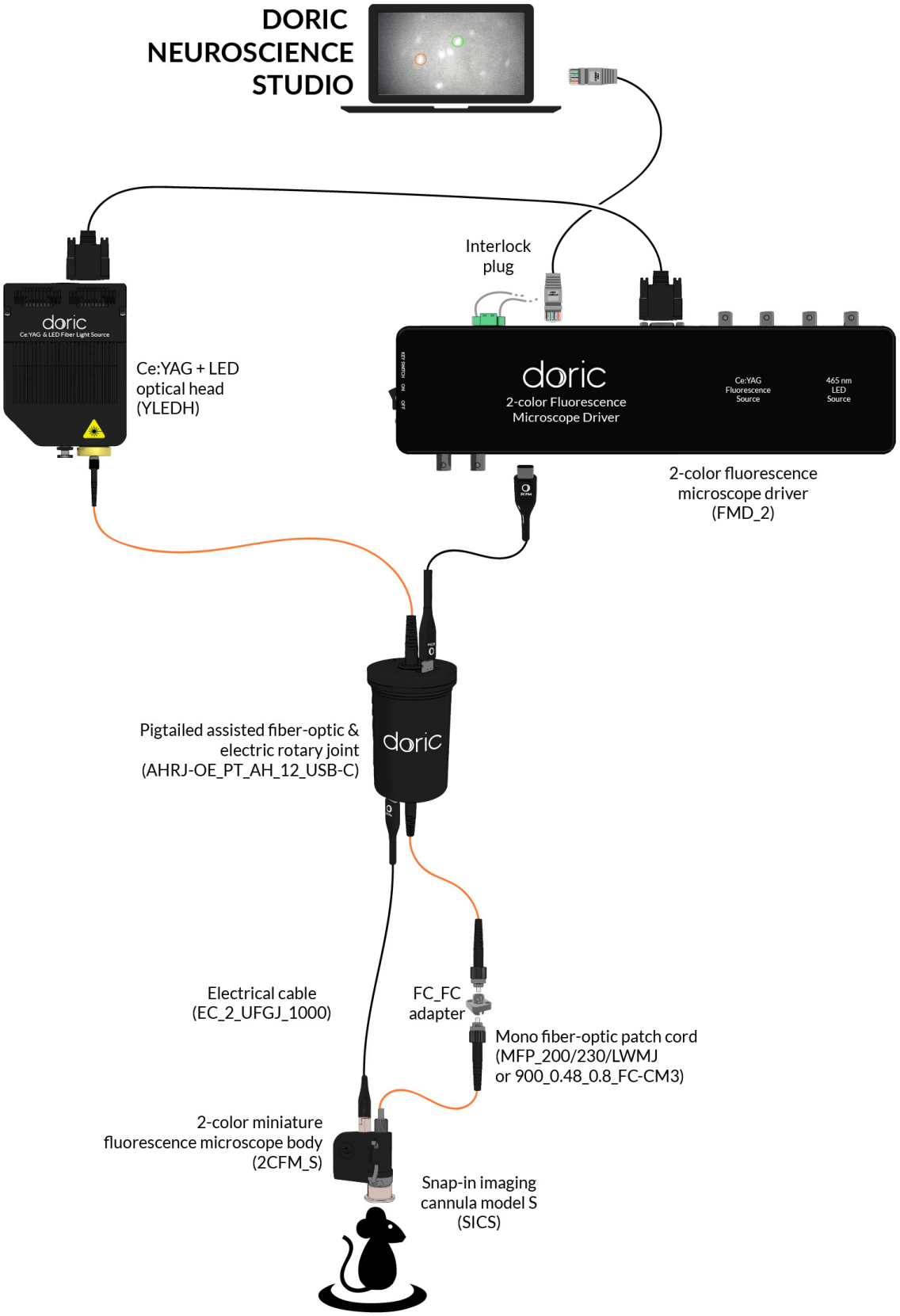
Electrical cable jacket
UFGJ or **LWMJ**†

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Optical fiber jacket
900 or **LWMJ**†

Excitations wavelengths (nm)
Excitation 1 / Excitation 2

*The optical fiber length is adjusted to fit the desired electrical cable length.
†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



2-color Fluorescence Microscopy System for Surface Imaging

For Deep-brain Imaging (150 µm to 8 mm depth)

This system contains all the items necessary to do deep-brain calcium imaging with GFP-like and RFP-like fluorophores of freely-moving animals.

This system includes specifically:

- Ce:YAG + LED (465 nm) Optical Head
- 2-color Fluorescence Microscope Driver
- 2-color Fluorescence Microscope Body *Model L*
- Snap-in Imaging Cannula *Model L* (3x)
- Protrusion Adjustment Ring Set *Model L*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder 2
- Clamp for Fluorescence Microscope Holder 2
- 2-color Fluorescence Microscope Snapping Tool
- 2-color Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: 2CMS-L□_□□□□_1000_□□□_458-561

2-color Fluorescence Microscope Body Optimized for **D** or **V**

Electrical cable jacket **UFGJ** or **LWMJ**†

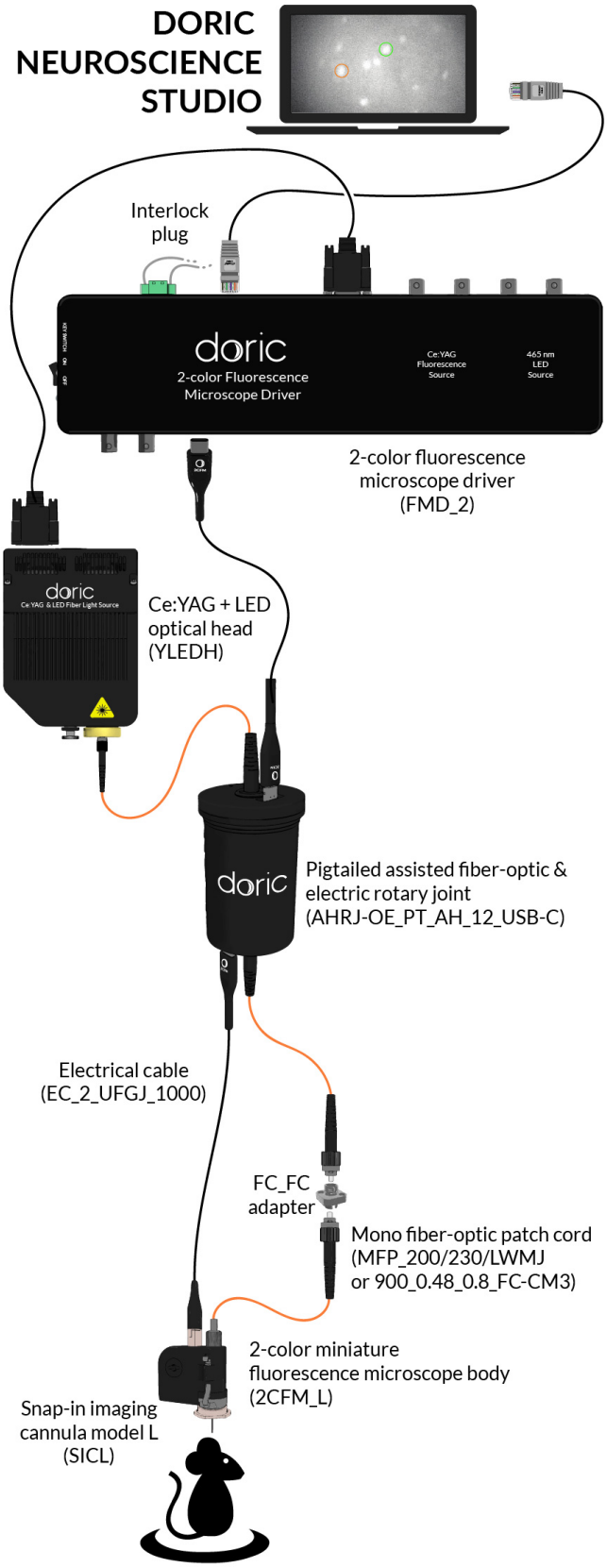
Electrical cable length (mm) **1000** mm is standard.

Optical fiber jacket **900** or **LWMJ**†

Excitation wavelengths (nm) Excitation 1 / Excitation 2

*The optical fiber length is adjusted to fit the desired electrical cable length.

†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



2-color Fluorescence Microscope System for Deep-brain Imaging

Twist-on efocus Fluorescence Microscopy System

For Deep-brain Imaging (150 µm to 8 mm depth)

This system contains all the items necessary to do deep-brain calcium imaging of freely-moving animals with the possibility of electronic adjustment of the distance between the implant tip and the focal plane. This system includes specifically:

- Connectorized LED (465 nm)
- Fluorescence Microscope Driver
- Twist-on efocus Fluorescence Microscope Body *Model L*
- Twist-on efocus Imaging Cannula *Model L* (3x)
- Protrusion Adjustment Ring Set *Model L*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Twist-on efocus Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: eTFMS-L_□□□□_1000_□□□_458_□_□□□

Electrical cable jacket
UFGJ or **LWMJ**†

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

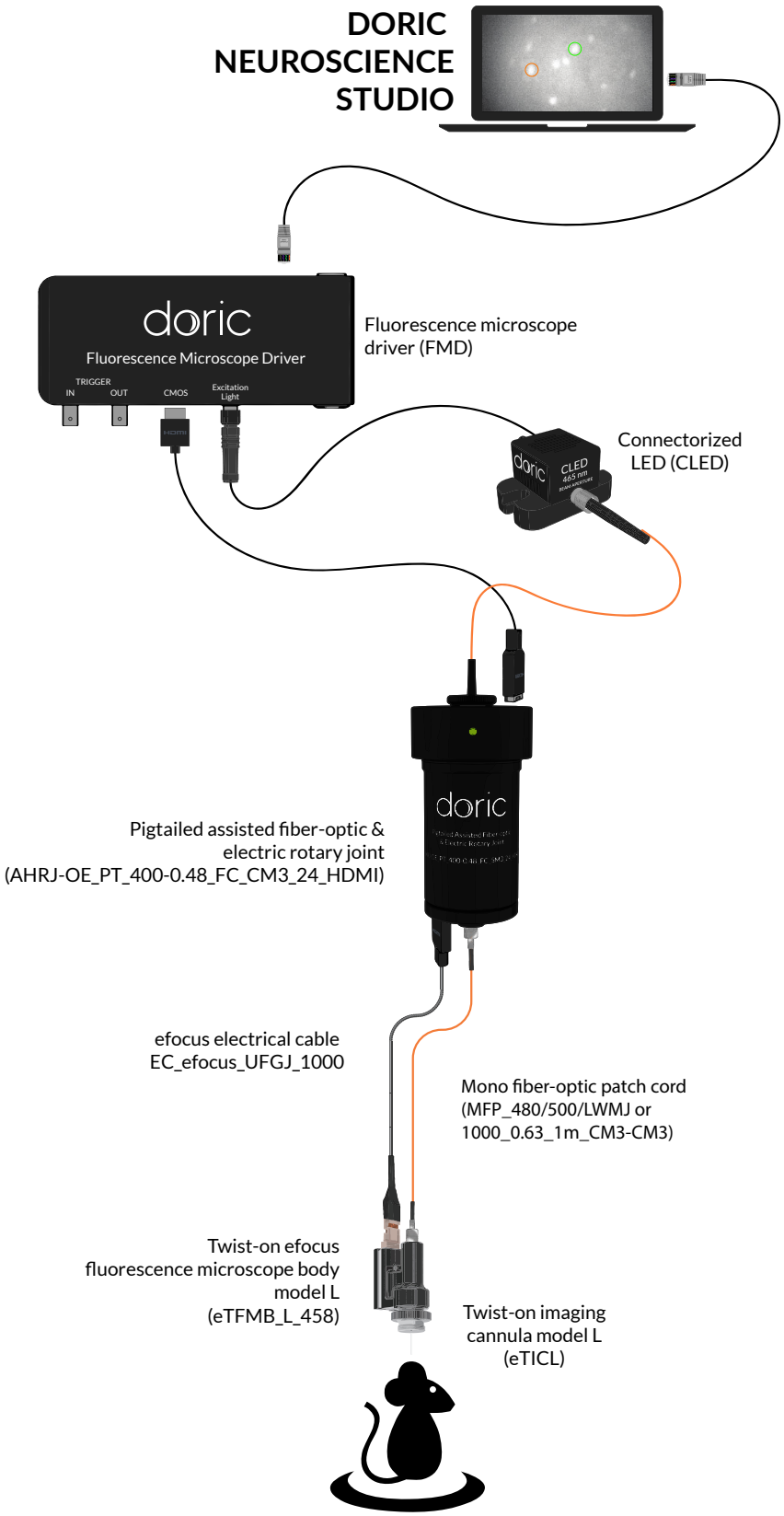
Optical fiber jacket
900 or **LWMJ**†

Excitation wavelength (nm)
458

Twist-on cannula type
D, **V** or **E**

GRIN diameter (µm)
500 or **1000**

*The optical fiber length is adjusted to fit the desired electrical cable length.
†The *Ultralight Fiberglass Jacket* (UFGJ) and the *0.9 mm Hytrel Jacket* (900) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



Twist-on efocus Fluorescence Microscopy System
for Deep-brain Imaging of GCaMP6

Twist-on Optogenetically Synchronized Fluorescence Microscopy System

For Deep-brain Imaging (up to 8 mm depth)

This system contains all the items necessary to do deep-brain calcium imaging synchronized with opsin activation of freely-moving animals with the possibility to adjust electronically the focus position at the tip of the implant. This system includes specifically:

- Ce:YAG + LED (465 nm) Optical Head & Driver with Bandwidth Filter
- Optogenetics TTL Generator 4-channel
- Fluorescence Microscope Driver
- eTOSFM Microscope Body *Model L*
- Twist-on efocus Imaging Cannula *Model L* (3x)
- Protrusion Adjustment Ring Set *Model L*
- Pigtailed Assisted Fiber-optic & Electric Rotary Joint
- Fluorescence Microscope Holder
- Clamp for Fluorescence Microscope Holder
- Twist-on efocus Dummy Microscope
- Doric Neuroscience Studio for control and analysis
- All required electrical cables and optical patch cords*

ORDERING CODE: eTOSMS-L_□□□□_1000_□□□_445/616_□_□□□

Electrical cable jacket
UFGJ or **LWMJ**†

Electrical cable length (mm)
1000 mm is standard.

Optical fiber jacket
1100 or **LWMJ**†

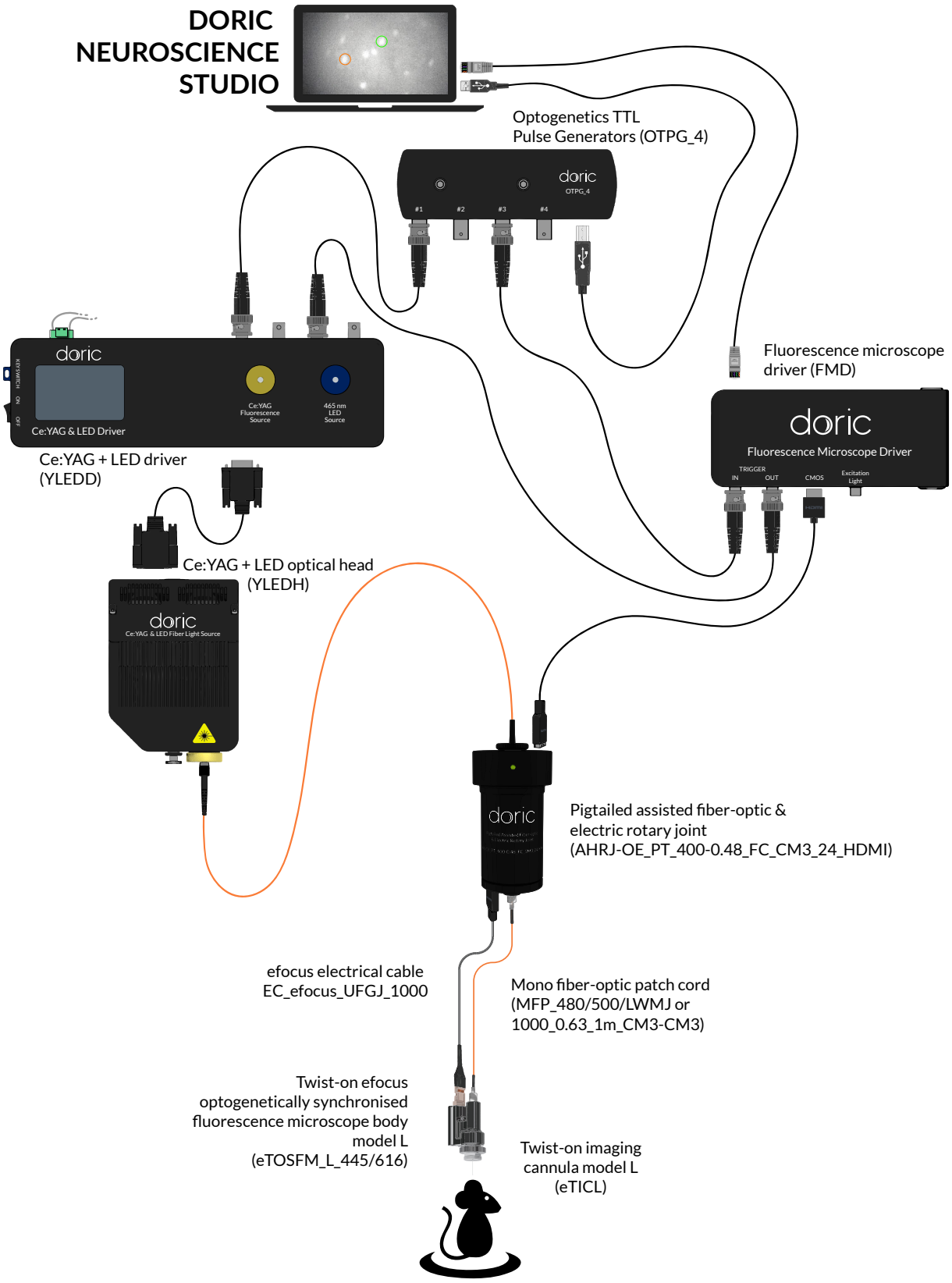
Excitation/Activation wavelength (nm)
445/616

Twist-on cannula type
D, **V** or **E** (see Twist-on efocus Imaging Cannula Model L)

GRIN diameter (µm)
500 or **1000**

*The optical fiber length is adjusted to fit the desired electrical cable length.

†The *Ultralight Fiberglass Jacket* (UFGJ) and the *1.1 mm Hytrel Jacket* (1100) are lighter and more flexible, while the *Lightweight Metal Jacket* (LWMJ) is more robust but heavier.



