Federal Agency for
Cartography and Geodesy

The importance of ground surveys and how we do them?

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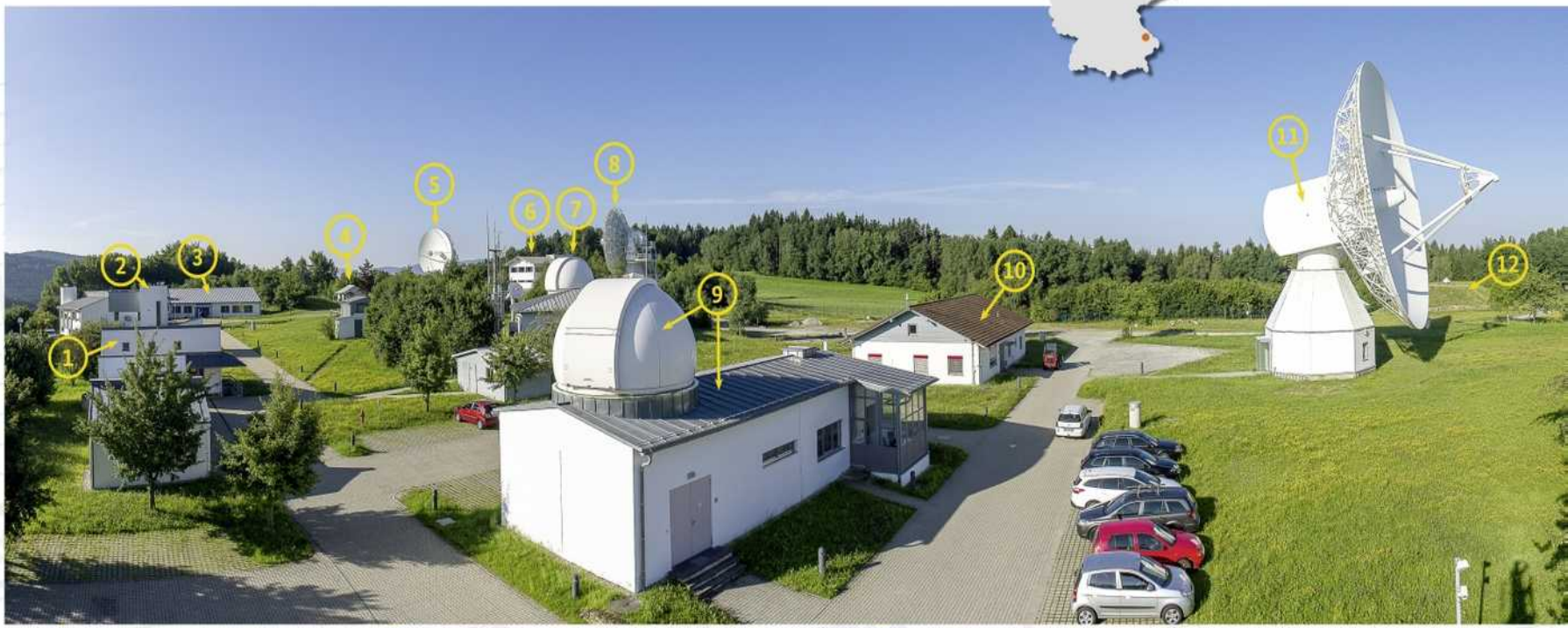
Federal Agency for Cartography and Geodesy

Bundesamt für
Kartographie und Geodäsie

Geodätisches Observatorium Wettzell

(Bayerischer Wald)

