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Area detector for small angle neutron scattering at KUR

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ABSTRACT

The two-dimensional position-sensitive neutron detector has been developed for the small angle neutron scattering experiments at KURRI. The construction and the performance of the detector are described.

I. INTRODUCTION

Position-sensitive detectors (PSDs) are being widely used in neutron beam experiments. Especially, a large area PSD is essential for small angle neutron scattering (SANS) experiments. Research Reactor Institute, Kyoto University is engaged in the development of PSDs for use at SANS which will be situated at a cold neutron guide of Kyoto University Reactor (KUR). A variety of neutron PSDs have been developed and well used in neutron research centers, such as ILL, BNL, ORNL and Risø.[1,2] Most of them are ^{3}He-filled multi-wire proportional chambers (MWPCs) for the use at steady neutron sources. The important points in our design of the PSD are the best compromise of accumulated knowledge on the performance of detectors and the easiness of manufacture and maintenance of PSDs.

II. CONSTRUCTION

A 51x51 cm^2 detector (Type D) was designed for the use at SANS. In order to check the performance of the MWPC, we made a small prototype PSD (Type A), in which the electrode construction of the MWPC is the same as the large detector. The characteristics of two PSDs are given in Table, and their electrode configurations are shown in Fig.1. The MWPC electrodes of Au-coated tungsten wires and an aluminized Mylar sheet are kept under tension by being fixed to frames of glass epoxy resin (G10). Each MWPC is installed in an aluminium high pressure vessel. In Type A PSD a flat entrance window is used. In Type D PSD, however, an additional spherical dome filled with ^{4}He at the same pressure with the counter gas, is attached on the flat window, preventing deformations of the vessel and

Characteristics of Two Neutron Detectors

	Type A	Type D
Active Area [cm²]	21x21	51x51
Resolution [pixels]	56x56	64x64
Pixel Size [mmxmm]	3.75x3.75	8x8
Case Material	Aluminium	Aluminium
Window	10mm Al.	14mm Al. (4mm dome plus 10mm diaphram)
Active Depth [cm]	2.6	2.6
Anode	20μ Au-coated W wires spacing 2.5mm	20μ Au-coated W wires spacing 4.0mm
Readouts	50μ Au-coated W wires spacing 1.25mm	50μ Au-coated W wires spacing 2.0mm
Cathodes	Alminized Mylar plus 50μ Au-coated W wires	50μ Au-coated W wires
Wire Plane Spacing [mm]	6.5	6.5
Fill Gas	$^3He-Ar-CO_2$	$^3He-Ar-CO_2$
Gas Pressure [Pa]	max. $4.3x10^5$	max. $7x10^5$
Gas Purifier	540 ℃ heated Ca-shot	540 ℃ heated Ca-shot

reducing the thickness of windows which cause neutron scattering. There are two ports for gas inlet and circulation and electrical feed-throughs on the backside of PSDs. The preamplifiers and the gas purifier are connected with them.

As shown in Fig.1, the electrode arrangement of the MWPCs is symmetrical and two orthogonal readout grids are used for X- and Y-position readout by measuring induced charges, respectively. The readout grids are kept on the ground potential. The regions between the grid and the cathode plane are regarded as drift gaps, increasing the neutron detection efficiency with rather low anode voltage. The readout electrodes are strips, connected in groups of two or three wires in Type A and four wires in Type D. The various position readout techniques are proposed for two-dimensional PSDs. Among them, we intended to use the "strip-per-strip" encoding method and compared it with the delay-line method.

III. PERFORMANCE

1)Choice of counter gas

From the easiness of handling, the mixture of ^3He and Ar was used as the main component of the counter gas. The selection of the quenching gas was performed by using a cylindrical proportional counter, and the mixture of $^3He50\%-Ar47.5\%-CO_2 2.5\%$ was determined to be the best for our

