Dual-beam Phase Referencing with VERA

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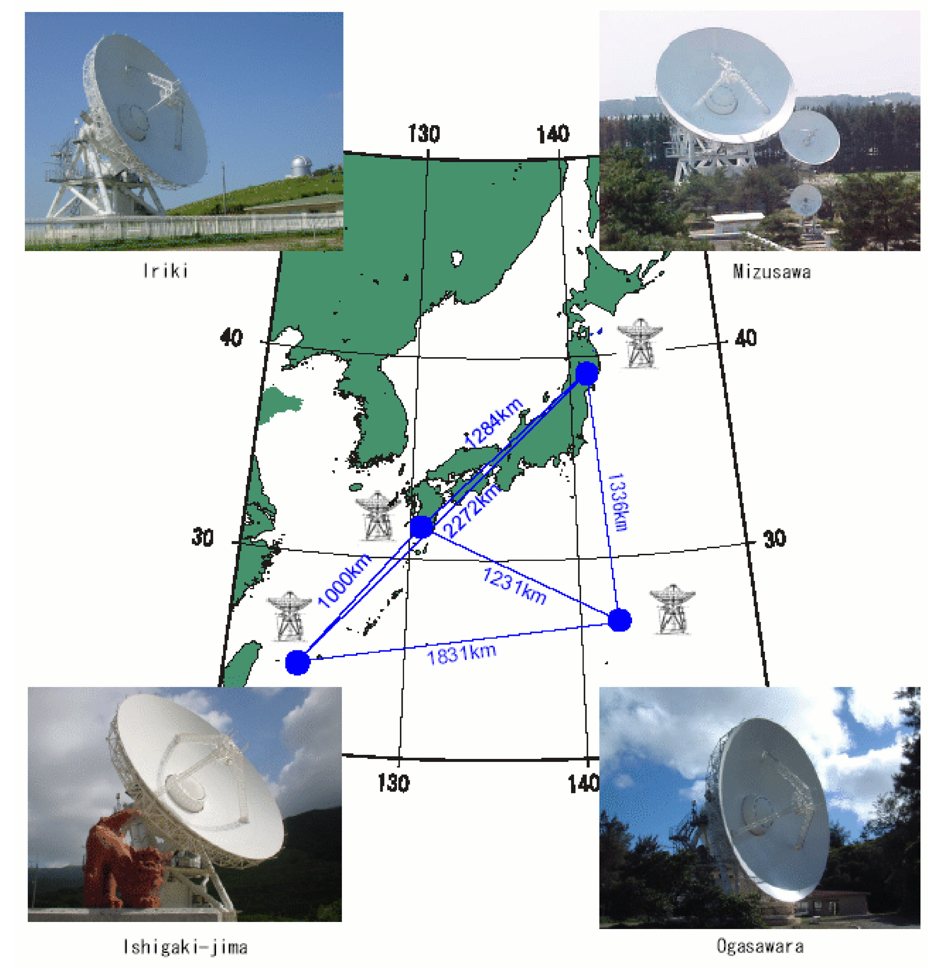
VERA : VLBI array for phase referencing astrometry

VERA (VLBI Exploration of Radio Astrometry) is a new VLBI array dedicated to phase referencing VLBI astrometry. VERA array has four 20m antennas with longest baseline of 2300 km, and each antenna is installed with a dual beam system, with which one can simultaneously observe a target source (e.g., Galactic maser source) and a reference source (e.g., QSO, radio galaxy). By removing the atmospheric fluctuation with dual-beam observation, VERA will measure the position of the target source relative to the reference with 10 micro-level accuracy, which allows us to measure parallax and proper motion of masers in the whole Galaxy's disk.

