Manual for external measurement setups for terahertz Time-Domain Spectrometer TDS-10XX

Table of contents

0. Basic setup

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

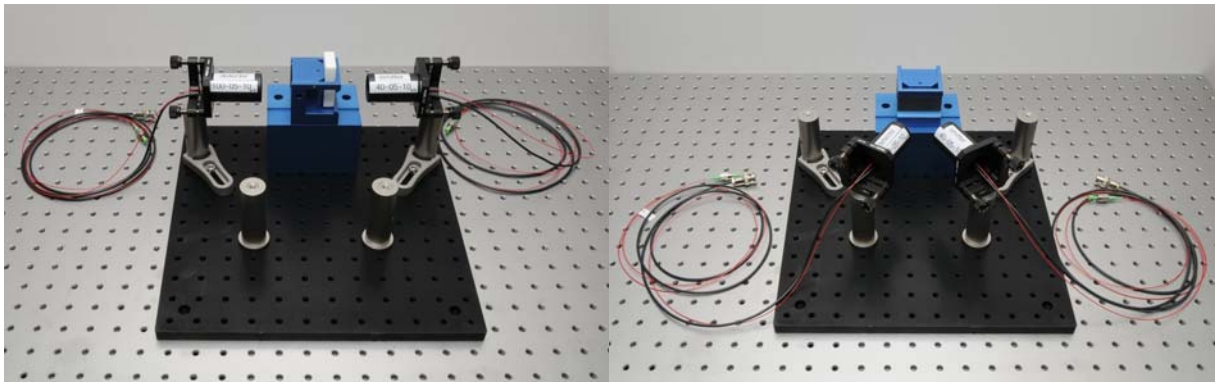


Figure 1: Fiber-coupled THz antennas in a basic transmission or reflection setup.

The position of the posts for transmission and reflection is essentially defined by the focal length of the THz lenses (FTL-f30mm). These positions do not need to be changed. However, if you have also bought an imaging unit and want to change between the two setups please see the following picture in case you need to setup the posts and antennas once again. Please note that the angle of incidence is roughly 30°.

