Measurement with a Coordinate Measuring Machine

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on behalf of the Luminosity Detector Group

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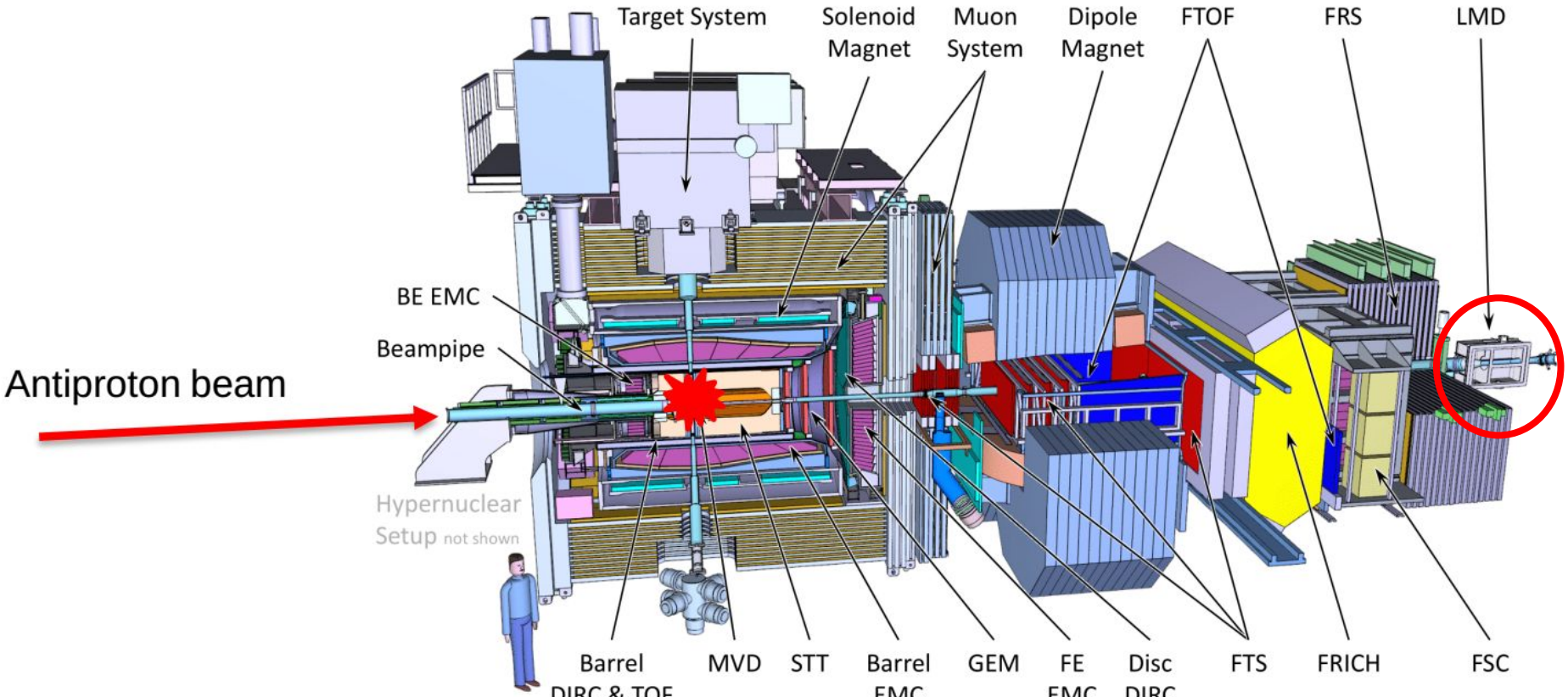
Johannes Gutenberg-Universität Mainz

