The 2002 local tie survey at the Onsala Space Observatory

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IVS VLBI monument
IGS GPS monument

The IVS VLBI monument

- Concrete telescope tower (ca 12 m).
- Telescope platform with azimuth encoders.
- Whole receiver cabin movable in elevation.
- No physical elevation axis, and no elevation axis endpoints.

The IGS GPS monument

Special difficulties at Onsala

- The IVS reference point does not exist as physical point and cannot be observed directly.
- The endpoints of the telescope elevation axis cannot be observed directly.
- The VLBI-telescope is enclosed by an optically opaque radome.
- The IGS reference point is located inside the GPS-monument and thus hardly accessible.

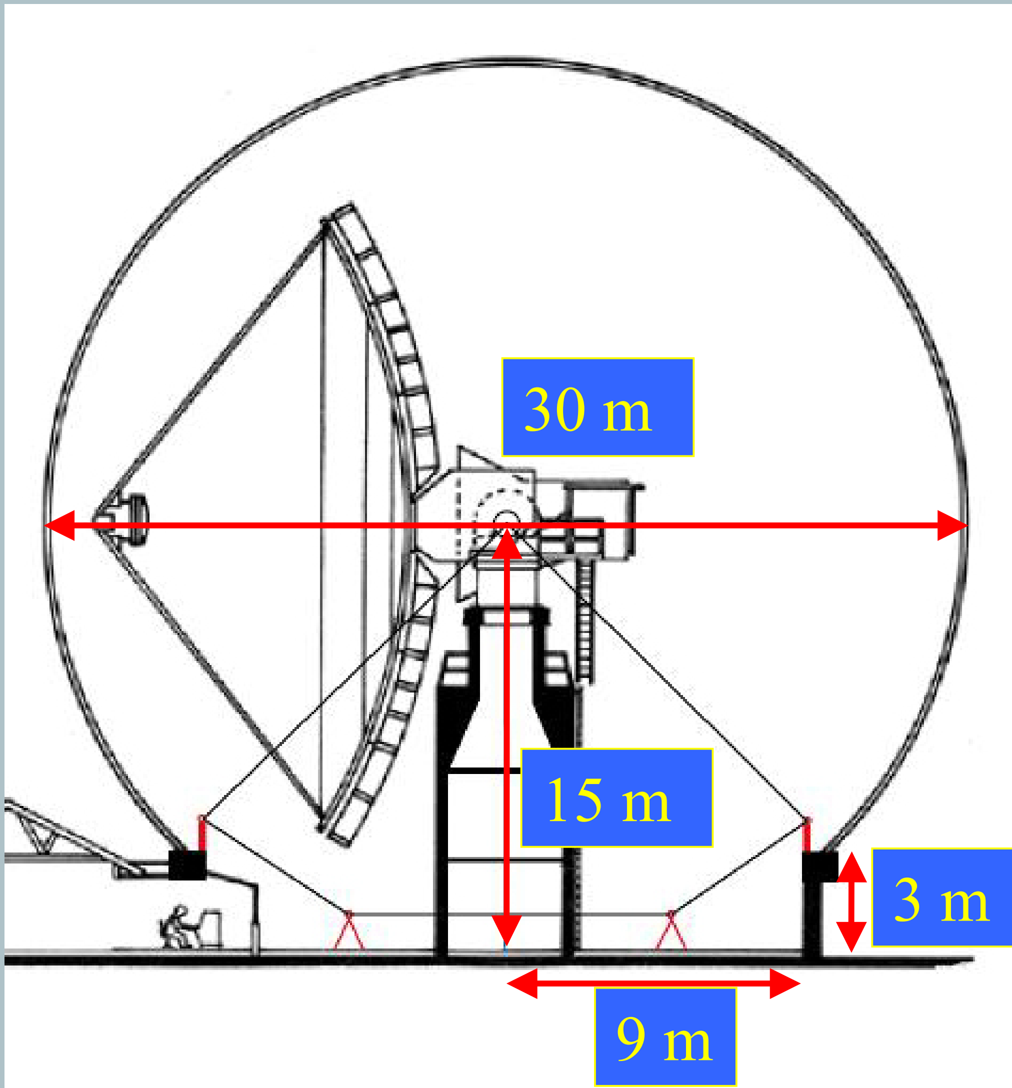
Project strategy

Establishment of new survey pillars inside the radome plus additional markers for the connection to the existing local network.

