ORNL/CP-100283

Low Intensity Beam Imaging – Position Sensitive Avalanche Counter

T. A. Lewis, Dan Shapira

Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831

J. Mas

Joint Institute for Heavy Ion Research, Oak Ridge National Laboratory, Oak Ridge TN 37831

Monitors of this type are mostly intended for the lowest intensity beams at the HRIBF at ORNL. They are used to aid the accelerator operator in focusing and steering the beam and by the experimenters at the focal plane of the spectrometers.

PRINCIPLES OF OPERATION

A schematic diagram of a typical Position Sensitive Avalanche Counter (PSAC) is shown in Fig. 1. The avalanche signal is picked up by sense wires whose ends are attached to delay line taps that propagate to both ends of the chain. The delay of the signal's arrival at either end is determined by the wire's position. The wires defining anode and cathode planes can be exchanged with foils. Minimum electrode spacing is 1/16 inch and is defined by the PC board thickness of each layer. To attain 1-mm resolution over a 6 × 6 cm square area, we can use 60 wires with 1-mm spacing between them. Two such detectors are needed: one each for X and Y position. The total expected propagation time is therefore 60*2 = 120 ns. This places a greater than 0.12 μsec limit on how fast signals can be handled. There are also other limitations to consider. The detector is an avalanche detector; we, therefore, have fast signal output. The actual duration of the signal is determined by the time it takes the detector to recover from an avalanche - which depends on factors such as gas pressure, the operating voltage, and the "gap" size (i.e., anode to cathode distance). The risetime is determined by the speed of electrons being removed from the avalanche area and is known to be in the order of 1 ns. Therefore, the recovery time should be about 2000 times longer, i.e., typically >2 μsec. This means that a top counting rate of $2 \cdot 10^4$ counts/sec is attainable when particles hit close to the same place in the detector. Higher rates are possible when the particles are spread out over a wider range.

PSAC PERFORMANCE

Bench test results

The diagram of the signal processing electronics used for the test reported here is shown in Fig. 2.

The detector container window openings were blanked off with two aluminum plates. On one of these plates was mounted an uncollimated α source. The two position signals, resulting from the time to pulse height conversion of the arrival time of signals to opposite sides of the delay lines were fed to two channels of an EG&G 811 peak sensing ADC. For diagnostic purposes the analog signals were fanned to a charge integrating ADC (LeCroy 2249W charge integrating ADC). The spectra shown in Fig. 3 have the two position signals and six spectra (IDs 3-8) showing the integrated current from the anode and from each side of the position plane.

The data shown were taken with 0.125" spacing between the cathode and position sensitive plane and 0.0625" between position sensing plane and the anode. The cathode voltage was -210 Volt and the anode was at 480 Volts. There was no collimation of the detector or the electrodes and at least at one end a clustering of position signal is obvious. The "holes" or depression seen in what should be a continous spectrum are probably due to inhomogeneity in the delay chips (one or two sections may be shorted). The large depression in what was labeled as X position may be due to a faulty chip or a bad socket.

Position calibration

A mask with many holes of different sizes was placed in front of the PSAC and an alpha source was placed in front of the mask. The two-dimensional pattern of X-Y hits recorded is shown in Fig. 4. The figures show

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

the hole pattern which was used – in general, 1-mm diameter holes were drilled with 4-mm center to center spacing. A few holes were enlarged to 2- and 3-mm diameters. These larger spots help navigate in X and Y. The problem with one of the delay chips is apparent in this figure. The figure on the right shows similar data taken with one of the position sensing planes changed out. Although the counting statistics are much lower, the problem apparently was removed. To get a rough idea of the X and Y positions, we assumed no distortion in the X-Y plane and projected all the peaks in one column to give us one position in the x direction and, similarly, the pattern associated with each row was projected to provide one Y position. The resulting X and Y calibration is displayed in Fig. 5.

