



Bundesamt für
Kartographie und Geodäsie



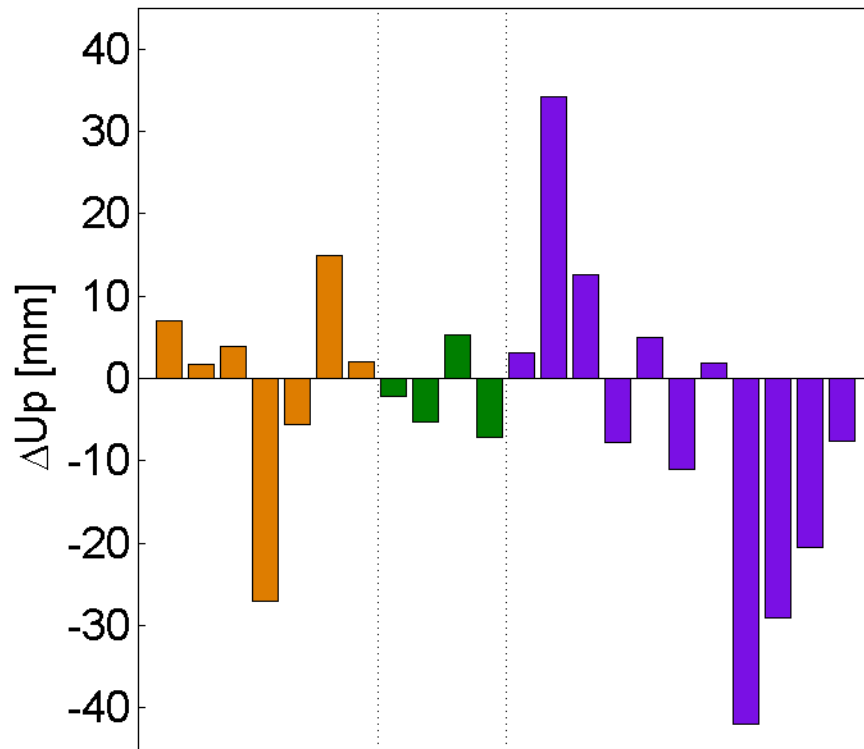
Ground survey and local ties on the Geodetic Observatory Wettzell

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The local tie problem



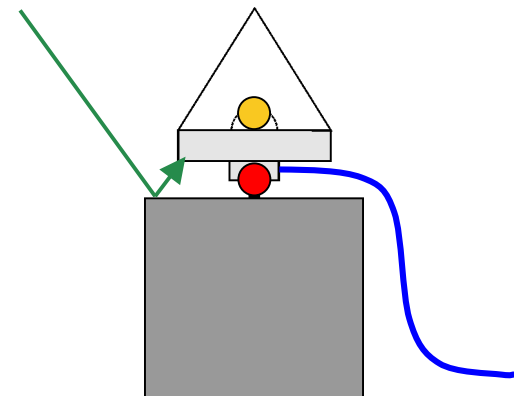
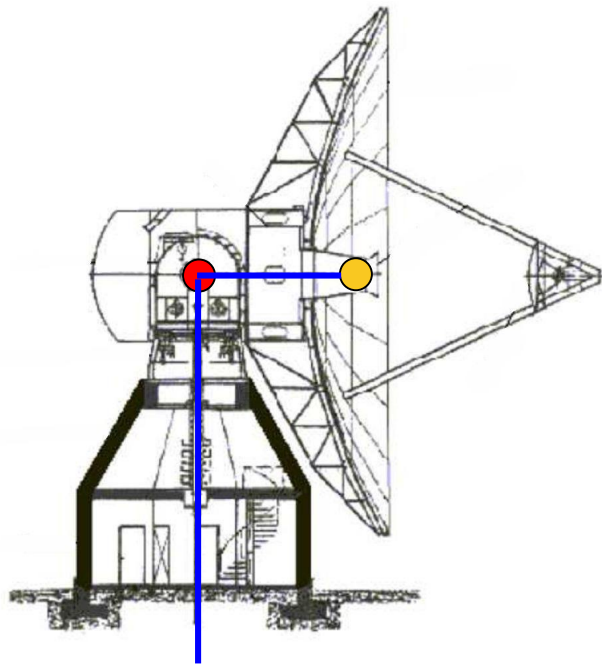
Local tie height differences at
Wettzell from ITRF2008D

