GEMINI 2D

USER TECHNICAL MANUAL

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Subject to change without notice

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Contents

1. Introduction

1.1 Brief Description

The GEMINI 2D is an ultra-stable interferometer, capable of generating two delayed and phase-locked replicas of the input light. The relative delay T_1 between these two replicas can be controlled by the user via software with extremely high reproducibility and phase stability (<1 attosecond, corresponding to <λ/1000 in the visible spectral region). This delay is introduced by mechanically moving an optic with a motorized positioner, whose position can be controlled via software. Its exceptional stability is made possible thanks to the employed common-path geometry, that makes the device completely insensitive to external noise and vibrations. During the scan of the delay T_1, the absolute arrival time of one of the two replicas is kept fixed. The GEMINI 2D Interferometer is thus the ideal device for generating a pair of replicas (i.e. controlling the state of polarization) of the incoming light with interferometric stability. The device works over a broad spectral range (from the Ultraviolet to the Mid-Infrared) and it is also compatible with ultrashort few-optical-cycle pulses, making it perfectly suitable e.g. for generating a pair of pump pulses in two-dimensional spectroscopy measurements.

1.2 Information, Warnings and Safety Instructions

1.2.1 Hazardous Voltage

The Controller Module can generate high output currents at high voltages. They may cause serious or even lethal injury if used improperly. Therefore, the equipment should only be operated by personnel, which is adequately trained and educated to prevent any improper use. Please follow general accident prevention rules:

- Never touch any part that might be connected to an output with a high voltage.
- Do not connect products from other manufacturers to the output connectors.
- Never use equipment that is damaged in any way.
- The Controller Module contains no user serviceable parts. Never open the case. Procedures which require opening the case must only be carried out by authorized, qualified and trained personnel.

Output connectors with dangerous signals are labelled with the following symbol:

***Figure 1**: "Caution, risk of electric shock" symbol.*

1.2.2 Unpacking

Please be careful when unpacking the GEMINI-2D Interferometer and the Controller Module. Inspect the products for signs of damage and only use equipment that shows no signs of damage. In case of any damage, contact NIREOS for replacement. Please save all packing materials in case you would like to transport or ship the product again.

1.2.3 Laser safety

Please be always careful and wear laser safety glasses when using the GEMINI-2D Interferometer with laser radiation, as there could be some back reflected or scattered light exiting from the input or output apertures.

1.2.4 Installation Instructions

The Controller Module must be installed horizontally with 3 cm air circulation area behind the ventilator. Insufficient air flow can cause overheating, which can result in a limited functionality of the controller.

1.2.5 Connection Instructions

Never use any other connecting cables than the connecting gear that you obtained from NIREOS. Never use any third-party adapters or cables. This can cause failure or malfunction.

The system is NOT hot-pluggable. Always make sure to power down the device before connecting or disconnecting any plugs. The only exception to this is the USB or Ethernet cables which may be removed or attached during operation.

NOTE: Please be careful in handling the GEMINI-2D Interferometer. Do not try to pull the white cable exiting the device. Always check the cable for possible signs of wear or damage. In case of any damage, contact NIREOS for replacement.

2. Setup and Adjustments

2.1 Hardware

2.1.1 Connections

- Connect the Controller Module to the AC adapter;
- Connect the Controller Module to the computer with the USB cable;
- Connect the Controller Module to the GEMINI 2D Interferometer with the DSUB-15 cable.

