XL-80 laser system

www.renishaw.com/xl80

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Contents
XL laser system - hardware

XL-80 applications

Legal information

Terms and conditions and warranty

Unless you and Renishaw have agreed and signed a separate written agreement, the equipment and/or software are sold subject to the Renishaw Standard Terms and Conditions supplied with such equipment and/or software, or available on request from your local Renishaw office.

Renishaw warrants its equipment and software for a limited period (as set out in the Standard Terms and Conditions), provided that they are installed and used exactly as defined in associated Renishaw documentation. You should consult these Standard Terms and Conditions to find out the full details of your warranty.

Equipment and/or software purchased by you from a third-party supplier is subject to separate terms and conditions supplied with such equipment and/or software. You should contact your third-party supplier for details.

International guidelines and conformance

EC and UKCA compliance

Renishaw plc hereby declares that the XL Laser System is in compliance with the essential requirements and other relevant provisions of:

- the applicable EU directives
- the relevant statutory instruments under UK law

A copy of the full EC Declaration of Conformity is available at:
www.renishaw.com/XLCE

REACH

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 ("REACH") relating to products containing substances of very high concern (SVHCs) is available at: **www.renishaw.com/REACH**

Disposal of waste electrical and electronic equipment

The use of this symbol on Renishaw products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling. Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, contact your local waste disposal service or Renishaw distributor.

Legal information

USA and Canadian regulations

FCC Compliance Statement

Information to the user (47CFR: part 15.19)

This device complies with Part 15 of the FCC rules. Operation is subject to the following conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Information to the user (47CFR: part 15.21)

The user is cautioned that any changes or modifications not expressly approved by Renishaw plc or authorised representative could void the user's authority to operate the equipment.

Special accessories (47CFR: part 15.27)

This unit was tested with shielded cables on the peripheral devices. Shielded cables must be used with the unit to ensure compliance.

Information to the user (47CFR: part 15.105)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.
This equipment generates, uses and can radiate radio frequency energy and, if not used in accordance with this user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense.

Canada – ICES

This ISM device complies with CAN ICES-003(A)/ NMB-003(A).

Cet appareil ISM est conforme à la norme ICES-003(A)/ NMB-003(A) du CAN.

China RoHS

For more information on China RoHS, visit:
www.renishaw.com/calcompliance

Legal information

Packaging material information

Packaging component	Material	94/62/EC code	94/62/EC number
Kit outer box	Cardboard – 70% recycled content	PAP	20
XL-80 outer box	Cardboard – 70% recycled content	PAP	20
Accessories outer box	Cardboard – 70% recycled content	PAP	20
Tripod outer box	Cardboard – 70% recycled content	PAP	20
Optics outer box	Cardboard – 70% recycled content	PAP	20
Optics/accessories packaging insert *	Cardboard – 70% recycled content	PAP	20
Optics/accessories plastic bags *	Low density polyethylene bag	LDPE	4
Optics/accessories packing foam *	Low density polyethylene	LDPE	4
Optics/accessories packing foam *	Polyurethane foam	PUR	113
Optics/accessories packing foam *	Polyurethane	PU	7
Optics/accessories bag *	High-density polyethylene	HDPE	2
Optics wax bag *	Paper	PAP	21

*Optics and accessories are packed in various transits outers; specific kit information can be obtained on request.

Safety information

USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE.

Ensure that you read and understand the XL laser system user guide before using any XL laser system.

The XL laser system can be used in a variety of environments and applications. To ensure the safety of the user and other personnel in the vicinity, it is therefore paramount that a comprehensive risk assessment is carried out for the machine under test before using the XL laser system.

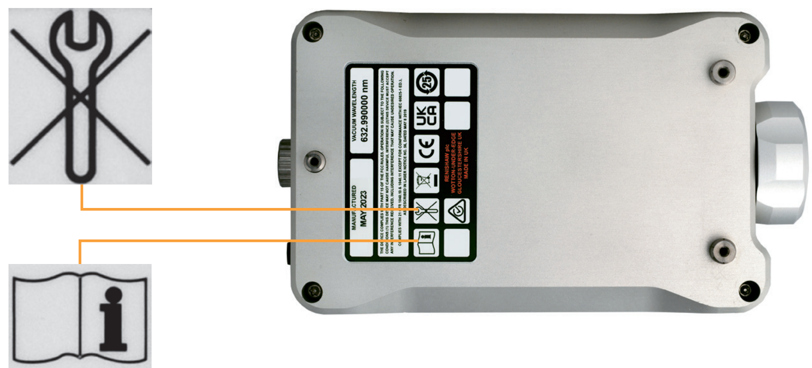
This should be carried out by qualified users (requiring machine competency, applicable technical knowledge and a trained risk assessor) with consideration for the safety of all personnel. The risks identified must be mitigated prior to using the product. The risk assessment should pay particular attention to machine, manual handling, mechanical, laser, electrical and power safety.

WARNING: There are no user-serviceable parts inside XL laser system products. Do not remove any part of the housing; to do so could expose the user to high voltages and/or Class 3R laser radiation.

CAUTION: Ensure that you read and understand the XL laser system user guide before using any XL laser system products.

Safety labelling

A laser safety label (supplied), appropriate to your country, must be affixed to the XL laser in the position shown.



Mechanical safety

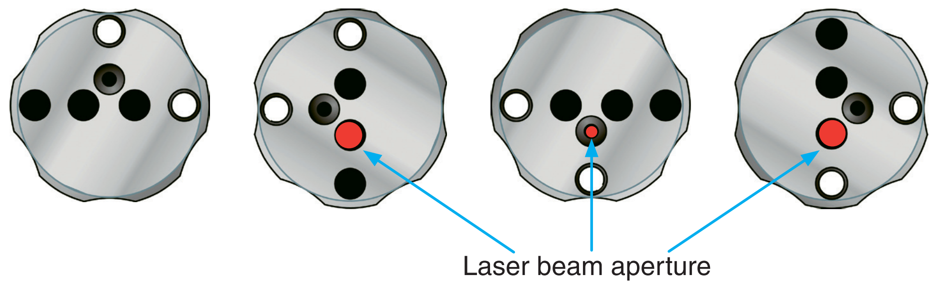
- When setting up and mounting the XL laser system, beware of pinch and/or crush hazards that may be created, for example, due to magnetic mounting bases or the universal tripod.
- Beware of trip hazards that may be created when using the XL laser system, for example, due to trailing cables.
- Exercise caution if XL laser system components are to be mounted to moving or rotating machinery. Beware of cables becoming entangled.
- Exercise extreme caution if XL laser system components are to be mounted to machinery that may accelerate rapidly or move at high speed, which could lead to items colliding or being ejected.
- If it is necessary to remove or disable any guards or safety features on the machine under test, it is the responsibility of the operator to ensure that appropriate alternative safety measures are adopted in line with the machine manufacturer's operating instructions or code of practice.
- If you are using a part program or error-correction parameters generated by the Renishaw software, it is the responsibility of the user to validate these at low feedrate and be prepared to operate an emergency stop button if necessary.

Laser optical safety

In accordance with (IEC) EN60825-1, Renishaw XL lasers are Class 2 lasers and safety goggles are not required (under normal circumstances the eye will blink and look away before damage can occur).

Do not stare directly into the beam. Do not direct the beam at other people or into areas where people unconnected with the laser work might be present. It is safe to view a diffuse-reflected beam during system alignment.

Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.



Rotating the shutter to the first position shown ensures no beam is emitted.

Do not pick up the XL laser by the shutter, as this will cause the shutter to detach from the laser and could cause damage to the system and/or injury to the operator.

Electrical and power safety

- The XL system has been qualified for use with the power supply unit supplied with the system. A specification for the power supply unit can be found **here**.
- Do not use or handle the power supply unit if it comes into contact with fluids (for example, coolant), or if the case is cracked or otherwise physically damaged.
- The power supply unit must not be positioned inside the machine volume.
- In the event of damage to the single-phase mains cabling section of the power supply (power lead), all power must be isolated from the equipment before any other action is taken.
- Never connect the system to devices not intended to be used with the XL laser system.

XL-80Q quadrature output

Do not use the quadrature output facility of the XL laser to provide positional feedback control for a machine. The system is not designed to be used for feedback control and injury could result to the operator if used for this purpose.

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XL-80 hardware

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System overview

XL laser

The XL laser system is a modular system, capable of measuring displacement, velocity, angular (pitch and yaw) displacement, flatness, straightness, parallelism and squareness, depending on the measurement kits supplied.

The XL laser is a single-frequency HeNe laser. It produces an extremely stable laser beam, with a wavelength that is traceable back to national and international standards.

NOTE: The XL Laser system must use CARTO software v4.5 or higher to ensure measurement accuracy.

XL-80Q quadrature laser

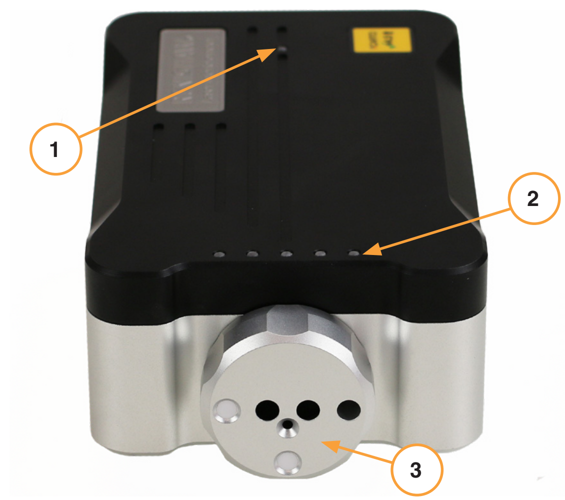
The XL-80 quadrature laser allows ‘raw’ interferometry signals to be supplied to custom-designed circuitry. This allows the laser to be used as a linear encoder system (not designed for closed loop feedback).

The quadrature signals are accessed via the auxiliary I/O connector on the XL laser rear panel. The option provides two levels of user-selectable quadrature resolution – 80 nm and 10 nm (**see Appendix A for more information**).

NOTE: XL-80Q may be subject to export control restrictions in your region.

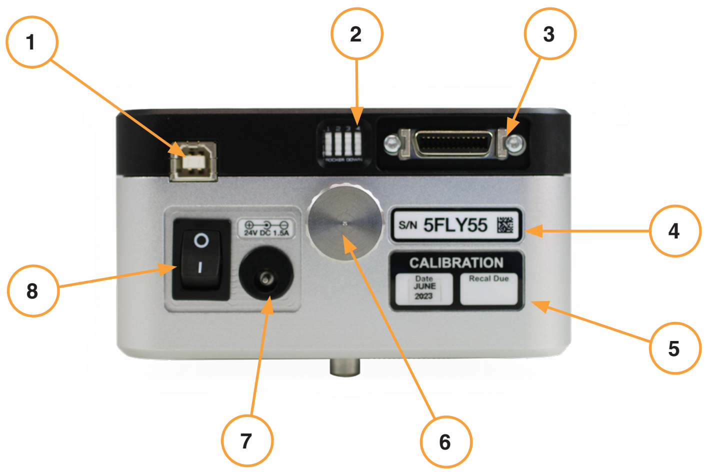
XL laser controls and indicators

The front panel includes the shutter mechanism. The top panel includes a laser status LED and five signal strength LEDs.



1	Laser status LED
2	Signal strength LEDs
3	Shutter

XL laser controls and indicators



1	USB socket		5	Calibration due date
2	DIP switches		6	Pitch adjustment
3	Auxiliary I/O		7	24 Vdc power input socket
4	Serial number		8	On/Off switch

XC-80 environmental compensator

The XL laser system specified accuracy for linear measurements is only valid when used with a calibrated XC-80 environmental compensator.

Changes in air temperature, pressure and relative humidity affect the wavelength of the laser light and subsequent measurement readings.

The XC-80 environmental compensator and its sensors very accurately measure the environmental conditions and compensate the wavelength of the laser beam for variations in air temperature, air pressure and relative humidity.

NOTE: For full details on XC-80 operation and specification, refer to the *XC-80 environmental compensator* user guide (Renishaw part no. F-9908-0294).

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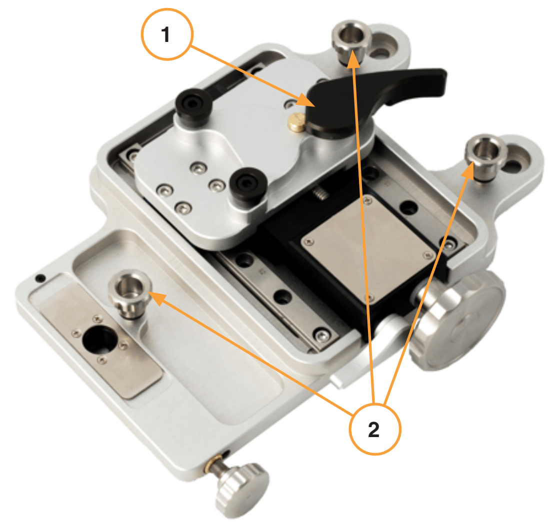
Tripod stage

The stage and universal tripod provide a stable mounting for the XL laser, allowing it to be set up at different heights and giving full alignment control of the laser beam.

Yaw and translation adjustment enable easy alignment.



1	Recesses for laser front feet
2	Fine translation control
3	Quick translation lever

4	Fine yaw control
5	Recess for laser rear foot

1	Stage release lever
2	Thumb screws × 3

Universal tripod

The tripod provides a stable mounting for the XL laser and allows the height to be adjusted.

1	Stage adaptor
2	Height adjustment crank
3	Leg angle locks

4	Leg extension locks
5	Column locks

Bubble level

The tripod stage kit is supplied with a bubble level. The bubble level is used to verify that the XL laser is level and for levelling the measurement optics.

1	Bubble level

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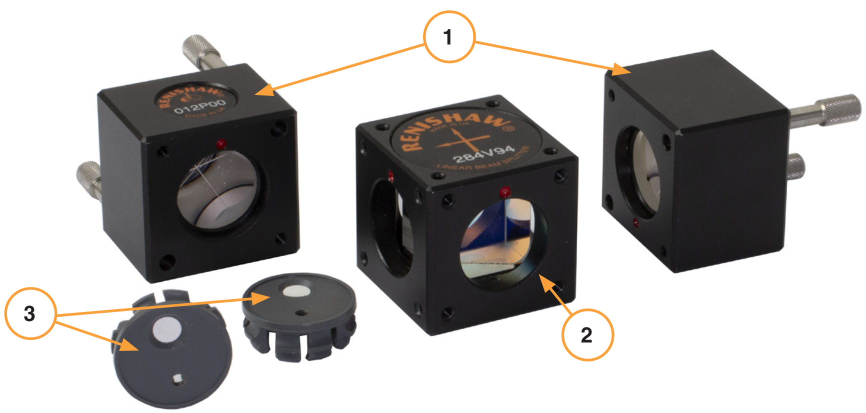
Linear measurement optics

The linear measurement optics are used for measuring linear positional accuracy.

The linear displacement is measured by the difference between the stationary beam splitter, retroreflector assembly and moving retroreflector. The targets mount directly onto the optics to improve the alignment process.



1	Linear reflectors × 2
2	Beam splitter

3	Targets × 2

Angular measurement optics

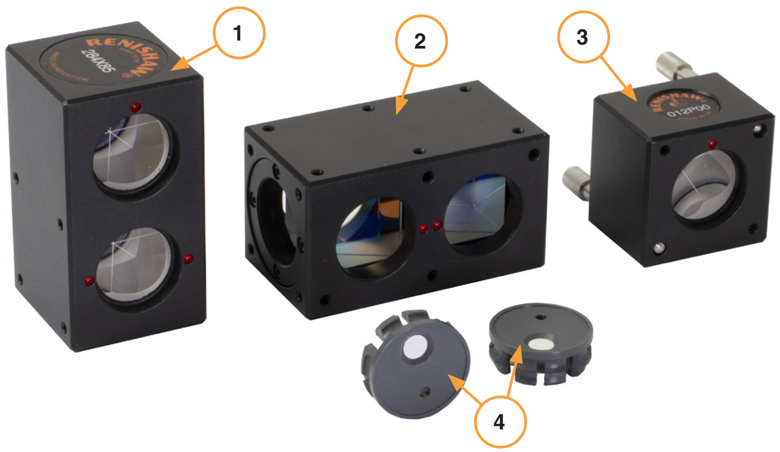
The angular measurement optics are used to measure angular displacements, particularly angular pitch and yaw. The angular displacement is achieved by measuring the difference between the angular interferometer and retroreflector.

1	Angular reflector
2	Angular interferometer

3	Targets × 2

Linear and angular optics combination kit

The linear and angular optics combination kit is a cost-effective option for users who only wish to perform these two measurements. It allows either linear or angular measurements to be made using the same optics.

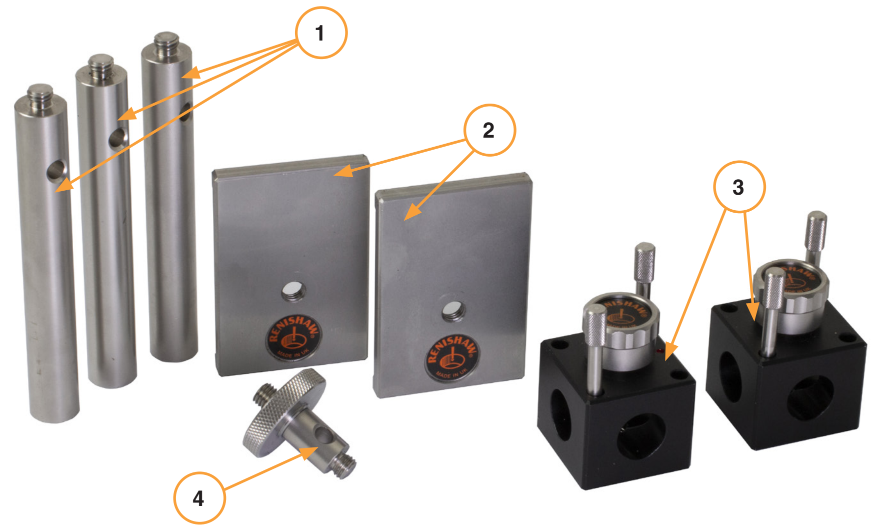


1	Angular reflector
2	Angular interferometer
3	Linear reflector
4	Targets × 2

NOTE: The linear and angular optics combination kit is not compatible with the long range linear accessory kit.

Optics mounting kit

The optics mounting kit is used to fit the Renishaw measurement optics to a CMM or machine tool. The system allows different measurement optics to be easily interchanged without the need to realign the XL laser.



1	Mounting pillars × 3
2	Base plate × 2
3	Clamp blocks × 2
4	M8 adaptor

Straightness measurement optics kit

The straightness measurement optics are used to measure straightness errors in a linear axis. Straightness errors are displacements perpendicular to the axis of travel, either vertical or horizontal depending on the mounting orientation of the optics.

The straightness measurement kit is available in two versions: short range (for measurements from 0.1 m to 4 m) and long range (for measurements from 1 m to 30 m).

1	Straightness reflector
2	Straightness interferometer

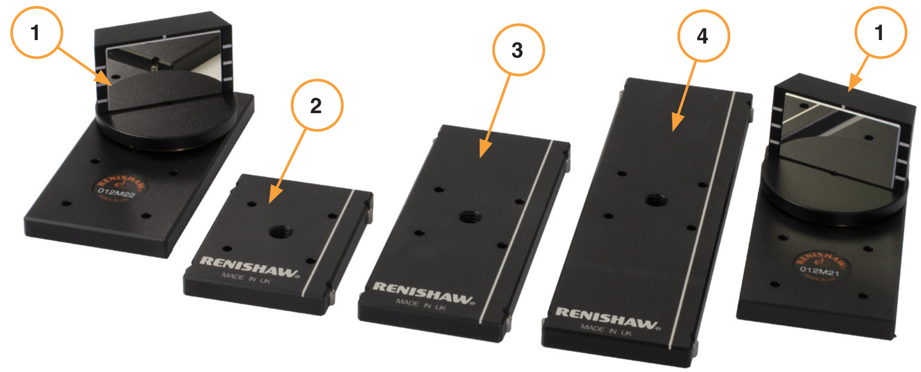
NOTE: The following accessories are required when measuring vertical straightness in a horizontal axis, or straightness in a vertical axis of a machine:

- Straightness shutter
- Large retroreflector
- Straightness base
- LS350 laser beam steering optic
- Fixed turning mirror
- Vertical turning mirror

Flatness measurement kit

The flatness measurement kit is used to measure the flatness of surface plates and granite tables.

The flatness turning mirrors allow the laser beam to be directed along any line of the surface plate without having to move the laser. A straight edge as long as the longest measurement line is required (not supplied in the kit).



1	Turning mirrors × 2	3	Flatness base (100 mm)
2	Flatness base (50 mm)	4	Flatness base (150 mm)

NOTE: The angular measurement optics are also required where the angular interferometer is attached to a turning mirror and the angular reflector is attached on top of the selected flatness base.

Squareness measurement kit

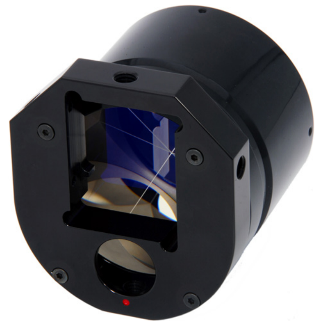
This kit allows the measurement of the axis squareness (perpendicularity). It must be used in conjunction with the straightness measurement optic.

1	Optical square
2	Clamp bracket
3	M3 × 6 mm cap screws
4	2.5 mm Hex key

When one axis is vertical, one of the following will be required:

Option 1	Option 2
Fixed turning mirror	Vertical turning mirror
LS350 laser beam steering optic	Straightness shutter
Straightness shutter	Large retroreflector
Large retroreflector	

Large retroreflector



The large retroreflector is used to measure the straightness of vertical axes. It can also be used in certain horizontal straightness configurations where it is not possible to place the stationary straightness reflector behind the interferometer.

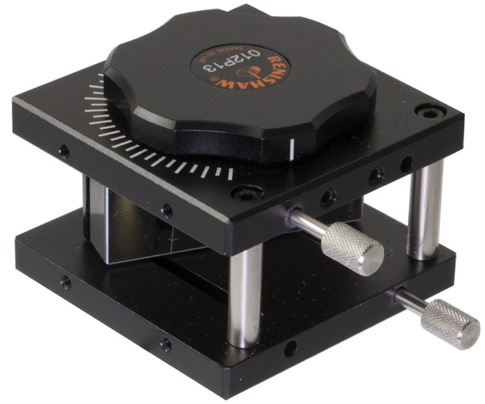
Straightness shutter

The straightness shutter has two rotational elements, allowing for compatibility with the straightness measurement optics in both horizontal and vertical orientations.

Vertical turning mirror

The vertical turning mirror is used for straightness measurements along vertical axes and can also be used in some horizontal axis measurements. The mirror deflects the linear beam by a nominal 90 degrees.

Swivel mirror



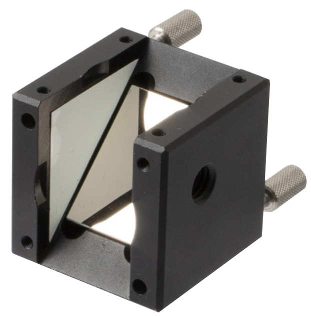
The swivel mirror is used to deflect the laser beam in the vertical plane through the range 0 degrees to 135 degrees.

The swivel mirror can be used in combination with linear, angular or straightness optics for measurements along machine diagonals, or on inclined axes. It can be attached to the optics for fast, easy set-up.

Straightness base

The straightness base is used as a mount for the straightness reflector and vertical turning mirror (or laser steerer with fixed turning mirror) for vertical straightness measurements.

Fixed turning mirror



The fixed turning mirror deflects the laser beam by a fixed angle of 90 degrees (to a tolerance of ±30 arc minutes).

Like the swivel mirror, it can be attached to the linear and angular measurement optics to help optical set-up and is used mainly when access to the required axis of measurement is restricted.

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LS350 laser beam steering optic

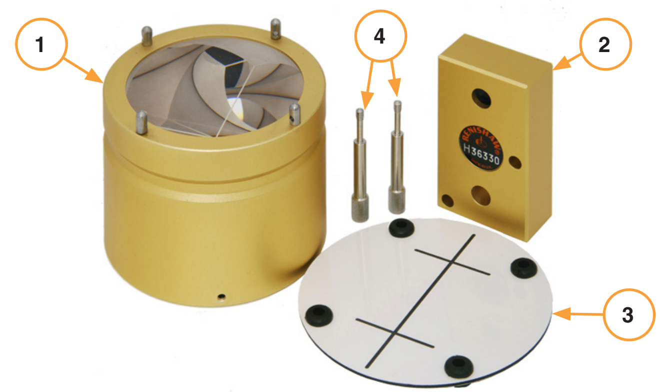
The laser steering optic is an alignment aid for the XL laser system. The device allows for easy adjustment in the vertical and horizontal plane of the laser beam and reduces the amount of adjustment to be made at the laser head using the tripod stage.

The laser beam steering optic can be used with the following optics:

- Linear optics
- Linear/angular combination kit
- Angular optics
- Straightness optics
- Fixed turning mirror
- Swivel mirror
- Optical square (in conjunction with fixed turning mirror)

Long-range linear accessory kit

The long-range large retroreflector and periscope returns the measurement beam from the periscope to the laser at the correct displacement to enter the laser detector port. This is designed for measurements up to 80 m.



1	Long-range large retroreflector	3	Target
2	Periscope beam-splitter	4	Clamp screws x 2

Small linear optics kit

The small linear optics kit allows the XL laser system to be used in applications where a small and light measurement optic is desirable, minimising its effect on a machine's dynamic performance and providing greater flexibility in mounting options.

1	Beam reducer optic
2	Small retroreflector
3	Mounting adaptor

Pan and tilt adaptor kit

The pan and tilt adaptor allows flexible mounting of laser calibration equipment at angles between 0 degree and 90 degree with an infinite pan rotation.

The pan and tilt adaptor can be used to:

- mount the XL-80 laser on a tripod or magnetic base for applications such as slant bed lathes.
- mount a retroreflector at an angle for convenient linear diagonal measurement.

1	Pan and tilt adaptor
2	Mag base adaptor
3	Clamp block adaptor
4	Tommy bar x 2

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System cases

Renishaw supplies storage cases in two sizes to protect the laser system from damage in storage and transit.

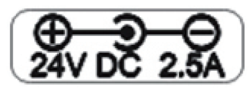
- The full system case is capable of housing the XL laser and XC compensator plus a full range of optics and accessories for all supported measurement configurations.
- The smaller base system case can house the XL laser and XC compensator kits plus optics and accessories for linear and angular measurement configurations.

The contents of the cases are described in the **system case pages**.

Tripod cases

A heavy-duty fabric case for safe storage and transportation of the Renishaw tripod.

Specifications

XL laser	
Laser source	HeNe laser tube (Class II)
Laser power	< 1 mW
Mode of operation	Continuous-wave (CW)
Nominal wavelength at Normal Temperature and Pressure (NTP)*	633 nm (nominal)
Vacuum wavelength	See underside of laser
Minimum beam divergence	0.14 mrads
Laser frequency accuracy	±0.05 ppm (3 years)
Recommended recalibration period	36 months
Preheat time	Less than 6 minutes
Outputs	USB 2 compliant **Auxiliary output**
Operating temperature	0 °C to 40 °C
Tolerable ambient temperature change once stabilised	±10 °C
Operating humidity	0 % to 95 % non-condensing
Input power connector	Inner core = 24 V Outer core = 0 V 
Note: XL laser is not protected against the ingress of fluids	
** Normal temperature and pressure = 20 °C, 101325 Pa, 50% RH, 450 ppm CO2*	

Specifications

System storage	
Storage temperature range	–25 °C to 70 °C
Storage humidity range	0 %RH to 95 %RH non-condensing
Storage pressure range	650 mbar to 1150 mbar

Power supply unit	
Input voltage	100 V to 240 V ±10%
Input frequency	47 Hz to 63 Hz
Output voltage	24 V ±2%
Maximum output current	1.5 A
Safety standard	EN (IEC) 62368-1:2014+A11:2017

USB (A-B) data cable	
Shielded USB2	Full or high speed
For cable length less than 3 m	28 AWG/2C (for data) 24 AWG/2C (for power)
For cable length greater than 3 m	28 AWG/2C (for data) 20 AWG/2C (for power)

Mounting stage and laser – alignment adjustment	
Pitch range	±1.5 °
Yaw range	±1.5 °
Horizontal translation range	72 mm

Tripod	
Positioning height range of laser when mounted on top of tripod	0.5 m to 1.5 m
Collapsed length	0.64 m
Weight	3.8 kg

Specifications

Linear measurement	
Standard range	0 m to 80 m
Accuracy (with XC compensator)	±0.5 ppm*
Resolution	0.001 µm
Maximum velocity	240 m/min (4 m/s)
Note: The accuracy values do not include the errors associated with the normalisation of the readings to a material temperature of 20 °C	
* k=2 (95% confidence) EA-4/02, ISO	

Angular measurement		
Axial range	0 m to 15 m	
Angular measurement range	±175 mm/m	
Accuracy angular	0.002A ±0.5 ±0.1M µrad	
Angular accuracy (calibrated)	0.0002A ±0.5 ±0.1M µrad*	
Resolution	0.1 µm/m	
Where:		
* for 20 °C ±5 °C	M = measurement distance in metres	A = displayed angular reading

Specifications

Straightness measurement		
Axial range	Short range	0.1 m to 4.0 m *
	Long range	1 m to 30 m
Straightness measurement range		±2.5 mm
Accuracy	Short range	±0.5% ±0.5 ±0.15M² µm
	Long range	±2.5% ±5 ±0.015M² µm †
Resolution	Short range	0.01 µm
	Long range	0.1 µm
Where:		
* Longer ranges are achievable with data stitch		% = percentage of displayed value
M = measurement distance in metres		† specifications do not include the effect of air turbulence

Squareness measurement		
Range		±3/M mm/m
Accuracy	Short range	±0.5% ±2.5 ±0.8M µm/m
	Long range	±2.5% ±2.5 ±0.08M µm/m
Resolution		0.01 µm/m
Where:		
M = measurement distance in metres of the longest axis		% = percentage of displayed value

Specifications

Flatness measurement	
Axial range	0 m to 15 m
Flatness measurement range	±1.5 mm
Accuracy	±0.6% ±0.02M^2 µm
Resolution	0.02 µm for 150 mm base 0.01 µm for 50 mm and 100 mm base
Where:	
M = length of the diagonal in metres	% = percentage of calculated flatness

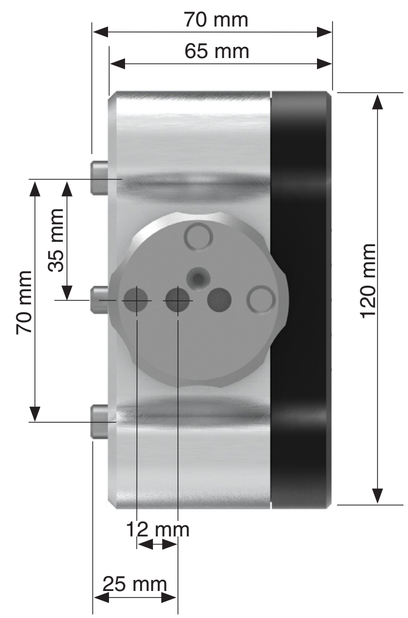
LS350 laser beam steering optic	
Steering angle range	±35 mm/m
Axial range	0 m to 10 m

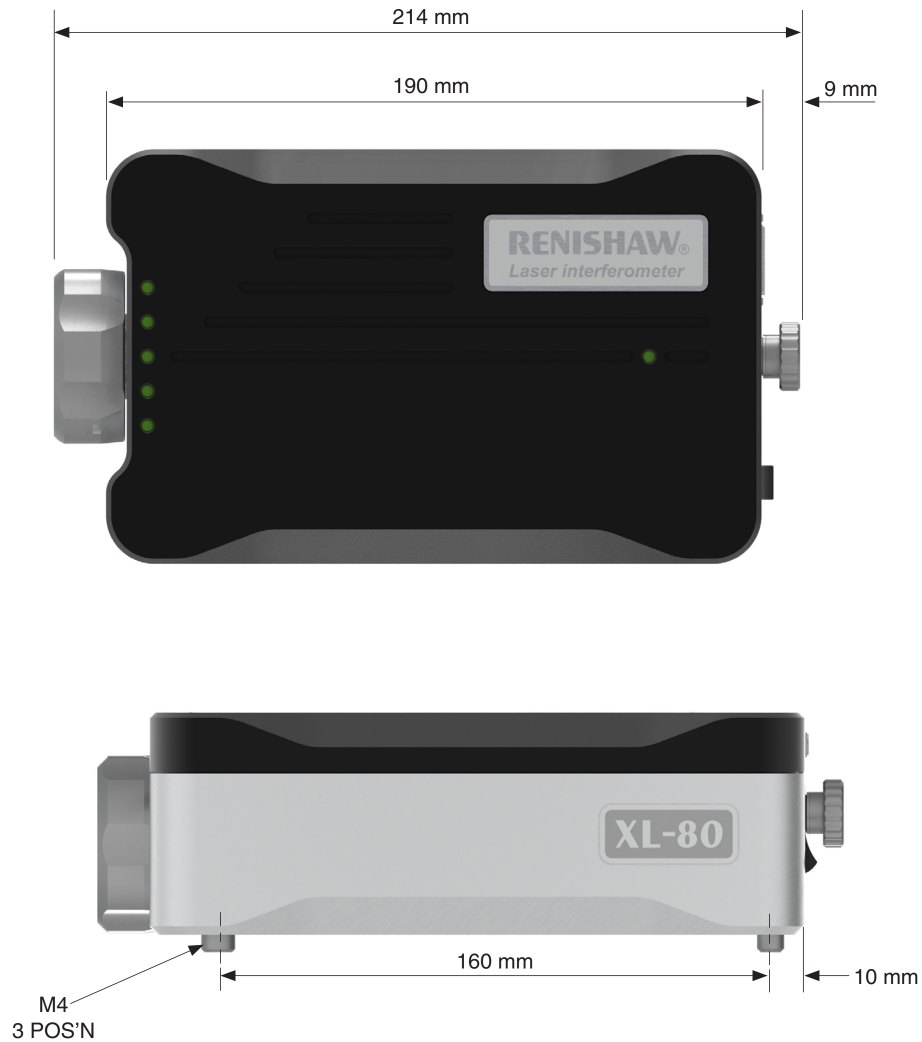
Small linear optics kit	
Maximum measurement range	4 m

Small retroreflector	
Size	15 mm diameter (standard retroreflector = 38 mm × 37 mm × 30 mm)
Weight	< 10 g (standard retroreflector = 100 g)

Dimensions and weights

XL-80 laser





Weight	1.85 kg

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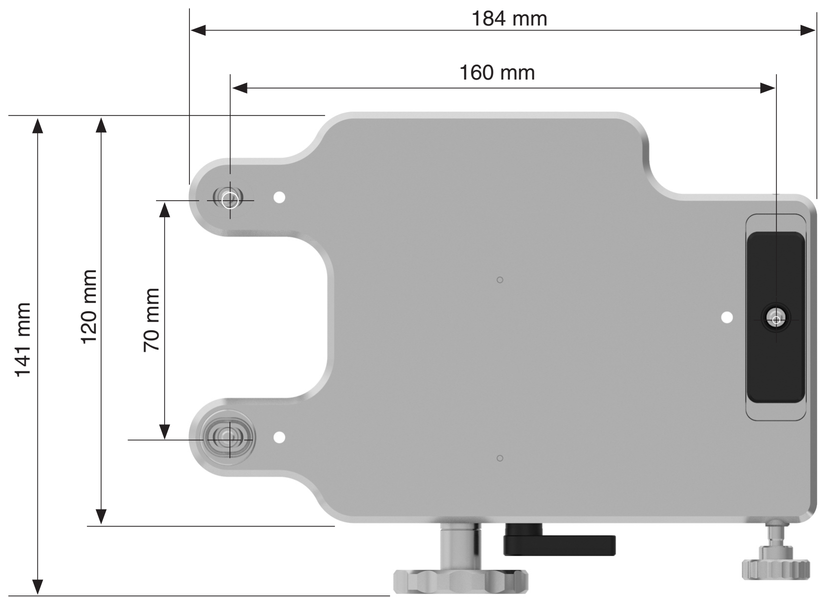
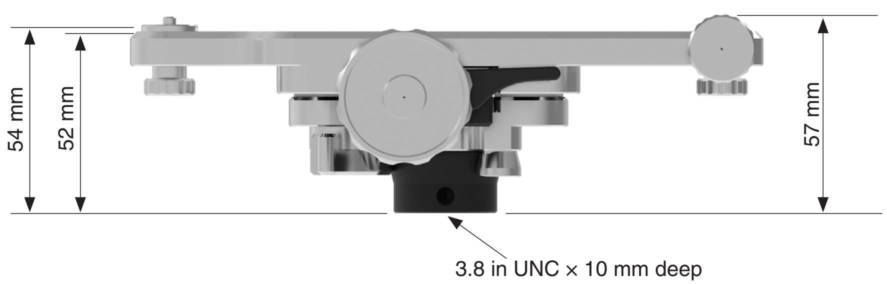
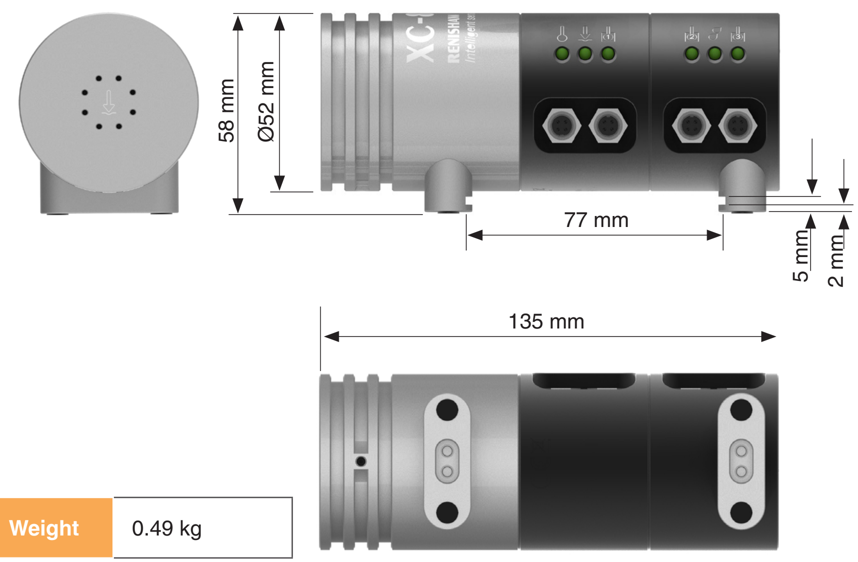
Tripod stage





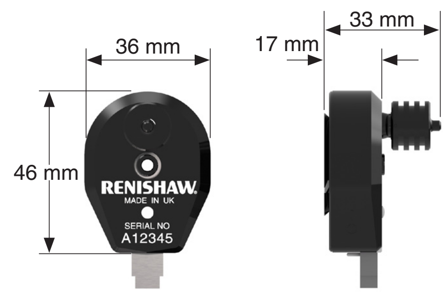
Weight	0.77 kg

XC environmental compensation



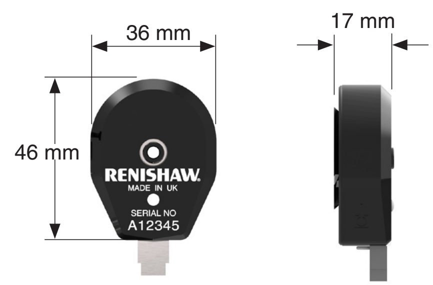
Weight	0.49 kg

Air temperature sensor



Weight	0.48 g

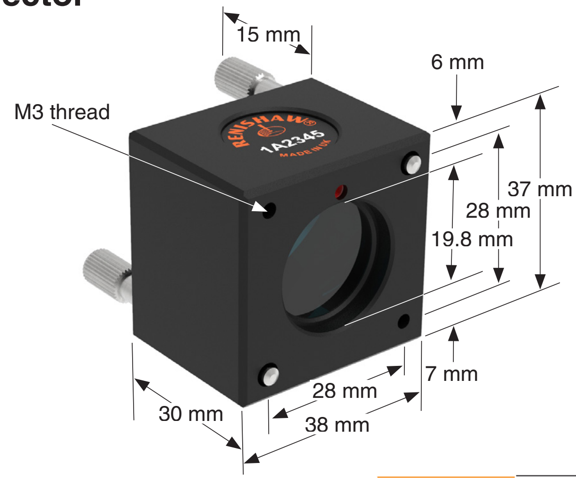
Material temperature sensor



Weight	0.45 g

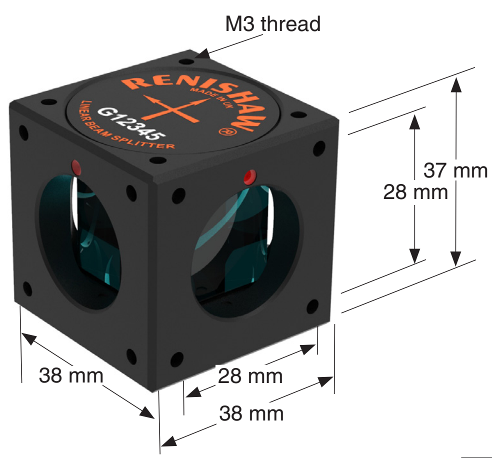
Linear measurement optics

Linear reflector



Weight	100 g

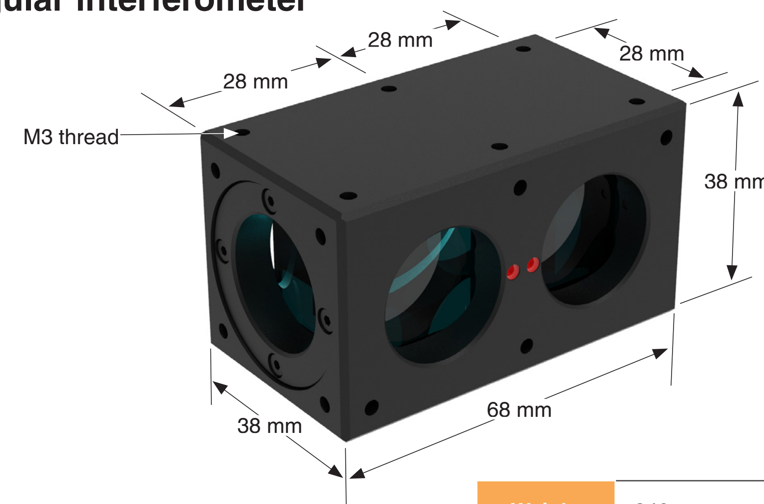
Linear beam splitter



Weight	81 g

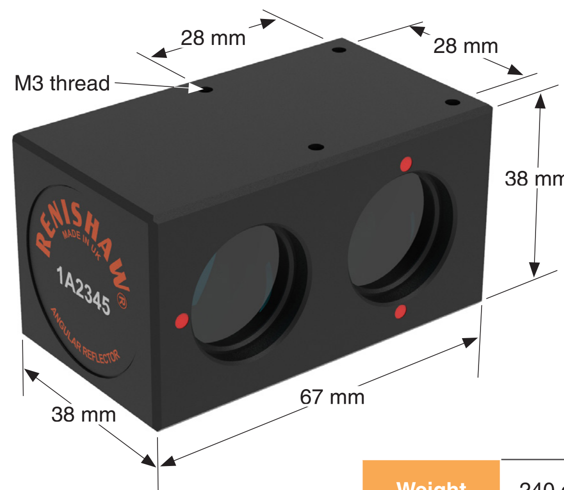
Angular measurement optics

Angular interferometer



Weight	240 g

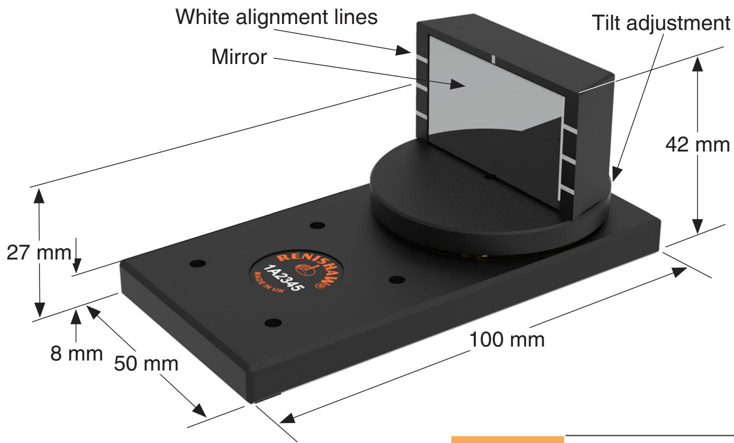
Angular reflector



Weight	240 g

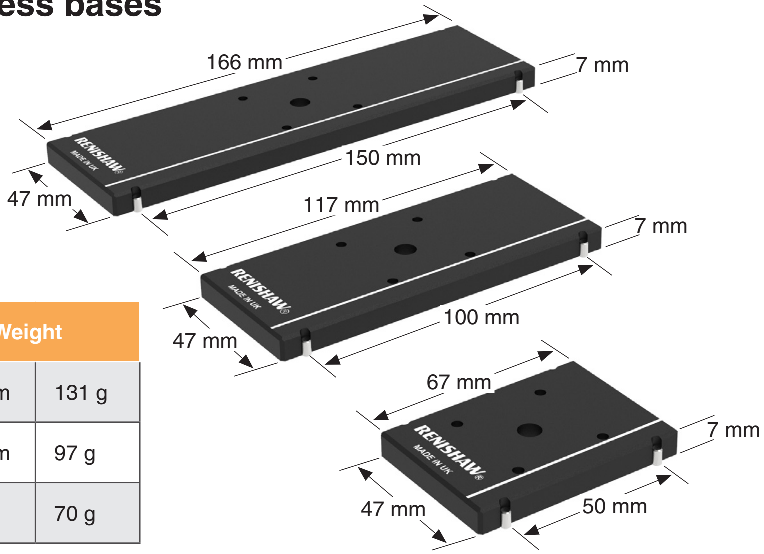
Flatness measurement optics

Flatness mirror



Weight	212 g

Flatness bases



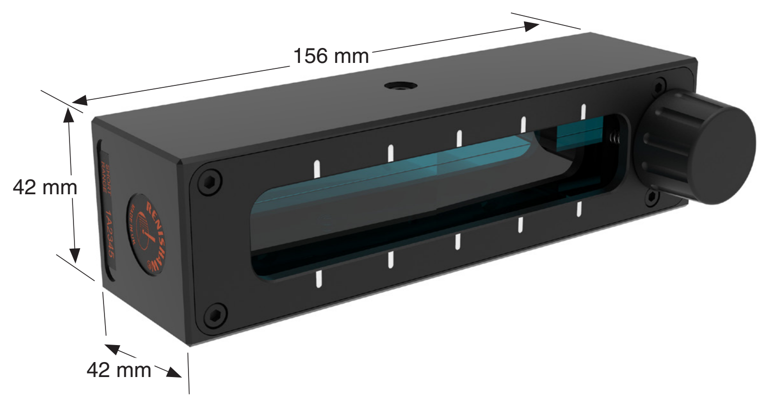
Weight	
150 mm	131 g
100 mm	97 g
50 mm	70 g

Straightness measurement optics (short and long range)

Straightness interferometer

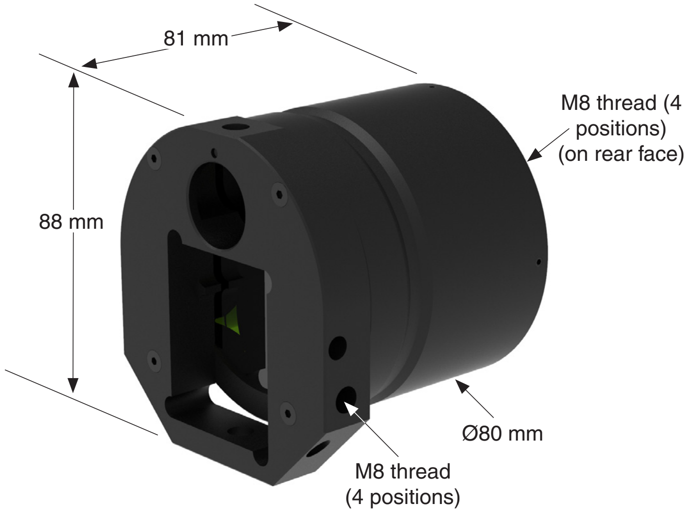
Weight	509 g

Straightness reflector



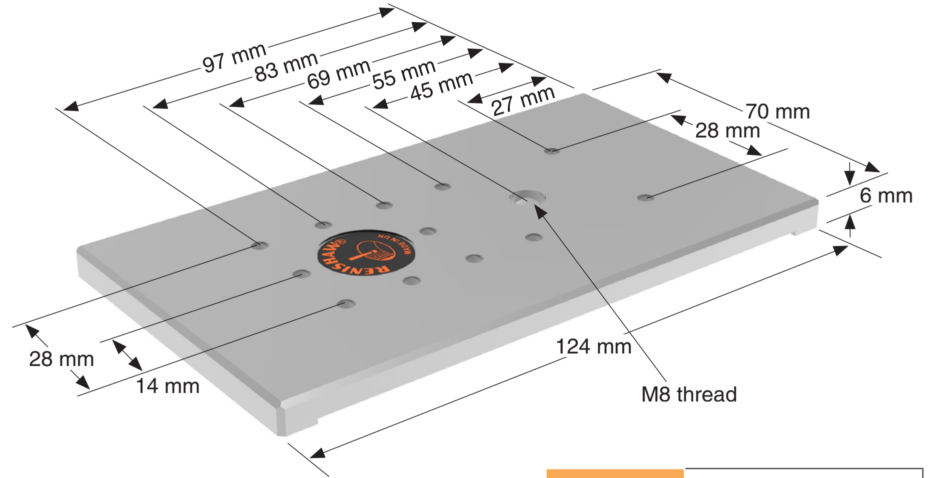
Weight	67 g

Large retroreflector



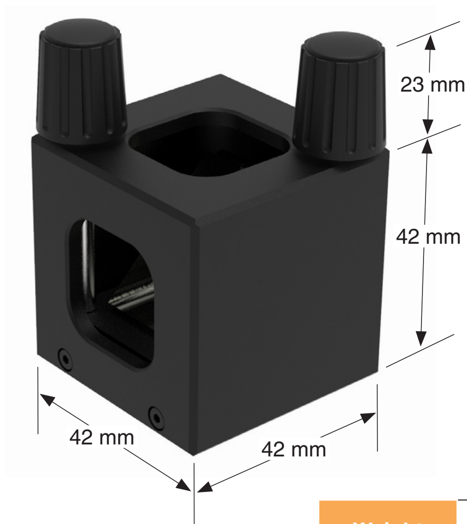
Weight	587 g

Straightness base



Weight	387 g

Vertical turning mirror



Weight	123 g

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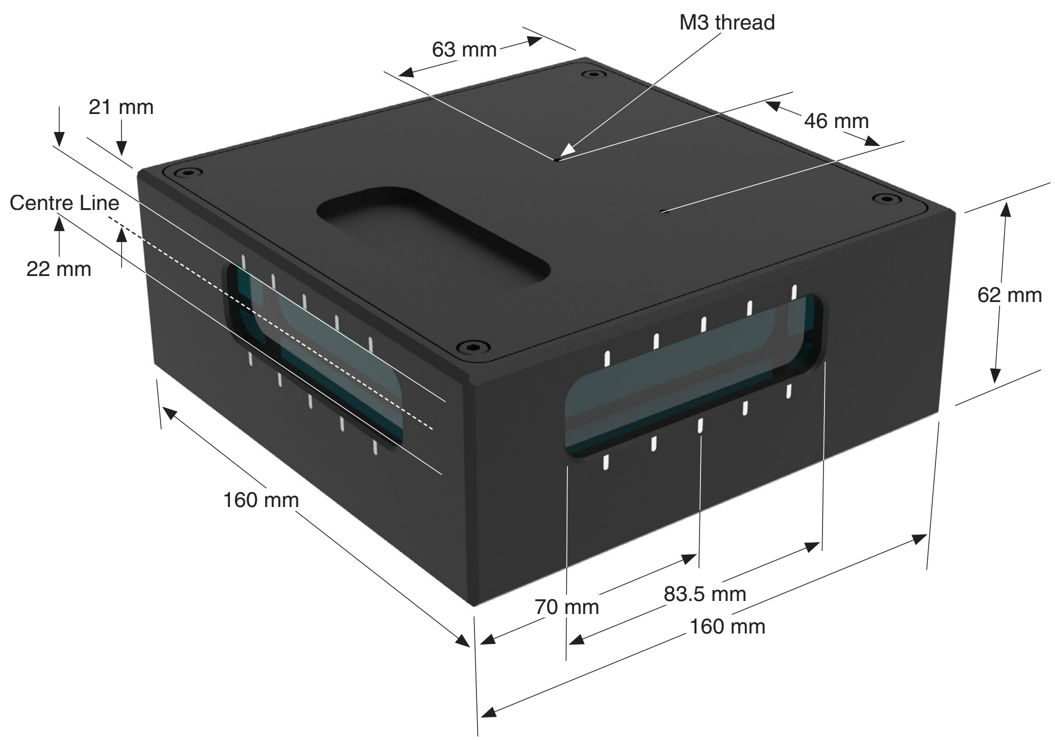
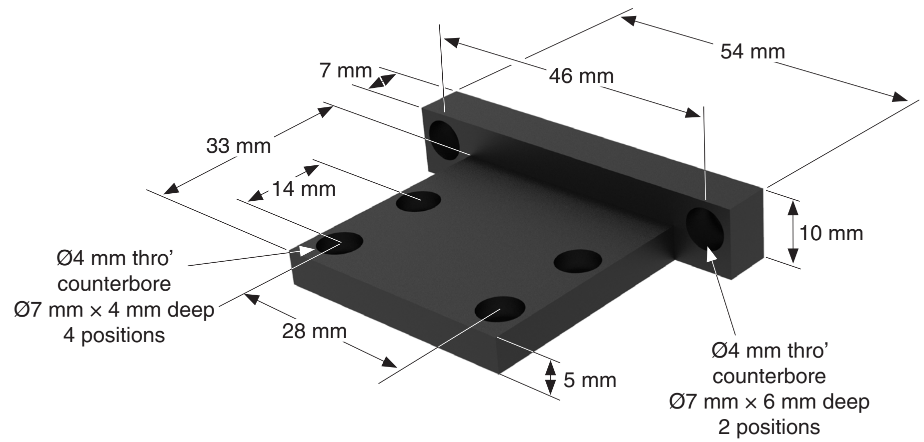
Squareness measurement optics

Optical square



Weight	2025 g

Bracket for optical square



Weight	50 g

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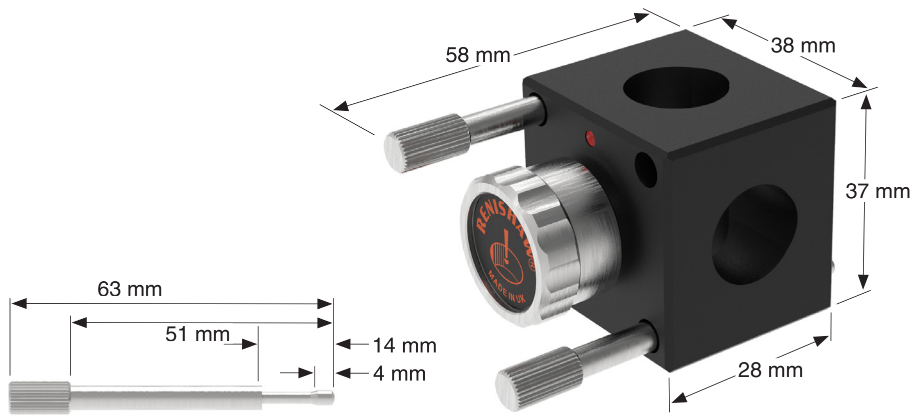
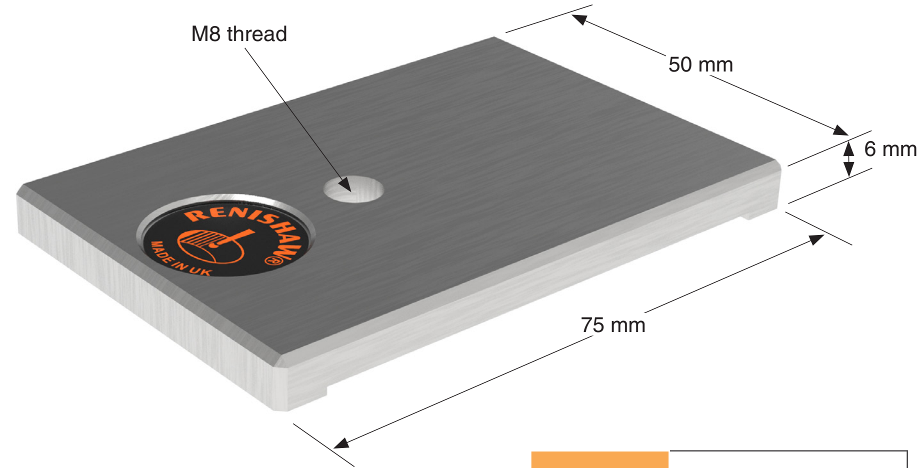
Optics mounting kit

Clamp block



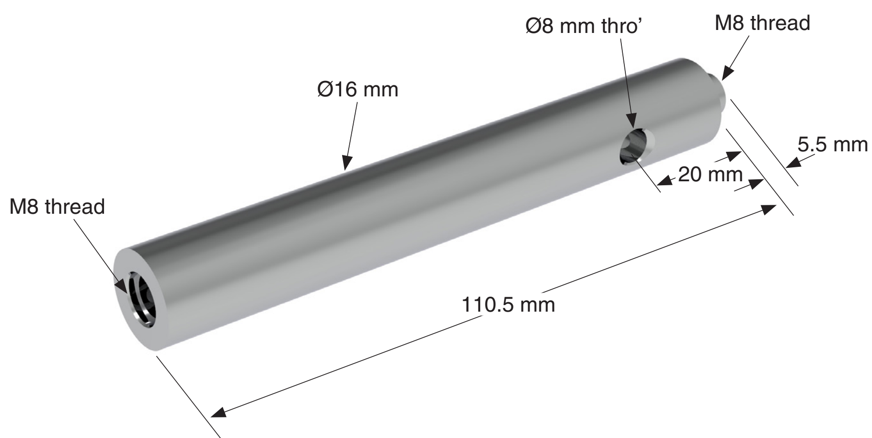
Weight	119 g

Base plate



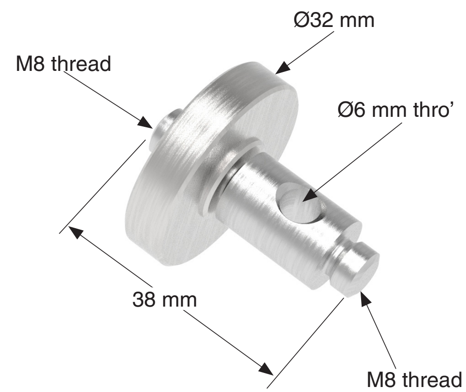
Weight	146 g

Mounting pillar



Weight	158 g

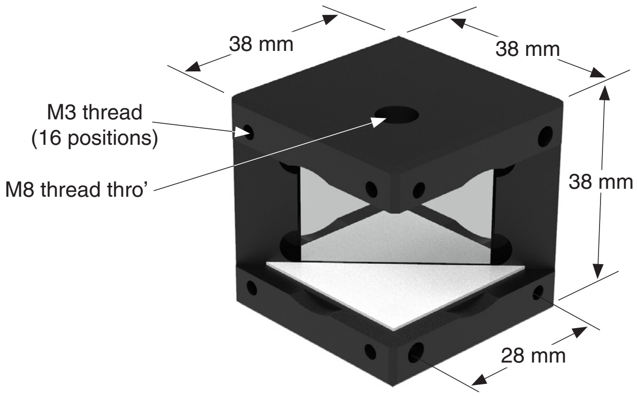
M8 adaptor



Weight	82 g

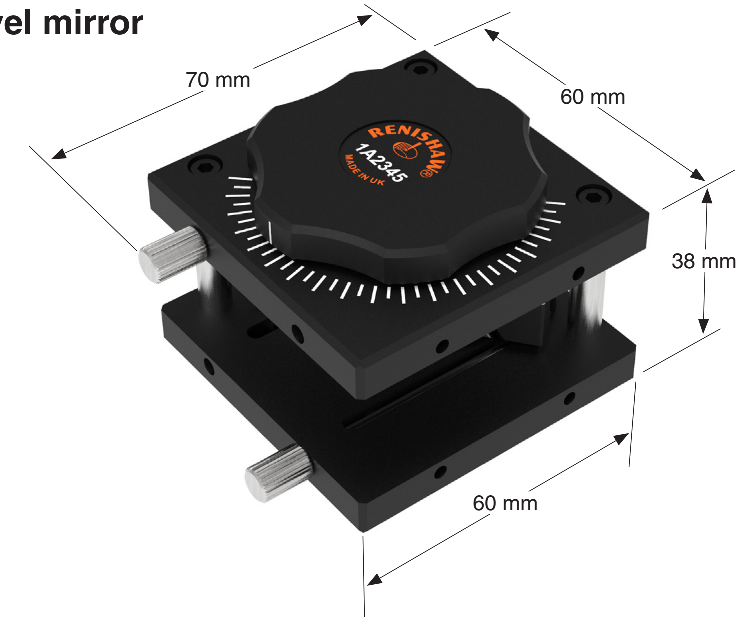
Accessories

Fixed turning mirror



Weight	110 g

Swivel mirror



Weight	200 g

LS350 laser beam steering optic

Weight	140 g

Full XL system case (tray removed)

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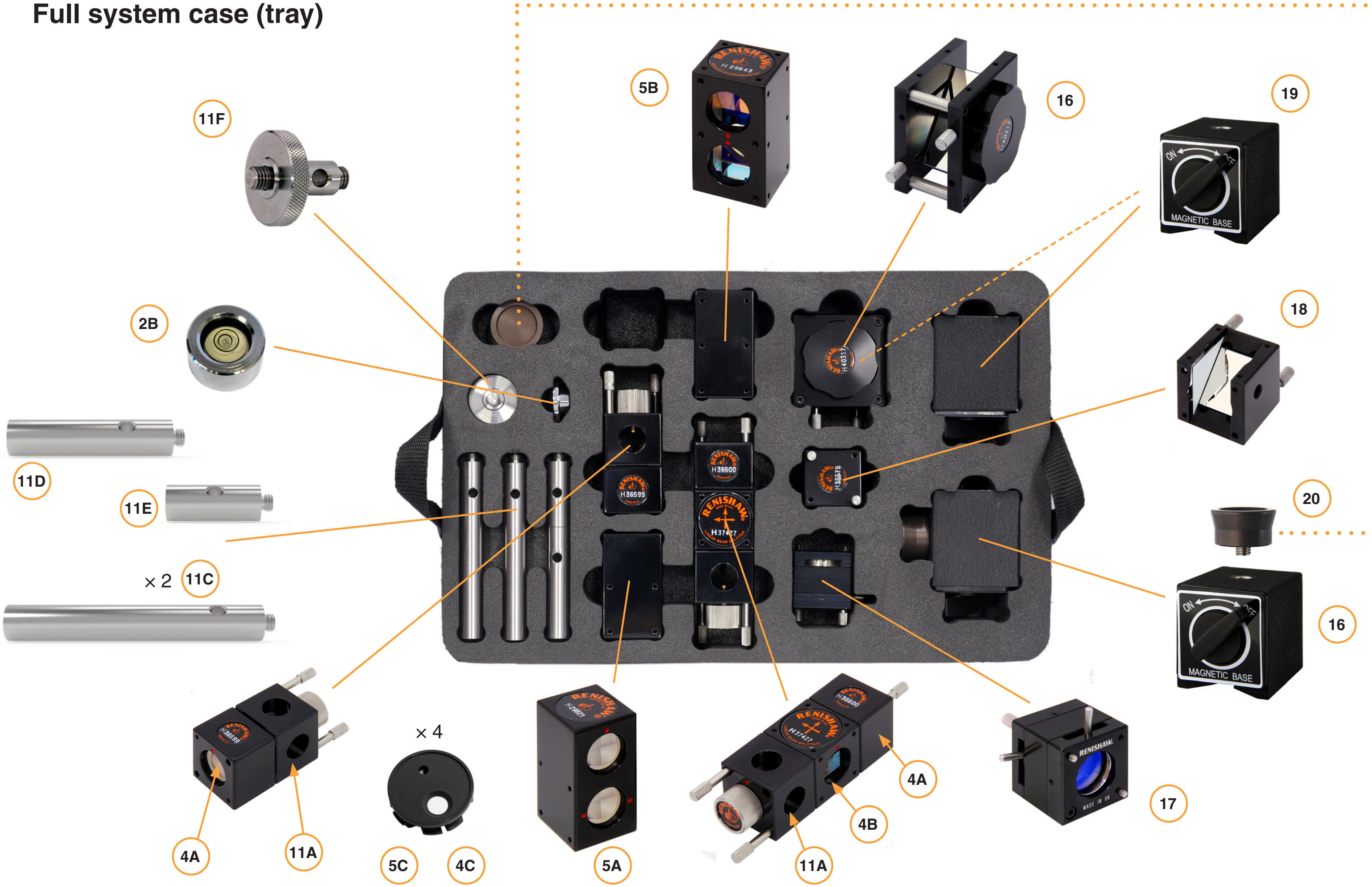
Full system case (tray)



Full XL system contents

Index	Part number	Part name	Includes	Part number	Index
1	A-9908-0405	XL-80 laser kit	XL-80 laser		1A
			Universal power supply	A-5103-4370	1B
			USB cable	A-9908-0286	1C
			AUX/I/O connector	A-9908-0329	Not shown
2	A-9908-0700	Tripod stage kit	XL tripod stage		2A
			Spirit level circular	A-9908-0323	2B
			XL tripod stage adaptor	A-9908-0770	Not shown, fitted to tripod
3	A-9908-0510	XC-80 compensator kit	XC-80 compensator		3A
			Material temperature sensor and cable	A-9908-0879	3B
			Air temperature sensor and cable	A-9908-0878	3C
			XC mounting plate	A-9908-0892	3D
			USB cable	A-9908-0286	3E
4	A-8003-0440	Linear measurement optics	Linear reflector (× 2)	A-8003-0219	4A
			Linear interferometer	A-8003-0557	4B
			Alignment target (× 2)	A-8003-0478	4C
5	A-8003-0441	Angular measurement optics	Angular reflector	A-8003-0181	5A
			Angular interferometer	A-8003-0186	5B
			Alignment target (× 2)	A-8003-0478	5C
6	A-8003-0443	Straightness optics – short range (0 m to 4 m)	Short range straightness reflector	A-8003-0615	6A
			Wollaston prism short range	A-8003-0393	6B
7	A-8003-0444	Straightness optics – long range (1 m to 30 m)	Long range straightness reflector	A-8003-0620	7A
			Wollaston prism long range	A-8003-0430	7B
8	A-8003-0665	Squareness measurement optics	Optical square		8A
			Bracket squareness optic	M-8003-1680	8B
			Cap head screw (× 4)		8C
			Hexagonal key		8E

Full XL system contents (continued)

Index	Part number	Part name	Includes	Part number	Index
9	A-8003-0442	Flatness measurement kit	Flatness mirror (× 2)	A-8003-0630	9A
			Base (150 mm)	A-8003-0256	9B
			Base (100 mm)	A-8003-0257	9C
			Base (50 mm)	A-8003-0258	9D
10	A-8003-4270	Long range linear accessory kit	Long range retroreflector	A-8003-2061	10A
			Periscope	A-8003-2039	10B
			Long range target	A-8003-4119	10C
			Clamp screw (short) – (× 2)	M-8003-0221	10D
11	A-8003-0447	Optics mounting kit	Clamp block (× 2)	A-8003-0262	11A
			Base plate (× 2)	A-8003-0522	11B
			Mounting pillar 110 mm (× 2)	M-8003-0470	11C
			Mounting pillar 70 mm	M-8003-0739	11D
			Mounting pillar 40 mm	M-8003-0740	11E
			M8 adaptor	A-8003-0979	11F
12	A-8003-4209	Universal (straightness) shutter			12
13	A-8003-0560	Vertical turning mirror			13
14	A-8003-0604	Large straightness retroreflector			14
15	A-8003-0576	Straightness base			15
16	A-8003-1304	Swivel mirror			16
17	A-8003-3072	Laser beam steerer LS350			17
18	A-8003-1325	Fixed turning mirror			18
19	A-9908-0780	Magnetic base			19
20	A-9908-0760	XL magnetic base adaptor			20

NOTE: 12 to 20 are additional items available.

