

Impact of Operations on Analysis

May 2011 TOW

WEH/BEC/MAT/AEN/KAK/AB 110425

Operational Issues

❖ **Module Handling**

- Make sure VSN is set correctly inside module before recording
- Write SDK version number, e.g., SDK 8.2, on field label

❖ **Timely Log file Upload**

- Upload your logs as soon as experiment/post-checks are complete

❖ **PLEASE Inform Coordinating Center about Changes in Station Status**

- Typical Problems
 - Increased SEFDs, e.g., warm receiver
 - Antenna slewing problems
 - Staffing Problems
 - Station not operational, i.e., “down” or unreliable
 - Observing conflicts
 - Insufficient media
 - Or any other issues that impact station performance or experiments that can be supported
- Report expected duration
 - One day, One week ...
 - If expected duration is unknown, a minimum estimate of duration is still helpful
- Send messages to ivs-urgent@ivscg.gsfc.nasa.gov
- This information will help the coordinating center determine how to handle the situation and get the best data possible.
- We need to hear about improvements in status as well.

❖ **Coordinating Center has three primary ways to deal with problems**

- Change Master Schedule
 - Mostly for observing conflicts and extended periods when a station may be “down”
- Modify scheduling parameters
 - Used for problems that limit station performance, e.g., warm receiver, antenna slewing degraded, temporarily or permanently
- Change scheduling status to “Tag-along”
 - Works well for temporary situations that may prevent observing or make station unreliable
 - Allows a station to contribute to network if it can observe, but limits bad consequences if it is unable to observe

❖ **If you don't observe send e-mail warning for correlators**

- See included message(marked DRAFT, but final) on policy

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❖ **Not enough BBCs/VCs drop-order (for geodesy)**

- See included e-mail on dropping channels
 - Selected channels to minimize impact on delay resolution function
 - Same rule for all 14 BBC/VC experiments to keep it simple
 - Stations should follow the same rule to minimize overall losses
 - 8 BBC/VC experiments, every station should have enough (we hope)
 - 14 BBC/VC experiments: drop order is 6, 11, 7, and 2
 - That is: one bad converter, drop #6; two, then drop #6 and #11; and so on.
- Recently #5 was added the fifth to drop, so now 6, 11, 7, 2, and then 5.

❖ **When to recool**

- By design most experiments can be run successfully with a warm receiver at one station, even two stations warm is not that bad, as you add more it gets progressively worse
- Generally we prefer you **NOT** stop the schedule to re-cool, except in some special circumstances:
 - There is not enough time after this experiment and before the next to re-cool
 - The experiment requires the highest sensitivity and is useless without a cool receiver, you will receive special instructions for the experiment in this case
 - You have personnel or equipment constraints that will not allow re-cooling after the session and before the next
 - Other situations as appropriate

❖ **Formatter Clock Jumps**

- The Mark IV correlator does not handle arbitrary formatter offsets
- If sub-second portion (available from gps-fmout or fmout-gps) of the clock offset exceeds about ± 30 milliseconds it must be reset.
- If the integer second portion (available normally from “sy=run setcl &”) of the clock offset exceeds about ± 5 seconds it must be reset.
- If larger than the limits, please correct as soon as possible
- You should **not** reset the clock if a jump results in a smaller offset than these limits.

❖ **Extra Cable delay**

- If you leave the cable extender for the cable measurement in the line by accident, don't take it out once the experiment has started unless you believe there is something wrong with the extender.
- Likewise do not make the cable measurement during the experiment. If you forget to make it beforehand, please wait until the end.
- Phase meter must be in the middle half of the range

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❖ **Mark III/IV/5 rack VC power levels**

- See included e-mail message for details about VC levels
- Set attenuators for minimum power level above 0.1 volts in all recorded channels (USB & LSB as appropriate) at zenith in clear weather
- IFADJUST command can be used for this if not too much RFI, it is worth a try anyway: set frequencies etc with mode set-up command, then try IFADJUST
- If this approach is used, it should not be necessary (hopefully) to change levels during an experiment because of rain or other events, please don't if possible, it can cause problems for correlator diagnostics if you do

Sensitivity Effects, Background

❖ Geodetic Precision is roughly proportional to observation sigma σ

$$\sigma \propto \frac{1}{SNR} \propto \sqrt{\frac{SEFD_1 SEFD_2}{T_{int}}} / S_c$$

- σ is the precision of the observation (sigma) or how good a measurement we are making (the smaller the better)
- SNR is the signal-to-noise ratio, or how much stronger the signal is than the noise (the larger the better)
- $SEFD_1$ is SEFD at antenna 1 (the smaller the better)
- $SEFD_2$ is SEFD at antenna 2 (the smaller the better)
- T_{int} is the integration (recording time) of observation (the larger the better)
- S_c is the correlated source flux (the larger the better)
- Note:
 - Observation sigma σ is inversely proportional to SNR
 - Observation sigma σ is proportional to square root of product of SEFDs
 - Observation sigma σ is inversely proportional to square root of T_{int} , recording time
 - For example: warm receiver with SEFD 3 times normal is the same as observing 1/3 of the time

Sensitivity Effects, Impacts

- ❖ Geodetic Precision and a Warm Receiver
 - If one station's receiver is warm, that station's SEFD might typically go up by a factor of three. Then the average sigma would go up a factor of $\sqrt{3}$ or about 1.7, a station position estimate that would have been precise to about 5 mm would instead be precise to about 8.5 mm.
 - Warm receiver with SEFD 3 times normal is the same as observing 1/3 of the time
 - Target (minimum) SNR values are typically 20 at X-band, there are no fringes of SNR falls below about 7. With an SEFD 3 times normal, the target SNR becomes 11, not fatal and many observations exceed the target.
 - A warm receiver at one station usually will not destroy an experiment as is, but it may prevent fringes to a high SEFD station if it was scheduled with a lower SNR target. For example, baselines to O'Higgins are typically scheduled with a target of 15. If Hobart warms-up the SNR is reduced below 9 and the Hobart-O'Higgins baseline will be marginal at best.

- ❖ Other effects that increase SEFD
 - Pointing off by one half of a full-width-half-maximum (FWHM) drops the response of the antenna by a factor of two and so doubles the SEFD and the sigma is increased by $\sqrt{2}$
 - If the focus is off, the same rule applies, if the response is down half, the SEFD is doubled and the sigma is increased by $\sqrt{2}$
 - Poor image rejection:
 - Front-end, doubles the noise level in all channels, so increases sigma by $\sqrt{2}$ (also does bad things to phase-cal: adds spurious signals)
 - VC/BBC, doubles the noise level in that channel, so increases the sigma by about a small amount, but also adds spurious signals

- ❖ Missing channels
 - Each lost channel reduces data yield by about 7%
 - In addition it can compromise the delay resolution function, please see the accompanying write-up by Axel Nothnagel
 - See recommended drop order above

- ❖ Phase-cal
 - Should be about 1% in power
 - Too strong reduces sensitivity and produces spurious signals
 - Phase-cal too weak spurious signals can be a problem

Examples of Problems

- ❖ **Reduced Channel Amplitude Caused by Spurious Signal, RFI, bad channels, etc.**
 - Sometimes channel must be deleted
 - See accompany fringe plots:
 - CRDS17 HartRAO autocorrelation: strong spur, channel deleted
 - R1086 Matera-Wetzell S Band
 - R1086 Matera autocorrelation: strong spur at Matera
 - R1167 Gilcreek-Westford S-band, bad BBC at Gc, RFI at Westford, note: sidelobes of MBD high
 - R1157 TIGO-Wetzell, Upper X-band problem at TIGO
 - R1171 Gilcreek-Hobart S-band, Hobart noisy LO in VC14
 - R1142 Seshan-Wetzell X-Band: Seshan roll-off in upper channels, all four channels deleted
 -
- ❖ **Gilcreek Maser Problem, Fall/Winter 2004-2005**
 - See accompany clock/residual plots from R1150 (\$04NOV22XA):
 - Problem: Gilcreek versus Westford, wrms=149 pico-seconds
 - Normal: Kokee versus Westford, wrms=29 pico-seconds
 - See accompany X and S fringe plots from R1154
 - Phase jump at X and S at Gilcreek
 - Very roughly the effect was to double Gilcreek's coordinate sigmas
 - Corresponds to losing about 75% of the data
- ❖ **Tape Overwriting**
 - See R1161 Gilcreek-Hobart Fringe Plot with significant data loss
- ❖ **Phase-cal epoch jumps**
 - S-band MBD delays jumps
 - When S-band ambiguity spacing was no longer 200 nanoseconds, now fixed
 - AEDIT plot for R1171 (Expt 3098), see Station O
 - If Phase-cal 5 MHz is interrupted there is 4 out of 5 chance the epoch will change
 - Possible causes:
 - Disconnecting and reconnecting Phase-cal 5 MHz cable, e.g., removing cable sign check extension cable during session, please don't.
 - Bad connectors
 - Bad power supplies
 - Anything else that can cause the epoch of Phase-cal pulse to change
- ❖ **Mark 5 Cable crosstalk**
 - See RD0701 Matera-West_5B fringe plot, including blow-up of Amp and Phase vs. time on separate plot
- ❖ **Multiple Formatter Jumps**
 - See AEDIT plot for experiment 3164

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- ❖ **Non-detection due to weak X-band**
 - See fringe plot of T2044 Urumqi-Crimea
- ❖ **Unstable Phase-cal**
 - See blow-up of Amp and Phase vs time from T2044 Urumqi-Crimea
- ❖ **Phase-cal Spurious signals**
 - See AEDIT plot for experiment 3151
- ❖ **Scheduling/Media error**
 - Fortaleza ran out of disk and had to use tape for an R1
 - The R1 mode requires 32 tracks and Fortaleza only has a Mark III recorder and so 28 tracks
 - Should have lost 2 channels (2:1 fan-out requires 2 tracks per channel)
 - Instead didn't record half of 4 different channels
 - Even worse USBs of VC1 and VC8 were lost, so no phase cal for LSBs
 - See HartRAO-Fortaleza fringe plot for T2047

missed_experiments.txt

Subject: DRAFT Messages for missed experiments
Date: Mon, 06 Apr 2009 17:37:29 -0400
From: Ed Himwich <Ed.Himwich@nasa.gov>
To: ivs-stations@ivscc.gsfc.nasa.gov

To: IVS Network Stations

From: Ed Himwich, IVS Network Coordinator

Re: E-mail messages for missed experiments

We would like to request that all stations send a message to the IVS OPS mail list to report anytime they miss an experiment that is shown for their station in the master schedule. This may seem unimportant since there is no data to send to the correlator. However, if the correlator does not know that a station failed to observe, correlation may be delayed unnecessarily to wait for data that will not arrive. Suggestions for the message contents are given below.

Please send the message no later than the nominal end time of the experiment (it could be sent before) or as soon as practical afterwards. The message should be sent to the IVS OPS mail list: "ivs-ops@ivscc.gsfc.nasa.gov". The subject line should include the experiment code, name of the station, and appropriate text such as "Did not observe" or "Will not observe", e.g.:

R1369, Fairbanks, Did not observe

To assist with message identification, please follow the pattern of the above example if possible. It would be helpful if the body of the message contains at least a short, but longer is better if practical, explanation of the reason the experiment was missed.

Please note that including the experiment code in the subject line will not only identify the experiment affected to the recipients but will also allow the ivscc mail system to route a copy of the message to experiment e-mail archive. The archive is available on the experiment web page which can be accessed from the HTML master files which are available through links at:

<http://ivscc.gsfc.nasa.gov/program/master.html>

The experiment e-mail archive is where all message relating to the experiment are collected and is where the correlators look for "Did not observe" and other messages, including "Ready"/"Start"/"Stop", that contain information they need to process the data.

Dropping_Channels.txt

Subject: Dropping Channels Gracefully for Geodesy

Date: Wed, 03 Sep 2008 14:05:12 -0400

From: Ed Himwich <Ed.Himwich@nasa.gov>

To: ivs-stations@ivsc.gsfc.nasa.gov

CC: pcfs@ivsc.gsfc.nasa.gov, Brian Corey <bec@haystack.mit.edu>

To: Stations Observing in Geodetic VLBI Experiments

From: Ed Himwich and Brian Corey

Re: Dropping Channels Gracefully

Ideally, all stations should have a full complement of working BBCs (or VCs, both hereafter referred to as "BBCs"). However, we recognize that there may be occasions when this is not possible. For many years we have had a standing recommendation that, for experiments that require 14 BBCs, a station with a single bad BBC should put it in position #6, i.e., BBC #6 should be "dropped". If a second BBC is bad, BBC #11 should be dropped. We hoped that the bad BBCs would be repaired rapidly so that a full complement would soon be available again. The point of these recommendations, originally developed by Dave Shaffer in the 1980s, is two-fold: (1) to have the least impact on the delay resolution function, in terms of both preventing the wrong peak from being picked in fringing and losing the least amount of observation precision, and (2) to avoid having different stations, operating independently, drop different BBCs, thereby causing even more data loss between them.

Due to the aging of equipment and the difficulty of obtaining repairs, there are times now when stations may have more than two BBCs that are not working and/or they may not be being repaired in a timely fashion. Consequently, Brian, with contributions from Alessandra Bertarini, has put together recommendations for which BBCs to drop when missing up to four. We are not planning to make a recommendation for going beyond dropping four BBCs for experiments that require 14 due to the rapid reduction in performance that occurs. Please note that the recommendations apply to all experiments requiring 14 BBCs. Although the recommendations are not optimal for all frequency sequences currently in use, they are nearly so. Very little improvement would be achieved by varying the recommendations for different experiments. Having to keep track of which BBCs should be dropped in which experiments would reduce the utility of the recommendations beyond what is justified, given the small improvement that would result. If a new frequency sequence is developed that requires a different drop order, the recommendation will be revised; for the foreseeable future however this is not a concern.

For now, there are only two qualifications to the experiment independence of the recommendations: (1) for the infrequent experiments that require only eight BBCs (RDVs primarily), stations should physically re-arrange the BBCs if necessary in order to have a full complement of BBCs, and (2) if a station knows that one or more channels are persistently lost to RFI or some other problem, they should try to use the bad BBCs in those positions first before applying the drop order. The second qualification has reduced importance compared to general recommendations; if applied it may lead to varying the drop order depending on the experiment. The following final paragraph of this message states the new recommendations independent of such complications.

For experiments requiring 14 BBCs, when a station does not have enough working BBCs (or VCs) to form a full set, we recommend the following order for dropping BBCs: 6, 11, 7, and finally 2. In other words: if a station has a single bad BBC, they should place it in position 6; when there are two bad BBCs, they should go in positions 6 and 11, and so on. The order of dropping BBCs is independent of the frequency sequence for

experiments using 14 BBCs.

Dropping_Channels.txt

Power_Level s. txt

Subject: Mark III/IV VC Levels
Date: Fri, 02 Mar 2001 10:00:12 -0500
From: Ed Himwich <weh@ivscc.gsfc.nasa.gov>
Reply-To: weh@ivscc.gsfc.nasa.gov
To: pcfs@ivscc.gsfc.nasa.gov, EVNtech <evntech@j.b.man.ac.uk>

To: Mark III and Mark IV Stations

From: Ed Himwich and Brian Corey

Re: Mark III/IV VC Levels

March 2, 2001

Introduction

This information is only relevant for stations with Mark III or IV Video Converters. It does not apply to stations with VLBA racks or VLBA racks modified for Mark IV by adding a Mark IV formatter (so-called VLBA4 systems). The remainder of this memo consists of two sections. The first titled "Operational Procedures" outlines important rules for working with Mark III and IV VCs. This section is somewhat simplified to give a clear set of guidelines for setting levels. The second section is titled "Discussion" and covers more of the details.

Operational Procedures

1. Always adjust the signal levels with the VC 10 dB pads in the signal path.
2. The power level in each video sideband that is being recorded should be greater than 0.1 volts on the front panel, but as low as possible above 0.1 volts. Please set the IF attenuators to the maximum value that keeps the levels above 0.1 volts for all sidebands that are being recorded (note: some modes record both sidebands in some or all VCs). This level should be set during dry weather with the antenna at zenith or wherever the system temperature is a minimum.
3. Please avoid changing IF attenuator settings during experiments. If all levels are set as low as possible, but above 0.1 volts, there should be no need to change them under normal conditions, including rain. If it was not possible to set the levels in dry weather before the experiment, it may be necessary to reduce the attenuation when the weather clears.

Discussion

As a rule, the IF levels for the Mark III and IV VCs should always be set with the 10 dB pad in the VCs switched in. With the pads in, the minimum front panel power level in the sidebands that are being recorded should be 0.1 volts. The values should be less than 0.5 volts if possible and in no case should be above 2.0 volts.

You can also adjust the levels using the TPI measurements from the VCs in the FS. A front panel sideband power reading of 1 volt should correspond to about 32768 counts. Therefore 0.1 volts is about 3300 counts. You should correct for the TPZERO (no signal) level of the converter. For example if the zero level is 600 counts, then the specification of 0.1 volts on the front panel would be the same as $3300+600=3900$ counts. Please note that the front panel may have a zero offset that should be corrected for if you are using the front panel to determine the level. The next version of the FS will include a new command, ifadjust, which will use the VC TPI counts to automatically determine the best attenuator levels.

Power_Level s. txt

The specification of 0.1 volts minimum level is necessary to overcome the intrinsic noise in VCs. (In addition for Mark IV VCs the level must be above 0.1 volts to make sure that there is sufficient input power for the AGC circuit to work properly.) The power levels should also be as low as possible, but above 0.1, in order to give as much dynamic range for Tsys measurements as possible. You will also want to make sure that the levels are low enough so that when the noise diode is turned on, the TPI measurements do not saturate under normal conditions. If you are unable to balance all of these conditions, please contact us.