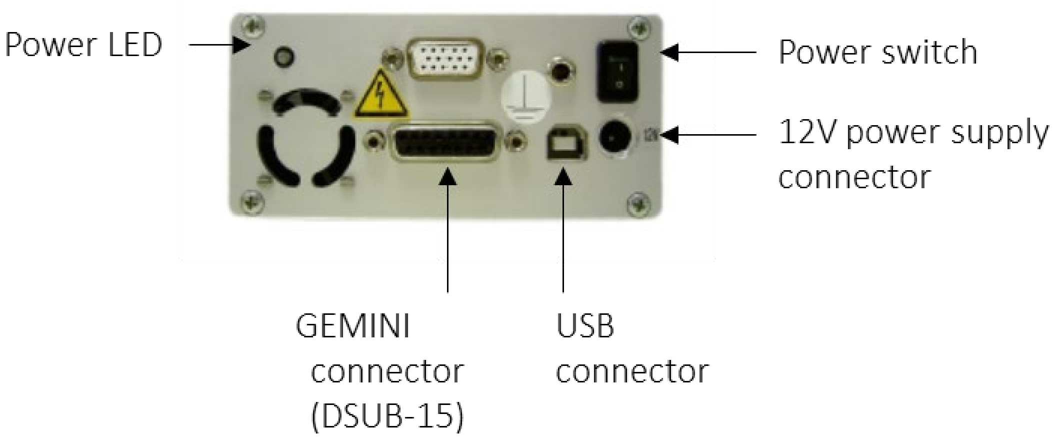


Figure 2: Picture of the Controller Module showing the connections.

NOTE: Remember to install horizontally the Controller Module, with 3 cm air circulation area behind the ventilator.

2.1.2 Mechanical Mounting

If needed, there are 4 threaded holes (M6 threads) to screw 4 posts to the GEMINI 2D Interferometer, that can be thus clamped and locked on an optical table. For more details regarding the position of the threaded holes, please go to Section 3.3 “Mechanical Drawings”.

NOTE: Please always handle with care the GEMINI 2D Interferometer. Sudden movements or shocks can cause a misalignment or break of the optics inside the device.

2.1.3 Optical Alignment

- POLARIZATION
  The first optical element of the GEMINI 2D Interferometer is a polarizer (**P1**) mounted on a rotation mount that can be rotated by the user. It is recommended to make sure that the first polarizer is oriented at ±45° and to enter the device with a beam linearly polarized at ±45°, to maximize the light throughput.
  Inside the GEMINI 2D, the ±45° polarized light is divided into two replicas, one with vertical polarization and one horizontal polarization, that are delayed by T_1. At the output of the GEMINI 2D, another polarizer (**P2**, mounted on a rotation mount) shall be oriented at ±45° to project the two replicas onto the same state of polarization.

NOTE: Please note that the direction of polarization is indicated by the 0° angle on the graduate scale.

NOTE: The polarizer P2 must be oriented at 0° (along the vertical direction) only when the precise optical alignment procedure is necessary (for more information, please check the document “Report: Calibration and Characterization”, paragraph 2).

NOTE: Never enter with a beam having perpendicular polarization with respect to the orientation of the first polarizer. In that case, the throughput of the device would be close to 0%.

- BEAM ALIGNMENT
  For a proper alignment of the beam, you can use the two apertures on the front and back faces of the GEMINI 2D Interferometer. You can finely adjust the diameter size of the two apertures depending on your beam size.

2.1.4 Optical Features

- RELATIVE DELAY T_1

  Depending on your version of the GEMINI 2D Interferometer, the relative delay T_1 can be:

  - **Symmetric** ("SYM"). The moving replica is scanned in time in a symmetric way around the "TIME ZERO" with respect to the fixed replica. The delay T_1 can be varied from –T to T.

  - **Asymmetric** ("ASY"). The moving replica is scanned in time in an asymmetric way around the "time zero" with respect to the fixed replica. The delay T_1 can be varied from –δT to 2T (approximately).

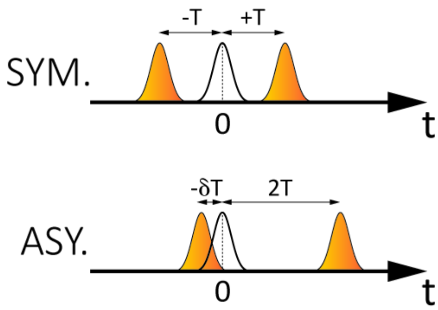


Figure 3*: Possible delay T_1 configurations. Top: "SYM" configuration; bottom: "ASY" configuration.*

NOTE: Please check the table in Section 3.1 "Technical Data" for more quantitative details.