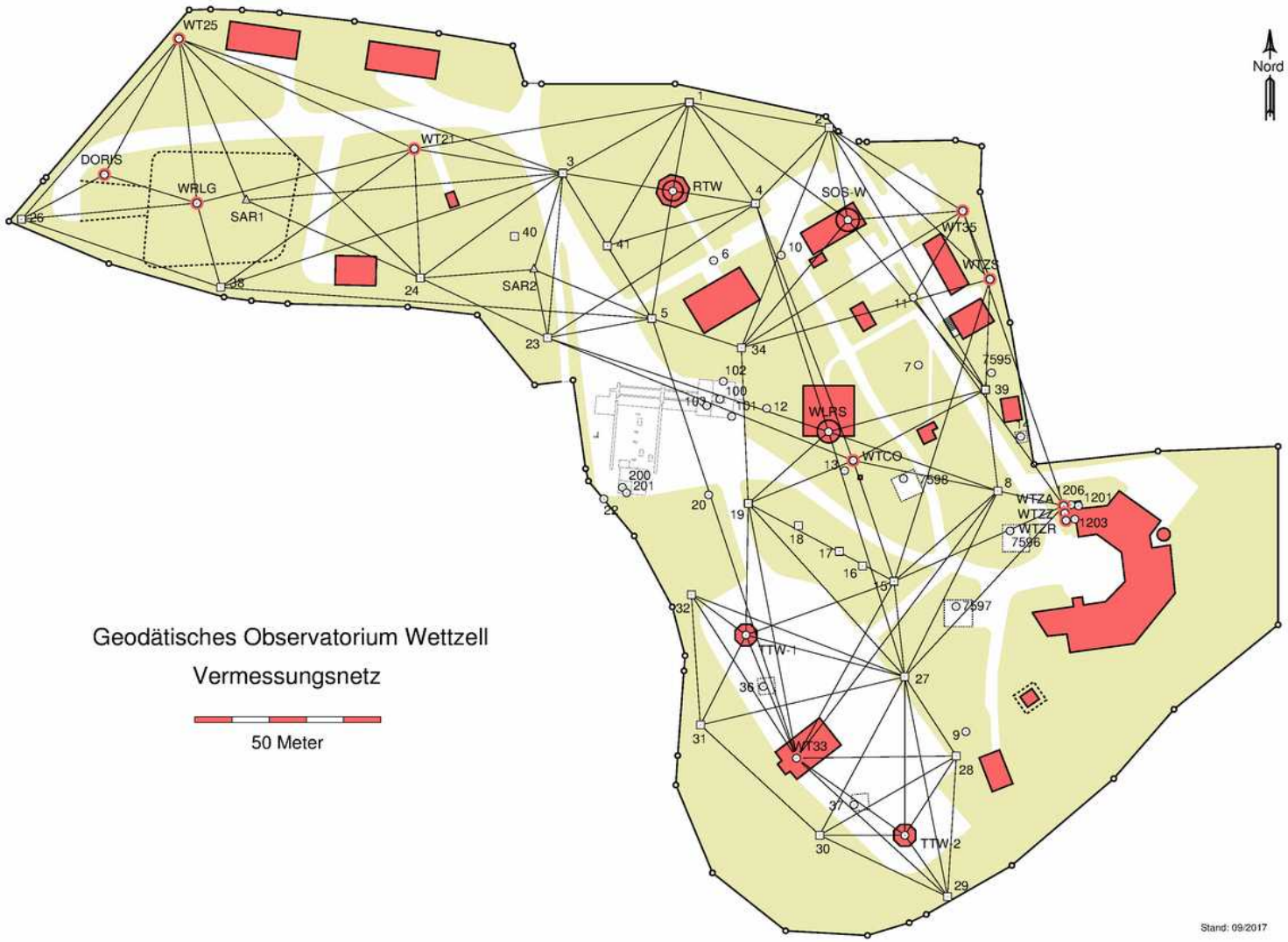


1 Zeitkeller
2 Turm mit Globales Navigationssatellitensystem (GNSS)
3 Hauptgebäude
4 Gravimeter 1
5 TWIN-Teleskop 1
6 TWIN-Betriebsgebäude
7 Wettzell Laser Ranging System (WLRS)
8 TWIN-Teleskop 2
9 Satellite Observing System-Wettzell (SOS-W)
10 Betriebsgebäude Radioteleskop
11 Das 20 m-Radioteleskop Wettzell (RTW)
12 Großringlaser G

Weiterführende Informationen

Bundesamt für Kartographie und Geodäsie -Geodätisches Observatorium Wettzell- • Sackenrieder Straße 25 • D-93444 Bad Kötzting • www.bkg.bund.de • www.fs.wettzell.de

Introduction
- Local Tie Network -



Introduction
- measurement equipment -

- Total Station, Laser-Tracker, Retro-Reflectors
- Angle & Range measurement

IVP Determination

GNSS-monuments: simple

VLBI- (or SLR-) telescopes: difficult

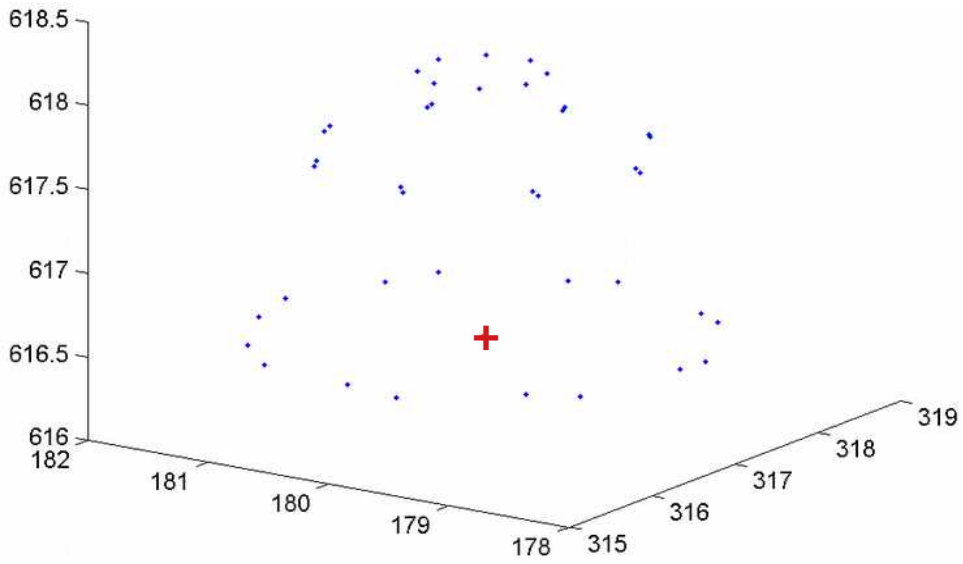
- Reference point: IVP (invariant point)
  - Intersection of azimuth and elevation axis
  - Not directly accessible
- observation of targets at the moving telescope
- construction of the invariant point
- Several hundred measurements per IVP determination

IVP Determination

- Mount a Retro-Reflector on the telescope
- Rotate in Azimuth & Elevation
- Measure from several different directions

