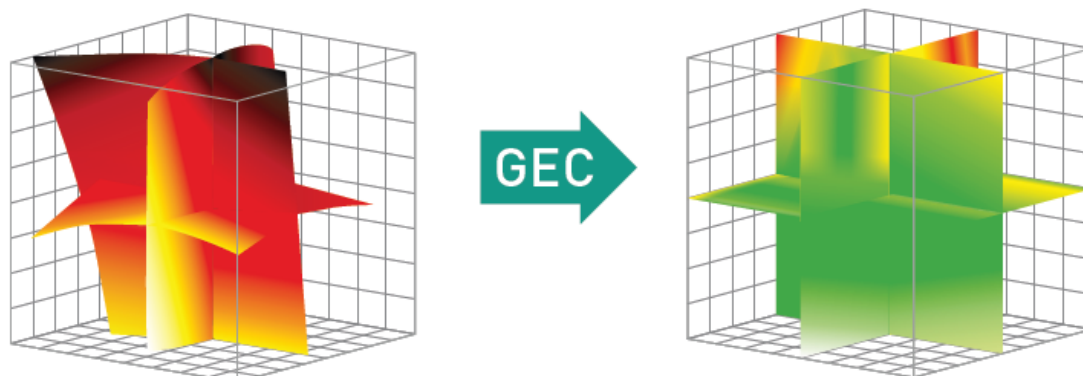


GEC

Geometric Error Compensation

Geometric Error Compensation



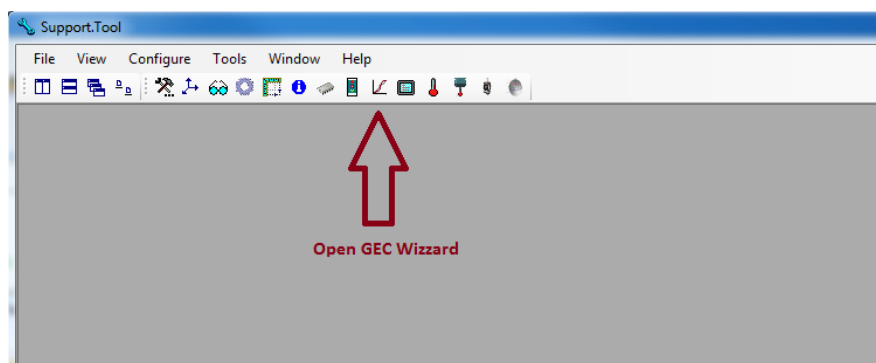
GEC involves the compensation of inherent geometric and thermal errors of CMMs. With the newest release of Pantec's GEC, dynamic temperature monitoring and compensation as well as linearity and squareness correction is already performed *inside* the Pantec controller. For those customers who require higher accuracy, the full 21-parameter error model (including roll, pitch and yaw errors) is available through our driver-based solution. Both GEC options cover the most common kinematic chains for CMMs, including machine configurations with the following axes sequences: Y-X-Z, X-Y-Z, X-Z-Y.

For convenience and ease of use, the entire compensation procedure is done through the Pantec Support Tool tuning and analysis software. The GEC Wizard incorporates the calibration laser and the machine type to add optimum flexibility in error capture, correction, and validation of results. An efficient design with minimal clicks offers a high level of operational convenience.

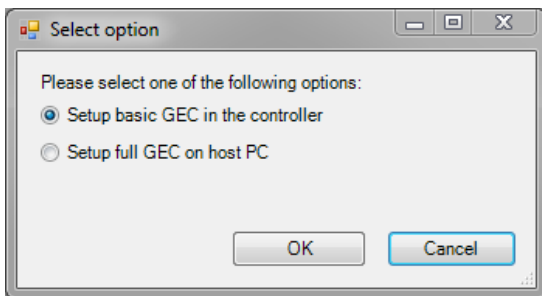
The Pantec Support Tool (v4.0.2) is used for the following steps:

- Set-up the GEC configuration
- Automatic or manual capturing of Laser and machine position
- Direct set-up of error
- Review and management of correction parameters in the GEC editor

