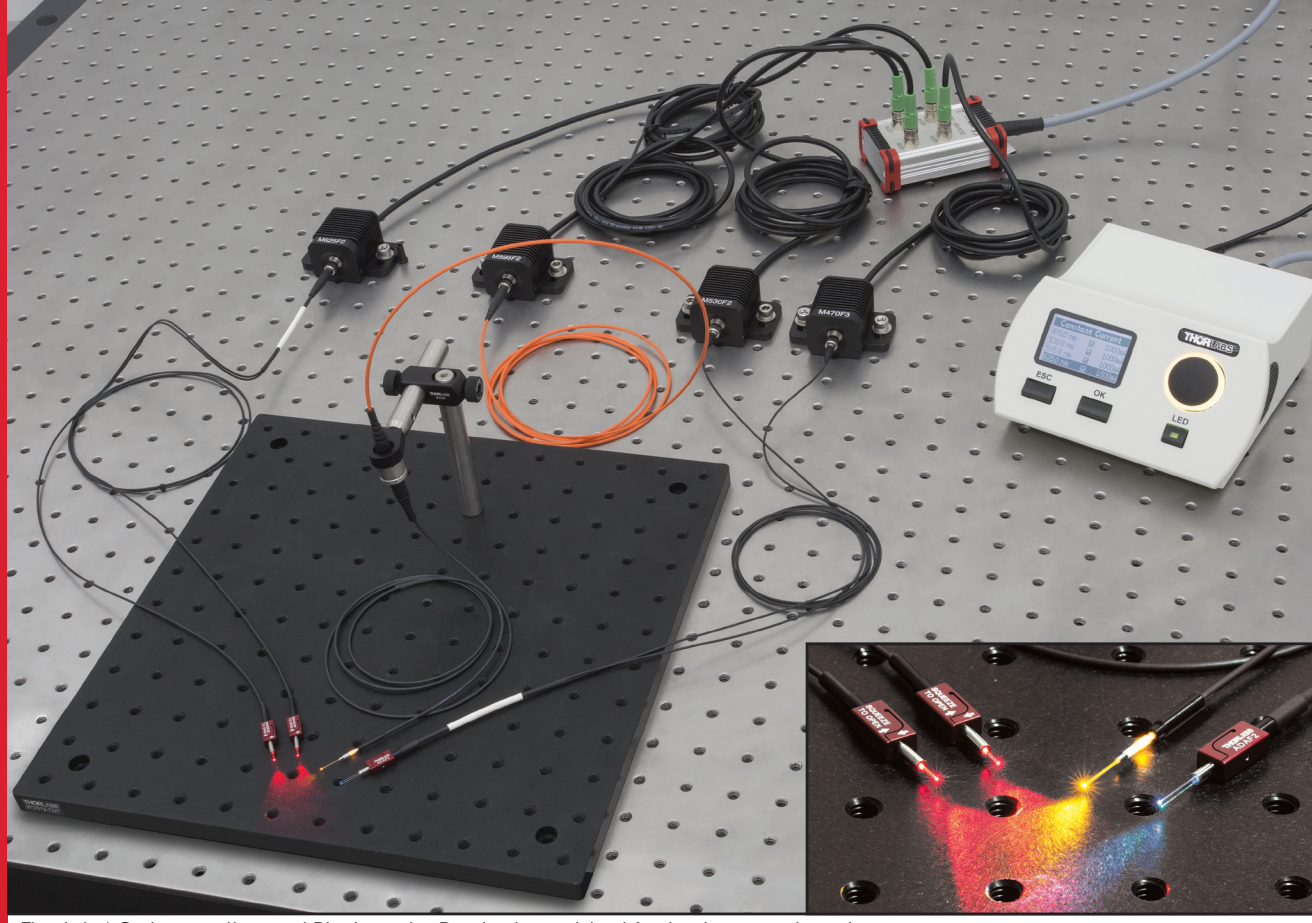
Optogenetics & Photometry



Thorlabs' Optogenetics and Photometry Products are ideal for *in vivo* experiments.

Fiber-Based Optogenetics & Photometry

Optogenetics is a ground-breaking field of modern neuroscience research that uses photonics tools to better understand neural networks. Light is used to directly stimulate or silence neurons, enabling scientists to study the linkages between specific neurons and behavior, as well as develop treatments for neurological diseases and brain-related injuries. Fiber photometry, an all-optical optogenetics technique, provides insight into the activity and behavior of neuronal populations by stimulating and measuring fluorescence signals that correspond to calcium dynamics.

Thorlabs offers a comprehensive suite of products tailored for *in vivo* neuroscience and optogenetics applications. All components needed for an experiment, such as LEDs, patch cables, rotary joints, cannulae, stereotaxic tools, and accessories, can be purchased through our online catalog with same-day shipping. Each product is designed with input from the neuroscience community, providing solutions for those entering the field and those with more specialized applications. Customers can also choose a pre-configured selection of products, and then add/replace items via our customizable optogenetics kits.