From Steigenberger et al., REFAG 2010



Local effects degrading global solutions

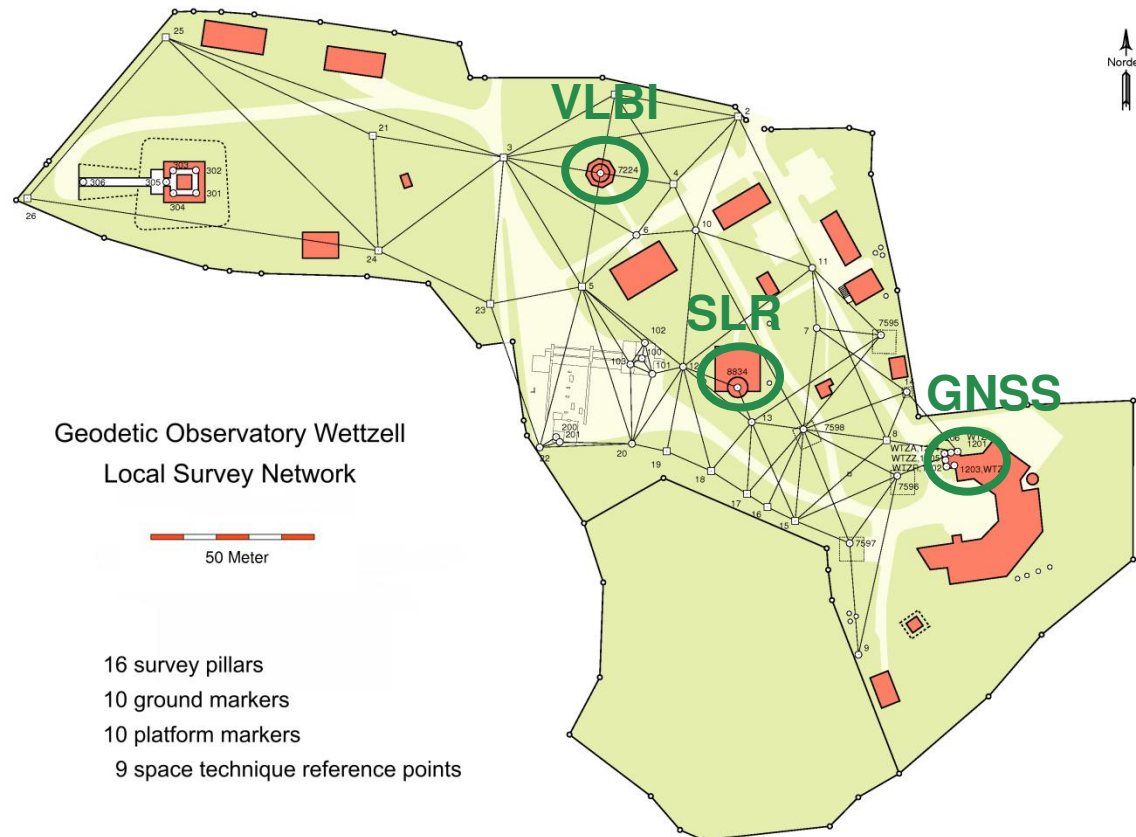
- local displacements of the antenna reference point
- insufficient knowledge or variations of the phase center w.r.t. the reference point
- delays in cables and electronic components
- Multipath effects





Local ground survey network

- Measuring the ties between the space technique reference points
- Monitoring the local stability of the reference points
- Identifying unstable monuments
- Realisation by classical survey techniques (theodolites, tachymeter, levels)