1. Open Support.Tool v4.0.2 and launch the GEC Wizard

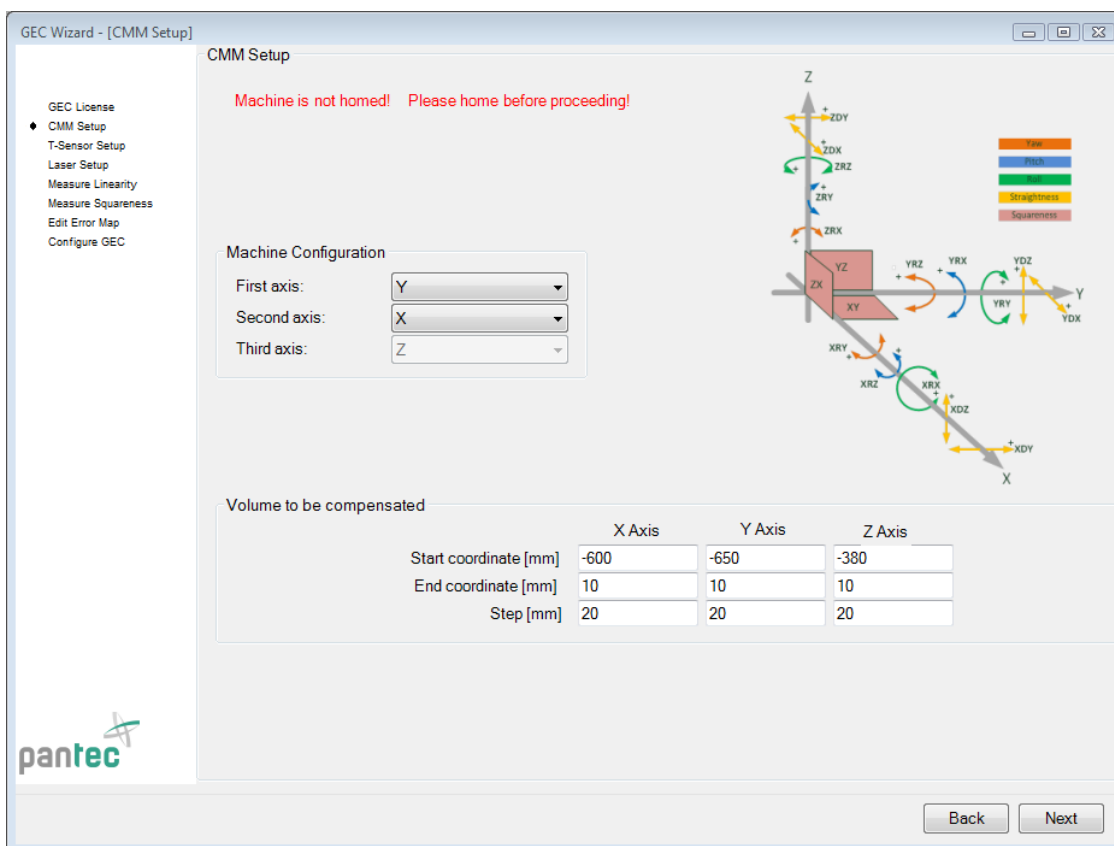


2. Choose the location of the compensation:



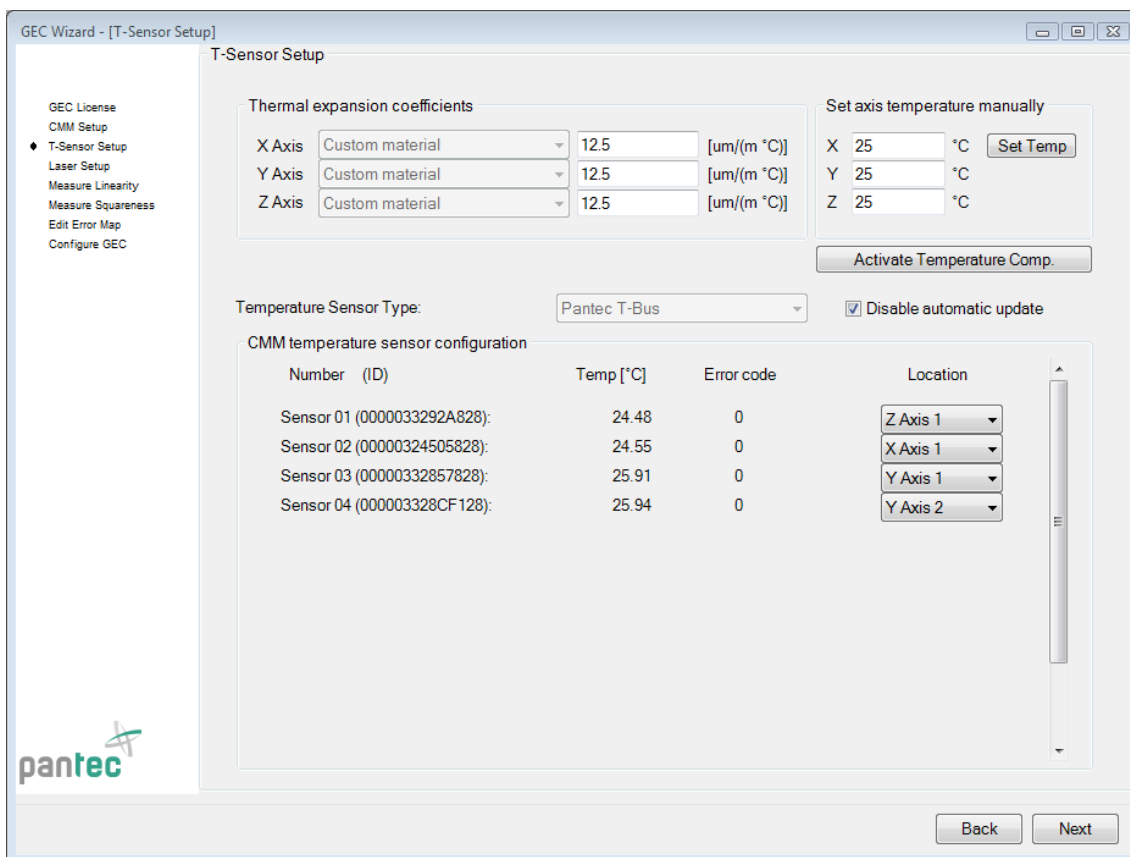
Select whether you want to configure a limited error compensation model (i.e. linearity, squareness errors as well as linear thermal expansion) in the EAGLE/CONDOR controller, or a full 21-error parameter model compensation computed by EAGLE.Driver on the host-PC.