THORLABS

Overview: Optogenetics

Optogenetics is a modern neuroscience technique for controlling neural activity using light, enabling the real-time *in vitro* or *in vivo* study of behavior and disease states related to neuron networks. Using light has several advantages over other methods for neuromodulation, such as a temporal resolution on the order of milliseconds that matches natural neuron activity, the ability to use different wavelengths to stimulate multiple sets of neurons independently, and easy scalability to *in vivo* experiments.

Optogenetics Components

As a leading supplier to the neuroscience community, Thorlabs' optogenetics product line contains all the key components necessary to build an optogenetics setup including light sources, patch cables, interconnects, cannulae, implant aids, and more. Although components are sold separately on our website, all of them are designed and tested to work with each other.

Build Your Setup Using Thorlabs' Optogenetics Products

Light Source

Driver + Fiber-Coupled LED

or

473 nm Multimode Laser

Light Guide

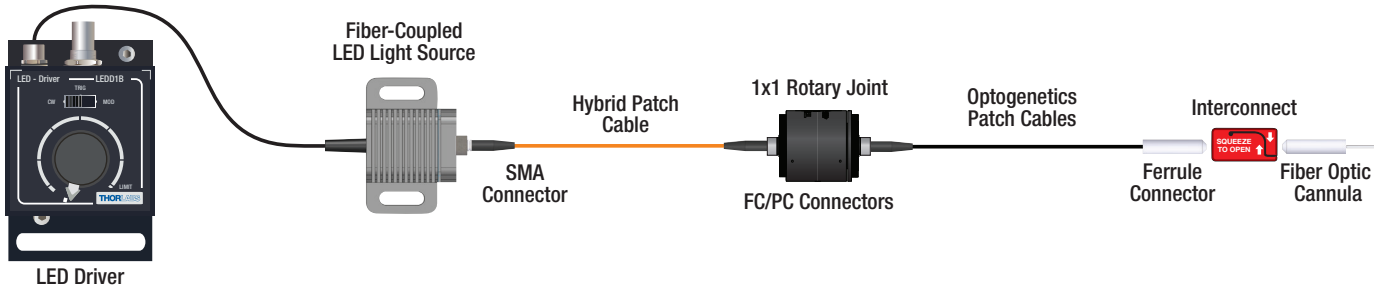
Single-Site Stimulation

Patch Cables, Rotary Joint, and Integrated Rotary Joint Patch Cables

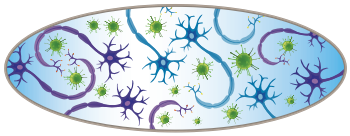
Bilateral Stimulation

Patch Cables, Rotary Joint Splitter, Bifurcated Fiber Bundles, and Couplers

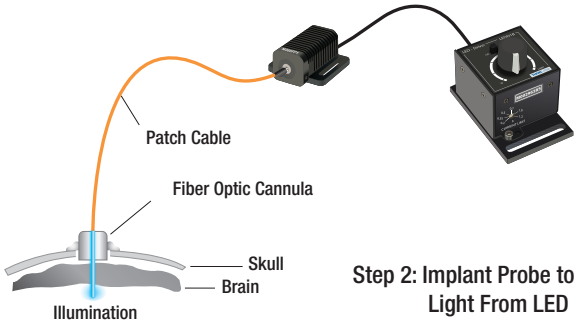
Example Single-Site Stimulation



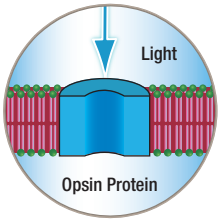
Typical *In Vivo* Procedure



Step 1: Express Light-Sensitive Opsins in Targeted Neurons



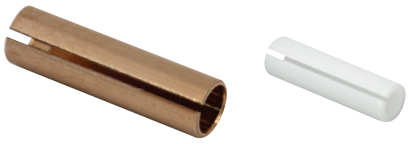
Step 2: Implant Probe to Deliver Light From LED



Step 3: Light Stimulus Triggers Neuron Firing

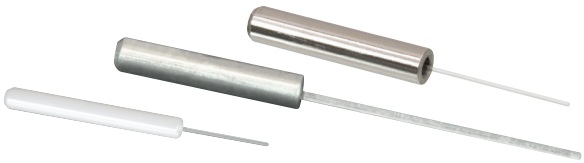
Interconnect

Interconnects for Ø1.25 mm and Ø2.5 mm Ferrules



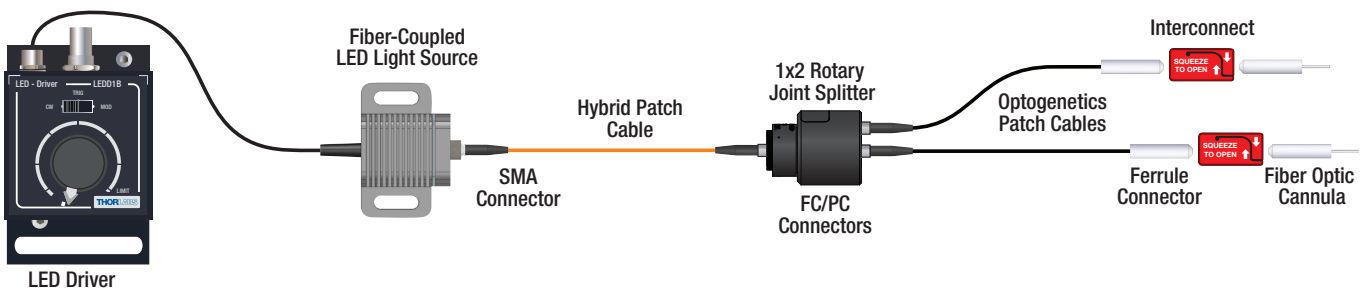
Phosphor Bronze and Ceramic Mating Sleeves for Ø1.25 mm and Ø2.5 mm Ferrules

