

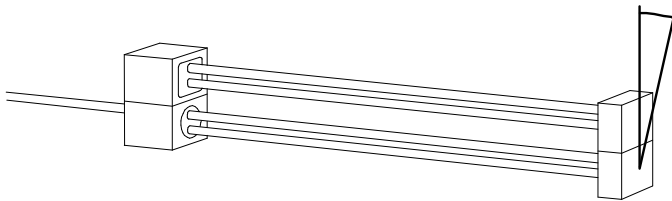
H "ZLM Angle / Straightness" Calibration Software

VDI, the German engineers' association, issued the "VDI/VDE 2617" standard for the determination of angular and straightness deviations in coordinate measuring machines. The two measurement programs "ZLM Angle" and "ZLM Straightness" allows coordinate measuring machines to be automatically inspected in accordance with this standard. "ISO 1101" is a standard applying to straightness measurements on workpieces. The "ZLM Straightness" program handles straightness measurements according to this standard as well; and it also can be used for measuring squareness and parallelism deviations.

As the two measuring programs "ZLM Angle" and "ZLM Straightness" are sold as a package and as their operation is largely the same, they are described in this section together. Normally, users of "ZLM Angle" and "ZLM Straightness" also use the "ZLM Position" program described in section G, which has much in common with the two programs described here. Therefore, you will find references to section G throughout this section.

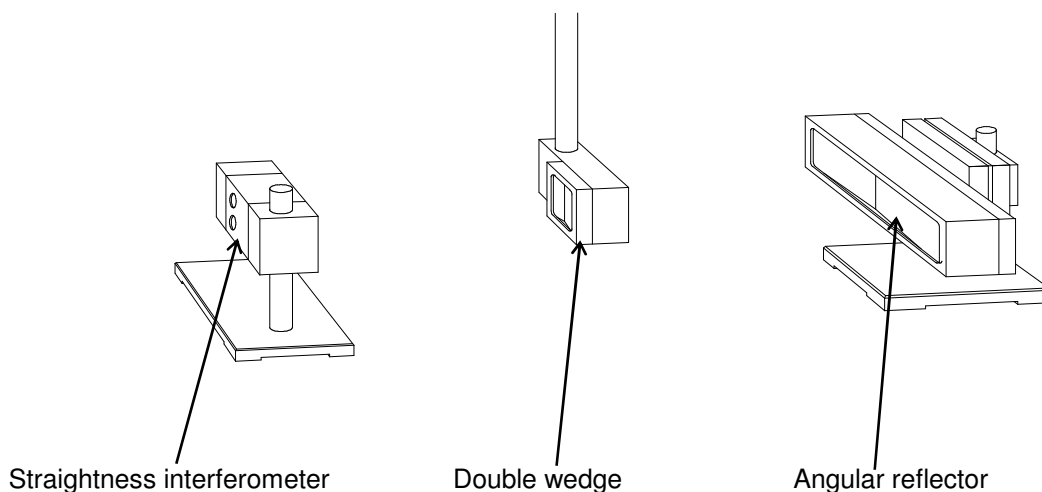
H 1 Measurement procedure

In angle measurement, the two partial laser beams, separated by a polarizing beam splitter, are directed at a double reflector. One of the partial beams has to be deflected. The path difference between the two partial beams is used for computing the angle.



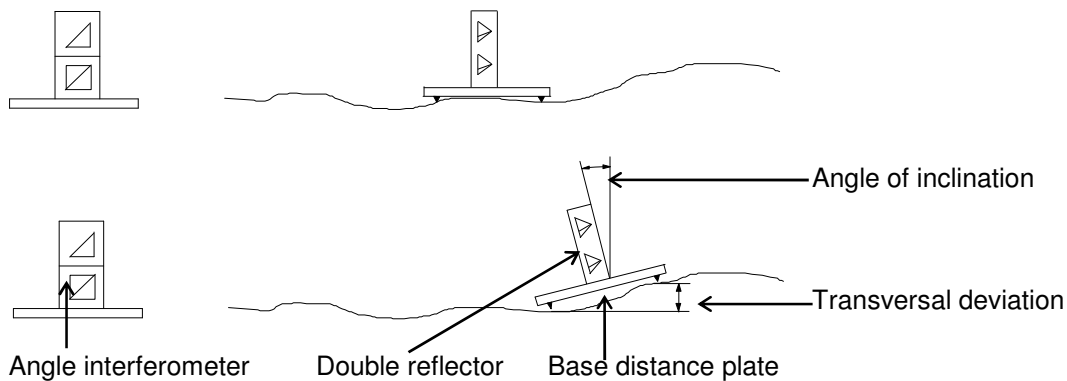
In straightness measurement, two methods can be distinguished:

The 1st method uses special optical components.



A displacement of the double wedge (in the illustration: horizontal displacement) changes the optical path lengths of the two beam portions separated by the straightness interferometer.

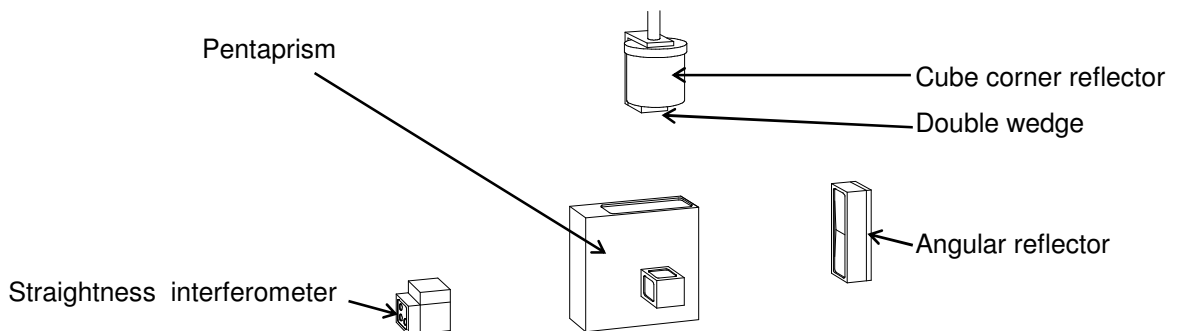
The 2nd method is a straightness measurement of workpieces by means of angle optics and a base distance plate. A double reflector mounted on the base distance plate is displaced repeatedly by the distance of the two support points of the plate. From the angles measured, the program determines the transversal deviation.



