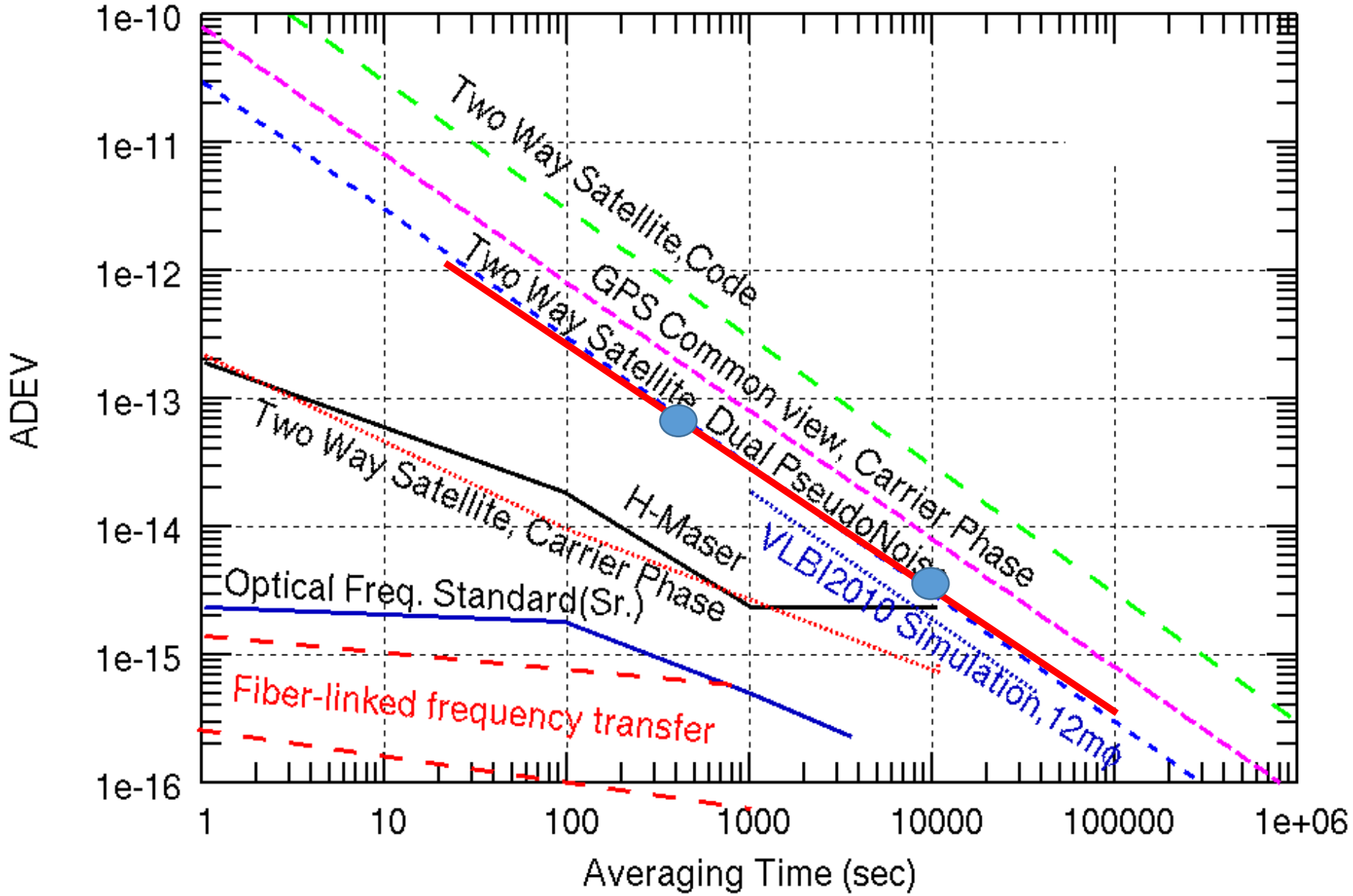
広帯域C型VLBI の国際観測 –開発の現状–

M. Sekido on behalf of VLBI-Freq Link team of NICT
T. Suzuyama(NMIJ)
And Collaboration with INRiM & INF, Italy

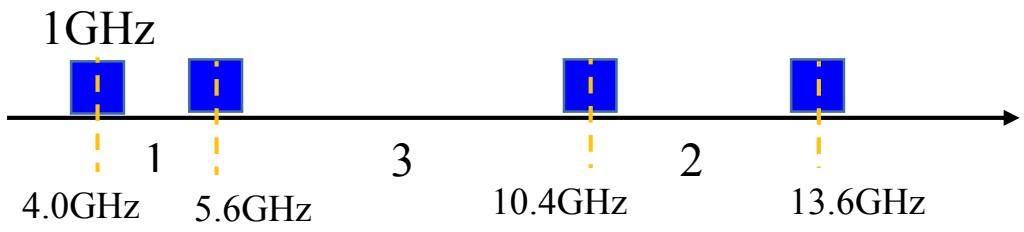
平成30 年度GGOS ワーキンググループ第2 回報告会

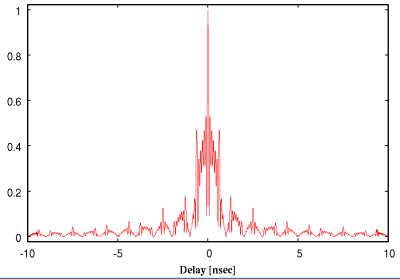

1e-10
1e-11
1e-12
1e-13
1e-14
1e-15
1e-16
ADEV
1
10
100
1000
10000
100000
1e+06
Averaging Time (sec)
Two Way Satellite,Code
GPS Common view, Carrier Phase
Two Way Satellite, Dual PseudoNois
Two Way Satellite, Carrier Phase
H-Maser
VLBI2010 Simulation,12m
Optical Freq. Standard(Sr.)
Fiber-linked frequency transfer

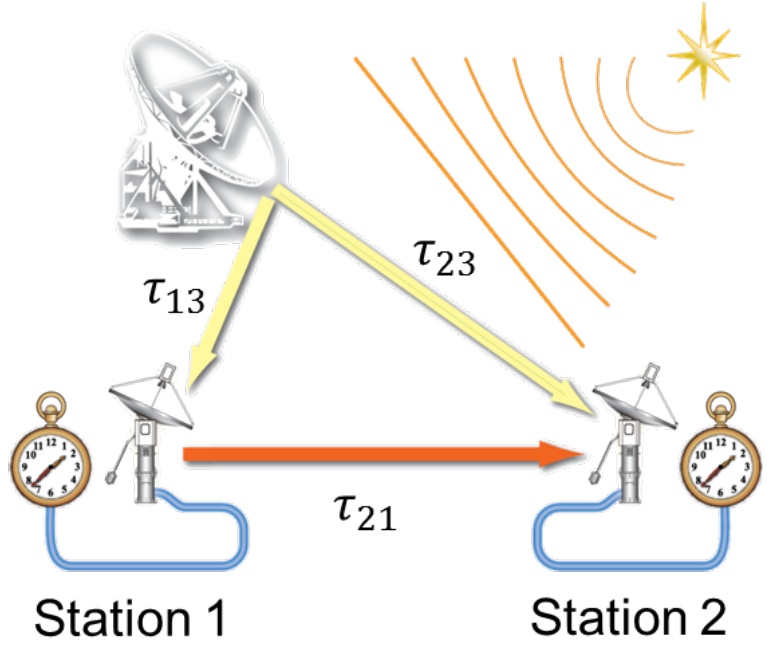
GALA-V Project Overview

Frequency comparison by using Transportable Broadband telescopes

- Radio Frequency： 3-14 GHz (VGOS Compatible)
- Data Acquisition： 4 band (1024 MHz width)
  - Nominal Freq. Array: Fc=4.0GHz, 5.6GHz, 10.4GHz, 13.6GHz
  - Effective Bandwidth：3.8GHz (10 times more than Conventional)

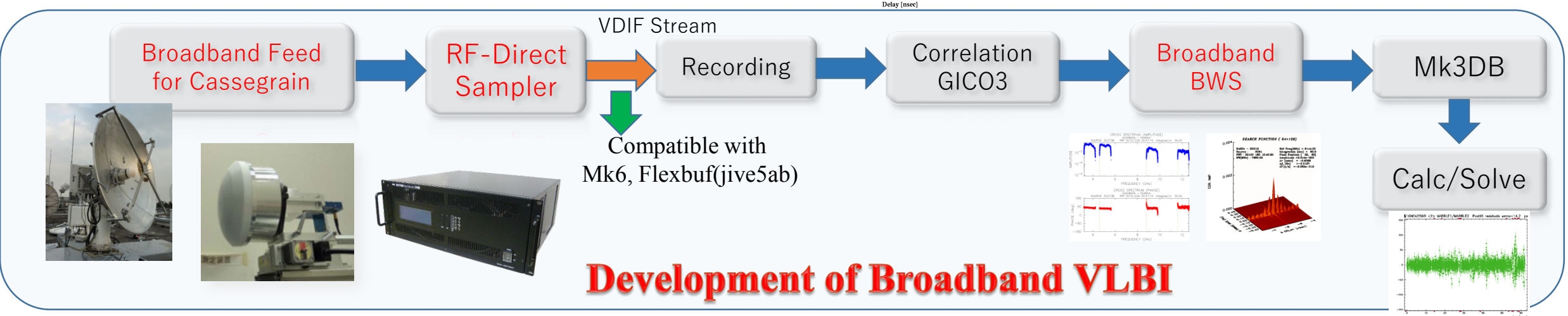






$$\tau_{21} = \tau_{13} - \tau_{23}$$

By using closure delay relation.

