Anechoic chamber calibrations of phase center variations for new and existing GNSS signals and potential impacts in IGS processing

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Outline

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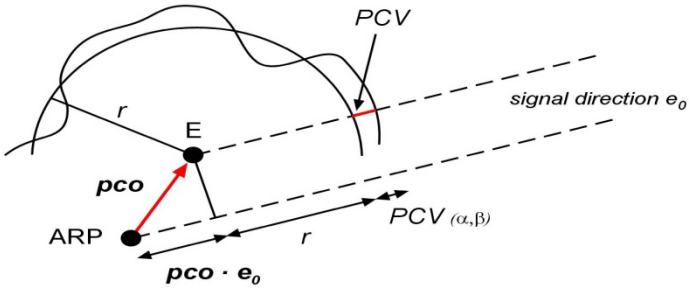
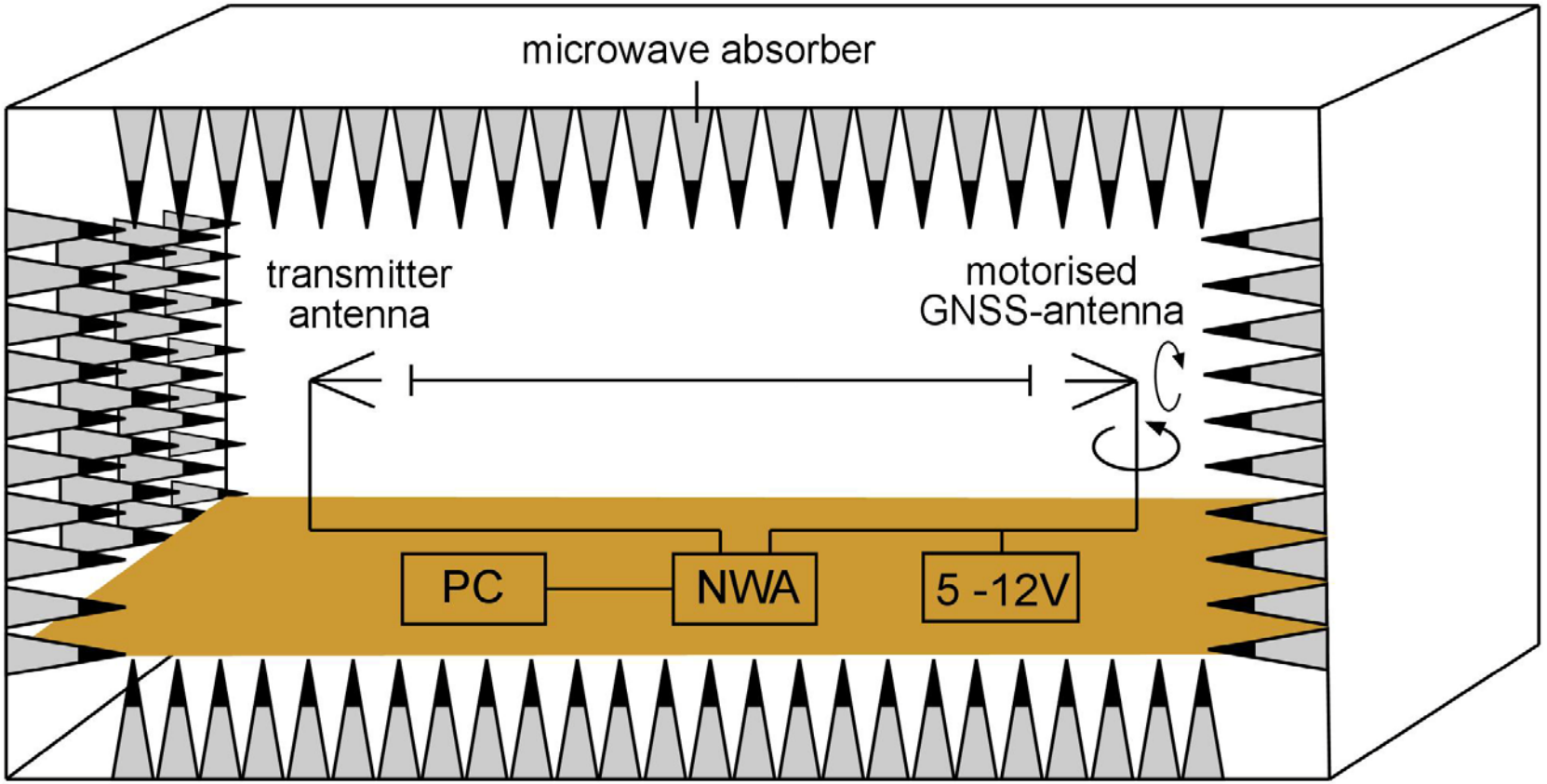
- Anechoic Chamber Bonn
  - Calibration setup and procedure
  - Calibration results and performance
  - Type mean for various antenna types
  - Frequency dependent PCV
- Comparison to other procedures
  - Robot
  - Field
  - IGS tables
- Application in IGS network
  - PPP tests with L3 linear combination
  - Difference to IGS tables for selected receivers
  - Effects of changed patterns
  - Coordinates, troposphere and phase



Calibration Setup



NetworkAnalyser (NWA): measurement of the phase variations
2-axis-Positioner: rotation of the antenna in azimuth and elevation
Absorber: Reduction of reflections and multipath effect

Concept of the laboratory procedure

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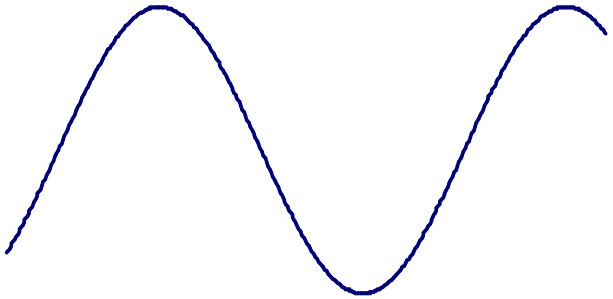
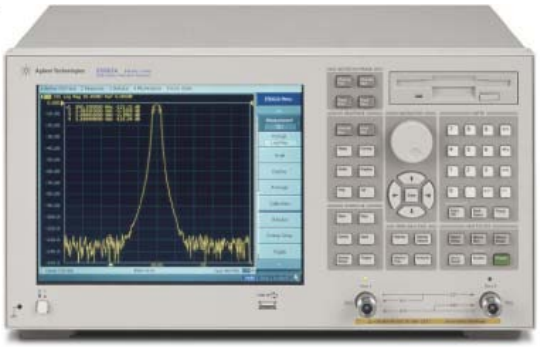
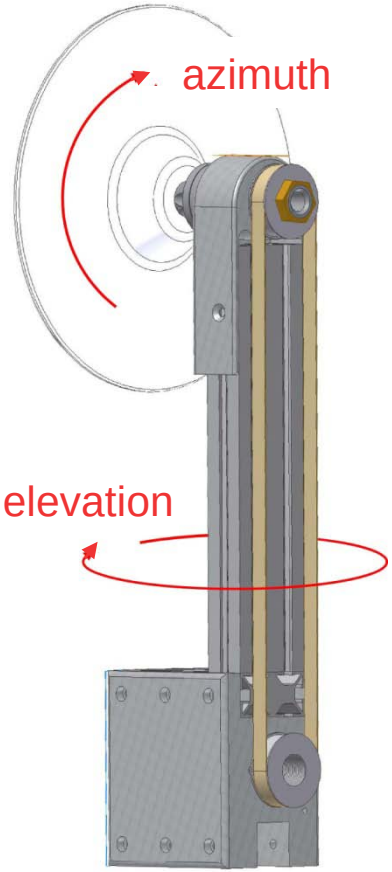
transmit a test signal
sine wave f



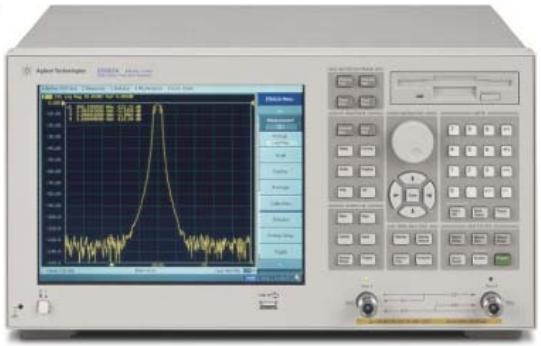
Frequency 1,15-1,65 GHz
Stepsize 200-1000



Antenna
Rotation



measure damping
+ phase difference



Antenna pattern
(PCO and PCV)

Antennenmesskammer Bonn - Aufsicht

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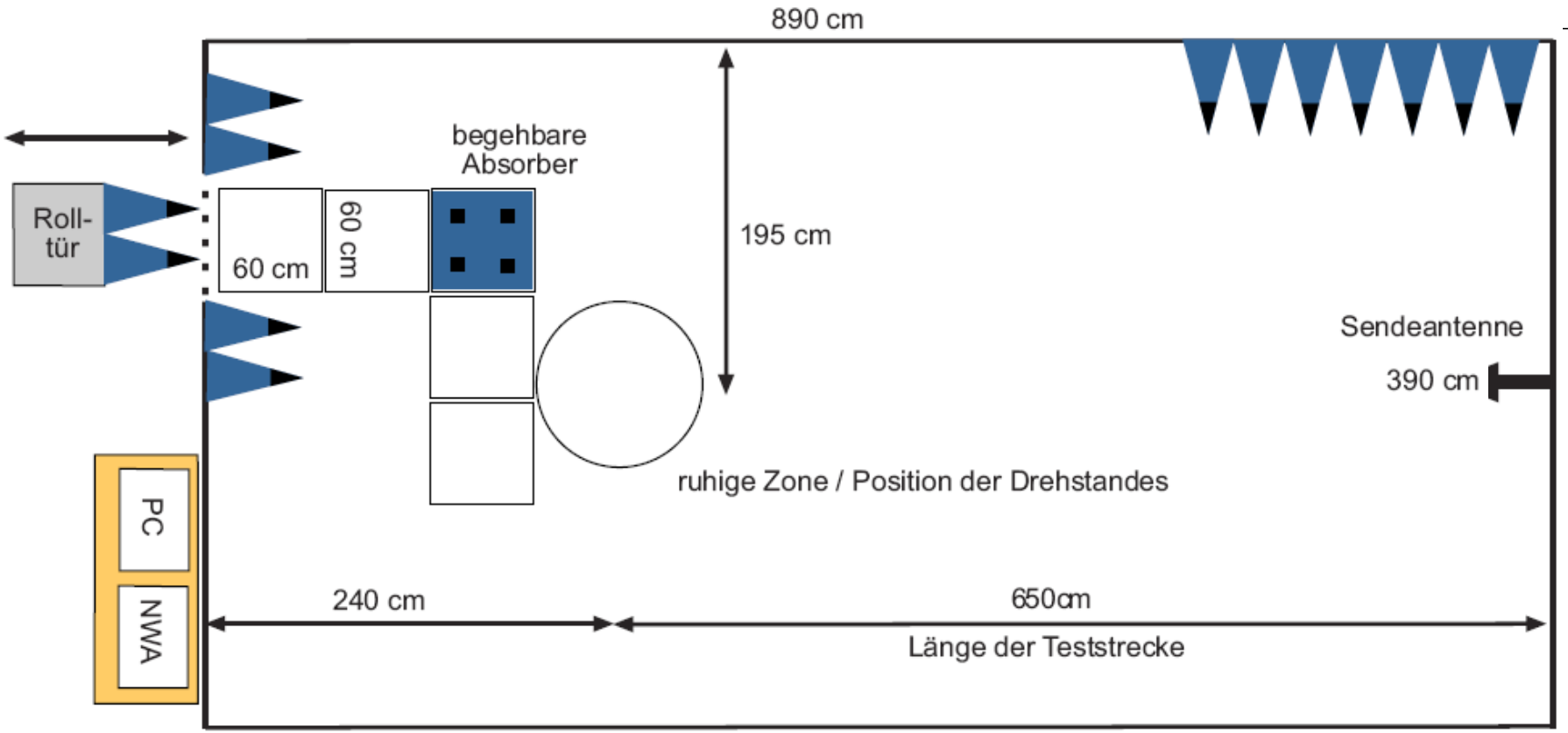

Bezirksregierung Köln – GEObasis.nrw

Universität Bonn (IGG)

igg

Inside view of Anechoic chamber
GEObasis.nrw, Bonn

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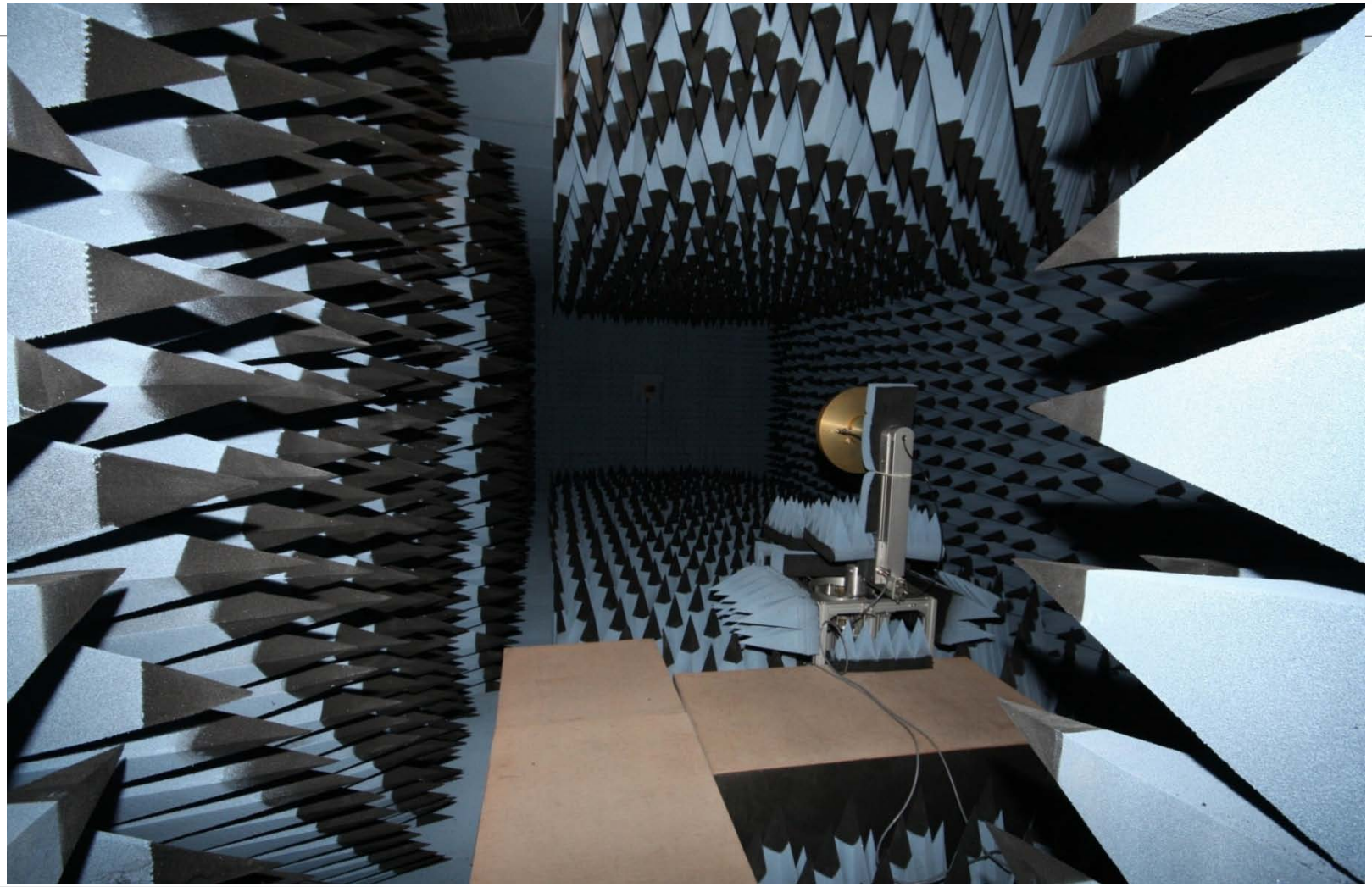