3. Configure the setup for the CMM



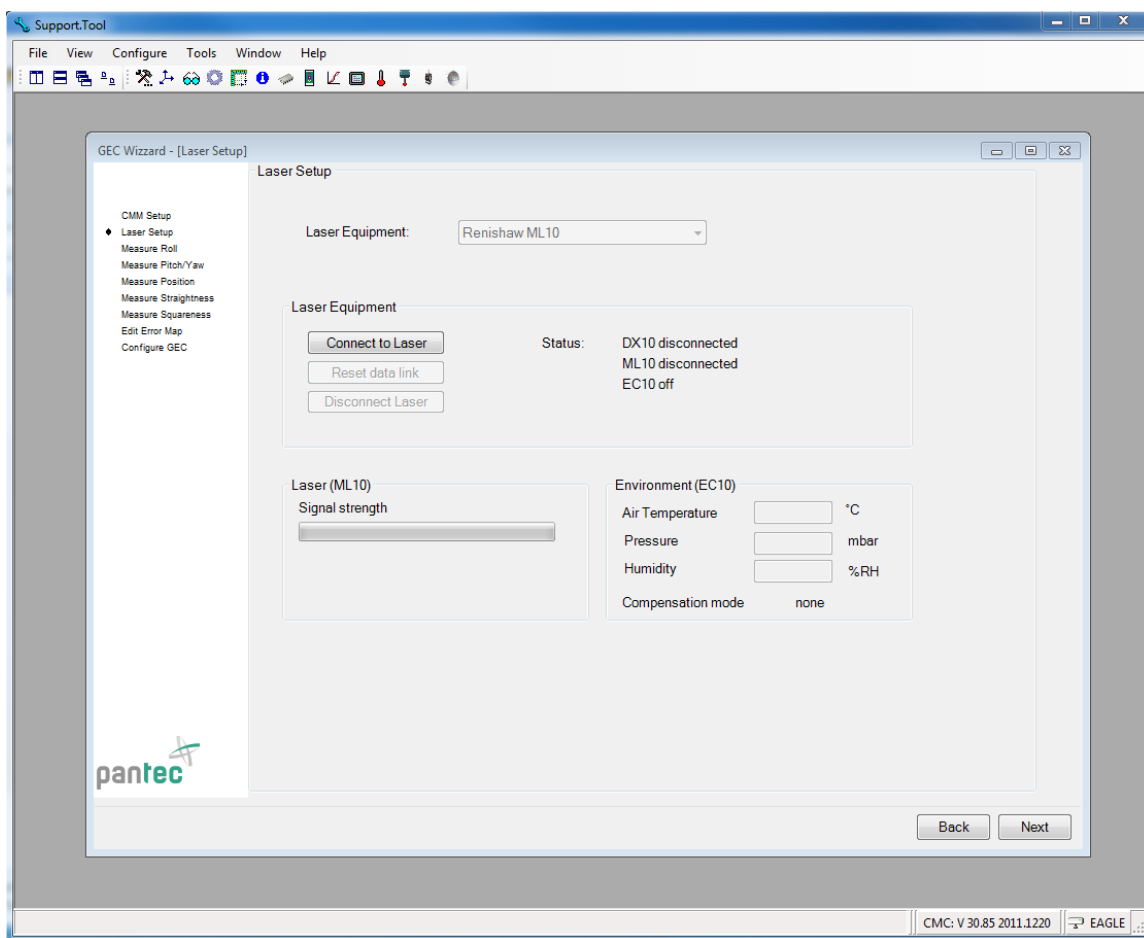
On the *CMM Setup* page of the GEC Wizard the CMM-related parameters, such as the machine dimensions, are defined. In case the machine is not homed, a warning is shown. It is mandatory to complete a home procedure before measuring the error parameters

