User guide
F-9908-0683-02-A

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XL laser system user guide

Legal information

Disclaimer

Renishaw has made considerable efforts to ensure the content of this document is correct at the date of publication but makes no warranties or representations regarding the content. Renishaw excludes liability, howsoever arising, for any inaccuracies in this document.

Renishaw reserves the right to make changes to this document and to the product described herein without obligation to notify any person of such changes.

Warranty

Equipment requiring attention under warranty must be returned to your equipment supplier.

Unless otherwise specifically agreed in writing between you and Renishaw, if you purchased the equipment from a Renishaw company, the warranty provisions contained in Renishaw's CONDITIONS OF SALE apply. You should consult these conditions in order to find out the details of your warranty but, in summary, the main exclusions from the warranty are if the equipment has been:

- neglected, mishandled or inappropriately used; or
- modified or altered in any way except with the prior written agreement of Renishaw.

If you purchased the equipment from any other supplier, you should contact them to find out what repairs are covered by their warranty.

Trade marks

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Legal information

International regulations and conformance

EC compliance

Renishaw plc declares that the XL system complies with the applicable directives, standard and regulations. A copy of the full EC Declaration of Conformity is available upon request.

In compliance with BS EN 61010-1:2010 the product is safe to use in the following environmental conditions:

- Indoor use only
- Altitude up to 2000 m
- Maximum relative humidity (non-condensing) of 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C
- Pollution Degree 2

WEEE

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, please contact your local waste disposal service or Renishaw distributor.

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

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.

RoHS compliance

Compliant with EC directive 2011/65/EU (RoHS).

Legal information

USA and Canadian regulations

FCC

Information to the user (47CFR:2001 part 15.19)

This device complies with Part 15 of the FCC rules. Operation is subject to the following conditions:
This device may not cause harmful interference.
This device must accept any interference received, including interference that may cause undesired operation.

Information to the user (47CFR:2001 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.

Information to the user (47CFR:2001 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:2001 part 15.27)

The user is also cautioned that any peripheral device installed with this equipment, such as a computer, must be connected with a high-quality shielded cable to ensure compliance with FCC limits.

Canada – Industry Canada (IC)

This device complies with RSS 210 of Industry Canada. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of this device.

L'utilisation de ce dispositif est autorisée seulement aux conditions suivantes : (1) il ne doit pas produire d'interference et (2) l'utilisateur du dispositif doit étre prêt à accepter toute interference radioélectrique reçu, même si celle-ci est susceptible de compromettre le fonctionnement du dispositif.

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Contents

XL laser system – hardware

Contents

XL laser system – applications

Safety information

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

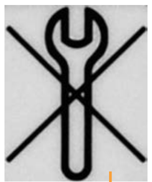
Ensure that you read and understand the XL laser system user guide before using any XL laser system.

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.

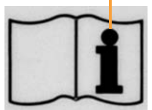
This should be carried out by qualified users (requiring machine competency, applicable technical knowledge and a trained risk assessor) with consideration for the safety of all personnel. The risks identified must be mitigated prior to using the product. The risk assessment should pay particular attention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

Safety labelling

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



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.



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

Mechanical safety

- When setting up and mounting the XL laser system, beware of pinch and/or crush hazards that may be created e.g. due to magnetic mounting bases or the universal tripod.
- Beware of trip hazards that may be created when using the XL laser system. e.g. 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.

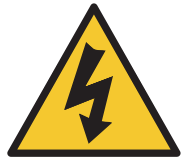
FDA compliance (USA) – complies with 21CFR1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated 24 June 2007.

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

Do not pick up the XL laser by the shutter. 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 this power supply unit can be found here.



- Do not use or handle the power supply unit if it comes into contact with fluids, e.g. coolant or 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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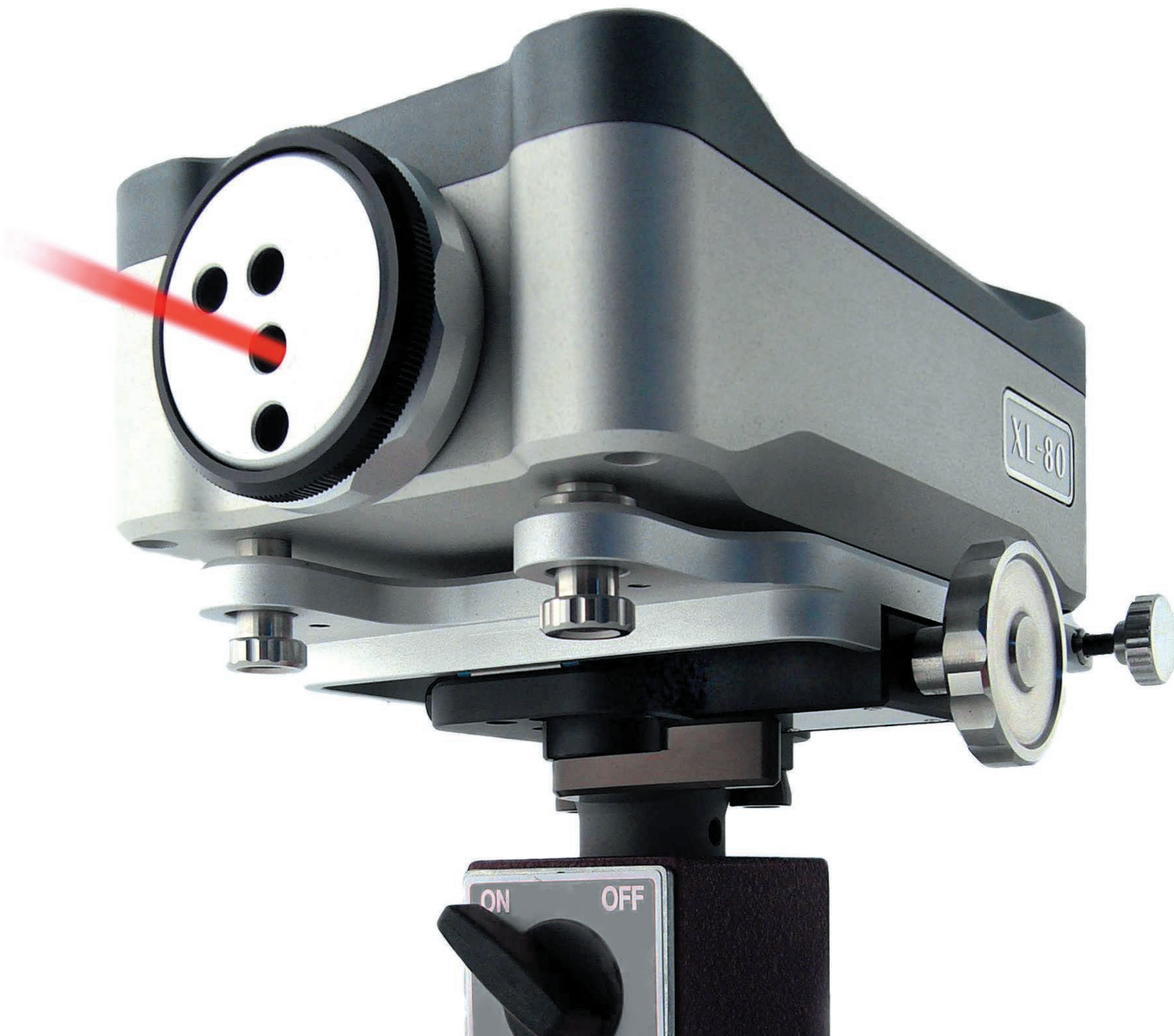
XL-80 hardware



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.

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).

XL-80Q may have export control restrictions in your region. Please contact your local Renishaw subsidiary for further information.

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	3	Shutter
2	Signal strength LEDs		

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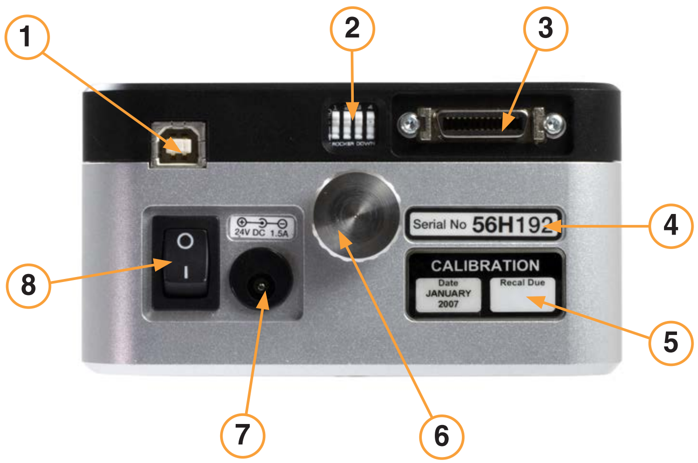
XL laser controls and indicators



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

XC-80 environmental compensator

The XL laser system specified accuracy for interferometric 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, therefore, the measurement readings taken.

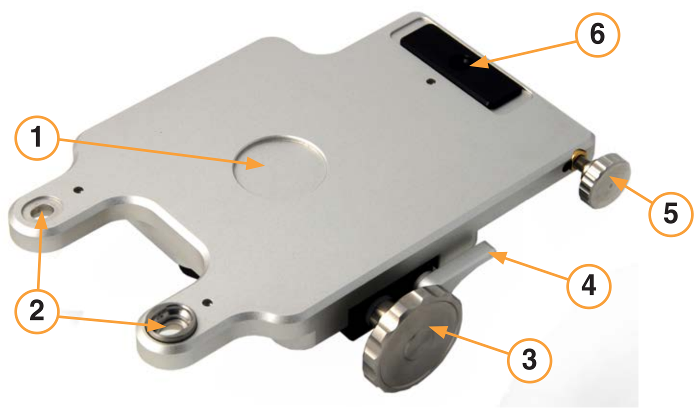
The XC-80 environmental compensator and it's sensors very accurately measure the environmental conditions and compensate the wavelength of the laser beam for variations in air temperature, air pressure and relative humidity.

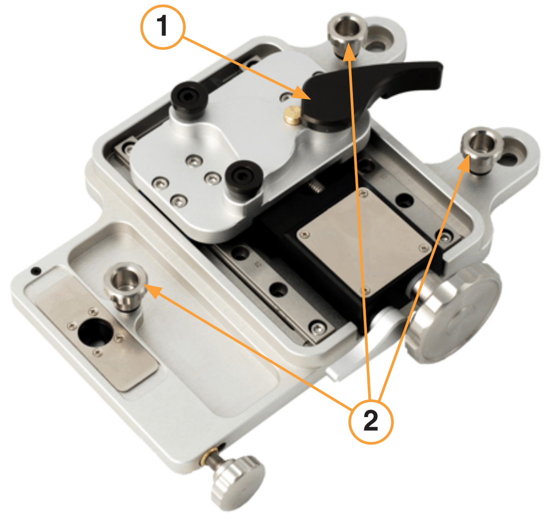
Note: For full details on XC-80 operation and specification please refer to XC-80 user guide.

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.

The stage is designed to provide yaw and translation adjustment to enable easy alignment.





1	Recess for bubble level	4	Quick translation lever
2	Recesses for laser front feet	5	Fine yaw control
3	Fine translation control	6	Recess for laser rear foot

1	Stage release lever
2	Thumb screws x 3

Universal tripod

The tripod is designed to provide a stable mounting for the XL laser and allow the height to be adjusted.

1	Stage adaptor	4	Centre column
2	Height adjustment crank	5	Leg extension locks
3	Leg angle locks	6	Rubber feet

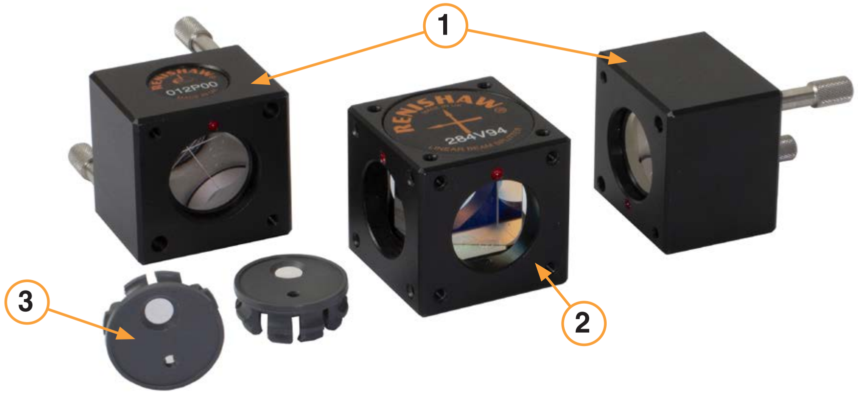
Bubble level

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

Linear measurement optics

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

The linear displacement is measured by the difference between the interferometer and retro-reflector. The targets are designed to mount directly onto the optics to improve the alignment process.



1	Linear reflectors x 2
2	Beam splitter
3	Targets x 2

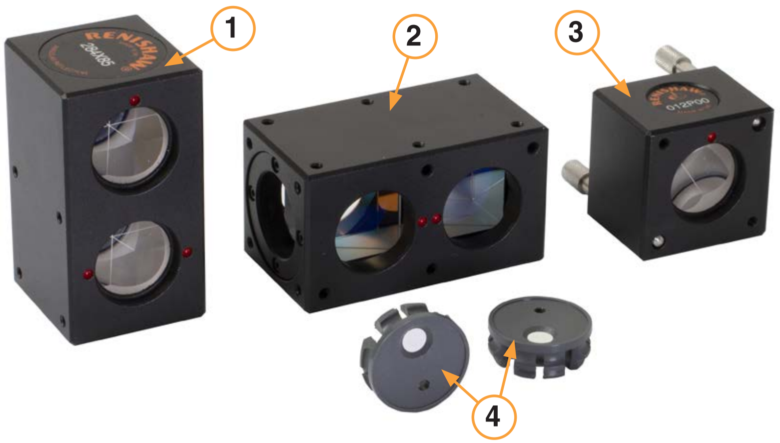
Angular measurement optics

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 retro-reflector.

1	Angular reflector
2	Angular interferometer
3	Targets x 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	3	Linear reflector
2	Angular interferometer	4	Targets x 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 has been designed so that different measurement optics can easily be interchanged without the need to realign the XL laser.

1	Mounting pillars x 3	3	Clamp blocks x 2
2	Base plate x 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 between 1 m to 30 m.

1	Straightness reflector
2	Straightness interferometer

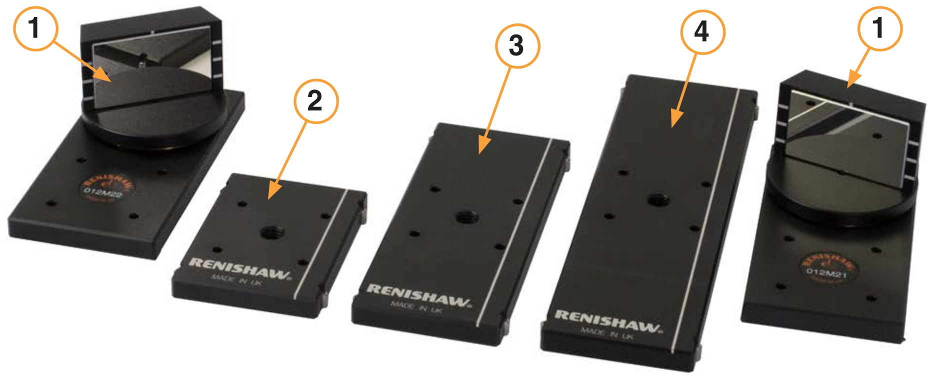
Note: Accessories are required when measuring vertical straightness in a horizontal axis, or straightness in a vertical axis of a machine:

- Straightness shutter
- Large retroreflector
- Straightness base
- LS350 laser beam steerering optic
- Fixed turning mirror
- Adjustable 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. You will also need a straight edge as long as the longest measurement line (this is not supplied in the kit).



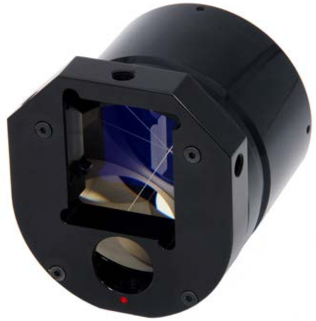
1	Turning mirrors x 2	3	Flatness base (100 mm)
2	Flatness base (50 mm)	4	Flatness base (150 mm)

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 axis squareness (perpendicularity). It must be used in conjunction with the straightness measurement optics and also, when one axis is vertical, the adjustable turning mirror, straightness shutter and large retroreflector .

Large retroreflector



The large retro-reflector 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.

Adjustable 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°.

Swivel mirror

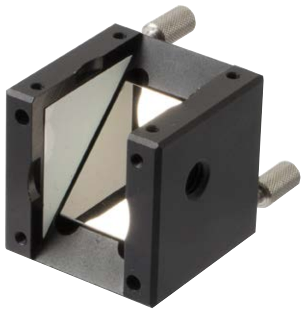
The swivel mirror is used to deflect the laser beam in the vertical plane through the range 0° to 135°.

The swivel mirror can be used in combination with linear, angular or straightness optics to allow measurements to be made 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 adjustable 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° (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.

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 steerer 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 retro-reflector and periscope returns the measurement beam from the periscope back 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

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	3	Mounting adaptor
2	Small retroreflector		

Pan and tilt adaptor kit

The pan and tilt adaptor is designed to allow flexible mounting of laser calibration equipment at angles between 0°- 90° 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.

System cases

Renishaw supplies storage cases in two sizes, designed 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 on pages 33 to 38.

Tripod cases

A heavy-duty fabric case allows 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 NTP*	633 nm (nominal)
Vacuum wavelength	See underside of laser
Minimum beam divergence	0.14 mrads
Laser frequency accuracy	±0.05 ppm (12 months) ±0.1 ppm (36 months)
Recommended recalibration period	36 months
Preheat time	Approximately 5 minutes
Outputs	USB 2 compliant Auxiliary output
Operating temperature	0 - 40 °C
Tolerable ambient temperature change once stabilised	± 10 °C
Operating humidity	0 - 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* CO_2	

Specifications

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

Power supply unit	
Input voltage	100 to 240 V ±10%
Input frequency	47 to 63 Hz
Output voltage	24 V ±2%
Maximum output current	1.5 A
Safety standard	EN (IEC) 60950

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 degrees
Yaw range	±1.5 degrees
Horizontal translation range	72 mm

Tripod	
Positioning height range of laser when mounted on top of tripod	0.5 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 µad*
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 to 4.0 m
	Long range	1 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:
M = measurement distance in metres *% = percentage of displayed value*
† subject to environmental conditions

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 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 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 to 10 m

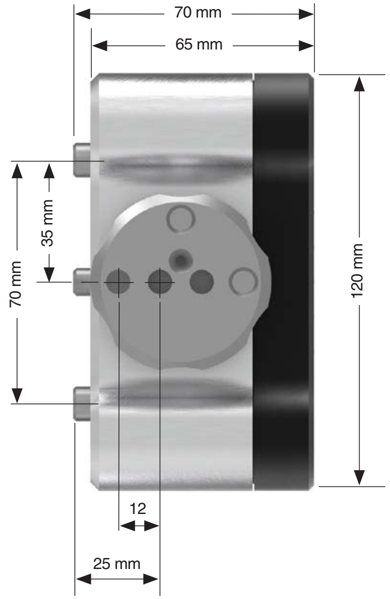
Small linear optics kit	
Maximum measurement range	4 m

Small retroreflector	
Size	15 mm diameter (standard retro-reflector = 38 mm x 37 mm x 30 mm)
Weight	<10 g (standard retro-reflector = 100 g)

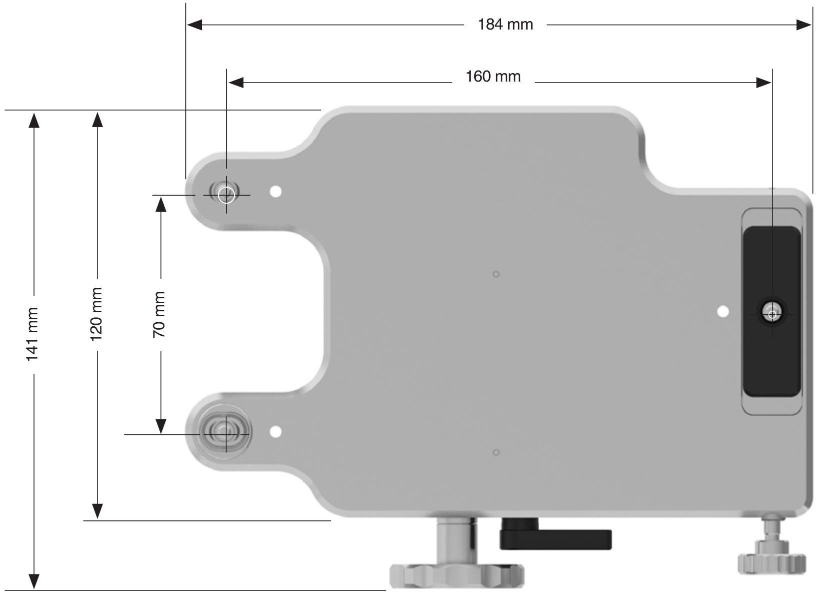
Dimensions and weights

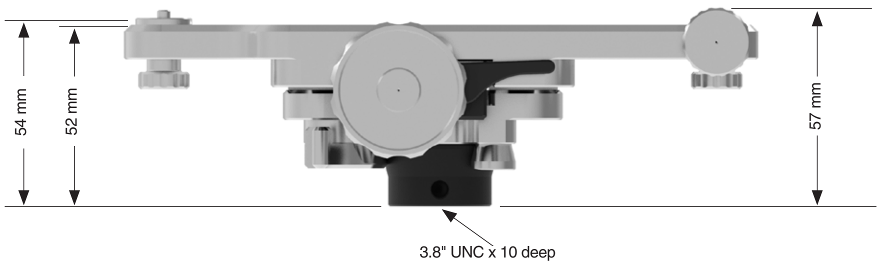
XL-80 laser

Weight	1.85 kg



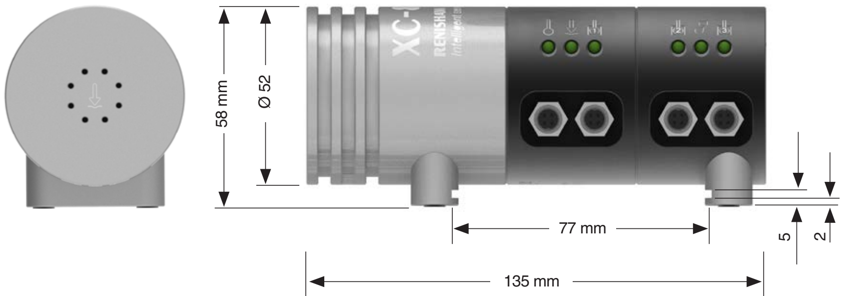
Tripod stage





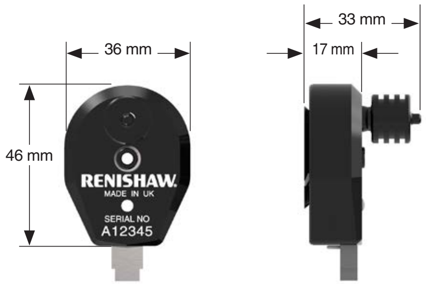
Weight	0.77 kg

XC environmental compensation



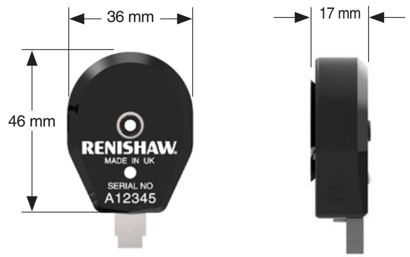
Weight	0.49 kg

Air temperature sensor



Weight	0.48 g

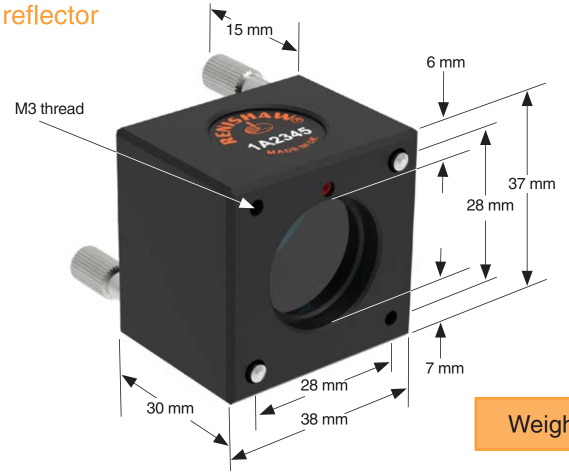
Material temperature sensor



Weight	0.45 g

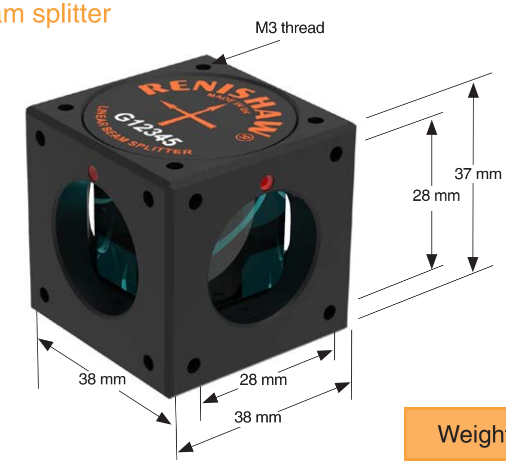
Linear measurement optics

Linear reflector



Weight	100 g

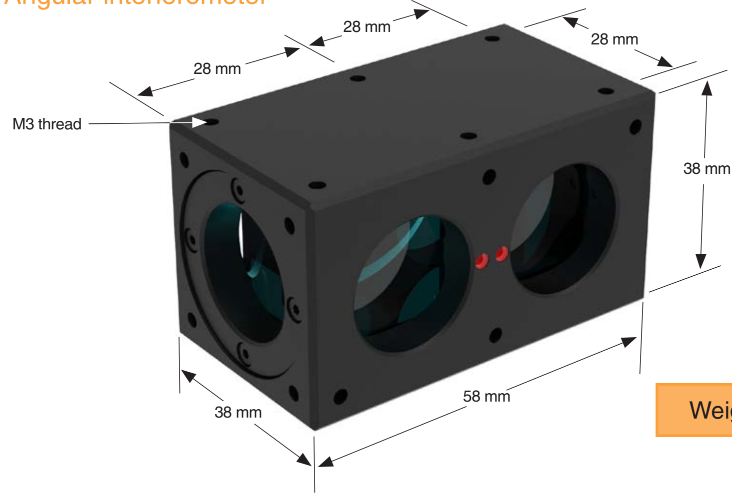
Linear beam splitter



Weight	81 g

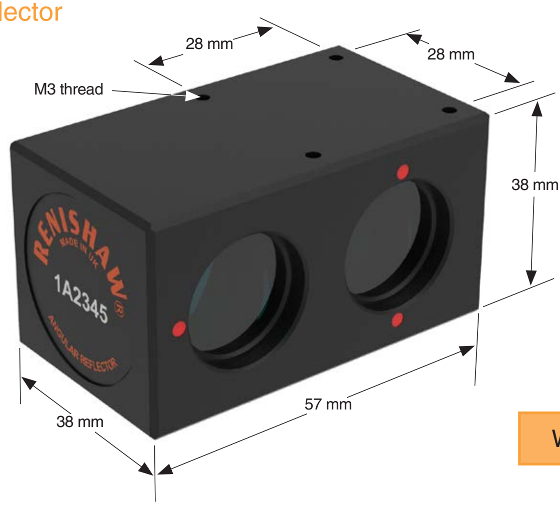
Angular measurement optics

Angular interferometer



Weight	240 g

Angular reflector



Weight	240 g

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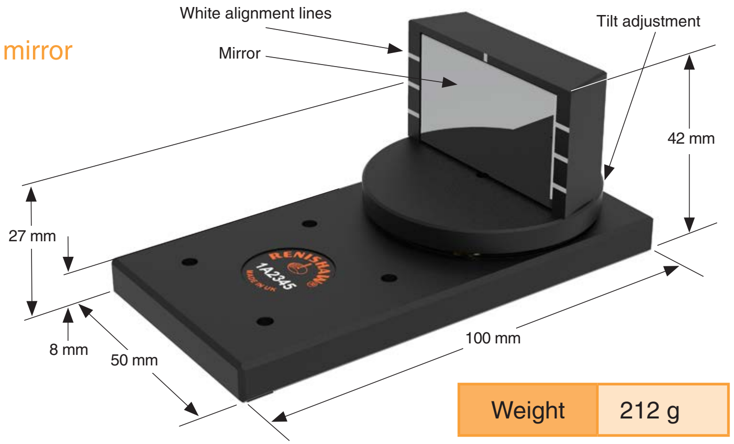
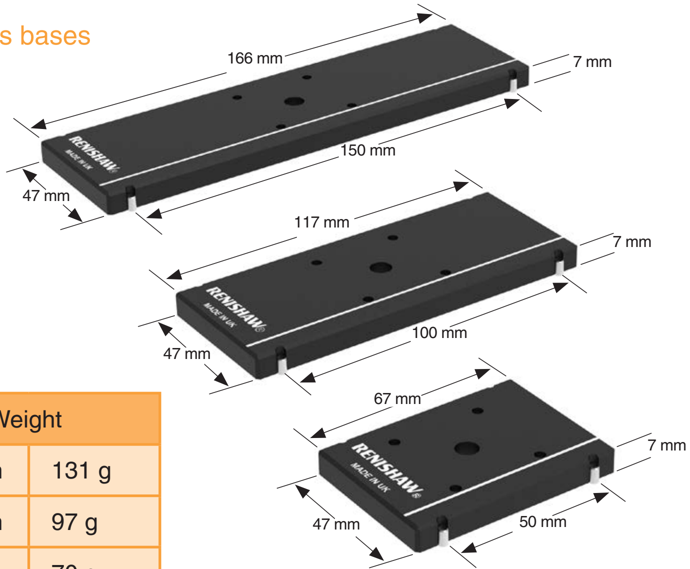
Flatness measurement optics

Flatness mirror



Weight	212 g

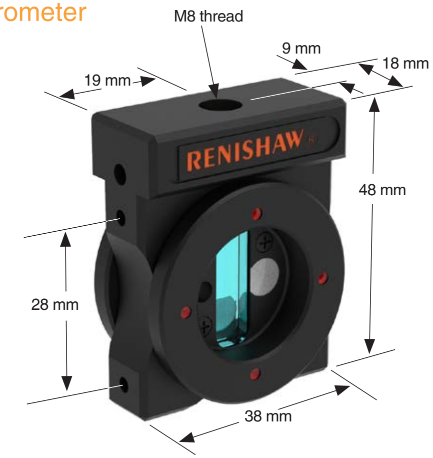
Flatness bases



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

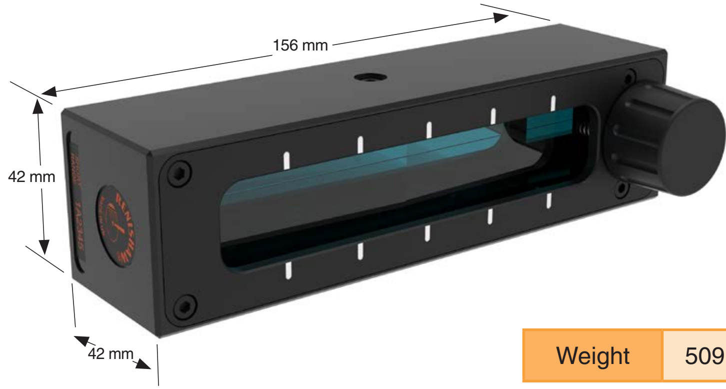
Straightness measurement optics (short and long range)

