Notes for September 2003 IVS TOW Meeting Correlator Class

MAT/KAK/AM/BEC/DRS 091303

· Give you a basic idea of how the correlator works. · Briefly outline the life cycle of an experiment at the correlator. · List some of the

To give you some idea of what happens to your data when it leaves the station, here is a summary of the basic steps we go through when processing an experiment:

- gathering of logs and schedules upon recording completion
- tapes and disks come in - inspected physically and put into library
- compile logs and schedule in format correlator likes
- based on info in the logs and ops messages, pick scan(s)to find fringes and tweak clocks
- also based on info in logs (after clock tweaks), select a small sample of scans interspersed throughout the schedule to check clock stability, playback quality, tape quality etc ... throughout experiment. These scans are called "pre-passes". based on pre-pass results, make any appropriate corrections to production processing parameters.
- construct fourfit control files and production processing lists based on results from pre-passes
- schedule/production process
- analyze results of production processing – re-fourfit and/or re-process any scans which need it
- evaluate station performance
- export data to analysis center
- possible re-processing on request from analysis center
- release disks and tapes

Part 4 – What the stations can do for the correlator

Ship the disks or tapes fast!!

Some notes on facilitating the shipping process:

- We look at the experiment as soon as all stations arrive, so ship them right away.
- Feedback on TRACK usage: not all the stations use TRACK regularly. The usage of TRACK is important for correlators, especially since the responsibility for tape/disk shipment has been given to correlators/stations.
- Customs declarations: some stations do not add to the shipment a declaration for the customs or the value declared for customs is too high. Both cause delays in delivery.
- Couriers: some are faster and more reliable than others.
- Correlators require e-mail addresses of station personnel who can be contacted. In case of stations where shifts are made we require an e-mail address for each shift.

Provide good documentation!

- Note that at the correlator, **ops messages are read first**. The logs are delved into only if problems encountered (other than comments). Document the routine stuff well, and document *anything* that could be considered out of the ordinary. Here are a few categories of things you should be sure to document well:

I) physical disk or tape

- Make sure Mark5 modules are labeled and shipped in accordance with the "**Mark5A Disk-Module Labeling and Management Procedures"** memo which is available on the Haystack Mark5 web site at http://web.haystack.edu/mark5/operations.html.
- For tape, accurately and precisely log damage/splices needed etc ... . Make sure tapes are properly packed for shipping, especially glass reels which have been known to break in transit.

II) ops messages

- Log everything carefully and put into ops messages (see above). Check all BBCs periodically. Note periods of poor antenna tracking etc … Here are some further notes on OPS messages:

a) information we focus on in the OPS messages:

- Session comments in the stop message (especially scans missed/problem scans (please give times **not** line numbers)/unusual conditions/equipment problems/start-stop times of problems/other comments)
- Weather Info
- Clock Info (offset from GPS/drift rates - whatever appropriate)
- Recorder Humidity
- Pointing/SEFD Info

b) information we focus on in TRACK and follow up OPS messages:

- Log Placement Info
- Disk/Tape Shipping/Inventory info (including labels & AWB number if known)

III) playback quality

a) mark5 disks

- Note if a disk or disks went bad during the course of recording. Note any unusual behaviors of the Mark5 system, or any other anomalies.

b) tapes

- Make sure head calibration and record current setting are properly done. Make sure drive is physically in good shape.
- Watch PER checks during experiment and note any problems / clean heads frequently.
- Note any changes in station drive which will change speed (mainly capstan replacement).
- Make sure footage counter is correct. Note missed scans. If a tape is bad (e.g. keeps losing vacuum), change it!
- Watch out for badly wound tapes (see next point) - they can influence the quality of the data.
- The tapes that correlators send to the stations should always be prepassed before recording. Tapes might be damaged during transport, and thus not necessarily well wound, or possibly well degaussed.

IV) clock/maser (timing)

- Give offset in standard format - note any possible ambiguities. Check that formatter is synced to correct whole second.
- Log all jumps and/or equipment changes which might cause them.
- State any rates/instabilities as clearly as possible.

V) phase cal

- Log any known problems with anything in the LO chain which might affect phase cal behavior or problems with the phase cal itself. Be sure to note replacing or re-setting of any BBC.

VI) other data quality issues

- Don't check the cable cal during an experiment, and don't remove the extender during the experiment if it has been left in by mistake. If either of these things do happen though, please note them.
- Check locally & inform correlator about *any* unusual problems you are aware of. Don't hesitate to ask the correlator for feedback!!

Avoid Severe Problems

There are a host of situations where problem data might be recoverable by efforts which go beyond the normal level of demand for corrective action (i.e. ones which if done would greatly degrade correlator efficiency or require extraordinary efforts or intervention). Under these circumstances a value judgement is made (usually by Goddard people) as to whether or not the unusual efforts and their cost is worth the effort to recover the data. A few examples of this might be:

- 1-2 Mark5 disk failures in an 8 pack after the data has been successfully recorded.
- severe tape tracking problems which are only recovered through manual intervention
- bad tape playback on multiple stations requiring special drive assignments which add additional passes
- formatter/decoder/rack errors which require special software patches to correct

Finally, there are a host of problems that cannot by any method be salvaged by tricks at the correlator. A short list of the most common ones might include:

- Multiple disk failures in a Mark5 module (more than two in an 8 pack) after the data has been successfully recorded
- no fringes (for reasons unknown to anyone - all likely problems tested) rare nowadays for geodetic stations
- any antenna/system problem at record time which degrades system sensitivity
- really bad tape playback/tracking problems
- unpatchable data formatting problems (i.e. stuck bits, wrong times in nasty places, missing CRCC)
- wrong polarization
- formatter +-30 milliseconds away from integer second (see special Mark IV considerations below)
- wrong schedule observed (it happens!)
- ?? too many more to list

The main point behind all this is to make sure however possible that the data you send to the correlator is a good as it possibly can be.

Note Special Considerations for the Mark IV Correlator

There are a few limitations of the Mark IV correlator which need to be kept in mind in order to avoid conditions which might result in uncorrelatable data, but which at recording time might seem like minor problems:

- The range of clock offsets we can correct for is limited (see other comments above). This is very important, as falling outside of this range may result in our inability to correlate. It is safest to make sure your clock is close to GPS and you report it accurately (especially correct sign).
- Logs are more important to us. The Mark IV correlator uses log information extensively and making "fake" logs in absence of a real log is much less desirable and more difficult. Please be extra careful that you write proper logs and send them promptly.
- The use of barrel rolling and fan out modes makes it a bit more difficult for us to diagnose problems. If you know about a problem and are going to run an experiment before being able to fix it, please describe it well in the closing OPS message.

Part 5 – What the correlator can do for the stations

Fringe fitting after the production correlation reveals most of the problems that arise at the stations. Control file preparation detects some problems too (e.g. wrong footage) and the fringe fitting of the trial correlation detects the rest (e.g. by checking oscilloscopes and SUs).

Stations should always read the correlator reports and are invited to ask if something is not clear. In the reports there is a short summary of the problems encountered during the correlation and the fringe fitting like: RFI, bad and/or missing tracks, IF problems, wrong frequency setup, wrong polarization, antenna failure, system problem that can degrade the sensitivity, SEFD, warm receivers, wrong formatter setting, wrong head calibrations, wrong footage, difference between the expected and the observed SNR, data formatting problems, clock performance.

Part 6 – Conclusion

You might realize, given all this, that the correlator is something like a oracle when it comes to assessing station data (i.e. in many respects the quality of the data reveals itself immediately upon the first sync-up and first examination of fourfit plots). Most problems are revealed by examining fourfit plots from resultant correlations; but many others are discovered/diagnosed also by observing the pre-passes in action (i.e. observing sync-up times, examining eye patterns on scope - observing lights etc ...). Usually after a few scans the quality of station data is fairly well known. Thus, please report your problems, as they cannot hide from the correlator!

We hope that the lecture portion of this class gives you a better idea of what is done with your data once it leaves the site. We also hope that we have given you good feedback on how you can help us, and that we have received feedback on how we can help you.

Part 7 - Correlator Demonstration

Since many of you may not have seen a Mark IV correlator run, if we have time after the talk/discussions, we will walk down to the correlator for sample scan demo.

TOW 2003 Correlator Class

Kerry Kingham
US Naval Observatory
Arno Mueskens
University of Bonn
Mike Titus
MIT Haystack Observatory

Introduction

- Basic idea of how the correlator works
- Brief outline of an experiment’s life cycle
- What you can do for us
- What we can do for you
- Demo


1
3
4
5
6
7
8

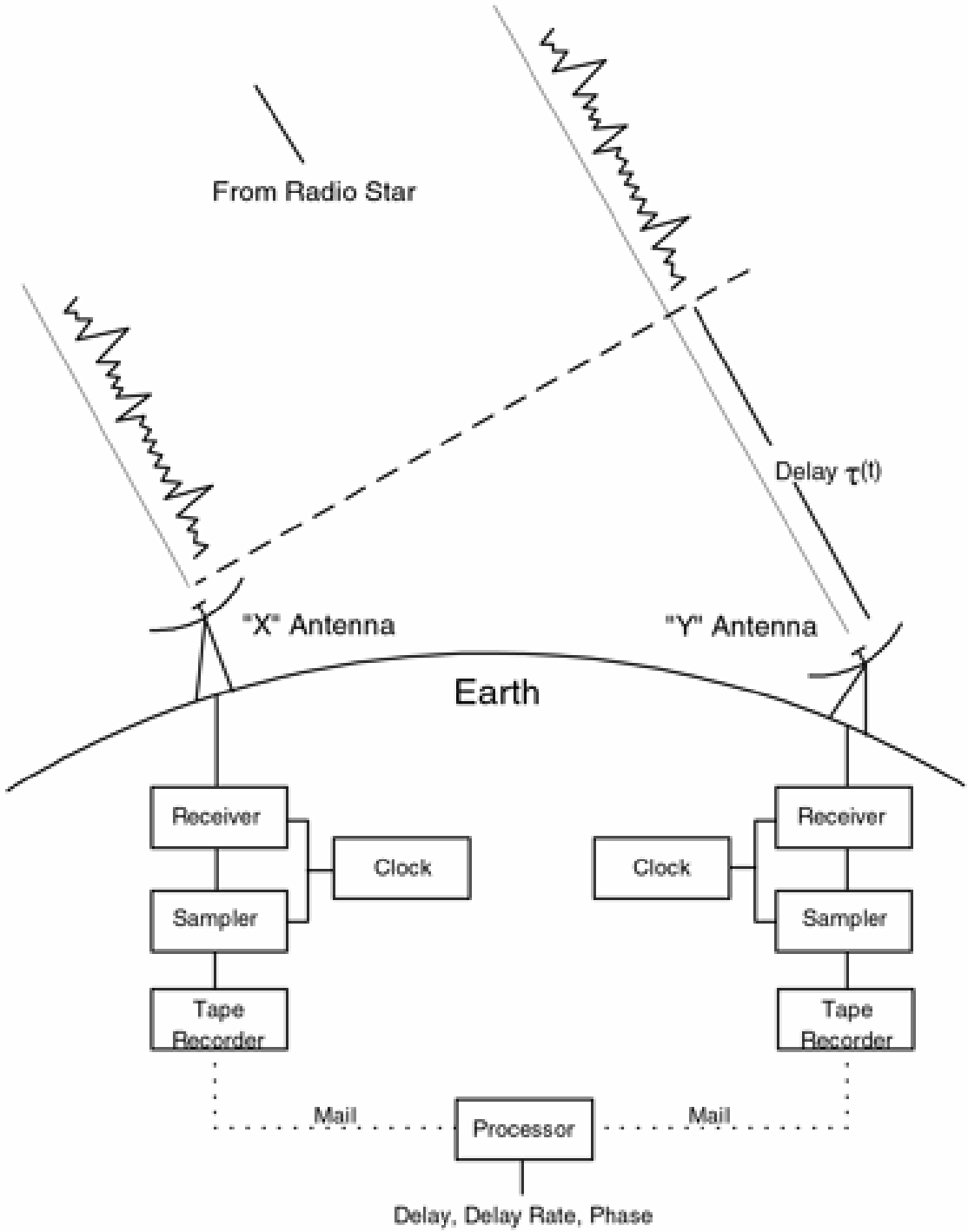

FIRE
0
1
2
3
4
5
6

What Does a Correlator Do?