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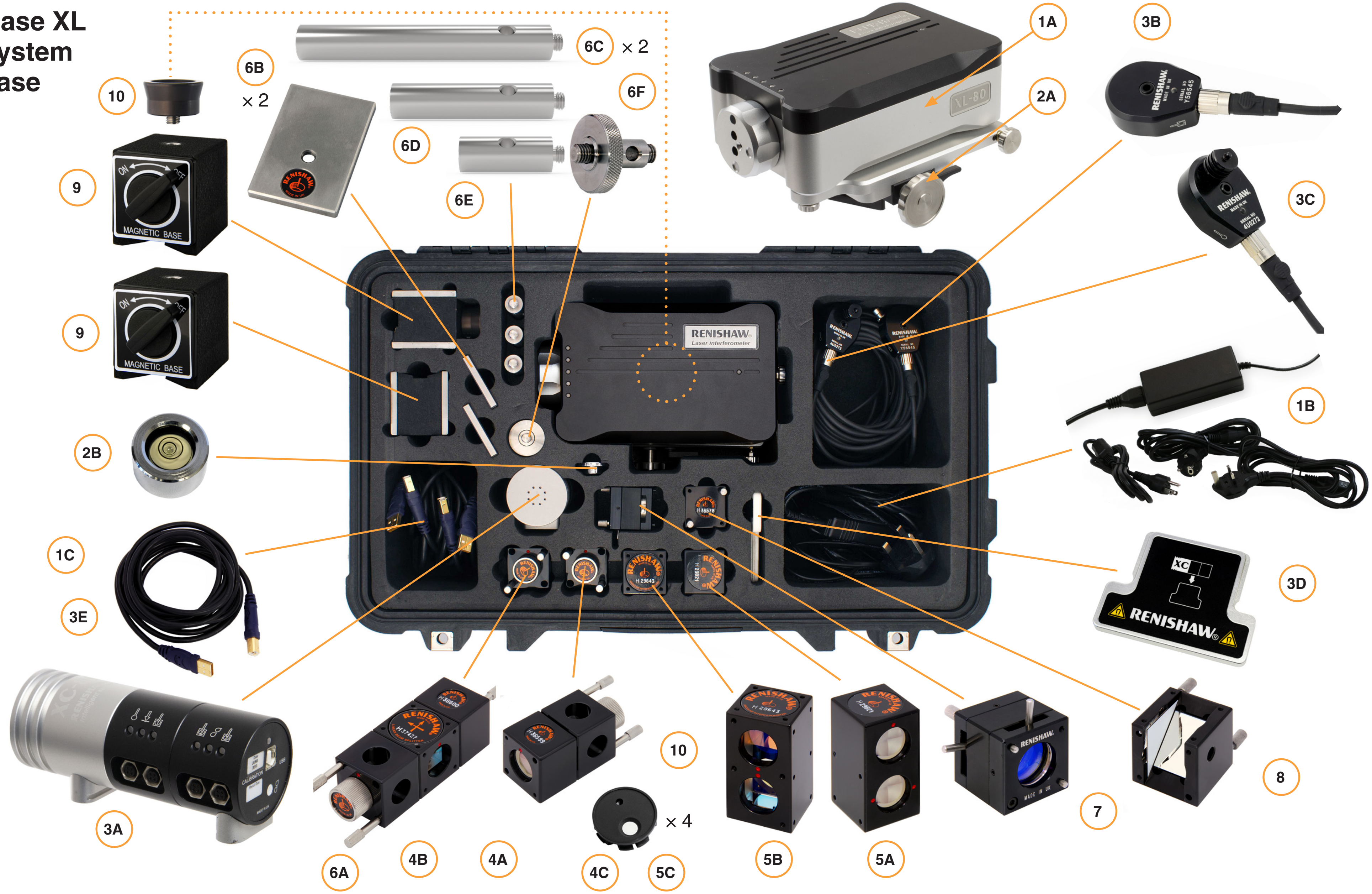
Base XL system case

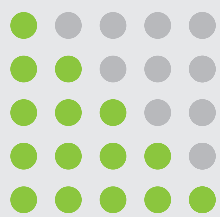


Base XL system case contents

Index	Part number	Part name	Includes	Part number	Index
1	A-9908-0405	XL-80 laser kit	XL-80 laser		1A
			Universal power supply	A-5103-4370	1B
			USB cable	A-9908-0286	1C
			AUX I/O connector	A-9908-0329	Not shown
2	A-9908-0700	Tripod stage kit	XL tripod stage		2A
			Spirit level circular	A-9908-0323	2B
			XL tripod stage adaptor	A-9908-0770	Not shown, fitted to tripod
3	A-9908-0510	XC-80 compensator kit	XC-80 compensator		3A
			Material temperature sensor and cable	A-9908-0879	3B
			Air temperature sensor and cable	A-9908-0878	3C
			XC mounting plate	A-9908-0892	3D
			USB cable	A-9908-0286	3E
4	A-8003-0440	Linear measurement optics	Linear reflector (× 2)	A-8003-0219	4A
			Linear interferometer	A-8003-0557	4B
			Alignment target (× 2)	A-8003-0478	4C
5	A-8003-0441	Angular measurement optics	Angular reflector	A-8003-0181	5A
			Angular interferometer	A-8003-0186	5B
			Alignment target (× 2)	A-8003-0478	5C
6	A-8003-0447	Optics mounting kit	Clamp block (× 2)	A-8003-0262	6A
			Base plate (× 2)	A-8003-0522	6B
			Mounting pillar 110 mm (× 2)	M-8003-0470	6C
			Mounting pillar 70 mm	M-8003-0739	6D
			Mounting pillar 40 mm	M-8003-0740	6E
			M8 adaptor	A-8003-0979	6F
7	A-8003-3072	Laser beam steerer LS350			7
8	A-8003-1325	Fixed turning mirror			8
9	A-9908-0780	Magnetic base			9
10	A-9908-0760	XL magnetic base adaptor			10

Diagnostics and troubleshooting

Signal strength LED status

LED status		Description	Actions
Solid red		Beam break – measurements cannot be made.	• Check laser beam is present. • If no laser beam, power cycle. • If issue persists, contact local Renishaw office.
Solid amber		Beam low – danger of beam break occurring.	• Check laser alignment. • If measuring separation > 40 m, use high gain mode. • If issue persists, contact local Renishaw office.
Single green LED indicates minimum beam strength, increasing up to 5 green LEDs for maximum beam strength.		Signal strength OK.	Open CARTO Capture software in XL mode.

Beam strength LEDs

At the front of the top panel of the XL laser there are five LEDs. These have a dual function:

1. **Preheat mode**
   When the XL laser is first switched on and is undergoing preheat, the beam strength LEDs turn amber. As the preheat sequence progresses, the LEDs go out in turn, indicating how far through the sequence the laser has progressed. When the final amber LED goes out the LEDs switch to 'beam strength' mode.

NOTE: When there is sufficient signal strength to maintain a single green LED, the system accuracy is independent of signal strength.

2. **Beam strength mode**
   When the laser is switched on and has stabilised, the five LEDs indicate the returned beam strength (the level of interference between reference and measurement laser beams returned from the external optics). This provides an indication of how well the laser and optics are aligned, as shown in the table above. These LEDs are in addition to the beam strength indication in the system software, but are helpful when working away from the computer screen.

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Laser status LED information

At the rear of the top panel of the XL laser there is a single LED (see image below for reference).

LED status		Description	Actions
Solid red		Error	• Check laser beam is present. • Power cycle the laser. • If issue persists, contact local Renishaw office.
Solid amber		Laser unstable	• Check laser alignment. • If issue persists, power cycle. • If issue persists, contact local Renishaw office.
Flashing red		Preheat cycle	No action required.
Solid green		Laser is stabilised	Open CARTO Capture software in XL mode

1	Laser status LED

Common causes of laser destabilisation

Back reflections

The feedback circuit which controls the heater and thus stabilises the laser is based on monitoring the output beam from the laser tube. If the laser beam is reflected back into the output beam aperture of the laser shutter, the detection circuitry can be confused as the reflected beam will interfere with the outgoing beam. This will lead to a loss of stability of the laser.

This is most likely to occur during system alignment, either due to the beam being misdirected back into the laser or the outgoing beam being reflected from the centre of the retroreflector. The loss of stability is temporary and the laser will restabilise once the reflection is removed.

Ambient temperature change

If the XL laser has been kept in a cold place (for example, stored in the boot of a car overnight in winter) and is taken into a warm factory to be used, the laser may become unstable. When the laser is switched on, the temperature of the laser tube stabilises at a lower temperature than if it had been kept in the working environment. If the ambient temperature around the tube increases significantly (due to self-heating and an increase in the ambient room temperature) the heater current may reduce to zero and the laser will become unstable.

If you encounter this problem, it can be overcome as follows:

1. Turn off the laser at least 15 minutes after the laser has first stabilised.
2. Wait a few seconds.
3. Turn on the laser.
4. Wait while the laser goes through a second preheat cycle and restabilises at a higher tube temperature.

Care and handling

Recalibration

Why recalibrate?

As with any calibration equipment, it is recommended that the XL laser is periodically recalibrated to give confidence that the system:

- is currently still within original specified (or required) performance
- is likely to remain within its specified (or required) performance until its next recalibration

This is why recalibration of calibration test equipment is a mandatory requirement of most quality management/assurance systems.

An added benefit of periodic calibration is that the inspection Renishaw carries out when recalibrating your XL laser can reveal any otherwise unidentified accidental damage. The recalibration procedure includes general cleaning.

Compared to your investment in the measurement system, staff and procedures, periodic recalibration is a modest additional cost and could prevent far more serious and costly problems arising later.

Recalibration periods

The Renishaw recommended recalibration period for an XL laser is 3 years.

NOTE: This is 3 years from sale by Renishaw rather than from factory calibration date as stated on the calibration certificates supplied with the new equipment, since the units are stored under controlled conditions by Renishaw prior to sale.

Renishaw recalibration periods are only a recommendation and are based on typical use of the equipment in a typical environment. Under such conditions your XL laser should still be performing within Renishaw's specification at the end of this period.

However, there are several factors that may generate the need for more or less frequent calibrations including:

- Environmental conditions
- Frequency and duration of use
- Harsh treatment of the equipment during storage, transportation or use
- Level of accuracy required by the user
- The requirements of company QA procedures and/or local regulations

Ultimately it is for you to determine the appropriate calibration period after taking into account your own operational environment and performance requirements.

Recalibration reminders

Because evidence of calibration is important for users and their customers, there are several reminders built into both the main system hardware and system software.

Hardware reminder

The recommended recalibration date is indicated on a label on the side of the XL laser unit.

Software reminders

Further reminders are built into the CARTO software. If an XL laser is out of calibration, the date of last recalibration and the recommended date for recalibration will be displayed on-screen.

Recalibration facilities

Recalibration of the XL laser requires specialist test rigs and software to give results comparable to the original factory calibration. Renishaw therefore recommends that items are returned to our specialist facilities via your local Renishaw office.

Periodic recalibrations and recalibrations following repairs (if required) are carried out in accordance with the same procedures used for new systems and an identical format certificate will be issued.

XL laser calibration

Calibration certificate

Each XL laser is delivered with a calibration certificate. This demonstrates that the system has been calibrated at the Renishaw factory against reference systems with traceability to National Standards. It is proof of the equipment's performance as tested before delivery. Visit the **Calibration product quality and conformance** webpage for more information.

The certificate is a valuable document and may be required to satisfy your own or your customer's quality assurance requirements.

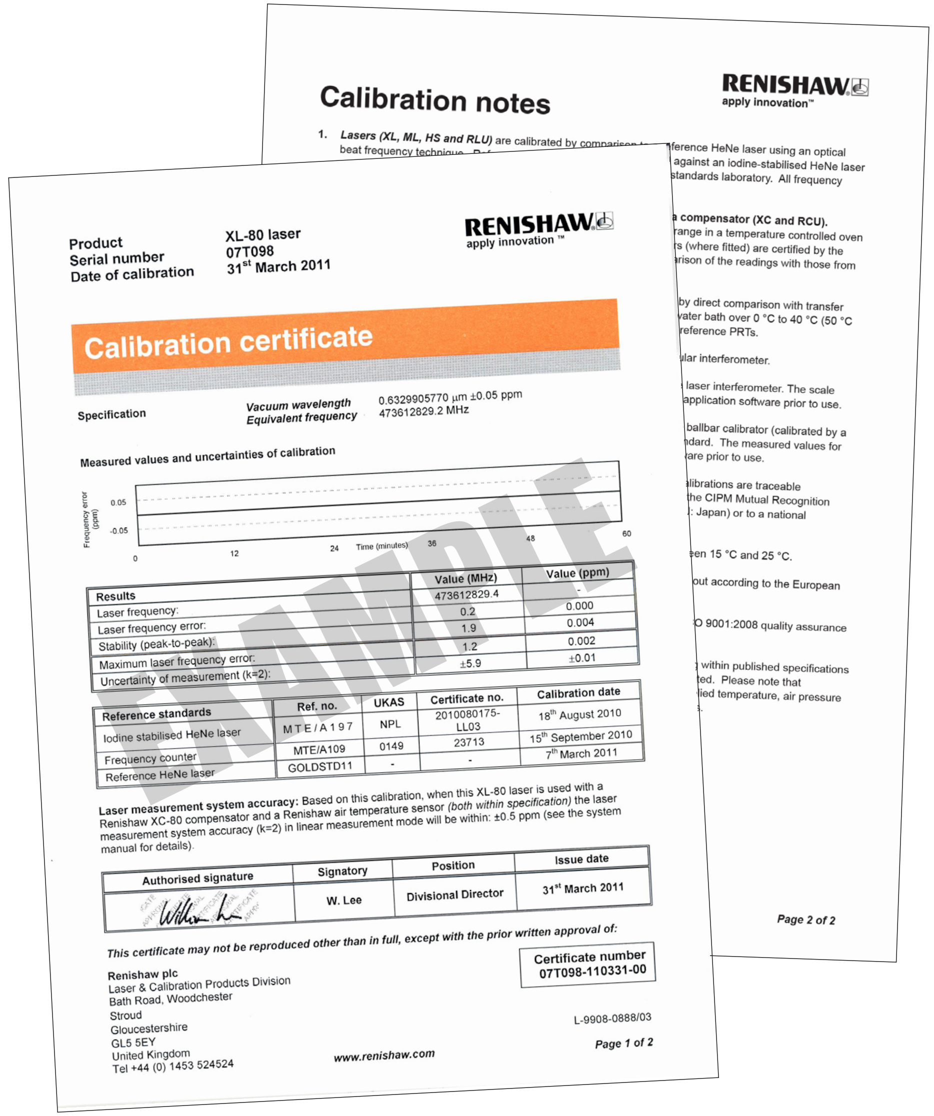
Duplicate documents can be supplied at an additional charge.

Certificate content

Each certificate is unique and is identified by a certificate number. All XL laser certificates provide the following key information:

- Serial number of calibrated XL laser
- Specific test results and graph
- Statement of accuracy
- Traceability data (calibration details, see below)
- Test conditions and methodology

The first page gives graphical representation of test results and specification limits, as well as tabulated details of the specific test results and uncertainty of measurement. User can visually verify whether or not the unit meets published specifications and/or your own requirements. To enable traceability, details of the test equipment used are given. The date of testing and the date of printing the certificate are separately noted and the results are signed by a Renishaw-authorised engineer.



The second page gives generic details of the test procedure, test environment, and applicable standards, in accordance with ISO 17025.

Care and maintenance

Optics

Cleaning of the optics should be a last resort

To maintain system performance, the XL optics must be kept clean by following good handling practice:

- Do not touch the optical surfaces.
- Minimise use in contaminated environments.
- Store securely when not in use.

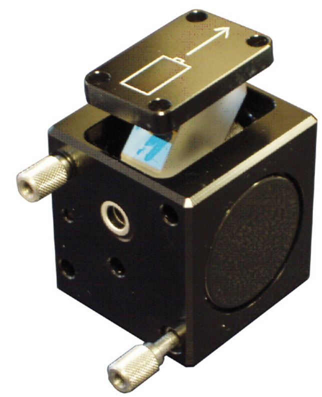
Cleaning recommendations

- Only use approved solvents for cleaning the optics: methylated spirit (preferred) or optical grade isopropyl alcohol (IPA).
- Wipe only with non-abrasive lens tissue or lint-free cloth wrapped around a cotton bud (do not use a cotton bud directly on the optic, as this may increase debris).
- Clean the optics using a gentle action. Never use a scrubbing action, as this might damage the coatings.

Failure to follow these recommendations may lead to damage to the coatings and glass elements of the optics.

Care of small linear optics kit

If contamination of the optical surfaces is suspected, undo the four cap screws holding the optics cartridge within the housing. Carefully invert the unit to separate it from the housing, and clean the optical surfaces using the recommended method.



When reassembling, ensure that the optics carrier is aligned against one of the long edges of the housing before fully tightening the cap screw. This ensures proper alignment of the optics within the housing.

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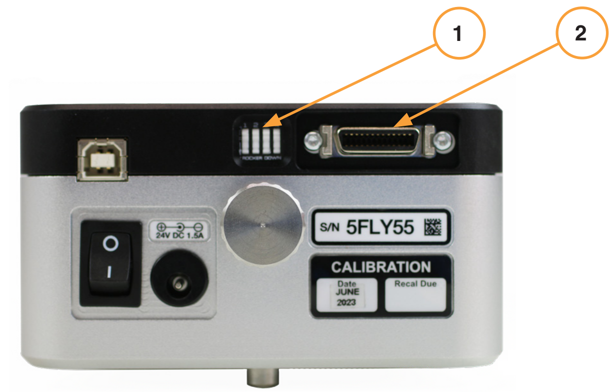
Appendix A

Auxiliary Input/Output

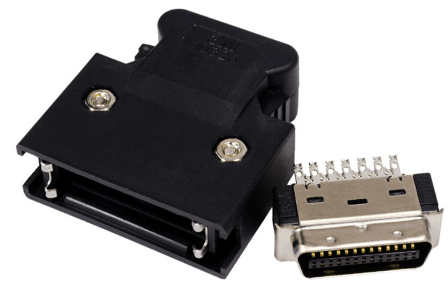
The XL laser auxiliary I/O functions are provided by the port on the back panel. Auxiliary functions provided are remote triggering, quadrature output and analogue output. The functions are selected and configured by means of four DIP switches.



1	DIP switches
2	Auxiliary I/O

Auxiliary Input/Output connector kit

An auxiliary I/O connector kit is provided with the XL laser kit to enable users to configure cable connections for use with the XL laser's auxiliary I/O port.



The cable can be configured to the user's own application and requirements by using the pin connections shown in the auxiliary I/O pin table.

It is recommended that a good-quality shielded cable is used, for example shielded twisted pair cable 28AWG (7/36).

Recommended cable types		
Function	Manufacturer	Model
Quadrature applications	Tyco (Madison cables) Alpha wire	xxQDKxxxxx and xxSDKxxxxx 349xC
Analogue and remote trigger applications	Alpha wire	346xC

When constructing a cable, the cable screen should be connected to the connector body. If twisted pair cable is used, the RS422 quadrature signals should share the same twisted pair; for example A and A/, B and B/.

DIP switch settings

There are four DIP switches on the back of the XL laser, each of which can be ON (rocker up position) or OFF (rocker down position). The table below summarises the DIP switch settings.

<table>
<tr><th>Switch number</th><th></th><th></th><th colspan="2">DIP switch 2</th><th colspan="2">DIP switch 3</th><th colspan="2">DIP switch 4</th></tr>
<tr><td></td><td>Switch position</td><td>Quadrature settings</td><td>ON</td><td>OFF</td><td>ON</td><td>OFF</td><td>ON</td><td>OFF</td></tr>
<tr><td rowspan="2">DIP switch 1</td><td>ON</td><td>Analogue settings</td><td colspan="4">Analogue gain (see table below)</td><td rowspan="2">Long range (high gain)</td><td rowspan="2">Short range (low gain)</td></tr>
<tr><td>OFF (default)</td><td>Digital settings</td><td>10 nm quadrature resolution *</td><td>80 nm quadrature resolution *</td><td>Hysteresis on *</td><td>Hysteresis off *</td></tr>
</table>

* Quadrature output is available as a factory set option

Analogue gain settings

DIP switch 2	DIP switch 3	Gain (±2%)	Measurement range
ON	ON	1 µm/V	±5 µm
ON	OFF	10 µm/V	±50 µm
OFF	ON	100 µm/V	±500 µm
OFF	OFF	1 mm/V	±5 mm

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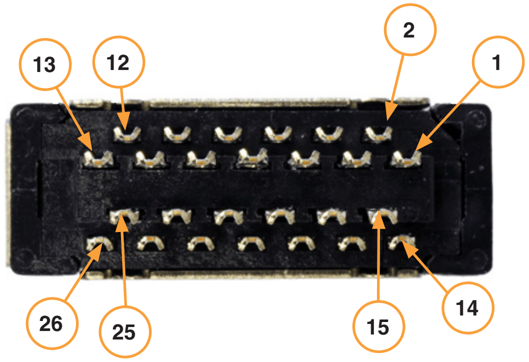
Auxiliary I/O connector



The table shows the Auxiliary I/O pin connections available from the connector.

Pin number	Function
1	Reserved – do not connect
2	0 V
3	Analogue position voltage output
4	0 V
5	Reserved – do not connect
6	Reserved – do not connect
7	/B output*
8	B output*
9	Reserved – do not connect
10	Reserved – do not connect
11	0 V
12	+5 V ±10%
13	0 V
14	Fast trigger input
15	Slow trigger input
16	Clear error and Datum input
17	0 V
18	Reserved – do not connect
19	Reserved – do not connect
20	/A output*
21	A output*
22	/ALARMOUT output*
23	ALARMOUT output*
24	Reserved – do not connect
25	Reserved – do not connect
26	Reserved – do not connect

* Quadrature output is available as a factory-set option

Appendix B

Remote triggering

The remote trigger facility allows data to be captured by the calibration software, upon receipt of a trigger signal generated remotely, for example, from a machine under test.

The trigger signal is input via the auxiliary I/O port on the rear panel of the XL laser. The XL laser supports two types of trigger signal – 'slow trigger' and 'fast trigger'. These are accessed by two different pins on the auxiliary I/O connector.

Fast trigger

The fast trigger mode provides a high-speed hardware trigger facility with a short delay (< 1 µs) between the leading edge of the trigger input pulse and the instant that the laser reading is recorded.

The fast trigger signal must be a clean, debounced TTL, CMOS or SSR signal applied to the fast trigger pin on the auxiliary I/O connector, as shown in Figure 1 opposite.

Fast trigger specifications	
Active edge	Falling
Minimum pulse width	1 µs
Maximum trigger rate	50 kHz
Trigger delay	±1 µs
Maximum input voltage	±12 Vw

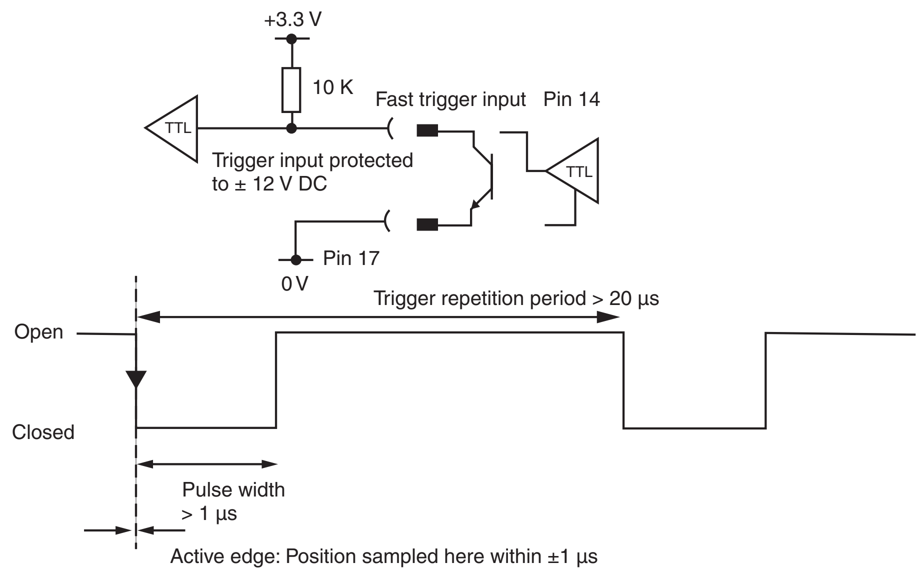


Figure 1 Electrical interface for fast triggering.

Slow trigger

The XL laser is triggered using a noisier trigger signal; for example, from a relay or switch as shown opposite. This signal is applied to the slow trigger pin of the auxiliary I/O port. The time delay between the leading edge of the trigger pulse and the instant the laser reading is received is longer than the fast trigger mode.

Slow trigger specifications	
Active edge	Falling
Minimum pulse width	5 ms
Switch debounce	< 20 ms
Trigger delay	8 ms
Maximum input voltage	±12 V

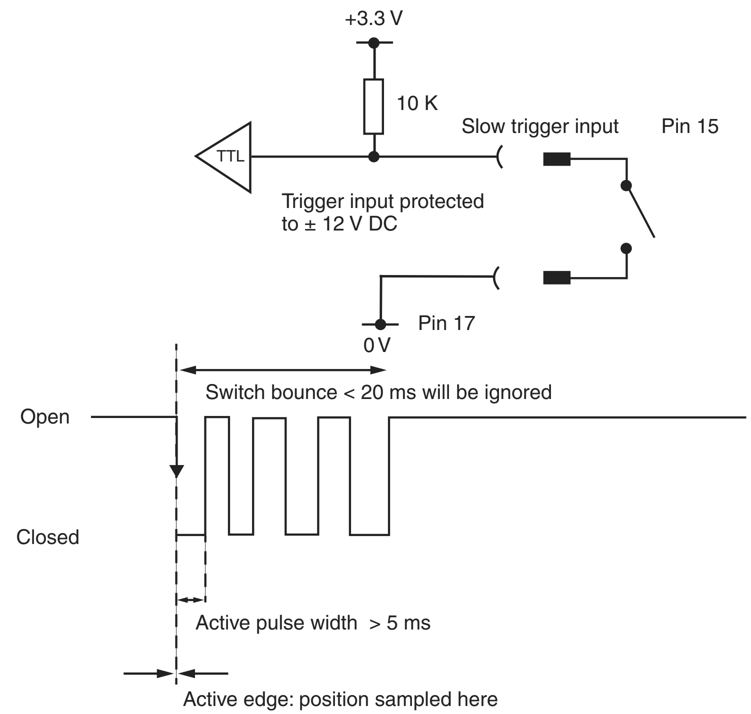


Figure 2 Electrical interface for slow triggering.

Appendix C

Quadrature output

Quadrature output is available as a factory-set option on the XL laser.

The quadrature output allows 'raw' interferometry signals to be supplied to custom-designed circuitry, to allow, for example, the laser to be used as a linear encoder system. The quadrature signals are accessed via a connector on the XL laser rear panel (see Auxiliary I/O connector pinout). Resolution is dependent on the configuration of the DIP switches (Switch 2 off = 80 nm, on = 10 nm).

Do not use the quadrature output facility of the XL laser to provide closed loop feedback control for a machine. The system is not designed to be used for feedback control and injury could result if used for this purpose.

XL-80Q may have export control restrictions in your region.

Format

These signals are not compensated for changes in the refractive index of air. The A, /A, B, /B, ALARMOUT and /ALARMOUT signals are provided in RS422 balanced differential line format.

Resolution

The 'A' QUAD 'B' signals are represented in diagram below.

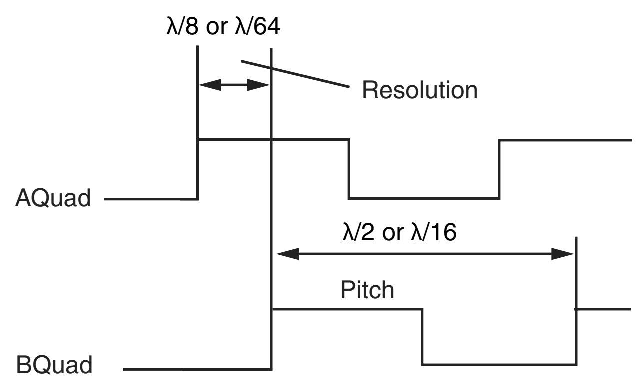


Figure 3 Resolution of quadrature signals.

The maximum quadrature resolution can be selected as λ/8 (approximately 80 nm) or λ/64 (approximately 10 nm), giving a pitch of λ/2 or λ/16 respectively.

Direction sign convention

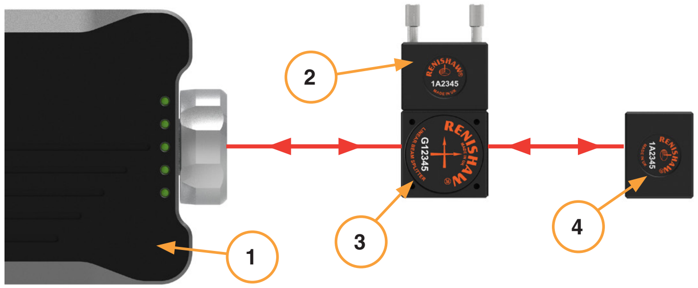


Figure 4 Linear measurement optical set-up.

1	XL laser	3	Linear beam splitter
2	Reference retroreflector	4	Measurement retroreflector

With the optics configured as shown above, the sign convention is as follows:

- For positive movement (measurement retroreflector moving away from XL laser) AQuad leads BQuad.
- For negative movement (measurement retroreflector moving toward XL laser) BQuad leads AQuad.

(See Figure 3)

Update rate

The quadrature output update rate is 20 MHz.

Accuracy

The transitions of the quadrature signals are accurate to within ±10 nm at low velocities. However, there is a very small propagation delay (D) between a change in the optic position and in the quadrature output. The true accuracy of the transition (ignoring air refraction errors, see below) is given by:

Accuracy = $\pm(10 + Dv)$ nm

where v = velocity in m/s

D = 600 nsec

Delays due to any customer interface should be added to D to obtain an estimate of transition accuracy in a specific application.

Wavelength environmental compensation

The quadrature outputs are not compensated for changes in the refractive index of air. The value will be subject to variation dependent on environmental conditions. See **XL-80Q operation with RCU10**.

Alarm conditions

The alarm lines will go active (ALARMOUT high, /ALARMOUT low) and latch in the following situations:

- The XL laser internal counter allows a movement of more than ±169.9 m ($2^{31} \times 79$ nm)
- A resolution of 10 nm is selected and the speed is greater than 0.2 m/s
- A resolution of 80 nm is selected and the speed is greater than 1.6 m/s
- The laser beam is broken (beam break)

Once set, the error line will remain active until a clear error signal has been issued on pin 16 as shown opposite.

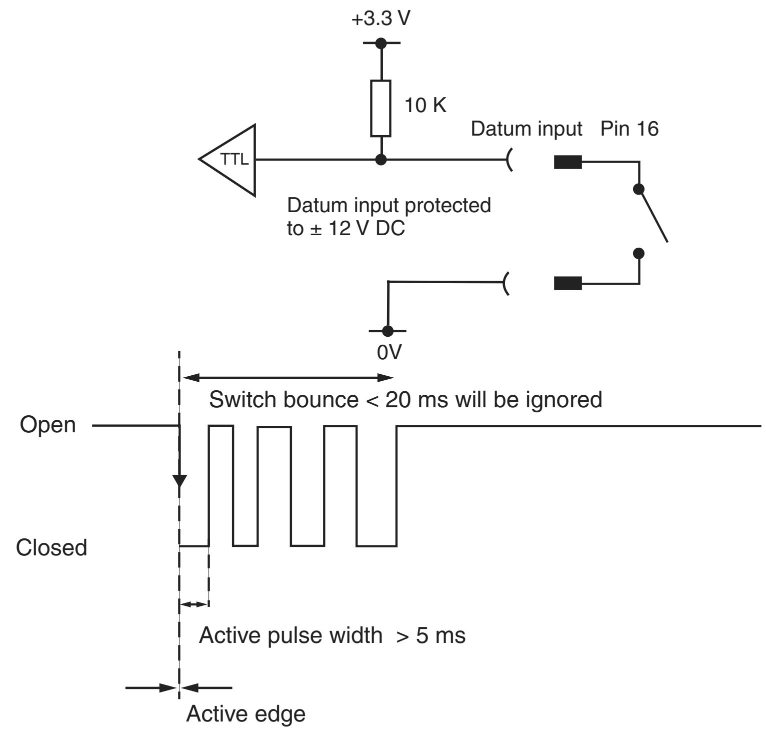


Figure 5 Electrical interface for clear error / datum.

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RS422 receiver circuitry

The image below shows a recommended circuit for the user end of RS422 receivers. A, B and ALARMOUT signals should be DC terminated with a 100 W to 120 W resistor.

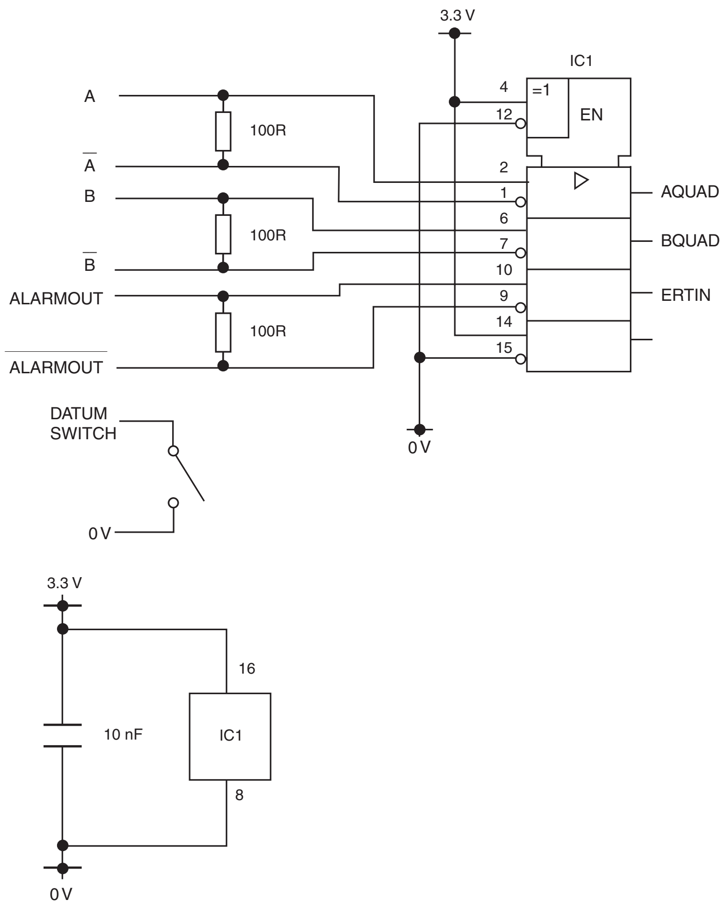
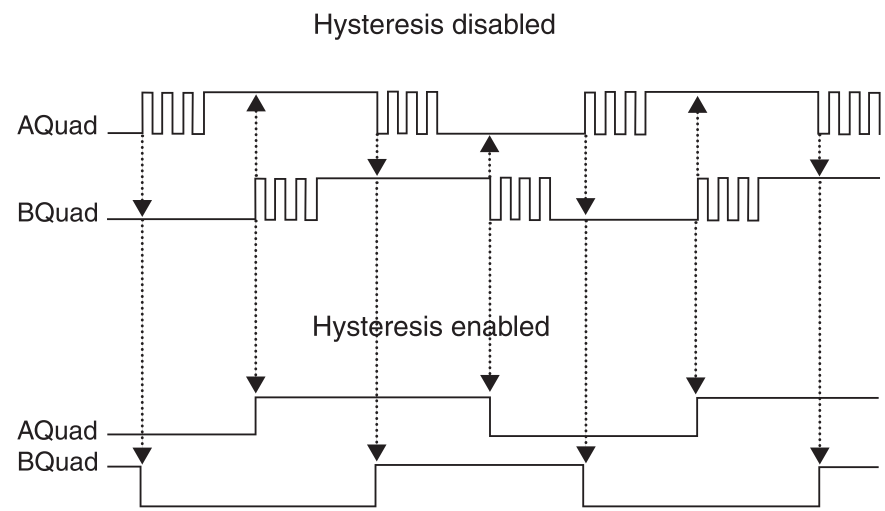


Figure 6 IC1 = MAXIM MAX3096
Recommended RS422 receiver

Hysteresis

Electrical noise or axis vibration can cause multiple edges to appear at each quadrature transition as shown below, even when stationary.



If a fast counter is not available, hysteresis may be applied (DIP switch 3 on), to clean up the edges so that only a single transition occurs each time. Note this will introduce one unit of resolution (10 nm / 80 nm) positional hystersis when the direction of travel is reversed.

Suggested extraction of valid data

The circuit shown below can be used to extract valid quadrature. The clock frequency should be selected according to the maximum velocity to be measured. The circuit produces an error signal if an invalid quadrature transition occurs. This can be caused by beam obstructions or by exceeding the maximum velocity.

By selecting a low enough clock frequency, slow 'edge picking' quadrature counters can be used.

$$Frequency \geq \left(\frac{1000}{\left(\left(\frac{resolution}{V\max} \right) - 10 - RxSkew \right)} \right)$$

Where:

- Frequency is in MHz
- Resolution is in nm = 80 nm or 10 nm
- Vmax is maximum velocity in m/s
- RxSkew is the receiver skew between the AQuad and BQuad channels in ns

Example calculation:
For Vmax = 1.6 m/s
Resolution = 80 nm
Typical RxSkew = 10 ns
Frequency of clock required ≥ 33.33 MHz

Or for a given frequency the velocity must be:

$$V\max \leq \left(\frac{resolution}{\left(\left(\frac{1000}{Frequency} \right) + 100 + RxSkew \right)} \right)$$

The maximum velocities possible are 1.6 m/s for 80 nm quadrature and 0.2 m/s for 10 nm quadrature.

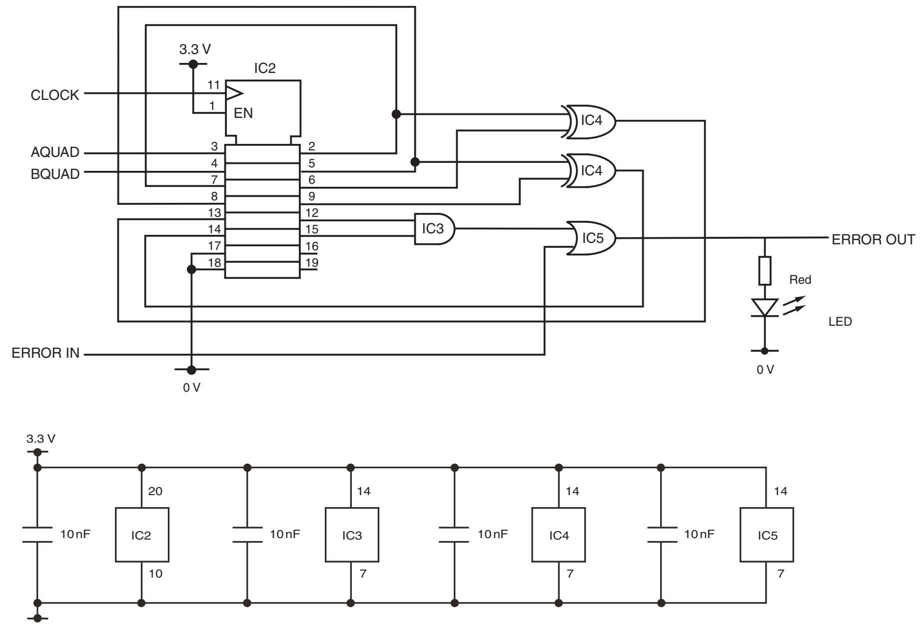


Figure 7 Circuit for extraction of valid data

IC2 = FAIRCHILD 74LVX273
IC3 = FAIRCHILD 74LVX08
IC4 = FAIRCHILD 74LVX86
IC5 = FAIRCHILD 74LVX32

NOTE: Tie all unused inputs of IC3, IC4 and IC5 to 0 V. The value of Rled will depend on the LED selected.

XL-80Q operation with RCU10

XL-80Q set-up:

XL-80Q DIP switch 2 must be set for appropriate quadrature resolution

“ON” = ≈10 nm resolution (λ/64)

“OFF” = ≈80 nm resolution (λ/8)

XL-80Q to RCU10 cable

Below is a summary of the wiring required between an XL-80Q (Auxiliary I/O connector) and an RCU10 (15-pin D-type male connector).

NOTE: A cable with twisted pairs and overall shield is recommended for the digital quadrature interface between the RCU10 and the XL-80Q.

1st pair	A Quad and /A Quad
2nd pair	B Quad and /B Quad
3rd pair	Error and /Error

XL-80Q		RCU10	
Pin number	Signal	Signal	Pin Number
2	0V	0V	2
22	/Alarm	/Error	3
23	Alarm	Error	11
7	/B Quad	/B Quad	5
20	/A Quad	/A Quad	6
8	B Quad	B Quad	13
21	A Quad	A Quad	14
4 and 16	External reset switch		

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RCU10 configuration

Below are the configuration settings for the RCU10 to XL-80Q. These settings are configured on the RCU10 using the RCU-CS software. For full details please consult the **RCU10 installation manual**.

RCU-CS: Configuration Tab.

Encoder type	RLE Axis 1
Wavelength	0.63281884600 µm
Resolution	~10 nm
Direction sense	Normal
Sample rate	20.0 MHz
Reference mark source	External port

Analogue signal output

The analogue signal output facility outputs a voltage which is proportional to the displacement of the measurement optics. It can be used for monitoring high-frequency vibration (for example, Piezo applications).

The analogue output function and the measurement range is selected by means of the DIP switches on the rear panel of the XL laser. There are two switches to select four range states.

The analogue signal, like the quadrature output, is not environmentally compensated.

The image below summarises the outputs of the auxiliary I/O when in the analogue gain setting:

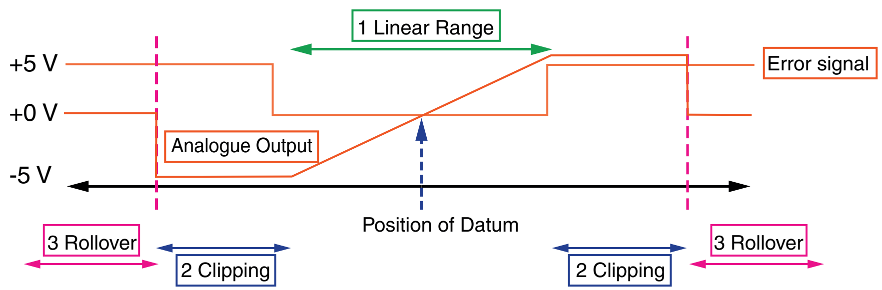

Figure 8 Auxiliary I/O outputs.

The analogue output exhibits a linear characteristic over a range of ±5 V from the datum position. Beyond this range, the output voltage is clipped and an error condition is output on the ALARMOUT line. If the rollover limit of ±40 mm is exceeded, the ALARMOUT signal becomes latched and the analogue output falls to 0 V.

The dynamic range of the analogue output is ± 5 V. An accuracy of ±2% is maintained over a range of ±4.5 V. The bandwidth of the analogue output is 100 kHz.

The following table outlines the error conditions that can occur and how they can be cleared:

Error condition	Auxiliary I/O error line	Analogue output	To clear the condition
During preheat	Active during	Zero during	Auto datum after preheat
Laser unstable	Active during	Driven	Datum not needed
Internal error	Latched after	Zero until datum	Datum to clear
Beam break	Active during	Zero until datum	Auto datum after Beam break
Overspeed	Latched after	Zero until datum	Datum to clear
Outside rollover limit	Latched after	Zero until datum	Datum to clear
Inside rollover limit	Active during	Clips at extents	Datum not needed

A pin on the auxiliary I/O connector allows the user to zero or datum the analogue output. The pin is pulled high internally and must be connected to 0 V on the connector to activate.

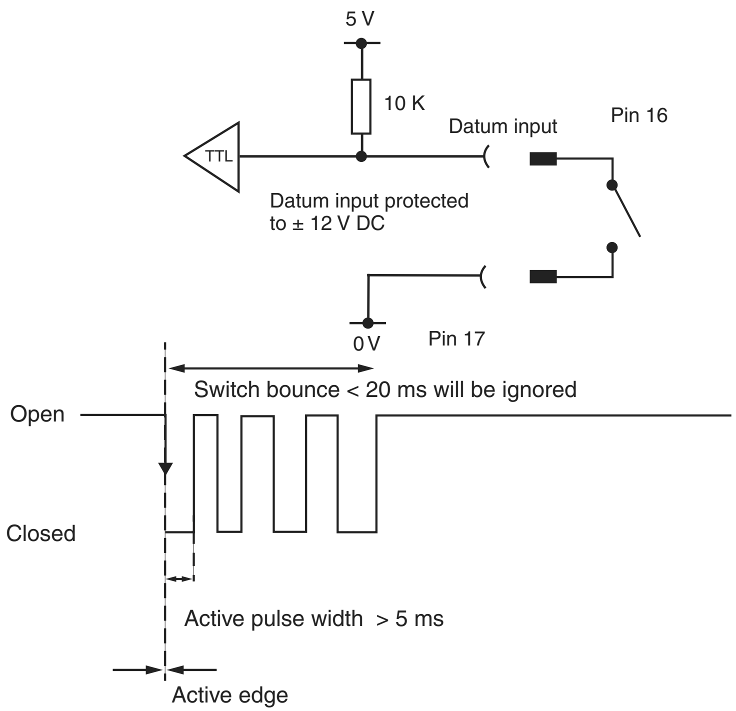

Figure 9 Electrical interface for clear error / datum.

The analogue output can also be datumed by breaking and then unbreaking the laser beam.

Electrical performance specification	
Output voltage range	±5 V
Accuracy (over ± 4.5 V range)	±2% of full scale
Rollover limit	±40 mm
Noise	±1% of full scale
Environmental compensation	None
Update rate	10 MHz
Propagation delay	< 4 µs
Maximum measured frequency	100 KHz
Transmission distance	3 m
DAC resolution	14 bits

XL-80 applications

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Introduction

Aims of the guide

- Provide the reader with the skills and confidence necessary to perform measurements using the XL laser system.
- Highlight the factors affecting measurements and methods of reducing/ eliminating them.
- Define the best practices for each measurement type.
- This guide will enable the user to perform a range of measurements, and capture measurement data for analysis.

Points to note

- The examples shown assume that the beam splitter with retroreflector attached (also known as an interferometer) is the stationary optic and the retroreflector is the moving optic.
- Procedures should be adapted when used in other configurations.
- This guide is intended to be used in conjunction with the **CARTO Capture, Explore and Compensate software user guides**.

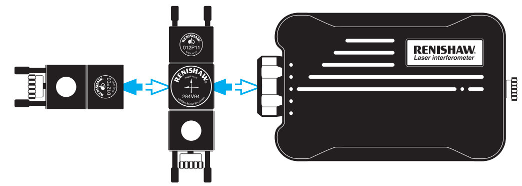
Introduction
Measurement modes

This guide includes:

Linear

Linear measurement is the most common measurement mode performed with a laser.

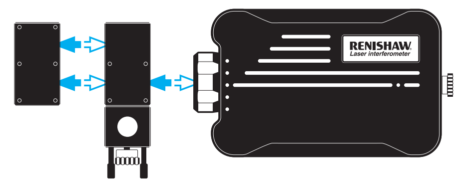
Any inaccuracy from the commanded position in a position critical motion system is often caused by factors such as changes in environmental conditions, mechanical wear, or angular pitch and yaw. Accuracy and repeatability are measured by driving to a series of pre-defined positions controlled by the motion system readout. At each position, a reading is then taken using the laser. The error is the difference between the controller readout and the laser readout.



Angular

Angular errors are often one of the biggest contributing factors to linear positioning errors.

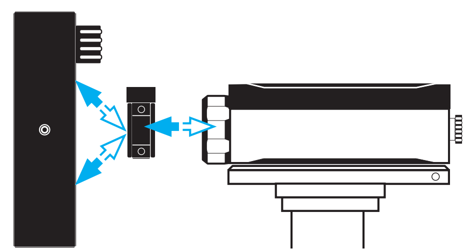
Angular errors are often caused by a bow in the motion of travel (pitch angle error) or slack guide leading to a rotation of the drive carriage (yaw angle error). The measurement technique is similar to that of linear measurement with readings being taken at a series of pre-defined positions to measure the angular change along the linear axis to ensure that the point of interest is in its correct linear position. Pitch and yaw errors are measured independently with the angular optics in different orientations.



Straightness

Straightness measurements are often a consequence of a vertical or horizontal deviation which is perpendicular to the axis of travel in a drive system or overall misalignment of guide rails.

The error is a vertical or horizontal deviation which is perpendicular to that of the motion of travel. Straightness errors are often caused by wear in the guide rails, an impact along the axis, or poor assembly of the drive carriage.



Measurement considerations

Alignment

Correct alignment of the laser is essential to provide an accurate measurement. Basic alignment rules are shown on the following pages; further alignment steps for each measurement type are detailed in each section.

Environment

The environmental conditions during measurements will significantly affect measurement accuracy. The factors below can introduce noise and drift to measurements:

- Thermal stability
- Shock and vibration
- Air turbulence

These should be reduced or eliminated where possible before commencing.

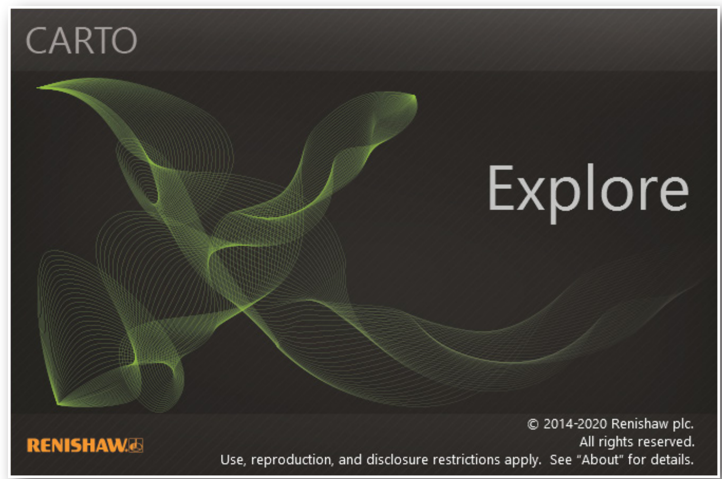
CARTO software suite

The XL system is used with the CARTO software suite. This is made up of three applications:

Capture	collects laser interferometry data
Explore	enables powerful analysis to international standards
Compensate	generates compensation files for precision applications

www.renishaw.com/carto

Click **here** to navigate to Calibration manuals and user guides.



Basic set-up

Setting up the tripod

Place the bubble level onto the tripod boss.

Adjust the tripod legs to ensure that the bubble is level.

NOTE: The height of the tripod should be set to approximately the height of the machine bed/optics.

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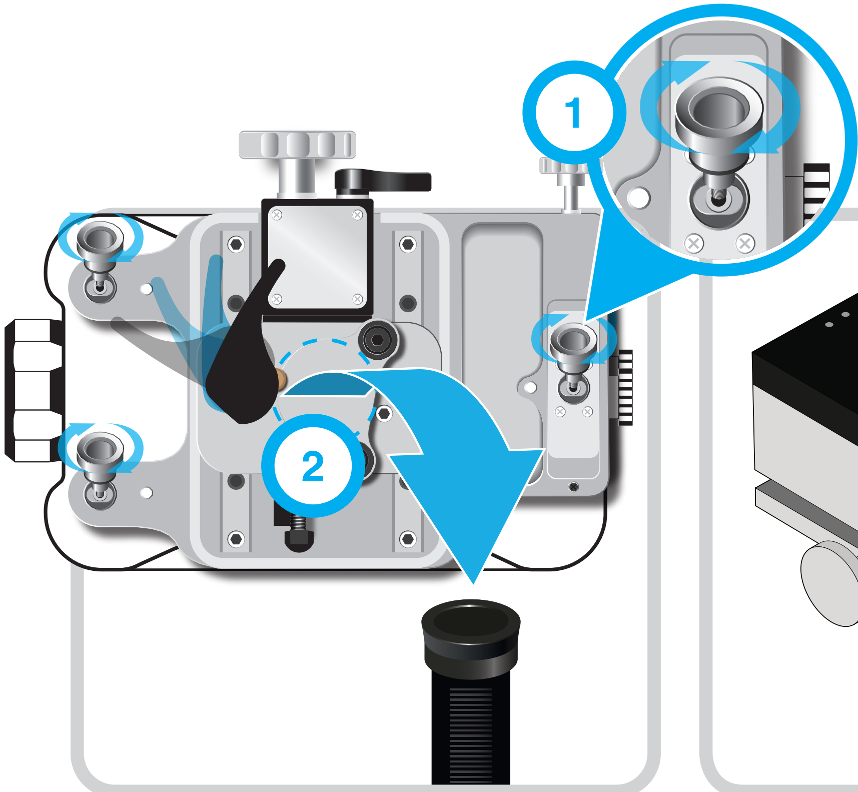
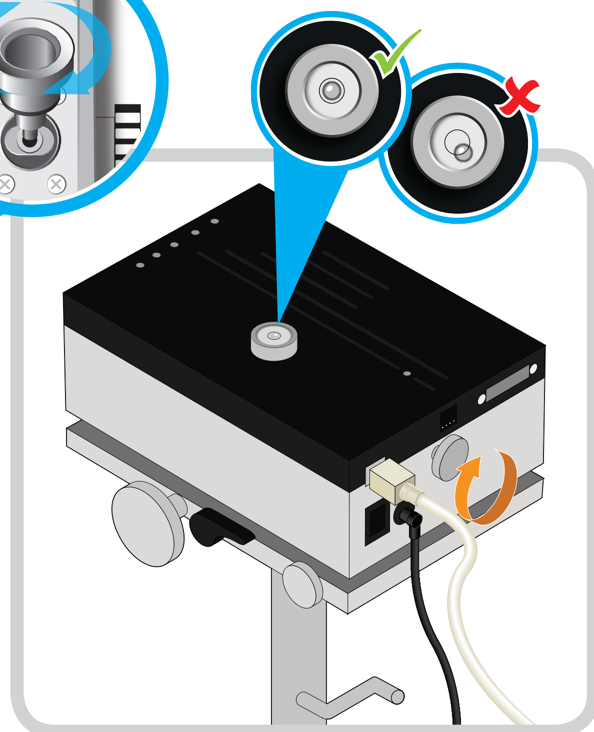
Basic set-up

Attaching the laser to the tripod

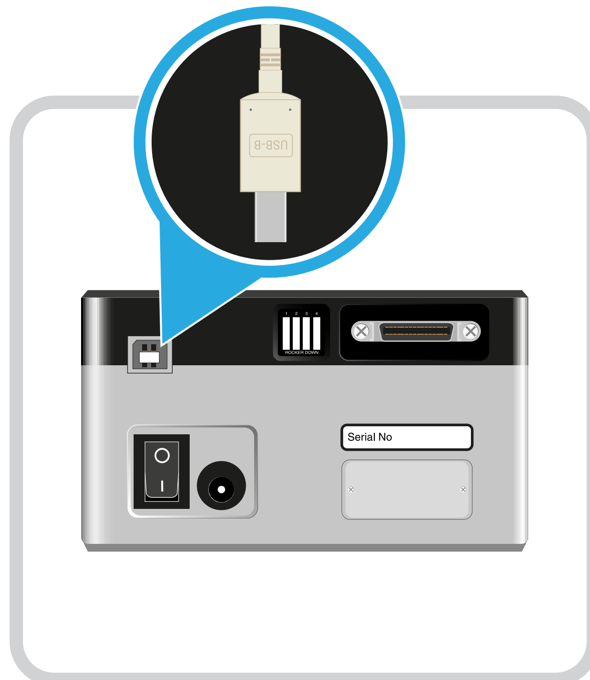


1. Attach the laser to the tripod stage using the three stage retaining screws.

2. Mount the tripod stage to the tripod.



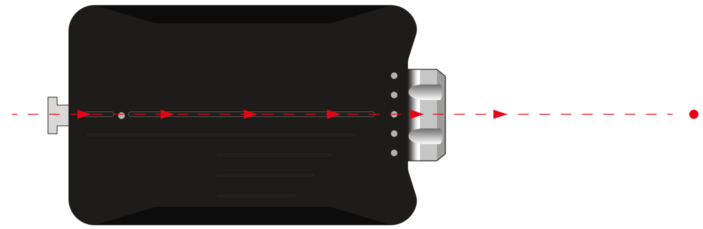
Place the bubble level on top of the XL laser and level the laser unit using the pitch adjust screw.



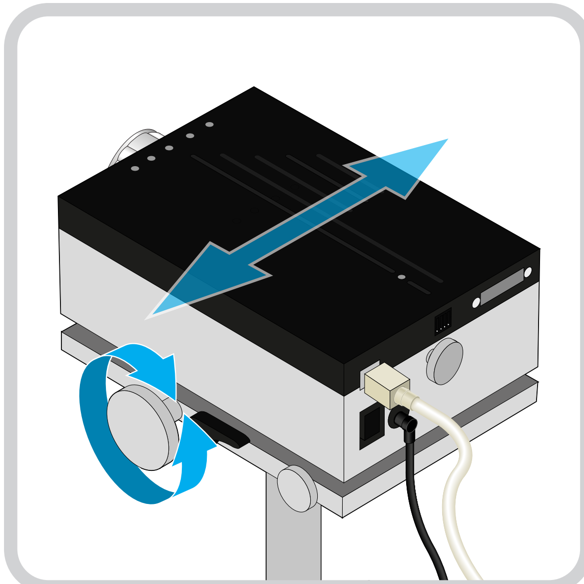
Connect the XL laser to the PC via the USB cable. Open CARTO Capture software and select the XL laser option.

Laser preparation

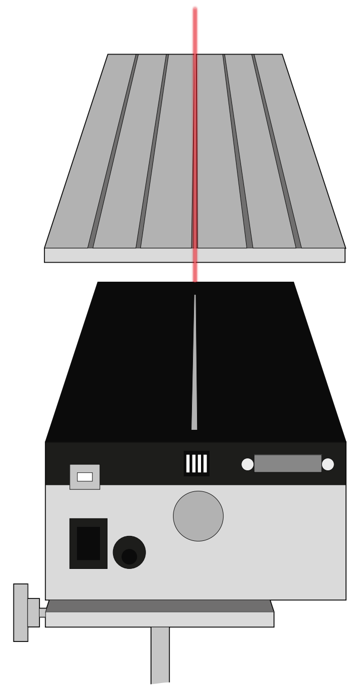
Set all laser stage adjustments to the mid-positions.



Height adjustment

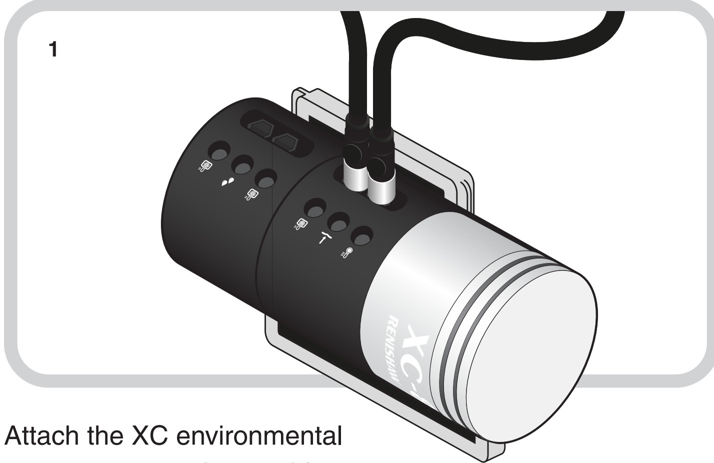


Horizontal translation adjustment



Set-up of the XC compensator

1



Attach the XC environmental compensator to the machine.

2

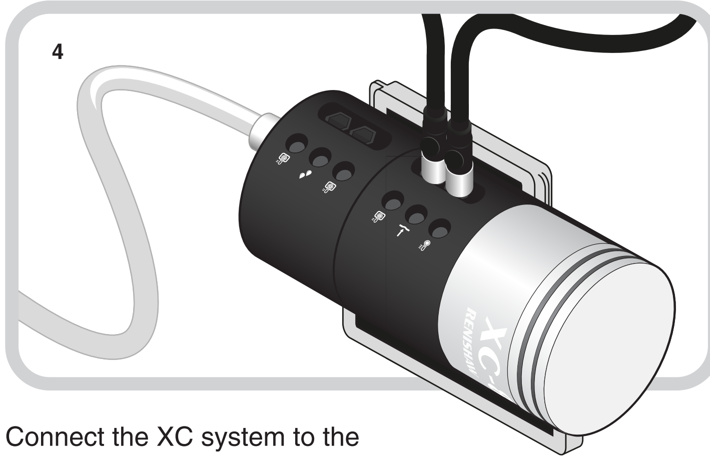
Connect the air and material sensors to the XC environmental compensator.

NOTE: The XC80 should only be orientated horizontally (as shown in picture).

3

Position the sensors on the machine. Position the air sensor along the laser measurement path. Position the material sensors as close as possible to the machine drive.

4

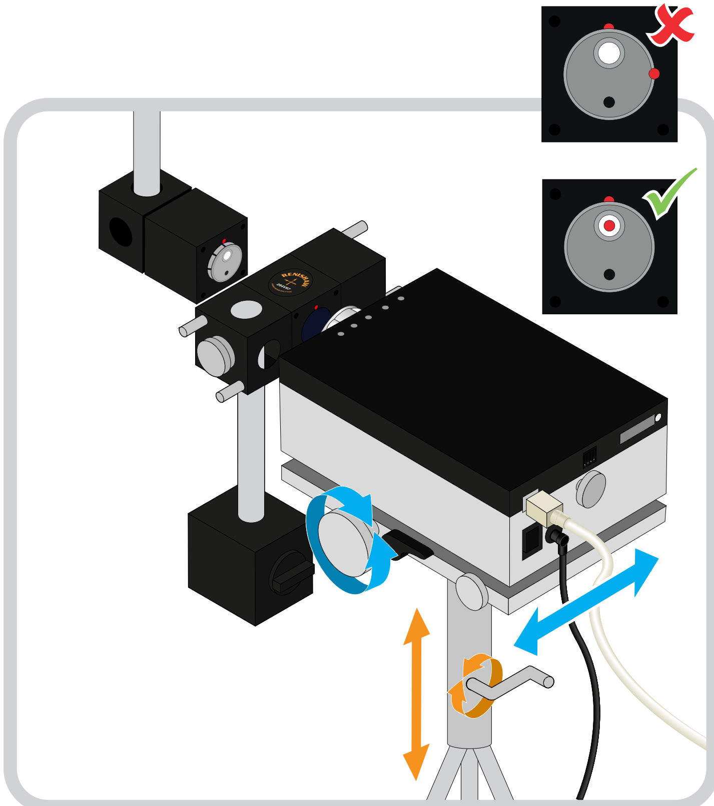


Connect the XC system to the PC using the USB cable provided.

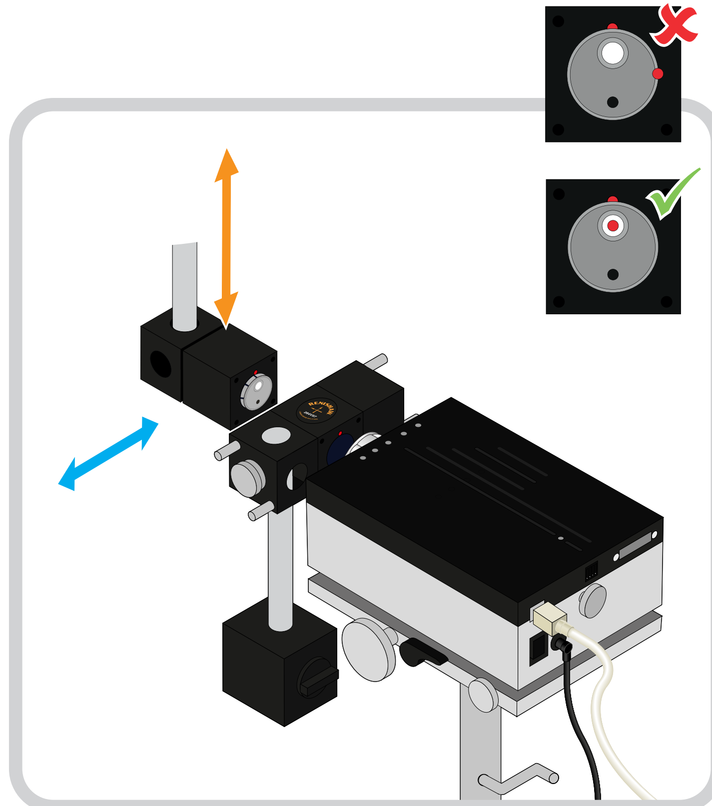
NOTE: Ensure that the cables do not obstruct moving components during operation.

Basic rules of alignment

Near field adjustment – when the moving retroreflector is closest to the stationary optic.



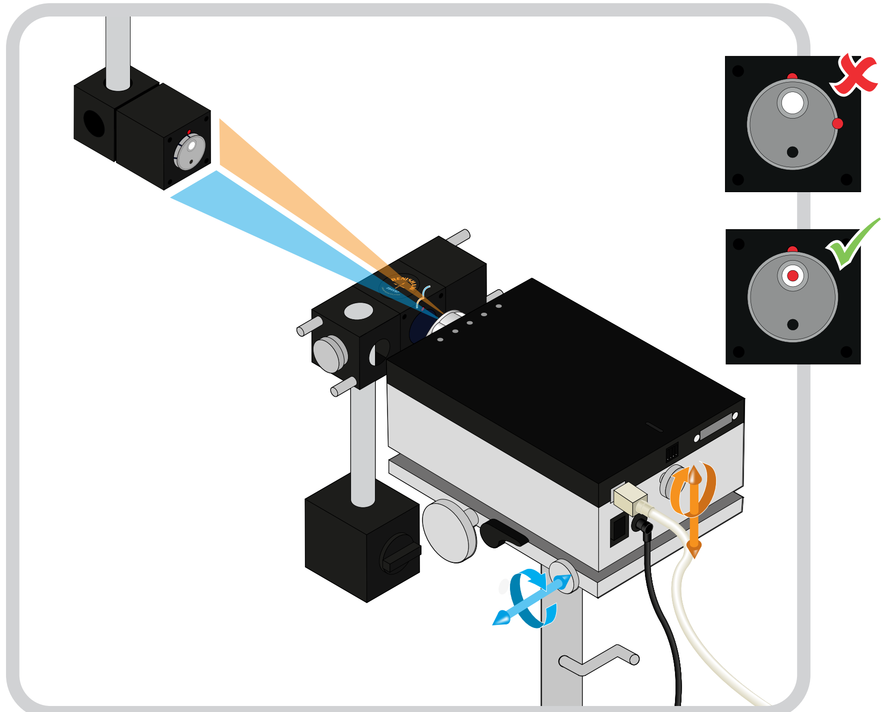
Method 1: Translate tripod.



Method 2: Translate the machine axes.

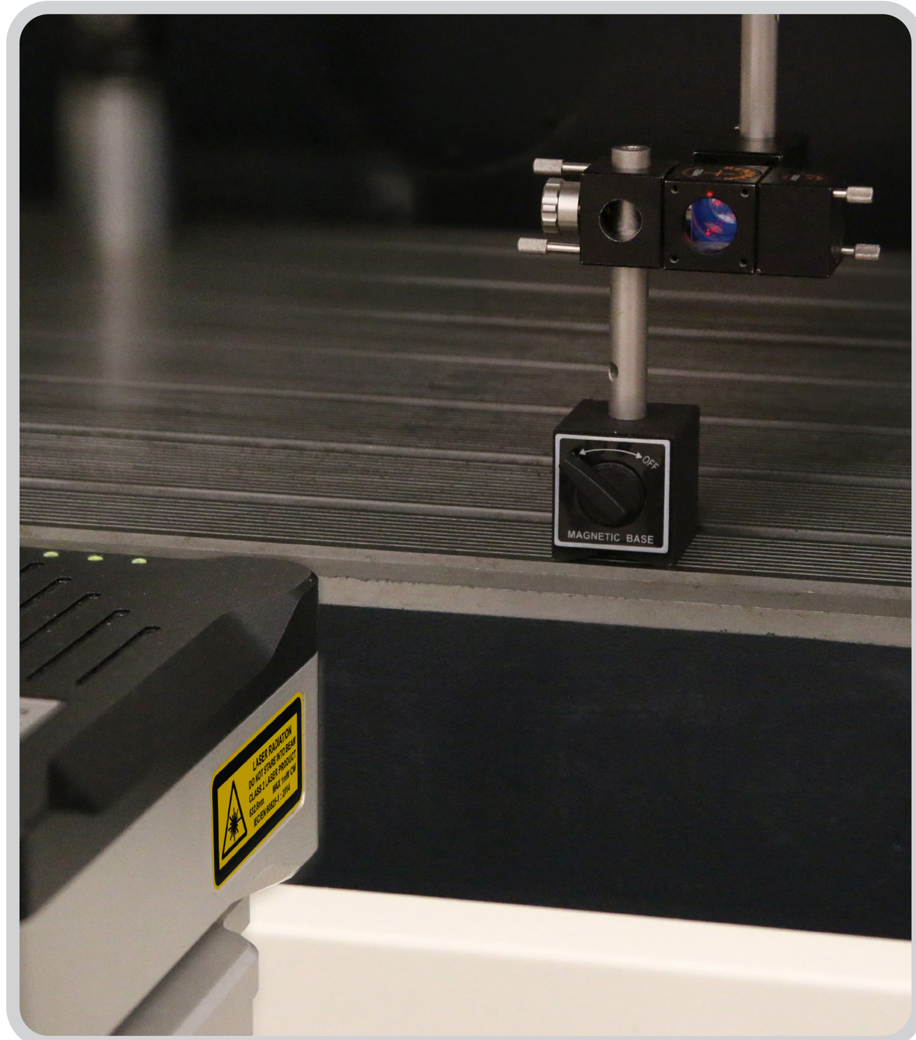
Basic rules of alignment

Far field adjustment – when the moving retroreflector is furthest from the stationary optic.



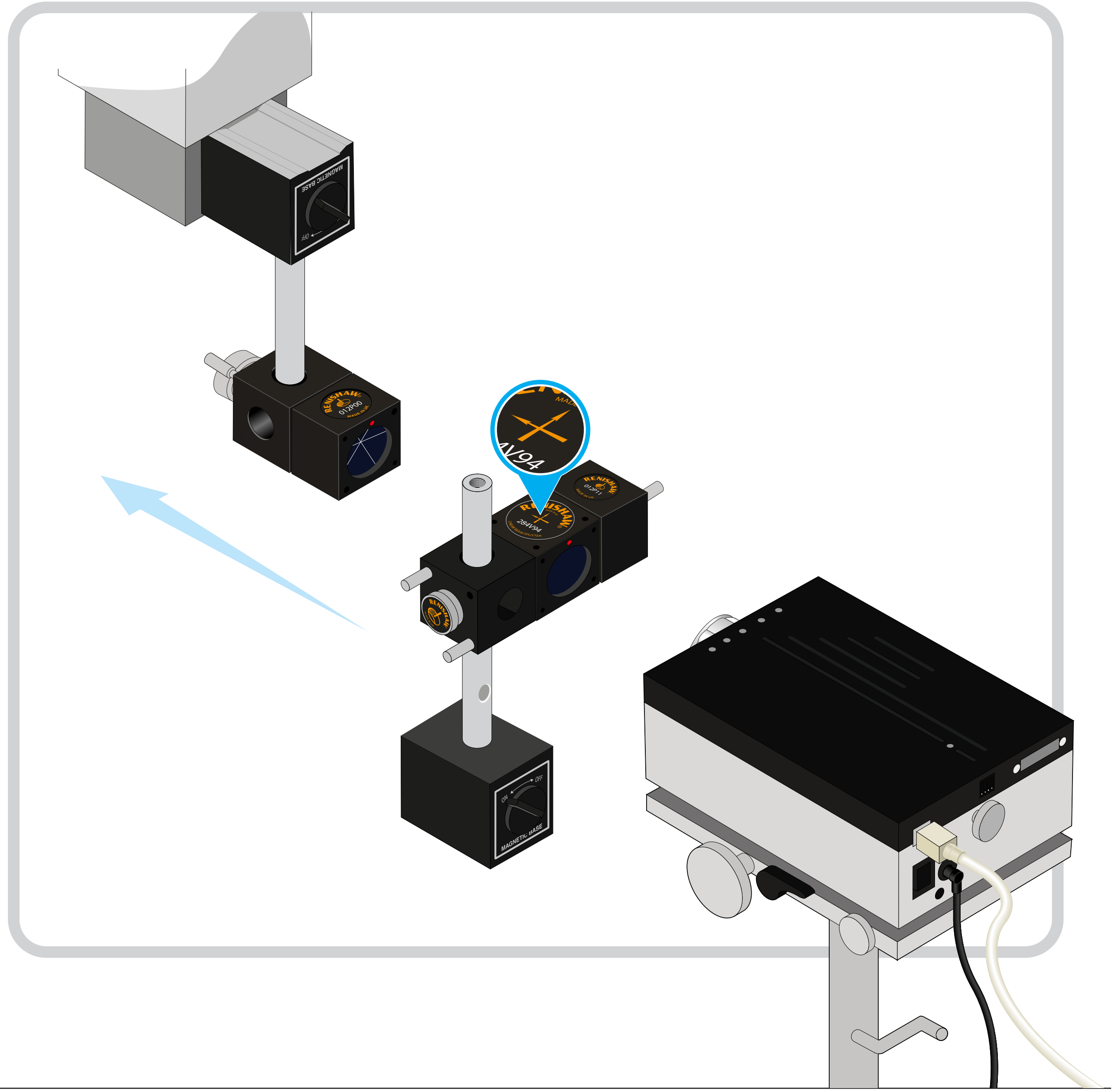
Adjust the pitch and yaw screws on the laser and tripod stage.