Straightness interferometer



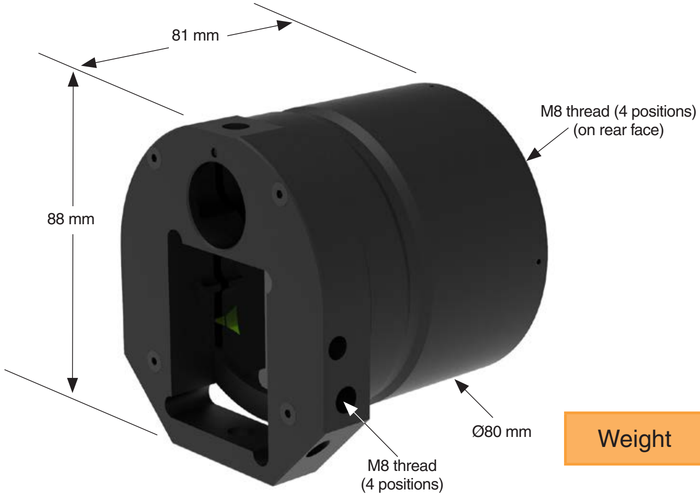
Weight	67 g

Straightness reflector



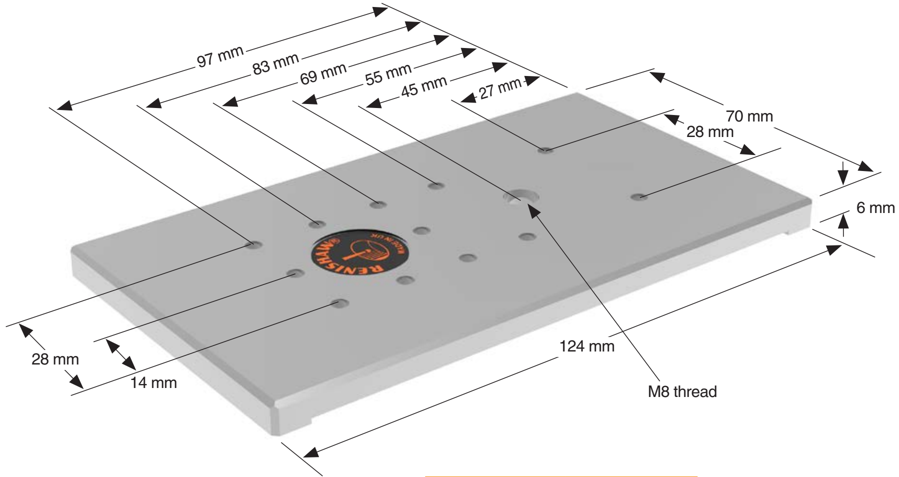
Weight	509 g

Large retroreflector



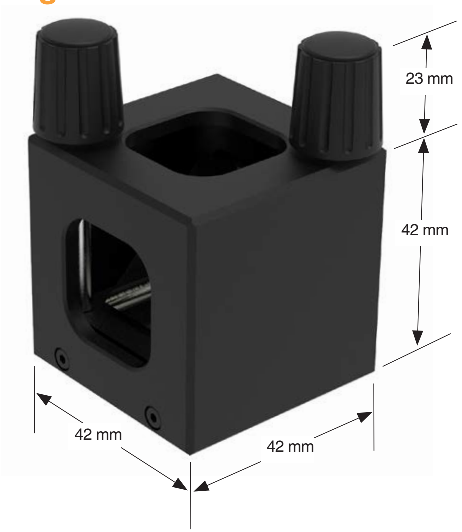
Weight	587 g

Straightness base



Weight	387 g

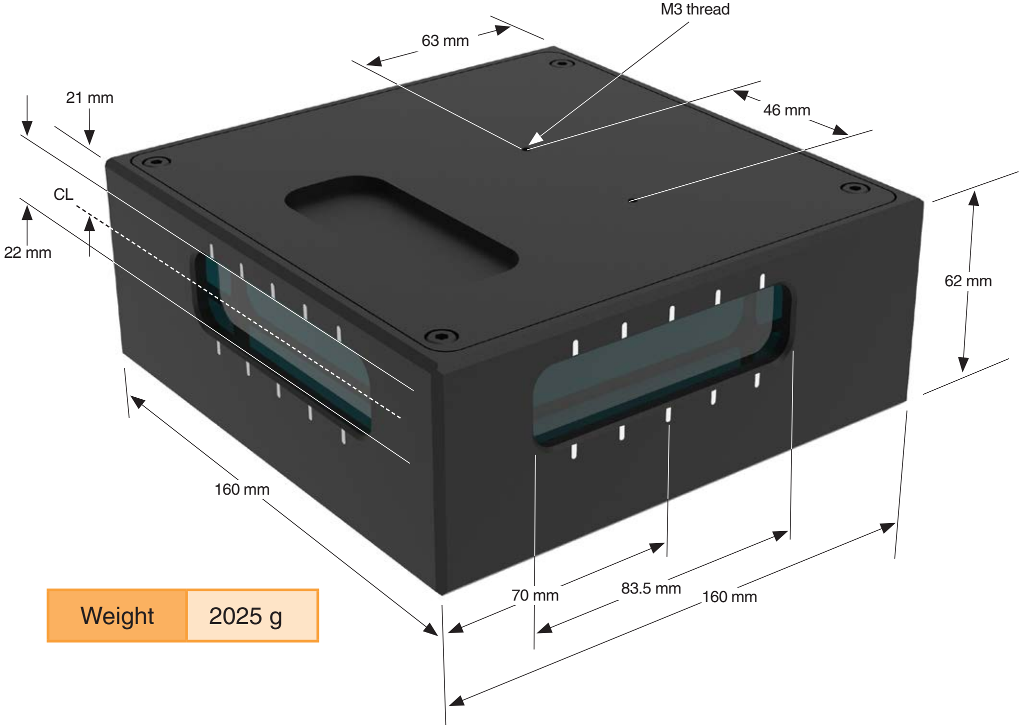
Adjustable turning mirror



Weight	123 g

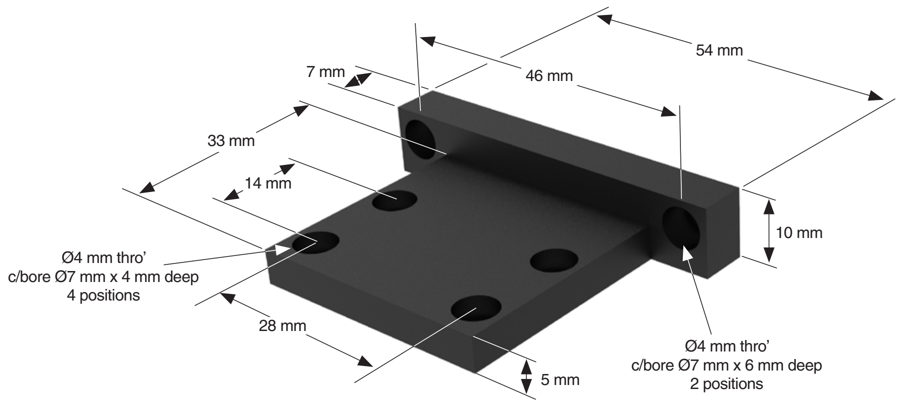
Squareness measurement optics

Optical square



Weight	2025 g

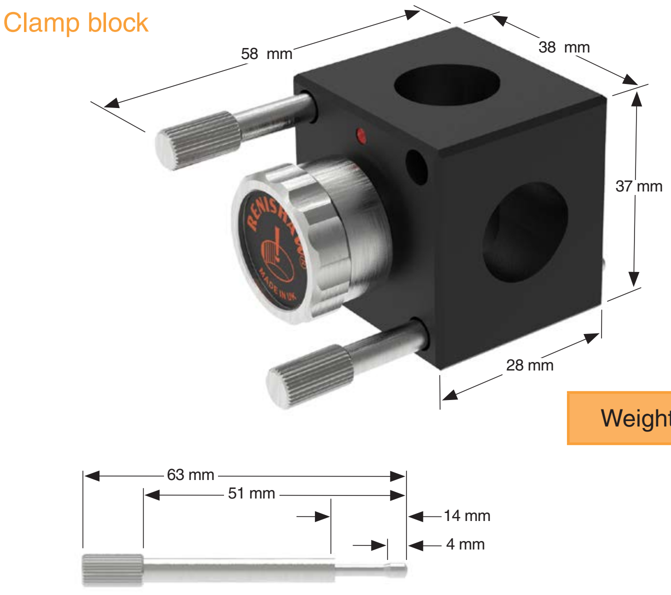
Bracket for optical square



Weight	50 g

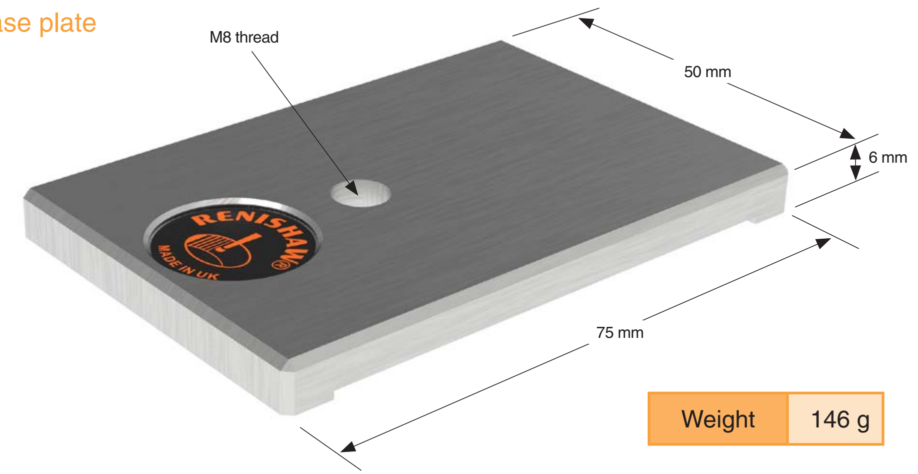
Optics mounting kit

Clamp block



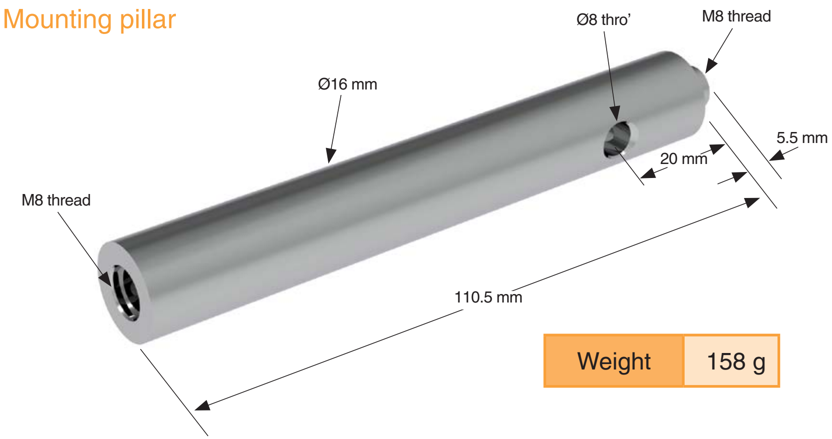
Weight	119 g

Base plate



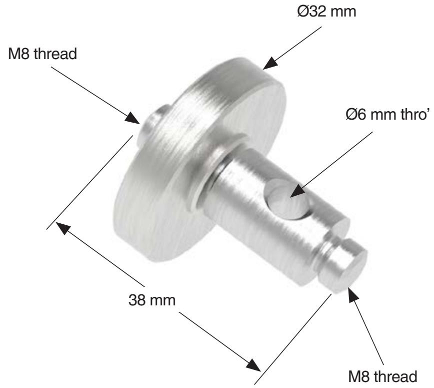
Weight	146 g

Mounting pillar



Weight	158 g

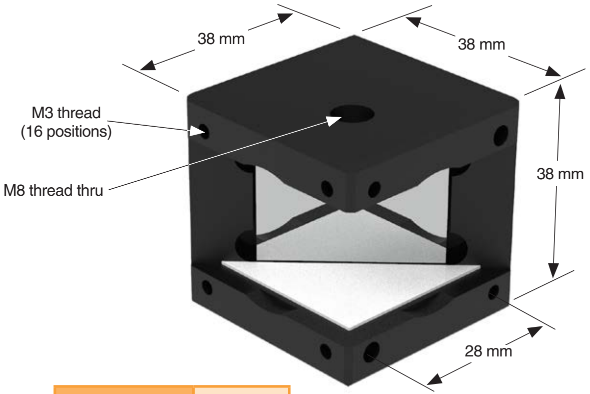
M8 adaptor



Weight	82 g

Accessories

Fixed turning mirror

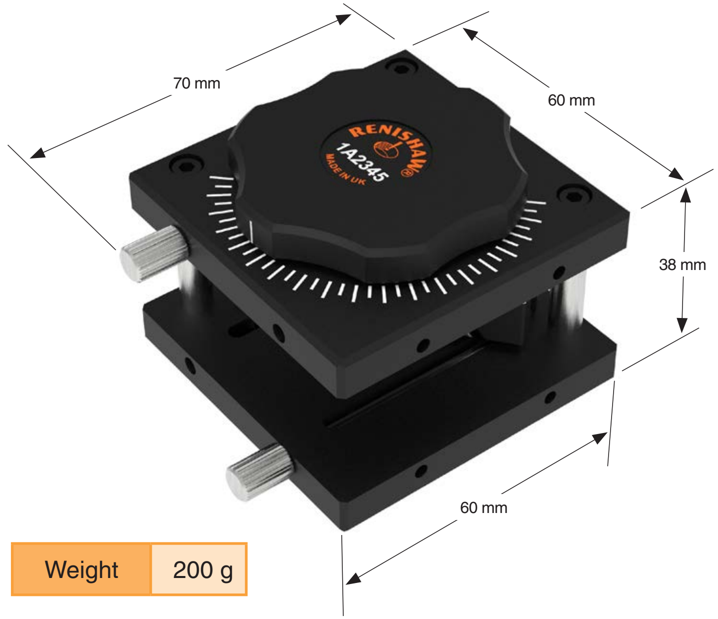


Weight	110 g

LS350 laser beam steering optic

Weight	140 g

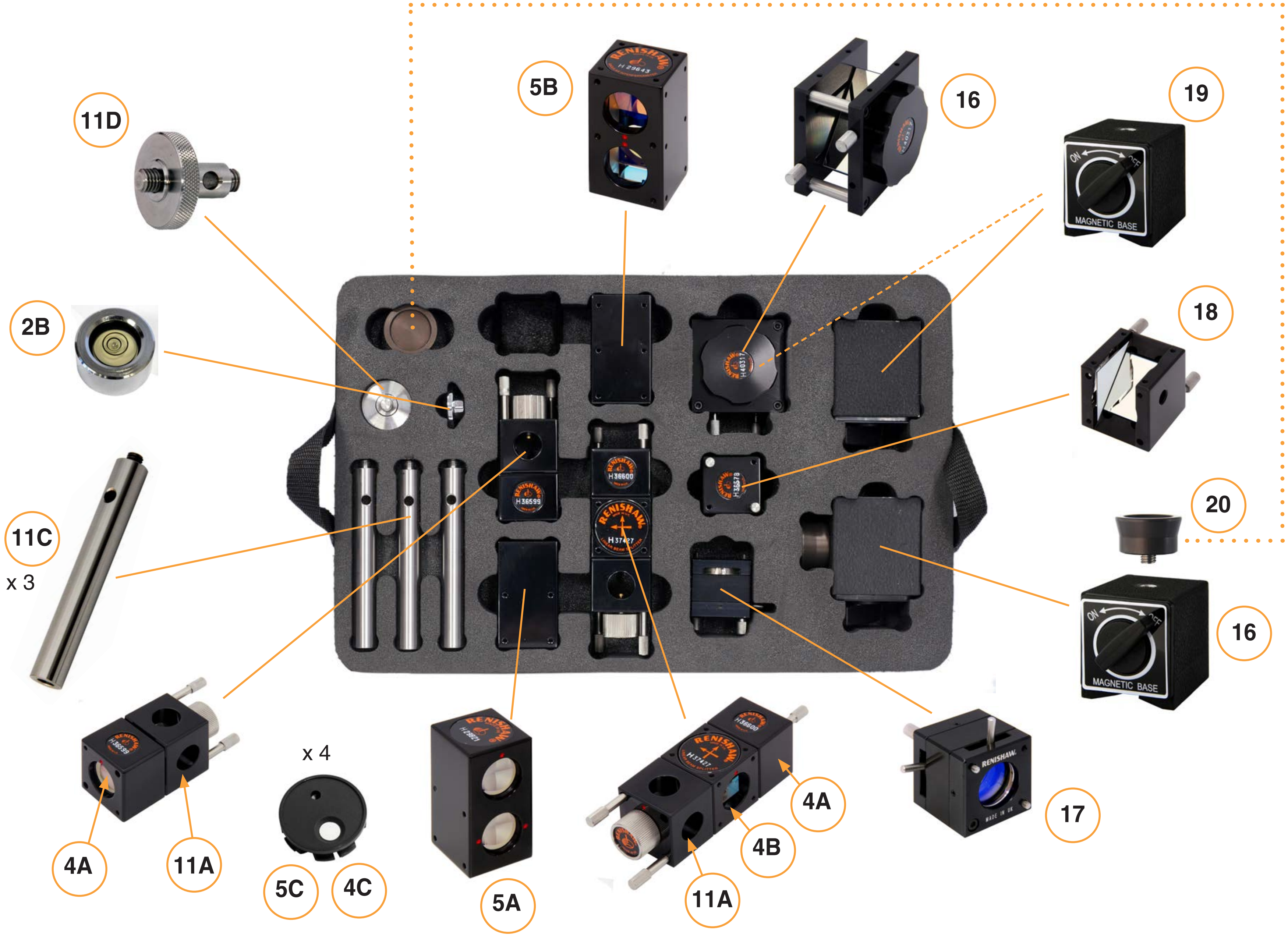
Swivel mirror



Weight	200 g

Full XL system case
(tray removed)

Full system case (tray)



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Full XL system contents

Index	Part number	Part name	Includes	Part number (qty 1)	Index
1	A-9908-0405	XL-80 laser kit	XL-80 laser		1A
			Universal power supply	A-9908-0299	1B
			USB cable	A-9908-0286	1C
			Laser software kit	A-9908-0201	not shown
			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 & cable	A-9908-0879	3B
			Air temperature sensor & 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 (qty 2)	A-8003-0219	4A
			Linear interferometer	A-8003-0557	4B
			Alignment target (qty 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 (qty 2)	A-8003-0478	5C
6	A-8003-0443	Straightness optics - short range (0-4 m)	Short range straightness reflector	A-8003-0615	6A
			Wollaston short range	A-8003-0393	6B
7	A-8003-0444	Straightness optics - long range (1-30 m)	Long range straightness reflector	A-8003-0620	7A
			Wollaston 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 (qty 4)		8C
			Hexagonal key		8E
9	A-8003-0442	Flatness measurement kit	Flatness mirror (qty 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

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Full XL system contents (additional items)

Index	Part number	Part name	Includes	Part number (qty 1)	Index
10	A-8003-4270	Long range linear accessory kit	Long range retroreflector	A-8003-2061	10A
			Periscope	A-8003-2039	10B
			Long range target	M-8003-2081	10C
			Clamp screw (qty 2)	M-8003-0221	10D
11	A-8003-0447	Optics mounting kit	Clamp block (qty 2)	A-8003-0262	11A
			Base plate (qty 2)	A-8003-0522	11B
			Mounting pillar (qty 3)	M-8003-0470	11C
			M8 adaptor	A-8003-0979	11D
12	A-8003-4209	Universal (straightness) shutter			12
13	A-8003-0560	Vertical turning mirror			13
14	A-8003-0604	Large straightness retro-reflector			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

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Base XL system case

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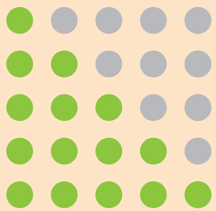
Base XL system case contents

Index	Part number	Part name	Includes	Part number (qty 1)	Index
1	A-9908-0405	XL-80 laser kit	XL-80 laser		1A
			Universal power supply	A-9908-0299	1B
			USB cable	A-9908-0286	1C
			Laser software kit	A-9908-0201	not shown
			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 (qty 2)	A-8003-0219	4A
			Linear interferometer	A-8003-0557	4B
			Alignment target (qty 2)	A-8003-0478	4C
5	A-8003-0441	Angular measurement optics	Angular interferometer	A-8003-0186	5A
			Angular reflector	A-8003-0181	5B
			Alignment target (qty 2)	A-8003-0478	5C
6	A-8003-0447	Optics mounting kit	Clamp block (qty 2)	A-8003-0262	6A
			Base plate (qty 2)	A-8003-0522	6B
			Mounting pillar (qty 3)	M-8003-0470	6C
			M8 adaptor	A-8003-0979	6D
7	A-8003-3072	Laser beam steerer			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 - measurement accuracy is reduced, danger of beam break occuring	• 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 Capture in XL mode

Beam strength LEDs

At the front of the top panel of the XL laser there are 5 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 will initially all turn amber. As the preheat sequence progresses, the LEDs will go out in turn, indicating how far through the sequence the laser has progressed. When the final amber LED goes out the LEDs will then switch to 'beam strength' mode.

2. Beam strength mode:
   When the laser is switched on and has stabilised, the 5 LEDs indicate the returned beam strength i.e. 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 system software, but are helpful when working away from the computer screen.

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

Laser status LED info

At the rear of the top panel of the XL laser there is a single LED. If this is illuminated red or amber after the laser has stabilised, this can indicate that the laser has become unstable.

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 amber		Pre-heat cycle	No action required
Solid green		Laser in stablised	Open Capture in XL mode

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 retro-reflector. 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, e.g stored in the boot of a car overnight in winter, and is then 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 will stabilise at a lower temperature than it would if it had been kept in the working environment. Thus 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 recalibration 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 the reason that 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 also show up accidental damage that you might have not been aware of. Renishaw's 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 expensive and bigger 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 XL laser has the calibration date indicated on a label on the rear of the unit.

Software reminders

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

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. You should keep it safe as it may be required to satisfy your own or your customers quality assurance requirements.

Duplicate documents can be supplied but there will be a charge for this service.

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. This enables you to see clearly 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 person.

The second page gives generic details of the test procedure, test environment, and applicable standards, all in accordance with requirements of 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 atmospheres.
- Store securely when not in use.

Cleaning recommendations

- Only use approved solvents for cleaning the optics: Methylated spirit and optical grade IPA only (methylated spirit is preferred to 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 beam reducer's optical surfaces is suspected, remove them from the housing for cleaning by undoing the four cap screws retaining the optics cartridge within the housing and then carefully inverting the unit to separate it from the housing.

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

Appendix A

Auxiliary I/O

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 I/O 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)	xxQDKxxxxx and xxSDKxxxxx
	Alpha wire	349xC
Analogue and remote trigger applications	Alpha wire	346xC

When constructing a cable, the cable's screen should be connected to the connector's body. If twisted pair cable is used, the RS422 quadrature signals should share the same twisted pair, i.e. A and A/, B and B/.DIP switch settings.

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.

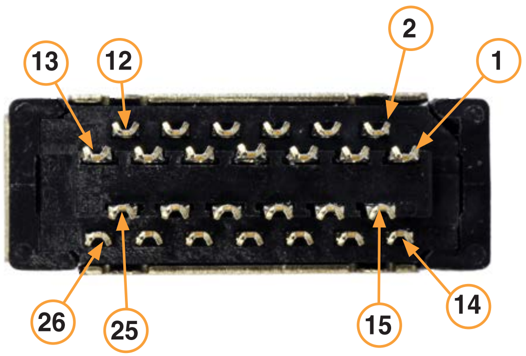
Switch number			DIP switch 2		DIP switch 3		DIP switch 4	
	Switch position	Quadrature settings	ON	OFF	ON	OFF	ON	OFF
DIP switch 1	ON	Analogue settings	Analogue gain (see table 2) †				Long range (high gain)	Short range (low gain)
	OFF (default)	Digital settings	10 nm quadrature resolution *	80 nm quadrature resolution *	Hysteresis on *	Hysteresis off *		

* Quadrature output is available as a factory set option
† Analogue 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

Auxiliary I/O connector



The table opposite 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
† Analogue 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, e.g. from a machine under test.

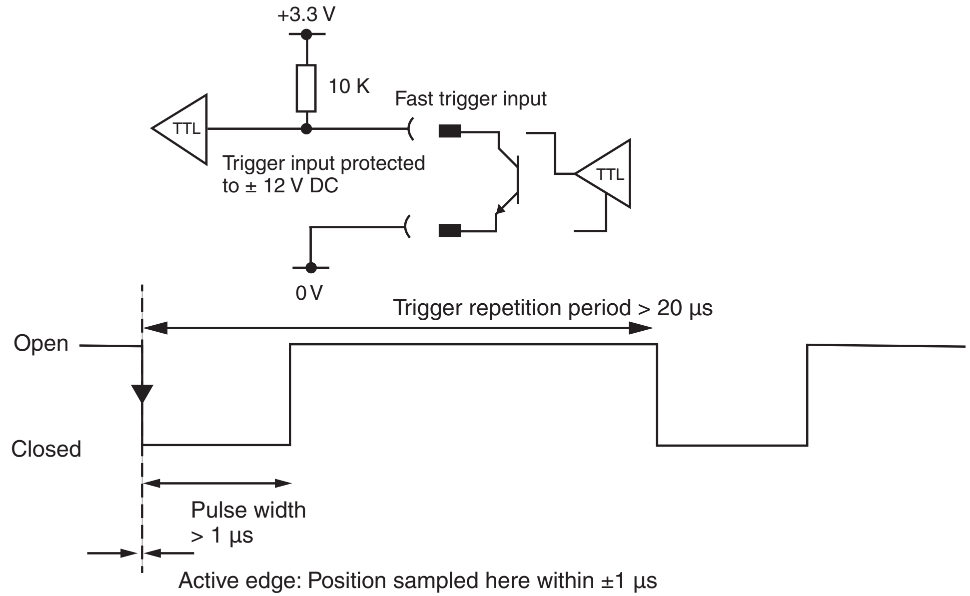
The trigger signal is input via the auxiliary I/O port on the rear panel of the XL laser. The XL laser supports two types of trigger signal - ‘slow trigger’ and ‘fast trigger’. These are accessed by two different pins on the auxiliary I/O connector.

Fast trigger

The fast trigger mode provides a high-speed hardware trigger facility with a short delay (< 1 µsec) 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 on next page.

Fast trigger specifications	
Active Edge	Falling
Minimum pulse width	1 µsec
Maximum trigger rate	50 kHz
Trigger delay	± 1 µsec
Maximum input voltage	± 12 V



Electrical interface for fast triggering

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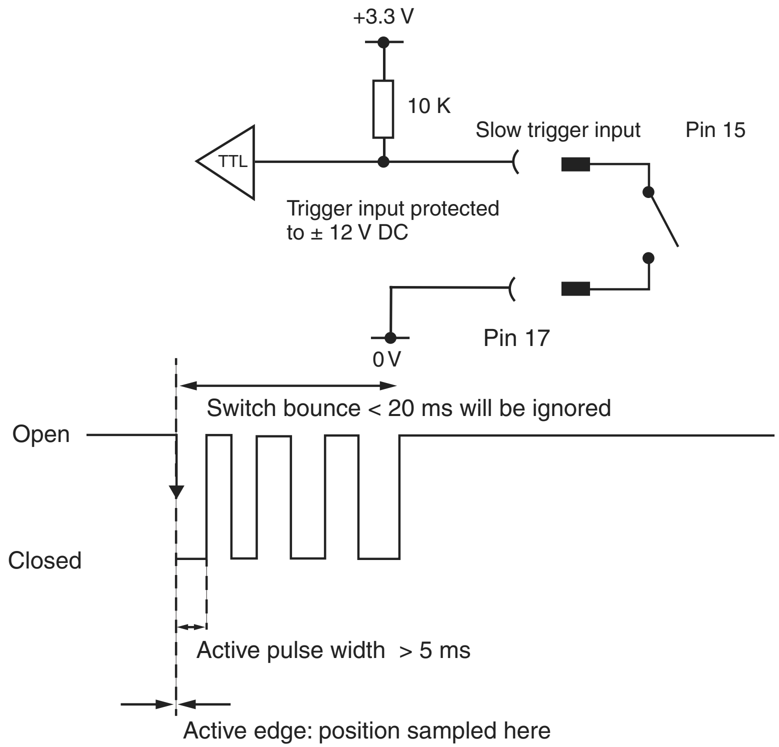
Slow trigger

This mode allows the XL laser to be 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



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.

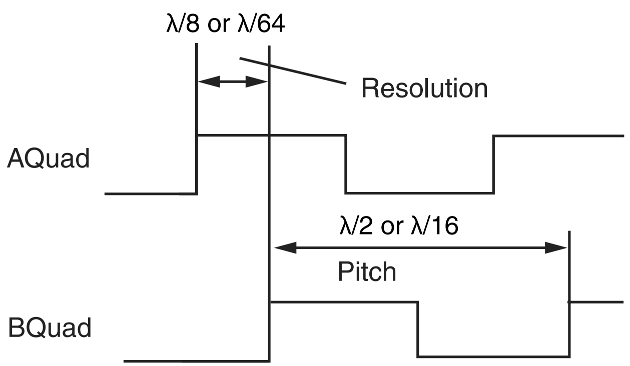
XL-80Q may have export control restrictions in your region. Please contact your local Renishaw subsidiary for further information.

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

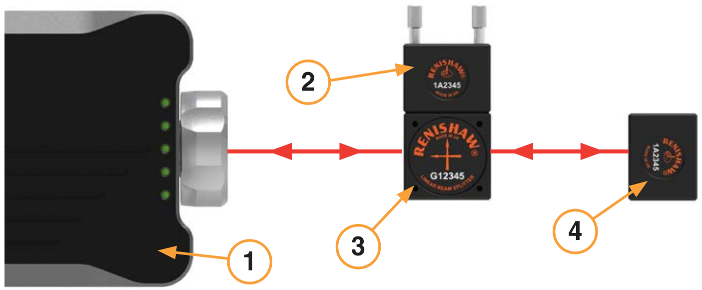
The 'A' QUAD 'B' signals are represented in diagram below.



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



Linear measurement optical setup

1	XL laser	3	Linear interferometer
2	Reference reflector	4	Measurement reflector

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

- For positive movement (measurement retro-reflector moving away from XL laser) A leads B.
- For negative movement (measurement retro-reflector moving toward XL laser) B leads A.

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. So the true accuracy of the transition (ignoring air refraction errors, see below) is given by:

Accuracy = ±(10 + Dv) nm

where v = velocity in m/sec

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

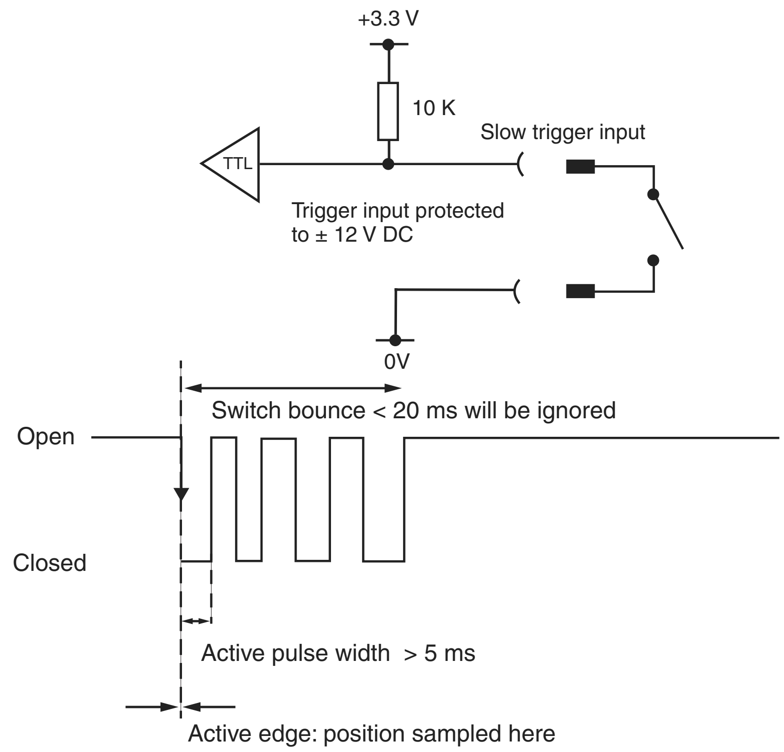
The quadrature outputs are not compensated for changes in the refractive index of air. Thus, the value will be subject to variation dependent on environmental conditions. See XL-80Q operation with RCU10.

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} × 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 (beambreak)

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

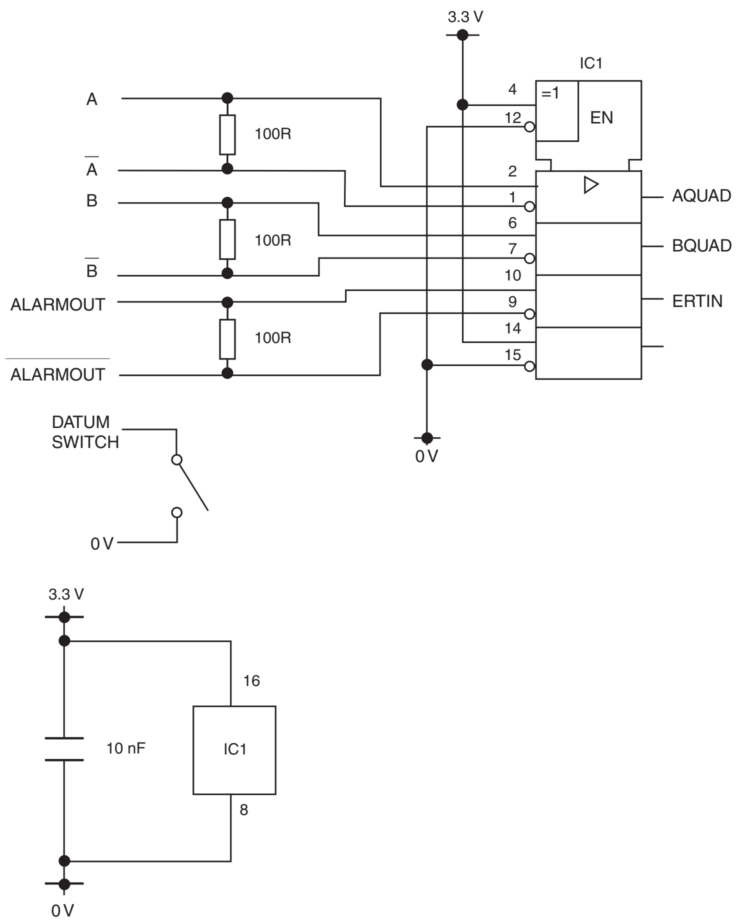


Electrical interface for clear error / datum

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 100W - 120W resistor.

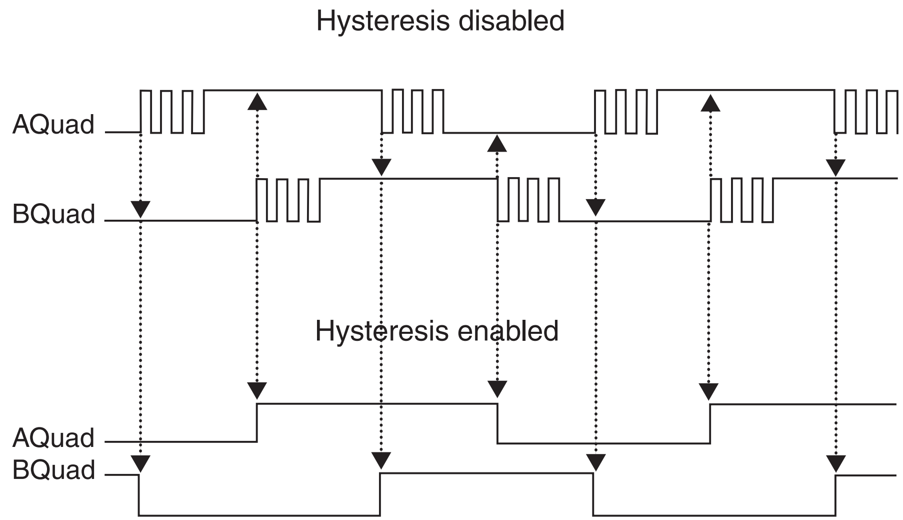


IC1 = MAXIM MAX3096

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 obstructs 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:

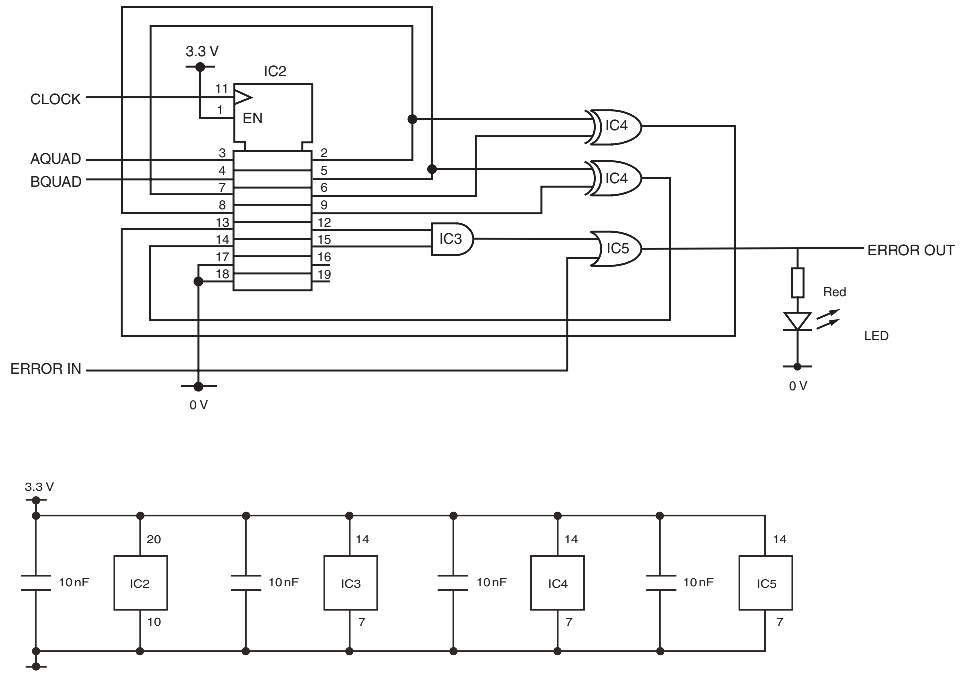
- Frequency is in MHz
- Resolution is in nm = 80nm or 10nm
- Vmax is maximum velocity in m/sec
- RxSkew is the receiver skew between the AQuad and BQuad channels in ns

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

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.



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 & IC5 to 0V. Value of Rled will depend on LED selected.

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XL-80Q operation with RCU10

XL-80Q Setup:

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 & 16	External Reset Switch		

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
Resolution	0.07910235580
Direction Sense	Normal
Sample Rate	20.0MHz
Ref. Mark Source	External Port

Analogue signal output

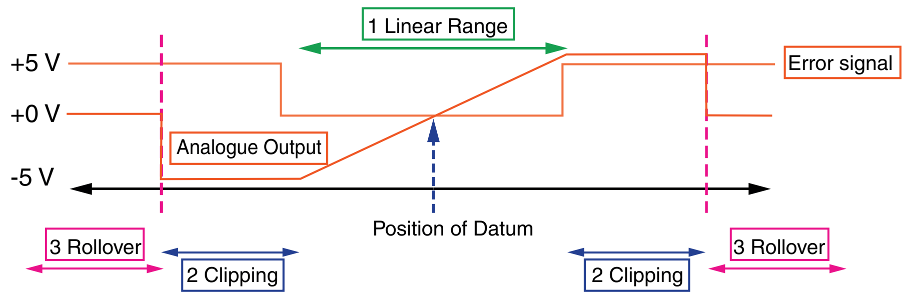
Analogue output is available as a factory set option.

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:



Auxiliary I/O outputs

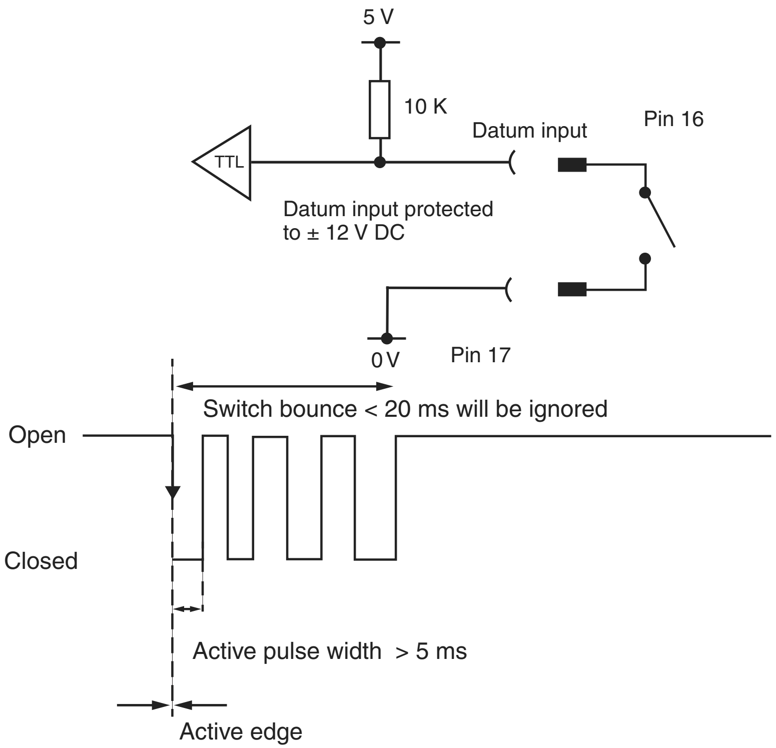
The analogue output exhibits a linear characteristic over a range of ± 5 V from the datum position. Beyond this range, the output voltage is clipped and an error condition is output on the ALARMOUT line. If the rollover limit of ± 40 mm is exceeded, the ALARMOUT signal becomes latched and the analogue 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 Beambreak
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 is provided on the auxiliary I/O connector which 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.



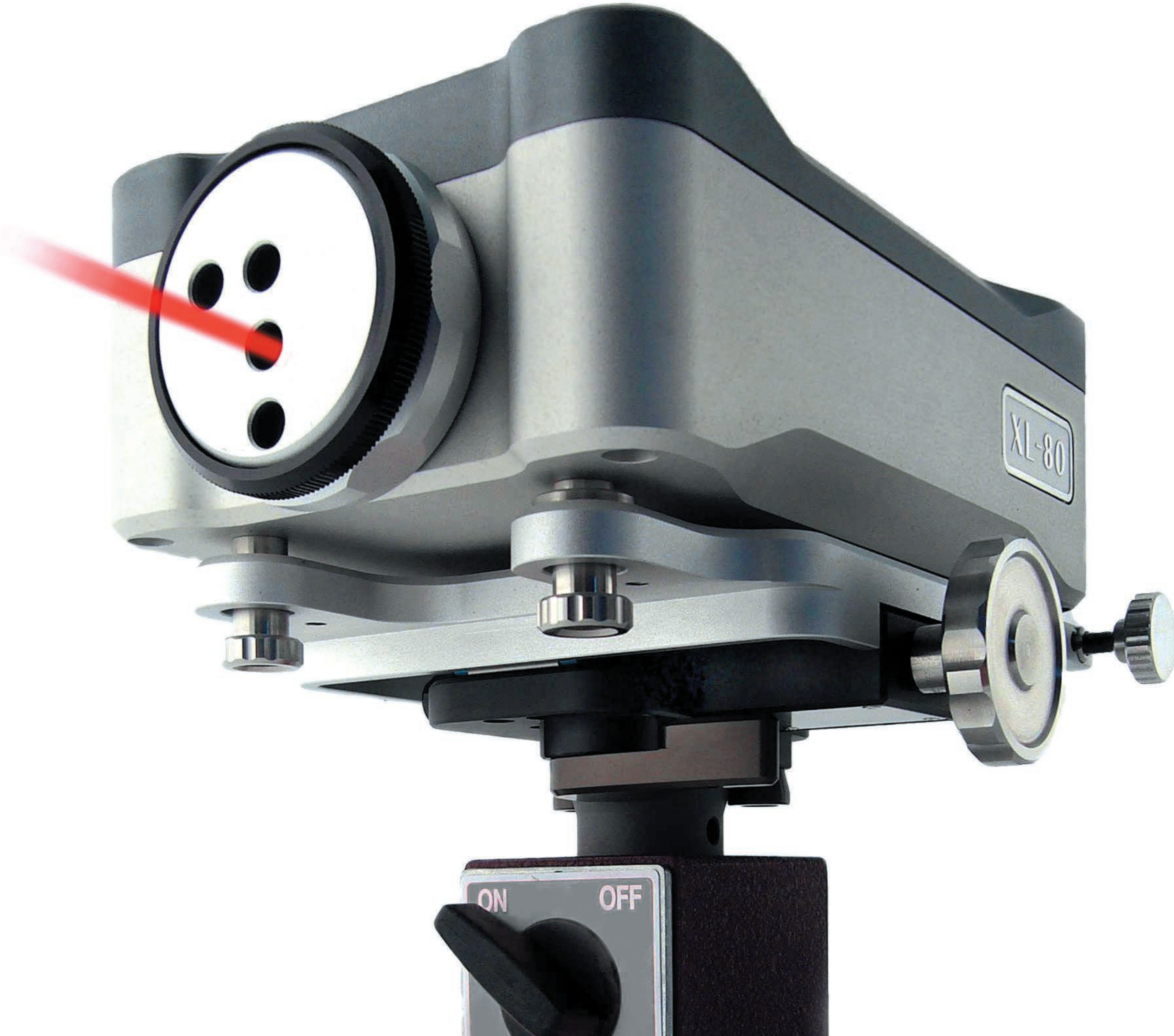
Electrical interface for clear error / datum.

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
Max measured frequency	100 KHz
Transmission distance	3 m
DAC resolution	14 bits

XL-80 applications

- Linear
- Angular
- Straightness



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.
- After reading this guide, the user will be able to perform a range of measurements, and capture measurement data for analysis.

Points to note

- The methods shown here are examples which assume that the 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

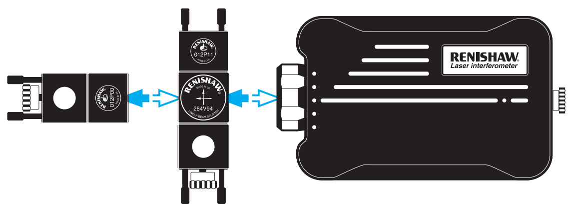
Measurement modes

This guide includes:

Linear

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

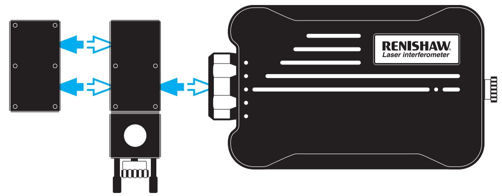
Any inaccuracy from the commanded position in a position critical motion system is often caused by mechanical wear, however factors such as angular pitch and yaw also have a significant influence. Accuracy and repeatability are measured by driving to a series of pre-defined positions controlled by the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



Angular

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

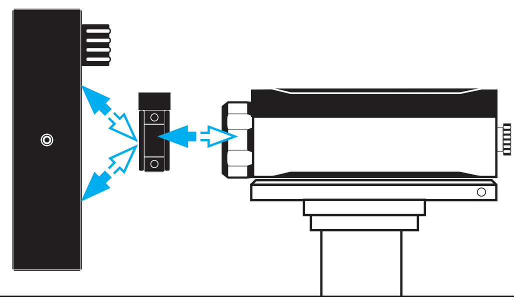
Angular errors are often caused by a 'bow' in the motion of travel (pitch angle error) or slack guide leading to a 'twisting' of the drive carriage (yaw angle error). The measurement technique is similar to that of linear measurement with readings being taken at a series of pre-defined positions to measure 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 bow 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 as a result of 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.

Once minimised, any further environmental changes can be reduced using the XC environmental compensator system and compensation automatically applied using CARTO Capture software.

