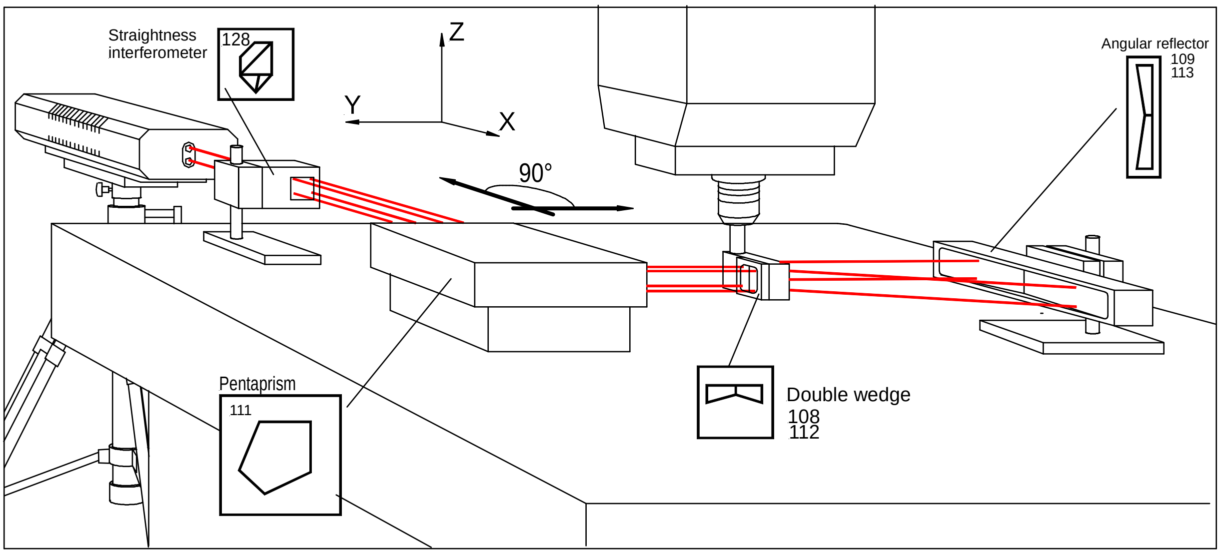
F Interferometer for Squareness measurement

The deviation of squareness of two machine axes can be measured as follows:

1. The straightness of a machine axis is measured.
2. The Angular reflector stops unchangedly as a reference after this measuring.
3. A 90°Pentagon prism (angular error ≦ 1“) becomes as a normal taken into the beam path of the second axis.
4. The straightness of the second axis is measured by the Pentagon prism to this in his position's unchanged Angular mirror.

The result are the straightness deviations of two axes in reference to the squareness standard (pentaprism).



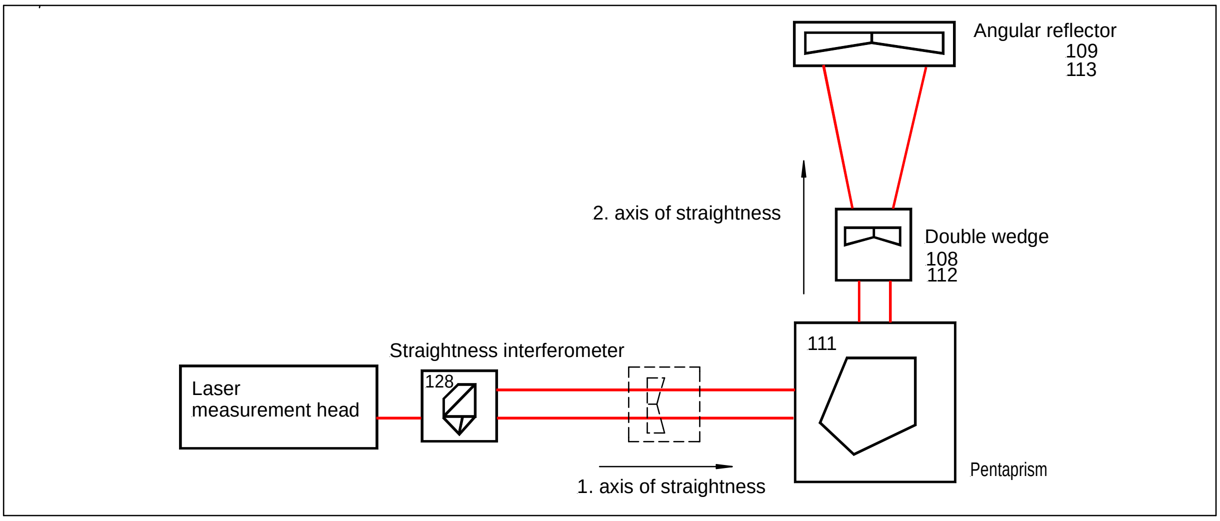


Fig. 1: Setup for squarness measurement (horizontal)

The squareness measuring can be looked (through adding further optical elements) as an expansion of the straightness measuring. The straightness measurings of the two axes must lie in the same level as their right-angled allocation.
Depending on position of the axes it will be distinguished in:

1. horizontal squareness measuring (Fig.1)
2. vertical squareness measuring (Fig.2).

