

## Manual External Measurement Setups

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**Basic Setup**

**Imaging Unit**

**Theta-2-Theta**

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## Index of Abbreviations

IU	Imaging Unit
T2T	Theta-2-Theta
THz	Terahertz

## 1 Basic Setup

If you purchased the fiber-coupled antennas without any stages you will get a very basic setup where you can mount the Terahertz (THz) antennas for transmission or reflection measurements (Figure 1). Additionally, the setup comes with a set of sample holders for large and small samples. Both sample holders can be used for transmission and reflection measurements.

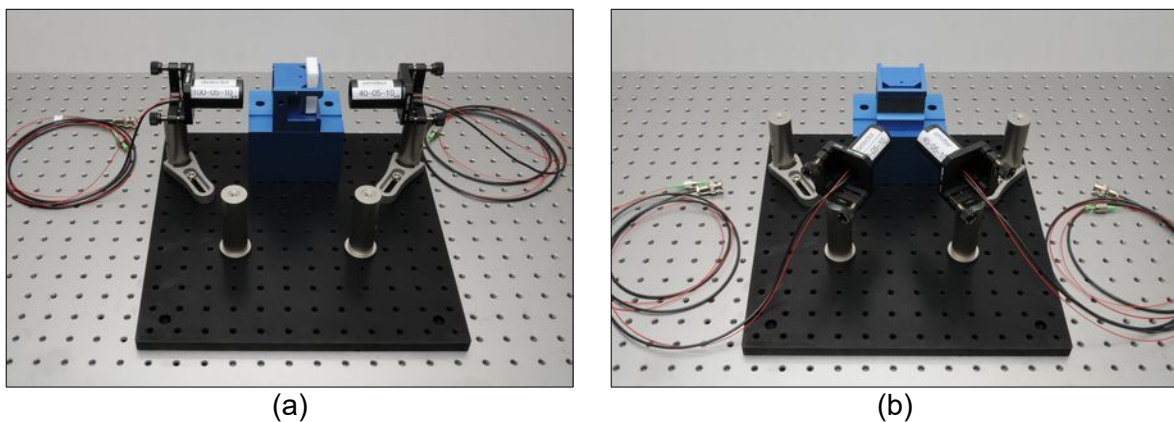


Figure 1: Fiber-coupled antennas in the transmission (a) and reflection (b) setup

The position of the posts for transmission and reflection is essentially defined by the focal length of the TPX lenses ([FTL-f32.5mm](#)). These positions do not need to be changed. However, if you have also bought an imaging unit and want to switch between the two setups please see Figure 2 in case you need to position the posts and antennas once again. Please note that the angle of incidence is roughly  $30^\circ$ .

When changing from the transmission to reflection setup just remove the sample holder from the base structure, turn it by  $90^\circ$  and put it back on.