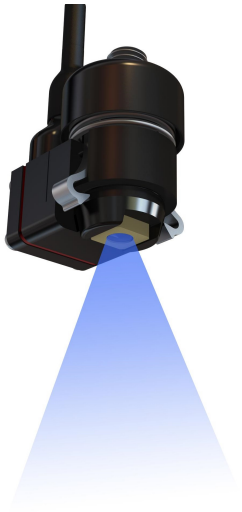
Twist-on efocus Optogenetically Synchronized Fluorescence Microscopy System for Deep-brain Imaging of GCaMP6

Fluorescence Microscope Bodies

Snap-in Fluorescence Microscope Bodies

Basic Snap-in Fluorescence Microscope Bodies

The *Basic Snap-in Fluorescence Microscope Body* is offered in two models: S or L. Both models have the dichroic beam-splitter, M3 optical connector, CMOS sensor etc. Each CMOS has a serial number stored within its cable that points to a specific set of mask correction filters recognizable to our software package. Model L has a 0.5 NA objective lens within its body while Model S has a plan-parallel plate instead and relies on the objective lens within the model S imaging cannula to create an image on the CMOS. When used for deep brain imaging, the fluorescence microscope body is used with an implantable imaging cannula that transfers the image from its bottom to its top.



Basic Snap-in Fluorescence Microscope Body

Table 79: *Basic Snap-in Microscope Body Excitation and Detection Spectra*

	SPECTRUM (nm)*	
SFMB Bodies	Excitation	Detection
GCaMP6	458/35	525/40
RCaMP2	549/15	609/57

Table 80: *Basic Snap-in Fluorescence Microscope Bodies Specifications*

	Basic Microscope Bodies	
SPECIFICATION	Model S	Model L
Mass without cables (g)	2.2	
Dimensions without cables in mm (W x L x H)	8.8 x 13.9 x 16.6	
Frame rate (fps)	45	
Objective lens NA	0.5	
FOV at image plane (pixel)	630 x 630	
FOV at object plane (µm)	700 x 700	350 x 350
Lens magnification	3.3x	6x

*Center wavelength/bandwidth

ORDERING CODE: SFMB_□_□□□□_1000_□□□

Model
S or **L**

Electrical cable jacket*
UFGJ or **LWMJ**

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Excitation wavelength (nm)
458 or **550**

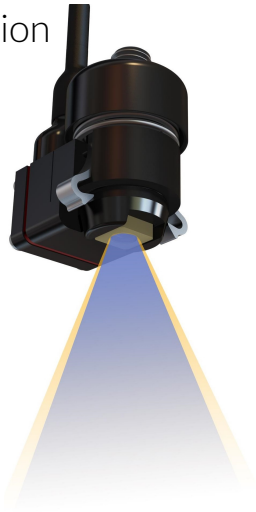
Notes:

- The optical fiber length is adjusted to fit the desired electrical cable length.
- Every microscope body comes with a protective cap.

*The *Ultralight Fiberglass Jacket* is lighter and more flexible, the *Lightweight Metal Jacket* is more robust but heavier.

Optogenetically Synchronized Fluorescence Microscope Bodies

The *Optogenetically Synchronized Fluorescence Microscope* or OSFM, combines fluorescence imaging and optogenetic stimulation/inhibition capabilities within the miniature fluorescence microscope. It can be used for freely-moving or head-fixed configurations. To avoid cross talk between optogenetic stimulation and fluorescence imaging, the OSFM hardware provides for at least two distinct spectral bands for light activation or fluorophore excitation (like blue and yellow) and at least two distinct spectral bands for imaging of fluorophores (like green and red). Either channel, blue-green or yellow-red can be used for opsin activation/inhibition or for calcium indicator excitation and imaging. As the field of opsins and calcium indicators is very dynamic, those spectral bands can be tailored to specs. For now, GCaMP6 + NpHR3.0 and RCaMP2 + ChR2 microscope versions are available.



Optogenetically Synchronized Fluorescence Microscope Body

Table 81: *OSFM Microscope Body Excitation and Detection Spectra*

	SPECTRUM (nm)*		
OSFM Bodies	Opsin activation	Excitation	Detection
GCaMP6 + NpHR3.0	616/76	445/62	525/40
RCaMP2 + ChR2	Compatible with 450, 473, 488	550/15	609/57

Table 82: *Optogenetically Synchronized Fluorescence Microscope Bodies Specifications*

	OSFM Microscope Bodies	
SPECIFICATION	Model S	Model L
Mass without cables (g)	2.2	
Dimensions without cables in mm (W x L x H)	8.8 x 13.9 x 16.6	
Frame rate (fps)	45	
Objective lens NA	0.5	
FOV at image plane (pixel)	630 x 630	
FOV at object plane (µm)	700 x 700	350 x 350
Lens magnification	3.3x	6x

*Center wavelength/bandwidth

ORDERING CODE: OSFM_□_□□□□_1000_□□□/□□□

Model
S or **L**

Electrical cable jacket*
UFGJ or **LWMJ**

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Excitation and activation wavelengths (nm)
445/616 or **550/475**

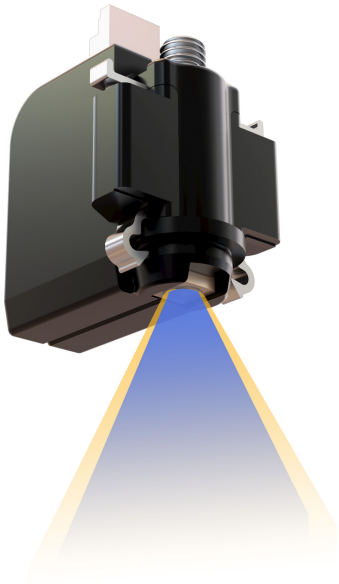
Notes:

- The optical fiber length is adjusted to fit the desired electrical cable length.
- Every microscope body comes with a protective cap.

*The *Ultralight Fiberglass Jacket* is lighter and more flexible, the *Lightweight Metal Jacket* is more robust but heavier.

2-color Fluorescence Microscope Bodies

The *2-color fluorescence microscope body* combines two CMOS sensors for simultaneous imaging of two different fluorophores. Due to the chromatic aberrations of GRIN lenses, the position of each image sensor is adjusted to correct the chromatic shift and image the same object plane in both colors. As the chromatic shift is related to the length of the GRIN lens, the correction is valid for one specific length of GRIN lens. For now, Green (GFP like) + Red (RFP like) systems are offered: two systems optimized for Snap-in Imaging Cannulas type D and type V, and one system optimized for surface imaging.



2-color Fluorescence Microscope Body

Table 83: *2-color Microscope Bodies Excitation and Detection Spectra*

	SPECTRUM (nm)*	
2-color Bodies	Excitation	Detection
CMOS 1	465	520/35
CMOS 2	561	615/45

Table 84: *2-color Fluorescence Microscope Bodies Specifications*

	2-color Microscope Bodies	
SPECIFICATION	Model S	Model L
Dimensions without cables in mm (W x L x H)	18 x 17 x 9.5	
Frame rate (fps)	45	
Objective lens NA	0.5	
FOV at image plane (pixel)	600 x 600	
FOV at object plane (µm)	730 x 730	330 x 330
Lens magnification	3x	6.5x

*Center wavelength/bandwidth

ORDERING CODE: 2CFM_□_458/561

Model
S, **LD** or **LV**

Excitation wavelengths (nm)
Excitation 1 / Excitation 2

Notes:

- The Electrical Cable for 2-color Fluorescence Microscope Bodies is required for the use of this device.
- The optical fiber length is adjusted to fit the desired electrical cable length.
- Every microscope body comes with a protective cap.

Twist-on Fluorescence Microscope Bodies

Twist-on efocus Fluorescence Microscope Body

The *Twist-on efocus Fluorescence Microscope* enables users to visualize larger brain areas in freely behaving animals studies. The large field of view up to 650 x 650 microns and the electronic depth adjustment of 300 microns allows calcium imaging at cellular resolution of a larger brain area. With a simple twist connector, the microscope offers an optimized way to secure the microscope body to the imaging cannula. The attachment/detachment is now easier and does not require tools.

Twist-on efocus Fluorescence Microscope Body

Notes:

- The Electrical Cable for efocus Fluorescence Microscope Bodies is required for the use of this device.
- The optical fiber length is adjusted to fit the desired electrical cable length.
- Every microscope body comes with a protective cap.
- The *Twist-on efocus Fluorescence Microscope Body* is only compatible with the *Twist-on efocus Imaging Cannulas*.

Table 85: *Twist-on Microscope Body and Imaging Cannula models for specific brain zones*

Brain Zones*	Cannula Model	Lens Diameter
0 to 2.6 µm below the skull surface	L type D	1000 mm
0 to 3.3 mm below the skull surface	L type D	500 mm
2.7 to 5.7 mm below the skull surface	L type V	500 mm
5.1 to 8.1 mm below the skull surface	L type E	500 mm

Table 86: *Twist-on efocus Fluorescence Microscope Bodies Excitation and Detection Spectra*

	SPECTRUM (nm)†	
eTFMB Body	Excitation	Detection
GCaMP6	458/35	525/40

Table 87: *Twist-on efocus Fluorescence Microscope Bodies Specifications*

SPECIFICATIONS	Model L
Mass without cables (g)	3.0
Frame rate (fps)	45
Cannula working distance (adjustable; µm)	0-300
Objective lens NA	0.4
FOV at image plane (pixel)	630 x 630
FOV at object plane (µm)	650 x 650
Lens magnification	3.5x

ORDERING CODE: eTFMB_L_458

Model

Excitation wavelengths (nm)

* Including the thickness of the skull.
† Center wavelength/bandwidth

Twist-on efocus Optogenetically Synchronized Fluorescence Microscope Body

The *Twist-on efocus Optogenetically Synchronized Fluorescence Microscope* combines optogenetic stimulation/inhibition capabilities and fluorescence imaging with electronic focus adjustment within the miniature fluorescence microscope. The large field of view up to 650 x 650 microns and the electronic depth adjustment of 300 microns allows calcium imaging at cellular resolution of a larger brain area. With a simple twist connector, the microscope offers an optimized way to secure the body to the imaging cannula. The attachment/detachment is now easier and does not require tools.

Twist-on efocus Optogenetically Synchronized Fluorescence Microscope Body

ORDERING CODE: eTOSFM_L_445/616

Model

Excitation and activation wavelengths (nm)

Notes:

- The Electrical Cable for efocus Fluorescence Microscope Bodies is required for the use of this device.
- The optical fiber length is adjusted to fit the desired electrical cable length.
- Every microscope body comes with a protective cap.
- The *Twist-on efocus Optogenetically Synchronized Fluorescence Microscope Body* is only compatible with the *Twist-on efocus Imaging Cannulas*.

Table 88: *eTOSFM Microscope Body Excitation and Detection Spectra*

	SPECTRUM (nm)*		
eTOSFM Body	Opsin activation	Fluorophore Excitation	Detection
GCaMP6 + NpHR3.0	616/76 (0-55 mW/mm²)	445/62	525/40

*Center wavelength/bandwidth

Table 89: *Twist-on efocus Optogenetically Synchronized Fluorescence Microscope Body Specifications*

SPECIFICATIONS	**Model L**
Mass without cables (g)	3.0
Frame rate (fps)	45
Cannula working distance (adjustable)	0-300 µm
Objective lens NA	0.4
FOV at image plane (pixel)	630 x 630
FOV at object plane (µm)	650 x 650

Table 90: *Twist-on Microscope Body and Imaging Cannula models for specific brain zones*

Brain Zones*	**Cannula Model**	**Lens Diameter**
0 to 2.6 µm below the skull surface	L type D	1000 mm
0 to 3.3 mm below the skull surface	L type D	500 mm
2.7 to 5.7 mm below the skull surface	L type V	500 mm
5.1 to 8.1 mm below the skull surface	L type E	500 mm

* Including the thickness of the skull.

Imaging Cannulas

Ordinary fiber-optic cannulas send light along the optical fiber but do not create or capture an image. The imaging cannula can transfer an image but only over a very short distance in highly turbid media like brain tissue. For areas near the brain surface use the *Imaging Cannula Model S*. For deeper brain regions use the *Imaging Cannula Model L* with image guiding gradient-index rod lens that brings the image from inside the brain to the skull surface. Each *Snap-in Imaging Cannula* comes with a protective cap and it is a good practice to put it on the implanted cannula when the microscope body is not in place.

Snap-in Imaging Cannula Model S

The *Snap-in Imaging Cannula Model S* looks inside brain tissue with an objective lens that brings the image from inside the first 150 µm of the brain to the microscope camera.

Note: One Protrusion Adjustment Ring Model S is included with each Snap-in Imaging Cannula Model S. If more rings are needed, a set can be purchased separately (**PARS_S**).

ORDERING CODE: SICS_2_2.4

Lens Magnification (x)

Lens Working distance in air (mm)

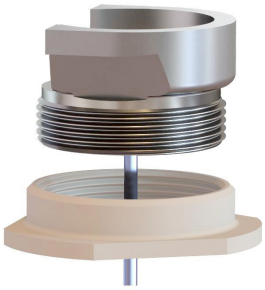
Snap-in Imaging Cannula Model S and Protrusion Adjustment Ring

Snap-in Imaging Cannula Model L

Standard Imaging Cannula Model L

As the choice of these lenses is quite limited, different depth ranges of brain tissue are accessed with different lens lengths while fine focusing is done with the protrusion adjustment ring that comes with each cannula. As cannulas might be re-used it is advisable to get a set of these rings as spare parts. The working distance of *D*, *V* and *E* imaging cannulas is 80 µm.

Note: Each Standard Imaging Cannula Model L is provided with one of each of the five models of Protrusion Adjustment Rings Model L. If more rings are needed, a set can be purchased separately (**PARS_L**).



Snap-in Imaging Cannula Model L and Protrusion Adjustment Ring

ORDERING CODE: SICL_□_500_80

Model
D, **V**, **E** (see Table 91)

Lens diameter (µm)

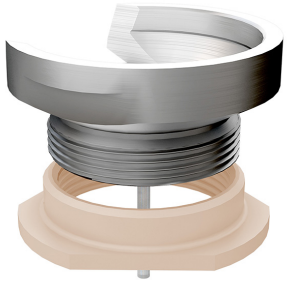
Working distance in water (µm)

Table 91: *Snap-in Imaging Cannula Model L Specifications*

Cannula Type	Range of Penetration Depth (mm)
D	0 - 3.46
V	2.87 - 5.96
E	5.30 - 8.39

efocus Imaging Cannula Model L

For deep brain regions (0 mm to 8 mm deep) use the efocus Imaging Cannula Model L that brings the image from inside the brain to the skull surface with an image guiding gradient-index rod lens. efocus Imaging Cannulas are compatible with efocus Fluorescence Microscope Bodies only.



efocus Imaging Cannula Model L and Protrusion Adjustment Ring

Note: Each efocus Imaging Cannula Model L is provided with one of each of the five models of Protrusion Adjustment Rings Model L. If more rings are needed, a set can be purchased separately (**PARS_L**).

ORDERING CODE: eSICL_□_500_80

Model
D, **V**, **E** (see Table 91)

Lens diameter (µm)

Working distance in water (µm)

Reduced Footprint Imaging Cannula Model L

Reduced Footprint Imaging Cannula

To improve the stability of the cannula on the animal, the base of the standard snap-in imaging cannula has been defined with a larger diameter. In opposition, the *Reduced Footprint Imaging Cannula* has been designed with an outer diameter as small as 3.5 mm to image exiguous area of the brain (e.g. olfactory bulb). In the *Reduced Footprint Imaging Cannula*, the GRIN lens protrusion length is user defined with steps of 250 microns. There is no protrusion adjustment ring.

ORDERING CODE: RFICL_□_□.□□_80

Model
D for deep, **V** for very deep or
E for extra deep

GRIN lens protrusion length
0.25 mm increments (see Table 92)

Working distance in water (µm)

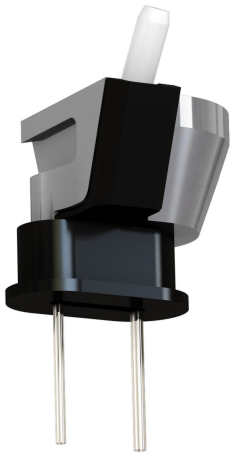
Table 92: *Reduced Footprint Imaging Cannula Model L Specifications*

Cannula Type	GRIN lens protrusion length (0.25 mm increments)
D	0 - 3.00
V	2.43 - 5.43
E	4.85 - 7.85

Note: The protrusion length of the GRIN lens is determined from the base of the imaging cannula to its tip.

2-channel Optogenetics and Imaging Cannula Model L

The *2-channel Optogenetics and Imaging Cannula* has two parallel implants, a GRIN lens for deep-brain imaging, and a 200 µm diameter optical fiber for optogenetic stimulation of another brain area. For now, this imaging cannula is used for experiments not requiring the use of a rotary joint. The development of a compatible rotary joint is in progress.



2-channel Optogenetics and Imaging Cannula model L

ORDERING CODE: **2OICL_□.□□_□□.□□_□.□**

GRIN lens protrusion length
0 to 7 mm in 0.25 mm increments

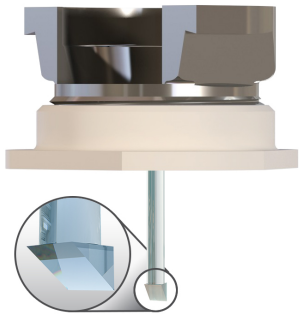
Fiber protrusion length
0 to 10 mm in 0.25 mm increments

Pitch between the two implants (center-to-center)
1 to 3.5 mm in 0.5 mm increments

Note: The protrusion length of the GRIN lens and the fiber is determined from the base of the imaging cannula to their tips.

Imaging Cannula Model L with Prism

While the standard Imaging Cannula Model L images horizontal plane sections of the brain (0-8 mm depth), the Imaging Cannula Model L with Prism allows the imaging of sagital-coronal plane sections. The GRIN lens and the right-angle prism at its tip bring images to the skull surface. This imaging configuration has the advantage of leaving the brain tissue intact above the region of interest. Four orientations of the prism are available depending on the brain region of interest.



Imaging Cannula Model L with Prism

Notes:

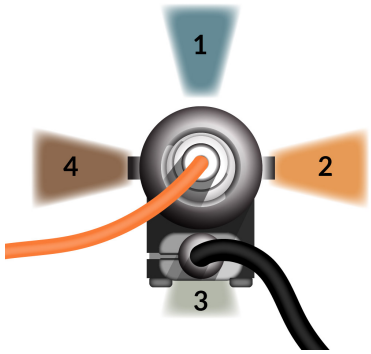
Table 93: *Imaging Cannula Model L with Prism Specifications*

Cannula Type	Range of Penetration Depth (mm)
D	0 - 3.5
V	2.9 - 5.9
E	5.4 - 8.3

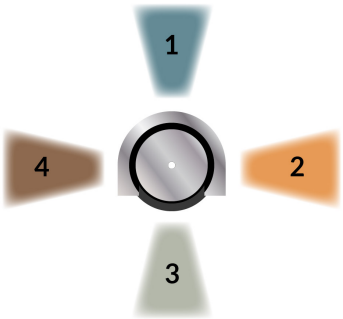
- The range of penetration depth is determined from the surface of the skull or the bottom of the focusing ring to the lower tip of the prism.
- Each Imaging Cannula Model L with Prism is provided with one of each of the five models of Protrusion Adjustment Rings Model L. If more rings are needed, a set can be purchased separately (**PARS_L**).