The procedure of measuring rotatory and straightness deviations is similar to the ascertainment of position uncertainty: Several measuring positions along a line corresponding to the laser beam path are travelled to from both directions. The program expects a positioning sequence by the linear method (see section G 1.2 "Positioning methods"). The program also supports the unidirectional linear method, although this is not provided for in the "VDI/VDE 2617" standard.

According to "VDI/VDE 2617", rotatory and straightness deviations must be ascertained in both coordinate directions on a measuring line located approximately at the centre of the measuring volume. At least 11 positions must be measured per measuring line. The positions must be distributed all over the measuring range and be spaced at different intervals.

For squareness measurement, first make a straightness measurement relative to one measuring axis. The use a pentaprism to deflect the beam by very precisely 90°, and make a straightness measurement relative to the second measuring axis (normal to the first one).

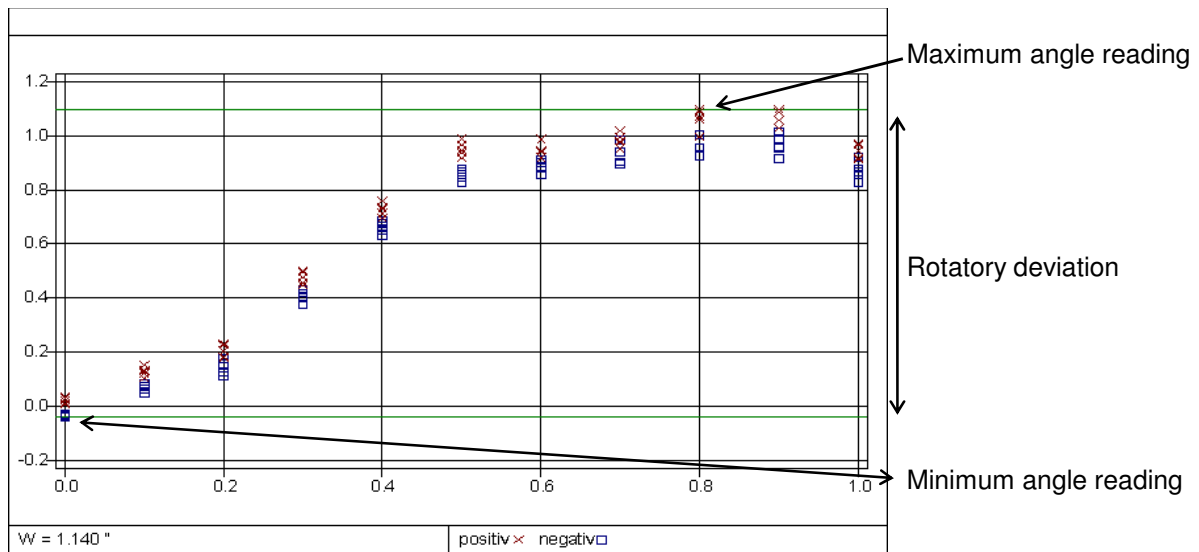


A parallelism measurement can be carried out with two pentaprisms. Here, too, first make a straightness measurement relative to one measuring axis. The effect a beam offset with two pentaprisms, and make a straightness measurement relative to the second measuring axis.

A parallelism measurement with a normal straightness measuring arrangement is feasible in such a way as to displace the double wedge first and the angular reflector afterwards. Please mind, however, that a tilt introduced during displacement of the angular reflector will give rise to a considerable measuring error. Therefore, first check the axis on which the angular reflector is mounted for any rotatory deviations.