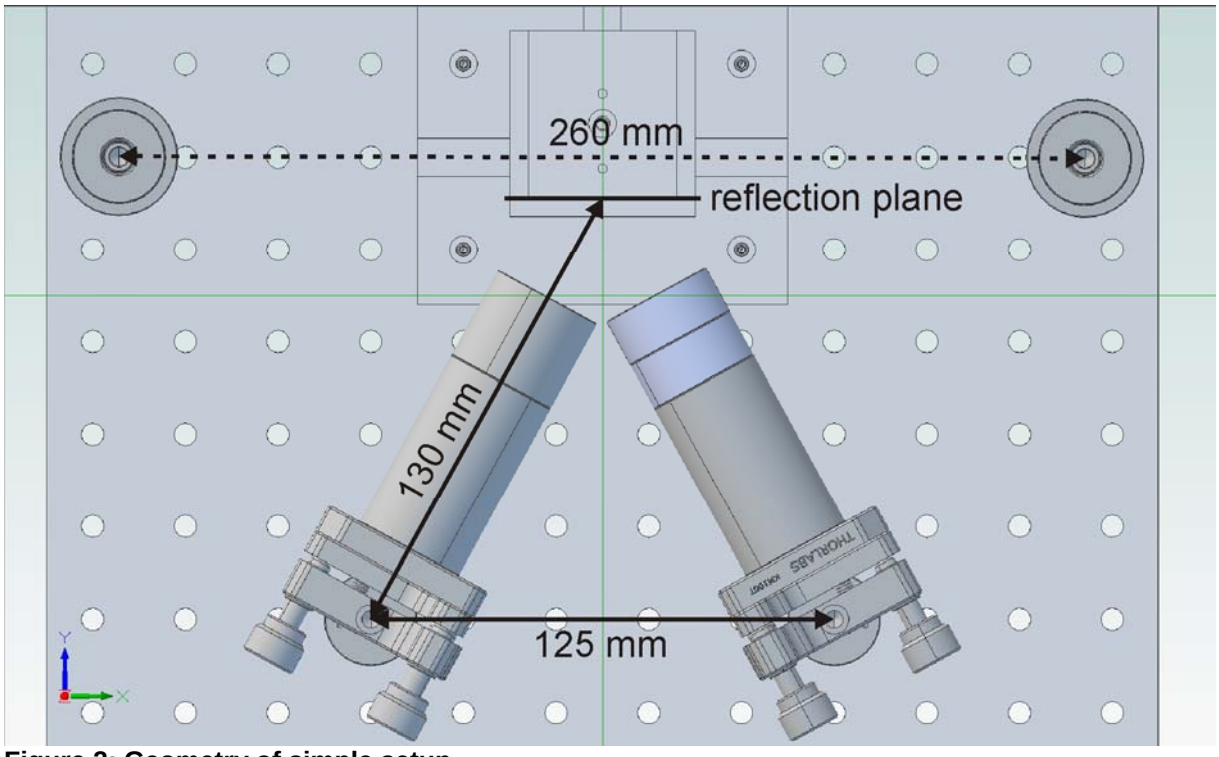


Figure 2: Geometry of simple setup.

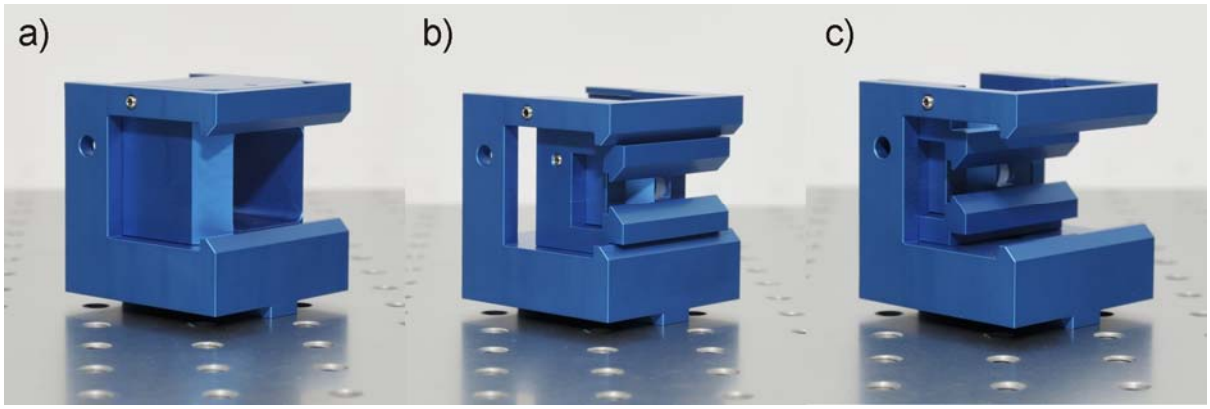


Figure 3: Close up of sample holder for a) collimated beam, focused beam in b) reflection and c) transmission.

When changing from transmission to reflection just remove the sample holder from the base structure, turn it by 90° and put it back on.

Attention:

When working with a focused beam please remember to shift the small sample holder to the center position when for the transmission configuration (picture on the left side). Otherwise, the sample will not be at the focal point. The small sample holder must be shifted to the frontal reference plane for reflection measurements (see center picture) in order to make sure that the antennas focus on the same plane as for the large sample holder (see picture on the left).

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

1. Parts for imaging stage

For your external imaging setup there are two possible arrangement options. You will find the following parts preassembled:

- aluminum base plate on which the x-stage is mounted onto
- y-stage to be mounted onto the x-stage (fixed to the base plate for transport)
- terahertz emitter and detector antenna packages including focusing THz lenses (FTL-f30mm) and the two mounts
- Mini-Din cable for hooking up the x-stage to the spectrometer
- Mini-Din cable for connecting the y-stage to the x-stage (daisy-chain configuration)

i) two posts and clamps for fixing the antenna packages face to face (transmission setup)

ii) second base plate for setup with reflecting geometry to be mounted onto the y-stage (including jig with a mirror for reference measurements)

Warning:

For safety reasons you must never put your hand on one of the stages while it is moving. The linear stages can cause serious damage to your hand and fingers. Hence, before you can 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).

