Determination of coordinates of Atca, Ceduna and Mopra with centimeter accuracy in a global VLBI experiment at K-band

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1 Summary

We request 12 hours of observing time at Atca, Ceduna, Mopra, Hobart26, Parkes, Hartrao, and Seshan25 for running a geodetic style K-band observations in order to determine coordinates of stations Atca, Ceduna, and Mopra with an accuracy of 5–10 cm. Data will be correlated at Bonn.

2 Why precise coordinates are needed

Precise position of observing stations is needed for various VLBI applications. The most demanding application is absolute astrometry. For this application the ratio of the site position error to the Earth's radius, $\sigma_x/R_\oplus$, should be not worse than about the targeted accuracy of source coordinates. In order to reach a nanoradian (0.2 mas) level of accuracy of source positions, site positions error should be less than 1 cm. The second demanding application is differential astrometry. The requirement for accuracy of site position is diluted with respect to the requirement of the absolute astrometry by a factor of distance between the target and the calibrator. For a typical separation of target/calibrator $2^\circ = 1/30$ rad and the targeted accuracy 0.5 nrad (0.1 mas), the tolerable position error is 10 cm. One of the applications of differential astrometry is space navigation. Errors in a priori position of station Mopra introduced noticeable errors in results of VLBI experiments for tracking the Huygens probe in the atmosphere of the Titan. Even for observations made for imaging significant position errors will results in smearing and reducing the dynamic range.

3 Past observations

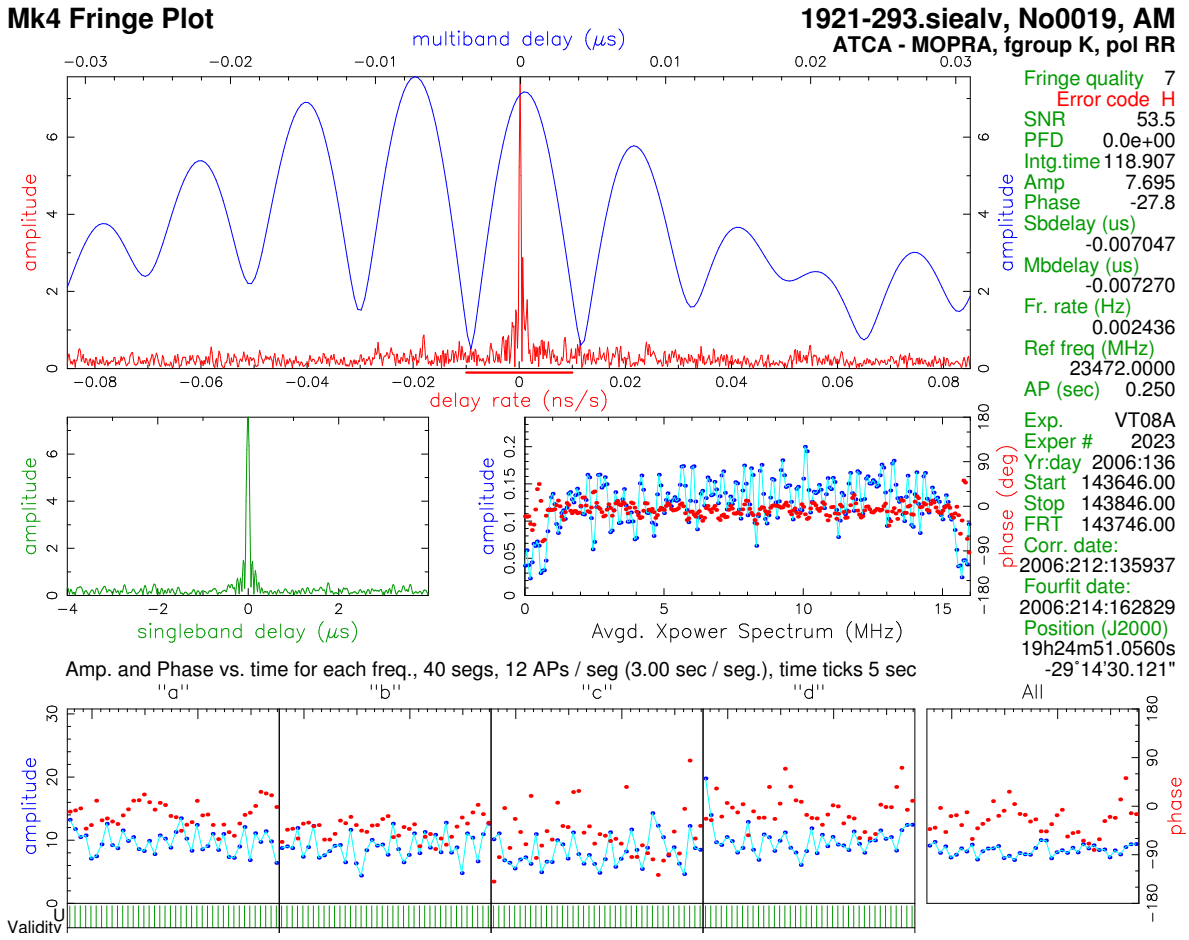
On 2006.05.16 a two hour fringe test, experiment vt08a, at stations ATCA_014, MOPRA, CEDUNA and HOBART26 was performed. A sequence of bright compact sources at K-band were observed. We have utilized the ATNF/PCEVN disk based recording with the aggregated data rate of 256 Mbps (4 IF channels at 23472 MHz, 23488 MHz, 23600 MHz and 23616 MHz, each 16 MHz bandwidth). The observed data were electronically transferred to JIVE where they were reformatted into the MkIV format and packed into Mk5A