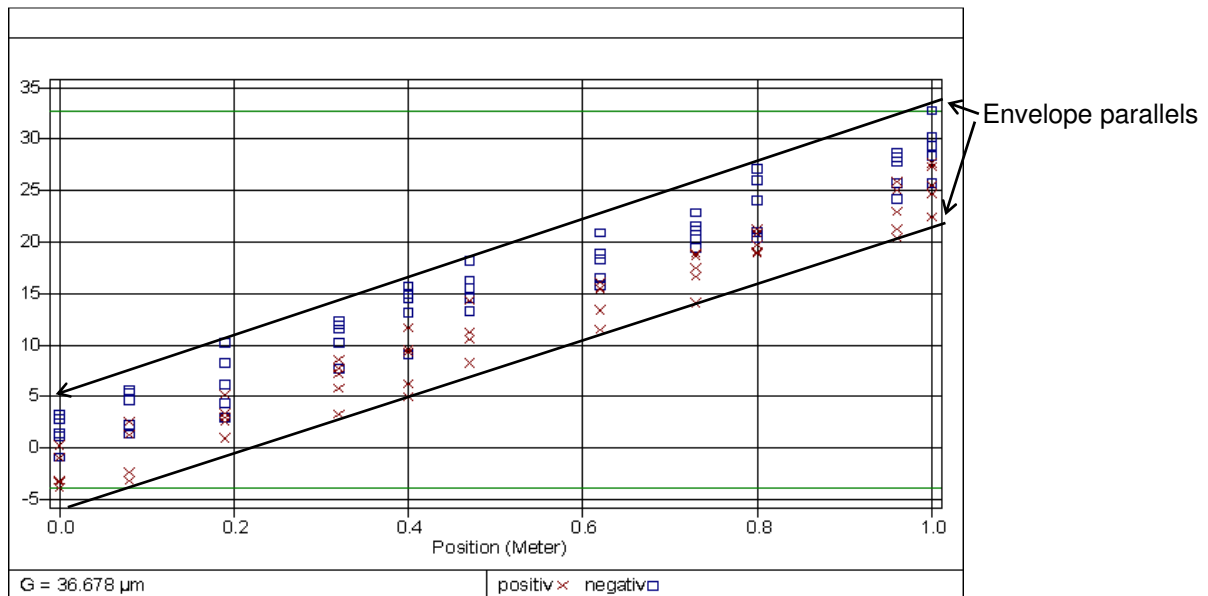
H 2 Parameters

In an angle measurement, a number of angle readings are taken at each measuring position. The "Rotatory deviation A" is the difference between the greatest and smallest of all angle readings taken, irrespective of the position and travel direction.

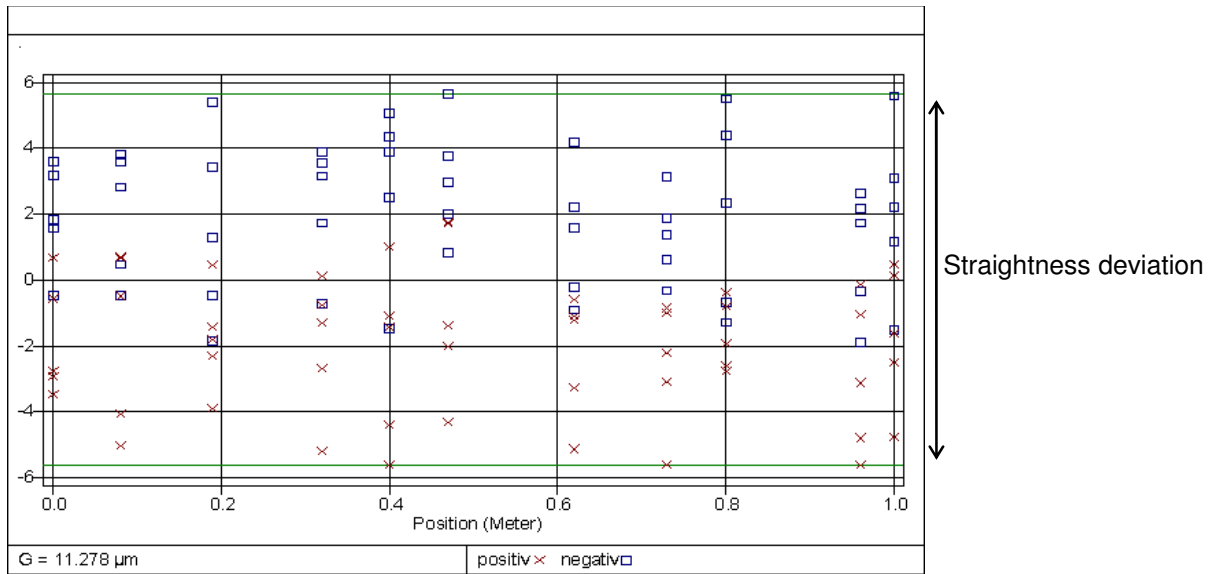


In a straightness measurement, the laser beam usually is not exactly aligned with the axis being measured. This would cause major errors if the difference between maximum and minimum readings were defined as a parameter.

Therefore, a "Straightness deviation S" has been defined as the distance between two parallels that include between them all measuring points while having the minimum possible distance from one another. The program calls these straight lines "envelope parallels".



When fitting the envelope parallels, the program transforms all readings in such a way that after transformation the two lines are approximately parallel with the ordinate axis.



The program also offers a least-squares fitting procedure, in which a straight line is determined for which the sum of the squares of distances from the line is minimum. This procedure, too, is followed by a transformation aimed at placing the straight line in parallel with the ordinate axis. But in this case, the difference between maximum and minimum is always either greater than or equal to the difference between maximum and minimum in envelope parallel fitting.

H 3 Operation of the "ZLM Angle" and "ZLM Straightness" program modules

Start these program modules just as you would start the "ZLM Position" module (see sections G 2.1 and C 3).

H 3.1 Window elements

The window elements of the "ZLM Angle" and "ZLM Straightness" modules hardly differ from those of "ZLM Position".