a) Local network measurements and the IGS-reference point.

b) Telescope measurements inside the radome to determine the IVS-reference point.

c) GPS observations on local network points.



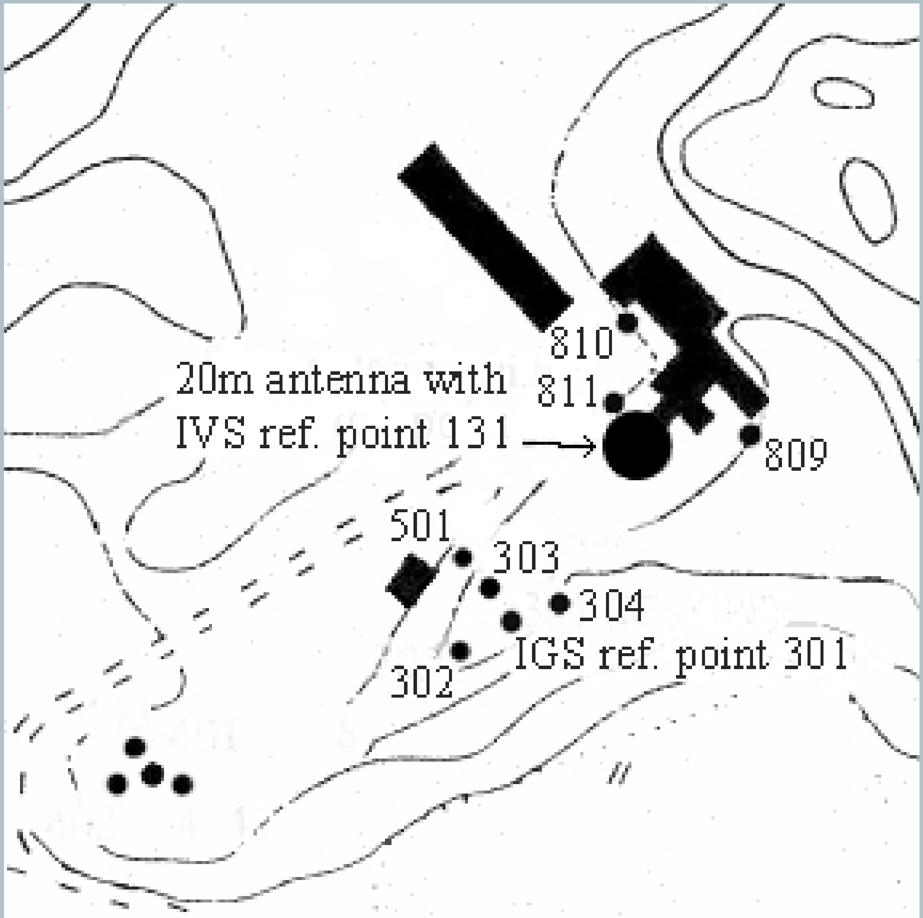
- New survey pillars on the radome foundation wall to achieve reasonable zenith distance measurements (ca 40 gon).
- New bottom markers to connect to outside network.
- Views through opened doors and windows.