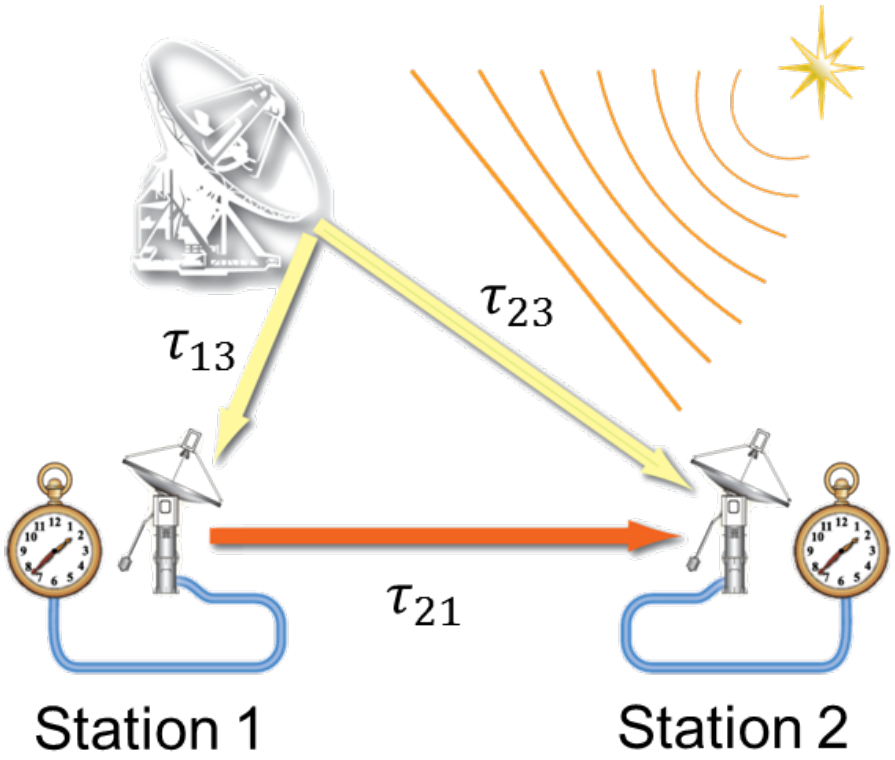


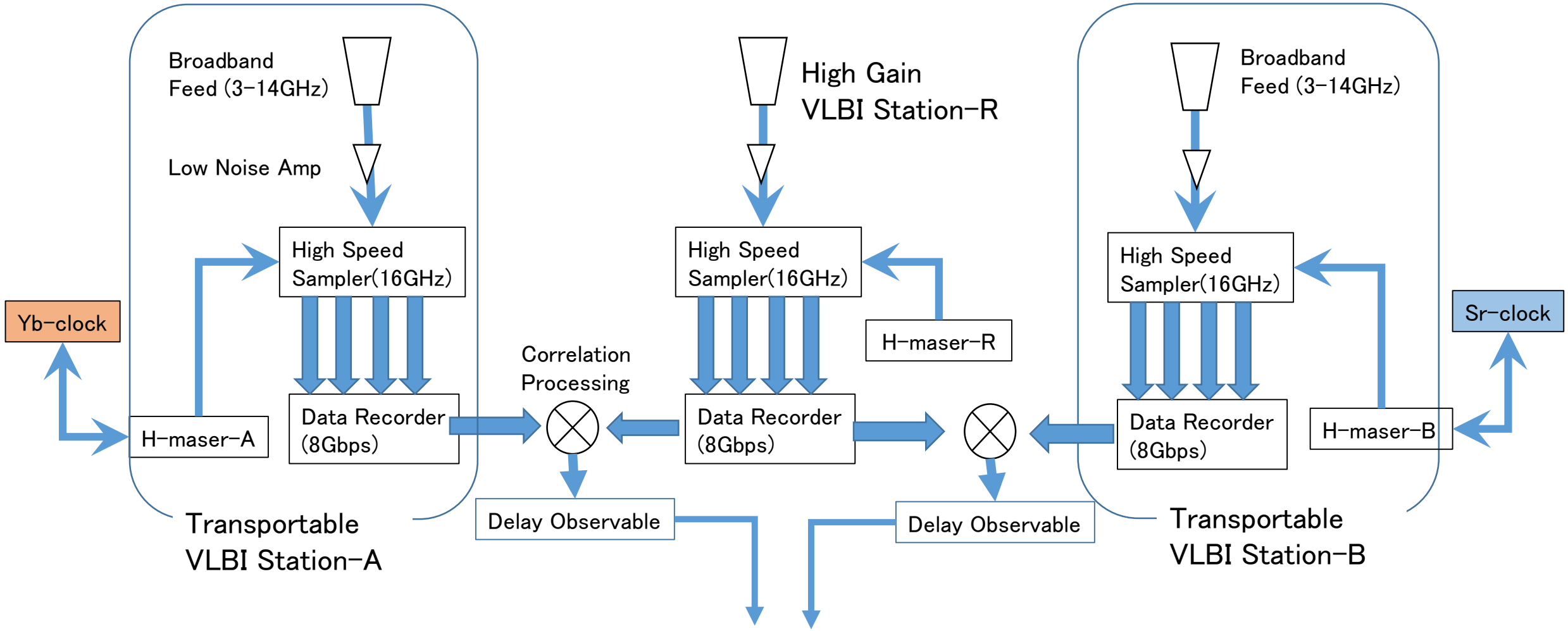
‘Small - Small’ Baseline via closure delay

- Closure delay relation used for ‘small-small’ baseline.

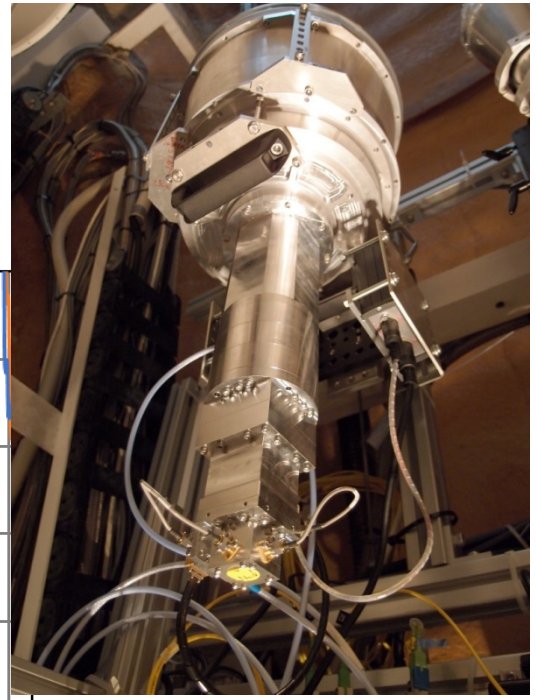
$$\tau_{21}(t_1) = \tau_{23}(t_1) - \tau_{13}(t_1) - \tau_{13}(t_1)\dot{\tau}_{12}$$

- Advantage of Small Antenna:
  - Fast Slew and Small Distortion
  - Large Diameter’s effects are canceled out.
  - Lower Cost
- Disadvantages:
  - Lower Sensitivity,
  - source structure effect in closure delay.

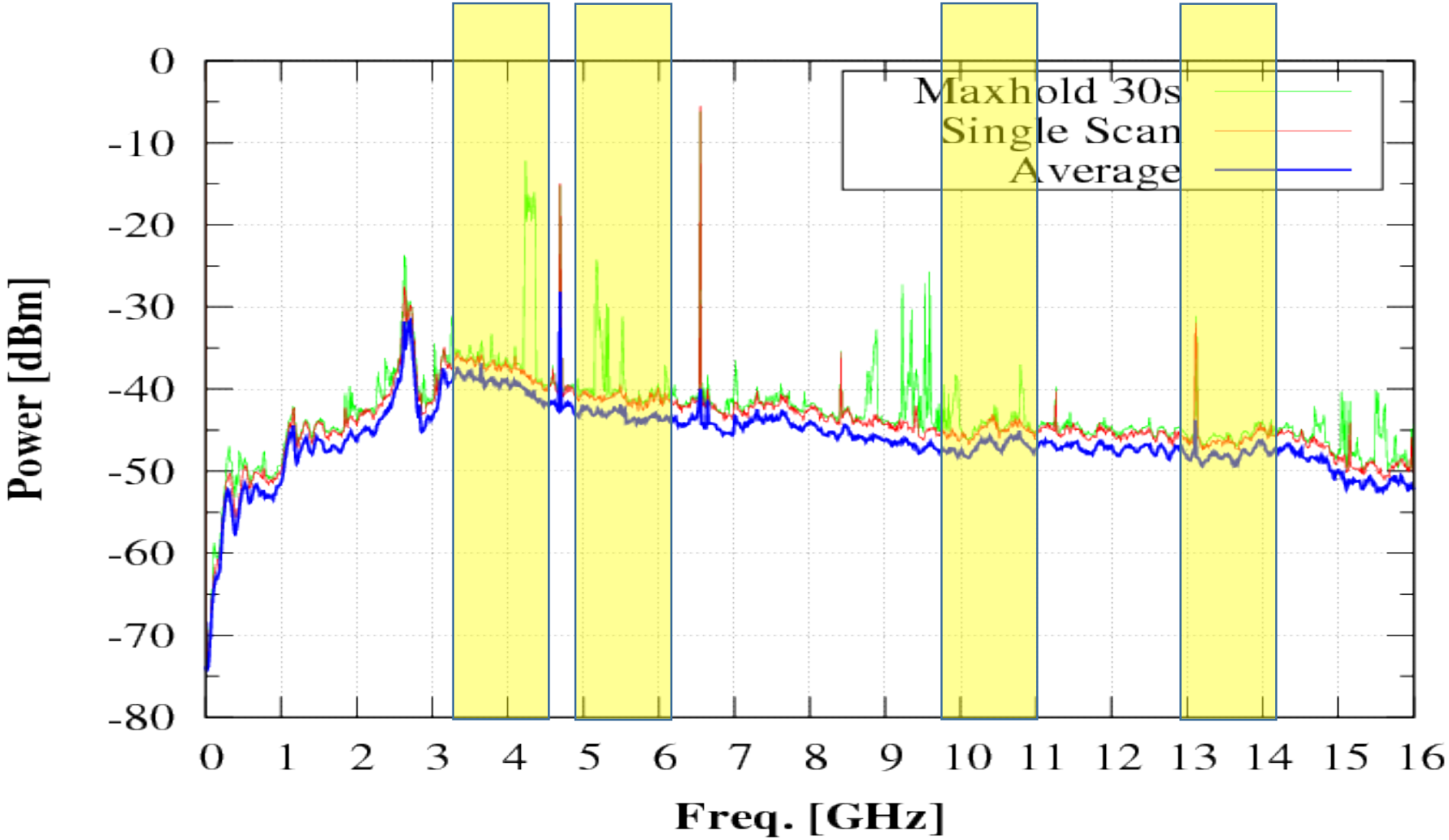



Broadband
Feed (3-14GHz)
Low Noise Amp
High Speed
Sampler(16GHz)
Yb-clock
H-maser-A
Data Recorder
(8Gbps)
Transportable
VLBI Station-A
High Gain
VLBI Station-R
High Speed
Sampler(16GHz)
H-maser-R
Correlation
Processing
Data Recorder
(8Gbps)
Delay Observable
Delay Observable
Broadband
Feed (3-14GHz)
High Speed
Sampler(16GHz)
Sr-clock
H-maser-B
Data Recorder
(8Gbps)
Transportable
VLBI Station-B
VLBI Delay Analysis
Clock difference between H-maser-A and B.