PANDA Collaboration Meeting
October 11, 2022

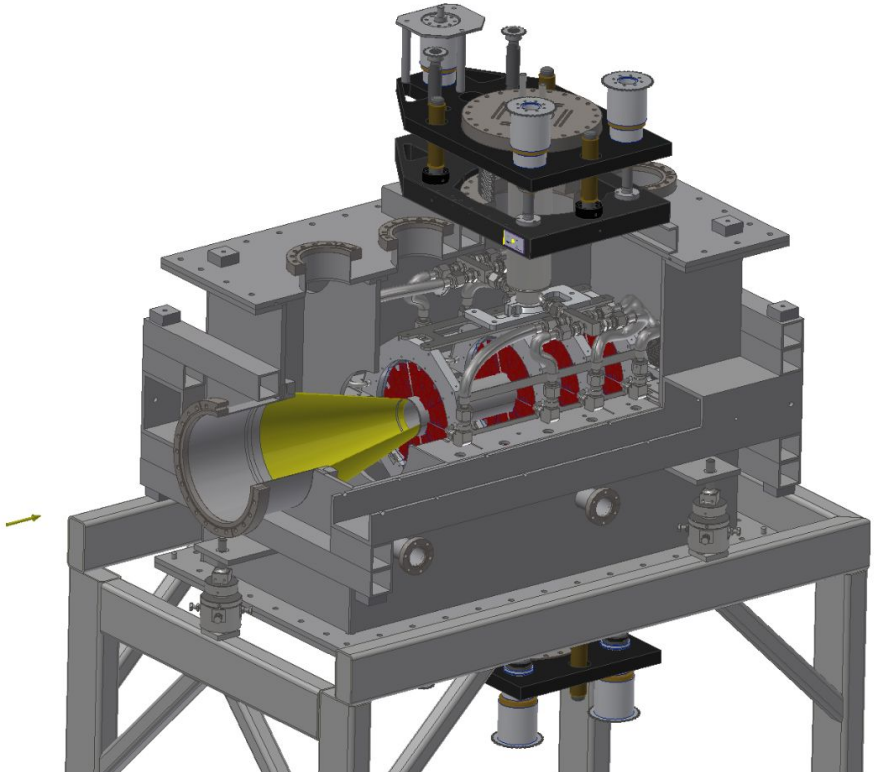
HIM
Helmholtz-Institut Mainz

The Luminosity Detector at PANDA



Luminosity Detector

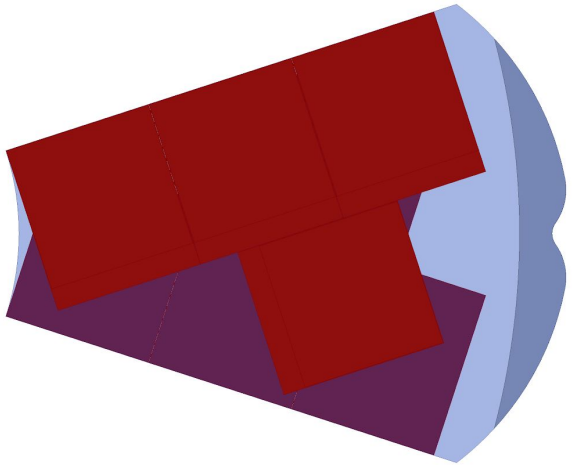
4 planes in line
10 modules on each plane
8 sensors on each module
320 pixel sensor in total

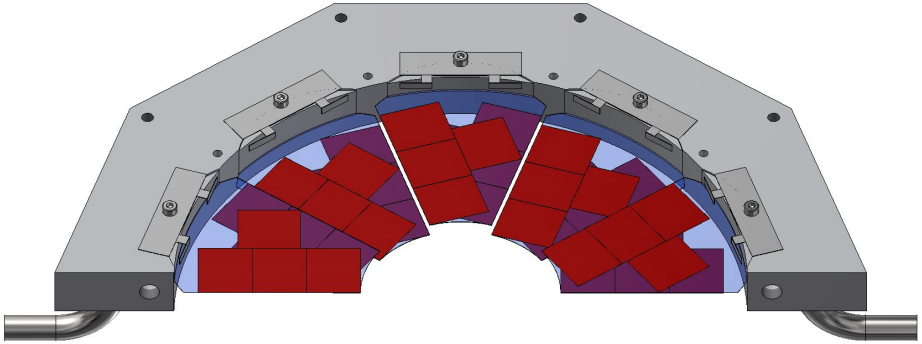


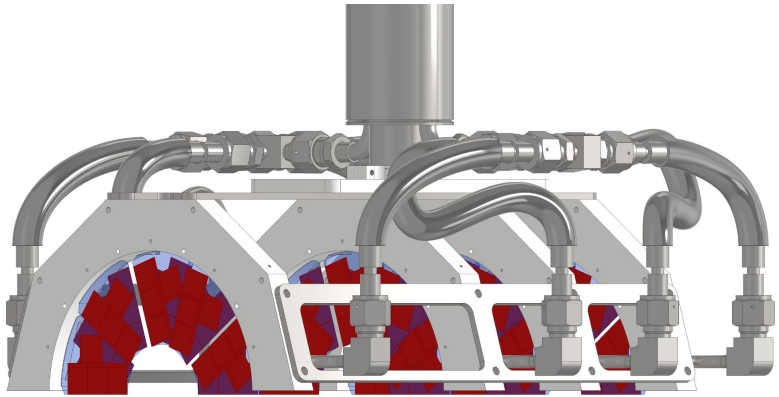
Arrangement of the Sensors

320 sensors glued on 40 CVD diamond wafers

- 4 planes with 10 modules
- Full azimuthal range





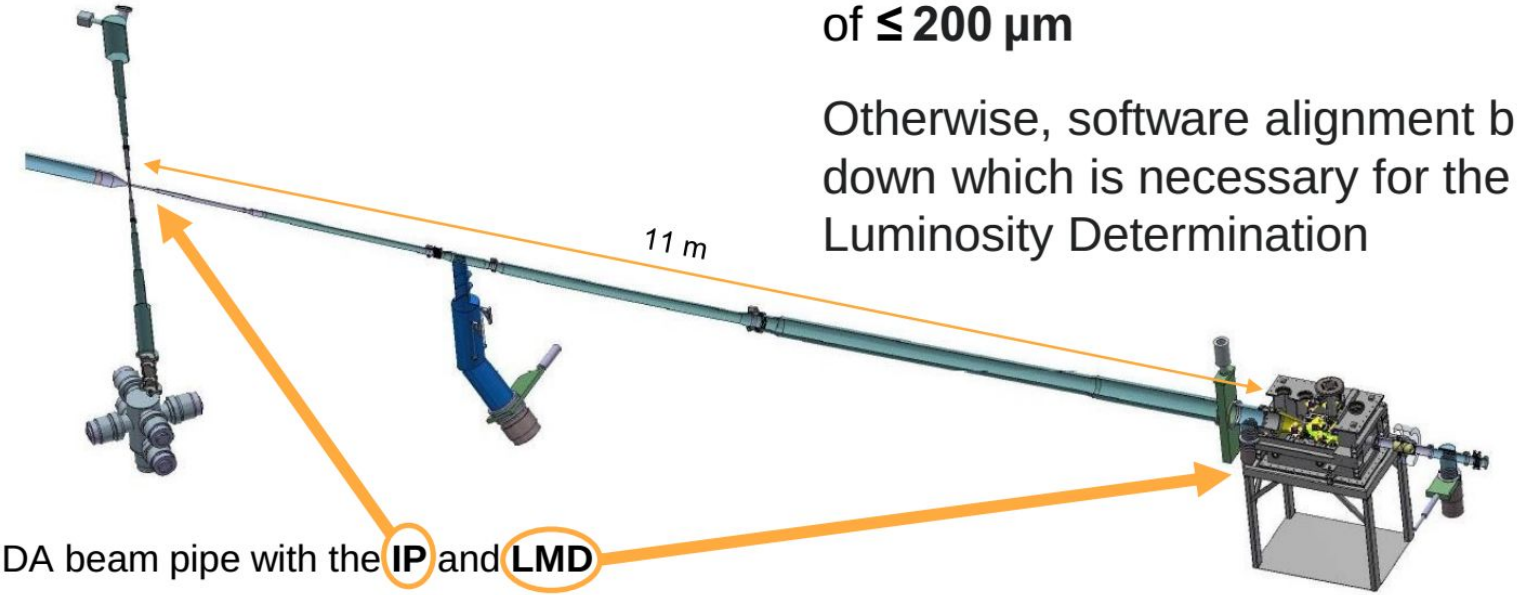


Motivation

Tracking requires precise alignment

Position of the HV-MAPS relative to the IP must be known with a precision of **≤ 200 µm**

