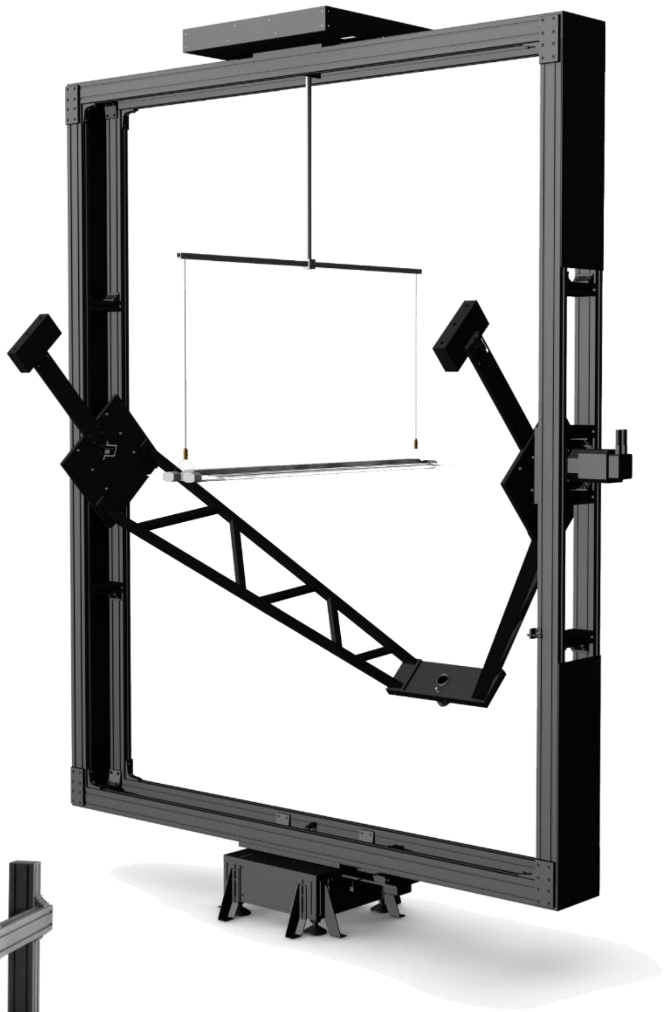
TechnoTeam
Bildverarbeitung GmbH

# Software manual

## RiGO801
## Goniophotometer



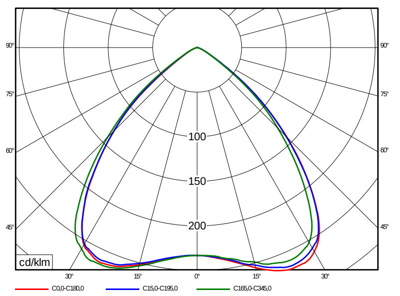
# Contents

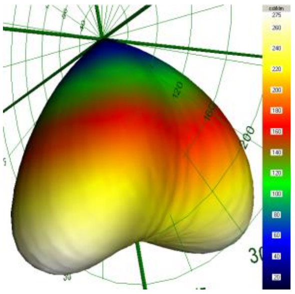

1 INTRODUCTION ....... 4
2 MEASURING PRINCIPLE ....... 5
2.1 FUNDAMENTALS AND AGREEMENTS ....... 5
2.2 RAY MEASUREMENT WITH THE CAMERA ....... 5
2.3 LUMINOUS INTENSITY DISTRIBUTION MEASUREMENT WITH THE CAMERA ....... 6
2.4 LUMINOUS INTENSITY DISTRIBUTION MEASUREMENT WITH THE PHOTOMETER ....... 7
2.5 LUMINOUS FLUX MEASUREMENT WITH THE PHOTOMETER ....... 8
3 PROGRAM START ....... 9
3.1 START CONFIGURATIONS ....... 9
3.2 INITIALIZATION OF THE AXES ....... 10
4 LENS CHANGE ....... 11
4.1 LENS SELECTION ....... 11
4.2 LENS CALIBRATION ....... 11
5 ALIGNING THE MEASUREMENT OBJECT ....... 14
6 CARRYING OUT A MEASUREMENT ....... 16
6.1 SELECTING THE MEASURING METHOD ....... 16
6.2 SETTING THE ANGULAR RANGE AND MEASURING RESOLUTION ....... 17
6.3 SETTING THE CAMERA ....... 22
6.4 SETTING THE PHOTOMETER ....... 25
6.5 PARAMETERIZING THE MEASURING INSTRUMENTS ....... 26
6.6 MEASUREMENT DETAILS ....... 28
6.7 ALIGNING THE MEASUREMENT OBJECT ....... 29
6.8 STARTING THE MEASUREMENT ....... 30
6.9 STABILIZING PROCEDURE ....... 31
6.10 END OF MEASUREMENT AND DISPLAYING THE MEASUREMENT RESULTS ....... 32
7 DISPLAY OF MEASUREMENT RESULTS ....... 33
7.1 GENERAL DIALOG FEATURES ....... 33
7.2 TAB „DETAILS OF MEASUREMENT " ....... 33
7.3 TAB „LID GRAPH“ ....... 33
7.4 TAB „LID TABLE“ ....... 34
7.5 TAB „RAYS OF CAMERA IMAGES“ ....... 35
7.6 TAB „MEASURING DEVICES“ ....... 35
7.7 TAB „BURN-IN DATA“ ....... 36
7.8 TABS “POLE-MONITORING-GRAPHIC” AND “POLE-MONITORING-TABLE” ....... 37
8 MEASURING PROJECTS ....... 38

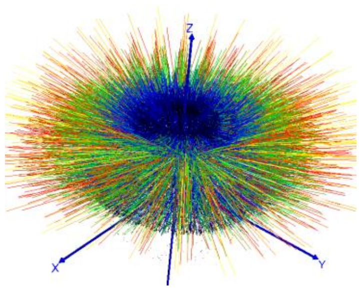
8.1 MEASURING PROJECT EDITOR ........ 38
8.2 CARRY OUT A MEASURING PROJECT ........ 41
8.3 MEASURING PROJECT NAVIGATOR ........ 43
9 SPECTROMETER EXTENSION MODULE ........ 44
9.1 GENERAL ........ 44
9.2 MANUAL SPECTROMETER MEASUREMENT ........ 44
9.3 POSITION CONTROLLED MEASURING SEQUENCE ........ 46
10 OTHER PROGRAM FEATURES ........ 54
10.1 DATA-IO ........ 54
10.2 SINGLE ACCESS TO THE HARDWARE COMPONENTS ........ 57
10.3 PROGRAM ERRORS ........ 59
10.4 PROGRAM DIRECTORIES AND CALIBRATION FILES ........ 60
11 FILE FORMATS RIGO801 ........ 61
11.1 LUMINOUS INTENSITY DISTRIBUTION *.TTL ........ 61
11.2 RAY FILE *.TTR ........ 64
12 LITERATURE ........ 65

# 1 Introduction

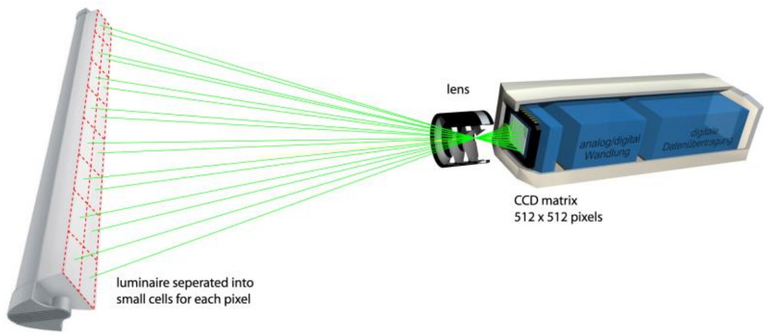
The goniophotometer type Rigo801 is a measuring device for measuring luminous fluxes, luminous intensity distributions, and ray data of LEDs, lamps and luminaires. The applied near-field measuring principle according to Prof Riemann ([Riem91], [DE297]) allows measurements to be made in the position of use and far within the photometric near-field range.

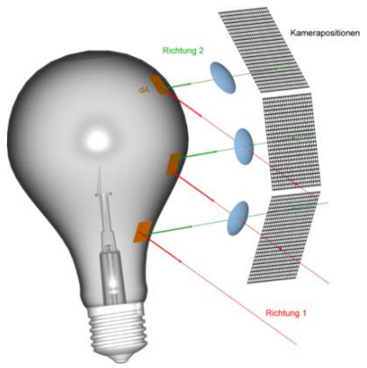





The measuring installation is set up in such a way that a luminance measuring camera is moved at a constant distance around the virtual goniometer center by taking photos of the measurement object at many different positions.



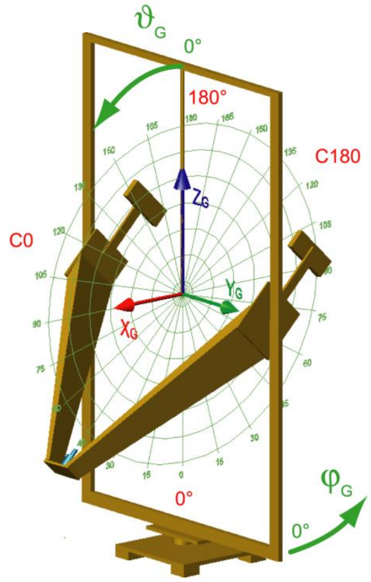

The radius of the camera sphere is considerably smaller than the photometric near-field range. Nevertheless, the far-field condition is fulfilled because each measurement is composed of isolated single measurements of the optical imaging of a measurement object range onto a camera pixel, and because each camera pixel covers an object range which is very small in relation to the distance of the object. Therefore, the size of the measurement objects is theoretically limited only by the radius of the camera sphere, i.e., by the distance between the camera and the center point of the goniometer. Due to the measuring principle, the measurement object does not necessarily have to be positioned in the center point of the camera sphere.

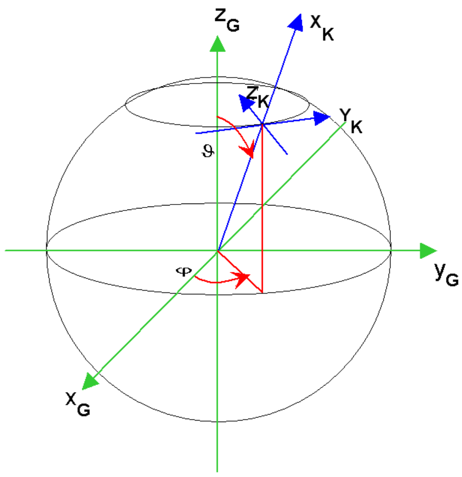
During the measurement, the camera records a four-dimensional luminance field in the vicinity of the measurement object. From this, not only LID curves and luminous fluxes but also ray data can be calculated.

# 2 Measuring principle

## 2.1 Fundamentals and agreements

### 2.1.1 Coordinate systems

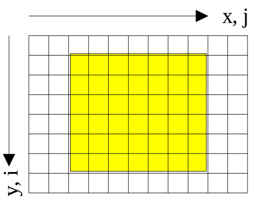


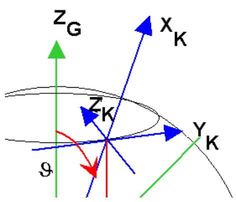




The above figures show the coordinate system of the goniometer (index G). The $\varphi$ - axis is in a vertical position and rotates the outer frame, the $\vartheta$ - axis is in a horizontal position and moves the inner frame. Besides the goniometer coordinate system, also the camera coordinate system, the image coordinate system as well as the C-plane coordinate system are defined.

The measured ray data are saved in the goniometer coordinate system shown, whereas the luminous intensity distribution data are saved in the correspondingly rotated C-plane coordinate system. In the left-hand figure, the C-plane coordinate system is drawn in. Here, the gamma coordinates are contra-rotating to the theta coordinates in the goniometer coordinate system (y - and z – axis are mirrored).

The figures below show the camera- and the image coordinate system. However, these are of interest to the user only in exceptional cases.

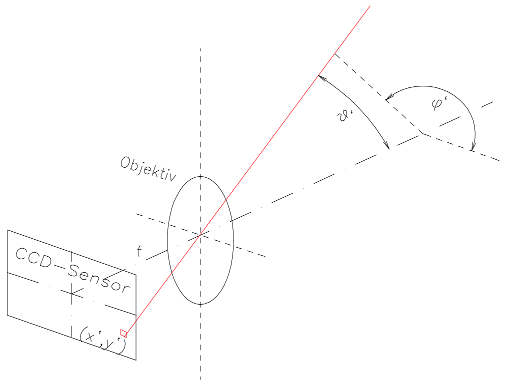


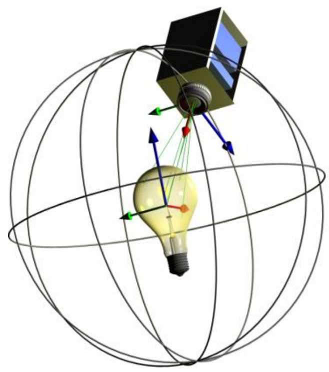




## 2.2 Ray measurement with the camera

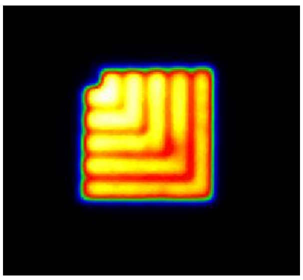
In each luminance image captured, the pixels define vectors in the camera coordinate system, i.e., the image coordinates $(x', y')$, the camera geometry and the knowledge of the optical imaging through the camera lens define the vector base point and the direction in relation to the optical axis of the camera.

The knowledge of the camera positions $(x_K, y_K, z_K)$ and of the „viewing direction“ of the camera $(\vartheta_K, \varphi_K)$ (direction of the optical axis, usually in the direction of the intersection of the goniometer axes) enables the conversion of the directions of the vectors, in the following called rays, into the world coordinate system.



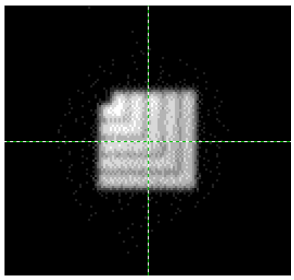
The rays are assigned the corresponding luminous flux portions of the luminance pixels by multiplying with the solid angle of the pixel and another pixel-dependent quantity (cosine weighting). Furthermore, a data reduction of the rays takes place.



Luminance image

Calculation of the luminous flux portions

$$\Delta\Phi(i, j) = L_{i,j} \cdot c_{i,j} \cdot \Delta\Omega_{i,j}$$



Extracted ray data

The amount of all rays determined in the luminance images captured results in a five-dimensional data field $\Phi(x, y, z, \vartheta, \varphi)$, called ray data record. In the ray data record measured, all photometric information of light radiation is contained.

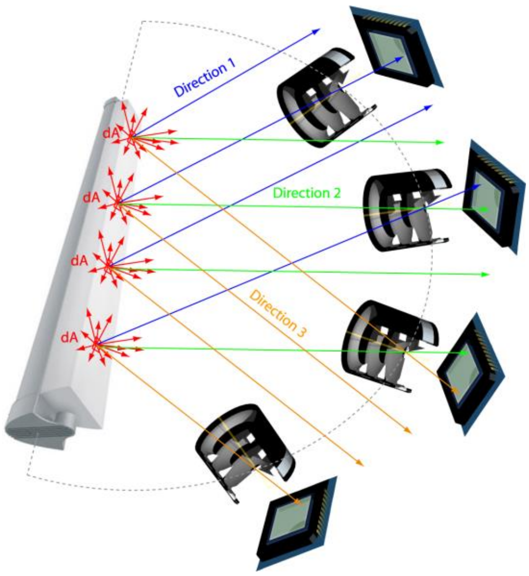
At first, the ray data measured exist in a TechnoTeam - format which can be converted to all commonly available ray data formats by means of the program *Converter801*. For detailed information the user is referred to the *Converter801* manual.

## 2.3 Luminous intensity distribution measurement with the camera

The far-field luminous intensity distribution $I(\vartheta, \varphi)$ can directly be calculated from the ray data obtained. This method is also applied by all common simulation procedures. For this, the directions of the rays are discretized, the amplitudes of the rays of each discrete ray direction are summed up, and the result is standardized at constant solid angles for each direction. This procedure corresponds to the photometric basic formula for the luminous intensity:

$$I(\gamma) = \frac{d\Phi}{d\Omega} \;\; [\text{Candela } cd]$$

The figure opposite shows the recording of directions, starting from different surface elements of the measurement object, captured at various camera positions. Thus, a luminous intensity value is always composed of data obtained at several camera positions.




## 2.4 Luminous intensity distribution measurement with the photometer

The photometer and the camera are moved together on a spherical surface around the measurement object through the movement of the two axes φ and ϑ. The measurement of the luminous intensity distribution with the photometer presupposes that the photometer is positioned beyond the photometric near-field range of the measurement object and that the measurement object is aligned centrally in the goniometer. In this case, the connection between the illuminances and the luminous intensities is a device constant which results from the geometrical set-up of the measurement system.

### 2.4.1 Photometric near-field range

Due to a real expansion of the luminaire and the photometer head, a minimum distance between the luminaire and the photometer head (the so-called photometric near-field range) results as a function of the luminous intensity distribution and the allowable error. It can be determined by measuring the illuminance as a function of the distance and calculating the luminous intensity. The photometric near-field range is obtained when the luminous intensity does not differ by more than the allowable deviation from the final value.

In practice, one starts out from the assumption that the error of commonly available measurement objects is negligibly small (< 1 %), if the measurement distance is 15-times larger than the biggest luminaire dimension. This error assessment is exactly valid only for Lambertian radiators. The photometric near-field range should be the larger the greater the change of the luminance (or also of the luminous intensity) of a luminaire is (e.g. spot radiators, optical projection systems).

In summary, it can be said that the photometric near-field range depends on the following factors:

- the allowable error
- the largest expansion of the light source
- the largest expansion of the photosensitive surface of the receiver
- the direction-dependent luminous intensity distribution of the light source

- the local luminous intensity distribution of the light source
- the direction-dependent evaluation of the radiation by the receiver.

## 2.5 Luminous flux measurement with the photometer

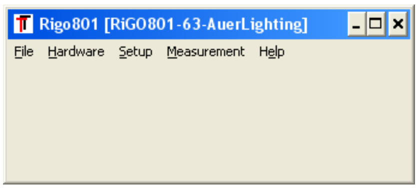
From the illuminance of a single photometer measurement value, the luminous flux portion of this value can be calculated by considering the size of the spherical segment to which this photometer measurement value applies. For this, the radius of the sphere and also the distance to neighboring capture positions have to be taken into account. For obtaining the total luminous flux –which is of interest – the single partial luminous fluxes must be summed up. The luminous flux measurement with the photometer can be made also within the photometric near-field range of the measurement object, and is independent of the position of the measurement object. This measuring method of the integration of the illuminances is anchored in some fundamental standards ([CIE84], [DIN5032-1]). The corresponding basic photometric formula results to:

$$\Phi = \int \mathrm{E}\,\mathrm{d}\mathrm{A} = \mathrm{r}^2 \int \sin(\vartheta)\,\mathrm{d}\vartheta\,\mathrm{d}\varphi\,.$$

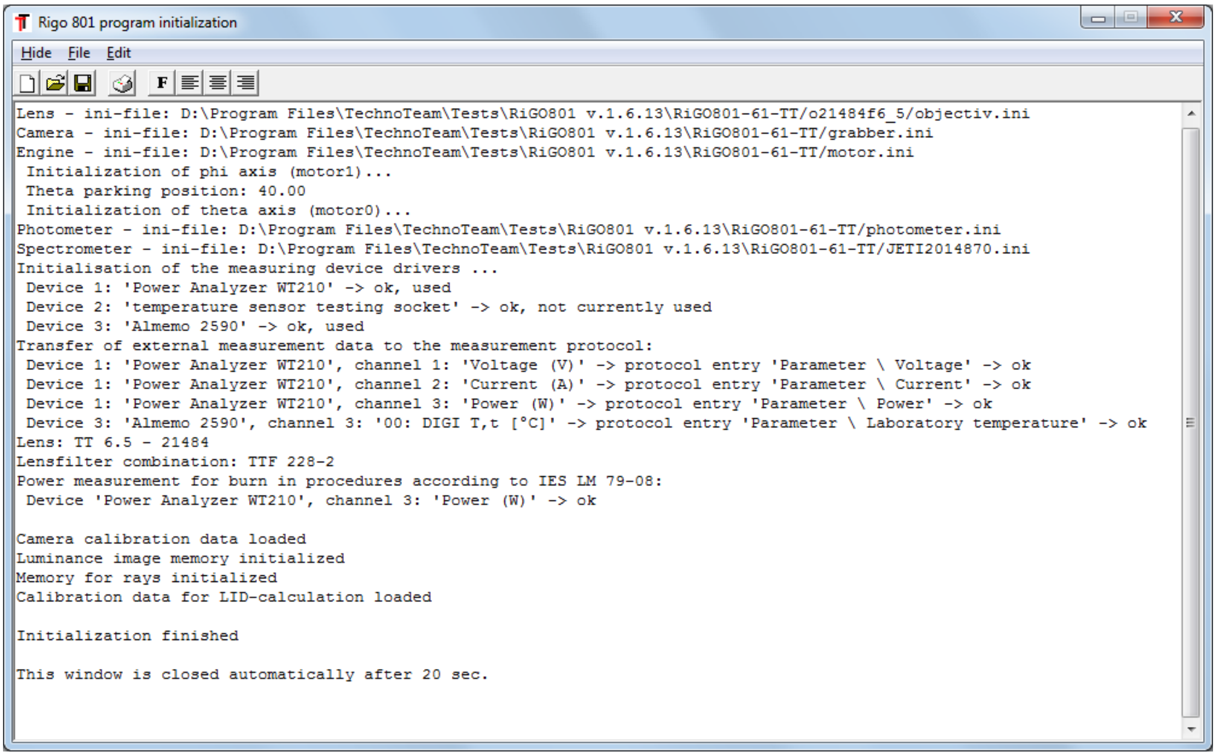
In the case of the RiGO801 goniophotometers, the luminous flux measurement is always based on this measuring method, which is also applied for a camera-based luminous intensity distribution measurement. The luminous fluxes integrated by the luminance measuring camera are standardized to the luminous fluxes measured with the photometer, i.e., the camera is used as a system making relative measurements only.

# 3 Program start

The program can be started via the Windows-Start menu (e.g. *Start > Programs > TechnoTeam > Rigo801*). Alternatively, you can also install icons with a corresponding link on the desktop which can then be used to start the program by double-click.



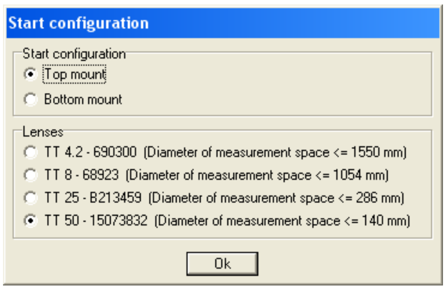

During start-up, the necessary calibration data are loaded consecutively, and the hardware components of the goniometer, i.e. the camera, the motors and the photometer, are initialized. During this phase, an additional window pops up which informs the user of the progress of the initialization. This window can either be closed manually or it is closed automatically after 20s.




During the program initialization phase there are also the connections to integrated external measuring devices, e.g. power analyzers, established (see 6.5 and 10.2.5). The configured links between measuring device channels and test report fields (e.g. voltage, current, power, temperature) are proofed as well. In case of reported errors or inconsistencies the configuration of the related devices needs to be checked in the menu *Hardware ->Measure devices*.

## 3.1 Start configurations

At the beginning of the initialization phase, the currently set device configuration is queried via a dialog.

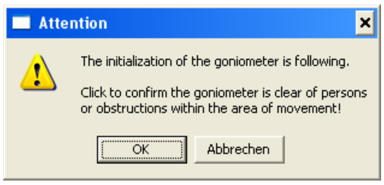



If the goniometer provides an upper and a lower luminaire mount, the currently installed mount must be selected at this point. Later changes of the post configuration require a restart of the RiGO801 program. A wrong selection of the start configuration is detected and reported during the initialization of the theta axis. This security check is also done while the program is running so that a Theta movement with invalid mechanical configuration is excluded.

At this point the required lens can be chosen as well. This can also be done later (see 4) without restarting the program. The adjacent standing maximum DUT diameters are helpful for selecting the best suitable lens. When the configuration is confirmed by the Ok button and the selection of the lens has been changed a warning message appears regarding a required lens calibration procedure (see 4.2).

## 3.2 Initialization of the axes

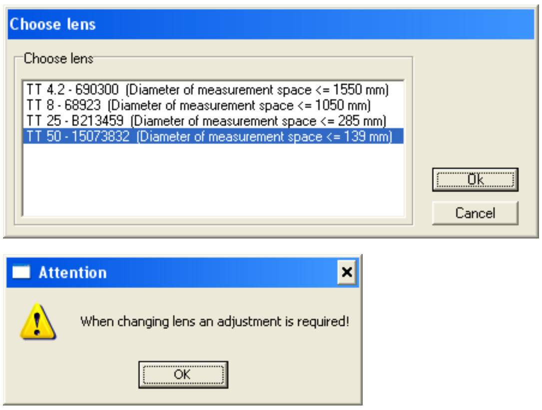
After having chosen the start configuration, the goniometer axes are initialized. In the case of drives with incremental encoders (built until 2011), first the reference positions of the axes are searched for (homing), and then the axes are moved into parking position. Goniometers with absolute encoders move the axes directly into their parking positions. As the movement of the axes represents a danger, the user must first check the safety conditions and then acknowledge the following message by pressing the *OK* button. Please refer to the operation manual for details.



# 4 Lens change

## 4.1 Lens selection

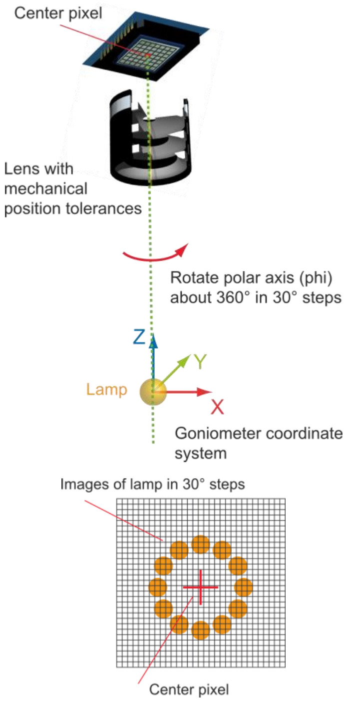
Before making a measurement, the best suited lens must be chosen. This can already be done when starting the measurement program (see 3.1) or also via the menu item *Setup > Changing lenses…* at any time.




The lens which is most appropriate for the current measurement object can be selected on the basis of the maximum measurement object diameters shown opposite. Fundamentally, always that lens should be selected which provides the largest image of the measurement object by making sure that no elements leave the image during measurement. When a new lens is selected, a warning message is displayed telling the user that a lens calibration is necessary (see below).

## 4.2 Lens calibration

### 4.2.1 Fundamental principle




For calculating the directions of the rays (see 2.2), the exact knowledge of the pixel coordinate of the optical axis is required (rotation center in the image). This coordinate depends on the lens and – due to small position tolerances - changes its position whenever the lens is fixed. Therefore, the position of the optical axis must be determined again after each lens change.

