AT/20.1/013

STATUS AND FUTURE OF THE PTI

R.P.Norris

11 March 1986
(Revised 21 March 1986)

1.0 PRESENT STATUS

1.1 Phase Stability

The PTI will soon be operational with a bandwidth of 0.5MHz. and a phase stability which is limited by the Rubidium standard at Parkes. The probable performance of the Rubidium is illustrated by Fig.1. At present it drifts by about 0.6μs/day (Dave Cooke, private communication), implying a frequency accuracy of about 7 parts in 10^{12}, or 1 turn/minute at 2.3GHz. Note, however, that this is not the Allan variance, or stability, of the oscillator, since this drift rate is the result of a random walk in frequency since the last time the Rubidium was adjusted. Thus this drift rate is consistent with the expected Allan variance which is better than 1 part in 10^{12}, as illustrated by the diagram in Fig. 2.

A frequency accuracy of 1 in 10^{12} may be achieved either by adjusting the Rubidium, or, effectively, by tweaking the fringe rate in the interferometer observing program. The program TID already has this facility, and allows an offset fringe rate to be entered in the menu. Thus we may assume a realistic Allan variance better than 10^{-12}. Therefore, the interferometer should have a phase stability better than 1 radian in 10 minutes at 18cm, or 1 radian in 40 seconds at 1.3cm.

1.2 Spectral Line Observations

The PTI in its present form is perfectly adequate for spectral line observations of OH masers. One such class of experiments involves visibility measurements of OH/IR sources, which can be used to estimate shell sizes, to study interstellar scattering, or possibly to measure the distance to the galactic centre. Another class of OH experiments is to measure the relative positions of the masers on OH/HII regions, in order to study the kinematics of star formation.

The only known problems with observations of OH masers are:

Distribution:
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1. They require the 64m antenna at Tidbinbilla, which is more difficult to get than the 34m antennas.

2. The 64m L-band receiver is currently operational only at 1667±5 MHz. For 1612MHz observations, an IF filter must be removed. I believe this is straightforward, but we should as soon as possible formally request this, to see if there are any problems.

Observations of water vapour masers might just be possible, but would be restricted by both the bandwidth and the short coherence time of the interferometer.

1.3 Visibility measurements of continuum sources

The present PTI is capable of measuring visibilities (and hence source sizes) of continuum sources which have a flux density in excess of about 50 mJy. The principal use of such measurements is to determine the sources' suitability for use as calibrators. In some instances, however, such measurements might give vital clues to the astrophysics of a source.

1.4 Astrometry

The PTI in its present form may be adequate for astrometry, in that the figures quoted above allow sufficient time for the telescope to be nodded between a source and a nearby calibrator whilst tracking the phase. Note, however, that this depends critically on the performance of the Rubidium assumed above. If the Rubidium is slightly worse than this, astrometry will not be possible. If the Rubidium is as good as the published figures (i.e. better than assumed above), astrometry on some sources at least will be straightforward.

2.0 FUTURE OPTIONS

The PTI could be upgraded in essentially two different ways: increase the bandwidth and improve the phase stability. I will consider each of these in turn.

2.1 An increase in bandwidth

The bandwidth may be increased to about 5MHz (or perhaps 10MHz) relatively simply, but the existing link phase compensation scheme will not then work. Thus there are two alternative ways of increasing the bandwidth:

1. Increase the bandwidth and abandon link compensation. To implement this requires the construction of a new delay unit, which could use essentially the same design as the old one but use faster chips and more delay, and the construction of a new IF converter at Tidbinbilla. Such a system would suffer from phase variations of perhaps 1 turn in 10 minutes, caused by the link delay, but this would be no problem to a mode of observation using a phase reference source within the beam. Such a mode is therefore ideal for pulsar proper motion observations.

2. Increase the bandwidth and use a new link compensation scheme. The design of such a scheme is under active consideration. This alternative requires construction of similar hardware to that described above, plus new IF converters at both the Parkes and Tid ends. This alternative can also use both links to produce a 10MHz usable band. This is the recommended option. Costs in hardware and manpower are currently being evaluated.

2.2 Phase Stabilisation

The alternative ways of achieving phase stability are:

1. Use a phase-stabilised link LO transfer scheme
2. Use satellite-linked LO's.
3. Use independent stable standards at each end.

Each of these will now be considered in turn.