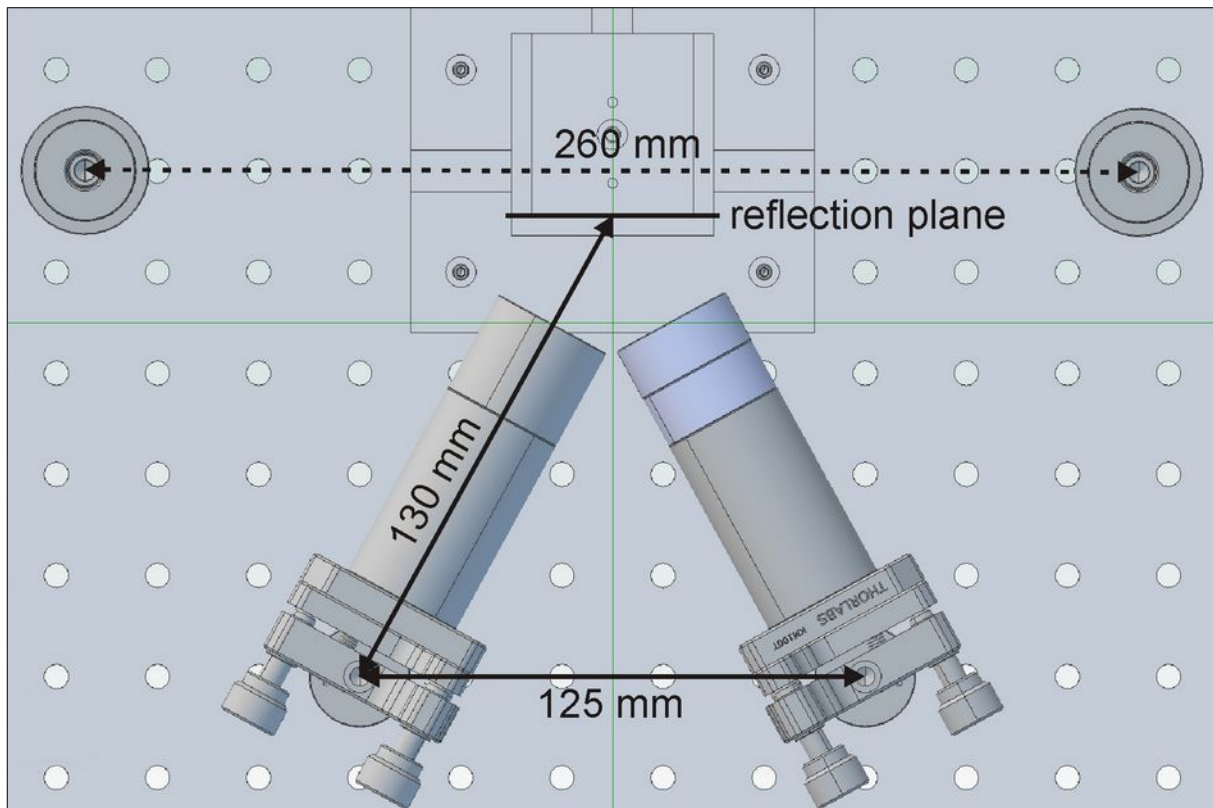


Figure 2: Layout of the basic setup



## Warning

For measurements with a collimated beam you need to use the large sample holder (Figure 3a). When working with a focused beam you need to use the small sample holder shifted to the center position for transmission measurements (Figure 3b) and to the frontal reference for reflection measurements (Figure 3c). Otherwise the sample will not be at the focal point.

Both samples holders have a sled that is used to push the sample to the reference plane. The sled can be fixed using the small set screw.

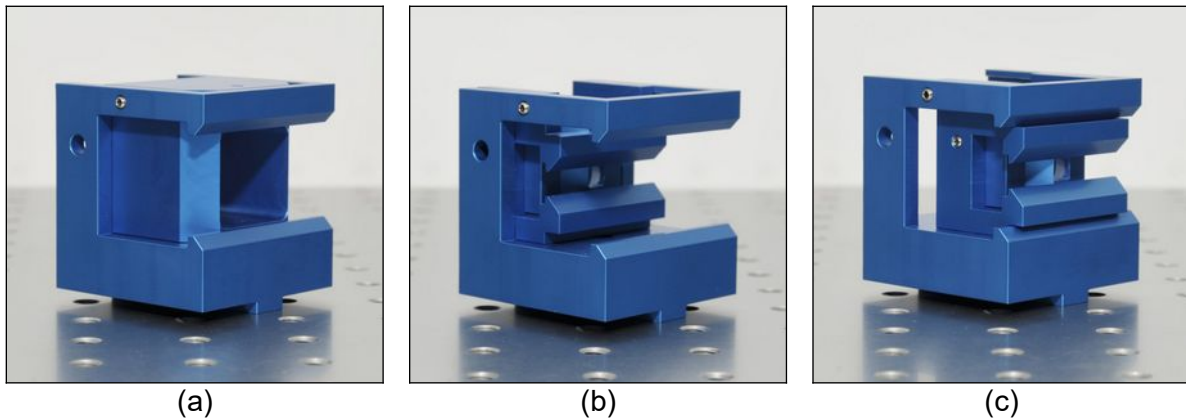


Figure 3: Sample holder for a collimated beam (a) or focused beam in transmission (b) and reflection (c)

## 2 Imaging Unit

You will find the following (pre-assembled) parts within our package of the [Imaging Unit \(IU\)](#):

- Aluminium base plate with two posts for the THz antennas
- x-stage mounted onto the base plate
- y-stage to be mounted onto the x-stage<sup>1</sup>
- Mini-Din or M8 cable<sup>2</sup> for the connection of the x-stage and the spectrometer
- Aluminium plate for reflection measurements to be mounted onto the y-stage<sup>3</sup>  
(with a mirror for reference measurements)

<sup>1</sup> Mounted onto the base plate during transport

<sup>2</sup> Depends on the connector on your spectrometer

<sup>3</sup> Packed separately during transport

 **Warning**

For safety reasons you must never put your hands near the stages while in use. The linear stages can cause serious damage to your hand and fingers. Before you change the configuration of the stages please always disconnect them from the spectrometer and power supply (if a separate power supply is used for the imaging stage).