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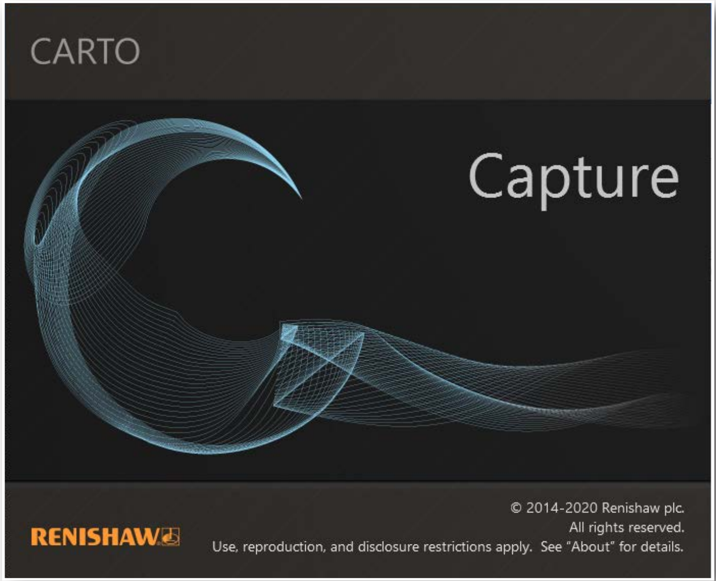
CARTO Software suite

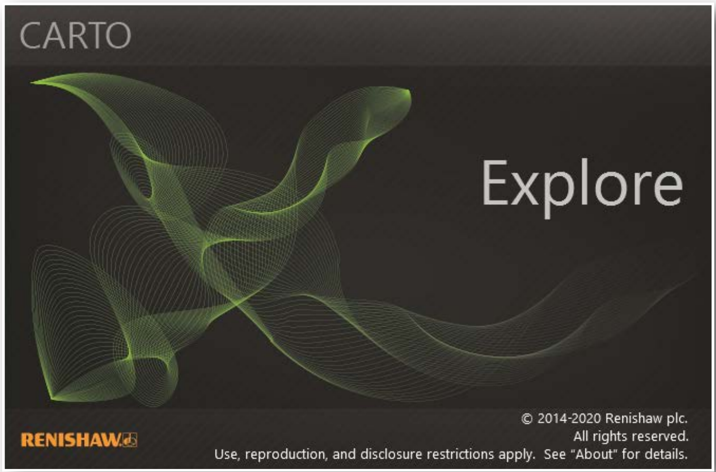
The XL system is used with the CARTO software suite. This is made up of three applications;

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

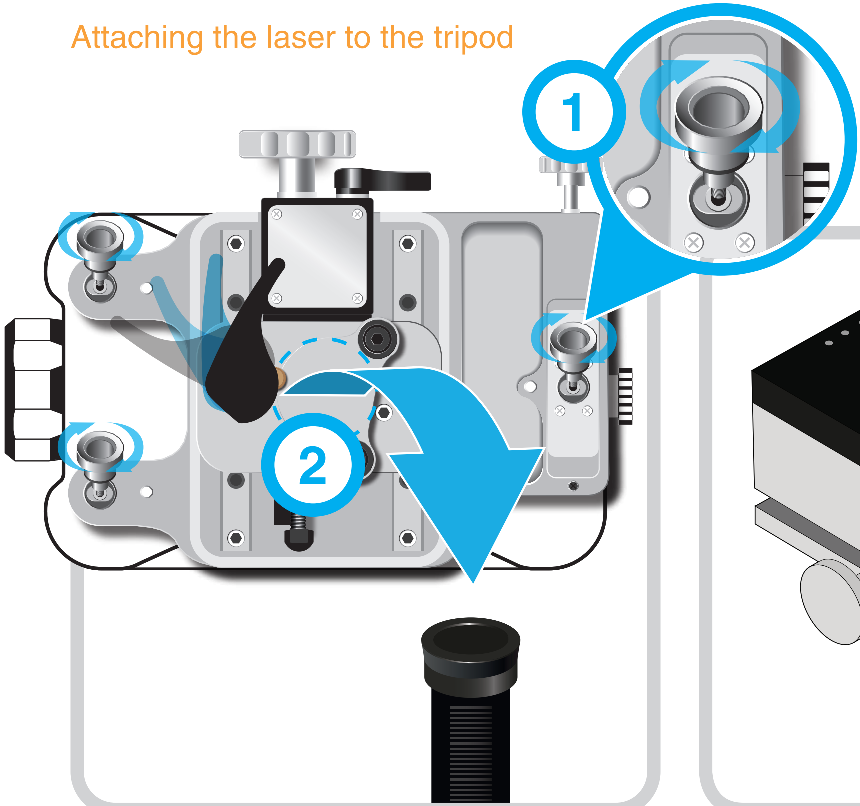
Place the bubble level onto the tripod boss

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

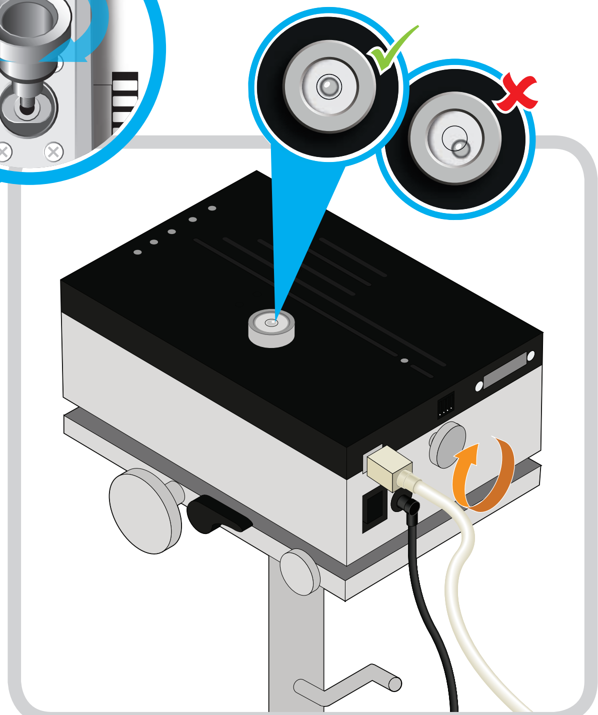
Basic set-up

Attaching the laser to the tripod

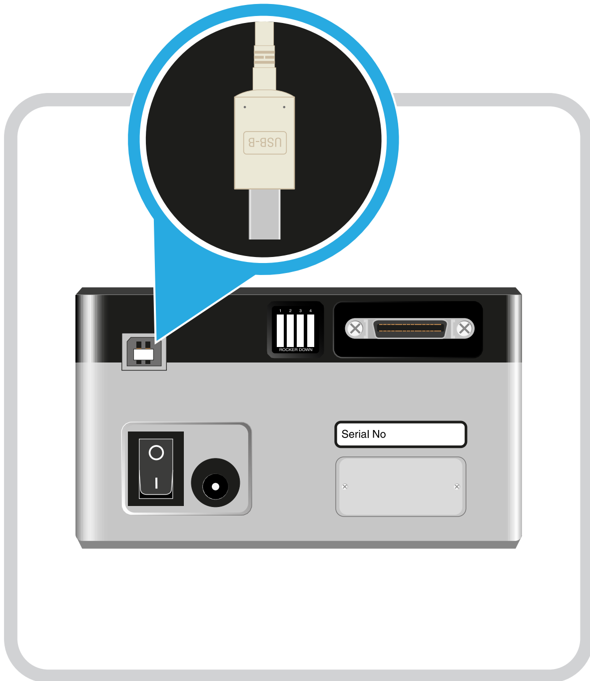


1. Attach the laser to the tripod stage using the three stage retaining screws.

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



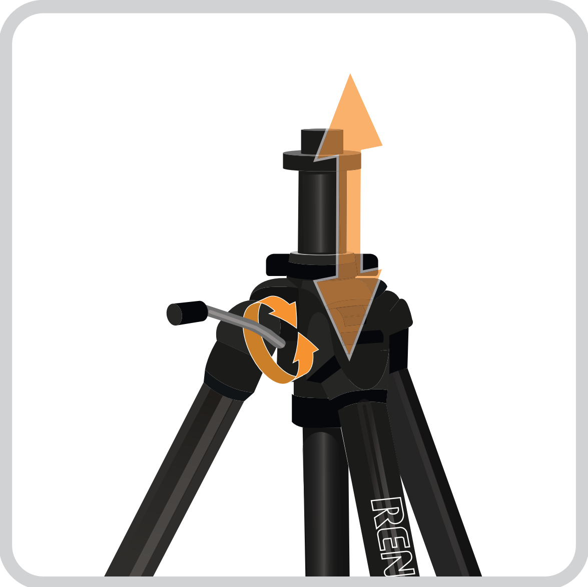
Connect the XL laser to the PC via the USB cable. Open CARTO Capture software and select the XL laser option

Visual alignment

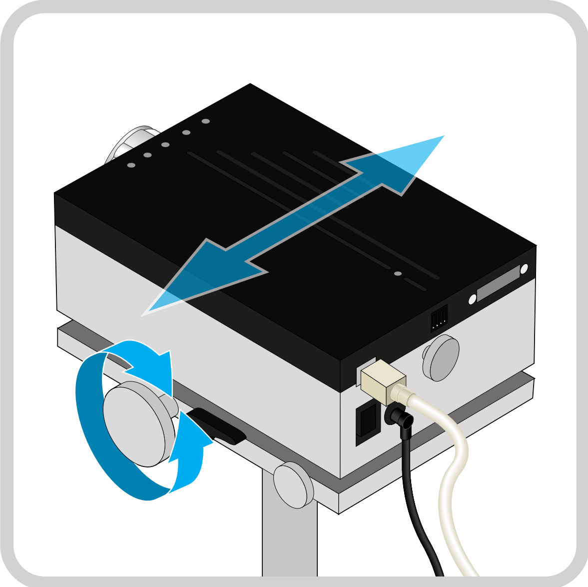
Set all laser stage adjustments to the mid-positions.

Set the tripod's vertical and horizontal adjustment away from the end of its travel

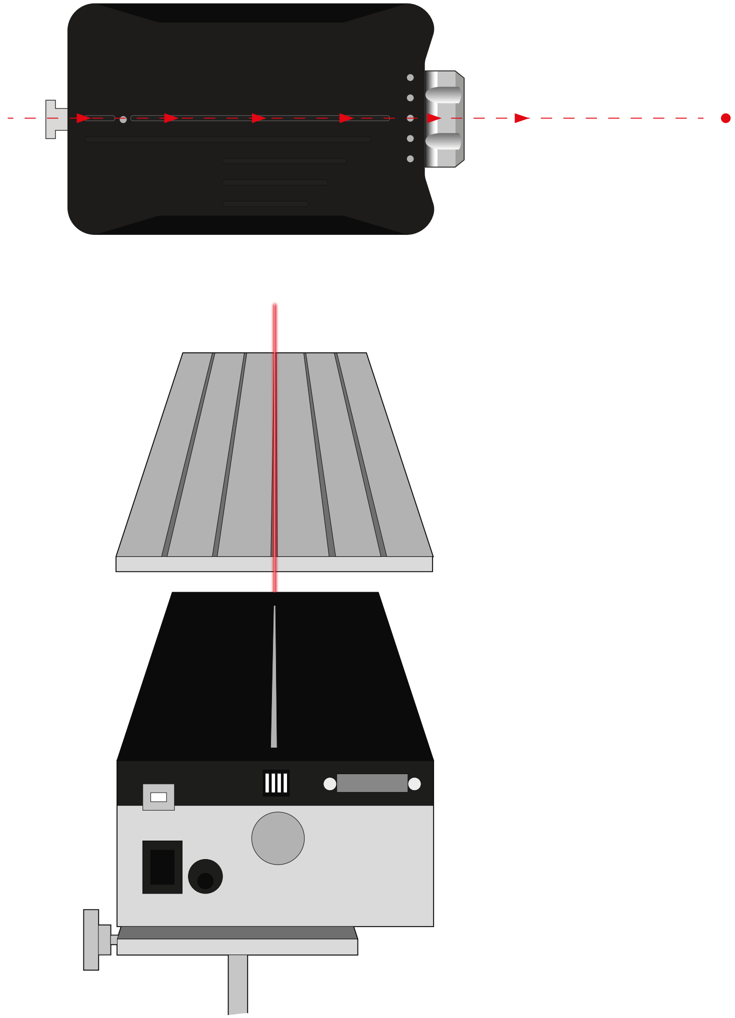
Visually align the unit to the machine axis of travel by moving or adjusting the tripod



Height adjustment

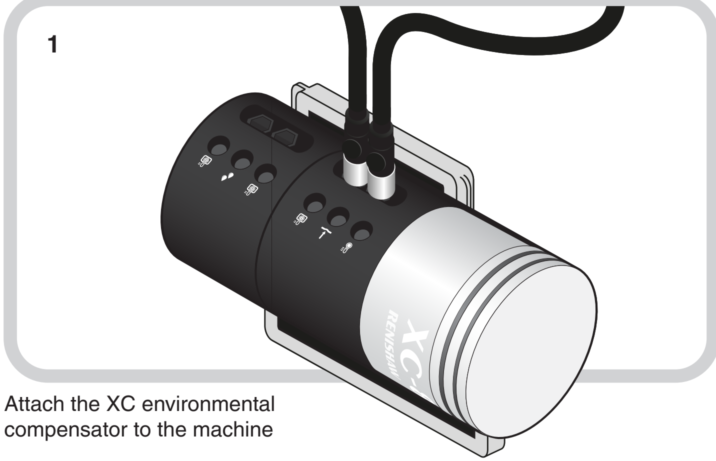


Horizontal translation adjustment



Set up of the XC compensator

1



Attach the XC environmental compensator to the machine

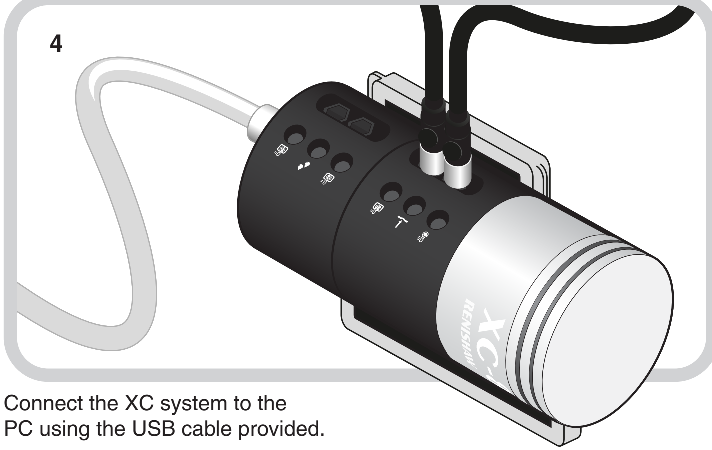
2

Connect the air and material sensors to the XC environmental compensator

3

Position the sensors on the machine – the air sensor should be along the laser measurement path – the material sensors should be as close as possible to the machine drive. If difficult they can also be placed along the laser measurement path

4

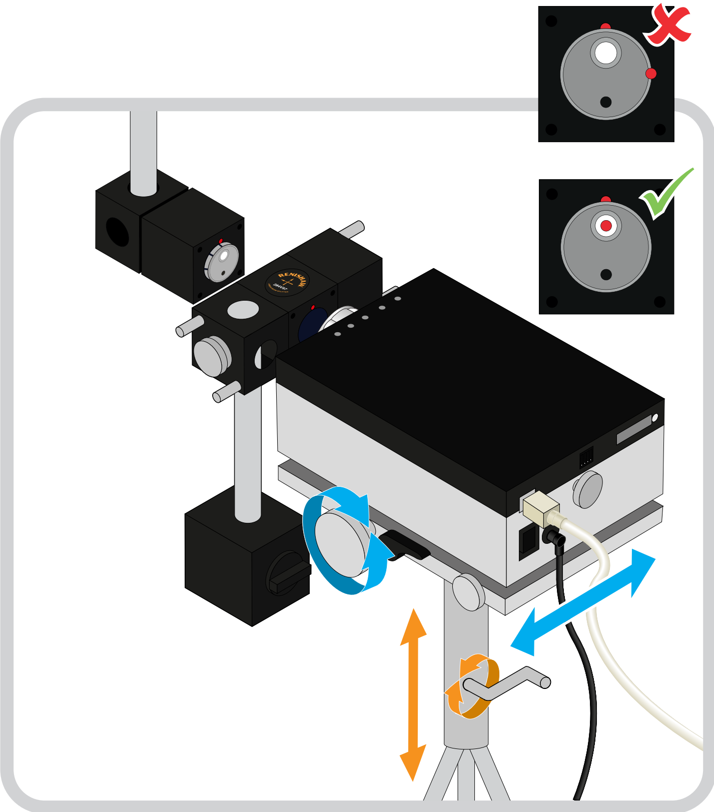


Connect the XC system to the PC using the USB cable provided.

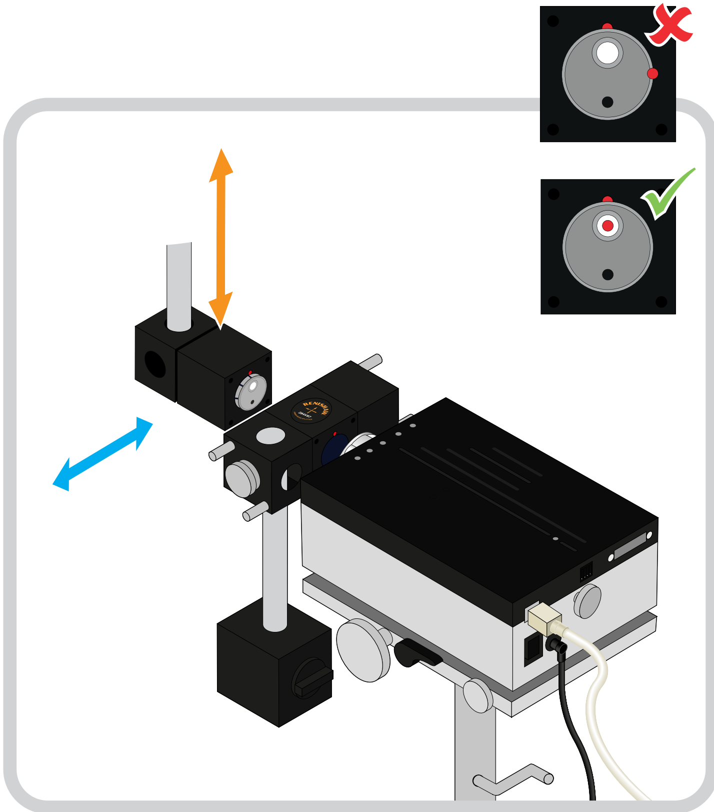
Note: Care should be taken to ensure that the cables do not obstruct moving components during operation.

Basic rules of alignment

Near field adjustment – when the measurement retroreflector is closest to the laser.



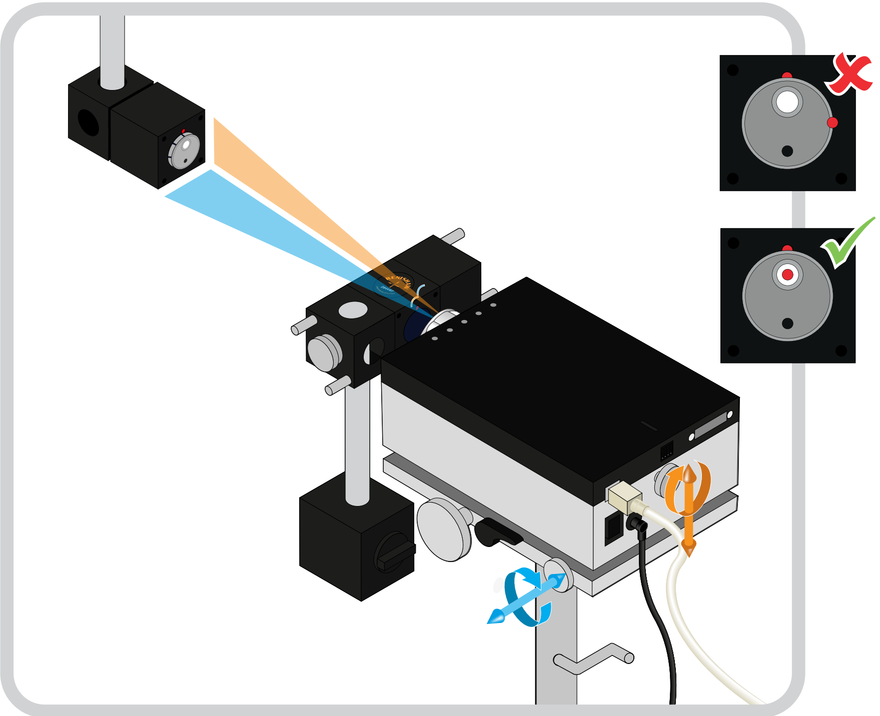
Translate tripod or…



…Translate the machine axes

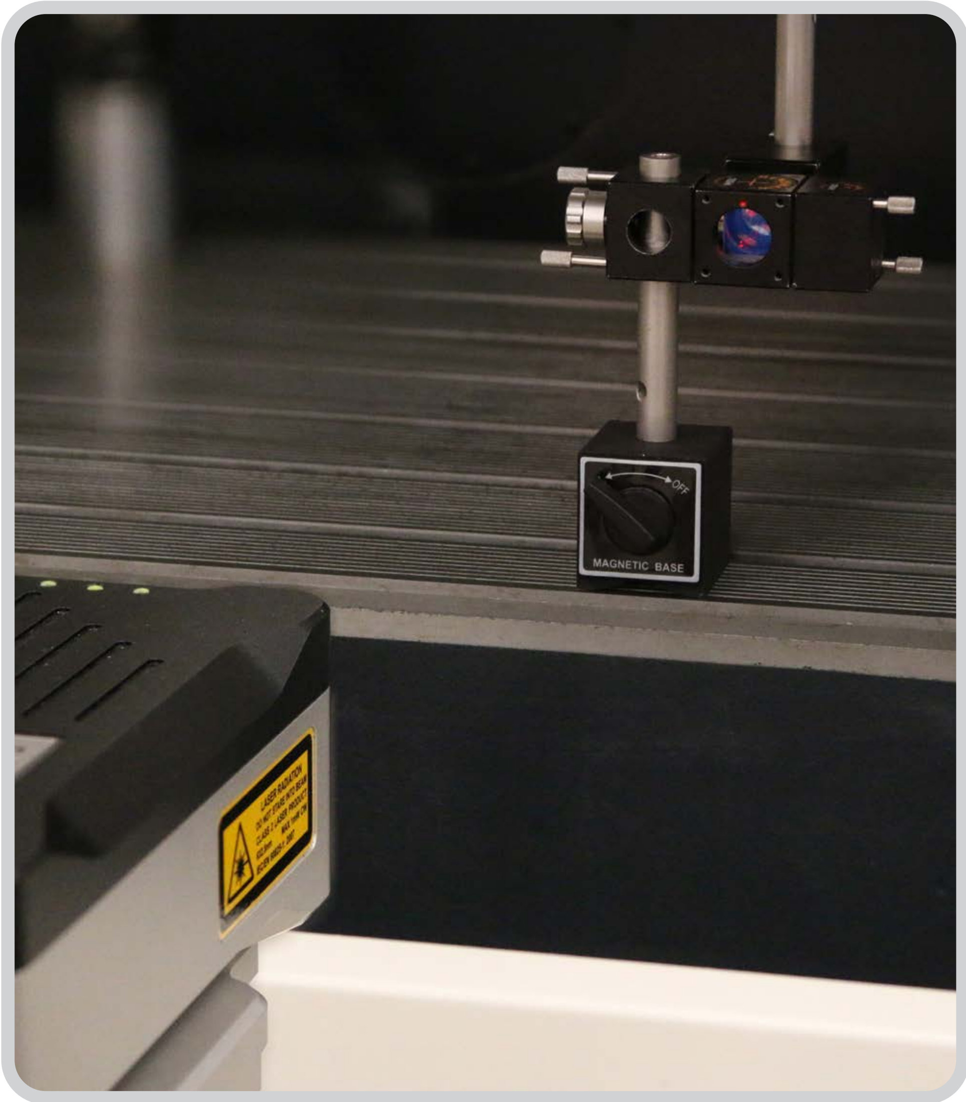
Basic rules of alignment

Far field adjustment – when the measurement retroreflector is furthest from the laser.



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

Linear measurement



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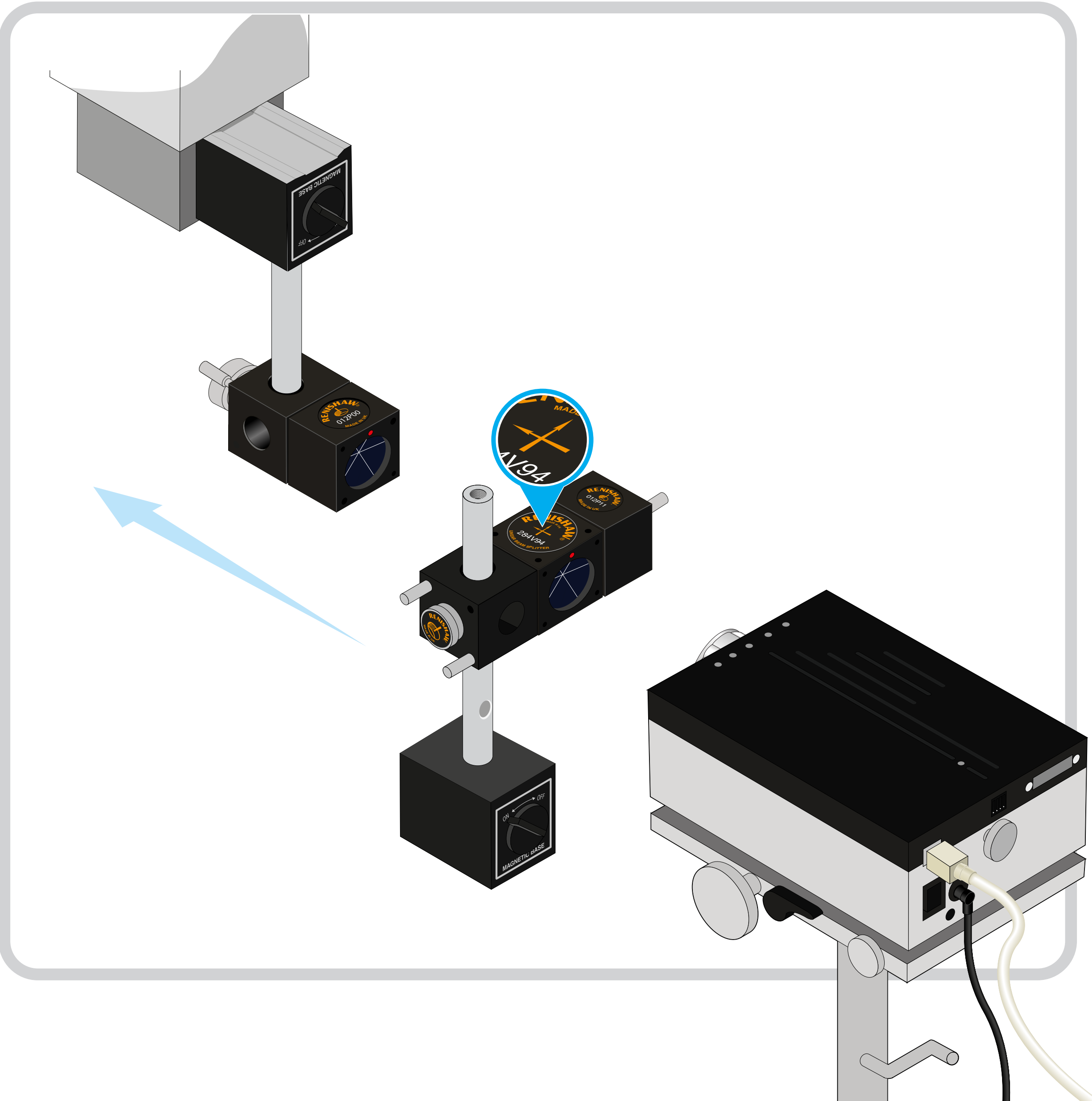
Mounting the optics

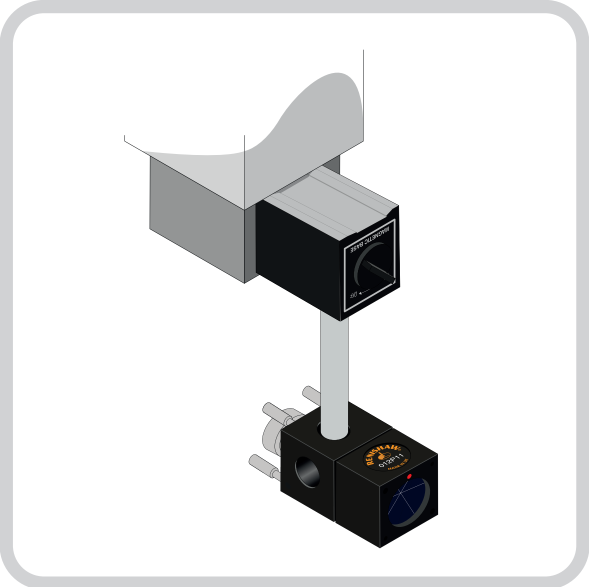
The linear measurement set up



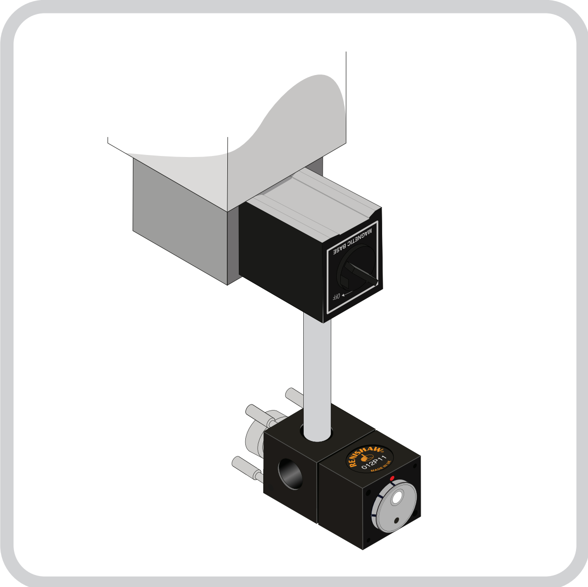
Mounting the optics

Mounting the retroreflector

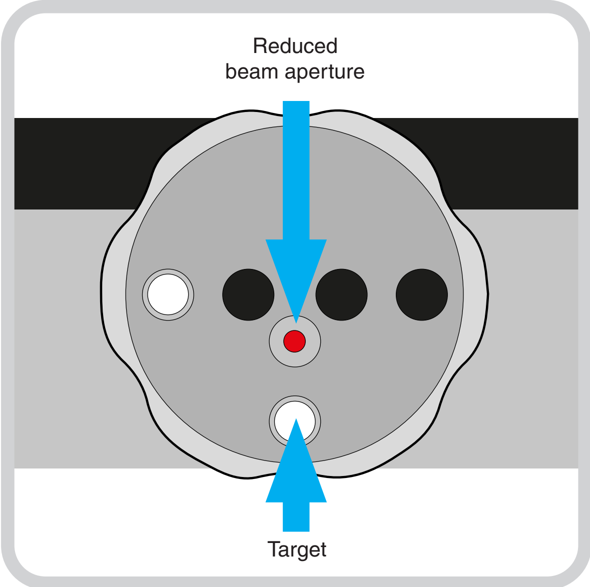
The linear measurement set up



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



Attach the target onto the face of the retroreflector

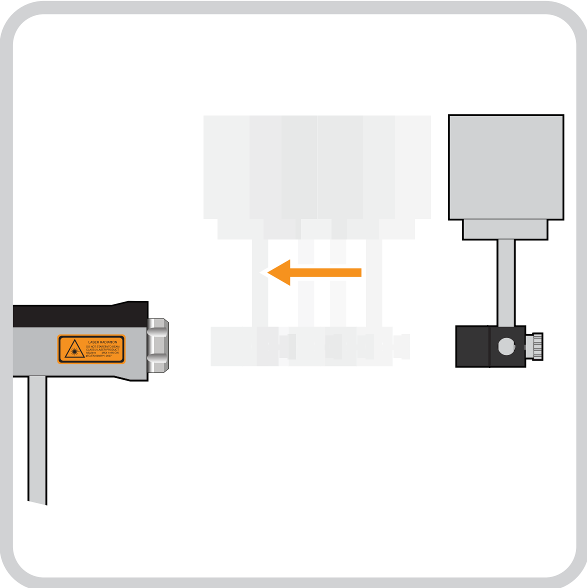


Rotate the laser shutter to emit a reduced diameter beam

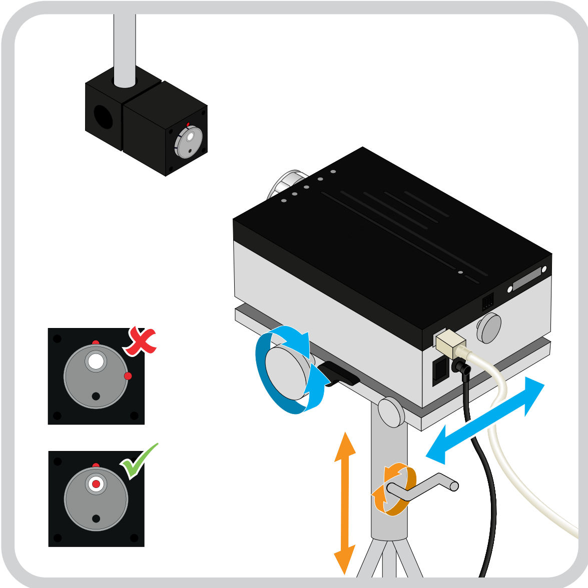
Mounting the optics

Mounting the retroreflector

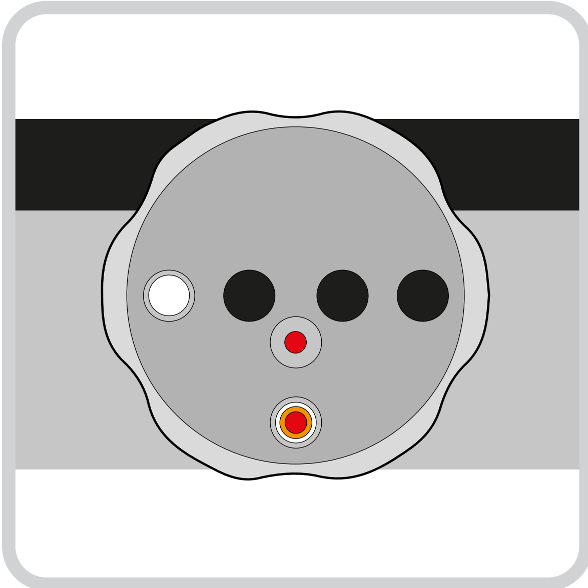
The linear measurement set up



Drive the retroreflector to the ‘near field’ position



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

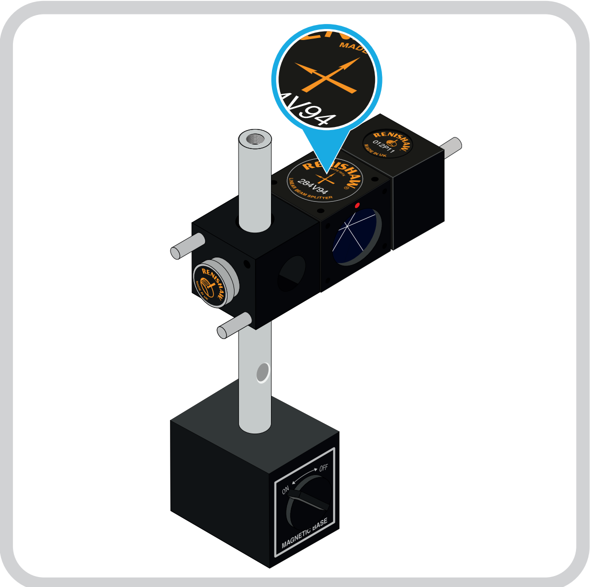


Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter – if not translate the laser or the machine

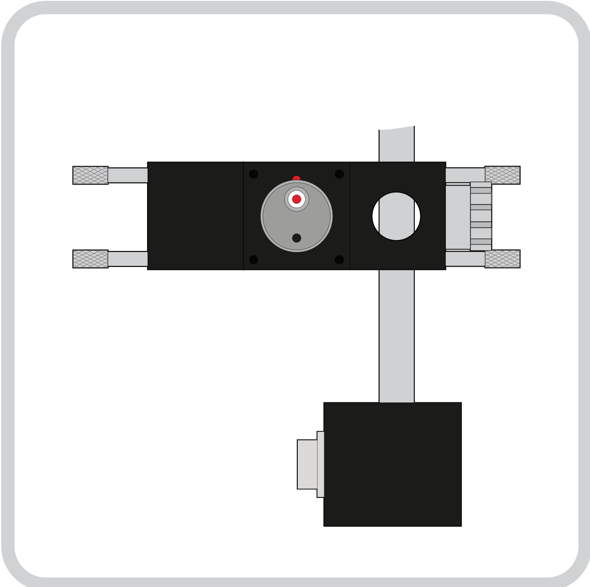
Mounting the optics

Mounting the retroreflector

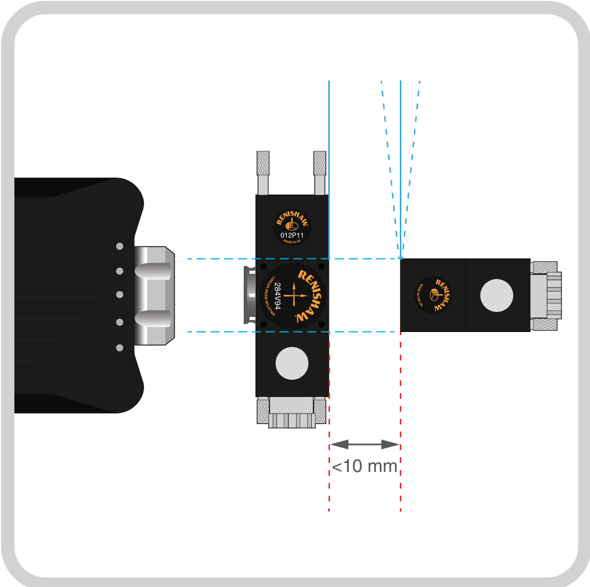
The linear measurement set up



Assemble the interferometer assembly as shown



Attach target to input aperture and align with the beam



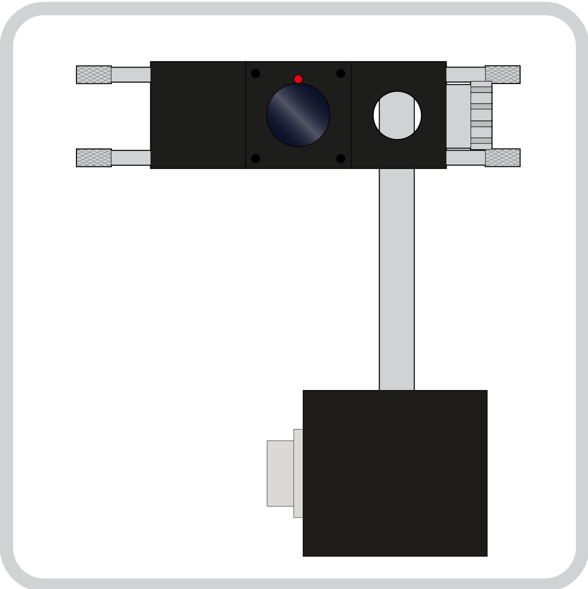
Mount to the stationary element of the machine;

- As close as possible minimising the distance between the optics
- Square to the axis
- Parallel to the retroreflector

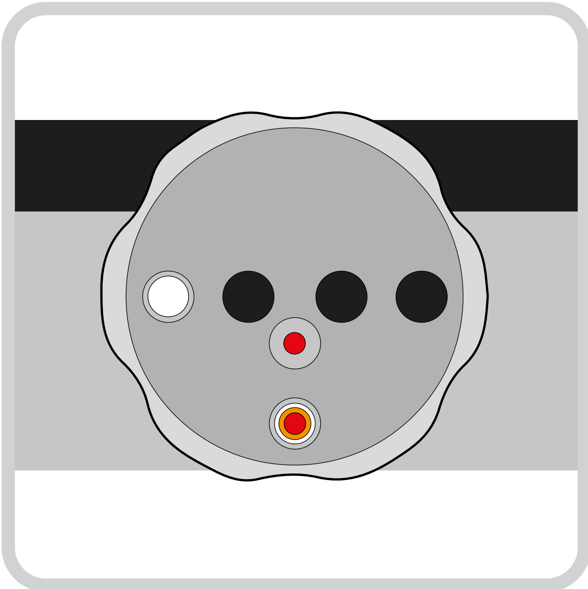
Visual alignment

Mounting the linear interferometer

The linear measurement set up



Remove the target

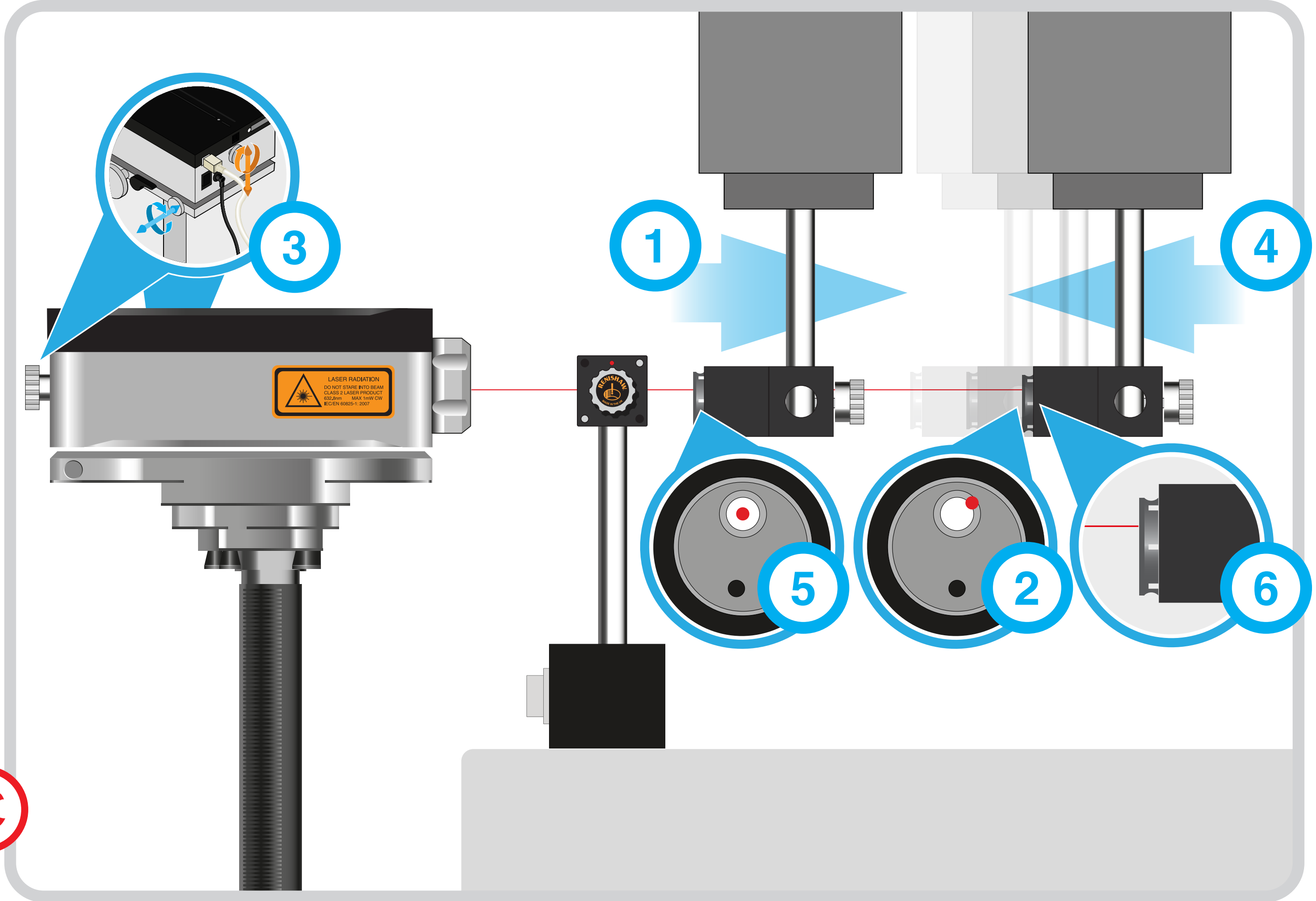


Ensure that the two return beams are overlapping on the shutter target. Adjust as required.