2.1.5 External Controls

- TIME ZERO Control

  The GEMINI 2D is already set with T_1=0. However, shipment and handling can cause small misalignments of the optics that can cause a shift in T_1. In this case, the relative delay T_1 can be finely tuned by the user by rotating the manual control "TIME ZERO" with a screwdriver (see Figure 4).

  NB. *A change in the "TIME ZERO" by rotating the manual control could lead to the need to perform a recalibration procedure of the delay axis. For more details, please contact NIREOS customer service at info@nireos.com*

Figure 4: *Picture of the GEMINI 2D, showing the "TIME ZERO" manual control.*

<u>How to properly find TIME ZERO?</u>

There are 3 different ways to properly find the correct T_1.

To do that, always enter the GEMINI 2D Interferometer with a broadband light (coherent or incoherent) and be sure that the two output replicas have parallel polarization at ±45°.

- <u>Using a spectrometer</u>

  Measure the light exiting the GEMINI 2D with a spectrometer. In this configuration, the spectrometer measures the spectral interference between the two replicas delayed by T_1. If $T_1 \neq 0$, then the measured spectrum is characterized by spectral fringes, which gets larger as the delay T_1 goes to zero. When $T_1=0$, the measured spectrum corresponds to the spectrum of the input light, without spectral fringes. This effect is shown in Figure 5 for 3 different values of T_1 (0, 15 and 150 fs).

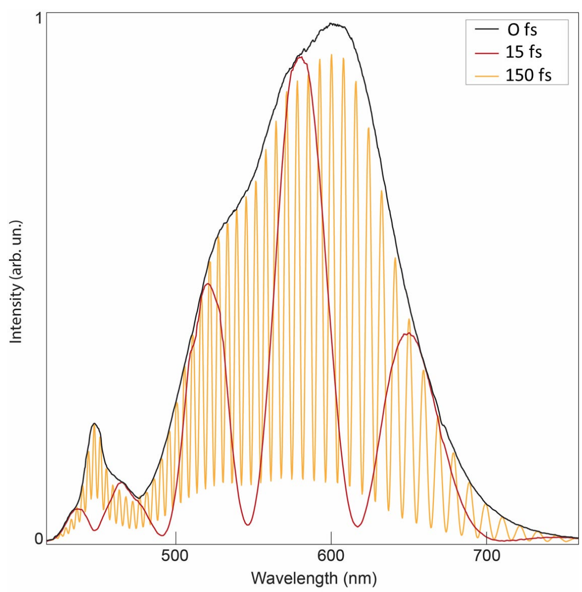


Figure 5: *Spectra of the light exiting the GEMINI 2D measured at different values of T_1.*

- Using a photodiode
  Measure the light exiting the GEMINI 2D with a single-pixel photodiode while scanning the delay T_1 via software (the delay can be controlled by moving the motorized positioner by a few millimetres). Associate to each position of the motor (in mm) the corresponding signal acquired from the photodiode. The result is the so-called interferogram (shown in Figure 6) as a function of the position of the motor (which is proportional to T_1). If the light has a sufficiently broad spectrum, the peak of the interferogram clearly indicates the exact TIME ZERO position.

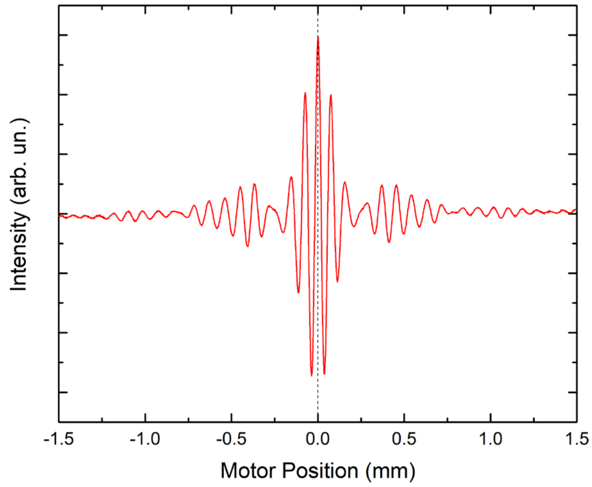


Figure 6: Interferogram of a broadband light exiting the GEMINI 2D measured with a single-pixel detector.