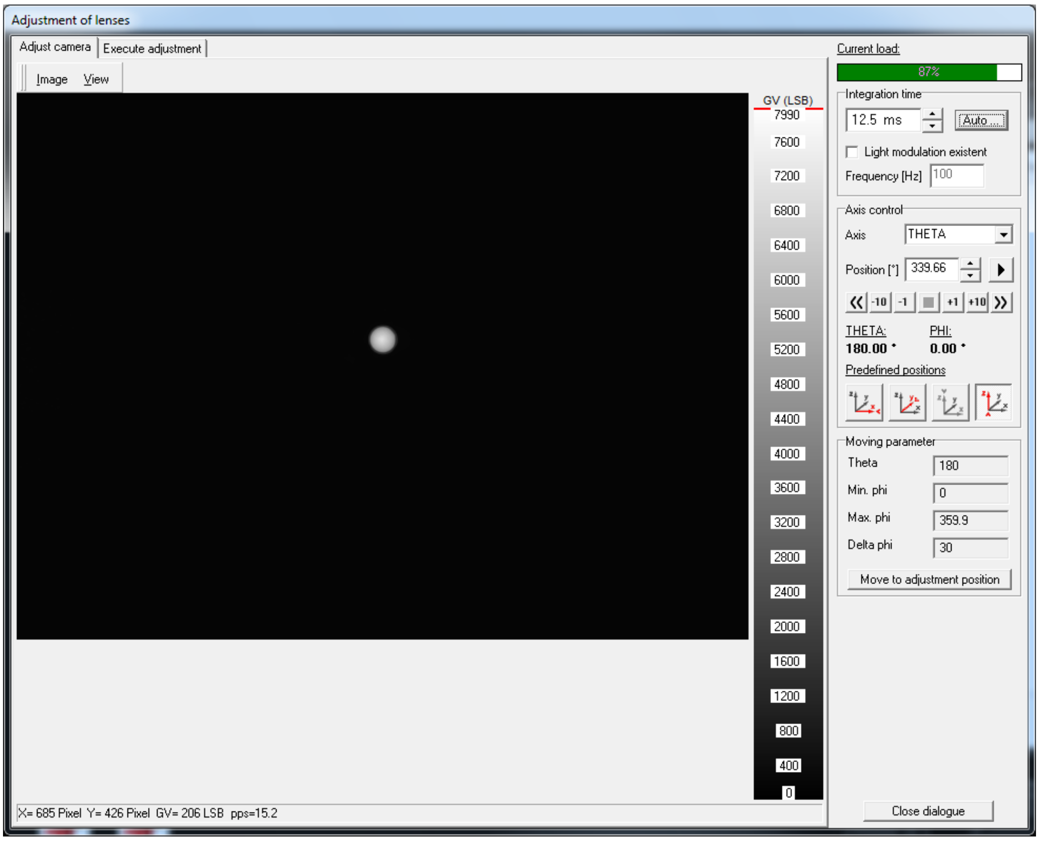
The measuring principle is simple. An ordinary lamp or LED is positioned in the center of the goniometer, and the camera is rotated by 360° from the viewing direction of the pole. In doing so, the alignment light source in the image describes a more or less large circle whose center is the wanted pixel coordinate of the optical axis. For aligning, a light source with a luminance distribution as homogeneous as possible should be used and whose size should neither be too small (< 10 pixels) nor too large (not larger than ¼ of the image field). For LED- and lamp goniometers, LEDs with Lambertian radiation characteristic without exchangeable optical head are optimum, whereas for big goniometers frosted incandescent lamp or also globe lamps are most appropriate.

### 4.2.2 Procedure

First, the alignment light source must be positioned roughly in the center of the goniometer (< 50 mm eccentric). If no mount with a suitable length is prepared, also the dialog *Align measuring object* (see 5) can be used.

The lens alignment dialog can be found by selecting the menu item *Setup > Lens calibration…*. The dialog consists of the two tabs *Adjust camera* and *Execute adjustment*.

### Tab „Adjust camera“




In the image area of the tab, the current camera image is displayed live. For adjusting, the camera must first be moved to the measuring position in the pole using the button *Move to adjustment position* (theta 180° or 0° depending on configuration). Now, the load of the camera must be set to 50% up to 95% (see 6.3).

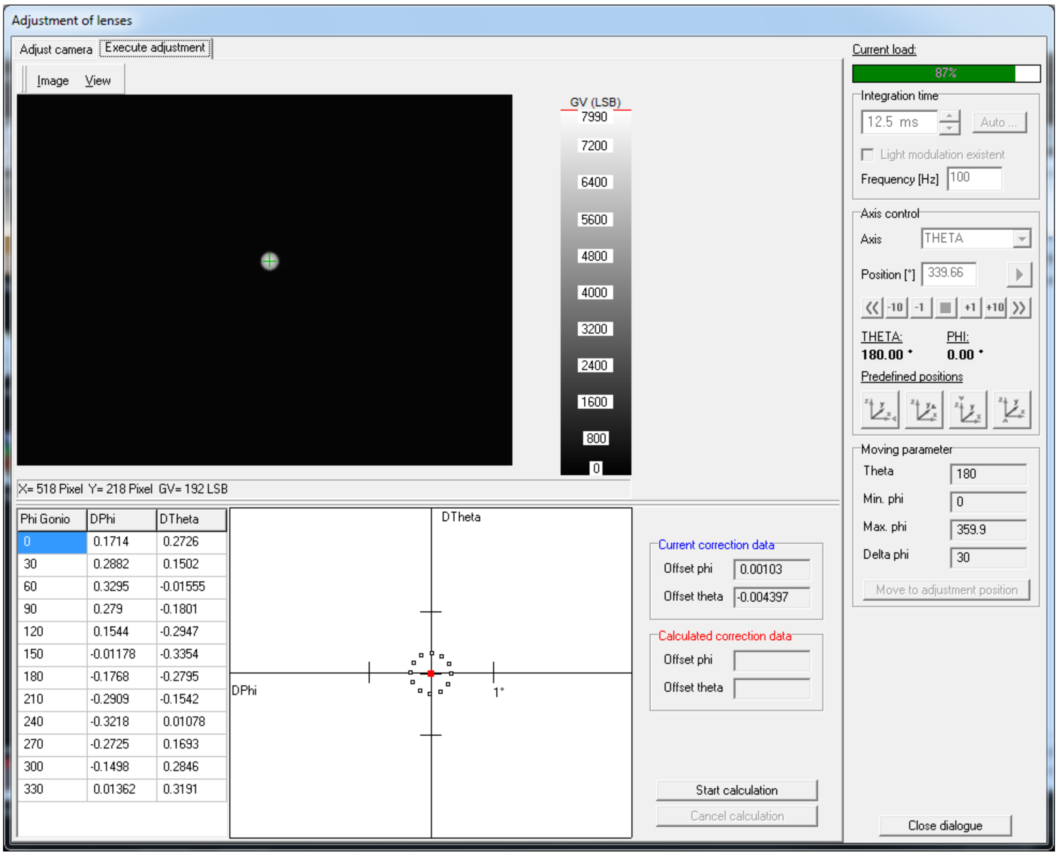
After the setting of the camera is finished, the user can switch over to the tab *Execute adjustment* by mouse click.

### Tab „Execute adjustment“

While switching over to this tab, the current load is checked and, if necessary, a warning message is displayed.

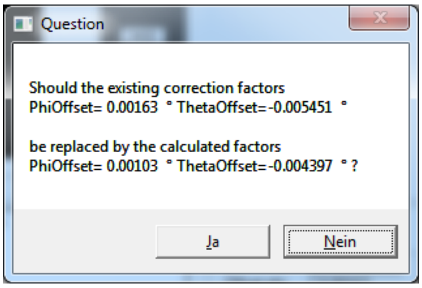
By pressing the button *Start calculation* the adjusting movement is started. In the dialog area *Moving parameter* it can be seen at which points images are captured. In the example shown, the images are captured at an angle of theta=180° at a distance of deltaPhi=30°.

At each position, an image is captured and the center of the alignment light source is calculated, which is then represented both in tabular form and graphically. The points should roughly describe a circle.




If the alignment light source is inappropriate (too small or too big), or if the size of the light source fluctuates too strongly or if the light source is positioned too far away from the center, warning messages or error messages will be displayed. In the case of a warning message, the user may either terminate or go on with the alignment process. However, in the case of an error message (e.g. alignment light source is too small), the lens calibration will be aborted.

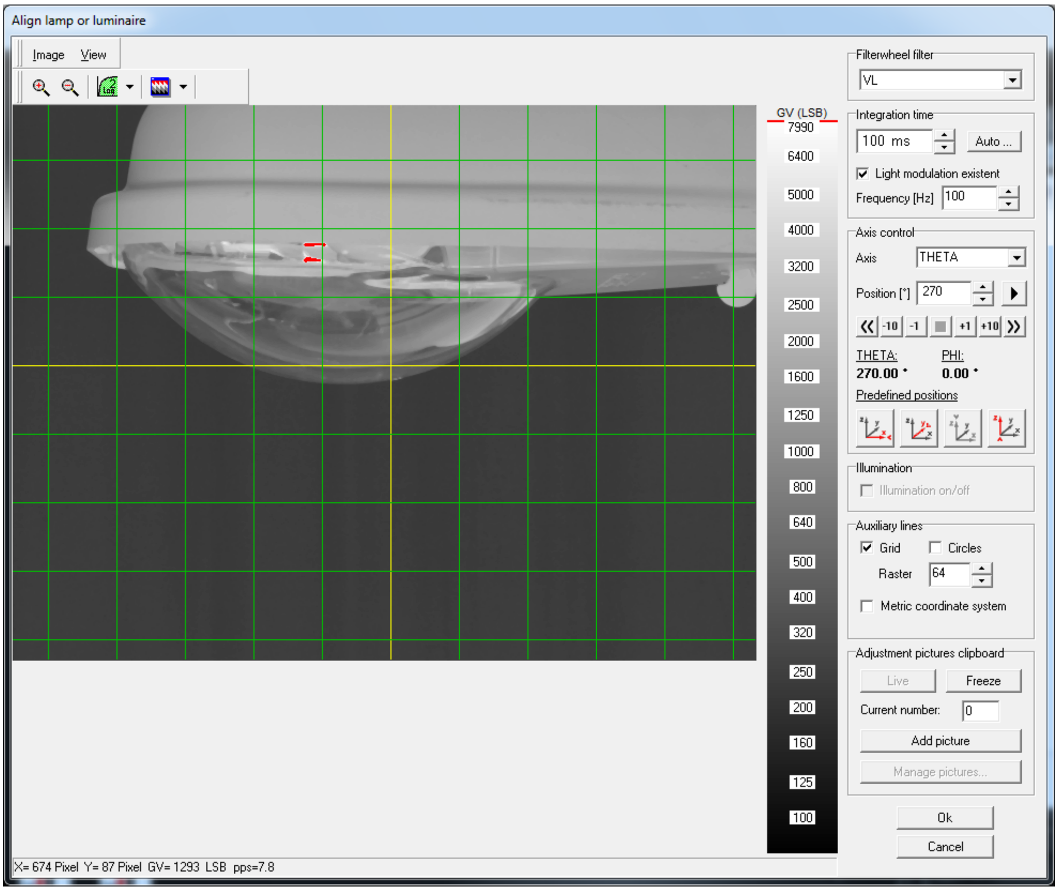
In the dialog area *Current correction data* , those values are displayed which are currently used for correction. In the diagram, this value is marked with a blue square. During the circular movement, the values are continuously updated in the dialog area *Calculated correction data* or they are marked with a red square in the diagram. The two squares should be nearly coincident because the tolerances are usually small. In case of larger deviation it should be proofed if the right lens is used and fixed tightly enough.




When the circular movement is complete, a dialog box is displayed showing the old and also the new correction factors. By pressing the button *Yes* the user can save the data and use them until the next lens change.

# 5 Aligning the measurement object

The dialog for aligning the measurement object is accessed via the menu item *Measurement > Align measuring object …* .




This dialog helps to align the measurement object in the goniometer by means of the camera. For facilitating the following evaluation of the measured data it is recommendable to adjust the rotation and the tilt of the DUT at this point instead of manipulating the results. However, the position of the DUT doesn't need to be set precisely to the light center according to the normative requirements for far-field goniophotometers (see 2 and 6.1). Nevertheless it is recommendable not to place the luminous areas not too far outside the center because this extends the *moving area of* these elements and increases the risk of moving out of the image at other positions. Furthermore this also increases the optical flow of the image contents which is linked to the best choice of the measuring resolution (see 6.2.3).

For LID measurements in far-field mode (photometer measurements) of course it is required to position the DUT according to the related standards for far-field measurements. If only the luminous flux result is of interest the centering of the DUT is not important (see 2.5).

Another aspect of the alignment procedure comes into account when the ray data results are to be used for evaluations in simulation programs. Here the precise position of the ray data center in relation to the DUT structure is of major interest for the setup of the simulation. The alignment pictures taken from different orthogonal positions are a valuable help for protocolling this center point.

The image area of the dialog displays the continuously made camera shots. The intersection of the yellow lines marks the viewing direction of the camera towards the goniometer center.

For a better orientation of the position in the image, some further lines can be drawn in using the selection boxes *Grid* and *Circles*. The distance between neighboring grid lines can be modified by means of the up-down button found below the selection boxes. The selection box *Metric coordinate system* shows a metric coordinate system, which is scaled only linearly in the image. Therefore, in the case of wide-angle lenses some inaccuracies may be expected.

The image brightness can be adapted using the dialog area *Integration time*, which is described in the corresponding section of paragraph 6.3. In contrast to the integration times for the measuring mode, time settings up to 500 ms can be made here.

When using goniophotometers with filter wheel camera, the filter wheel position can be selected in the dialog area Filter wheel filter. This is useful, for example, if you wish to switch from VL- over to the glass filter in order to achieve better sensitivity.

If the goniophotometer is equipped with an incident light illumination unit, this can be switched on and off in the dialog area *Illumination*. Whether incident or back light is better suitable for bringing out the relevant structures depends on the DUT (e.g. LED housing or glass bulb).

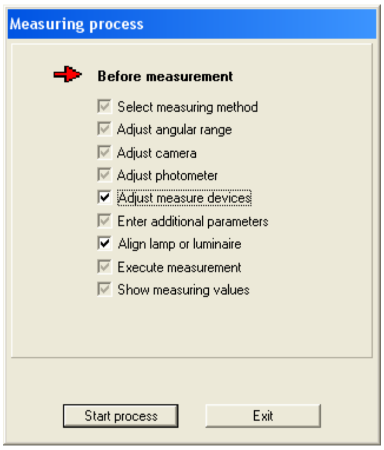
In most cases, it is necessary to remove the gray filter from the lens and to turn the room lighting on in order to be able to fully recognize the measurement object. A logarithmic scaling of the color palette via the pop-up menu *View* often improves the information content in the image. Selecting other color palettes can also be useful.

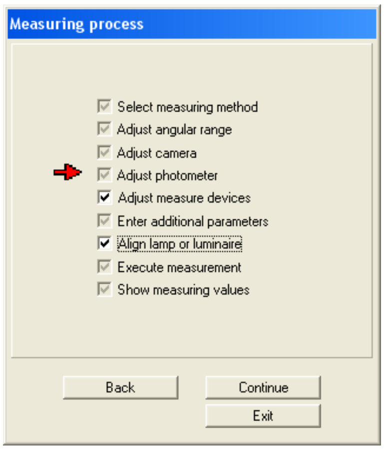
The dialog area *Axis control* contains control elements for the manual positioning of the camera. Different positions of the camera allow the user to check the alignment of the lamp or also luminaire on the basis of the live image displayed. Useful are orthogonal viewing directions. A detailed description of the dialog area can be found in the corresponding section of paragraph 6.3.

If the images of the alignment are relevant for later evaluations, they should be saved using the pop-up menu *Image* . It is advisable to use the BMP image format because this lossless format doesn't produce artefacts on the thin lines of the coordinate system as the JPEG format does. Furthermore, the dialog area *Adjustment pictures clipboard* also allows the user to put the images into an internal clipboard. Then, after the measurement, the images are attached to the TTR file and can be called in all TTR – display dialogs. The advantage is that only one measurement file containing all relevant information is necessary. If only the luminance distribution (*.ttl) is to be saved, this function cannot be used.

The settings made here are independent of the parameters of the measurement.

# 6 Carrying out a measurement




Before making a measurement, the appropriate lens must be set (see 4). Also, the a priori alignment of DUT in the goniometer is advantageous (see 5).

The measuring process is started using the menu item *Measurement > Execute measurement…*. Thus, the dialog *Measuring process* is initiated. It contains a list of the steps which are necessary for parameterising the measurement. If required, optional steps can be switched on or also off. A red arrow in the left-hand part of the dialog gives information about the current list item.

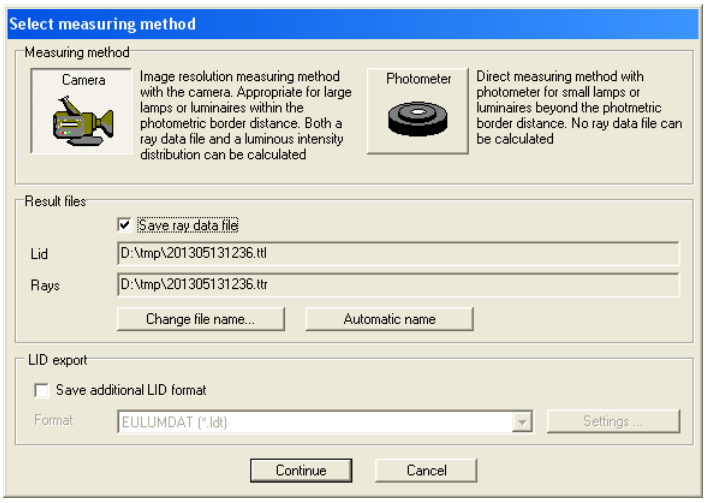
Each entry in the list is provided with an own dialog, which opens automatically after the entries in the preceding dialog have been made.

If one of the sub-dialogs is closed by pressing the button *Cancel*, the user can go back to any preceding list items by pressing the button *Back* in the dialog *Measuring process.*

Using the button *Continue* the user can go on with the processing at that point which is marked through the red arrow.

In the following, the single dialogs are described in the order in which they are called.

## 6.1 Selecting the measuring method




### 6.1.1 Dialog area „Measuring method“

In the dialog area *Measuring method*, the user can decide whether the luminance distribution shall be measured with the camera (near-field mode) or the photometer (far-field mode). A camera measurement is required when the far-field condition (sufficiently long photometric distance) is not fulfilled (see 2.4.1) or when ray data shall be measured. Elsewise LID measurements can also be performed by using the photometer in conventional far-field mode. Then, as in the case of a classical far-field goniophotometer, the object must be positioned exactly in the center of the goniometer according to the basic standards.

If only the luminous flux shall be measured, the photometer mode can be chosen regardless of the size and the position of the measurement object (see 2.5). The advantage is that the measuring speed is higher as the photometer values are read out at a higher cycle rate and, thus, the moving speed of the goniometer axis is higher.

### 6.1.2 Dialog area „Result files“

In the dialog area *Result files*, the file names for the measuring results can be entered. The luminance distribution is saved in the TechnoTeam file format *.ttl (TechnoTeam luminance distribution), whereas the optional ray data are saved in the TechnoTeam *.ttr (TechnoTeam Ray) format. The default file name contains the date and the time of the current measurement. Using the button *Change file name …* any desired file name and location can be fixed via the file selection dialog. The button *Automatic name* generates a new file name together with the current time.

The TTL – file contains – in addition to the luminance distribution data – all parameters of the measurement, the camera and photometer settings, and monitoring - data. The TTL - format is described in great detail in paragraph 11.1 „Luminous intensity distribution *.ttl“ .

The option of saving the ray data is only available for measurements with the camera. Here, using the button *Save ray data file* the saving of the ray data in a TTR – file can be activated. The TTR format can be converted to different standard file formats by means of the TechnoTeam - program *Converter801*.

### 6.1.3 Dialog field „LID export“

In the dialog field *LID Export* the user may select – by means of the selection box *Save additional LID format* – whether the TTL output file shall be additionally saved in another format. By pressing the button *Settings …* a dialog is opened which contains information about the export format chosen. Here, a parameterization of the export format chosen is possible as well. Please refer to 10.1.1 for a detailed description of the export formats and their settings.

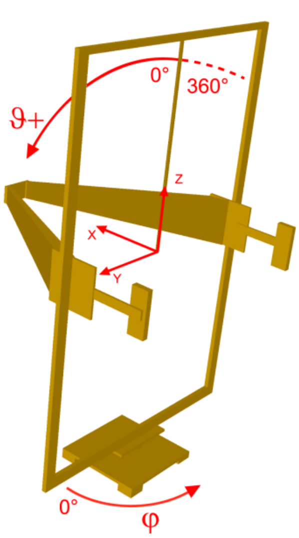
## 6.2 Setting the angular range and measuring resolution

The angular range and the measuring resolutions are set in the dialog *Adjust angular range*. For optimizing the measuring time it should be ensured to set the angular range of the measurement to the area of the light distribution. Aspects of the best choice of the measuring resolution are explained in section 6.2.3.

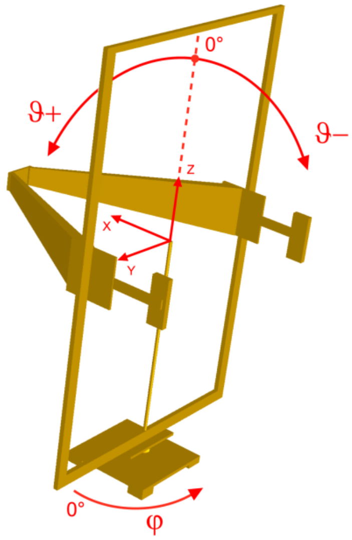
### 6.2.1 Coordinate system

All RiGO801 goniophotometer are based on the cartesian coordinate system (x, y, z) centered to the goniometer and with the z axis always directing upwards. Thus the theta angle (goniometer arm) starts at the top with 0 degree. In contrast, the 0 degree of a type C coordinate system is directed downwards. This difference is to be considered when handling the measuring program. However, the output of the photometric data is done in the type C coordinate system.

Depending on the design of the goniometer, the lamp suspension is provided at the top and/or at the bottom. The 0° - position of the theta –axis (goniometer arm) is always at the top for both versions. In the case of a goniometer with top lamp suspension, the goniometer arm can be moved continuously from 0° to 360° minus the dead angle. A bottom lamp suspension prevents the bottom pole from being run over. For this case, the angular range is fixed at 180° to –180° minus the dead angle.



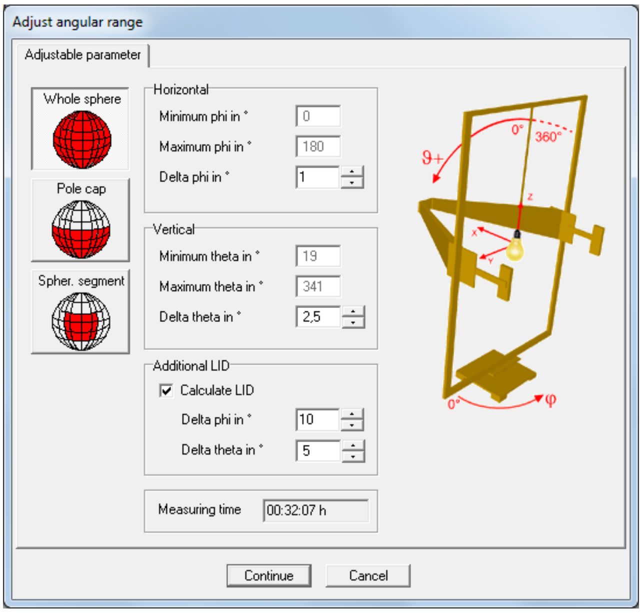

Top lamp suspension




Bottom lamp suspension

The Cartesian goniometer coordinate system (x, y, z) is identical for both versions. The position of the axes is of importance for ray conversion (refer to *Converter801* manual)

### 6.2.2 Angular measurement modes

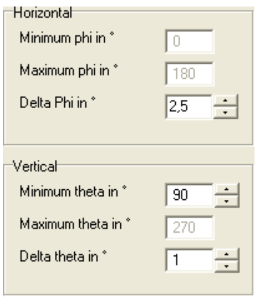



Using the button *Whole sphere* the complete angular range is set. In this mode the theta arm moves from the minimum to the maximum angle, thus, because of passing the pole, two C-planes are measured during one scan. In this mode, only the angle resolutions in horizontal (delta phi) and in vertical direction (delta theta) are adjustable.

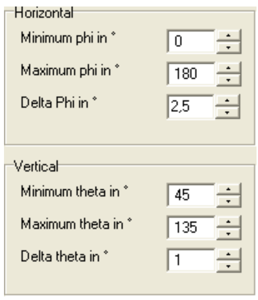
Using the buttons *Pole cap* or also *Spher. segment* the measurement can be limited to some certain angular ranges. In these cases, compared with the full sphere, some further angle parameters can be chosen.

In pole cap mode it is not allowed to pass any pole of the coordinate system (Theta=0° / Theta=180°) to prevent double measured angular ranges.

Pole cap




Spher. segment




In the field *Measuring time* the time estimated by the program in consideration of the fixed angular ranges and resolution for the measurement is displayed. In the case of goniophotometers equipped with the camera type DX4, the measuring time also depends on the integration time chosen of the camera. Thus, the measuring time displayed in this dialog can maximally slightly more than doubled, for example, when a current integration time is changed from 1 ms to 50 ms. The relation between measuring time and angular theta resolution is nonlinear for angular steps larger than 1 degree, especially in case of short exposure times of the camera. This is because the frame rate is adapted to the maximum angular speed by skipping camera images.

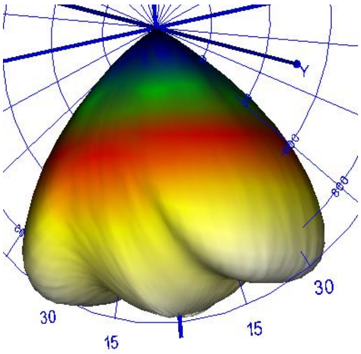
### 6.2.3 Choice of measurement resolution and calculating an additional LID

In the camera measuring mode the angular measuring resolution can be selected in both axes between 0.1 ° and 2.5 °. In photometer mode a maximum C or Phi angle increment of 90 ° is allowed. Understanding the RiGO801 measuring principle (see 2) facilitates the choice of appropriate measurement resolutions in both axial directions. Since this is a digital scanning system, the Nyquist-Shannon sampling theorem must be taken into account, which requires at least twice the sampling frequency as the maximum existing signal frequency. In case of violation of the sampling theorem aliasing effects can be expected in the reconstruction of the signal.

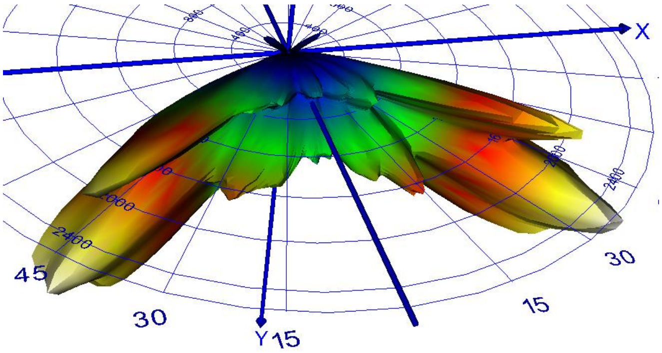
Signal frequencies correspond here figuratively the gradients of the three-dimensional light intensity distribution and the change of the image content in the adjacent camera images (motion vectors / optical flow). The sampling frequencies correspond to the angular resolution of the two goniometer axes. According to the expected gradients of the LID and expected optical flow the appropriate angular resolution must be selected. Unsuitable angular resolutions lead to aliasing effects that show up as artifacts in the LID.

*Angular resolution in accordance with the LID gradients*

The criterion of angular resolution based on the LID gradient is clear and corresponds to the criterion that applies to classical far-field goniophotometer. A sufficient accurate reconstruction of distributions with large gradients using individual nodes requires suitably small sampling intervals. This is particularly the case with the radiation characteristic of spots or downlights but even with wide radiating luminaires with regions of high gradient. The following figures show the LIDs of a linear luminaire with little gradients and of a street light with large gradients. In the first case a resolution of 2.5° x 2.5° would be sufficient, in the second case a higher resolution, for example 1.5° x 1.5°, is recommended, since larger gradients are present in both axial directions.




LID with low gradients



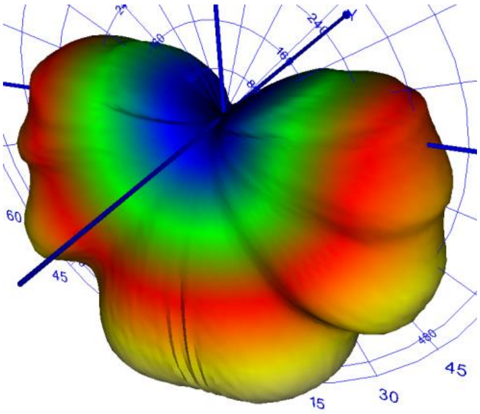

LID with high gradients

For measuring a spotlight with pointed but rotationally symmetrical LID, whose maximum is oriented in polar direction, would be, for example, only an increased measurement resolution in the scanning direction necessary but not in Phi direction, since there are no large gradients.

With some experience you know the expected distributions from the measured object and can use this knowledge for the appropriate choice of angular resolutions. In in case of doubt for unknown distributions one measures simply with a higher resolution and decides on the basis of 3D - representation if the resolution for later measurements can be reduced if necessary.