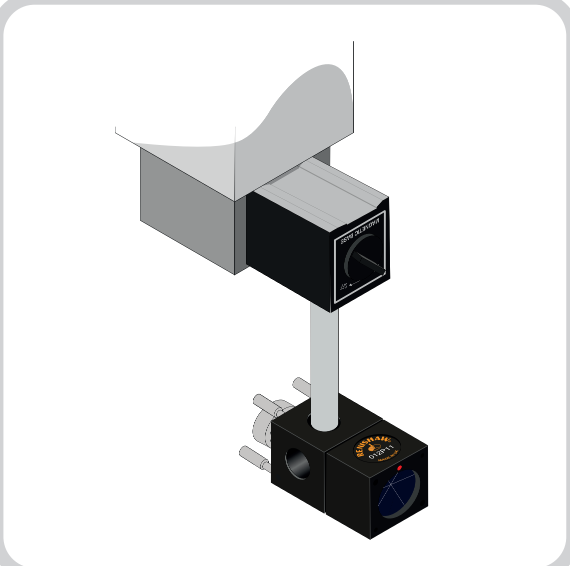
Visual alignment

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

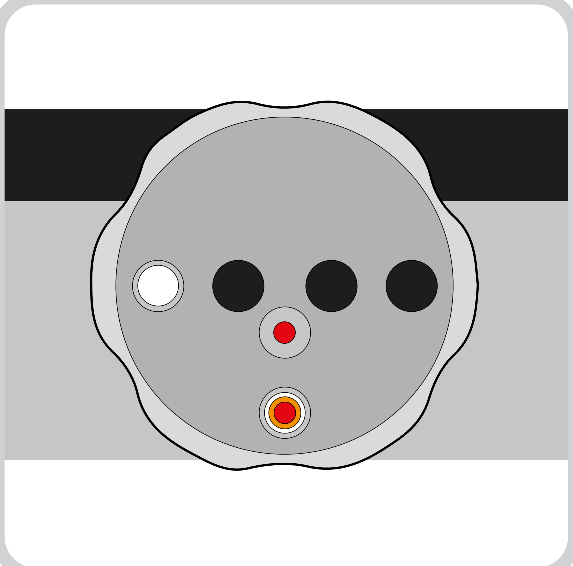
Repeat until the two beams remain in the centre of the target over full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position



Visual alignment



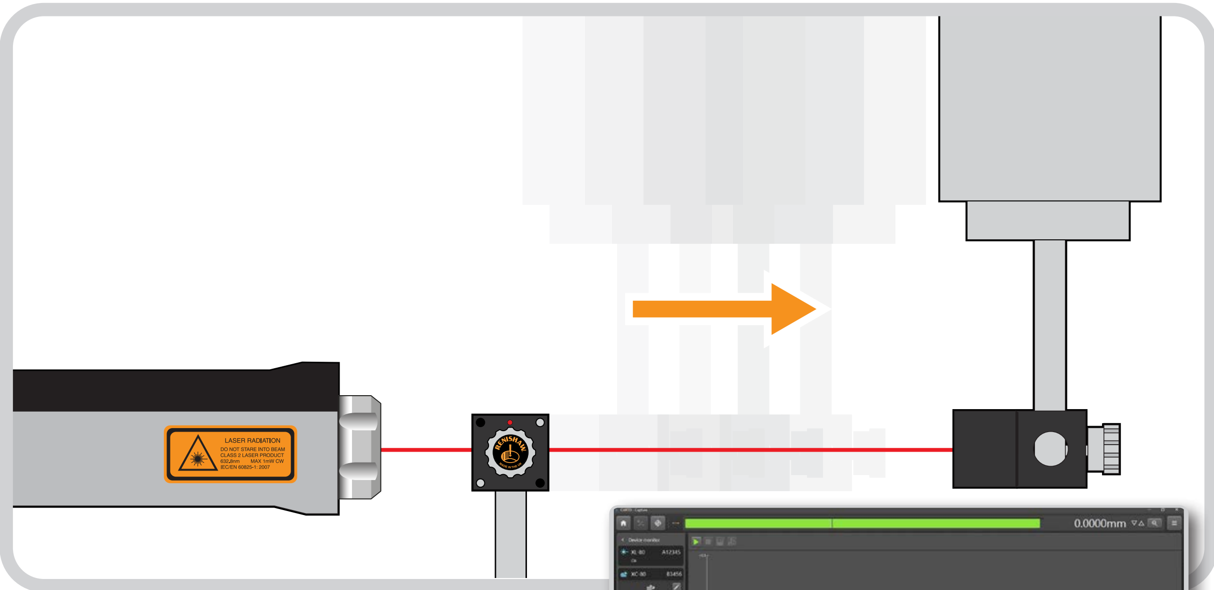
Remove the target

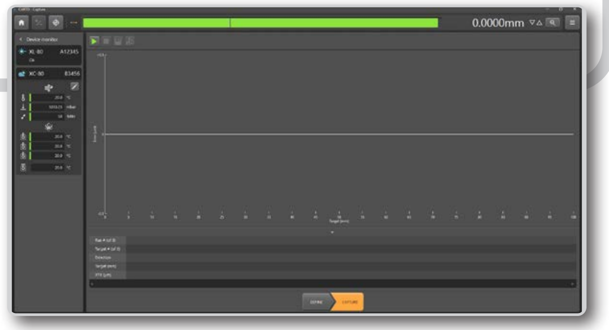


Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target

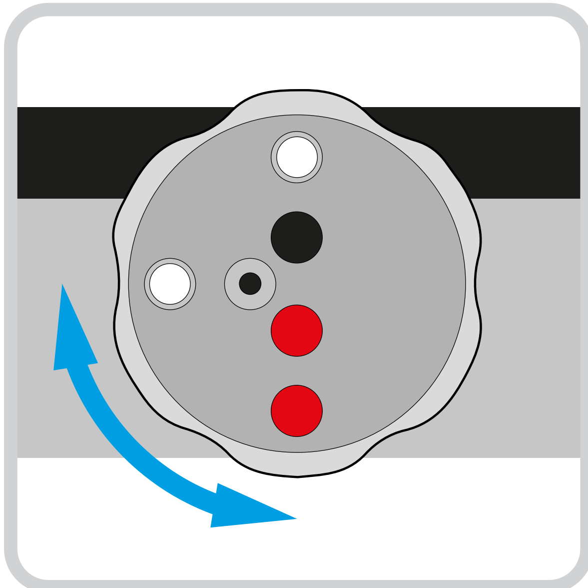
Fine alignment

Removal of cosine errors





At the far position, carefully adjust the pitch/yaw until the signal strength bar at the top of the Capture software screen is maximised.



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

Note: If beam obstruct is shown at the far position, use the 6mm beam position on the shutter

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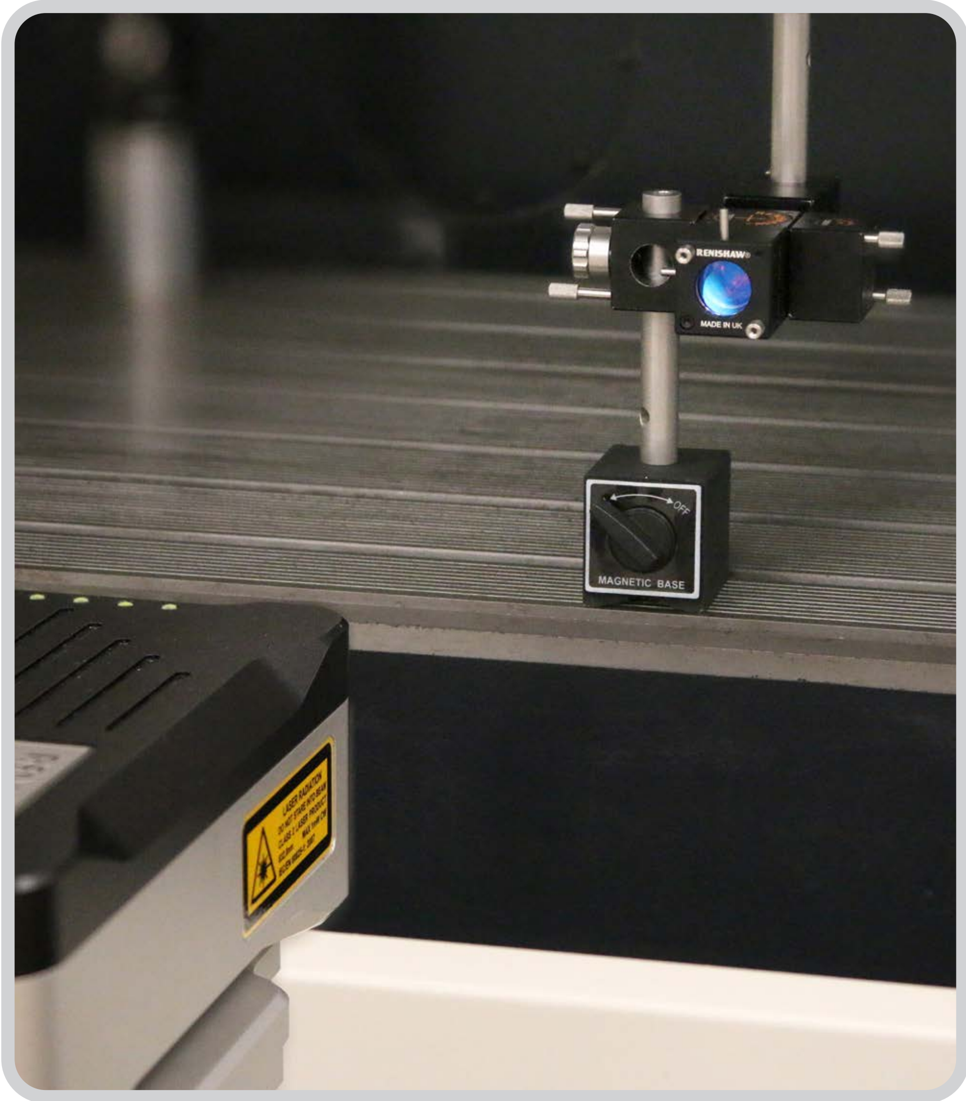
Linear measurement

With LS350 laser beam steerer



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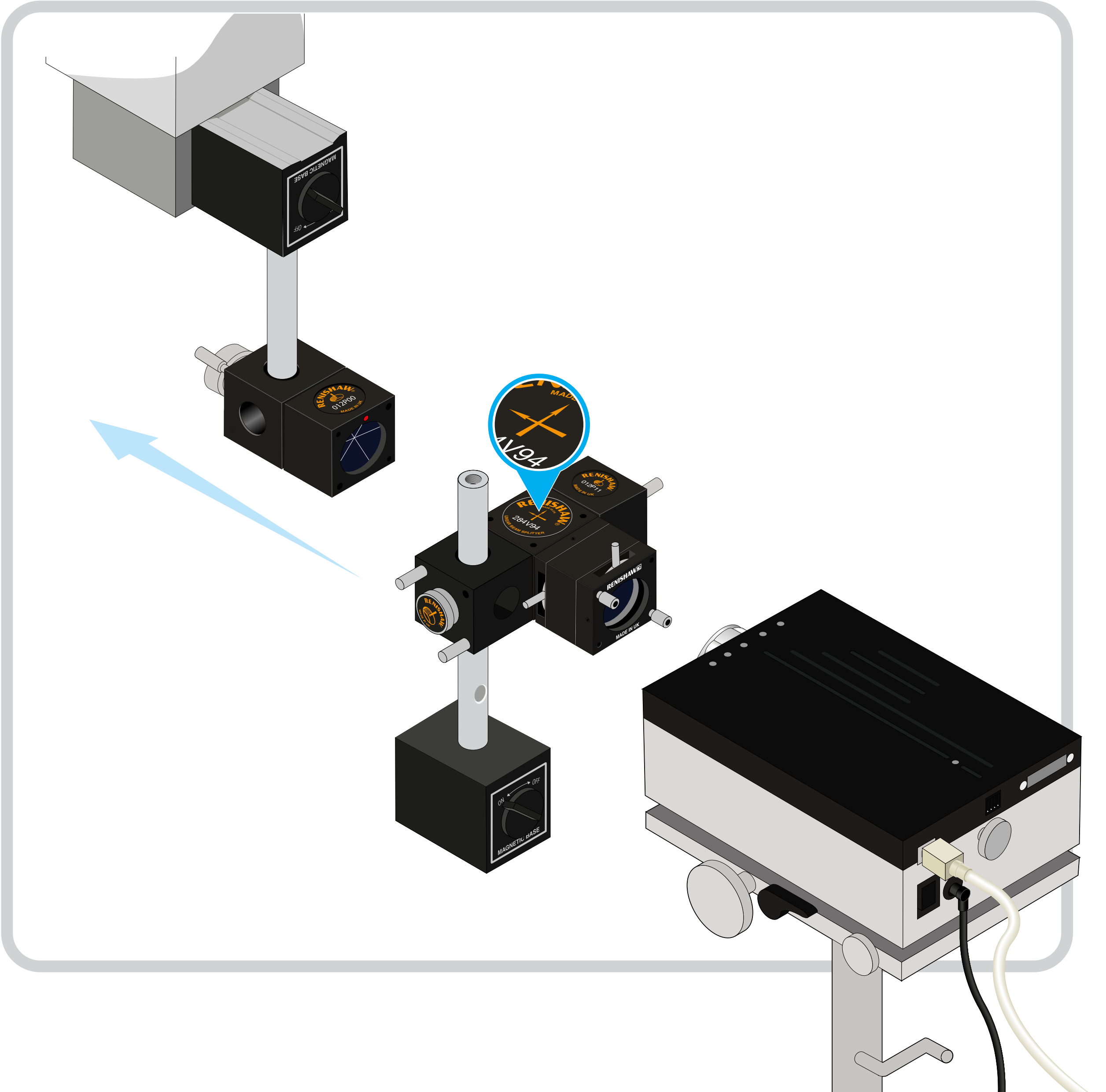
Mounting the optics

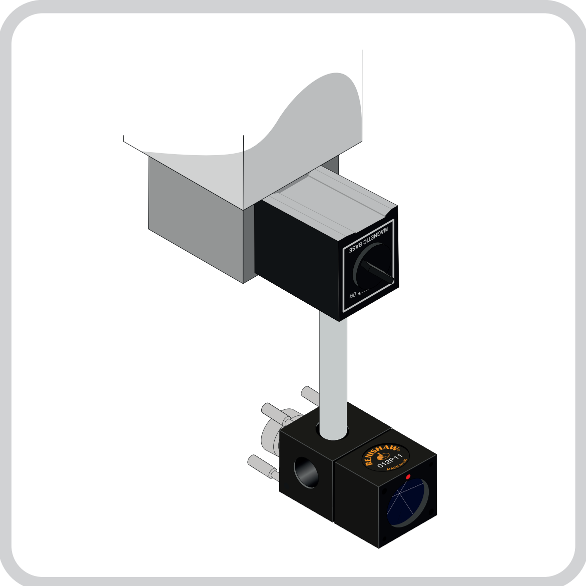
The linear measurement set up with beam steerer (overview)



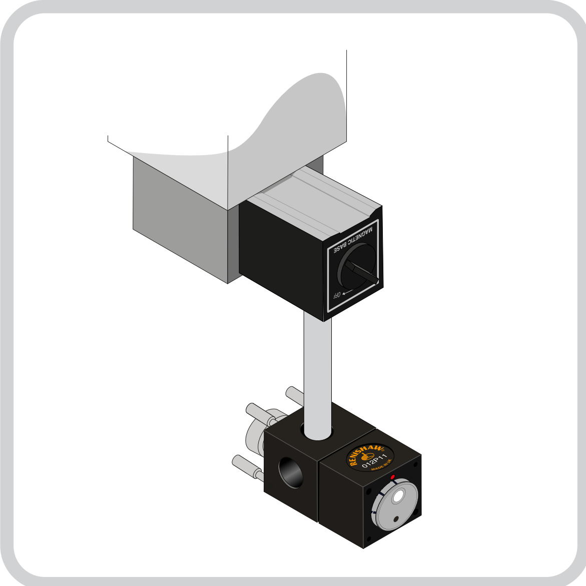
Mounting the optics

Mounting the retroreflector

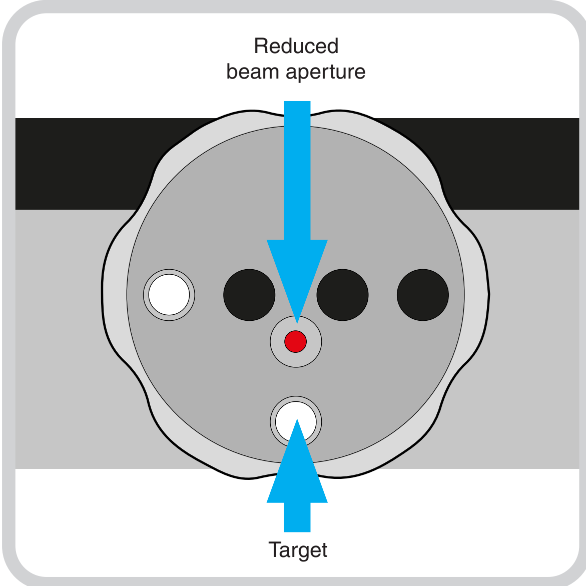
The linear measurement set up



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

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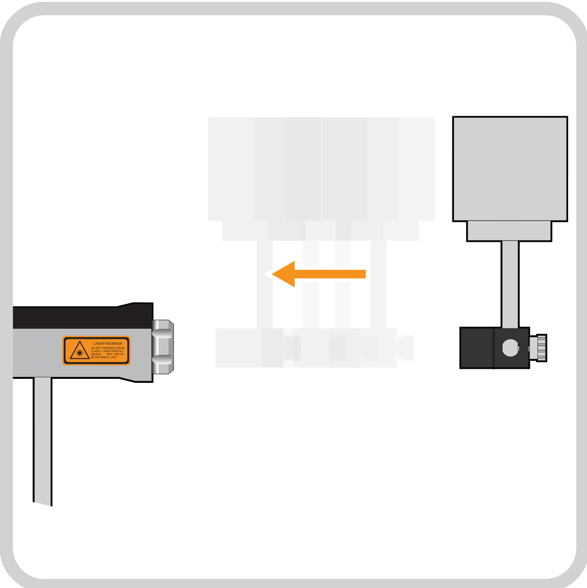
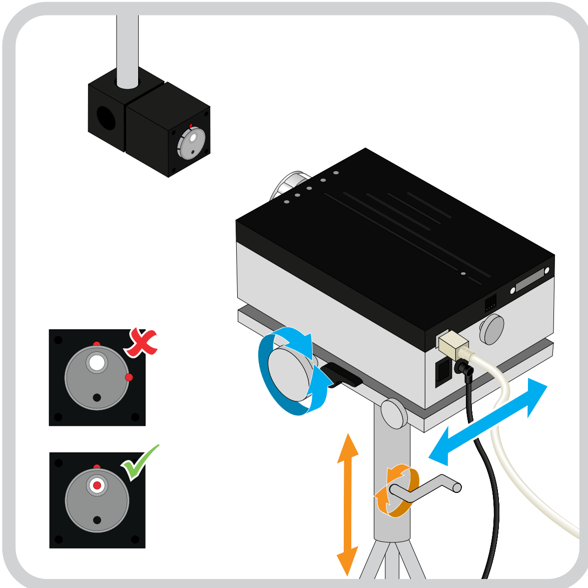
Mounting the optics

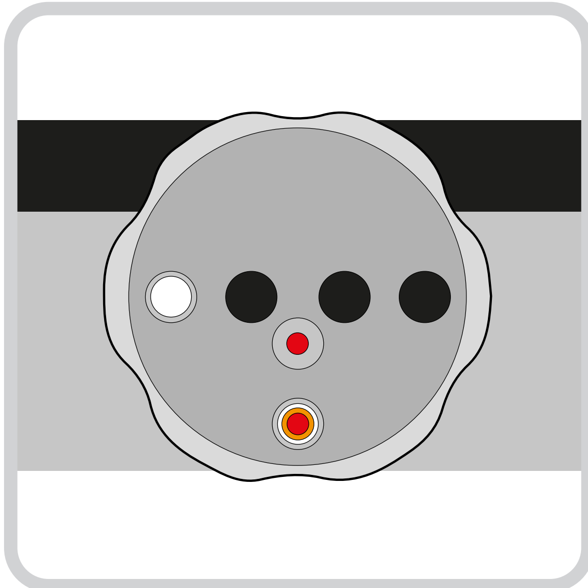
Mounting the retroreflector



Drive the retroreflector to the ‘near field’ position



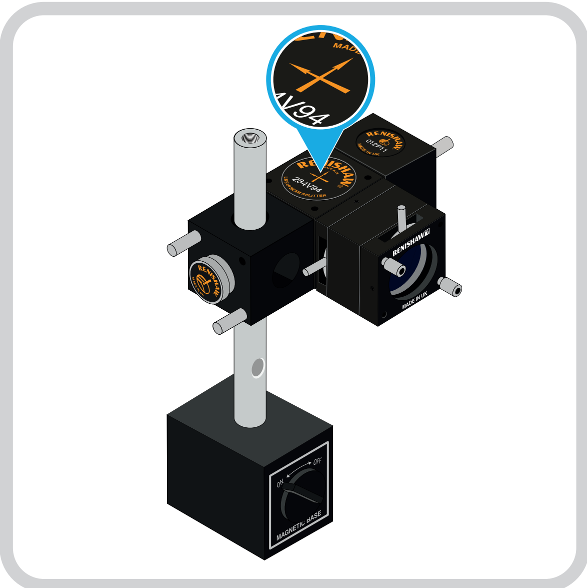
Adjust the beam to the centre of the white target using the translation screws



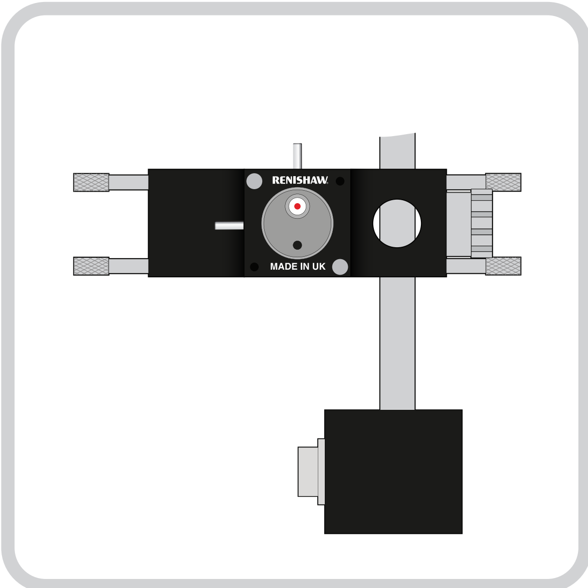
Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter – if not translate the laser or the machine

Mounting the optics

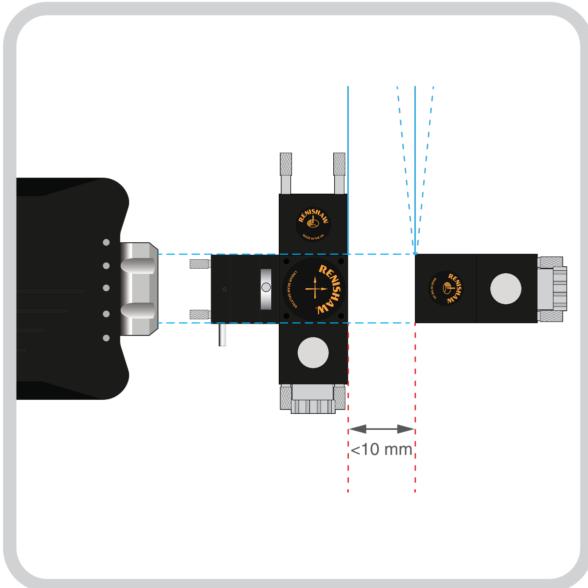
Mounting the linear interferometer



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 target to the beam steerer and align with the beam

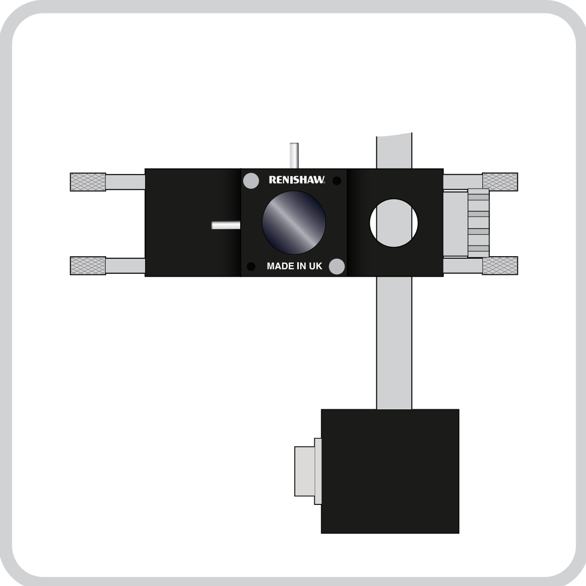


Mount to the stationary element of the machine;

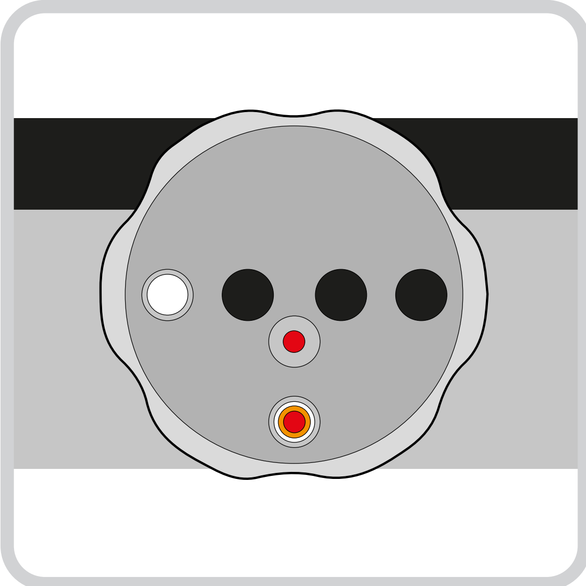
- As close as possible minimising the distance between the optics
- Square to the axis
- Parallel to the retroreflector

Visual alignment

Mounting the linear interferometer



Remove the target



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

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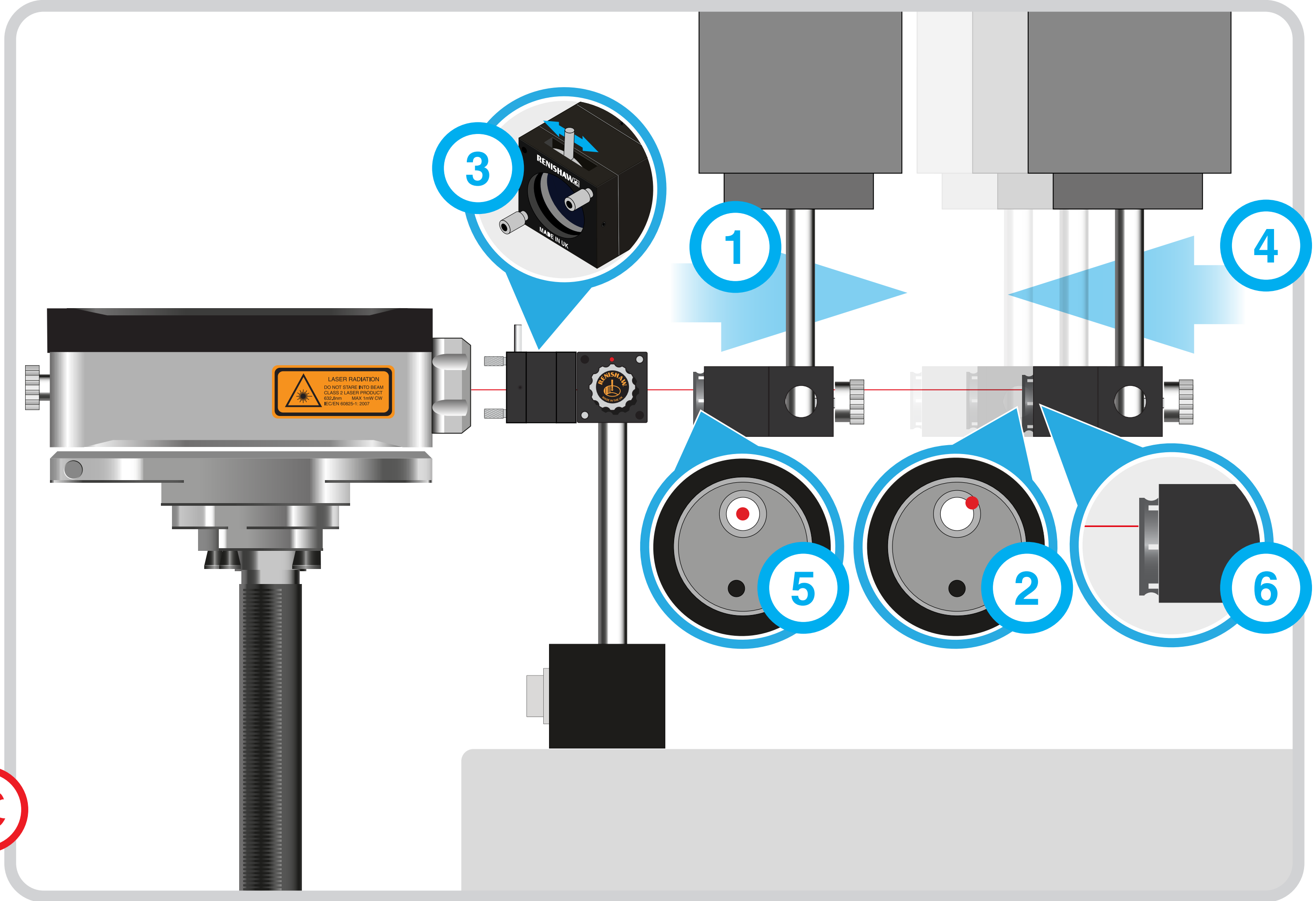
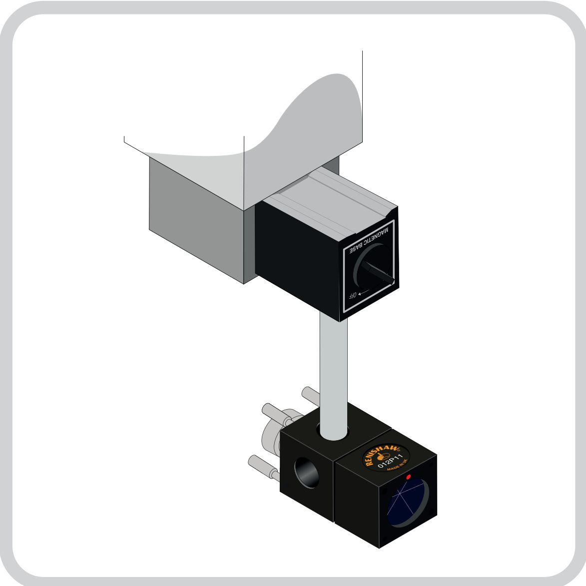
Visual alignment

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 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

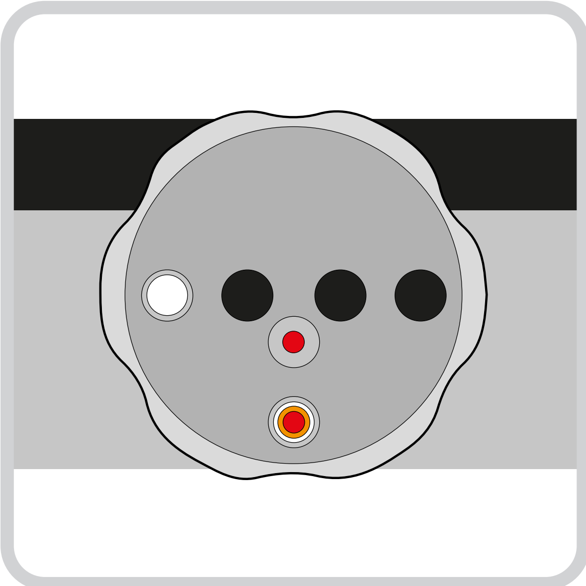
Repeat until the two beams remain in the centre of the target over full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position



Visual alignment



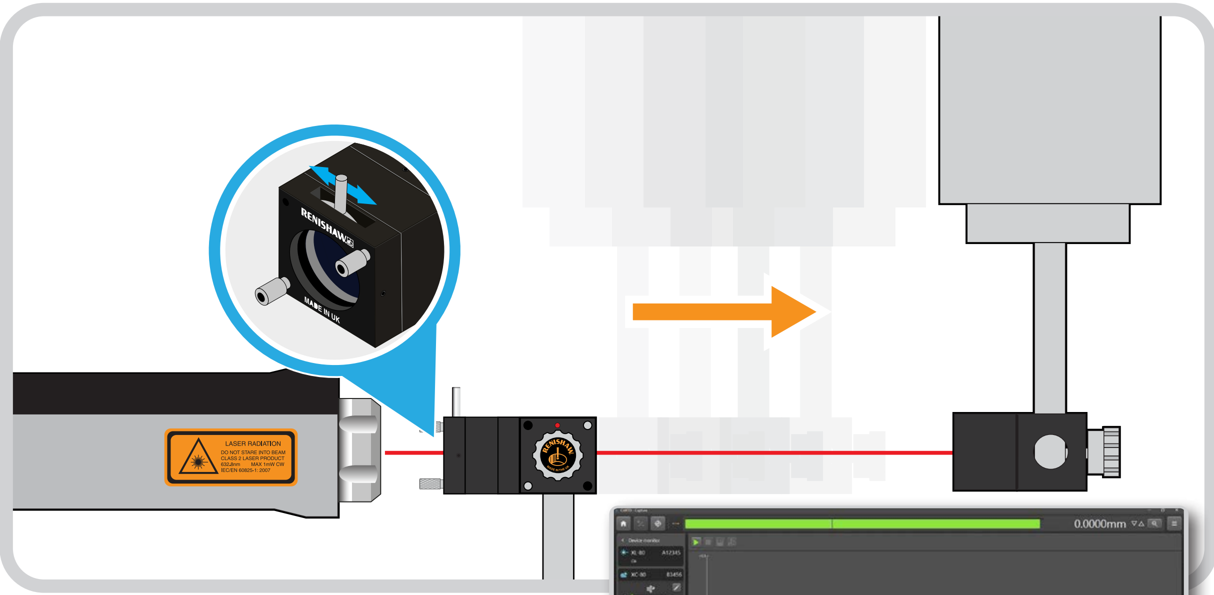
Remove the target

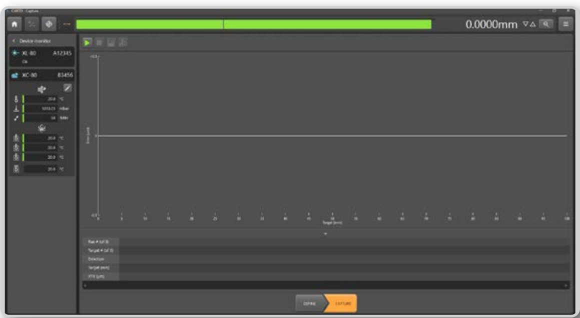


Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target

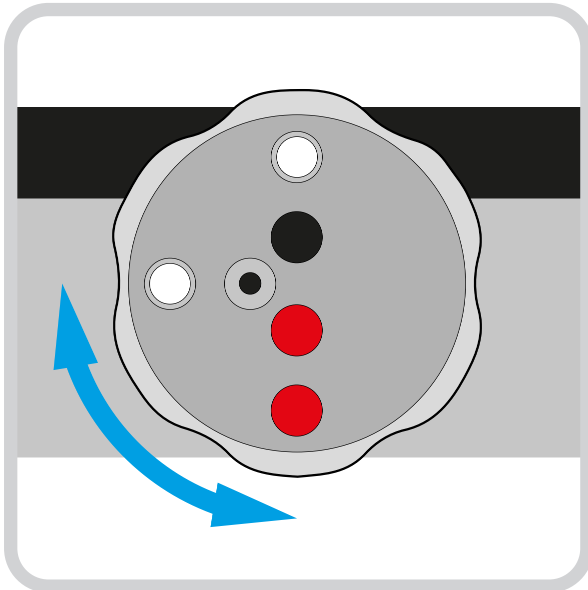
Fine alignment

Removal of Cosine Errors





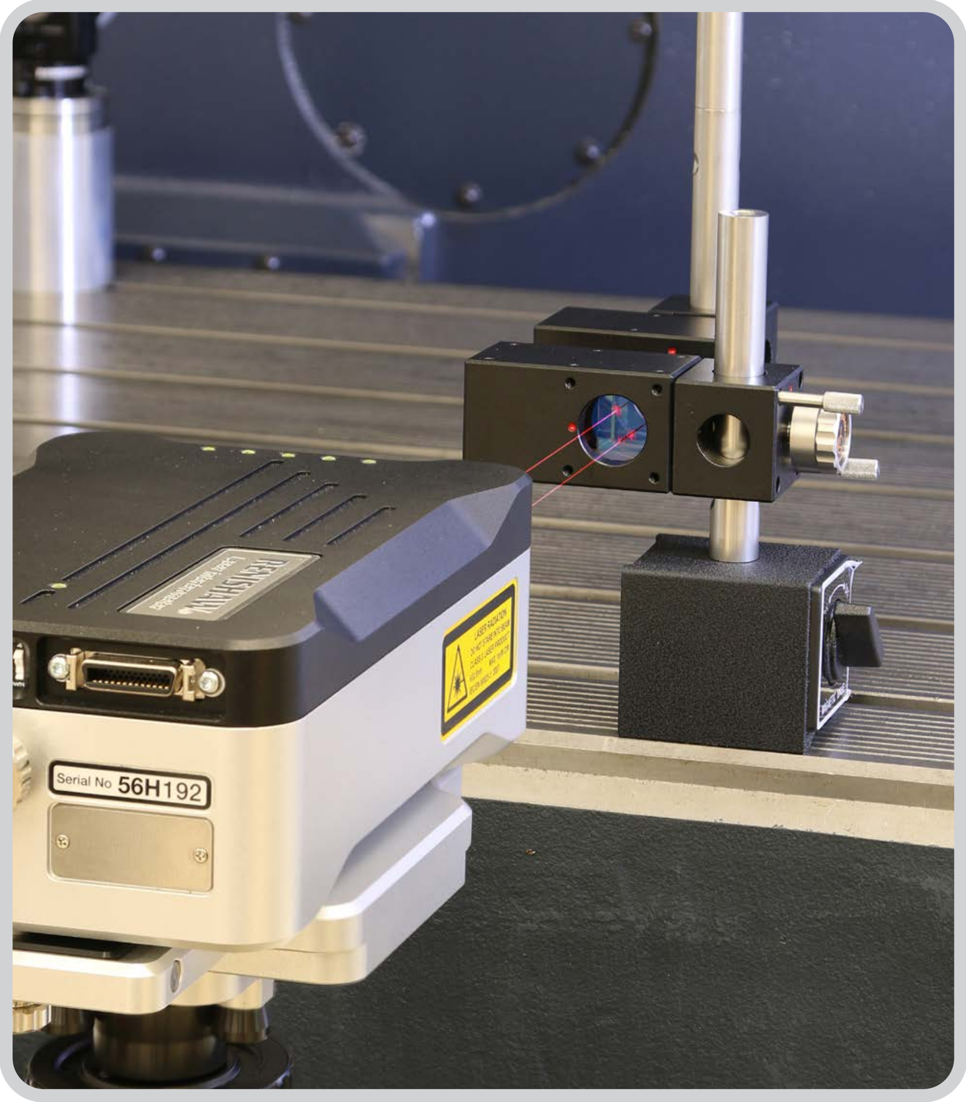
At the far position, carefully adjust the pitch/yaw until the signal strength bar at the top of the Capture software screen is maximised



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

Note: If beam obstruct is shown at the far position, use the 6mm beam position on the shutter

Angular measurement (pitch/yaw)

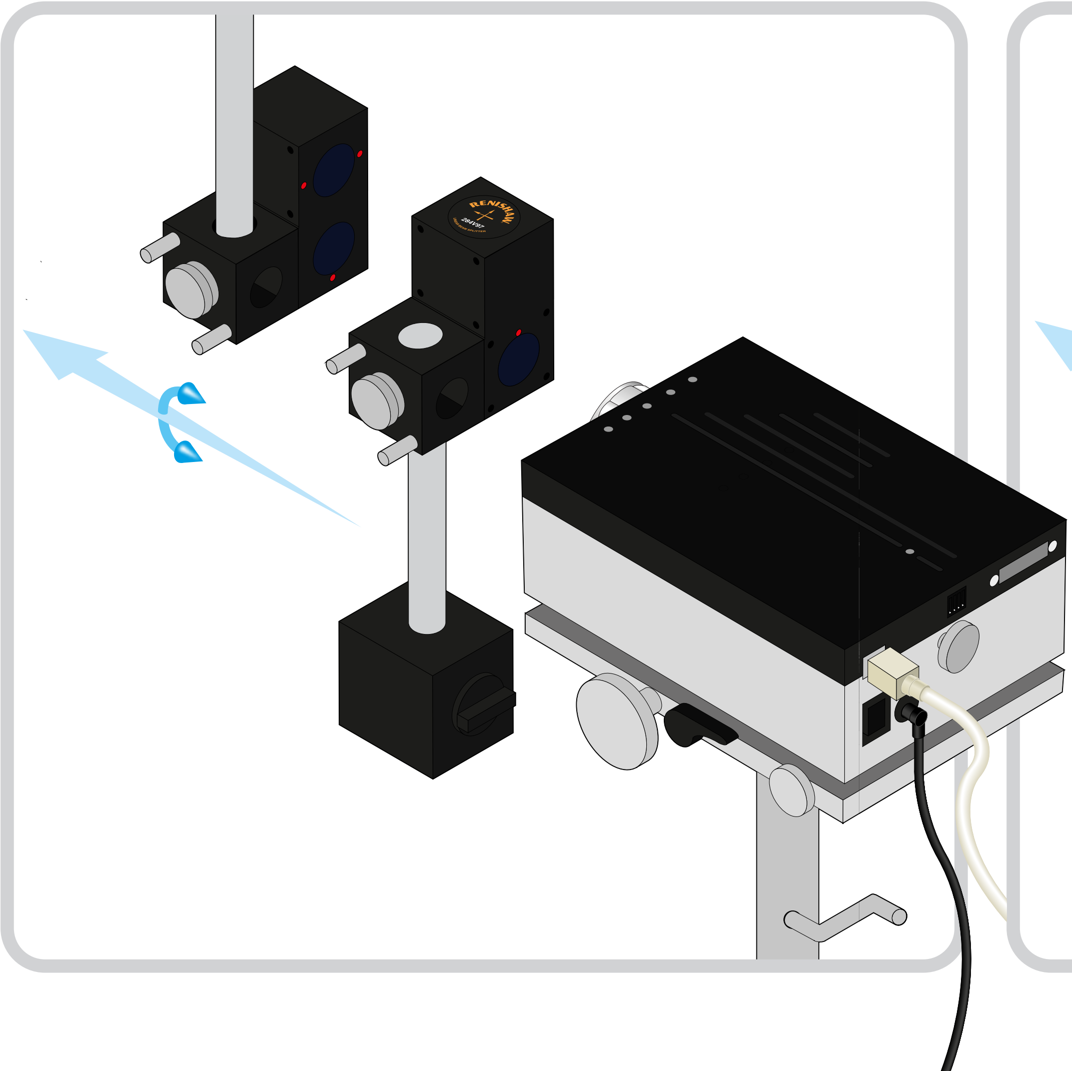


Note: Environmental compensation is not necessary when taking angular measurements. Therefore, the XC Compensator and environmental sensors are not required.