Linear measurement



Mounting the optics

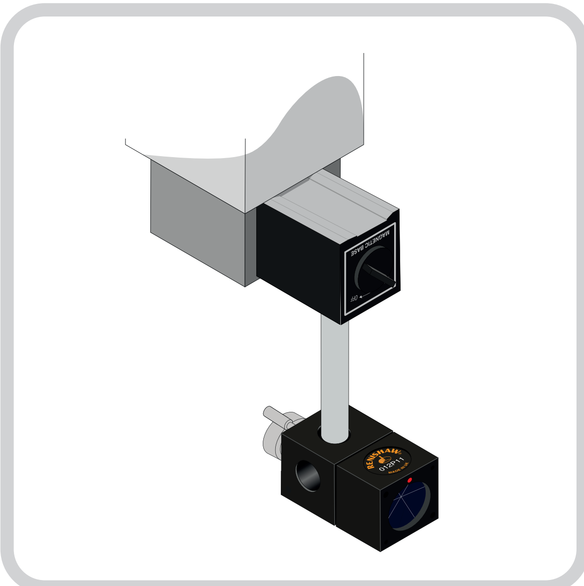
The linear measurement set-up.



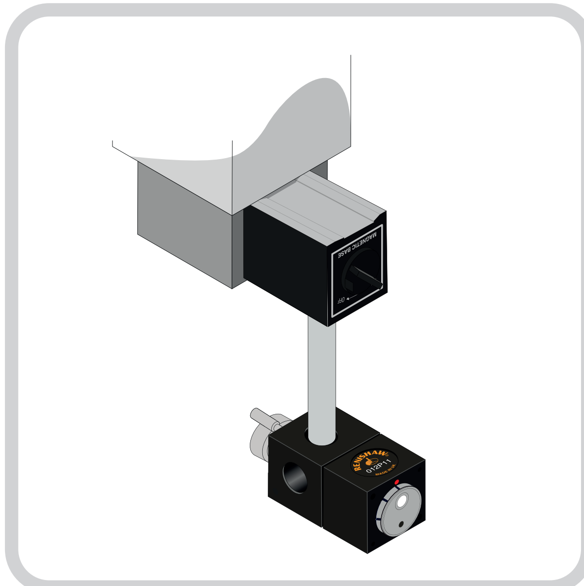
Mounting the optics

Mounting the retroreflector

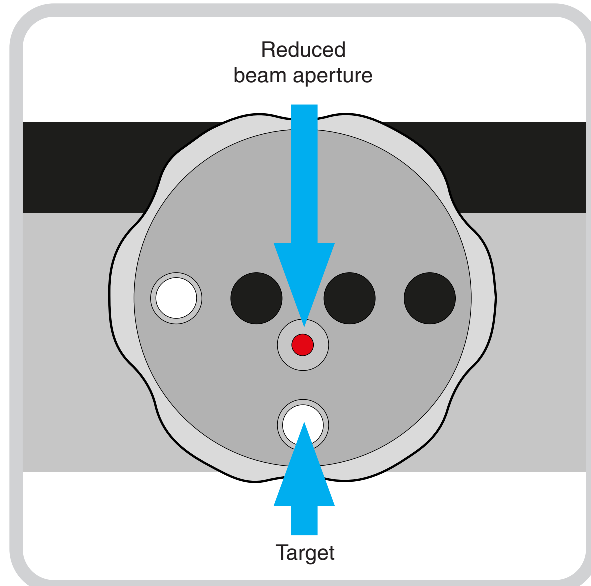
The linear measurement set-up.



Assemble the retroreflector assembly as shown. Mount to the moving element of the machine.



Attach the target onto the face of the retroreflector.

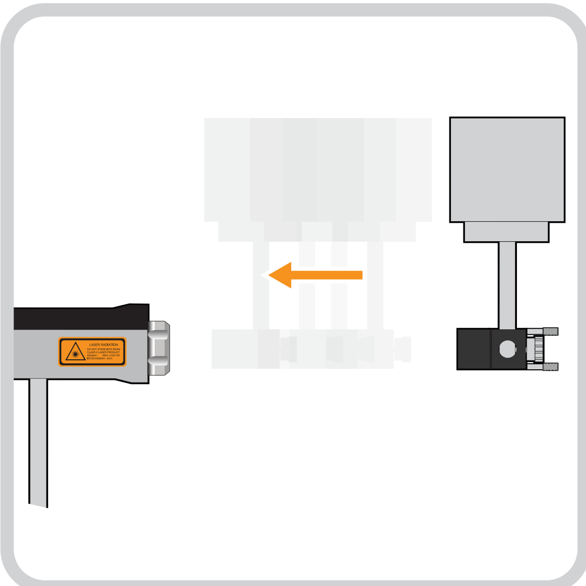


Rotate the laser shutter to emit a reduced diameter beam.

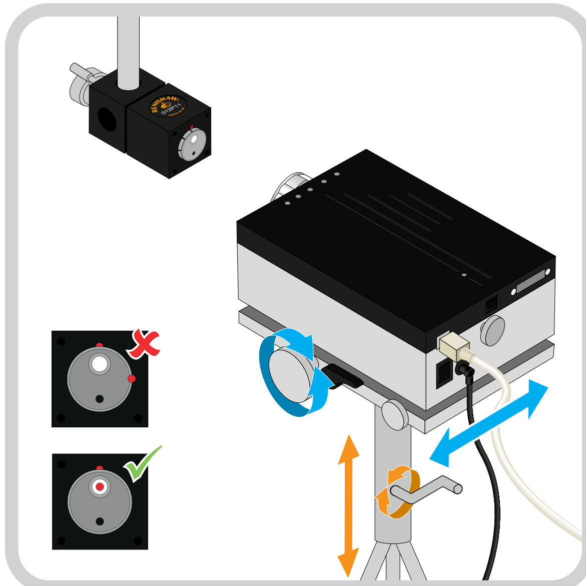
Mounting the optics

Mounting the retroreflector

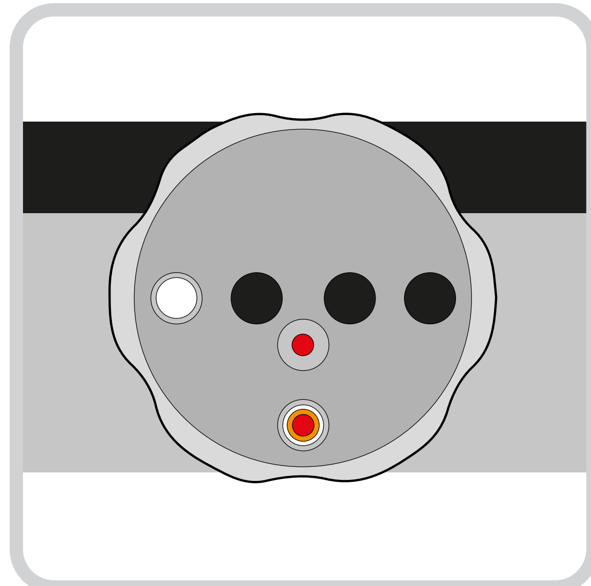
The linear measurement set-up.



Drive the retroreflector to the 'near field' position.



Adjust the beam to the centre of the white target using the translation screws.

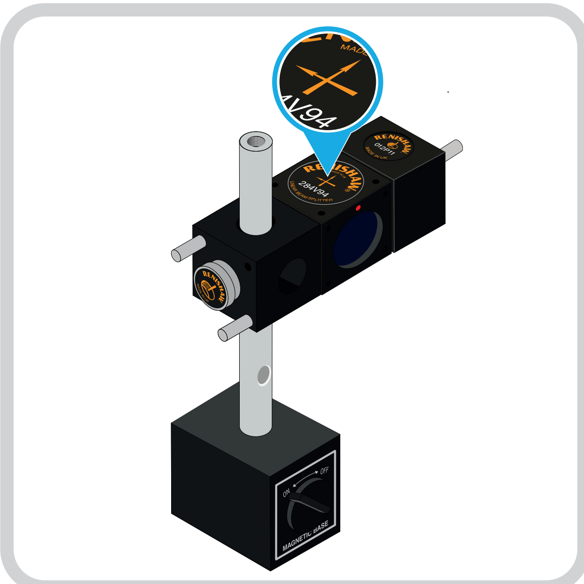


Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, translate the laser or the machine.

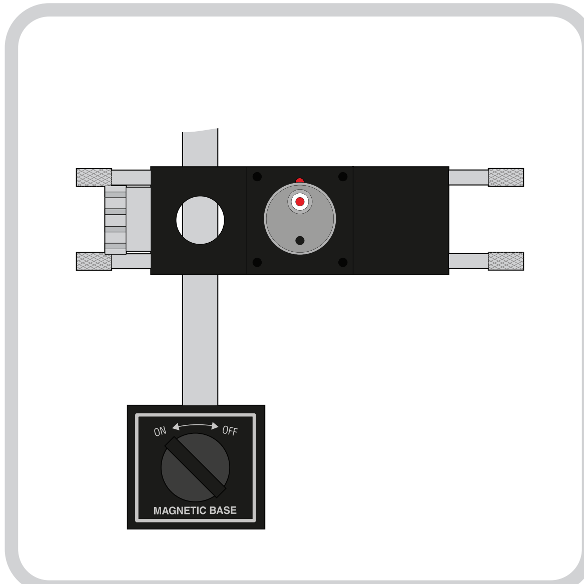
Mounting the optics

Mounting the interferometer

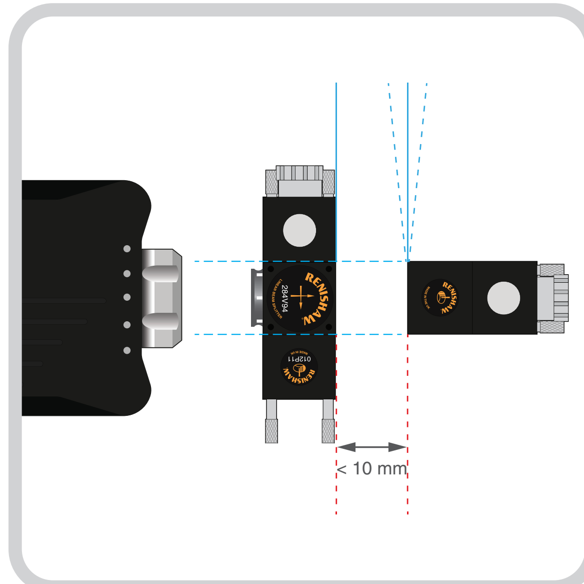
The linear measurement set-up.



Assemble the interferometer assembly as shown.



Attach the target to the input aperture and align it with the beam.



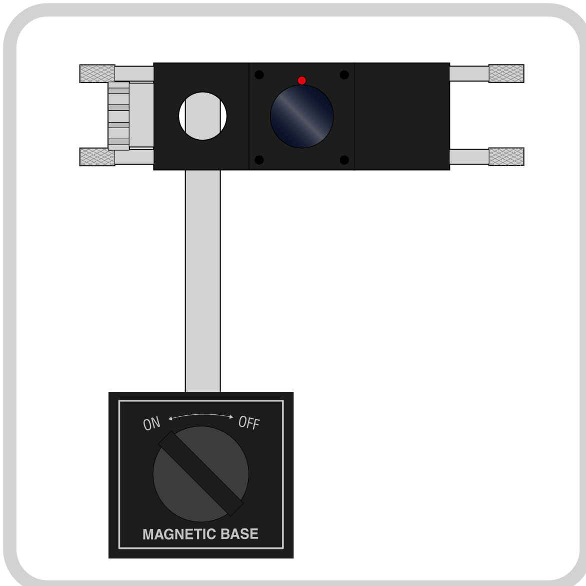
Mount to the stationary element of the machine:

- as close as possible, minimising the distance between the optics;
- square to the axis; and
- parallel to the retroreflector.

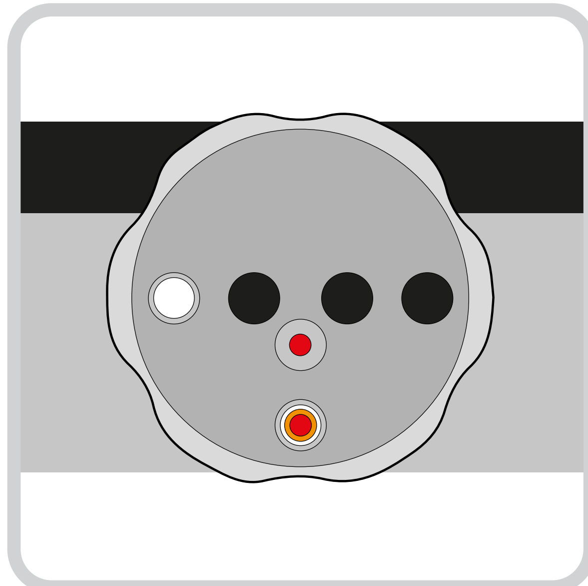
Visual alignment

Mounting the linear interferometer

The linear measurement set-up.



Remove the target.



Ensure that the two return beams are overlapping on the shutter target. Adjust as required.

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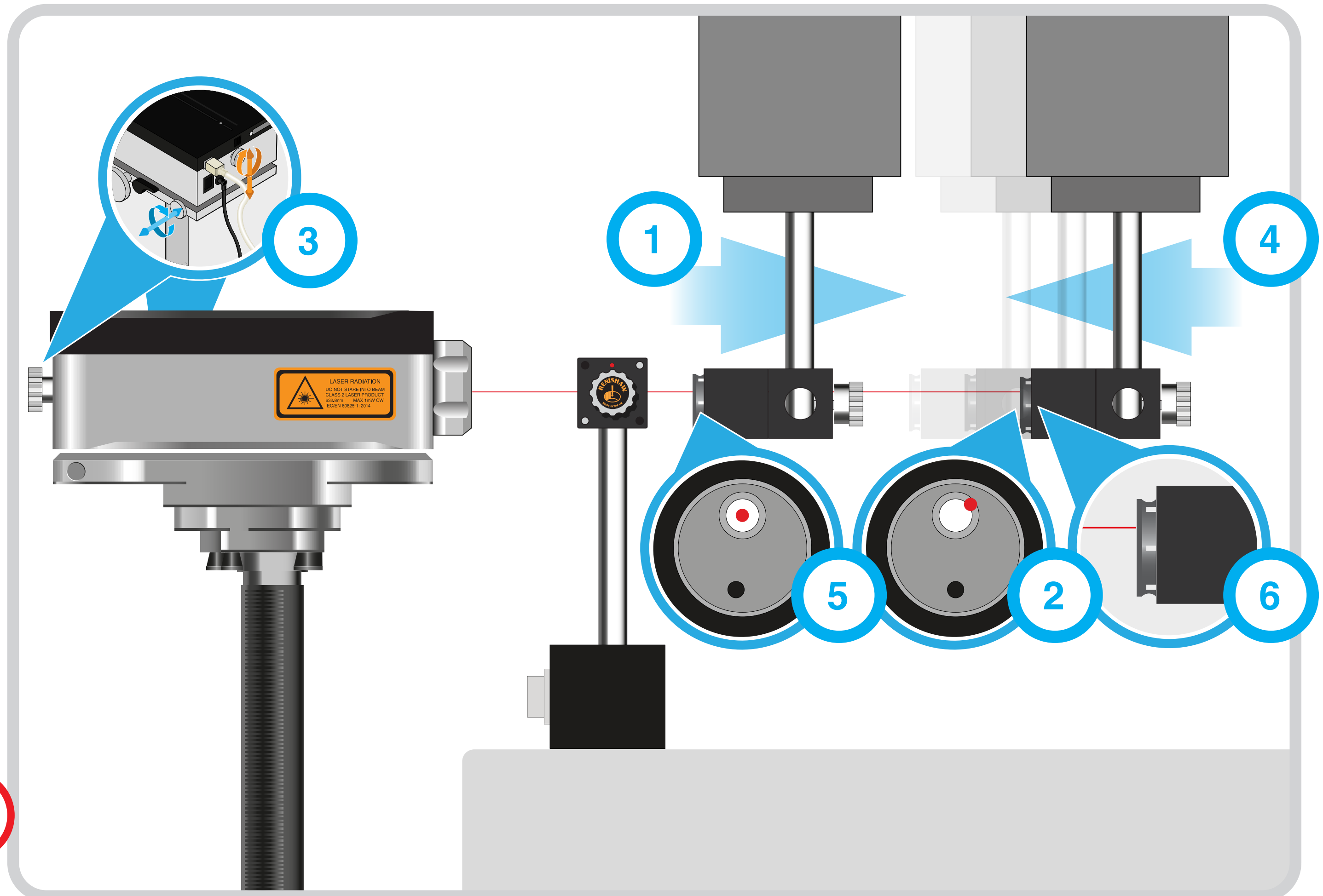
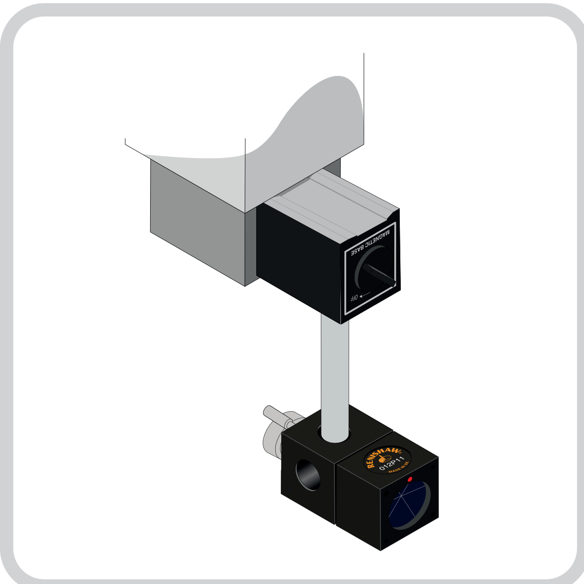
Visual alignment

1. Use the machine to move the reflector away from the interferometer.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the pitch and yaw so the beam hits the centre of the target.
4. Use the machine to drive the reflector towards the interferometer.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Ensure the laser beam is on the centre of the target along the axis.

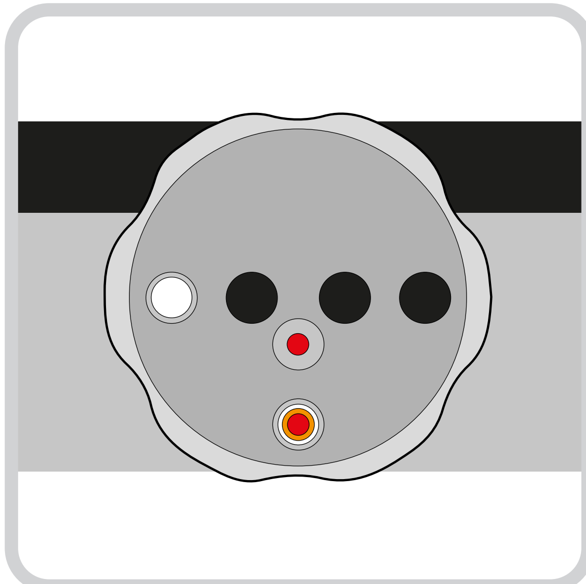
Repeat until the two beams remain in the centre of the target over the full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position.



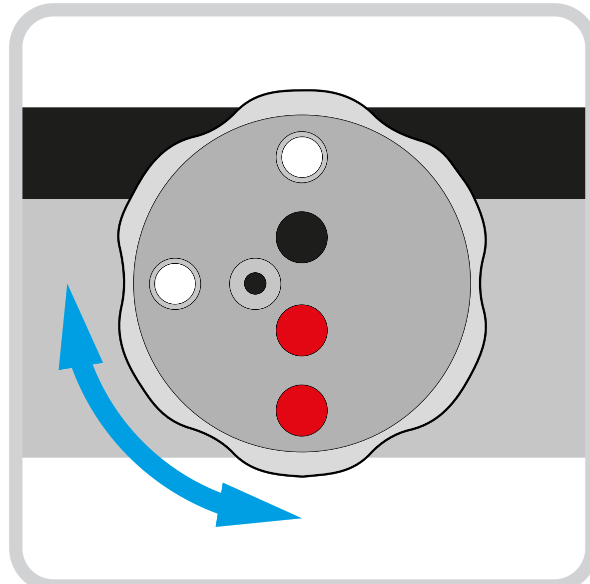
Visual alignment



Remove the target.



Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target.

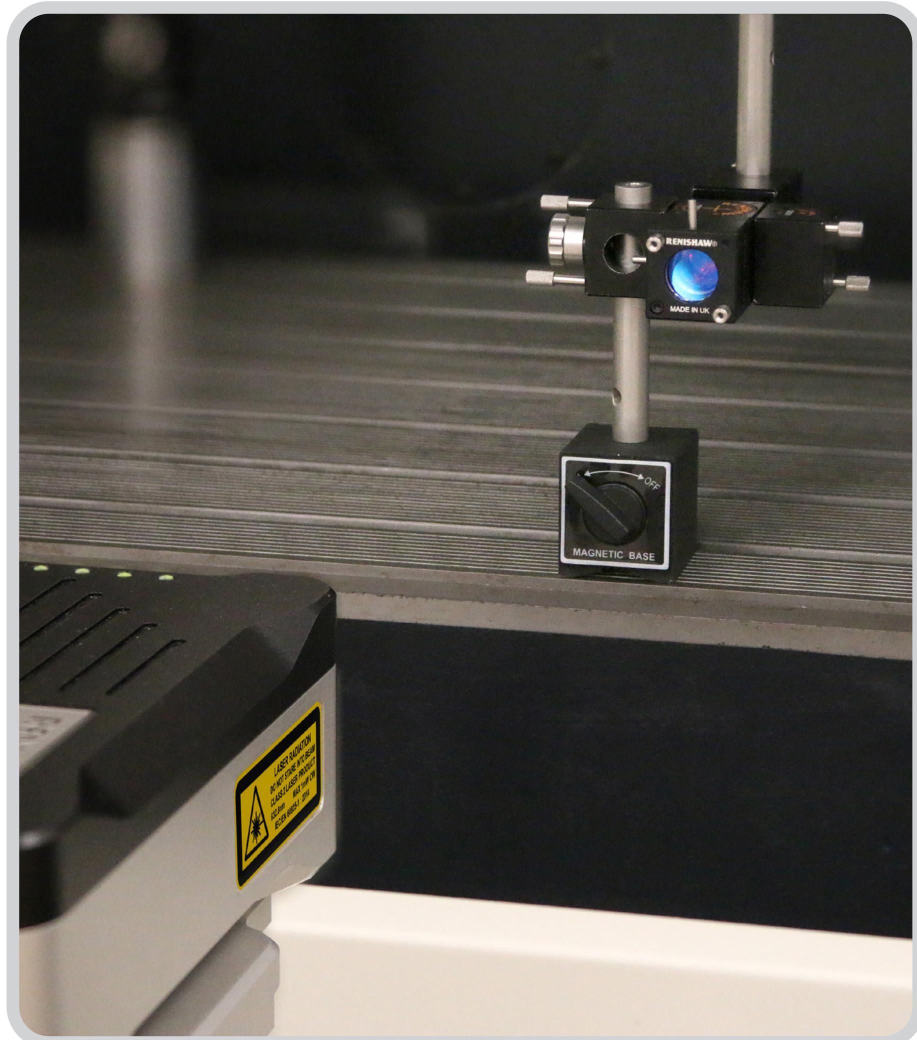


Rotate the XL laser shutter to the open position ready for data capture.

Instructions to capture linear data can be found **on page 91.**

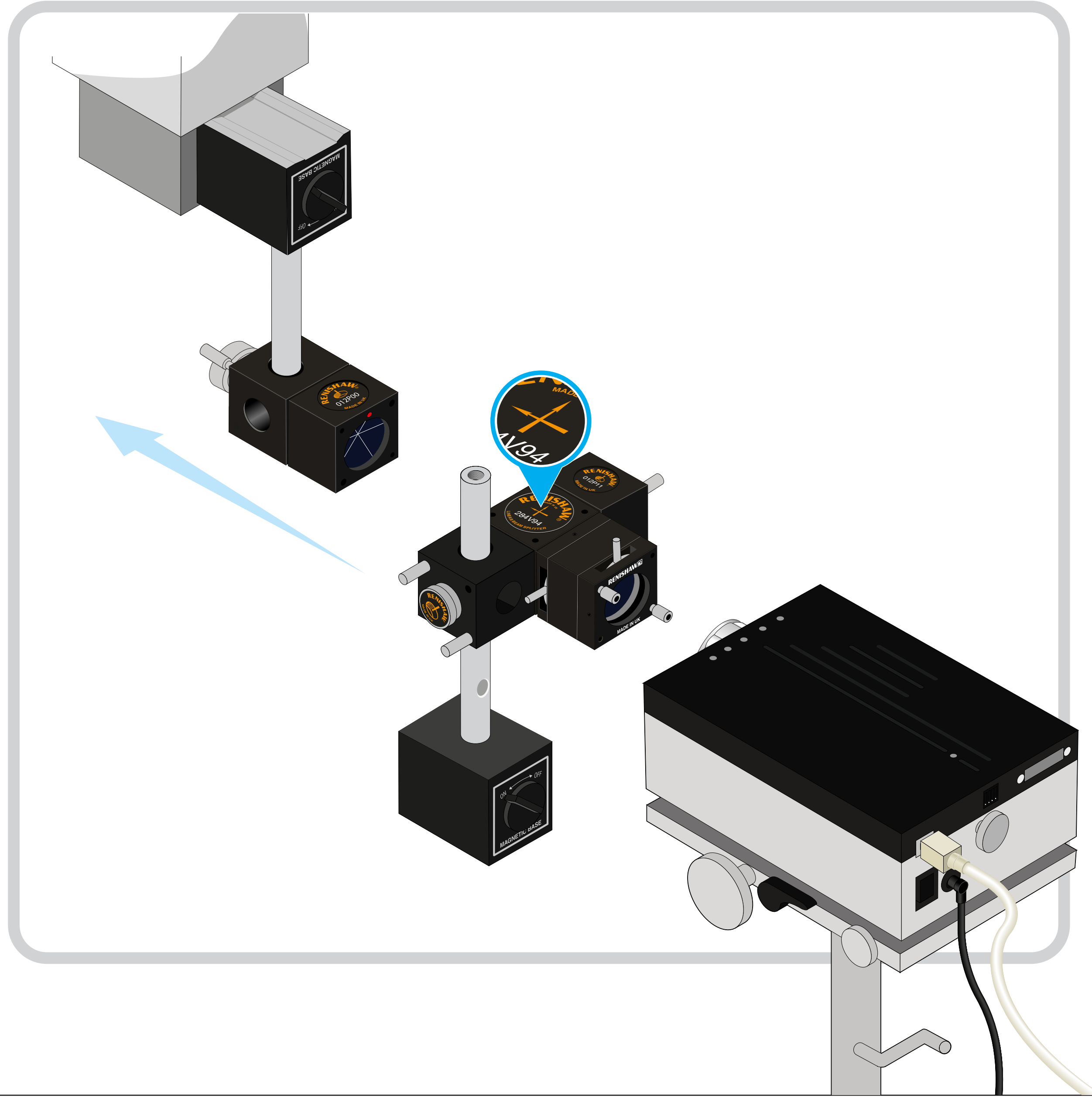
Linear measurement

With LS350 laser beam steerer



Mounting the optics

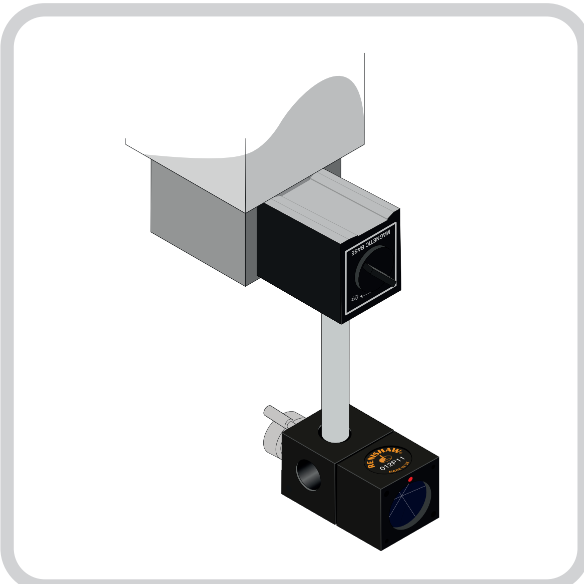
An overview of the linear measurement set-up with beam steerer.



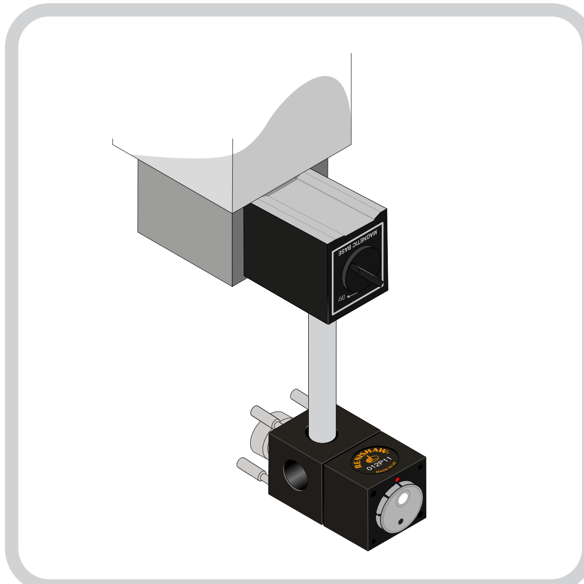
Mounting the optics

Mounting the retroreflector

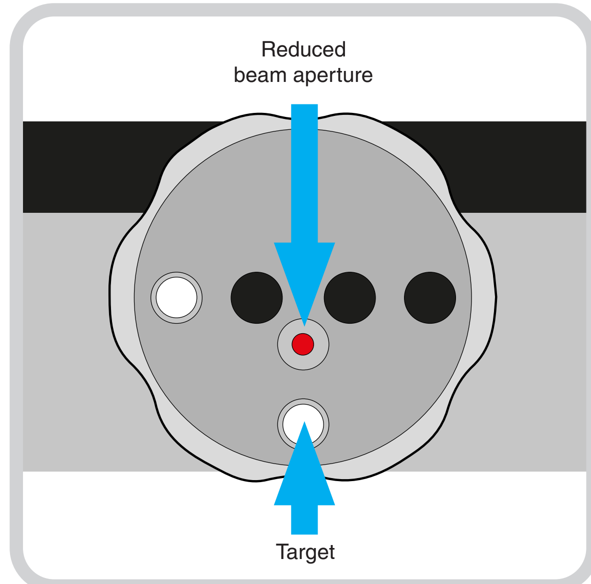
The linear measurement set-up.



Assemble the retroreflector assembly as shown. Mount to the moving element of the machine.



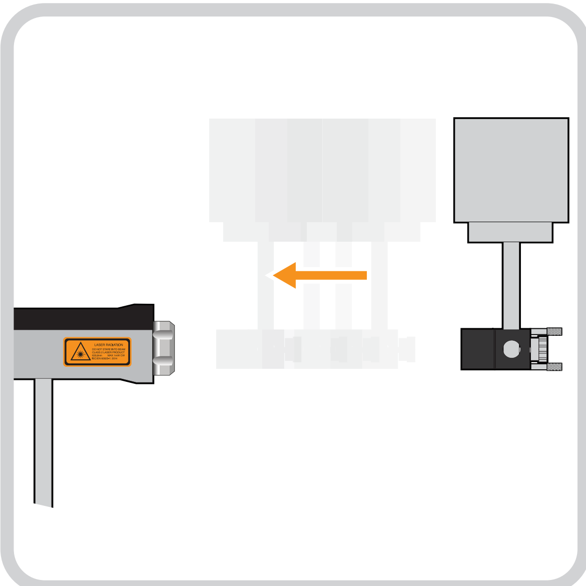
Attach the target onto the face of the retroreflector.



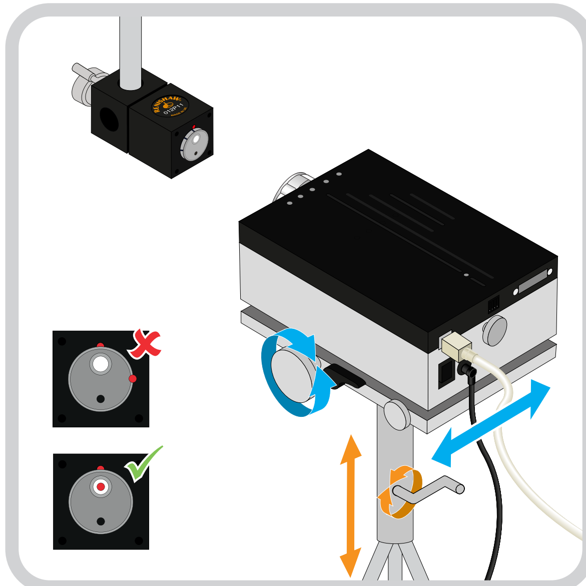
Rotate the laser shutter to emit a reduced diameter beam.

Mounting the optics

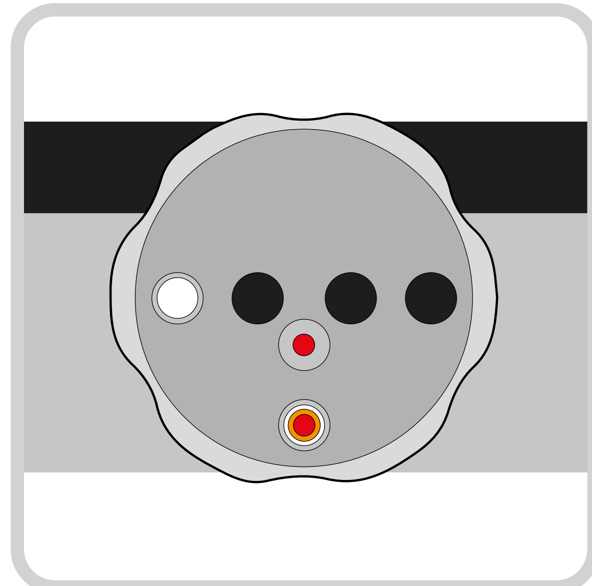
Mounting the retroreflector



Drive the retroreflector to the near field position.



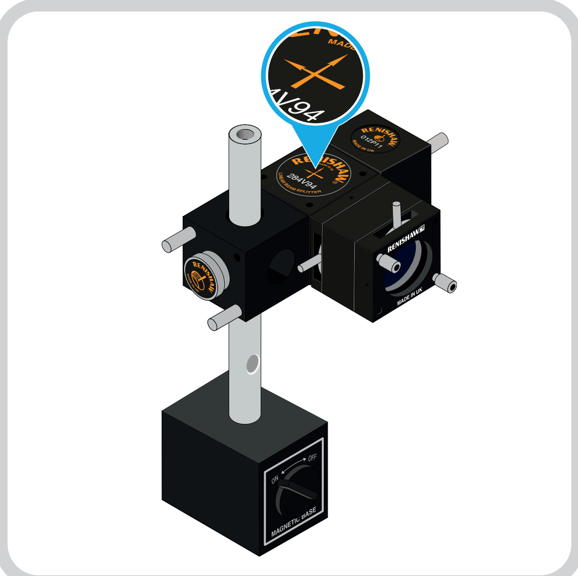
Adjust the beam to the centre of the white target using the translation screws.



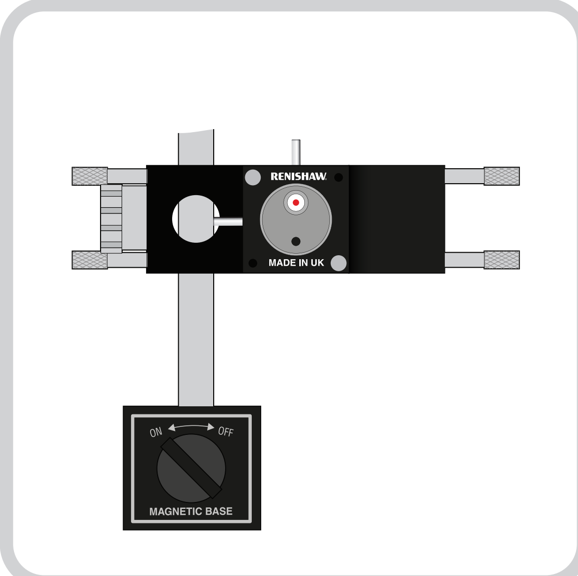
Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, translate the laser or the machine.

Mounting the optics

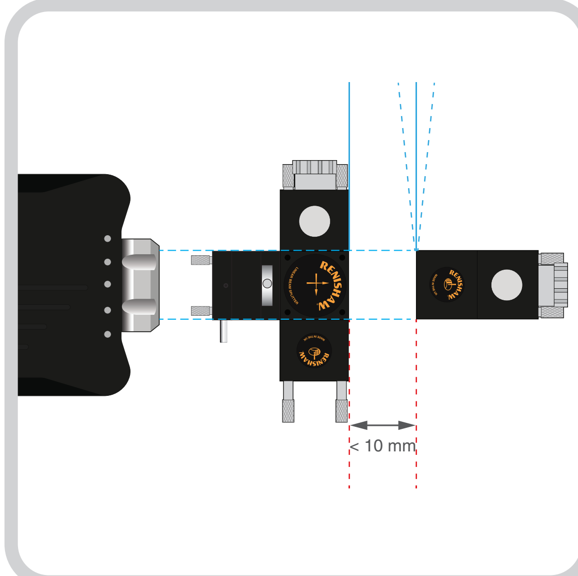
Mounting the linear interferometer



Assemble the interferometer assembly and mount the beam steerer onto the input face of the beam splitter as shown. Ensure that the levers are in their mid-position.



Attach the target to the beam steerer and align it with the beam.

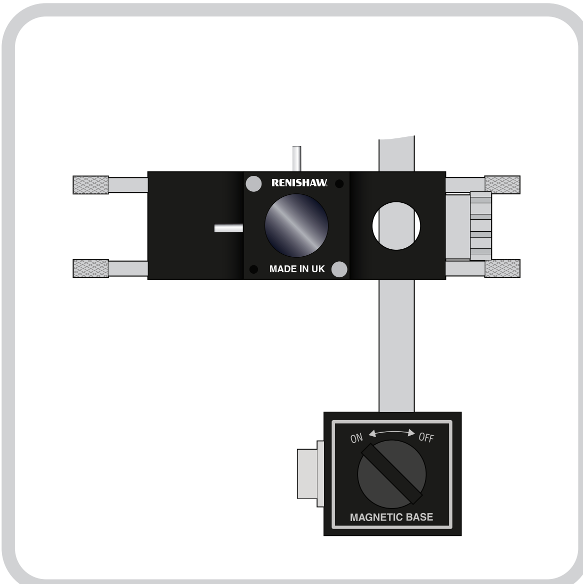


Mount to the stationary element of the machine:

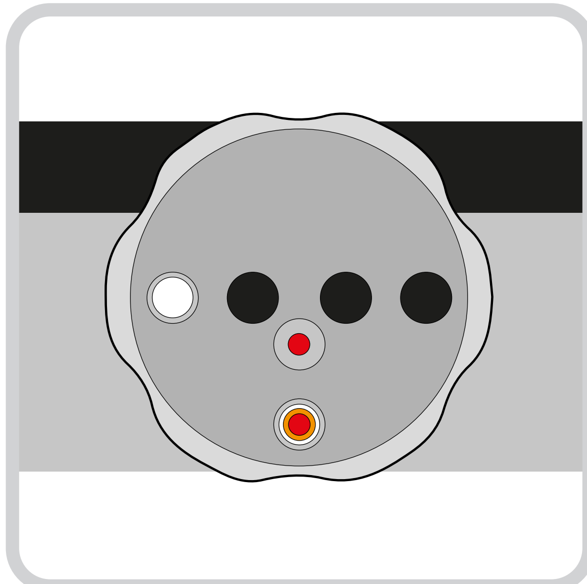
- as close as possible, minimising the distance between the optics;
- square to the axis; and
- parallel to the retroreflector.

Visual alignment

Mounting the linear interferometer.



Remove the target.

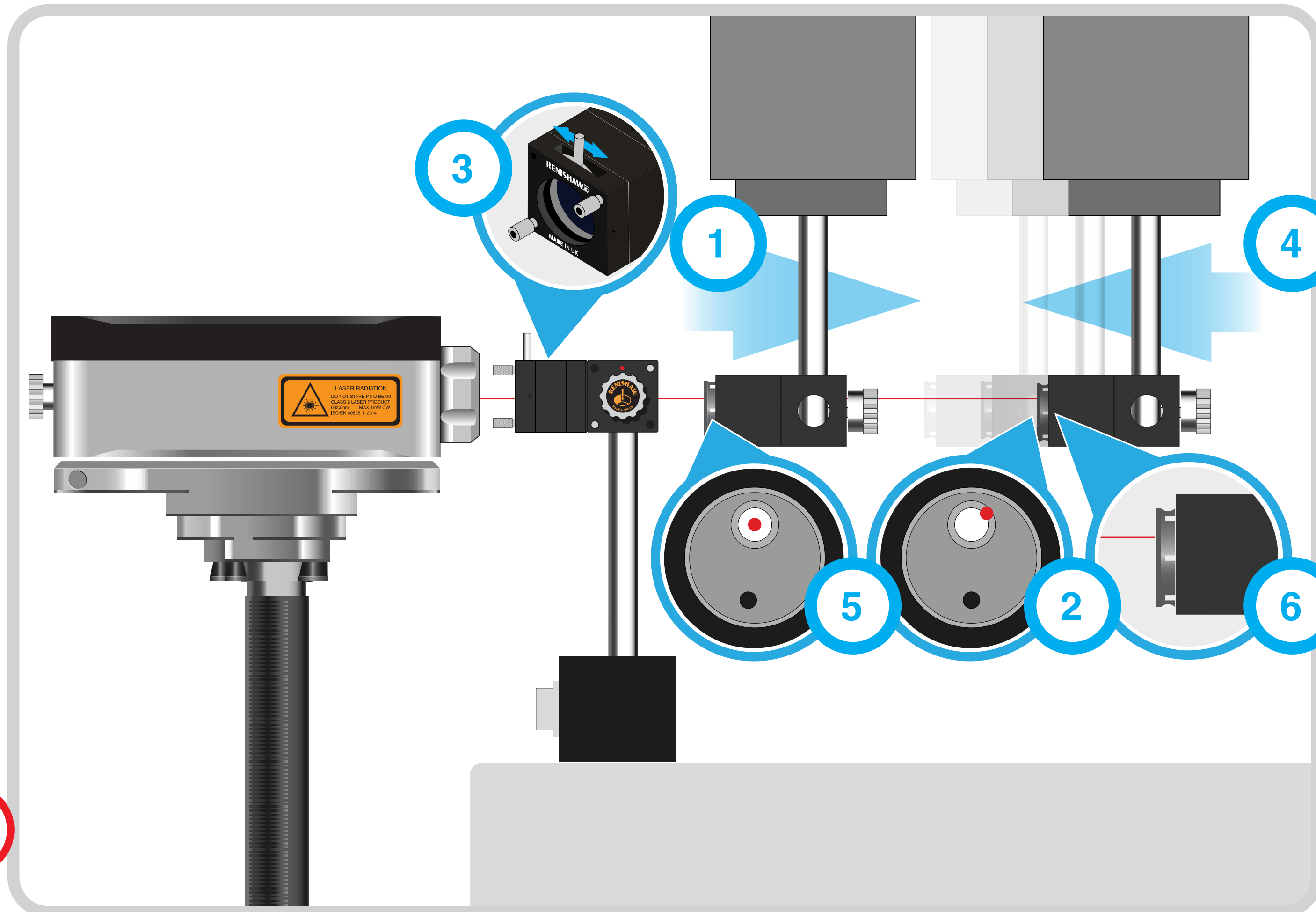


Ensure that the two return beams are overlapping on the shutter target. Adjust as required.

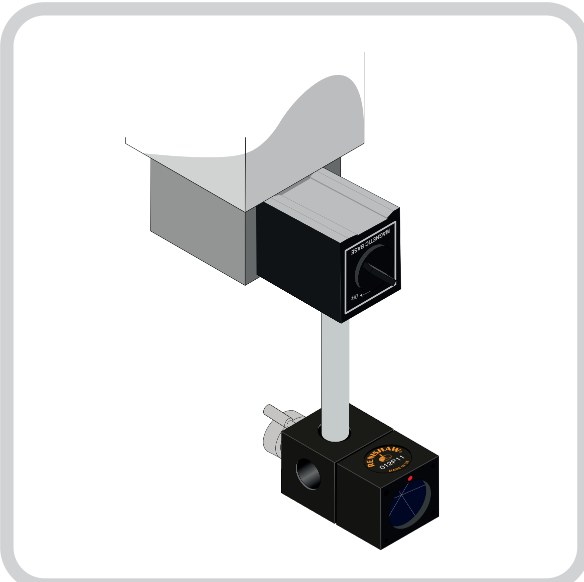
Visual alignment

1. Use the machine to move the reflector away from the interferometer.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the beam steerer so the beam hits the centre of the target
4. Use the machine to drive the reflector towards the interferometer.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Ensure the laser beam is on the centre of the target along the axis.

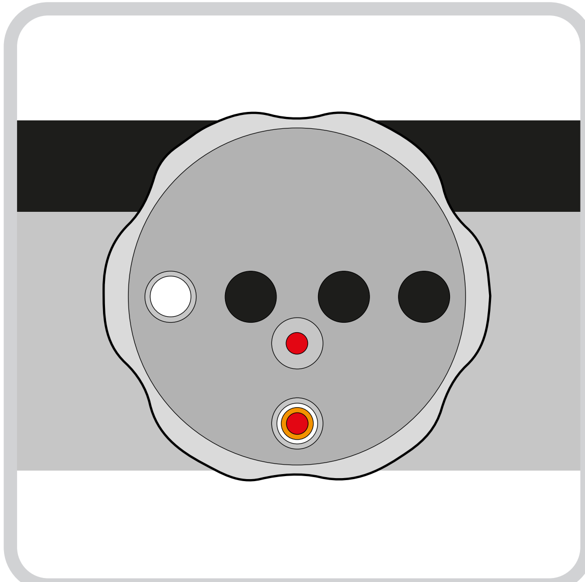
Repeat until the two beams remain in the centre of the target over the full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position.



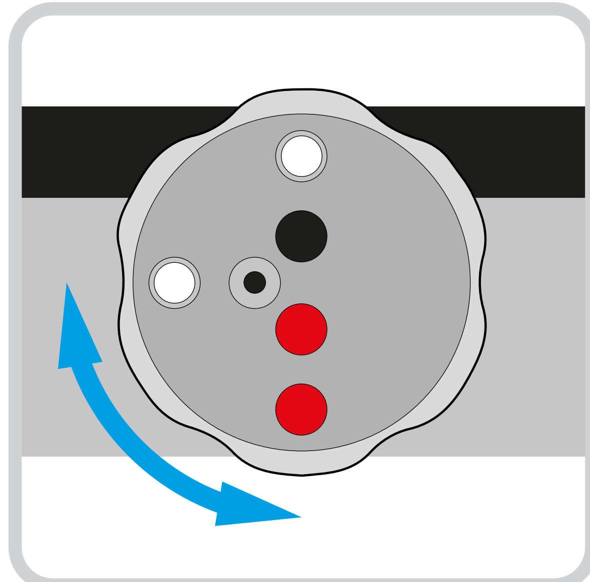
Visual alignment



Remove the target.

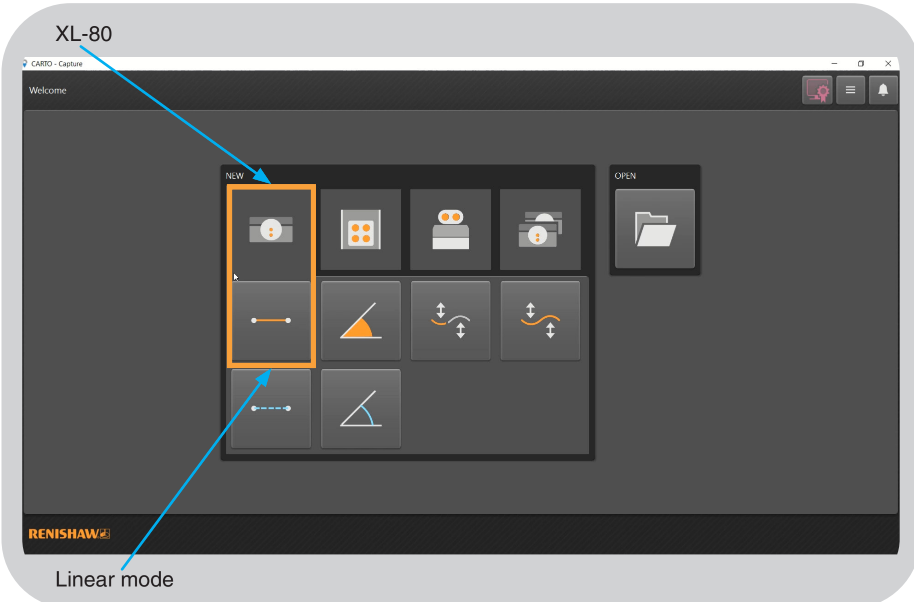


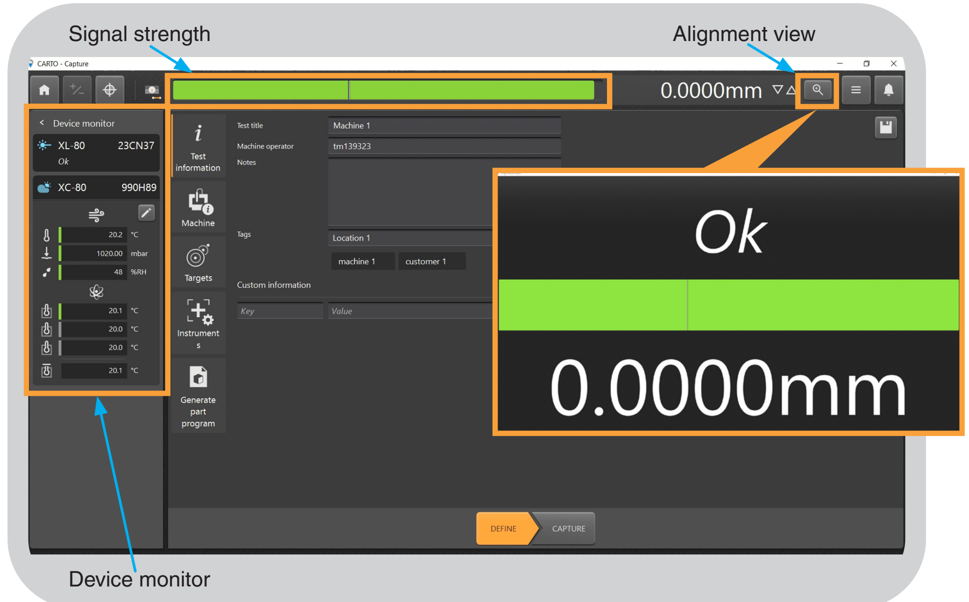
Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target.



Rotate the XL laser shutter to the open position ready for data capture.

Linear data capture





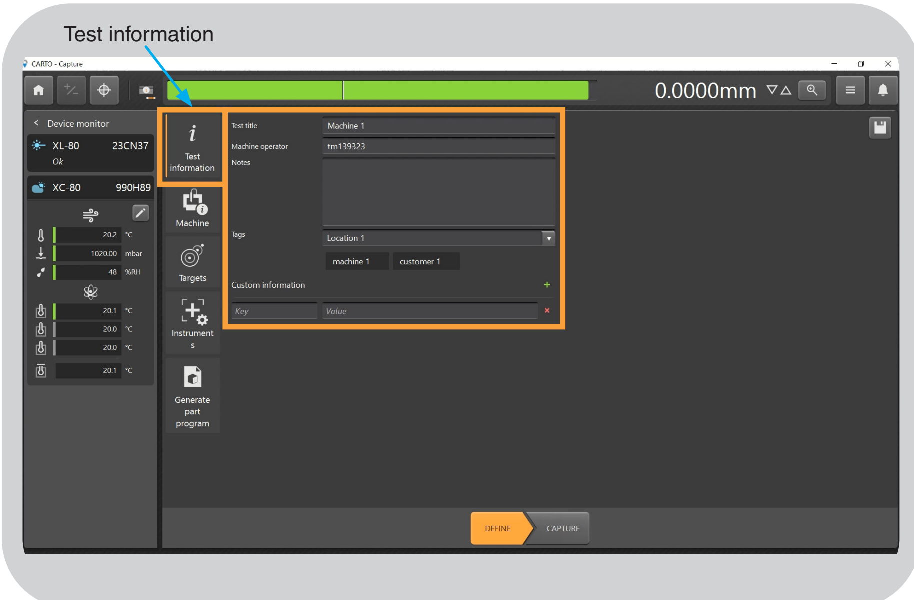
Run the Capture application and select ‘Linear mode’.

The application will open in the view shown. Ensure that the XL-80 and XC-80 are connected to the laptop.

- **Device monitor** – shows the status of connected hardware.
- **Signal strength** – gives and indication of alignment.
- **Alignment view** – gives a simple full screen view of signal strength and current laser reading to aid alignment.

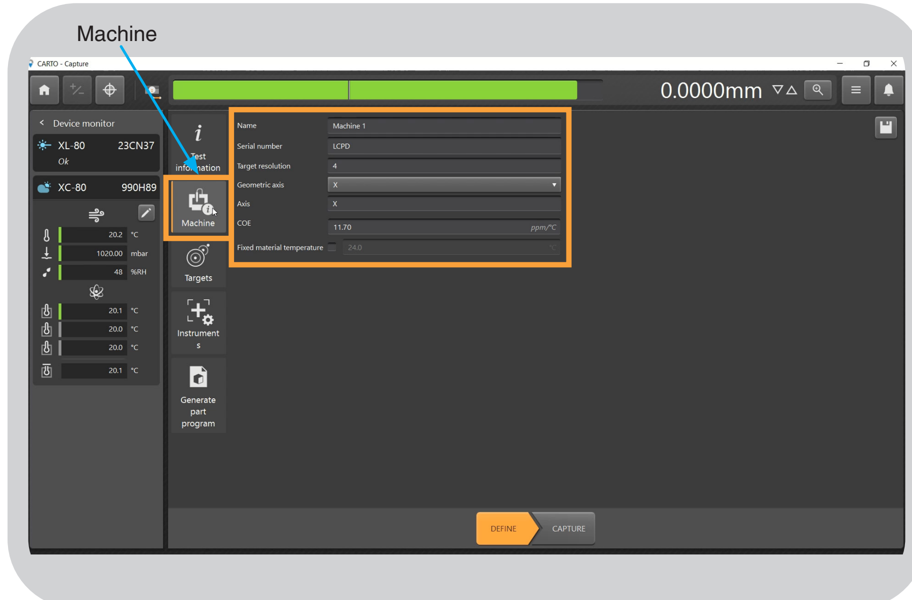
Linear data capture

The ‘Test information’ tab is a place to enter general information for test identification within the CARTO database.



- **Test title** – title to be used when referring to the test.
- **Machine operator** – name of operator conducting the test.
- **Notes** – information which may be useful about the test.
- **Tags** – apply tags to aid filtering of data in Explore.
- **Custom information** – allows customised fields to be created and included in the test record.

In the ‘Machine’ tab, enter information which is specific to the machine and axis under test.

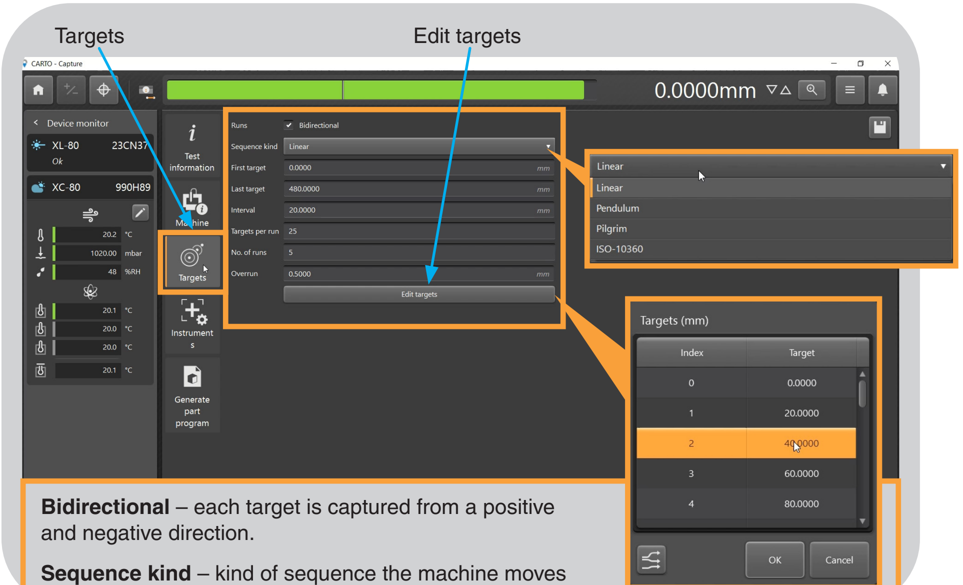


- **Name** – name of the machine under test.
- **Serial number** – serial number of machine under test.
- **Target resolution** – number of decimal places for targets. This must not be higher than the machine resolution.
- **Geometric axis** – select the axis under test to match the set-up.
- **Axis** – allows a custom axis name to be used.
- **COE** – coefficient of expansion value of the machine under test.
- **Fixed material temperature** – option to use a fixed temperature.

Linear data capture

In the ‘Targets’ tab, enter the positions to capture data and the sequence required to capture them.

Targets can be manually edited or randomised using the ‘Edit targets’ button.



Bidirectional – each target is captured from a positive and negative direction.

Sequence kind – kind of sequence the machine moves between targets for data capture. See appendix in *CARTO Capture* user guide (Renishaw part no. F-9930-1007) for more information.

First target – input the first position for data capture.

Last target – input the last position for data capture.

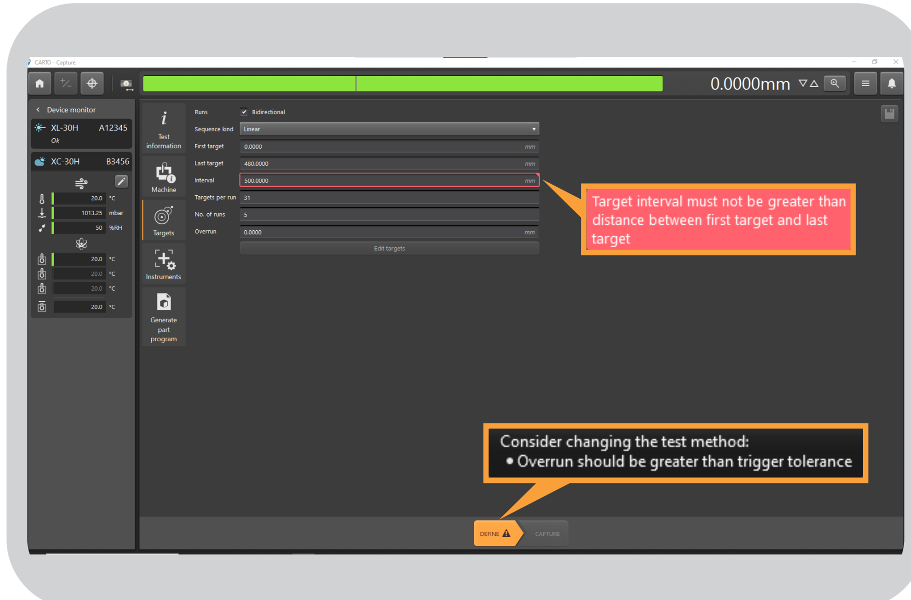
Interval – distance between targets.

Targets per run – if the interval value has been entered this will be updated accordingly.

Number of runs – determine the number of times the target sequence is repeated.

Overrun – distance required for turn around at end of the axis (including first target and last target).

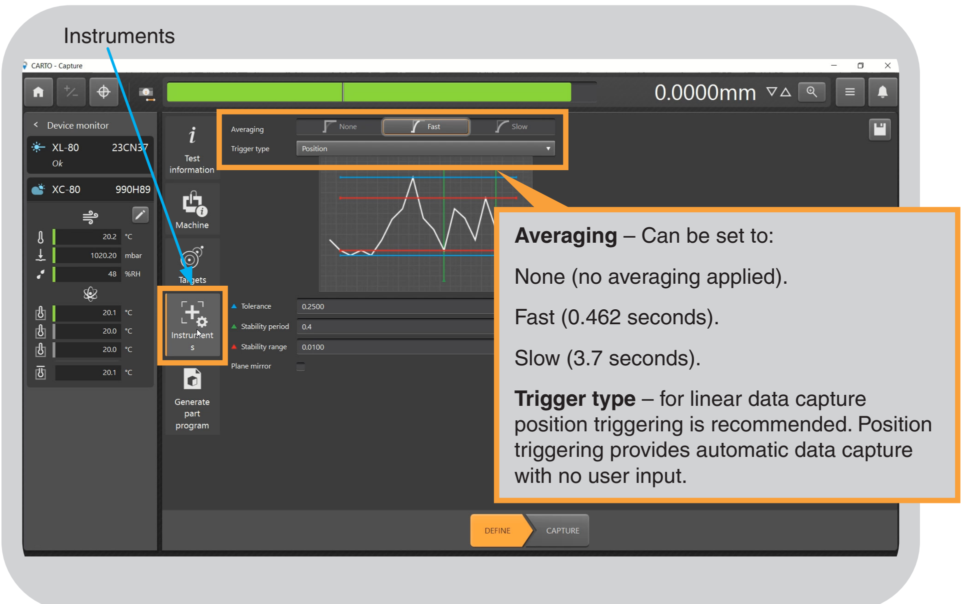
Edit targets – targets can be individually edited or randomised.



Any **red** highlighted box or warning triangles highlight potential problems with the test method. Hover the mouse over the area for a tooltip with more information on how to correct the issue..

Linear data capture

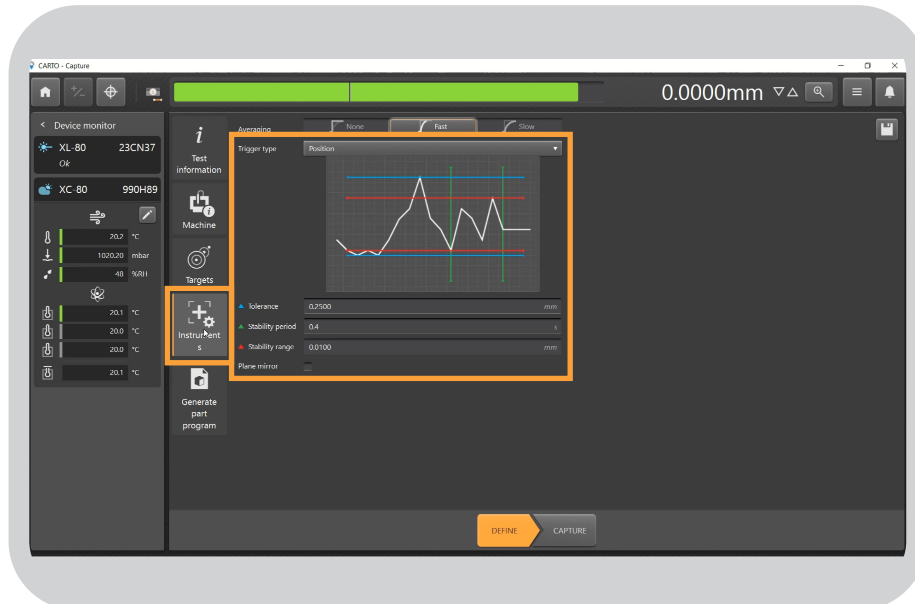
In the 'Instruments' tab, select the averaging type required and preferred trigger method.



For linear data capture the read out at the top of the screen monitors the laser position, therefore data capture is automatic. However the following options are also available:

- **Manual** – using F9 key or middle mouse button.
- **TPin** – using an external source to trigger through the Aux I/O input on the XL-80. **See Appendix B.**
- **Time** – calculate the move time based on feedrate and trigger distance.

When using position trigger type the trigger parameters must be set correctly to ensure that the software recognises when data should be captured.



- **Tolerance** – the distance either side of the set target value considered to be acceptable.
- **Stability period** – the period of time that the machine must stay within the set stability range.
- **Stability range** – the maximum position variation considered to be acceptable.

If the machine is outside of any of the trigger parameters, data will *not* be captured.

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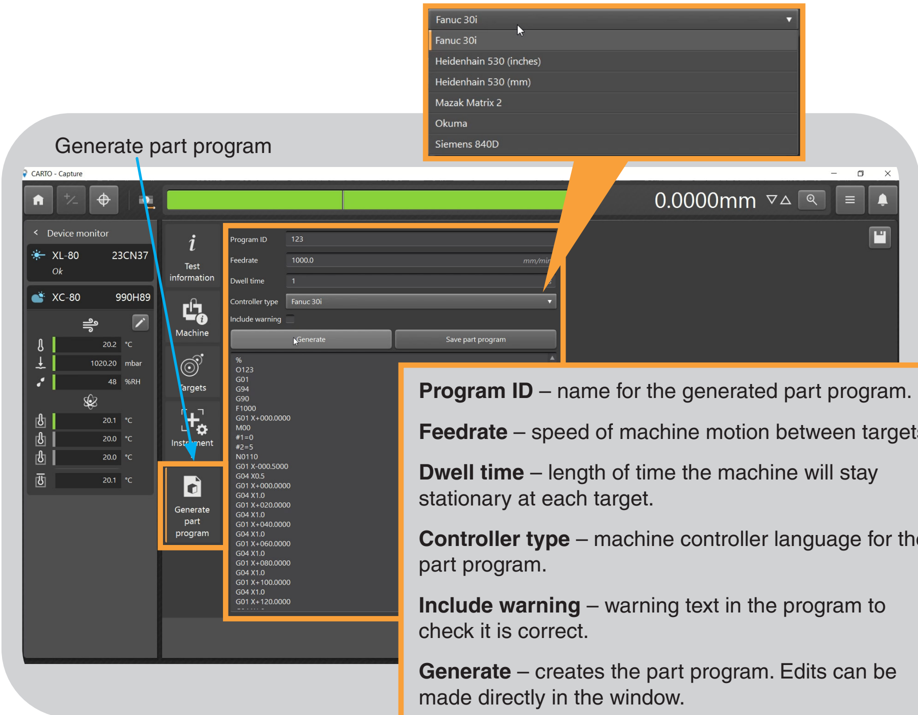
Linear data capture



Program ID – name for the generated part program.

Feedrate – speed of machine motion between targets.

Dwell time – length of time the machine will stay stationary at each target.

Controller type – machine controller language for the part program.

Include warning – warning text in the program to check it is correct.

Generate – creates the part program. Edits can be made directly in the window.

Save part program – launches a browser to save to a suitable location for transfer to the controller.

To create a machine part program use the 'Generate part program' tab, enter a program name and feedrate.

Default dwell time is based upon previous selections such as averaging and trigger parameters, however this can be modified if required.

Select a supported controller type, generate the program and save to a suitable location for transfer to the machine.

There is no requirement to set sign direction for linear tests. The software monitors the targets and compares them to the overrun move to set them automatically.

1. Press 'Start test'.
2. A dialogue box may appear to datum the laser. Do this with the optics close together (ideally less than 10 mm) to minimise deadpath error. The dialogue box will not appear on repeat tests of the same axis (unless the beam is broken) the XC-80 will continue environmental compensation at the datum position.
3. The read-out will be set to the value of the first target.
4. The test status bar advises the next steps.

Linear data capture

Press start on the machine controller. Using position trigger type, data will be collected automatically.

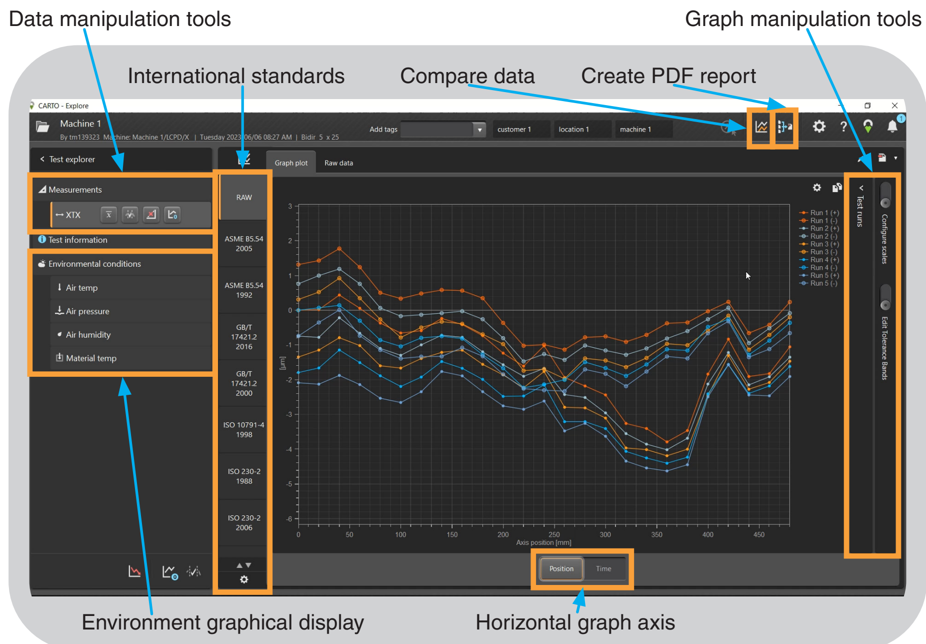
The test status is displayed in the top right of the screen.

The test status will indicate when the test is complete. ‘Save’ the test.

A dialogue box will appear to allow further detail or ammendments to be added to the test record.

Linear data capture

Analysing test data



Select ‘Analyse’ to launch the Explore application.

The application will open in the view shown.

Linear data capture

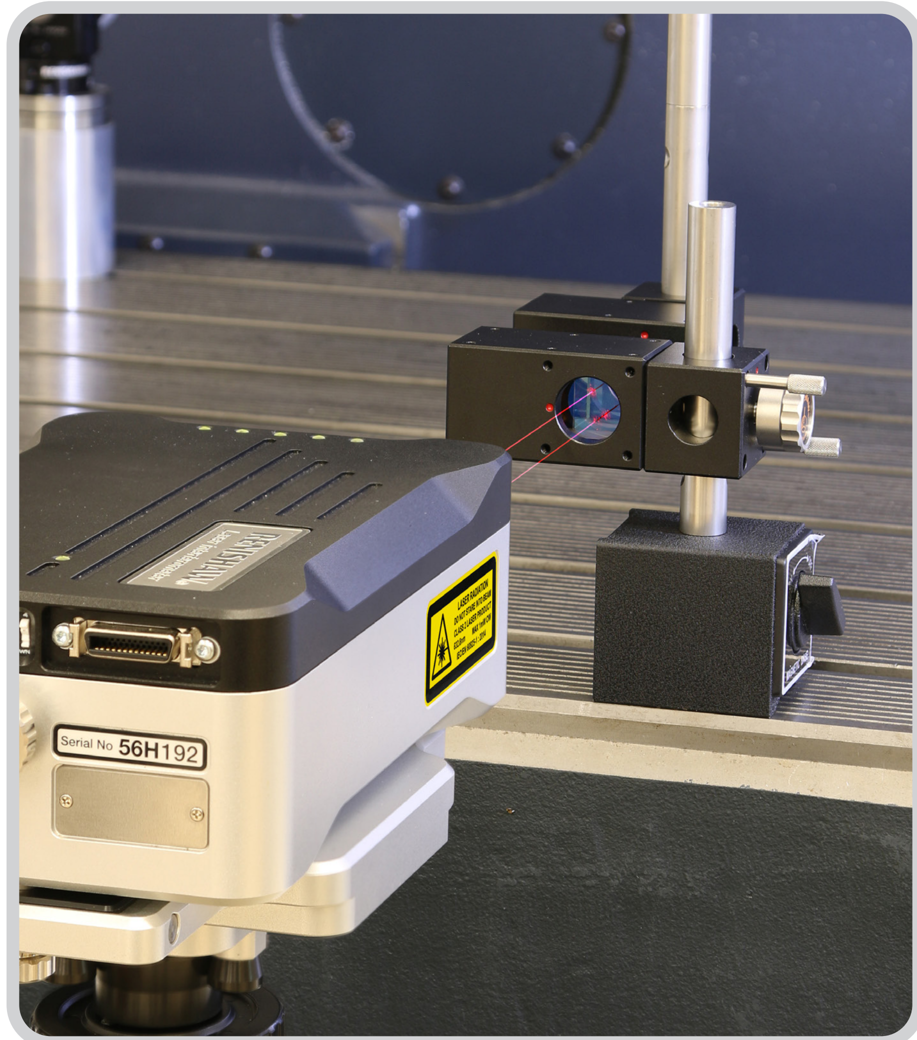
Analysing the environmental test data

Environmental data can be viewed in the graph plot. Select ‘Environmental conditions’ to display all data or select the individual sensor.