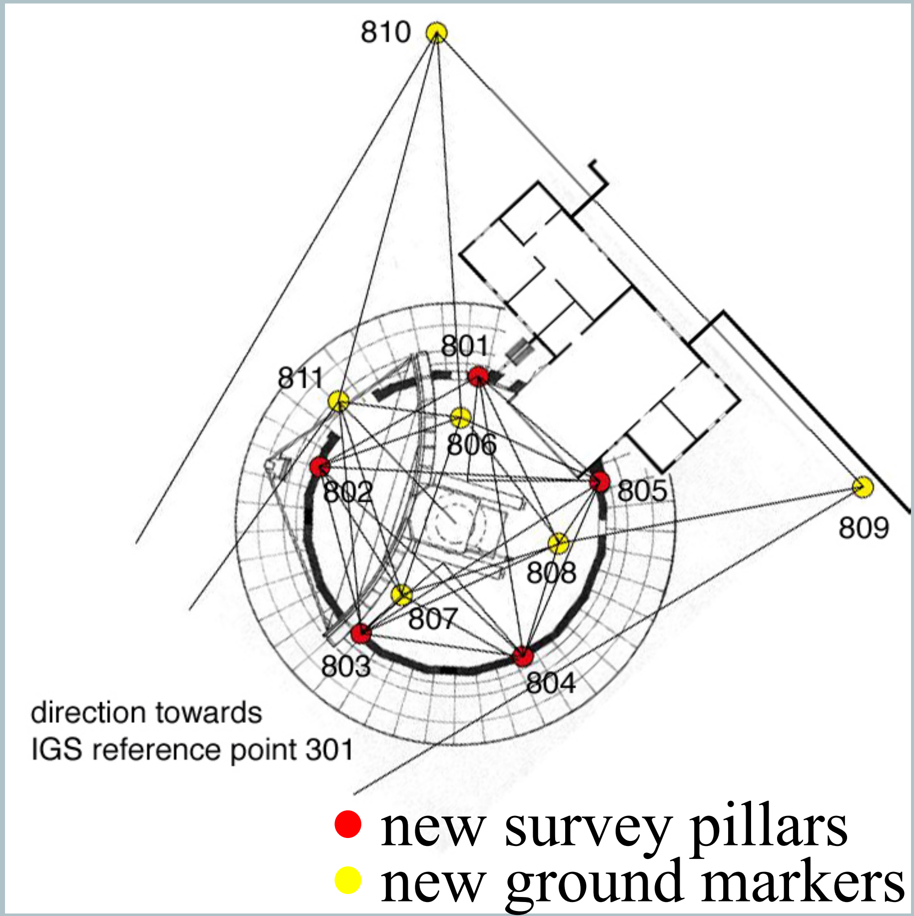
New survey pillars and markers

5 new survey pillars on the radome foundation wall.

3 new ground markers inside the radome building plus additional outside markers.

The local network





Local network measurements

- Horizontal directions: Leica T2002.
- Horizontal distances: Leica TCR1102.
- Precise digital leveling: Zeiss DINI 10T.
- Data analysis with the commercial software Netz2D of the Universität Karlsruhe and in-house leveling data analysis software.
- Mean h./v. standard deviations: ± 0.2 mm / ± 0.1 mm.
- For the IGS-reference point: ± 0.2 mm / ± 0.6 mm.

Telescope measurements (1)

Epoch-1:

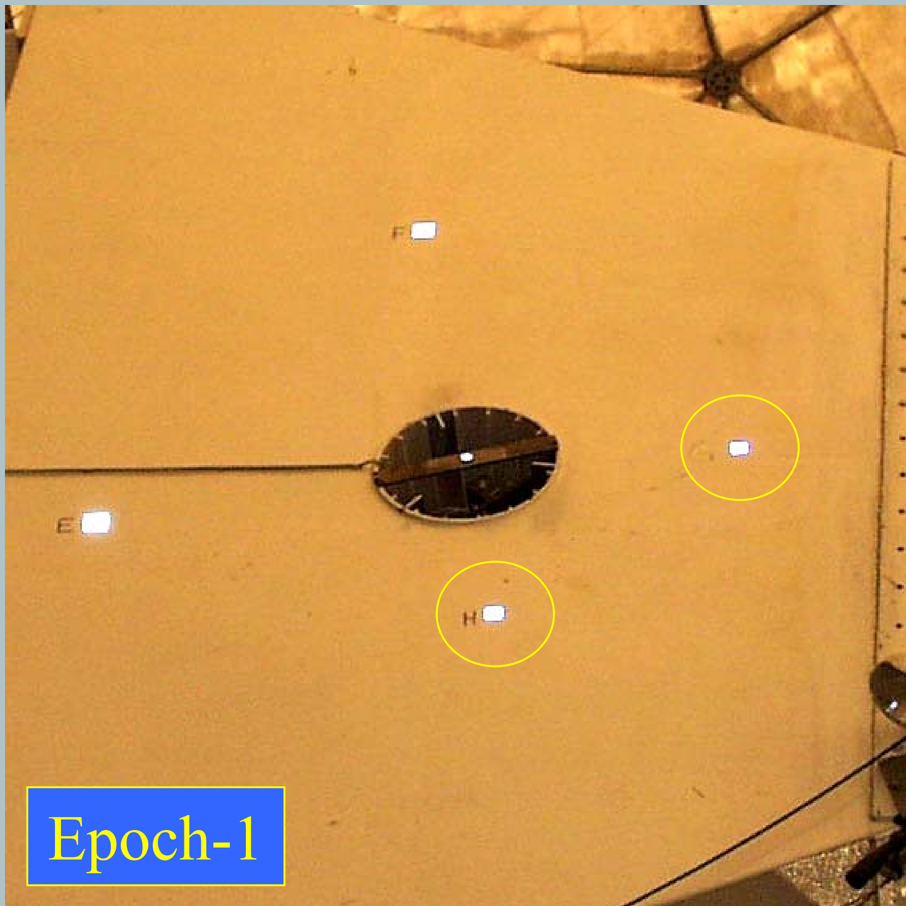
- Installation of target markers on the telescope cabin, two on each side.
- Positioning the telescope in 15 different azimuth and 10 different elevation positions.
- Simultaneous observation of the target markers with two theodolites on baselines formed by pairs of two survey pillars each.

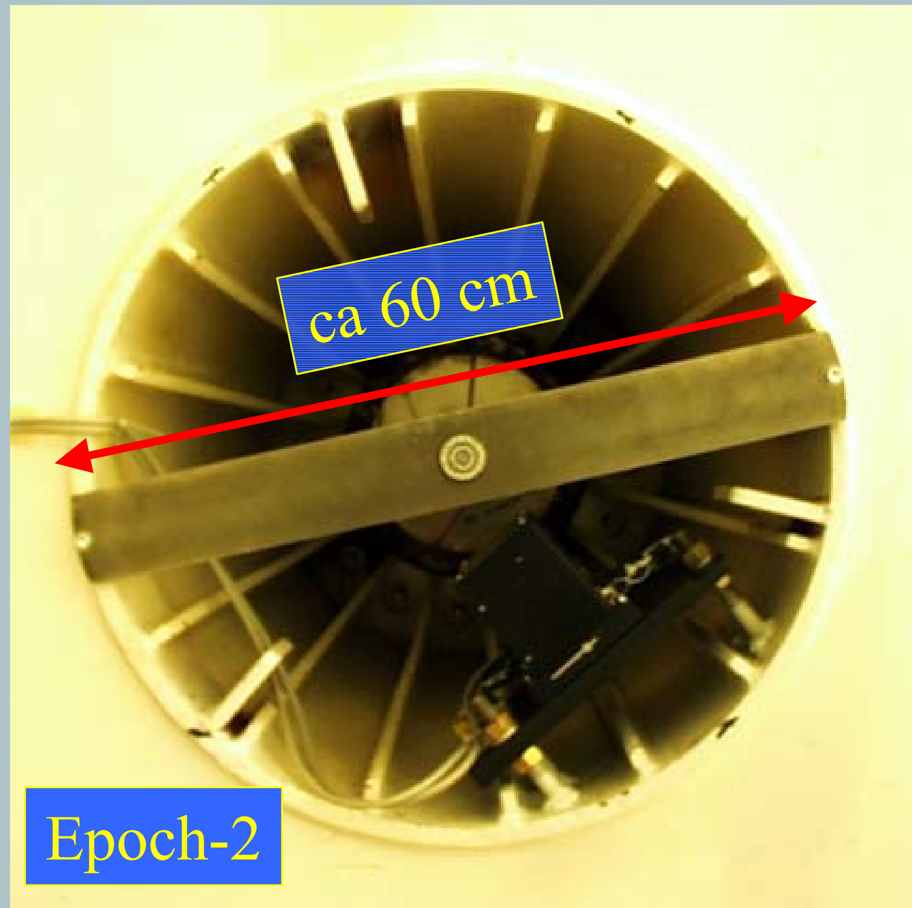
Telescope measurements (2)