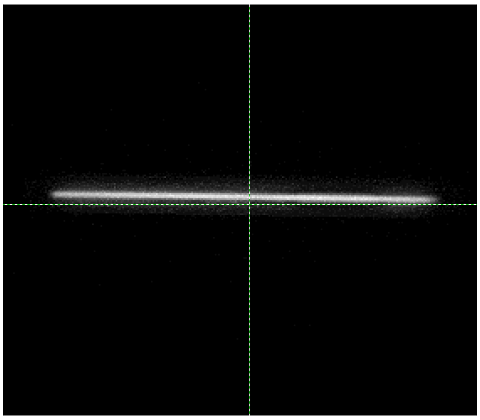
### *Angular resolution corresponding to the change of the image content*

The digital sampling also takes place in the image. The image information of successive images of a light source is changing (optical flow) and there are more or less large gaps between the corresponding areas. Are these gaps too large, it is comparable to using excessive wide sampling steps which can lead to aliasing effects. The RiGO 801 measurement program is equipped with a smoothing algorithm that reduces these effects but nevertheless it comes to artifacts in the LID in certain situations. The following figure shows a measurement with aliasing artifacts in the C90-C180 plane.

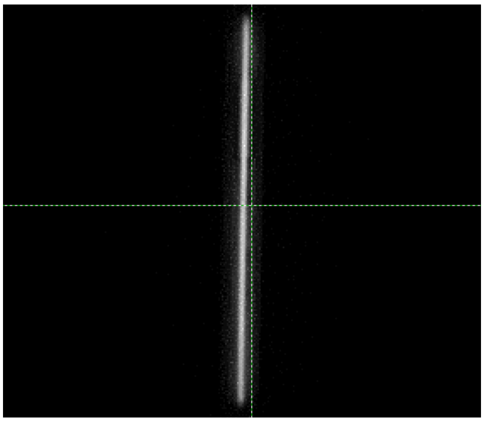


Aliasing artefacts in around the C90-C180 plane

The effects occur only in the range of the C90-C180 plane, so that here apparently the change of the image information is too large. In this case it is a long and narrow light which is vertically located in the image in this area. The outer regions of the light here move most, ie, the motion vectors of the outer areas of the image are particularly long and it comes to larger sampling gaps. The following pictures show the camera images of the light at Phi = 0 ° and phi = 90 °.



Luminaire at Phi = 0°



Luminaire at Phi = 90°

To reduce the sampling gaps the resolution in phi need to be increased, e.g. to 1 degree. In this case it’s not relevant to increase also the theta resolution because the gaps are mainly depending on the rotation in phi direction.

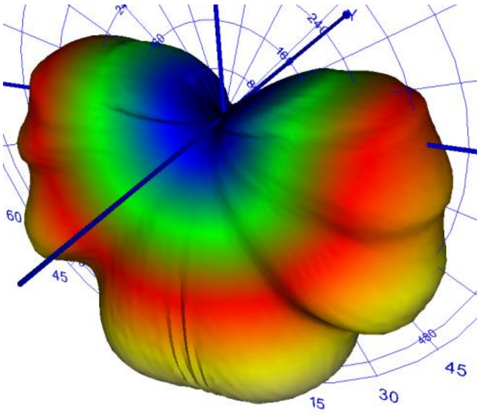
This results in a simple rule of thumb: **Measurements of long and narrow light sources with higher phi resolution.**

Remaining artefacts, even when using higher angular resolutions, usually disappear after reducing the angular resolution for the final LID file (see following section).

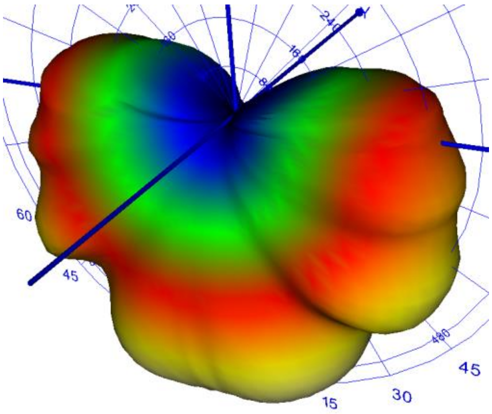
*Calculation of an additional LID with reduced angular resolution*

Due to the measuring principle of the RiGO801 goniophotometers it is often measured with higher resolution than for the later output in the target format of the luminous intensity distribution necessary or customary. A reduction of the resolution can be carried out with the RiGO801 LID export filters (see 6.1.3 and 10.1.1), LumCAT or other programs with which light intensity distributions can be edited.

A high-quality recalculation of a LID in a lower resolution can also be carried out directly on the basis of the measured ray data (see 2.3). One solution is to open the TTR ray file with the program *Konverter801* and recalculate the LID (refer to *Konverter801* manual). More convenient is the calculation of a separate LID parallel to the measurement by using the option *Additional LID* inside the dialog *Adjust angular range*. This feature is very convenient especially for elimination of aliasing effects and also works without additional measuring time parallel with the measurement. The result is separate TTL - file with supplemented filename. The following figures demonstrate the difference between LID with original resolution containing artefacts and a recalculated LID with lower resolution.

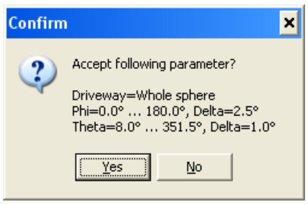



Aliasing artefacts in around the C90-C180 plane




Recalculated LID in lower resolution with smoothed aliasing effects

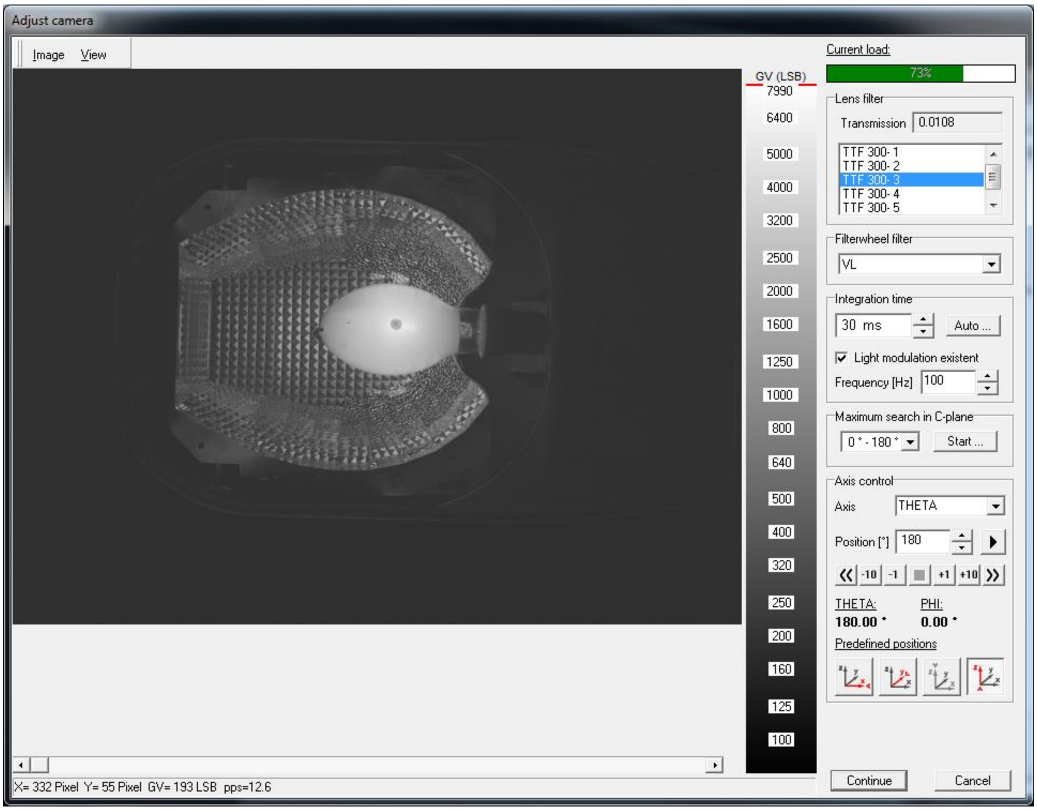
### 6.2.4 Closing the dialog




When the button *Continue* is pressed, a safety query is displayed asking the user to confirm the parameters set in the dialog. Afterwards, the measurement process is continued.

# 6.3 Setting the camera

## 6.3.1 General dialog features




The integration time of the measuring camera remains unchanged during the measurement. Thus, an optimal integration time together with a neutral density glass filter for the maximum luminance of the test piece must be adjusted before the measurement is started.

In order to achieve an optimum signal-to-noise ratio just as an optimum exploitation of the measuring dynamic range, the dynamic range of the camera image (dialog area *Current load*) should be > 80% for the radiation direction with the highest occurring luminance. In general, the measurement can still be made at a maximum dynamic range of 99 %. In this case, however, it is highly probable that – due to fluctuations of the light sources or even at other positions with slightly higher luminance maxima – overriding may occur. Therefore, in practice, dynamic ranges of larger than 95 % would be avoided. For this purpose, the camera can be positioned either manually or semi-automatically in the radiation direction concerned using the dialog areas *Maximum search in C-plane* and *Axis control*.

During the display of the dialog, the continuing image capture of the camera remains switched on in the image window. The gray scale value palette *GV (LSB)* arranged to the right allows the visual estimation of the image brightness by displaying the connection between the actual brightness values and the gray values. Any overdriven regions in the image are marked red.

In the pop-up menu *Image* the current camera image can be saved or copied into the clipboard. In the pop-up menu *View* the display of the camera image can be changed.

In the single dialog areas on the right-hand side of the dialog, either values are indicated or some various operations can be executed.

### 6.3.2 Dialog field „Current load“

In the dialog area *Current load*, the brightness maximum prevailing in the current image related to the maximum possible gray value is displayed as relative value. When the load is 90 % or higher, the color of the field with the maximum changes over to yellow, in the case of overdriving, it turns red.

### 6.3.3 Dialog field „Lens filter“

In the dialog field *Lens filter*, the user must indicate those filters which are currently mounted in front of the lens. The correct selection of the filters used is absolutely necessary for lenses whose focal length is smaller than or equal to 25 mm as – with decreasing focal length - the filters cause increasing additional vignetting in the image (shading), which is corrected using the calibration data.

A single filter can be marked in the list of all available filters via mouse click. If more than one filter is mounted, each additional filter can also be marked via Shift- or Ctrl-mouse click. If no filter is used, the selection can be undone via Ctrl-mouse click. Thus, no entry is selected.

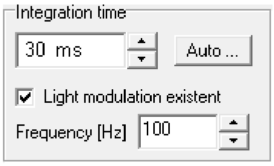
Using the list of filters, the transmittance resulting from the filter combination chosen is displayed. However, the transmittance does not have an effect on the measurement as the luminances of the camera are processed as relative measuring parameters and then standardized to the luminous flux measured with the photometer (see paragraph 2.5).

### 6.3.4 Dialog field „Filter wheel filter“

If the goniophotometer is equipped with a filter wheel camera, the filter wheel position can be set here. The filter wheel can be provided with neutral density glass filters or with spectral filters (color filters, special filters). The use of spectral filters allows the spectral adaptation of the camera to be modified according to the filter glasses, for example, to separate the blue and the yellow spectral range – in the case of white LEDs – with the filters BG25 and OG530.

For a standard measurement, however, the V(λ)-filter must be chosen for luminance adaptation.

### 6.3.5 Dialog field „Integration time“




In the dialog field *Integration time*, the integration time of the camera can be varied between 0.5 ms and 50 ms, either by making an entry directly in the input field or by means of the arrow keys. The latter allow the times to be varied in pre-defined steps. In the case of a manual input, integration times can be entered with a resolution of 100 µs. Using the button *Auto* one of the pre-defined integration time steps can be selected with maximum dynamic range. If necessary, however, the time will have to be adapted using the arrow keys or by making an entry directly in the input field.

If the luminance presents a modulated time curve, the integration time must amount to a whole multiple of the periodic length. Otherwise, image flickering would occur which can result in extremely noisy LID curve measurement data. For the simple case of an incandescent lamp with an operating voltage of 50Hz, for example, a luminous flux modulation of 100 Hz will result so that only those integration times lying in a time grid of 10 ms are valid.

In the case of discharge lamps with magnetic ballast, an intensity modulation of 100 Hz also occurs at an operating voltage of 50 Hz. However, the intensity behavior in the second half-wave may differ from that of the first half-wave, which leads to the fact that - fundamentally speaking – a period of 50 Hz results and, thus, only integration times in a time grid of 20 ms are valid for obtaining a stable measuring signal.

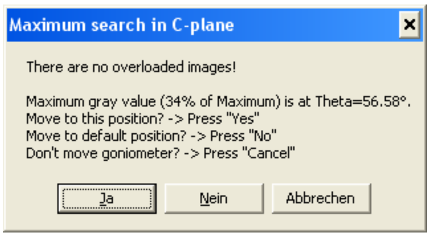
In the case of higher modulation frequencies, the flickering effects can be neglected if some periods lie in the integration time. For example, an LED modulated with 400 Hz has a periodic length of 2.5 ms so that from about 20 ms on, any integration time can be chosen. In the case of luminaires with electronic ballast and considerably higher modulation frequencies in the kHz –range, modulation does not have to be taken into consideration on condition that the ballast supplies a modulation which is independent of the line frequency.

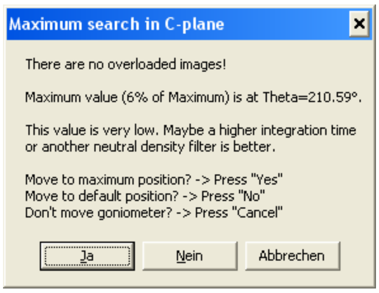
In order to facilitate the choice of valid integration times, the selection box *Light modulation existent* can be activated, and the modulation frequency can be entered in the box *Frequency [Hz]*. This function limits the time inputs automatically to multiples of the periodic length.

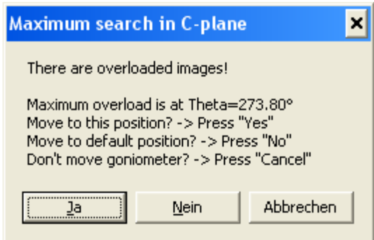
In many cases, the radiation direction with the highest occurring luminance (brightness in the camera image) is not exactly known. The dialog offers two options for seeking this point: Firstly, C-planes can be scanned automatically, and secondly, some single positions in the goniometer can be approached manually.

### 6.3.6 Dialog field „Maximum search in C-plane“


In the dialog field *Maximum search in C-plane*, complete C-planes can be scanned by the camera within the angular range configured for the measurement, thus allowing the user to search for the maximum brightness in this range. In the selection list available in this dialog field, the desired C-plane is selected. After pressing the button *Start…* , the search is started. When the search is finished, the goniometer stops at the end of the C-plane. Depending on the measurement result, one of the following windows opens:

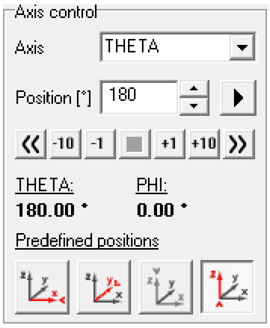



If the button *Yes* is pressed, the goniometer approaches the position found of the maximum. Furthermore, the integration time can be varied there, or the goniometer can slightly be moved manually around this position in order to possibly find a position nearby (on a neighboring C-plane) with an even higher brightness. If the dynamic range is very small or if there is some overdrive at this position, the search for the maximum should be repeated with an adapted integration time.

### 6.3.7 Dialog field „Axis control“



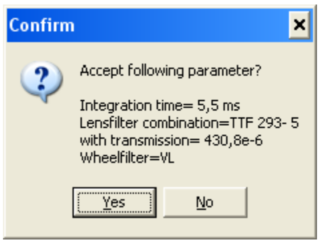

In the dialog field *Axis control*, a goniometer position can be entered in the two angles *Theta* and *Phi*. By pressing the button the camera can be moved to this position.

In addition, by pressing the buttons a relative positioning of the camera is possible. The buttons , and allow a manual start-stop operation. By using the buttons or also , the goniometer is moved by -1° or -10° and 1° or 10°, resp.

By means of the manual camera positioning, it is possible – on the one hand – to manually search for the brightest point and – on the other hand – to move the camera to an appropriate position for changing the neutral glass filters. By pressing the button , the movement of the goniometer can also be terminated prematurely.

The buttons offer the possibility to approach the pre-defined positions (x-axis: $\vartheta$=90°, $\varphi$=0°), (y-axis: $\vartheta$=90°, $\varphi$=90°), (z-axis: $\vartheta$=0°, $\varphi$=0°) and (negative z-axis: $\vartheta$=180°, $\varphi$=0°). Additional pre-defined positions can be configured when requested.

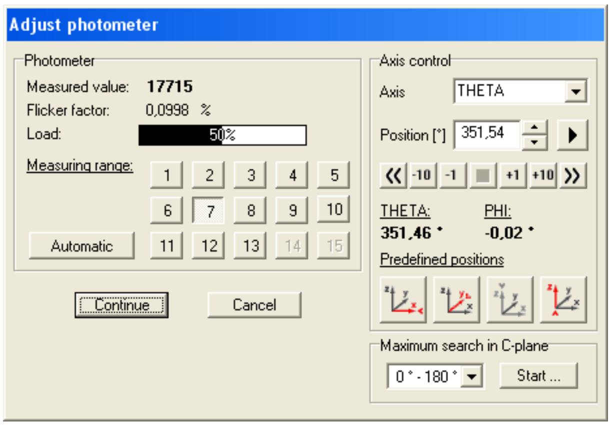
### 6.3.8 Closing the dialog




After pressing the button *Continue* a security prompt is displayed in which the user is requested to confirm the parameters set in the dialog. Afterwards, the measurement process is continued.

## 6.4 Setting the photometer

As in the case of the camera, no modification of the measuring range of the photometer is made during the measurement. However, the optimum measuring range for the radiation direction with the maximum illuminance must be set.

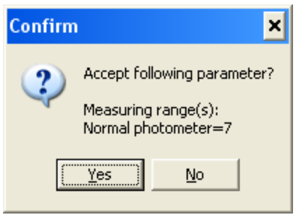



The dialog field *Photometer* contains the buttons – in a numbered form – for toggling between the measuring ranges. Measuring range 1 is the most sensitive. The number of available ranges depends on the photoelectric current amplifier used.

The currently measured illuminance is displayed next to *Measured value*, the dynamic range in the display *Load*.

If the photometer is able to measure also the modulation or also the flicker factor of the light source, this is displayed in the text field *Flicker factor*. In this case, the capacity utilization of the photometer refers to the modulation maximum rather than to the average of the 20 ms / 50 Hz (or also 50 ms / 20 Hz) integration period of the photoelectric current amplifier.

It is advisable to carry out the selection of the measuring range always at the position of maximum illuminance. For this, as for the camera setting, the automatic maximum search can be used (see 6.3.6). Before starting the maximum search, however, it is advisable to position the photometer approximately in the main radiation direction and to select an appropriate measuring with a load which is not too high. After the maximum scan, the position of the illuminance maximum found is approached, and the measuring range with the highest load of the photometer should be chosen. In the case of asymmetrical or also greatly inhomogeneous radiations, the maximum search must be repeated, if necessary, in another C-plane in order to reduce the risk of overdrive in other angular ranges.




After pressing the button *Continue*, a safety prompt is displayed in which the user is requested to confirm the parameters set in the dialog. Afterwards, the measurement is continued.

## 6.5 Parameterizing the measuring instruments

### 6.5.1 General dialog features

The RiGO801 software offers the possibility of incorporating external measuring instruments, e.g. for detecting electrical parameters or temperatures. This is realized by TechnoTeam ActiveX device drivers. Before starting each C-plane, the measurement data of the connected measuring devices are acquired during the measurement and then saved in the TTL – measurement file. Additional non-supported measuring devices can be integrated on demand.

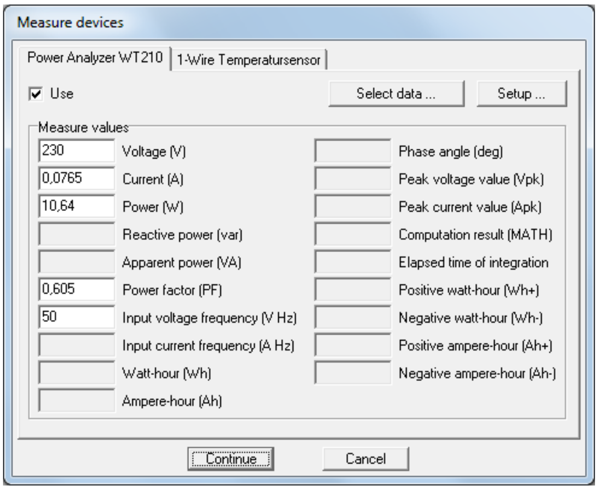
For selected measuring device channels it's possible to transfer the calculated mean values to the corresponding fields of the measuring report. This configuration needs to be done by TechnoTeam.

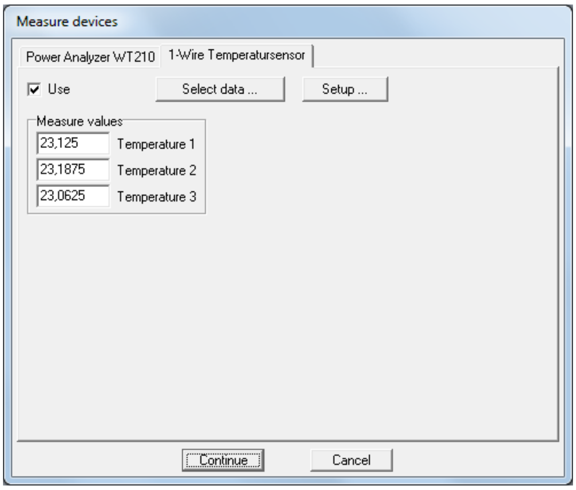
In the dialog *Measure devices*, which is displayed at this point of the parameterization sequence, all devices incorporated in the process are represented by a tab.

### 6.5.2 Tabs of the measuring instruments

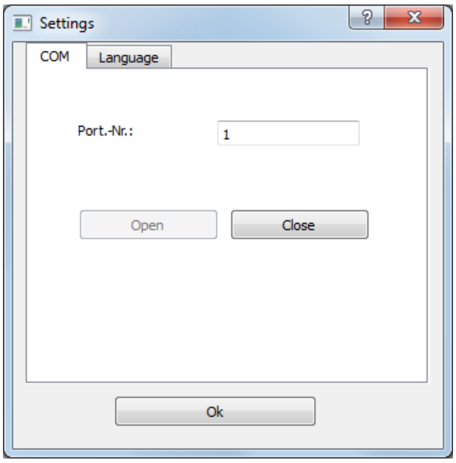
In each tab, there is the option *Use* by means of which the data acquisition for this measuring instrument can be activated during the goniometer measurement. In the case that the instrument is not correctly initialized yet, only the button *Setup* is active by means of which the device-specific set-up dialog can be opened. If the device is available, result fields and the designations will be listed in the dialog field *Measure values* for all detectable measuring parameters. By pressing the button *Select data* the user can fix – via a device-specific dialog – which measuring values must be acquired. Then, these values will be activated in the list in the field *Measure values*.

The two figures below show the tabs for the power analyzer type WT210 (Yokogawa) and the temperature acquisition with 1-wire sensors (DS1820).





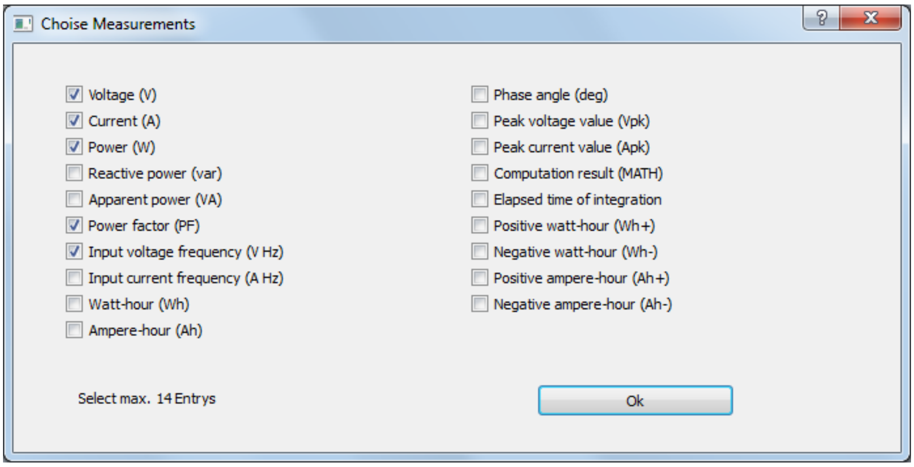

*Power analyzer type WT210 (Yokogawa)*




This figure shows the set-up dialog for the power analyzer type WT210. Below the tab *COM* the COM – port to which the device is connected must be indicated. By pressing the button *Open* the connection is made.

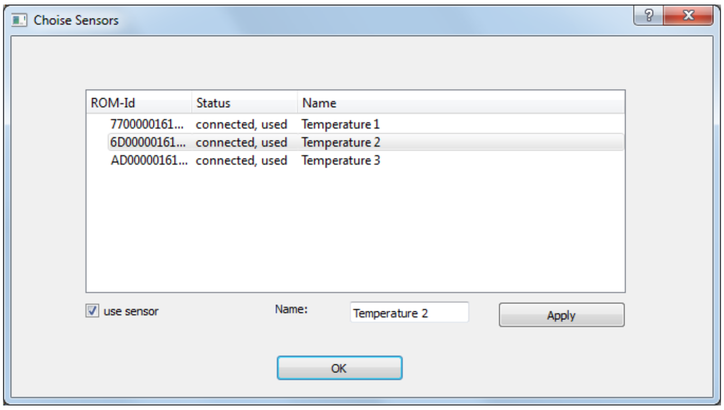
The tab *Language* contains a list of the available languages. All entries made here are saved in the RiGO801 configuration and loaded at the next program start.

By pressing the button *Select data ...* the dialog for selecting the active measuring values is opened.



*Temperature sensors (1 - wire, DS1820)*

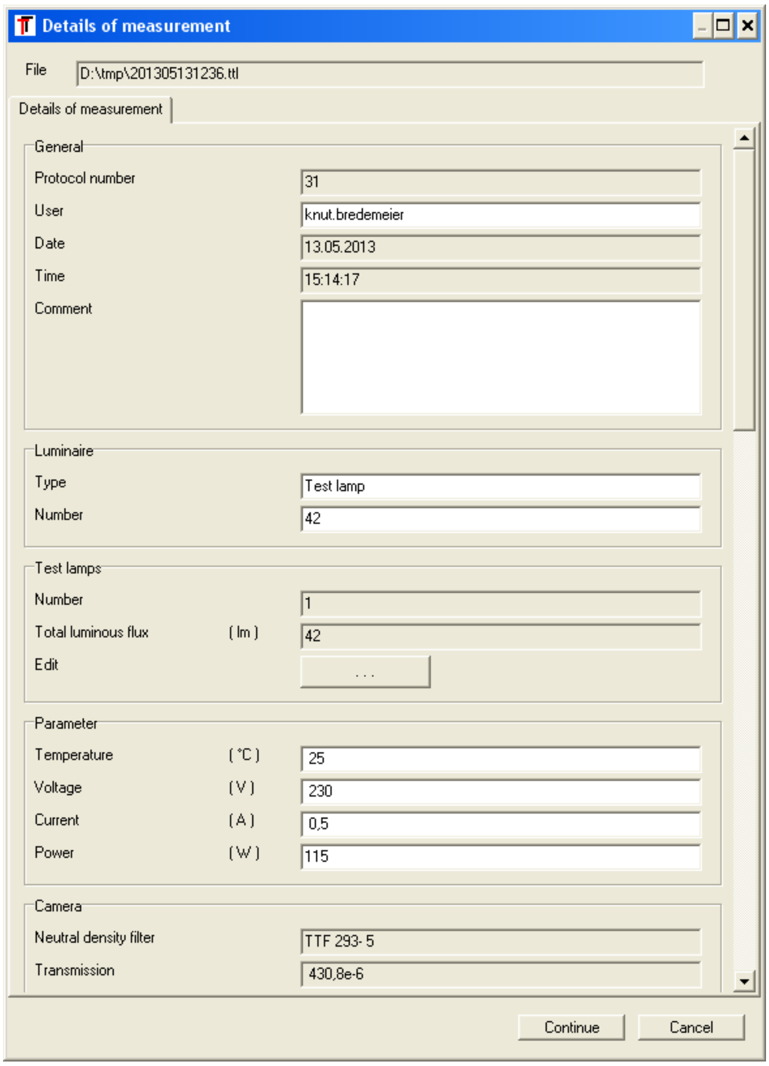
The dialog for choosing the measuring data of the device driver for 1-wire temperature sensors lists all available 1-wire sensors together with their ROM-ID. In the column *Name* each sensor can be assigned a designation. For this, click on the line containing the sensor, change the designation in the input field *Name* and finally, click on the button *Apply*.




