EARTHQUAKE EARLY WARNING SYSTEM PLAN B

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ABSTRACT

The earthquake Early Warning System Plan B (EWS-B) is a complementary approach to the Plan A (EWS-A). It helps to quickly increase the areal coverage of early warning service to the entire Taiwan region by taking advantage of the existing communication system of the on-going telemetered seismic networks . Presently, the Central Weather Bureau Seismic Network (CWBNET) is operating 50 telemetered 3-component seismic stations. The recent addition of 25 stations of the Taiwan Telemetered Seismic Network(TTSN)will make a network of 75 stations over Taiwan.It is possible that the number of stations may eventually reach 100. This real-time communication network reaching so many points all over Taiwan is indeed amost valuable asset in the development of a comprehensive early warning system for earthquake here. So, while Plan A is concentrating on the digital hardware and detection/communication software,Plan B heads off the complementary tasks of:

1. design and utilization of the existing real-time communication data lines to serve the purpose of earthquake early warning without interfering the existing normal seismic monitoring function,
2. construction of necessary hardware to assure timely data transmission and signal processing,
3. research into the nature of large fault ruptures and near-field strong motion recordings to identify useful waveform characteristics in order to issue early warnings fo M > 7 events. The goal is to determine epicenter and, particularly, magnitude within 10sec of strong shaking arrival in the source area, and

4. construction of a laboratory test system that incorporates the sensors, communication lines, and the central processing PC into a network.Real recordings and simulated data for earthquakes of all magnitudes will be used to access the ability and reliability for discrimination and issuance of warning signals.

At the onset when the EWS-B was first proposed in January 1993, we were considering the use of a switching circuit installed at all stations that,upon the arrival of strong shaking, would switch the input signals of a field station from weak motion velocity sensors to strong motion forced balanced sensors(FBAs that sense the ground acceleration). Subsequently, a study of the bandwidth of the digital transmission line currently in use by the CWBNET shows that of the 9600 bps lines, generally only 4800 bps is occupied for real-time seismic monitoring. So, the thrust of EWS-B is redirected to the use of the remaining 4800 bps channels. A problem arises here that requires the design of a connection circuit that would require (1) reformatting the 9600 baud data rate output from the newly ordered free field instruments (for which a 9600 bps output digital stream is required of the manufacturer), and (2) reformatting the 4800 bps data in the transmission lines in order to form the input into the receiver PC. This problem of a connection circuit is again resolved by the free-field instrument manufacturer's agreeing to provide selectable output baud rates on one hand, and on the other hand by Dr. Willie Lee's software modification of the PC software at the receiver end to admit input of selectable baud rates.

With the above progress, the EWS-B is in the process of collecting all useful near-field strong motion recordings and to generate numerous simulated strong motion data in order to accomplish realistic laboratory tests. Figure 1 shows the current system configuration of Plan B. The top left is the current CWBNET operation block diagram. The bottom right illustrate the principal research and development activities of the Plan B. Digital acceleration data streams taking off from the receiver modems each at 4800 bpi will feed into a R232/485 interface for guaranteed noise-freequality. Each 8 pairs cable will be input into a 16-channel input receiver which introduces the properly demultiplexed data into PC-1. PC-1 is the principal waveform holding device. For each additional 16-channel digital input, a waveform holding PC-n will be employed (see the dashed boxes at bottom right. PC-2 and PC-3 are the principal computing power that will scan and process the input signals. The earning warning output should not require more than a fraction of a second in computation time.Figure 2 gives a sample data set showing the great complexity of the acceleration, velocity and displacement signals of the M 5.8 Sierra Madre earthquake, California recorded at about 20 km from the epicenter at Pasadena by the STS-1 broadband instruments. These complex signals indeed show the potential to extract magnitude information during the first 5 - 10 seconds of the strong motion arrival. Yet, much research and numerical experiments are needed to transform ideas and theory into reliable application in earthquake early warning. Currently, we are designing a four-point discriminator for large (M> 7) events as:

α-test: The P waveform, either velocity or displacement, will be used. Our preliminary finding shows that for large events, the predominant period of the P signal is large.

β-test: The S waveform or its maximum amplitude will be used, either velocity or displacement. The displacement amplitude may reach a fraction of one meter.

γ-test: The areal dimensions of isoseismal contour with a pre-determined the peak ground acceleration. For a M > 7 event, the areal dimensions of the 0.25g acceleration isoseismal contour may reach 1,000 km^2. Both the PGA and the areal dimensions are still being refined. In practical applications, these values are also related to the strong motion attenuation curves and the site response.