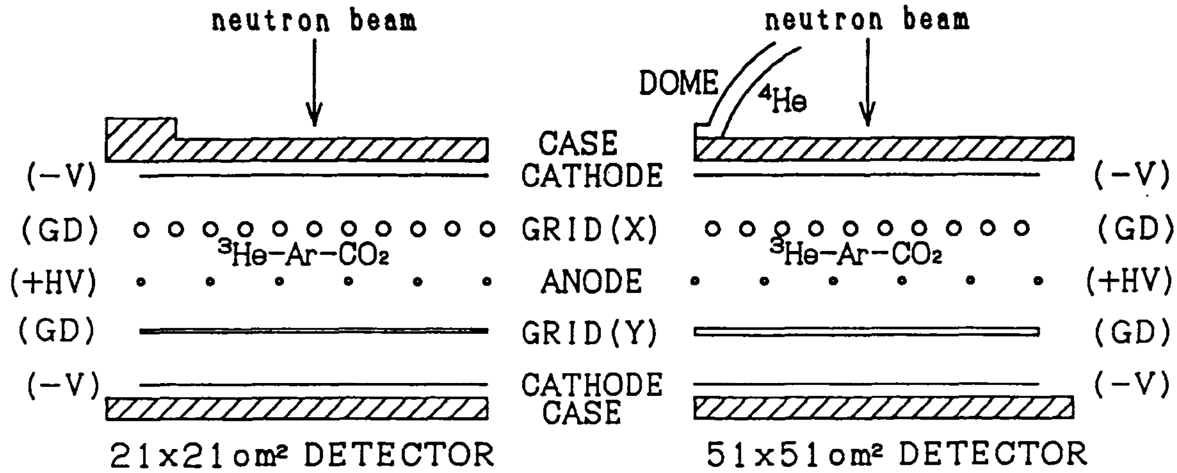


Fig.1. Electrode configurations of two position-sensitive detectors (Type A and Type D).

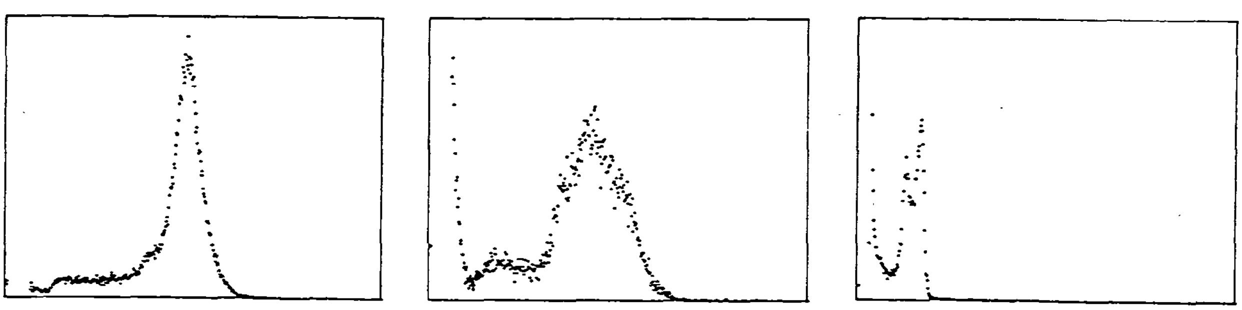
PSD. The filling of 4.5×10^5 Pa counter gas into our MWPC gives an efficiency of 96% for 4 Å neutron.

2)Gas purification

As a large quantity of glass epoxy resin is used in the electrode fixing frame of our MWPCs, it is inevitable to remove water and oxygen from the counter gas. The purification system containing Ca metal shots is heated to 540°C and the counter gas is circulated by convection and purified. Enough purification is achieved with 24 hrs operation.

3)Characteristics of MWPC

With the PSD (Type A) filled 3.5×10^5 Pa ^3He50%-Ar47.5%-CO_2 2.5% the characteristics of the MWPC was checked in the thermal neutron beams from an Ni guide tube. Figure 2 a) shows the pulse height spectrum obtained on the anode of the MWPC. The best performance was obtained by applying +2500 V on the anode and -500 V on the cathodes. The resolution of the sum peak is 13%, and the neutron signal



a) b) c)

Fig.2. Pulse height spectra for neutrons. a) Total anode signal, b) signal induced on the grid strip just in the beam line, and c) signal induced on the grid strip separated by five strips from the beam line.