NINJA Broadband Feed Dual-Pol



Current State at Kashima 34m
Broadband Signal



RBW=3MHz
Whole BW~12GHz

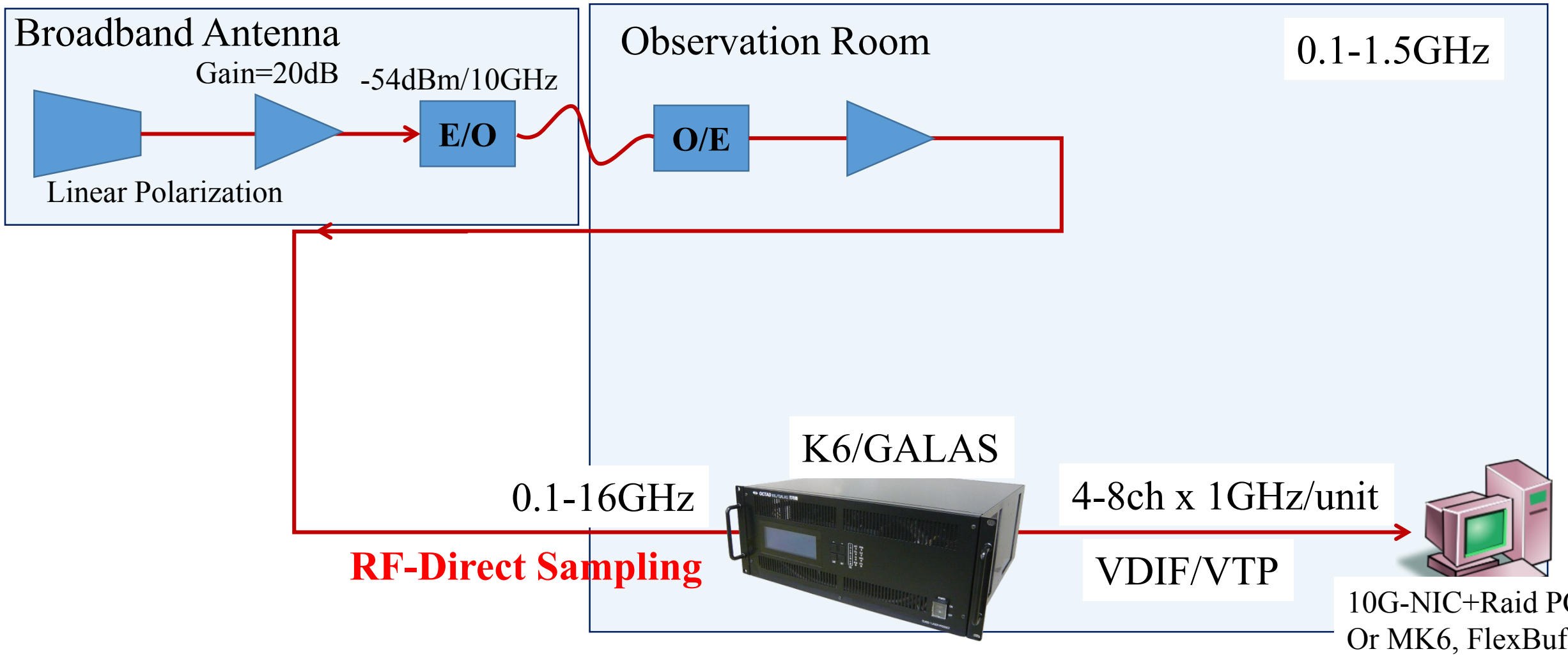
N=12GHz/3MHz
=36dB

Total Powe~-45+36
=-9dBm
< -5dBm (RFI)

Data Acquisition System

300k=-174 dBm/Hz
-74dBm/10GHz

We have to be careful to compromise (1)avoiding saturation of system and (2) increase of noise figure, as discussed by Chris(2012) .



