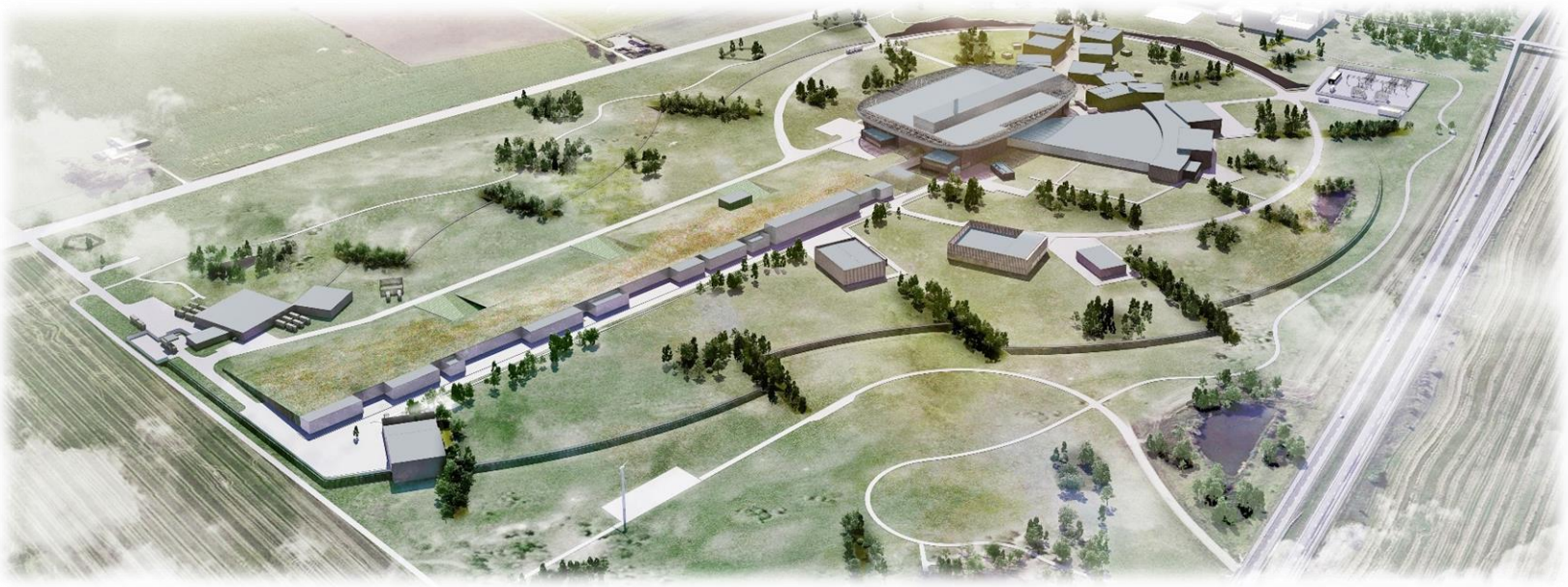

TARGET MONITORING PLUG (TMP) @ ESS

2019.10.15 I E. ROSENTHAL

Y. BESSLER, U. GIESEN, G. NATOUR

Mitglied der Helmholtz-Gemeinschaft

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ZEA-1 Central Institute of Engineering, Elektronics and Analytics | ZEA
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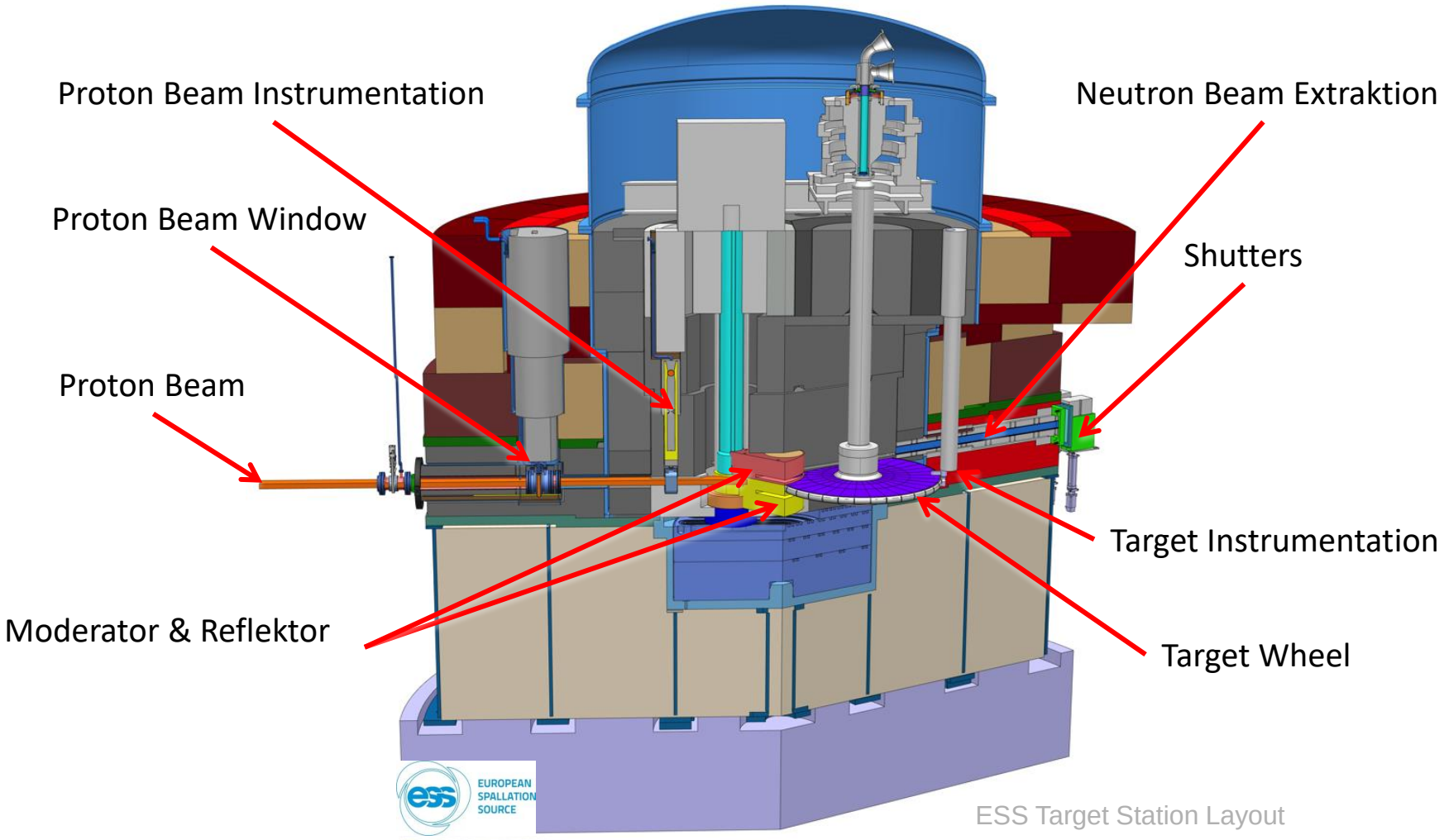
ESS OVERVIEW

ESS TARGET MONOLITH

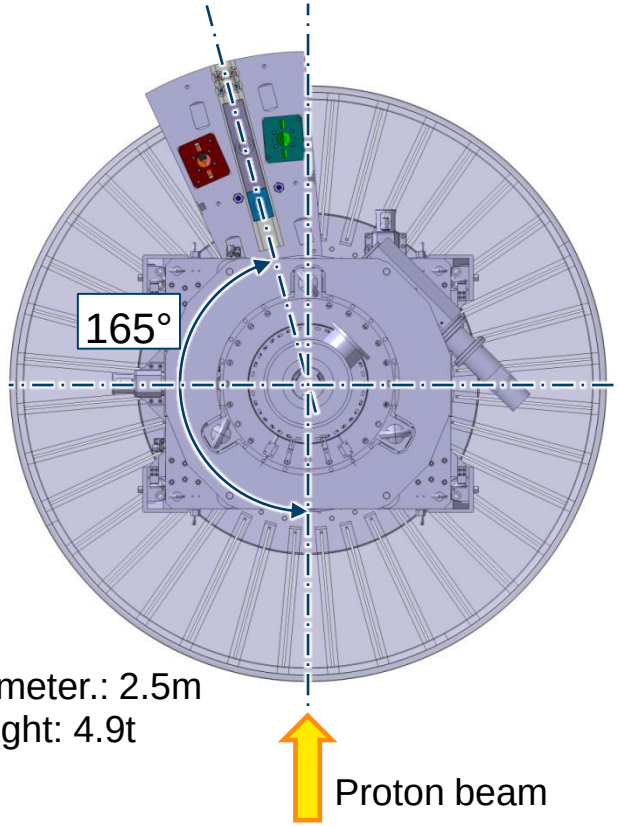


ESS Target Station Layout

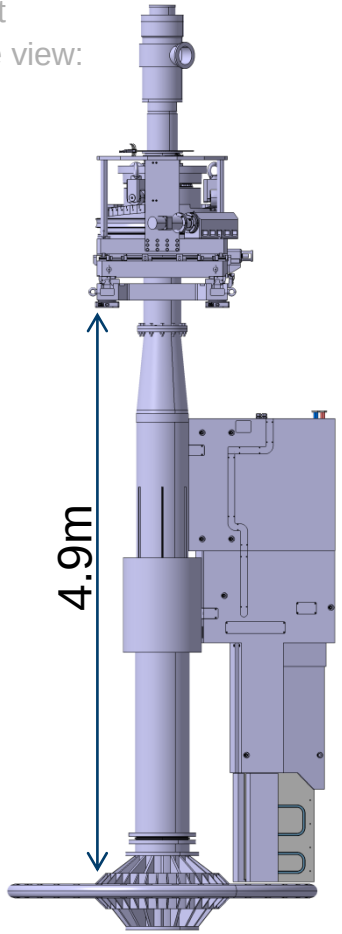
TARGET MONITORING PLUG (TMP)

All measurement systems are integrated inside the Target monitoring plug

ESS Target
Wheel top view:



ESS Target
Wheel side view:



- the Target Monitoring Plug (TMP) is positioned directly above the target wheel
- it is located at the opposite of the target shaft, turned away from the spallation center and angled by 15° off-axis to the proton beam

