VLBA Electronics Memo No. 136

AIR CONDITIONING SYSTEM AND PULSECAL PHASE STABILITY

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The capability of the pulsecal phase measurements to calibrate the receiver path length variations depends on the phase/delay stability of the reference (pulsecal) signal injected in the receiver (frontend). Block diagram in Fig. 1 shows the signal path of the pulsecal signal from the station hydrogen maser to frontends in the vertex room. The cable length between the LO Transmitter (in the station building) and the LO Receiver (in the vertex room) is measured using 500 MHz round trip path length, and therefore effects of these variations will be accounted while applying phasecal data to measure receiver path length changes. But variations in the remaining electronics (including cables) are going to effect the phasecal accuracy, and therefore should be minimised. The temperature coefficient of the delay variations for the LO Transmitter and LO Receiver are -1.7 ps/$°C$ and 0.8 ps/$°C$ respectively (measured by L. Beno), and comb generator in the Pulsecal Generator (L110) module is $\approx$ 1 to 2 ps/$°C$ (from A. Rogers). In addition, variations in the cable lengths of the (i) 100 MHz signal from maser to LO Transmitter in the station building, (ii) 500 MHz refrence signal from LO Receiver to Pulsecal Generator, and (iii) pulsecal signal distribution cables in the vertex room are going to effect the phasecal accuracy. This memo examines effect of air conditioning temperature variations on phase stability of these cables and suggests steps to minimize the variations.

(1) The 100 MHz signal from maser to LO Transmitter uses (i) about 8 feet of Precision make low temperature coefficient cable (17 ppm/$°C$) which runs from maser to type N bulk head panel in the C-rack, for part of the length under the floor and for part of the length above the floor, and (ii) about 6 feet of standard 0.141 semi rigid cable in the C-rack. An example of the temperature variations in the building HVAC air, C-rack, and D-rack is shown in Fig. 2. Temperature variations in the C-rack are somewhat larger than those seen in the D-rack. At Pie Town the 100 MHz cable from the maser to the C-rack is insulated using 1/2" thick foam insulation. Temperature variations monitored using a probe located directly on the cable show about 4-5 $°C$ p-p temperature variations instead of about 7 $°C$ p-p variations of the HVAC air. The cable length variations of the 500 MHz round trip path monitor is shown in Fig. 3. This shows about 2 ps p-p cable length variations. The length variations for the 100 MHz reference signal from the maser to the LO Transmitter are expected to be roughly similar (or somewhat larger than the 500 MHz round trip cable). Therefore we may expect about 2-3 ps length variations of the 100 MHz reference signal cable. Fortunately it is simple to minimize these variations by making following modifications: (i) changing the routing of the 100 MHz reference signal cable from the maser to the LO Transmitter, i.e. by directly connecting the 100 MHz output from the maser to the C-rack at the level of the LO Transmitter, and (ii) using a 3/8" Heliax cable (+/-9 ppm/$°C$) instead of the Precision cable for this connection, and (iii) using a short length of about 1 foot of the Precision make low temperature coefficient cable to connect the signal in the C-rack to the LO Transmitter. This will minimize the length of the signal path

and avoid exposing the reference signal cable to large temperature variations under the floor. Temperature variations in the C-rack and in the electronics room (Room 104) are much smaller than those under the floor. Using 3/8" Heliax cable with low temperature coefficient is desirable wherever practical. L. Beno is planning to implement these changes.

(2) The modifications suggested above, to the cables carrying the 100 MHz reference signal from the maser to the LO Transmitter, should cut down the variations due to these cables to $\leq$1/3 ps p-p. However other electronics will still be effected by HVAC air temperature variations. To minimize the HVAC air temperature variations following approach is under consideration. Presently we have nominal air temperature control setting of $74°F$, and relative humidity (RH) setting at 40%. Also the HVAC compressor control is set such that air is cooled down to about $45°F$. Referring to Psychrometric chart in Fig. 4 suggests that every time the compressor comes on to cool the air, it will also cause condensation of moisture. This in turn necessitates humidifier to come on, to keep the RH of 40%, thus adding heat. We can change the RH to 30%. This is desirable humidity setting from considerations of the life time for the tape recorder heads and tapes. Further we may also change the HVAC gas boiling point to cause the air to cool down to $50°F$ instead of presently to $45\ °F$, by replacing the existing thermal expanssion valve on the HVAC control by adjustable thermal expanssion valve (cost approx. \$100 – 200 each plus labor). This will reduce the air conditioner cooling capacity from 5 ton to somewhat lower value, but as we have large excess cooling capacity it should not be serious. However this should minimize p-p temperature swings in the HVAC air which should minimize air temperature variations elsewhere in the electronics and thus improve the stability. J. Ruff is planning to study practicality of these modifications.