Further development

The PSAC was deployed in the momentum dispersion region of the momentum analyzer part of the RMS ("finger region") and later installed in the Momentum Achromat focus region. In these tests and during the calibration tests the position signals (TAC outputs) were read and digitized in a CAMAC ADC (AD811 by EG\&G-Ortec). The acquisition rate was limited by CAMAC I/O to well below 10000 cts/sec, but the number of hits the detector was able to sustain was around 20000 cts/sec. It appears that the detector could tolerate more and we plan to test its counting capabilities after putting it in the direct path of the beam.

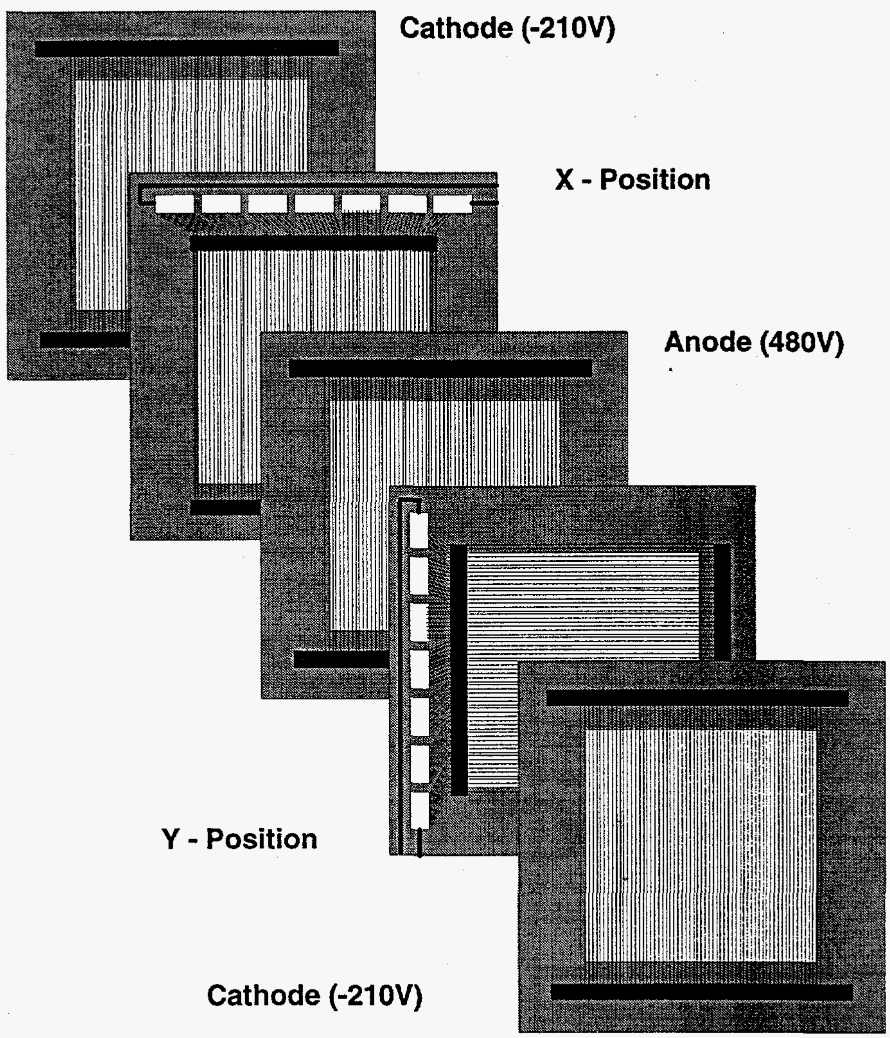

Fig. 1. A double position sensitive PSAC – there are two position sensing planes placed between an anode and two cathodes defined by wire planes.

