VLB ARRAY MEMO No. 491

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To: VLBA

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Subject: Suggested Specifications for "Antenna Fringe Rotation" Module

Fringe rotation at the antennas could be implemented by offsetting the maser frequency standard (see Memo #326). In this method the offset frequency standard and formatter seconds tick derived from the offset frequency would track the source so that

$$t^1 = t + \vec{r}.\hat{e} - \text{atmos}$$

where

t	=	Maser time (nominally UTC)
$\vec{r}$	=	vector from earth center to station
$\hat{e}$	=	source direction
atmos	=	atmospheric delay
t^1	=	offset clock or "earth centered" clock

In units which are independent of frequency the offset box should achieve the following performance:

a) Accuracy <1 picosecond

b) Epoch accuracy <1 microsecond

c) Slew rate > antenna slew rate (≈400 microsec/sec)

Discussion:

a) Accuracy - ability to accurately follow a prescribed model

The accuracy of 1 picosecond would ensure that the offset clock errors are small compared with the instrumental errors. (However even one picosecond is inadequate for differential astrometry which should be essentially noise limited or 10 femptoseconds for an SNR of 400 at 43 GHz.)

b) Epoch

The offset must be applied at a well determined epoch otherwise the phase actually applied will differ from the model phase. Given the earth rotation velocity is about 1 microsec/sec keeping epoch errors under 1 microsec will keep phase errors under 1 picosecond.

c) Slewing

The offset clock must be "slewed" from one source to another without the electronics driven by the offset frequency going "out of lock" - otherwise the "earth centered" clock will jump and the astrometric information will be destroyed. The slew rate should not be slower than the antenna slew rate and probably should be much faster to allow for rapid switching within an antenna beam.

d) The electronics being driven by the offset frequency should have time constants shorter than 100 millisec to prevent phase errors being developed by the fringe acceleration of approximately 100 picosec sec^{-2}.

Motivation:

In my opinion, the main motivation for doing the fringe rotation at the antennas is to reduce the cost of the correlator. The astrometric performance of the offset box would have to be tested and even if satisfactory we should be aware that the following types of observation will be degraded:

1] Differential astrometry between 2 sources in the antenna beam (one being outside the processor beam).

This type of observation will have to be done by beam switching the offset thereby making observations more sensitive to atmospheric and instrumental fluctuations. Whereas with simultaneous observations of this type the atmospheric and instrumental phase fluctuations cancel.

2] Wide Field of View Observations

Observations of objects which cover a field of view which is wider than the processing window will have to be made by beam switching the offset and will therefore be degraded in sensitivity. Whereas fringe station at the processor allows multiple beams to be processed in multiple passes or even in one pass for a reduced number of baselines or channels.

3] Multiple Antennas

If some VLBA antennas are located near other antennas it will not be possible for multiple antennas to simultaneously acquire VLBI data while pointing at different sources.