Cannula



Variety of Lengths, Materials, and Fiber Options Available

Example Bilateral Stimulation



Overview: Fiber Photometry

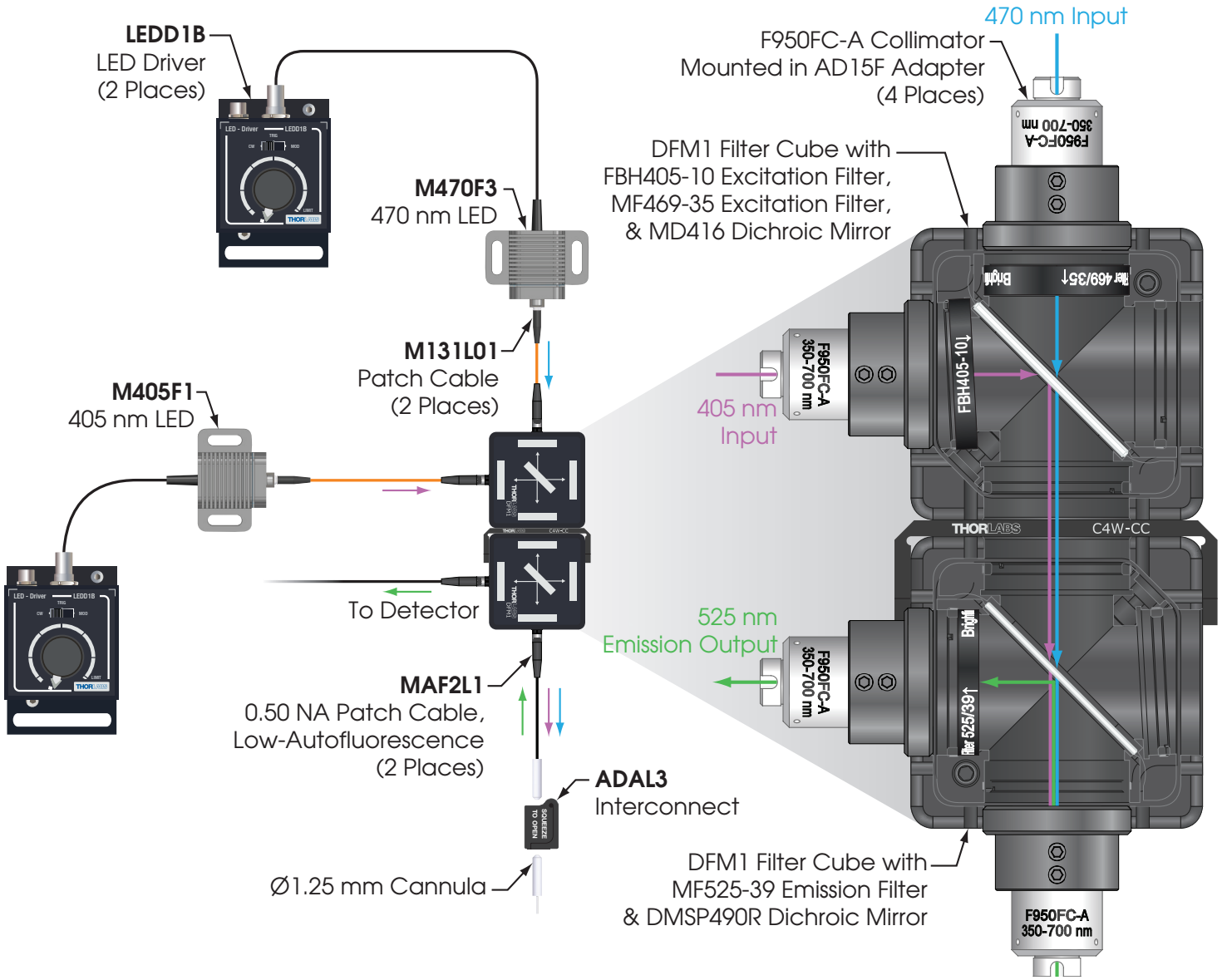
Fiber photometry is an optogenetic technique that both stimulates and collects fluorescence from fluorescent indicators, like GCaMP variants, in a freely moving specimen. This method detects changes in the fluorescence intensity from populations, allowing for calcium dynamics related to neuronal activity or activity patterns in neural circuits to be measured with fast acquisition times.

Fiber Photometry Components

In addition to generalized optogenetics equipment, Thorlabs offers the components essential to constructing a fiber photometry setup. Multiple light sources can be used to stimulate a sample by using a series of mounting cubes that hold both dichroic and fluorescence filters, as shown in the example setup below. Detailed information about Thorlabs' offerings for the individual components of a fiber photometry setup can be found in the following pages.

