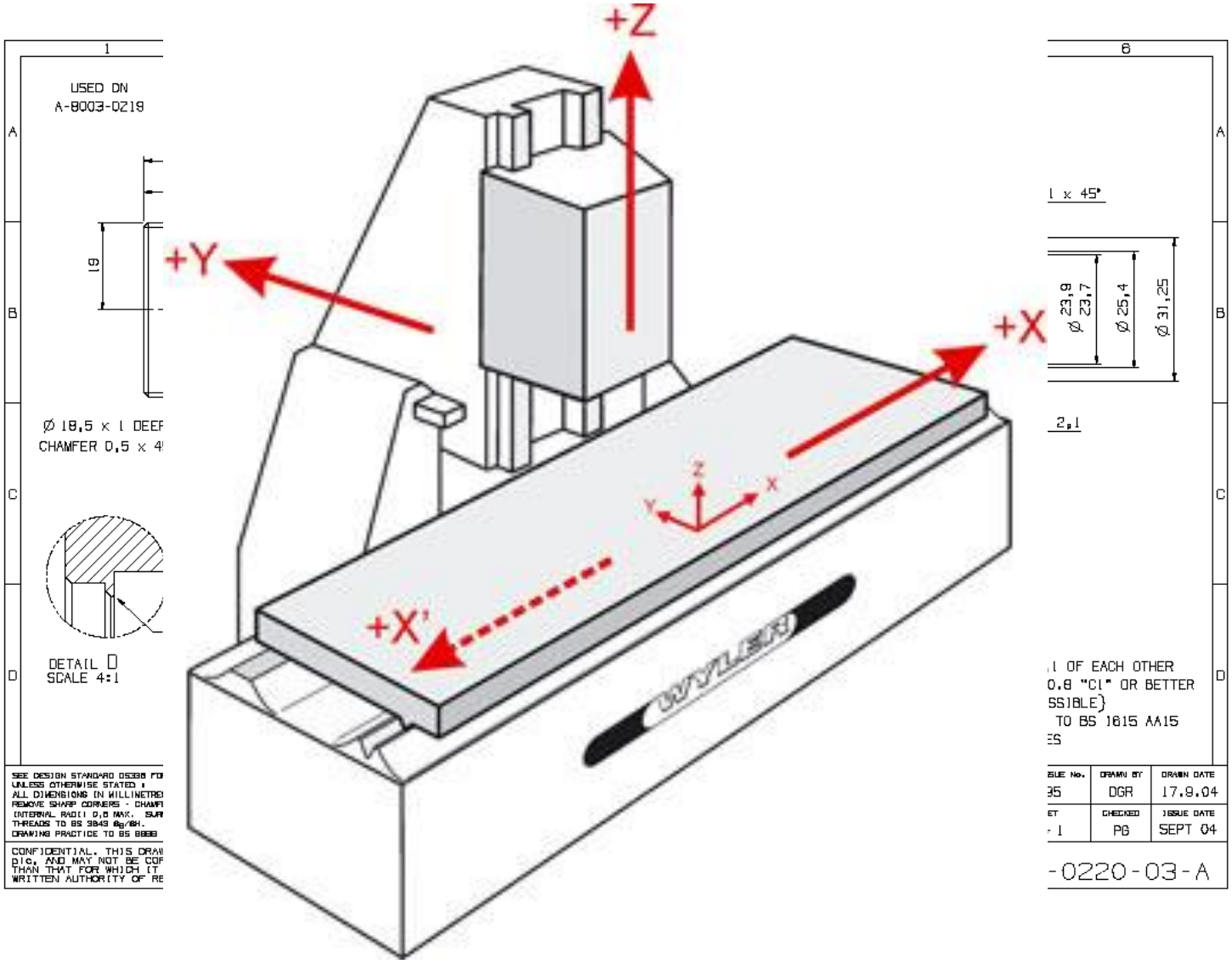
# Machine Measurement

# What Are Your Machine Tool Requirements?



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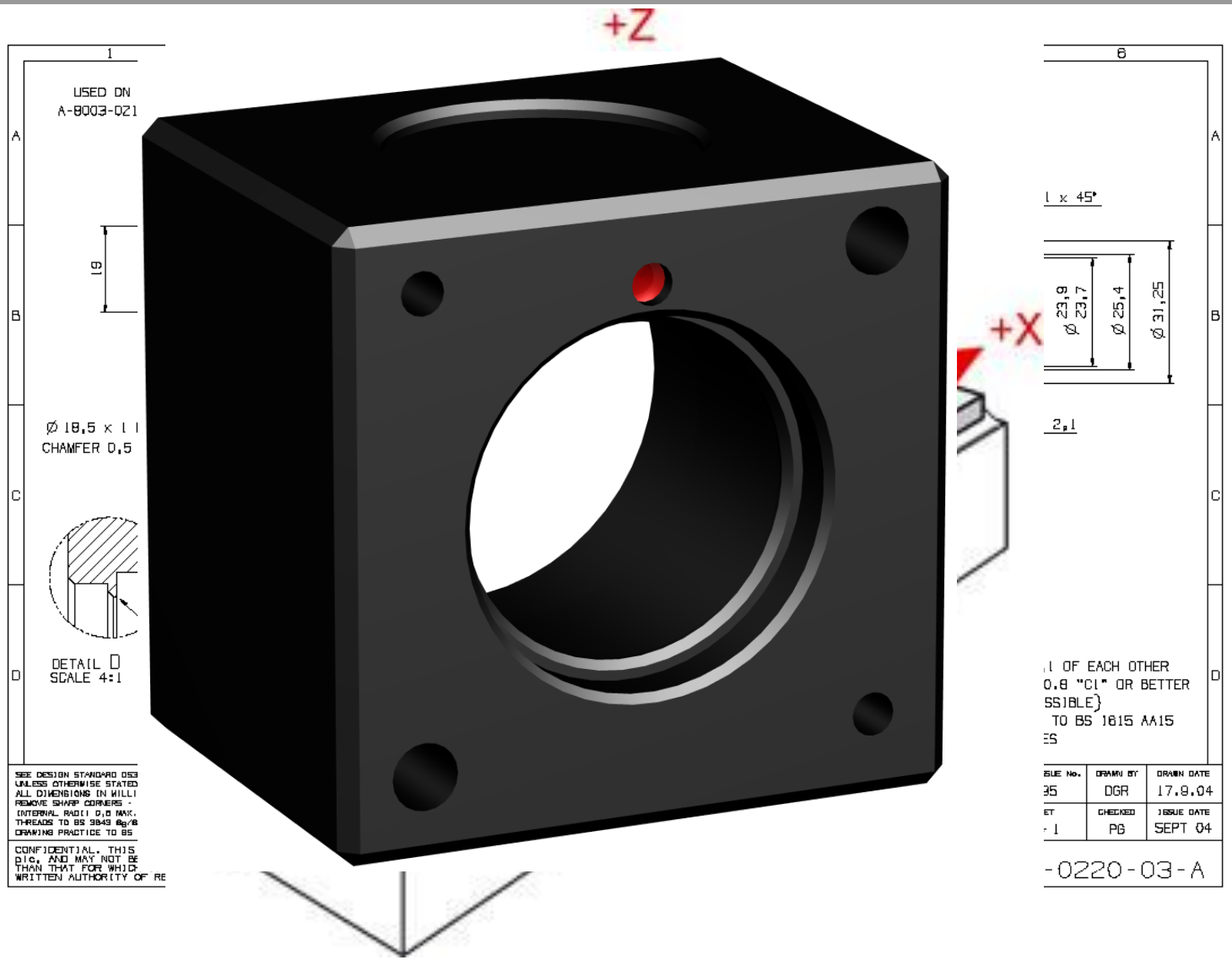
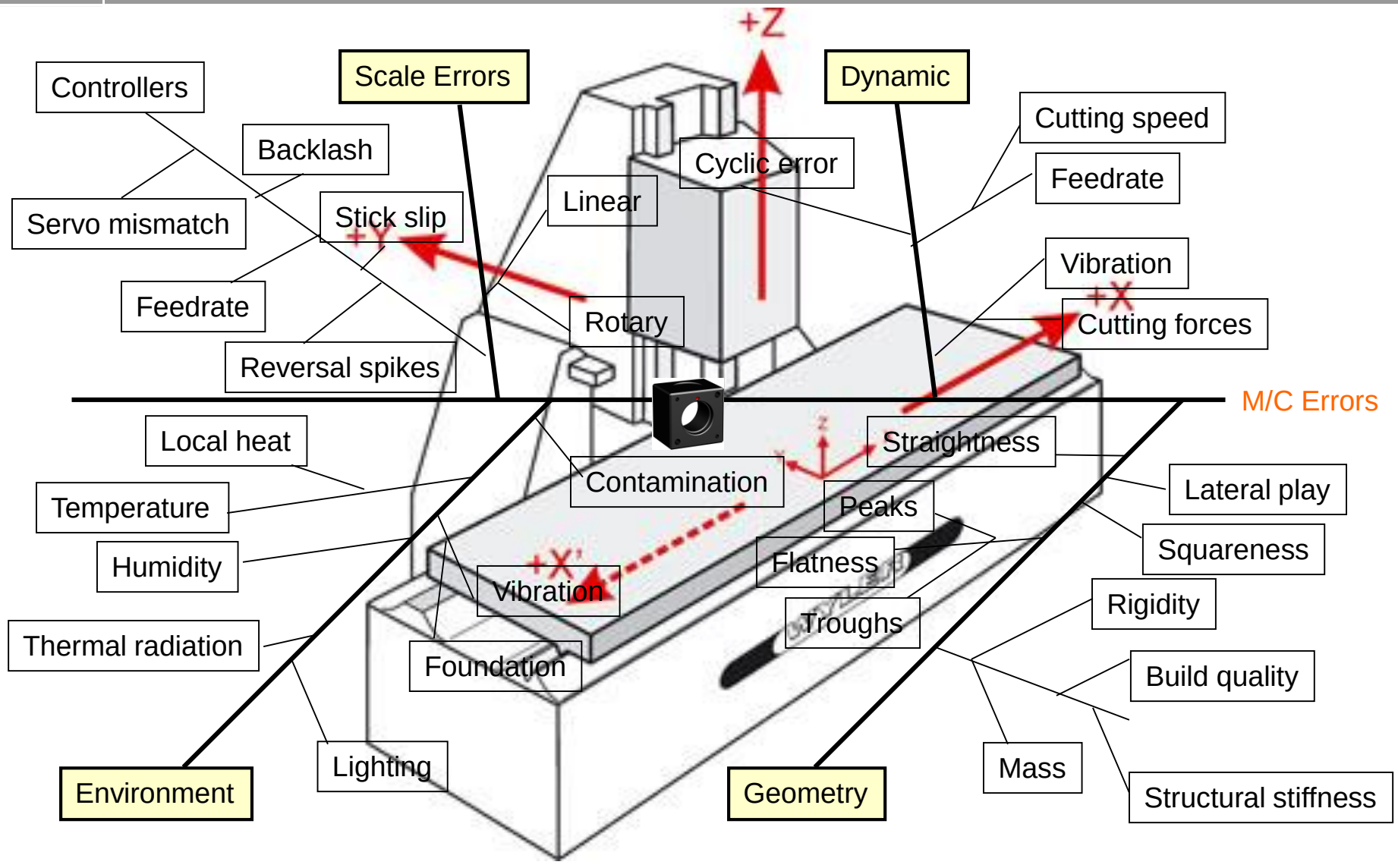
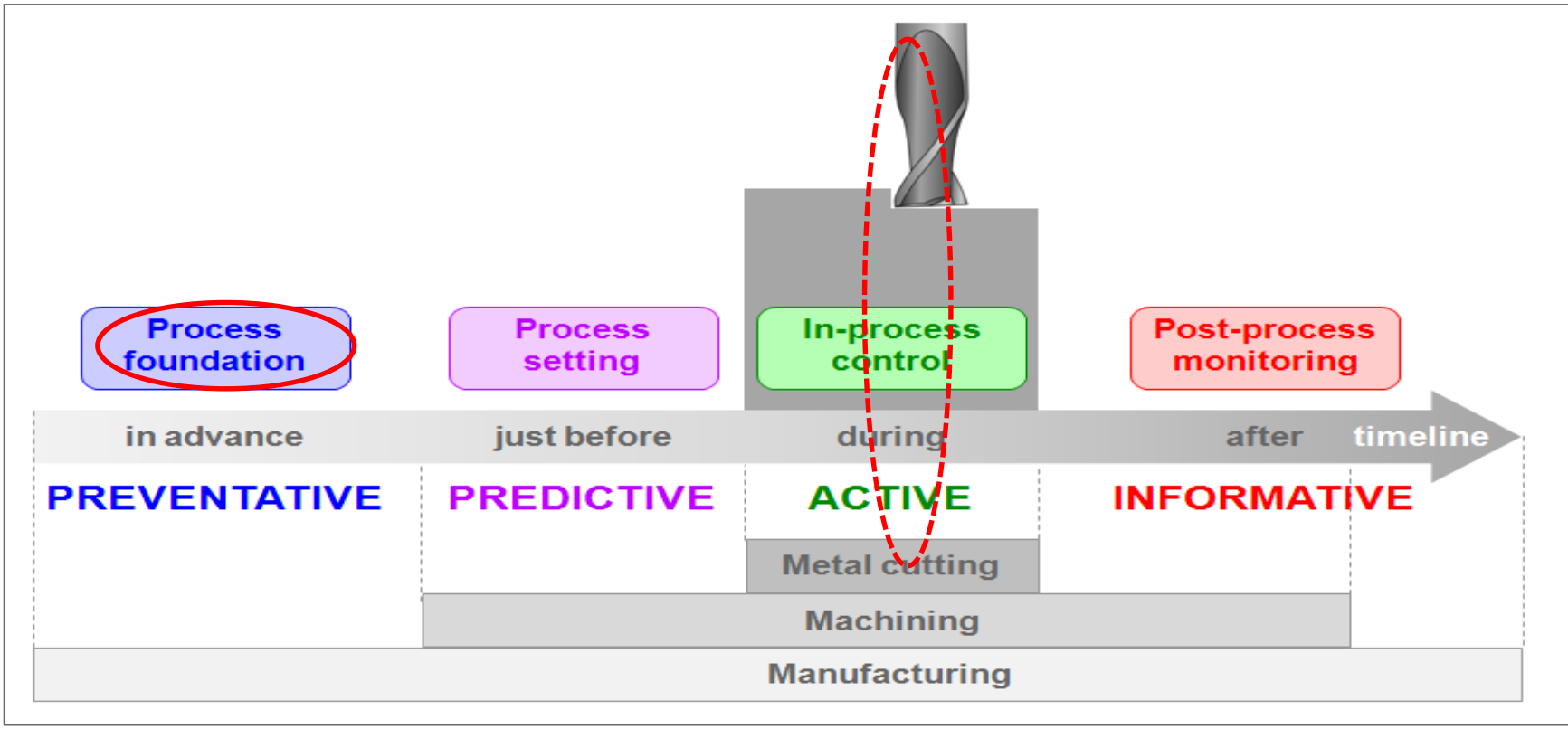
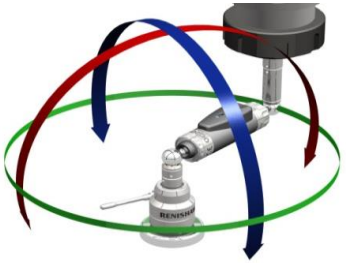


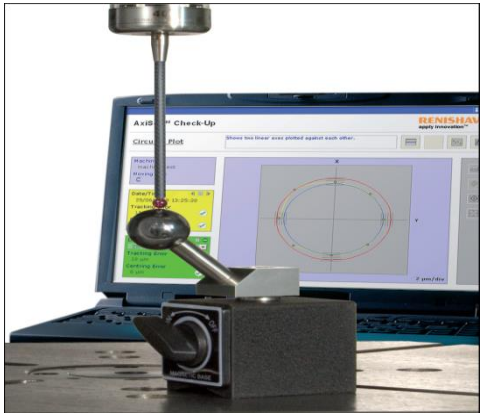
# Machine Tool Positional and Contouring Errors




Process foundation
Process setting
In-process control
Post-process monitoring
in advance
just before
during
after
timeline
PREVENTATIVE
PREDICTIVE
ACTIVE
INFORMATIVE
Metal cutting
Machining
Manufacturing



**QC20-W**
wireless
ballbar system
Check the performance
of your machine
and diagnose problems



**AxiSet**
Measure and
report multi-
axis machine
performance in
minutes

**XL-80 laser system**
Provides a detailed
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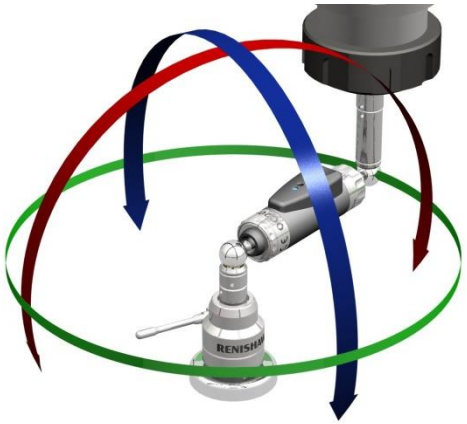
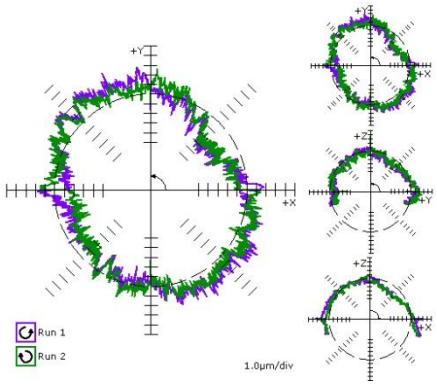
machines positioning
performance

# QC20 Ballbar – The Industry Standard!

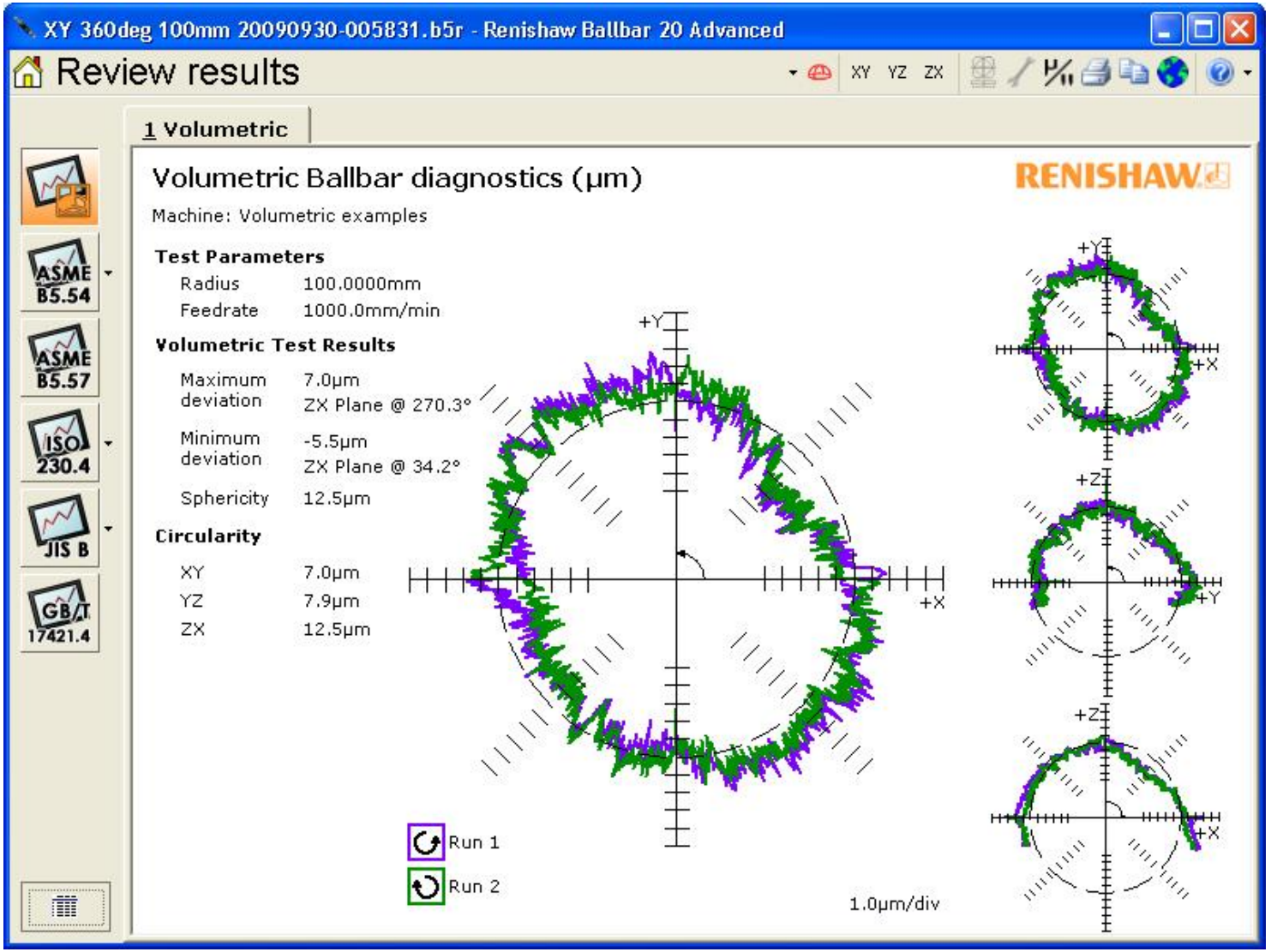
- A verification device for a range of machine tools
- Very quick and simple test (Typically 10 minutes)
- Diagnoses twenty machine tool errors
- Volumetric verification
- Test any 2 linear axes XY YZ ZX
- Software - simple to use and very powerful
- Use to identify machine faults
- Use to “Bench-mark” machine capability
- Gives an early warning of potential problems