Epoch-2:

- After telescope maintenance work re-adjusting the telescope balance weights.
- Installation of two magnetic target markers as synthetic endpoints of the elevation axis.
- Positioning the telescope to 15 different azimuths.
- Simultaneous observation of the target markers with two theodolites on baselines formed by pairs of two survey pillars each.

Targets on the telescope cabin



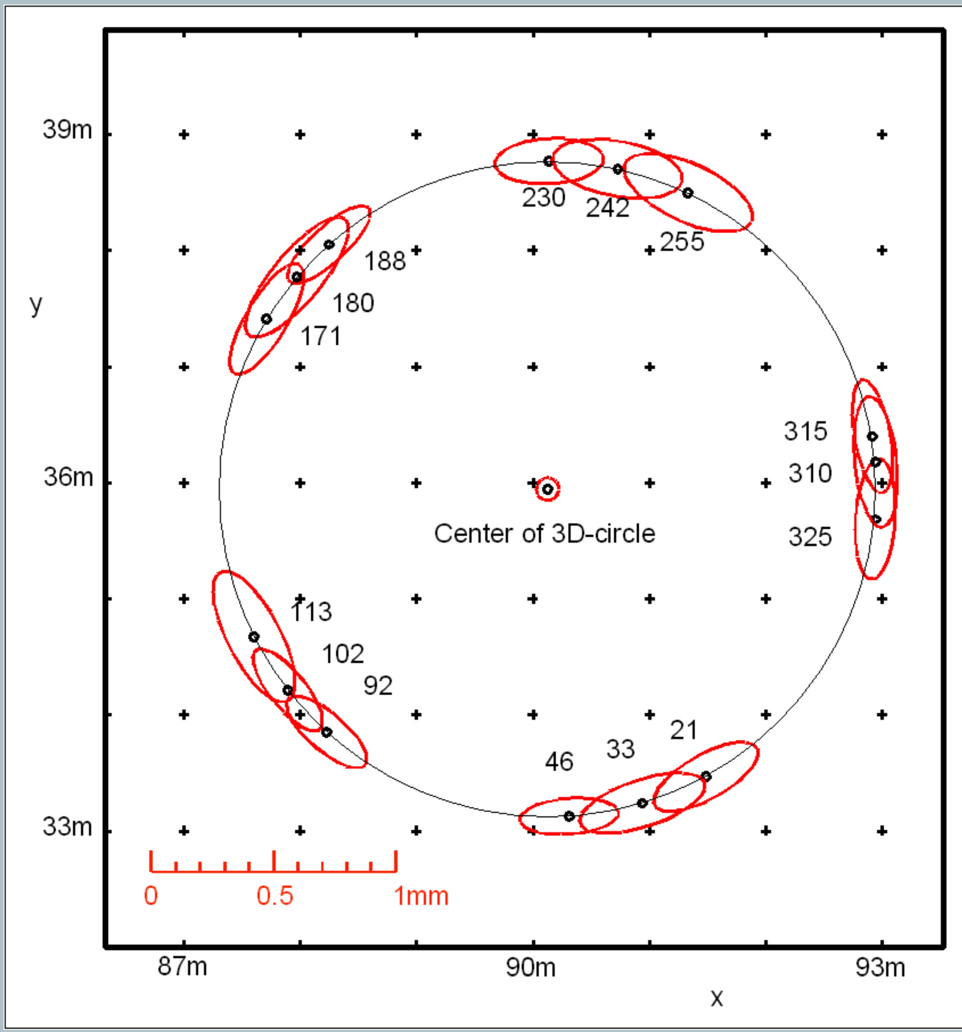


- Epoch-1: 600 new points observed at the telescope cabin (5 work days).
- Epoch-2: 30 new points observed (1 work day)