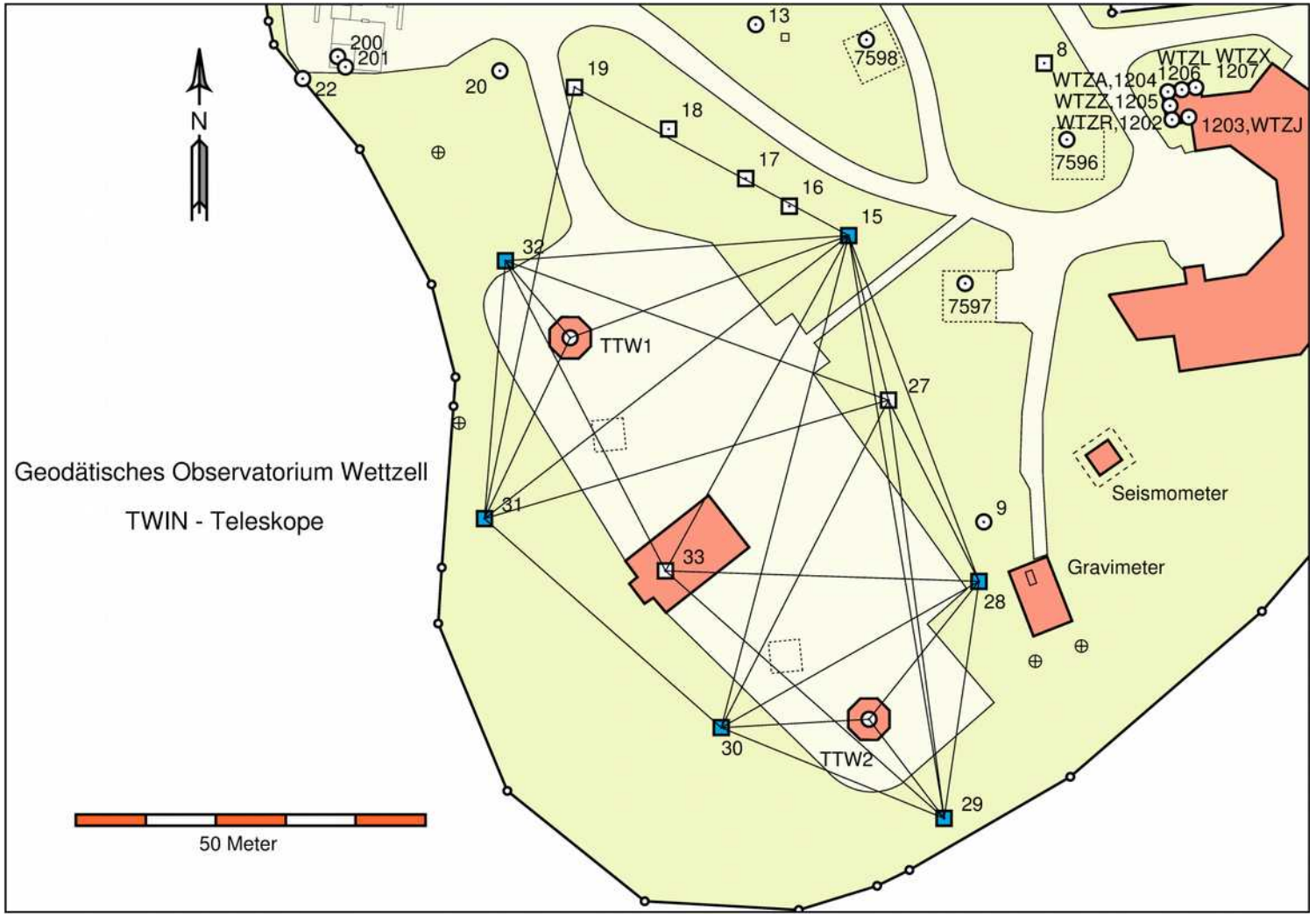
→ Result: Sphere with System Reference Point as center