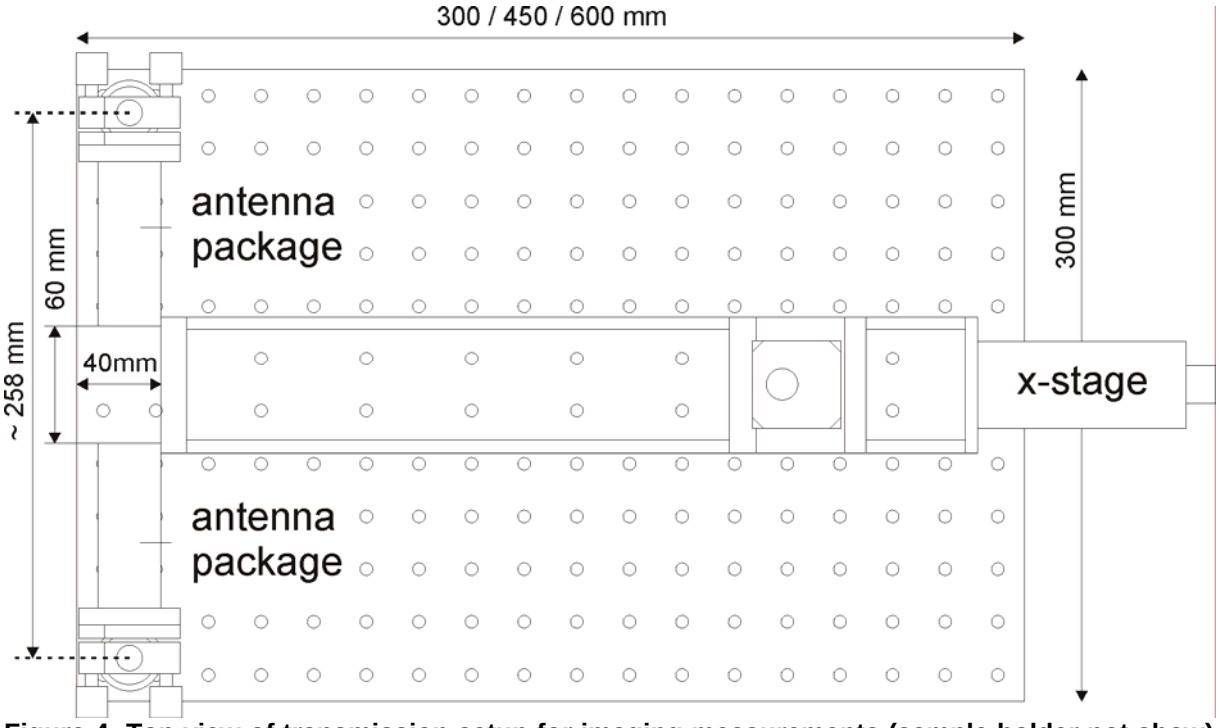


Figure 4: Top view of transmission setup for imaging measurements (sample holder not show). Please note that the antenna packages include the focusing THz lenses with their lens tubes.