Otherwise, software alignment breaks down which is necessary for the Luminosity Determination



PANDA beam pipe with the **IP** and **LMD**

Sources of Uncertainty I

LASER tracker measures position of **SMRs*** attached to the LMD

[Faro Europe GmbH]

Exemplary LASER tracker
(30 µm accuracy)

Measurement Step	Type	Estimated Precision
LMD Position in PANDA Hall	LASER Tracker	30 µm

Exemplary SMR* (mirror inside)

[MetrologyWorks GmbH]

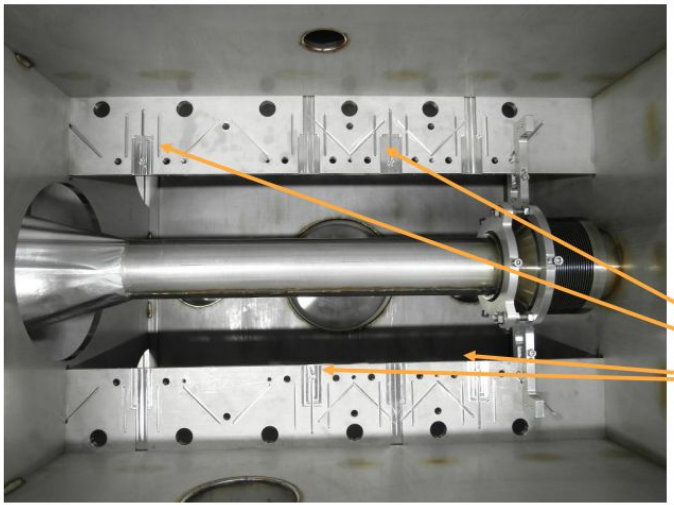
SMR Nests attached to the box will hold the SMRs by means of a magnet

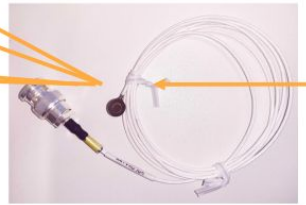
***S**pherically **M**ounted **R**etroreflector

Sources of Uncertainty II

Capacitive proximity sensors will measure the position of the Half Detectors relative to their own position
Necessary because of the LSM

Measurement Step	Type	Estimated Precision
LMD Position in PANDA Hall	LASER Tracker	30 µm
Half Detector Position inside Vacuum Box	Capacitive Sensors	1 µm





One of our capacitive proximity sensor (≤ 1 µm accuracy)

Sources of Uncertainty III

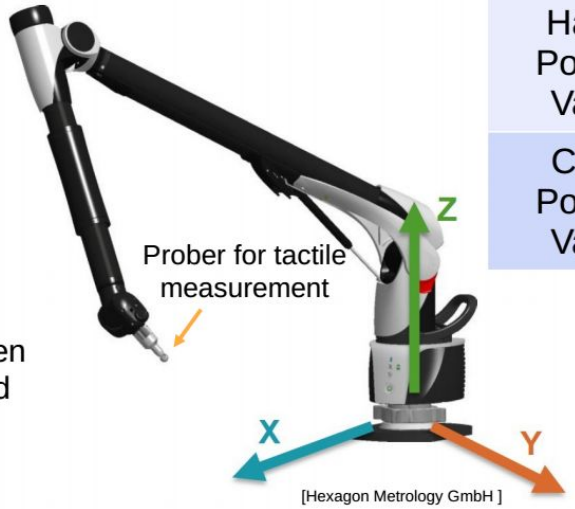
Measurement Arm measures position of the capacitive sensors and the positions of the SMRs

Establishes a connection from outside to the inside of the box

[MetrologyWorks GmbH]

SMR
(Optical center measured by Laser tracker)

Reference Ball
(Interface between Laser tracker and Arm)

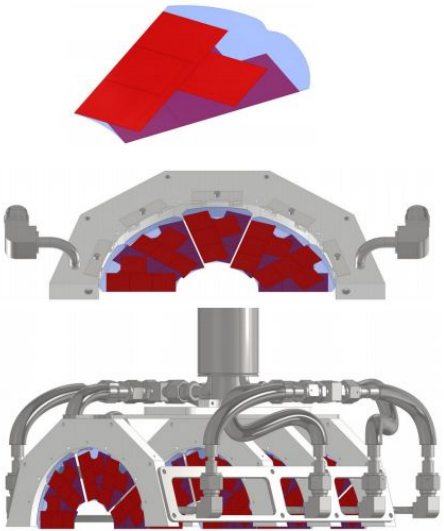


[Hexagon Metrology GmbH]

Measurement Step	Type	Estimated Precision
LMD Position in PANDA Hall	LASER Tracker	30 µm
Half Detector Position inside Vacuum Box	Capacitive Sensors	1 µm
Cap. Sensor Position inside Vacuum Box	Measurement Arm	50 µm

Sources of Uncertainty IV

A stationary **CMM*** will measure the **Modules**, the **Half Planes** and the **Half Detectors**



