ITA–JPN Broadband VLBI Experiment for Optical Clock Comparison


EVGA2019
GALA-V Project Overview

Frequency comparison by using transportable broadband telescopes.

- Radio Frequency: 3.2-14 GHz
- Data Acquisition: 4 band (1024MHz width/band)
  - Nominal Freq. Array: Fc=3.7GHz, 5.3GHz, 9.3GHz, 12.1GHz
  - Effective Bandwidth: 3.3GHz (10 times wider than conventional system)

\[ \tau_{21} = \tau_{13} - \tau_{23} \]

Closure delay is computed for small antenna pairs.

1GHz, 3GHz, 5GHz, 7GHz, 9GHz, 11GHz, 13GHz, 15GHz

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Broadband VLBI Experiments
Frequency Link Experiment : INRiM-INAF-NICT

Target: Intercontinental Frequency Link of Optical Frequency Standard. In addition to existing techniques: TWSTFT, GPS(PPP, IPPP)

Aug. 2018 : 2.4m Antenna installed at INAF/Medicina
Antenna, DAS, FS-PC, Container are transported from Japan to Medicina for two year term contract. Local trench, optical fiber installation are prepared by INAF and INRiM.
Installation at Medicina

- Visiting in 21 Jul- 3rd Aug. (for 10 days)
- Unpacking 1.5d, Antenna Assemble 2.5d, Network set up, Antenna Testing 1.5d, Pointing 2d, VLBI Fringe test 2d, Meeting 0.5day.

Container for Antenna Control

Data Acquisition PC, 10G-net, Clock Fiber Link from INRiM
Peoples of INAF/Medicina and INRiM. Meeting after installation

1st Aug. Meeting for maintenance of Antenna, Reference signal, and power supply.
VLBI Observations

• Stations: MBL1(2.4m)@Medicina, MLB2(2.4m)@Koganei, Kashima34m@Kashima

• Observing Frequency: (6.0, 8.5, 10.4, 13.3 GHz), BW:1GHz, 1bit

• Polarization: V-pol (2.4m), V+H-pol (34m)

• Session: No less than 28 hours (Disk Capacity 70TB limited). > 400 scans

• Sessions: Oct.: 3 sessions, Nov.: 3 sessions, Dec.:3 sessions,
  2019 Jan.: 2 sessions, Feb.: 2 sessions; Total 13 Sessions.

• Sources: selected from larger flux sources from ICRF3
‘Node-Hub’ style VLBI

- **Closure delay** relation used to derive delay between ‘small-small’ baseline.
  \[ \tau_{21}(t_1) = \tau_{23}(t_1) - \tau_{13}(t_1) + \tau_{13}(t_1)\dot{\tau}_{21}(t_1) \]

- **Advantages of using small antennas**:
  - Quick slew and small distortion.
  - Large antenna’s effects are canceled out.
  - Lower cost.

- **Disadvantage**:
  - Lower sensitivity, ←boosting SNR with large diameter telescope
  - Source structure effects to closure delay.
Delay residuals of 'Node-Hub' style VLBI

NH-VLBI delay residual is no larger than standard.

- OB(100km) baseline residual $\sim 13\text{ps}$
- OD and DB (8700km) baseline $\sim 26\text{ps}$

Broadband VLBI delay precision is precise enough to use NH-VLBI.
Delay residuals of ‘Node-Hub’ style VLBI

- OB (100km) baseline residual ~ 14ps
- OD and DB (8700km) baseline ~ 30 ps
Delay residuals of ‘Node-Hub’ style VLBI

- OB(100km) baseline residual $\sim 16\,\text{ps}$
- OD and DB (8700km) baseline $\sim 25\,\text{ps}$
Preliminary summary of Sr/Yb Freq. Link by single session in the experiments for Dec. 2018- Feb.2019

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Does this cause by Radio Source Structure?

One of the Error Sources: Splitting of Residual
1. Broadband 2.4m diameter GALA-V system was installed at INAF/Medicina. We started frequency link experiments from Oct. 2018. We are targeting frequency link in order of -16.

2. Node-Hub style VLBI scheme in our experiments works properly with small (2.4m) Broadband VLBI station. This might be an future option of VLBI observation with low cost terminal.

3. Significant source dependent delay residual need to be investigated.
Acknowledgements

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• Our project is supported by VLBI Analysis software Calc/Solve, Antenna Control Field System9, scheduling software Sked are developed by NASA/GSFC.

Thank you for your Attention