The squareness measuring can be used for the two straightness options: **2m length** and
10m length

The optics modules of the squareness measuring are:

1 Straightness interferometer 128	***269302-4012.824***
1 Offset prism 120	***269302-4008.424***
1 Double wedge 108 2m	***269302-4010.824***
or **112 10m**	***269302-4011.224***
1 Angular reflector 109 2m	***269302-4010.924***
or **113 10m**	***269302-4011.324***
1 Pentaprism 111	***269302-4011.124***
1 Corner reflector 116	***269302-4011.624***
1 90°Beam bender 110	***269302-4011.024***

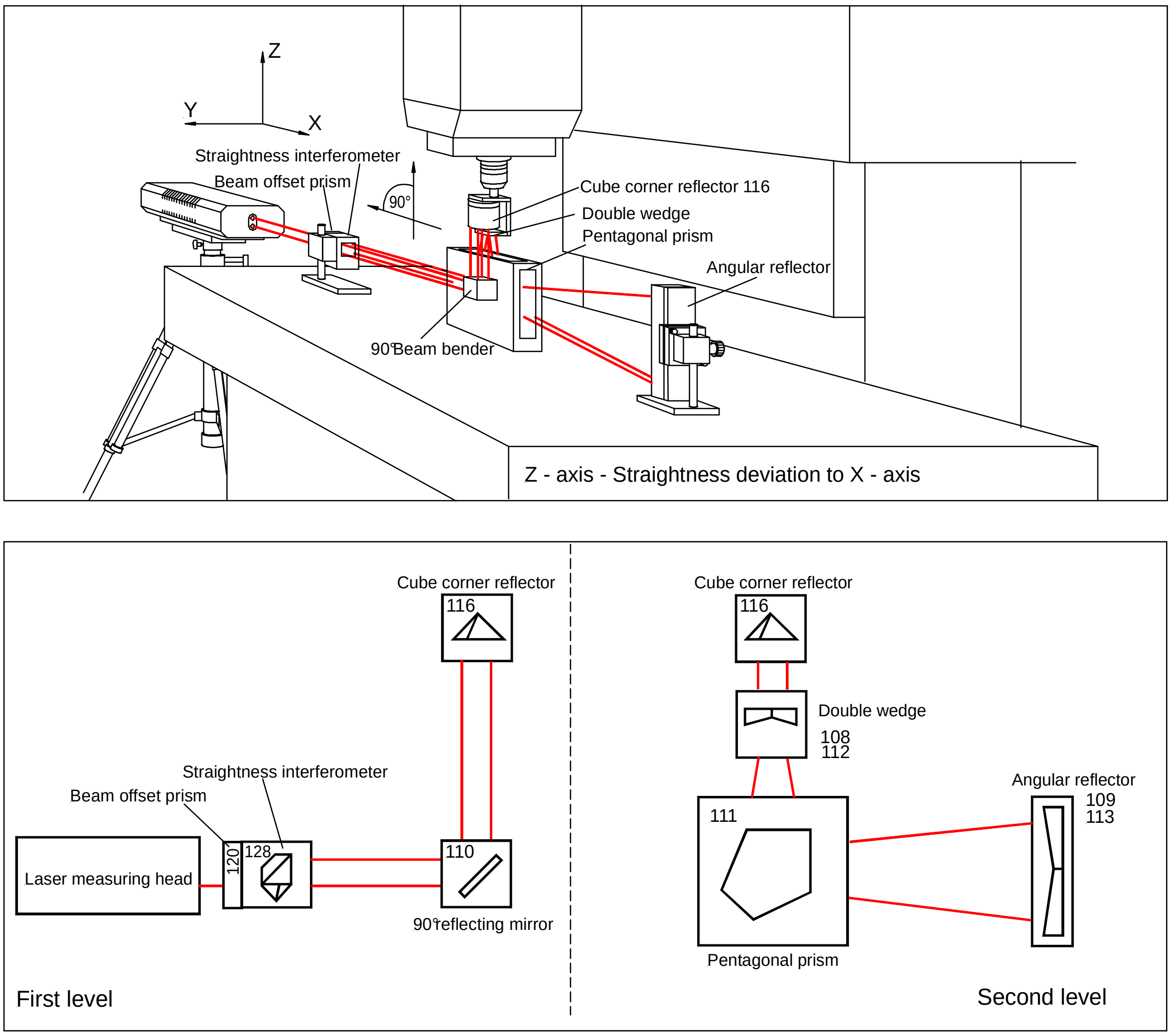


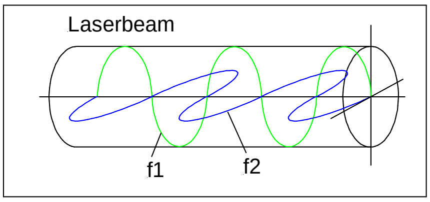
Fig. 2 : Setup for squarness measurement (vertical)

