Comparison of results between CVN and K5 software correlators

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- How to compare
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    if not carried out at correlation processing
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CVN (China VLBI Network) Correlator

- software correlator developed by SHAO (Shanghai Astronomical Observatory) for the lunar mission
- upgraded to a general purpose
- FX correlator
- Earth-centered epoch

see Poster Presentation “P214” by Juan ZHANG for details

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K5 Software Correlator

- software correlator developed by NICT since 2003 for K5/VSSP sampler data
- dedicated to geodetic VLBI
- XF correlator (“cor”, “cor_new”) for 1bit AD
- FX correlator (“fx_cor”, “fx_cor_new”) for 1bit and multi-bit AD
- Data Format: K5/VSSP + Mark-IV, Mark-5, VDIF, ADS3000
- Baseline base correlator

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How to Compare

Correction of Earth Centered Epoch

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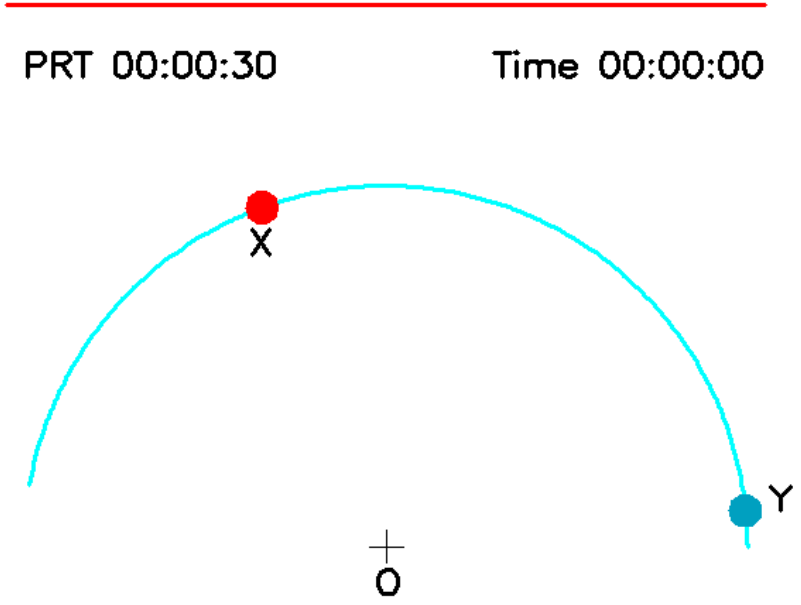
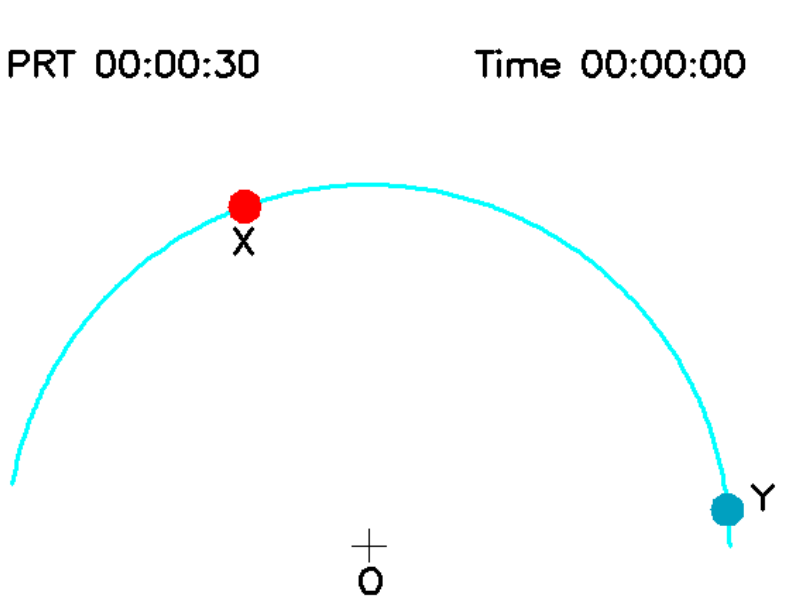
Observed Delay

