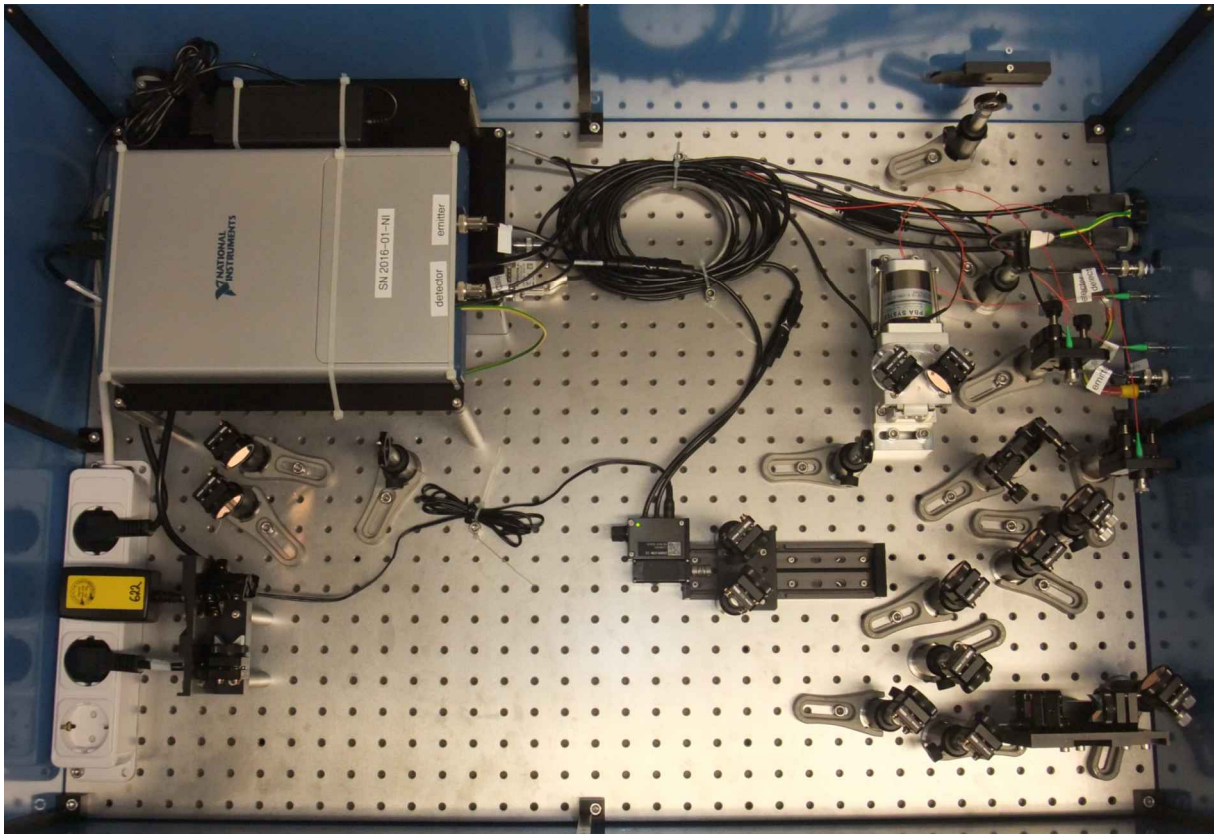


## How-to guide

### Working with a pre-assembled THz system



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## 0. Preparation / Basics

If you are using a pre-assembled THz system you will find all the components mounted to a bread board (excluding the laser that you supply yourself). This bread board needs to be fixed on an optical table using the clamps provided. The optical path was aligned using a laser with a similar wavelength as yours to make sure that the preparations done at BATOP will enable you to set up your THz spectrometer quickly. We recommend using an optical power meter as well as an IR-viewer and / or a laser viewing card in order to align the laser beam. These tools will help you to speed up the adjustment process of the optical path considerably.



