Status Report of VLBI Group of NICT/Kashima

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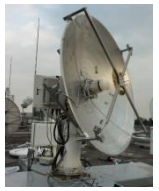
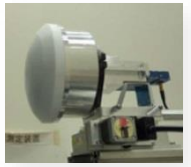
Activities of NICT/Kashima VLBI Group

- **Broadband VLBI(GALA-V) Development**
  - **Broadband Feed, RF-Direct Sampling, Wideband Bandwidth Synthesis**
  - **Signal path from Observation, Correlation, DB Creation, Baseline Analysis is ready. Domestic experiments have been conducted.**
- **Participating VLBI Observation of IVS**
  - **Antenna: Kashima 34m, Kashima 11m, Koganei 11m**
  - **Sessions(10-15 times): R1, T2, APSG, CRF, and AOV(6 times) in 2016**



- **34m Antenna Status**
  - **Corrosion at Backup structure of main reflector.**
    - **Refurbishment work design is being contracted will finish in Dec.**
    - **Refurbishment work will be done in the first half of 2018.**
  - **Leakage of Helium gas for cooling the receivers.**
    - **Leakage started from this Feb. and get degraded to stop cooling in this June.**
    - **Helium return tube of 25m length was determined to be the cause of leakage.**
    - **Replacement will be in Sep. with expecting recovery to normal state.**

GALA-V Project Overview

Frequency comparison by using Transportable Broadband telescopes

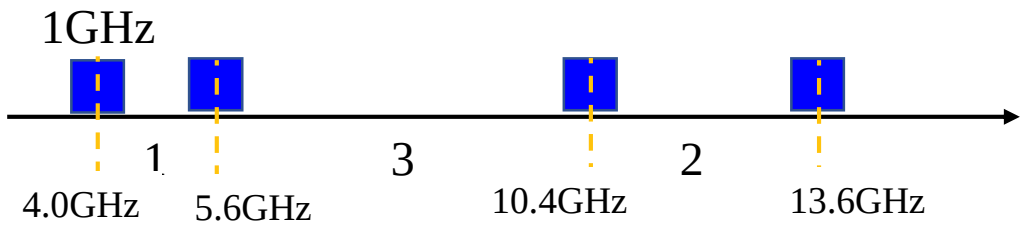
- VLBI Sensitivity :VLBI Sensitivity$=\propto D_1 D_2 \sqrt{BT}$

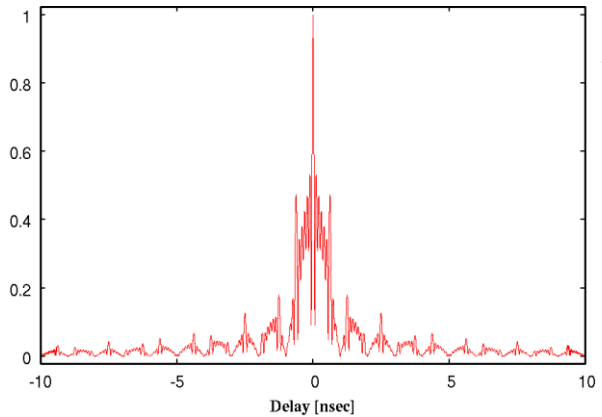
  B: 32MHz → 1024MHz (32 times)

■Radio Frequency： 3-14 GHz

■Data Acquisition： 4 band (1024 MHz width)

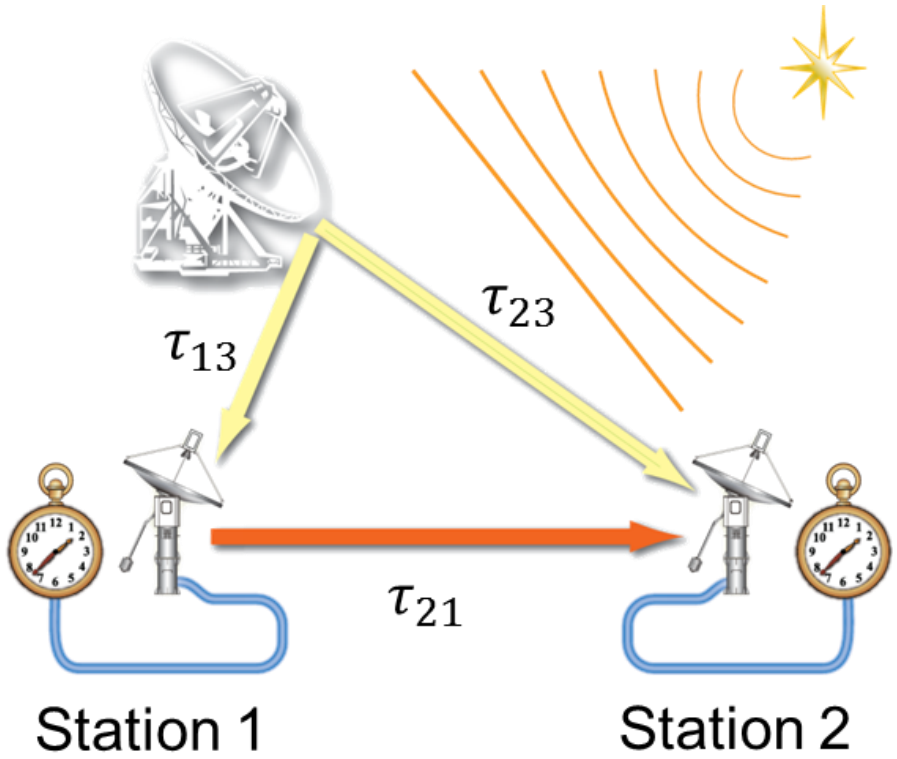
- ■ Nominal Freq. Array: Fc=4.0GHz, 5.6GHz, 10.4GHz, 13.6GHz
- ■ Effective Bandwidth：3.8GHz (10 times more than Conventional）





Delay Resolution Function

10 time higher resolution will be gained by broader bandwidth

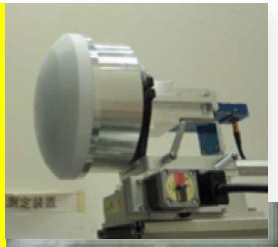


$$\tau_{21} = \tau_{13} - \tau_{23}$$

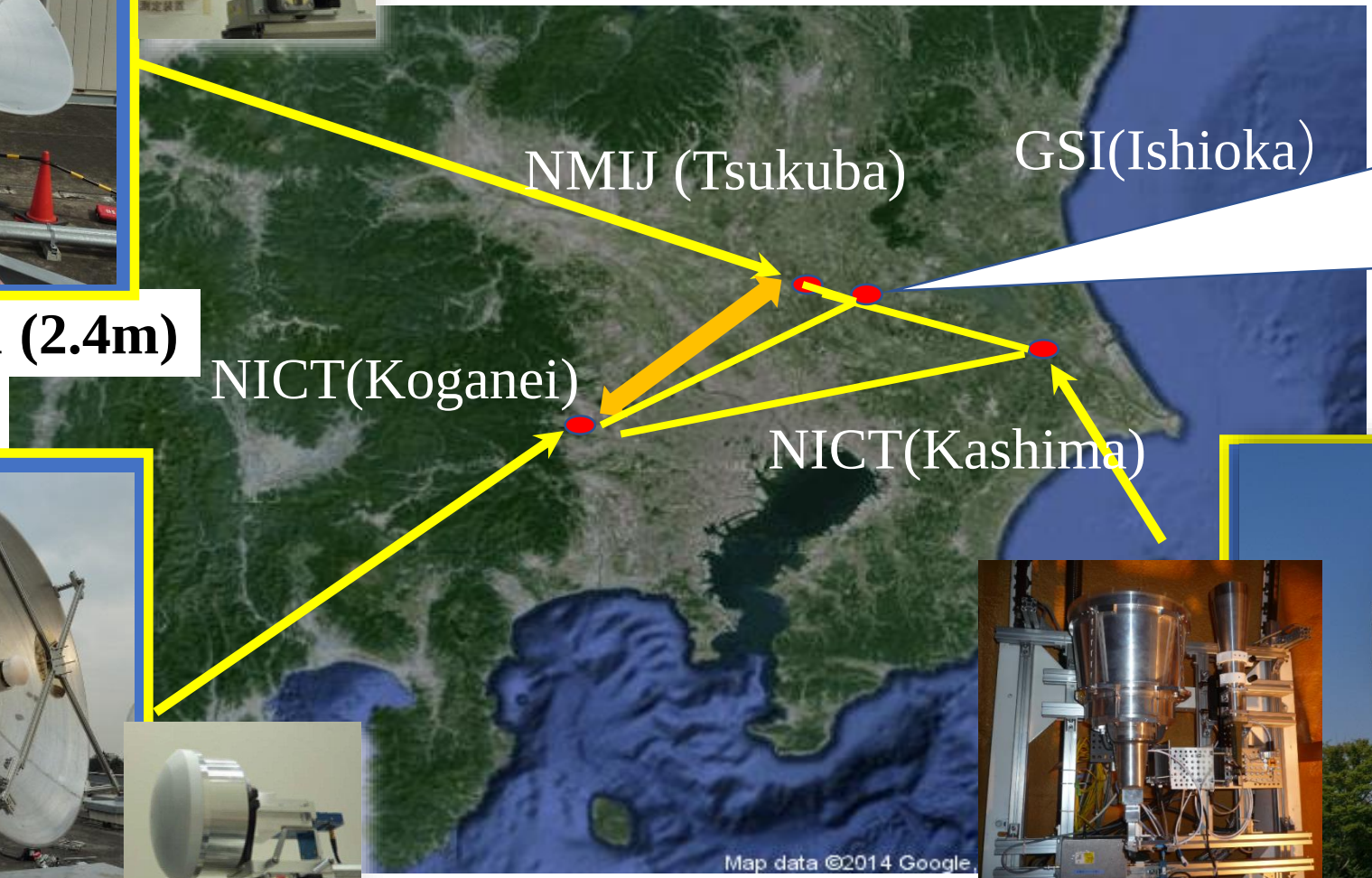
By using closure delay relation.

