Session 2. VLBI for Geodynamics

Convener: Prof. Valeri Shulga (IRA NASU, Ukraine)

GEODETIC VLBI EUROPEAN CAMPAIGNS: SCHEDULE, OBSERVATION, CORRELATION, ANALYSIS

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Nowadays geodetic VLBI is a routine process which runs as a service. Main phases of this conveyer are following: scheduling observations which is done by an Operating Centre, observations which are carried out simultaneously by 2–20 stations for 24 hours, correlation which is done by a dedicated supercomputer called "correlator", post-processing, submission of databases with observations to Data Centres and final analysis. Successful VLBI experiment is possible only as a result of coordinated efforts of many individuals. I will expose how this conveyer is working smoothly. I will consider in details the correlation phase and the specific problems which can be detected during correlation: radio interference, spurious signal in phase calibration, errors in tapes reading and how these factors affect the final results. A Geodetic VLBI European session consists of making a schedule, observing, correlate and analyse the data collected from all the stations. I will do an overview in this report of these points taking more attention of the correlation, the problems that I find during correlation and present status of the Bonn correlator.

INTRODUCTION

A Geodetic VLBI session is carried out simultaneously by 2–20 stations for 24 hours, which observe at the same time a set of radio-sources. The selected sources should be compact sources to have a very strong SNR at X band (about 3.6 cm wavelength) and at S band (about 13.4 cm wavelength) and should not have an appreciable proper motion.

The observations are scheduled with the aim to have an uniform distribution of sources in the sky observed from each station during the observing time.

During the observation each station produces a log file, where all the data about the ongoing observation are stored.

The correlation process consists of three main parts, the fringe search, the correlation and the post-processing.

The correlated data are then ready to be analysed geodetically and/or astronomically.

SCHEDULING AND OBSERVING

The schedule of a VLBI session is performed on the basis of the availability of as many telescopes as possible for that session. Each geodetic sessions takes normally 24 hours.

The most important aspect preparing a schedule for a geodetic observation is that from each telescope the sources have to be observed more or less uniformly in all the azimuth direction and for all the elevations.

In a geodetic observation it is not important that all the stations have to observe the same source at the same time and for the same time period. The SNR for each baseline must be strong enough to obtain good fringes during correlation, for this reason the radiotelescopes that have a good SEFD, can observe the source for smaller amount of time (as minimum 90 sec.), while the smaller telescopes have to observe the sources for longer time.

During the observation each station produces a log file, where all the informations about the ongoing observation are stored. There are informations about the setup of the recorder, the system temperature of the receiver, the configuration of the recorder the parity error rate of the writing system *etc.*