Inside View II Transmitter

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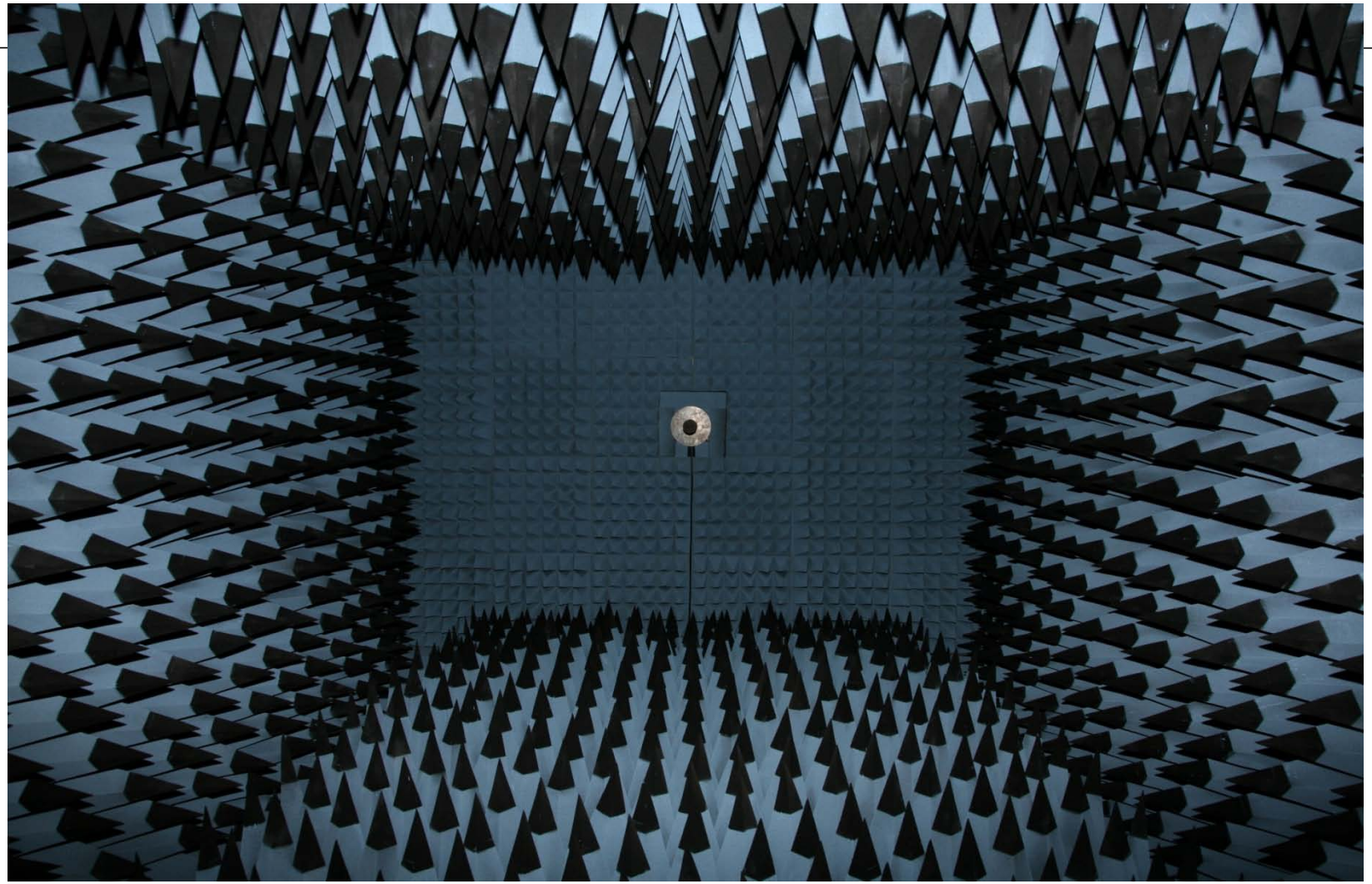

Frequency dependent variations - GNSS-frequencies -

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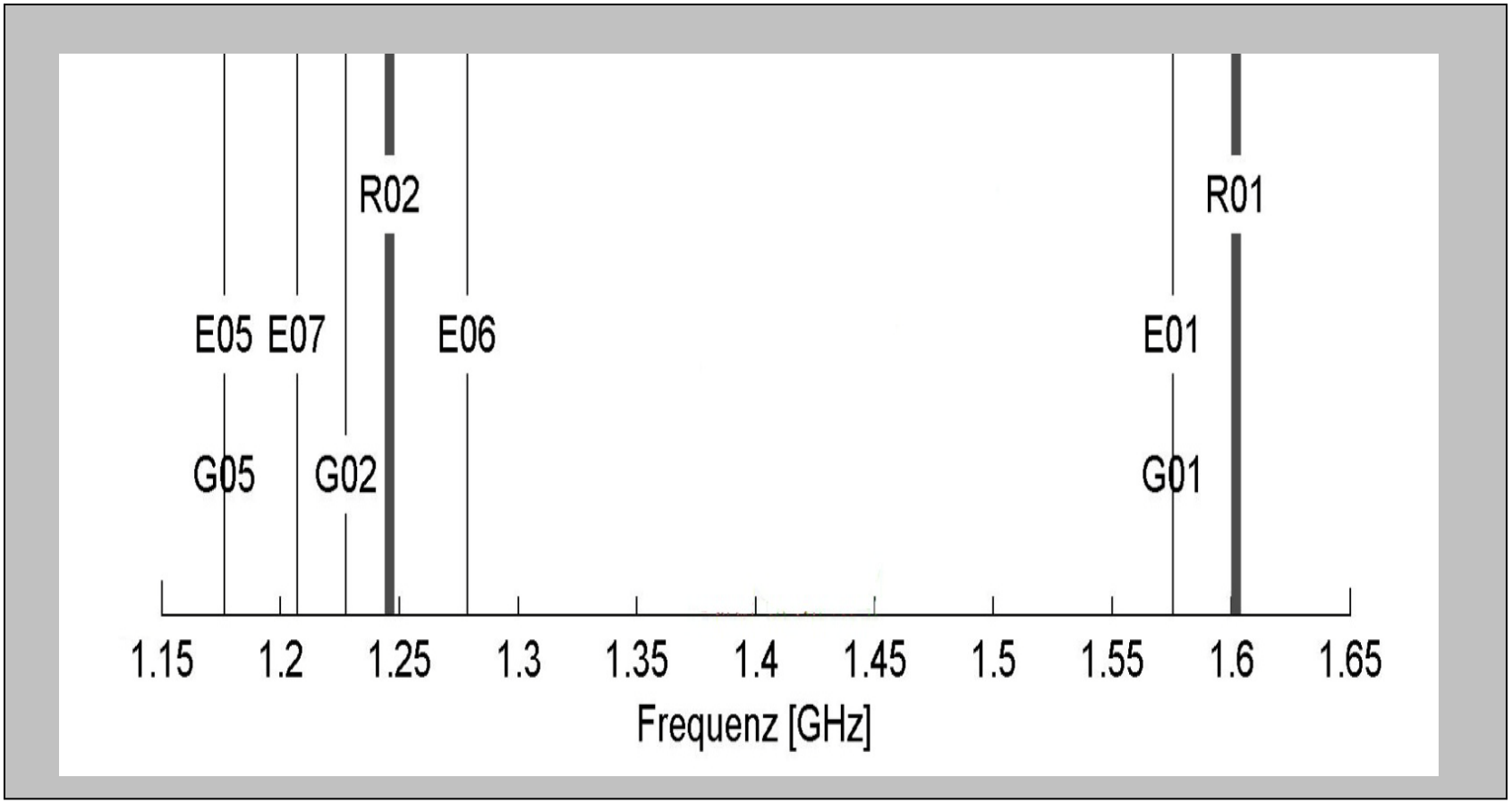
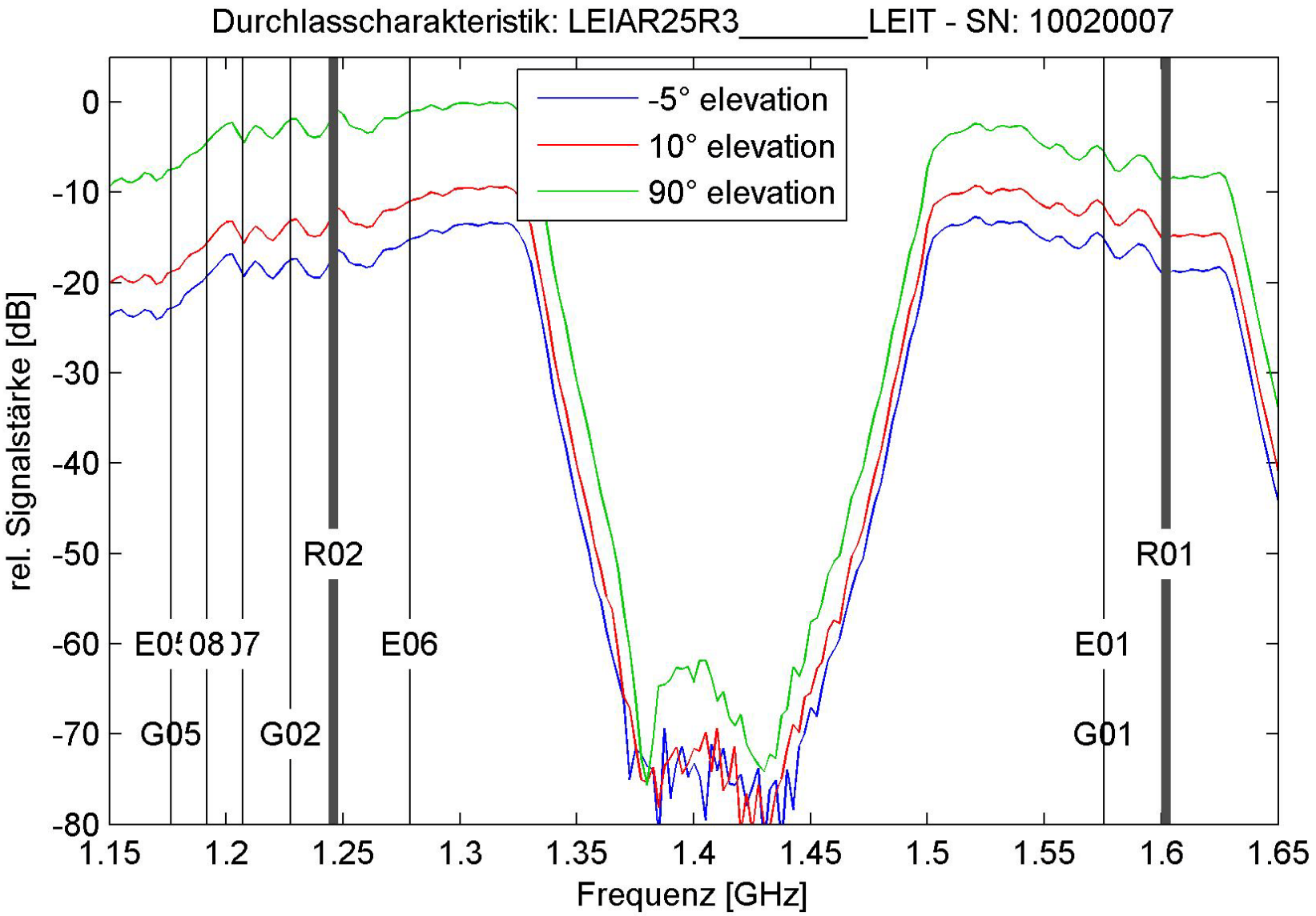