Example: Satellite Observing System Wettzell

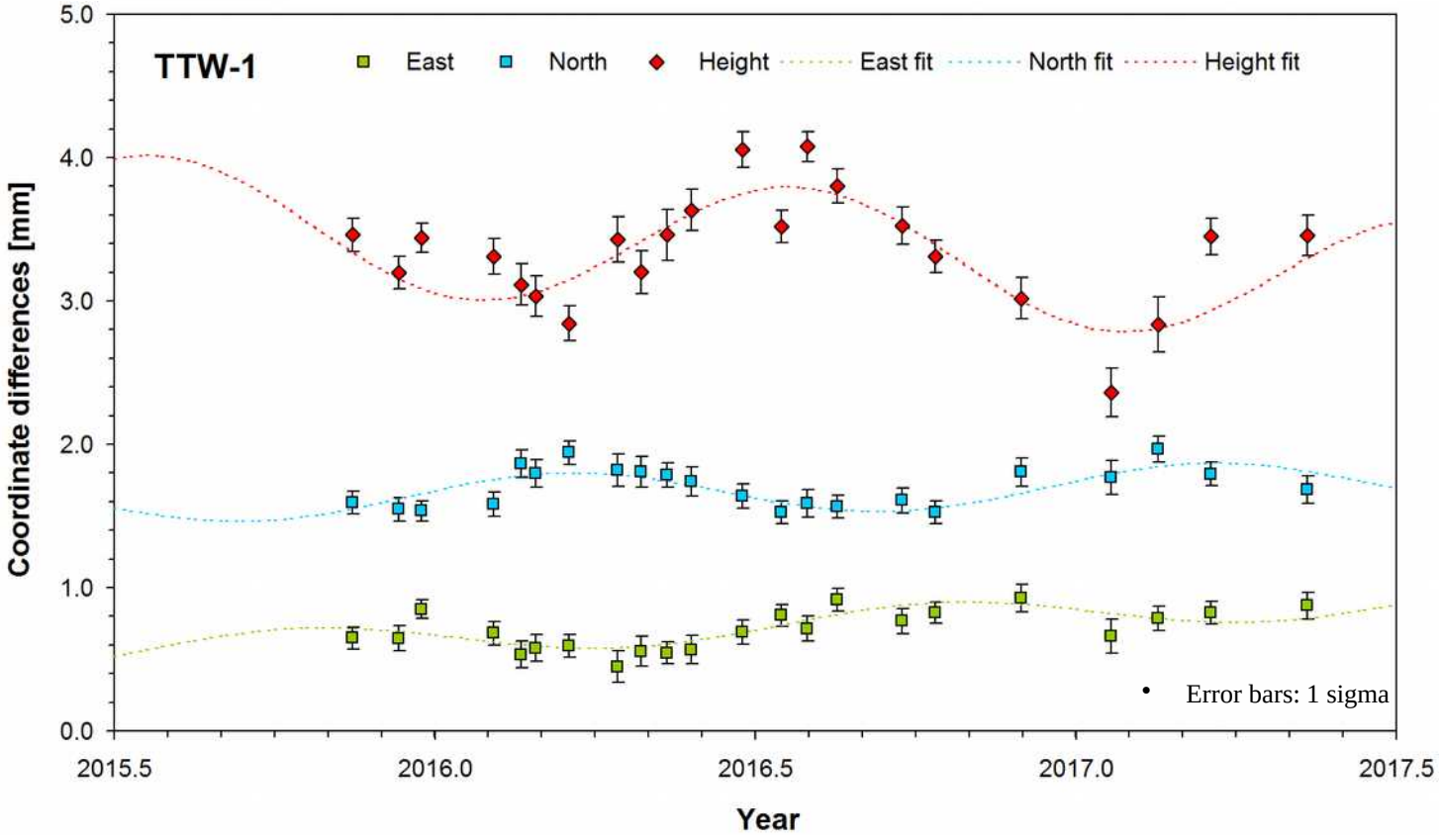


Requirement: Both axis do intersect!

Monitoring Network
- example TWIN Radiotelescopes -



VLBI Permanent Monitoring - reference point TTW-1 -



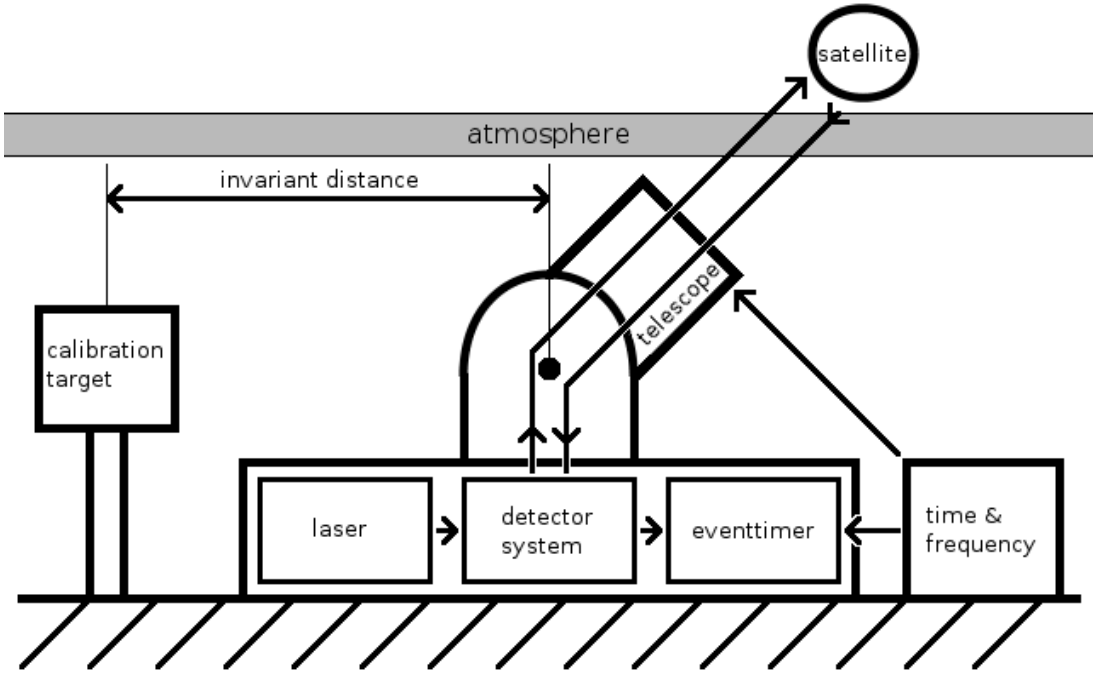
- Least-square-fit: $y = a + bt + c\cos(\omega t) + d\sin(\omega t)$ • mit $\omega = 2\pi / Jahr$

[LOSSIN, 2013]

Component	b [mm/y]	c [mm]	d [mm]	Amplitude [mm]	Phase [°]	rms error [mm]
TTW-1 East	0,18	0,031	-0,108	0,11	285,9	0,086
TTW-1 North	0,07	0,037	0,147	0,15	76,0	0,091
TTW-1 Height	-0,22	-0,405	-0,193	0,45	205,4	0,246