Ideally the front panel levels should be as low as possible above 0.1 volts, during normal measurements, through varying ground pick-up and weather. Please note it is very undesirable to change the attenuator settings during an experiment since this will change the delay through the system. This should not be necessary and will cause some correlator diagnostics to be difficult to use (and therefore more difficult for the correlator to give you useful feedback). In the worst case, if there is a problem with your station's phase-cal and it is necessary to use manual phase-cal at the correlator, it will introduce a clock jump, which will significantly degrade the geodetic solution. In particular, this means you should not change the levels at X-band when it starts to rain. Ideally, your attenuator settings should be adjusted for dry weather and left in that state. The signal level will increase during wet weather, but there should be enough dynamic range to prevent VC overflows. You also shouldn't change the IF attenuators for low-elevation observations. However, if the TPI overflows for low elevation observation you should probably inform us so that the elevation mask for your station can be adjusted in SKED.

Ideally, the signal levels of the IFs coming into the rack should be such that, when the VC sideband levels are set as specified above, the IF attenuators are in the range of 10-43 dB. If more than 43 dB of attenuation are required, the error in Tsys due to the measurement of TPZERO will start to exceed 1%. On the other hand, if the attenuators are less than 10 dB the signal is weak enough that there is concern about spurious signals in the rack interfering with the phase-cal in IF. This is reduced as the power level is increased. So the best compromise is when the signal is strong enough that correct attenuator settings are relatively high, but below 43 dB. It is relatively easy to get the attenuators settings down to this level if they are too high by adding attenuators before the rack. On the other hand, increasing the settings requires adding amplification external to the rack.

There are some problems with the linearity of the output of the power detectors in the VCs. This issue is still being investigated. The nonlinearities cause fractional errors in Tsys measurements of a few percent when TPICAL is about 20,000 counts, and the error varies roughly quadratically with power level. If high accuracy Tsys measurements are needed, the value of TPICAL should be kept as low as possible consistent with the minimum 3300 count level above the TPZERO level for normal operations. Of course there are other calibration errors that can affect Tsys results at the 10% level as well.

Please note that the TPZERO reading for each sideband in each VC should be about 300-1000 counts. If it is more than 2000 counts it should certainly be fixed.

An additional point is that in the absence of significant RFI and bandpass problems, the power for the two sidebands should be within 1 dB. If it isn't, the VC should be fixed.

On the Effects of Missing Tracks

Axel Nothnagel, Institute of Geodesy and Geoinformation, University of Bonn, Nussallee 17, D-53115 Bonn, Germany. E-mail: nothnagel@uni-bonn.de

1 Introduction

In recent VLBI sessions of the Europe series we suffered a considerable loss of data and, even more importantly, a loss of data quality from radio frequency interference (RFI), formatter failures, and data recording deficits. In this paper we try to summarize the basics of bandwidth synthesis with special emphasis on the effects of missing data channels. It should be understood that each channel scheduled to be observed is necessary for achieving the good data quality which we aim at. In this paper frequencies and bandwidths are used according to the current Mark III (narrow band) setup. All explanations apply to the wide band case (720 MHz and 125 MHz) in the same way.

The Signal-to-Noise-Ratio (SNR) of an interferometer, defined as the inverse of the standard deviation of fringe phase in radians, is given by

$$SNR = \eta \sqrt{\frac{A_1 A_2 2BT}{T_{s1} T_{s2}}} \cdot \frac{F}{2k} \quad (1)$$

where k = Boltzmann's Constant, F = correlated flux density of the source in units of watts per steradian of the emitting region per m^2 of antenna collecting area per Hertz of observing bandwidth, T_{si} = system temperature at station i , A_i = effective area of antenna i , B = total recorded bandwidth, T = total integration time ($2BT$ is the total number of bits at the Nyquist rate), η = loss factor to account for clipping and signal losses (Clark et al., 1985).

The accuracy of a group delay σ_τ determined from a cross-correlated stream of bits representing the coherent signal of a radio source received by two telescopes may be deduced from the SNR as

$$\sigma_\tau = \frac{1}{2\pi SNR \Delta f_{rms}} \quad (2)$$

with Δf_{rms} = root-mean-squared spanned bandwidth or rms frequency deviation about the mean of the observing frequencies.

$$\Delta f_{rms} = \sqrt{\sum_{i=1}^n \frac{\omega_i^2}{n} - \left(\sum_{i=1}^n \frac{\omega_i}{n}\right)^2} \quad (3)$$

where ω_i are the individual center frequencies and n is the number of channels. Combining (1) and (2) leads to

$$\sigma_\tau = \frac{2k}{F} \cdot \sqrt{\frac{T_{s1} T_{s2}}{A_1 A_2 2BT}} \cdot \frac{1}{2\pi \eta \Delta f_{rms}} \quad (4)$$

Under the assumption that we cannot increase the effective aperture of the telescopes with economical costs and that the noise of the receivers is at their lower limits we may only use an increased recording bandwidth to improve the accuracy of the delay determination.

2 The Single-Channel Case

In order to understand the basics of and the necessity for bandwidth synthesis we should first look at the single band delay determination. Consider that we have recorded a single channel of a certain bandwidth B with a rectangular bandpass. After cross-correlating two coherent signals of the same source the cross correlation function would become

$$R_{xy}(\tau) = 2 \cos [\theta + \omega^0(\tau) + \pi B \tau] \frac{\sin \pi B \tau}{\pi B \tau} \quad (5)$$

with θ being the local oscillator phase difference, ω^0 the local oscillator frequency and τ the group delay (Rogers, 1970).

The envelope function of this cross-correlation function has the form of a so-called sinc-function $((\sin x)/x)$ which would be equivalent to a Fourier transform of the bandpass from the frequency domain into the lag domain. The sinc-function has a delay width of approximately

$$\Delta_\tau = \frac{1}{B} \quad (6)$$

with B being the bandwidth of the bandpass. The delay width is important since it determines, at least in part, the inherent accuracy of the delay determination, i.e the sharper the peak, the more accurate the determination of the location of the maximum on the τ axis (Fig. 1). From (6) and Figure 1 it can easily be deduced that we could improve the delay accuracy just by increasing the bandwidth (e.g. Beyer, 1985). This, however, has its limitations since it requires coherence across the whole band and an enormous, ever increasing, recording capacity.

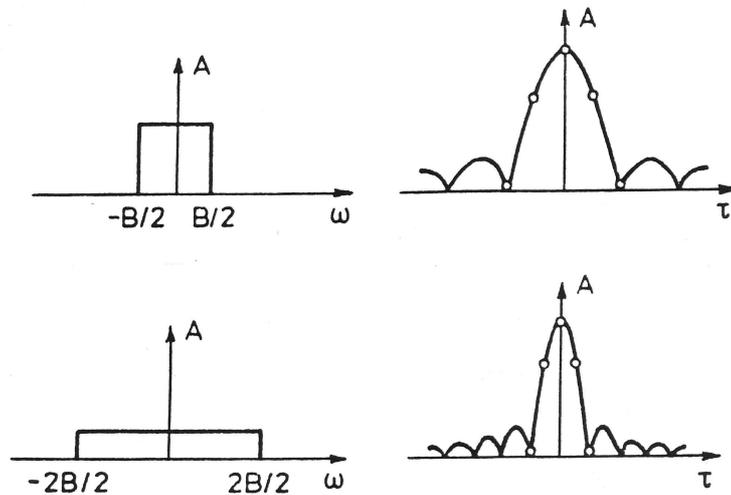


Figure 1: Fourier transform from frequency domain into lag domain with bandwidth B and $2B$ (Beyer, 1985)

3 Bandwidth Synthesis

In order to improve the delay determination under economic restrictions, Rogers (1970) "solved the problem in a rather ingenious way" - as Whitney (1974) wrote - by developing the bandwidth synthesis method.

Similar to antenna aperture synthesis where a number of small telescopes synthesize the aperture of a much larger telescope (e.g. VLA or Westerbork Synthesis Radio Telescope) a wide frequency band is sampled using a number of narrow bands, in the case of Mark III/IV/V of 2 to 16 MHz bandwidth. This is achieved by placing two channels at the extreme frequencies defining the total spanned bandwidth, 720 MHz at X band and 125 MHz at S band. In addition, a number of intermediate frequency channels are introduced in between according to a certain scheme which is discussed later. Using only these narrow bands the whole bandwidth (between the first and the last frequency) is synthesised and the accuracy of the delay determination is improved.

In order to describe the frequency band - time lag (delay) relationship Rogers (1970) defined a complex delay function for an ideal situation

$$D(\tau) = \int_0^{\infty} S_{xy}(\omega) e^{-i\omega\tau} e^{-i\omega_0\tau} \frac{d\omega}{2\pi} \quad (7)$$

with $S_{xy}(\omega)$ being the cross-spectral function, ω the radio frequency and ω_0 the local oscillator frequency. The envelope or magnitude of this function is called the delay resolution function (DRF).

The delay resolution function of any synthesis frequency setup has an envelope which represents the Fourier transformed of the channel bandwidth similar to Fig. 1a with a main peak at 0 delay and first nulls at plus and minus $1/B$. In the case of Mark III with 2 MHz channel bandwidths (Fig. 2) the envelope has a base width of about -500 nsec to +500 nsec (from $(2MHz)^{-1}$). Underneath this envelope there are distinguished peaks with sharp edges. The lower dashed line represents the level of the sidelobes if the total bandwidth would be synthesised perfectly.

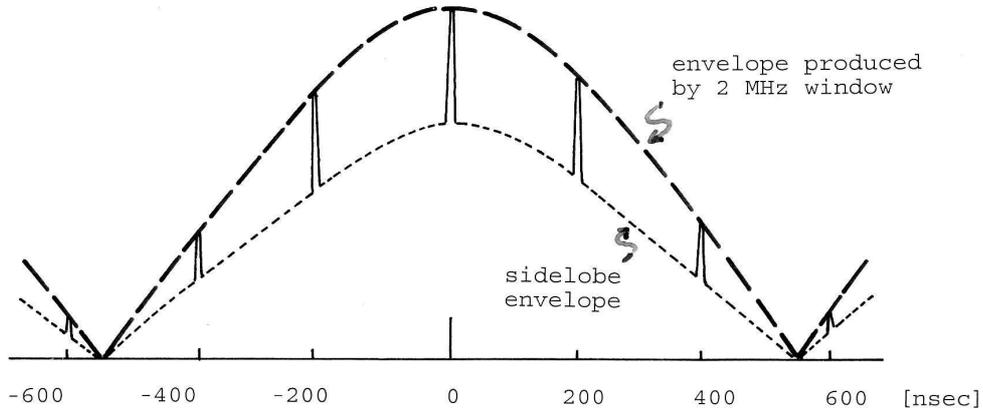


Figure 2: Semi-complete delay resolution function with envelope of 2 MHz channel bandwidth with main lobe, ambiguous peaks and envelope of sidelobes.

Now, let's turn to the criteria of how and where to place the intermediate channels. If we would use only the two bands at the lower and upper edge of the current Mark III S band bandpass spanning about 85 MHz there would be peaks underneath the envelope every $(85MHz)^{-1}$ or about 12 nsec. This of course would be an ambiguity spacing too narrow to be solved in the analysis. One way to overcome this problem is the introduction of one or more frequency channels in between.

The basis for the selection of the band separations is the fact that the sharp peaks in Figure 2 are spaced $1/S$ where S is the greatest common denominator of all $n(n-1)/2$ frequency differences of n frequency bands used to synthesise the total bandwidth (currently 5 MHz at S band and 10 MHz at X band). $1/S$ is the so-called ambiguity spacing. If, for example, one introduces another band at $\omega_1 + 5$ MHz the smallest common denominator of all frequency differences would be 5 MHz. The resulting ambiguity spacing is then

$(5\text{MHz})^{-1}$ or 200 nsec as it is in the current Mark III standard S band setup. However, there is a large number of sidelobes within one ambiguity spacing almost as high as the main peak (Fig. 3).

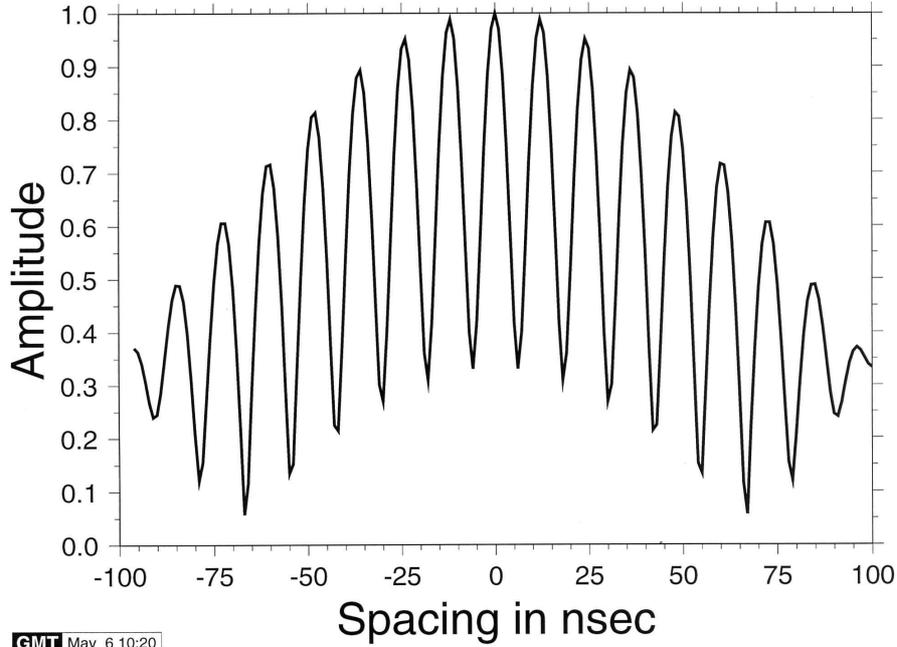


Figure 3: Central part of the delay resolution function for a 0, 5, 85 MHz frequency setup. N.B.: This is only the portion between -100 and +100 nsec of Figure 2.

If we consider that the delay resolution function represents the ideal situation it is quite understandable that the fringe fitting process which uses a “maximum likelihood method” (Rogers, 1970) may select the wrong peak in the case of bandpass irregularities and/or a high noise level. Therefore, more frequency channels are introduced between the two bandpass edges which serve the purpose of reducing the level of the sidelobes to a level which is uncritical for the fringe fitting process. In addition, more channels increase the signal-to-noise-ratio (SNR) by providing more bits to be correlated and subsequently more reliable cross-correlation coefficients.

The frequency channel separation is selected for an optimal suppression of the sidelobes with an optimal ambiguity spacing. The initial selection of the channel separation was done using an algorithm which is based on the Golomb ruler theory (Taylor and Golomb, 1985). A Golomb ruler describes the separation of elements (e.g. frequency bands or antenna separation in an array) on the basis of non-redundant difference sequences, i.e. integer sequences which have the property that the difference of each pair of integers is distinct from the difference of each other pair (Robertson, 1991). However, in practice technical limitations like harmonic interference and limited bandwidth require a certain compromise. Therefore, 0, 1, 4, 10, 21, 29, 34, 36 times 10 MHz are used to span the 360 MHz bandwidth of Mark III X band observations and 0, 2, 5, 11, 16, 17 times 5 MHz synthesise 85 MHz of S band. The central parts of the resulting delay resolution functions within the limits of plus/minus one and a half ambiguity spacings are shown in Figures 4 and 5. It is immediately obvious that with only 6 channels at S band the suppression of the sidelobes is less successful than with 8 channels at X band. In addition, more channels at X band produce a higher SNR according to formula (1).

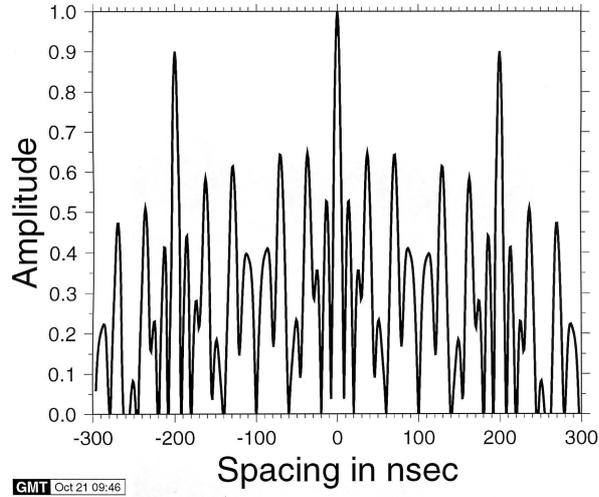


Figure 4: Central part of delay resolution function with 8 channels at X band.

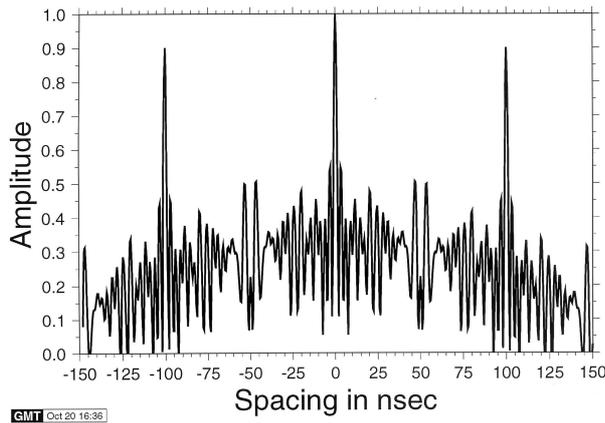


Figure 5: Central part of delay resolution function with 6 channels at S band.