- By eye
  If the input light has a broad spectrum, the TIME ZERO can be found simply by looking at the light spot transmitted by the GEMINI 2D. When $T_1 \neq 0$ the spot has the same colour of the incoming light (Figure 7(a)). When T_1 approaches 0, spatial fringes start to appear (see Figure 7(b)). TIME ZERO corresponds approximately to the central point of the spatial fringe pattern (see Figure 7(c)).

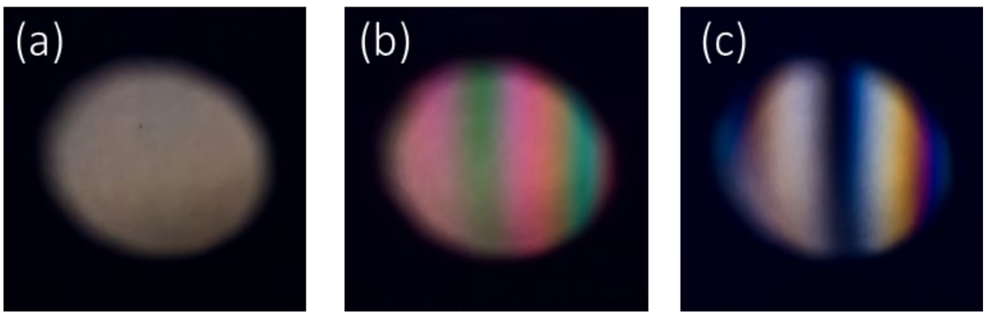


Figure 7: Pictures of the light spot transmitted by the GEMINI-2D at different values of T_1.

- <u>DISPERSION Control</u>

  The dispersion introduced by the GEMINI 2D Interferometer can be finely and continuously adjusted by rotating the control "DISPERSION" with a screwdriver (see the Figure 8). By rotating in the direction of the + (-), you increase (decrease) the positive dispersion.

Figure 8: Picture of the GEMINI 2D, showing the "DISPERSION" manual control.

NOTE: As these two controls (TIME ZERO and DISPERSION) modify the total thickness of material travelled by light, please note that they affect also the arrival time of the fixed replica, which can be slightly anticipated or delayed, depending on the direction of rotation of the control screws (a clockwise rotation leads to an increase of the thickness of the material, so that the replica is delayed; an anti-clockwise rotation leads to a decrease of the thickness of the material, so that the replica is anticipated).

