VLBA TEST MEMO NO. 39

Phasecal phase stability with the new Pulsecal generator at Pie Town

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The observing setup for the phase stability tests (on 1992SEP01) is shown in the schemetic diagram (figure 1). The Observations were made at frequency bands S/X with fexfer in split mode and the antenna was stowed till atleast 1500 UT. The RF frequencies of the 10 kHz tones in various baseband converters, and their phases (in terms of phase of the injected rf signal, first local oscillator, and BBC LO) are also given in figure 1. Notice the dependence of the BBC output phases on the RF signal, first LO and the BBC LO signals for various BBCs. For BBCs 1,2,3 it is rf phase minus first LO phase minus BBC LO phase; for BBCs 4,5,6 it is rf phase minus first LO phase plus BBC LO phase; for BBCs 7,8 it is minus rf phase plus LO phase minus BBC LO phase. Our objective was to find out magnitude of phase variations of different signals and causes of their variations by comparing dependence on the RF, first LO, and BBC LO signals and their frequencies. We assume that to first order all rf sdgnals are effected by same delay, and similarly all three 2-16 GHz synthesizers, and 5 MHz reference for all BBCs are affected same amount.

DATA:

1 Figure 2 shows the length variations with time of the 500 MHz reference cable between the LO Transmitter in C-rack and the LO Receiver in the B-rack.
2. Figures 3 and 4 show temperature with time monitored by various temperature monitors in the antenna and the station building. Unfortunately the ambient temperature monitor (Address #411B) was not working during this period.
3. Figure 5 shows phasecal phase of the 10 kHz tones in all the BBCs. Frequency of the RF signal, first LO and the BBC LO for each 10 kHz BBC signal are marked on the phasecal phases in the figure.

DISCUSSIONS:

Building temperature plots in figure 3 show periodic temperature variations of about one hour periodicity with p-p temperature variations of about 6-7 deg C for the Contempo (air conditioner unit) air output. These variations are damped out to about 3-4 deg C in C-rack, ~2 deg C in DAR, and show <2 deg C variations in the electronics and control room temperatures.

The cable length variations (cablecal) in figure 2 donot show any noticable ripple with periodicity of about 1 hour. This indicates that the length changes of the .141 semirigid cable in the C-rack plus the Heliax cable under the floor level due to the temperature cycling are not significant (at a few psec), and the assumption of the temperature coefficient of the standard .141 semirigid cable in the VLBA Electronics Memo. #134 are too high.

The BBC output phases in figure 5 show a lot of features. There are a number of occasions like epoch t1,t2 etc. marked in the figure when the phases show jumps or rapid variations. Also there is about one hour periodicity in the phases, which has larger p-p variations with higher BBC LO frequency and opposite sign for BBCs 1,2,3,7,and 8 than BBCs 4,5 and 6. This indicates that it is due to the BBC LO and is probably due to variations in the 5 MHz reference. BBC7 phase has a lot more jumps than any other BBC phase. This is probably due to input connections to the BBC7. Phase jumps at epochs t1, t4, and t10 seem to be proportional to rf/first LO frequency, and are not seen in the cablecal and therefore are (probably) due to phasecal rf signal. Phase jump around t8 seems to be first LO dependent.

By summing or taking difference of the output phases from different BBCs we can see phase stability dependence on RF signal, first LO and BBC LO frequencies. This gives an idea about the phase stability of the rf (injected) pulsecal, first LO, and BBC LO signals. In turn we can estimate stability of the 500 MHz reference, the 5 MHz BBC LO reference. We have considered the following combinations of phases:

Figure	Trace	Phase combination	Dependence
6	1	BBC3-BBC1	$\phi_{rf480} - \phi_{BBC480}$
	2	BBC6-BBC4	$-(\phi_{rf480} - \phi_{BBC480})$
	3	BBC8-BBC7	$\phi_{rf380} - \phi_{BBC380}$
7	4	BBC4-BBC1	$\phi_{rf780} - \phi_{LO1800} + \phi_{BBC1020}$
	6	BBC5-BBC2	$\phi_{rf280} - \phi_{LO1800} + \phi_{BBC1520}$
8	5	BBC4+BBC1	$\phi_{rf17000} - \phi_{LO17000}$
	7	BBC5+BBC2	$\phi_{rf17000} - \phi_{LO17000}$

The phase dependence on the RF frequency difference, first LO frequency difference, and BBC LO frequency differences are marked on the traces in figures 6-8.

Compare traces 1,2, and 3 in figure 6. We would have expected that trace 1 phase variation will be proportional to 480 MHz of rf phasecal generator minus proportional to 480 MHz of 5 MHz BBC LO reference. Similarly we would have expected the phase variations of trace 2 to be just those of trace 1 with sign reversal, and the trace 3 would have variations of about .8 compared to that of the trace 1. However amplitude of 1 hour ripple in trace 2 is almost 1.5 times that in trace 1, and the amplitude of the ripple in trace 3 is less than half of that in the trace 1. This show that all the BBC phases donot vary in the same way. We reach at the same conclusion by seeing one hour periodicity ripple in traces 5 and 7 in figure 8.