To compare environmental data against position:

- Select ‘Compare’.
- Switch the graph view to display ‘Time’.
- Add ‘All environmental channels’ or ‘Individual environmental channels’.

Angular measurement (pitch/yaw)



NOTE: Environmental compensation is not necessary when taking angular measurements, therefore, the XC environmental compensator and environmental sensors are not required.

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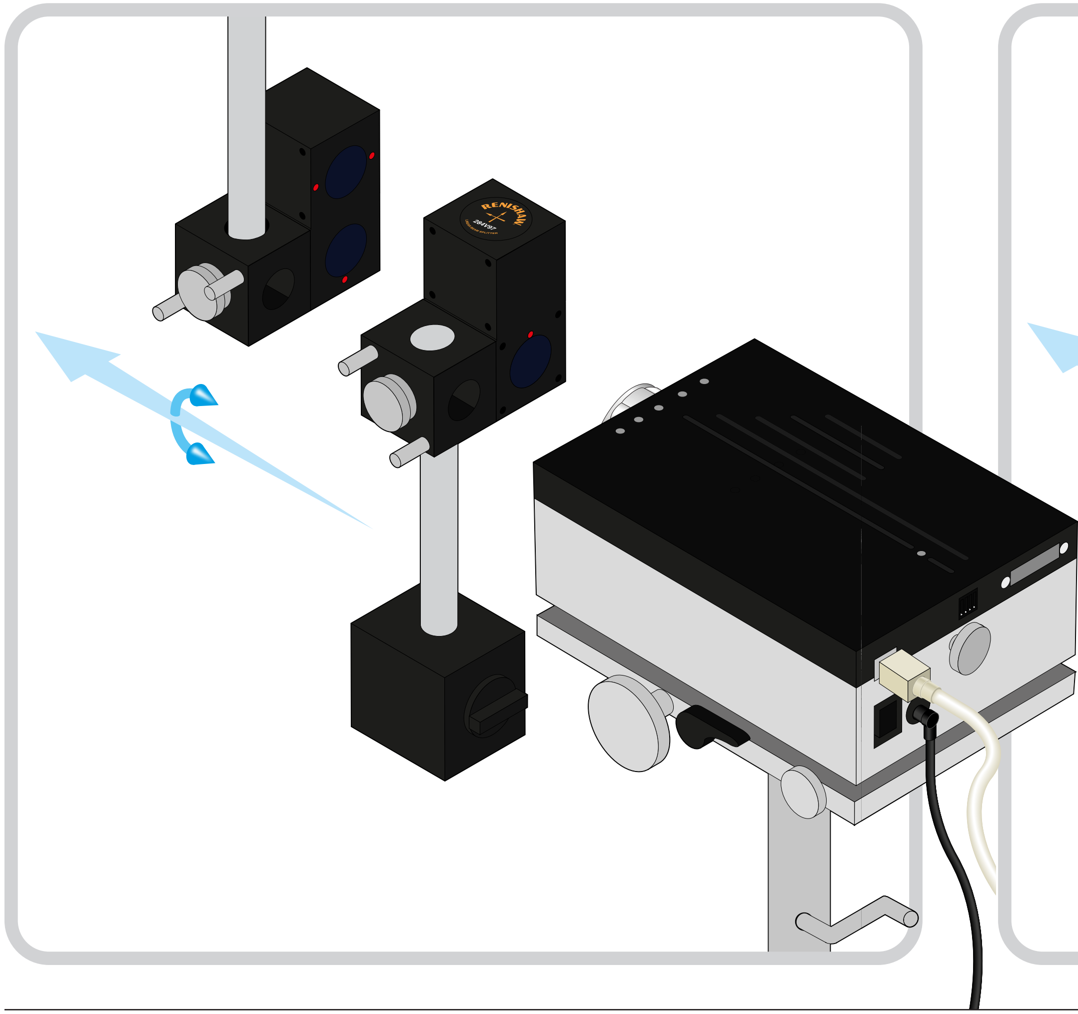
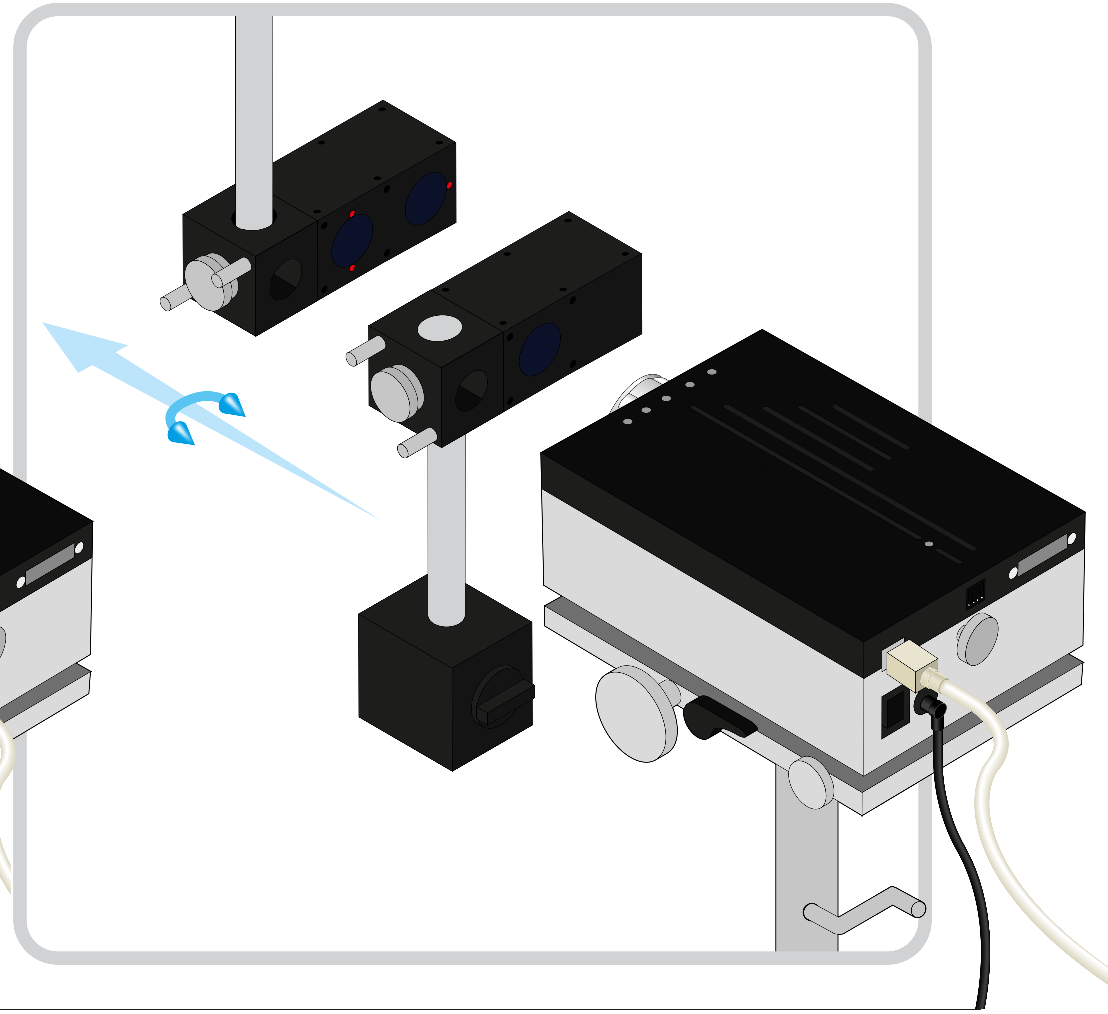
Mounting the optics

The pitch/yaw measurement set-ups – horizontal axis.

Pitch angle



Yaw angle



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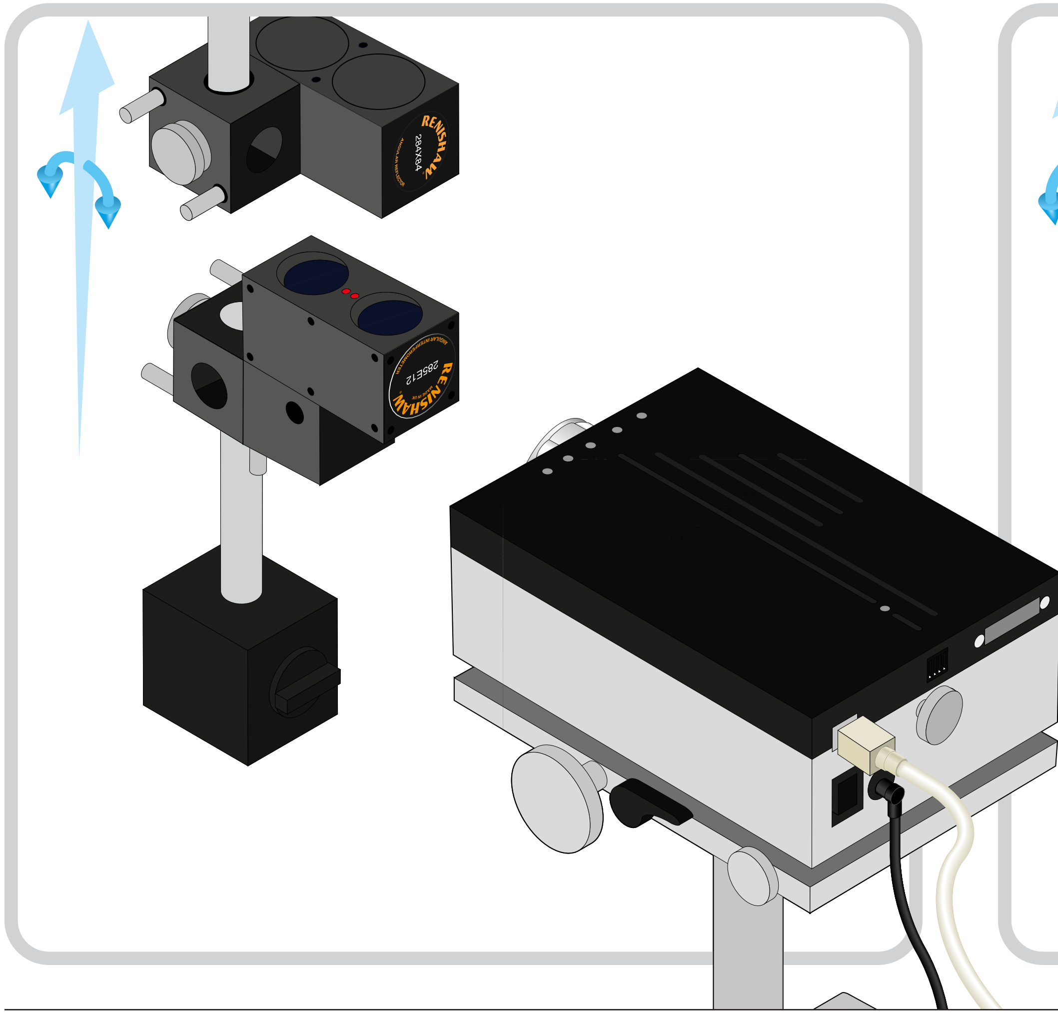
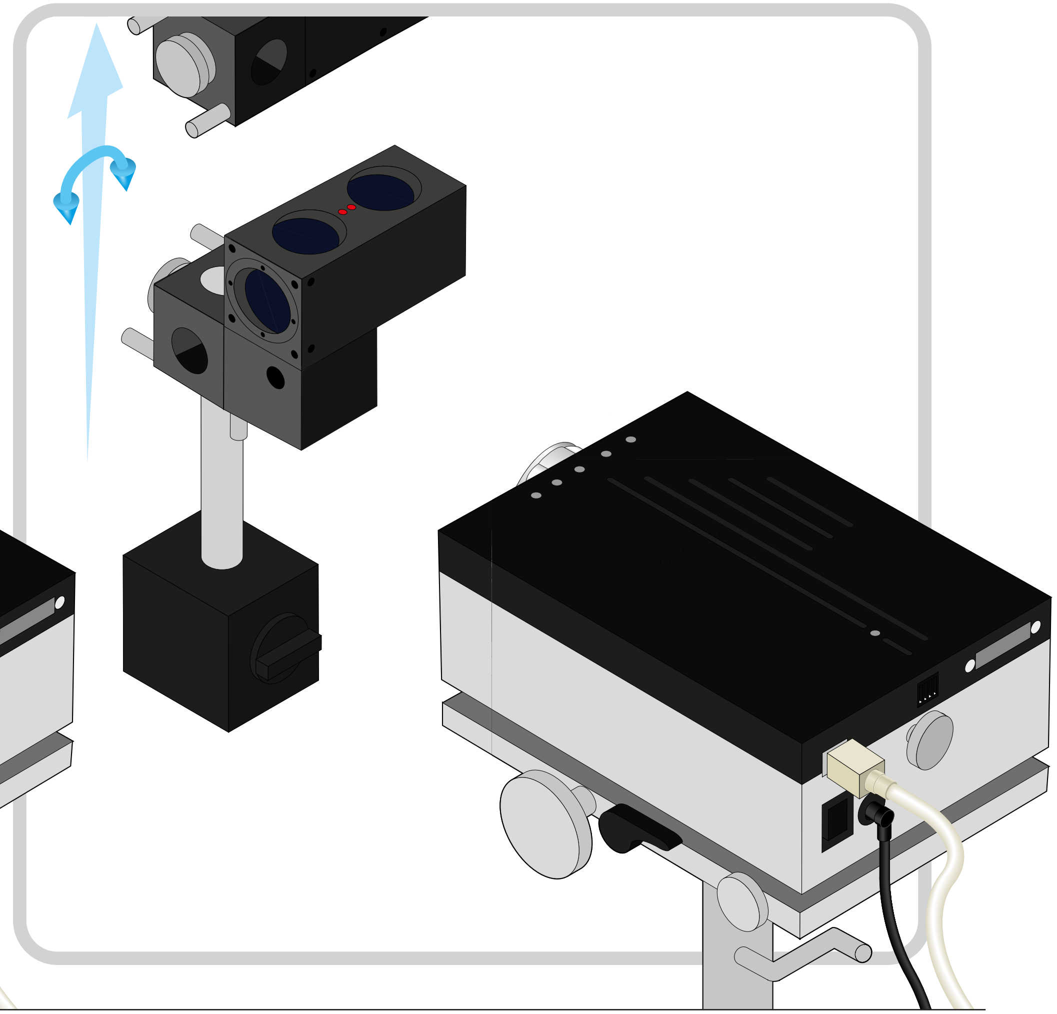
Mounting the optics

The pitch/yaw measurement set-ups – vertical axis.

Pitch angle

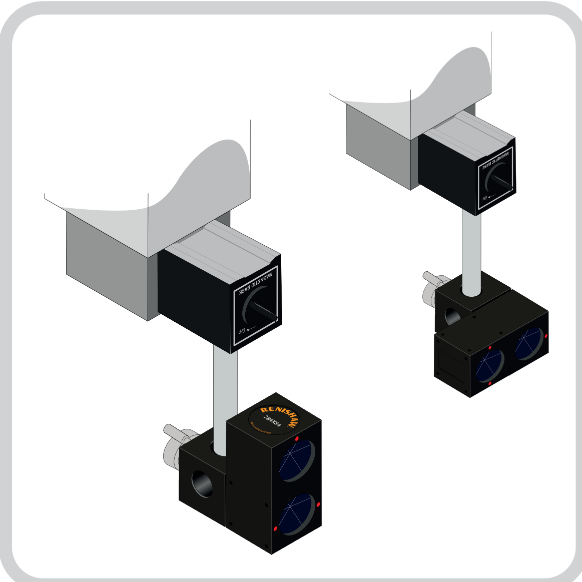


Yaw angle

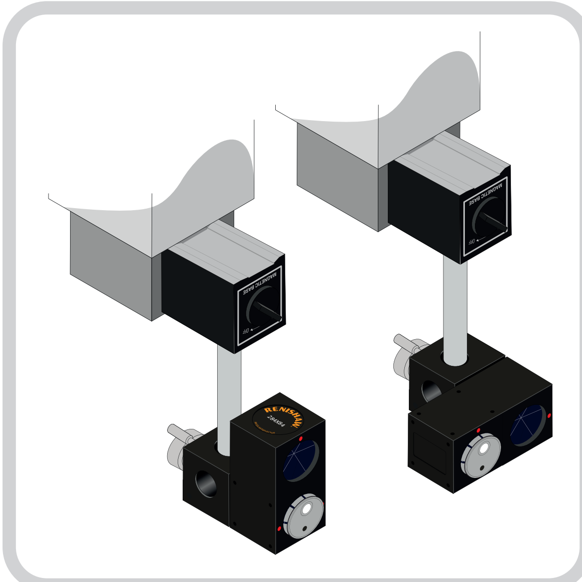


Mounting the optics

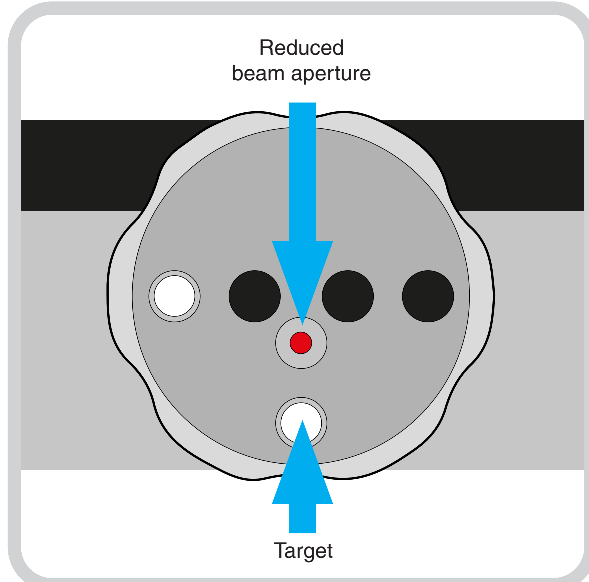
Mounting the retroreflector



Assemble the retroreflector assembly as shown. Mount to the moving element of the machine.



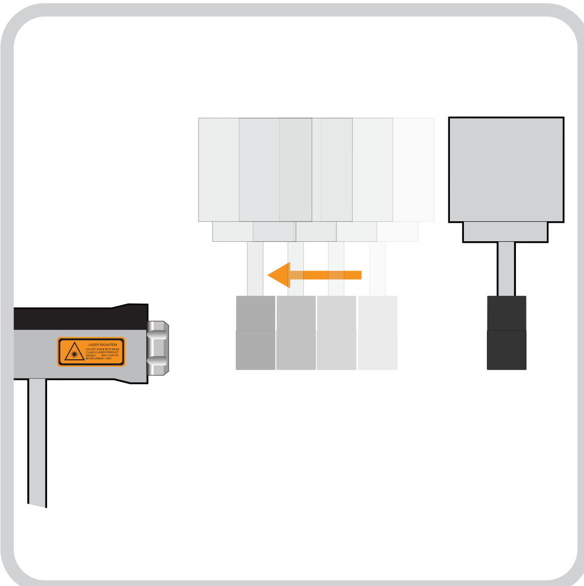
Attach the target onto the face of the retroreflector.



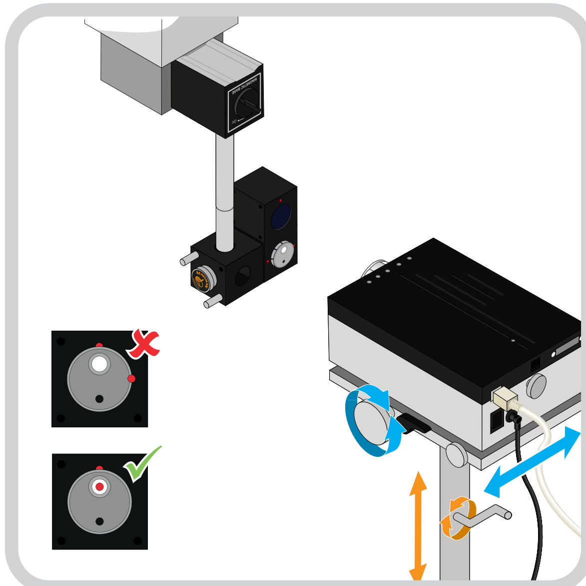
Rotate the laser shutter to emit a reduced diameter beam.

Mounting the optics

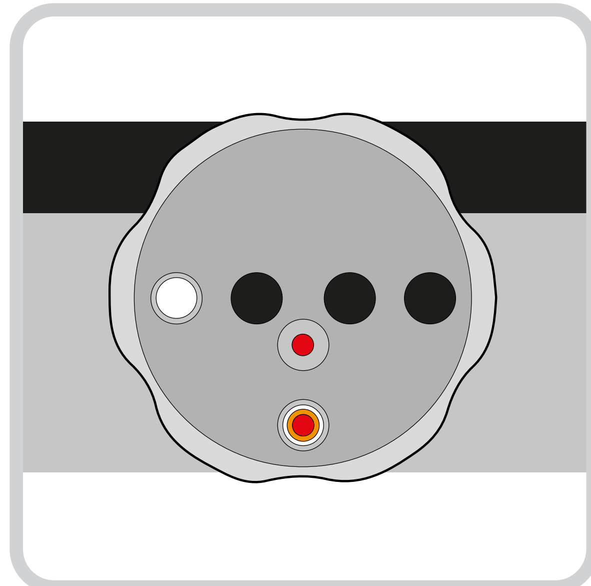
Mounting the retroreflector



Drive the angular retroreflector to the near field position.



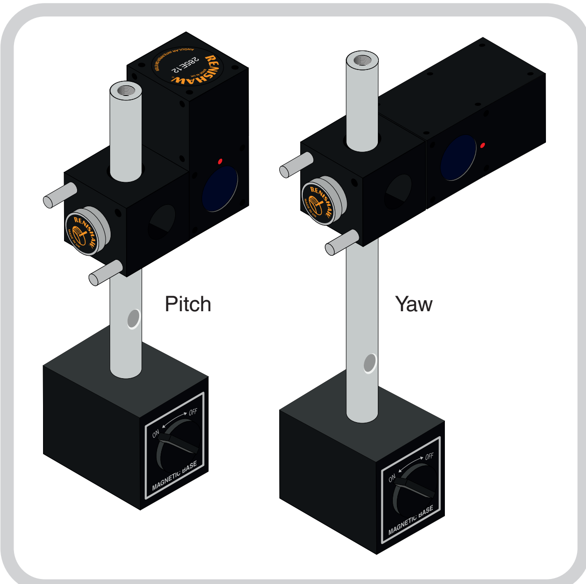
Adjust the beam to the centre of the white target using the translation screws.



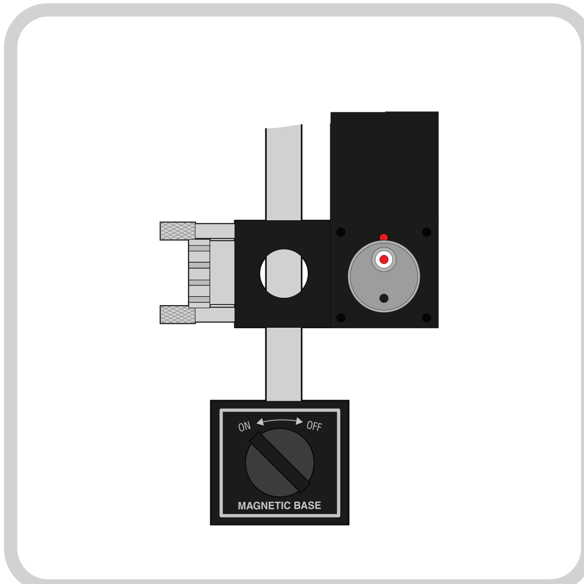
Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, translate the laser or the machine.

Mounting the optics

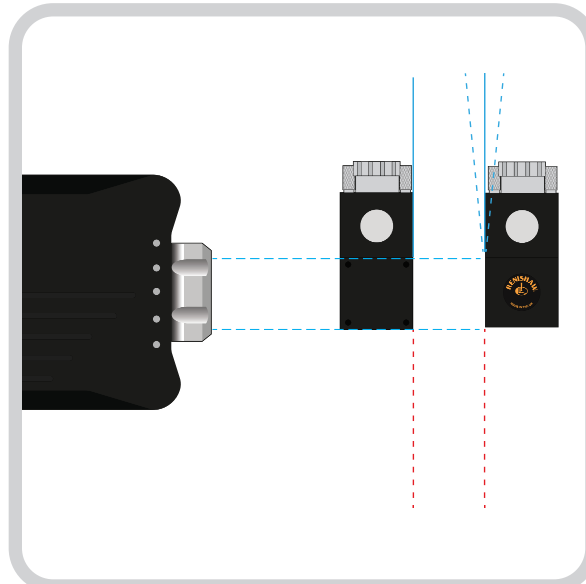
Mounting the angular interferometer



Assemble the interferometer assembly as shown.



Attach the target to input aperture and align it with the beam.



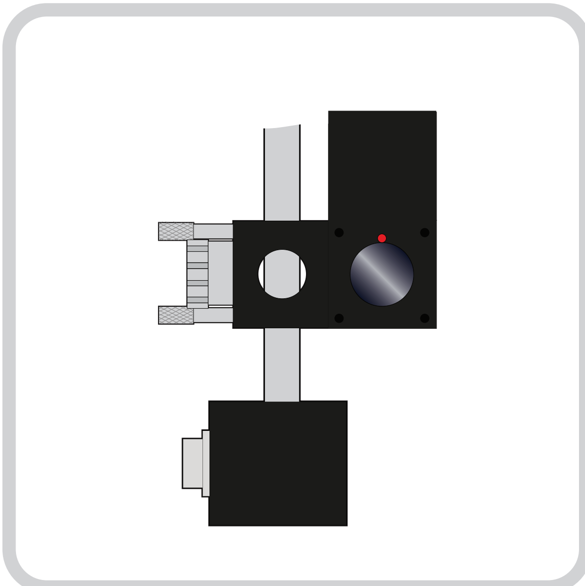
Mount to the stationary element of the machine:

- as close as possible, minimising the distance between the optics;
- square to the axis; and
- parallel to the retroreflector.

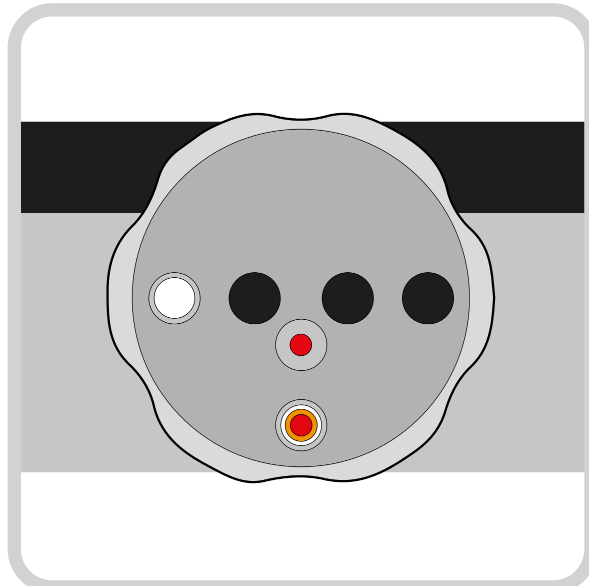
Visual alignment

Mounting the angular interferometer

The angular measurement set-up.



Remove the target.

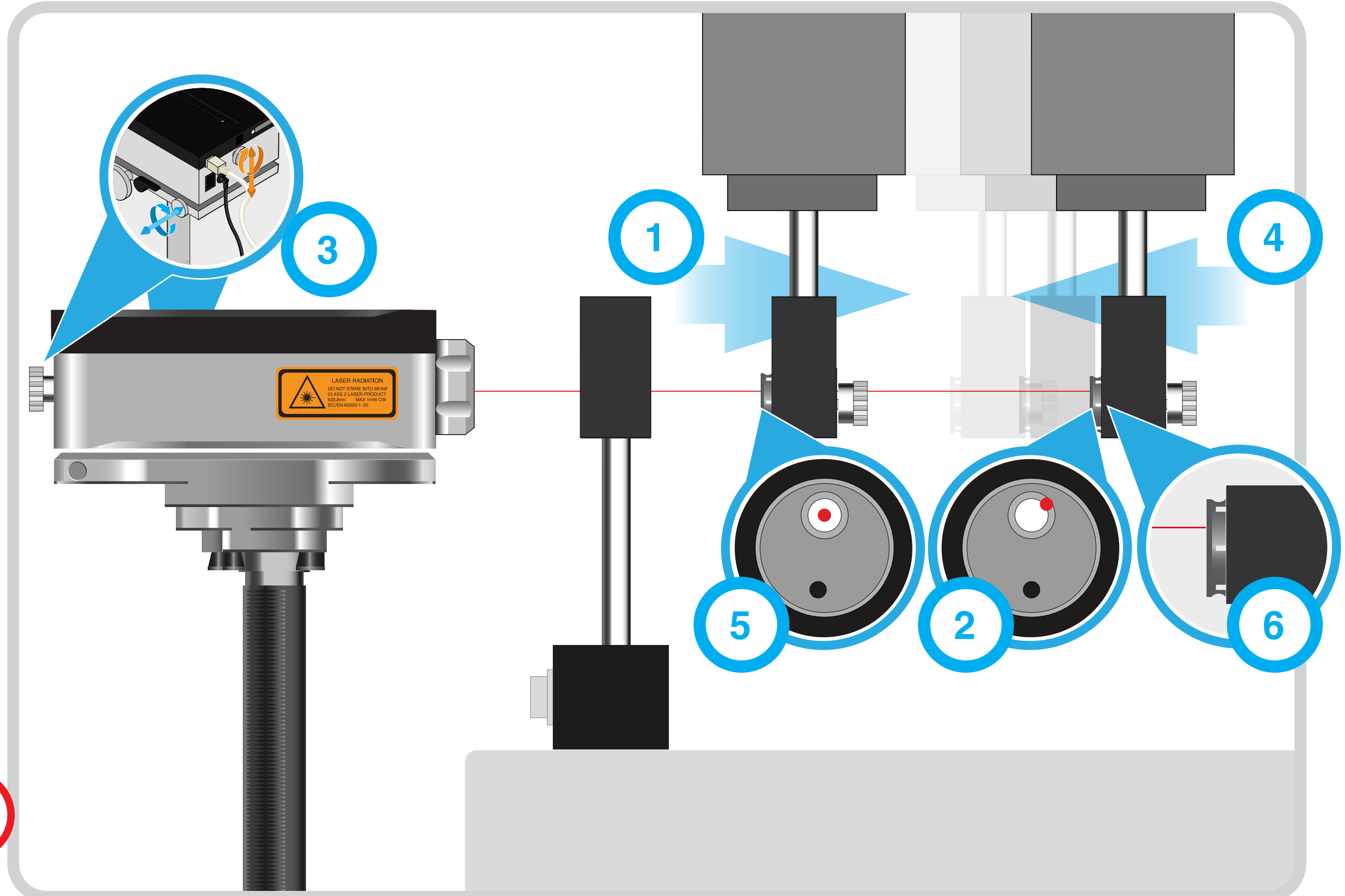


Check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, adjust the position of the interferometer.

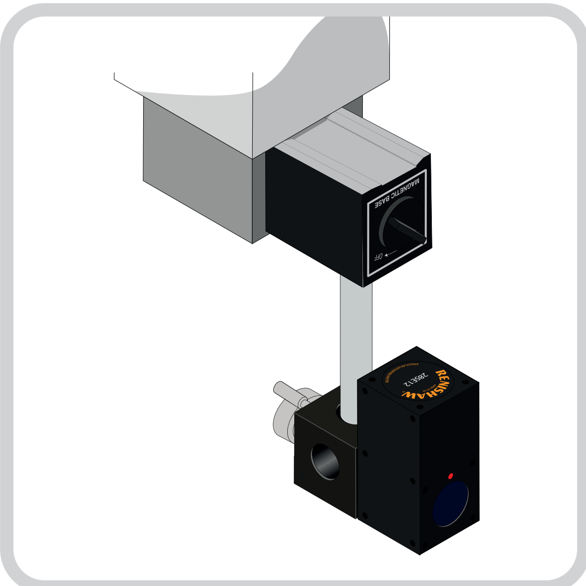
Visual alignment

1. Use the machine to move the reflector away from the interferometer.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the pitch and yaw so the beam hits the centre of the target.
4. Use the machine to drive the reflector towards the interferometer.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Check the beam position along the axis.

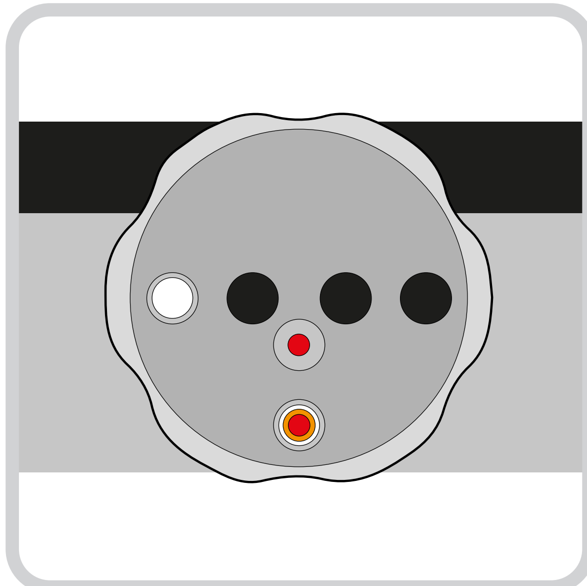
Repeat until the beam remains in the centre of the target over the full length of the axis travel.



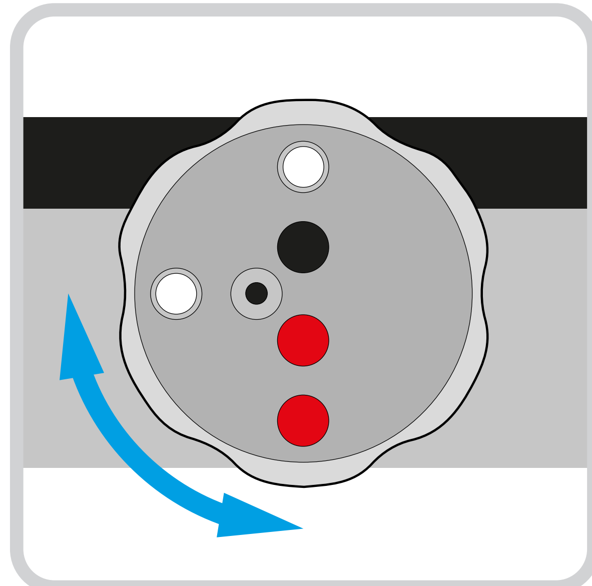
Visual alignment



Remove the target from the retroreflector.



Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target.



Rotate the shutter to an open position, and check that the signal strength stays green over the full axis of travel.

Instructions to capture angular data can be found **on page 117**.

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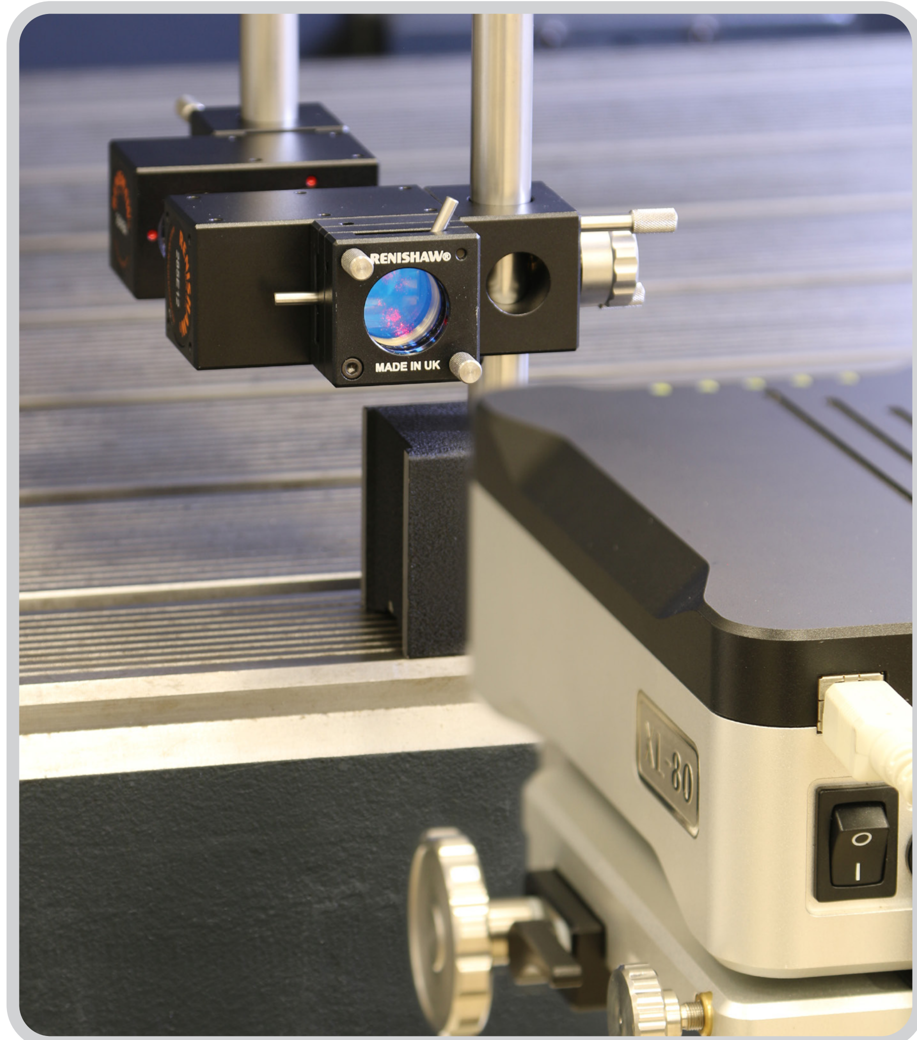
Angular measurement (pitch/yaw)

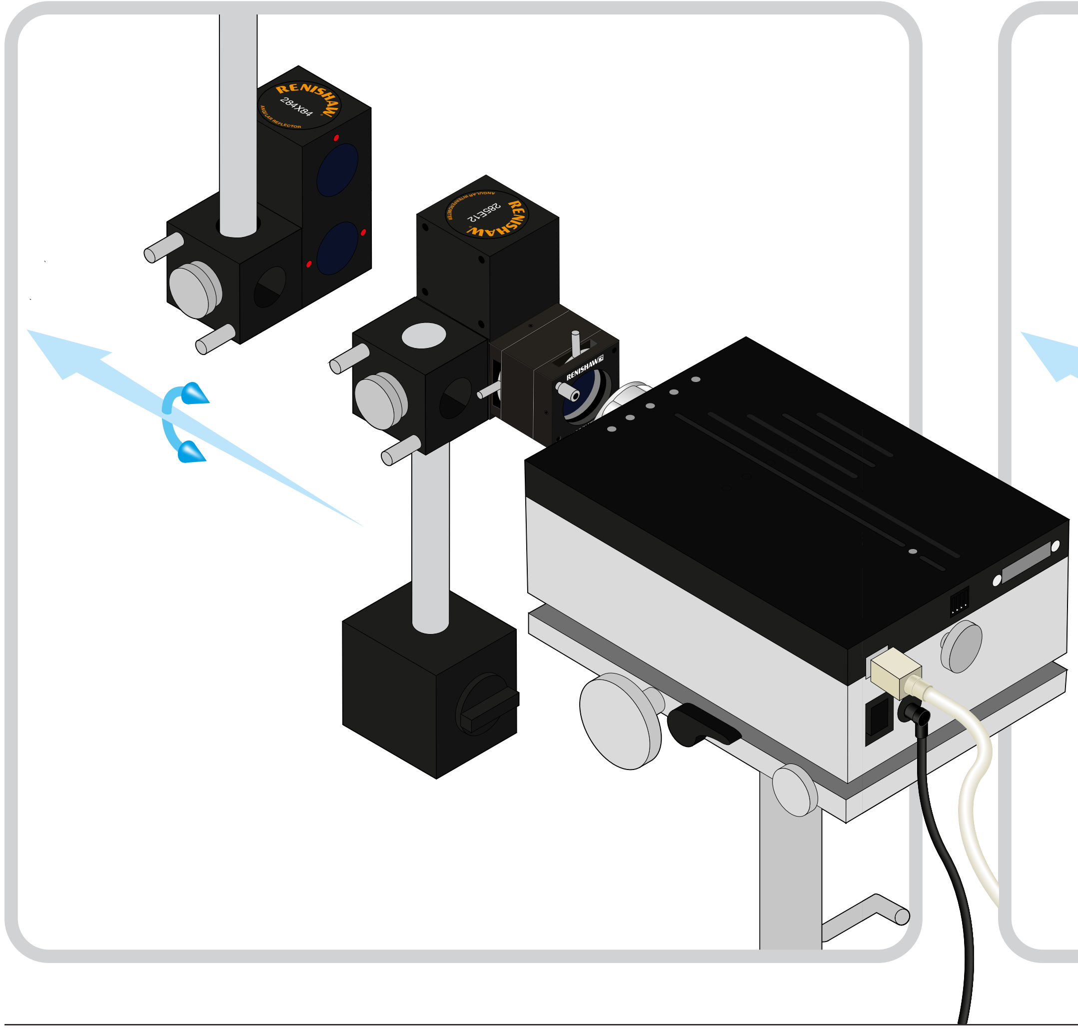
With LS350 laser beam steerer



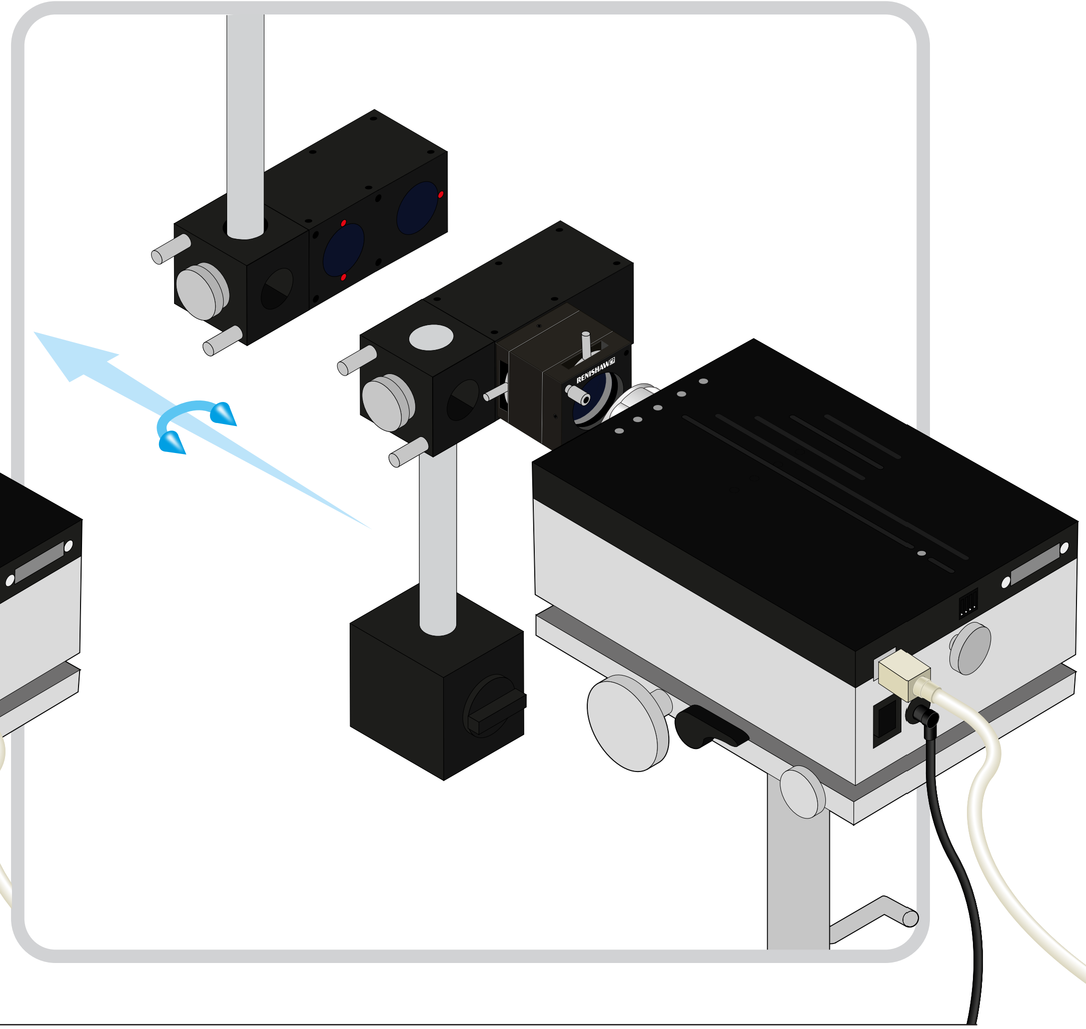
Mounting the optics

The pitch/yaw measurement set-ups – horizontal axis.

Pitch angle



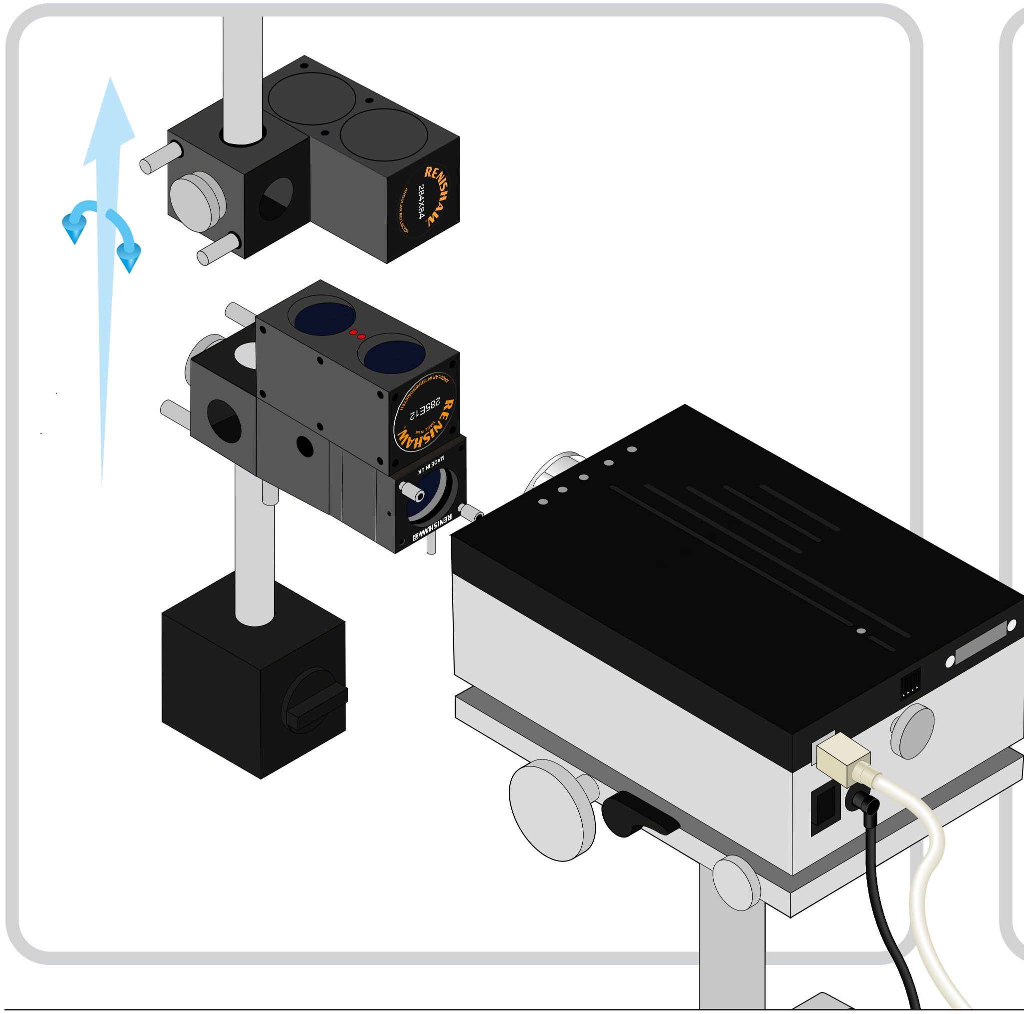
Yaw angle



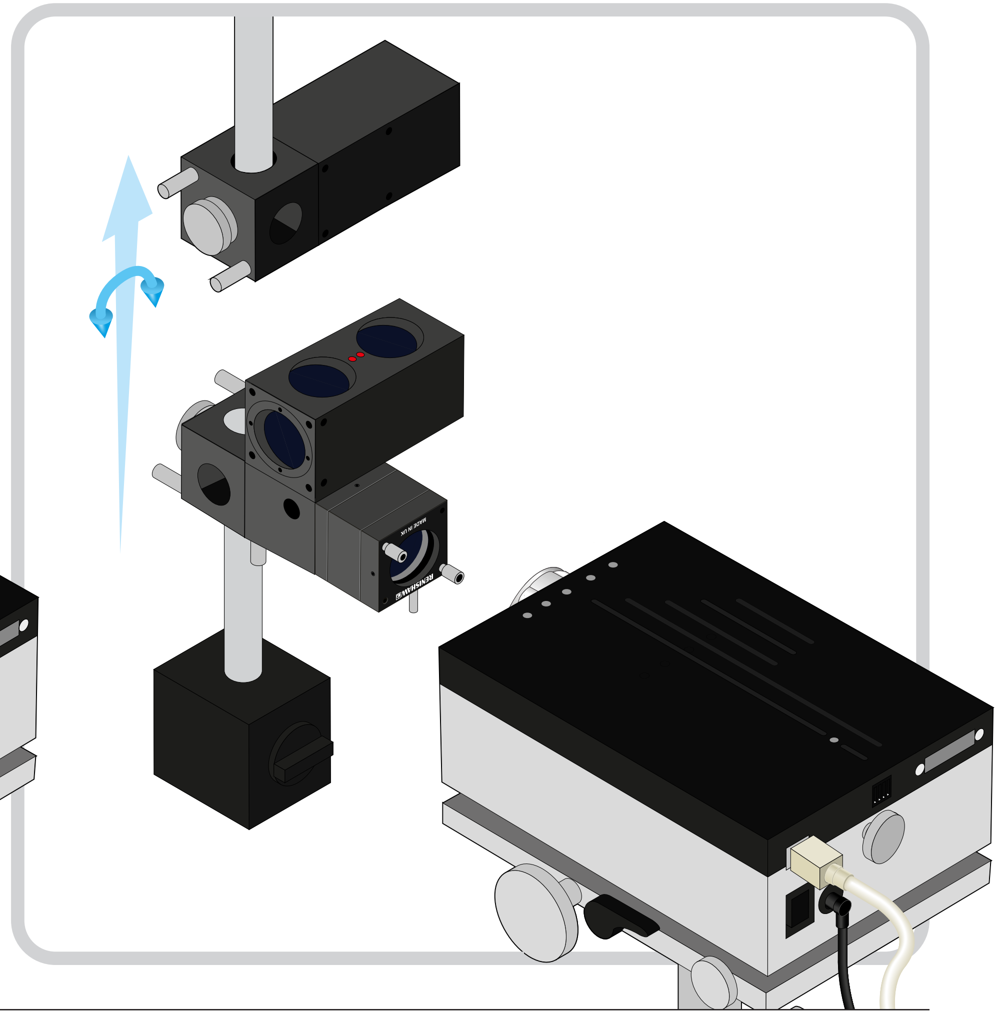
Mounting the optics

The pitch/yaw measurement set-ups – vertical axis.

Pitch angle

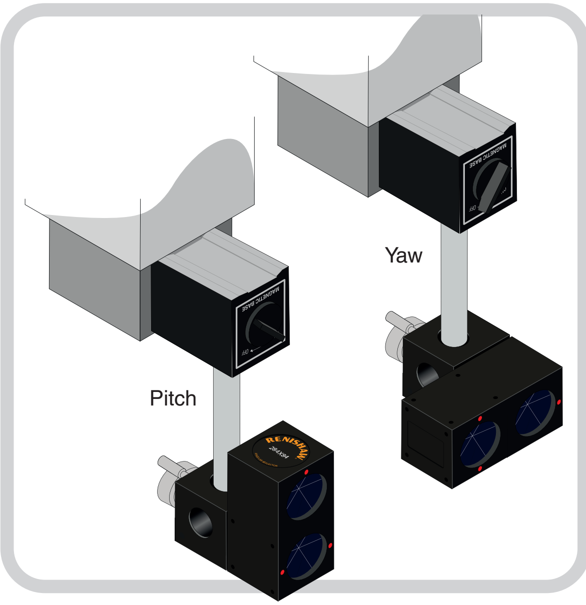


Yaw angle

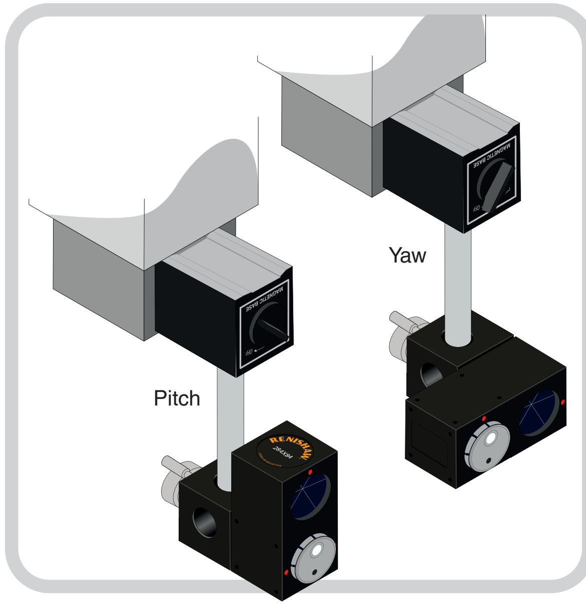


Mounting the optics

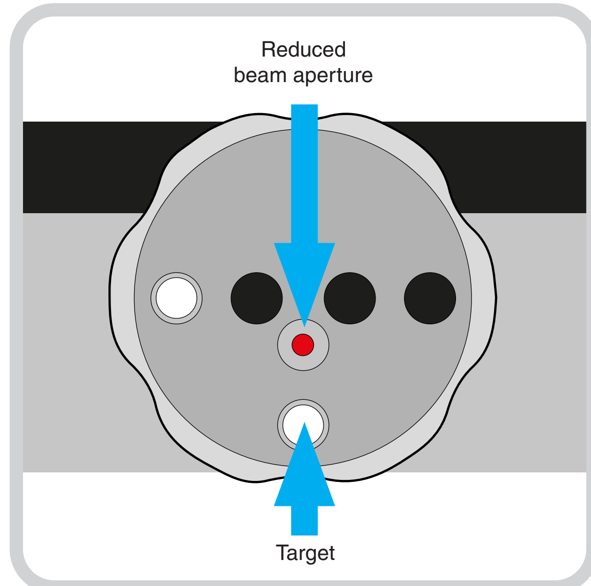
Mounting the angular retroreflector



Assemble the retroreflector assembly as shown. Mount to the moving element of the machine.



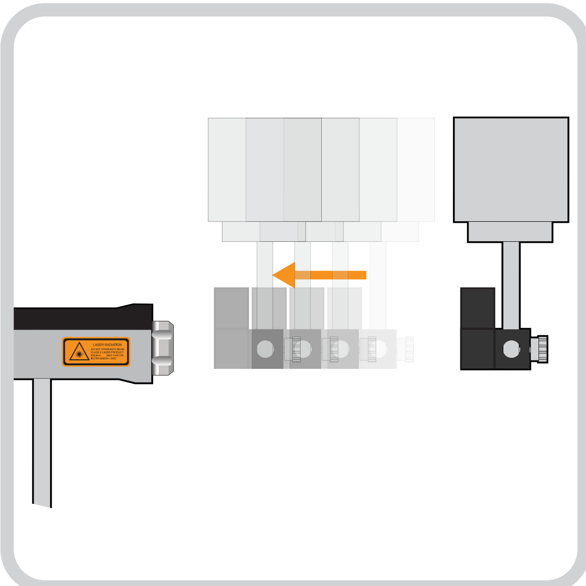
Attach the target onto the face of the retroreflector.



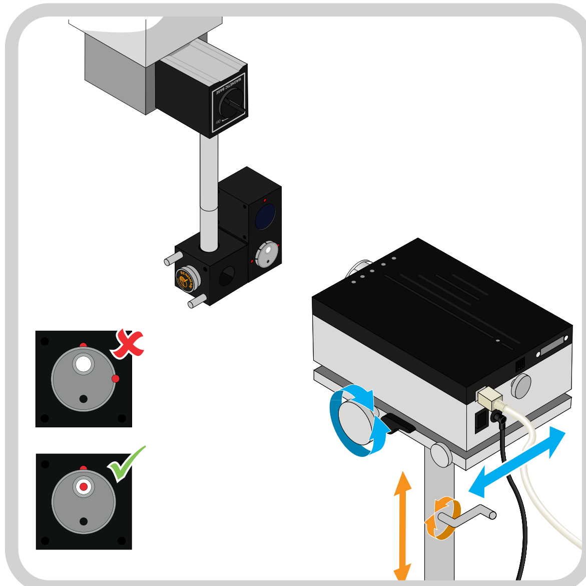
Rotate the laser shutter to emit a reduced diameter beam.

Mounting the optics

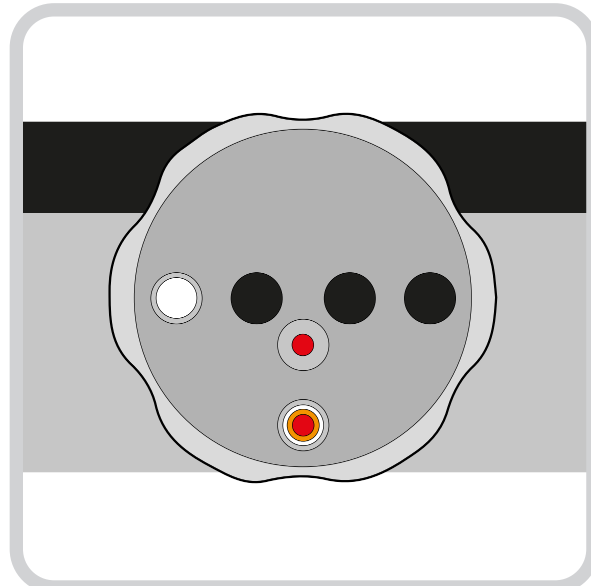
Mounting the angular retroreflector



Drive the retroreflector to the near field position.



Adjust the beam to the centre of the white target using the translation screws.



Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, translate the laser or the machine.

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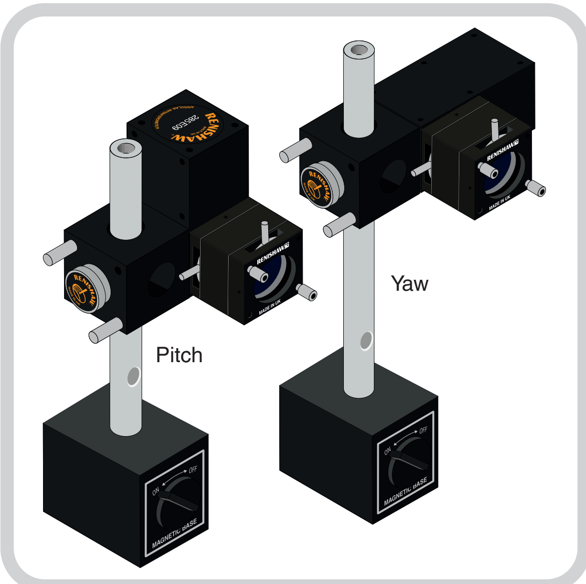
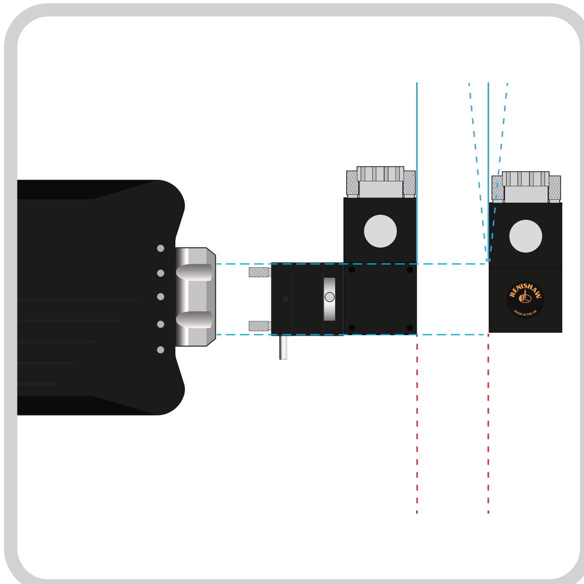
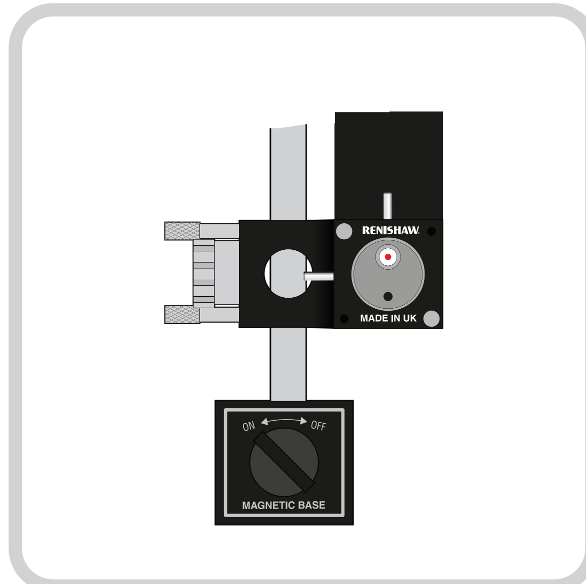
Mounting the optics

Mounting the angular interferometer







Assemble the interferometer assembly and mount the beam steerer onto the input face of the beam splitter as shown. Ensure that the levers are in their mid-position.

Mount to the stationary element of the machine:

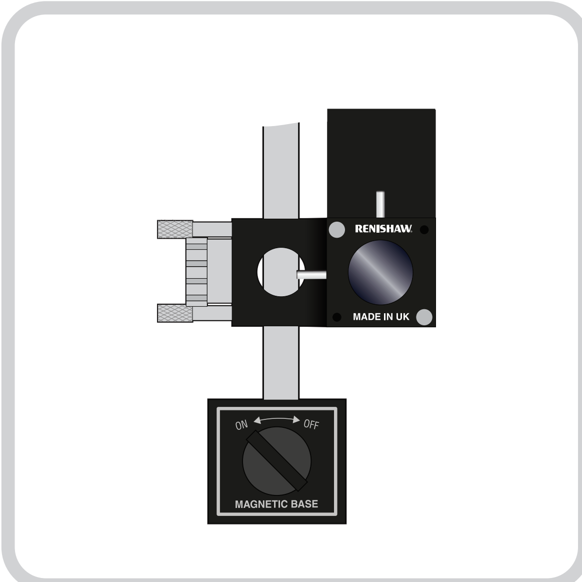
- as close as possible, minimising the distance between the optics;
- square to the axis; and
- parallel to the retroreflector.

Attach the target to input aperture and align it with the beam.

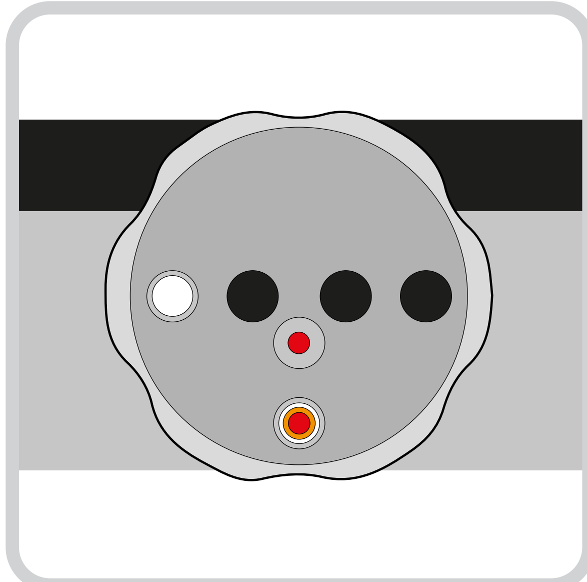
Visual alignment

Mounting the angular interferometer

The angular measurement set-up.



Remove the target.

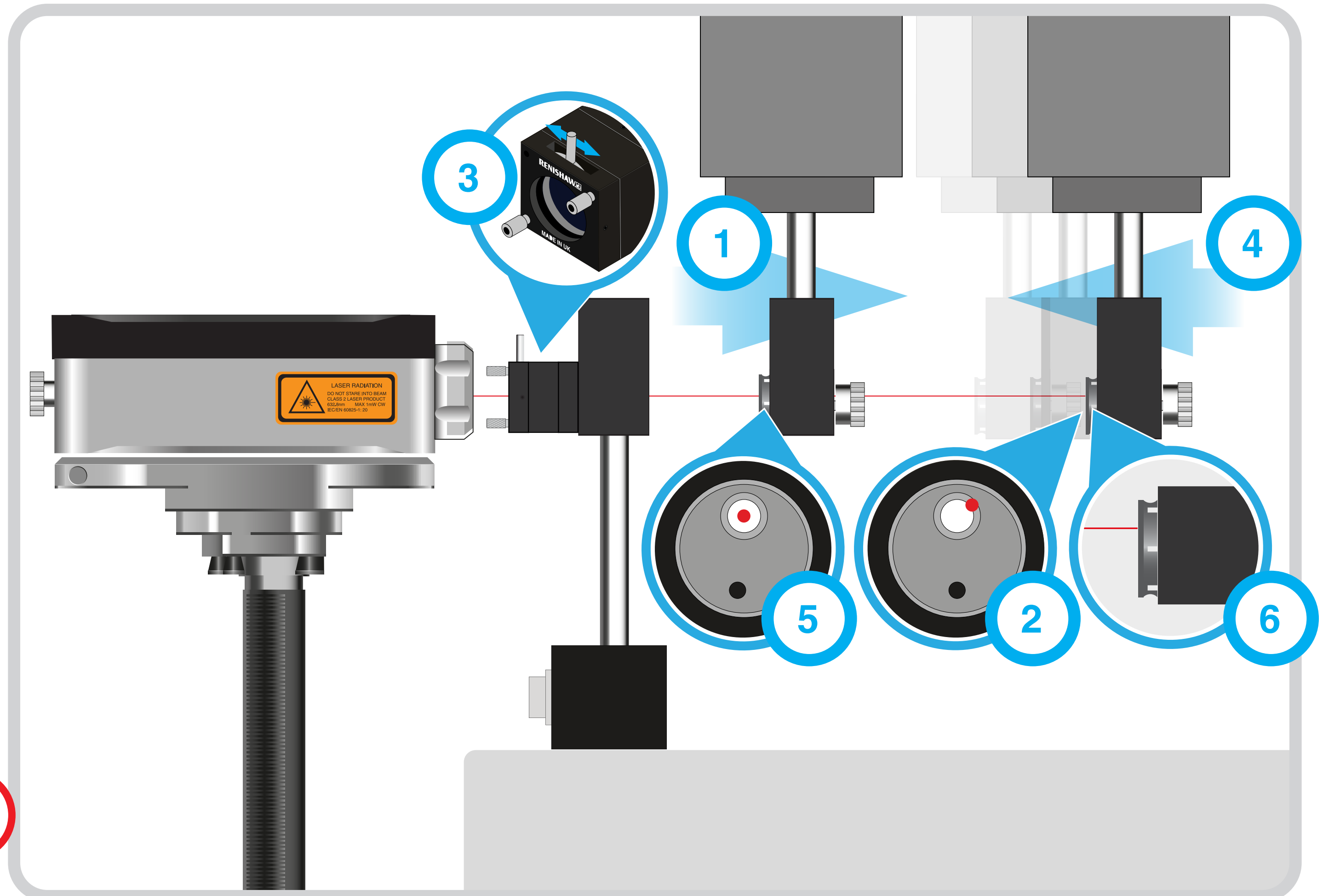


Check that the returned beam hits the centre of the target on the XL laser shutter. If it does not, adjust the position of the interferometer.

Visual alignment

1. Use the machine to move the reflector away from the interferometer.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the beam steerer so the beam hits the centre of the target.
4. Use the machine to drive the reflector towards the interferometer.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Check the beam position along the axis.

Repeat until the beam remains in the centre of the target over the full length of the axis travel.



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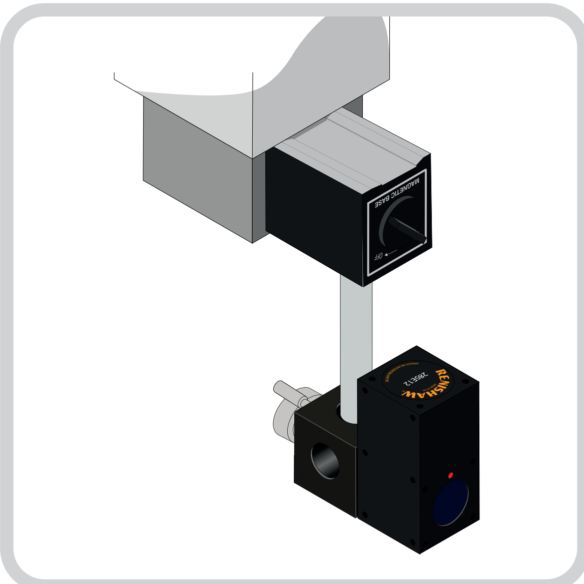
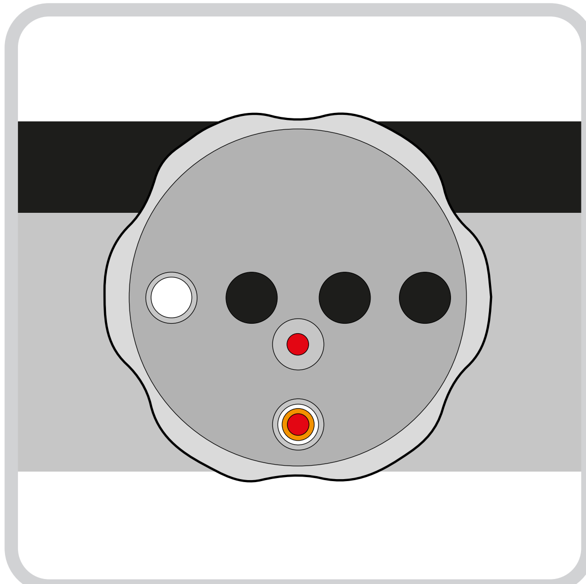
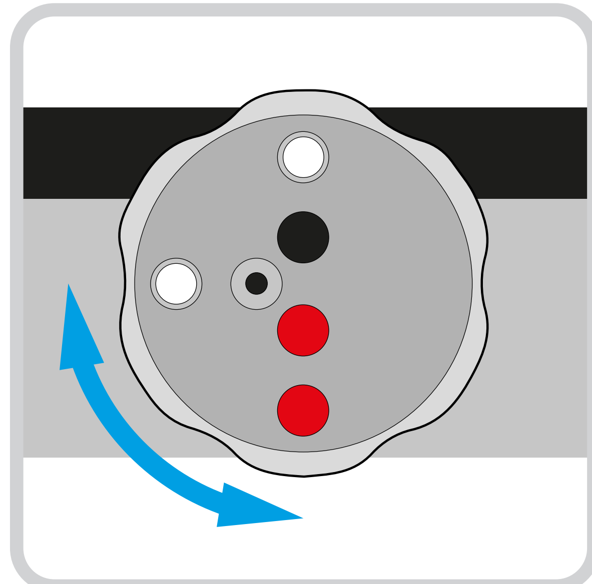
Visual alignment



Remove the target from the retroreflector.