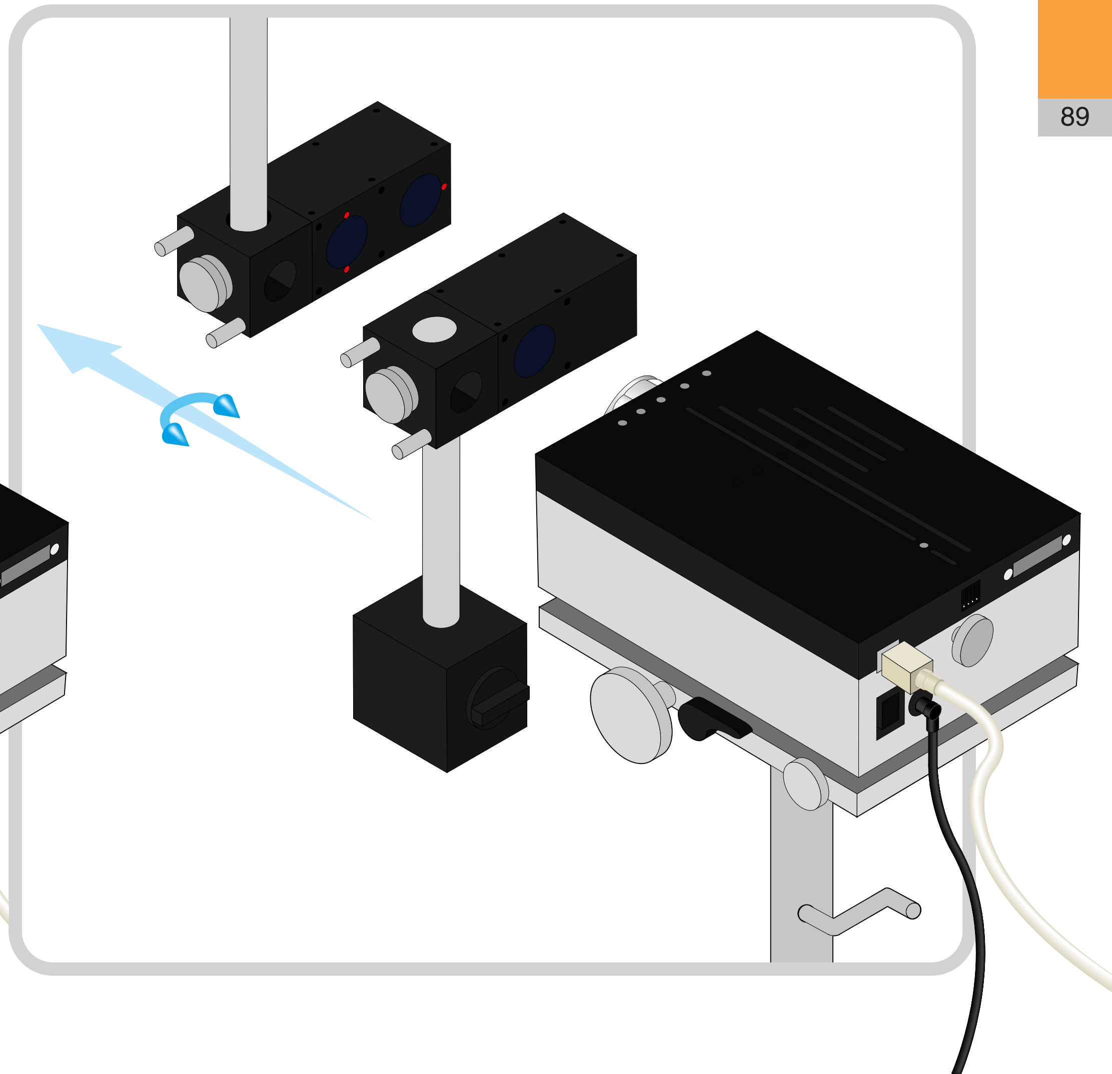
Mounting the optics

The pitch/yaw measurement set ups – horizontal axis

Pitch angle



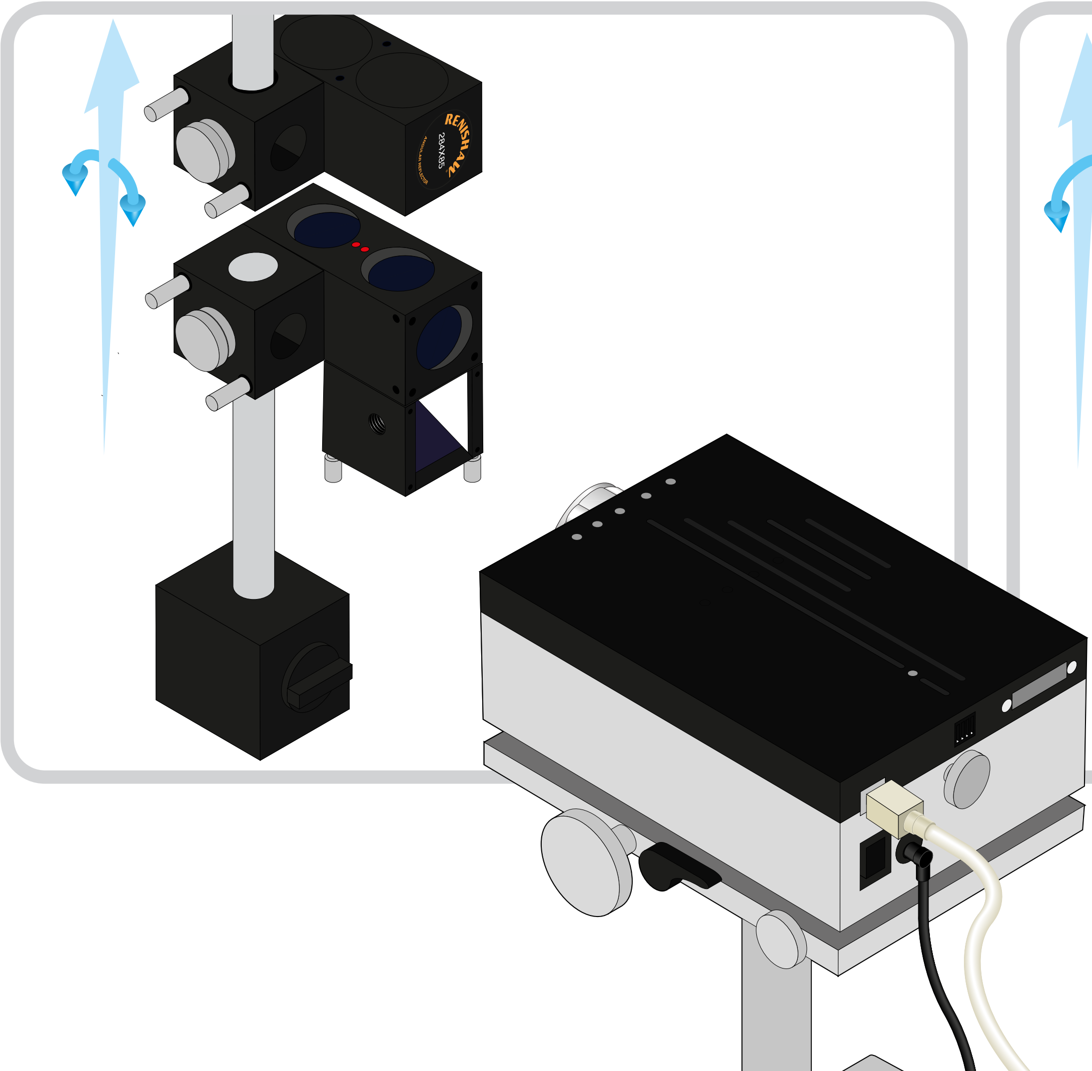
Yaw angle



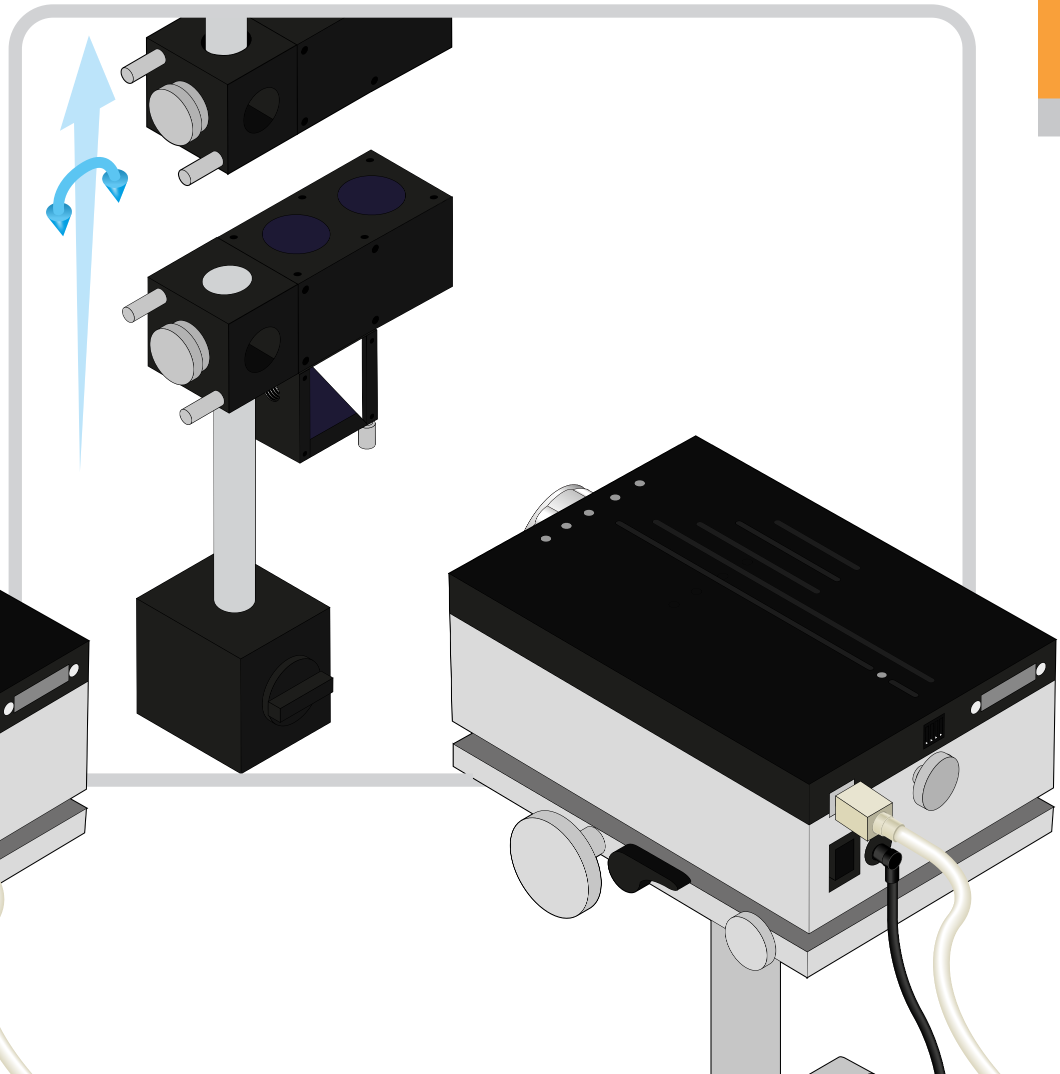
Mounting the optics

The pitch/yaw measurement set ups – vertical axis

Pitch angle

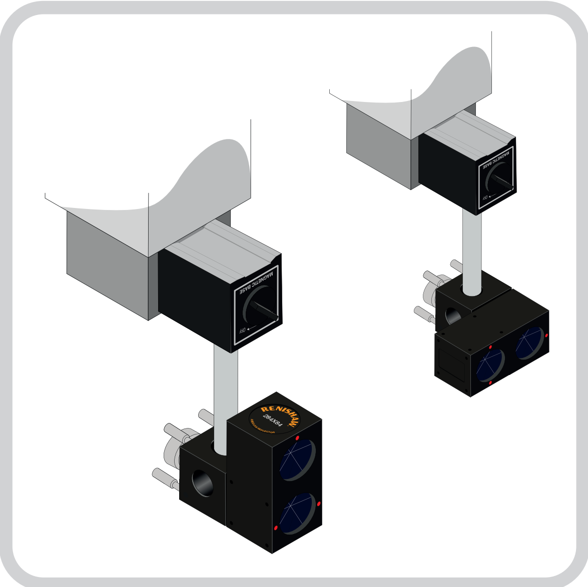


Yaw angle

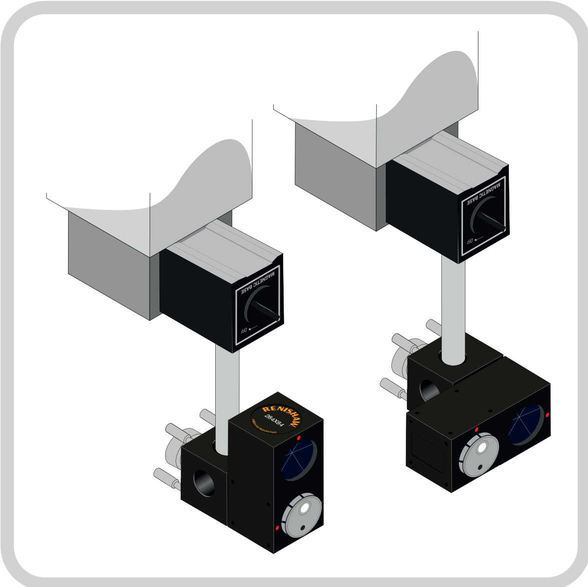


Mounting the optics

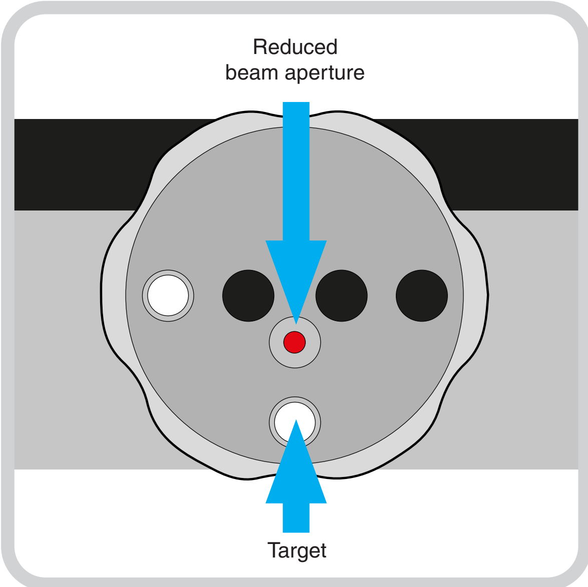
Mounting the retroreflector



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

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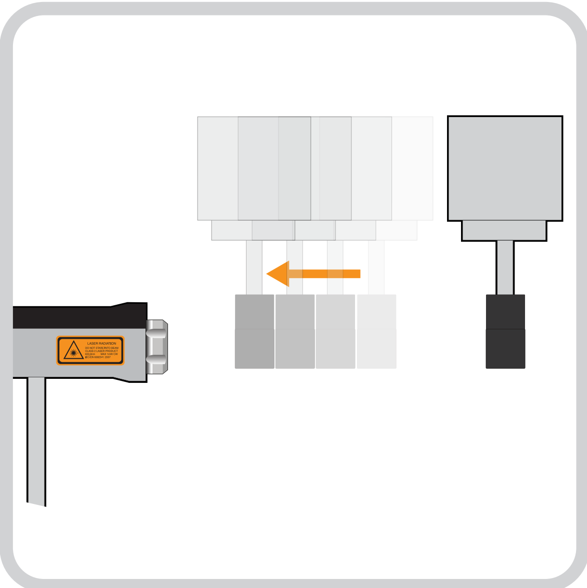
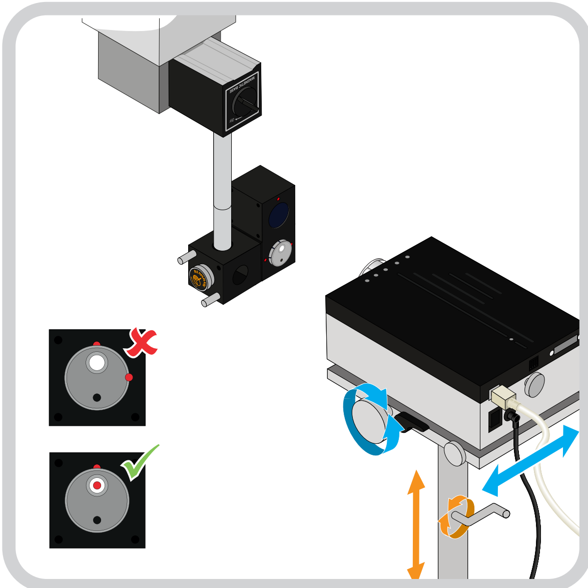
Mounting the optics

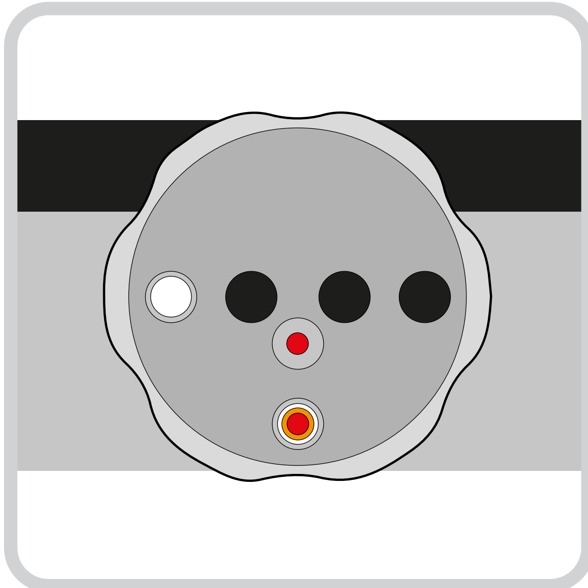
Mounting the retroreflector



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 not translate the laser or the machine

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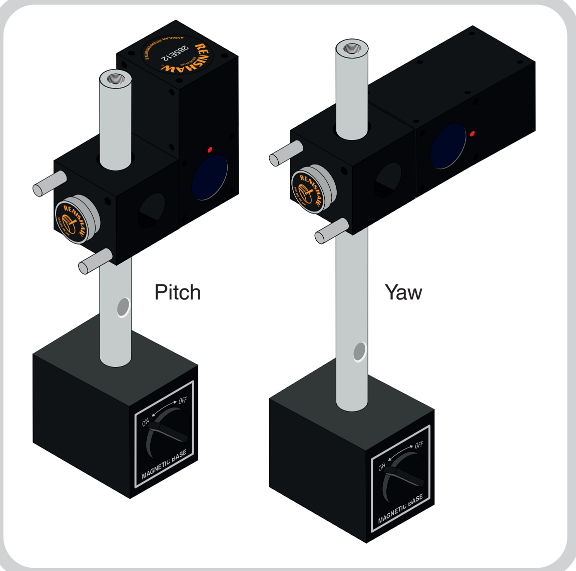
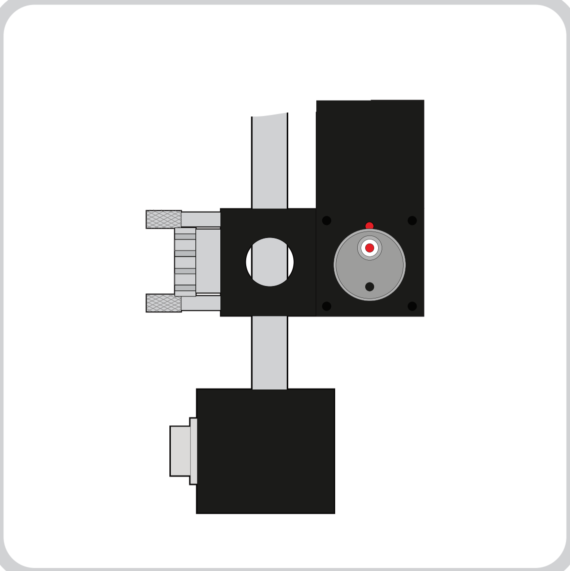
Mounting the optics

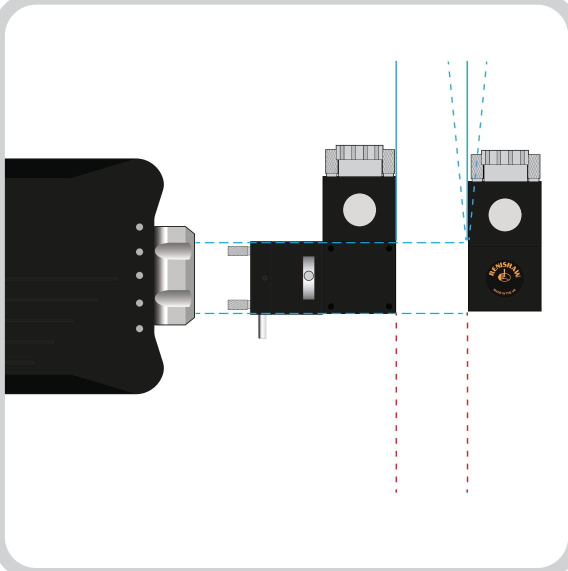
Mounting the angular interferometer



Assemble the interferometer assembly as shown



Attach target to input aperture and align with the beam



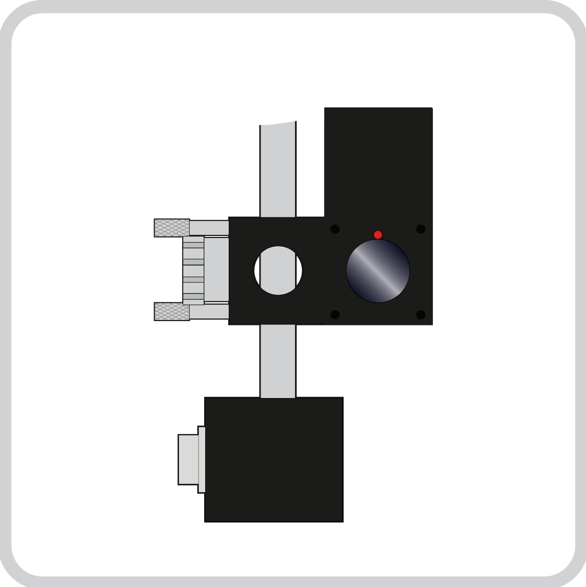
Mount to the stationary element of the machine;

- As close as possible minimising the distance between the optics
- Square to the axis
- Parallel to the retroreflector

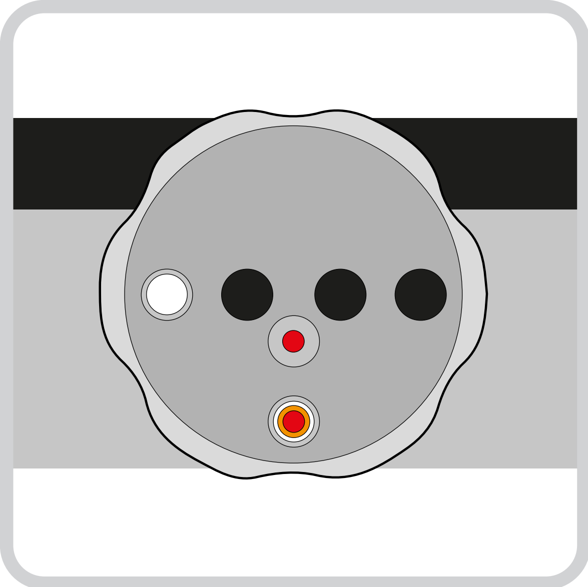
Visual alignment

Mounting the angular interferometer

The linear measurement set up



Remove the target

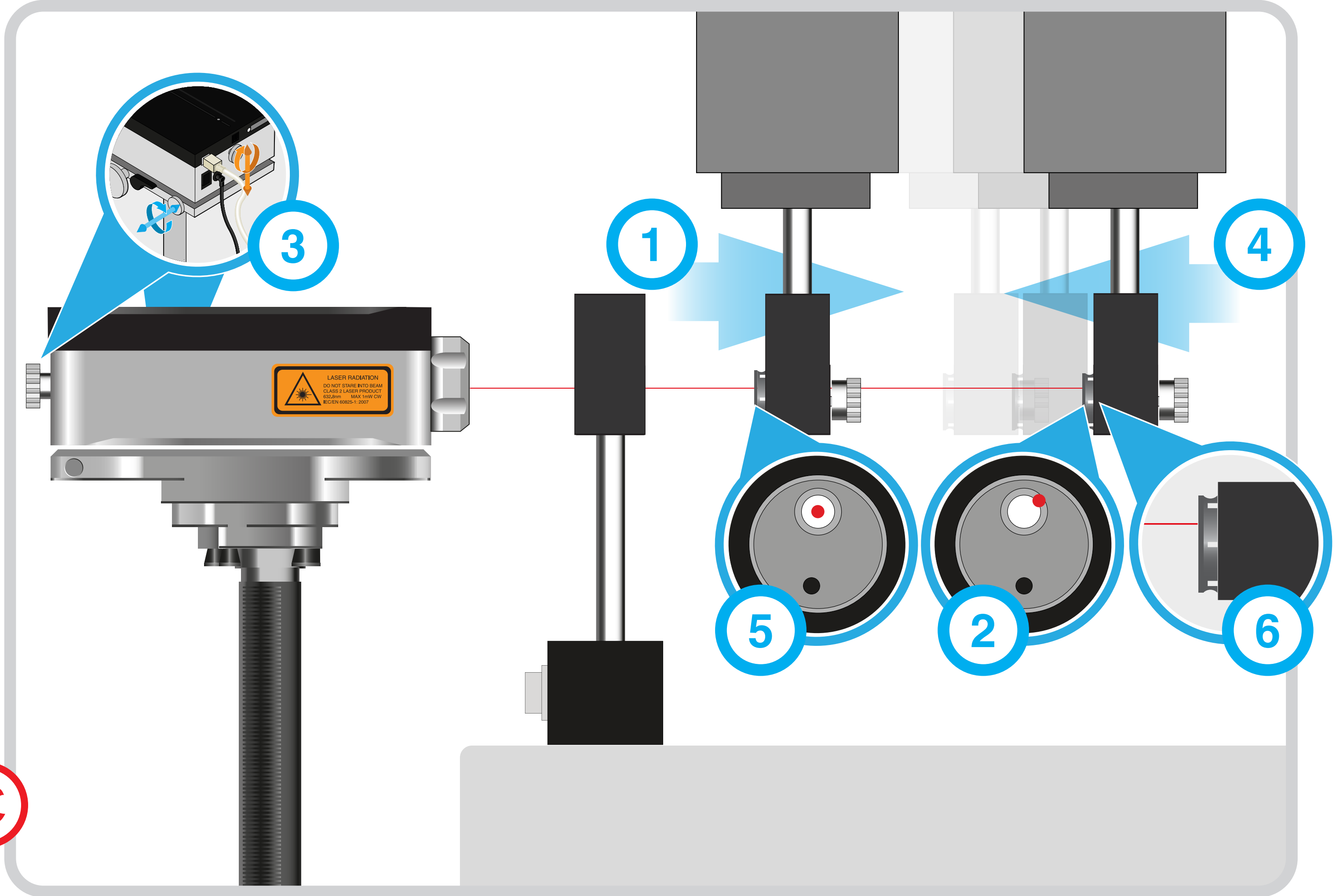


Check that the returned beam hits the centre of the target on the XL laser shutter – if not adjust the position of the interferometer

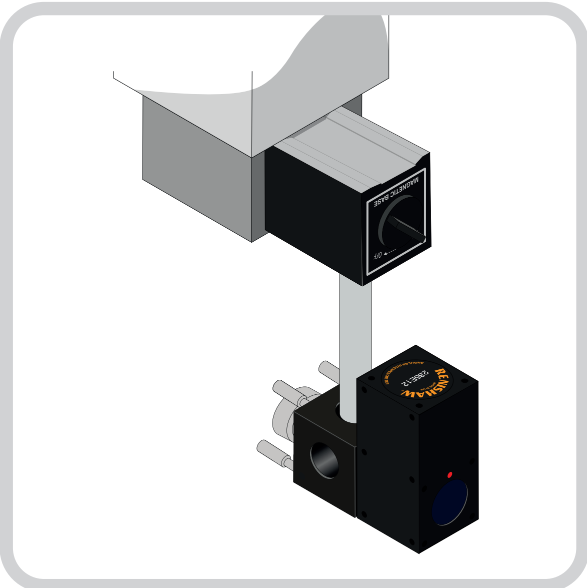
Visual alignment

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 beam position along axis

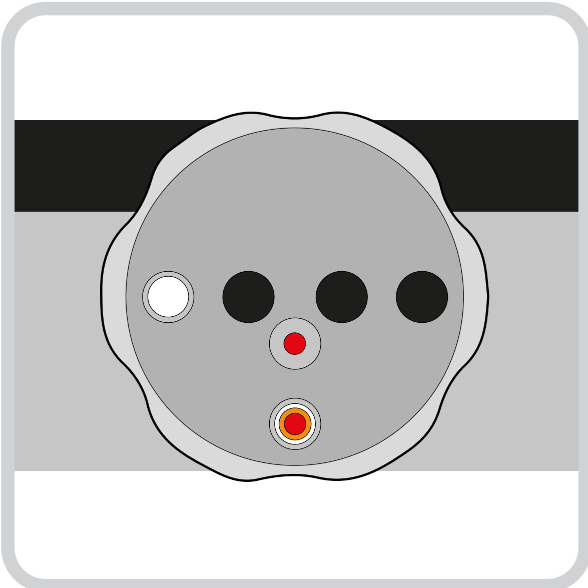
Repeat until the beam remains in the centre of the target over full length of the axis travel



Visual alignment



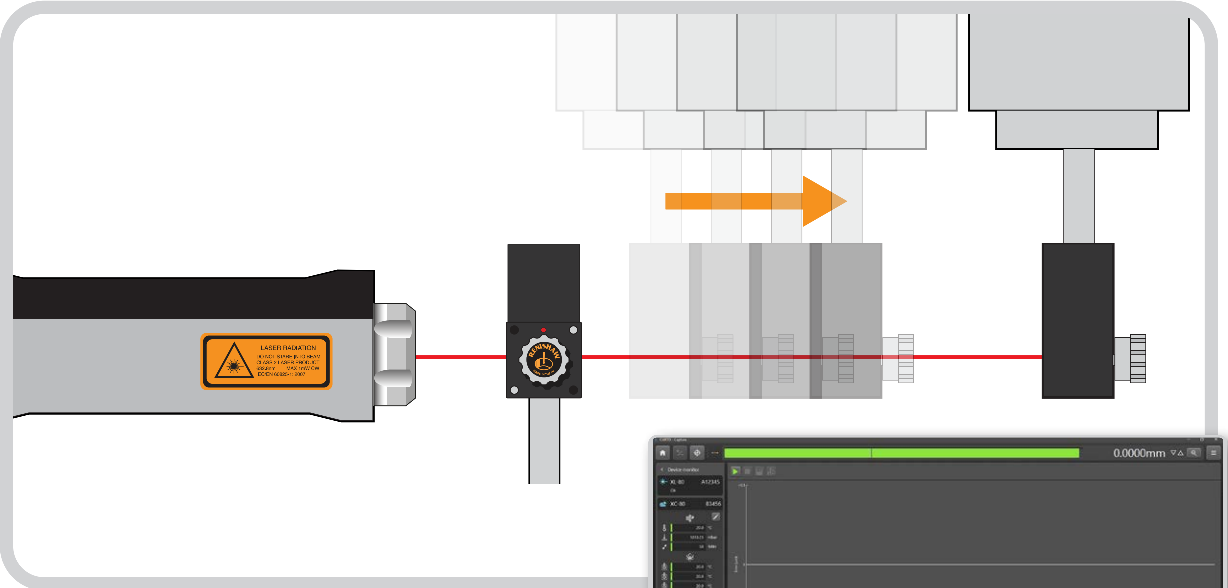
Remove the target from the retroreflector

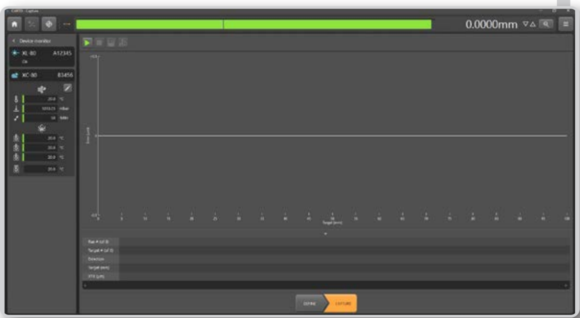


Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target

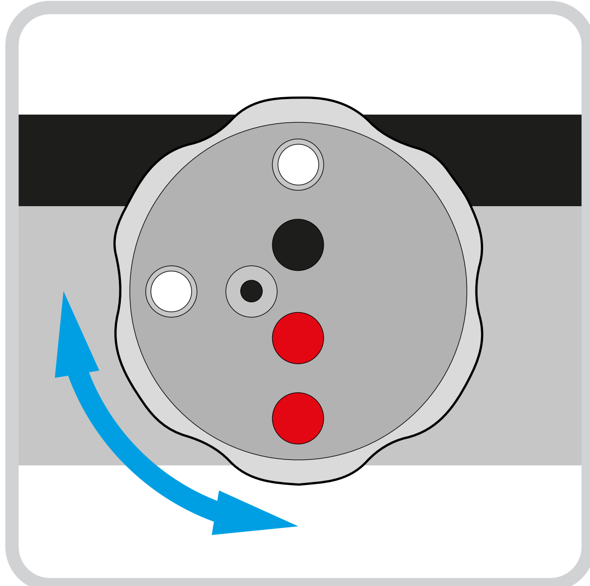
Fine alignment

Removal of cosine errors





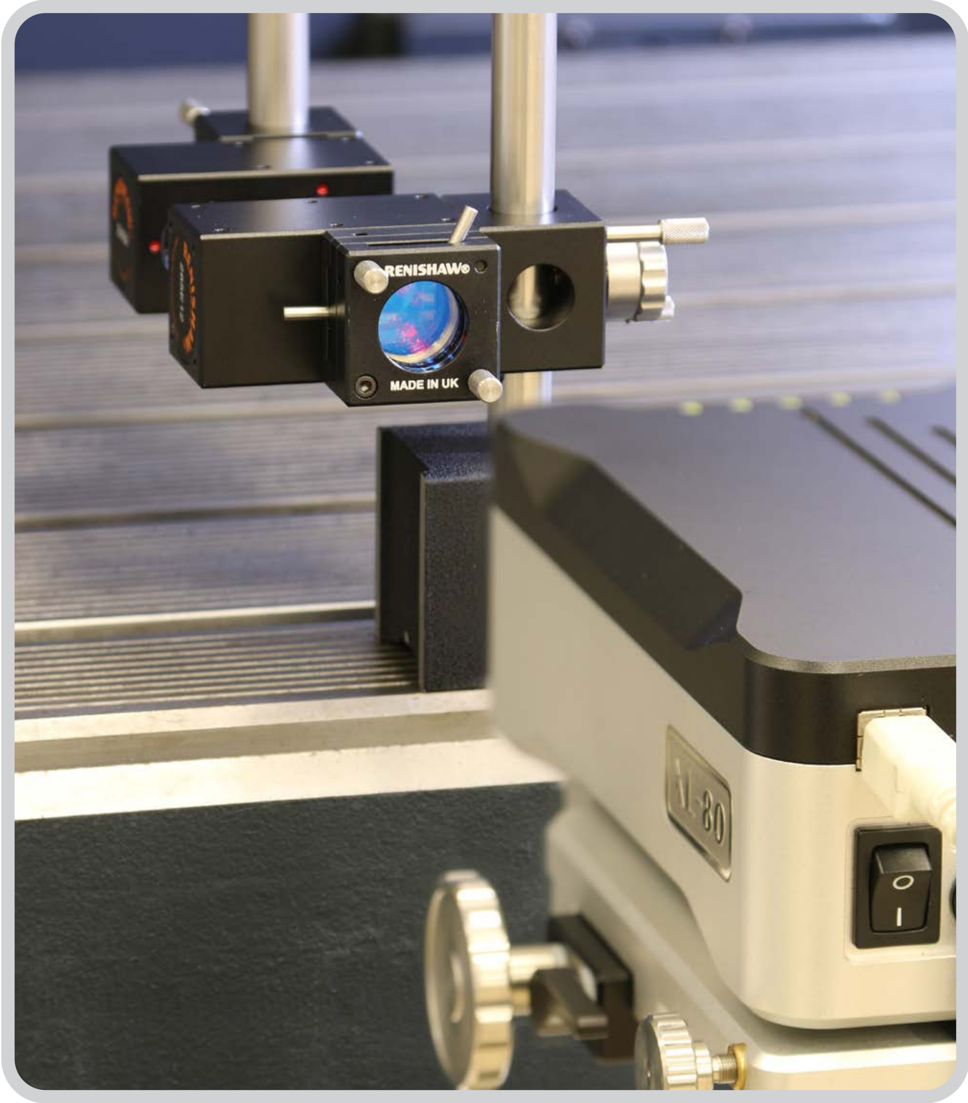
At the far position, carefully adjust the pitch/yaw until the signal strength bar at the top of the CARTO software screen is maximised.