Applications

- Monitor and Record Neuronal Activity
- Optogenetic Control of Neurons
- Population Dynamics Studies
- Analyze Activity Patterns in Neural Circuits
- Record Calcium Dynamics



To excite GCaMP6 in a neuronal population of interest, 470 nm and 405 nm LED sources are used to hit the maximum absorption and isosbestic points of the fluorophore, respectively. Modulating the output of the excitation sources allows the two emission signals to be read independently, providing information about signal variations that can be attributed to system noise.

Fiber-Coupled LEDs

LEDs are commonly used for *in vivo* optogenetic and photometry experiments as they provide high-power output over a broad range of wavelengths and exhibit superior illumination homogeneity compared to lasers. Additionally, electronic modulation of a fiber-coupled LED may be preferred over using a mechanical shutter or other modulation technique.

Blue, 470 nm Light from the M470F3 is Ideal for ChR2 Excitation

Features

- UV (385 nm) to Red (625 nm) LEDs Target Common Opsins
- Compatible with Fiber Optic Cannulae and Optogenetics Patch Cables via SMA Interface
- Modulate Output Using Thorlabs' LED Drivers

Specifications

LED Item #	Wavelength	Common Proteins	Output Power[a]	Color
M385F1[b]	385 nm	EBFP, moxBFP	10.7 mW	UV
M405F1[b]	405 nm	mmilCFP, hcriGFP	3.7 mW	UV
M430F1[b]	430 nm	ChR2	7.5 mW	Violet
M455F3	455 nm	ChIEF, bPAC	24.5 mW	Royal Blue
M470F3	470 nm	ChR2, ChR2-SFO, GFP	21.8 mW	Blue
M490F3	490 nm	Rh-CT, ChR2 (E123A)	3.1 mW	Blue
M505F3	505 nm	ChRGR, Opto-α1AR, Opto-β2AR	11.7 mW	Cyan
M530F2	530 nm	C1V1, VChR1	9.6 mW	Green
M565F3	565 nm	Arch, VChR1-SFO	13.5 mW	Lime
M595F2	595 nm	ChR2-SFO, eNpHR3.0	11.5 mW	Amber
M625F2	625 nm	ReChR	17.5 mW	Red

a. Typical output power measured with a Ø400 µm Core, 0.39 NA multimode fiber.
b. Precautions must be taken to prevent looking directly at the UV light and UV light protective glasses must be worn to avoid eye damage. Exposure of the skin and other body parts to UV light should be avoided.

LED Drivers

These LED drivers are compatible with the fiber-coupled LEDs above and can also accept an external signal to modulate the LED (the DC2200 also has internal modulation modes). Each LED is equipped with an integrated EEPROM chip for storing key information about the LED that can be read by the DC2200, DC4100, and DC4104 drivers.

Specifications

Item #	LEDD1B	DC2200	DC4100	DC4104
Photo				
Channels	1	1	4 – Simultaneous Modulation	4 – Independent Modulation
Maximum LED Current	1.2 A	2.0 A	1.0 A per Channel	1.0 A per Channel
Modulation Frequency	5 kHz (External)	20 Hz to 100 kHz (Internal)[a] DC to 250 kHz (External)[b]	100 kHz (External; Sine Wave)	100 kHz (External; Sine Wave)
EEPROM Compatible	No	Yes	Yes	Yes

a. Sine, Square, or Triangle Waveforms
b. For modulation not exceeding 20% of full scale current. Other waveforms accepted, but maximum frequency will be reduced.

S1FC473MM

Multimode Laser for Optogenetics

The S1FC473MM Fiber-Coupled Laser provides 50 mW of output power and a wavelength of 473 nm, making it an ideal source for exciting channelrhodopsin. It includes a pigtailed Fabry-Perot laser diode and current controller in a single benchtop unit. The unit's output can also be externally modulated at 5 kHz full depth / 30 kHz small signal.

Specifications

Item #	Wavelength	Output Power	Modulation	Bulkhead Connector
S1FC473MM	473 nm	50 mW	5 kHz (Full) / 30 kHz (Small Signal)	FC/PC

Rotary Joints

RJ1
1x1 Rotary Joint

RJ2
1x2 Rotary Joint Splitter

The RJ1 1x1 Rotary Joint and RJ2 1x2 Rotary Joint Splitter (50:50) are used to prevent fiber damage caused by specimen movement, making them essential components for both optogenetics and fiber photometry experiments. Each rotary joint features precision bearings for extremely smooth rotation and low signal strength variations as the joint rotates. A low start-up torque of <150 µN·m ensures that the joint will rotate freely as the specimen moves. The input and output ports have a tightly toleranced insert that enables repeatable and optimized alignment between patch cables and rotary joint.

Tested with both LEDs and multimode laser sources, these rotary joints show low transmission variation during rotation when used with FC/PC fiber patch cables with a ≥Ø200 µm core and 0.22 to 0.50 NA, reducing artificial signal variations.