- Height transfer from the bottom points to the trunnion axes via vertical angle measurements.
- Horizontal orientation via most distant survey pillars.

Data analysis

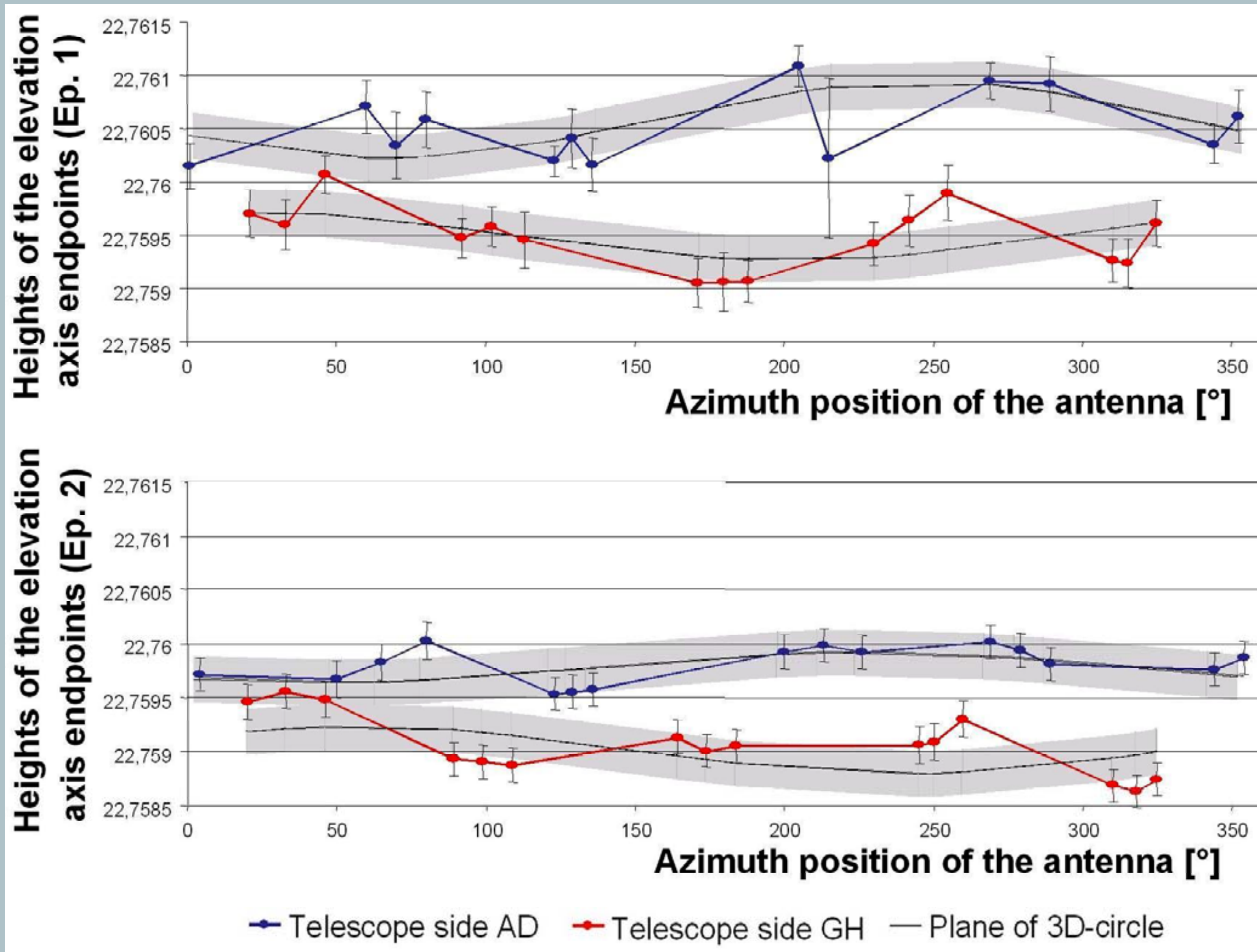
- 3D-analysis using the software Netz3D of the Universität Karsruhe.
- One-step 3D circle fits to the determined new points applying complete covariance information to determine the 3D elevation axis endpoints.
- One-step 3D circle fit to the elevation axis endpoints to determine azimuth axis and thus also the IVS-reference point.