4. Configure the setup for thermal expansion compensation



To compensate for the effects of thermal expansion a first order correction model is applied. On the *T-Sensor Setup* page, the linear thermal expansion coefficients of the scales attached to the CMM can be adjusted. If a Pantec T-Bus is connected to the controller, the current temperature data provided by the available sensors are shown. Each temperature sensor can be associated to the corresponding axis. Alternative temperature sensor types may be incorporated via our software interface.

5. Laser Setup



On the Laser Setup page the user is intended to connect to a laser. Currently, the Renishaw XL80 and ML10 (via USB interface) including their corresponding environmental measurement stations are supported. Once connected, the current laser signal strength and environmental data are displayed.

Subsequently, the various error parameters are measured with the laser or using other devices. It is recommended to measure the parameters according to the order presented in the GEC Wizard.

6. Measurement of roll errors

GEC Wizard - [Measure Roll]

GEC License
CMM Setup
T-Sensor Setup
Laser Setup
◆ Measure Roll
Measure Pitch/Yaw
Measure Linearity
Measure Straightness
Measure Squareness
Edit Error Map
Configure GEC

Measure Roll

Parameter

Roll XX (XRX)
 Roll YY (YRY)
 Roll ZZ (ZRZ)

Offset to the base of CMM quill:

X [mm]:
Y [mm]:
Z [mm]:

CMM operation

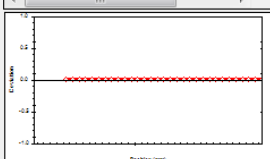
Start Coordinate: mm
End Coordinate: mm
Step: mm
Velocity: mm/s

Controller Position: mm

Reverse direction

Roll X (XRX)

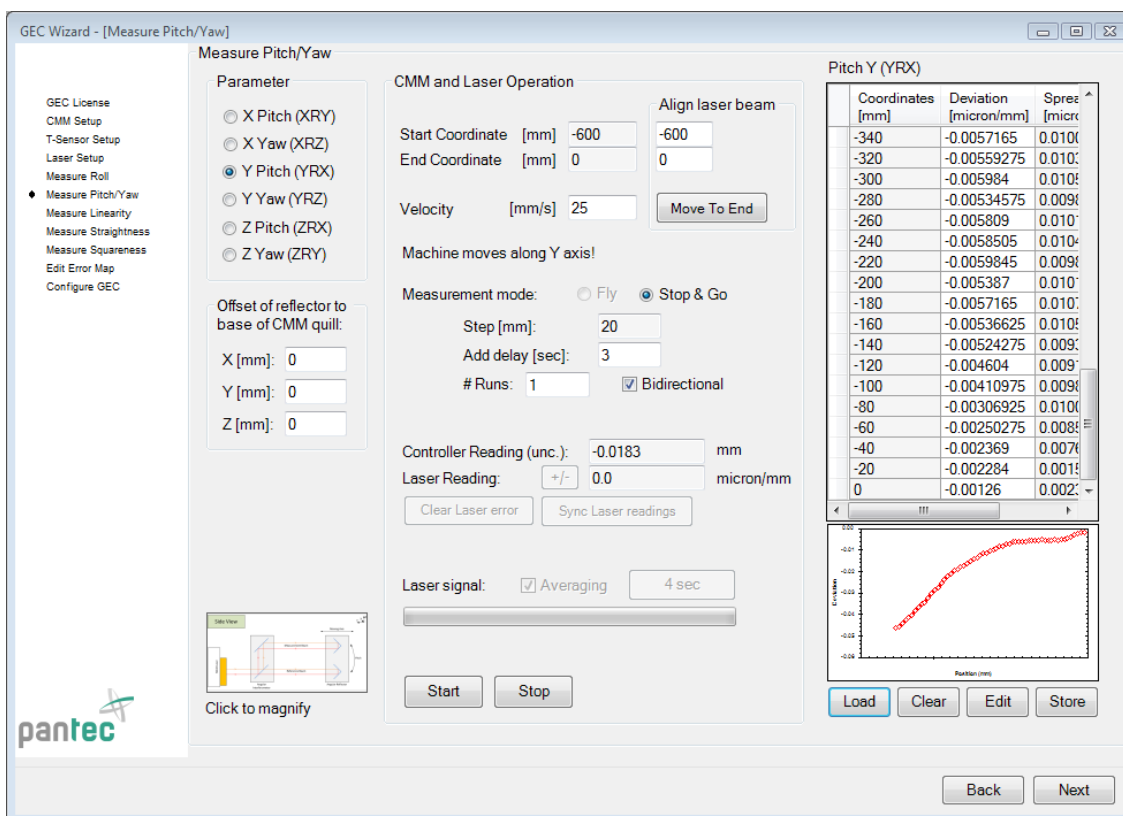
Coordinates [mm]	Deviation [micron/mm]	Spres [micron]
-600	0	
-580	0	
-560	0	
-540	0	
-520	0	
-500	0	
-480	0	
-460	0	
-440	0	
-420	0	
-400	0	
-380	0	
-360	0	
-340	0	
-320	0	
-300	0	
-280	0	
-260	0	