disk-packs using technology developed at the Metsähovi Observatory, Finland. Then the Mk5A disk-packs with data were shipped to Bonn for correlation.

The minimal goal of the fringe test was to get fringes at all antennas. The second goal was to evaluate feasibility of getting reasonable group delays. The maximal goal of this test was to get sub-meter accurate position of ATCA, Ceduna, and Mopra.

We have found fringes (see figure 1) at all stations, except Ceduna. Lack of fringes at baselines with Ceduna is thought to be due to setup problems

Figure 1: Fringe plot at Mopra/ATCA_014 baseline during the fringe test.



Quality of group delay was as good as expected. We ran geodetic solutions using the Calc/Solve software program. The root mean square of the group delay residuals was 187 ps over 45 used observations. We managed to get a preliminary positions site positions which are listed in table reft:pos.

The formal uncertainties reported in the table are not realistic, because a) the network had small size; b) the schedule did not include observing low elevation sources. Realistic uncertainties are deemed to be of order of 1.5–2 meter for the vertical coordinate and 0.2–0.4 meter. Roughly speaking the error ellipse has a size of the observer.

Even preliminary station coordinates from the vt08a experiment helped to improve

Table 1: Position of stations in meters ATCA_014 and MOPRA from analysis of the K-band fringe test on 2006.05.16

ATCA_014	X	−4751640.926	± 0.2
ATCA_014	Y	2791700.280	± 0.07
ATCA_014	Z	−3200490.918	± 0.07
MOPRA	X	−4682770.655	± 0.3
MOPRA	Y	2802618.851	± 0.07
MOPRA	Z	−3291759.147	± 0.07

results of phase referencing observations of the spacecraft Huygens with respect to the quasar J0744+2120 located at 30′ away. Remaining errors of 1.5 meter of position of station Mopra introduce errors of $\sim$ 50 ps in fringe phase. At the same time, the stochastic noise of these observations is 15 ps, and a phase gradient is still clearly seen at baselines Mopra/Parkes.

4 Proposed observations

We propose to observe for 12 hours at K-band at Atca, Ceduna, Mopra, Hobart26, Parkes, Hartrao, Seshan25. The aim of the observations is to improve coordinates of Mopra, Atca and Ceduna. To tie site positions to the International Terrestrial Reference frame, we need to include in the schedule at least two stations with well known coordinates. We suggest to include Hobart26 and Parkes. To improve accuracy of positions of targeted sites, we propose to include remote stations Hartrao and Seshan25.

All stations will be observing at 23 GHz at four IFs spread over 304 MHz with an aggregated data rate of 256 Mbps. The stations Atca, Ceduna, Mopra, Parkes will be utilizing the ATNF/PCEVN disk based recording system, while stations Hobart26, Seshan25, Hartrao will be using Mark5a. The disks from Atca, Ceduna, Mopra, Parkes will be electronically transferred to JIVE via optical fiber where they will be re-written into Mark5A and then shipped to Bonn for correlation.

We will be observing the sequence of bright compact sources from the VERA catalogue of confirmed K-band calibrators. Each source will be observed for 120 seconds. The sequence of sources will be optimized for uniformity of sky coverage. Every hour 2-3 sources at elevations 15–25 degrees will be observed. The schedule will be generated by NASA SKED software. Slow antenna Parkes will be scheduled in a tagged alone mode.

Final data analysis will be performed at NASA using Calc/Solve software program. The expected accuracy of site positions is 5–10 cm. This should be sufficient for differential astrometry and space navigation.