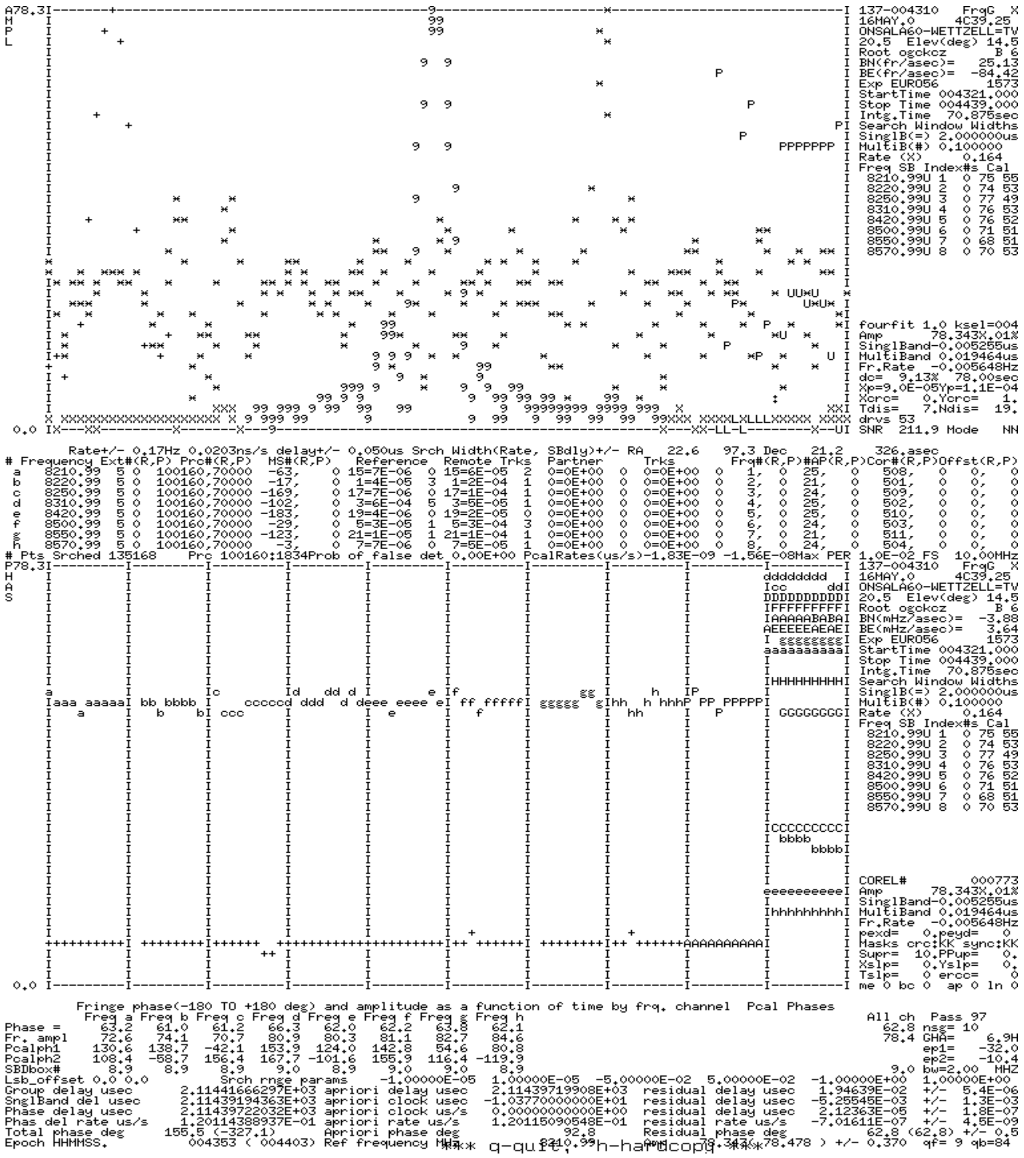

Figure 1: Mark III fringe plot

When the observation ends the operators at the telescope have to put the log files into one data centre (f.e. CDDISA) and to send the recorded magnetic tapes to the correlator centre that is in charge for that experiment.

CORRELATION AND POST-PROCESSING

As soon as all the log files, the schedule file and all the magnetic tapes are collected by a correlator centre the Fringe search of the new experiment starts.

Some steps have to be done before starting the correlation. The first is to give a number to the new experiment, because at a correlator all the experiments have a code name that is only numeric and not alfa-numeric.

Then some control files have to be created. The first control file is extracted from the scheduling file and contains informations as the a priori coordinates of the stations, clock offsets and drift between the maser at the stations and the reference time (GPS time), track position for each pass and informations about each scan. The second control file is extracted from the stations log files and it contains informations such as the code of