2.3 Phase-stable LO link.

Suppose the LO's at frequency f_{LO} are locked to a signal which is sent on a round trip of the links, and that the path delays in the two directions differ by dT. Then the phase error introduced is $dT.f_{LO}$. Thus for stability at S-band, we require the two delays (Pks-Tid and Tid-Pks) to differ by less than 0.5ns on all timescales of interest. The link specifications in each direction are for a total delay variation of 3ns rms and 18ns peak-peak on a 1minute timescale, plus a maximum drift rate of 1 microsecond/hour, but the specifications give no hint of the recipricocity of these figures. The delays may differ substantially from each other because of multi-path propogation, but we have no information as to how severe a problem this might be.

To evaluate the feasibility of link stabilisation, therefore, we should measure the difference in delays between the outgoing and returning signals. Ths is a difficult measurement, but there is another measurement we can make which should give us a lower limit to the delay difference, and which is illustrated in Fig. 3. It uses the fact that we have two links in each direction, and these generally work at different (although nearby) frequencies. Thus any difference in delay between these two links gives us a lower limit to the delay difference between the outward and return links.

The measurement is straightforward and uses an Eldorado 992 microwave counter (thanks to Alan Young for pointing this out). The effect of making this measurement will be to give us some idea of whether link LO stabilisation is achievable.