CVN: Earth Centered

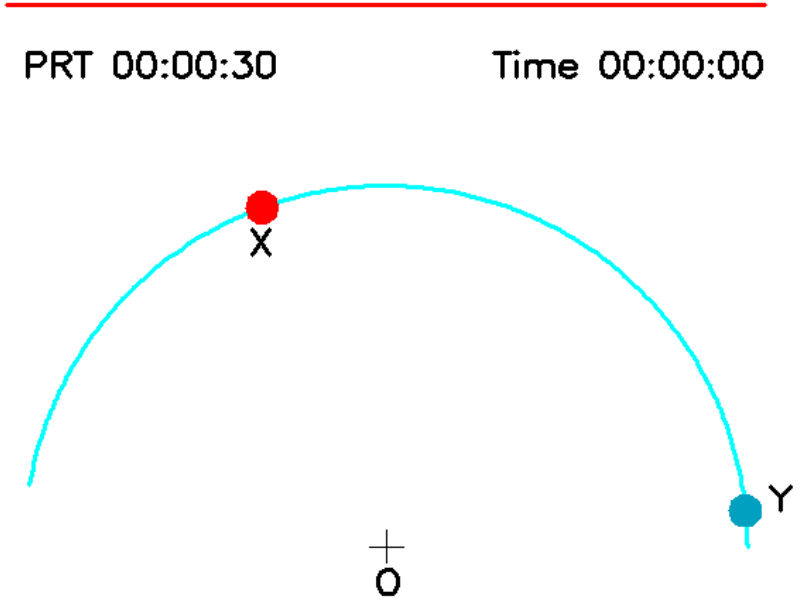


K5: Baseline Base

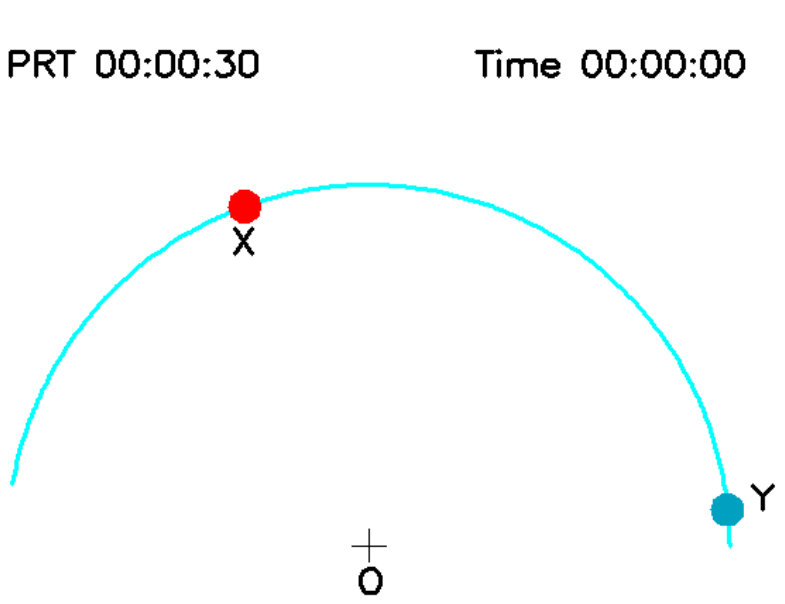


Observed Delay

CVN: Earth Centered

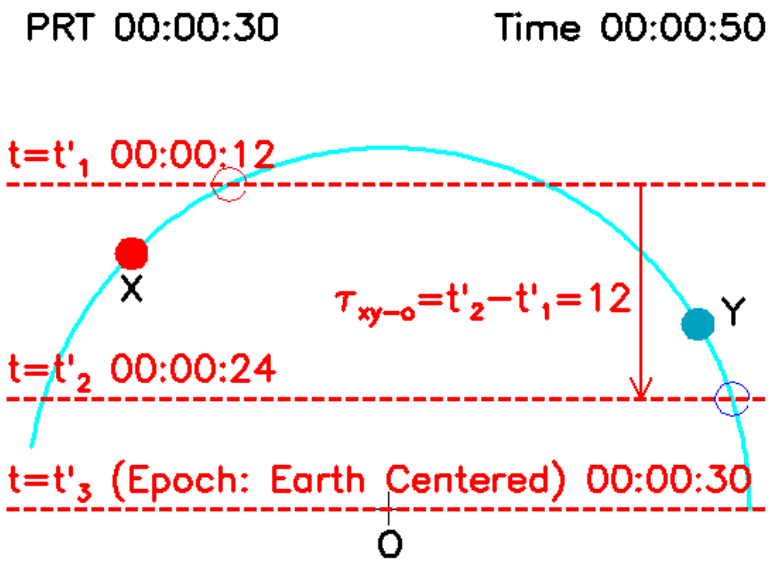


K5: Baseline Base

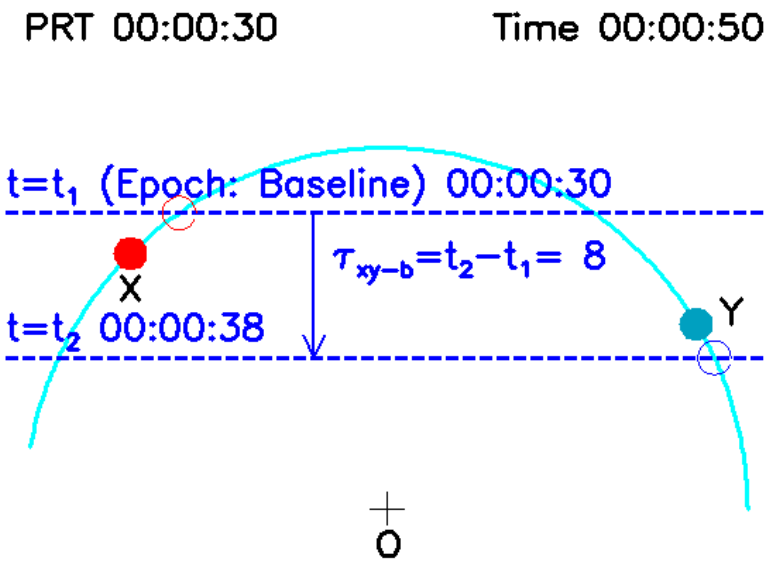


Observed Delay

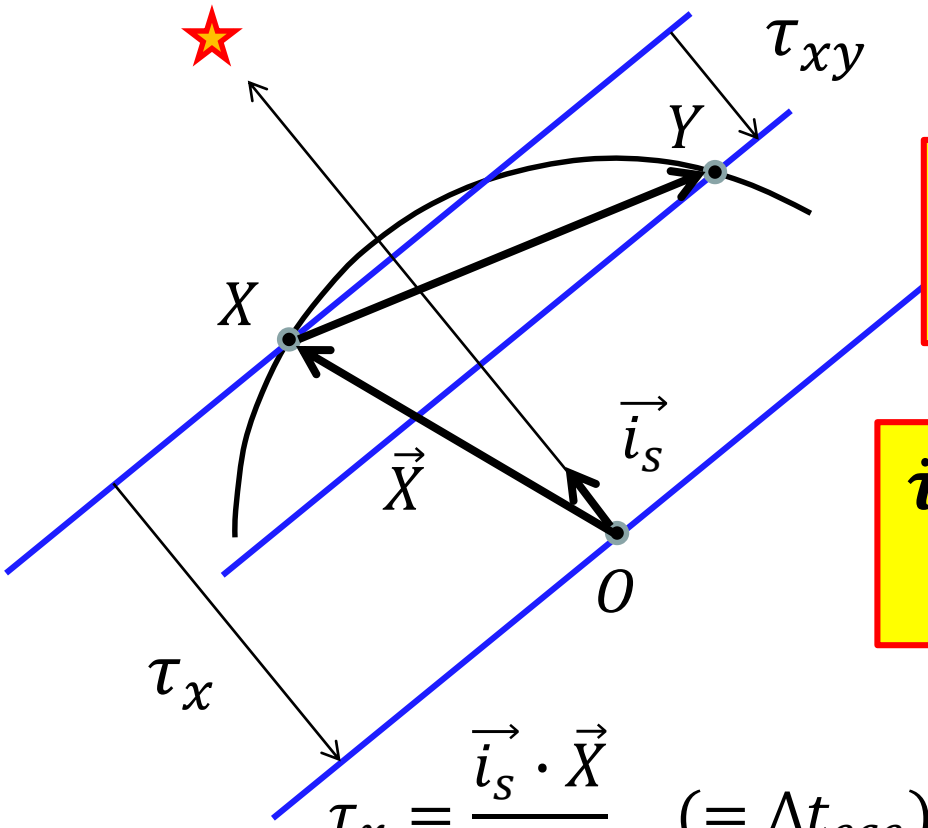
CVN: Earth Centered



K5: Baseline Base



Correction of Earth Centered Epoch (simple explanation)



$$\tau_x = \frac{\vec{i_s} \cdot \vec{X}}{c} \quad (= \Delta t_{ece})$$

Delay

$$\boldsymbol{\tau_{xy-o} = \tau_{xy-b} - \tau_x \cdot \dot{\tau}_{xy}}$$

Delay Rate

$$\boldsymbol{\dot{\tau}_{xy-o} = \dot{\tau}_{xy-b} - \dot{\tau}_x \cdot \dot{\tau}_{xy} - \tau_x \cdot \ddot{\tau}_{xy}}$$