δ-test: A Green's function method of magnitude determination. For a large event, the Green function is dependent on the seismic moment and the propagation path. In the absence of a reliable 3-D crustal structure, it is possible to examine the long-period part of the Green function to the extend that crustal layering is no longer important. In this way, a halfspace Green function may be used to extract the magnitude with sufficient accuracy. This needs to be carefully examined.

Besides the generation of early warning signals on continuously real-time scanning and processing of the input strong motion data,which is the main goal of the EWS-B project, the prediction of strong shaking at various target areas is also part of this earthquake damage mitigation program. This will involve the study of strong motion attenuation and site response research. For these subjects, much progress has been made by scientists in Taiwan, and a careful synthesis on these research results will render their contributions towards Taiwan's earthquake early warning and damage mitigation program that CWB is currently conducting.

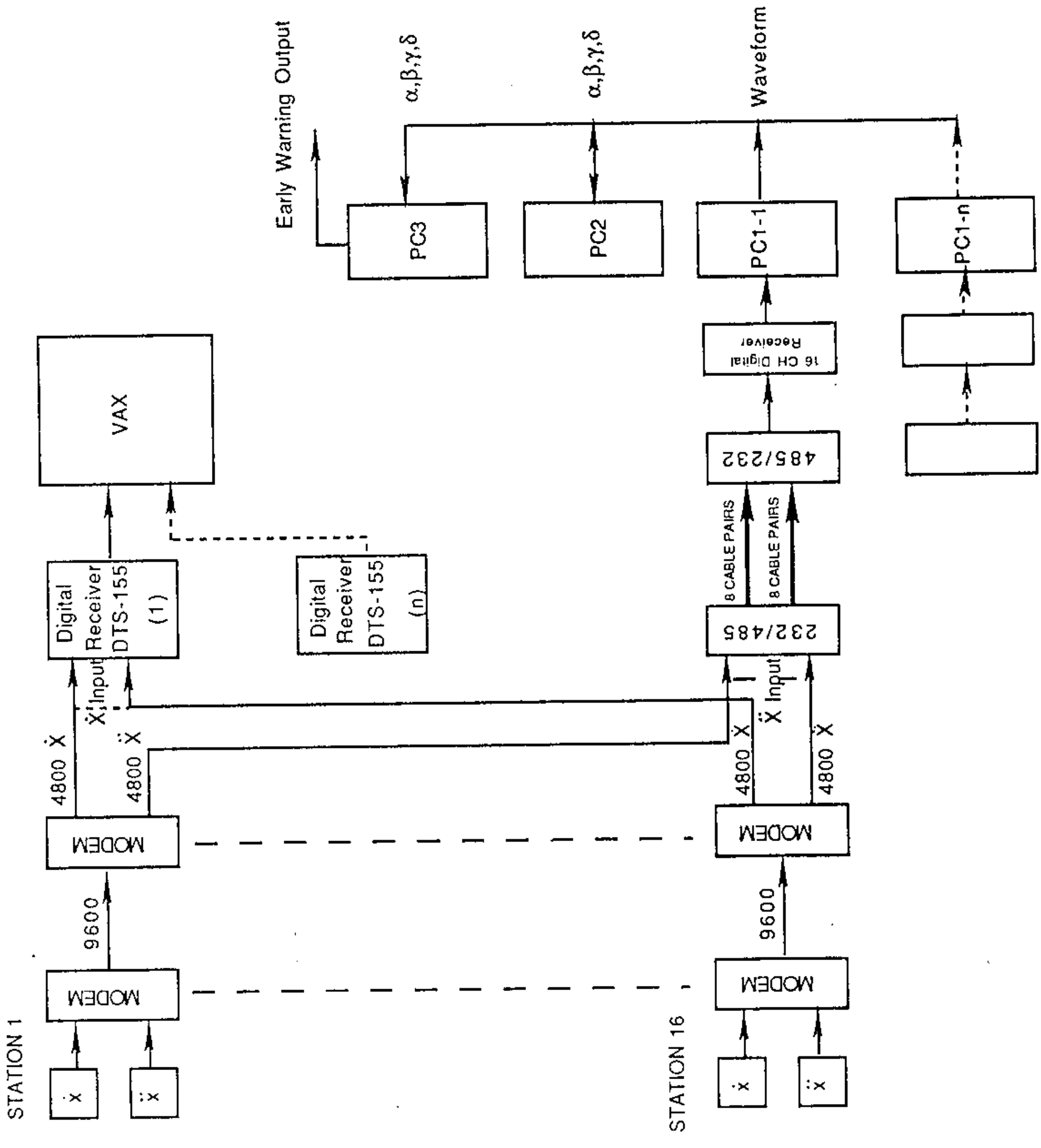
Early Warning Output
α,β,γ,δ
α,β,γ,δ
Waveform
PC3
PC2
PC1-1
PC1-n
VAX
16 CH Digital Receiver
485/232
8 CABLE PAIRS
8 CABLE PAIRS
232/485
Digital Receiver DTS-155 (1)
Digital Receiver DTS-155 (n)
Input
Input
4800
4800
4800
4800
9600
9600
MODEM
MODEM
MODEM
MODEM
STATION 1
STATION 16