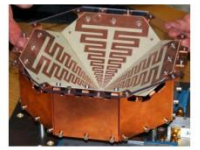
Broadband VLBI Stations in Japan

MARBLE1 (2.4m)



NINJA Feed
For Marble





Ishioka 13m

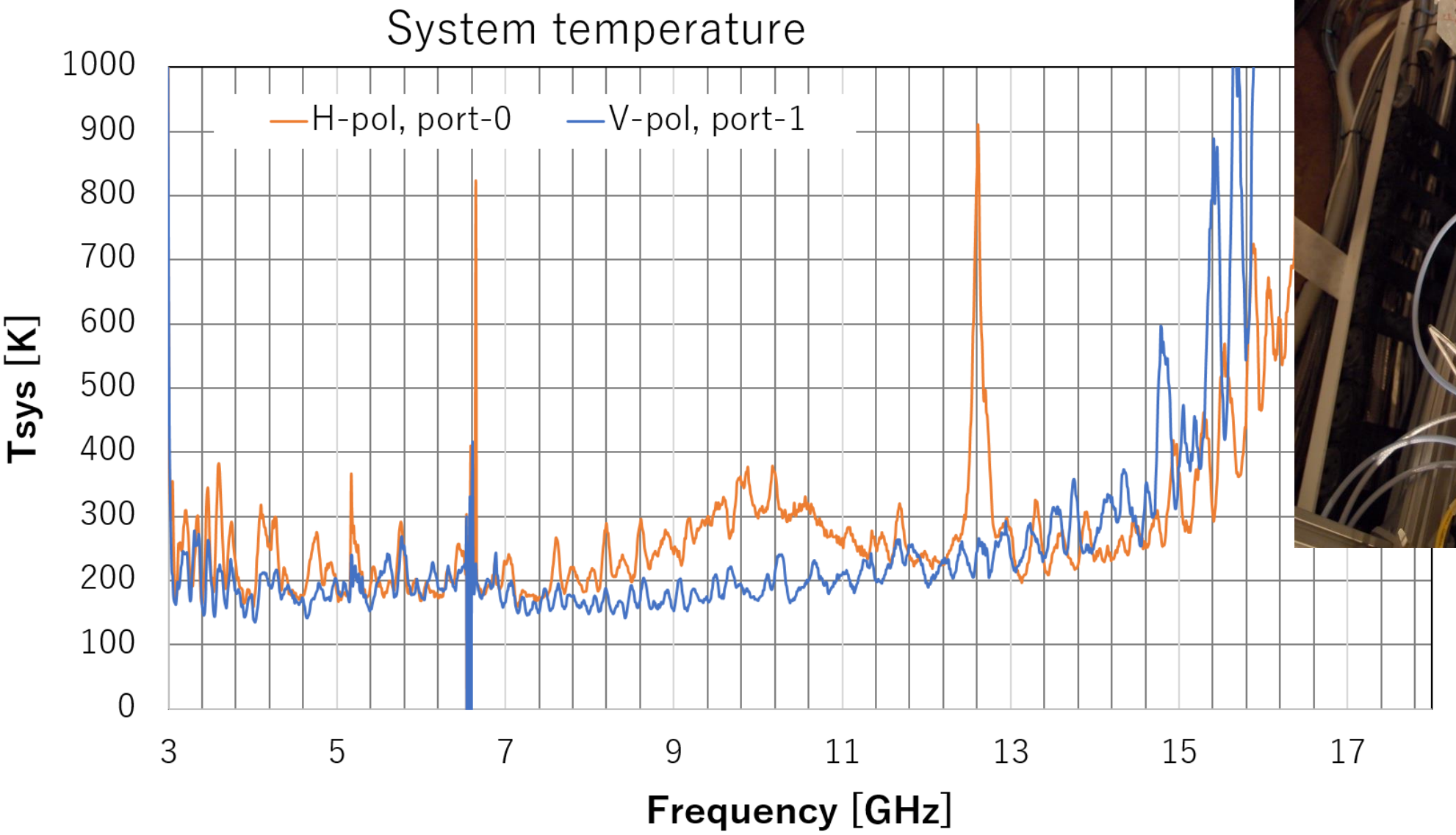
MARBLE2(2.4m)