(3) In the vertex room we have used 3/8" Heliax cable for the 500 MHz reference signal from the B-rack to the pulsecal bin located in the feed cone. Also we have used either 3/8" Heliax cable or low temperature coefficient Precision make semi rigid 0.141 cable for distributing the pulsecal generator signal to various frontends. To check phase stability for the vertex room temperature changes we step changed the vertex room temperaure settings at Pie Town and Los Alamos on 93Feb01 while monitoring the pulsecal phases. Fig. 5 shows the temperature monitors in the vertex room and Fig. 6 shows the pulsecal phases at Pie Town. Similarly Figs. 7 and 8 show the vertex room temperature monitors and the pulsecal phases at Los Alamos. We do not see any obivious effect of vertex room temperature step in the pulsecal phases. It seems the pulsecal phases are fairly insensitive to the vertex room temperature changes (—for S/X band observations phase changes of $\leq$ a few degrees for about 5°C vertex room temperature change, and at this level it becomes difficult to seperate this from other effects). But it will be desirable to put some thermal insulation around the 500 MHz reference signal cable between the B-rack and the pulsecal bin, and pulsecal signal distribution cables to various frontends. We suggest that 1" foam insulation be put around these cables.

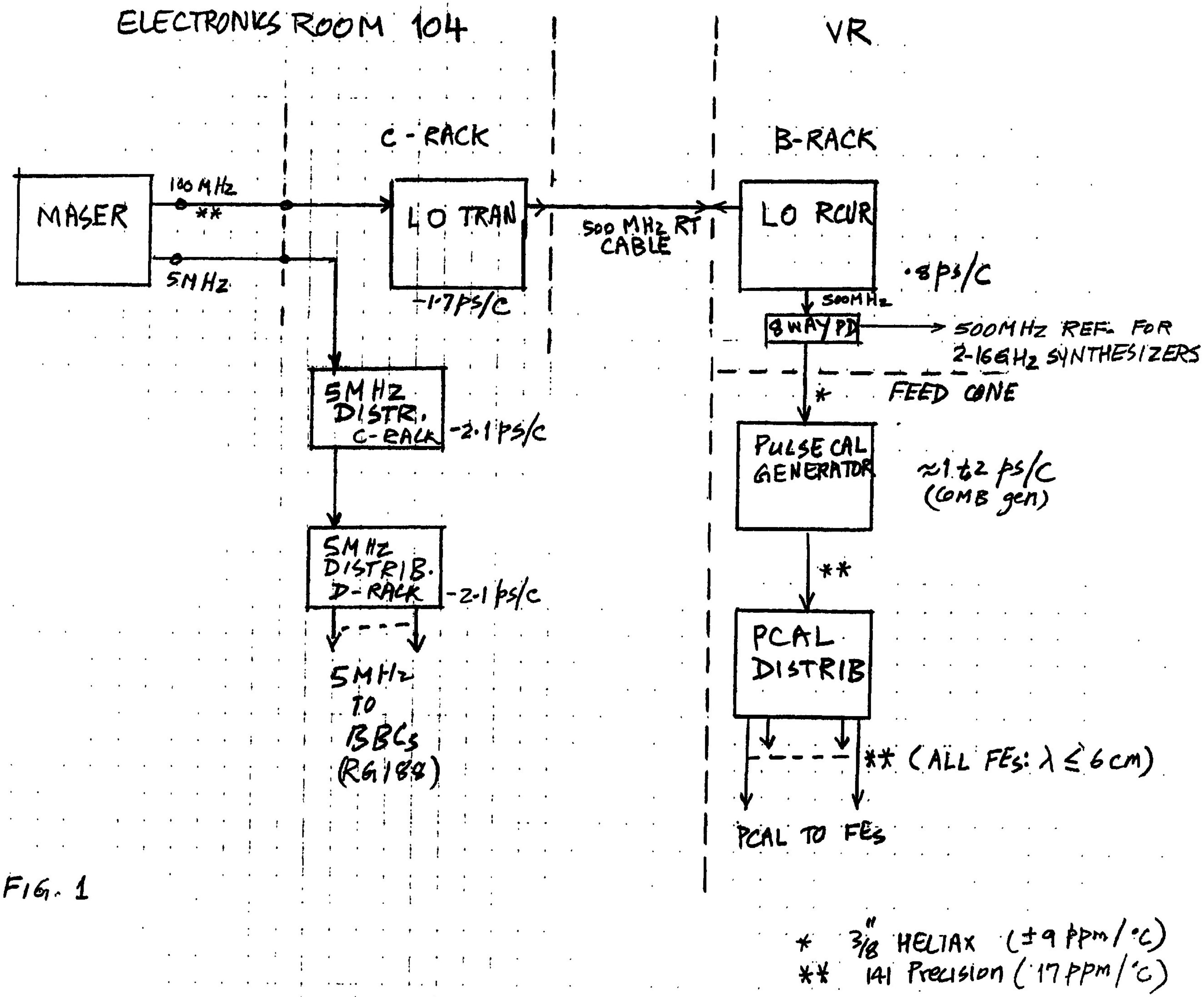
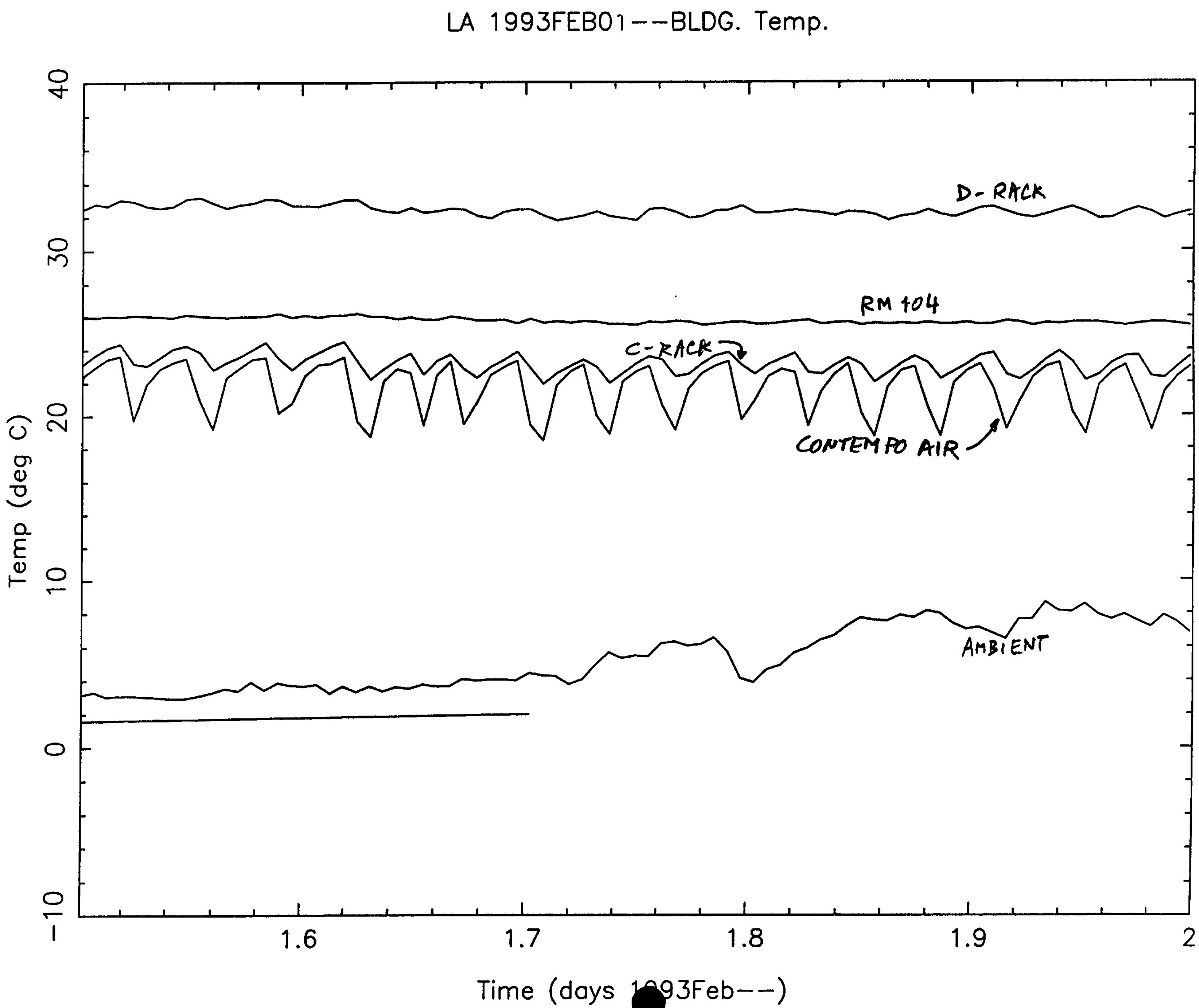