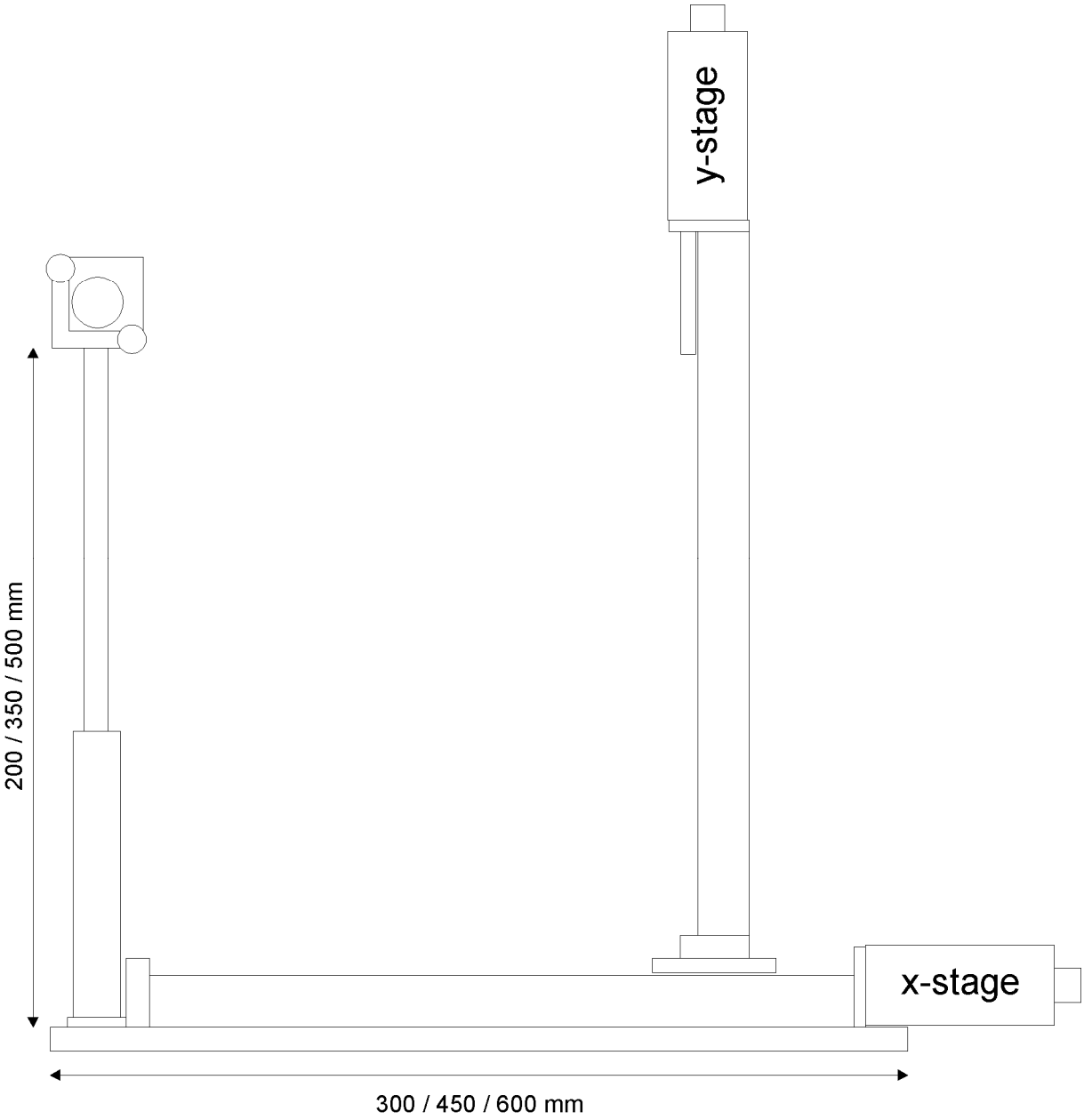


Figure 5: Side view of transmission setup for imaging measurements (sample holder not shown).

imaging area	15 cm x 15 cm	30 cm x 30 cm	45 cm x 45 cm
imaging stage weight (T + R)	5.4 kg	7.2 kg	8.9 kg
bread board size	30 cm x 30 cm	30 cm x 45 cm	30 cm x 60 cm
mount height above bread board	20 cm	35 cm	50 cm

