Development of a Novel Fast-response Neutron Beam Monitor

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Introduction

During the last year we have been involved with the development of fast response neutrons detectors. Such detectors are required for couple of applications. A prominent example of such applications is intense neutron beam monitoring in next generation of accelerator-based neutron sources. Such accelerators are now under construction in several countries. For example, in Japan, Japan proton accelerator research complex (J-PARC) is being built. In this project very intense thermal neutron beams will be available and therefore appropriate neutron detectors are required to provide information on the neutron beam such as intensity, spatial and time distribution. In such a harsh environment, detector radiation durability is of crucial importance as well.

This report is devoted to the preliminary results of a novel fast neutron beam monitor, which is based on the parallel plate avalanche chamber (PPAC). Choice of PPAC was made due to its fast response, radiation resistance, high-count rate and position measurement capability.

Parallel plate avalanche counters

A PPAC consists simply of two thin metalized foils mounted in parallel, with a small gap of a few mm in between (Fig. 1). PPAC is employed at a few torr of a hydrocarbon gas like isobutene, and under a strong electric field *E* in the gap. Due to the high-reduced electric field, *E/P*, (*P* is gas pressure) released electrons by ionizing radiations initiate electron avalanche and form a very fast signal (~1 ns rise time) due to the high drift velocity of electrons.

Detector can be easily made position sensitive, if an electrode is made of a grid of parallel thin wires or parallel strips. Then, position data can be obtained by means of conventional methods like delay line or charge division method.

The neutron-sensitive PPAC

Our prototype detector consists of three parts: The converter sheet, which produces recoil charged particles, the PPAC and detector housing.

Converter; the converter is a thin layer of ^{6}LiF evaporated on aluminum backing. In order to obtain a good pulse height spectrum converter sheet is placed a few centimeters far from PPAC.

PPAC; a schematic illustration of our PPAC has been shown in Fig. 2. It consists of an aluminized Mylar foil electrode as anode and cathode made of a grid of gold-plated tungsten wires (30 μm) with 2 mm spacing. Anode-cathode gap is 2 mm and position information is obtained by using delay-line technique.

Detector housing; detector assembly is mounted in the detector housing, which is made of aluminum. The detector is operated in the gas flow mode with isobutene gas.

Test experiments results

Test experiments were carried out with using an Am-Be neutron source. Fast neutrons were thermalized by employing appropriate thickness of polyethylene. A typical detector pulse height spectrum is shown in Fig. 2. Figure 3 shows a typical signal waveform, obtained with fast current sensitive preamplifier (VT120, Ortec). The signal rise time of ~ 4 ns and ~ 6 nsec pulse width (FWHM) is easily obtainable. Such signals are well suited for the time dependent beam monitoring applications under high count rates.

A projection of position spectrum is shown in Fig. 4. The obtainable spatial resolution is equal with wires spacing (2 mm). Delay line system was composed of delay chips with 3 ns delay between adjacent wires and 100 ps time resolution.

Summary and conclusion

A novel neutron beam monitor with very fast response and position measurement capability has been successfully developed. Fast signals with ~ 4 ns rise time and ~6 ns pulse width together with 2 mm position accuracy were easily obtained. This detector looks very promising for beam monitoring in J-PARC project and so on.

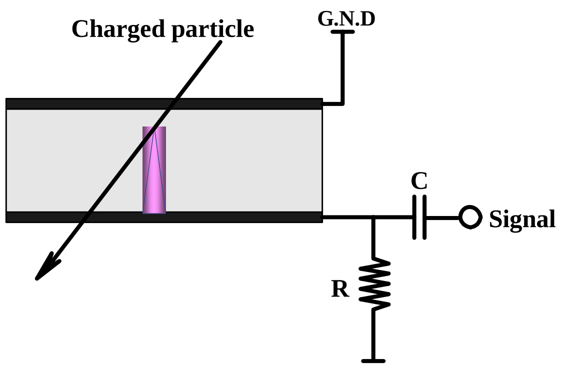

Figure 1. PPAC principle of operation.