Specifications

Item #	Rotational Variation of Transmission	Typical Transmission		Start-Up Torque	Wavelength Range
		LED[a]	Laser[a]		
RJ1	±1.5% (Typ.)	>60%	>70%	<150 µN·m	400 – 700 nm
RJ2	±1.75% (Typ.)	>30%[b]	>35%[b]		

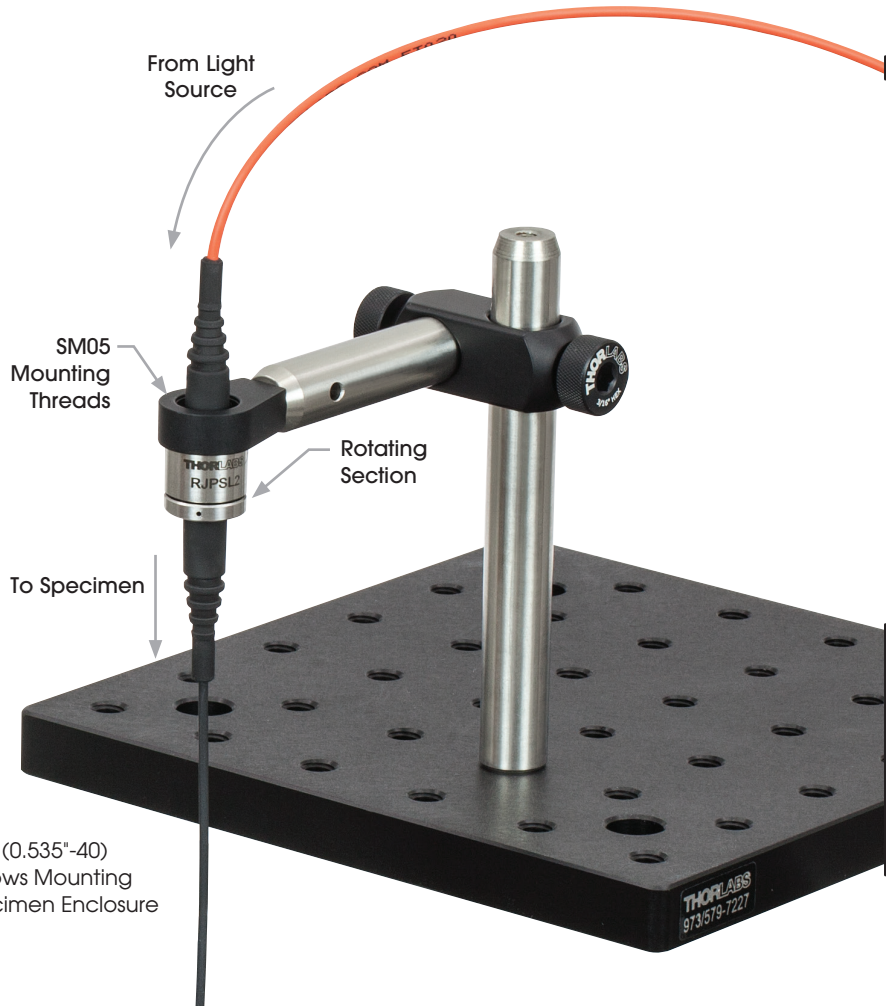
a. Specified for patch cables with the recommended fiber core diameter and NA.
b. Transmission per Output Leg

Rotary Joint Patch Cables

These patch cables feature a built-in rotary joint interface that allows the cable to freely rotate, reducing the risk of fiber damage during an experiment. Each rotary joint is precision machined and has sealed metal bearings for extremely smooth rotation, long lifetime, and low signal strength variations as the joint rotates. The following custom options are available, many of which are available from stock.

Rotary Joint Patch Cable Options

Core Diameters Available	200 or 400 µm
Numerical Aperture	0.39
Transmission	>63% (<2.0 dB) Through Rotary Joint
Transmission Variation	±8% (±0.4 dB)



Standard Patch Cables

Fiber optic patch cables are used to connect a light source to an implanted cannula. Many options are available from stock to suit a variety of experimental requirements.

M87L01
Patch Cable with SMA905 Connector on One End and LC Ferrule on the Other

Fiber Options

- Core Diameter: 105 to 400 µm
- Numerical Aperture: 0.22, 0.39, or 0.50

Cable Jackets

Ø1/16" Heat-Shrink Tubing

Ø2.0 mm PVC Tubing

Ø2.3 mm Stainless Steel Tubing

Connector and Ferrule Options

Input Side	Output Side
 SMA905 Connector	 LC (Ø1.25 mm) Ferrule
 FC/PC Connector	 FC (Ø2.5 mm) Ferrule

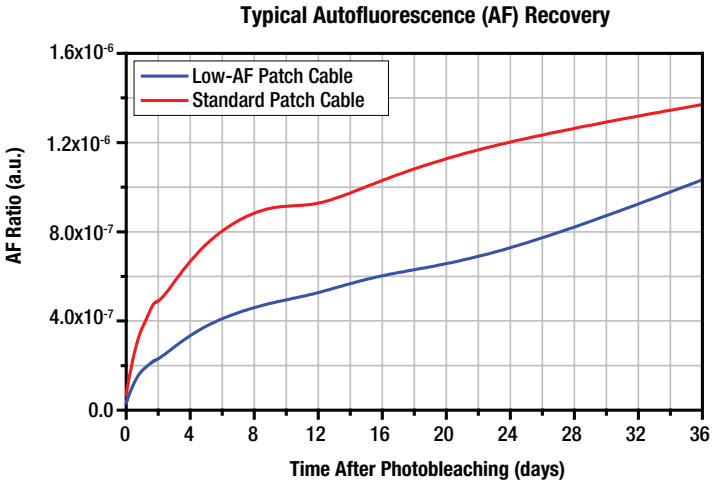
Low-Autofluorescence Multimode Patch Cables