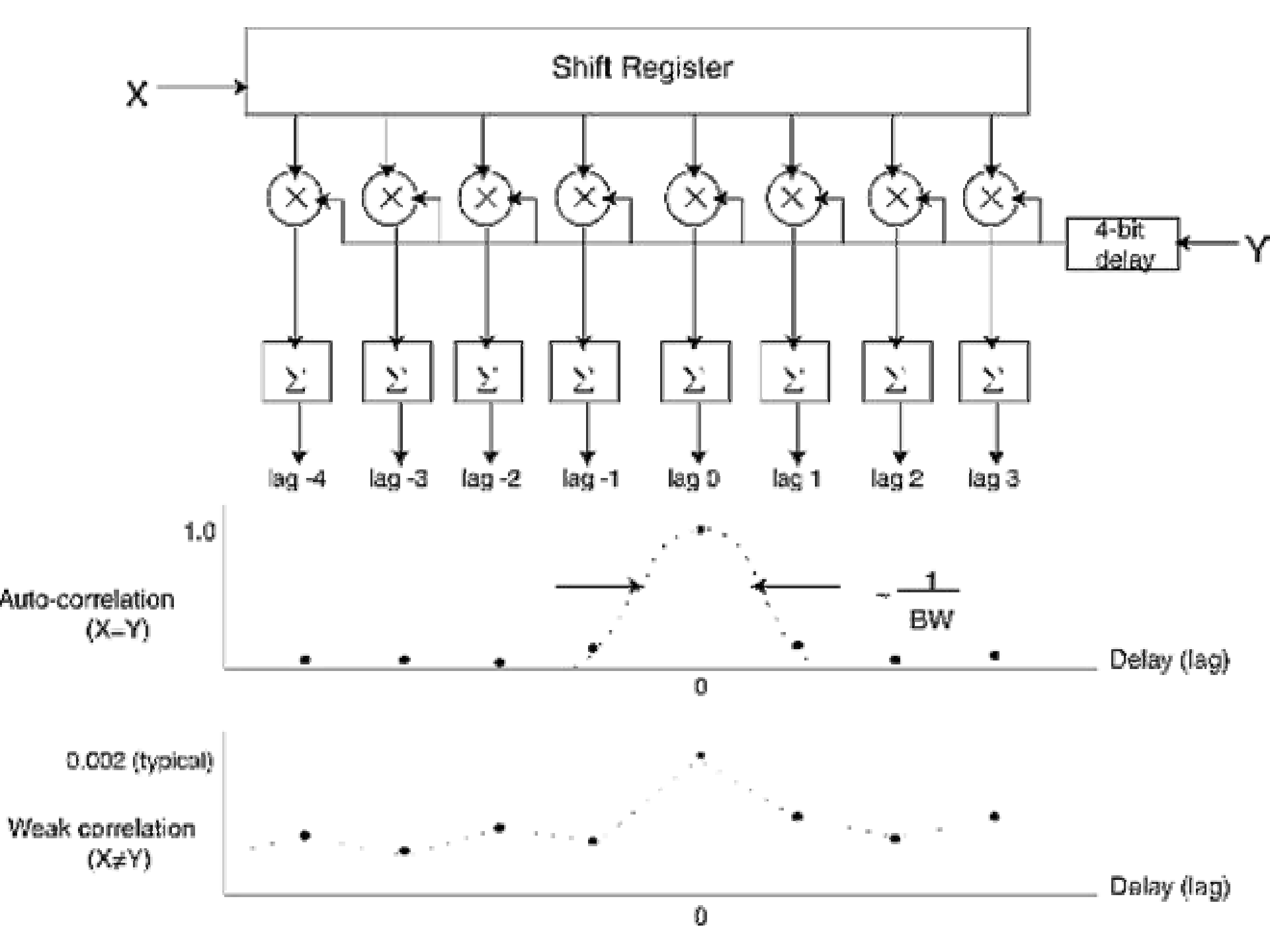
Kerry Kingham
Washington Correlator

The Correlator Makes VLBI Possible!

- Output of DAT at each antenna is a string of 1s and 0s
- These strings of binary data are not very useful until they are processed by the Correlator
- The output of the correlator is what is used for Geodesy, Astrometry and Astrophysics


From Radio Star
Delay τ(t)
"X" Antenna
"Y" Antenna
Earth
Receiver
Clock
Sampler
Tape Recorder
Clock
Receiver
Sampler
Tape Recorder
Mail
Processor
Mail
Delay, Delay Rate, Phase

Simple “real” correlator

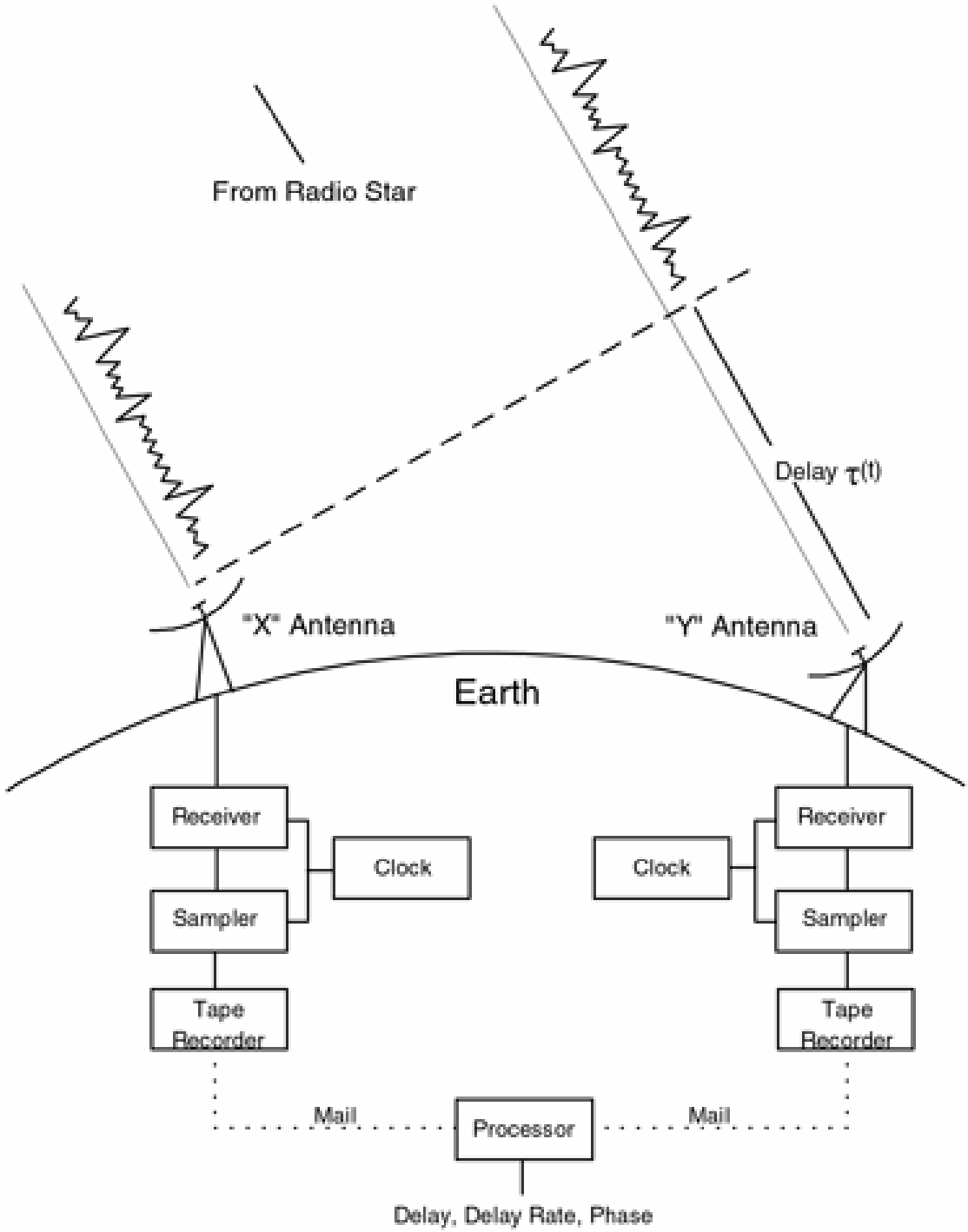

X
Shift Register
4-bit delay
Y
Σ
lag -4
lag -3
lag -2
lag -1
lag 0
lag 1
lag 2
lag 3
1.0
Auto-correlation
(X=Y)
1
BW
Delay (lag)
0
0.002 (typical)
Weak correlation
(X≠Y)
Delay (lag)
0

But wait!

VLBI situation is more complex and dynamic …

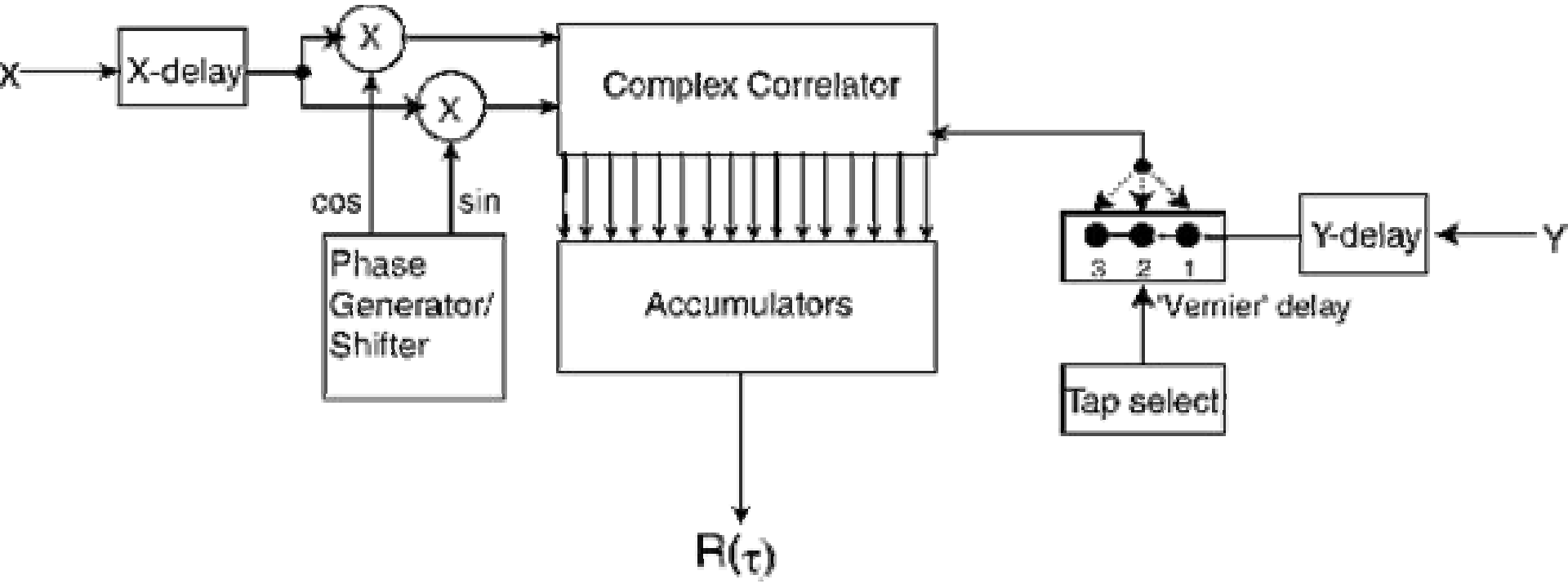
Delay offset between antennas

Doppler shift from Earth's Rotation


From Radio Star
Delay τ(t)
"X" Antenna
"Y" Antenna
Earth
Receiver
Clock
Sampler
Tape Recorder
Clock
Receiver
Sampler
Tape Recorder
Mail
Processor
Mail
Delay, Delay Rate, Phase