Signal processing electronics for X-Y sensitive PSAC

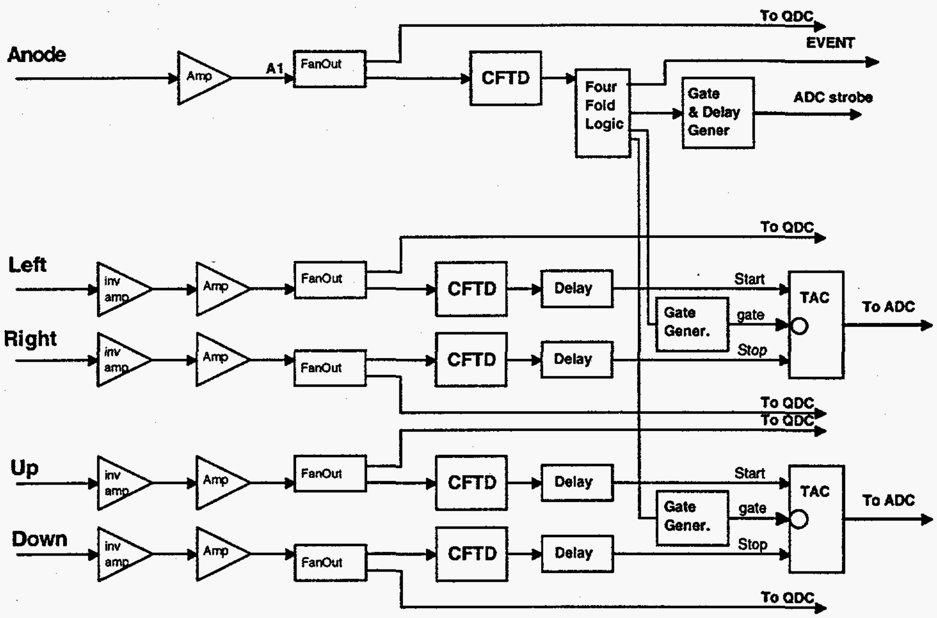

Fig. 2. Signal processing electronics used of bench testing the double-sided PSAC with α particles. CFTD is a constant fraction timing discriminator.

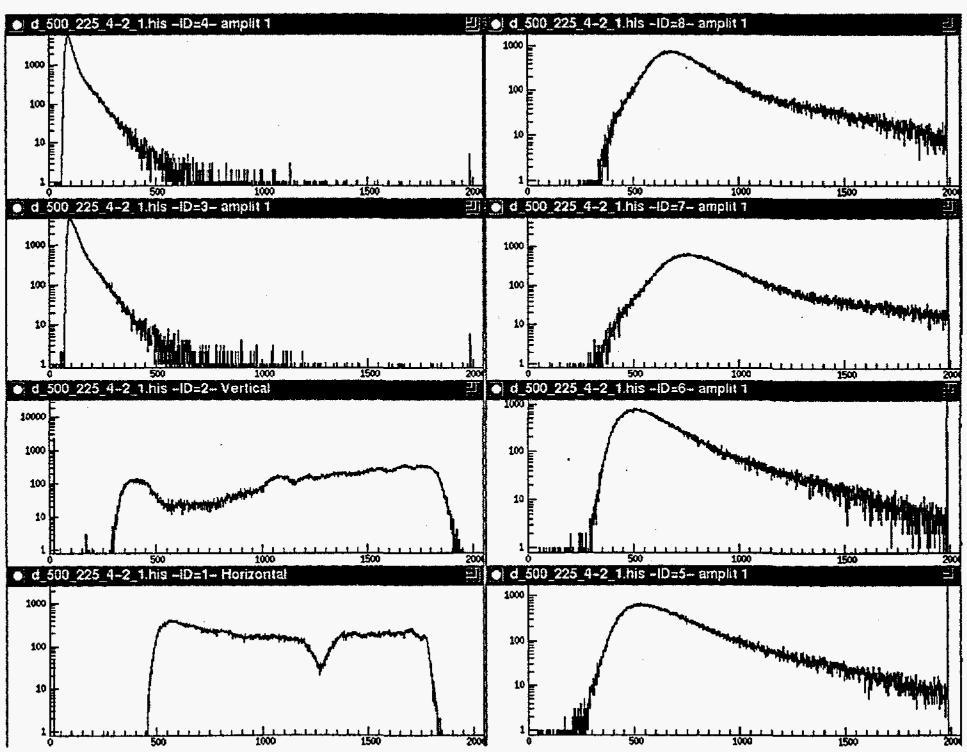

Fig. 3. Position signals for an uncollimated α source. The charge integrals from the anode and sense planes are also shown.