3D-circle fits, example



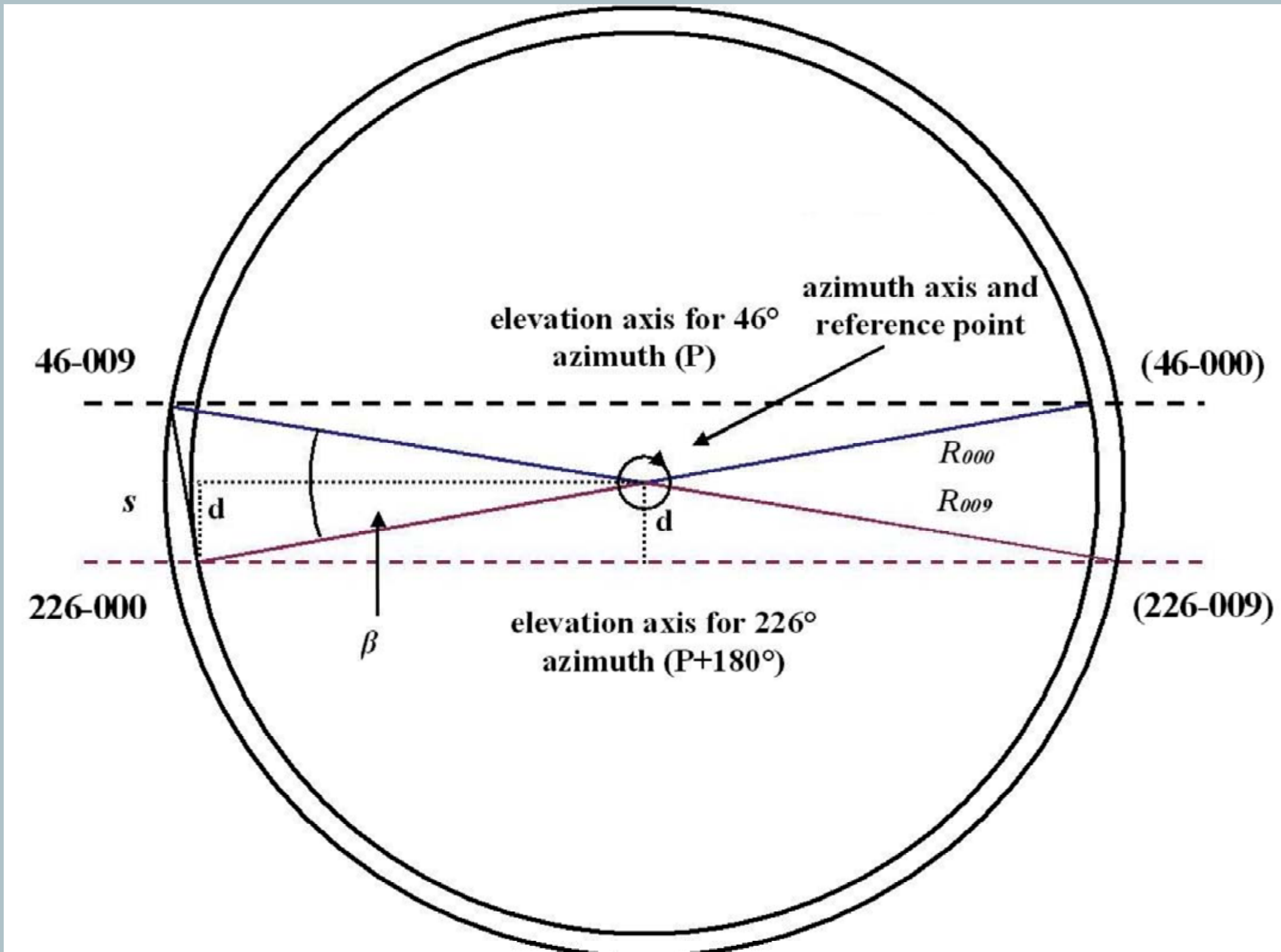
- Projection of the error ellipses of one elevation axis endpoint to the local xy-plane.
- The centre of the 3D-circle is determined on the level of ± 0.1 mm in all three dimensions.