xy-o: Earth Centered Epoch
xy-b: Baseline Base

Correction of X-Station Clock Offset

if not carried out at correlation processing

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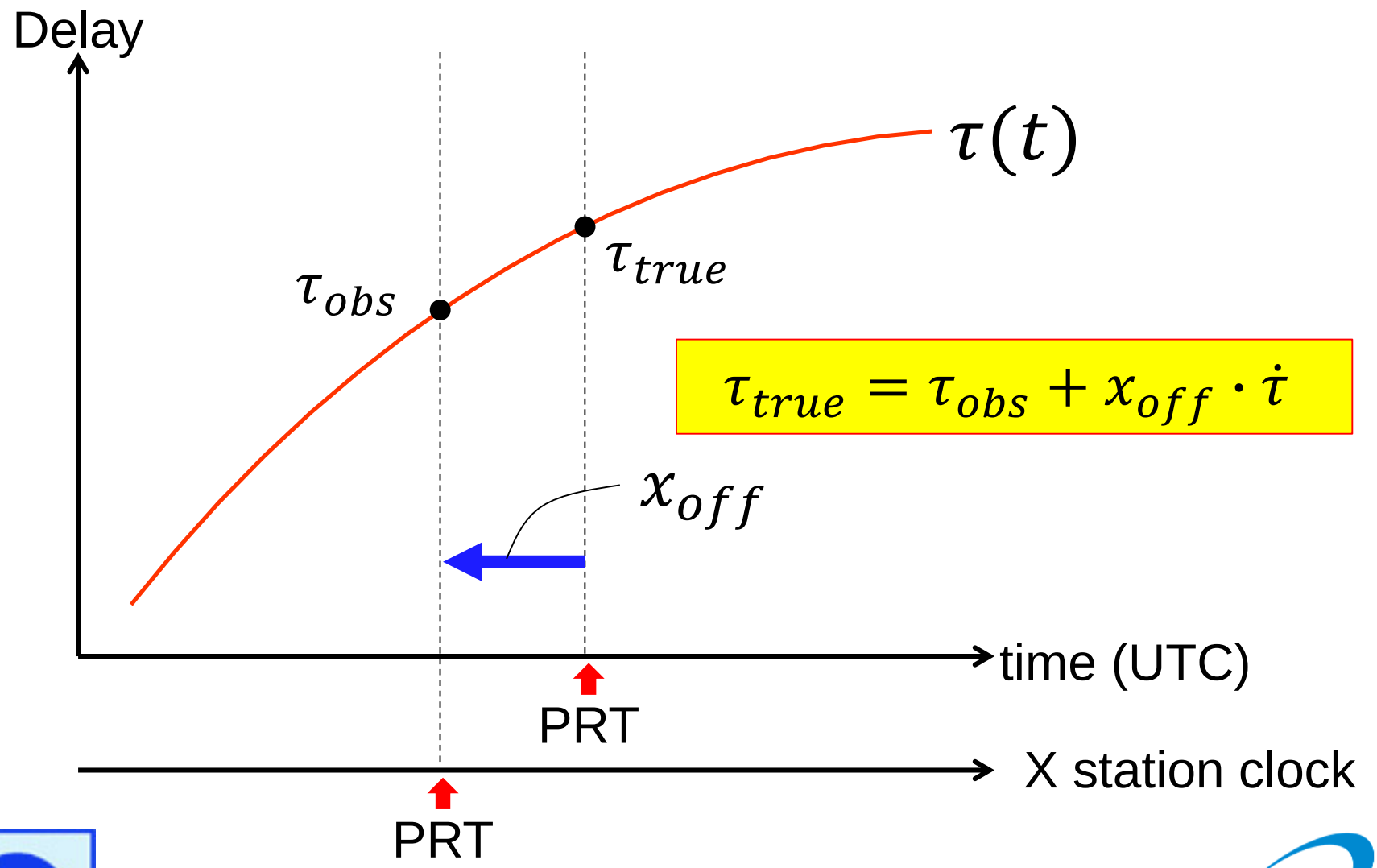
Correction of Clock Offset of Reference (X) Station



Summary of Corrections

Delay

$$\tau_{xy-o} = \tau_{xy-b} + (x_{off} - \tau_x)\dot{\tau}_{xy}$$

Delay Rate

$$\dot{\tau}_{xy-o} = \dot{\tau}_{xy-b} - \dot{\tau}_x\dot{\tau}_{xy} + (x_{off} - \tau_x)\ddot{\tau}_{xy}$$

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Comparison

Data Used for Comparison

Experiment

Experiment Code	K14349
Date & Time	2014/349 07:00UT – 08:00UT
Stations	NYALES20, SESHAN25, TSUKUB32, WETTZELL
# of Scans	30
Frequency Bands	S (6 CHs), X (10 CHs)