ELECTRONICS ROOM 104
VR
C-RACK
B-RACK
MASER
100 MHz
**
5 MHz
LO TRAN
-1.7 ps/C
500 MHz RT CABLE
LO RCVR
.8 ps/C
500 MHz
8 WAY PD
500 MHz REF. FOR 2-16 GHz SYNTHESIZERS
FEED CONE
*
5 MHz DISTR. C-RACK
-2.1 ps/c
5 MHz DISTRIB. D-RACK
-2.1 ps/c
5 MHz TO BBCs (RG188)
PULSE CAL GENERATOR
≈1 to 2 ps/C (COMB gen)
**
PCAL DISTRIB
** (ALL FEs: λ ≤ 6 cm)
PCAL TO FEs
* 3/8" HELIAX (±9 ppm/°C)
** 141 Precision (17 ppm/°C)

FIG. 1



LA 1993FEB01--BLDG. Temp.
Temp (deg C)
40
30
20
10
0
-10
1
1.6
1.7
1.8
1.9
2
Time (days 1993Feb--)
D-RACK
RM 104
C-RACK
CONTEMPO AIR
AMBIENT

FIG. 2

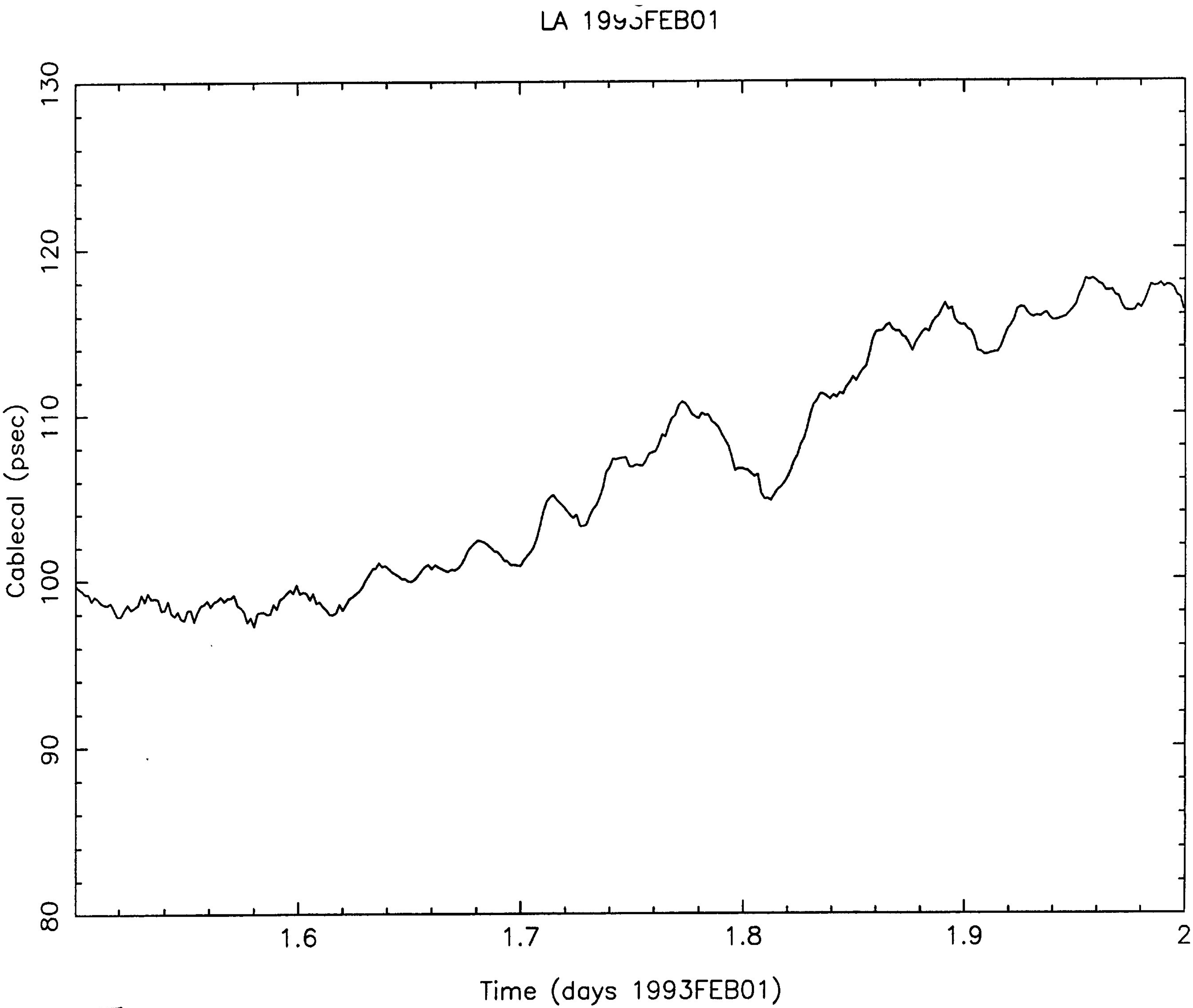

LA 1993FEB01
130
120
110
100
90
80
Cablecal (psec)
1.6
1.7
1.8
1.9
2
Time (days 1993FEB01)