Relative position of telescope axes



- Amplitude of the oscillation reflects the divergence of the azimuth axis vs. the local vertical.
- Epoch-1: 21´´ ± 6´´.
- Epoch-2: 13´´ ± 6´´.
- Difference in mean height reflects non-orthogonality of the azimuth and elevation axis: 40´´± 8´´.

Telescope axes offset



- 10 pairs of diametral endpoints determined in Epoch-2.
- Thus, the axes offset could be determined.
- Axes offset:
  6.0 ± 0.4 mm.

GPS measurements

- Choke-ring GPS antennas on 4 points of the local network, plus the IGS-site.
- Receivers: Ashtech and TurboRogue.
- Static GPS observations for 55 days in total.
- Analysis using the GPS analysis software package Bernese Version 4.2 in a L1-only approach.
- Achieved repeatabilities (mm):

  NEU: 0.6 || 1.0 || 1.7

Helmert transformation

- Transformation of the local-tie to ITRF.
- Using identical points observed with classical methods and GPS.
- Mean residual of the transformation: 0.8 mm.

Standard deviations of the reference points (mm):

IGS: ± 0.2 / ± 0.3 || ± 0.2 / ± 0.2 || ± 0.6 / ± 0.5

IVS: ± 0.1 / ± 0.1 || ± 0.1 / ± 0.1 || ± 0.1 / ± 0.1

Results and conclusions (1)

- The IVS-reference point has been coordinated in the local reference frame with 3D standard deviations on the level of $\pm$ 0.25 mm.
- The 3D-local-tie between the IVS- and the IGS-reference points has been determined on the sub-millimetre level.

Results and conclusions (2)

- A previously unknown axis offset at the VLBI telescope of 6.0 mm ± 0.4 mm has been detected.
- A non-orthogonality of the azimuth and elevation axis of 40´´ ± 8´´ has be detected.
- A divergence of the azimuth axis from the local vertical of 21´´ ± 6´´ (epoch-1) and 13´´ ± 6 ´´ (epoch-2) has been detected.

Results and conclusions (3)

- The local-tie information is available with its complete covariance information both in a local and a global reference frame.
- A SINEX-file containing the local-tie information has been created and submitted to the IERS.

Thank you for your attention!