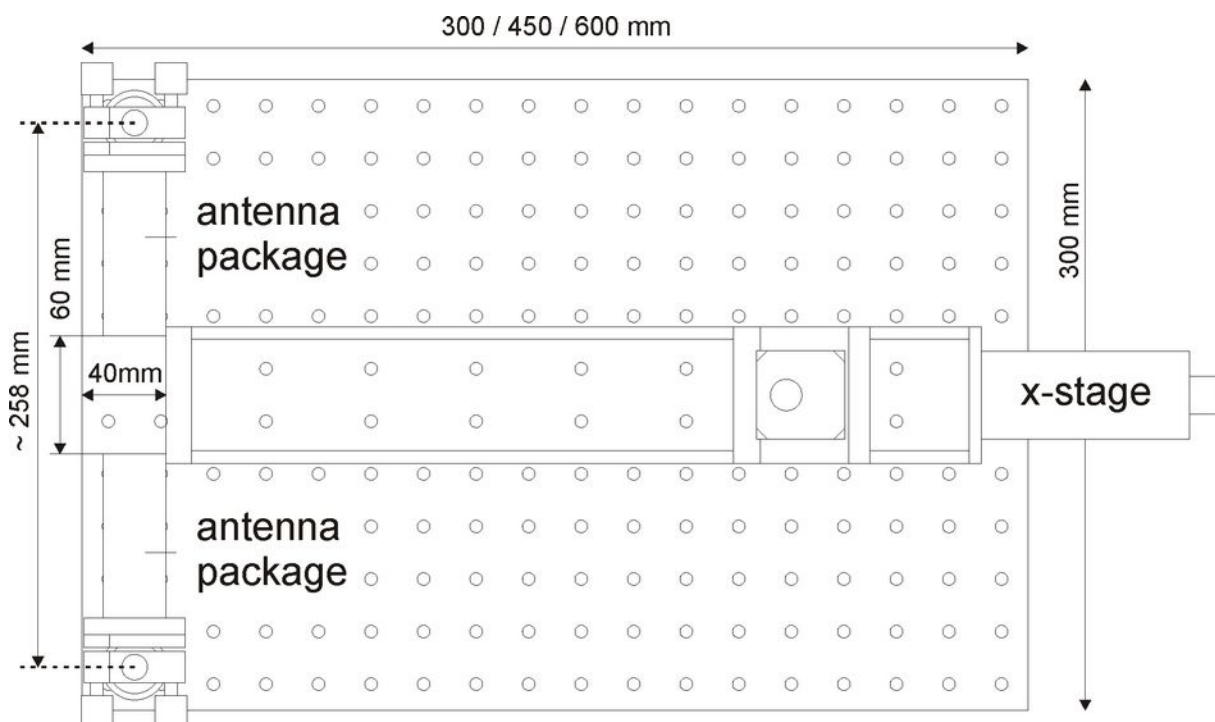


Figure 4: Top view of the **Imaging Unit** set up for transmission measurements. The antenna package includes the THz antenna and focusing TPX lens.