FIG 3

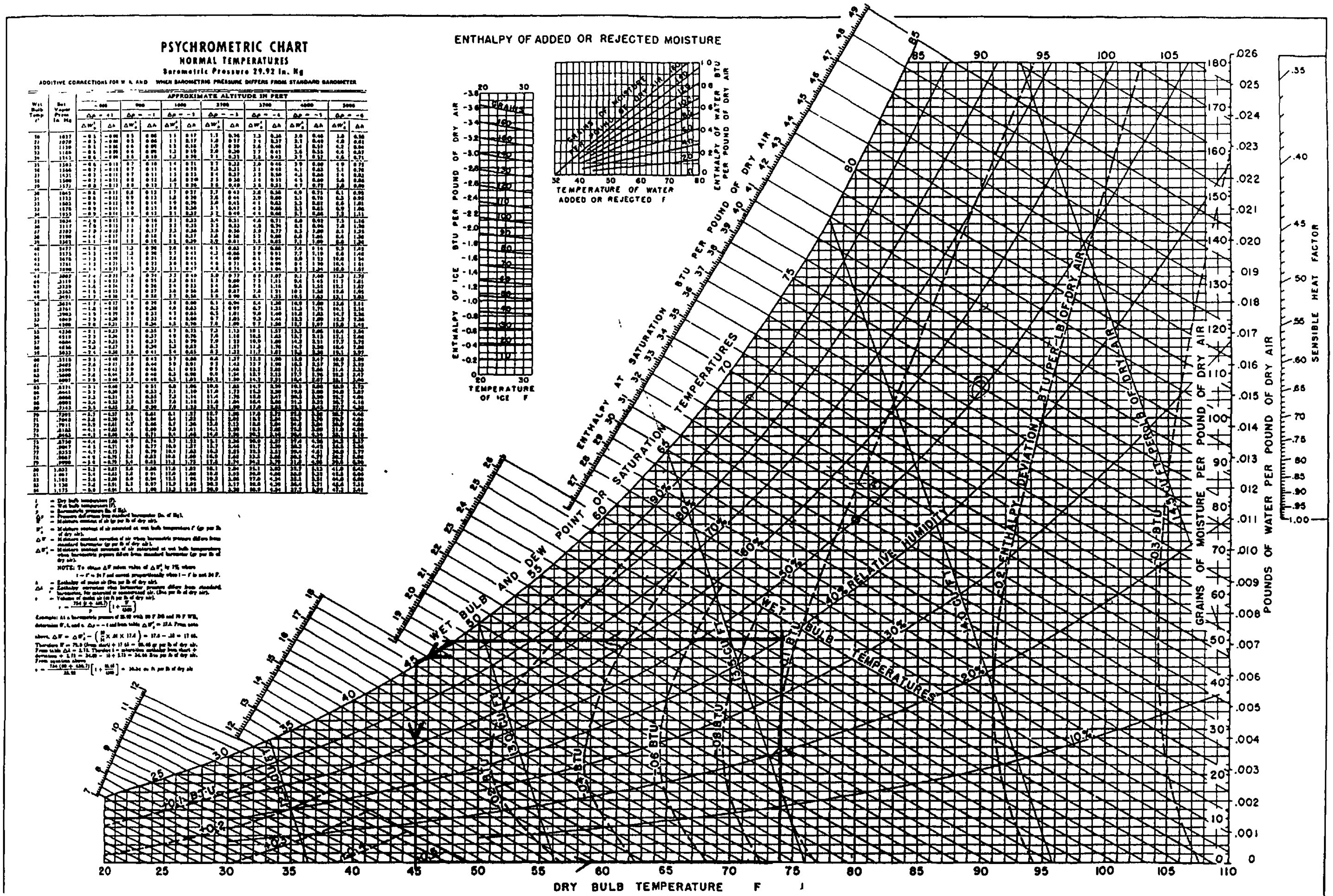
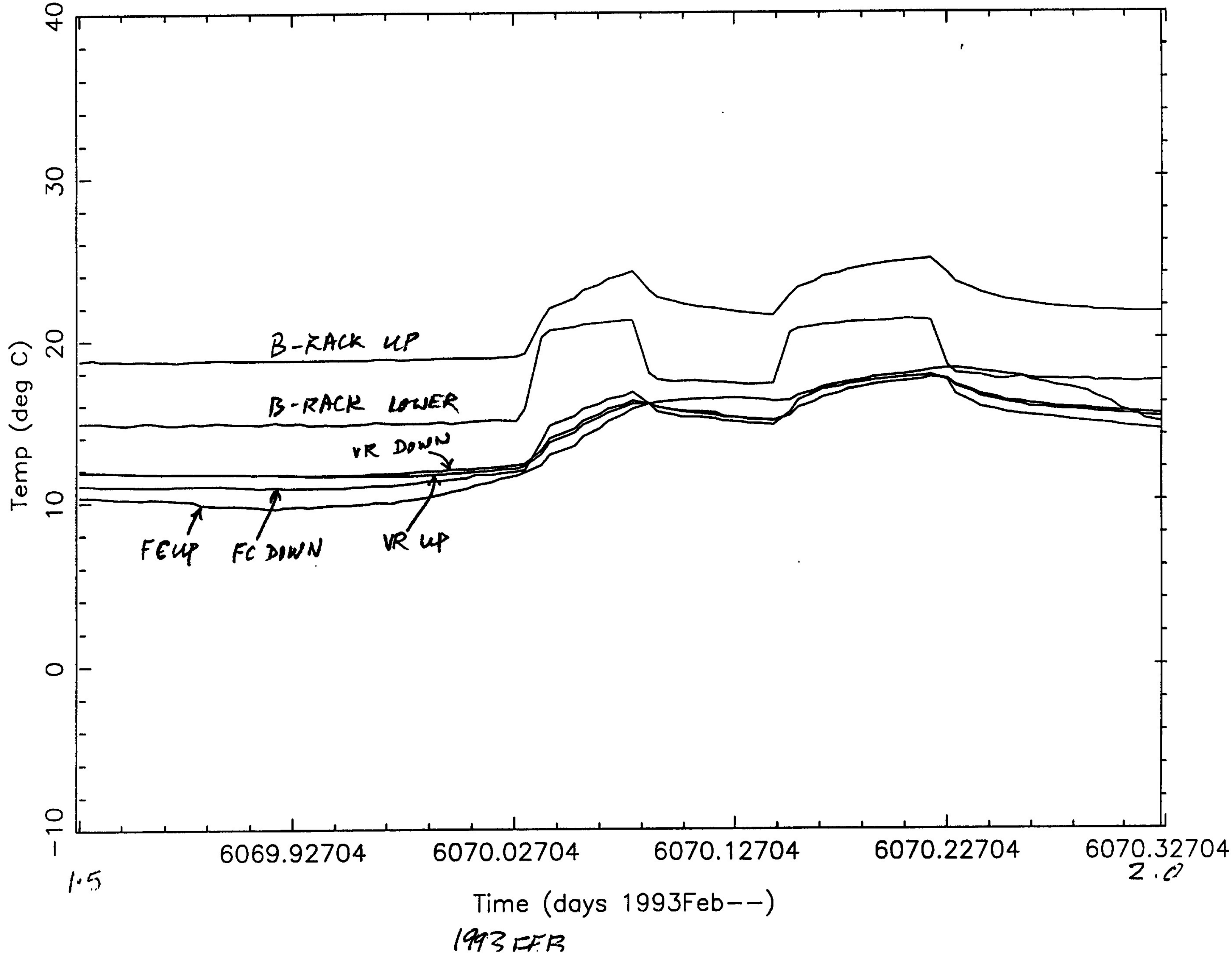