The angular error due to roll is commonly not measured by a laser, but by other tools and devices. On this page the user can move the machine in steps along the predefined grid, perform the measurement and then enter the deviations into the given fields corresponding to the current coordinates. It is also possible to load external data, as well as scaling and storing the entered data for later use.

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 PANTEC Metrology Seite: 6 von 12

7. Measurement of pitch and yaw errors



After the rough alignment of the laser the precise alignment and actual laser measurement are done with the GEC Wizard according to the following steps:

- Open the “Measure Pitch/Yaw” page
- Select Pitch or Yaw for the desired axis
- Align laser using the “Move To End”/”Move To Start” button and ensure that the signal strength is sufficient and does not change significantly along the whole moving path
- If the laser beam was obscured it may be necessary to click on “Clear laser error”.
- Make sure that the rotation direction is correct: tap on mirror and check if the laser reading follows the right-hand rule. The rotation direction can be changed by clicking on the “+/-” button.
- At the start coordinates click on “Zero laser readings”
- Enter the number of runs and whether to perform the measurement bidirectional or unidirectional
- Press “Start” to begin with automatic data gathering
- When data gathering is completed it is recommended to store the data in a file (for potential later use) by clicking on the “Store” button below the diagram.
- To redo the measurement click on “Clear” below the diagram and press “Start” again

8. Measurements of linearity and straightness deviations

GEC Wizard - [Measure Linearity]

GEC License
CMM Setup
T-Sensor Setup
Laser Setup
Measure Roll
Measure Pitch/Yaw
• Measure Linearity
Measure Straightness
Measure Squareness
Edit Error Map
Configure GEC

Measure Linearity

Parameter

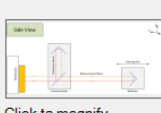
X Linearity (XDX)
 Y Linearity (YDY)
 Z Linearity (ZDZ)

Reflector Setup

Retro Reflector
 Plane Mirror

Offset of reflector to base of CMM quill:

X [mm]: 0
Y [mm]: 0
Z [mm]: 0



Click to magnify

CMM and Laser Operation

Align laser beam

Start Coordinate [mm] -600 -600
End Coordinate [mm] 0 0

Velocity [mm/s] 25 Move To End

Measurement mode: Fly Stop & Go

Step [mm]: 20
Add delay [sec]: 3
Runs: 1 Bidirectional

Controller Reading (unc.): 99.9997 mm
Laser Reading: +/- 0.0 mm

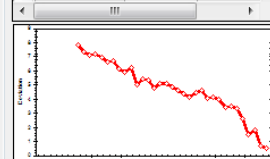
Clear Laser error Sync Laser readings

Laser signal: Averaging 4 sec

Start Stop

Linearity X (XDX)

Coordinates [mm]	Deviation [micron]	Spread [micron]
-15	0.458375	75
-35	0.648375	75
-55	1.752125	71
-75	1.4445	75
-95	2.543	71
-115	3.342625	78
-135	3.450125	78
-155	3.418125	75
-175	3.950375	78
-195	4.0685	75
-215	4.0355	78
-235	4.595125	75
-255	4.4105	78
-275	4.11525	81
-295	4.355	84
-315	4.549625	81
-335	4.828125	81
-355	5.095	84



Load Clear Edit Store

Back Next

The procedure for linearity and straightness errors is the same as shown in the previous step. The only additional option concerns the chosen mirror setup.