2.4 Satellite linked LO's

Linking LO's by satellite is likely to need several man-years of development. Such effort is unlikely to be available unless this route is chosen for the AT LBA, in which case it will not be available until 1989 or thereabouts. It therefore seems that this option is probably not worth exploring in the near future.

2.5 Independent Stable Standards

Tidbinbilla already has the use of a H-maser. Thus the question becomes: can we get a standard at Parkes? One option would be to borrow a maser from JPL. This might be possible if their own people become interested in using the PTI. Another option would be to see if the U.WA group would be interested in lending us one of their prototype cryo cavities for 'field testing'. I suggest we explore this possibility once their development becomes further advanced.

3.0 THE IMMEDIATE FUTURE

I propose the following actions:

1. Make a detailed design and costing of the 2nd option to increase bandwidth, and, if feasible, start construction as soon as possible.

2. Measure the difference in delays as described in Section 2.3 above. If this is sufficiently small, then further work should explore the possibility of stabilising the link. If it is too large, then we will probably have to wait for the AT frequency standard to become available.

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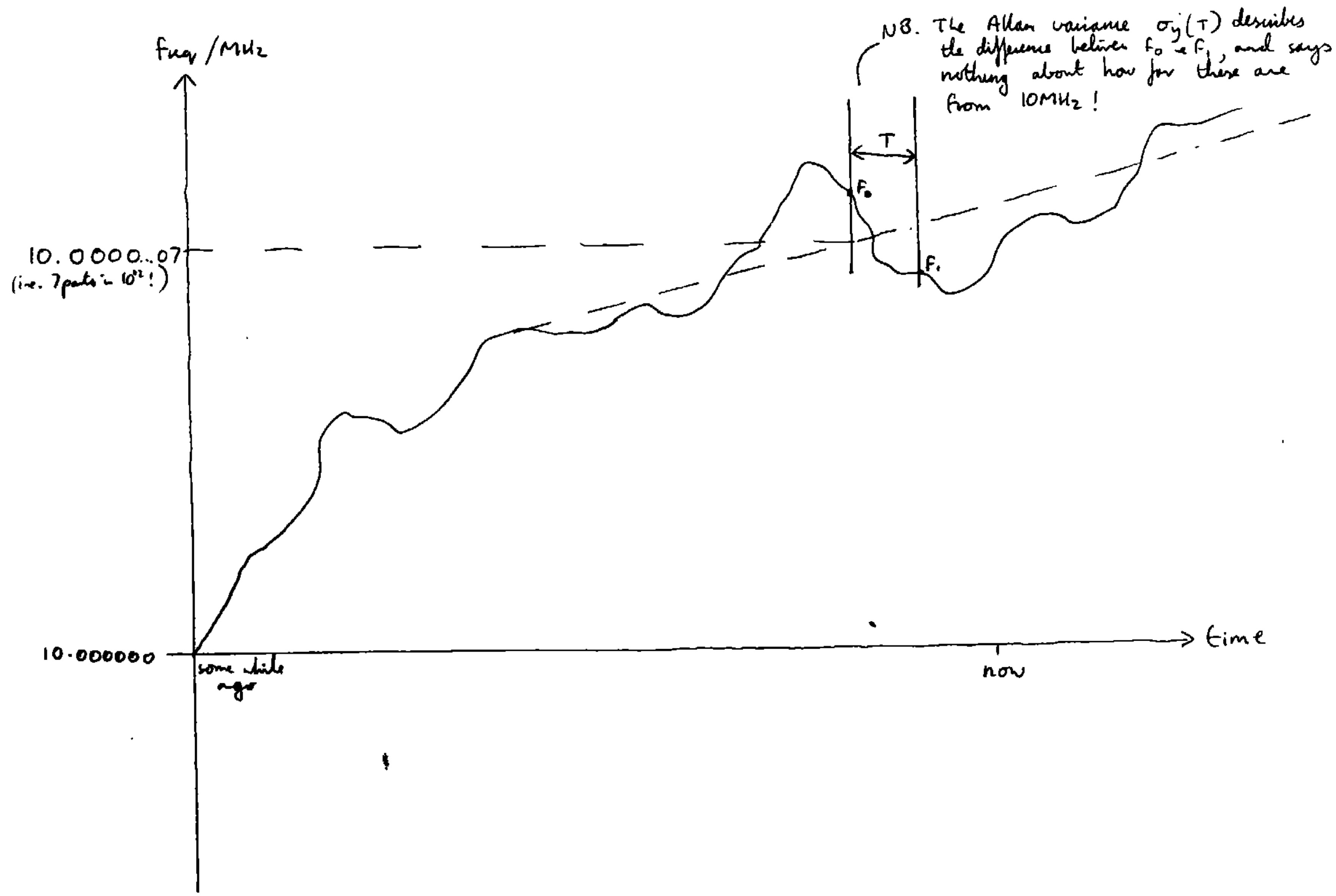