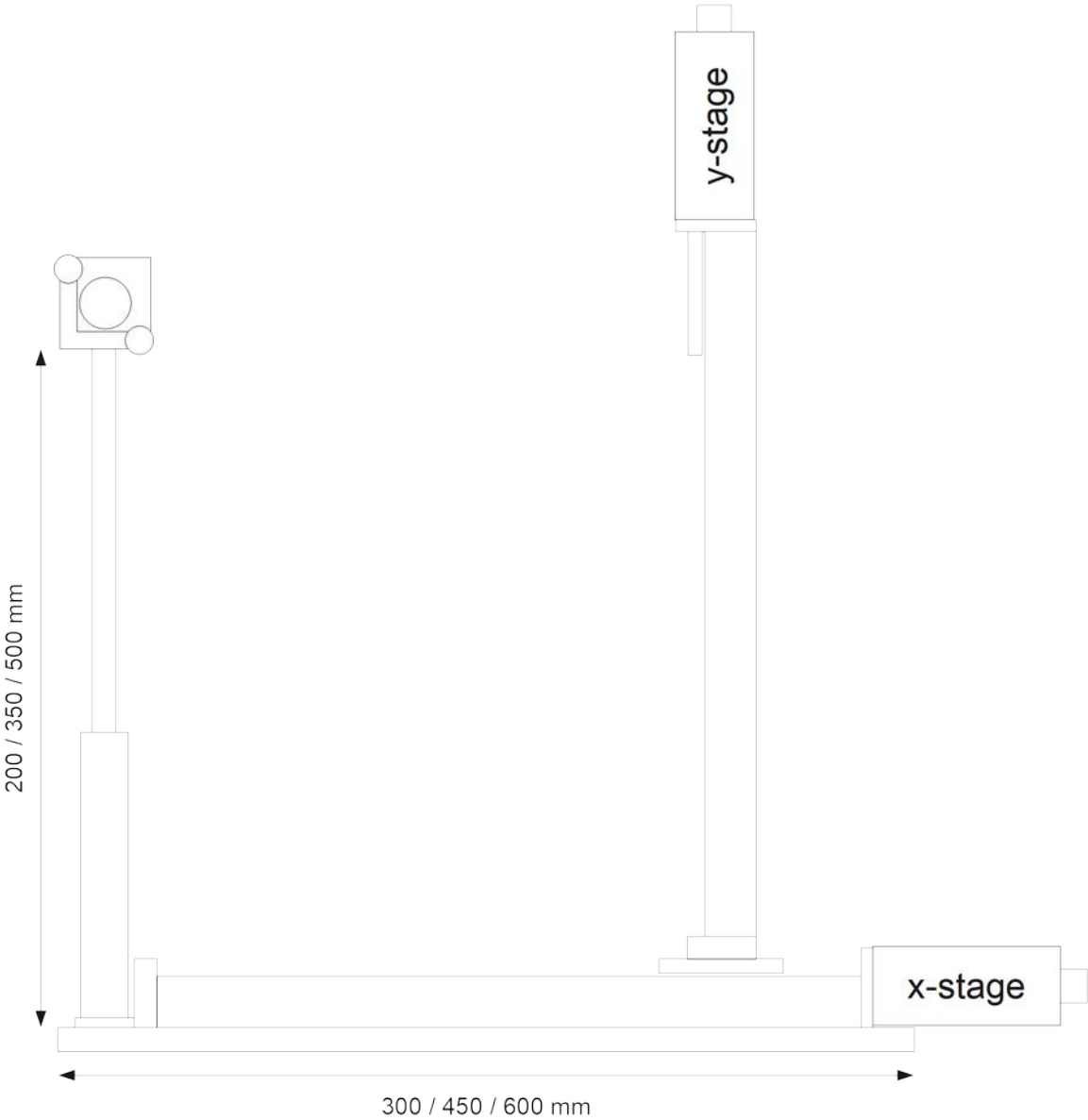


Figure 5: Side view of the **Imaging Unit** set up for transmission measurements

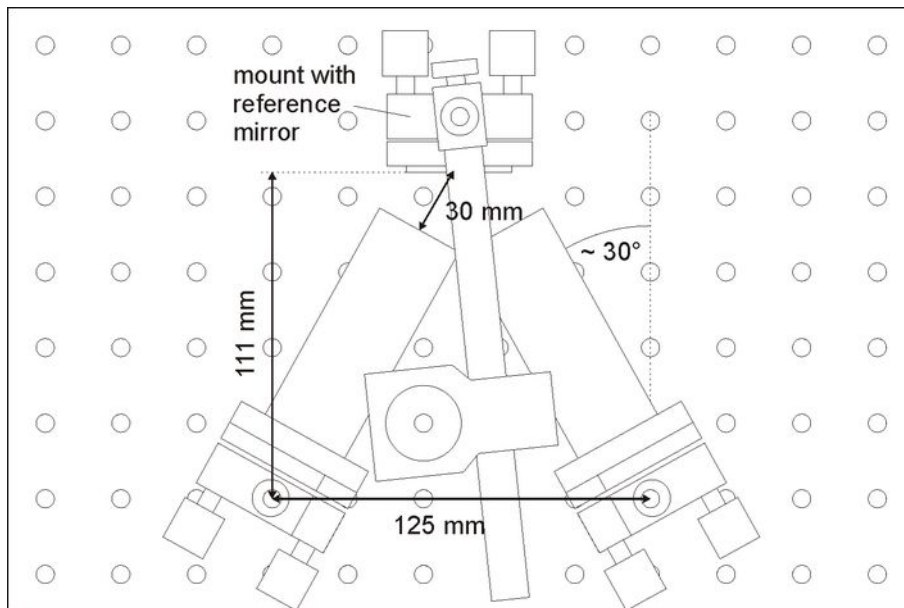


Figure 6: Top view of the aluminium plate for reflection measurements with the mirror for reference measurements in place. The plate has to be mounted to the y-stage of the [Imaging Unit](#). This setup is used for fixed objects. The antenna package includes the THz antenna and focusing TPX lens.



## 2.1 Transmission Measurement

For transmission measurements the two THz antennas have to be positioned face to face. The **Imaging Unit** is pre-assembled for measurements with a collimated<sup>4</sup> or focused beam using our **Extender Tube** and focusing TPX lens (**FTL-f32.5mm**). It is not necessary to alter the position of the THz antennas between both types. But you probably need to optimize the alignment of the THz antennas, again. Please keep in mind that there will be a time shift of the THz pulse of about 25 ps due to the different optical length (with/without the focusing TPX lens) in the THz beam bath.

The x-stage is positioned in the center of the breadboard and the THz beam passes in front of the stage. So the y-stage will not block the THz beam if the x-stage is moved to its end position. The THz antennas have to be mounted as high as the y-stage at its home position to make use of the full range of the linear stages.



Figure 7: **Imaging Unit** set up for transmission measurements with a focused THz beam using our **Extender Tube** and focusing TPX lens (**FTL-f32.5mm**)

<sup>4</sup> The spatial resolution of the collimated beam is very limited due to the large beam diameter