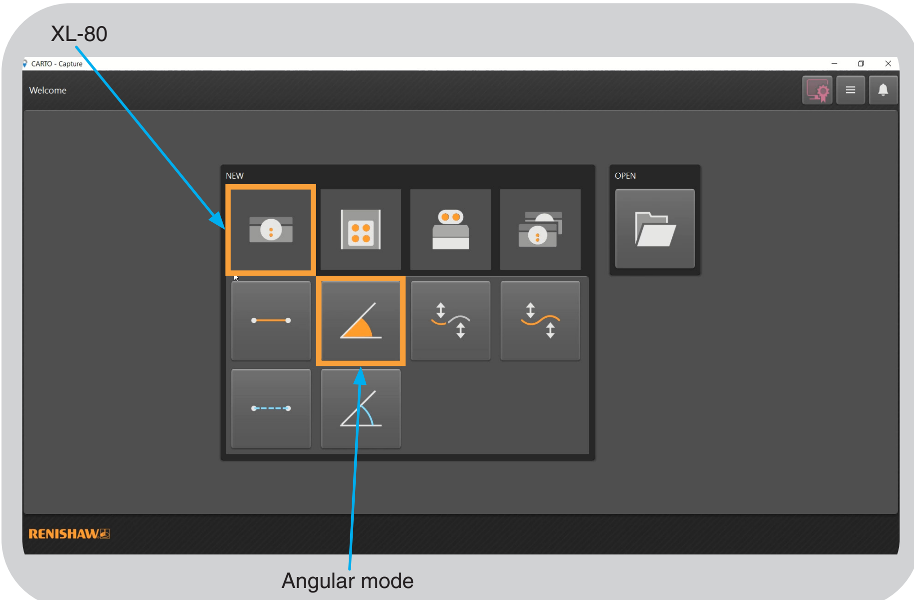
Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target.



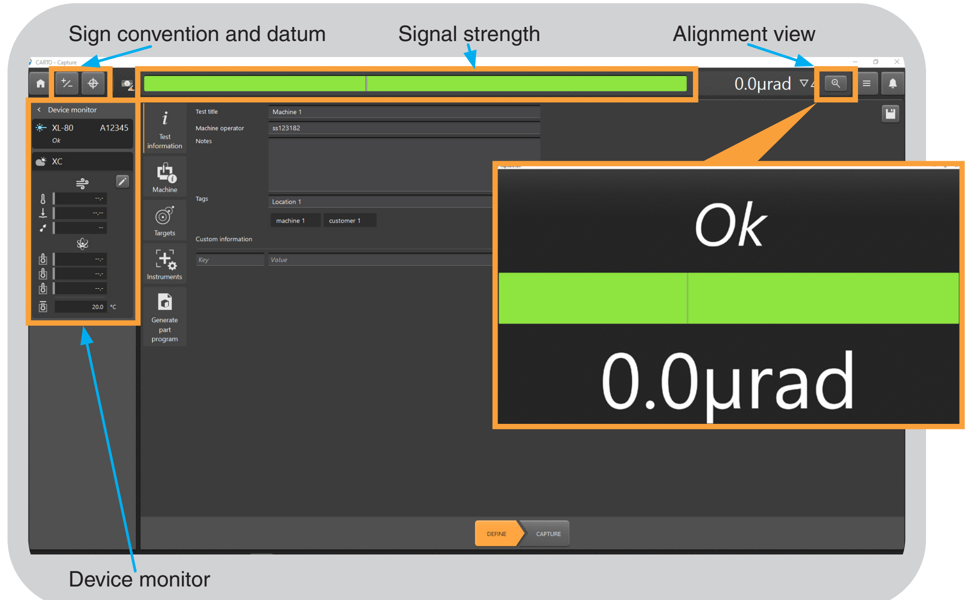
Rotate the XL laser shutter to the open position ready for data capture.

Angular data capture

The application will open in the view shown.
Ensure that the XL-80 is connected to the laptop.



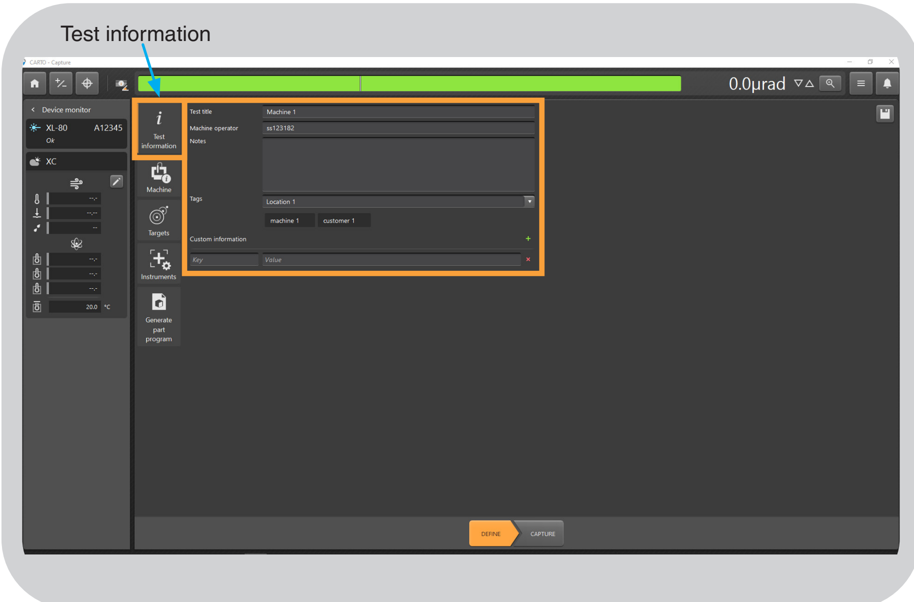
Run the Capture application and select 'Angular mode'.



- **Sign convention** – used to determine the direction of the errors.
- **Datum** – sets the error reading to zero at the first target position.
- **Device monitor** – shows the status of connected hardware.
- **Signal strength** – gives an indication of alignment.
- **Alignment view** – a simple full screen view of signal strength and current laser reading to aid alignment.

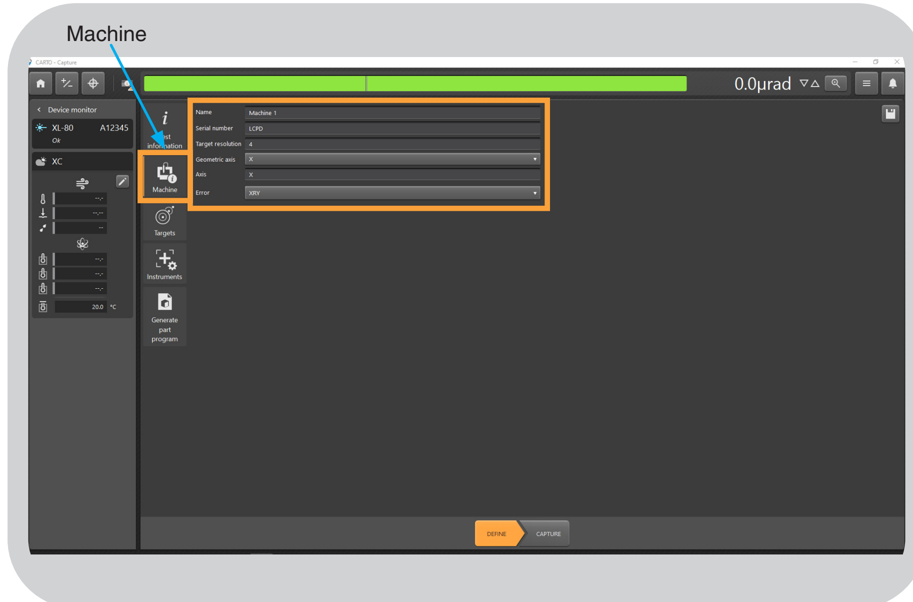
Angular data capture

The ‘Test information’ tab is a place to enter general information for test identification within the CARTO database.



- **Test title** – title to be used when referring to the test.
- **Machine operator** – name of operator conducting the test.
- **Notes** – information which may be useful about the test.
- **Tags** – apply tags to aid filtering of data in Explore.
- **Custom information** – allows customised fields to be created and included in the test record.

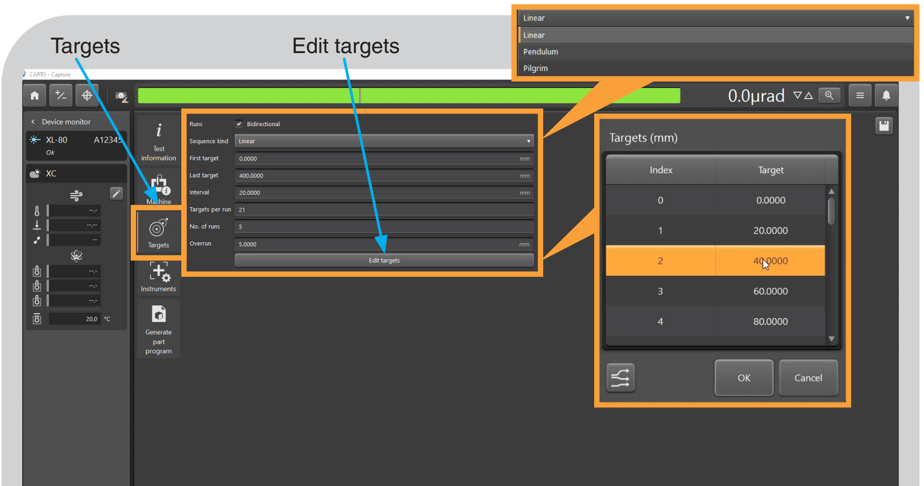
In the ‘Machine’ tab enter information which is specific to the machine and axis under test.



- **Name** – name of the machine under test.
- **Serial number** – serial number of machine under test.
- **Target resolution** – number of decimal places for targets. This must not be higher than the machine resolution.
- **Geometric axis** – select the axis under test to match the set-up.
- **Axis** – allows a custom axis name to be used.
- **Error** – the axis which the rotational error is being measured.

Angular data capture

Targets can be manually edited or randomised using the ‘Edit targets’ button.



Bidirectional – each target is captured from a positive and negative direction.

Sequence kind – kind of sequence the machine moves between targets for data capture. See appendix in *CARTO Capture* user guide (Renishaw part no. F-9930-1007) for more information.

First target – input the first position for data capture.

Last target – input the last position for data capture.

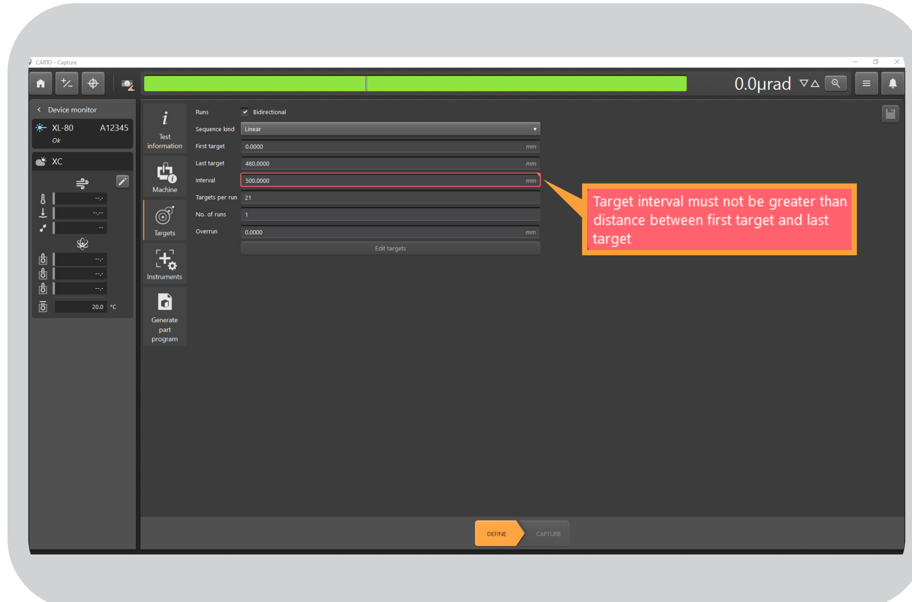
Interval – distance between targets.

Targets per run – if the interval value has been entered this will be updated accordingly.

Number of runs – determine the number of times the target sequence is repeated.

Overrun – distance required for turn around at end of the axis (including first target and last target).

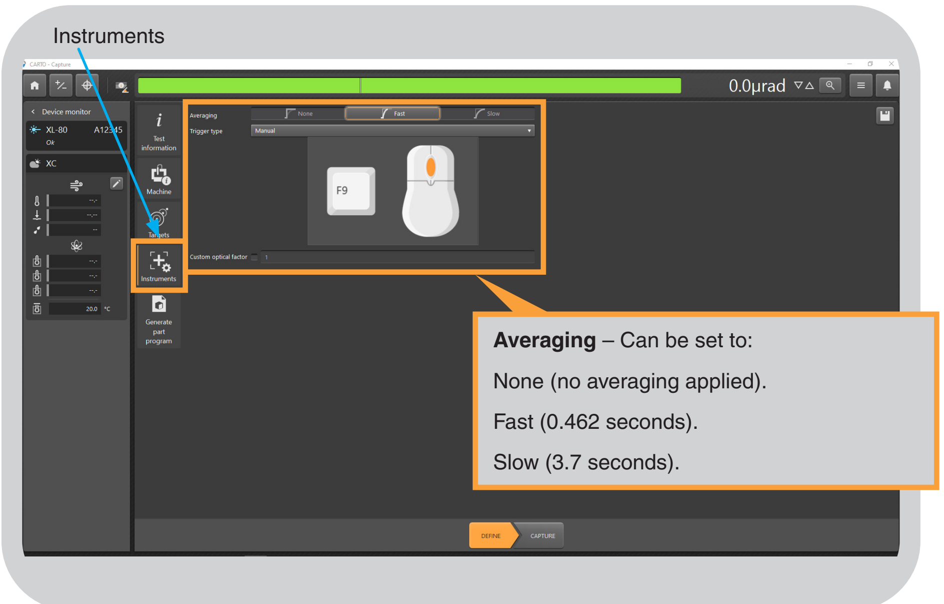
Edit targets – targets can be individually edited or randomised.



Any **red** highlighted box highlights potential problems with the test method. Place the mouse over the text field for more information.

Angular data capture

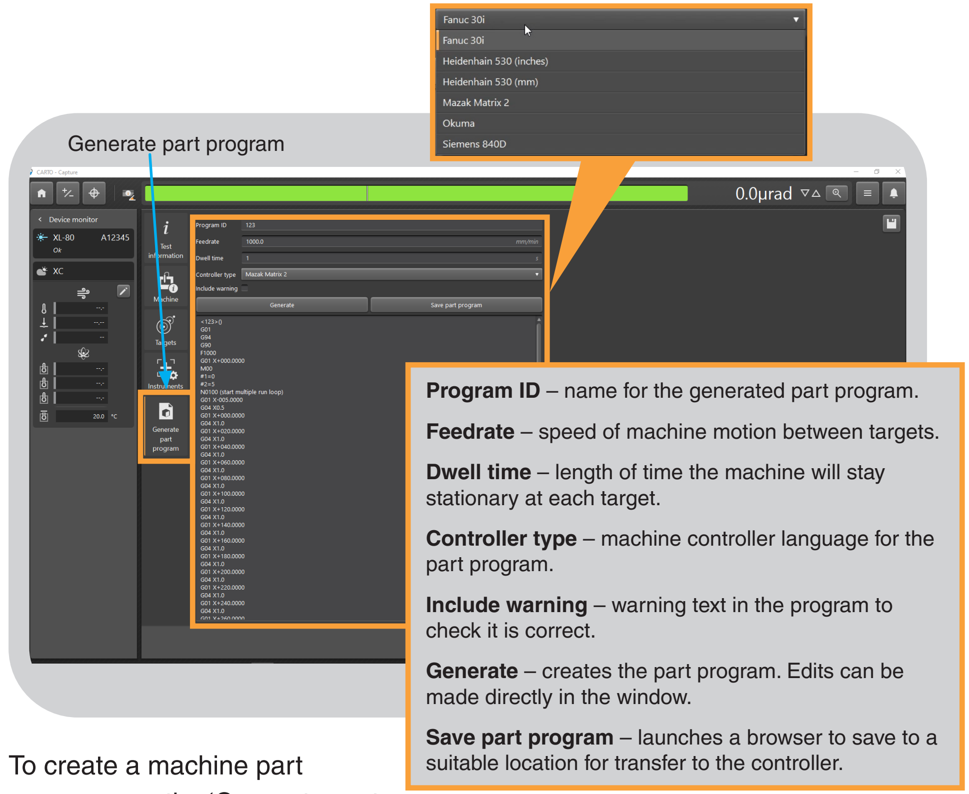
In the ‘Instruments’ tab, select the averaging type required and preferred trigger method.



For angular data capture the following trigger methods are available:

- **Manual** – using F9 key or middle mouse button.
- **TPin** – using an external source to trigger through the Aux I/O input on the XL-80. **See Appendix B**.
- **Time** – calculate the move time based on feedrate and trigger distance.

NOTE: If calibrated angular optics are being used then enter the calibration value into the ‘Custom optical factor’ field.



To create a machine part program use the ‘Generate part program’ tab, enter a program name and feedrate.

Default dwell time is based upon previous selections such as averaging and trigger parameters, however this can be modified if required.

Select a ‘Supported controller type’, ‘Generate’ the program and ‘Save’ to a suitable location for transfer to the machine.

Angular data capture

1. Check the error sign convention for the optical set-up and set accordingly in the software.

2. Drive the machine to the first target position and press ‘Start test’.

3. ‘Start test’ will datum the error value to zero.

4. The test status bar advises the next steps.

Press start on the machine controller.

- **Using manual triggering** – press F9 key or middle mouse button at each target when the machine stops.
- **For TPin or time based triggering** – data will be collected automatically.

The test status is displayed in the top right of the screen.

Angular data capture

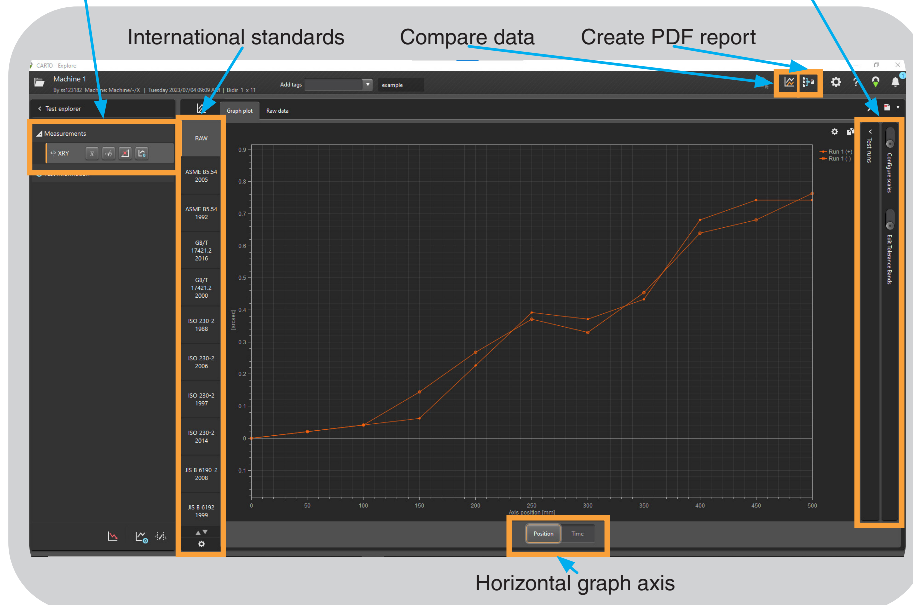
The test status will indicate when the test is complete. ‘Save’ the test.

A dialogue box will appear to allow further detail or ammendments to be added to the test record.

Angular data capture

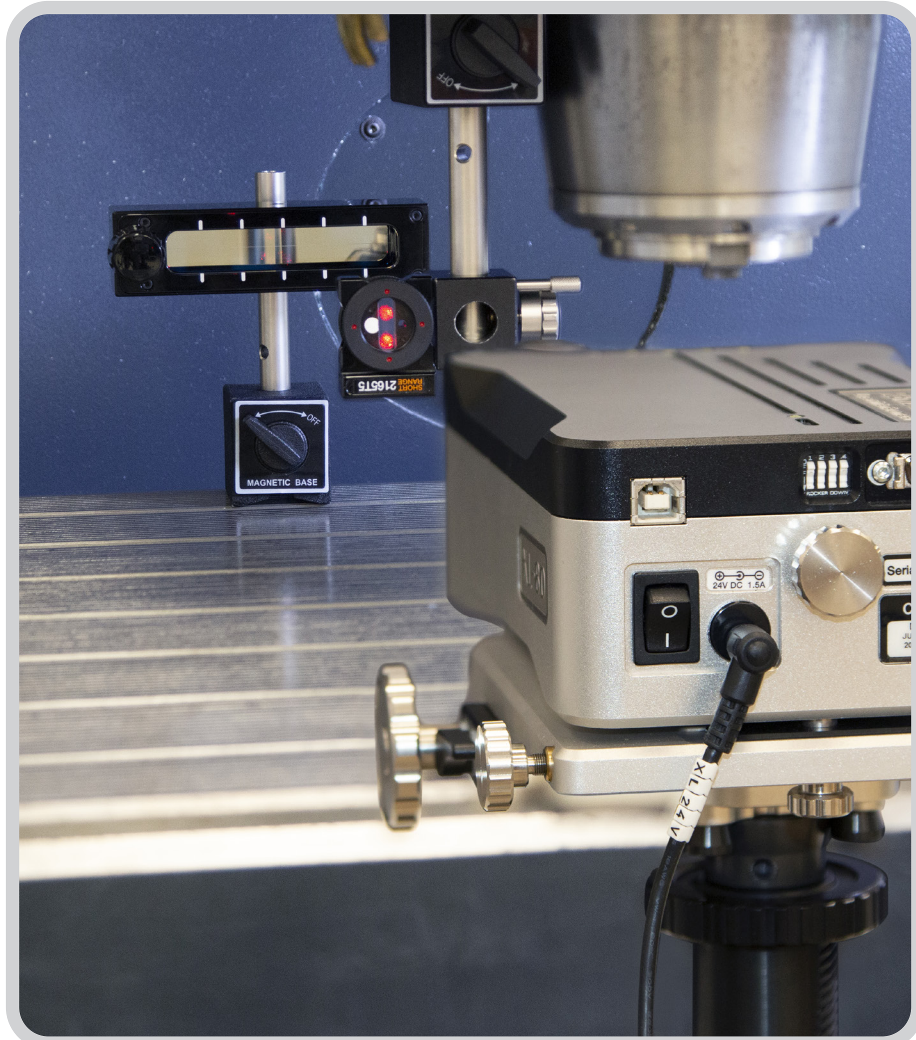
Analysing test data

Select 'Analyse' to launch the Explore application.



The application will open in the view shown.

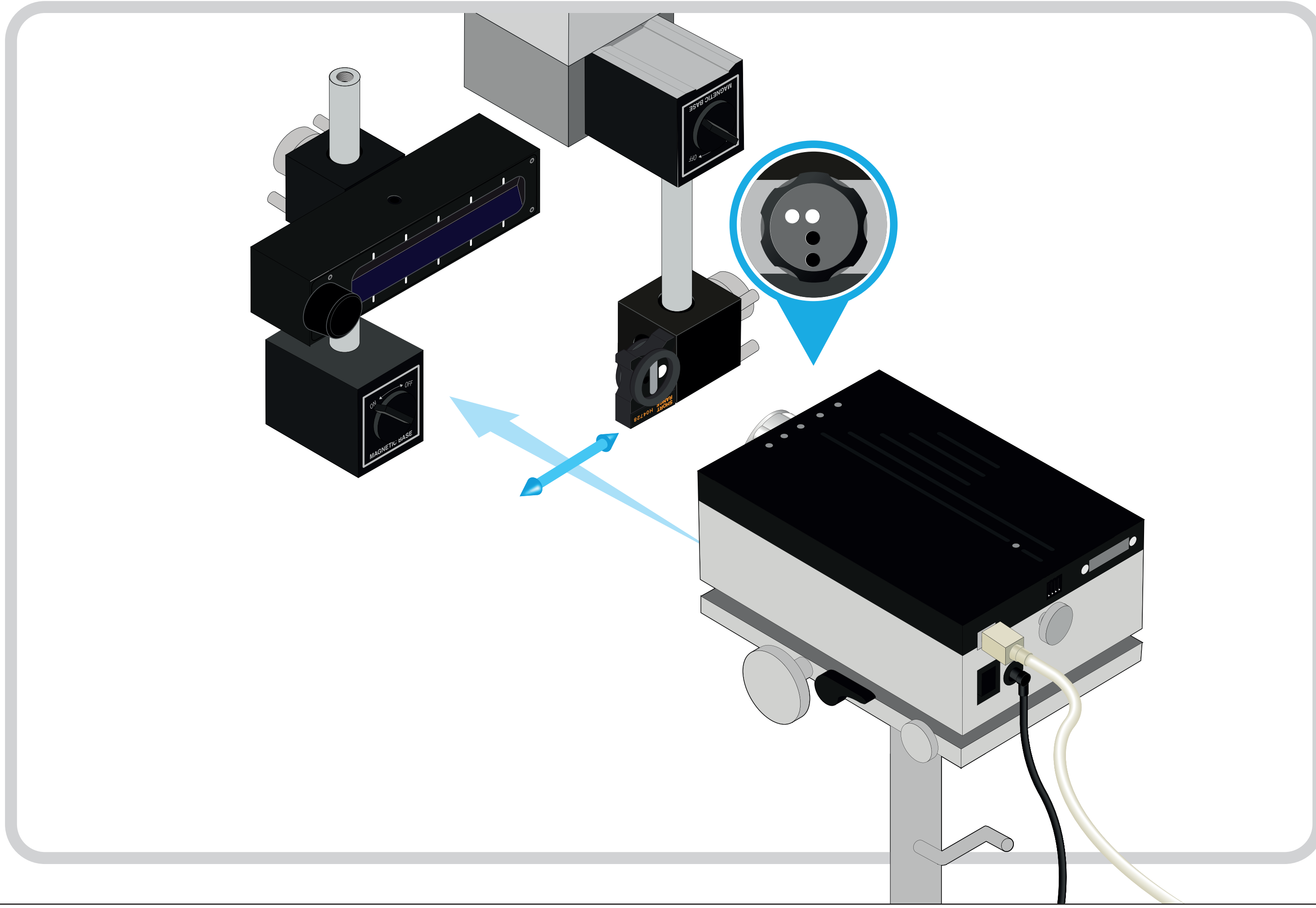
Straightness measurement (horizontal axis – horizontal plane)



NOTE: Environmental compensation is not necessary when taking straightness measurements, therefore, the XC environmental compensator and environmental sensors are not required.

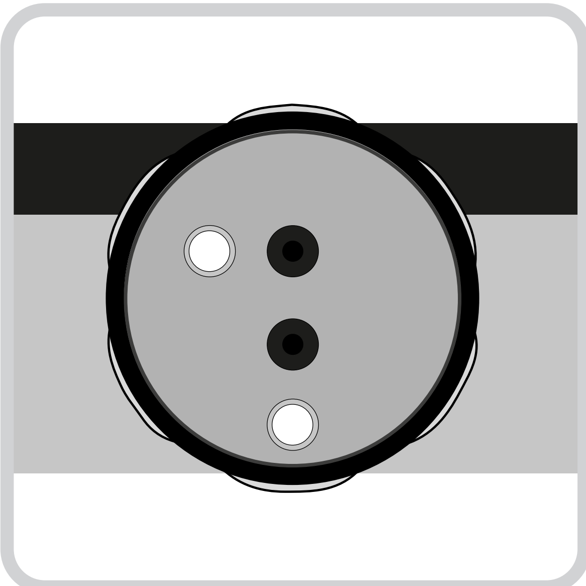
Mounting the optics

Horizontal measurement plane

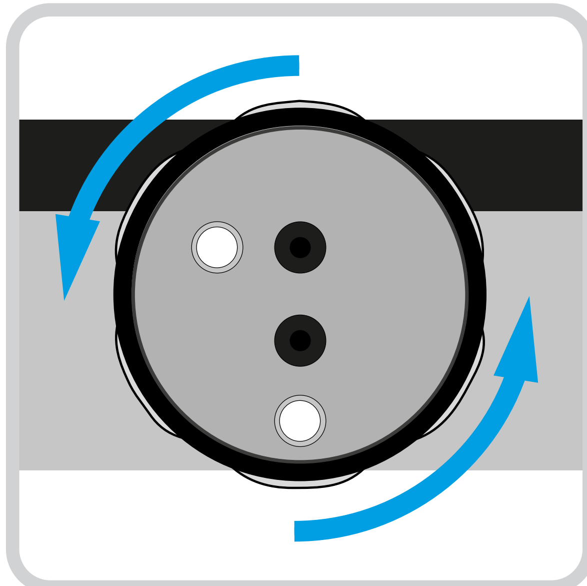


Horizontal axis

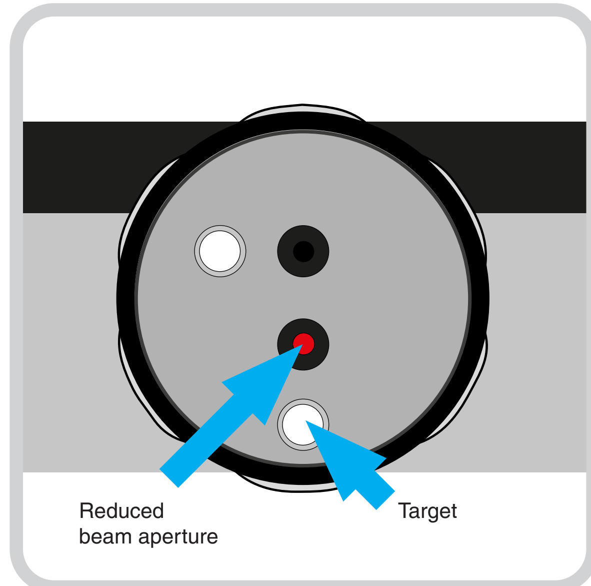
Horizontal measurement plane



Attach the straightness shutter to the laser in the orientation shown.



Rotate the black bezel of the laser shutter.



Continue rotating until a reduced diameter beam is emitted.

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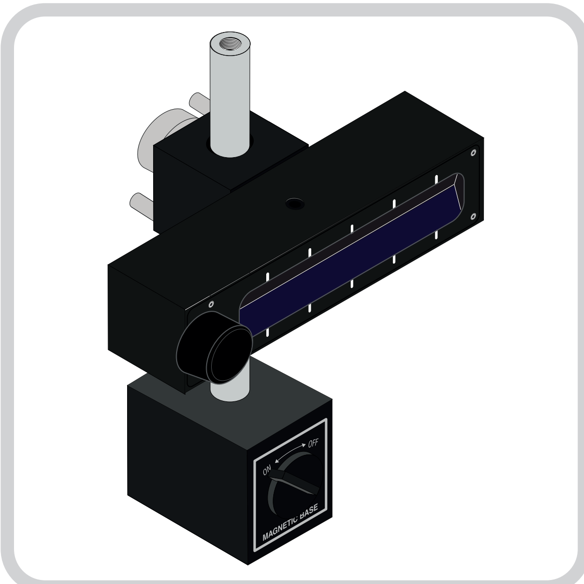
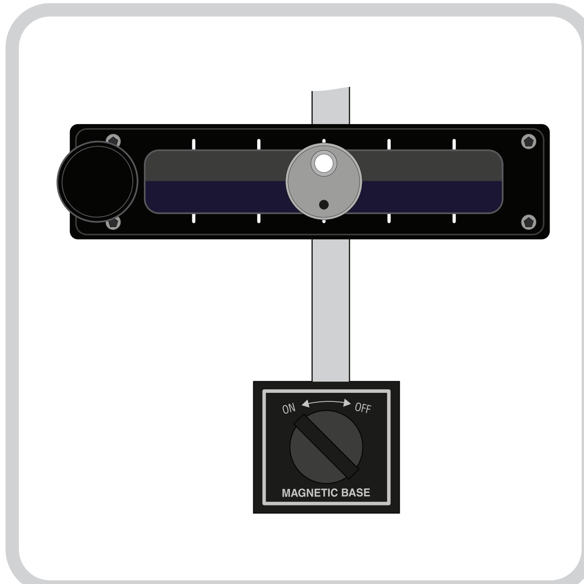
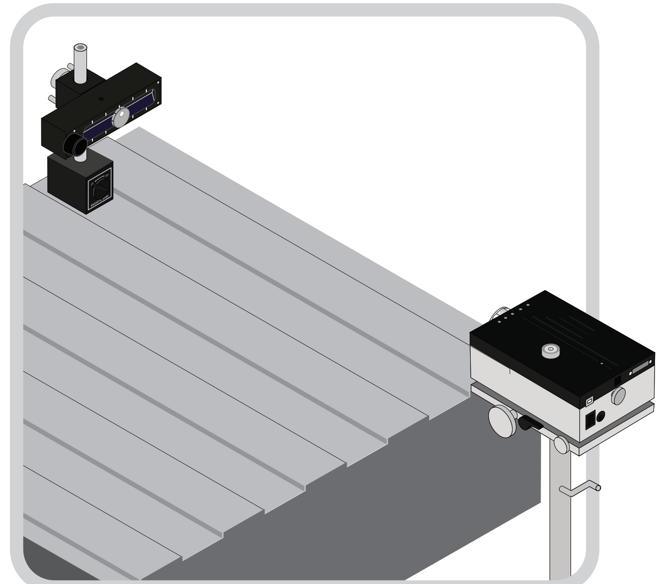
Mounting the optics

Mounting the straightness reflector







Assemble the straightness reflector as shown above.

Attach the target to the centre of the straightness reflector.

Mount to the stationary element of the machine in the farthest position along the axis of travel. Translate the straightness reflector so that the beam is on the centre of the white target.

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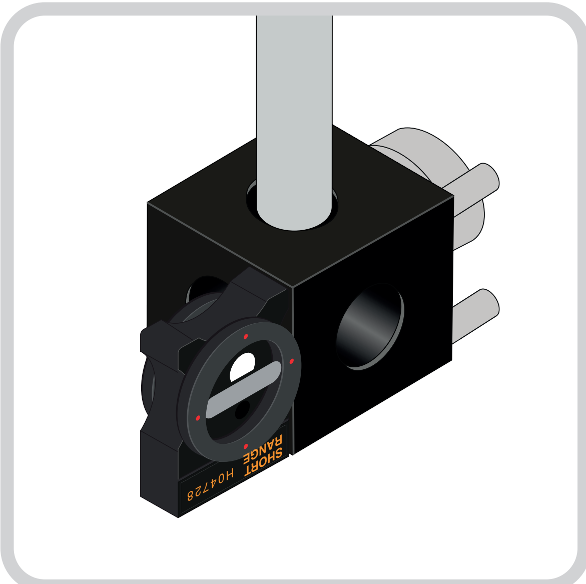
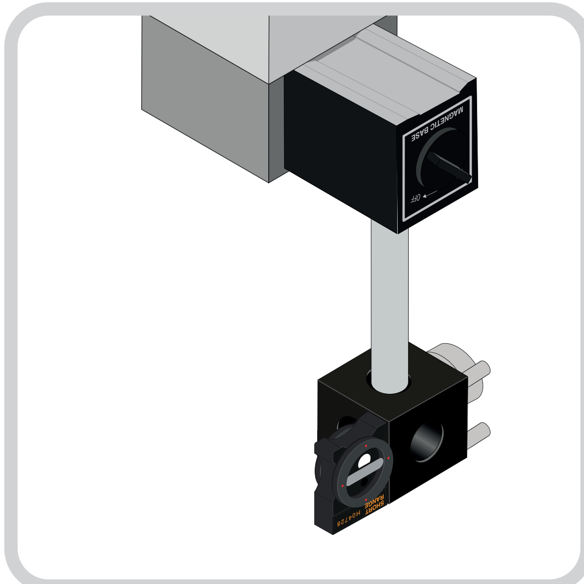
Mounting the optics

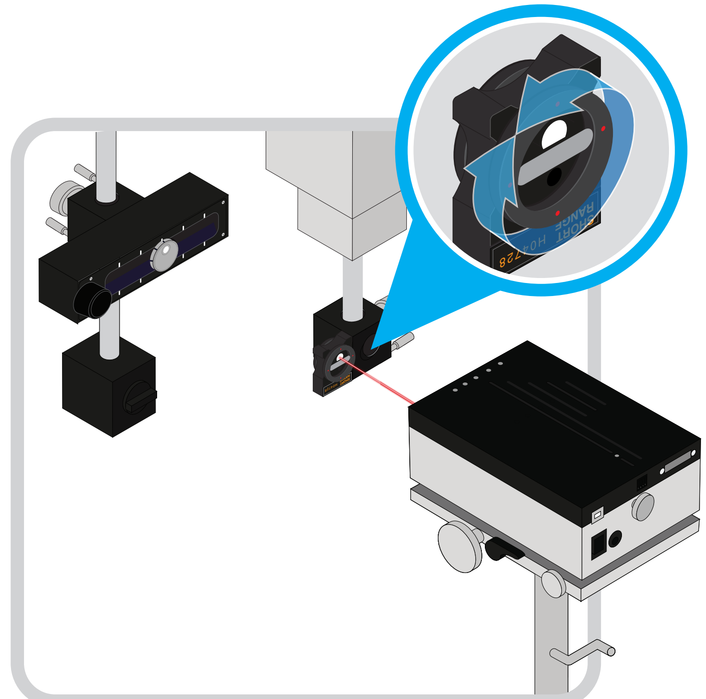
Mounting the straightness interferometer



Assemble the straightness interferometer assembly as shown.



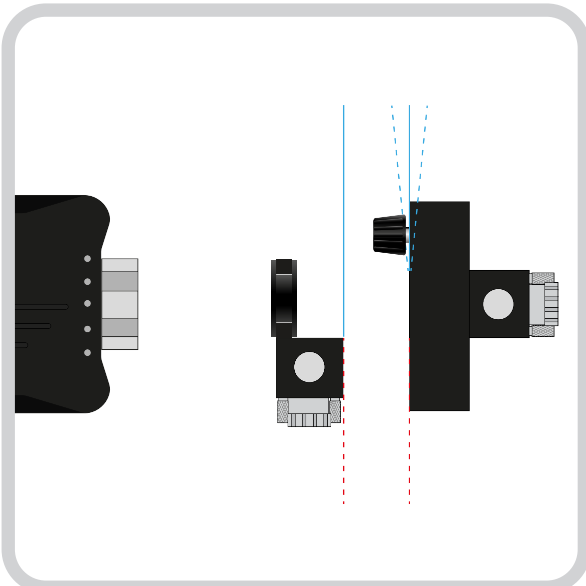
Mount to the moving element of the machine.



Ensure that the target on the straightness interferometer is in the same orientation as the reflector. If not, rotate the face of the interferometer.

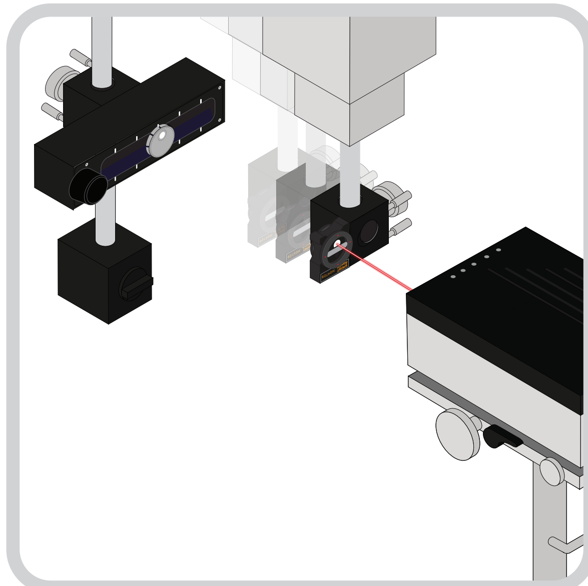
Mounting the optics

Mounting the straightness interferometer

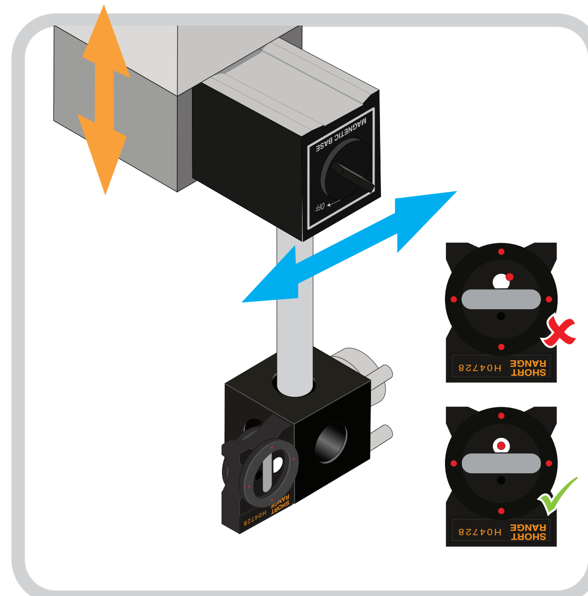


Ensure the optics are:

- square to the axis; and
- parallel to the retroreflector.



Drive the interferometer to the near field position.



Translate the machine until the beam is on the white target.

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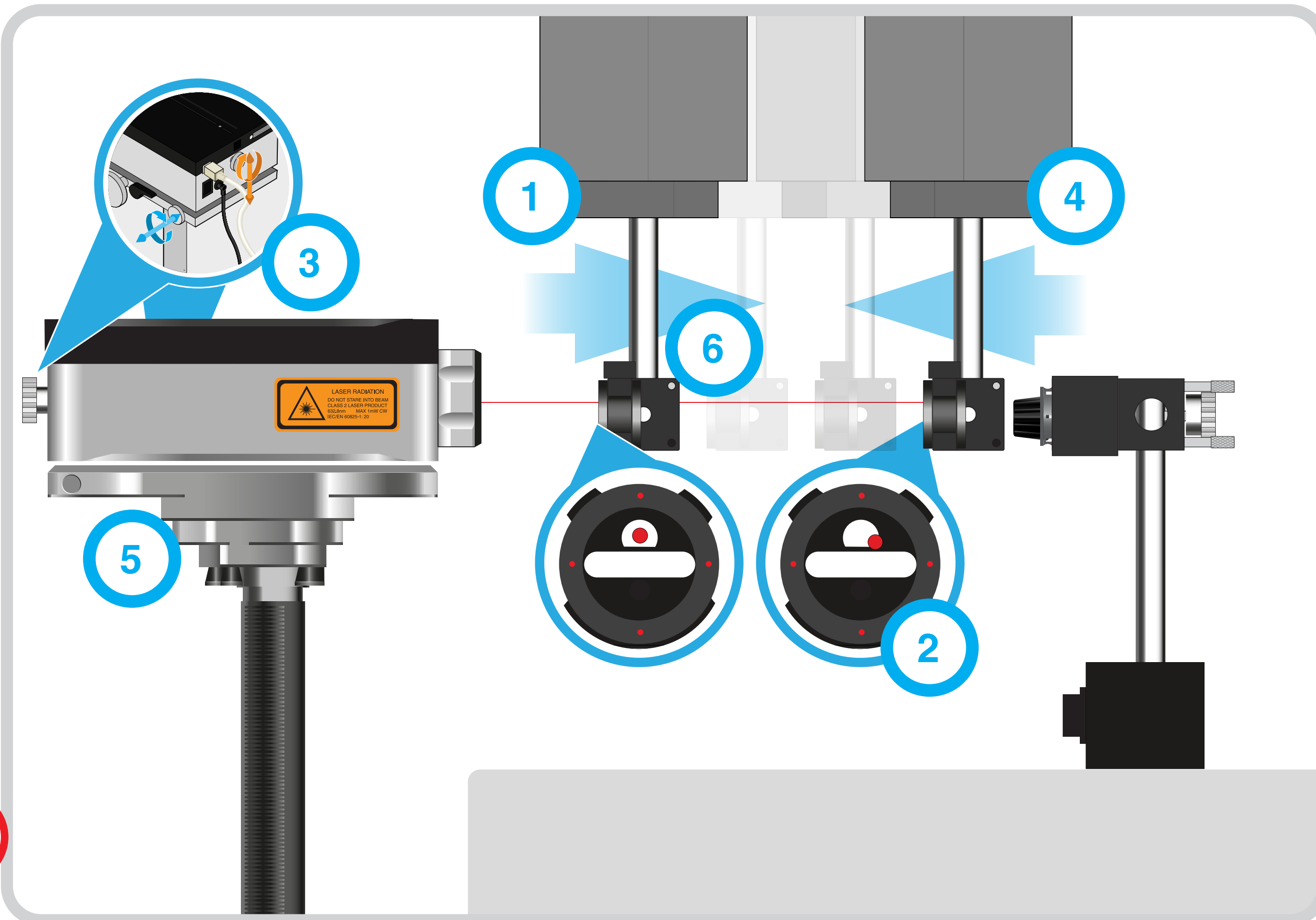
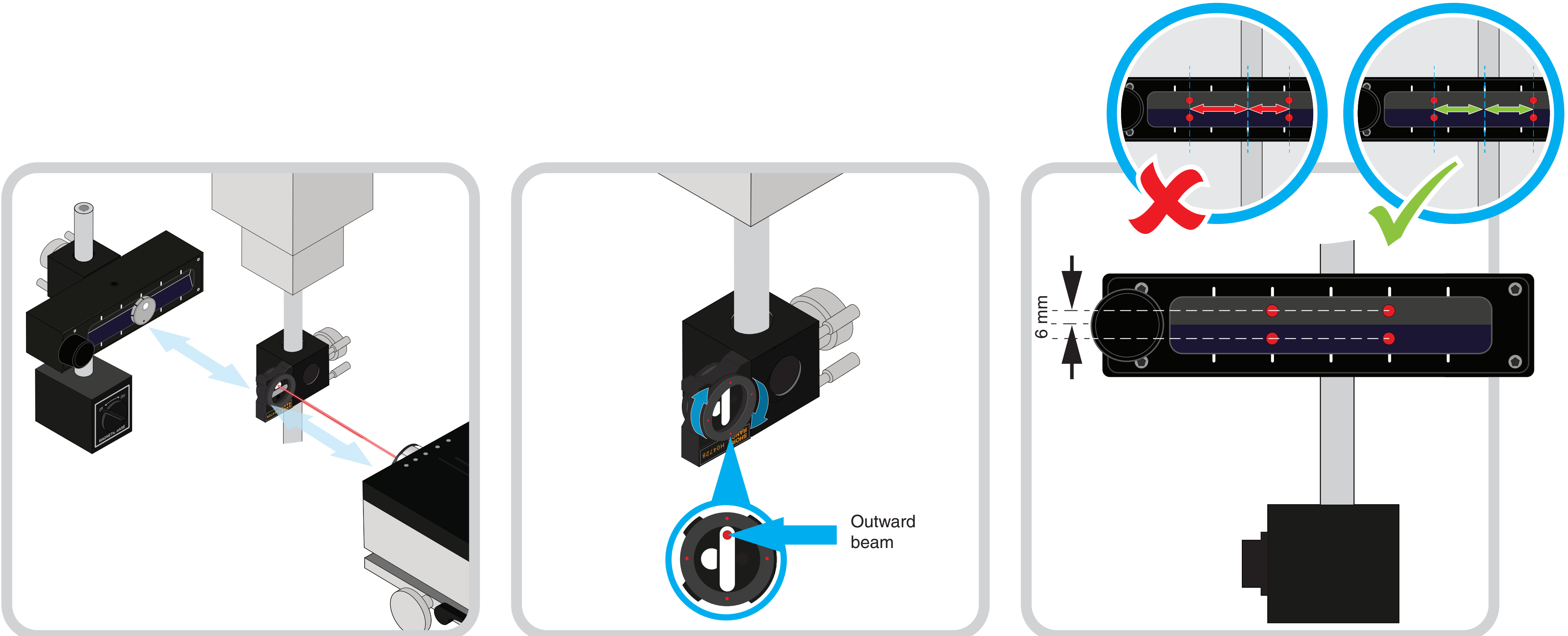
Visual alignment

1. Drive the interferometer towards the retroreflector.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the pitch and yaw so that the beam hits the centre of the target.
4. Drive the interferometer towards the laser.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Ensure the laser beam is on the centre of the target along the axis.

Repeat until the two beams remain in the centre of the target over the full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position.



Visual alignment



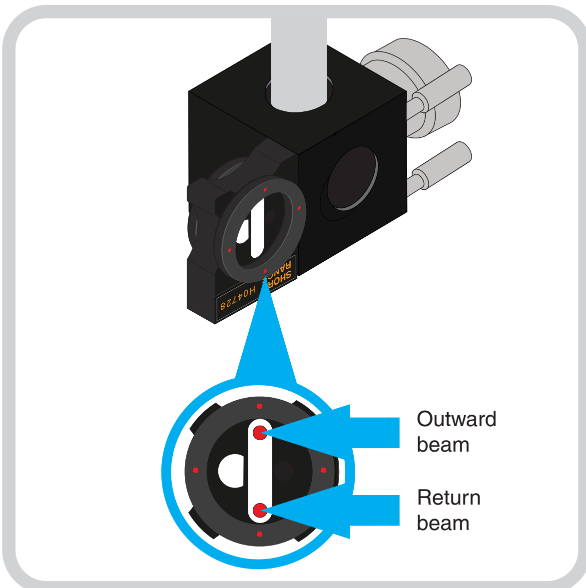
Position the interferometer halfway along the axis of travel.

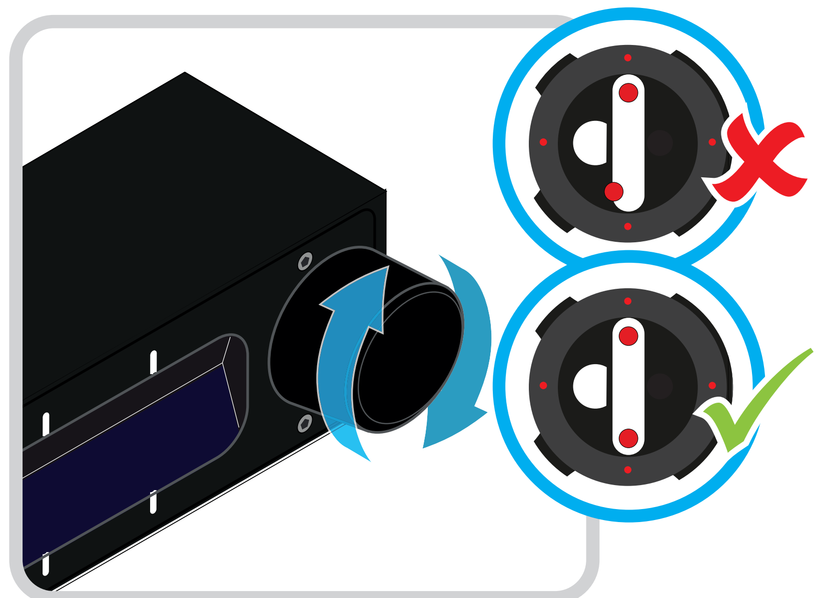
Rotate the face of the interferometer so that the beam passes through the top of the aperture.

The beams should hit the straightness reflector equally spaced from the centre of its long axis and 6 mm from the centre of its short axis.

Visual alignment

Return beam alignment



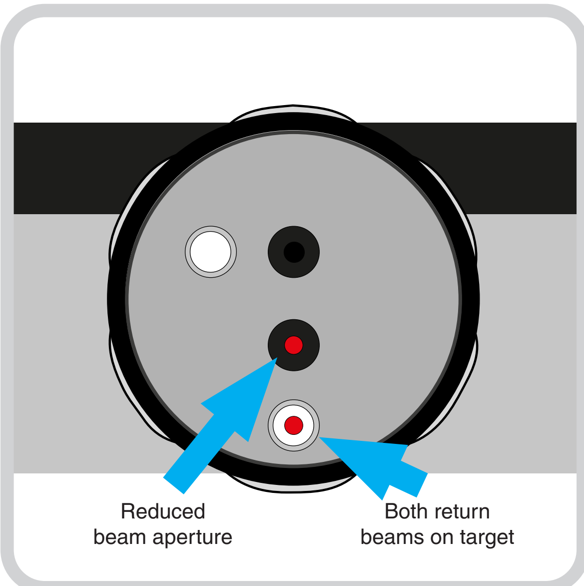


Ensure that the returned beam from the reflector enters the centre line of the interferometer.

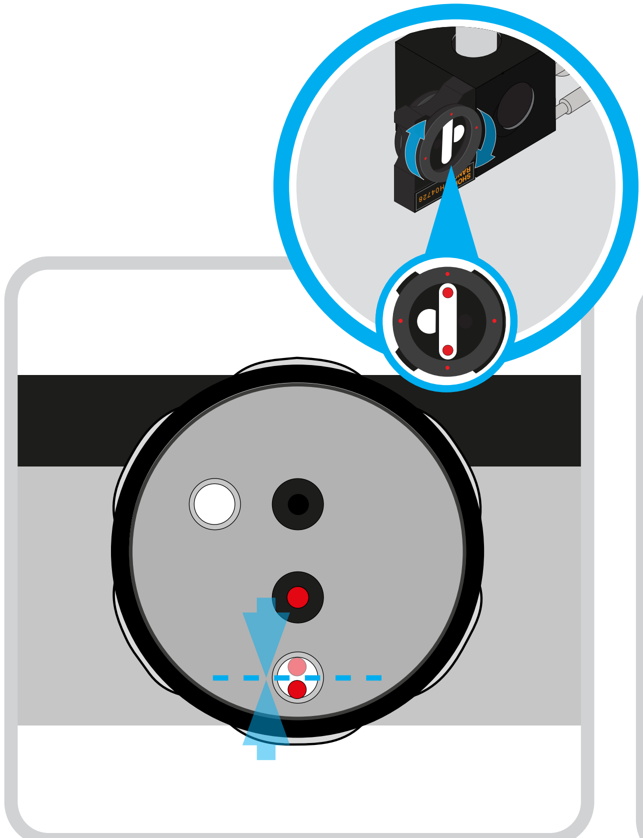
If the return beam is to the left or right of the straightness interferometer, adjust the tilt control knob.

Visual alignment

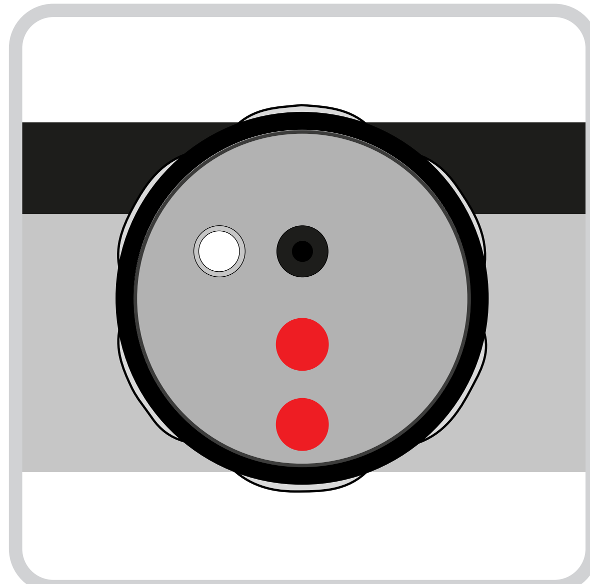
Straightness shutter



Ensure that the two laser beams are overlapping on the shutter target.



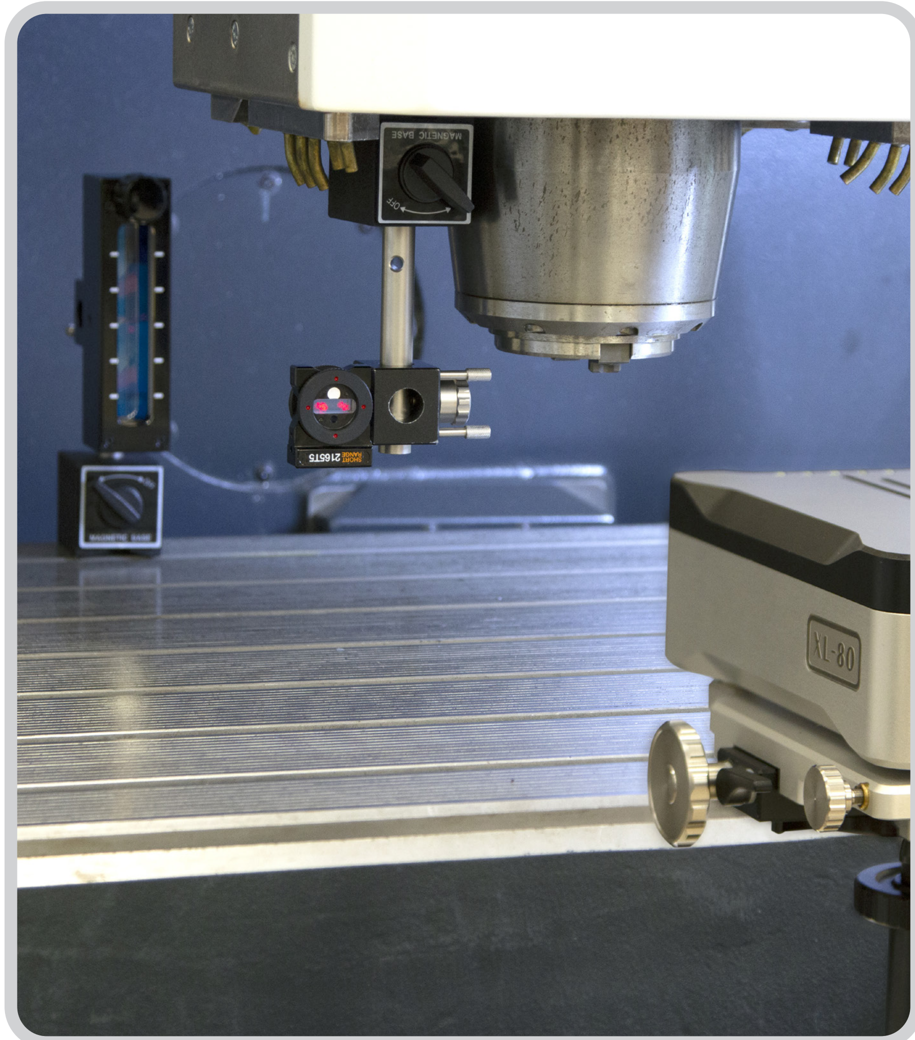
If the beams are not overlapping, finely rotate the interferometer face.



Rotate the shutter until the 6 mm beam is emitted.

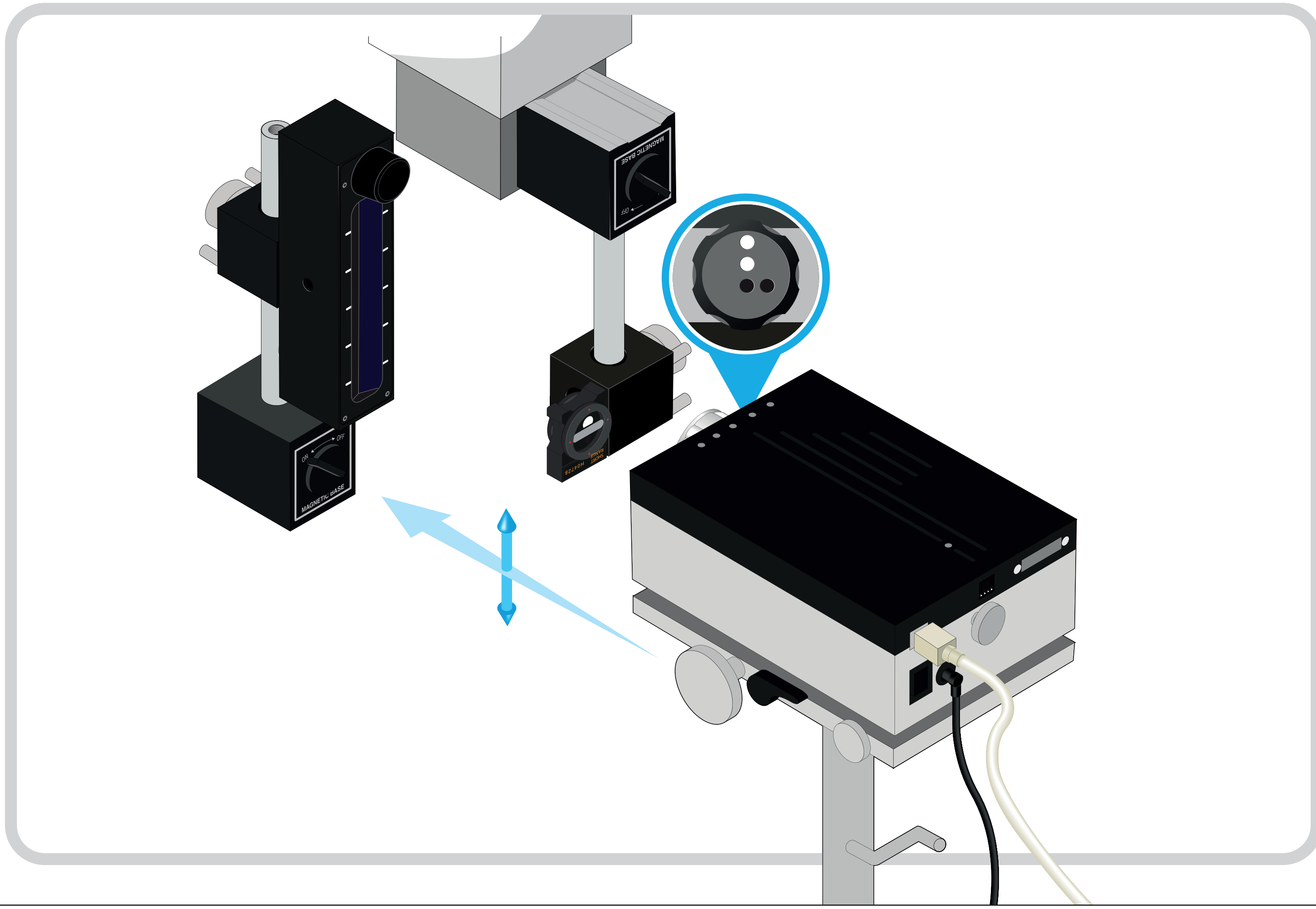
Instructions to capture straightness data can be found **on page 166**.

Straightness measurement (horizontal axis – vertical plane)



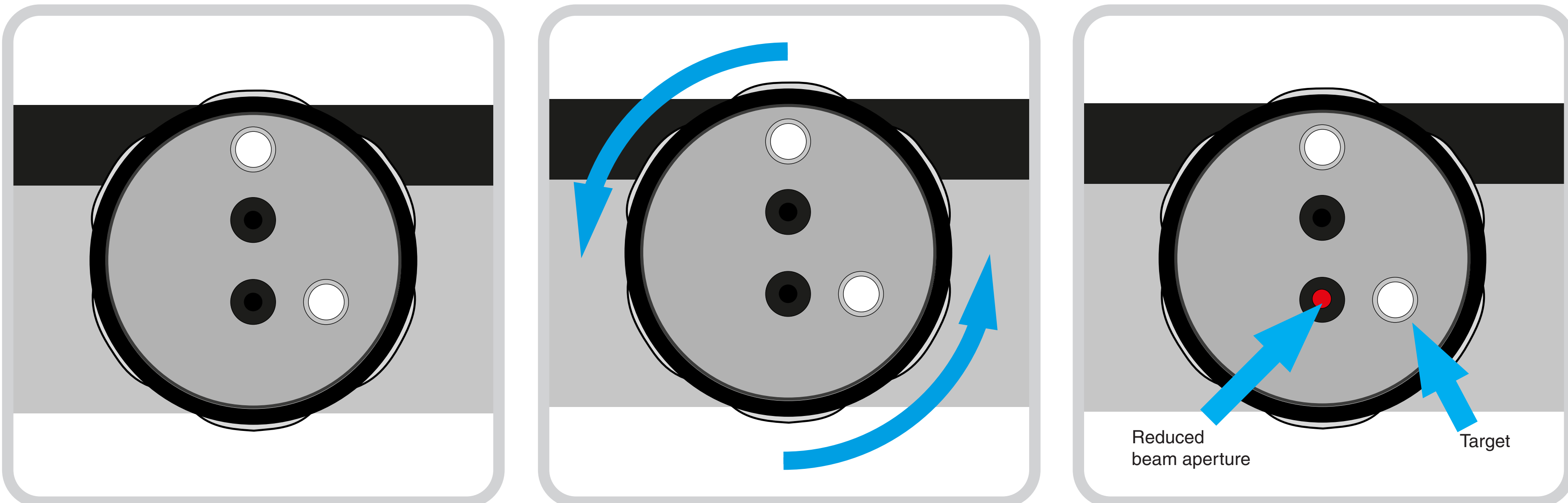
Mounting the optics

The straightness measurement set-ups – along a horizontal axis.



Mounting the optics

Horizontal axis – vertical measurement plane



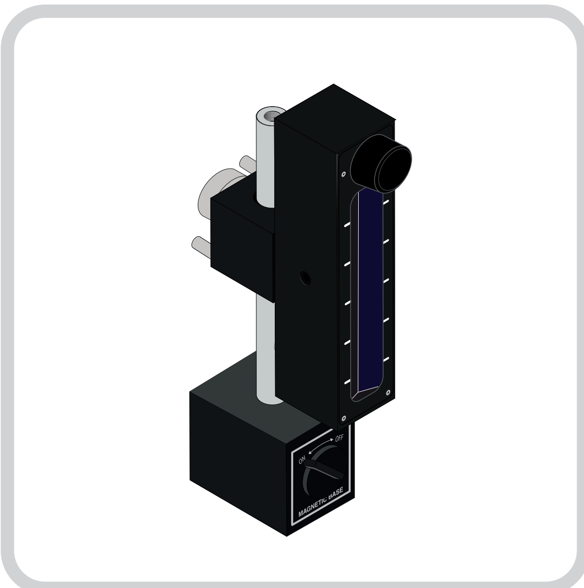
Attach the straightness shutter to the laser in the orientation shown.

Rotate the black bezel of the laser shutter.

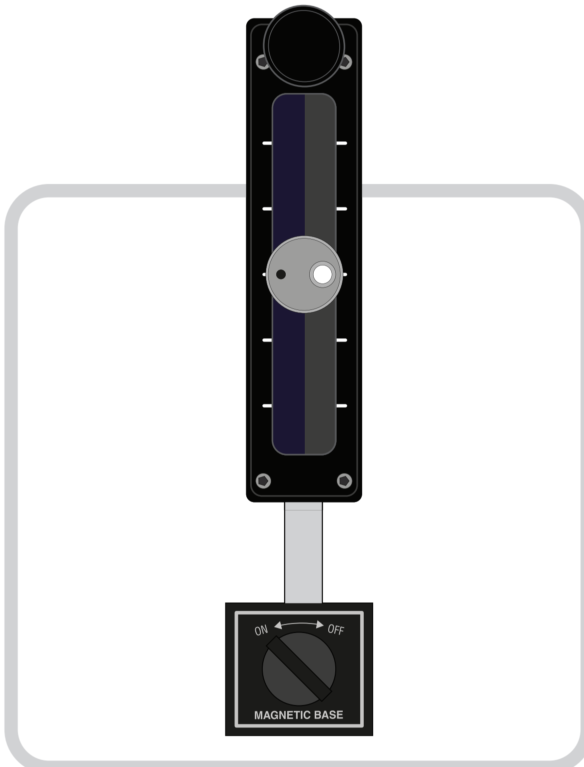
Continue to rotate until a reduced diameter beam is emitted.

Mounting the optics

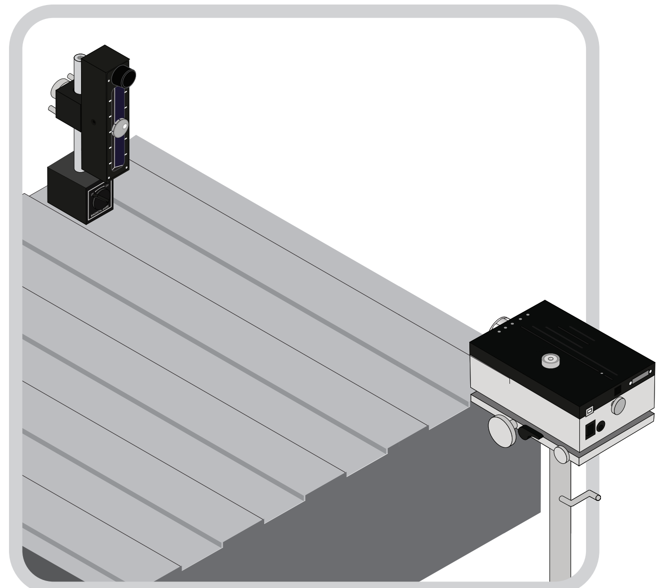
Mounting the straightness reflector



Assemble the straightness reflector as shown.



Attach the target to the centre of the straightness reflector.



Mount to the stationary element of the machine in the farthest position along the axis of travel. Translate the straightness reflector so that the beam is on the centre of the white target.