Fig. 1 : How the 10MHz Rubidium Standard behaves

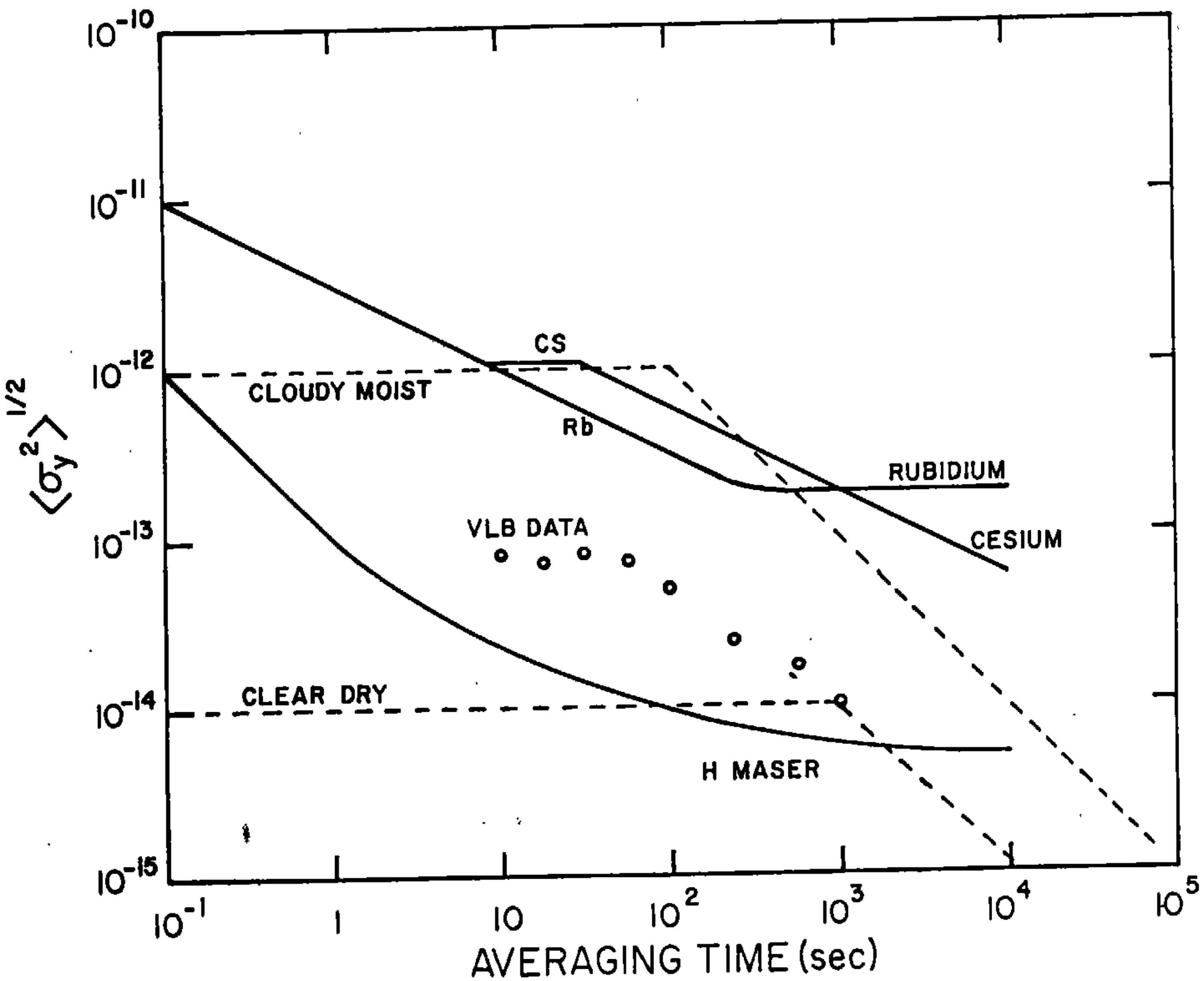