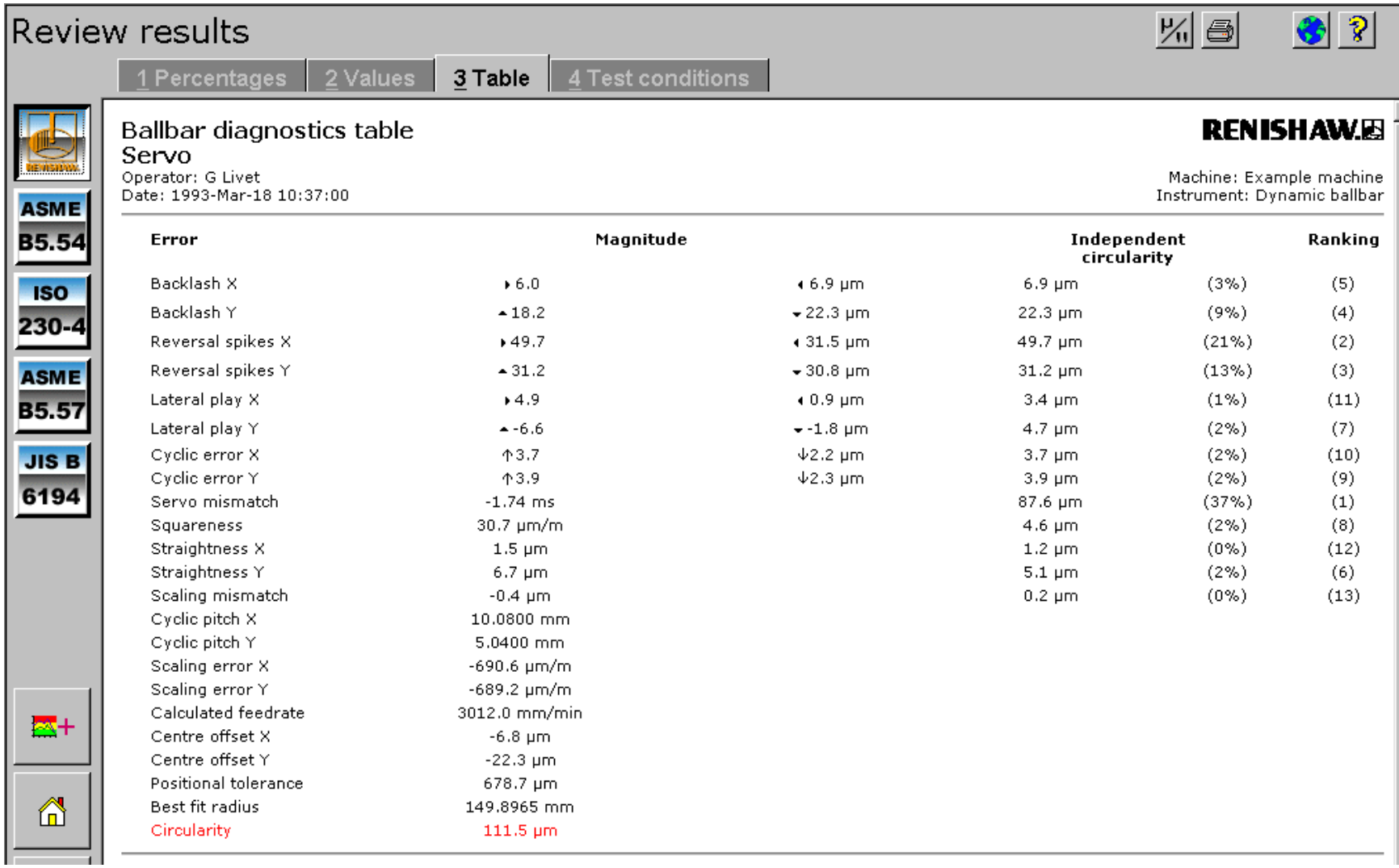



# QC20 Ballbar Test

# Result - Percentages Graph



# Result - Diagnostic Table




Ballbar diagnostics table
Servo

RENISHAW

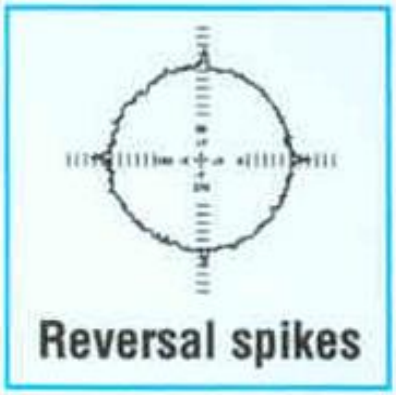
Operator: G Livet
Date: 1993-Mar-18 10:37:00

Machine: Example machine
Instrument: Dynamic ballbar

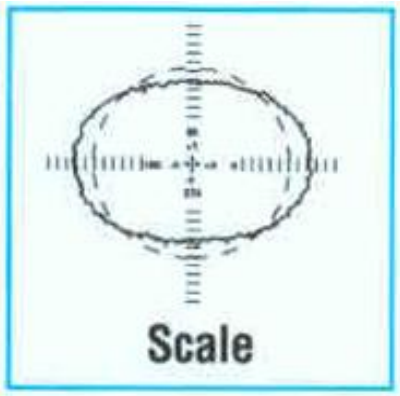
| Error | Magnitude | | Independent circularity | | Ranking |
|---|---|---|---|---|---|
| Backlash X | ▸6.0 | ◂6.9 µm | 6.9 µm | (3%) | (5) |
| Backlash Y | ▴18.2 | ▾22.3 µm | 22.3 µm | (9%) | (4) |
| Reversal spikes X | ▸49.7 | ◂31.5 µm | 49.7 µm | (21%) | (2) |
| Reversal spikes Y | ▴31.2 | ▾30.8 µm | 31.2 µm | (13%) | (3) |
| Lateral play X | ▸4.9 | ◂0.9 µm | 3.4 µm | (1%) | (11) |
| Lateral play Y | ▴-6.6 | ▾-1.8 µm | 4.7 µm | (2%) | (7) |
| Cyclic error X | ↑3.7 | ↓2.2 µm | 3.7 µm | (2%) | (10) |
| Cyclic error Y | ↑3.9 | ↓2.3 µm | 3.9 µm | (2%) | (9) |
| Servo mismatch | -1.74 ms | | 87.6 µm | (37%) | (1) |
| Squareness | 30.7 µm/m | | 4.6 µm | (2%) | (8) |
| Straightness X | 1.5 µm | | 1.2 µm | (0%) | (12) |
| Straightness Y | 6.7 µm | | 5.1 µm | (2%) | (6) |
| Scaling mismatch | -0.4 µm | | 0.2 µm | (0%) | (13) |
| Cyclic pitch X | 10.0800 mm | | | | |
| Cyclic pitch Y | 5.0400 mm | | | | |
| Scaling error X | -690.6 µm/m | | | | |
| Scaling error Y | -689.2 µm/m | | | | |
| Calculated feedrate | 3012.0 mm/min | | | | |
| Centre offset X | -6.8 µm | | | | |
| Centre offset Y | -22.3 µm | | | | |
| Positional tolerance | 678.7 µm | | | | |
| Best fit radius | 149.8965 mm | | | | |
| Circularity | 111.5 µm | | | | |

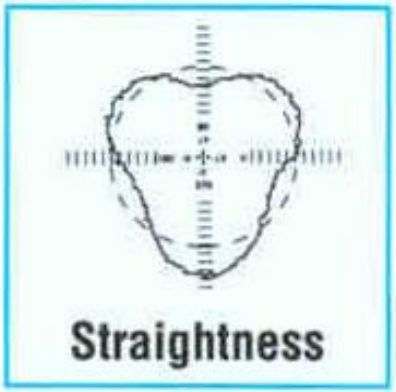
# Identify and rank errors

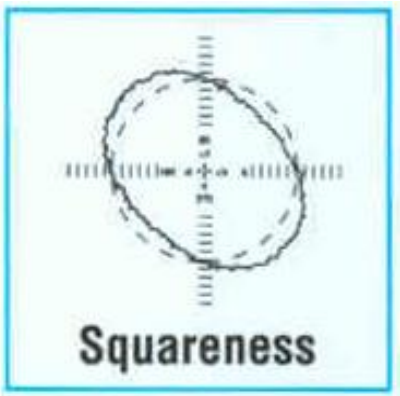
- Decide on corrective action depending on error type

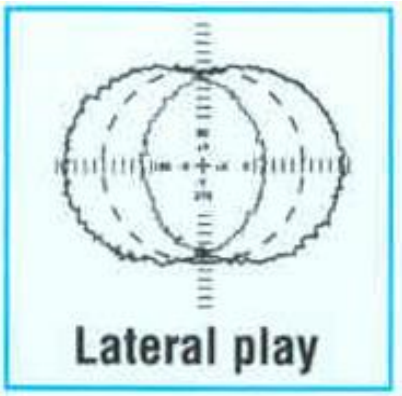





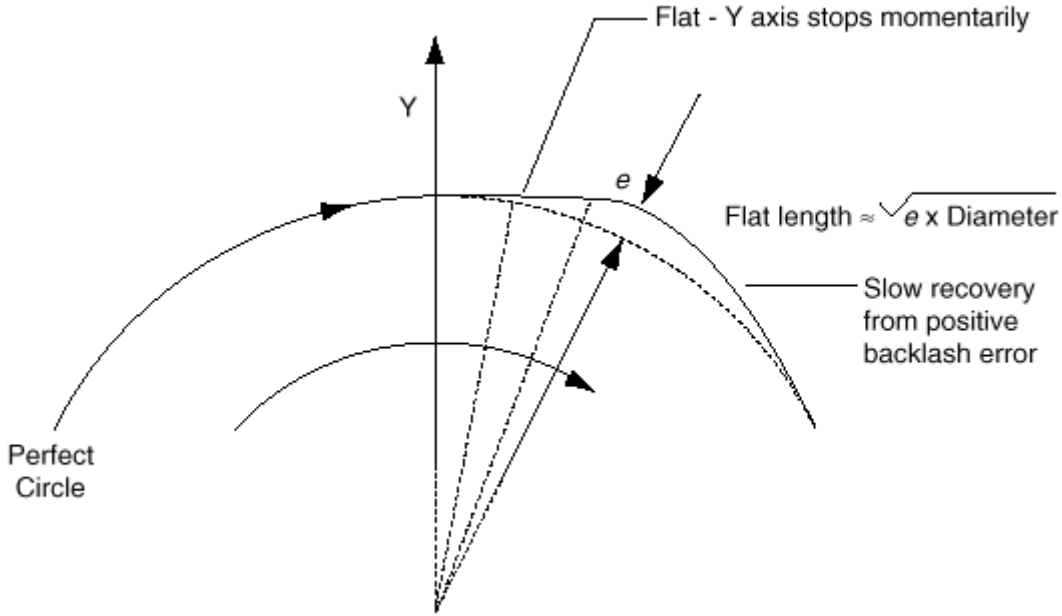



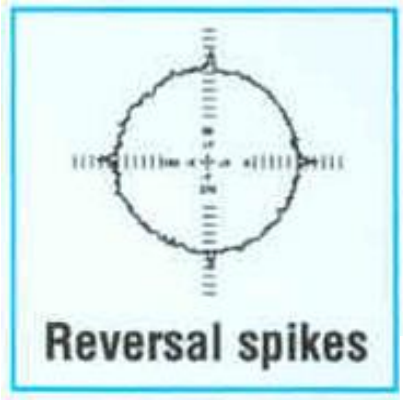



# Error Analysis

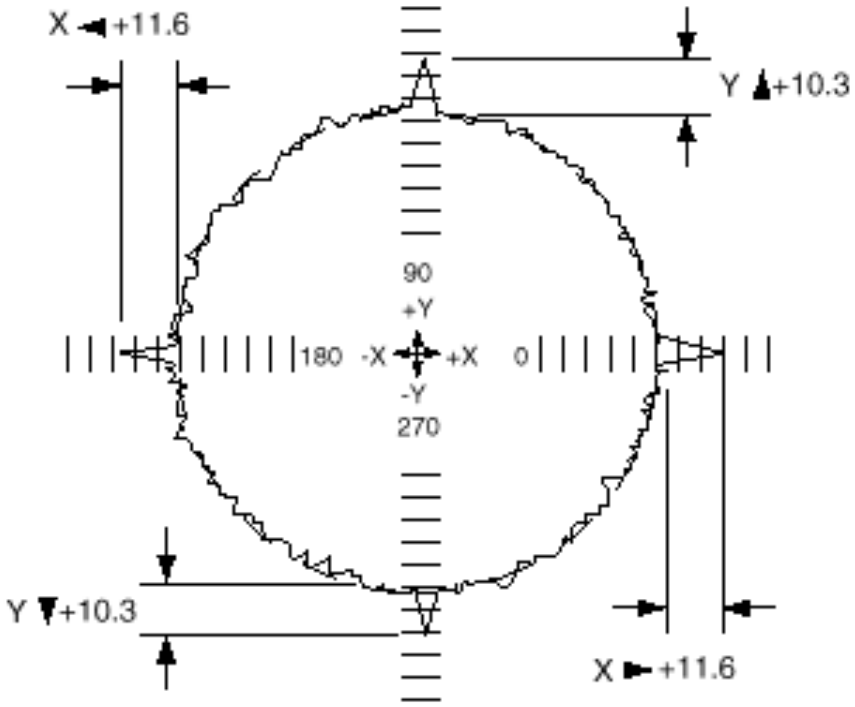

**Backlash** – Physical lost motion in the axis of travel during change of direction. This will have a direct affect on positioning and contouring ability.



# Error Analysis



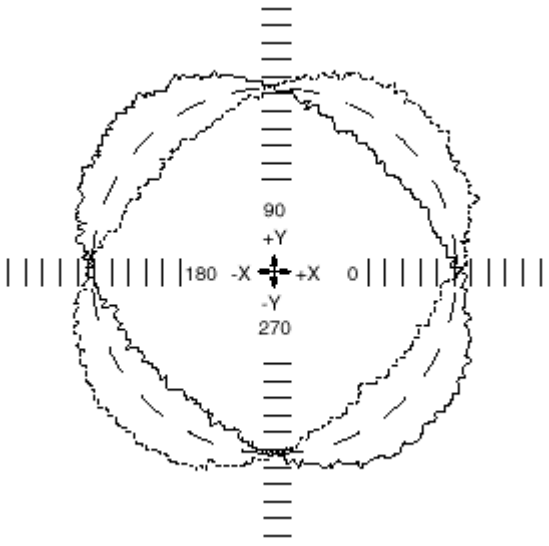

**Reversal Spikes** - The ‘dwell’ in the change in direction of the axis that the servo is driving. This will have a direct affect on contouring ability.



# Error Analysis

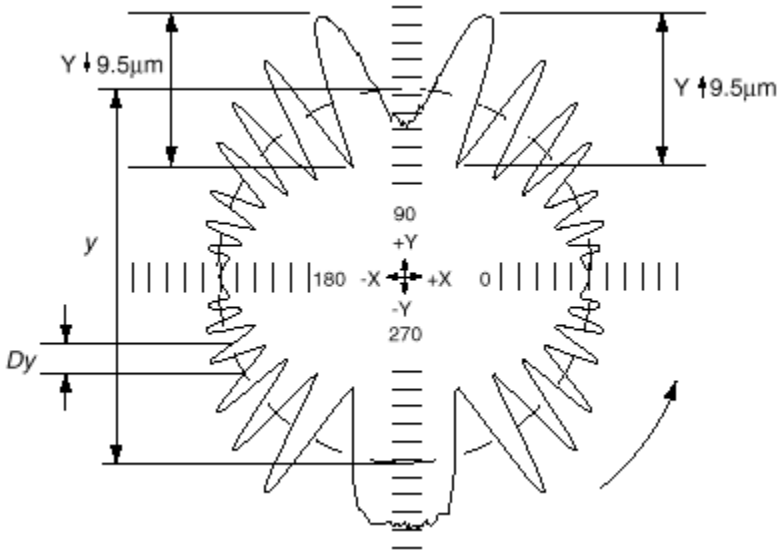

**Servo Miss-match** – This is caused by one axis servo moving faster than the other causing an oval shaped movement of the axis. As the test is done in both directions we can distinguish it from a squareness error. This will have a direct affect on contouring ability.

| Planes being tested | Value given by software | Leading axis |
|---|---|---|
| XY | +ve | Y leads X |
| XY | -ve | X leads Y |
| ZX | +ve | X leads Z |
| ZX | -ve | Z leads X |
| YZ | +ve | Z leads Y |
| YZ | -ve | Y leads Z |

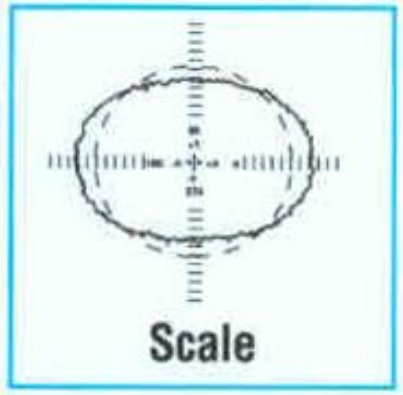


# Error Analysis

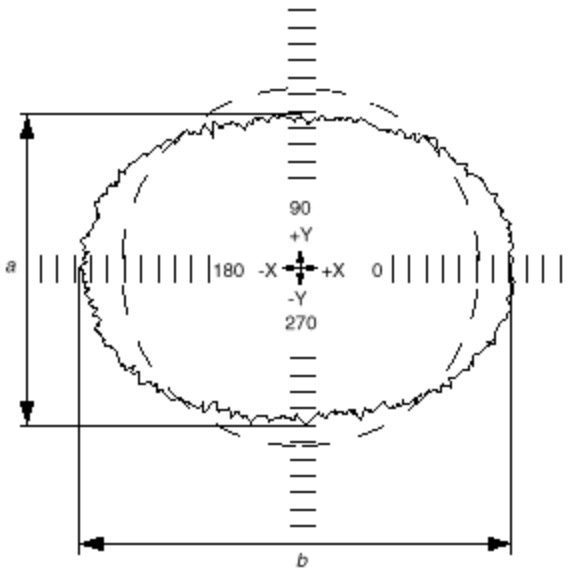

**Cyclic Error** – The run-out of the ballscrew caused by a ‘drunk’ ballscrew, or eccentricity of the ballscrew or encoder mountings. This will have a direct affect on positioning and contouring ability.



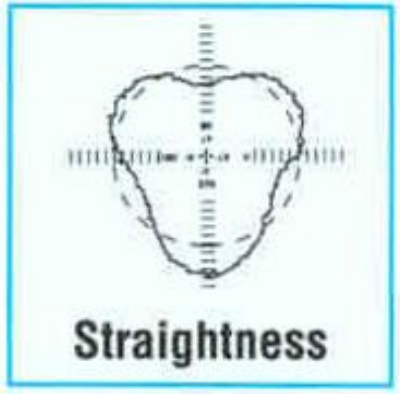
# Error Analysis



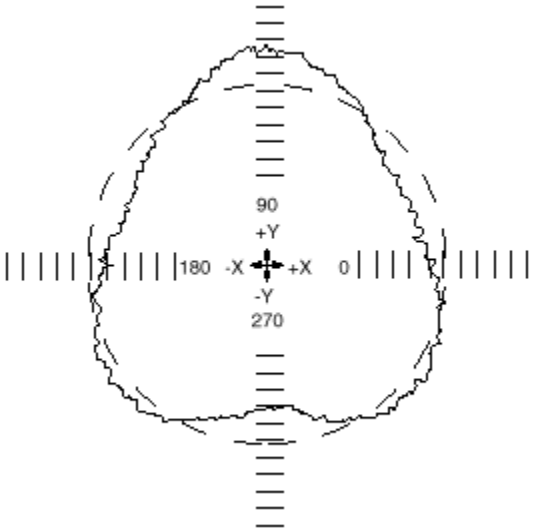

**Scaling error** – Here one axis is moving a different distance to the other. A reason for this is wear in the ballscrew and can be cured by pitch error compensation using XL80 / ML10. This will have a direct affect on positioning ability.

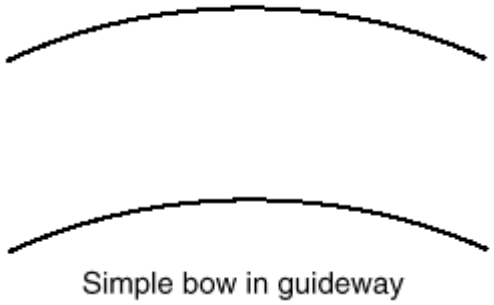


# Error Analysis



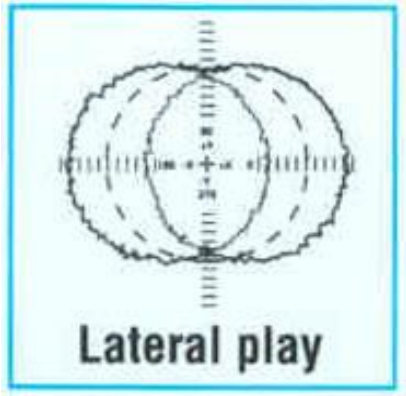

**Straightness** – This indicates the condition of the guideways of the machine. It can show the guides to be bent possibly due to a crash or worn in the normal working area of the machine. This will have a direct affect on positioning and contouring ability.