## Warning

You can mount your sample holder onto the y-stage using the M6 tabs on the stage. Please make sure that your screws are short enough and do not inhibit the stage movement. Otherwise the linear stage may be damaged. Additionally, the sample holder shall not extend further down than the stage of the y stage. If not complied with, moving the y-stage into its end position may result in damage to the stages. Please also try to keep the weight of your sample holder (and sample) as low as possible. Otherwise it may affect the performance of the linear stages and the rigidity of the setup.

Before you put your setup into operation make sure there is enough clearance between your sample holder and the two antenna packages. If not, the sample holder may damage the mounts that hold the antenna packages.

## 2.2 Reflection Measurement

For reflection measurements there are two mounting options for the THz antennas. Depending on the size and weight of your sample you can mount the THz antennas (Figure 8a) or the sample (Figure 8b<sup>5</sup>) to the y-stage. The basic geometry (distances and angle of incidence) are the same for both setups.



## Warning

If you mount the antennas to the y-stage make sure that the BNC cables and optical fibers coming from the antennas are positioned in a way that allows full flexibility during the imaging procedure while avoiding that they become entangled with the linear stages. Additionally, please ensure that the M6 screws are short enough when mounting the y-stage to the x-stage and the base plate to the y-stage. Otherwise the linear stages may be damaged. When changing the setup from transmission to reflection please take care that the posts used in the transmission setup do not block the movement of the imaging stage. If one of them does, you need to detach it temporarily.

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<sup>5</sup> The translation stage mounted to the y-stage is an optional part and has to be ordered separately.