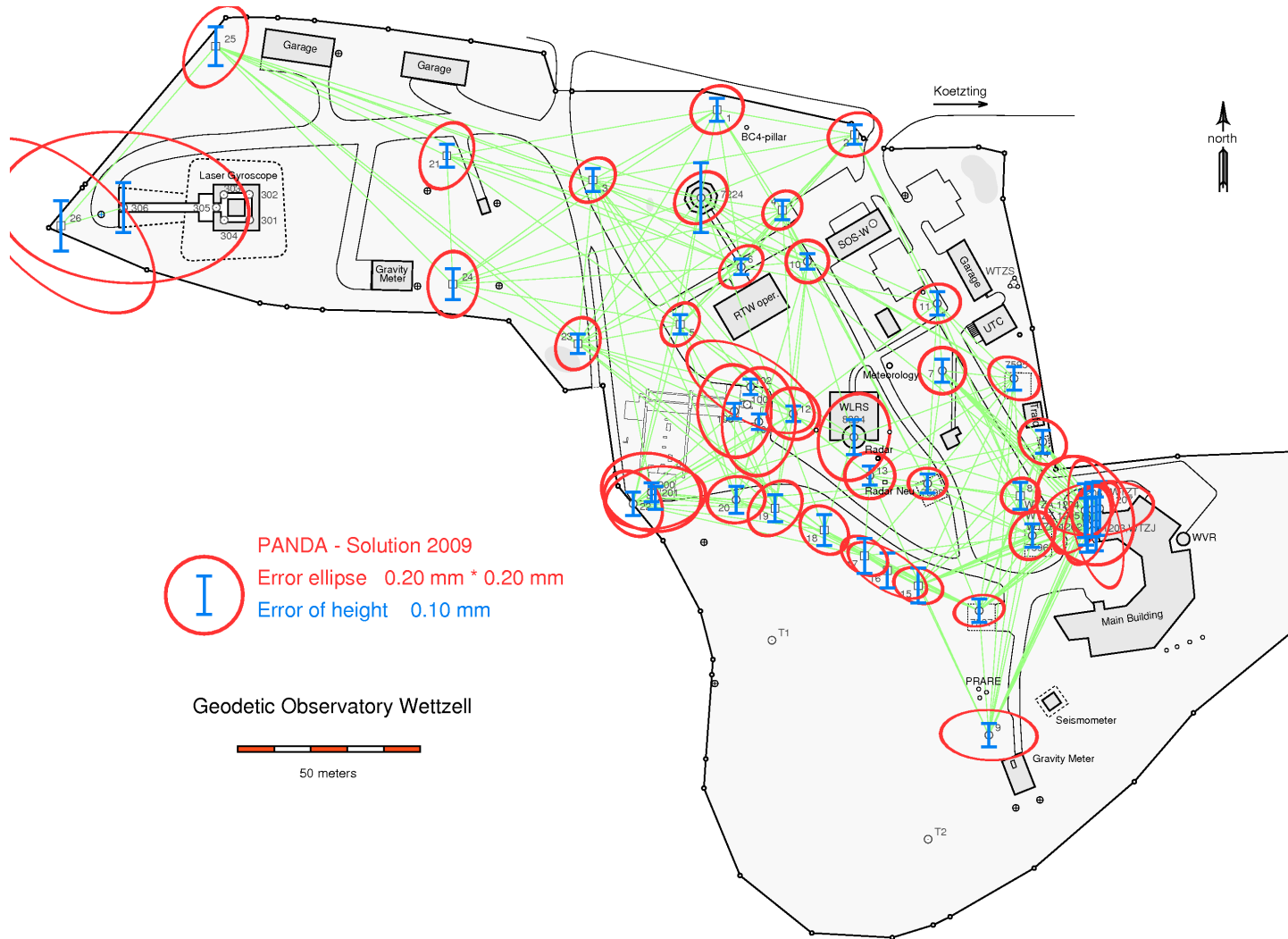


Measuring campaigns

Epoch	Authors	number of pillars	number of ground markers	number of platforms	total number (location)	total number (height)
1985	Kipar/Stichling	7	4	4	15	15
1990	Klesen	6	4	3	13	13
1993	Lang	6	6	5	17	9
1995	Fundheller	6	4	4	14	14
1996	Lang	12	8	5	25	17
1997	Jocham	6	7	8	21	21
2000	Zernecke	16	9	9	19	34
2002	Fischer/Becker	16	10	11	37	37
2004	Becker	15	10	11	-	36
2006	Becker	15	10	10	5	35
2009	Mähler	16	10	10	36	36