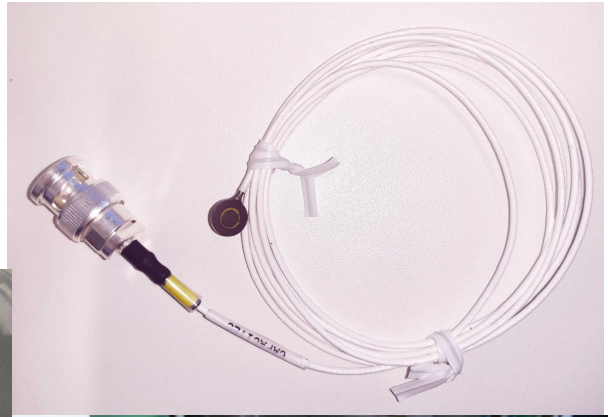
Measurement Step	Type	Estimated Precision
LMD Position in PANDA Hall	LASER Tracker	30 µm
Half Detector Position inside Vacuum Box	Capacitive Sensors	1 µm
Cap. Sensor Position inside Vacuum Box	Measurement Arm	50 µm
Pixel Sensor Position inside Half Detector	Stationary CMM*	2.5 µm - 5 µm
Total	-	≈ 60 µm

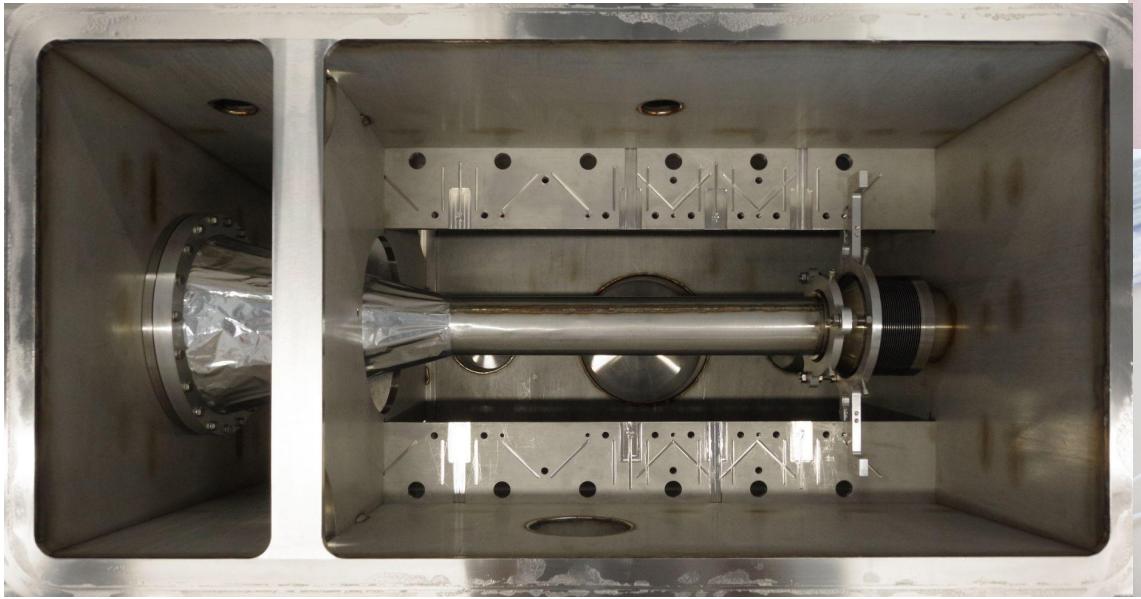
***C**oordinate **M**easuring **M**achine