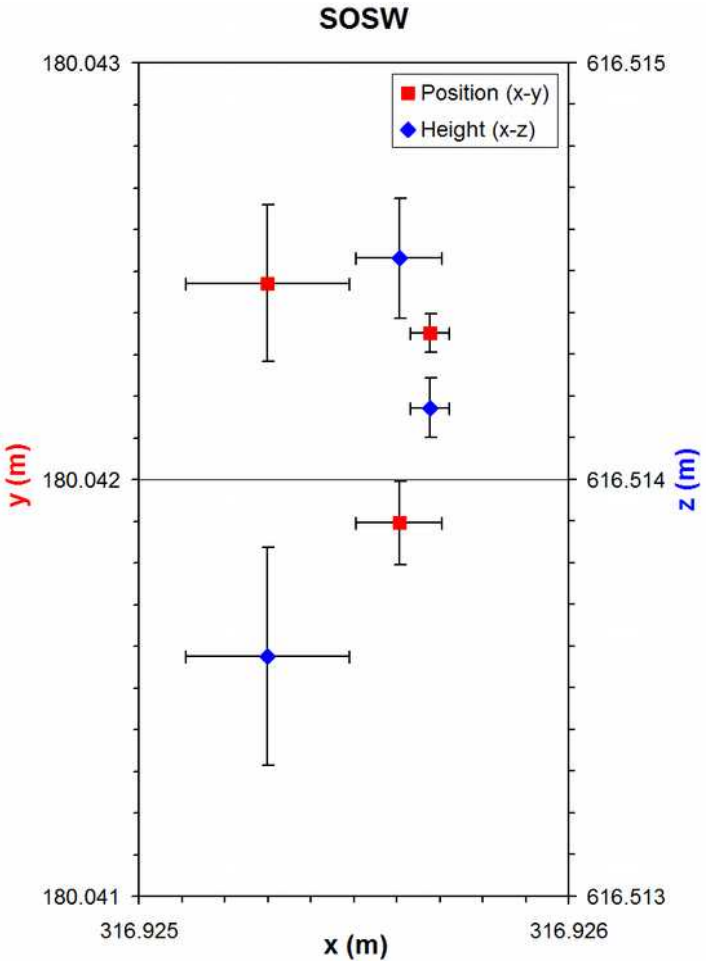
Satellite Laser Ranging
- principle -

- Time of flight measurement to determine the distance to objects in space.
- Reference is time of flight measurement to target of well known distance