Correlation and Post Processing

CVN	CVN correlator + Fourfit
K5	K5 correlator (fx_cor_new) + KOMB

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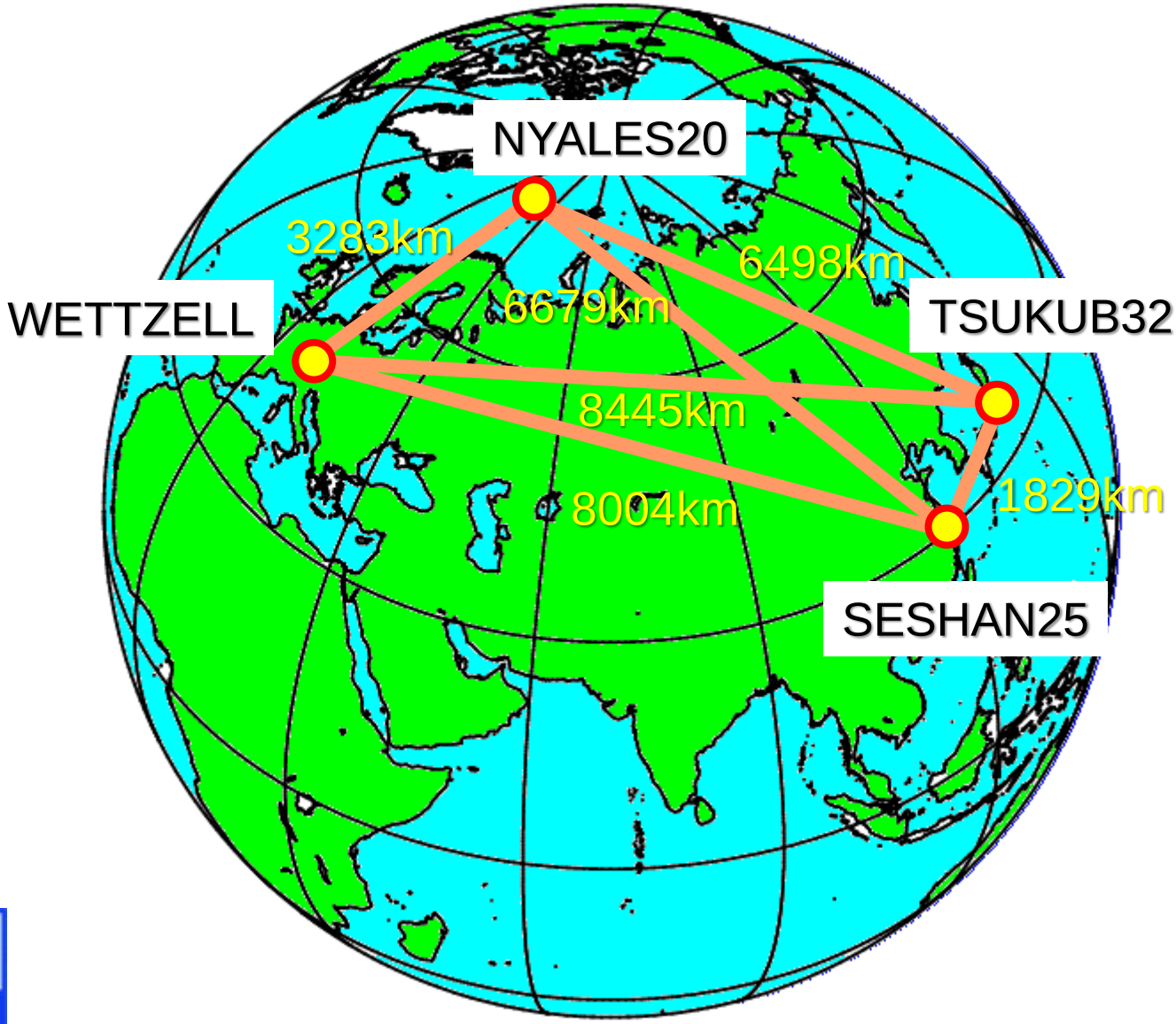
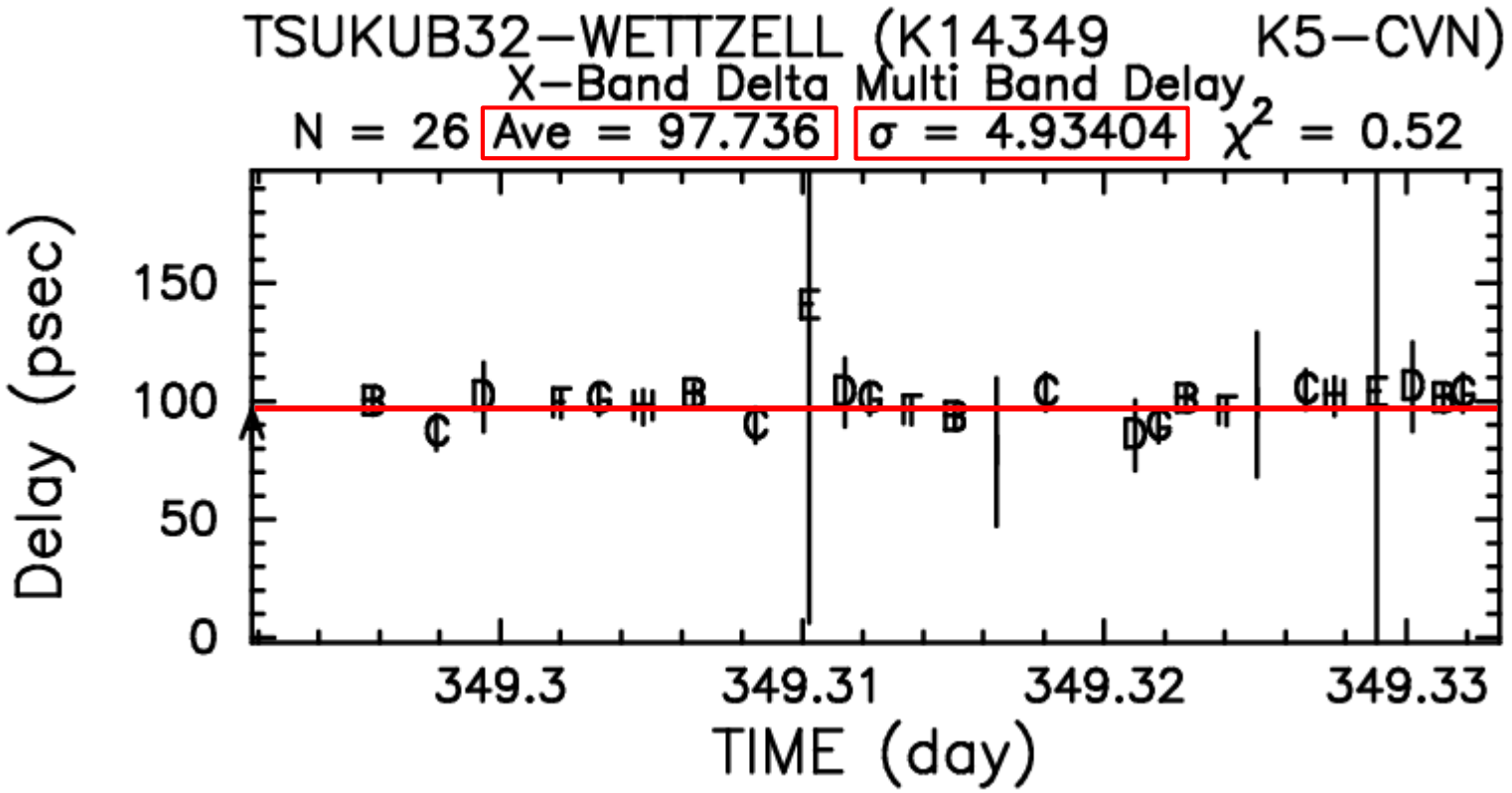
Location of Stations