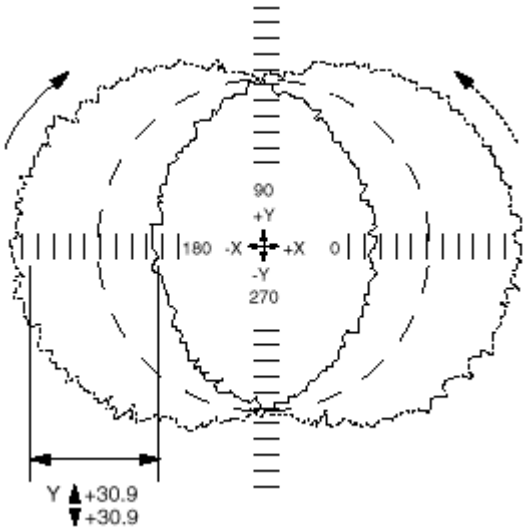



Simple bow in guideway

# Error Analysis

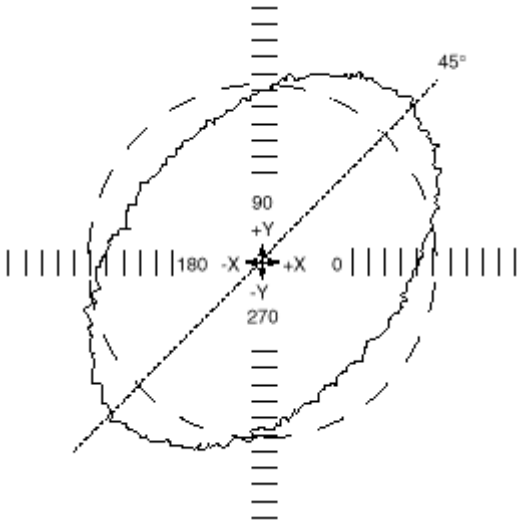


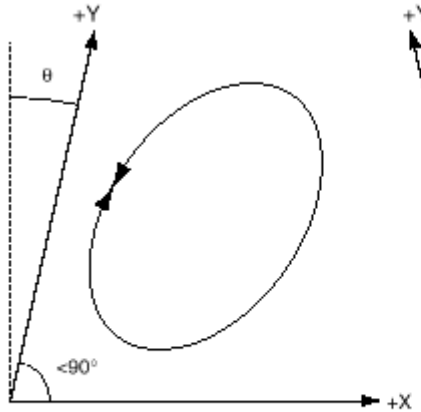

**Lateral Play** – The ‘slop’ in the axis guideways of the machine also known as ‘yaw’. This will have a direct affect on positioning and contouring ability.



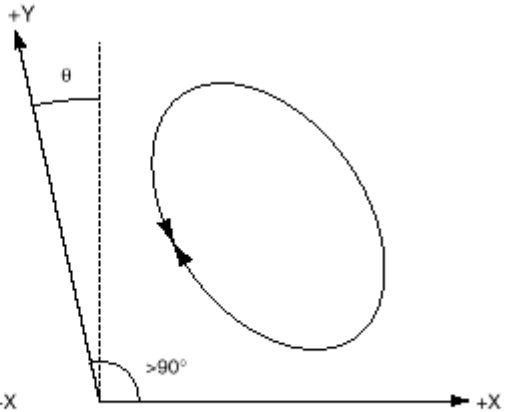
# Error Analysis


**Squareness** – This is simply the out of square to each other of the two axes being tested. This condition is unaffected by the federate of the test. This will have a direct affect on positioning and contouring ability.




Negative squareness error when negative direction on both axis

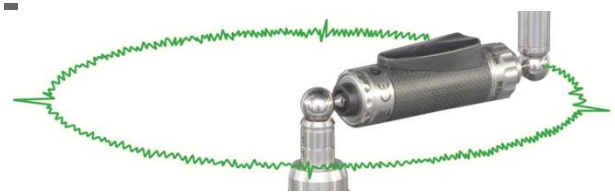



Positive squareness error when positive direction on both axis

# Who Needs the Ballbar system

## Production Department

- Checking machines are capable of producing parts to drawing specifications - before you start cutting



- Machine performance quickly validated after a crash
- Monitor machine tool performance
- Match accurate work to accurate machines

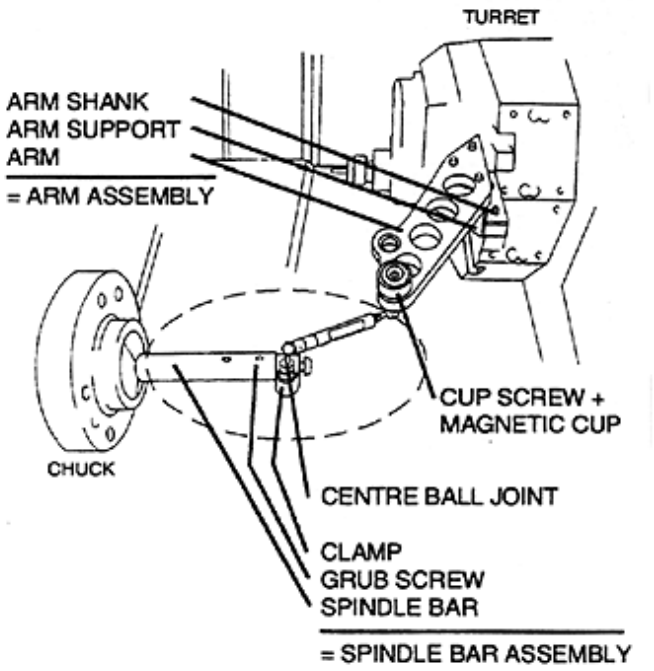
# Who Needs the Ballbar system

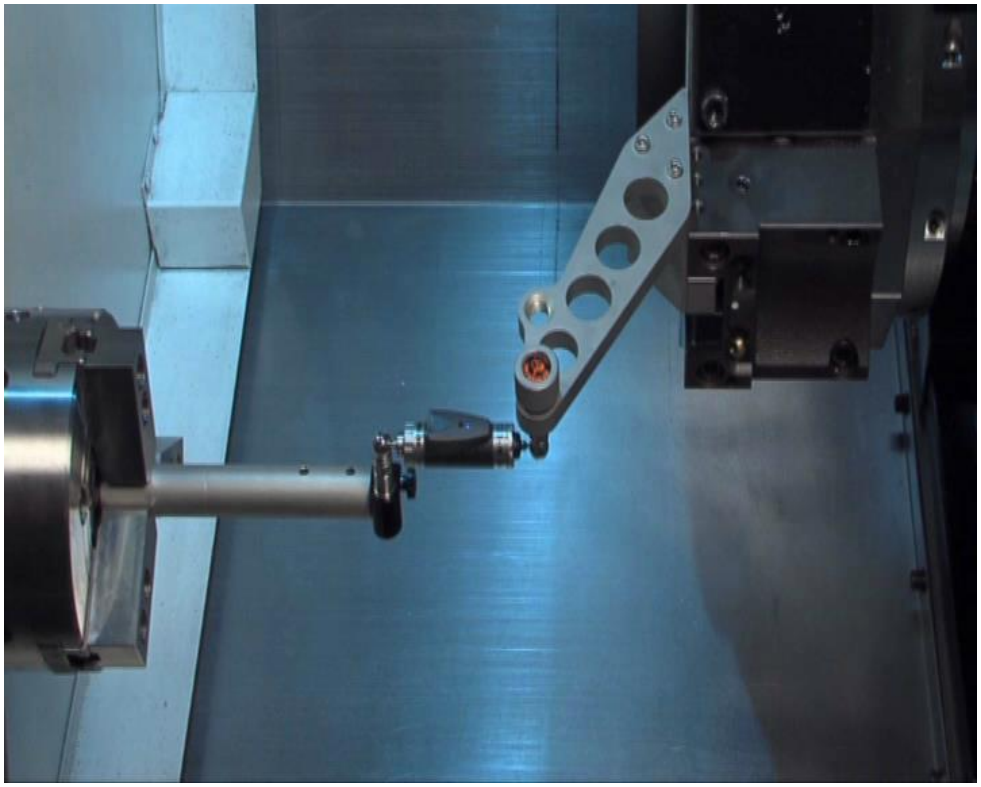
**Maintenance Department**

- **Planned maintenance program, rather than fire fighting!**
- **Early warning of potential problems**
- **Make quick adjustments to improve machine performance**

# 360 Lathe Adapter

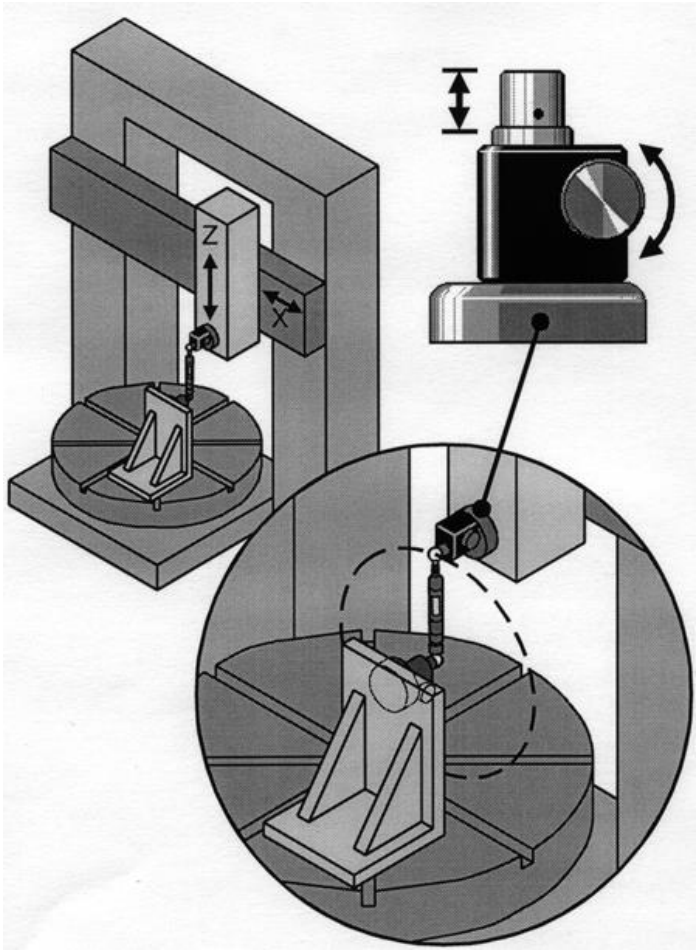
**Adding the 360 degree adapter to the standard kit allows testing of CNC Lathes**



# VTL Adapter

- Allows testing of any 2 axis CNC machine tool
- Special retractable centre-mount
- Example applications include :-
  - Vertical turning lathes
  - Laser cutting machines
  - Pick & place machines
  - Wire eroding machines

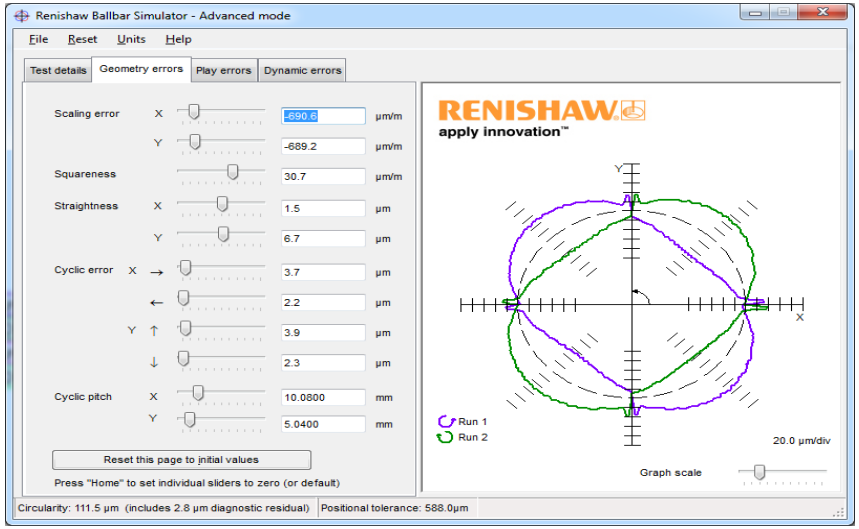


# Error Simulation Software

**Ballbar result**

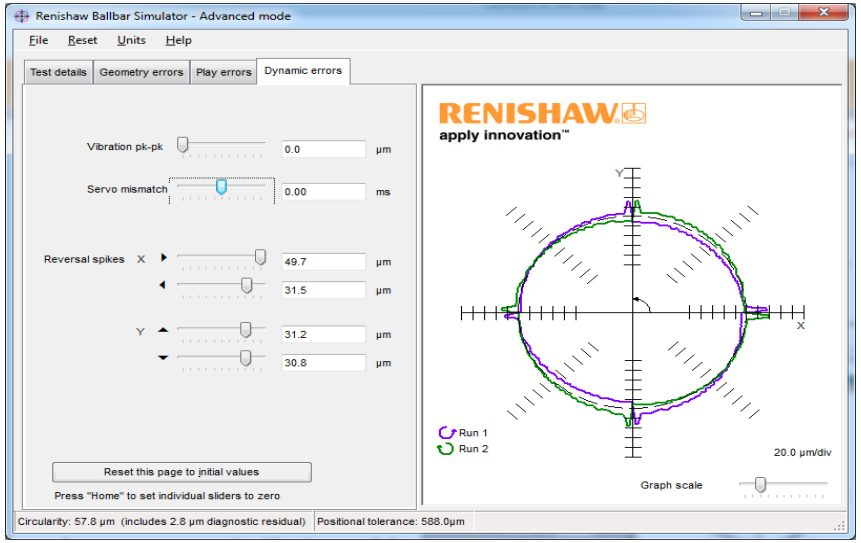
**-1.74ms Servo error**

**Circularity = 111um**




**If servo error is removed**

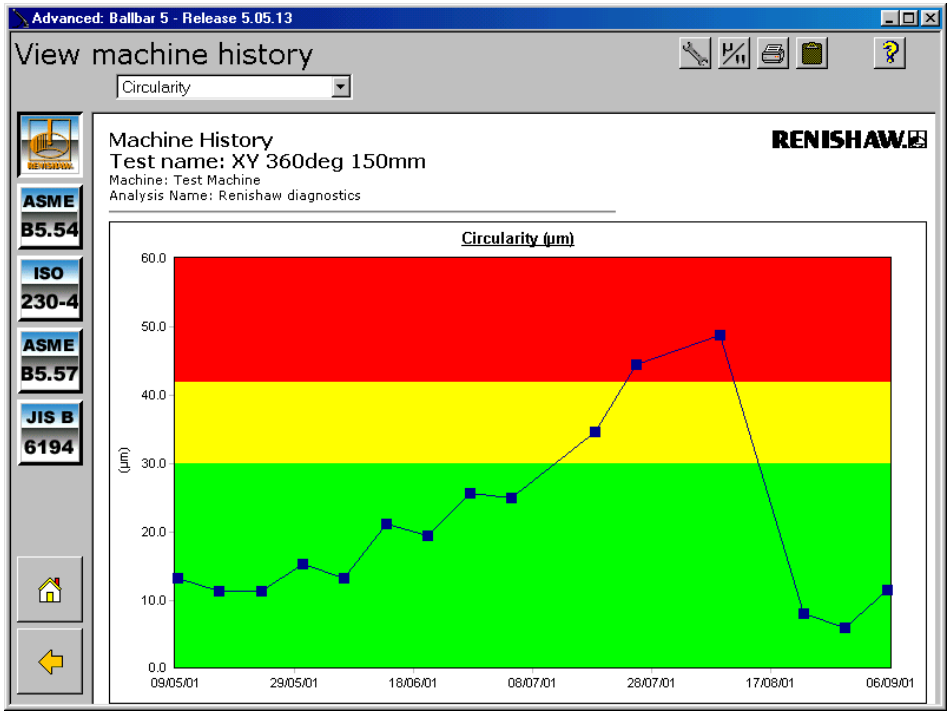
**Circularity = 57um**

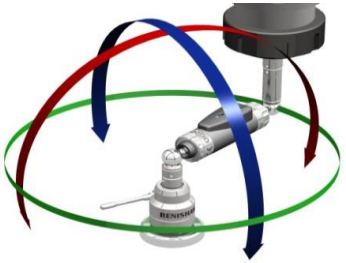



**Predict the Machine Improvements that could be made in advance**

# Ballbar History

- Schedule regular tests to spot drift and deviation
- View results from a series of tests for any parameter
- Apply “Pass”, “Warning” & “Fail” Tolerance Bands





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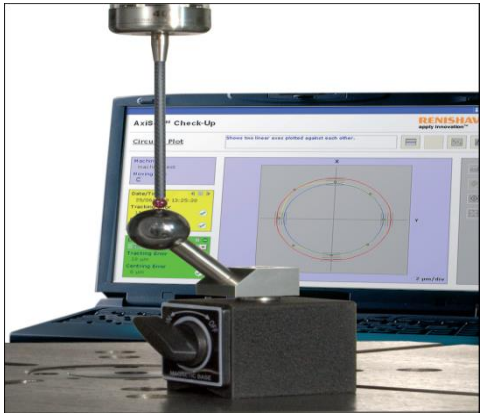

**AxiSet**
Measure and
report multi-
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performance in
minutes

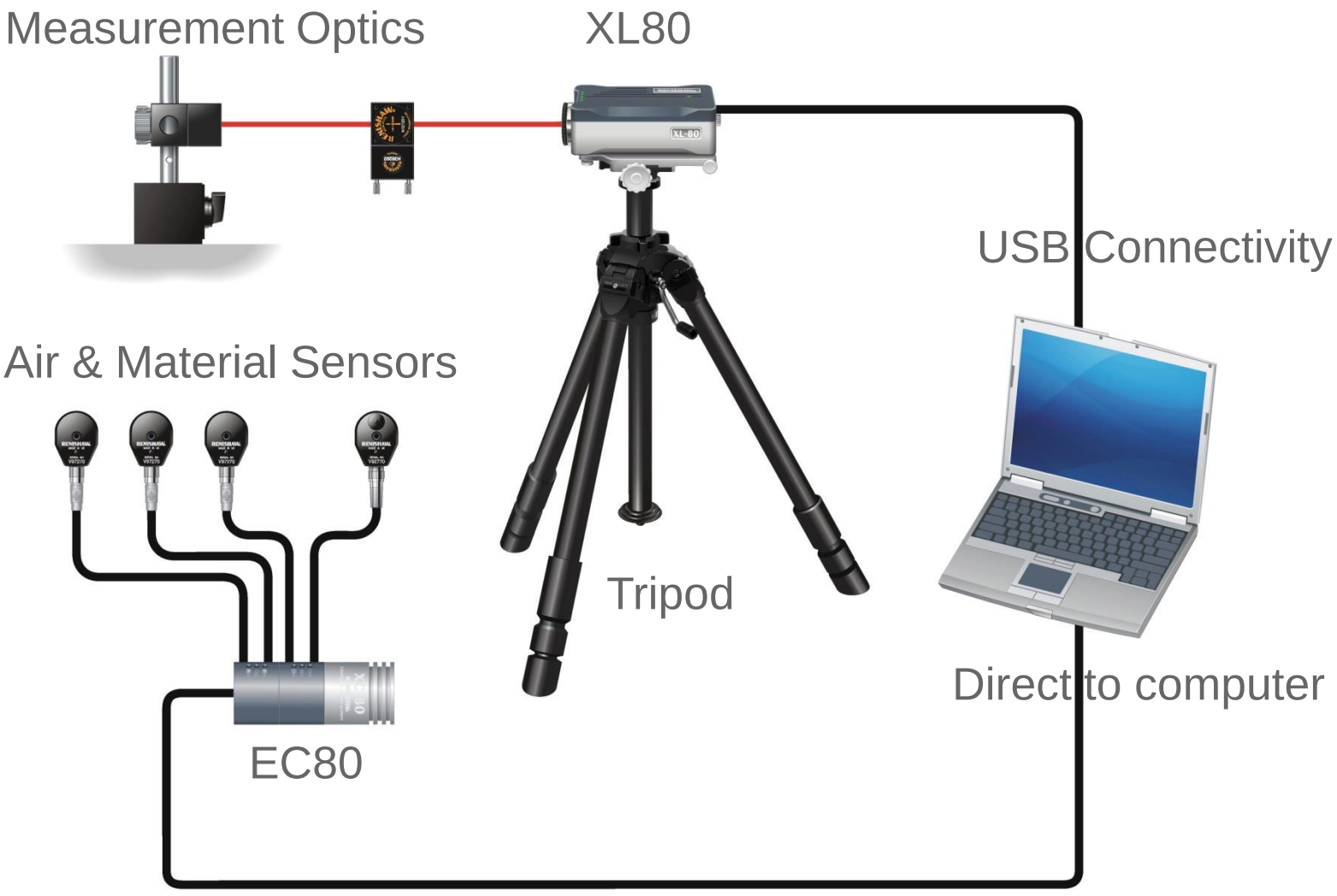
**XL-80 laser system**
Provides a detailed
picture of your
machines positioning
performance

# XL80 Laser System – The Industry Standard

- A Calibration tool used to calibrate Machine Tools, CMM's and motion control systems
- Used for corrective maintenance when and where necessary
- Data gathered is analysed to National & International standards
- Giving traceability back to NPL
- Measurements up to 80 metres
- Output power <1mW (class II) Eye safe laser