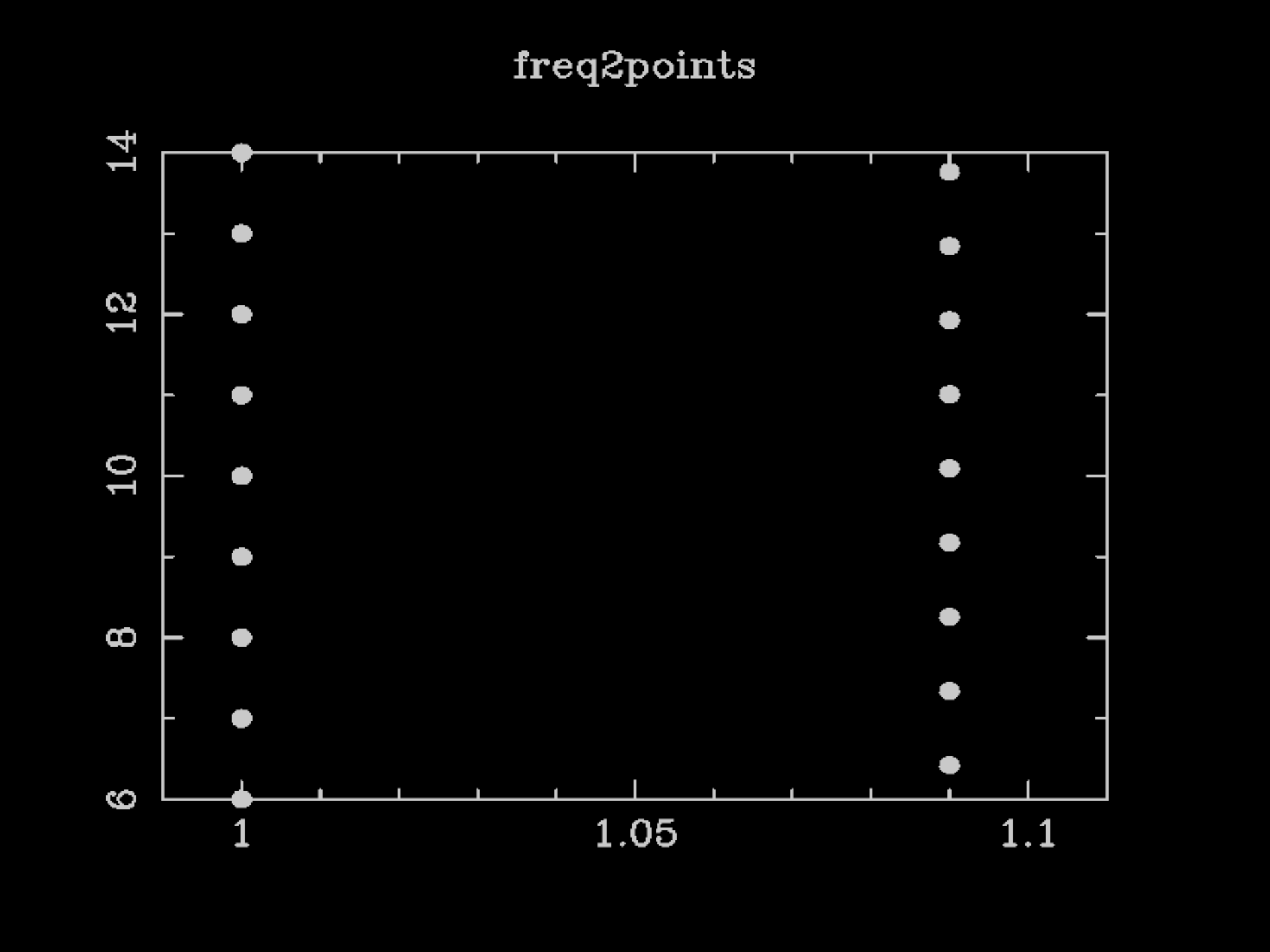
Complex correlator

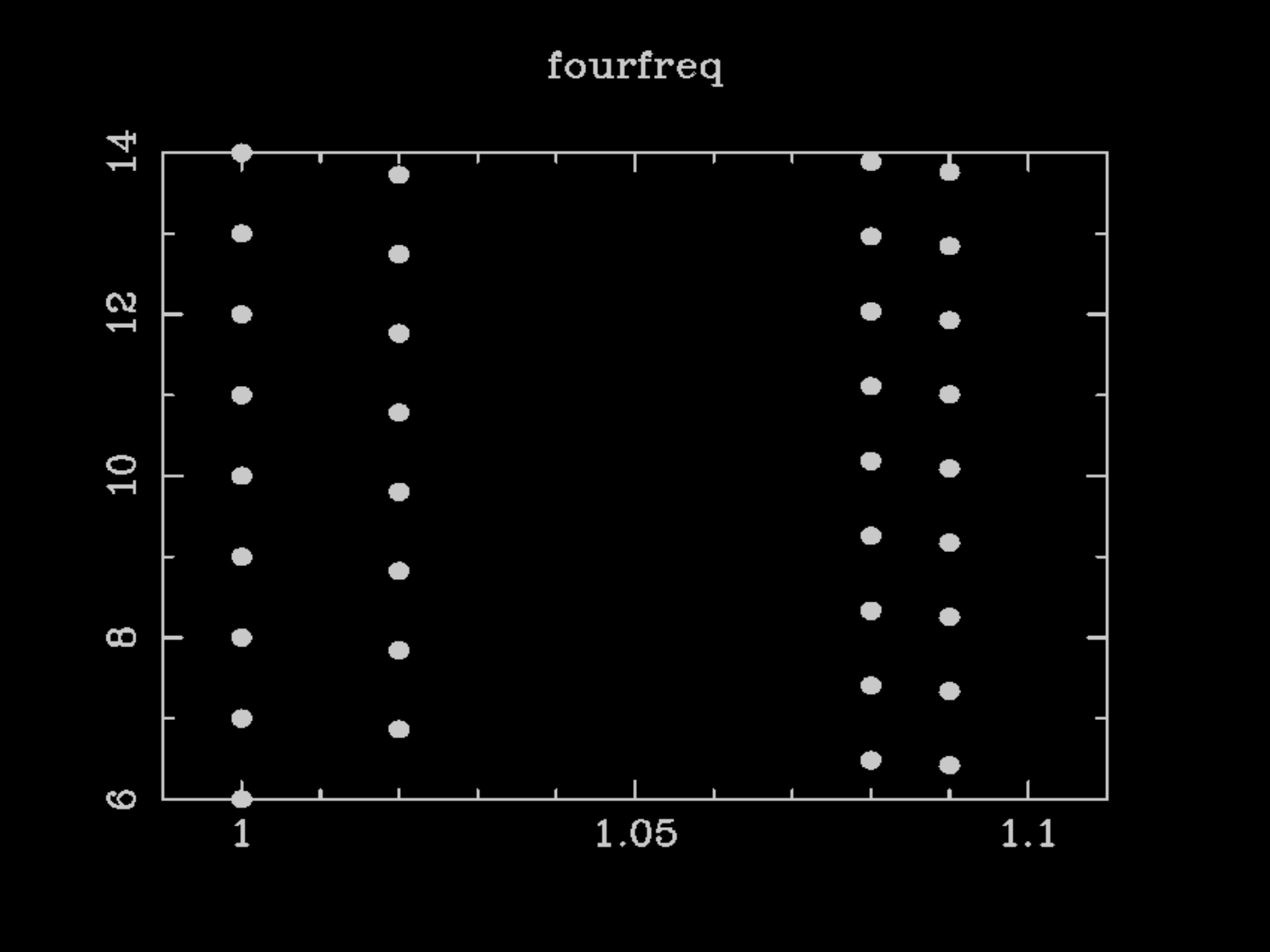
Need phase rotation and delay

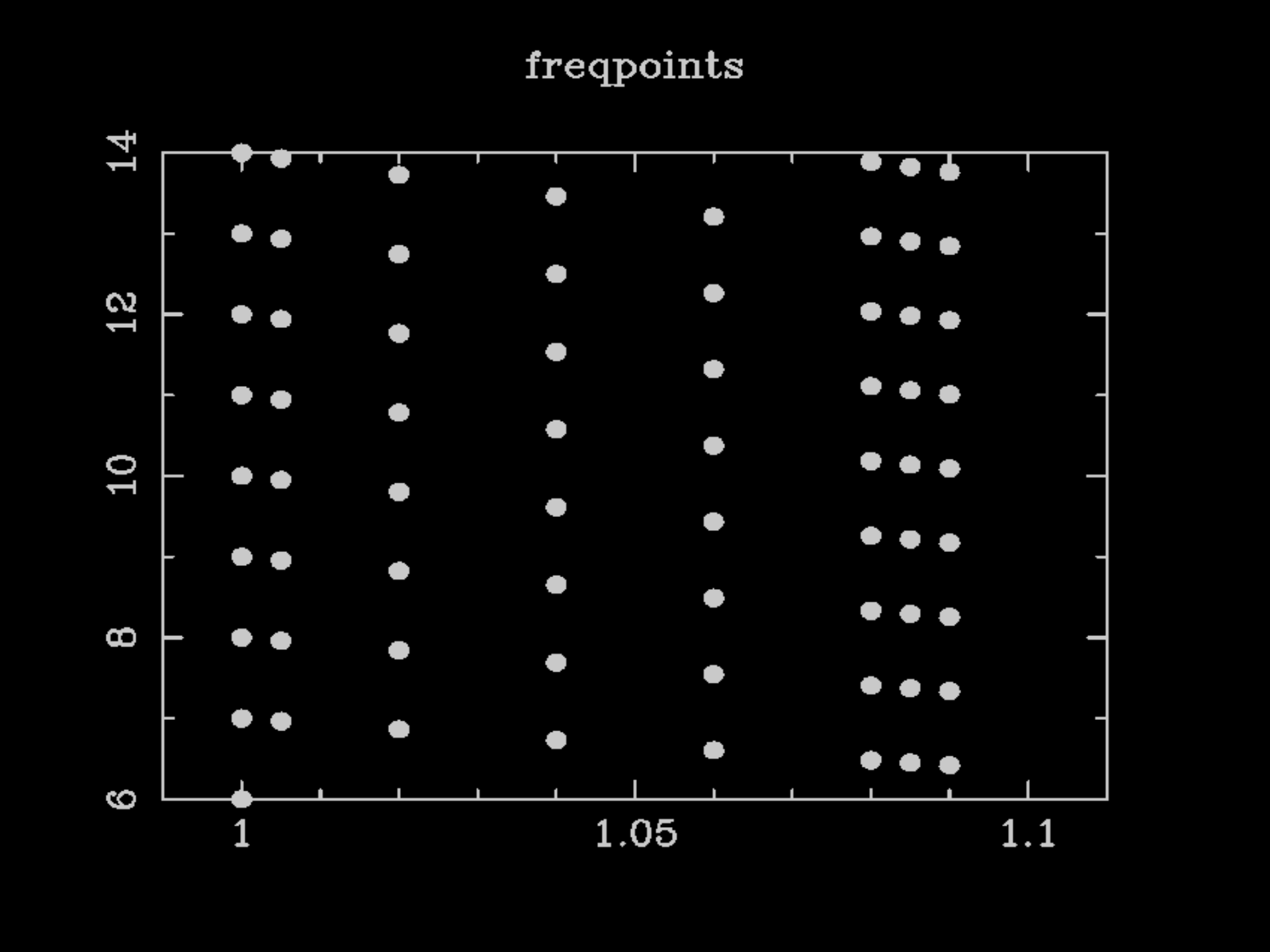

X
X-delay
X
X
Complex Correlator
cos
sin
Phase
Generator/
Shifter
Accumulators
R(τ)
3
2
1
Y-delay
Y
'Vernier' delay
Tap select

Bandwidth synthesis

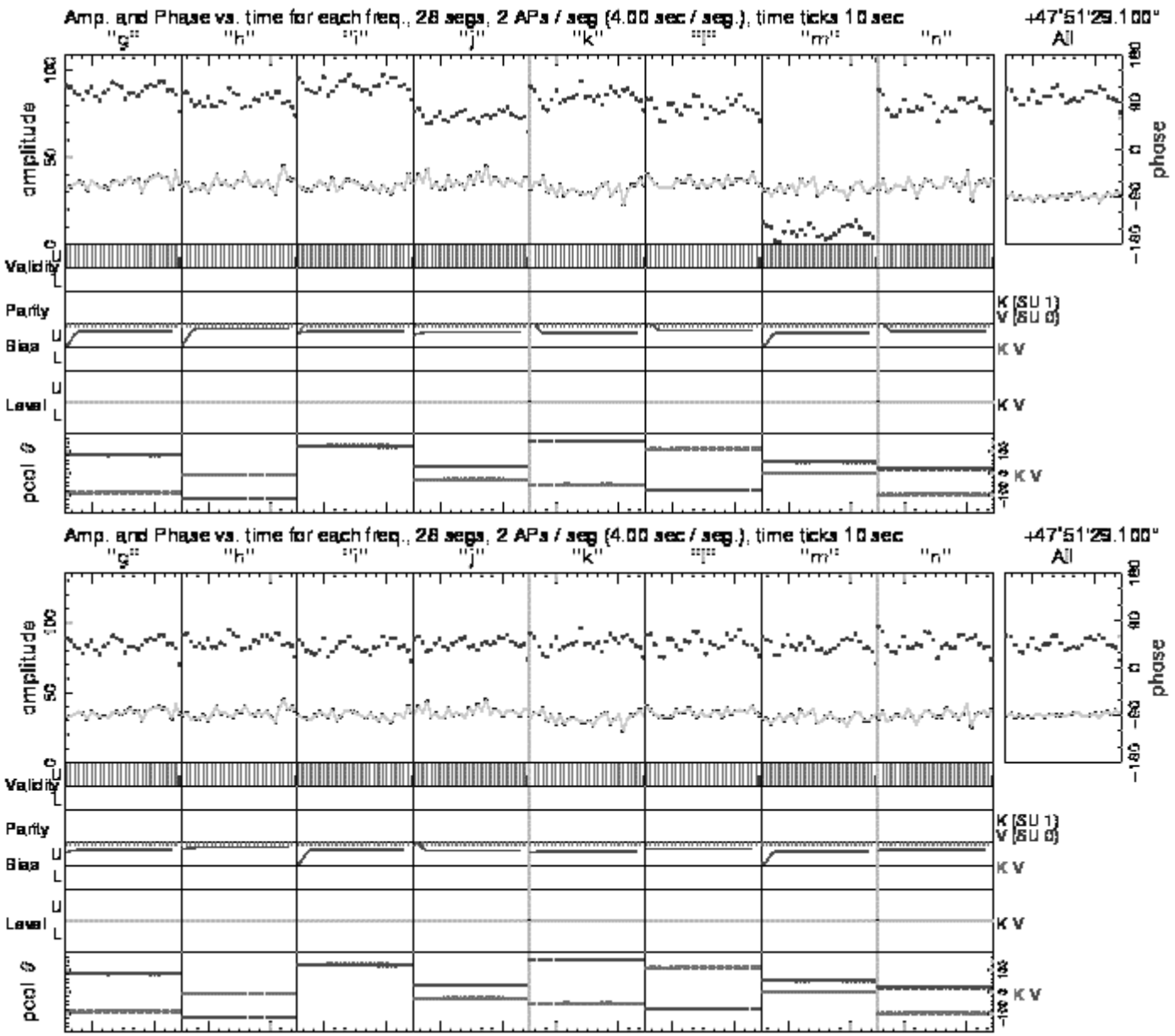
… for more accurate delay


freq2points
14
12
10
8
6
1
1.05
1.1

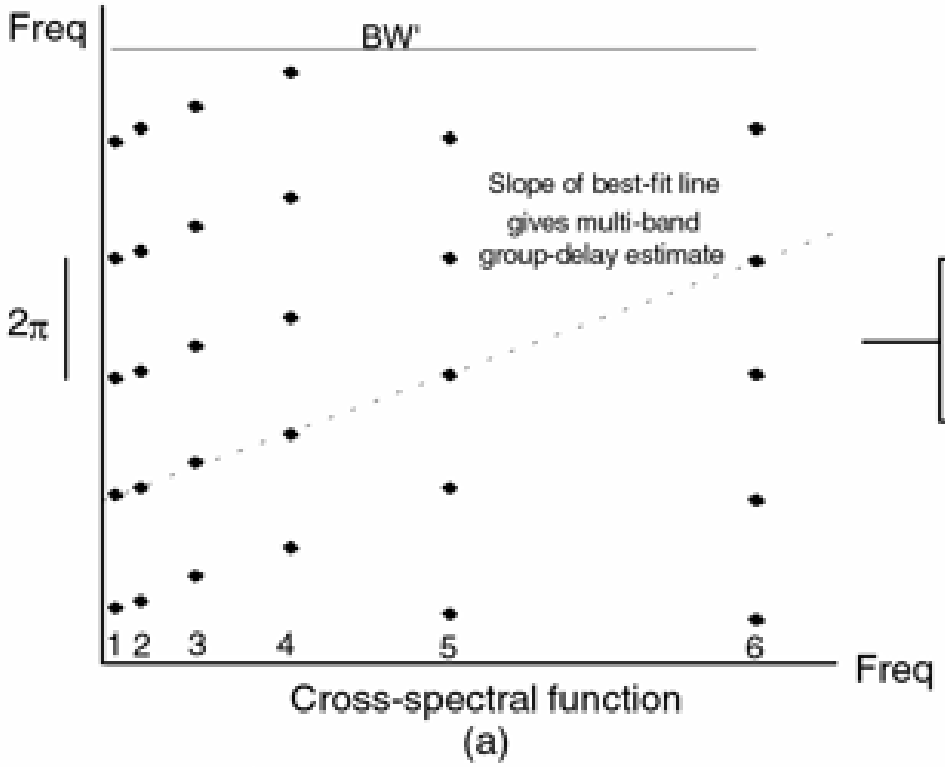

fourfreq
14
12
10
8
6
1
1.05
1.1


freqpoints
14
12
10
8
6
1
1.05
1.1

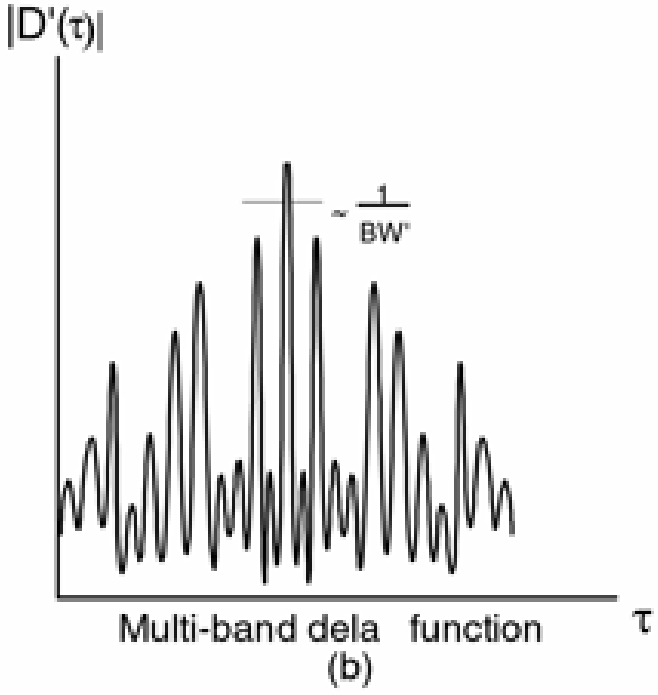
Phase-cal aligns the channels:

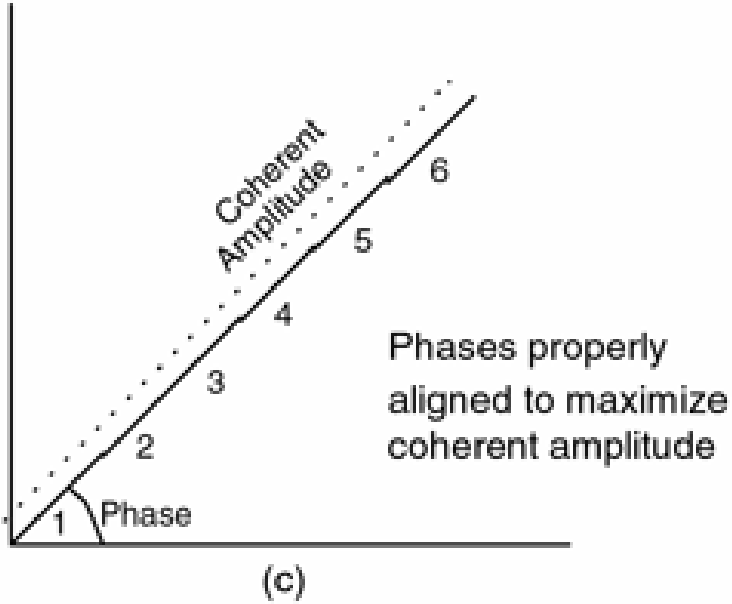


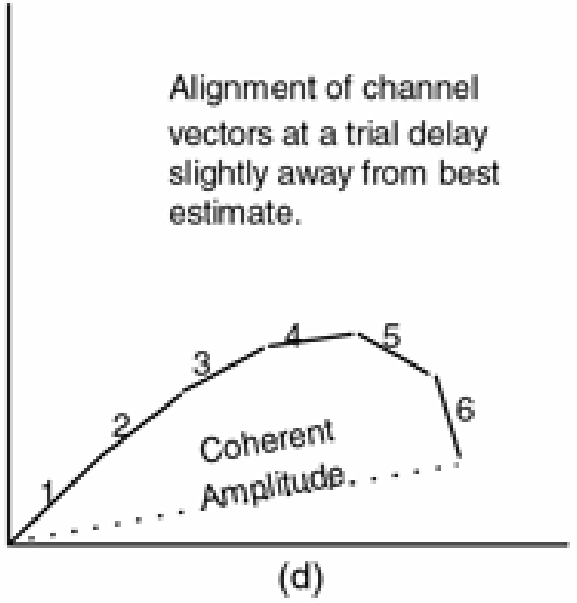
Multiband delay and ambiguities


Freq
BW'
Slope of best-fit line
gives multi-band
group-delay estimate
2π
1 2 3 4 5 6
Freq
Cross-spectral function
(a)

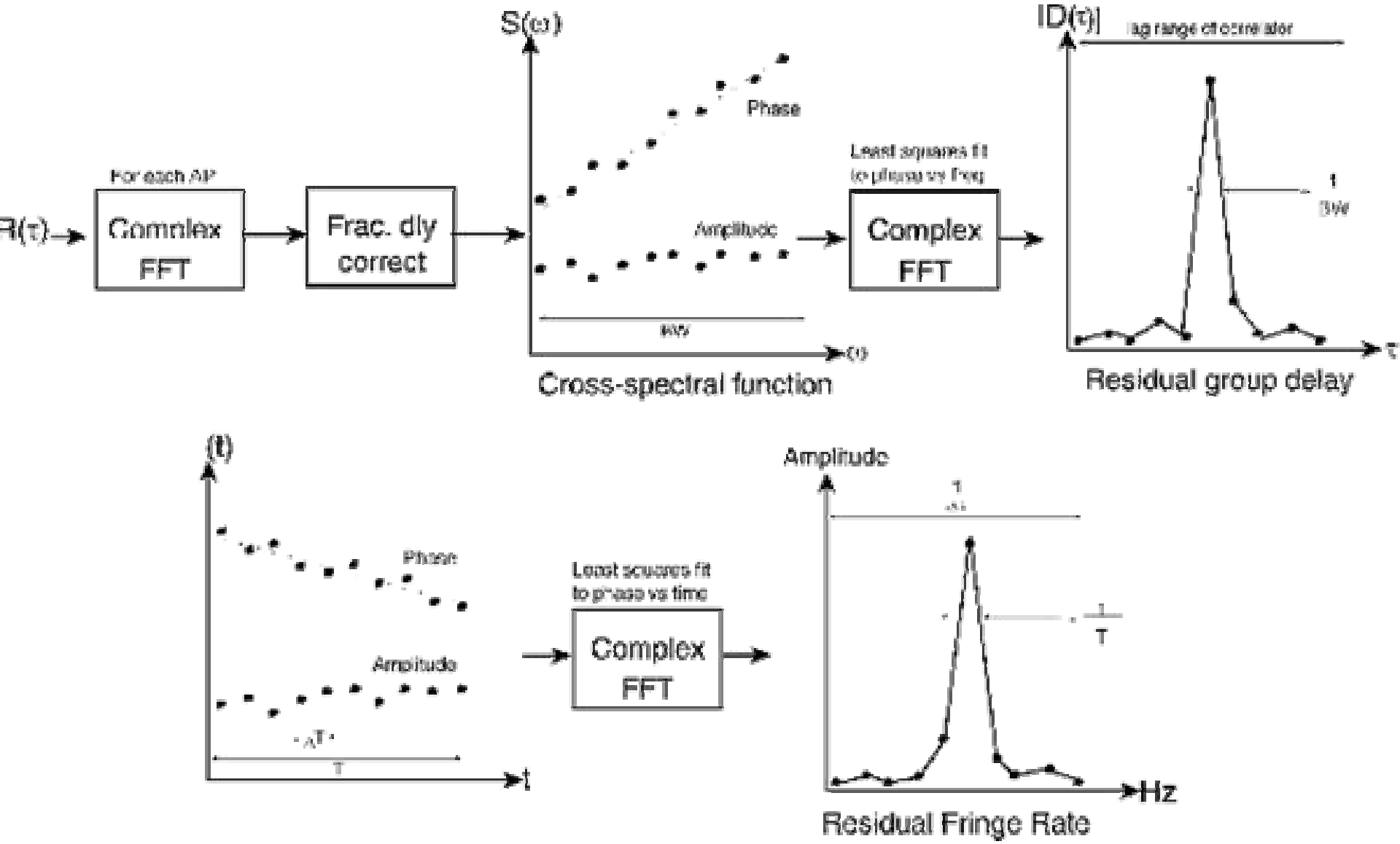
Complex FFT


|D'(τ)|
~ 1/BW'
Multi-band dela function
(b)
τ


Coherent
Amplitude
1 2 3 4 5 6
Phase
Phases properly
aligned to maximize
coherent amplitude
(c)


Alignment of channel
vectors at a trial delay
slightly away from best
estimate.
1 2 3 4 5 6
Coherent
Amplitude
(d)

Delay and delay rate


R(τ)
For each AP
Complex FFT
Frac. dly correct
S(ω)
Phase
Amplitude
ω
Least squares fit to phase vs freq
Complex FFT
ID(τ)
Cross-spectral function
Residual group delay
(t)
Phase
Amplitude
T
Least squares fit to phase vs time
Complex FFT
Amplitude
Hz
Residual Fringe Rate