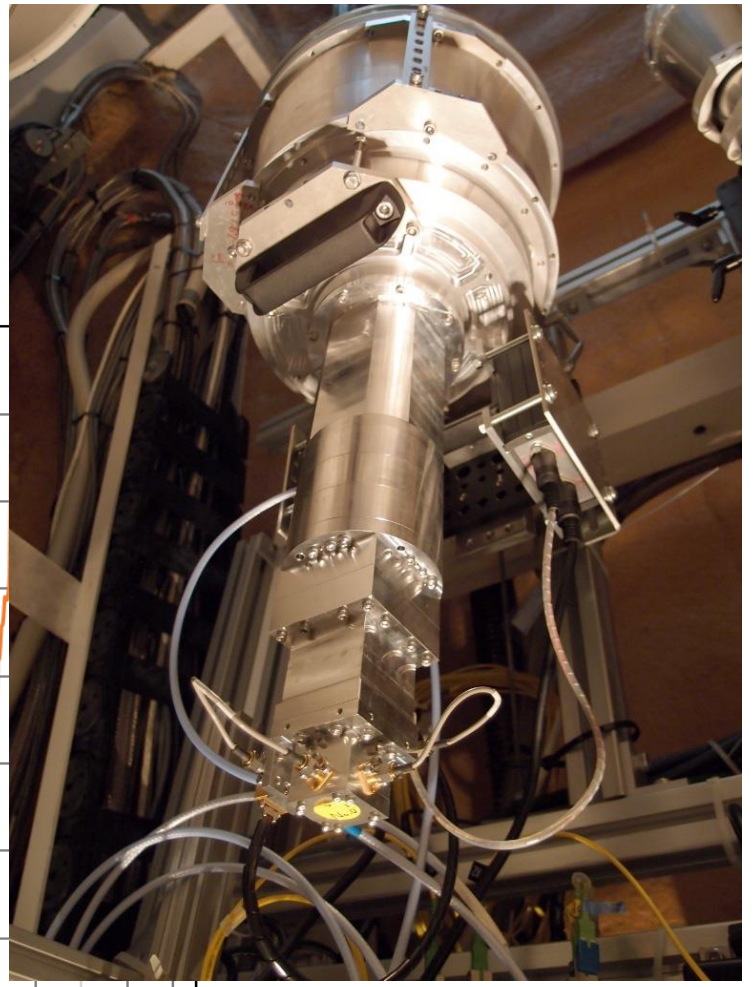
NINJA Feed
For Marble

Broadband
NINJA Feed

Kashima 34m

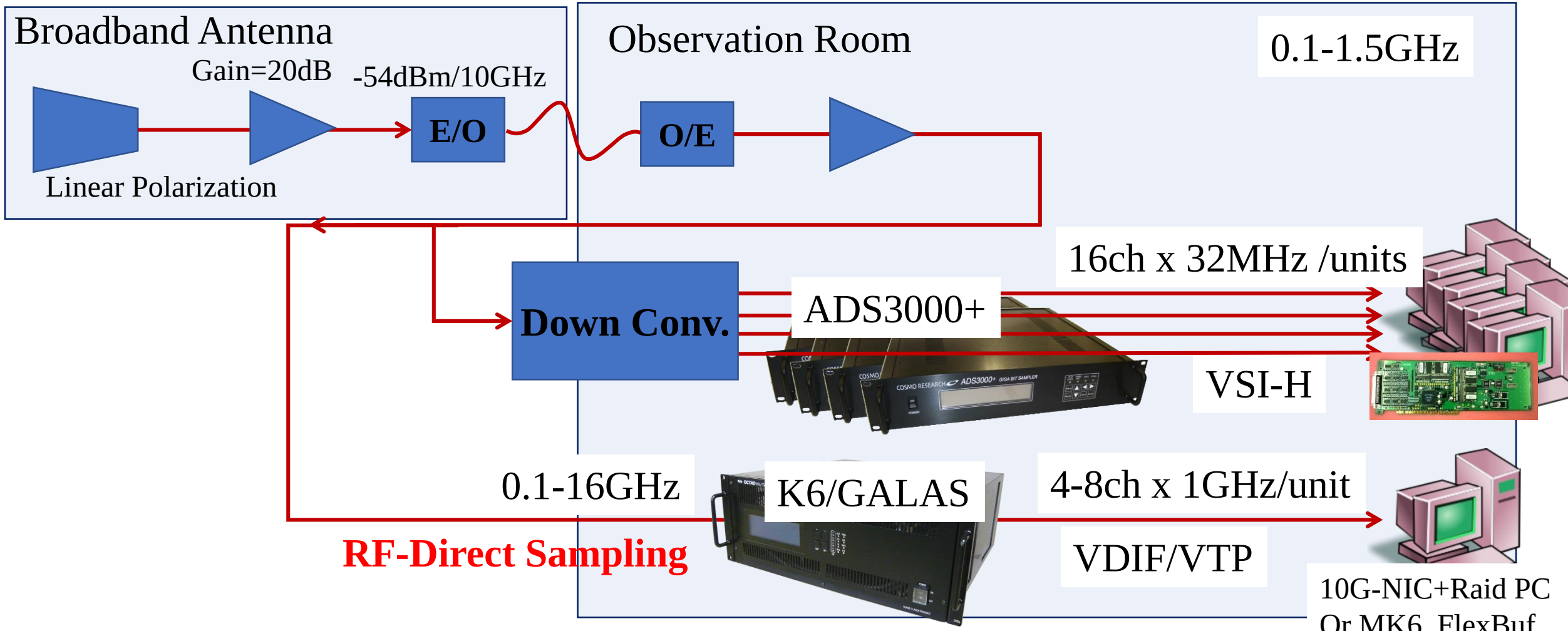
NINJA Feed Dual-Pol mounted in July





Data Acquisition System

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



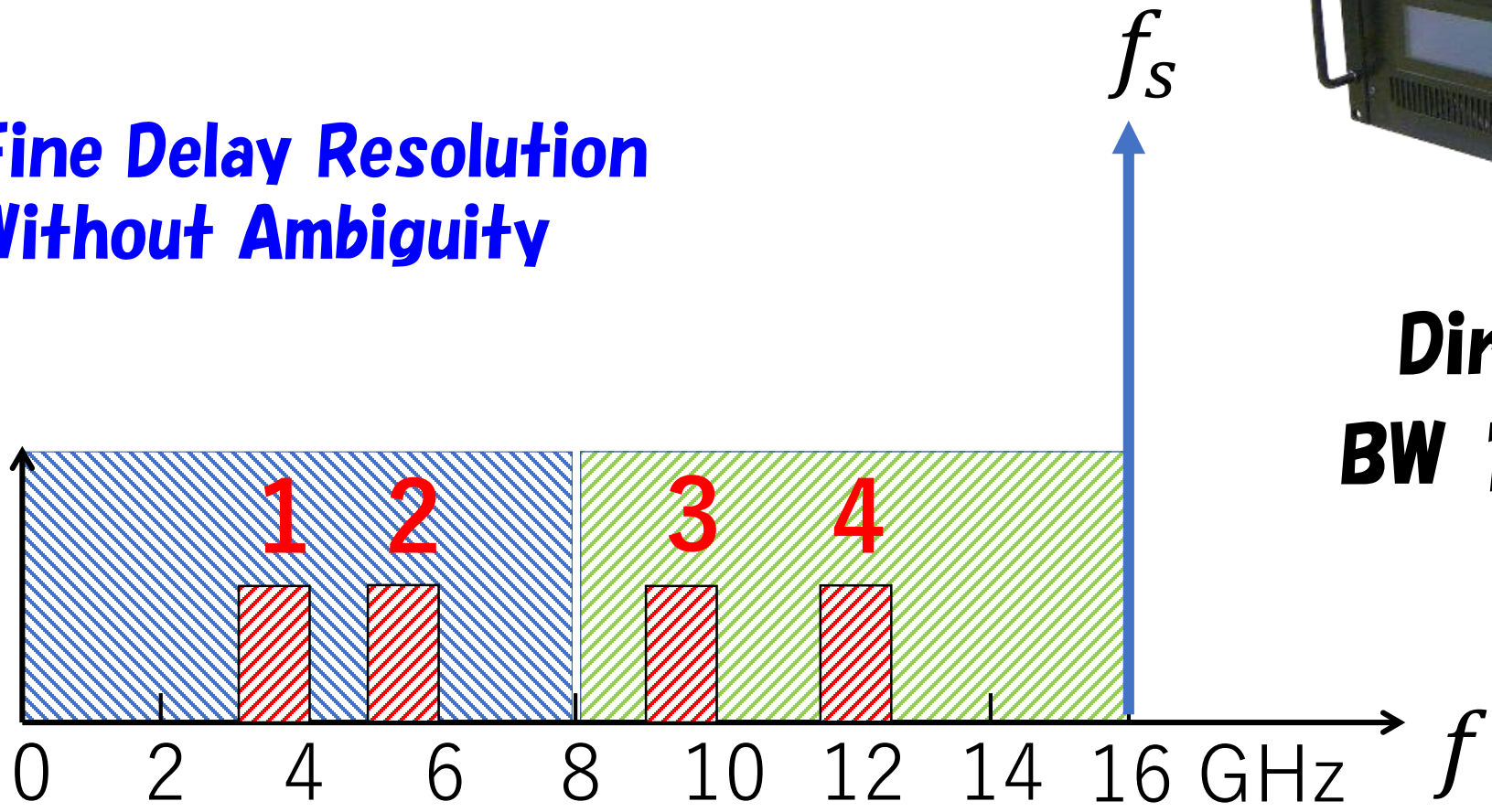
As close as Zero Redundancy

Frequency allocation

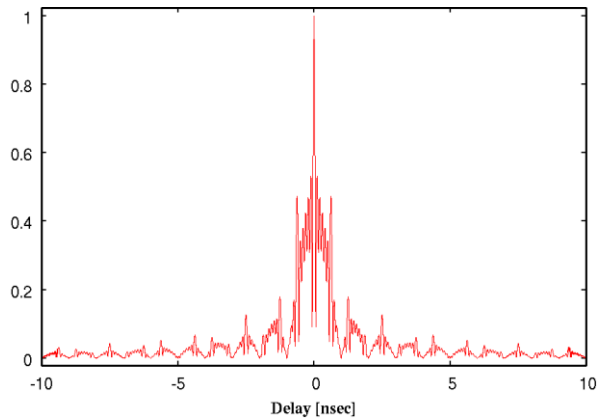
Direct Sampling

BW 1024MHz each

Fine Delay Resolution
Without Ambiguity

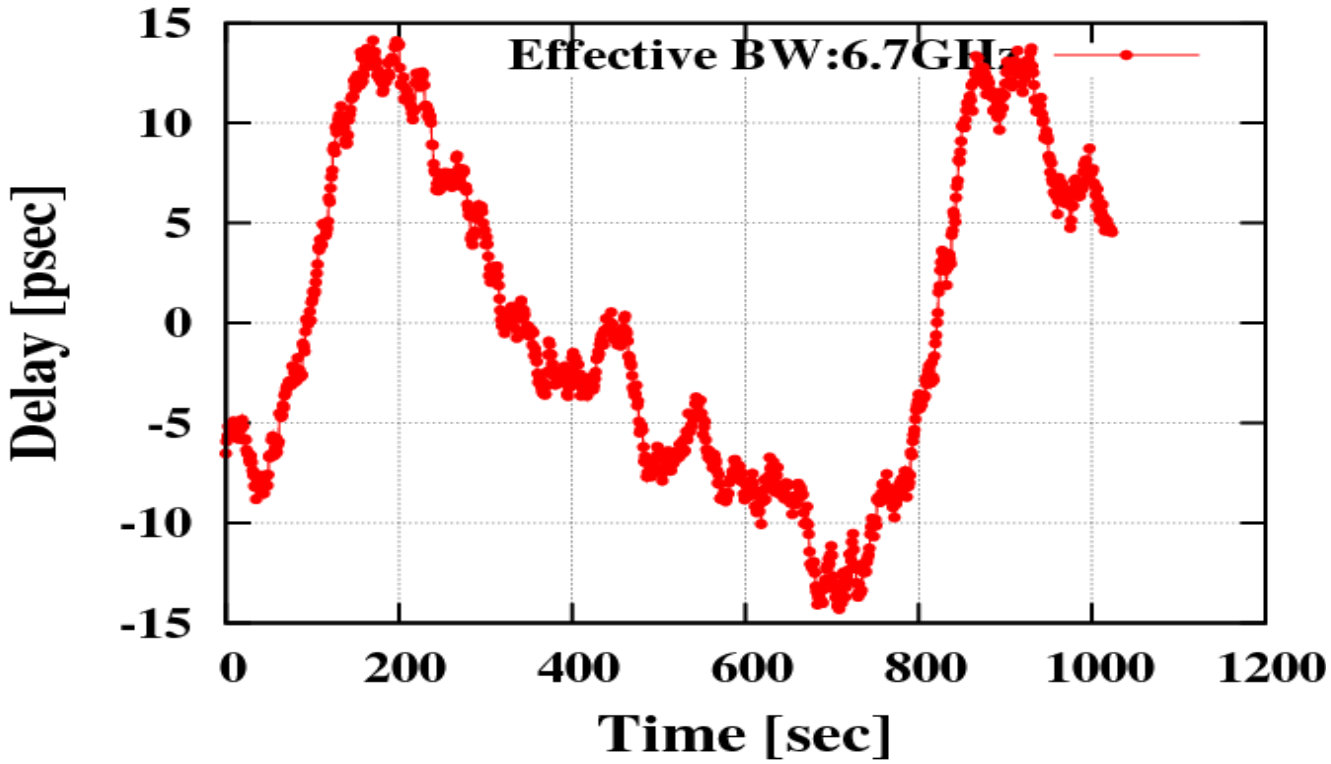


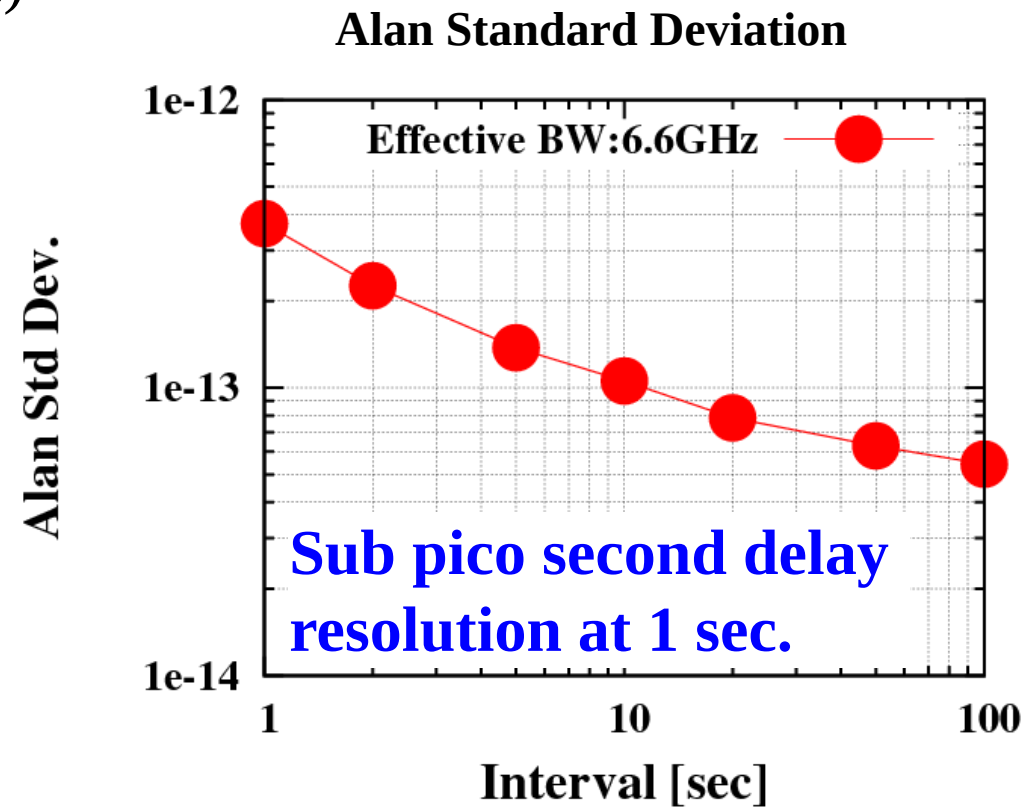
Lower Edge= 3.2, 4.8, 8.8, 11.6GHz



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)



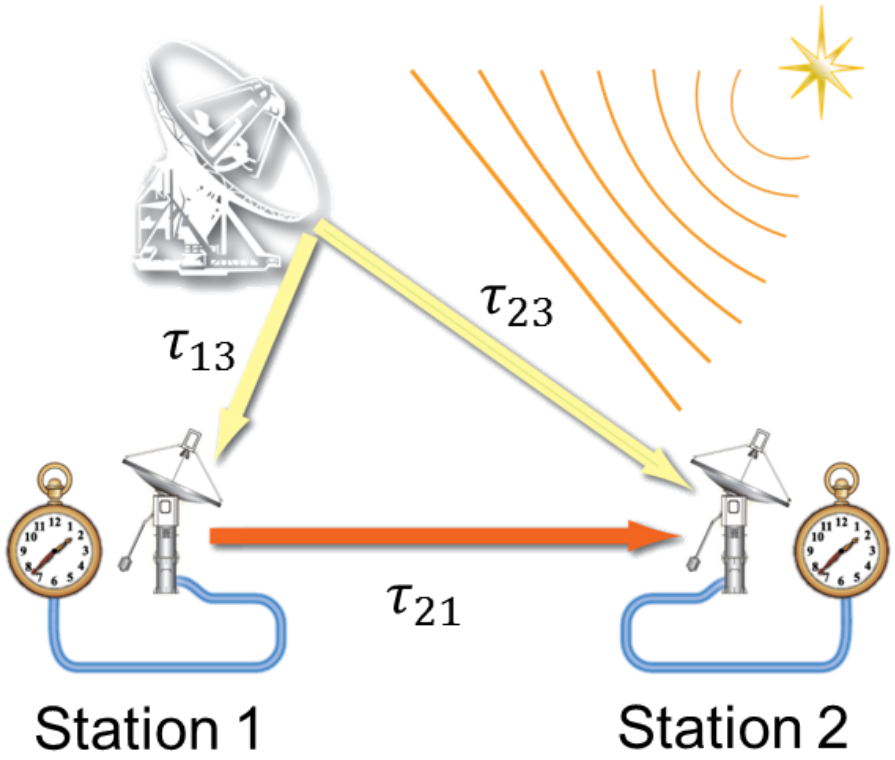


‘Small – Small’ Baseline

- Small diameter antenna pair is used for Atomic Clock comparison.
- 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:
  - Quick Slew and Small Distortion
  - Large Diameter’s effects are canceled out.
  - Lower Cost
- Disadvantage:
  - Lower Sensitivity,
  - Source Structure Effect in closure delay.

