

New options with twin telescopes in VLBI

Axel Nothnagel , Judith Pietzner
Institut für Geodäsie und Geoinformation
Universität Bonn





Wettzell Geodetic Observatory is a global (VLBI) super-point

Necessity for

- monitoring excentricity vectors with sub-mm accuracy (in geocentric cartesian system)
- monitoring of telescope deformation stability
- both with sub-yearly time resolution

Drawbacks of terrestrial survey approach

- total station measurements are topocentric
- axes need to be defined by rotations of the telescopes
- GPS needed for determination of transformation parameters
 - inherent problems like phase center variations, multipath
 - uncertainties through replacing total stations/reflectors by GPS antennas
 - limited accuracy, and can only be done every few years

Solution: monitoring by interferometry

- regular VLBI sessions with Wettzell Triple
- phase delay solutions
 - precision of observables $\sim 0.2 - 0.3$ mm (group delay $1.5 - 2$ mm)
 - ionospheric/atmospheric refraction cancel

Planning of operation

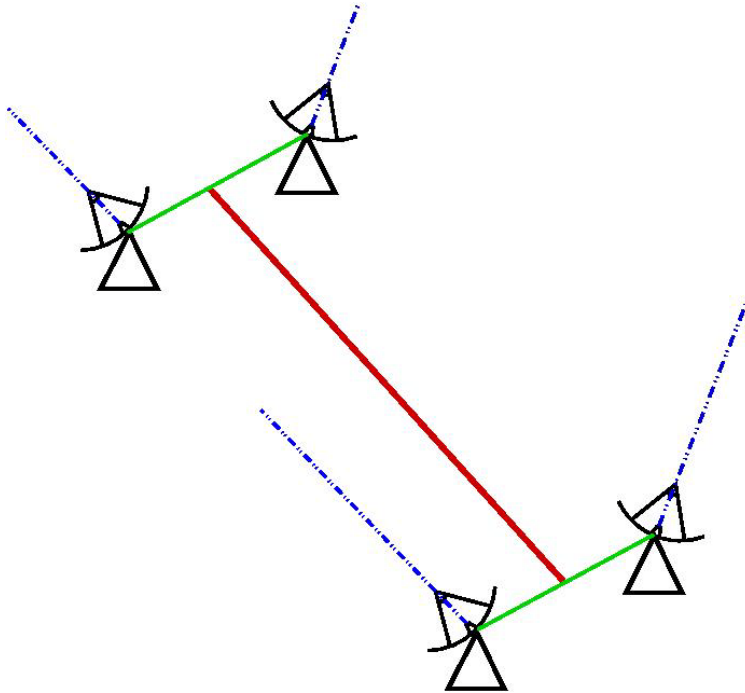
- Alternating use of both telescopes in single telescope mode
- Simultaneous operation