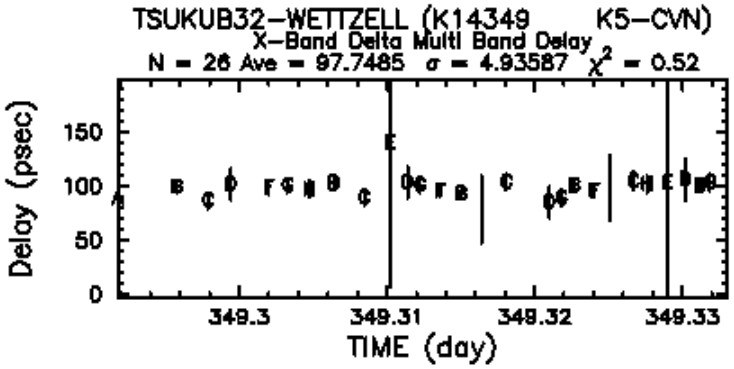


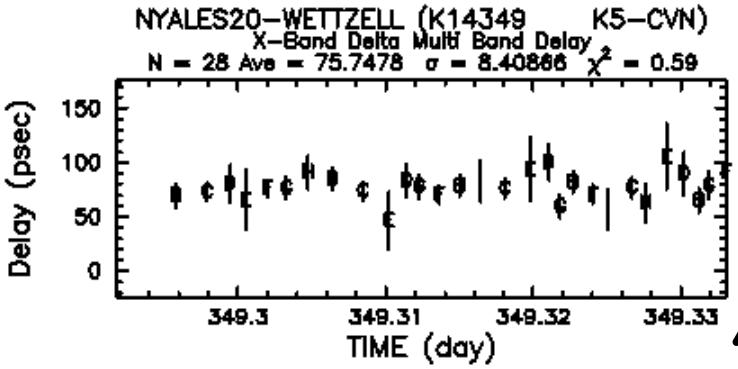
Results

X-Band Delay

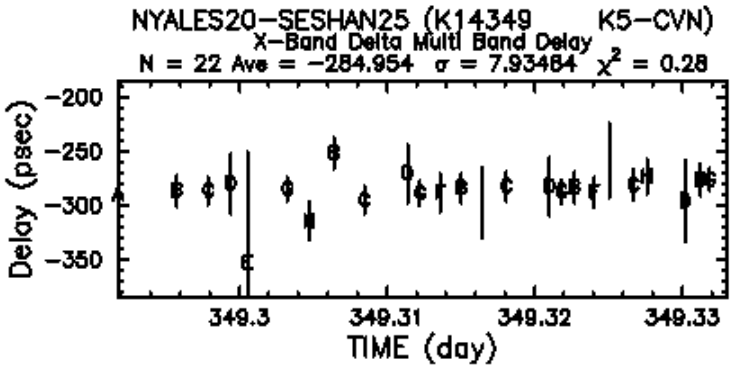

TSUKUB32−WETTZELL (K14349 K5−CVN)
X−Band Delta Multi Band Delay
N = 26
Ave = 97.736
σ = 4.93404
χ² = 0.52
Delay (psec)
150
100
50
0
349.3
349.31
349.32
349.33
TIME (day)