- Most accurate laser on the market of it's type +/- 0.5 ppm

# XL80 laser system



# XL80 laser system

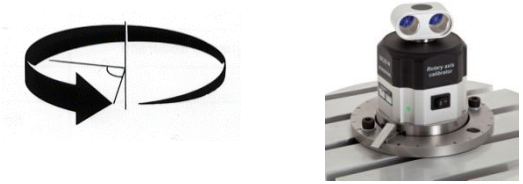
**Linear accuracy & repeatability**

**Angular (pitch & yaw)**

**Squareness**

**Straightness**

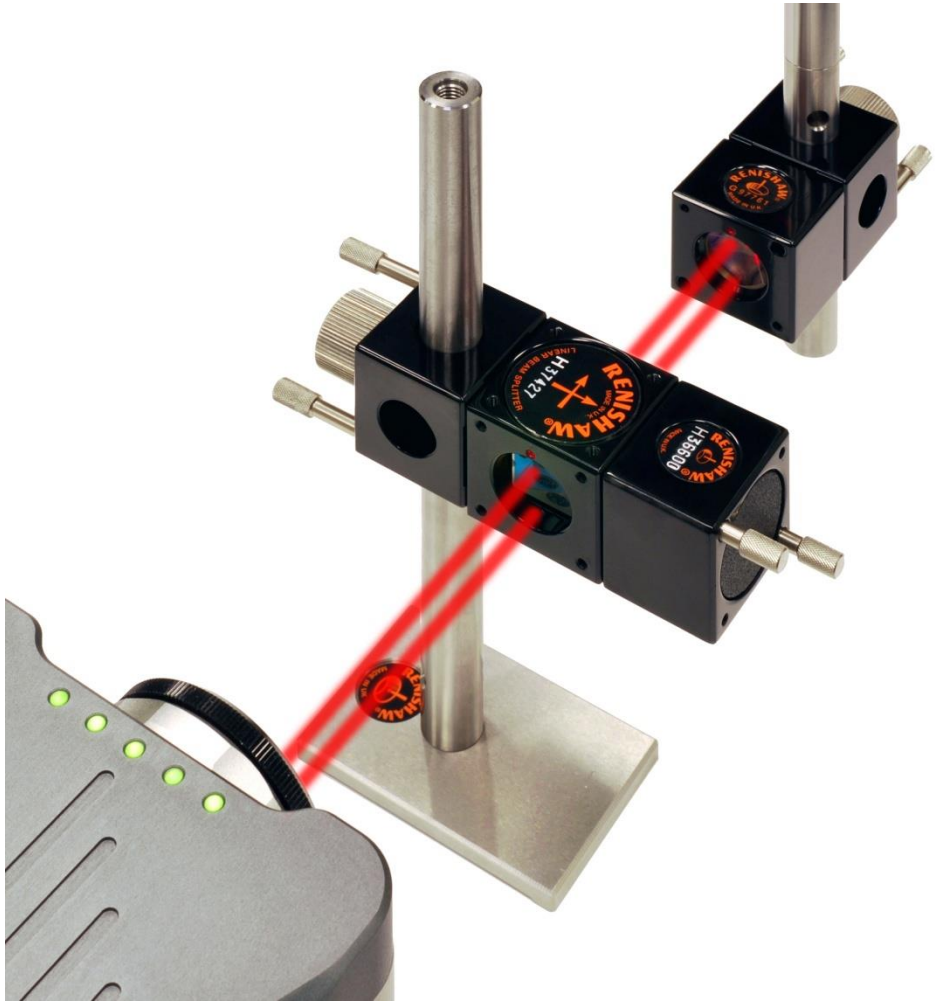
**Rotary axes**



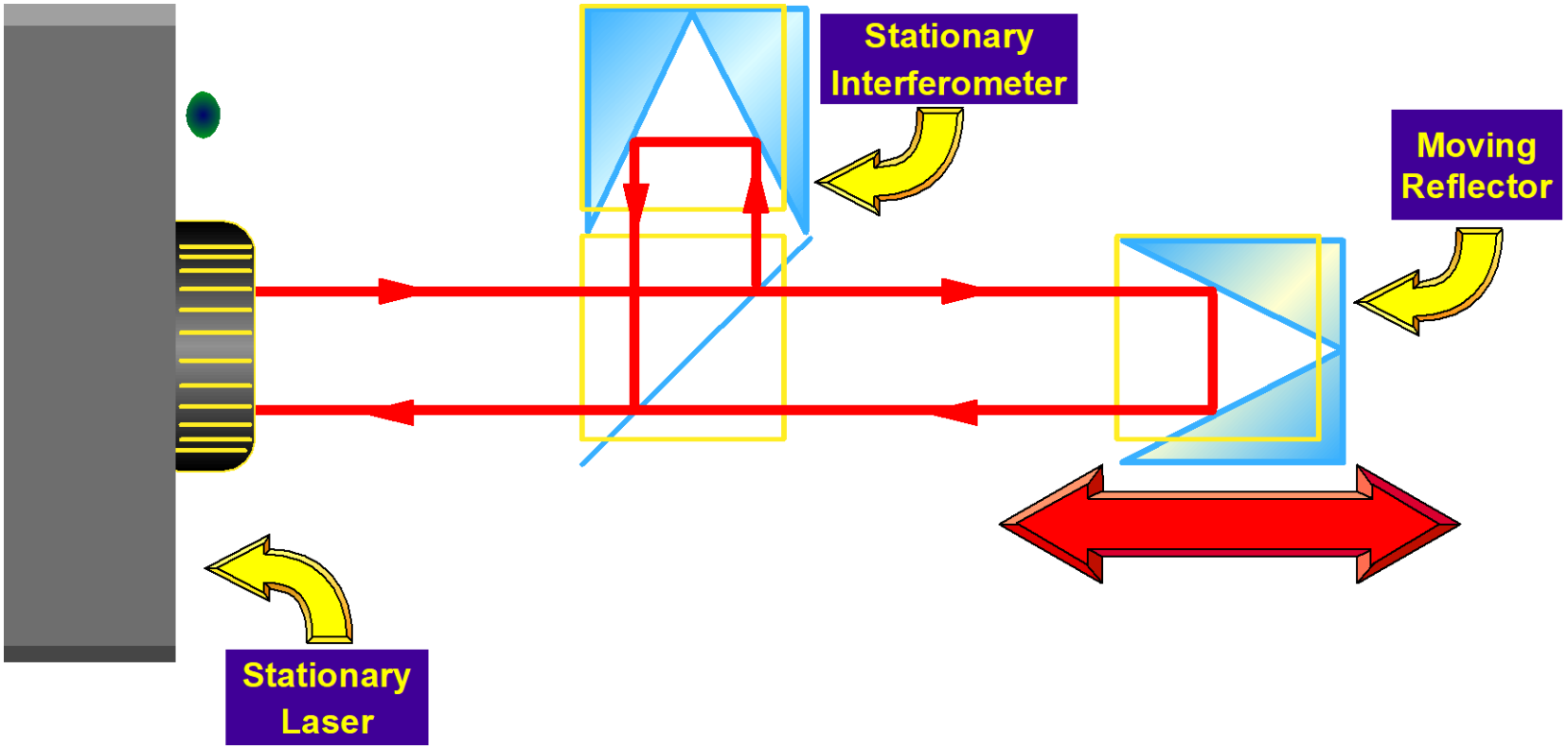
**Flatness**

# Example Linear set-up

- Position - Over travel & Under travel
- Repeatability
- Dynamic
- Automatic linear error compensation

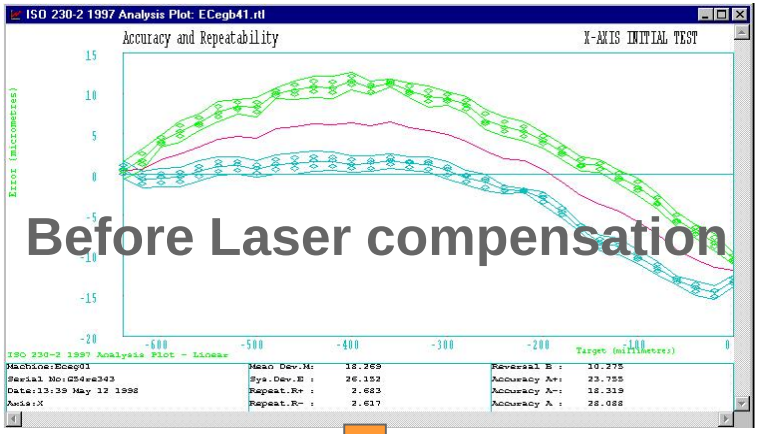


# Linear Measurement

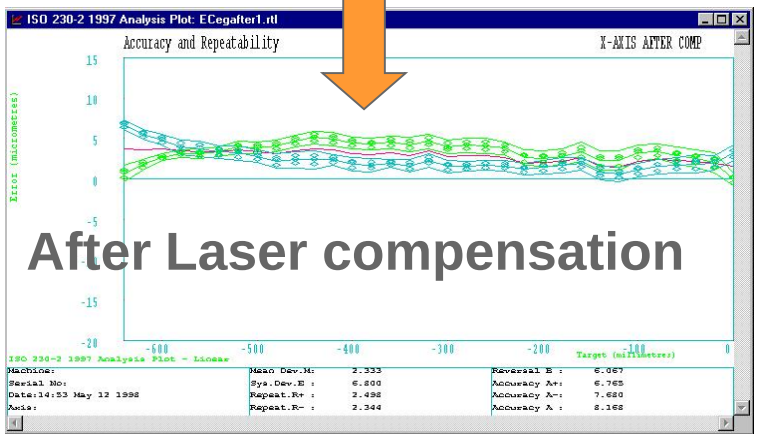


# Before and after linear correction

- XL80 improves machining accuracy...