Solution of 2009 campaign

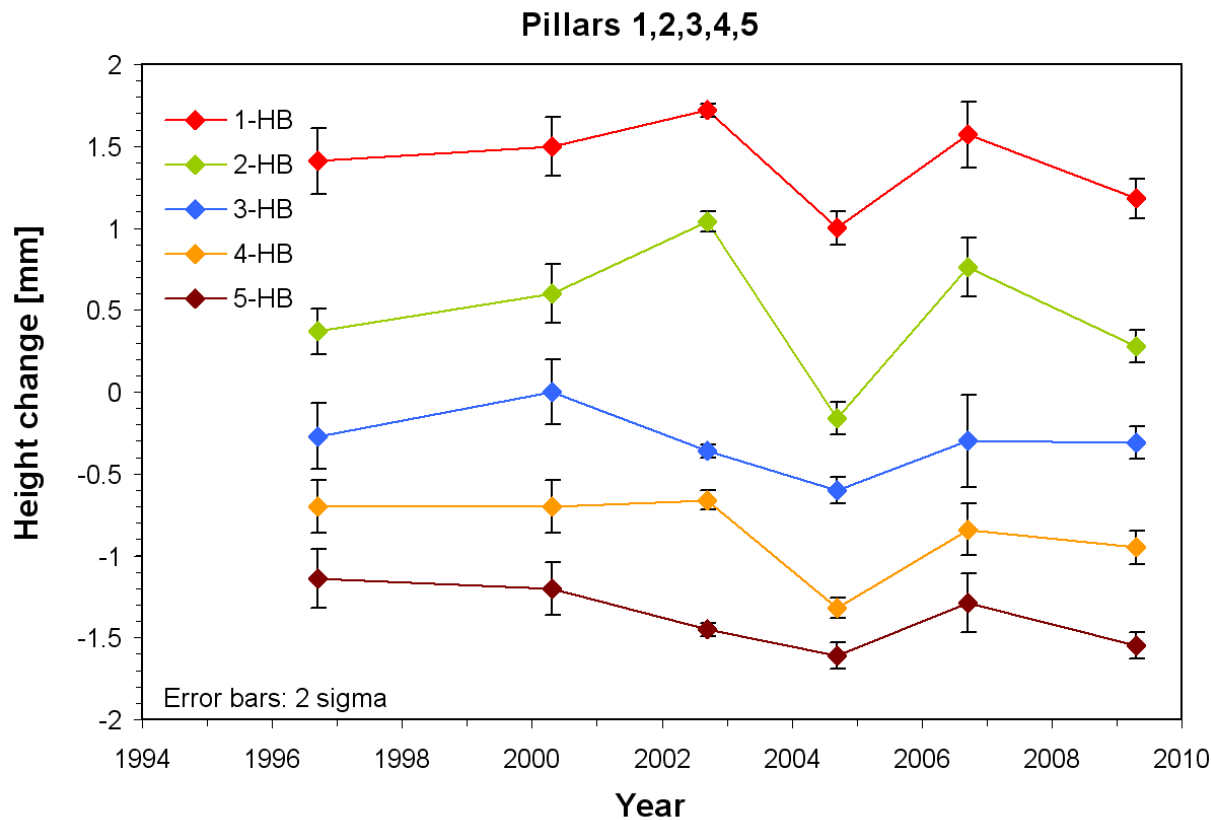




Height variations

Pillars 1 – 5 (around radio telescope)

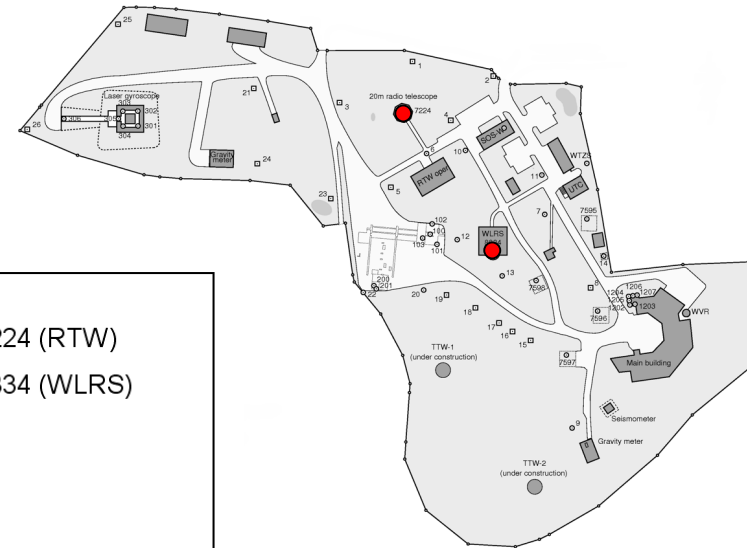
- Stable over 15 years within ± 0.5 mm
- subsidence between 2002 and 2004