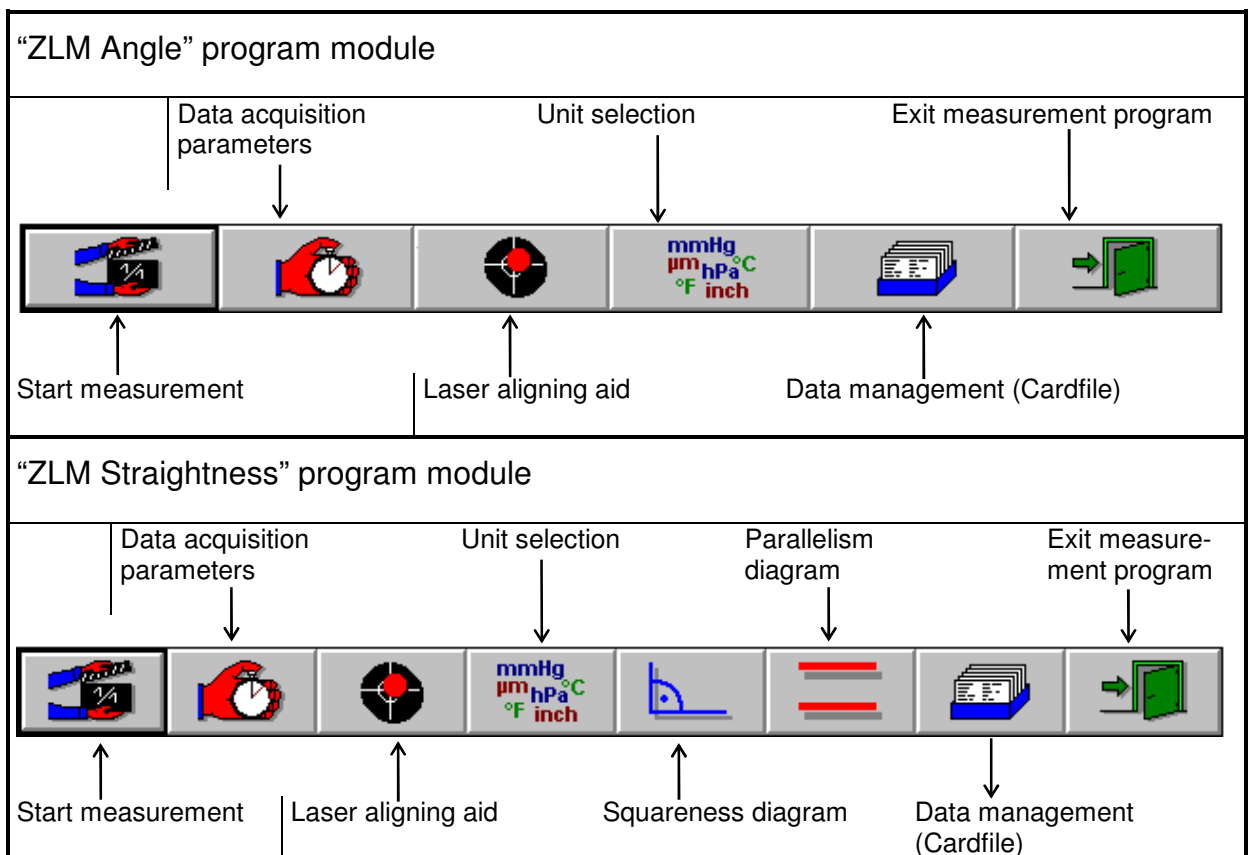
Row of buttons

Display of the current reading

Large button showing a diagram generated from the measured data currently in the memory

Display of the number of readings currently in the memory and the positioning method

Indication of laser stability and light intensity



The controls for data display and unit selection are operated same as in "ZLM Position".

H 3.2 Preparation for measurement

In measurements of rotatory and straightness deviations, the program does not correct the measured data for the influences of atmospheric properties and material temperature, because these influences are that low that a compensation would not improve the measurement results.

Access the "Parameters" dialog box by opening the **"Measure"** menu and choosing the **"Configuration"** option or by clicking the  button.

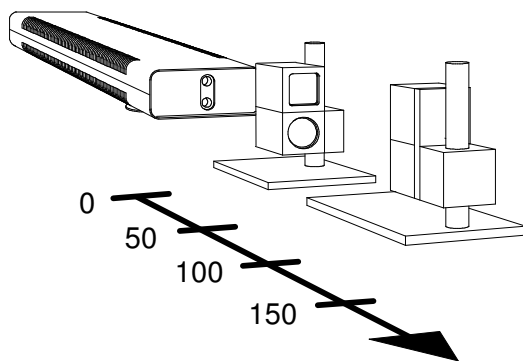
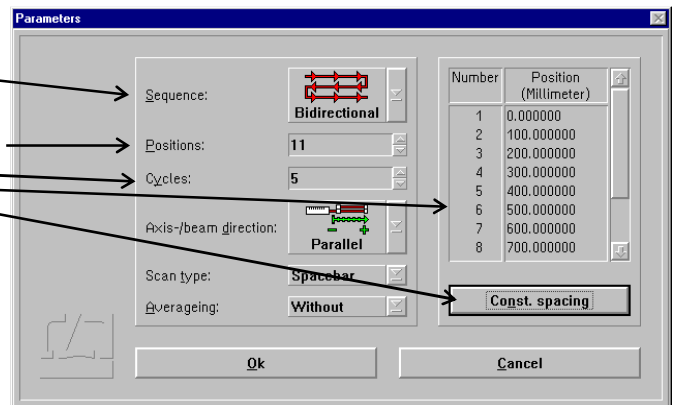
H 3.2.1 Preparation for an angle measurement

In angle measurement, the program only supports the linear and unidirectional linear methods.

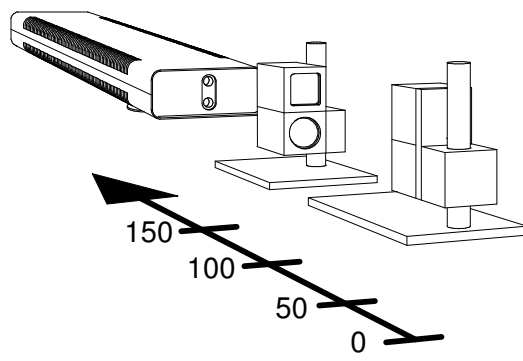
Select the positions same as in "ZLM Position".

The ZLM 500 laser interferometers use a high-frequency heterodyne method.

For an accurate angle measurement (better than 7 seconds of arc per metre), therefore, the program needs to know the position of the measuring axis relative to the laser beam in order to introduce an equivalent correction.