Hardware and software structure

...of current Mark IV correlator

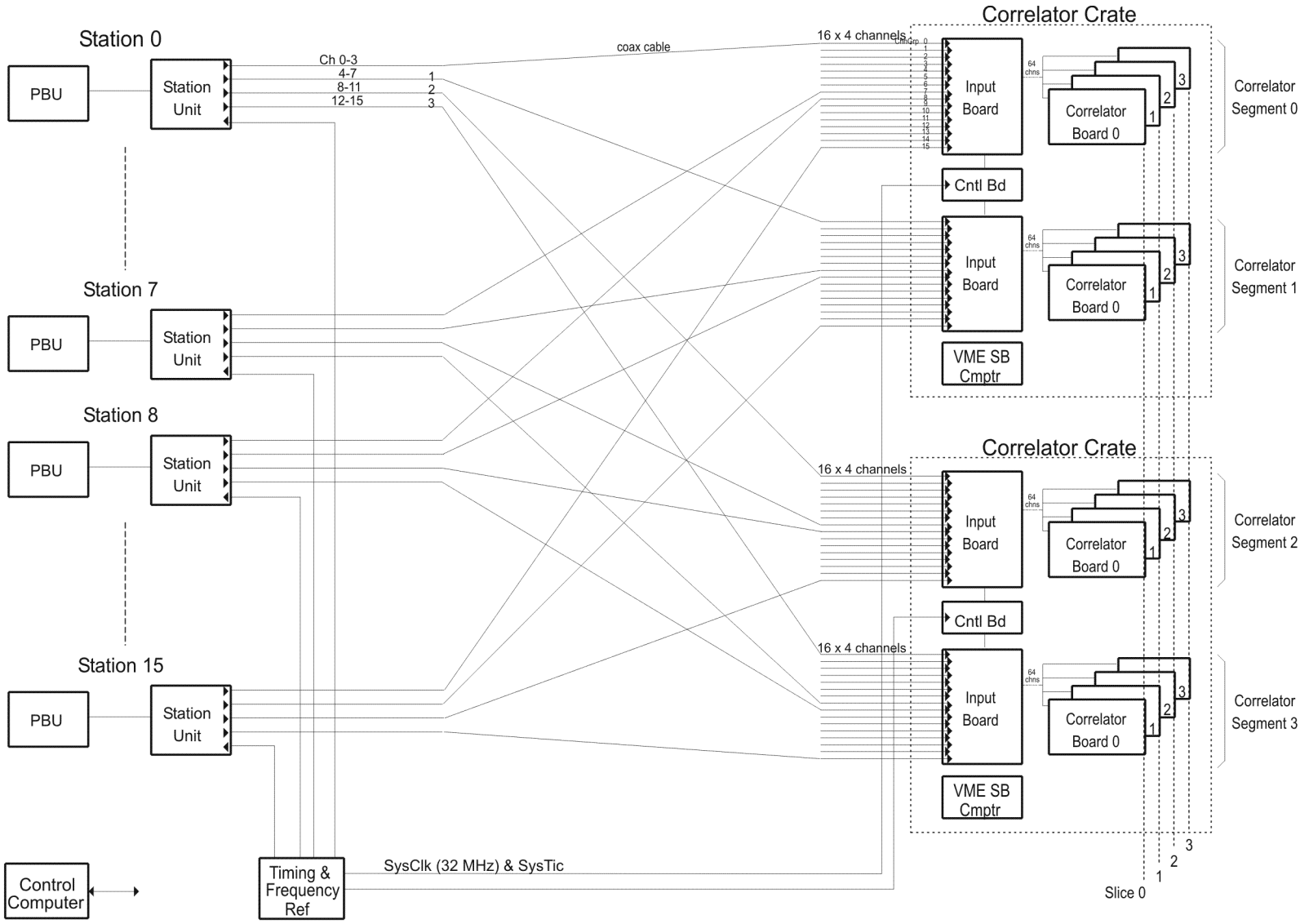


Figure 1: Correlator Block Diagram

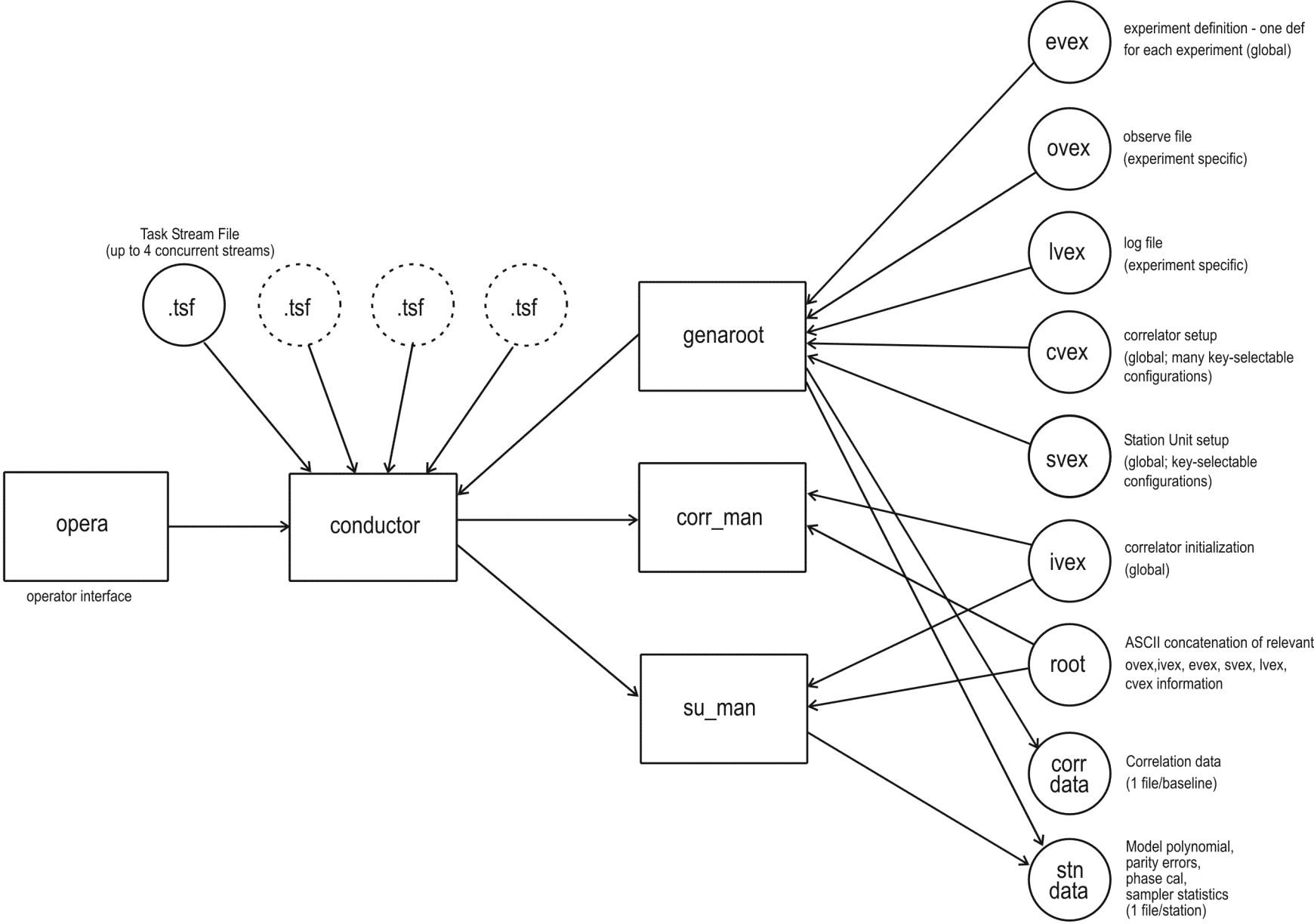
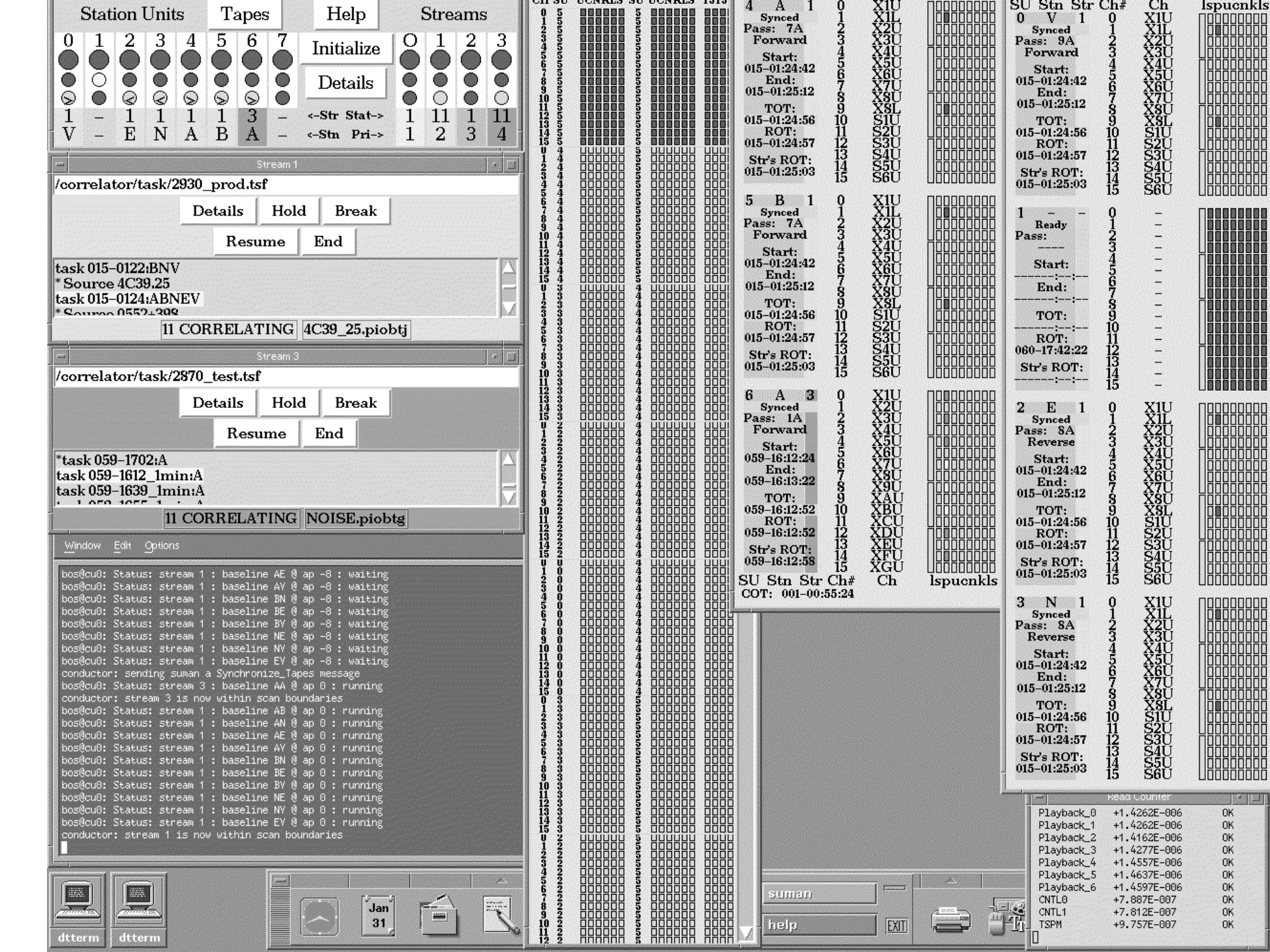


Figure 13: Simplified Mark 4 Correlator Software Block Diagram

ARW 981104
sequence1.drw


Station Units
Tapes
Help
Streams
Initialize
Details
<-Str Stat->
<-Stn Pri->
Stream 1
/correlator/task/2930_prod.tsf
Details
Hold
Break
Resume
End
task 015-0122:BNV
* Source 4C39.25
task 015-0124:ABNEV
11 CORRELATING
4C39_25.piobtj
Stream 3
/correlator/task/2870_test.tsf
Details
Hold
Break
Resume
End
*task 059-1702:A
task 059-1612_1min:A
task 059-1639_1min:A
11 CORRELATING
NOISE.piobtg
Window
Edit
Options
bos@cu0: Status: stream 1 : baseline AE @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline AV @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline BN @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline BE @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline BV @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline NE @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline NV @ ap -8 : waiting
bos@cu0: Status: stream 1 : baseline EV @ ap -8 : waiting
conductor: sending suman a Synchronize_Tapes message
bos@cu0: Status: stream 3 : baseline AA @ ap 0 : running
conductor: stream 3 is now within scan boundaries
bos@cu0: Status: stream 1 : baseline AB @ ap 0 : running
bos@cu0: Status: stream 1 : baseline AN @ ap 0 : running
bos@cu0: Status: stream 1 : baseline AE @ ap 0 : running
bos@cu0: Status: stream 1 : baseline AV @ ap 0 : running
bos@cu0: Status: stream 1 : baseline BN @ ap 0 : running
bos@cu0: Status: stream 1 : baseline BE @ ap 0 : running
bos@cu0: Status: stream 1 : baseline BV @ ap 0 : running
bos@cu0: Status: stream 1 : baseline NE @ ap 0 : running
bos@cu0: Status: stream 1 : baseline NV @ ap 0 : running
bos@cu0: Status: stream 1 : baseline EV @ ap 0 : running
conductor: stream 1 is now within scan boundaries
SU Stn Str Ch# Ch lspucnkls
COT: 001-00:55:24
Head Counter
Playback_0 +1.4262E-006 OK
Playback_1 +1.4262E-006 OK
Playback_2 +1.4162E-006 OK
Playback_3 +1.4277E-006 OK
Playback_4 +1.4557E-006 OK
Playback_5 +1.4637E-006 OK
Playback_6 +1.4597E-006 OK
CNTL0 +7.887E-007 OK
CNTL1 +7.812E-007 OK
TSPM +9.757E-007 OK
suman
help
EXIT
dtterm
dtterm
Jan
31

Overview of the life cycle for an experiment at the correlator

- Gather logs and schedules
- Inspect incoming media - put into library
- Compile logs and schedule in correlator format
- pick scans to find fringes
- select and run “pre-pass” scans

Overview continued …

- Construct processing/fourfit control files
- Schedule/production process/cleanup
- Analyze results/evaluate stations
- Export
- Release disks/tapes

What you can do for us

- Ship the disks or tapes fast!!
- Provide good documentation
- Avoid/fix severe problems before session
- Note special considerations for correlator

More details on shipping

- Ship right away
- Use TRACK
- Declare customs properly
- Use a good Courier
- Provide email notification

More details on documentation

- Put it in OPS messages - they are read first!
- Media (Disk/Tape) physical integrity
- Playback quality
- Clock/Maser
- Other regarding data quality, like
  - phase cal (LO OK?)/cable cal (don’t change)
  - any system performance issue
- Other issues

More details on severe problems

Possibly recoverable problems

- Mild to moderate tape tracking problems
- 1-2 Mark5 disk failures (in 8 pack)
- Bad playback other than tracking
- Errors which require special software patches

Unrecoverable severe problems

- Multiple (>2 of 8) Mark5 disk failures
- no fringes - for unknown reasons
- antenna/system performance/sensitivity
- unpatchable formatting problems
- wrong polarization
- formatter +- 30 milliseconds from int. sec.
- etc etc etc … (too many to list!)

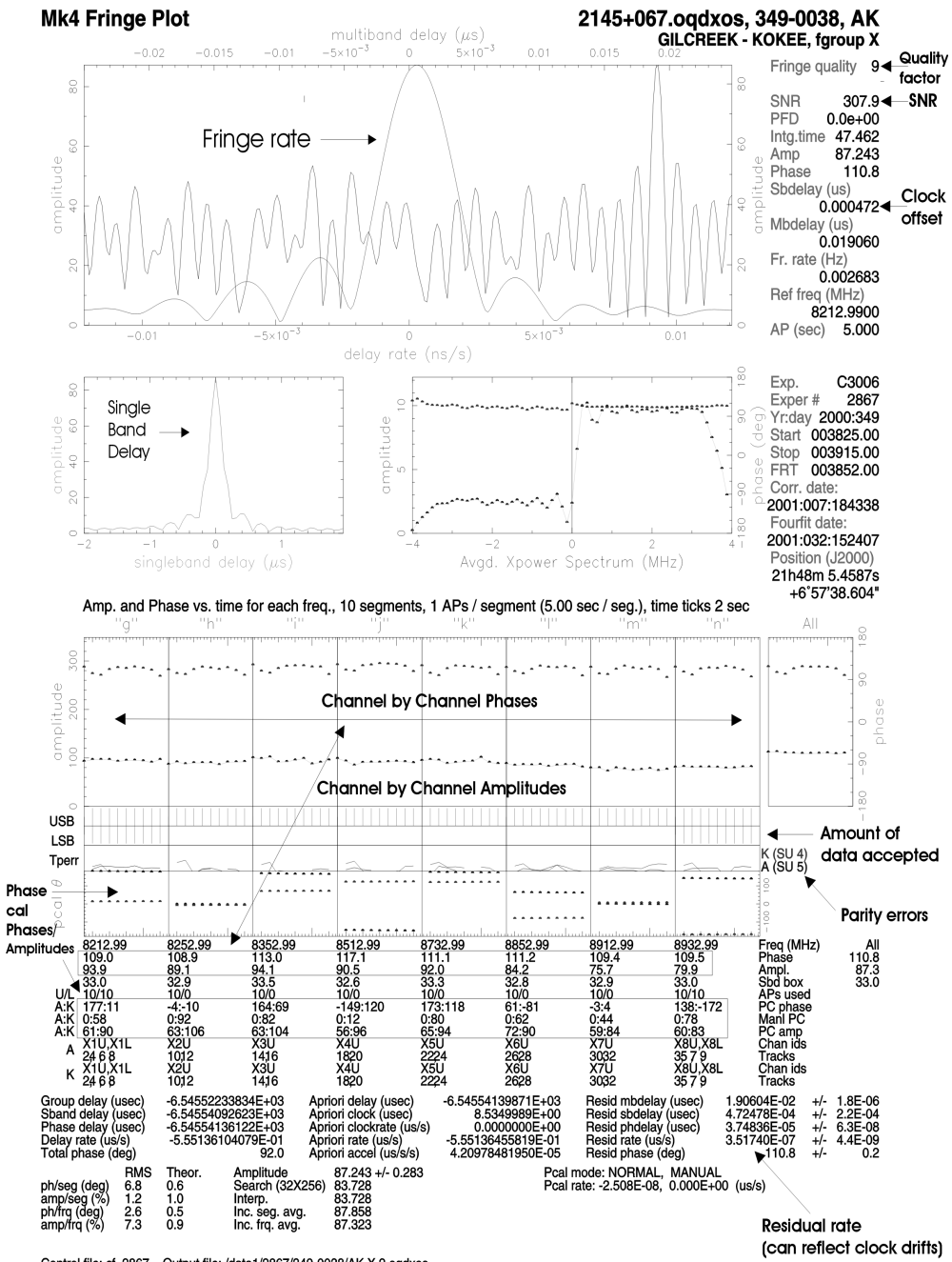
Special considerations

- Clock offset limitations
- Machine readable logs
- Barrel rolling/fan out effects