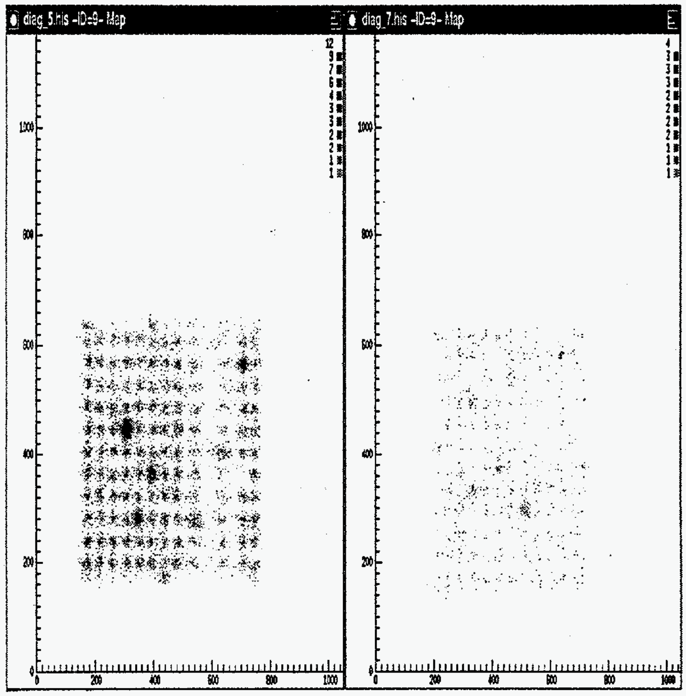

Fig. 4. Hit pattern on the PSAC with perforated mask in front. The frame on the left is with the faulty plane and the one on the right with a new (corrected) plane.

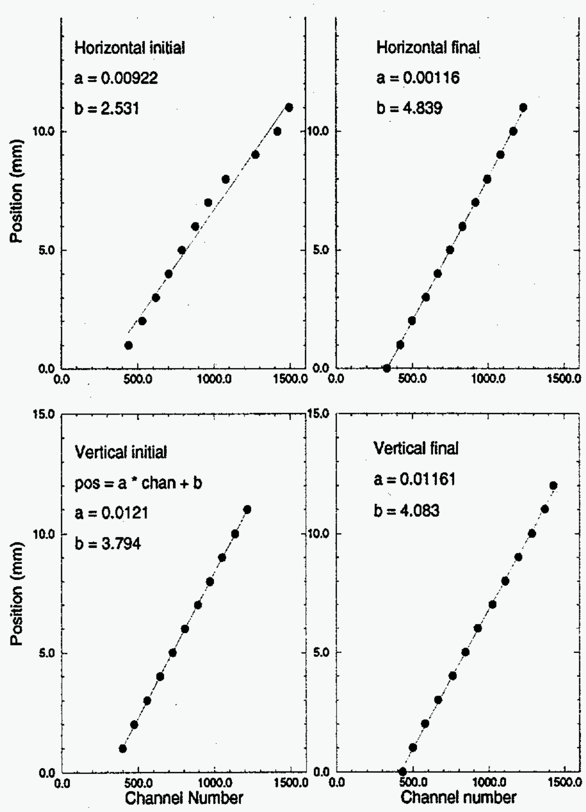

Fig. 5. X and Y position calibration – before (initial) and after (final) changing the faulty plane.