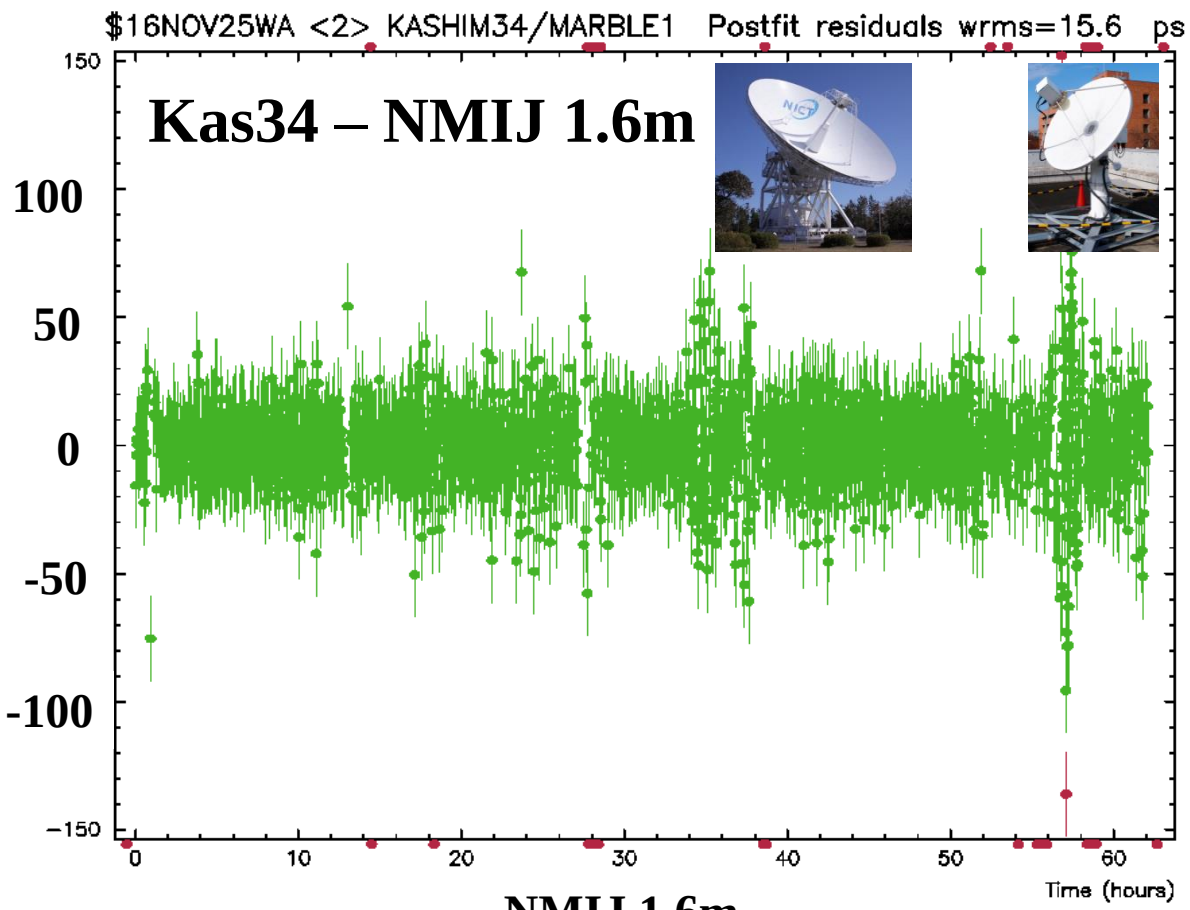


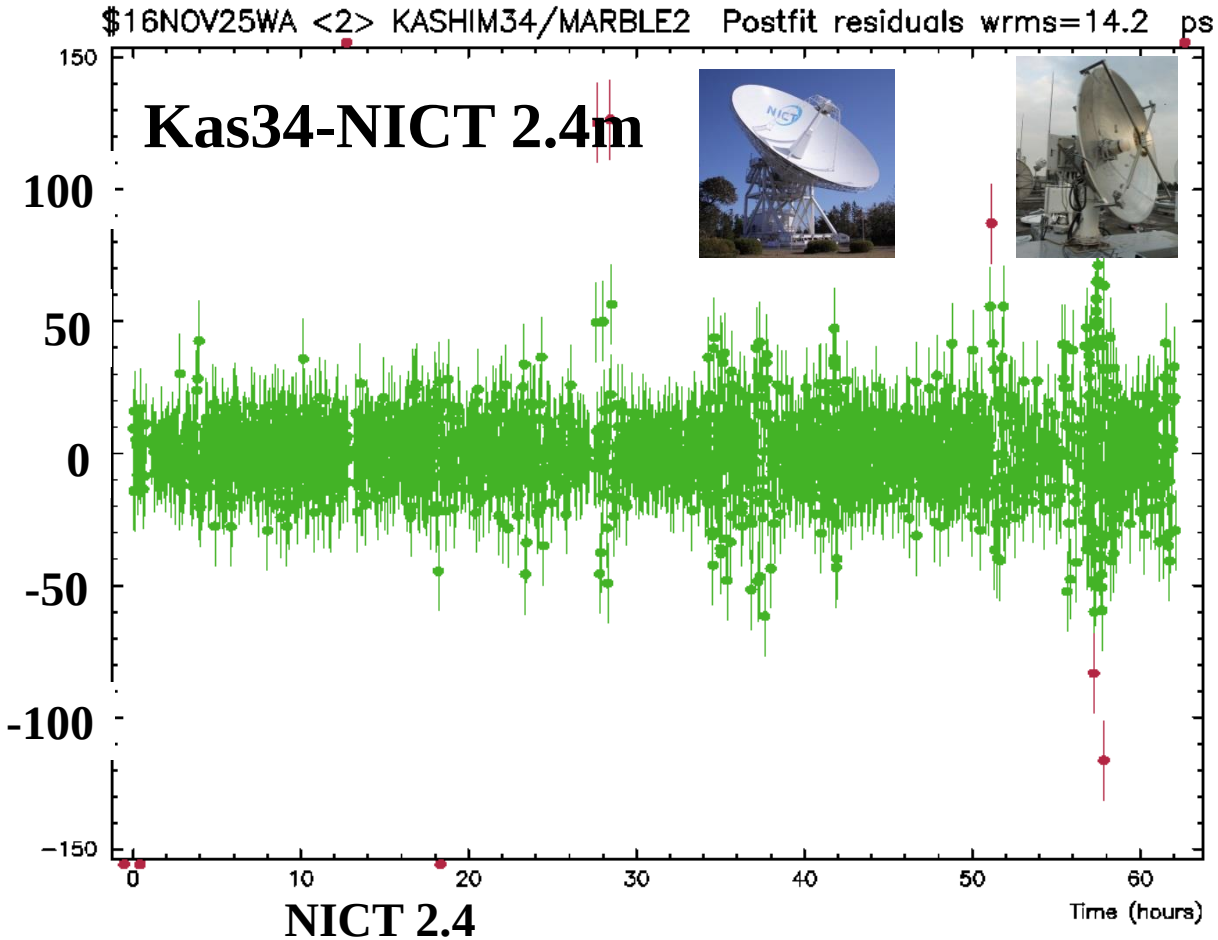
CALC/SOLVE Residual

Baseline Length

Kashim34 -NMIJ 1.6m : 48718193.8 mm 0.6 mm
Kashim34 - NICT 2.4m : 109427397.8 mm 0.7 mm
NICT 2.4m - NMIJ 1.6m : 70218038.2 mm 0.8 mm

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

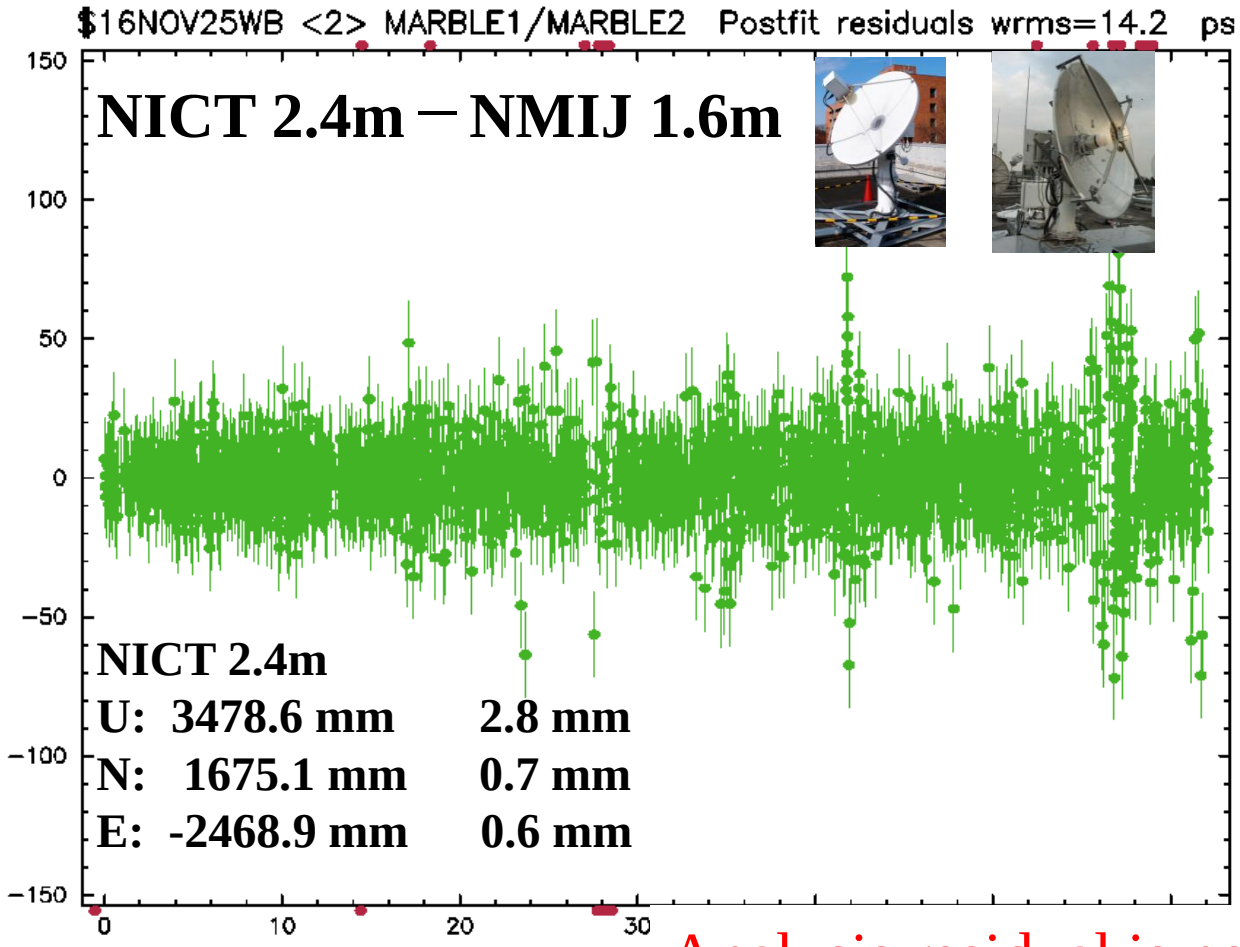
X: -3942068754.6 mm 1.8 mm
Y: 3368281011.8 mm 1.5 mm
Z: 3702003908.5 mm 1.7 mm

