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A Leveling System for the CDF Central Muon Chambers*

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Abstract

The electronic level sensors used in aligning the drift chambers of the CDF central muon tracking system are described. Operation and readout of the level transducers using CAMAC is outlined. Calibration studies and field use show angle measurement to be better than 0.3 mR.

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Leveling System for the CDF Central Muon Drift Chambers

1. Introduction

The drift chambers for the CDF central muon tracking system can measure the angle of a particle track relative to a line between a pair of wires using drift time differences [1]. If the direction of the line relative to the $p\bar{p}$ interaction point is known, the particle momentum is determined from the angle measurment for charged particles coming from the central magnetic field of the detector. The chambers are built so that the pairs of wires will lie on a radial line from the $p\bar{p}$ vertex once the chambers are adjusted to the correct orientation. But because of small irregularities in the stacking of the wedges and in moving the arches, proper adjustment is impossible until the arches are in their final position, at which point the muon chambers are inaccessible. Therefore we must be able to measure chamber attitude remotely. In this note we describe the electronic level sensing system for the central muon chambers and we report on the system's performance during use at CDF.

2. System Description

Figure 1 shows a single muon chamber with 4 layers at increasing radial distance from the $p\bar{p}$ interaction region and 4 towers in ϕ. The chambers are designed so that in a given tower the wires from alternating layers will lie along a radial line extending from the $p\bar{p}$ vertex. Then the drift time difference for either wire pair in a tower yields the angle of a charged particle track relative to a radial line. In general the chambers will be initially misaligned by some angle α_c. Using the adjustable bolts that hold the muon chambers in place inside the ironwork of the calorimeter wedges α_c can be varied. The sensor reading yields

α_c directly so that reading out the sensors and adjusting the bolts aligns the chambers.

Figure 2 is a photograph of a level sensor. The sensors are attached to end of the chambers. The level sensor consists of a glass vial similar to a common carpenter's level,which is partially filled with an electrolytic fluid [2]. Electrodes built into each end of the vial are connected to a pair of resistors to form a Wheatstone bridge, as in figure 3. The electrolyte forms variable resistors in the bridge, so that for a clockwise rotation of the vial, the resistance on the one side increases, while the resistance on the other side decreases. Given an input voltage at the top of the bridge, the voltage on the right increases, while the left voltage decreases. The voltage dependence on tilt is linear over a range of 15-20 mR about horizontal, depending on the individual unit, with a slope of 15-20 μR per ADC count.

The sensors will function for a wide range of AC or DC input voltages. However, a sustained current will degrade the electrolyte over a period of time. To avoid deterioration, the input voltage for the bridge is pulsed only during measurement. The voltage pulse comes from a special CAMAC module designed and built at the University of Illinois, called a 12-channel leveler module. The module buffers and sends the pulse to 12 sensors in parallel, then receives and buffers the output voltages and sends them to a commercial CAMAC 16-channel differential ADC unit, in parallel. The ADC used has 12 bits with an input voltage range of -5 to +5 volts [3]. The 12-channel leveler also sums the input voltages for 3 adjacent channels and sends the summed voltage to the remaining 4 ADC channels, for monitoring purposes. Readout occurs when the ADC module is instructed to scan all inputs. In response the ADC module generates a NIM pulse which triggers the pulse generator in the 12-channel leveler. There is one sensor per wedge, for 48 total, so the CAMAC system consists of 4 12-channel leveler modules and 4 ADC modules.

The levelers are sensitive for at most only ± 20 mR about the horizontal, whereas nominal orientation for a given wedge varies over the full 2π radians. Therefore, a leveler for a given wedge is mounted such that it will be level when $\alpha_c = 0$. This is accomplished as follows: the vial, with leads attached to the electrodes, is placed in an aluminum housing that is then filled with epoxy. This subassembly is loosely attached to the brass mounting block that screws onto the drift chambers. Also on the mounting block are the resistors for the Wheatstone bridge as well as a cable connector. The mounting block is then attached to a jig designed for this purpose, at an angle corresponding to the particular wedge in the arch that the sensor will be used for. The jig is leveled using a machinist's precision level. The vial subassembly is moved by hand until 0 volts are read out of the Wheatstone bridge, at which point the subassembly is permanently glued to the mounting block. The leveler unit is then calibrated by stepping the jig through a range of known angles, and recording the ADC output for each step. The data are stored as a lookup table so that subsequent ADC readings for a given leveler can be translated into milliradians from horizontal. Figure 4 shows a plot of typical calibration data for a single leveler. These curves are highly reproducible. Even after several weeks, repeating a calibration produces the same curve with a variation of no more than 0.3 mR (15 counts). This change comes mainly from leveling the jig. For an installed sensor, the drift with time is only a few counts, as in figure 5. Angular resolution of tracks in the drift chambers is limited by multiple scattering of the particles in the calorimeters to about 2.3 mR at 50 GeV, so that the accuracy of the levelers is better than needed.