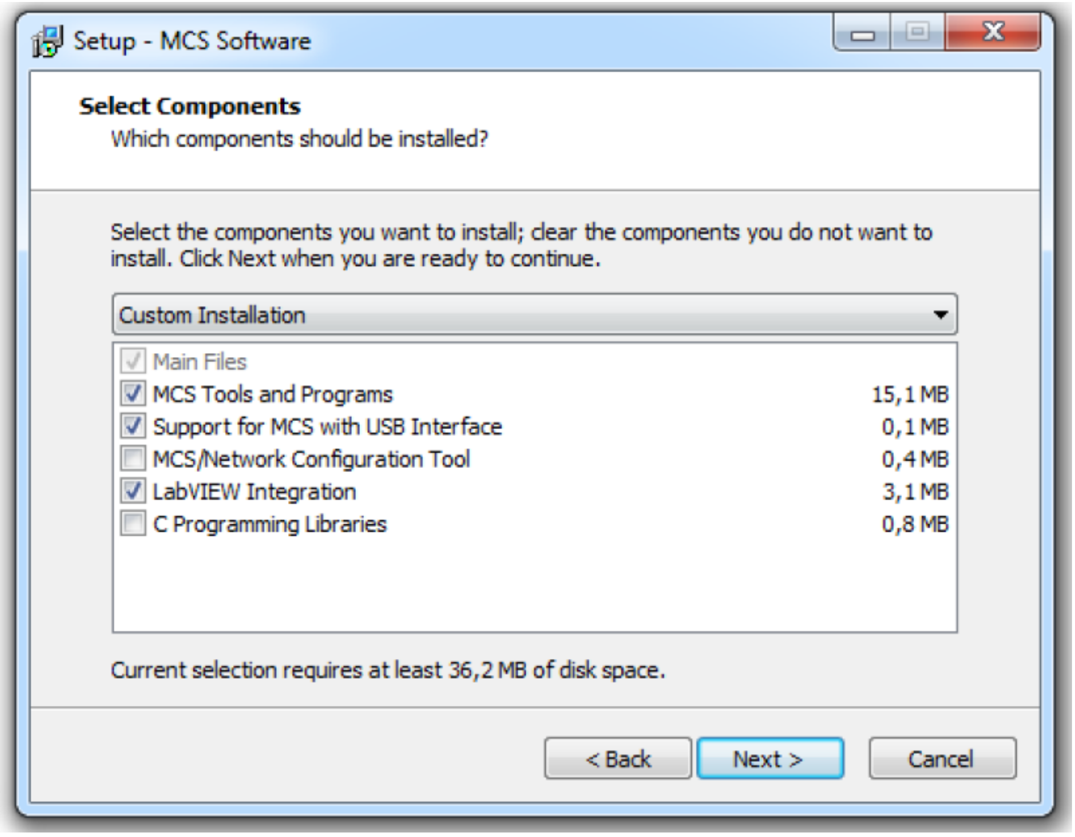
2.2 Software

2.2.1 Software Installation Guide

Please note that the positioner inside the interferometer that acts on the delay τ is from Smaract GmbH.

INSTALLING MCS SOFTWARE

In the NIREOS pen drive you will find a link with all the software needed to use the Controller Module and to develop your own software. Run the installer MCS_Installer in the MCS folder. In the installation you must first select the software folder where most of the files will be installed (default: C:\SmarAct). The installer allows to select different software components for installation:



- Select MCS Tools and Programs to install utilities like the firmware updater and the configuration tool.
- The installation of USB support drivers, needed for communicating with MCS devices over USB, can be disabled by deselecting the Support for MCS with USB Interface option. USB support is not needed if only MCS with RS232 interface will be used. However, if the USB support is not installed, the software will not be able to connect to MCS with a USB interface and will show errors. If the option is selected, the installer

will ask for permission to run the Usb-To-Serial driver installer at the end of the installation process. The driver can also be installed manually by running the program CDMxxxx_Setup.exe in the Drivers folder in the NIREOS pen drive.

- For developing applications with LabVIEW select LabVIEW Integration. If more than one LabVIEW version is installed, you can choose the version to install the LabVIEW commands in one of the next steps. To install additional LabVIEW versions just run the installer again and select another LabVIEW version (the other software doesn't have to be installed again). Note that the LabVIEW commands are only available for MCS devices with USB interface.
- Select C Programming Libraries to install libraries and header files for writing your own programs in C or C++ (or other languages that are compatible with the programming libraries).

WHERE FILES ARE INSTALLED

The MCS folder is inside the Smaract folder which you have selected during installation.
The Programs folder contains tools and applications for the MCS.
Documentation is installed in the Documentation folder in the MCS folder.
If LabVIEW Integration was selected in the installer, the MCS LabVIEW commands are installed in the program folder of the selected LabVIEW version and can be dragged directly from a LabVIEW commands palette into your program. LabVIEW programming examples are installed in the folder SmarAct\MCS\LabVIEW\Examples.
The software development kit (SDK) for developing programs with the MCS C API is installed under SmarAct\MCS\SDK if C Programming Libraries is selected. This path is defined in the environment variable MCS_SDK which can be used in development tools to find the SDK folder.