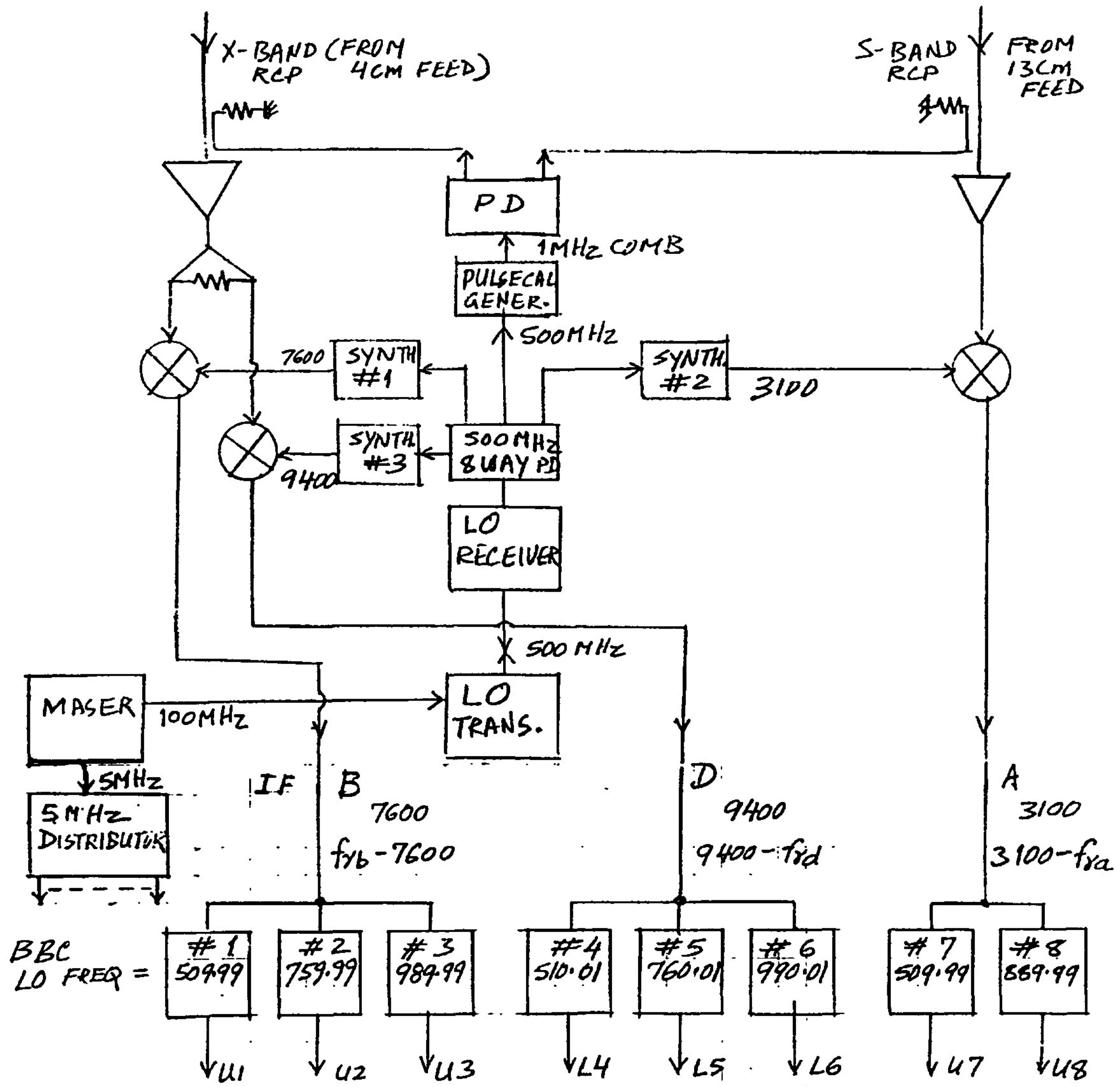
From a comparision of various traces in figures 6,7 and 8 we can model delay variations of 500 MHz, and 5 MHz reference signals. A crude (model) estimate gives variations of about 25 psec (p-p) for 5 MHz reference, and about 15 psec (p-p) with opposite sign for the 500 MHz reference signal.

In figure 8 there is a large phase drop of more than 35 degrees around 11.5 UT in traces 5 and 7. The slopes for the drop in the two traces are not excatly same. It is not clear what is causing this, though it is likely to be due to more than one reason. It seems to be RF or first LO dependent, and something in the vertex room is likely cause.

CONCLUSION:

It seems that phase variations are not smooth and there are a number of phase glitches of upto about 10 degrees. Also output of all BBCs donot get effected by same amount (of phase/dely). The phasecal system is doing its intended job of measuring phase stability of the receiving system, and very roughly there seems to be about 15 psec p-p delay variations of the 500 MHz reference. It is likely to be due to 100 MHz reference from MASER and the LO Transmitter. This needs to be minimised. There is also some indication that phase of either first LO or pulsecal rf signal (in vertex room) changes, but this needs to be varified and its extent determined.