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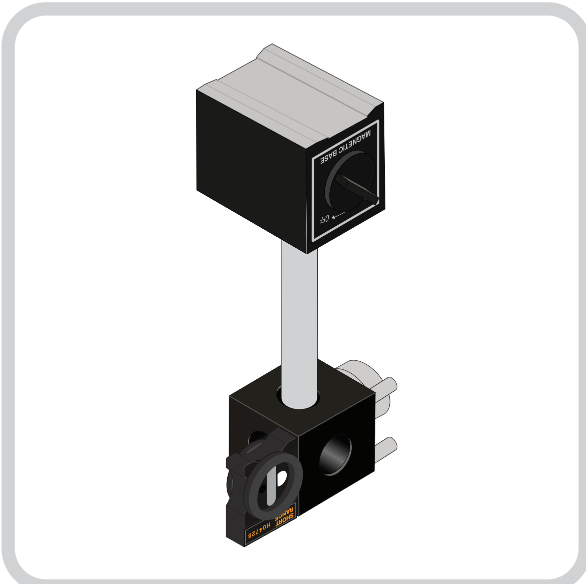
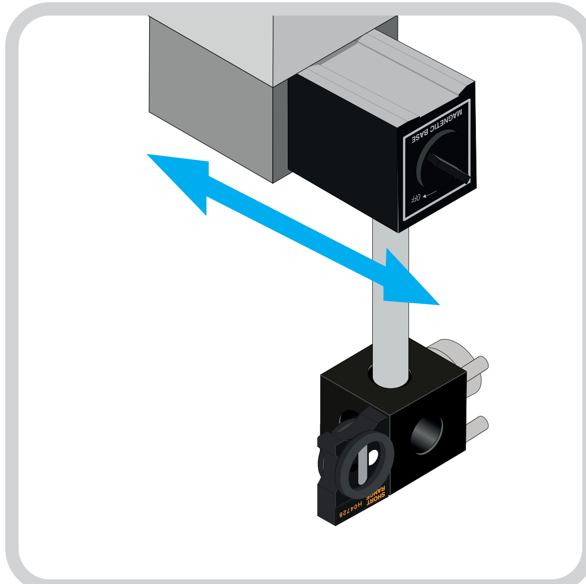
Mounting the optics

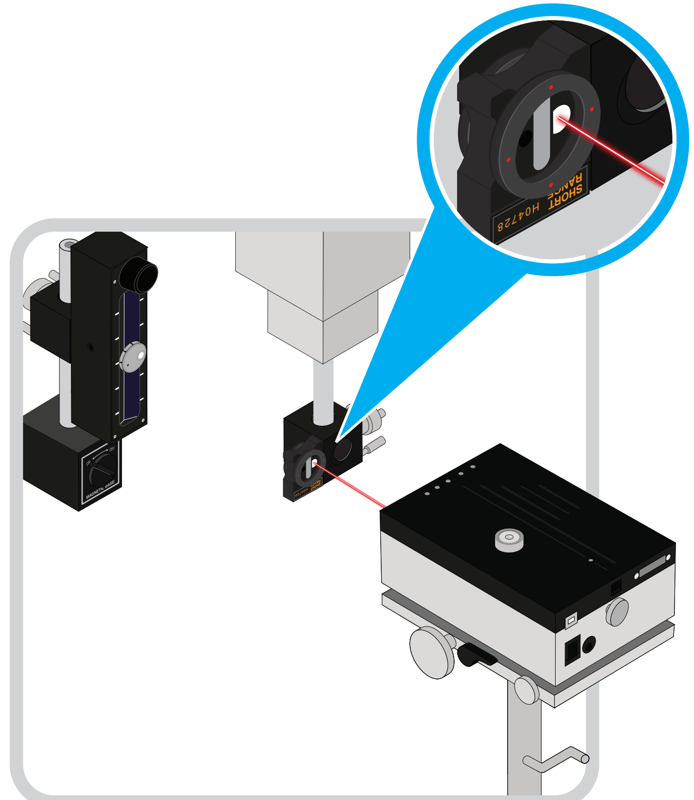
Mounting the straightness interferometer



Assemble the interferometer assembly as shown.



Mount to the moving element of the machine.



Rotate the interferometer so that the white target is in the same orientation as the target on the reflector.

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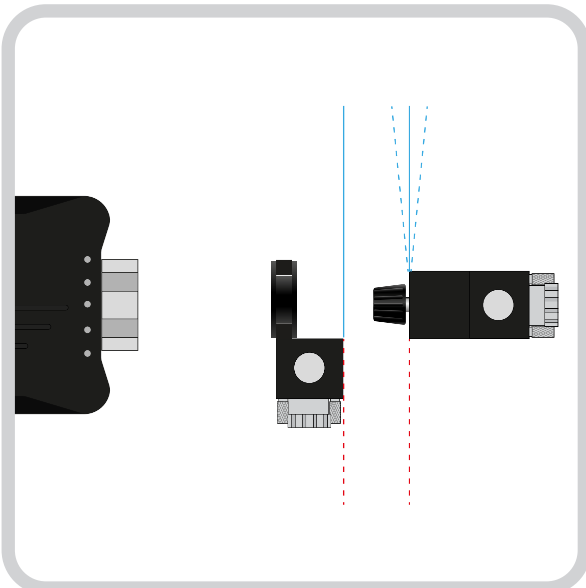
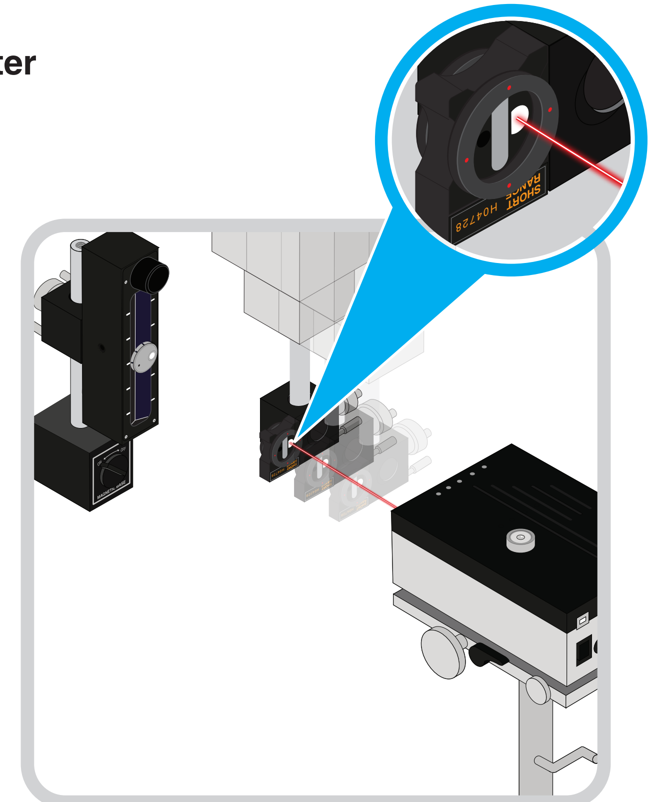
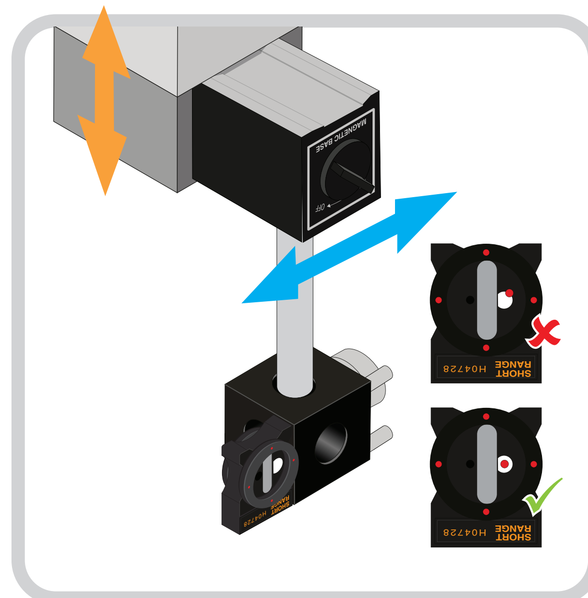
Mounting the optics

Mounting the straightness interferometer







Ensure the optics are:

- square to the axis; and
- parallel to the retroreflector.

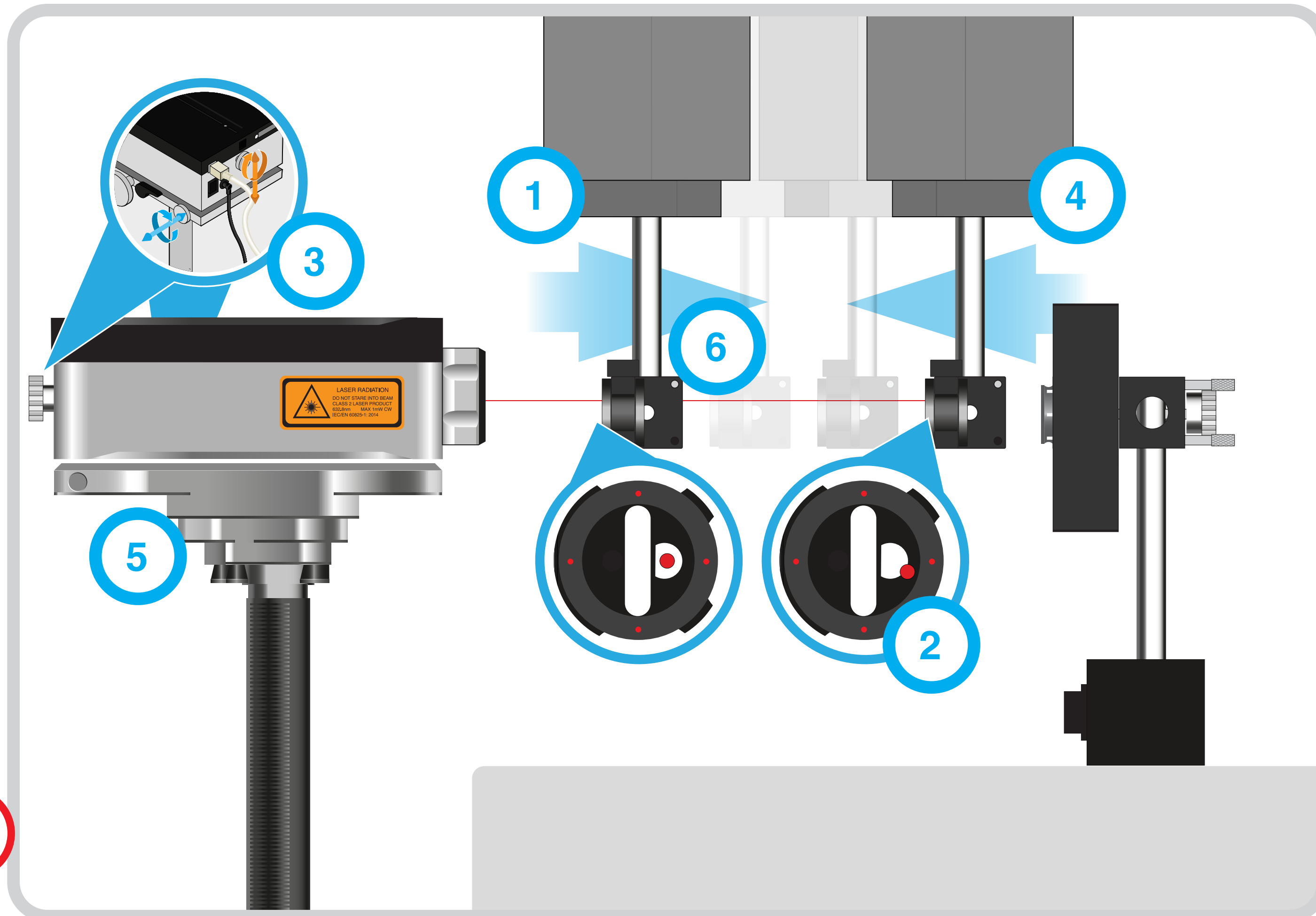
Drive the interferometer to the near field position.

Translate the machine until the beam is on the white target.

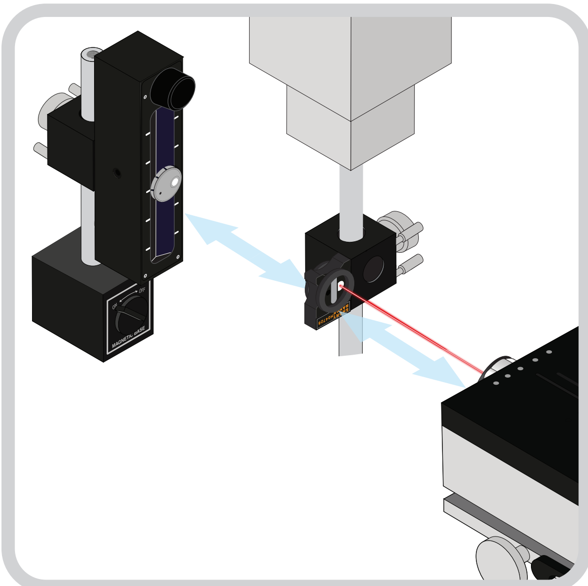
Visual alignment

1. Drive the interferometer towards the retroreflector.
2. Stop if the beam drifts past the edge of the target shutter.
3. Adjust the pitch and yaw so that the beam hits the centre of the target.
4. Drive the interferometer towards the laser.
5. Use the tripod/tripod stage to translate the beam back to the centre of the target.
6. Ensure the laser beam is on the centre of the target along the axis.

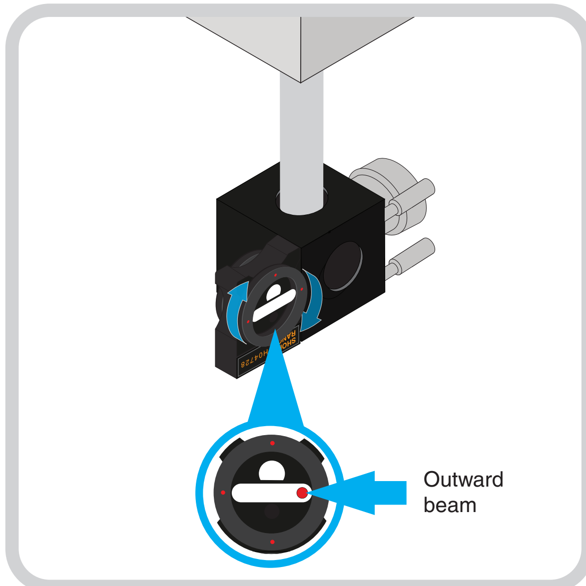
Repeat until the two beams remain in the centre of the target over the full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position.



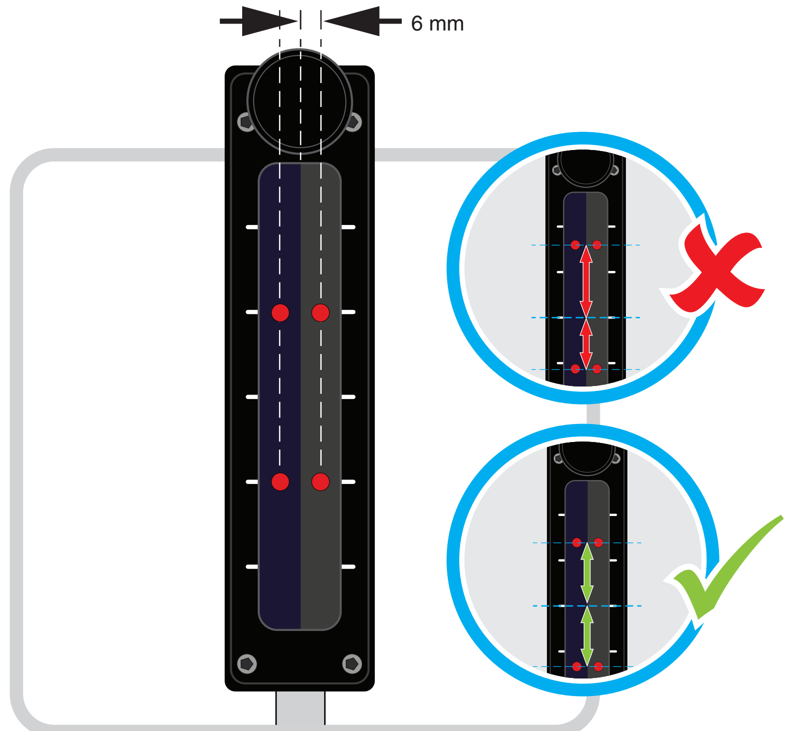
Visual alignment



Position the interferometer halfway along the axis of travel.



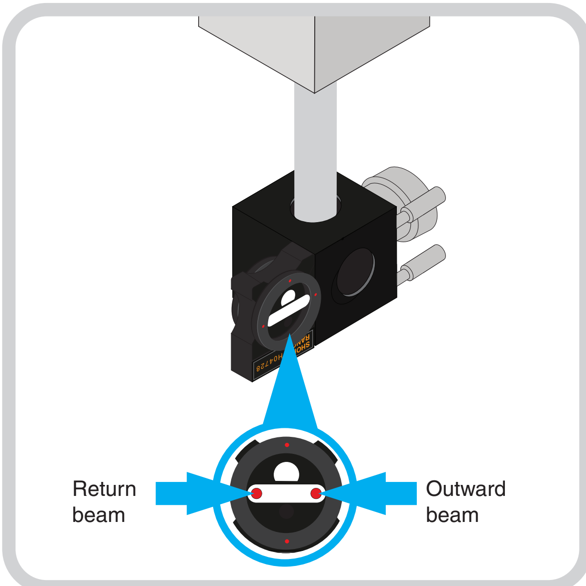
Rotate the face of the interferometer so that the beam passes through the right-hand side of the aperture.



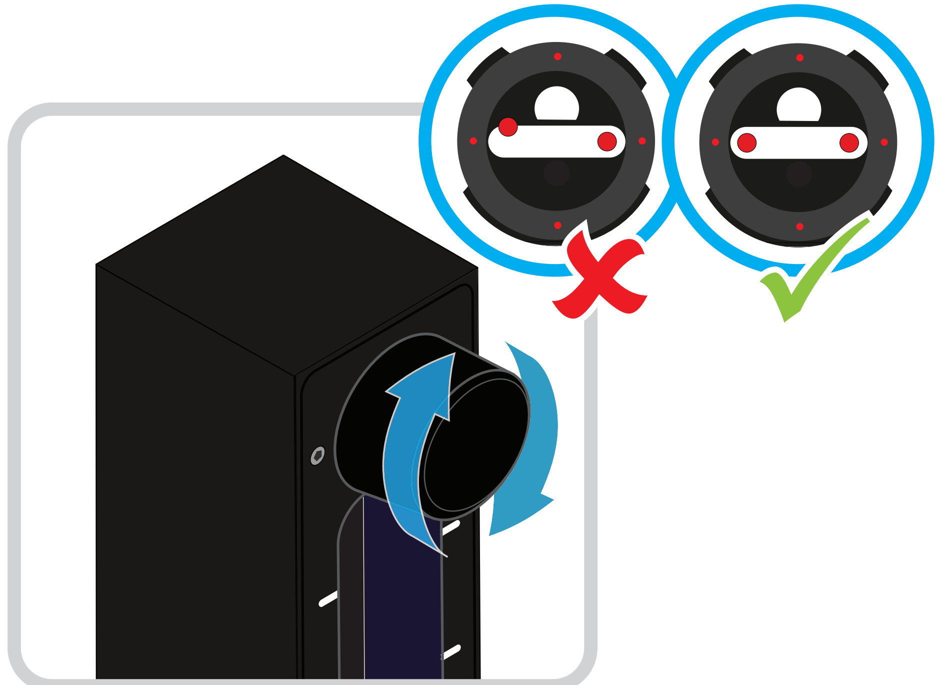
The beams should hit the straightness reflector approximately halfway from the centre of its long axis and 6 mm from the centre of the short axis.

Visual alignment

Return beam alignment



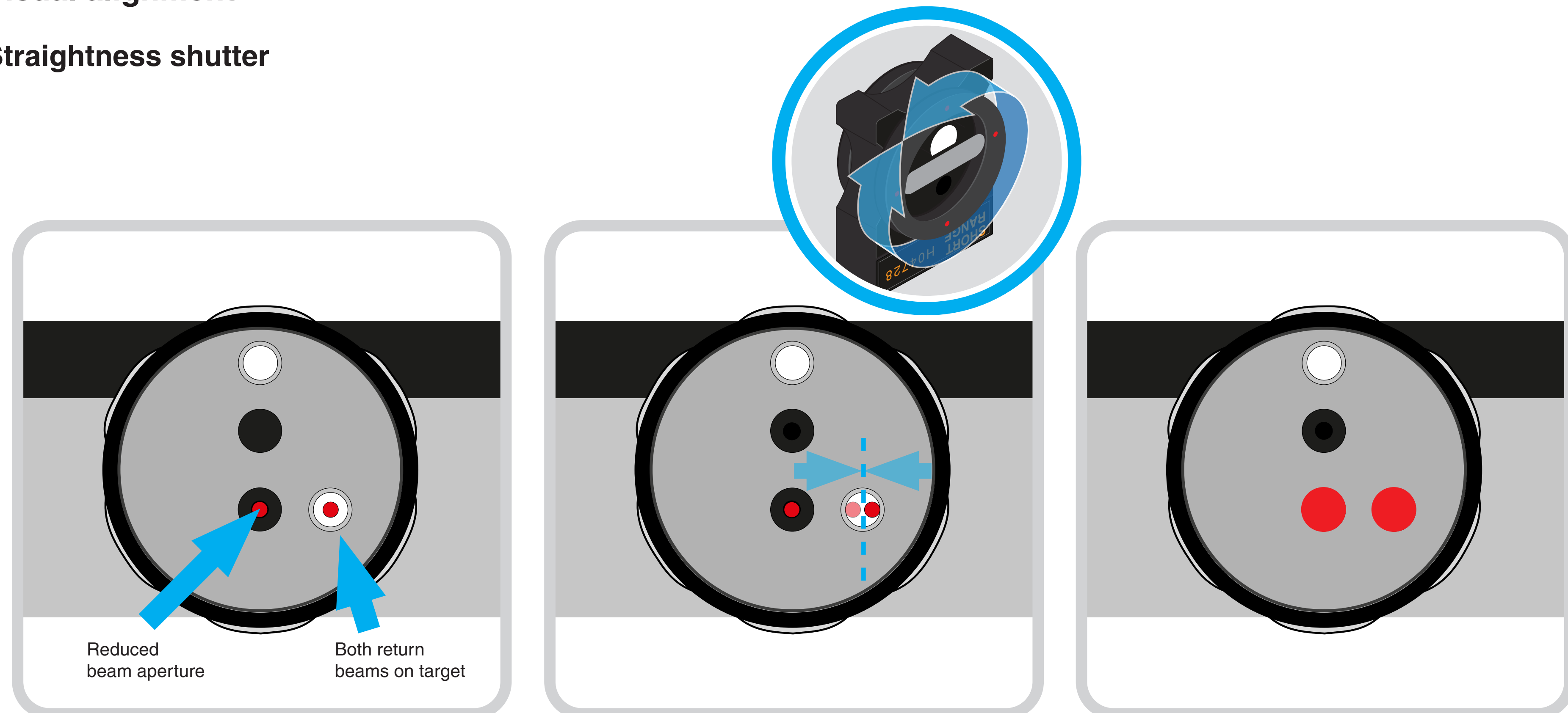
Ensure that the returned beam from the reflector enters the centre line of the interferometer.



If the return beam is above or below the straightness interferometer, adjust the tilt control knob.

Visual alignment

Straightness shutter



Ensure that the two laser beams are overlapping on the shutter target.

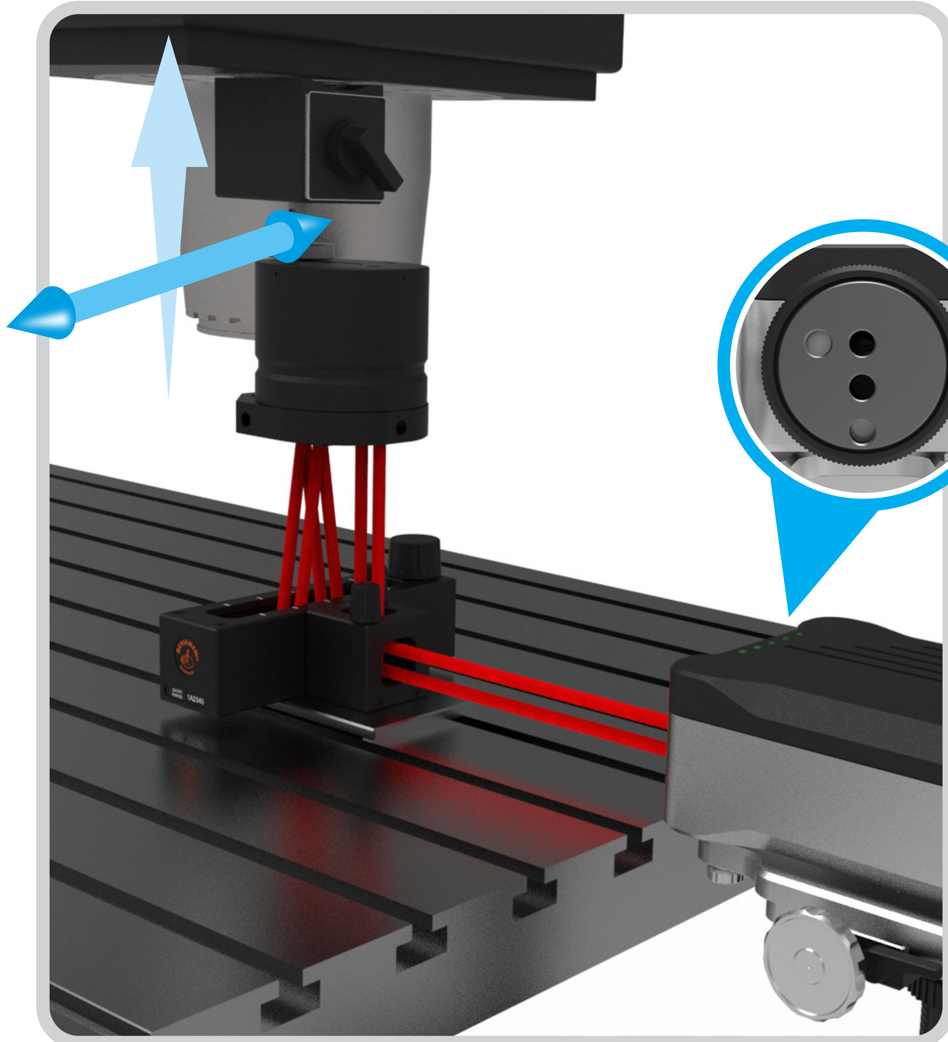
If the beams are not overlapping, finely rotate the interferometer face.

Rotate the shutter until the 6 mm beam is emitted.

Instructions to capture straightness data can be found **on page 166**.

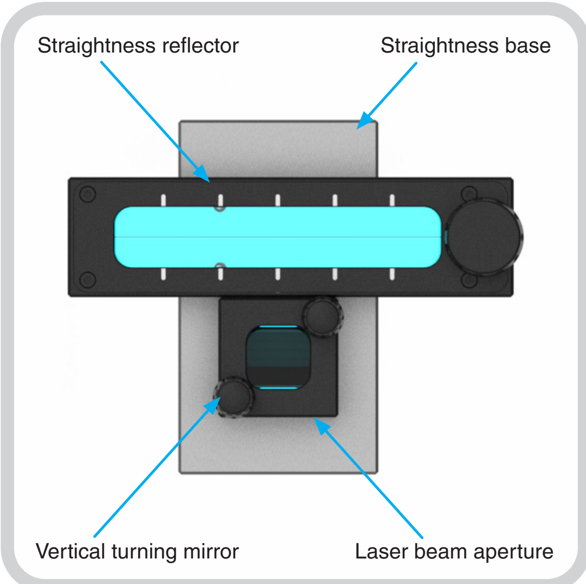
Straightness measurement (Vertical axis — horizontal plane)

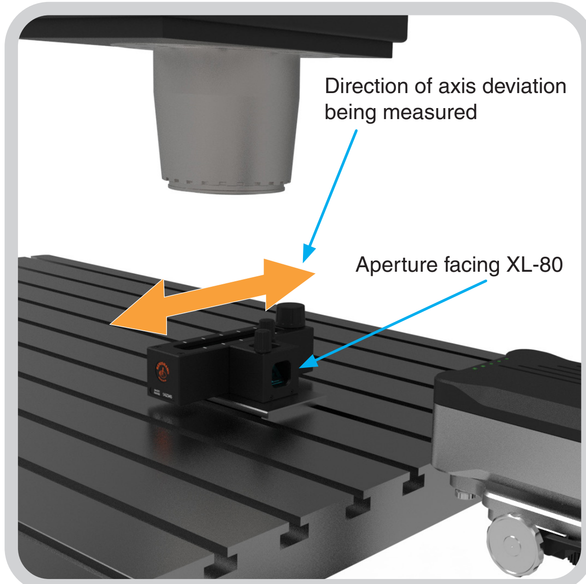
This section outlines the method for carrying out vertical straightness measurement using a vertical turning mirror.

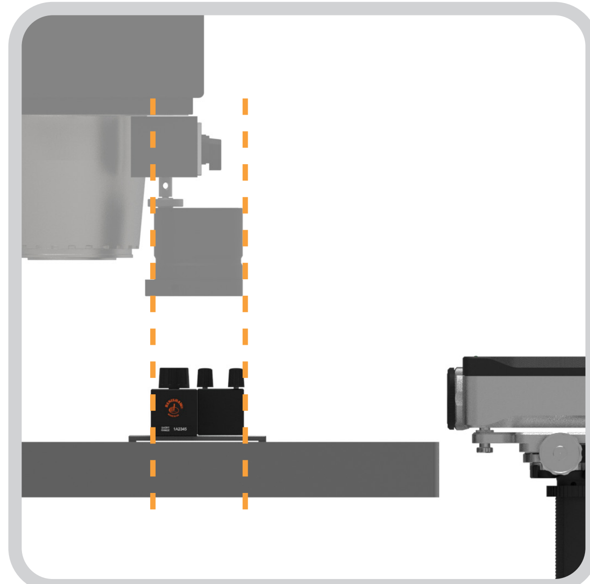


NOTE: Environmental compensation is not necessary when taking straightness measurements, therefore, the XC environmental compensator and environmental sensors are not required.

Vertical straightness







Attach the straightness reflector and vertical turning mirror to the straightness base.

Secure in place using four M3 x 6 mm cap head screws from the underside of the straightness base.

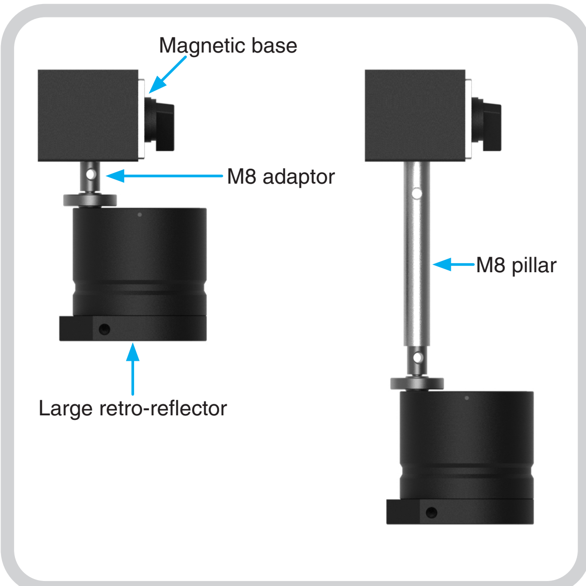
Position the straightness base assembly so that:

- the length of the straightness reflector is parallel to the axis deviations to be measured.
- the vertical turning mirror aperture is facing the XL-80.

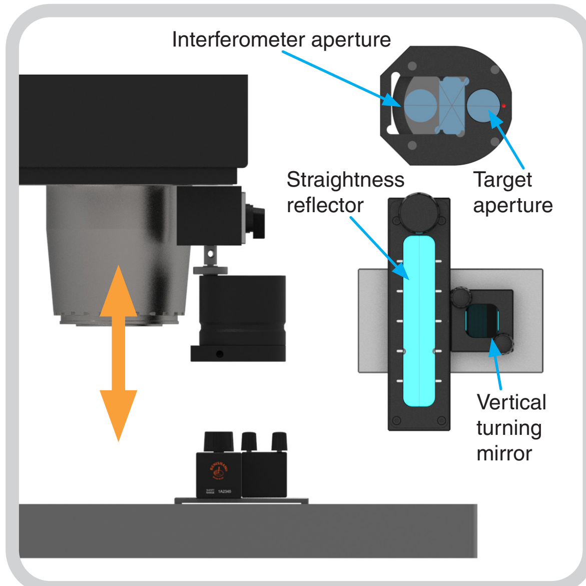
Clamp the straightness base to the machine table ensuring that it is:

- directly below the intended location for the large retro-reflector.
- square to the measurement axis.

Vertical straightness

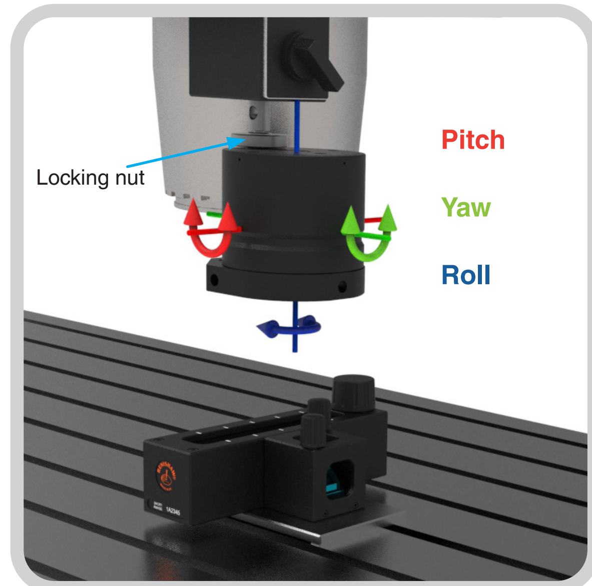


Assemble the large retro-reflector, M8 adaptor and magnetic base as shown. The M8 pillars can be used if extension is required.



Attach to the moving part of the machine ensuring the large retro-reflector is orientated as follows:

- the target aperture is above the vertical turning mirror.
- the interferometer aperture is above the straightness reflector.



Check that the large retro-reflector is square to the machine in pitch, yaw, and roll. If required make adjustments and tighten the locking nut on the M8 adaptor to prevent rotation.

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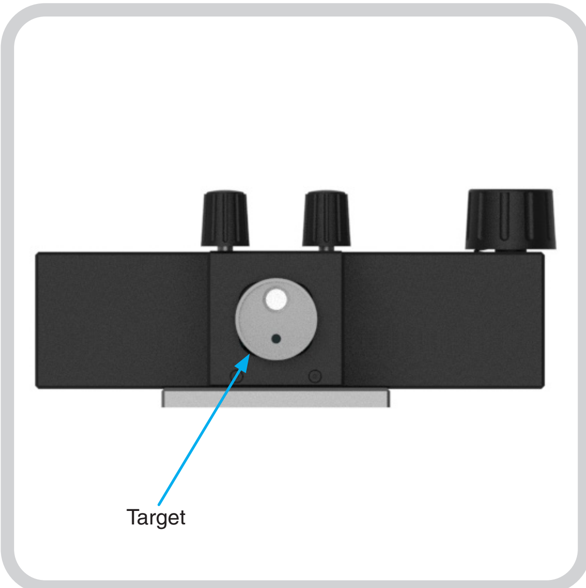
Vertical straightness

Attach the straightness shutter to the laser in the orientation shown.

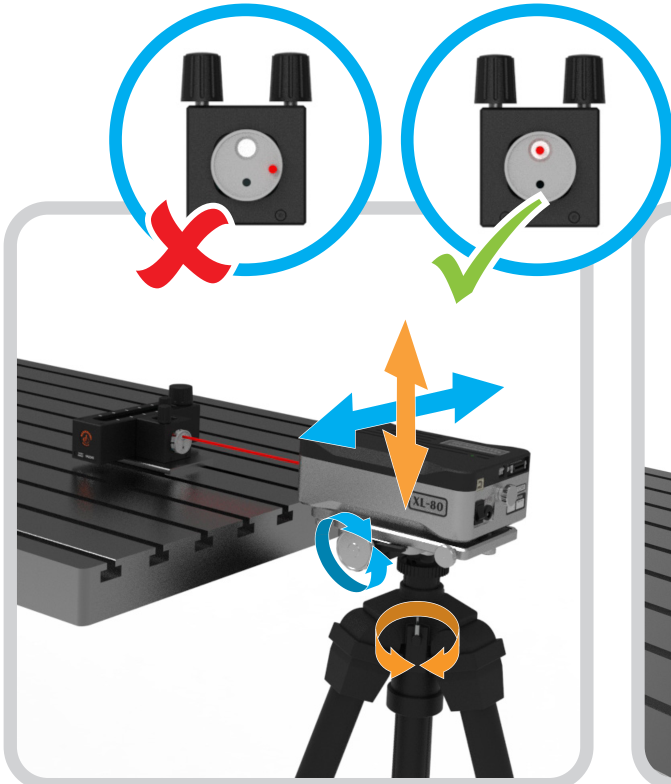
Rotate the black bezel of the laser shutter.

Continue rotating until a reduced diameter beam is emitted.

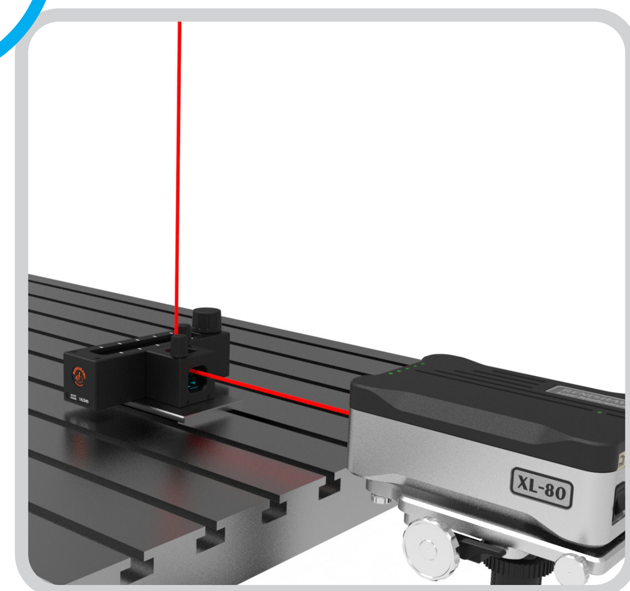
Vertical straightness



Fit a target to the aperture of the vertical turning mirror with the white spot at the top.

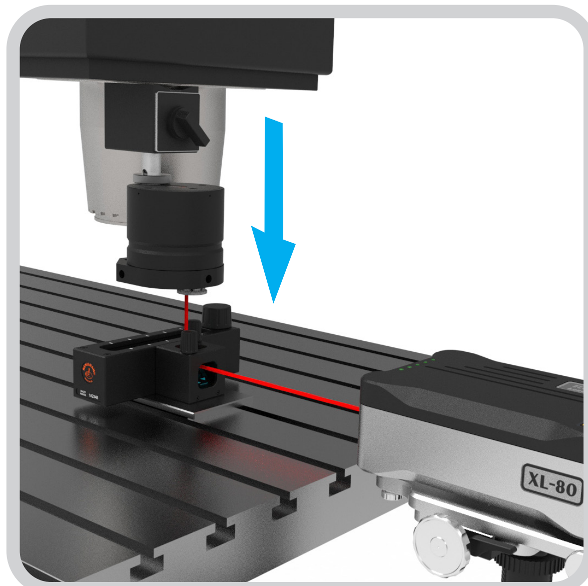


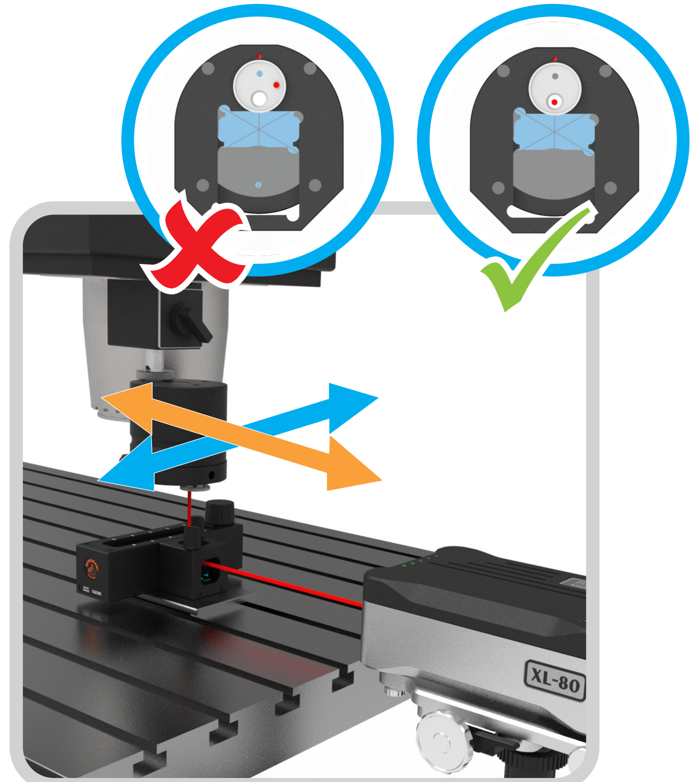
Adjust the beam to the centre of the white target using the translation screws.



Remove the target from the vertical turning mirror.

Vertical straightness





Fit a target to the input aperture of the large retro-reflector in the orientation shown.

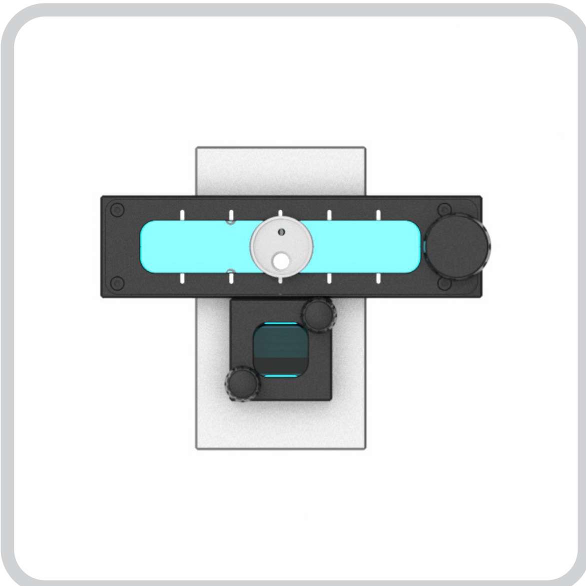
Lower the spindle towards the straightness base assembly ensuring that:

- it is as close as possible to the vertical turning mirror.
- the face of the alignment target is still visible.

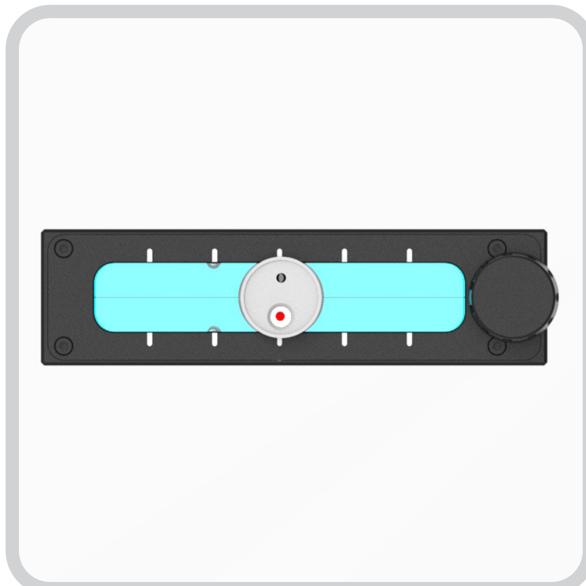
Translate the spindle until the laser beam is on the centre of the white target.

If the spindle is fixed then translate the machine bed and the laser.

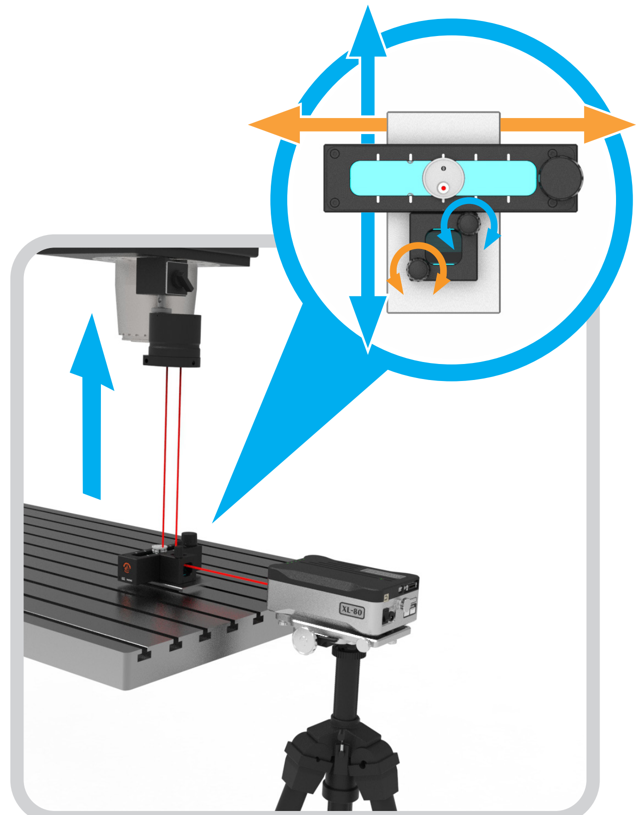
Vertical straightness



Remove the target from the large retro-reflector and place onto the centre of the straightness optic in the orientation shown.



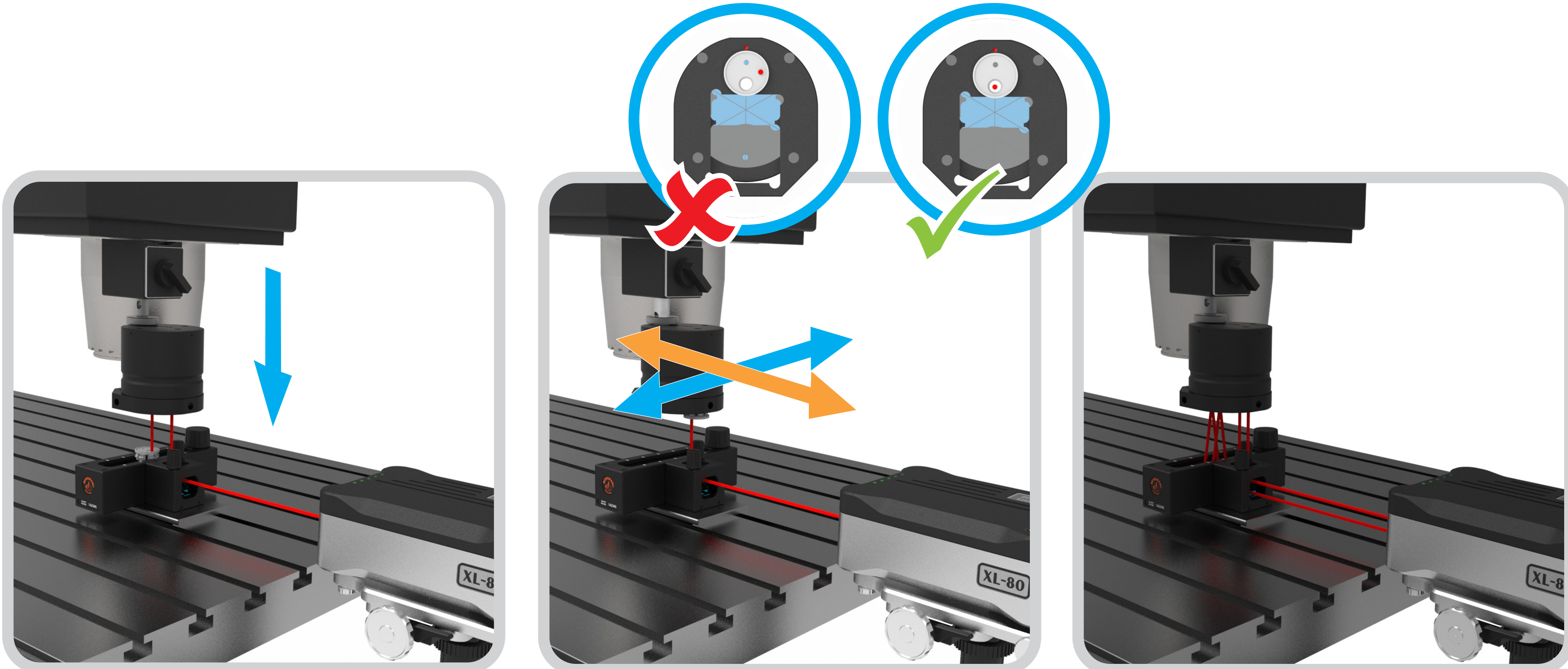
Ensure that the laser beam is on the centre of the white target. Translate the spindle if required.



Drive the spindle away from the straightness base assembly.

Check the location of the laser beam on the white target. Use the adjustment thumbscrews to align the beam back to the centre of the white target.

Vertical straightness



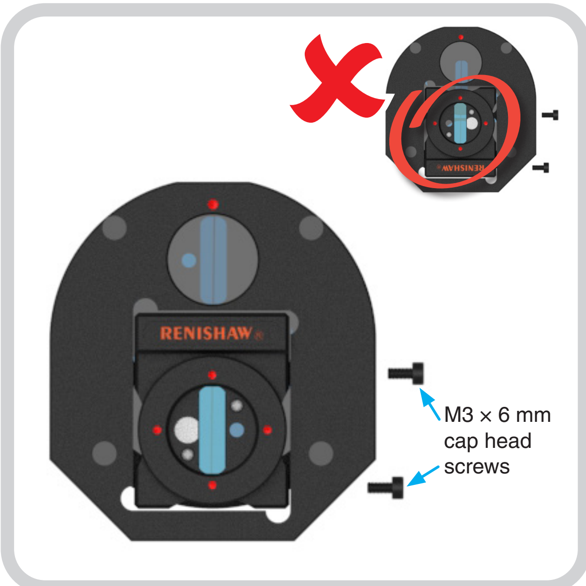
When the laser beam is aligned to the target at the upper limit of axis travel, lower the spindle towards the straightness base assembly as close as possible.

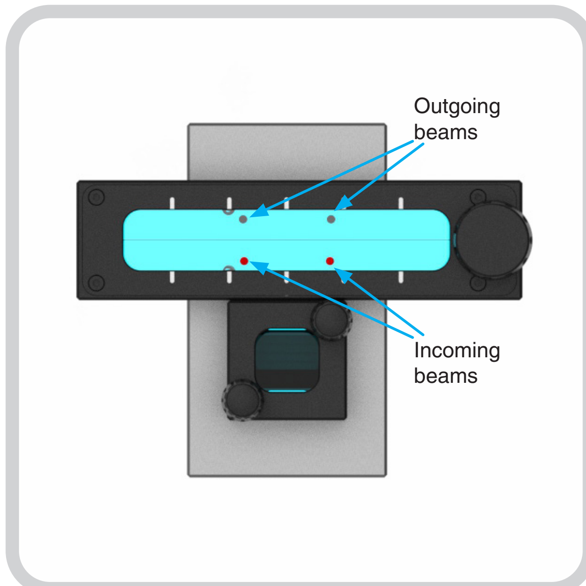
Place the target on the large retro-reflector.
If required translate the spindle so that the laser beam is on the centre of the white target.

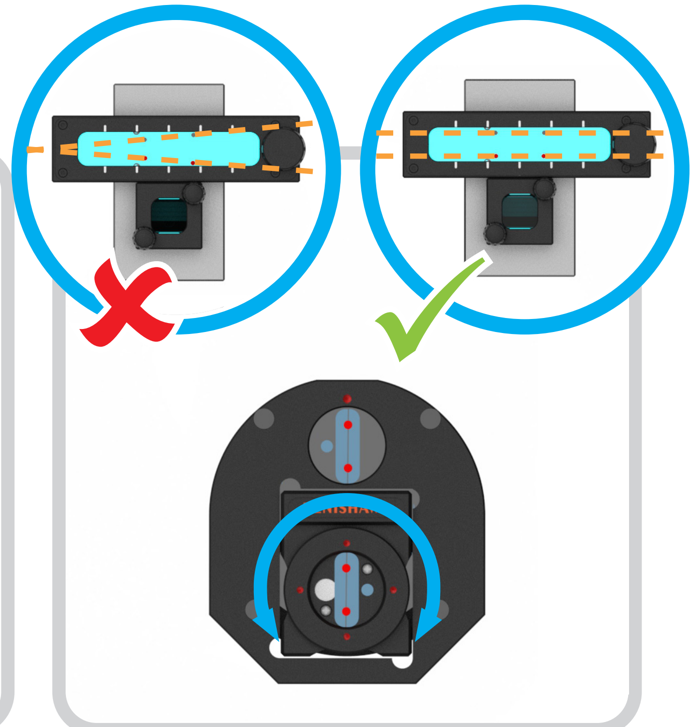
Repeat the previous three steps until the laser beam remains on the centre of the white target along the full axis of travel.

Remove the target.

Vertical straightness







Place the straightness interferometer into the large retro-reflector in the orientation shown. Secure into place with the two M3 × 6 mm cap head screws.

NOTE: To avoid damage to optical surfaces, it is advisable to cover the vertical turning mirror and straightness reflector in case screws are dropped.

Drive the spindle half way up the measurement axis. The laser beam should pass through the straightness interferometer, it is then split and returns to the straightness reflector as two separate beams.

Rotate the face of the straightness interferometer so that the two beams are parallel to the long axis of the reflector housing.

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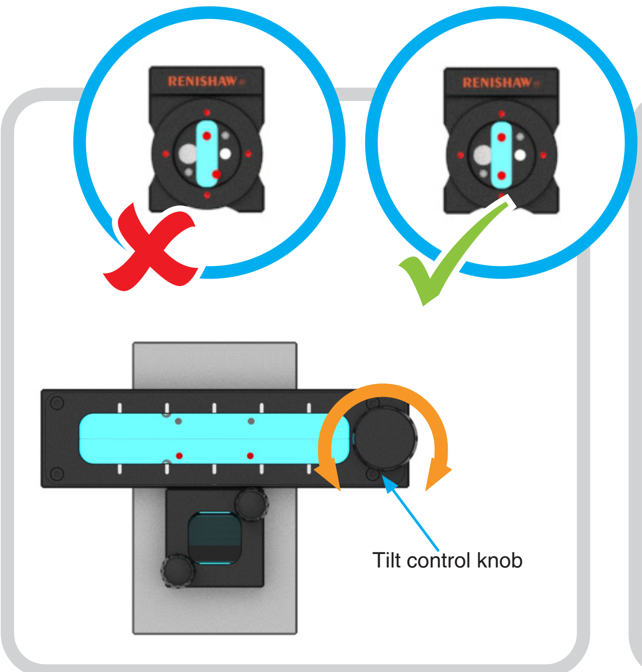
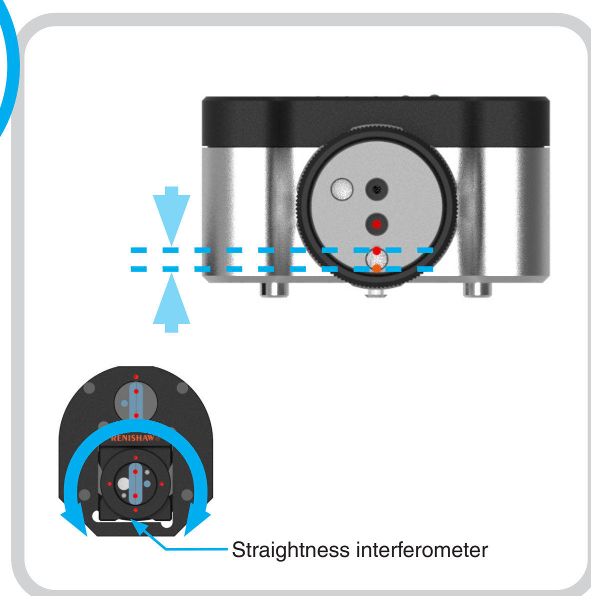
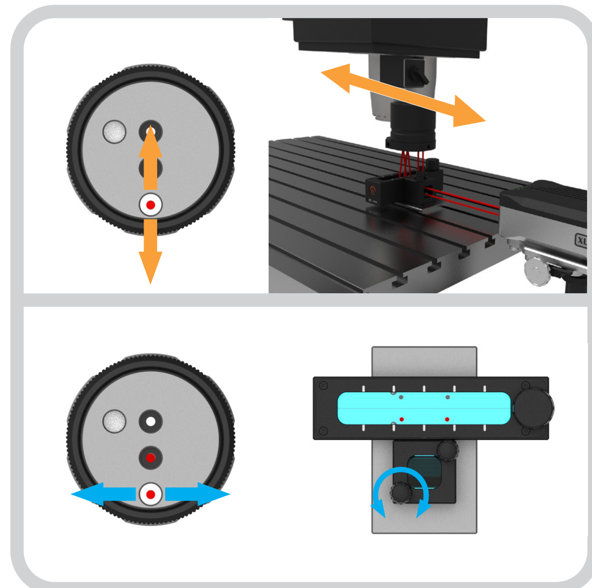
Vertical straightness







Adjust the tilt control knob on the straightness reflector until the two return beams pass through the straightness interferometer.

Rotate the straightness interferometer until the two beams overlap on the face of the straightness shutter.

If the return beams are not on the centre of the shutter target:

- translate the large retro-reflector or straightness base for vertical mis-alignment using the machine controller.
- adjust the tilt control knob of the vertical turning mirror for horizontal mis-alignment.

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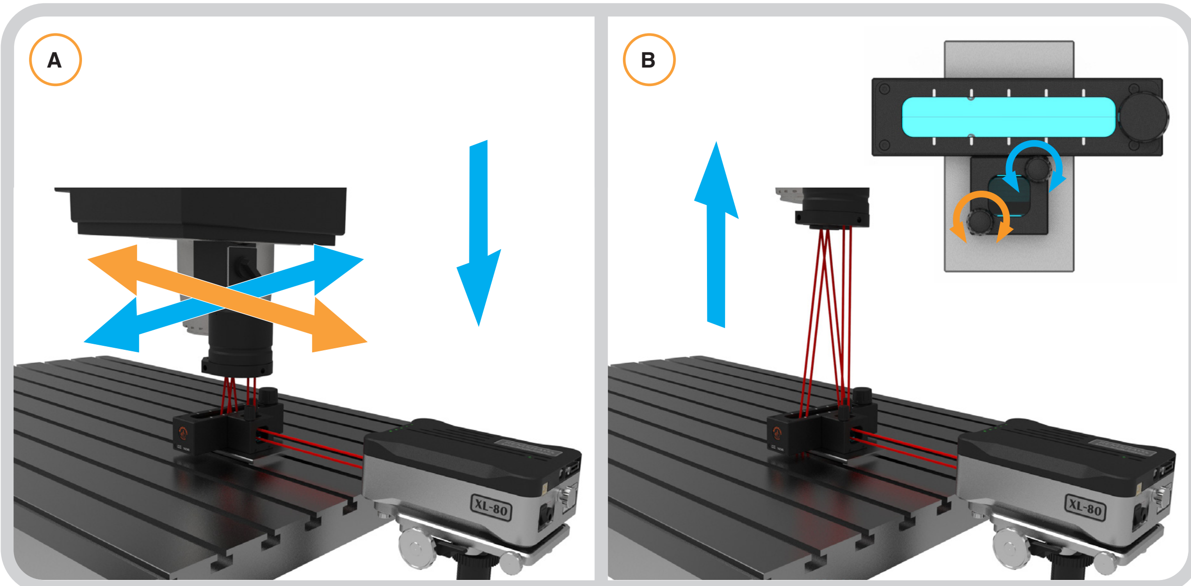
Vertical straightness



Drive the spindle along the full axis of travel whilst observing the laser beam on the straightness shutter. If misalignment occurs:

A: Translate the large retro-reflector or straightness base when close to the straightness base assembly.

B: Use the tilt controls on the vertical turning mirror when far away.

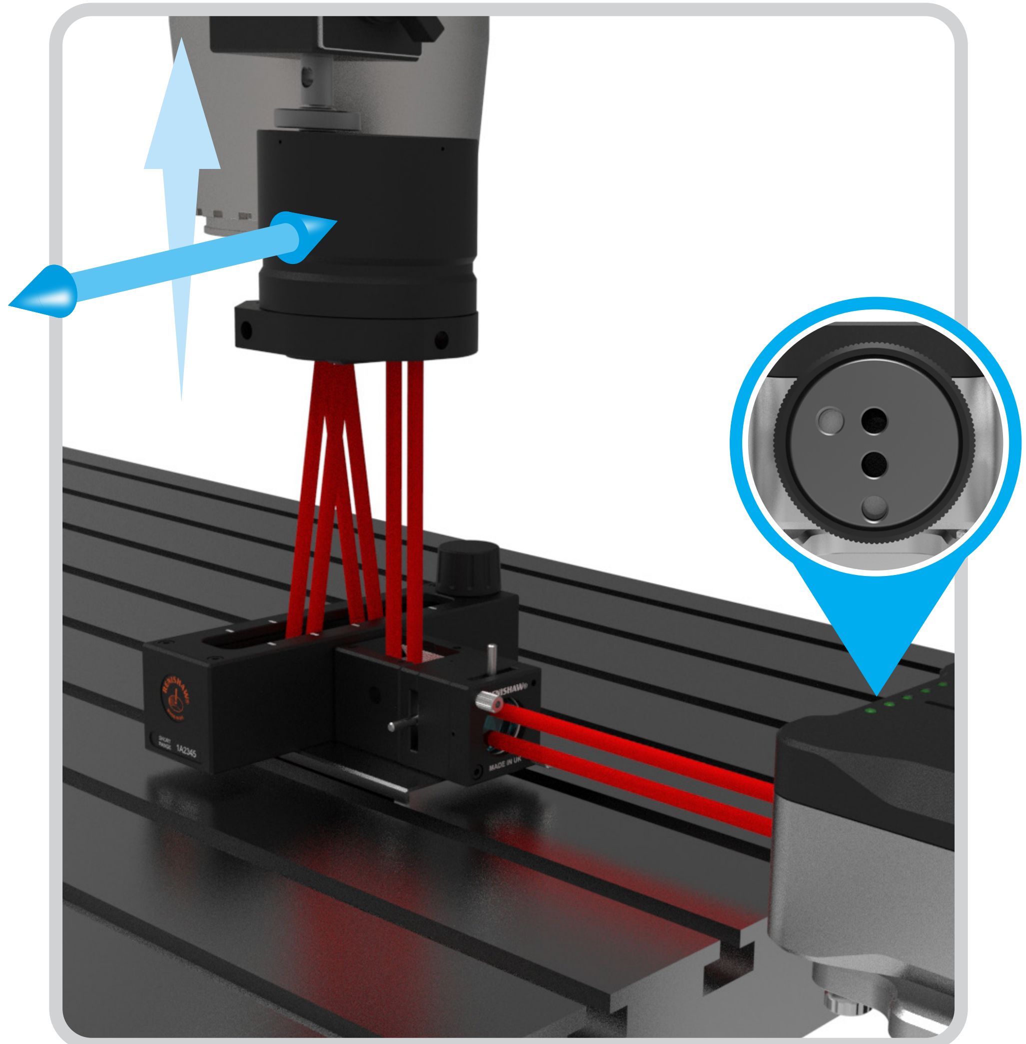
Rotate the black bezel of the straightness shutter until the large apertures are open and the 6 mm beam is emitted.

Instructions to capture straightness data can be found **on page 166**.

Straightness measurement (Vertical axis — horizontal plane)

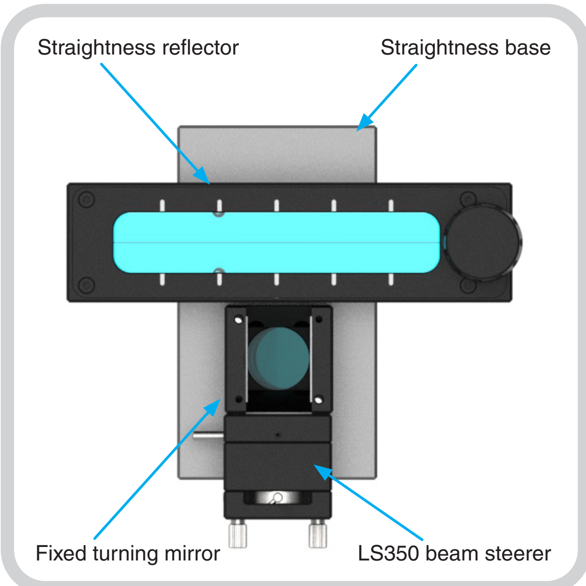
With LS350 laser beam steerer

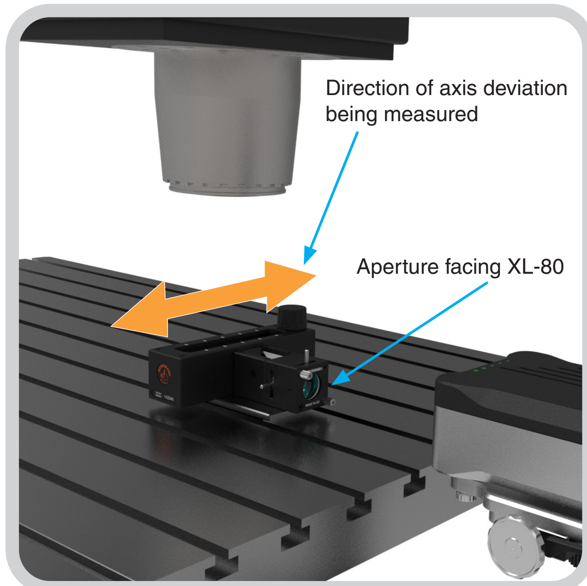
This section outlines the method for carrying out vertical straightness measurement using a fixed turning mirror and LS350 beam steerer.

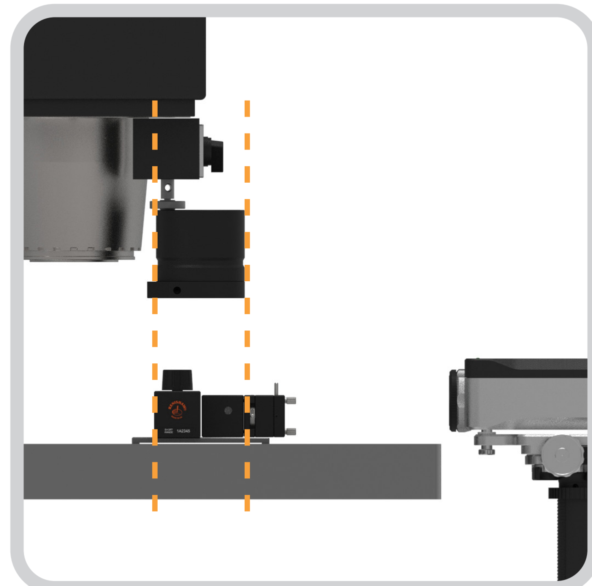


NOTE: Environmental compensation is not necessary when taking straightness measurements, therefore, the XC environmental compensator and environmental sensors are not required.

Vertical straightness







Attach the straightness reflector and fixed turning mirror to the straightness base.

Secure in place using four M3 x 6 mm cap head screws from the underside of the straightness base.

Screw the LS350 laser beam steerer to the face of the fixed turning mirror.

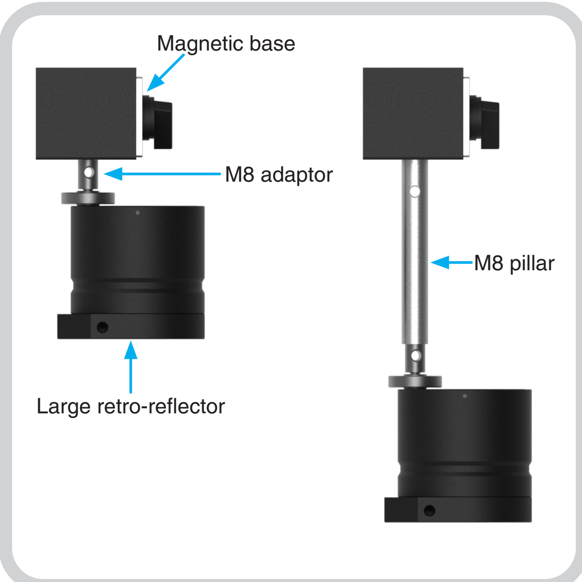
Position the straightness base assembly so that:

- the length of the straightness reflector is parallel to the axis deviations to be measured.
- the LS350 beam steerer aperture is facing the XL-80.

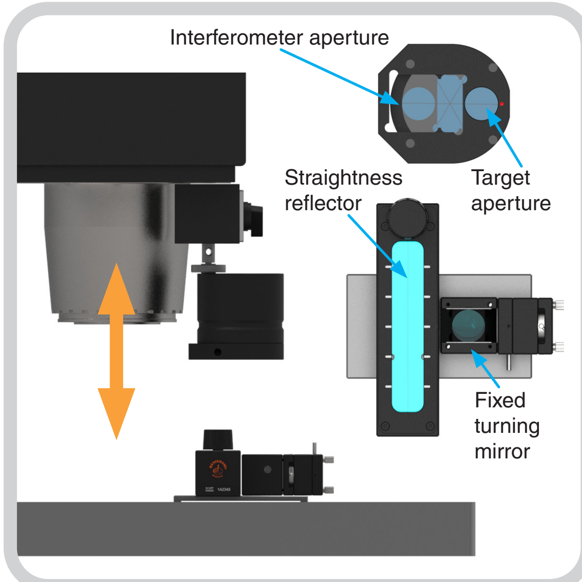
Clamp the straightness base to the machine table ensuring that it is:

- directly below the intended location for the large retro-reflector.
- square to the measurement axis.

Vertical straightness

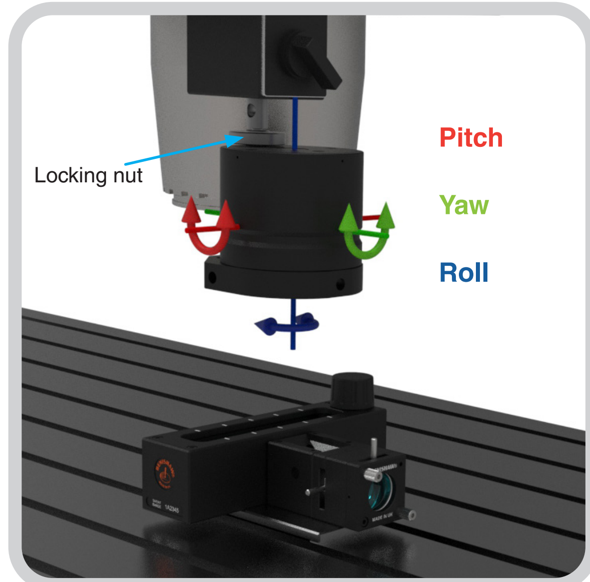


Assemble the large retro-reflector, M8 adaptor and magnetic base as shown. The M8 pillars can be used if extension is required.



Attach to the moving part of the machine ensuring the large retro-reflector is orientated as follows:

- the target aperture is above the fixed turning mirror.
- the interferometer aperture is above the straightness reflector.



Check that the large retro-reflector is square to the machine in pitch, yaw, and roll. If required make adjustments and tighten the locking nut on the M8 adaptor to prevent rotation.

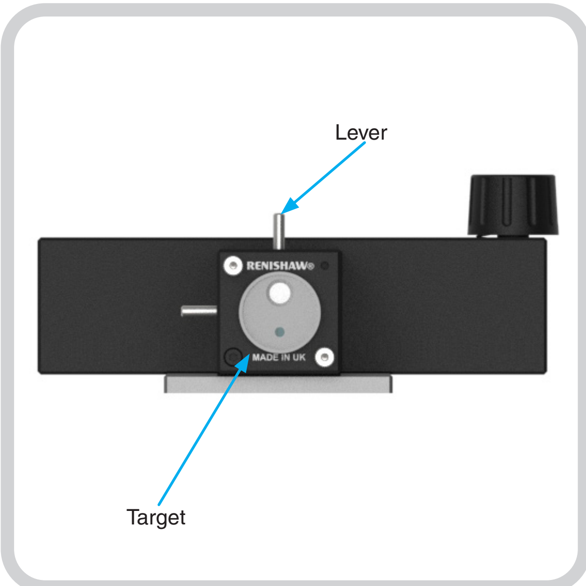
Vertical straightness

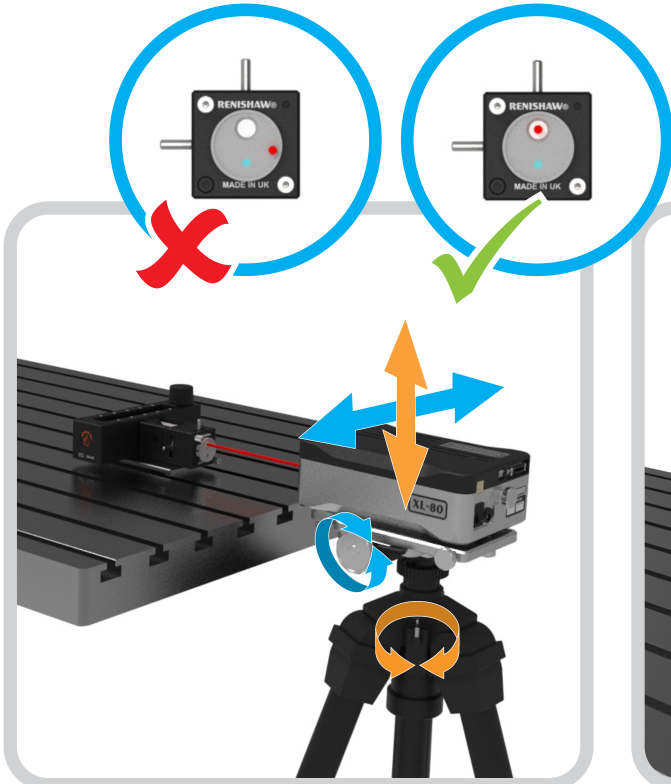
Attach the straightness shutter to the laser in the orientation shown.