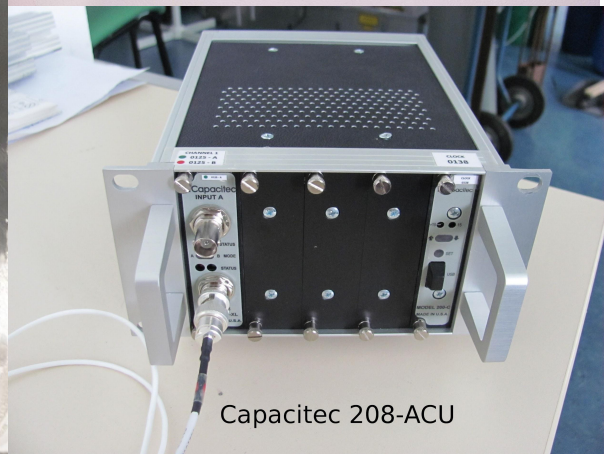
Capacitiv Sensors

Capacitec

- 2 mm range
- ~40 nm resolution





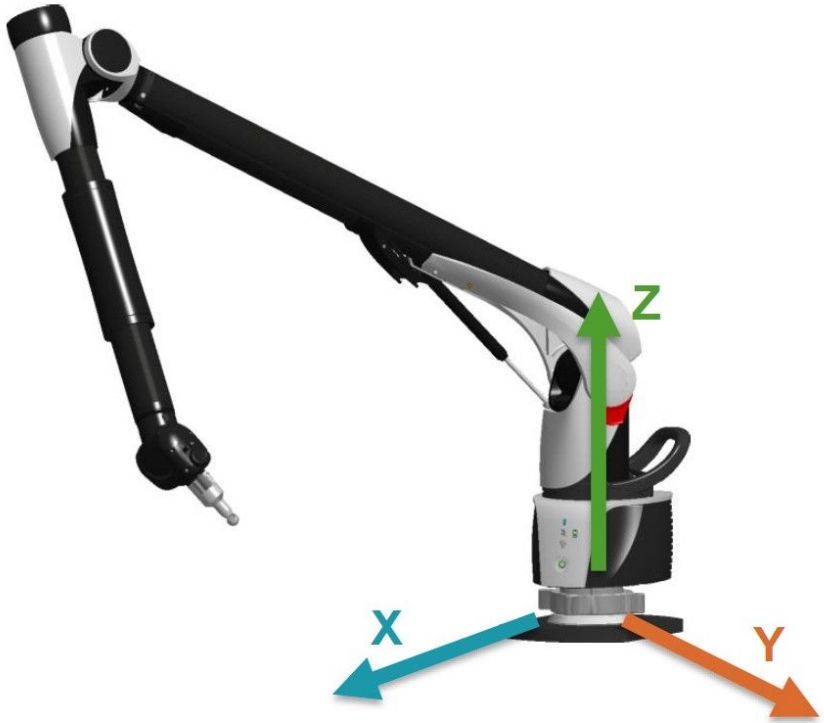


Capacitec 208-ACU

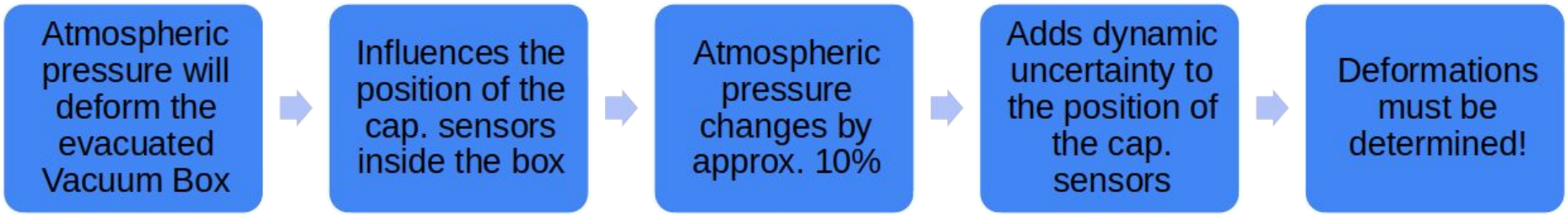
Measurement Arm

Hexagon Romer 75

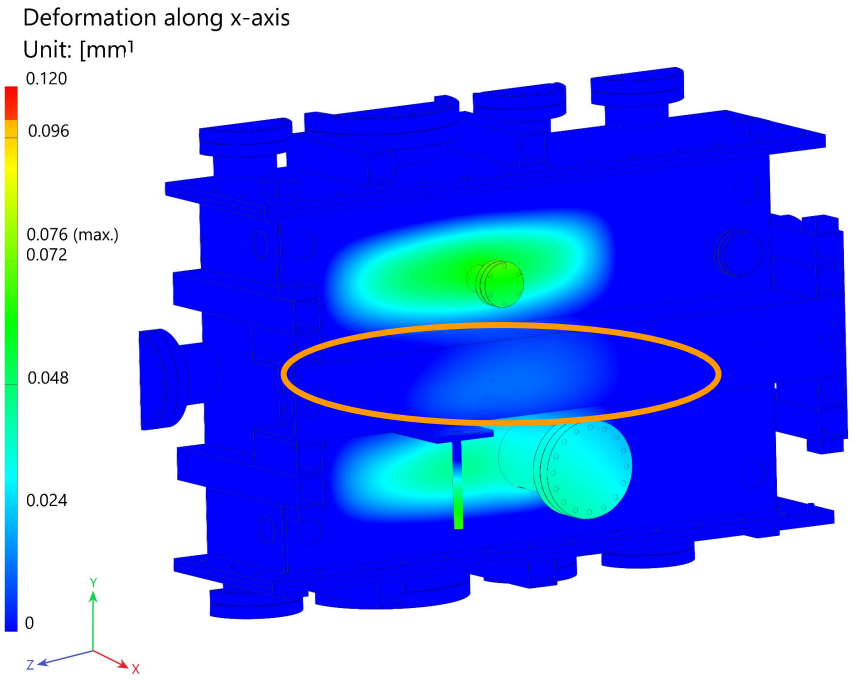
- Only tactil measurement possible
- Measuring distance: 1.25 m
- Accuracy: 26 µm
- Easy to transport:
  - < 10 kg
  - No calibration after transport

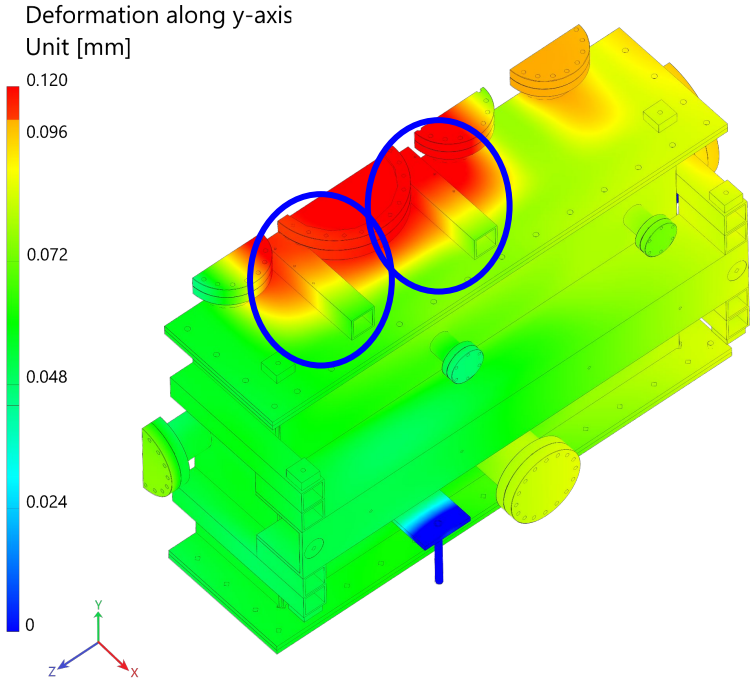


Deformation of the Vacuum Box



Simulated Deformation of Vacuum Box





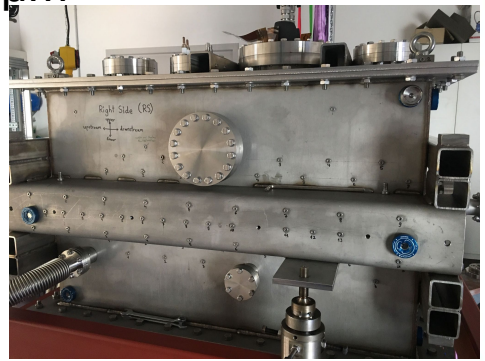
Goal: Max. permissible deformation of 200 µm at height of cap. sensors