### **Warning:**

Since you are working with invisible short pulse laser radiation please follow all the safety measures recommended by the laser manufacturer. Any disregard may cause a serious injury to your eyes.



### **Attention:**

In order to align your laser beam you will find three apertures in the THz setup that the beam has to pass through correctly (see Figure 1). These apertures will make sure that your laser beam is as collinear as possible to the one used at BATOP. This is especially important as the laser beam needs to be perfectly parallel to the movement direction of the linear stage. It is also critical that the laser beam is well collimated. Otherwise, the beam diameter will not match up with the chosen aspheric lenses mounted to the free space antennas or the collimators for the fiber-coupled antennas. If you are not sure about the divergence of your laser beam please characterize the laser beam beforehand.

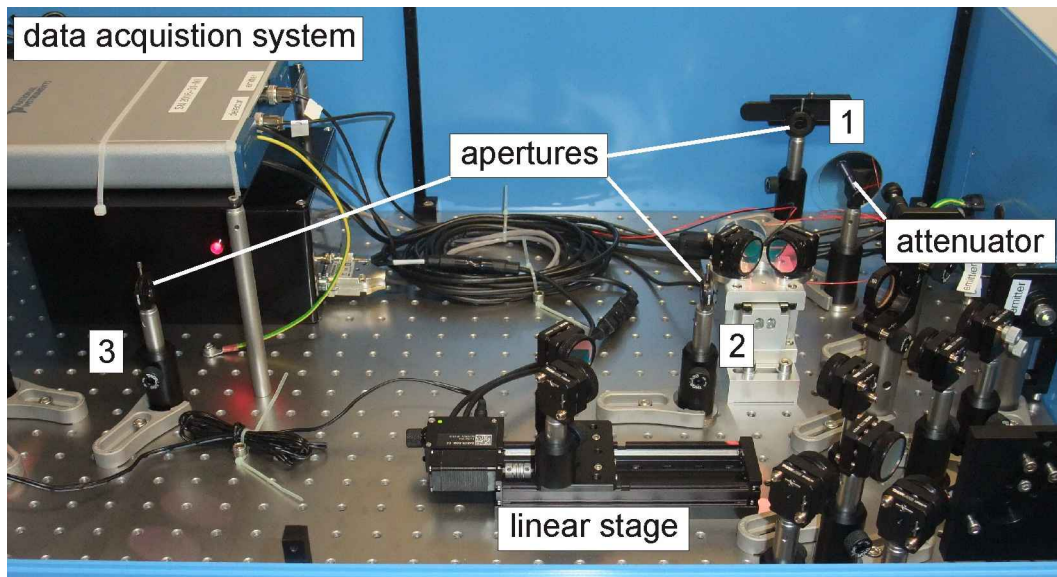


Figure 1: Inside of a pre-assembled THz system with apertures for laser beam alignment.

Besides the optical parts you will also find power supply units for the linear stage and the data acquisition system as well as USB cables to hook up the electronics to your computer. Before connecting your equipment please read the manuals on the hardware and software carefully. In any case you have to begin with the laser beam adjustment as described in the subsequent chapters before it makes sense to work on the THz signal.