The installer creates shortcuts to programs and documents in the Start menu.

2.2.2 Software Examples

In the NIREOS pen drive you will find a link to useful software examples written in LabView. For more details, please read the “COMPLETE OPERATIONAL EXAMPLE (LABVIEW AND NI-DAQ)” manual.

3. Appendix

3.1 Technical Data

VERSION		S	M	L
Spectral range [nm]		300 - 3500		
Max. Delay T_1 [fs @ λ=600 nm]	SYM	± 400	± 700	± 1050
	ASY	-100 → 700	-100 → 1300	-100 → 2000
Delay T_1 Stability		< 1 attosecond		
Modes of Operation		Continuous Scan or Step Scan		
Dimensions [mm]		147.5 x 175.5 x 98		
Weight [kg]		1		

NOTE: in Step Scan mode, the user can select the desired Waiting Time for each delay T_1 via software.

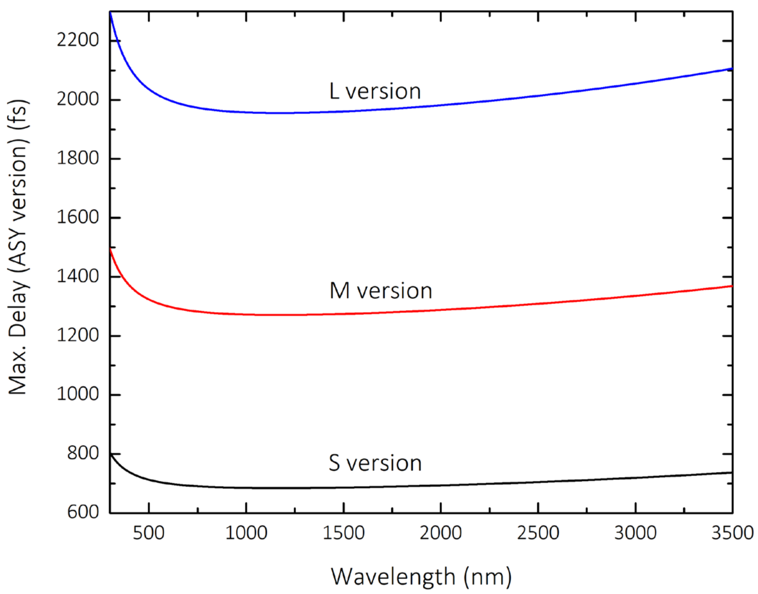


Figure 10: *Maximum delay T_1 relative to the asymmetric (ASY) configuration achievable with the three different models (S, M and L) as a function of wavelength.*

3.2 Available Versions and Descriptions*

The GEMINI 2D Interferometer is available in different versions:

GEMINI-(2D).xxx.y

- (2D): A **GEMINI 2D** Interferometer is designed to:
  - Keep the introduced dispersion constant during a scan of the delay T_1;
  - Keep the absolute arrival time of one of the two replicas fixed during a scan of the delay T_1.

NOTE: NIREOS also produces a simpler version of interferometer (**GEMINI** Interferometer), which is suitable for those cases where the control on dispersion and on the absolute arrival time are not an issue (for example, for time-resolved measurements in which the interferometer is placed after the sample or for steady-state measurements). For more information and possible applications of the GEMINI Interferometer, please contact us at info@nireos.com or visit www.nireos.com.

- xxx: **Configuration of the relative delay T_1** (**SYM**: symmetric, **ASY**: asymmetric). For more details, please read the paragraph “RELATIVE DELAY T_1” in Section 2.1.4.

