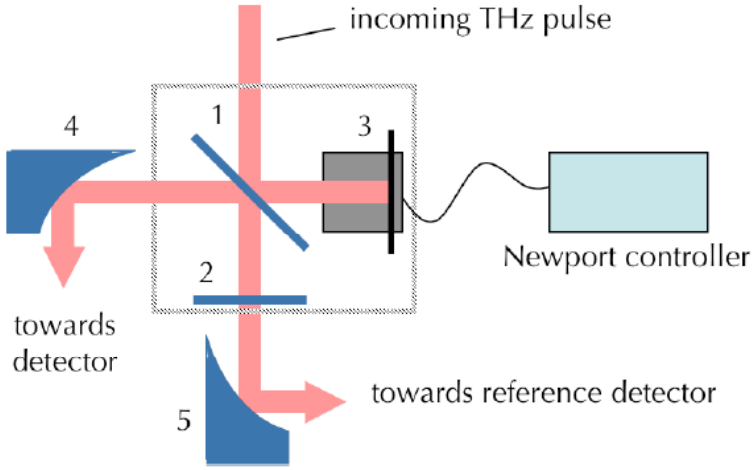
# Bunch Length Interferometer System

Thank you for purchasing the RadiaBeam Bunch Length Interferometer System (BLIS). This manual will give you some basic guidelines for the installation of the device. We have also included a paper detailing the experimental procedure and data analysis. Please contact us at (800) 589-7001 with any questions or support needs.

**CAUTION!!!** The beamsplitters used in the BLIS are very fragile. Never touch them, and use extreme caution when working around them.

## 1. Operating principle

The BLIS is a compact THz interferometer designed for the autocorrelation of the intense, sub-mm and mm-wavelength, spatially-coherent radiation pulses. Before operating BLIS the user must obtain 1 or 2 THz detectors, of which the most common room-temperature operated devices are Golay cells. While the BLIS geometry is prearranged to install Golay cells, it can be easily adapted for other types of bolometers or pyroelectric detectors.




The device schematics (above) include the following components:

1. 45°-beamsplitter
2. 90°-beamsplitter
3. Front surface mirror on translation stage
4. Detector focusing mirror
5. Reference detector focusing mirror

The incoming spatially coherent THz radiation pulse, *I(t)*, initially amplitude-splits at the 45°-beamsplitter (1). The transmitted component split again at the 90°-beamsplitter (2) and recombines with the other initially reflected component, which has subsequently been reflected off the mirror (3), which is attached to the translation stage. The path-length difference between the two arms, $\tau$, can be varied by moving the translation stage.

By systematically measuring the signal at the detector for different values of $\tau$, one can obtain the autocorrelation function of the input pulse:

$$S(\tau) \propto \int I(t) I(t+\tau) dt$$

The intensity of the fraction of the input pulse transmitted through the 90°-beamsplitter can be measured with the reference detector, allowing normalization of the intensity at the autocorrelation detector. The reference detector option is strongly recommended in situations with significant shot-to-shot fluctuations in the intensity of the incoming pulse.

Due to the strong diffraction anticipated at the longer-wavelength end of the THz spectrum, the BLIS system was engineered to be very compact, in order to minimize losses and errors in the measurements.

## 2. Basic installation

The BLIS can be used with or without nitrogen flow. For information about the steps necessary for nitrogen-flow operation, see Section 3. In this section, the basic installation steps are discussed.

It is critical for the proper operation of the BLIS to have an input THz pulse collimated before the interferometer entrance. Typically, when dealing with sources of small spatial extent (e.g. coherent transition radiation), this collimation is achieved with the focusing parabolic mirror approximately one focal length removed from the source. It is generally recommended to install BLIS as close to the source as possible, enabling use of relatively short focal length collimating mirrors (*EFL* = 15 - 30 cm).

Both output ports of the device include focusing 90° parabolic mirrors (4,5) to maximize the signal at the detectors. To optimize the error-tolerance, the focusing mirrors are chosen to have a very small focal length (*EFL* = 50.8 mm). Note: if one chooses to use larger detectors (such as cooled bolometers, in the case where signal strength demands it), which may not be positioned at the focal spots of the parabolic mirrors, we recommend that the user does not replace the mirrors (4,5) but rather builds an additional transport line from the original BLIS mirror focus towards the detector entrance.