3. Results of field use

The leveler system was used during the stacking of the calorimeter wedges to build the first arch for CDF. Four levelers were installed at various heights on the arch, and the sag of the arch under the increasing load of each additional wedge was observed. Figure 5 shows the ADC outputs during the weeks of the arch stacking. After the arch was completed and had settled for a few days, the sensor readings did not vary by more than 2 counts (20 to 40 μR) over a period of 3 weeks. The sudden drop at day 32 is attributed to the unstacking of the topmost wedge. The magnitude of the change agrees well with the measurement made by the surveyor.

4. Conclusion

The leveler system described here provides a compact, simple, accurate means of aligning and monitoring the orientation of the CDF central muon drift chambers. Using calibration lookup tables the chambers can be adjusted to within 300 μR of their nominal orientation.

References

1. CDF NIM paper, section 4.1 'Central Muon Detector'

2. Frederick's Company, P.O. Box 67, Huntingdon Valley, PA. 19006 part number 0711-1401-99.

3. Joerger Enterprises, 166 Laurel Rd., East Northpoint, NY 11731

Differential ADC model ADC-P

Figure Captions

Figure 1. Cross section of a single muon chamber, showing the tilt angle α_c of the chamber relative to a radius extending from the $p\bar{p}$ interaction vertex. α_c must be known to make a p_t measurement.

Figure 2. Front, back, and side of an electronic level sensor for the drift chambers of the CDF central muon tracking system. The electrolyte-filled vial is imbedded in epoxy in the aluminum housing on the right. The housing is glued to the rest of the unit with an orientation such that it will be horizontal when the chambers are nominally aligned for the the wedge indicated by the markings on the front of the sensor.

Figure 3. Schematic illustration of the sensor circuit. Resistance between the leads at either end of the vial and ground varies linearly with the tilt of the sensor over a range of 20 mR about horizontal. Differential voltage output of the Wheatstone bridge is digitized and read out by computer.

Figure 4. Calibration data for a typical level sensor unit. The sensor is mounted on a jig and stepped through a sequence of angles, with the digitized voltage outputs stored as a look-up table. Calibration curves are reproducible to better than 300 μR.

Figure 5. Level measurements made during and after the stacking of the first roman arch at CDF. A constant offset has been added to each curve for clarity of presentation. From bottom to top, the curves show data from the first, third, sixth, and eighth wedges of the arch, respectively, counting from the bottom of

the arch. The dip at the far right corresponds to the removal of the top wedge from the arch and the consequent relaxtion of the arch.