FIGURE 1 – OBSERVING SET UP



RF FREQ OF SIGNAL IN			10kHz Tone RF FREQ
BBC 1,2,3	$\nu_{rf1,2,3}$	$7600 + BBCLO_{1,2,3} + .01$	8110, 8360, 8590 MHz
4,5,6	$\nu_{rf4,5,6}$	$9400 - BBCLO_{4,5,6} - .01$	8890 8640 8410
7,8	$\nu_{rf7,8}$	$3100 - BBCLO_{7,8} - .01$	2590 2210

phase of signal in BBC	BBC sideband	Frequency	Phase
1,2,3	U1, U2, U3	$\nu_{rf1,2,3} - 7600 - BBC_{1,2,3}$	$\phi_{rf1,2,3} - \phi_{7600} - \phi_{BBC1,2,3}$
4,5,6	L4, L5, L6	$\nu_{rf4,5,6} - 9400 + BBC_{4,5,6}$	$\phi_{rf4,5,6} - \phi_{9400} + \phi_{BBC4,5,6}$
7, 8	U7, U8	$-\nu_{rf7,8} + 3100 - BBC_{7,8}$	$-\phi_{rf7,8} + \phi_{3100} - \phi_{BBC7,8}$

FIG. 2

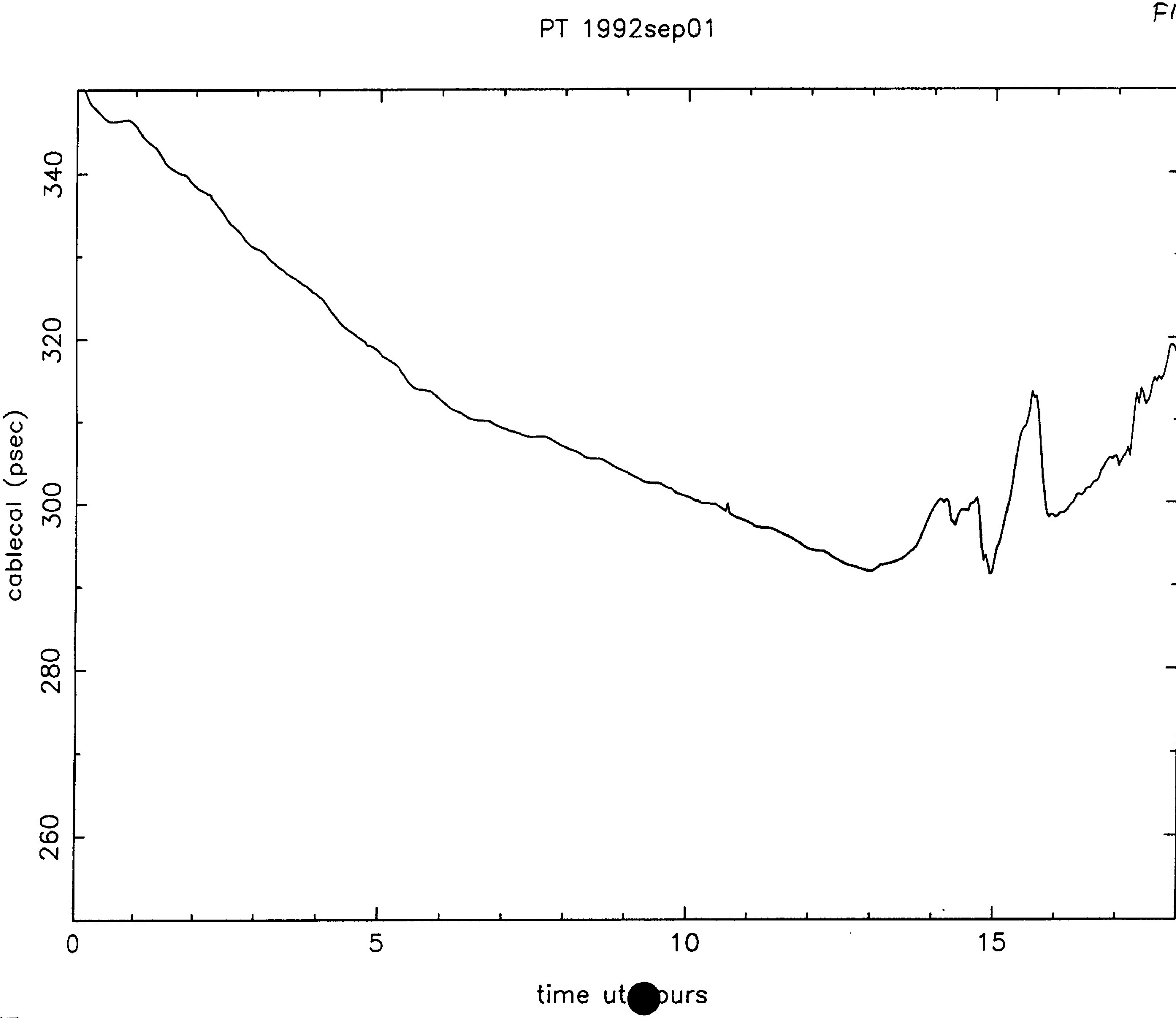


FIGURE 2

FIG. 3

PT 1992sep01 BLD. TEMPs.