GEC Wizard - [Measure Straightness]

GEC License
CMM Setup
T-Sensor Setup
Laser Setup
Measure Roll
Measure Pitch/Yaw
• Measure Straightness
Measure Squareness
Edit Error Map
Configure GEC

Measure Straightness

Parameter

X axis (XDY)
 Y axis (YDX)
 Z axis (ZDX)

Straightness

Horizontal
 Vertical

DX10 Options

Long
 Short

Offset of reflector to base of CMM quill:

X [mm]: 0
Y [mm]: 0
Z [mm]: 0

CMM and Laser Operation

Align laser beam

Start Coordinate [mm] -600 -600
End Coordinate [mm] 0 0

Velocity [mm/s] 25 Move To End

Measurement mode: Fly Stop & Go

Step [mm]: 20
Add delay [sec]: 3
Runs: 1 Bidirectional

Controller Reading (unc.): 99.9997 mm
Laser Reading: +/- 0.0 mm

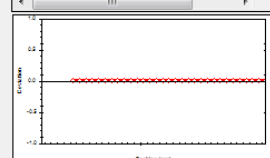
Clear Laser error Sync Laser readings

Laser signal: Averaging 4 sec

Start Stop

Straightness XDY

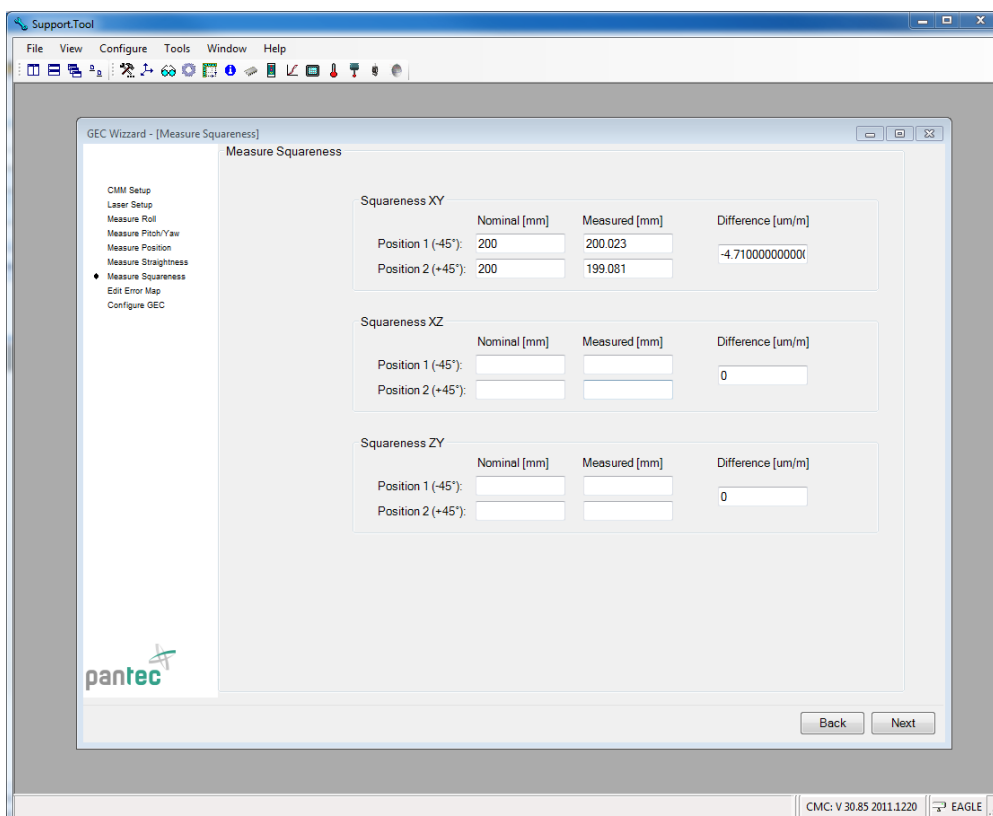
Coordinates [mm]	Deviation [micron]	Spread [micron]
-600	0	
-580	0	
-560	0	
-540	0	
-520	0	
-500	0	
-480	0	
-460	0	
-440	0	
-420	0	
-400	0	
-380	0	
-360	0	
-340	0	
-320	0	
-300	0	
-280	0	
-260	0	



Load Clear Edit Store

Back Next

9. Squareness measurement



GEC Wizard - [Measure Squareness]

Measure Squareness

CMM Setup
 Laser Setup
 Measure Roll
 Measure Pitch/Yaw
 Measure Position
 Measure Straightness
 • Measure Squareness
 Edit Error Map
 Configure GEC