VERA Array Map

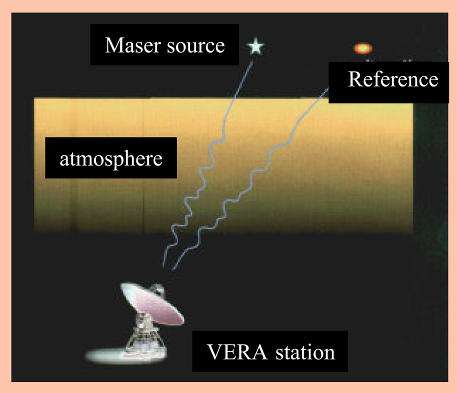


VERA array map and site views

Project summary : progress in past years

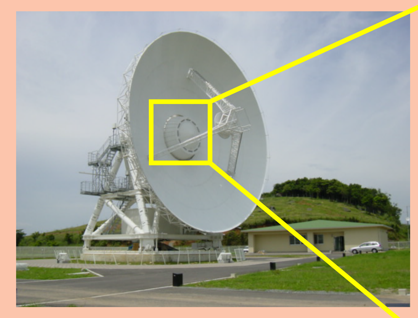
1999 Dec.	Funded for 3 stations.
2000 Apr.	Construction started
2001 Mar.	3 stations completed 4th station funded
2001 Oct.	First light as single dishes
2002 Feb.	First fringe in single beam mode
2002 Mar.	4th station completed
2002 May.	First fringe in dual beam mode
2002 Sep.	First observation with full array
2003 May	First geodetic observation with full array

VERA's Dual-Beam System



VERA antenna has dual beams that can be separated by as large as 2.2 degree. By observing a maser and a reference source (QSO or radio galaxy) simultaneously, VERA suppresses atmospheric fluctuation.

