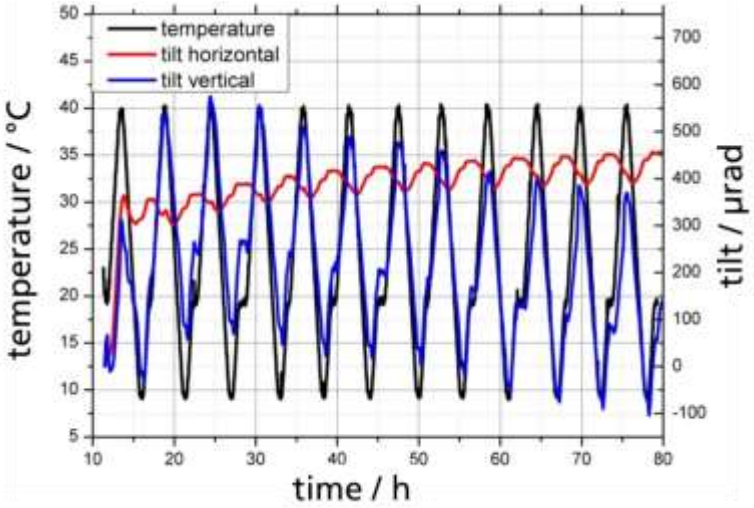
OPTICAL COMPONENT CHARACTERISATION I

Thermomechanical Testing

Michael Strotkamp, michael.strotkamp@ilt.fraunhofer.de

source: Weiss Umwelttechnik

source: Thorlabs



OUTLINE

- Motivation
- Mirror mounts – basics
- Measurement
- Results

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Motivation – Spaceborn lasers for LIDAR

- Lasers for airborne and spaceborne LIDAR-systems
- Profiling of wind speed, trace gases (CH_4, CO_2, H_2O, …)

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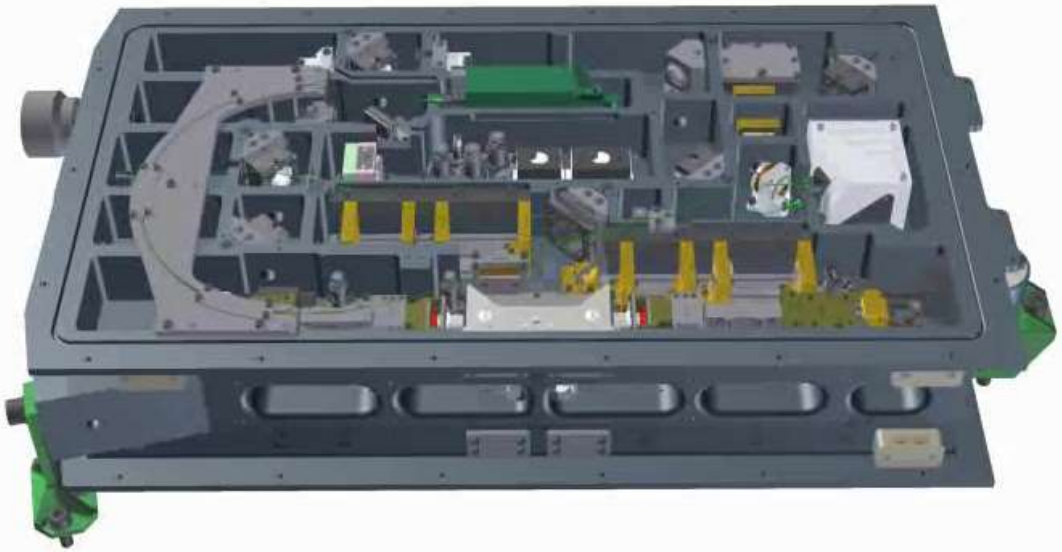
Motivation – Spaceborn lasers for LIDAR

- Lasers for airborne and spaceborne LIDAR-systems
- Profiling of wind speed, trace gases (CH_4, CO_2, H_2O, …)
- Strong limitations for electrical power, mass and volume
- Operation & transport: vibrations, shocks, thermal loads
- Stable high energy single-frequency ns-pulses



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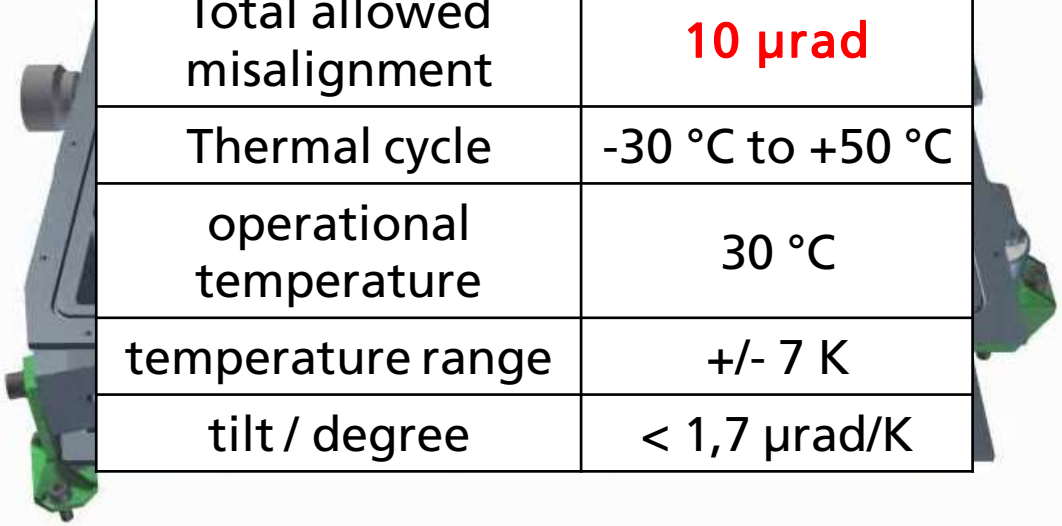
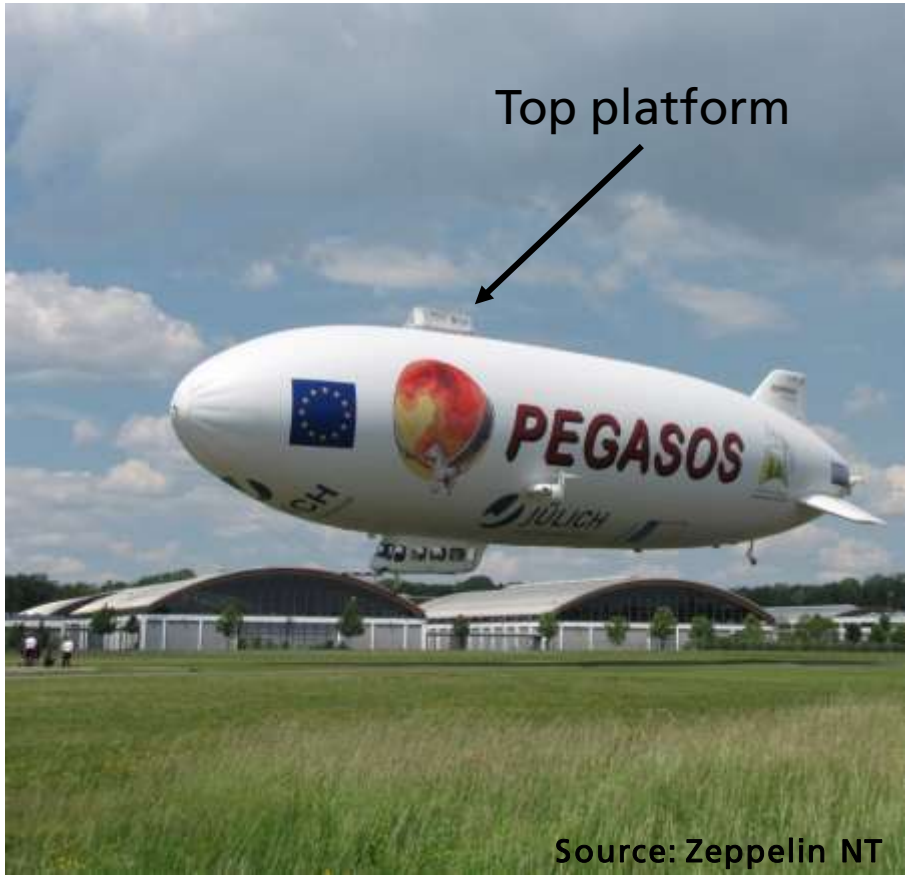


Total allowed misalignment	10 µrad
Thermal cycle	-30 °C to +50 °C
operational temperature	30 °C
temperature range	+/- 7 K
tilt / degree	< 1,7 µrad/K

Motivation – Airborn lasers for LIF

- Measurement of Hydroxyl (OH*) radical with LIF at 308 nm
- Laser mounted on top of an airship
- Ambient pressure 800 to1000 hPa
- Ambient temperature 10 to 40 °C



JÜLICH FORSCHUNGSZENTRUM

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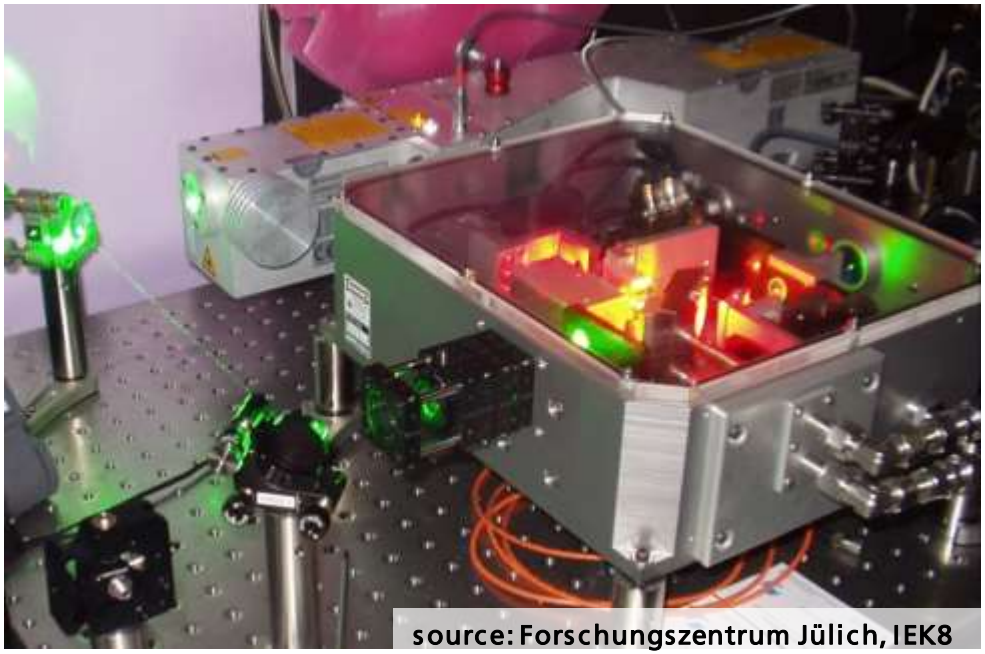
Motivation – Airborn lasers for LIF