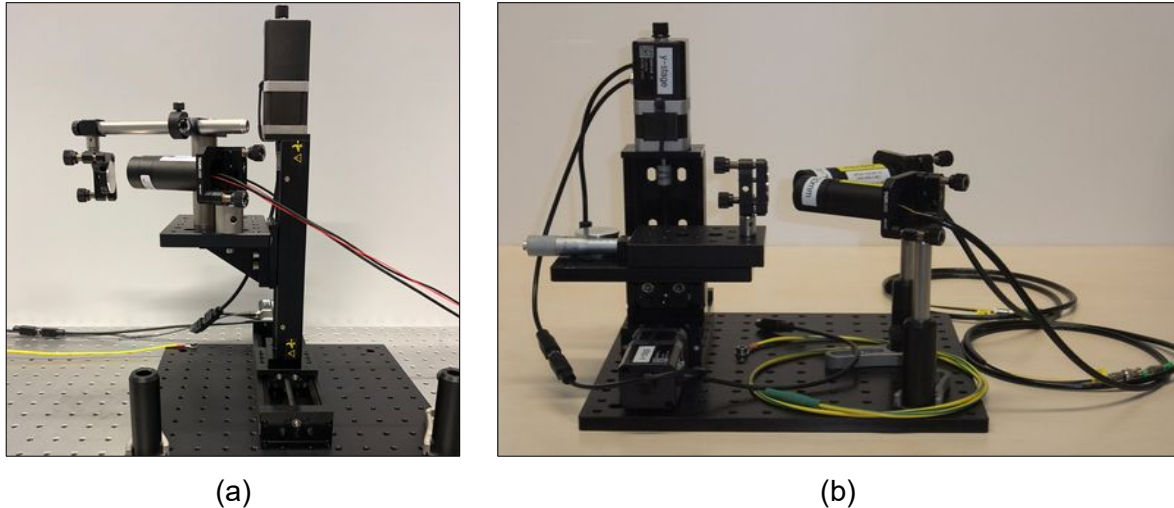


Figure 8: **Imaging Unit** set up for reflection measurements with a focused THz beam using our **Extender Tube** and focusing TPX lens (**FTL-f32.5mm**). The THz antennas (a) or the sample (b) can be mounted to the y-stage.

At first we recommend using the reference mirror in order to optimize the THz signal. Afterwards you can remove the reference mirror. The plane that the THz antennas scan is about 50 mm away from the edge of the small base plate. Hence, you can use this value in order to position your sample at the right distance. You may fine tune the distance by conducting a slow scan and matching the peak position to the reference measurement. Ideally, the plane of the sample and the movement directions of the imaging stage are parallel. This way, the THz pulse reflected from the front surface remains at the same time delay for every position on the object. In order to achieve this you need to determine the peak position at different positions on the x-y-plane and adjust the orientation of your sample.

## 3 Angular Resolved Measurement

For angular resolved measurements you can use the Theta-2-Theta (**T2T**) setup. It can be operated manually (**T2T-m**) or automatically (**T2T-a**) using the **T3DS** software. For both configurations the angle of incidence can be chosen between  $15^\circ$  and  $90^\circ$ . Smaller angles are not recommended, because the tips of the antenna packages may collide.

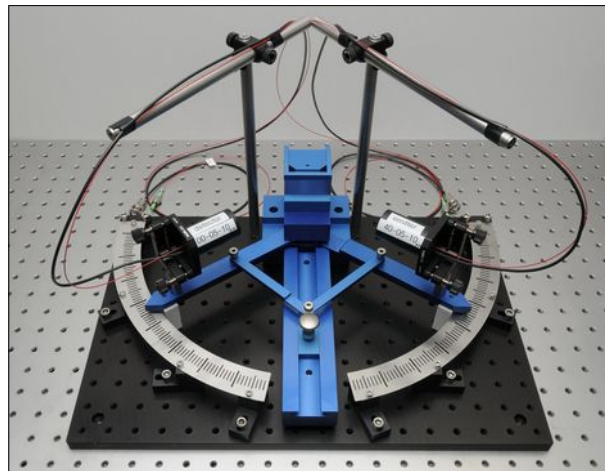


Figure 9: Manual **T2T-m** setup

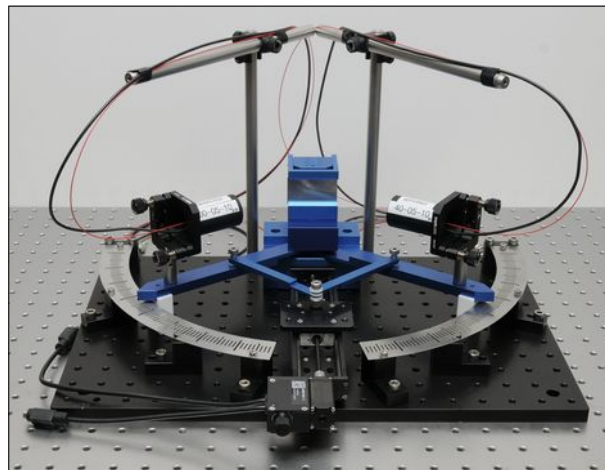


Figure 10: Automatic **T2T-a** setup



## Warning

This setup uses TPX lenses with a focal length of about 67 mm, because of the larger distance between the mount of the THz antenna and the center of rotation. Hence, the distance between the tip of the lens tube and the reflection plane is roughly 65 mm. Do not use the standard focusing TPX lenses (FTL-f32.5mm) with this setup.