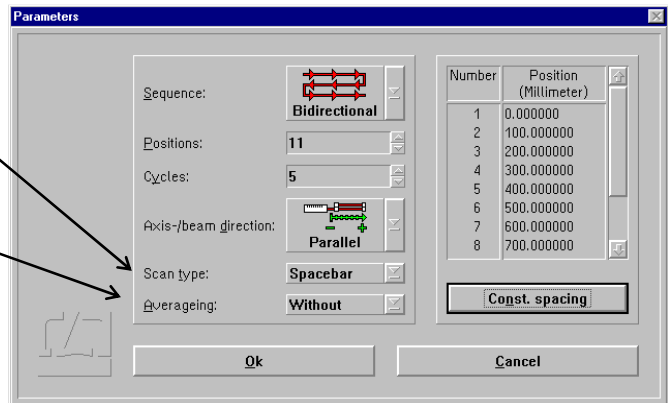
Axis and beam directions parallel



Axis and beam directions antiparallel

Taking a reading (data acquisition) can be triggered by the **Space bar** of the computer keyboard or by an external signal. Select this in the **"Scan type"** list box.

It is recommended to use time averaging in order to filter out vibrations. In the **"Short term averaging"** list box, select the averaging period somewhat shorter than the expected standstill time of the object under test.

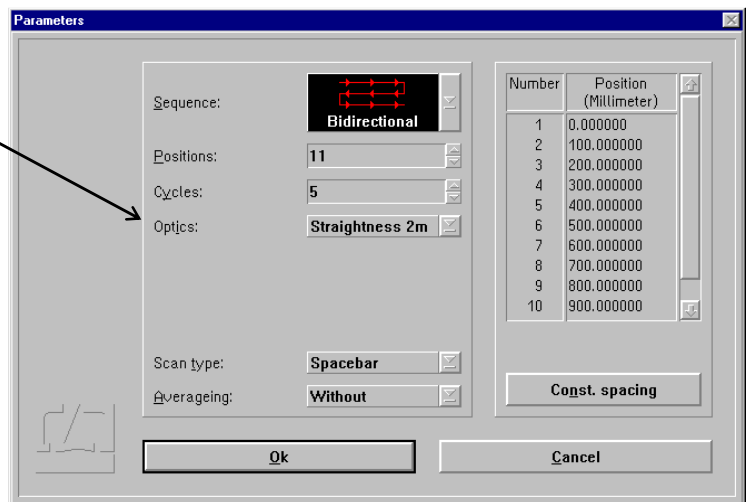


As the program has no position information, it cannot effect automatic reading, nor can it recognize errors in the positioning sequence.

H 3.2.2 Preparation for a straightness measurement

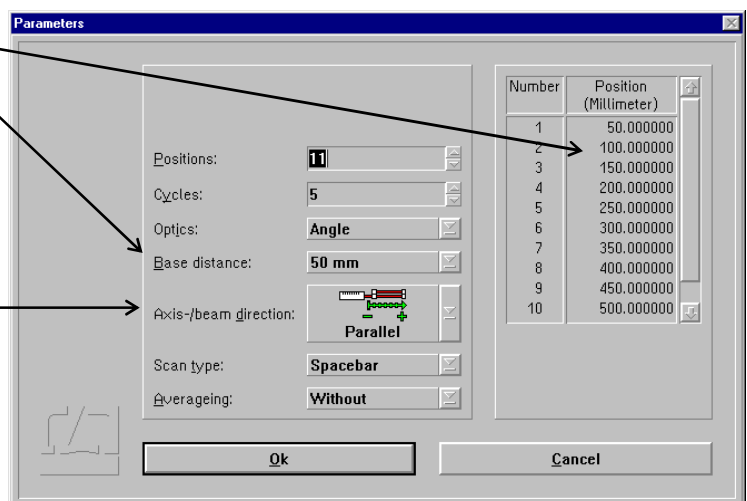
First specify whether you want to measure straightness with the straightness optics or the angle optics and base distance plate.

If you use straightness optics, enter positioning method and measuring positions same as in a position or angle measurement.



If you use angle optics, the measuring positions are determined by the selection of the base distance plates.

Same as in a "normal" angle measurement, specify the position of the measuring axis relative to the laser beam.



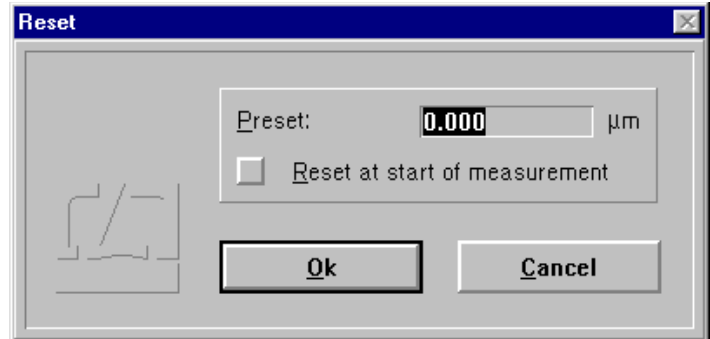
The facilities for setting the type of data acquisition triggering and time averaging are identical to those in angle measurement.

H 3.3 Measurement

In a measurement, the operation of "ZLM Straightness" and "ZLM Angle" is similar to the operation of "ZLM Position" (see section G 2.5). The paragraphs below only describe the differences from "ZLM Position".

For angle and straightness measurements, dead distance compensation is neither possible nor needed.

Therefore, the "Reset" dialog box has no dead distance input boxes.



If in an angle measurement you expect angular deviations greater than 1° , take care to ensure at the time of resetting that the reflectors are positioned normal to the measuring axis, since otherwise the program has to determine the angle by trigonometric functions.

During the measurement, only two additional displays are presented on the screen: target position, and maximum deviation among the readings taken so far. The current deviation can be seen from the large-size numerical display.