- Measurement of Hydroxyl (OH*) radical with LIF at 308 nm
- Laser mounted on top of an airship
- Ambient pressure 800 to1000 hPa
- Ambient temperature 10 to 40 °C
- Frequency doubled tunable dye laser
- Commercial mirror mounts
- Decrease of the output power during former flights (2008)

pressure: 800 to1000 hPa

temperature: 10 to 40°C



source: Forschungszentrum Jülich, IEK8

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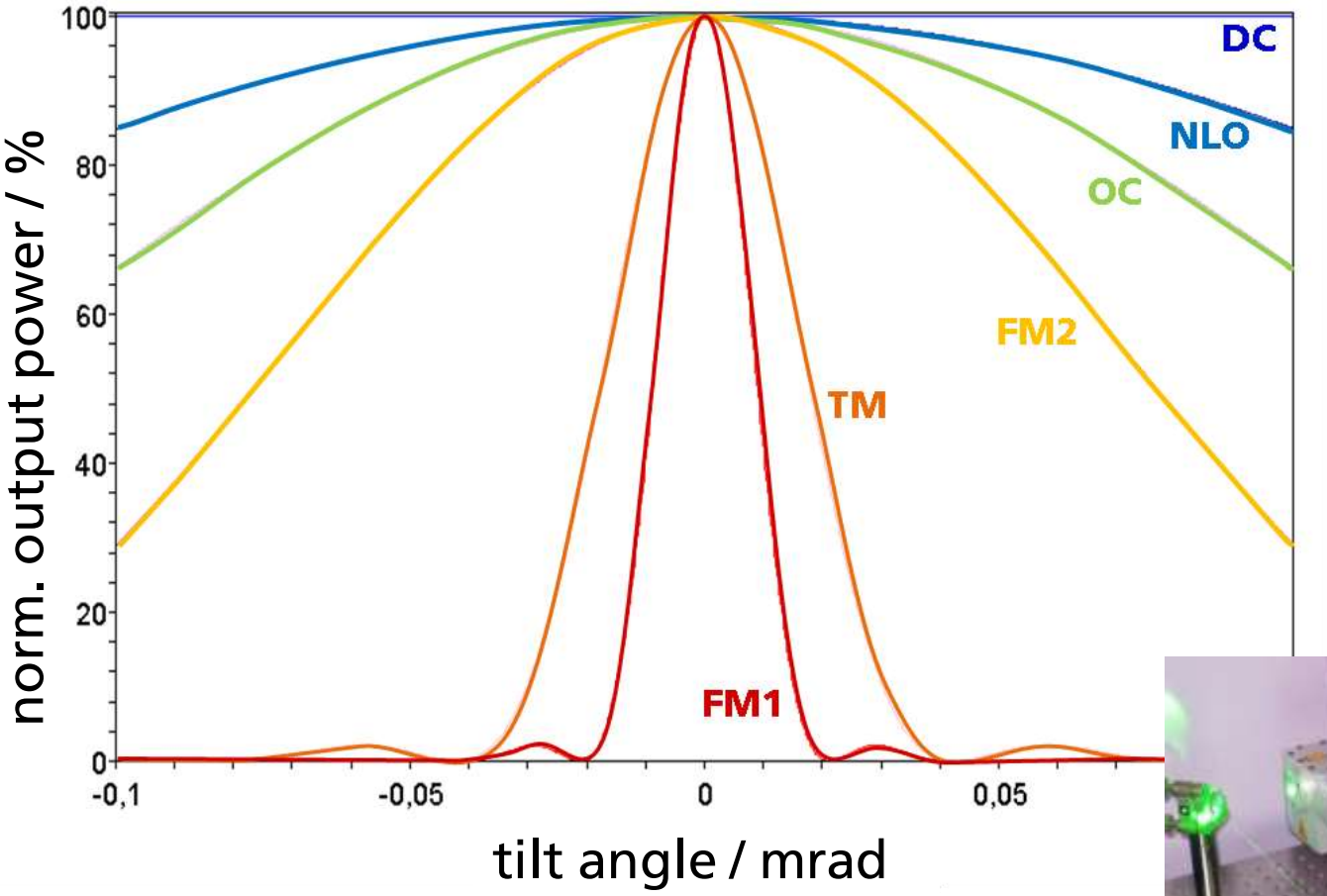
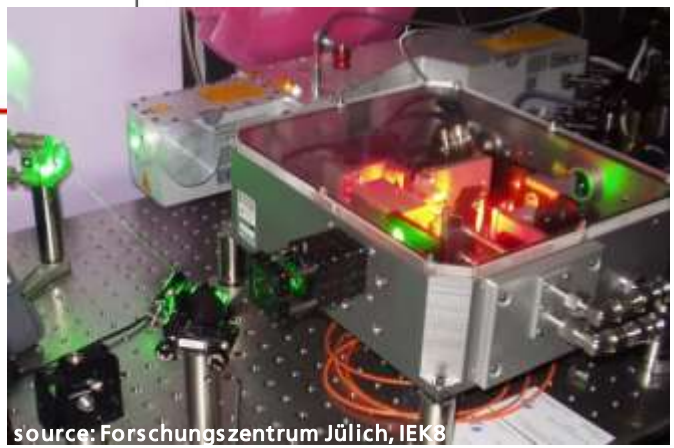
Motivation – Airborn lasers for LIF



20 µrad tilt stops laser emission completely


source: Forschungszentrum Jülich, IEK8

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OUTLINE

- Motivation
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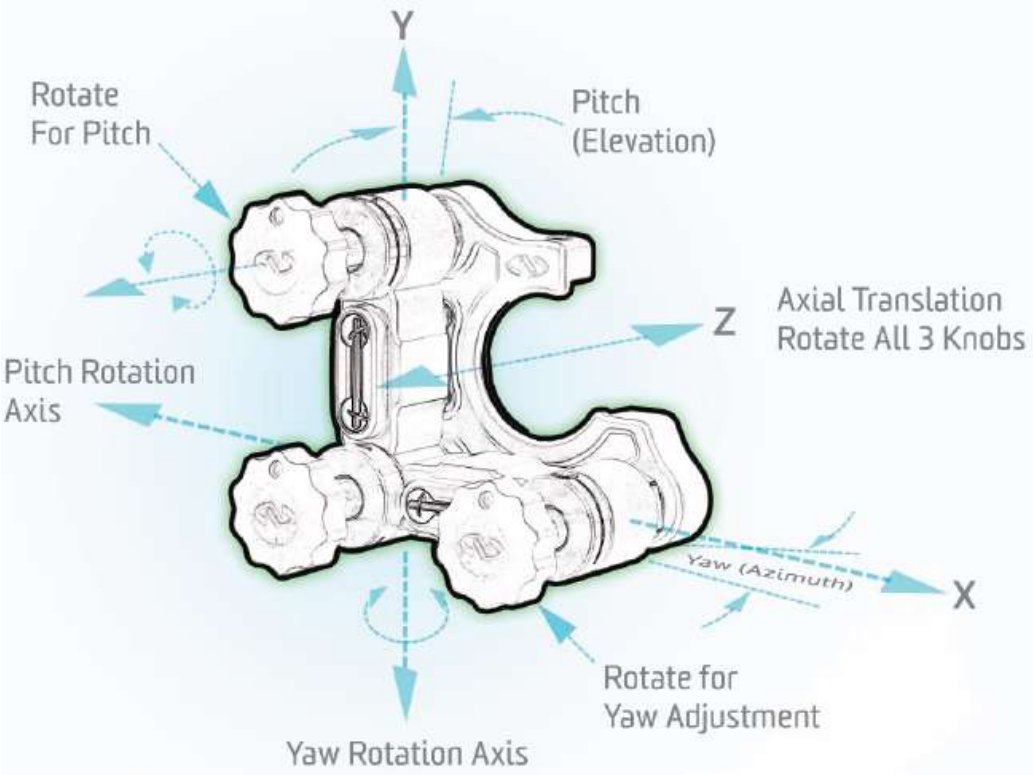
Mirror mounts – Principle

- Mirror mounted in frontplate
- Springs pull against backplate
- Screws in barrels push frontplate for adjustment
- Alternatively , micrometer adjuster or (piezo)motors
- Each angle separately adjustable
- Translation via 3 screws
- Lockable



source: Newport

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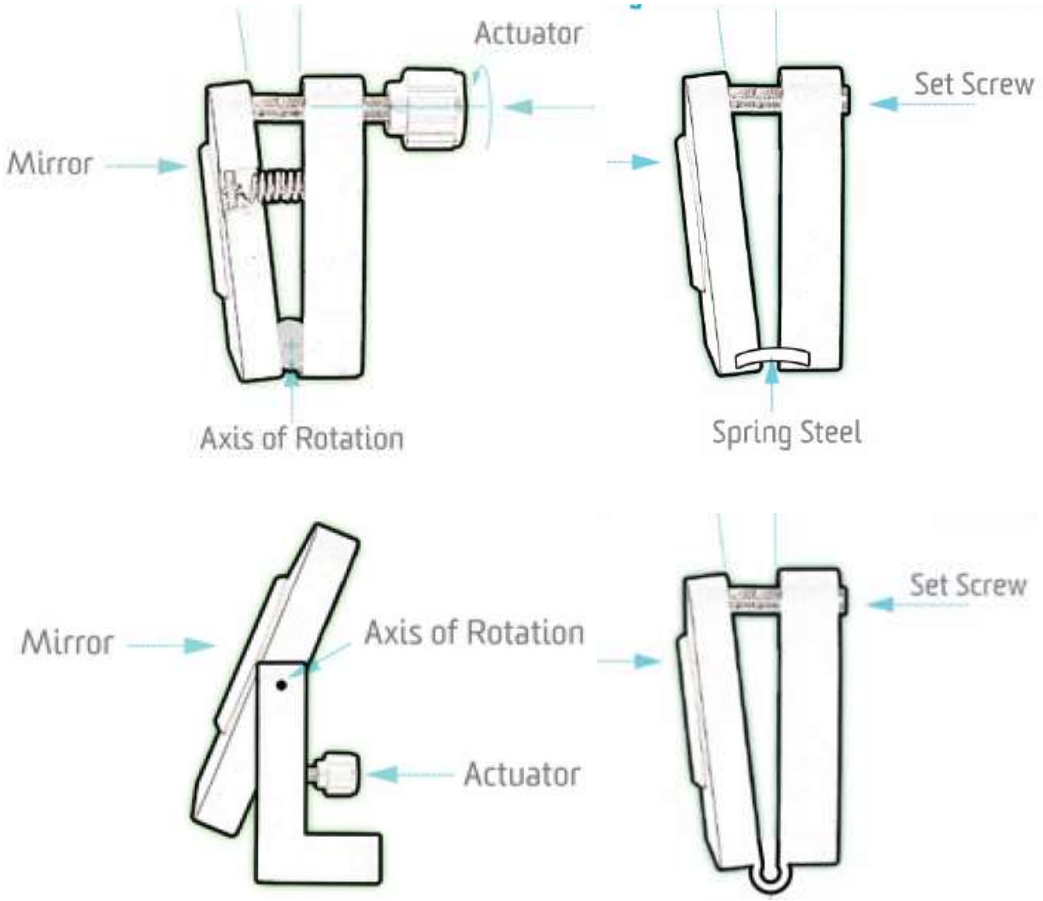
Mirror mounts – Different types

- Kinematic
  - Most commonly used
- Flexure
  - Monolithic or spring
  - Compact, unsusceptible to vibrations
- Gimbal
  - Axis of rotation on mirror surface
  - Complex, large, expensive



source: Newport

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Mirror mounts – Assembly of mirror