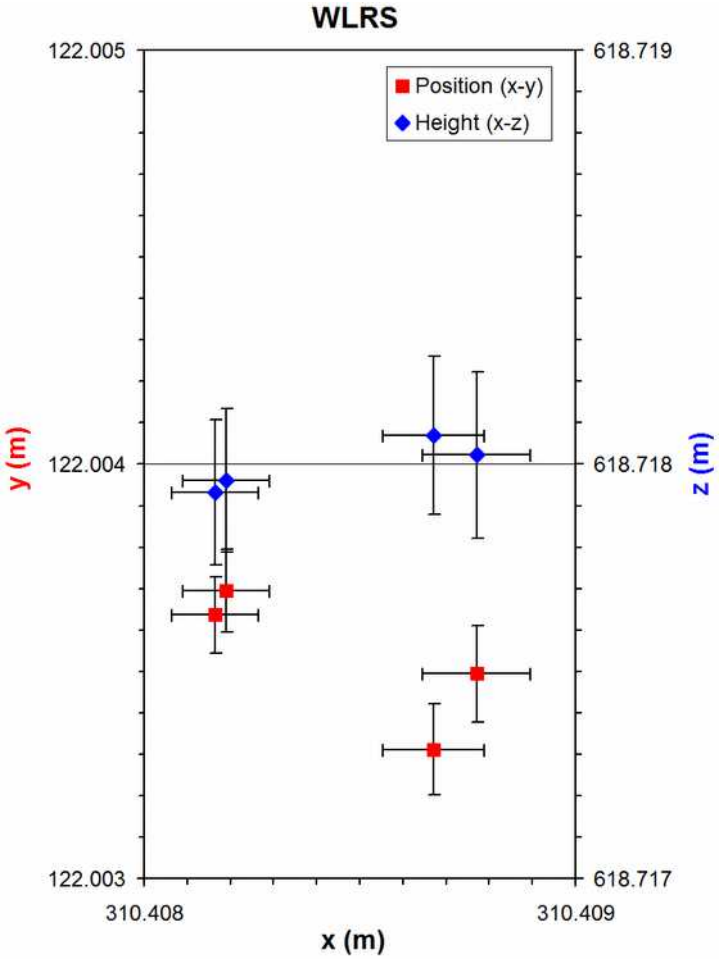


Satellite Laser Ranging
- reference point stability -

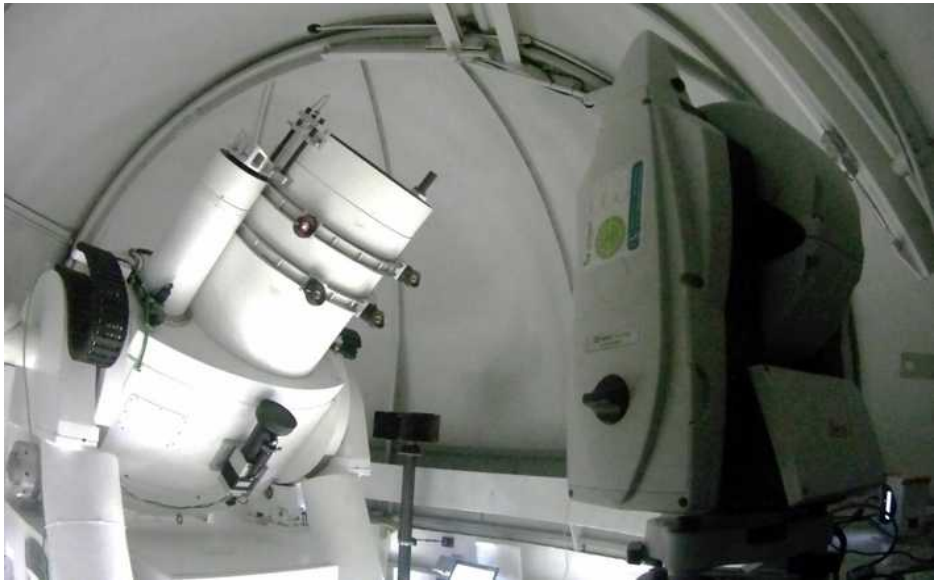
2009-2015

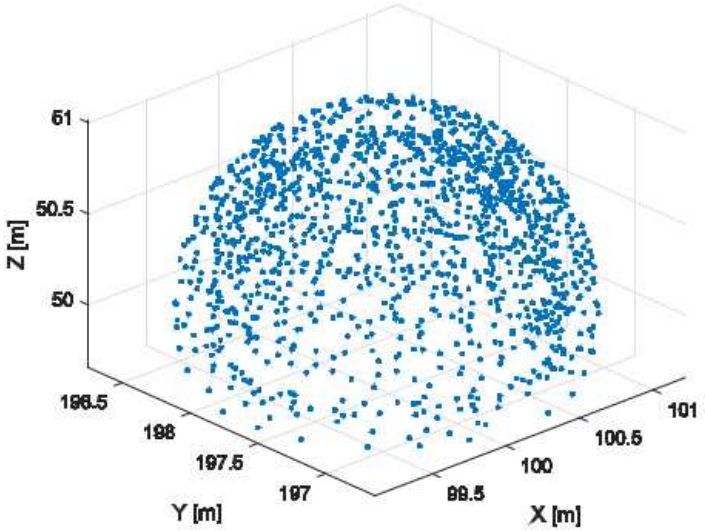


2012-2015



Satellite Laser Ranging
- SOSW axis intersection -

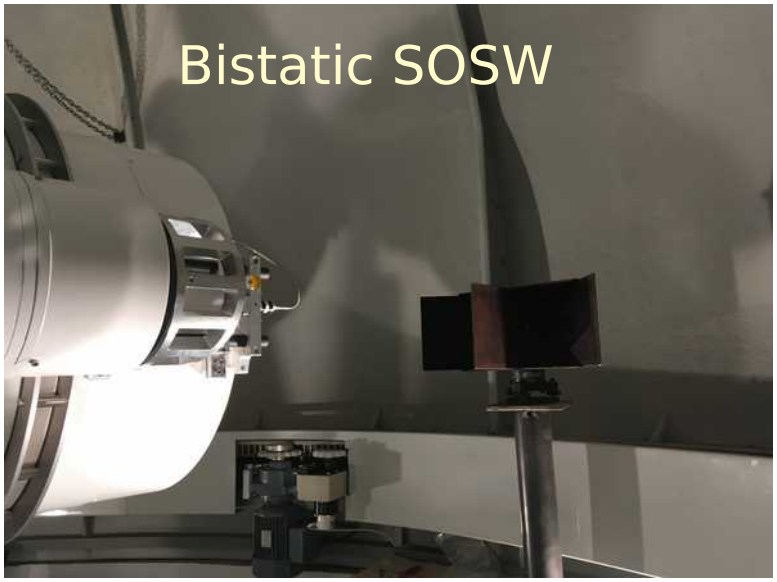


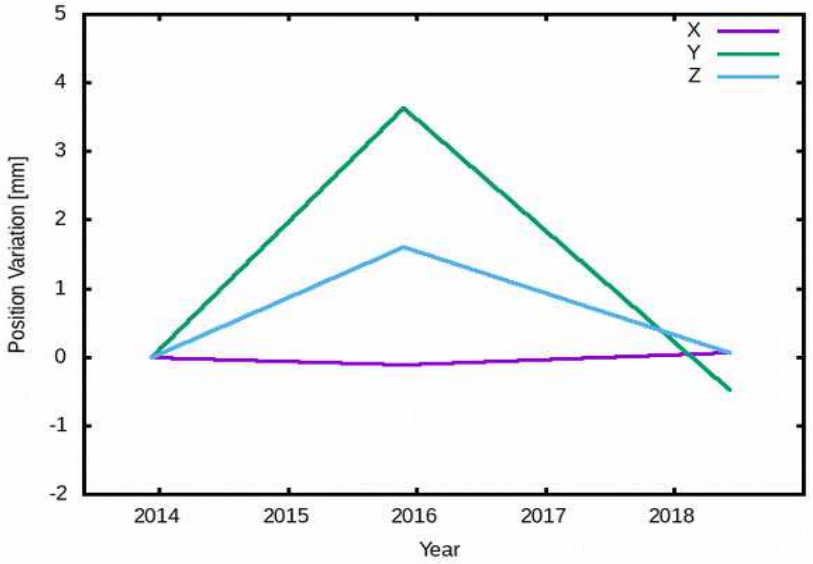


	X in m	Y in m	Z in m	e_{AO} in mm
IRP-I	100.16246	197.69374	50.01237	-0.03
IRP-II	**100.16246**	**197.69376**	**50.01234**	**-0.02**
Sphere	100.16247	197.69375	50.01234	–