Table 94: *Regions of interest observed with the Imaging Cannula Model L with Prism*

Microscope Body top view
(for reference)



Imaging Cannula top view
(for reference)



ORDERING CODE: SICL_□_500_80_P_□

Model
D, **V**, **E** (see Table 93)

Lens diameter (μm)

Working distance in water (μm)

Region of interest
1, **2**, **3**, **4** (see Table 94)

Twist-on Imaging Cannula Model L

Twist-on efocus Imaging Cannula Model L

Twist-on efocus Imaging Cannula Model L and Protrusion Adjustment Ring

For deep brain regions (0 mm to 8 mm deep) use the Twist-on efocus Imaging Cannula Model L that brings the image from inside the brain to the skull surface with an image guiding gradient-index rod lens. The Twist-on efocus Imaging Cannulas are compatible with Twist-on efocus Fluorescence Microscope Bodies only. For a larger field of view, it is possible to use a GRIN diameter of 1000 µm instead of 500 µm.

Note: Each Twist-on Imaging Cannula Model L is provided with one of each of the five models of Protrusion Adjustment Rings Model L. If more rings are needed, a set can be purchased separately (**PARS_L**).

Table 95: *Twist-on Imaging Cannula Model L Specifications*

GRIN diameter (µm)	Cannula Type	Range of Penetration Depth (mm)
500	D	0 - 3.3
	V	2.7 - 5.7
	E	5.1 - 8.1
1000	D	0 - 2.6

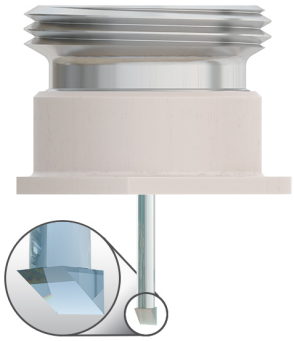
ORDERING CODE: eTICL_□_□□□

Model
D, **V**, **E** (see Table 95)

Lens diameter (µm)
500 or **1000**

Twist-on Imaging Cannula Model L with Prism

While the standard Imaging Cannula Model L images horizontal plane sections of the brain (0-8 mm depth), the Twist-on Imaging Cannula Model L with Prism allows the imaging of sagital-coronal plane sections. The GRIN lens and the right-angle prism at its tip bring images to the skull surface. This imaging configuration has the advantage of leaving the brain tissue above the region of interest intact. Four prism orientations are available depending on the brain region of interest.



Twist-on Imaging Cannula Model L with Prism

Table 96: *Twist-on Imaging Cannula Model L with Prism Specifications*

GRIN diameter (µm)	Cannula Type	Range of Penetration Depth (mm)
500	D	0 - 3.3
	V	2.7 - 5.7
	E	5.2 - 8.2
1000	D	0 - 2.7

Notes:

- The penetration depth range is determined from the surface of the skull or the bottom of the focusing ring to the lower tip of the prism.
- Each Twist-on Imaging Cannula Model L with Prism is provided with one of each of the five models of Protrusion Adjustment Rings Model L. If more rings are needed, a set can be purchased separately (**PARS_L**).

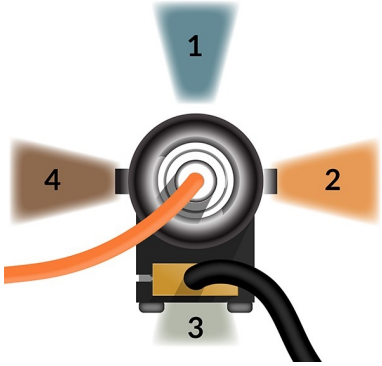
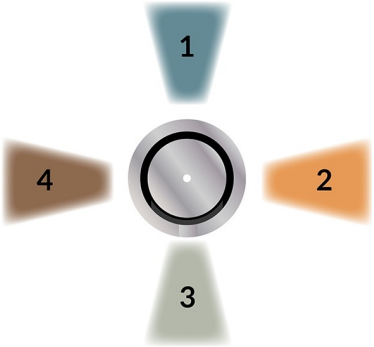
ORDERING CODE: TICL_□_□□□_P_□

Model
D (see Table 96)

Lens diameter (µm)
500 or **1000**

Region of interest
1, **2**, **3**, **4** (see Table 97)

Table 97: *Regions of interest observed with the Twist-on Imaging Cannula Model L with Prism*

Microscope Body top view (for reference)	**Imaging Cannula top view** (for reference)
	

Fluorescence Microscope Drivers

Fluorescence Microscope Driver

This driver has been designed for the Basic Snap-in and the Optogenetically Synchronized Fluorescence Microscope Bodies. It allows for computer control over the excitation LED light source, image capturing and its broadcast at video rate to single or multiple computers via high speed Ethernet communication. It can be triggered or synchronized with external recording devices and it can trigger other devices.

Fluorescence Microscope Driver

ORDERING CODE: FMD

2-color Fluorescence Microscope Driver

The *2-color Fluorescence Microscope Driver* allows for computer control over excitation light sources (blue LED and yellow Ce:YAG source), images capturing from both CMOS and the broadcast at video rate to single or multiple computers via high speed Ethernet communication. It is compatible with the 2-color microscope body.

2-color Fluorescence Microscope Driver

ORDERING CODE: FMD_2

Fluorescence Microscope Accessories

Electrical Cable for Fluorescence Microscope Bodies

Electrical Cable for 2-color Fluorescence Microscope Bodies

2-color Fluorescence Microscope Bodies are connectorized in order to allow for more flexibility. Like Basic and OSFM Fluorescence Microscope Bodies, the jacket of the electrical cable can be customized with a lighter and more flexible Ultralight Fiberglass Jacket (UFGJ) or a more robust but heavier Lightweight Metal Jacket (LWMJ).

Electrical cable for 2-color Fluorescence Microscope Bodies

ORDERING CODE: EC_2_□□□□_1000

Electrical cable jacket
UFGJ or **LWMJ**

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Note: The 2-color Electrical Cable is required for the use of the 2-color Fluorescence Microscope Bodies.

Electrical Cable for efocus Twist-on Fluorescence Microscope Bodies

efocus Fluorescence Microscope Bodies are connectorized in order to allow for more flexibility. The jacket of the electrical cable can be customized with a lighter and more flexible Ultralight Fiberglass Jacket (UFGJ, recommended for mice) or a more robust but heavier Lightweight Metal Jacket (LWMJ, recommended for rats).

Electrical cable for efocus Fluorescence Microscope Bodies

ORDERING CODE: EC_efocus_□□□□_1000

Electrical cable jacket
UFGJ or **LWMJ**

Electrical cable length (mm)
1000 mm is standard.
Other values on request (up to 3000 mm).

Note: The efocus Electrical Cable is required for the use of the efocus Twist-on Fluorescence Microscope Bodies.

Fluorescence Microscope Holders

Fluorescence Microscope Holder

For *in vitro* and head-fixed observations, it is desirable to have a *Fluorescence Microscope Holder* coaxial with microscope that fits stereotaxic instrumentation or micromanipulators. As our optical connector has axial position, we constructed the holder to be an optical interface as well. The microscope holder allows for imaging while implanting the cannula from a stereotaxic frame.

Fluorescence Microscope Holder

Note: The Fluorescence Microscope Holder is only compatible with Single-color Fluorescence Microscope Bodies.

ORDERING CODE: FMH

Fluorescence Microscope Holder 2

A specific pigtailed microscope holder has been designed to fit the 2-color fluorescence microscope bodies. This holder can be used to image the brain during the implantation of the cannula or during experiments requiring a head-fixed in vivo configuration. The microscope holder is compatible with

Fluorescence Microscope Holder 2

stereotaxic instruments and connects to the microscope body via a CM3 connector. The input patch cord has a standard length of 1.0 m.

Note: The Fluorescence Microscope Holder 2 is compatible with all our Fluorescence Microscope Bodies.

ORDERING CODE: FMH_2

Clamp for Fluorescence Microscope Holder

This adaptor allows for an easy fit between our Fluorescence Microscope Holders and most stereotaxic frames.

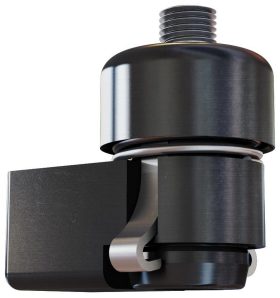
Clamp for Fluorescence Microscope Holder

ORDERING CODE: CLAMP_FMH

Dummy Microscopes

Dummy Microscope

The dummy microscope is a look-alike, inexpensive replica of the Snap-in Fluorescence Microscope Body that fits any snap-in imaging cannula. It is meant to be secured to the rodents head to habituate it to the feel and weight of a microscope before using the real microscope body. The dummy microscope has an M3 connector and can be connected to a CM3 optical patch cord.



Dummy Microscope Model L

Table 98: *Dummy Microscope Ordering Code*

Microscope Body Model	Ordering Code
Basic and OSFM model S	**DSMB-S**
Basic and OSFM model L	**DSMB-L**

2-color Dummy Microscope

The 2-color dummy microscope has the same shape and weight as the 2-color fluorescence microscope body model S and L. This dummy microscope is compatible with all cannula types.

2-color Dummy Microscope Model L

ORDERING CODE: DSMB-□_2

Model
S or **L**

Twist-on efocus Dummy Microscope

The Twist-on efocus Dummy Microscope is a look-alike, inexpensive replica of the Twist-on efocus Fluorescence Microscope Body that fits any Twist-on efocus Imaging Cannula. It is meant to be secured to the rodents head to habituate it to the feel and weight of a microscope before using the real microscope body. The Twist-on efocus Dummy Microscope has an M3 connector and can be connected to a CM3 optical patch cord.

Twist-on efocus Dummy Microscope Model L

ORDERING CODE: eDTMB-L

Fluorescence Microscope Snapping Tools

Fluorescence Microscope Snapping Tool

This tool is used to easily detach the Basic Snap-in and the OSFM microscope body from the imaging cannula.

Fluorescence Microscope Snapping Tool

ORDERING CODE: FMST

2-color Fluorescence Microscope Snapping Tool

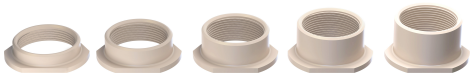
The 2-color Fluorescence Microscope Snapping Tool comprises two different pairs of tweezers, one for attaching and one for detaching the 2-color fluorescence microscope body from the imaging cannula.

2-color Fluorescence Microscope Snapping Tool

ORDERING CODE: FMST_2

Protrusion Adjustment Ring Set

As the point of observation can be anywhere within the brain, a set of protrusion adjustment rings of different heights is available. By combining an imaging cannula model L with the right protrusion adjustment ring it is possible to cover most parts of the brain. The height of the rings is 2.0 mm, 2.7 mm, 3.4 mm, 4.2 mm and 4.9 mm. Within the set, there are 8 rings for each height. For the model S, one protrusion adjustment ring (height of 4.5 mm) is required to observe the brain from the surface to 1.1 mm deep. The set is composed of 10 identical rings.



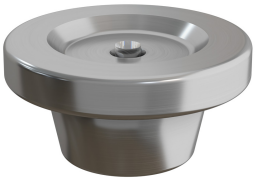
Protrusion Adjustment Ring Set for Microscope Body Model L

Table 99: *Protrusion Adjustment Ring Set Ordering Codes*

Microscope Body Model	Ordering Code
S	**PARS_S**
L	**PARS_L**

External Relay Lens Accessory

Our snap-in imaging cannulas create an image at the bottom part of its mechanical body that is perfect for our miniaturized microscopes. However, for conventional and specialized microscopes like the two photon microscope, the image is simply not accessible. To correct this situation we have made a relay lens accessory that fits the interior of



External Relay Lens Accessory

the cannula and brings the image to the top of the cannula where access to the image is not obstructed. The optics used in our relay lens accessory is a gradient index (GRIN) lens having the following specifications:

Table 100: *External Relay Lens Accessory Specifications*

SPECIFICATION	VALUE
Diameter	1 mm
Numerical aperture	0.5
Magnification	1:1
Design wavelength	520 nm

Note: the object and image working distances can be adjusted by changing the distance between the relay lens and the microscope objective.

ORDERING CODE: ERLA_1

Lens magnification (x)

Fiber Photometry

In neuroscience, fiber photometry denotes a method whereby a chronically implanted optical fiber delivers excitation light to neurons tagged with a fluorescent calcium indicator(s) and collects their overall activity-induced fluorescence. Within the field of view, the fluorescence microscopy indicates activity of each tagged neuron, while the fiber photometry sums up the activity-induced fluorescence of all neurons expressing the indicator(s).

Distinguishing the very weak fluorescence variations from relatively high noise levels requires careful selection of components within the system, from light sources to detectors. The connectorized LED module (CLED) as excitation source offers sufficient spectral intensity for most fluorescent markers, stable power and speckle-free illumination. An interesting alternative is a combination of UV or blue LEDs with the Ce:YAG source filtered to a required wavelength. The latter offers all the advantages of LED illumination, but with higher intensity in the 500-600 nm range. Laser sources could be considered when using small diameter core fibers with low NA and/or multiple color excitations requiring narrow spectral filtering.

The heart of the Fiber Photometry System is the Fluorescence Mini Cube (FMC) that directs excitation light into an optical fiber leading to the fiber-optic cannula. The fluorescence of the sample captured by the cannula is returned into the FMC, filtered and redirected into a detection fiber that goes to the high sensitivity photodetector. The opto-mechanical design of the fluorescence mini-cube, the filter selection and the coupling optics alignment play an important role in increasing the signal to noise ratio.

Typically, excitation optical power in mW range produces fluorescence responses in nW range. The detection of such a low level signal requires a low-noise amplified photodetector. As the optical isolation of each component is essential in this power range, the optical fibers must have protective jackets to avoid possible effects of ambient light on the measurement. The worst DC noise might be coming from the autofluorescence of the probe or the patch cord itself. To keep this noise in check, low autofluorescence optical fibers must be used and their length kept to a bare minimum. To prevent injecting light into optical fiber cladding, the fiber optic collimator must under fill the fiber NA and the light spot on the fiber's end face should be smaller than its core diameter.

Fiber Photometry Systems

1-site Fiber Photometry Systems

GCaMP Isosbestic and Functional Excitations - 405 and 465 nm

This *1-site Fiber Photometry System* measures the 405 nm (isosbestic point) excited GCaMP fluorescence, and the 465 nm excited calcium-dependent GCaMP fluorescence, on a single photodetector. The fluorescence emission can be demodulated by lock-in detection, or by sequential acquisition. The *GCaMP Isosbestic and Functional Excitations - 405 and 465 nm System* contains:

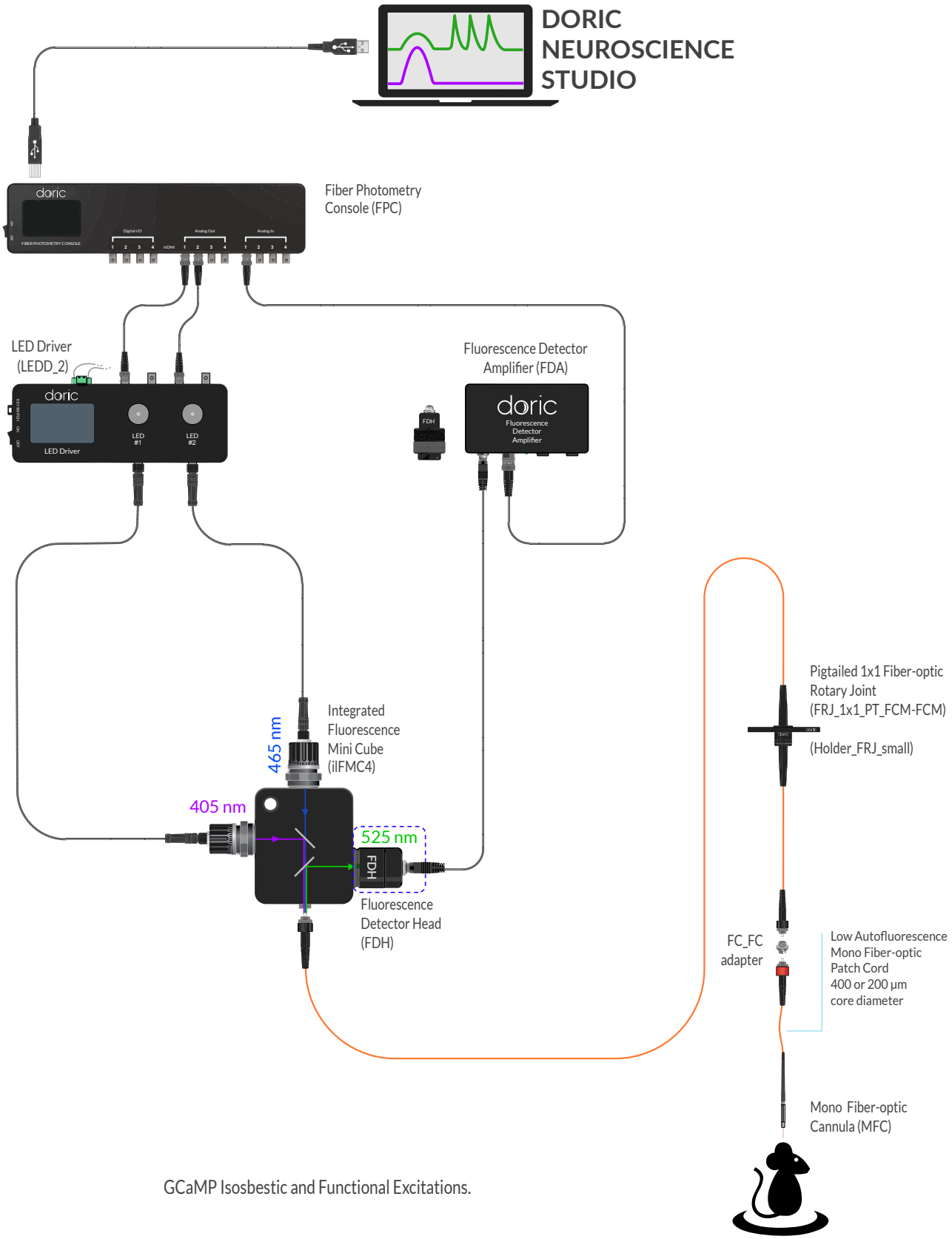
- 2-channel LED Driver
- Integrated Fluorescence Mini Cube with 4 ports - Lock-in or Sequential Detection of GCaMP Isosbestic and Functional Excitations
- Pigtailed 1x1 Fiber-optic Rotary Joint
- 1x1 Fiber-optic Rotary Joint Holder
- Rotary Joint Gimbal Holder
- Mono Fiber-optic Cannulas (10x)
- Fiber Photometry Cannula Holder
- Fiber Photometry Console for data acquisition and illumination control
- Doric Neuroscience Studio Software
- Fiber Photometry Rack to mount the whole system
- All required electrical cables and optical patch cords

ORDERING CODE: FPS_1S_405/GFP_□□□-0.57

Cannula fiber diameter (µm) —— **400** or **200**

Cannula numerical aperture ——

Note: Other light sources and different fluorophore combinations are possible. Please do not hesitate to request your preferences.


DORIC
NEUROSCIENCE
STUDIO
Fiber Photometry
Console (FPC)
LED Driver
(LEDD_2)
Fluorescence Detector
Amplifier (FDA)
Integrated
Fluorescence
Mini Cube
(iIFMC4)
465 nm
405 nm
525 nm
FDH
Fluorescence
Detector Head
(FDH)
Pigtailed 1x1 Fiber-optic
Rotary Joint
(FRJ_1x1_PT_FCM-FCM)
(Holder_FRJ_small)
FC_FC
adapter
Low Autofluorescence
Mono Fiber-optic
Patch Cord
400 or 200 µm
core diameter
Mono Fiber-optic
Cannula (MFC)
GCaMP Isosbestic and Functional Excitations.