Dual-beam antenna

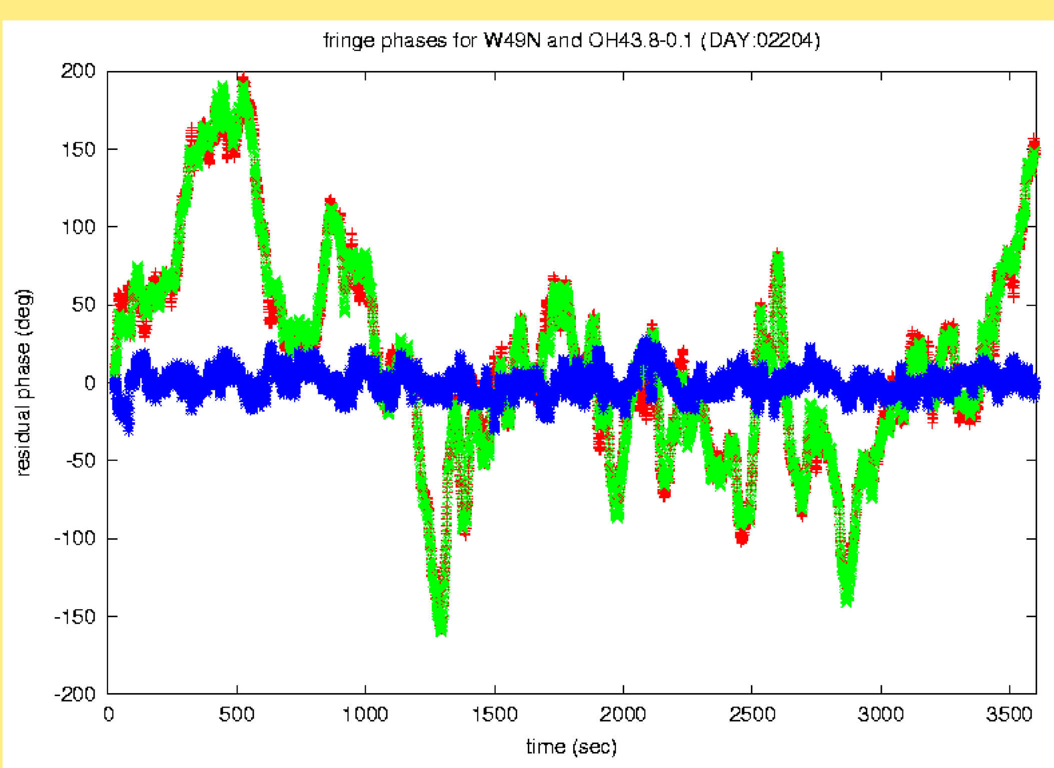


Dual-beam platform

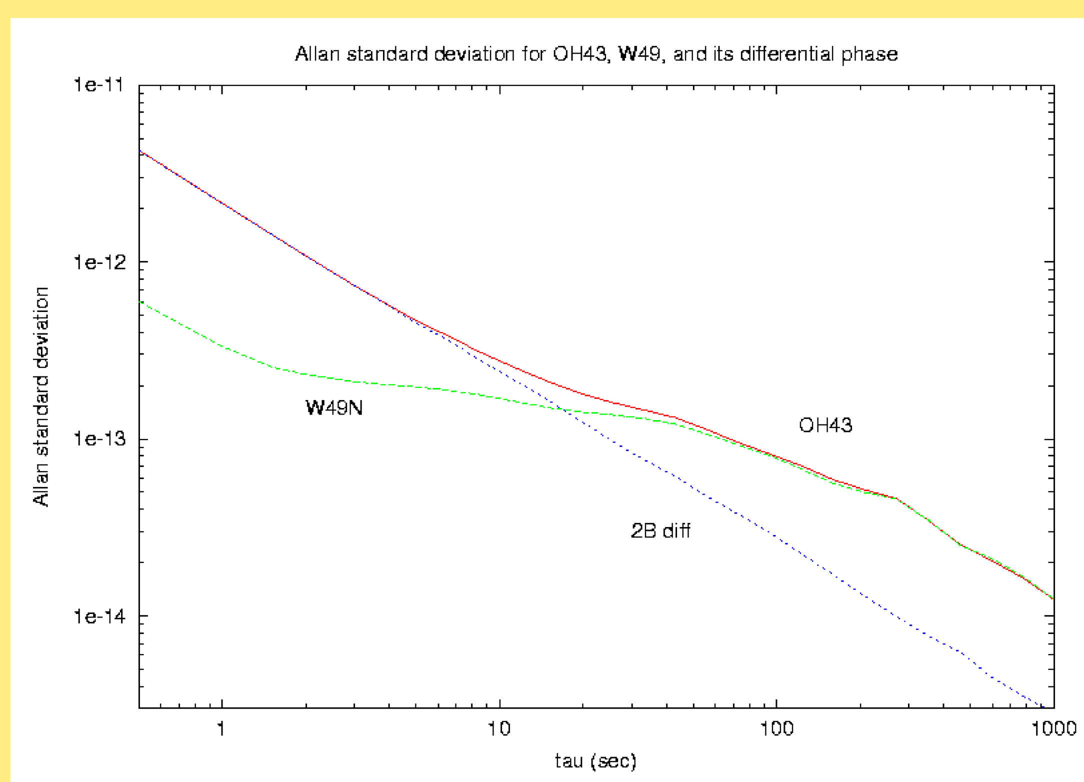
Receivers on the platform

Phase Referencing observations

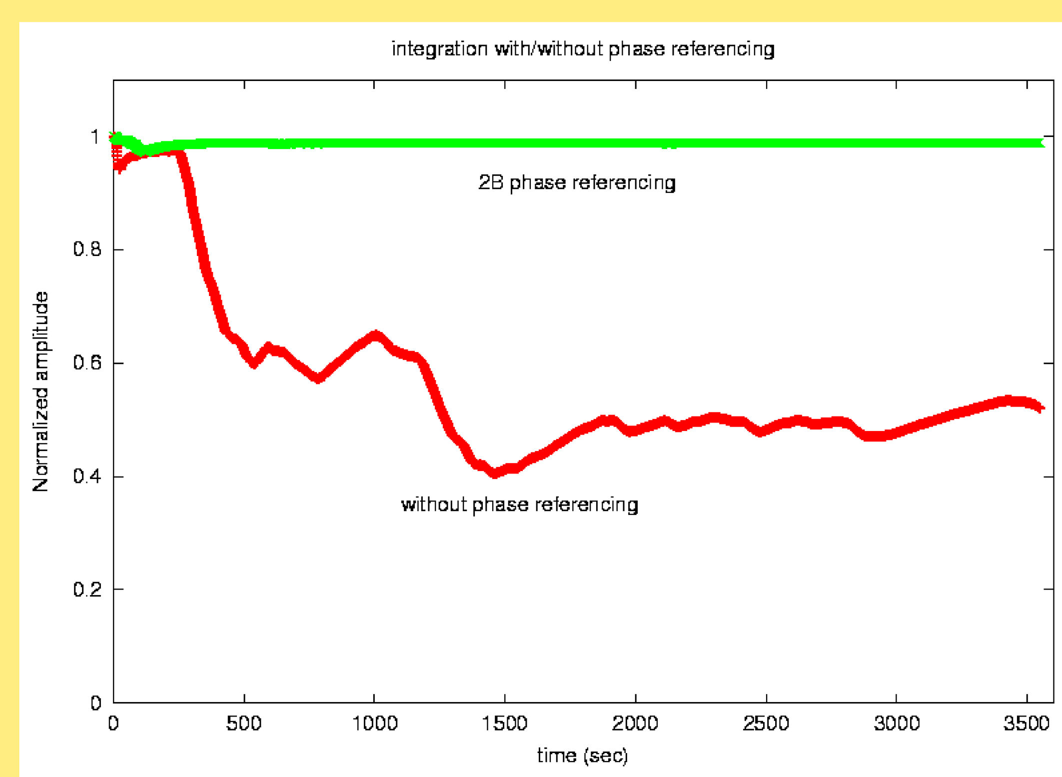
On 20 February 2002, we have made the first interferometric observation between Mizusawa and Iriki station, and fringes have been successfully obtained for Orion-KL H2O masers and continuum source DA193. On 29 May 2002, the dual-beam fringes have been detected for the first time with Mizusawa-Iriki baseline. In this observation, two adjacent H2O masers W49N and OH43.8-0.1, separated by 0.65 degrees on the sky, were detected simultaneously. Since then, a number of test observations have been carried out to evaluate VERA's phase referencing capability. Figures below are examples of dual-beam observation of W49N - OH43.8-0.1 maser pair. The left panel shows the fringe phases for both masers at the intensity peak channel as well as the difference of the