Leica AR25 R3 Damping



Leica AR25 R3 Damping vs Elevation

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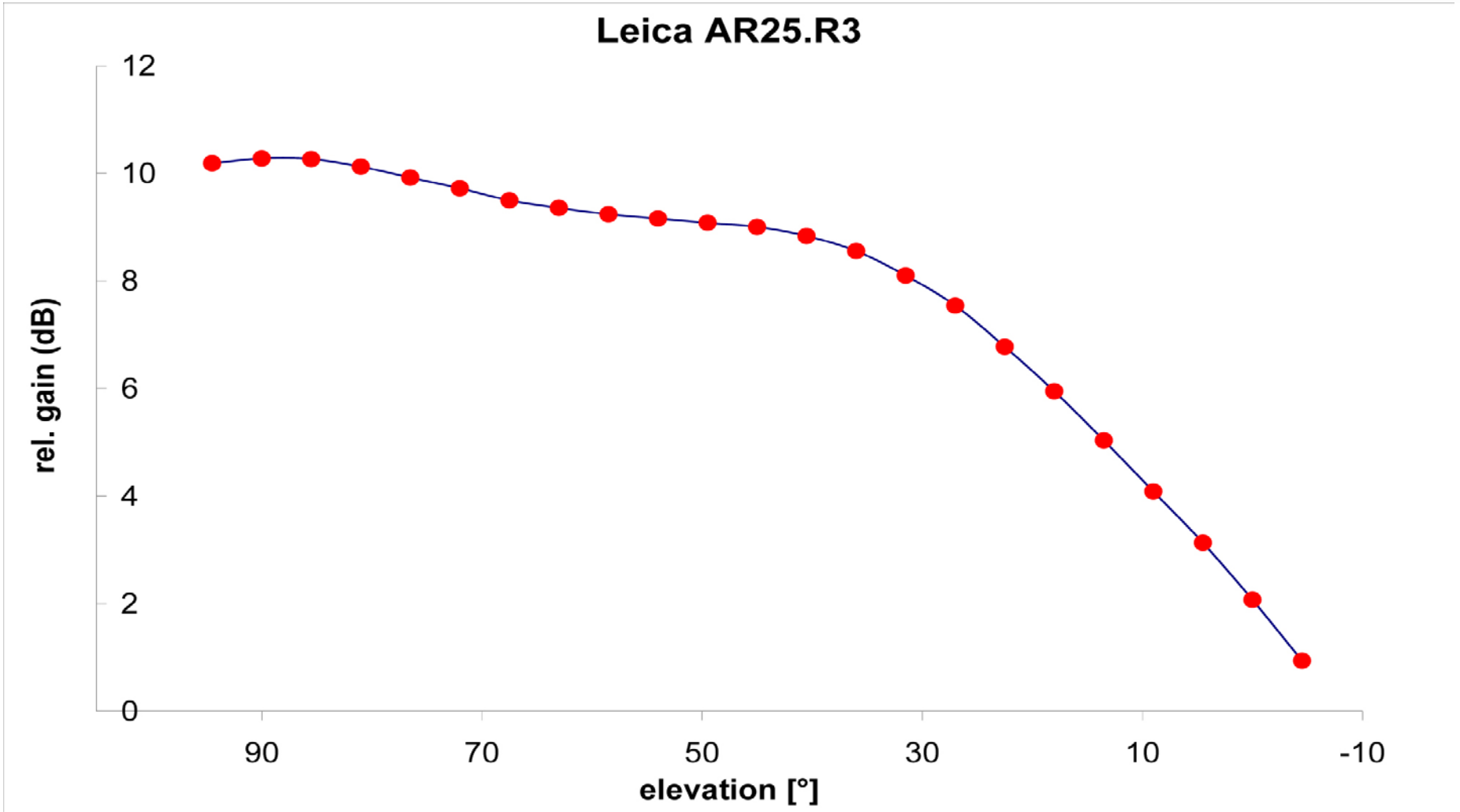
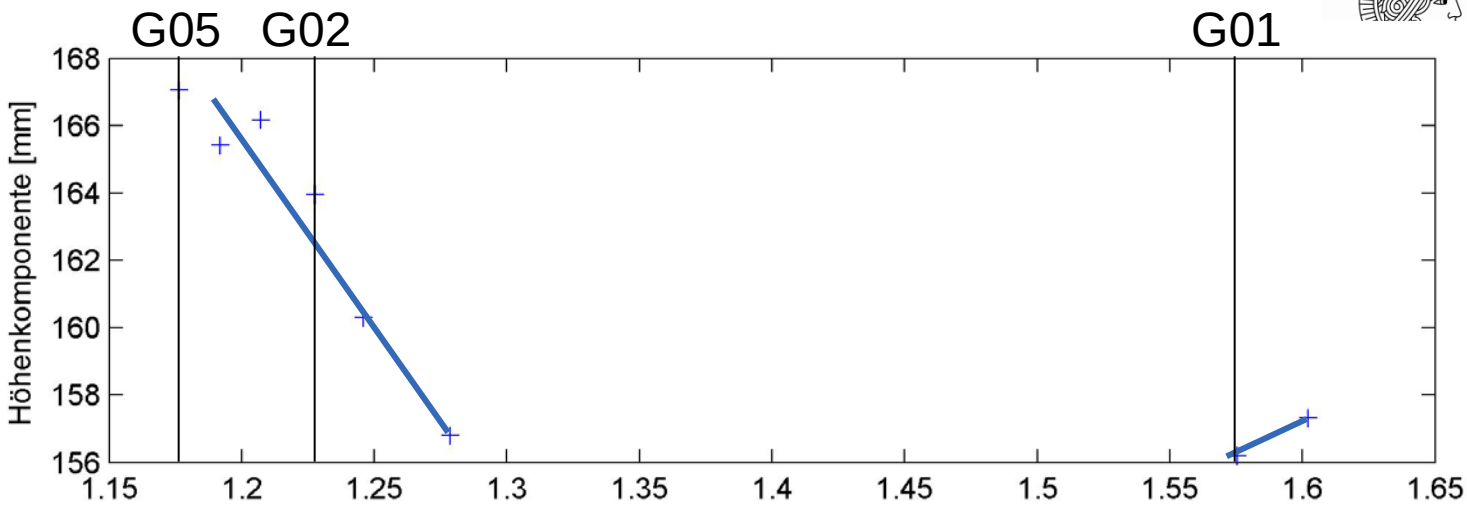
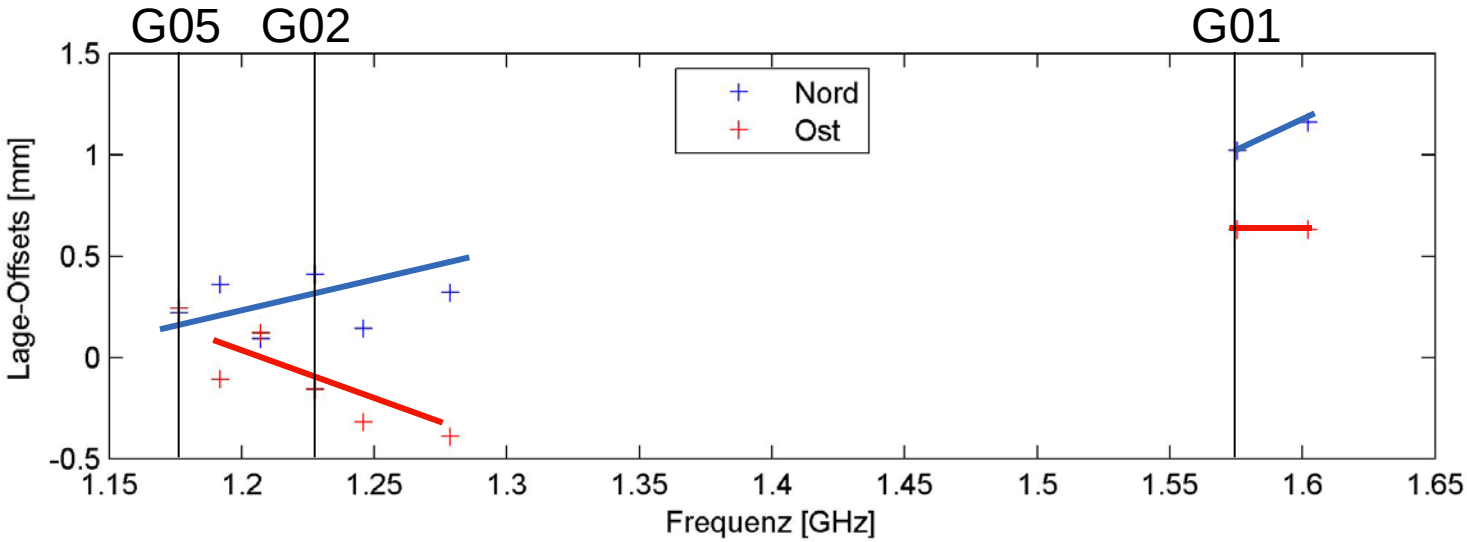
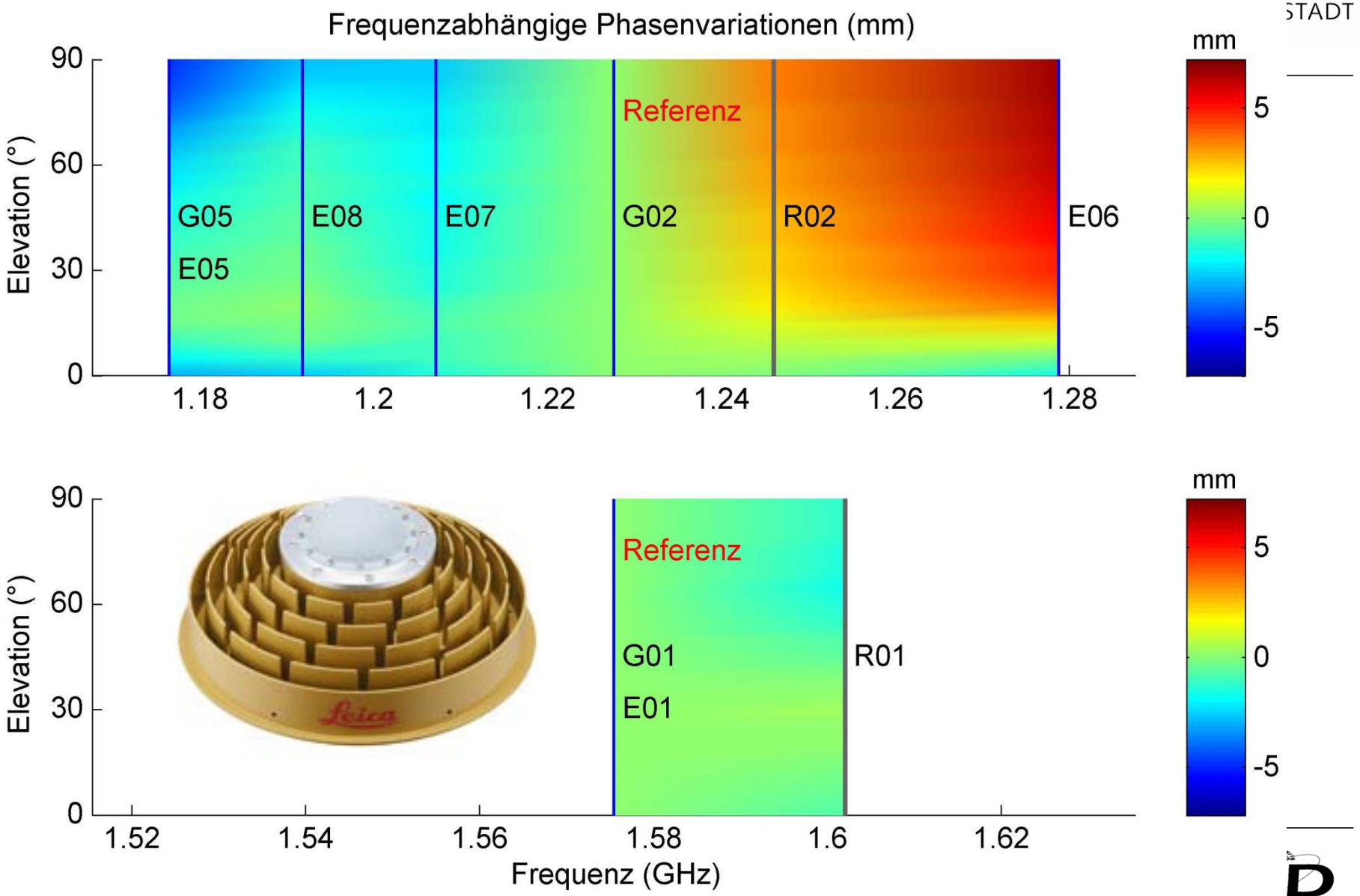