[LÖSLER, “A Modified Approach for Process-integrated Reference Point Determination”]

Satellite Laser Ranging
- in-dome calibration targets -

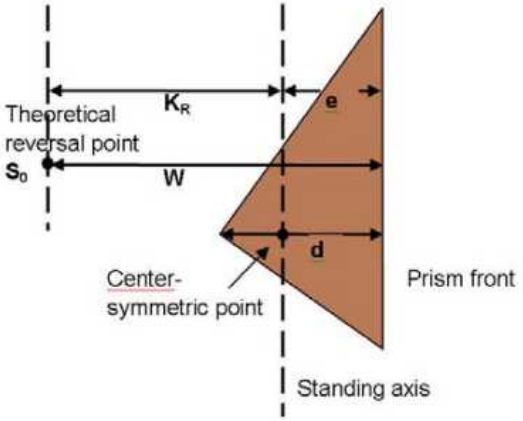




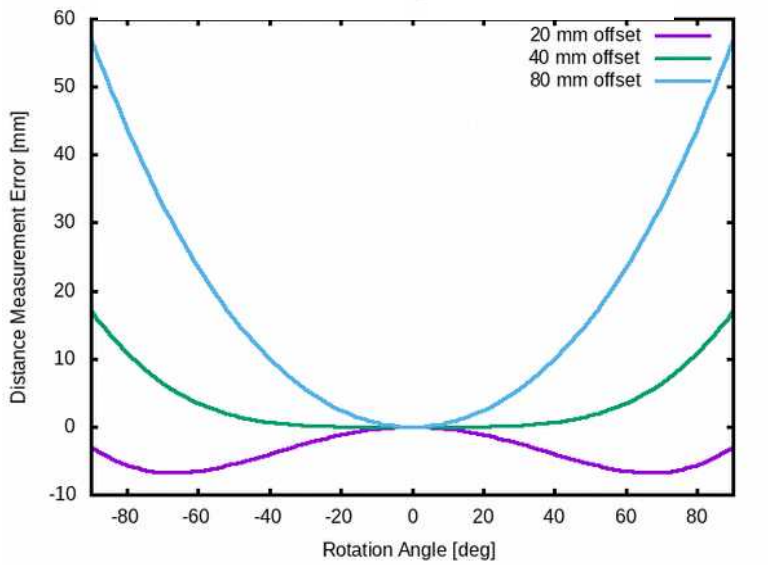
Satellite Laser Ranging
- common calibration target -

Custom target on motorized rotation stage
→ reflector constant TBD

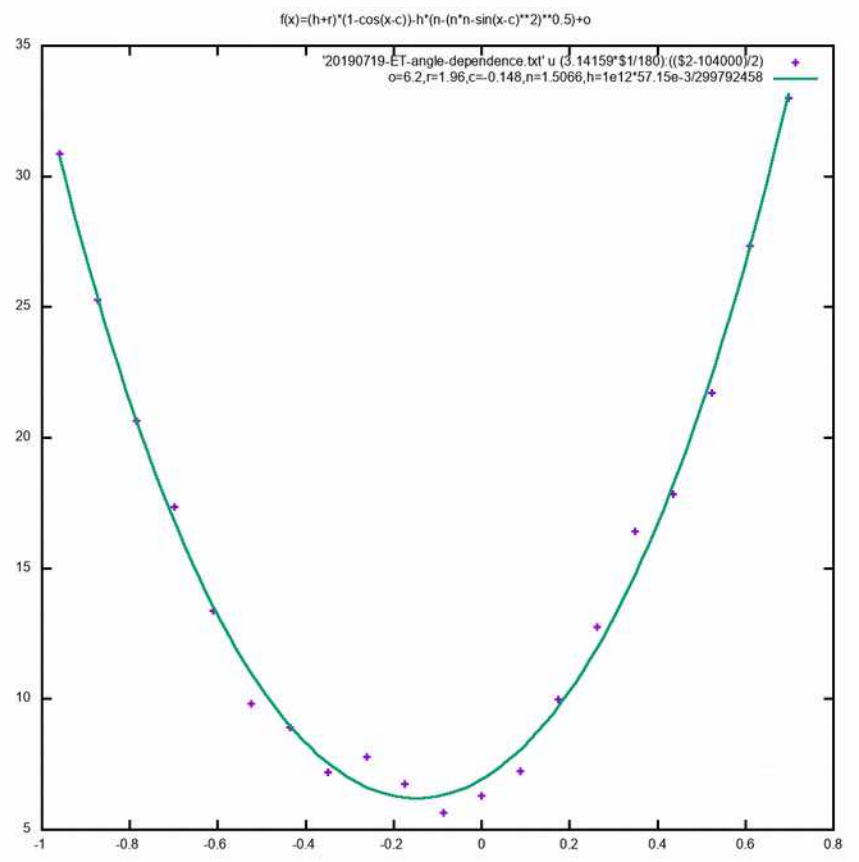
Satellite Laser Ranging
- reflector tilt measurement -



$$\Delta d = e \cdot (1 - \cos\alpha) - d \cdot \left(n - \sqrt{n^2 - \sin^2\alpha}\right)$$



[LEICA, “Surveying Reflectors”]