Squareness XY			
	Nominal [mm]	Measured [mm]	Difference [um/m]
Position 1 (-45°):	200	200.023	-4.7100000000000000
Position 2 (+45°):	200	199.081	

Squareness XZ			
	Nominal [mm]	Measured [mm]	Difference [um/m]
Position 1 (-45°):			0
Position 2 (+45°):			

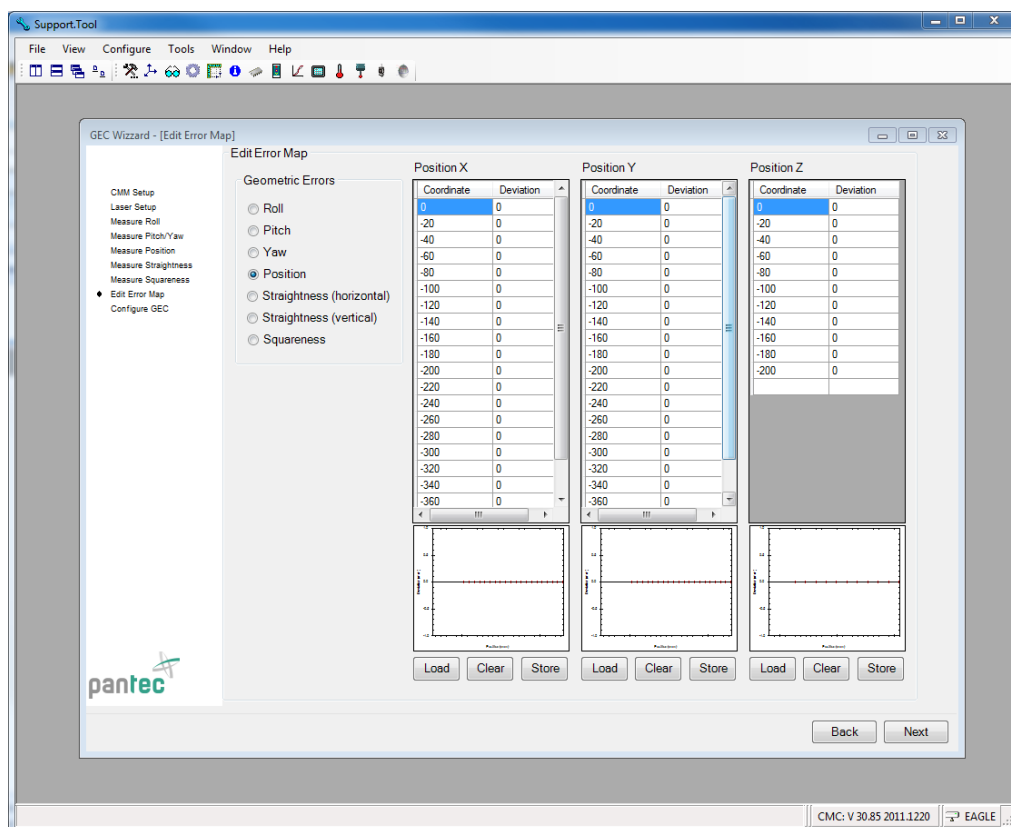
Squareness ZY			
	Nominal [mm]	Measured [mm]	Difference [um/m]
Position 1 (-45°):			0
Position 2 (+45°):			