Leica AR25 R3 PCO Variation

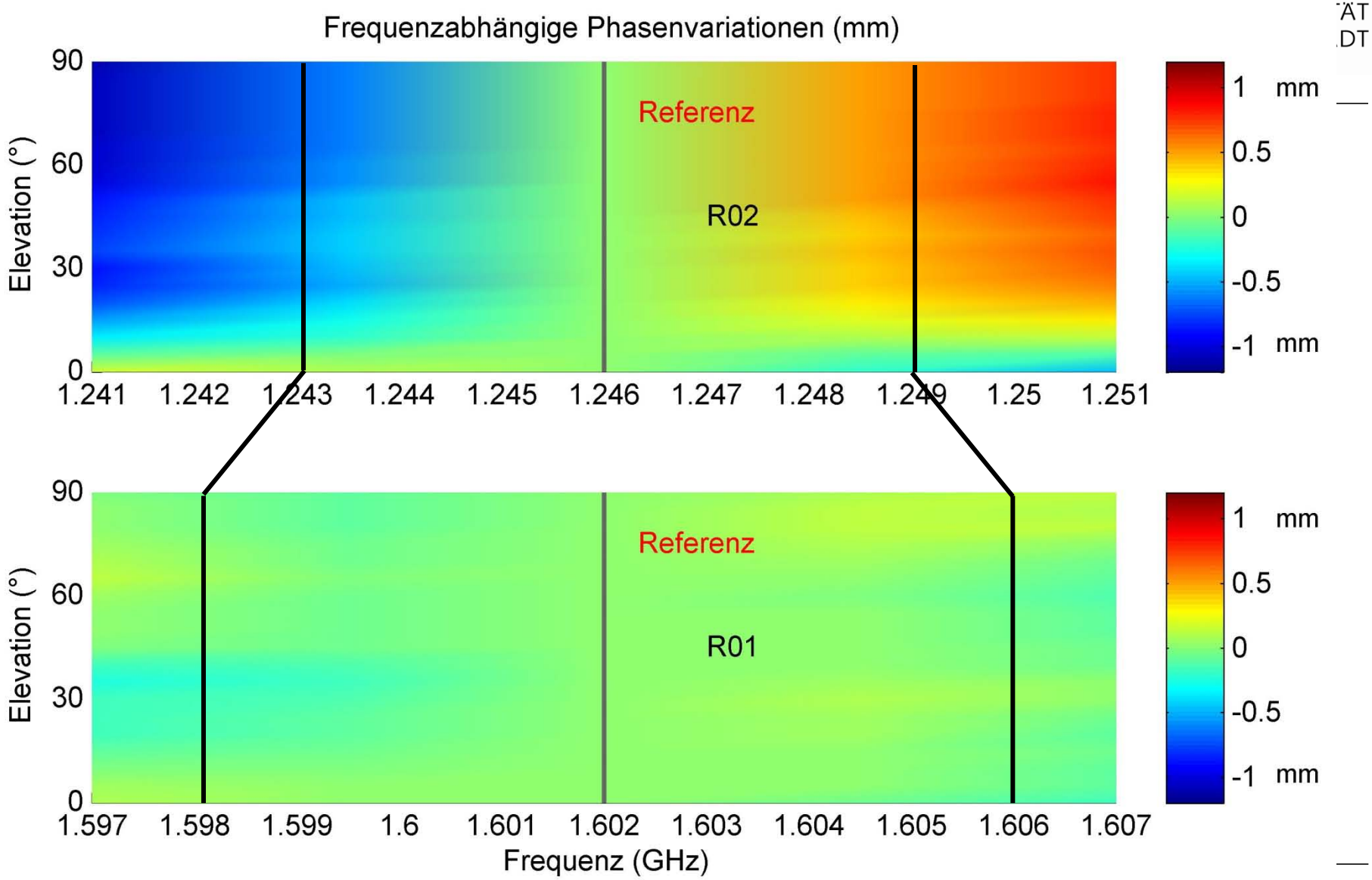




Leica AR25 R3 Complete Variation



Leica AR25 R3 **GLONASS-Frequencies**



Trimble Zephyr Geodetic GNSS Complete

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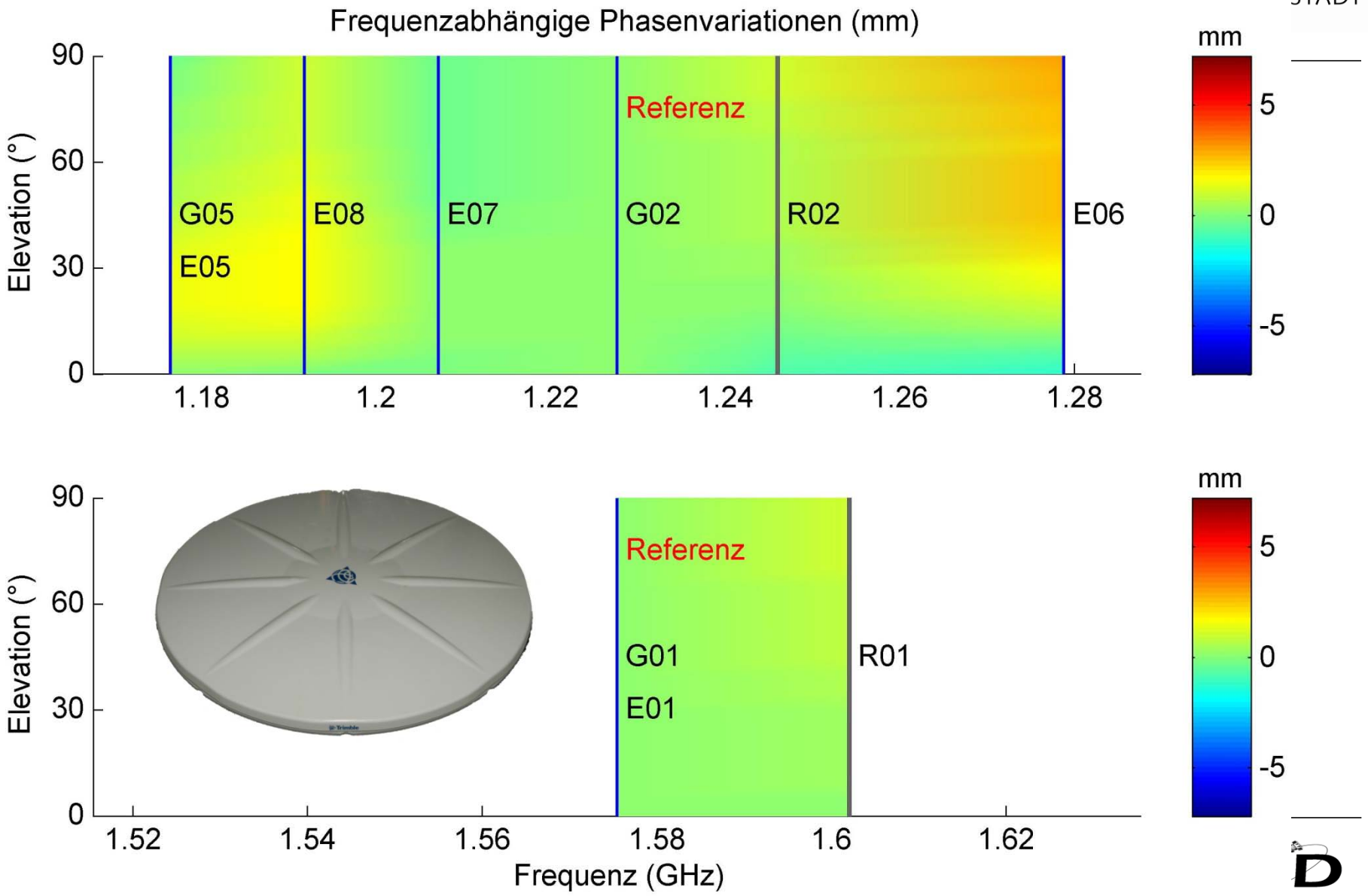
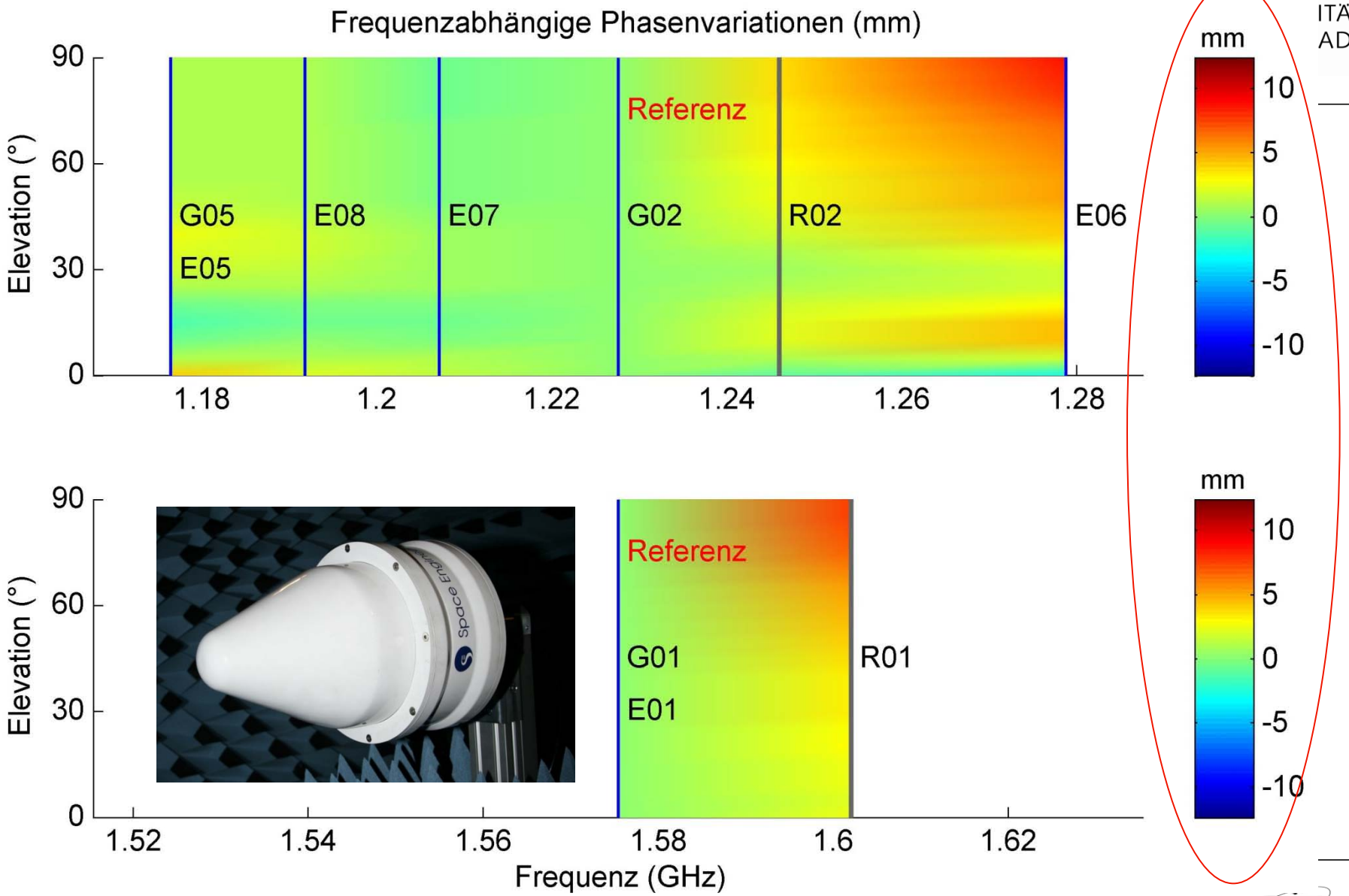


Space Engineering (GESS) Complete Variation



Conclusions on Frequency Dependence

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All antennas-types have a particular behaviour

But in general:

No obvious functional relation between L1 und L2

Significant difference between GPS and GLONASS PCO

Variations within the two GLONASS-Bands not significant, level of about +-0.5 maximally

„Ringversuch 2009“
Comparison of Chamber and Robot Calibration

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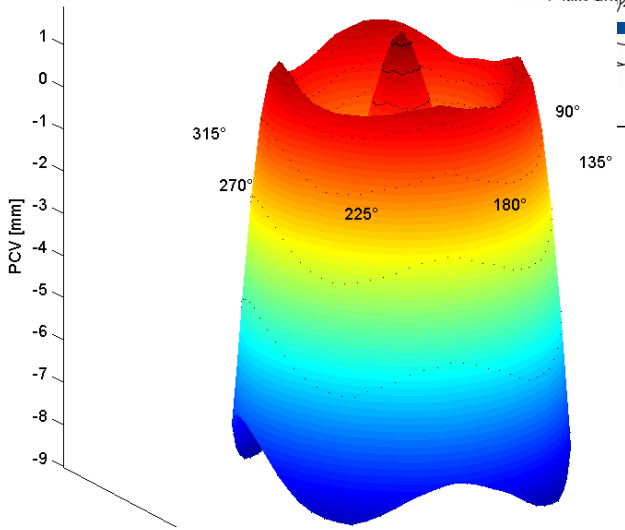
3 types of Calibraiton:

Relative:	Geodätisches Institut, TU Dresden (TUDr)
Absolute by Robot:	Institut für Erdmessung, Uni Hannover
Absolute Chamber:	Institut für Geodäsie und Geoinformation, Uni Bonn

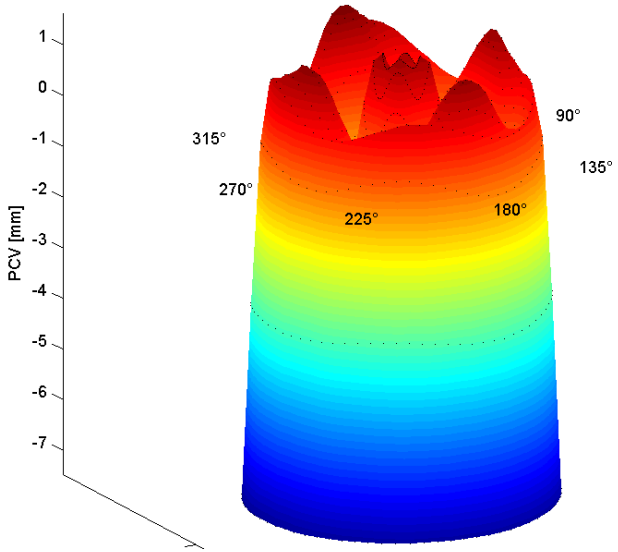
Antenna Types:

- Leica AR25
- Leica AT504GG
- Trimble Zephyr Geodetic Modell 2

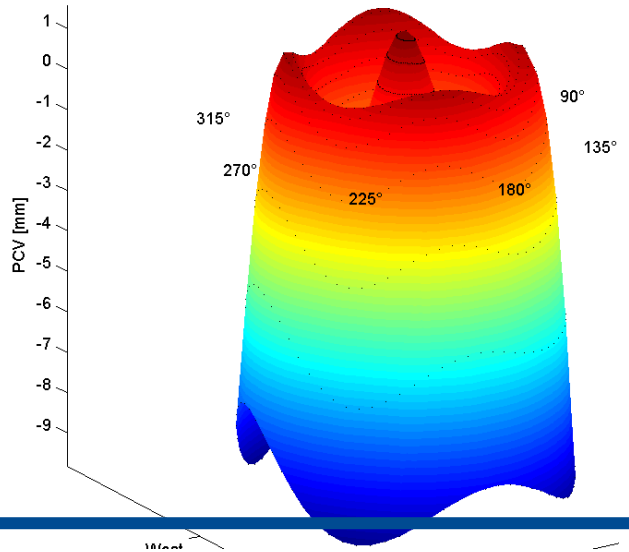
Leica AR25 (L1)



chamber calibration



rel. calibration (TUDr)



robot calibration (IfE)

Leica AR25 (L1)

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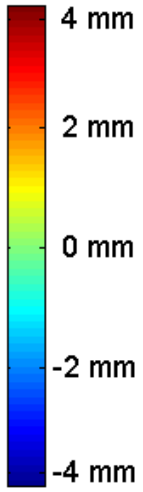
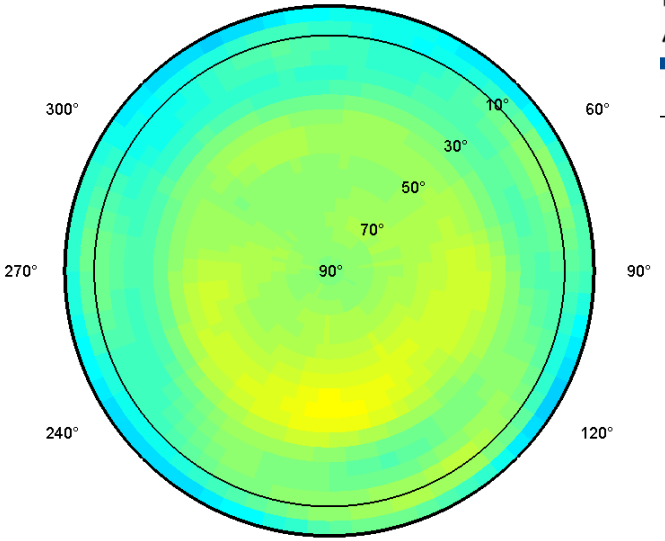
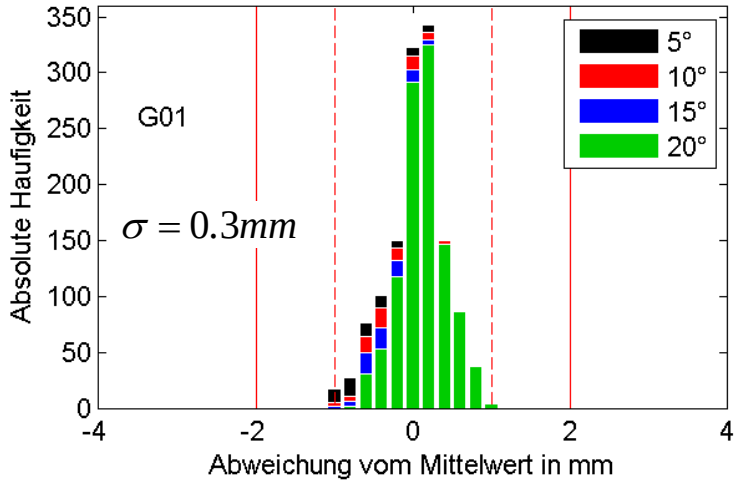
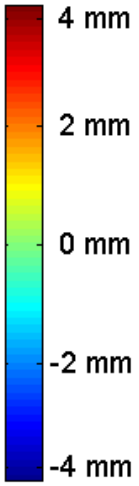


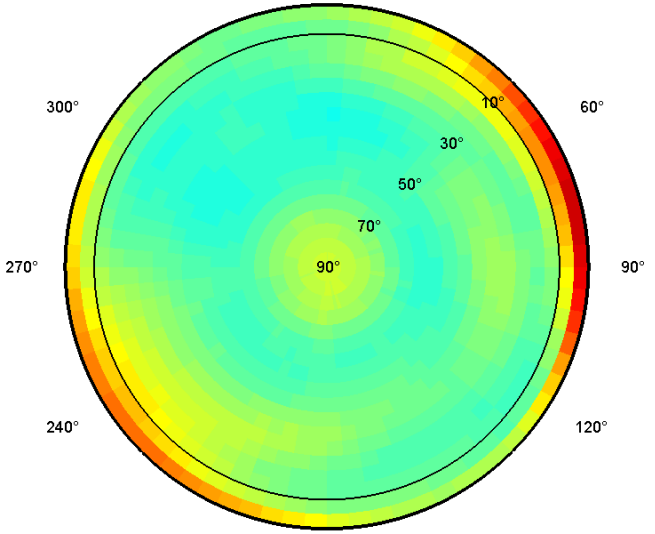


robot - chamber

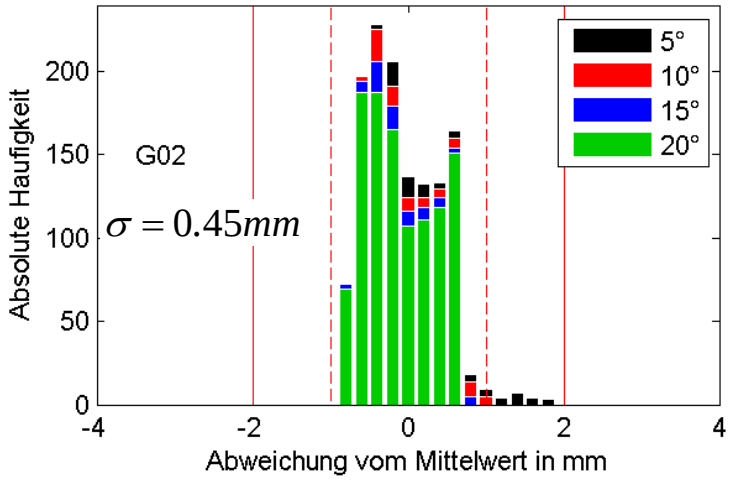


Leica AR25 (L2)





robot - chamber



Leica AR25 (R1)