Functional description

A Pentagon prism is used as measuring normal. This embodies the 90° angle with a low measuring inaccuracy (≦ 1“). The measurement of the axes (in its 90° refer ence to each other) is made by straightness measurings according to the interferometrical principle (how it is described on the pages E1-E11). After measuring the first axis the Angular reflector remains at its place. The **Angular reflector** (the straightness normal) is the common reference of two measuring axes to each other.
For the squarreness measurement of the axes the beam path is enlarged.
To this the **90°beam bender** (screw together at the Pentaprism), **Corner reflector** with **Double wedge** (screwed together at the moved part of the measuring axis) and **Pentaprism** are inserted in the beam path. *(Fig. 3, Fig. 4a, Fig. 4b show the beam path in the levels).*

The light emerging from the laser unit enters a straightness interferometer as the measuring beam. The vibration planes of the two frequencies emitted, f1 and f2, are perpendicular to each other.

In the laser beam, the vibration plane of f1 is vertical, and that of f2 is horizontal.



Because of their different vibration planes, the two frequencies are separated by a beam-splitting polarization coating in the straightness interferometer. Frequency f1 is deflected by 90°, as its vibr ation plane is parallel to the position and direction of the beam-splitting polarizer coat. It then passes the interferometer's half-wave plate, gets its vibration plane rotated by 90° and is deflected again by 90 ° by the interferometer. Frequency f1 then passes a quarter-wave plate, after which it is again parallel to f2, which has passed the interferometer unaffected, thanks to its different direction of polarization. Passing the respective retardation plates (f1: $\lambda/2$ and $\lambda/4$ plates, f2:0 $\lambda/2$ plate) subjects both frequencies to circular polarization. They pass the 90° beam bender and are reflected by the corner reflector to the double wedge.
On striking the double wedge, both frequencies are refracted at a defined angle and then fall, via the pentaprism (straightness standard), perpendicularly on to surfaces of the angular reflector, which reflects them back on themselves to the interferometer via pentaprism, double wedge, corner reflector and 90° beam bender.
When they pass the retardation plates, both frequencies regain plane polarization, are reflected by the optical layers depending on their polarization direction and strike the respective corner reflector in the lower level of the optical arrangement (level II). Analogously to level I (Fig. 4), both frequencies again travel along the optical path formed by interferometer, 90° beam bender, corner reflector, double wedg e, angular reflector and back; when they pass the retardation plates again, their vibration planes are rotated. Now, frequency f1 vibrates horizontally and frequency f2 vertically, relative to the direction of beam incidence. Thus, f2 is not reflected by the polarizing splitter and passes it to return to the laser head, whereas f1 is reflected by the polarizing splitter by 90° and also returns to the laser head.
With the double wedge being stationary, detector E1 registers the differential frequency of the laser (f1 - f2 = 640 MHz), which is equal to the electronic reference signal E2 detected in the laser head. If the double wedge is moved, the optical path lengths of the two frequencies passing it are changed, so that the respective measuring distance δz becomes either shorter or longer. The frequency changes (df1, df2) are proportional to the transverse displacement of the double wedge. They are detected by detector E1, since the beam has travelled the optical path twice.

$$\Delta f = (f1 + 4df1) - (f2 - 4df2) \quad \text{bzw.} \qquad \Delta f = (f1 - 4df1) - (f2 + 4df2)$$

depending on the direction of mirror displacement.

In the high-frequency section of the laser interferometer system, the two detected signals (E1 and E2) are compared with each other. The result obtained is the frequency shift produced by the Doppler effect; this shift is a measure of the wanted transverse displacement of the double wedge. With unchanged adjustment of the angular reflector - a basic requirement for squareness measurement - the squareness error between the two machine axes is obtained from the two straightness measurements by means of the pentaprism (the squareness standard).