Back Next

CMC: V 30.85 2011.1220 EAGLE

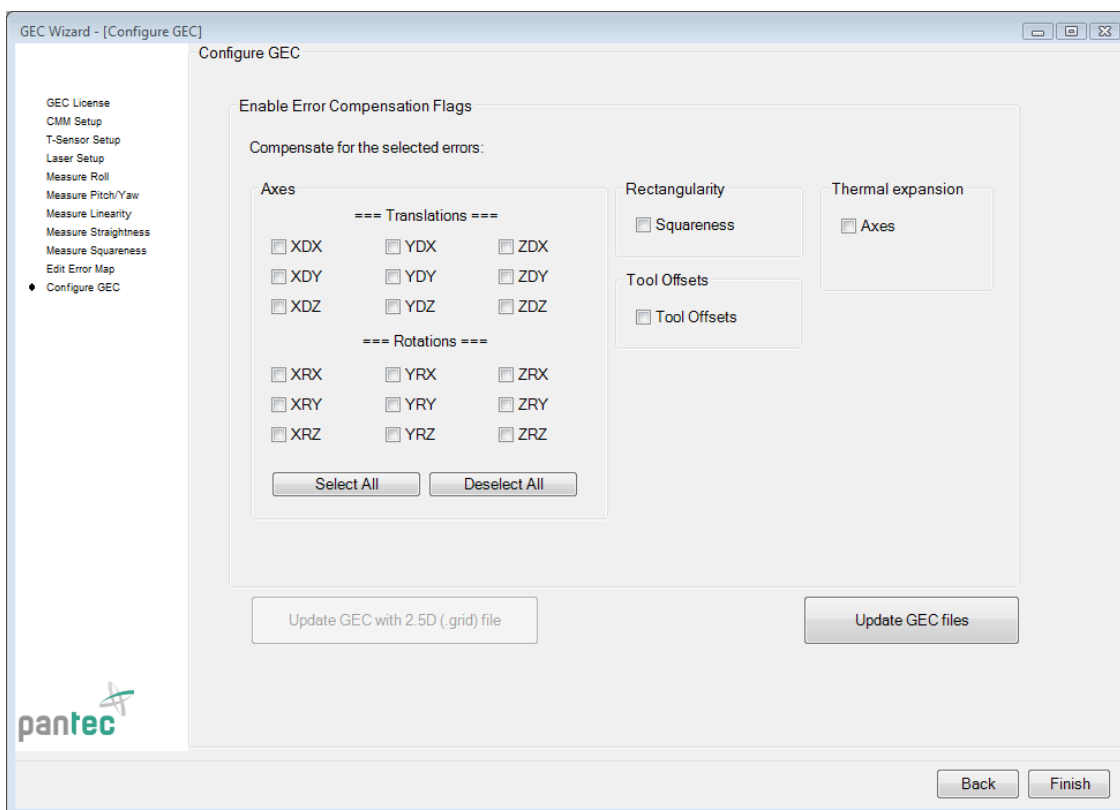
The squareness error is commonly measured with gauges. Enter the values for nominal and measured distance into the corresponding fields for squareness XZ and ZY. The compensation parameter is computed immediately.

10. Error map editor



The error map editor allows further adjustment of the error compensation data.

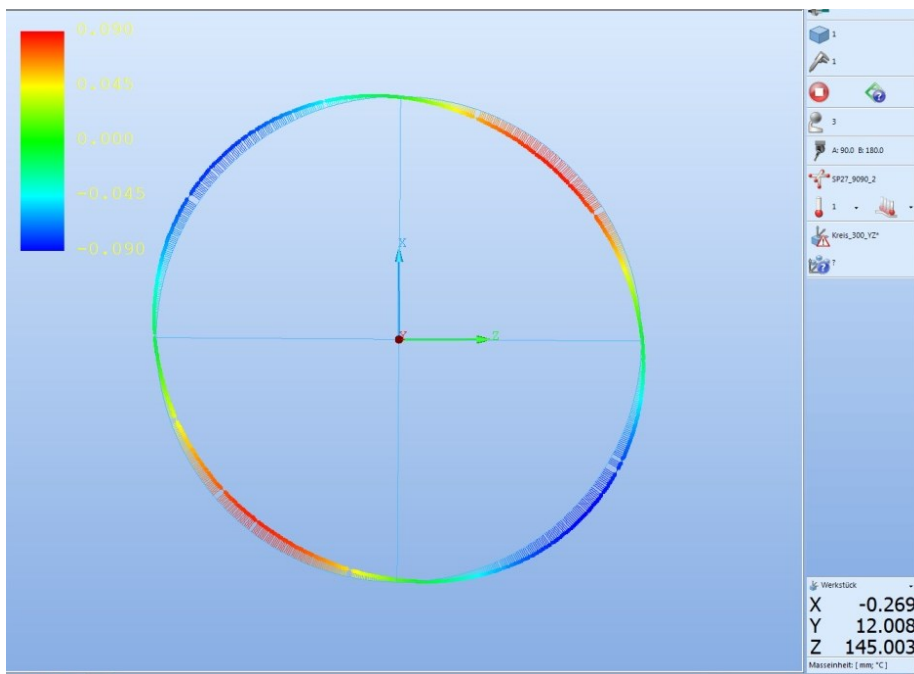
11. Configuration of the geometric error compensation



On the final page the various compensation parameters can be activated and deactivated. The compensation data files and the GEC configuration are written when pressing the button “Update GEC files”.

12. Example: squareness compensation

In this example the measurement of a 300.001 mm ring measured in the XZ plane without compensation shows a clear deviation from rectangularity.



Using the GEC Wizard the squareness compensation parameter was determined. After the update of the compensation data files with the new values the situation improves significantly. The remaining deviations are due to other error components.