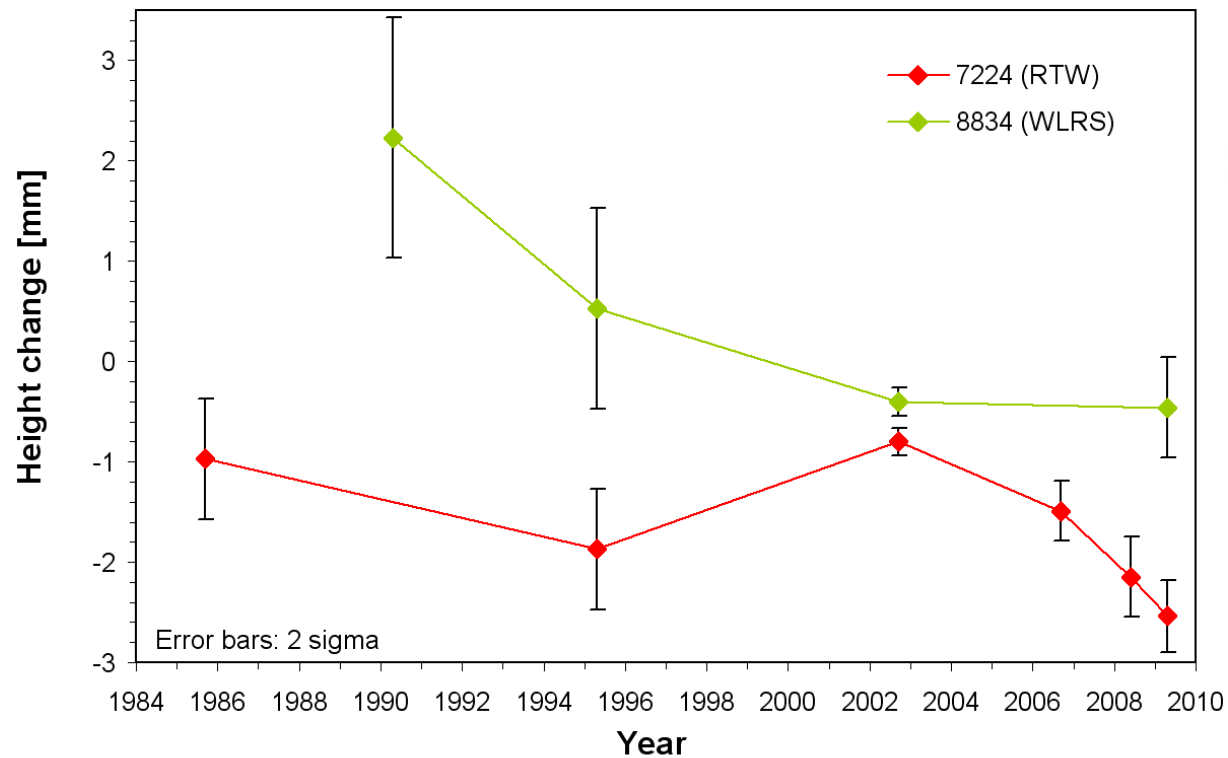


Reference points VLBI and SLR

- larger error bars
- abrasion of elevation bearing after 2002



Reference points VLBI (RTW), SLR (WLRs)