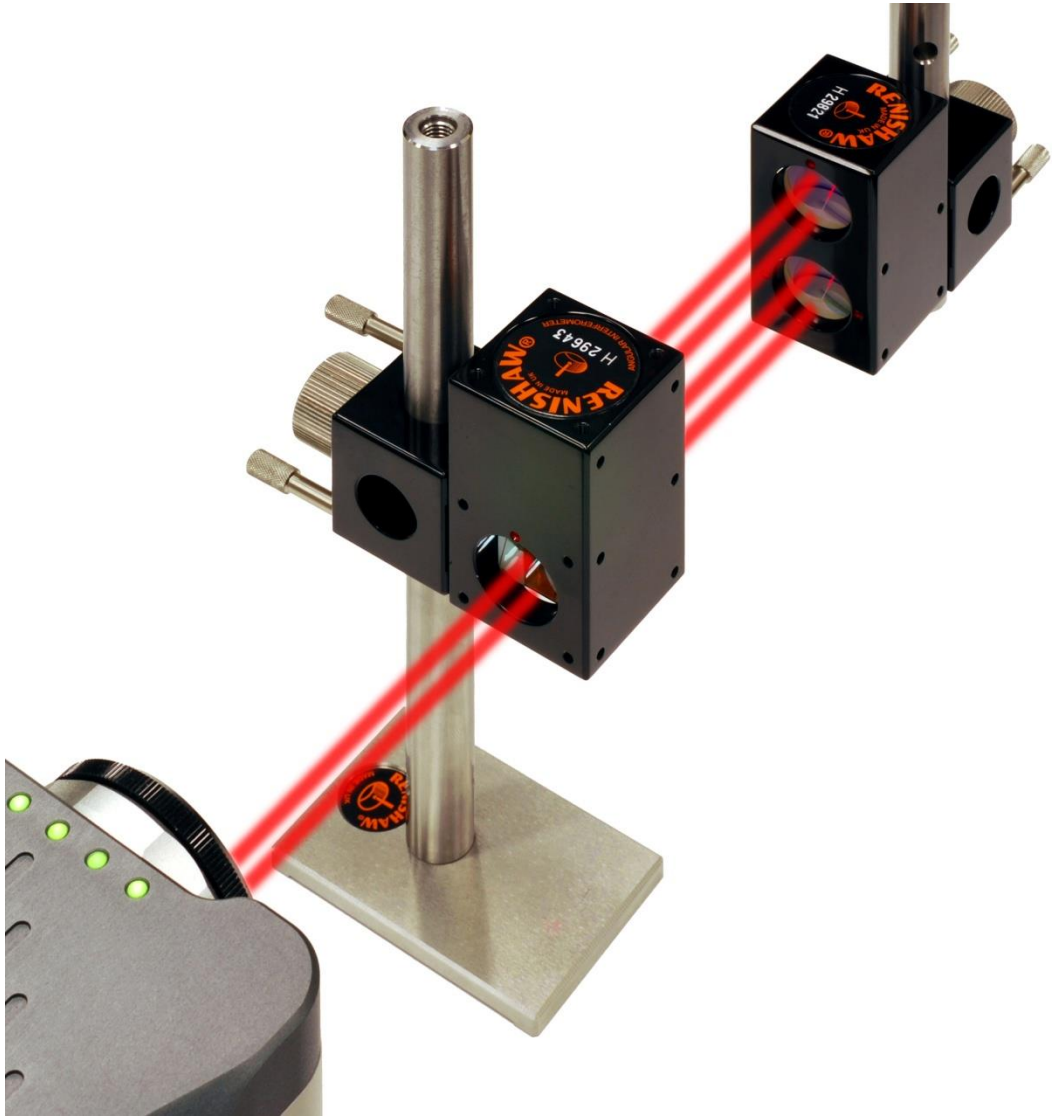



- Before Laser compensation




- After Laser compensation

# Angular measurement

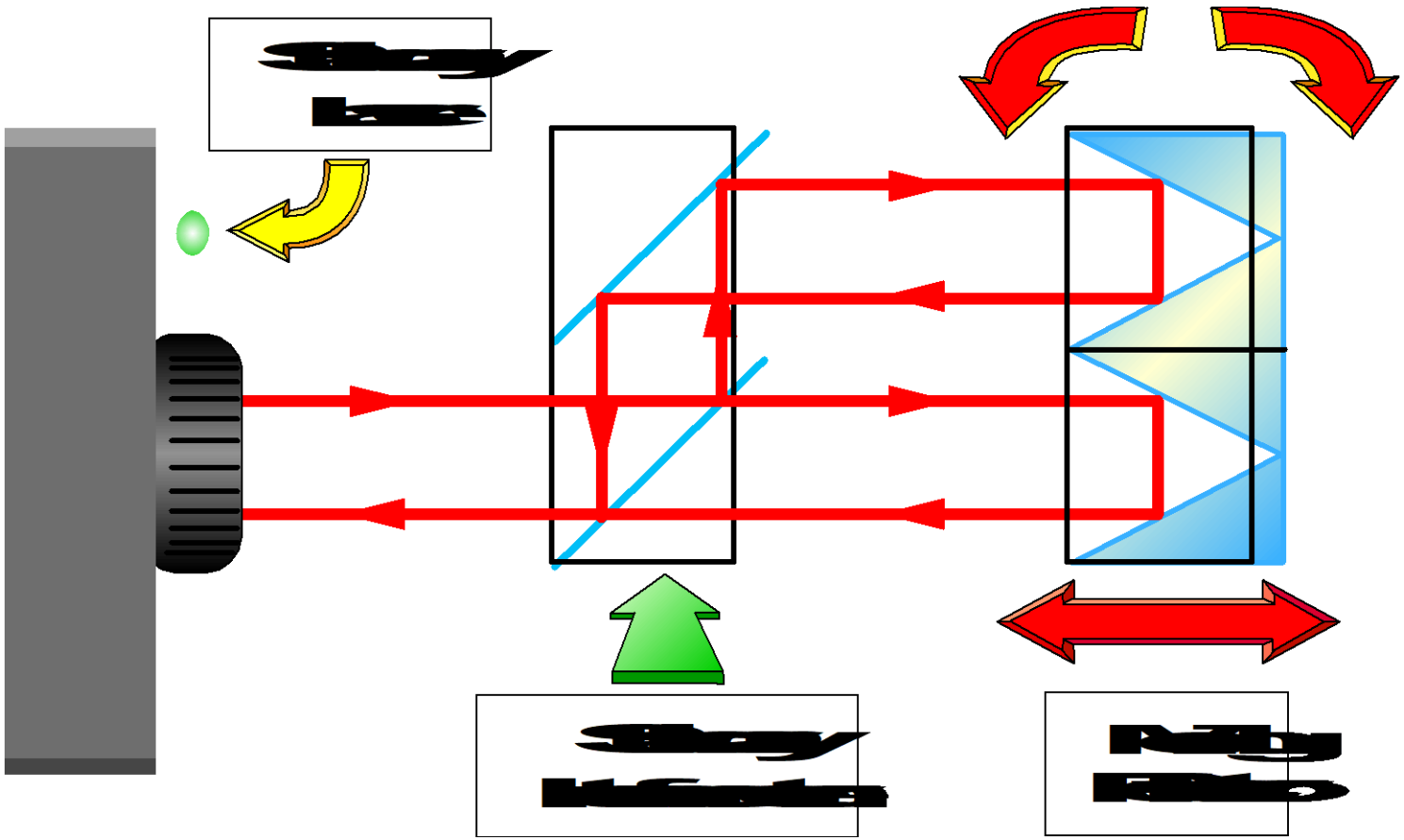



PITCH

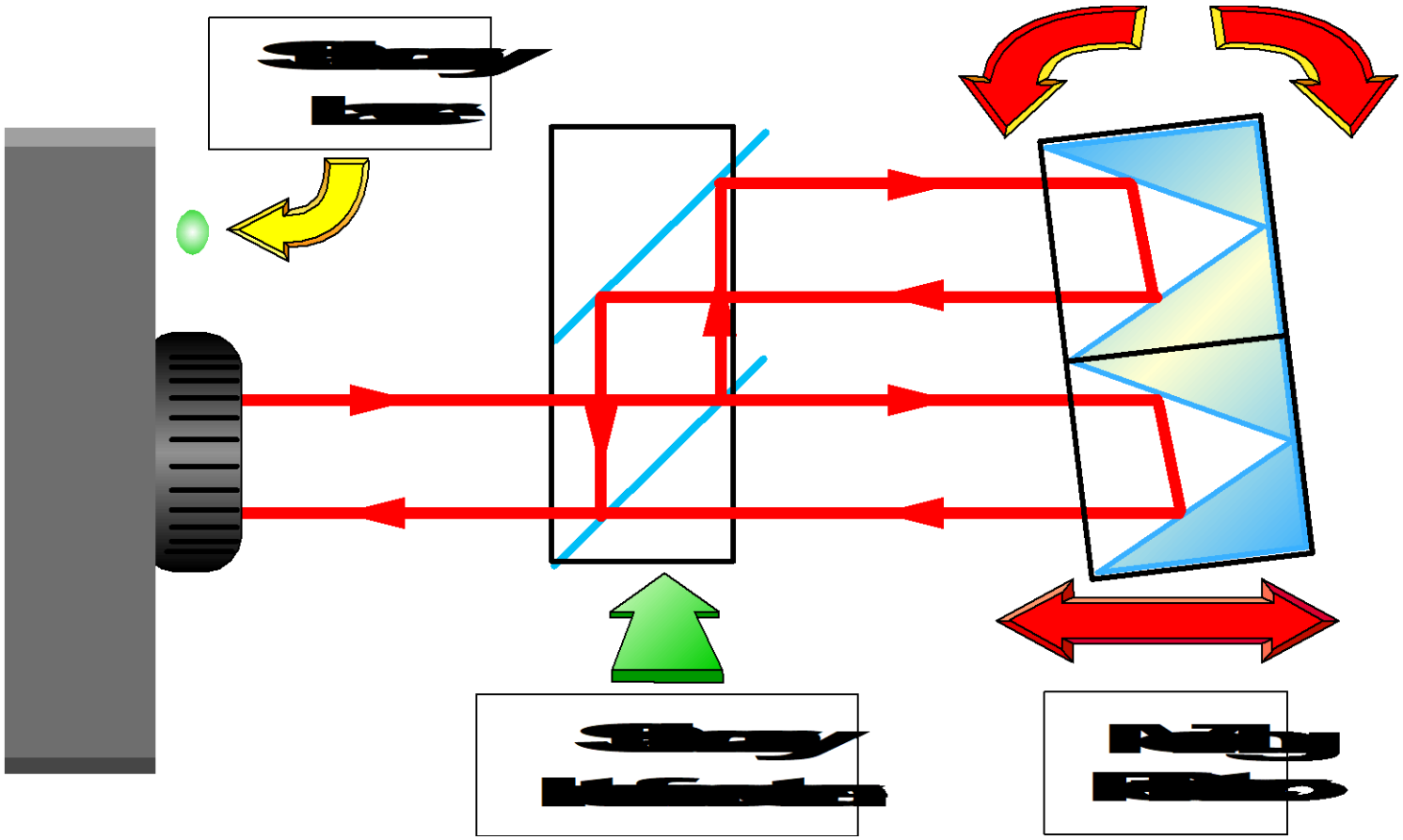
&

YAW

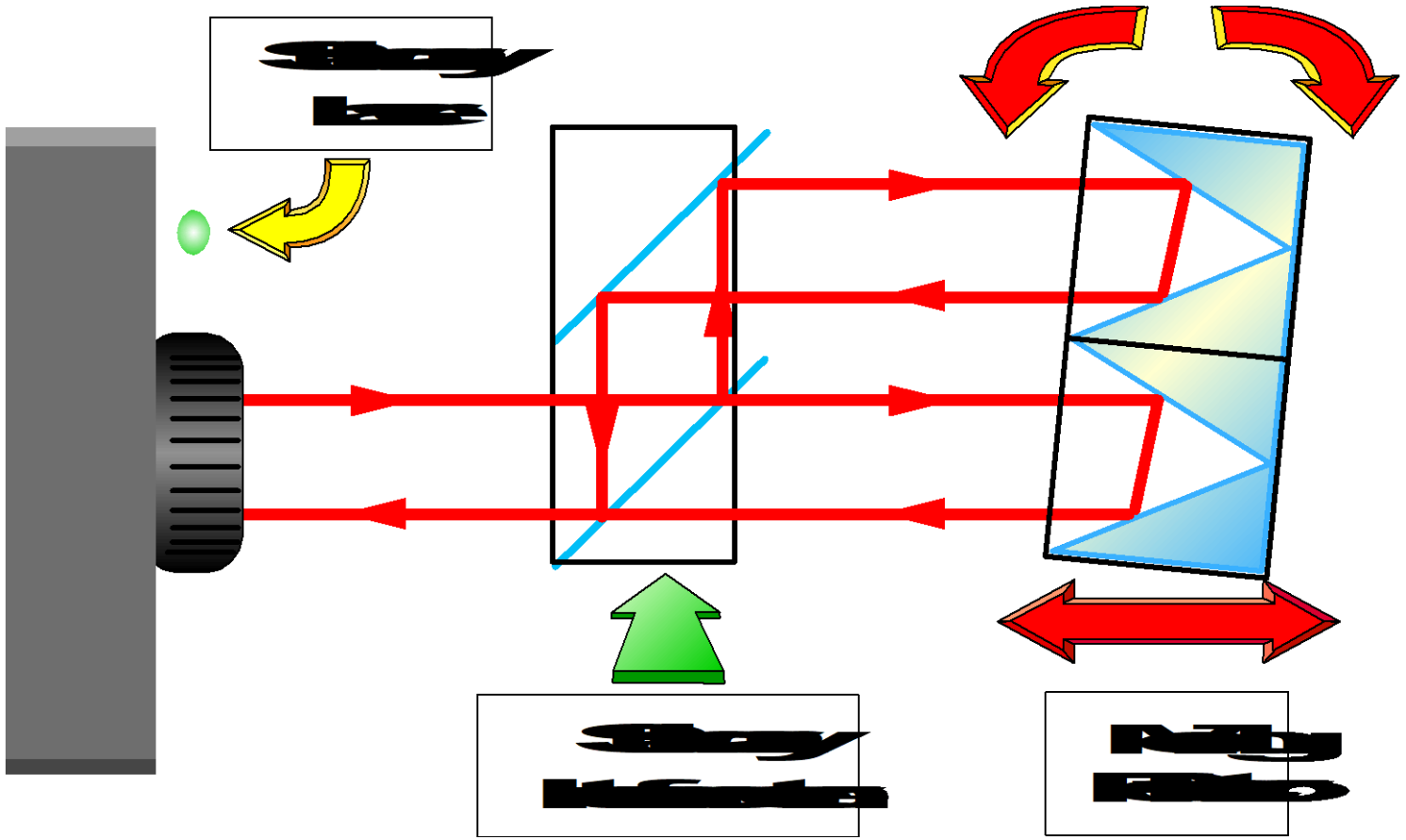
# ANGULAR MEASUREMENT



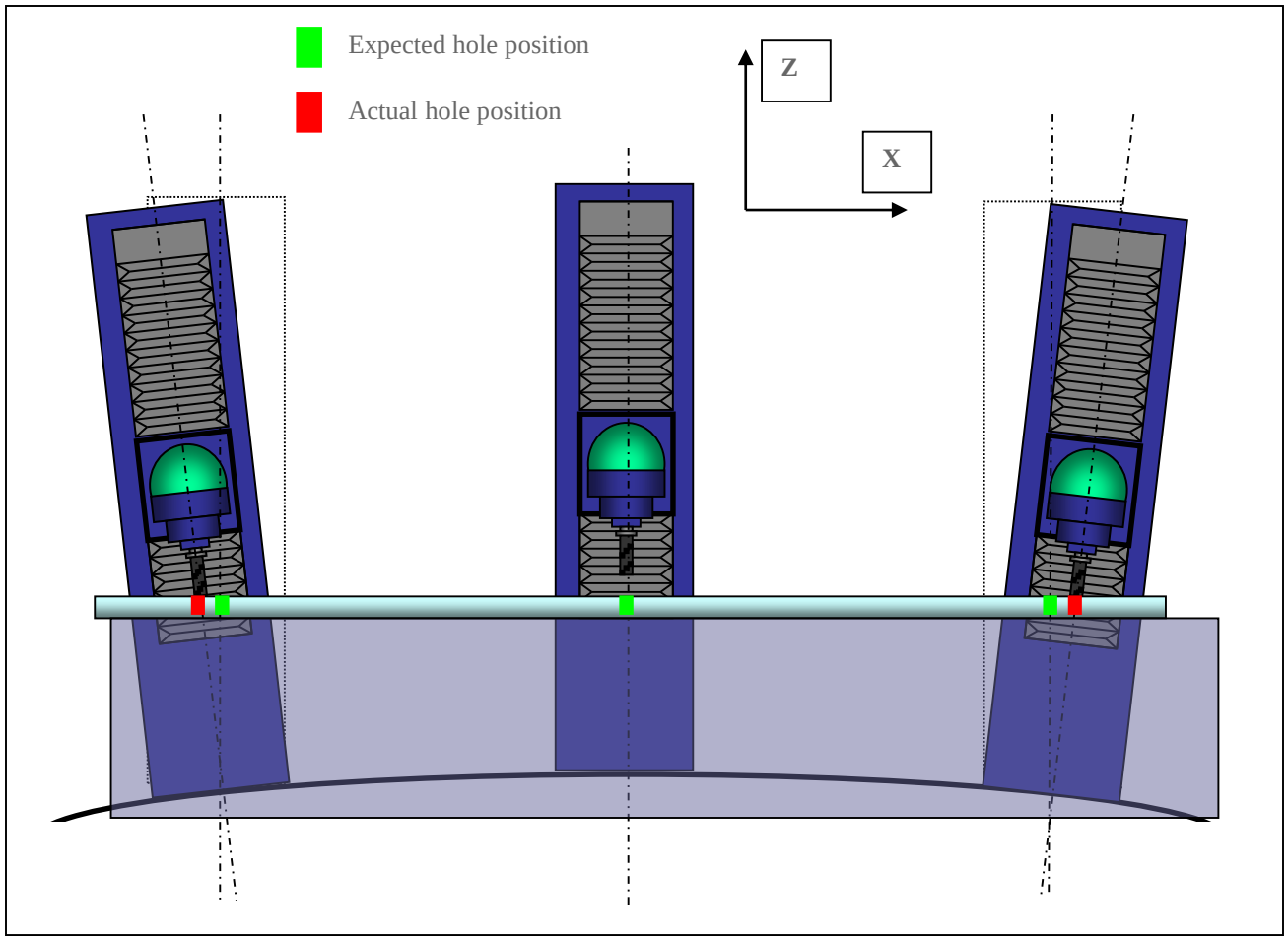
# ANGULAR MEASUREMENT



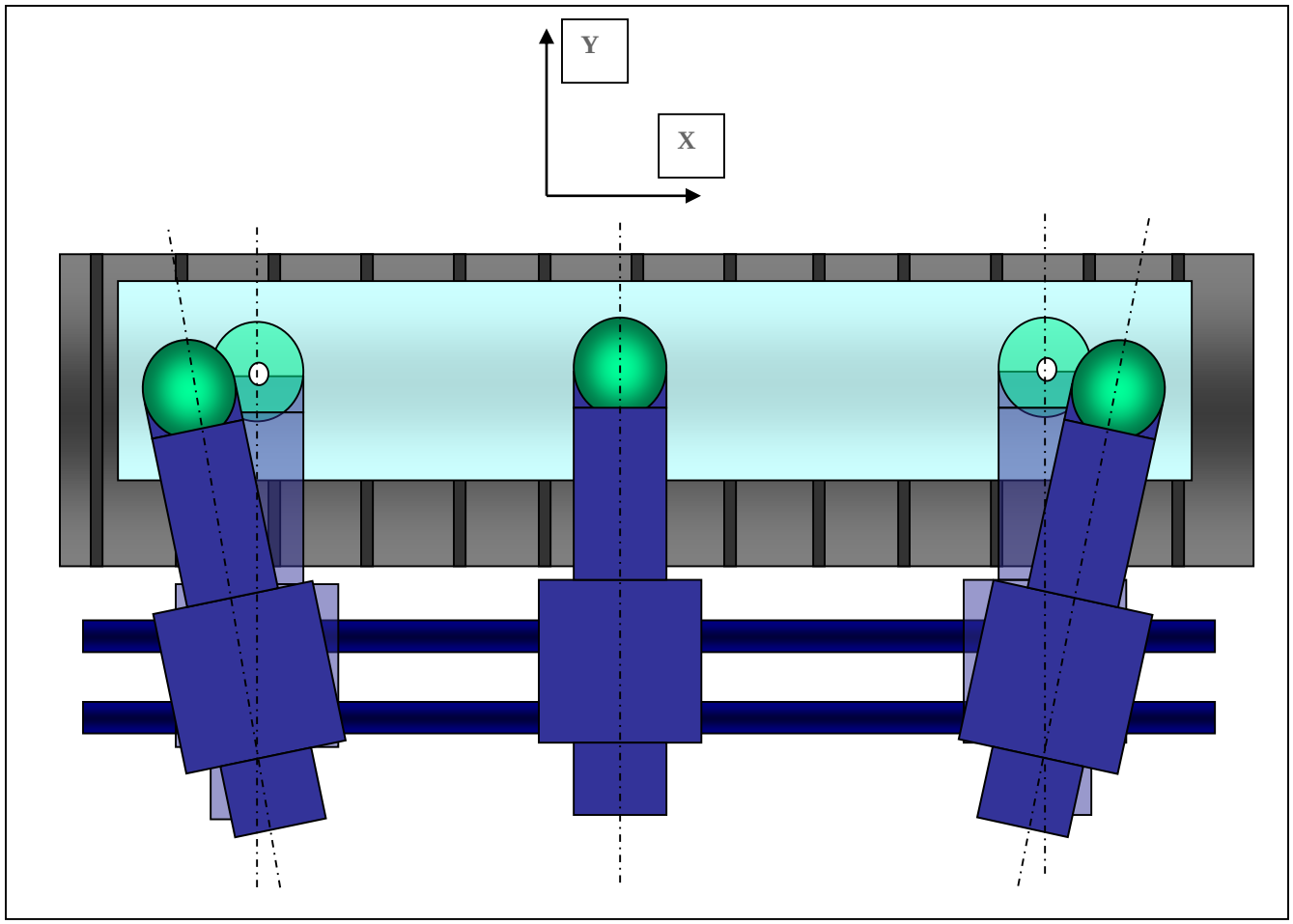
# ANGULAR MEASUREMENT



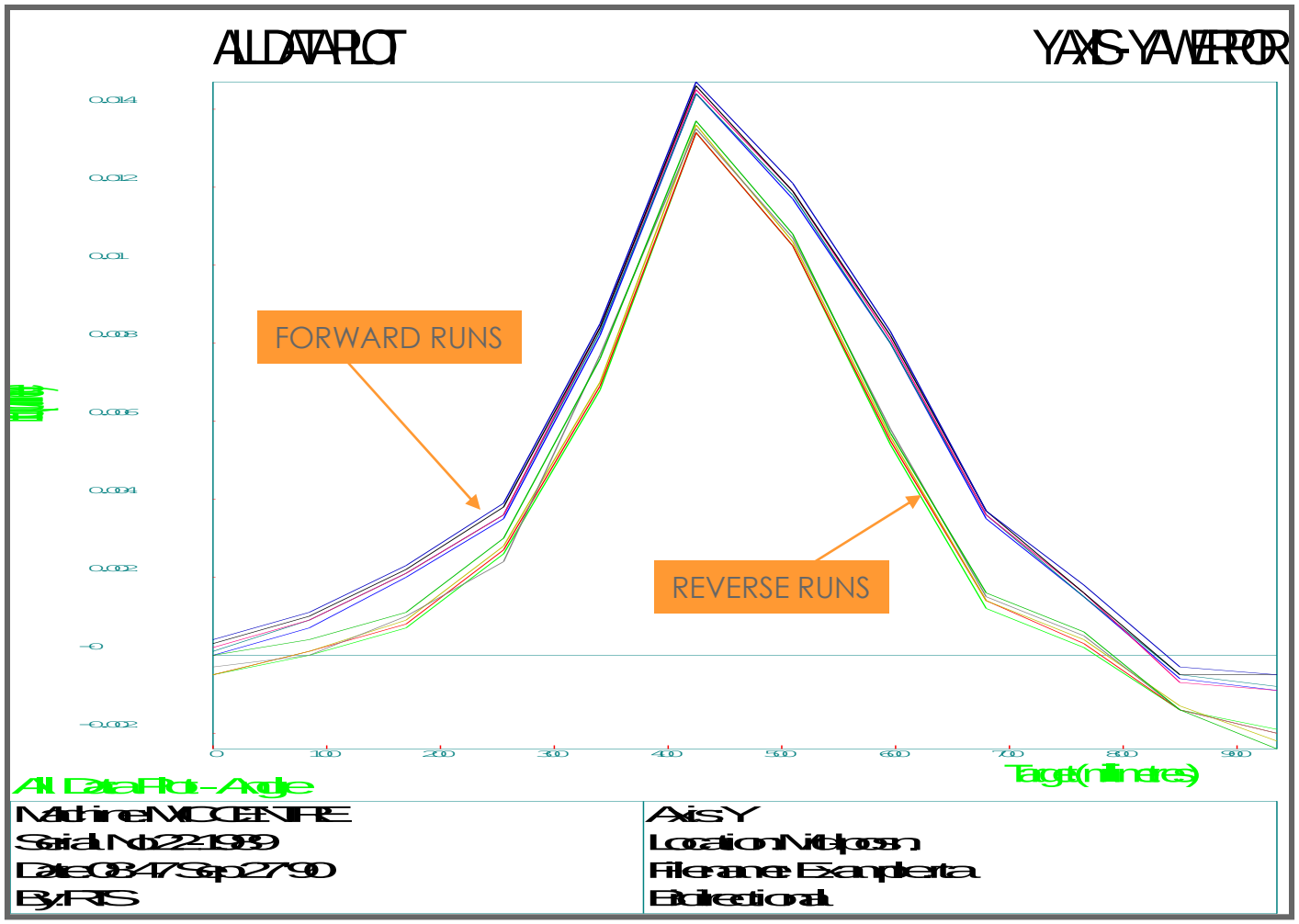
# Effect of Pitch – Z and X axis Positional Errors



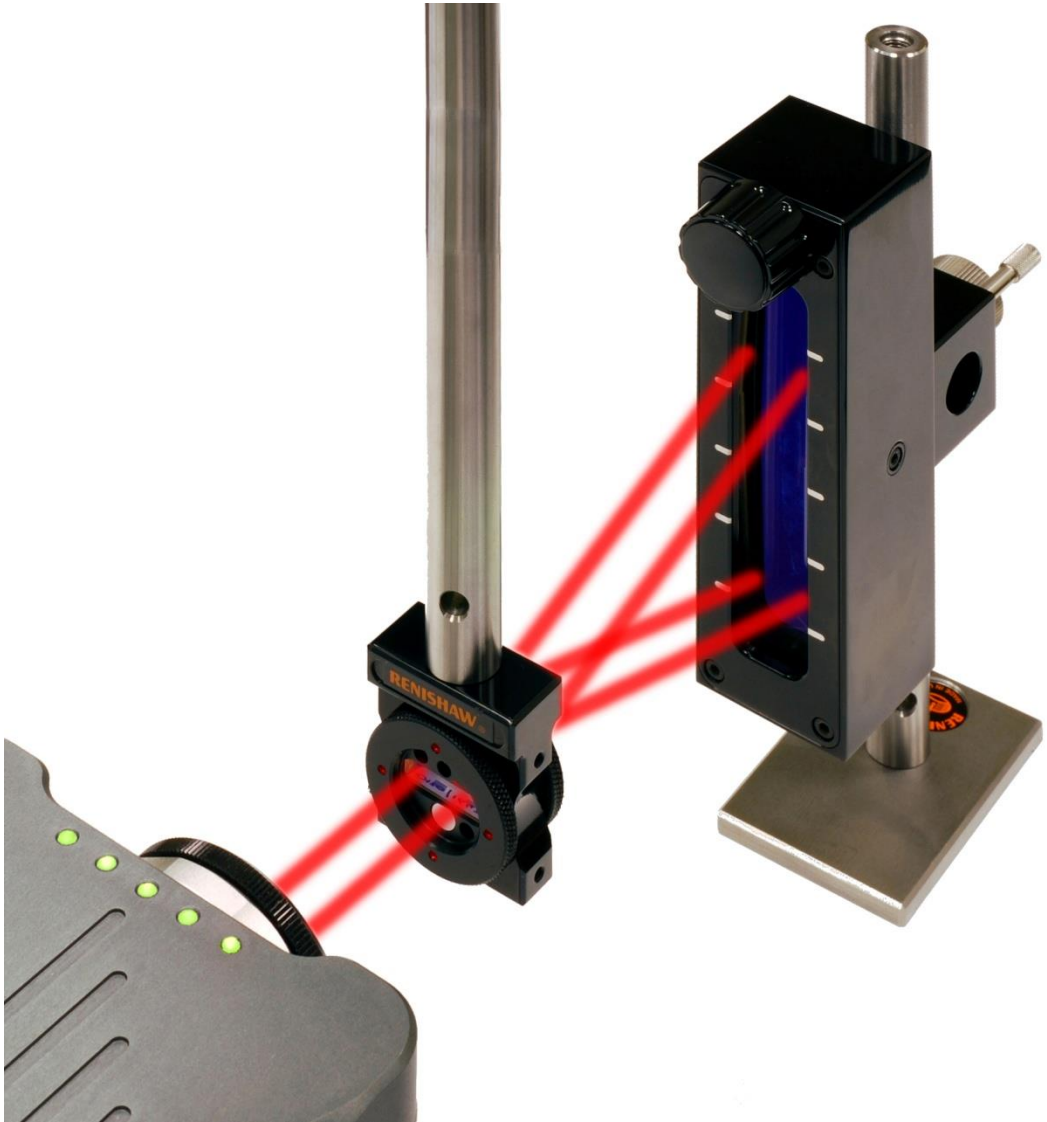
# Effect of Yaw – X and Y axis Positional Errors