FIG. : 2. (FROM ROGERS AND MORAN)

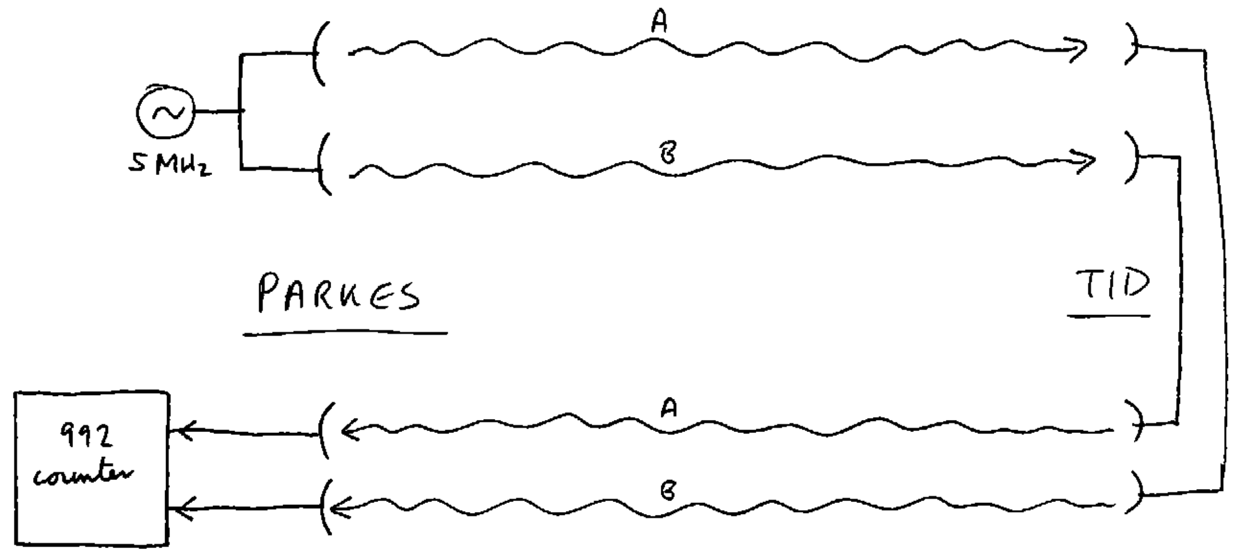
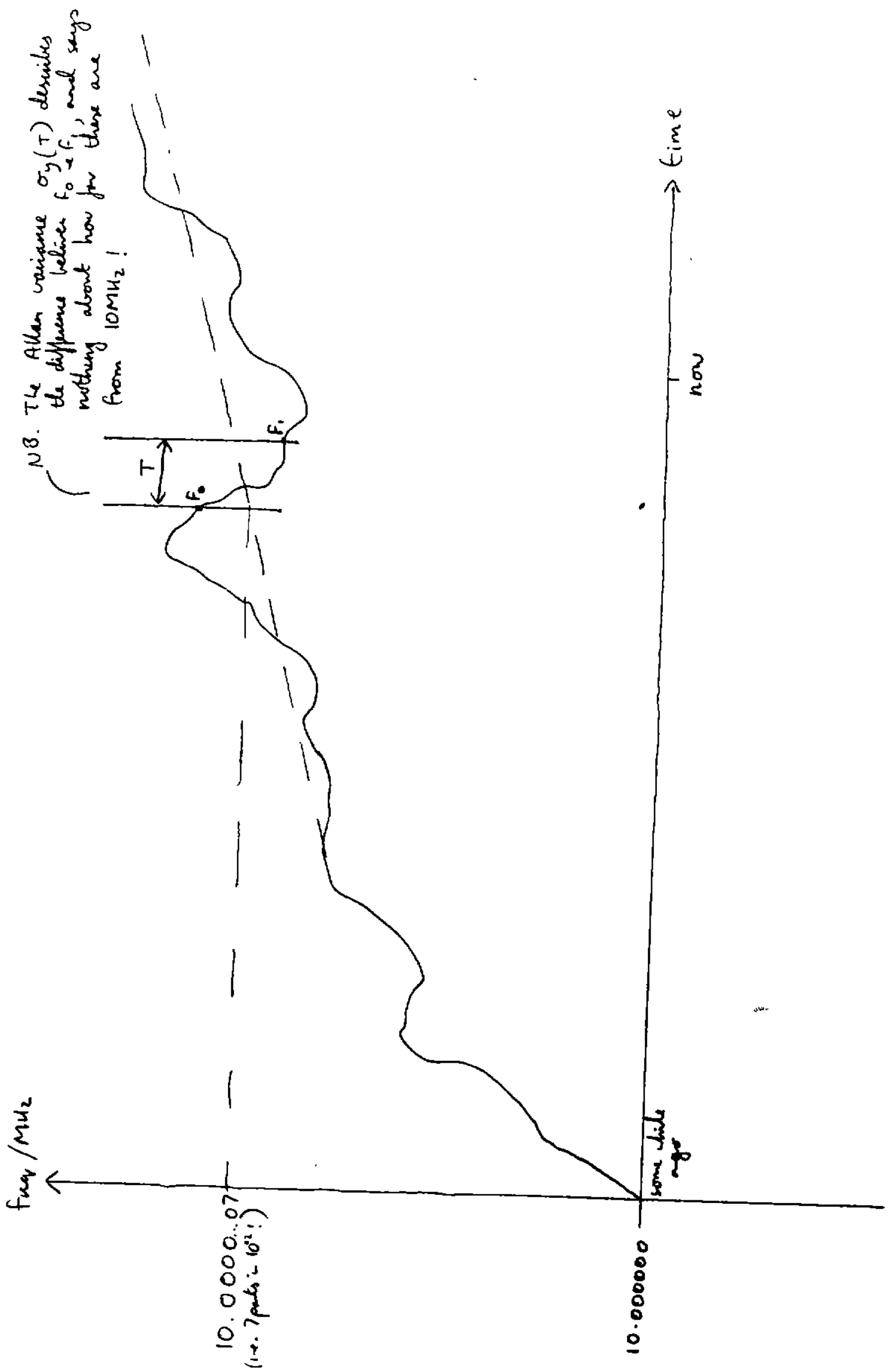