Using the option *Use sensor*, the selected sensor is activated for data acquisition or also deactivated. In the column *Status*, the connection status is displayed just as activation.

## 6.6 Measurement details

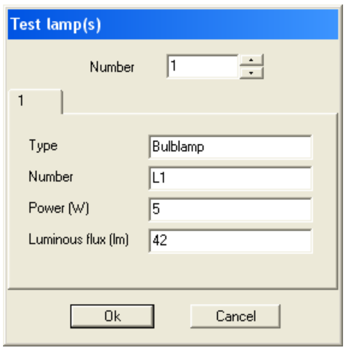
### 6.6.1 General dialog features




In this dialog, nearly all parameters are displayed which will be saved later in the luminous intensity distribution file *.ttl. The structure of the file format is described in detail in paragraph 11.1.

The tab *Details of measurement* contains entries marked gray and white. The entries marked gray are generated automatically by the program or also they have been entered by the elsewhere already. The entries marked white can now be processed. These entries shall facilitate the future work with the results of measurement.

### 6.6.2 Dialog field „Test lamps“




The dialog field *Test lamps* contains the line *Edit* with the button „...“. If this button is pressed, the dialog *Test lamp(s)* will be opened where the features of the test lamps used in the luminaire are edited. For each lamp, a separate tab is displayed where its parameters - *Type*, *Number*, *Power (W)* and *Luminous flux (lm)* – can be entered. When making these entries, please note that they concern the test lamps rather than lamp settings, i.e., all lamps entered are used in the luminaire for the measurement.

When exporting the files to other file formats for luminous intensity distributions, these test lamps are put together to a lamp setting with the sum of all test lamp currents. In this case, the indication of the type is of importance for the first lamp only.

The sum of the luminous fluxes of all lamps used results in the *Total luminous flux*. The total luminous flux – together with the luminous flux determined through measurement - is necessary for calculating the efficiency in evaluation programs (e.g. LumCAT).

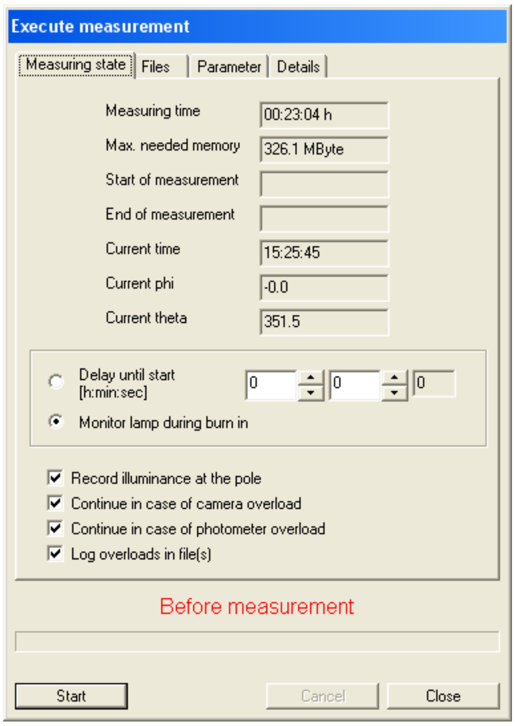
In the case of lamp measurements, either the number of lamps shall be 0, or the luminous flux of each test lamp entered shall be specified to be 0! Then, the system automatically starts out from a lamp measurement with absolute luminous intensities when exporting to other file formats or when loading in LumCAT.

The data concerning the test lamps will be saved in the TTL file only as additional information. Furthermore, the calculation of the standardization to cd/klm will start only when reading in the TTL-file. Thus, the data do not have any influence on the measurement and can be added any time later.

## 6.7 Aligning the measurement object

If the option is activated in the list of measurement sequences, the dialog for aligning the measurement object (see 5) is displayed at this point of the setting up of the measurement. Here, alignment can possibly be checked again, however, it would always be advisable to carry out alignment before the measurement starts.

## 6.8 Starting the measurement




After having done all necessary preparatory work and after having made all entries, the dialog *Execute measurement* is opened. It remains visible during the whole measurement and gives information about the stage of processing.

Before pressing the *Start* button one selects the startup mode *Delay until start [h:min:sec]* or the automatic start after the stabilization procedure (see 6.9) with *Monitor lamp during burn-in*.

The selection box *Record illuminance at the pole* activates the monitoring of the illuminances at the pole during the measurement. The data are saved in the TTL-file and shown in the form of a diagram and table in the results display. Thus, it is possible for the user to evaluate the stability of the light source during the measurement. This function only makes sense when there is some radiation towards the pole, and when the illuminance distribution is not too inhomogeneous.

The selection boxes *Continue in case of camera / photometer overload* and *Log overloads in file(s)* change the standard reaction in case of overloads. It's usually advisable to enable these options so that the measurement continues, the positions of overload are logged and a warning is given only at the end of the measurement.

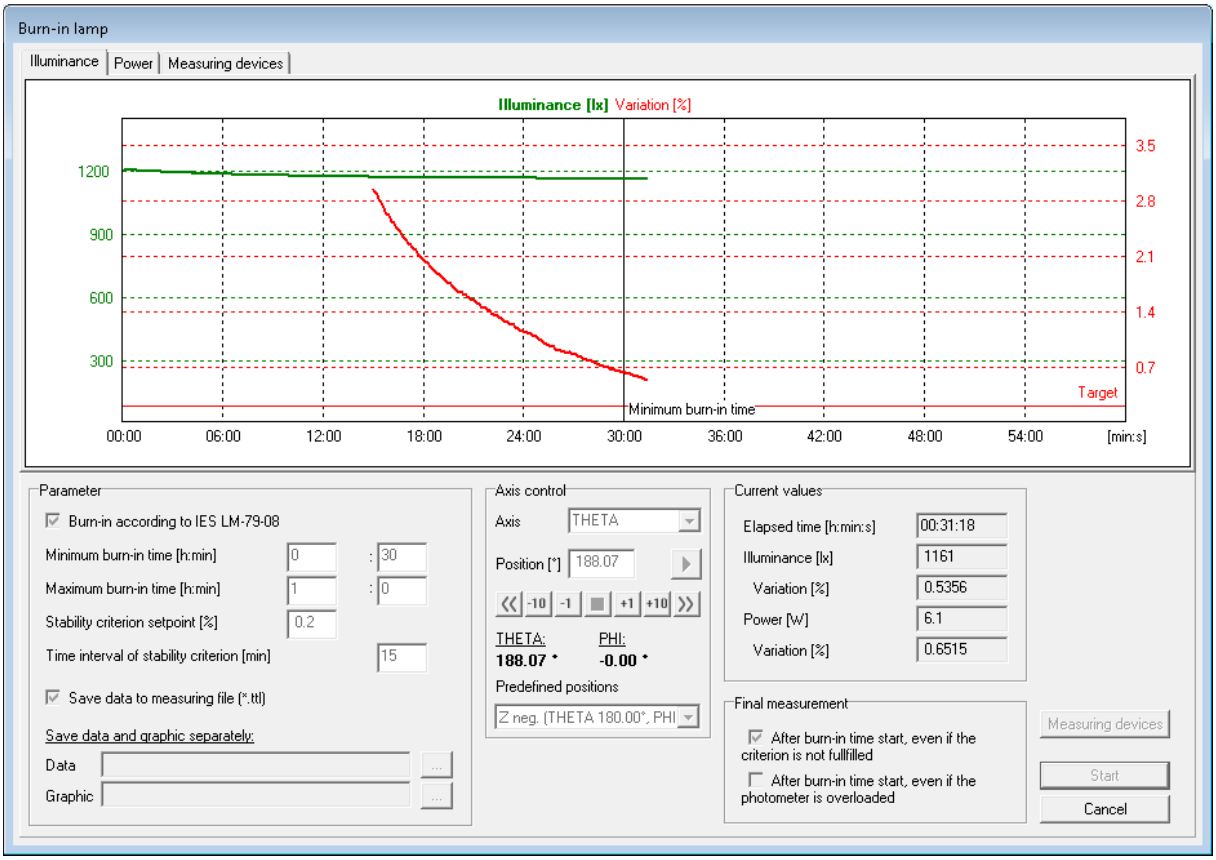
The corresponding protocol files can be found under the names *„[Measurement file]_overflow_cam.txt“* or also *„[Measurement file]_overflow_pe.txt“* in the same directory of the measurement files. The camera log file contains the columns phi, theta and number ob overloaded pixels for each overloaded image. The photometer log file only contains the columns phi and theta. If the number of overloads in relation to the number of measuring positions is very small, the impact should be negligible.

In den fields *Current phi* or also *Current theta*, the current position of the goniometer is shown. After starting the measurement by pressing the button *Start*, the fields *Start of Measurement* and *End of Measurement* will be filled out by the program. The progress bar allows the user to estimate the portion of the captures already taken in comparison to the whole measurement.

Using the button *Cancel* a measurement can be terminated prematurely. In this case, it will not be stopped immediately but only after the end of the current C-plane. **The button ”Cancel“ cannot be used as EMERGENCY STOP!**

# 6.9 Stabilizing procedure

## 6.9.1 General dialog features

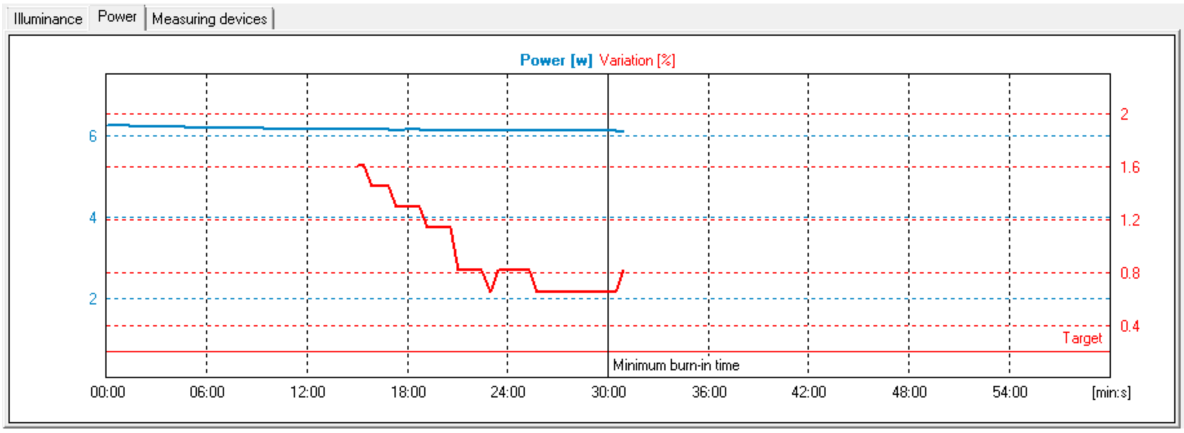



Using the function *Burn-in lamp* the program can be made to start a measurement automatically when the luminous flux of the DUT has reached a stability criterion. The dialog *Burn-in lamp* is opened when the user has selected the option *Monitor lamp during burn-in* in the dialog *Execute measurement*. In this case, the luminous flux of the lamp is monitored indirectly via the illuminance measured with the photometer. For this purpose, the photometer should be brought to a position of the measurement object with sufficient illuminance. In most cases, this condition is fulfilled when the last adjustment step was the setting of the photometer (see 6.4). Otherwise, the photometer can be positioned accordingly in the dialog field *Axis control*.

The stability value is the ratio between the minimum and the maximum illuminance occurring within one time interval. The aim is to obtain stability criteria over a longer time period as the light source must remain stable for the whole duration of the measurement. Thus, only those time intervals which are of an appropriate length are beneficial, for example 15 minutes. The values of the stability criterion are usually in the range from 0.2% to 0.5%.

After starting the process by pressing the button *Start*, illuminances are continuously measured and drawn in the diagram (left-hand Y – axis). Only after the time interval boundary is reached, the first error value can be calculated, and the error axis is displayed in the diagram (right-hand Y-axis). Now, the error values are continuously determined – in each case for the previous time interval - and then drawn in the diagram in the form of an error curve. From the time entered in the field *Minimum burn-in time [h:min]* on, the measurement starts automatically when the error has dropped below the stability criterion threshold. If, however, the threshold has not been reached by the time entered in the field *Maximum burn-in time [h:min]*, the measurement will start nevertheless provided that the corresponding option is selected in the dialog field *Final measurement*.

During the stabilization phase the data of the external coupled devices (see 6.5) are acquired as well and shown as table in the tab sheet *Measuring devices*. In case a power analyzer is available the option *Burn-in according to IES LM-79-8* gets available. This option fixes in accordance to this standard the minimum stabilization time to 30 minutes, the length of the time interval to 15 minutes and the maximum of the stability criterion to 0.5%. Additional to the illuminance also the electrical power is acquired and rated with the stability criterion. The graph is presented in the *Power* tab sheet.




Trend of the power during stabilization phase

The data of the stabilization process will be saved in the TTL – file if the option *Save data to measuring file* is selected (default). All data are visualized in the result file. The data just as the diagram graphics can also be saved in separate files if file names are entered in the diagram field *Save data and graphic separately*.

Using the button *Cancel* monitoring can be terminated prematurely, and the measurement can immediately be started if the user wants to do so.

## 6.10 End of measurement and displaying the measurement results

After each measurement, the measurement results are displayed in a dialog. This dialog is described in paragraph 7. If overloads occur during the measurement, a corresponding warning message is displayed. In this case it is recommended to analyze the logged files (see 6.8).

# 7 Display of measurement results

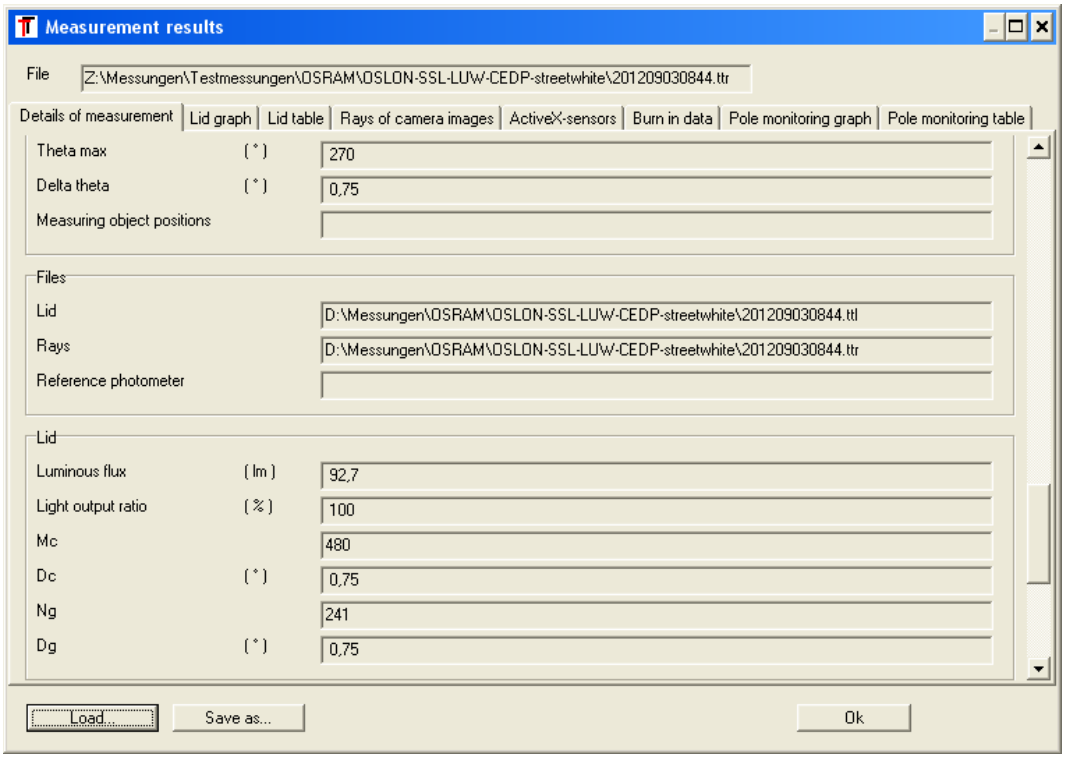
## 7.1 General dialog features

The dialog for displaying the measurement results is available in all RiGO programs (*RiGO801*, *Converter801* and *3D-Viewer*). All relevant data of the TTL measuring file are visualized, and, in the case of a TTR ray file, also information on the ray data is displayed.

The subordinate data displays are represented in tab windows. In the lower dialog area, the button *Load* is provided which allows another measuring file to be loaded (TTL or TTR). The file can then be saved using the button *Save as ...* (e.g. after changing the measuring lamps).

## 7.2 Tab „Details of measurement "

The tab *Details of measurement* is already described in paragraph 6.6 with respect to the setting up of a measurement. After the measurement, in the area *Lid* the luminous flux measured is entered in the field *Luminous flux*. Furthermore, under *Light output ratio*, the operating efficiency based on the luminous flux of the test lamp and on the luminous flux measured is entered.

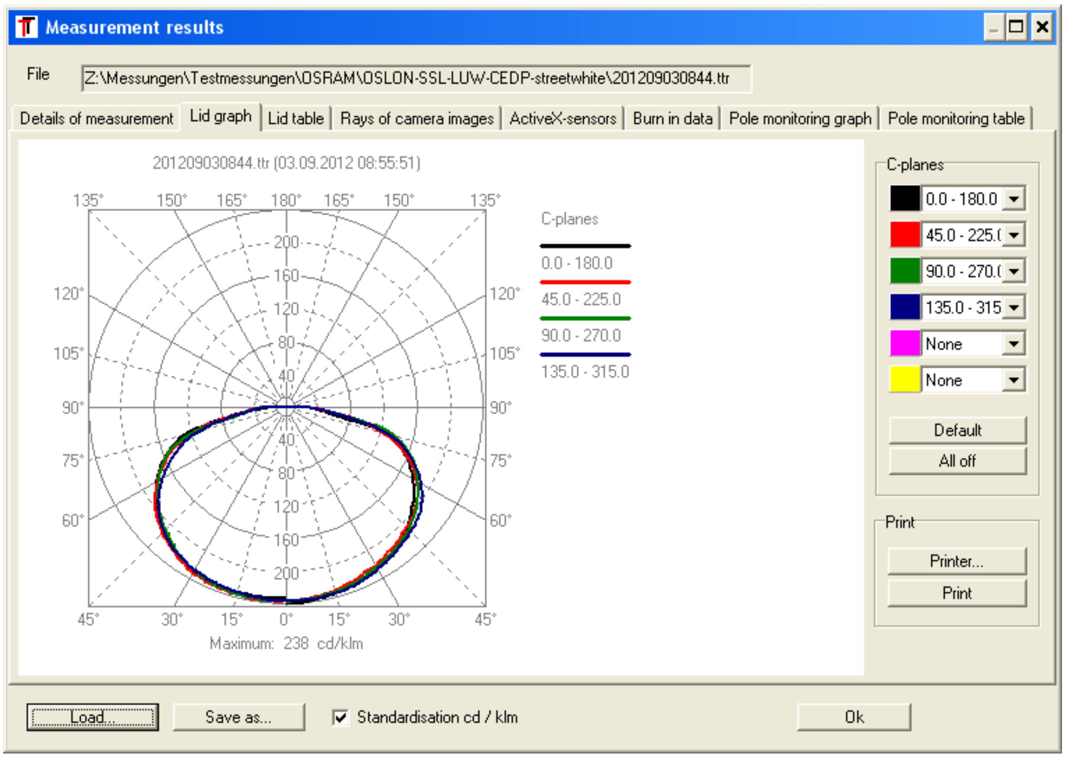



## 7.3 Tab „Lid graph“

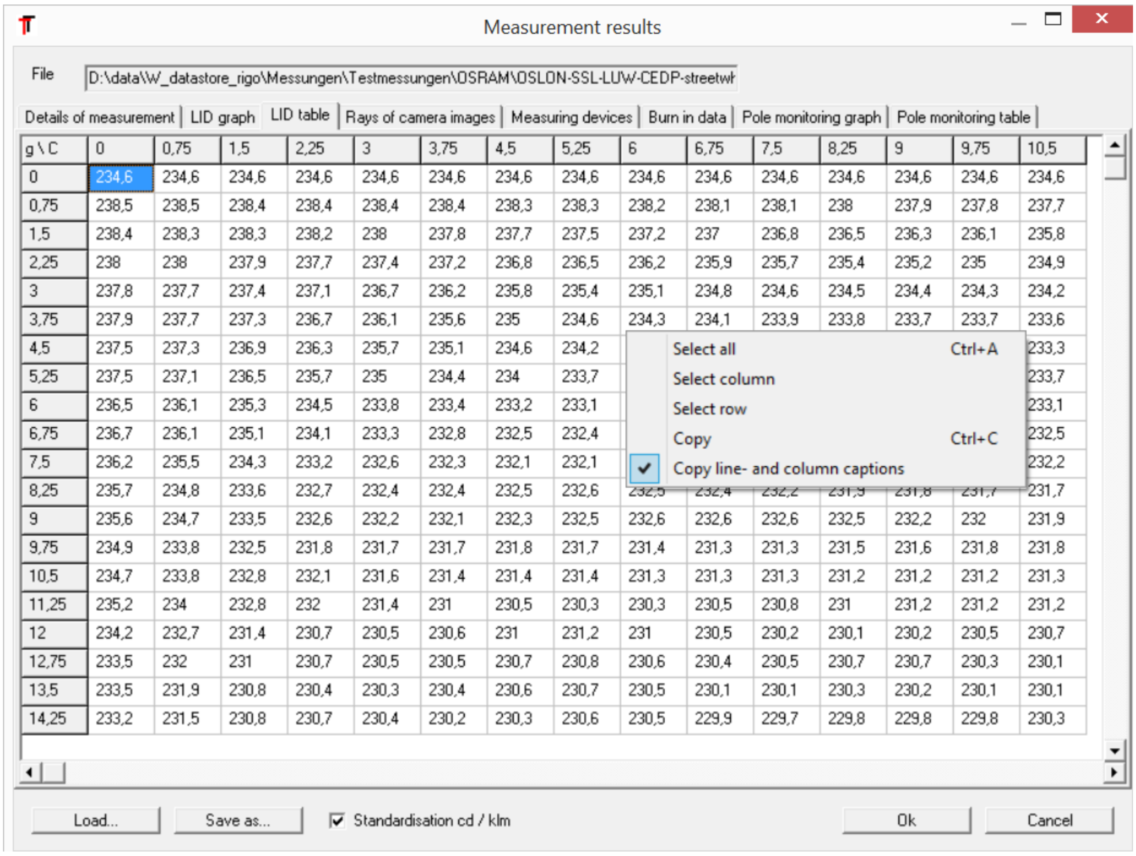
The tab *Lid graph* shows a polar diagram of the luminous intensity distribution. In the combo boxes on the right, the C-planes to be displayed can be chosen. The pre-defined colors can be changed to the color ranges by a mouse click.

Using the button *Print* a printout of the graphic on the default printer currently set in the operating system can be obtained. The representation will then be identical to what is displayed on the screen at this moment. The default printer can be changed by pressing the button *Printer…*.

Using the selection box *Standardization cd / klm* the user can select whether the absolute values measured of the luminous intensity are displayed or whether the luminous intensity is displayed in a form standardized to a lamp luminous flux of 1000 lm.




## 7.4 Tab „Lid table“

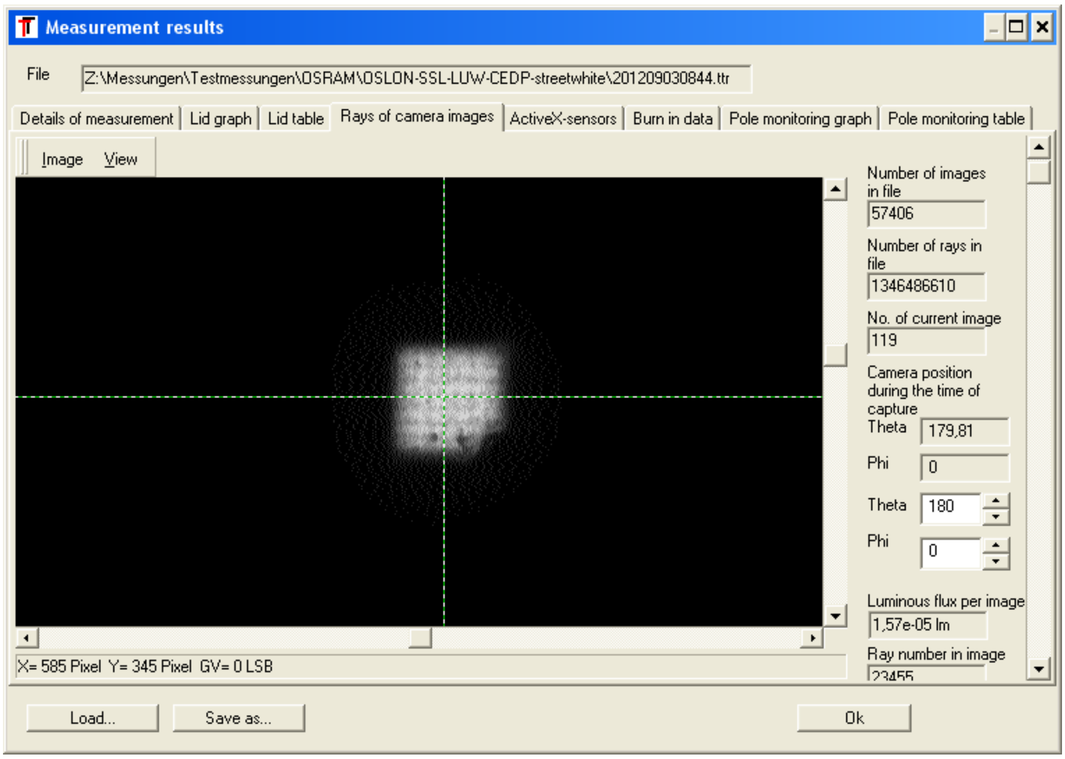


| g \ C | 0 | 0,75 | 1,5 | 2,25 | 3 | 3,75 | 4,5 | 5,25 | 6 | 6,75 | 7,5 | 8,25 | 9 | 9,75 | 10,5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 | 234,6 |
| 0,75 | 238,5 | 238,5 | 238,4 | 238,4 | 238,4 | 238,4 | 238,3 | 238,3 | 238,2 | 238,1 | 238,1 | 238 | 237,9 | 237,8 | 237,7 |
| 1,5 | 238,4 | 238,3 | 238,3 | 238,2 | 238 | 237,8 | 237,7 | 237,5 | 237,2 | 237 | 236,8 | 236,5 | 236,3 | 236,1 | 235,8 |
| 2,25 | 238 | 238 | 237,9 | 237,7 | 237,4 | 237,2 | 236,8 | 236,5 | 236,2 | 235,9 | 235,7 | 235,4 | 235,2 | 235 | 234,9 |
| 3 | 237,8 | 237,7 | 237,4 | 237,1 | 236,7 | 236,2 | 235,8 | 235,4 | 235,1 | 234,8 | 234,6 | 234,5 | 234,4 | 234,3 | 234,2 |
| 3,75 | 237,9 | 237,7 | 237,3 | 236,7 | 236,1 | 235,6 | 235 | 234,6 | 234,3 | 234,1 | 233,9 | 233,8 | 233,7 | 233,7 | 233,6 |
| 4,5 | 237,5 | 237,3 | 236,9 | 236,3 | 235,7 | 235,1 | 234,6 | 234,2 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 233,3 |
| 5,25 | 237,5 | 237,1 | 236,5 | 235,7 | 235 | 234,4 | 234 | 233,7 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 233,7 |
| 6 | 236,5 | 236,1 | 235,3 | 234,5 | 233,8 | 233,4 | 233,2 | 233,1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 233,1 |
| 6,75 | 236,7 | 236,1 | 235,1 | 234,1 | 233,3 | 232,8 | 232,5 | 232,4 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 232,5 |
| 7,5 | 236,2 | 235,5 | 234,3 | 233,2 | 232,6 | 232,3 | 232,1 | 232,1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 232,2 |
| 8,25 | 235,7 | 234,8 | 233,6 | 232,7 | 232,4 | 232,4 | 232,5 | 232,6 | 232,5 | 232,4 | 232,2 | 231,9 | 231,8 | 231,7 | 231,7 |
| 9 | 235,6 | 234,7 | 233,5 | 232,6 | 232,2 | 232,1 | 232,3 | 232,5 | 232,6 | 232,6 | 232,6 | 232,5 | 232,2 | 232 | 231,9 |
| 9,75 | 234,9 | 233,8 | 232,5 | 231,8 | 231,7 | 231,7 | 231,8 | 231,7 | 231,4 | 231,3 | 231,3 | 231,5 | 231,6 | 231,8 | 231,8 |
| 10,5 | 234,7 | 233,8 | 232,8 | 232,1 | 231,6 | 231,4 | 231,4 | 231,4 | 231,3 | 231,3 | 231,3 | 231,2 | 231,2 | 231,2 | 231,3 |
| 11,25 | 235,2 | 234 | 232,8 | 232 | 231,4 | 231 | 230,5 | 230,3 | 230,3 | 230,5 | 230,8 | 231 | 231,2 | 231,2 | 231,2 |
| 12 | 234,2 | 232,7 | 231,4 | 230,7 | 230,5 | 230,6 | 231 | 231,2 | 231 | 230,5 | 230,2 | 230,1 | 230,2 | 230,5 | 230,7 |
| 12,75 | 233,5 | 232 | 231 | 230,7 | 230,5 | 230,5 | 230,7 | 230,8 | 230,6 | 230,4 | 230,5 | 230,7 | 230,7 | 230,3 | 230,1 |
| 13,5 | 233,5 | 231,9 | 230,8 | 230,4 | 230,3 | 230,4 | 230,6 | 230,7 | 230,5 | 230,1 | 230,1 | 230,3 | 230,2 | 230,1 | 230,1 |
| 14,25 | 233,2 | 231,5 | 230,8 | 230,7 | 230,4 | 230,2 | 230,3 | 230,6 | 230,5 | 229,9 | 229,7 | 229,8 | 229,8 | 229,8 | 230,3 |

On the tab *Lid table* the measurement values of the single C-planes are displayed in tabular form. By pressing the left-hand mouse button and dragging the mouse pointer or also via the context menu (right-hand mouse button), a well-defined data area of the table can be marked. Via the context menu entry *Copy* the data area marked can be copied into the clipboard of the operating system.