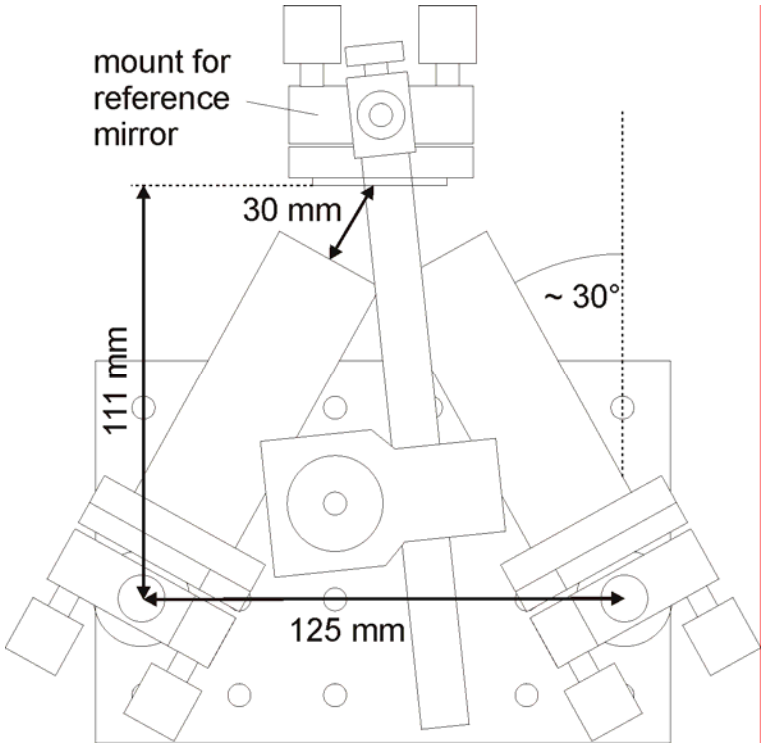


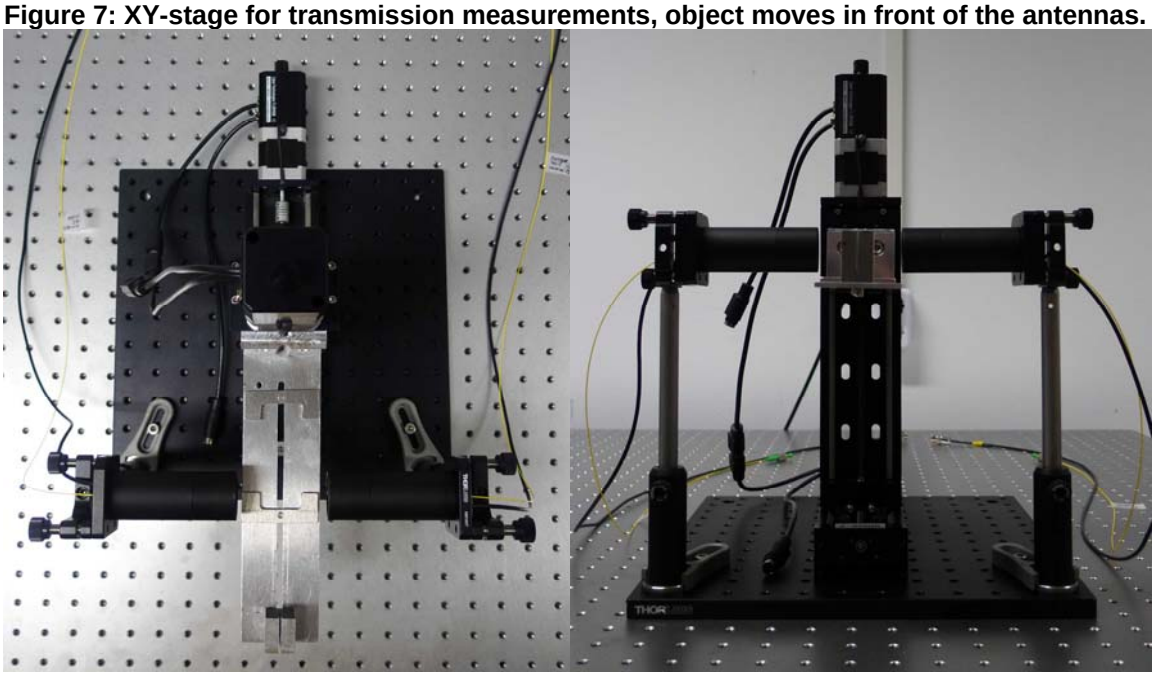
Figure 6: Top view of small base plate for reflection setup, including jig with reference mirror. This setup is used for a fixed object with the antennas being attached to the imaging stage. Please note that the antenna packages include the focusing THz lenses with their lens tubes.

2. Transmission setup

In the transmission setup the two terahertz antennas are positioned face to face. The gap between the packages has to be roughly 60 mm when using focusing THz lenses (FTL-f30mm). You do not need to reposition the antenna packages if you choose to detach the lens tubes containing the focusing THz lenses but you may need to optimize the alignment of the two packages once again. Additionally, you have to remember that removing the lenses will result in a time shift of the terahertz peak of about 25 ps because of the reduced optical length of the terahertz beam path. Finally, please bear in mind that the spatial resolution is very limited when using a collimated beam due to the large beam diameter.

The x-stage should be placed in the center of the breadboard between the packages and in a way that, the terahertz beam passes by the front tip of the stage (see Figure 4 and Figure 7). Consequently, if the x-stage is moved to its end position the y-stage will not block the terahertz beam. Secondly, the position of the antenna packages should be as high as the stage of the y-stage in its home position to make use of the full range of the linear stages for the imaging measurements (see Figure 5).

Figure 7: XY-stage for transmission measurements, object moves in front of the antennas.



Caution:

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) low as it may otherwise 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.