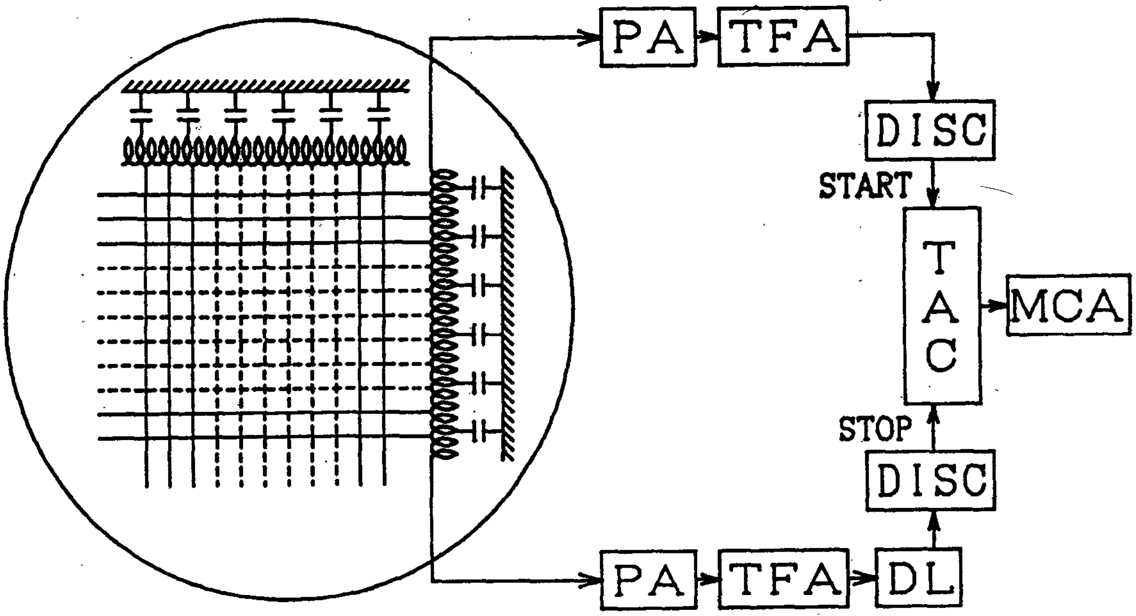


Fig.3. A block diagram of the position decoding using the delay-line.

is easily discriminated from the background noise. On the readout grids the signals are distributed over fifteen strips, and the pulse height spectra are well separated from noise level, as shown in Fig.2 b) and c). Therefore, the position determination is easily made by using "strip-per-strip" encoding method. Under the this condition the MWPC is operated with an avalanche charge of $\sim 5\times10^6$ electrons corresponding to a gas gain of ~ 150.

4)Position resolution for neutrons

Neglecting count rate capability, the delay-line encoding is more attractive in the sense of its simple construction and long term stability than the "strip-per-strip" encoding method. The delay-line readout was applied in the PSD Type A. As shown in Fig.3, the signal induced in the readout strips propagates towards both sides of the delay-line, and the difference in time of arrival at both ends gives a measure for the position of the avalanche. The delay-lines have 83 taps, each of which is connected to a readout strip being made up of two grid wires. The total delay time is 1328 nsec. The position resolution for neutrons is measured by using a pinhole of a cadmium mask on the face of the PSD. As shown in Fig.4, the detector response is linear, and the position resolution is determined to be 5 mm FWHM.

IV. CONCLUDING REMARKS

The basic tests with the 21x21 cm^2 PSD promissed an excellent performance of the large area detector. The 51x51 cm^2 PSD will be used for the SANS experiments at KUR, after checking the total performance such as uniformity, count rate capability, and long term stability.