Wettzell Twin/Triple in 24h multi-station network sessions

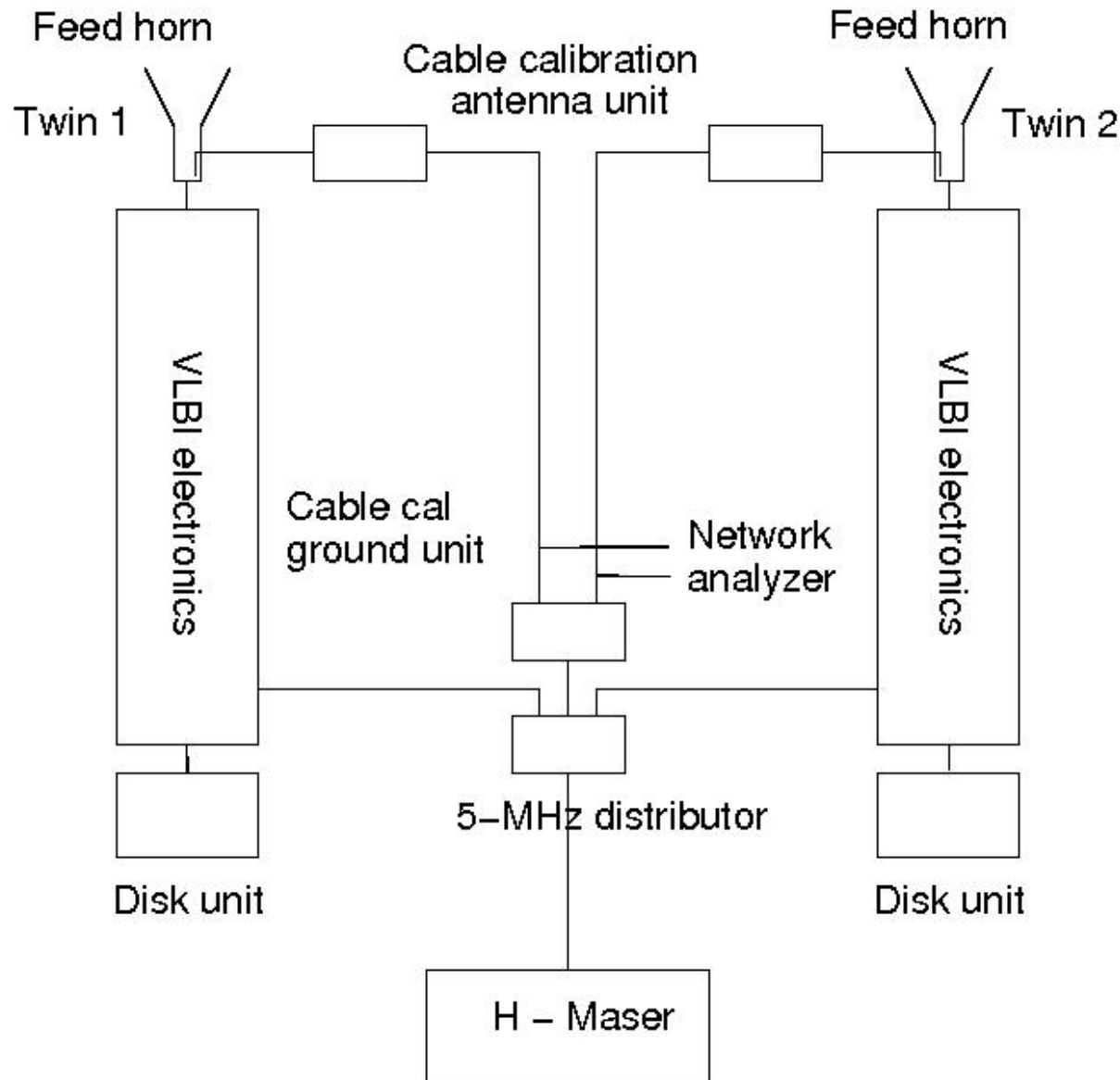
- Wettzell configuration unique in the world
- More twin telescope installations in the world

Current VLBI observing sessions

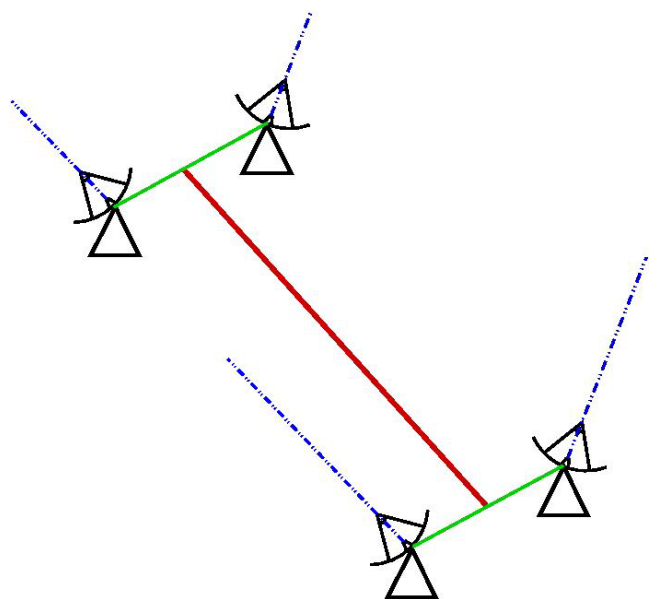
- 24h multi-station network sessions
- 1h UT1 Intensive sessions