Figure 1

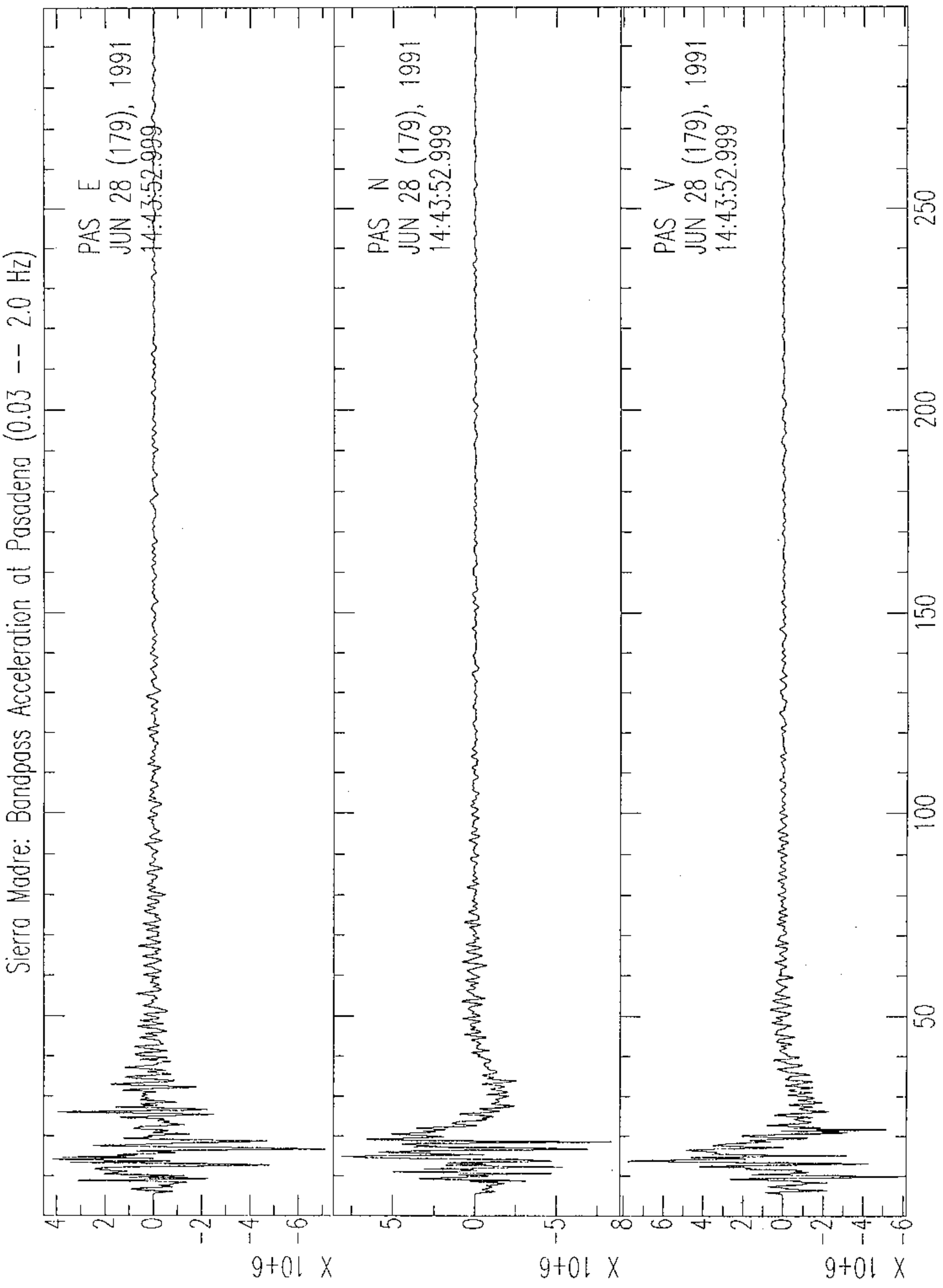
Sierra Madre: Bandpass Acceleration at Pasadena (0.03 -- 2.0 Hz)
PAS E
JUN 28 (179), 1991
14:43:52.999
PAS N
JUN 28 (179), 1991
14:43:52.999
PAS V
JUN 28 (179), 1991
14:43:52.999
X 10+6
X 10+6
X 10+6
50
100
150
200
250