- Methods of assembling optical components to mounts
  - Clamping
  - Threaded ring
  - Adhesive
  - Retaining plate

source: Newport

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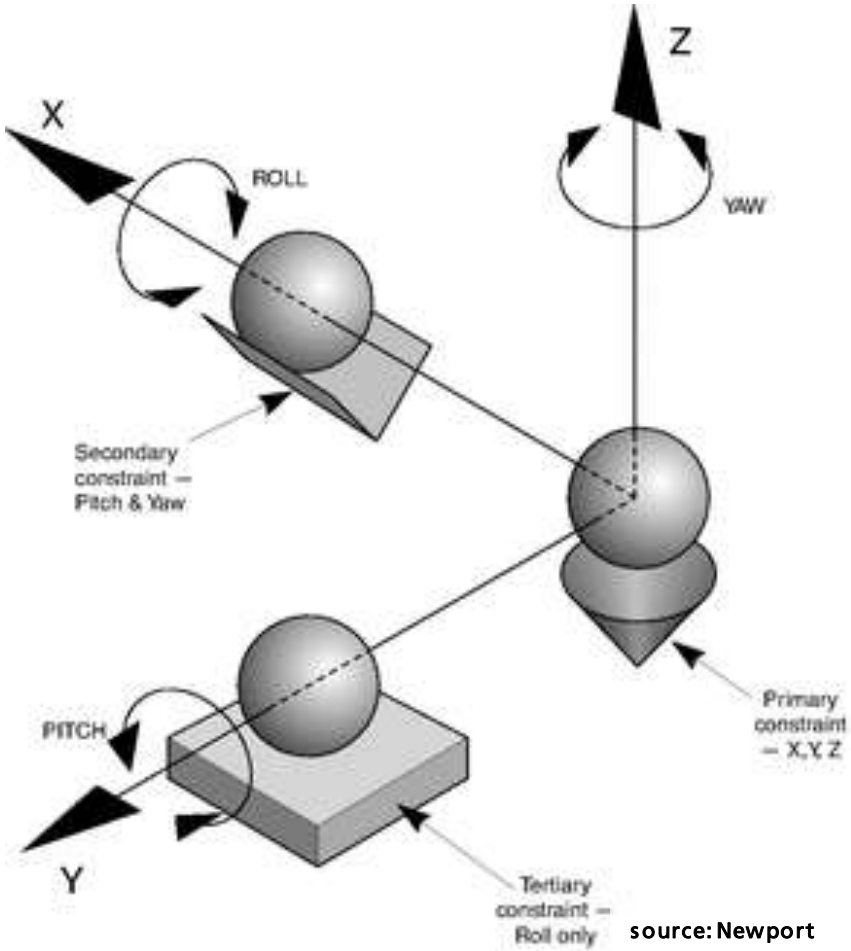
Mirror mounts – Kinematic mount

- Constrains equal the six degrees of freedom (3 translation, 3 rotation)
- Mirror in system defined by three balls
- Balls mounted in cone, groove and on plane at the mount

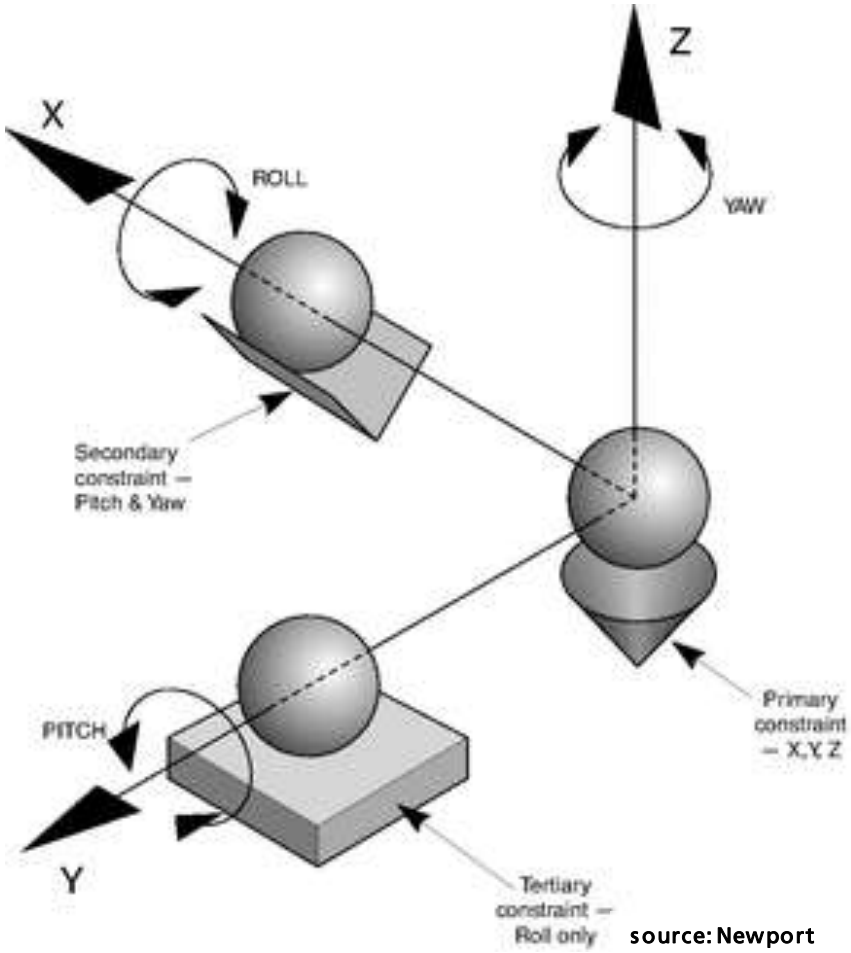


source: Newport

Fraunhofer ILT

Mirror mounts – Kinematic mount

- Constrains equal the six degrees of freedom (3 translation, 3 rotation)
- Mirror in system defined by three balls
- Balls mounted in cone, groove and on plane at the mount
- Cone: eliminates translation
- Groove: eliminates yaw and pitch
- Plane: eliminates roll

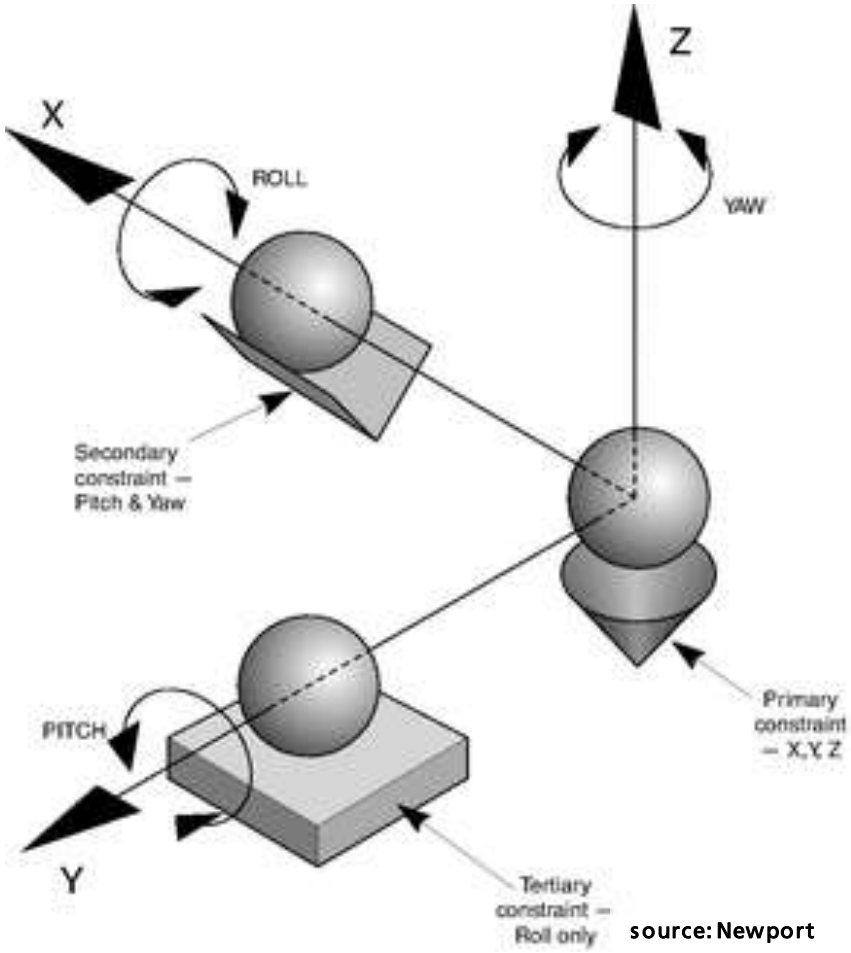


source: Newport

Fraunhofer ILT

Mirror mounts – Kinematic mount

- Constrains equal the six degrees of freedom (3 translation, 3 rotation)
- Mirror in system defined by three balls
- Balls mounted in cone, groove and on plane at the mount
- Cone: eliminates translation
- Groove: eliminates yaw and pitch
- Plane: eliminates roll
- Thermal expansion -> balls in groove and on plane translate
- No stress/misalignement due to temperature changes (theo.)



source: Newport

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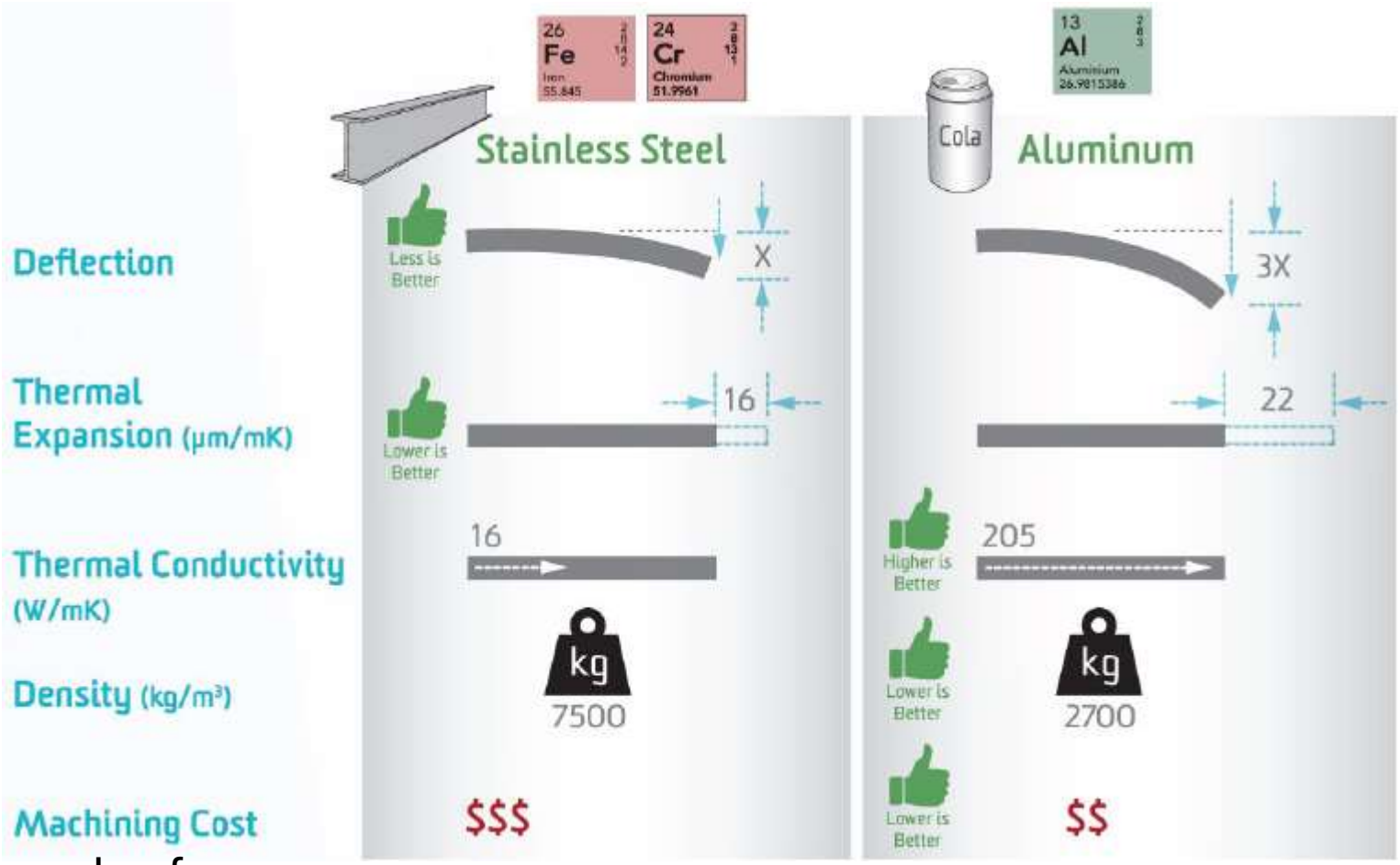
Mirror mounts – Materials



source: Newport

- Mounts made of
  - Steel: uniform temperature changes (room temperature)
  - Aluminum: temperature gradients (in setup)