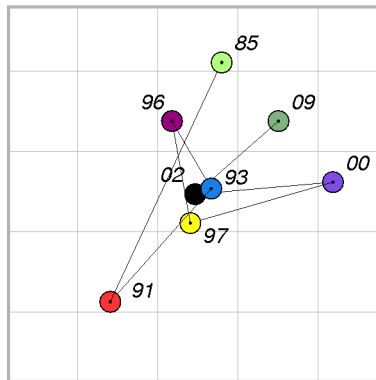


Horizontal displacements

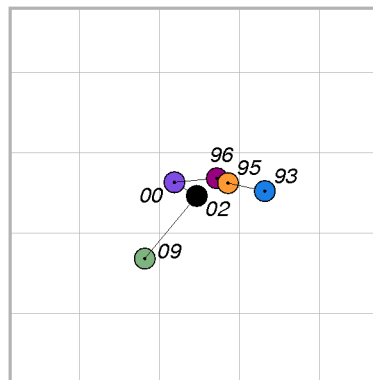


Ground marker 9, 11 Platforms 7597, 7598

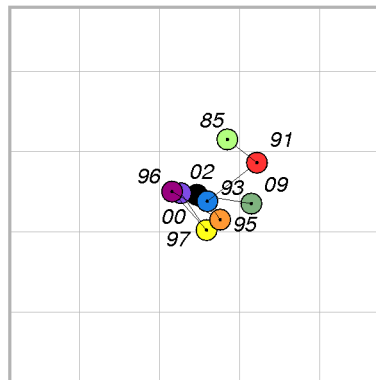
Point 009



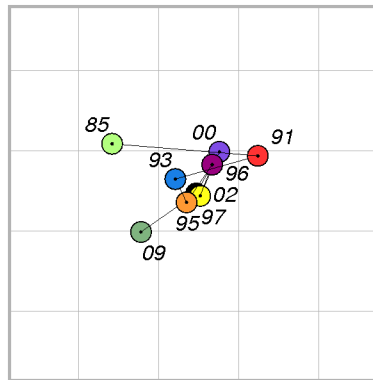
Point 011



Pad 7597



Pad 7598



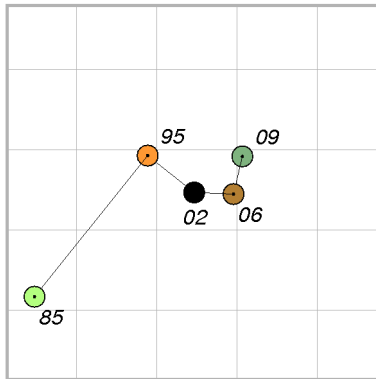


Horizontal displacements

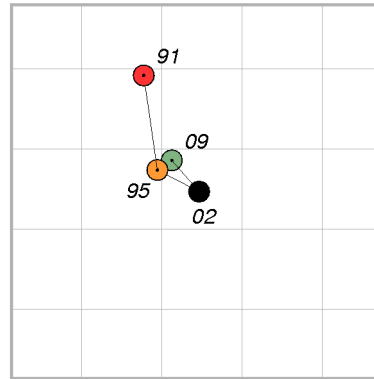


Reference points 7224, 8834, 1202, 1204

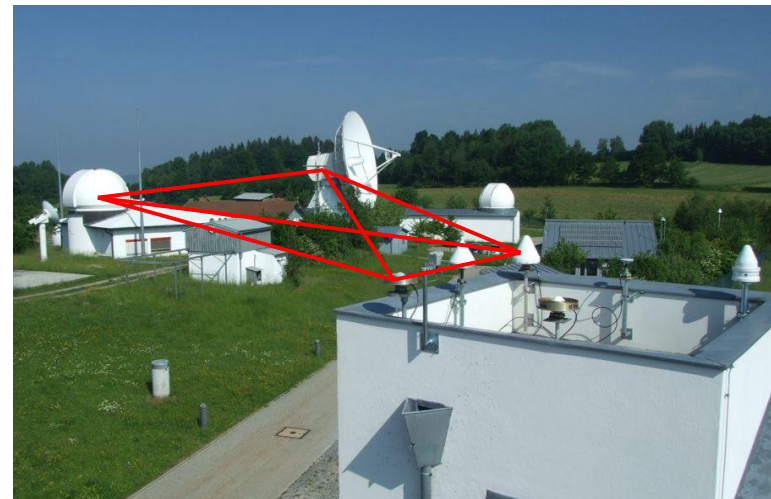
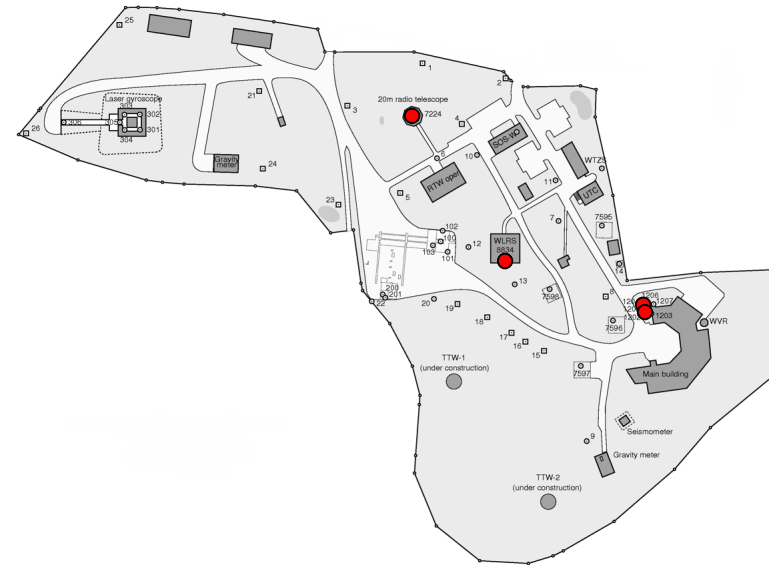
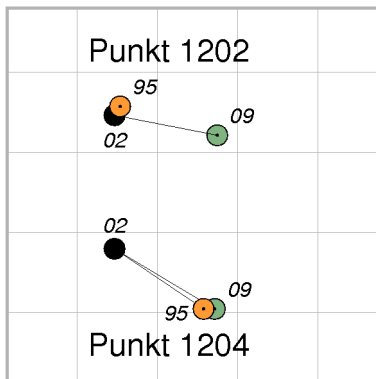
RTW 7224