Manufactured with components that reduce the emitted autofluorescence (AF) in the visible spectrum, these patch cables are suitable for fiber photometry applications where high sensitivity is required to measure the changes in fluorescence that indicate neural activity within a specimen. Typical applications for these patch cables include GFP excitation (470 nm) and RFP excitation (565 nm).

Low-AF is tested and verified for 470 nm and 565 nm excitation. For optimal performance, low-AF patch cables should undergo a photobleaching procedure prior to use to minimize autofluorescence emissions.

Features

- 400 µm Core, 0.50 NA Multimode Fiber
- Non-Specimen End:
  - FC/PC Connector
- Specimen End:
  - FC/PC Connector
  - Ø1.25 mm Ferrule (LC)
  - Ø2.5 mm Ferrule (FC)



Plot comparing the recovery of autofluorescence for a low-autofluorescence (AF) and standard patch cable after photobleaching at 470 nm for 12 hours.

MAF2L1
Low-AF Patch Cable with FC/PC Connector and Ø1.25 mm Ferrule

Patch Cables & Couplers

Bifurcated Fiber Bundles

BFYF1LS01
Bifurcated Fiber Bundle, Ø200 µm Core, 0.22 NA, SMA905 to Ø1.25 mm Ferrules, 1 m Long

Features

- FC/PC or SMA905 Connector
- Ferrules: LC (Ø1.25 mm) or FC (Ø2.5 mm)
- Fiber: Ø200 µm or Ø400 µm Core; 0.22 or 0.39 NA

Our bifurcated multimode fiber optic cables, also known as Y-cables, are ideal for optogenetics experiments that require simultaneous *in vivo* stimulation. The ceramic ferrules are compatible with our implantable fiber optic cannulae, while the SMA905 or FC/PC connector can be connected to an LED light source.

Dual-Core Multimode Patch Cables

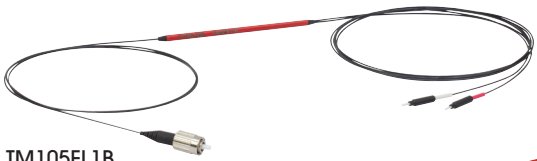
Features

- Two Ø200 µm Core, 0.39 NA Fibers, 700 µm Core Spacing
- FC/PC or SMA905 Input Connectors
- Dual-Core FC Stainless Steel Ferrule

Thorlabs' dual-core multimode fiber optic patch cables are specifically designed to be used with our implantable dual-core fiber optic cannulae. They allow high-intensity light from two different sources to be implanted within a specimen in close proximity (~1 mm), and are therefore ideal for applications such as bilateral stimulation or silencing.

Dual-Core Patch Cable are Designed to Work with our Interconnects and Dual-Core Implantable Cannula

Fiber Optics Couplers



TM105FL1B
1x2 Coupler with Ø105 µm Core, 0.22 NA Fiber

TT200SS2A
2x2 Coupler with Ø200 µm Core, 0.39 NA Fiber

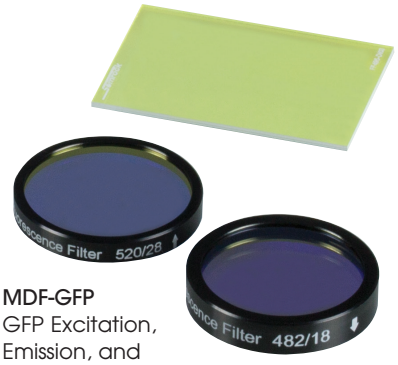
Features

- 1x2 or 2x2 Configurations
- Fiber: Ø105 µm to Ø200 µm Core; 0.22 or 0.39 NA
- FC/PC or SMA905 Connector
- LC (Ø1.25 mm) or FC (Ø2.5 mm) Ceramic Ferrules

Both 1x2 and 2x2 couplers can be used to split light from a single LED or laser evenly into the two output legs. This configuration is commonly used for bilateral stimulation where two fiber optic implants need to be illuminated using a single light source. 2x2 couplers can also be used in simultaneous stimulation applications where two light sources are combined in a single fiber to illuminate at two wavelengths using a single implant.

Fluorescence Filters

Thorlabs offers excitation, emission, and dichroic filters specifically designed for fiber photometry, as well as fluorescence imaging applications. Manufactured to high optical performance specifications and designed for durability, each filter features a >90% transmission over the wavelength band and a sharp cutoff (T<0.001%) outside this range. Since standard fluorescence measurements generally require an excitation, emission, and dichroic filter, filter sets for common fluorophores are available. A list of all compatible fluorophores and their kits, as well as additional bandpass and laser line filters, can be found on our website www.thorlabs.com.