## 1. Input beam adjustment



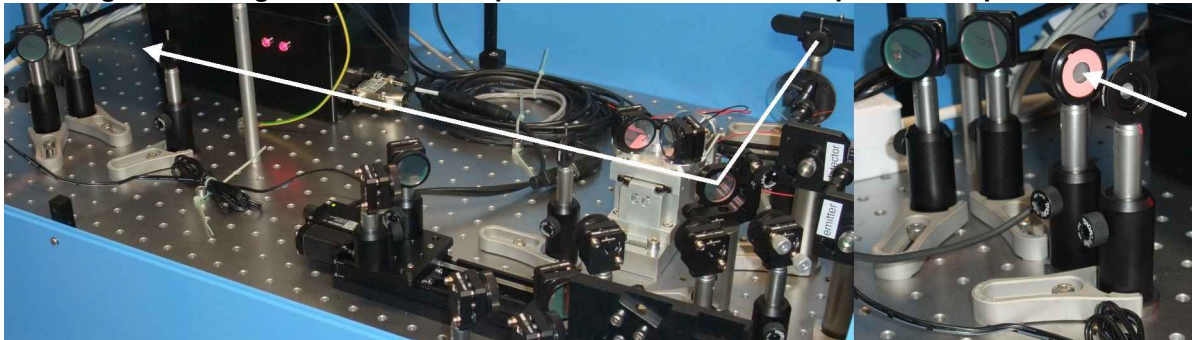
**Caution:**

As the THz spectrometer was tested with a different laser source than yours you need to make sure that the laser beam entering the system does not damage the THz antennas. Therefore, please see the test report for the laser specifications and the measured power levels at different points in the THz system. Set your power levels accordingly in order to avoid damage to the antennas. Additionally, please note that the laser beam entering the system needs to be p-polarized. Otherwise the beam splitter and other components will not work properly.

The pre-assembled THz system comes with three apertures for aligning your laser beam with the optical path of the THz spectrometer (see Figure 1). The beam height above the bread board is typically about 100 mm. As a result, you need to set the beam height of your laser beam to roughly 187 mm above your optical table (height of bread board plus feet). **We suggest that you use a mirror close to the edge of the bread board in order to couple the laser beam into the THz setup.** This helps you to simplify the input beam adjustment. If the system comes with housing we suggest removing the whole lid to get better access to the optical parts inside.

The alignment procedure starts by threading the laser beam through all apertures using the IR viewer or the laser viewing card. Little by little reduce the aperture diameters down to their minimum and readjust the orientation of the laser beam that is fed into the setup. We suggest that you use apertures 1 & 2 as a starting point. Then you can move on to the combination of apertures 1 & 3 to get a more accurate first alignment. **If you find that the laser beam is not split 1:1 at the beam splitter than you need to check the polarization of the laser beam entering the THz setup.**

**Figure 2: Designated laser beam path with sensor for final optimization procedure.**



For the next step you'll need the power meter to finalize the optical alignment. In order to fine tune the laser beam path open the second aperture, reduce the aperture diameter of the first and third aperture to their minimum and try to improve the optical power behind the third aperture by altering the orientation of the laser beam entering the setup. **Once the power is at a maximum your laser beam is collinear to the one used to pre-align the THz system. This step is crucial as it determines the quality of the laser beam alignment.** Once you're done with the alignment procedure of the laser beam you may now open all apertures.



**Caution:**

Before you move on to optimize the illumination of the THz antennas please check the power levels before the antennas / collimators one final time and compare these values to the numbers specified in the test report. Adjust the attenuator according to the requirements if needed.

## 2. Working with free space antennas



**Caution:**

As you provide your own laser make sure that the pulse fluence of the laser spot on the antenna gap does not exceed the specifications. As we supply the antennas with a chosen aspheric lens, the optical power needs to be adapted to the beam diameter, repetition rate and pulse duration. If you have any questions in this regard please see the test report, the spec sheets of the antennas, visit our website or contact us.

After you have finished the alignment of the laser beam through the apertures you can check if the antennas are illuminated correctly by hooking them up to a multimeter (directly or via the side panel) and measure their resistance with and without illumination. You need to compare these values to the data sheet. **If you find that the resistance under illumination is not as low as specified you may adjust the orientation of the last mirror before the antennas. You can use the knobs on the mounts but be careful as the antenna resistance is very sensitive to small changes in orientation.**

Once the resistances match the data sheet (concentrate on the ratio with and without illumination) you can connect the antennas back to the hardware and start looking for a THz signal using the T3DS software. Please follow the instructions provided in the software and hardware manuals. In general you can adjust the THz beam path as well as the optical path in order to improve the signal strength. However, since the THz path has been optimized at BATOP and you just optimized the antenna illumination we expect that only minor adjustments are needed in order to optimize the THz signal. You can have a look on the test report in order to compare your results to the reference measurement. **Make sure that you use the transmission setup without focusing lenses. This is the setup that the specifications have been determined with.**