CALC/SOLVE Residual

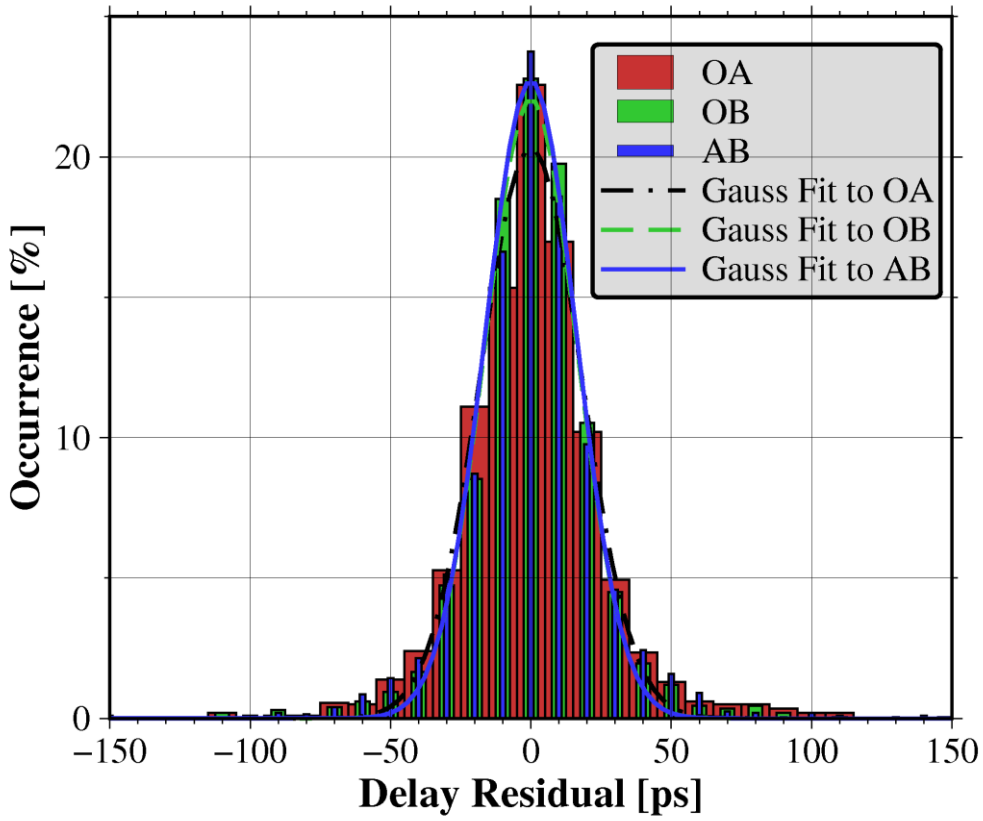
Baseline Length
MBL1(1.6m) – MBL2(2.4m): 70218041.2 mm 0.7 mm

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

WRMS Delay Residual ~ 15 psec

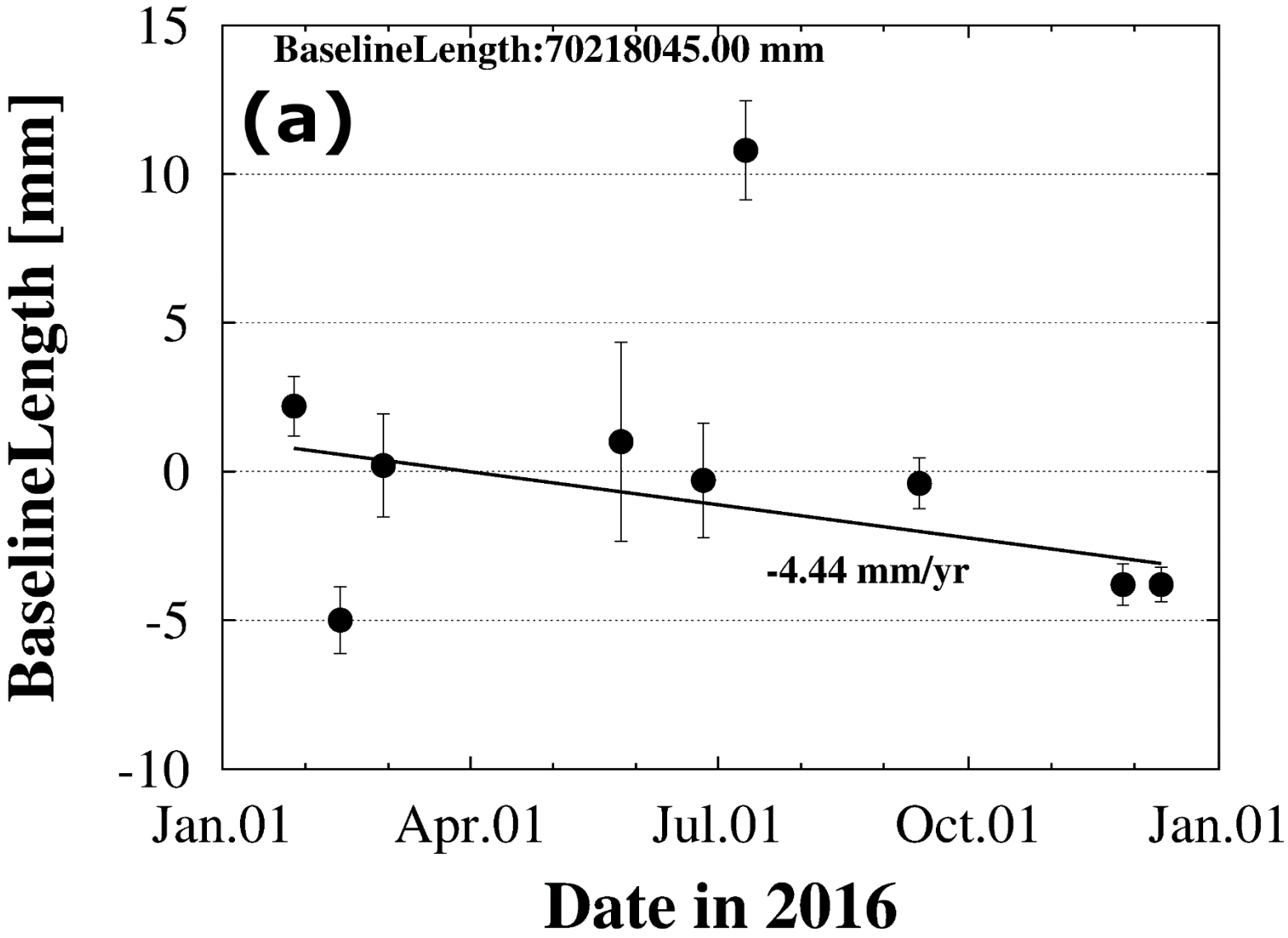


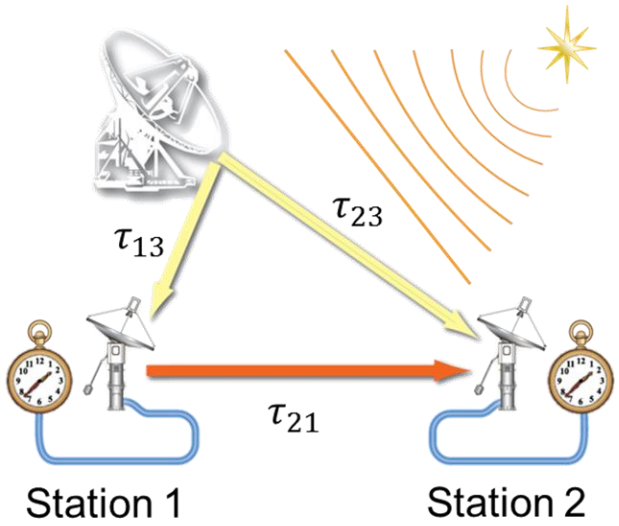
O:Kashim34
A:MARBLE1 NMIJ 1.6m
B:MARBLE2 NICT 2.4m



Analysis residual is no more dominated by measurement precision, but unknown excess delay, it may be troposphere.