WLRs 8834



Point 1202, 1204





Transformation into the global geocentric system

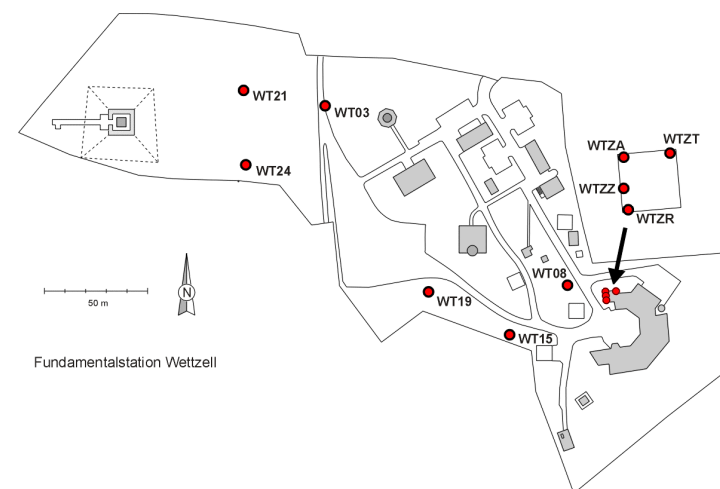
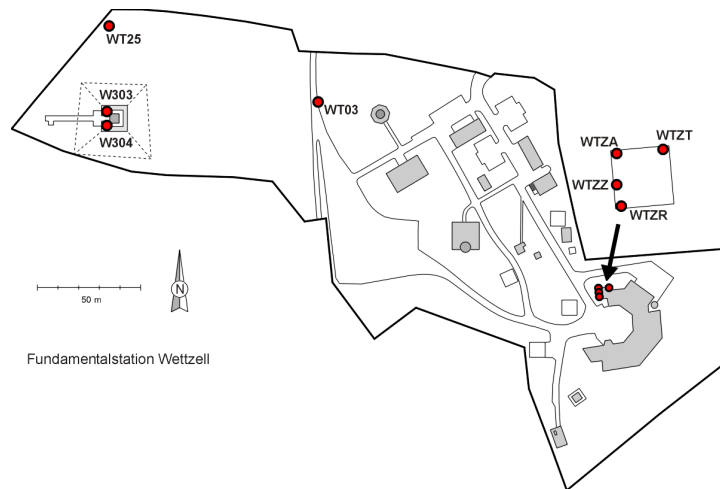
2 GPS campaigns over 4 and 8 days

Combination of (global) GPS solutions with (local) terrestrial solution

Downweighting of GPS solutions

GPS: Orientation

Ground survey: Scale





Ties in the local system

Campaigns 2000 – 2002:

Monument	East	North	Up
7224 (RTW)	269.71763	187.68928	622.46626
8834 (WLRS)	310.40892	122.00340	618.71835
1202 (WTZR)	376.04271	97.53539	619.36530
1204 (WTZA)	375.55467	100.55705	619.25295

Distances:

Monuments	Distance [m]
7224 - 8834	77.35931
7224 - 1202	139.43587
8834 - 1202	70.04924
1202 - 1204	3.06288

Ties in the global geocentric system

Epoch 266 / 2002

Monument	X (4075...)	Y (931...)	Z (4801...)
7224 (RTW)	539.79484	735.36954	629.43206
8834 (WLRS)	576.76821	785.56424	583.62893
1202 (WTZR)	580.59188	853.76594	568.11113
1204 (WTZA)	578.40099	852.76439	570.00272