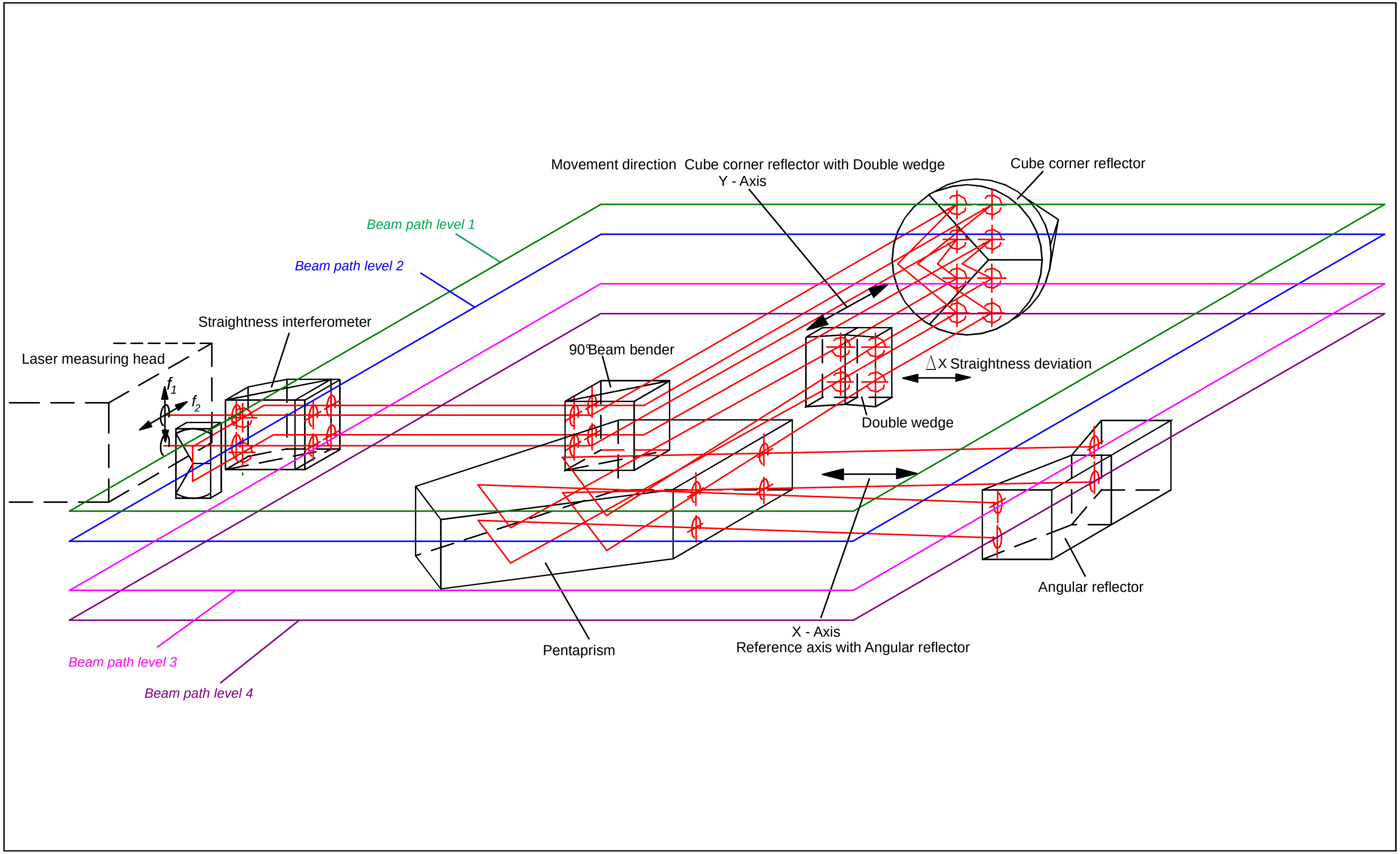


Fig. 3: Optical path - Squareness measurement

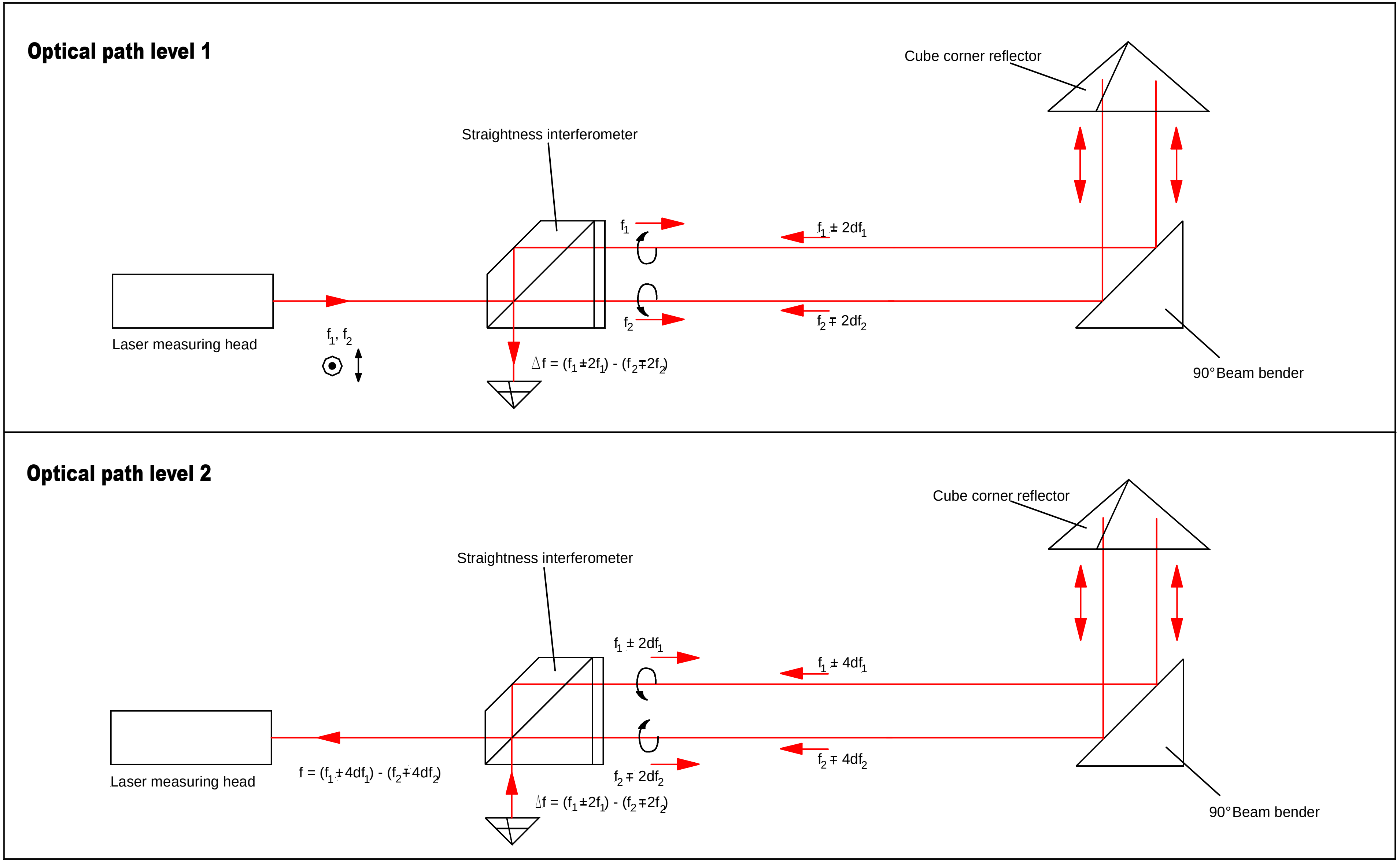


Fig. 4a: Operating principle straightness interferometer / squareness

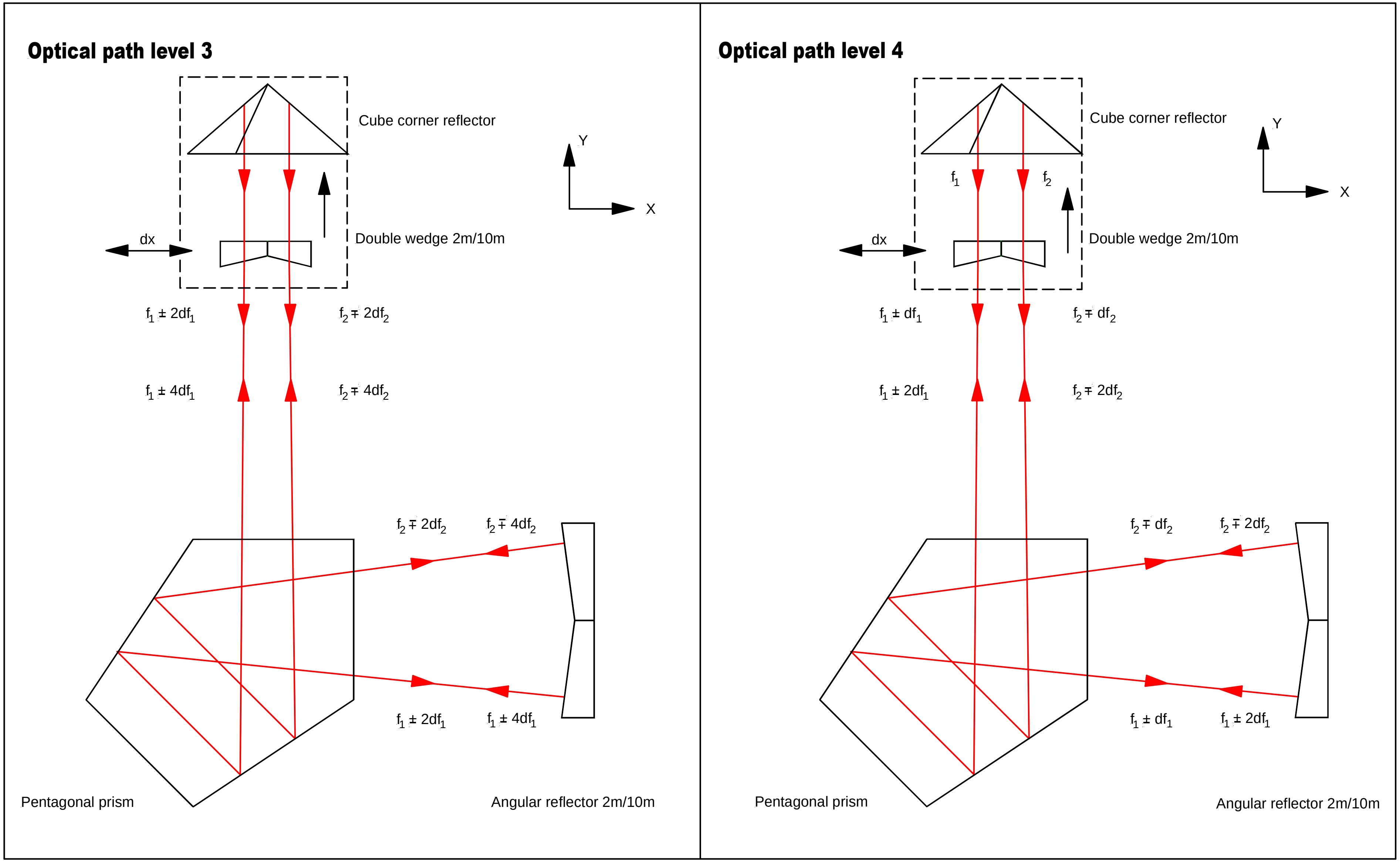


Fig. 4b: Operating principle straightness interferometer / squareness

Assembly

The optical and mechanical modules and components of the equipment are shown by Fig. 5.
Figs. 6 and 7 illustrate their assembly.

Squareness interferometer

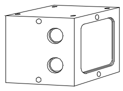
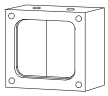
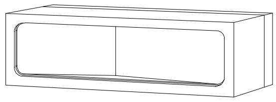
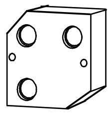
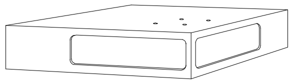
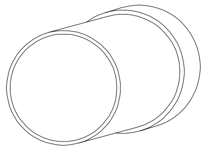
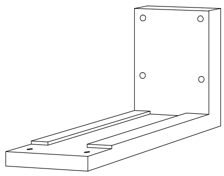
