

**Microscope Detection Unit  
(MDU-2, for inverted/upright microscopes)**

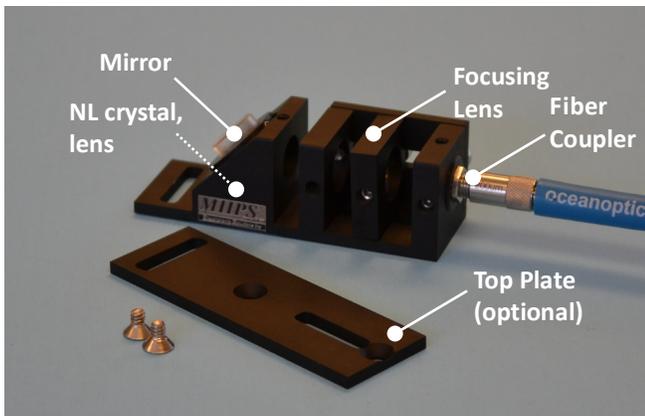
User Manual

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## 1. General Description and Specifications

The MIIPS<sup>®</sup> Microscope Detection Unit, hereafter referred to as “MDU”, is designed to facilitate MIIPS<sup>®</sup> pulse measurement and compression at the focal plane of a microscope. Its major components are listed in Fig. 1. The actual look might vary. MDU contains a nonlinear crystal for second harmonic generation (SHG) as well as other optical elements to separate SHG photons from the laser light and couple them into a fiber. The nonlinear crystal is mounted on a 130-160 $\mu$ m thick cover slip (Corning<sup>®</sup> cover glass #1), and its parameters are optimized for laser pulses from a typical Ti:Sapphire laser (700-900nm range), generating SHG light within 350-450 nm band. Notice that for transform limited pulses with a Gaussian spectrum, the SHG bandwidth  $\Delta\lambda_{SHG}$  is related to the bandwidth of the fundamental laser spectrum  $\Delta\lambda_L$  as  $\Delta\lambda_{SHG} = \Delta\lambda_L / (2\sqrt{2})$ ; for pulses with high order dispersion, narrower bandwidths will be obtained. The MDU is designed to be placed just like a microscope slide, and its output is compatible with the compact fiber-coupled spectrometer used for MIIPS<sup>®</sup>. MDU specifications are summarized in the Table below.



**Fig.1.** Microscope Detection Unit for inverted and upright microscopes (MDU-2). For the upright geometry, the top plate is attached and the unit is flipped. The nonlinear (NL) crystal parameters, mirror size/type, filter type/location, and the dimensions of the top plate might vary.

**Table.** MDU specifications

Dimensions	3.5"×1"×1.125" (main unit); 3.5"×3"×0.125 (top plate)
Weight	< 3 oz
Collection N.A. (input)	~0.45, compatible with higher NA objectives
SHG crystal *	BBO, 10 $\mu$ m, theta = 33.7° (typ.); customizable
Filter	BG39 glass (typ.); customizable
Laser spectral range (input)	700-900 nm (typ.); customizable
SHG spectral range (output)	350-450 nm (typ.); customizable
Max. incident laser power	20 mW @ 80 MHz rep. rate; <1 $\mu$ J/pulse
Microscope objective	5x to 100x, air, oil or water immersion

\*Other crystal thicknesses and phase-matching orientations are available upon request.

## 2. Laser Safety

MDU is a passive optical device that contains a nonlinear crystal, a mirror, and imaging optics. When used with a laser, all precautions relevant to laser use must be followed. **All people in the laboratory where the laser is operating must wear appropriate laser safety goggles while handling MDU.** The laser light incident on the input port of MDU will be directed towards the output port.



**WARNING:** Never look directly into the output port of MDU even if wearing safety goggles. Serious eye damage could result.

MDU is designed for  $\leq 20$  mW of incident laser power from a high-repetition rate oscillator ( $\sim 100$  MHz). The use of higher laser intensities, or energies per pulse, could result in optical damage, not covered by warranty. BioPhotonic Solutions Inc. is not liable for the use of MDU for purposes other than those expressed in this manual.

## 3. Alignment Procedure

Please read 'Laser Safety' section first!

The following alignment steps are applicable only when the MDU is used in conjunction with an inverted microscope, having a X-Y translation stage for sample positioning.

1. Find the optimal focus distance using a reference microscope slide (not supplied) with the microscope cover slip facing towards the objective lens.
2. Position MDU at the center of the X-Y stage such that the MDU's mirror is approximately centered above the microscope objective. To prevent the MDU from sliding, it is important to fix the MDU with clips used for retaining microscope slides. Sometimes it is also useful to fix the device on the X-Y translation stage with a couple of small strips of electrical tape.
3. Cautiously adjust the X-Y translation to fine-tune the coupling into the MDU and find the SHG (blue) light emerging from the MDU's output port. Use a standard white business card to trace the beam, center it the fiber input (second aperture). If the SHG beam has been observed, skip to Step 6; otherwise, see the next Step.
4. If no SHG light has been observed in Step 3, take out the BG39 filter from the MDU

(see Laser Safety notes) and adjust the X-Y translation until you see the laser beam passing through the MDU. Center the IR beam at the fiber coupler input.

5. Put the BG39 filter back into place. In most cases, the SHG light should be observed now. Adjust the objective focusing if needed. If no SHG is observed, there is a possibility that the polarization of the input laser light is not compatible with the orientation of the SHG crystal. Re-orient the MDU and look for SHG as indicated above.
6. When the SHG beam is coupled into the spectrometer fiber, the SHG spectrum could be monitored using the MIIPS<sup>™</sup> software, or the original spectrometer's software. One might need to adjust the X-Y stage and focusing slightly (moving less than 0.01 mm) to optimize the SHG signal coupling into the fiber. By iteratively optimizing the X- and Y- axes of the translation stage one can find the optimum. Note that such optimization is very sensitive to the MDU displacement and takes some practice. If the signal is lost during this optimization process, return to Step 3. If the SHG signal is too intense and saturates the spectrometer attenuate the input laser beam.
7. Once the coupling is optimized, the setup is ready for MIIPS<sup>®</sup>!