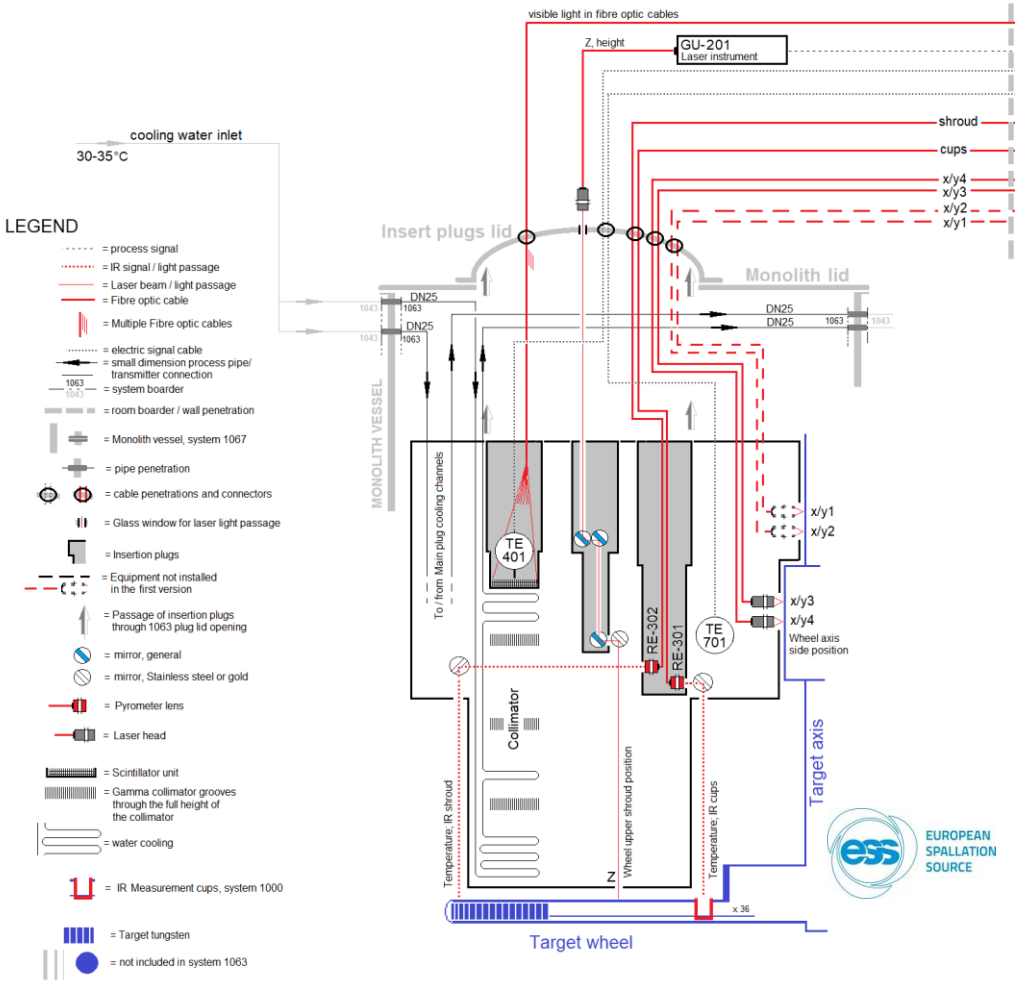
TASKS

Design, manufacturing and implementation of an independent measuring system

- x/y/z position of the target
- tilting of the shaft
- vibrations of the shaft
- temperature monitoring

Requirements

- radiation hard design
- no electronics inside the (vacuum) monolith vessel
- exchangeable design
- opening for the collimator insert
- active cooling



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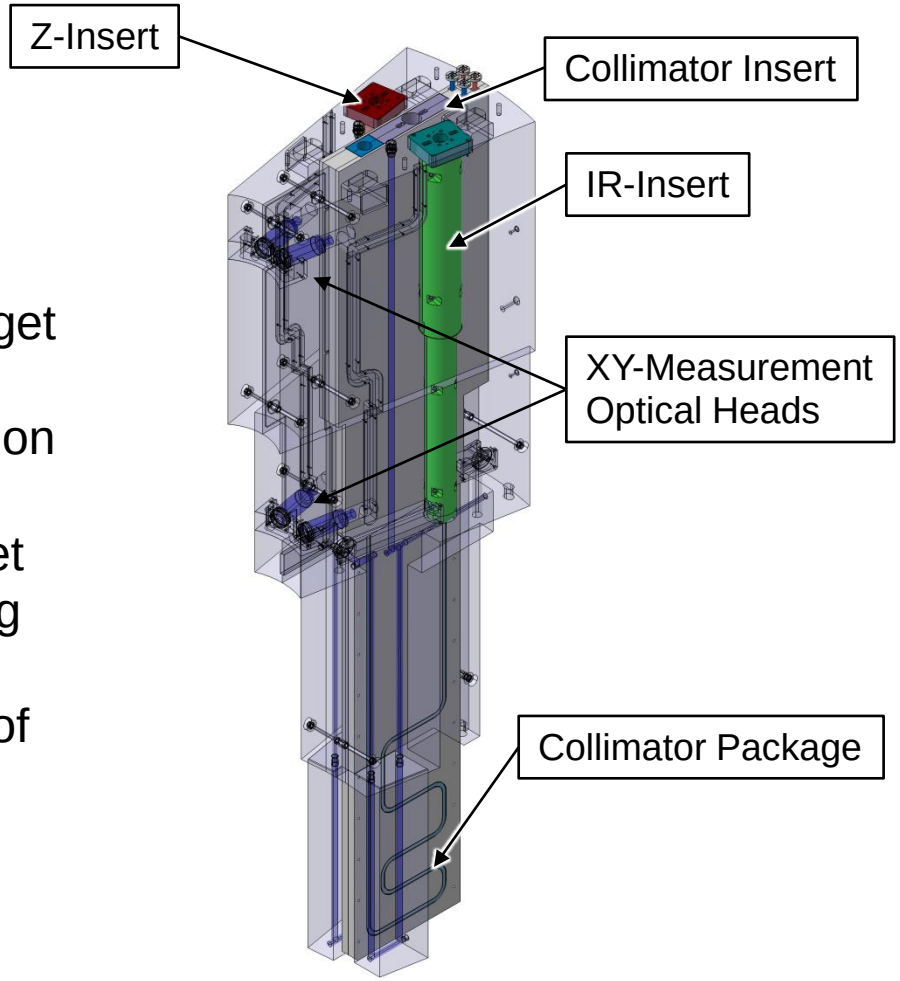
TMP DESIGN

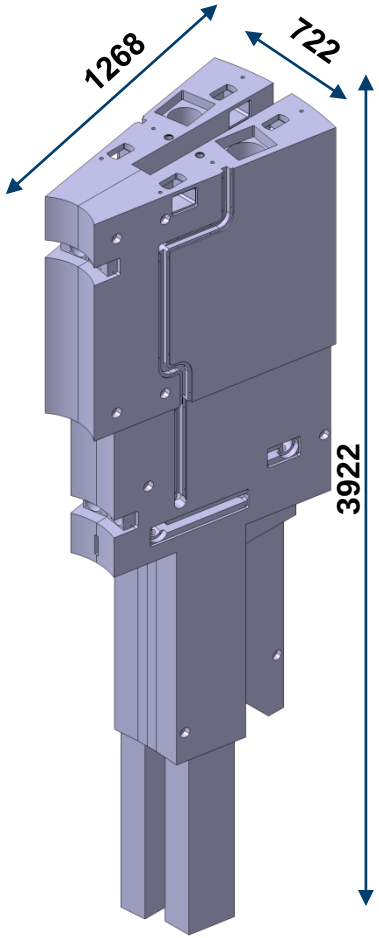
- measurement the xy position of the target
- measurement the z position of the target wheel
- measure shaft vibration during operation

- measurement the helium coolant outlet temperature from each cassette during operation
- measurement of the rim temperature of the target wheel



TMP – MAIN BODY

- the main body consists of four individual parts, that are bolted to one assembly



Body Assembly (1.4306):
m_{total} = 8667kg

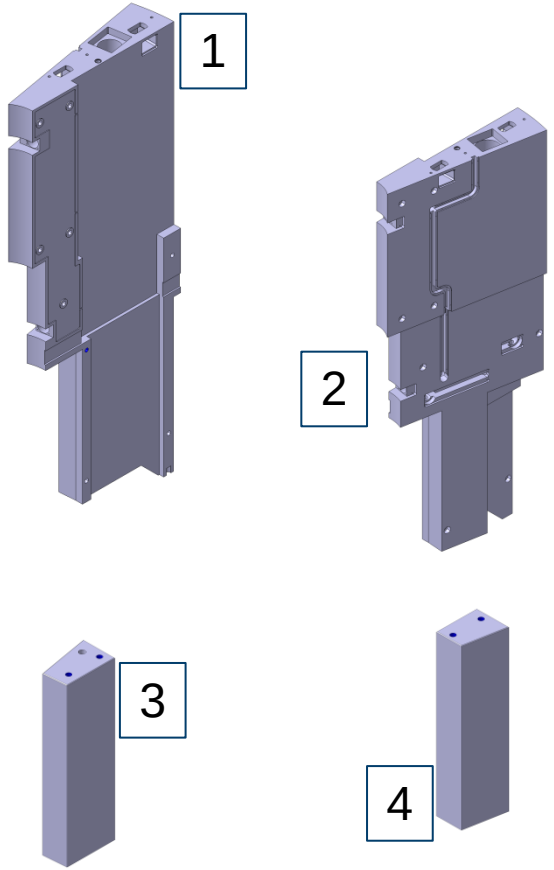
4 Component Parts:

No.1: m_1 = 4084kg
3140 x 361 x 1268

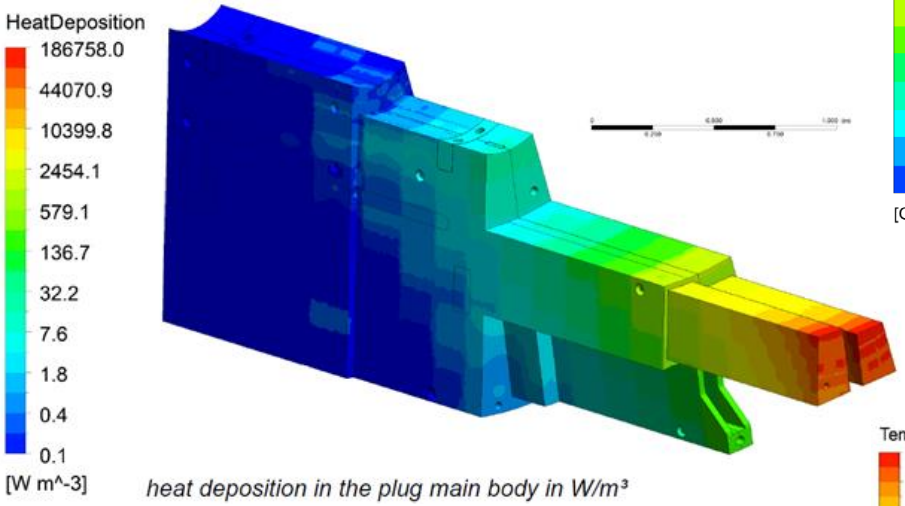
No.2: m_2 = 4003kg
3140 x 361 x 1268

No.3: m_3 = 314kg
922 x 184 x 290

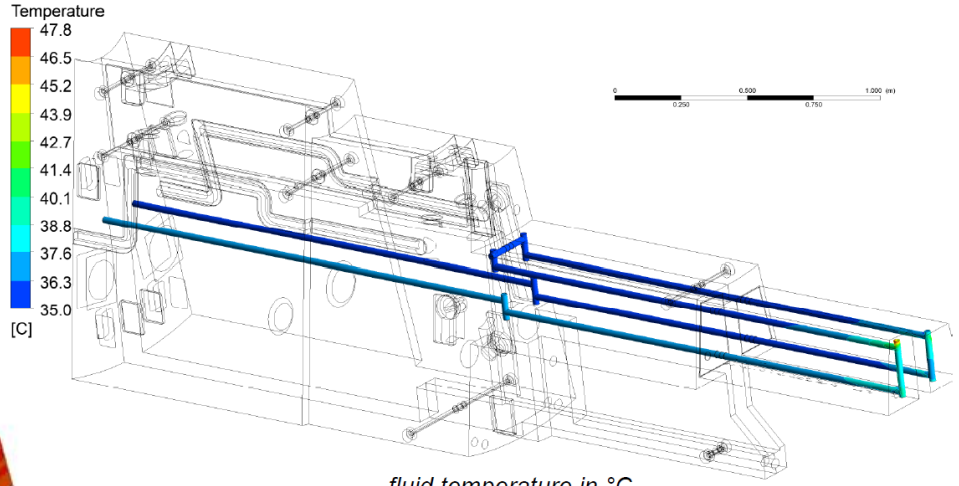
No.4: m_4 = 266kg
922 x 184 x 231



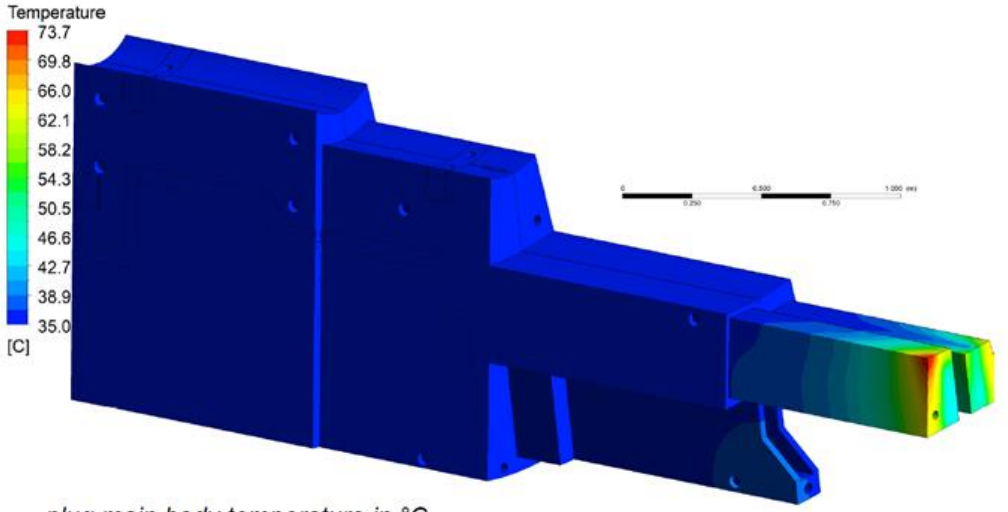
COOLING CONCEPT



heat deposition in the plug main body in W/m³



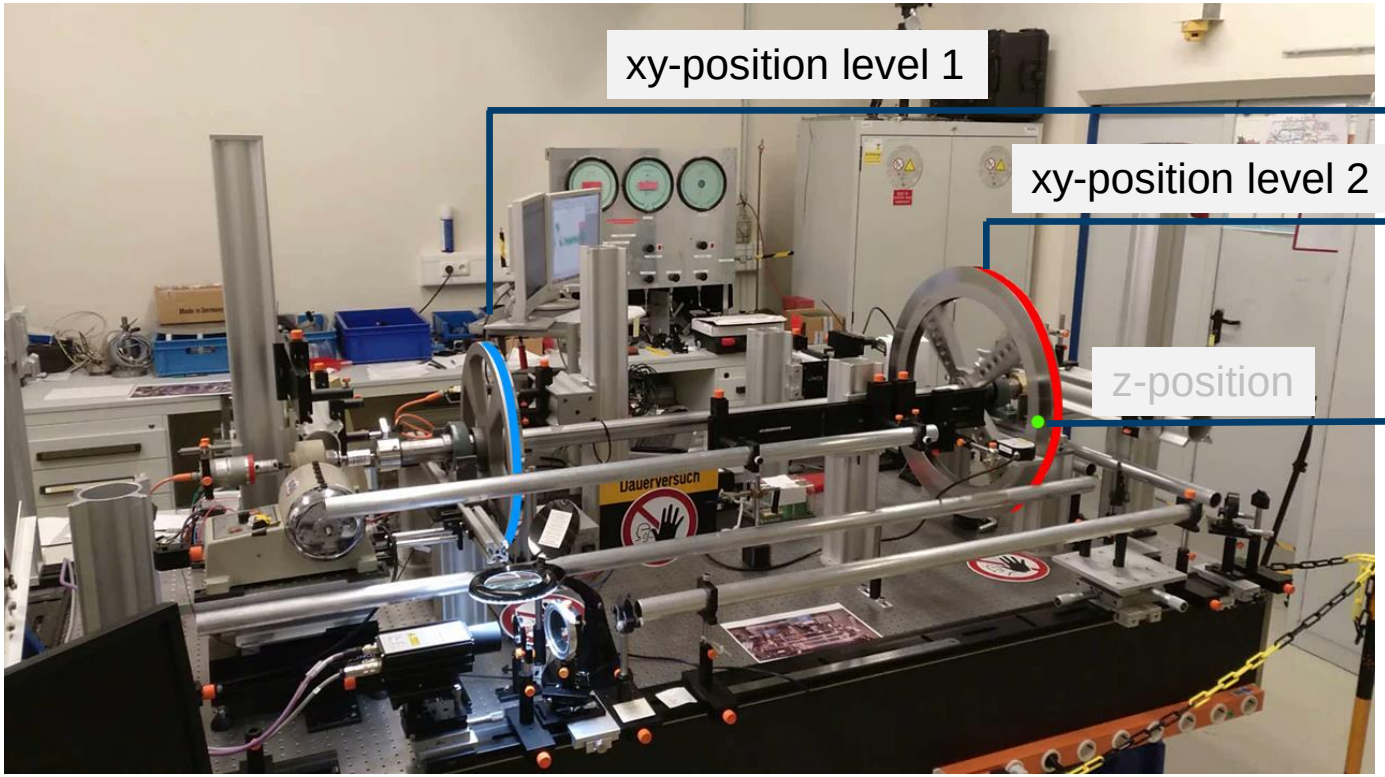
fluid temperature in °C



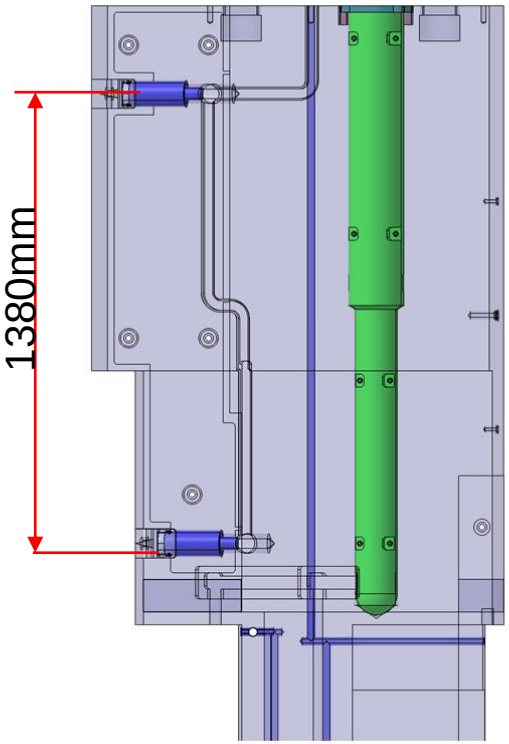
plug main body temperature in °C

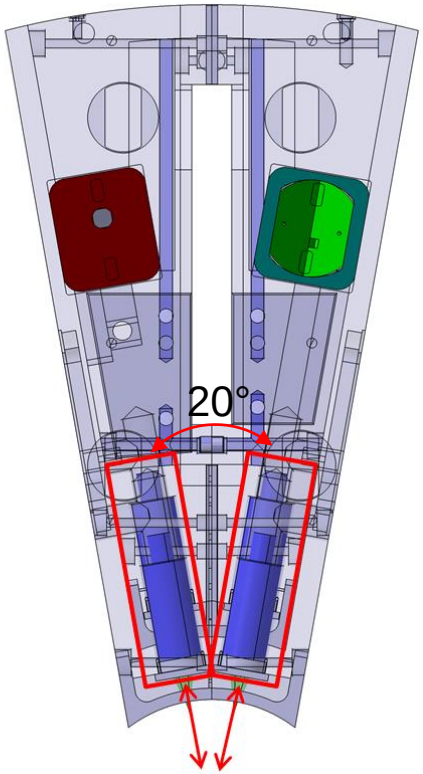
- cooling fluid: water
- pressure difference: 2300 Pa.
- operation pressure 3 bar
- design pressure 10 bar
- mass flow rate: 0.18 kg/s
- inlet temperature: 35 °C