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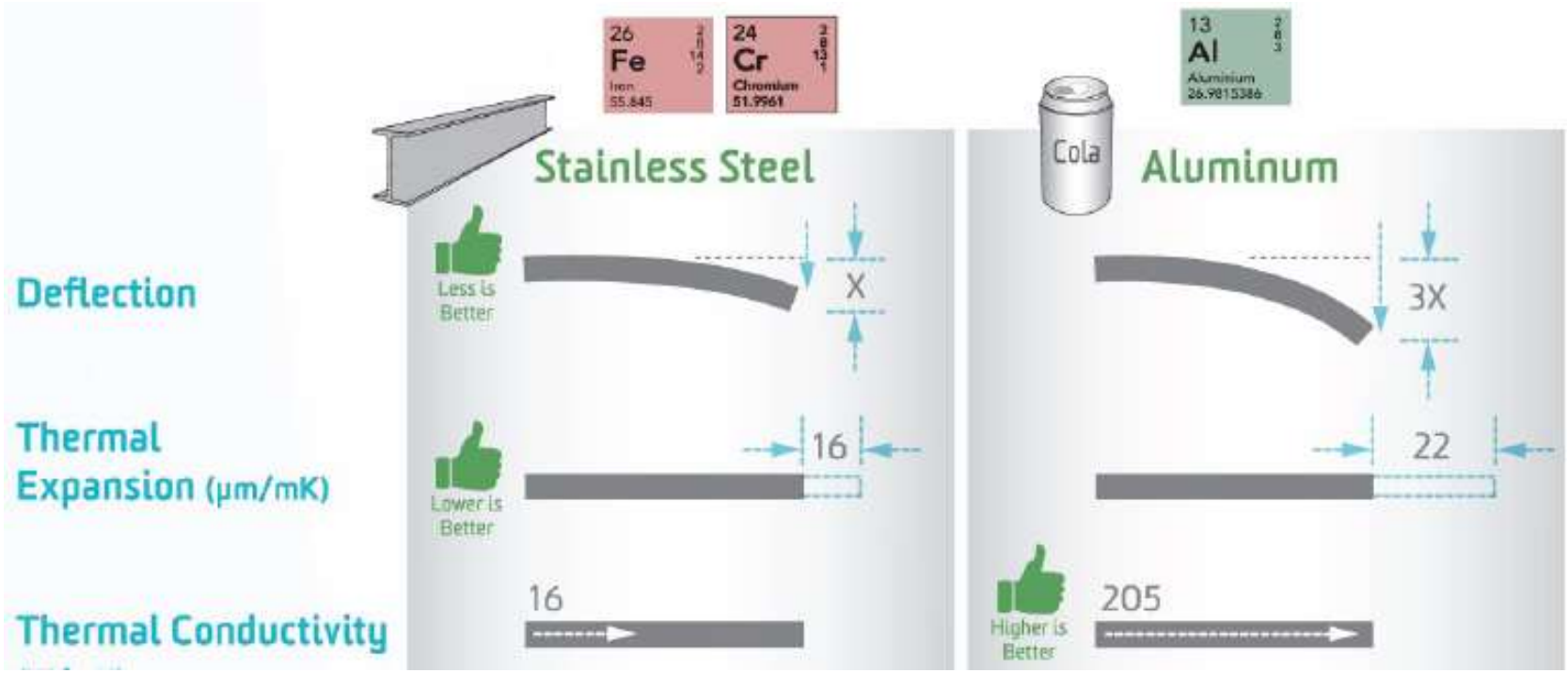
Tips for usage of mirror mounts

- Match materials



source: Newport

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Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals

source: Thorlabs

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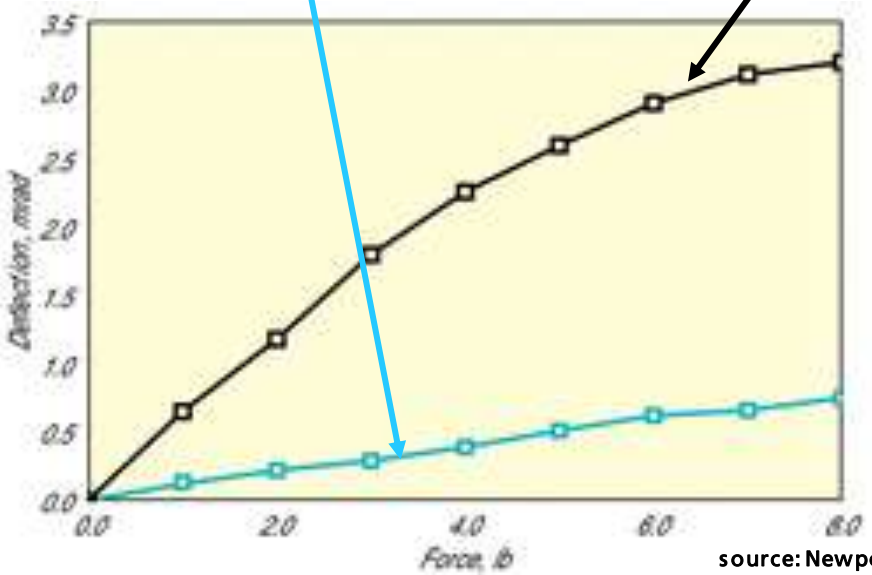


source: Newport

Fraunhofer ILT

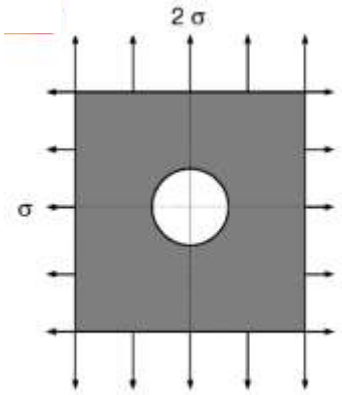
Tips for usage of mirror mounts

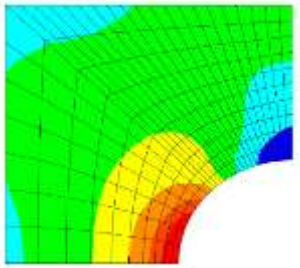
- Match materials
- Use wide posts/pedestals
- Mount optics out of setup

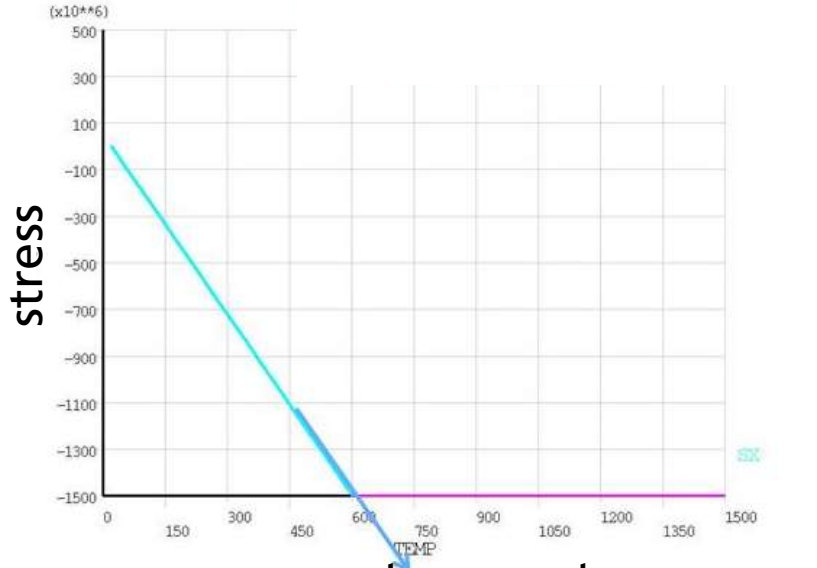
source: Thorlabs

Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals
- Mount optics out of setup
- Heat treat modified steel mechanics







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Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals
- Mount optics out of setup
- Heat treat modified steel mechanics
- Mount as low as possible

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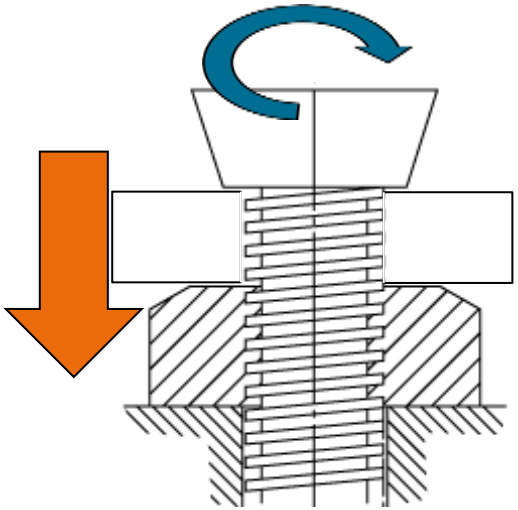
Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals
- Mount optics out of setup
- Heat treat modified steel mechanics
- Mount as low as possible
- Use defined torque