PSYCHROMETRIC CHART
NORMAL TEMPERATURES
Barometric Pressure 29.92 In. Hg
APPROXIMATE ALTITUDE IN FEET
ENTHALPY OF ADDED OR REJECTED MOISTURE
GRAINS OF MOISTURE PER POUND OF DRY AIR
TEMPERATURE OF WATER ADDED OR REJECTED F
ENTHALPY OF WATER BTU PER POUND OF DRY AIR
ENTHALPY OF ICE BTU PER POUND OF DRY AIR
TEMPERATURE OF ICE F
ENTHALPY AT SATURATION BTU PER POUND OF DRY AIR
SATURATION TEMPERATURES
WET BULB AND DEW POINT OR SATURATION TEMPERATURES
RELATIVE HUMIDITY
WET BULB TEMPERATURES
ENTHALPY DEVIATION BTU PER LB OF DRY AIR
CU FT PER LB OF DRY AIR
GRAINS OF MOISTURE PER POUND OF DRY AIR
POUNDS OF WATER PER POUND OF DRY AIR
SENSIBLE HEAT FACTOR
DRY BULB TEMPERATURE F

FIG. 4

PT 1993FEB01--VR Temp.



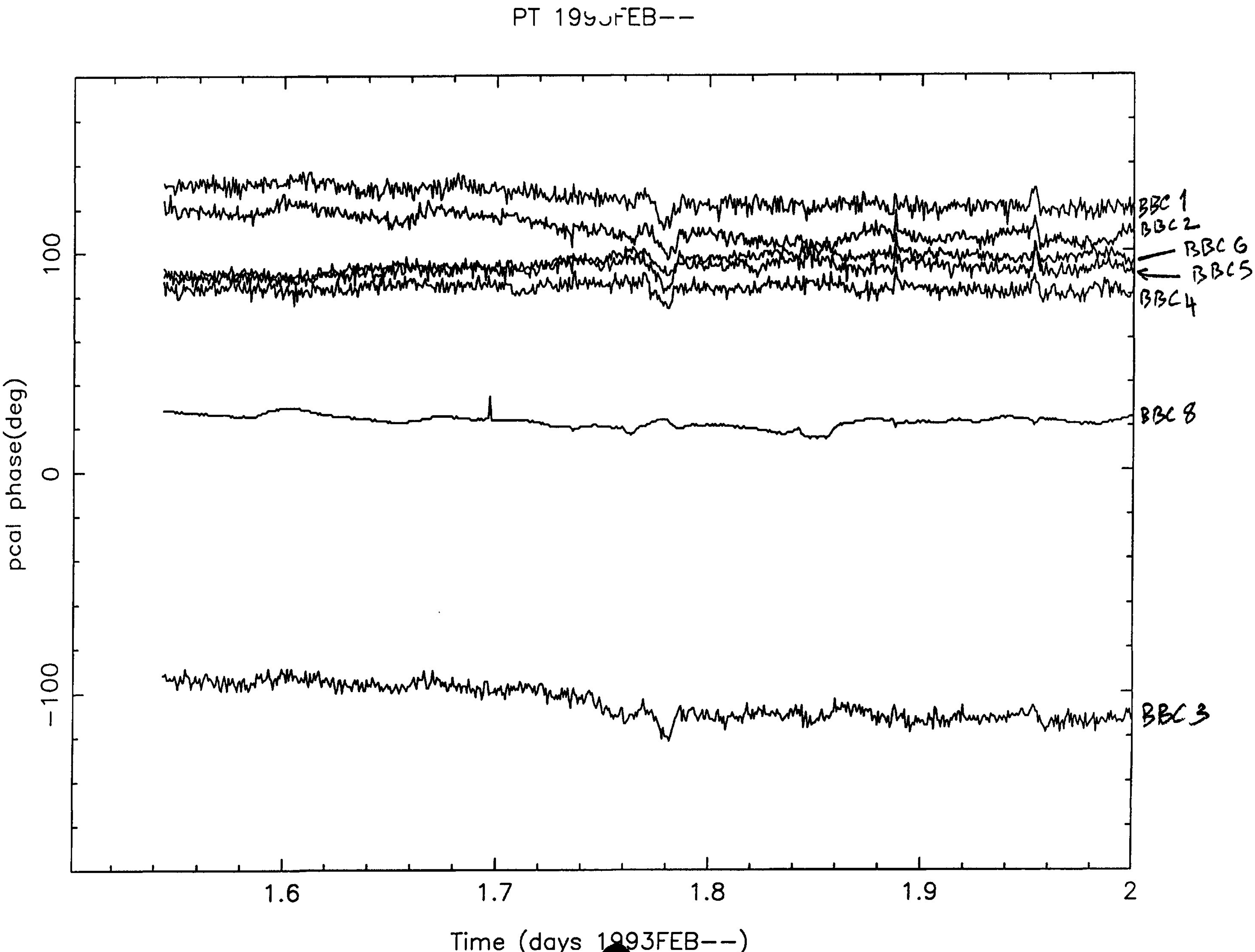
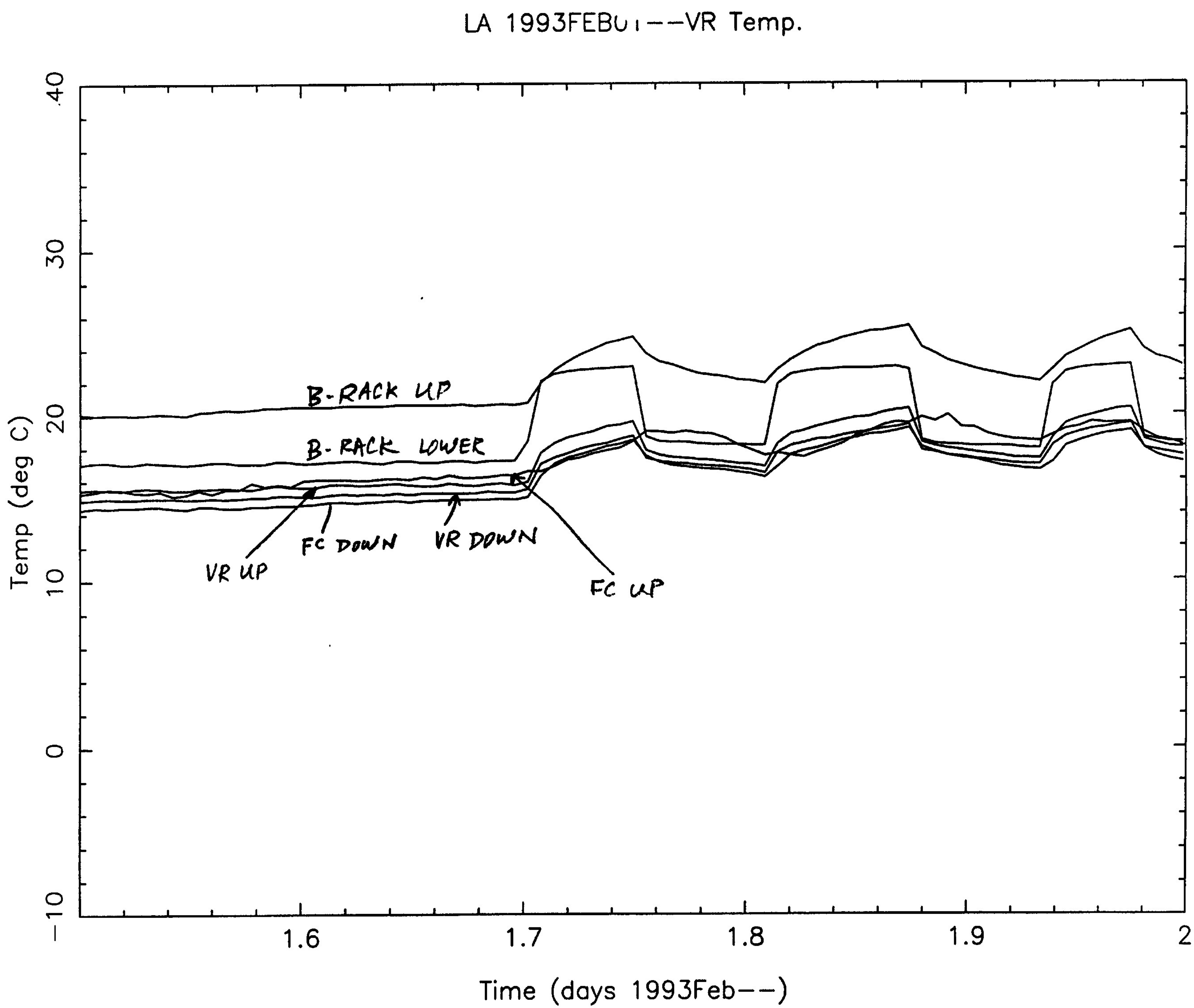

PT 1993FEB--
pcal phase(deg)
100
0
−100
1.6
1.7
1.8
1.9
2
Time (days 1993FEB--)
BBC 1
BBC 2
BBC 6
BBC 5
BBC 4
BBC 8
BBC 3

Fig 6.