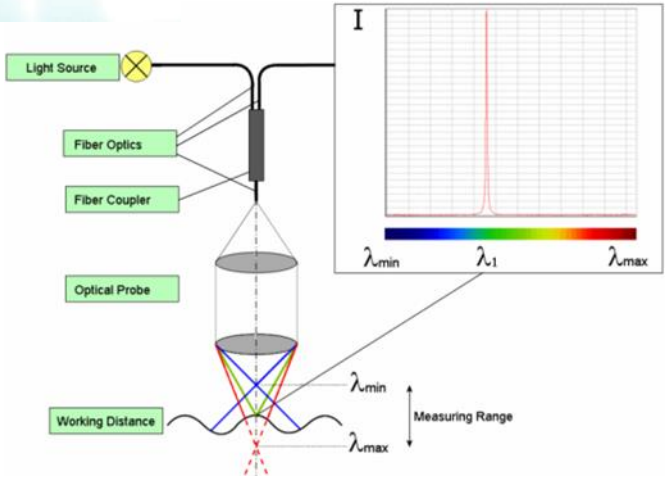
XY – MEASUREMENT
TEST SETUP



XY – MEASUREMENT



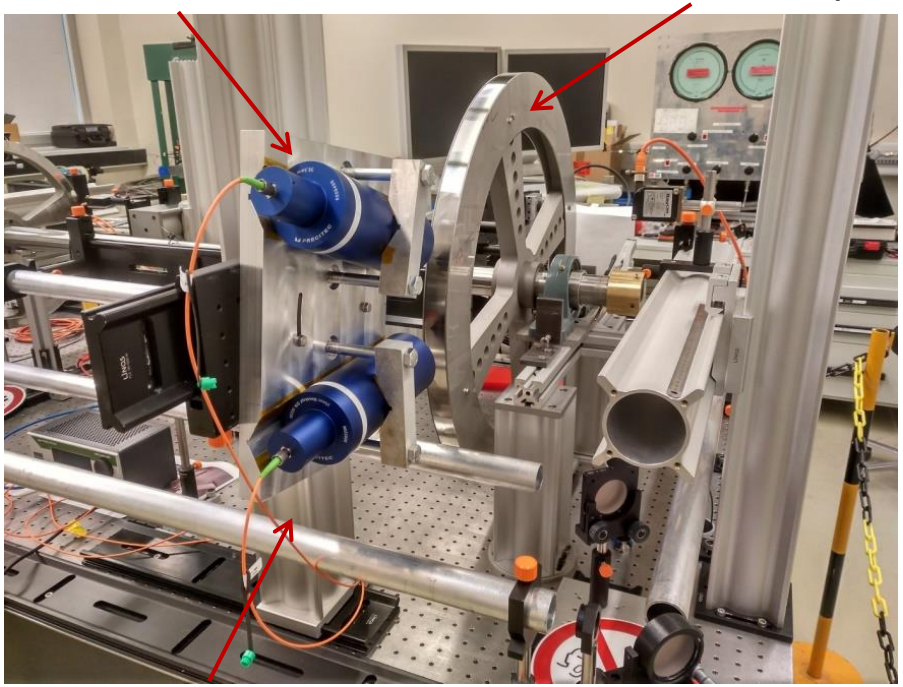




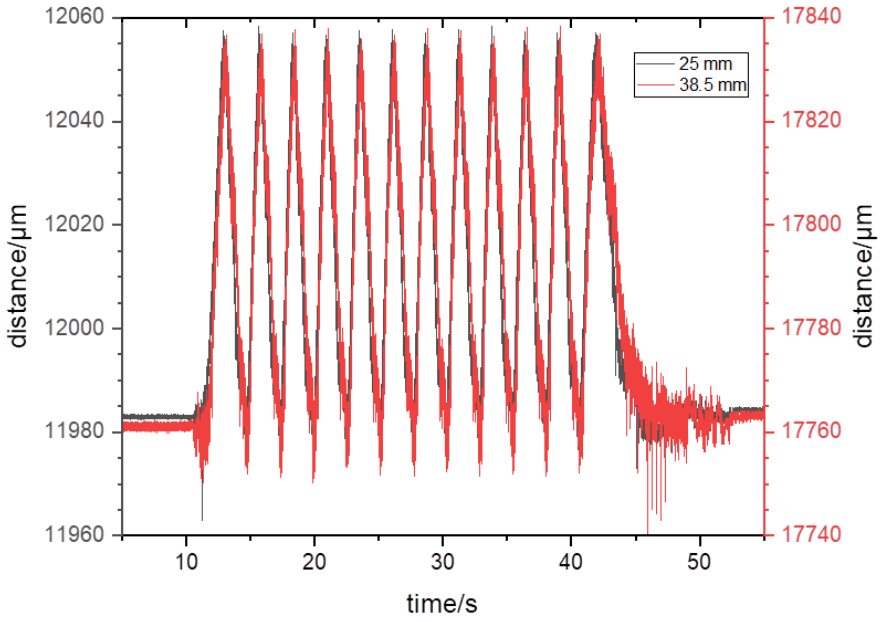
XY – POSITION TESTING

sensor head $38.5mm$

rotation wheel (=shaft diameter)

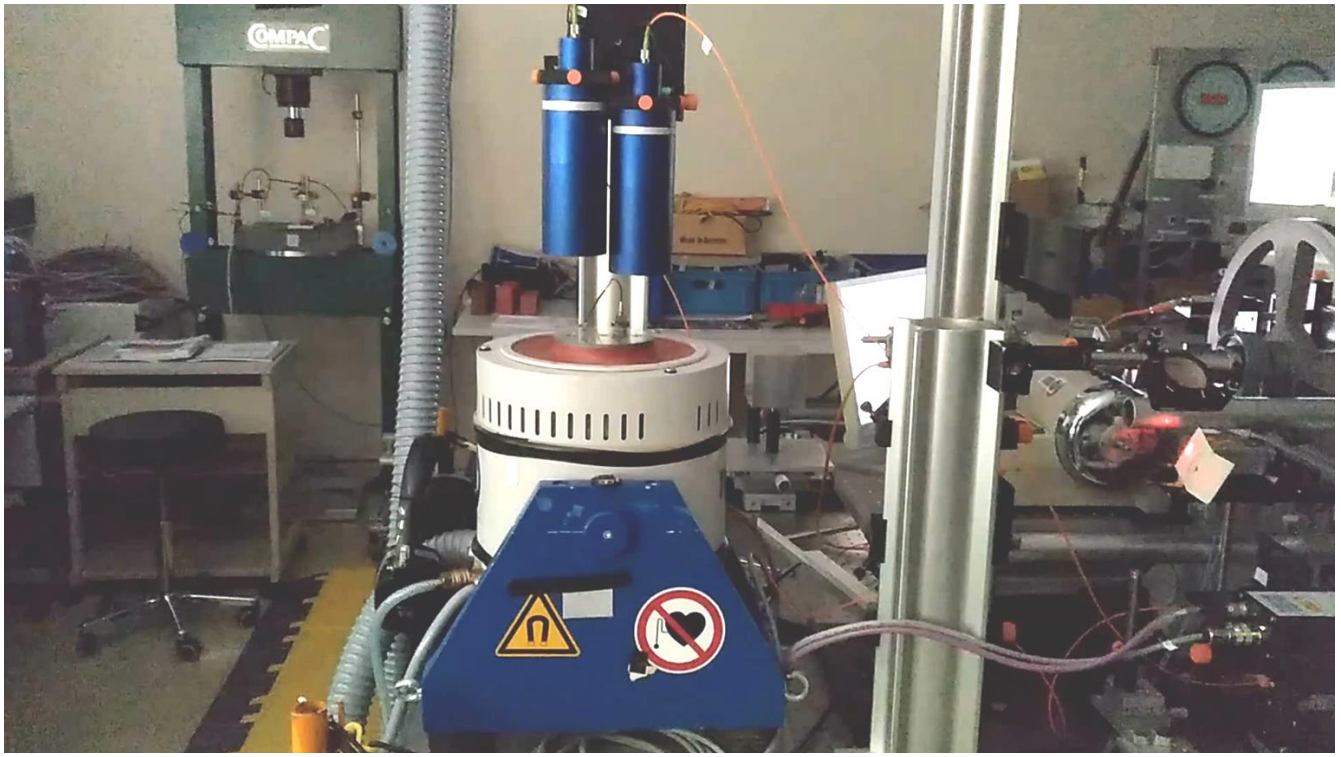


sensor head $25mm$

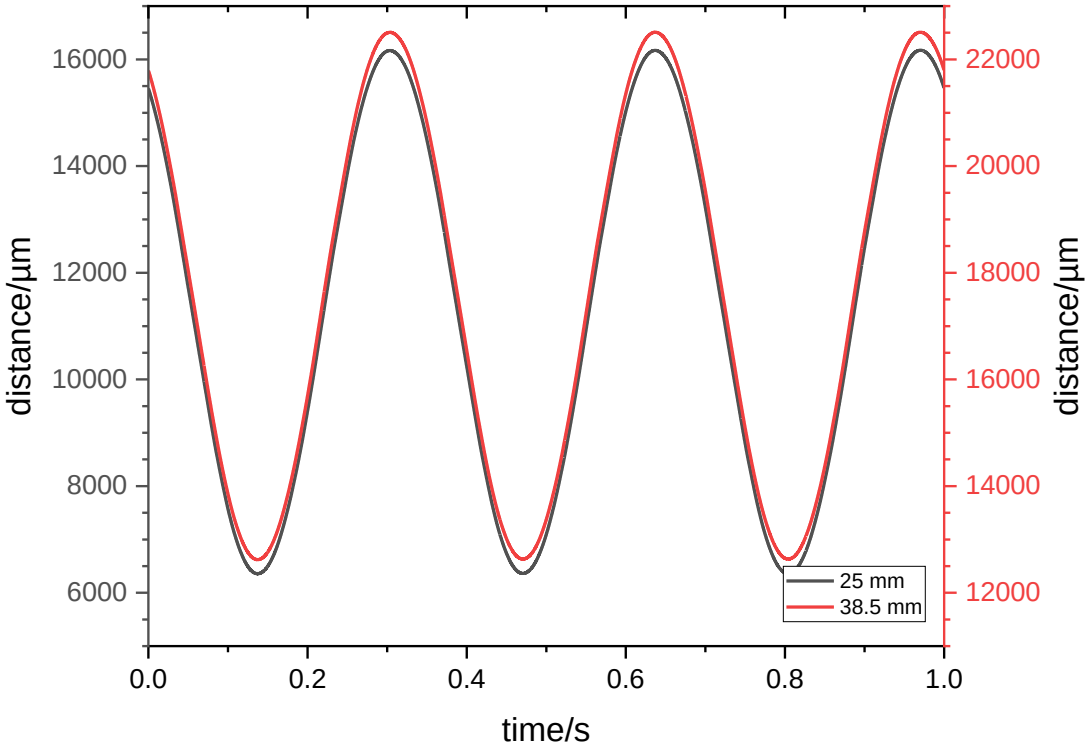


measuring the out-of-roundness ($\sim 90\mu m$) of the rotation wheel at the original rotation speed