Figure 2A

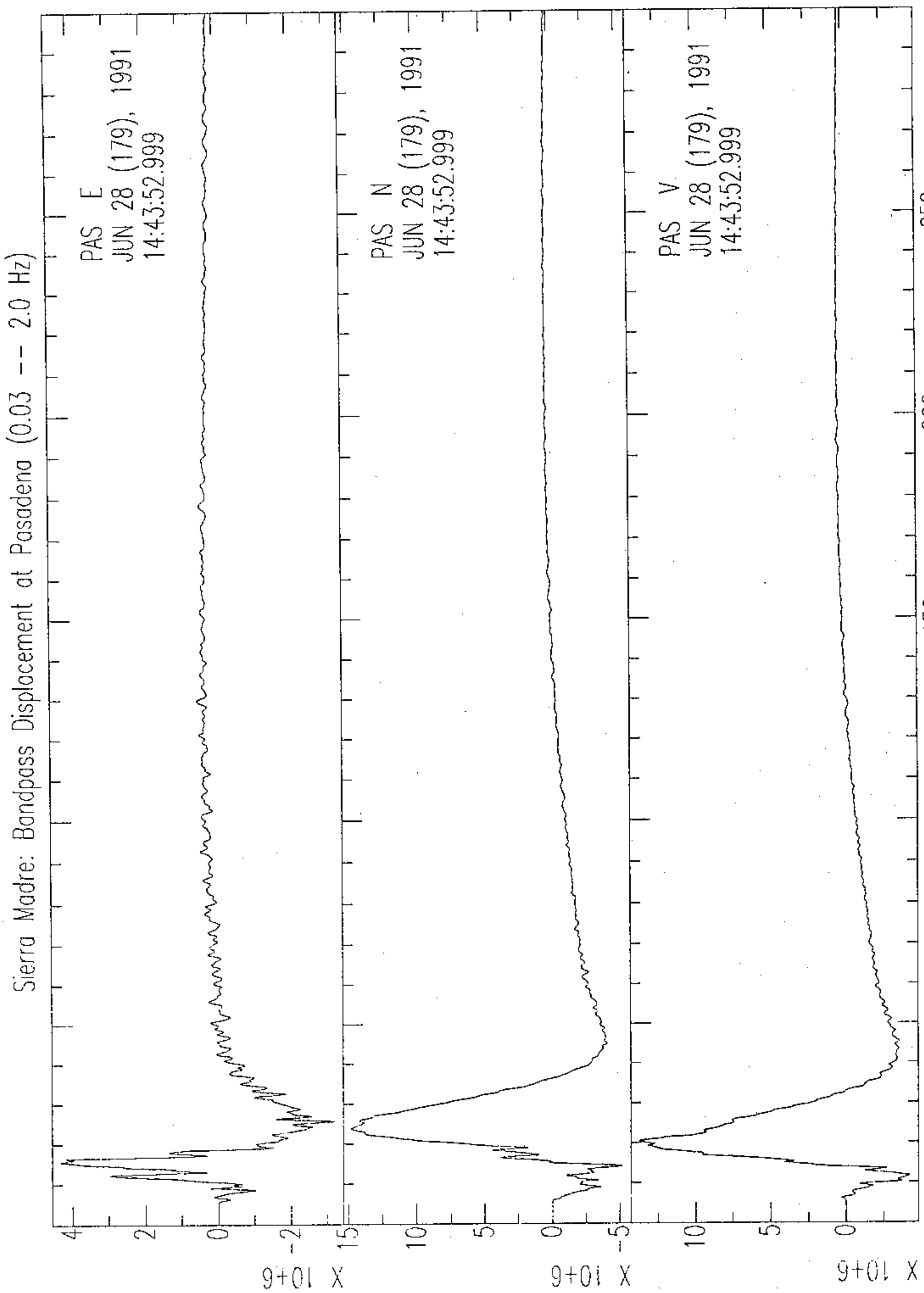
Sierra Madre: Bandpass Displacement at Pasadena (0.03 -- 2.0 Hz)
PAS E
JUN 28 (179), 1991
14:43:52.999
PAS N
JUN 28 (179), 1991
14:43:52.999
PAS V
JUN 28 (179), 1991
14:43:52.999
X 10+6
X 10+6
X 10+6
50
100
150
200
250