4 Effects of Missing tracks

As we have seen in the previous section tracks are introduced in between the two extreme channels for an increase in SNR and for the suppression of sidelobes in the delay resolution function. Since each channel scheduled to be observed has its specific "purpose" the loss of a channel due to radio frequency interference, formatter failure, or recording deficits not only reduces the SNR by $1/\sqrt{(n-1)/n}$ but also distorts the delay resolution function. Figure 6 shows the central part DRF (just one ambiguity spacing of it) of the undisturbed (no RFI) Matera S band channels in the Europe-3/97 session (channels 2 and 6 are missing due to RFI). It is obvious that the sidelobes within the ambiguity spacing may easily be detected as the main lobe in case of low SNR or bandpass irregularities. In the data analysis of the resulting group delays, for example with OCCAM or Calc/Solve, the deficit becomes even more obvious. Fig. 7 shows the delay residuals on the Matera - Yebes baseline where abnormally large deviations from the expected level of a few tens of picoseconds are easily discernable. The reason for this is that for a number of scans the fringe fitting process (FRNGE or fourfit) has indeed chosen the wrong peak generating pseudo-ambiguity levels of odd

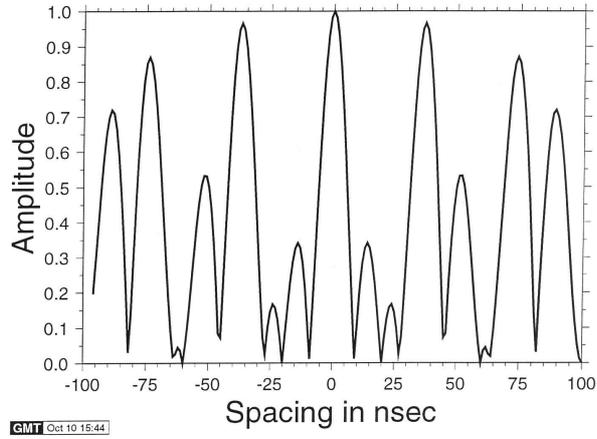


Figure 6: Central part of Delay Resolution Function of Matera using only S band tracks 1, 3, 4, and 5.

separations.

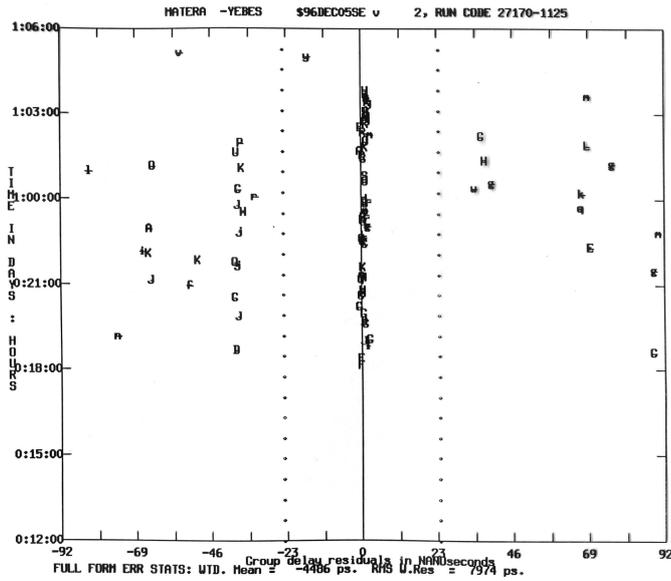


Figure 7: Delay fit residuals on the baseline Matera - Yebes with pseudo-ambiguities caused by missing tracks.

Generally, these observations have to be discarded since their separation from the main lobe may only be computed with low accuracy. However, the author has devised a routine which forces the fringe fitting process to home in on the correct peak. The procedure uses initial Solve delay residuals and converts them into FRNGE/fourfit multiband residual delays (correlator model residuals) and subsequently into search windows of about 10 nsec. With these search windows the fringe fitting process is repeated with a high success rate. However, all scans with missing tracks suffer from a reduced SNR which lead to reduced data quality. Although this software is now available it should not become a routine requirement to use it.

5 Conclusion

The ensemble of frequency channels in the geodetic VLBI Mark III setup serves the purpose of providing sufficient SNR and delay resolution with low sidelobes. Missing tracks reduce the SNR and require an iterative method to narrow the fringe fitting search window, a procedure which is rather laborious and non-routine. The staff at the observing stations and at the correlators should, therefore, take utmost care that all channels are recorded and processed properly.

References

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Rogers, A.E.E; Very Long Baseline Interferometry with Large Effective Bandwidth; Radio Science, Vol. 5, p. 1239 - 1247; 1970

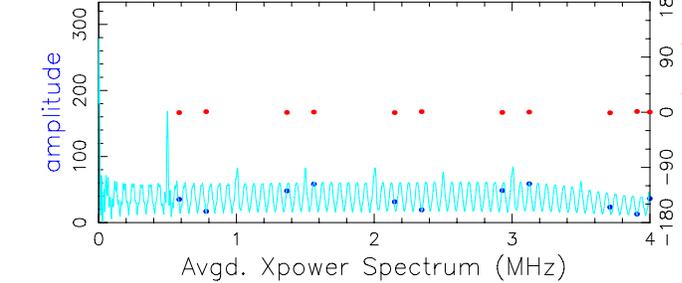
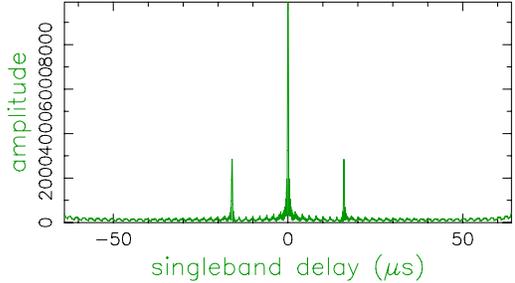
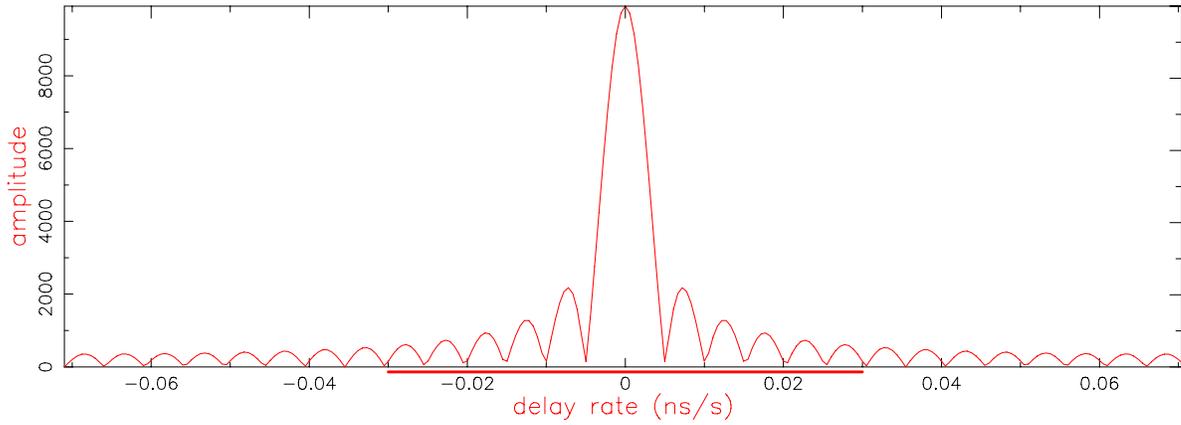
Taylor, H., S.W. Golomb; Rulers, Part I: CSI Technical Report 85-05-01, Communication Science Institute, Univ. Southern California, Los Angeles, CA.; 1985

Whitney, A.R.; Precision Geodesy and Astrometry via Very Long Baseline Interferometry; PhD thesis, Massachusetts Institute of Technology, Cambridge, 1974

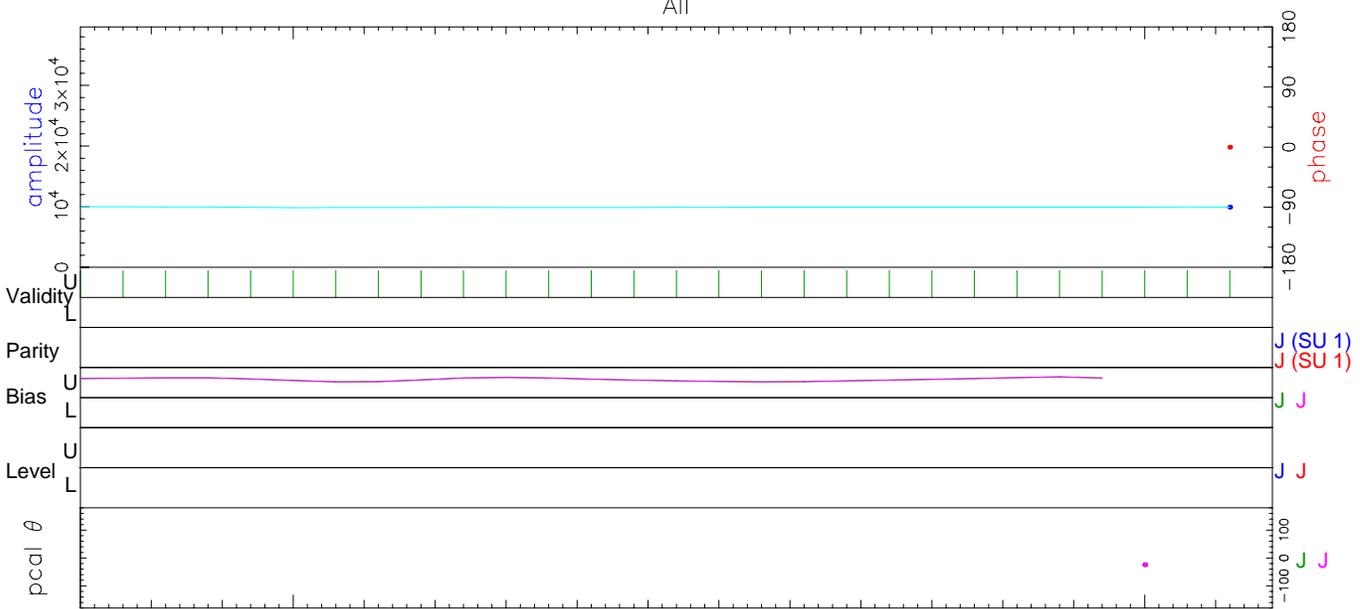
Mk4 Fringe Plot

0302-623.rktinp, 075-1719, JJ
HARTRAO - HARTRAO, fgroup S, pol RR

Fringe quality 9
 SNR 14593.5
 PFD 0.0e+00
 Intg.time 82.513
 Amp 9912.812
 Phase 0.0
 Sbdelay (us) 0.000004
 Mbdelay (us) 0.000000
 Fr. rate (Hz) 0.000000
 Ref freq (MHz) 2347.9900
 AP (sec) 3.000
 Exp. CRDS17
 Exper # 7578
 Yr:day 2005:075
 Start 171945.00
 Stop 172109.00
 FRT 172025.00
 Corr. date: 2005:082:135744
 Fourfit date: 2005:097:190245
 Position (J2000) 03h03m50.6313s -62°11'25.550"



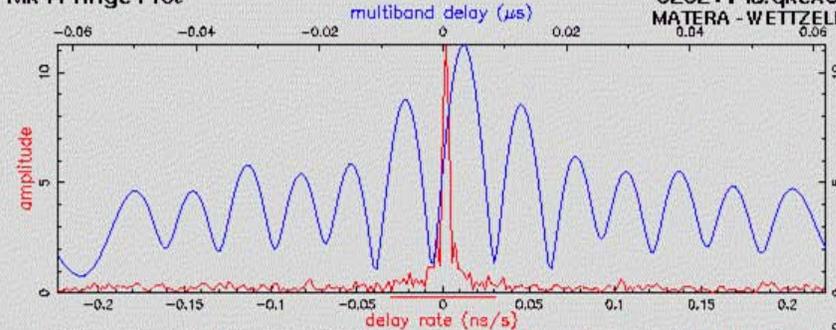
Amp. and Phase vs. time for each freq., 28 segs, 1 APs / seg (3.00 sec / seg.), time ticks 1 sec



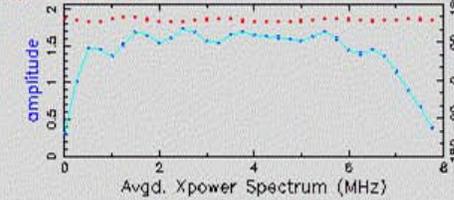
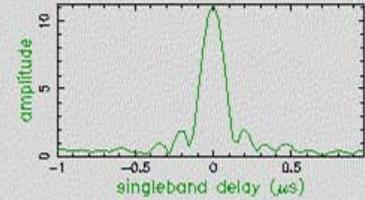
2347.99				Freq (MHz)			
0.0				Phase			
9912.8				Ampl.			
1025.0				Sbd box			
U/L 28/0				APs used			
J:J 10:10				PC freqs			
J:J -23:-23				PC phase			
J:J 0:0				ManI PC			
J:J 45:45				PC amp			
J S5U				Chan ids			
J 27,29				Tracks			
J S5U				Chan ids			
J 27,29				Tracks			
Group delay (usec)	0.0000000000E+00			Apriori delay (usec)	0.0000000000E+00	Resid mbdelay (usec)	0.00000E+00 +/- 9.4E-06
Sband delay (usec)	3.86891376835E-06			Apriori clock (usec)	0.0000000E+00	Resid sbdelay (usec)	3.86891E-06 +/- 9.4E-06
Phase delay (usec)	-3.29551128270E-09			Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	-3.29551E-09 +/- 9.3E-09
Delay rate (us/s)	6.61744490042E-22			Apriori rate (us/s)	0.0000000000E+00	Resid rate (us/s)	6.61744E-22 +/- 1.9E-10
Total phase (deg)	0.0			Apriori accel (us/s/s)	0.0000000000E+00	Resid phase (deg)	0.0 +/- 0.0
	RMS	Theor.	Amplitude	9912.812 +/- 0.679			
ph/seg (deg)	0.0	0.0	Search (64X8)	9912.812	Pcal mode: NORMAL, NORMAL		
amp/seg (%)	0.4	0.0	Interp.	9912.812	Pcal rate: -4.657E-08, -4.657E-08 (us/s)		
ph/frq (deg)	0.0	0.0	Inc. seg. avg.	9912.812	Bits/sample: 1		
amp/frq (%)	0.0	0.0	Inc. frq. avg.	9912.812	Sample rate(MSamp/s): 8		
					Data rate(Mb/s): 8		nlags: 1024

Mk4 Fringe Plot

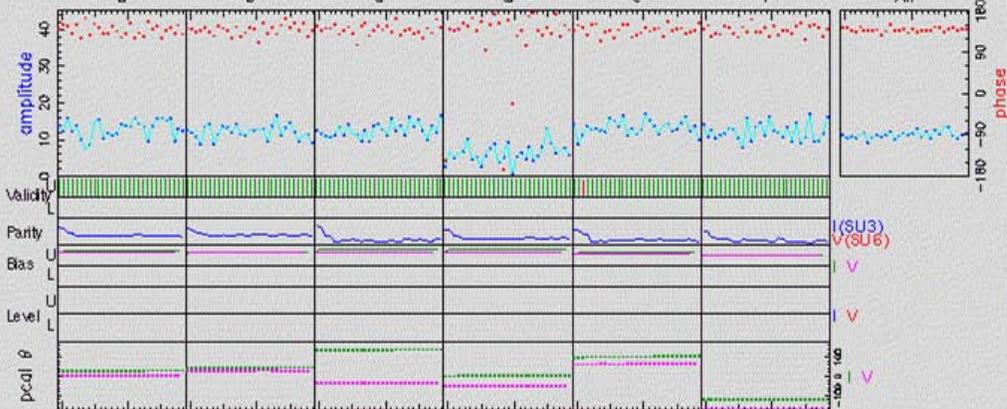
0202+149.qkexcp, 246-0548, IV
MATERA - WETZELL, fgroup S, pol RR



Fringe quality 8
SNR 67.5
PFD 0.0e+00
Intg.time 113.963
Amp 11.274
Phase 138.8
Sbdelay (us) -0.002950
Mbdelay (us) 0.003324
Fr.rate (Hz) 0.003008
Reffreq (MHz) 2232.9900
AP (sec) 1.000
Exp. R1086
Exper # 3033
Yr.day 2003.246
Start 054856.00
Stop 055052.00
FRT 054954.00
Corr. date: 2003.251:172919
Fourfit date: 2003.254:170820
Position (J2000) 02h04m 50.4139s +15°14'11.043"



Amp. and Phase vs. time for each freq., 29 segs, 4 APs / seg (4.00 sec / seg.), time ticks 5 sec



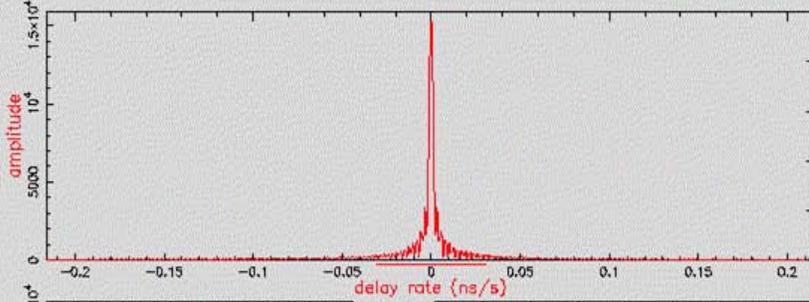
	2232.99	2240.99	2256.99	2312.99	2344.99	2352.99	Frq (MHz)
UL	1160	1160	1160	1160	1160	1160	41
IV	6010.6010	6010.6010	6010.6010	6010.6010	6010.6010	6010.6010	138.8
IV	30.6	45.30	139.33	2.50	102.63	-121.174	11.3
IV	5.6	5.4	0.2	2.0	4.2	-5.1	32.9
IV	88.54	88.49	83.47	40.50	85.47	94.44	
I	81.0	82.0	83.0	84.0	85.0	86.0	
V	11.13	15.17	19.21	23.25	27.29	31.33	
V	11.13	15.17	19.21	23.25	27.29	31.33	
Group delay (usec)	-6.10007338599E+01		Apriori delay (usec)	-6.10040582179E+01	Resid mbdelay (usec)	3.32436E-03	+/- 4.8E-05
Spand delay (usec)	-6.10070077581E+01		Apriori clock (usec)	9.9201001E+00	Resid sbdelay (usec)	-2.94564E-03	+/- 1.0E-06
Phase delay (usec)	-6.10038855954E+01		Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	1.72623E-04	+/- 2.1E-06
Delay rate (us/s)	-1.67241726164E-01		Apriori rate (us/s)	-1.67243040997E-01	Resid rate (us/s)	1.31483E-06	+/- 3.2E-08
Total phase (deg)	-23.9		Apriori accel (us/s/s)	-2.74176283945E-06	Resid phase (deg)	138.8	+/- 1.7
RMS	4.5	Theor. Amplitude	11.274 +/- 0.167	Pcal mode: NORMAL, NORMAL			
ph/seg (deg)	4.5	Search (256/64)	10.730	Pcal rate: 3.639E-08, 4.353E-08 (us/s)			
amp/seg (%)	8.6	Interp.	10.796	Bits/sample: 1			
ph/seg (deg)	8.6	Inc. seg. avg.	11.274	Sample rate (MSamp/s): 16			
amp/seg (%)	22.0	Inc. frq. avg.	11.277				