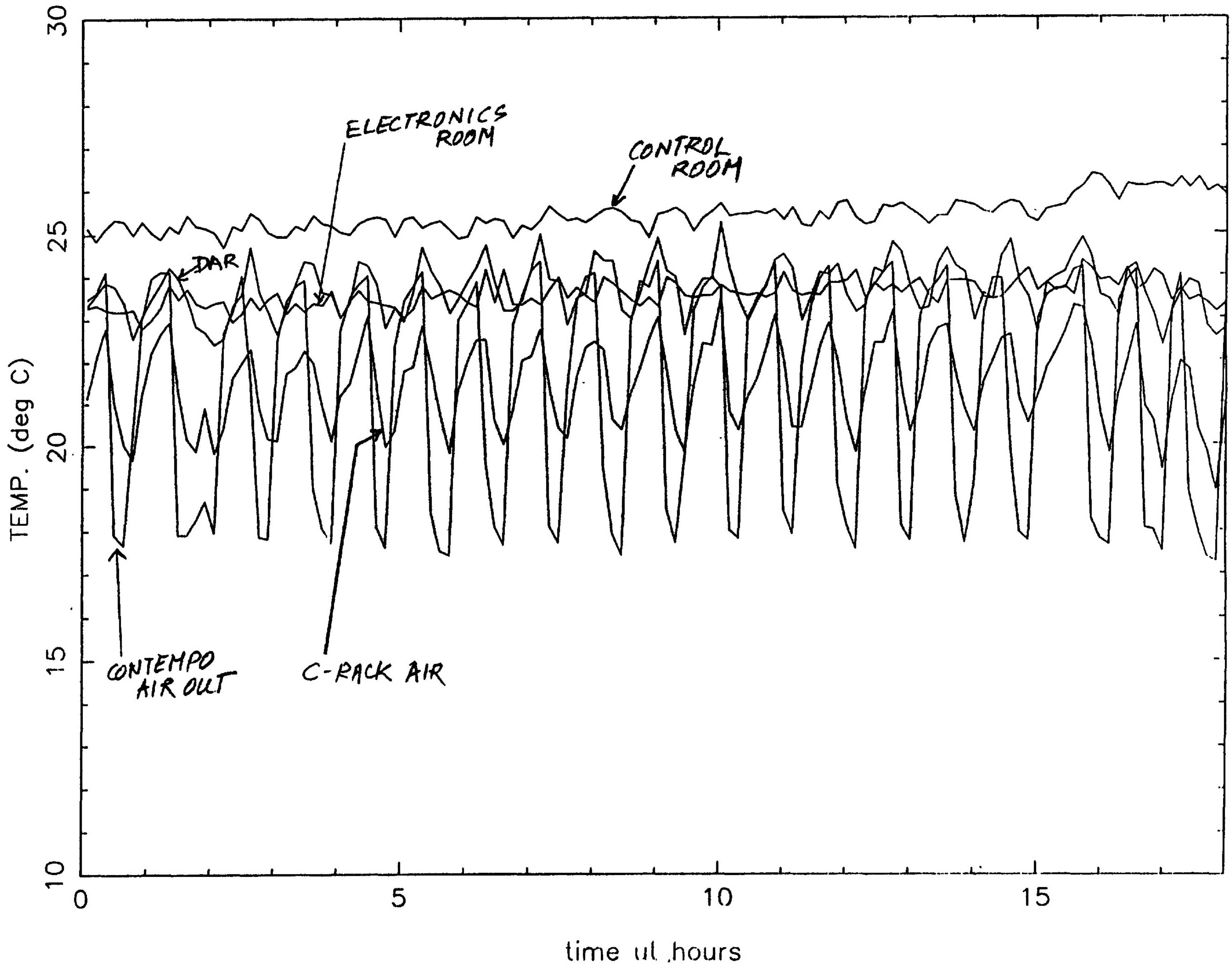
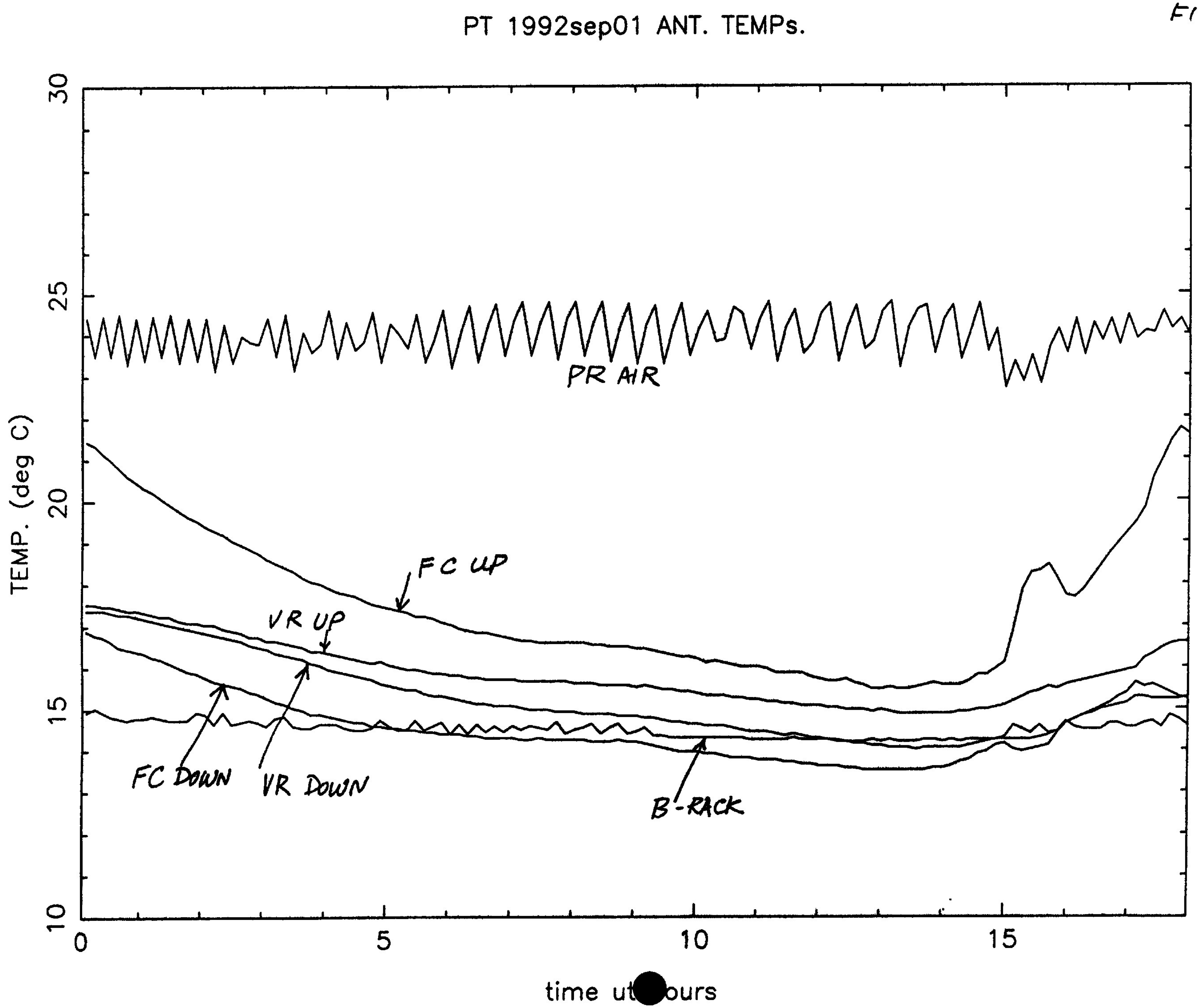