Analysis tools

Fourfit plots and aedit

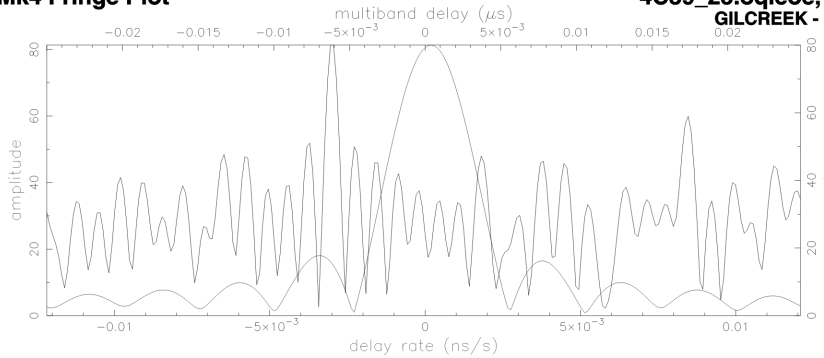
What we "spot check" on the fourfit plot at Pre-pass time:



Before Pcal Adjustments

Mk4 Fringe Plot — **4C39_25.oqleoe, 349-1515, AK**

GILCREEK - KOKEE, fgroup X

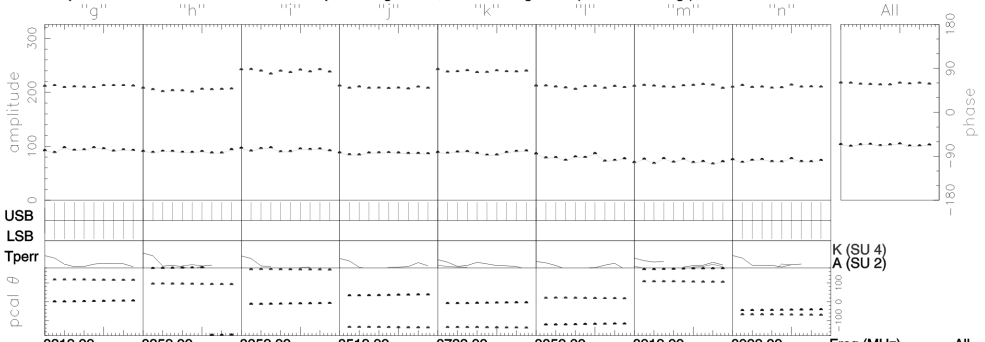


Fringe quality 8

SNR	290.3
PFD	0.0e+00
Intg.time	48.467
Amp	81.468
Phase	57.9
Sbdelay (us)	0.004591
Mbdelay (us)	-0.006151
Fr. rate (Hz)	0.001528
Ref freq (MHz)	8212.9900
AP (sec)	5.000

Exp.	C3006
Exper #	2867
Yr:day	2000:349
Start	151530.00
Stop	151620.00
FRT	151555.00
Corr. date:	2001:013:164023
Fourfit date:	2001:056:215326
Position (J2000)	09h27m 3.0139s
	+39°02'20.852"

Amp. and Phase vs. time for each freq., 10 segments, 1 APs / segment (5.00 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
	52.7	45.3	83.8	49.8	83.3	51.3	53.4	51.7	Phase	57.9
	93.1	89.3	93.2	86.3	87.7	78.1	71.6	72.8	Ampl.	83.8
	33.0	32.9	33.5	32.7	33.4	32.8	33.0	33.1	Sbd box	33.1
U/L	10/10	10/0	10/0	10/0	10/0	10/0	10/0	10/10	APs used	
A:K	1:114	179:92	-12:169	33:-138	-8:-139	-122:17	173:105	-46:-71	PC phase	
A:K	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	Manl PC	
A:K	62:87	64:104	63:102	56:95	65:94	72:88	60:83	61:82	PC amp	
A	X1U,X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U,X8L	Chan ids	
	2 4 6 8	1012	1416	1820	2224	2628	3032	35 7 9	Tracks	
K	X1U,X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U,X8L	Chan ids	
	2 4 6 8	1012	1416	1820	2224	2628	3032	35 7 9	Tracks	

Group delay (usec)	-1.50700901344E+03	Apriori delay (usec)	-1.50700286221E+03	Resid mbdelay (usec)	-6.15123E-03	+/-	2.0E-06
Sband delay (usec)	-1.50699827170E+03	Apriori clock (usec)	8.5349989E+00	Resid sbdelay (usec)	4.59052E-03	+/-	2.4E-04
Phase delay (usec)	-1.50700284264E+03	Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	1.95730E-05	+/-	6.7E-08
Delay rate (us/s)	1.35282056167E-02	Apriori rate (us/s)	1.35280865067E-02	Resid rate (us/s)	1.19110E-07	+/-	4.6E-09
Total phase (deg)	-99.6	Apriori accel (us/s/s)	4.56934496521E-05	Resid phase (deg)	57.9	+/-	0.2

	RMS	Theor.	Amplitude	81.468 +/- 0.281
ph/seg (deg)	1.4	0.6	Search (32X256)	79.081
amp/seg (%)	1.4	1.0	Interp.	79.081
ph/frq (deg)	14.1	0.5	Inc. seg. avg.	81.498
amp/frq (%)	10.5	0.9	Inc. frq. avg.	83.794

Pcal mode: NORMAL, NORMAL
Pcal rate: 4.267E-08, -2.432E-08 (us/s)

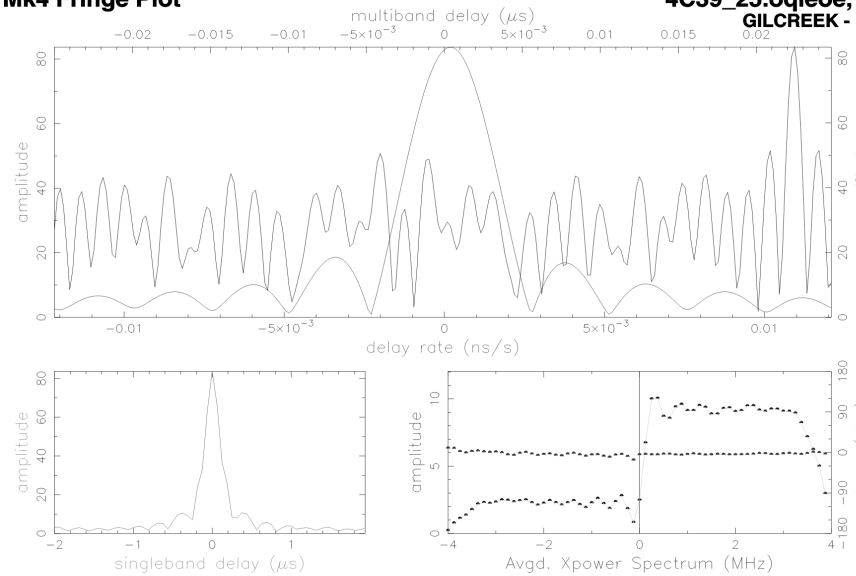
Control file: /correlator/data/2867/cf_2867_nophases Output file: Suppressed by test mode

After Pcal Adjustments

Mk4 Fringe Plot

4C39_25.oqleoe, 349-1515, AK

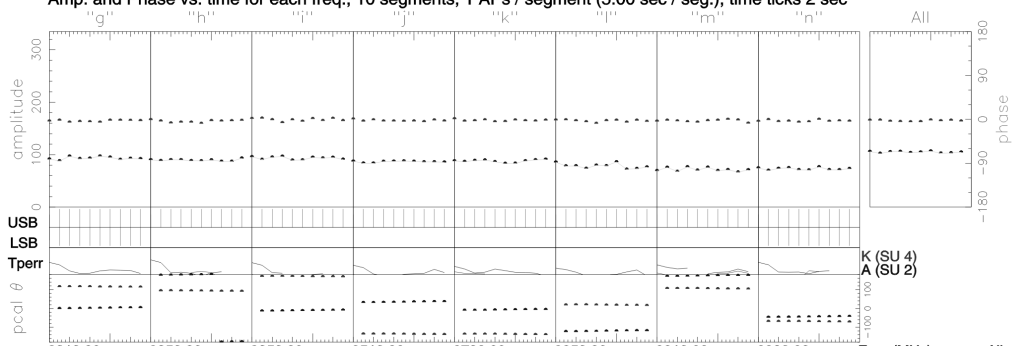
GILCREEK - KOKEE, fgroup X



Fringe quality 9

SNR	298.6
PFD	0.0e+00
Intg.time	48.467
Amp	83.706
Phase	-3.4
Sbdelay (us)	0.002143
Mbdelay (us)	0.022415
Fr. rate (Hz)	0.001524
Ref freq (MHz)	8212.9900
AP (sec)	5.000
Exp.	C3006
Exper #	2867
Yr:day	2000:349
Start	151530.00
Stop	151620.00
FRT	151555.00
Corr. date:	2001:013:164023
Fourfit date:	2001:056:215441
Position (J2000)	09h27m 3.0139s
	+39°02'20.852"

Amp. and Phase vs. time for each freq., 10 segments, 1 APs / segment (5.00 sec / seg.), time ticks 2 sec



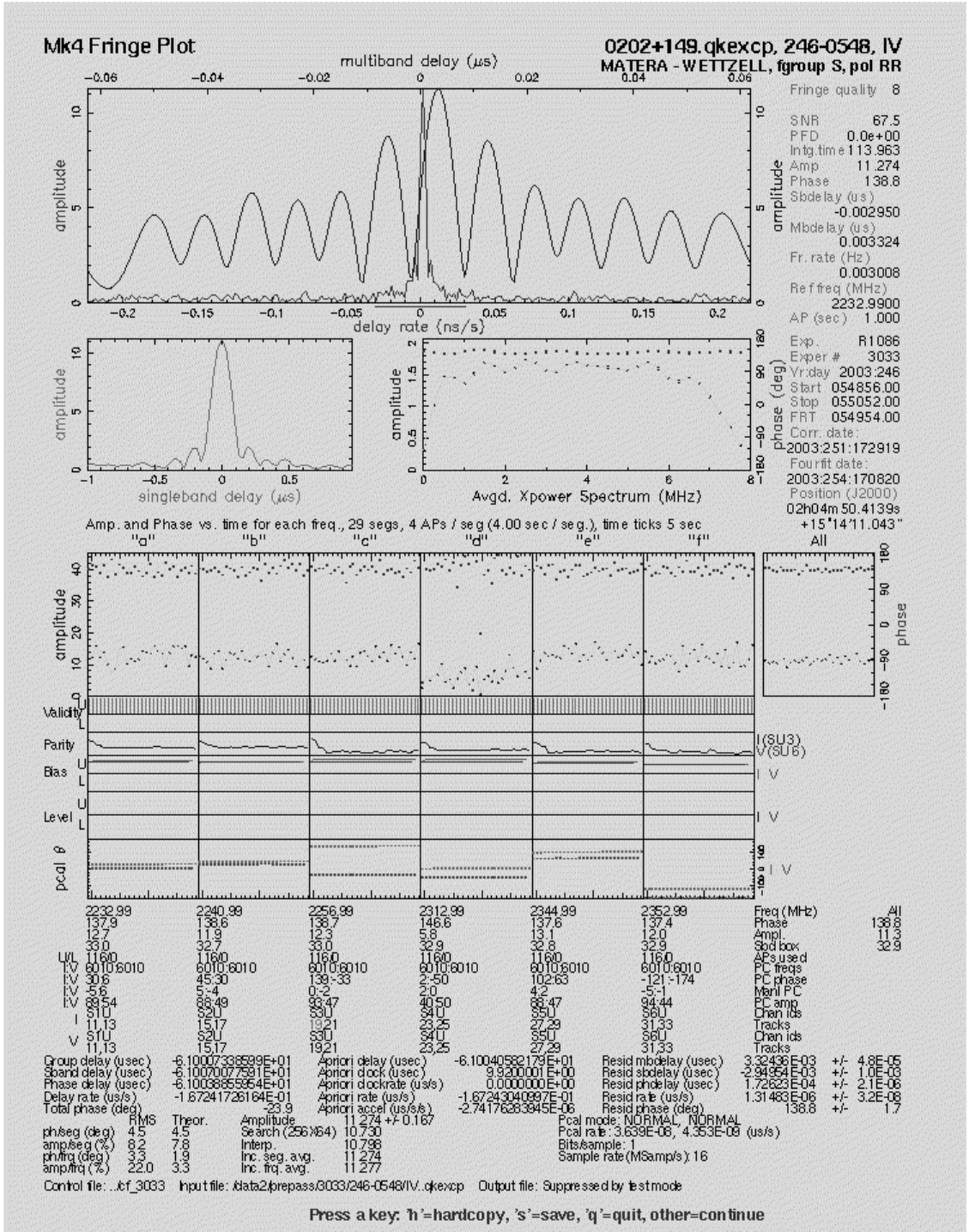
	8212.99	8252.99	8352.99	8512.99	8732.99	8852.99	8912.99	8932.99	Freq (MHz)	All
	-3.8	-4.6	-1.3	-3.1	-2.9	-3.8	-3.6	-3.7	Phase	-3.4
	93.0	89.2	93.1	86.3	87.6	78.1	71.5	72.7	Ampl.	83.7
	33.0	32.9	33.5	32.7	33.4	32.8	33.0	33.1	Sbd box	33.0
U/L	10/10	10/0	10/0	10/0	10/0	10/0	10/0	10/10	APs used	
A:K	1:114	179:92	-12:169	33:-138	-8:-139	-122:17	173:105	-46:-71	PC phase	
A:K	0:58	0:92	0:82	0:12	0:80	0:62	0:44	0:78	Manl PC	
A:K	62:87	64:104	63:102	56:95	65:94	72:88	60:83	61:82	PC amp	
A	X1U,X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U,X8L	Chan ids	
	2 4 6 8	10 12	14 16	18 20	22 24	26 28	30 32	35 7 9	Tracks	
K	X1U,X1L	X2U	X3U	X4U	X5U	X6U	X7U	X8U,X8L	Chan ids	
	2 4 6 8	10 12	14 16	18 20	22 24	26 28	30 32	35 7 9	Tracks	