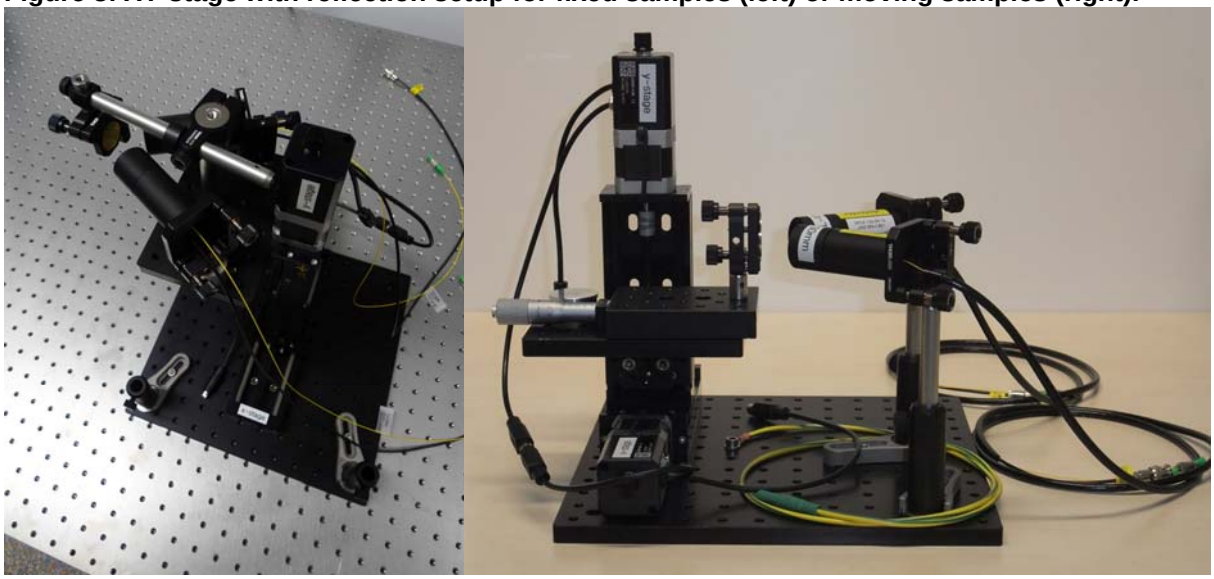
3. Reflection setup

For the reflection setup there are two possible mounting options. Depending on the size of your sample you can a) mount the antennas to the xy-stage (in case the object is very heavy or larger than the travel range) or b) fix the sample to the xy-stage. Figure 8 shows both setups and the latter with an additional manual z-stage. In Figure 6 you can see how the two antennas would be fixed to a small bread board which is then mounted to the y-stage. The basic geometry (distances and angle of incidence) are the same for both setups.

Caution:

If you mount the antennas to the xy-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.

Figure 8: XY-stage with reflection setup for fixed samples (left) or moving samples (right).



At first we recommend using the reference mirror in order to optimize the terahertz signal. Afterwards you need to remove the reference mirror jig at the ½" to 1" adapter. The plane that the 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 object / 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 object 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 state you need to determine the peak position at different positions on the xy-plane and adjust the orientation of your sample.

4. T2T setup for angular resolved measurements

The T2T setup is used for angular resolved measurements, it can either be operated manually (T2T-m) or automatically (T2T-a) using the T3DS software. The angle of incidence can be chosen from 15 – 90° for both configurations. Smaller angles are not recommended because the tips of the antenna packages may collide.

Attention:

This setup uses lenses with a focal length of about 67 mm because of the larger distance between the antenna mount 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 lenses (FTL-f30mm) with this kind of setup.