# Typical angular result

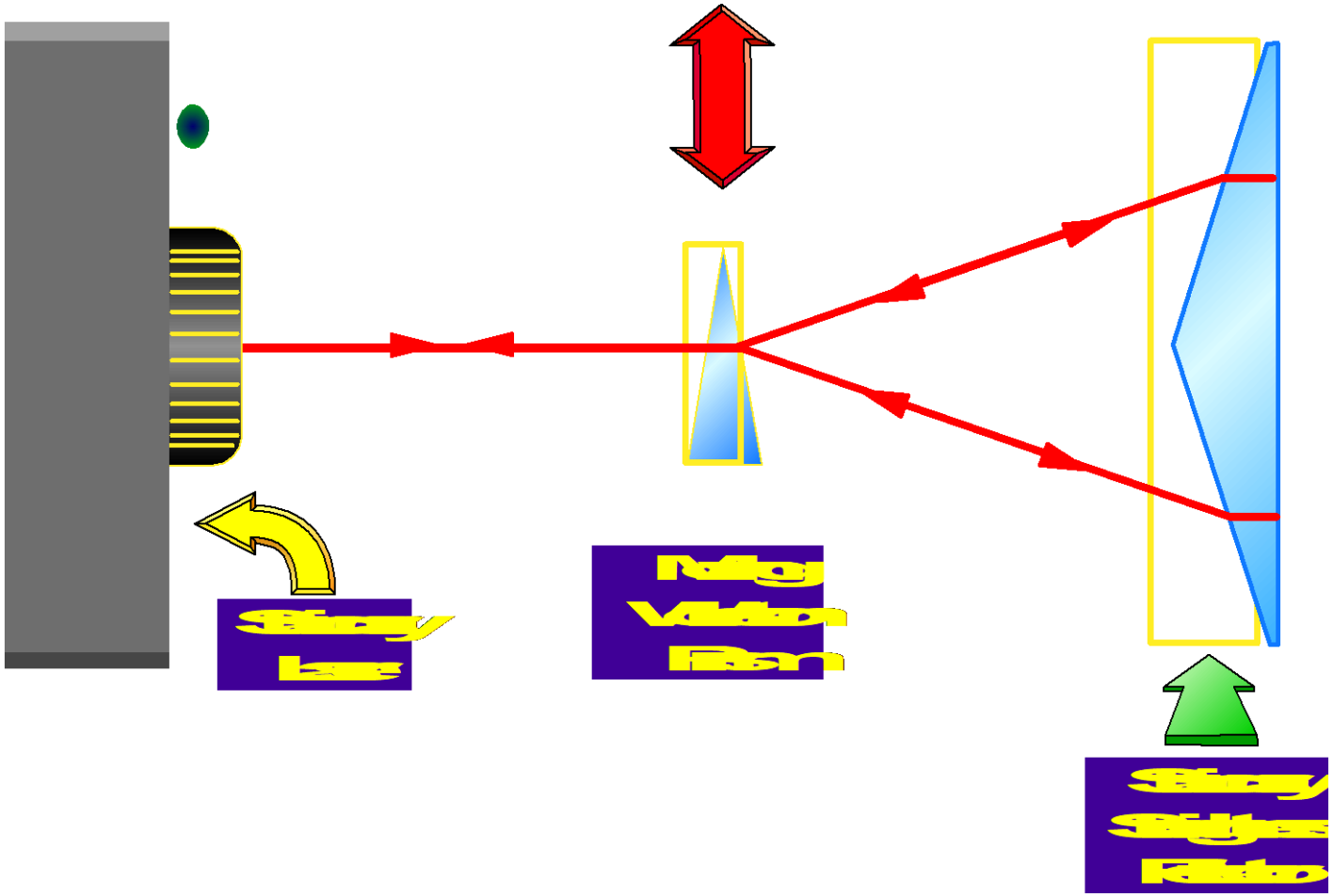


# Straightness Measurement

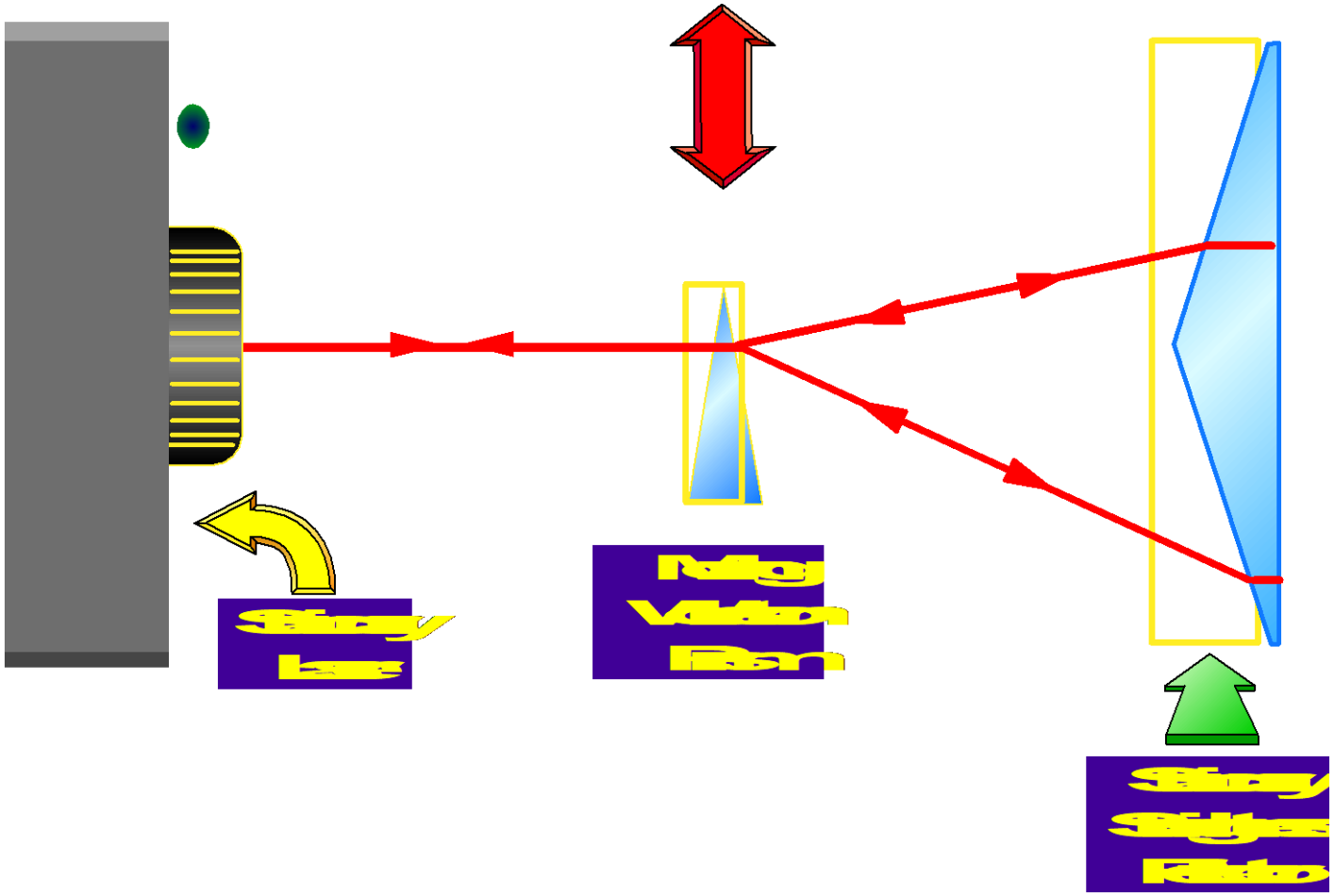



- BENDING OF SLIDES
- WEAR IN SLIDES
- MISALIGNMENT IN GUIDEWAYS

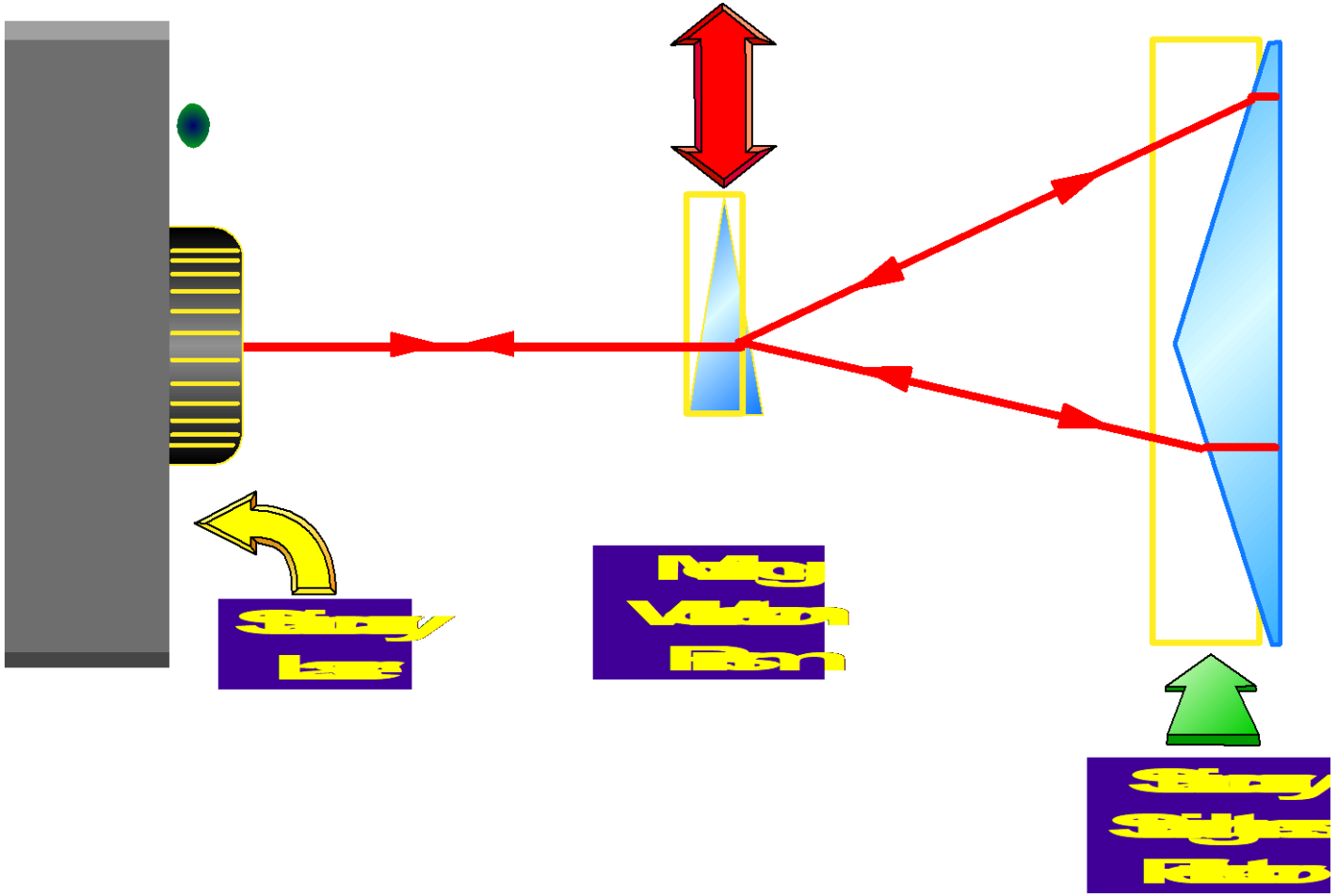
# Straightness Measurement



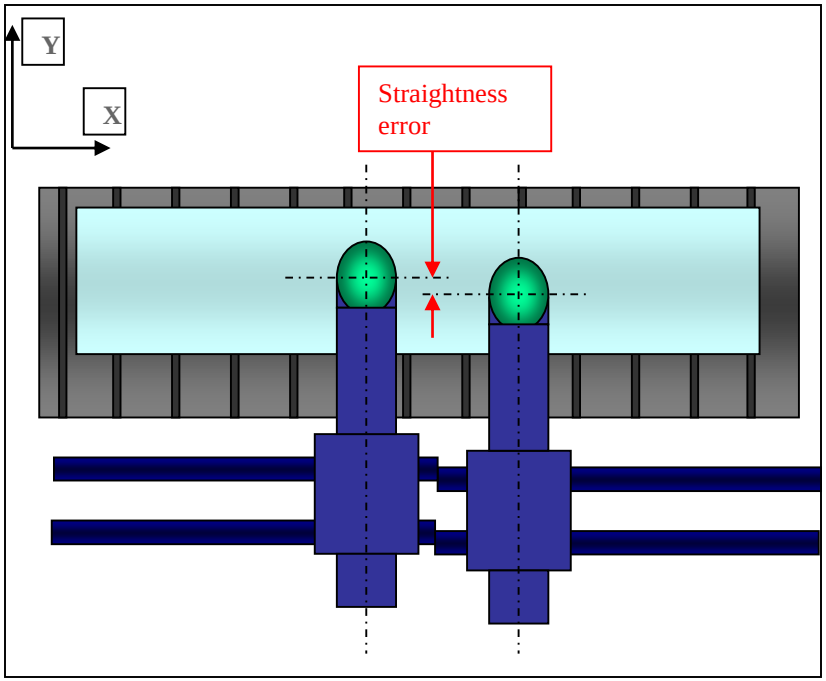
# Straightness Measurement

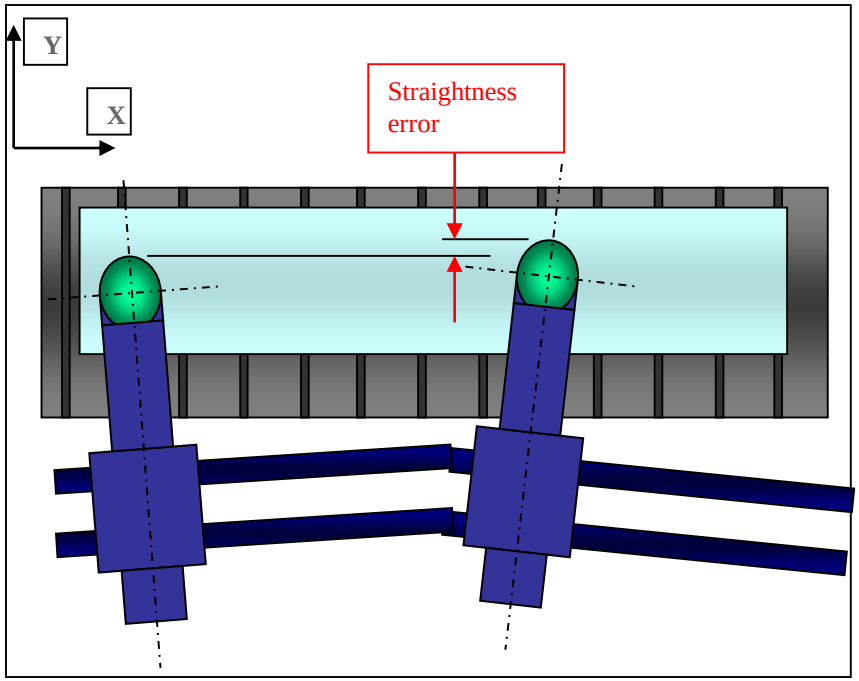


# Straightness Measurement

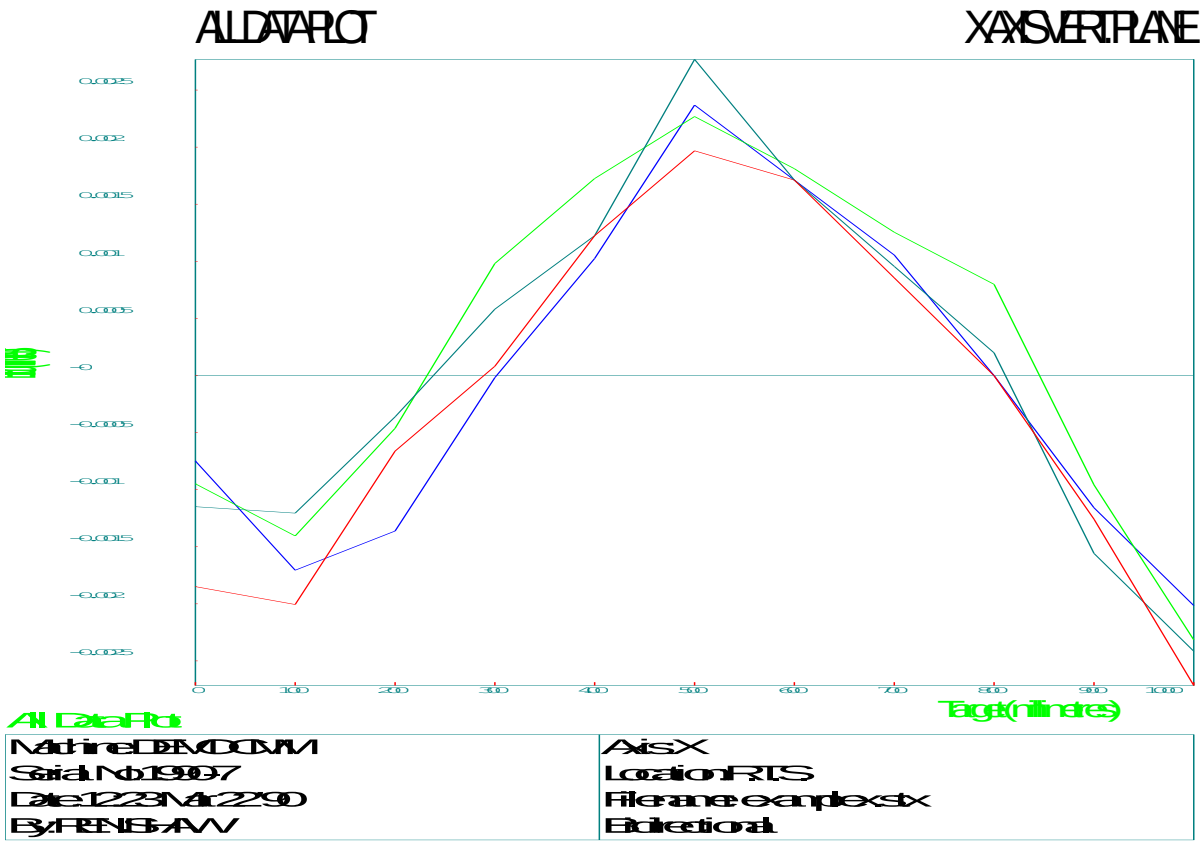


# Effects of Straightness



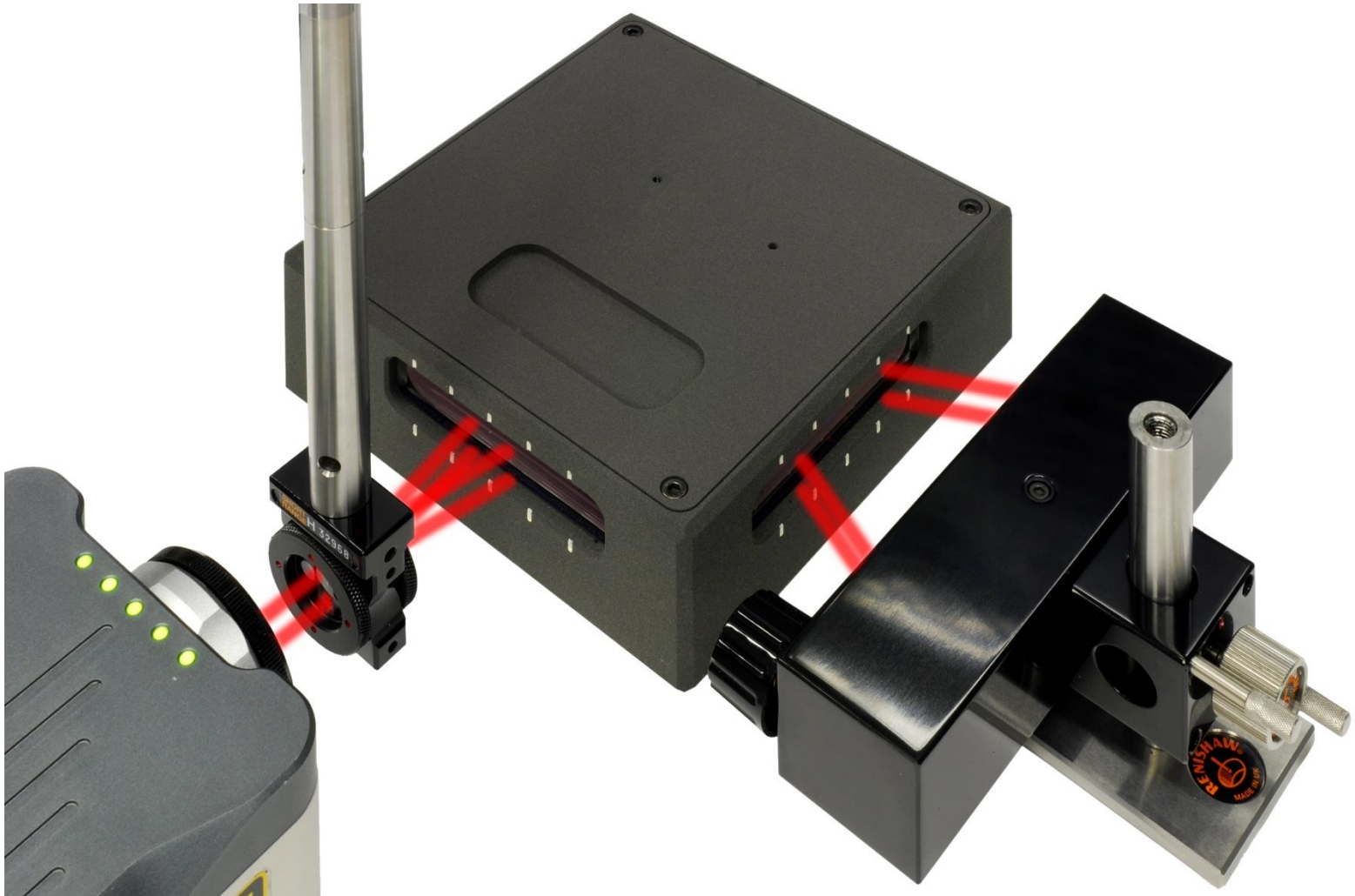



# Straightness Measurement

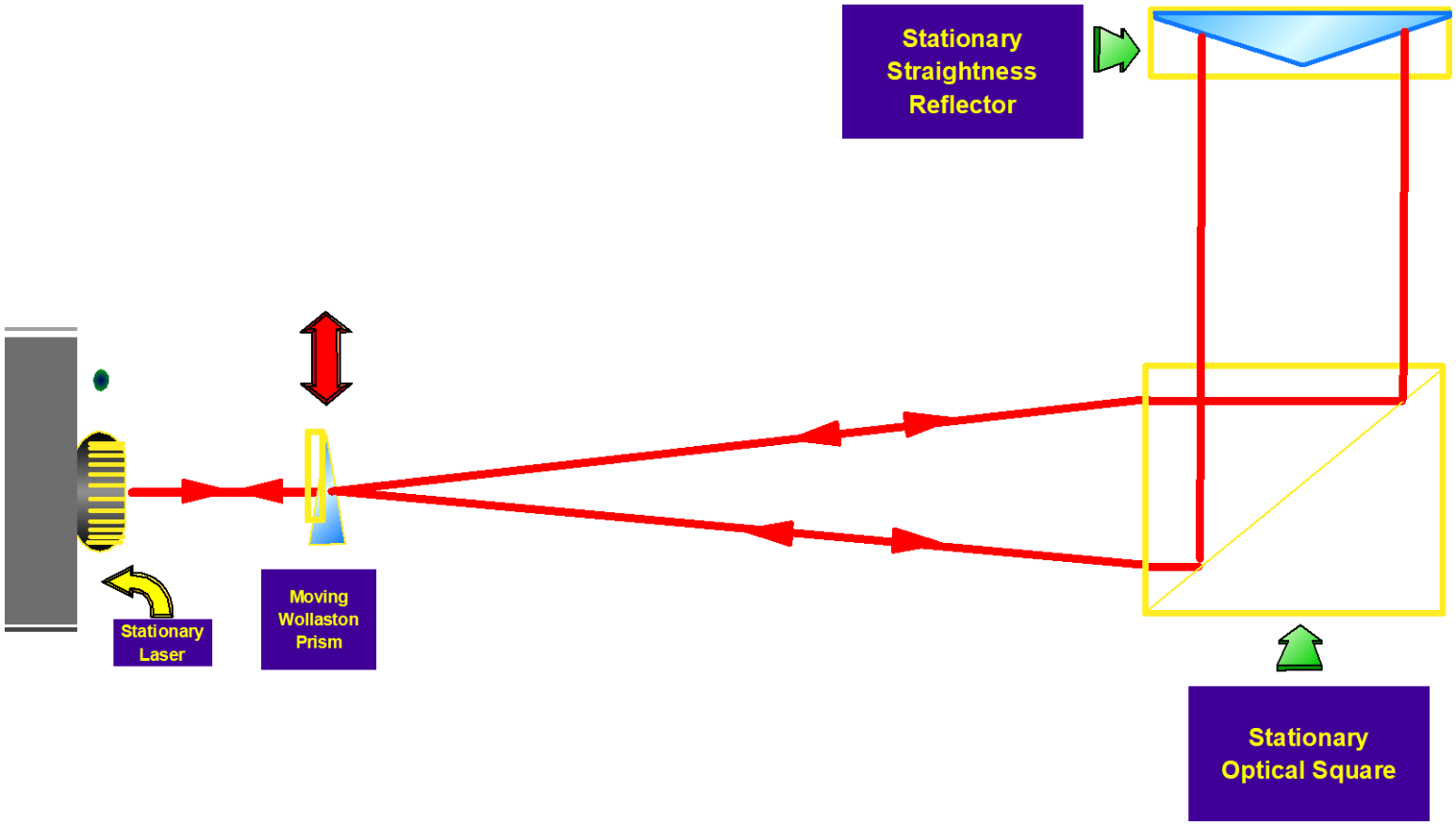


# Squareness Measurement

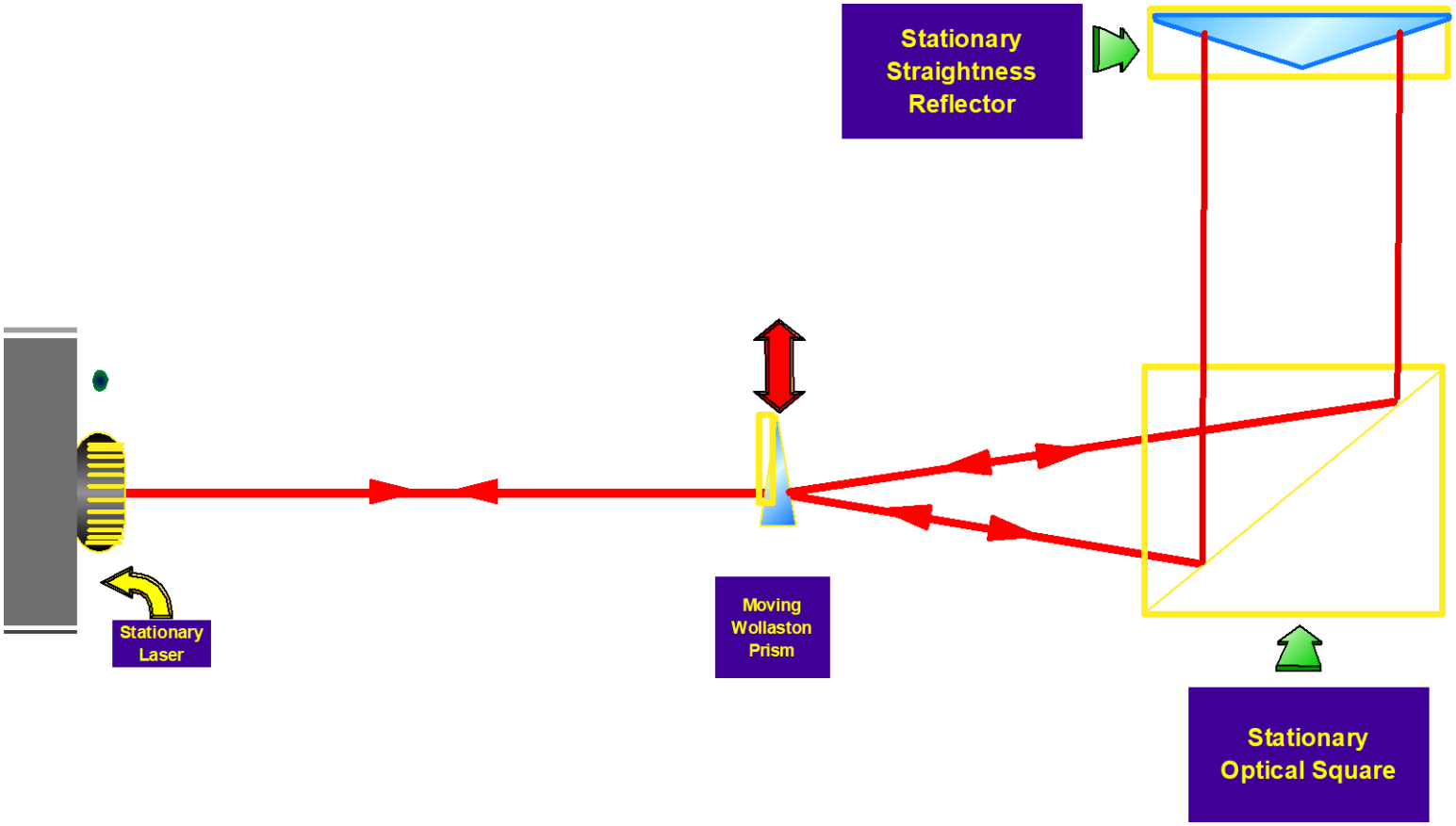
- Determines the out-of square of two axes