Using the selection box *Standardization cd / klm* the user can select whether the absolute values measured of the luminous intensity are displayed or whether the luminous intensity is displayed standardized to a lamp luminous flux of 1000 lm.

## 7.5 Tab „Rays of camera images“

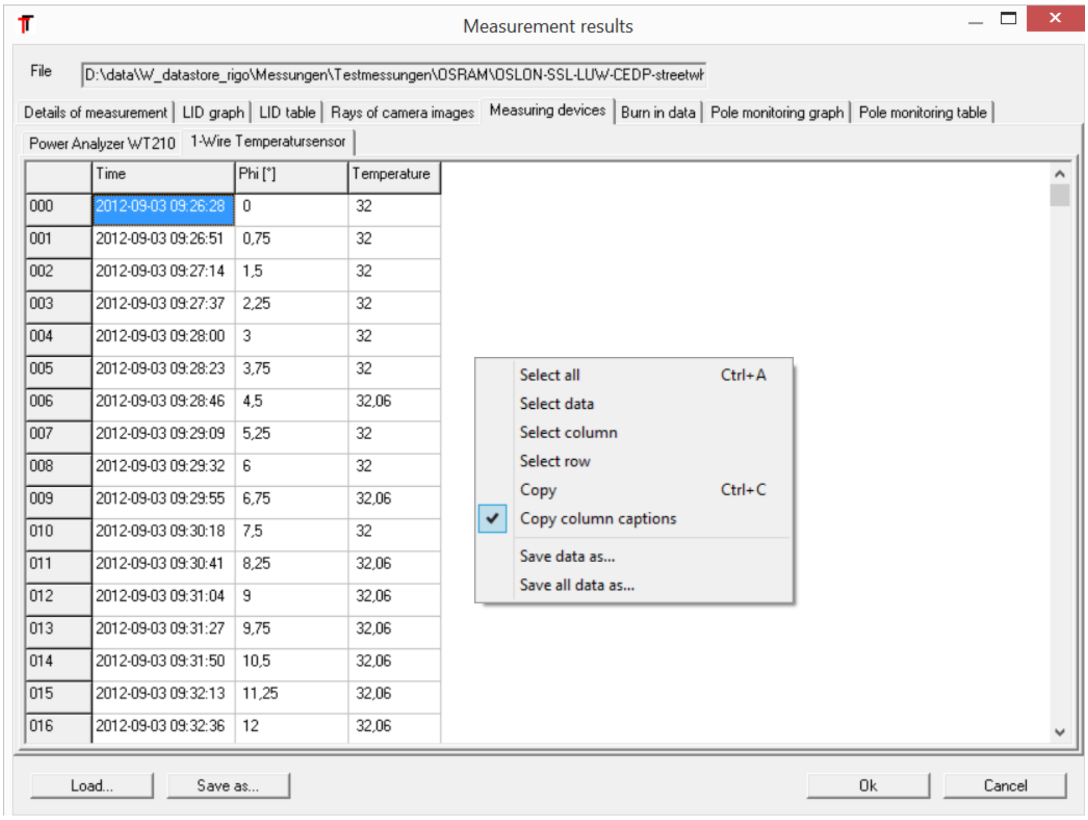



If the user has decided to save the ray data (see 6.1.2), the tab *Rays of camera images* is added to the dialog. The slider provided on the right allows the user to select any capture of the data record. The appertaining recording parameters are shown in the display fields on the left. In particular, the position of the camera at the moment of image capture can clearly be seen (text fields *Theta* and *Phi*).

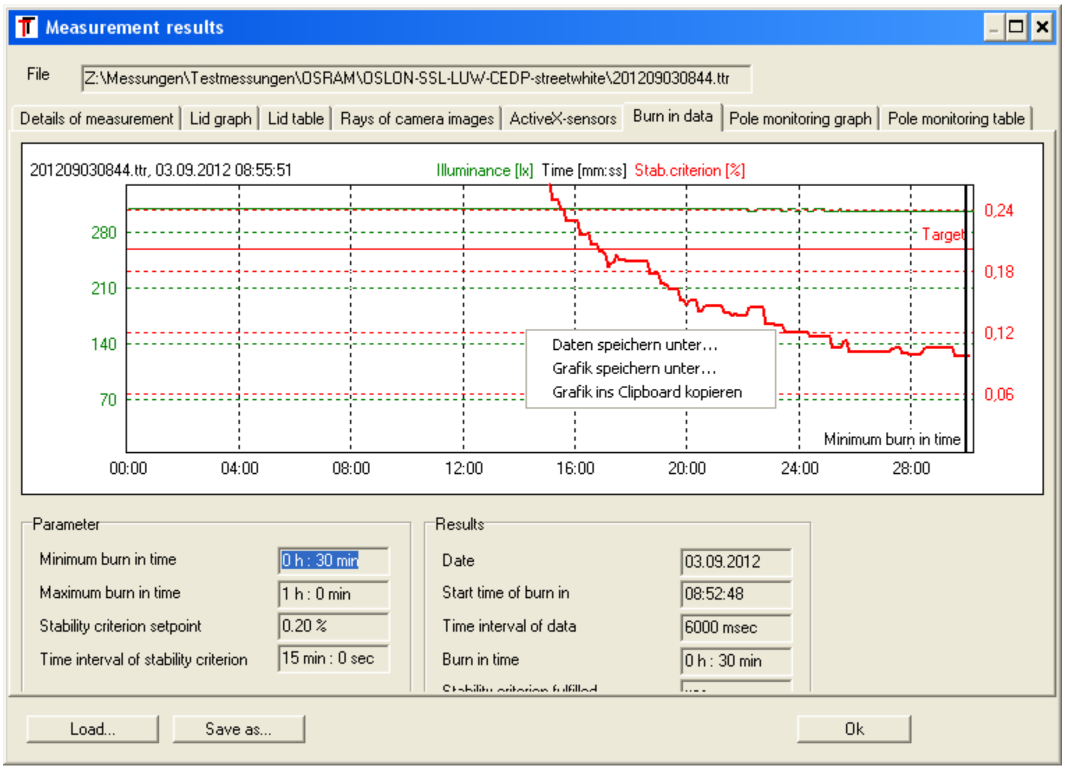
## 7.6 Tab „Measuring devices“

If measurement values supplied by incorporated measuring instruments have been logged during the measurement (see 6.5), these data can be found on the tab *ActiveX-Sensors*. For each instrument, a subordinate tab is available. The data are displayed in a table. Each line contains those values measured before starting the respective C-plane.

Data exchange with external programs can be realized via the clipboard. In the context menu of the right-hand mouse button, the user finds all functions for marking table areas as well as exporting data to a file. The usual key combinations to carry out these actions are available, too.




## 7.7 Tab „Burn-in data“

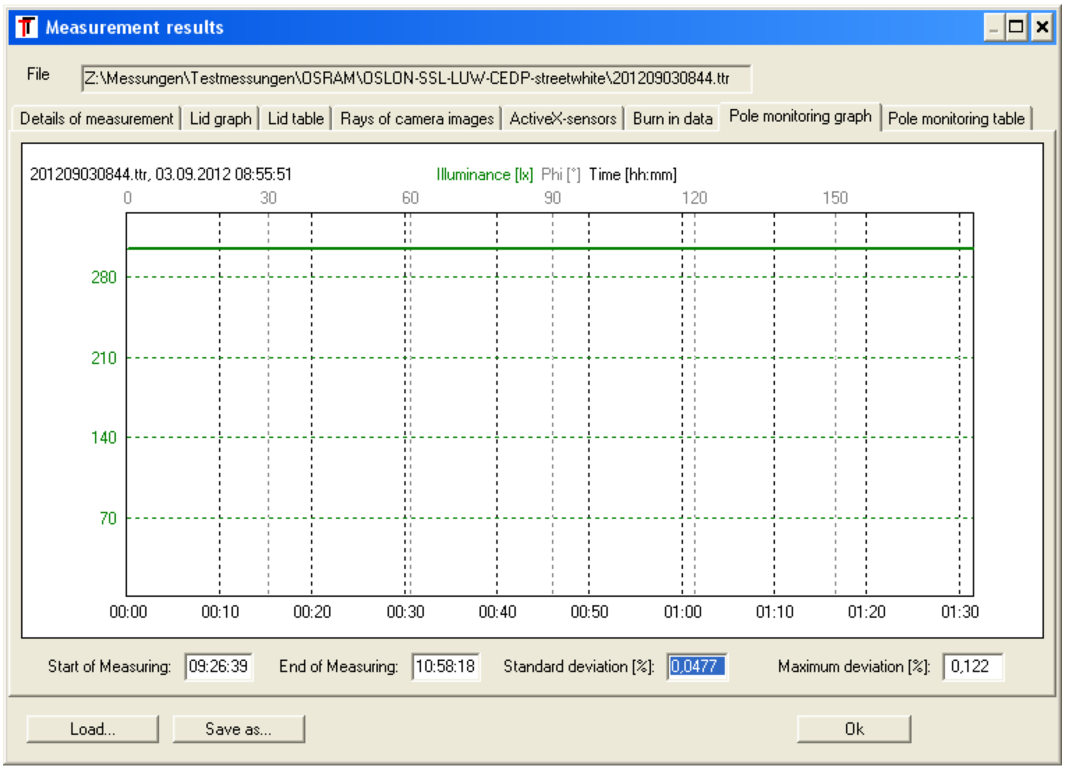


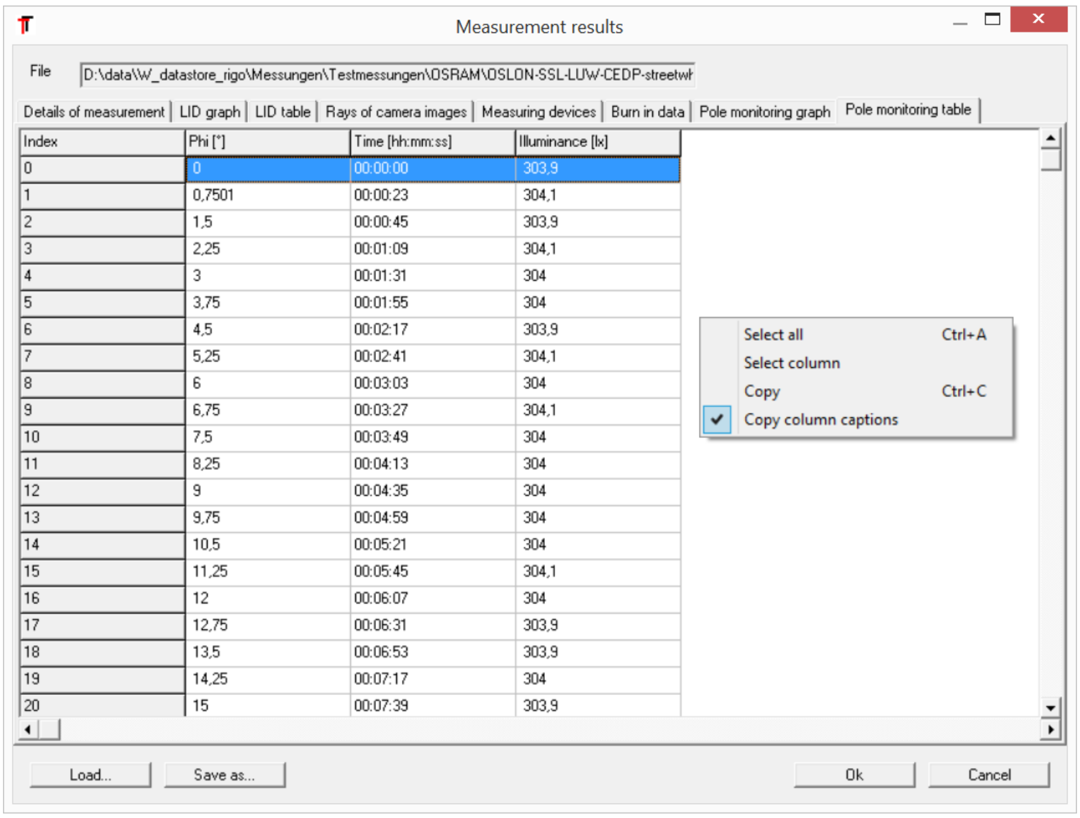

If the measurement has been started automatically with the function *Burn-in lamp* (see 6.5), the data logged during the stabilization phase can be viewed on this tab.

Via the context menu of the diagram (right-hand mouse button), the diagram can be saved as image file, or the underlying data are saved as an ASCII file.

## 7.8 Tabs “Pole-monitoring-Graphic” and “Pole-monitoring-Table”

The logging function *Pole monitoring* being activated (see 6.8), the illuminances of the pole for each C-plane are contained in the TTL file. These tabs, *Pole monitoring graph* and *Pole monitoring table*, visualize these data in the form of a diagram or a table. Via the context menus of the diagram and the table, the graphic or also the data can be saved or exported into the clipboard.



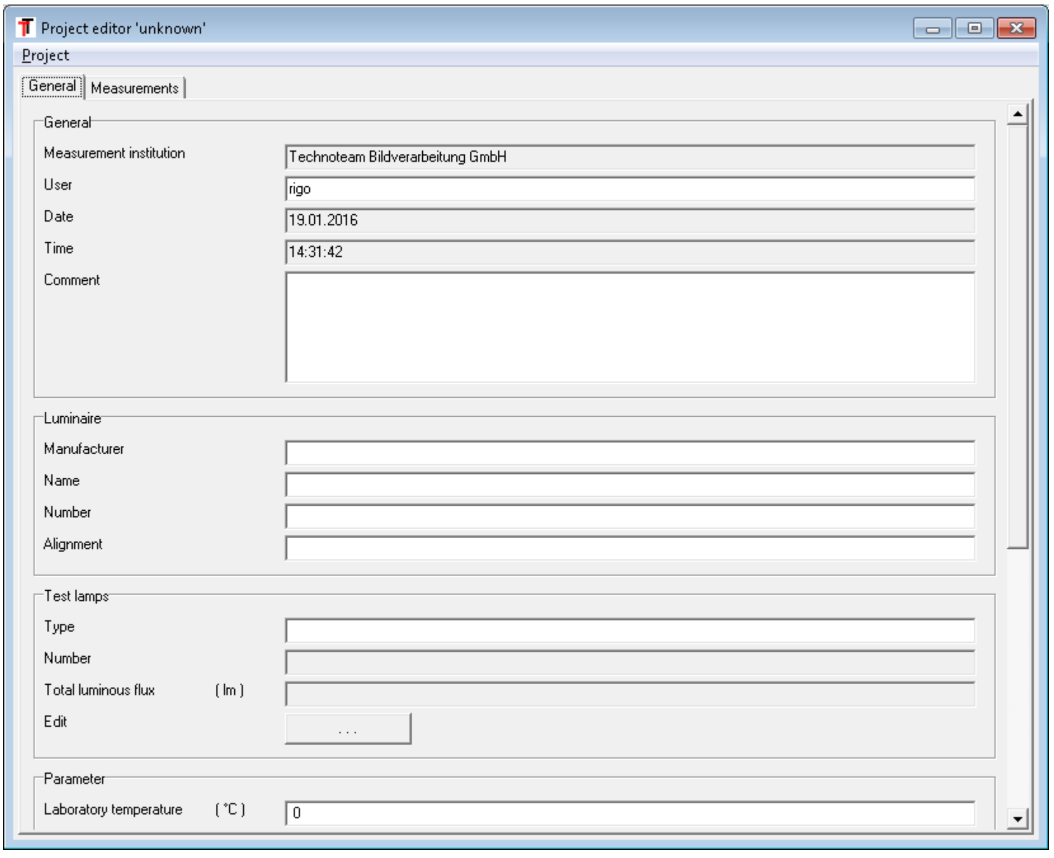

| Index | Phi [°] | Time [hh:mm:ss] | Illuminance [lx] |
|---|---|---|---|
| 0 | 0 | 00:00:00 | 303,9 |
| 1 | 0,7501 | 00:00:23 | 304,1 |
| 2 | 1,5 | 00:00:45 | 303,9 |
| 3 | 2,25 | 00:01:09 | 304,1 |
| 4 | 3 | 00:01:31 | 304 |
| 5 | 3,75 | 00:01:55 | 304 |
| 6 | 4,5 | 00:02:17 | 303,9 |
| 7 | 5,25 | 00:02:41 | 304,1 |
| 8 | 6 | 00:03:03 | 304 |
| 9 | 6,75 | 00:03:27 | 304,1 |
| 10 | 7,5 | 00:03:49 | 304 |
| 11 | 8,25 | 00:04:13 | 304 |
| 12 | 9 | 00:04:35 | 304 |
| 13 | 9,75 | 00:04:59 | 304 |
| 14 | 10,5 | 00:05:21 | 304 |
| 15 | 11,25 | 00:05:45 | 304,1 |
| 16 | 12 | 00:06:07 | 304 |
| 17 | 12,75 | 00:06:31 | 303,9 |
| 18 | 13,5 | 00:06:53 | 303,9 |
| 19 | 14,25 | 00:07:17 | 304 |
| 20 | 15 | 00:07:39 | 303,9 |

# 8 Measuring projects

In addition to the functionality of single measurements described in Chapter 6 is possible to run measurement projects with multiple measurements. So, for example multi-channel measurements with different color filters (optional filter wheel / color camera) can be carried out conveniently. For goniophotometers that are equipped with a color measuring camera (filter wheel), this program module is enabled by default. On demand the module can be enabled for other applications.

## 8.1 Measuring project editor

Using the measuring project editor (menu *File -> Measuring project – editor …*) a measurement project is created. At the start of the editor a dialog opens that contains the two tabs *General* and *Measurements*. The general specifications are nearly identical to those of the individual measurements (see 6.6).

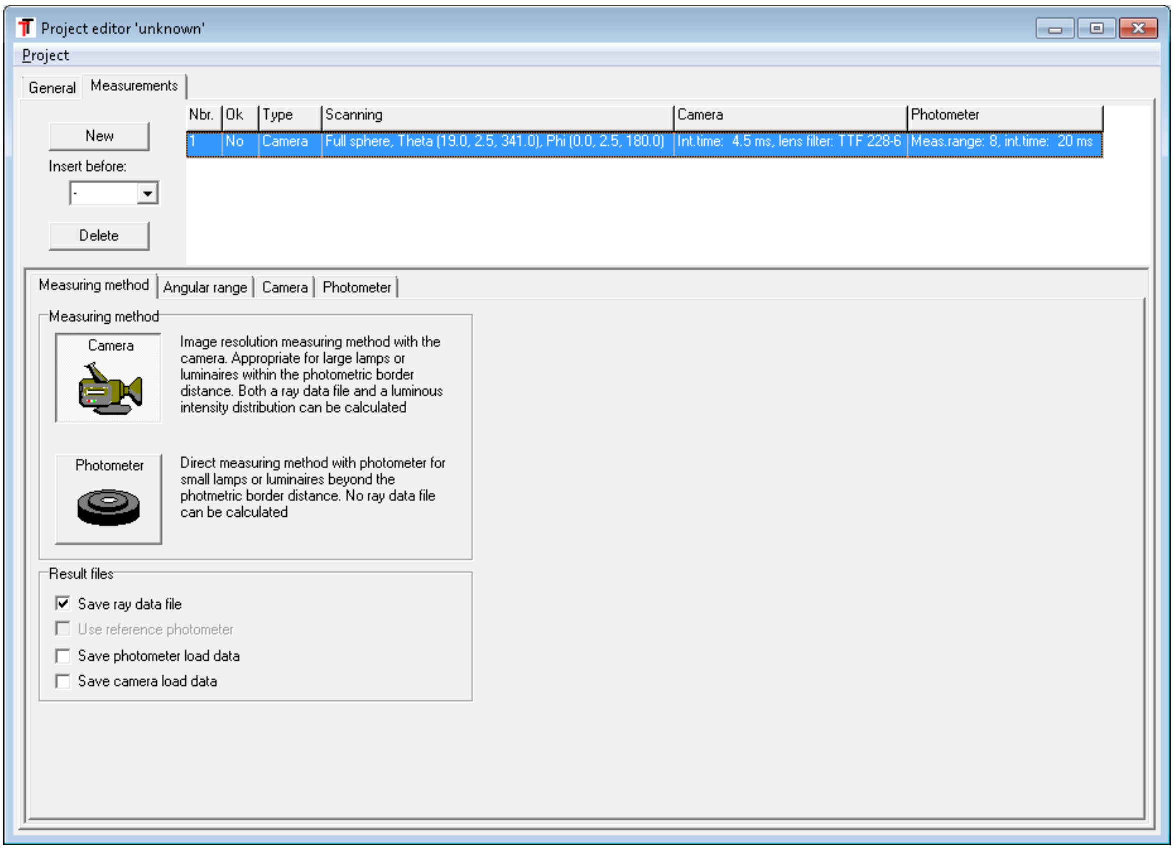



At the top of the tab *Measurements* the list of measurements is shown and at the bottom are the dialogs for configuring the selected entry. A new list entry is created with the button *New* or via the context menu of the right mouse button. Using the tabs *Measuring method*, *Angular range*, *Camera* and *Photometer* the measurement can be set up according to section 6.

New list entries are created as a copy of the currently selected entry. If one wants to make, for example, measurements with different filter positions, the first measurement is set up completely and based on this settings the following measurements are derived. Only the affected parameters are changed in the tab *Camera*.

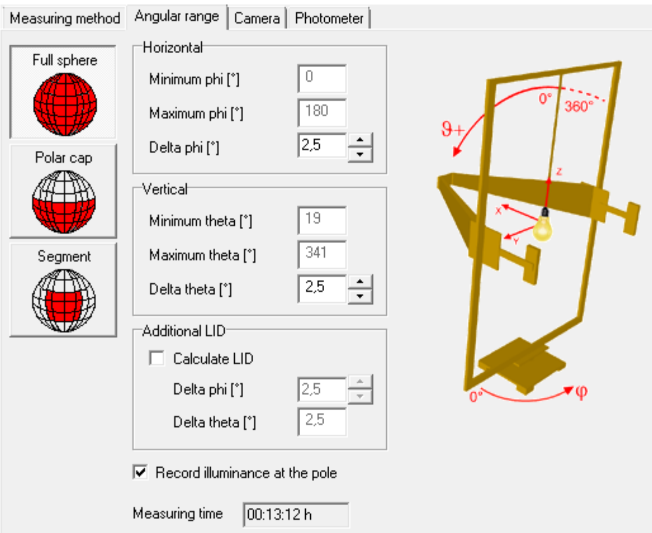
### 8.1.1 Measuring method

As additional option this tab provides the storage of saturation data of the camera and photometer for all sensor positions in separate files. When required, the measuring project navigator (see 8.3) can display this saturation data in form of images to have a detailed overview about the sensor saturations.



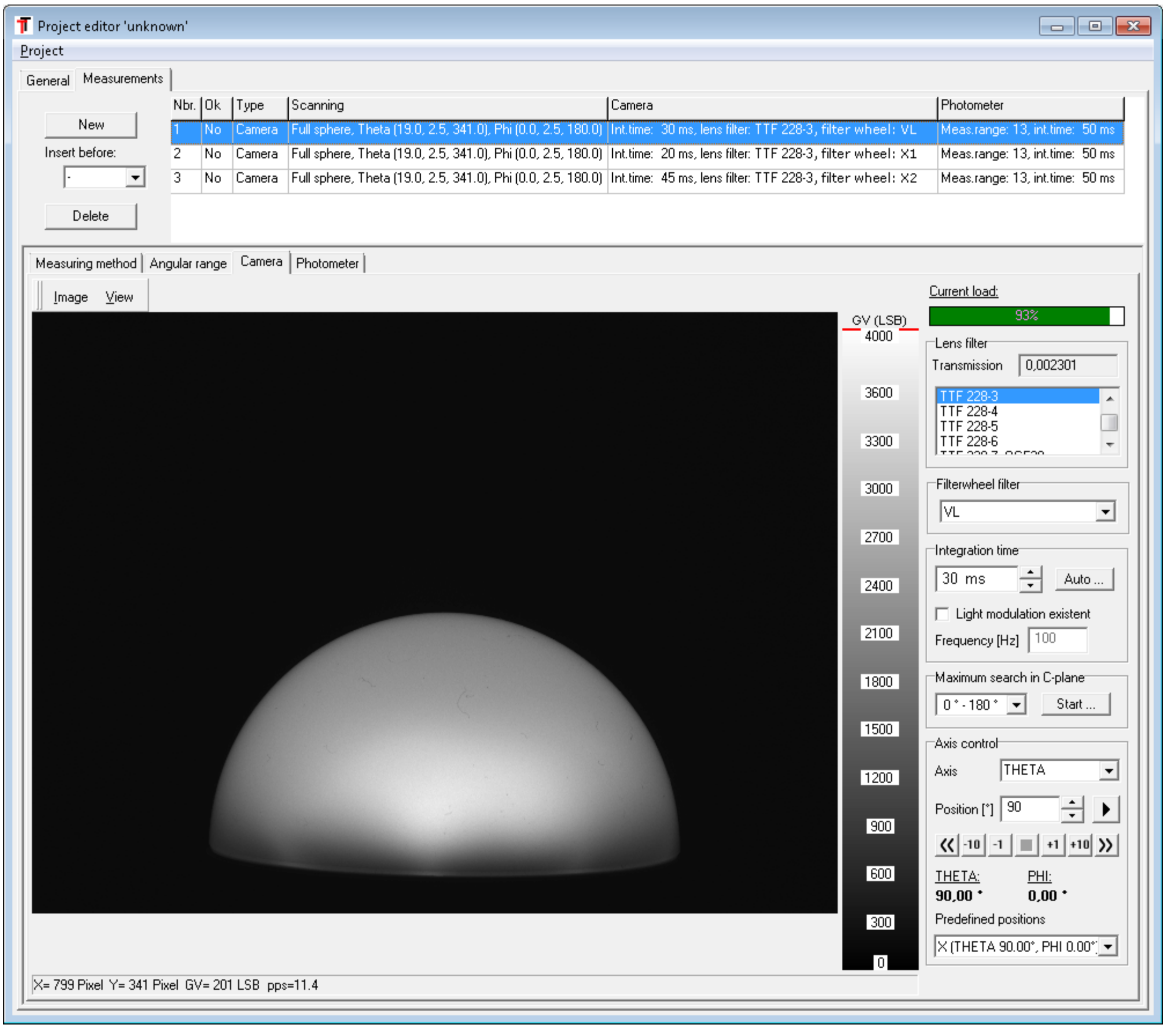

### 8.1.2 Angular range

In contrast to the single measurement settings dialog, the option *Record illumination at the pole* (see 6.8) is already defined at this place.