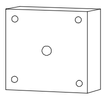
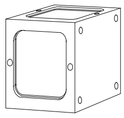
Straightness interferometer 128 269302-4012.824		Quantity: 1
Double wedge 108 (2m) / 112 (10m) 269302- 4010.824 269302- 4011.224		Quantity: 1
Angular reflector 109 (2m) / 113 (10m) 269302-4010.924 269302-4011.324		Quantity: 1
Beam offset prism 120 269302-4008.424		Quantity: 1
Pentaprism 111 269302-4011.124		Quantity: 1
Cube corner reflector 116 269302-4011.624		Quantity: 1
Angle bracket 521 269302-4010.425		Quantity: 1
Adapter plate 522 269302-4018.110		Quantity: 1
90°Beam bender 269302-4011.024		Quantity: 1

Fig. 5a : Optical and mechanical modules and components - Squareness (Part 1)

Squareness interferometer

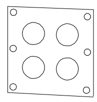
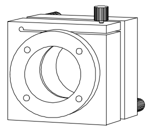
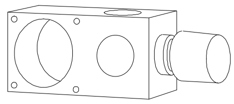
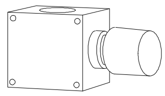
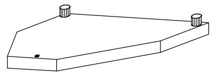
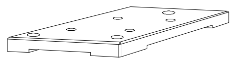
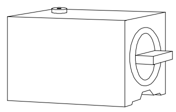
Blende 519 269302-4014.310		Quantity: 2
Tiltable fixture 524 269302-4010.925		Quantity: 1
Clamping fixture 508 269302-4010.125		Quantity: 2
Clamping fixture 507 269302-4010.325		Quantity: 1
Adjusting plate 548 269302-4012.425		Quantity: 1
Mounting plate 504 269302-4014.410		Quantity: 2
Magnetic base 506 260298-3000.128		Quantity: 2
Column 200 / 140 oder 90 260297-9900.128		Quantity: 2
Set of screws 269302-4005.624		Quantity: 1
Knurled screw 29 269302-4011.225		Quantity: 4
Knurled screw 45 269302-4011.425		Quantity: 2

Fig. 5b: Optical and mechanical modules and components - Squareness (Part 2)