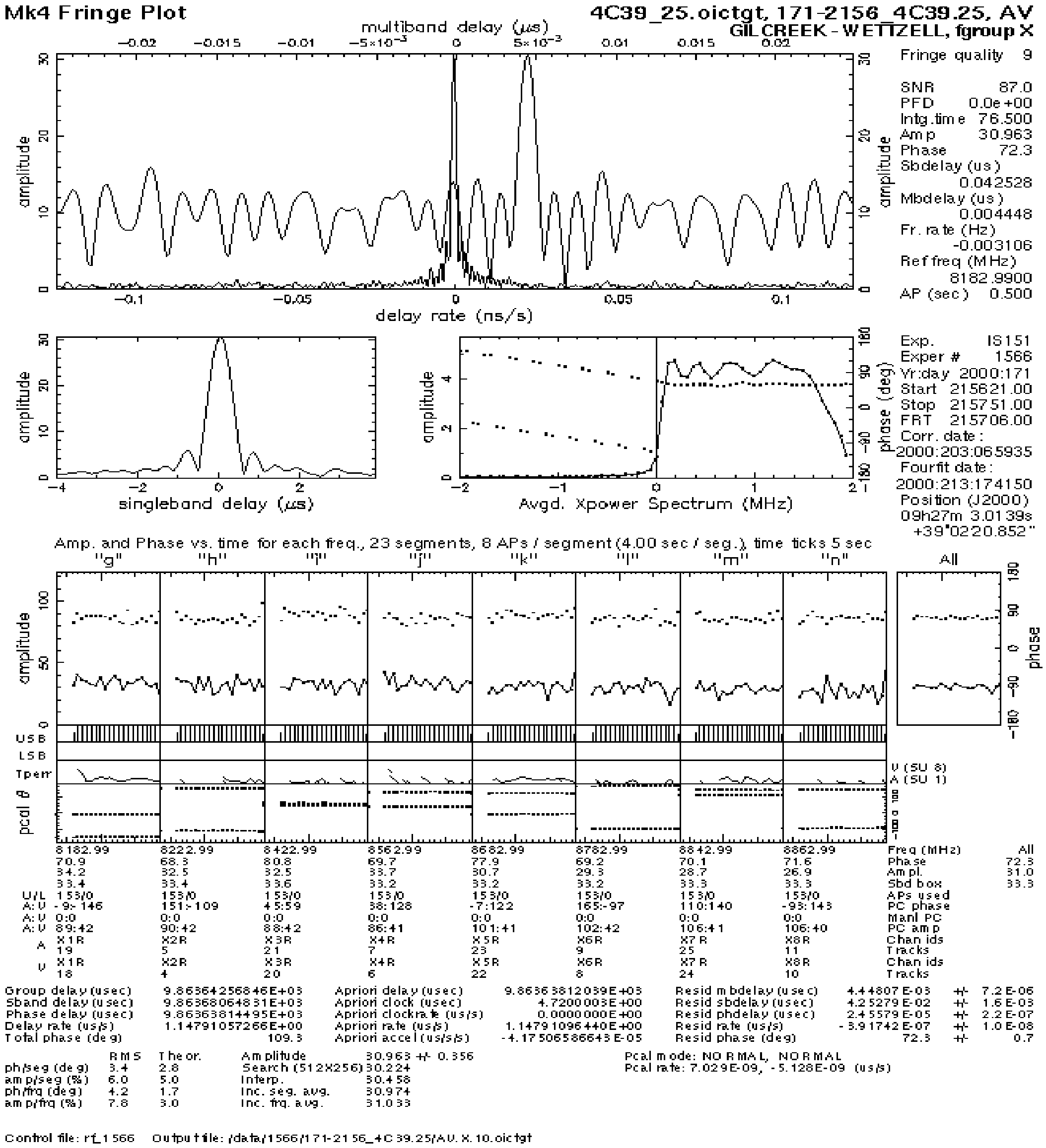

Figure 2: Mark IV fringe plot

the recorded tapes at each station, beginning and ending time-footage of the scan for each station and on which tracks the data were recorded. The transfer files are the last control that have to be prepared. The files have information about which scans and which baselines have to be correlated.

The correlation process consists of three main parts, the fringe search, the correlation and the post-processing. The fringe search has the purpose to determine the offset between the maser at the stations with an accuracy better than 0.05 μsec, to check the quality of the data and some other parameters as the right footage and head position and which is the best combination recorder-tape for all the stations.

When everything is prepared the correlation can start. The raw correlated data are transparent for the operators at the correlator, for this reason is started in an automatic way a post-processing software. The output of this software can be seen on the screen as fringe plots. Two examples of fringe plots, one from Mark III and one from Mark IV correlator, are shown in Fig. 1 and Fig. 2, respectively.

The most important informations that can be extracted from a fringe plots are: the baseline, the source, the elevation of the source over the two station, the single band delay, the multi band delay, the SNR, information about the phase calibrator, the fringe amplitude and the residual fringe phase for each observed channel.

The quality of data correlated for each baseline and each scan are then classified with a quality factor (q. f.) code. It ranges from the values 9 to a value 0. The value 9 is given when all the parameters are good, then the values decrease if the residual fringe phase, or the fringe amplitude for each are spread inside a single channel or they have different average values. The worse case is qualified with a q. f. 3. If the fringe amplitude is at one channel more than 50% lower than the average value the q. f. assigned at that scan is 2. A signal amplitude of the phase calibrator lower than the minimum acceptable threshold classifies the scan with a q. f. 1. An SNR lower than 7 is qualified with a q. f. 0 and means that the data are not recoverable. Other q. f. code can be assigned as q. f. "D" if the parity error rate with whom the data are written on the tape is to high, so all data of one or more channels are not recoverable. The q. f. "E" is given if the peak of the multiband delay is not central peaked, but it is very close at the border of the window.

PROBLEMS AND SOLUTIONS

The most common problems that can be detected at the correlator are:

a) the clock offset between the formatter and the GPS time is not correct. This is usually solved by getting only one frequency and looking if the true clock offset is in a larger window of about 50 μsec;

b) the data recorded on one tape have a high number of parity error rate that does not allow to recover at all the data on one or more tracks. The parity error threshold can be erased for the station whose data are bad. It can be done checking that the signal's quality does not decrease too much;

c) one or more frequencies are not at all recoverable at one station or for one baseline. Then all data of this station, or of this baseline are refringed discarding these frequencies;

d) also if the fringe amplitude is at one channel more than 50% lower than the average value at more than 30% of the scans this frequency is discarded in the final fringe;

e) an amplitude too low for the phase calibrator signal at one station can be eliminated using the manual phase calibration. It consists of getting one scan with a strong SNR and giving at each channel the values that allows to adjust the residual fringe phase for all the channels in the selected scan and to apply that values for all data of the station.

When the correlation and the post-correlation processes are ended and all these problems are solved, the data can be analysed with the geodetic CALC/Solve software.

CONCLUSION

Most of the problems that can happen during the observation can be recovered in some way in the correlation and the post-correlation process. Nevertheless, some of the consequences will come out only later during the analysis. For example we see bigger error in the least squares fitting of the baseline lengths.