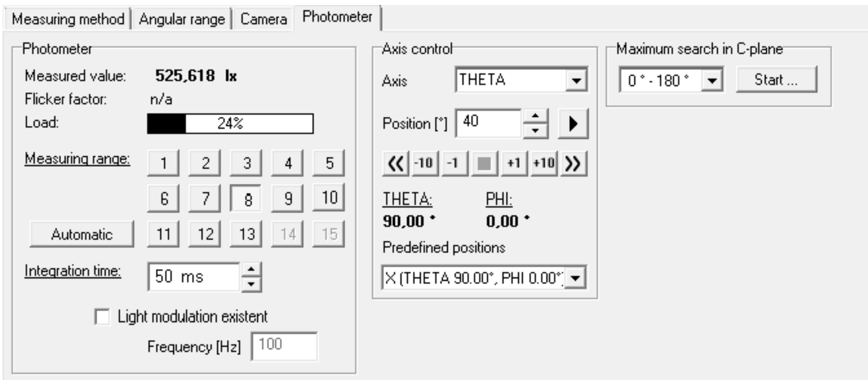

### 8.1.3 Camera

The parameterization of the camera is handled in detail in section 6.3. The following figure shows the camera settings for the first measurement with selected V(λ) filter. The measurement list view shows that the following measurements are set to filter X1 and X2 with individual integration times.



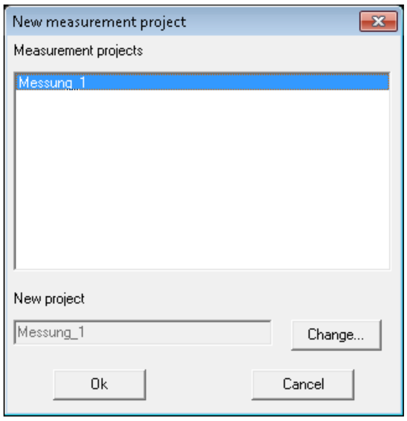

## 8.1.4 Photometer

The setup of the photometer is described in section 6.4.

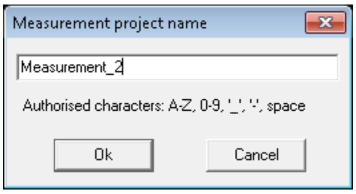



## 8.1.5 Storage

In contrast to single measurements measuring projects are stored in a special directory defined by the configuration (e.g. d:\measurements\projects). Each project gets its own directory and all project parameters are saved in the file *project.prj*. When saving a new project by choosing *Project -> Save as ...* the dialog *New measurement project* opens which contains the list of existing projects and the button *Change ...* for selecting a new name.

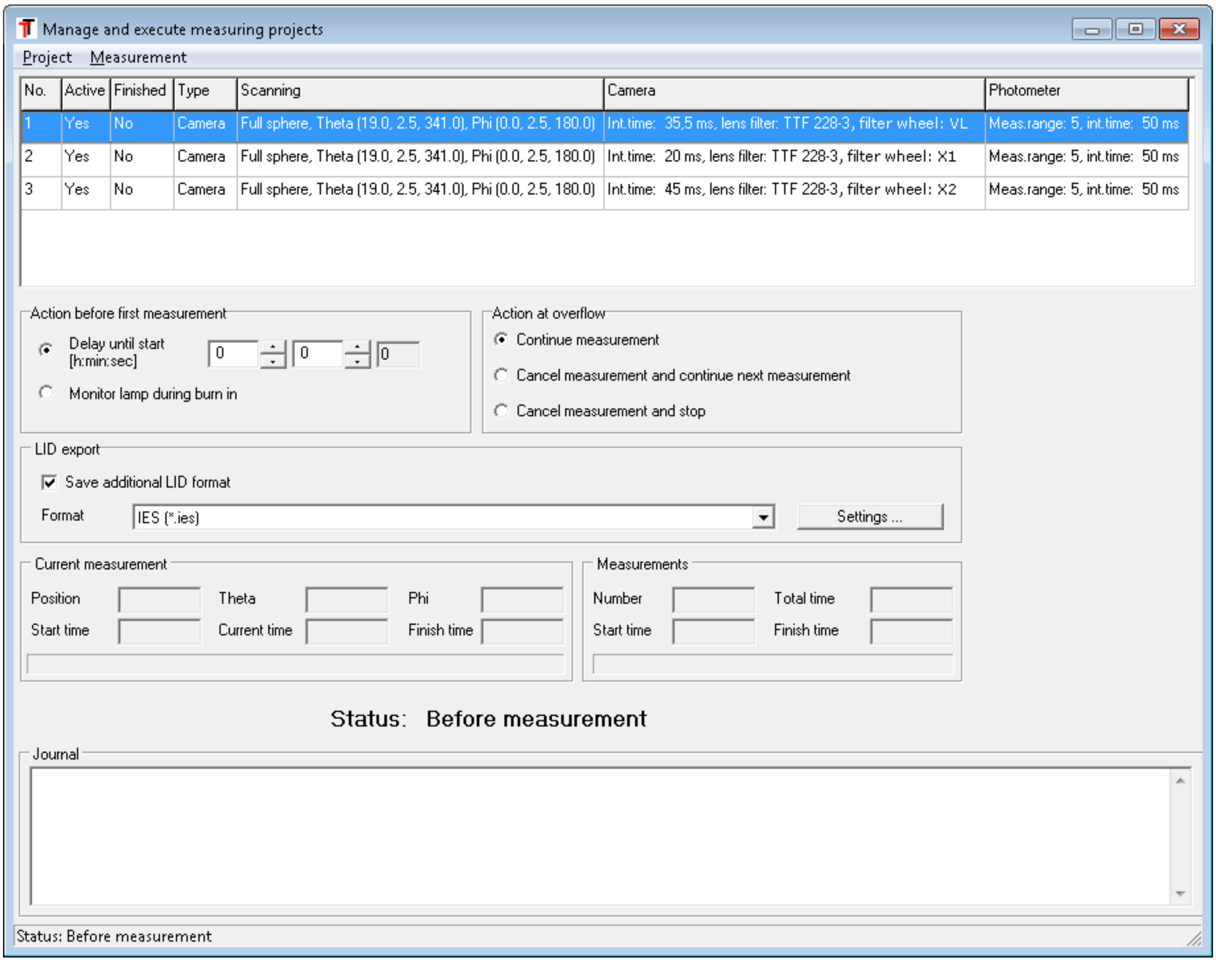



The project name input dialog only allows characters that don't interfere with the valid file system characters because this name is also used as the project directory name.

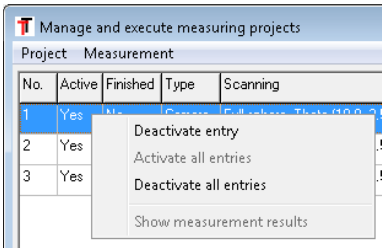



## 8.2 Carry out a measuring project

The menu *Measurement -> Execute measuring project …* opens the following dialog. In this example a project has already been loaded by using the menu item *Project -> Open …*.



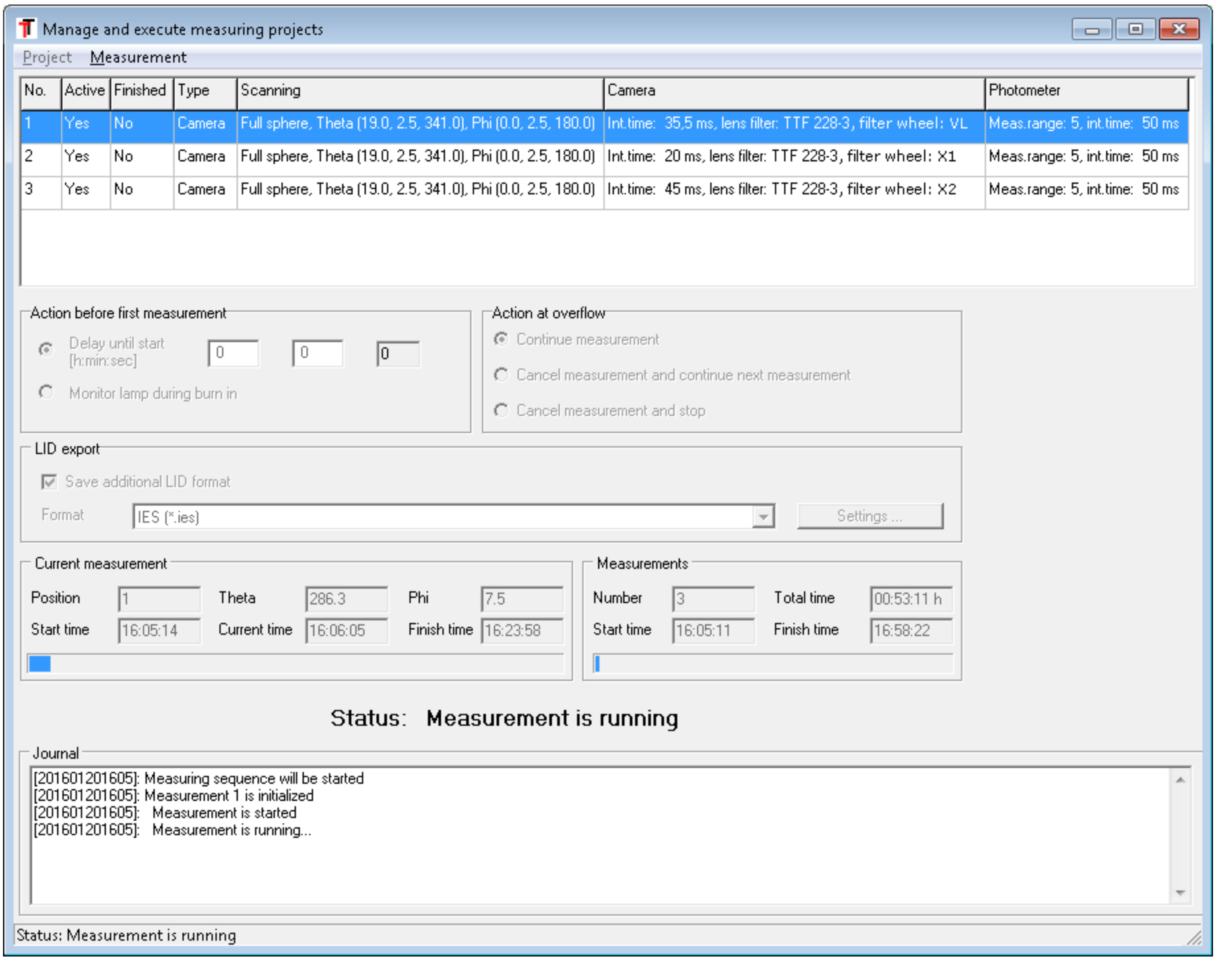
The column *Active* indicates whether a measurement is to be performed or not. This status can be changed by double-clicking or using the context menu of the right mouse button. The column *Finished* shows whether the measure has already been executed and measured data are available.




If an already completed measurement is reselected for execution, a warning appears that the existing data will be deleted when the measurement starts.

In the same way as a single measurement the measuring project can be started delayed or automatically after a stabilization phase (see 6.8). The behavior in case of saturation/overload can also be specified here. Overloads are in contrast to the single measurement recorded in the general log file of each measurement (see below).

The measuring process is started with *Measurement -> Start*.




The status of the current measurement is displayed in the area *Current measurement* and information about the total progress including an estimated measuring time is given under *Measurements*.

The filenames of the measurements are automatically generated and are composed of a continuous measuring number, the measurement resolution and the filter wheel position (e.g. *M26_cam_cap_0_500x0_500_VL.ttr*). For each measurement a log file with the extension

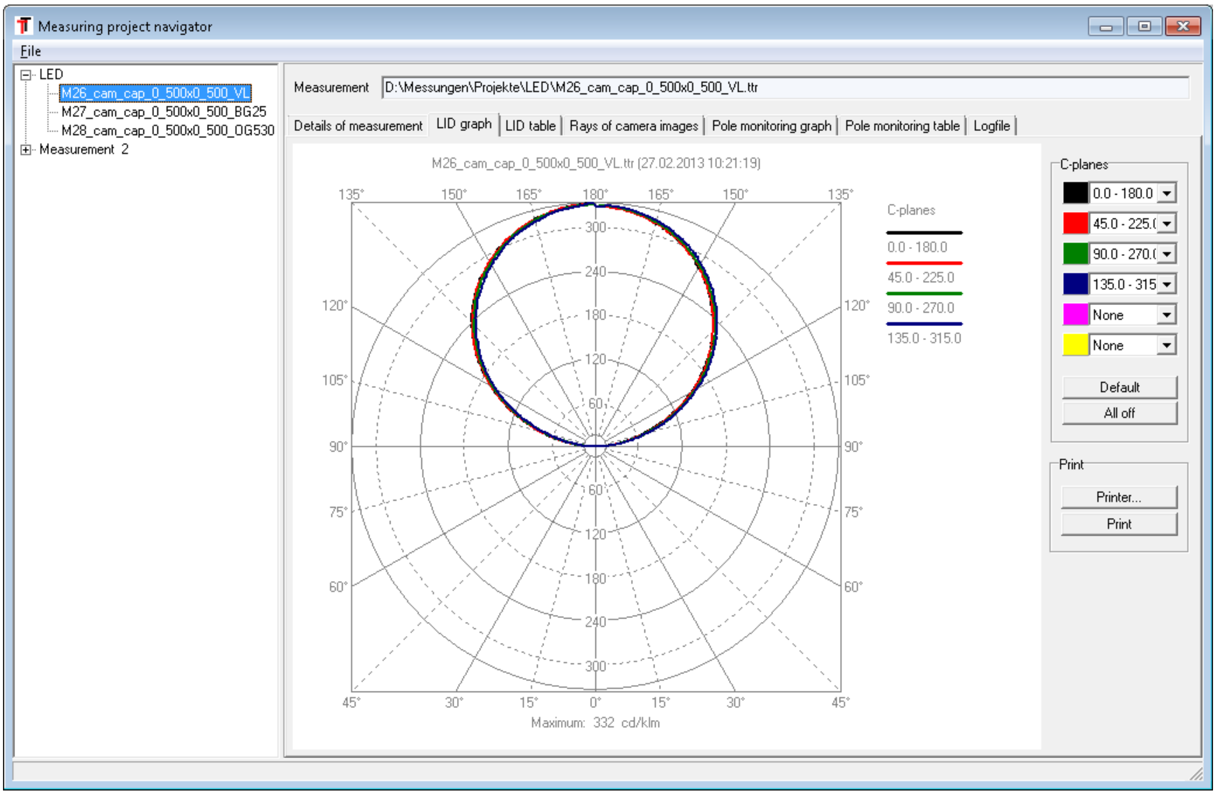
*_LOG.TXT* is created. In addition to general information about the start and end of measuring the log files contain positions of overloads and if errors occur, the complete error report.

Detail of a log file with overload messages:

```
[201302271403]: Project: D:\Measurements\Projects\G\project.prj
[201302271403]: Filename: M27_cam_cap_0_500x0_500_BG25
[201302271403]: Measure started
[201302271403]: Overflow Camera (Theta -4.712414e+00, Phi 0.000000e+00)
[201302271403]: Overflow Camera (Theta 2.855948e+00, Phi 0.000000e+00)
[201302271403]: Overflow Camera (Theta 1.395580e+01, Phi 0.000000e+00)
```
…

## 8.3 Measuring project navigator

The measuring files of a project can be opened directly by using the File -> Open … menu of the RiGO801 measuring program or the Converter801 or they can be explored by using the special measuring project navigator with *File -> Measuring project – navigator …*. The navigator displays a tree view of the projects with their belonging measurements. The results of the selected measurement are displayed in the usual way in the right pane. Additionally the result view of the navigator offers the tab *Logfile*.



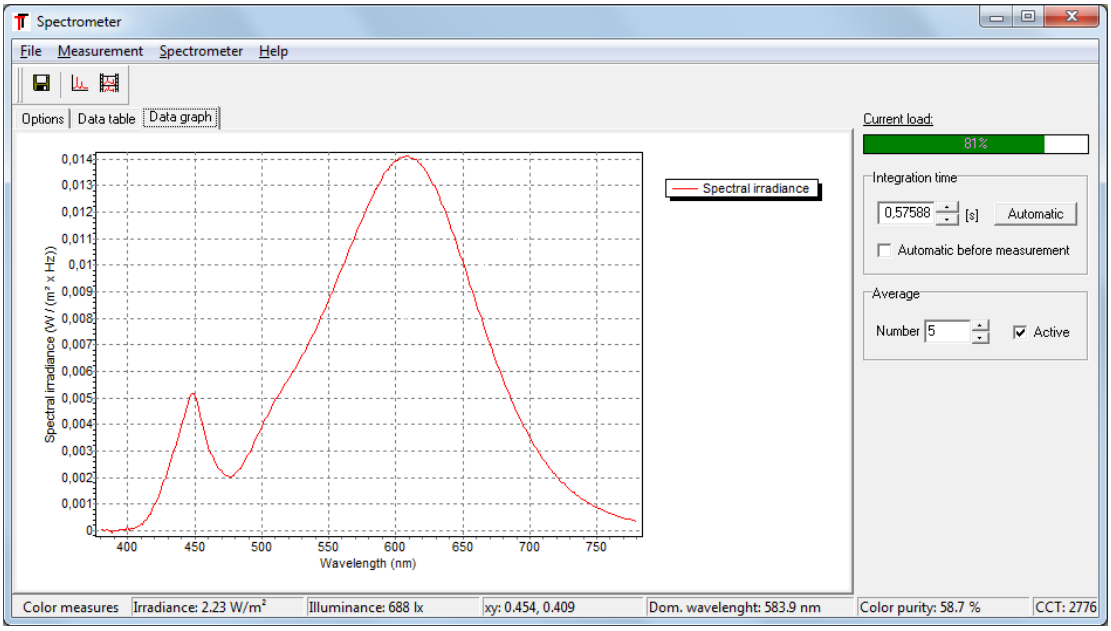
# 9 Spectrometer extension module

## 9.1 General

The spectrometer extension module embeds the functionality of spectrometer measurements in the RiGO801 software. This module allows spectrometer measurements to be carried out manually or automatically as sequence of single measurements on the basis of a list of positions. Part of the evaluation is the calculation of the mean spectral power distribution (SPD) and derived values (e.g. color coordinates, CRI) according to LM79 and ED 13032-4.

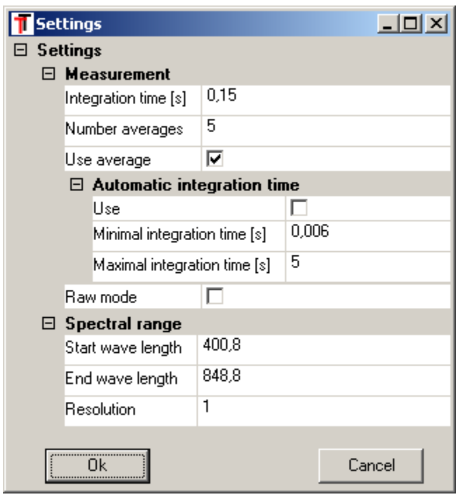
## 9.2 Manual spectrometer measurement

The menu item *Hardware > Spectrometer...* opens the dialog for the manual spectrometer measurement. In the right-hand part, the spectrometer dialog offers some options for the parameterization of the spectrometer. The left-hand part of the dialog can be used for representing the measured spectra in a diagram.




### 9.2.1 Parameterization

All settings necessary for a spectrometer measurement can be made in the measurement parameter dialog (menu item *Measurement > Settings…*). Some important settings and also the dark signal correction option (depending on the type of spectrometer) are additionally available in the right-hand part of the main dialog.



### Setting of the integration time

The integration time of the spectrometer is set in the group box *Integration time*. Using the button *Automatic before measurement* the user can fix the integration time to be determined automatically through a series of trial measurements immediately before the actual measurement. The saturation degree of the measurement made last is visualized by the saturation indication *Current load*. In case of lower saturation levels (< 30%) it is useful to activate the averaging function.

### Smoothing of the measuring values

The measuring values of each spectrometer measurement can be smoothed by averaging. In the group box *Average* averaging can be activated (option *Active*), and the intensity of smoothing can be parameterized through the number of the partial measurements applied (edit field *Number*).

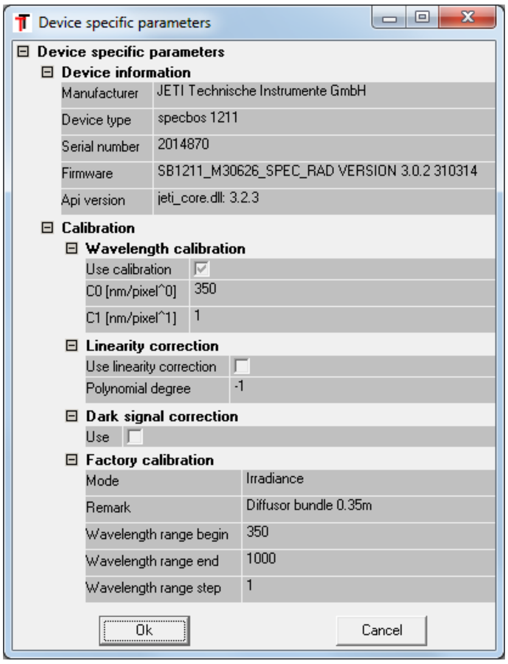
### Settings of the spectral range

The settings of the spectral range can be made in the dialog for the measuring parameters (menu item *Measurement > Settings…*). In the section *Spectral range*, the user can fix both the wavelength range (entries *Start wave length [nm]* and *End wave length [nm]*) and the spectral resolution (entry *Resolution [nm]*).

If the spectrometer does not support variable measuring range and resolution settings, the spectrum will be determined with the help of the device parameters, and resolution will be reduced numerically. If the device resolution amounts to a multiple of the desired output resolution, an appropriate low-pass filter will be applied before the spectral values are calculated by linear interpolation at the desired wavelengths from the spectrum measured.

### Spectrometer device parameters

Using the menu item *Spectrometer > Device settings…* a dialog containing device-specific parameters can be opened. The parameter regarding the wavelength calibration and the linearity and dark signal correction are not relevant for the JETI spectrometer devices used for the RiGO801 goniophotometers.




### Spectrometer calibration

This dialog is not relevant for the used JETI spectrometer devices because the calibration is included in the spectrometer.

### 9.2.2 Do measurements

Single measurements can be made using the button of the tool bar or the menu item *Measurement > Single measurement*.

The tool bar button or the menu item *Measurement > Live* activates or deactivates the continuous measuring mode.

### 9.2.3 Measuring results

The graph of the spectral data displayed in the context menu offers various options of data representation. By pressing the left-hand mouse button, the user may select a certain range which allows the enlargement of the data range shown. Enlarged data ranges can be shifted by pressing the right-hand mouse button. An enlarged representation can be reset via the context menu entry *Display > Reset zoom*. The default settings of the display can be restored using the context menu item *Display > Default*.

In the status bar of the dialog several calculated values are displayed (xy chromaticity values, color temperature, color saturation, dominant wavelength, color rendering indices).

The result of a measurement can be saved in the *.tsd-, *.csv- or *.isd-format using the menu item *File > Save as…*.

The file format *.tsd (Technoteam Spectral Data) is a binary format in which all relevant device parameters and settings are saved in the header. The format allows several measurements to be saved. For this, it must be made sure that the header information is compatible. Any incompatibility can be caused by modified parameters of the spectral range (e.g. resolution) or different additional information.

The file format *.isd (Instrument Systems Data) is a ASCII character format for spectral data, developed by the company Instrument Systems.

If an existing file is selected for being saved, the user will be requested whether the measurement shall be attached or whether the file shall be overwritten


Using the menu item *File > Convert file…* the tsd-file format can be converted into the *.csv-format, which can be read by Excel (csv - comma-separated values) or the *.isd-format. For this, first the tsd-source file is selected, and then the csv- or isd-target file. To the csv-file all information contained in the tsd-file will be given out in a hierarchically structured way (see 9.3.6).

## 9.3 Position controlled measuring sequence

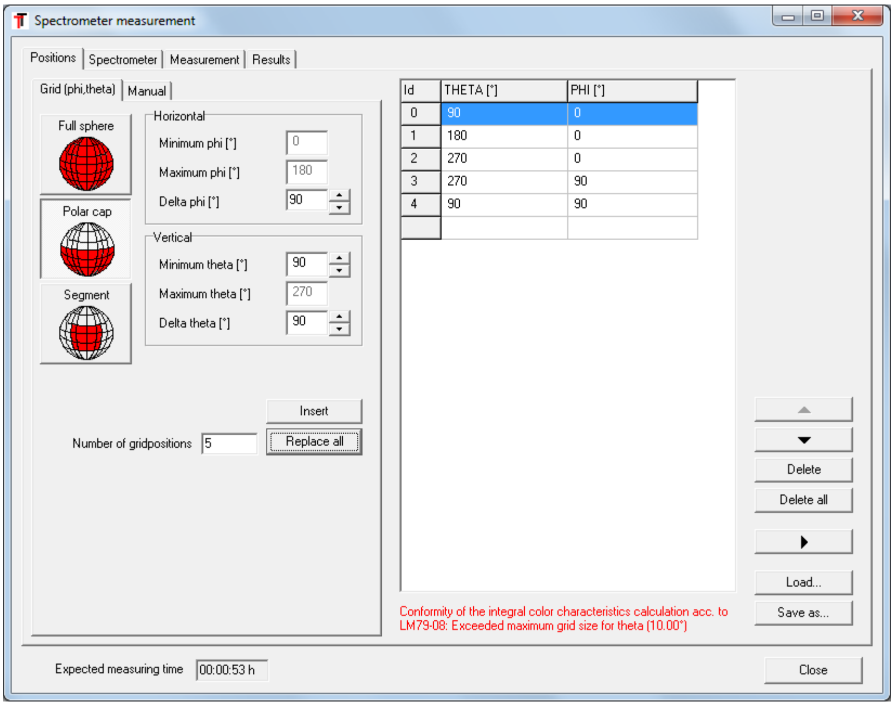
### 9.3.1 Measurement process

The parameterization of the spectrometer and the measuring sequence, the carrying out of the measuring sequence as well as the visualization of the results take place on the basis of a dialog via the menu item *Measurement > Spectrometer measurement...* of the goniometer software. In the dialog of the spectrometer measurement, the single steps of the parameterization and of the execution of a measuring sequence are summarized in the form of tab pages.

The generation and the management of the spectrometer positions can be effected via the tab *Positions*. The parameterization of the spectrometer or also of the single measurements is carried out in the tab *Spectrometer*. The tab *Measurement* is used for the parameterization and execution of the measurement. Then, the results of a measuring sequence are shown in the tab *Results*.

### 9.3.2 Generation of the list of positions

For each measuring sequence, a list of positions must be established. This list contains the φ-θ-positions of the single measurements of the spectrometer measurement. The positions are generated via one of the two tabs *Phi-Theta-Grid* or *Manual* arranged in the left-hand part of the dialog. The right-hand half of the dialog shows the list of the positions generated.



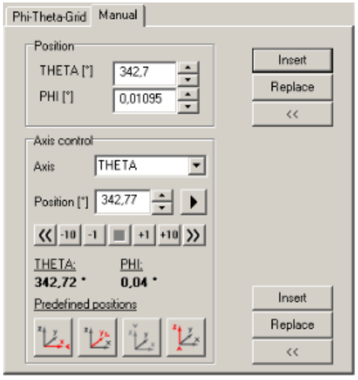

Single positions marked in the list can be edited using the buttons , , *Delete* and *Delete all* . By pressing the button  , the spectrometer is moved to the desired position. The current list of positions can be saved using the buttons *Save as ...* and *Load ...* in the form of various formats, and it can also be reloaded again later.

Below the item list it is stated whether the list is compliant with the standard LM-79-08 or not. In the above case, the maximum increment in theta exceeds 10 degrees and thus the positions are not compliant. In case of conformity to LM-79-08 the middle spectrum and the derived parameters are calculated and stored in the CSV file (see 9.3.6).

#### *Phi-Theta-grid*

The tab *Phi-Theta-Grid* is used to generate a group of positions. These are arranged in a φ-θ-grid of the spherical coordinate system of the goniometer. In order to keep the measuring time short, the positions are arranged in theta-direction in a meander-shaped way. Analogous to the dialog *Adjust angular range* of a goniometer measurement (see 6.2), it is possible – depending on the selected traversing regime (*Full sphere*, *Polar cup* or *Segment*) – to adjust the tracking limits (*Minimum phi [°]*, *Maximum phi [°]*, *Minimum theta [°]* and *Maximum theta [°]*) as well as the resolution of the grid (*Delta phi [°]*, *Delta theta [°]*). For LM-79-08 compliant position lists the increment in Theta must not exceed 10 degrees.