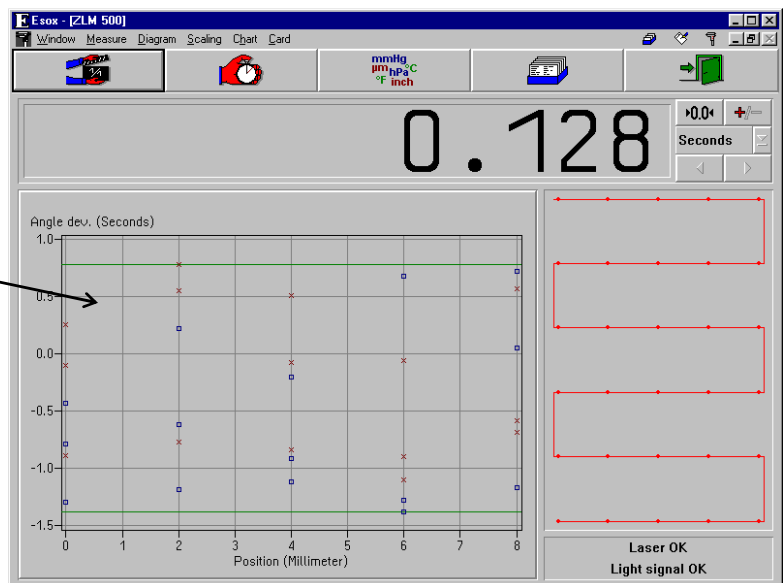
The programs cannot check whether the positions are travelled to in the correct sequence. An interruption of a measurement may be due to either of the following events:

1. The laser is unstable or becomes unstable during the measurement.
2. The light intensity received by the detector is too low or becomes too low during the measurement

In angle and straightness measurements, too, the measurement can be continued after an error, provided that the reading is re-referenced to the readings taken before (see section G 2.5.4).

H 3.4 Analysis of a measurement

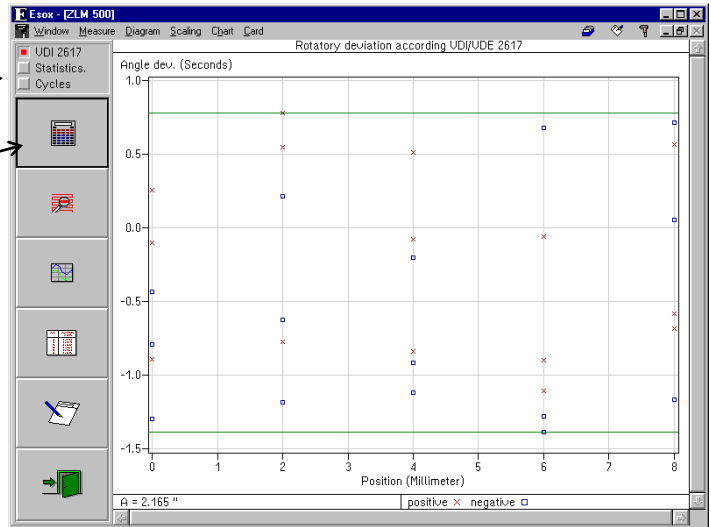
Same as in "ZLM Position", diagram presentation can be started by clicking the large button in the bottom left corner, or by selecting the "Diagram" option in the "Diagram" menu in angle measurement, or the "Straightness" menu in the "Diagram" menu in straightness measurement.



The top left portion of the window differs between "ZLM Angle" and "ZLM Straightness".

In "ZLM Angle" you can select between diagram presentation conforming to VDI/VDE 2617, statistical analysis, and presentation of individual readings.

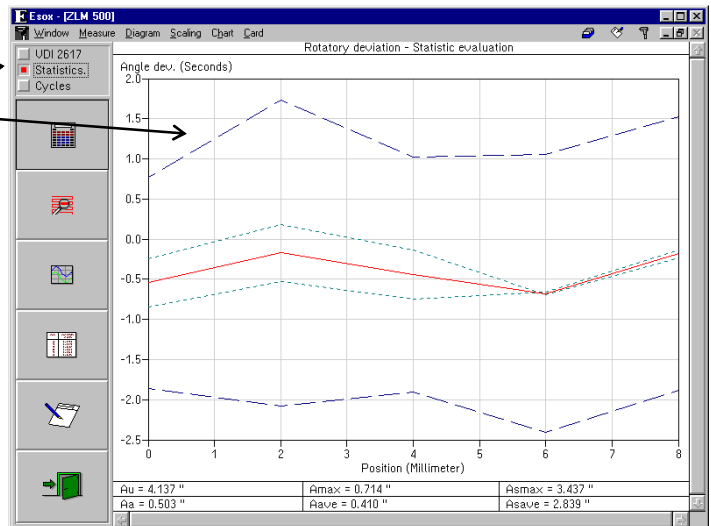
In case of the VDI/VDE 2617 diagram, the button below the selection field can be clicked to display the value of the "Rotatory deviation A".



With static analysis selected, a diagram is shown that is analogous to the analysis of a position measurement according to VDI/VDE 2617.

Please mind that this presentation is not included in VDI/VDE 2617 itself.