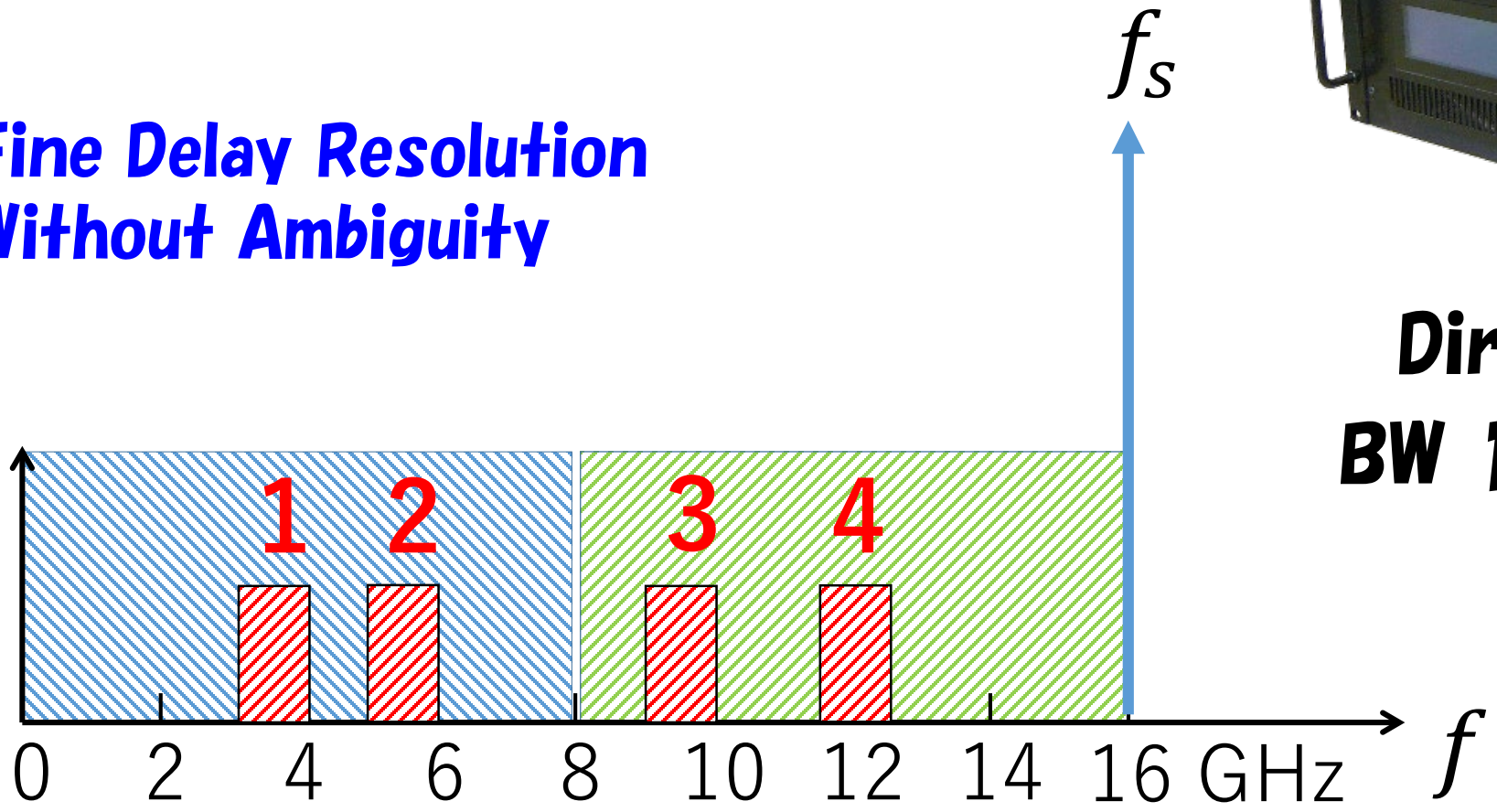
As close as Zero Redundancy

Frequency allocation

Direct Sampling

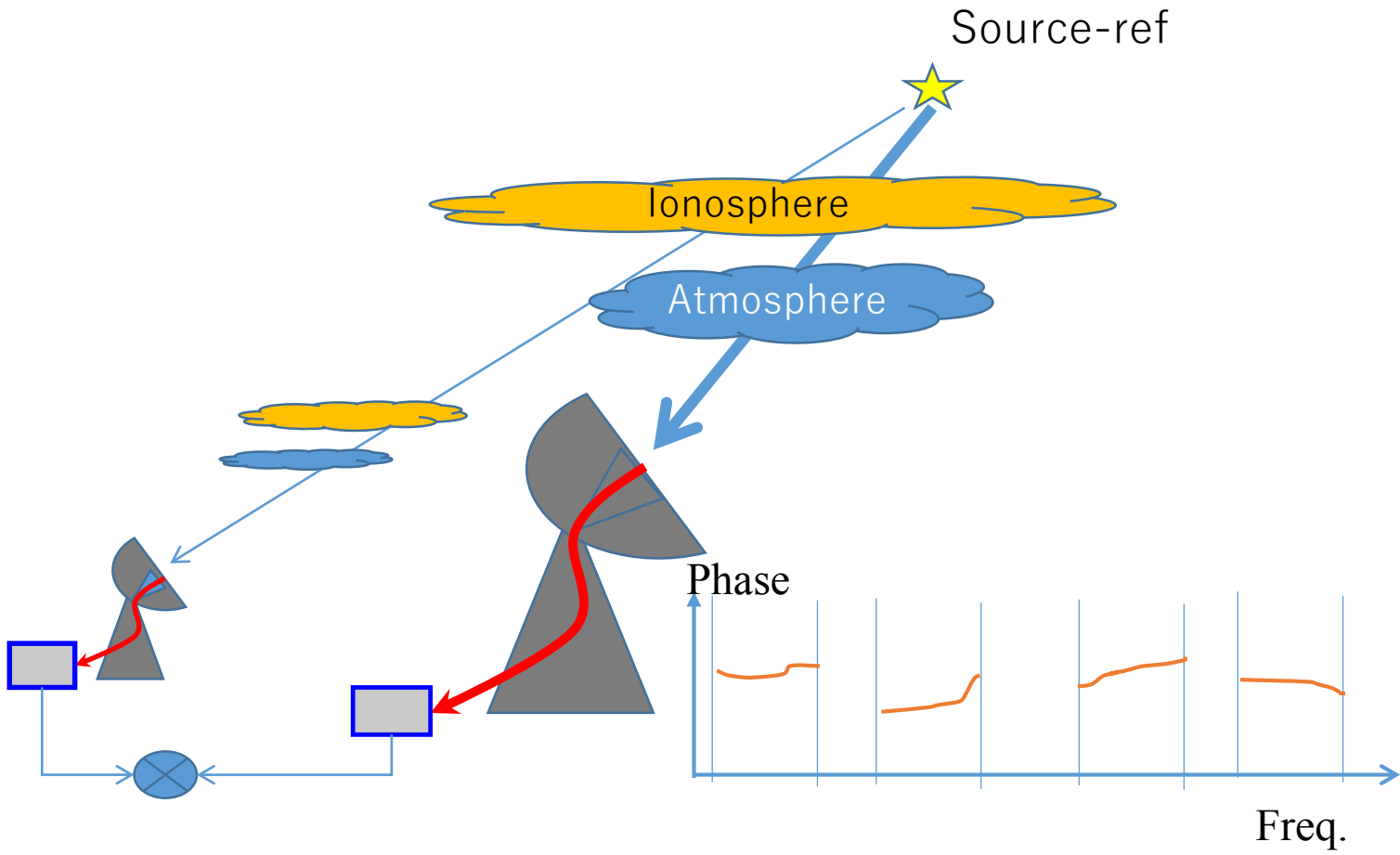
BW 1024MHz each

Fine Delay Resolution
Without Ambiguity



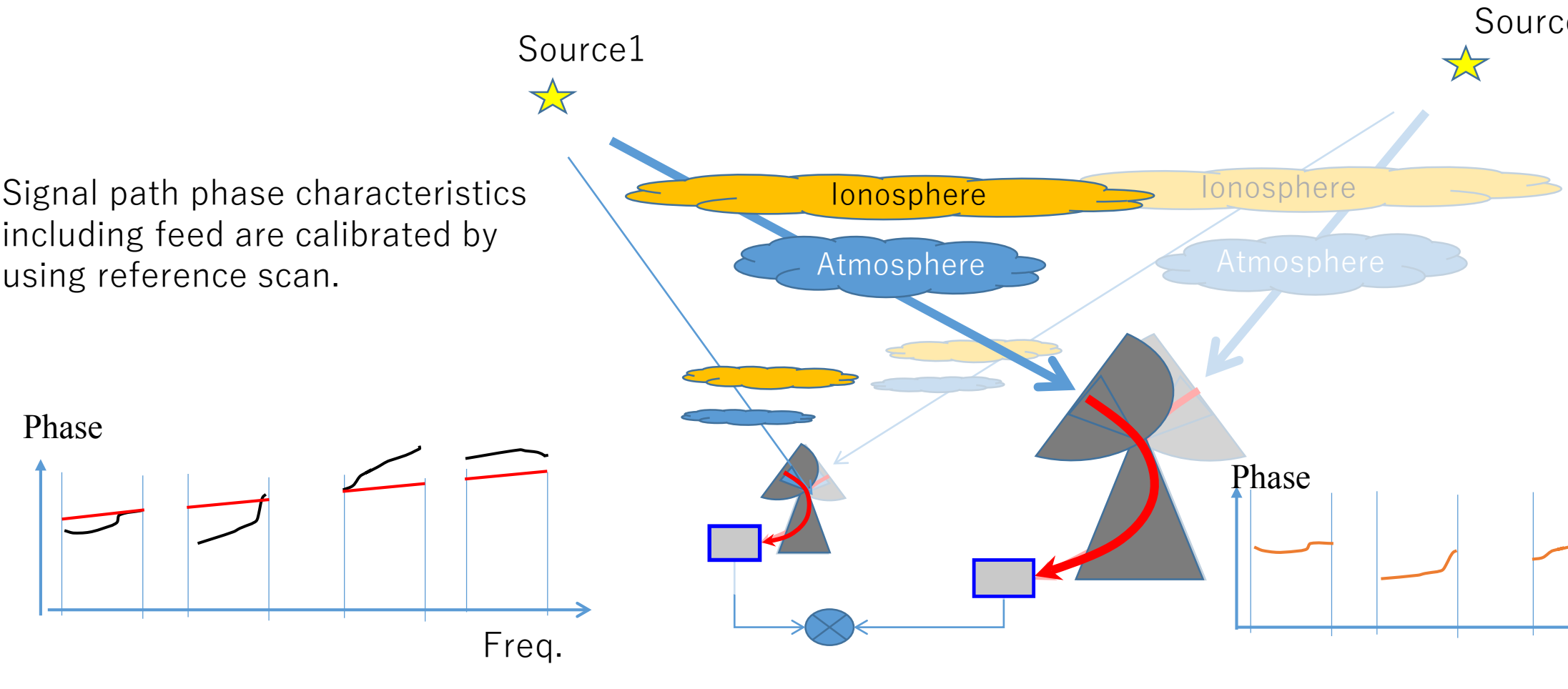
Lower Edge= 3.2, 4.8, 8.8, 11.6GHz

Procedure of Broadband Phase Calibration with radio source



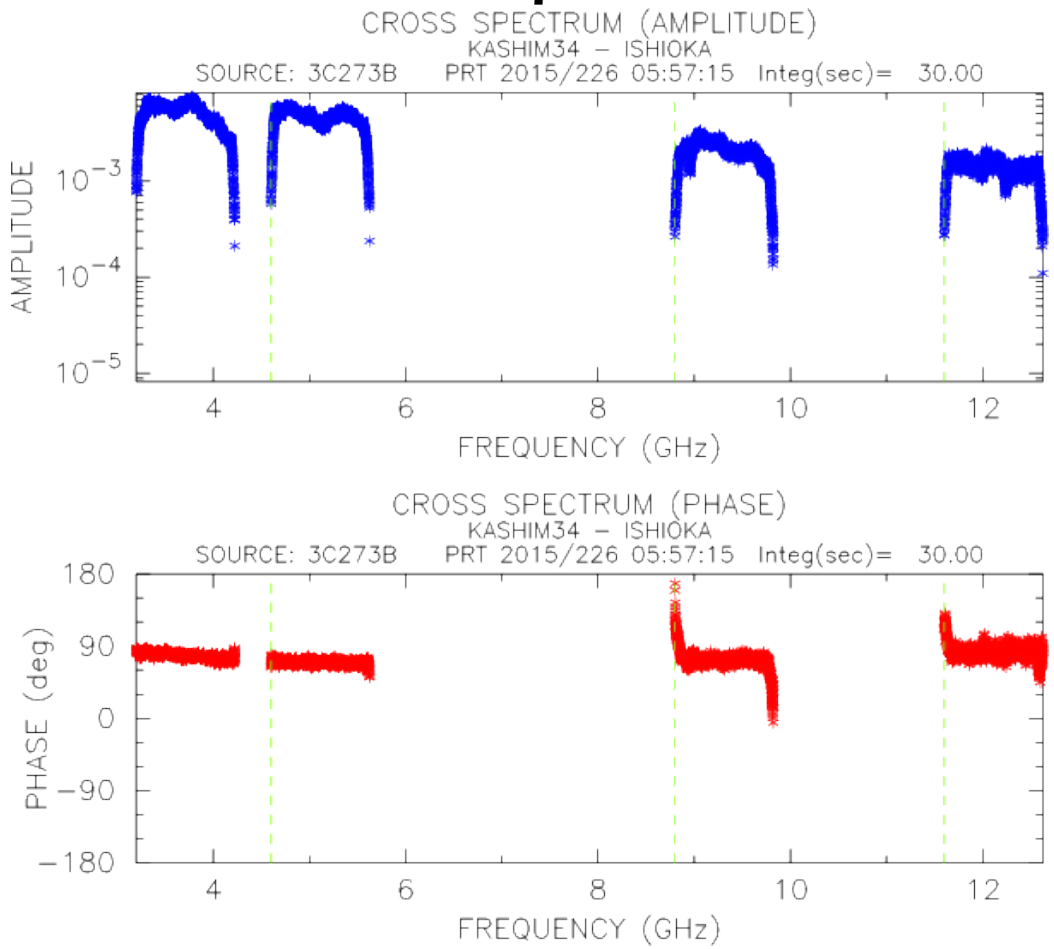
Procedure of Broadband Phase Calibration with radio source

Signal path phase characteristics including feed are calibrated by using reference scan.

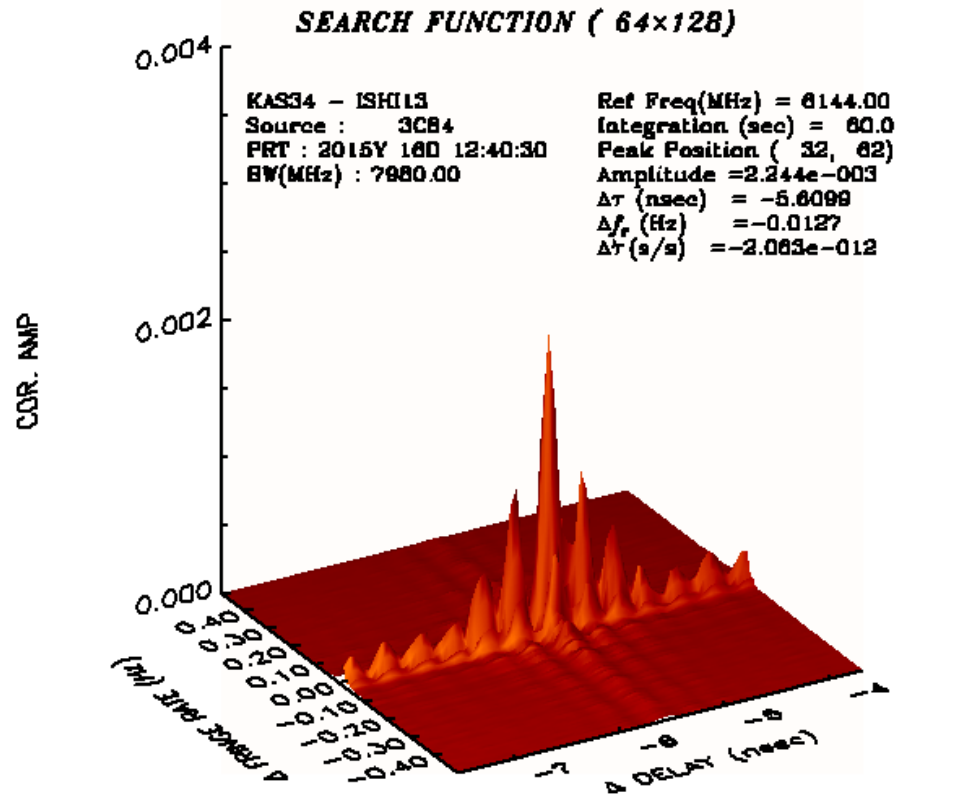


Full Bandwidth Synthesis #1-#(6-14GHz)