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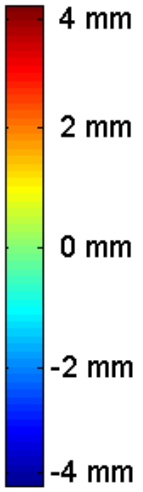
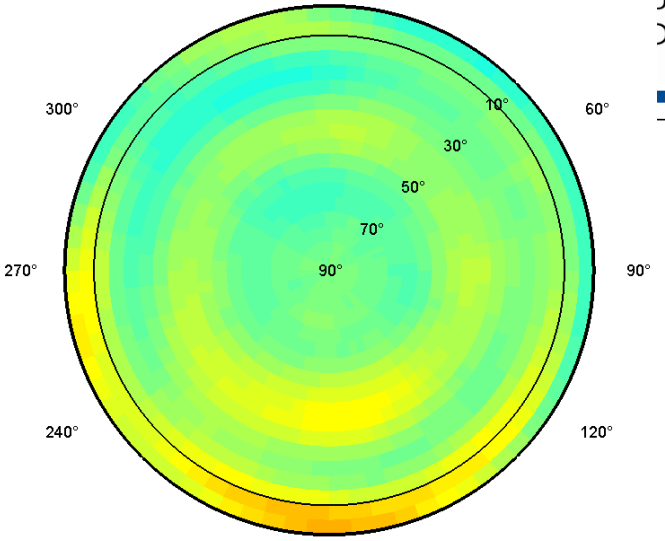
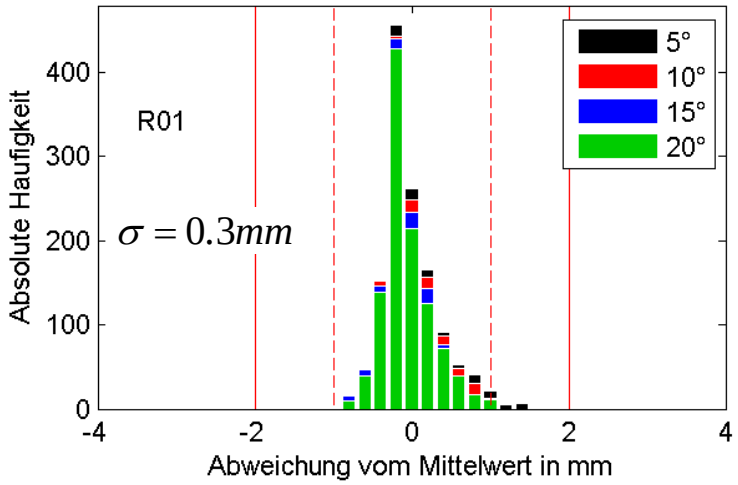
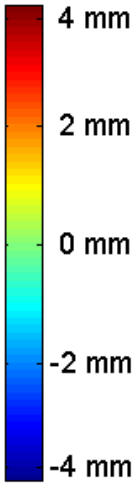


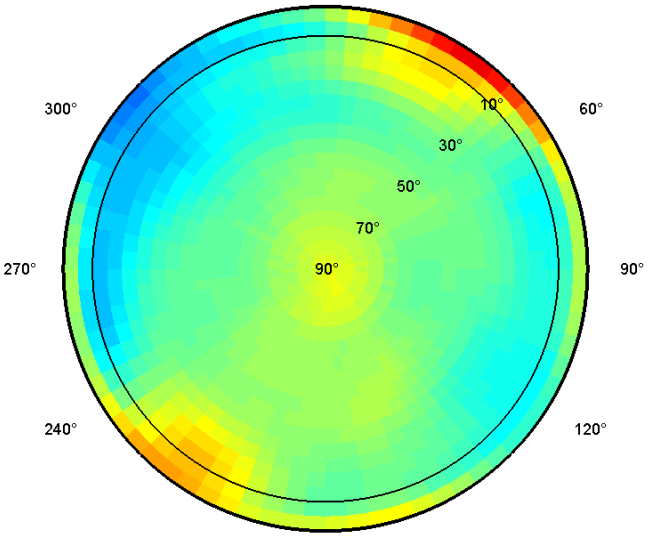


robot - chamber

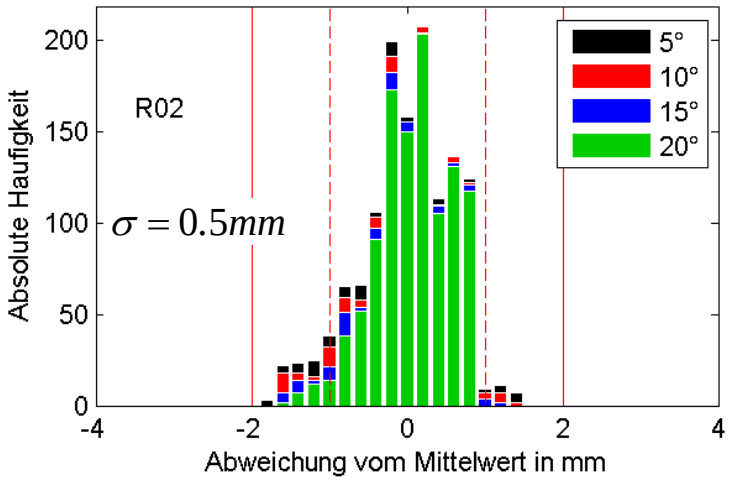


Leica AR25 (R2)

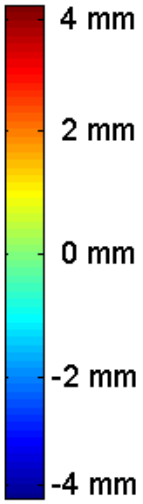


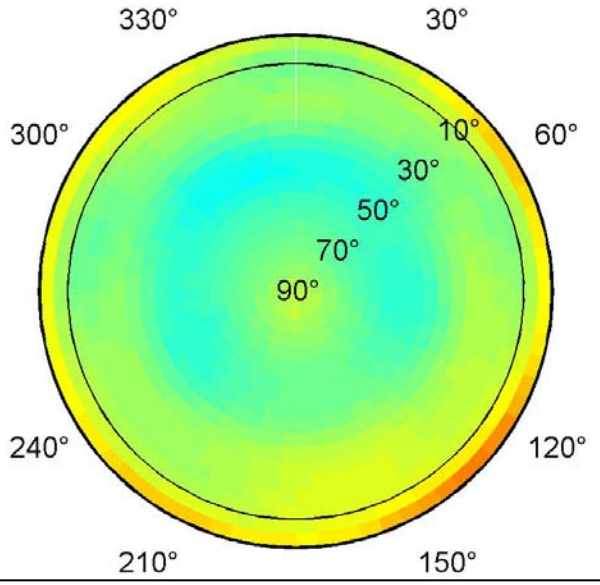


robot - chamber

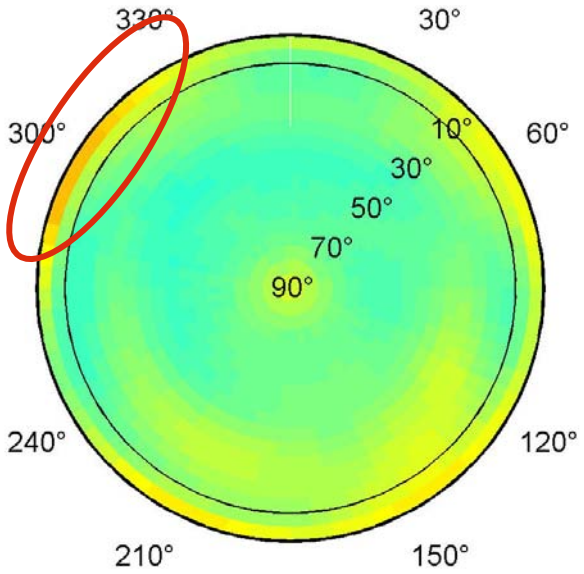


Trimble Zephyr Geodetic 2 (L1)

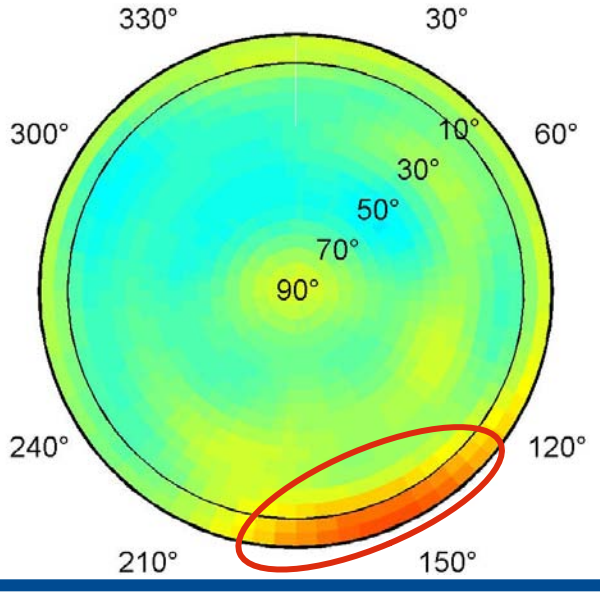




robot 1 - chamber

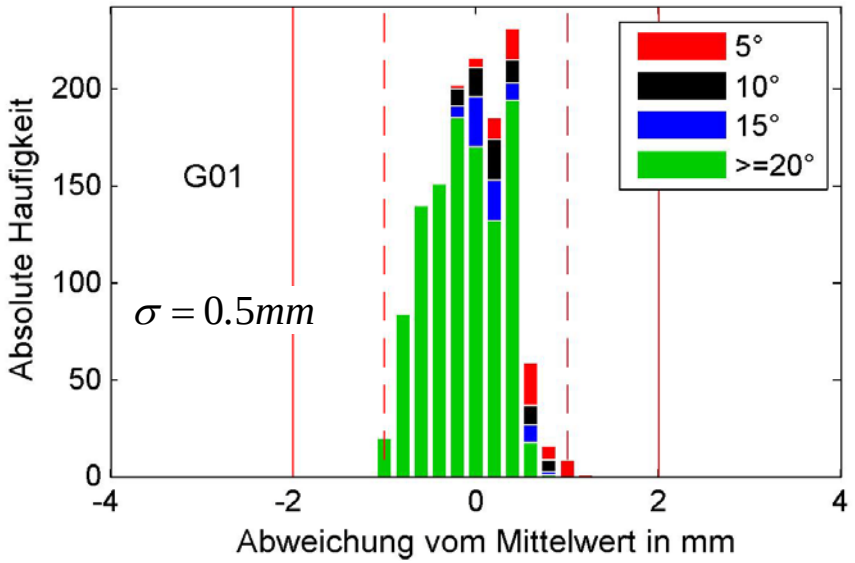


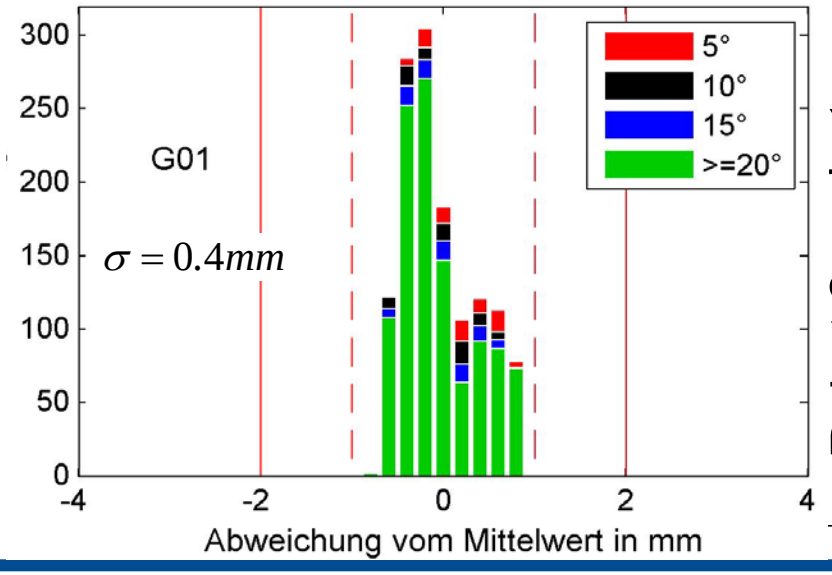
robot 2 - robot

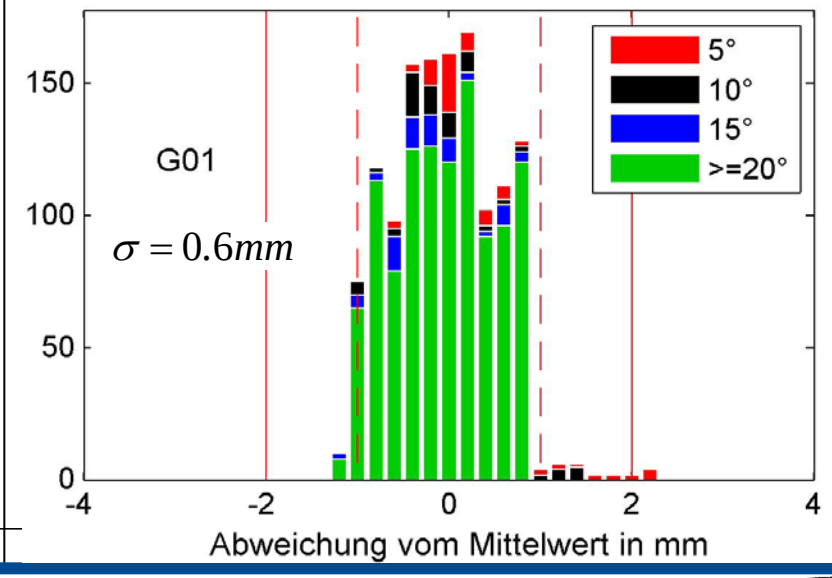


robot 3 - chamber

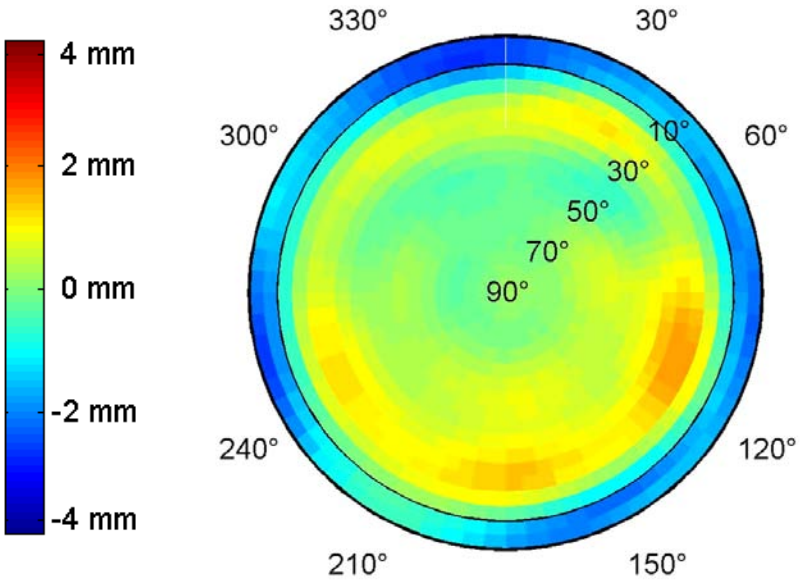
Trimble Zephyr Geodetic 2 (L1)