GCaMP Isosbestic and Functional Excitations, and Red Fluorophore Fluorescence

This *1-site Fiber Photometry System* contains all the items necessary to do photometry measurements of two independent colors in freely-moving animals like GFP-like and RFP-like fluorophores. It also measures the 405 nm (isosbestic point) excitation of GCaMP fluorescence. The GCaMP fluorescence emission can be demodulated by lock-in detection or by sequential acquisition. It is also possible to use lock-in demodulation to ensure a proper spectral separation of the green and red fluorophore emissions. The *GCaMP Isosbestic and Functional Excitations, and Red Fluorophore Fluorescence System* contains:

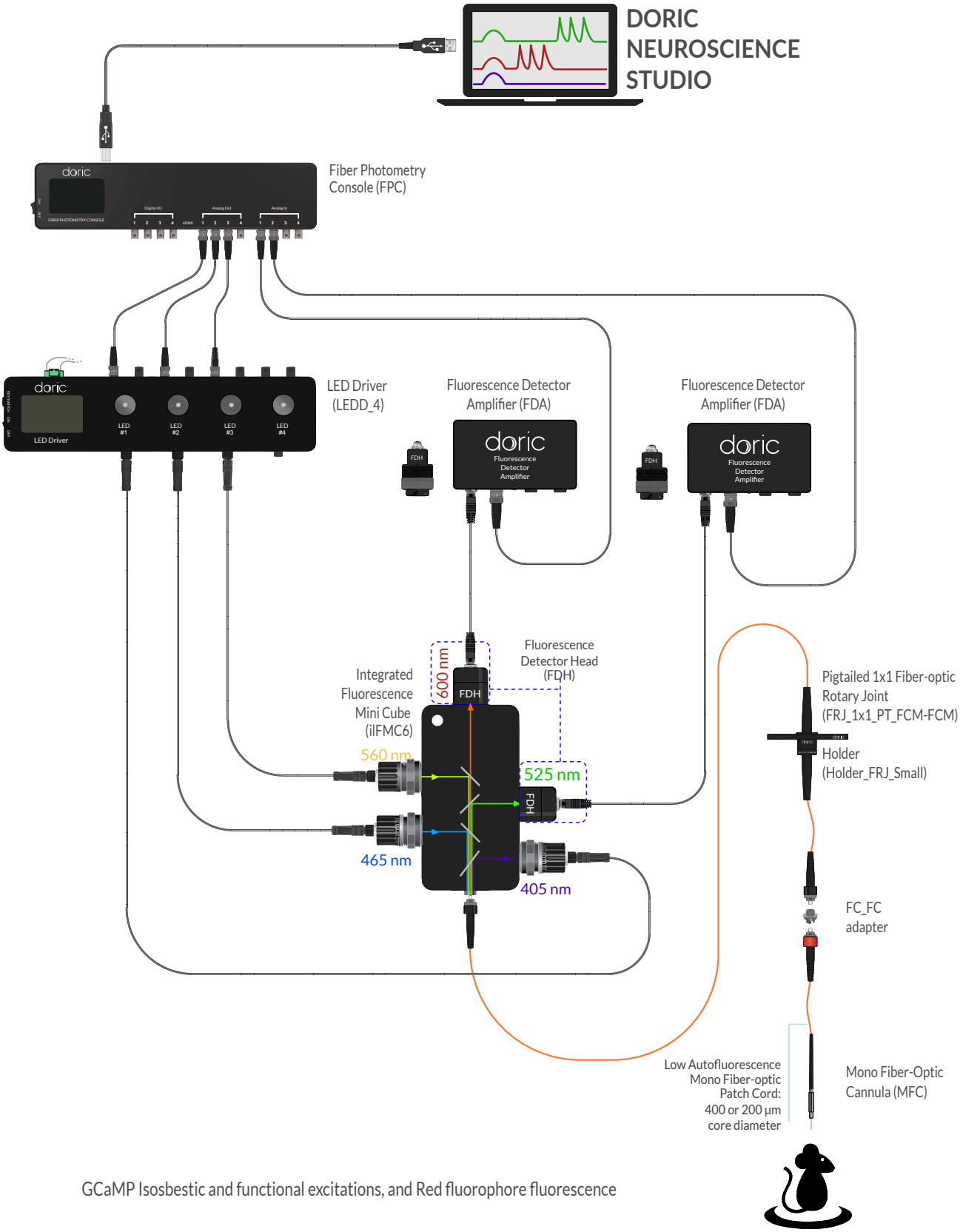
- 4-channel LED Driver
- Integrated Fluorescence Mini Cube with 6 ports - Two Fluorophores Fluorescence and GCaMP Isosbestic Excitation
- Pigtailed 1x1 Fiber-optic Rotary Joint
- 1x1 Fiber-optic Rotary Joint Holder
- Rotary Joint Gimbal Holder
- Mono Fiber-optic Cannulas (10x)
- Fiber Photometry Cannula Holder
- Fiber Photometry Console for data acquisition and illumination control
- Doric Neuroscience Studio Software
- Fiber Photometry Rack to mount the whole system
- All required electrical cables and optical patch cords

Note: Other light sources and different fluorophore combinations are possible. Please do not hesitate to request your preferences.

ORDERING CODE: FPS_1S_405/GFP/RFP_□□□-0.57

Cannula fiber diameter (µm)
400 or **200**

Cannula numerical aperture



GCaMP Isosbestic and functional excitations, and Red fluorophore fluorescence

GCaMP Isosbestic and Functional Excitations and Opsin Activation

This *1-site Fiber Photometry System* measures the GCaMP isosbestic point and the GCaMP functional calcium-dependent fluorescence, on a single photodetector. The fluorescence emission can be demodulated by lock-in detection, or by sequential acquisition. This system allows the activation of an opsin (570-650 nm). The *GCaMP Isosbestic and Functional Excitations, and Opsin Activation System* contains:

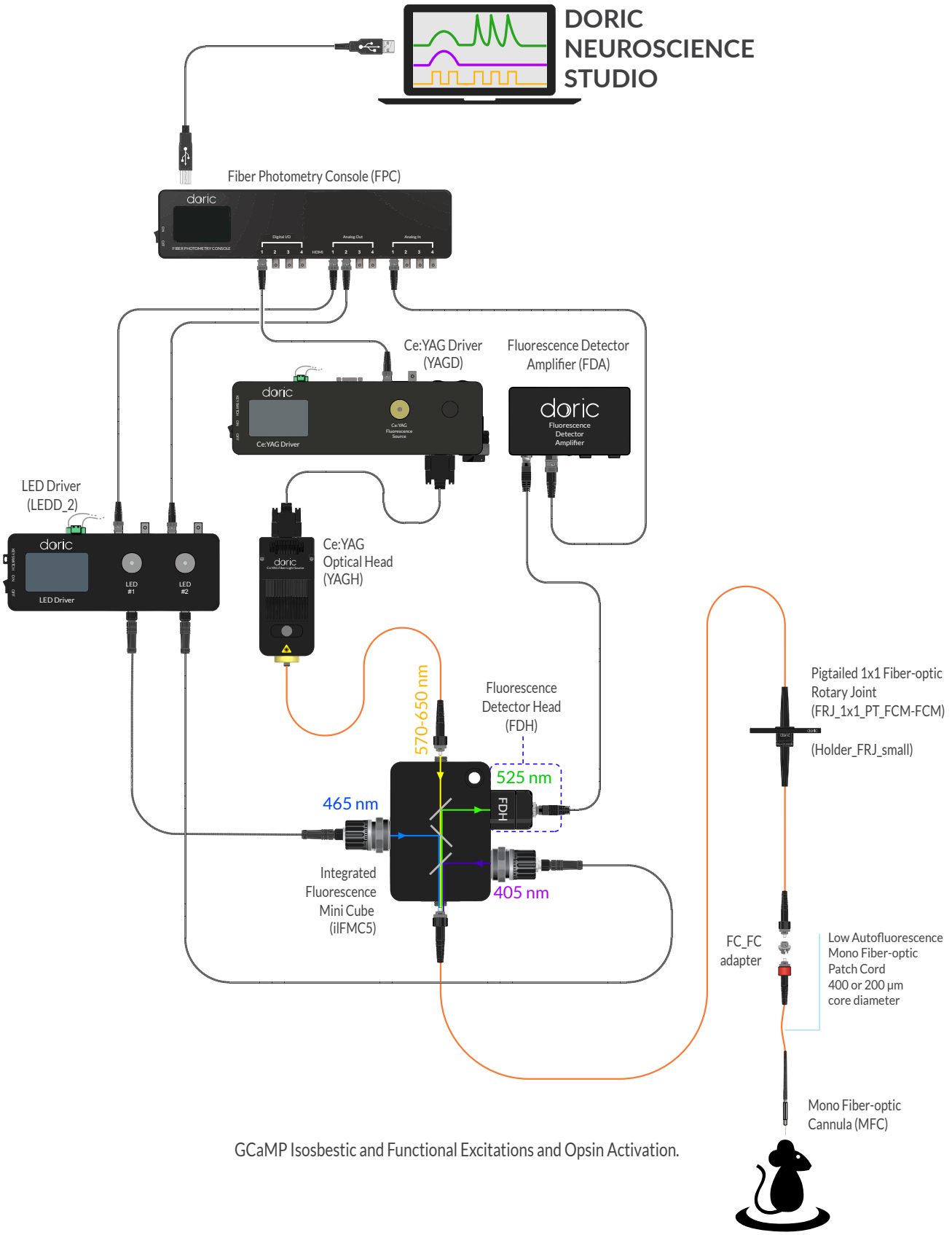
- 2-channel LED Driver
- Ce:YAG Optical Head
- Ce:YAG Driver
- Bandpass Filter For Ce:YAG Fiber Light Sources
- Integrated Fluorescence Mini Cube with 4 ports - Excitation, Fluorescence and Opsin Activation
- Pigtailed 1x1 Fiber-optic Rotary Joint
- 1x1 Fiber-optic Rotary Joint Holder
- Rotary Joint Gimbal Holder
- Mono Fiber-optic Cannulas (10x)
- Fiber Photometry Cannula Holder
- Fiber Photometry Console for data acquisition and illumination control
- Doric Neuroscience Studio Software
- All required electrical cables and optical patch cords

Note: Other light sources, such as laser diodes, and different fluorophore combinations are possible. Please do not hesitate to request your preferences.

ORDERING CODE: FPS_1S_405/GFP/opsin_□□□-0.57

Cannula fiber diameter (µm)
400 or **200**

Cannula numerical aperture



GCaMP Isosbestic and Functional Excitations and Opsin Activation.

2-site Fiber Photometry Systems

2-site GCaMP Isosbestic and Functional Excitations

This *2-site Fiber Photometry System* measures the 405 nm (isosbestic point) excited GCaMP fluorescence, and the 465 nm excited calcium-dependent GCaMP fluorescence, on a single photodetector. The fluorescence emission can be demodulated by lock-in detection, or by sequential acquisition. The measures are done in two different brains areas.

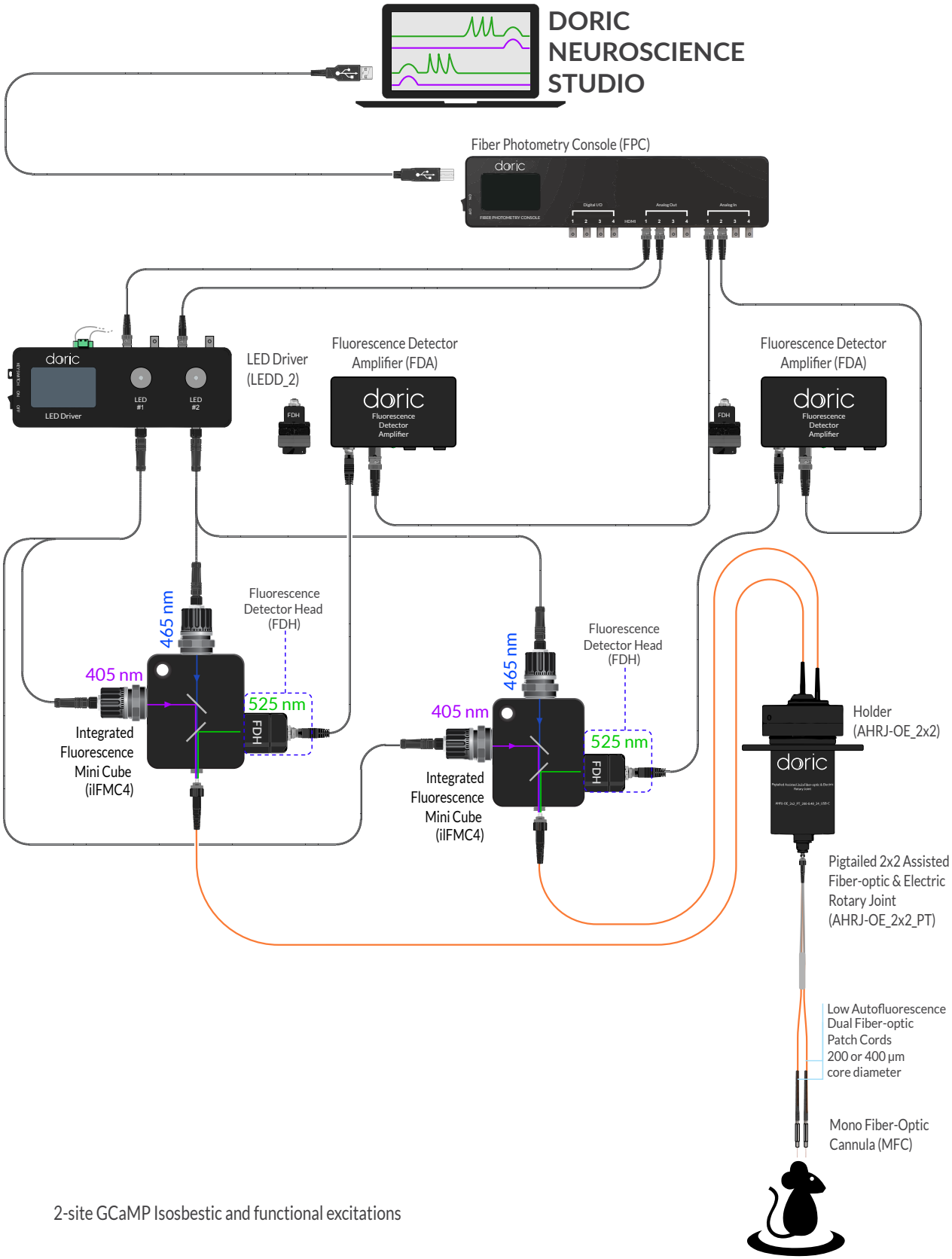
The *2-site GCaMP Isosbestic and Functional Excitations* contains:

- 2-channel LED Driver
- Integrated Fluorescence Mini Cube with 4 ports - Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations (filter set optimized for 405 nm excitation and GFP; (2x)
- Pigtailed 2x2 Assisted Fiber-optic & Electric Rotary Joint
- 2x2 Fiber-optic Rotary Joint Holder
- Mono or Dual Fiber-optic Cannulas (10x)
- Fiber Photometry Cannula Holder
- Fiber Photometry Console for data acquisition and illumination control
- Doric Neuroscience Studio Software
- Fiber Photometry Rack to mount the whole system
- All required electrical cables and optical patch cords

ORDERING CODE: FPS_2S_405/GFP_□□□-0.57

Cannula fiber diameter (µm)
400 or **200**

Cannula numerical aperture


DORIC
NEUROSCIENCE
STUDIO
Fiber Photometry Console (FPC)
LED Driver
(LEDD_2)
Fluorescence Detector
Amplifier (FDA)
Fluorescence Detector
Amplifier (FDA)
Fluorescence
Detector Head
(FDH)
Fluorescence
Detector Head
(FDH)
465 nm
405 nm
525 nm
Integrated
Fluorescence
Mini Cube
(iIFMC4)
Integrated
Fluorescence
Mini Cube
(iIFMC4)
Holder
(AHRJ-OE_2x2)
Pigtailed 2x2 Assisted
Fiber-optic & Electric
Rotary Joint
(AHRJ-OE_2x2_PT)
Low Autofluorescence
Dual Fiber-optic
Patch Cords
200 or 400 µm
core diameter
Mono Fiber-Optic
Cannula (MFC)
2-site GCaMP Isosbestic and functional excitations

Bundle-imaging Fiber Photometry Systems

Scaling up fiber photometry measurement with photodiode based systems to a large number of samples can be difficult. This is due to the increasing number of components required, such as mini cubes, cables and sensors. With some compromises on time resolution and sensitivity, an alternative approach is to relay the image of an optical fiber bundle to an image sensor. The opposite end of the bundle can be split, with each connected to different samples. On the camera, the signal of each sample can be distinguished by measuring the average count coming from each individual fiber in the bundle.

GCaMP Isosbestic & Functional Excitations

The *GCaMP Isosbestic & Functional Excitations Bundle-imaging Fiber Photometry System* contains all items necessary to perform fiber photometry measurements on a large number of animals and sites with GFP-like fluorophores. It also measures the 405 nm (isosbestic point) excitation of GCaMP fluorescence. The GCaMP fluorescence emission can be demodulated by sequential acquisition.
The base *GCaMP Isosbestic & Functional Excitations Bundle-imaging Fiber Photometry System* contains the following elements.

- 2-channel LED driver
- Bundle-imaging Fluorescence Mini Cube with 4 ports - Isosbestic and Functional Excitations
- Bundle-imaging Fiber Photometry Driver
- 4-port USB3.0 Hub
- Photometry Rack for BFPS
- All required electrical cables

Note: Cannulae, rotary joints and other elements used are to be defined for each application, and are not specified here.