- Simultaneous observations in two directions
 - More observations
 - Better sampling of the atmosphere for estimation of the zenith wet delay
 - Better separation of atmosphere parameters from clock and geodetic target parameters

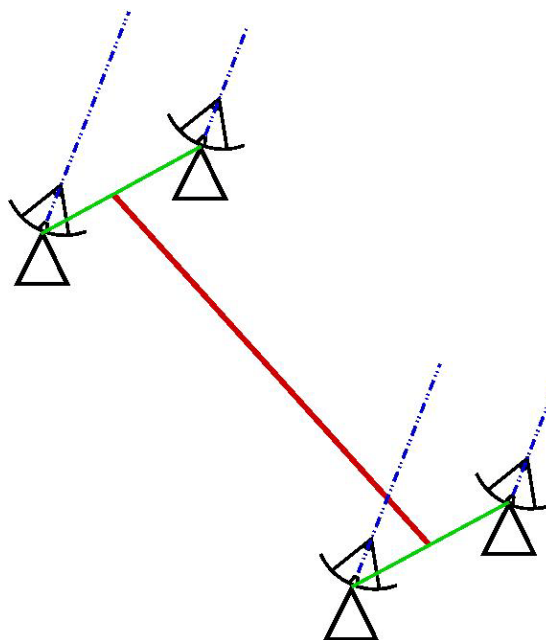
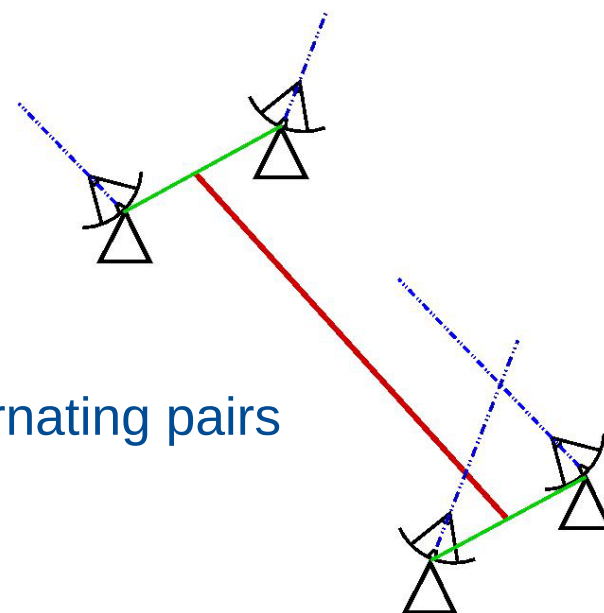