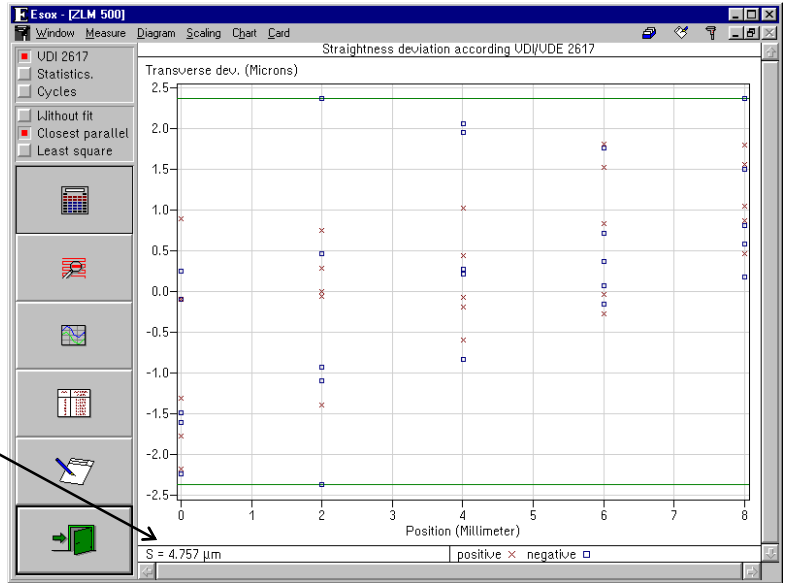
The quantities at the bottom margin of the screen are determined analogously to the parameters of VDI/VDE 2617.



| Quantities in angle measurement | | Analogous quantity in position measurement | |
|---------------------------------|----------------------|--------------------------------------------|-------------------------|
| Au | Angle uncertainty | P | Position uncertainty |
| Aa | Angle deviation | Pa | Position deviation |
| Bmax | Maximum backlash | Bmax | Maximum backlash |
| Bave | Average backlash | Bave | Average backlash |
| Asmax | Maximum angle spread | Psmax | Maximum position spread |
| Asave | Average angle spread | Psave | Average position spread |

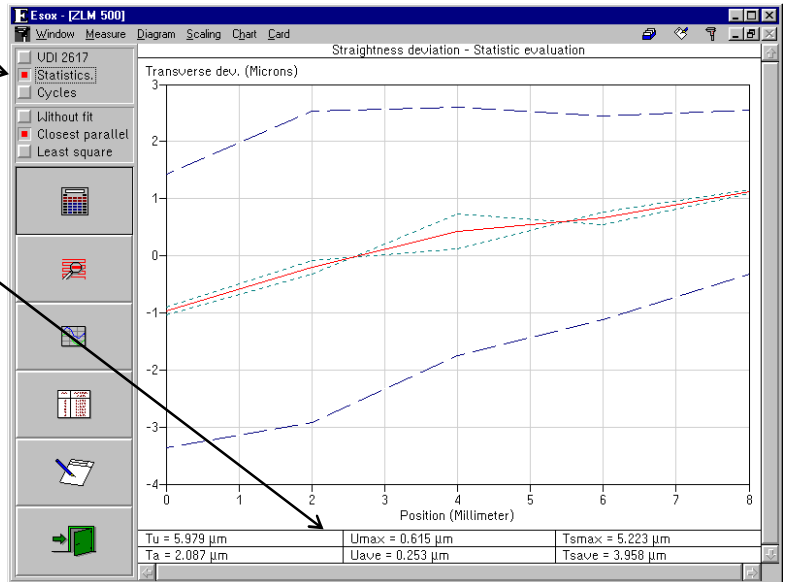
In "ZLM Straightness" you have an additional option besides VDI/VDE 2617, Statistics and Cycles: you can select between fitting methods (see section H 2 "Parameters"). For the standard analysis, you should use the "Envelope parallels" option.

With VDI 2617 selected in the top field, the "**Straightness deviation S**" is displayed on the bottom margin. The value is computed from the difference between the maximum and minimum readings of the diagram points displayed.



In a statistical analysis of a straightness measurement, too, the diagram and parameter computation are analogous to position measurement according to VDI/VDE 2617.

Here, too, this presentation is not contained in VDI/VDE 2617 itself.

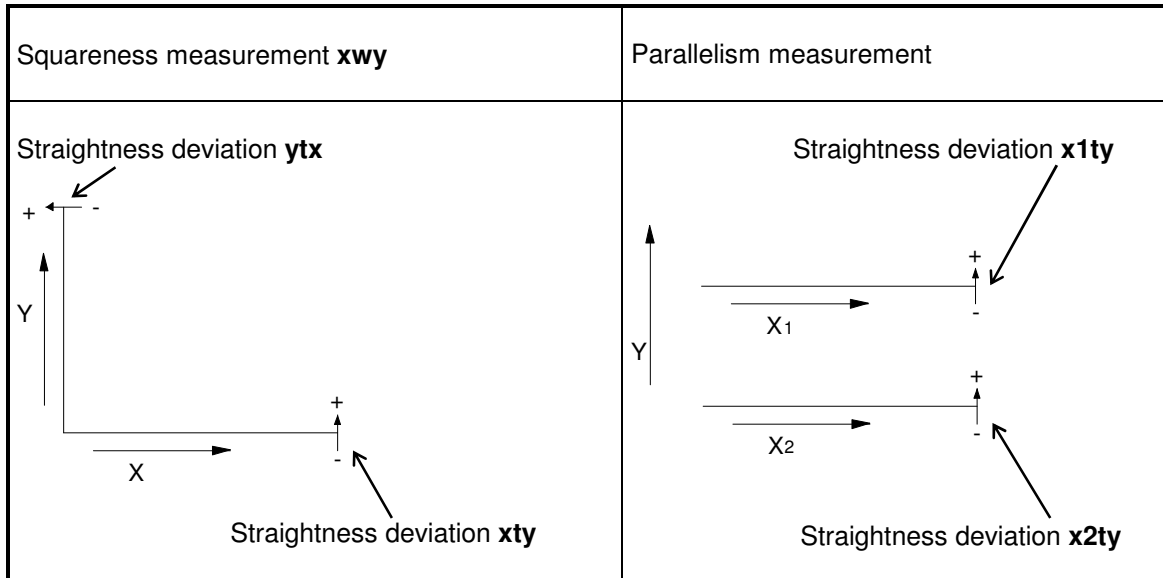


| Quantities in straightness measurement | | Analogous quantity in position measurement | |
|----------------------------------------|-------------------------------------|--------------------------------------------|-------------------------|
| Tu | Transversal position uncertainty | P | Position uncertainty |
| Ta | Transversal position deviation | Pa | Position deviation |
| Bmax | Maximum backlash | Bmax | Maximum backlash |
| Bave | Average backlash | Bave | Average backlash |
| Tsmax | Maximum transversal position spread | Psmax | Maximum position spread |
| Tsave | Average transversal position spread | Psave | Average position spread |

H 3.5 Determination of parallelism and squareness deviations

To determine deviations of parallelism or squareness, make two straightness measurements along two measuring axes. The program will then combine the data records of the two measuring axes and find the squareness or parallelism deviation.