Figure 2B

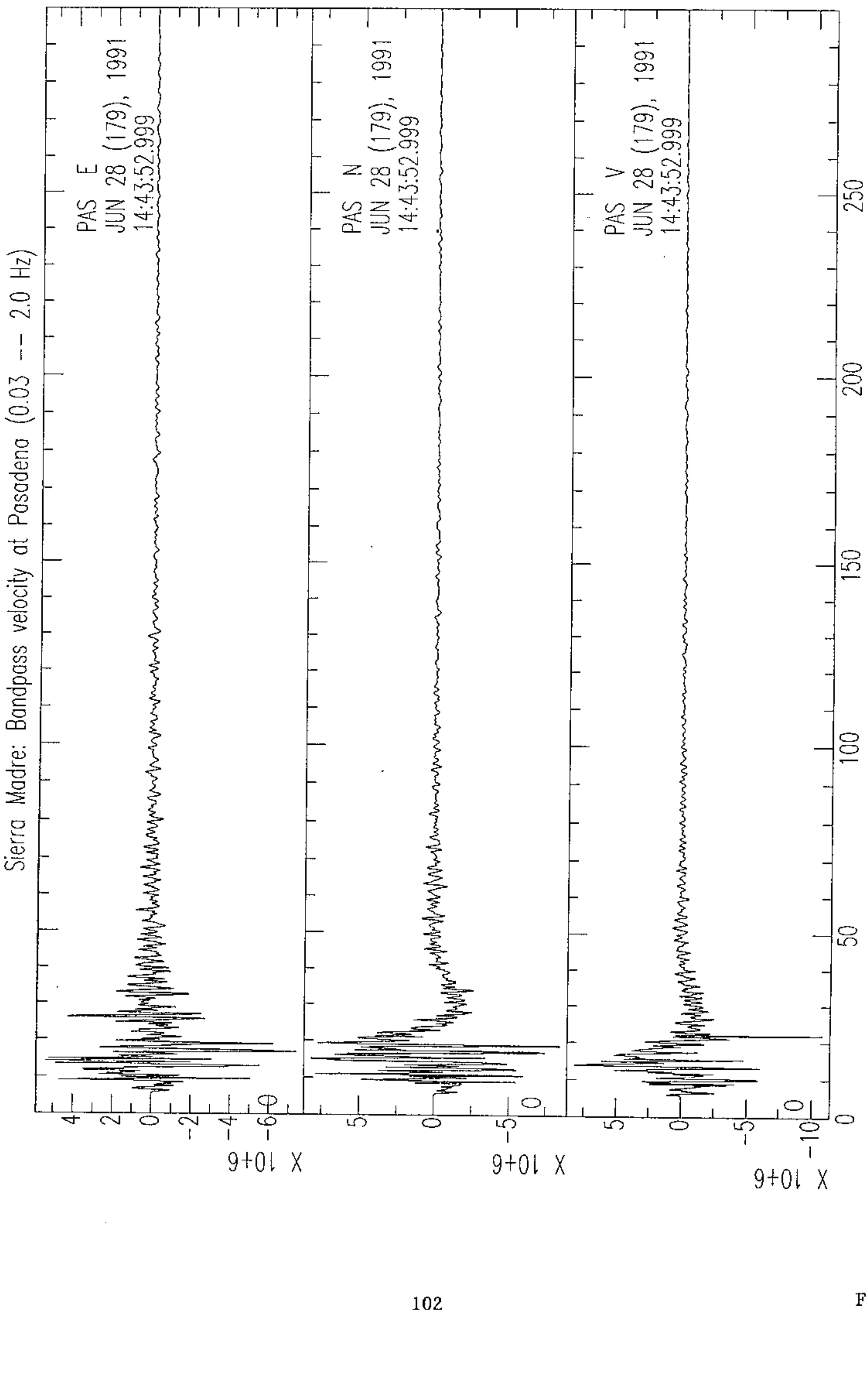
Sierra Madre: Bandpass velocity at Pasadena (0.03 -- 2.0 Hz)
PAS E
JUN 28 (179), 1991
14:43:52.999
PAS N
JUN 28 (179), 1991
14:43:52.999
PAS V
JUN 28 (179), 1991
14:43:52.999
X 10+6
X 10+6
X 10+6
0
50
100
150
200
250

Figure 2C