ORDERING CODE: BFPS_405/GFP

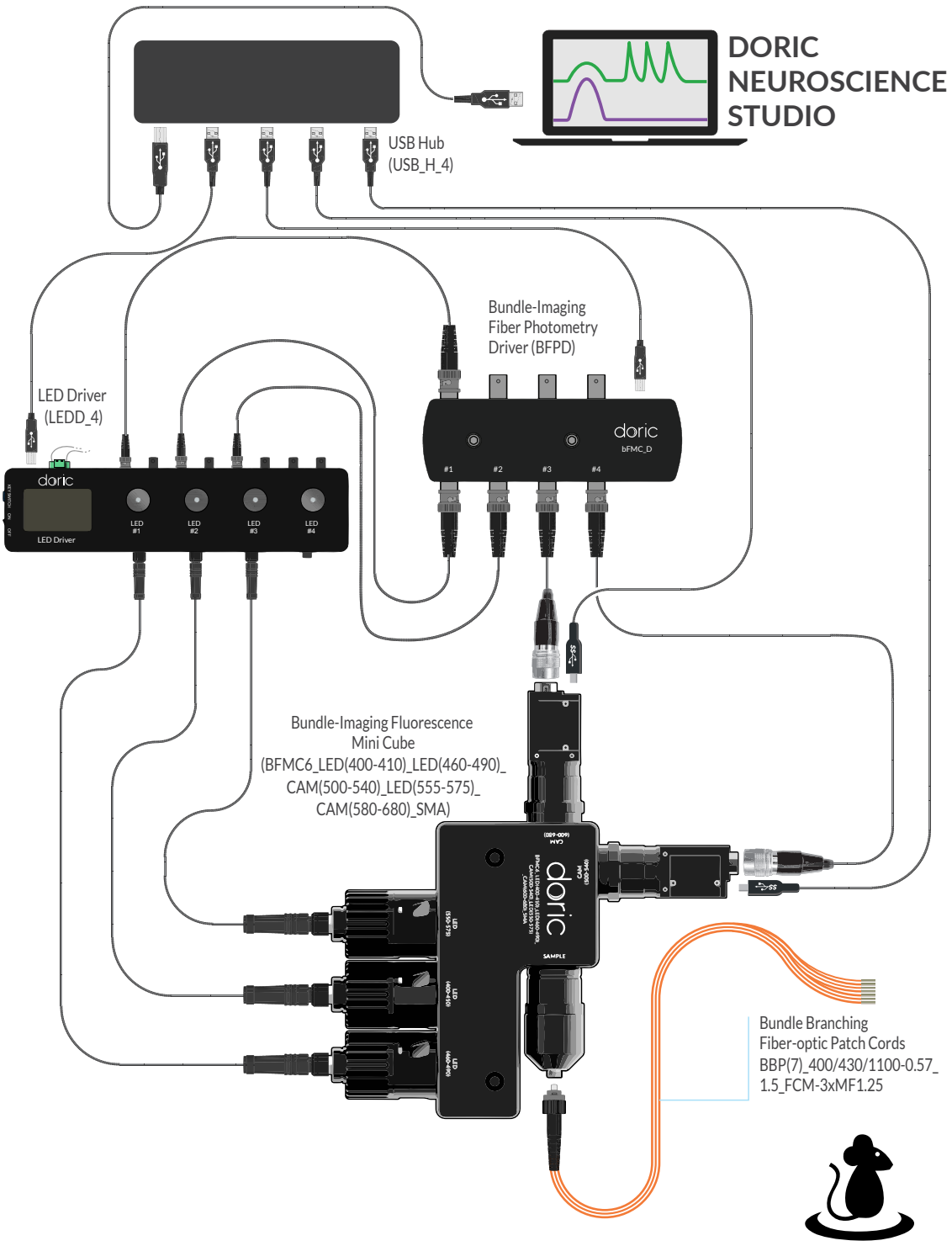
GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Fluorescence

The *GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Fluorescence Bundle-imaging Fiber Photometry System* contains all items necessary to perform fiber photometry measurements on a large number of animals and sites with GFP-like and RFP-like fluorophores. It also measures the 405 nm (isosbestic point) excitation of GCaMP fluorescence. The GCaMP fluorescence emission can be demodulated by sequential acquisition.
The base *GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Fluorescence Bundle-imaging Fiber Photometry System* contains the following elements.

- 4-channel LED driver
- Bundle-imaging Fluorescence Mini Cube with 6 ports - GCaMP Isosbestic and Functional Excitations, & Red Fluorophore Fluorescence
- Bundle-imaging Fiber Photometry Driver
- 4-port USB3.0 Hub
- All required electrical cables
- Photometry Rack for BFPS

Note: Cannulas, rotary joints and other elements used are to be defined for each application, and are not specified here.

ORDERING CODE: BFPS_405/GFP/RFP



GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Photometry System

Fiber Photometry Console

Fiber Photometry Console

This FPGA based data acquisition unit synchronizes the control of excitation light and the detection of the induced fluorescence. This device seamlessly integrates with the Doric Neuroscience Studio that provides user interface for multi-channel photometry experiments. The software interface enables control over the CW excitation light pulses, or the sinusoidal waveform trig of an external source (i.e. LED driver) with 4 TTL and 4 analog voltage outputs. The software interface displays real-time recording data of up to 4 detector input signals. Signal processing such as averaging, subtraction, multiplication to calculate the $\Delta F/F_0$ and other new functionalities are being developed. Updates will be freely available as they are released. Main features:

- 4 Digital Input/Output TTL, 25 MS/s, via 4 BNC connector; In : 3 kΩ, Out : 30 Ω
- 4 Analog Input ±10 V, 17 bits, 15 kS/s, via 4 BNC connector; 124 kΩ
- 4 Analog Output ±5V, 16 bits, 25 MS/s, via 4 BNC connector; 6 Ω
- 1 digital communication SPI and LVDS via custom pinout HDMI connector
- USB2 connection to computer, cable included
- Compatible with Doric Neuroscience Studio with photometry-oriented interface
- All software updates included

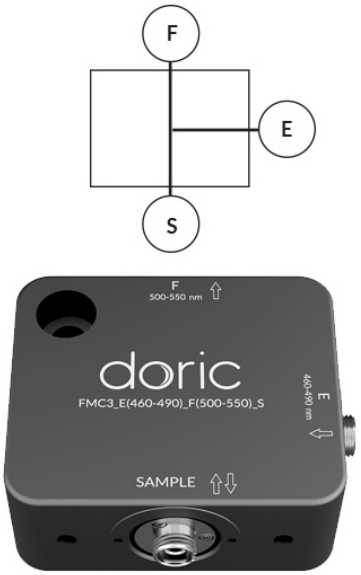
ORDERING CODE: FPC

Connectorized Fluorescence Mini Cubes

The fiber photometry experiments may require a different number of excitation and detection channels, an optional optogenetically synchronized activation/silencing channel etc., directly affecting the number of fluorescence cube ports. The sample itself requires fixed or rotating port. As there are number of different possibilities of assigning these ports, our cube classification is based on a number of ports. So far, we offer fluorescence mini cube models with 3, 4, 5, 6 and 7 ports where each port is assigned one of the following functions: E for tagged neurons excitation band or IE for GCaMP isosbestic excitation band, F for fluorescence band, O for optogenetics activation or silencing and S for the sample. For extremely low light level applications, the fluorescence port code letters F, F1, F2, etc., can be replaced by PMT, meaning that the fiber-optic receptacle is replaced by a photomultiplier tube attached directly to the mini cube.

Fluorescence Mini Cube with 3 ports

Single excitation band fiber photometry measurements use a *Fluorescence Mini Cube with 3 ports*, with one port for the excitation light, one for the fluorescence detection and one for the sample being tested. The cube has a dichroic mirror to separate the excitation light from the fluorescence emission and may incorporate narrow bandpass filters that limit the excitation or fluorescence spectrum. Currently we offer configurations for GFP-like or RFP-like fluorophores. The 3 ports' mini cube filters can be customized on request.
On the image E is for excitation, F for fluorescence and S is for the fixed sample port.



Fluorescence Mini Cube 3 ports

Table 101: *Fluorescence Mini Cube 3 ports Ordering Codes*

Filter Set	Excitation Band (nm)	Detection Band (nm)	Ordering Code
GFP-like	460-490	500-550	**FMC3_E(460-490)_F(500-550)_S***
RFP-like	540-570	580-680	**FMC3_E(540-570)_F(580-680)_S***

*To use with a PMT, in the ordering code replace **F** for **PMT**, *e.g.* FMC3_E(460-490)_PMT(500-550)_S

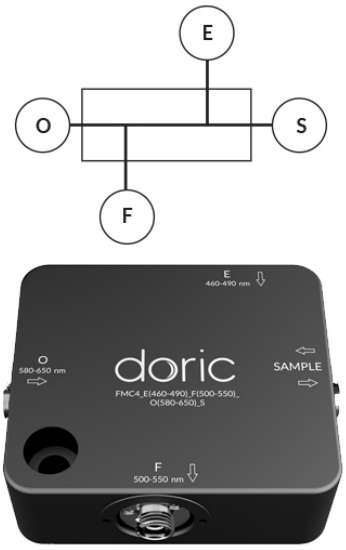
Fluorescence Mini Cube with 4 ports

- **Excitation, Fluorescence and Opsin Activation**

This cube is for measurements involving an excitation, an optogenetic activation/silencing, fluorescence detection and sample ports. Such a cube can be used for GCaMP fluorescence measurements combined with the activation of red opsins in the 580-650 nm band.
On the image E is for excitation, F for fluorescence, O for opsin activation/silencing and S is for the fixed sample port. The numbers in the brackets of the ordering code are for the corresponding wavelength bands.

ORDERING CODE:

FMC4_E(460-490)_F(500-550)_O(580-650)_S*



FMC4, Excitation, Fluorescence and Opsin Activation

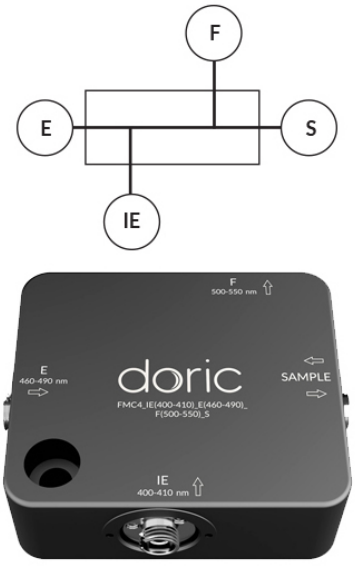
- **Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations**

This cube permits excitation of the GCaMP isosbestic point with 400-410 nm light and fluorophores with 460-490 nm light. The single detector measures both signals within the fluorescence detection window from 500-540 nm. The separation of GCaMP isosbestic and functional excitations is possible if both excitations are modulated.

On the image IE and E are ports for excitations, F is for fluorescence detection and S is the for fixed sample port. The numbers in the brackets of the ordering code denote the corresponding wavelength bands.

ORDERING CODE:

FMC4_IE(400-410)_E(460-490)_F(500-550)_S*

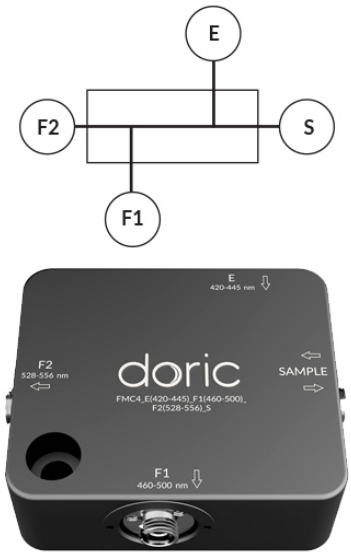


FMC4, Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations

*To use with a PMT, in the ordering code replace **F** for **PMT**, *e.g.* FMC4_E(460-490)_PMT(500-550)_O(580-650)_S

- **FRET Cube (One Excitation and Two Fluorescence Detection Ports)**

This cube is used to excite the donor fluorophore with a 420-445 nm excitation wavelength band. The donor fluorophore loses part of that energy to fluorescence in the 460-500 nm band, while the rest is transferred in a distance dependent radiationless manner to the acceptor fluorophore. The fluorescence emitted by the acceptor is detected in the 528-556 nm window.



FMC4, FRET Cube

ORDERING CODE:

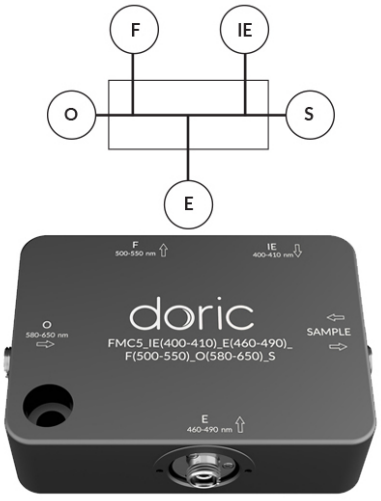
FMC4_E(420-445)_F1(460-500)_F2(528-556)_S*

On the image E is for excitation, F1 and F2 for two spectrally different fluorescences and S is for the fixed sample port. The numbers in the brackets are for the corresponding wavelength bands.

Fluorescence Mini Cube with 5 ports

- **GCaMP Isosbestic and Functional Excitations, and Opsin Activation**

The GCaMP isosbestic point is excited by 400-410 nm bandwidth light and the 460-490 nm spectral window excites its functional fluorescence. The 500-550 nm spectral window collects the functional fluorescence of GCaMP. At the same time, an opsin is excited with 580-650 nm light.



FMC5, GCaMP Isosbestic and Functional Excitations, and Opsin Activation

ORDERING CODE:

FMC5_IE(400-410)_E(460-490)_F(500-550)_O(580-650)_S*

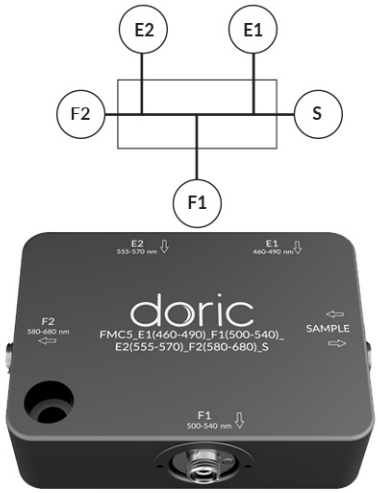
*To use with a PMT, in the ordering code replace **F** for **PMT**, *e.g.* FMC5_IE(400-410)_E(460-490)_PMT(500-550)_O(580-650)_S

- **Separated Two Fluorophores Fluorescence**

This cube is used for green and red fluorophore excitation and their respective detection wavelengths. Other fluorophore combinations are possible.

ORDERING CODE:

FMC5_E1(460-490)_F1(500-540)_E2(555-570)_F2(580-680)_S*



FMC5, Separated Two Fluorophores Fluorescence

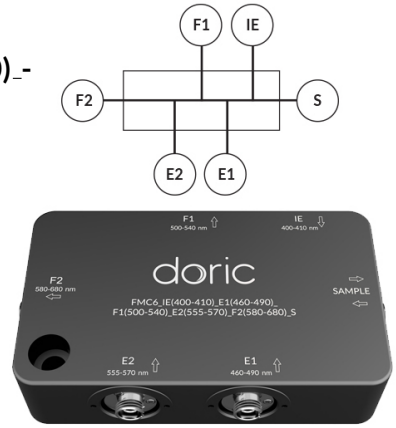
Fluorescence Mini Cube with 6 ports

- **Two Fluorophores Fluorescence and GCaMP Isosbestic Excitation**

This cube can be used to detect the fluorescence from two calcium indicators and the GCaMP isosbestic point. The separation of functional and isosbestic fluorescence signals of GCaMP is possible if the light sources are modulated.

ORDERING CODE:

FMC6_IE(400-410)_E1(460-490)_F1(500-540)_E2(555-570)_F2(580-680)_S*



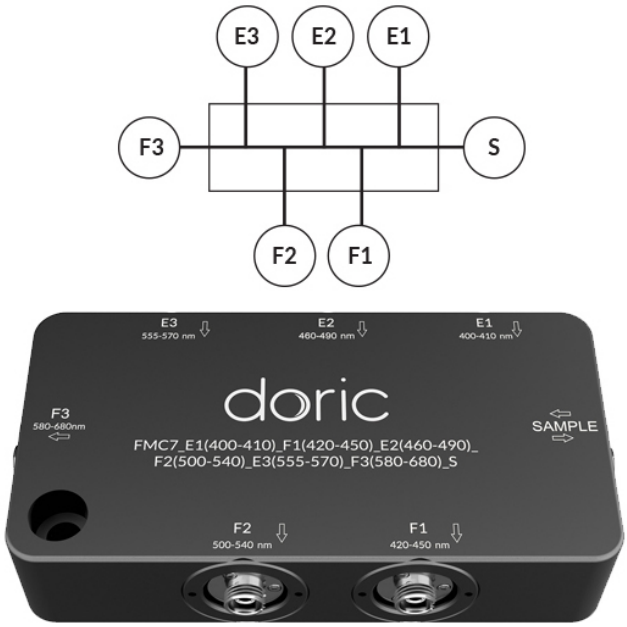
FMC6, Two Fluorophores Fluorescence and GCaMP Isosbestic Excitation

*To use with a PMT, in the ordering code replace **F** for **PMT**, *e.g.* FMC5_E1(460-490)_PMT(500-540)_E2(555-570)_PMT(580-680)_S

Fluorescence Mini Cube with 7 ports

- **Three Fluorophores Fluorescence**

This mini cube separates three different indicators simultaneously.



FMC7, Three Fluorophores Fluorescence

ORDERING CODE:

FMC7_E1(400-410)_F1(420-450)_E2(460-490)_F2(500-540)_E3(555-570)_F3(580-680)_S*

*To use with a PMT, in the ordering code replace **F** for **PMT**,
e.g. FMC7_E1(400-410)_PMT(420-450)_E2(460-490)_PMT(500-540)_E3(555-570)_PMT(580-680)_S

Integrated Fluorescence Mini Cubes

In order to optimize signal detection and simplify usage, it is desirable to minimize the number of fiber optic connections to a Fluorescence Mini Cube. By taking advantages of the new *Doric Fluorescence Detector*, and our *Built-in LED Optical Heads*, it is possible to have an *Integrated Fluorescence Mini Cube*. The *Integrated Fluorescence Mini Cubes* include a number of built-in detectors and LED light sources on various ports to improve *Fluorescence Mini Cube* performance.

- The *Built-in Fluorescence Detector Head* allows for an increase in signal transmission of 30% due to the proximity of the detector active surface and signal source, as well as the reduced number of optical connections. A *Fluorescence Detector Amplifier* is provided for each detector head. All *Fluorescence Mini Cube* **F** ports come with a *Built-in Fluorescence Detector Head*.
- The *Built-in LED Optical Head* removes the need for light source patch cords. The Intensity Adjustment Ring allows additional fine control of light intensity, ideal for low-power fiber photometry experiments. All *Fluorescence Mini Cube* **E** and **IE** ports come with a *Built-in LED Optical Head*.
- All ports used for opsin activation/silencing, identified with **O**, have an FC receptacle.
- Any built-in device can be replaced by an *FC Receptacle* if requested. To order a cube without *Built-in LED Optical Heads*, use the ordering code for the iFMC: *e.g.* iFMC3_E(460-490)_F(500-550)_S for the iIFMC3_E(460-490)_F(500-550)_S

Integrated Fluorescence Mini Cubes with 4 ports - LED & Doric Fluorescence Detector Head

Integrated Fluorescence Mini Cubes with 3 ports - LED & Doric Fluorescence Detector Head

Single excitation band fiber photometry measurements use a *Fluorescence Mini Cube with 3 ports*, with one port for the excitation light, one for the fluorescence detection and one for the sample being tested. The cube has a dichroic mirror to separate the excitation light from the fluorescence emission and may incorporate narrow bandpass filters that limit the excitation or fluorescence spectrum. Currently we offer configurations for GFP-like or RFP-like fluorophores. The 3 ports' mini cube filters can be customized on request.

On the image E is for excitation, F for fluorescence and S is for the fixed sample port.

Integrated Fluorescence Mini Cube 3 ports

Table 102: *Integrated Fluorescence Mini Cube 3 ports Ordering Codes*

Filter Set	Excitation Band (nm)	Detection Band (nm)	Ordering Code
GFP-like	460-490	500-550	**iIFMC3_E(460-490)_F(500-550)_S**
RFP-like	540-570	580-680	**iIFMC3_E(540-570)_F(580-680)_S**

Integrated Fluorescence Mini Cubes with 4 ports - LED & Doric Fluorescence Detector Head

- **Excitation, Fluorescence and Opsin Activation**

iIFMC4, Excitation, Fluorescence and Opsin Activation

This cube is for measurements involving an excitation, an optogenetic activation/silencing, fluorescence detection and sample ports. Such a cube can be used for GCaMP fluorescence measurements combined with the activation of red opsins in the 580-650 nm band.