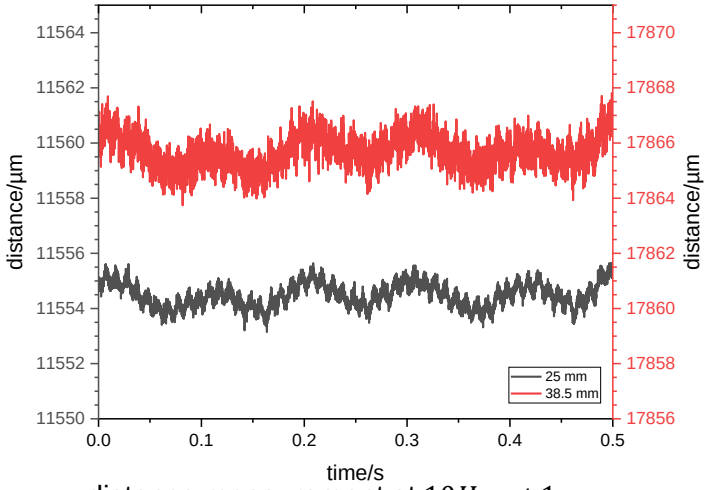
XY – VIBRATION & POSITION TESTING



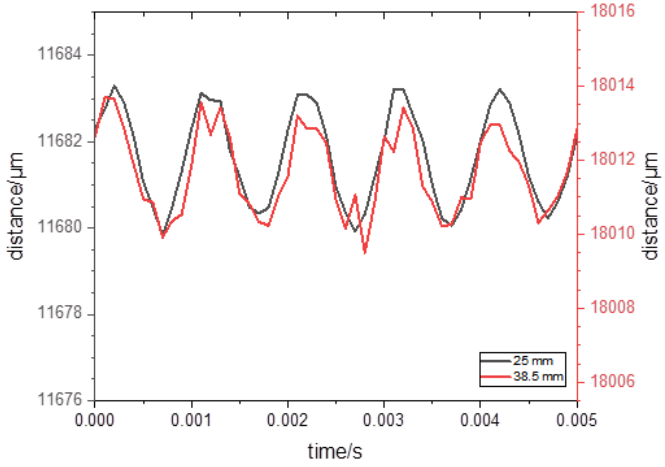
XY – VIBRATION & POSITION TESTING



sensor heads $25mm$ and $38.5mm$ distance measurement at nominal shaker value of $3Hz\ at\ 10000\mu m_{pp}$

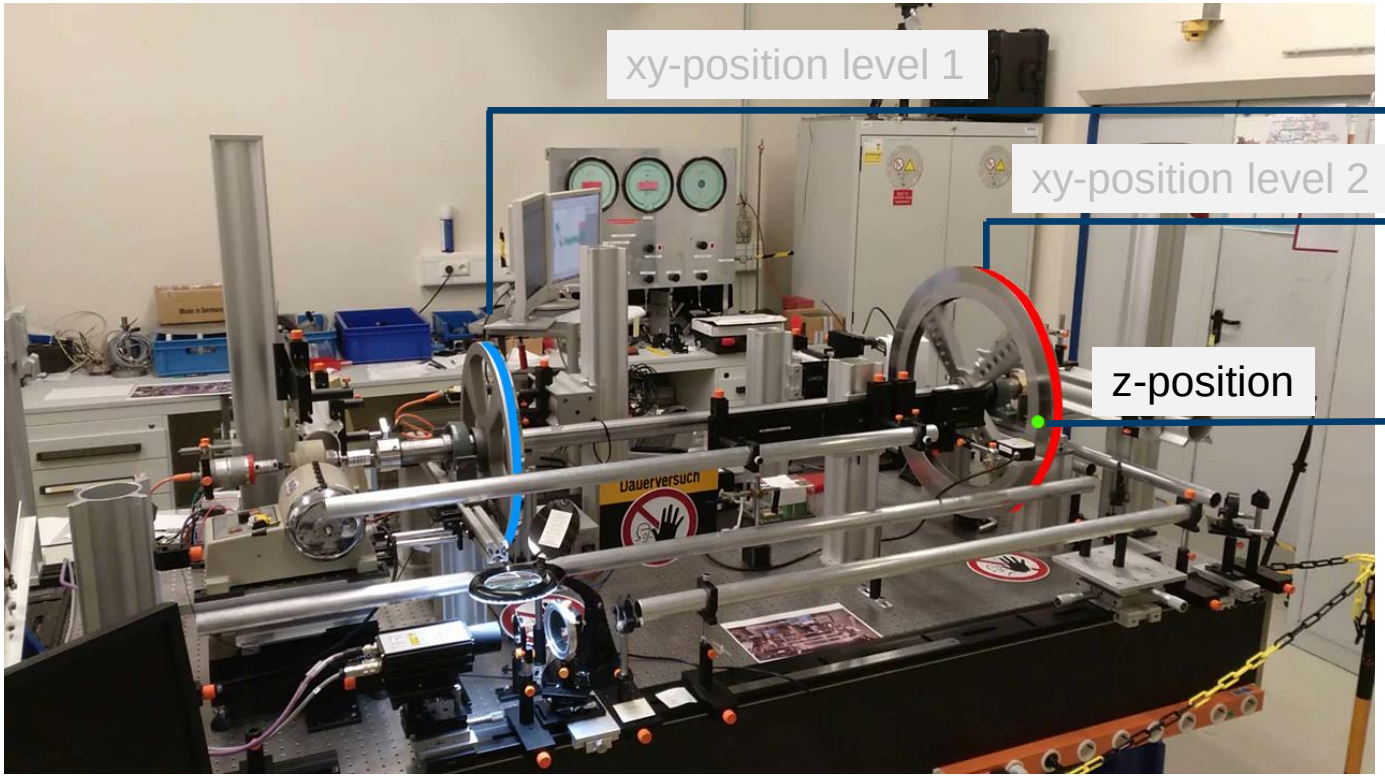


distance measurement at $10Hz\ \ at\ 1\mu mpp$



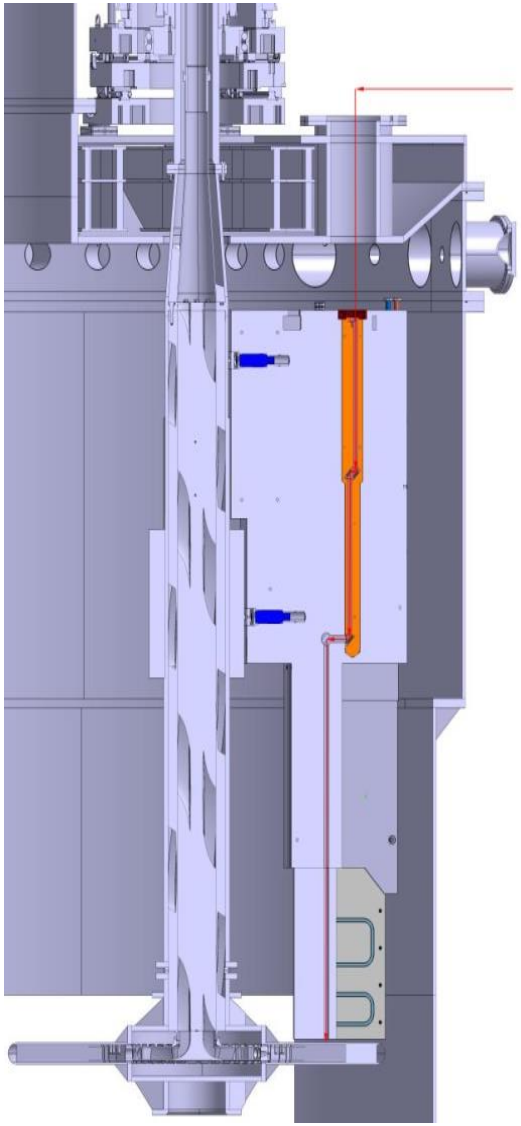
distance measurement at $1000Hz\ at\ \ 3\mu m_{pp}$

Z – MEASUREMENT
TEST SETUP



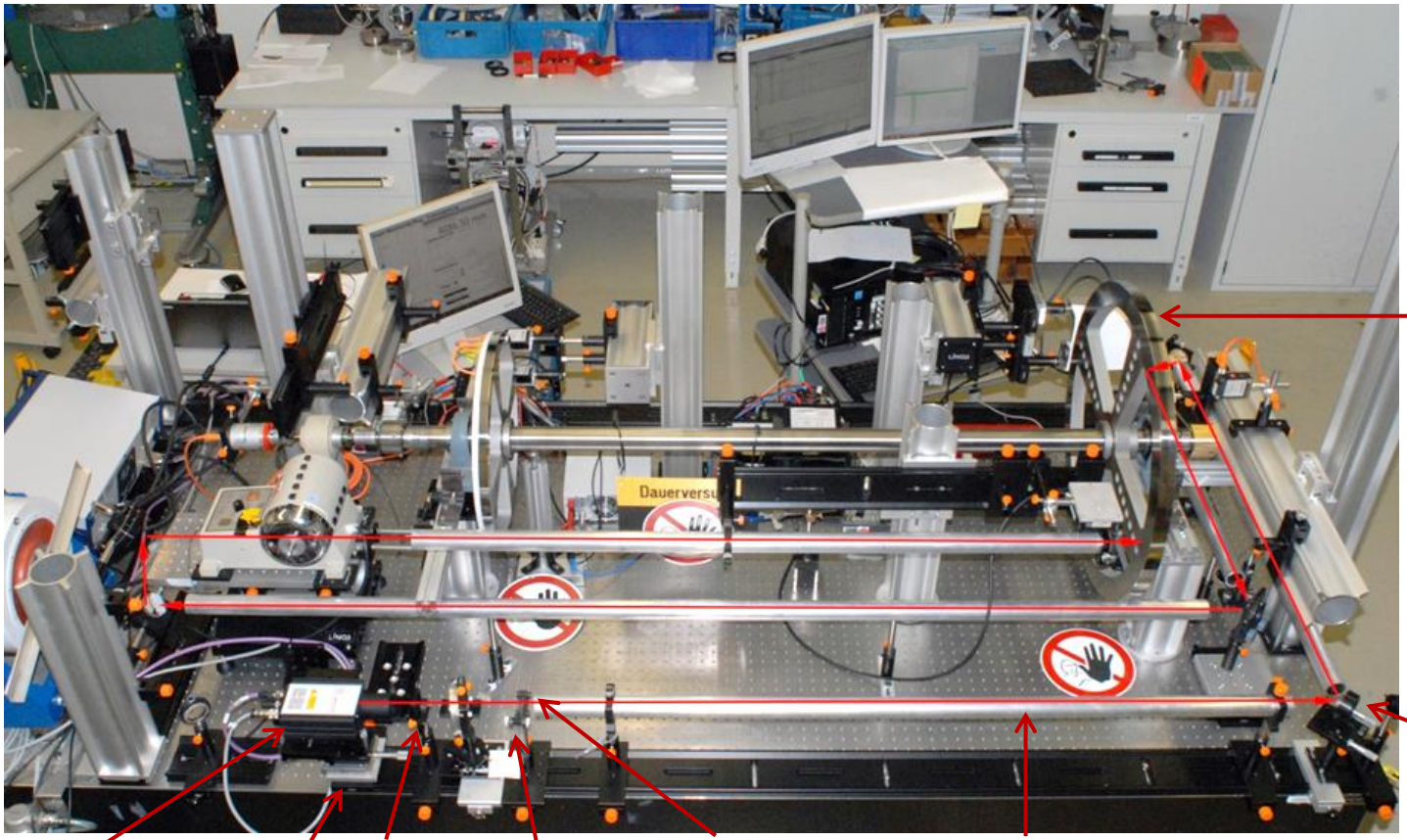
Z – MEASUREMENT

- laser distance measurement device using a phase comparison method µ-epsilon ILR1183-30
- diffuse reflection of a high-frequency modulated laser beam is compared with the reference beam by a phase comparison method
- no fiber coupling possible
- measuring instruments is assembled approx. 1 m up to 1.5 m outside of the monolith vessel



