

Very Simple Off-The-Shelf Laser and Viral Injector Systems for In Vivo Optical Neuromodulation

V2.0

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Please note, part numbers for products are liable to change at any time; contact the manufacturer for updates, and please notify the authors of this white paper as well. Feedback always welcome!

0. Introduction

This document describes systems that may be less flexible than described elsewhere in this site, but have the advantage of being very easy to use. As always, the landscape of optics and hardware is a moving target and it's important to call vendors (or feel free to contact us) as things are changing.

1. Fiber-coupled lasers

You can order pre-fiber coupled lasers from Shanghai Laser or other reliable inexpensive laser companies. For example, we'll go through the examples for Shanghai Laser:

<http://www.lasercentury.com/product.asp?id=47>

473 nm can hit ChR2 or Mac, 532 nm can hit Arch or Halo (green lasers are the cheapest), and 593 nm can hit Arch or Halo. You can specify the fiber diameter (e.g., 100 or 200 microns might be typical).

Also ask for the academic discount; can be cheaper.

You will want to drive the laser with a digital computer pulse, e.g. a TTL pulse. If you are going to buy a 10 kHz/30 kHz TTL-coupled laser, calculate the power so that the radiant flux out the tip is at least 200 mW/mm^2 – perhaps up to 1000 mW/mm^2 or more, if you're using short pulses of light (but be aware of heating! Illuminating at much more than 200 mW/mm^2 for a long time is damaging to the brain, most likely). For example, for a 100 micron diameter fiber attached to a 532 nm laser, and a desired irradiance at the tip of 200 mW/mm^2 , the needed to get the desired output would be $\pi * (0.05 \text{ mm})^2 * 200 \text{ mW/mm}^2 = 1.5 \text{ mW}$. So with a coupling efficiency of 50% (which is what they quote for a 100 micron diameter fiber attached to a 532 nm laser on a Shanghai Laser), you'll need a 3 mW laser... but a much better way (especially if you are going to couple to a downstream commutator, or a splitter-like device called an FC-PC connector, then you should get a much brighter laser to compensate for losses) is to get a more powerful laser, and then use analog amplitude and temporal control to precisely dial down the amplitude. **This gives you more control.** Having TTL control is okay, but then you can't change the amplitude easily, if you buy a pre fiber-coupled laser (where you can't just stick a neutral density filter in the beam). You can try 10 kHz/30 kHz analog control – which will let you modulate the light power by an analog light source. Note that analog controlled lasers should be calibrated so you know what the output power is, for a given analog input.

Your fiber might break, in which case you might need to attach a new fiber to a connector and replace the fiber. Be sure that you know what connector type (FC or SMA) you order; you may need to order a connector kit (e.g., from Ocean Optics or Thorlabs or other sources) to repair the fiber or add a new connector. The SMA connector seems to be very common, but if you're using a Doric commutator that fits the FC/PC connector, then stick with FC/PC.

In all cases, know your laser vendor's return policy. You'll probably want to get your laser, test out its performance with a power meter (e.g., Newport 1815C with 818-SL detector and an OD3 attenuator option), and validate it both under CW and pulse modes. Get a quote before purchasing. Make sure the fiber end is as you want it (e.g., free).

Other companies worth exploring (we ourselves have not tried all of these): Laserglow, RGLase (<http://www.rglase.com/>), <http://www.thinklasers.com/fiber-coupled-lasers.html>, Shanghai Dream Laser (*not* the same as Shanghai Laser!)

You can get an optical commutator for in vivo behavior, this will release torsion in the optical fibers caused by the animal's movement; it can be purchased from Doric Lenses www.doriclenses.com.

2. Controlling the laser

For a digital or analog laser: you can control it easily with a computer-controlled DAC. This is a commodity – you can use the Molecular Devices Digidata, for example, if you have a patch clamp rig already there. NiDaq boards are easy to use and inexpensive, and many labs have them already. Or if you have any kind of pulse generator (e.g., Master-8) or function generator, you can control a TTL-controllable laser.

For NiDaq boards: it's easiest to program them through the National Instruments calls from MATLAB (Data Acquisition Toolbox).

NiDaq boards: consider the following:

NI USB-6008 (note: for analog lines, only 150 updates/second)

NI USB-6211 (up to 250ksamples/second analog output)

NI USB-6221 (even faster)

And so forth.

2. THE INJECTOR

If you want a good, simple, single point injector, use the WPI UMP3-1 stereotax-mounted injection pump with controller. In order to have a 35 or 36 gauge needle you need to order from WPI along with their 10 microliter syringe; the needle tip is easily bent, however, making consistent injections over a long period of time unlikely. Somewhat more robust: you can insert a Hamilton syringe directly into the pump (use a 33 gauge needle, say), and it can then suck up and inject virus. (E.g., you can get a Hamilton 33-gauge needle six pack (7762-06) and a 10 microliter syringe (7653-01) from www.hamiltoncompany.com/Syringes.)

If you want a powerful, more flexible, but harder to use pump that can infuse virus through flexible polyethylene tubes attached to syringes mounted in the pump, use the Harvard Apparatus PhD2000 displacement pump. Place the syringes in the pump, attach tight-fitting polyethylene tubes to them, and insert thin needles (36 gauge steel cannulas, or pulled glass micropipettes) into the ends.

In either case, fill the entire apparatus with silicone oil or another oil so that there is no air in the system. Then at low speed suck the virus into the tip of the needle. Insert the needle into the brain like an electrode. Infuse slowly (0.1 uL/min), then wait 10-30 mins afterward for the virus to diffuse, before withdrawing the needle slowly.