The Translation Stage is operated with a Newport ESP100 Controller. Connect the cable from the BLIS to the "Axis 1" connector on the back of the ESP100. The ESP100 communicates through RS232 with a computer and should be connected to the computer with a standard serial cable (not a null-modem cable). The ESP100 comes with a CD-ROM which includes an operating manual and some useful programs. The user may communicate directly through RS232 with commands, or use the ESP-Util program to control the motion of the stage. Note: the ESP-Wizard program should first be used to generate an initialization script for the stage, MFN25-PP. Then this script should be

opened in ESP-Util or sent directly via RS-232 to begin operation with the controller. Please see the manual (on the ESP100 CD-ROM) for more information.

While all the components of BLIS are pre-aligned by the manufacturer, the user should check the alignment of the system when it is placed in the location at which it will be used. For this purpose there is an alignment laser integrated into BLIS at the location of the focusing mirror (4). The mirror has a small hole at the center to allow a laser beam to be injected backwards into the system. There are 3 basic steps:

1. Insert the alignment laser into its holder, behind focusing mirror (4). Point the BLIS so that it's input port is facing a flat white surface (i.e., a wall), at least 1 meter away. Turn the laser on. If only one spot is visible on the wall, then the alignment is acceptable, and no adjustment needs to be done in this step. If there are two spots, then continue to align the internal optics. The bright spot is the laser reflected off mirror (3) and beamsplitter (1). The dim spot is the laser reflected from beamsplitter (1) to beamsplitter (2), and then transmitted back through beamsplitter (1). Remove the lucite tube containing the reference focusing mirror (5) (be careful not to touch the beamsplitter). You will see three set screws in the wall of the BLIS, which control the alignment of beamsplitter (2). Adjust these set-screws with a 5/64 hex wrench until the two spots overlap. Now both beamsplitters and the front surface mirrors are aligned with respect to each other.

2. Now the alignment laser is used to properly position the focal point of the focusing mirrors (4) and (5) at the detector entrance port. First place the detector(s) in position. If the laser spots hit the detector window(s) correctly then proceed to the next step. If not, rotate the focusing mirror until the reflected laser spot hits the center of the detector. The mirror is held by one 1/4-20 bolt; this must be loosened with a 3/16 hex wrench. Then, using a finger (use gloves) inserted into the hole cut in the lucite tube, the mirror can be rotated, and the bolt re-tightened when in correct position.

3. By either translating the whole device, or by manipulating transport/collimating mirrors (not included into the BLIS), make sure that the alignment laser beam is guided towards the source of the input THz pulse, at the appropriate angle.

Now that the optics are aligned and the detectors are in place, the user may carry out the measurement.

**Warning!!!** For the CTR bunch length measurements with BLIS and Golay cells, one has to minimize detectors exposure to x-rays. Excessive irradiation will degrade Golay cells performance prematurely.

## 3. Nitrogen-flushed installation

In the THZ spectrum range of interest there are numerous intense water vapor absorption lines. It is strongly recommended while using BLIS to nitrogen-flush the whole transport-BLIS system.

The user must design their transport system to be nitrogen sealed. For convenience, an extension of the BLIS from the input port is designed to attach to a 3.5" OD tube. If the end of user's transport line is designed to be 3.5" OD tube, it can be inserted into the BLIS input port and secured with 1/4-20 bolts. This will complete the nitrogen seal from the transport line to the BLIS.

The nitrogen connection must be included in the user's transport line. The nitrogen will then flow through the transport line, through the BLIS, and exit through the alignment laser hole in reference mirror (4).

**Warning!!!** The nitrogen flow should be very gentle, as low as possible to ensure that, while water vapor is being evacuated from the system, there is no significant pressure differential around the beamsplitters. The beamsplitters are very fragile and small pressure/flow will break it.

Once the transport system has been installed, the steps of Section 2 (above) can be followed to complete the setup.