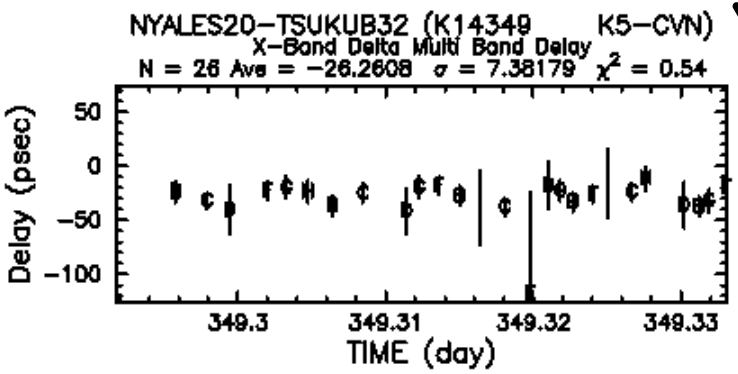
X-Band Delay

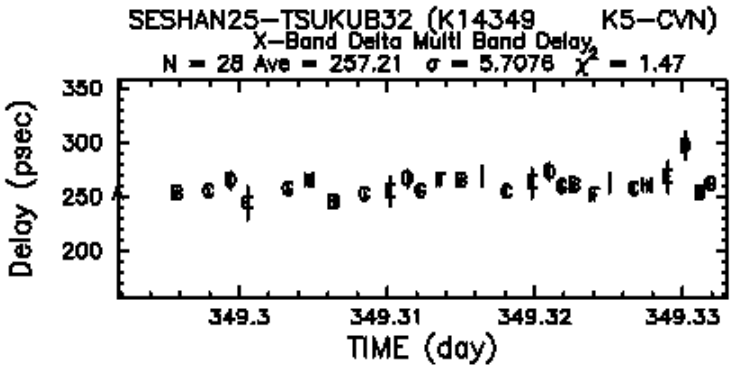


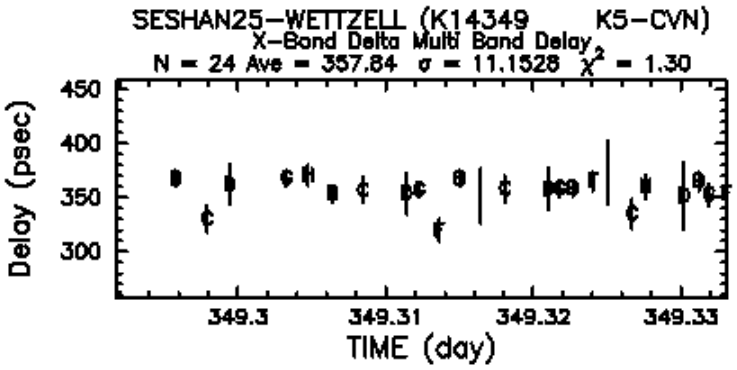


100 psec

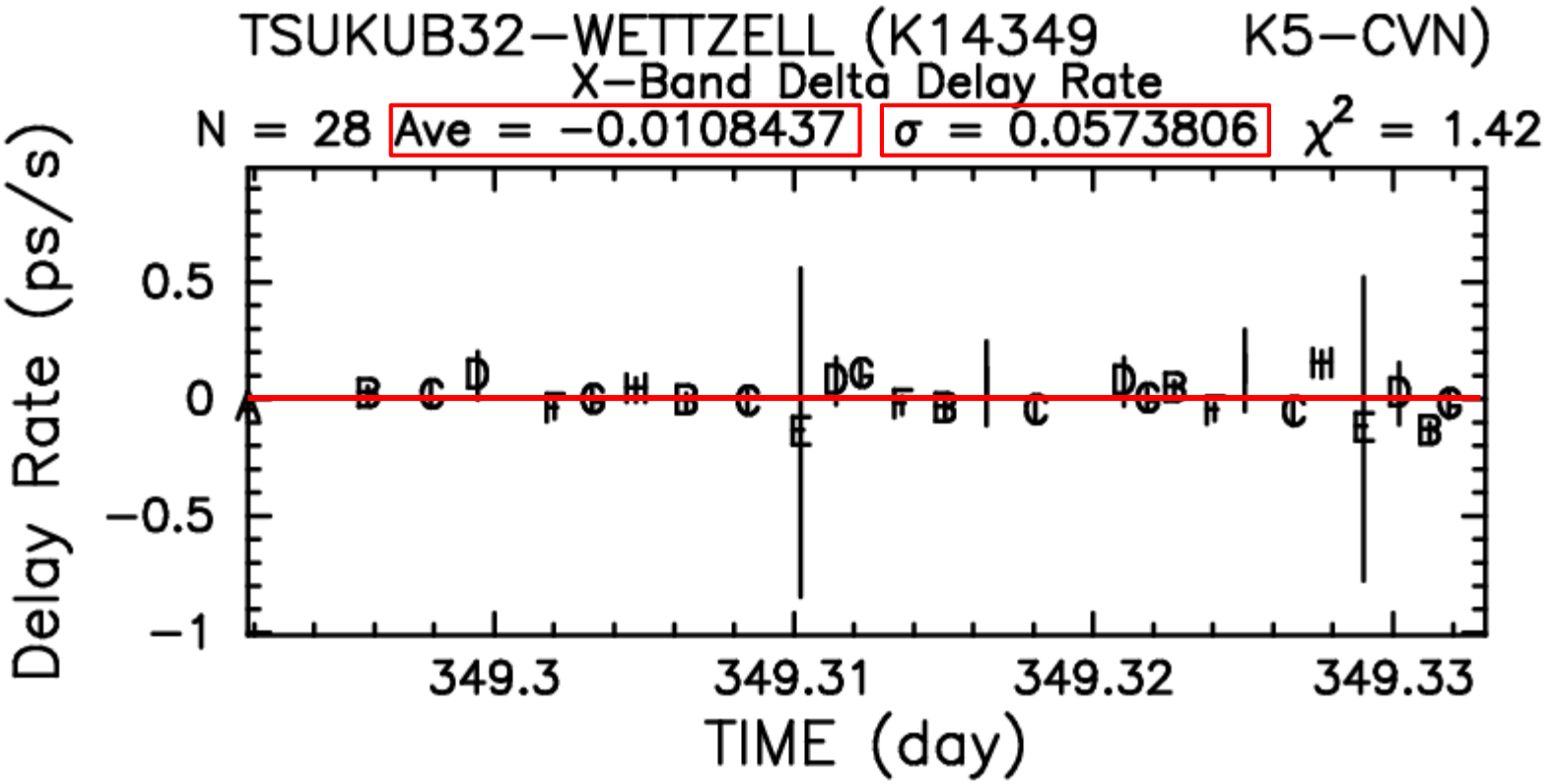




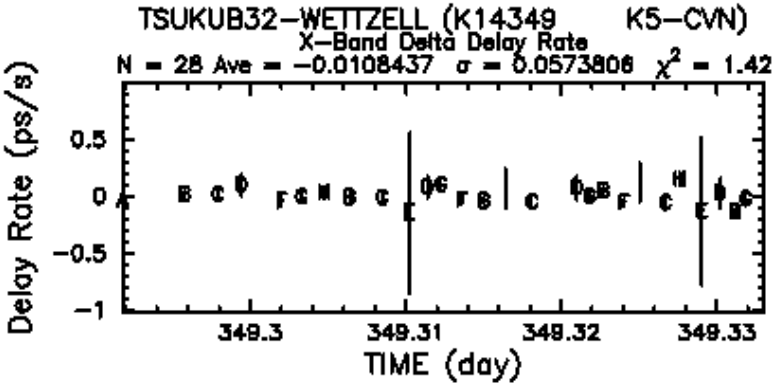


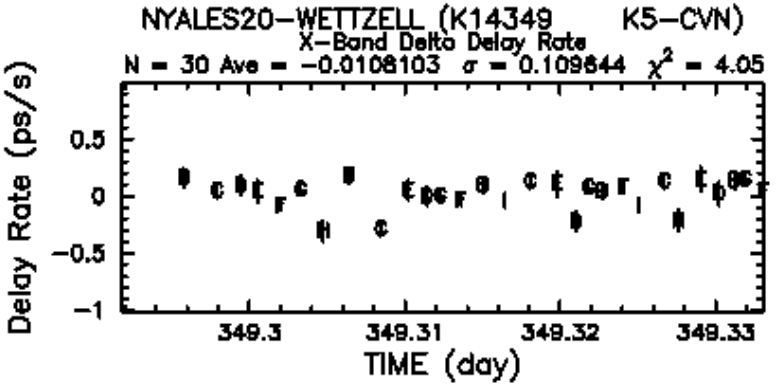


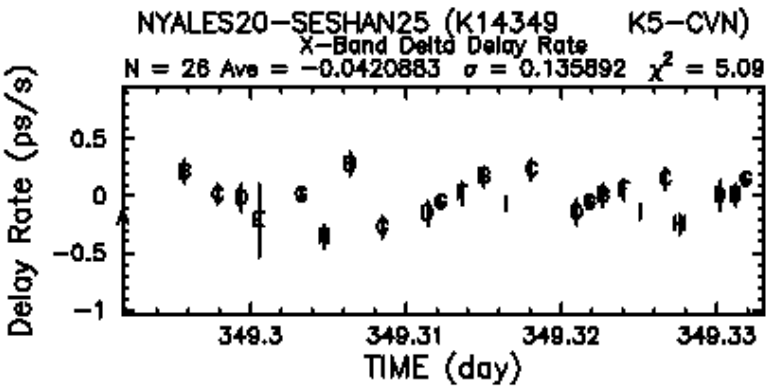
X-Band Delay Rate

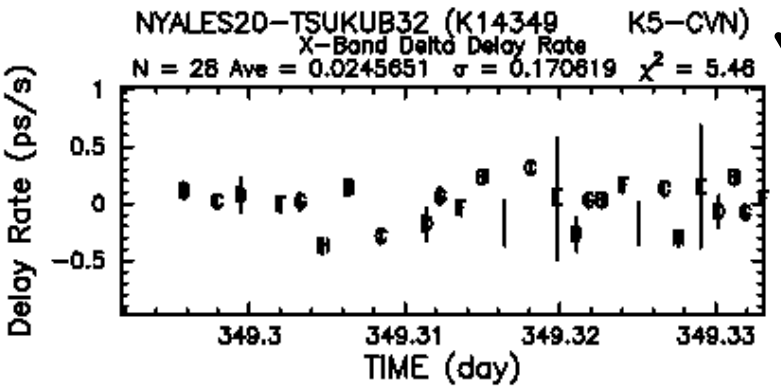


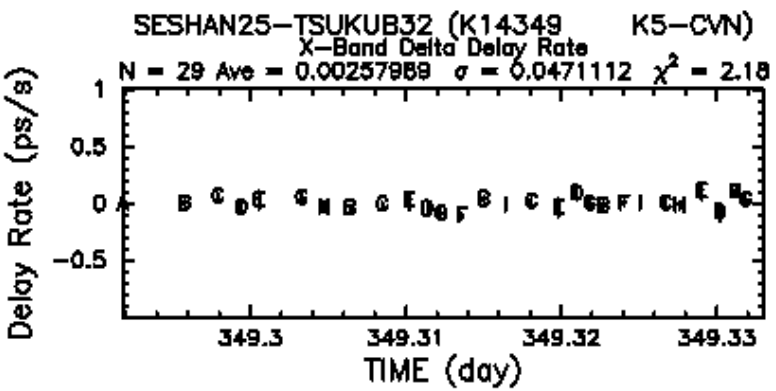
X-Band Delay Rate

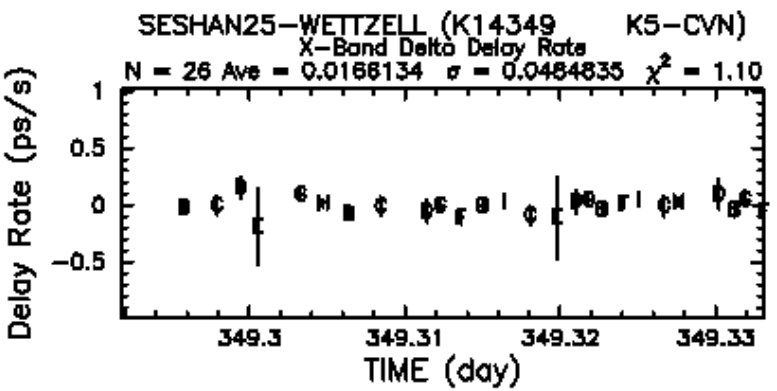


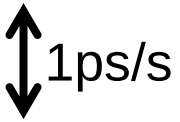




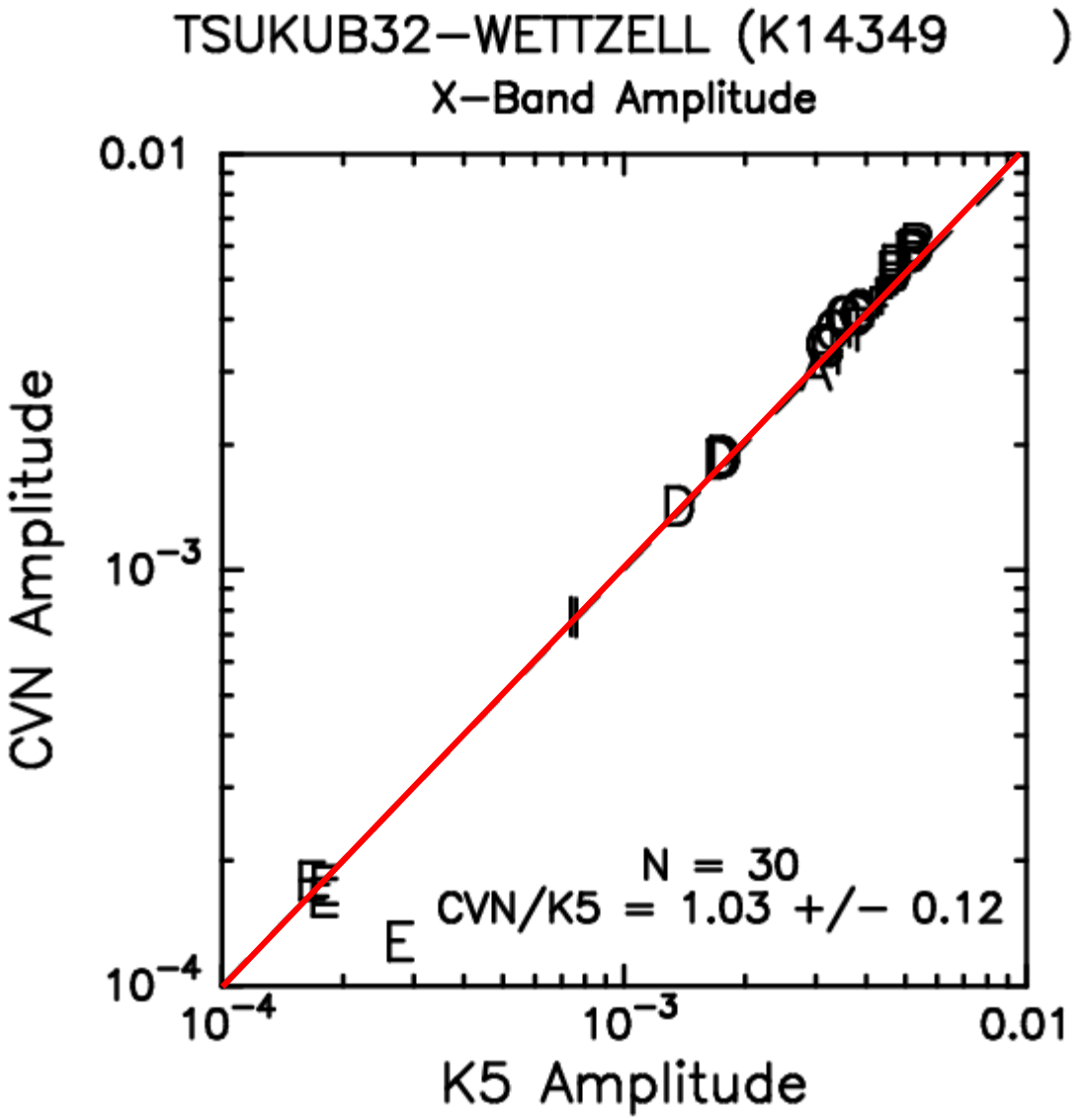




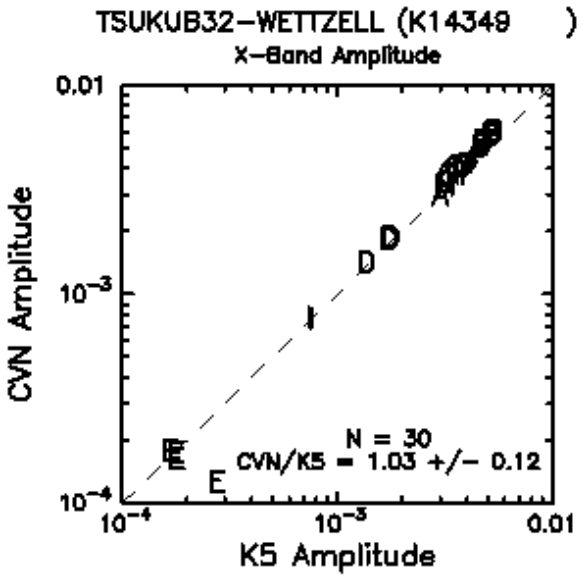


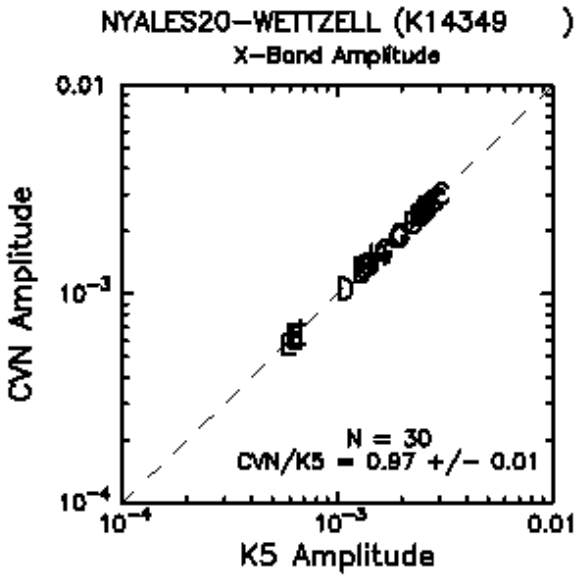


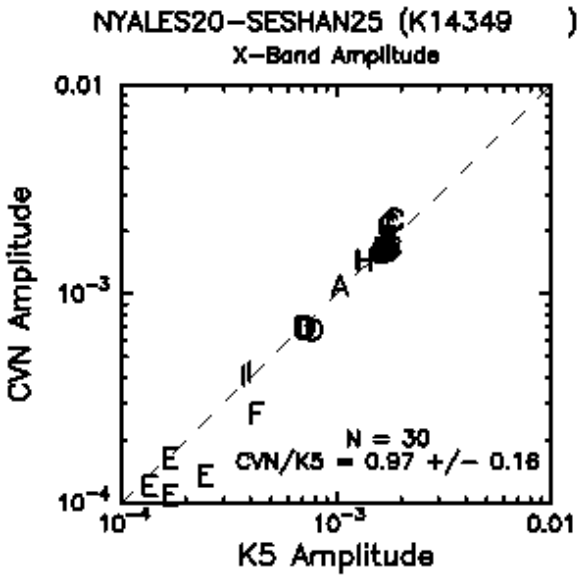
X-Band Amplitude