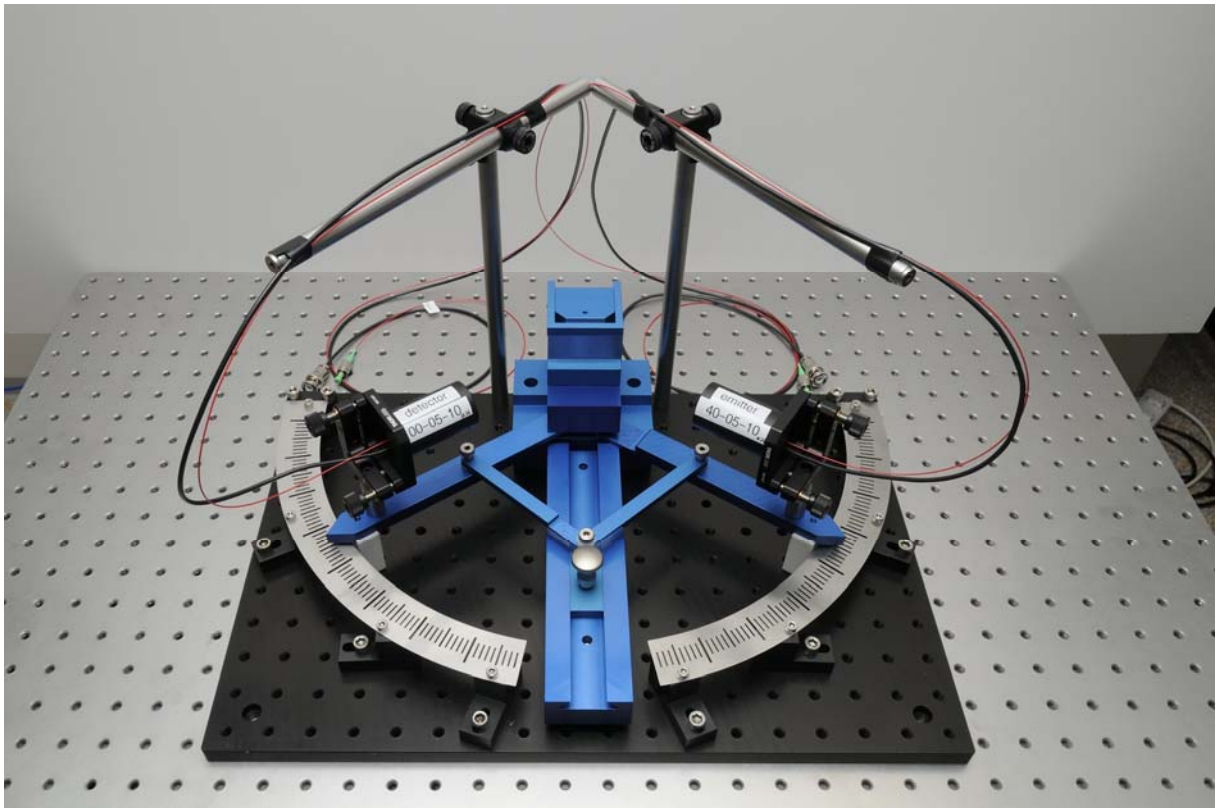


Figure 9: Manual T2T setup with sled to move the antennas to the designated position.

For the manual setup the angle of incidence can be changed by moving the sled to a designated position. In contrast, the automatic setup uses a linear stage to change the angle of incidence using the T3DS software. This allows conducting a number of scans at various angles without the need of rearranging the antennas manually.

The T2T setup can make use of the same external sample holder as the simple setup described in section 0. The parts fit onto the base structure much the same way. Please note that for very large angles of incidence part of the THz beam might be blocked by the sample rather than being reflected.