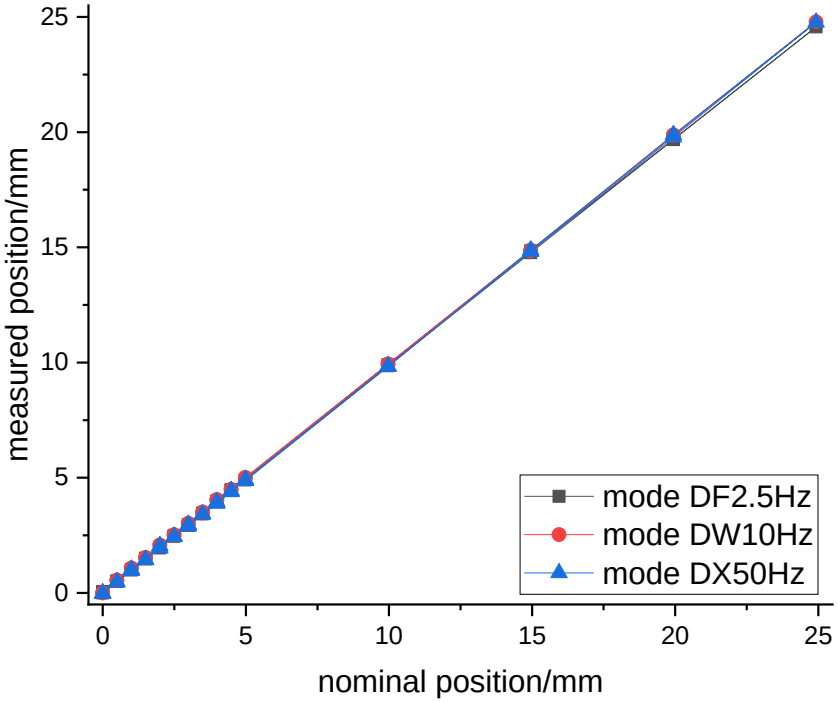
Insert with 4 mirrors inside

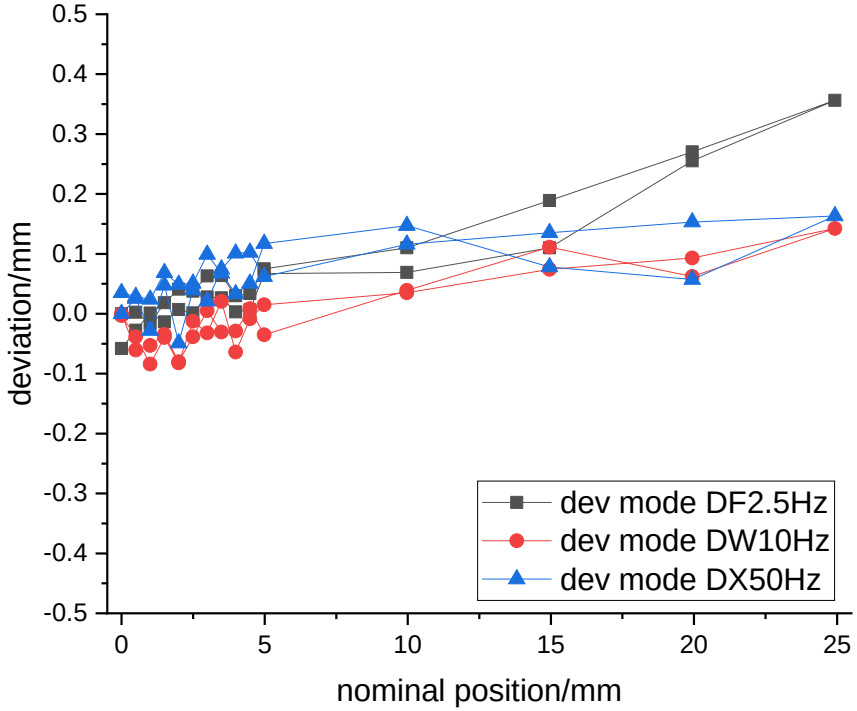
Z – POSITION TESTING



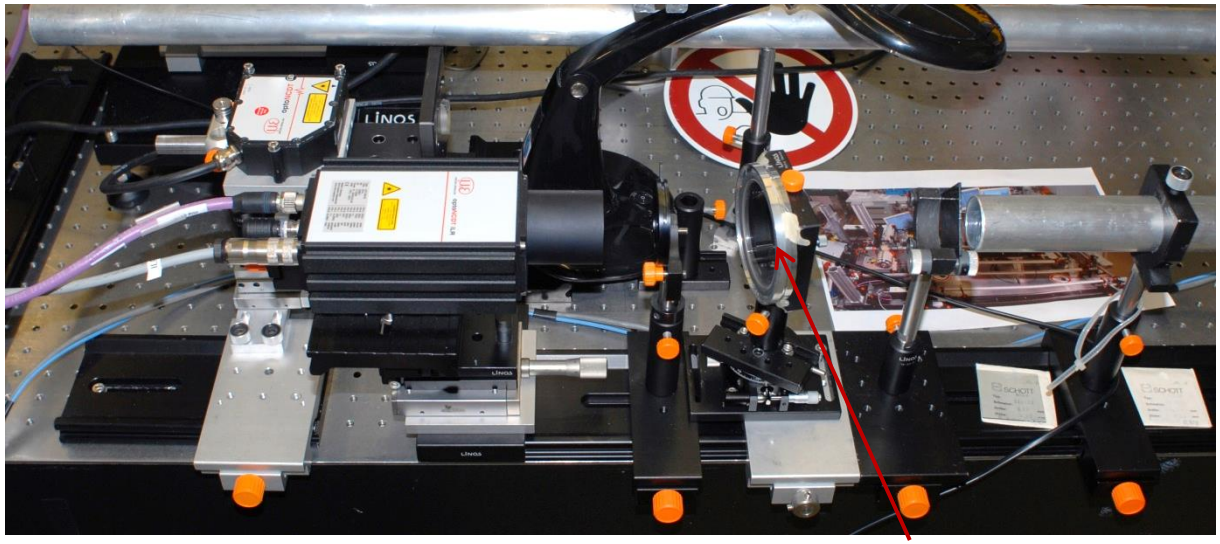
Z – POSITION TESTING

testing on a turning wheel with lateral movement and with distance changes

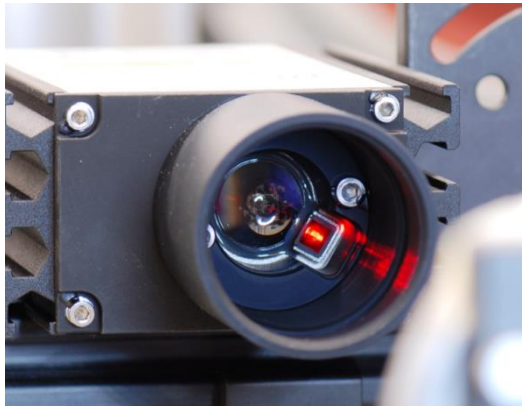




Z – POSITION TESTING



vacuum window



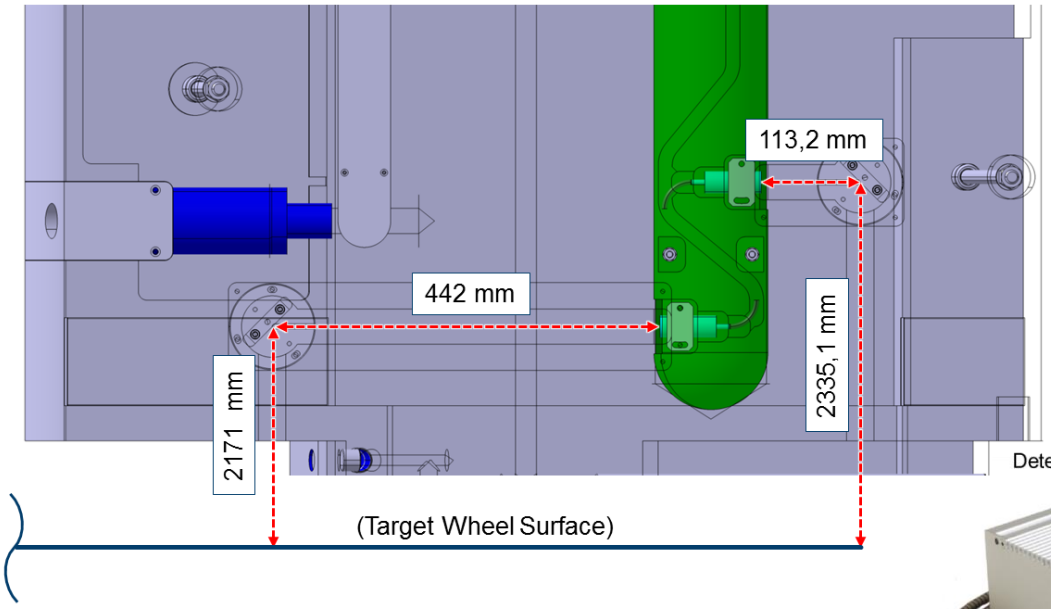
the vacuum window must be positioned in an angle of 5° related to the optical path to avoid reflexes from the window front side