Control file: _bf_3033 Inpt file: xdata2/prepass/0303/246-0548/IV.qkexcp Output file: Suppressed by testmode

Press a key: 'h'=hardcopy, 's'=save, 'q'=quit, other=continue

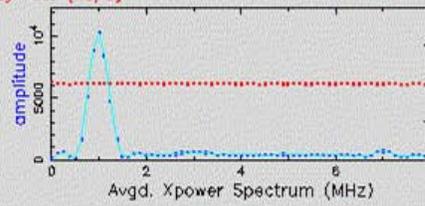
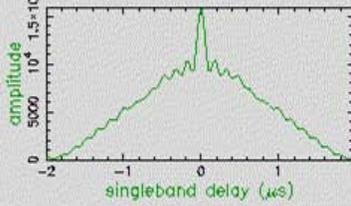
Mk4 Fringe Plot

0202+149.qkexcp, 246-0548, II
MATERA - MATERA, fgroup S, pol RR



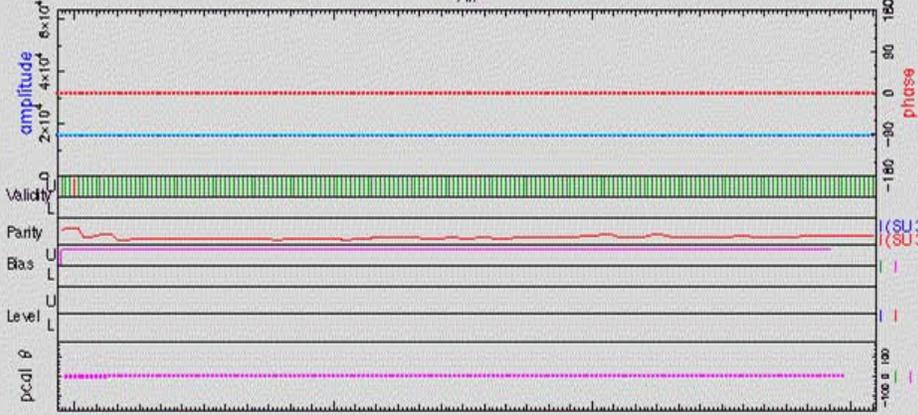
Fringe quality 9

SNR 49986.9
PFD 0.0e+00
Intg.time 186.276
Amp 15894.372
Phase 0.0
Sbdelay (us) -0.000022
Mbdelay (us) 0.000000
Fr.rate (Hz) 0.000000
Refitfreq (MHz) 2312.9900
AP (sec) 1.000



Exp. R1086
Exper # 3033
Yr.day 2003.246
Start 054856.00
Stop 055206.00
FRT 054954.00
Corr.date:
2003.251:172919
Fourfit date:
2003.254:170654
Position (J2000)
02h04m 50.4139s
+15°14'11.043"

Amp. and Phase vs. time for each freq., 190 segs, 1 APs / seg (1.00 sec / seg.), time ticks 1 sec
All



2312.99	Freq (MHz)		
0.0	Phase		
15894.4	Amp		
65.0	Sbd box		
1900	APs used		
6010.6010	PC freq		
303	PC phase		
22	Merl PC		
42.42	PC amp		
84U	Chan ids		
23.25	Tracks		
84D	Chan ids		
23.25	Tracks		

Group delay (usec)	0.0000000000E+00	Apriori delay (usec)	0.0000000000E+00	Resid mbdelay (usec)	0.000000E+00	+/-	1.4E-06
Scand delay (usec)	-2.19518688039E-05	Apriori clock (usec)	0.0000000E+00	Resid sbdelay (usec)	-2.19518E-05	+/-	1.4E-06
Phase delay (usec)	3.79627560832E-08	Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	3.79628E-08	+/-	2.8E-09
Delay rate (us/s)	-1.07202607387E-21	Apriori rate (us/s)	0.0000000000E+00	Resid rate (us/s)	-1.07203E-21	+/-	2.5E-11
Total phase (deg)	0.0	Apriori accel (us/s/s)	0.0000000000E+00	Resid phase (deg)	0.0	+/-	0.0

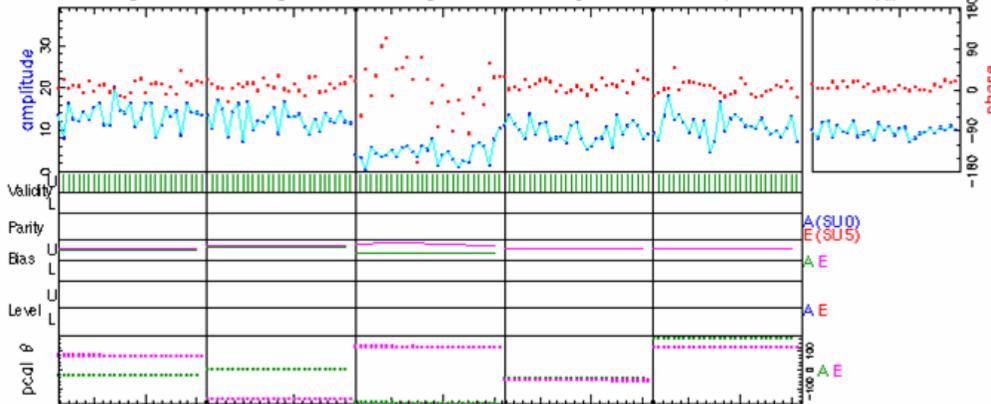
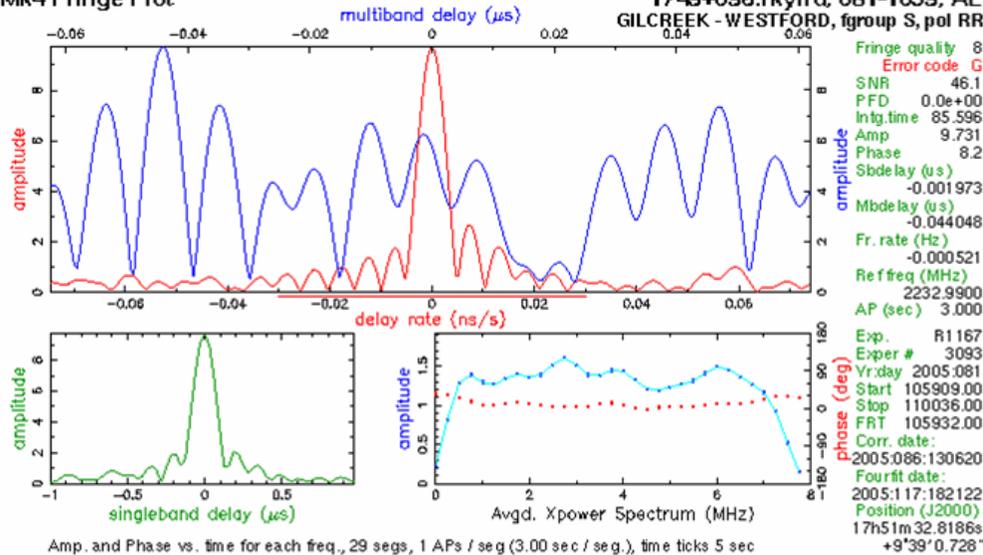
phibeg (deg)	0.0	RMS	0.0	Theor.	0.0	Amplitude	15894.372	Search (512x8)	15894.372	Pcal mode:	NORMAL, NORMAL
ampbeg (%)	0.0							Interp.	15894.372	Pcal rate:	3.172E-08, 3.172E-08 (us/s)
phifig (deg)	0.0							Inc. seg. avg.	15894.368	Bits/sample:	1
ampfig (%)	0.0							Inc. frq. avg.	15894.372	Sample rate (MSamp/s):	16

Control file: _cf_3033 Input file: /data2/prepass/0303/246-0548/II.qkexcp Output file: Suppressed by test mode

Press a key; 'h'=hardcopy, 's'=save, 'q'=quit, other=continue

Mk4 Fringe Plot

1749+096.rkyffd, 081-1059, AE
GILCREEK - WESTFORD, fgroup S, pol RR



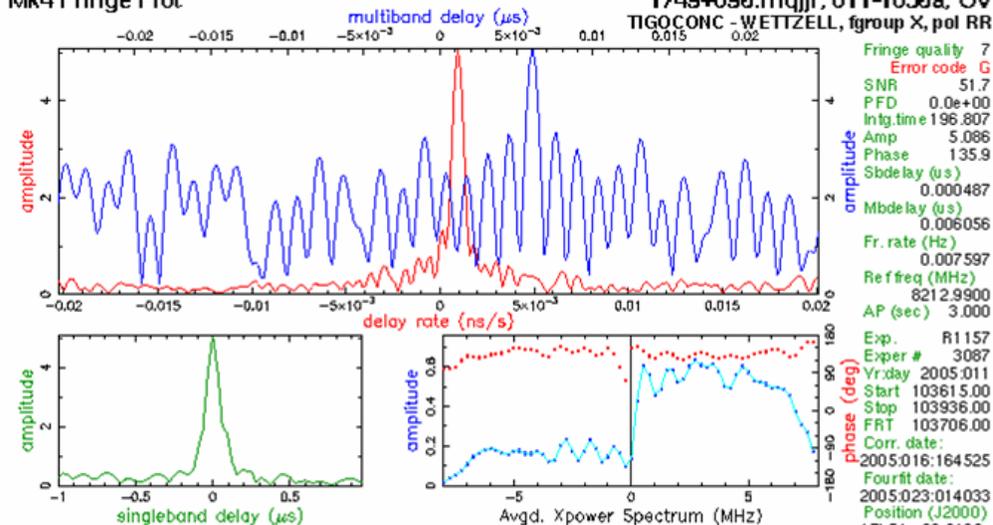
	2232.99	2256.99	2312.99	2344.99	2352.99	Freq (MHz)	All
6.7	9.7	12.2	11.9	4.1	Phase	8.2	
13.3	12.3	3.1	9.4	10.6	Ampl.	9.7	
33.1	33.1	32.1	33.0	32.6	Sbd box	32.9	
U/L 290	290	290	290	290	APs used		
A/E 6010:6010	6010:6010	6010:6010	6010:6010	6010:6010	PC freqs		
A/E -28:76	2-150	-173:124	-44:53	168:122	PC phase		
A/E -3:7	1:7	2:2	-1:2	0:2	Manl PC		
A/E 25:51	24:47	20:15	22:43	25:44	PC amp		
A SUU	SUU	SUU	SUU	SUU	Chan ids		
A 11,13	19,21	23,25	27,29	31,33	Tracks		
E SUU	SUU	SUU	SUU	SUU	Chan ids		
E 11,13	19,21	23,25	27,29	31,33	Tracks		
Group delay (usec)	-1.15911303435E+04	Apriori delay (usec)	-1.15910862957E+04	Resid mbdelay (usec)	-4.40479E-02	+	7.2E-05
Sband delay (usec)	-1.15910862682E+04	Apriori cband (usec)	1.4341201E+01	Resid sbdelay (usec)	-1.97256E-03	+	1.5E-03
Phase delay (usec)	-1.15910862054E+04	Apriori cband h (usec)	3.400000E-07	Resid phase lag (usec)	1.02500E-05	+	3.1E-06
Delay rate (usec)	7.19378882573E-01	Apriori rate h (usec)	7.19379146165E-01	Resid rate h (usec)	-2.63592E-07	+	6.2E-08
Total phase (deg)	-275.2	Apriori accel (usec/s)	6.60535090689E-05	Resid phase (deg)	8.2	+	2.5
pcal mode: NORMAL, NORMAL							
pcal rate: -8.719E-09, -3.894E-08 (usec/s)							
Bits/sample: 1							
Sample rate (M Samples): 16							
Data rate (Mbps): 80							
lags: 32							

Control file: ..K_T3093 Input file: /data3/3093/081-1059/AE.rkyffd Output file: Suppressed by kst mode

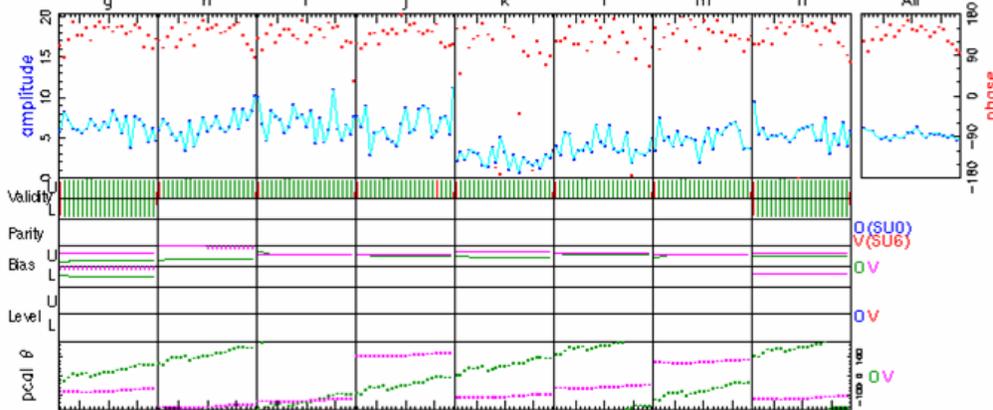
Press a key: 'h'=hardcopy, 's'=save, 'q'=quit, other=continue

Mk4 Fringe Plot

1749+096.rhqjrr, 011-1036a, OV
 TIGOCOCONC - WETZEL, fgroup X, pol RR



Amp. and Phase vs. time for each freq., 23 segs, 3 APs / seg (9.00 sec / seg.), time ticks 10 sec

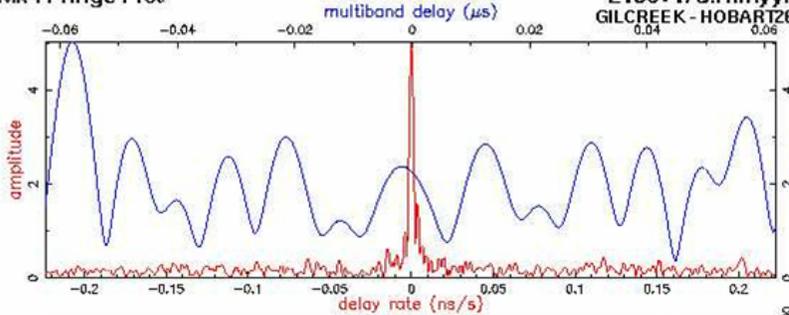


	8212.99	8252.99	8352.99	8512.99	8732.99	8852.99	8912.99	8952.99	Freq (MHz)	All
U/L	67/67	67/0	67/0	67/0	67/0	67/0	67/0	67/67		
O:U	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	PC freqs	
O:V	22-78	111-161	-133-130	-46-110	56-108	163-59	-75:75	154-117	PC phase	
O:W	2:0	-5:0	1:0	-2:0	5:0	6:0	0:0	-5:0	Manl PC	
O:X	32:53	33:49	31:53	28:51	12:53	16:53	23:51	27:49	PC amp	
O:Y	X1U, X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U, X8L	Chan ids	
O:Z	2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32	3,5,7,9	Tracks	
O:AA	X1U, X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U, X8L	Chan ids	
O:AB	2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32	3,5,7,9	Tracks	
Group delay (usec)		-1.25187133379E+04		Apriori delay (usec)		-1.25187193936E+04		Resid mbdelay(usec)	6.05589E-03	+- 1.1E-05
Sband delay (usec)		-1.25187189070E+04		Apriori cband (usec)		-1.1982428E+01		Resid sbdelay(usec)	4.86579E-04	+- 9.5E-04
Phase delay (usec)		-1.25187193476E+04		Apriori cband h (usec)		-1.6000000E-07		Resid phase delay (usec)	4.59490E-05	+- 5.4E-07
Delay rate (usec)		1.42000036843E+00		Apriori rate h (usec)		1.41999955697E+00		Resid rate h (usec)	8.11461E-07	+- 6.5E-09
Total phase (deg)		66.7		Apriori accel (usec/s)		4.09210929593E-05		Resid phase (deg)	135.9	+- 1.6
phseg (deg)	RMS 17.5	Theor. 5.2	Amplitude 5.086	+- 0.098	Pcal mode: NORMAL, NORMAL					
ampseg (%)	9.9	9.1	Search (256X256)	5.034	Pcal rate: 1.441E-07, 3.060E-08 (usec)					
ph/rq (deg)	3.7	2.9	Inkmp.	5.047	Bits/sample: 1	SampCnNorm: dsabled				
amp/rq (%)	29.6	5.1	Inc. seg. avg.	5.326	Sample rate (M Samp/s): 16					
			Inc. fq. avg.	5.084	Data rate (mb/s): 160					nlags: 32

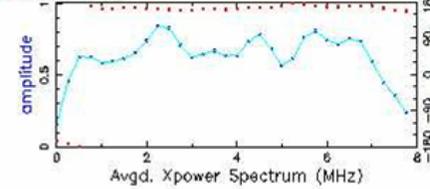
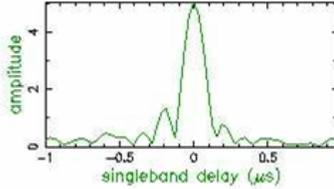
Control file: c_L_3087 Inpuffile: /data3/3087/011-1036a/O U.rhqjrr Outbuffile: /data3/3087/011