*Single positions*




The function of the tab *Manual* is to generate some single positions and to approach spectrometer positions for trial measurements. In the group box *Position*, coordinates can be defined and added to the list of positions using the buttons *Insert* or also *Replace*.

The button  is used to insert the currently selected position list entry in the coordinate fields of the group box *Position*. The operating elements contained in the group box *Axis control* allow the user to approach goniometer positions manually for testing purposes.

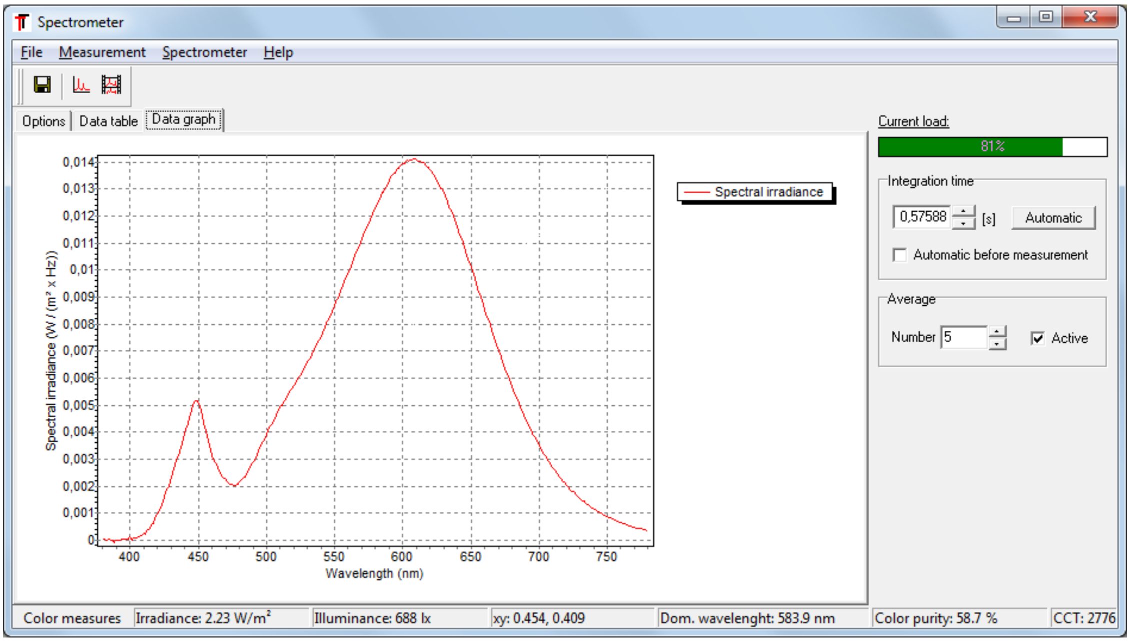
Analogous to the group box *Position*, the positions of the axes can be added to the list of positions. Furthermore, it is possible to adopt a position of the list of positions as axis position and to move the spectrometer into the desired position.

*Estimation of the measuring duration*

From the travelling times which result when approaching the measuring positions, and from the integration time chosen, the duration of the measuring sequence is estimated and displayed in the main dialog (position at the bottom left). The estimated measuring duration is displayed only when one of the tabs *Positions* or *Spectrometer* is active.

### 9.3.3 Parameterization of the spectrometer

The dialog of the tab *Spectrometer* enables the user to parameterize the spectrometer hardware. Except for the menu bar, which is not available here, this dialog corresponds to that of the manual measuring value recording (see 9.2).

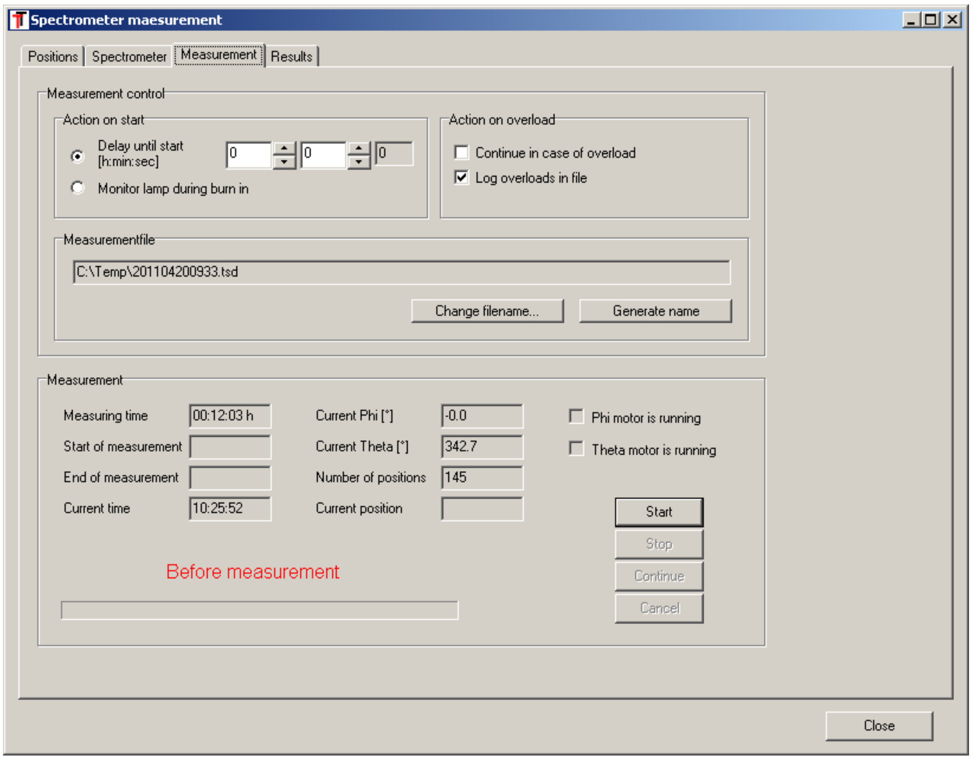



Basically the option *Automatic before measurement* can be activated to adjust the integration time to the position dependent irradiance prior each measurement. However, this results to long measurement times in areas with low irradiance (maximum integration time 60s) and to unpredictable total measuring times. Alternatively, the setting of a fixed integration time in the maximum of the distribution and an averaging of for example 5 or 10 measurements per position is recommended. Carrying out the spectrometer measurement after a LID measurement, the position of the maximum can be taken from the measurement protocol (section LID) and be used for setting the integration time at this position.

### 9.3.4 Spectrometer measurement

The function of the tab *Measurement* is to assist the parameterization and execution of the measuring sequence. In the upper group box *Measurement control*, the name of the target file (group box *Measurement file*), the program behavior in the case of overloads (group box *Action on overload*), and an optional waiting or stabilization before starting the measurement (group box *Action on start*) can be fixed. The lower group box *Measurement* is used for executing and controlling the measurement.

The measuring data are saved in the TechnoTeam-format for spectral data *.tsd, and additionally exported in the *.csv – format (csv - Comma-Separated Values) or the *.isd – format. After each measurement, the spectral data are displayed in the tab *Results*.




*Name of the result file*

The name of the measurement file can be fixed either on the basis of the dialog by pressing the button *Change filename …* or automatically by pressing the button *Generate name*. If the file name is generated automatically, this is done on the basis of the current measuring time (e.g. 2011-04-04, 10:48 → 201104041048.tsd).

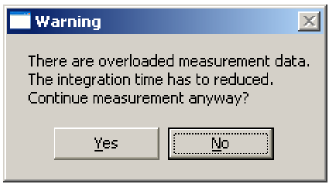
*Starting action*

In the group box *Action on start* , the stating conditions are defined. When the option *Delay until start* is activated, the waiting time entered there is kept. If the option *Monitor lamp during burn in* is active, the measurement starts when a stable operating condition is reached (see 6.9).

### *Behavior in the case of overload*

In the group box *Action on overload*, the actions carried out by the program in the case of overloaded measuring values during the spectrometer measurement are fixed.

If the option *Continue in case of Overload* is activated, the measurement will be continued without any warning message in the case of overloads. If, however, this option is not active, a warning message will be displayed, and the user will be asked whether they want to go on with the measurement or not.

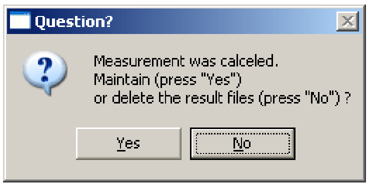



The option *Log overloads in file* allows overloads to be recorded. Any occurring overloads are documented in text files with the name „*_overload_spectro.txt“ (*-Wildcard for the name of the measurement file).

### *Measuring process*

If the list of positions contains at least one valid entry, and if there is one valid dark signal measurement (depending on the type of spectrometer used, the measurement can be started in the group box *Measurement* by pressing the button *Start* . In this group box, the estimated measuring duration, the start and the end of the measurement, the current spectrometer positions, the measurement progress (in the form of a progress bar) as well as the status of motion of the motors are displayed. A spectrometer measurement can be stopped or continued by pressing the buttons *Stop* and *Continue*, respectively, or it can be aborted by using the button *Cancel*.

If a measurement has been cancelled, the result file still remains valid and saves all single measurements which were valid up to the moment of cancellation. Immediately after each abortion carried out by the user, they are asked whether the measuring results shall be deleted or not

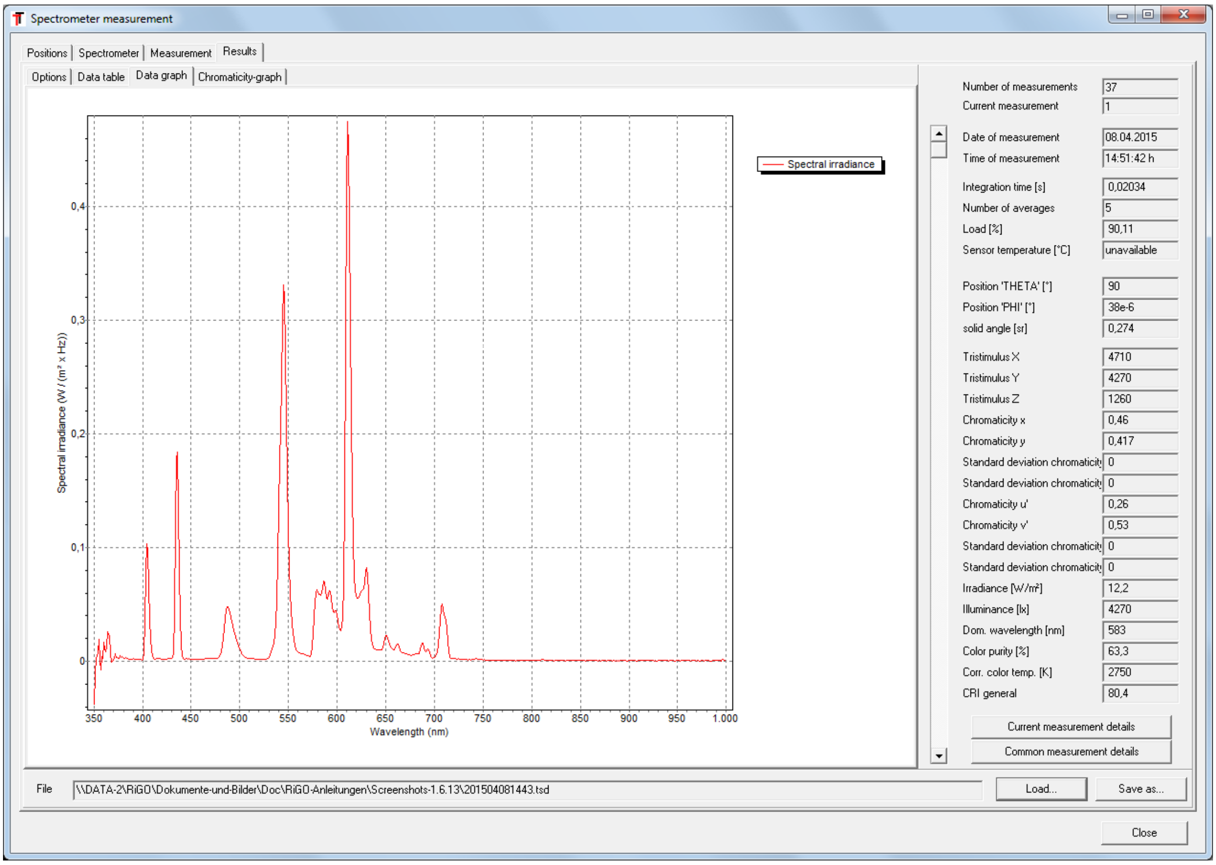


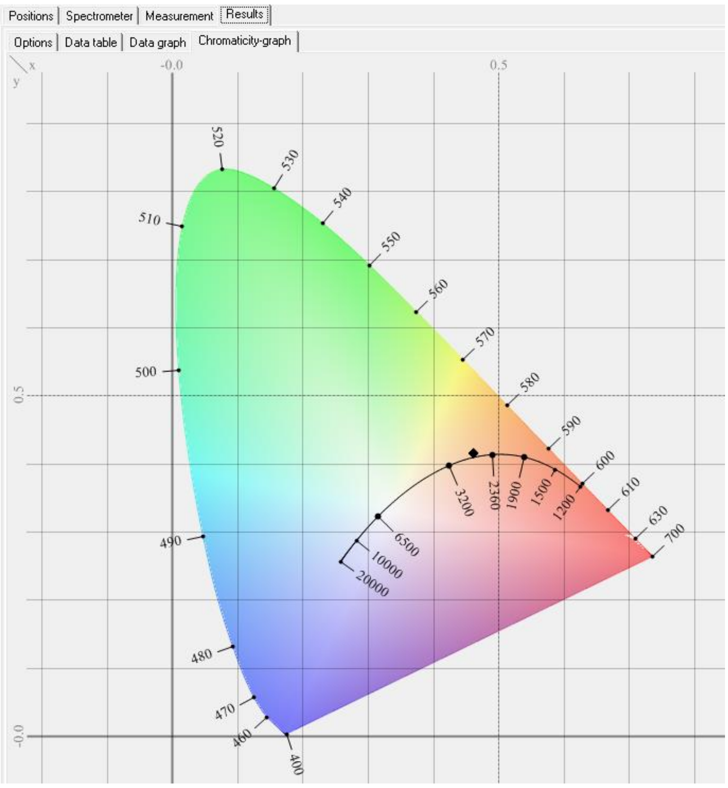

## 9.3.5 Measuring results

After completion of the measurement sequence, the results are displayed automatically by the tab *Results*. In addition, measuring sequences can also be loaded, displayed and saved again by pressing the buttons *Load* and *Save as …* (for data formats see 9.2.3).

In the left-hand part of the dialog, the measuring data of a single measurement are displayed. A single measurement can be selected by means of the scroll bar to the right of the display area.

In the tab *Data graph*, the data are graphically represented, whereas they are shown in the form of a table in the tab *Data table* (for usage refer to 9.2.3). In the chromaticity diagram (tab *Chromaticity-graph*) the color values calculated from the spectral data are displayed. On the right side of the dialog various additional information and calculated values of the spectral measurement (e.g. color coordinates, CRI) are listed for each individual measurement.




The chromaticity diagram provides various ways of data representation via the context menu. The color values for the 2 or 10 degrees standard observer can be calculated (menu item *observer*) and be represented in different color spaces (menu *color space*). Zooming of the data area is possible by using the mouse wheel. The zoom level can be reset with *Zoom reset*.

By pressing the buttons *Actual measurement details* or also *Common measurement tasks* all parameters and results of the currently selected single measurement or also of the measuring sequence loaded can be displayed.

### 9.3.6 Structure of the CSV data file

The CSV data file of a spectrometer measurement is stored parallel to the TSD file and can, for example, be opened with common spreadsheet programs (if necessary, adjust delimiter to semicolon). The structure of the CSV file reflects the hierarchical XML structure of the TSD file. There are general basic information, information on the total measurement, and finally, in columns sorted, the data of the individual measurements. Below substantial extracts from the structure are explained.

#### *Basic information*

These details include information about the software driver and the device. The information regarding the wavelength and linearity calibration and the dark signal correction are irrelevant for the spectrometers from JETI (Specbos1211) used for RiGO801 goniophotometers.

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Driver information | Description | Software driver for spectrometer, manufacturer of spectrometer: JETI Technische Instrumente GmbH | | |
| 2 | | Manufacturer | TechnoTeam Bildverarbeitung GmbH http://www.technoteam.de | | |
| 3 | | Date | Mar 13 2015 | | |
| 4 | | Version | 2.0 | | |
| 5 | Device specific parameters | Device information | Manufacturer | JETI Technische Instrumente GmbH | |
| 6 | | | Device type | specbos 1211 | |
| 7 | | | Serial number | 2014870 | |
| 8 | | | Firmware | SB1211_M30626_SPEC_RAD VERSION 3.0.2 310314 | |
| 9 | | | Api version | jeti_core.dll: 3.2.3 | |
| 10 | | Calibration | Wavelength calibration | Use calibration | 1 |
| 11 | | | | C0 [nm/pixel^0] | 350 |
| 12 | | | | C1 [nm/pixel^1] | 1 |
| 13 | | | Linearity correction | Use linearity correction | 0 |
| 14 | | | | Polynomial degree | -1 |
| 15 | | | Dark signal correction | Use | 0 |
| 16 | | | Factory calibration | Mode | Irradiance |
| 17 | | | | Remark | Diffusor bundle 0.35m |
| 18 | | | | Wavelength range begin | 350 |
| 19 | | | | Wavelength range end | 1000 |
| 20 | | | | Wavelength range step | 1 |

#### *General information about measurement -> spectral range*

| | B | C | D |
|---|---|---|---|
| 21 | Spectral range | Start wavelength | 350 |
| 22 | | End wavelength | 1000 |
| 23 | | Resolution | 1 |

#### *General information about measurement -> Measuring results*

| | B | C | D | E |
|---|---|---|---|---|
| 40 | Measurement values | Conformity to LM-79-08 (color characteristics) | 1 | |
| 41 | | Mean color characteristics | tristimulus X | 4703,89 |
| 42 | | | tristimulus Y | 4258,88 |
| 43 | | | tristimulus Z | 1256,66 |
| 44 | | | Chromaticity x | 0,460297 |
| 45 | | | Chromaticity y | 0,416749 |
| 46 | | | Standard deviation chromaticity x | 0,446716 |
| 47 | | | Standard deviation chromaticity y | 0,400272 |
| 48 | | | Chromaticity u' | 0,260041 |
| 49 | | | Chromaticity v' | 0,529736 |
| 50 | | | Standard deviation chromaticity u' | 0,258598 |
| 51 | | | Standard deviation chromaticity v' | 0,521351 |
| 52 | | | Irradiance [W/m²] | 12,1477 |
| 53 | | | Illuminance [lx] | 4258,59 |
| 54 | | | Dom. wavelength [nm] | 583,369 |
| 55 | | | Color purity [%] | 63,0059 |
| 56 | | | Corr. color temp. [K] | 2741,32 |
| 57 | | | Radiant flux [W] | 7,36763 |
| 58 | | | Luminous flux [lm] | 2583,27 |

If measuring values exist that are derived from the complete sequence of spectral power distributions, these are listed here. Currently, these are only the averages values according to LM-79-08 or EN 13032-4. The flag *Conformity to …* indicates whether these data are available (see 9.3.2) and in this case a list of these values follows. At the end of the file the underlying mean SPD is also output.

### *Single measurements -> Measurement settings*

In this branch, the spectrometer settings for each individual measurement are output.

| | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 59 | Measurement settings | Integration time [s] | | 0,0203375 | 0,0203375 | 0,0203375 |
| 60 | | Number averages | | 5 | 5 | 5 |
| 61 | | Use average | | 1 | 1 | 1 |
| 62 | | Average device intern | | 0 | 0 | 0 |
| 63 | | Automatic integration time | Device intern | 0 | 0 | 0 |
| 64 | | | Use | 0 | 0 | 0 |
| 65 | | | Minimal integration time [s] | 0,005 | 0,005 | 0,005 |
| 66 | | | Maximal integration time [s] | 60 | 60 | 60 |

### *Single measurements -> Additional information*

This branch includes some relevant information about the individual measurements, such as axis positions and color values.

| | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 68 | Additional information | Axes | Position 'THETA' [°] | 89,9995 | 99,9997 | 110 |
| 69 | | | Position 'PHI' [°] | 3,80E-05 | -1,90E-05 | 0 |
| 70 | | | solid angle [sr] | 0,273808 | 0,269648 | 0,257296 |
| 71 | | Color characteristics | Tristimulus X | 4713,46 | 4723,81 | 4726,77 |
| 72 | | | Tristimulus Y | 4271 | 4284 | 4281 |
| 73 | | | Tristimulus Z | 1257,74 | 1268,04 | 1263,35 |
| 74 | | | Chromaticity x | 0,4602 | 0,4597 | 0,4602 |
| 75 | | | Chromaticity y | 0,417 | 0,4169 | 0,4168 |
| 76 | | | Standard deviation chromaticity x | 0 | 0 | 0 |
| 77 | | | Standard deviation chromaticity y | 0 | 0 | 0 |
| 78 | | | Chromaticity u' | 0,2598 | 0,2596 | 0,26 |
| 79 | | | Chromaticity v' | 0,5298 | 0,5297 | 0,5297 |
| 80 | | | Standard deviation chromaticity u' | 0 | 0 | 0 |
| 81 | | | Standard deviation chromaticity v' | 0 | 0 | 0 |
| 82 | | | Irradiance [W/m²] | 12,19 | 12,2 | 12,28 |
| 83 | | | Illuminance [lx] | 4271 | 4284 | 4281 |
| 84 | | | Dom. wavelength [nm] | 583,3 | 583,3 | 583,4 |
| 85 | | | Color purity [%] | 63,3 | 63,1 | 63,2 |
| 86 | | | Corr. color temp. [K] | 2746 | 2751 | 2743 |
| 87 | | | CRI chromaticity difference | 9,90E-04 | 4,50E-04 | 8,00E-04 |
| 88 | | | CRI general | 80,44 | 80,69 | 80,76 |
| 89 | | | CRI, sample 1 | 98,2 | 98,3 | 98,3 |

### *Single measurements -> Measurement*

Here, finally, the spectral radiance, the measurement times and modulations of the measurements are given.

| | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 103 | Measurement | Capture time | Begin | 08.04.2015 14:51 | 08.04.2015 14:51 | 08.04.2015 14:51 |
| 104 | | | End | 08.04.2015 14:51 | 08.04.2015 14:51 | 08.04.2015 14:52 |
| 105 | | Signal level [0...1] | | 0,90112 | 0,90231 | 0,908841 |
| 106 | | | | | | |
| 107 | | | Wavelength | Spectral irradiance | | |
| 108 | | | nm | W / (m² x Hz) | | |
| 109 | | | 350 | -0,0381443 | -0,0306348 | 0,0465094 |
| 110 | | | 351 | -0,0116987 | -0,0159438 | 2,04E-04 |
| 111 | | | 352 | 0,00231122 | -0,0167983 | 0,00753356 |
| 112 | | | 353 | 0,00413206 | -7,82E-04 | 0,0110006 |

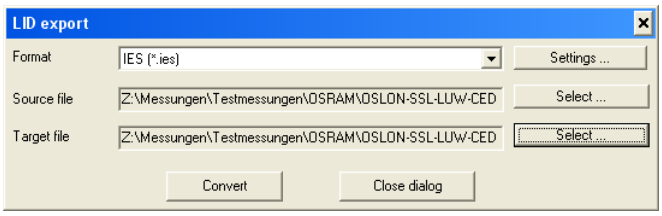
# 10 Other program features

## 10.1 Data-IO

### 10.1.1 LID – export

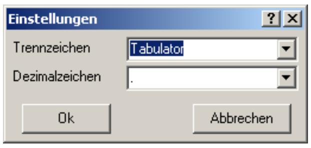
The RiGO801 software is well able to output the luminous intensity distribution available in the TTL – format in various file formats. Beside the common LID file formats there are also export filters available for calculating illuminance distributions or transformations of the LID.

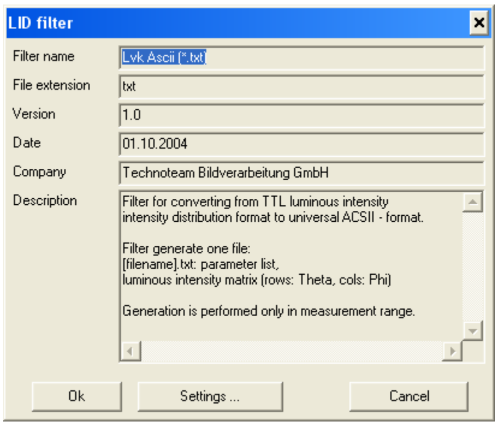
This export function can be activated during the parameterization of the measurement (see 6.1.3), or it can be called subsequently via the menu item *File > Lid export ...*. In the latter case, the following dialog is displayed.




*Export format Ascii*

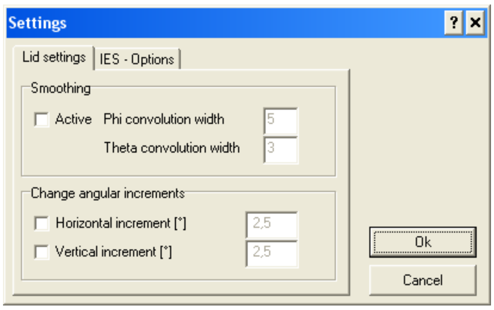
The Ascii-export format is a universal ASCII – format containing the entries made in the ttl-file in a text-readable form (e.g. import to spreadsheet program). The luminous intensity matrix (lines: theta, columns: phi, first line: phi angle, first column: theta angle) is output only for the measured angular range and in absolute luminous intensities.

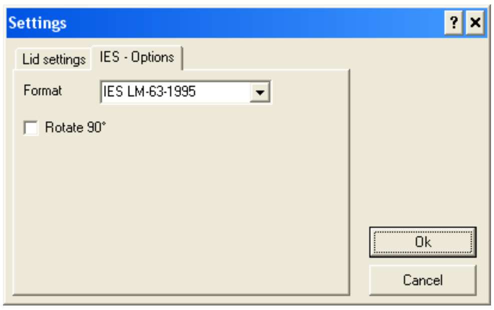



*Export format IES*

The IES-format stands as a synonym for a number of downward-compatible formats according to the North American standard LM-63 for photometric data and information linked to them.




In the tab *LID settings* optimal smoothing as well as a modification of the measuring grid can be set.

In the tab *IES Options* the format specifications can be set in the combo box *Format* , and using the selection box *Rotate 90°* the rotation of the C-planes by 90° can be set according to the luminaire alignment following the Anglo-American standard.

### *Export format LDT (Eulumdat)*

EULUMDAT is a format for exchanging photometric data for the luminous intensity distribution of light sources dating from the year 1990. The typical file extension is *.ldt. In continental Europe, the format has become the industrial standard for transmitting photometric data. Here, the LID values are contained as cd/klm – standardized values without decimals. As the format is not applicable to test lamps but to luminaires only, the test lamps contained in the ttl-file are summed up to a lamp mount by the summation of the luminous flux. If no test lamp is available (number of test lamps is 0 or total luminous flux is 0), a virtual lamp ‚test lamp‘ with a measured luminous flux equal to the luminous flux of the luminaire is specified (light output ratio of the luminaire 100%).

Analogous to the export format IES, an optional smoothing and also an optional modification of the measuring grid can be set in the tab *LID settings*.

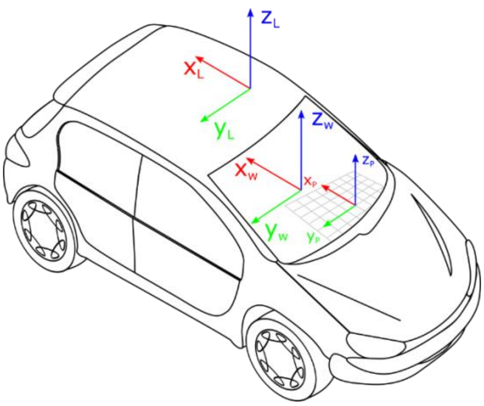
### *Illuminance distribution on a plane surface (*.pf)*

With this export filter the illuminance distribution on a plane surface can be calculated. The output format is a floating point image in TechnoTeam .pf - format that can be analyzed with the software LMK LabSoft. The positions and orientations of the light intensity distribution and the calculation of plane with respect to the world coordinate system can be freely defined.