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

Angular measurement (pitch/yaw)

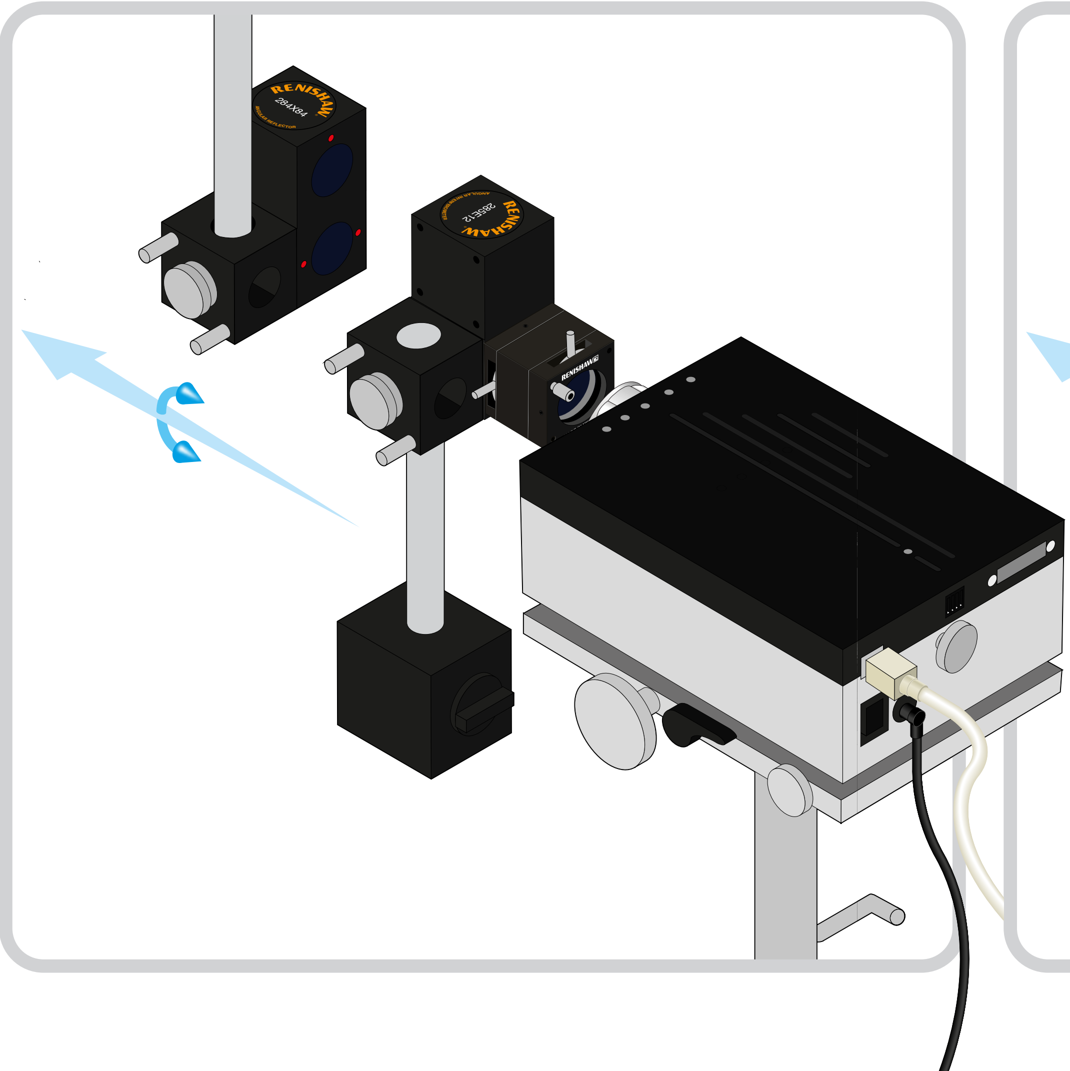
With LS350 laser beam steerer



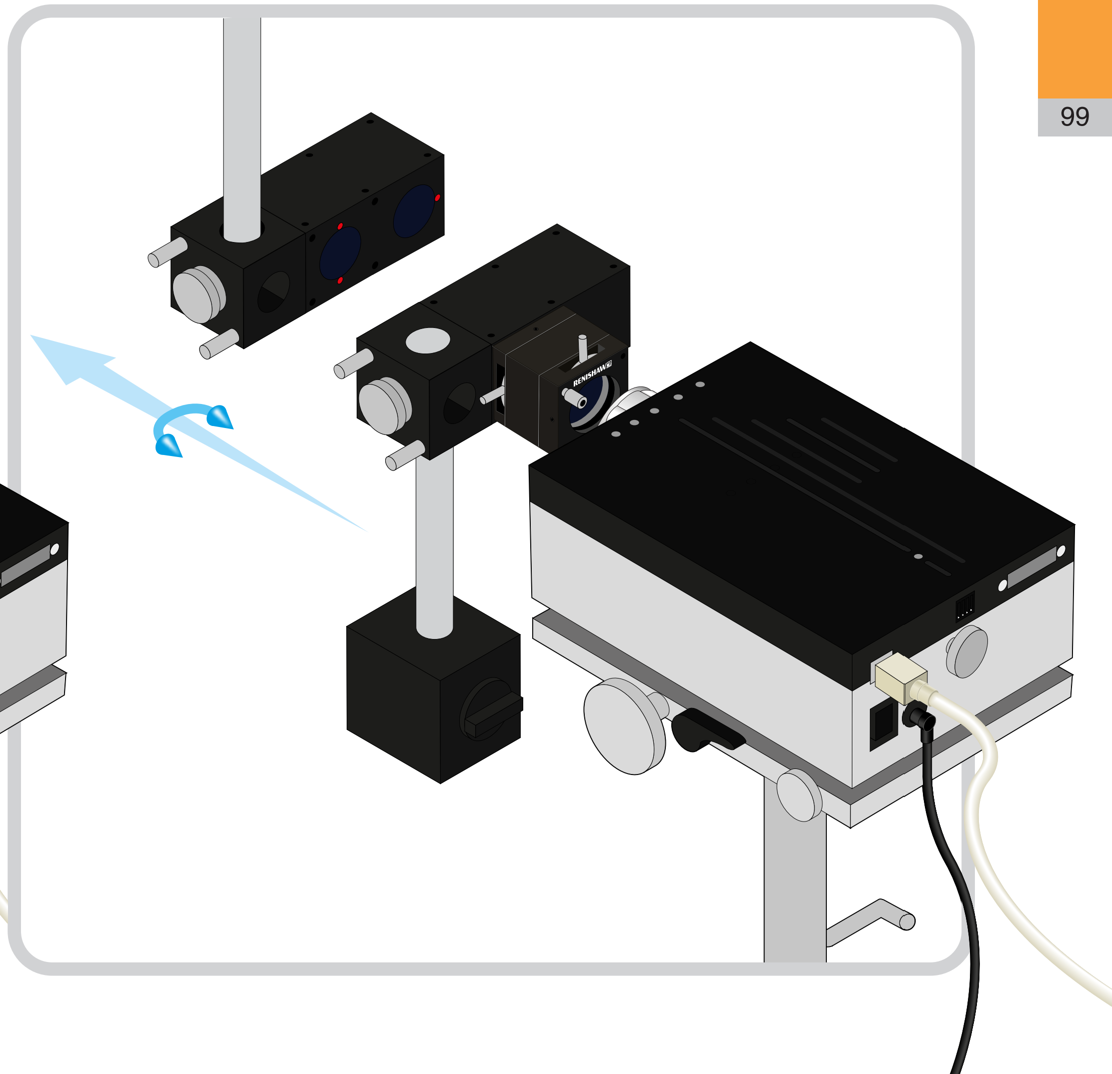
Mounting the optics

The pitch/yaw measurement set ups – horizontal axis

Pitch angle



Yaw angle



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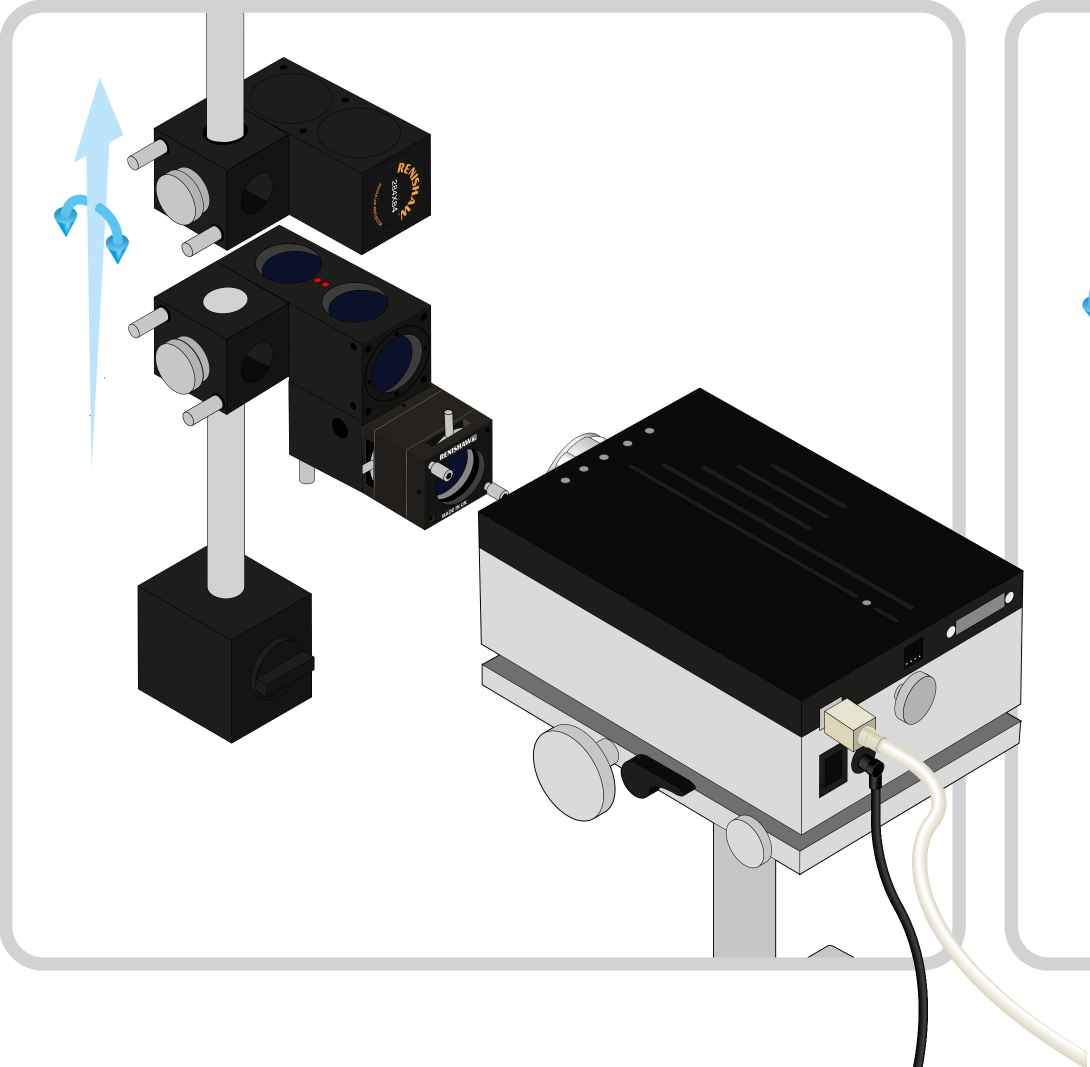
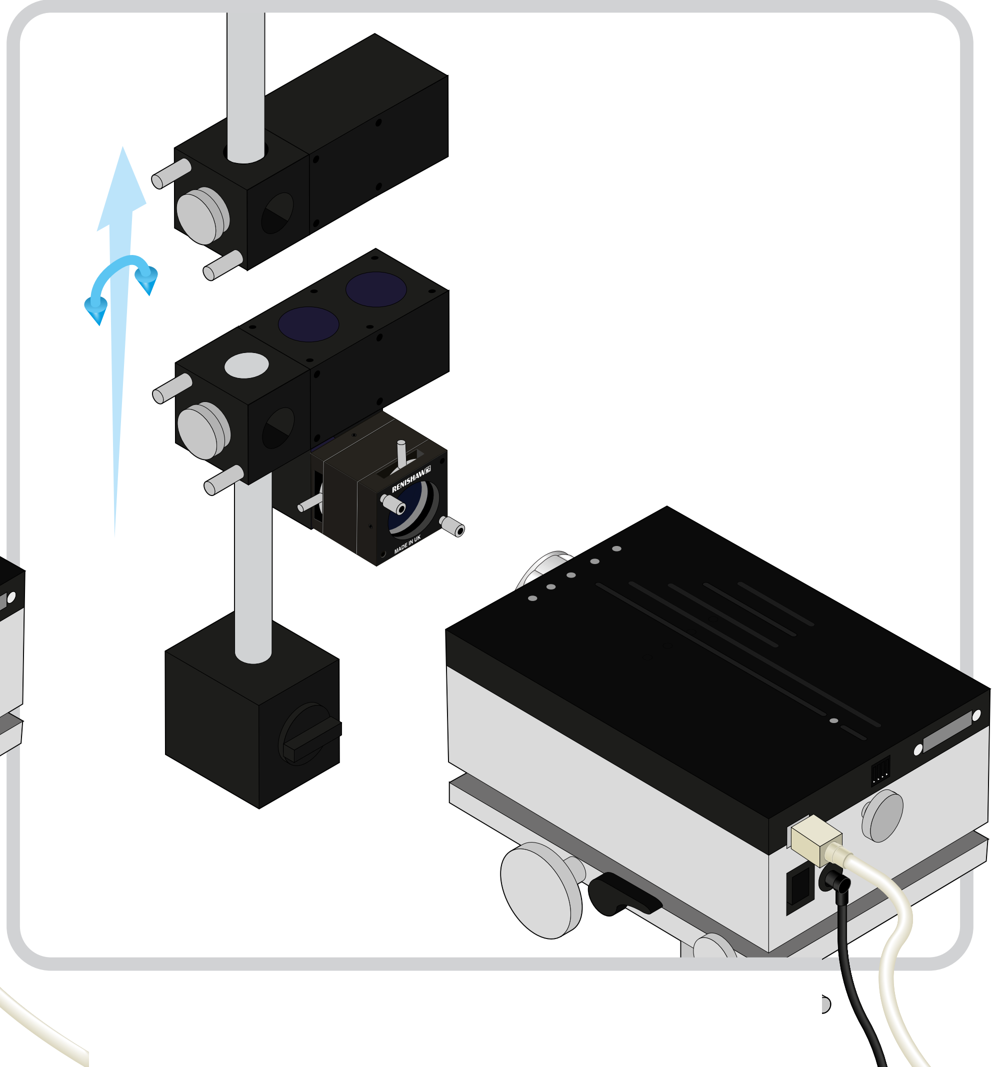
Mounting the optics

The pitch/yaw measurement set ups – vertical axis

Pitch angle

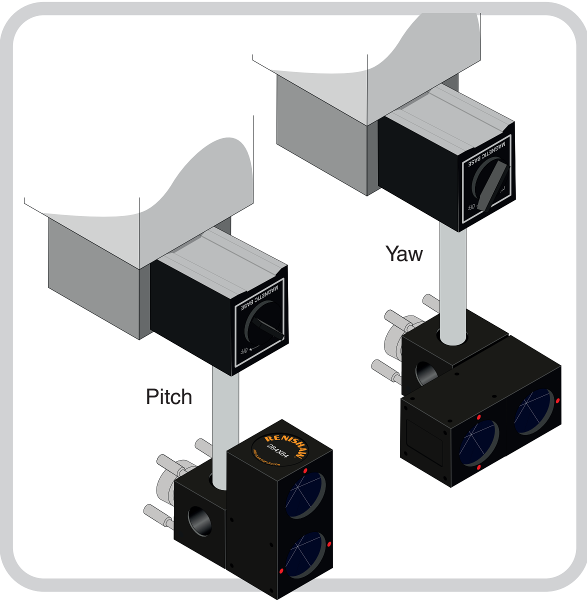


Yaw angle

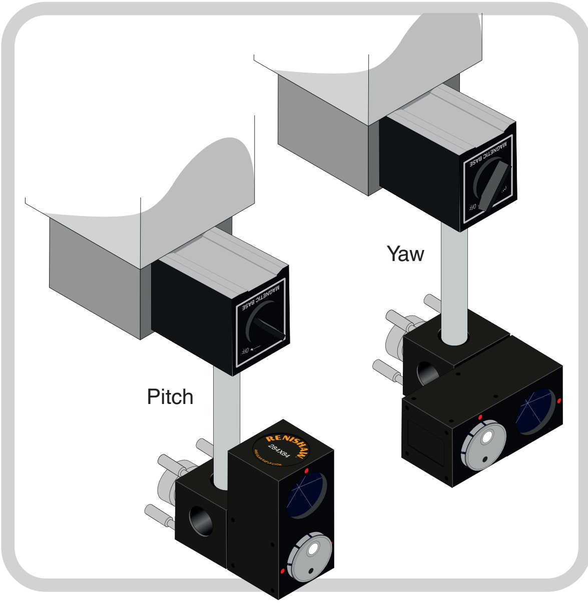


Mounting the optics

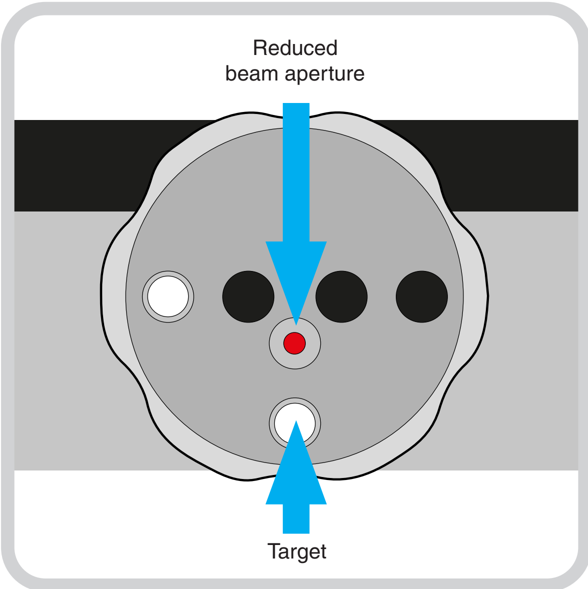
Mounting the retroreflector



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



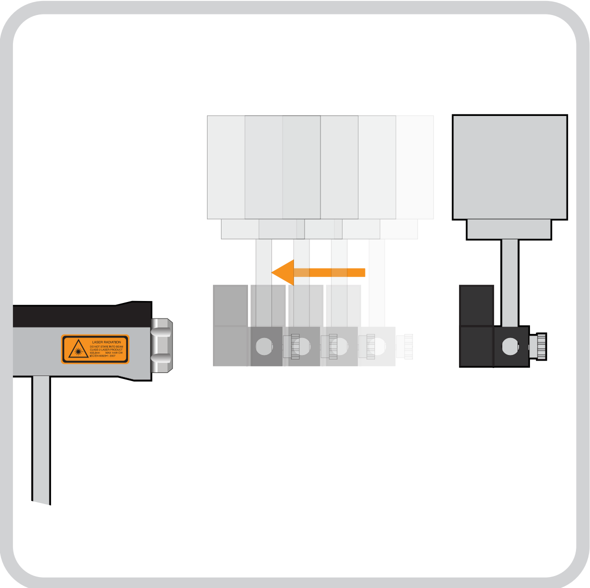
Attach the target onto the face of the retroreflector



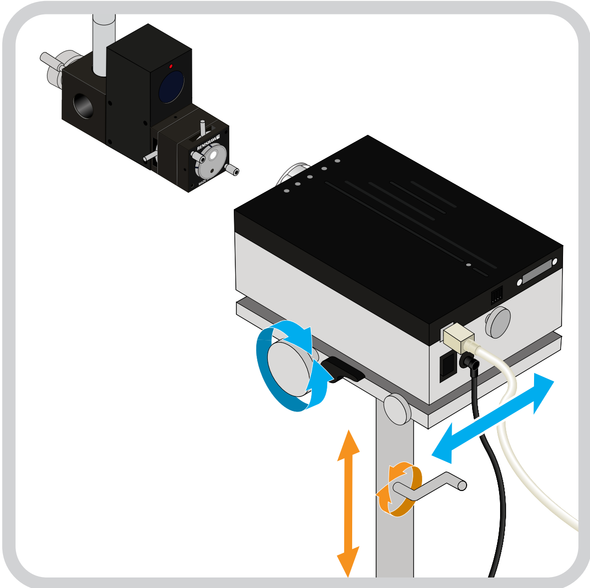
Rotate the laser shutter to emit a reduced diameter beam

Mounting the optics

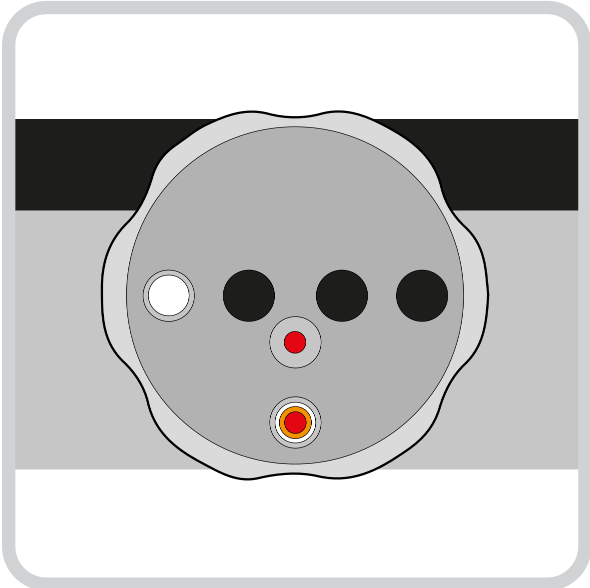
Mounting the retroreflector



Drive the retroreflector to the 'near field' position



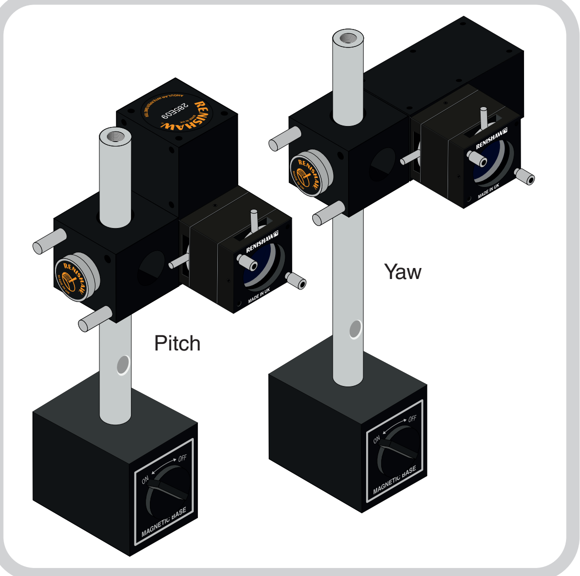
Adjust the beam to the centre of the white target using the translation screws



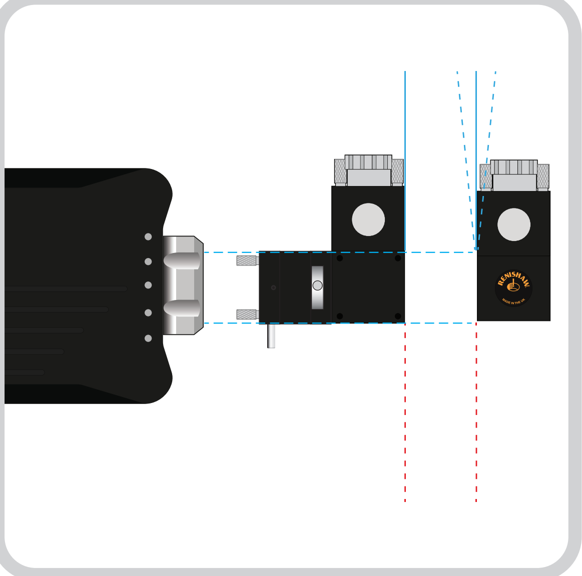
Remove the target and check that the returned beam hits the centre of the target on the XL laser shutter – if not translate the laser or the machine

Mounting the optics

Mounting the angular interferometer

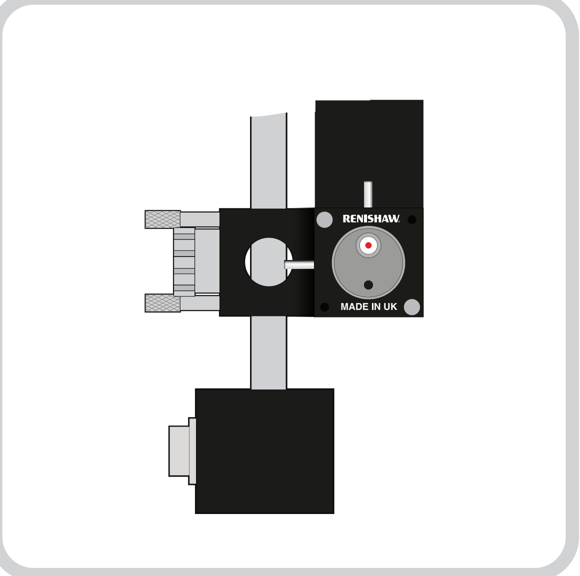


Assemble the interferometer assembly and mount the beam steerer onto the input face of the beam splitter as shown. Ensure that the levers are in their mid-position



Mount to the stationary element of the machine;

- As close as possible minimising the distance between the optics
- Square to the axis
- Parallel to the retroreflector

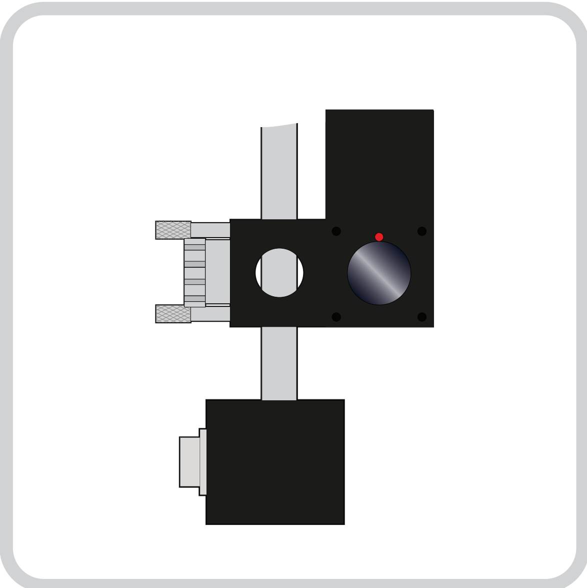


Attach target to input aperture and align with the beam

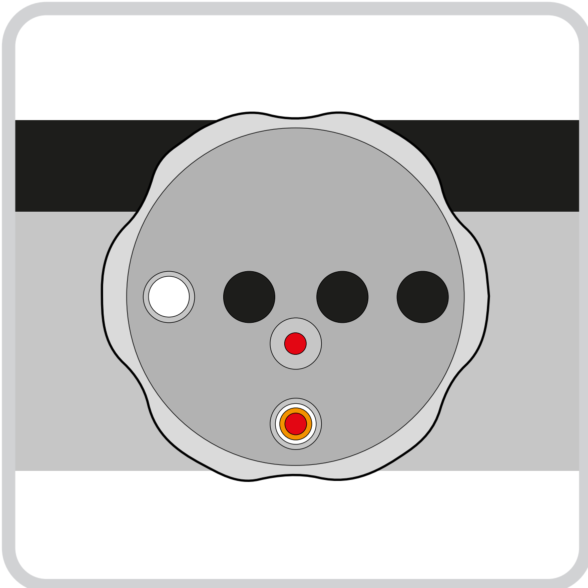
Visual alignment

Mounting the angular interferometer

The angular measurement set up



Remove the target

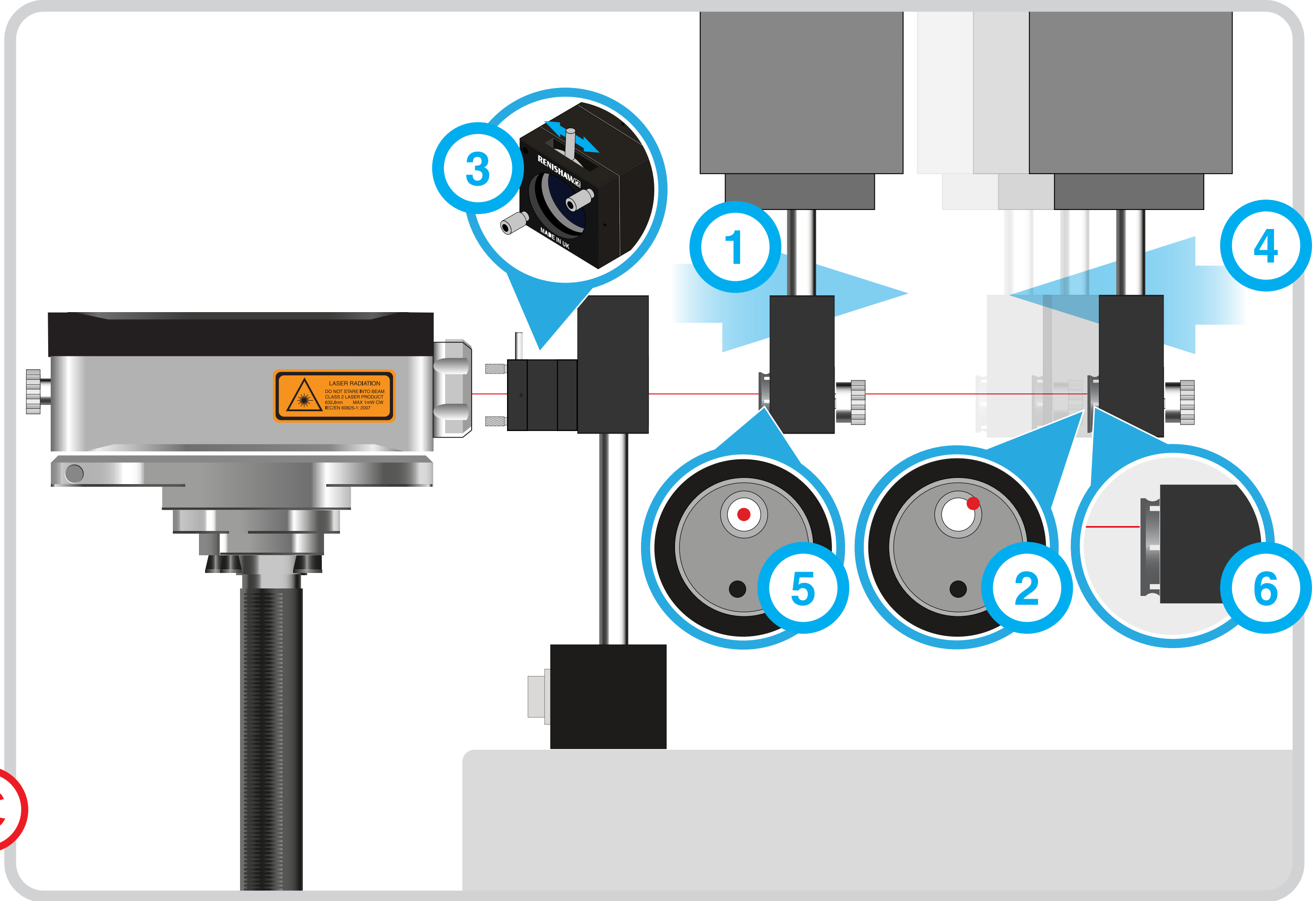


Check that the returned beam hits the centre of the target on the XL laser shutter – if not adjust the position of the interferometer

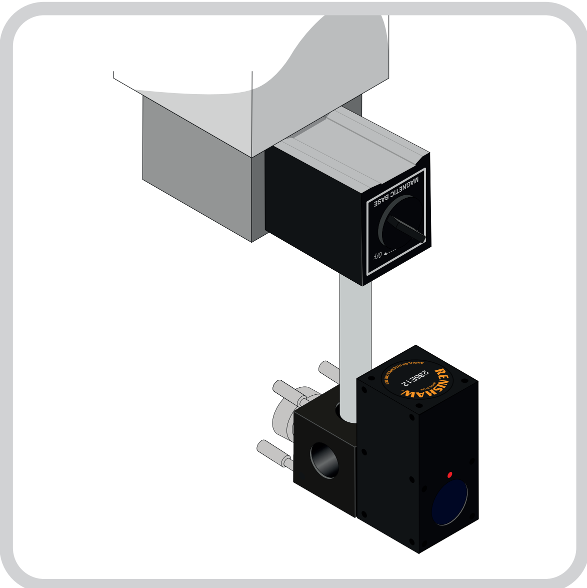
Visual alignment

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 beam position along axis

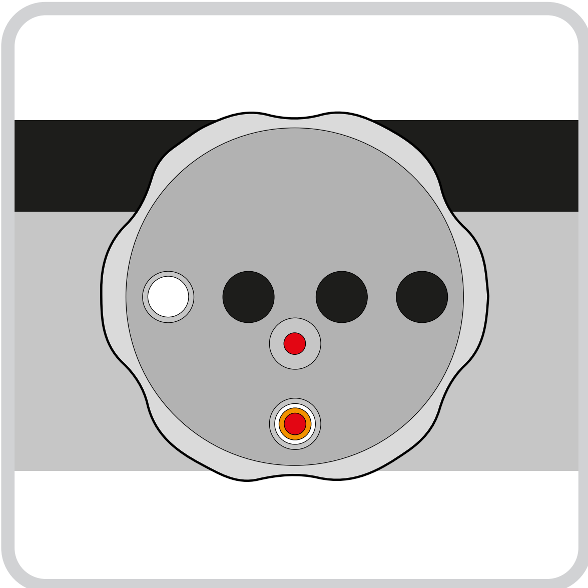
Repeat until the beam remains in the centre of the target over full length of the axis travel



Visual alignment



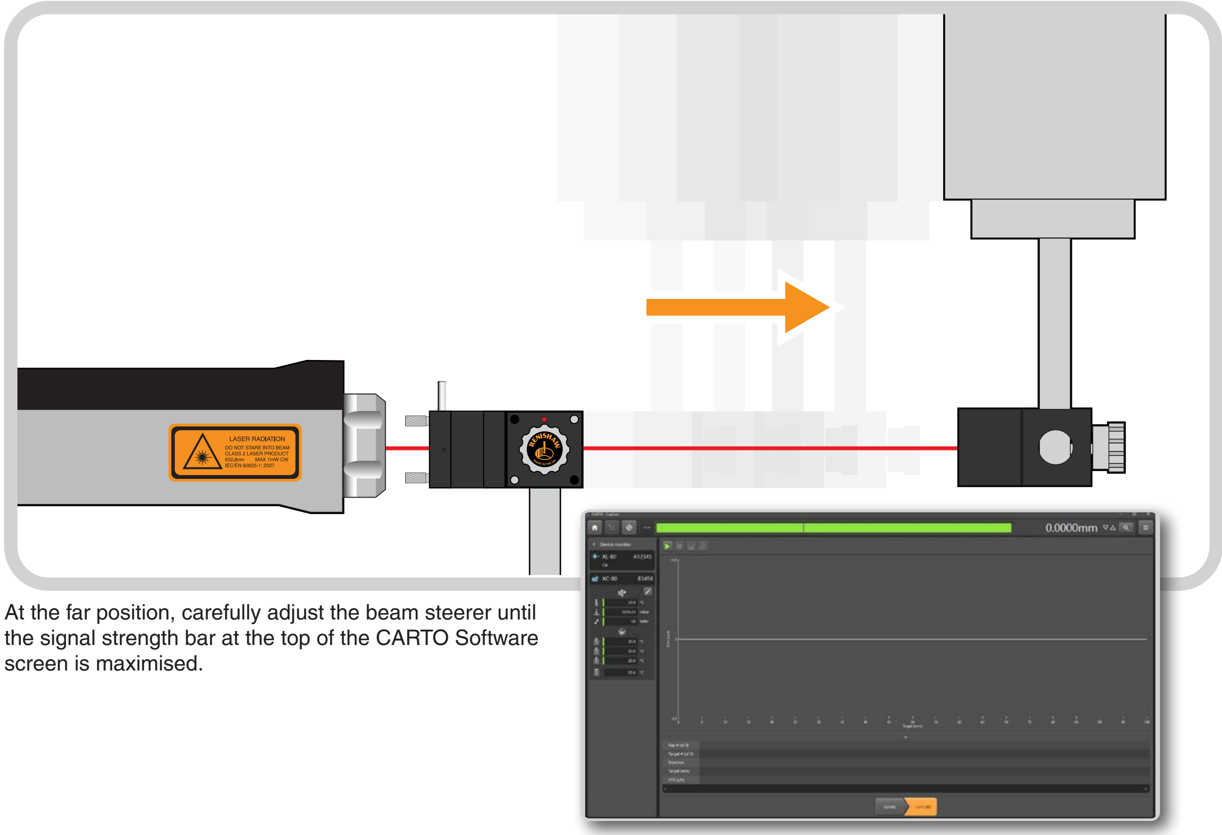
Remove the target from the retroreflector



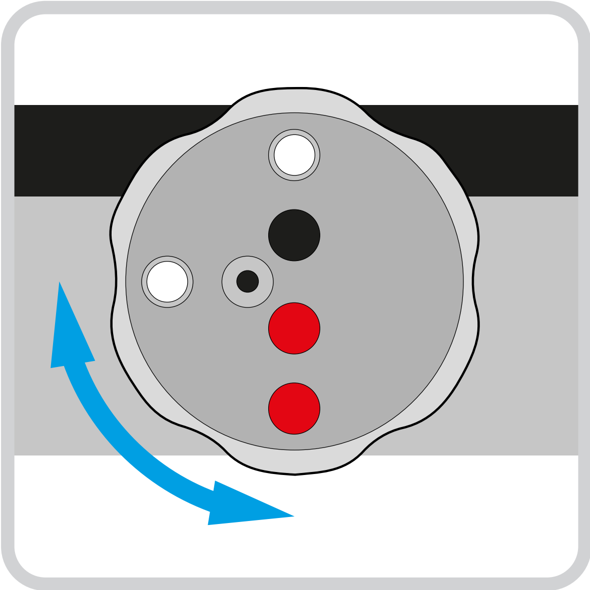
Ensure that the two return beams are overlapping on the shutter target. Use the tripod height adjustment and the horizontal adjustment on the tripod stage to bring the beams back to the centre of the target

Fine alignment

Removal of cosine errors



At the far position, carefully adjust the beam steerer until the signal strength bar at the top of the CARTO Software screen is maximised.