Goal: Symmetry between the two square tubes

Measurement of the Deformation of Vacuum Box

Master thesis by J. Petersen

1. Reference & Reproducibility
   ⇨ Accuracy of better than 30 µm
2. Lid closing reproducibility
   ⇨ Lid placement better than 33 µm
3. Closed box
   ⇨ Deformation of about 30 µm
4. Box under vacuum

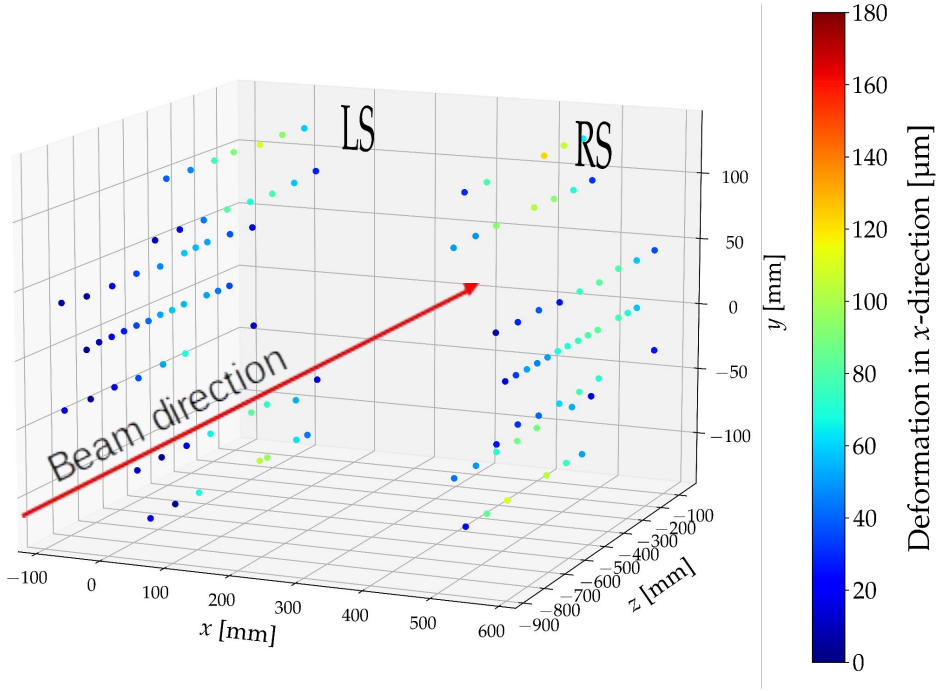


Deformation of Vacuum Box under Vacuum I

Deformation between evacuated and inflated state of the Vacuum Box

Results Box:

1. Reproducible deformation in the downstream part
2. Symmetry between Left Side and Right Side
3. Deformation in the order of 100 µm

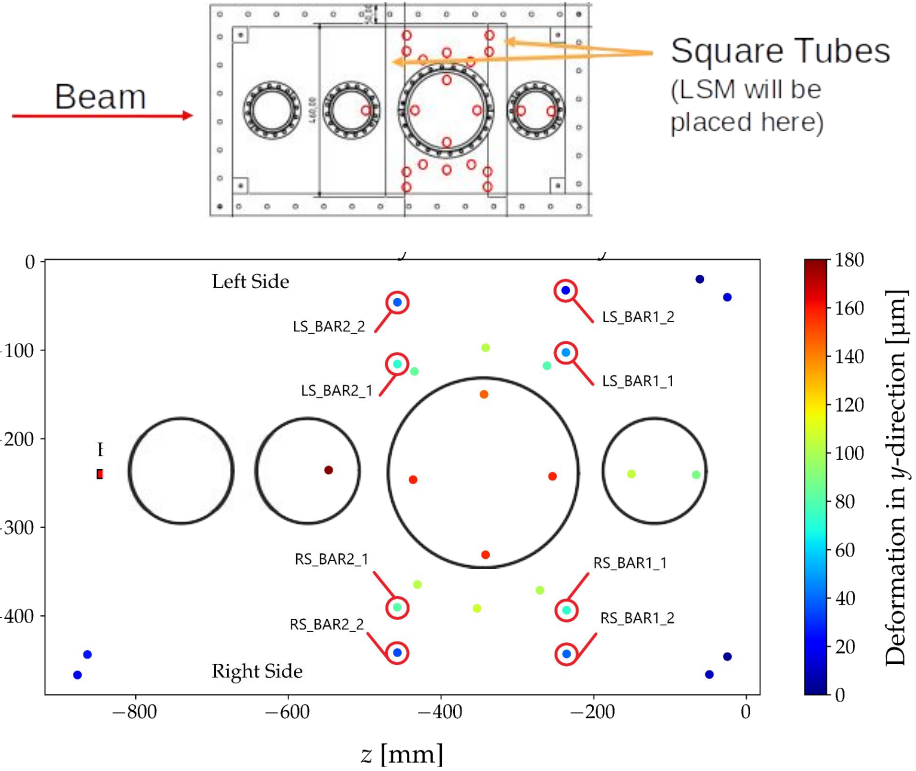


Deformation of Vacuum Box under Vacuum II

Deformation between evacuated and inflated state of the Vacuum Box

Results Lid:

1. Symmetrical deformation of the square tubes (important for possible tilting of the LSM)
2. Reproducible deformation
3. Order of magnitude of deformation plays a minor role



Stationary CMM

Zeiss O-INSPECT 543

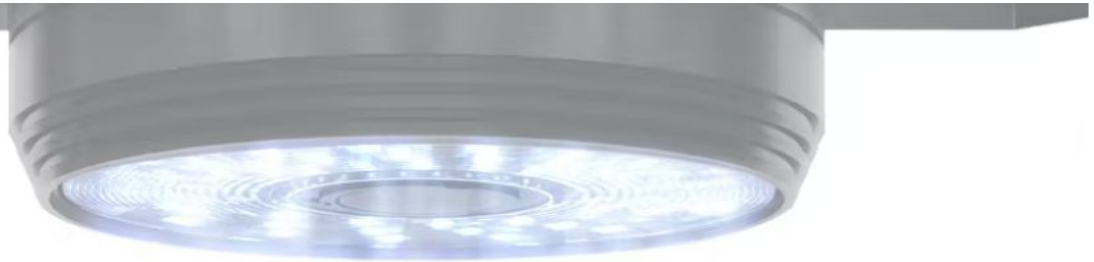
- Optical and tactil measurement
- Measuring volume: 50 cm x 40 cm x 30 cm
- Accuracy: 1.7 µm - 4.9 µm