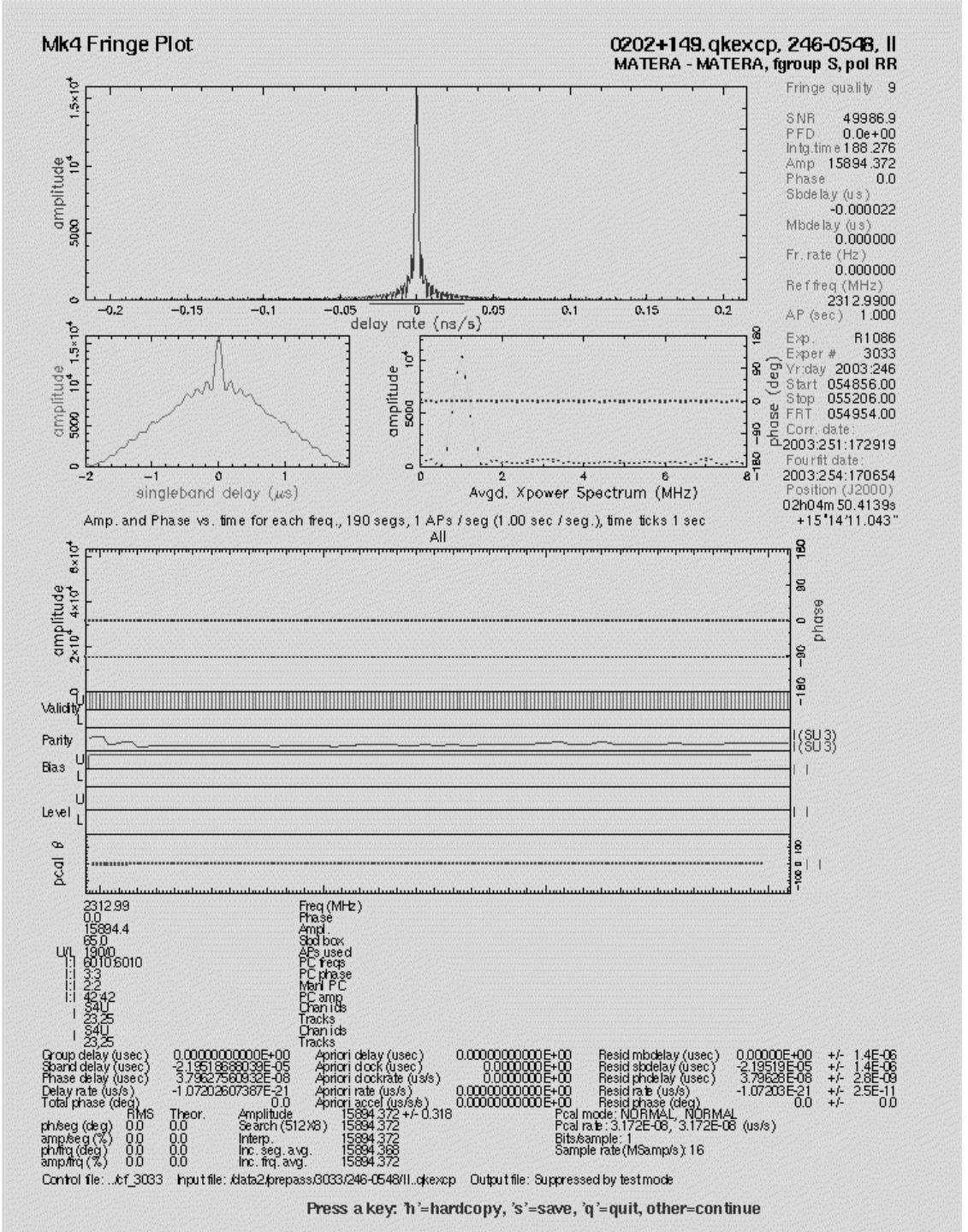
Group delay (usec)	-1.50698044769E+03	Apriori delay (usec)	-1.50700286221E+03	Resid mbdelay (usec)	2.24145E-02	+/- 1.9E-06
Sband delay (usec)	-1.50700071947E+03	Apriori clock (usec)	8.5349989E+00	Resid sbdelay (usec)	2.14274E-03	+/- 2.3E-04
Phase delay (usec)	-1.50702863337E+03	Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	-1.15461E-06	+/- 6.5E-08
Delay rate (us/s)	1.35282294357E-02	Apriori rate (us/s)	1.35280865067E-02	Resid rate (us/s)	1.42929E-07	+/- 4.5E-09
Total phase (deg)	-160.8	Apriori accel (us/s/s)	4.56934496521E-05	Resid phase (deg)	-3.4	+/- 0.2

	RMS	Theor.		
			Amplitude	83.706 +/- 0.280
ph/seg (deg)	1.4	0.6	Search (32X256)	82.545
amp/seg (%)	1.4	1.0	Interp.	82.545
ph/frq (deg)	0.9	0.5	Inc. seg. avg.	83.726
amp/frq (%)	9.7	0.9	Inc. frq. avg.	83.712

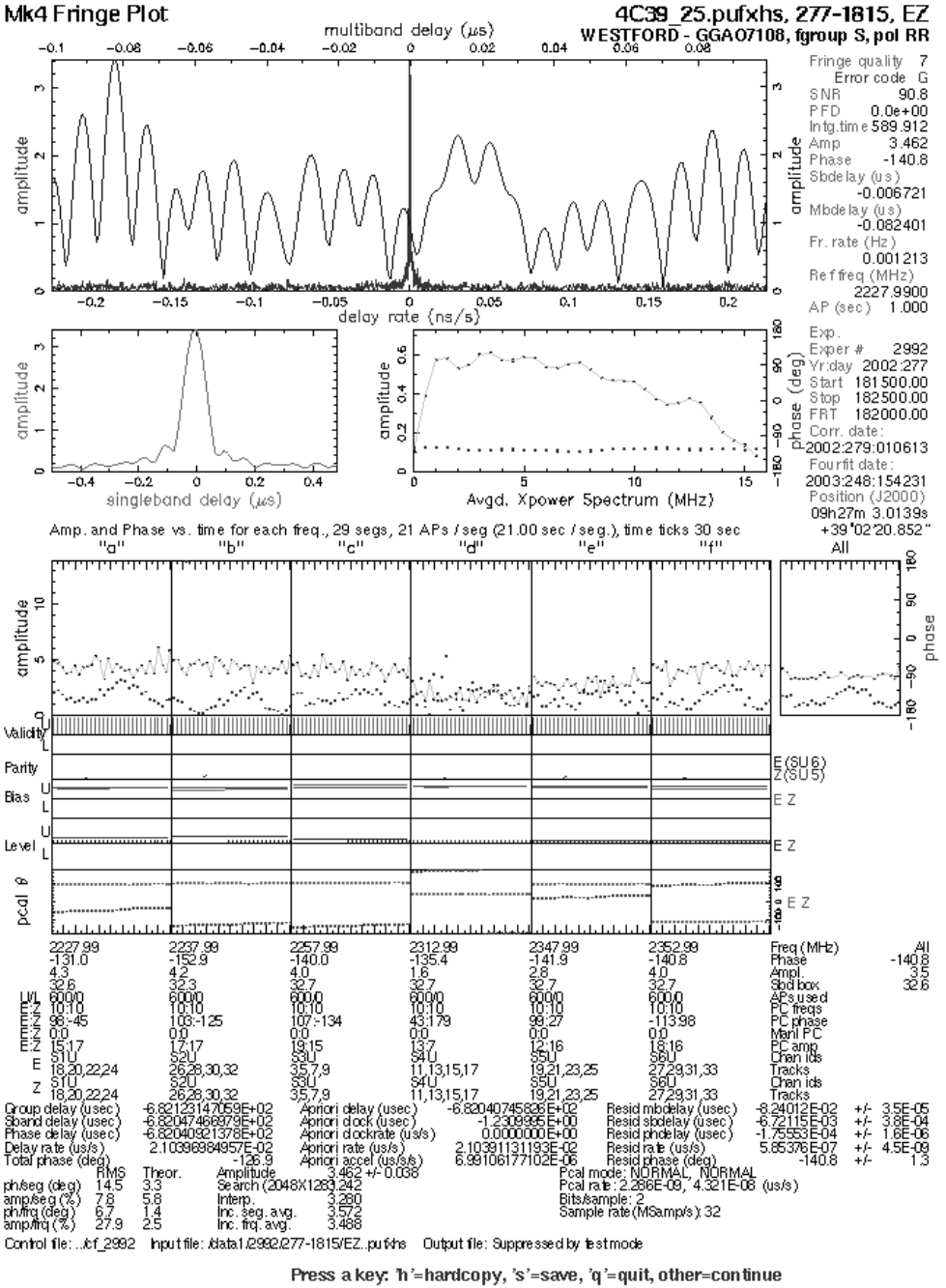
Pcal mode: NORMAL, MANUAL
Pcal rate: 4.267E-08, 0.000E+00 (us/s)

Control file: ../cf_2867 Output file: Suppressed by test mode


Mk4 Fringe Plot
0202+149.qkexcp, 246-0548, IV
MATERA - WETTZELL, fgroup S, pol RR
multiband delay (μs)
amplitude
delay rate (ns/s)
singleband delay (μs)
Avgd. Xpower Spectrum (MHz)
phase (deg)
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
Ref freq (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
"a" "b" "c" "d" "e" "f" All
Validity
Parity
Bias
Level
pcal θ
phase
I(SU3) V(SU6)
2232.99 2240.99 2256.99 2312.99 2344.99 2352.99 Freq (MHz) All
137.9 138.6 138.7 146.6 137.6 137.4 Phase 138.8
12.7 11.9 12.3 5.8 13.1 12.0 Ampl. 11.3
33.0 32.7 33.0 32.9 32.8 32.9 Sbd box 32.9
U/L 1160 1160 1160 1160 1160 1160 APs used
I:V 6010:6010 6010:6010 6010:6010 6010:6010 6010:6010 6010:6010 PC freqs
I:V 30:6 45:30 139:-33 2:-50 102:63 -121:-174 PC phase
I:V -5:6 5:-4 0:-2 2:0 4:2 -5:-1 Manl PC
I:V 89:54 88:49 90:47 40:50 88:47 94:44 PC amp
I S1U S2U S3U S4U S5U S6U Chan ids
I 11,13 15,17 19,21 23,25 27,29 31,33 Tracks
V S1U S2U S3U S4U S5U S6U Chan ids
V 11,13 15,17 19,21 23,25 27,29 31,33 Tracks
Group delay (usec) -6.100073385991E+01 Apriori delay (usec) -6.100405821791E+01 Resid mbdelay (usec) 3.32438E-03 +/- 4.8E-05
Sbband delay (usec) -6.100700775911E+01 Apriori clock (usec) 9.9200001E+00 Resid sbdelay (usec) -2.94954E-03 +/- 1.0E-03
Phase delay (usec) -6.100388559564E+01 Apriori clockrate (us/s) 0.0000000E+00 Resid phdelay (usec) 1.72623E-04 +/- 2.1E-06
Delay rate (us/s) -1.672417261164E-01 Apriori rate (us/s) -1.672430409971E-01 Resid rate (us/s) 1.31483E-06 +/- 3.2E-08
Total phase (deg) -23.9 Apriori accel (us/s/s) -2.741762839345E-06 Resid phase (deg) 138.8 +/- 1.7
RMS Theor. Amplitude 11.274 +/- 0.167
ph/seg (deg) 4.5 4.5 Search (256X64) 10.730
amp/seg (%) 8.2 7.8 Interp. 10.798
ph/frq (deg) 3.3 1.9 Inc. seg. avg. 11.274
amp/frq (%) 22.0 3.3 Inc. frq. avg. 11.277
Pcal mode: NORMAL, NORMAL
Pcal rate: 3.639E-08, 4.353E-09 (us/s)
Bits/sample: 1
Sample rate (MSamp/s): 16
Control file: ../cf_3033 Input file: /data2/prepass/3033/246-0548/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 188.276
Amp 15894.372
Phase 0.0
Sbdelay (us) -0.000022
Mbdelay (us) 0.000000
Fr. rate (Hz) 0.000000
Ref freq (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) 02h04m50.4139s +15°14'11.043"
amplitude
delay rate (ns/s)
singleband delay (μs)
Avgd. Xpower Spectrum (MHz)
phase (deg)
Amp. and Phase vs. time for each freq., 190 segs, 1 APs / seg (1.00 sec / seg.), time ticks 1 sec
All
Validity
Parity
Bias
Level
pcal θ
2312.99 Freq (MHz)
0.0 Phase
15894.4 Ampl.
65.0 Sbd box
U/L 19000 APs used
60106010 PC freqs
3:3 PC phase
2:2 Manl PC
42:42 PC amp
S4U Chan ids
23,25 Tracks
S4U Chan ids
23,25 Tracks
Group delay (usec) 0.000000000000E+00
Sband delay (usec) -2.195186880039E-05
Phase delay (usec) 3.796275600932E-08
Delay rate (us/s) -1.072026073B7E-21
Total phase (deg) 0.0
Apriori delay (usec) 0.000000000000E+00
Apriori clock (usec) 0.000000000000E+00
Apriori clockrate (us/s) 0.000000000000E+00
Apriori rate (us/s) 0.000000000000E+00
Apriori accel (us/s/s) 0.000000000000E+00
Resid mbdelay (usec) 0.00000E+00 +/- 1.4E-06
Resid sbdelay (usec) -2.19519E-05 +/- 1.4E-06
Resid phdelay (usec) 3.79628E-08 +/- 2.8E-09
Resid rate (us/s) -1.07203E-21 +/- 2.5E-11
Resid phase (deg) 0.0 +/- 0.0
RMS Theor.
ph/seg (deg) 0.0 0.0
amp/seg (%) 0.0 0.0
ph/frq (deg) 0.0 0.0
amp/frq (%) 0.0 0.0
Amplitude 15894.372 +/- 0.318
Search (512X8) 15894.372
Interp. 15894.372
Inc. seg. avg. 15894.368
Inc. frq. avg. 15894.372
Pcal mode: NORMAL, NORMAL
Pcal rate: 3.172E-08, 3.172E-08 (us/s)
Bits/sample: 1
Sample rate (MSamp/s): 16
Control file: ../cf_3033 Input file: /data2/prepass/3033/246-0548/II..qkexcp Output file: Suppressed by test mode
Press a key: 'h'=hardcopy, 's'=save, 'q'=quit, other=continue