Cross Spectrum

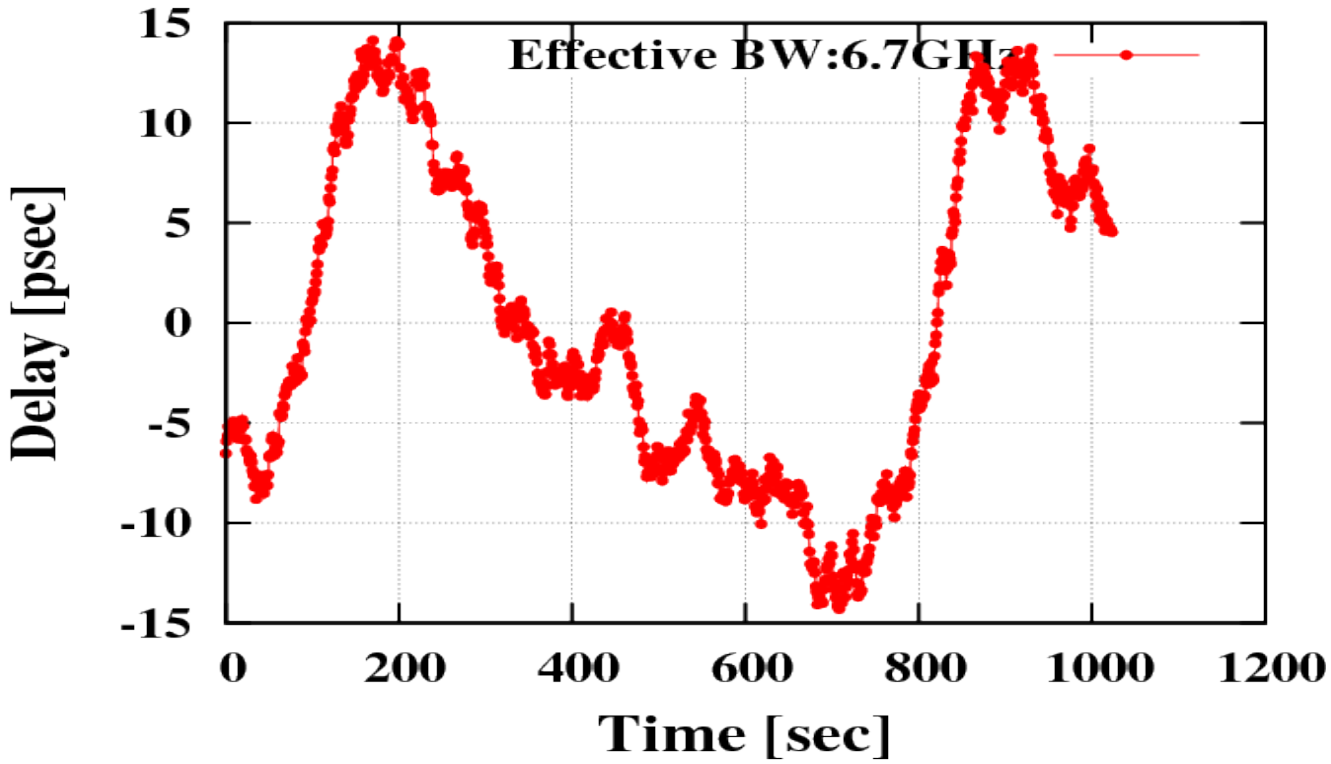


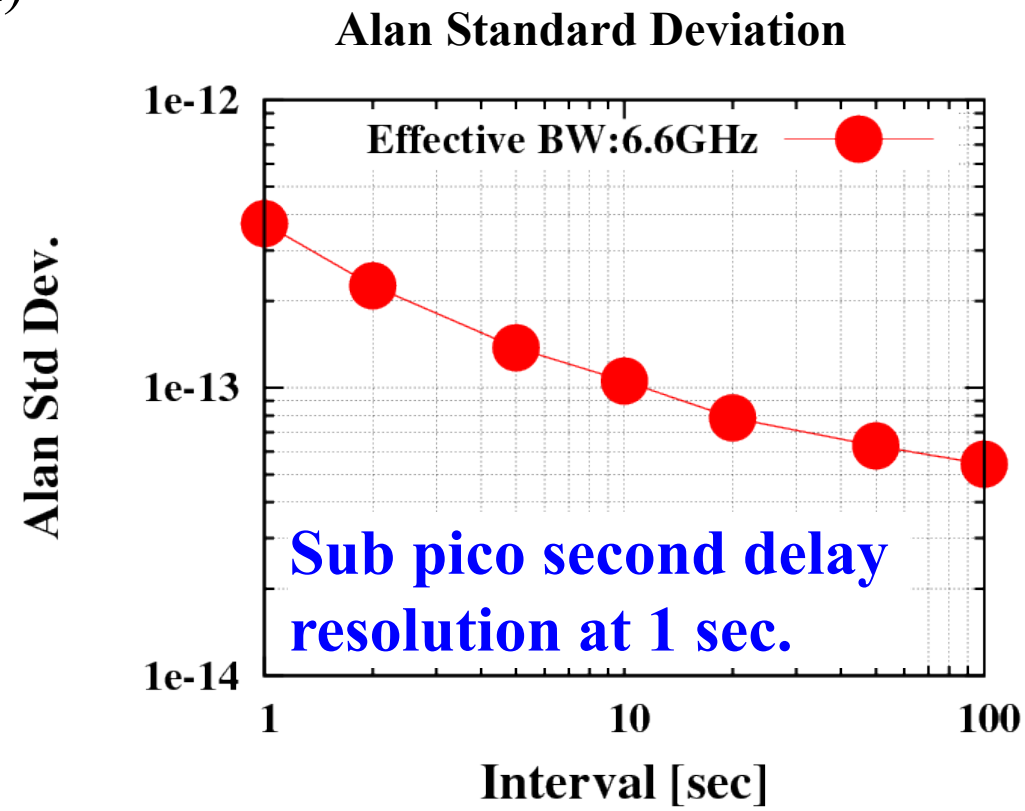
Delay Resolution Function



Delay Behavior Broadband Group Delay (3.2-12.6GHz) Kashima34 – Ishioka 13m

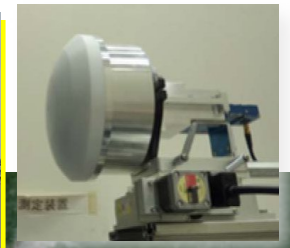
Exp. on 14 Aug.2015,
Freq. array=(Lower Edge=3.2, 4.8, 8.8, 11.6GHz)

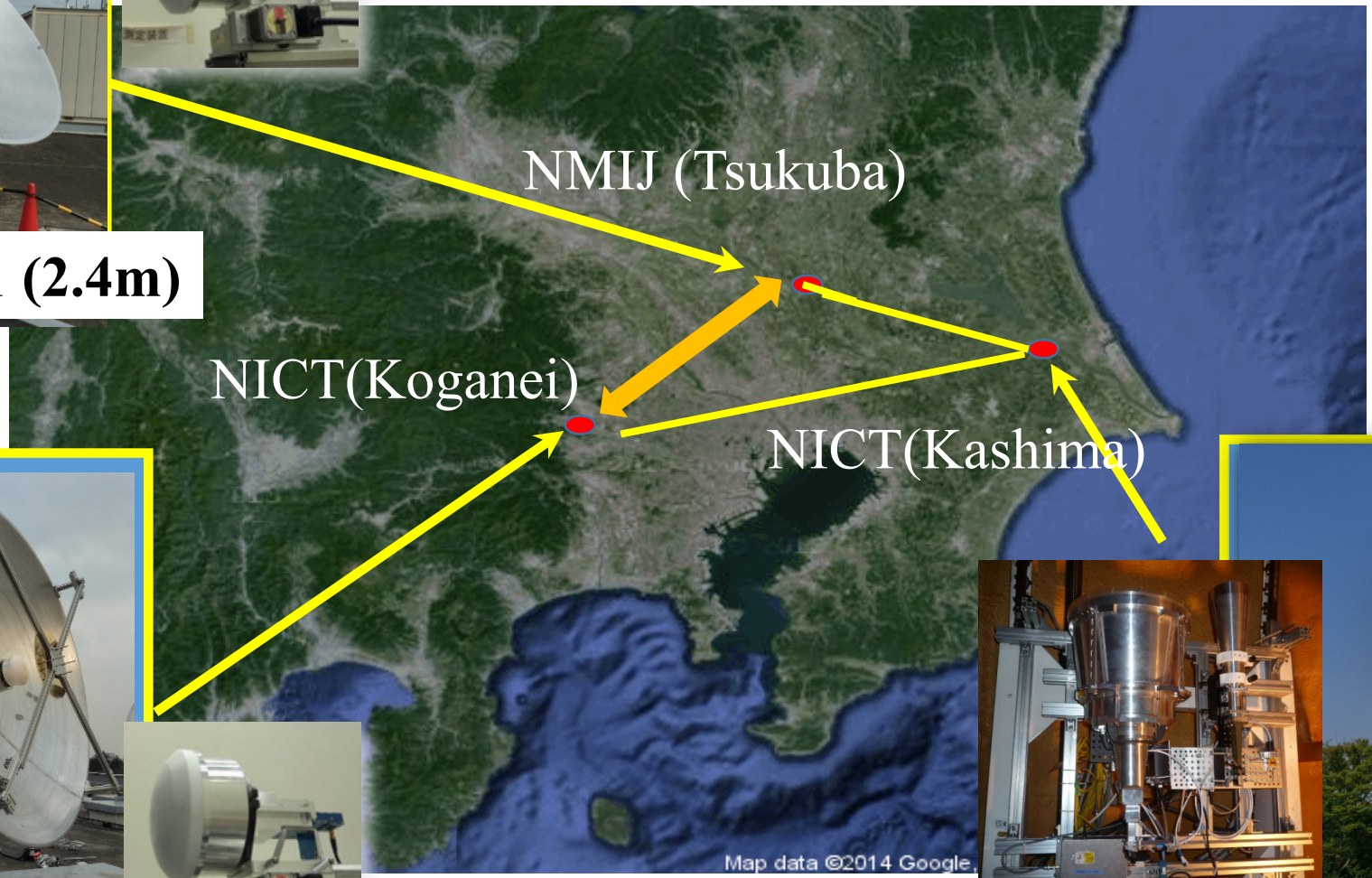




Broadband VLBI: Domestic Test Experiment

MARBLE1 (2.4m)





MARBLE2(2.4m)

NINJA Feed
For Marble

Broadband
NINJA Feed

Kashima 34m(NICT)

Delay Precision

Broadband(small-small)

v.s.