Mk4 Fringe Plot

2150+173.rmhyy1, 108-1809, AH
GILCREEK - HOBART26, fgroup S, pol RR

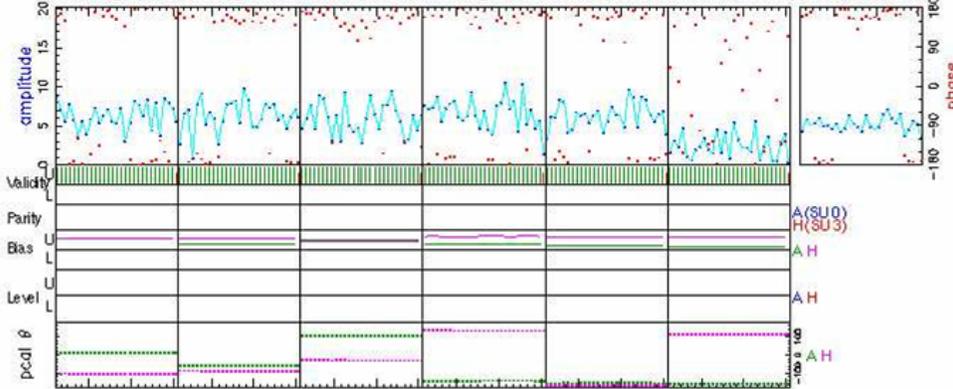


Fringe quality 8
Error code G
SNR 36.7
PFD 0.0e+00
Intg.time 169.226
Amp 5.033
Phase 170.1
Sbdelay (us) 0.001363
Mbdelay (us) -0.057863
Fr. rate (Hz) -0.000896
Ref freq (MHz) 2232.9900
AP (sec) 1.000



Exp. R1171
Exper # 3098
Yrday 2005:108
Start 180912.00
Stop 181204.00
FRT 180951.00
Corr. date: 2005:115:143642
Fourft date: 2005:115:165055
Position (J2000) 21h52m24.8194s +17°34'37.795"

Amp. and Phase vs. time for each freq., 29 segs, 6 APs / seg (6.00 sec / seg), time ticks 10 sec



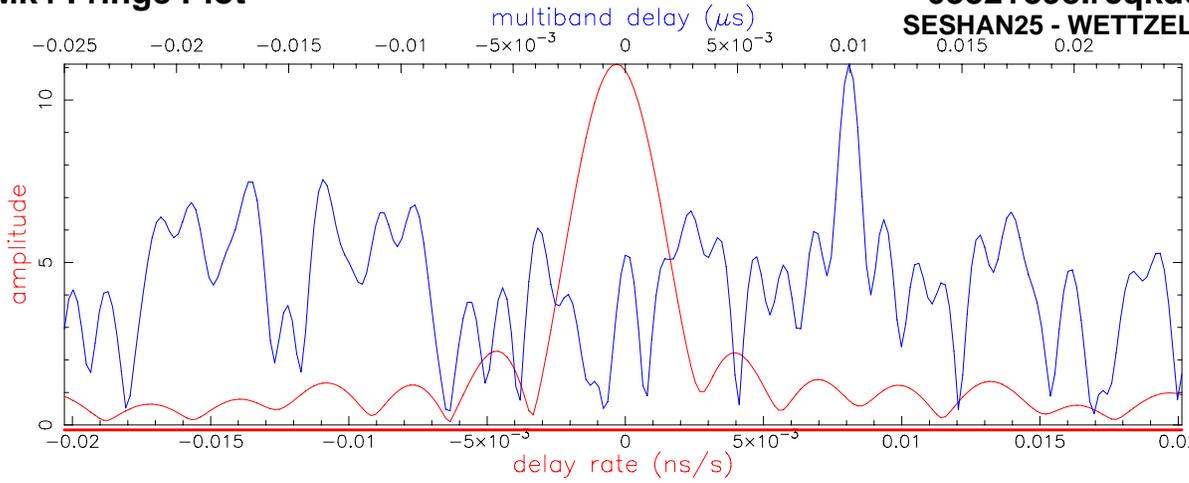
	2232.99	2240.99	2256.99	2312.99	2344.99	2352.99	Freq (MHz)	All
U/L	1720	1720	1720	1720	1720	1720		
AH	6010:6010	6010:6010	6010:6010	6010:6010	6010:6010	6010:6010		
AH	13-103	-59-57	106-30	-141:134	-155-167	-158:111		
AH	-5.0	3.0	2.0	1.0	-2.0	1.0		
AH	30.47	28.48	27.63	28.45	28.46	30.20		
A	51U	52U	53U	54U	55U	56U		
A	11,13	15,17	19,21	23,25	27,29	31,33		
H	51U	52U	53U	54U	55U	56U		
H	11,13	15,17	19,21	23,25	27,29	31,33		
Group delay (usec)	1.15998702641E+04	A priori delay (usec)	1.15999281270E+04	Resid mbdelay (usec)	-5.78629E-02	±	8.9E-05	
Sband delay (usec)	1.15999294904E+04	A priori c/dck (usec)	1.8147976E+01	Resid sbdelay (usec)	1.36341E-03	±	1.9E-03	
Phase delay (usec)	1.15999283386E+04	A priori c/dck rate (us/s)	1.4999999E-07	Resid phdelay (usec)	2.11626E-04	±	3.9E-06	
Delay rate (us/s)	-9.94332442627E-01	A priori rate (us/s)	-9.94332021689E-01	Resid rate (us/s)	-4.20999E-07	±	3.9E-08	
Total phase (deg)	353.1	A priori accel (us/s/s)	-7.59461740955E-06	Resid phase (deg)	170.1	±	3.1	
ph/seg (deg)	15.2	Search (512x64)	4.736	Pcal mode: NORMAL, NORMAL				
amp/seg (%)	16.6	Intrp.	4.736	Pcal rate: 6.791E-09, -1.295E-08 (us/s)				
ph/seg (deg)	6.5	Inc. seg. avg.	5.155	Bits/sample: 1	SamPCrNorm: disable			
amp/seg (%)	34.0	Inc. fq. avg.	5.057	Sample rate (M Samp/s): 16				
				Data rate (Mbit/s): 96				

Control file: c:_3098 Input file: /data2/prepass/3098/108-1809/AH.rmhyy1 Output file: /data2/prepass/3098/108-1809/AH.5.1.mhyy1

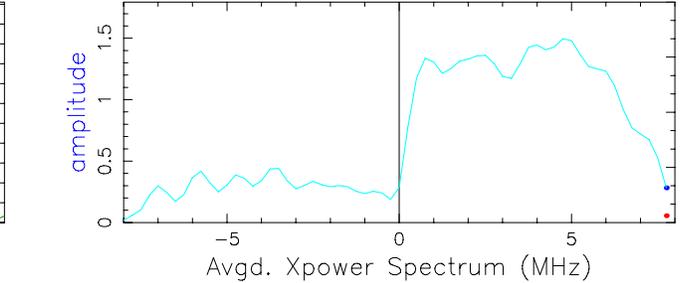
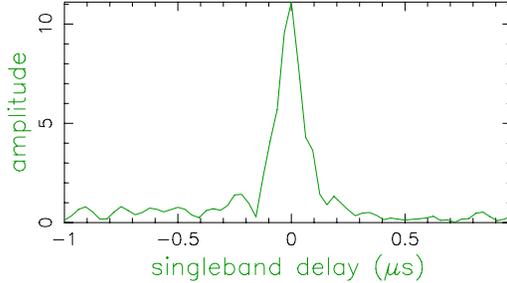
Press a key: 'h'=handcopy, 'p'=previous, 'n'=next, 's'=save, 'q'=quit, other=continue

Mk4 Fringe Plot

0552+398.rcqkdq, 272-0111, CV
 SESHAN25 - WETTZELL, fgroup X, pol RR

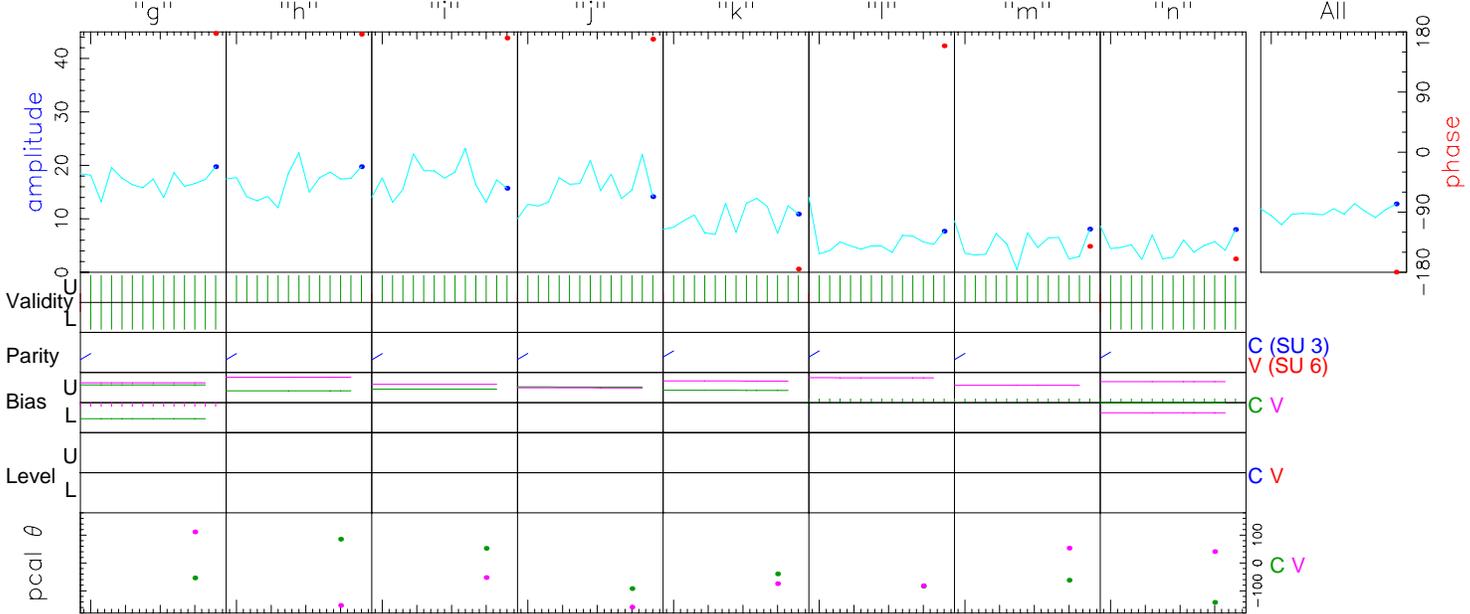


Fringe quality 7
 Error code G
 SNR 50.5
 PFD 0.0e+00
 Intg.time 39.353
 Amp 11.241
 Phase 170.3
 Sbdelay (us) -0.007407
 Mbdelay (us) 0.009974
 Fr. rate (Hz) -0.002107
 Ref freq (MHz) 8212.9900
 AP (sec) 3.000



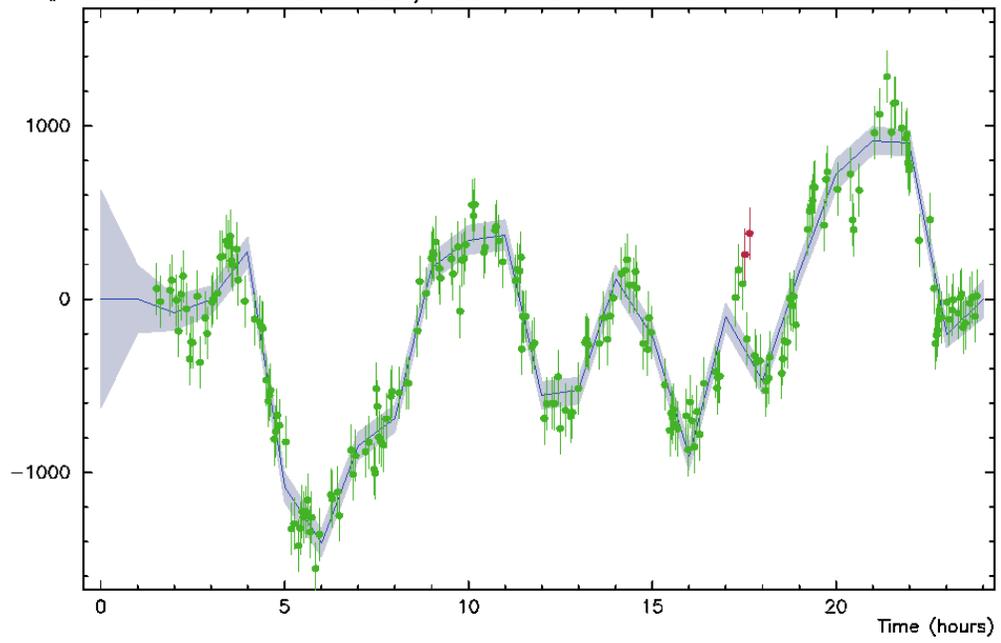
Exp. R1142
 Exper # 3076
 Yr:day 2004:272
 Start 011157.00
 Stop 011239.00
 FRT 011219.00
 Corr. date: 2004:276:213534
 Fourfit date: 2005:119:194317
 Position (J2000) 05h55m30.8056s +39°48'49.165"

Amp. and Phase vs. time for each freq., 14 segs, 1 APs / seg (3.00 sec / seg.), time ticks 2 sec

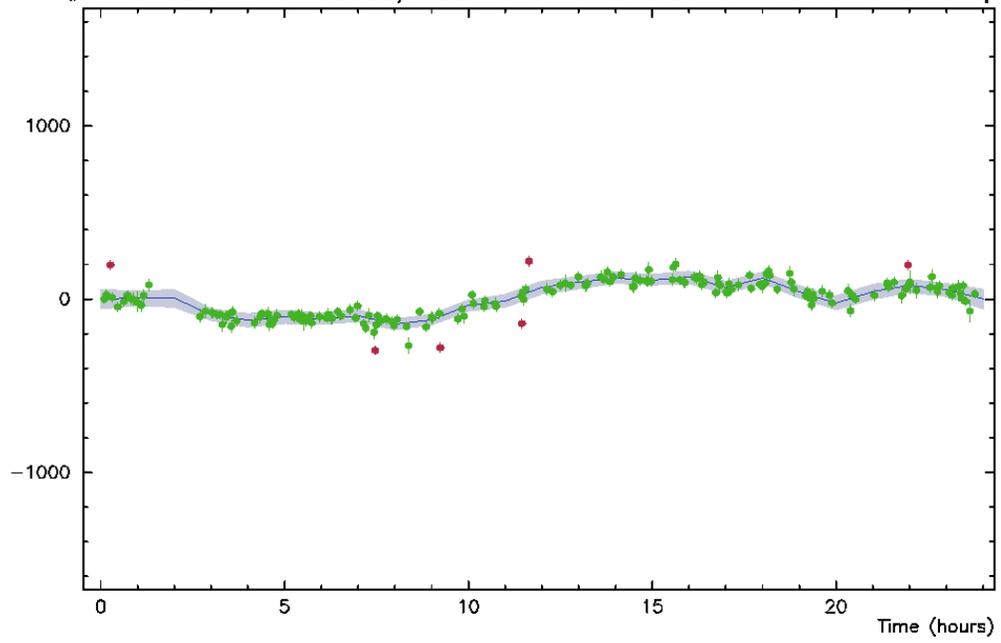


	8212.99	8252.99	8352.99	8512.99	8732.99	8852.99	8912.99	8932.99	Freq (MHz)	All
U/L	14/14	14/0	14/0	14/0	14/0	14/0	14/0	14/14	APs used	170.3
C:V	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	PC freqs	11.3
C:V	-54:111	86:-153	53:-53	-92:-159	-39:-75	-83:-83	-62:53	-141:40	PC phase	32.8
C:V	1:0	0:0	-2:0	-4:0	5:0	-8:0	6:0	4:0	ManI PC	
C:V	43:41	48:38	45:41	36:37	26:40	18:41	14:38	18:36	PC amp	
C	X1U,X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U,X8L	Chan ids	
V	2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32	3,5,7,9	Tracks	
	2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32	3,5,7,9	Chan ids	
									Tracks	
Group delay (usec)		-2.55791849100E+03		Apriori delay (usec)		-2.55792846521E+03		Resid mbdelay (usec)	9.97421E-03	+/- 1.1E-05
Sband delay (usec)		-2.55793587181E+03		Apriori clock (usec)		-6.5386245E+01		Resid sbdelay (usec)	-7.40660E-03	+/- 9.7E-04
Phase delay (usec)		-2.55792840760E+03		Apriori clockrate (us/s)		-9.4000000E-07		Resid phdelay (usec)	5.76090E-05	+/- 5.5E-07
Delay rate (us/s)		-1.46684328124E+00		Apriori rate (us/s)		-1.46684305371E+00		Resid rate (us/s)	-2.27532E-07	+/- 3.2E-08
Total phase (deg)		-155.6		Apriori accel (us/s/s)		-4.08101362948E-06		Resid phase (deg)	170.3	+/- 1.6
RMS	5.9	4.1		Amplitude	11.241 +/- 0.223					
ph/seg (deg)	5.9	4.1		Search (32X256)	10.896					
amp/seg (%)	9.0	7.1		Interp.	10.896					
ph/frq (deg)	8.4	3.0		Inc. seg. avg.	11.271					
amp/frq (%)	50.8	5.2		Inc. frq. avg.	11.279					
				Apriori mode: NORMAL, NORMAL						
				Pcal rate: -3.309E-09, 2.565E-08 (us/s)						
				Bits/sample: 1						
				Sample rate(MSamp/s): 16						
				Data rate(Mb/s): 160						
										nlags: 32