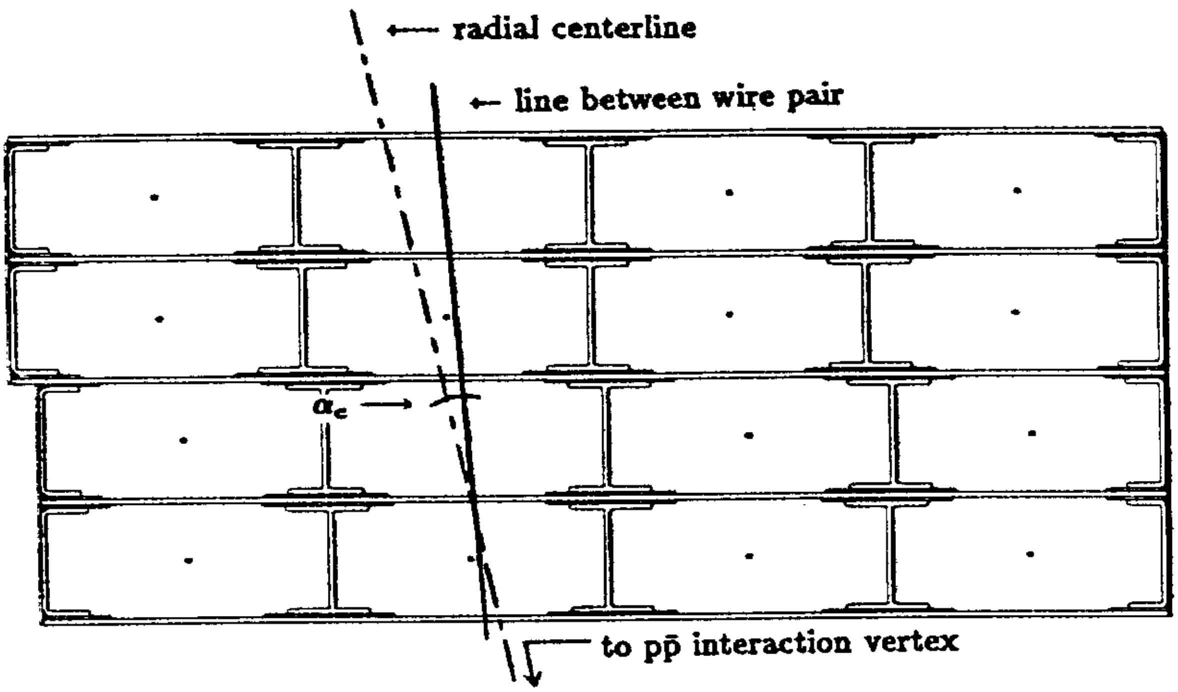
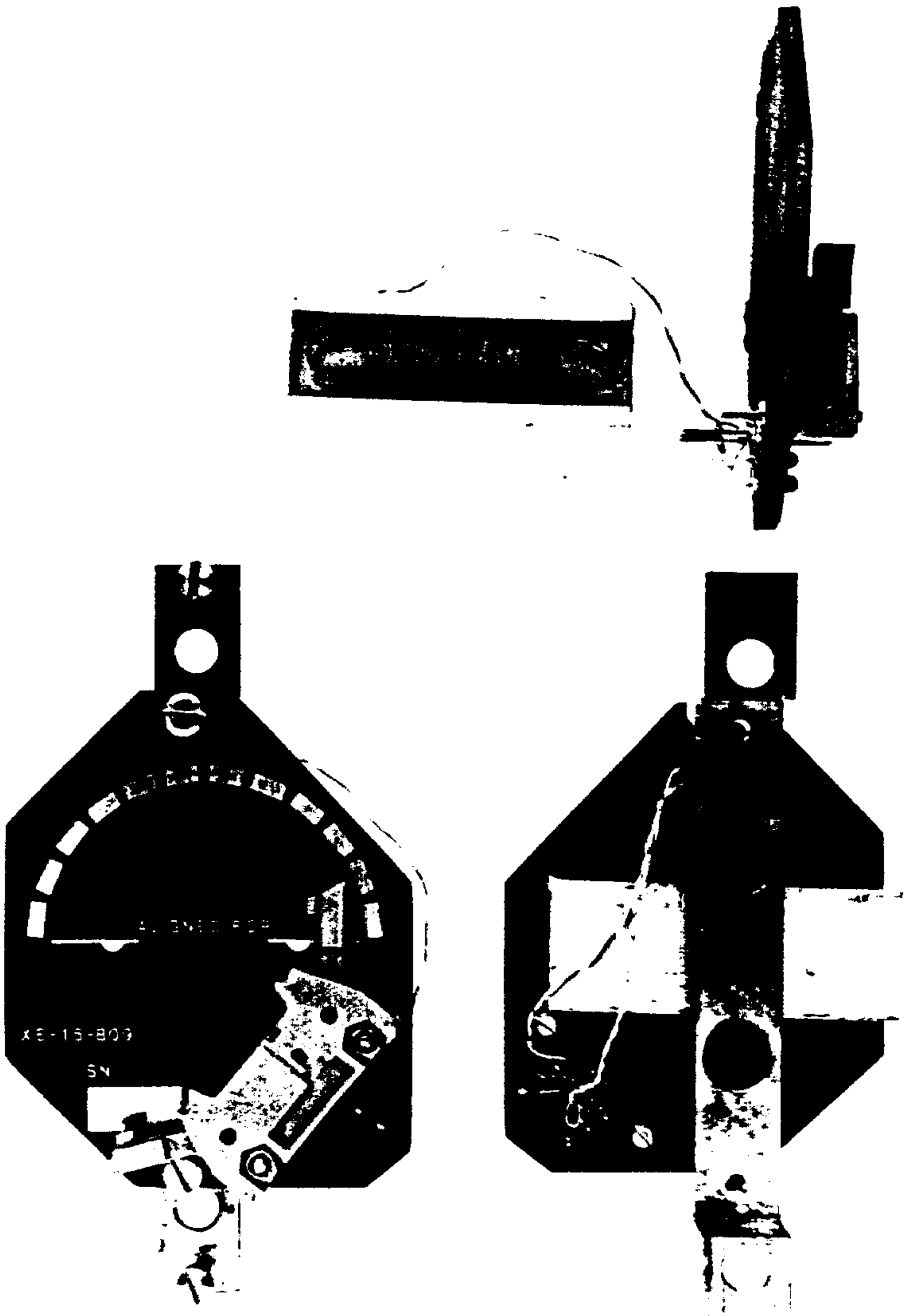