two. While the fringe phases of the two sources show rapid variations due to atmospheric fluctuation, their difference is rather flat and stable, demonstrating that the atmospheric fluctuation has been efficiently canceled out by dual-beam observation. The middle panel shows the Allan standard deviation of the fringe phases and the differential phase. The Allan standard deviation of the differential phase goes down with the power low index of -1, showing that the remaining phase error is mostly white-phase noise, probably due to the S/N limit for the fainter maser OH43.8-0.1. The right panel shows the coherence function for W49N phase and differential phase. When the integration is performed using differential phase, the amplitude remains constant for an hour.



Fringe phases for W49N (green), OH43.8-0.1 (red) and their difference (blue)



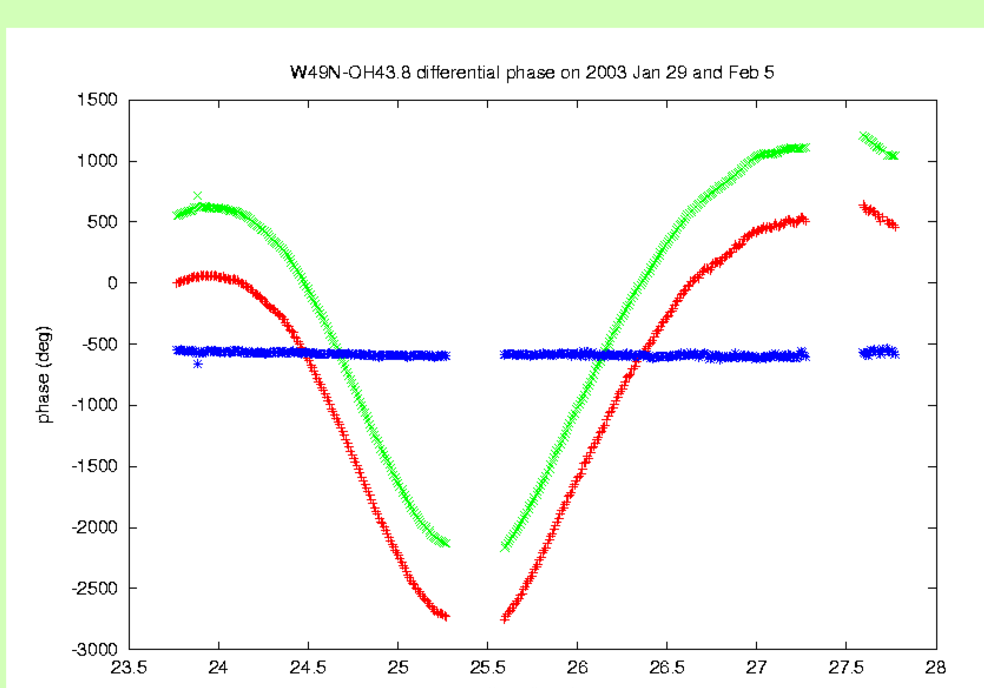
Allan standard deviation for fringe phases of W49N, OH43.8-0.1 and their difference