Stability
requirements:
1 - 3 ps



2 sources, 2 pairs

2 sources, 2 alternating pairs



1 source, 6 baselines

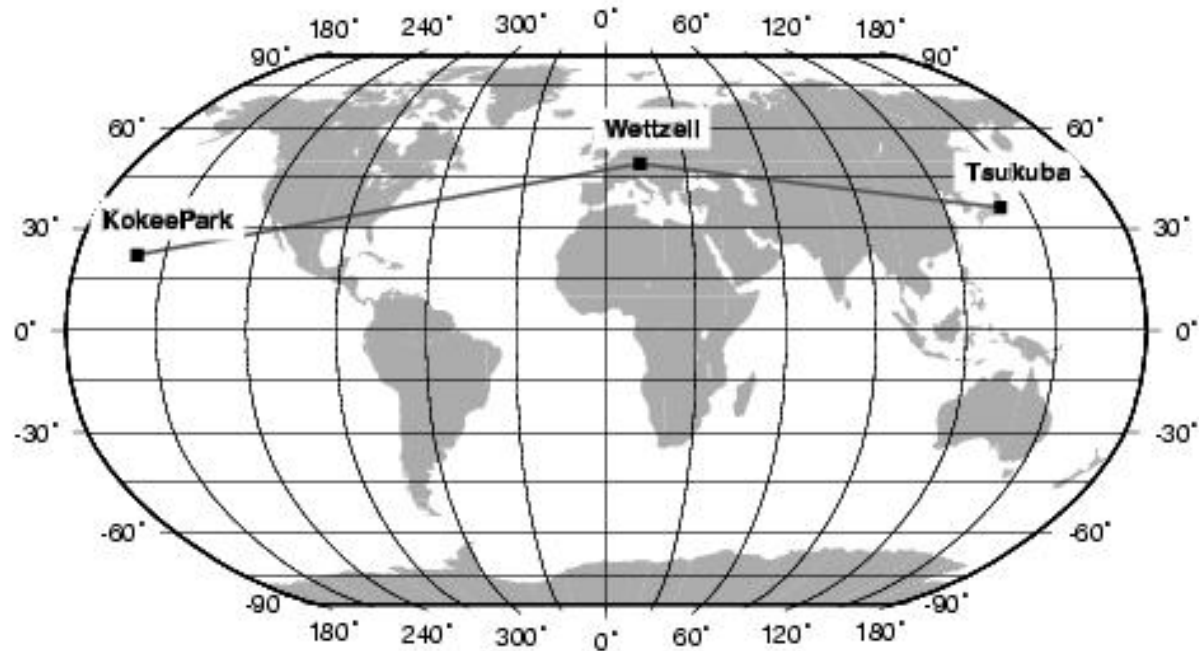
- Simulations for one hour observing time
- Simple approach for observing plan

UT1-UTC	Standard baseline	Twin telescopes	Standard baseline	Twin telescopes
	Wettzell – Kokee Park		Wettzell -Tsukuba	
Standard dev.	16,9 μ s	7,7 μ s	11,0 μ s	7,5 μ s
n	30	62	43	66
Standard dev. • sqrt(n)	92,4 μ s	60,7 μ s	71,8 μ s	60,6 μ s

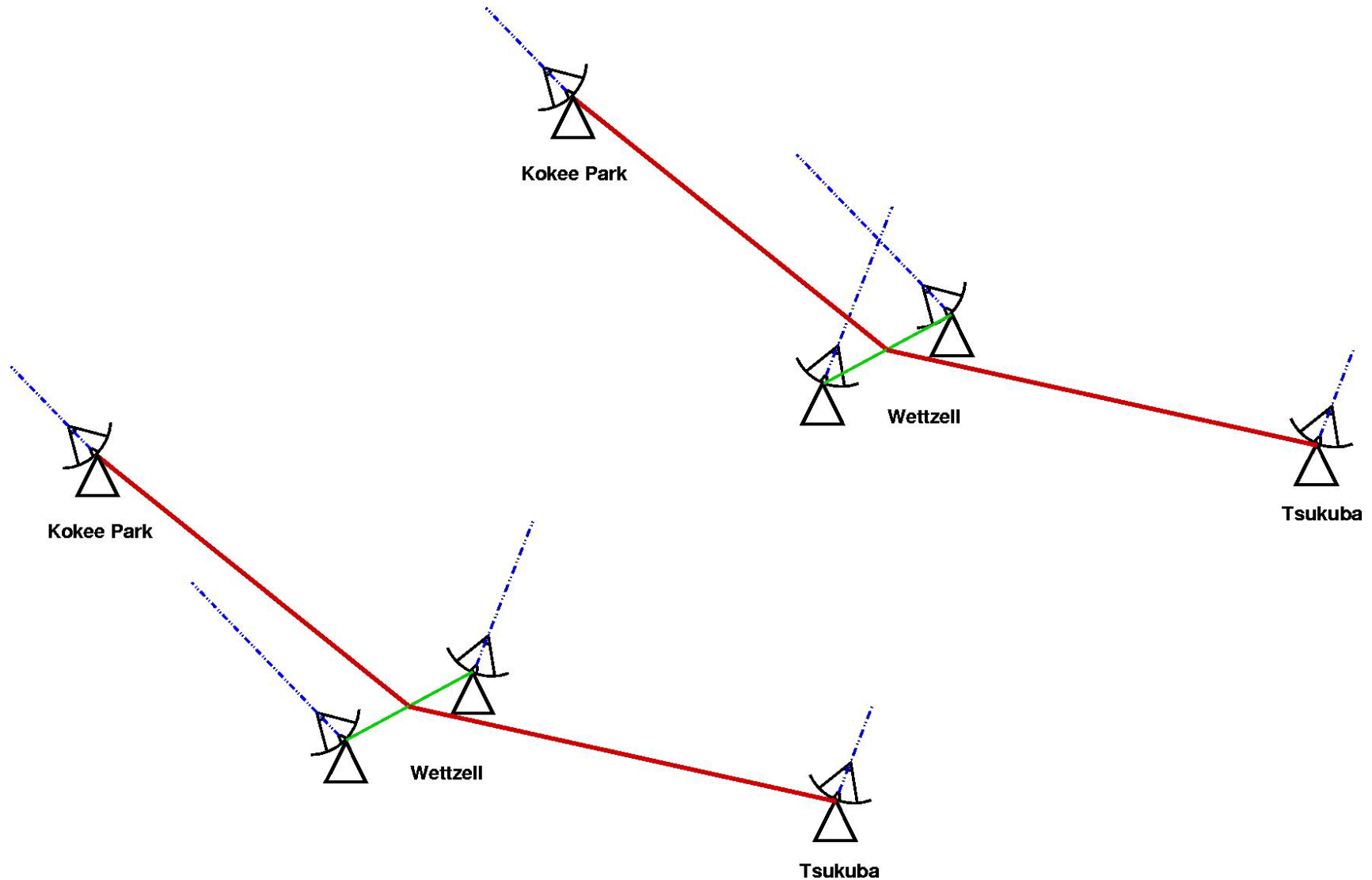
Int1: Mo – Fr, 18.30 UT, Wettzell – Kokee Park