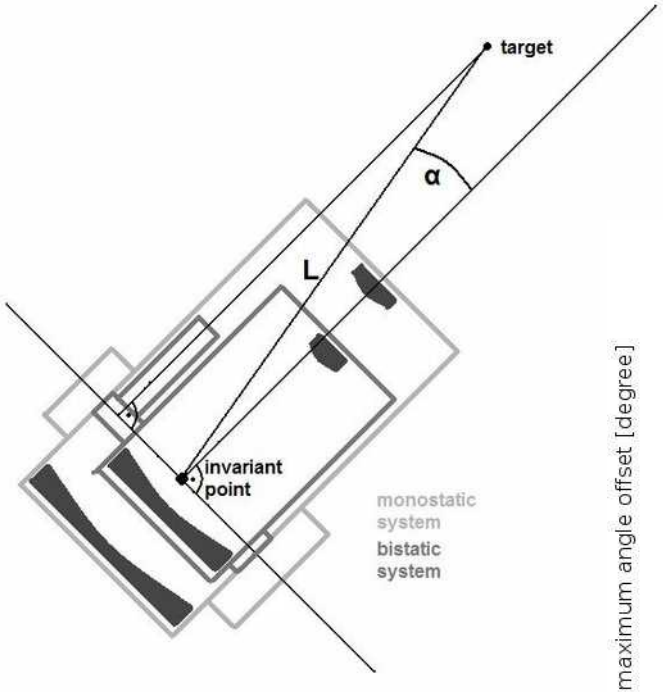
Satellite Laser Ranging
- bistatic calibration target -

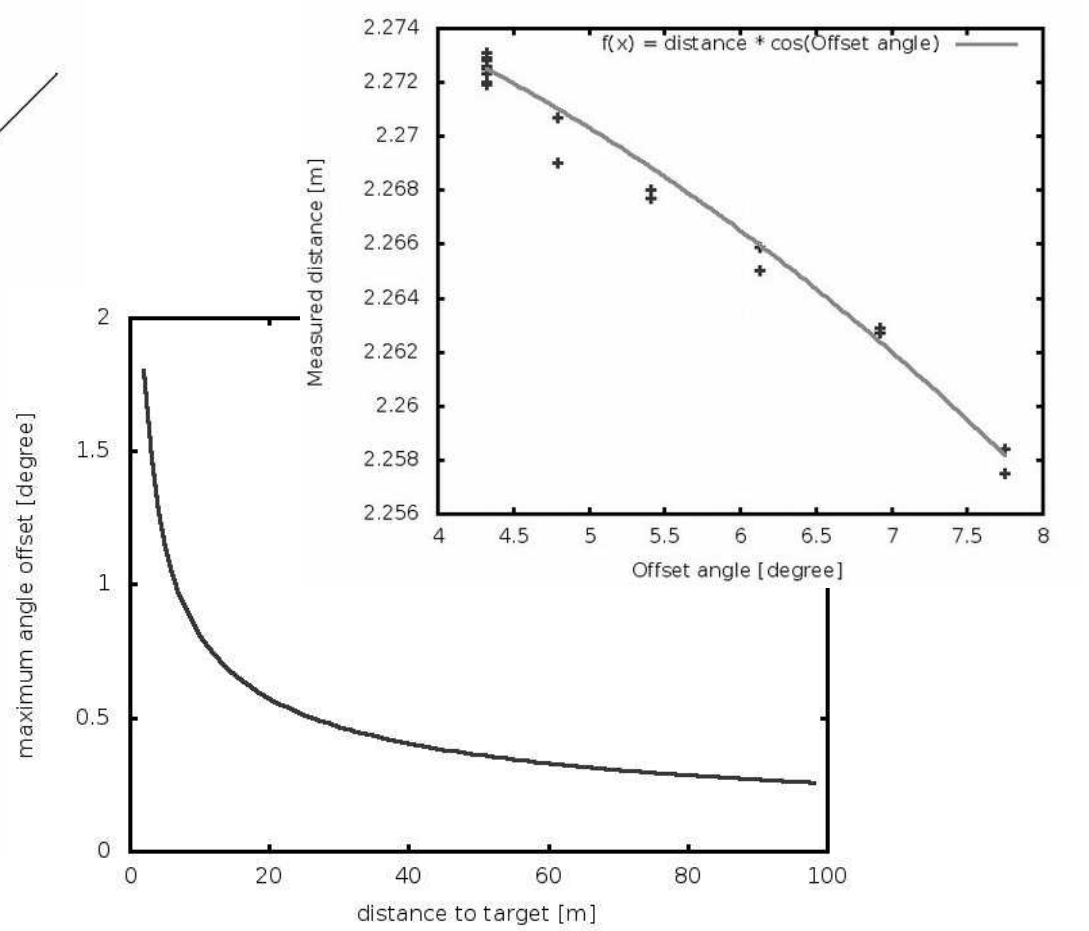
Attention:
- telescope azimuth pointing
  towards reflector position
- close to 0 degree elevation

Else: geometry bias

Satellite Laser Ranging
- geometry bias -

Plane wave front in the near-field cause geometry bias in case of offset pointing





Conclusion & Outlook

- System Reference Points seem to be stable at the 1 mm level (massive objects)
- Further verification of the stability of the Calibration Targets needed
  → especially sub-daily, seasonal variation
- Permanent monitoring of selected points planned
  → Redesign of Common Target (Station Fiducial) in progress
- Long-Term Goal: definition of a space-time reference point

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