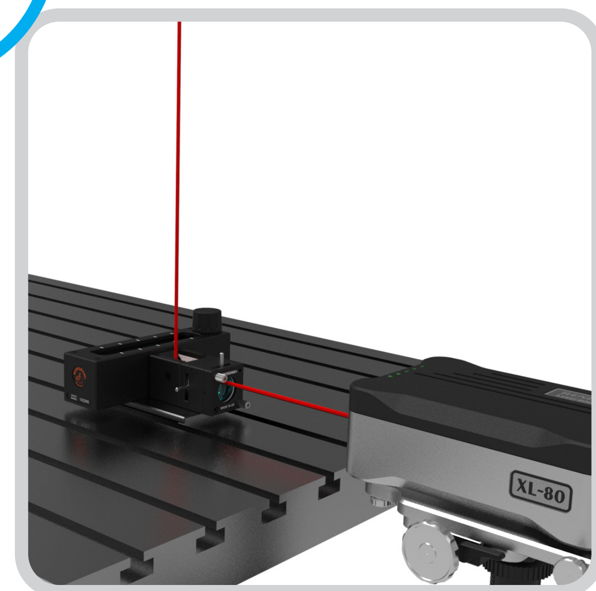
Rotate the black bezel of the laser shutter.

Continue rotating until a reduced diameter beam is emitted.

Vertical straightness







Fit a target to the aperture of the LS350 beam steerer with the white spot at the top.

Ensure the lever is in the upright, central position.

Adjust the beam to the centre of the white target using the translation screws.

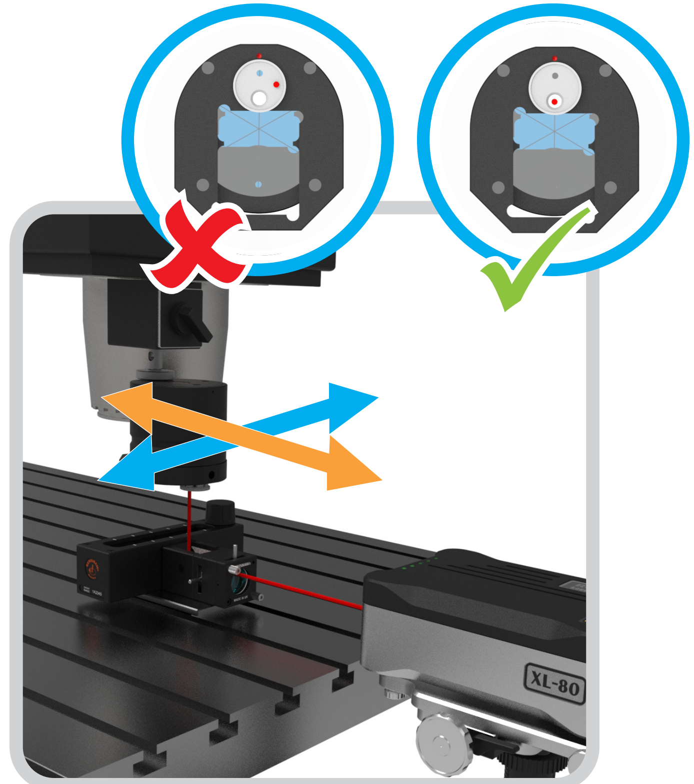
Remove the target from the LS350 beam steerer.

Vertical straightness

Fit a target to the input aperture of the large retro-reflector in the orientation shown.

Lower the spindle towards the straightness base assembly ensuring that:

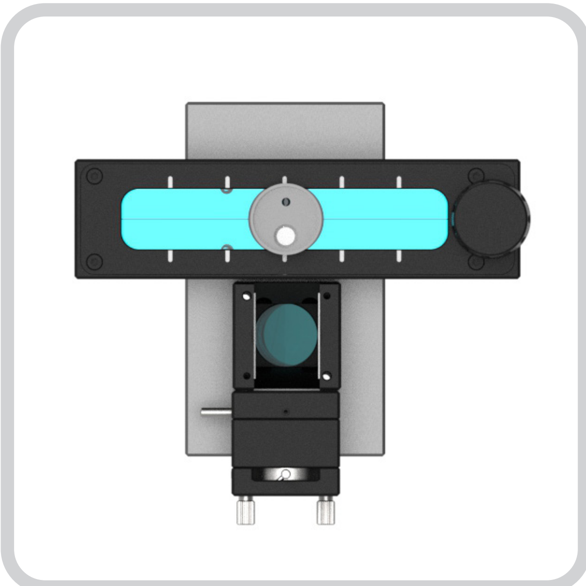
- it is as close as possible to the fixed turning mirror.
- the face of the alignment target is still visible.



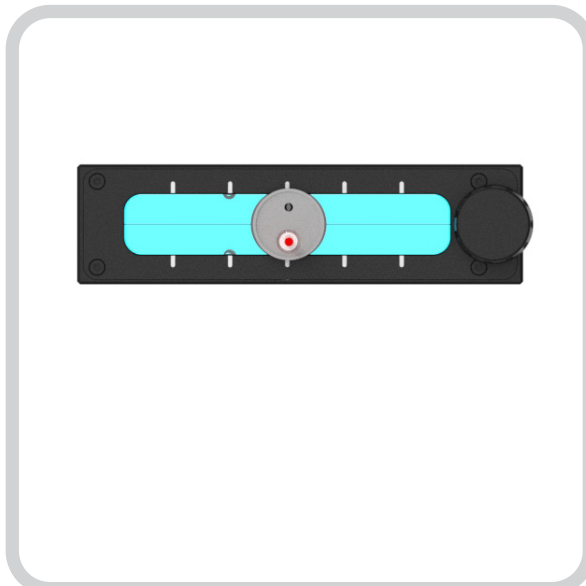
Translate the spindle until the laser beam is on the centre of the white target.

If the spindle is fixed then translate the machine bed and the laser.

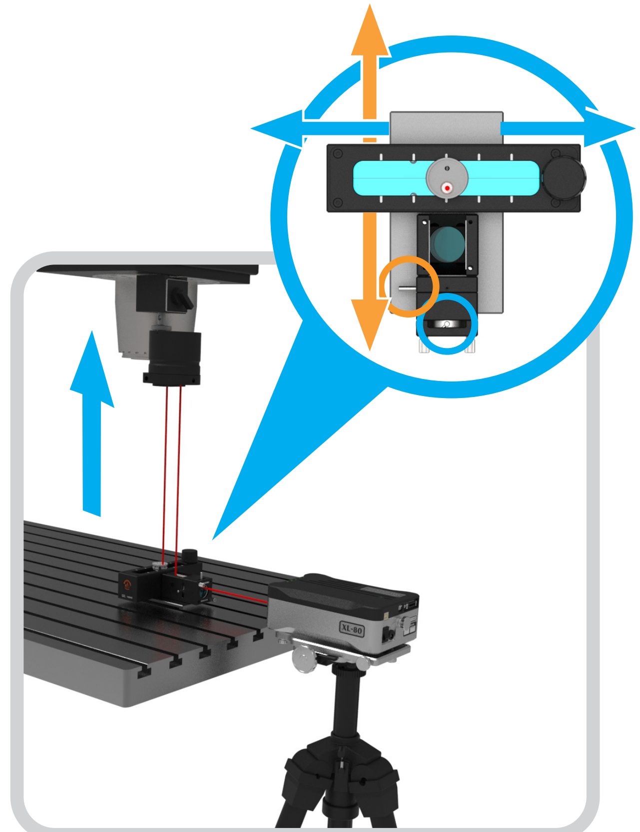
Vertical straightness



Remove the target from the large retro-reflector and place onto the centre of the straightness optic in the orientation shown.



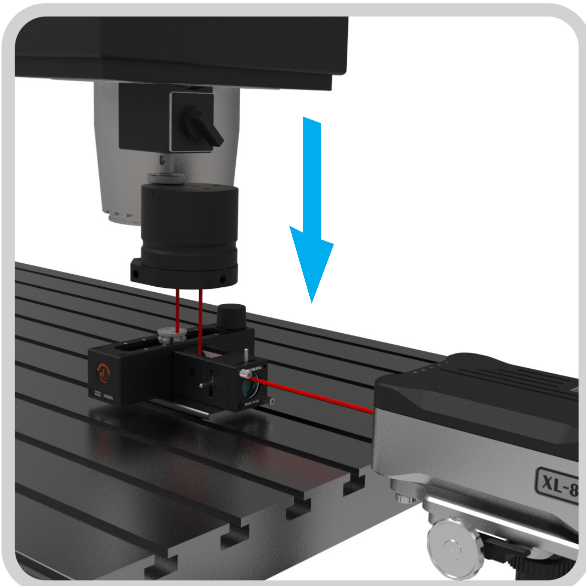
Ensure that the laser beam is on the centre of the white target. Translate the spindle if required.



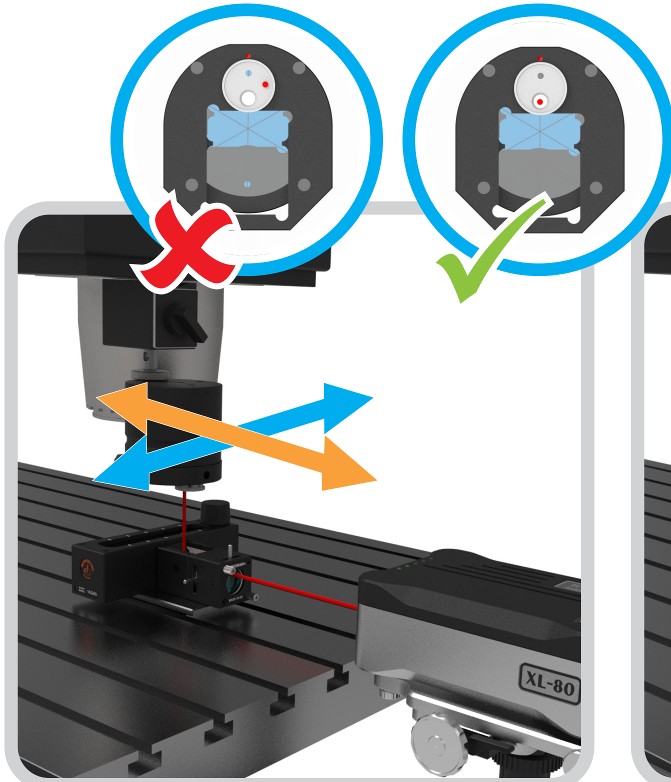
Drive the spindle away from the straightness base assembly.

Check the location of the laser beam on the white target. Use the adjustment levers on the LS350 beam steerer to align the beam back to the centre of the white target.

Vertical straightness



When the laser beam is aligned to the target at the upper limit of axis travel, lower the spindle towards the straightness base assembly as close as possible.



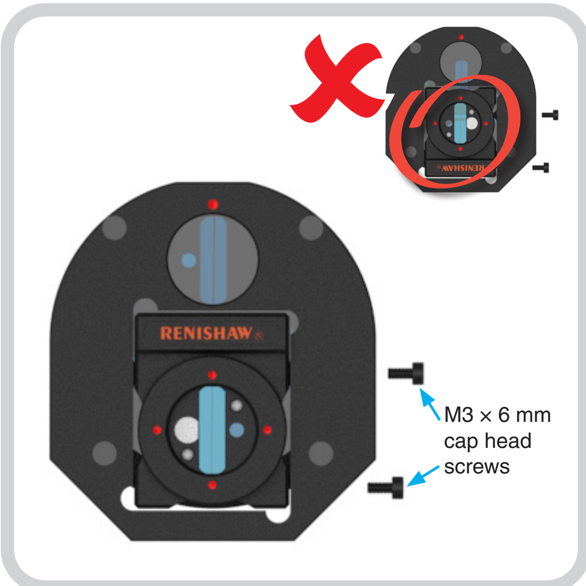
Place the target on the large retro-reflector.

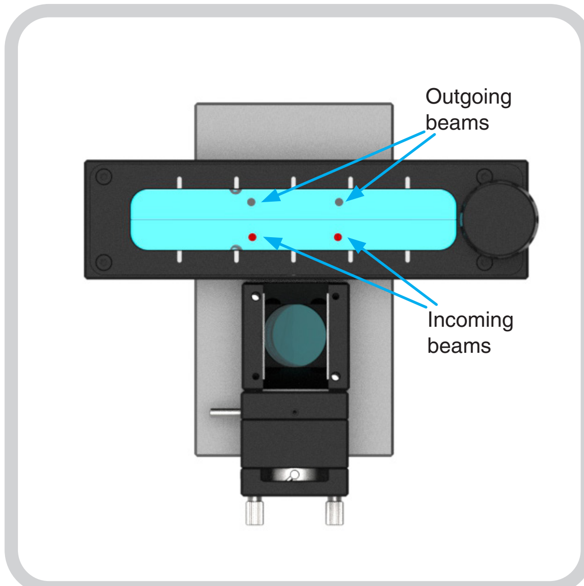
If required translate the spindle so that the laser beam is on the centre of the white target.

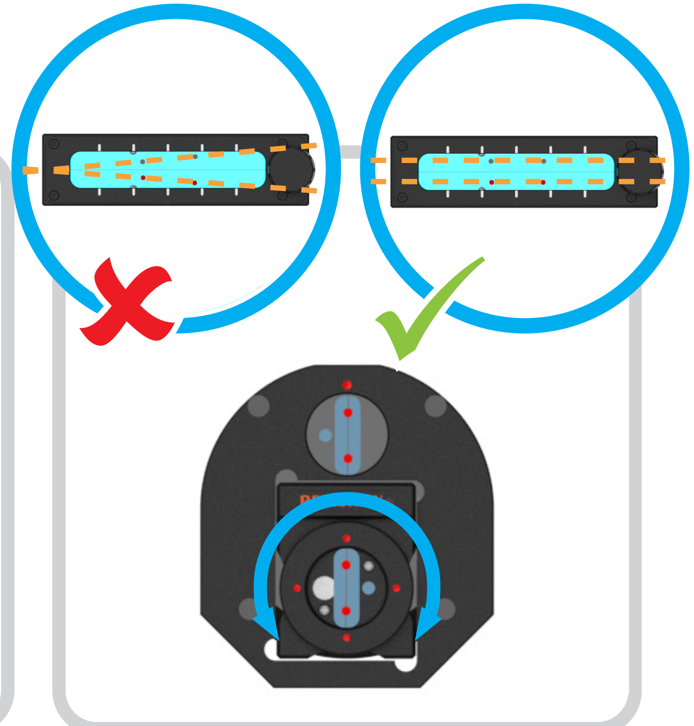
Repeat the previous three steps until the laser beam remains on the centre of the white target along the full axis of travel.

Remove the target.

Vertical straightness







Place the straightness interferometer into the large retro-reflector in the orientation shown. Secure into place with the two M3 × 6 mm cap head screws.

NOTE: To avoid damage to the optical surfaces, it is advisable to cover the fixed turning mirror and straightness reflector in case screws are dropped.

Drive the spindle half way up the measurement axis. The laser beam should pass through the straightness interferometer, it is then split and returns to the straightness reflector as two separate beams.

Rotate the face of the straightness interferometer so that the two beams are parallel to the long axis of the reflector housing.

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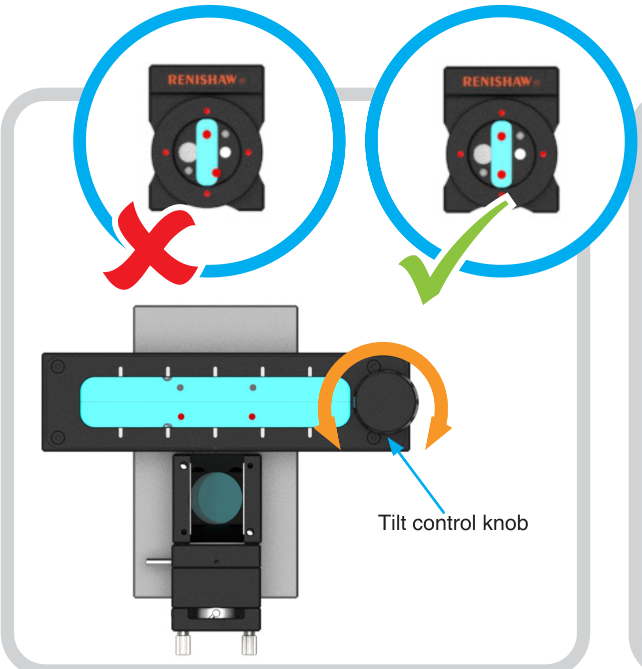
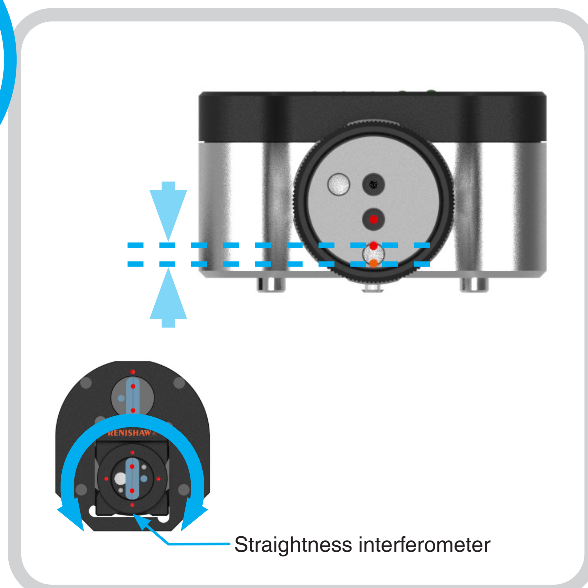
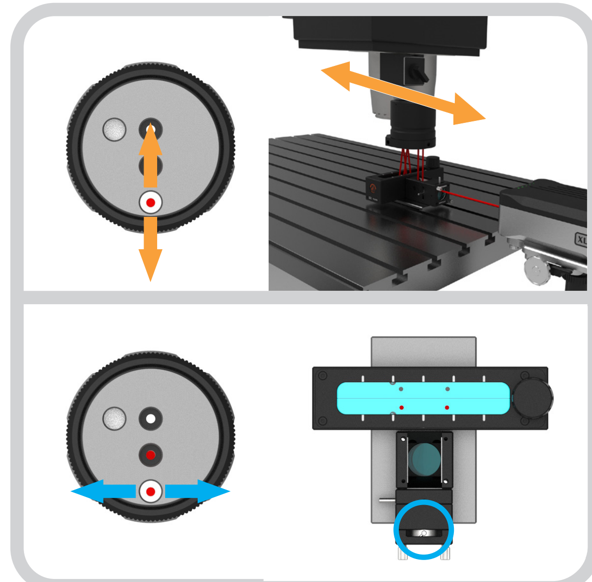
Vertical straightness







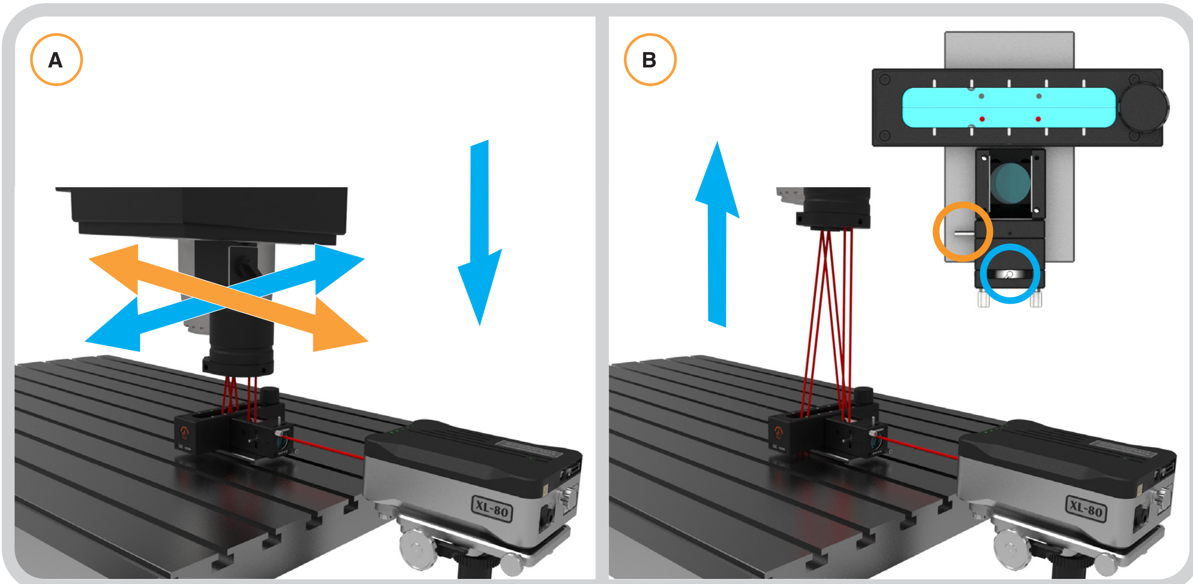
Adjust the tilt control knob on the straightness reflector until the two return beams pass through the straightness interferometer.

Rotate the straightness interferometer until the two beams overlap on the face of the straightness shutter.

If the return beams are not on the centre of the shutter target:

- translate the large retro-reflector or straightness base for vertical mis-alignment using the machine controller.
- adjust the lever of the LS350 beam steerer for horizontal mis-alignment.

Vertical straightness



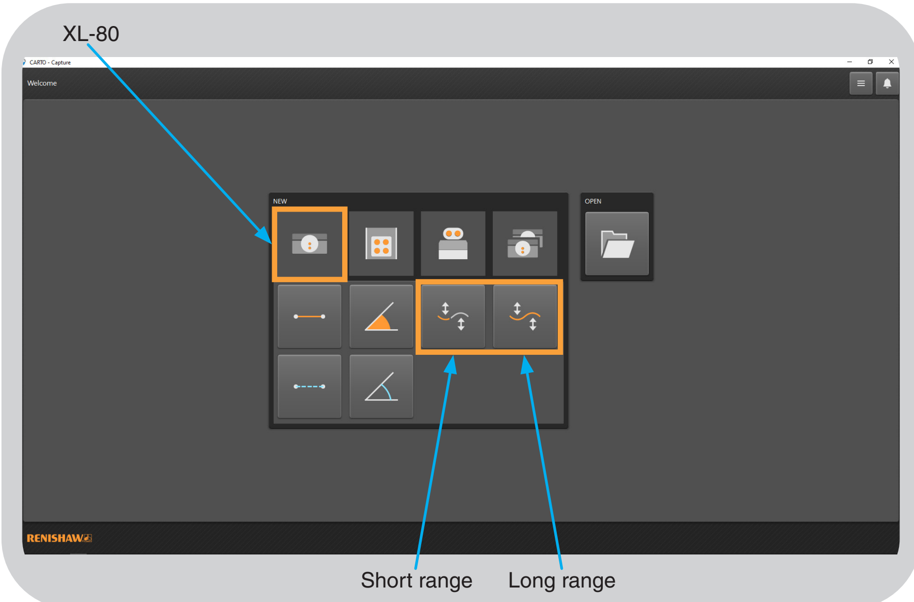
Drive the spindle along the full axis of travel whilst observing the laser beam on the straightness shutter. If misalignment occurs:

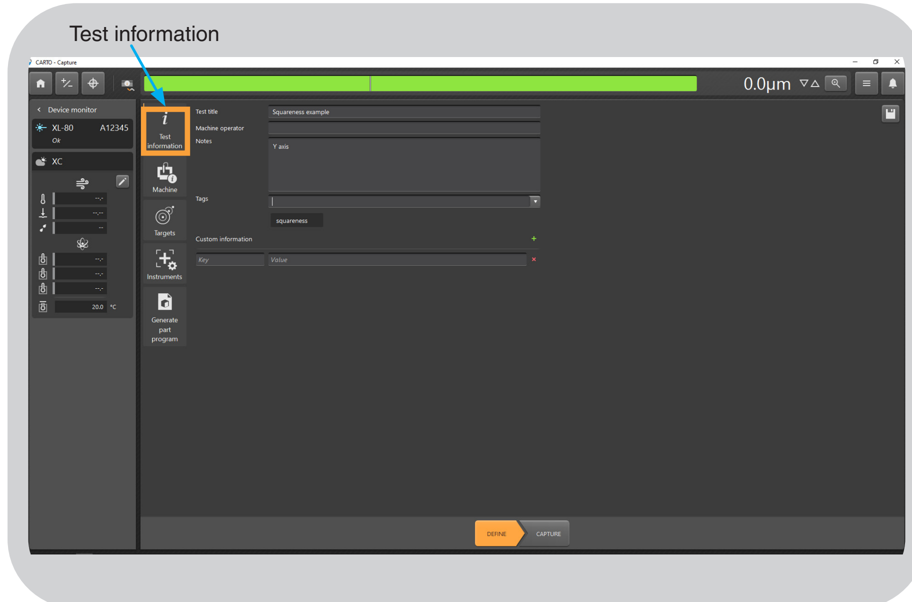
A: Translate the large retro-reflector or straightness base when close to the straightness base assembly.

B: Use the tilt controls on the vertical turning mirror when far away.

Rotate the black bezel of the straightness shutter until the large apertures are open and the 6 mm beam is emitted.

Straightness data capture





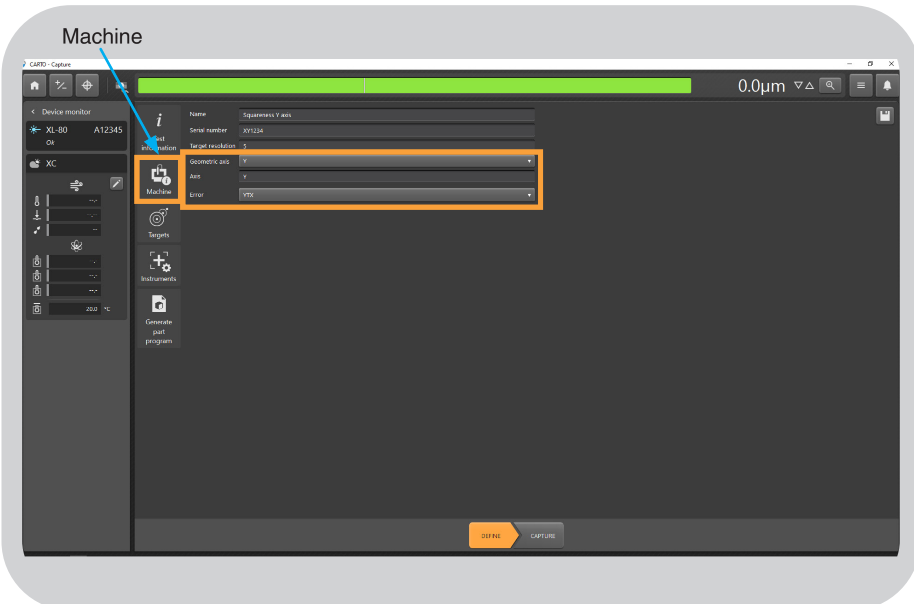
From the Capture home screen select short range or long range straightness as appropriate.

- Short range for an overall axis length of 0.1 m to 4 m.
- Long range for an overall axis length of 1 m to 30 m.

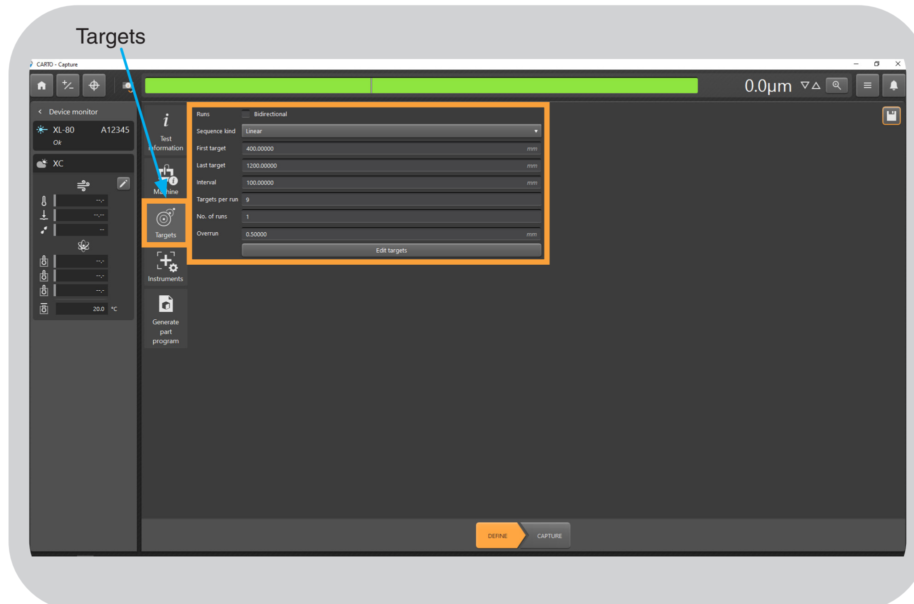
NOTE: The axis lengths quoted can be increased by measuring sections and then using the datastitch function within Explore to stitch the data.

The ‘Test information’ tab is a location where text can be entered about the test.

Straightness data capture



The ‘Machine’ tab must have the ‘Geometric axis’ and ‘Error’ fields set correctly.



In the ‘Targets’ tab, select ‘Bidirectional’ if the test is required to run in positive and reverse directions along the axis. Enter the target positions, number of runs and sequence kind.

For more information about ‘sequence kind’ refer to the Appendix in the *CARTO Capture* user guide (Renishaw part no. F-9930-1007).

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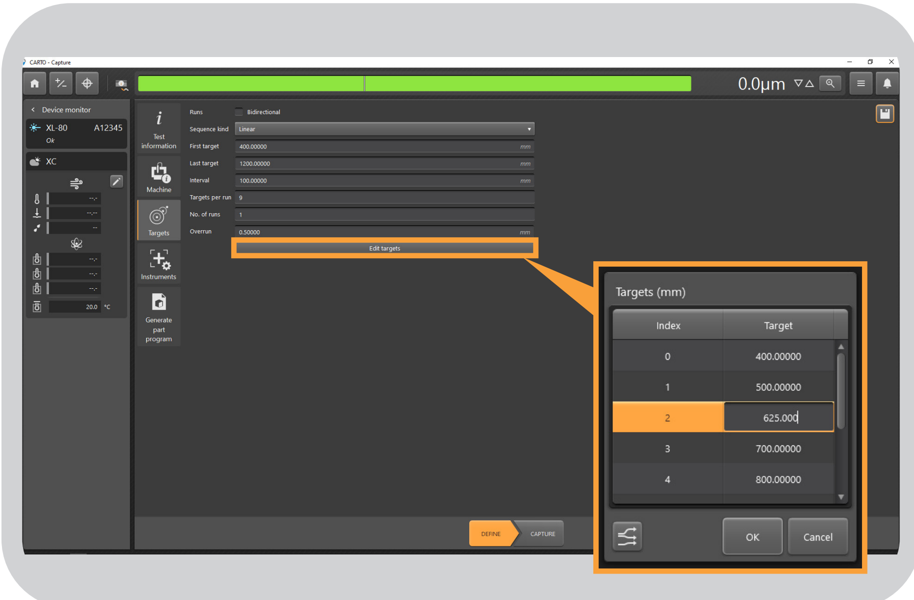
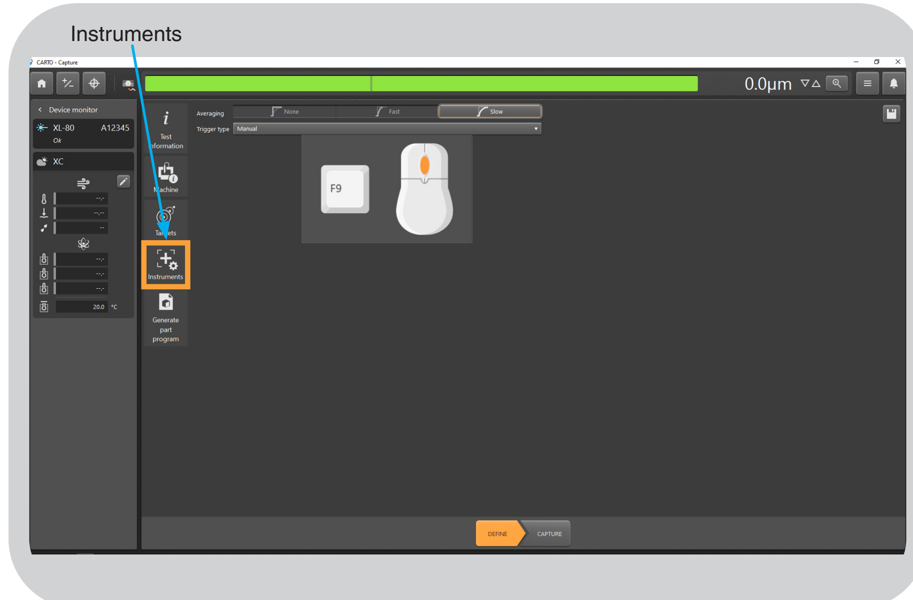
Straightness data capture

In the 'Instruments' tab, select the averaging type required and preferred trigger method.

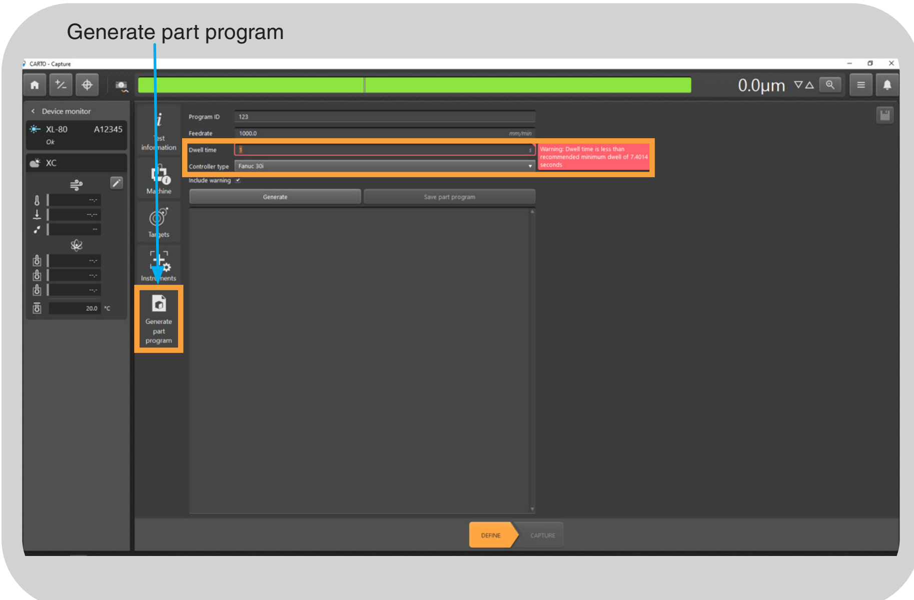




The test method created will contain equally spaced targets between the start and end positions. To customise the targets select 'Edit targets' and change as required.

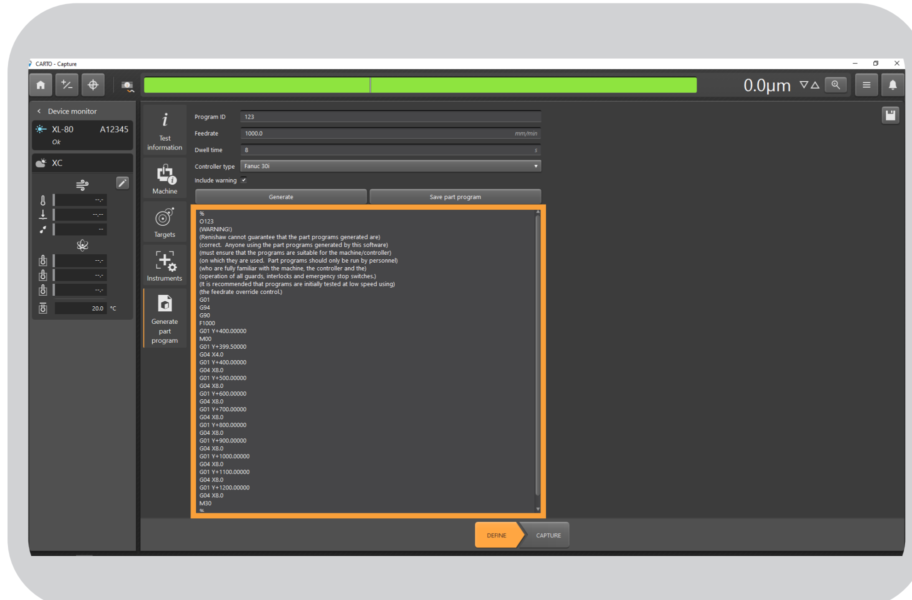
- **Averaging** – straightness data capture is more susceptible to environmental changes caused by air turbulence and vibration, therefore slow averaging is recommended.
- **Trigger type** – the data capture method. Most commonly used is 'Manual', using the middle mouse key at each position or F9 on a keyboard.

Straightness data capture



The part program tab will have the Dwell time automatically populated based on the averaging type that was selected in the ‘Instruments’ tab.

The time can be edited, but if it is below the minimum threshold the box will turn red. Place the mouse over the text field for more information.



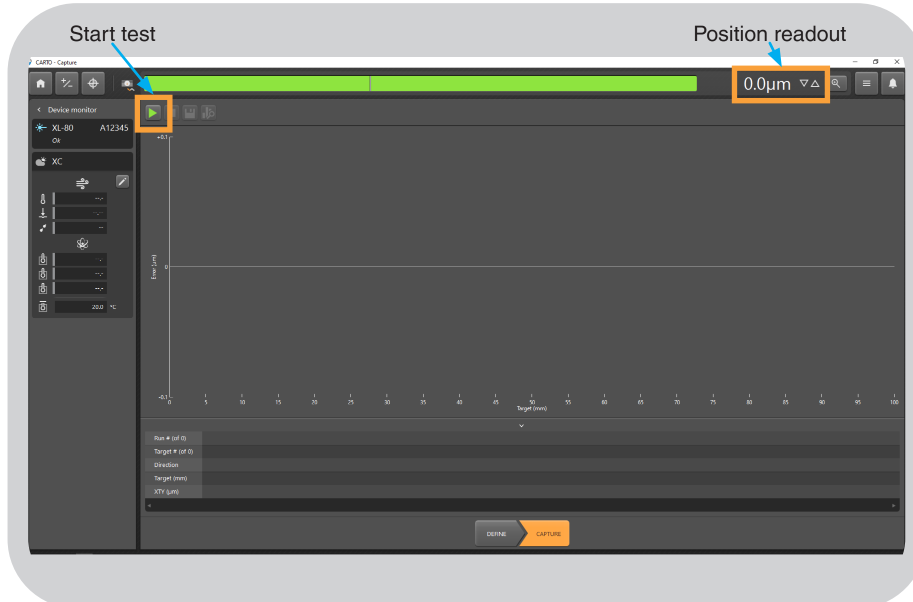
Enter a program ID, feedrate for the machine and select the controller type from the drop down list of supported controllers.

The part program can then be generated and saved for transfer to the controller.

Straightness data capture

Switch to the ‘Capture’ tab.

Check the sign convention for the optical configuration set-up **(See Appendix D)** and set the sign convention in the software. Press ‘Cycle start’ on the machine to drive to the first target position.



Select the correct part program in the controller and press ‘Cycle start’ to drive the machine to the first target. The machine will then pause using the ‘M00’ command in the program.

When the machine arrives at the first target, press ‘Start test’. The Capture software will then datum the position readout.

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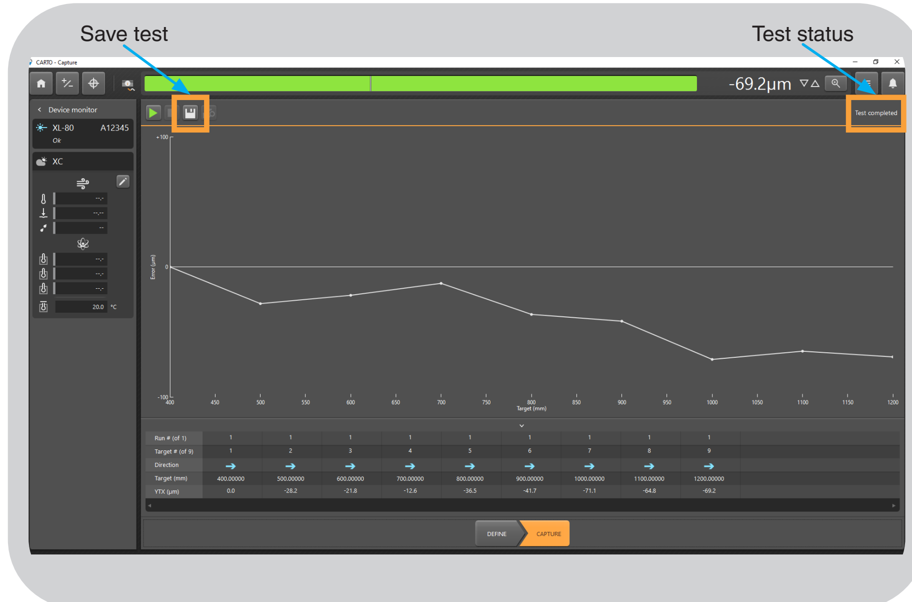
Straightness data capture

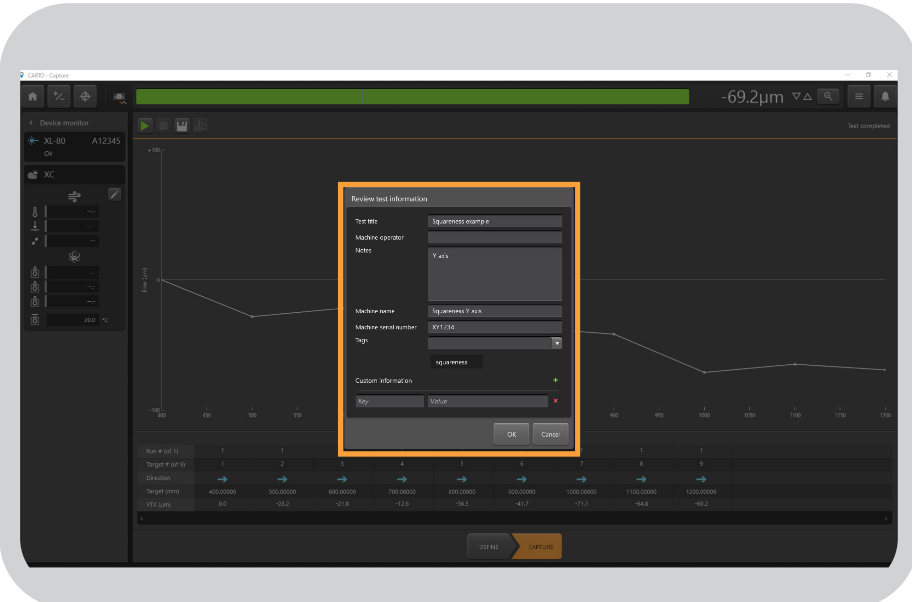


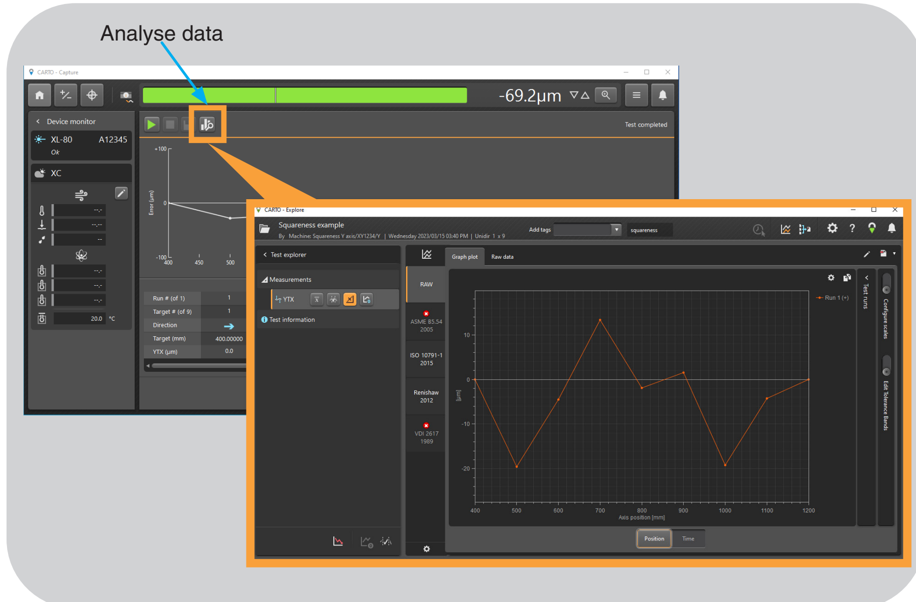
Press ‘Cycle start’ again on the machine. Use F9 on the keyboard or the middle mouse button to capture:

- the overrun position,
- the first target after the overrun,
- all target positions after (including any overruns).

When the test is complete, press ‘Save’.

Straightness data capture





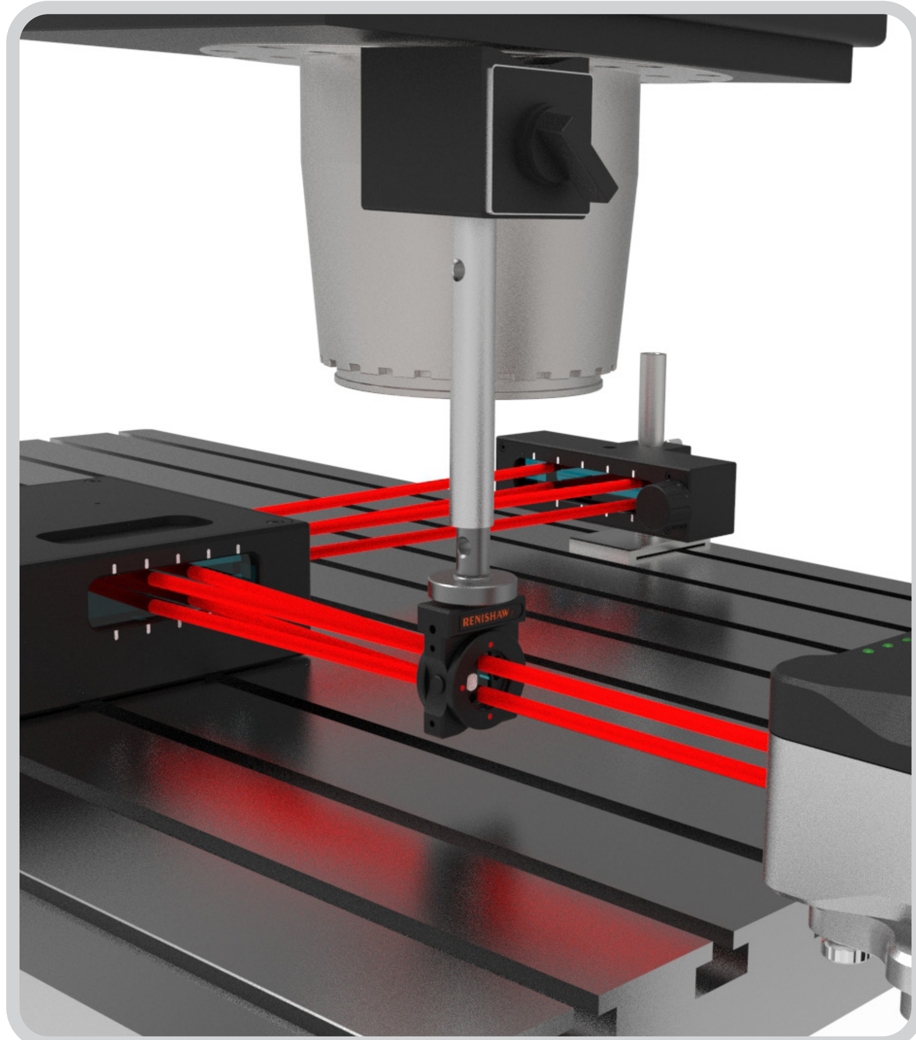
A dialogue box will appear for additional information to be saved.

Enter text into the relevant fields to help filter and find test data from the CARTO database.

Data can be analysed by launching the Explore application.

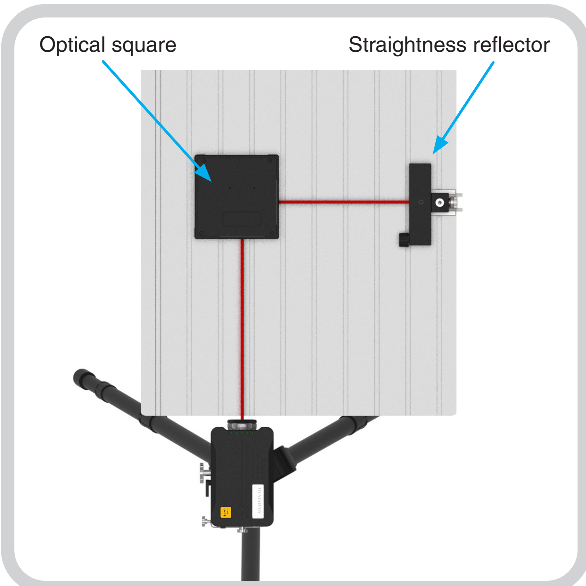
Visit the *CARTO Explore* user guide (Renishaw part no. F-9930-1008) for more information.

Squareness (Horizontal to horizontal axis)



NOTE: Environmental compensation is not necessary when taking straightness measurements, therefore, the XC environmental compensator and environmental sensors are not required.

Alignment for axis 1



Position the optical square at the intersection of the two axes to be measured.

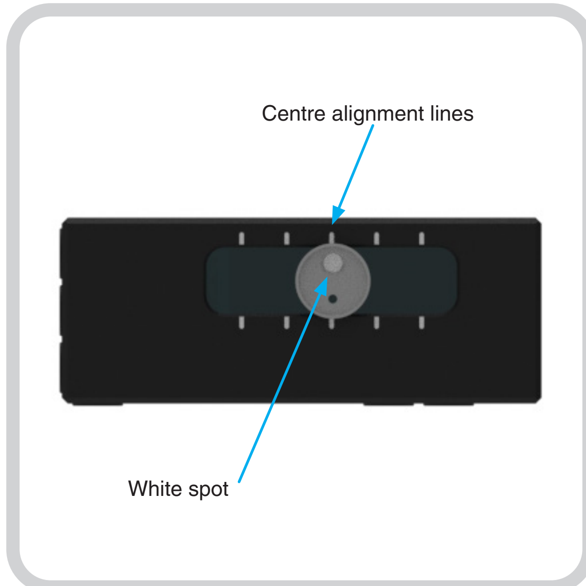
- Ensure that it is flat on the table.
- One optical aperture must be facing the laser.
- The other must be facing along the second axis.

Attach the straightness shutter to the laser in the orientation shown.

Rotate the black bezel of the laser shutter.

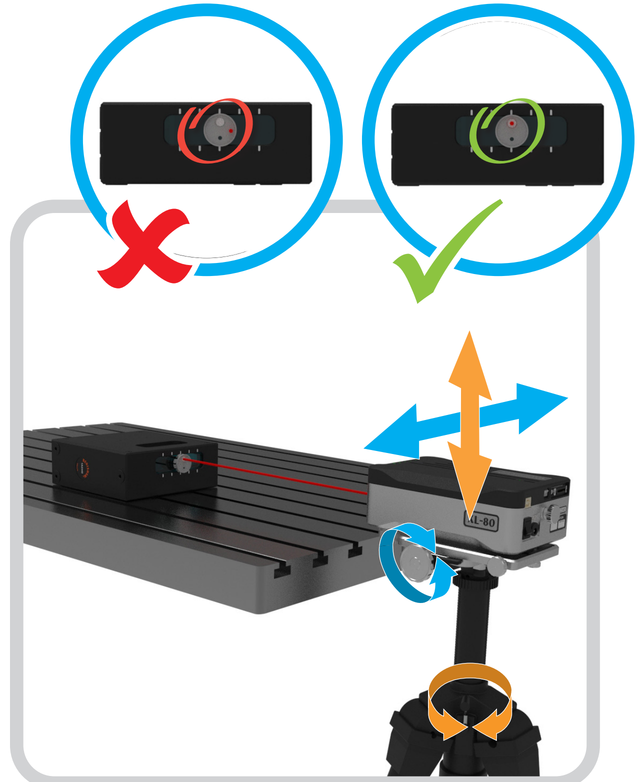
Alignment for axis 1

Continue rotating until a reduced diameter beam is emitted.



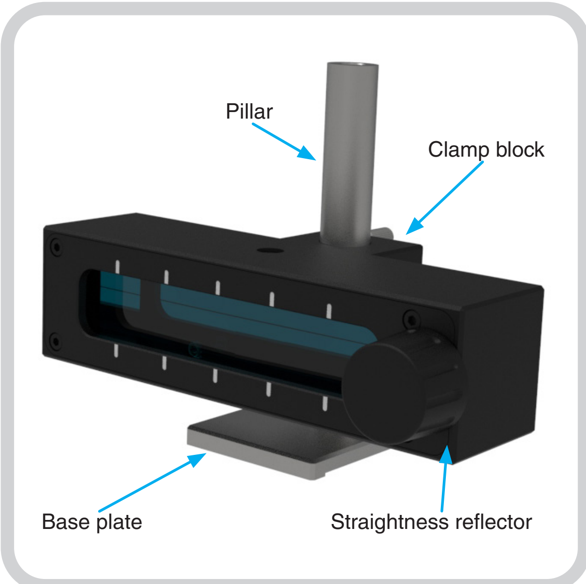
Fit the target to the aperture facing the laser so that:

- It is aligned with the *centre* alignment lines.
- The white spot is at the top.

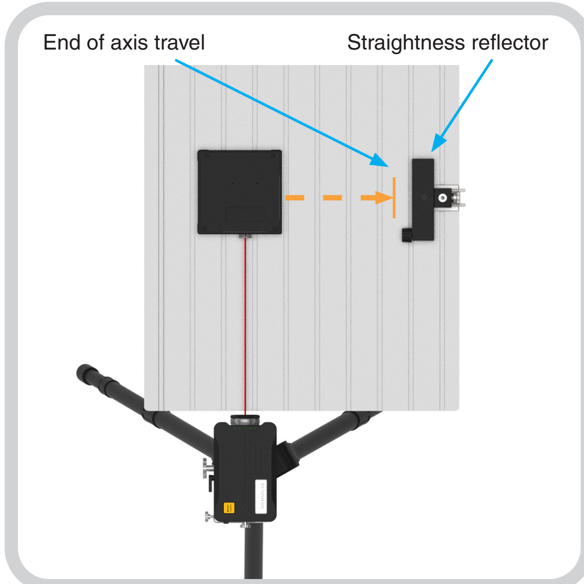


Adjust the beam to the centre of the white target using the translation screws.

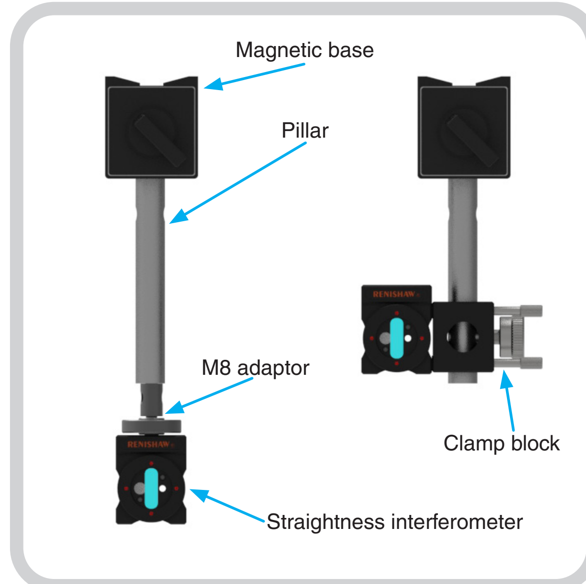
Alignment for axis 1



Assemble the straightness reflector using the base plate, pillar and clamp block.



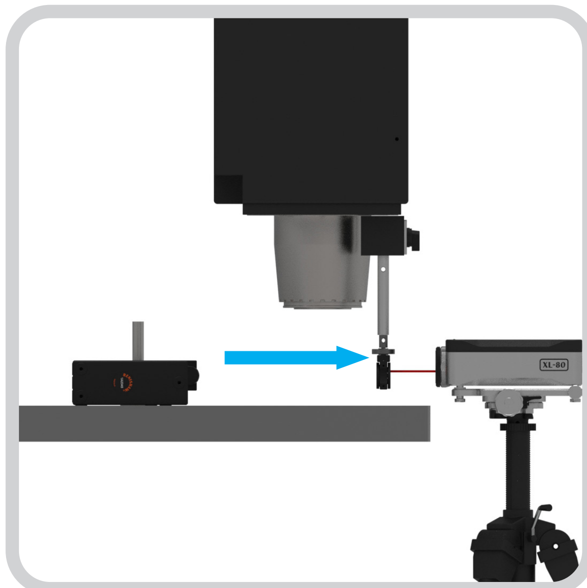
Position the straightness reflector beyond the end of travel of the second axis.



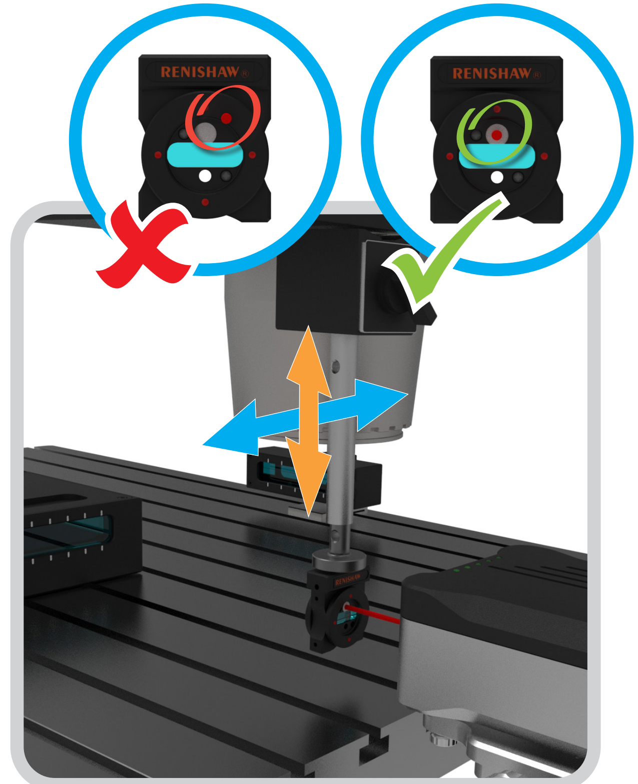
Assemble the straightness interferometer and mount to the spindle using the magnetic base.

Alignment for axis 1

Rotate the straightness interferometer until the white target is at the top.

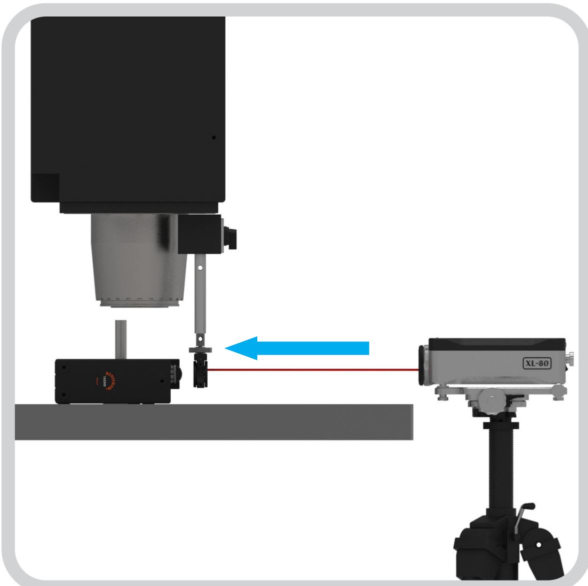


Drive the spindle so that the straightness interferometer is close to the laser.



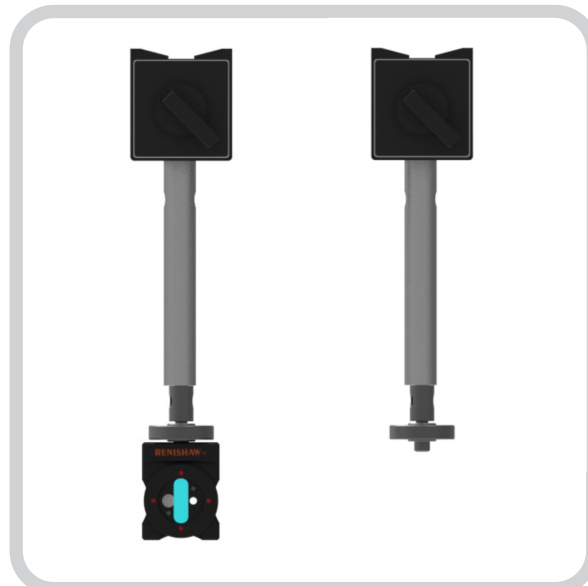
Translate the spindle until the laser beam is on the centre of the white target.

Alignment for axis 1



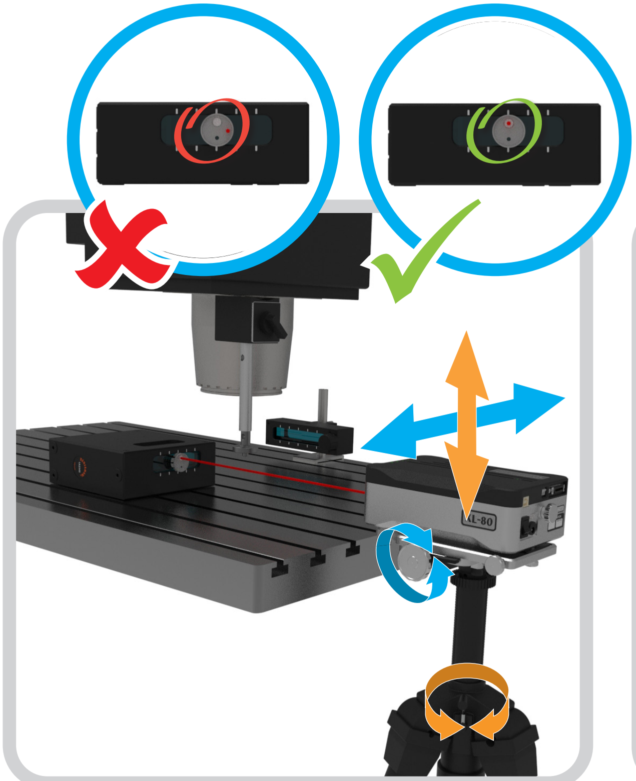
Drive the spindle so that the straightness interferometer is closest to the squareness optic.

Adjust the pitch and yaw on the laser and align the beam to the centre of the white target.

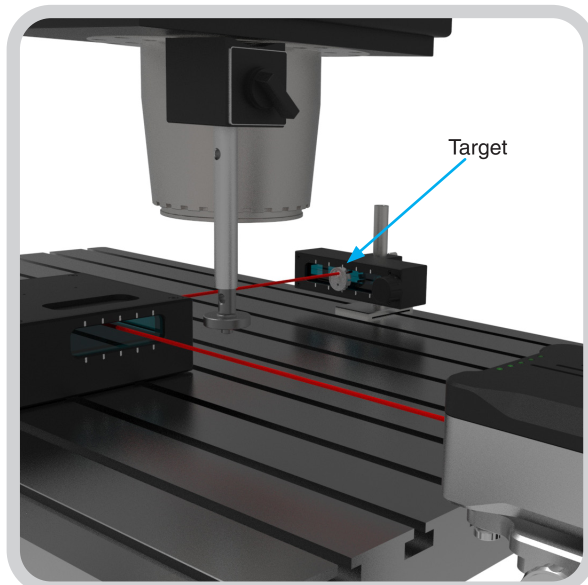


When the laser beam is aligned along the axis, remove the straightness interferometer.

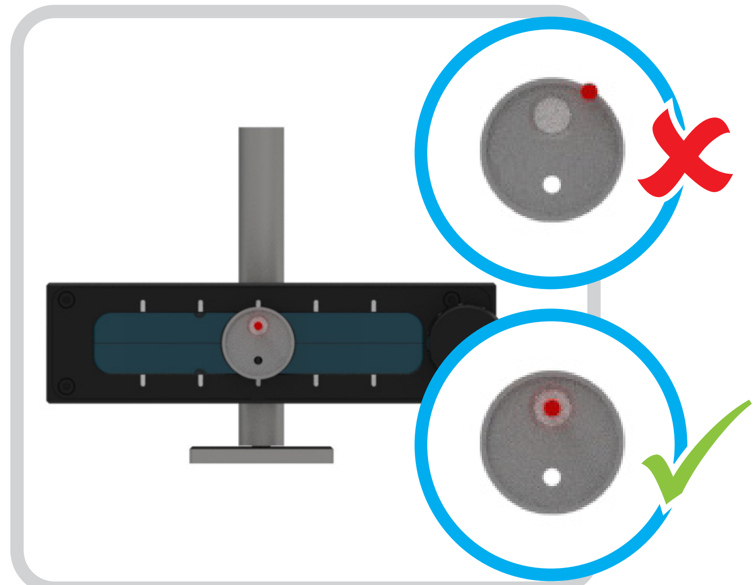
Alignment for axis 1



Translate the laser until the beam hits the centre of the white target mounted in the optical square.

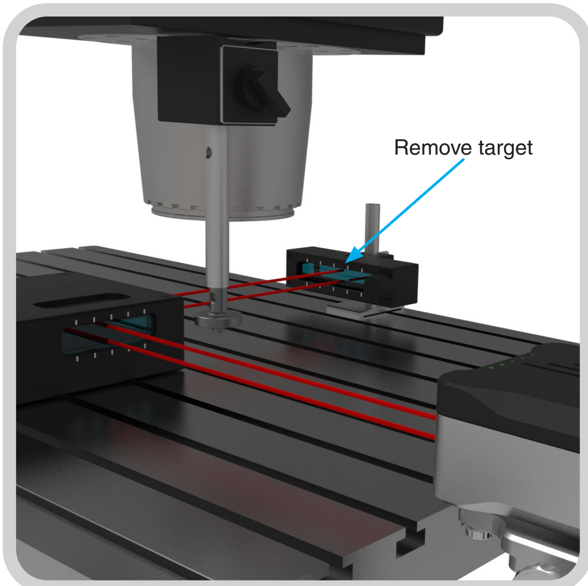


Carefully remove the target from the optical square and place it to the centre of the straightness reflector with the white target at the top.

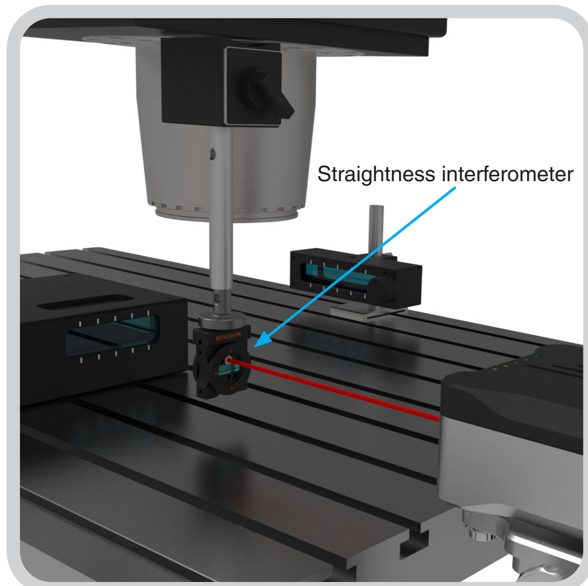


Adjust the straightness reflector so that the laser beam from the optical square hits the centre of the white target.

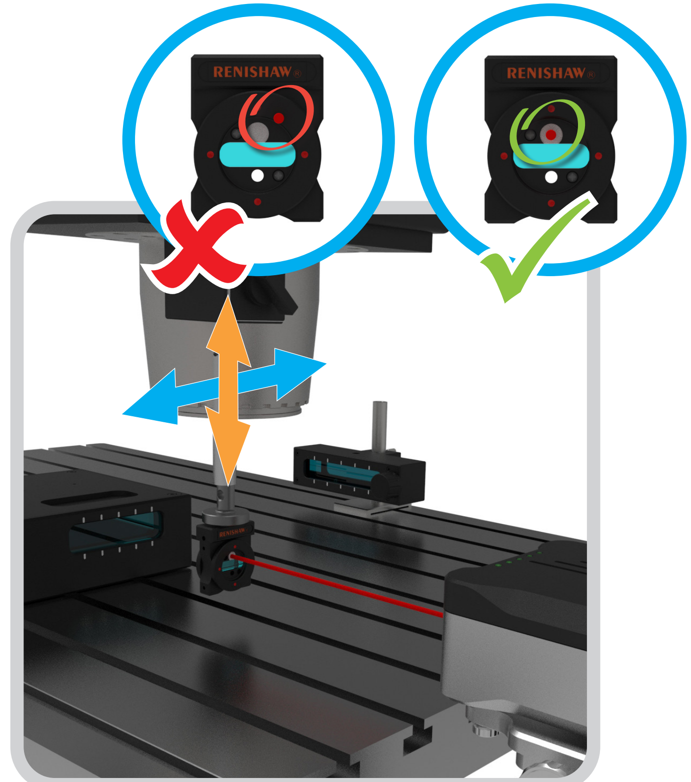
Alignment for axis 1



Remove the target from the straightness reflector.