Z – POSITION TESTING

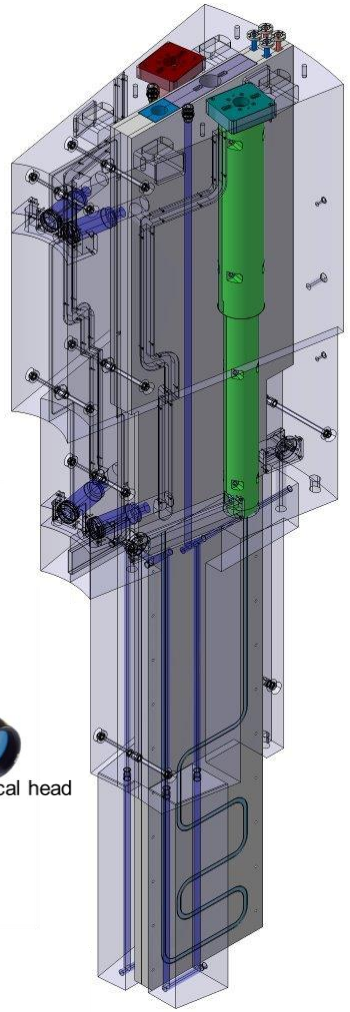
ILR1183 measure modes	deviation (ILR1183-ILD2220) mean	deviation (ILR1183-ILD2220) standard deviation	deviation (ILR1183-ILD2220) $(peak\text{-}peak)_{max}$
	mm	mm	mm
DF 2.5 Hz	0.048	0.135	0.563
DW 10 Hz	0.065	0.136	1.194

TEMPERATURE MEASUREMENT

TEMPERATURE – MEASUREMENT

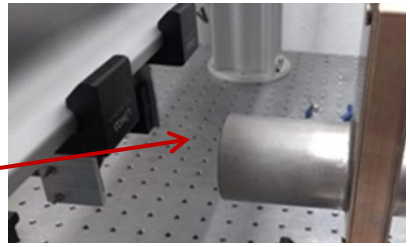


Picture: Dr. Mergenthaler GmbH & Co. KG

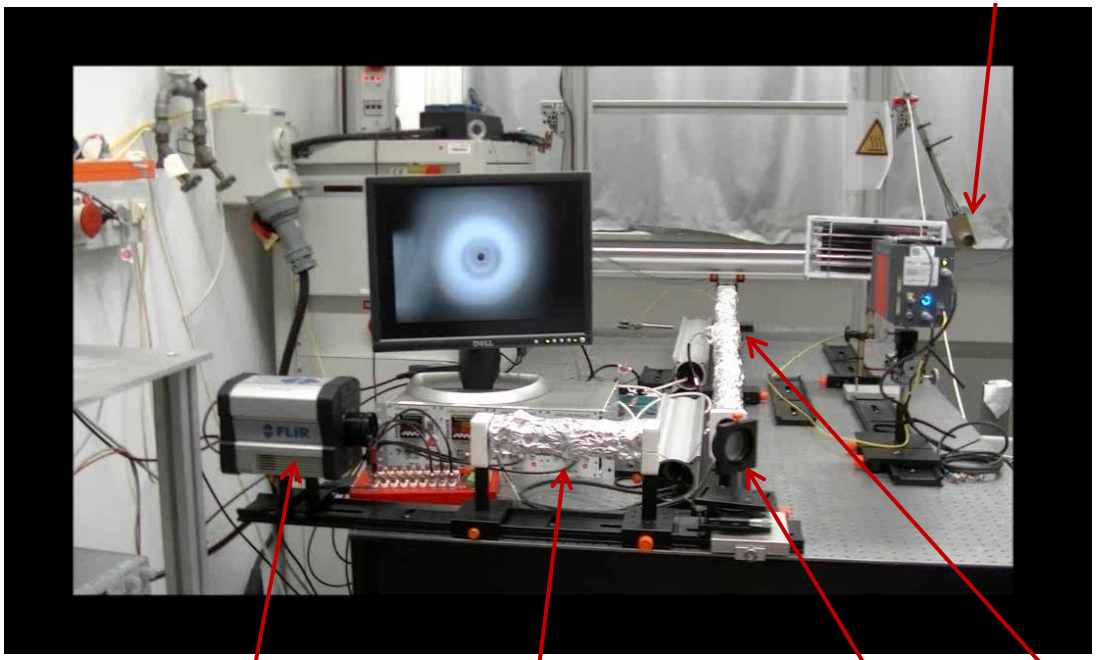


- exchangeable optical heads
- fibers are guided through channels with streaming steps
- pyrometer detector and controller are located outside the monolith
- identical design for rim and cup measurement

TEMPERATURE TESTING



pendulum with heated cups



- original cup dimensions and materials
- cup temperature: room temperature up to $400°C$
- original cup speed
- original dimensions of the optical path
- heated optical path in three sections
- virtual pyrometer with variable measurement rate, integration-time and spot size

optical path, section 1

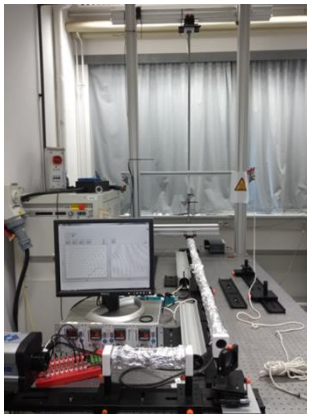
IR mirror

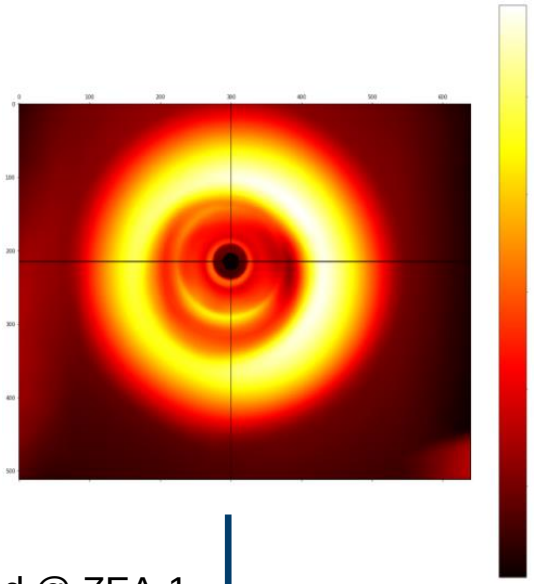
optical path, section 2&3

calibrated thermal camera
(in combination with a software algorithm -> virtual pyrometer)

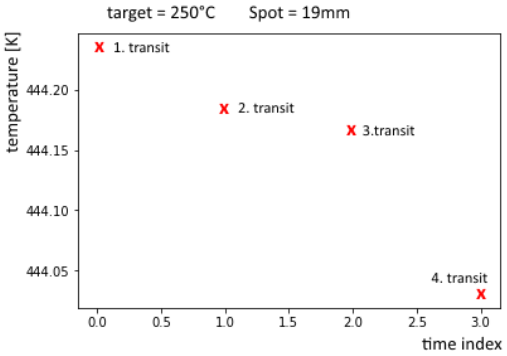
TEMPERATURE TESTING

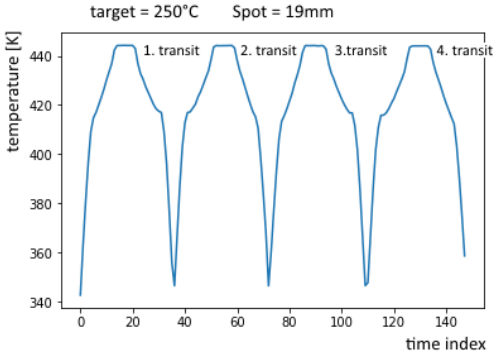
Concept of virtual pyrometer:
variable measurement rate, integration- time and spot size

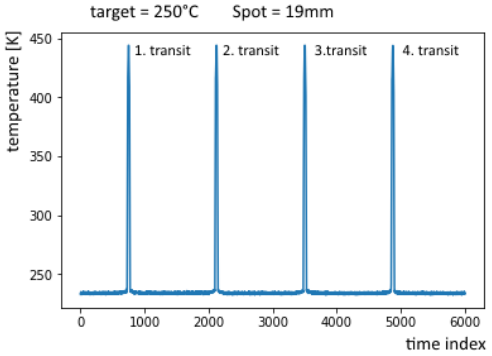




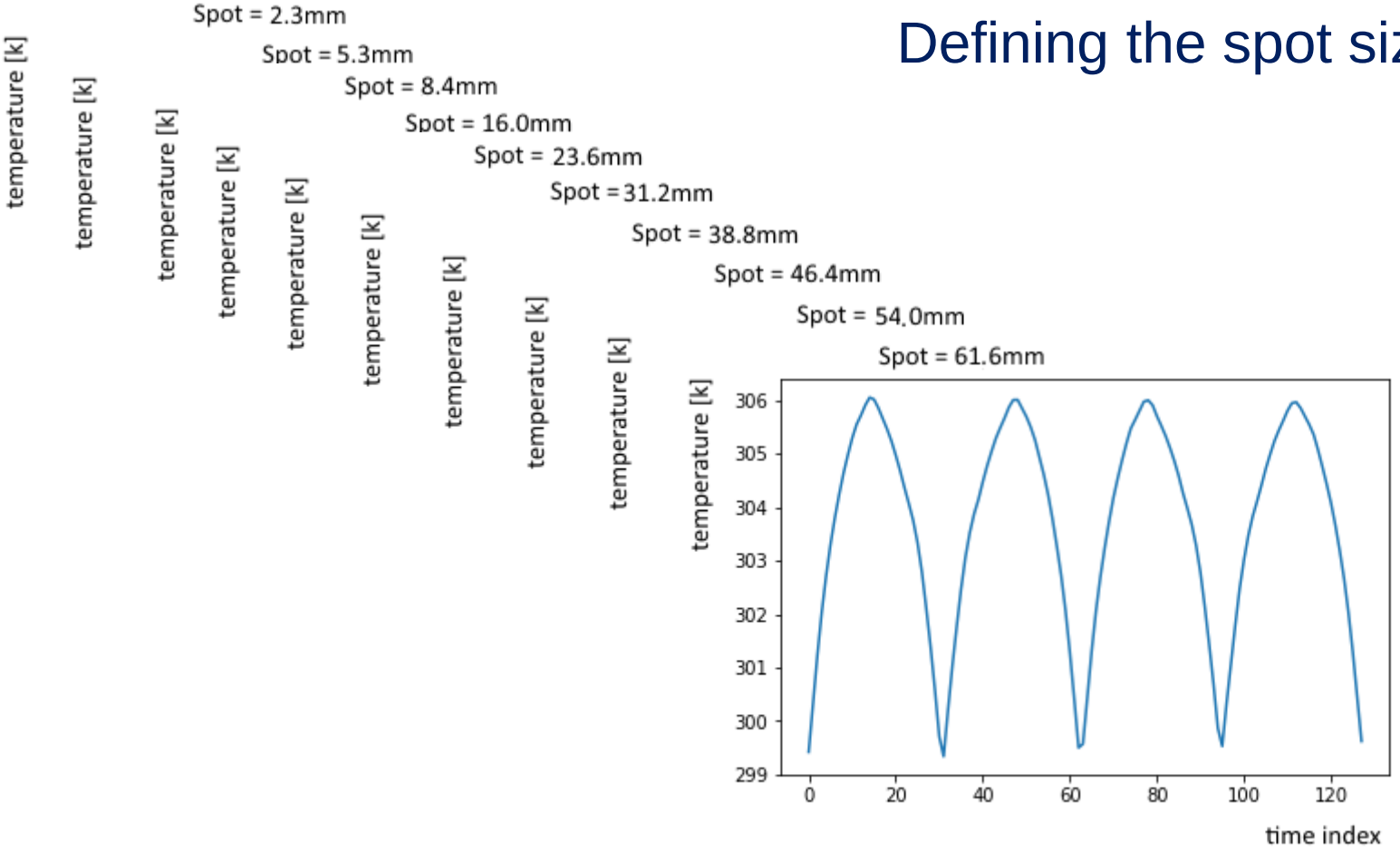
Virtual pyrometer algorithm developed @ ZEA-1