On the image E is for excitation, F for fluorescence, O for opsin activation/silencing and S is for the fixed sample port. The numbers in the brackets of the ordering code are for the corresponding wavelength bands.

ORDERING CODE:

iIFMC4_E(460-490)_F(500-550)_O(580-650)_S

- **Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations**

iIFMC4, Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations

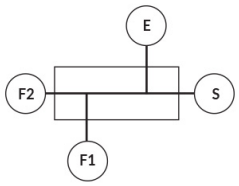
This cube permits excitation of the GCaMP isosbestic point with 400-410 nm light and fluorophores with 460-490 nm light. The single detector measures both signals within the fluorescence detection window from 500-550 nm. The separation of GCaMP isosbestic and functional excitations is possible if both excitations are modulated.

On the image IE and E are ports for excitations, F is for fluorescence detection and S is the for fixed sample port. The numbers in the brackets of the ordering code denote the corresponding wavelength bands.

ORDERING CODE:

iIFMC4_IE(400-410)_E(460-490)_F(500-550)_S

- **FRET Cube (One Excitation and Two Fluoresce Detection Ports)**



iIFMC4, FRET Cube

This cube is used to excite the donor fluorophore with a 420-445 nm excitation wavelength band. The donor fluorophore loses part of that energy to fluorescence in the 460-500 nm band, while the rest is transferred in a distance dependent radiationless manner to the acceptor fluorophore. The fluorescence emitted by the acceptor is detected in the 528-556 nm window.

ORDERING CODE:

iIFMC4_E(420-445)_F1(460-500)_F2(528-556)_S

On the image E is for excitation, F1 and F2 for two spectrally different fluorescences and S is for the fixed sample port. The numbers in the brackets are for the corresponding wavelength bands.

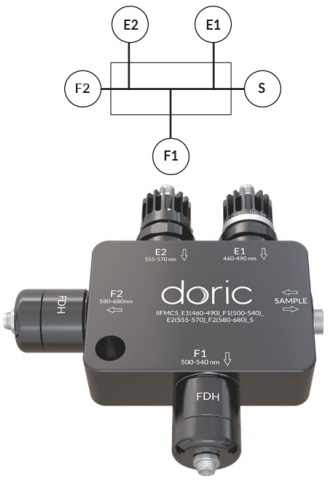
Integrated Fluorescence Mini Cubes with 5 ports - LED & Doric Fluorescence Detector Heads

- **Separated Two Fluorophores Fluorescence**

This cube is used for green and red fluorophore excitation and their respective detection wavelengths. Other fluorophore combinations are possible.

ORDERING CODE:

iIFMC5_E1(460-490)_F1(500-540)_E2(555-570)_F2(580-680)_-S



iIFMC5, Separated Two Fluorophores Fluorescence Cube

- **GCaMP Isosbestic and Functional Excitations, an**

The GCaMP isosbestic point is excited by 400-410 nm bandwidth light and the 460-490 nm spectral window excites its functional fluorescence. The 500-550 nm spectral window collects the functional fluorescence of GCaMP. At the same time, an opsin is excited with 580-650 nm light.

ORDERING CODE:

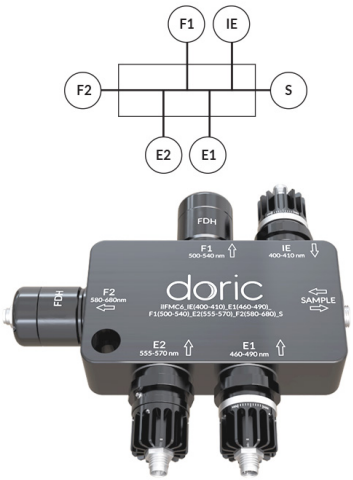
iIFMC5_IE(400-410)_E(460-490)_F(500-550)_O(580-650)_S

iIFMC5, GCaMP Isosbestic and Functional Excitations, and Opsin Activation

Integrated Fluorescence Mini Cubes with 6 ports - LED & Doric Fluorescence Detector Heads

- **Two Fluorophores Fluorescence and GCaMP Isosbestic Excitation**

This cube can be used to detect the fluorescence from two calcium indicators and the GCaMP isosbestic point. The separation of functional and isosbestic fluorescence signals of GCaMP is possible if the light sources are modulated.



iIFMC6, Two Fluorophores Fluorescence and GCaMP Isosbestic Excitation Cube

ORDERING CODE:

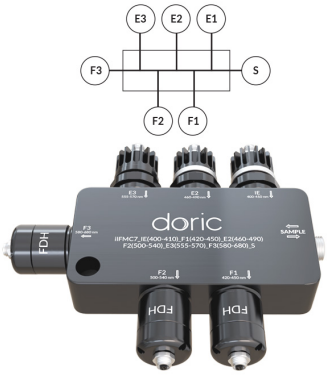
iIFMC6_IE(400-410)_E1(460-490)_F1(500-540)_E2(555-570)_F2(580-680)_S

Notes: The **E2(555-570)** *Built-in LED Optical Head* has no **Intensity Adjustment Ring**.

Integrated Fluorescence Mini Cubes with 7 ports - LED & Doric Fluorescence Detector Heads

- **Three Fluorophores Fluorescence**

This mini cube separates three different indicators simultaneously.



iIFMC7, Three Fluorophores Fluorescence

ORDERING CODE:

iIFMC7_E1(400-410)_F1(420-450)_E2(460-490)_F2(500-540)_E3(555-570)_F3(580-680)_S

Notes: The **E3(555-570)** *Built-in LED Optical Head* has no **Intensity Adjustment Ring**.

Rotary Fluorescence Mini Cubes

Unmounted Rotary Fluorescence Mini Cube with 6 ports

Fluorescence recording of freely moving subjects is a challenge for neuroscience researchers due to low signal and external sources of noise. Here we present a modified version of our *Doric Integrated Fluorescence Mini Cube* that can be mounted on the rotor of a specialized version of our *24-channel Assisted Electrical Rotary Joint*. This configuration increases collection efficiency by removing one optical connection while reducing motion related signal variation.

- LED light sources are built directly into the fluorescence mini cube, and are optimized to deliver low excitation power.
- The integrated detector is an amplified photodiode circuit with comparable specifications to our *Doric Fluorescence Detector* (See section).
- To connect these devices to an *LED Driver* and a *Fluorescence Detector Amplifier*, a *24-channel Assisted Electrical Rotary Joint for Fluorescence Mini Cube* (See section) is required. Each rotary joint can hold up to two fluorescence mini cube.
- The *Rotary Fluorescence Mini Cubes* are modular, allowing them to be removed from a rotary joint and replaced. They can be ordered individually or added onto an existing system for added flexibility.

Two Rotary Fluorescence Mini Cubes with 6 ports- Integrated on an Assisted Electrical Rotary Joint

Rotary Fluorescence Mini Cubes with 3 ports

- **1 LED & 1 Integrated Fluorescence Detector-**
  For GFP-like Fluorophore

Single excitation band fiber photometry measurements use a *Fluorescence Mini Cube with 3 ports*, with one port for the excitation light, one for the fluorescence detection and one for the sample being tested. The cube has a dichroic mirror to separate the excitation light from the fluorescence emission and may incorporate narrow band-pass filters that limit the excitation or fluorescence spectrum. Currently we offer configurations for GFP-like fluorophores.

ORDERING CODE:
RFMC3_E(460-490)_F(500-550)

Rotary Fluorescence Mini Cubes with 4 ports

- **2 LED & 1 Integrated Fluorescence Detector-**
  Lock-in or Sequential Detection for GCaMP Isosbestic and Functional Excitations

This cube permits excitation of the GCaMP isosbestic point with 400-410 nm light and fluorophores with 460-490 nm light. The single detector measures both signals within the fluorescence detection window from 500-550 nm. The separation of GCaMP isosbestic and functional excitations using lock-in demodulation or sequential detection.

ORDERING CODE:
RFMC4_IE(400-410)_E(460-490)_F(500-550)_S

- **1 LED & 2 Integrated Detectors-**
  FRET (Fluorescence Resonance Energy Transfer)

This cube is used to excite the donor fluorophore in a 420-445 nm excitation wavelength band. The donor fluorophore loses part of that energy to fluorescence in the 460-500 nm band, while the rest is transferred in a distance dependent radiationless manner to the acceptor fluorophore. The fluorescence emitted by the acceptor is detected in the 528-556 nm window.

ORDERING CODE:

RFMC4_E(420-445)_F1(460-500)_F2(528-556)_S

Rotary Fluorescence Mini Cubes with 6 ports

- **3 LED & 2 Integrated Detectors-**
  GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Fluorescence

This cube can be used to detect the fluorescence from two calcium indicators and the GCaMP isosbestic point. The separation of functional and isosbestic fluorescence signals of GCaMP is possible if the light sources are modulated using lock-in demodulation or sequential detection.

ORDERING CODE:

RFMC6_IE(400-410)_E1(460-490)_F1(500-540)_E2(555-570)_F2(580-680)_S

Bundle-imaging Fluorescence Mini Cubes

6-port Bundle-imaging Fluorescence Mini Cube

Performing fiber photometry on a large number of sites and animals can be inconvenient due to the large number of photoreceivers and patch cords required. By bundling the connective patch cords together and using a camera, it is possible to measure a great number of sites or animals at once.
The *Bundle-imaging Fluorescence Mini Cube* is able to perform such measurements. This is done by imaging a fiber bundle onto a camera using a microscope objective. These otherwise function as any fluorescence mini cube.

- The light source ports can be shipped with integrated LED light sources (**LED** ports) or with FC receptacles (**FC** ports).
- The camera ports can be shipped with integrated cameras (**CAM** ports) or with standard C-mounts (**CM** ports).
- To accomodate larger fiber bundles, an SMA fiber optic receptacle (**SMA** ports) is used on the sample port.

Bundle-imaging Fluorescence Mini Cubes with 4 ports- Sequential Detection for GCaMP Isosbestic and Function

4-port Bundle-imaging Fluorescence Mini Cube

This cube permits excitation of the GCaMP isosbestic point with 400-410 nm light and fluorophores with 460-490 nm light. The camera measures both signals within the fluorescence detection window from 500-540 nm. The separation of GCaMP isosbestic and functional excitations is possible if both excitations are interleaved.

ORDERING CODE:

- ***Integrated Cube:***

BFMC4_LED(400-410)_LED(460-490)_CAM(500-550)_SMA

- ***Connectorized Cube:***

BFMC4_FC(400-410)_FC(460-490)_CM(500-550)_SMA

Bundle-imaging Fluorescence Mini Cubes with 6 ports- GCaMP Isosbestic & Functional Excitations, & Red Fluorophore Fluorescence

This cube can be used to detect the fluorescence from two calcium indicators and the GCaMP isosbestic point. The separation of functional and isosbestic fluorescence signals of GCaMP is possible if the light sources are interleaved. This cube contains two cameras, one for each fluorescence port.

ORDERING CODE:

- ***Integrated Cube:***

BFMC6_LED(410-420)_LED(460-490)_CAM(500-540)_LED(555-575)_CAM(580-680)_SMA

- ***Connectorized Cube:***

BFMC6_FC(410-420)_FC(460-490)_CM(500-540)_FC(555-575)_CM(580-680)_SMA

Photodetectors

Doric Fluorescence Detector

This photodetector system designed specifically for use in fiber photometry experiments consists of the detector head and the detector amplifier. Its high gain and low noise allow for detection of signals in the sub-picowatt to nanowatt range. When used with a modulated light source and a lock-in amplifier it can detect signals in the femtowatt range.

Doric Fluorescence Detector

Fluorescence Detector Head

When the detector is not integrated into the iFMC, the Fluorescence Detector Head is fitted with an FC adapter to connect it to a signal source. The detector uses a specialized shielded cable to connect to the amplifier, keeping noise to a minimum.

Fluorescence Detector Amplifier

The Fluorescence Detector Amplifier amplifies the signal coming from the detector head and transmits it to a recording system using a BNC output. The amplifier has two detection modes (AC/DC), each selectable for all three (1x, 10x, 100x) amplification levels, allowing 6 different amplification configurations. The DC detection mode is optimal for use with interleaved measurements or during large-bandwidth

continuous measurements. The AC detection mode is optimal for lock-in modulation/demodulation and the elimination of low-frequency noise. Its output analog voltage (5 V) can be monitored with a DAQ board for data recording or an oscilloscope for live signal.

Notes:

- The *Fluorescence Detector Head* and the *Fluorescence Detector Amplifier* are always shipped together with a *Detector Cable*.
- A battery pack is included with each Fluorescence Detector for cordless use.

Table 103: *Doric Fluorescence Detector Specifications*

SPECIFICATION	VALUE		
Wavelength Range (nm)	320-1100		
Peak Sensitivity Wavelength (nm)	960		
Peak Responsivity (A/W)	0.6		
Output Impedance (Ω)	50		
NEP (W/√Hz)	<12		
CW Saturation Power (nW)	4.75		
DC Bandwidth (Hz)	0-1000		
AC Bandwidth (Hz)	30-1000		
Output Connector	Male BNC		
Detector Material	Si		
Detector Size (mm x mm)	1.1 x 1.1		
Amplification level	*1x*	*10x*	*100x*
Transimpedance Gain (V/A)	$2x10^9$	$2x10^{10}$	$2x10^{11}$
Maximum Conversion Gain (V/W)	$1.2x10^9$	$1.2x10^{10}$	$1.2x10^{11}$

ORDERING CODE: DFD_FOA_FC

Newport Visible Femtowatt Photoreceiver Module

This battery-operated photoreceiver has high gain and detects CW light signals in the sub-picowatt to nanowatt range. When used in conjunction with a modulated light source and a lock-in amplifier to reduce the measurement bandwidth, it achieves sensitivity levels in the femtowatt range. For this Newport product Doric offers an add-on fiber-optic adapter that improves coupling efficiency between the large core, high NA op-

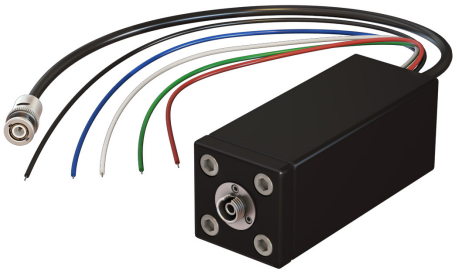
Newport Visible Femtowatt Photoreceiver Model 2151 + Doric FC Adapter

tical fibers used in fiber photometry and the relatively small detector area. Its output analog voltage (0-5 V) can be monitored with an oscilloscope or with a DAQ board to record the data with a computer.

Table 104: *Newport Visible Femtowatt Photoreceiver Module Specifications*

SPECIFICATION	**VALUE**
Model	2151
Wavelength Range (nm)	320-1050
Bandwidth (-3 dB)	DC-750 Hz (DC), 30-750 Hz (AC)
Conversion Gain, Maximum (V/W)	1×10^{11}
Responsivity (Peak)	0.5 A/W
Transimpedance Gain (V/A)	2×10^{10} & 2×10^{11}
Output Impedance (Ω)	100
NEP ($W/\sqrt{Hz}$)	16 f
Saturation Power CW	0.5 nW
Output Connector	Male BNC
Detector Material	Si
Detector Diameter (mm)	1.0
Power Requirements	Internal 9 V battery
PRODUCT	**Ordering Code**
Newport Photoreceiver Module + Doric FC Adapter	**NPM_2151_FOA_FC**
Doric FC Adapter only	**FOA_2151_FC**

Photosensor Module H10722-20

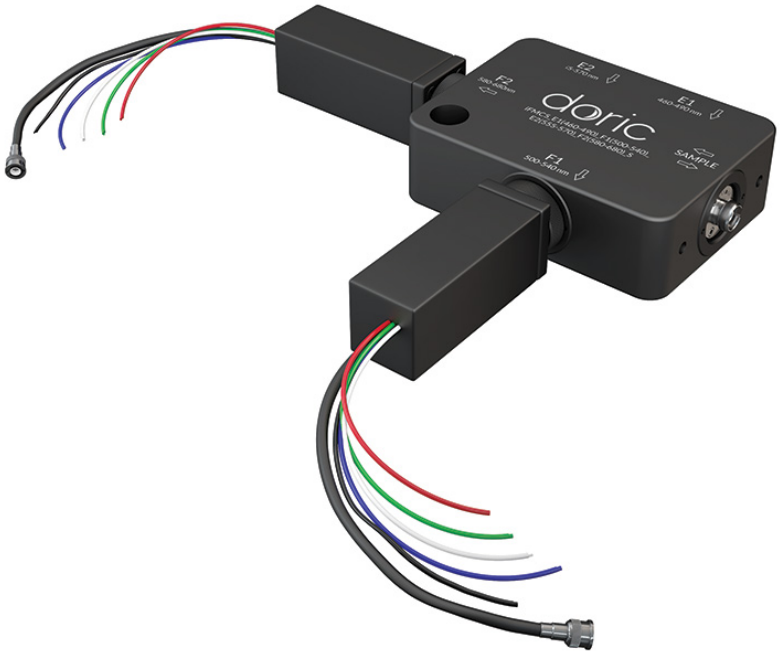


Hamamatsu H10722-20 Photosensor Module with a FC connector

The *Hamamatsu H10722-20 Photosensor Module* is compatible with our cubes and is the most sensitive detector we offer for very low light level detection. Unlike other ports of our mini cubes that have receptacles and a focusing lens, the port for this sensor has a lens that adjusts the beam size to fit the size of the PMT and instead of a receptacle, it has a thread that matches the thread on the Doric adapter for the photosensor. The photomultiplier tube (PMT) is highly sensitive and can be easily damaged if exposed to high optical power. The photosensor module requires a power supply model C10709.

Table 105: *Limit of Detection for each Photodetectors*

	Minimum optical power detected (W)	
Photodetector	in CW	with lock-in
Newport 2151	0.4×10^{-12}	4.2×10^{-15}
Hamamatsu H10722	6.0×10^{-15}	not tested in lock-in



Hamamatsu H10722-20 Photosensor modules directly attached to the mini cube

ORDERING:

To get PMT ready cube, replace fluorescence port code from the Fluorescence Mini Cube, F, F1 or F2 with PMT (*e.g.* FMC3_E(460-490)_**PMT**(500-550)_S).

Power Supply for PMT Module C10709

This Power Supply unit can drive photomultiplier tube modules. Both drive voltages and control voltages can be supplied from this one unit.

Power Supply for PMT Module C10709

ORDERING CODE: PS_PMT

Fiber Photometry Accessories

Fiber Photometry Rack for FMC5

This small *Fiber Photometry Rack* can fit the Fiber Photometry Console, the 2-channel LED driver, 2 LEDs, 2 photodetectors (Doric or Newport) and up to 2 FMC5. It is suitable for use with the following systems: all the 1-site Fiber Photometry Systems and the 2-site Fiber Photometry Systems for GCaMP recording with two excitation wavelengths.

Fiber Photometry Rack for FMC5

ORDERING CODE: PR_5

Fiber Photometry Rack for FMC7

This rack-mount (19”) *Fiber Photometry Rack* allows for the housing of more complex systems requiring the bigger 4-channel LED driver. It is suitable for use with systems using FMC6 or FMC7, or for multi-site fiber photometry systems as the 2-site Fiber Photometry Systems for GCaMP Isosbestic and Functional Excitations.