radial centerline
line between wire pair
α_c
to $p\bar{p}$ interaction vertex

Fig. 1



mu leveler, fig 2

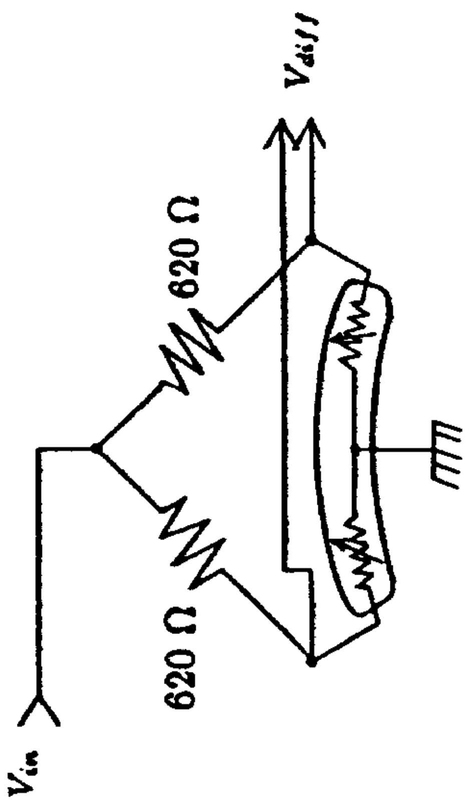