Figure 3: Measurement of link delay differences

These figures should be attached to AT/20.1/013



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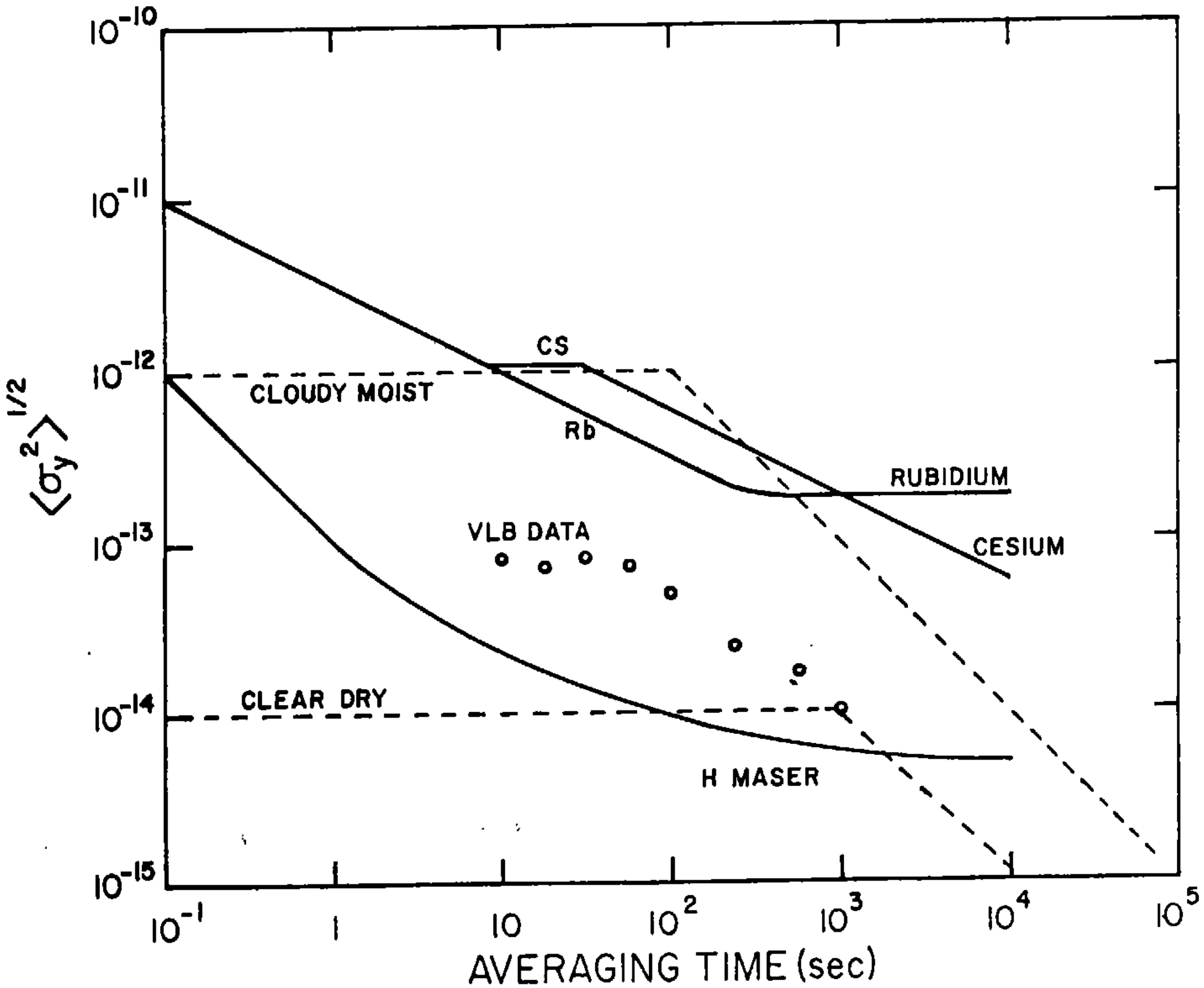

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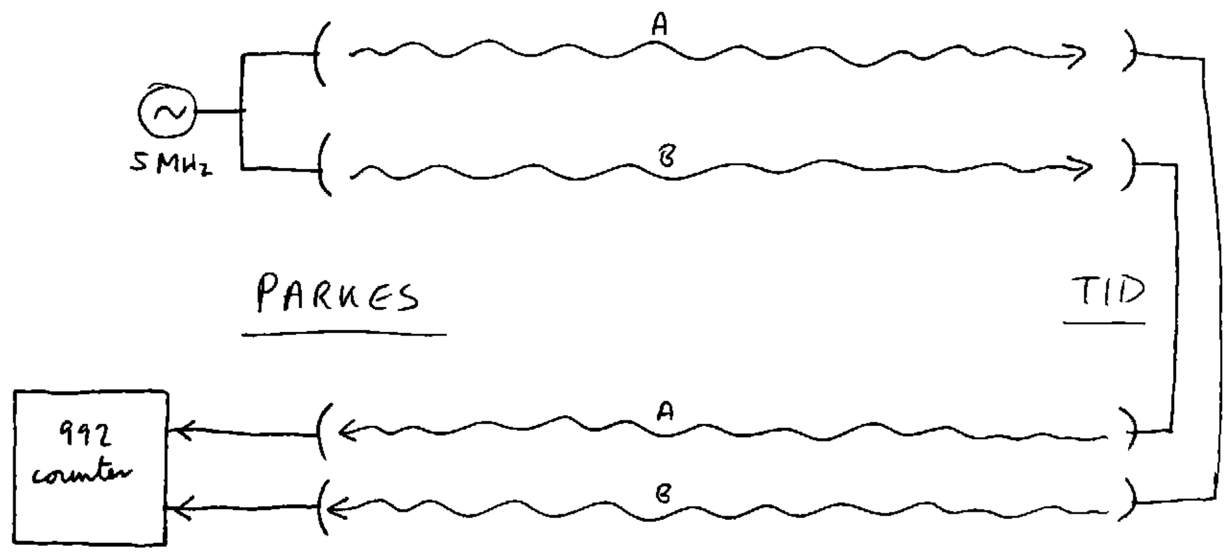

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