Training was in March and May

More complicated as Measuring Arm

Preparation for the measurement of LMD components started

Stationary CMM

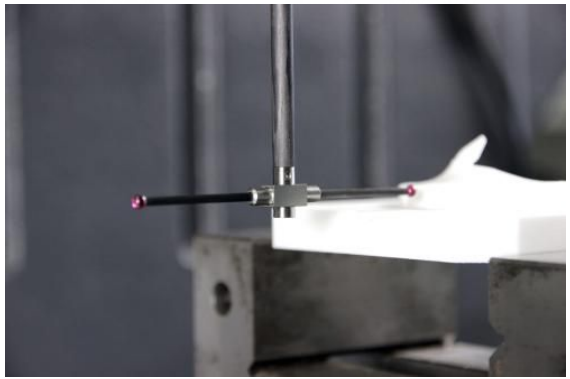


Optical measurement:

- 2D measurement
- In z-axis only points possible

Tactile measurement:

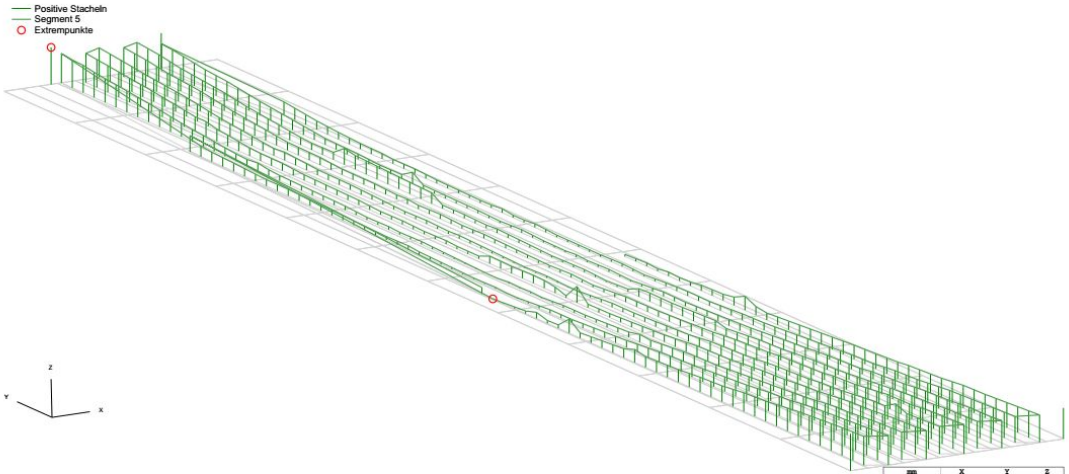
- 3D measurement
- Scanning possible
- Different prober available



Examples

ZEISS CALYPSO
6.6.20

Bauteilname	**Quarzglas**		
Zeichnungsnummer			
Auftragsnummer		Teile Ident	2
Firma	HIM	Zeit	05.07.22 12:26
Abteilung	PALUMA	Prüfer	Master
KMG-Nr	184966	Text	

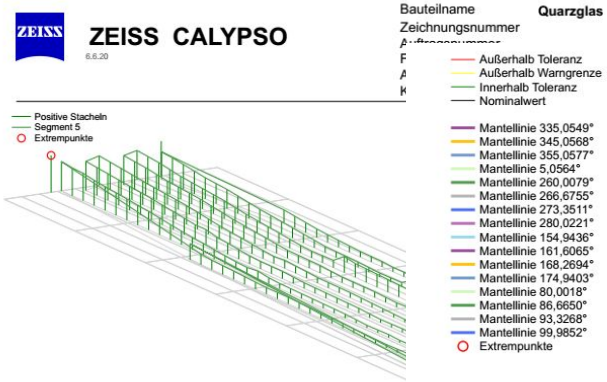


mm	X	Y	Z
Eckpunkte 1	-27,6089	-390,6332	9,3930
2	28,7890	-390,6332	9,3189
3	28,7896	-3,2463	9,7557
4	-27,6083	-3,2463	9,8298
Max 0,0216	-15,2705	-3,3558	9,8350
Min 0,0000	-22,5076	-218,0849	9,5808

Name	Messwert	Oberer Grenzwert	Punkte	Filtertyp	Lc	W/U	Tasterradius	Vmess[mm/sec]	Berechnungsmethode
Ebenheit1	0,0216	0,0000	680	Kein Filter	-	-	1,5002		Minimum-Element

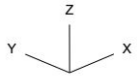
(6.6_15) PkgProtocol

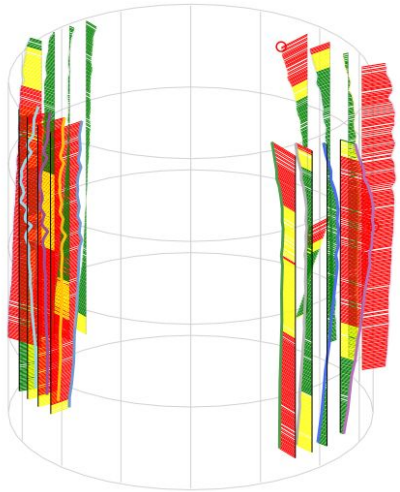
Examples



Bauteilname **Quarzglas**
Zeichnungsnummer

- Außerhalb Toleranz
- Außerhalb Warngrenze
- Innerhalb Toleranz
- Nominalwert
- Mantellinie 335,0549°
- Mantellinie 345,0568°
- Mantellinie 355,0577°
- Mantellinie 5,0564°
- Mantellinie 260,0079°
- Mantellinie 266,6755°
- Mantellinie 273,3511°
- Mantellinie 280,0221°
- Mantellinie 154,9436°
- Mantellinie 161,6065°
- Mantellinie 168,2694°
- Mantellinie 174,9403°
- Mantellinie 80,0018°
- Mantellinie 86,6650°
- Mantellinie 93,3268°
- Mantellinie 99,9852°
- Extrempunkte