Fiber Photometry Rack for FMC7

ORDERING CODE: PR_7

Bundle-imaging Fiber Photometry Driver

The *Bundle-imaging Fiber Photometry Driver* is used to coordinate the many devices used by a *Bundle-imaging Fiber Photometry System*. These include LED light sources and cameras. The driver is connected to a computer or the HUB using a USB cable, provided with the system.

ORDERING CODE: BFPD

4-port USB3.0 Hub

The *4-port USB3.0 Hub* is used to transfer the high-density data throughput involved in using the *Bundle-imaging Fiber Photometry System*. The hub is provided with all necessary electrical cables.

ORDERING CODE: USB_H_4

Fiber Photometry Cannula Holders

Fiber Photometry Cannula Holder

The *Fiber Photometry Cannula Holder* is designed to enable the recording of the fluorescence during the implantation of the cannula. It is a stainless steel rod having an FC receptacle on one end that allows a light delivery patch cord to be plugged in and at the other end a receptacle where a cannula can be screwed on. The two receptacles are mutually connected with an internal optical fiber housed within the 6.35 mm diameter rod that fits most popular micro-manipulators. To avoid unnecessary optical losses, the selected optical fiber parameters such as the core diameter and NA match those used in the fiber photometry system.

ORDERING CODE: FPCH_□□□_□□□/□□□/□□□□-□.□□_1.0_FC-□□□

Rod length (mm)
100 or **150**

Fiber-optic code
400/430/LWMJ-0.57 or **200/230/LWMJ-0.57**

Fiber length (m)
From ferrule to tip
1.0 m is standard.

Termination codes
ZF1.25, **ZF2.5** or **CM3**
(see Table 48)

Notes:

- The *Fiber Photometry Cannula Holder* is compatible with Mono Fiber-optic Cannulas.
- A holder compatible with Dual Fiber-optic Cannulas is available on request.
- An optional clamp (**SCL**) can be used to fix the Fiber Photometry Cannula Holder on stereotaxic apparatus.

Behavioral Tracking

Technically speaking, the behavior study of freely-moving animals resembles the filmmaking or film production process involving scriptwritting, choreography, recordings, editing etc. From the neuroscientist stand point it requires:

A) the recording of neuronal activity of the specific brain region using calcium imaging, fiber photometry or electrophysiology,

B) the behavioral tracking or simply filming of the animal activity in a given situation synchronized with the recordings of neural activity,

C) the behavior triggers that can be external in the form of the stage event or internal in the form of light or electric signals directed to specific brain region.

Optogenetics enable precise triggering or silencing of the brain cells with light. The electrophysiology can be used to deliver electrical trigger signals and to record the neuronal activity. The chronically implanted fluorescence microscopes and fiber photometry probes can monitor the neuronal activity. The filming of the animal is complementary information needed to establish correlation between the neuronal activity of the specific brain region and the animal behavior. The Doric Neuroscience Studio software seamlessly integrates neuronal imaging, fiber photometry, electrophysiological recording, optogenetics stimulation and behavioral tracking of the freely-moving animals. Another first from Doric.

Behavior Tracking Cameras

USB 3.0 Behavior Tracking Camera

USB 3.0 Behavior Tracking Camera with Wide-angle Lens

These Doric Color and B&W cameras use an USB 3.0 interface standard typical of high-performance industrial cameras. This interface provides a framework for streaming high-speed video and related control data. The camera control and the image acquisition are done through the Doric Neuroscience Studio software. The system includes a Trigger cable to synchronize with external devices. The power is feed directly to the camera by the USB cable. An articulated holder is also included with the Behavior Tracking Camera.

The purchase of the USB 3.0 Behavior Tracking Camera includes:

- Camera (B&W or Color)
- C-Mount camera lens for 1/2 sensor, 1.5MP
- Articulated holder
- Trigger cable

Table 106: *USB 3.0 Behavior Tracking Camera Specifications*

SPECIFICATION	VALUE
Video formats	B&W 1920 x 1080 Y800 Color 1920 x 1080 RGB32
Frame rate @ full resolution	60
Resolution	H: 1920, V: 1080
Format	1/2.8 ”
Pixel size	2.9 µm x 2.9 µm
Lens mount	C/CS
Interface	USB 3.0
Exposure	20 µs to 30 s
Gain	0 to 72 dB

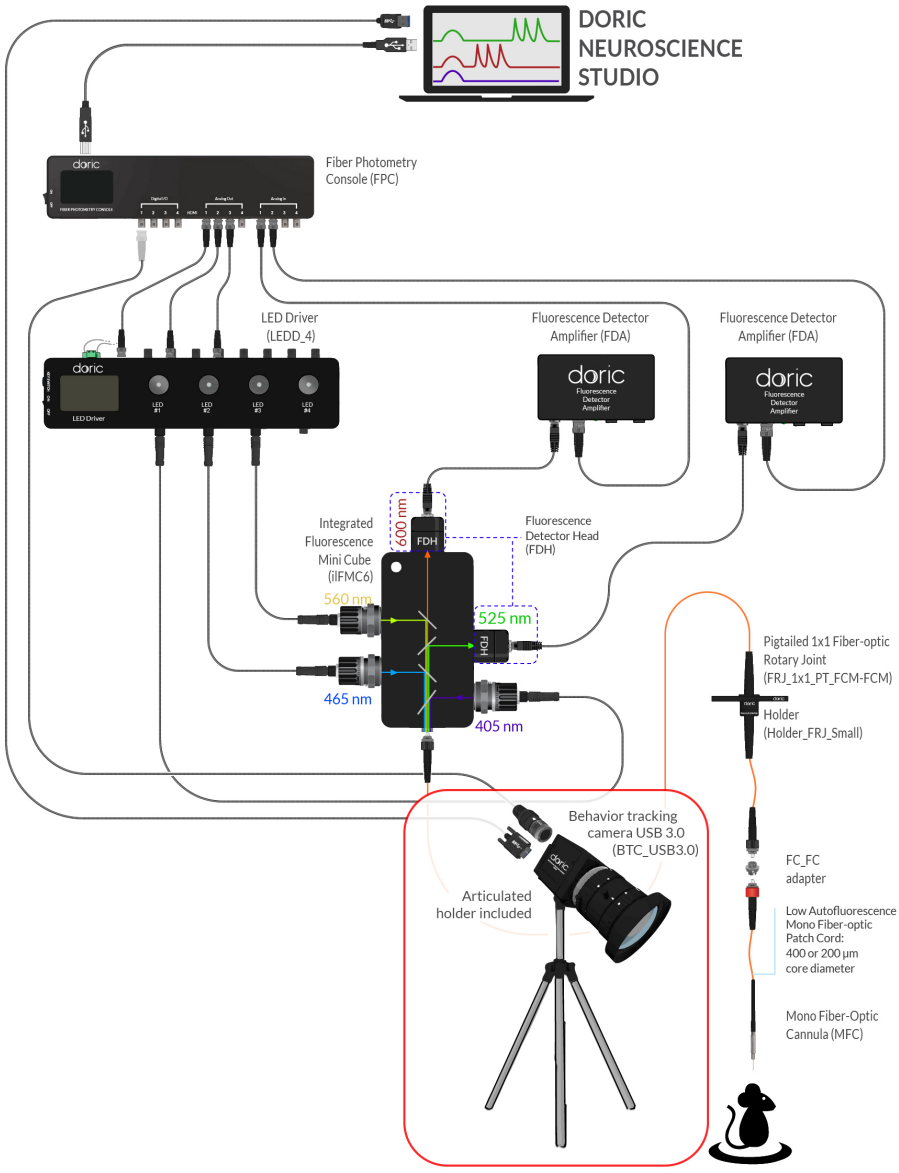
*Minimum object distance

Table 107: *Behavior Tracking Camera Lens Specifications*

Focal Length (mm)	Iris Range	MOD* (m)	FOV @ 1 m
5	F1.4 - 16C	0.10	1.0 x 1.0

Table 108: *Behavior Tracking Camera Ordering Codes*

CHROMA	Ordering Code
Color (RGB32)	**BTC_USB3.0_CO**
B&W (Y800)	**BTC_USB3.0_BW**



USB3 Behavioral Tracking Synchronized within a GCaMP Isosbestic and Functional Excitations and Red Fluorophore Fluorescence System

GigE Behavior Tracking Camera

GigE Behavior Tracking Camera with Wide-angle Lens

The Doric Color and B&W cameras use a GigE Vision interface standard typical of high-performance industrial cameras. This interface provides a framework for streaming high-speed video and related control data over Ethernet networks. The camera control and the image acquisition are done through the Doric Neuroscience Studio software. The system includes a Power/Trigger cable to synchronize with external devices. If the system is coupled with a fluorescence microscope driver, a Gigabit PoE+ Switch is included to the system. This switch allows the connection of multiple Ethernet devices to a single Ethernet port on the computer and feeds the camera power directly through the Ethernet cable. An articulated holder is also included with the Behavior Tracking Camera.

The purchase of the GigE Behavior Tracking Camera includes:

- Camera (B&W or Color)
- C-Mount camera lens for 1/2 sensor, 1.5MP
- Articulated holder
- Power/trigger cable
- PoE+ Switch (when coupled with a microscope driver)

Table 109: *GigE Behavior Tracking Camera Specifications*

SPECIFICATION	VALUE
Video formats	B&W 1920 x 1200 Y800 Color 1920 x 1200 RGB32
Frame rate @ full resolution	50
Resolution	H: 1920, V: 1200
Format	1/2.8 ”
Pixel size	2.8 µm x 2.8 µm
Lens mount	C/CS
Interface	GigE
Exposure	20 µs to 30 s
Gain	0 to 48 dB

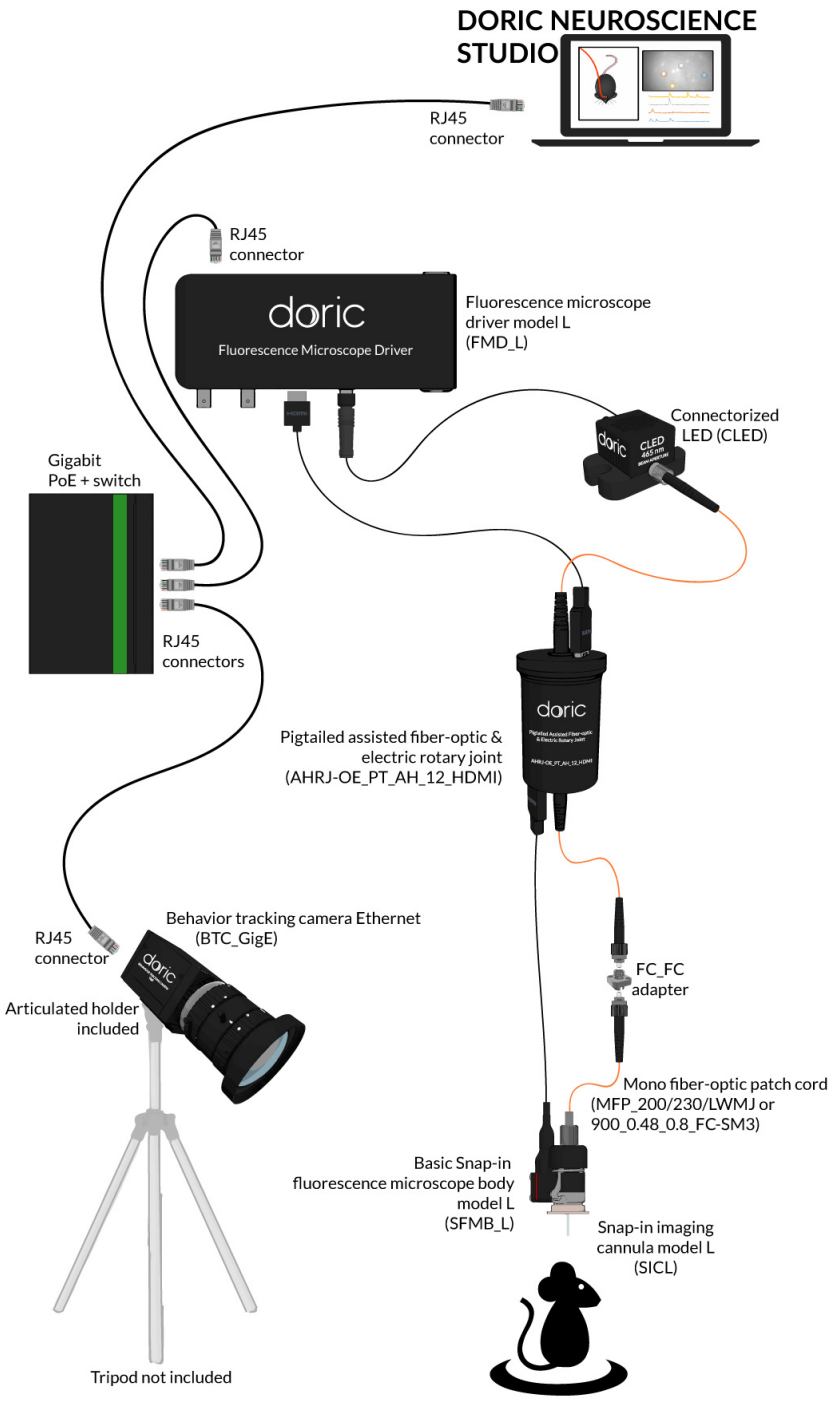
Table 110: *Behavior Tracking Camera Lens Specifications*

Focal Length (mm)	Iris Range	MOD* (m)	FOV @ 1 m
5	F1.4 - 16C	0.10	1.0 x 1.0

Table 111: *Behavior Tracking Camera Ordering Codes*

CHROMA	Ordering Code
Color (RGB32)	**BTC_GigE_CO**
B&W (Y800)	**BTC_GigE_BW**

*Minimum object distance

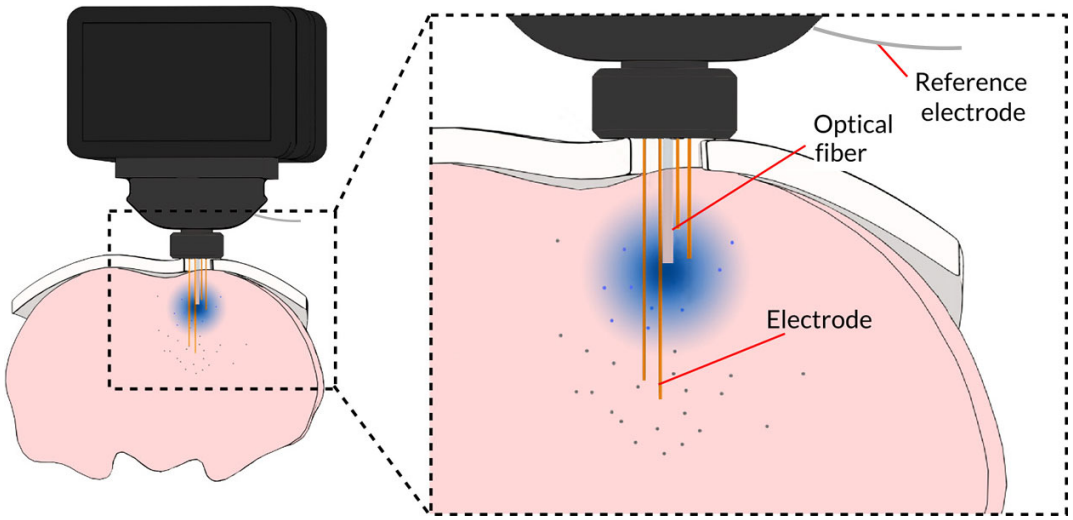


Ethernet Behavioral Tracking Synchronized to the Basic Miniature Fluorescence Microscopy System

Optogenetically Synchronized Electrophysiology (OSE)

The systems that combine optogenetics with electrophysiological recordings open up new possibilities for neuroscience. They require delivery of appropriate optical signals to the point of interest within the neural tissue and detection and processing of the electrical spikes from neural activity. The system definition starts from the chronically implanted opto-electric cannula for behaving animals or from the opto-electric probes for *in vitro* experiments or *in vivo* head-fixed configuration. For freely-moving studies, there is the wireless/fiberless option.

Detachable Fiberless & Wireless Headstage and Opto-electric Cannula



Detachable Fiberless & Wireless Headstage and the Opto-electric Cannula implanted in the brain

Optogenetically Synchronized Electrophysiology Systems

Fiberless & Wireless (Fi-Wi) OSE System

Tethering lab animals with fibers and wires compromises their ”freely-moving” status for behaviour studies. Going wireless and fiberless effectively removes those limitations. *Fi-Wi OSE System* features the opto-electric cannula with one LED and up to four recording electrodes, the fiberless and wireless headstage* for communication between the cannula and the control console, and finally the electrophysiology console that configures the stimulation and recording parameters and displays the real-time data. The recording tips of the opto-electric cannulas are custom made for specific experiments which ensure flexibility in recording and illuminating different brain areas.

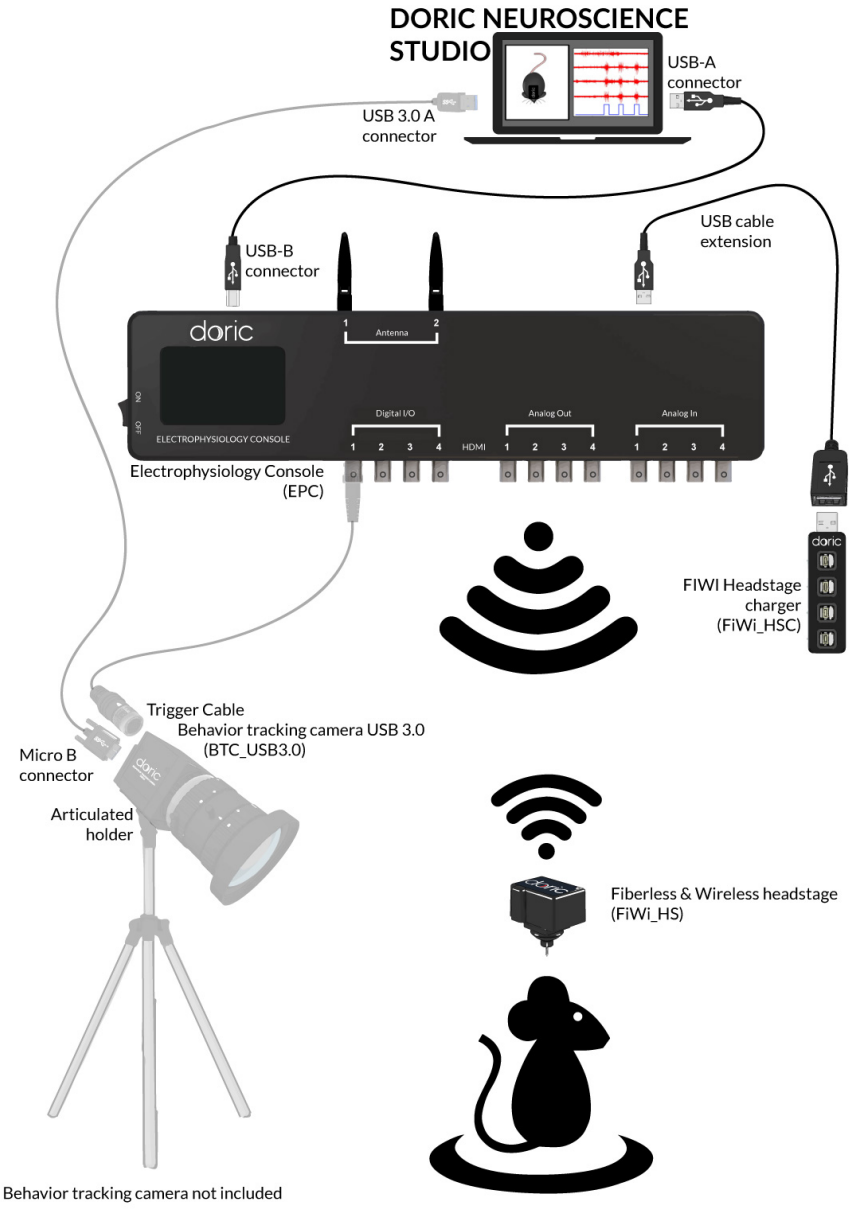
This system contains all the items necessary to record synchronized electrophysiological signals with optogenetic stimulation of freely-moving animals.