source: Thorlabs



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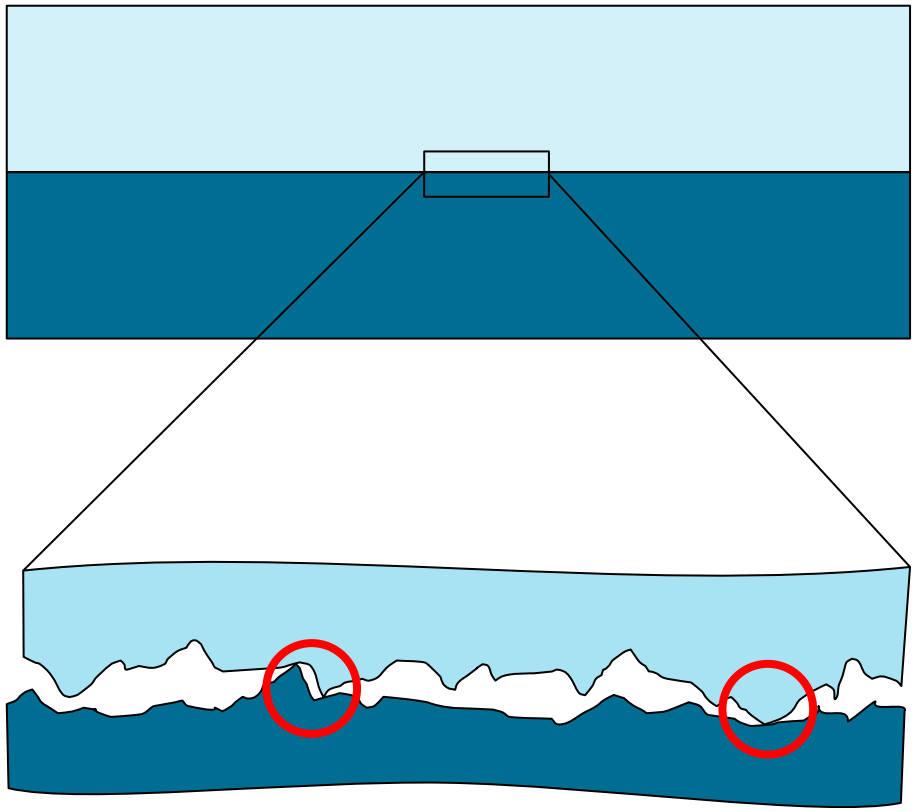
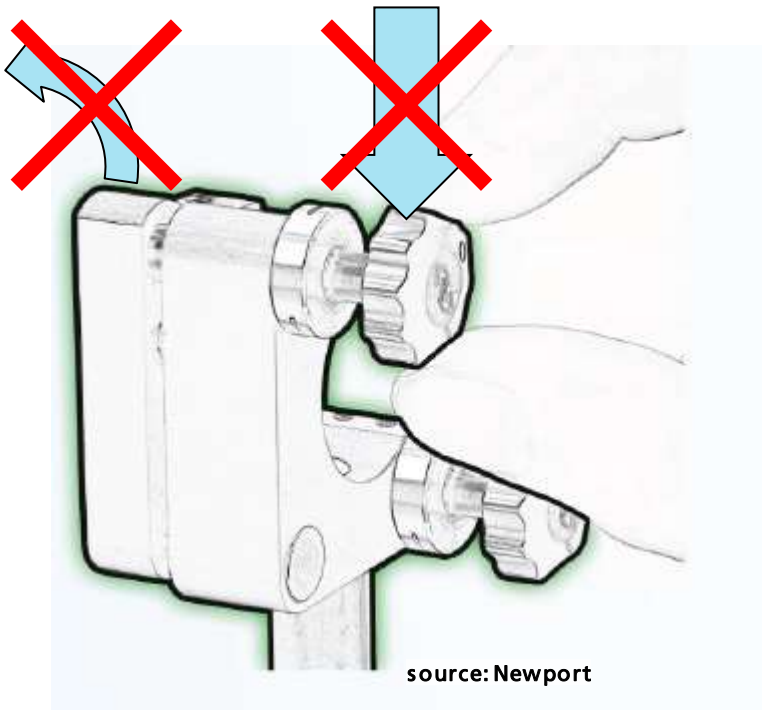
Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals
- Mount optics out of setup
- Heat treat modified steel mechanics
- Mount as low as possible
- Use defined torque
- Polish and clean surface



Tips for usage of mirror mounts

- Match materials
- Use wide posts/pedestals
- Mount optics out of setup
- Heat treat modified steel mechanics
- Mount as low as possible
- Use defined torque
- Polish and clean surface
- Keep frontplate parallel
- Only torque force on screws



OUTLINE

- Motivation
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Measurement – Climatic chamber

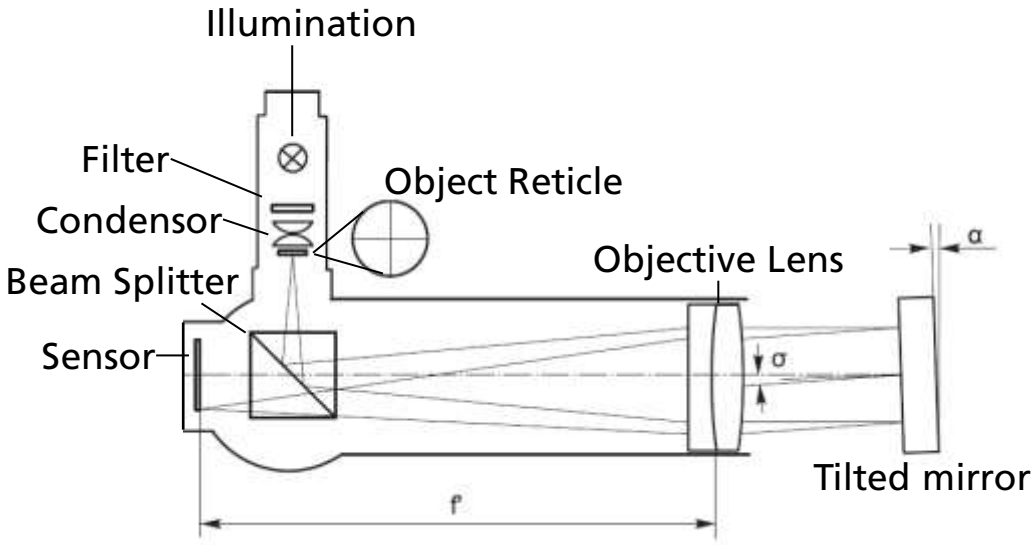
- Control of temperature and humidity
- Test chamber: 750 × 580 × 540 mm³ (270 l)
- Expansion: 1150 x 1000 x 1200 mm³ (1380 l)
- Temperature range: –50 °C to +160 °C
- Temperature changing rate: 10 K/min
- Optional online optical inspection

source: Weiss Umwelttechnik

Fraunhofer ILT

Measurement – Autocollimator

- Measurement of tilt
- Projection of an crosshair onto a target mirror
- Tilt of mirror transformed to deflection on sensor

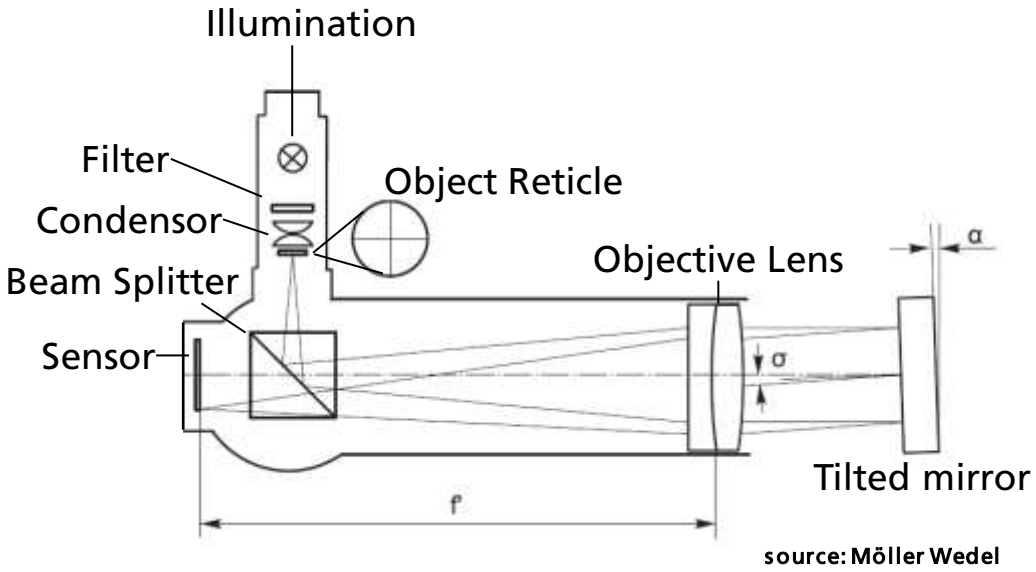


source: Möller Wedel

Fraunhofer ILT

Measurement – Autocollimator

- Measurement of tilt
- Projection of an crosshair onto a target mirror
- Tilt of mirror transformed to deflection on sensor
- Measurement of pitch and yaw relative to baseplate
- Field of view:
  6300 µrad × 4700 µrad
- Resolution: 0,05 µrad
- Absolute accuracy: 2 µrad



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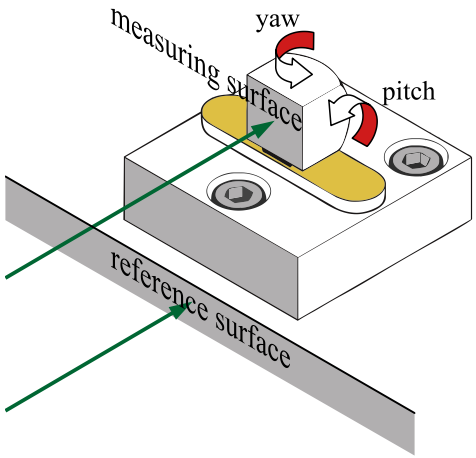

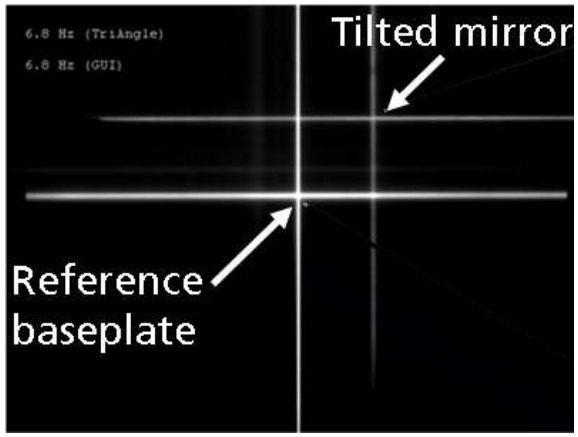

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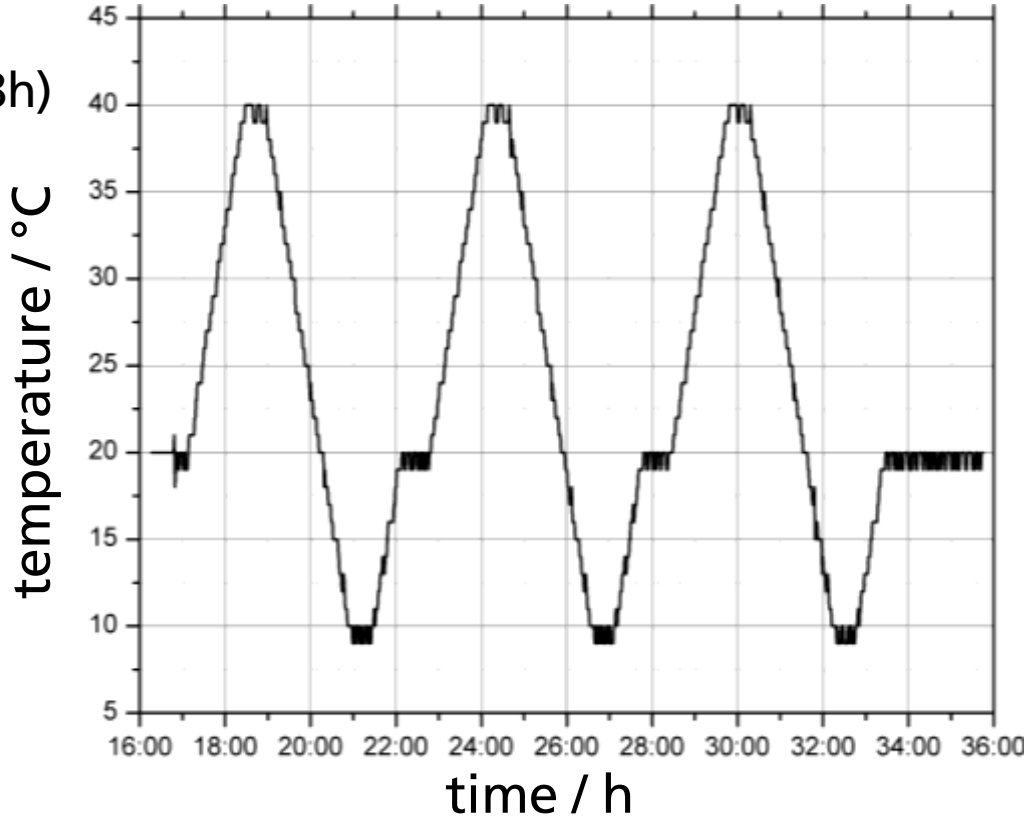
Measurement – Temperature cycles