Position Solution of MBL1-MBL2

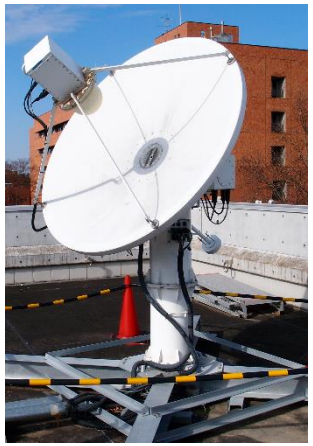




$$\tau_{21} = \tau_{13} - \tau_{23}$$

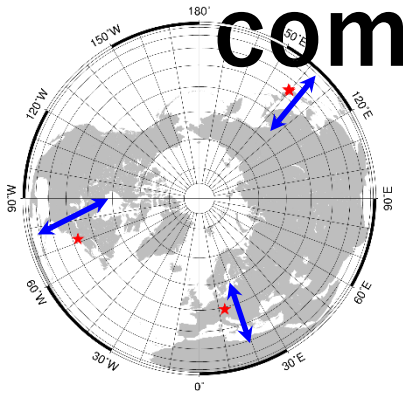
NICT 2.4m

NMIJ 1.6m



Subjects to be Prepared for Int' Continental Baselines

1. Bandwidth Synthesis software for correlation output of linear polarization combination.



- Because of different palaractic polarization angle of stations over intercontinental distances, all combinations of 2 sets of linear polarization(V,H) have to be cross correlated (V_x V_y ,V_x H_y,H_x V_y ,H_x H_y).
- It used to be not necessary to pay attention, because of circular polarization.
- Synthesis algorithm has been developed(M-Vidal et al.A&A,2016).
- Synthesis software implementation is task to be done.

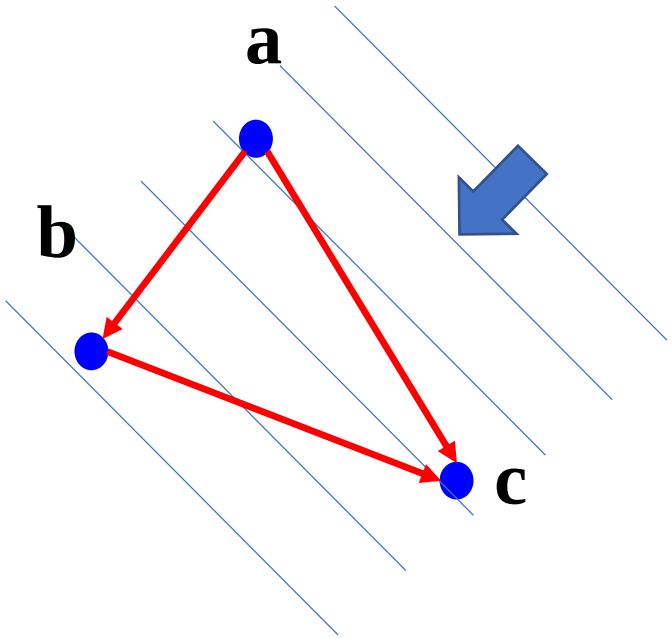
2. Radio source structure effects!

Effect of Radio Source Structure

- Xu Minghui(SHAO), Anderson M. James(GFZ):
  - Minghui Xu, et al.(2016) analyzed radio source structure effect via closure delay by using CONT14 data.

VLBI Observable

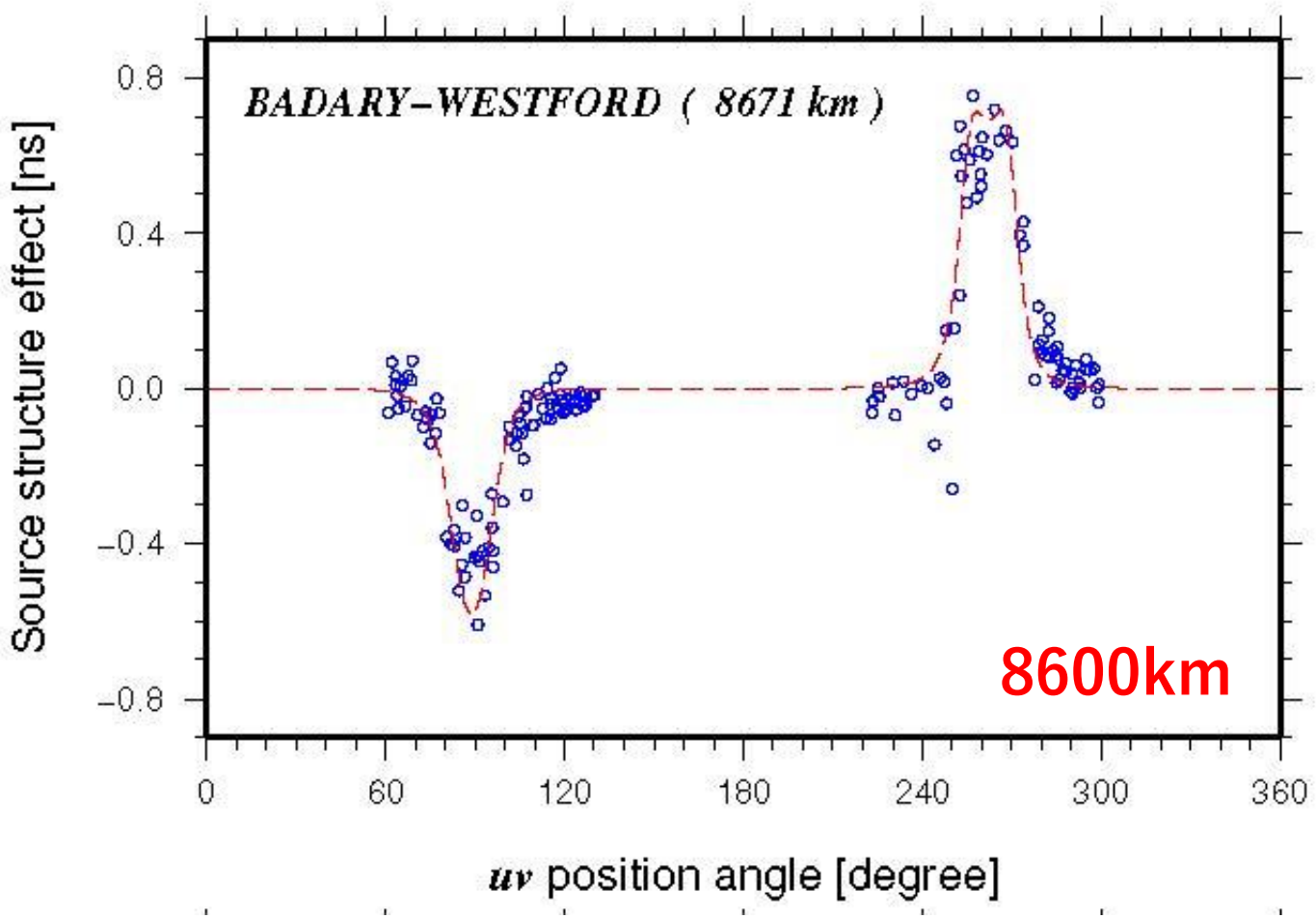
$$\tau_{ab}^{obs} = \tau_{ab}^{geo} + \tau_{ab}^{atm} + \tau_{ab}^{ins} + \tau_{ab}^{str}$$