Conventional 8180-8680MHz

S/X **500MHz(T2 session)**

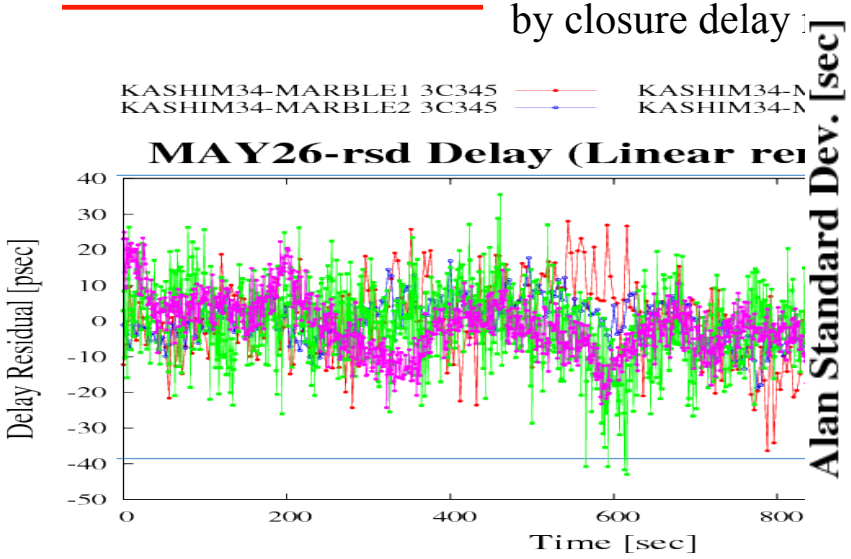
2.4m Diameter

1.6m Diameter

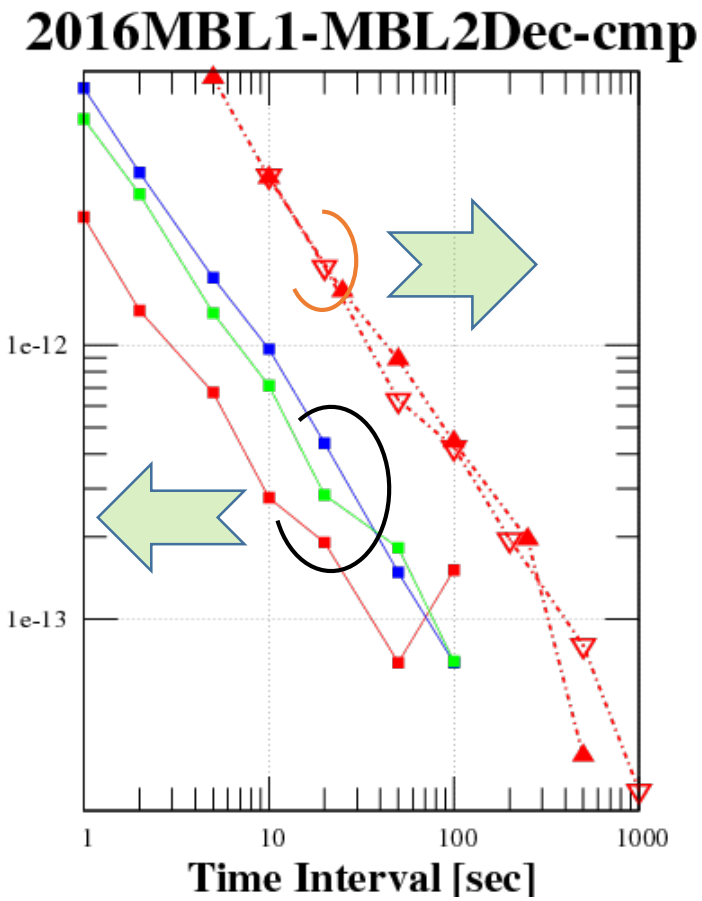
3C273B

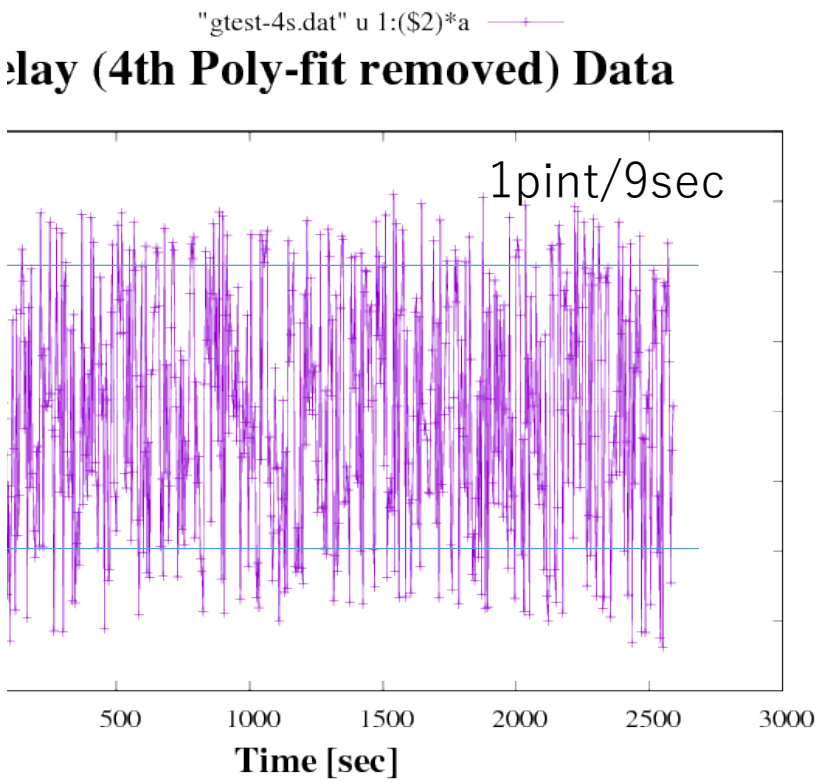
4C39.25

Broadband ‘small-small’ bas
by closure delay



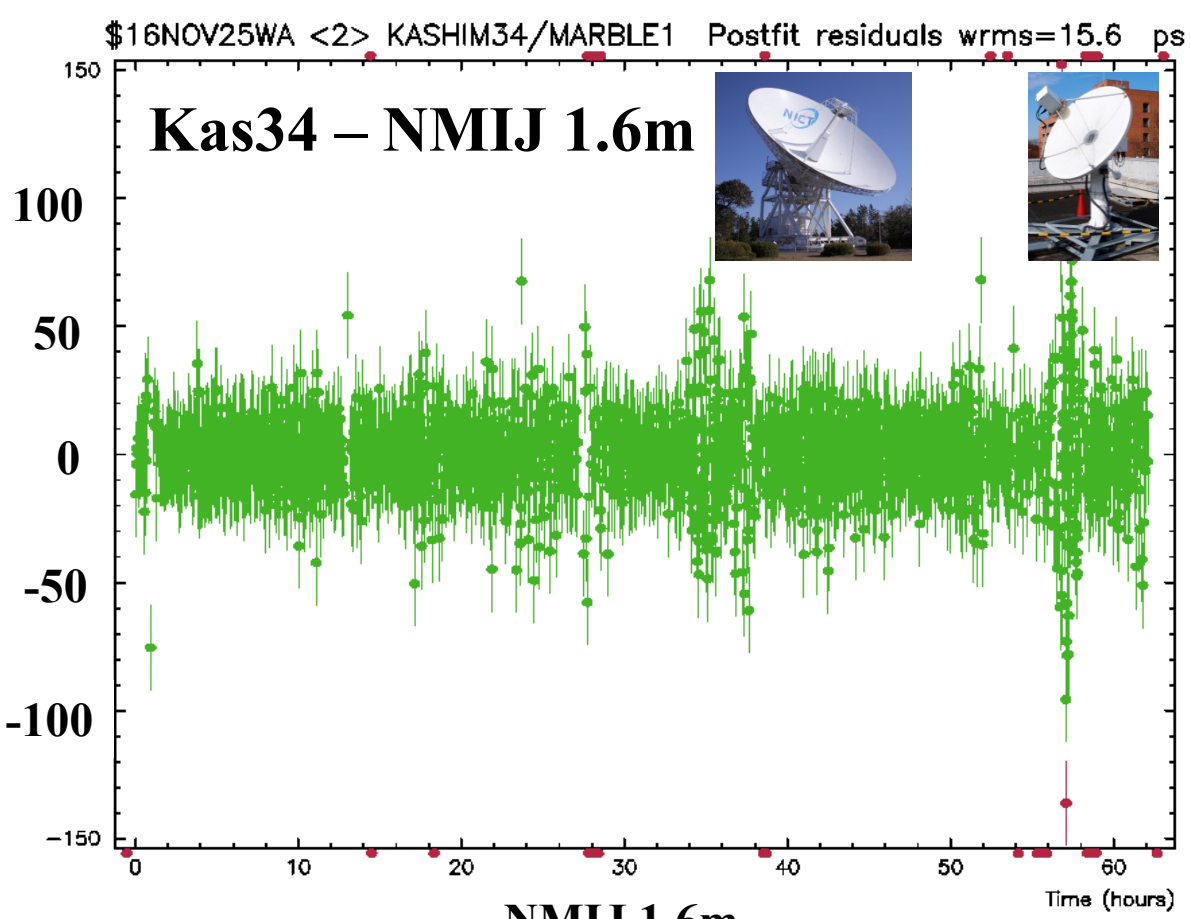
1pint/1sec

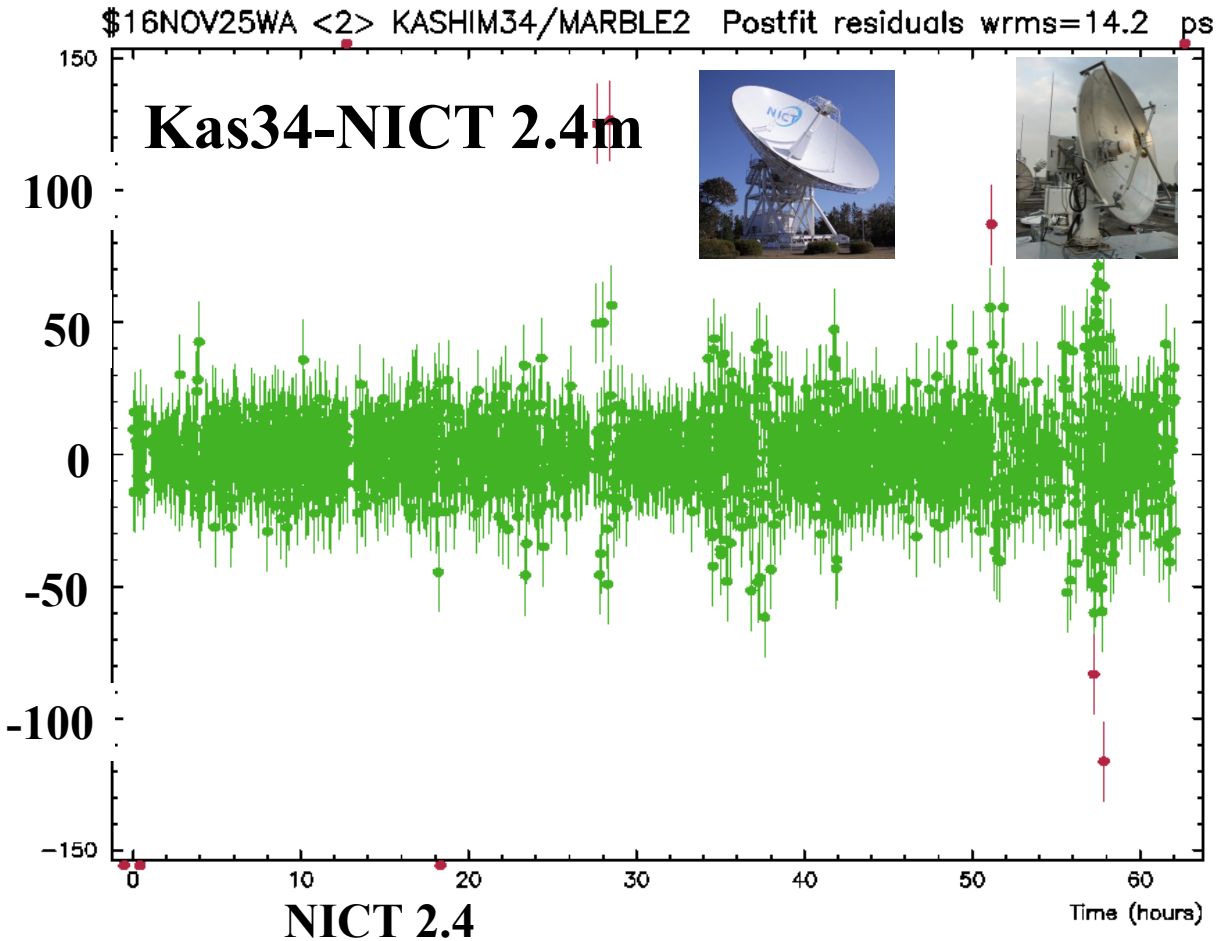




CALC/SOLVE Broadband(5.4-11G Hz) Residual