- Mirror mounts cycled in climatic test chamber:
  20°C-40°C-10°C-20°C (duration18h)

Source: Weiss



Fraunhofer ILT

Measurement – Temperature cycles

- Mirror mounts cycled in climatic test chamber:
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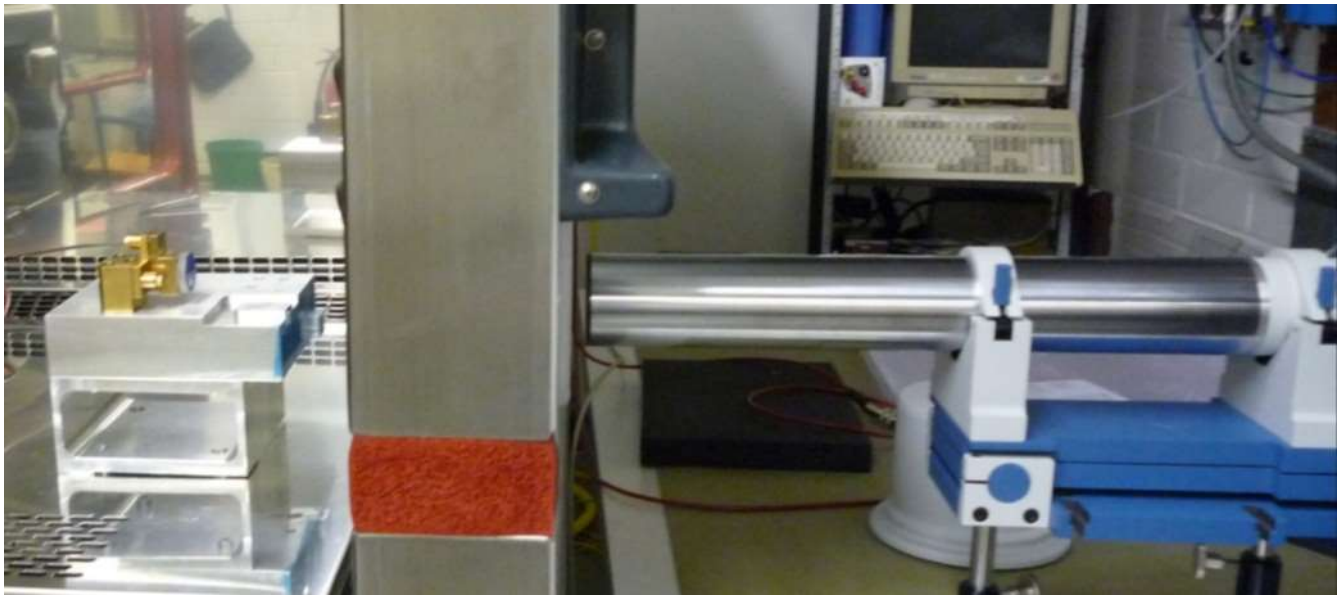
- Online measuring of tilts in both directions with autocollimator



Measurement – Temperature cycles

- Mirror mounts cycled in climatic test chamber:
  20°C-40°C-10°C-20°C (duration18h)
- Online measuring of tilts in both directions with autocollimator
- Tests with three mounts used in laser and six alternatives

source: Thorlabs, Siskiyou, Newport

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OUTLINE

- Motivation
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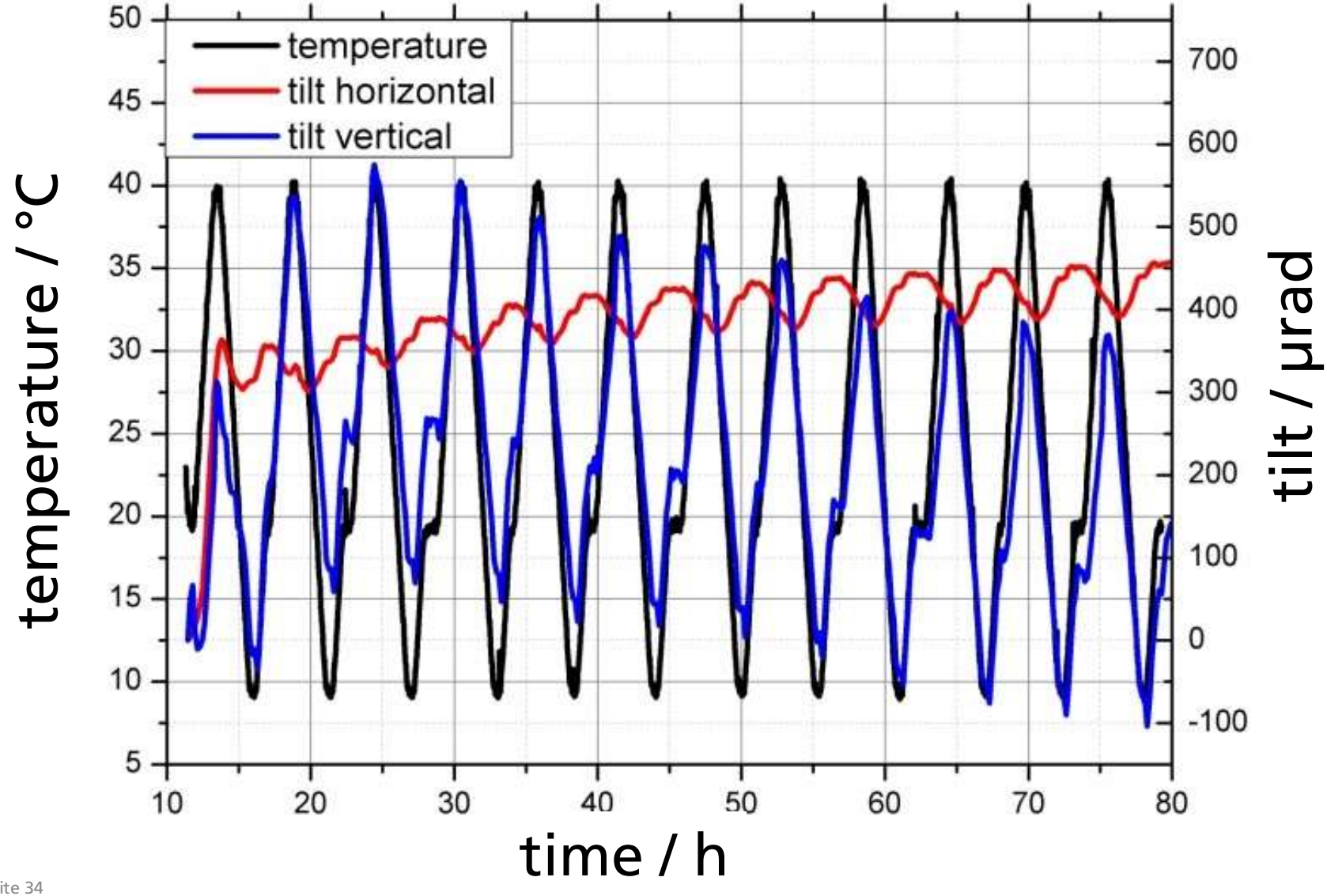
Results – Mount used in laser



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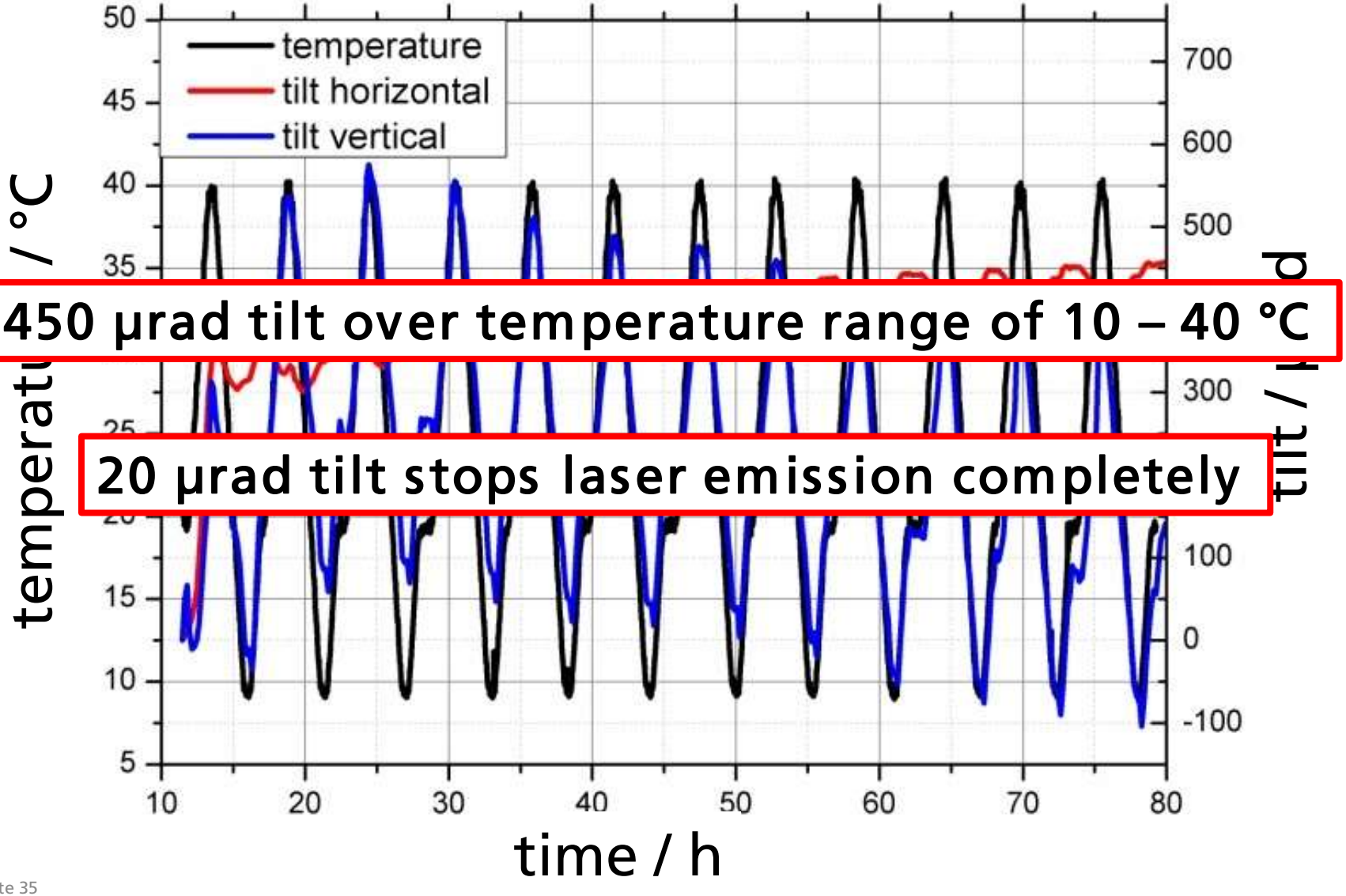
Results – Mount used in laser