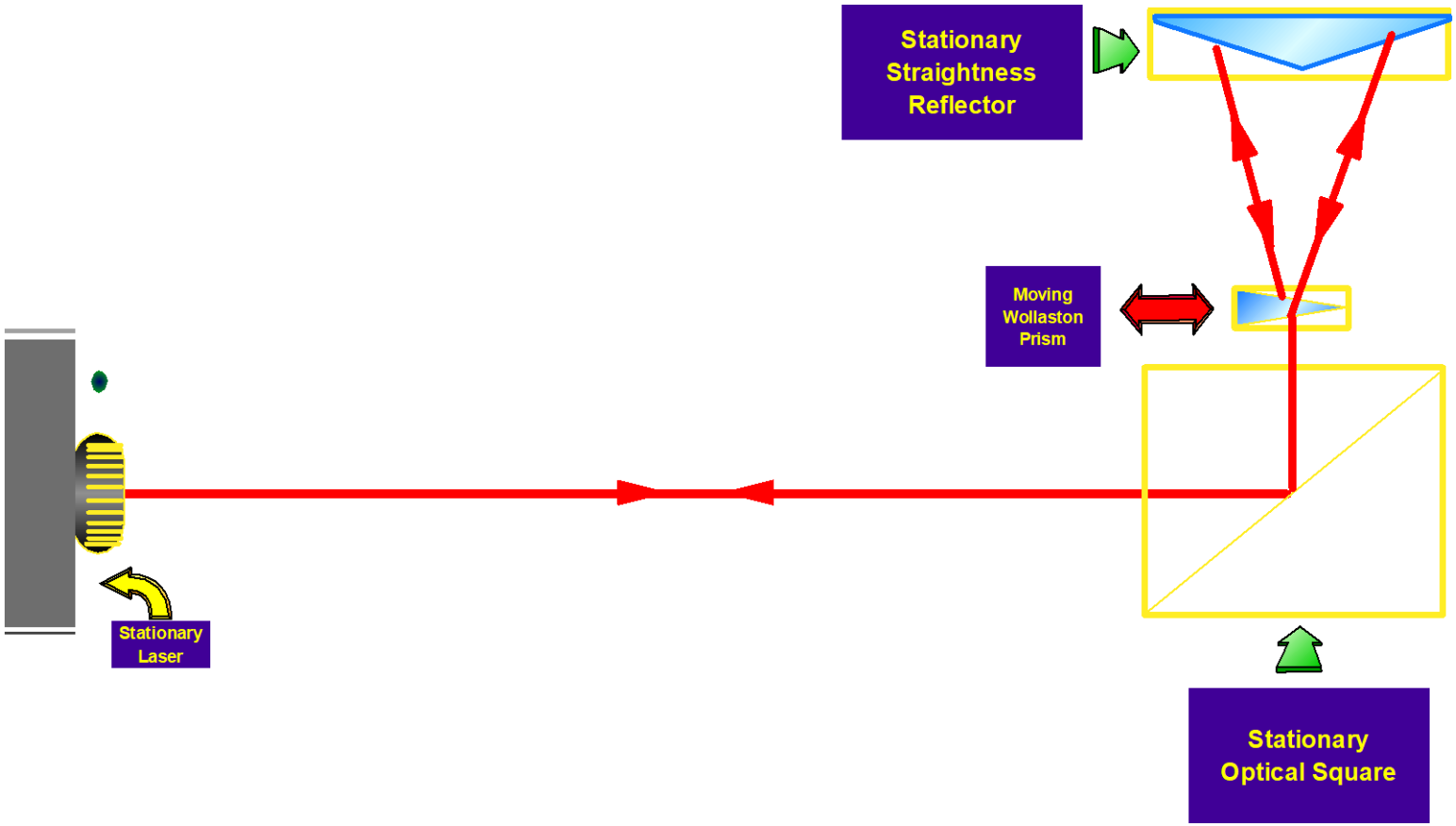
# Squareness Measurement



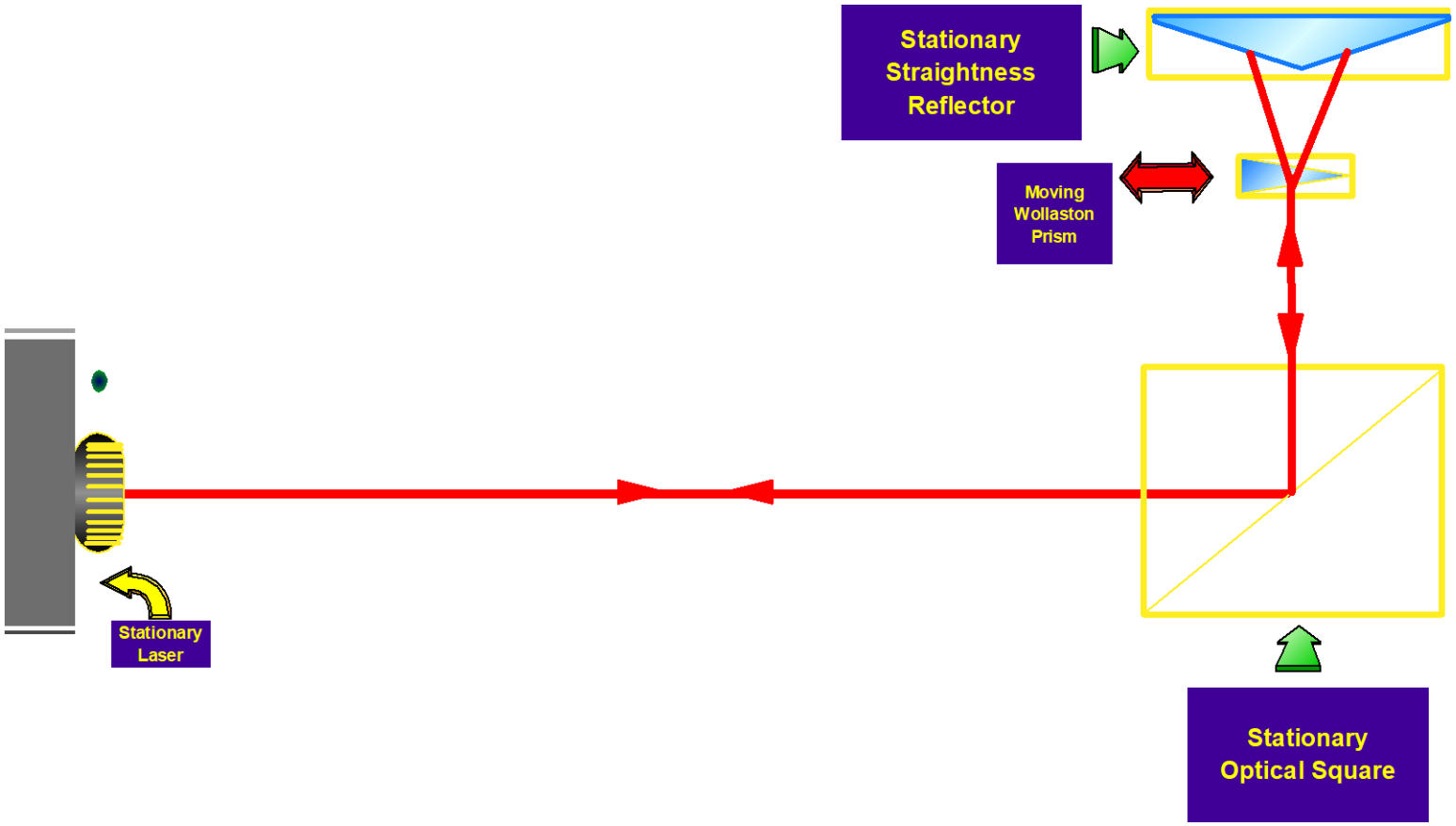
# Squareness Measurement



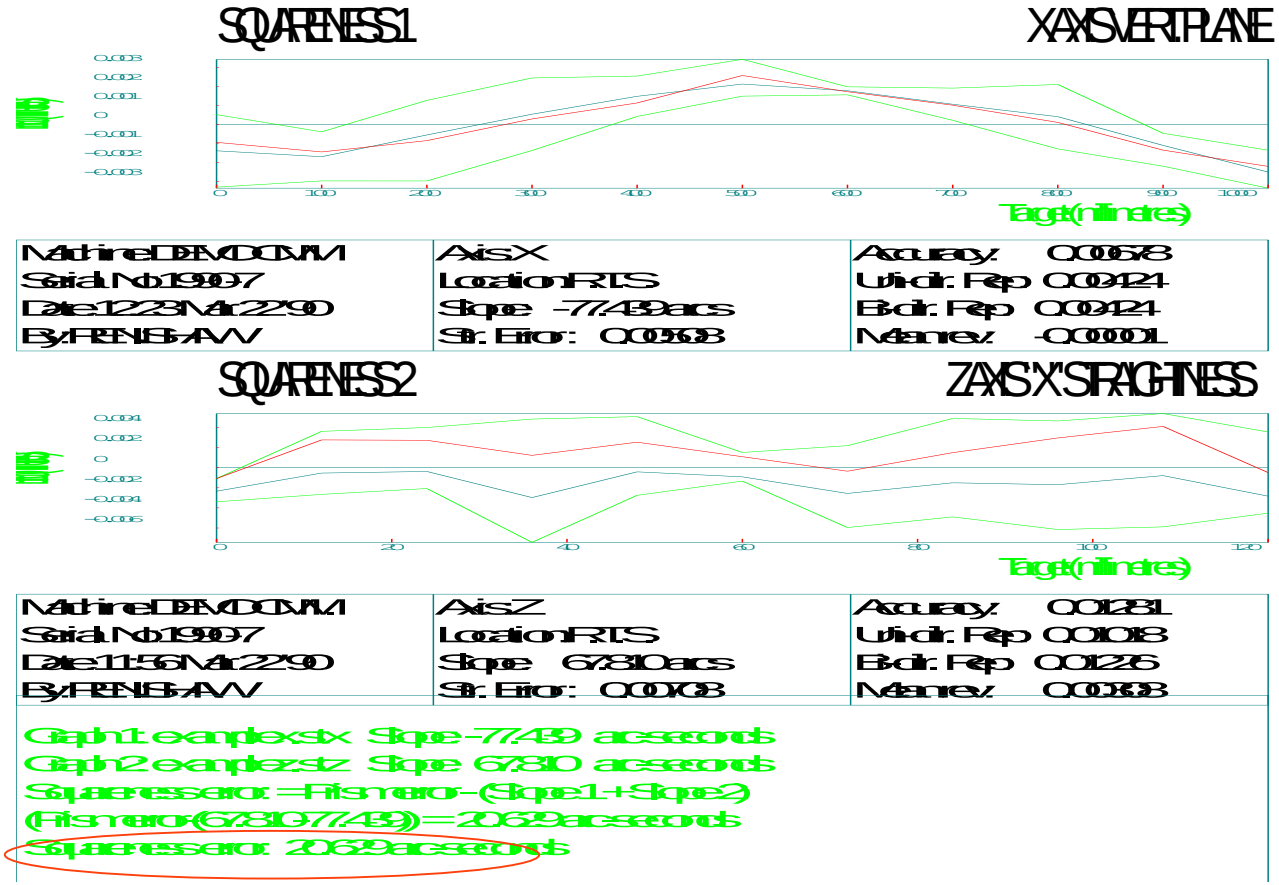
# Squareness Measurement



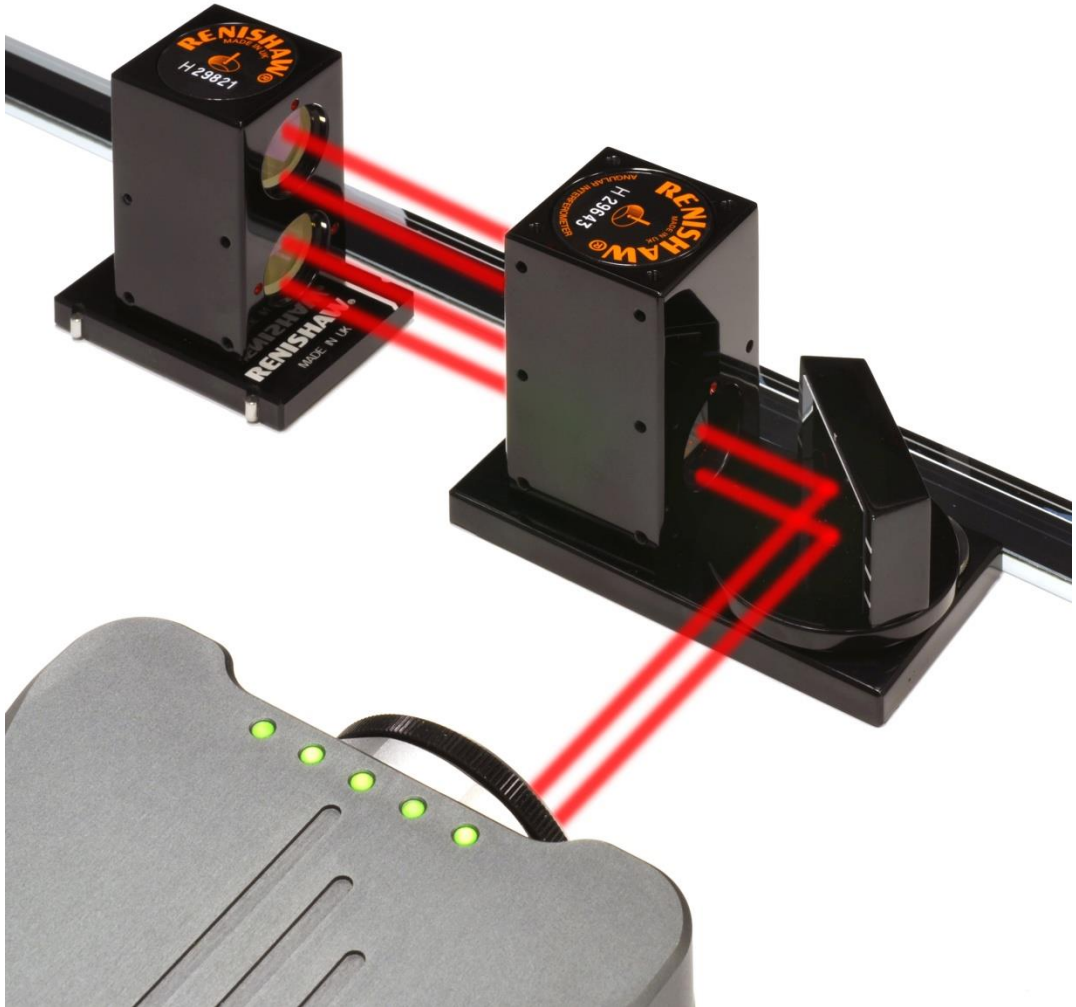
# Squareness Measurement



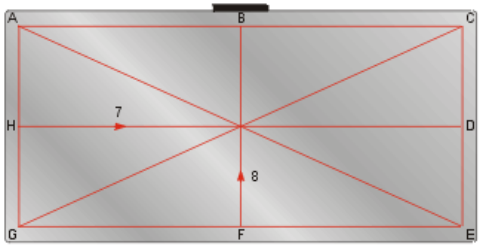
# Squareness Measurement



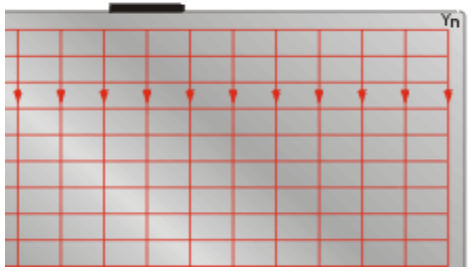
# Flatness Measurement



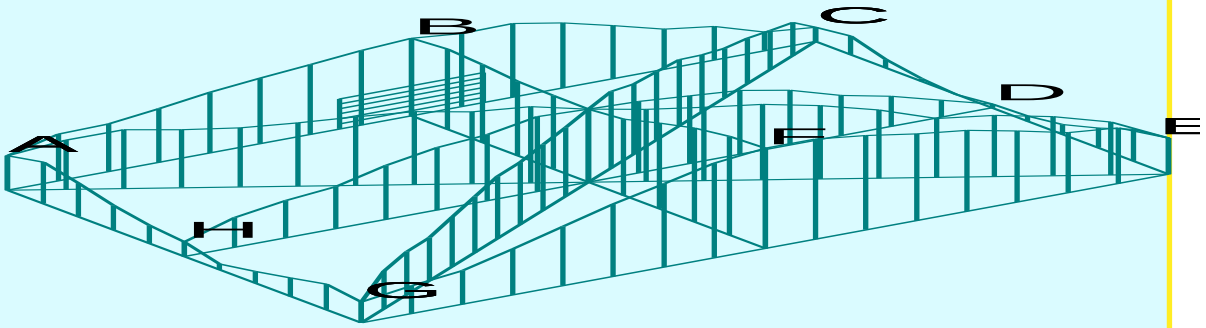

- Moody Method




- Grid Method



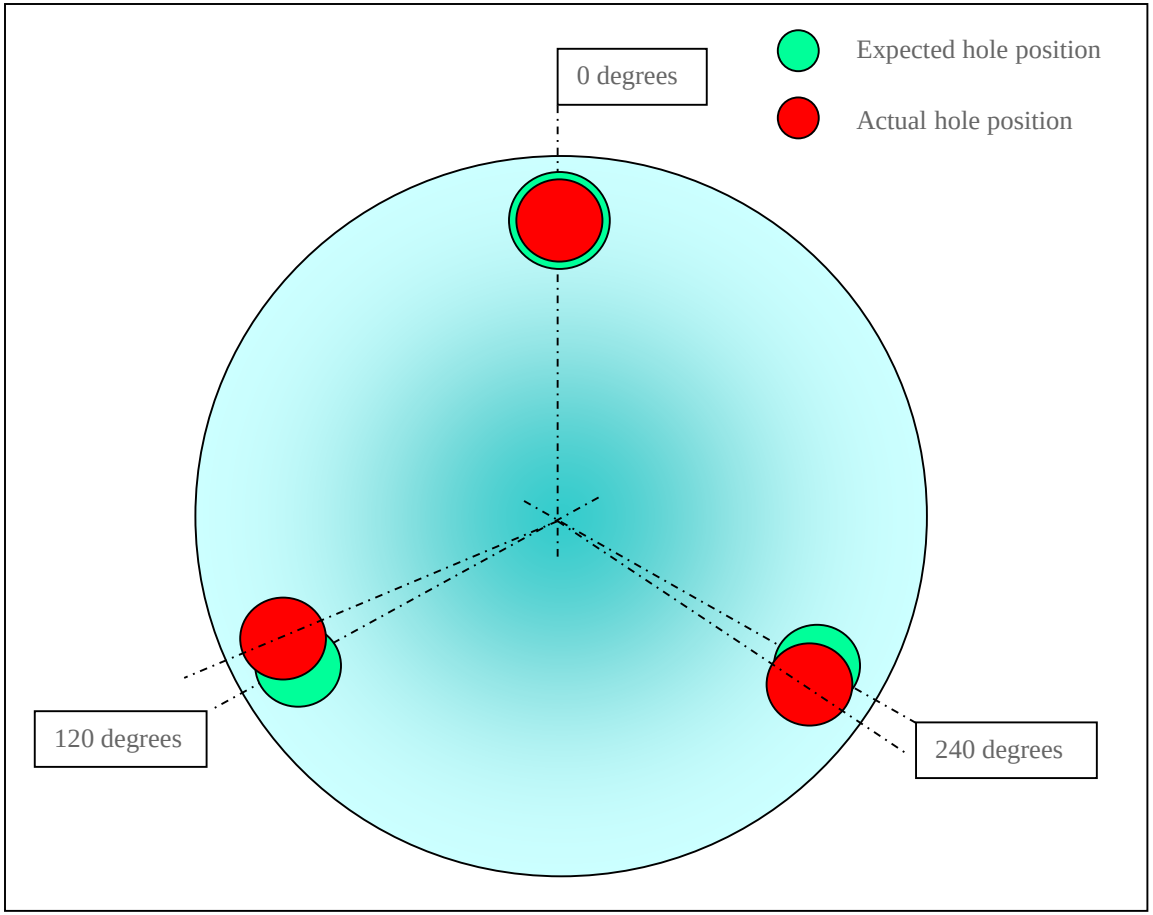
# Flatness Measurement



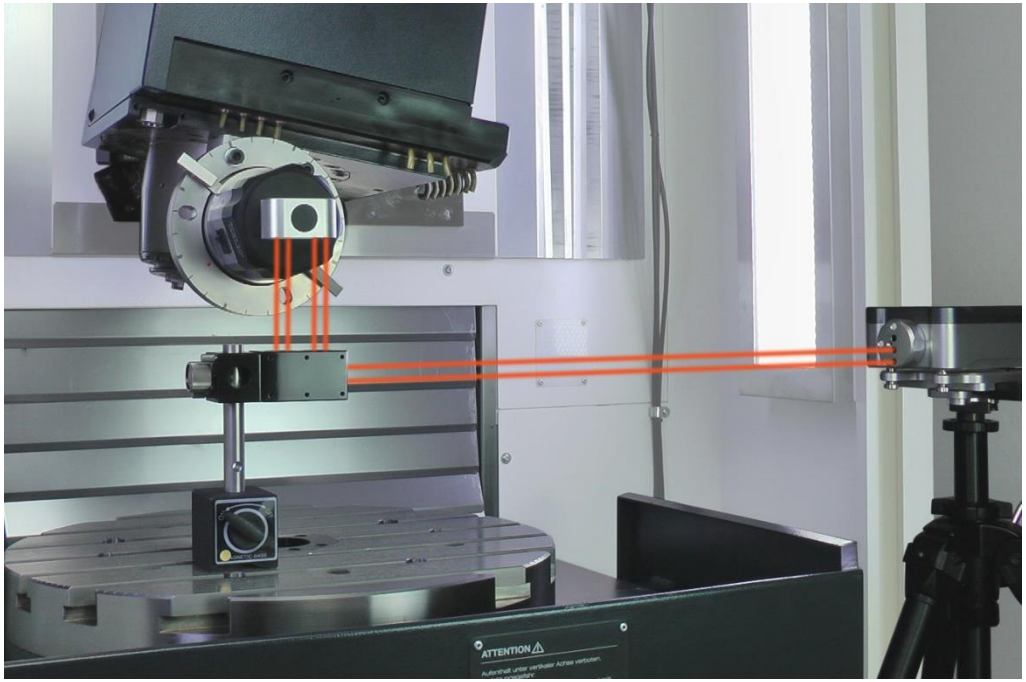
# Rotary Measurement


- Automatic self-calibration
- Automatic data capture over 360 degrees
- Used vertically or horizontally
- Wireless connection
- Accuracy +/- 1 arc sec

# Effect Of Rotary Miss-positioning

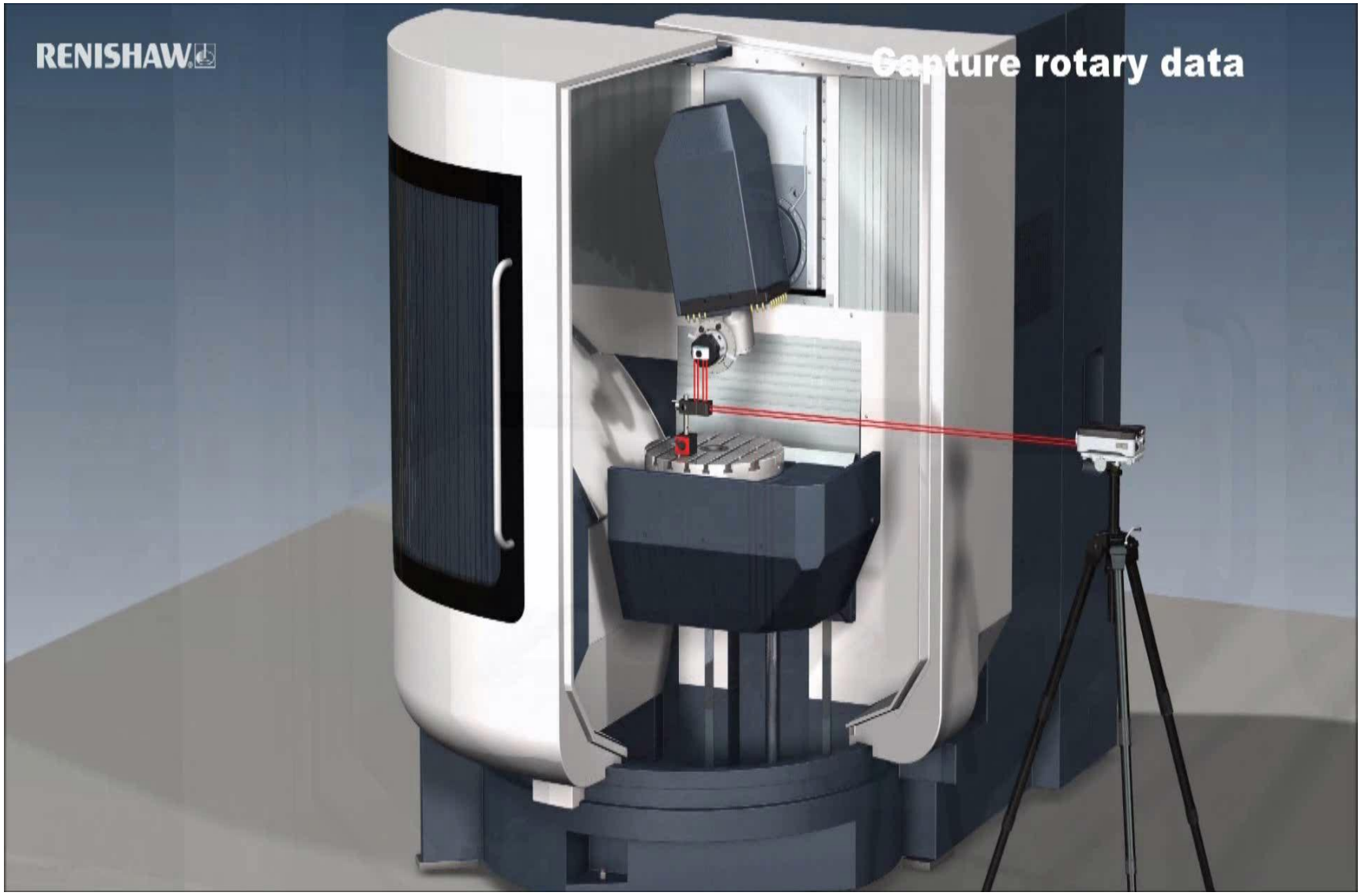