For the manually operated setup the angle of incidence can be changed while moving the sled. The automatically operated setup uses a linear stage to adjust the angle of incidence via the [T3DS](#) software. This gives you the opportunity to conduct a number of scans at various angles without the need of rearranging the antennas manually.

The [T2T](#) setup uses the same external sample holder as the basic setup (section 1). Please note that for very large angles of incidence part of the THz beam might be blocked by the sample rather than being reflected.



## Warning

Both setups may be used to change just one angle (incidence or reflection) by detaching one of the antenna arms from the sled/linear stage. If you do so please make sure to keep the remaining lever horizontal. Detaching a lever on just one side is not recommended as it may interfere with the movement of the sled or linear stage. Especially for the automatic setup this may cause damage to the equipment.

Please note that the long posts have been removed for transport. Please attach them in a way that the THz antenna cables/fibers can move freely over the whole range.

## 4 Connecting your External Measurement System

Independent of your measurement setup you need to hook up your emitter and detector antenna to the panel on the right hand side of your TDS system. Therefore, please connect the emitter antenna to the *emitter out* port and the detector antenna to the *detector in* port and the optical fibers to the corresponding FC/APC ports next to the BNC ports (Figure 11). Additionally, please equip the remaining BNC ports with the 50  $\Omega$  caps provided.



Figure 11: Orientation of the fiber connector to the fiber port

**Warning**

When hooking up the fiber-coupled antennas make sure that the key on the connector lines up with the key slot on the fiber port (Figure 12). Otherwise the optical power will not be coupled into the fiber.

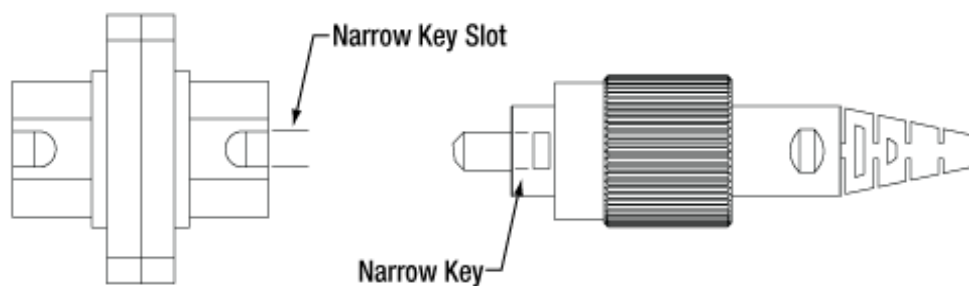


Figure 12: Orientation of the fiber connector to the fiber port

**Warning**

Please note that the emitter antenna package includes a polarizer in order to get a single polarization for the THz beam.<sup>6</sup> Similarly, the detector antenna has a preferred polarization for detecting the THz beam. On the mounts you will find a label indicating the correct orientation in order to make sure the polarization fits the external reflection setup. The T3DS calculator software assumes an s-polarized THz beam on the sample surface and applies the corresponding formulas. So it is important to set up the fiber-coupled antennas correctly.

Once you have connected your THz antennas just hook up your x-stage to the spectrometer using the Mini-Din or M8 cable<sup>7</sup> provided. The y-stage can be connected directly to the x-stage in a daisy-chain configuration. In case of a rotation stage simply connect the stage to the Mini-Din or M8 port.

<sup>6</sup> The polarizer is only included if the THz antenna is bought as part of a TDS system

<sup>7</sup> Depends on the connector on your spectrometer



## Warning

Please note that as long as the software has not been started you can position the stage manually using the knob on the stage itself. Once the software has been started avoid using the knobs under any circumstances. If the knobs are not in the neutral position the software cannot operate the stages. Note, that stage movement is always indicated by the orange LED on the stage.

In case the external linear stages do not function properly please consult the Zaber manual or contact us. If the power supply through the Mini-Din or M8 cable is not sufficient we advise you to hook up the additional power supply that comes with the shipment (may be required for larger imaging stages).



## Warning

Please always hook up the ground wire (yellow/green cable) of your setup to the spectrometer in order to ensure a proper grounding of your external setup. Otherwise your THz signal may display a high noise level.



## 5 Contact Details

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

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