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Position sensitive proportional counter

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Abstract. We are developing a Position Sensitive Proportional Counter for X-rays in the energy range from 2 keV to 20 keV. With the sensitive circular area of 30 mm diameter, it can be used as an imaging detector at the focal plane of a soft X-ray optics. For two demensional position determination of an X-ray event, two multi wire cathode grids of 50 μm wire spaced at 0.5 mm are used. The final position of the event is obtained by calculating the center of gravity of the charge spread. Accuracy of the order 50 μm can be achieved by this method. The main anode grid made up of 25 μm wire spaced at 1 mm gives the standard energy resolution of the proportional counter. Another anode grid is used as an anti-coincidence counter to achieve high degree of background rejection.

Key words : PSPC, X-Ray imaging, proportional counter

1. Introduction

Proportional counters are extensively used in X-ray astronomy and position sensitive proportional counters (PSPC) find use in the focal plane of the X-ray mirrors like that used in the Einstein Observatory and ROSAT satellite (reference). We are developing a small area PSPC for use in the proposed Indian Multi-wavelength Astronomical Satellite (IMAS). It is proposed that this PSPU will be used for testing the gold-coated aluminum sheets used for the conical X-ray mirrors of IMAS. In this paper we describe the design and construction of the PSPC.

2. Design

The PSPC is basically made up of four electrodes (see Figure 1). The anode A1 and the corresponding cathodes K1 and K2 forms the main detector. The anode A2 is used as an anti-coincidence detector to reject the high energy or charged particle events. Each electrode is a grid of thin gold plated stainless steel with an open area of 56.5 mm by 56.5 mm, in which the wires are soldered on the supporting "plastic" frame. The anode grids are made up of 25 μm diameter wires spaced 1 at mm (in A1) and 2 mm (in A2) respectively. The cathode grids K1 and K2 are made up of 50 μm diameter wire spaced at 0.5 mm The detector has a window of 50 μm thick aluminised mylar. There is a drift region of 10 mm after the mylar window. The spacing between the window and the grids, as well as the various grid potentials are as shown in the fig.

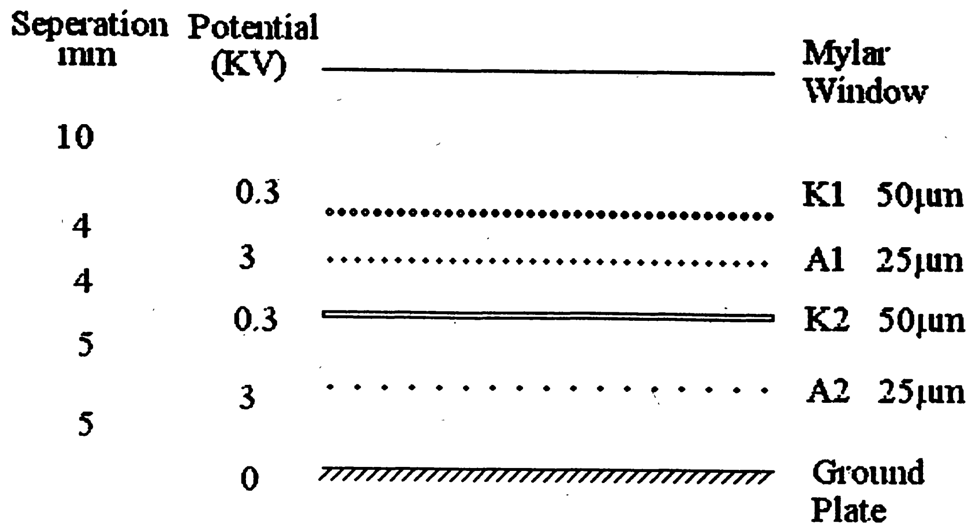

Figure 1. Four electrodes of the PSPC with their respective position, potentials and interelectrode spacing.

3. Position sensing

An X-ray photon, after passing through the window, interacts with the counter gas in the drift region and produces a photo electron. The photo electron then looses its energy by collision ionisation with the counter gas, and produces the primary electron cloud. This cloud drifts towards the positively biased cathode K1 and then towards the anode Al. Near the anode the charge multiplication occurs. The multiplied charge cloud, which is spread symmetrically with respect to the original position of the incident photon, leads to induced signals at the two cathodes K1 and K2.

The cathode K1 and K2 are main position sensing electrodes. Both are kept perpendicular to each other in order to achieve two dimensional position sensitivity. Each cathode is divided into 16 cathode strips of 7 wires connected to each other. In a typical X-ray event two to five adjacent strips are excited depending on the energy of the photon. The charge collected by any strip is proportional to the fractional area of the secondary charge cloud covered by the strip. Thus by measuring the charge collected by each strip and finding the center of gravity of the charge spread we can find out the precise position of the incident X-ray photon.

4. Electronics and software

As described above, to determine position and energy of an incident X-ray photon we have to process 16 + 16 cathode signals + 1 anode signal, which requires 33 channels of analog processing i.e. amplifier, peak detector etc. To reduce this number two strips of each cathode grids are interconnected, limiting the final signals from each cathode to eight. These interconnections are made in such a way that a unique determination of the strips originally excited is possible. This procedure is based on the assumptions that (1) in any event minimum two and maximum five strips are excited, (2) all the excited strips are adjacent, and is carried out by the processing software.

Each cathode strip is connected to a separate charge sensitive preamplifier and a post amplifier. The amplified signal is given to a peak detector via a gate operated by the control logic. The signals from the anode A1 and A2 are given to the control logic, which decides whether the event is acceptable or not. The acceptable event is the one in which there is a signal above the minimum threshold from only anode A1. On receiving a genuine event the control logic sends a trigger to the PC and closes the gates so that in the case of high event rate the information in each channel is not destroyed before being processed. It also opens the gates and resets all the peak detectors after a fixed time delay. This is the dead time of the detector, which in our case is about 200 μs.

The 17 signals from the 17 peak detectors, one anode signal and eight cathode signals from each cathode, (signal from A2 is used only by control logic) are then given to a multiplexer. The multiplexer output is given to a very fast ADC which in turn is connected with the PC. On receiving a trigger from the control logic PC selects the first multiplexer input and gives a signal to ADC. After a fixed time it reads the output of the ADC. It then selects another input of the multiplexer and gives a signal to ADC. This is repeated 17 times to get the 17 digital signals. This entire process is to be finished within the fixed dead time after which the control logic resets the system.

Out of the 17 digitized signal, one from the anode gives the energy of the incident X-ray photon, and the eight signals from each cathode contains position information of the event in respective direction. From the order of the eight signal in each direction the processing software first derives the numbers of the originally excited adjacent strips. Now it has information about both the position of the excited strips as well as the charge induced in each strip. The software then calculates the center of gravity of the charge spread to give the final position of the event.

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References

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