Fig. 3

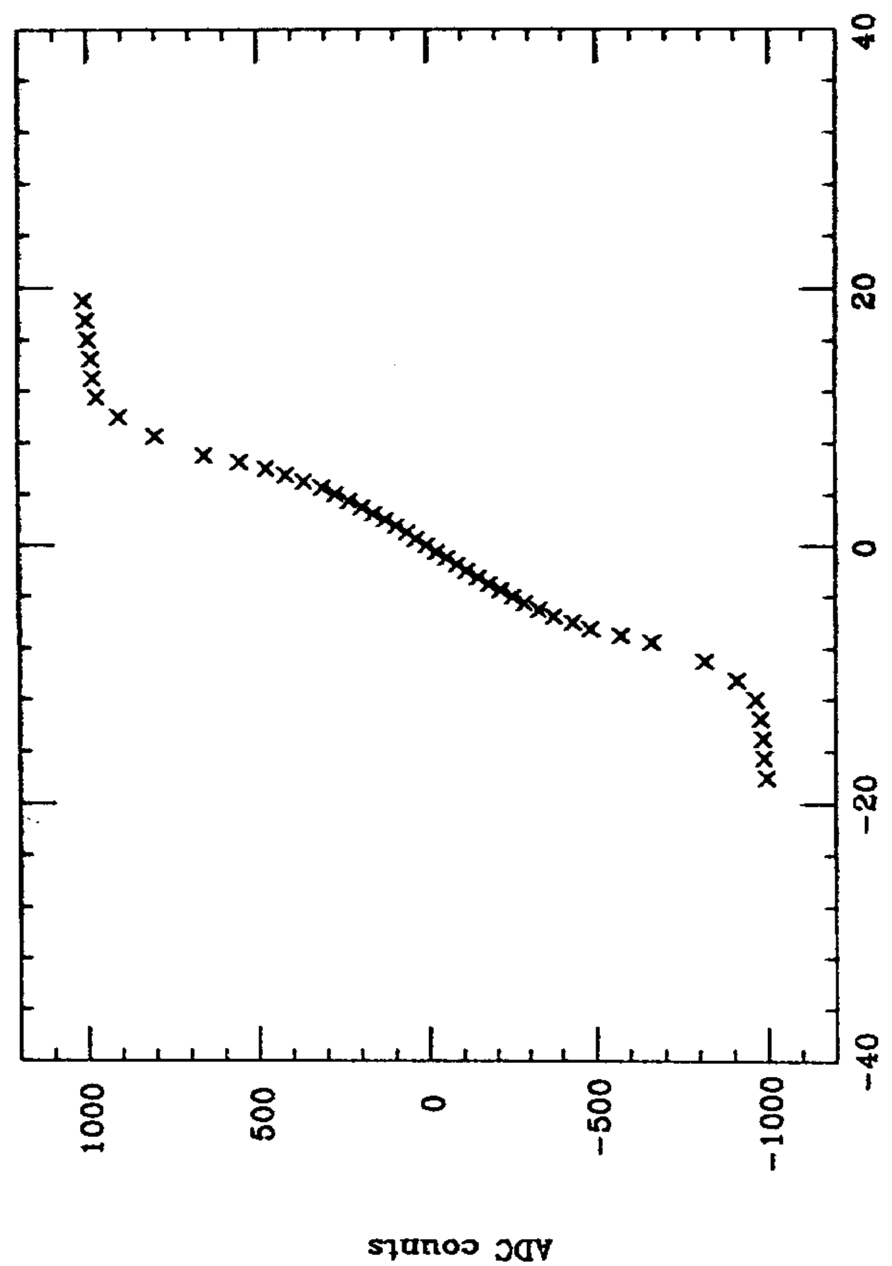


Fig. 4

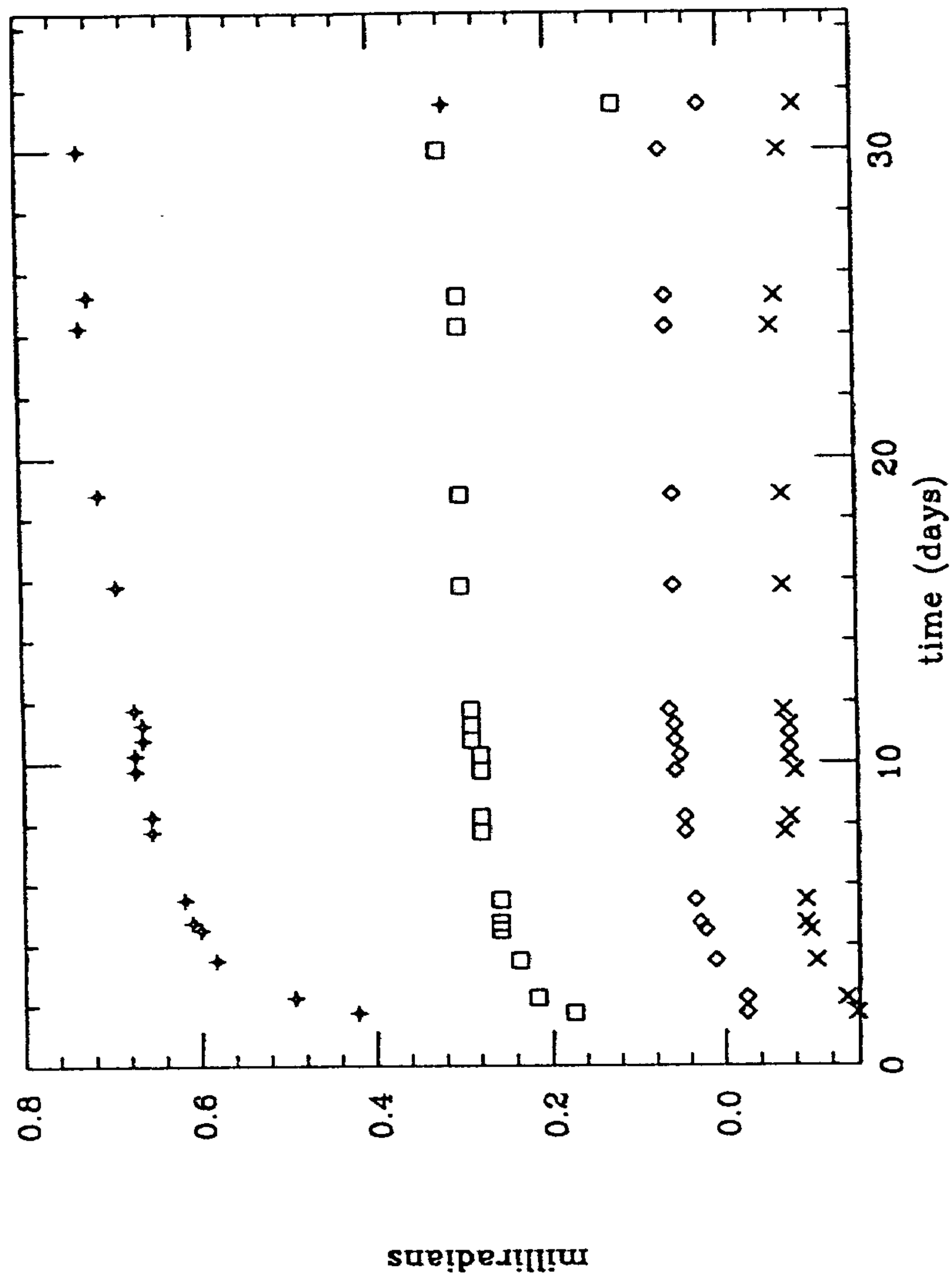


Fig. 5