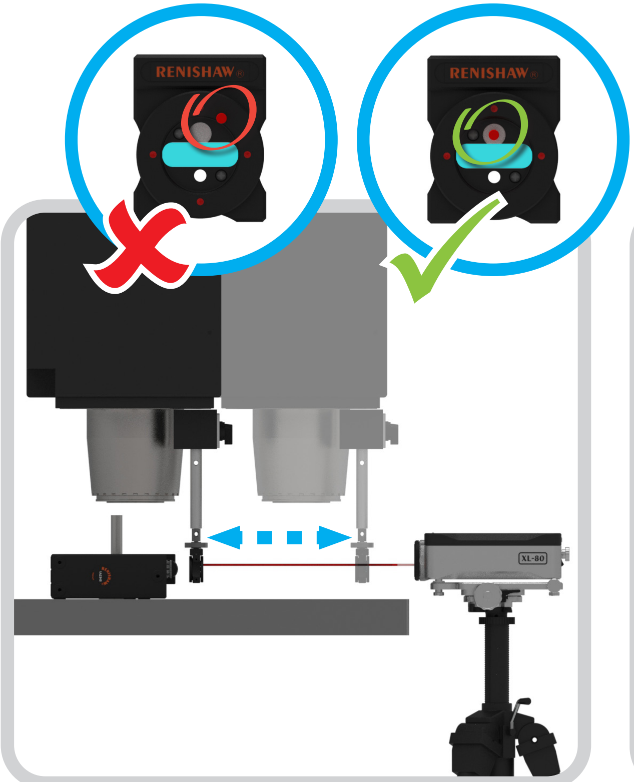


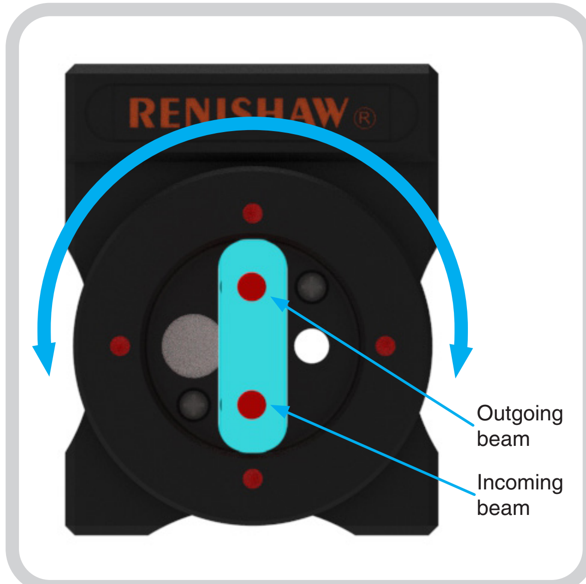
Fit the straightness interferometer to the M8 pillar and lock in place with the M8 locking nut.

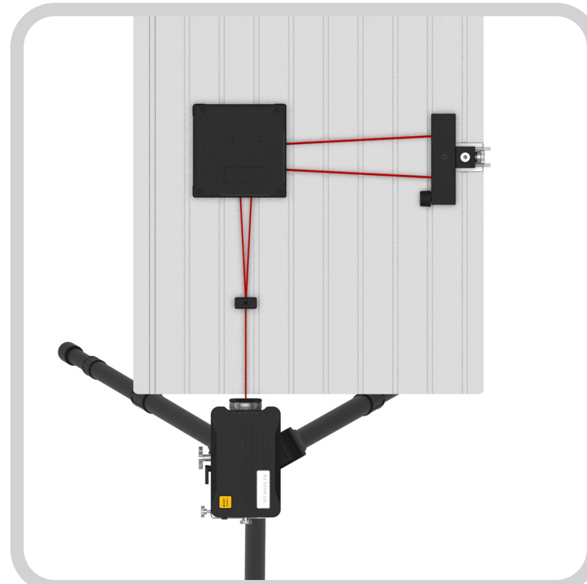


Translate the machine spindle until the beam hits the white target of the straightness interferometer.

Alignment for axis 1







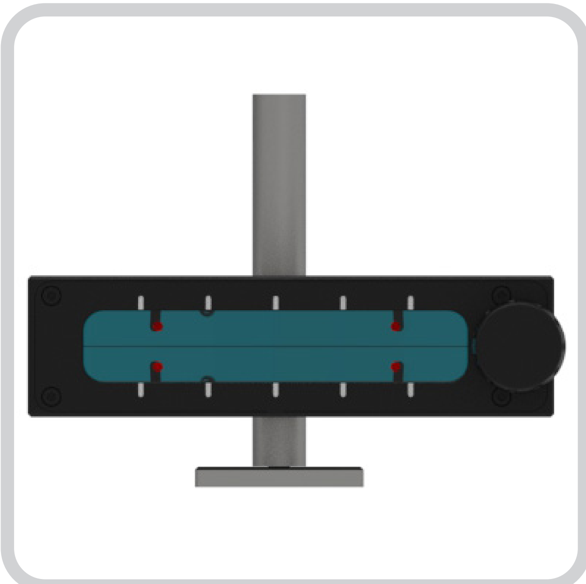
Drive the spindle along the full axis of travel and ensure that the laser beam remains on the target.

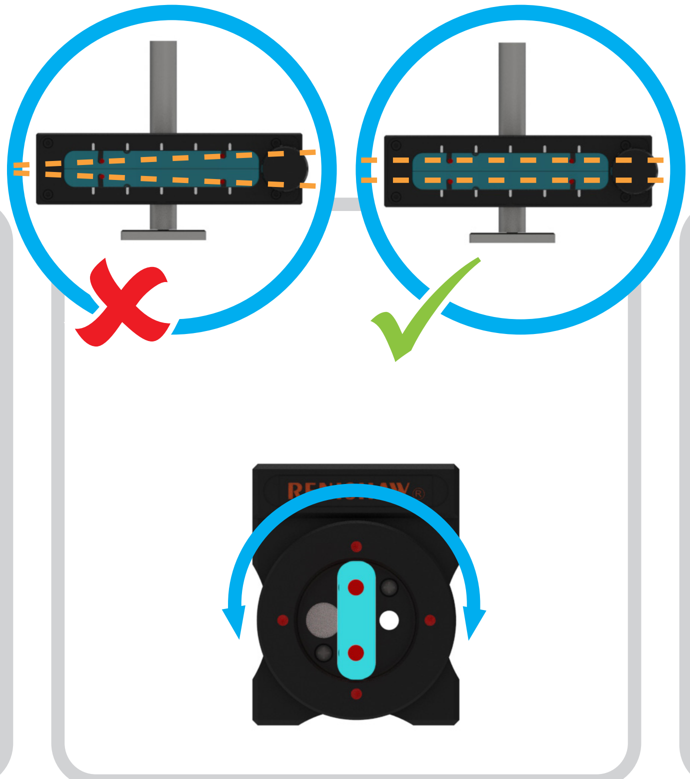
If it does not, then re-alignment of the laser will be required.

Rotate the face of the straightness interferometer so that the beam passes through the upper side of the optic.

The beam will emerge as two horizontally diverging beams which pass through the optical square to the straightness reflector.

Alignment for axis 1



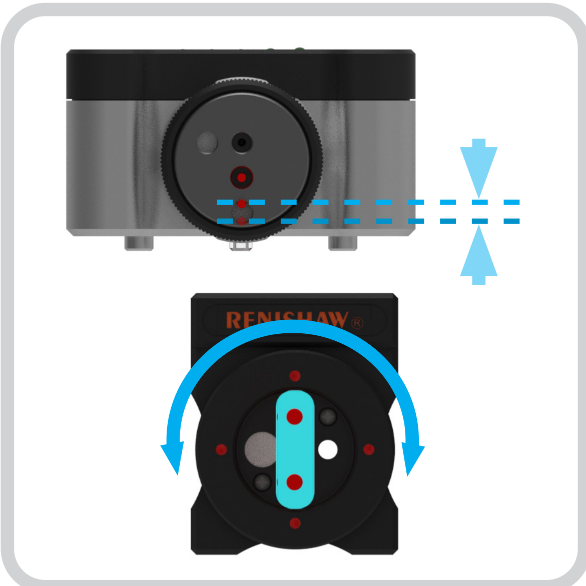


The two diverging beams should meet the straightness reflector equally spaced from the centre alignment line.

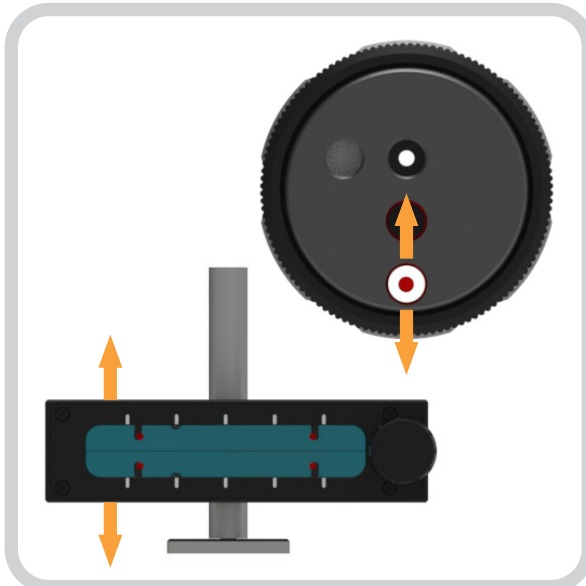
Rotate the face of the straightness interferometer so that the two beams are parallel to the long axis of the reflector housing.

Ensure that the reflected beams pass though the optical square and return to the centre of the white target on the shutter.

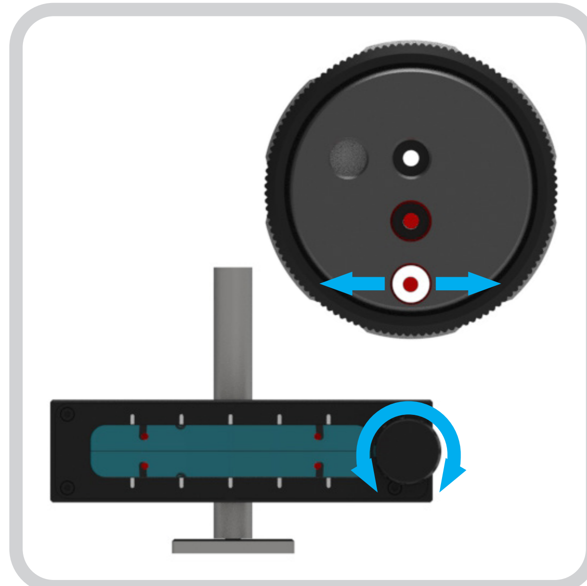
Alignment for axis 1



Rotate the straightness interferometer until the two beams overlap on the face of the straightness shutter.



If the two beams are returned above or below the centre of the white target, carefully translate the straightness reflector vertically.

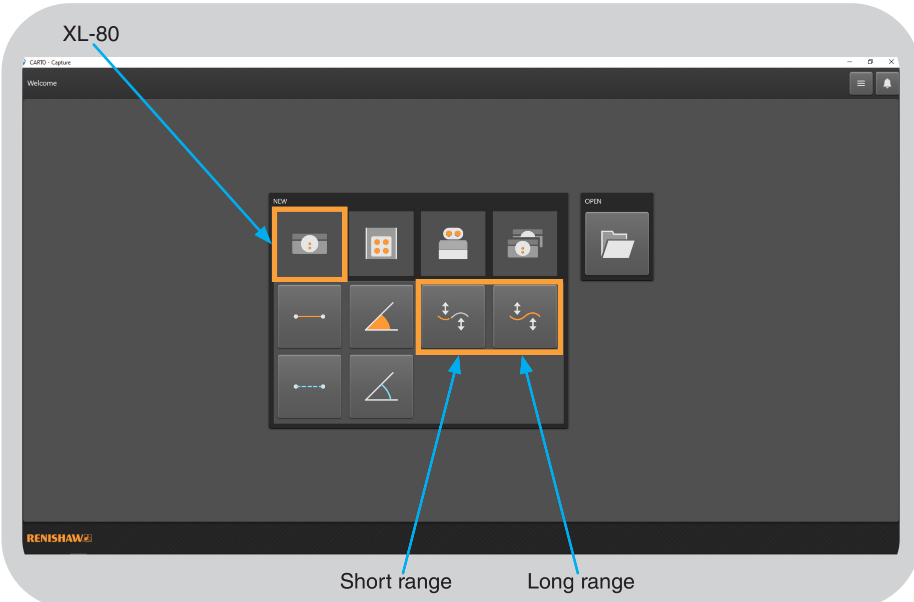


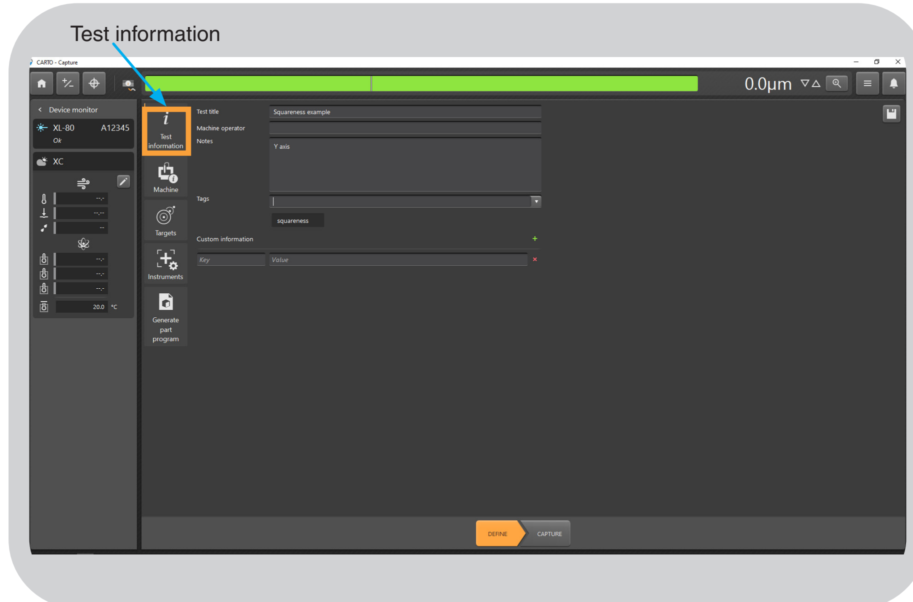
If the two beams are to the left or right of the white target, adjust the tilt control knob on the straightness reflector.

Alignment for axis 1

Rotate the black bezel of the straightness shutter until the large apertures are open. Check the signal strength along the axis of travel.

Axis 1 data capture



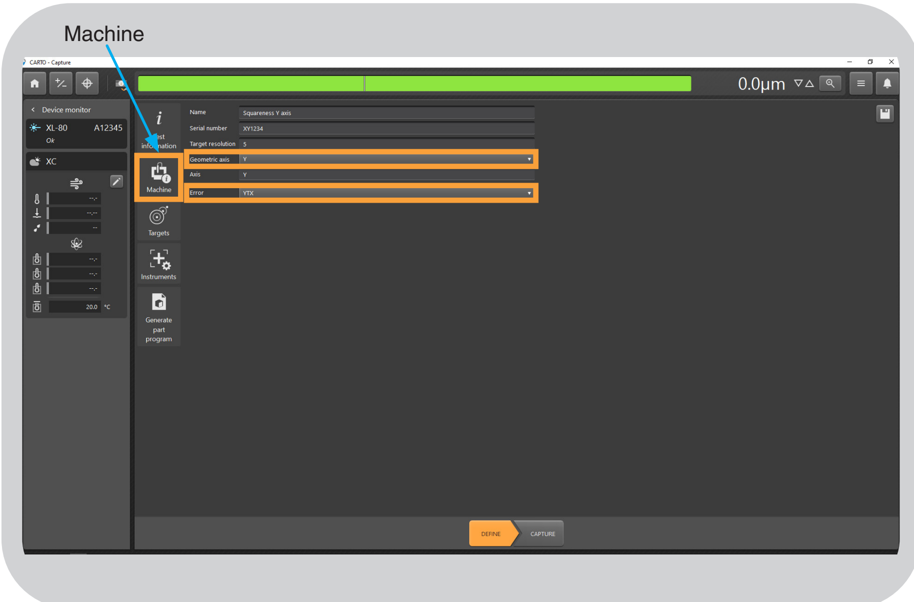


From the Capture home screen select short range or long range straightness as appropriate.

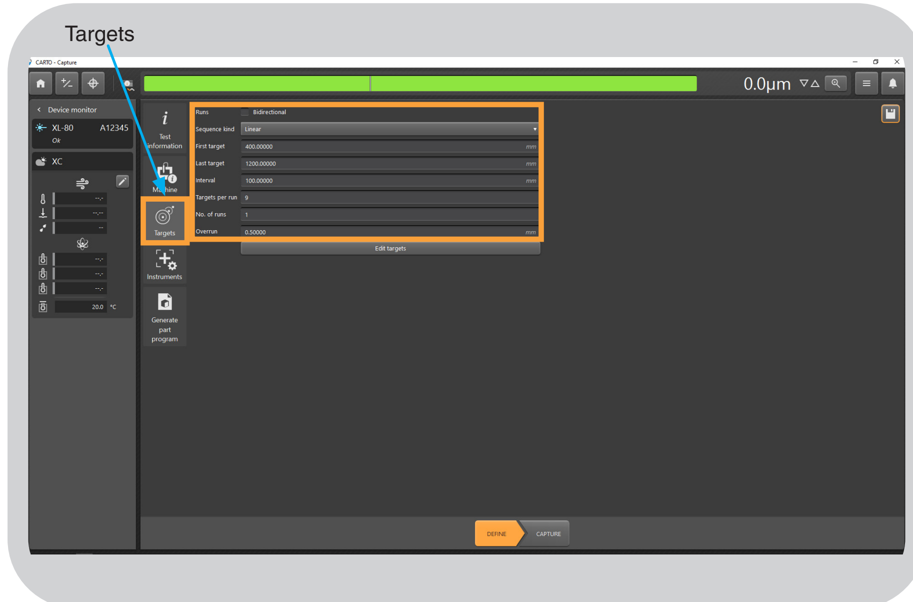
- Short range for an overall axis length of 0.1 m to 4 m.
- Long range for an overall axis length of 1 m to 30 m.

The 'Test information' tab is an optional location where text can be entered about the test.

Axis 1 data capture



The ‘Machine’ tab must have the ‘Geometric axis’ and ‘Error’ fields set correctly. All other fields in this tab are optional.

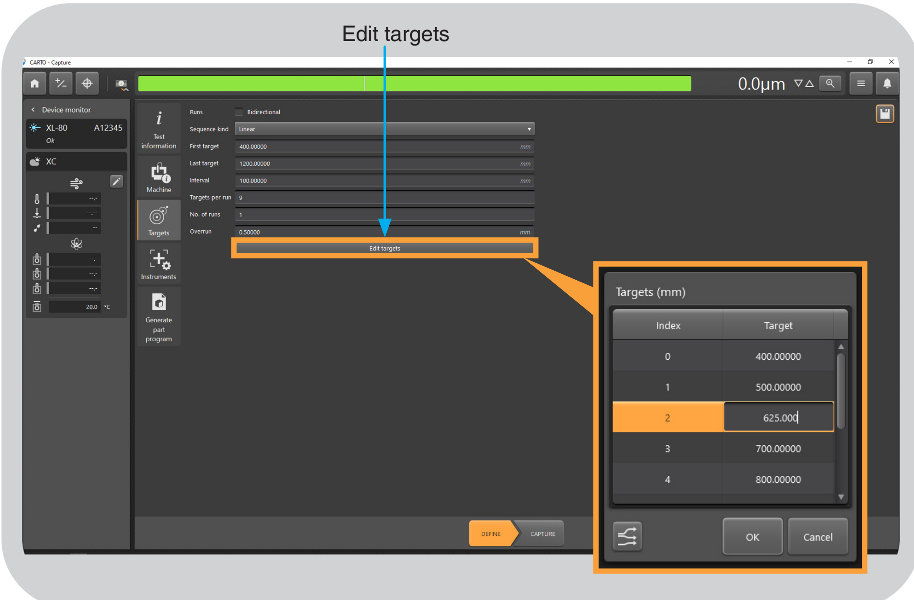


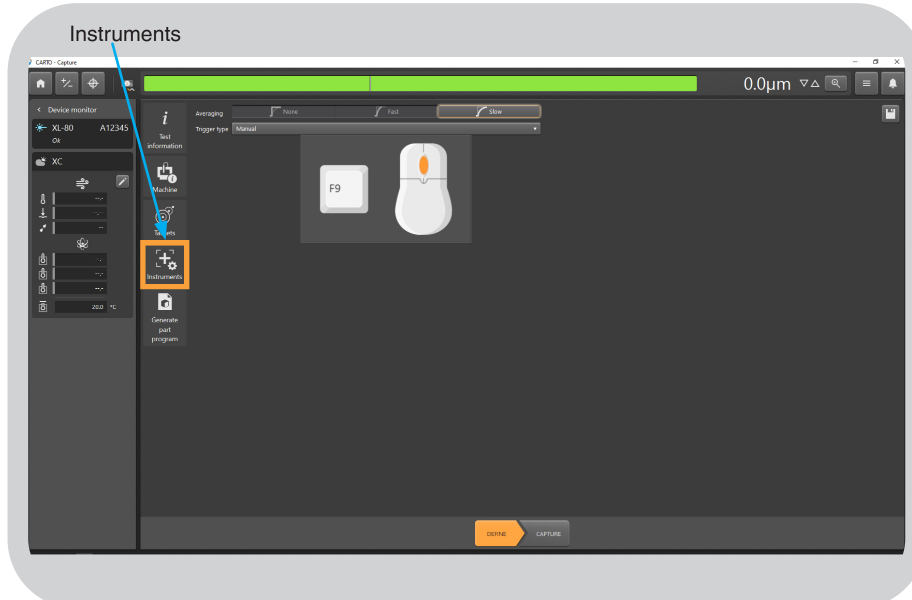
In the ‘Targets’ tab, select ‘Bidirectional’ if the test is required to run in positive and reverse directions along the axis. Enter the target positions, number of runs and sequence kind.

For more information about ‘sequence kind’ refer to the Appendix in the *CARTO Capture* user guide (Renishaw part no. F-9930-1007).

Axis 1 data capture

The ‘Instruments’ tab contains ‘averaging’ and ‘trigger type’.

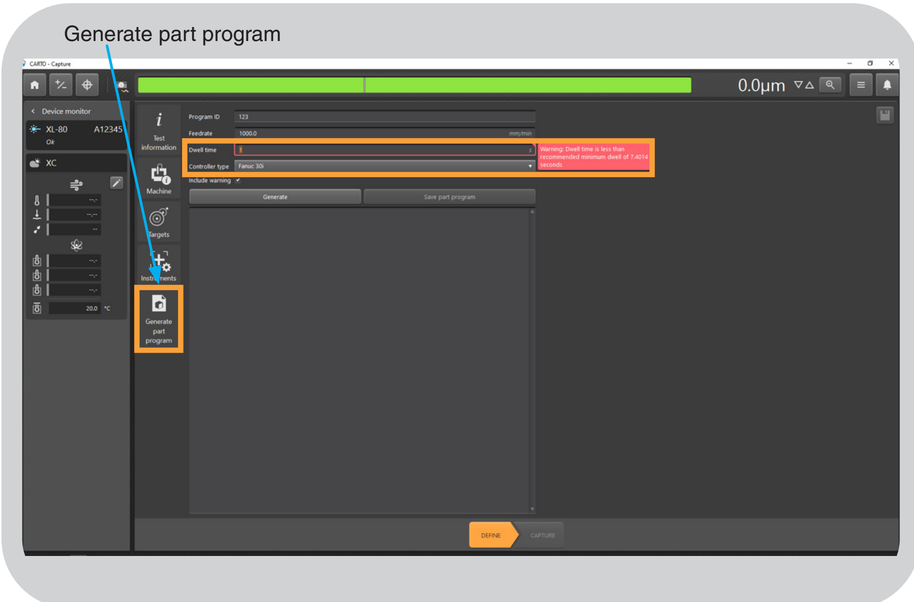


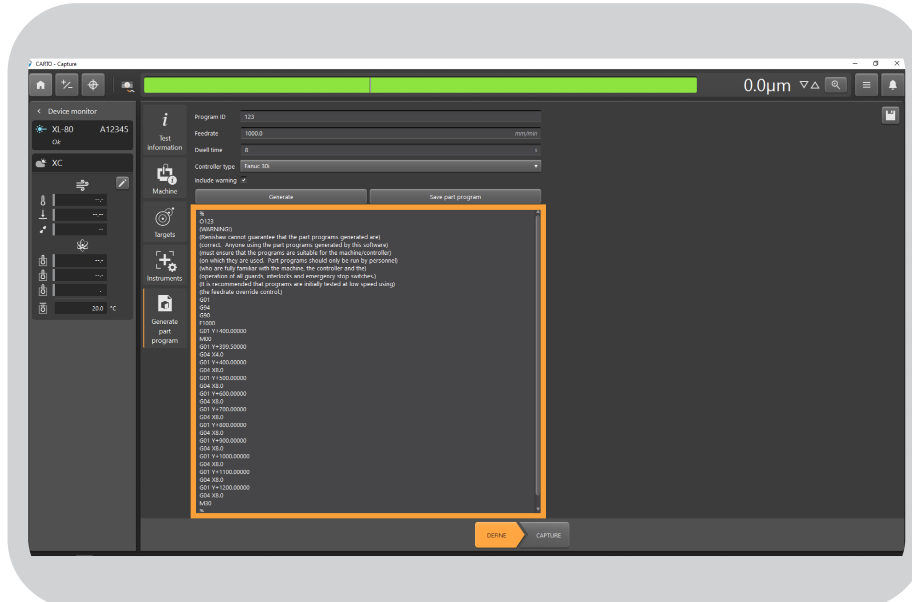


The test method created will contain equally spaced targets between the start and end positions. To customise the targets select ‘Edit targets’ and change as required.

- **Averaging** – straightness data capture is more susceptible to environmental changes caused by air turbulence and vibration, therefore slow averaging is recommended.
- **Trigger type** – the data capture method. Most commonly used is ‘Manual’, using the middle mouse key at each position or F9 on a keyboard.

Axis 1 data capture





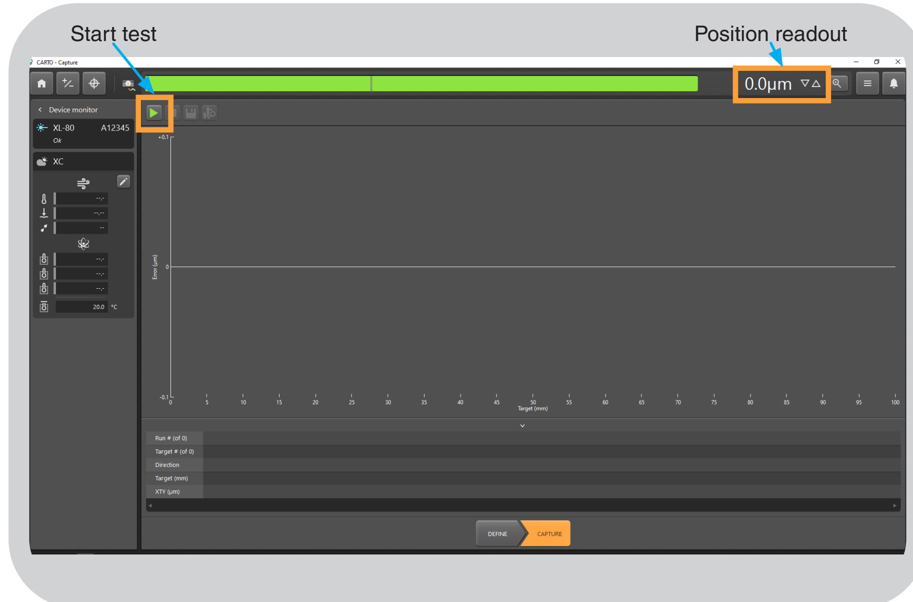
The ‘Generate part program’ tab will have the ‘Dwell time’ automatically populated based on the averaging type that was selected in the ‘Instruments’ tab.

The time can be edited, but if it is below the minimum threshold the box will turn red. Place the mouse over the text field for more information.

Enter a program ID, feedrate for the machine and select the controller type from the drop down list of supported controllers.

The part program can then be generated and saved for transfer to the controller.

Axis 1 data capture



Switch to the ‘Capture’ tab.

Check the sign convention for the optical configuration set-up (**See Appendix D**) and set the sign convention in the software. Press ‘Cycle start’ on the machine to drive to the first target position.

Select the correct part program in the controller and press ‘Cycle start’ to drive the machine to the first target. The machine will then pause using the ‘M00’ command in the program.

When the machine arrives at the first target, press ‘Start test’. The Capture software will then datum the position readout.

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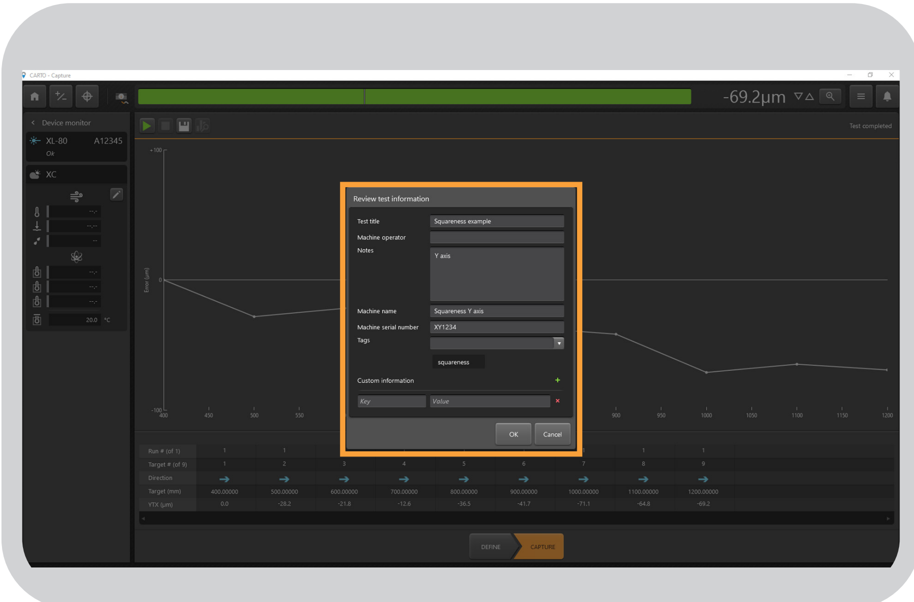
Axis 1 data capture

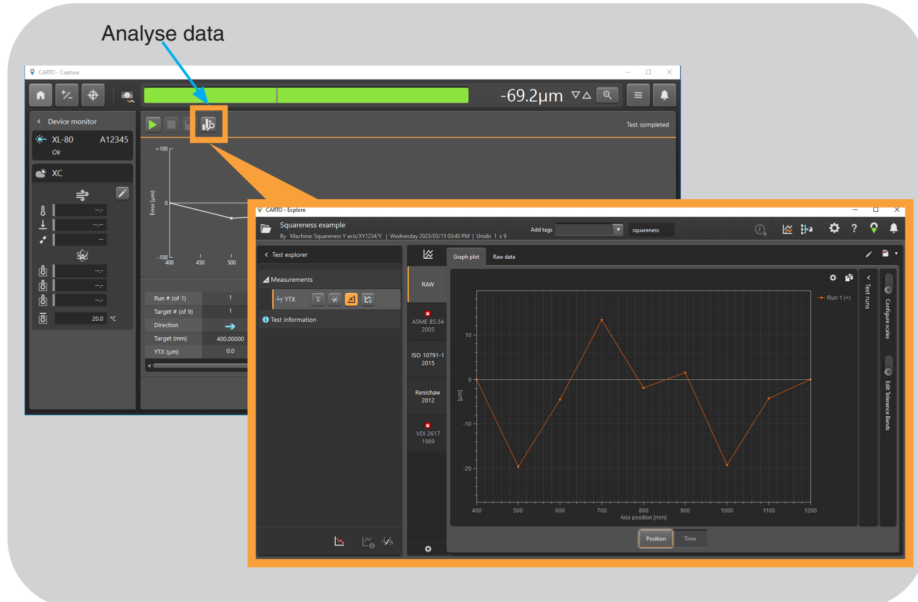
Press ‘Cycle start’ again on the machine. Use F9 on the keyboard or the middle mouse button to capture:

- the overrun position,
- the first target after the overrun,
- all target positions after (including any overruns).

When the test is complete, press ‘Save’.

Axis 1 data capture





A dialogue box will appear for additional information to be saved.

Enter text into the relevant fields to help filter and find test data from the CARTO database.

Data can be analysed by launching the Explore application.

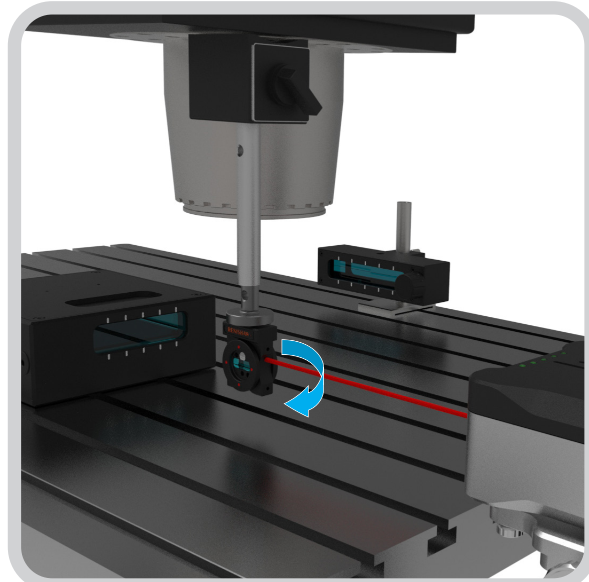
NOTE: At this stage the data is straightness only, not squareness.

Alignment for axis 2

CAUTION: The straightness reflector must not be adjusted or moved in any way. The alignment of the straightness reflector acts as the reference from which the squareness calculations are made.

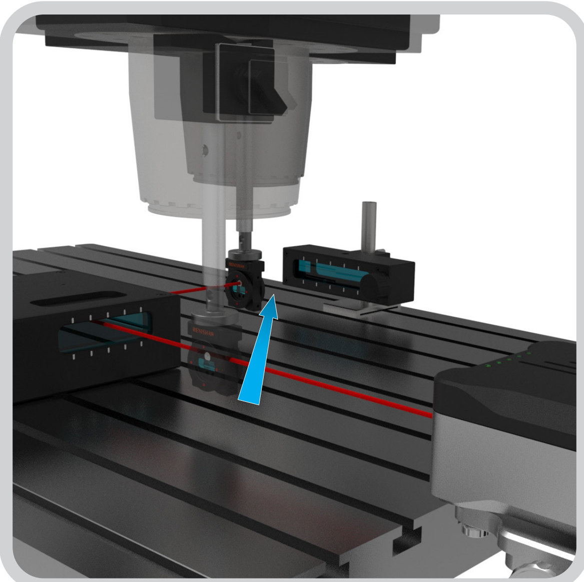
Rotate the black bezel of the laser shutter until the reduced diameter beam is emitted.

Rotate the straightness interferometer until the white target is at the top.

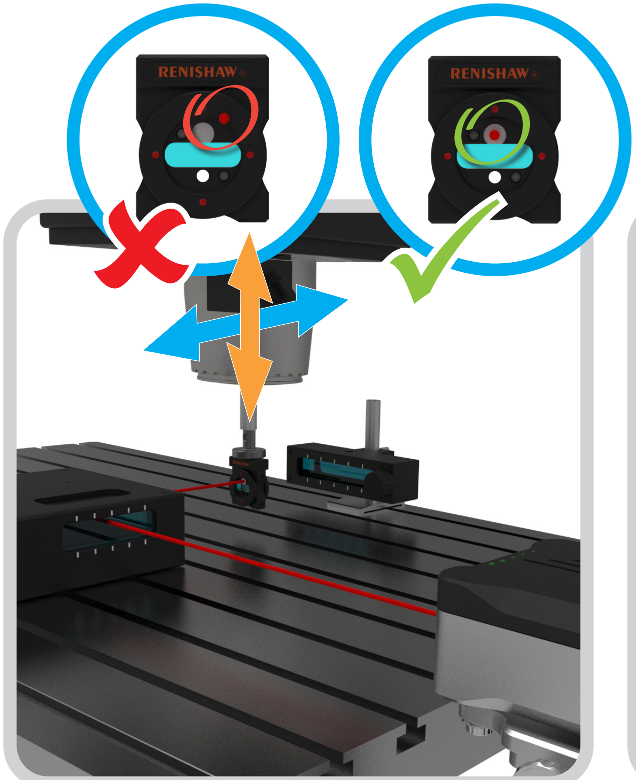


Rotate the straightness interferometer through 90 degrees.

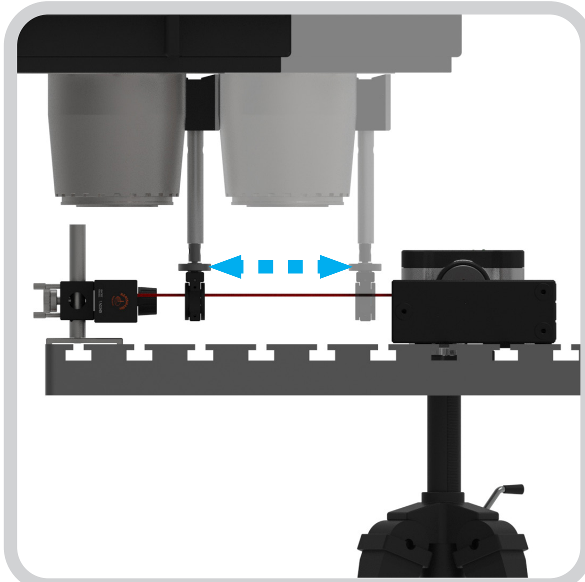
Alignment for axis 2



Drive the spindle so that the straightness interferometer is in line with the beam on the second axis.



Translate the spindle until the laser beam is on the centre of the white target.



Drive the spindle along the full axis of travel and ensure that the laser beam remains on the centre of the white target.

NOTE: When the straightness interferometer is close to the straightness reflector there will be reduced signal strength. Depending on the optics being used this will be within:

- 100 mm for short range optics
- 1 m for long range optics

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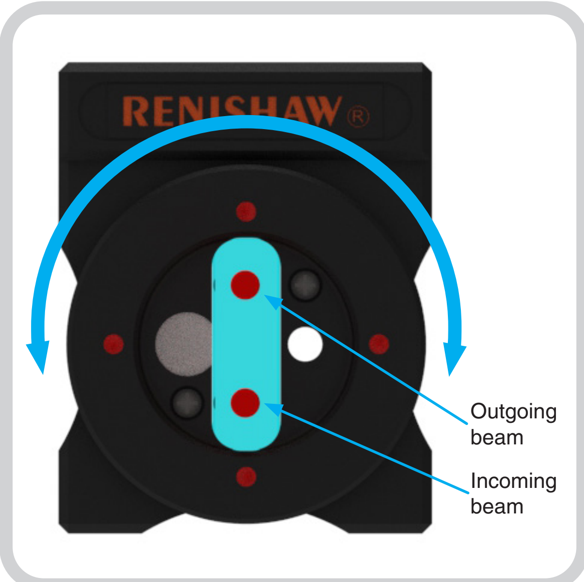
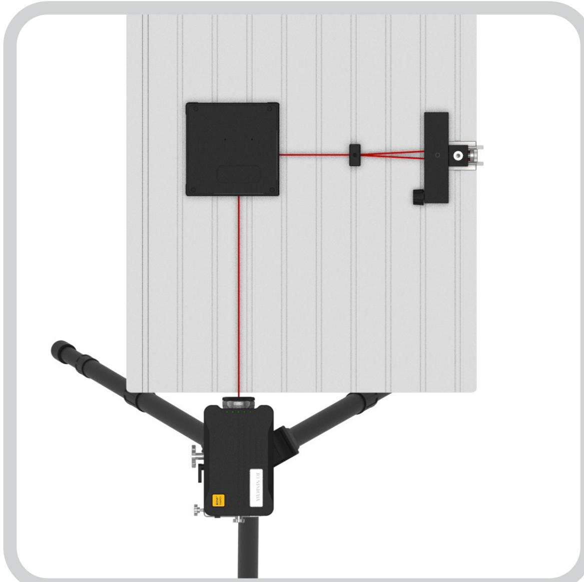
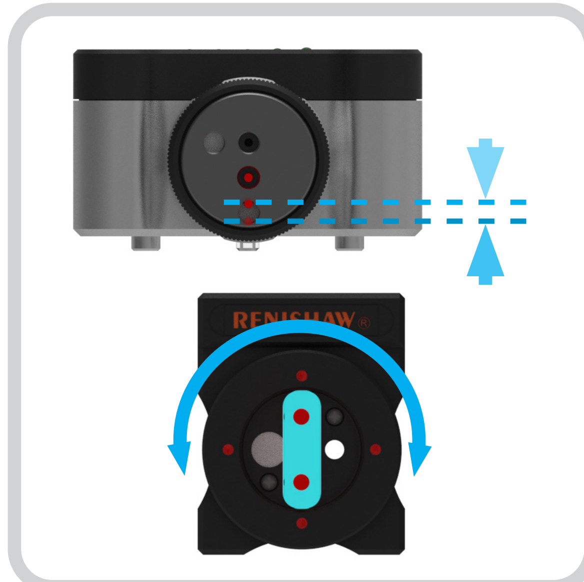
Alignment for axis 2



Rotate the face of the straightness interferometer so that the beam passes through the upper side of the optic.



The beam will pass through the optical square as a single beam and then appear as two horizontally diverging beams after the straightness interferometer.



Rotate the straightness interferometer until the two beams overlap on the face of the straightness shutter.

Alignment for axis 2

Rotate the black bezel of the straightness shutter until the large apertures are open.

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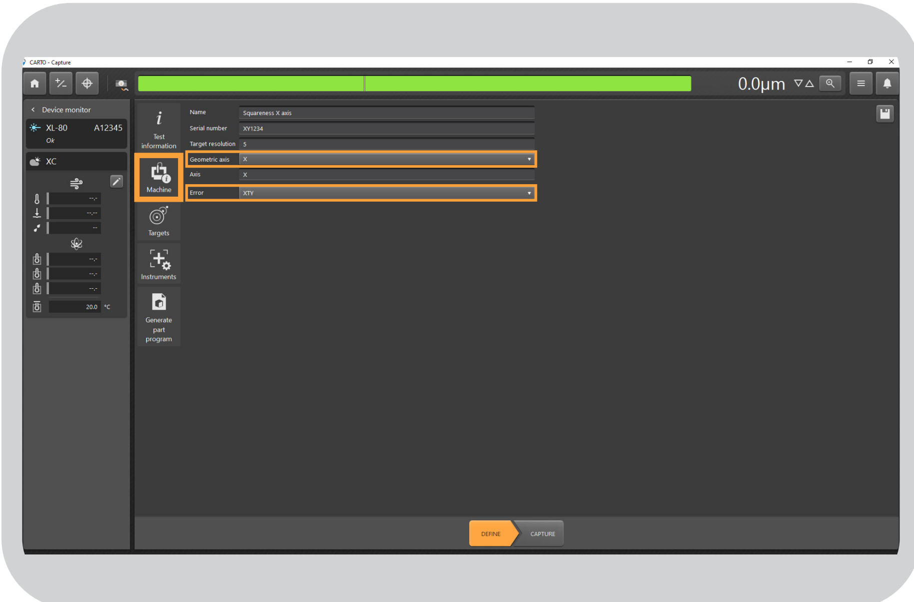
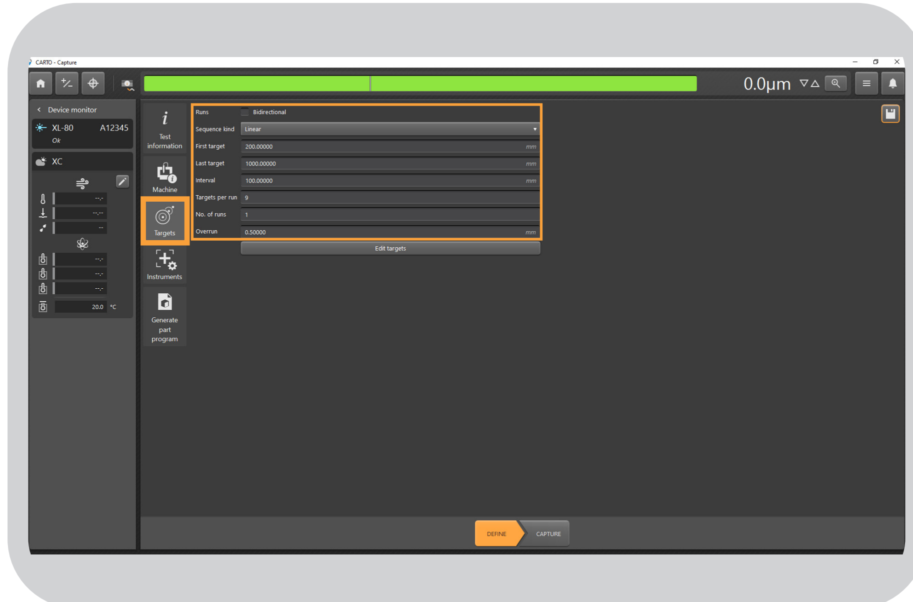
Axis 2 data capture



In Capture select the ‘Define’ tab, select ‘Machine’ and change the ‘Geometric axis’ and ‘Error’ fields to match the machine.



Enter new targets for the second axis in the ‘Targets’ tab.

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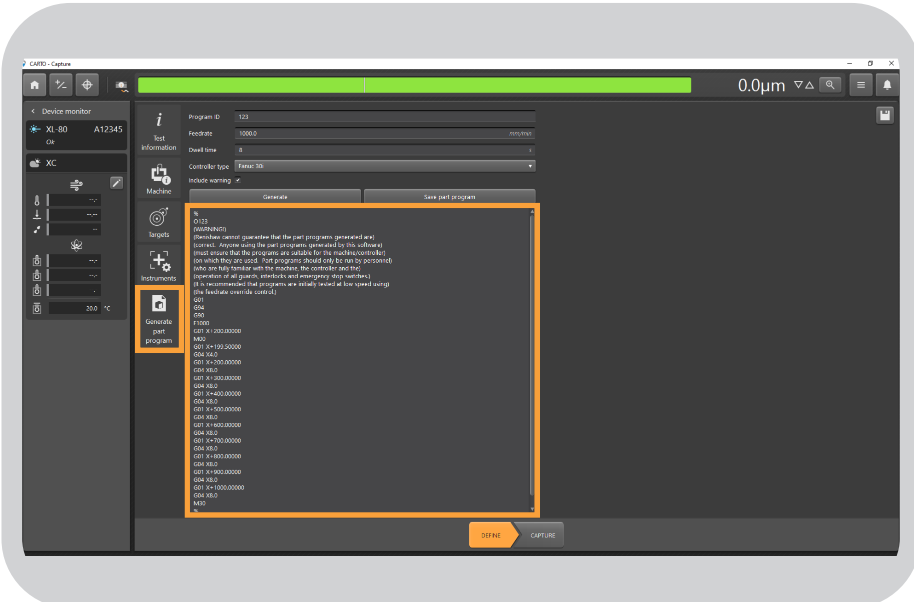
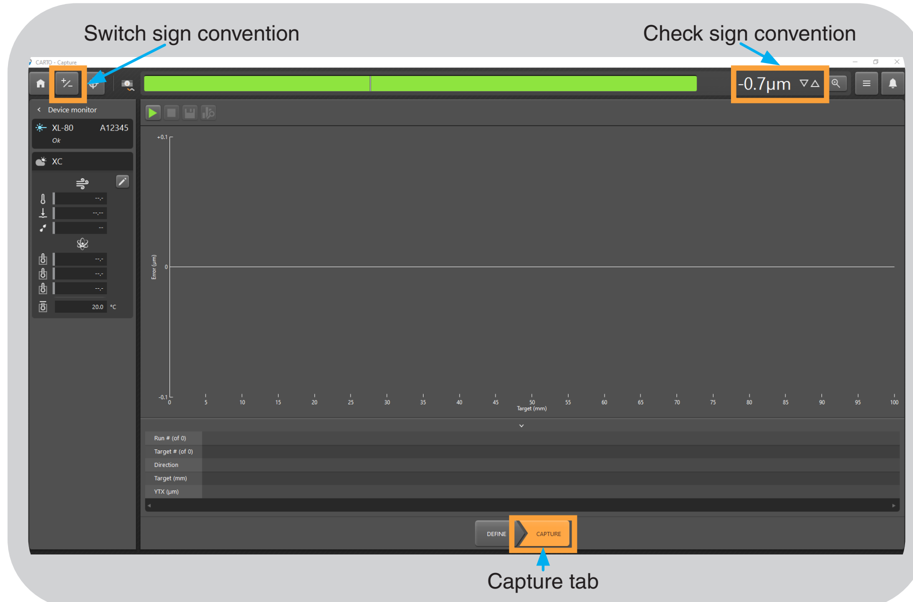
Axis 2 data capture



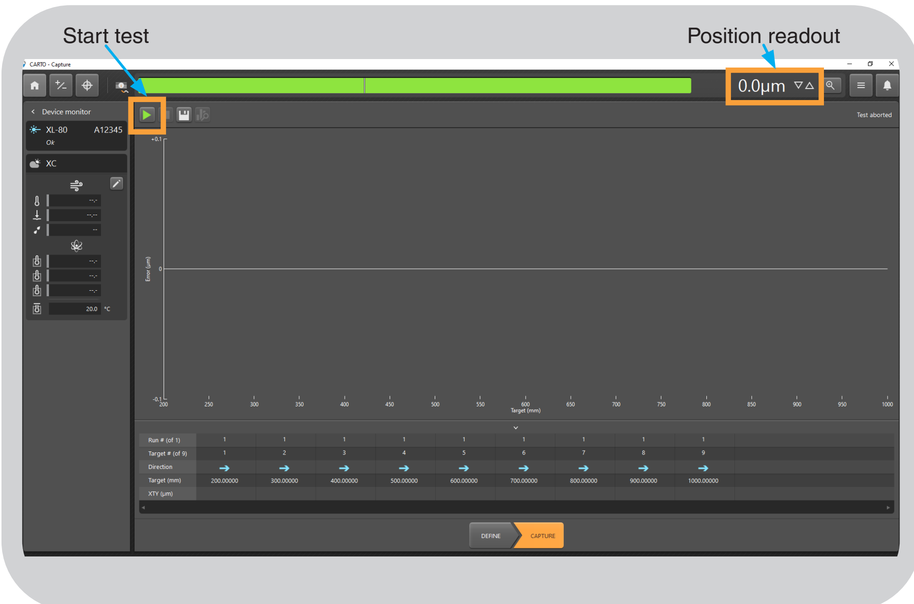


Create a new part program for the second axis in the ‘Part program’ tab and copy it to the machine controller.

Switch to the ‘Capture’ tab.

Check the sign convention for the optical configuration set-up (**See Appendix D**) and set the sign convention in the software. Press ‘Cycle start’ on the machine to drive to the first target position.

Axis 2 data capture



Select the correct part program in the controller and press ‘Cycle start’ to drive the machine to the first target. The machine will then pause using the ‘M00’ command in the program.

When the machine arrives at the first target, press ‘Start test’. The Capture software will then datum the position readout.

Press ‘Cycle start’ again on the machine. Use F9 on the keyboard or the middle mouse button to capture:

- the overrun position,
- the first target after the overrun,
- all target positions after (including any overruns),
- when the test is complete, press ‘Save’.

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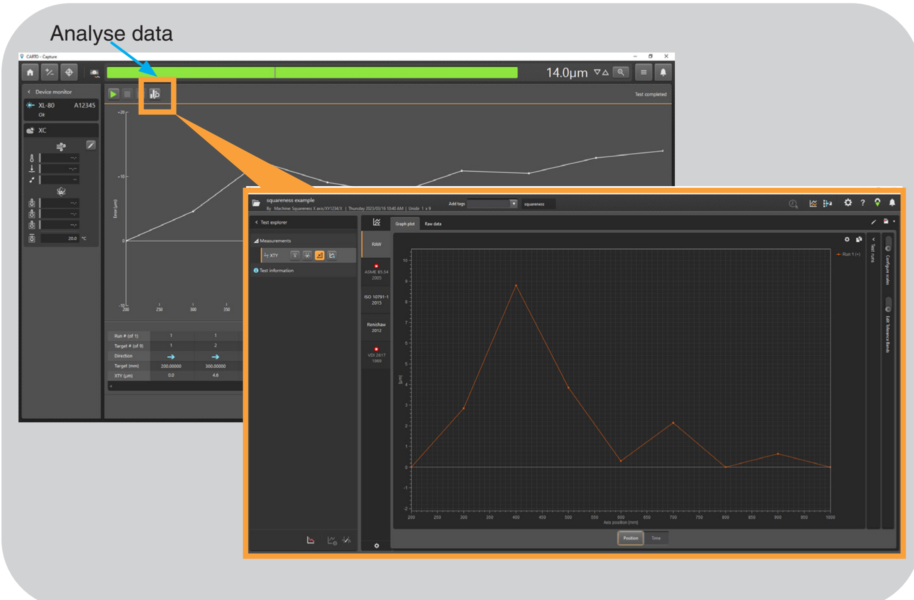
Axis 2 data capture

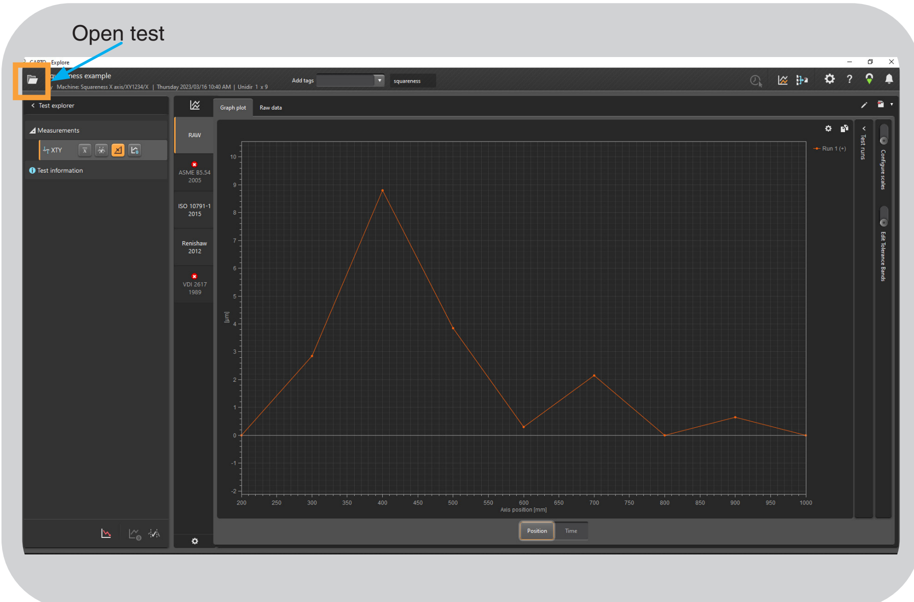


Data can be analysed by launching the Explore application.

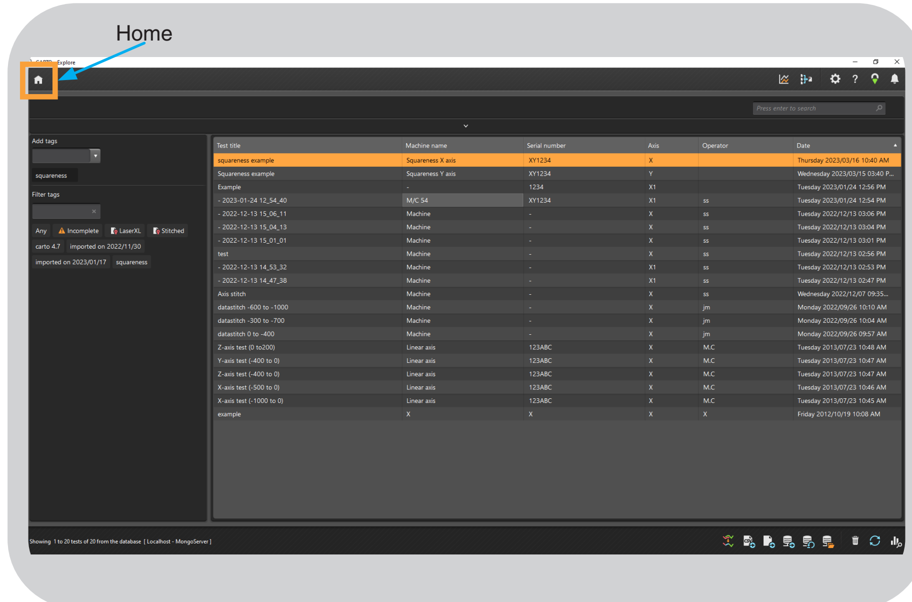
Visit the CARTO Explore user guide (Renishaw part no. F-9930-1008) for more information.

NOTE: At this stage the data is straightness only, not squareness.

Squareness analysis

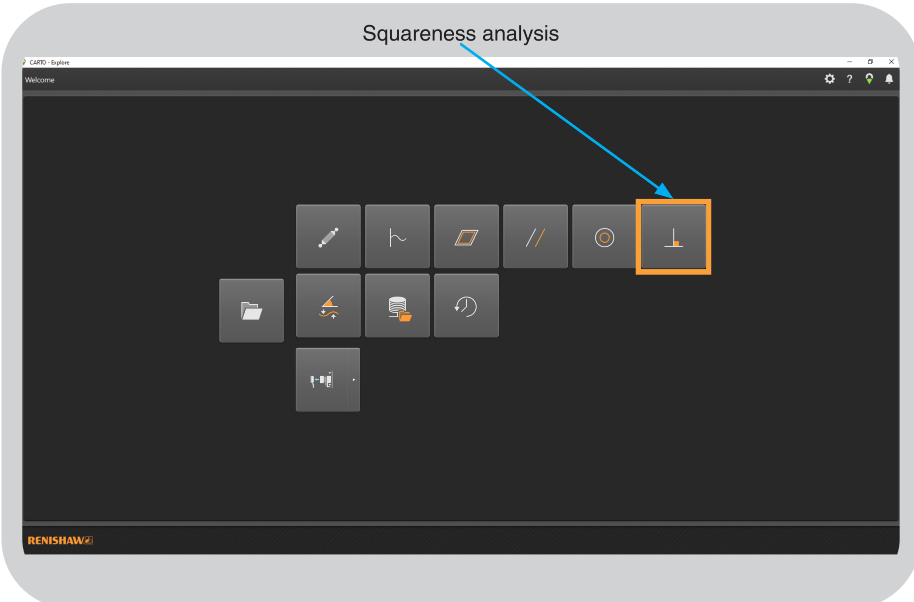


Select the 'Open test' button to navigate back to the test browser.

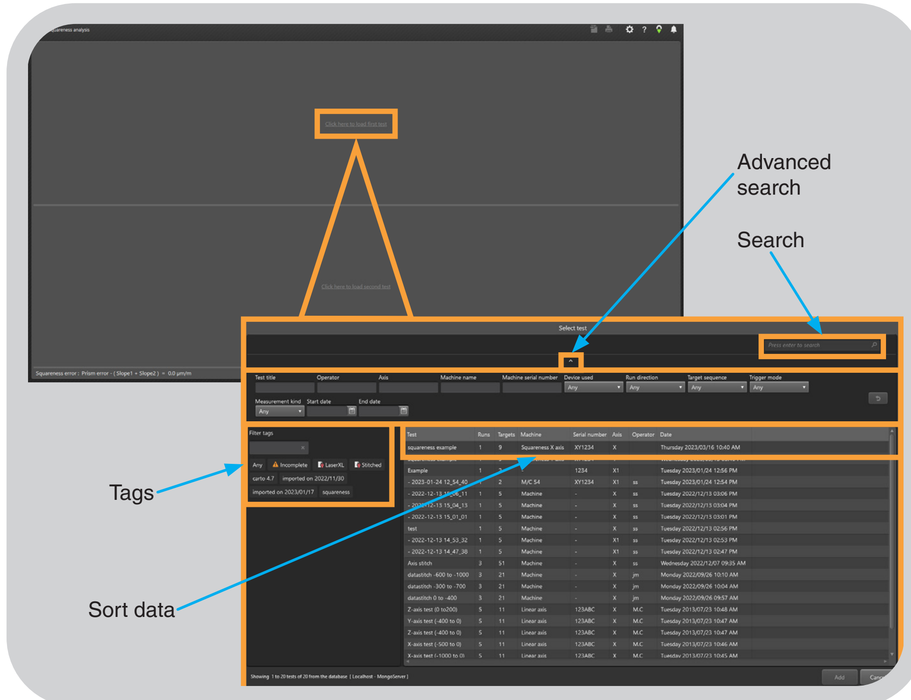


Press the 'Home' button to navigate back to the Explore landing page.

Squareness analysis



Select 'Squareness analysis'.



Browse to load the first test. To help filter tests within the database:

- use the search box,
- use the advanced search panel
- sort data by date or title
- select tags if they have been assigned to data

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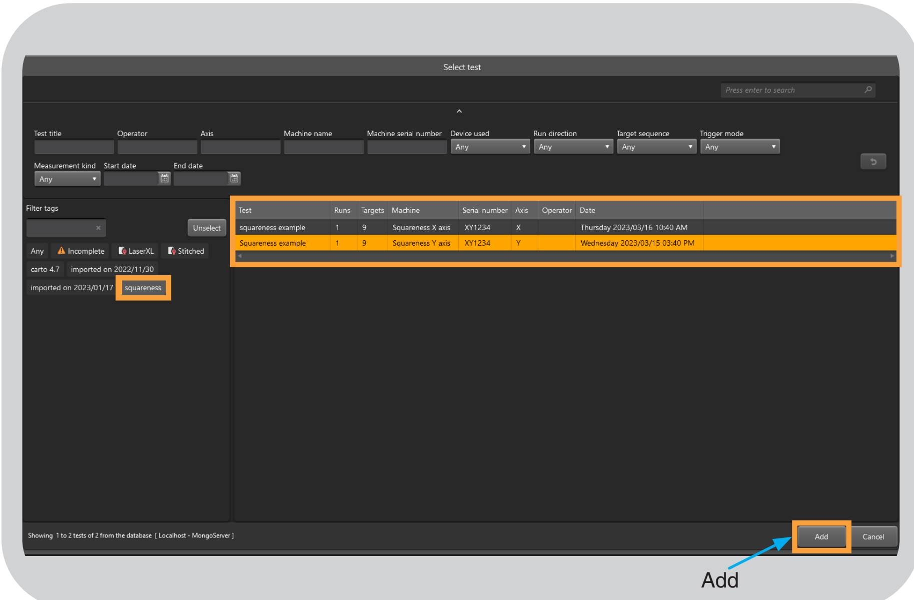
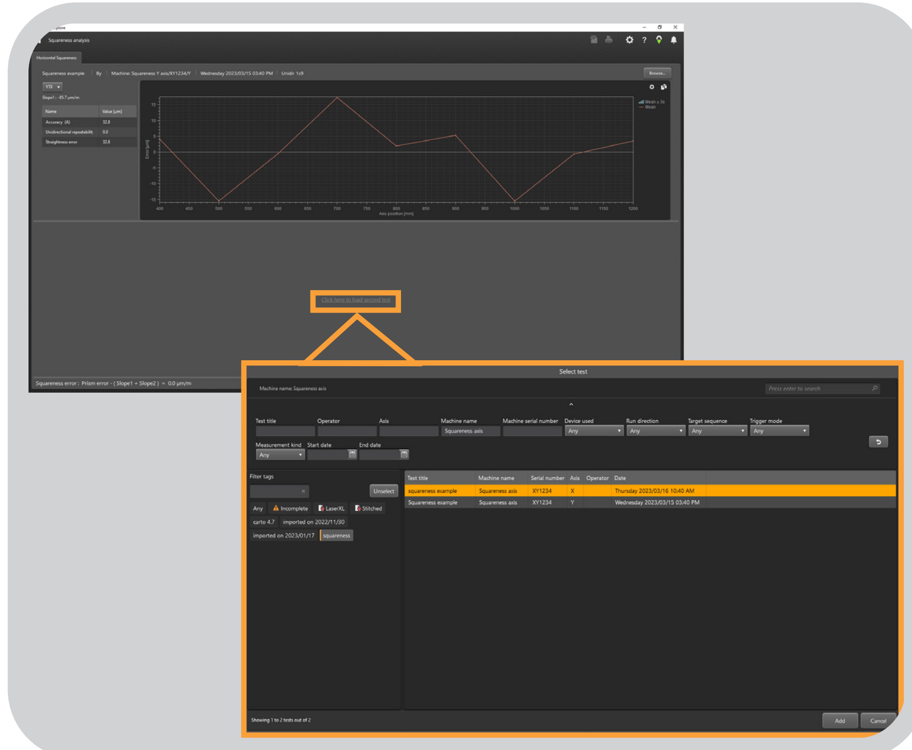
Squareness analysis



Select the test and press ‘Add’.

NOTE: in the example a tag has been used to filter data.

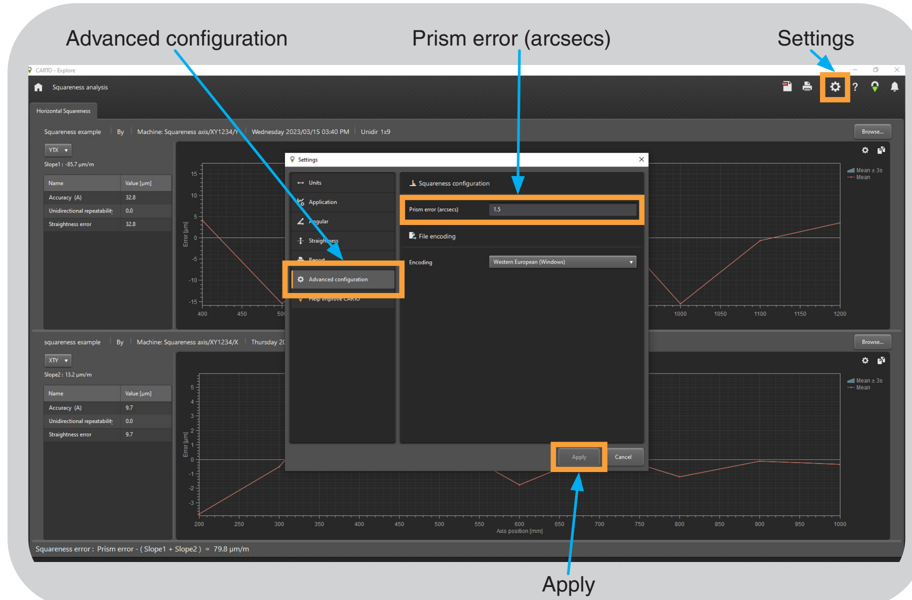


Select and add the second axis test data.

Squareness analysis

When the second axis is added the squareness error is displayed at the bottom left of the application.

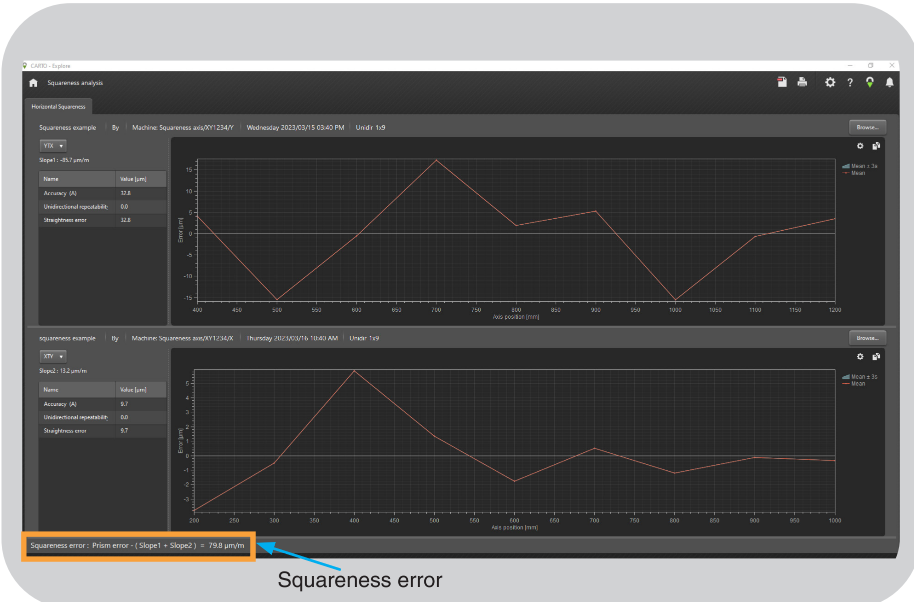
NOTE: The calculation states 'prism error' – the user must ensure that this has been added into the software on the first use of an optical square.



The prism error is printed onto the optical square on the inside of the optic and can be seen through the aperture window.

Navigate to 'Settings', 'Advanced configuration' and then enter the value in the 'Prism error (arcsecs)' field.

Squareness analysis

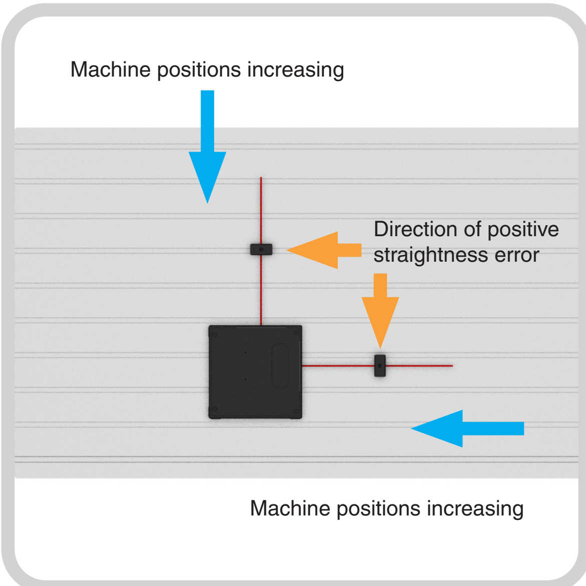


When the prism error has been added to the software application the squareness error will be updated.

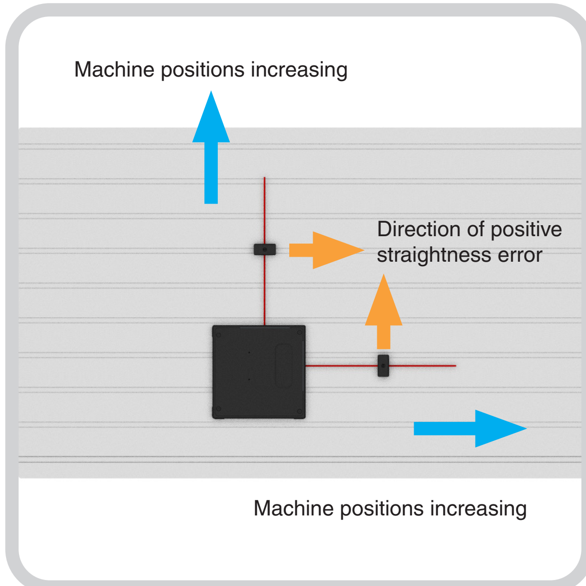
Appendix D – Sign convention

Before capturing data it is important to ensure that sign convention is set correctly. The two diagrams below show how the sign convention is defined within the software.

Alternative sign conventions can be used, but ensure that they are recorded at the time of measurement and maintained throughout the calculation of squareness errors.

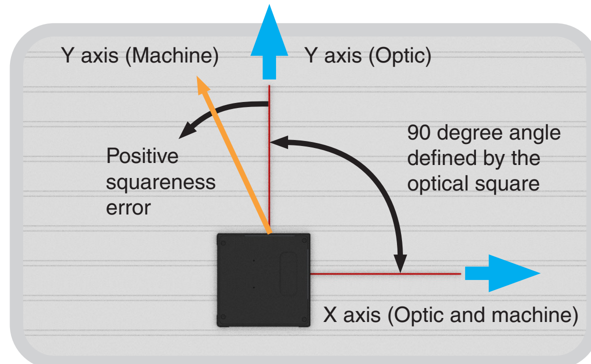


Target positions increasing towards the square.



Target positions increasing away from the square.

Using the sign convention methods in the first two images, the calculated squareness error will be positive if the angle between the two axes is greater than 90 degrees (the third image).



Before taking readings, confirm that the sign convention is correct. Gently push the straightness interferometer in the specified direction of a positive error, then confirm that the software is increasing in a positive value.

If it does not, then use the +/- button on the toolbar of the software to change the sign convention.

CAUTION: If the straightness reflector is the moving optic, the rule is reversed. When pushing on the straightness interferometer in a positive direction, the error should be set to read negative in the software.

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