Integration performance with/without phase referencing

Toward Phase Referencing Astrometry

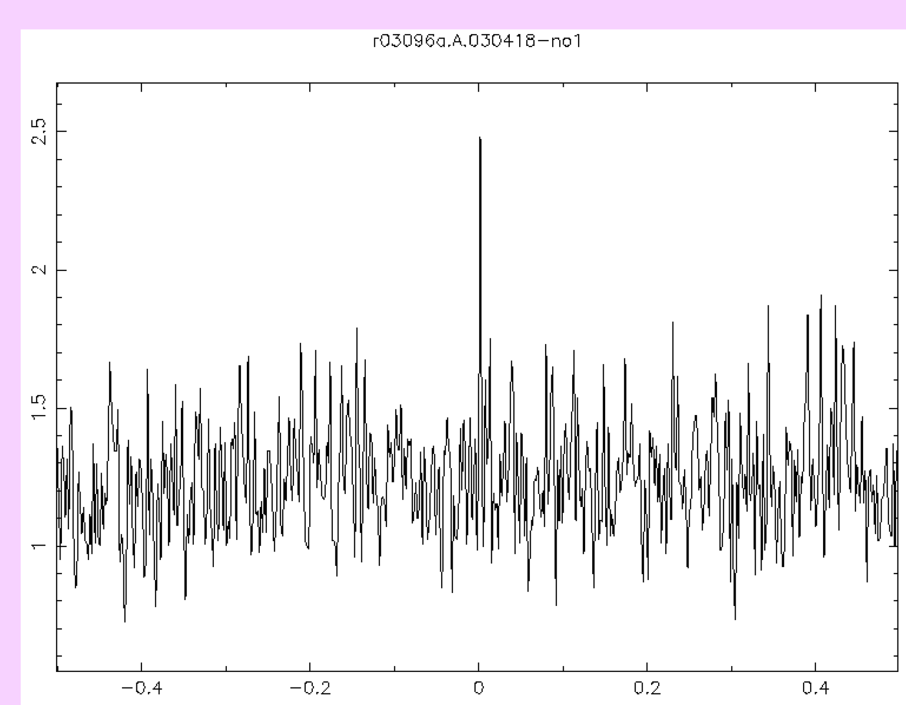
Since the beginning of 2003, monitoring observations of pair sources have been started to evaluate astrometric capability of VERA. Right panel shows an example of such observation. Two curves show the differential phase of W49N - OH43.8 pair observed on 29 Jan. and 5 Feb. 2003 (one week interval). The modulation is due to error in baseline measurement as well as in correlator apriori model, but when the difference of the two was taken, it remains constant with RMS phase error of 16 deg (large offset is due to oscillator initial phase). From this result, one can expect that the separation of two masers remains constant for a week, with a crude accuracy estimate of ～100 micro-arcsec.



Differential Fringe phases for W49N-OH43.8 pair on 29 Jan. (red) and 5 Feb. (green), and their difference (blue)

Application of Long-term Integration : detection of GRB030329

In April 2003, we have performed 5-epoch monitoring observation of GRB030329, one of the brightest gamma-ray burst occurred at the end of March. The observations were made in dual-beam mode at 22 GHz band, with phase reference source J1051+2119 separated by 1.6 degree. The right panel shows an example of fringes detected during the monitoring, with an equivalent integration time of ～20 min. Rough estimate gives the flux density of ～20 mJy.



Fringe of GRB030329 at 22 GHz.

References : Honma et al. 2003, PASJ, in press (Vol.55, No.4, 2003 Aug.), astro-ph/0306060