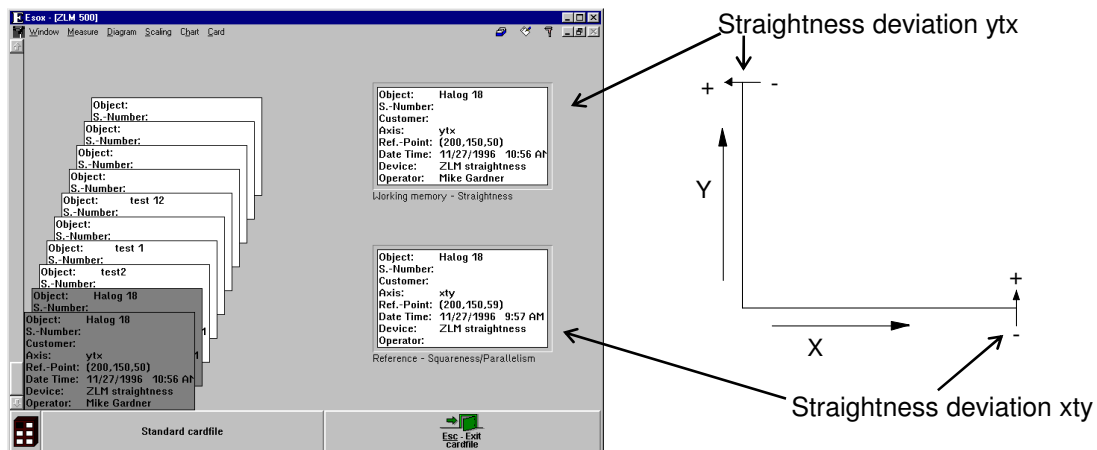
In the straightness measurements, mind the signs of the transversal deviations. The illustrations below show how to select the signs.



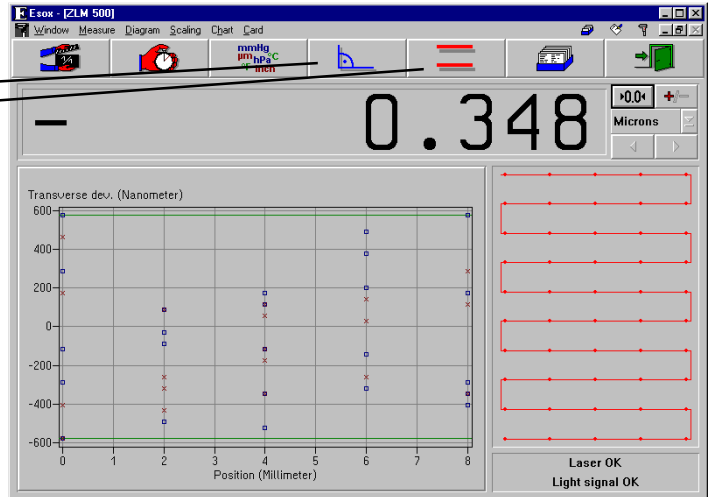
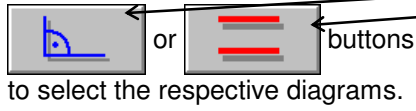
Before a measurement, shift the double wedge to check whether the correct sign has been set; correct it, if necessary, by the numerical display.

After the measurement, load the two card files for straightness measurement into the computer's main memory.

Only in squareness measurement it is important to position either card in its proper place.

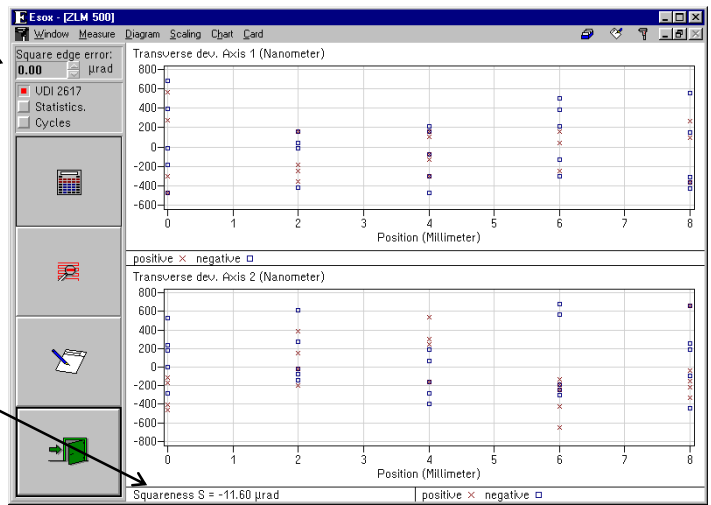


Use the "Squareness" or "Parallelism" items in the "Diagram" menu or the



In squareness measurement you can enter the deviation of the pentaprism from 90°. →

At the bottom margin, the amount of the squareness deviation is displayed.



In parallelism analysis, the parallelism deviation is indicated below the upper diagram.