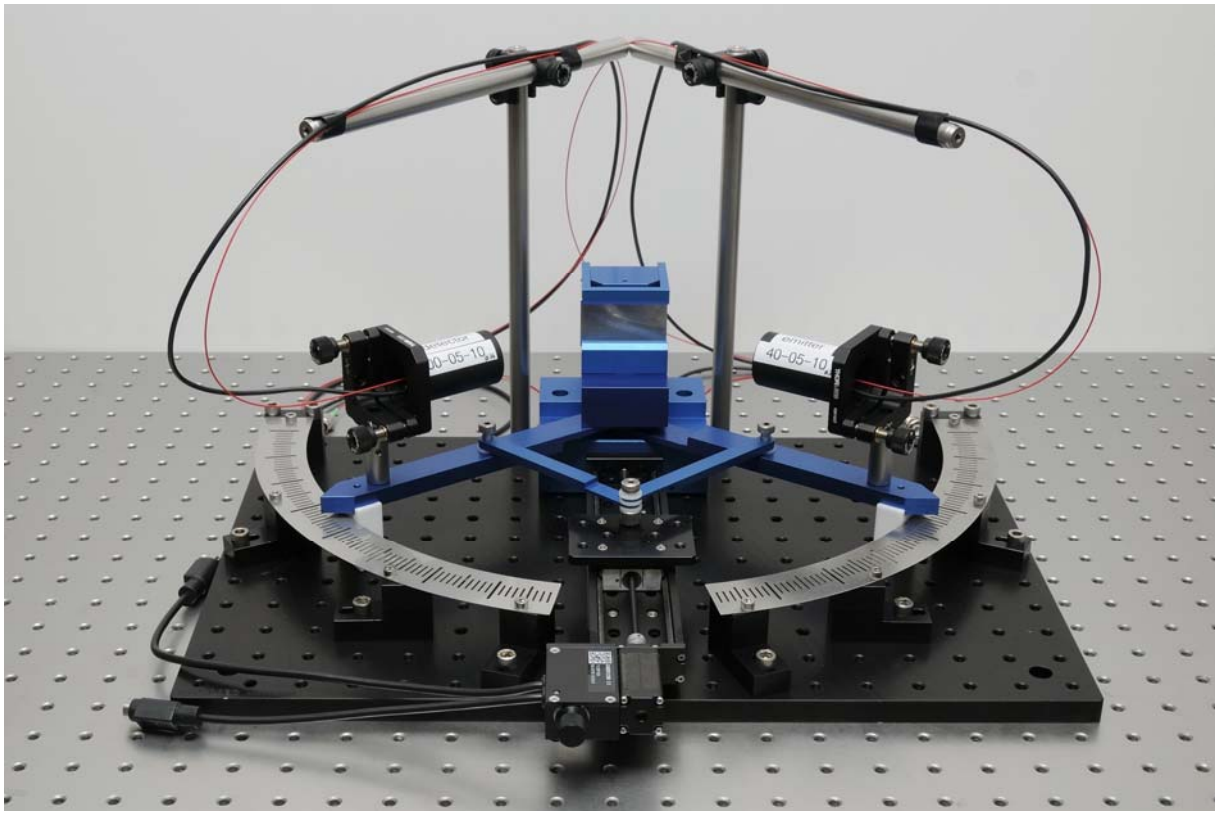


Figure 10: Automatic T2T setup with linear stage to adjust the angle of incidence using the T3DS software.

Caution:

Both setups may be used to change just one angle (incidence or reflection) by removing 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 may have been removed for transport. If so, please reattach them in a way that the antenna cables / fibers can move freely over the whole range of antenna positions.

5. 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 sytem. Therefore, please connect the emitter antenna to the “emitter out” port, the detector antenna to the “detector in” port and the optical fibers to the corresponding FC/APC ports next to the BNC adapters as shown in Figure 12. Additionally, close the open BNC ports using the 50 Ω caps provided.

Attention:

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. Otherwise the optical power is not coupled into the fiber.

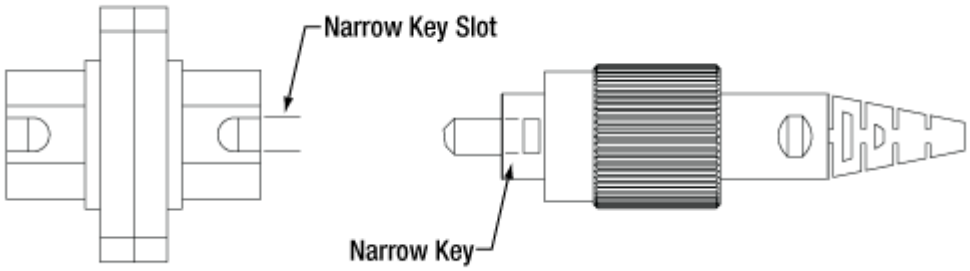


Figure 11: Orientation of the fiber port and the fiber connector of the external antennas.

Attention:

Please note that the emitter antenna package includes a polarizer in order to get a single polarization for the THz beam. Similarly, the detector antenna has a preferred polarization for detecting the THz beam. On the mounts you will find arrows indicating which side has to be fixed to the post 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. Hence, it is important to set up the fiber-coupled antennas correctly.

Once you have connected your antennas just hook up your x-stage to the spectrometer using one of the Mini-Din cables provided. The second cable can then be used to connect the y-stage to the x-stage in a daisy-chain configuration. In case of a rotation stage simply connect the stage to the Mini-Din port.

Attention:

Please note that as long as the software has not been started you can position a 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 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).

Figure 12: Panel on the right hand side of a TDS system with ports for electrical and optical connection of THz antennas, external stages (imaging unit or angular scanning unit), the delay line and the data acquisition system (DAQ). The panel shown is configured for the use of the external fiber-coupled antennas.

6. Contact details

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

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