WRMS Delay Residual ~ 16ps





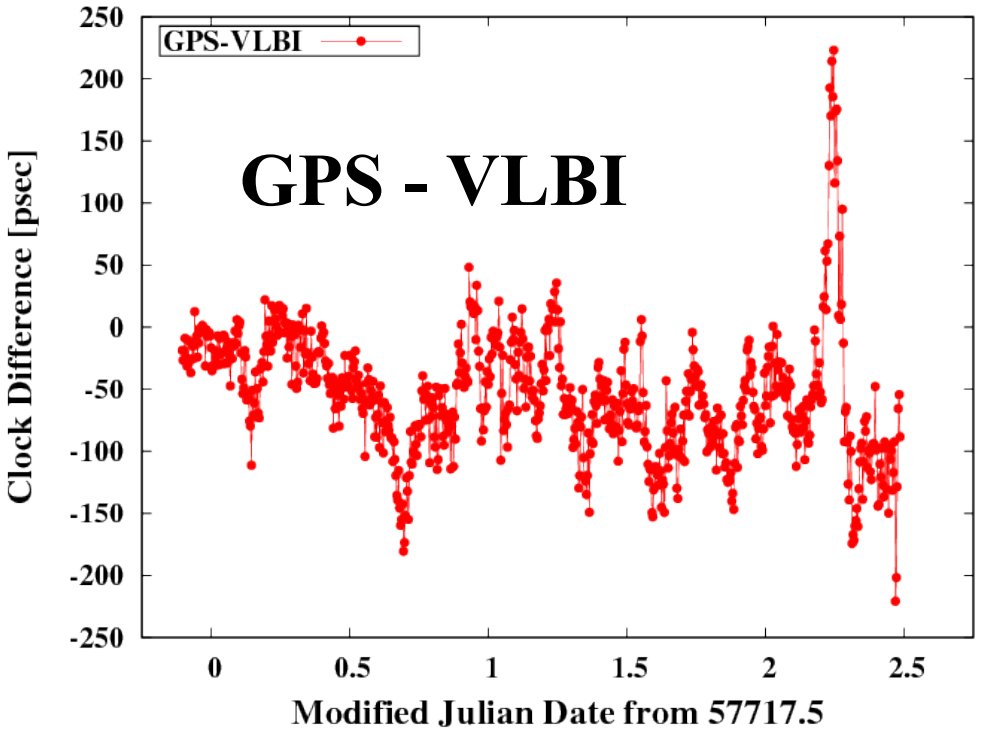
NMIJ 1,6m

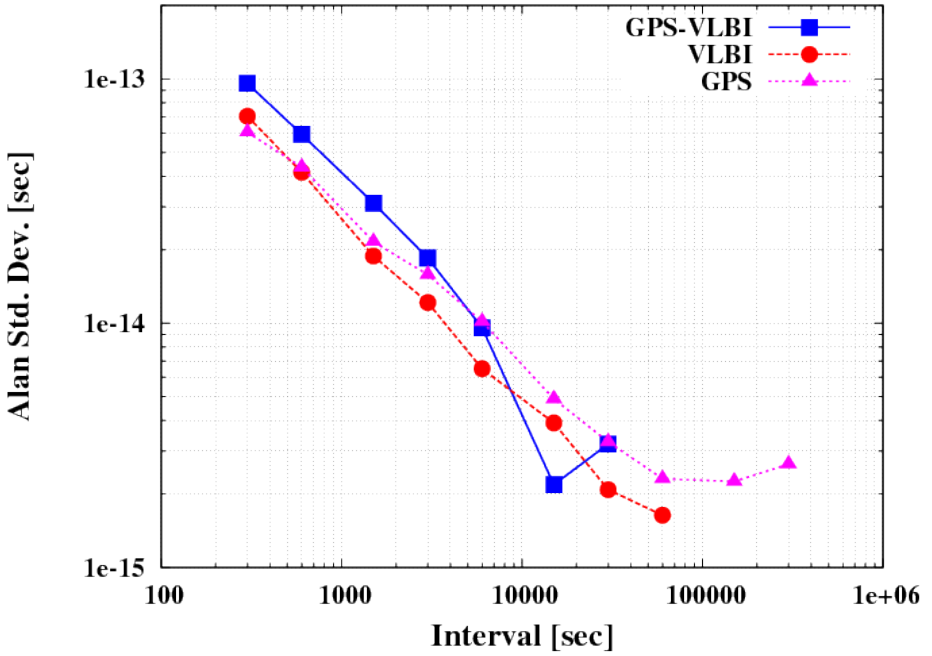
X ：	-3962279099.2 mm	1.9 mm
Y ：	3308886482.2 mm	1.5 mm
Z ：	3733538092.1 mm	1.8 mm

NICT 2.4

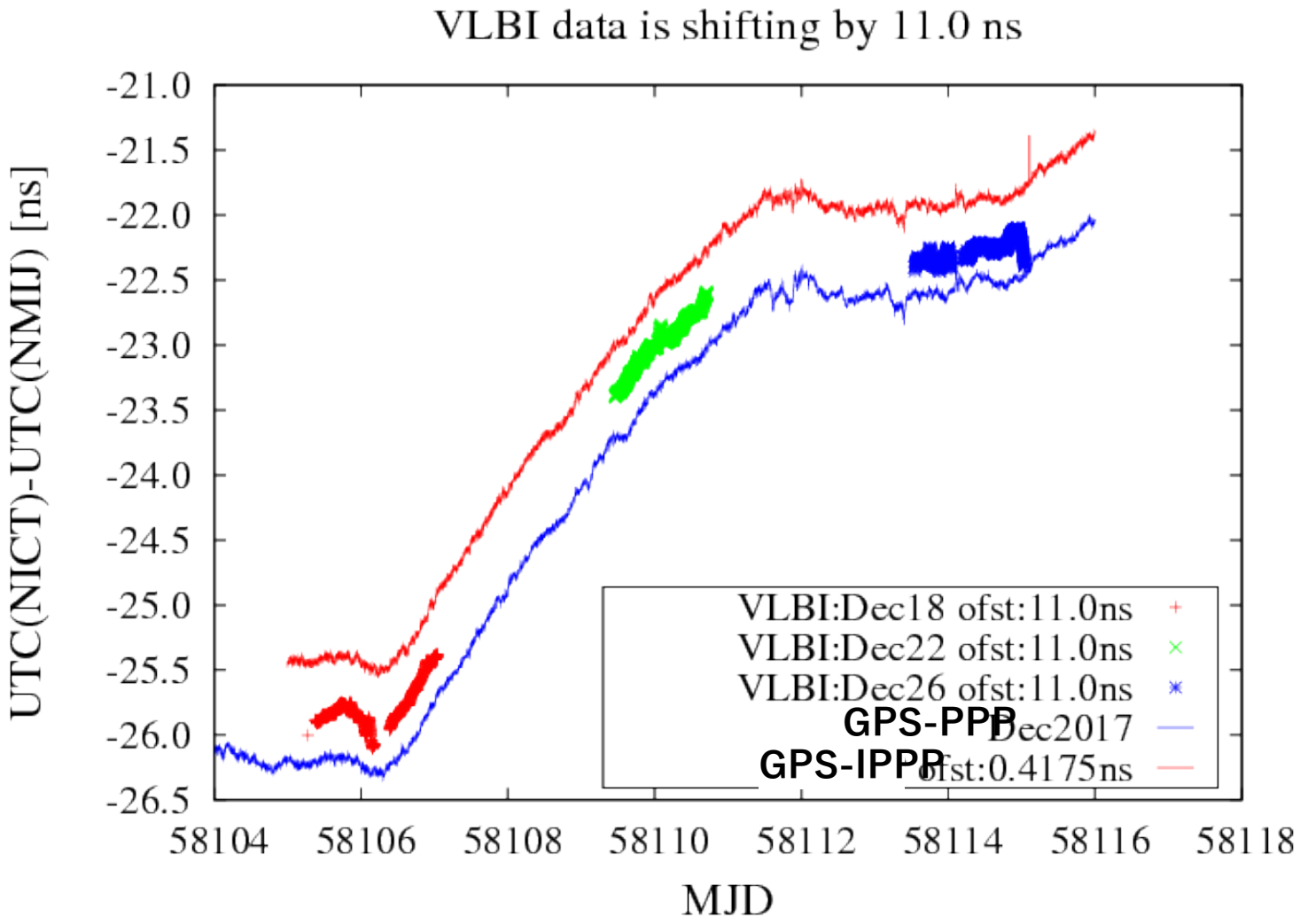
X:	-3942068754.6 mm	1.8 mm
Y:	3368281011.8 mm	1.5 mm
Z:	3702003908.5 mm	1.7 mm

Clock Comparison via VLBI and GPS-ppp
2016Nov25 UTC(NICT) – UTC(NMIJ)