Int2: Sa + Su, 07.00 UT, Wettzell - Tsukuba

Int3: Mo, 07.00 UT, Wettzell - Tsukuba



Join Int1 and Int2 in one common session

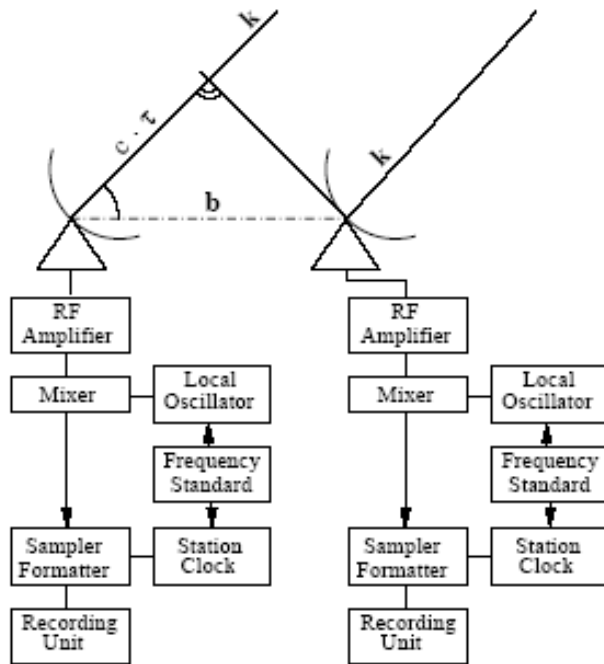


- Simulations for one hour observing time
- Simple approach for observing plan

UT1-UTC	Standard baseline	Standard baseline	Twin telescope Plus Kk + Ts
	Wettzell – Kokee Park	Wettzell - Tsukuba	Kokee Park - Wettzell -Tsukuba
Standard dev.	16,4 μ s	14,8 μ s	10,2 μ s
n	28	28	56
Standard dev. • sqrt(n)	86,5 μ s	78,6 μ s	76,6 μ s