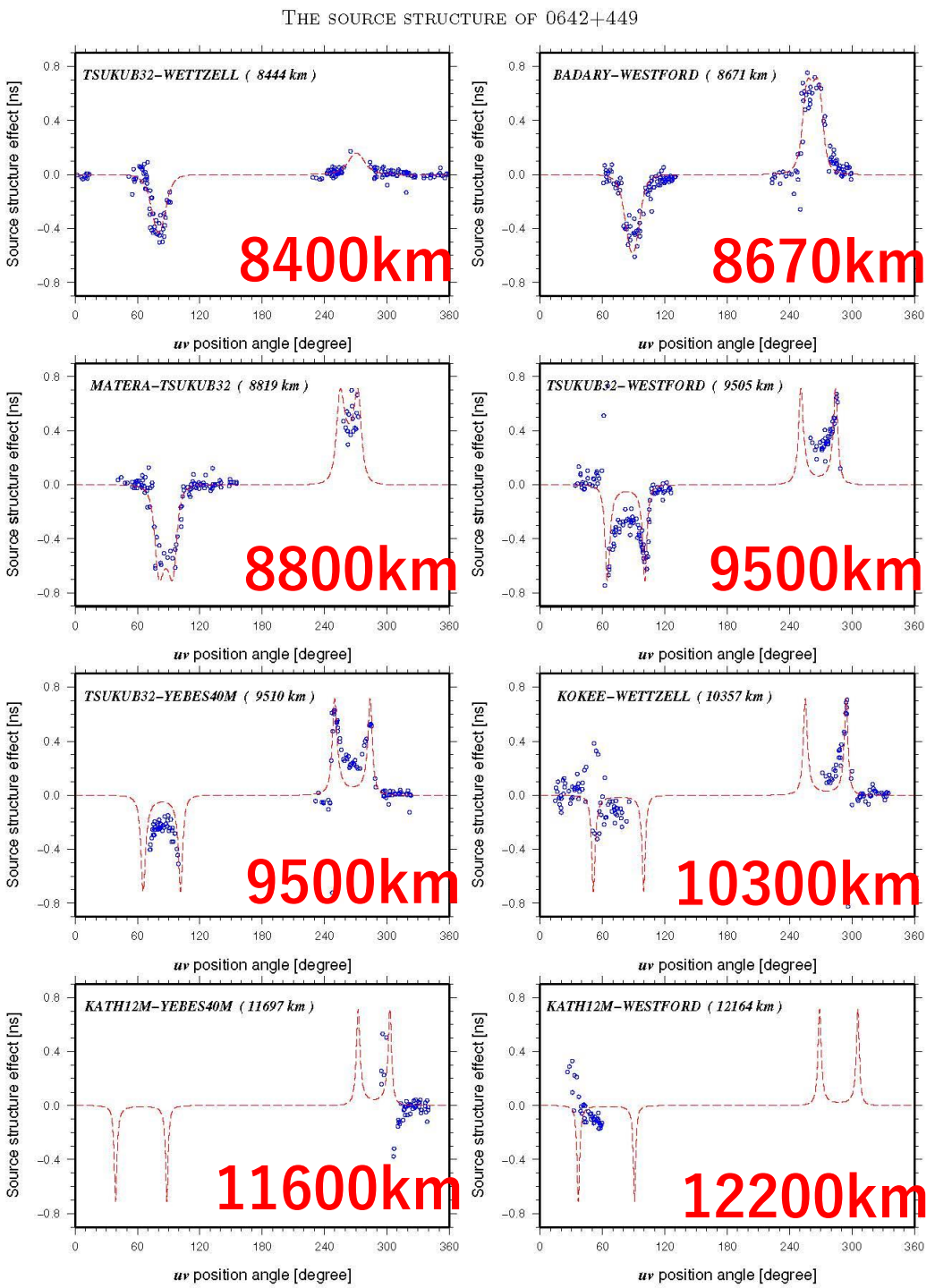


Closure Delay

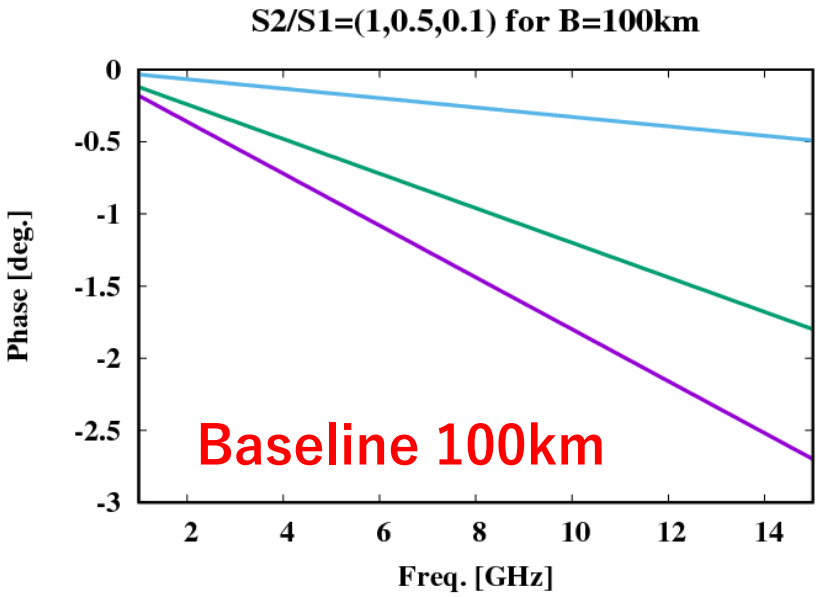
$$\tau_{ab}^{obs} + \tau_{bc}^{obs} + \tau_{ca}^{obs} = \tau_{ab}^{str} + \tau_{bc}^{str} + \tau_{ca}^{str}$$

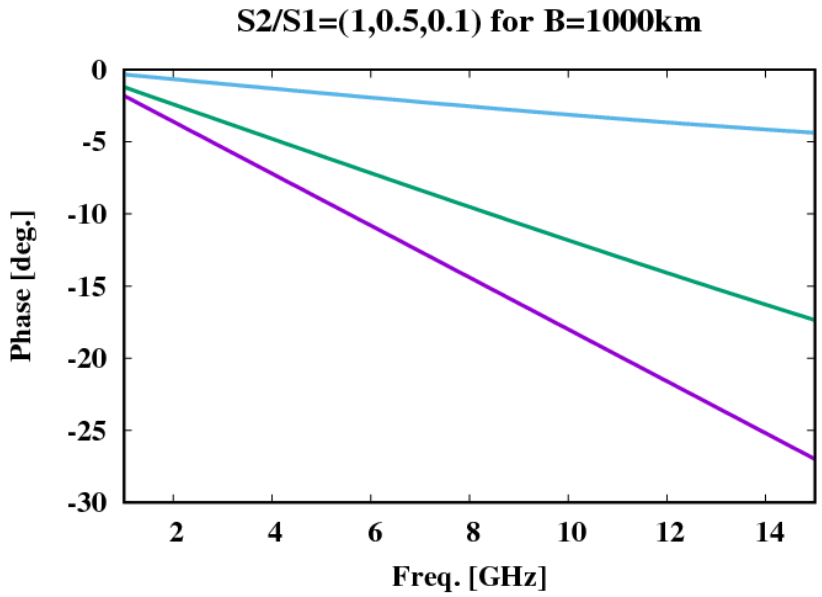
Two pints source model was used to fitting group delay of 0642+449 in CONT14.