MDF-GFP
GFP Excitation, Emission, and Dichroic Filters

Selected Filter Sets

Item #	Design Fluorophore	Excitation Band	Emission Band	Dichroic (Reflection/ Transmission Band)
MDF-WGFP	Wild Type GFP (WGFP)	445 ± 22.5 nm	510 ± 21 nm	415 - 470 nm / 490 - 720 nm
MDF-GFP	Green Fluorescent Protein (GFP)	469 ± 17.5 nm	525 ± 19.5 nm	452 - 490 nm / 505 - 800 nm
MDF-GFP2	Green Fluorescent Protein (GFP) / Alexa Fluor® 488	482 ± 9 nm	520 ± 14 nm	350 - 488 nm / 502 - 950 nm
MDF-TOM	tdTomato	531 ± 20 nm	593 ± 20 nm	350 - 555 nm / 569 - 950 nm

Cage Cubes for Fluorescence Filters

DFM1
Cage-Compatible Cube for Mounting Fluorescence Filters

Our filter cubes are made to hold fluorescence filter sets, making them ideal of integration into fiber photometry setups. Each filter cube has two excitation and two emission ports, as well as an insert to hold a rectangular optic, such as a dichroic filter or beamsplitter. Two orientations, left- and right-turning, are available and each filter cube is cage-system compatible.

Accepted Filter Dimensions

Type	Dimensions	Thickness
Excitation	Ø25 mm	5.0 mm
Emission	Ø25 mm	3.5 mm
Dichroic	Min: 25.0 mm x 35.6 mm Max: 25.2 mm x 36.0 mm	Min: 1.0 mm Max: 2.0 mm

High-NA Achromatic Collimators

Thorlabs offers 0.54 NA achromatic collimators ideal for use with our high-NA, low-autofluorescence multimode fiber patch cables in fiber photometry applications. These collimators feature an achromatic doublet for high performance across the visible spectrum with low spherical aberration, and are AR coated for 350 to 700 nm. The collimator housing accepts either an FC/PC 2.2 mm wide key or an SMA905 connector.

Front Back

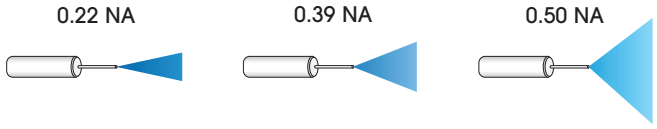
F950FC-A
FC/PC High-NA Multimode Collimator

Cannula & Interconnects

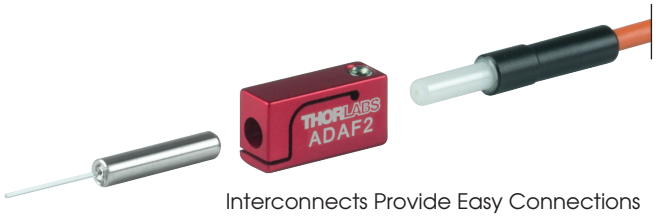
Features

- Implant Delivers Light through Multimode Fiber into Tissue
- Lightweight Implants Minimize Stress on the Specimen
- Many Fiber and Ferrule Combinations Available (See Table Below for Options)
- Contact Tech Support to Request Custom Cannulae

Thorlabs offers a wide selection of fiber optic cannulae from stock (see table below for options) and also manufactures custom cannulae upon request.



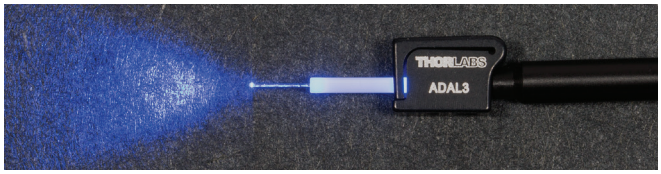
Numerical Aperture (NA) defines the angle of the cone of light leaving the fiber tip at the end of the cannula.



Interconnects Provide Easy Connections Between a Patch Cable and Cannula

Cannulae Tip Options

Cannula With Diffuser Tip



Cannula Without Diffuser Tip

Ø1.25 mm Ceramic

Ø2.5 mm Ceramic

Ø1.25 mm Stainless Steel

Ø2.5 mm Stainless Steel

Ø2.5 mm Stainless Steel, Dual Core

Fiber Optic Cannulae Options

Cannula Type	Standard (Output Angle Based on Fiber NA), Diffuser Tip (Highly Scattering with Wide Angle Output), or Dual Core
Core Diameter	105 µm, 200 µm, 300 µm, or 400 µm
Numerical Aperture	0.22, 0.39, or 0.50
Ferrule Type	LC (Ø1.25 mm) or FC (Ø2.5 mm)
Ferrule Material	Ceramic (Zirconia) or Stainless Steel
Fiber Length	2 mm, 5 mm, 10 mm, or 20 mm (Cleaved); 50 mm (Uncleaved)

Interconnects & Mating Sleeves

ADAL3

ADAF2

ADAL1

ADAF4-5

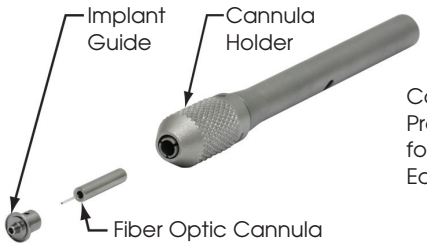
Interconnects and mating sleeves provide low-loss mating between optogenetics patch cables and fiber optic cannulae. They are compatible with both stainless steel and ceramic (zirconia) ferrules. Interconnects facilitate easy connections and disconnections from an implanted cannula, requiring >80% less force to disconnect compared to mating sleeves. Mating sleeves are preferred for very lightweight (~0.18 g), low-profile connections between a patch cable and cannula.