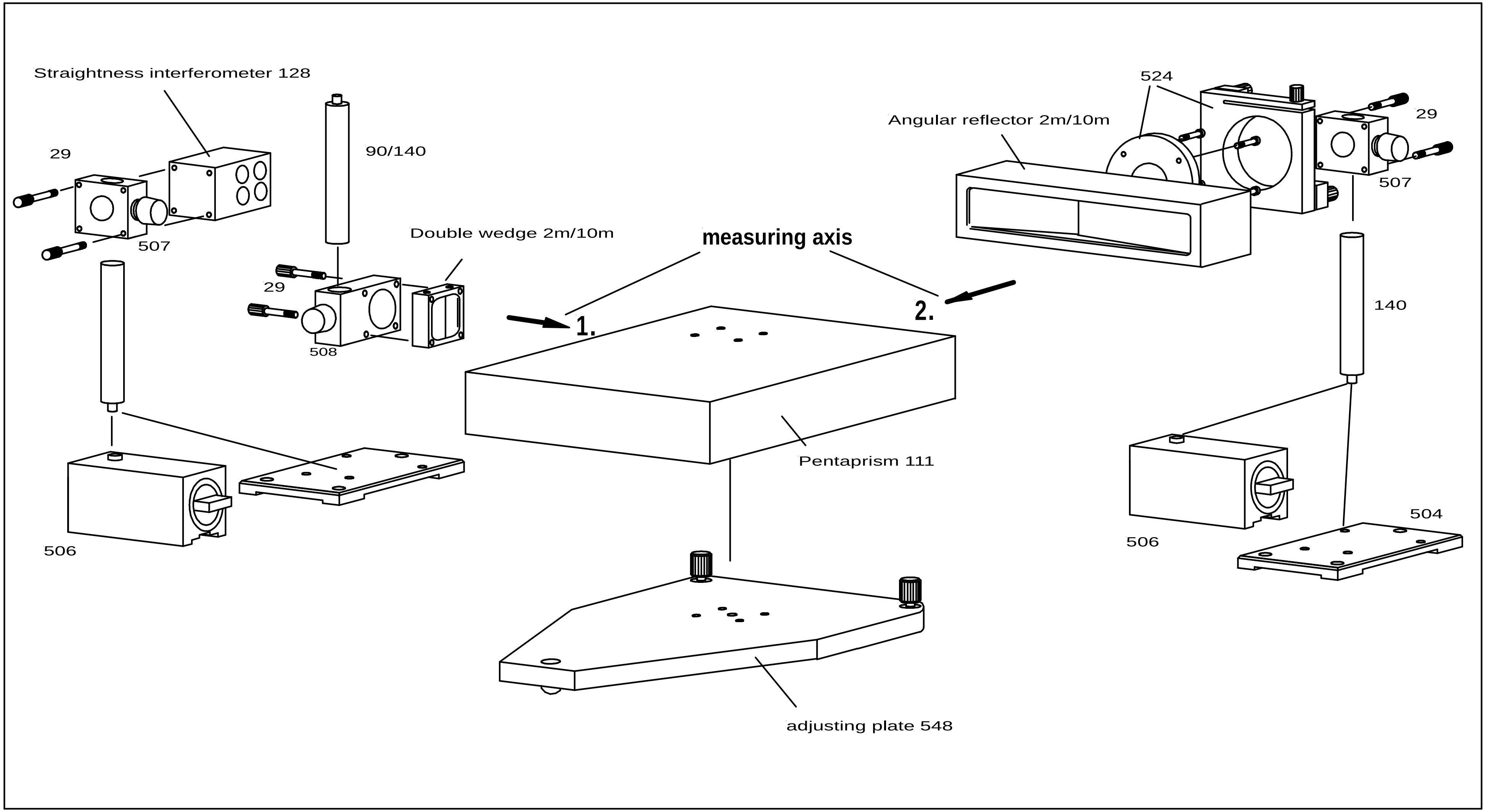


Fig.6: Squareness Interferometer, horizontal configuration (assembly drawing)