-
-
-
-
-
-
-

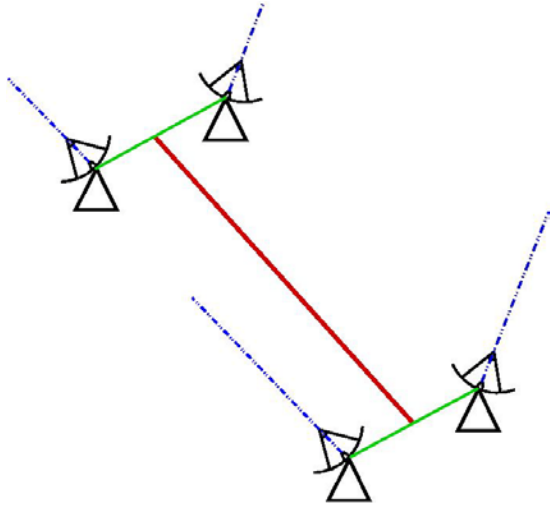
- Phase and clock stability of twin instruments has to be guaranteed
- Twin Telescope Wettzell will be of benefit to UT1-UTC Intensive sessions
 - Twin telescope at both ends $\rightarrow$ 30 – 40%
 - Twin telescope with two singles $\rightarrow$ 30 – 40%
 - N.B.: $\text{SQRT}(N)$ effect
- Complete simulations with stochastic clocks and atmospheres to follow



$$\tau = -\frac{1}{c} \vec{b} \cdot \vec{k}$$

$$\tau_{Obs} = -\frac{1}{c} \begin{pmatrix} x_a - x_b \\ y_a - y_b \\ z_a - z_b \end{pmatrix} \cdot R(UT1) \cdot \vec{k} + T_{0a} + T_{1a} - (T_{0b} + T_{1b}) + atm_a - atm_b$$

Estimated parameters: UT1-TAI, T_{0b} , T_{1b} , atm_a , atm_b

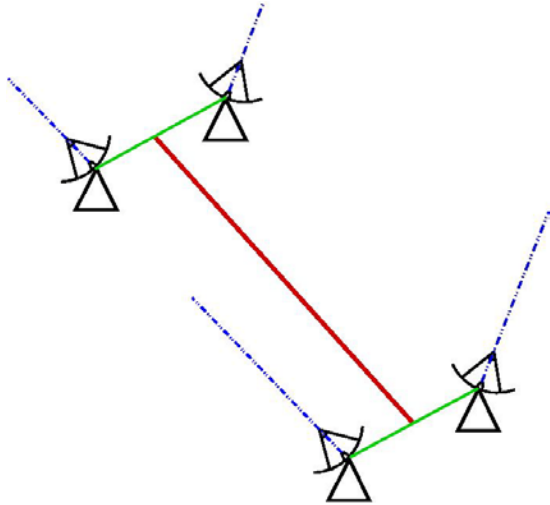


$$\tau_{Obs_1} = -\frac{1}{c} \vec{b} \cdot R(UT1) \cdot \vec{k} + T_{0a_1} + T_{1a_1} - (T_{0b_1} + T_{1b_1}) + atm_a - atm_b$$

$$\tau_{Obs_2} = -\frac{1}{c} \vec{b} \cdot R(UT1) \cdot \vec{k} + T_{0a_2} + T_{1a_2} - (T_{0b_2} + T_{1b_2}) + atm_a - atm_b$$

Parameters:

UT1-TAI, T_{0b_1} , T_{1b_1} , T_{0a_2} , T_{1a_2} , T_{0b_2} , T_{1b_2} , atm_a , atm_b