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

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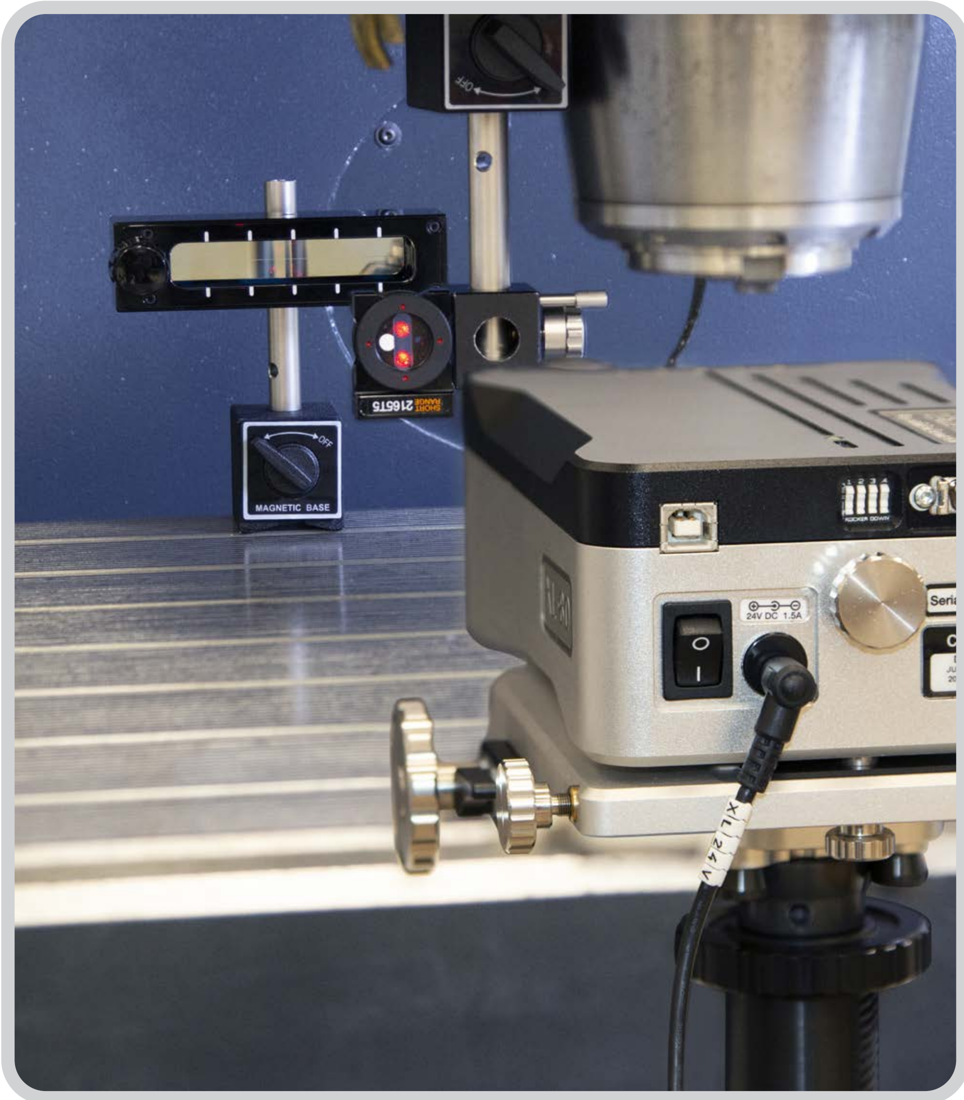
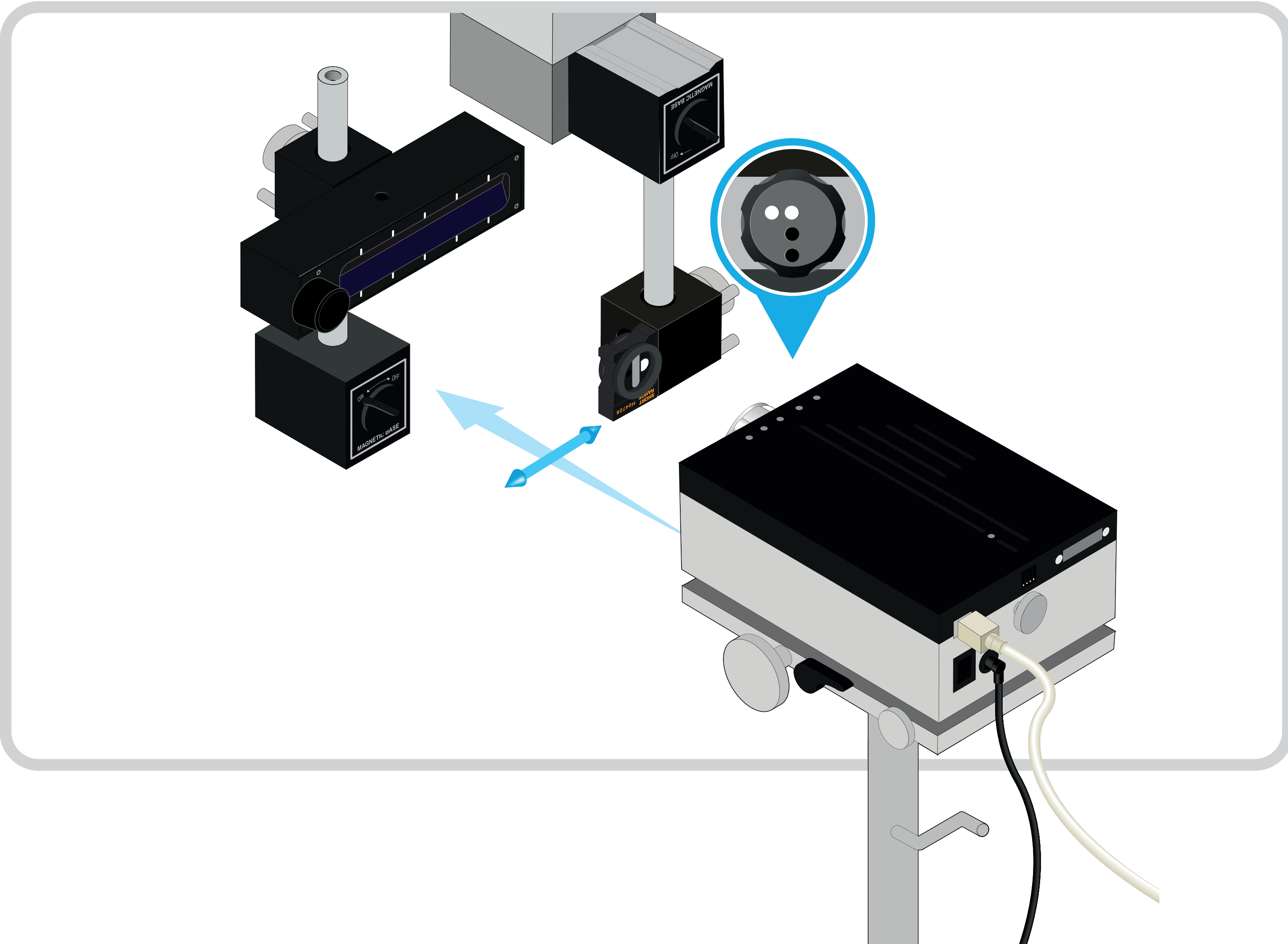
Straightness measurement (horizontal axis – horizontal plane)



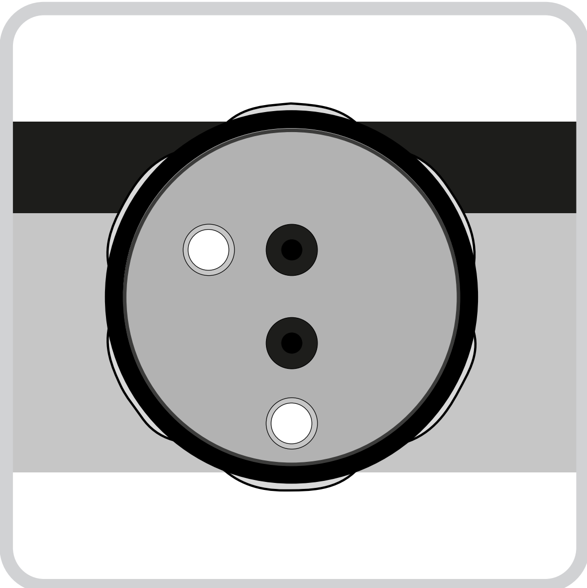
Mounting the optics

Horizontal measurement plane

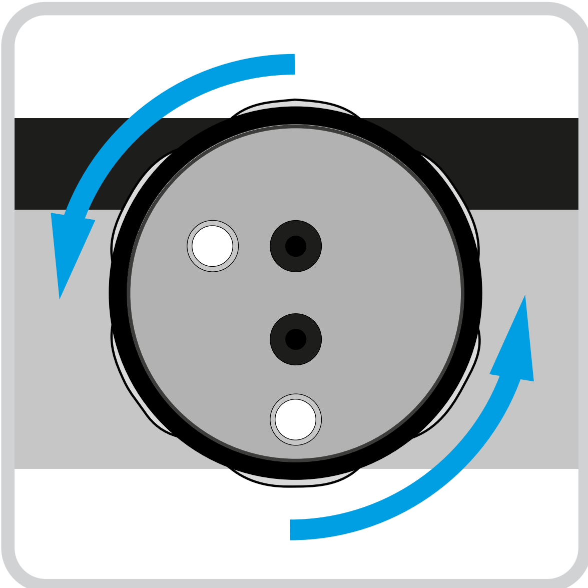


Horizontal axis

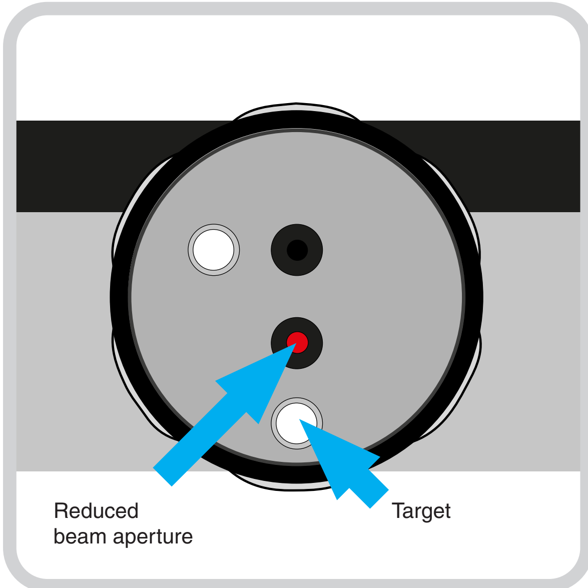
Horizontal measurement plane



Attach the straightness shutter to the laser in the orientation shown



Rotate the black bezel of the laser shutter…



…until a reduced diameter beam is emitted

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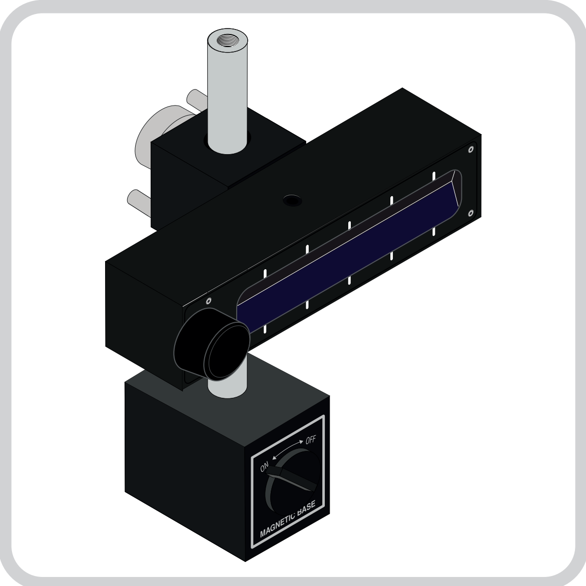
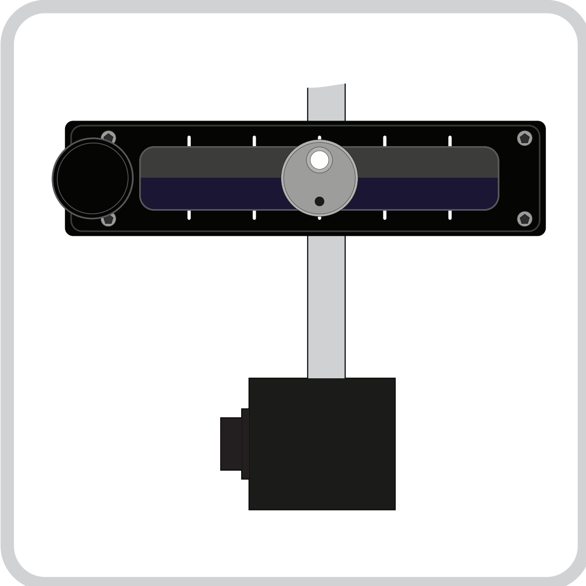
Mounting the optics

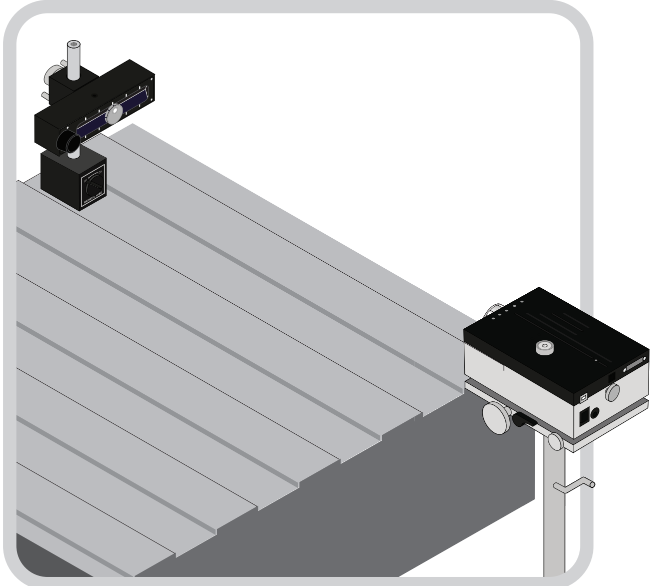
Mounting the straightness retroreflector



Assemble the retroreflector as shown



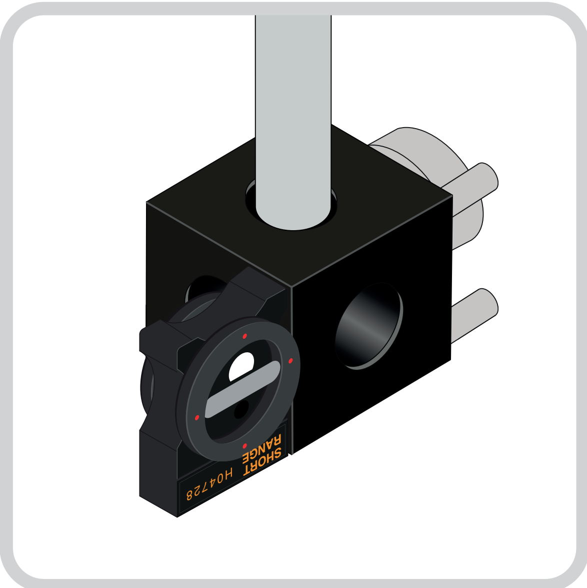
Attach the target to the centre of the retroreflector



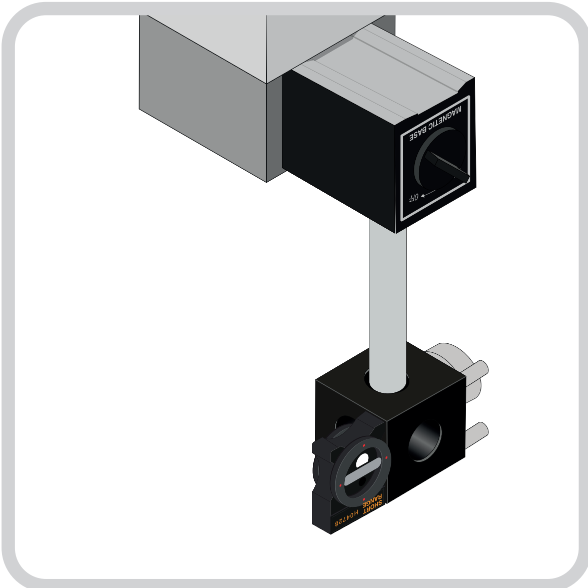
Mount to the stationary element of the machine in the farthest position along the axis of travel. Translate the retroreflector so that the beam is on the centre of the white target.

Mounting the optics

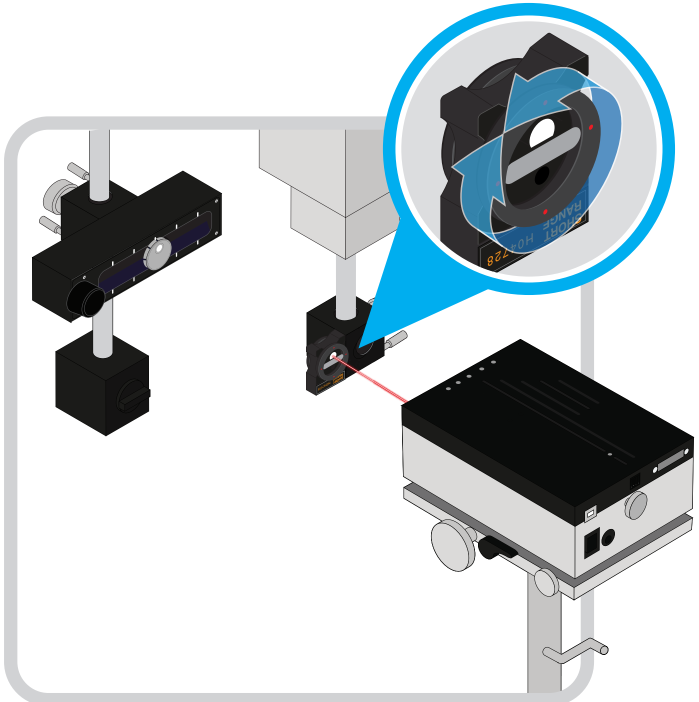
Mounting the large retroreflector



Assemble the interferometer assembly as shown



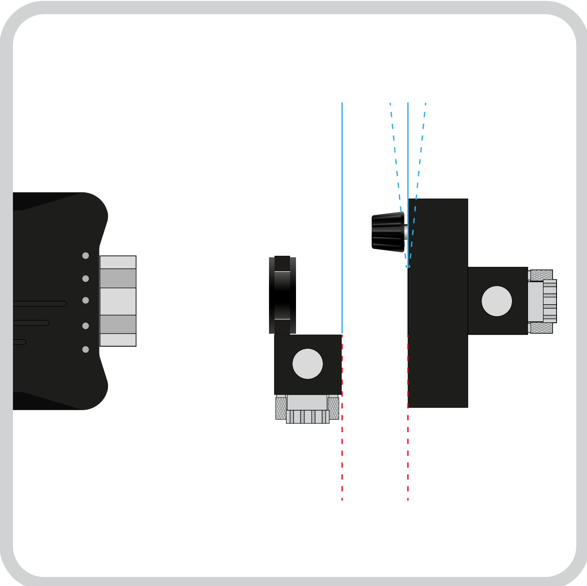
Mount to the moving element of the machine



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

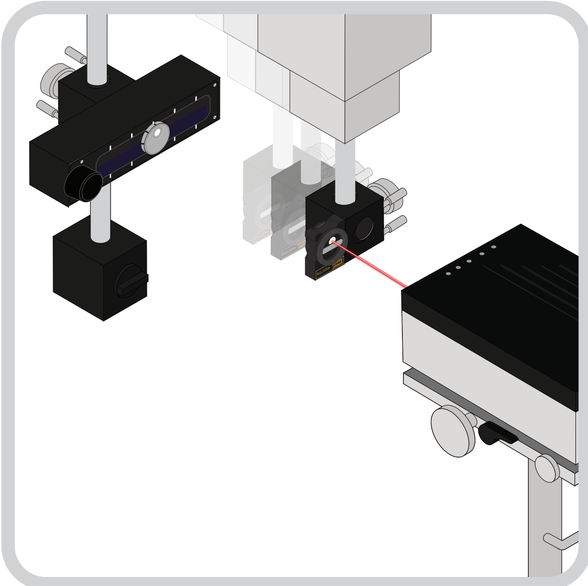
Mounting the optics

Mounting the straightness interferometer

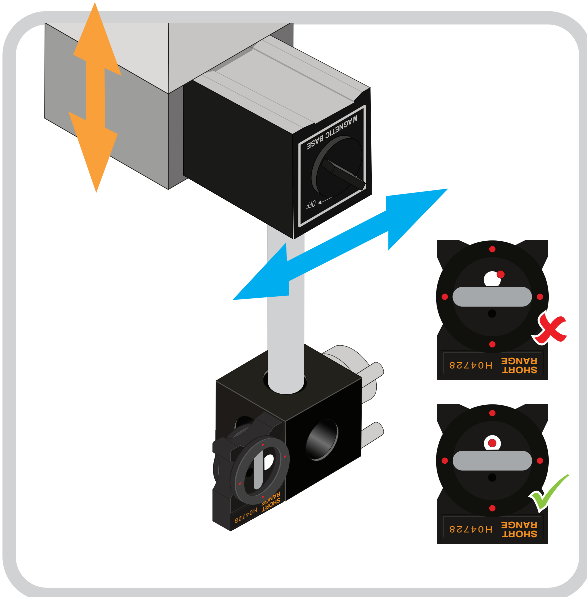


Mount to the stationary element of the machine:

- Square to the axis
- Parallel to the retroreflector



Drive the interferometer to the near field position

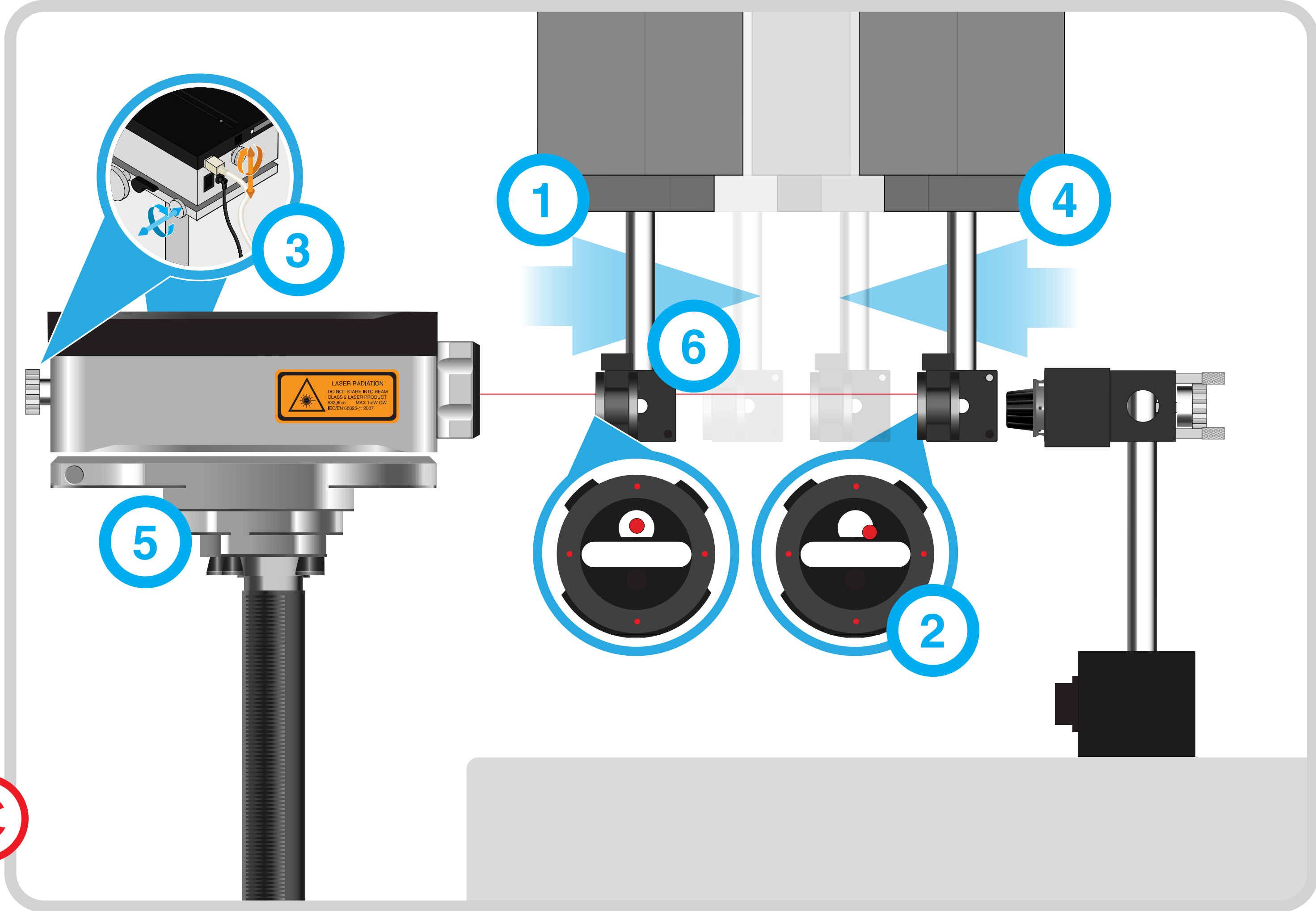


Translate the machine until the beam is on the white target

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 full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position



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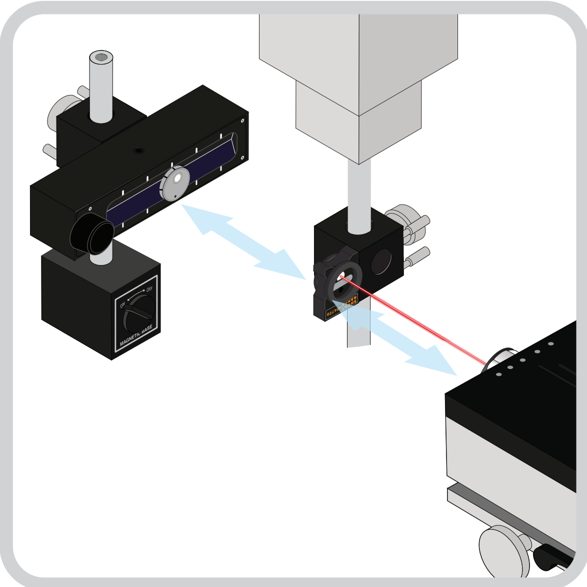
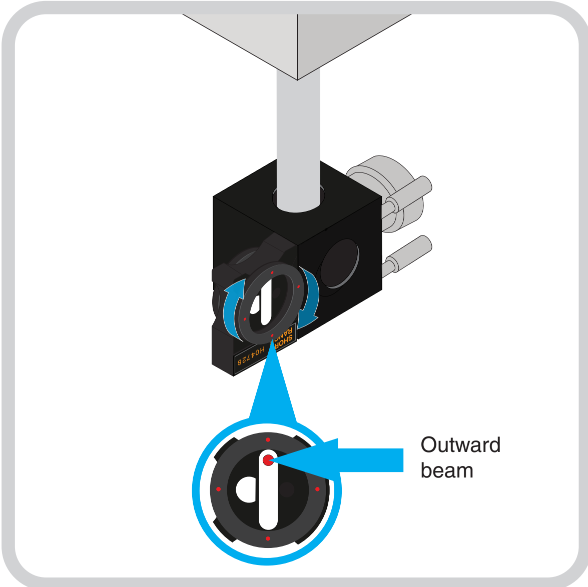
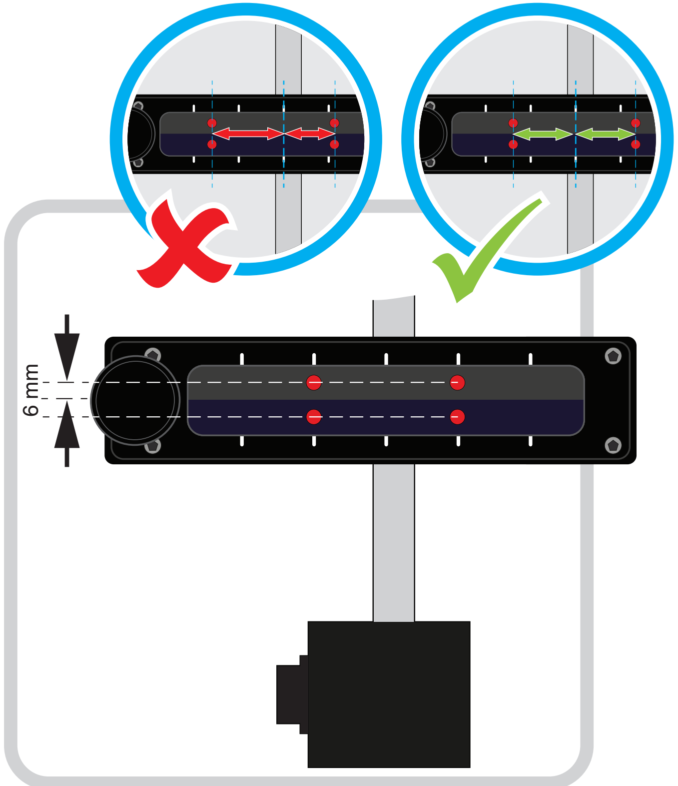
Visual alignment



Position the interferometer half way 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. If it does not, translate as required

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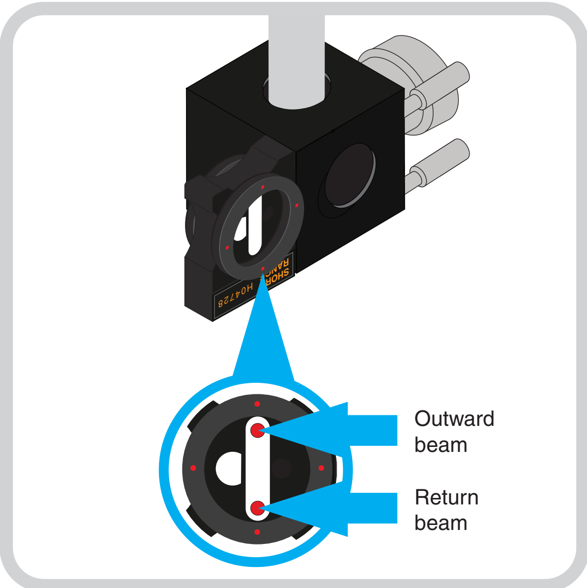
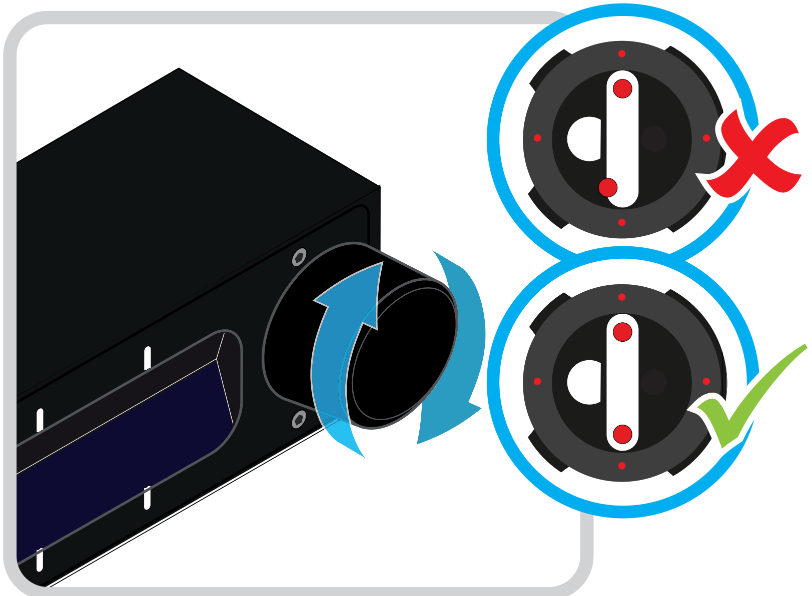
Visual alignment

Return beam alignment



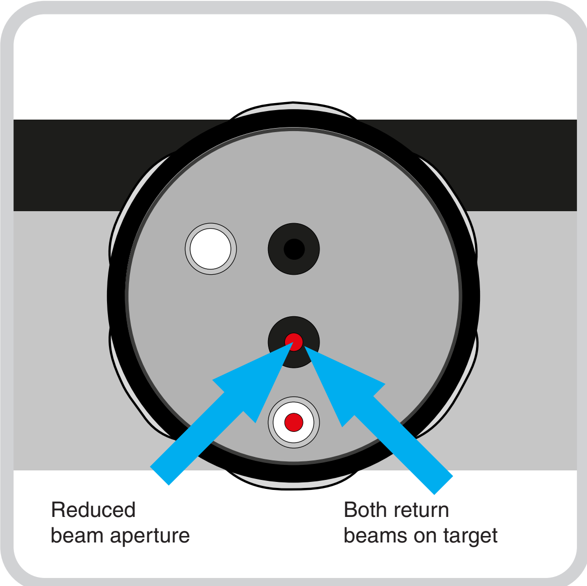
Ensure that the returned beam from the reflector enters the centre line of the interferometer



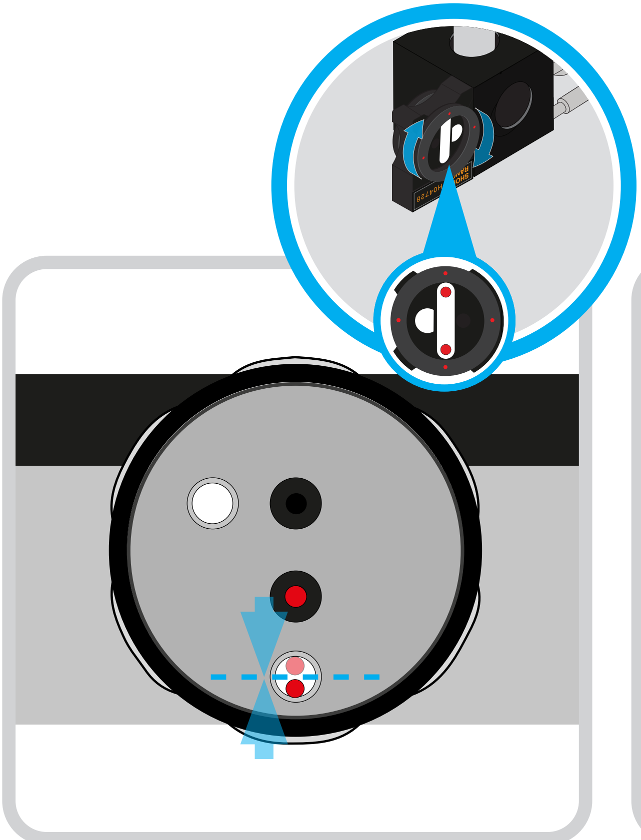
If the beams are to the left or right of the centre then adjust the tilt control knob

Visual alignment

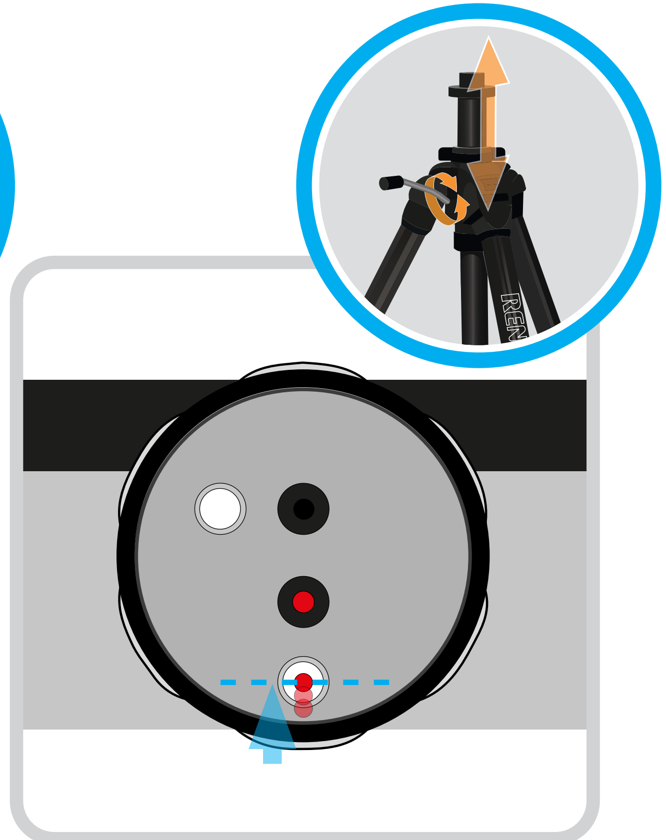
Straightness shutter



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



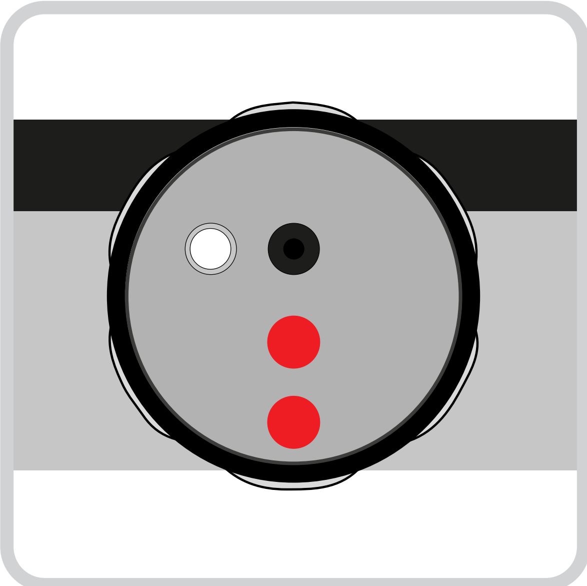
If the beams are not overlapping, finely rotate the interferometer face



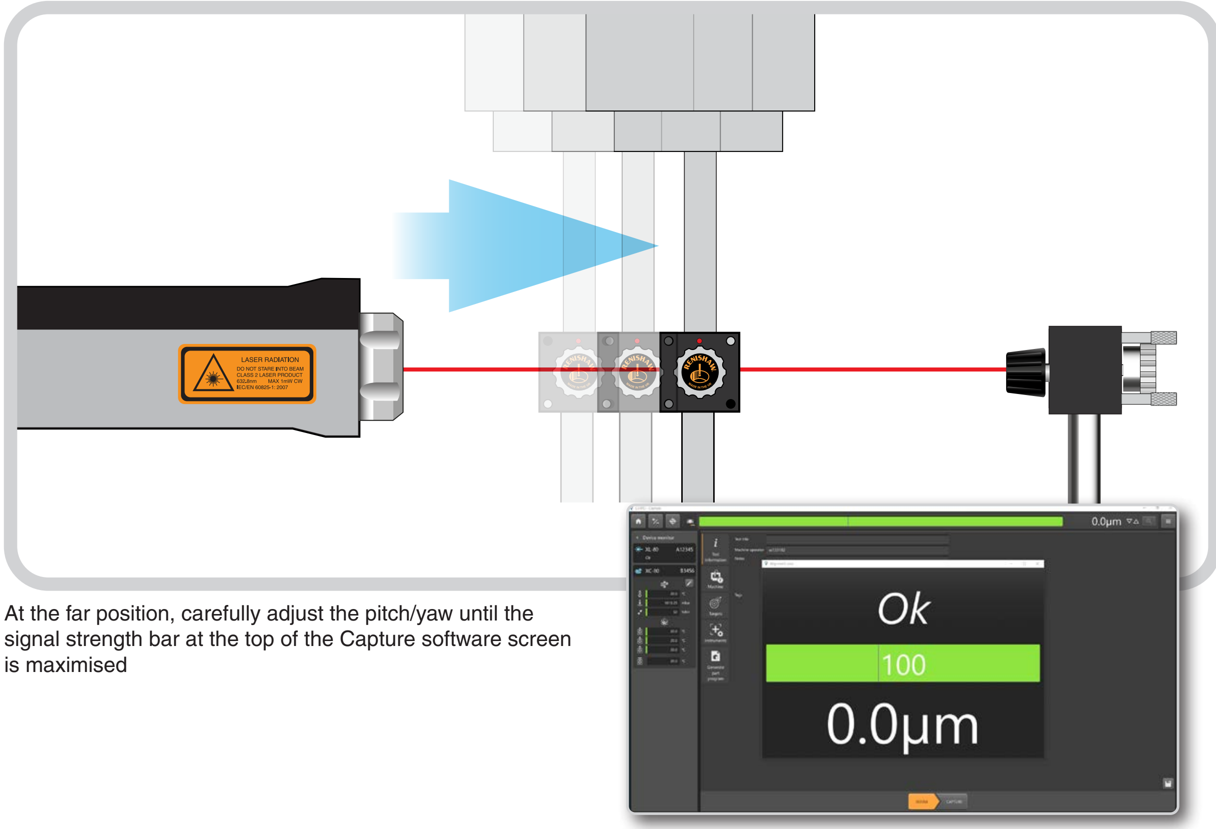
If the beams are the incorrect height, use the translation on the tripod

Visual alignment

Straightness shutter



Rotate the shutter until the 6 mm beam is emitted



At the far position, carefully adjust the pitch/yaw until the signal strength bar at the top of the Capture software screen is maximised