Specifications

Item #	Type	Compatible Ferrule Size	Weight	Disconnect Force
ADAL3	Interconnect	LC (Ø1.25 mm)	0.4 g	0.89 N (0.2 lbf)[a]
ADAF2		FC (Ø2.5 mm)	1 g	4.4 N (1.0 lbf)[a]
ADAL1	Ceramic (Zirconia) Mating Sleeve	LC (Ø1.25 mm)	0.05 g	4.23 N (0.95 lbf)
ADAL4-5[b]	Phosphor Bronze Mating Sleeve		0.06 g	3.15 N (0.71 lbf)
ADAF1	Ceramic (Zirconia) Mating Sleeve	FC (Ø2.5 mm)	0.18 g	25.83 N (5.81 lbf)
ADAF4-5[b]	Phosphor Bronze Mating Sleeve		0.26 g	23.53 N (5.29 lbf)

a. Force needed to disconnect a ferrule when squeeze force is applied to quick release. b. Sold in Packs of 5

Prior to an *in vivo* optogenetics experiment, a cannula is implanted within the specimen. A stereotaxic apparatus allows the surgeon to precisely position the cannula during implant surgery. Thorlabs' cannula holders and adapters provide compatibility between stereotaxic equipment and cannulae. Implant guides provide an improved interface between the cannula and specimen, with better adhesion and stability during an experiment.



Cannula Holders Provide an Interface for Stereotaxic Equipment

Cannula Holders and Adapters

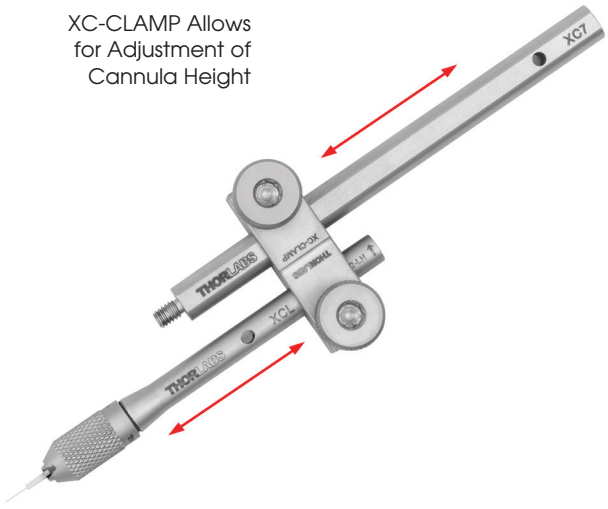
The XCL and XCF Stereotaxic Cannula Holders are designed to securely hold a fiber optic cannula when using stereotaxic guidance to implant the cannula. For easy sterilization and repeated use, the holder and chuck are constructed entirely using stainless steel. The chuck is designed to hold a cannula without slipping during implantation. It can be tightened and loosened by rotating the knurled sleeve.

These cannula holders can be attached directly to an adapter arm by using the left-handed 8-32 tap at the end of the cannula holder. Alternatively, the XC-CLAMP can be used to allow for coarse height adjustment between the cannula holder and the XC7 adapter arm.

Features

- Stainless Steel Construction for Easy Sterilization
- Use Less Force than Competing Solutions, Reduces Stress on the Specimen

XC-CLAMP Allows for Adjustment of Cannula Height



Specifications

Item #	Description
XCL	Holder for Ø1.25 mm Cannula
XCF	Holder for Ø2.5 mm Cannula
XC5	Adapter Arm, Ø5 mm
XC7	Adapter Arm, Ø7.9 mm
XC-CLAMP	Adapter Clamp for Ø7.9 mm Adapter Arm

Cannula Implant Guides

OGL
Implant Guide for LC (Ø1.25 mm) Cannula

OGF
Implant Guide for FC (Ø2.5 mm) Cannula

Features

- Improves Adhesion and Stability During Implantation
- Compatible with Ø1.25 mm and Ø2.5 mm Fiber Optic Cannulae with ≥5 mm Length
- Mounting Surface with Grooved Ring for Dental Cement
- Lightweight Surgical Titanium Construction (≤0.11 g)
- Weep Holes for Glue and Epoxy to Secure a Cannula

The OGL and OGF Cannula Implant Guides provide guidance and stability for a fiber optic cannula during an implantation procedure. The bottom surface of each implant guide features a roughened surface and circular groove (see images above) that increases the surface area available for dental cement and improves adhesion to the specimen. A 1.6 mm long protrusion on the implant guide helps stabilize the guide when implanted. Each implant is constructed using lightweight surgical titanium (≤0.11 g) which can be sterilized prior to use.

Worldwide Support

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