Distances:

Monuments	Distance
7224 - 8834	77.35932
7224 - 1202	139.43587
8834 - 1202	70.04923
1202 - 1204	3.06288

Difference
to local
distances:

Difference
0.011 mm
-0.002 mm
-0.015 mm
-0.004 mm



Invariant points (IVP)

- intersection of azimuth and elevation axis
- usually not directly accessible
- observation of markers at the moving telescope
- construction of the invariant point
 - independent determination of azimuth and elevation axis, intersection
 - determination of the center of elevation arcs at different azimuths, center of azimuth circle
 - 3D least square adjustment (sphere, const. distance)



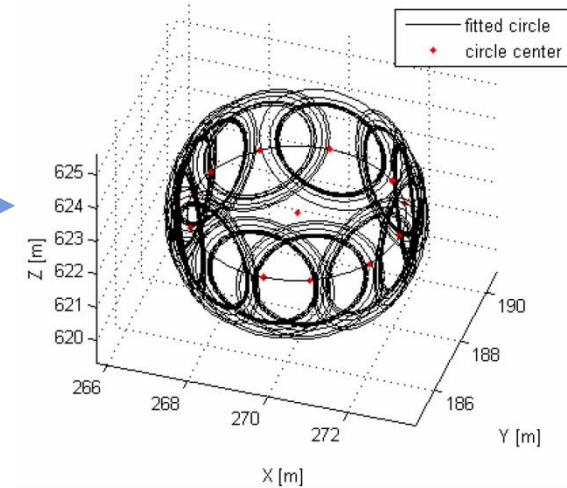
Example 1 of IVP determination



Radio Telescope Wettzell (Lösler, 2008)

Tachymeter data:

Method	East	North	Up
2D adjustment + height (NetzCG)	269.71713	187.69011	622.46484
3D adjustment (JAG3D)	269.71715	187.69011	622.46482
circle adjustment	269.71720	187.69008	622.46502
max. difference	0.07 mm	0.03 mm	0.2 mm



Laser tracker data:

Method	East	North	Up
3D adjustment (JAG3D)	269.71739	187.69056	622.46506
Difference to tachymeter data	0.24 mm	0.45 mm	0.24 mm



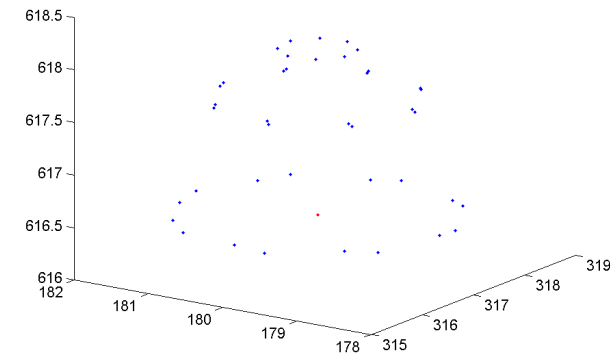
Example 2 of IVP determination



- Satellite Observing System Wettzell (Mähler, 2009)

Campaign 09-23-2009:

Method	East	North	Up
geodetic 3D adjustment (PANDA)	316.92439	180.04240	616.51425
sphere adjustment (MatLab LSGE-bib.)	316.92438	180.04237	616.51454
circle adjustment	316.92438	180.04250	616.51454
max. difference	0.01 mm	0.13 mm	0.29 mm



Campaign 09-01-2009:

Method	East	North	Up
geodetic 3D adjustment	316.9253	180.0426	616.5134
Difference to above	0.9 mm	0.1 mm	0.85 mm



- The space technique reference points show no significant displacements w.r.t. the local network
- Good repeatability, also when using different instruments → small systematic errors
- Stable markers show displacements not exceeding 2-3 mm in 24 years
- Unstable markers can be clearly identified when the network is made up by a sufficient number of markers forming a stable geometry
- Construction work is a major source of marker displacements
- Determination of invariant points:
 - Different adjustment techniques yield the same results within ± 0.15 mm
 - Difference between tachymeter and laser tracker results do not exceed 0.5 mm
 - Different campaigns yield differences up to 1 mm (network geometry, environmental conditions, deformations)
- The precision of the local ties in Wettzell are in the order of 1-2 mm