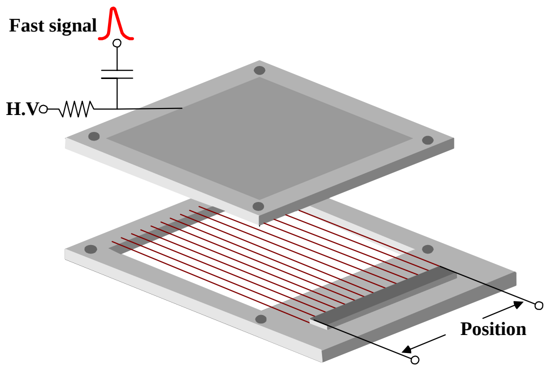

Figure 2. Schematic representation of our PPAC.

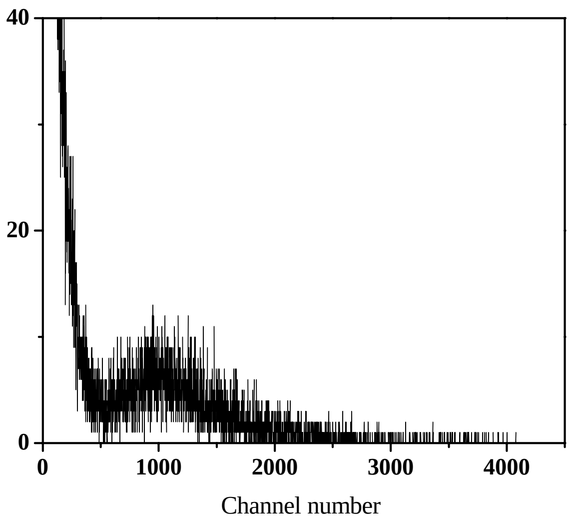

Figure 3. Typical pulse height spectrum.

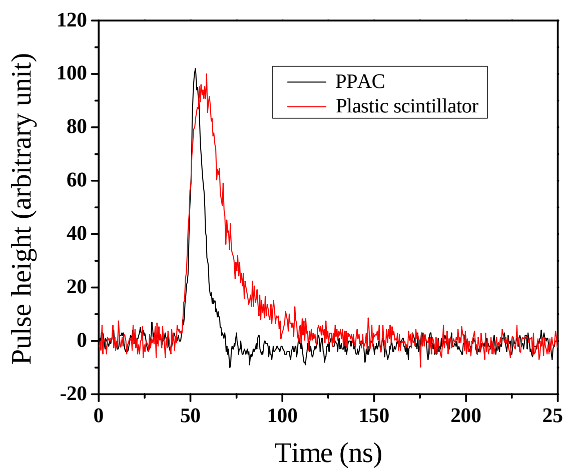

Figure 4. Typical signal waveform, compared with scintillator. Scintillator shows much longer decay time.

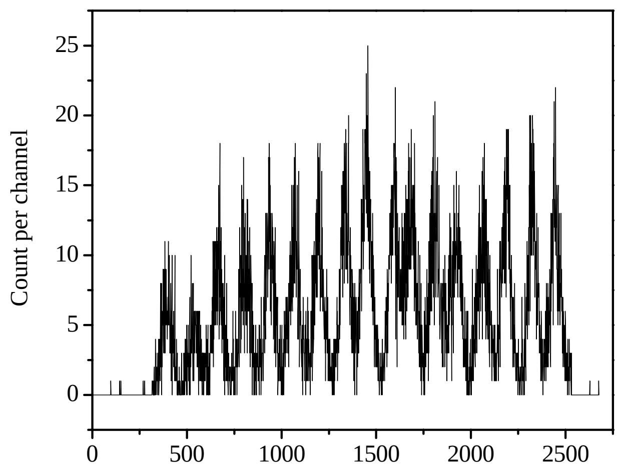

Figure 5. Results of position measurement according to delay line method.