Trimble Zephyr Geodetic 2 (L2)

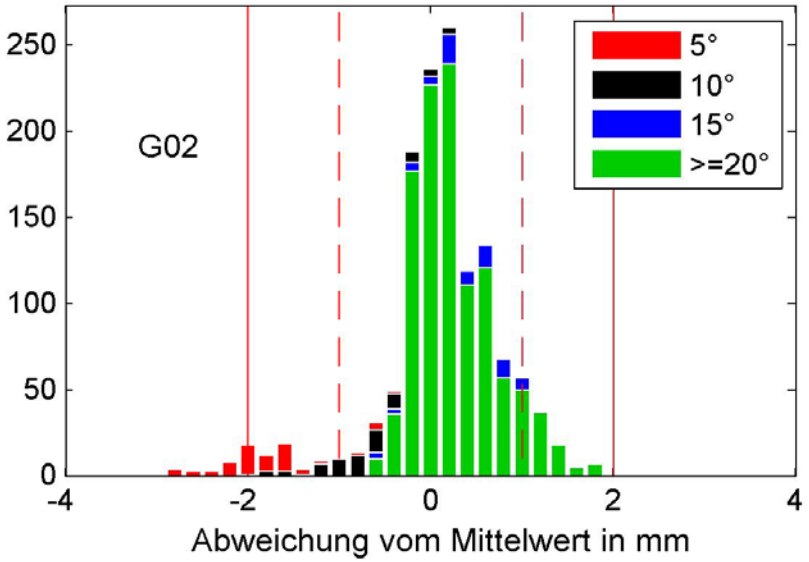


Robot 1 - chamber

$$\sigma_{(5°-90°)} = 0.7mm$$

$$\sigma_{(10°-90°)} = 0.5mm$$

$$\sigma_{(15°-90°)} = 0.4mm$$



Robot 3 - chamber

IPGD

Conclusions Ringversuch

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Robot vs. Chamber

- Differences of 1,0 – 2,0 mm (Elevationen > 10°)
- Differences of 1,0 – 3,0 mm (Elevationen 0° bis 10°)
- L1 & R1 in general better than L2 & R2
- Robot 1 vs. Robot 2 only slightly better

Differences are related to residual effects of both methods:

Type Mean

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Leica AR25R3 SN 6xxx8 vs. SN 6xxx9 (L2)

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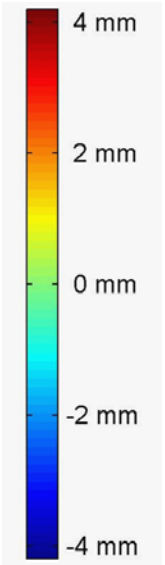
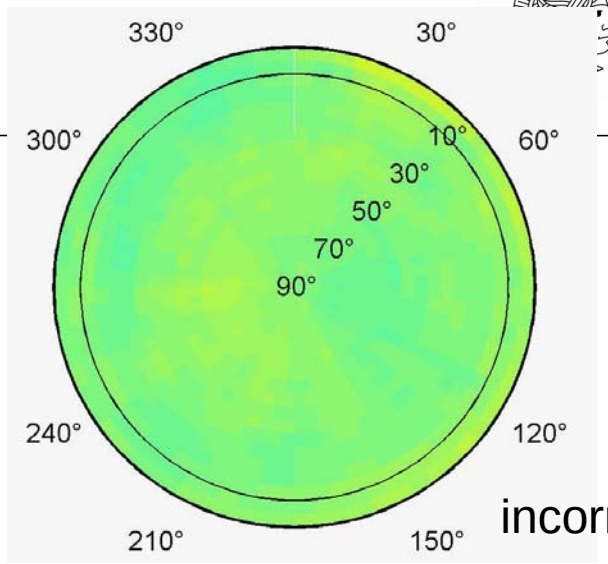
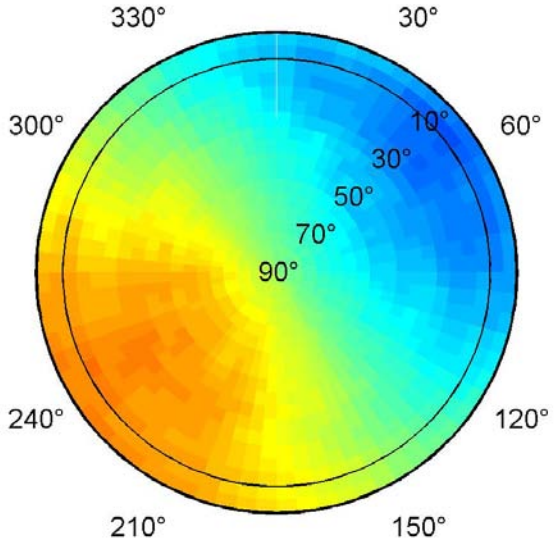




Δ PCV

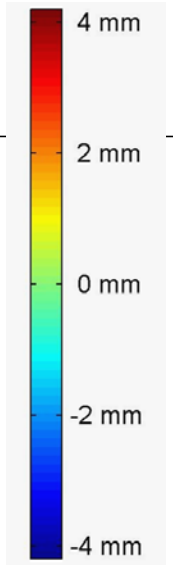
incorrect

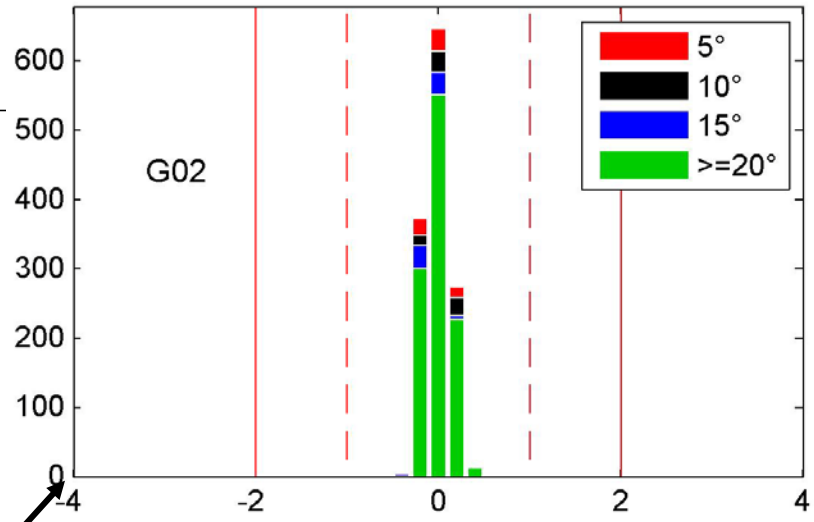
North [mm]	East [mm]	Up [mm]
-0.35	-0.53	164.98
1,04	1.28	164.57
1.39	1.81	0.41



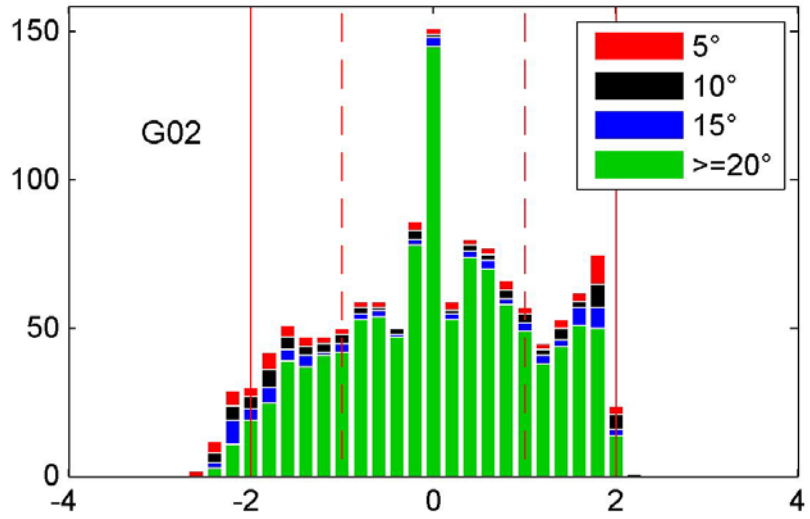
Δ (PCV & PCO)

Leica AR25R3 SN 6xxx8 vs. SN 6xxx9 (L2)

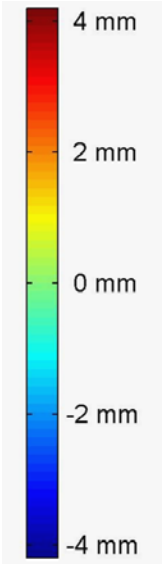


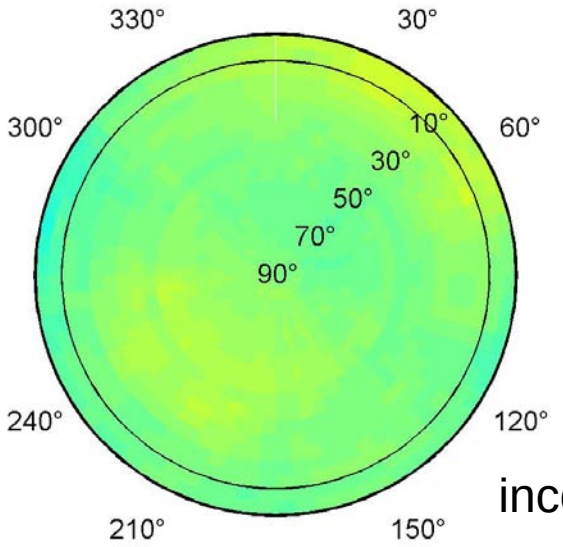


No significant PCV-variatons
(figure shows precision of calibration)



Leica AR25R3 SN 6xxx8 vs. SN 7xx14 (L2)

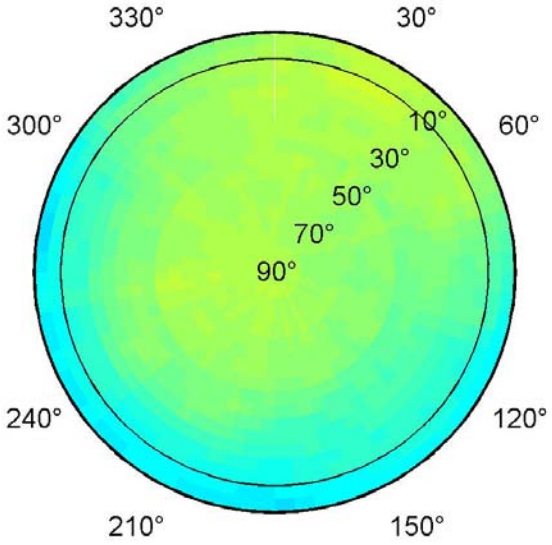




Δ PCV

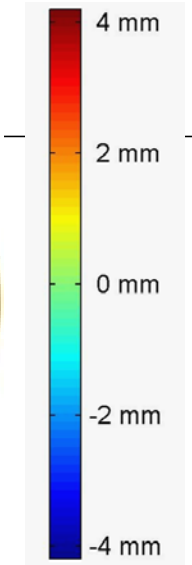
incorrect

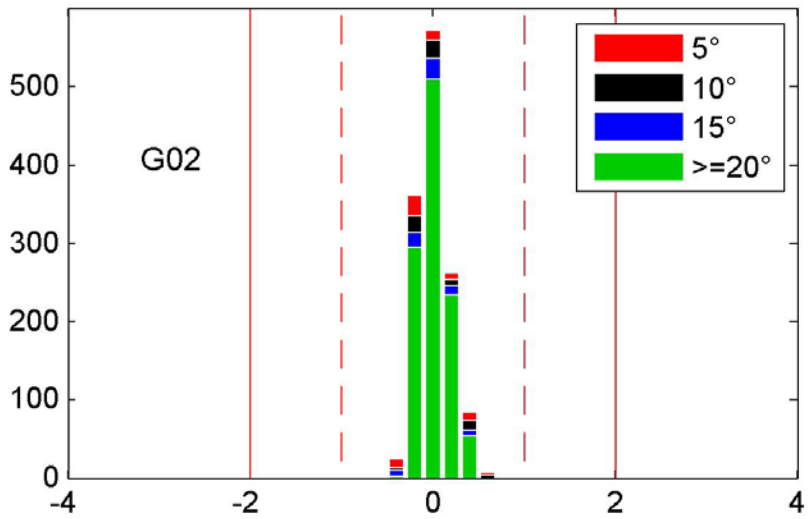
North [mm]	East [mm]	Up [mm]
1.50	1.32	165.48
1.04	1.28	164.57
0.46	0.04	0.91



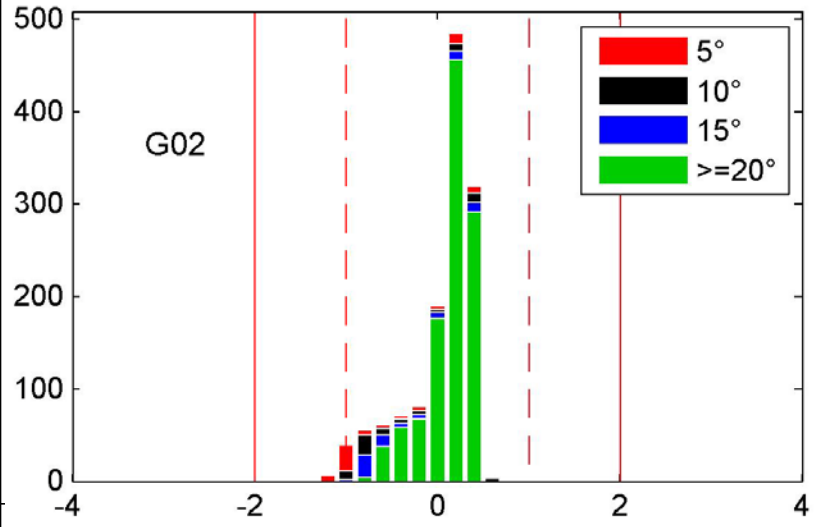
Δ (PCV & PCO)

Leica AR25R3 SN 6xxx8 vs. SN 7xx14 (L2)