FIGURE 3

FIG. 4


PT 1992sep01 ANT. TEMPs.
TEMP. (deg C)
30
25
20
15
10
0
5
10
15
time ut hours
PR AIR
FC UP
VR UP
FC DOWN
VR DOWN
B-RACK

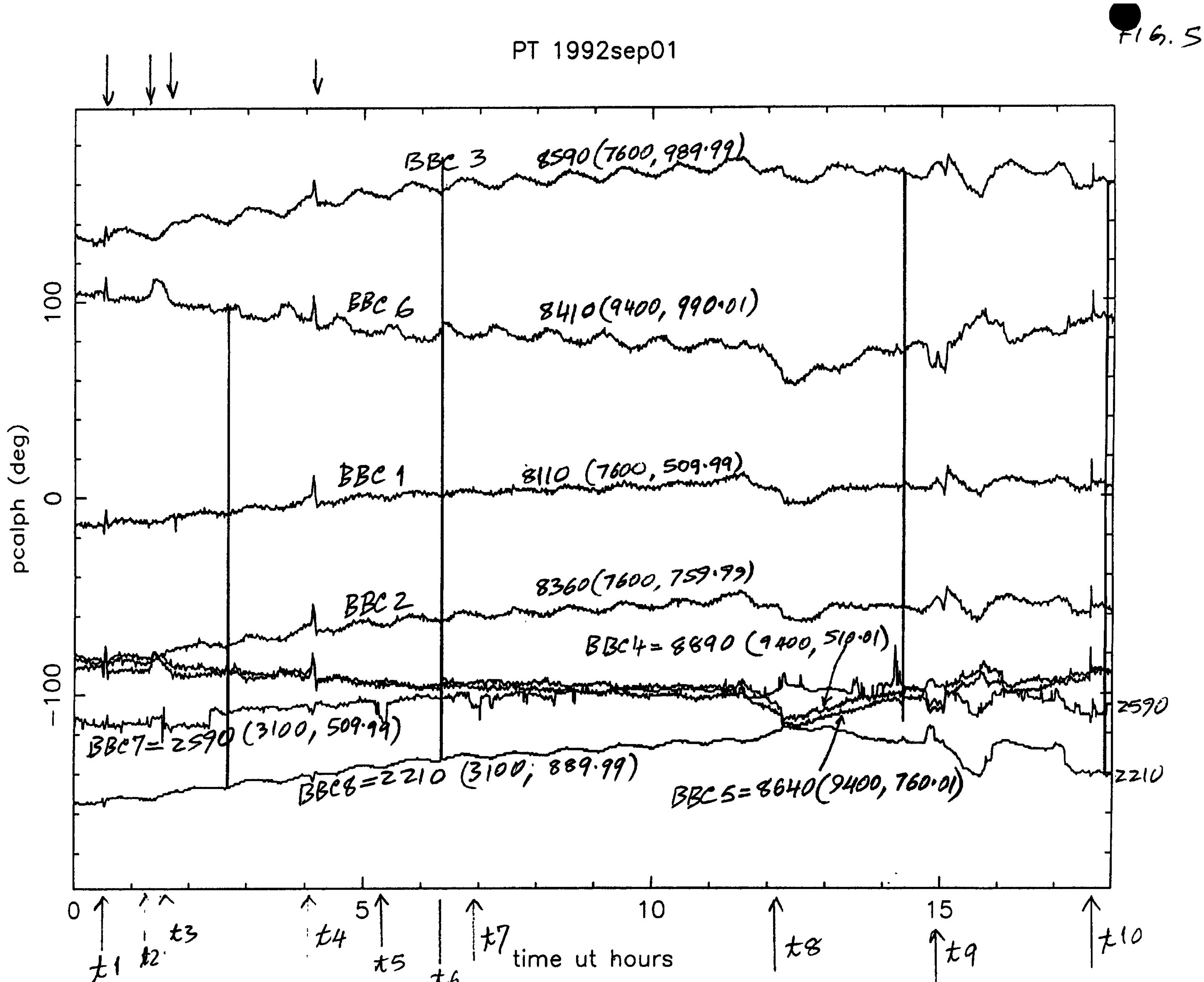
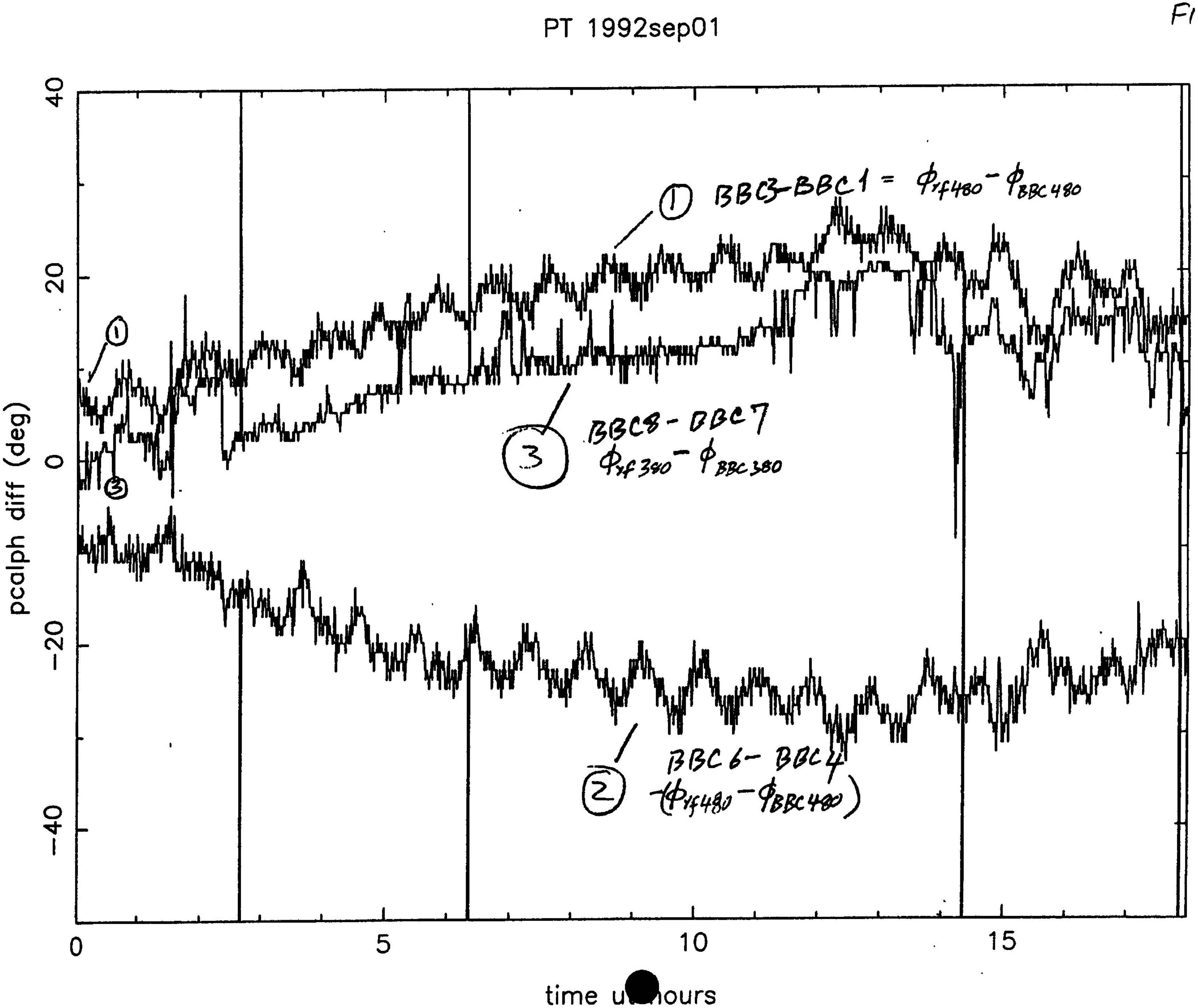