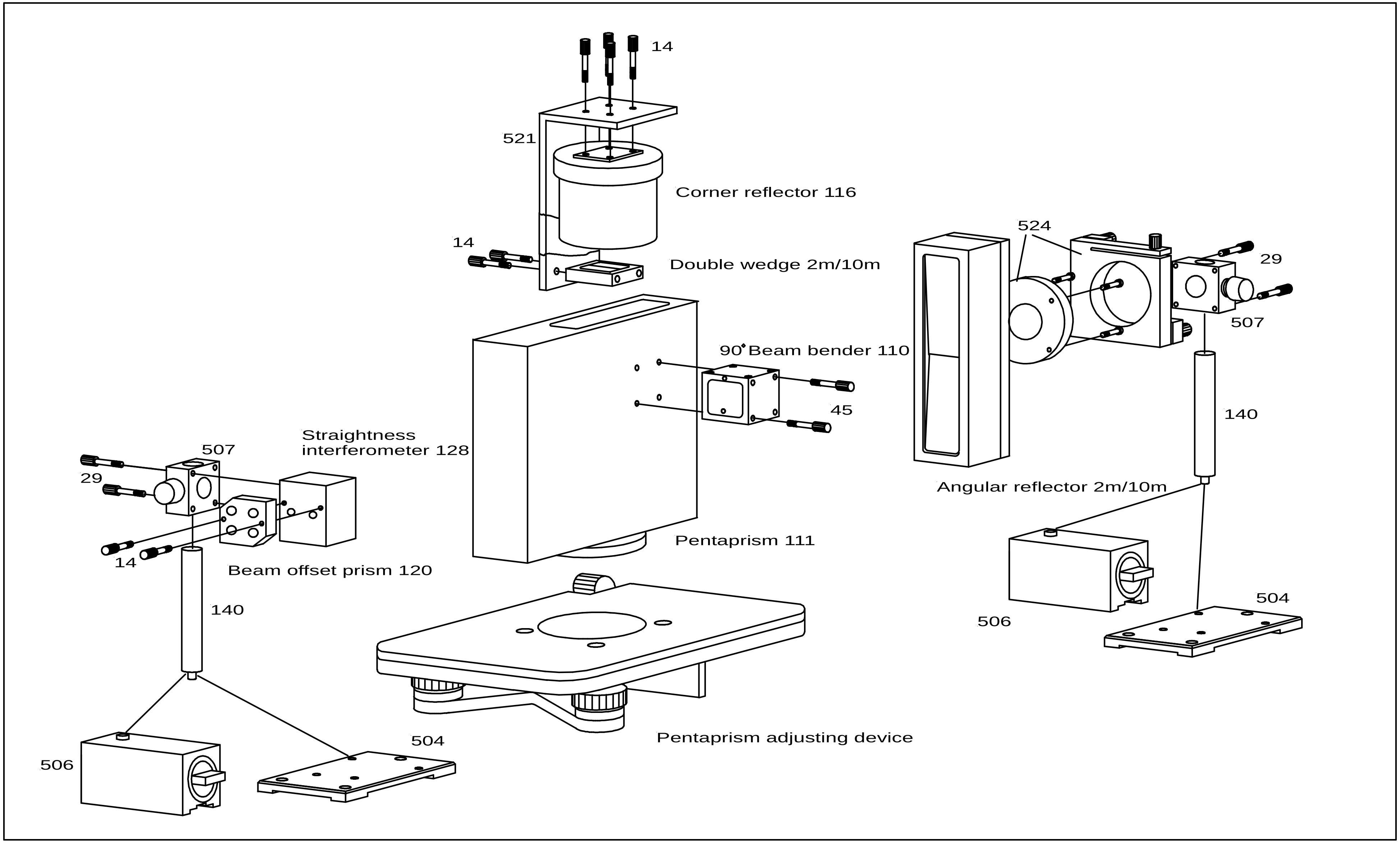


Fig. 7: Squareness Interferometer, vertical configuration (assembly drawing)

Adjustment

If all components are assembled, the justification can start. The installation procedure (for horizontal and vertical setup) should follow the sequence of steps described below:

1) Adjustment for straightness measuring of the base axis
corresponds to the description "Adjustment" in the chapter "Straightness interferometer" (page E7 to E11)

2) Adjustment of the square axis:

- The Angular reflector remains unchanged in its position.
- Find out a place suitable for the fastening of the Pentagon prism
- Fastening of the Corner reflector and the double wedge at the moveable part of the measurement object.
  example: Fig.1, Fig.2 Spindle chuck (pinole)
- lateral shifting of the laser measuring head and straightness interferometer by 40 mm.
- Position adjustment and directional alignment of the laser beam about straightness interferometer, 90°Beam bender, Cube corner reflec tor, Double wedge on the Angular reflector.

IMPORTANT

During this adjustment all construction elements can be changed in their position ***(-except the Angular reflector!!!)****.*

Tip

Because of the multiple convolution of the beam path this adjusting step takes time. Therefore careful preparations for the geometry of the setup are necessary before the adjustment starts.
It is expediently to use two four-beam stops 519. The first one should be fastened at the 90°Beam bender and the second one should be fastene d at the Double wedge. The Cube corner reflector must be assembled so that the laser beam hits on the areas (not on the edges, see Fig. 8).

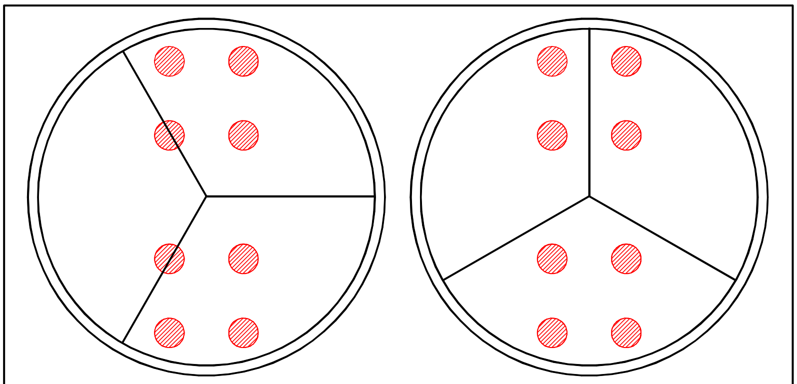
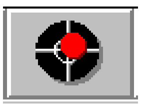


Fig. 8: The beam position at the Cube corner reflector.

3) Covering of measuring beam and reference beam



The adjustment is to carried out according to the chapter "Straightness interferometer" pages E10 and E11.