# Rotary Measurement

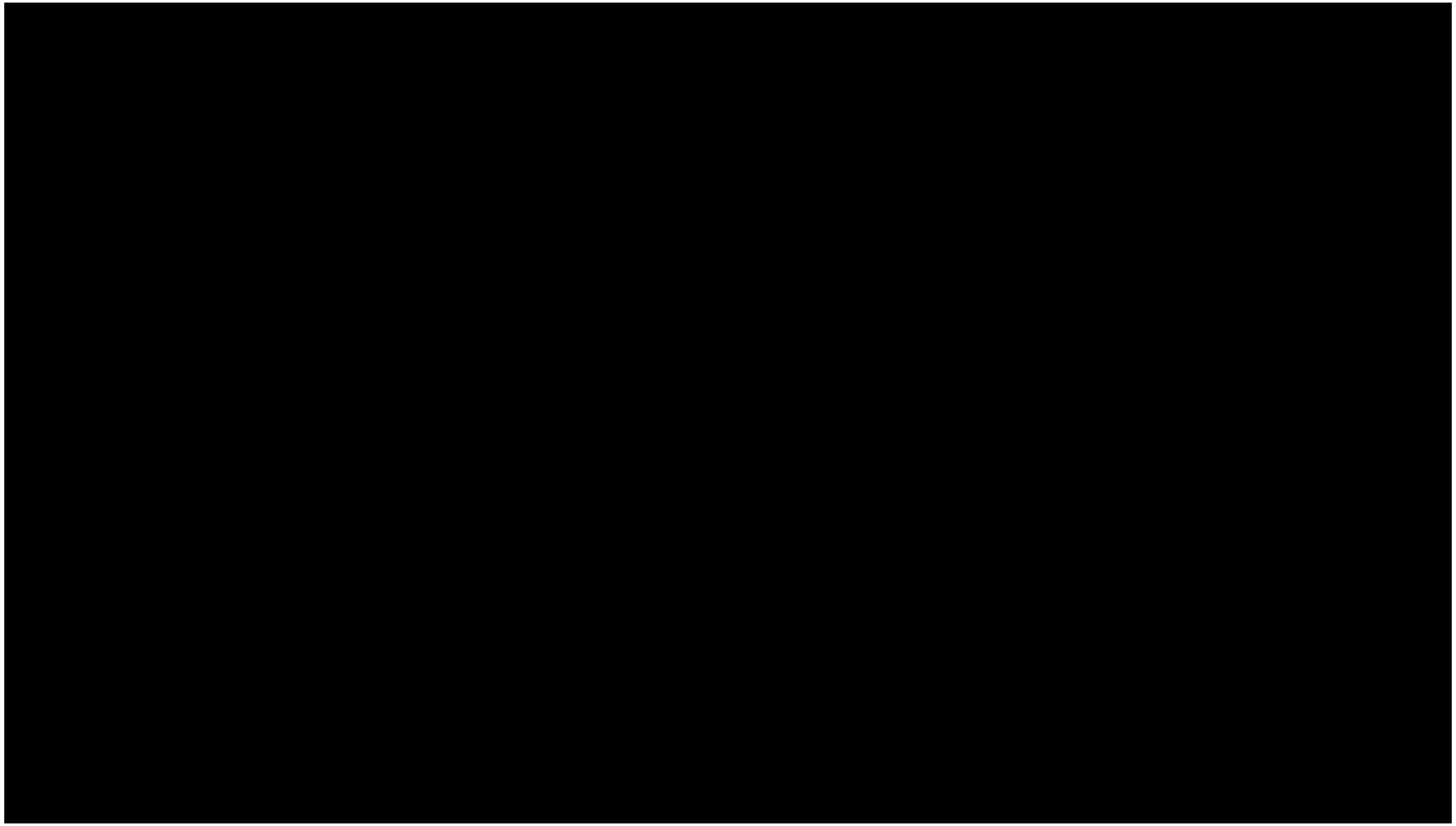



- Easy, accurate and fast
- Fully automatic data capture
- Lightweight and portable

# Rotary Measurement



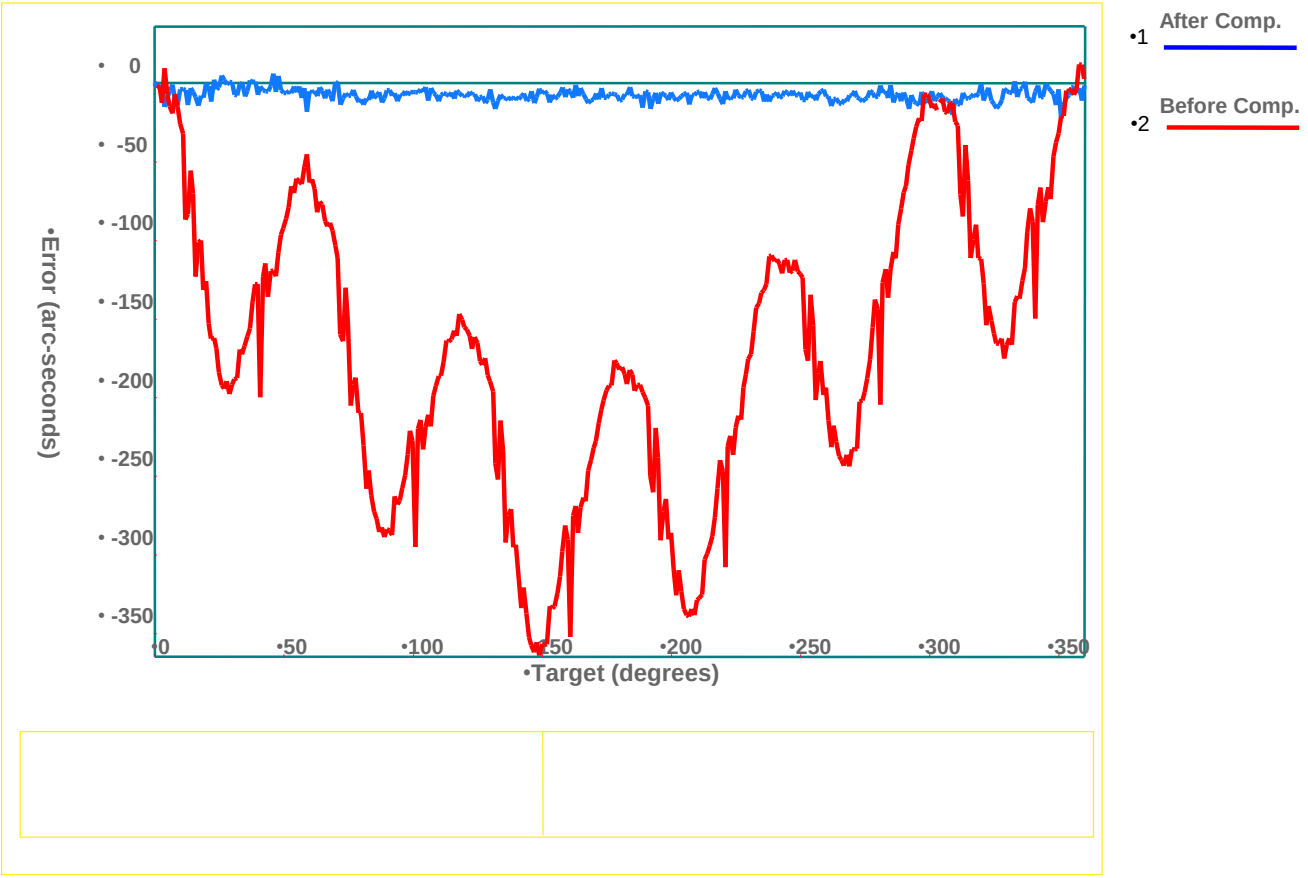
# Rotary Measurement – Off Axis Centreline



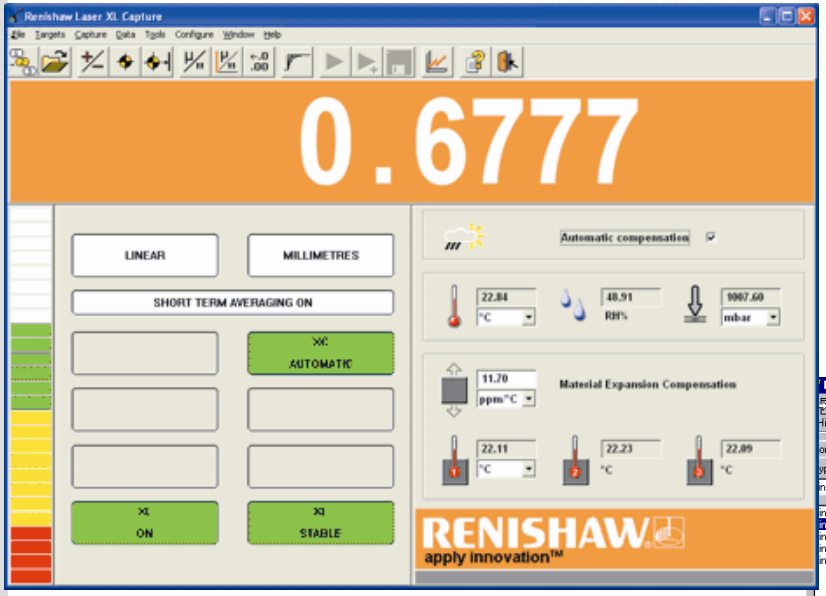
# Rotary Measurement

•TREND ANALYSIS

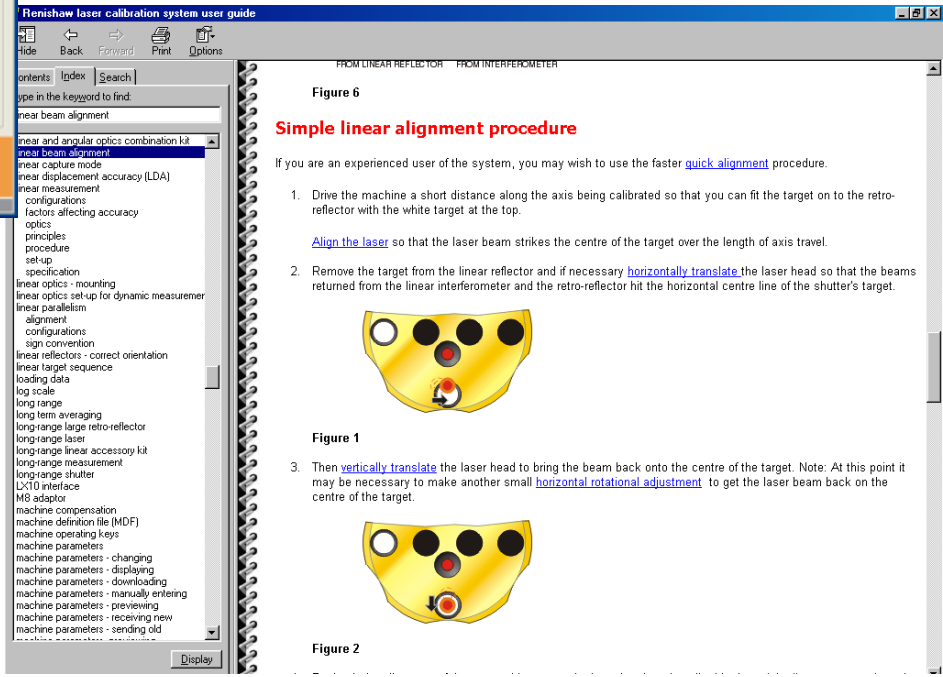
•ROTARY AXIS CALIBRATION



# LaserXL Windows Software



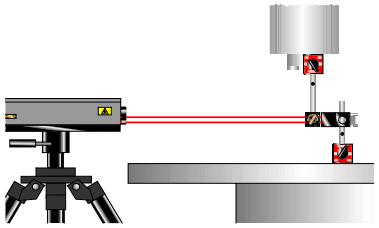

•Easy to use software



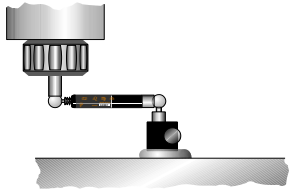

•Click into help files

# The Machine Performance Measurement Cycle

Calibrate

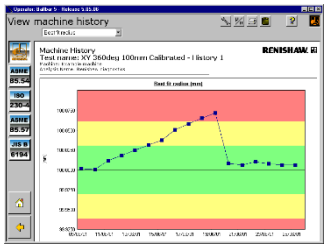


Bench mark

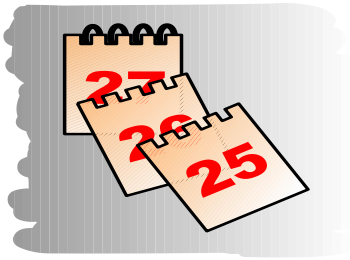


Fix

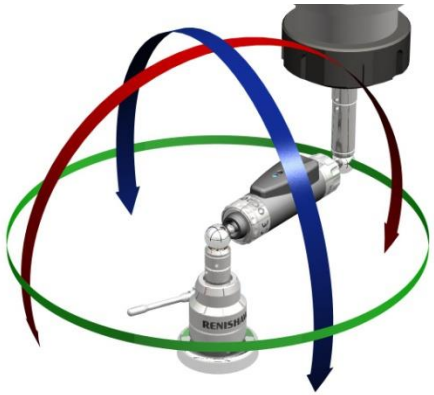
Monitor




Verify



# Maximising Your Manufacturing Process






## Questions ?