- Fiberless & Wireless Headstage (2x)
- Fi-Wi Opto-electric Cannula (3x)
- Electrophysiology Console
- Fi-Wi Headstage Charger
- Fi-Wi Dummy Headstage
- Fi-Wi Cannula Implantation Holder
- Fi-Wi Test Cannula
- Doric Neuroscience Studio Software
- All required cables

ORDERING CODE: **FiWiS_□□**

Fiberless & Wireless headstage
OE, O or E (see table 113)

*A Wireless Optogenetic Headstage with Multichannel Electrophysiological Recording Capability, Gagnon-Turcotte G, et al., Sensors 2015, 15(9), 22776-22797



Fiberless optogenetics and wireless electrophysiological recordings system

Fiberless & Wireless Headstages

Fiberless & Wireless Headstage

Detachable Fiberless & Wireless Headstage

The *Fiberless and Wireless Headstage* records electrophysiological data from brain electrodes, controls the activation of an implanted LED and transfers all the information to the electrophysiology console. It is an electronic component that could be placed or removed from a chronically implanted cannula on the head of an animal. Typically, one needs at least two headstages so that one can be charged while the other is in use. Each headstage includes a 60 mAh battery, an LED driver, an electrophysiology recording system and a radio frequency transmitter.

Table 112: *Fiberless & Wireless Headstage Specifications*

SPECIFICATION	VALUE
Transmission range	3 meters (2 meters with 2 simultaneous headstages)
Continuous operating time (10% duty cycle LED + 4 ephy channels)	1.5 hours
Sample rate	4 ch @ 14.3 KHz
Size	19 x 15 x 10 mm
Weight (including battery)	2.8 g (2.5 g for FiWi_HS-O)
Battery	60 mAh, 1.2 g

Table 113: *Fiberless & Wireless Headstages Ordering Codes*

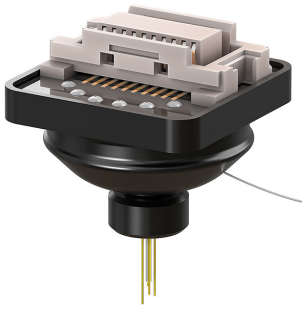
TYPE	Ordering Code
Opto-electric	**FiWi_HS-OE**
Optic only	**FiWi_HS-O**
Electric only	**FiWi_HS-E**

Notes:

- Simplified headstage versions are also available with only optical or only electrical features (see Table 113). Note that the choice of Fi-Wi Cannulas must match the type of the chosen headstage.
- The *Fi-Wi Headstage Charger* can recharge the headstage battery in less than 1 hour (**FiWi_HSC**).

Fiberless & Wireless Cannulas

Fi-Wi Opto-electric Cannula



Fi-Wi Opto-electric Cannula with 1 optical fiber and 4 electrodes

The *Fi-Wi Opto-electric Cannulas* are opto-electric devices designed to be chronically implanted on the skull of an animal. The base of the receptacle is smaller to facilitate implantation. The optical fiber is connectorized to an LED, that brings the light directly into a specific brain area, with to 1 to 4 electodes recording the activity of the brain. The LED activation is done by the headstage and the delivered light intensity can be modulated throughout the experiment (0-100%, DC to 1000 Hz, different pulsed shapes). The position of the fiber and the electrodes is customized within a 100 µm tolerance. The tungsten electrodes and the impedance could be chosen between 0.2 and 1.2 MΩ.
The cannula has an electrical connector to hold the fiberless and wireless headstage in place. Between experiments, the headstage can be easily disconnected from the cannula and reconnected at the appropriate time.

Table 114: *Fi-Wi Opto-electric Cannula Specifications*

SPECIFICATION	VALUE
LED	465 nm - 8 mW @ 150 mA (256 mW/mm^2) 525 nm - 3.5 mW @ 150 mA (112 mW/mm^2) 595 nm - 1.5 mW @ 150 mA (48 mW/mm^2) 635 nm - 4.0 mW @ 150 mA (128 mW/mm^2)
Optical fiber	250 µm diameter, NA 0.66
Electrodes	25 µm diameter, 0.7 to 1.2 MΩ 50 µm diameter, 0.2 to 0.3 MΩ
Size	10 x 10 x 7 mm
Weight	0.3 g

ORDERING CODE: FiWi_C-OE__□□□_□_□.□_FLT

LED central wavelength (nm)
465, **525**, **595** or **635**

Number of electrodes
1, **2**, **3** or **4**

Optical fiber length (mm)

Optical fiber termination
FLT

Notes:

- Simplified cannula versions are also available with only optical or only electrical features. Note that the choice of Fiberless & Wireless Headstage must match the type of chosen Fi-Wi Cannulas.
- Choose the ordering code according to the type of cannula wanted. Use the PDF on our website to indicate the position of each electrode/optical fiber in the cannula and their length.

Electrophysiology Console

Electrophysiology Console

4-channel Electrophysiology Console

The *Electrophysiology Console* is an FPGA based component that controls bi-lateral wireless communication between the computer and the Fi-Wi headstage. The electrophysiological recording parameters and the LED stimulation sequence for optogenetics stimulation patterns are defined in the Doric Neuroscience Studio software and sent to the headstage via the console. The headstage can be also trigged by any external source (optical gate, tracking software, etc.). After the stimulation, the data collected are transferred via RF frequency over a distance up to 5 m.

The *Electrophysiology Console* can handle up to 2 headstages at the same time and each headstage can stream live 4 electrophysiological recording traces. The console and the headstage are in continuous communication which allows the activation, the cessation or the modification of the recording and stimulation parameters within 30 ms. The recorded data can be displayed, commented, saved and recalled within our software.

Main features:

- 2 antennas allowing the control/recording up to 2 headstages at the same time
- 4 Digital Input/Output TTL, 25 MS/s, via 4 BNC connectors (could be used as triggers)
- 4 Analog Output 5 V, 16 bits, 25 MS/s, via 4 BNC connectors (IN/OUT)
- 1 Digital communication SPI and LVDS via custom pinout HDMI connector
- USB2 connection to computer, cable included
- Compatible with Doric Neuroscience Studio with Fi-Wi interface
- All software updates included

ORDERING CODE: **EPC**

Optogenetically Synchronized Electrophysiology Accessories

Fi-Wi Headstage Charger

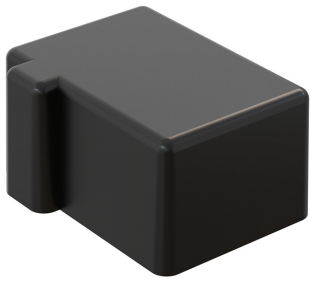
The *Fi-Wi Headstage Charger* is a device that can recharge the headstage battery in less than 1 hour. It can also inactivate unused headstages.

FiWi Headstage Charger

ORDERING CODE: FiWi_HSC

Fi-Wi Dummy Headstage

The *Fi-Wi Dummy Headstage* has the same shape and weight as the *Fiberless & Wireless Headstage*. The Fi-Wi Dummy Heastage can be secured on the implanted Fi-Wi Cannulas and allows the habituation of the weight and the feel of the real Fiberless & Wireless Headstage. This dummy is compatible with all the *Fi-Wi Opto-electric Cannulas*.



Fi-Wi Dummy Headstage

ORDERING CODE: FiWi_DHS

Fi-Wi Test Cannula

The *Fi-Wi Test Cannula* is a replica of the *Fi-Wi Opto-electric Cannula* that can be connected to any *Fiberless & Wireless Headstage*. The *Fi-Wi Test Cannula* can be used to test the headstage functions and the illumination patterns in the experiment location.

Fi-Wi Test Cannula

ORDERING CODE: FiWi_TC

Fi-Wi Cannula Implantation Holder

The *Fi-Wi Cannula Holder* is designed to secure the Fi-Wi Opto-electric Cannula during the implantation. The Fiberless & Wireless Headstage can be connected to the cannula when this one is on the holder, allowing the activation of the LED and the recording with the electrodes for a better positioning of the cannula during implantation. This holder offers the possibility of installing the cannula with the headstage in two different orientations.

Fi-Wi Cannula Implantation Holder

Notes:

- An adapter of 10 cm long can be added at one end of the holder (**SIA**; see Table 73).
- An optional clamp (**SCL**) can be used to secure the Fi-Wi Cannula Holder on stereotaxic apparatus.

ORDERING CODE: SCH_FiWi

Doric Neuroscience Studio

A wide variety of different instruments are used in neurophotonics experiments. Light sources, cameras, detectors, microscopes and data acquisition units are but a few of the many devices that can be required. To ensure optimal usability of our devices, we have created the *Doric Neuroscience Studio*, a complimentary software provided with equipment manufactured by Doric Lenses.

The *Doric Neuroscience Studio* is designed for integrated control of all devices required to perform a neurophotonics experiment. This allows convenient synchronization of output signal generation, device control, data acquisition and data processing. In addition, it comes with a suite of tools to perform basic analysis of behavior, photometric, electrophysiological and image-based data.

Software Modules

The primary purpose of the *Doric Neuroscience Studio* is the control and synchronization of the devices we manufacture. The software contains a module for each product requiring computer control. In addition, there are analysis modules for most forms of data acquired by these devices.

- Our **Light source** device modules are easy to use, as the software allows the generation of complex pulse patterns in many formats from the light source driver itself. These additional functions are otherwise inaccessible when the light sources are used as stand-alone devices.
- Our **Behavior tracking camera** device module allows the monitoring of an experimental subject while synchronized with other devices. Our analysis modules can be used to synchronize behavior video with photometric and electrophysiological data.
- Our **Photometry** device modules synchronize a multitude of input and output signals from electronic devices using our *Fiber photometry console*. This includes the generation of TTL and analog pulse sequences to control light

sources, as well as data acquisition from photodetectors and cameras. Our analysis module allows simple signal processing of photometric data.

- Our **Miniaturized fluorescence microscopy** device modules are used for light source control and data acquisition from *Miniature fluorescence microscopes*. Our **Image analysis** module performs basic image processing as well as automated cell detection for recorded microscope images.
- Our **Electrophysiology** device modules are used to send and receive signal from electrodes implanted in experimental subjects. These devices include both wired and wireless cannulas. Our analysis module does basic signal processing of electrophysiology data. Also included is an optrode simulation module that evaluates light propagation from an opto-electric cannula.

LED Illumination Accessories

Fan Power Adapter

The renewed line of Doric LED Drivers (**LEDD**) has a new connector pinout that does not include pins for fan power. It is thus essential to use a *Fan Power Adapter* when using *Connectorized Multi LEDs* or *Multi LEDs + Fiber-optic Rotary Joints*. This power adapter is suitable for up to 4 channels and sold with corresponding M8 cables.

Table 115: *Fan Power Adapter Ordering Codes*

Adapter	Compatible with	Ordering Code
	• LEDC2 • LEDC3 • LEDC4 • LEDFRJ (Multi LEDs)	**FPA**

Optical Breadboard for Connectorized LED

An *Optical Breadboard for Connectorized LED* is available to mount systems including two *Connectorized LEDs*.

Table 116: *Optical Breadboard Ordering Codes*

Breadboard	Compatible with	Ordering Code
	• CLED • CLDM	**LEDB**

Ce:YAG Fluorescent Illumination Accessories

Filter Holder for Ce:YAG Fiber Light Source

Doric standard bandpass filters (see Table 11) are sold already mounted in a *Filter Holder* and each Ce:YAG optical head is delivered with one empty filter holder model. Additional or replacement *Filter Holder* can be purchased using the following ordering code.

Table 117: *Filter holder for Ce:YAG Fiber Light Source*

Filter holder	Compatible with	Ordering Code
	• YBPF_525/030 • YBPF_549/015 • YBPF_559/034 • YBPF_582/075 • YBPF_593/040 • YBPF_612/069	**YFH**

Rotary Joints Accessories

Holders for Rotary Joints

Table 118: *Rotary Joints Holders Ordering Codes*

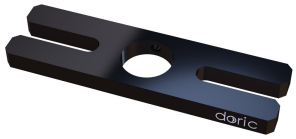
Rotary Joint Holders	Compatible with	Ordering Code
	• FRJ_1x1 • FRJ_1x1_PT	**Holder_FRJ_small**
	• FRJ_1x2 • FRJ_1x4 • ERJ • HRJ-OE • LEDFRJ (1ch)	**Holder_FRJ_large**
	• FRJ_2x2	**Holder_FRJ_2x2**
	• AHRJ-OE • AHRJ-OE_PT • AERJ	**Holder_ARJ**
	• AHRJ-OE_2x2 • AHRJ-OE_2x2_PT	**Holder_AHRJ-OE_2x2**

Table 119: *Holders for Rotary Joints Combinations - Ordering Codes*

Rotary Joint Holders	Compatible with	Ordering Code
	• ERJ + FRJ_1x1 • ERJ + FRJ_1x2	**Holder_ERJ**
	• AERJ + FRJ_1x1 • AERJ + FRJ_1x2	**Holder_AERJ**

Gimbal and Cable Holders for Rotary Joints

Table 120: *Ordering Codes for Rotary Joints Gimbal and Cable Holders*

Holder	Compatible with	Ordering Code
	• FRJ_1x1 • FRJ_1x1_PT • FRJ_1x2 • FRJ_1x4 • ERJ • HRJ-OE • LEDFRJ (1ch)	**GH_FRJ**
	• ERJ • HRJ-OE	**HCH**

Adapters for Rotary Joints

Table 121: *Ordering Codes for Rotary Joints Adapters*

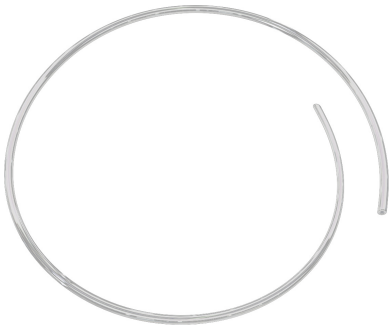
Harwin 12 to Omnetics 12 Adapter	Compatible with	Ordering Code
	• ERJ • AERJ • HRJ-OE • AHRJ-OE	**ADAPTER_HO12**

Cannulas Accessories

Polyethylene Tubing for Opto-fluid Cannulas

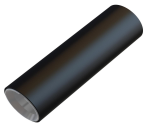
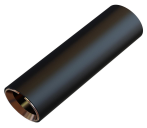
This *Polyethylene Tubing* is used to connect the Opto-fluid Cannulas to a liquid delivery system. The tubing is attached on the 25-gauge stainless insert of the OsFC or to the fluid injector in the case of the OmFC or the iOFC. The clear tube makes fluid flow visible. The 2-meter polyethylene tube has an inner diameter of 0.4 mm and an outer diameter of 0.8 mm.

Table 122: *OFC Polyethylene Tubing Ordering Codes*

OFC Polyethylene Tubing	Compatible with	Ordering Code
	• OsFC • OmFC • iOFC	**PT_OFC_2**

Mating Adapters

Table 123: *Mating Adapters Ordering Codes*

DESCRIPTION	PRODUCT	Ordering Code
Zirconia Sleeve ID 1.25 mm		**SLEEVE_ZR_1.25**
Zirconia Sleeve ID 2.5 mm		**SLEEVE_ZR_2.5**
Zirconia Sleeve ID 1.25 mm with Black Cover		**SLEEVE_ZR_1.25_BK**
Zirconia Sleeve ID 2.5 mm with Black Cover		**SLEEVE_ZR_2.5_BK**
Bronze Sleeve ID 1.25 mm		**SLEEVE_BR_1.25**
Bronze Sleeve ID 2.5 mm		**SLEEVE_BR_2.5**
Bronze Sleeve ID 1.25 mm with Black Cover		**SLEEVE_BR_1.25_BK**
Bronze Sleeve ID 2.5 mm with Black Cover		**SLEEVE_BR_2.5_BK**
FC/FC Mating Adapter - Square		**ADAPTER_FC_SQ**
FC/FC Mating Adapter - Round		**ADAPTER_FC_RO**
M3/M3 Mating Adapter - Square		**ADAPTER_M3_SQ**
M3/M3 Mating Adapter - Rectangular		**ADAPTER_M3_RC**
SMA/SMA Mating Adapter		**ADAPTER_SMA**

Connectors

M3 Connectors offer a secured, light and small connection for multimode fibers. The standard material of the flange and the screw is titanium. Alternative to the titanium is the peek plastic.

M3 Connector - parts included: ferrule, screw, strain relief

Table 124: *M3 Connectors Ordering Codes*

	Ordering Code	
Ferrule Inner Diameter (µm)	**Titanium**	**Peek Plastic***
125	**CM3_125**	**CM3(P)_125**
127	**CM3_127**	**CM3(P)_127**
230	**CM3_230**	**CM3(P)_230**
235	**CM3_235**	**CM3(P)_235**
245	**CM3_245**	**CM3(P)_245**
330	**CM3_330**	**CM3(P)_330**

*Peek plastic can be used instead of metal for MRI compatibility.

Dust Caps

Table 125: *Dust Caps Ordering Codes*

DESCRIPTION	PRODUCT	Ordering Code
SMA Receptacle Cap		**CAP_SMA**
FC Receptacle Cap		**CAP_FC**
Ferrule 1.25 mm Cap		**CAP_Ferrule_1.25**
Ferrule 2.5 mm Cap		**CAP_Ferrule_2.5**
M2 Receptacle Cap		**CAP_M2**
M3 Receptacle Cap		**CAP_M3**
Stainless Steel M3 Receptacle Cap		**CAP_M3_S**
Guiding Socket Receptacle Cap		**CAP_GS**

All our products are supplied with the appropriate dust caps.

Cables

Table 126: *Cables Ordering Codes*

DESCRIPTION	PRODUCT	Ordering Code
M8 male / M8 female, 1.5 m long		**Cable_M8-M8**
BNC / BNC, 0.6 m long		**Cable_BNC-BNC**

Other Accessories

Table 127: *Other Accessories Ordering Codes*

DESCRIPTION	PRODUCT	Ordering Code
Cleaver		**Cleaver**
1.25 mm Fiber-optic Swab (25/bag)		**Swab**

For any questions or comments, do not hesitate to contact us by:

Phone 1-418-877-5600

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