Spread of PC residuals larger in L 2



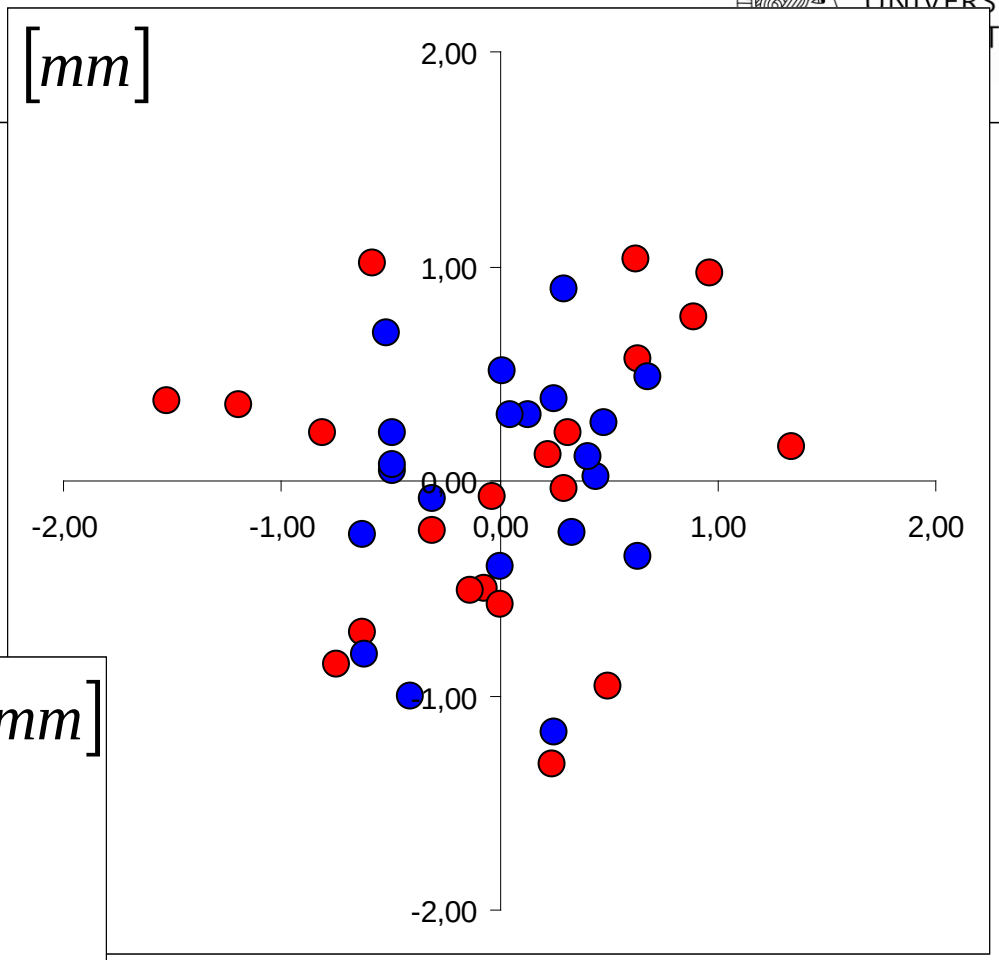
Type Mean

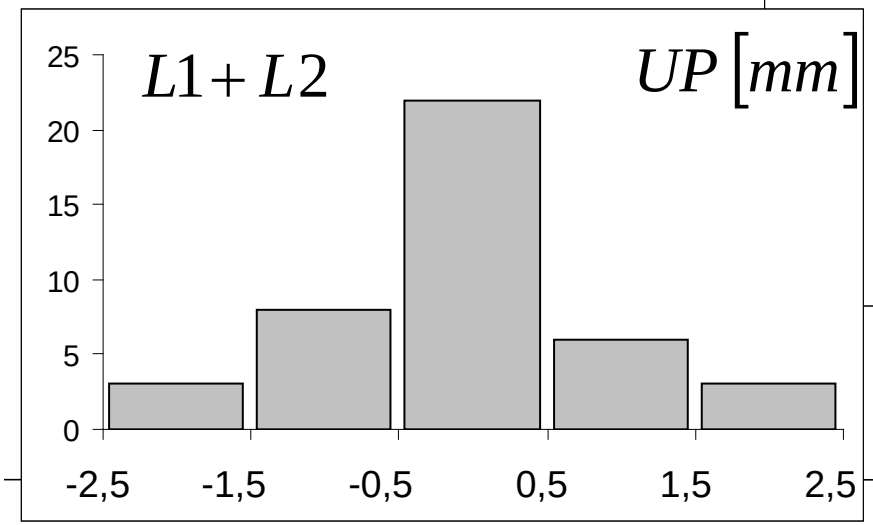
Spread of PCOs:

21 Leica AR25R3 Antennen

- $\sigma_{L1,North+East} \approx 0.6mm$
- $\sigma_{L2,North+East} \approx 0.9mm$

$\sigma_{L1,L2,UP} \approx 1\,mm$





Conclusion Type Mean

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- In general no significant variation in PCV
- PCO show variation at the mm level with Std. Dev. < 1 mm
- Deviation from type mean 1-2mm
- Differences between two antennas may amount to 2-3mm
- Variation in PCO not identical for L1 and L2
- Similiar for antennas of various types and manufacturers

Effects in IGS-type processing

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Zero Baseline

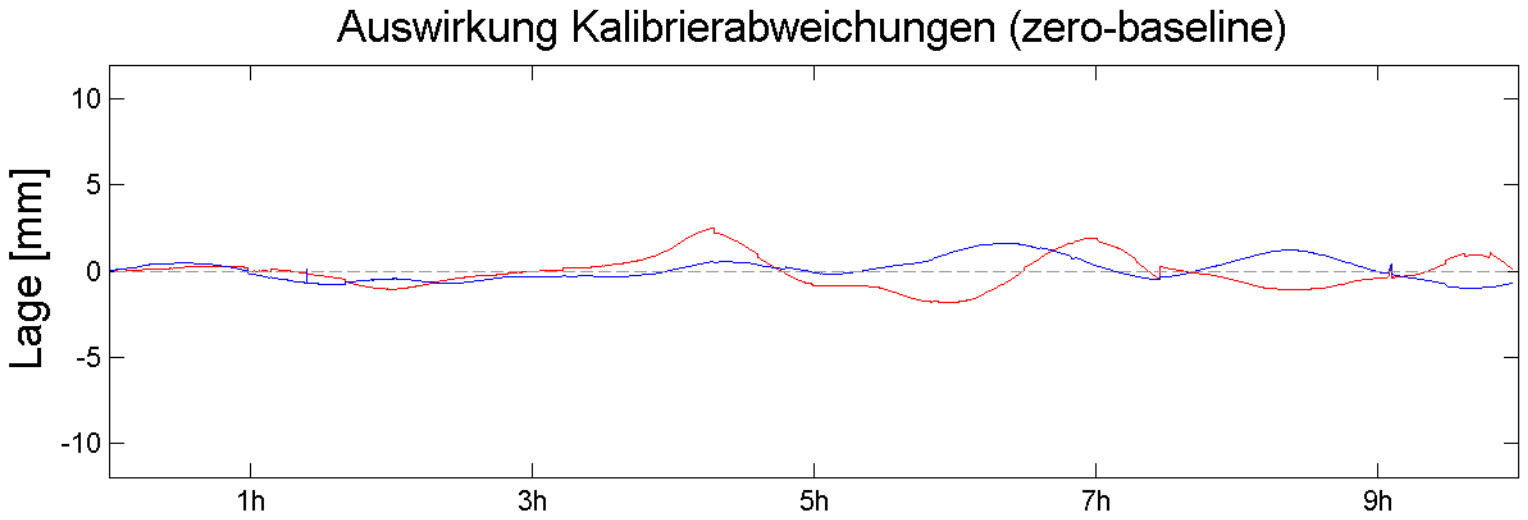
NAPEOS processing

- PPP with L3 linear combination
- 3° Cut off

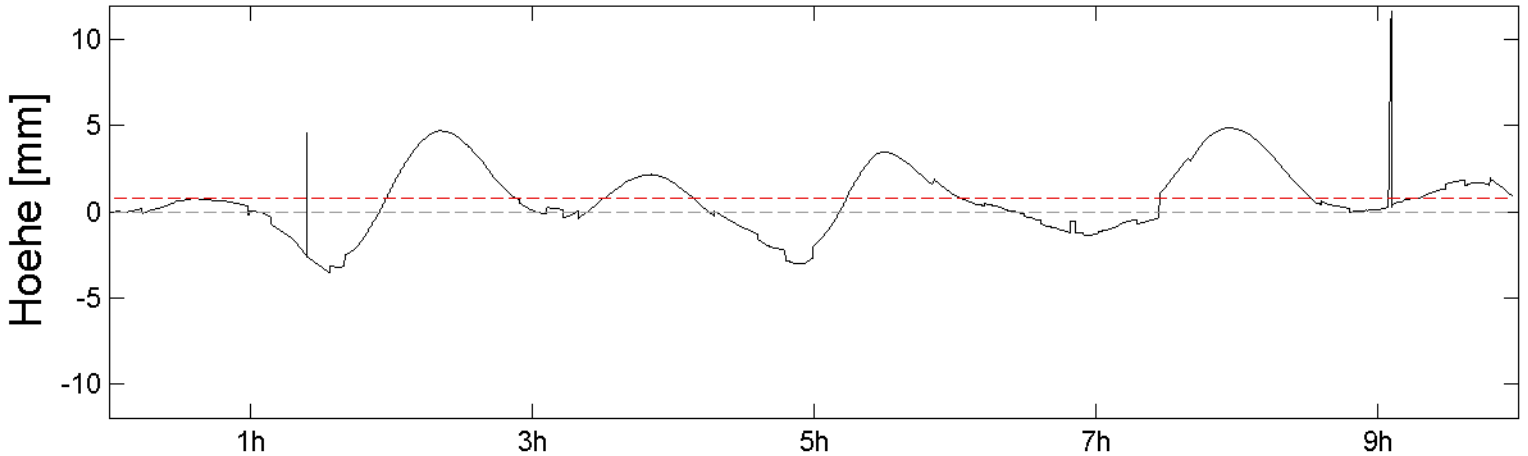
Effect of changed PC-correction tables in in:

- Coordinates
- Troposphere
- Phase Residuals

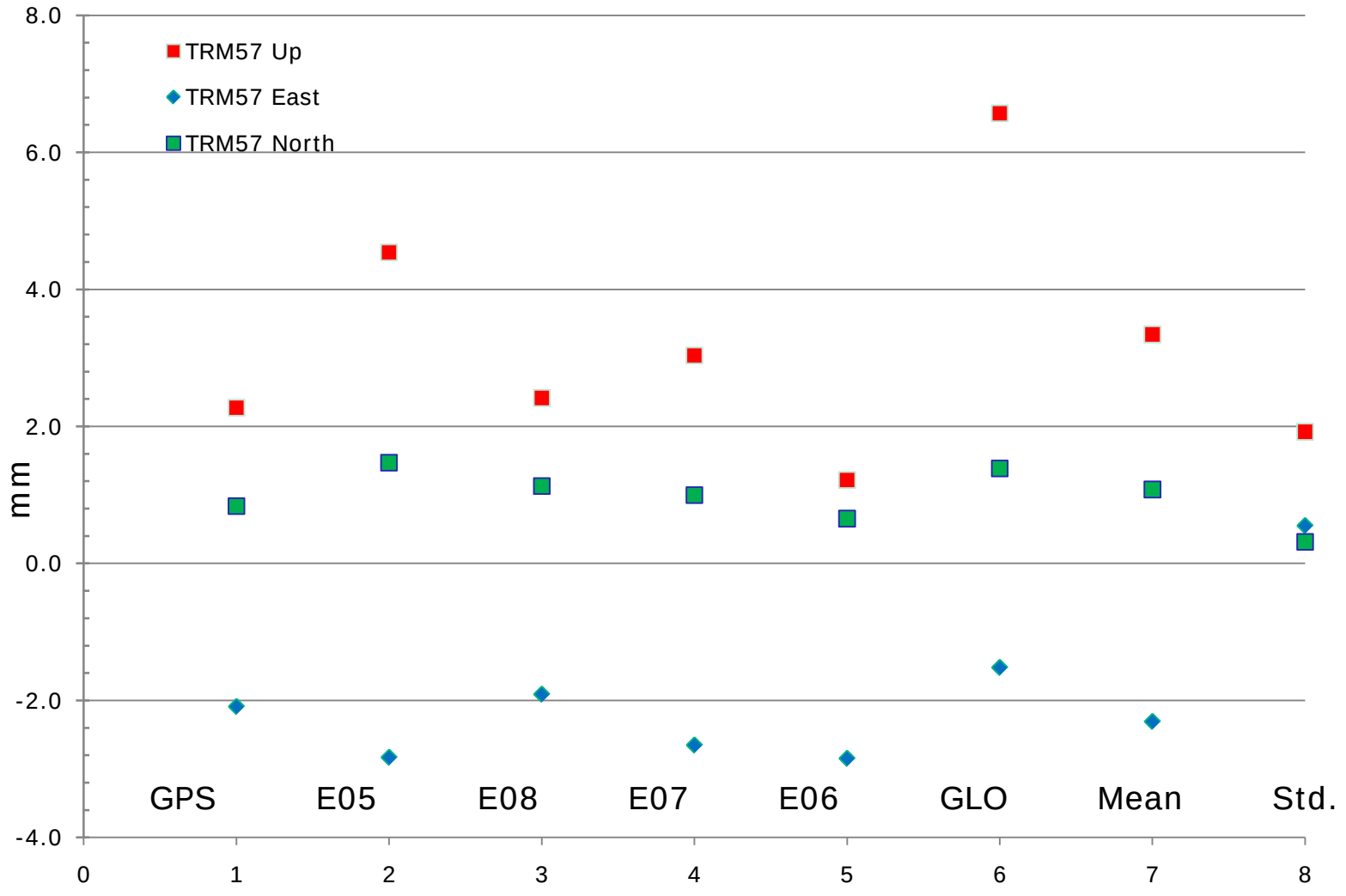
Leica AR25 (L0)