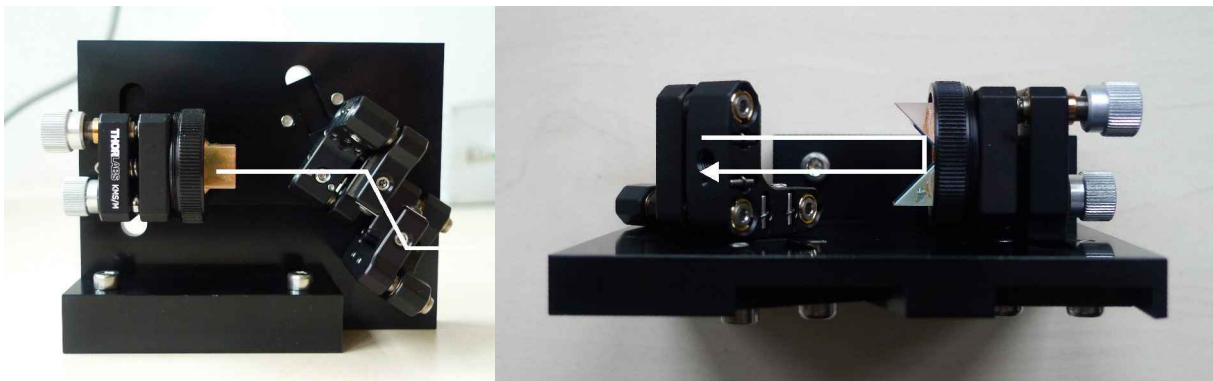
### 3. Working with fiber-coupled antennas



**Caution:**

As you provide your own laser make sure that the optical power inside the fiber does not exceed the antenna specifications before connecting them to the setup. In order to check this criterion we supply another single-mode fiber of the same type with two FC/APC connectors. Before hooking up the antennas please confirm with this optical fiber that the maximum optical power that can be coupled in matches the antenna specifications. If you have any questions in this regard please see the test report, the spec sheets of the antennas, visit our website or contact us.

In case of fiber-coupled antennas there are two possibilities. For 1550 nm antennas the dispersion compensation is typically accomplished using special optical fibers attached to the THz antenna. In contrast, for 800 nm and 1000 nm antennas the dispersion compensation is accomplished using a pulse stretcher incorporating two ruled gratings for each antenna (see Figure 3). In both cases the two laser beams for the emitter and detector antenna pass a number of optical elements before they are each directed towards a separate collimator and coupled into the single mode fibers.