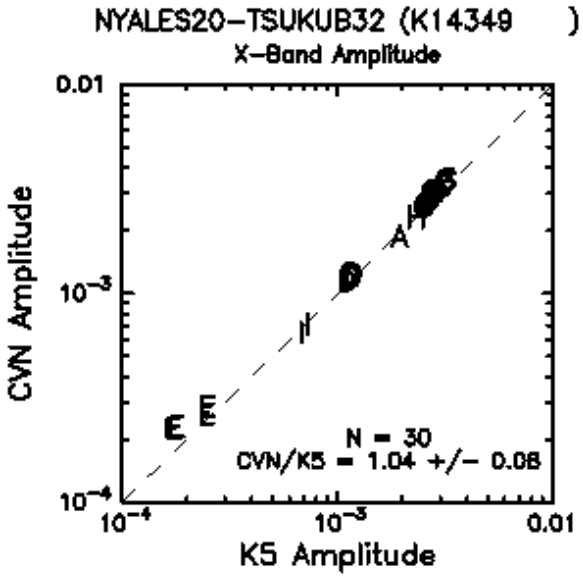


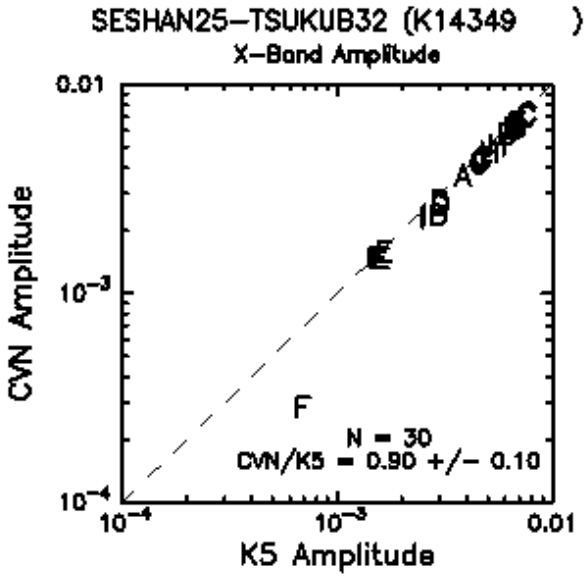
X-Band Amplitude

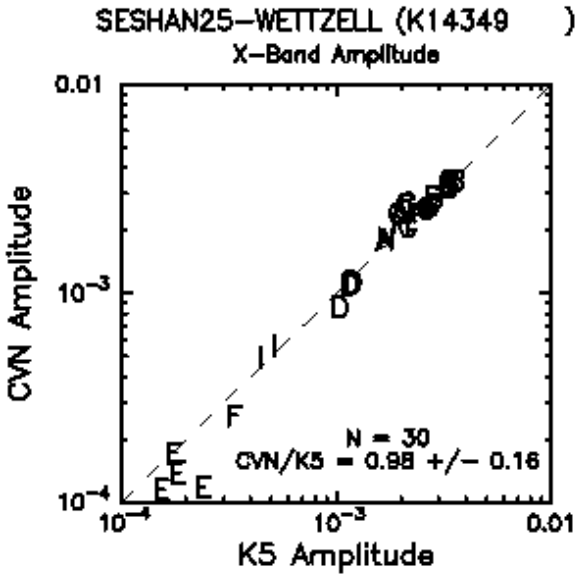












SUMMARY OF COMPARISON (X-Band)

FINE DELAY K5-CVN (psec)

	Ts-Wz	Ny-Wz	Ny-Sh	Ny-Ts	Sh-Ts	Sh-Wz	Ave
ave	97.7	75.7	-285	-26.3	257.2	357.8	79.5
σ	4.9	8.4	7.9	7.4	5.7	11.1	7.6

DELAY RATE K5-CVN (ps/s)

	Ts-Wz	Ny-Wz	Ny-Sh	Ny-Ts	Sh-Ts	Sh-Wz	Ave
ave	-0.010	-0.011	-0.042	0.025	0.003	0.017	-0.003
σ	0.050	0.11	0.136	0.171	0.047	0.048	0.094

AMP CVN/K5

	Ts-Wz	Ny-Wz	Ny-Sh	Ny-Ts	Sh-Ts	Sh-Wz	Ave
ave	1.03	0.97	0.97	1.04	0.90	0.98	0.98
σ	0.12	0.01	0.16	0.08	0.1	0.16	0.11

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Conclusions

- CVN and K5 results are well-coincide with each other:

observed delays : $\bar{\sigma} = 7.6$ psec,
observed delay rates : ave $= 0.00$ $\bar{\sigma} = 0.09$ ps/s,
and amplitudes (ratio): ave $= 0.98$ $\bar{\sigma} = 0.10$

for X band.

- Offsets seen in delay is due to the difference of fringe fit algorithm that reflects an instrumental delay (phase structure in a channel and band). These offsets can be treated as a clock offset at a baseline analysis.

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Conclusions (continued)

- K5 correlator is used at GSI/Tsukuba for routine IVS processing, so that CVN correlator can be used for IVS routine processing.

Acknowledgements

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Gracias

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