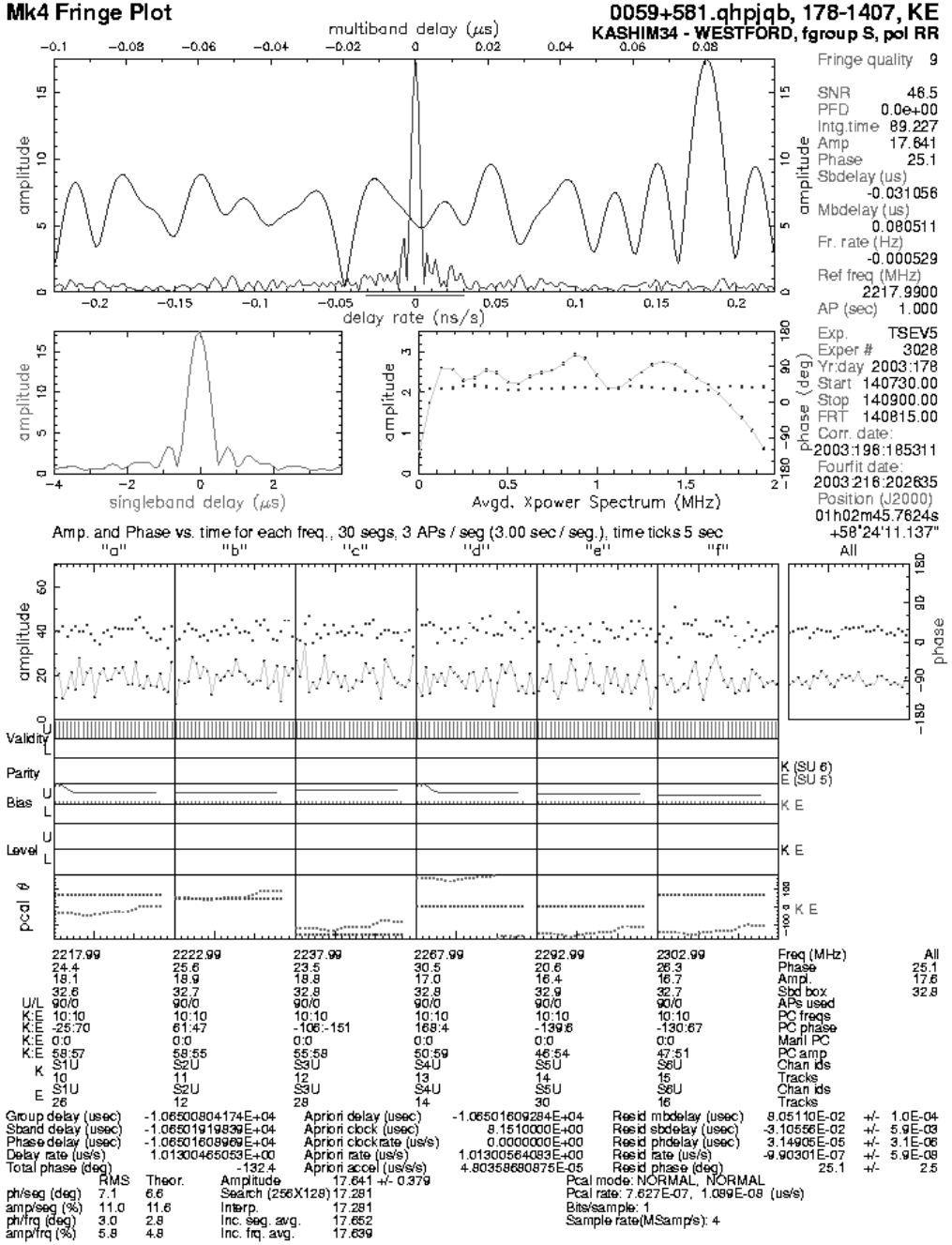
ghostscript



Mk4 Fringe Plot

0059+581.qhpjqb, 178-1407, KE

KASHIM34 - WESTFORD, fgroup S, pol RR



Fringe quality 9

SNR	46.5
PFD	0.0e+00
Intg.time	89.227
Amp	17.641
Phase	25.1
Sbdelay (us)	-0.031056
Mbdelay (us)	0.080511
Fr. rate (Hz)	-0.000529
Ref freq (MHz)	2217.9900
AP (sec)	1.000
Exp.	TSEV5
Exper #	3028
Yr:day	2003:178
Start	140730.00
Stop	140900.00
FRT	140815.00
Corr. date:	2003:196:185311
Fourfit date:	2003:216:202635
Position (J2000)	01h02m45.7624s
	+58°24'11.137"

	2217.99	2222.99	2237.99	2267.99	2292.99	2302.99	Freq (MHz)	All
	24.4	25.6	23.5	30.5	20.6	26.3	Phase	25.1
	18.1	18.9	18.8	17.0	16.4	16.7	Ampl.	17.6
	32.6	32.7	32.8	32.8	32.9	32.7	Sbd box	32.8
U/L	90/0	90/0	90/0	90/0	90/0	90/0	APs used	
K:E	10:10	10:10	10:10	10:10	10:10	10:10	PC freqs	
K:E	-25:70	61:47	-106:-151	168:4	-139:6	-130:67	PC phase	
K:E	0:0	0:0	0:0	0:0	0:0	0:0	Manl PC	
K:E	58:57	58:55	55:58	50:59	46:54	47:51	PC amp	
K	S1U	S2U	S3U	S4U	S5U	S6U	Chan ids	
	10	11	12	13	14	15	Tracks	
E	S1U	S2U	S3U	S4U	S5U	S6U	Chan ids	
	26	12	28	14	30	16	Tracks	

Group delay (usec)	-1.06500804174E+04	Apriori delay (usec)	-1.06501609284E+04	Resid mbdelay (usec)	8.05110E-02	+/-	1.0E-04
Sband delay (usec)	-1.06501919839E+04	Apriori clock (usec)	8.1510000E+00	Resid sbdelay (usec)	-3.10556E-02	+/-	5.9E-03
Phase delay (usec)	-1.06501608969E+04	Apriori clockrate (us/s)	0.0000000E+00	Resid phdelay (usec)	3.14905E-05	+/-	3.1E-06
Delay rate (us/s)	1.01300465053E+00	Apriori rate (us/s)	1.01300564083E+00	Resid rate (us/s)	-9.90301E-07	+/-	5.9E-08
Total phase (deg)	-132.4	Apriori accel (us/s/s)	4.80358680875E-05	Resid phase (deg)	25.1	+/-	2.5

	RMS	Theor.
ph/seg (deg)	7.1	6.6
amp/seg (%)	11.0	11.6
ph/frq (deg)	3.0	2.8
amp/frq (%)	5.8	4.8

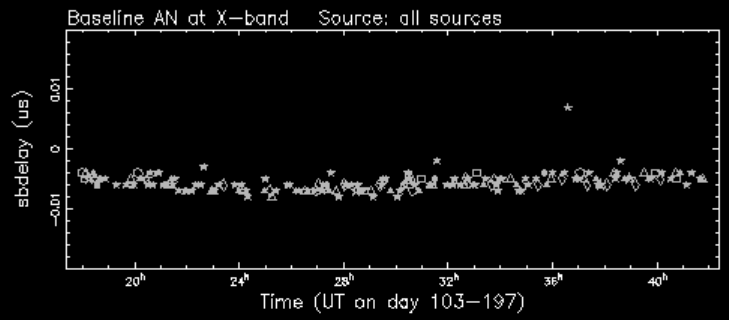
Amplitude	17.641 +/- 0.379
Search (256X128)	17.281
Interp.	17.281
Inc. seg. avg.	17.652
Inc. frq. avg.	17.639

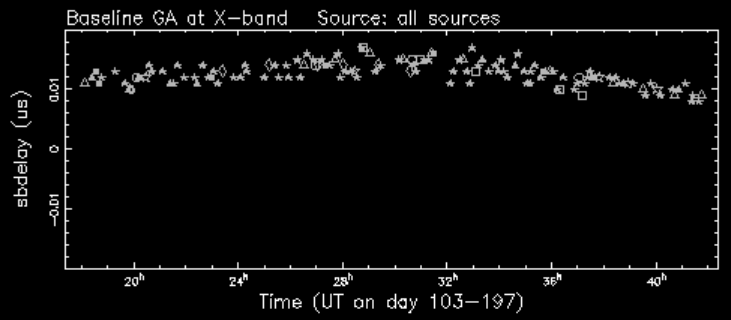
Pcal mode: NORMAL, NORMAL
Pcal rate: 7.627E-07, 1.089E-08 (us/s)
Bits/sample: 1
Sample rate(MSamp/s): 4

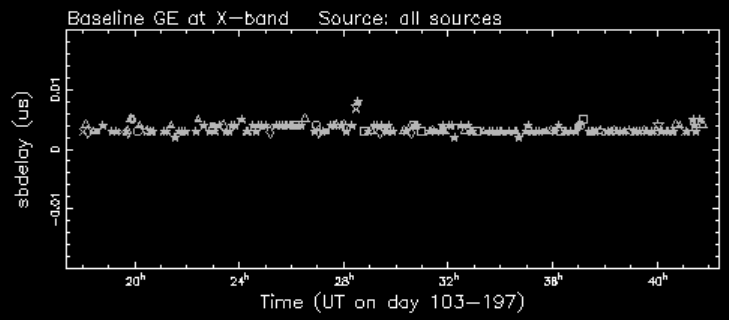
Control file: ../cf_3028 Input file: /data1/3028/178-1407/KE..qhpjqb Output file: Suppressed by test mode

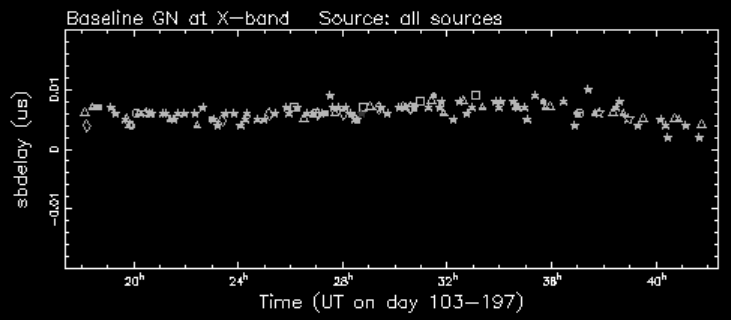
PGPLOT Window 1

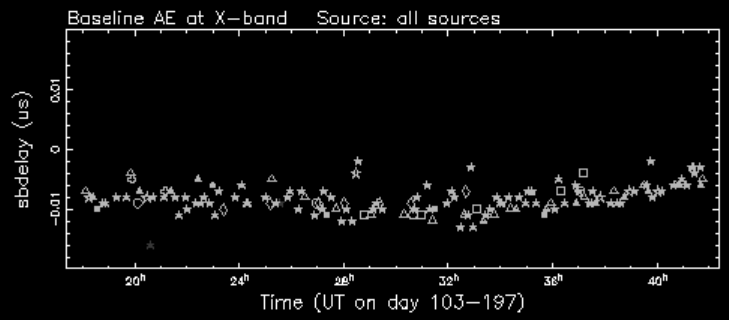
AEDIT plot – Expt 3030, Freq X

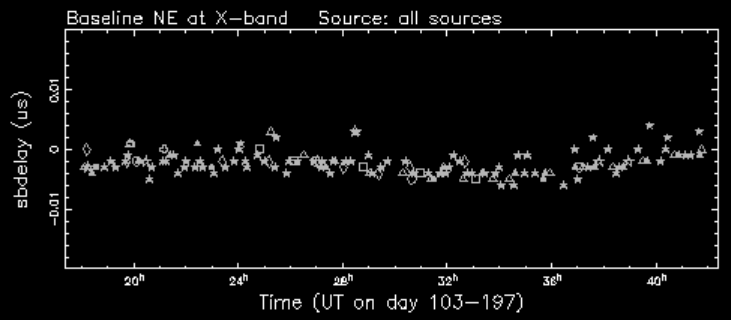












Symbol key: ○ = 1357+769, × = 0727−115, □ = 2136+141, △ = 0133+476, ◊ = 1611+343, ✱ = 0955+476
▲ = 0552+398, ⊕ = 3C418, ■ = 1308+326, ♦ = 0014+813, ★ = the rest

What we can do for you

- Provide feedback after checkout
  - IF/freq./pol./clock/LO/pcal performance
  - antenna/system/setup/formatter performance
  - RFI/recording problems
  - any/many other issues!
- Provide correlator reports upon completion.
  - Contains summary/evaluation

Conclusion

Correlator is a powerful diagnostic tool!

Correlator Demonstration