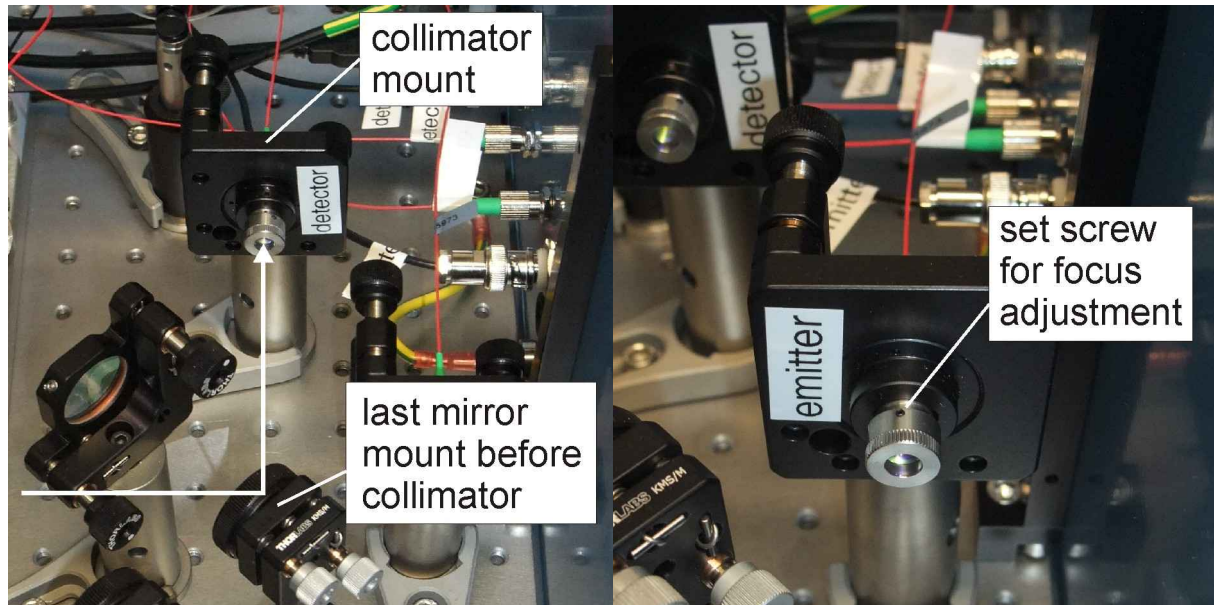


**Figure 3: Laser beam path through a pulse stretcher, based on ruled transmission gratings.**

After aligning the laser beam that is coupled into the system please now hook up your power meter to the optical fiber provided and attach the other end of the fiber to the side panel / connector / collimator (depending on your THz system). By adjusting the orientation of the collimator mount and the mount of the last mirror before the collimator you can now maximize the light coupled into the fiber.

In case you are not able to achieve the power level specified in the test report you may also need to adjust the focus of the collimator (could be the case if your beam diameter is much different). To do so please loosen the set screw on the tip of the collimator slightly and turn the ring holding the front lens. Now, you need to optimize the power by adjusting the mirror and collimator orientation once more. If you do not get an increasing power level you have to turn the front lens into the opposite direction and repeat the procedure described. With this iterative process you should be able to get the same power level inside the fiber as specified in the test report. **At the end of this process you have to fix the set screw and do one final optimization step before repeating this procedure with the second collimator.**

After adjusting the optical power for both collimators you can remove the optical fiber, attach the antennas to the corresponding side panel / connector / collimator and start measuring the resistances with and without illumination. If the ratio between the two resistances does not match the specifications this is an indication that the optical power on the THz antenna might not exactly be the same as in the test report.



If you attached the antenna fiber directly to the collimator you need to readjust the orientation of the last mirror before the collimator, the collimator itself or the focal length of the collimator. If your antenna fiber is attached to the side panel / connector you may lose some optical power due to the coupling (not uncommon for 780 nm systems because of the small mode field diameter). **In this case you can adjust the attenuator slightly to increase the power level in general. However, only minor adjustments of the power level should be made as this will influence the power level for other antennas as well.**

Once the resistances match the data sheet (concentrate on the ratio with and without illumination) you can connect the antennas to the data acquisition unit and start looking for a THz signal using the T3DS software. Please follow the instructions provided in the software and hardware manuals. In general you can adjust the THz beam path as well as the optical path in order to improve the signal strength. However, since you already optimized the illumination of the antennas we recommend focusing on the THz beam path. Hence, you need to adjust the orientation of the antenna packages. Have a look on the test report in order to compare your results to the reference measurement. **Make sure that you use the transmission setup without focusing lenses. This is the setup that the specifications have been determined with.**



**Attention:**

**If your THz signal is smaller and the band width narrower than specified in the test report this could be an indication that the dispersion compensation does not work as well for your laser source. The most likely reason is a difference in the wavelength between the two lasers used. A second possibility is a much shorter pulse duration / wider bandwidth of the laser leading to higher order dispersion effects. In case the results of the test report cannot be reproduced at all please get in touch with us.**

## 4. Contact details

If you have any further questions or remarks, please do not hesitate to contact us.

BATOP GmbH  
Wildenbruchstr. 15  
D-07745 Jena  
Germany

e-mail: [info@batop.de](mailto:info@batop.de)

Tel.: +49 3641 634009 0  
Fax.: +49 3641 634009 20