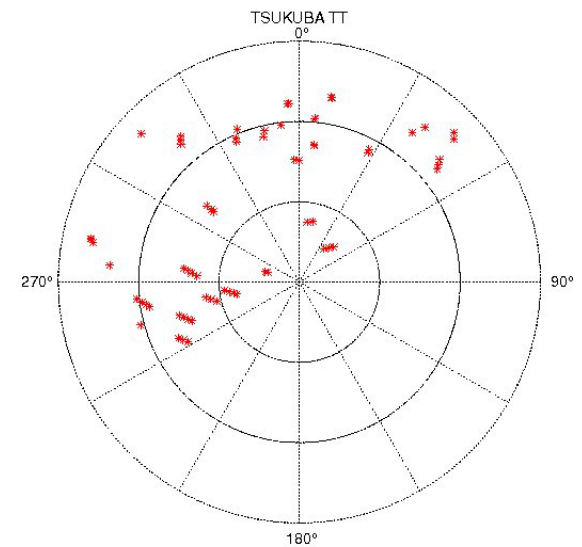
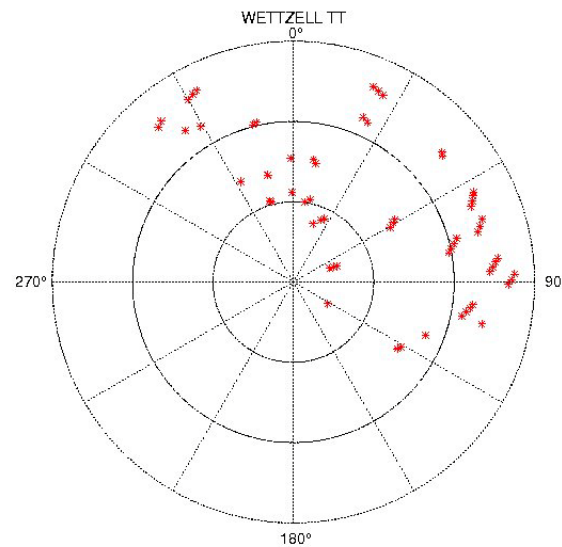
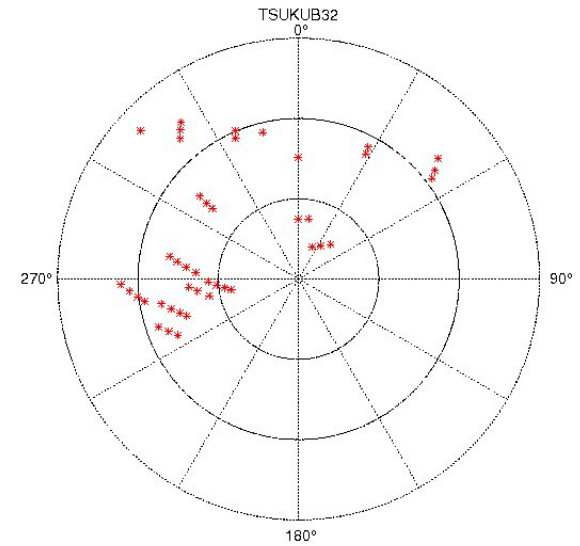
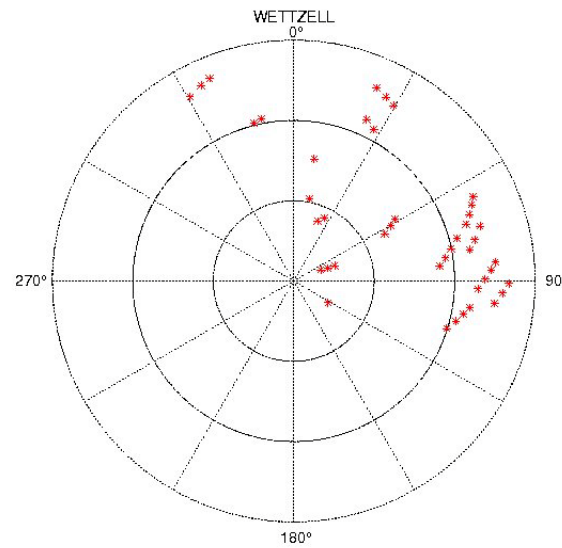


$$\tau_{Obs_1} = -\frac{1}{c} \vec{b} \cdot R(UT1) \cdot \vec{k} + T_{0a_1} + T_{1a_1} - (T_{0b_1} + T_{1b_1}) + atm_a - atm_b$$

$$\tau_{Obs_2} = -\frac{1}{c} \vec{b} \cdot R(UT1) \cdot \vec{k} + T_{0a_1} + T_{1a_1} - (T_{0b_1} + T_{1b_1}) + atm_a - atm_b$$

Parameters: UT1-TAI, T_{0b_1} , T_{1b_1} , atm_a , atm_b

Standard baseline



2 twin telescopes