450 µrad tilt over temperature range of 10 – 40 °C

20 µrad tilt stops laser emission completely

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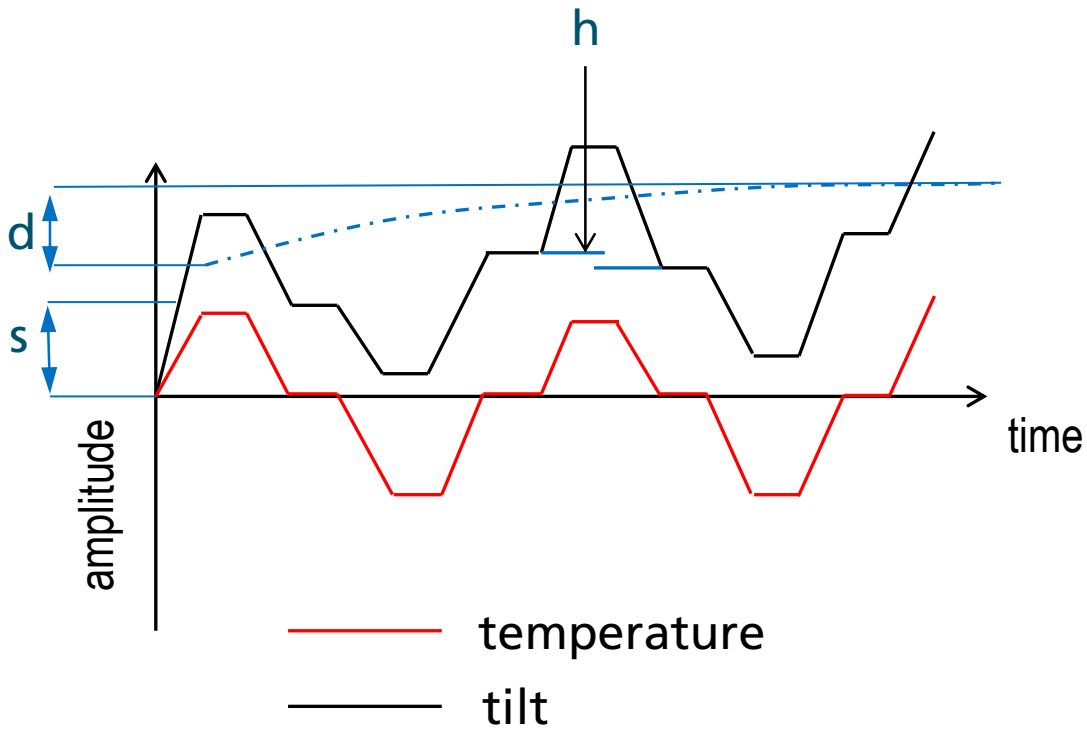
Results – Characteristic effects

- Superposition of four effects
  - Settling (s) at the beginning
  - Cyclical tilt
  - Hysteresis (h) at same temperature
  - Drift (d) over time



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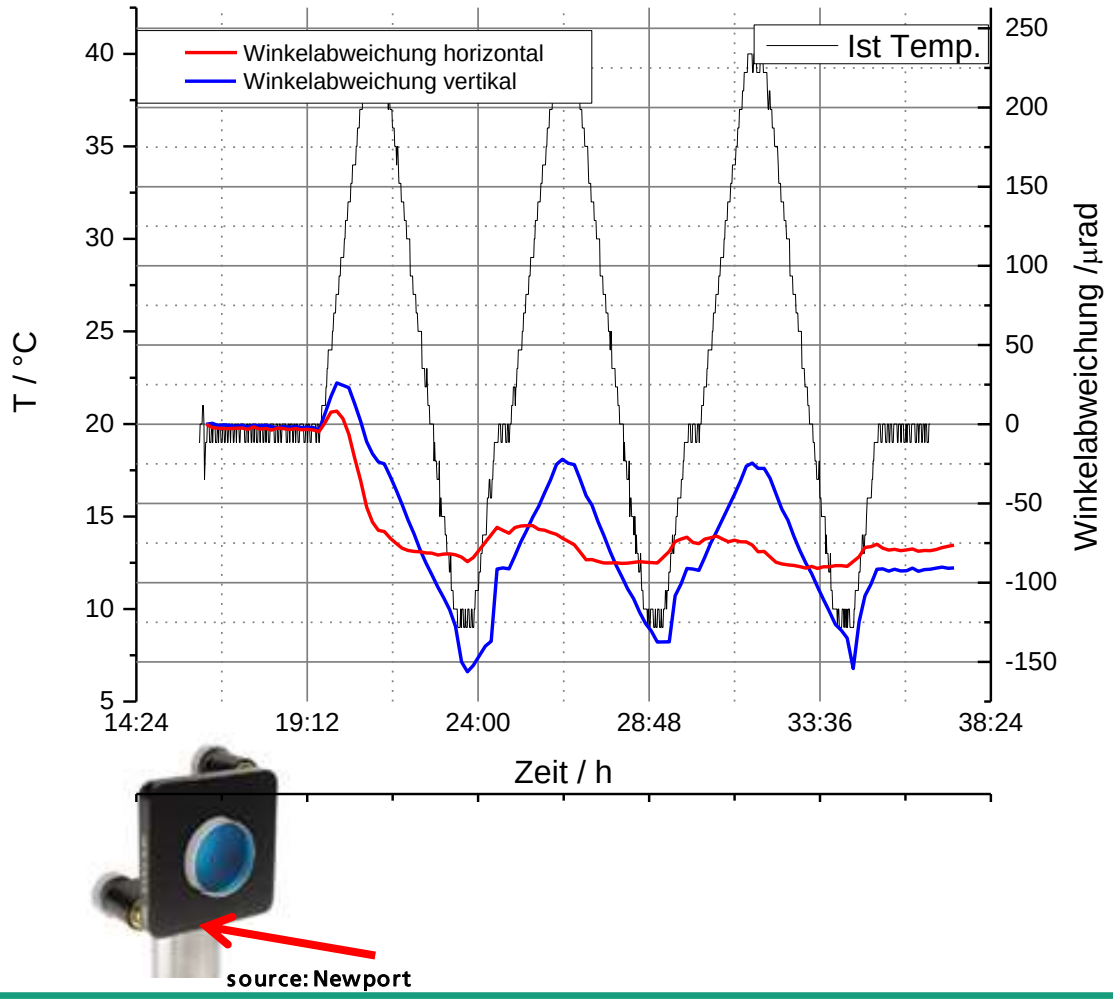
Results – Influence on settling

- Settling independent of vibrations
- Settling after mount on post



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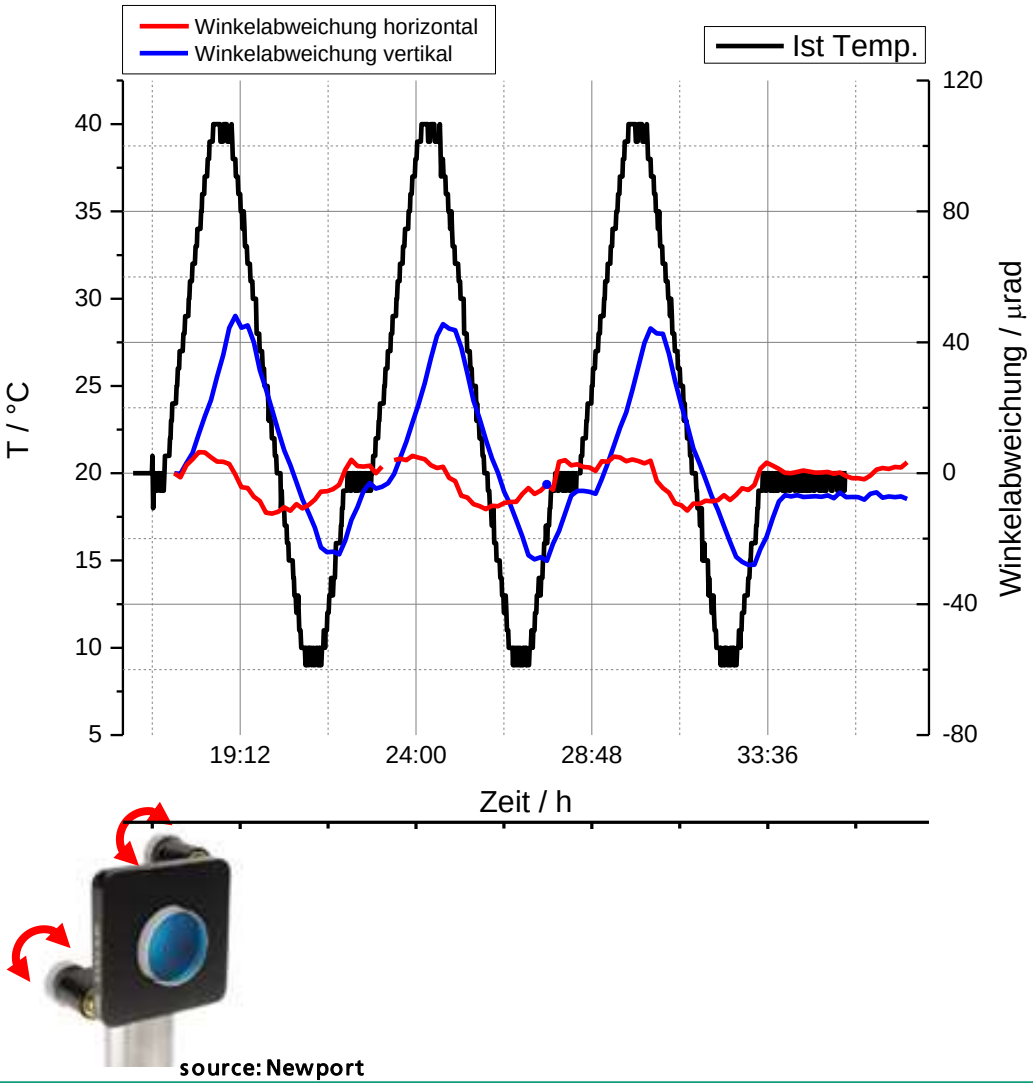
Results – Influence on settling

- Settling independent of vibrations
- Settling after mount on post
- No Settling after adjustment