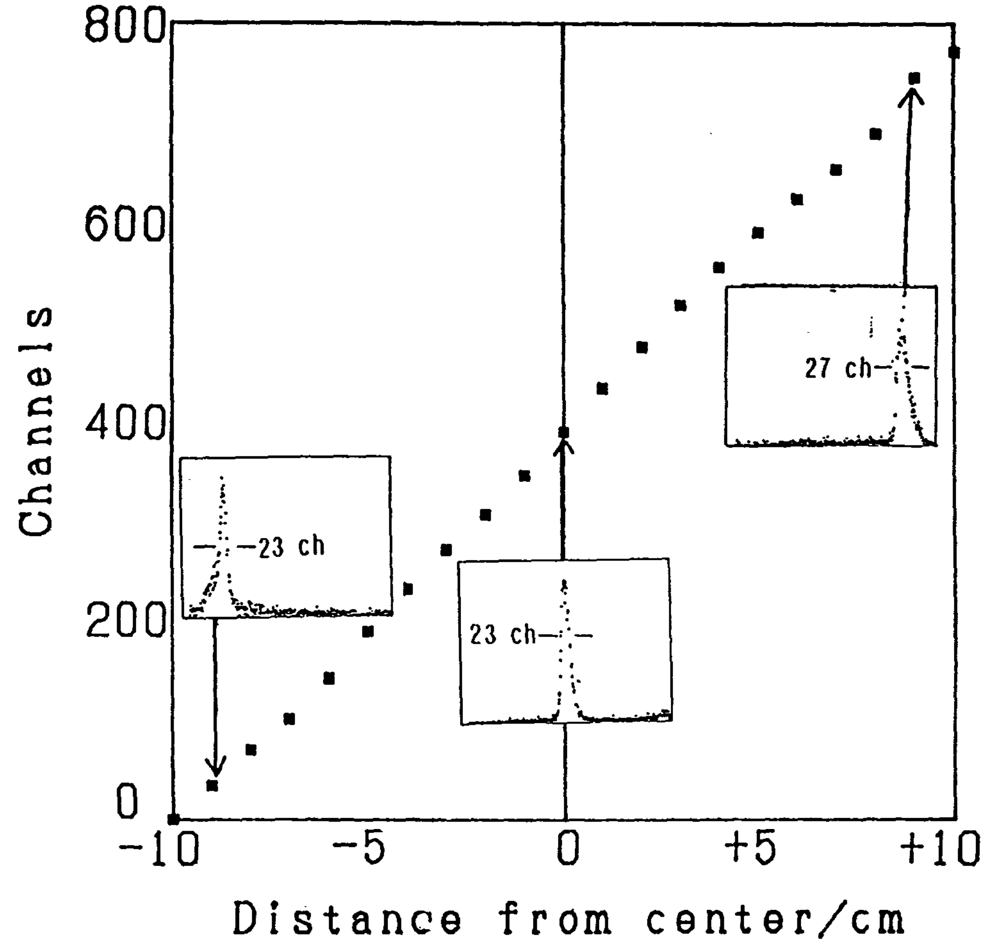


Fig.4. Relation between impact position (X) and channel assignment. 1 channel = 3.6 nsec = 0.25 mm. The inserts show the response to a pinhole beam giving the position resolution.

References

1. P. Convert and J. B. Forsyth (eds), Position-Sensitive Detection of Thermal Neutrons, Academic Press, London (1983).
2. J. K. Kjems, R. Bauer, B. Breiting, and A. Thuesen, Neutron Scattering in the 'Nineties, p.489 (1985).

Q(I.Kanno): What is the material of the dome and also the chamber itself? Is the pressure of ^{4}He in the dome almost the same with the one of active gas?

A(Y.Maeda): Both the dome and chamber are made of Al. The pressure of ^{4}He and active gas are almost the same. It is important to make the window thin and avoid deformations of the vessel. The pressure difference is kept to be less than 0.1Kg/cm^2 and the maximum displacement of the diaphragm is 1mm.

Q(H.Tietze): What is the decay time of the counting pulses obtained?

A(Y.Maeda): About 50μsec. But it depends on the position. The signal induced on read-wire just in the beam line has an additional signal due to Ar ion arriving directly at the wire. The delay of this signal from the signal induced by avalanche is ~200μsec.

Q(R.K.Crawford): Have the various encoding methods possible with this detector been compared?

A(Y.Maeda): Neglecting counting rate capability, the delay-line encoding is the most attractive in the sense of its simple construction and long term stability. After checking the total performance such as uniformity and counting rate capability, we want to decide whether "strip per strip" encoding is necessary or not.