LA 1993FEB01--VR Temp.
B-RACK UP
B-RACK LOWER
VR UP
FC DOWN
VR DOWN
FC UP
Temp (deg C)
Time (days 1993Feb--)
-10
0
10
20
30
40
1.6
1.7
1.8
1.9
2
FiG.7

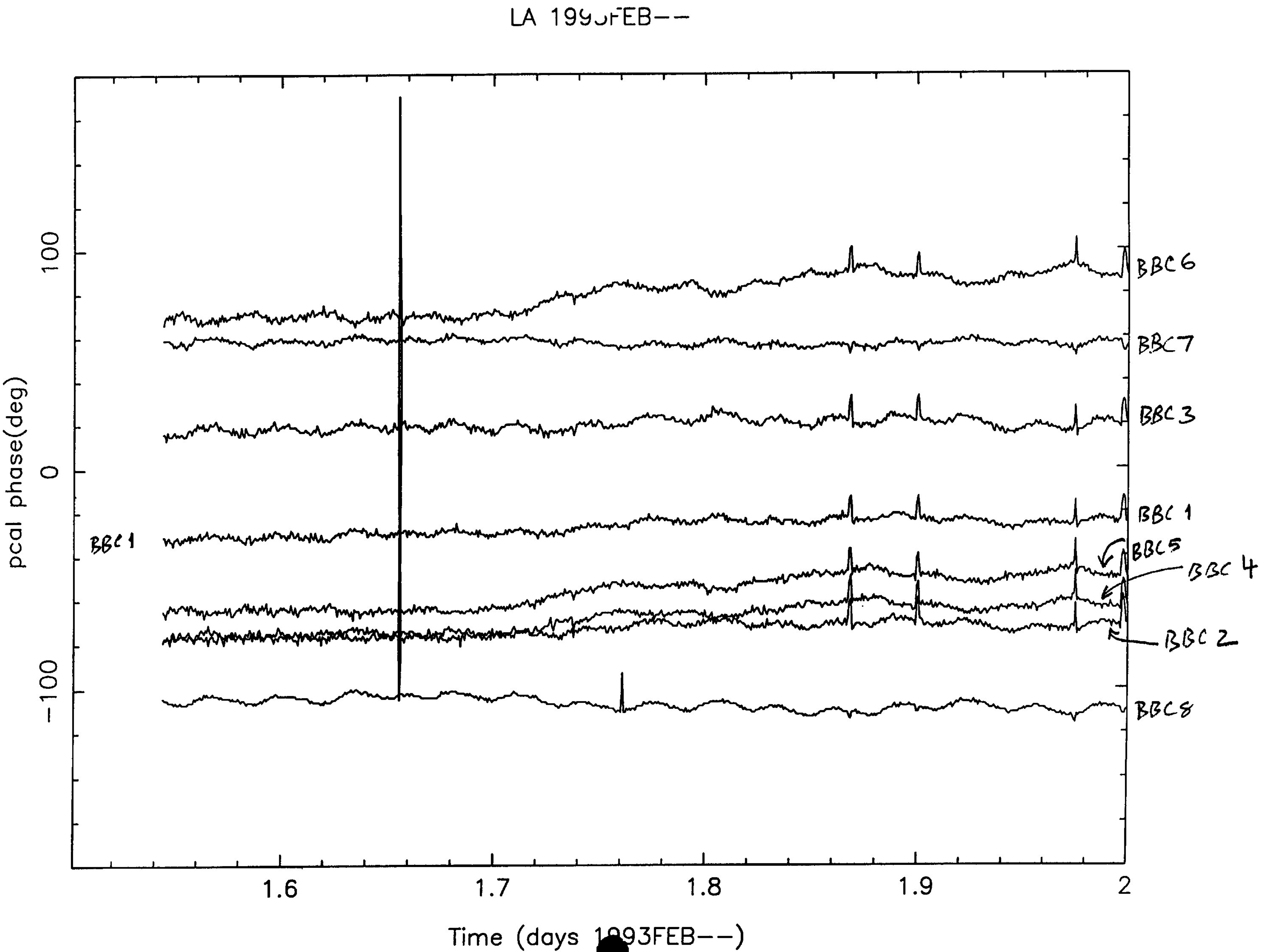

LA 1993FEB--
pcal phase(deg)
100
0
-100
1.6
1.7
1.8
1.9
2
Time (days 1993FEB--)
BBC6
BBC7
BBC3
BBC1
BBC5
BBC4
BBC2
BBC8
BBC1

Fig 8