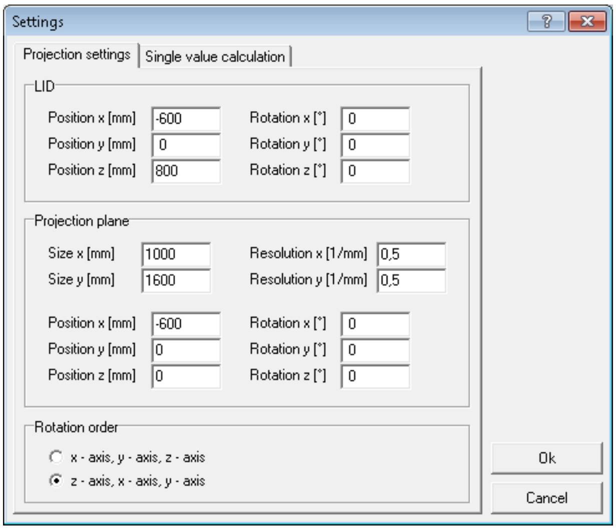
The explanation of the functions is carried out below in the example of the calculation of a illuminance distribution in the passenger compartment of a car. In this example, due to the short distance between lamp and calculation plane, a near-field LID has been calculated from the ray data (refer to Software manual *Converter801*).

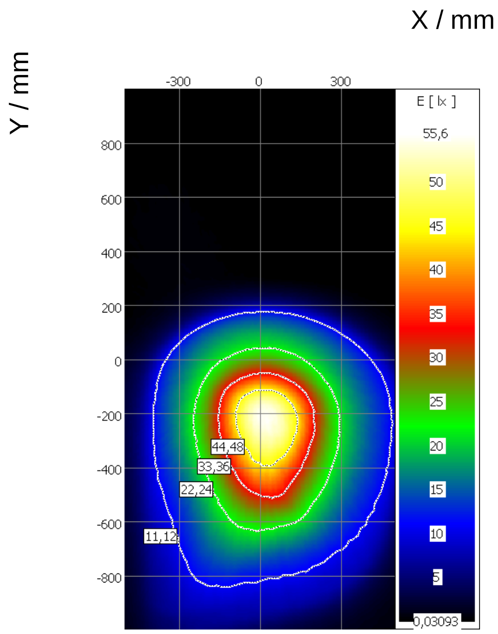
The export filter defines three coordinate systems. The basis is the world coordinate system $X_W/Y_W/Z_W$. Furthermore, there are the DUT coordinate system ($X_L/Y_L/Z_L$) and the plane coordinate system ($X_P/Y_P/Z_P$), which are positioned with respect to the world coordinate system.

In this example, the world coordinate system is assumed in the middle of the passenger compartment. The reading lamp (DUT coordinate system is positioned at $X_W$ = -600 mm and $Z_W$ = 800 mm. The orientation of the light doesn’t need to be changed, since the measurement has already taken place in the installation orientation. The calculation plane for the illuminance distribution is set to $X_W$ = -600 mm, $Y_W$ = 0 mm and $Z_W$ = 0 mm with the size of 1000 mm x 1600 mm and the resolution of 0.5 px/mm.




The parameters are entered under *Settings* in the *projection settings* tab. Depending on the preferred approach of the rotation parameters the rotation order can be selected between x-y-z and z-y-x.




Projection settings

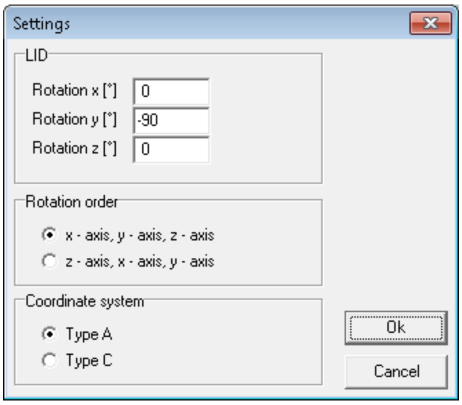
Result image of the illuminance distribution with isolux lines

In the *single value calculation* tab, a list of coordinates (format LabSoft position list) can be indicated where the corresponding illuminance levels are taken and written to a separate text file. For the evaluation of the illuminance image (TechnoTeam .pf - Format) the software LMK LabSoft is necessary.

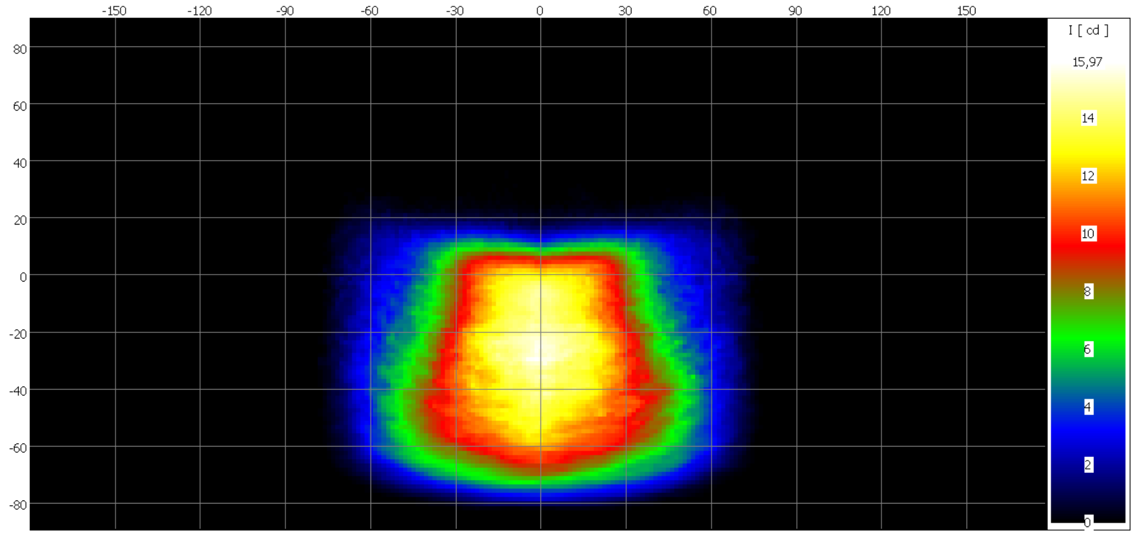
### *Luminous intensity distribution map (*.pf)*

This export filter generates the matrix of the luminous intensity distribution as floating point image in the TechnoTeam .pf format. The LID can be freely rotated in three directions. As coordinate systems are A - and C – type available.

One application is, for example, the projection of the LID of a headlamp in A - coordinates. In the following example, a reading light has been aligned to the pole and measured in the C - plane coordinate system.




However, the usual alignment of headlamps in an A – type measurement is to the equator. The rotation of the pole oriented DUT about 90° around the Y axis brings it to this equator orientation. The result of this typical headlamp distribution map in A - coordinates is shown below.




LID in Type-A coordinates as image

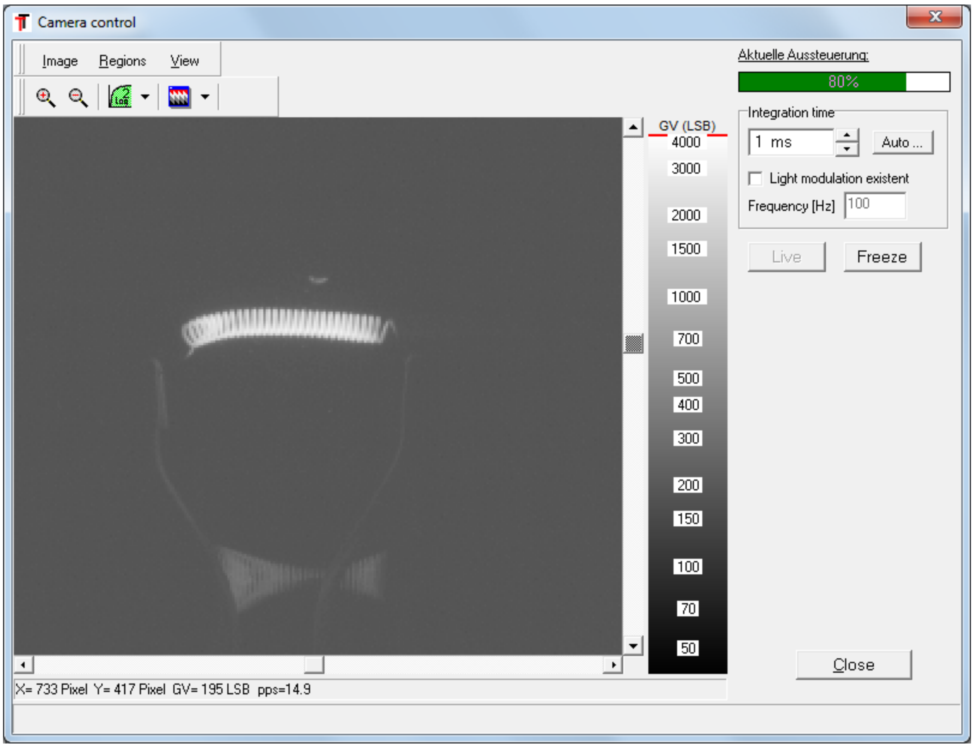
### 10.1.2 Loading a result file

Via the menu item *File > Open…* luminous intensity distributions (*.ttl) and ray files (*.ttr) can be read (see 7).

## 10.2 Single access to the hardware components

Via the menu item *Hardware* the single controllable components of the goniophotometer can be accessed. This is helpful for certain setting and adjustment work as, for example, for setting the optionally incorporated measuring instruments, for the offset-measurement of the photometer, or when the goniometer shall be moved to a well-defined position. However, accessing the hardware components individually is not necessary for carrying out general measuring operations.

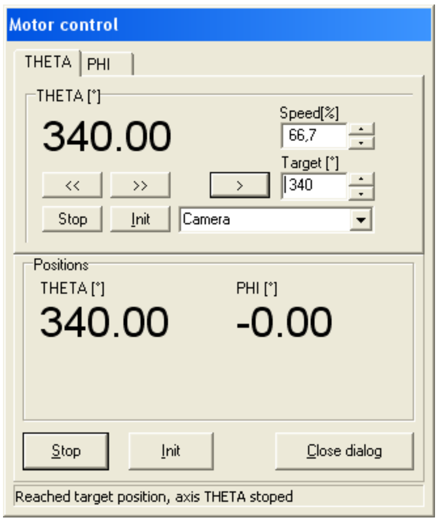
### 10.2.1 Camera



Via the menu item *Hardware > Camera…* the dialog *Camera control* is opened. This dialog contains only those basic components which are relevant for the image display. They are described in detail in the paragraphs 5 and 6.3.

By pressing the button *Close* the dialog is closed.

### 10.2.2 Goniometer (Motor control)




After choosing the menu item *Hardware > Goniometer…* the dialog *Motor control* is opened.

The upper section of the dialog contains an own tab for each of the available axes.

In the lower section, the current position of the goniometer is shown.

A motor destined for control is selected by clicking with the mouse on the corresponding tab.

By using the buttons *Init*, the current axis or also all axes are initialized and moved to the parking position(s). Normally, this is not necessary here as all axes have already been initialized at program startup.

The speed is selected in the box *Speed*. It is indicated in per cent and relates to the maximum speed fixed for this motor. A change of the speed only relates to any positioning made in this dialog and, thus, does not influence the measuring speed.

In the box *Target* the desired position can be entered. After pressing the button  or by pressing the Return key, the desired position is approached.

By pressing the *Stop* buttons, the current axis or all axes are stopped immediately.

These two buttons  and  are used to move the device freely in both directions. By pressing the button  the motor moves in the direction of some smaller positions, by pressing the button  it moves in the opposite direction. Movement stops automatically when releasing the left-hand mouse button or also when the end positions in the respective direction have been reached.

Sensor selection

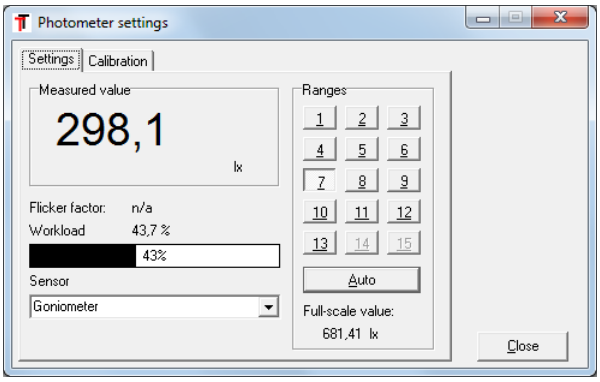
The goniometer positions displayed always relate to the sensor selected in the combo box. Depending on the mounting position of the sensor on the camera arm of the goniometer, a position offset is added to the position of the camera. Camera, photometer and spectrometer are available as sensors depending on the respective device configuration.

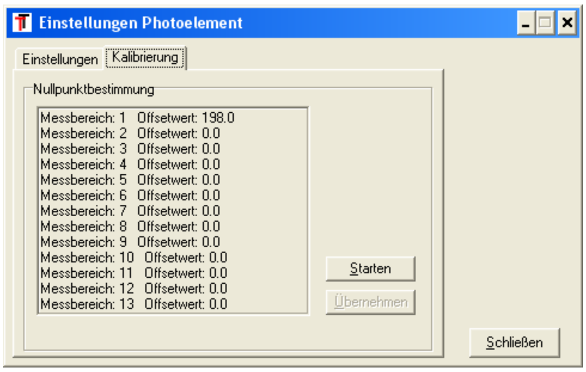
By pressing the button *Close dialog* the dialog can be closed.

### 10.2.3 Photometer

After choosing the menu item *Hardware > Photometer…* the dialog *Photometer settings* is opened. The first tab - *Settings* – shows the control dialog of the photometer as described in a similar way in paragraph 6.4. The second tab - *Calibration* - contains the function for the dark offset measurement in all measuring ranges.

The measurement of the offset values is necessary only in the case of some older photometers of the type TechnoTeam-DigiPhot3 if the room temperature changes greatly or if very tightly radiating luminaires shall be measured. For the offset measurement, the photometer must warm up for at least 0:30h. The photometer head is covered light-proof with a cap, and the offset measurement is started by pressing the button *Start*.




After confirming the concluding message, the offset values determined are then saved in the configuration file. Afterwards, all measuring ranges must show a value near or around 0.

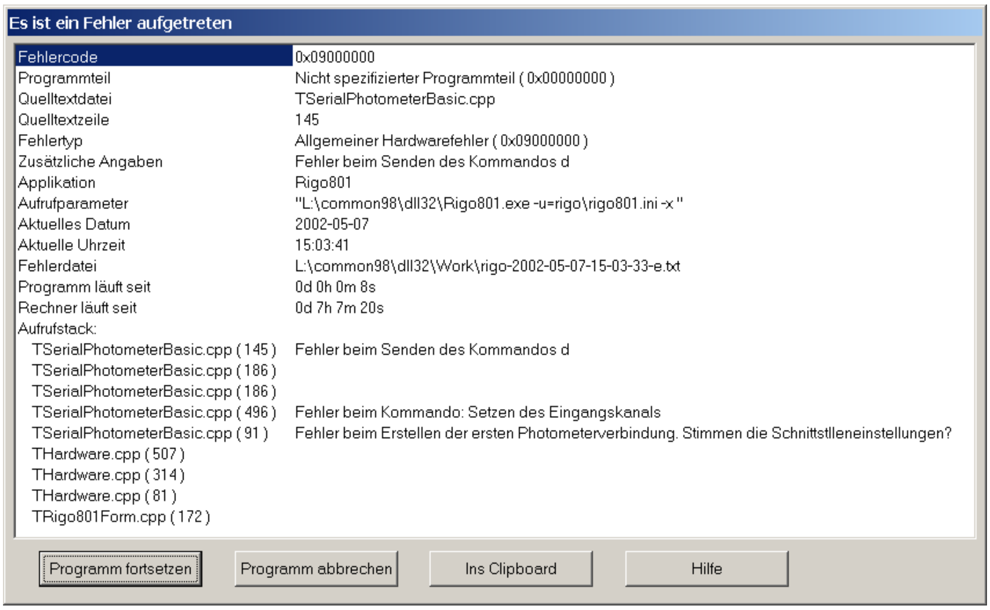
### 10.2.4 Spectrometer

The optional spectrometer is described in detail in section 8.

### 10.2.5 Measuring instruments

The external measuring instruments and everything which is connected with them are dealt with in detail in section 6.5. If – on program startup – an error message is displayed during the initialization of an external measuring instrument, the user may try via this dialog to adapt the settings of the instrument concerned. A typically occurring error results from connection problems due to modified interfaces.

## 10.3 Program errors




Although the software has been developed with great care, errors can never be completely excluded. Whenever the user detects an error occurring during work with the program, a message should be given to the developers including all available information which could be connected with this error. In the case of a program crash or malfunction or faulty measurement values, it is very helpful to know the last entries, measurement parameters and the program behavior immediately before the error has occurred.

In some cases, an error is detected within the program itself. If this error cannot be removed automatically, in general an error window is opened which contains all parameters determined by the program. Even if the actual cause of error can possibly not be displayed, the information shown can supply some valuable hints.

In the following example, the cause of error was that the photometer was not supplied with electric current. Therefore, it was not possible for the program to communicate with it during program startup.

All messages displayed are saved in a file. The file name can be found in the line *Error file* of the text displayed in the error window. In this particular case, this file contained the following information:

```
E 0x9000000 0x3bc TSerialPhotometerBasic.cpp(145) Error while transmitting
the command d
T 0x9000000 0x3bc TSerialPhotometerBasic.cpp(186)
T 0x9000000 0x3bc TSerialPhotometerBasic.cpp(186)
T 0x9000000 0x3bc TSerialPhotometerBasic.cpp(496) Error in the command:
Setting the input channel
T 0x9000000 0x3bc TSerialPhotometerBasic.cpp(91) Error in making the first
photometer connection. Are the interface settings correct?
T 0x9000000 0x3bc THardware.cpp(507)
T 0x9000000 0x3bc THardware.cpp(314)
T 0x9000000 0x3bc THardware.cpp(81)
T 0x9000000 0x3bc TRigo801Form.cpp(172)
```

This exact error description can also be copied into the clipboard by pressing the button *Ins Clipboard* .

In the case of serious errors such as failed access to hardware components, it is not recommendable to go on with the program. It can then be aborted immediately by pressing the button *Abort program*. In the case of some simple errors such as file access errors, the continuation of the program is uncritical. When in doubt or if further errors occur, the software should be restarted.

## 10.4 Program directories and calibration files

All RiGO801 program files are copied into that directory specified in the installation procedure (e.g. C:\Programs\TechnoTeam\Rigo801 of June 6, 2011). Furthermore, the following subdirectories are created:

| | |
|---|---|
| .\Work | In this directory, the error files are saved. During each program startup, a new file is generated. The program name is automatically composed of the date and the time. Error files which are older than 6 days are deleted during program startup. |
| .\Rigo-[Projektname] | This directory contains all files which are necessary for the proper operation of the program. Apart from the exceptional cases specified below, no manual modifications should be made to these files. |

# 11 File formats Rigo801

The Rigo801 software allows the generation of various result files in each measurement such as:

- The luminous intensity distribution file (file extension *.ttl, as TechnoTeam Luminous intensity distribution). This file is generated during each measurement, irrespective of whether it is made with the camera or with the photometer.
- The ray data file (file extension *.ttr, as TechnoTeam Rays). The ray data file is output only at the user's request in the case of measurements made with the camera.

In the case of measurements made with the spectrometer, the following result files are generated:

- The binary TechnoTeam-spectral ray data file (file extension *.tsd, as TechnoTeam Spectral data).
- Additionally, also the *.csv – format (csv - Comma-Separated Values) as well as the *.isd-format (isd – Instrument Systems Data) are exported.

## 11.1 Luminous intensity distribution *.ttl

This file is a text file available in the Windows INI format, i.e., the file is subdivided into sections each of which can contain several entries. The sections can come in any order, for example:

```
[Measurement]
Type=Camera
Rays=Yes

[Files]
Lid=C:\tmp\test.ttl
Rays=C:\tmp\test.ttr
```

The general parameters provided in the form of lists for display or processing are fixed via a description file (template.ini). The first tab *Information on measurement* of the display of the measurement results (see 6.6) is the user interface to these parameters. If an extension of the entries is desired, please get into contact with us.

The TTL – format contains a lot of additional information which is not provided in other formats for luminous intensity distributions. Therefore, the TechnoTeam LID – export filter (see 6.1.3) and the evaluation program LUMCat of the Czibula & Grundmann engineering GbR company extract only part of the information contained. The file format has an open layout. If a user wants to create or also adapt their own evaluation software, the following format description will serve as a basis.

In the following, only the most important sections are mentioned. In the second column, it is specified whether the information given by the user can be edited in the dialog (D), or whether it is generated automatically by the program (A), and whether it is used in LUMCat (L).

| Section | | Content and meaning |
|---|---|---|
| **[General]** | DAL | Contains the entry **Log number**. The measurements are consecutively numbered automatically. |
| | | Contains the entry **Date**. Number of days since 30 December 1899 as floating-point number. |

| | | |
|---|---|---|
| | | Contains the entry **Time**. Given as floating-point number (as a fraction of 24 h).<br><br>The entry **Editor** contains the name of the person making the measurement in the form of an ASCII-string.<br><br>In the entry **Commentary** also multi-line commentaries can be made. The desired line breaks must be replaced by „\n“. |
| **[Luminaire]** | DL | The entries **Type** and **Number** contain the strings which can be entered by the user. |
| **[Lamp]** | DL | The entry **Number** contains the number of the lamps used.<br><br>For each lamp, **Type** and **Number** of the lamp can be entered. Both entries are treated as ASCII-strings.<br><br>Further entries for each lamp relate to **Power** and (current) **luminous flux**. These entries are regarded as floating-point numbers. |
| **[Parameters]** | DL | Parameters that can be indicated are **Laboratory temperature**, **voltage**, **current**, **power**. |
| **[LID]** | AL | This section contains the **luminous flux** measured by the photometer as well as the number **Mc** of the C-planes, their angle distance **Dc**, the number **Ng** of the luminous intensities for each C-plane and their angle distance **Dg**. |
| **[LID/C]** | AL | Contains a list of the angles of the C-planes. |
| **[LID/G]** | AL | Contains a list of the angles of the luminous intensities for each C-plane. |
| **[LID/Data]** | AL | The calculation of absolute and standardized luminous intensity values from the values indicated here is explained in the following paragraph. |
| **[Measurement]** | A | General information on the measuring method chosen. |
| **[Files]** | A | Contains the original file names of the result files. |
| **[Track of movement]** | A | Contains information on the positions approached by the goniometer during the measurement. |
| **[Lens]** | A | Information on the measuring lens used. |
| **[Camera]** | A | Information on the integration time and the neutral density filters used. |
| **[Photometer]** | | Measuring range of the photometer. |
| **[Rays]** | A | Number of the camera images used and of the rays generated. |
| **[PoleMonitoring]** | A | Logging of the illuminances on the pole (see 6.8 and 7.8).<br><br>For each pole illuminance, the Phi – angles and the time stamps are saved. The values are indicated in each case in the variables **PoleVal** (lx), **Phi** (°) and **Time** (DateTime – format, number of days since 30 December 1899 in the form of floating-point numbers as vectors with the length **Count** (number of scans).<br><br>`[PoleMonitoring]`<br>`Count=360`<br>`Time=41324.718620 41324.719016 …`<br>`Phi= 0   0,5  …`<br>`PoleVal=303.88   304.07   303.95 …` |
| **[BurnIn]** | A | Data logged during the burn-in phase of the object to be measured (see 6.9 and 7.7).<br><br>The first two variables **AxisThetaPos** and **AxisPhiPos** indicate the angu- |

lar position of the goniometer during the burn-in phase in [°]. The following 4 variables - MinBurnInTimeS, MaxBurnInTimeS, CritIntervalS and CritValuePcnt – correspond to the information contained in the dialog field *Parameter*. The other variables contain data relating to the progress of the burn-in procedure.

The variable **ResultData** contains the illuminances [lx], the standard deviations and the error value [%] (variation in the time interval). As the separator ,|‘ is used. The timeline can be calculated from the information **BurnInStartTime** and **BurnInTimeIntervalMs** [msec].

If the logging of the measurement data recorded by external measuring instruments is activated (see 6.5 and 7.6), these data are also logged during the burn-in procedure. Then, the data are stored in the section [BurnInOcxData] (refer to the description concerning section [OCX-MeasureDevicesData]).

```
[BurnIn]
AxisThetaPos=1.800140e+02
AxisPhiPos=1.000000e-02
MinBurnInTimeS=3600
MaxBurnInTimeS=3600
CritIntervalS=120
CritValuePcnt=2.000000e-01
PartOfMeas=1
GraphicFileName=
BurnInTimeS=3.600000e+03      # real burn in time [sec]
# time distance of m.values
BurnInTimeIntervalMs=6.000000e+03
CritFulFilled=0   # burn-in criterion fulfilled y/n
IlluOverflow=0    # photometer value overload y/n
MeasContinued=1   # measurement after burn in y/n
# start time, format see polemonitoring
BurnInStartTime=4.126147e+04
ResultData=5.481e+02 3.964e-02 0.000|5.480e+02 3.335e-
02 0.000|…
```

**[OCX-MeasureDevicesData]** A

This section contains the measurement data of external measuring instruments logged during the measurement (see 6.5 and 7.6).

The number of measuring instruments is indicated in the section **[OCX-MeasureDevicesData]** with the variable **Number** .

For each measuring instrument, there is an own section available **[OCX-MeasureDevicesData/DeviceN]** (Index N). The variable **NumberResults** indicates the number of the measuring channels included (measured quantities), and **NumberData** indicates the number of the measured data (length of the data vectors). The names of the measuring channels are saved in the variables **ResultNameN**.

The measured data vectors for each channel are stored in the variables **DN** (Index N, separator ,|‘). At the beginning, the Phi - position [°] and the time stamp [DateTime – format] are shown followed by the measurement values of the respective channel.

```
[OCXMeasureDevicesData/Device0]
Name=Power Analyzer WT210
NumberResults=5
ResultName0=Voltage (V)
ResultName1=Current (A)
ResultName2=Power (W)
ResultName3=Power factor (PF)
```

```
ResultName4=Input voltage frequency (V Hz)
NumberData=601
D0=150.00|41316.742218|2.955000e+01|5.790000e+00|1.711
000e+02| 1.000000e+00|0.000000e+00
```

A In the case of a measurement made with the camera, the illuminance distribution measured by the photometer is saved in the same format as the luminous intensity matrix in the section **[Lvk/Photodata]**. Depending on the far-field constellation of the photometer, this distribution differs from the luminous intensity distribution more or less strongly. However, it can be used as a comparison to the luminous intensity distribution if, for example, some undefined structures turn up (e.g. unstable light source).

### 11.1.1 Calculation of absolute and standardized luminous intensities from the TTL – file

If the direct evaluation of the TTL – measurement file is of interest, absolute luminous intensity values can be calculated from the values contained in the TTL – file by applying the following equation:

$$I_{absolut} = I_{TTL} \cdot \frac{\Phi_{gemessen}}{1000\,lm}.$$

For the standardization to 1000 lm test lamp luminous flux (cd/klm), the total luminous flux of the test lamps from the section `[Lamp]` must also be taken into account:

$$\Phi_{lampen} = \sum_i \Phi_{i\ \ lampe},$$

$$I_{cd/klm} = I_{absolut} \cdot \frac{1000\,lm}{\Phi_{lampen}} = I_{TTL} \cdot \frac{\Phi_{gemessen}}{\Phi_{lampen}}.$$

## 11.2 Ray file *.ttr

During the measurement of the luminous intensity distribution with the measuring camera, images are continually captured. Then, rays are calculated from these captures. Already during image capture, a luminous intensity distribution is automatically calculated from these rays, and written into a luminous intensity distribution file (file extension *.ttl) after the completion of the measurements.

Furthermore, the rays generated can also be saved in a ray file (file extension *.ttr). A description of the file format is contained in the Manual on the software „C*onverter801*“.

# 12 Literature


[CIE84] CIE 84, Technical Report, The Measurement Of Luminous Flux

[DE297] Anordnung zur Messung der Lichtstärkeverteilung von Leuchten und Lampen. Gebrauchsmuster DE 297 06 488.6, 11.04.1997

[EN13032-4] EN 13032-4:2015, Light and lighting. Measurement and presentation of photometric data of lamps and luminaires. LED lamps, modules and luminaires

[LM79] LM-79-08, Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products

[Riem91] Riemann, M.; Poschmann, R.; Schmidt, F.: Verfahren und Anordnung zur Messung der Lichtstärkeverteilung von Leuchten und Lampen. Patent DE 41 10 574, 30.03.1991