Segment	Typ	Höhe/Winkel	Punkte	Ausreißer
Segment 1	Mantellinie	335,0549°	261	8
Segment 2	Mantellinie	345,0568°	261	7
Segment 3	Mantellinie	355,0577°	261	11
Segment 4	Mantellinie	5,0564°	261	91
Segment 5	Mantellinie	260,0079°	261	9
Segment 6	Mantellinie	266,6755°	261	9
Segment 7	Mantellinie	273,3511°	261	9
Segment 8	Mantellinie	280,0221°	261	16
Segment 9	Mantellinie	154,9436°	261	0
Segment 10	Mantellinie	161,6065°	261	0
Segment 11	Mantellinie	168,2694°	261	0
Segment 12	Mantellinie	174,9403°	261	0
Segment 13	Mantellinie	80,0018°	261	0
Segment 14	Mantellinie	86,6650°	261	0
Segment 15	Mantellinie	93,3268°	261	5
Segment 16	Mantellinie	99,9852°	260	5

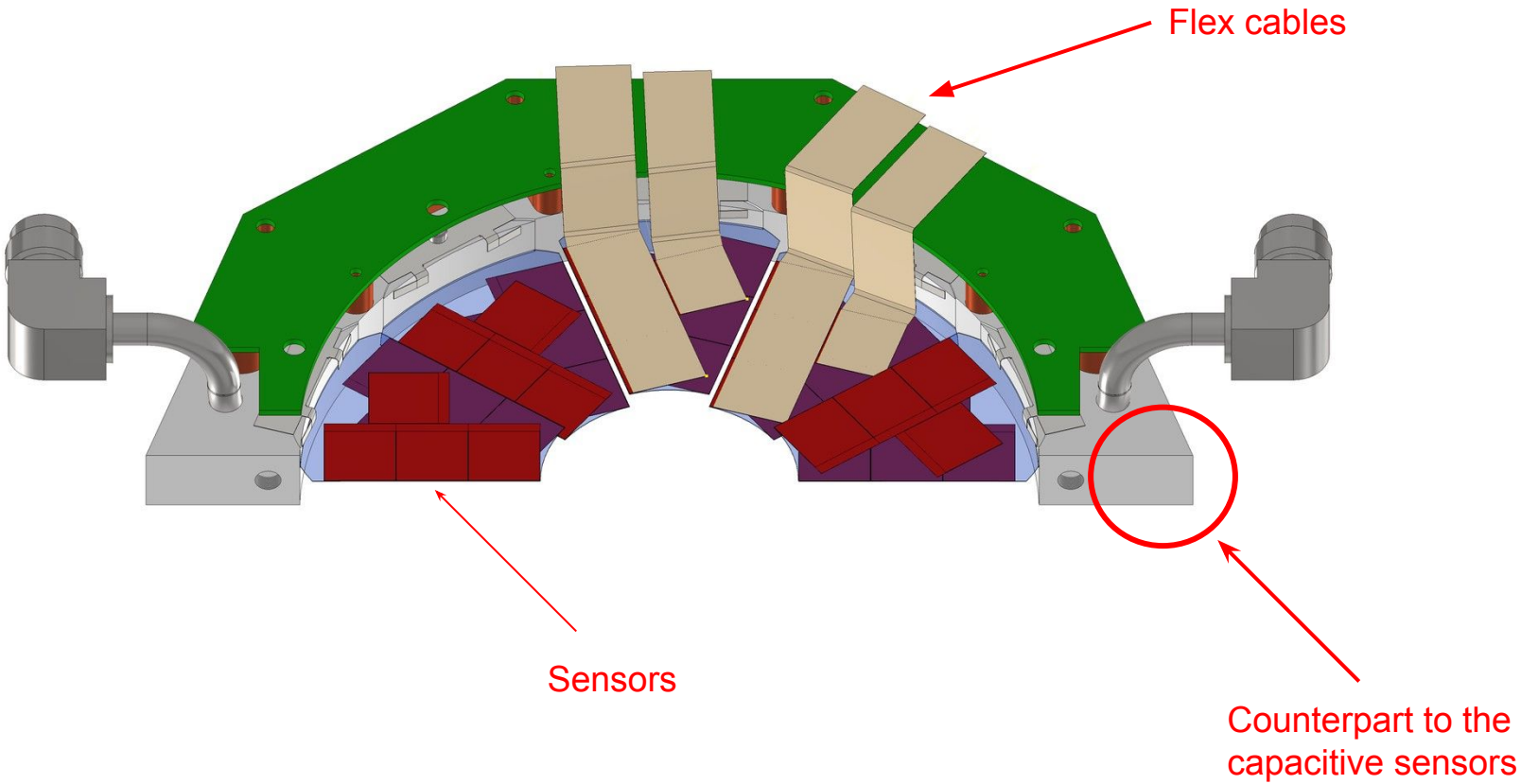
(6.6_15) PlotProtocol

Name	Messwert	Obe
Ebenheit1	0,0216	

(3.6_15) PlotProtocol

Name	Messwert	Oberer Grenzwert	Punkte	Filtertyp	Lc	W/U	Tasterradius	Vmess[mm/sec]	Berechnungsmethode
Zylinderform	0,0844	0,0500	3713	Tiefpass Spline	-	150 -	1,4999	5,000	Minimum-Element

Measurements on the half plane



Conclusion

Measurement Arm and Stationary Coordinate Measuring Machine available for Survey of the LMD

Measurement Arm:

- Accuracy better than 30 µm
- First measurement done

Stationary CMM

- Accuracy better than 5 µm
- Training was in March and May
- Preparation for measurements of LMD components ongoing