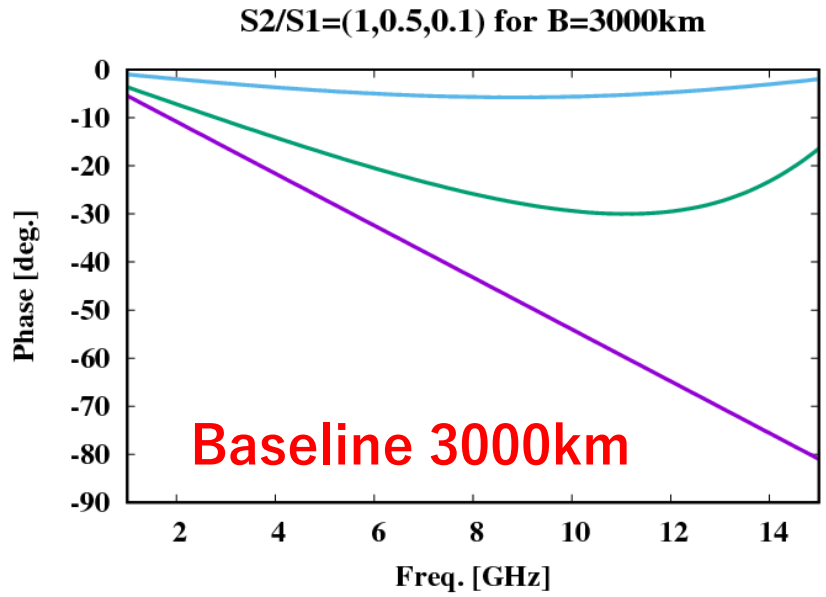


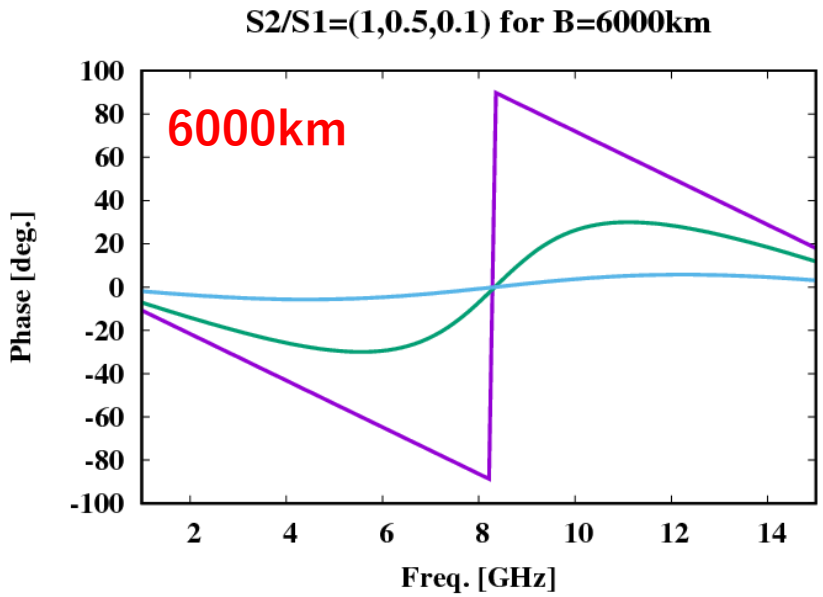


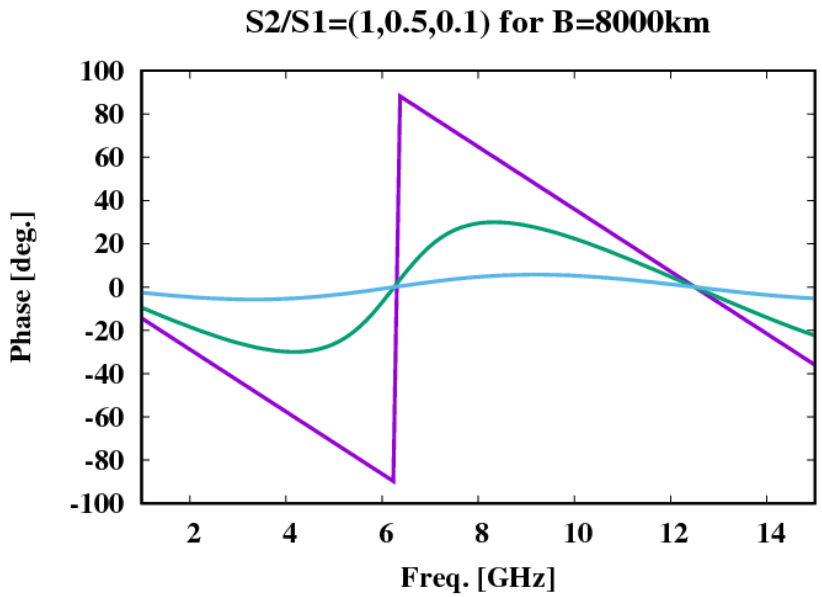
Correlation Phase

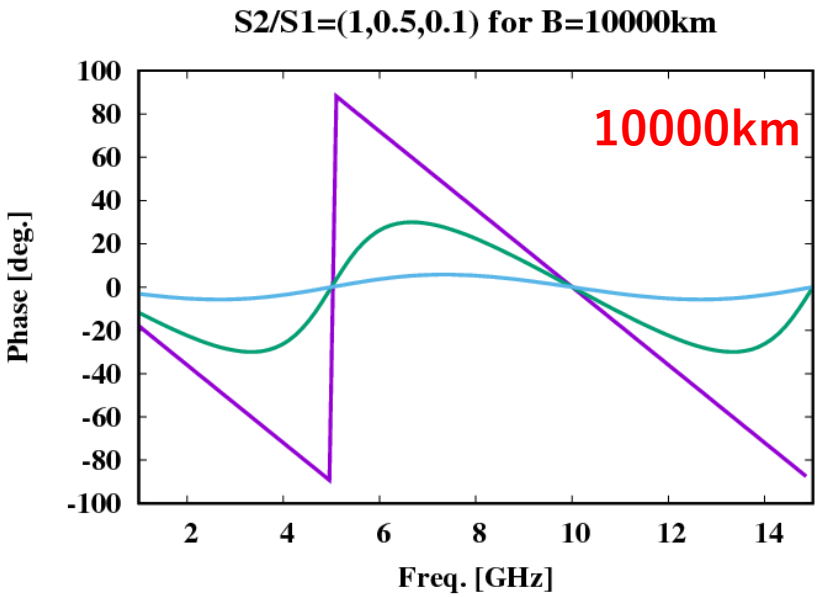




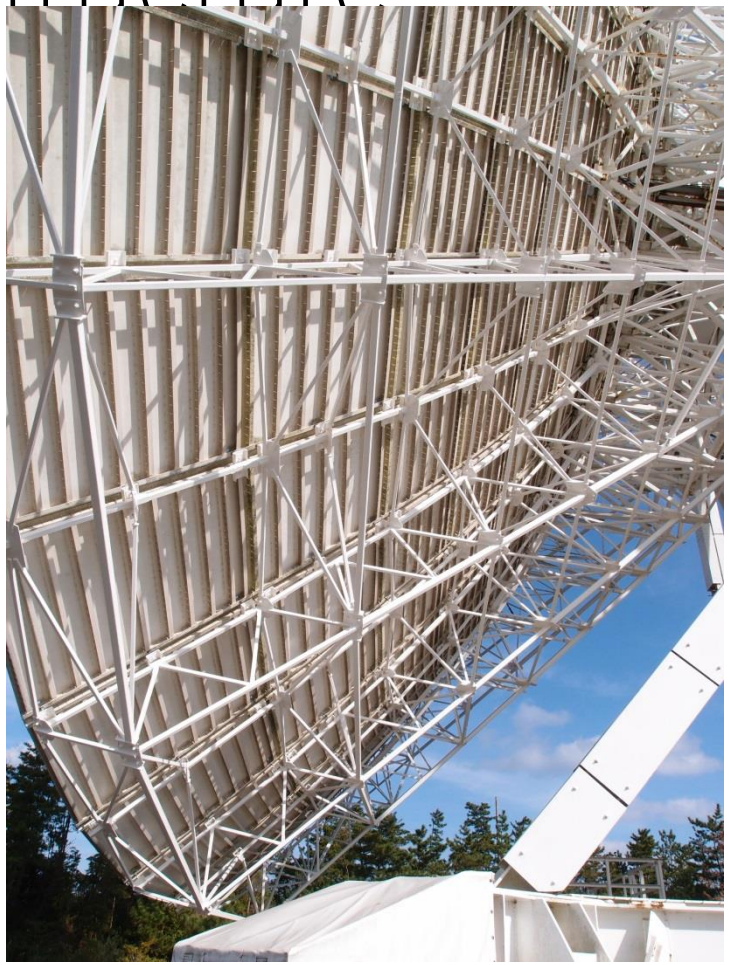








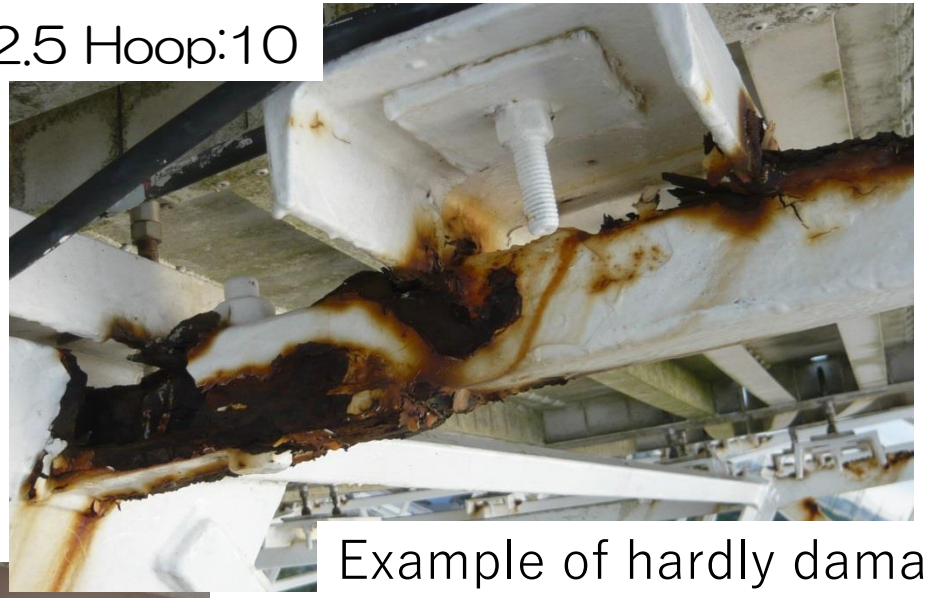
34m antenna : collosion at Backup strucrure



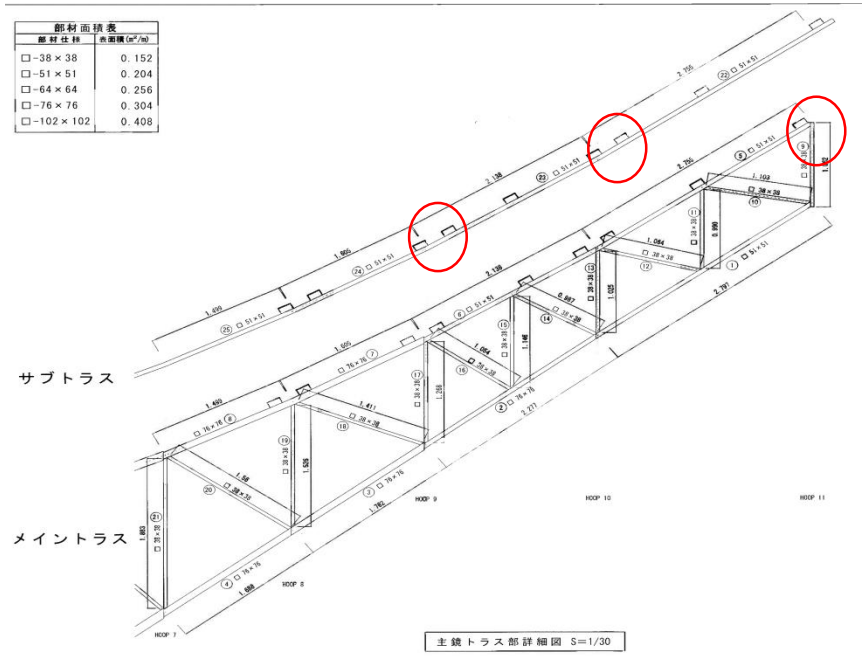
34m Backup Structure Inspection in Dec. 2016

Trass12.5 Hoop:9

Trass12.5 Hoop:10



Example of hardly damaged portion

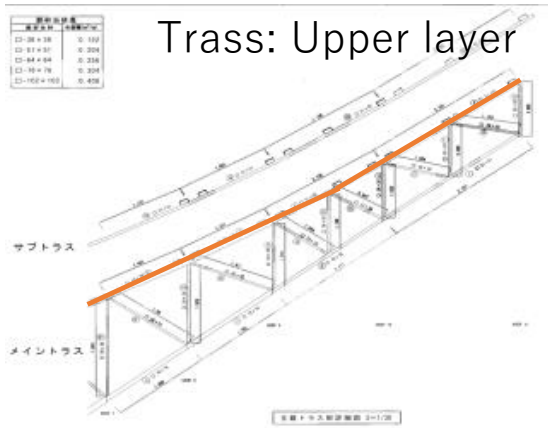


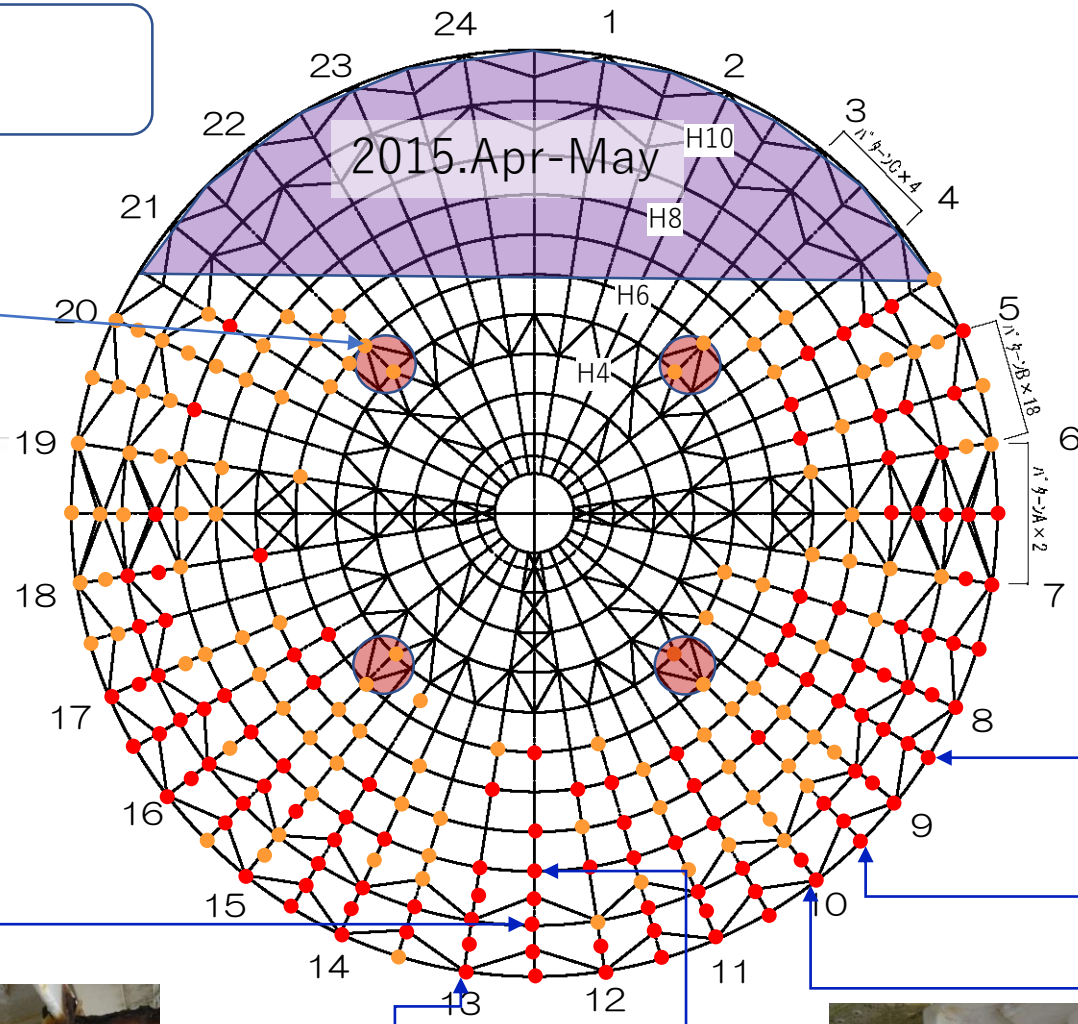
Trass:8.5 Hoop:11

34m Backup Structure Inspection in Dec. 2016

- Welding
- Repaint

Quadruple pods






Trass:8.5 Hoop:11


Trass:9.5 Hoop:11


Trass:10 Hoop:11


Trass:12.5-Hoop:10


Trass:13-Hoop:11


Trass:12.5 Hoop:9

Short term Plans(2017-2018)

- Broadband Experiments on Intercontinental Baselines
  - Stations: Kashima, Hobart, Ishioka,…
  - Purposes:
    - Investigation of Radio source structure effect
    - Polarization parallactic angle
- 34m antenna maintenance work
  - Backup structure repair work in the first half of 2018.

Thank you for Attention

Acknowledgements

- Development of Broadband Feed was supported by a grant (2013-2014) of Joint Development Research from National Astronomical Observatory of Japan(NAOJ).
- Broadband experiments with Ishioka Station was kindly supported by GSI.
- Highs speed research network environment is supported by JGN.