\$04NOV22XA <3> GILCREEK/WESTFORD Residuals + clock wrms=149.4 ps

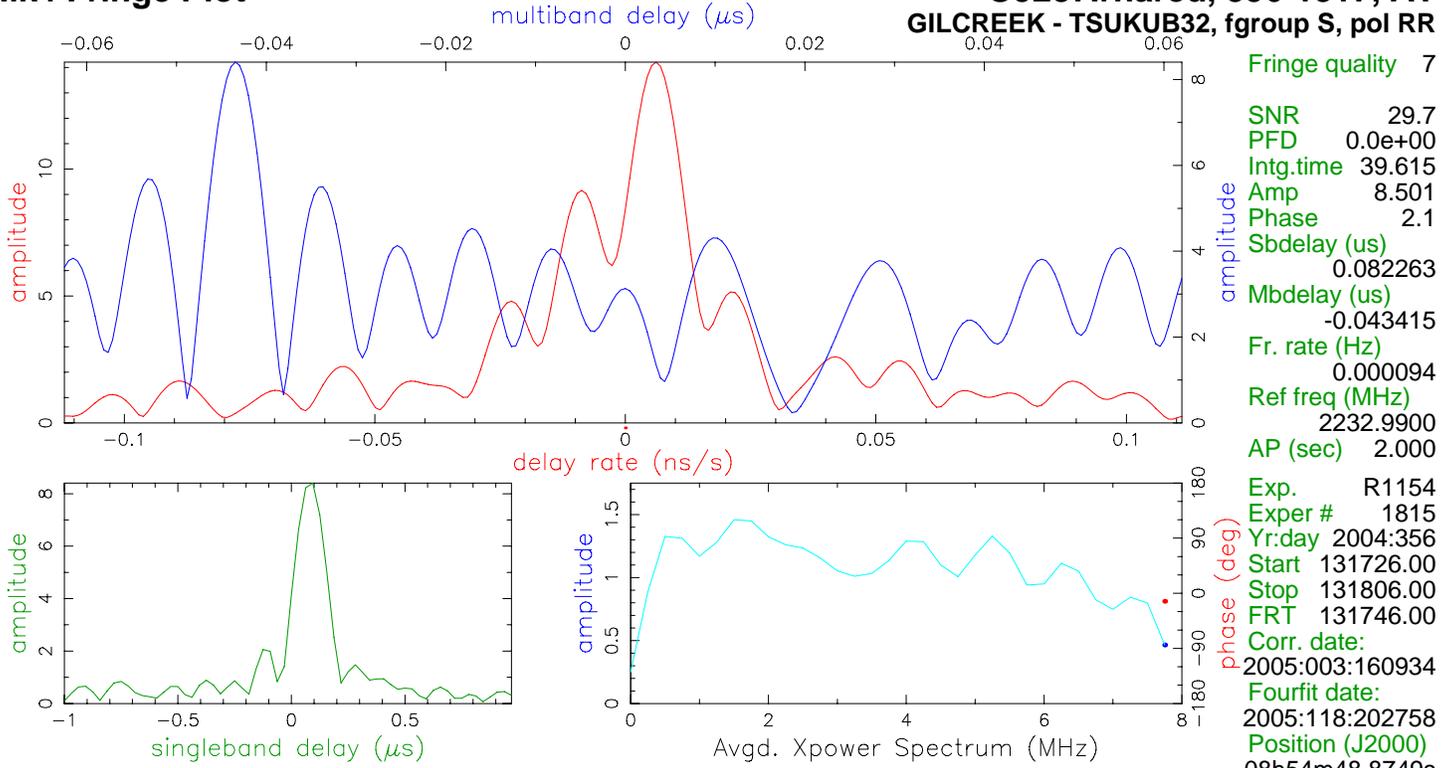


\$04NOV22XA <3> KOKEE/WESTFORD Residuals + clock wrms=29.3 ps

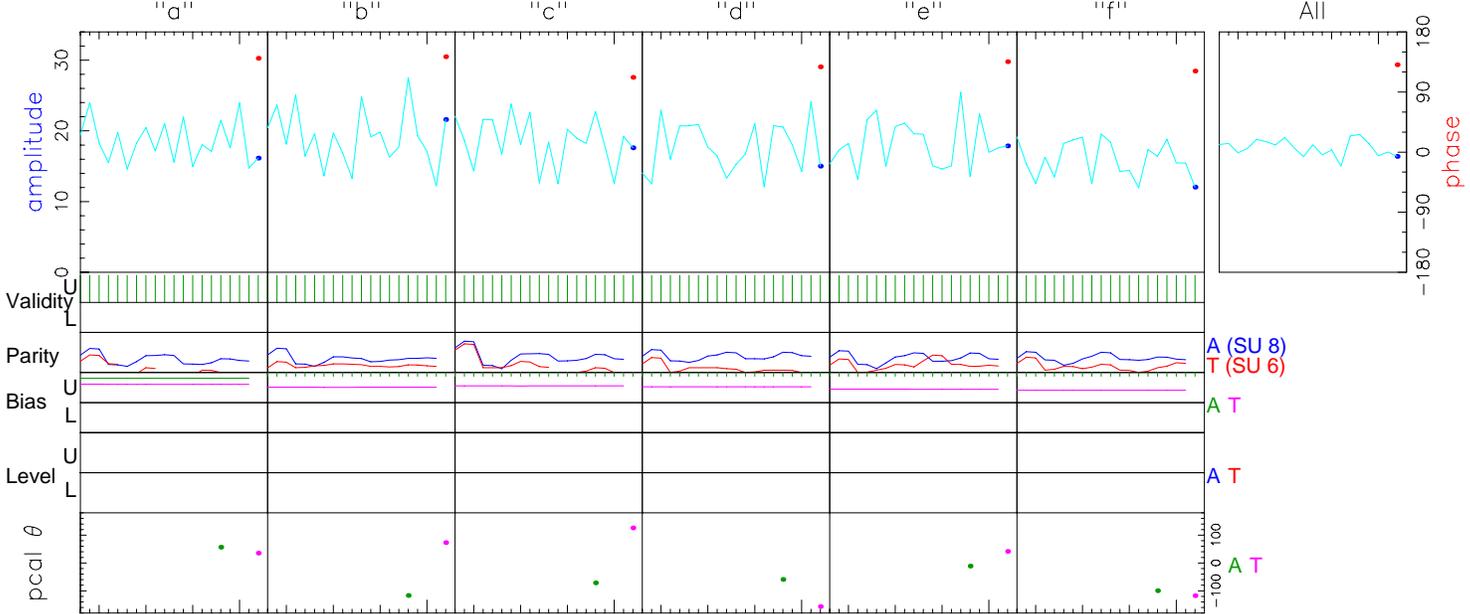


Mk4 Fringe Plot

OJ287.rhared, 356-1317, AT
GILCREEK - TSUKUB32, fgroup S, pol RR



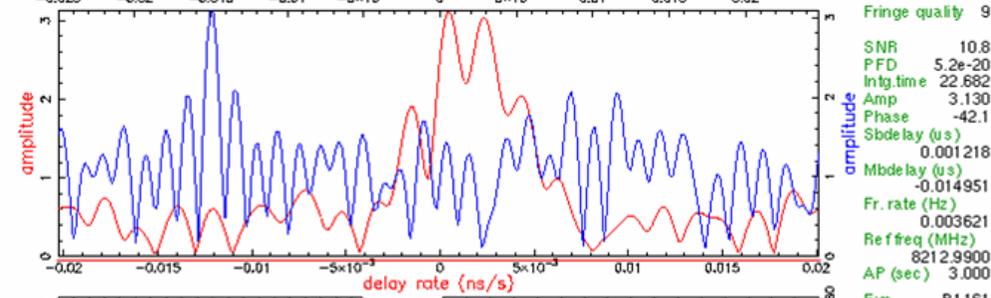
Amp. and Phase vs. time for each freq., 20 segs, 1 APs / seg (2.00 sec / seg.), time ticks 2 sec



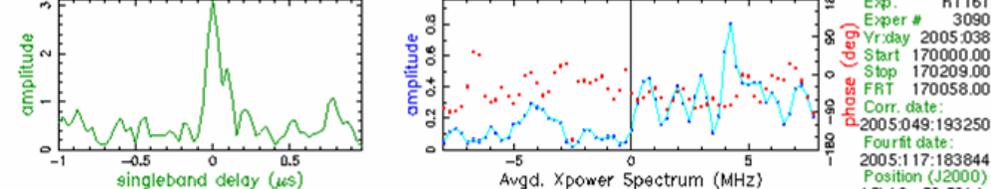
	2232.99	2240.99	2256.99	2312.99	2344.99	2352.99	Freq (MHz)	All
	-0.9	5.9	-0.3	5.9	-1.8	3.4	Phase	2.1
	8.2	9.0	8.9	8.4	8.3	8.3	Ampl.	8.5
	35.7	35.7	35.6	35.7	35.8	35.3	Sbd box	35.6
U/L	20/0	20/0	20/0	20/0	20/0	20/0	APs used	
A:T	6010:6010	6010:6010	6010:6010	6010:6010	6010:6010	6010:6010	PC freqs	
A:T	57:35	-117:74	-71:126	-60:-157	-12:42	-100:-117	PC phase	
A:T	0:1	0:1	0:0	0:-7	0:3	0:2	ManI PC	
A:T	31:42	29:43	29:44	28:43	29:41	30:40	PC amp	
S1R		S2R	S3R	S4R	S5R	S6R	Chan ids	
A	11,13	15,17	19,21	23,25	27,29	31,33	Tracks	
S1R		S2R	S3R	S4R	S5R	S6R	Chan ids	
T	11,13	15,17	19,21	23,25	27,29	31,33	Tracks	
Group delay (usec)		3.56529822268E+03	Apriori delay (usec)		3.56534163759E+03	Resid mbdelay (usec)	-4.34149E-02	+/- 1.1E-04
Sband delay (usec)		3.56542390031E+03	Apriori clock (usec)		7.6237335E+00	Resid sbdelay (usec)	8.22627E-02	+/- 2.3E-03
Phase delay (usec)		3.56534164018E+03	Apriori clockrate (us/s)		-2.7999998E-07	Resid phdelay (usec)	2.59169E-06	+/- 4.8E-06
Delay rate (us/s)		-1.15005449666E+00	Apriori rate (us/s)		-1.15005449666E+00	Resid rate (us/s)	0.00000E+00	+/- 2.1E-07
Total phase (deg)		82.5	Apriori accel (us/s/s)		-6.61359613283E-06	Resid phase (deg)	2.1	+/- 3.9
RMS		Theor.	Amplitude	8.501 +/- 0.286	Pcal mode: NORMAL, NORMAL			
ph/seg (deg)	31.5	8.4	Search (64X64)	8.272	Pcal rate: 3.076E-08, -1.125E-08 (us/s)			
amp/seg (%)	110.6	14.7	Interp.	8.272	Bits/sample: 1	SampCntNorm: disabled		
ph/frq (deg)	3.2	4.3	Inc. seg. avg.	17.639	Sample rate(MSamp/s): 16			
amp/frq (%)	3.7	7.5	Inc. frq. avg.	8.485	Data rate(Mb/s): 96			
						nlags: 32		

Mk4 Fringe Plot

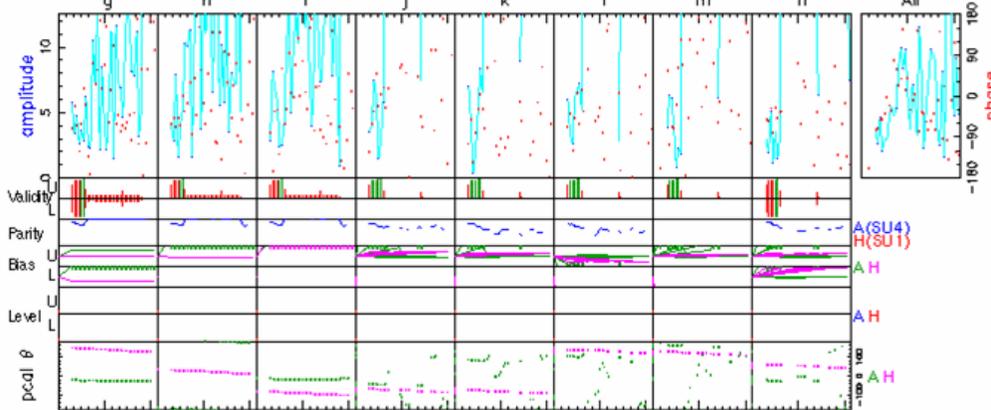
1508-055.rjfbmn, 038-1700b, AH
GILCREEK - HOBART26, fgroup X, pol RR



Fringe quality 9
SNR 10.8
PFD 5.2e-20
Intg.time 22.682
Amp 3.130
Phase -42.1
Sbdelay (us) 0.001218
Mbdelay (us) -0.014951
Fr. rate (Hz) 0.003621
Ref freq (MHz) 8212.9900
AP (sec) 3.000
Exp. R1161
Exper # 3090
Yr:day 2005.038
Start 170000.00
Stop 170209.00
FRT 170058.00
Corr. date: 2005.049:193250
Fourfit date: 2005.117:183844
Position (J2000) 15h10m53.5914s -5°43'7.417"



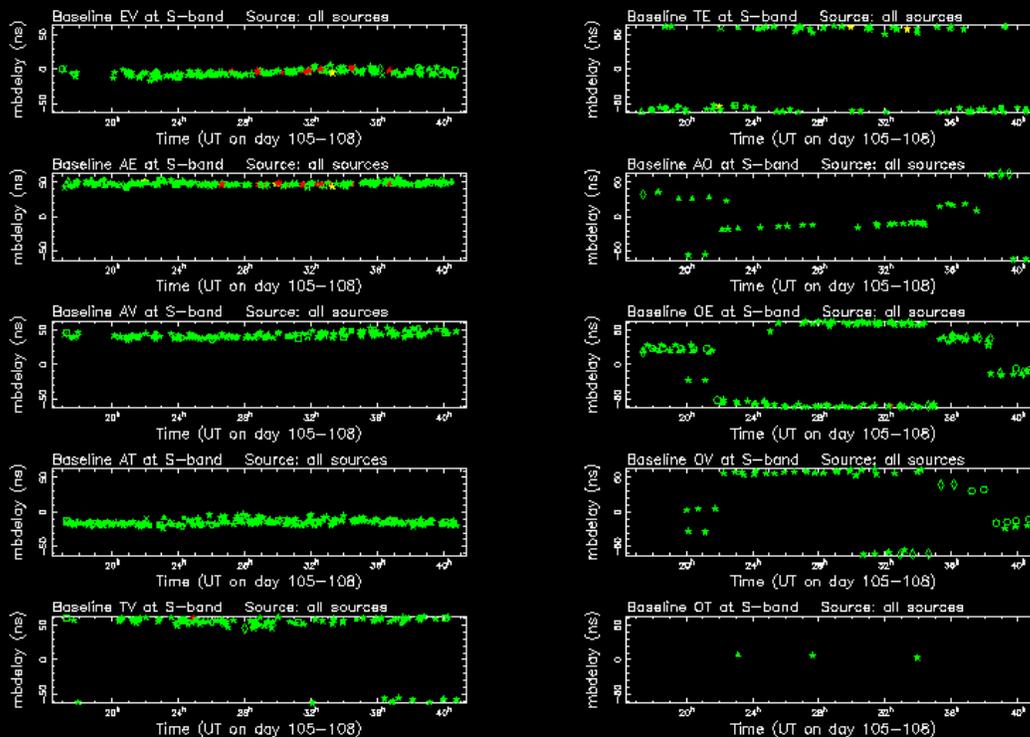
Amp. and Phase vs. time for each freq., 43 segs, 1 APs / seg (3.00 sec / seg.), time ticks 10 sec



	8212.99	8252.99	8352.99	8512.99	8732.99	8852.99	8912.99	8952.99	Freq (MHz)	All
Validity	-44.8	-45.0	-43.0	-20.7	-38.8	-44.0	-62.7	-40.3		-42.1
Parity	3.0	3.8	2.6	3.2	3.8	4.1	2.1	3.0		3.1
Bias	32.7	33.5	34.4	33.2	33.5	33.1	6.0	35.0		33.0
Level	U/L	379.57	370	370	230	270	260	242		
Pcal	AH	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010	4010:4010		
	AH	-24:137	-180:22	-19:93	-48:77	79:82	103:132	157:120		
	AH	3:64	-5:2	5:7	-8:34	2:16	-4:31	3:58		
	AH	37.25	39.25	36.28	14.28	16.26	14.27	17.27		
	A	X1U, X1L	X2U	X3U	X4U	X5U	X6U	X7U		
	H	X1U, X1L	X2U	X3U	X4U	X5U	X6U	X7U		
		2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32		3,5,7,9
		2,4,6,8	10,12	14,16	18,20	22,24	26,28	30,32		3,5,7,9
Group delay (usec)		-5.36554247401E+03		A priori delay (usec)		-5.36552752279E+03		Resid mbdelay (usec)		-1.49512E-02
Sband delay (usec)		-5.36552830523E+03		A priori cband (usec)		1.7409105E+01		Resid sbdelay (usec)		1.21756E-03
Phase delay (usec)		-5.36552753704E+03		A priori cband h (usec)		4.5399999E-05		Resid phase lag (usec)		-1.42545E-05
Delay rate (ns/s)		-1.03304296346E+00		A priori rate h (ns/s)		-1.03304346336E+00		Resid rate h (ns/s)		5.00090E-07
Total phase (deg)		-2.3		A priori accel (ns/s/s)		1.07614129564E-05		Resid phase (deg)		-42.1
	RMS	Theor.	Amplitude	3.130 +/- 0.290	Pcal mode: NORMAL, MANUAL					
ph/seg (deg)	24.8	28.5	Search (120X256)	3.067	Pcal rate: -5.921E-08, 0.000E+00 (us/s)					
amp/seg (%)	67.0	49.8	Inknp.	3.073	Bits/sample: 1	SamprnNom: dsabled				
ph/frq (deg)	10.5	14.0	Inc. seg. avg.	3.287	Sample rate (M Samples): 16					
amp/frq (%)	20.7	24.5	Inc. frq. avg.	3.058	Data rate (mb/s): 160					lags: 32

Control file: c:\3090 Inputfile: jdkh2\geodesy\3090\038-1700b\AH_rjfbmn Outputfile: Suppressed by kstmod