Zero-Baseline: IfE vs. Bonn

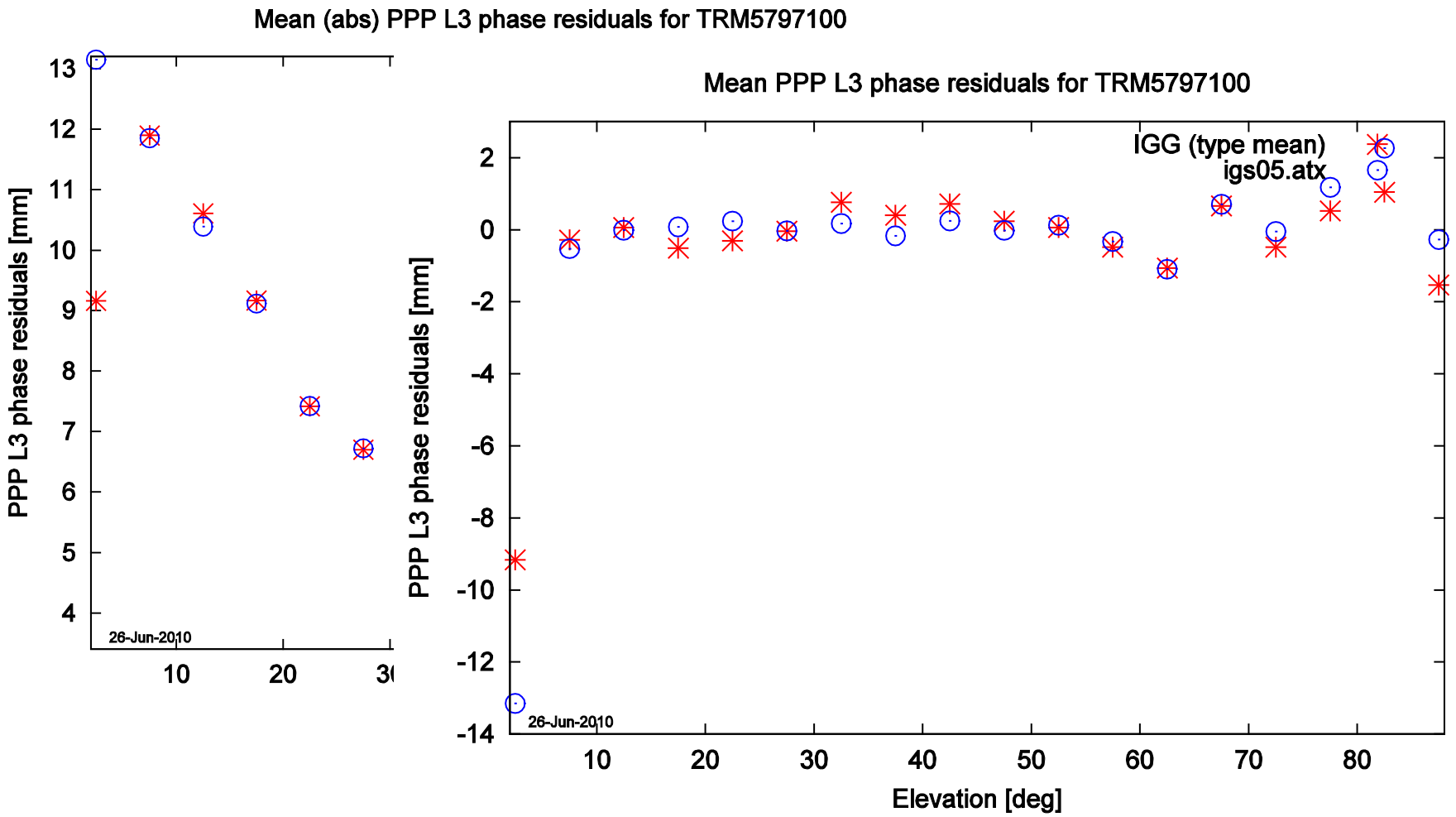


TRM5597 Coordinate vs. Frequency

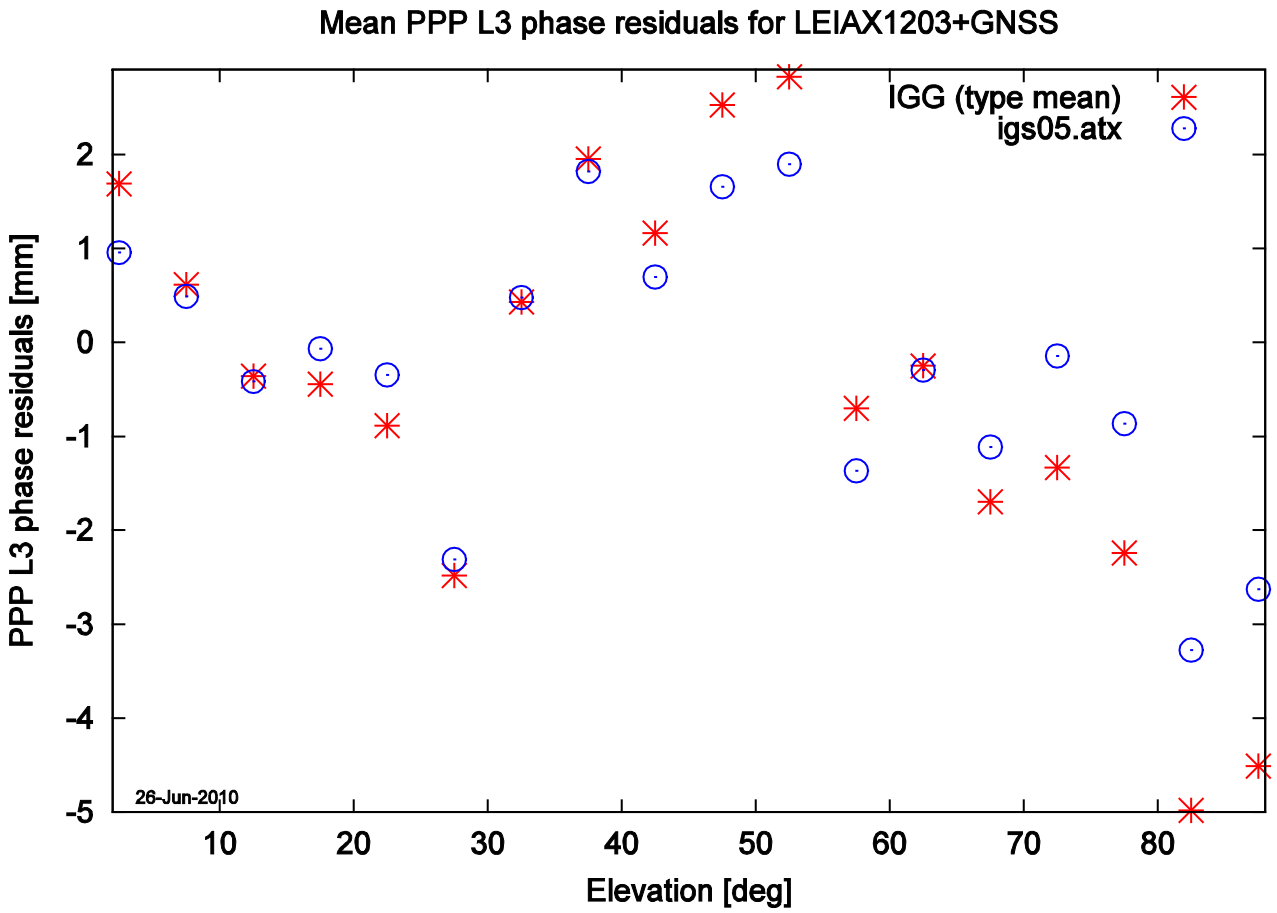


TRM57971 Troposphere

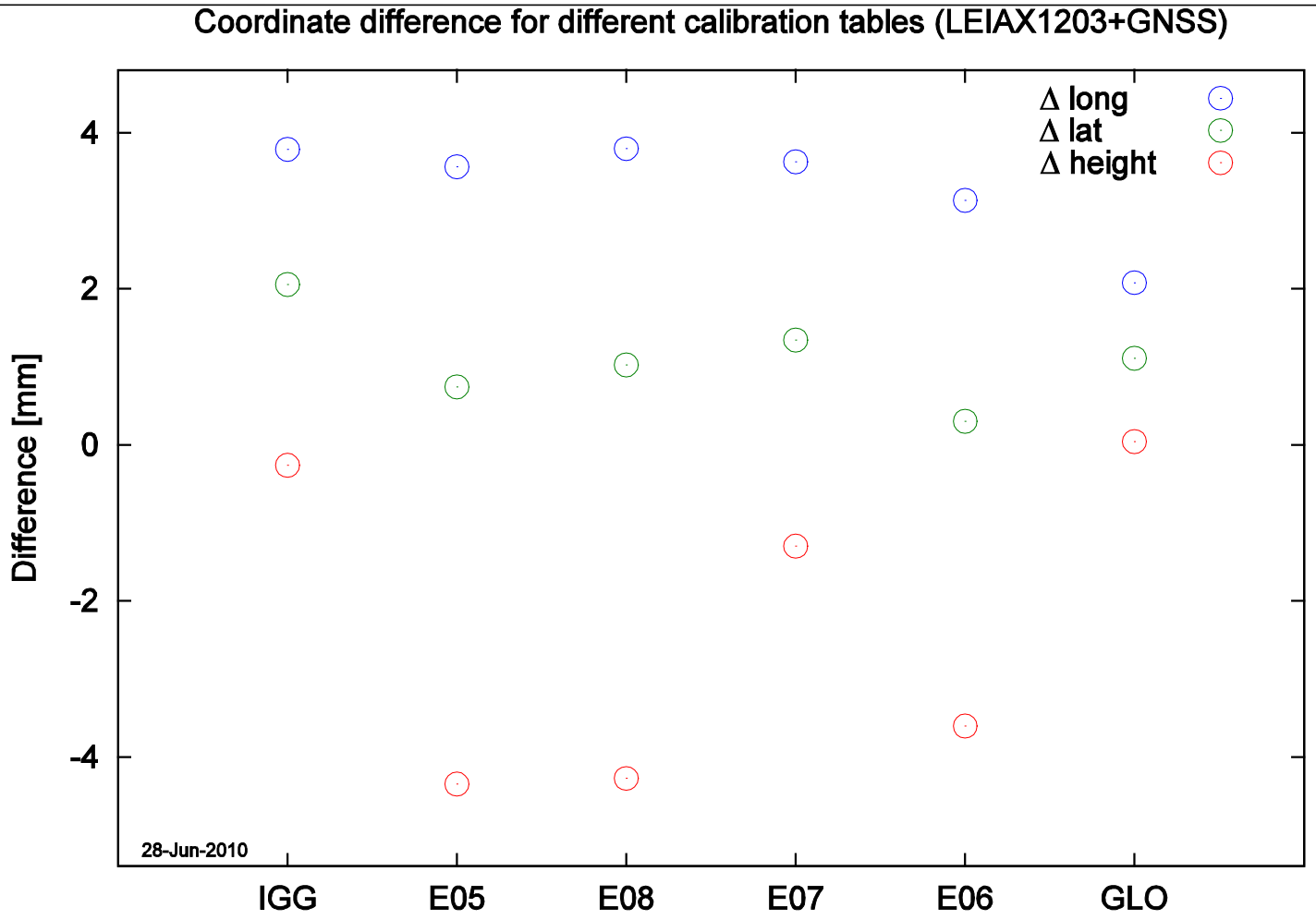
TRM5797100 L3-Phase



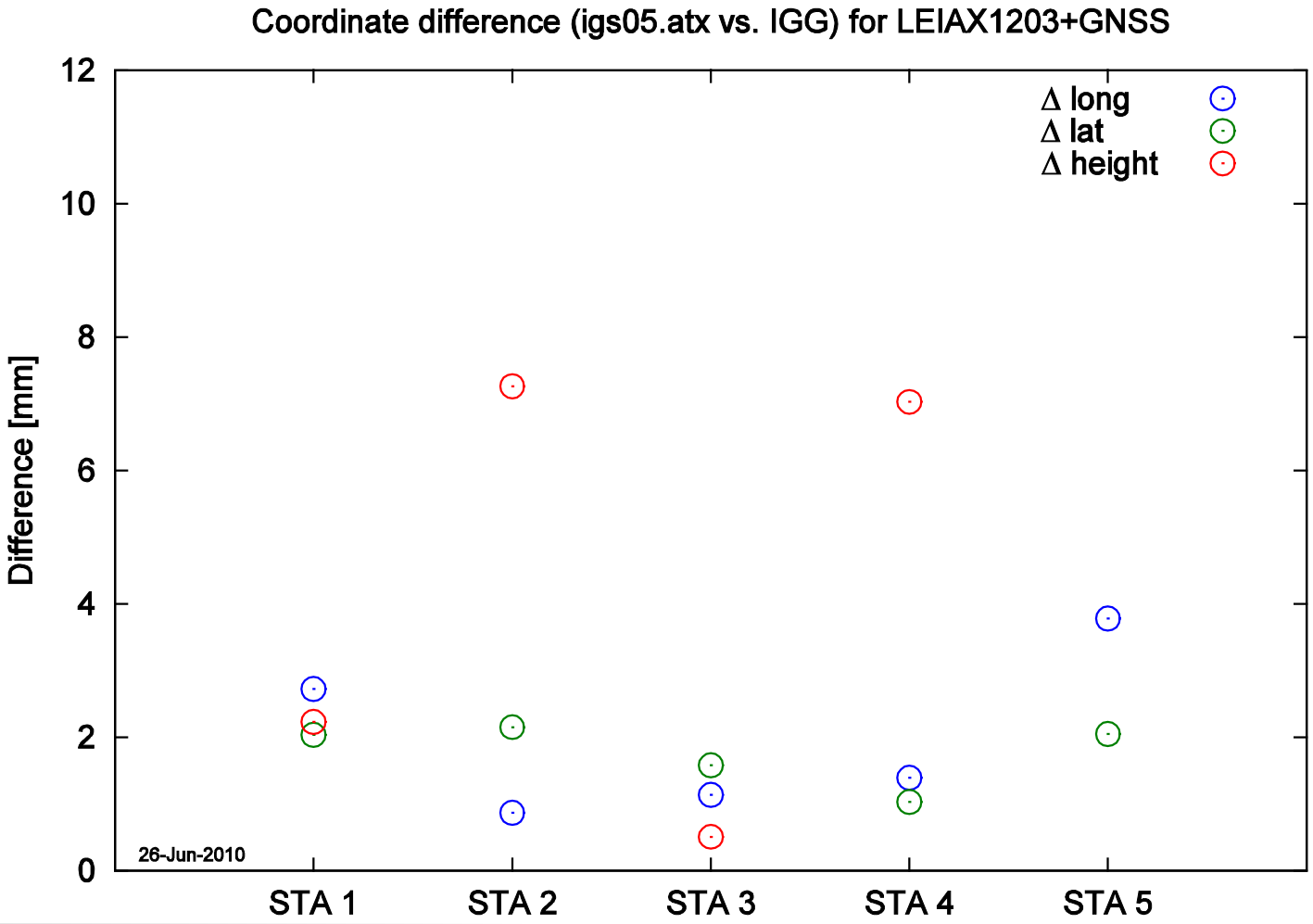
LEIAX1203


Mean PPP L3 phase residuals for LEIAX1203+GNSS
IGG (type mean)
igs05.atx
26-Jun-2010
PPP L3 phase residuals [mm]
Elevation [deg]
2
1
0
-1
-2
-3
-4
-5
10
20
30
40
50
60
70
80

LEIAX1203 Coordinates vs Frequ.



LEIAX1203 Coordinates at Sites



Summary Processing

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Effects of change in calibration table:

Zero Baseline:

- Coordinate differences of 1-2mm (L1, L2) to be expected
- L3/L3+Tropo combinations correspondingly larger

IGS L3 PPP:

- Systematic coordinate changes N,E 1-3, Up 4-8 mm
- Individual antenna effect dominates
- Depending on antenna frequency dependency by 1-4 mm
- Site dependent

Conclusions + Outlook

TECHNISCHE UNIVERSITÄT DARMSTADT

- Facilty for easy and efficient calibration of antennas
- Good agreement with robot and field calibration
- All GNSS frequencies are calibrated
- Damping is measured
- Experiments on the near field are facilitated

- More than 100 antennas calibrated
- Routine service for German SAPOS and federal authorties

Future:

Complete system calibration by GNSS Signal simulator, frequency standard, calibrated components … (funding !)

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Vielen Dank!

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BKG