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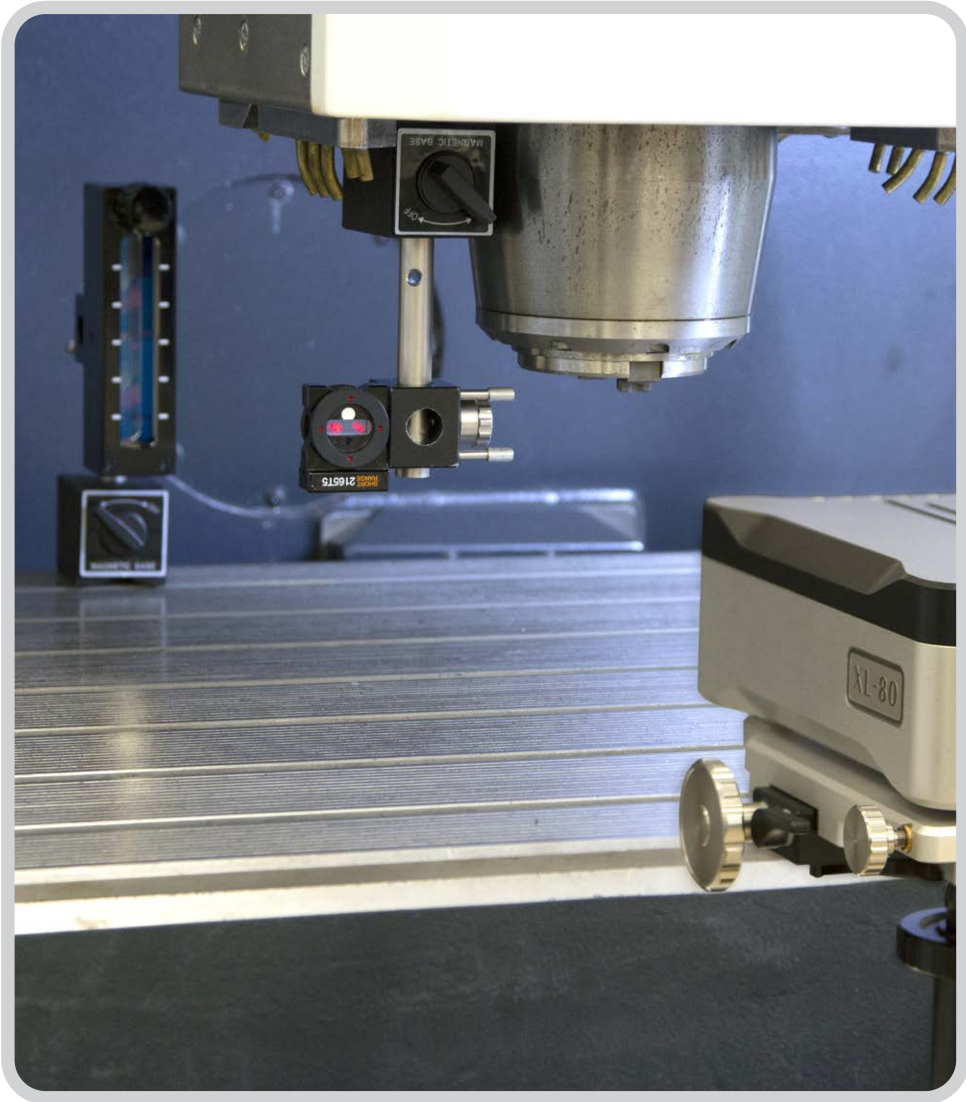
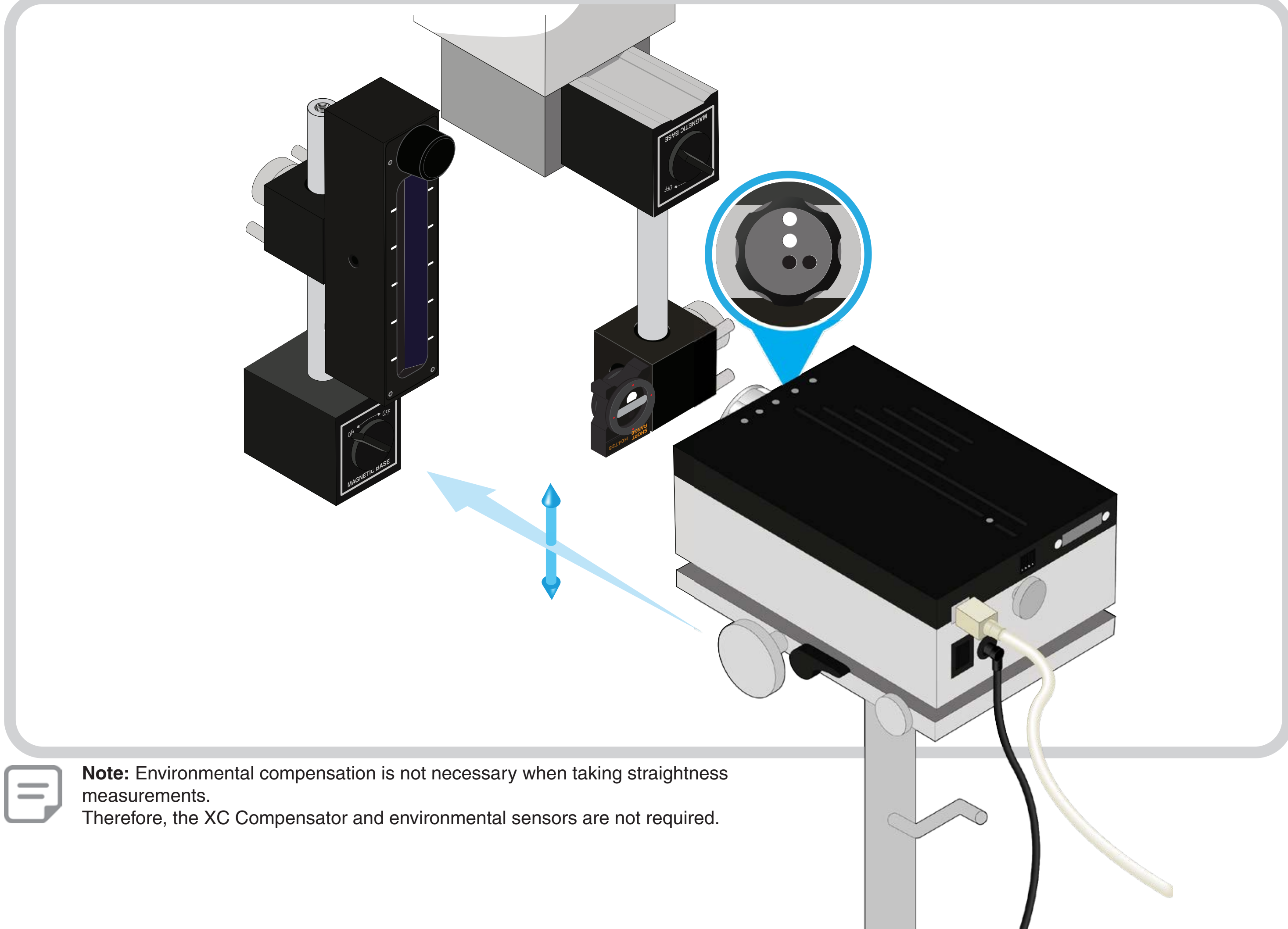
Straightness measurement (horizontal axis – vertical plane)



Mounting the optics

The straightness measurement set ups – along a horizontal axis

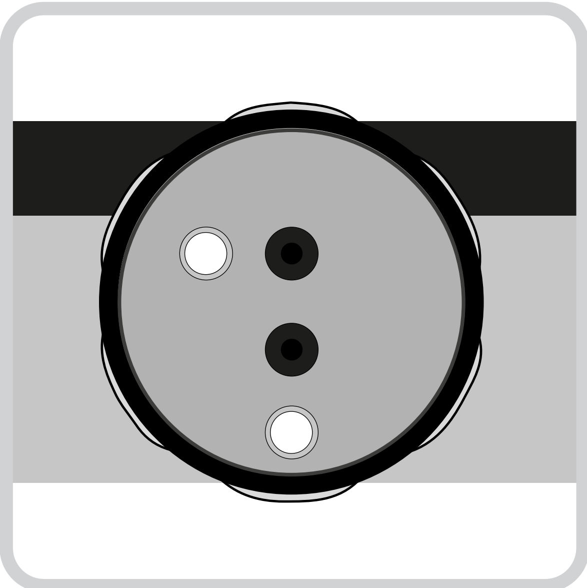
Horizontal measurement plane



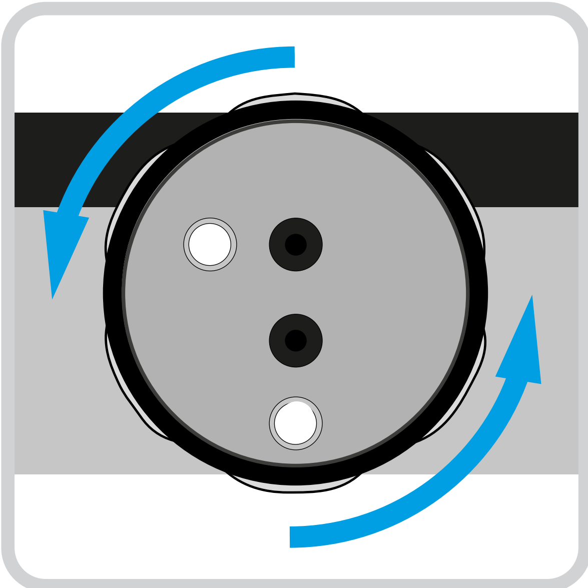
Note: Environmental compensation is not necessary when taking straightness measurements.
Therefore, the XC Compensator and environmental sensors are not required.

Mounting the optics

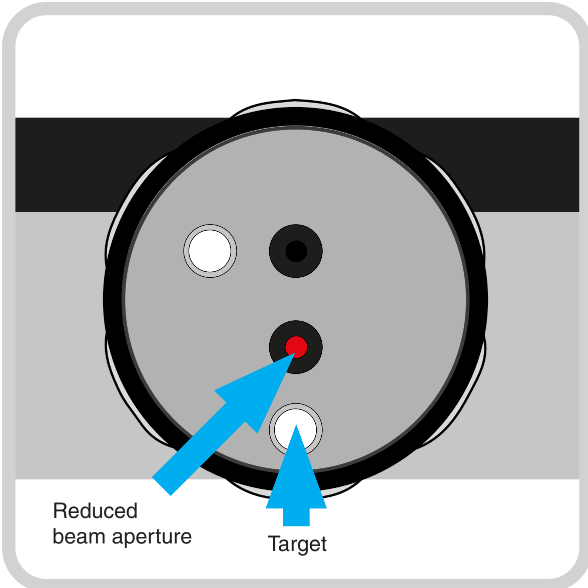
Horizontal axis – Vertical measurement plane



Attach the straightness shutter to the laser in the orientation shown



Rotate the black bezel of the laser shutter…



…until a reduced diameter beam is emitted

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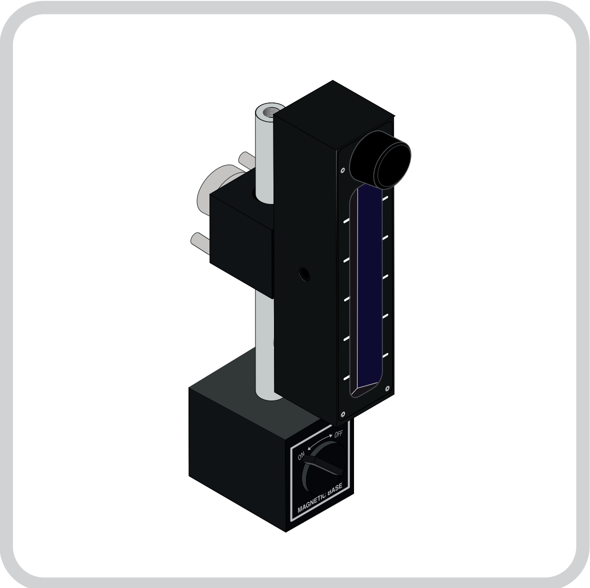
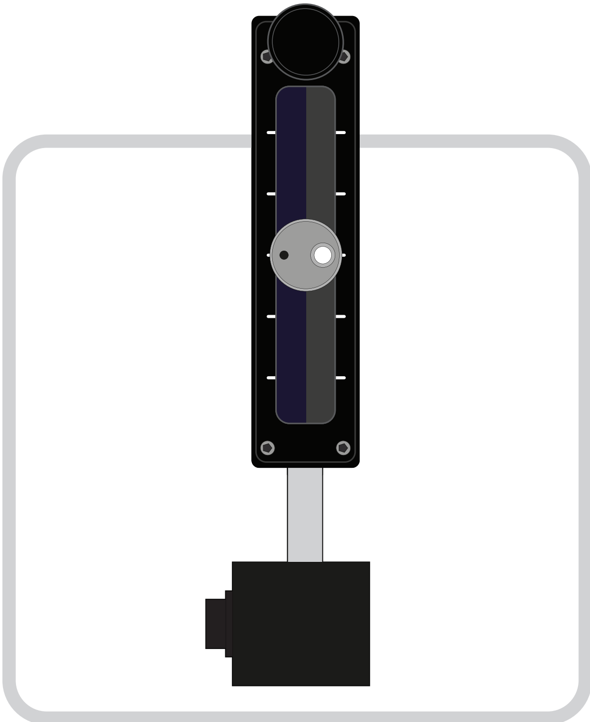
Mounting the optics

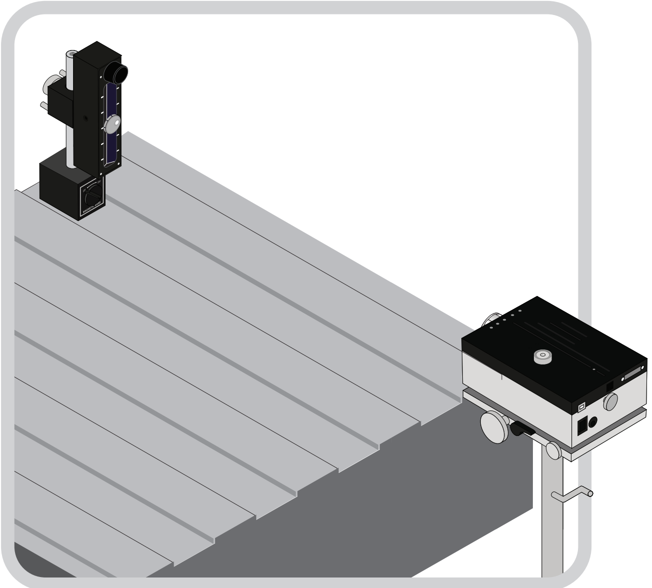
Mounting the retroreflector



Assemble the retroreflector as shown



Attach the target to the centre of the retroreflector



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

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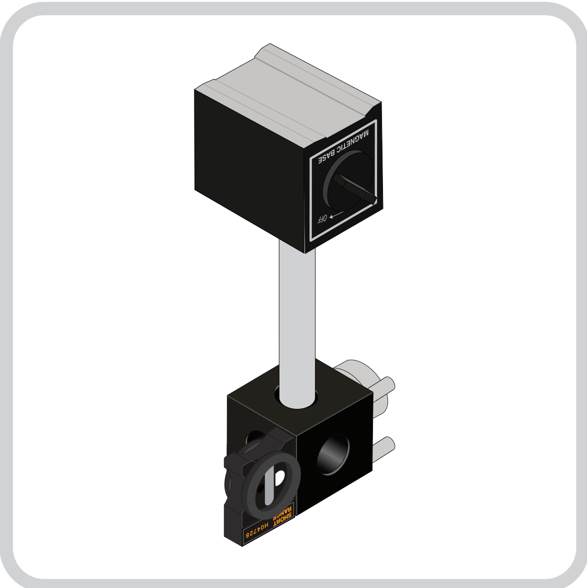
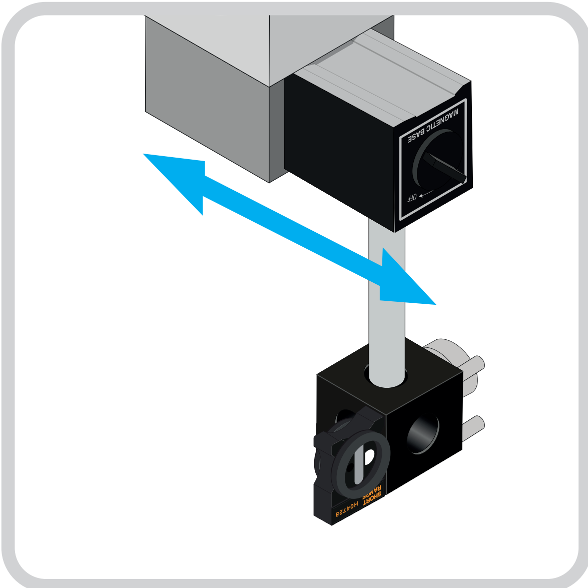
Mounting the optics

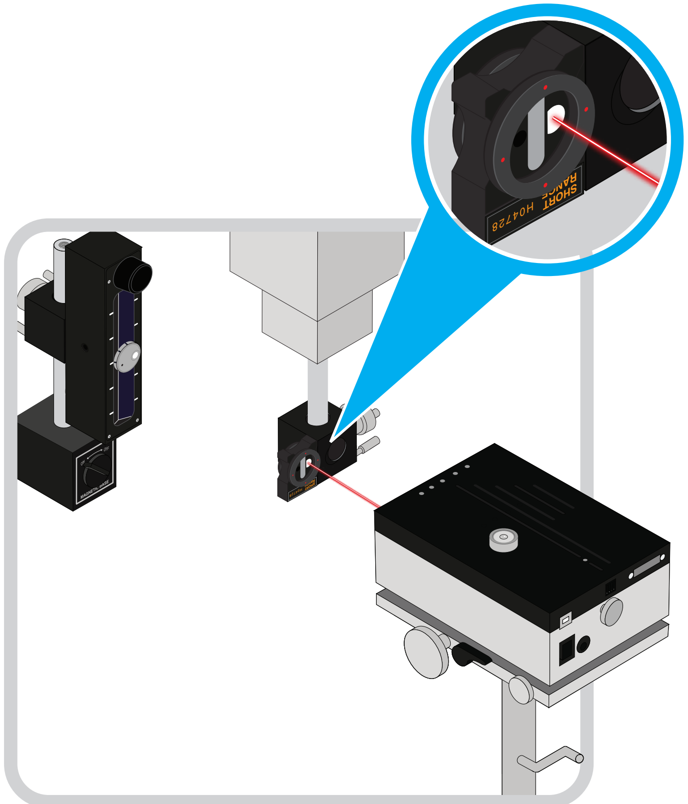
Mounting the straightness interferometer



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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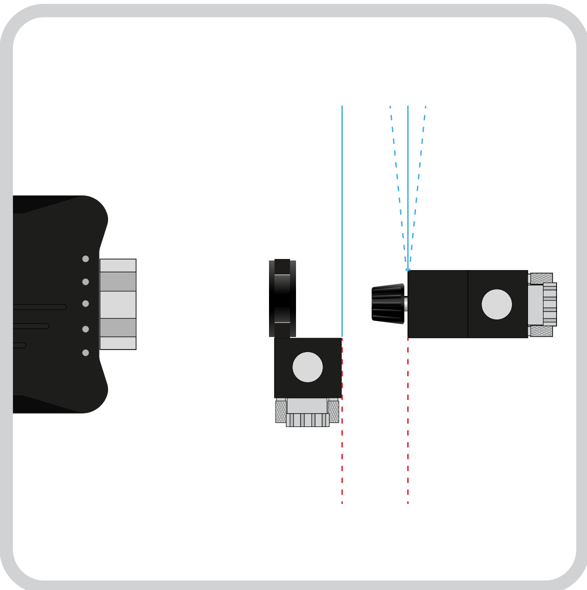
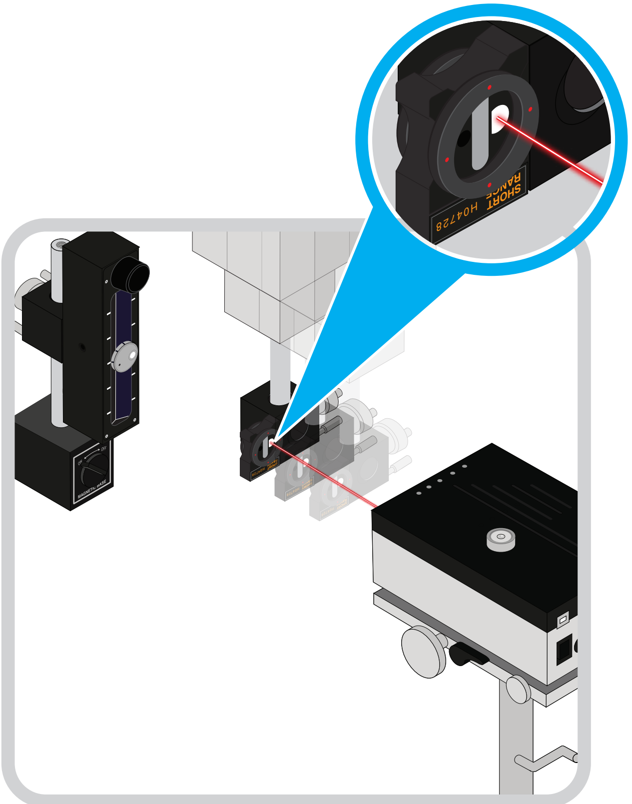
Mounting the optics

Mounting the straightness interferometer

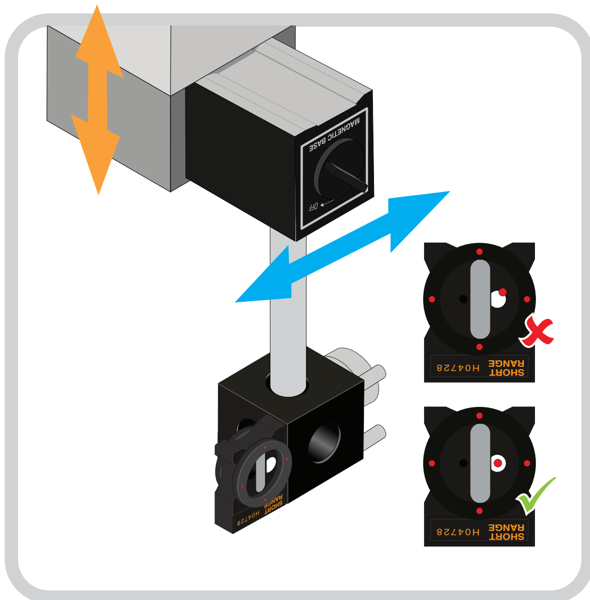


Mount to the stationary element of the machine:

- Square to the axis
- 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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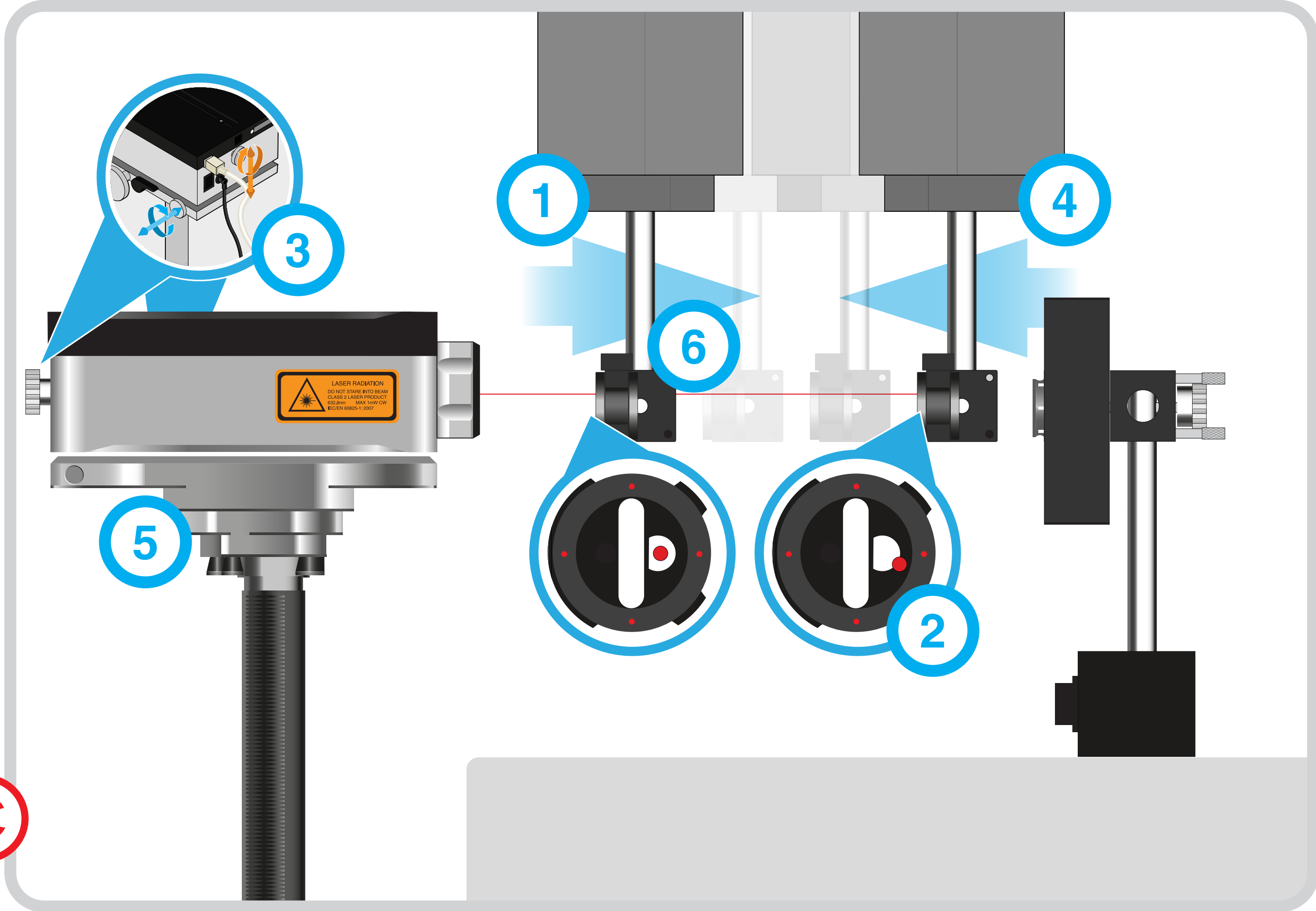
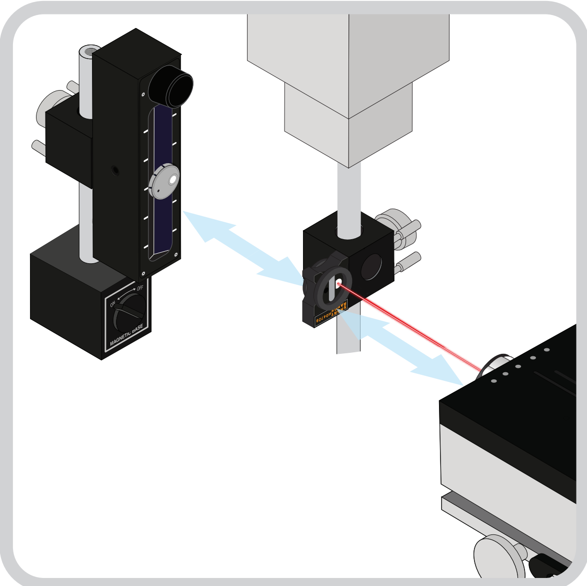
Visual alignment

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

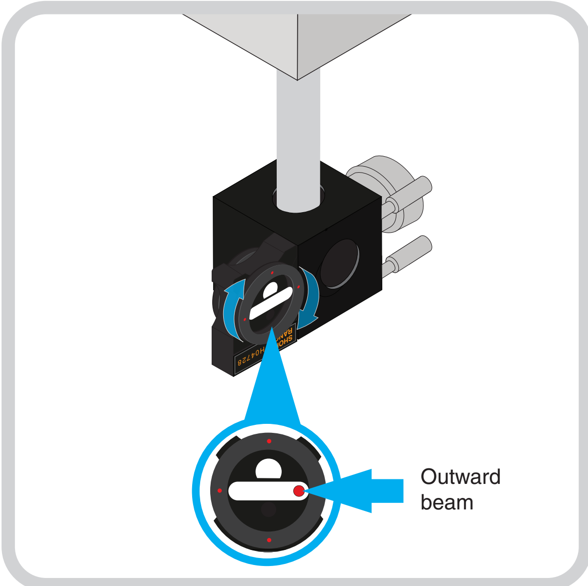
Repeat until the two beams remain in the centre of the target over full length of the axis travel, and signal strength stays in the green when the XL laser shutter is rotated to the open position



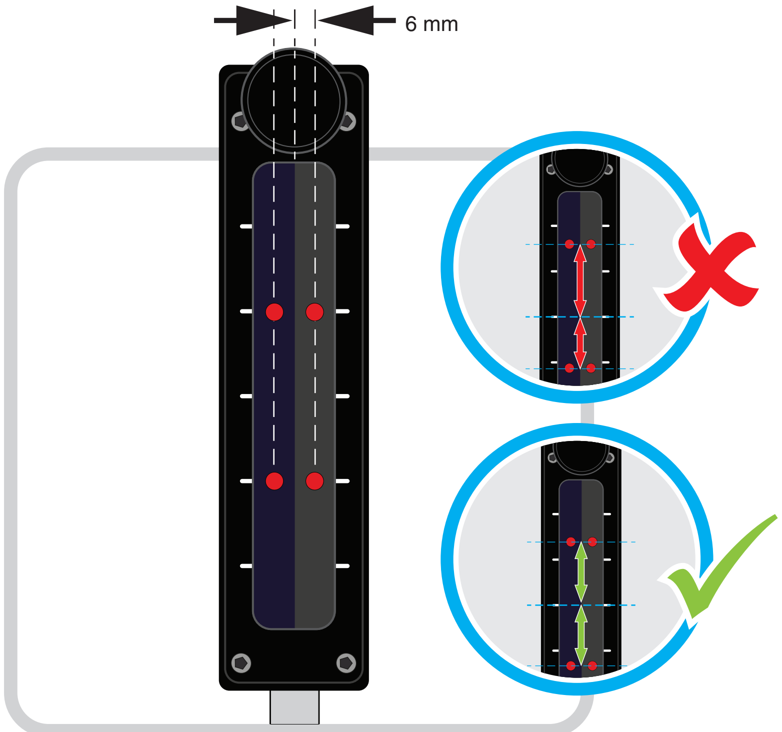
Visual alignment



Position the interferometer half way 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. If it does not, translate as required

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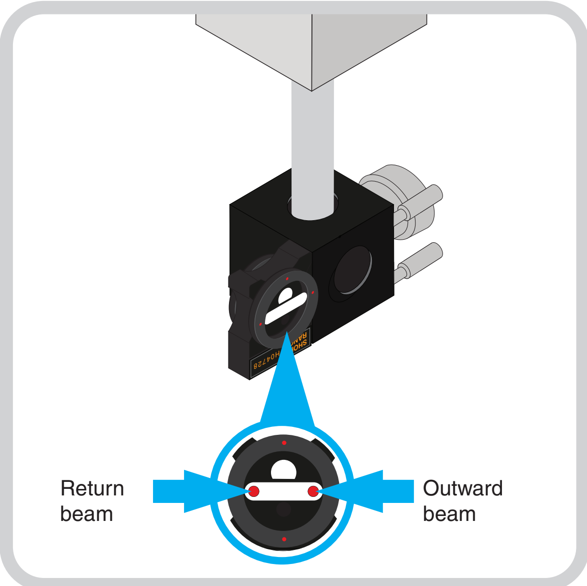
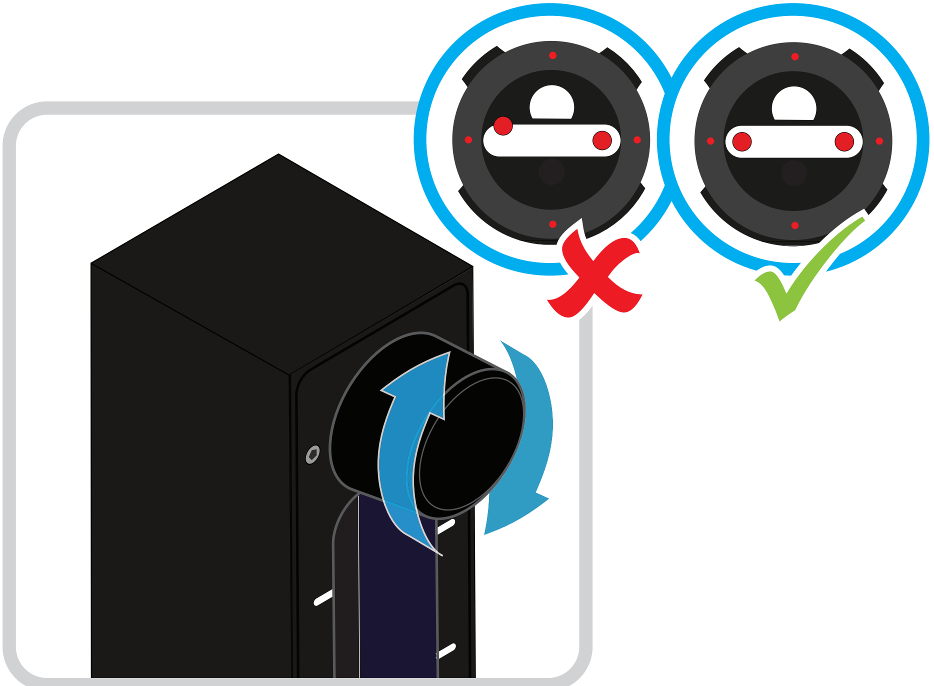
Visual alignment

Return beam alignment



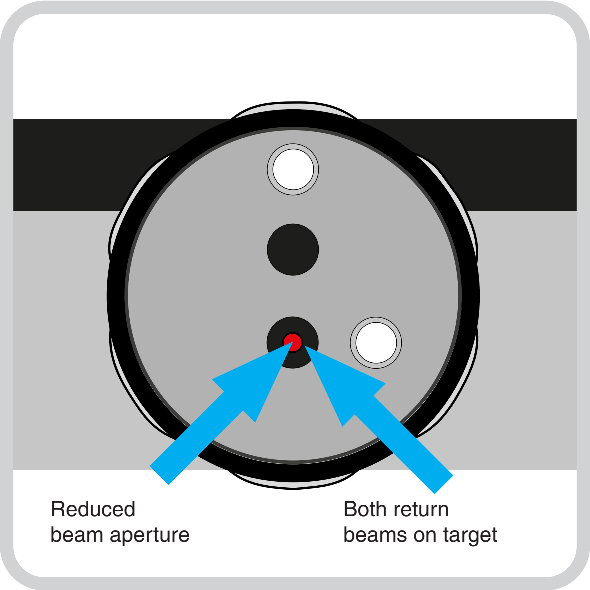
Ensure that the returned beam from the reflector enters the centre line of the interferometer



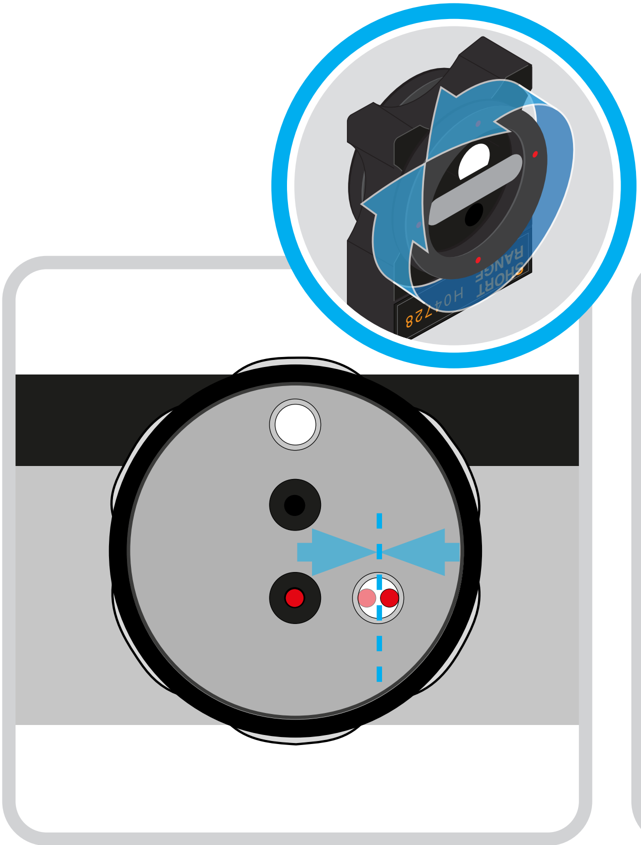
If the beams are above or below the centre then adjust the tilt control knob

Visual alignment

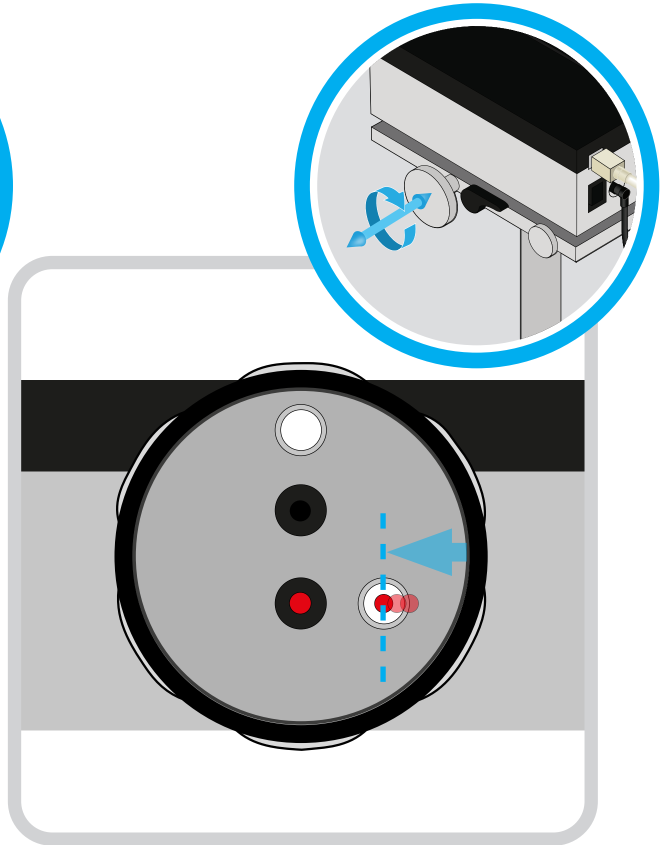
Straightness shutter



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



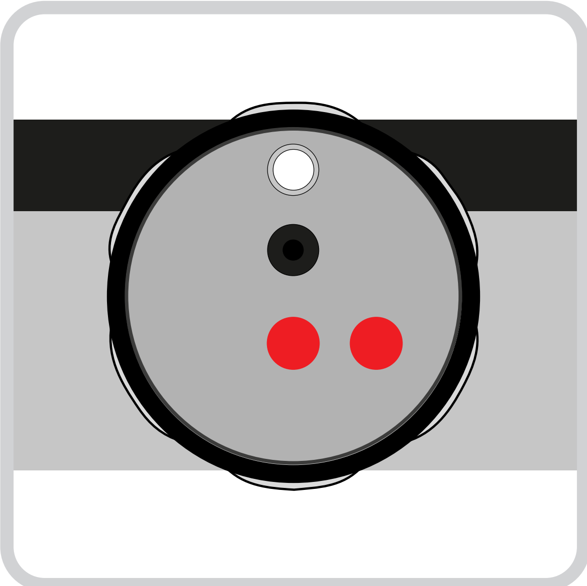
If the beams are not overlapping, finely rotate the interferometer face



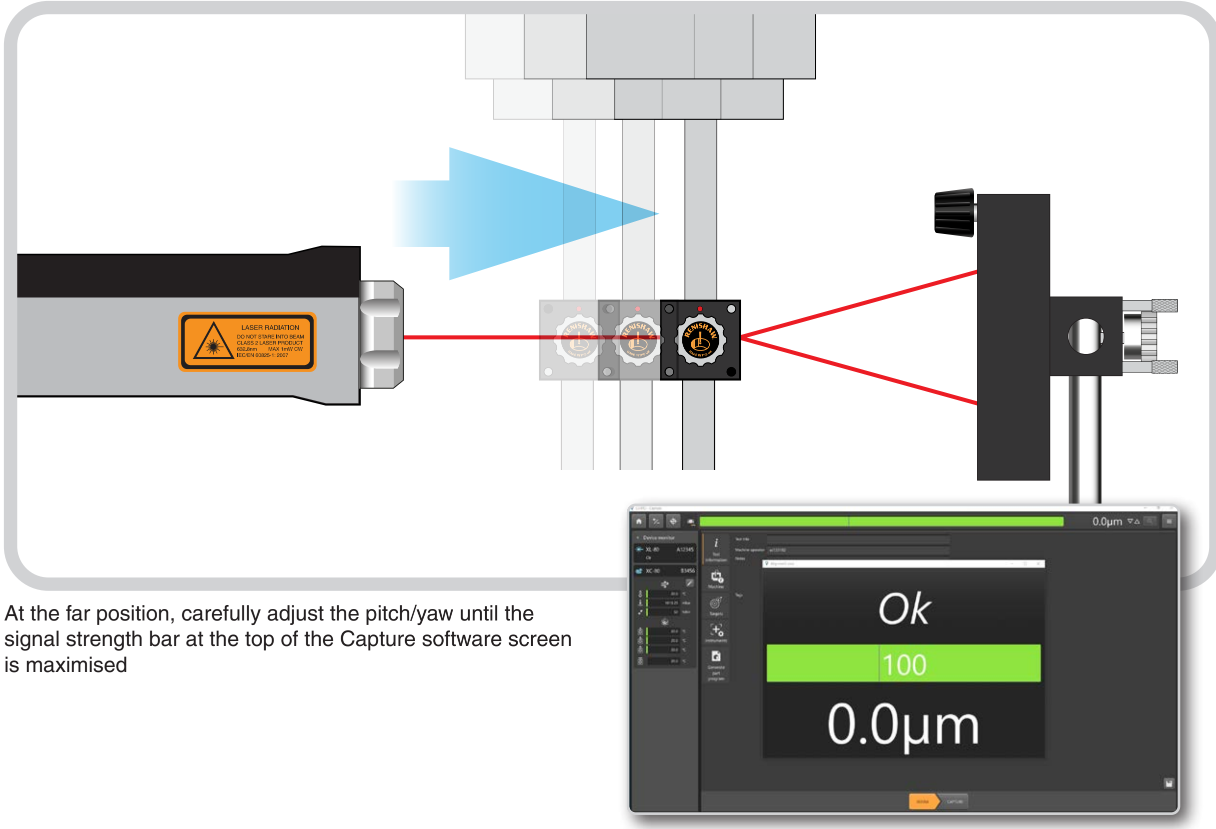
If the beams are off centre, use the translation on the tripod stage

Visual alignment

Straightness shutter



Rotate the shutter until the 6 mm beam is emitted



At the far position, carefully adjust the pitch/yaw until the signal strength bar at the top of the Capture software screen is maximised

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