FIG. 5
PT 1992sep01
BBC 3
8590(7600, 989.99)
BBC 6
8410(9400, 990.01)
BBC 1
8110 (7600, 509.99)
BBC 2
8360(7600, 759.99)
BBC4= 8890 (9400, 510.01)
BBC7= 2590 (3100, 509.99)
BBC8=2210 (3100, 889.99)
BBC5=8640(9400, 760.01)
2590
2210
pcalph (deg)
100
0
-100
0
5
10
15
time ut hours
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10

FIG. 6


PT 1992sep01
40
20
0
-20
-40
pcalph diff (deg)
0
5
10
15
time u hours
1 BBC3-BBC1 = φrf480 − φBBC480
3 BBC8 - BBC7
φrf380 − φBBC380
2 BBC6 - BBC4
-(φrf480 − φBBC480)

FI 7

PT 1992sep01

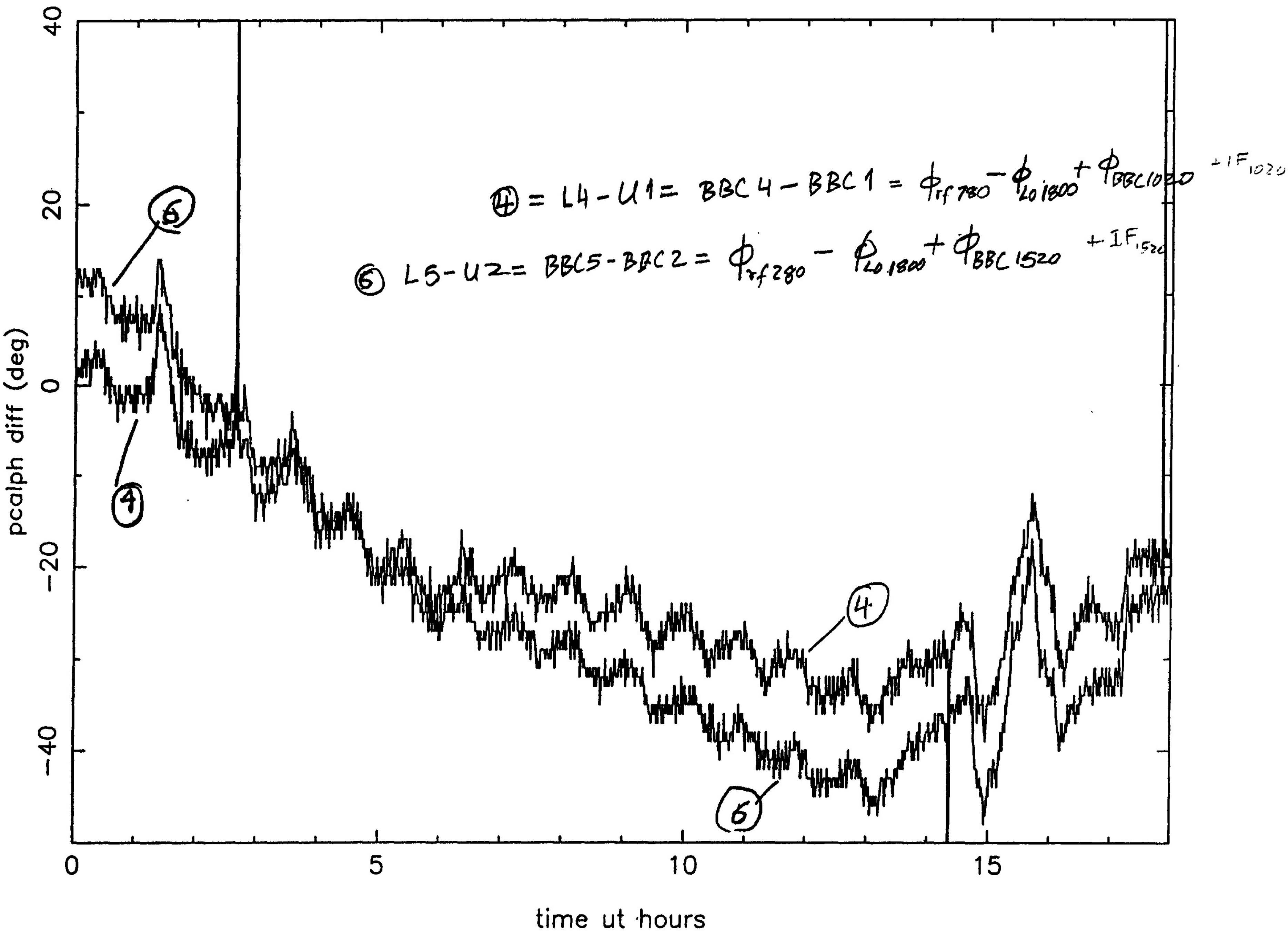
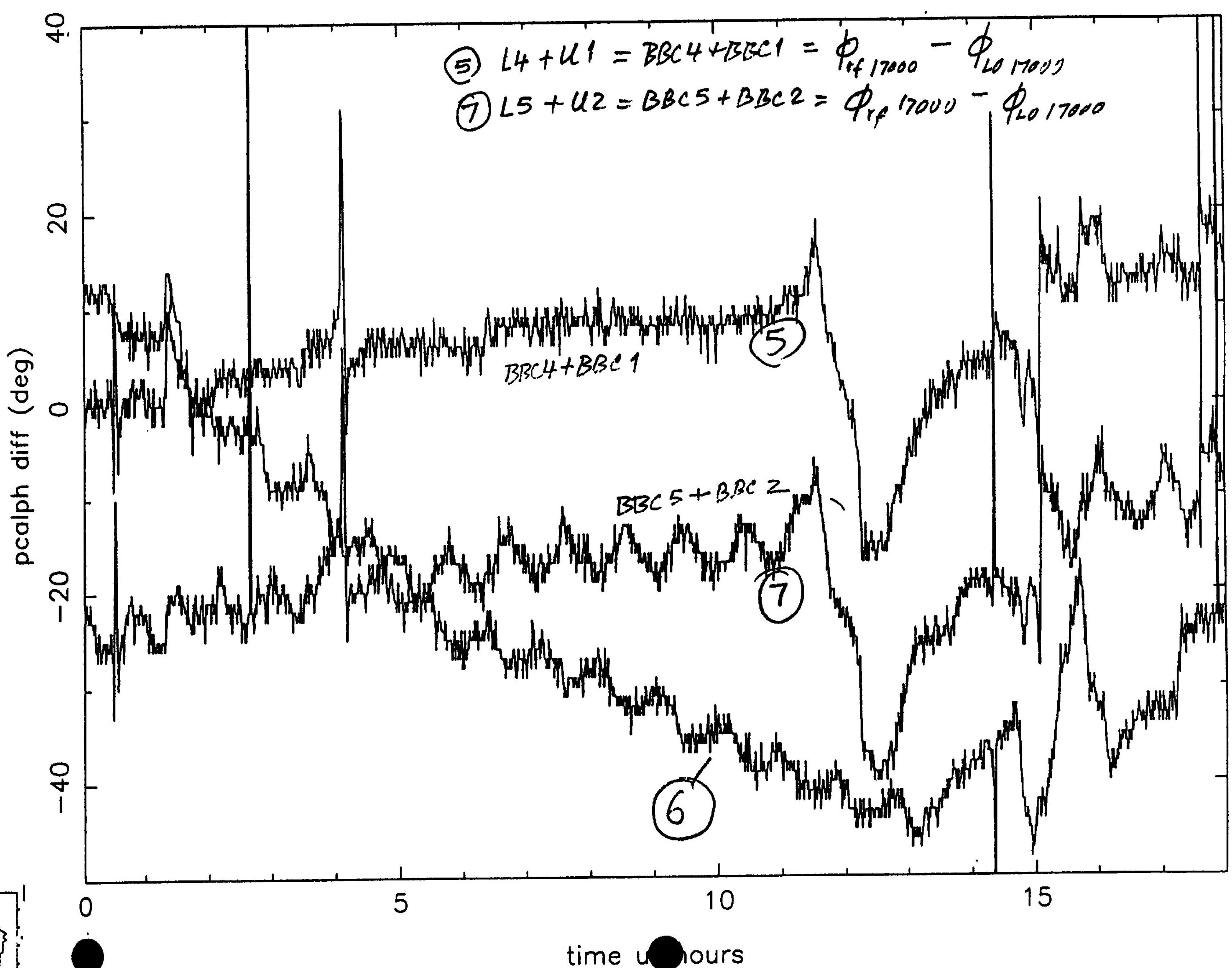


FIGURE 7

PT 1992sep01

FIG. 8



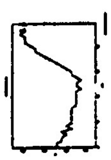


FIGURE 8