TEMPERATURE TESTING



Defining the spot size

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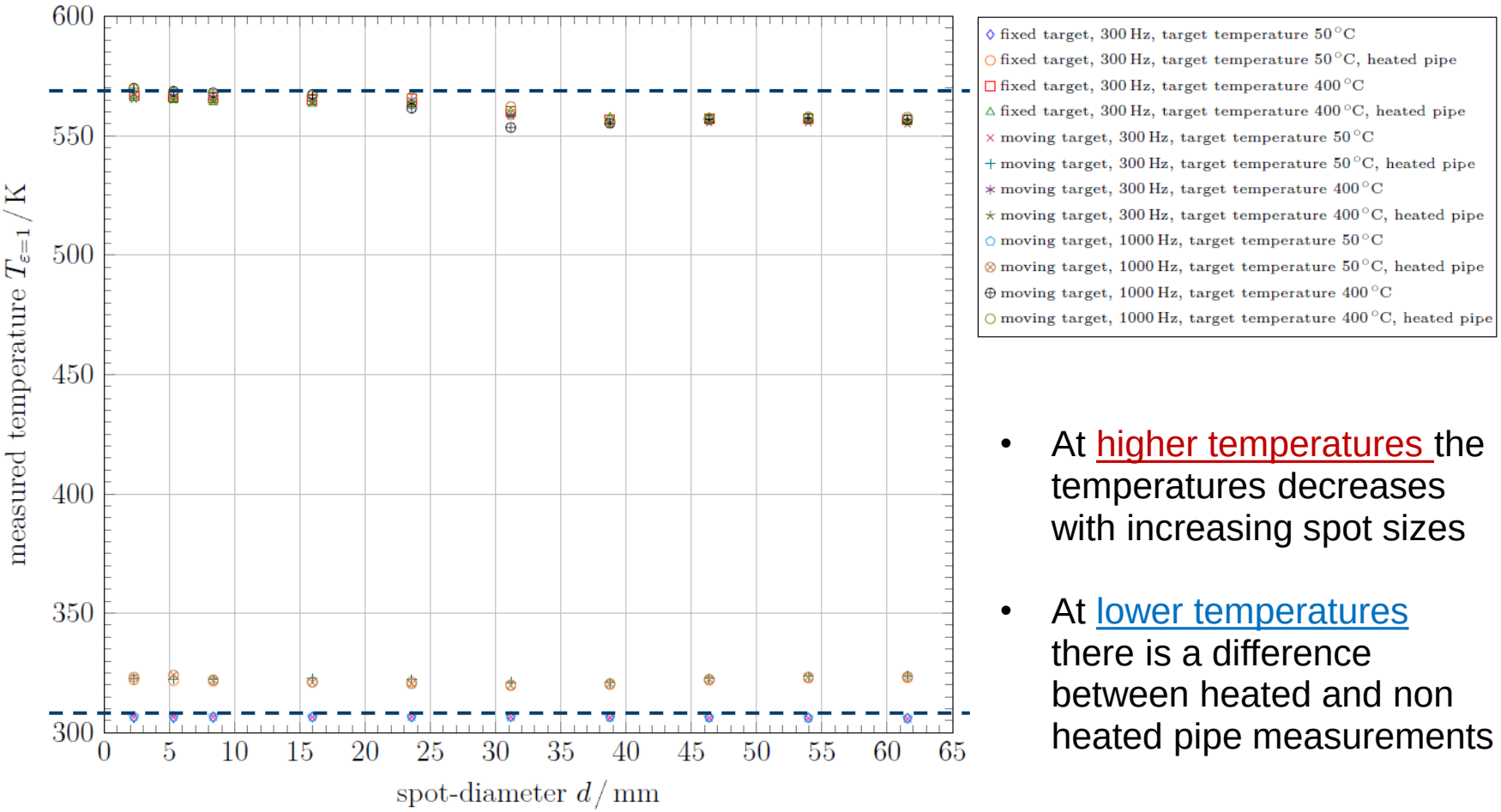
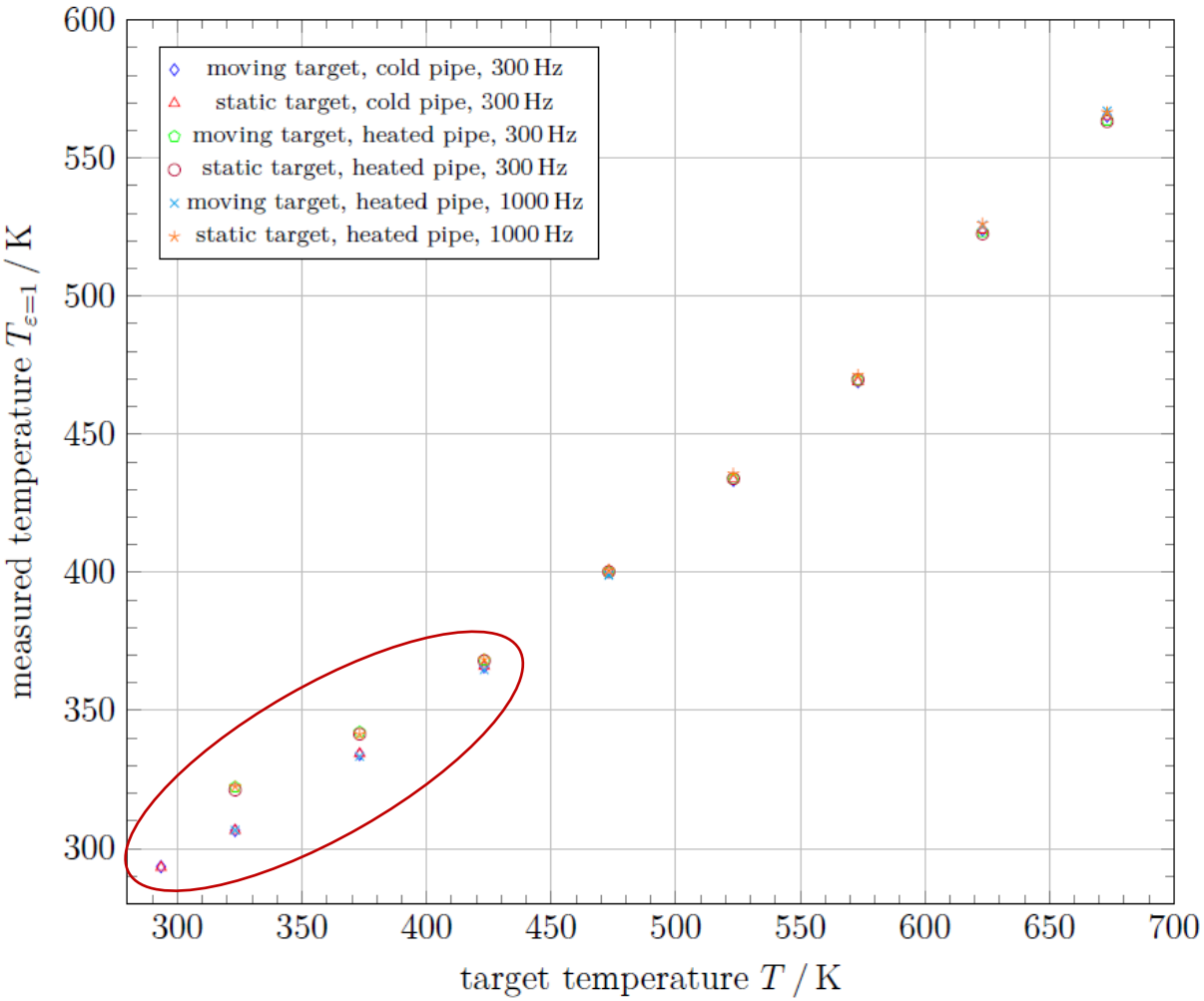
TEMPERATURE TESTING



- At higher temperatures the temperatures decreases with increasing spot sizes
- At lower temperatures there is a difference between heated and non heated pipe measurements

TEMPERATURE TESTING



- Fixed spot size: 20mm
- the repeatability of the measurements is very good, in consideration of the changing parameters
- precise temperature measurements (rim and cups) are only possible if the temperature, to be measured, is higher than the maximum temperature of the shielding

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SUMMARY

- TMP Body
  - Radiation hard design
  - No electronics inside the (vacuum) monolith vessel
  - Exchangeable design
- x/y -measurement
  - measurement range $\pm 10mm$.
  - accuracy better than $\pm 0.05mm$. (in an range of 5µm)
  - frequency much better than $3Hz$ (in an range of 1000Hz)
- z-measurement
  - measurement range $0 - 25mm$ (more or less no limitation)
  - accuracy better than $\pm 0.5mm$ (in an range of 0.25mm)
  - frequency $2Hz$ (no vibration measurement possible)
- temperature measurement
  - indirect measurement of 36 sectors possible
  - measurement range $125 - 500°C$.
  - measurement repeatability better than $\pm 5K$
  - accuracy $\pm 2K$
  - frequency better $500Hz$

THE INVOLVED TEAM @ ZEA-1

Yannick Beßler
Ulrich Giesen
Carsten Grates
Christoph Happe
Robert Lohoff
Dennis Marschall
Ghaleb Natour
Eberhard Rosenthal
Helmut Soltner
Jörg Wolters

…and many more

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Engineering and Technology | ZEA-1
Technology for Excellent Science

Federal Ministry of Education and Research

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