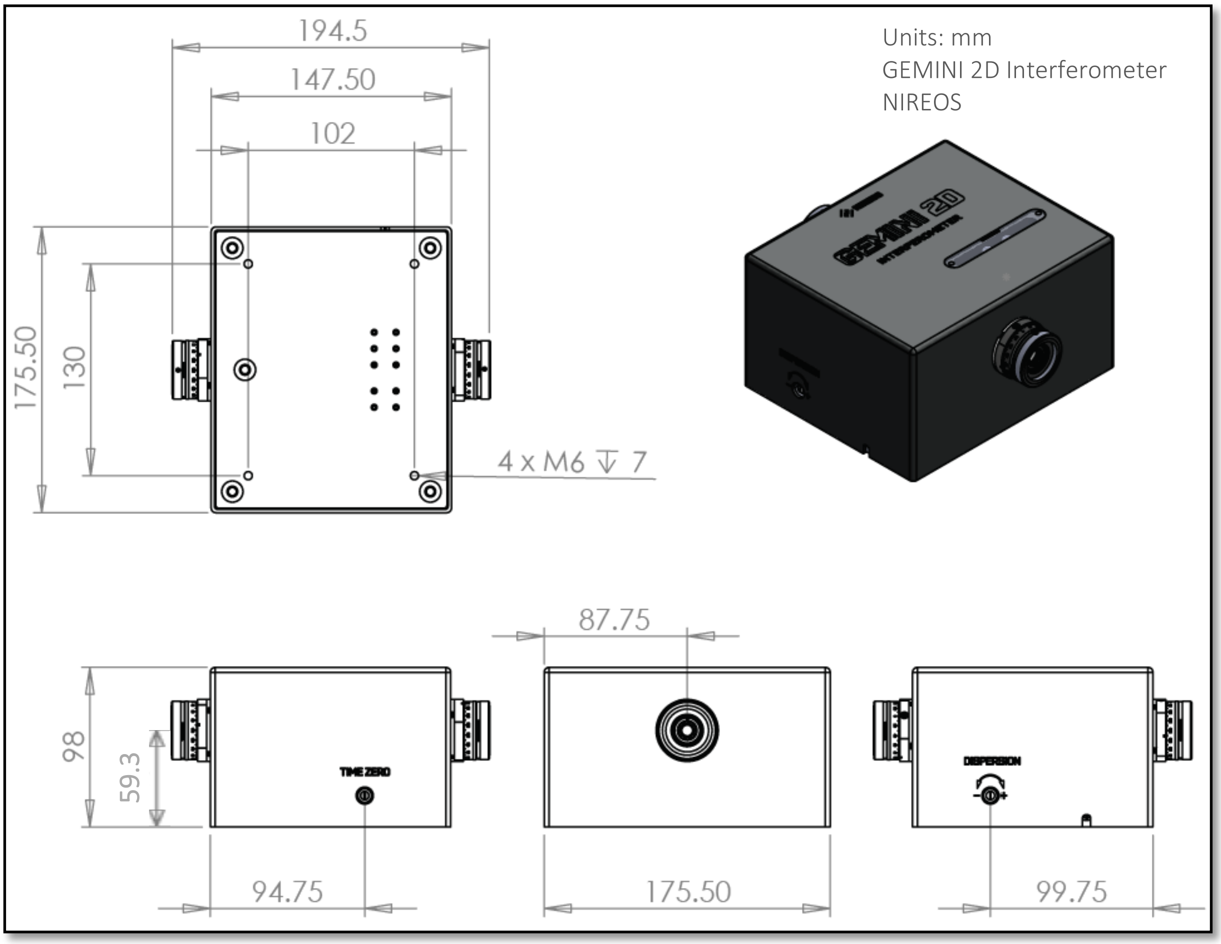
- y: **Maximum achievable relative delay T_1** (**S**: small, **M**: medium, **L**: long). For more details, please read the table in Section 3.1.

Example: GEMINI-2D.ASY.L:

Interferometer with dispersion and absolute arrival time controls, asymmetric configuration of the delay T_1, “long” maximum achievable delay T_1 (T_1=2000 fs at λ=600 nm).

** For customized products or more information, please contact NIREOS at info@nireos.com*

3.3 Mechanical Drawings



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