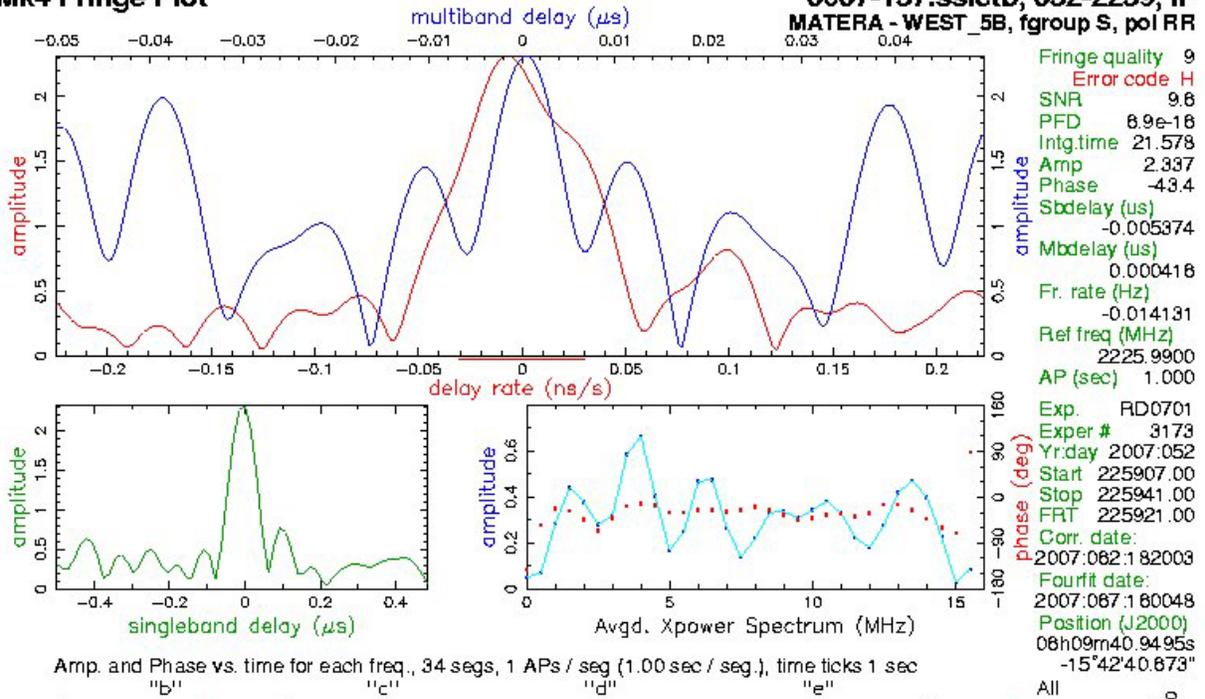
AEDIT plot - Expt 3098, Freq S



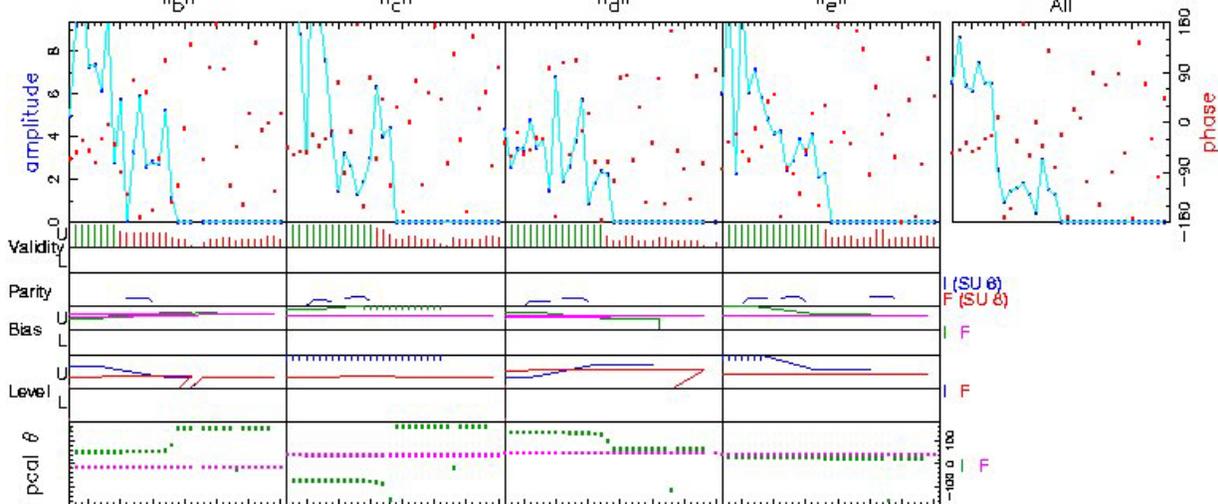
Symbol key: \circ = 0454-234, \times = 0256+075, \square = 2320+506, \triangle = 1221+809, \diamond = 30448, \star = 1923+210
 \blacktriangle = CT426, \oplus = 2113+293, \blacksquare = 1751+288, \bullet = 0556+238, \ast = the rest

Mk4 Fringe Plot

0607-157.ssictb, 052-2259, IF
MATERA - WEST_5B, fgroup S, pol RR



Amp. and Phase vs. time for each freq., 34 segs, 1 APs / seg (1.00 sec / seg.), time ticks 1 sec

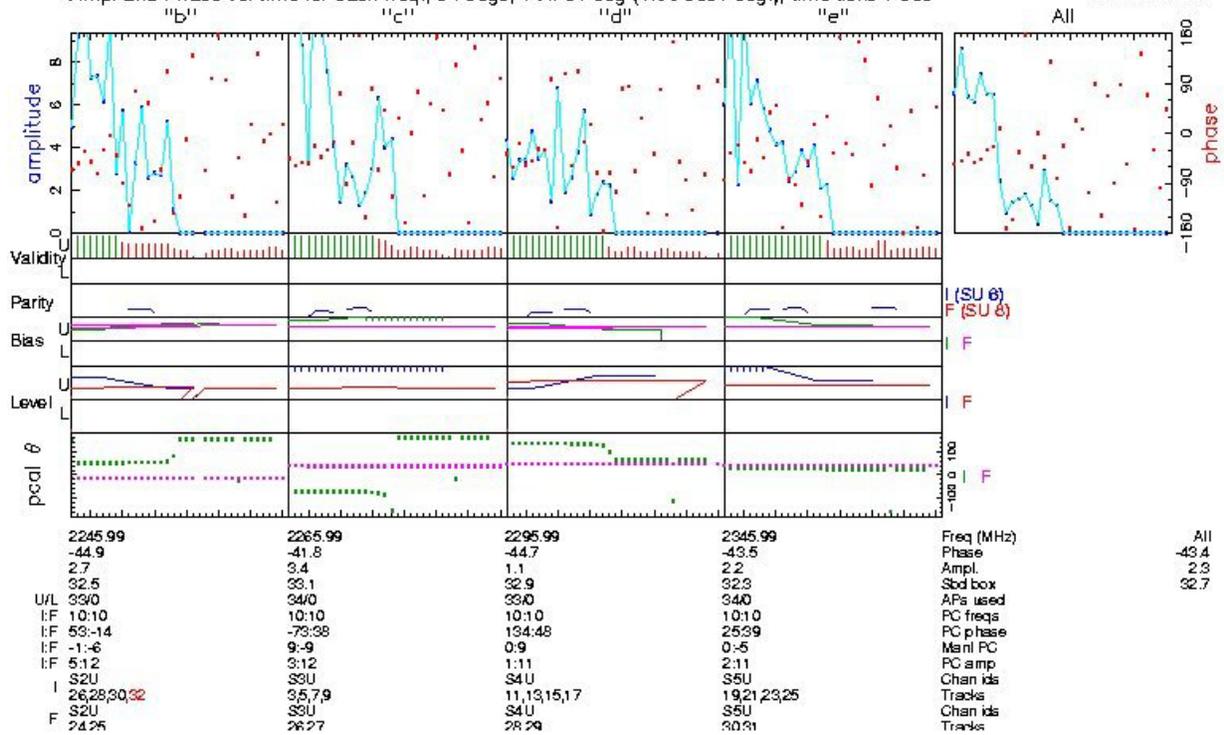


	2245.99	2265.99	2295.99	2345.99	Freq (MHz)	All
U/L	33/0	34/0	32/0	34/0		
I/F	10:10	10:10	10:10	10:10		
I/F	53:-14	-79:38	134:48	25:39		
I/F	-1:-6	9:-9	0:9	0:-5		
I/F	5:12	3:12	1:11	2:11		
I	S2U	S3U	S4U	S5U		
I	26,28,30,32	35,7,9	11,13,15,17	19,21,23,25		
F	S2U	S3U	S4U	S5U		
F	24,25	26,27	28,29	30,31		
Group delay (usec)	-5.51382375620E+03		Apriori delay (usec)	-5.51382417254E+03	Resid mbdelay (usec)	4.16340E-04
Stand delay (usec)	-5.51382954696E+03		Apriori clock (usec)	4.8396960E+01	Resid sbdelay (usec)	-5.57442E-03
Phase delay (usec)	-5.51382422688E+03		Apriori clockrate (us/s)	1.6800001E+06	Resid phdelay (usec)	-5.41595E-05
Delay rate (us/s)	-1.49920660598E+00		Apriori rate (us/s)	-1.49920289733E+00	Resid rate (us/s)	-3.70865E-06
Total phase (deg)		-212.5	Apriori apcal (us/s/s)	3.03545210903E-05	Resid phase (deg)	-43.4
	RMS	Theor.	Amplitude	2.337 +/- 0.243		12.1
pv/seg (deg)	32.3	34.0	Search (128X64)	2.294	Post mode: NORMAL, NORMAL	
amp/seg (%)	127.6	59.3	Interp.	2.295	Post rate: -2.687E-06, -4.729E-08 (us/s)	
ph/seg (deg)	1.3	10.3	Inc. seg. avg.	2.401	Bits/sample: 2	
amp/frq (%)	35.3	18.0	Inc. frq. avg.	2.288	Sample rate (MSamp/s): 32	
					Data rate (Mb/s): 256	
					nlags: 32	

Control file: cf_3173 Input file: /data/geodesy/3173/052-2259/IF.ssictb Output file: /data/geodesy/3173/052-2259/IF.S.57.ssictb

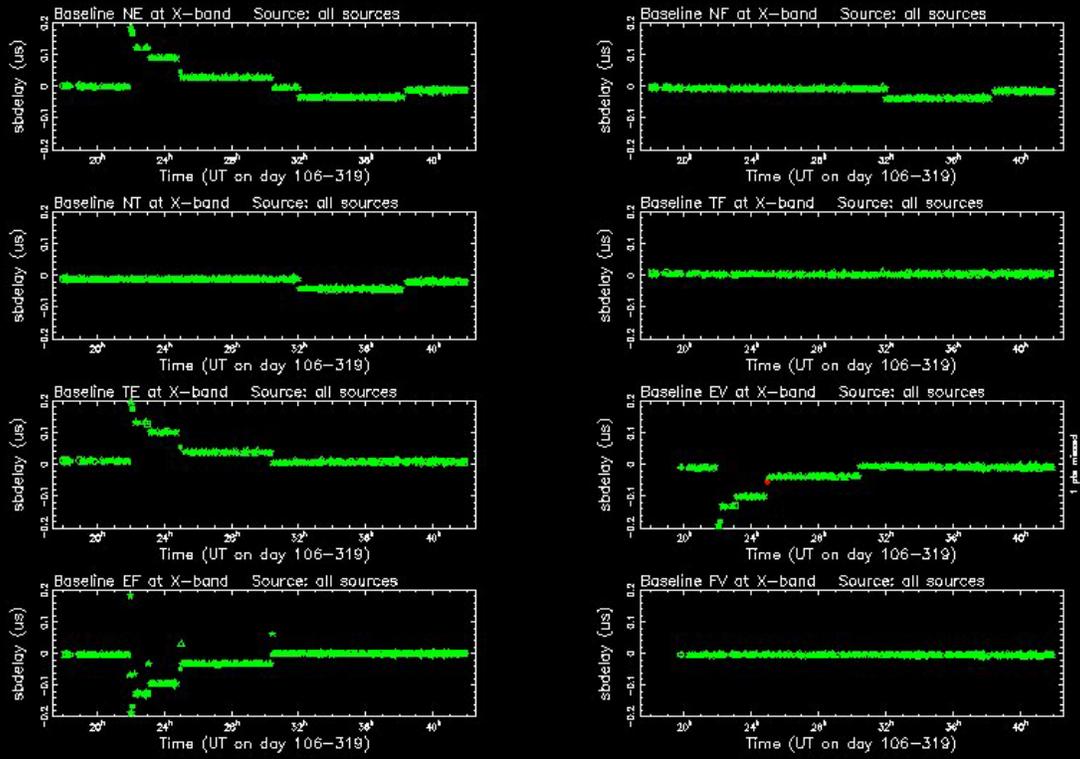
Amp. and Phase vs. time for each freq., 34 segs, 1 APs / seg (1.00 sec / seg), time ticks 1 sec

UNCONFIRMED
-15°42'40.673"



C
C
F
[
|
F
E
F
E
C

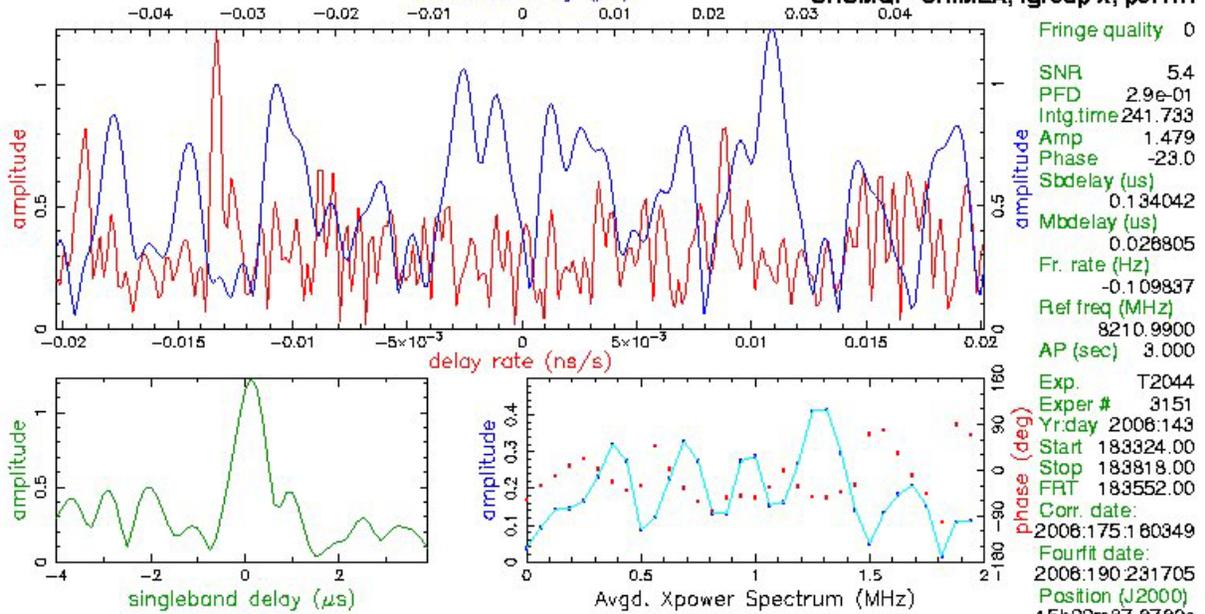
AEDIT plot – Expt 3164, Freq X



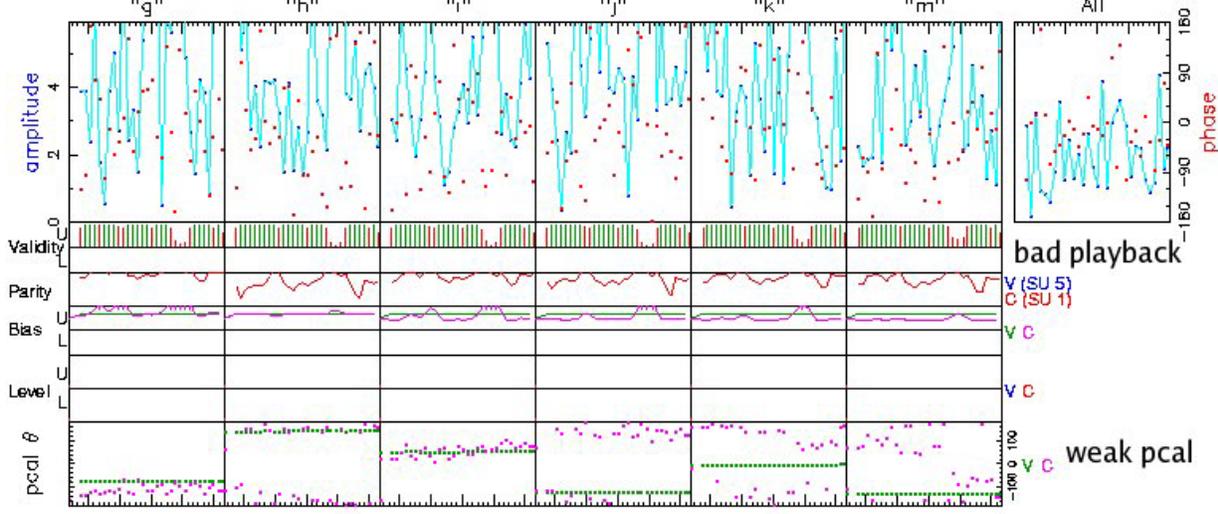
Symbol key: \circ = 4C39.25, \times = 0133+476, \square = 2145+067, \triangle = 1739+522, \diamond = 1749+096, \star = 0Q208
 \blacktriangle = 1803+784, \blacklozenge = 1811+343, \blacksquare = 0119+115, \blacklozenge = 2209+236, \star = the rest