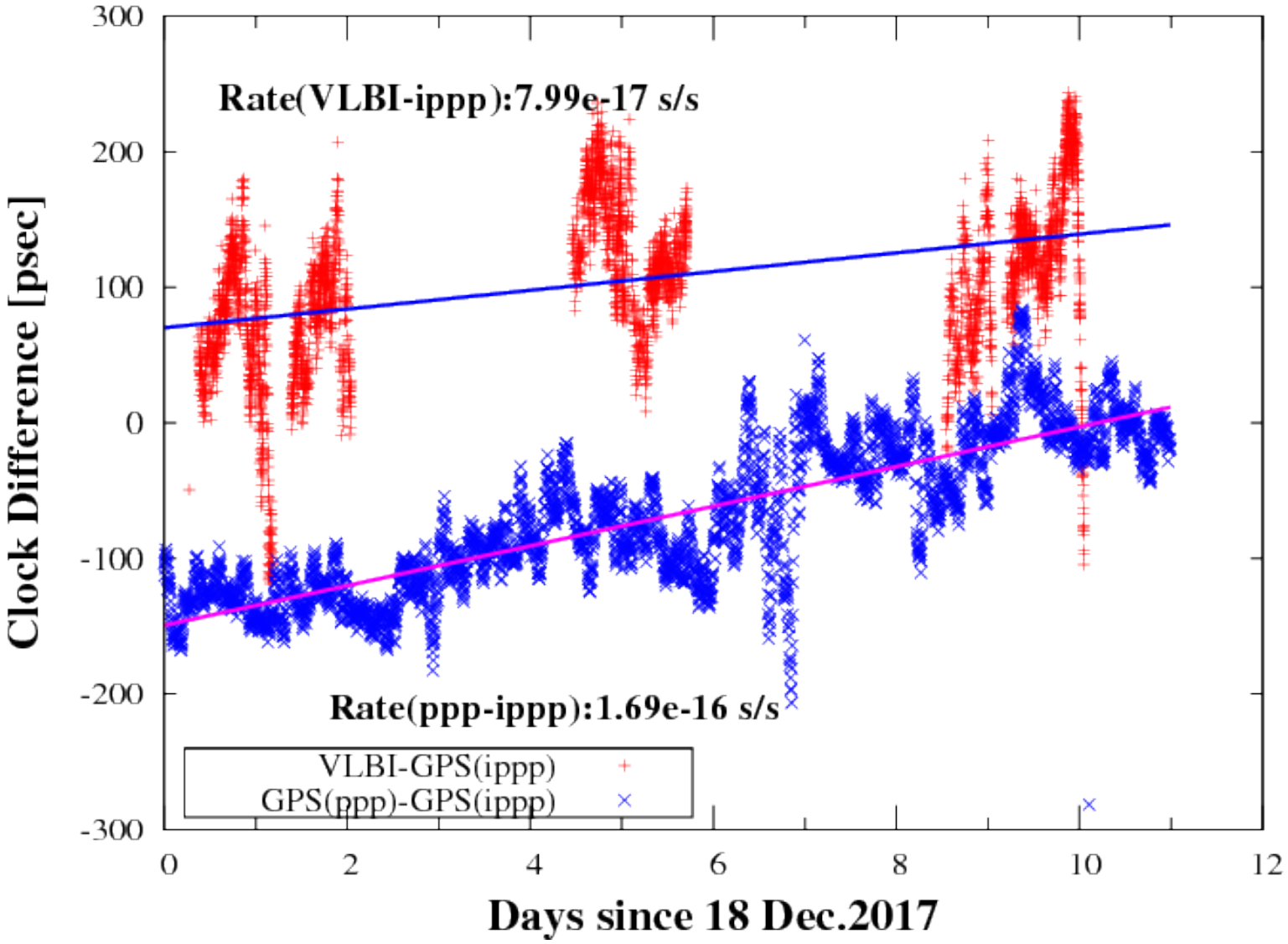


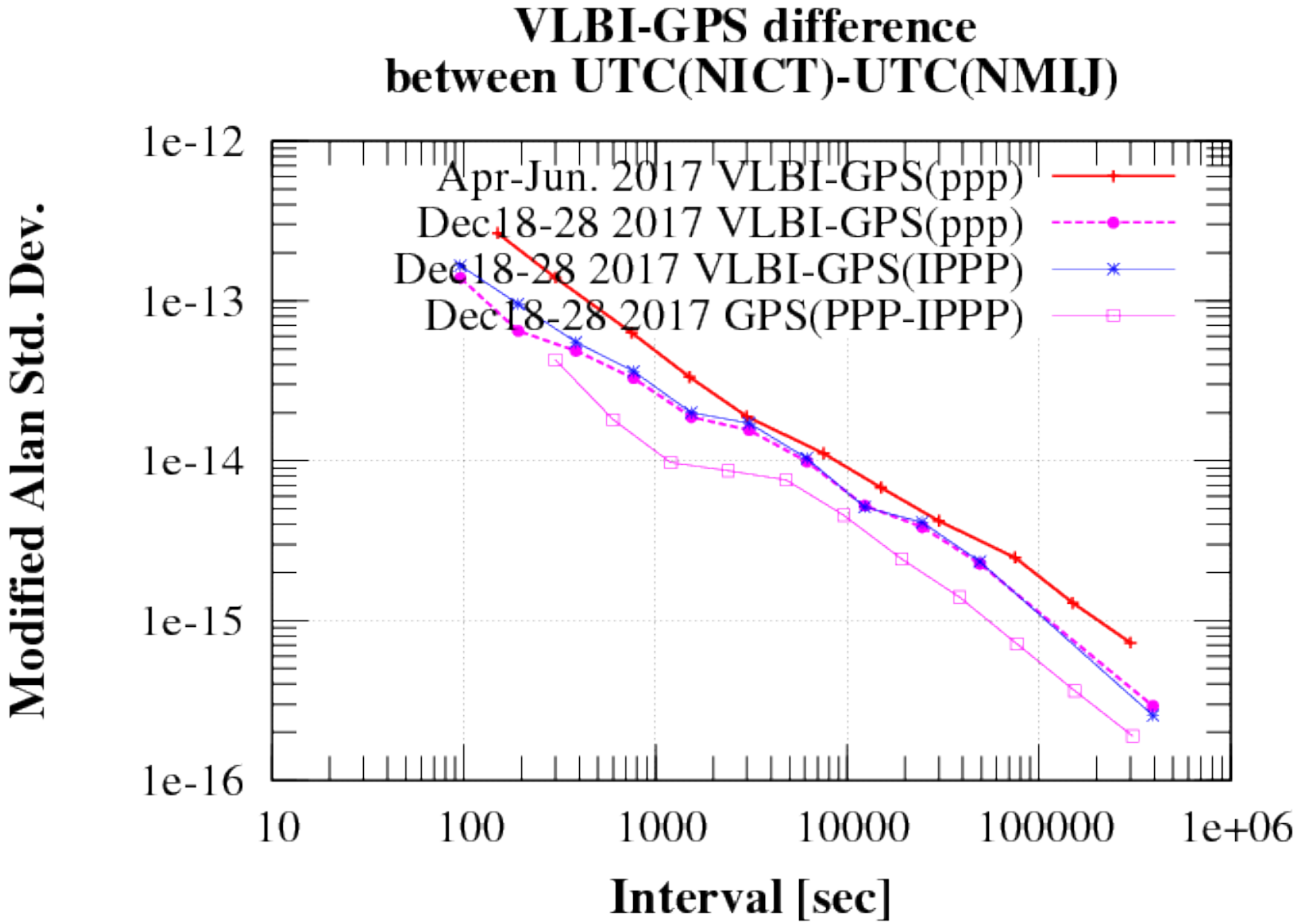


UTC(NICT)-UTC(NMIJ) monitored by VLBI, GPS



Comparison:VLBI-IPPP, GPS(ppp)-IPPP

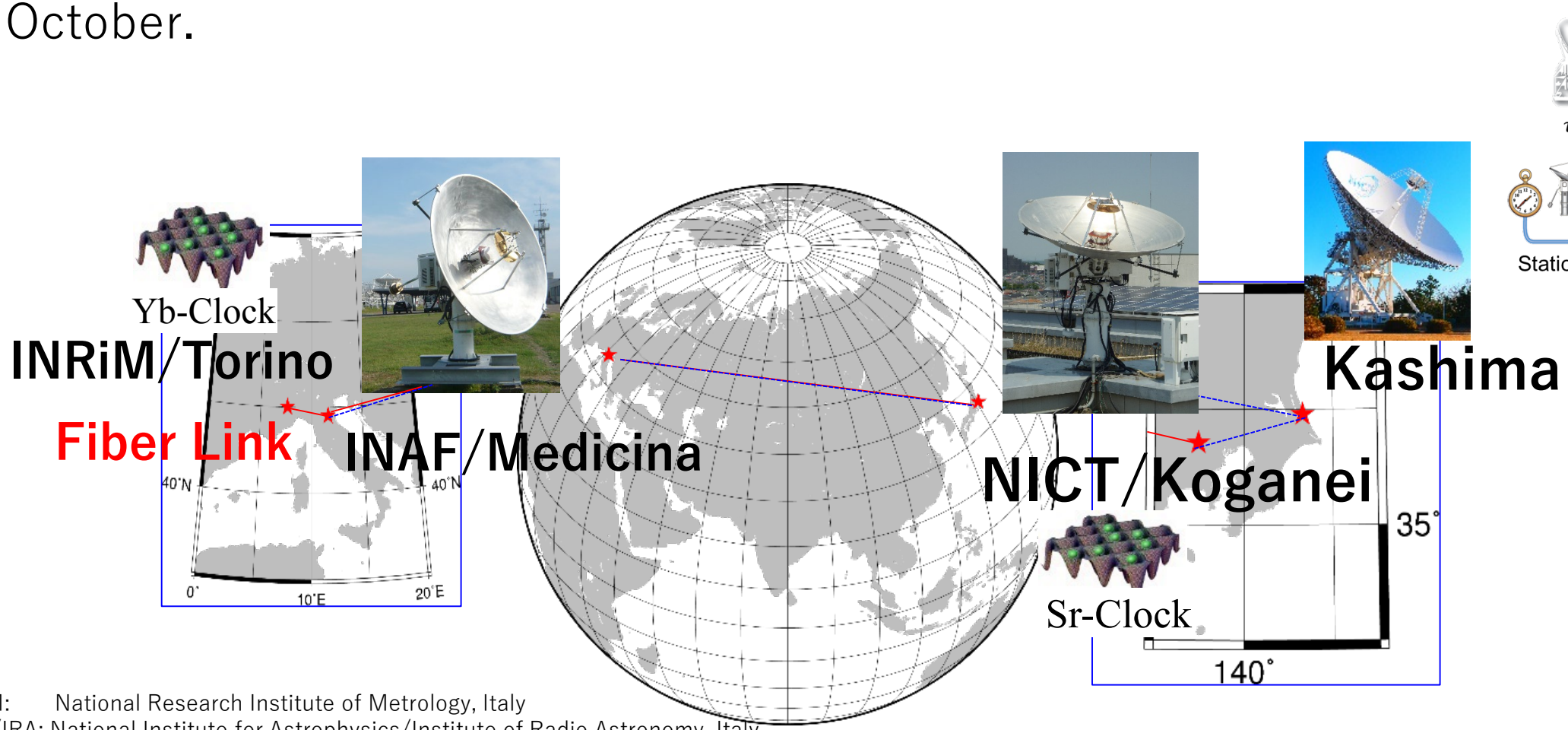


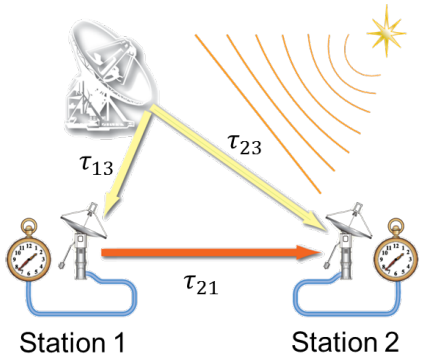


Note: “Modified Allan STD” here is computed by using linear interpolation with neighbor data. Thus it is underestimation than real Allan STD.

Frequency Link INAF-INAF/IRA-NICT by VLBI

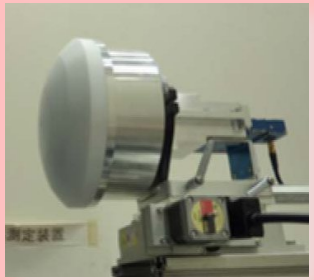
In 2018 July, one of the 2.4m antenna was installed at Medicina VLBI station of INAF/IRA. We have started test VLBI experiment from October.





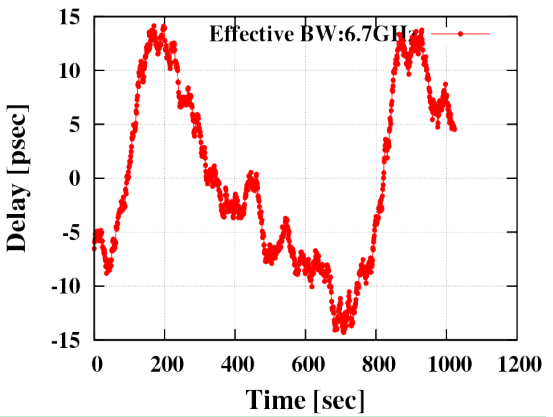
INRiM: National Research Institute of Metrology, Italy
INAF/IRA: National Institute for Astrophysics/Institute of Radio Astronomy, Italy
NICT: National Institute of Information and Communications Technology, Japan

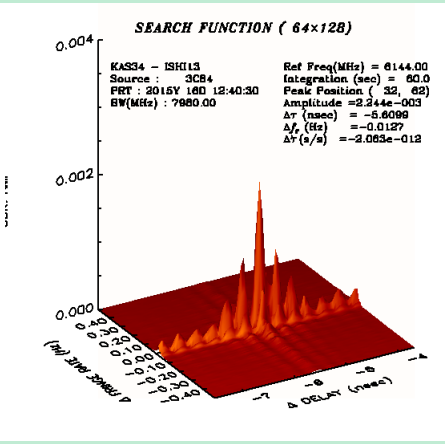
Summary



Broadband Feed: NINJA

RF-Direct Sampling K6/GALAS





Broadband bandwidth Synthesis

1. 広帯域VLBIシステムは1秒でサブピコ秒精度の計測を実証.
2. VLBI 周波数比較は (Passive, Free from Satellite, Long term stability) といった利点・特徴を持つ.
3. 今後の改善点：
    1. 天体の選択 (電波源構造, Radio Flux)
    2. バンド幅合成,(電離層).