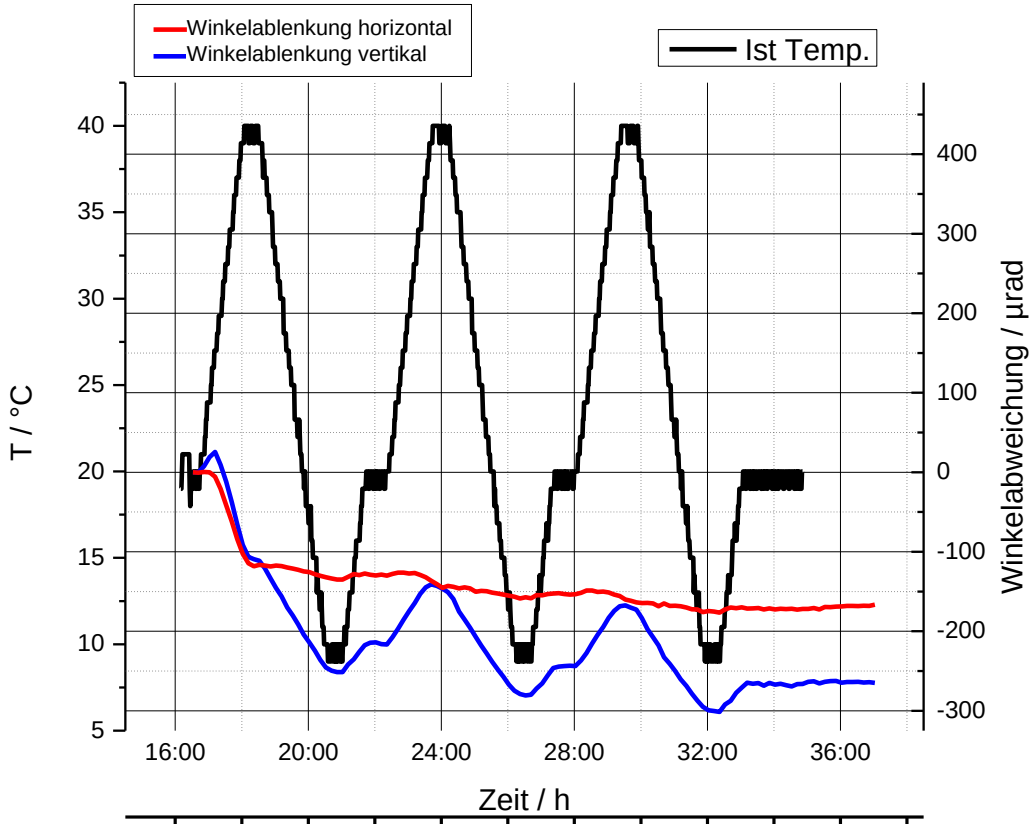


source: Newport

Fraunhofer ILT

Results – Influence on settling

- Settling independent of vibrations
- Settling after mount on post
- No Settling after adjustment
- Settling after remount of mirror



source: Newport

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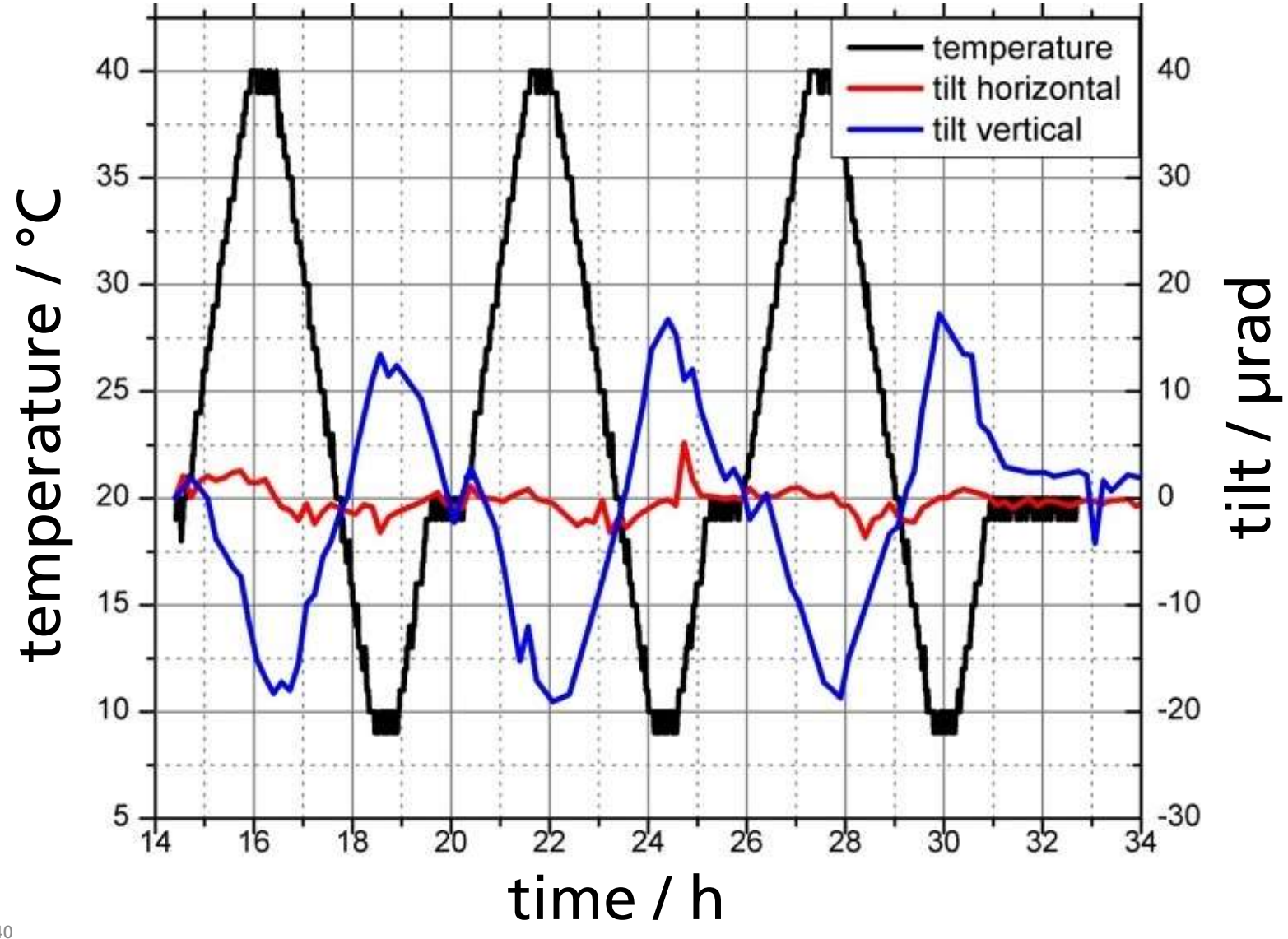
Results – Best alternative mount tested



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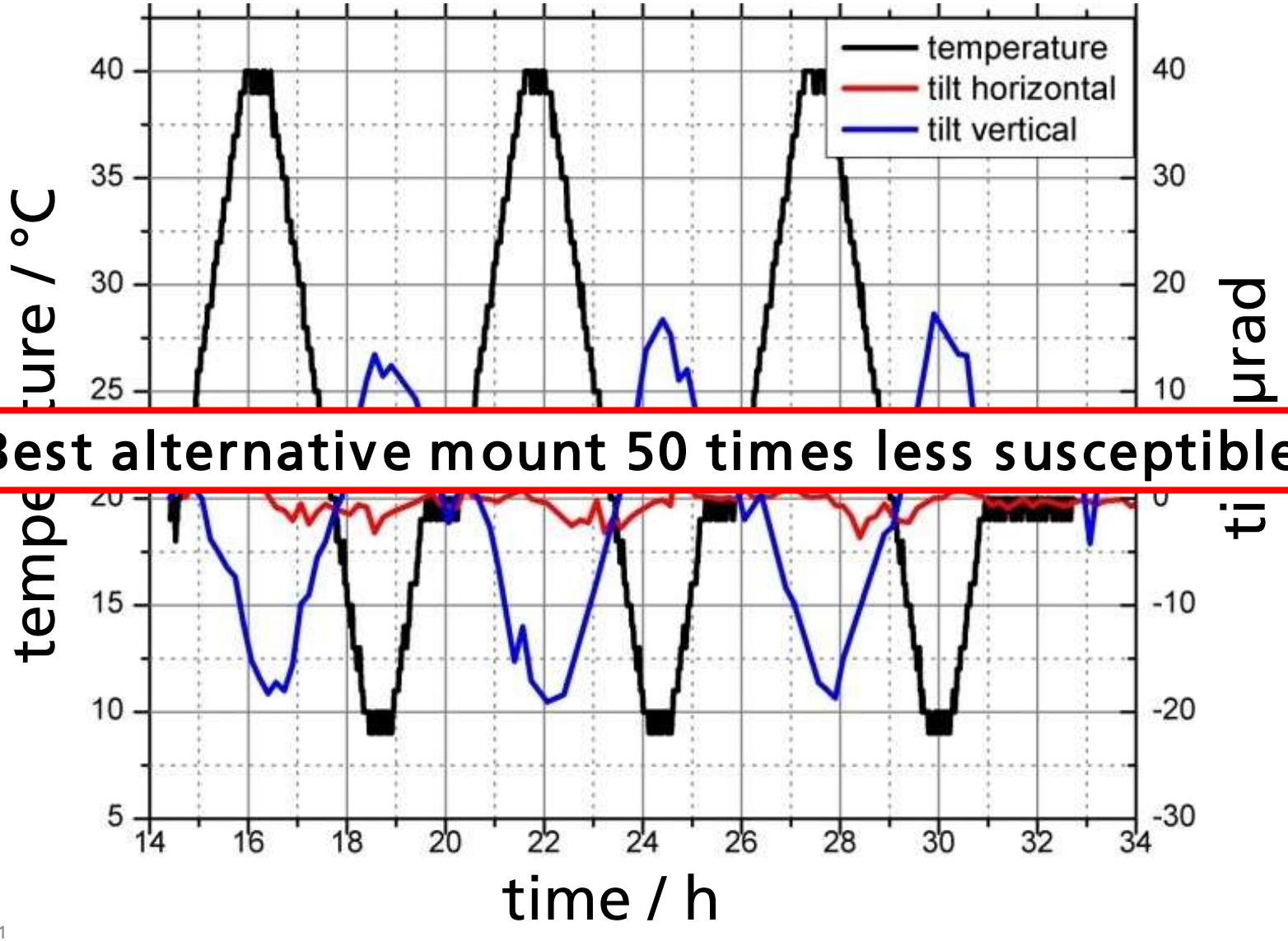
Results – Best alternative mount tested



Best alternative mount 50 times less susceptible

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Results – Overview of all mounts tested

usage	type	material kind	horizontal tilt	vertical tilt	horizontal setting	vertical setting	horizontal drift	vertical drift
Deflection comm.	1" Center Mount	aluminium kinematic	40	90	65	65	5 / 0	0
NLO oven comm.	Blank Plate	aluminium kinematic	25	60	25	10	0	0
Resonator comm.	0.5" Corner Mount	aluminium kinematic	60	475	300	225	25 / 5	+100 / -30
alternative #1	1" Center Mount	brass flexure	5	35	0	0	0	0
alternative #2	1" Center Mount	stainless steel flexure	35	40	0	5	0	10 / 0
alternative #3 comm.	0.5" Center Mount	stainless steel flexure	50	45	0	10	0	0
alternative #4 comm.	1" Center Mount	stainless steel kinematic	70	90	10	20	-10	0
alternative #5 comm.	1" Center Mount	stainless steel kinematic	30	30	10	0	30 / 20	0
alternative #6 comm.	0.5" Center Mount	aluminium kinematic	80	70	0	70	50 / 30	80 / 40

SUMMARY

- Thermomechanical tests for rugged laser
- Different types of mounts
- Matched materials for specific application
- Several tips for the usage of mirror mounts
- Tests with climatic chamber and autocollimator
- Tilt as superposition of different effects

Thank you for your attention!

Any Questions?