Mk4 Fringe Plot non detection due to weak X band

1519-273.sgkiwu, 143-1833b, VC
URUMQI - CRIMEA, fgroup X, pol RR

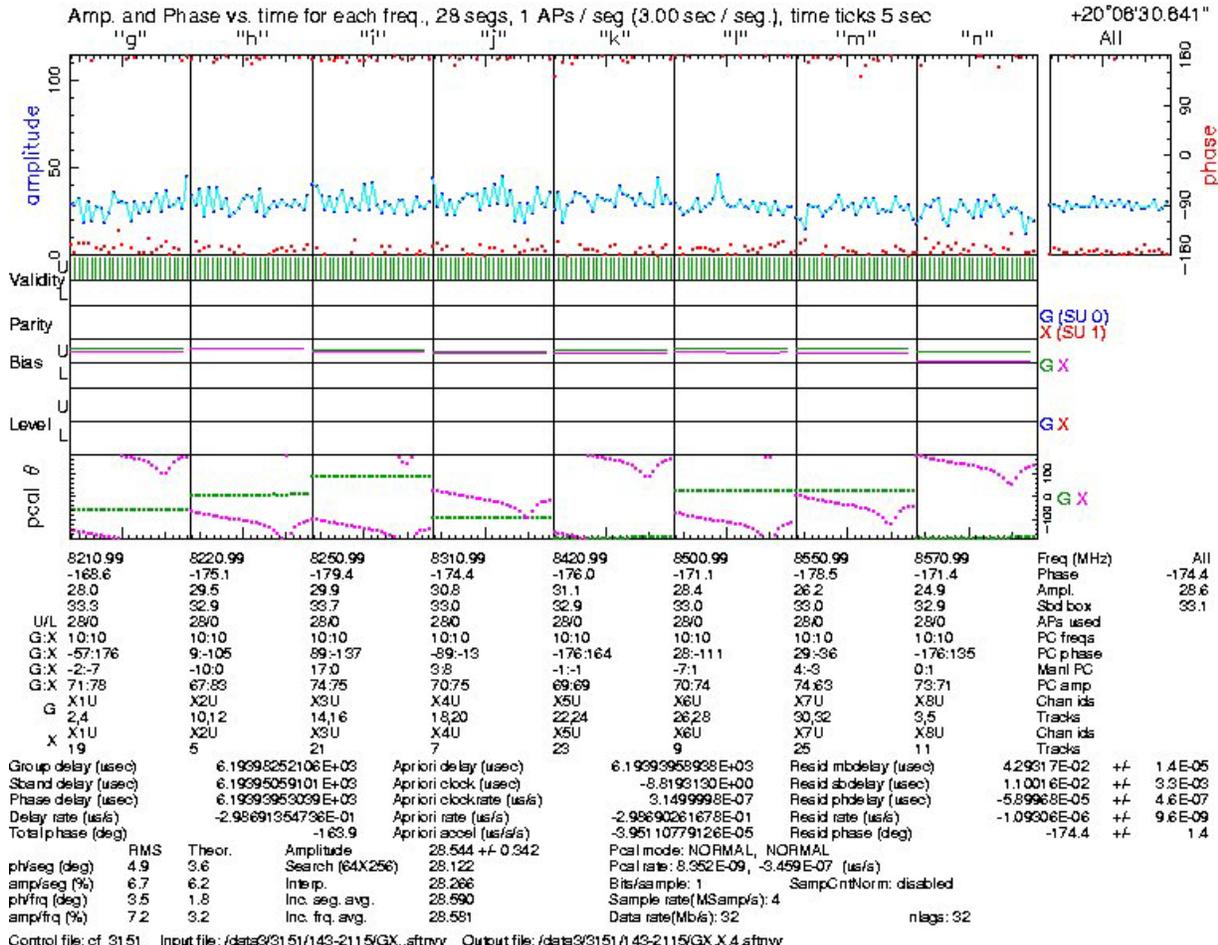


Amp. and Phase vs. time for each freq., 33 segs, 3 APs / seg (9.00 sec / seg), time ticks 10 sec

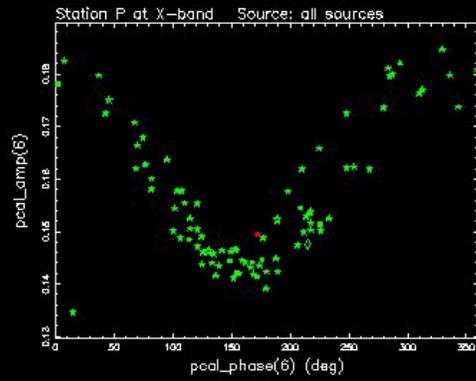
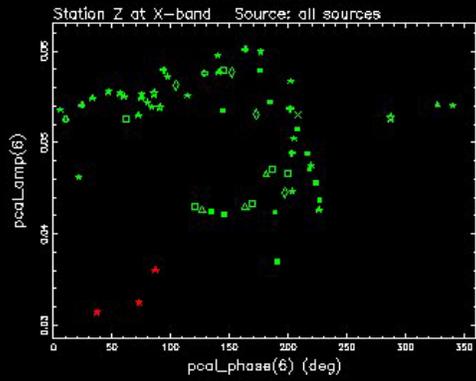
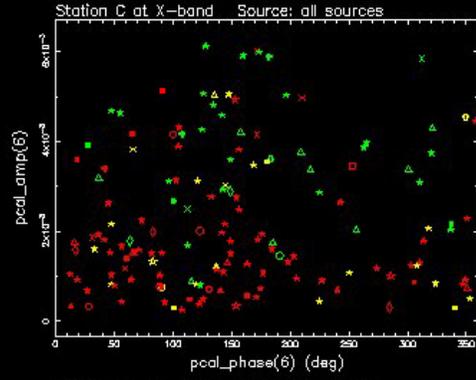
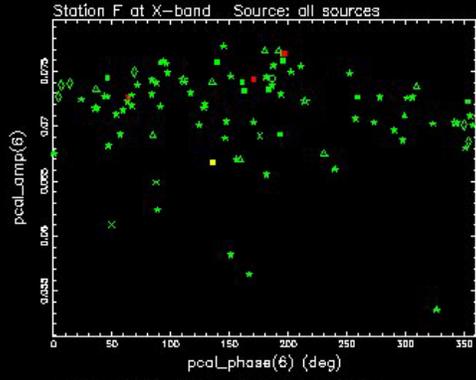


	8210.99	8220.99	8250.99	8310.99	8420.99	8650.99		All		
	3.8	-62.9	-27.2	-99.7	4.4	-32.7		Phase		
	2.4	1.1	1.6	2.5	1.3	0.7		Ampl.		
	33.9	10.4	15.3	34.2	16.6	56.1		Sbd box		
U/L	92/0	92/0	92/0	92/0	92/0	92/0		APs used		
V:C	10:10	10:10	10:10	10:10	10:10	10:10		PC freqs		
V:C	-75-110	140:172	51:55	-122:143	-5:150	-130:123		PC phase		
V:C	-2:33	444	-3:37	-15:4	28:61	-11:25		ManI PC		
V:C	18:4	23:3	12:4	20:3	25:1	22:0		PC amp		
V	X1U	X2U	X3U	X4U	X5U	X7U		Chan ids		
V	2,4	10,12	14,16	18,20	22,24	30,32		Tracks		
C	X1U	X2U	X3U	X4U	X5U	X7U		Chan ids		
C	19	5	21	7	23	25		Tracks		
Group delay (usec)		2.40669493701 E+03			2.40666813217 E+03		Resid mbdelay (usec)	2.68048E-02	+-	2.4E-04
Stand delay (usec)		2.40680217999 E+03			-6.7943168 E+00		Resid sbdelay (usec)	1.54042E-01	+-	5.5E-02
Phase delay (usec)		2.40666812438 E+03			-5.6840001 E+06		Resid phdelay (usec)	-7.78520E-06	+-	7.6E-06
Delay rate (us/s)		-8.72886621719 E-01			-8.72873242118 E-01		Resid rate (us/s)	-1.33796E-05	+-	4.5E-08
Total phase (deg)			325.0		-1.22351645688 E-05		Resid phase (deg)	-23.0	+-	22.4
	RMS	Theor.	Amplitude	1.479 +/- 0.276			Postmode: NORMAL, MANUAL			
phVseg (deg)	30.9	58.5	Search (256X256)	1.180			Post rate: 2.778E-09, 0.000E+00 (us/s)			
ampVseg (%)	105.1	102.2	Interp.	1.187			Bits/sample: 1	SampCntNorm: disabled		
phVfreq (deg)	22.7	23.9	Inc. seg. avg.	1.478			Sample rate(MSamp/s): 4			
ampVfreq (%)	45.0	41.7	Inc. freq. avg.	1.458			Data rate(Mb/s): 24			nlags: 32

Control file: cf_3151 Input file: /data3/3151/143-1833b/VC.sgkiwu Output file: /data3/3151/143-1833b/VC.X.2.sgkiwu



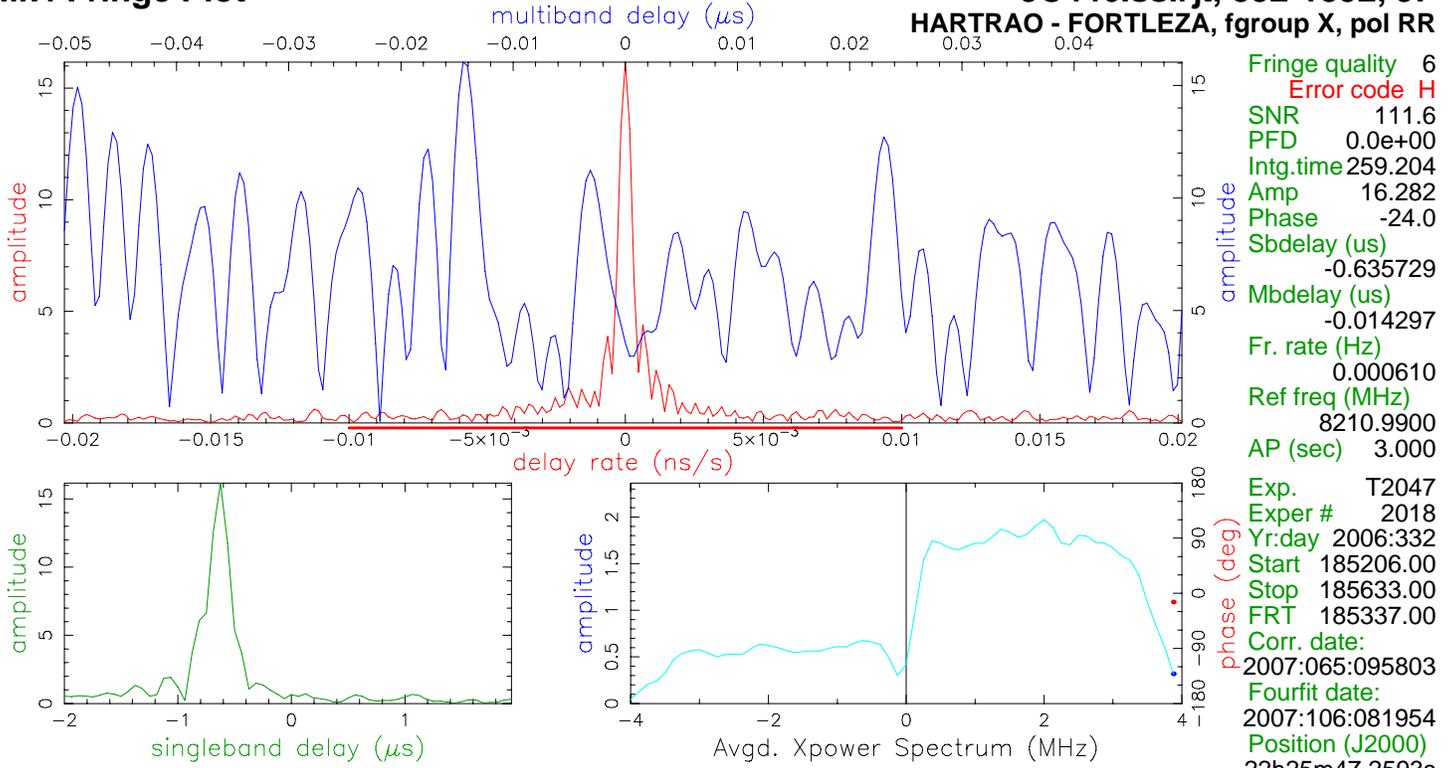
AEDIT plot – Expt 3151, Freq X



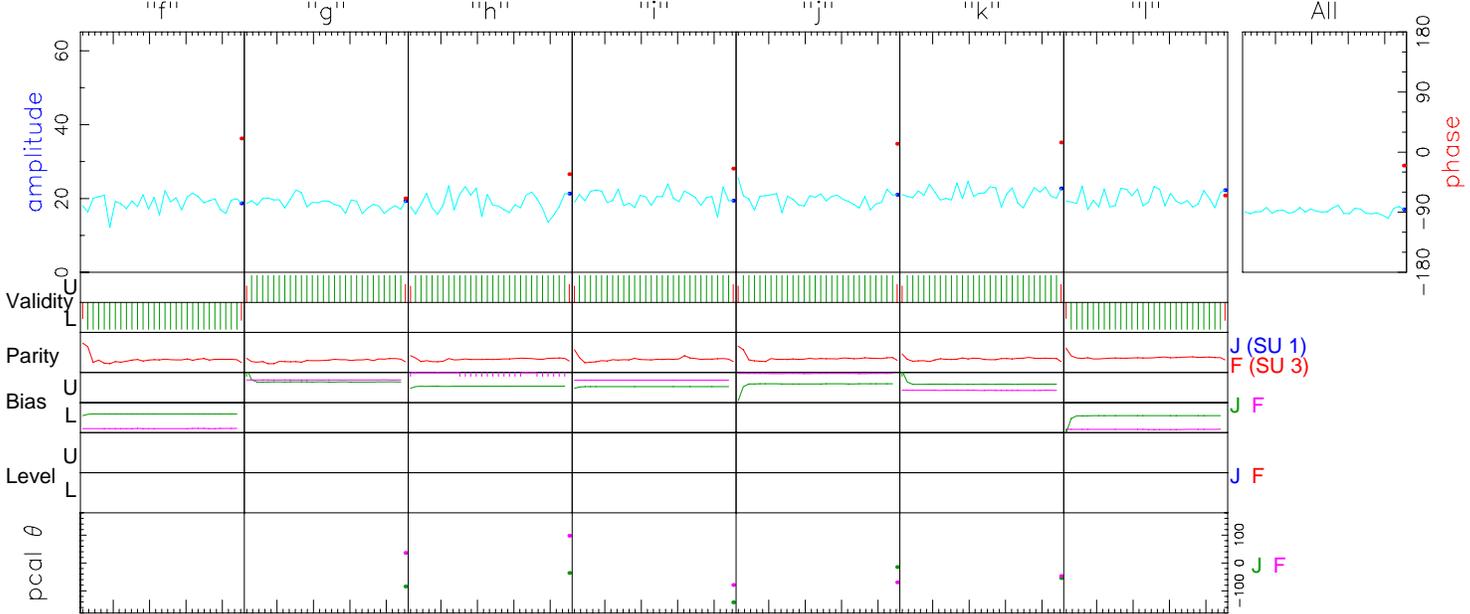
Symbol key: \circ = 0059+581, \times = 1044+719, \square = 2201+315, \triangle = 1611+343, \diamond = 2145+067, \star = 0727-115
 \blacktriangle = CT226, \blacklozenge = 3C274, \blacksquare = 1741-038, \blacklozenge = 1034-293, \star = the rest, \circ = 1958-179

Mk4 Fringe Plot

3C446.ssrjrt, 332-1852, JF
 HARTRAO - FORTLEZA, fgroup X, pol RR



Amp. and Phase vs. time for each freq., 30 segs, 3 APs / seg (9.00 sec / seg.), time ticks 10 sec



	8210.99	8220.99	8250.99	8310.99	8420.99	8500.99	8570.99	Freq (MHz)	All
U/L	0/89	89/0	89/0	89/0	89/0	89/0	0/89		
J:F	0:0	10:10	10:10	10:10	10:10	10:10	0:0		
J:F	-90:-90	-73:36	-24:98	-130:-79	-3:-70	-43:-47	-90:-90		
J:F	0:0	0:0	0:0	0:0	0:0	0:0	0:0		
J:F	0:0	41:32	37:33	41:31	38:34	42:34	0:0		
J	X2R	X3R	X4R	X5R	X6R	X7R	XAR		J (SU 1)
F	6,8	10,12	14,16	18,20	22,24	26,28	7,9		F (SU 3)
F	X2R	X3R	X4R	X5R	X6R	X7R	XAR		J F
F	6,8	10,12	14,16	18,20	22,24	26,28	7,9		J F
Group delay (usec)		-4.49135983934E+03	Apriori delay (usec)		-4.49134554281E+03	Resid mbdelay (usec)		-1.42965E-02	+/- 1.1E-05
Sband delay (usec)		-4.49198127229E+03	Apriori clock (usec)		-8.4346485E+00	Resid sbdelay (usec)		-6.35729E-01	+/- 7.9E-04
Phase delay (usec)		-4.49134555093E+03	Apriori clockrate (us/s)		1.8000000E-07	Resid phdelay (usec)		-8.11703E-06	+/- 2.2E-07
Delay rate (us/s)		-1.56072078833E+00	Apriori rate (us/s)		-1.56072089214E+00	Resid rate (us/s)		1.03809E-07	+/- 2.3E-09
Total phase (deg)		-145.9	Apriori accel (us/s/s)		2.73943640255E-05	Resid phase (deg)		-24.0	+/- 0.6
ph/seg (deg)	RMS 12.5	Theor. 2.8	Amplitude Search (256X256)	15.224	15.224	Pcal mode: NORMAL, NORMAL			
amp/seg (%)	5.3	4.8	Interp.	15.224	15.224	Pcal rate: -2.847E-08, 1.001E-09 (us/s)			
ph/frq (deg)	29.9	1.3	Inc. seg. avg.	16.667	16.667	Bits/sample: 1	SampCntNorm: disabled		
amp/frq (%)	18.6	2.2	Inc. frq. avg.	19.185	19.185	Sample rate(MSamp/s): 8			
						Data rate(Mb/s): 56	nlags: 32		